Université de Montréal

Frame Semantics for the field of climate change:

Discovering frames based on Chinese and English terms

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Ce mémoire intitulé

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Présenté par

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A été évalué par un jury composé des personnes suivantes

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Abstract

Most of the existing Mandarin Chinese specialised dictionaries of environmental terms are paper dictionaries, compiled and revised more than ten years ago, and contain mainly noun terms. Terminological information is restricted to knowledge conveyed by the term and its English equivalent(s). For readers who want to learn about semantic or syntactic properties of terms and for readers who want to see usage of terms in real contexts of specialised texts, information provided in existing dictionaries is insufficient. In this research, we compiled an online Mandarin Chinese terminological resource, describing Chinese verb terms in the field of climate change. This resource makes up for some of the deficiencies of existing Chinese environmental dictionaries, revealing meaning(s) of the term through actantial structure(s) and showing, through annotated contexts, semantic and syntactic properties of the term as well as its practical usages in specialised texts. This resource better meets the needs of the audience.

The theoretical basis underpinning this research is Frame Semantics (Fillmore, 1976, 1977, 1982, 1985; Fillmore & Atkins, 1992), and the FrameNet built from it. The main objective of this research is to discover and define Chinese semantic frames in the field of climate change, and to establish relations between the Chinese frames defined. The Chinese semantic frames are discovered with the help of the methodology of the multilingual environmental dictionary DiCoEnviro (and its accompanying resource Framed DiCoEnviro) (L'Homme, 2018; L'Homme et al., 2020). In order to make this methodology applicable to a Sino-Tibetan language, Chinese, we modified and adapted this methodology to suit the description of Chinese terms and definition of Chinese semantic frames. Some of the changes and adaptations are based on the Chinese FrameNet (CFN) (Liu & You, 2015).

In order to discover Chinese semantic frames, a monolingual Mandarin (Chinese) Climate Change Corpus (MCCC) was first compiled. This corpus contains 224 authentic Chinese specialised texts in the field of climate change, totaling 1,228,333 Chinese characters, which is 547,592 Chinese words. Following this, candidate terms were automatically extracted from MCCC using the corpus

management and analysing software – Sketch Engine. After manual analysis and validation, which of the candidate terms are true terms was clarified. Subsequently, the actantial structure of each term was written by analysing the contexts where the term occurs. Next, each sense of a polysemous term was placed in a separate entry and 16-20 contexts were selected for each entry. Then, each context was annotated in terms of three layers – semantic structure, syntactic function and syntactic group. After this, the terms were classified according to the scenarios they evoke. Terms that depict the same scene or situation in the field of climate change, have similar actantial structure, and share the majority of circumstants are categorised into one semantic frame (criteria based on the project DiCoEnviro (L'Homme, 2018; L'Homme et al., 2020)). After Chinese semantic frames were identified, each frame was defined. Finally, the discovered Chinese frames were linked according to the eight types of frame relations proposed by Ruppenhofer et al. (2016). To be displayed online, term entries and semantic frames were encoded in XML files.

Guided by this research methodology, we eventually discovered and defined 23 Chinese semantic frames. The end result of this research is a frame-based Mandarin Chinese terminological resource specialised in the field of climate change. This terminological resource consists of two parts. The first part is the description of a total of 39 Chinese verb terms. With each meaning of a polysemous verb term placed in a separate entry, there are a total of 59 entries (each entry contains the actantial structure and annotated contexts). A total of 1,027 contexts were annotated. The second part of this resource presents the 23 Chinese semantic frames identified as well as the relations between frames.

Keywords : verb terms, semantic frames, Mandarin, climate change, terminological resource, Frame Semantics, Chinese FrameNet

Résumé

La plupart des dictionnaires spécialisés de termes environnementaux en mandarin sont des dictionnaires papier, compilés et révisés il y a plus de dix ans, et contiennent principalement des termes nominaux. Les informations terminologiques se limitent aux connaissances véhiculées par le terme et son ou ses équivalents anglais. Pour les lecteurs qui souhaitent connaître les propriétés sémantiques ou syntaxiques des termes et pour les lecteurs qui veulent voir l'usage des termes dans des contextes réels de textes spécialisés, les informations fournies par les dictionnaires existants sont insuffisantes. Dans cette recherche, nous avons compilé une ressource terminologique en ligne du mandarin, décrivant les termes verbaux chinois dans le domaine du changement climatique. Cette ressource comble certaines des lacunes des dictionnaires environnementaux mandarin existants, en révélant le(s) sens du terme à travers la(les) structure(s) actantielle(s) et en montrant, à travers des contextes annotés, les propriétés sémantiques et syntaxiques du terme ainsi que ses usages pratiques dans des textes spécialisés. Cette ressource répondra mieux aux besoins du public.

La base théorique qui sous-tend cette recherche est la Sémantique des cadres (Fillmore, 1976, 1977, 1982, 1985; Fillmore & Atkins, 1992), et le FrameNet construit à partir de celle-ci. L'objectif principal de cette recherche est de découvrir et de définir des cadres sémantiques chinois dans le domaine du changement climatique, et d'établir des relations entre les cadres chinois définis. Les cadres sémantiques chinois sont découverts à l'aide de la méthodologie du dictionnaire environnemental multilingue DiCoEnviro (et de sa ressource d'accompagnement Framed DiCoEnviro) (L'Homme, 2018; L'Homme et al., 2020). Afin de rendre cette méthodologie applicable à une langue sino-tibétaine, le chinois, nous avons modifié et adapté cette méthodologie pour qu'elle convienne à la description des termes chinois et à la définition des cadres sémantiques chinois. Certaines de ces modifications et adaptations sont basées sur le Chinese FrameNet (CFN) (Liu & You, 2015).

Afin de découvrir les cadres sémantiques chinois, un corpus monolingue en chinois mandarin sur le changement climatique (MCCC) a d'abord été compilé. Ce corpus contient 224 textes

authentiques chinois spécialisés dans le domaine du changement climatique, qui totalisent 1,228,333 caractères chinois, soit 547,592 mots chinois. Puis, les termes candidats ont été automatiquement extraits du MCCC à l'aide du logiciel de gestion et d'analyse de corpus – Sketch Engine. Après une analyse et une validation manuelle, nous avons déterminé quels termes candidats sont des termes réels. Par la suite, la structure actancielle de chaque terme a été écrite en analysant les contextes où le terme apparaît. Ensuite, chaque sens d'un terme polysémique a été placé dans une entrée séparée et 16-20 contextes ont été sélectionnés pour chaque entrée. Puis, chaque contexte a été annoté en fonction de trois couches – structure sémantique, fonction syntaxique et groupe syntaxique. Ensuite, les termes ont été classés en fonction des scénarios qu'ils évoquent. Les termes qui dépeignent la même scène ou situation dans le domaine du changement climatique, qui ont une structure actantielle similaire et qui partagent la majorité des circonstants sont classés dans un seul cadre sémantique (critères basés sur le projet DiCoEnviro (L'Homme, 2018; L'Homme et al., 2020)). Après avoir identifié les cadres sémantiques chinois, chaque cadre a été défini. Enfin, les cadres chinois découverts ont été reliés selon les huit types de relations entre cadres proposés par Ruppenhofer et al. (2016). Pour être affichés en ligne, les entrées de termes et les cadres sémantiques ont été encodés dans des fichiers XML.

Guidés par cette méthodologie de recherche, nous avons finalement relevé 23 cadres sémantiques chinois et nous les avons définis. Le résultat final de cette recherche est une ressource terminologique en chinois mandarin basée sur des cadres et spécialisée dans le domaine du changement climatique. Cette ressource terminologique se compose de deux parties. La première partie est la description d'un total de 39 termes verbaux chinois. Chaque sens d'un terme verbal polysémique étant placé dans une entrée séparée, il y a au total 59 entrées (chaque entrée contient la structure actantielle et les contextes annotés). Au total, 1,027 contextes ont été annotés. La deuxième partie de cette ressource présente les 23 cadres sémantiques chinois identifiés ainsi que les relations entre les cadres.

Mots clés : termes verbaux, cadres sémantiques, Mandarin, changement climatique, ressource terminologique, Sémantique des cadres, FrameNet Chinois

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Typographical conventions

Terms: Chinese term (with Chinese phonetic alphabet on the top) plus sense number, e.g. jiā jù 加剧$_1$

Concepts or notions: double quotation marks, e.g. “融化”, “absorption”

Frame names: frame name in Chinese plus frame name in English,

e.g. [温度变化|Change_of_temperature]

Other lexical items in the text: italics for English lexical items; no specific marks (with Chinese phonetic alphabet on the top) for Chinese lexical items, e.g. *absorb*, biànhuà 变化

English translations of Chinese terms: English translation inside inverted comma, e.g. jiā jù 加剧$_1$ ‘intensify’

Actants and circumstants in English: first letter capitalised, e.g. Agent, Time

List of symbols and abbreviations

CFN	Chinese FrameNet
CPB	Chinese Proposition Bank
CTB	Chinese Treebank
FD	Framed DiCoEnviro
FE	Frame Element
FN	FrameNet
ISO	International Organization for Standardization
LU	Lexical Unit
MCCC	Mandarin (Chinese) Climate Change Corpus
MV	Mandarin VerbNet
N	Noun
NLP	Natural Language Processing
OLST	Observatoire de Linguistique Sens-Texte
PERF	Marker of perfect tense
PROG	Marker of progressive tense
SUPP	Support verb
V	Verb

To my parents,

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Finally, I would like to dedicate my dissertation to my family. The understanding, support and encouragement of my parents have been a great source of energy for me to persevere to the end. Thank you, dad and mum, I have been able to complete this stage of my studies, and my gratitude and love will be the greatest strength for my future journey.

I would like to dedicate this dissertation to all the teachers, parents and friends who have supported me through this journey.

"不是因為看到希望而堅持，而是因為堅持而看到希望。" – Anonymous

'It is not because we have seen hope that we persevere, it is because we persevere that we see hope.' (my translation)

1 Introduction

This research looks into semantic frames categorising Mandarin Chinese verb terms identified from a specialised corpus in the field of climate change. This specialised corpus compiled as the very first step of this research serves as the source of Mandarin terms and contexts where these terms occur. For the purpose of discovering frames, Mandarin verb terms are described in terms of their semantic and syntactic properties. The end result of this research is a frame-based Mandarin Chinese terminological resource consisting of two parts – one is the description of Mandarin specialised verb terms; the other one presents the semantic frames identified as well as the relations between frames. This research proposes a way of writing specialised term entries with regard to their practical usages in specialised texts. This research provides a new angle for studies into Chinese terminology and lexicography.

1.1 Statement of the problem

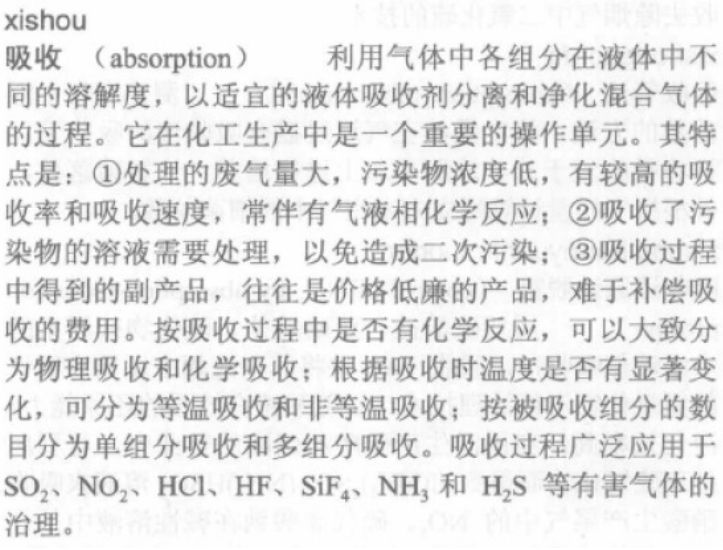
To find out how environmental terms are described in today's available Chinese dictionaries specialised in the domain of the environment, we found ten Chinese dictionaries of environmental terms (see Table 1). These dictionaries have different purposes of compilation and different readerships. In the following paragraphs, we present three representative dictionaries – 《环境科学大辞典》 (*Environmental Science Dictionary*) (2008), 《英汉双解生态与环境词典》 (*English-Chinese Bilingual Ecology & Environment Dictionary 3rd ed.*) (1999), and 《環境科學名詞辭典》 (*An English Chinese Dictionary of Environmental Sciences*) (1986).

<1> 《环境科学大辞典》 (*Environmental Science Dictionary*) (2008)

The 《环境科学大辞典》 (*Environmental Science Dictionary*) (2008) contains 8,380 important and common nominal terms in all disciplines of environmental science. The dictionary aims to clear up doubts and confusion on the part of its readers, including environmental scientists, as well as a wide range of professionals in science, engineering, agriculture, medicine, law, economics and management. To inform the reader of the knowledge conveyed by terms, the

information in the term entry consists mainly of an explanation of the concept denoted by the term.

For example, the information in the dictionary entry of the term 吸收 xī shōu 'absorption' (see Figure 1) includes the pronunciation of the term in Chinese phonetic alphabet – xishou, its English equivalent between brackets – (absorption), and an explanation of the concept designated by the term 吸收 xī shōu 'absorption'. It is important to note that the definition of 吸收 xī shōu 'absorption' here does not explain the meaning of the term 吸收 xī shōu 'absorption' itself; rather, it explains the process of 气体吸收 qì tǐ xī shōu 'gas absorption', which is the process of the separation and purification of a gas mixture using a liquid absorber in chemical production.



xishou

吸收 （absorption） 利用气体中各组分在液体中不同的溶解度，以适宜的液体吸收剂分离和净化混合气体的过程。它在化工生产中是一个重要的操作单元。其特点是：①处理的废气量大，污染物浓度低，有较高的吸收率和吸收速度，常伴有气液相化学反应；②吸收了污染物的溶液需要处理，以免造成二次污染；③吸收过程中得到的副产品，往往是价格低廉的产品，难于补偿吸收的费用。按吸收过程中是否有化学反应，可以大致分为物理吸收和化学吸收；根据吸收时温度是否有显著变化，可分为等温吸收和非等温吸收；按被吸收组分的数目分为单组分吸收和多组分吸收。吸收过程广泛应用于 SO_2、NO_2、HCl、HF、SiF_4、NH_3 和 H_2S 等有害气体的治理。

Figure 1. – Term entry 吸收 xī shōu 'absorption' in《环境科学大辞典》(*Environmental Science Dictionary*) (2008, p. 731)

Very similar in entry content to 《环境科学大辞典》 *(Environmental Science Dictionary)* (2008) are the online dictionary 《環境科學大辭典》[1] *(Environmental Science Dictionary)* (see Appendix 1.1) (2002) compiled by the National Academy for Educational Research of Taiwan and

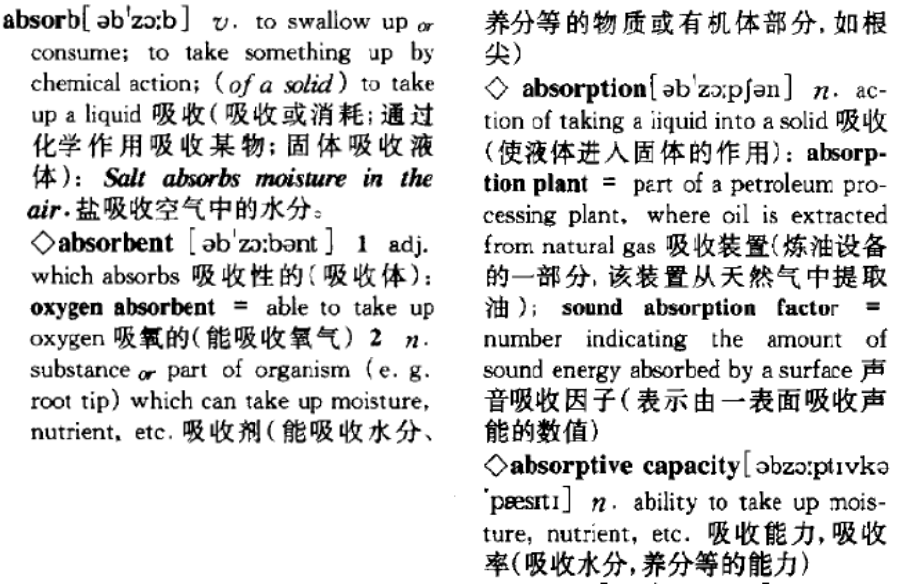
[1] The online 《環境科學大辭典》has been compiled by National Academy for Educational Research (Taiwan) based on its paper version 《環境科學大辭典》 *(Environmental Science Dictionary)* (Yu et al., 2002).

《环境科学与工程技术辞典》 *(Dictionary of Environmental Science and Engineering Technology)* (2005) (see Appendix 1.2).

<2>《英汉双解生态与环境词典》 (*English-Chinese Bilingual Ecology & Environment Dictionary 3rd ed.*) (1999)

The original author of this dictionary is P.H. Collin, and the Chinese translation and revision was done by Wang et al. at the Department of Environment and Chemistry, Beijing University of Technology. This dictionary is suitable not only for readers who already know basic vocabulary in the field of the environment, but also for non-specialists. The dictionary features simple definitions of terms and a wealth of example sentences for each term. Example sentences are taken from newspapers and magazines in the UK and the US.

Figure 2 shows the entry of the term *absorb* in the dictionary. We can see the term *absorb*, its pronunciation in International Phonetic Alphabet, its part of speech, a brief English definition and a Chinese translation of the definition, followed by an English example sentence containing the term *absorb* and a Chinese translation of the example sentence. Under the heading of *absorb*, there are also the term *absorbent*, the noun *absorption*, and the noun phrase *absorptive capacity*.



absorb[əbˈzɔːb] *v*. to swallow up *or* consume; to take something up by chemical action; (*of a solid*) to take up a liquid 吸收(吸收或消耗;通过化学作用吸收某物;固体吸收液体): ***Salt absorbs moisture in the air***.盐吸收空气中的水分。

◇**absorbent** [əbˈzɔːbənt] **1** adj. which absorbs 吸收性的(吸收体): **oxygen absorbent** = able to take up oxygen 吸氧的(能吸收氧气) **2** *n*. substance *or* part of organism (e. g. root tip) which can take up moisture, nutrient, etc. 吸收剂(能吸收水分、养分等的物质或有机体部分,如根尖)

◇ **absorption**[əbˈzɔːpʃən] *n*. action of taking a liquid into a solid 吸收(使液体进入固体的作用): **absorption plant** = part of a petroleum processing plant, where oil is extracted from natural gas 吸收装置(炼油设备的一部分,该装置从天然气中提取油); **sound absorption factor** = number indicating the amount of sound energy absorbed by a surface 声音吸收因子(表示由一表面吸收声能的数值)

◇**absorptive capacity**[əbzɔːptɪvkəˈpæsɪtɪ] *n*. ability to take up moisture, nutrient, etc. 吸收能力,吸收率(吸收水分,养分等的能力)

Figure 2. – Term entry of *absorb* in 《英汉双解生态与环境词典》 (*English – Chinese bilingual ecology & environment dictionary 3rd ed.*) (1999, p. 2)

<3> 《環境科學名詞辭典》 (*An English Chinese Dictionary of Environmental Sciences*) (1986)

This dictionary contains more than 45,000 terms related to environmental science and can be used by those engaged in environmental science research and related work, including research personnel and scientists, teachers and students in universities and colleges, management personnel, and translators and editors. The content of entries of the dictionary are mainly the English terms and their corresponding Chinese equivalents. As can be seen from Figure 3, the entry of the English term *absorb* contains only its two Chinese equivalents: 吸收 (xī shōu) 'absorb' and 吞并 (tūn bìng) 'swallow up'.

absorb 吸收，吞併
absorbability 吸收能力，吸收性
absorbance 吸收率，光密度
absorbancy index 吸光指數
absorbate 被吸收的物質
absorbed dose 吸收劑量
absorbed layer 吸收層
absorbent [1] 吸收性的，有吸收力的 [2] 吸收劑
absorbent bed 吸收床，吸收層
absorbent cotton 脫脂棉
absorbent filter 吸收過濾器
absorbent paper 吸水紙
absorbent solution 吸收溶液
absorber [1] 吸收器 [2] 減震器，緩衝器
absorber cooler 吸收（器的）冷卻器
absorber washer 吸收洗滌器
absorbing apparatus 吸收裝置
absorbing capacity 吸收能力，吸收量
absorbing chemical 吸收試劑
absorbing column 吸收柱，吸收塔
absorbing duct 消音器，吸音管
absorbing medium 吸收介質
absorbing moisture 吸濕
absorbing power 吸收力
absorbing silencer 吸收消聲器
absorbing surface 吸收表面
absorbing tower 吸收塔

Figure 3. – Term entry of *absorb* in 《環境科學名詞辭典》 (*An English Chinese Dictionary of Environmental Sciences*) (1986, p. 3)

Other dictionaries with terminological information very similar to that given in《環境科學名詞辭典》 (*An English Chinese Dictionary of Environmental Sciences*) (1986) include 《英汉双向环境工程词典》 (*English-Chinese and Chinese-English Dictionary of Environmental Engineering*) (2009) (see Appendix 1.3), 《英汉环境科学词汇》 (*An English-Chinese Dictionary of Environmental Science*) (2000) (see Appendix 1.4), 《英日汉环境辞典》 (*English-Japanese-Chinese Environmental Dictionary*) (1988) (see Appendix 1.5), 《英汉・汉英环境科学与工程词汇手册》 (*An English-Chinese Chinese-English Glossary of Environmental Science and Engineering*) (2012) (see Appendix 1.6), and 《英德汉环境词典》 (*English-German-Chinese Environmental Dictionary*)(2001) (see Appendix 1.7).

From the dictionaries presented above (and in Table 1), we can see that most of the existing Chinese dictionaries of environmental terminology are paper dictionaries, compiled and revised more than ten years ago. Additionally, the terms included are mainly nouns, and the terminological information given consists mainly of explanations about the knowledge conveyed by the terms and their equivalents in languages such as English. There is no information on the semantic and syntactic properties of terms, nor on the links between terms. Moreover, usages of terms in authentic specialised texts as well as real contexts where terms occur are also absent in most of today's available Chinese dictionaries of environmental terms.

Readers of specialised environmental dictionaries include those working in the field of the environment or related fields – researchers working on environmental protection, students and professors specialising in the field of the environment, officials of environmental agencies, and enterprises. Students, writers, and the general public who are concerned about the environment are also readers of specialised environmental dictionaries. For readers who want to learn about semantic or syntactic properties of terms, for readers who want to know about relations between terms, for readers who want to see usages of terms in real contexts of specialised texts, information provided in existing specialised environmental dictionaries is insufficient.

Table 1 compares the above-mentioned 10 available Chinese environmental dictionaries in terms of year of publication, source, mode of presentation (print or online) and content of entry.

No.	Name of dictionary	Year of Publication	Source	Mode	Content of entry
1	《环境科学大辞典》 *Environmental Science Dictionary*	2008	Mainland China	Paper	Chinese term, its English equivalent, and explanation
2	《環境科學名詞辭典》 *An English Chinese Dictionary of Environmental Sciences*	1986	Taiwan	Paper	English term and its Chinese equivalent(s)
3	《英汉双解生态与环境词典》 *English-Chinese Bilingual Ecology & Environment Dictionary, 3rd ed*	1999	Mainland China	Paper	English term, its pronunciation in International Phonetic Alphabet, its part of speech, a brief English definition with Chinese translation, an English example sentence and its Chinese translation.
4	《環境科學大辭典》 *Environmental Science Dictionary*	2002	Taiwan	Online & Paper	Chinese term, its English equivalent, and explanation
5	《英汉双向环境工程词典》 *English-Chinese and Chinese-English Dictionary of Environmental Engineering*	2009	Mainland China	Paper	English term and its Chinese equivalent(s)
6	《英汉环境科学词汇》 *An English-Chinese Dictionary of Environmental Science*	2000	Mainland China	Paper	English term and its Chinese equivalent(s)
7	《环境科学与工程技术辞典》 *Dictionary of Environmental Science and Engineering Technology*	2005	Mainland China	Paper	Chinese term, its English equivalent, and explanation
8	《英日汉环境辞典》 *English-Japanese-Chinese Environmental Dictionary*	1988	Mainland China	Paper	English term, and its Japanese and Chinese equivalents
9	《英汉・汉英环境科学与工程词汇手册》 *An English-Chinese Chinese-English Glossary of Environmental Science and Engineering*	2012	Mainland China	Paper	English term and its Chinese equivalent(s)
10	《英德汉环境词典》 *English-German-Chinese Environmental Dictionary*	2001	Mainland China	Paper	English term (with part of speech) and its German and Chinese equivalent(s)

Table 1. – Information of the ten Mandarin Chinese dictionaries specialised in the field of the environment

To begin with, most dictionaries do not include terms of parts of speech other than nouns. In fact, as has long been proposed by other approaches to terminology including the textual approach (Bourigault & Slodzian, 1999) and the lexical-semantic approach (L'Homme, 2004, 2020), terms could be in the linguistic form of not only nouns, but also verbs, adjectives and adverbs. For a few dictionaries that do include verb terms, the valence and argument structures of verb terms are absent.

Argument structure is essential for understanding the meaning(s) of a verb term. The argument structure reflects deep semantic relations (Gu, 1994). Sometimes different sentence constructions of a verb actually have the same argument structure. The analysis of this argument structure can lead us to a proper understanding of the exact meaning shared by these sentences. Besides, whether a sentence is valid or not is dependent upon whether it conforms to the argument structure and whether argument(s) of the verb is(are) present or not (Huang, 2007).

The second insufficiency is that in existing dictionaries there is no information about usage of the term in specialised texts. Authentic contexts containing the term can help users understand the knowledge behind the term, the meaning of the term as well as the situation(s) in which the term is used in the specialised field.

The third insufficiency is that different meanings of polysemous terms are often not distinguished properly in most available specialised dictionaries in the field of the environment. For example, in the case of the term 吸收 (xī shōu) 'absorb', we observed that in the Mandarin Climate Change Corpus (MCCC) (see Section 4.1), the verb 吸收 (xī shōu) 'absorb' has two meanings, occurring in two situations in the field of climate change. One is the situation of 植物吸收二氧化碳 (zhí wù xī shōu èr yǎnghuà tàn) 'plants absorb carbon dioxide', where the opposite of the term 吸收 (xī shōu) 'absorb' is 释放 (shì fàng) 'release'. The other is the situation in the context of 地表吸收辐射 (dì biǎo xī shōu fú shè) 'the Earth's surface absorbs radiation', where the opposite of 吸收 (xī shōu) 'absorb' is 反射 (fǎn shè) 'reflect'. Nevertheless, the distinction is not drawn between these two

meanings of the term 吸收 (xī shōu) 'absorb' in the three environmental dictionaries we have presented earlier (see Figure 1, Figure 2 & Figure 3).

Lastly, relationships between specialised terms in the whole conceptual structure of the domain of the environment are absent in many currently available dictionaries of environmental terminology. Terms and especially relationships between terms offer us the means to access the conceptual structure or knowledge organisation of a specialised domain (Ahmad & Rogers, 2001). Compared with general-language lexical units, terms in a specialised field are far more interconnected within the knowledge framework of the field. Thus, it is quite conceivable that a full comprehension of the meaning(s) of a term relies on a proper understanding of the conceptual framework that the term evokes.

Therefore, we would like to compile an online terminological resource based on Frame Semantics (Fillmore, 1976, 1977, 1982, 1985; Fillmore & Atkins, 1992), a model that can describe and account for the semantic and syntactic features of terms. This terminology resource will make up for the insufficiencies of existing Chinese environmental dictionaries and better meet the needs of the audience.

Although there have been reports (Dolbey et al., 2009; Faber, 2011; Schmidt, 2009; L'Homme, 2008) of applying Frame Semantics/FrameNet methodology to terminology and compiling frame-based terminological resources, there are few examples of such research literature, and most of them focus on languages other than Chinese. Furthermore, no relevant research literature has been found on Chinese frame-based online specialised dictionary in the field of climate change/the environment. This is the background of the proposed research direction "discovering Chinese semantic frames in the field of climate change" in this dissertation.

1.2 Objectives of the research

The main objective of this research is to discover and define Chinese semantic frames in the field of climate change, an important sub-domain of the field of the environment. The multilingual

environmental dictionary DiCoEnviro[2] and its accompanying resource Framed DiCoEnviro[3] serve as basis for this research.

The specific objectives of this research are as follows:

(1) Compile a monolingual Mandarin Chinese specialised corpus in the field of climate change;

(2) With the methodology of Chinese FrameNet (CFN) as reference, adapt the research methodology of the project DiCoEnviro and its accompanying resource Framed DiCoEnviro to suit it for the description of Chinese specialised terms and Chinese semantic frames;

(3) Describe Mandarin (Chinese) verb terms in the field of climate change: write their actantial structures; annotate contexts where terms occur with the help of Chinese grammar – annotate realisations of participants (actants and circumstants) of a verb term in its contexts in terms of three layers, namely their respective semantic roles played in the context, their syntactic functions (i.e. grammatical functions) and their syntactic groups (i.e. phrase types);

(4) Discover, identify and define Chinese semantic frames in the field of climate change.

(5) Establish relations between the Chinese frames defined.

1.3 Hypotheses of the research

In this research, we formulate the following three hypotheses:

Hypothesis 1: Chinese terminology can be described and analysed using a specific terminological research method.

There are many existing Chinese environmental dictionaries that contain Chinese terms in the field of the environment. We hypothesise that Chinese environmental terminology can be described using the research methodology of the dictionary DiCoEnviro (L'Homme, 2015, 2018;

[2] DiCoEnviro: http://olst.ling.umontreal.ca/cgi-bin/dicoenviro/search_enviro.cgi
[3] A framed version of DiCoEnviro: http://olst.ling.umontreal.ca/dicoenviro/framed/index.php

L'Homme et al., 2020), which is a multilingual dictionary containing environmental terminology in French, English, Spanish, Italian and Portuguese.

Hypothesis 2: When applying the research methodology of the project DiCoEnviro to describe Chinese terminology, the characteristics of Chinese terms need to be taken into account.

Unlike Indo-European languages, such as English and French, Chinese is a language of monosyllabic morphemes[4] and belongs to the Sino-Tibetan family of languages. Conceivably, compared with English and French, Chinese has different morphological, lexical and syntactic features. These differences pose difficulties when describing terms and annotating contexts. It is important that we adapt our research methods according to the characteristics of Chinese terms. For example, we need to put forward Chinese annotation labels of syntactic functions and syntactic groups.

Hypothesis 3: Chinese terminology shares features with English and French terminology.

The natural environment is the same for speakers of different languages in different parts of the world, so many concepts are the same, only expressed differently in different languages. Therefore, we can hypothesise that there are terms in English and Chinese that express the same concepts, actions and processes. We can also assume that for an English term, if we find a Chinese term that designates the same concept, then the Chinese term is equivalent to the English term.

1.4 Structure of the dissertation

This dissertation consists of six chapters.

[4] Chinese is basically a language of "one-syllable morpheme"– the majority of one-syllable characters (even though not being "words") do bear meaning(s), and they are called one-syllable morphemes (Fang, 2009, pp. 25-26). Detailed explanation of morphemes and word-formation of Chinese can be found in Appendix 8.

This present introduction chapter points out insufficiencies of currently available Chinese dictionaries of environmental terminology. After this, the chapter outlines the research objectives and formulates three hypotheses.

Chapter 2 reviews five existing Chinese lexical resources: Chinese FrameNet (CFN) – a net of Chinese semantic frames; Mandarin VerbNet (MV) – a lexical-semantic knowledge base; Sinica Treebank, a tagged corpus of parsed sentences; Chinese Proposition Bank (CPB), a corpus of semantically annotated texts; and HowNet, a knowledgebase. The Chinese FrameNet (CFN), created by a research group led by Professor Kaiying Liu and Professor Liping You at Shanxi University (China) and based on the English FrameNet (FN), serves as an important reference for the methodology developed in this dissertation. The chapter shows that considerable progress has been achieved in the compilation of (online) Chinese lexical resources. However, no literature has been found on the application of the theory of Frame Semantics to the description of Mandarin Chinese terms in the field of climate change/environment.

Chapter 3 explains Frame Semantics (Fillmore, 1976, 1977, 1982, 1985; Fillmore & Atkins, 1992), the theoretical framework underpinning this research. The chapter firstly introduces Fillmore's case grammar (1966, 1968), and explains how case grammar later developed into the theory of Frame Semantics. After explaining the concept of "semantic frame", the chapter illustrates it with examples from the Chinese language. Regarding the application of Frame Semantics to specialised terminology, the project of Chinese Medical Event FrameNet (CMEF) is explained in detail.

Chapter 4 elaborates on the research methodology for the compilation of the Chinese terminological resource. The specific steps of the methodology are: 1) construction of the corpus MCCC; 2) extraction of candidate terms; 3) validation of candidate terms; 4) sense distinction; 5) actantial structure; 6) selection of contexts; 7) annotation of contexts; 8) definition of semantic frames; 9) establishment of relations between semantic frames; 10) encoding of term entries and semantic frames.

Chapter 5 starts by presenting the compiled online Mandarin Chinese terminological resource (http://olst.ling.umontreal.ca/dicoenvirozh/dicoenviro-bilingue-fr.html) as well as the Chinese frames discovered (http://olst.ling.umontreal.ca/dicoenviro/framed/index.php, the part of Chinese frames). It then compares English terms and Chinese terms with an in-depth analysis of their similarities and differences. This is followed by a comparison between Chinese frames defined and existing English frames in Framed DiCoEnviro. Finally, difficulties encountered when writing Chinese term entries and how they are resolved are discussed in detail.

The last chapter summarises the dissertation before pointing out the originality and significance of the current research and proposes research directions for future research looking into specialised terminological resources based on Frame Semantics.

2 Existing Chinese lexical resources

2.1 Chinese FrameNet (CFN)

Chinese FrameNet (CFN) is a semantic knowledge base of Mandarin Chinese lexis. Professor Kaiying Liu, Professor Liping You and their research group at Shanxi University (China) have been working on the project since 2004. With Fillmore's Frame Semantics (1982, 1985) as theoretical basis and the Berkeley English FrameNet as reference, the CFN project has constructed 309 Chinese frames, among which 238 frames were translated from the English FrameNet and 71 frames were defined for the CFN. A total of 3,151 lexical units are categorised and encoded in semantic frames. The eventual goal of the CFN project is to build a large-scale Chinese semantic dictionary based on authentic Chinese corpus data; by describing lexical units in semantic Web markup language, CFN will be a semantic dictionary that is computer-readable and intelligible (Liu & You, 2015). Without doubt, CFN constitutes a valuable semantic resource for Chinese frame semantic analysis and Chinese language processing.

The construction of CFN is based on four corpora of authentic Chinese texts – the CCL corpus (compiled by the center for Chinese Linguistics, Peking University), the CIPS-ParsEval-2009, and the two corpora compiled by Shanxi University – the Shanxi Tourism Corpus and the Chinese Reading Comprehension Corpus, CRCC.

The CFN project mainly consists of a frame database, a database of lexical units and a database of annotated sentences (including a database of phrase type analysis and a database of syntactic analysis). The frame database describes lexical units according to the frame they belong to. Each semantic frame contains a frame name, a frame definition, core frame elements, non-core frame elements, frame relations and lexical units in the frame. Table 2 illustrates the frame of [到达|Arriving] in CFN, a frame adapted directly from the English FrameNet. (See Appendix 2 for the English Translated version of Table 2). We can see from Table 2 that all frame elements in this frame are clearly defined.

到达| Arriving	
定义：指转移体到达目标的过程。目标可直接表达出来，或从上下文中得到理解，或者动词本身隐含目标之义	
核心框架元素	
目标[goal]	目标是转移体运动终止之地，或行将终止之地。例如，我们在午夜前到了巴黎
转移体[thm]	转移体指移动的物体
非核心框架元素	
伴随者[thm_c]	指除转移体以外的其他移动的物体
形容[dep]	形容指用来描写转移体到达的状态。例如，威尔士公主微笑着回来了
目标状态[g_c]	转移体到达目标时目标所呈现出的状态
修饰[manr]	表现修饰的话语用于对动作特性的描述，用来描述运动的速度、姿态和其他情况。例如，送信人慢慢地走进房间
方法[mns]	该框架元素用于表现转移体到达的方式
传送模式[mot]	传送模式指作用于主体的运动模式，通过传送主体的主体身体或交通工具实现。例如，我们乘汽车赶到加拿大；我步行到了墨西哥
路径[path]	路径指运动的轨道，既非源点，也非目标
源点[src]	源点即明确表达运动的出发点，该框架中出现表达源点的用语是可能的，但出现的频率却相对不高。例如，她昨天从纽约来到这里
时间[time]	该框架元素表现到达这一动作出现的时间
框架关系	
父框架： 子框架： 总框架：[位移情境/Motion_scenario] 分框架： 参照：	
词元	
到达 v，来到 v，进入 v，抵达 v，返回 v，走到 v，走进 v，赶到 v，回来 v，归来 v，到 v，回到 v	

Table 2. – Frame [到达|Arriving] in the Chinese FrameNet (Liu & You, 2015, p. 40)

In the database of lexical units, information encoded for each unit include a definition of the lexical unit and annotation report(s) delineating construction patterns and syntactic realisations of frame elements. Tables 3 and 4 illustrate the annotation reports of huò xī 获悉. Table 3 provides us with a clear picture of how each argument of the predicate verb huò xī 获悉 'learn (of an event)' is realised syntactically, the phrase types and syntactic functions of each argument. More importantly, this report informs us on the frequency of each argument in actual contexts. For example, we can see from Table 3 that "mns(方法)[means]", though being a frame element for huò xī 获悉 'learn (of an event)', appears less frequently in actual contexts compared with "time(时间)", a non-core frame element. Table 4 shows the 6 syntactic construction patterns of argument

structure for the verb huò xī 获悉 'learn (of an event)'. It can be seen clearly that the first argument structure "cog(认知者) evid(根据) tgt(获悉) cont(内容)" is the most common in contexts.

框架元素 [Frame element]	标注数量 [Number of annotation]	短语类型 [Phrase type]	句法功能 [Syntactic function]	出现次数 [Frequency]	元素类型 [Type of element]
cog （认知者）	18	np	subj	18	核心元素
cont（内容）	19	dj	obj	17	核心元素
		np	obj	2	
evid（根据）	16	pp	adva	16	核心元素
mns（方法）	1	vp	va	1	核心元素
time（时间）	6	tp	adva	6	非核心元素

Table 3. – Annotation report of LU 获悉 v. - Syntactic realisations of FEs of 获悉 v. (Liu & You, 2015, p. 75)

标注数量	语义搭配模式				
11（总数）	cog（认知者）	evid（根据）	tgt（获悉）	cont （内容）	
10	np	pp		dj	
	subj	adva		obj	
1	np	pp		np	
	subj	adva		obj	
1（总数）	cog（认知者）	supp（支撑词）	time（时间）	tgt（获悉）	cont （内容）
1	np		tp		np
	subj_s		adva		obj
4（总数）	cog（认知者）	time（时间）	evid（根据）	tgt（获悉）	cont （内容）
4	np	tp	pp		dj
	subj	adva	adva		obj
1（总数）	time（时间）	cog（认知者）	tgt（获悉）	cont （内容）	
1	tp	np		dj	
	adva	subj		obj	
1（总数）	cog（认知者）	tgt（获悉）	cont （内容）		
1	np		dj		
	subj		obj		
1（总数）	cog（认知者）	mns（方法）	tgt（获悉）	cont （内容）	
1	np	vp		dj	
	subj	va		obj	

Table 4. – Annotation report of LU 获悉 v. – syntactic patterns of argument structure of 获悉 v. (Liu & You, 2015, p. 75)

In the annotated sentence database, sentences containing the target lexical unit are annotated semantically and syntactically in terms of three layers: syntactic function, phrase type and frame elements. The CFN has developed a complete and detailed set of annotation guidelines (Liu & You, 2015) that are particularly suitable for Chinese sentence annotation. The labels of phrase

types and syntactic functions devised based on Chinese grammatical rules help account for syntactic realisations of frame elements. Here is an example of an annotated sentence in CFN. This sentence was extracted from CRCC.

此外，〈tot-np-subj 酸雨控制区〉〈supp 应〉〈tgt=包含 包括 v〉〈par-np-obj 酸雨污染最严重地区及其周边二氧化硫排放最大区域〉。
"In addition, the acid rain control area should include areas where the acid rain pollution is the most serious and regions where the emission of sulphur dioxide is the largest."
(Liu & You, 2015, p. 85)

The target term (marked as "tgt") described in this sentence is 包含 bāo hán 'contain', belonging to the frame [包括|include]. "Total" and "part" are the two frame elements of this frame. "Total" is syntactically realised by 酸雨控制区 suān yǔ kòng zhì qū 'acid rain control area', a noun phrase acting as subject of the target verb 包含 bāo hán 'contain' while the frame element "part" is realised by "酸雨污染最严重地区及其周边二氧化硫排放最大区域", a noun phrase acting as object of 包含 bāo hán 'contain'.

The complete sentence annotation system adapted for Mandarin Chinese will surely provide valuable assistance for researchers when carrying out semantic and syntactic analysis of Chinese sentences.

2.2 Mandarin VerbNet (MV)

Mandarin VerbNet (MV) is a comprehensive lexical semantic knowledge base centering on the categorisation and semantic annotation of Chinese verbs (Liu & Wan, 2019). The Mandarin VerbNet project, led by Professor Mei-Chun Liu, began at National Chiao Tung University (Taiwan), and then continued at the City University of Hong Kong. Based on the frame-based constructional approach, the MV (as of Feb. 2019) has defined and categorised approximately 800 verbs, among which 520 have been annotated semantically and syntactically. The MV lexicographers are currently working on the annotation and categorisation of 2000 frequently-used verbs in Mandarin Chinese. The ultimate goal of this on-going project is to establish an effective

categorisation and annotation system that is well suited to account for the semantic analysis of Chinese verbs that incarnates inherent unique grammatical features (Liu & Wan, 2019).

The construction of the Mandarin VerbNet is based on strong corpus evidence. All the contexts for annotation are taken from the following two corpora: 5 million-words *Sinica Balanced Corpus* （中央研究院平衡语料库）and 1 billion-words *Chinese Gigaword* （中文十亿词语料库）. The Chinese Word Sketch Engine developed by *Sinicacademi* serves as a consultation tool.

The frame-based construction approach devised within the MV project is a combination of Frame Semantics (Fillmore, 1982, 1985) and Constructional Grammar (Goldberg, 1995, 1997, 2010). Under this approach, the analysis of a Chinese verb starts from the delineation of the semantic frame that the verb is associated with. For each frame, both frame elements and "defining constructions" are explicitly defined (Liu & Wan, 2019, p. 48). According to Liu & Chang (2015), the meaning of a given frame is expressed not only through its frame elements, but also manifested from the grammatical constructional patterns (or "defining constructions") where the verb is used. Figure 4 shows the basic frame of "Caused-to-move" in the Mandarin VerbNet.

Basic frame: CAUSED-TO-MOVE

Frame Relation

CAUSED-MOTION CAUSED-TO-MOVE

Definition

A Mover causes a Figure to move from a Source to a Ground_Location

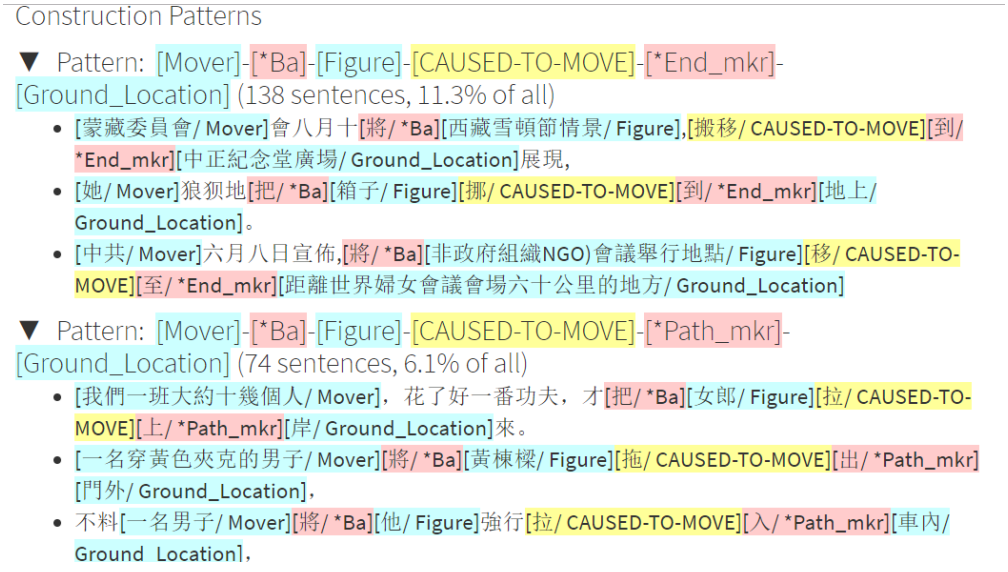
Lemma

搬	移	遷	移動	推	拉	拖	挪	帶	滾	搬移	挪動
move	move	move	move	push	pull	drag	move	take	roll	move	move

Core Frame Elements

Mover Figure Ground_Location

(Source:http://verbnet.lt.cityu.edu.hk/#/frame/CAUSED-MOTION/CAUSED-TO-MOVE)



(Source:http://verbnet.lt.cityu.edu.hk/#/frame/CAUSED-MOTION/CAUSED-TO-MOVE)

Figure 4. – Basic frame Caused-to-move in Mandarin VerbNet

As can be clearly observed, the "CAUSED-TO-MOVE" frame is specified with not only frame elements, but also two constructional patterns with annotated example contexts.

The frame-based constructional approach developed within the MV project is well suited to describe semantic frames and verbs in Chinese. For many Chinese verbs, relying solely on frame elements for semantic distinction might not be sufficient. Following is an example by Liu & Wan (2019) to show how constructional patterns help distinguish the right frame that a verb belongs to. The Chinese verbs 搬 bān 'move' and 放 fàng 'put' are associated with the same frame "Caused-motion", share similar participants – Placer, Figure and Location. However, salient differences exist in their constructional patterns, which could serve as important evidence for further semantic distinctions between the two verbs.

(a) Placer-prominent transitive BA construction: 我 把 书 搬到*/ 在 桌子上
I BA book move */ at the table
我 把 书 放 到/在桌子上
I BA book put / at the table

(b) Ground-prominent locative inversion: *桌上 搬着 一本书。
*the table move a book
桌上 放着 一本书。
table put a book (Liu & Wan, 2019, p. 48)

The pattern of locative inversion is associated with the Placement frame, but not the Caused-to-move frame. The fact that bān 搬 'move' does not function in the locative inversion pattern reveals that bān 搬 'move' does not evoke the Placement frame. This suggests the necessity of making further semantic distinctions and argues for the creation of sub-frames under the general frame "Caused-motion". Based on different "collo-constructional features" (Liu & Wan, 2019, p. 48), MV lexicographers established two subframes: Caused-to-move frame and Placement frame.

The frame-based constructional approach allows for a finer classification of Chinese verbs. MV lexicographers established a hierarchy of frames consisting of four layers – archi-frame > primary frame > basic frame > micro-frame. Table 5 illustrates the hierarchy of the archi-frame "Caused-motion" and its sub-frames as presented on the Mandarin VerbNet.

Archi-frame	Primary frame	Basic frame
Caused-motion	Carry	
	Caused-to-move	
	Place	Place-container
		Place-location
		Place-surface
	Release	
	Throw	

(Source : http://verbnet.lt.cityu.edu.hk/#/)

Table 5. – Archi-frame "Caused-motion", its primary frame and basic frame (MV)

2.3 Sinica Treebank

Sinica Treebank (中文句結構樹資料庫) (Chen et al., 1999) is an electronic database providing annotated tree structures of Chinese sentences. The Sinica Treebank project started in 1997 and is carried out by lexicographers at the Chinese Knowledge and Information Processing (CKIP), the Academia Sinica (Taiwan), with a general aim of providing an annotated corpus for Chinese Language Processing (Chen et al., 1999). All the sentences annotated are extracted from the 5 million-word *Sinica Corpus*. The current Sinica Treebank Version 3.0 contains 61,087 trees, totalling 361,834 Chinese words. An online search interface has been developed for users to consult tree structures and 1000 tree structures are open for download through its website.

In an aim to accurately and effectively parse Chinese sentences, linguists at CKIP have proposed an analysing system that is based on the Information-based Case Grammar (ICG) and Head-Driven Principle. From the perspective of ICG, each word conveys two facets of meaning: meaning and grammatical meaning. Meaning is reflected in arguments and adjuncts while grammatical meaning is shown through the grammatical class of the word (phrase type /syntactic group) in contexts and grammatical constraints including restraints in the order and form of different sentence components (Chen et al., 1999, p. 88). With a clear semantic orientation, Sinica Treebank has defined 60 semantic roles, among which 5 are used for physical entities and the rest, for predicates denoting events.

Here is an annotated tree structure taken from Sinica Treebank.

The sentence (/sentence segment) parsed is:

我们 决定 合力 做 一大束 忘忧草。
we decide together make a big bunch daylily
'We decide to make a bunch of daylily together.'

Its tree structure as presented in Sinica Treebank is:

S(agent:NP(Head:Nhaa: 我 们)|Head:VE2: 决 定 |goal:VP(manner:Dh: 合 力 |Head:VC31: 做 |theme:NP(quantifier: DM:一大束|Head:Nab:忘忧草)))

– "决定[decide]" as Head of the sentence (code: 1129W)

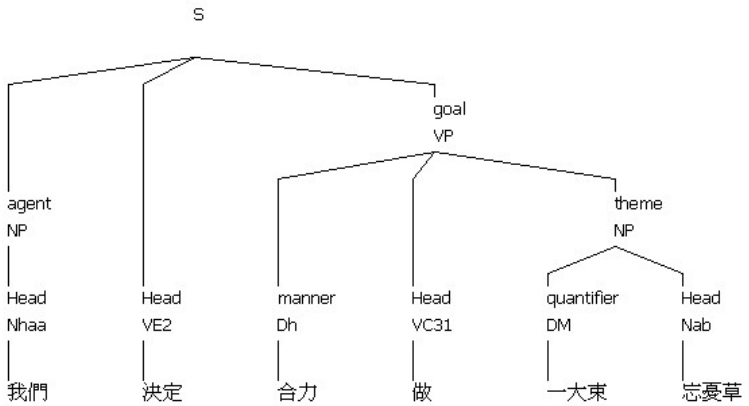


Figure 5. – A Chinese sentence tree structure from Sinica Treebank (Tree code: 1129W)

Figure 5, taken from the Sinica Treebank, is an illustration of the above tree structure. In this tree structure, each constituent of the sentence labeled with a semantic role and a grammatical function. The verb 决定 jué dìng 'decide' is the head of the whole sentence, thus marked as "Head". "VE2" signifies that the verb 决定 jué dìng 'decide' needs to be followed by its object and has only two arguments (Agent and Goal). 我们 wǒ men 'we' plays the semantic role of "Agent" while 合力做一大束忘忧草 hé lì zuò yī dà shù wàng yōu cǎo 'make a bunch of daylily together' realises the "Goal". Syntactically, 我们 wǒ men 'we' has the phrase type of NP (Noun phrase) while 合力做一大束忘忧草 hé lì zuò yī dà shù wàng yōu cǎo 'make a bunch of daylily together' is marked as VP (Verb phrase).

The tree structure then leads the user to probe further into each argument. 我们 wǒ men 'we' is its head in itself, therefore marked as Nhaa, meaning personal pronoun. For the syntactic realisation of "Goal" - 合力做一大束忘忧草 hé lì zuò yī dà shù wàng yōu cǎo 'make a bunch of daylily together', head of this VP is the verb 做 zuò 'make'; 一大束忘忧草 yī dà shù wàng yōu cǎo 'a bunch of daylily' plays the semantic role of Theme (syntactically as NP) while 合力 hé lì 'together' realises the role of "Manner (syntactically as Dh, adverb denoting manner)". In 一大束忘忧草 yī dà shù wàng yōu cǎo 'a bunch of daylily', the head of this NP is 忘忧草 wàng yōu cǎo 'daylily' (individual noun marked as Nab) while 一大束 yī dà shù 'a bunch of' takes the semantic role of "quantifier" with the phrase type of DM (quantity phrase).

As can be clearly seen from the example reproduced in Figure 5, one important merit of the Sinica Treebank is that the project has developed a detailed classification of Chinese words. The Treebank not only presents grammatical information of each word and constituents of sentences from the analysis of surface sentence structures, but also reveals the semantic relationships between words by digging into the deep structure of sentence and assigning a semantic role to each word or phrase.

2.4 Chinese Proposition Bank (CPB)

The Chinese Proposition Bank (CPB) is a complementary project to the Chinese Treebank (CTB) (a large-scale annotated Chinese corpus). Started in 1998 at the University of Pennsylvania (USA) by a research group led by Nianwen Xue, the CTB project aims to build an annotated Chinese corpus with rich syntactic information. The Chinese Tree Bank 9.0, released in June 2016, contains 132,076 Chinese sentences that have been tokenized, POS tagged and syntactically bracketed. Overall, the project adopts a semi-automatic approach in its 3-step sentence annotation process: Chinese sentences are firstly tokenized with the help of a word-segmenter; after manual validation, segmented Chinese sentences are then attached with POS tags using a POS tagger; after post-correction by linguists, the tagged sentences are processed through a parser to have the sentences syntactically bracketed. Table 6 illustrates the processes of sentence annotation in the CTB project.

As can be observed from Table 6, Chinese sentence annotation in the Chinese Treebank project has a clear syntactic orientation and focuses only on surface syntactic information. In order to improve the Treebank to account for the facet of meaning, the research group led by Nianwen Xue has been working on another project since the early 2000s, i.e. the Chinese Proposition Bank (CPB), the primary task of which is to add semantic information to the parsed trees in the CTB. The CPB project places its main focus on predicate verbs and their nominalisations. Predicates (or nominalised form of predicates) are attached the label of *Rel*, and semantic role labels are assigned to each of the arguments of the predicate (or its nominalisation). In general, arguments[5] are labelled as *Arg 0, 1, 2, 3, 4, 5* while adjuncts (optional participants) are labelled as *Arg M*.

[5] In this dissertation, the terms *argument* and *argument structure* are used when referring to other authors' work (e.g. in Chapter 2) while the terms *actant* and *actantial structure* are used when referring to this research.

(a) Raw data:
他还提出一系列具体措施和政策要点。
(b) Segmented:

他 还 提出 一系列 具体 措施 和 政策 要点。

He also propose one series concrete measure and policy essential

("He also proposed a series of concrete measures and essentials on policy.")

(c) POS-tagged:

他/PN 还/AD 提出/VV 一/CD 系列/M 具体/JJ 措施/NN 和/CC 政策/NN 要点/NN。/PU

(d) Bracketed:

(IP (NP-SBJ (PN /he))

(VP (ADVP (AD /also))

(VP (VV /propose)

(NP-OBJ (QP (CD /one)

(CLP (M /series)))

(NP (NP (ADJP (JJ /concrete))

(NP (NN /measure)))

(CC /and)

(NP (NN /policy)

(NN /essential))))))

(PU))

Table 6. – A Chinese syntactically-annotated sentence in the Chinese Treebank (Xue et al., 2005, p. 211)

Figure 6 illustrates a tree structure with semantic information encoded in CPB. The parsed sentence is 警方 正在 详细调查事故原因 ‘The police are thoroughly investigating the cause of the accident.’ In this example, 调查 ‘investigate’ is the predicate verb, thus labelled as “*Rel*”. Two arguments of the predicate are 警方 ‘police’, labelled as *Arg0* and 事故原因 ‘accident cause’, marked as *Arg1*. 正在 ‘now’ and 详细 ‘thoroughly’ are the two adjuncts (optional participants), both labelled as “*ArgM*”. 正在 ‘now’ has the meaning of *Time* (or temporal element), thus attached the label “ArgM-TMP” while 详细 ‘thoroughly’ realises the semantic role of *Manner*, thus marked as “ArgM-MNR”.

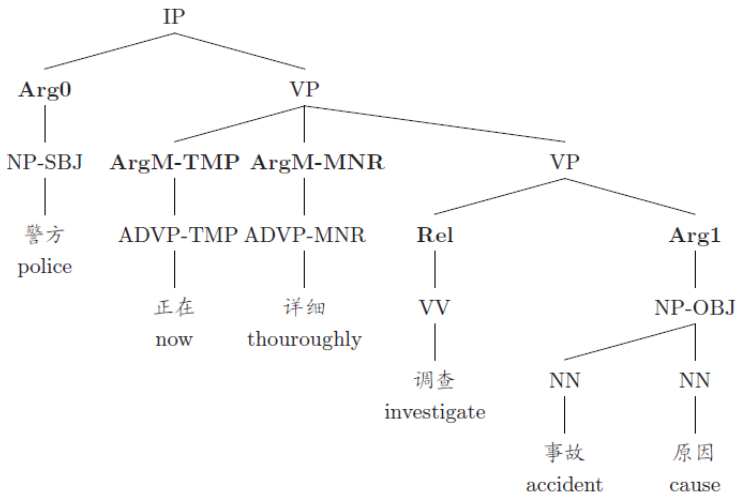


Figure 6. – a tree structure with semantic information encoded in CPB (Xue, 2008, p. 229)

With arguments of predicates labelled, the CPB project is able to proceed to another important task – distinguish senses of predicates and categorise the senses into framesets. “Frameset” is defined in the CPB project as “a set of subcategorization frames that realize a particular sense” (Xue, 2007, p. 3). In the Chinese Proposition Bank 3.0, released in July 2013, a total of 24,642 Chinese verbs have been assigned to framesets. Table 7 is an example taken from the CPB – the predicate 存 ‘deposit, exist, preserve’ has three senses and thus is categorised into three

framesets. The criterion for this sense distinction is that for each sense of 存 cún 'deposit, exist, preserve', the sets of arguments are different.

Besides the goal of capturing the semantics of predicates as reflected in their arguments, another very important objective of the CPB project, as emphasised by Xue (2007), is to reveal and categorise different types of syntactic variations (or syntactic alternations) that can often be observed in the argument structures of certain Chinese predicates. The CPB project elaborates on five classes of verbs in Chinese that show salient syntactic alternations, or different syntactic realisations in their argument structure. The first class of verbs contain verbs that can be used both transitively and intransitively without any change in the verb form. Verb derivations of 放 fàng 'put, place' and verbs that carry the sense of "existing" are two other classes of verbs that demonstrate alternations. Verbs that generally having two arguments (agent and location/event/theme) but can have the second argument omitted in actual contexts are the fourth type of verbs for which syntactic alternations can be observed. The fifth class of verbs are verbs implying changes in state or location.

Compared with the 60 semantic role labels used in the Sinica Treebank, the set of argument labels used by CPB seems to be a little general. The labels *Arg0*, *Arg1*, *Arg2*, *Arg3*, *Arg4* and *Arg5* for core arguments, carrying no semantic information in themselves, do not explicitly incarnate the semantic nature of each core argument. This methodological choice of argument labels reflects the different objectives for Sinica Treebank and CPB. The Sinica Treebank aims to build tree structures that not only contains grammatical syntactic analysis but also reveals semantic relationships between each word/phrase. This explains the detailed categorisation of word classes and the 60 semantic labels used for semantic analysis. In comparison, the most important objective of the CPB is to probe into syntactic variations present in argument structures of certain classes of Chinese verbs. As pointed out by Xue (2007), using labels of *Arg0* to *Arg5* for arguments consistently across different syntactic structures (where a predicate carries the same sense) proves to be enough for the analysis of syntactic alternations in which a predicate can be found.

存

Frameset 1: “deposit”

Semantic roles:

Arg0: entity making deposit

Arg1: sum of money

Arg2: financial institution

a. [**ArgM-TMP** 二十年 前] [**Arg0** 每 人] [**ArgM-ADV** 平均] [**ArgM-ADV** 才]
20 years ago each person average only
[**Rel** 存] [**Arg1** 二十元 钱]。
deposit 20 yuan money
“Twenty years ago, on average each person has only a deposit of 20 yuan.”

b. [**Arg1** 大批 资金][**Rel** 存] [**Arg2** 在中小金融机构]。
large amount fund deposit in mid-sized small financial institution
“A large amount of funds are deposited in mid-sized or small institutions.”

Frameset 2: “exist”

Semantic roles:

Arg0: location

Arg1: thing that exists

c. [**ArgM-TMP** 现][**Arg0** 全球][**ArgM-ADV** 仅][**Rel** 存]
Now the whole world only exist
[**Arg1** 一千多 只 大熊猫]。
over one thousand CL Giant Panda

“There exist only a little more than one thousand giant pandas in the whole world.”

Frameset 3: “preserve”

Semantic roles:

Arg0: preserver

Arg1: thing preserved

Arg2: instrument

d. [**Arg2** 方志] 可以 [**Rel** 存] [**Arg 1** 史], 资治， 教化。
chronicle can preserve history , maintain order, civilize
“Chronicles can be used to preserve history, maintain social order and teach civilized behavior.”

e. [**Arg0** 我们][**Arg2** 用 方志] [**Rel** 存] [**Arg1** 史， 资治， 教化。
We with chronicle preserve history, maintain order, civilize
“We can use preserve history, maintain social order and teach civilized behaviors with chronicles.”

Table 7. – Framesets of the verb 存 (cún) ‘deposit, exist, preserve’ in CPB (Xue, 2007, pp. 3-4)

2.5 HowNet (知网)

HowNet (知网), or HowNet Knowledge Database, is a large-scale high-quality Chinese-English knowledgebase with rich semantic information. The initial idea of the construction of HowNet was formed in 1988, when the founder of HowNet, Zhendong Dong, posed the important question of how to build a large-scale knowledgebase that can support natural language processing. The HowNet project was formally launched in 1997 by Zhendong Dong and Qiang Dong at the Research Centre of Computer & Language Engineering, Chinese Academy of Sciences. The first version of HowNet was released in 2000. The past thirty years has witnessed tremendous advancement of this project. HowNet now contains 229,767 Chinese and English entries, 35,202 concepts and 2,196 sememes. Since 2019, the core data of HowNet has been made publicly accessible through OpenHowNet[6], an online searching platform that allows users to consult entries of HowNet and view the sememe tree structure of the concept described in the entry.

Relationship is a key word in the HowNet project. The goal of the construction of HowNet is to reveal relationships between concepts as well as relationships between different attributes of a concept (Dong et al., 2010, p. 53). HowNet is concept oriented. Figure 7 shows how the concept conveyed by the word "doctor" is related to other concepts in the Concept Relation Net (CRN) of HowNet.

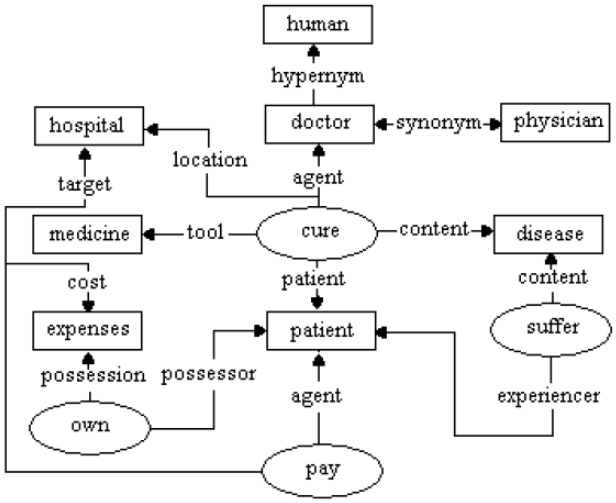


Figure 7. – The word "doctor" as presented in the Concept Relation Net (CRN) (Dong et al., 2010, p. 54)

[6] OpenHowNet: https://openhownet.thunlp.org/

In HowNet, sememe is the “basic unit of meaning” (Dong et al., 2010, p. 53) that cannot be further divided and a concept is defined by sememe(s). Figure 8 shows the sememes of each of the four concepts conveyed by the word píng guǒ 苹果 ‘apple’.

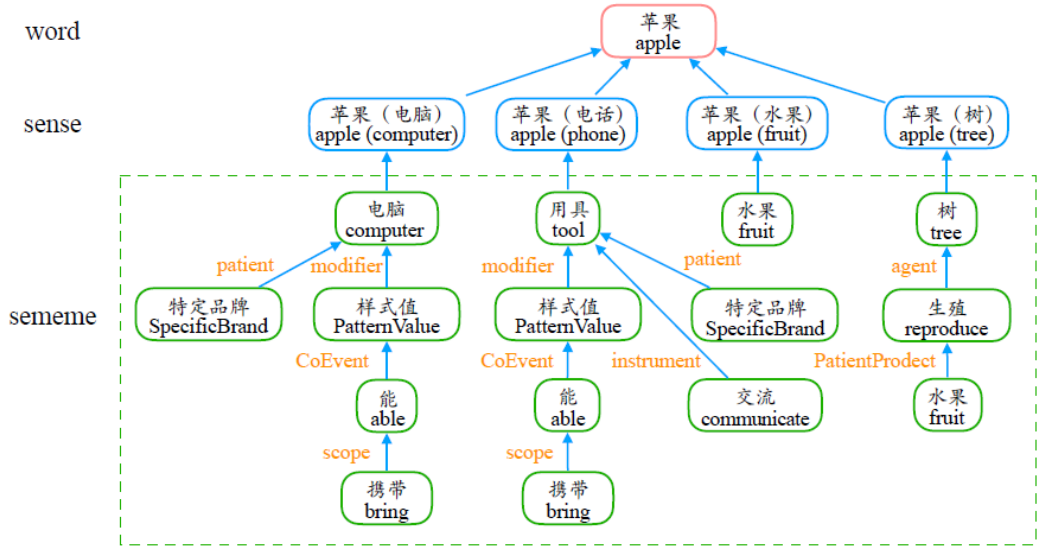
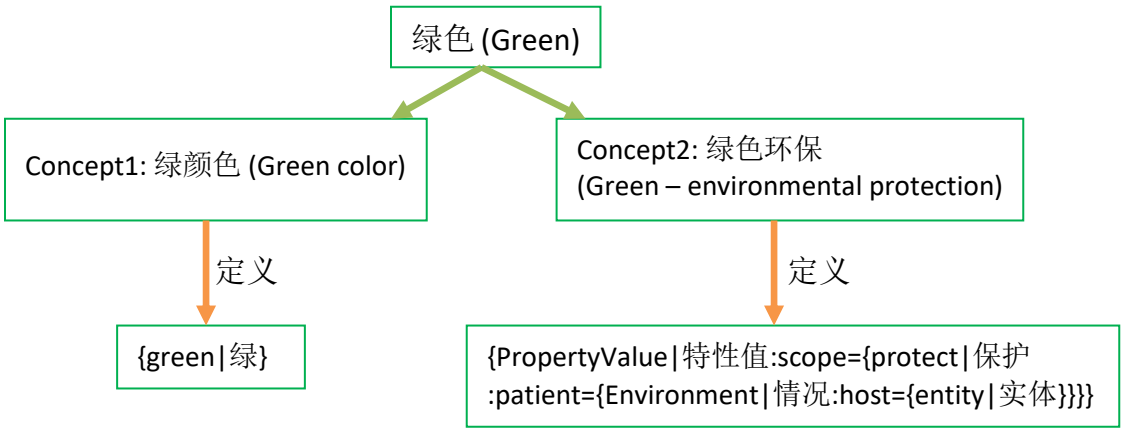


Figure 8. – The Chinese word píng guǒ 苹果 ‘apple’ as annotated based on sememes in HowNet (Qi et al., 2019, p. 2)

HowNet does not only focus on nouns. Figure 9 illustrates the two concepts conveyed by the adjective lǜ sè 绿色 ‘green’ and the definition of each concept based on sememes.



(Zhu et al., 2019, p. 35)

Figure 9. – Concepts and sememes conveyed by the word lǜ sè 绿色 ‘green’ in HowNet

As illustrated in Figure 9, the Chinese word 绿色 lǜ sè 'green' designates two concepts – the first is the color green, the other is green in the sense of being environmentally-friendly. The definition of the concept of green color is simple with only one sememe "green|绿" whereas the definition of the second concept entails relationships between four different sememes. The first sememe is "PropertyValue|特性值" – "绿色 (Green)" is a property value, the "scope" ("dynamic role" of "PropertyValue") of which corresponds to some kind of protection. The relationship between the second sememe "protect|保护" and the third sememe "Environment|情况" plays the role of patient of "protect|保护". The host of "Environment|情况" is an entity.

2.6 Comparison of the five Chinese lexical resources

The above presentation of the five Chinese lexical resources shows that these resources are constructed for different purposes, are inspiring different applications and are addressing different needs in the Chinese natural language processing community. Table 8 compares the five Chinese lexical resources reviewed above from four aspects: nature of the lexical resource, goal of construction, classes of words serving as targets for annotation, and domain of texts for annotation.

For this domain-specific research looking into Chinese semantic frames in the field of the environment, the five available resources reviewed above will certainly become helpful references. Chinese FrameNet has developed two set of labels for syntactic functions and phrase types respectively; Mandarin VerbNet proposes the frame-based constructional approach for categorising verb into finer frames; the Sinica Treebank shows how detailed semantic analysis can be presented clearly in a tree structure; the Chinese proposition bank unveils the common types of syntactic alternations in Chinese argument structures of certain types of verbs; HowNet applies a sememe-based method of sense distinction for Chinese word.

Name of resource	Nature of resource	Objective of construction	Target for annotation	Domains of texts
Chinese FrameNet (CFN)	Net of Chinese semantic frames	Build a large-scale Chinese semantic dictionary	Nouns, verbs, adjectives	Texts from a variety of different domains – literary texts, tourism texts, legal texts, news, texts from encyclopaedias, and others
Mandarin VerbNet (MV)	Lexical-semantic knowledge base	Categorise Chinese verbs	Verbs	Texts from Sinica Corpus and Chinese Gigaword (news texts)
Sinica Treebank	Tagged corpus of parsed sentences	Build a syntactically and semantically annotated corpus	Each segmented word of a sentence	Texts from Sinica Corpus, covering a wide variety of themes - society, literature, arts, sciences, daily life, philosophy
Chinese Proposition Bank (CPB)	Corpus of texts semantically annotated	Add semantic information to tree structures in Chinese Treebank; Elaborate on syntactic variations of argument structures	Predicates and their nominalisations	Government articles, news & magazine articles, texts from online weblogs and forums etc.
HowNet	Knowledgebase / ontology	Build a large-scale knowledgebase	Nouns, verbs, adjectives, adverbs	/[7]

Table 8. – Comparison of the five Chinese lexical resources

From Table 8, we can also observe that none of the five lexical resources is purely dedicated to one particular specialised field, though specialised senses of certain Chinese words can be found in certain entries of these resources. Without a doubt, the domain-specific lexical resource that will be built in this research will constitute a complement for existing lexical resources.

[7] Different from the other four resources, HowNet does not include, in its word entry, annotation of contexts from authentic texts. Domains of texts used for the compilation of HowNet are not indicated on the webpage of OpenHowNet. Thus, we left the column “Domains of texts” blank here for HowNet.

3 Theoretical framework

3.1 Frame Semantics

3.1.1 The origin – Case grammar

In the late 1960s, Fillmore (1966, 1968) argued that the dominant linguistic theory, transformational grammar (TG), at the time overemphasised the role of syntax and that the study of languages only from the surface syntactic level is insufficient, because these syntactic components have different surface forms in different languages and are thus not universal. One particular example is seen in Chinese: in Chinese sentences, subjects and even objects are often omitted. Fillmore (1966, 1968) argued for a close integration of syntax and semantics, with semantic research as the starting point, since deep structures driven by semantics are more appropriate for characterising and explaining universals than those driven by syntax.

Fillmore (1968) proposed the theory of "case grammar". "Case" refers to "the underlying syntactic-semantic relationship" (Fillmore, 1968, p.42). Fillmore (1968) believes that every language has "deep-structure cases" (p.42) and searching for potential universal deep semantic structures can help explain the generation of surface syntactic structures across languages. Looking into the semantic case relations between predicate verbs and their arguments, Fillmore (1968: 46) put forward six cases: Agentive, Instrumental, Dative, Factitive, Locative, and Objective. Connecting syntax with semantics, case relationships provide a novel semantic angle for studies probing into syntax.

Fillmore (1968) then used sentences with "open the door" to illustrate case grammar.

(1) John opened the door.
(2) The door was opened by John.
(3) The key opened the door.
(4) John opened the door with the key.
(5) John used the key to open the door. (Fillmore, 1968, p. 47)

Though with different perspectives, the above five sentences basically describe the same event and the semantic relationships between any of the two words “John”, “key”, “open”, “door” remain unchanged. It is “John” who “opens” the “door” with the “key”. Though “John” is not present in (3), “John” realises the case “Agent”. Although “key” has different syntactic functions in (3) and (5), it is in the case of “Instrument”.

The analysis of cases is also applicable to Chinese and can help explain the deep semantic structure of Chinese sentences. The following examples (1) - (6) share the same meaning despite their different surface syntactic structures. 小明 xiǎomíng ‘Xiaoming’ realises the “Agent” though it plays different syntactic functions in (1) and (5) and though it is not present in (2) and (4). 石头 shí tou ‘stone’ is always associated with the case “Instrument” even though it is at the position of subject of sentence (2).

(1) 小明 打破了 窗户。
Xiaoming break-PERF window
‘Xiaoming broke the window.’

(2) 石头 打破了 窗户。
Stone break-PERF window
‘A stone broke the window.’

(3) 小明 用 石头 打破了 窗户。
Xiaoming use stone break-PERF window
‘Xiaoming used a stone to break the window.’

(4) 窗户 打破了。
Window break-PERF
‘The window was broken.’

(5) 窗户 被 小明 打破了。
window passive preposition Xiaoming break-PERF
‘The window was broken by Xiaoming.’

(6) 窗户 被 小明 用 石头 打破了。
Window passive preposition Xiaoming use stone break-PERF
‘The window was broken by Xiaoming with a stone.’

(7) 妈妈 在 洗 衣服。
mum PROG wash clothes
‘Mum is washing clothes.’

(8) 洗衣机　　洗　　衣服。
washing machine　wash　clothes
'The washing machine is washing clothes.'

(9) 衣服　　洗　　好[8]了。
clothes　wash　PERF
'The clothes have been washed.'

妈妈 'Mum' in sentence (7), 洗衣机 'washing machine' in sentence (8) and 衣服 'clothes' in sentence (9) are all subjects and have the same syntactic role, but they realise different semantic roles. The subject of sentence (7), 妈妈 'Mum', is the subject of the verb 洗 'to wash', while the subject of sentence (8), 洗衣机 'washing machine', is an instrument in relation to the verb 洗 'to wash'. In (8) the subject 洗衣机 'washing machine' is an instrument in relation to the verb 洗 'to wash', while in (9) the semantic role of the subject 衣服 'clothes' is that of a Patient, which bears the action of 洗 'to wash'.

Another important concept that Fillmore (1968) established in Case Grammar is that of "case frame". Case frame is mainly applied to analyse semantic structures of verbs or verbal phases. As explained by Fillmore (1982, p.115), each case frame corresponds to a "scene or situation"; a proper understanding of the background knowledge and conceptual structure of such "schematized scenes" is prerequisite to understanding "the semantic structure of the verb".

Let us reconsider the example of mum washing clothes (7)-(9). As can be analysed from sentences (7)-(9), the deep frame of the verb 洗 'to wash' is + [____O (I) (A)]; "+" indicates that the cases O (Object), I (Instrument), A (Agent) can co-occur in one sentence and "__" indicates that there is a verb in the frame. When using the verb 洗 'to wash' , we must determine the thing being washed – Object; the Agent that initiate the action of 洗 'to wash' or the Instrument used to wash are not

[8] 好 'good' is used after the verb, indicating that the action initiated by the verb has finished.

obligatory (thus they are presented in brackets in the deep frame). It is based on *case frame* that Fillmore (1982) proposed the concept of "semantic frame" later in his Frame Semantics.

3.1.2 Semantic frame

In the mid 1970s, Fillmore proposed the theory of Frame Semantics on the basis of his Case Grammar. Frame Semantics explains the meaning of words by looking into how languages hinge on the way people conceptualise situations. Frame Semantics is a cognitive theory that reveals the link between language and our experience and knowledge already acquired and stored in our mind. The core idea of this theory is that we understand the meaning of a word in the *semantic frame* that this word activates (Fillmore, 1982, 1985).

Semantic frames are defined as "specific unified frameworks of knowledge, or coherent schematizations of experience" (Fillmore, 1985, p. 223). "The frame structures the word-meanings, and that the word 'evokes' the frame" (Fillmore, 1982, p. 117).

> By the term frame I have in mind any system of concepts related in such a way that to understand any one of them you have to understand the whole structure in which it fits; when one of the things in such a structure is introduced into a text, or into a conversation, all of the others are automatically made available.
>
> (Fillmore, 1982, p. 111)

To further illustrate the concept of "frame", let us look at the following two sentences in Chinese:

(10) 小珊， 你 今年 得了 多少 压岁钱？
Xiaoshan you this year get-PERF how much lucky money
'Xiaoshan, how much lucky money did you get this year?'

If a Chinese speaker hears this sentence, he/she will know that this is probably what Xiao Shan is asked during the Chinese New Year, the Lunar New Year. This is because 压岁钱 (yā suì qián) 'lucky money' evokes the New Year situation in his/her minds. According to Chinese traditional custom, 压岁钱 (yā suì qián)

'lucky money' is given by the elders to their juniors on the Lunar New Year's Eve, It represents best wishes of the elders to their juniors. It is only with this background knowledge that we can understand the meaning of 压岁钱 'lucky money'. This New Year's Eve scenario is a frame - [Celebrating the Chinese New Year] frame, in which besides 压岁钱 'lucky money', there are also 除夕 'New Year's Eve', 春节 'Spring Festival', 守岁 'stay up late or all night on New Year's Eve', 春联 'Spring Festival couplets', 年货 'special purchases for the Spring Festival', 年夜饭 'family reunion dinner', 拜年 'wish somebody a Happy New Year/pay a New Year call'.

(11) 小薇， 小宇， 好不容易 才 吃上 你们 的 喜糖 啊！
Xiaowei Xiaoyu so hard *adv.* eat you DE1 happiness candies *interjection*
'Xiaowei, Xiaoyu, finally we get to eat your happiness candies!'

When a Chinese speaker hears this sentence, he/she will know that 小薇 'Xiaowei' and 小宇 'Xiaoyu' are a newly married couple, because when a Chinese speaker hears the phrase 吃喜糖 'eat the happiness candies', the scene of 婚礼 'wedding' will immediately arise in his/her mind. This scene is actually a knowledge frame or a cognitive frame. Thus, a Chinese speaker understands the meaning of 吃喜糖 'eating wedding candy' or 喜糖 'happiness candies' against the background frame of [结婚|Marriage]. In Chinese culture, 喜糖 'happiness candies' are the candies that the couple gives to their guests, friends, or relatives when they get married. Conceivably, without such background knowledge, one cannot understand the true meaning of 喜糖 'happiness candies'.

One particular example that Fillmore uses to illustrate the concept of semantic frame is the Commercial Event Frame (1977a, 1977b). This frame captures the scene of buying – a buyer buys goods from the seller, and selling – a seller sells goods to the buyer. Four participants featuring

this frame are buyer, goods, money and seller. The conceptual structure underlying this frame also exists in Chinese. Chinese words 买 (mǎi) 'buy', 购买 (gòumǎi) 'purchase', 出售 (chūshòu) 'sell', 卖 (mài) 'sell', 售卖 (shòumài) 'sell', 支付 (zhīfù) 'pay', 买方 (mǎifāng) 'buyer', 卖方 (màifāng) 'seller' belong to the Commercial Event Frame since they all describe the scene of this buying-selling event. When we encounter any one of these words in real-life context, the entire scene of this event will be automatically activated in our mind. This frame of commercial event also exemplifies another important notion in Frame Semantics, i.e. perspective.

As elaborated by Fillmore (1977a), a certain sentence that describes buying or selling activities captures usually only a part of the whole commercial event scene from a certain perspective. Each of the verbs "buy", "sell", "charge" and "pay" foregrounds a different perspective and highlights a particular relation between two participants of the whole scene. For example, the following two sentences describe the commercial event scene from two different perspectives.

(12) 我 去 蛋糕店 买了 三 块 蛋糕。
I go the bakery buy-PERF three *measure word* cake
'I went to the bakery and bought three cakes.'

(13) 珊珊 已经 把 房子 卖了。
Shanshan already *preposition* house sell-PERF
'Shanshan has sold the house.'

The verb 买 (mǎi) 'buy' in (12) foregrounds the relation between the buyer 我 (wǒ) 'I' and the goods 三块蛋糕 (sānkuàidàngāo) 'three cakes' while the verb 卖 (mài) 'sell' in (13) foregrounds the relation between 珊珊 (shānshān) 'Shanshan' and 房子 (fángzi) 'house'. The commercial event can be observed from different perspectives, leading to different choice of verbs and syntactic structures.

Each perspective highlights only part of the whole scene. If we want to highlight the relation between the buyer and goods, we would use the verb "buy" (买 (mǎi) in Chinese). If we want to highlight the relation between the seller and goods, we would use the verb "sell" (卖 (mài) in Chinese).

According to Frame Semantics, the meaning of a word should be understood against the framework of a whole set of conceptual structures or experiential spaces. How a conceptual framework is expressed syntactically is dependent upon the perspective adopted.

Frame Semantics firstly inspired the development of lexical resources in the general language – the English *FrameNet* project and *FrameNet* in many other different languages.

3.2 Application of Frame Semantics to terminology

Frame Semantics is pertinent for the description of terms; it offers terminologists a way to present linguistic properties of the term and illustrate how terms of a field are anchored in the conceptual structure / knowledge organisation of the field (L'Homme, 2018).

Researchers (Schmidt, 2009; L'Homme, 2018) have already elaborated on the pertinence of applying Frame Semantics to the description of specialised terms. Frame Semantics and FrameNet have already inspired the development of specialised lexical resources in fields as various as football – Kicktionary (Schmidt, 2009), law – the Italian Legal FrameNet (Venturi, et al., 2009), molecular biology – BioFrameNet (Dolbey et al., 2006; Dolbey, 2009), coastal engineering (Garcia de Quesada, 2010), environment – DiCoEnviro (L'Homme, 2015, 2018; L'Homme et al., 2020) and the medical domain (Zhong, 2020).

Medical domain

The project of Chinese Medical Event FrameNet (CMEF), carried out at the Zhongnan University of Economics and Law (ZUES), is an application of Frame Semantics into the description of medical event terms. This project is a Graduates Innovation Education Project of ZUES. The title of this research project is 医学领域事件本体资源库的构建研究 'The Research on the Construction of Event Ontology Repository in the Medical Field' (project number: 201910806) (Zhong, 2020).

The Chinese Medical Event FrameNet (CMEF) has been constructed based on the principles of Chinese FrameNet (CFN) developed by the research group at Shanxi University, China. Medical

terminology represents a large knowledgebase. As explained by Zhong (2020), the Chinese Medical Event FrameNet for the time being only covers the treatment part of medical event terminology and only contains Chinese semantic frames discovered in the treatment phase of the field of medical events. Chinese Medical event terms targeted are terms that describe the treatment process of health care workers rescuing patients.

The project of Chinese Medical Event FrameNet (CMEF) firstly divides medical framenet into four levels according to the framenet levels proposed by Prof. Kaitai Fan (2005) in his article entitled "汉语框架语义分析系统研究" [Systemic Study of Chinese Frame Semantic Representation] (Fan et al., 2005). As seen in Figure 10, these four levels are 框架域 (kuàng jià yù) 'Frame Domain', 框架分域 (kuàng jià fēn yù) 'Frame Sub-domain', 框架类 (kuàng jià lèi) 'Frame Category' and 框架 (kuàng jià) 'Frame'. Specifically, 框架域 (kuàng jià yù) 'Frame Domain', the highest level 医疗 (yī liáo) 'medical treatment', shows that all the frames in the framenet belong to the field of medical events. This 框架域 (kuàng jià yù) 'Frame Domain' is composed by three 框架分域 (kuàng jià fēn yù) 'Frame Sub-domains': 预防 (yù fáng) 'prevention', 患病 (huànbìng) 'suffer from an illness', and 诊治 (zhěn zhì) 'make a diagnosis and give treatment'. 框架类 (kuàng jià lèi) 'Frame Category' is a further division of 框架分域 (kuàng jià fēn yù) 'Frame Sub-domains' and has nine categories (Figure 10).

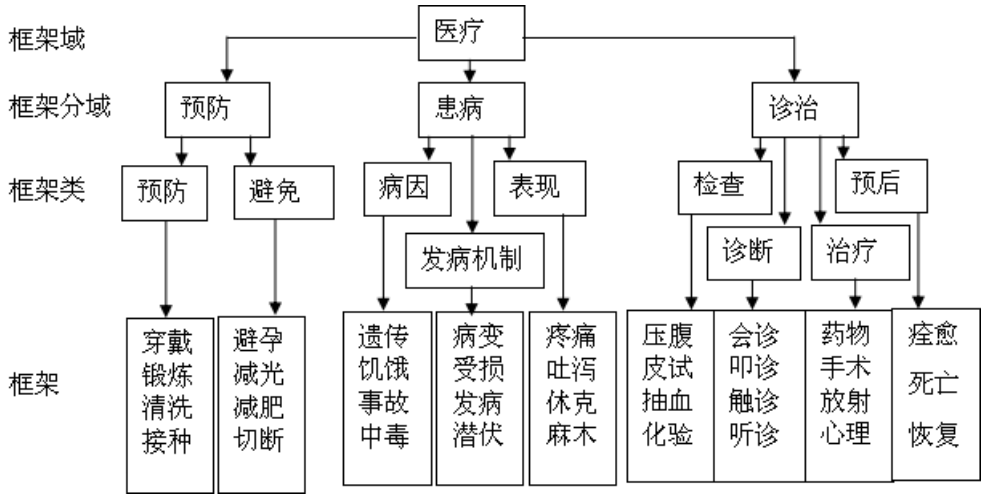


Figure 10. – Levels of semantic frames in the field of medical events (Zhong, 2020, p. 83)
(See Appendix 3 for the English translated version of Figure 10)

框架 ‘Frame’ is the basic level of the framenet. As can be seen from Figure 10, the level of 框架 ‘Frame’ contains a total of 35 Chinese semantic frames. The Table 9 shows the number of Chinese lexical units in the frames of CMEF.

Frame category	Frames	Number of lexical units
病因 [Cause of disease]	[遗传|Heredity] [饥饿|Hunger] [事故|Accident] [中毒|Poisoning]	51
发病机制 [Pathogeny]	[病变|Pathology] [受损|Injured] [发病|Attack] [潜伏|Incubate]	28
表现 [Express]	[疼痛|Pain] [吐泻|Vomiting and diarrhoea] [休克|Shock] [麻木|Numbness] [瘫痪|Paralysis]	411
检查 [Examination]	[化验|Laboratory test] [压腹|Abdominal examination] [皮试|Skin test]	121
诊断 [Diagnosis]	[会诊|(Group) consultation] [叩诊|Percussion] [触诊|Palpation] [听诊|Auscultation]	35
治疗 [Treatment]	[药物|Medication] [手术|Surgical operation] [放射|Radiation] [心理|Psychotherapy]	143
预后 [Prognosis]	[死亡|Death] [恢复|Recover] [痊愈|Recure]	13

Table 9. – The number of Chinese lexical units in the frames of CMEF (Zhong, 2020, p.82)

The frame category [病因] contains 51 lexical units while [表现] has 411 lexical units. The frame category [发病机制] contains 28 lexical units while [诊断] has 35 lexical units and [治疗] has 143 lexical units. These lexical units are mainly from 《肿瘤学》(*Oncology*) (Wei & He, 2015), 《精神病学》 (*Psychiatry*) (Hao & Lu, 2018), 《新编同义词词林》 (*New thesaurus*) (Kang, 2015), 《新世纪汉英分类词典》 (*A new century classified Chinese-English dictionary*) (Yu, 2003).

As Zhong (2020) introduces, the Chinese Medical Event FrameNet now contains semantic frames including [药物治疗|Medication_treatment], [手术治疗|Surgical_treatment] and [放射治疗|Radiation_treatment]. See Table 10 For the frame of [手术治疗|Surgical_treatment] in CMEF.

Regarding the construction method of semantic frames in CMEF, let us look at how the semantic frame [手术治疗|Surgical_treatment] was built and how contexts were annotated. The first step (step 1) consists of determining the name of the frame 手术治疗 (shǒu shù zhì liáo) 'surgical treatment'. The second step (step 2) is to give a definition of the frame [手术治疗|Surgical_treatment]. As seen in Table 10, the definition is 医护人员对病人病变或缺陷的器官进行切除，修补或替换的过程 'The process by which medical personnel remove, repair or replace a diseased or defective organ of a patient'. The next step (step 3) is to find core-frame element. Here for this frame (Table 10), the three core-frame elements are 医生 Doctor (Doc), 护士 Nurse (Nur) and 病人 Patient (Pat). The next step (step 4) is to list all the non-core frame elements. As shown in Table 10, the 11 non-core frame elements are 病因 Reason (Rea), 处所 Place (Pla), 方式 Manner (Man), 准备 Preparation (Pre), 麻醉 Anesthesia (Ane), 手段 Means (Mea), 工具 Tool (Too), 目的 Purpose (Pur), 结果 Result (Relt), 亲属 Relatives (Rel), 探望者 Visitor (Vis). The last step (step 5) is to list lexical units belonging to this semantic frame. As listed in Table 10, the eleven lexical units 术前沟通 (shù qián gōu tōng) 'preoperative communication', 消毒 (xiāo dú) 'disinfection', 除菌 (chú jūn) 'sterilization', 全身麻醉 (quánshēn má zuì) 'general anesthesia', 局部麻醉 (jú bù má zuì) 'local anesthesia', 切除 (qiē chú) 'excision', 修补 (xiū bǔ) 'repair', 替换 (tì huàn) 'replacement', 心脏搭桥 (xīnzàng dā qiáo) 'heart bypass', 换肾 (huànshèn) 'kidney transplantation', 植皮 (zhí pí) 'skin grafting'.

框架名 Frame name	手术治疗|Surgical treatment	
框架描述 Frame description	医护人员对病人病变或缺陷的器官进行切除，修补或替换的过程	
核心框架元素 Core frame elements	医生 Doctor (Doc)	为病人进行手术治疗的人
		例: 救死扶伤是医生责无旁贷的天职
	护士 Nurse (Nur)	手术护士是辅助主刀医生进行手术的人
		例: 护士为主刀医生擦汗
	病人 Patient (Pat)	身体器官发生病变或有缺陷的人
		例: 他有先天性心脏病
非核心框架元素 Non – core frame elements	原因 Reason (Rea)	促使病人进行手术治疗的原因,即病因
		例: 吸烟把肺吸坏了，得切除一部分
	处所 Place (Pla)	病人接受医护人员治疗的地点,手术室等
		例: 他现在正躺在医院手术台上
	方式 Manner (Man)	医护人员帮助病人消除疾病行为的方法描述，主要指向医护人员
		例: 情况紧急，需要马上做手术
	准备 Preparation (Pre)	术前使用各种放大措施使病人能在较佳状态下渡过手术
		例: 医生在手术前会讲明手术中可能出现的意外情况
	麻醉 Anesthesia (Ane)	医护人员(麻醉师)对病人进行局部麻醉或全身麻醉，尽量减少病人因手术产生的痛苦
		例: 大手术需要全身麻醉
	手段 Means (Mea)	医护人员使用手术等工具为病人手术的方法
		例: 在标记处切开
	工具 Tool (Too)	医护人员进行手术时所需的各类医疗器械
		例: 医生用手术刀切开肌肉组织
	目的 Purpose (Pur)	医护人员帮助病人消除疾病的目的
		例: 主刀医生切除了肿瘤
	结果 Result (Relt)	手术完成的后续事件，手术所带来的影响，包括病人苏醒、病人恢复等
		例: 刚做完手术就转到ICU去了
	亲属 Relatives (Rel)	陪同病人做手术的人，必要时需要对手术中出现的各种紧急情况签字
		例: 情况紧急,需要病人家属签字
	探望者 Visitor (Vis)	看望病人的人
		例: 爷爷病了,我想去看看他
词汇单元 Lexical units	术前沟通，消毒，除菌，全身麻醉，局部麻醉，切除，修补，替换，心脏搭桥，换肾，植皮	

Table 10. – The frame of [手术治疗|Surgical_treatment] in CMEF (Zhong, 2020, p. 85)

(See Appendix 4 for the English translated version of Table 10)

In the project CMEF, real contexts containing target terms are annotated. Constituents in the sentences realising core or non-core frame elements are annotated and attached with English labels of frame elements. For example, the following annotated contexts are for the semantic frame [手术治疗|Surgical_treatment]. Each context contains a different lexical unit in the frame.

（1）＜Pat患者＞＜Tim在进入＜Pla手术室＞前＞，＜ Man通常会采取手术区皮肤的**消毒**办法＞＜ Pur来降低皮肤上的细菌，以此来预防手术部位的感染＞。
<Pat patients ><Tim before entering <Pla the operating room >< Man usually takes the **disinfection** method of the skin in the operating area ><Pur to reduce bacteria on the skin, so as to prevent the infection of the surgical site >

（2）＜Doc医护人员＞＜ Too利用电热或红外线烤箱高热烘烤＞ ＜ Pur进行**除菌**＞。
<Doc medical staff >< Too Use electric heating or infrared oven at high heat ><Pur for **sterilization.**

（3）＜Ane采用**全身麻醉**的＞＜Pat病人＞＜Tim在麻醉期间＞＜ Relt没有任何意识，所以不会感觉到疼痛＞。
<Ane under **general anesthesia**><Pat patient ><Tim during anesthesia ><Relt was unconscious and therefore did not feel pain＞.
（4） ＜ Ane采用**局部麻醉**的＞＜ Pat患者＞＜ Res意识是清醒的＞。
<Ane under **local anaesthesia**>< Pat patient >< Res conscious >.

（5）＜Pat很多女性＞ ＜Rea因为治疗子宫疾病的原因＞ ＜Man不得不将重要的生殖器官**切除**＞。
<Pat many women >< Rea cause of the treatment of uterine diseases ><Man had to **remove** important reproductive organs >.

（6）＜Doc 医生＞ ＜ Man利用唇腭裂修复术＞ ，＜ Rea对先天性的唇腭裂＞ ＜Mea进行**修补**＞，＜ Pur使面部能恢复美观，同时治疗吞咽、进食、发音等口腔功能＞。
<Doc Doctor>< Man uses cleft lip and palate repair >< Rea to repair congenital cleft lip and palate ><Mea **repair**><Pur to restore facial appearance and treat oral functions such as swallowing, eating and pronunciation >

（7）＜Pat我＞＜Tim 18岁的时候＞＜ Rea发现右眼有白内障，当时双眼的度数约为800度＞，＜Man最后右眼动了白内障手术，也就是“晶体**替换**手术” ＞。
<Pat ME ><Tim 18 years old >< Rea It was found that there was a cataract in the right eye, and the degree of both eyes was about 800 degrees at that time >< Man finally the right eye had cataract surgery, also known as “lens **replacement** operation”.

（8） ＜Pat一般人＞＜ Man做**心脏搭桥**手术＞＜ Rea大多数都是因为冠心病而导致的＞。
<Pat ordinary people>< Man have **heart bypass** surgery >< Rea most are caused by coronary heart disease

（9）＜ Pat尿毒症病人＞ ＜ Man最理想的疗法是肾脏**移植**＞。
<Pat uremia patients>< Man The ideal treatment is kidney **transplantation** >

（10）＜ Pat病人＞ ＜ Rea外伤后皮肤坏死导致骨头或者肌腱外露，皮肤就无法自己愈合＞，＜ Man需要**植皮**＞ ＜ Pur才能覆盖＞。
< Pat patient >< Rea skin necrosis after trauma causes exposed bones or tendons, and the skin cannot heal by itself >< Man requires **skin graft** ><Pur to cover >.

This chapter first summarises the theoretical basis of this research – Frame Semantics (Fillmore, 1976, 1977, 1982, 1985; Fillmore & Atkins, 1992) and how Frame Semantics was developed from Case Grammar (Fillmore, 1966, 1968). In particular, the chapter illustrates the concept of "semantic frame" with examples from the Chinese language. Following this, the chapter presents the project of Chinese Medical Event FrameNet (CMEF) – an application of Frame Semantics into the field of medical events. Described in detail are the construction of four levels of frame hierarchy, the construction of one particular semantic frame in the project CMEF – [手术治疗|Surgical_treatment] and ten annotated contexts for this frame.

Without a doubt, the development of terminological resources (in different specialised fields) based on Frame Semantics will never stop, which directly pushes Frame Semantics to the application of interdisciplinary terminology.

Both the example given in this chapter and the research presented in this dissertation show that there is still a lot of room for development and a long way to go in the future in the multidisciplinary and multilingual application of the theory of Frame Semantics.

4 Methodology

This chapter presents the methodology for constructing the specialised Chinese terminological resource. In this resource, Chinese lexical items in the domain of climate change (one sub-domain of the environment) are encoded and described based on Fillmore's Frame Semantics (1976, 1977, 1982, 1985) (see Section 3.1). This resource is inspired by two available terminological resources that are compiled based on Frame Semantics – a specialised resource of the environment named DiCoEnviro and its accompanying resource Framed DiCoEnviro, and a general language resource in Chinese called the Chinese FrameNet (CFN). Accordingly, the methodology for this research has been adapted from the methodology devised for English and French within the *DiCoEnviro* project (L'Homme, 2015, 2016, 2018) as well as the methodology developed for Mandarin Chinese in the project Chinese FrameNet (Liu & You, 2015).

The research methodology follows a bottom-up approach – all information essential for the description of Chinese terms come from the specialised corpus Mandarin Chinese Climate Change Corpus (MCCC) compiled in this research. The specific steps of the methodology are presented in detail in Sections 4.1 to 4.9.

4.1 Construction of the Mandarin Chinese Climate Change Corpus (MCCC)

The compilation of a specialised Chinese corpus is the starting point of this research. Specialised texts form a sound basis for terminological research (L'Homme, 2004, p. 119). To achieve the final goal of discovering Chinese semantic frames in a specialised field such as the field of climate change, the analysis and distinction of meanings of Chinese terms is a crucial task. A specialised corpus, a collection of authentic running texts in a specialised domain, is the most reliable and valuable source of not only terms, but also real contexts facilitating the semantic analysis of terms.

The Mandarin Chinese Climate Change Corpus (henceforth MCCC) is a monolingual Mandarin Chinese corpus specialised in the domain of climate change, an important subdomain of the field of the environment. MCCC now contains 224 authentic Chinese texts, totalling 1,228,333 Chinese

characters (counted by Microsoft Word), which is 547,592 Chinese words[9] as counted by *Sketch Engine*.

4.1.1 Text selection criteria

MCCC is compiled according to explicit and stringent criteria. As emphasised by L'Homme (2004, pp. 125-127), texts to be compiled into a corpus should be representative and this representativeness can be achieved by taking into careful consideration of a number of criteria such as the domain, language (including regional variations), language used to write the text, level of specialisation, text type, medium, publication date, size of corpus and balance of corpus. Based on all these criteria, a list of criteria (presented in Table 11) has been established for the selection of Chinese texts to be included into MCCC.

	Criteria
Language	Texts originally written in Chinese; A small number of translated texts are also acceptable as long as they are judged by a native Chinese speaker to possess high level of naturalness in the language
Regional originality	Mainland China, Hong Kong and Taiwan
Size	Around 1 million Chinese characters (as counted by Microsoft Word)
Number of text	Around 200 texts written by different authors
Medium	Written texts in electronic form
Subject	Climate change, global warming, greenhouse effect
Text type	Introductory texts, academic journal articles, master's thesis, book chapters
Authorship	Texts written by experts and researchers in the field of the environment or related fields
Publication date	Written from 2015-2020
Sources of texts	Three important searching platforms for e-resources in China - CNKI [中国知网], Wangfang Data [万方数据], and VIP [维普]; and Google Search Engine

Table 11. – List of criteria for corpus text selection

[9] These two numbers are both important parameters reflecting the size of MCCC because 字 'character' and 词 'word' are both key concepts in Chinese linguistics. Generally speaking, a monosyllabic morpheme in Chinese is represented by a Chinese character and the majority of morphemes in Chinese correspond to Chinese characters (Liu et al., 1983, p. 1; Fang, 1992, p. 45). 词 'word' in Chinese is formed by at least one character. The concepts of 字 'character' and 词 'word' in Chinese are explained in detail in Section 4.3.1 and in Appendix 8.

4.1.1.1 Geographic dispersion

The majority of texts (201 texts) in the corpus MCCC are from mainland China. For the purpose of reflecting regional variations, 23 texts from Hong Kong and Taiwan are also incorporated in MCCC.

Mandarin, or Mandarin Chinese, or Modern Standard Mandarin is the official national language of China. As defined by ISO (International Organization for Standardization), Chinese is a "macrolanguage" that is composed of 16 different "individual languages" (ISO 639-3[10]). Mandarin Chinese, Yue Chinese and Min Nan Chinese are among these 16 individual languages[11]. Each individual language has its own dialects. Mandarin Chinese, the standard variety being Modern Standard Chinese '普通话', is the official language of mainland China. Its many different dialects include 陕西话 'Shaanxi dialect' and 四川话 'Sichuanese'. Yue Chinese '粤语', the standard form being Cantonese '广东话', is mainly spoken in Guangdong, Guangxi, and Hong Kong. Yue Chinese also has its own dialects (e.g., the Taishanese '台山话'). Min Nan Chinese or Southern Min '闽南语', mainly spoken in Taiwan and Fujian[12] '闽南语 also has its own dialects (e.g., Teochew '潮州话') .

[10] The international standard ISO 639-3, established by ISO, specifies names and codes for languages in the world. The macrolanguage of Chinese, for example, is given the code "zho". Mandarin Chinese, Min Nan Chinese and Yue Chinese are specified as "cmn", "nan", and "yue" respectively (ISO 639-3).

[11] These 16 individual languages of Chinese are fairly distinct from each other in terms of pronunciation. Because of this, communication in speech is virtually impossible between speakers of two different individual languages. For example, Cantonese and Taiwanese (or Hokkien) are unintelligible to Mandarin-speakers in mainland China. In spite of this, people speaking different individual languages could communicate with each other perfectly through written texts as the same writing system is shared by speakers from different regions. Specifically, these varieties of Chinese display clear one to one sound correspondence and share the same basic vocabularies and grammatical structures (Hu, 1981, p. 6).

[12] Min Nan Chinese or Southern Min '闽南语' is called 台語 (or 台湾话) 'Taiwanese' in Taiwan and 福建话 'Hokkien' in Fujian (闽南语会话手册 [Minnan phrasebook]).

Though sharing the same writing system, written texts from mainland China and those from Hong Kong and Taiwan are different in graphic form. People in Hong Kong and Taiwan write in traditional Chinese characters whereas people in mainland China use simplified Chinese characters, which look like a simplified version of traditional characters. The equivalent Chinese word for 'climate', for instance, is 氣候 (qì hòu) 'climate' in traditional characters and 气候 (qì hòu) 'climate' in simplified Chinese characters. The word 變化 (biànhuà) 'change' in traditional characters appears as 变化 (biàn huà) 'change' in simplified Chinese characters. Since this difference resides only on the graphic level, mainland Mandarin-speakers can read texts from Hong Kong and Taiwan without much difficulty, and vice versa (people in Hong Kong and Taiwan can read texts written in simplified characters). For text processing, the conversion between traditional Chinese characters and simplified characters can be automated with very high precision. In this research, the conversion of traditional characters into simplified ones was realised with the tool 繁转简 'Complicated into Simplified' in Microsoft Word (see Section 4.1.2).

Mandarin has different names in different regions. Mandarin is called 普通话 (pǔ tōnghuà) 'common language' in mainland China and 國語 (guó yǔ) 'national language' in Taiwan. Under the influence of geographical, historical, cultural and dialectical differences between Taiwan and Mainland China, some divergences had been gradually arising between Taiwan Mandarin and Modern Standard Mandarin (Shi & Deng, 2006, pp. 371-372). Today, differences between Taiwan Mandarin and Modern Standard Mandarin can be easily observed on the word level. One example found in the MCCC is that when referring to the phenomenon of El Niño, Taiwanese authors use the word 聖嬰現象 (shèng yīng xiànxiàng) 'holy baby phenomenon', reflecting the literal meaning of El Niño in Spanish – 'the (Christ) child'[13]. In comparison, Mainland Chinese authors use 厄尔尼诺现象 (è ěr ní nuòxiànxiàng) 'El Niño phenomenon'. 厄尔尼诺 (è ěr ní nuò), a direct transliteration of 'El Niño', reflects the sound of the original Spanish word; 现 (xiàn)

[13] Literal meaning of *El Niño* in Spanish is from *Oxford Dictionary of ENGLISH* (2005).

xiàng 象 is the equivalent of 'phenomenon'. More examples of word-level differences can be found in 中華語文知識庫[14][Chinese Linguipedia]. In the field of the environment for instance, the term yōu 優 yǎng huà 養化 'fine nutrition' is used in Taiwan when denoting the phenomenon of eutrophication whereas the term fù yíngyǎnghuà 富营养化 'rich nutrition' is used in mainland China for the same phenomenon.

4.1.1.2 Language in which texts were written

The vast majority of texts in the corpus MCCC were originally written in Chinese by native Chinese speakers, except for a few trans-edited texts. Texts No.1-5 are translated articles from official websites including the United Nations (UN), the Intergovernmental Panel on Climate Change (IPCC) and World Meteorological Organization (WMO). Given the fact that these translated texts have been validated and approved by international organisations as mentioned above, the quality of translation is largely guaranteed. Texts No. 8-10 from Taiwan, and Text No. 125, No. 174, No. 187, and No. 223 from mainland China are also texts that have been trans-edited into Chinese. However, these texts show a high level of naturalness in the language, which justifies their presence in the corpus. Before incorporating translated texts into the corpus, language quality and fluency of all these texts have been validated by the researcher herself (a native Chinese speaker).

4.1.1.3 Subject

Texts compiled in MCCC are from a variety of different topics related to climate change such as greenhouse effect, causes of climate change, consequences and impacts of climate change, and measures taken to adapt to and mitigate climate change. Texts have been collected from the Internet by using keyword search. Keywords used in the searching process include qì hòubiànhuà qì 气候变化/气 hòubiànqiān 候变迁 'climate changes', qì hòubiànnuǎn 气候变暖 'climate becomes warm', quánqiúbiànnuǎn 全球变暖 'the globe becomes

[14]中華語文知識庫 www. chinese-linguipedia.org/search_difference_results.html

warm/global warming', 地球变暖 (dì qiúbiànnuǎn) 'the Earth becomes warm', and 温室效应 (wēn shì xiàoyìng) 'greenhouse effect'. Extensive searches were carried out both in simplified and traditional Chinese characters.

4.1.1.4 Text types and sources

Texts in MCCC mainly include academic journal articles, book chapters, and other online articles from official organisation websites. Texts from mainland China were mostly found with the help of the Chinese Resources Searching Platform of Xi'an Jiaotong University, a platform that allows readers access to the scanned versions of a large number of books stored in the university library and also offers readers easy access to the three most important searching platforms for e-resources in China, including CNKI (中国知网), Wangfang Data (万方数据), and VIP (维普). Articles from Taiwan and Hong Kong were all found with keyword search in Google.

4.1.2 Text processing

	MCCC
Language	Mandarin Chinese
Graphic norm	Simplified characters
Size	547,592 Chinese words
Geographic originality	Mainland China, Hong Kong and Taiwan
Date	2015-2020
Subject	causes of climate change; greenhouse effect; consequences and impacts of climate change; measures to mitigate climate change
Type of corpus	Written texts
Text type	Introductory texts, academic journal articles, master's thesis, book chapters
Authorship & readership	Texts written by experts; Readers include experts and non-professionals (learners, students, general public)
Sources of texts from mainland China	Chinese Resources Searching Platform of Xi'an Jiaotong University
Sources of texts from Hong Kong & Taiwan	Official governmental websites of Hong Kong and Taiwan; other reliable websites

Table 12. – Summary of main features of MCCC

All the texts collected are written texts in electronic format. To facilitate later processing of these electronic texts with the corpus tool *Sketch Engine*, all texts have been converted from their original .pdf or .html format into .docx WORD format. While converting the texts, information on the author (if present in the text), all images, and references were deleted. For texts from Hong Kong and Taiwan, traditional Chinese characters were all converted into simplified characters under the Microsoft Word environment with the help of the function 繁转简 'Complicated into Simplified' under the Reviewing toolbar.

Given all the above considerations, MCCC has been compiled (See Appendix 5 for specific details of the corpus). A summary of main features of MCCC is given in Table 12.

4.2 Extraction of candidate terms

In this step, all texts in MCCC are uploaded to the corpus management tool *Sketch Engine*[15] to extract potential candidate terms. To realise the segmentation of each Chinese sentence and the attachment of part-of-speech tags to each part of a Chinese sentence, Sketch Engine uses the segmenter and POS-tagger developed in the Penn Chinese Treebank by a research group led by Xue & Xia (1998-2000) from the University of Pennsylvania. The POS-tagging tool is the Stanford Log-linear Part-Of-Speech Tagger developed within the Penn Chinese Treebank project by Xia (2000). Regarding performance of these two tools, Xue et al. (2005) explain that the accuracy of the segmenter is 94.89% (F- measure score) while the accuracy of the part-of-speech tagger is 94.47% (p. 230). With these embedded Natural Language Processing (NLP) tools as support, Sketch Engine can produce two kinds of lists with its two functions – Wordlist and Keywords. The main difference between Wordlist and Keywords is that Wordlist extracts linguistic forms that are potential words in Chinese from a focus corpus such as MCCC, whereas Keywords compares the focus corpus with a large-size general-language reference corpus so as to extract words that are representative and typical of the focus corpus.

[15] Sketch Engine|Language corpus management and query system. http://www.auth.sketcheninge.eu

To decide on which functionality to use in this phase of extracting candidate terms, we compare the two functionalities - Keywords and Wordlist. The first 10 Chinese words extracted by Keywords are presented in Table 13 (this is only a reproduction of the first part of the term extraction results of Keywords, see Appendix 6 for the first 42 candidate terms). The reference corpus that Sketch Engine compares MCCC with is the 13.5-billion-words Chinese Web corpus 2017 Simplified (zhTenTen17) – a Chinese general-language corpus, compiled with texts found on the Internet. By comparing MCCC with this reference corpus, the function *Keywords* helps identify Chinese words found in MCCC that have a high specificity score. These words are likely to be terms in the field of climate change because they have a high relative frequency in the focus MCCC corpus whereas a very low relative frequency (of less than 1) in the reference corpus *zhTenTen17*.

	Word	Frequency		Relative Frequency		Score
		Focus	Reference	Focus	Reference	
1	变暖 'become warm'	2,412	45,170	3,560.121	2.722	956.72
2	增温 'temperature increases'	754	8,492	1,112.907	0.512	736.82
3	IPCC	422	3,357	622.874	0.202	518.89
4	高信度 'high confidence'	339	39	500.365	0.002	500.19
5	冰川 'glacier'	1,972	99,240	2,910.68	5.981	417.1
6	海平面 'sea level'	337	8,274	497.413	0.499	332.58
7	增暖 'warming'	225	562	332.101	0.034	322.19
8	冰盖 'ice sheet'	292	6,038	430.993	0.364	316.74
9	变率 'variability'	207	1,014	305.533	0.061	288.88
10	海冰 'sea ice'	282	8,758	416.233	0.528	273.09

Table 13. – The first 10 terms extracted from MCCC by the functionality *Keywords* of Sketch Engine

Keywords function extracts potential terms from all parts of speech and does not allow for an extraction of terms belonging to a particular part of speech. To be able to ensure comparability

of the term extraction results of Keywords and Wordlist, it is better to apply the same settings and criteria; therefore, words from all parts of speech were selected when applying Wordlist. Table 14 shows the first 10 Chinese words (all parts of speech) extracted by Wordlist from MCCC (this is only a reproduction of the first part of the extraction results of Wordlist, see Appendix 7 for the first 42 words extracted by Wordlist).

	Word	Frequency
1	的 *structural particle*	38,571
2	和 'and' *conjunction*	8,995
3	在 'at/in' *preposition*	7,036
4	气候 'climate'	7,036
5	变化 'change'	6,425
6	是 'is'	4,899
7	年 'year'	4,589
8	全球 'globe'	4,363
9	了 *aspectual particle*	3,744
10	对 'for' *preposition*	3,528

Table 14. – The first 10 words extracted from MCCC by the functionality *Wordlist* of Sketch Engine

Wordlist presents all the words identified in MCCC. As can be observed from Appendix 7, Chinese words extracted by Wordlist are displayed according to descending order of frequency in MCCC. Wordlist offers us a first overview of MCCC by showing us the most frequent words used in this specialised corpus. If we exclude Chinese grammatical words from the Wordlist, then the two most frequent words appearing in MCCC are 气候 (qì hòu) 'climate' and 变化 (biànhuà) 'change', followed by 全球 (quánqiú) 'globe' and 影响 (yǐngxiǎng) 'influence'. These words are all important terms in the field of climate change.

Nevertheless, as pointed out by L'Homme (2004, p. 169), words having high frequency counts in a corpus are not necessarily terms in a specialised domain and words with a low frequency account may turn out to be real terms. Indeed, high-frequency words 也(yě) 'also' (adverb) and 有(yǒu) 'have' (verb) extracted by Wordlist do not have a real terminological status in the field of environment.

Terms belonging to parts of speech of nouns, verbs, adjectives, adverbs are central to terminological research. However, as can be observed from Appendix 7, among the first 42 words on the wordlist, 16 words belong to parts of speech other than these four parts of speech and can thus firstly be eliminated for this research looking into Chinese terms. The first word on the list 的(de) 'of', for example, is a structural particle; the second one 和(hé) 'and' is a conjunction indicating coordination in Chinese grammar; the third word 在(zài) 'in/at' is a preposition which, when followed by an object, bears the meaning of Location. After a careful validation, we find that among the first 42 words on the Wordlist, 26 words are not true terms in the field of the environment. The overall ratio of "noise", therefore, is 26/42 (= 0.619).

Comparing a specialised focus corpus with a general-language reference corpus to extract lexical forms having a relative frequency "anormalement élevée" (unusually high) in the focus corpus is a commonly-used method for extracting specialised terms in terminology (L'Homme, 2004, p.169). This is the method supporting the *Keywords* function in Sketch Engine. As can be seen from Appendix 6, all the keywords are presented according to the order of specificity score, along with specific statistics of their relative frequency. Keywords 增暖(zēngnuǎn) 'warm' *(vi.)* and 暖化(nuǎn huà) 'warm' *(vi.)*, for example, have a relative frequency of lower than 0.25 in the reference corpus, yet an unusually high frequency of 332.101 and 326.197 respectively in MCCC. This stark statistical difference in frequency constitutes convincing evidence that can be used by terminologists to validate the status of 增暖(zēngnuǎn) 'warm' and 暖化(nuǎn huà) 'warm' as terms in MCCC.

As can also be observed from Appendix 6, except for 11 forms in Roman alphabetic letters, the rest 31 candidate terms are worth considering as terms in the field of climate change. Candidate terms 冰盖 (bīnggài) 'ice sheet', 冰川 (bīngchuān) 'glacier', 气溶胶 (qì róngjiāo) 'aerosol', 二氧化碳 (èr yǎnghuà tàn) 'carbon dioxide' are all specialised terms denoting physical entities. There are also noun terms that denote important concepts in this specialised field – 气候 (qì hòu) 'climate'. Verb terms denoting activities in the domain have also been identified by Keywords – 增温 (zēngwēn) 'temperature rises', 增暖 (zēngnuǎn) 'warm', 暖化 (nuǎnhuà) 'warm', 减缓 (jiǎnhuǎn) 'mitigate'.

In fact, if we take a closer look at the forms in Roman alphabetic letters, we find that GHG and CO_2 refer respectively to *greenhouse gas* and *carbon dioxide*. The two Chinese terms corresponding respectively to these two symbols 温室气体 (wēn shì qì tǐ) 'greenhouse gas' and 二氧化碳 (èr yǎnghuà tàn) 'carbon dioxide' - are real terms in the domain. Counting GHG as a potential term 二氧化碳 (èr yǎnghuà tàn) 'carbon dioxide' is already there on the wordlist), the overall ratio of "noise" of Keywords is 17/42 (= 0.405).

Weighing the merits and shortcomings of Wordlist and Keywords of Sketch Engine, this research will rely on Keywords for candidate term extraction, the main reason being that Keywords has a lower "noise" ratio. Because Chinese verbs are the main focus of study for this research, the list of candidate terms extracted by Keywords is manually validated to keep only Chinese verbs (details explained in Section 4.3.2). The research places its focus on Chinese verb terms that are the most representative and significant in the field of climate change; therefore, it is preferable to have the score of specificity as the basis of term extraction. As discussed earlier, Wordlist displays Chinese words that are the most frequently seen in MCCC; however, the fact that words having a high frequency in MCCC does not mean these words are truly significant or typical in MCCC, nor does it validate directly the terminological status of these words.

4.3 Validation of candidate terms

This step consists of manually analysing and validating the candidate terms provided by *Keywords*. Chinese words that are truly terms conveying specialised meanings in the field of climate change/environment are included in the final list of terms for description.

4.3.1 Delimitation of Chinese terms

Before validating Chinese terms, we should clarify which lexical items can be considered as terms in the Chinese language. This research adopts the lexical-semantic approach to terminology in defining a term as a *lexical unit*. The concept of *lexical unit* applied here was defined by Cruse (1986) in his book *Lexical Semantics* and later applied to terminology (L'Homme, 2004, 2020). As defined by Cruse (1986, p. 77), a lexical unit refers to "the union of a lexical form and a single sense". To be clearer, a lexical unit is "a lexical form (that can behave as an autonomous unit in a sentence) that conveys a specific meaning" (L'Homme & Bernier-Colborne 2012, p. 393). Based on these definitions, a Chinese term in this research is a *lexical unit* that conveys a specialised meaning in the field of the environment.

For this research examining Chinese specialised terms, a term is defined as a 'lexical unit', rather than a 'word' because 'lexical unit' is a much more robust notion for Chinese. To start with, if we regard Chinese terms simply as words, then problematic cases will surely arise when we realise that some Chinese terms are actually each composed by two or more words. To illustrate, the lexical form 气候变化 qì hòubiànhuà 'climate change' identified in the MCCC is a lexical unit, or a term denoting changes in climate that manifest themselves as changes of the global atmospheric compositions that are directly or indirectly caused by human activities. This meaning conveyed by the form 气候变化 as a whole is a specialised meaning in the domain of environment that is not straightforwardly derivable from its composing words 气候 qì hòu 'climate' and 变化 biànhuà 'change', though these two words 气候 qì hòu 'climate' and 变化 biànhuà 'change' are each a meaningful free unit that can stand

alone in sentences. In other words, the meaning carried by the form 气候变化 is not merely the meaning of qì hòu 气候 'climate' plus the meaning of biànhuà 变化 'change'.

Moreover, as mentioned in Appendix 8, the concept of 'word' itself is not clear-cut for Chinese. Chinese characters feature entries of Chinese language dictionaries used by native Chinese speakers. The fact that today's modern Chinese has evolved from ancient Chinese for which each character represents at least one word seems to hinder intuitive judgement of words on the part of native Chinese speakers. In fact, as underscored by Hsieh (2016, p.204), a unanimous consensus over the notion of 'word' in Chinese has not yet been reached in Chinese linguistics because sometimes it is very difficult to determine whether a linguistic item made up of two characters is a single word or two words.

Cruse (1986, p.24), in his book "Lexical Semantics", outlines the two criteria for delimiting English lexical unit on the syntagmatic level.

(i) a lexical unit must be at least one semantic constituent.
(ii) a lexical unit must be at least one word. (Cruse, 1986, p. 24).

Based on Cruse (1986)'s two criteria and taking into account of special features of the Chinese language, criteria for identifying lexical units in Chinese can be established. A Chinese lexical item is a lexical unit if it fulfills the following criteria:

(1) A lexical unit is composed by at least one word in Chinese.
(2) A lexical unit carries a constant meaning – when appearing in different contexts, its contribution to the meaning of each of the contexts are the same.

The lexical item bīngchuān 冰川 'glacier' is an example of a Chinese term in the field of climate change since it is a lexical unit conveying the sole specialised meaning "glacier" in the field of climate change. The term is composed of two Chinese characters – bīng 冰 'ice' and chuān 川 'river; plain'.

The lexical item 暖化 (nuǎn huà) 'warm', for instance, is a lexical unit satisfying all these criteria. The following three example contexts show how the lexical item 暖化 (nuǎn huà) 'warm' behaves in the corpus MCCC.

(14) …，气候 系统 正 逐渐 暖化，…
climate system PROG gradually warm
'…, climate system is gradually warming, …'
(Source: 215 中国地表温度对气候变暖响应研究)

(15) …，而且 暖化 的 速度 甚至 还 在 加快，…
and that warm DE1 speed even still PROG quicken
'…, and the speed of warming is even accelerating, …'
(Source: 8 極端氣候系列報導(1)屢創新高的地表溫度)

(16) …，海洋 暖化 导致 珊瑚 白化。
seas and oceans warm lead to coral bleaching
'…, ocean warming lead to the bleaching of coral reefs'
(Source: 19 氣候變化小百科)

(*Criterion 1*) 暖化 (nuǎn huà) 'warm' is a synthetic word composed of a free morpheme 暖 (nuǎn) 'warm' and a bound morpheme 化 (huà) '-ize;-ify'. It is a word and thus can act as an autonomous unit and shoulder different syntactic functions in different contexts – predicate in (14), attribute modifying 速度 (sù dù) 'speed' in (15) and head word of the verbal phrase 海洋暖化 (hǎi yáng nuǎn huà) 'ocean becomes warm' in (16) that acts as the subject of the sentence. (*Criterion 2*) The contribution of 暖化 (nuǎn huà) to the meaning of each of the three contexts are the same since it conveys the same meaning of 'become warm'.

4.3.2 Verbs as object of study

Leafing through many of today's specialised dictionaries (whether in Chinese or English), we will find that most of them are repertoires of technical nouns in their respective domains. One possible reason behind this preference for nouns, as elaborated by L'Homme (2020), is that the connection between noun terms and a specialised field that these nouns are associated with seems to be more evident and immediate, facilitating the establishment of their "terminological status" (p. 61). However, acknowledging the importance of nouns in terminology is not to say that

lexical items belonging to other parts of speech cannot be terms. In fact, as has long been proposed by other approaches to terminology including the textual approach (Bourigault & Slodzian, 1999) and lexical-semantic approach (L'Homme, 2004, 2020), terms could be in the linguistic form of not only nouns, but also verbs, adjectives and adverbs.

For most of today's Chinese dictionaries of environmental terminology, nouns (and nominal compounds) have been the primary focus of description (as discussed in Section 1.1). There is an obvious research insufficiency on Chinese verbs as specialised terms in the field of the environment. To fill in this gap, this research will look into Chinese verbs in the field of environment and expound on their status as specialised terms.

4.3.3 Criteria for identifying verb terms in Chinese

For many verbs on the list of *Keywords*, their status as specialised terms in the field of climate change can be easily confirmed. Lexical units 酸化 (suānhuà) 'acidify', 蒸发 (zhēng fā) 'evaporate', and 辐射 (fú shè) 'radiate', for example, can be easily associated with a specialised field such as the field of the environment since one has to have some specialised knowledge so as to be able to grasp the meaning of each of the three units. Therefore, these terms are kept on the final list. The score of specificity calculated by *Sketch Engine* also offers valuable references for the identification of specialised terms. Lexical units such as 变暖 (biànnuǎn) 'become warm', 增温 (zēngwēn) 'temperature rises', 增暖 (zēngnuǎn) 'warmth increases', 暖化 (nuǎnhuà) 'become warm' have a very high score of specificity (over 270), which means that their presence in the general language corpus is very low; therefore, they are highly likely to be specialised terms.

Nevertheless, more specific criteria needs to be established for identifying verbs as specialised terms because many verbs on the *Keywords* list seem to be verbs frequently used in everyday life, their connection with specialised knowledge of the field of environment cannot be immediately

inferred and their statuses as terms are thus not readily ascertained (e.g. 减少 ‘decrease’, 变化 ‘change’, 上升 ‘rise’).

According to the lexico-semantic approach to terminology (L’Homme, 2020, pp.72-75), four criteria can be employed to validate whether a lexical unit is a term or not. The first criterion is that a term in a specialised domain is a lexical unit if it contains specialised knowledge of the field. As pointed out by L’Homme (2020), this criterion is more suitable for determining the status of nominal terms. The second criterion is that a predictive lexical unit is highly likely a term in a specialised domain if its argument(s) have already been recognised as terms. As will soon be discussed, these two criteria work perfectly well also for Chinese.

The third criterion of “morphological relations” (L’Homme, 2020, p. 74) draws on derivational morphological changes – an important linguistic phenomenon in word-formation in languages such as English and French. The example elaborated by L’Homme (2020, p. 74) are lexical units *pollute*, *pollution*, *pollutant*, *polluted* and *polluting*, which resembles each other not only morphologically in their lexical forms, but also semantically in their meanings. With the aid of this phenomenon in word-formation, the third criterion helps identify verbs *pollute*, *polluted* and *polluting* as terms if the nouns *pollutant* and *pollution* have already been defined as terms. In Chinese, the relation between 污染 ‘pollute’, the equivalent verb for *pollute*, and 污染物, equivalent for *pollutant*, seems to be very similar to that in English; by adding 物 ‘object’ to 污染 ‘pollute’, the verb 污染 ‘pollute’ becomes a noun 污染物 ‘pollutant’. However, this kind of morphological change between verbs and nouns cannot be generalized in the Chinese language. There are only a few affixes in Chinese including 阿 (*particle*), 老 ‘old’, 节 ‘festival’, 初 (*particle*), 小 ‘small; little; young’ as in 阿姨 ‘auntie’, 老师 ‘teacher’, 初一 ‘junior high’, 第三 ‘the third’, 小孩 ‘child’ and a few suffixes including 子, 儿, 者, 化, etc. as in 椅子 ‘chair’, 花儿 ‘flower’, 读

zhě 者 ‘reader’, lǜ huà 绿化 ‘green’ (Liu et al., 1983). For Chinese verbs that can also act as nouns, their forms never change. To illustrate, when verbs jiào yù 教育 ‘educate; education’, juédìng 决定 ‘decide; decision’, fēn xī 分析 ‘analyse; analysis’, fā xiàn 发现 ‘discover; discovery’, pànduàn 判断 ‘judge; judgement’, gān rǎo 干扰 ‘interfere; interference’ function as nouns, their form never show derivational change. Given these points, this criterion of morphological relations is generally not applicable for identifying Chinese terms.

The fourth criterion is to indentify terms with the help of “paradigmatic relations” between terms (L’Homme 2020, pp. 74-75). Lexico-semantic relations including synonymy, antonymy (and other opposite relations), hyponymy and meronymy are valuable clues for recognising terms. If a lexical unit has been confirmed as a term in a specialised field, then other lexical units sharing lexical relations with this term are also terms.

Based on and adapted from these criteria applicable for English and French, three criteria for validating the status of Chinese lexical units can be established for this research. The first criterion is that a term should convey specialised knowledge in a specialised subject area. For this research, lexical units carrying specialised knowledge in the field of climate change, environment or relevant fields like meteorology and climatology should be identified as terms. According to this criterion, lexical units such as qì hòu 气候 ‘climate’, qì wēn 气温 ‘air temperature’, wēn shì xiàoyìng 温室效应 ‘greenhouse effect’, and wēn shì qì tǐ 温室气体 ‘greenhouse gas’ correspond to terms. Though all these terms identified are of nominal nature, they will help validate the terminological status of Chinese verbs when employing the second and the third criterion.

The second criterion is to examine the status of realisations of actants of a predicate verb. If actants of the predicate are realised with terms, then the predicate itself should be identified as terms. To illustrate, xī shōu 吸收 ‘absorb’ is a potential candidate term appearing on the list of *Keywords* with a low score of specificity (10.61) (See Appendix 6). In the following two contexts from MCCC,

we can see that 吸收 ‘absorb’ has two actants – Cause (what absorbs) and Patient (what is being absorbed). In context (17), the two actants of 吸收 ‘absorb’ are linguistically realised by 温室气体 ‘greenhouse gas’ and 能量 ‘energy’, which can be confirmed as terms in the field of climate change according to the first criterion; in context (18), the two actants are realised by 二氧化碳 ‘carbon dioxide’ and 海洋 ‘ocean’, two terms as ascertained with the help of the first criterion. Therefore, we are confident in recognising 吸收 ‘absorb’ as a term.

(17) 温室 气体 能 吸收 地球 表面 的 辐射 能量，
greenhouse gas can absorb the Earth surface DE1 radiation energy

吸收后再向四面八方散热，使近地表大气保持温暖，这种现象就是气候学所称的「温室效应」。

(Source: 21 氣候變遷(臺灣交通部中央氣象局))

‘Greenhouse gases can absorb radiant energy from the Earth’s surface and then dissipate it in all directions, keeping the near-surface atmosphere warm, a phenomenon known in climatology as the ‘greenhouse effect’.

(18) 此外，
人类 活动 排放 的 二氧化碳 有 大约 百份之三十被海洋 吸收，
human activity emit DE1 carbon dioxide exist about 30 precent sea ocean absorb

造成海洋酸化，海水中的碳酸根离子因而减少，严重影响珊瑚的钙化过程及骨骼生长。

(Source: 19 氣候變化小百科)

‘In addition, about 30 per cent of the carbon dioxide emitted by human activity is absorbed by the oceans, causing ocean acidification, which reduces the carbonate ions in seawater and seriously affects the calcification process and skeletal growth of corals.’

The third criterion draws support from an important feature in the morphology of Chinese for identifying Chinese verb terms. In Chinese, many single-character free morphemes can function as independent verbs in contexts. This free morpheme, if combined with other bound morphemes, will form other verbs, which are semantically related to the free morpheme. The single-character free morpheme 变 ‘change’, for instance, is a free morpheme that can stand

alone in sentences functioning as a verb (e.g. 她变了好多。 'She has changed a lot.') 变 'change', however, can combine with other morphemes like 化, 迁, and 改 to form other verbs 变化 'change vi.', 变迁 'change', 改变 'change vt.', which all carry the meaning of the verb 变 'change'. This criterion is thus based on the assumption that Chinese verbs sharing one same character/morpheme are possibly sharing the meaning of this common character. Therefore, if 变化 'change vi.' has been defined as a term in the field of the environment, then 变迁 'change' and 改变 'change vt.' should also be considered as terms in the field. In contexts of MCCC, the bound morpheme 融 appear in three verbs 融化 'melt', 消融 'melt' and 融解 'melt'. Since these three lexical units share the same character 融, it is highly likely that they bear similar meaning. If 融化 'melt' is recognised as a term, then 消融 'melt' and 融解 'melt' are most likely terms as well.

The fourth criterion is to identify terms in the light of paradigmatic relationships between lexical units. Lexical relations such as synonymy (or near-synonymy) and opposition are particular helpful in identifying verb terms in Chinese. For instance, if 上 升 'rise' is defined as a term in the field of climate change, then its near synonym 升 高 'rise/ascend' and its opposite 下 降 'fall' should all be identified as terms in the field.

4.3.4 Criteria for selecting terms for this research

A Chinese lexical item on the list of *Keywords* identified by *Sketch Engine* must satisfy the following six criteria before being included into the final list of terms for this research.

Firstly, as discussed earlier in Section 4.3.1, the Chinese lexical item identified as a term is a lexical unit carrying a specialised meaning in the field of climate change, including the field of the

environment or other related fields such as meteorology and climatology. The Chinese lexical item identified as a term must be a lexical unit satisfying the two criteria – (1) it is composed by at least one word in Chinese; (2) it carries a constant meaning – when appearing in different contexts, its contribution to the meaning of each of the contexts are the same.

In addition, as explained in Section 4.2, the function Keywords of Sketch Engine does not allow users to extract words that pertain to a specific part of speech, so the list of keywords proposed contain words from all parts of speech. Only verbs are selected as object for this research. Candidate terms that are nouns should be eliminated from the final list of terms for description. To illustrate, among the first 10 keywords identified by *Sketch Engine*, five nouns – 冰川 (bīngchuān) 'glacier', 海平面 (hǎipíngmiàn) 'sea level', 冰盖 (bīnggài) 'ice sheet', 变率 (biàn lǜ) 'variability', and 海冰 (hǎibīng) 'sea ice' have been eliminated. Candidate terms are kept on the list if they are verbs in Chinese and if they function as verbs in MCCC contexts. However, taking into consideration of the fact that the Chinese language is non-inflectional and many verbs can also act as nouns in contexts without any change in their forms, a closer examination of behaviours of each verb in contexts is essential. Verbs that are found only used as nouns in running texts in MCCC are eliminated from the final list. A case in point is the lexical item 强迫 (qiǎng pò) 'to force' extracted as a keyword by Sketch Engine. Obviously, 强迫 (qiǎng pò) 'to force' is a verb in Chinese. Nevertheless, usages of 强迫 (qiǎng pò) 'to force' as a single verb with the meaning of 'to force' are not observed in MCCC; rather, all occurrences of 强迫 (qiǎng pò) appears as in the term 辐射强迫 (fú shè qiǎng pò) 'radioactive forcing', which is a value in physics with W/m^2 as its measuring unit. Because 强迫 (qiǎng pò) is never used as a single verb in contexts of MCCC, it is eliminated from the final list.

Lastly, to ensure sufficient contextual information for sense distinction and term description at later stages, terms on the Keywords list with an occurrence of over 90 in MCCC are selected for this research.

	Term	Frequency	Specificity score
1	增温 ‘temperature rises’	754	736.82
2	增暖 ‘to warm’	225	322.19
3	暖化 ‘to warm’	221	272.44
4	减缓 ‘mitigate’	703	171.01
5	升温 ‘temperature rises’	916	124.03
6	观测 ‘observe’	812	90.14
7	预估 ‘predict’	389	80.38
8	停滞 ‘stagnate’	304	80.36
9	退缩 ‘retreat’	220	77.66
10	消融 ‘melt’	146	63.31
11	排放 ‘emit’	1438	56.73
12	融化 ‘melt’	223	52.81
13	突变 ‘change suddenly’	253	51.48
14	升高 ‘rise’	623	48.53
15	变化 ‘change’	6425	44.11
16	累积 ‘accumulate’	355	43.14
17	辐射 ‘radiate’	767	35.3
18	变迁 ‘change’	235	34.18
19	估算 ‘estimate’	207	29.43
20	上升 ‘rise’	1447	24.45
21	蒸发 ‘evaporate’	104	19.39
22	降温 ‘temperature falls’	164	15.97
23	加剧 ‘intensify’	185	15.81
24	减弱 ‘attenuate’	128	15.8
25	波动 ‘fluctuate’	464	14.58
26	反射 ‘reflect’	98	12.43
27	减少 ‘reduce’	1286	11.49
28	评估 ‘estimate’	699	11.35
29	氧化 ‘oxidize’	106	11.24
30	吸收 ‘absorb’	410	10.61
31	增加 ‘increase’	2036	10.22
32	增多 ‘increase’	170	10.21

Table 15. – List of validated verb terms (Validation results of the *Keywords* list of Sketch Engine)

The final list of validated verb terms is shown in Table 15 above, following the order of score of specificity. Additional verb terms identified according to Criterion D. (=paradigmatic relations) are listed in Table 16. These verbs are identified as terms because they share certain paradigmatic relations with the terms in Table 15. For each term, Table 16 shows its frequency of occurrence in the corpus and specifies what kind of paradigmatic relations it shares with which term already recognised. As can be seen from Table 16, each of these additional verb terms also has a frequency of occurrence of over 90.

	Term + (Additional term identified)	Frequency of **Term +** in MCCC	paradigmatic relations **Term +** shares with **Term Keyword**	**Term Keyword** (Term already recognised by Sketch Engine as Keyword)
1	加速 'accelerate'	177	Opposite	减缓 'slow down'
2	加快 'speed up'	90	Opposite	减缓 'slow down'
3	缓解 'alleviate'	98	Near-synonym	减缓 'mitigate'
4	降低 'fall'	423	Opposite	升高 'rise high'
5	下降 'fall'	507	Opposite	上升 'rise'
6	改变 'change'	538	Near-synonym	变化 'change'
7	释放 'release'	211	Near-synonym	排放 'emit'
8	增强 'strengthen'	259	Opposite	减弱 'attenuate; weaken'
9	加强 'strengthen'	304	Opposite	减弱 'attenuate; weaken'
10	估计 'estimate'	119	Near-synonym	估算 'estimate'
11	预测 'predict'	264	Near-synonym	预估'predict'

Table 16. – List of additional verb terms identified

4.4 Sense distinction

As in English, polysemy is a prevalent linguistic phenomenon in the Chinese language. The term "polysemy" comes from the Greek word "πολνσημεία", which means "multiple meaning" (McCaughren, 2009, p. 107). Polysemy denotes the phenomenon when a word has separate different meanings yet these meanings are related (Cowie, 2009, p. 28). As will be discussed later in more detail in this research, many Chinese terms identified in MCCC convey more than one meaning in the field of climate change. This step is about distinguishing meanings (*a.k.a* senses)

of polysemous Chinese terms. Contexts where a polysemous term appears are what the sense distinction is largely dependent upon. A careful observation and examination of contexts provide evidence for the distinction of meanings.

- Sense distinction based on the lexico-semantic tests of Cruse (1986)

The lexico-semantic tests proposed by Cruse (1986) assist with distinguishing senses of a polysemous lexical unit from the angle of semantics. Among the tests put forward by Cruse (1986), three tests proving to be applicable for distinguishing senses of polysemous Chinese terms include the test of synonymy, the test of opposite, and the combination test[16]. Now we will look into these tests and see how they help identify different senses of a polysemous Chinese term.

The first test for distinguishing senses of polysemous Chinese terms is the test of synonymy. According to Cruse (1986, p. 55), for two occurrences of a lexical form, we can try substituting each of the two occurrences by a synonym; if the synonym works in some contexts but not in others, then the indication is that the lexical form has two senses. To give an illustration of how this test works for differentiating senses of a polysemous term, let us look at the term shì fàng 释放 'to release' and the following two contexts of shì fàng 释放 'to release' found in MCCC.

(19) a. 人类 活动 释放 的 温室 气体 增强 了 包裹 效应。
human activities release DE1 greenhouse gas enhance-PERF wrap effect
'Greenhouse gases released by human activities have enhanced the wrapping effect.'

b. 人类 活动 排放 的 温室 气体 增强 了 包裹 效应。
human activities emit DE1 greenhouse gas enhance-PERF wrap effect
'Greenhouse gases emitted by human activities have enhanced the wrapping effect.'

(20) a. …植物 同时 释放 氧气 和 吸收 二氧化碳…
plant at the same time release oxygen and absorb carbon dioxide
'... plants simultaneously release oxygen and absorb carbon dioxide...'

b. …*植物 同时 排放 氧气 和 吸收 二氧化碳…
plant at the same time emit oxygen and absorb carbon dioxide
* '...plants simultaneously emit oxygen and absorb carbon dioxide...'

[16] The names for these tests are given in this research.

One synonym for 释放 ‘to release’ is 排放 ‘to emit’. By substituting 释放 ‘to release’with 排放 ‘to emit’, we will see that in the first case (19), but not the second (20), 释放 ‘to release’is synonymous with 排放 ‘to emit’, suggesting that 释放 ‘to release’ has two separate senses. In fact, 排放 ‘to emit’ has a negative connotation. Looking up 排放 ‘to emit’ in 《现代汉语词典》(*Modern Chinese dictionary*), its meaning is 排出（废气、废水、废渣）(‘discharge exhaust gas, waste water and waste residue’)(2012). The meaning of morpheme 排 in 排放 ‘to emit’ is 消除, 推开, 排斥 (‘eliminate, exclude’) (《现代汉语大词典》[*Modern Chinese dictionary*], 2007). This explains why 排放 ‘to emit’ cannot function in the second case (20).

A closer examination of the two contexts will also tell us that the predicative term 释放 ‘to release’ takes a different number of actants in the two contexts. 释放 ‘to release’ in (19a) takes three actants – Patient (the thing being released) CO_2, Cause (of this release) 人类活动 ‘human activities’ and Destination (to where the released CO_2 goes to) 到大气中 ‘to the atmosphere’. By contrast, 释放 ‘to release’ in (20a) takes only two actants – Source (of this release) 植物 ‘plant’ and Patient (the thing being released) 氧气 ‘oxygen’. In fact, 释放 ‘to release’ depicts two different situations in the two contexts – in (19a) it is human activity that causes carbon dioxide to be released into the atmosphere (it is not human activity being the source that releases carbon dioxide; the source is possibly the fissile fuel when it is burned) whereas in (20a) it is plants being the source that spontaneously releases oxygen. These two instances of 释放 ‘to release’, depicting two scenes, correspond to two semantic frames. (The concept of “semantic frame” is explained in Section 3.1.2)

The second test utilised to detect polysemy is the test of opposite. As explained by Cruse (1986, p. 55), for two occurrences of a lexical form, we can try applying an opposite item in the two contexts; if this lexical item shares an opposite relation with one occurrence but not the other, then the indication is that the lexical form has two senses. To illustrate how this test of opposite works, let us look into the two contexts of 释放 shì fàng 'to release' again.

As can be seen in context (20a), 吸收 xī shōu 'absorb' stands in opposite relation with 释放 shì fàng 'to release'. 植物 zhí wù 'plant' can be the source that can both 释放 shì fàng 'to release' and 吸收 xī shōu 'absorb' gases. Nevertheless, 吸收 xī shōu 'absorb' shares no opposite relation with 释放 shì fàng 'to release' in context (19a), indicating that 释放 shì fàng 'to release' has two separate senses.

The third test applied in determining that a lexical form is polysemous is the combination test. As pinpointed by Cruse (1986, p. 61), two occurrences of a lexical form cannot be combined to form an accurate sentence if these two occurrences manifest two distinct senses. To clarify how this test works, let us reconsider 释放 shì fàng 'to release' and its two contexts. A simplified version of context (19a) and context (20a) is respectively 人类活动释放气体 rén lèi huódòng shì fàng qì tǐ 'human activities release gases' and 植物释放气体 zhí wù shì fàng qì tǐ 'plant release gas'. The fact that combing these two occurrences of 释放 shì fàng 'to release' will lead to an erroneous sentence indicates that 释放 shì fàng 'to release' has two different senses.

signifies that a sentence is semantically incorrect.

(21) #人类 活动 和 植物 释放 气体
human activity and plants release gas(s)
'human activities and plants release gases'

- Sense distinction based on transitivity of Chinese verbs

Besides the above-mentioned three tests, syntactic behaviours of a lexical item in different contexts also serve as important clues for determining whether it conveys different senses. One natural clue for sense distinction is transitivity of verbs. If a particular verb is used both intransitively and transitively in the corpus MCCC, then these two usages manifest two senses of the verb. This phenomenon is elaborated by Levin (1995, pp. 2-3) as "causative/inchoative alternation", a type of "transitivity alternation". As an example, following are two contexts of the term 加剧 jiā jù 'intensify'. In context (22), 加剧 jiā jù 'intensify' functions as a intransitive verb whereas in context (23) it is used as transitive verb followed by direct object 温室效应 wēn shì xiàoyìng 'greenhouse effect'. The transitive 加剧 jiā jù 'intensify', when used in contexts (23) bears the meaning of 'cause something to intensify'. With regards to the actantial structure, the transitive 加剧 jiā jù 'intensify' takes on two actants X 加剧 jiā jù Y ('X intensify Y') whereas the intransitive 加剧 jiā jù 'intensify' takes only one actant as in X 加剧 jiā jù (X intensify).

In this research, the intransitive 加剧 jiā jù$_{1a}$ 'intensify' and the transitive 加剧 jiā jù $_{1b}$ 'intensify' are thus presented as in three separate entries 加剧 jiā jù $_{1a}$ 'intensify', and 加剧 jiā jù $_{1b}$ 'intensify' because they have different actantial structures. We would also like to make explicit the causative/inchoative alternation between the transitive and intransitive 加剧 jiā jù 'intensify'. Taking into consideration of the fact that the semantic difference between these two lexical units is subtle, the intransitive 加 jiā 剧 jù 'intensify' is marked as 加剧 jiā jù $_{1a}$ 'intensify' while the transitive 加剧 jiā jù 'intensify' is marked as 加 jiā 剧 jù $_{1b}$ 'intensify' to show they are semantically related.

(22) 因此，人类活动排放的温室气体不断累积，

二氧化碳 浓度 不断 上升, 气候 变化 不断 加剧。

carbon dioxide concentration unceasing rise climate change unceasing intensify

'Therefore, greenhouse gases emitted by human activities continuously accumulate, the concentration of carbon dioxide continuously rises, and the climate change continuously intensifies.'

(Source: 151 全球变暖停滞的研究进展回顾)

(23) 但 HCFCs 和 HFCs 浓度 的 上升 加剧 了 温室 效应。

but HCHCs and HFCs concentration DE1 rise intensify-PERF greenhouse effect

'The increase of the concentration of HCFCs and HFCs has intensified the greenhouse effect.'

(Source: 195 温室效应及第四代制冷工质)

♦ Verb/Noun distinction of multicategory verb/noun Chinese terms

In Chinese, some words can have grammatical functions of two or more parts of speech – a linguistic phenomenon called "conversion of parts of speech" (Li & Cheng, 2008, p. 12). These words are given the name jiānlèi cí 兼类词 'multi-category word' in Chinese grammar. One particular example of a multi-category verb/noun term is biànhuà 变化 'change', which can function both as a noun and a verb as observed from contexts of the corpus MCCC. Thus, biànhuà 变化 'change' corresponds to two lexical units - biànhuà 变化$_1$ 'change' (v.) and biànhuà 变化$_{1.1}$ 'change' (n.). In our terminological resource, these two senses are presented separately in two entries. The following contexts (24) – (29) show how biànhuà 变化 'change' behaves in the specialised corpus MCCC.

(24) 根据估算,

海 水 温度 变化 1°C ,

sea water temperature change

'The sea water temperature changes 1°C,'

会导致海平面发生约 1m 的波动, ……。

'It is estimated that a change in sea water temperature of 1°C will result in a fluctuation of sea level of about 1m. ……'

(Source: 176 深时古气候对未来气候变化的启示)

(25) 从历史上看,

随着气温上升,

两极 的 海 冰 会 不断 变化,

the two poles of the Earth DE1 sea ice SUPP unceasing change

'sea ice at the poles will unceasingly change,'

从而会导致海洋环流的翻转。
'Historically, sea ice at the poles will unceasingly change as temperatures rise, which can lead to an overturning of ocean circulation.'

(Source: 125 气候变暖与我们的生活)

(26) 地球 轨道 的 微小 变化
the Earth orbit DE1 small change
'small change of the orbit of the Earth'

就能改变阳光在地球表面上的季节性分布和地理性分布。
'Small changes in the Earth's orbit can alter the seasonal and geographic distribution of sunlight over the Earth's surface.'

(Source: 73 缓解全球气候变暖的自然对策)

(27) 在冰冻圈方面，越来越多的观测记录显示，
冰冻圈 已经 发生了 巨大 的 变化，
cryosphere PERF SUPP-PERF tremendous DE1 change
'cryosphere has changed tremendously,'

因冰川退缩、冰盖消融等造成的冰量损失速度还在加快。
'In the case of the cryosphere, a growing number of observations shows that the cryosphere has already changed dramatically and that the rate of ice loss due to the retreat of glaciers and the melting of ice caps is accelerating.'

(Source: 107 气候变化科学问答第二章)

(28) 那么，今后 超强 台风 的 袭击 会 出现 哪些 变化呢？
then in the future super typhoon DE1 strike be likely to SUPP what change
'Then, for super typhoon strikes, what changes will occur in the future?'

(Source: 78 极端天气——全球变暖与频频发生的热浪、干旱、洪水)

(29) 政府间气候变化专门委员会 (IPCC) 第五次报告指出，自 20 世纪 50 年代以来，
地球 气候 系统 观测 到 的 很多 变化
the Earth climate system observe PERF DE1 many change
'the many changes observed in the climate system of the Earth'

在几十年乃至上千年时间里都是前所未有的，
大气和海洋已变暖，积雪和冰量已减少，海平面已上升，
温室气体浓度已增加。
'The fifth report of the Intergovernmental Panel on Climate Change (IPCC) notes that many of the changes observed in the Earth's climate system since the 1950s have been unprecedented over decades and even millennia. The atmosphere and oceans have been warming; snow and ice volume have been decreasing; sea levels have been rising; and greenhouse gas concentrations have been increasing.'

(Source: 178 生态系统对全球变暖的响应)

In contexts (24) and (25), 变化 (biànhuà) ‘change’ acts as a verb whereas in context (26) - (29) it functions as a noun. As can be clearly observed, a Chinese verb such as 变化 (biànhuà) ‘change’ never changes its form in contexts no matter what position it occupies in syntactic structure; a multi-category verb/noun term such as 变化 (biànhuà) ‘change’ will always remain in the same form whether it functions as a verb or a noun. Therefore, it is very difficult to determine the part of speech of a verb/noun multi-category Chinese term. Nevertheless, we can rely on contextual information to make such distinction. In the following paragraphs, we look into how this verb/noun distinction can be made based on <1> syntactical analysis, <2> the analysis of syntactic realisations of actants of the verb/noun term, and <3> collocations.

<1> Verb/ Noun distinction based on syntactical analysis

We can determine the part of speech of a verb/noun multi-category Chinese term through syntactical analysis. For example, we can look for modifiers of the verb/noun term in context, or we can rely on properties of nouns and verbs in Chinese grammar to ascertain whether the verb/noun term functions as a noun or a verb. In the context (24), 变化 ‘change’ shoulders the syntactic function of the sentence predicate with 海水温度 (hǎi shuǐ wēn dù) ‘temperature of sea water’ as its subject. Therefore, we know that 变化 (biànhuà) ‘change’ here functions as a verb. 变化 (biànhuà) ‘change’ in the context (25) also behaves as a verb because it is modified by the adverb 不断(地) (bú duàn dì) ‘unceasingly’ and the sole function of an adverb is to modify verbs in Chinese grammar. Besides, 变化 (biànhuà) ‘change’ must be a verb here because it follows closely to the modal verb 会 (huì) ‘be likely to’.

In the context (29), 变化 (biànhuà) ‘change’ is modified by 很多 (hěn duō) ‘many’. Because 很多 (hěn duō) ‘many’ is a word that explains a characteristic of objects rather than actions, 变化 (biànhuà) ‘change’ here acts as a noun.

<2> Verb/Noun distinction based on the analysis of syntactic realisations of actants of the multi-category verb/noun term

We can determine the part of speech of a verb/noun Chinese term by analysing syntactic realisations of its actant(s). Let us observe again the contexts (24) – (29) taken from the corpus MCCC for the verb/noun term biànhuà 变化 'change'.

No matter acting as a noun or a verb, for the term biànhuà 变化 'change', we need to know what is undergoing change. Semantically speaking, we need to know what the Patient of biànhuà 变化 'change' is. Therefore, we know that biànhuà 变化 'change' only has one actant and its actantial structure is {X|Patient} biànhuà 变化. As previously discussed, biànhuà 变化 'change' in (24) is a verb since it functions as the sentence predicate with hǎi shuǐ wēn dù 海水温度 'the temperature of the sea water' being its subject. In (26), biànhuà 变化 'change' is modified by the adjective wēi xiǎo 微小 'small'; dì qiú guǐ dào 地球轨道 'the orbit of the Earth' is also a modifier of biànhuà 变化 'change'. Therefore, we know that biànhuà 变化 'change' here is a noun.

Let us now consider the Patient of the term biànhuà 变化 'change' in the two contexts (24) and (26). In (24), the syntactic realisation of the Patient of biànhuà 变化 'change' is hǎi shuǐ wēn dù 海水温度 'the temperature of the sea water', which acts as the subject of biànhuà 变化 'change'. In contrast, the Patient of biànhuà 变化 'change' in (26) is realised with dì qiú guǐ dào 地球轨道 'the orbit of the Earth', which behaves syntactically as a modifier of the term biànhuà 变化 'change'. Among the 20 annotated contexts of biànhuà $变化_1$ 'change'(v.) in our compiled resource, there are 17 contexts where the syntactic realisation of the Patient acts as the subject of the term biànhuà $变化_1$ 'change'(v.). However, for biànhuà $变化_{1.1}$ 'change'(n.), there are no cases where the syntactic realisation of the Patient acts as the subject of the term.

Based on this analysis, we know that for a verb/noun term that has only one actant – Patient, if the syntactic realisation of the actant acts as the subject of the term, then the term probably behaves as a verb; if the syntactic realisation of the actant acts as a modifier (e.g. attributive) of the term, then the term probably functions as a noun.

<3> Verb/Noun distinction based on collocations

A multi-category verb/noun Chinese term selects different collocations depending on whether it functions as a noun or a verb. For instance, certain support verbs collocate with the term when the term acts as a noun, but they do not collocate with the term when the term functions as a verb. Thus, collocations can be reliable clues for us to ascertain the part of speech of a verb/noun term in contexts.

For example, in (27), the verb/noun term 变化 biànhuà 'change' occurs as in the collocation 发生变化 fā shēngbiànhuà 'changes occur'. 发生 fā shēng 'happen, occur' is the support verb of the term 变化 biànhuà 'change'. An analysis of the grammatical structure of this sentence will tell us that the verb 发生 fā shēng 'happen, occur' is the sentence predicate, with 冰冻圈 bīngdòngquān 'cryosphere' acting as its subject and 巨大的变化 jù dà de biànhuà 'tremendous change' as its object. 变化 biànhuà 'change' here is a noun, modified by the adjective 巨大 jù dà 的 de 'tremendous'. Nevertheless, when 变化 biànhuà 'change' behaves as a verb, it does not collocate with the verb 发生 fā shēng 'happen, occur'. Based on this analysis, we are confident to say that when a multi-category verb/noun Chinese term collocates with the support verb 发生 fā shēng 'happen, occur', then the term is highly likely a noun.

In (28), 变化 biànhuà 'change' collocates with the verb 出现 chūxiàn 'appear, occur'. 变化 biànhuà 'change' here functions as a noun, with 出现 chūxiàn 'appear, occur' as its support verb. 会出现 huì chūxiàn 'is likely to occur' acts

as the sentence predicate, with the noun phrase 超强台风的袭击 (chāoqiángtáifēng de xí jī) 'strike of super typhoon' being its subject and 哪些变化 (nǎ xiē biànhuà) 'what changes' being its object. However, when functioning as a verb, 变化 (biànhuà) 'change' does not collocate with 出现 (chūxiàn) 'appear, occur'. Therefore, when a multi-category verb/noun Chinese term collocates with the support verb 出现 (chūxiàn) 'appear, occur', the term is highly probably a noun.

In fact, this step of sense distinction and the next step of formulating actantial structure are taking place at the same time. With careful examination of the contexts of a polysemous term, the actantial structure for each meaning of the term is formed in this step.

4.5 Actantial structure

This step formulates the actantial structure (i.e. argument structure) of each predicative Chinese term and assigns semantic role labels to actants. This step basically follows the practice of how actantial structure is written for English and French in the project *DiCoEnviro* (L'Homme, 2015, 2016, 2018, L'Homme et al., 2020), but with adaptations for Chinese. When presenting the actantial structure, each actant of a Chinese verb term is presented as in a *typical term*, a term typically used in Chinese to realise the actant. Actants of a Chinese term are then attached with their respective semantic role labels.

Actants (or arguments), as opposed to circumstants (or adjuncts), are absolutely essential for understanding the meaning of a predicative term. The distinction between *actant* and c*ircumstant* was originally proposed by Tesnière (1959) in his Theory of Valence 配价 (pèi jià). As elaborated by Tesnière (1959), the valence of a verb is the number of actants that the verb dominates (p. 239). Associated with the dominating verb in meaning, actants are constituents that are obligatory for the verb to express its meaning; circumstants, by contrast, are not

semantically linked with the verb and their presence are thus non-compulsory (Tesnière, 1959, p.121).

To clarify these two concepts, let us look into the intransitive Chinese verb 加剧 $_{1a}$ 'intensify'. To be able to understand the meaning of the intransitive verb 加剧 (jiā jù) 'intensify', we must know what is (or the thing that is) undergoing the process of intensifying. In other words, we must understand the meaning of 加剧 (jiā jù) 'intensify' against the structure "X加剧 (jiā jù)", X being an essential participant of 加剧 (jiā jù) 'intensify'. By contrast, the information regarding for example when and where the process of melting takes place is optional; the meaning of 加剧 (jiā jù) 'intensify' is still complete if the information of Location and Time are absent. Therefore, X, playing the semantic role of the Patient 受事 (shòu shì), is the sole actant of 加剧 (jiā jù) 'intensify' and "Patient{X} 加剧 (jiā jù)" is the actantial structure of the verb. Figure 11 depicts how the actantial structure of 加剧 (jiā jù) 'intensify' is presented in the Chinese terminological resource. 状况 (zhuàngkuàng) 'situation' and 现象 (xiànxiàng) 'phenomena' are chosen as two typical terms for "X" since these two general terms cover the meaning of the realisations of the Patient found in the corpus MCCC (现象 (xiànxiàng) 'phenomena' is a general term for realisation of Patient – 温室效应 (wēn shì xiàoyìng) 'greenhouse effect', 热岛效应 (rè dǎo xiàoyìng) 'tropical island effect' and 蒸发 (zhēng fā) 'evaporation' while 状况 (zhuàngkuàng) 'situation' is a more general term for other patients including 暖化 (nuǎnhuà) 'warming', 消融 (xiāo róng) 'melt'). When moving the curser above these two words 状况 (zhuàngkuàng) 'situation' and 现象 (xiànxiàng) 'phenomena', the semantic role that it realises 受事 (shòu shì) 'Patient' will appear in a yellow box. This way of presenting the actantial structure of a Chinese term follows the practice of that in the project DiCoEnviro (L'Homme, 2015, 2018; L'Homme et al., 2020).

Besides relying on intuitive judgement on the part of the researcher herself, the actantial structure of a Chinese predicative term is also abstracted from running contexts containing the term in the MCCC. Although intuition proves in the majority of cases to be sufficient in determining the presence and the number of actants of a Chinese verb, it is better if we can base our decision on more objective evidence. As highlighted by Zhang (2016), the method of elimination (消元法 xiāoyuán fǎ) can be applied to ascertain the obligatory participant(s) of a Chinese verb or adjective. According to this method, if the elimination of a certain constituent in a sentence leaves a grammatically erroneous sentence, then this eliminated constituent must be an obligatory participant (Zhang, 2016, pp. 92-94). To illustrate how this method works, let us look at the following sentences containing the term 消融 xiāoróng 'melt'. Sentence (30) is a real context found in the MCCC.

(30) 具有高信度的是，如果继续排放二氧化碳，

海洋	酸化	将	持续	加剧	数个	世纪，
seas and oceans	acidify	will	continue	intensify	several	century

并将严重影响海洋生态系统。

'There is a high degree of confidence that if carbon dioxide emissions continue, ocean acidification will continue to intensify for centuries and will seriously affect marine ecosystems.'

(Source: 2 气候变化 2014 综合报告(IPCC))

* signifies that a sentence is ungrammatical.

a. *将 持续 加剧 数个 世纪
will continue intensify several century
(海洋酸化 'ocean acidification' is eliminated)

b. 海洋 酸化 将 持续 加剧
seas and oceans acidify will continue intensify
(数个世纪 'several centuries' is eliminated)

c. 海洋酸化 将 加剧
seas and oceans will intensify
(持续 'continuously' is eliminated)

d. 海洋 酸化 加剧
seas and oceans acidify intensify
(将 'will' is eliminated)

As can be clearly seen in Example (30), 海洋酸化 hǎi yángsuānhuà ‘ocean acidification’ is an actant of the verb 加剧 jiā jù ‘intensify’, because the elimination of it results in a grammatically wrong sentence (30a). In other words, the meaning of 加剧 jiā jù ‘intensify’ will be incomplete if 海洋酸化 hǎi yángsuānhuà ‘ocean acidification’ is not present in the context. By contrast, the elimination of the Duration 数个世纪 shù gè shì jì ‘several centuries’ and Manner 持续 chí xù ‘continuously’ leads respectively to a grammatically correct sentence (30b) and (30c), which means that information of Duration and Manner are not essential, but only optional for the verb to express its meaning.

(See Mel’čuk (2004) for a different method for determining actant(s) of a verb.)

Figure 11. – Actantial structure of the term 加剧 jiā jù ‘intensify’ as presented in the interface of the resource

Once the number and nature of actants of a verb term has been determined, each actant is then assigned a semantic role label according to the semantic relation it holds with to the verb term.

There has been no consensus over a fixed set of semantic roles in the sphere of linguistic studies. Different researchers design their own set of semantic roles according to their specific research

purposes. As mentioned earlier, both Mandarin VerbNet (MV) and Chinese FrameNet (CFN) projects choose to assign frame-relevant roles to actants of predicates so that the labels themselves help reveal some meaning of the actant being annotated. However, here in this research labels used for semantic roles are a set of general role labels (See Table 17). The main advantage of using general semantic role labels is that it facilitates comparison of actants between terms, especially terms from different semantic frames.

	语义角色标签 (ZH)	Corresponding Semantic role labels in English (EN)
1	主事	Agent
2	原因	Cause
3	条件	Condition
4	程度	Degree
5	目的地	Destination
6	方向	Direction
7	持续时间	Duration
8	终点	Ending point
9	范围	Expanse
10	频率	Frequency
11	工具	Instrument
12	处所	Location

	语义角色标签 (ZH)	Corresponding Semantic role labels in English (EN)
13	方式	Manner
14	材料	Material
15	方法	Method
16	受事	Patient
17	目的	Purpose
18	结果	Result
19	来源	Source
20	起点	Starting point
21	载体	Support
22	时间	Time
23	数值	Value

Table 17. – Chinese labels of semantic roles

This research follows the practice of the English and French DiCoEnviro projects in using a list of general semantic roles (Table 17). In an aim of facilitating Chinese users of this terminological resource, a set of Chinese semantic role labels have been used. Chinese semantic role labels 主事 (zhǔshì) 'agent', 受事 (shòushì) 'patient', 处所 (chùsuǒ) 'location', 时间 (shíjiān) 'time', 来源 (láiyuán) 'source' and 工具 (gōngjù) 'instrument' come from the list of Chinese semantic roles of the project HowNet in Wang (2008)'s article entitled "Semantic role labelling in Chinese using HowNet". Chinese semantic role labels 结果 (jiéguǒ) 'Result', 原因 (yuányīn) 'Cause', 目的 (mùdì) 'Purpose', 方式 (fāngshì) 'Manner', 范围 (fànwéi) 'Range', 方向 (fāngxiàng) 'Direction', 材料 (cáiliào) 'Material', 条件 (tiáojiàn) 'Condition', 起点 (qǐdiǎn) 'Starting point', 终点 (zhōngdiǎn) 'Ending point' are from the list of Chinese case roles in the book 《现代汉语句型》(*Modern Chinese Sentence Pattern*) (Li, 1986).

The rest Chinese semantic role labels (including 程度 chéng dù 'degree', 目的地 mù dì dì 'destination', 持续时间 chí xù shí jiān 'duration', 方法 fāng fǎ 'method' and 数值 shù zhí 'value') are translated directly from their corresponding English semantic roles used in the English project of DiCoEnviro.

To display the actantial structure on Web, it is firstly written in XML file. Figure 12 illustrates how the actantial structure of 加剧 jiā jù 'intensify' is written in the XML file of the term 加剧1a jiā jù 'intensify'. The XML file used here is the XML sample file designed and structured for the display online of the project DiCoEnviro. Tags of the XML file were defined by terminologists of the French project of DiCoEnviro.

Figure 12. – The actantial structure of 加剧 jiā jù 1a 'intensify' encoded in the XML file

4.6 Selection of contexts

This step entails selecting contexts to be placed into each term entry. For the purpose of showing users how a term is used in authentic running texts in the specialised filed of climate change and how actants (i.e. arguments) and circumstants (i.e. adjuncts) of a term can be realised differently in real contexts, 16-20 contexts are manually selected for each term entry from the Concordance results returned by *Sketch Engine*. In Sketch Engine, the function of Concordance displays together all the contexts found in the corpus MCCC that contain the term under investigation (See Appendix 9). It is ensured that each set of 16 contexts reflect the same meaning of a term.

Specifically, contexts are selected according to specific criteria. The following three criteria are based on L'Homme (2015, p. 35). Firstly, the 16-20 contexts selected should be from different sources and different authors. As highlighted by L'Homme (2015), the fact that a term is used by different specialists in the domain and the fact that its usage can be found in various different sources prove that the status of a lexical unit as a term in the specialised field has already been fully established. Besides, this will also allow the reader to see various different usages of a term by different authors.

The second criterion is selecting contexts in which actants and circumstants are present. It should be noted that a context where all the participants (actants and circumstants) of a predicative term are present is rarely seen in running texts. In real contexts, it is more often the case where one actant and/or some circumstants are absent in the surface structure. As emphasised by Zhang (2016, p.97), even obligatory participants can be absent from surface sentence structure because of the influence brought by grammatical meaning and contextual meaning. In this step, efforts are made to trying to collect 16-20 contexts that in a whole could allow readers to know how the actant(s) of a predicative term can be realised differently in syntax and what possible types of circumstants that the term can have in real contexts. For example, the contexts selected for the term 加剧$_{1a}$ 'intensify' should allow the reader to see different possible syntactic realisations of its Patient, including 温室效应 'greenhouse effect', 暖化 'warming', 趋势 'trend', 酸化 'acidification', 污染 'pollution' etc. and various possible circumstants including 原因 'Cause', 方式 'Manner', 时间 'Time', 持续时间 'Duration', 程度 'Degree' etc. and how each of these circumstants is realised syntactically. For instance, contexts selected for 加剧$_{1a}$ 'intensify' reflect that circumstant 方式 'Manner' could be realised syntactically as 持续 'continuously', 急速 'rapidly' and 不断 'constantly'.

Following are four example contexts selected for the Chinese term 加剧$_{1a}$ 'intensify' .

(31) 具有高信度的是，如果继续排放二氧化碳，

海洋 酸化 将 持续 加剧 数个 世纪，

seas and oceans acidify will continue intensify several century

并将严重影响海洋生态系统。

'There is a high degree of confidence that if carbon dioxide emissions continue, ocean acidification will continue to intensify for centuries and will seriously affect marine ecosystems.'

(Source: 2 气候变化 2014 综合报告(IPCC))

(32) 但 人为 引致 的 温室 气体 增加 使 温室 效应 加剧，

but man-made lead to DE1 greenhouse gas increase make greenhouse effect intensify

气候系统变暖，此现象称为全球暖化。

'However, the increase in anthropogenic greenhouse gases is intensifying the greenhouse effect and warming the climate system, a phenomenon known as global warming.'

(Source: 17 氣候變化 GovHK 香港政府一站通)

(33) 极端天气、气温上升、海洋暖化、冰川融化，

种种 现象 清楚 证明 气候 变化 正 急速 加剧，

all kinds of phenomenon clear prove climate change PROG rapidly intensify

地球不断升温。

'Extreme weather, rising temperatures, warming oceans and melting glaciers – all kinds of phenomena are clear evidence that climate change is rapidly intensifying, and that the planet is heating up.'

(Source: 27 香港气候变化报告 2015)

(34) 厄尔尼诺 加上 不断 加剧 的 全球 变 暖，

El Niño plus unceasing intensify DE1 globe change warm

将使 2019 年成为整个气候观测史上最温暖的一年。

'El Niño, combined with unceasingly intensifying global warming, will make 2019 the warmest year in the entire history of climate observations.'

(Source: 170 全球气候变暖趋势急剧加速)

The third important criterion is to select contexts that reflect construction patterns and lexical combinations of a verb term. As mentioned earlier, semantic properties of a predicate are also reflected from its construction or syntactic patterns (Levin, 1993). To illustrate, for the intransitive verb 加剧$_{1a}$ 'intensify', we should select not only contexts where 加剧 'intensify' acts as sentence predicate '谓语' as in the construction X 加剧 (X signifies actant), but also contexts where it behaves as attribute as in 不断加剧的X 'the constant intensified X' and head of noun phrase X 的加剧 'the intensification of X'. In Chinese, a verb cannot only occupy the syntactic position of predicate in a sentence, but could also occupy the syntactic position of subject, object, attribute,

or head of noun phrase. Therefore, it is more preferable if contexts selected could reflect this variation.

Most importantly, as will be discussed later in this research, relying solely on actantial structure to distinguish different senses of a polysemous Chinese term turns out to be not enough in a number of cases. For these cases, patterns of lexical combinations do offer important clues for meaning distinction. Overall, contexts showing different syntactic structures and lexical combinations of a predicate are more preferable.

4.7 Annotation of contexts

In this step, realisations of participants (actants and circumstants) of a predicative term, in its contexts selected in the previous step are carefully annotated in terms of three layers, namely their respective semantic roles played in the context, their syntactic functions (i.e. grammatical functions) and their syntactic groups (i.e. phrase types).

Annotation of contexts is accomplished under the XML environment. The XML file used in this step is the XML sample file with a schema and a series of tags specifically designed for the project DiCoEnviro. All tags are in French. Figure 13 shows how a context of the term 加剧$_{1a}$ ‘intensify’ is annotated in the XML file.

Figure 13. – An annotated context of 加剧$_{1a}$ encoded in the XML file

1. 在气候变暖的情况下，极地的变化涉及强烈的正反馈过程，即冰雪融化导致地表反照率降低，意味着留在地球的热量增加， 温室效应进一步 **加剧**。 [107气候变化科学问答第二章 0 ZY 25/11/2019]
2. 极端天气、气温上升、海洋暖化、冰川融化，种种现象清楚证明 气候变化 正 急速 **加剧**，地球不断升温。 [27香港气候变化报告2015 0 ZY 25/11/2019]
3. 自工业革命以来，全球温室气体浓度持续加速升高，气候系统能量收支不平衡， 全球变暖 不断 **加剧**。 [151全球变暖停滞的研究进展回顾 0 ZY 25/11/2019]
4. 地球表面温度上升可能会引发其他的转变， 当中某些 转变可使 **暖化** **加剧**(正反馈)。 [18氣候變化的原因_GovHK 0 ZY 25/11/2019]
5. 20世纪以来， **气候变暖** **趋势** **加剧**，降水减少，冰川物质损失较多。 [391984_2016年全球参照冰川物质平衡时空变化特征 0 ZY 25/11/2019]
6. 具有高信度的是，如果继续排放二氧化碳， **海洋** **酸化**将 持续 **加剧** 数个世纪，并将严重影响海洋生态系统。 [2气候变化2014综合报告(IPCC) 0 ZY 25/11/2019]
7. 最后我们了解到由于人类活动的影响， **温室效应** 严重 **加剧**，使得地球出现了更多的严重的极端气候以及许多气象灾害。 [183探究温室效应的影响 0 ZY 25/11/2019]
8. 随着 **全球气候** **变暖**进一步 **加剧**，《巴黎协定》制定的1. 5 ℃温控目标面临的挑战愈发严峻。 [291.5 ℃温控目标下地球工程对中国气温影响的区域差异预估 0 ZY 25/11/2019]
9. 但 人为引致的温室气体 增加使 **温室效应** **加剧**，气候系统变暖，此现象称为全球暖化。 [17氣候變化GovHK香港政府一站通 0 ZY 25/11/2019]
10. 全球暖化与气候变迁议题，伴随着科技文明兴起、生态环境改变、 **极端** **气候** **加剧**，已是全世界不得不面对的现象，对人类的生存环境造成严重冲击。 [22氣候變遷與空氣品質 0 ZY 25/11/2019]
11. 因此，人类活动排放的温室气体不断累积，二氧化碳浓度不断上升， **气候** **变化** 不断 **加剧**。 [172人类消费与全球气候变暖 0 ZY 25/11/2019]
12. 由图3可以看出，自20世纪70年代末至今，长沙市地面最高气温呈波动上升趋势。除海拔、纬度等固定的因素外，人口密度、工业发展程度、森林覆盖面积等直接影响了地面温度的高低，表明 城镇化的加速 发展使得 **城市** **热岛效应** **加剧**，地面温度逐年上升。 [208长沙城市化发展背景下的气候变化特征 0 ZY 25/11/2019]
11. 在未来全球进一步变暖的背景下，江淮地区梅雨期平均气温进一步升高，降水进一步增多，且随着排放量的增加， **降水的空间分布** **不均匀性**也在 **加剧**。 [79江淮流域梅雨期气候对全球气候变暖的响应 0 ZY 25/11/2019]
13. Trenberth(2005)指出，地面气温的升高，一方面会使地表蒸发加剧，有利于大气持水能力的增强，意味着形成降水的可能性增大；另一方面， **地表** **蒸发** **加剧**易 导致局地干旱，使降水的空间分布不均匀可能性增大。 [79江淮流域梅雨期气候对全球气候变暖的响应 0 ZY 25/11/2019]
14. 新疆区域夏季高温过程的影响相对复杂。一方面，气温异常偏高是引发区域干旱重要因素，另一方面， 高山区和高空出现的高温 过程又能够引起 **河流源区冰川消融** **加剧**，地表、地下径流量增多，通过河道以及地下水的平移输送，为绿洲提供更多的可用水资源量，甚至引发特殊区域河流出现冰川消融洪水、融冰降水混合型洪水以及冰坝溃决型洪水 [3，7] . [114气候变暖背景下2015年夏季新疆极端高温过程及其影响 0 ZY 25/11/2019]
15. 地球系统模式预估， 到21世纪末在所有RCP情景下 **全球海洋** **酸化**都将 **加剧**，在RCP2.6情景下，到本世纪中叶之后将缓慢恢复。 [2气候变化2014综合报告(ipcc) 0 ZY 25/11/2019]
16. 当前福建省土地利用类型的不断改变，植被覆盖率不断减小，且 **城市** **热岛效应** 不断 **加剧**，一定程度上影响着极端温度事件的发生。 [61福建省极端温度事件对气候变暖的响应 0 ZY 25/11/2019]
17. 在气候变化与生物多样性降低的双重影响下， **生态系统受到的** **干扰** **加剧**、脆弱性增加，生态系统稳定性下降，甚至发生生态系统类型的变化，造成生态系统功能失调并发生退化，其调节功能如水体净化、空气净化、气候调节等以及支撑功能等受到不同程度的影响，引发严重的生态问题。 [98气候变化对生物多样性及相关人类惠益的影响与应对 0 ZY 25/11/2019]
18. 如未来温室气体的持续排放，全球平均地表温度上升，海冰覆盖面积及厚度可能继续缩减，海洋持续的升温将改变海水热容量与海水层化，影响海水蒸散.降雨等水循环过程，并促使热量从海洋表层渗透到深海并影响深海环流系统，导致气候进一步变暖以及 **气候系统内部反馈变化** **加剧**。 [25臺灣氣候變遷科學報告2017 0 ZY 25/11/2019]
19. 厄尔尼诺加上 不断 **加剧**的 **全球** **变暖**，将使2019年成为整个气候观测史上最温暖的一年。 [170全球气候变暖趋势急剧加速 0 ZY 29/12/2019]
20. **温室效应**的 **加剧**导致全球变暖，这会给气候、生态环境及人类健康等多方面带来影响地球表面温度升高会使更多的冰雪融化，反射回宇宙的阳光减少，极地更变暖，海平面慢慢上升，降雨量也会增加。 [198温室效应之谜 0 ZY 29/12/2019]

Figure 14. – Annotated contexts of the term 加剧$_{1a}$ ‘intensify’.

On clicking the hyperlink of 注释语境 (‘Annotated context’) on the term entry, the page with all the annotated contexts will appear. Following (Figure 14 & Table 18) is a screen shot taken from the online Chinese resource of the annotated contexts of the term 加剧$_{1a}$ ‘intensify’. As can be seen from this page, the annotation contains the following information:

- The target Chinese verb term in bold black color (**加剧**).
- Syntactic realisations of participants
  - Syntactic realisation of actants of the term displayed in bold (the underlined part illustrates head of the realisation) (e.g. 全球变暖);

- different types of participants are attached different colors* (e.g. the sole actant of 加剧 – Patient is in blue; one of the circumstants – Cause is in teal) (e.g. 全球变暖； 人为引致的温室气体增加)

* Colors are assigned in a systematic and consistent manner across annotated contexts for different terms.

❄ Moving the curser above each colored realisation of participants, the semantic role that each participant plays will appear in yellow box.

❄ Syntactic function (i.e. grammatical function) and syntactic group (i.e. phrase type) of realisation of each participant is shown in the summarizing table at the bottom of the page (e.g. 持续-状语(副词短语)).

❄ A summary of all annotation information is shown in the table at the bottom of the page (Table 18).

加剧 1a		
Actants		
受事	主语 (动词短语) (9) 主语 (名词短语) (6) 间接联系 (动词短语) (2) 间接联系 (名词短语) (2) 中心语 (动词短语) 定语 (名词短语)	温室效应 (4) 变暖 (3) 变化 (2) 热岛效应 (2) 酸化 (2) 不均匀性 冰川消融 干扰 暖化 气候 气候变化 蒸发 趋势
其他		
时间	状语 (副词短语) 状语 (时间短语)	到21世纪末 正
方式	状语 (副词短语) (6)	不断 (4) 急速 持续
原因	间接联系 (动词短语) (2) 间接联系 (名词短语) (2)	发展 增加 转变 过程
持续时间	宾语 (时间短语) 状语 (时间短语)	20世纪以来 数个世纪
程度	状语 (形容词短语)	严重
结果	间接联系 (动词短语)	导致局地干旱

Table 18. – Summary table of annotation information of the term 加剧$_{1a}$ ‘intensify’

When annotating Chinese contexts, only parts of the context that are syntactically linked with the target term under investigation are annotated. For instance, when annotating the following context containing the target term 加剧$_{1a}$ ‘intensify’, we need to determine which part of this sentence needs to be annotated. In this context, the boundary of our annotation is situated at {气候变化 正 急速加剧} because only this part is associated with the target term 加剧$_{1a}$ ‘intensify’ on the syntactic level (the boundary is shown as {}). Other parts of the sentence are not included for annotation because they are not linked with the term syntactically.

(35) 极端天气、气温上升、海洋暖化、冰川融化，种种现象清楚证明{气候变化}受事-主语-名词短语{正}时间-状语-副词短语{急速}方式-状语-副词短语**加剧**，地球不断升温。
‘Extreme weather, the rise of air temperature, the warming of oceans, the melting of glaciers, all these phenomena clearly show that climate change is rapidly intensifying and that the earth is constantly warming.’

The labels attached to a sentence constituent show the semantic role, syntactic function (i.e. grammatical function) and syntactic group (i.e. phrase type) of this constituent in relation to the target term.

With regard to syntactic functions, in the Chinese grammar, 主语 ‘Subject’, 谓语 ‘Predicate’, 宾语 ‘Object’, 定语 ‘Attribute’, 状语 ‘Adverbial’, 补语 ‘Complement’ are six main grammatical functions of Chinese words in sentences. Table 19 illustrates labels of syntactic functions used in this step to annotate participants of predicative Chinese terms. In the third column of the table, Chinese characters with two dots under are the target term. These labels are adapted from the labels adopted by the Chinese FrameNet (CFN) project (Liu & You, 2015, pp. 54-55). The main difference between the labels of syntactic function used in the CFN project and this research is that CFN uses English labels whereas this research adopts the original Chinese labels. The only notable difference lies in the label 间接联系, a label that is translated directly from the English label “Indirect Link” from the English project DiCoEnviro. This label partially corresponds to the label of 外部论元 ‘External’ in the CFN. The label of “Indirect link” is assigned to constituent(s)

that are participants of the verb term, but that do not hold a syntactic relation with it. Because this situation is also frequently observed when annotating Chinese contexts in this research, this label of 间接联系 jiànjiēliánxì 'Indirect link' is included as a syntactic function.

The label of 间接联系 jiànjiēliánxì 'Indirect link' is attached to sentence constituents under the following three circumstances:

<1> The subject of the sentence is the participant of the target term, yet it does not share direct syntactic relation with the target term. For instance, in the following context containing the target term 加快 jiākuài 'accelerate', the subject of the whole sentence, 全球变暖 quánqiúbiànnuǎn 'global warming', plays the role of circumstant 原因 yuányīn 'Cause' of the target term 加快 jiākuài 'accelerate', yet it is not directly linked with the target term on the syntactic level because it is not the subject of the target term 加快 jiākuài 'accelerate', rather it is the subject of the verb 导致 dǎozhì 'lead to'.

(36) 全球 变 暖 导致 全球 水 循环 加快…
the whole world change warm lead to the whole world water circulate quicken
'Global warming leads to the acceleration of global water circulation...'
(Source: 137 全球变暖背景下极端降水变化率与气温的响应关系)

<2> In a complex Chinese sentence (复句 fùjù), when the realisation of a participant of the target term is omitted because it appears already in the preceding sentence, this constituent is marked "Indirect link". The following context with the target term 加速 jiāsù 'accelerate' is a case in point.

(37) 而南极大陆的冰盖损失主要来自北部的南极半岛和南极洲西部，〈其消融速率 patient-indl-np〉在 1992 年至 2001 年间为每年减少 300±670 亿公吨(相当于 0.08 ±0.19mm yr^{-1} 的海平面上升)，在 2001 年至 2011 年间〈tgt **加速**〉到每年减少 1470±740 亿公吨(相当于 0.40±0.21mm yr^{-1} 的海平面上升)。

'The loss of ice cover on the Antarctic continent is mainly from the Antarctic Peninsula and West Antarctica in the north, whose ablation rate was 30 ± 67 billion metric tons per year between 1992 and 2001 (equivalent to the sea level rise of 0.08 ± 0.19 mm yr^{-1}), and accelerate to a reduction of 147 ± 74 billion metric tons per year between 2001 and 2011 (equivalent to the sea level rise of 0.40 ± 0.21 mm yr^{-1}).

句法功能标签 **Labels of Syntactic function/ Grammatical function**	**Corresponding labels in English**	**Examples found in MCCC** **MCCC 语料库实例**
主语	Subject	〈气候暖化〉增加出现极端高温的机会 〈Climate warming〉 **increases** the occurrence of extreme high temperature
间接联系	Indirect link	使〈地球〉累积更多热能 make 〈the earth〉 **accumulate** more heat energy 使〈气温〉升高 make 〈air temperature〉 **increase**
宾语	Object	减缓〈全球气候变暖〉 **mitigate** 〈global climate warming〉
定语	Attribute	〈降水量的〉增加 The **increase** of precipitation 〈格陵兰冰原的〉融化 The **melting** 〈of Greenland ice field〉
状语	Adverbial	全世界的气温都慢慢在〈不断地〉上升 Air temperature of the whole word is slowly and 〈gradually〉 **increasing** 人类活动产生的温室气体〈迅速〉增加 Greenhouse gas produced by human activities **increases** 〈rapidly〉
补语	Complement	那里的永久冰消失得〈更快〉 Permanent ice there **disappear** 〈much faster〉 全球气温上升得会〈更高、更快〉 The global temperature will **rise** 〈higher and more quickly〉
中心语	Head	海冰吸收的〈热量〉在 1%左右 〈Heat〉 **absorbed by** sea ice is around 1% 人类活动排放的〈温室气体〉不断累积 〈Greenhouse gas〉 **emitted** by human activities accumulate gradually
兼语	Pivot	帮助〈人类〉更好地适应未来气候变化 **help** 〈the human〉 to better adapt to the future climate change 帮助〈香港〉为气候变化做好准备 **help** 〈Hong Kong〉 to be well prepared for climate change
兼语补语	Complement of pivot	帮助人类更好地〈适应〉未来气候变化 **help** humans to better 〈adapt to〉 future climate change
连谓成分	Verbal construction in series	每年可〈减少〉排放 59,500 公吨二氧化碳 each year can 〈reduce〉 **emit** 59,500 tons of carbon dioxide

Table 19. – Labels of syntactic functions for annotation

<3> In the pivotal structure "V1+N+V2" of a special kind of Chinese sentence called 兼语句 jiān yǔ jù 'pivotal sentence', if V2 is the target Chinese verb term while N undertakes the role of a participant of the term, N is assigned the syntactic function of "Indirect link". Let us look at the following pivotal sentence containing the target term 改变 gǎi biàn 'change vt.'. In this pivotal structure, V1 is realised by a verb phrase 温度上升 wēn dù shàngshēng 'temperature rises' while the target term acts as V2. Here, since N realises the actant of target term 改变 gǎi biàn 'change vt.', 气象条件 qì xiàng tiáojiàn is labelled as 间接联系 jiān jiēlián xì 'Indirect link'.

(38) 此外， (温度 上升 V1)使 (气象 条件 N) (改变 V2)…
besides temperature rise make meteorological condition change
'In addition, the rise of temperature makes the meteorological conditions change…'
(Source: 22 氣候變遷與空氣品質)

Table 20 lists labels of syntactic groups (phrase types) used in this step to annotate participants of predicative terms. These labels are adapted from the labels adopted by the Chinese FrameNet (CFN) project (Liu & You, 2015, pp. 107-119).

Syntactic Group/ Phrase Type 短语类型	**English translation of labels of Syntactic Group**	**Examples in MCCC MCCC 语料库实例**
名词短语	NP (Noun Phrase)	全球气候的变化 'change of the global climate'; 全球的平均降雨量 'global average rainfall'; 我们 'we'
动词短语	VP (Verb Phrase)	气候暖化 'climate warms';
形容词短语	AP (Adjective Phrase)	最敏感 'the most sensitive'; 稳定和温暖 'stable and warm'
副词短语	DP (Adverb Phrase)	不断地 'unceasingly';
介词短语	PP (Prepositional Phrase)	在 20 世纪初期 'at the beginning of 20th century'; 由于全球气温变暖 'because of global warming'
时间短语	TP (Time Phrase)	2019 年夏天 'summer of 2019'; 本世纪末 'end of this century'
处所短语	LP (Location Phrase)	地球上 'on the earth';
数量短语	MP (Phrase of amount)	1.2±0.4 毫米 '1.2±0.4 millimetres'
单句型短语	Phrase of simple sentence	全球气候变暖带来洪水、干旱、飓风等一系列极端天气 'Global climate warming brings a series of extreme weathers including flood, drought, and hurricane'

Table 20. – Labels of syntactic groups for annotation and examples found in MCCC

4.8 Definition of semantic frames

This step consists in discovering and defining semantic frames. A semantic frame depicts a scene or situation that could be evoked by lexical units categorised into this frame. Drawing support from actantial structure and annotated contexts, lexical units evoking the same scene are manually grouped into a frame. Criteria regarding to what lexical units pertain to a semantic frame are borrowed from the project DiCoEnviro (L'Homme, 2015, 2018; L'Homme et al., 2020). Lexical units sharing the following characteristics are put into one frame:

- Depicting the same scene or situation;
- Having similar actantial structure with the same number and nature of actants;
- Sharing the majority, if not all circumstants.

Part of speech	Actantial structure	Role 1 (Actant)	Circumstant
vi.	加剧: 状况, 现象 ~	Patient	Time, Manner, Cause, Duration, Degree
vi.	减弱: 活动, 现象 ~	Patient	Time, Manner, Cause, Duration, Degree
vi.	增强: 程度 ~	Patient	Time, Manner, Cause, Duration, Degree

Table 21. – Comparison of information on participants of three verb terms

For instance, an analysis of the actantial structures and contextual annotations of lexical units 加剧 (jiā jù) 1a 'intensify', 减弱 (jiǎnruò) 1a 'attenuate' and 减缓 (jiǎnhuǎn) 'mitigate' tells us that they belong to one same frame because they share a similar actantial structure with a sole actant of Patient and a similar set of circumstants (including Time, Manner, Cause, Duration, Degree) (See Table 21) and are depicting the same scene where the degree of Patient decreases. Therefore, these three lexical units are grouped into the frame [程度变化|Change_of_degree] (illustrated in Table 22). The way of presenting a Chinese frame is adapted from the Framed DiCoEnviro (L'Homme & Robichaud, 2014; L'Homme, 2015, 2016, 2018), the Chinese FrameNet project (Liu & You, 2015) also serves as important reference.

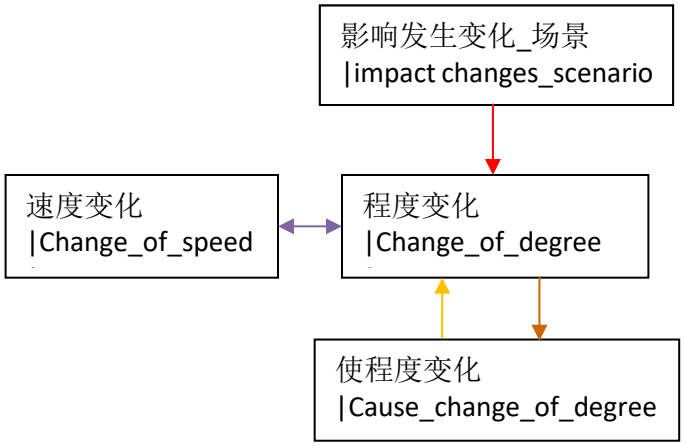
<table>
<tr><td colspan="2">程度变化| Change_of_degree</td></tr>
<tr><td colspan="2">定义（definition）：
The degree of a Patient changes
受事的程度发生变化
语境例句 （example context）：
自工业革命以来，全球温室气体浓度持续加速升高，气候系统能量收支不平衡，全球变暖不断加剧。 [Source : 151 全球变暖停滞的研究进展回顾]</td></tr>
<tr><td>核心框架元素 CoreFEs
1. 受事 [Patient]</td><td>非核心框架元素 Non-coreFEs
1. 方式 [Manner]
2. 原因 [Cause]
3. 时间 [Time]
4. 持续时间[Duration]
5. 条件[Condition]
6. 程度[Degree]</td></tr>
<tr><td colspan="2">词元 (Lexical units)
加剧 1a vi., 减弱 1a vi., 增强 1a vi.</td></tr>
<tr><td colspan="2">框架关系(Frame relations)
图例(Legend):
导致
是…的结果
子框架
参见
 
</td></tr>
</table>

Table 22. – Chinese semantic frame [程度变化| Change_of_degree]

When a semantic frame has been discovered, the frame is defined precisely with the following information specified:

- Definition of semantic frame

  The definition is written with the semantic role of the actant(s) and actant(s) are underlined.

- Frame elements (i.e. participants), including core-frame elements (i.e. actants) and non-core

frame elements (i.e. circumstants)

When listing participants of a Chinese verb term, the term core-frame element (core FEs) is used for actants while the term non-core frame element (non-core FEs) is used for circumstants.

- Lexical units categorised into the frame
- One example annotated context

For each lexical unit categorised into a frame, one context is selected to be put into the frame.

- Relationships with other frames (if applicable) (This will be explained in Section 4.9)

4.9 Establishment of relations between semantic frames

Each semantic frame defined in the previous step is a lexical reflection of background knowledge of a scene or scenario in the domain of climate change. The frame [融化|Melting], for example, depicts the situation where ice or snow melts and thus bears the knowledge that solid form of water (e.g. glacier, or ice) becomes the liquid water because of rises in temperature. Since the background knowledge of various different scenes in the domain of climate change is undoubtedly interconnected, the semantic frames defined are interconnected rather than isolated from each other. The frame [融化|Melting] and [水分的散发|Water_emanating], for example, belong to the same upper frame [相态变化|Change_of_phase]. The frame [温度变化|Change_of_temperature] is situated before the frame [相态变化|Change_of_phase] according to temporal order. Relations between these frames are illustrated in Figure 15.

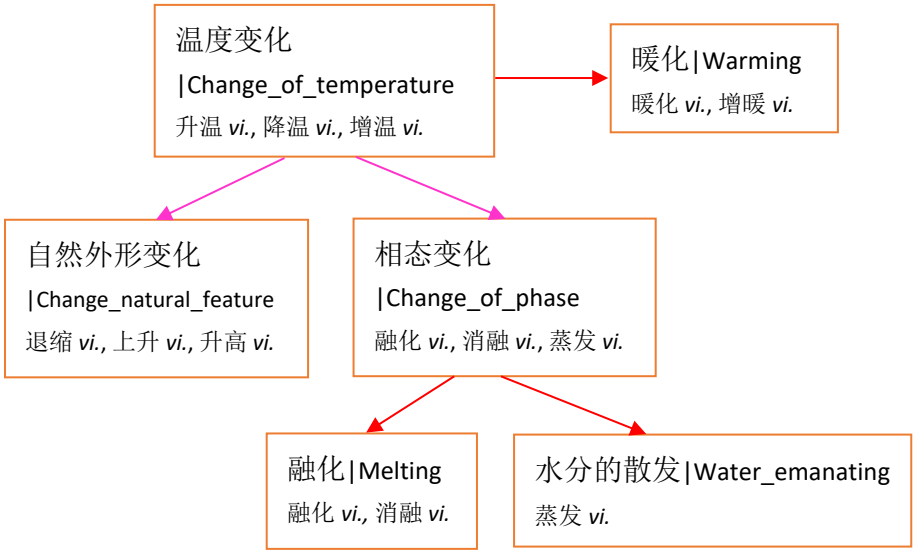


Figure 15. – Frame relations between the frames [温度变化], [相态变化] and [融化]

In this final step, semantic frames discovered and defined in the previous step are linked in the light of the relations they bear. Information on relations between a frame and other frame(s) is presented at the end of each frame. The eight types of frame relations defined by the English FrameNet (Fillmore & Baker, 2015; Ruppenhofer et al., 2016) serve as basis for the definition of relations between frames in this research.

The eight types of frame relations in the English FrameNet (Fillmore & Baker, 2015; Ruppenhofer et al., 2016) are presented below (the examples are from this research, Chinese translation of these relations in brackets):

- Inheritance: Inherits from '继承自,父框架', Is inherited by '被继承,子框架'

A lower frame *inherits from* its upper frame if the lower frame contains all the frame elements of the upper frame and if the lower frame is a type of the upper frame. (The lower frame may contain some specific elements that are not in the upper frame). For example, the frame [融化|Melting] inherits from [相态变化|Change_of_phase] and [相态变化|Change_of_phase] is inherited by [融化|Melting]. This is because all the frame elements of the frame [相态变化|Change_of_phase] are present in the frame [融化|Melting] and [融化|Melting] is a kind of [相态变化|Change_of_phase] (see Figure 15).

- Perspective: Perspective on '透视于', Is perspectivitized in '被透视于'

The upper frame *is perspectivitized in* the lower frame if the upper frame can be viewed from at least two different perspectives and the lower frame reflects one of the perspectives. To illustrate, the frame [温室效应|Greenhouse_effect] is perspectivitized in the frame [积累|Accumulating] as the scene depicted by [积累|Accumulating] (whereby greenhouse gases accumulate in the atmosphere) is one of the perspectives that [温室效应|Greenhouse_effect] can be viewed from. Another perspective to view [温室效应|Greenhouse_effect] is [反射|Reflect], which captures the scene where radiation is reflected from the ground into the atmosphere.

- Using: Uses '使用 (shǐ yòng)', Is used by '被用于 (bèi yòng yú)'

Frame A uses Frame B if Frame B depicts a part of the general background against which we can understand the situation described by Frame A.

- Subframe: Subframe of ‘总 框 架’, Has subframe(s) ‘分 框 架’

Frames B, Frame C, and Frame D are subframes of Frame A if Frame A describes a complex process consisting of a sequence of stages or steps that are represented in order by Frames B, Frame C, and Frame D.

- Chronology: Precedes ‘在…之前, 前续事件’, Is preceded by ‘在…之后, 后续事件’

Frame A *precedes* Frame B if the event described by Frame A happens before that described by Frame B according to chronological order. For example, [温度变化|Temperature_change] precedes [自然外形变化|Change_of_natural_feature] since a change in temperature happens before changes of natural features (e.g. sea level rises, ice retreats) (see Figure 15).

- Causation: Is causative of ‘导致…’, Is inchoative of ‘是…的结果’

These two relations are related to the transitivity of verbs in frames. Similar as *change* in English, the verb 改变 ‘change’ has both transitive and intransitive uses. The intransitive 改变 ‘change *vi.*’ is assigned to the frame [变化|Change_of_state] whereas the transitive 改变 ‘change *vt.*’ is placed in the frame [使变化|Cause_change_of_state]. The frame [使变化|Cause_change_of_state] is causative of [变化|Change_of_state] while [变化|Change_of_state] is inchoative of [使变化|Cause_change_of_state].

- See also ‘参见’

Different from the first seven types of relations, this relation is not draw on semantic ground. This relation aims to help the reader differentiate certain seemingly similar frames. For instance, the relation of “See also” is established between the frame [速度变化|Change_of_speed] and [程度变化|Change_of_degree] because these two frames are similar yet capture two different scenes that necessitate careful differentiation. These two frames contains two groups of lexical units – [速度变化|Change_of_speed] contains 加速 ‘accelerate’, 加快 ‘quicken; speed up’, while [程度变化|Change_of_degree] contains 加剧 ‘intensify’, 减弱 ‘attenuate’, 增强 ‘strengthen’.

Besides the eight types of relations from FrameNet, another relation used in this research is the relation “Is opposed to” defined in the Frame DiCoEnviro project (L’Homme & Robichaud, 2014; L’Homme, 2016, 2018, L’Homme et al., 2020).

- Is opposed to ‘与…对立’

Two frames are opposed to each other if there is an inverse relationship between the two scenes captured by the two frames. For example, the frame [吸收|Take_in] *is opposed to* the frame [反射|Bounce_back]. The frame [吸收|Take_in] describes the scene of heat or radiation being taken in by the Earth or atmosphere while [反射|Bounce_back] depicts the situation where the heat or radiation is being bounced back from the Earth or atmosphere.

The way of presenting frame relations is borrowed from the project Framed DiCoEnviro. As in Framed DiCoEnviro, each type of frame relation is assigned a different color.

The term entries in the Mandarin Chinese terminological resource compiled in this research can be accessed online at the following URL:
http://olst.ling.umontreal.ca/dicoenvirozh/dicoenviro-bilingue-fr.html

5 Frame-based Mandarin Chinese terminological resource

This chapter starts by presenting the compiled online Mandarin Chinese terminological resource (Section 5.1) as well as the Chinese frames discovered (Section 5.2). It then compares English terms and Chinese terms with an in-depth analysis of their similarities (Section 5.3) and differences (Section 5.4). This is followed by a comparison between Chinese frames defined and existing English frames in Framed DiCoEnviro (Section 5.5). Finally, difficulties encountered when writing Chinese term entries and how they are resolved are discussed in detail (Section 5.6).

5.1 Term entries compiled

The Mandarin Chinese terminological resource compiled in this research is a specialised resource constructed based on Frame Semantics. It focuses on the description of Chinese verb terms identified in the field of climate change and now contains a total of 39 Chinese verb terms. With each entry focuses on a specific meaning, the resource contains a total of 59 Chinese term entries. This online resource is now embedded in the online dictionary DiCoEnviro.

The list of terms in this resource is shown in Figure 16. On clicking on a term, the term entry will be displayed.

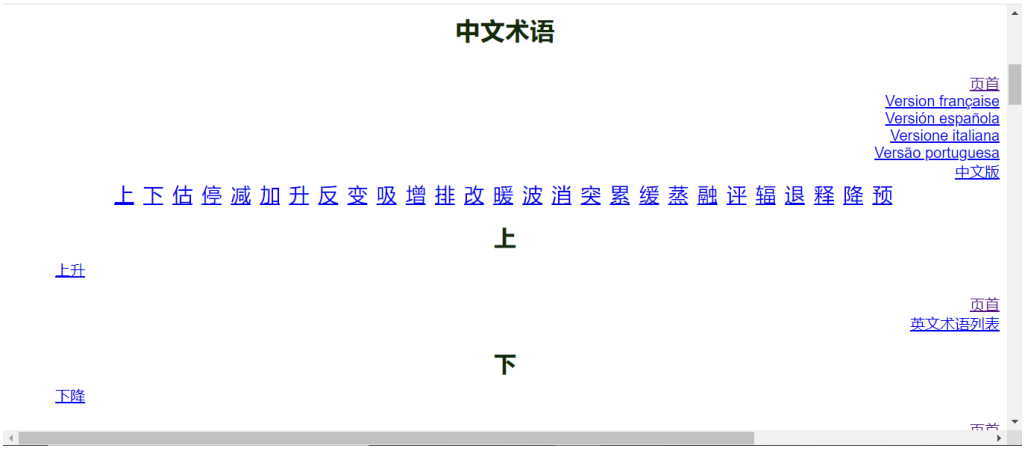


Figure 16. – List of Chinese terms

Figure 17 shows the main entry of the Chinese term xiāoróng 消融$_1$ ‘melt’. As seen in Figure 17, each term entry is structured to display firstly the headword (the term) with its sense number, then the part of speech of this term, followed by the subject field that the term belongs to, and then the actantial structure, and lastly contextual annotations. For this case, the headword xiāoróng 消融 is followed by a sense number 1. Its part of speech is dòng cí 动词 ‘verb’. When moving the curser above the typical term in the actantial structure (e.g. bīngchuān 冰川 ‘glacier’), the user will see the semantic role (e.g. shòushì 受事 ‘Patient’) that this actant fills. When moving the curser above the green button, a list of actual linguistic realisations of the actant extracted from the corpus will appear (e.g. bīngchuān 冰川 ‘glacier’, bīngxuě 冰雪 ‘ice and snow’, hǎibīng 海冰 ‘sea ice’, bīngjià 冰架 ‘ice shelf’ etc.). On clicking the link zhùshì yǔjìng 注释语境 ‘annotated contexts’, a separate page of detailed annotations of contexts found in the corpus will be displayed (Figure 18). Toward the end of this page, users can see a summarising table (Table 23) with all three-layer annotated information – syntactic realisations of actants and circumstants, their syntactic functions and syntactic groups (see Section 4.7).

Figure 17. – Entry of the term xiāoróng 消融$_1$ ‘melt’

1. 高山地区， **冰川 消融**，雪量越来越少。 [58地球危机 0 ZY 03/12/2019]
2. 只有在这个关键条件下，在地球轨道参数这样更长周期驱动因子的谐调作用下，冰川、大气、海洋和地壳的相互作用才会导致一定时期内 **冰川 消融** 或冰川湖失稳溃决，向北大西洋注入过量淡水。 [224重大气候突变会不会发生 0 ZY 03/12/2019]
3. 2015年时的一项研究认为 **拉森B 冰架**将于2020年前 完全 **消融**。 [25气候变化警钟长鸣 0 ZY 03/12/2019]
4. 除了北大西洋地区发生可能性极为微小的重大气候突变外，科学界关注的其他与气候变暖相关的突变事件还包括：北极海冰消失及其对气候的影响，**西伯利亚等区域永久 冻土 消融**引发甲烷突然大量释放，北冰洋沿岸陆地、高山和热带海洋珊瑚礁等生态系统生物灭绝，西南极冰盖失稳崩裂及其海平面快速上升，人口稠密地区重大持久的超级干旱事件等。 [224重大气候突变会不会发生 0 ZY 03/12/2019]
5. 随着全球气候变暖，欧洲正遭受高温热浪侵袭，2015年欧洲经历了500年来最热夏季， 气温升高导致 **冰川 消融**，海平面上升。 [54基于区域气候模式未来气候变化研究综述 0 ZY 03/12/2019]
6. 高温 过程致使 **高海拔山区 （雪） 冰** 迅速 **消融**，也会引发洪水等次生灾害。 [76气候变暖背景下2015年夏季新疆极端高温过程及其影响 0 ZY 03/12/2019]
7. 随着气温升高， **冰川 消融**，海平面升高，引起海岸滩涂湿地、红树林和珊瑚礁等生态群丧失，海岸侵蚀，海水入侵沿海地下淡水层，沿海土地盐渍化等，造成海岸、河口、海湾自然生态环境失衡，给海岸带生态环境带来灾难。 [113气候变暖，比你感受的严重 0 ZY 03/12/2019]
8. 全球变暖会使全球降水量重新分配、 **冰川和 冻土 消融**、海平面上升等，不仅危害自然生态系统的平衡，还威胁人类的生存。 [75气候变暖并未停滞 0 ZY 03/12/2019]
9. 但是自从 **安地斯山 冰河**因 暖化而 **消融**后，波波湖的水源跟着消失，整个湖渐渐走向干涸的命运。 [39極端氣候系列報導二波波湖蒸發了 0 ZY 03/12/2019]
10. 另一方面， **北极 海冰**大量 **消融**，迫使北极熊不得不花更多时间待在陆地上。 [94气候变化的“连锁反应” 0 ZY 03/12/2019]
11. 最近几年，关于全球冰川的研究揭示， **全球 冰川** 正在 加速 **消融**。 [150全球变暖驶入快车道 0 ZY 03/12/2019]
12. 世界各地的气候异常和变暖趋势使得气候变化已被明显感知： **北极 海冰** 持续 **消融**，全球冰川体积和北半球的春季积雪范围逐步减小，全球海平面进一步上升。 [117气候变暖对城市园林树木的影响 0 ZY 03/12/2019]
13. 积雪对于温度变化非常敏感，尤其是 在春季 **冰雪 消融**之时。 [21氣候變遷(臺灣交通部中央氣象局) 0 ZY 03/12/2019]
14. 过去几十年来 **北极夏季 海冰** 快速 **消融**，1997—2014年北极9月份海冰范围每年平均减少1.3×105km2，约是1979—1996年的4倍；海冰厚度也大幅减少，1975—2012年北极中心地区冰厚减少了65%。 [41IPCC《全球1.5℃增暖特别报告》冰冻圈变化及其影响解读 0 ZY 03/12/2019]

Figure 18. – Annotated contexts of the term 消融$_1$ (xiāoróng) ‘melt’

消融 1		
Actants		
受事	主语 (名词短语) (10) 间接联系 (名词短语) (4)	冰川 (6) 海冰 (3) 冻土 (2) 冰架 冰河 冰雪 （雪）冰
其他		
处所	状语 (处所短语)	高山地区
范围	状语 (副词短语)	完全
原因	间接联系 (动词短语) (2) 间接联系 (名词短语)	暖化 气温升高 过程
方式	状语 (副词短语) (4)	加速 快速 持续 迅速
时间	状语 (时间短语) (2)	在春季 正在
持续时间	状语 (时间短语)	过去几十年来

Table 23. – Summarising table of annotation of the term 消融$_1$ (xiāoróng) ‘melt’

5.2 Semantic frames discovered

A semantic frame is assumed to reflect the cognitive structure of a particular scenario stored in our mind. Participants involved in this situation are referred to as frame elements (Liu & You, 2015). To be able to understand the meaning of a lexical unit, we need to understand the background knowledge provided by the semantic frame that this lexical unit activates (see Section 3.1.2).

Based on the Chinese term entries compiled, a total of 23 Chinese semantic frames were discovered. These frames are encoded under the environment of the Framed DiCoEnviro project[17]. Figure 19 illustrates how the frame [程度变化|Change_of_degree] is presented online. Shown at first is the definition of the frame in both Chinese and English. This is followed by three example contexts containing the lexical units (displayed in bold) categorised into this frame. Then, there is a note indicating the corresponding relation between this Chinese frame with an existing English frame in the FD (the Framed DiCoEnviro). Specified next are the participants (i.e. frame elements) – Participants (1) indicate obligatory participants while Participants (2) are optional. In the section "Participants (2)", each participant is followed by a number between brackets, which indicates the occurrences of each participant in the contexts of all lexical units in the annotated contexts. For the frame [程度变化|Change_of_degree], the first optional participant yuányīn 原因 'Cause' is followed by a number of 20 in bracket, which means that yuányīn 原因 'Cause' appears 20 times in the contexts of all three lexical units – jiǎnruò 减弱$_{1a}$ 'attenuate', jiā jù 加剧$_{1a}$ 'intensify', zēngqiáng 增强$_{1a}$ 'strengthen'. On the right side of "participants" is "frame relations" with frames shown in black boxes and arrows indicating relations that is frame shares with other frames. At the left bottom corner, Chinese lexical units grouped into this frame are enumerated. Clicking on any of the lexical units will lead the user to the actual term entry.

[17] Chinese frames are encoded here: http://olst.ling.umontreal.ca/dicoenviro/framed/index.php (The part of Chinese frames)

Figure 19. – Chinese semantic frame [程度变化|Change_of_degree]

The names of the 23 Chinese frames, the lexical units each frame contains as well as the total number of lexical units in each frame are presented in Table 24. As can be seen in this table, different senses of a term are categorised into different frames. If a polysemous term has two different senses, these two senses are placed in two different frames. For instance, the three senses of the polysemous term jiǎnhuǎn 减缓 'mitigate; slow down' belong to three different frames – jiǎnhuǎn 减缓$_{1a}$ 'slow down' in [速度变化|Change_of_speed], jiǎnhuǎn 减缓$_{1b}$ 'slow down' in [使速度变化|Cause_change_of_speed], and jiǎnhuǎn 减缓$_{2}$ 'mitigate' in [程度变化|Change_of_degree].

No.	Name of frame	Number of LUs	LU
1	经历变化 'undergo change'	7	变化 1, 变化 1.1, 改变 1a, 改变 1a.1, 波动 1, 突变 1, 突变 1.1
2	使变化 'cause change'	1	改变 1b
3	暖化 'warming'	2	增暖 1, 暖化 1
4	温度变化 'temperature change'	5	升温 1, 增温 1, 降温 1, 增暖 1, 暖化 1
5	程度变化 'change of degree'	3	减弱 1a, 加剧 1a, 增强 1a
6	使程度变化 'cause change of degree'	5	减弱 1b, 加剧 1b, 增强 1b, 减缓 2, 缓解 1
7	速度变化 'change of speed'	3	减缓 1a, 加快 1, 加速 1a
8	使速度变化 'cause change of speed'	2	减缓 1b, 加速 1b
9	影响发生变化_场景 'impact changes_scenario'	/	non-lexical frame
10	数值数量变化 'change of value, number or amount'	8	上升 1, 下降 1, 升高 1, 降低 1a, 增加 1, 增加 2, 增多 1, 减少 1a
11	使数值数量变化 'cause change of value, number or amount'	3	增加 3, 减少 1b, 降低 1b
12	融化 'melting'	2	消融 1, 融化 1
13	水分的散发 'water emanating'	1	蒸发 1
14	相态变化 'change of phase'	3	消融 1, 融化 1, 蒸发 1
15	自然界事物特征变化 'change of natural feature'	3	上升 2, 升高 2, 退缩 1
16	排放 'emitting'	4	排放 1, 辐射 1, 释放 1, 释放 2
17	吸收 'absorbing'	1	吸收 1
18	反射 'reflecting'	1	反射 1
19	积累 'accumulating'	1	累积 1
20	预测 'predicting'	4	预估 1a, 预估 1b, 预测 1a, 预测 1b
21	预测_场景 'predicting_scenario'	/	non-lexical frame
22	估计 'estimating'	2	估计 1, 估算 1
23	评价 'assessing'	1	评估 1

Table 24. – Lexical units grouped into each Chinese frame

The 23 Chinese semantic frames described are compared with existing English frames in FD. Their corresponding relations are shown in Table 25. The Chinese frame [经历变化|Undergo_change] is considered to correspond perfectly to the English frame [Undergo_change_of_state] because they capture the same situation, share the same core-frame element – Patient that undergoes

change – as well as a similar set of non-core frame elements. The Chinese frame [程度变化|Change_of_degree] is partially equivalent to the English frame [Change_of_impact] because the situation captured by [Change_of_impact] – the speed or intensity at which a Patient occurs changes – is considered to be two situations captured by two Chinese frames – [程度变化|Change_of_degree] (the degree or intensity of a Patient changes) and [速度变化|Change_of_speed] (the speed of a Patient changes).

No.	Chinese frame	Correspondence	English frame in FD
1	经历变化 'undergo change'	Perfect	[Undergo_change_of_state]
2	使变化 'cause change'	Perfect	[Cause_change_of_state]
3	暖化 'warming'	Partial	[Change_of_temperature]
4	温度变化 'temperature change'	Perfect	[Change_of_temperature]
5	程度变化 'change of degree'	Partial	[Change_of_impact]
6	使程度变化 'cause change of degree'	Partial	[Cause_change_of_impact]
7	速度变化 'change of speed'	Partial	[Change_of_impact]
8	使速度变化 'cause change of speed'	Partial	[Cause_change_of_impact]
9	影响发生变化_场景 'impact changes_scenario'	/	the corresponding English frame is not found in FD
10	数值数量变化 'change of value, number or amount'	Partial	[Change_position_on_a_scale]
11	使数值数量变化 'cause change of value, number or amount'	Partial	[Cause_change_position_on_a_scale]
12	融化 'melting'	Partial	[Change_of_phase]
13	水分的散发 'water emanating'	Perfect	[Water_emanating]
14	相态变化 'change of phase'	Perfect	[Change_of_phase]
15	自然界事物特征变化 'change of natural feature'	Perfect	[Change_of_natural_feature]
16	排放 'emitting'	Perfect	[Emitting]
17	吸收 'absorbing'	Perfect	[Soaking_up]
18	反射 'reflecting'	Perfect	[Reflecting]
19	积累 'accumulating'	Perfect	[Accumulating]
20	预测 'predicting'	Perfect	[Predicting]
21	预测_场景 'predicting_scenario'	Perfect	[Predicting_scenario]
22	估计 'estimating'	Perfect	[Estimating]
23	评价 'assessing'	Perfect	[Assessing]

Table 25. – Chinese frame and relation with English frame

Similarities and differences between Chinese and English frames will be explained in Section 5.5.

5.3 Similarities between Chinese and English terms

In many cases, for a particular Chinese verb term, we can find a corresponding English verb term that denotes the same action, movement or process as the Chinese term. Chinese and English terms are considered to be equivalents if they designate the same concept. To illustrate, for the English intransitive term melt$_{1a}$, which denotes the process where ice, snow or glaciers become water because of temperature change, we find 融化$_1$ 'melt' (intransitive) in Chinese that denotes the same concept as melt$_{1a}$. 融化$_1$ 'melt', thus, is an equivalent of melt$_{1a}$.

Comparing the Chinese terms described in this research with their equivalent English terms, we observe that most of the Chinese terms have the same actantial structures as their respective English counterparts, with the same number and nature of actants. This validates the assumption in L'Homme and Pimentel (2012) that a term in one language and its equivalent in another language probably have the same actantial structure. For instance, the actantial structure of the Chinese term 融化$_1$ 'melt' is 融化 $_1$: 受事{冰川}~, which is the same as that of its English equivalent melt$_{1a}$: Patient{ice}~. To give another example, the transitive term 改变$_{1b}$ 'change' has two actants as shown in its actantial structure – 改变 $_{1b}$: 主事{人类}或原因{暖化}~受事{环境}. This structure is the same as that of the English equivalent change$_{1b}$: Agent{human} or Cause{warming} ~ Patient{climate}. It is also observed that a Chinese term and its equivalent English term also share some, if not all circumstants. To illustrate, the term 融化$_1$ 'melt' has circumstants including 原因 'Cause', 时间 'Time', 方式 'Manner', 结果 'Result', which are also shared by its English counterpart melt$_{1a}$.

It is important to note that although a Chinese term and its corresponding English term can share the same actantial structure, the converse situation – an English term is the equivalent of a

Chinese term if their actantial structures are the same – may not be true, because a Chinese term and its antonyms could also have the same actantial structure. To give an example, the Chinese term 降低 (jiàng dī)$_1$ 'reduce; cut down', actantial structure being 降低 $_1$: 温度 'temperature'~ and one of its antonyms rise$_1$ (rise$_1$: temperature ~) have the same actantial structure.

For some Chinese terms (e.g. 排放 (pái fàng) 'emit', 累积 (lěi jī) 'accumulate'), their actantial structures are similar to those of their respective English equivalents, yet the order of the actants can be different. Let us consider the Chinese term 排放 (pái fàng) 'emit', whose actantial structure can be written as 排放：主事{人类}或原因{活动}目的地{向大气中}~受事{温室气体}. Here in this structure, the position of 目的地 (mù dì dì) 'Destination' can be either right before the term after Agent|Cause or after Patient. Linguistic realisations of these two structures are both identified from the annotated contexts of 排放 (pái fàng) 'emit'. Nevertheless, for the actantial structure of the English equivalent emit (2), the position of actant Destination cannot be placed before the verb term right after Agent|Cause.

(39) a. 排放：主事{人类}或原因{活动}~受事{温室气体}目的地{到大气中}

context:

人类 活动 排放 大量 温室 气体 到 大气 中。

human activity emit a large amount of greenhouse gas to the atmosphere in

'Human activities emit large amounts of greenhouse gases into the atmosphere.'

(Source: 气候变化小百科(香港天文台))

En. emit$_2$: Agent {human} or Cause {activity} ~ Patient {gases} Destination {into the atmosphere}

b. 排放：主事{人类}或原因{活动}目的地{向大气中}~受事{温室气体}

context:

人类 向 大气 中 排放了 过多 的 二氧化碳。

human towards the atmosphere in emit-PERF too much DE1 carbon dioxide

*'Human towards the atmosphere emit too much carbon dioxide.'

(Source: 86 南极全球变暖导致植物快速生长)

*En. emit$_2$: Agent{human} or Cause{activity} Destination {into the atmosphere} ~ Patient

For Chinese, when the actant 目的地 ‘Destination’ is realised in two different positions, the preposition used is not the same. If occurring right after 主事|原因(Agent|Cause) before the verb term, the linguistic realisation of 目的地 ‘Destination’ acts as adverbial adjunct of the predicate and therefore, as specified in the Chinese grammar, must start with prepositions like 向 (*preposition*) ‘towards’, 往 (*preposition*) ‘toward; in the direction of; to’. In comparison, if appearing at the end right after the Patient, the realisation of 目的地 ‘Destination’ functions as 补语 ‘complement’ with the preposition 到 ‘to’.

5.4 Differences between Chinese and English terms

Difference 1: Differences in corresponding relations between form and meaning

Two lexical units, or two terms in English, represented by one single lexical form can correspond to two lexical units in Chinese represented by two different lexical forms. For example, the lexical form *emit* in English conveys three meanings in the field of climate change – emit $_1$: a source releases gas into the atmosphere; emit $_2$: a country or human activities release gases into the atmosphere; emit $_3$: a surface sends out heat or light. In Chinese, these three meanings are associated respectively with three different lexical forms. The Chinese equivalent term for emit$_1$ is 释放 ‘release’, for emit $_2$ is 排放 ‘emit’ and for emit $_3$ is 散发 ‘send out’.

En. emit$_1$: Source {soil} ~ Patient {gas} Destination {into the atmosphere}
Zh. 释放：来源{土壤}~ 受事{气体}目的地{到大气中}
En. emit$_2$: Agent {country} or Cause {activity} ~ Patient {greenhouse gas} Destination {into the atmosphere}
Zh. 排放： 主事{人类}或原因{活动}目的地{向大气中} ~ 受事{温室气体}
En. emit$_3$: Source {surface} ~ Patient {light}
Zh. 散发： 来源{表面} ~ 受事 {光}

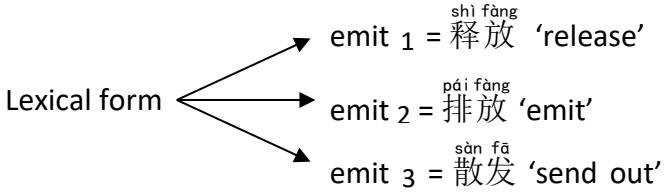


Figure 20. – Chinese equivalent term for emit 1, emit 2 and emit 3

Another example is seen in the lexical form *warm* in English. In English, the lexical form *warm* carries three meanings and thus corresponds to three lexical units – the intransitive verb *warm (1a)*, the transitive verb *warm (1b)* and the adjective *warm (2)*. For the intransitive *warm (1a)*, its Chinese equivalent is nuǎnhuà 暖化 'warming'. However, nuǎnhuà 暖化 'warming' is not an equivalent for the transitive *warm (1b)* because nuǎnhuà 暖化 'warming' can only be used intransitively. The Chinese equivalent term for the adjective warm 2 is in a different lexical form wēnnuǎn 温暖.

En. warm 1a: Patient {climate} ~
Zh. 暖化: 受事{气候} ~
En. warm 1b: Cause {change, gas} ~ Patient {climate}
En. warm 2: ~ Patient {climate}
Zh: 温暖: ~ 的受事{气候}

On the other hand, there also exist cases when two Chinese terms represented by one single lexical form in Chinese are equivalent to two different terms represented by two different lexical forms in English. To illustrate, the Chinese lexical form jiǎnhuǎn 减缓 corresponds to two different lexical units – jiǎnhuǎn 减缓1: human or activity ~ speed of something and jiǎnhuǎn 减缓2: human or activity ~ degree of something. Although *mitigate* is found to be an equivalent to jiǎnhuǎn 减缓2 'mitigate' since the meaning of *mitigate* is to make something "less unpleasant, serious, or painful" (*Cobuild English-Chinese Dictionary*, 2006), it is not an equivalent to jiǎnhuǎn 减缓1 'slow down'. The English equivalent that bears the same meaning with jiǎnhuǎn 减缓1 would be *retard* or *slow down*. In this case, two lexical units

associated with the Chinese lexical form jiǎnhuǎn 减缓 correspond to two different terms in two different lexical forms in English.

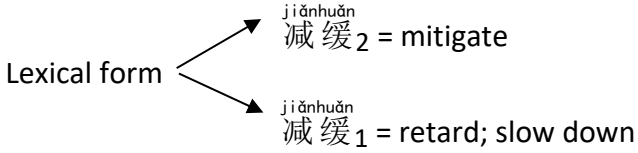


Figure 21. – English equivalent terms for jiǎnhuǎn 减缓1 and jiǎnhuǎn 减缓2

Difference 2: Differences in equivalence relations

- One-to-many equivalence relations

To begin with, for a term in English, sometimes we could find more than one term in Chinese that are equivalent to this English term. These two Chinese terms must be synonyms or near-synonyms as they both convey the same meaning as the English term. For the English verb term *melt (1a)*: ice ~, for instance, two equivalent Chinese terms can be found in the corpus MCCC – rónghuà 融化 'melt; thaw; thawing' and xiāoróng 消融 'melt', which are near-synonyms[18] in Chinese. rónghuà 融化 'melt; thaw; thawing' and xiāoróng 消融 'melt' are two equivalent Chinese terms for *melt (1a)* as they both denotes the same process as that of *melt (1a)* and thus carries the same meaning as *melt (1a)*.

It is interesting to observe that rónghuà 融化 'melt; thaw; thawing' and xiāoróng 消融 'melt' share one Chinese character róng 融 'melt; thaw', which in both terms bears the meaning of solid turning into liquids. Thus, from the outside lexical form, we know that rónghuà 融化 'melt; thaw; thawing' and xiāoróng 消融 'melt' share one semantic component of solid turning into liquids and since these two terms appear in contexts of climate change, we know that they both conveying the concept of ice and glaciers turning into water as a result of global warming. Therefore, synonyms in Chinese sometimes do

[18] rónghuà 融化 'melt; thaw; thawing' and xiāoróng 消融 'melt' are near-synonyms 'jìnyì cí 近义词' but not synonyms 'tóngyì cí 同义词'. Although xiāoróng 消融 'melt' and rónghuà 融化 'melt; thaw; thawing' both denote the concept of "melt" by sharing the same morpheme róng 融 'melt; thaw', rónghuà 融化 'melt; thaw; thawing' denotes only one concept – róng 融 'melt; thaw' whereas xiāoróng 消融 'melt' designates two concepts – xiāo 消 'disappear' and róng 融 'melt; thaw'.

contain the same character(s). Terms found in similar contexts in a particular field are highly probably synonyms if they have shared character(s) in their external lexical forms. However, in English, for the case of the concept of 融化 ‘melt; thaw; thawing’ the two synonyms of *melt (1a)* and *thaw (1a)* display no outside clues in their lexical forms of their status as synonyms.

Regarding the actantial structure, we can see from the following comparison that *melt (1a)*, 融化 ‘melt; thaw; thawing’ and 消融 ‘melt’ share the same actantial structure. This example validates the assumption in L’Homme & Pimentel (2012) that a term in one language and its equivalent term in another language probably have the same actantial structures.

En. melt $_{1a}$: Patient {ice} ~
Zh. 融化 $_{1}$: 受事 {冰川} ~
Zh. 消融 1: 受事 {冰川} ~
En. melt $_{1b}$: Cause {warming} ~ Patient {ice}

To give another example, 变化$_{1}$ ‘change’ and 改变$_{1a}$ ‘change; alter; transform’ are two Chinese equivalent terms for change $_{1a}$. 变化$_{1}$ ‘change’ and 改变$_{1a}$ ‘change; alter; transform’ are near-synonyms[19]. Similar as the first instance, 变化$_{1}$ ‘change’ and 改变$_{1a}$ ‘change; alter; transform’ share one same character 变 ‘become different; change; become; change into; alter; transform’, which denotes the concept of ‘change’ by itself and can be used as an independent verb for the process of ‘change’. Both conveying one same concept, 变化$_{1}$ ‘change’ and 改变$_{1a}$ ‘change; alter; transform’ are near-synonyms and their synonymous status can be inferred from their lexical

[19] 变化$_{1}$ ‘change’ and 改变$_{1a}$ ‘change; alter; transform’ are near-synonyms rather than synonyms. 变化$_{1}$ ‘change’ and 改变$_{1a}$ ‘change; alter; transform’ both designate the concept of “change” as they both have the morpheme 变 ‘become different; change; become; change into; alter; transform’. However, 变化$_{1}$ ‘change’ is more often used to denote changes that occur naturally whereas 改变$_{1a}$ ‘change; alter; transform’ is usually used to emphasise that there is an outside force.

form. Although 改变 ‘change; alter; transform’ and 变化$_1$ ‘change’ are synonyms in Chinese, they do have syntactical differences which lie in their transitivity. When functioning as a verb, 变化$_1$ ‘change’ can only be intransitive as in sentence 气候在变化… ‘the climate is changing ……’ whereas 改变 ‘change; alter; transform’ can be both transitive and intransitive.

En. change $_{1a}$: Patient {climate} ~
Zh. 改变 $_{1a}$: 受事 {情况} ~
Zh. 变化 $_{1}$: 受事 {气候} ~
En. change $_{1b}$: Agent {human} or Cause {warming} ~ Patient {climate}
Zh. 改变 $_{1b}$: 主事{人类}或原因{暖化} ~ 受事{环境}
En. change $_{1a.1}$: ~ in Patient {climate}
Zh. 改变 $_{1a.1}$: 受事{气候}发生的 ~
Zh. 变化 $_{1.1}$: 受事{气候}发生的 ~

Similarly, a Chinese term can have more than one English equivalent. For example, the Chinese term 降低 ‘reduce; decrease’ has two English equivalents – reduce $_{1b}$ and decrease $_{1b}$. Reduce $_{1b}$ and decrease $_{1b}$ are near synonyms with similar actantial structures.

Zh. 降低 $_{1b}$: 原因{变化} ~ 受事{温度, 排放}
En. reduce $_{1b}$: Agent {human, tree} or Cause {change} ~ Patient {emission}
En. decrease $_{1b}$: Cause {change} ~ Patient {emission}

- Gaps observed between Chinese terms and English terms.

For some Chinese terms, their corresponding equivalent terms in English are not readily available. One concrete example is the Chinese term 升温 ‘temperature rises’. The Chinese term 升温 ‘temperature rises’ consists of two characters – the free morpheme 升 means “rise; go up; ascend” while 温 is a bound morpheme in this term meaning “temperature”. The term is used to denote the fact that the temperature of something rises, or the temperature of an area rises;

however, there is no English term that could cover the meaning of both shēng 升 'rise; go up; ascend' and wēn 温 'temperature'. To express the same process in English, we need to rely on a simple sentence like "the temperature of sth. rises/increases" or "there is an increase in the temperature of sth.".

Zh. 升温: 受事{表面} ~
地球不断升温。
'The temperature of the Earth is unceasingly rising.'

Difference 3: Nominalisation in English does not exist in Chinese

For some English verb terms, their nominalisation with –tion, -sion, -ing suffix will constitute noun terms that need to be treated as separate new entries. For instance, the nominalisation of the verb melt $_{1a}$ is a noun term melting $_{1}$ of the verb term emit $_{2}$ is noun term emission $_{2.1}$ of the verb term intensify $_{1a}$ is intensification $_{1a.1}$. When acting as subject or object in a sentence, the verb *melt* will appear in its nominalised form *melting* (see Example 1).

Example 1: Contexts of melting from English *DiCoEnviro*

- The clause '*Melting along the Himalayan glaciers accelerates*' as subject:

Melting along the Himalayan glaciers accelerates, causing some Tibetan people to relocate. (RAPPORTPENTAGONE)

- 'Melting' as object:

There will likely be reduced snow accumulations available for spring melting… (3CANADAENVIRO)

In stark contrast, the derivational change of nominalisation in English does not work for Chinese. Chinese verbs assume their status as verb while keeping the same form when being in the position of sentence subject or object. To illustrate, the following five contexts show how the term pái fàng 排放 'emit' behaves in the corpus MCCC. In all five contexts, the term pái fàng 排放 'emit' acts as verb and its lexical form remains unchanged despite shouldering five different syntactic functions.

(40) a. 排放 (pái fàng) 'emit' *(vt.)* as predicate (排放作谓语)

人类 活动 排放了 大量 的 温室 气体。

human activity emit-PERF a large amount of DE1 greenhouse gas

'Human activities have emitted large amounts of greenhouse gases.'

(Source: 108 气候变化科学问答第四章)

b. 排放 (pái fàng) 'emit' *(vt.)* as subject (排放作主语)

例如， 如果 排放 与 热量 利用 有关，

for instance if emit with quantity of heat use relate to

但物理上却发生在热量用户的边界之外，或者排放与发电有关，但物理上却发生在供电行业的边界之外，那么这类排放可描述为间接排放。

(Source: 2 气候变化 2014 综合报告(IPCC))

'For example, emissions are described as indirect if they relate to the use of heat but physically arise outside the boundaries of the heat user, or to electricity production but physically arise outside of the boundaries of the power supply sector.' (IPCC Climate Change 2014 Synthesis Report)

c. 排放 (pái fàng) 'emit' *(vt.)* as object (排放作宾语)

通过 减少 排放 实现 对 大气 中 温室气体 浓度 的 调整，

through reduce emit realise *preposition* atmosphere in greenhouse gas concentration DE1 adjust

取决于从大气中清除各种气体的化学和物理过程。

(Source: 20 氣候變遷問答(臺灣中央氣象局))

'Reducing emission to adjust the concentration of greenhouse gases in the atmosphere is dependent upon the chemical and physical processes of eliminating different kinds of gases from the atmosphere.'

d. 排放 (pái fàng) 'emit' *(vt.)* as attributive (排放作定语)

此外，

人类 活动 排放 的 二氧化碳 有 大约 百份之三十被 海洋 吸收，

human activities emit DE1 carbon dioxide *SUPP* about 30 percent *preposition* sea ocean absorb

造成海洋酸化，海水中的碳酸根离子因而减少，严重影响珊瑚的钙化过程及骨骼生长。

(Source: 19 氣候變化小百科)

'In addition, around 30 present of carbon dioxide emitted by human activities has been absorbed by the ocean, causing the acidification of the ocean. This leads to a reduction of carbonate ions in the sea, which has a serious impact on the calcification process and the skeletal growth of coral reefs.'

e. 排放 (pái fàng) 'emit' *(vt.)* as head (排放作中心语)

工业燃煤、 汽车 尾气、农作 废弃物燃烧等都加剧了 温室气体的排放，

industrial fire coal vehicle tail gas agricultural waste burn etc. intensify-PERF greenhouse gas emit

使得地球不易散热，产生大气变暖的效应。

(Source: 122 气候变暖让春天提前了)

'Industrial fire coal, tail gas of vehicles, the burning of agricultural waste – all these have intensified the emission of greenhouse gases, making the Earth difficult to dissipate heat, causing the effect of the warming of the atmosphere.'

Indeed, Chinese verbs can have syntactic functions other than sentence predicate. In fact, a Chinese verb, as explained in Chinese grammar, sometimes can function not only as sentence predicate, but also as subject, attribute, object, complement or adverbial adjunct (Li & Cheng, 2008, pp. 31-32). When a verb occurs in a context, there is no syntactic marker following the verb to indicate its syntactic function in the context. The only way of knowing its syntactic function is by analysing the relations between the term and the words that it combines.

As for the case of 排放 (pái fàng) 'emit' *vt.*, a careful examination of the term with its surrounding words in the five contexts reveals that the term has five different syntactic functions in these five contexts – predicate in (40a), subject in (40b), object of the verb 减少 (jiǎnshǎo) 'reduce; decrease' in (40c), attribute of 二氧化碳 (èr yǎng huà tàn) 'carbon dioxide' in (40d) and head '中心语 (zhōng xīn yǔ)' of 温室气体 (wēn shì qì tǐ) 'greenhouse gas' in (40e). Besides, it can be clearly seen that the term keeps the same lexical form 排放 (pái fàng) in all five contexts despite shouldering different syntactic functions. In contrast with English where a verb appears in its nominalised form when acting as subject or object in a clause, the verb term 排放 (pái fàng) 'emit' remains unchanged when behaving as subject in (40b) and object in (40c).

Unlike English where in many cases a verb undergoes the process of nominalisation and becomes a noun when acting as subject or object, Chinese verbs assume their status as verb while keeping the same lexical form when shouldering different syntactic functions. Even in the most doubtful construction like …的 (de) 加剧 (jiā jù) 'the intensification of…' and …的 (de) 融化 (róng huà) 'the melting of …', 加剧 (jiā jù) 'intensify' and 融化 (róng huà) 'melt' are still behaving as verbs (see Section 5.6.1.1 for a more detailed discussion).

Difference 4: Syntactic differences

- Differences in transitivity

Generally speaking, a verb taking an object is a transitive verb while a verb that can function without an object is intransitive. In both English and Chinese, there are verb terms that are capable of acting both transitively and intransitively. For example, the verb term zēng jiā 增加 'increase' in Chinese can be used either as an intransitive verb or transitive verb, so is the verb "increase" in English, which is an equivalent of zēng jiā 增加 'increase'.

Among the 39 Chinese verb terms described in this research, eight can be used both transitively and intransitively, namely zēng jiā 增加 'increase', jiǎn shǎo 减少 'reduce; decrease; cut down', zēng qiáng 增强 'strengthen; enhance', jiā jù 加剧 'intensify', jiǎn ruò 减弱 'attenuate; weaken', jiā sù 加速 'quicken; speed up; accelerate', jiā kuài 加快 'quicken; speed up; accelerate', jiàng dī 降低 'reduce; cut down'. It can be observed that five of them are compound word with verb-complement internal structure '动补结构 dòng bǔ jié gòu'. To illustrate, the verb jiǎn ruò 减弱 'attenuate; weaken' is formed with the first character jiǎn 减 'reduce; decrease; cut', a verb meaning reduce, decrease or cut and the second character ruò 弱 'weak', an adjective indicating the result of the action of jiǎn 减 'reduce; decrease; cut' – "to reduce to become weaker". zēng qiáng 增强 'strengthen; enhance', the antonym of jiǎn ruò 减弱 'attenuate; weaken', can also act both transitively and intransitively. Similar as jiǎn ruò 减弱 'attenuate; weaken', zēng qiáng 增强 'strengthen; enhance' is also formed with the first character zēng 增 'increase; gain; add' indicating the action followed by the second character qiáng 强 'strong, powerful' implying the result of the action zēng 增 'increase; gain; add'. Interestingly, zēng qiáng 增强 'strengthen; enhance' is formed with the first character zēng 增 'increase; gain; add' (antonym of the character jiǎn 减 'reduce; decrease; cut') and qiáng 强 'strong, powerful' (antonym of the character ruò 弱 'weak').

Verb terms that are both transitive and intransitive	
1	Terms that are antonym of 1
zēng jiā 增加 ‘increase’	jiǎnshǎo 减少 ‘reduce; decrease; cut down’
zēngqiáng 增强 ‘strengthen; enhance’, jiā jù 加剧 ‘intensify’	jiǎn ruò 减弱 ‘attenuate; weaken’
jiàng dī 降低 ‘reduce; cut down’	
jiā sù 加速 ‘quicken; speed up; accelerate’	

Table 26. – Chinese verb terms that are both transitive and intransitive, and their antonymic relations

A Chinese verb term and its equivalent in English may have differences in their transitivity. One specific example is the English term *change* and its Chinese equivalent biànhuà 变化 ‘change’. When behaving as a verb, both *change* and biànhuà 变化 ‘change’ can be intransitive. Nevertheless, biànhuà 变化 ‘change’ can never take an object whereas *change* can be used transitively. The closest Chinese equivalent of change in terms of transitivity is gǎi biàn 改变 ‘change’. Similar as change, gǎi biàn 改变 ‘change’ is capable of being an intransitive verb gǎi biàn 改变‘change’ $_{1a}$ (equivalent to change $_{1a}$), transitive verb gǎi biàn 改变 $_{1b}$ ‘change’ (equivalent to change$_{1b}$) and a noun gǎi biàn 改变 ‘change’$_{1a.1}$ (equivalent to change$_{1a.1}$).

Another example is the English verb *warm* and its Chinese equivalent nuǎnhuà 暖化 ‘to become warm’. Similar as warm, which is originally an adjective, nuǎnhuà 暖化 ‘to become warm’ is also a verb derived from an adjective nuǎn 暖, meaning “warm”. nuǎnhuà 暖化 ‘to become warm’ is formed with the adjective nuǎn 暖 ‘warm’ plus suffix huà 化. Here, huà 化is a suffix to convert an adjective into a verb. Though warm is capable of acting both transitively and intransitively, nuǎnhuà 暖化 ‘to become warm’ can only be intransitive.

- Differences in inflectional change

When entering into sentences, verb terms in English display inflectional changes in that they are subjected to number '数', tense '时' and aspect '体' (Qin & Wang, 2010, p. 31). However, Chinese verbs are not subjected to these changes. Their lexical form remains invariable regardless of differences in number, tense or aspect.

b. tense (时-现在时、过去时)

In English, times can be expressed in the verbal form. In contrast with the grammatical means used by English, Chinese applies lexical or syntactical means to indicate tense and the verb form remains unchanged. Regarding means of lexis, words implying tense include for example 现在 (xiànzài) 'now' for present, 曾经 (céngjīng) (*adverb*) 'once' or 曾 (céng) (*adverb*) 'once' for past, 将 (jiāng) (*adverb*) 'will' or 将要 (jiāngyào) (*adverb*) 'will' for the future. The following contexts show how tense is expressed by means of lexis in the corpus MCCC. The present tense in (41) is indicated by 现在 (xiànzài) 'now' while the past tense in (42) is expressed via 曾 (céng) (*adverb*) 'once'. In (43), the term 上升 (shàngshēng) 'rise' is not inflected to express the future tense. This information about tense and aspect is expressed through the time adverb 将于 (jiāng yú) (*adverb*) 'will'.

(41) 地球 现在 处于 一种 冷 的 冰室 气候 状态，
Earth now be in a kind of cold DE1 icehouse climate state
以大陆高纬度地区覆盖冰盖为特征，人类就是在这样的冰室气候状态下演化的，而人类文明是从最近一次的间冰期开始出现。
'The Earth is now in a cold icehouse climate state, characterised by ice caps covering the high latitudes of the continents. Humans have evolved under the icehouse climate state like this, and human civilisation has emerged since the most recent interglacial period.'
(Source: 177 深时古气候与未来地球)

(42) 地球 气温 曾 在 5500 万 年 前 极速 **攀升**，…。
Earth air temperature PERF at 55 million years before rapidly climb
'The Earth's temperature climbed extremely rapidly 55 million years ago, ...'
(Source: 184 探寻全球变暖之策)

(43) …，天文台预计香港年平均气温将于本世纪末上升 3℃至 6℃（相对于 1986 - 2005 年）。
'The Observatory expects the annual average temperature of Hong Kong to rise by 3°C to 6°C by the end of the century (relative to 1986 - 2005).' (Source: 28 香港氣候行動藍圖 2030+)

c. aspect (体-进行体、完成体)

In terms of aspect '体', English verbs can express progressive aspect '进行体' and perfective aspect '完成体'. While progressive aspect in English is expressed with the form of "be+V-ing", perfective aspect is realized via "have/has + V-ed". However, as explained by Li & Cheng (2008), progressive state in Chinese is expressed via adverbs including 正, 在, 正在 (p. 405), and/or the aspectual particle 着(p. 423); perfective aspect is indicated with two aspectual particles 了 (p. 423) and 过 (p. 440). To illustrate, in (44), the verb term 消融 'melt' is not inflected to show that the present continuous aspect of the process of 消融 'melt'. The progressive aspect is conveyed by adverb phrase 正在 (*adverb*) while the present tense is implied and elaborated by the whole context. Progressive aspect in (44), (45) and (46) is expressed respectively with adverb 正 (*adverb*) and 正…着 (*adverb*). In (47), 已经 'already' and 了 (*aspectual particle*) show that the action of 上升 'rise' has already accomplished; the term 上升 'rise' is not inflected to indicate the perfective aspect. Perfective aspect is conveyed respectively with adverb 了 (*aspectual particle*) and 过 (*aspectual particle*) in (48) and (49).

(44) 最近几年，关于全球冰川的研究揭示，
全球 冰川 正在 加速 消融。
global glaciers PROG accelerate melt
'In recent years, research on global glaciers has revealed that global glaciers are melting at an accelerating rate.' (Source: 150 全球变暖驶入快车道)

(45) 最近关于海洋资料的分析，让这朵"阴云"逐渐散去，揭示出了一个惊人的事实：
全球 海洋 正 加速 增暖……
global ocean PROG accelerate warm
'Recent analysis of ocean data has lifted this 'cloud' and revealed a startling fact: the global ocean is warming at an accelerating rate .....' (Source: 158 全球海洋变暖加速)

(46) 而额外 加入的二氧化碳 正 悄悄 改变着 海洋 的 化学 成分。
extra add carbon dioxide PROG quietly change-PROG ocean DE1 chemical composition
'And the addition of carbon dioxide is quietly changing the chemical composition of the oceans.'
(Source: 112 气候变化知多少)

(47) 自 工业 革命以来，全球 气温 已经 上升了 1℃。
since industrial revolution global air temperature already rise-PERF 1℃。
'Since the Industrial Revolution, global temperatures have risen by 1°C.'
(Source: 125 气候变暖与我们的生活)

(48) 在过去的 100 多年（1880～2012）中，
全球 平均 温度 上升了 0.85±0.2℃。
global average temperature rise-PERF 0.85±0.2℃。
'Over the last 100 years or so (1880-2012), the average global temperature has risen by 0.85 ± 0.2°C.'
(Source: 116 气候变暖打乱二十四节气)

(49) 自 1961 年以来，如此 强度的 龙卷风 在 中国 只 发生 过 5 次。
since 1961 such intensity tornado in China only happen PERF 5 times
'Tornadoes of this intensity have occurred in China only five times since 1961.'
(Source: 78 极端天气——全球变暖与频频发生的热浪、干旱、洪水)

5.5 Comparison between Chinese and English frames

5.5.1 Similarities between Chinese and English frames

Semantic frames capture scenarios or situations in human experiences. The frame [buy], for example, describes the scenario where a buyer obtains a goods by paying money to the seller. Because situations in life experiences are very similar in different languages, an assumption can be made that semantic frames are independent of language. In other words, for a given English frame, we will find a corresponding Chinese frame.

To test this assumption, we compared the Chinese frames discovered in the domain of climate change in this research with existing English frames, identified for the same domain, in the Framed DiCoEnviro. For an English frame, we will find a Chinese frame that is similar, if not exactly the same with the English frame. Therefore, the assumption made earlier – frames are independent of languages – is indeed validated for the English-Chinese language pair. To illustrate, for the English frame [Change_natural_feature], we defined the Chinese frame [自然界事物外

形变化|Change_natural_feature], which identical to the English frame: i.e. it captures the scenario in nature when a Patient (e.g. glaciers) changes shape (e.g. glaciers melt and their shape changes). The frame elements of the two frames are also similar. The English frame has one core-frame element – Patient, so does the Chinese frame. The English frame and Chinese frame share 8 common non-core elements, namely Duration (持续时间), Value (数值), Manner (方式), Time (时间), Cause (原因), Condition (条件), Expanse (范围), Degree (程度).

5.5.2 Differences between Chinese and English frames

Nevertheless, the English frames and Chinese frames are not without differences. The first difference is that some English frames correspond to two Chinese frames. For instance, the English frame [Cause_change_of_impact] is split into two frames in Chinese – [使程度变化|Cause_change_of_degree] and [使速度变化|Cause_change_of_speed] because in the corpus two separate groups of Chinese lexical units are identified for these two frames. The frame [使程度变化|Cause_change_of_degree] records lexical units 减弱$_{1b}$ 'attenuate', 减缓$_{2}$ 'mitigate', 加剧$_{1b}$ 'intensify', 增强$_{1b}$ 'strengthen' and 缓解$_{1}$ 'alleviate' while the frame [使速度变化|Cause_change_of_speed] contains lexical units 减缓$_{1}$ 'slow down' and 加速$_{1b}$ 'accelerate'. We can clearly see that the two senses of the lexical item 减缓 'slow down; mitigate' are recorded in these two distinct frames. This meets our methodology requirement that each different sense of a lexical item should be placed into separate distinct frames.

The second difference is that not every English frame has a corresponding Chinese frame. For instance, while the Chinese frame [温度变化|Temperature_change] has been discovered to be corresponding to the English frame [Change_of_temperature], a Chinese frame corresponding to the English frame [Cause_temperature_change] has not been discovered. This is because the lexical items *cool* and *warm* can be both inchoative and causative verbs. Therefore, we can say "the Earth will warm" where warm is acting intransitively; and also "Energy from the sun warms

the Earth's surface" where warm is a transitive verb. Thus, the inchoative warm (1a) and cool (1a) are recorded in the English frame [Change_of_temperature] while the causative warm (1b) and cool (1b) are placed in the frame [Cause_temperature_change].

In contrast, the Chinese lexical units in the frame [温度变化|Temperature_change], including 升温 shēngwēn 'rise of temperature', 增温 zēngwēn 'increase of temperature' and 降温 jiàngwēn 'fall of temperature', are inchoative and cannot be used as causative verbs. On the syntactic level, we know that 升温 shēngwēn 'rise of temperature', 增温 zēngwēn 'increase of temperature' and 降温 jiàngwēn 'fall of temperature' can only act as intransitive verbs, but not transitive verbs. For example, we cannot say 温室气体 升温地表 wēn shì qì tǐ shēngwēn dì biǎo 'greenhouse gases warm the Earth's surface', but only 温室气体使地表 升温 wēn shì qì tǐ shǐ dì biǎoshēngwēn 'greenhouse gases cause the temperature of the Earth's surface to rise'. Here in 温室气体使地表 升温 wēn shì qì tǐ shǐ dì biǎoshēngwēn 'greenhouse gases cause the temperature of the earth's surface to rise', we are expressing the meaning of the causative warm (1b) (something warms something else) by applying the pivotal sentence structure using the first verb 使 shǐ 'make; cause'. Since causative verbs similar to warm (1b) do not exist in Chinese, the Chinese frame [使温度变化|Cause_change_of_temperature] does not exist.

5.5.3 Other observations

As highlighted by Liu & You (2015), content of semantic frames reveals knowledge including syntagmatic relations of meaning, paradigmatic relations of meaning and knowledge of event inference and reasoning. Chinese frames established in this research also unveil these three kinds of knowledge.

- Syntagmatic relations

Participants (1) (i.e. core frame elements) and participants (2) (i.e. non-core frame elements) displayed in each Chinese frame show syntagmatic relations between different constituents of

sentences. To give a specific example, the frame of [排放|Emitting] describes the situation where 主事或源头放出受事到目的地中 ‘an Agent or a Source discharges a Patient into a Destination’. One example context recorded in this frame is 人类向大气中排放了过多二氧化碳 ‘Humans emit too much carbon dioxide into the atmosphere’. From this frame, we know how participants(1) – 主事 ‘Agent’| 源头 ‘Source’, 受事 ‘Patient’, and 目的地 ‘Destination’ – usually co-occur in contexts and what sequential order they possibly follow. For instance, Agent(e.g. 人类 ‘human’ usually precedes the verb term 排放 ‘emit’ whereas Patient (e.g.二氧化碳 ‘carbon dioxide’) follows the term 排放 ‘emit’.

- Paradigmatic relations

When defining frames, we group Chinese lexical units with identical actantial structures into one frame. Lexical units categorised in one frame describe the same situation and activate the same cognitive processes. The component of “lexical units” specified in each frame reflects paradigmatic relation of meanings (Liu & You, 2015, p.13). As observed in the Chinese frames, lexical units in one frame can be synonyms or antonyms. To illustrate, the frame [速度变化|Change_of_speed] depicts the scenario where the speed of a Patient (e.g. global warming) changes. Lexical units categorised into this frame are 加速$_{1a}$ ‘accelerate’, 减缓$_{1a}$ ‘slow down’, and 加快$_{1}$ ‘quicken; speed up; accelerate’. Regarding lexical relation, 加速$_{1a}$ ‘accelerate’ is synonymous with 加快$_{1}$ ‘quicken; speed up; accelerate’ while 减缓$_{1a}$ ‘slow down’ is antonymous with 加速$_{1a}$ ‘accelerate’ and 加快$_{1}$ ‘quicken; speed up; accelerate’. Indeed, sharing the same meaning, synonymous lexical units can be in one frame if they describe the same situation. Antonymous lexical units could also be put in one frame could have very similar actantial structure and be used to describe one same scenario.

Nevertheless, it does not mean lexical units in every frame are synonyms or antonyms. To elaborate, [相态变化|Change_of_phrase] contains lexical units including 融化 (róng huà) 'melt', 消融 (xiāo róng) 'melt', 蒸发 (zhēng fā) 'evaporate', in this case, 蒸发 (zhēng fā) 'evaporate' shares no synonym or antonym relation with the other two lexical units.

5.6 Difficult points

5.6.1 Difficulties in sense distinction

As in any other languages, polysemy is a linguistic phenomenon prevalent in Chinese. An accurate determination of different senses of a polysemous lexical unit is a crucial prerequisite for the description of the term. Sense, as defined by Cruse (1986, p. 49), is "the meaning aspect of a lexical unit". For this research looking into Chinese terms, difficulties arise when distinguishing different senses of polysemous Chinese lexical units.

5.6.1.1 Distinguish parts of speech of Chinese lexical items

Part of speech constitutes obvious evidence for different senses of a term. If a term behaves as in different parts of speech in real contexts, each part of speech of the term must be a separate sense. In English, language that is largely inflectional and derivational, we can sometimes tell the part of speech of a term by examining its lexical form. To begin with, if a term ends with suffix such as –ify (e.g. intensify), -ate (e.g. accelerate), the term must be a verb. Attaching derivational affix to a simple word can turn this word into a new word belonging to a different part of speech. Adding the suffix –tion to two verbs intensify and accelerate, for example, we will have two nouns intensification and acceleration. Though this kind of derivation is not observable for all English words and some words do keep the same form when realised as different parts of speech (e.g. *change*, *increase*), the inflectional characteristic of English could still help us distinguish the parts of speech of these words. For instance, when *change* and *increase* appear in contexts with their inflected form *(have/has) changed*, *(is/are) changing*, *(have/has) increased*, *(is/are) increasing*, we are certain that they act as verbs.

In stark contrast with English and French, Chinese is a language largely non-inflectional and non-derivational. In Chinese, sentences are formed not relying on morphological changes of words, but on word order '词序 cí xù' and empty words '虚词 xū cí' (Fang, 1992, p. 6). As explained earlier, the lexical form of a word always remains unchanged even if the word shoulders different syntactic functions or belong to different part of speech. The form of a Chinese verb always stays the same in all circumstances and is never affected by number, person, gender, tense or aspect.

The fact that Chinese is a language largely non-inflectional and non-derivational causes real difficulties when distinguishing part of speech of Chinese terms.

Difficulty 1 : How to distinguish part of speech of multi-category words '兼類詞 jiān lèi cí' in different contexts?

In Chinese, the linguistic phenomenon of a word belonging to two or more parts of speech is defined as 兼类 jiānlèi 'belonging to different part of speech at the same time'; though a multi-category word shoulders different parts of speech in different contexts and possesses properties of two (or more) word classes, its meaning shows no notable difference (Fang, 1992, p. 86). Following are examples of multi-category words found in real contexts in MCCC.

(50) a. 生态系统 会 迅速 **改变**
ecosystem will rapidly change
'ecosystem will **change** rapidly'
b. 不可逆转 的 **改变**
irreversible DE1 change
'irreversible **change**'

(51) a. **干旱** 地区/ 环境
arid area environment
'**arid** region/environment'
b. 最 严重 的 **干旱**
most severe DE1 drought
'the most severe **drought**'

(52) a. 升 温 可 **加速** 水分 循环
rise temperature can accelerate water circulation
'temperature rise can accelerate circulation of water'

b. 全球 冰川 **加速** 退缩
globe glaciers speed up retreat
'glaciers all over the globe is retreating **acceleratedly**'

(53) a. 大气 的 温室 气体 浓度 持续 上升
atmosphere DE1 greenhouse gases concentration continuously rise
'concentration of greenhouse gas in the atmosphere **rises** continuously'

b. 气候 变化 所 带来 的 大多数 影响 也 会 持续 数世纪 之久
climate change support-bring DE1 majority influence also will last centuries long
'Most influences brought by climate change will last for centuries.'

The four terms 改变 gǎibiàn 'change', 干旱 gānhàn 'drought/arid', 加速 jiāsù 'accelerate' and 持续 chíxù 'continue' are all multi-category words that behave differently in different contexts. In the first example, 改变 gǎibiàn 'change' functions as an intransitive verb (50a) and a noun (50b). The term 干旱 gānhàn 'drought/arid', as shown in the second example, can be an adjective, 'arid' (51a) or, a noun, 'drought' (51b). 加 jiā 速 sù 'accelerate' can be an intransitive verb (52a), or a transitive verb (52b), or an adverb modifying the verb 退缩 tuìsuō 'retreat'. The term 持续 chíxù can be both an adverb, 'continuously' (53a) , or a verb, 'continue/last' (53b). In each of the examples, one lexical form belongs to two parts of speech; however, the two meanings represented by one lexical form are related. 改变 gǎibiàn 'change' in (50a) acts as a verb, meaning 'things undergo new changes in their form or nature' while 改变 gǎibiàn 'change' in (50b) is a noun, denoting 'the new state of things happened to their form or nature'.

How to distinguish part of speech of multi-category words in real contexts? An essential prerequisite for an accurate identification is a thorough understanding of the properties of words belonging to each part of speech. In Chinese, adjectives and verbs are considered as 谓词 wèicí 'predicate word' since they can act as predicates of sentences and can be modified by adverbial

phrases (Fang, 1992, p. 68). Adverbs in Chinese are easy to identify since the main function of adverbs is to modify verbs. Grammatical features of nouns, generally speaking, is that nouns can be modified by phrases signifying number or amount and that nouns cannot be modified by adverbs. “The real difference between nouns and “predicate word” is that a “predicate word” can be predicates, can be modified by adverbs and can be followed by aspectual particles 了 le, 着 zhe etc; but nouns cannot (my translation)” (Zhu, 1961, p. 56). Looking for contextual evidence that reflect the above-mentioned grammatical features of different classes of words, we can distinguish parts of speech of multi-category words without much difficulty. For example, we find two occurrences of 变化 biànhuà ‘change’ in (54) – the first 变化 biànhuà ‘change’ is modified by an adjective 明显 míngxiǎn ‘noticeable’ while the second 变化 biànhuà ‘change’ is modified by pronoun 这些 zhèxiē ‘these’; 变化 biànhuà ‘change’ are not predicates of the two sentences. This evidence shows that these two 变化 biànhuà ‘change’ are nouns. In comparison, 变化 biànhuà ‘change’ in context (55) is the predicate of the whole sentence and is modified by two adverbs expressing time – 在 zài ‘in process of’ and 一直 yìzhí ‘always’; therefore, 变化 biànhuà ‘change’ here functions as a verb.

(54) 20 世纪 50 年代以来，整个地球系统发生了明显的变化，这些变化在几十年乃至上千年时间内都未曾出现。

‘Since the 1950s, notable changes have been happening to the whole Earth system and these changes have never appeared during the past tens or thousands of years.’

(55) 气候在整个地球历史中和所有时间尺度上一直在变化。

‘Climate is constantly changing in the whole history of the Earth and in all scales of time.’

Difficulty 2: Does 增加 zēngjiā ‘increase’ behave as a noun when preceded by a 的 de in context? Is 增加 zēngjiā ‘increase’ a multi-category word? If so, does it mean we need to create a separate entry for this usage?

As discussed in the above example, it is indisputable that the term 变化 biànhuà ‘change’ can be both a noun and an intransitive verb depending on the context. However, it is very hard to determine the part of speech of terms 增加 zēngjiā ‘increase’, 融化 rónghuà ‘melt’ and 上升 shàngshēng ‘rise’ in the following contexts extracted from MCCC. To the eyes of native Chinese speakers, it is quite obvious that 增加 zēngjiā ‘increase’, 融化 rónghuà ‘melt’ and 上升 shàngshēng ‘rise’ are all verbs describing activities in Chinese. Nevertheless, whether these terms still function as verbs in the following contexts does raise doubt. This doubt is caused by the fact that in these contexts, each of these terms is preceded by a structural particle 的 de ‘DE1’ (的 de is a postposition that links a noun to its complement) and that the three 的 de ‘of’ phrases 温室气体浓度的增加 wēn shì qì tǐ nóng dù de zēngjiā ‘The increase of concentration of greenhouse gas’ (56), 西南极洲的阿蒙森海冰川的融化 xī nán jí zhōu de ā méng sēn hǎi bīngchuān de rónghuà ‘the melt of glacier’ (57) and 气温的上升 qì wēn de shàngshēng ‘the rise of air temperature’ (58) stand syntactically at the position of subject in the three contexts respectively. Moreover, these phrases seem to describe the process or phenomenon of increasing, melting and rising rather than the action or activity of increasing, melting and rising. The three lexical units seem to have gained properties of nouns in these contexts.

(56) 温室气体浓度的增加使地球气候变暖
‘The increase of concentration of greenhouse gas causes the warming of the Earth’s climate.’

(57) 西南极洲的阿蒙森海冰川的融化已经不可逆转
‘The melt of … glacier of western Antarctica has become irreversible.’

(58) 因此气温的上升将使水气增加
‘Therefore, the rise of air temperature will cause an increase of steam.’

This doubt remains when we look at the English translation of the three contexts – the three terms turn into nouns in the English translation. Should we consider these terms as multi-category words similar to 变化 biànhuà ‘change’ or should we treat them only as verbs?

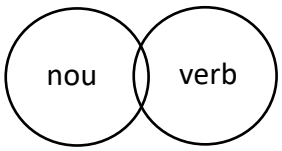
In fact, this linguistic phenomenon has long been a focus of discussion in Chinese linguistics since 1960s. The discussion revolves around the phrase zhè běn shū de chū bǎn 这本书的出版 'the publishing of this book', the point at issue being how to parse this kind of structure and whether chū bǎn 出版 'publish' acts as a noun or a verb.

(59) 这本书 的 出版 是 有 重要 意义的。
this book DE publish is SUPP great significance
'The publishing of this book is of great significance.'

(60) 这本书 的 迟迟 不 出版 是 有 原因 的。
this book DE tardy NEG publishing is SUPP cause DE
'The tardy un-publishing of this book has a cause'

When analysing (59), Zhu (1961, p. 57) argues that the phrase zhè běn shū de chū bǎn 这本书的出版 'the publishing of this book' in the sentence is a noun phrase with zhè běn shū 这本书 'this book' being the attribute of chū bǎn 出版 'publish' and that chū bǎn 出版 'publish' still acts as a verb in this noun phrase. He expounds that zhè běn shū de chū bǎn 这本书的出版 'the publishing of this book' is a noun phrase not because this phrase is at the position of the subject of the sentence but because this structure itself is nominal and cannot function as predicate nor can it be modified by an adverb (1961, p. 57). He explains why chū bǎn 出版 'publish' keeps its properties as a verb with sentence (60). Indeed, the two adverbs chí chí 迟迟 'slow' and bù 不 'NEG' modifying chū bǎn 出版 'publish' can only be regarded as adverbial adjunct. As specified in Chinese grammar, the sole function of adverbs is to be adverbial adjunct and that adverbs can only modify verbs, adjectives or the whole predicate part of the sentence. Therefore, chū bǎn 出版 'publish' still owns properties of a verb. Zhu's arguments receive support from other Chinese linguists and scholars including Guo (2018) and Yu, Duan & Zhu (2005).

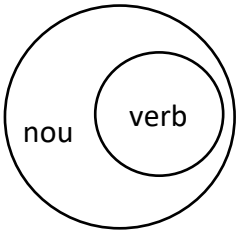
Shen (2012) points out that nouns and verbs in English are in a discrete relation (Figure 22) whereas nouns and verbs in Chinese share an inclusion relation (Figure 23).



英语 “名动分立”

‘Discrete relation between nouns and verbs in English’

Figure 22. – Discrete relation between nouns and verbs in English (Shen, 2012, p. 11)



汉语 “名动包含”

‘Inclusion relation between nouns and verbs in Chinese’

Figure 23. – Inclusion relation between nouns and verbs in Chinese (Shen, 2012, p. 11)

When comparing with English, Shen (2012) emphasizes that all Chinese verbs are in fact “verb-nouns”, owning properties of both nouns and verbs, and correspond to the “V-ing” form in English. As illustrated in Figure 23, all Chinese verbs also possess properties of nouns; however, not all nouns can function as verbs. In Chinese, a single character represents one syllable. A monosyllabic word is a one-character word and a dissyllabic word is composed of two Chinese characters. For instance, biànhuà 变化 ‘change’ is a dissyllabic word while shuǐ 水 ‘water’ is a monosyllabic word. Shen (2012) argues that differentiating whether a Chinese word is monosyllabic or dissyllabic is in fact more important than differentiating whether it is a noun or a verb. Compared with dissyllabic verbs, monosyllabic Chinese verbs demonstrate stronger verbal properties; dissyllabic Chinese verbs demonstrate stronger noun properties and weaker verb properties. One particular example is that the monosyllabic word biàn 变 ‘change’ behaves always as a verb in all possible contexts; however, the dissyllabic word biànhuà 变化 ‘change’ owns noun properties and therefore can behave either as a noun or a verb depending on the context.

The Grammatical Knowledge Base of Contemporary Chinese, developed by researchers at the Institute of Computational Linguistics (Peking University), is a dictionary of grammatical information of around 80 thousand Chinese words. These Chinese words are categorised according to their parts of speech. The database contains detailed grammatical properties of each word. An annotated 60-million-word corpus of contemporary Chinese has also been built based on this dictionary. In this dictionary, Chinese verbs including 出版 (chū bǎn) 'publish' and 增加 (zēng jiā) 'increase' are classified as a sub-category of verbs – verbs with noun properties. Since a significant proportion of Chinese verbs do possess noun properties, Yu et al. (2005, p. 75) argue that considering these words as multi-category words will not reduce difficulties for computer processing. Quantitative research was conducted in aim of finding out whether these Chinese verbs with noun properties behave more as a noun or as a verb in real corpus. As calculated in this research, the frequency of 出版 (chū bǎn) 'publish' used as a verb and a noun is 2344 while the frequency of 出版 (chū bǎn) 'publish' used as a noun is 886, their probability being P(v) = 0.73 and P(vn) = 0.27 respectively. Since P(v) > P(vn), 出版 (chū bǎn) 'publish' has just begun to shift to a noun.

Another valuable reference when deciding on the part of speech of these verbs with noun properties is the 现代汉语词典 (xiàndài hàn yǔ cí diǎn) (*Modern Chinese dictionary*). This dictionary is the most authoritative dictionary of the Chinese language in mainland China. The dictionary is written by lexicographers in the language research institute of Chinese Academy of Social Sciences. The dictionary contains 13,000 Chinese characters and 69,000 entries for words. Part of speech of each word is clearly marked. When consulting this dictionary, we can find that 变化 (biànhuà) 'change' is marked as a noun and a verb whereas 增加 (zēng jiā) 'increase', 上升 (shàngshēng) 'rise', 融化 (rónghuà) 'melt' are only marked as verb.

Based on the discussion above, this research decides to consider Chinese verbs preceded by a 的(de) in contexts still as verbs. All the Chinese verbs described in this research are dissyllabic verbs. A concordance search in the MCCC corpus shows that contexts where a verb is preceded by 的(de) (DE1) are present in the corpus for most, if not all verbs being described. As discussed earlier, these verbs express noun properties when preceded by 的(de) (DE1). This seems to confirm Shen's argument that dissyllabic verbs manifest stronger properties as nouns rather than verbs.

The following contexts (61)-(63) also support the argument that verbs are still keeping their properties as verbs when acting as the head of nominal 的(de) (DE1) phrase. In the following contexts, 增加(zēng jiā) 'increase', 上升(shàngshēng) 'rise', 融化(rónghuà) 'melt' have similar behaviours as in (56), (57) and (58). However, the main difference lies in that each of the three terms is modified by a word before being preceded by 的(de) (DE1) in (61), (62) and (63). In (61), 渐渐(jiànjiàn) 'gradually', which modifies 增加(zēng jiā) 'increase', is undoubtedly an adverb. So are 完全(wán quán) 'completely' and 不断(bú duàn) 'unceasingly', which modifies respectively 融化(rónghuà) 'melt' and 上升(shàngshēng) 'rise' in (62) and (63). If we assume that 增加(zēng jiā) 'increase', 融化(rónghuà) 'melt' and 上升(shàngshēng) 'rise' here act as nouns, then we are enlarging the function of adverbs in saying that adverbs can modify nouns. However, as specified in Chinese grammar, the sole function of adverbs is modifying verbs (Fang, 1992, p. 76). These contexts prove that each term in the nominal 的(de) (DE1) phrase still keep its properties as a verb.

(61) 地球温度的渐渐增加是地球大气本身不断调节所获得的结果
'The gradual increase of the Earth's temperature is the result of the continuous adjustment of the Earth's atmosphere'

(62) 不过，格陵兰冰原的完全融化是一个缓慢的过程，…
'However, the complete melt of Greenland ice field is a slow process, …'

(63) 随着气温的不断上升，持续变化着的状态是一个"新常态"。
'Along with the continuous rise of the air temperature, the constant changing state is a "new norm"'.

5.6.1.2 Distinguish senses of polysemous terms

Many specialised Chinese terms convey more than one meaning in the field of climate change. Lexical-semantic tests or "ambiguity tests" proposed by Cruse (1986, pp. 54-62) provide great assistance for distinguishing senses of polysemous lexical units.

- xī shōu 吸收 'absorb'

(64) 太阳以短波辐射传送能量至地球，大约有三分之一被大气和地球直接反射回太空，剩下的三分之二主要穿透大气被地球吸收，其次被大气所吸收。
'The Sun transmits energy to the Earth in short-wave radiation, about one-third of which is reflected directly back into space by the atmosphere and the Earth. The remaining two-thirds penetrating mainly through the atmosphere and being absorbed by the Earth, and to a lesser extent by the atmosphere.'

(65) 树木是自然的二氧化碳调节系统，它们可以吸收二氧化碳，释放氧气…
'Trees are natural carbon dioxide regulators and they absorb carbon dioxide and release oxygen...'

To determine whether xī shōu 吸收 'absorb' in the four contexts convey one single meaning or more than one meaning, we could apply the third test (oppositeness). fǎn shè 反射 'reflect' is the opposite of xī shōu 吸收 'absorb' in (64), but not xī shōu 吸收 'absorb' in (65), suggesting that xī shōu 吸收 'absorb' in (64) and (65) convey different meanings. Also, xī shōu 吸收 'absorb' in the two contexts depict two different scenes. xī shōu 吸收 'absorb' in (64) describes the scene of energy coming from the sun is either absorbed by the earth and atmosphere, or reflected by the earth and atmosphere. In this scene, xī shōu 吸收 'absorb' and fǎn shè 反射 'reflect' is in opposite relation with each other xī shōu 吸收 'absorb'. (65) depicts the scene of carbon dioxide being absorbed by plants while oxygen being released by plants. xī shōu 吸收 'absorb' in this scene is opposite to shì fàng 释放 'release'.

- jiǎnhuǎn 减缓 'slow down/mitigate'

(66) a. 屋顶园境可由天台着手**减缓**市区热岛效应，从而有助改善香港的市区环境。
'Rooftop gardening can help improve Hong Kong's urban environment by mitigating the urban heat island effect from the rooftop.'

b. 需要注意的是，近些年一些科学团队在研究地球工程，希望通过地球工程能够**减缓**全球变暖的速率。
'It is important to note that in recent years a number of scientific teams have been researching geoengineering in the hope that it will slow down the rate of global warming.'

Both Test 2 and Test 3 could be deployed in analysing the meaning of 减缓 jiǎnhuǎn. 减缓 jiǎnhuǎn in first case (66a), but not the second has the synonym 减轻/缓解 jiǎnqīng huǎnjiě 'alleviate' and opposite 加剧 jiā jù 'intensify', indicating that 减缓 jiǎnhuǎn has two separate senses. 减缓 jiǎnhuǎn in (66a) 减缓热岛效应 jiǎnhuǎn rè dǎoxiàoyìng 'mitigate the urban heat island effect' has the meaning of lighten, alleviate and mitigate. 减缓 jiǎnhuǎn in (66b) carries the meaning of slowing down. Table 27 shows different lexical relations of the two senses of 减缓 jiǎn huǎn 'slow down; mitigate'. In the context of climate change, the English word *mitigate* is often translated into 减缓 jiǎnhuǎn 'slow down; mitigate'. However, *mitigate* is in fact equivalent to 减缓$_1$ jiǎnhuǎn 'mitigate'. In English, "mitigate something means to make it less unpleasant, serious, or painful" (*COBUILD English-Chinese Dictionary*, 2006).

Sense	English equivalent	Synonym	Antonym
减缓 1	mitigate	减轻 'lighten', 缓解 'alleviate'	加剧 'intensify', 加重 'make or become more serious'
减缓 2	slow down	减慢 'slow down'	加快 'quicken/speed up'

Table 27. – English equivalents, synonyms and antonyms of 减缓$_1$ jiǎnhuǎn and 减缓$_2$ jiǎnhuǎn

5.6.2 Difficulties in context annotation

- Delimitation of the scope of annotation

The first difficulty arising in the process of sentence annotation is to determine the boundary for annotation - that is to determine which part or parts of a sentence need to be annotated. As accentuated by Liu & You (2015), we should annotate all the constituents within the "largest phrase" 最大短语 zuì dà duǎn yǔ where the target lexical unit occurs. The largest phrase is the phrase composed by all the constituents dominated by the target lexical unit; within the largest phrase, all the constituents are inferior to the target lexical unit (Liu & You, 2015). According to this principle, the largest phrase of a verb encompasses such constituents as its subject, object, adverbial modifier(s), complement(s), etc.

To give a specific example, let us look at the following sentence selected for the target term 改变 gǎi biàn 'change'.

(67) 暖化的气候改变台湾降雨的特性。 (source: 26 臺灣氣候的過去與未來)

'Warmed climate changes the characteristics of precipitation of Taiwan.'

To delimit the boundary for annotation, we need to delimit the largest phrase dominated by the target term 改变 gǎi biàn 'change', which behaves in this sentence as a transitive verb. While 暖化的气候 nuǎn huà de qì hòu 'warmed climate' functions as the subject of the term indicating 原因 yuán yīn 'Cause', 台湾降雨的特性 tái wān jiàng yǔ de tè xìng 'characteristics of the precipitation in Taiwan' behaves as the object of the term indicating 受事 shòu shì 'Patient'. Based on this analysis, the boundary for our annotation is {暖化的气候改变台湾降雨的特性 nuǎn huà de qì hòu gǎi biàn tái wān jiàng yǔ de tè xìng}, with all the constituents dominated by the verb 改变 gǎi biàn 'change'.

The example above is quite straightforward. Nevertheless, since texts in the corpus MCCC are specialised texts written by experts in specialised fields, the majority of sentences selected for annotation are longer and more complex sentences expressing complicated concepts and logical relations. When a sentence is long with complicated syntactic structure, delimiting the "largest phrase" for target term is not without difficulties. For a complex long sentence, the prerequisite for an accurate identification of the "largest phrase" is a thorough understanding of the inner

structure of the sentence – the number of clauses in the sentence and the relations between clauses. However, this is not straightforward for Chinese because Chinese is a language that, as explained by Qin & Wang (2010), formal clues such as conjunctions are sometimes absent when expressing complex logical relations. Although conjunctions like 因为(yīn wéi)……所以(suǒ yǐ) 'because/so' are used in complex sentences to express logical relations between clauses in Chinese, they are not used as frequently as in English (Qin & Wang, 2010). In Chinese, sentences are written and narrated according to chronological order of events – what happens first is followed by what happened next and according to natural processes of events – condition or cause is expressed first followed by the results (Qin & Wang, 2010).

We usually say that English is a language that emphasises 形合(xíng hé) 'hypotaxis' whereas Chinese tends to be 意合(yì hé) 'parataxis'. For English, logic relations between clauses in a sentence are more often expressed explicitly through the use of conjunctions or relative pronouns, relative adverbs; for Chinese, however, logic relations are more often implied and can only be determined dependent upon meaning of clauses, word order as well as common sense (Qin & Wang, 2010).

For example, the following sentence is selected from the corpus MCCC for the description of the target term 加剧(jiā jù) 'intensify':

(68) 极端 天气、 气温 上升、 海洋 暖化、 冰川 融化，
extreme weather air temperature rises oceans warm glaciers melt
种种 现象 清楚 证明 气候 变化 正 急速 加剧，
all kinds of phenomenon clear prove climate change PROG rapidly intensifying,
地球 不断 升 温。
the Earth constantly rise temperature.
'Extreme weather, increase of air temperature, warming of ocean, melting of glacier, all these phenomena clearly show that climate change is rapidly intensifying and that the Earth's temperature is continuously increasing.' (Source: 27 香港气候变化报告 2015)

This sentence is a complex sentence containing four clauses; however, no conjunctions are present in this sentence. We need to depend upon the meaning of the sentence as well as

punctuation marks such as commas[20] to ascertain the relations between clauses. A careful analysis will tell us that this sentence can be divided into four parts:

(68) ①极端天气、气温上升、海洋暖化、冰川融化，②种种现象清楚证明③气候变化正急速加剧，④地球不断升温。

The first part ① explains the many different phenomena of climate change, the second clause ② is the main clause, followed by its subordinate noun clause – an object clause (consisting of clause ③ and ④). It should be noted that there is neither subordinate conjunction nor any punctuation connecting the main clause ② and its object clause ③. Besides, there is no coordinating conjunction, but only a comma connecting clause ③ and clause ④ to show their coordinate relation.

Now, when the internal structure of the sentence is clarified, we can easily draw the boundary for "largest phrase" – parts of the sentence that are syntactically linked with our target term 加剧 ‘intensify’. ①种种现象清楚证明 is the main clause; ②气候变化正急速加剧 is its one subordinate clause. Since clause ② is the part of the sentence that is closely related to the target term 加剧 ‘intensify’ while other clauses are independent of the target term, we only need to annotate clause ②. Here in this clause, 气候变化 ‘climate change’ acts as subject of 加剧 ‘intensify’, assuming the semantic role of 受事 ‘Patient’; 正 ‘an adverb indicating the continuous state of the action’ behaves as an adverbial modifier ‘状语’ of 加剧 ‘intensify’, indicating 时间 ‘Time’; and 急速 ‘rapidly’ functions as another adverbial modifier 状语 of 加剧

[20] In Chinese, the comma is used wherever there is a need for a pause. As explained in 新华字典 (*Xinhua dictionary*, 1999, p. 671), commas can be placed within a simple sentence (单句) to indicate pauses between the subject and predicate, between verb and its object or indicate pause after the adverbial adjunct. Commas can also be used within a complex sentence (复句) to indicate pauses between its clauses. In Chinese, conjunctions are not a must for connecting clauses.

'intensify', indicating 方式 'Manner'. Thus, the boundary for annotation is {气候变化 正 急速加剧}.

Annotation of sentence (68) (target term 加剧 'intensify')

(68) 极端天气、气温上升、海洋暖化、冰川融化，种种现象清楚证明{〈气候变化**受事**-主语-动词短语〉〈正时间-状语-副词短语〉〈急速方式-状语-副词短语〉〈tgt 加剧〉}，地球不断升温。

If we are describing a different verb, for instance, the verb 暖化 'warm' in clause 1. Then the boundary for annotation should be drew at {海洋 暖化 'sea/ocean warms'}, since this part of the sentence is the "largest phrase" of 暖化 'warm' with 海洋 'sea/ocean' functions as the subject of 暖化 'warm', indicating 受事 'Patient'. The rest sentence constituents are not dominated by the target term暖化 'warm' and thus is not syntactically linked with the term.

Annotation of sentence (68) (target term 暖化 'warm')

①极端天气、气温上升、{海洋受事-主语-名词短语暖化}、冰川融化，②种种现象清楚证明③气候变化正急速加剧，④地球不断升温。 (Source: 27 香港气候变化报告 2015)

Let us look at another sentence:

(69) 人类 活动 **释放** 的 温室气体 增强了 包裹 效应。
human activities release DE1 greenhouse gases strengthen-PERF wrapping effect
'Greenhouse gases released by human activities has strengthened the wrapping effect.'
(Source: 20 氣候變遷問答(臺灣中央氣象局))

The target term we are annotating here in this sentence is 释放 'release'. To determine the boundary for annotation, we need to firstly clarify the syntactic structure of this sentence. This sentence contains a single clause – the predicate of the clause is 增强 'strengthen', its subject

is a noun phrase 人类活动释放的温室气体 ‘the greenhouse gases released by human activities’ and its object is also a noun phrase 包裹效应 ‘wrapping effect’. The “largest phrase” syntactically linked with our target term 释放 ‘release’ is the noun phrase 人类活动释放的温室气体 ‘greenhouse gases released by human activities’, with 人类活动 ‘human activities’ as the subject of 释放 ‘release’, indicating 原因 ‘Cause’ and 释放 ‘release’ as the attribute of 温室气体 ‘greenhouse gases’. Therefore, the boundary for annotation is located at {人类活动释放的温室气体 ‘greenhouse gases released by human activities’}.

Annotation of sentence (69):

〈人类活动原因-主语-名词短语〉**释放**〈的温室气体受事-中心语-名词短语〉增强了包裹效应。

Sometimes our annotation goes beyond the annotation boundary pre-determined. This is the case when a participant of the target term is omitted because it is already present in the previous clause. For example, sentence (70) is a sentence extracted from the corpus MCCC for describing the target term 变化 ‘change’. This sentence consists of two clauses connected by the coordinating conjunction且 ‘and’. The boundary for annotation is identified to be around the second clause {且不断变化 ‘and is constantly changing’}. Here, the participant 受事 ‘Patient’ of the target term 变化 ‘change’ - 世界各地的气候 ‘the climate in different parts of the world’ is omitted in the second clause because it is already present in the first clause. Therefore, we assign the role of 受事 ‘Patient’ to the constituent 世界各地的气候 ‘the climate in different parts of the world’ in the first clause. However, because this constituent 世界各地的气候 ‘the climate in different parts of the world’ is syntactically beyond our annotation boundary, we label it with the syntactic function of 间接联系 ‘Indirect link’.

(70) 世界 各地 的 气候 是 千差万别的，{且 不断 **变化**}。
world different places DE1 climate is different and constantly change
'The climate in different parts of the world differs from each other tremendously, and is constantly changing.'

Annotation of sentence (70):
〈世界各地的气候受事-间接联系-名词短语〉是千差万别的，且〈不断方式-状语-副词短语〉变化。 (Source: 213 植树造林在全球气候变暖中的作用及其措施)

The instance where one participant of the target term can be outside the annotation boundary can be illustrated through the following example. The target term we are annotating here is the verb term 升高 shēng gāo 'rise high'.

(71) 根据政府间气候变化专门委员会在 2013 年 9 月公布有关气候科学最新的第五次气候评估报告，气候变化预计可能会导致全球海平面在本世纪末**升高** 1 米，并增加风暴潮的威胁。

(source: 28 香港氣候行動藍圖 2030+)

'According to the fifth climate assessment report, the newest report regarding climate science published by IPCC in September 2013, climate change is predicted to probably causing the global sea level to rise 1 metre by the end of this century and increasing the threat of storm surge.'

A careful analysis of the syntactic structure of the sentence will tell us that the sentence can be divided into three parts – the first part is a prepositional phrase starting with the proposition 根据 gēn jù 'according to', ② is the main clause followed by two object clauses (③ and ④) of the verb 导致 dǎo zhì 'lead to/result in'. 在本世纪末 zài běn shì jì mò 'at the end of the century' acts as adverbial modifier of the target term 升高 shēng gāo 'rise high', indicating 时间 'Time'; 1米 mǐ '1 meter' behaves as object of 升高 shēng gāo 'rise high', indicating 数值 shù zhí 'value'; 全球海平面 quán qiú hǎi píng miàn 'global sea level' functions as 受事 shòu shì 'Patient' of the term. Other parts of the sentence are not governed by the term 升高 shēng gāo 'rise high' and are thus outside of the "largest phrase". Thus, the annotation boundary is situated at {全球海平面 quán qiú hǎi píng miàn 在本世纪末 zài běn shì jì mò 升高 shēng gāo 1米 mǐ 'global sea level will rise by one meter at the end of this century'}. However, 气 qì

候变化 ‘climate change’, outside the annotation boundary, is linguistically the optional participant 原因 ‘Cause’ of the target term 升高 ‘rise high’, explaining the cause of the process presented by 升高 ‘rise high’ – rise of global sea level. Because 气候变化 ‘climate change’ in the main clause ① is the subject of the verb 导致 ‘lead to/result in’ in the main clause ① , but not syntactically connected with the term 升高 ‘wise high’, it is labeled 间接联系 ‘indirect link’ as its syntactic function.

Another difficult point in contextual annotation is to accurately delimit syntactic realisations of participants of a target term so as to label them with their semantic roles. When a sentence constituent identified as a participant is a phrase, we need to annotate the whole constituent, but not only the head word. To illustrate this point, let us look at the following sentence selected for the annotation of the target verb term 吸收 ‘absorb’.

(72) 没有被反射回太空的能量被地球表面和大气吸收了。
‘The energy not reflected into the space is absorbed by the Earth’s surface and atmosphere.’
(Source: 20 氣候變遷問答(臺灣中央氣象局))

As seen from the following annotation, when labelling the actant 受事 ‘Patient’, we annotate not only the head word – 能量 ‘energy’, but the whole noun phrase 没有被反射回太空的能量 ‘energy that is not reflected into the space’, because this phrase altogether behaves as subject of the term 吸收 ‘absorb’ When labelling the actant 目的地 ‘Destination’, we annotate not only 地球表面和大气 ‘the Earth’s surface and atmosphere’, but also the preposition 被 ‘preposition’ because this whole constituent 被地球表面和大气 acts as 状语 ‘adverbial’ the term 吸收 ‘absorb’.

〈没有被反射回太空的能量受事-主语-名词短语〉〈被地球表面和大气目的地-状语-介词短语〉〈tgt 吸收〉了。

6 Conclusion

The main objective of this research is to discover Chinese semantic frames in the field of climate change based on Frame Semantics (Fillmore, 1976, 1977, 1982, 1985; Fillmore & Atkins, 1992). The Chinese semantic frames are defined with the help of the methodology of Chinese FrameNet (CFN), as well as the methodology devised for the project DiCoEnviro and Framed DiCoEnviro. In order to discover Chinese semantic frames, this research first compiled a monolingual Mandarin Chinese specialised corpus containing 224 Chinese authentic texts in the field of climate change. Following this, Chinese semantic frames were discovered by describing the Chinese verb terms identified from the specialised corpus. It is hoped that this research could provide an insight into the application of Frame Semantics to the description of terms in non-Indo-European languages and enlighten future research into terminological resources based on Frame Semantics. Moreover, it is also hoped that the Chinese terminological resource built during this research would provide some assistance for scientists and researchers working on environmental protection and environmental science, professors and students specialising in the field of the environment and related fields, translators and editors working on environment-related contents, as well as the general public who are concerned about the environment.

As pointed out in Section 1.1, information provided in existing Chinese dictionaries of environmental terms is insufficient. Information absent from existing dictionaries include Chinese verb terms and their argument structures, usages of terms in specialised texts, properly distinguished meanings of polysemous terms, and relations between terms in the whole conceptual structure of the domain of the environment. The online Mandarin Chinese terminological resource compiled in this research makes up for some of these insufficiencies and better meet the needs of readers.

Devoted to a specific domain – the domain of climate change, the Mandarin Chinese terminological resource built in this research constitutes an important complement for existing general-language Chinese lexical resources. As observed from the comparison of the five existing Chinese lexical resources in Section 2.6, all the five resources are general-language resources –

none of them is purely dedicated to one particular specialised field, though specialised senses of certain Chinese words can be found in certain entries of these resources.

Although there have been reports (Dolbey et al., 2009; Faber, 2011; Schmidt, 2009; L'Homme, 2008) of applying Frame Semantics/FrameNet methodology to terminology and compiling frame-based terminological resources, there are few examples of such research literature, and most of them focus on languages other than Chinese. Besides, no relevant research literature has been found on Chinese frame-based online specialised dictionary in the field of climate change/the environment. To fill in this gap, this research looks into how Frame Semantics/FrameNet methodology can be applied to the description of Chinese terms in the field of climate change.

The methodology of this research has been adapted from the methodology devised for English and French within the DiCoEnviro project (L'Homme, 2015, 2018; L'Homme et al., 2020), with the methodology developed for Mandarin Chinese within the project Chinese FrameNet (CFN) (Liu & You, 2015) as reference. The methodology consists of the following nine steps: (1) Compile the Mandarin (Chinese) Climate Change Corpus (MCCC), establishing Chinese text selection criteria for MCCC; (2) Extract candidate terms with the help of Sketch Engine; (3) Validate candidate terms, manually analysing and validating the candidate terms provided by *Keywords* of Sketch Engine. Chinese terms with specialised meaning(s) in the field of climate change/the environment are included in the final list of terms for description; (4) Explore methods for differentiating meanings of polysemous terms; (5) Write actantial structures of the 59 senses (meanings) (of the 39 Chinese verb terms) based on the contexts in which the terms occur and attach semantic role labels to actants; (6) Select 16-20 contexts to be placed into each entry; (7) Annotate the contexts, labeling participants of a Chinese verb term in terms of their semantic roles played in the contexts, their syntactic functions and syntactic groups; (8) Discover and define Chinese semantic frames. A semantic frame describes a scene or situation that can be evoked by lexical units grouped into this frame; (9) Establish relations between semantic frames. Each semantic frame defined in the previous step is a lexical reflection of the background knowledge of the scene or scenario in the

domain of climate change; (10) To be displayed online, term entries and semantic frames were encoded in XML files.

In this research, a total of 39 Chinese verb terms were encoded and described. The online Mandarin Chinese terminological resource contains 59 entries, with each meaning of a polysemous term presented in one entry. A total of 1,027 contexts were annotated. Twenty-three Chinese semantic frames were discovered and defined. Lexical units sharing the following characteristics were put into one frame (Ruppenhofer et al., 2016): 1) depicting the same scene or situation in the field of climate change/the environment; 2) having similar actantial structure with the same number and nature of actants; 3) sharing the majority, if not all circumstants.

As seen from the results of this research, all our three hypotheses put forward in Chapter 1 (Section 1.3) are confirmed.

The first hypothesis, "Chinese terms can be described and analysed using a specific terminological research method", is confirmed by the results of this research. Chinese terms in the field of climate change can be described and analysed using the methodology of the multilingual dictionary DiCoEnviro and its accompanying resource Framed DiCoEnviro. However, some adjustments need to be made when processing Chinese characters '汉字 hàn zì'. Firstly, when extracting Chinese candidate terms, we need to use a software that can realise Chinese word segmentation and part-of-speech tagging. In this research we used the corpus management and analysing tool Sketch Engine. In addition, when verifying which of the candidate terms are genuine terms in Chinese, we need to first come up with validation and delimitation methods of Chinese lexical units. To be able to delimit Chinese lexical units, we need to analyse the characteristics of Chinese words according to Chinese morphology. Moreover, when encoding term information, we must ensure that the XML files can be written in Chinese characters and that Chinese characters can be displayed correctly online.

The second hypothesis, “when applying the methodology of the project DiCoEnviro to describe Chinese terms, the properties of Chinese terms need to be taken into account”, has also been confirmed. Firstly, when writing actantial structures of Chinese terms, we used a set of Chinese semantic role labels. When annotating contexts, we used Chinese labels of syntactic functions and syntactic groups, which were adapted from the labels adopted by the Chinese FrameNet (CFN) project (Liu & You, 2015). Secondly, in the annotated contexts of English and French entries in DiCoEnviro, head words of actants and circumstants are shown in italics; for Chinese annotated contexts, however, we highlight head words by underlining these words, because italics is rarely used in written Chinese. Similarly, on the first page of each entry of the English and French terms of DiCoEnviro, the actant(s) in the actantial structure as well as in the three contexts is(are) displayed in italics, whereas on the first page of each Chinese entry, the actant(s) in the actantial structure and in the three contexts is(are) shown in regular type.

The third hypothesis, “Chinese terms share features with English and French terms”, is also supported by the results of this research. Indeed, we found a number of Chinese – English equivalents in the field of climate change/the environment. As we discussed in Section 5.3, there are terminological equivalents in English and Chinese that designate the same concepts and express the same actions and processes. After all, for speakers of different languages in different parts of the world, the natural environment is the same, therefore many concepts are the same. We observed that a Chinese term and its English equivalent(s) share the same actantial structure – the number and nature of the actant(s) are the same. The examples we have given are 融化$_{1}$ (róng huà) ‘melt’ in Chinese and its English equivalent melt$_{1a}$ and the transitive term 改变$_{1b}$ (gǎi biàn) ‘change’ in Chinese and its English equivalent change$_{1b}$. It is also observed that a Chinese term and its equivalent English term also share some, if not all circumstants.

Research significance

First and foremost, this research constructed a Mandarin Chinese monolingual corpus specialised in the field of climate change – Mandarin (Chinese) Climate Change Corpus (MCCC). This corpus

contains 224 authentic Chinese specialised texts in the field of climate change, totaling 1,228,333 Chinese characters, which is 547,592 Chinese words. This corpus will serve as research materials for terminologists, lexicologists, and lexicographers. Other studies on Chinese terminology or lexicography can be conducted based on this specialised corpus.

In addition, we proposed a method for compiling Mandarin Chinese specialised dictionaries based on Frame Semantics. Specialised dictionaries compiled in this way will not only reveal practical usages of terms in specialised texts, carefully distinguish meanings of polysemous terms, but also help the user understand the meaning(s) of predicative terms by showing the user the actantial structures of predicative terms. More importantly, the specialised dictionary compiled following this method reflects the knowledge structure of the specialised field through relations between semantic frames. We hope that the frame-based terminological resource we have compiled in this research would provide some assistance for lexicographers, as well as to readers of specialised environmental dictionaries.

Furthermore, the frame-based terminological resource we have compiled is an example of the application of Frame Semantics to non-Indo-European languages, inspiring Chinese linguists and terminologists to carry out research in this area.

Research limitations and suggestions for future research

The object of this research is Chinese verb terms in the field of climate change. Future research can look into Chinese terms of other parts of speech (e.g. nouns, adjectives) in this field. In addition, the environmental discipline encompasses many different aspects. Besides climate change, there are also environmental protection, environmental planning and management, environmental assessment and monitoring, environmental laws and regulations, ecological balance, resources and energy, air pollution and prevention, water pollution control, and solid waste treatment, etc. Future research can focus on building corpora for each of these sub-domains and discovering semantic frames of each sub-domain and building a net of frames for the environmental discipline by establishing links between frames. This framenet in the field of

the environment will reveal the relations between different terms in the field of the environment and the knowledge structures behind the terms.

The emergence of framenets developed based on Frame Semantics (Fillmore, 1976, 1977, 1982, 1985; Fillmore & Atkins, 1992) has been a landmark in bringing the theory of Frame Semantics to application and in making multilingual processing practical. With the successful construction of framenets in many different languages, the next task is to apply the theory of Frame Semantics to the construction of terminological resources in different disciplines. In other words, besides further research and development of framenets in different languages, the next task is to apply framenet methodology to the construction of online terminological resources in various disciplines.

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Appendices

Appendix 1 Term entries in existing Chinese dictionaries of environmental terms

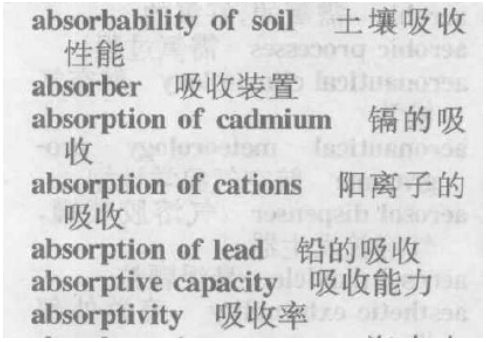
Appendix 1.1 Entry of the term 吸收 (xī shōu) 'absorption' in the online 《環境科學大辭典》(*Environmental Science Dictionary*)(2002), National Academy for Educational Research, Taiwan [臺灣國家教育研究院].

(Source : https ://terms.naer.edu.tw/detail/1317343/?index=6)

Appendix 1.2 Entry of the term 吸收 (xī shōu) 'absorption' in 《环境科学与工程技术辞典》 (*Dictionary of Environmental Science and Engineering Technology*) (Li, 2005, p. 679)

吸收 absorption 广泛用于环境治理的一种分离气体混合物的化工单元操作，又称气体吸收。吸收操作的目的可分为捕集气体混合物中的有用物质以制取产品和祛除有害物质以净化气体。吸收操作依据的是气体在液体中溶解度的差异，需要通过吸收设备来完成。吸收中用于处理气体的液体称为溶剂，气体中被吸收的组分称为溶质，溶剂吸收溶质后形成溶液，祛除了溶质的气体称为尾气。吸收所选用的溶剂应对溶质有较强的选择性，即溶质在溶剂中较其他组分有较大的溶解性。吸收设备可提供较大的气液接触面积，气液在设备中可并流也可逆流，溶质在气液间发生转移，从而完成吸收操作。依据吸收操作的特点，工业上通常将吸收分为物理吸收和化学吸收，单组分吸收和多组分吸收，等温吸收和非等温吸收等。

Appendix 1.3 Entry of the term *absorber* '吸收 (xī shōu) 装置 (zhuāng zhì)' in 《英汉双向环境工程词典》(*English-Chinese and Chinese-English Dictionary of Environmental Engineering*)(Xu, 2009, p. 1)



absorbability of soil 土壤吸收性能
absorber 吸收装置
absorption of cadmium 镉的吸收
absorption of cations 阳离子的吸收
absorption of lead 铅的吸收
absorptive capacity 吸收能力
absorptivity 吸收率

Appendix 1.4 Entry of the term *absorb* '吸收 xī shōu' in 《英汉环境科学词汇》

(*An English-Chinese Dictionary of Environmental Science*) (Yu, 2000, pp. 3-4)

absorb 吸收
absorbability 吸收性，吸收能力；吸收率
absorbable fiber 可吸收纤维
absorbance 吸收率，吸收系数；吸光度
absorbancy 吸收率，吸收系数
absorbancy index 吸光指数
absorbate 被吸收的物质
absorbed dose 吸收剂量
absorbed dose distribution 吸收剂量分布
absorbed dose rate 吸收剂量率
absorbed energy 吸收能
absorbed layer 吸收层
absorbency 吸收能力
absorbent 吸收剂；吸收的
absorbent bed 吸收床，吸收层
absorbent charcoal 活性炭
absorbent coating 吸收性涂层
absorbent cotton 脱脂棉
absorbent fiber 吸收性纤维
absorbent filter 吸收过滤器
absorbent paper 吸水纸
absorbent power 吸收能力
absorbent refrigerator 吸收式制冷机
absorbent resin 吸附树脂
absorbent solution 吸收溶液
absorber 吸收塔，吸收器；减震器；吸收剂；吸湿剂
absorber cooler 吸收(器的)冷却器
absorber plate 太阳能吸热片
absorber washer 吸收洗涤器
absorbing ability 吸收能力
absorbing apparatus 吸收装置
absorbing capacity 吸收量
absorbing chemical 吸收试剂
absorbing column 吸收柱，吸收塔
absorbing duct 消音器，吸音管
absorbing medium 吸收介质
absorbing moisture 吸湿
absorbing power 吸收力
absorbing silencer 吸收消声器
absorbing surface 吸收表面
absorbing tower 吸收塔
absorbing well 吸收井
absorptance 太阳能吸热量；吸收能力
absorptiometer 吸收(比色，光度)计；(液体)溶气计，(液体)吸气器
absorptiometry 吸光测定法
absorption 吸收(作用)
absorption air conditioning 太阳能空气调节系统
absorption apparatus 吸收装置；减震装置
absorption band 吸收谱带
absorption bottle 吸收瓶
absorption by molecule 分子吸收
absorption capacity 吸收能力
absorption cell 吸收池
absorption coating 吸波涂层
absorption coefficient 吸光系数，吸收系数
absorption coefficient of light 光吸收系数
absorption coil 吸收盘管
absorption color 吸收色
absorption column 吸收柱，吸收塔
absorption curve 吸收曲线
absorption factor 吸收因子
absorption filter 吸收滤光片
absorption function 吸收功能，吸收函数
absorption heat pumping (AHP) 吸收式热泵送(一种节能的先进技术)
absorption hygrometer 吸收湿度计
absorption line 吸收谱线
absorption liquid 吸收液
absorption loss 吸收损失
absorption material 消音器材，吸收

Appendix 1.5 Entry of the term *absorption apparatus* '吸收 装 置'(xī shōuzhuāng zhì)《英日汉环境辞典》*(English-Japanese-Chinese Environmental Dictionary)* (Wang, 1988, p. 1)

absorptiometry【吸光光度法(きゅうこうこうどほう)】吸光光度法，吸光测定法

absorption apparatus【吸收装置(きゅうしゅうそうち)】吸收装置

absorption photometry【吸光光度法(きゅうこうこうどほう)】吸光光度法（利用物质对光的吸收现象的化学分析法的总称）

absorption treatment of odor【悪臭成分の吸着除去(あくしゅうせいぶんのきゅうちゃくじょきょ)】吸收排除恶臭成分

Appendix 1.6 Entry of the term *absorber* '吸收器'(xī shōu qì)《英汉・汉英环境科学与工程词汇手册》*(An English-Chinese Chinese-English Glossary of Environmental Science and Engineering)* (Dai & Liu, 2012, p. 2)

absorbance 吸收率，光密度
absorbance unit full scale 满刻度吸光度单位
absorbancy index 吸光指数
absorbent 吸收剂；吸收性的
absorbent charcoal 活性炭，吸收性炭
absorbent cotton 脱脂棉
absorber 吸收器；缓冲器
absorber plate 太阳能吸热片
absorbing medium 吸收介质
absorptance 太阳能吸热量；吸收能力
absorptiometer 吸收计；溶气计
absorption air conditioning 太阳能空气调节系统
absorptive lining 吸水衬里；吸声板
absorptive-type filter 吸收型过滤器
absorptivity 吸收能力；吸收系数

Appendix 1.7 Entry of the term *absorb* '吸收 (xī shōu)' in《英德汉环境词典》

(English-German-Chinese Environmental Dictionary) (Li et al., 2001, pp. 2-3)

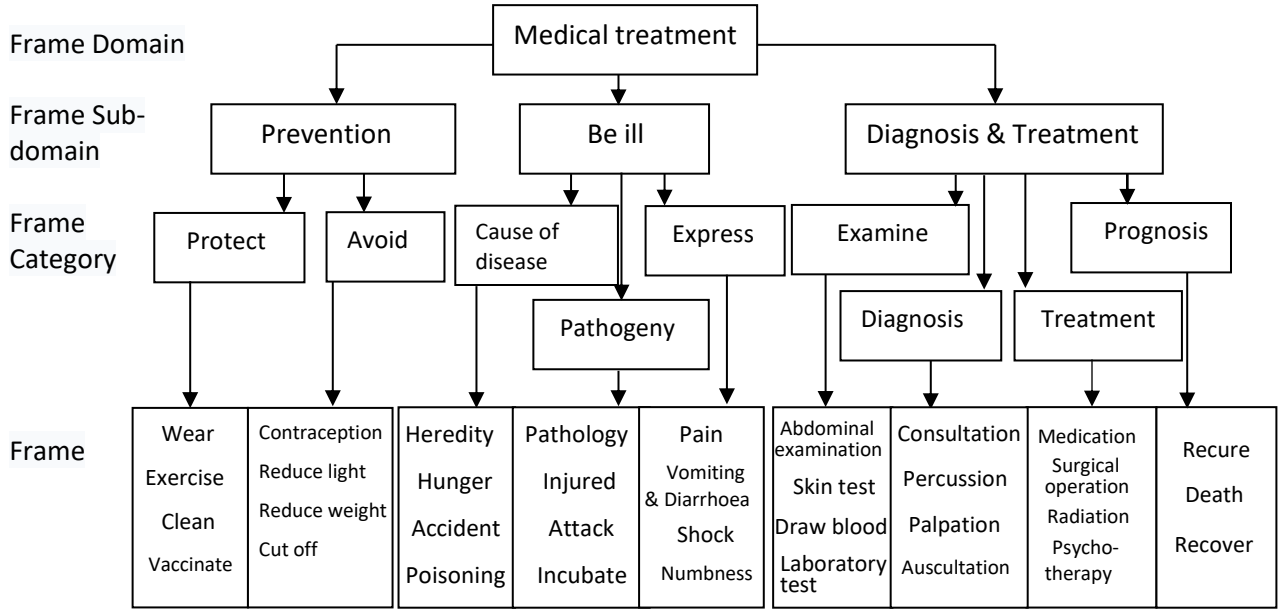
absorb *v/t*	aufsaugen, aufnehmen, ab-, resorbieren	吸收, 缓冲, 吞并, 接受
absorbability *n*	Aufnahmefähigkeit *f*, Absorbierbarkeit *f*	吸收能力, 吸收性, 吸收率
absorbency *n*	Saugfähigkeit *f*, Absorbierbarkeit *f*	吸收率, 吸收性, 吸收能力
absorbent *n*	Aufsaugmaterial *nt*, Absorbens *nt* Absetzbecken *nt*	吸收剂, 吸收质, 沉淀池
a.s and filter materials	Aufsaug-und Filtermaterialien *adj* ,saug-, absorptionsfähig, absorbierend	吸收与过滤材料, 有吸收能力的
absorber *n*	(*Sonnenenergie*)Strahlungsaufnehmer *m*, Kollektor *m*; Abscheider *m*	(太阳能)吸收器, 收集器, 分离器, 减震器, 缓冲器, 沉淀器
solar a.	Solarabsorber *m*	太阳能吸收器
absorbing plate *n*	(Solar)Absorber *m*, Absorberplatte *f*	吸收板, 太阳能吸收板
a. wall	‖*Lärm*‖Schallschluckwand *f*	【噪】吸声墙面
absorption *n*	Aufnahme *f*, Durchtränkung *f*, Einsaugen *nt*, Ab-, Resorption *f*	吸收(作用), 吸入, 吸除, 浸透
oceanic a. of heat	Wärmeaufnahme durch den Ozean	海洋吸热(作用)

Appendix 2 English Translated version of Table 2 – Frame [到达|Arriving] in the Chinese FrameNet (Liu & You, 2015, p. 40)

到达|Arriving	
定义：指转移体到达目标的过程。目标可直接表达出来，或从上下文中得到理解，或者动词本身隐含目标之义 Definition: The process by which an object Theme reaches its goal. The goal may be expressed directly, or can be understood from the context, or the verb itself implies the meaning of the goal	
核心框架元素 Core frame element	
目标 [goal] Goal [goal]	目标是转移体运动终止之地，或行将终止之地。例如，我们在午夜前到了巴黎 The goal is the place where the motion of the Theme ends, or about to end. For example, we ARRIVED in Paris just before midnight
转移体 [thm] Theme [thm]	转移体指移动的物体 Theme refers to an object that moves
非核心框架元素 Non-core frame element	
伴随者 [thm_c] Cotheme [thm_c]	指除转移体以外的其他移动的物体 Cotheme refers to other moving objects besides the Theme
形容 [dep] Depictive [dep]	形容指用来描写转移体到达的状态。例如，威尔士公主微笑着回来了 Depictive is used to describe the state in which the Theme arrives. For example, the Princess of Wales RETURNED with a smile
目标状态 [g_c]	转移体到达目标时目标所呈现出的状态 The state presented by the goal when the Theme reaches the goal
修饰 [manr] Manner [manr]	表现修饰的话语用于对动作特性的描述，用来描述运动的速度、姿态和其他情况，例如，送信人慢慢地走进房间 Manner expressions are used to describe characteristics of the action, to describe the speed, gesture, and other circumstances of the motion. For example, the messenger WALKS slowly into the room
方法 [mns] Means [mns]	该框架元素用于表现转移体到达的方式 This frame element is used to express the way in which the Theme arrives
传送模式 [mot] Mode_of_transportation [MoT]	传送模式指作用于主体的运动模式，通过传送主体的主体身体或交通工具实现。例如，我们乘汽车赶到加拿大；我步行到了墨西哥 The Mode_of_transportation refers to the mode of motion acting on the subject, achieved by the subject body of the subject or transportation vehicles. For example, we ARRIVED in Canada by car; I walked TO Mexico
路径 [path] Path [path]	路径指运动的轨道，既非源点，也非目标 Path refers to the track of motion. It is neither the source nor the goal
源点 [src] Source [src]	源点即明确表达运动的出发点，该框架中出现表达源点的用语是可能的，但出现的频率却相对不高。例如，她昨天从纽约来到这里。 The source expresses explicitly the point of departure of the motion. The occurrence of expressions of source in this frame is possible, but with a frequency that is relatively not high. For example, she ARRIVED here from

	New York yesterday
时间 [time] Time [time]	该框架元素表现到达这一动作出现的时间 This frame element expresses the time when the action of “arriving” occurs
框架关系 Frame relations	
父框架 Parent frame： 子框架 Child frame： 总框架 General frame：[位移情境/Motion_scenario] 分框架 Subframe： 参照 See also：	
词元 Lexcial unit	
到达 v，来到 v，进入 v，抵达 v，返回 v，走到 v，走进 v，赶到 v，回来 v，归来 v，到 v，回到 v	

Appendix 3 English translated version of Figure 10 – Levels of semantic frames in the field of medical events (Zhong, 2020, p. 83)



Appendix 4 English translated version of Table 10 – The frame of [手术治疗|Surgical_treatment] in the Chinese Medical Events FrameNet (CMEF) (Zhong, 2020, p. 85)

框架名 Frame name	手术治疗 surgical treatment	
框架描述 Frame description	The course of removal, repair, or replacement of a patient's diseased or defective organs by medical personnel	
核心框架元素 (Core elements)	医生 Doctor (Doc)	One who performs surgical treatment on a patient
		E.g. Healing the wounded and saving the dead is a doctor's unshirkable duty
	护士 Nurse (Nur)	A surgical nurse is a person who assists the surgeon in performing the operation
		E.g. The nurse wipes the surgeon's sweat
	病人 Patient (Pat)	A person with diseased or defective bodily organs
		E.g. He has congenital heart disease
非核心框架元素 (Non - core Elements)	原因 Reason (Rea)	What prompts a patient to undergo surgery is the etiology
		E.g. Smoking has ruined the lung, so a part of it has to be removed
	处所 Place (Pla)	The place where a patient is treated by medical staff, an operating room, etc
		E.g. He is now lying on the operating table in the hospital
	方式 Manner (Man)	Description of the methods used by medical staff to help patients eliminate disease behavior, mainly directed at medical staff
		E.g. The situation is urgent and requires an immediate operation
	准备 Preparation (Pre)	Various preoperative magnification measures are used before the operation to enable the patient to survive the operation in a better condition
		E.g. Before the operation, the doctor will explain what may happen during the operation
	麻醉 Anesthesia (Ane)	The medical staff (anesthesiologist) gives the patient local or general anesthesia to minimize the pain caused by the operation
		E.g. Major operations require general anesthesia
	手段 Means (Mea)	A method by which medical personnel use surgical tools to perform operations on patients
		E.g. Cut at the mark
	工具 Tool (Too)	All kinds of medical instruments needed by medical staff during the surgery
		E.g. The doctor cut the muscle tissue with a scalpel
	目的 Purpose (Pur)	The purpose of medical staff to help patients eliminate diseases
		The surgeon removed the tumor
	结果 Result (Relt)	The follow-up events after the completion of the operation, the impact of the operation, including the patient's awakening, the patient's recovery, etc.
		E.g. He was transferred to ICU right after the operation
	亲属 Relatives (Rel)	The person who accompanies the patient to perform the operation, if necessary, needs to sign off for any emergency that arises during the operation
		E.g. The situation is urgent and the patient's family members need to sign
	探望者 Visitor (Vis)	People who visit sick people
		E.g. Grandpa is ill. I want to go and see him
词汇单元 (Lexical Units)	Preoperative communication, disinfection, sterilization, general anesthesia, local anesthesia, excision, repair, replacement, heart bypass, kidney transplantation, skin grafting	

Appendix 5 Details of the texts compiled in the corpus Mandarin (Chinese) Climate Change Corpus (MCCC)

No.	Title of article 文章名称	Word count 字数	Full references 文献信息
	Articles from UN, IPCC, WMO		
1	WMO2018 年全球气候状况说明	26313	世界气象组织 [World Meteorological Organization (WMO)] (2019). 世界气象组织 2018 年全球气候状况声明. https://library.wmo.int/doc_num.php?explnum_id=5806
2	气候变化 2014 综合报告(IPCC)	113314	政府间气候变化专门委员会 (IPCC) (2014). 气候变化 2014: 综合报告 (核心撰写小组, R.K. Pachauri & L. A. Meyer Eds.). 政府间气候变化专门委员会第五次评估报告第一工作组、第二工作组和第三工作组报告. 瑞士: 日内瓦 IPCC. https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full_zh.pdf
3	气候变化联合国	2645	联合国[United Nations] (2019). https://www.un.org/zh/global-issues/climate-change
4	气候在变化活动手册 UN	6050	联合国粮食及农业组织（粮农组织）[Food and Agriculture Organization of the United Nations (FAO)] (2018). 活动手册 - 气候在变化, 粮食和农业也在变化. https://www.fao.org/3/I9860ZH/i9860zh.pdf
5	全球升温 1.5 °C 决策者摘要 IPCC	19932	政府间气候变化专门委员会 (IPCC) (2019). 全球升温 1.5°C 决策者摘要. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/09/IPCC-Special-Report-1.5-SPM_zh.pdf
	Articles from Hong Kong and Taiwan		
6	《氣候變化中的海洋和冰凍圈特別報告》	693	香港天文台 (2019). 《气候变化中的海洋和冰冻圈特别报告》. https://www.hko.gov.hk/tc/whatsnew/d3_whats_new_190930.htm
7	大氣暖化應控制在1.5℃之內－科技大觀園	320	王道還 (2018). 大氣暖化應控制在 1.5℃之內. https://scitechvista.nat.gov.tw/Article/C000003/detail?ID=5d438fde-5c50-483e-98a8-d74021050c41
8	極端氣候系列報導(1)屢創新高的地表溫度	2031	林如雲编译，汪中和编辑 (2016). 極端氣候系列報導（一）：屢創新高的地表溫度. https://highscope.ch.ntu.edu.tw/wordpress/?p=72926
9	極端氣候系列報導(2)波波湖蒸發了	1443	林如雲编译，汪中和编辑 (2016). 極端氣候系列報導（二）：波波湖蒸發了. https://highscope.ch.ntu.edu.tw/wordpress/?p=72927
10	極端氣候系列報導(3)暴風雪和豪大雨	915	林如雲编译，汪中和编辑 (2016). 極端氣候系列報導（三）：暴風雪和豪大雨. https://highscope.ch.ntu.edu.tw/wordpress/?p=72928
11	暖化的科學(1)引言全球溫度	1889	邱一庭 (2018). 科技大觀園 (Sci-Tech Vista) https://scitechvista.nat.gov.tw/Article/c000003/detail?ID=21289213-d877-4240-a587-26971811fce4

12	暖化的科學(2)溫室效應	1826	邱一庭 (2018). 科技大觀園 (Sci-Tech Vista) https://scitechvista.nat.gov.tw/Article/c000003/detail?ID=c2518258-fa83-49ce-a216-0ab0e3418531
13	暖化的科學(3)二氧化碳與暖化	2098	邱一庭 (2018). 科技大觀園 (Sci-Tech Vista) https://scitechvista.nat.gov.tw/Article/C000003/detail?ID=e31308bc-1e38-4b0d-a6cb-34b38350917e
14	暖化的科學(4)碳循環	2396	邱一庭 (2018). 科技大觀園 (Sci-Tech Vista) https://scitechvista.nat.gov.tw/Article/c000003/detail?ID=466fc18a-91ca-4d93-8187-111f286a9595
15	暖化的科學(5)國際抗暖之具體作為	2062	邱一庭 (2018). 科技大觀園 (Sci-Tech Vista) https://scitechvista.nat.gov.tw/Article/C000003/detail?ID=9a64da7c-86df-47bb-b9d3-36627ad815f0
16	氣候百問(交通部中央氣象局)	39208	臺灣交通部中央氣象局 (2018) https://www.cwb.gov.tw/Data/climate/Knowledge/pdf/ClimateFAQfinal2018Nov.pdf
17	氣候變化 GovHK 香港政府一站通	3208	GovHK 香港政府一站通. 氣候變化. https://www.gov.hk/tc/residents/environment/global/climate.htm
18	氣候變化的原因_GovHK	839	香港天文台 (Hong Kong Observatory) https://www.hko.gov.hk/tc/climate_change/human_activities.htm
19	氣候變化小百科	6206	香港天文台 (Hong Kong Observatory). 氣候變化小百科. https://www.hko.gov.hk/tc//climate_change/faq/faq.htm
20	氣候變遷問答(臺灣中央氣象局)	34122	臺灣交通部中央氣象局 (Central Weather Bureau) https://www.cwb.gov.tw/V8/C/K/Qa/index.html
21	氣候變遷(臺灣交通部中央氣象局)	5818	臺灣交通部中央氣象局 (Central Weather Bureau) https://www.cwb.gov.tw/V8/C/C/Change/index.html
22	氣候變遷與空氣品質	4872	陳伶伶 (2017). 氣候變遷與空氣品質對健康之衝擊. 《土木水利》, *44*(6), 15-18. DOI: 10.6653/MoCICHE.201712_44(6).0005
23	全球變暖下的香港(香港天文臺)	5429	香港天文台[(Hong Kong Observatory)] (2016). 全球變暖下的香港(第二版). 香港: 香港特別行政區政府香港天文台.
24	全球暖化下，臺灣只會越來越熱	3914	鄭兆尊, 朱吟晨, 童裕翔, 陳永明 (2018). 全球暖化下，臺灣只會越來越熱！. 《國家災害防救科技中心災害防救電子報》, 157, 1-13.
25	臺灣氣候變遷科學報告2017	18965	周佳, 陳維婷, 羅敏輝, 李明安, 許晃雄, 洪志誠, 鄒治華, 盧孟明, 洪致文, 陳正達, 鄭兆尊 (2017). 《臺灣氣候變遷科學報告 2017 - 物理現象與機制(總摘要)》. 臺灣: 國家災害防救科技中心.
26	臺灣氣候的過去與未來	12182	國家災害防救科技中心 / 中央研究院環境變遷研究中心; 科技部「臺灣氣候變遷推估資訊與調適知識平台計畫」(2018). 《臺灣氣候的過去與未來：臺灣氣候變遷科學報告 2017—物理現象與機制重點摘錄》.
27	香港氣候變化報告 2015	49177	香港環境局 (2015). 《香港氣候變化報告 2015》. https://www.enb.gov.hk/sites/default/files/pdf/ClimateChangeChi.pdf
28	香港氣候行動藍圖2030+	36096	香港環境局 (2017). 《香港氣候行動藍圖 2030+》. https://www.enb.gov.hk/sites/default/files/pdf/ClimateActionPlanChi.pdf

	Articles from Mainland China		
29	1.5 ℃温控目标下地球工程对中国气温影响的区域差异预估	9181	孔锋，薛澜，孙劭，王品 (2019). 《科学技术与工程》[Science Technology and Engineering], 2019, *19*(6), 285-297.
30	1.5～4℃升温阈值下亚洲地区气候变化预估	5842	徐影, 周波涛, 吴婕, 韩振宇, 张永香, 吴佳 (2017). 《气候变化研究进展》, 2017, *13* (4), 306-315. doi:10.12006/j.issn.1673-1719.2016.239
31	1.5℃全球温控目标浅析	6395	张永香，黄磊，周波涛, 徐影, 巢清尘 (2017).《气候变化研究进展》, 2017(4), 299-305.
32	1.5℃增暖对全球和区域影响的研究进展	6484	doi:10.12006/j.issn.1673-1719.2017.159 翟盘茂, 余荣, 周佰铨, 陈阳，郭建平，卢燕宇 (2017).《气候变化研究进展》, 2017, *13*(5), 465-472.
33	1.5℃温控目标下气候工程对中国极端高温强度影响的空间差异研究	8863	孔锋 (2019).《长江流域资源与环境》, 2019(10), 2491-2503.
34	140 年后的地球将有多热北极都能长棕榈树	460	《科学大观园》编辑部 (2019). (来源: 中国科学报), 《科学大观园》, 2019(6), 7.
35	1970_2016 年冈底斯山冰川变化	6982	刘娟，姚晓军，许君利 (2019).《地理学报》, 2019(7), 1333-1344.
36	1977-2017 年萨吾尔山冰川变化及其对气候变化的响应	5256	王炎强，赵军， 张明军 (2019). 《自然资源学报》, 2019(4), 802-814.
37	1980_2011 年全球不同地区冰川物质平衡变化分析	6841	张国飞，李祥飞，李忠勤 (2018).《冰川冻土》, 2018(2), 214-222.
38	1982_2016 年北极开阔水域变化	9090	李海丽，柯长青 (2017).《海洋学报》, 2017(12), 109-121.
39	1984_2016 年全球参照冰川物质平衡时空变化特征	6961	梁鹏斌，李忠勤，何海迪 (2018).《冰川冻土》, 2018(3), 415-425.
40	CO_2 的新用途	128	《能源与环境》编辑部 (2019). 《能源与环境》, 2019(03), 22.
41	IPCC《全球 1.5℃增暖特别报告》冰冻圈变化及其影响解读	6775	苏勃， 高学杰，效存德 (2019). 《气候变化研究进展》, 2019(4), 395-404.
42	报告：碳捕获封存是缓解气候变化有效工具	545	《气体净化》编辑部 (2018). 《气体净化》, 18(6), 64.
43	北方草原区气候变化影响与适应	5995	萨茹拉，丁勇，侯向阳 (2018).《中国草地学报》, 2018(2), 109-115.
44	冰冻圈告急：2018 气候变化影响下中国冰川研究	10637	沈永平 王国亚 刘君言 李朝 (2018). https://www.greenpeace.org.cn/wp-content/uploads/2018/11/《冰冻圈告急：2018 气候变化影响下中国冰川研究》.pdf
45	捕获空气中的二氧化碳	1471	林夕 (2019).《大科技：百科新说》, 2019 (2).
46	捕集二氧化碳的希望之路	2464	章晓彤，李芳芹，任建兴, 冯海军, 侯鑫, 马闯 (2019). 《上海节能》, 2019(9), 745-748.
47	从 CMIP5 看全球 1.5 ℃升温	2039	赵宗慈, 罗勇, 黄建斌 (2018).《气候变化研究进展》, 2018, 14 (2), 218-220.

48	从特定温度段天数变化研究中国对全球变暖的响应	5642	刘新，杜中波, 杜珺, 郭林熹 (2017). 《山东科技大学学报：自然科学版》, 2017(2), 19-26.
49	大气污染控制工程-温室效应	3106	刘立忠 (2015). 温室效应, 《大气污染控制工程》, pp. 296-298. 北京: 中国建材工业出版社.
50	地球变暖的救星——将二氧化碳转化为工业原料	826	本刊编辑部 (2017). 《环球聚氨酯》, 2017(4), 47.
51	地球变暖的原因和后果	1411	周颖 (2017). 《国土绿化》, 2017.12, 47.
52	地球变暖与温室效应	5049	陈光磊 (2015). 地球变暖与温室效应. 《生态与生存》, pp. 21-24. 南京: 东南大学出版社.
53	地球变暖——最大的气象灾害	1364	高峰 (2017). 《百科探秘：航空航天》, 2017(9), 25-26.
54	地球的“蓝色心脏”亟待保护	1485	刘诗平 (2019).《海洋世界》, 2019(6), 114-115.
55	地球发烧后果严重	726	周军 (2019).《小学生导读》, 2019(3), 28-29.
56	地球将会变得有多热	2096	蒋葳 (2016).《百科知识》, 2016(20), 22-23.
57	地球三极与全球气候变化	2549	陆龙骅 (2019). 《知识就是力量》, 2019(3), 26-29.
58	地球危机	546	编辑任红雨 (2019). 《科学大观园》, 2019(22), 52-55.
59	地球真的变暖了	553	本刊编辑部 (2017). 《百科探秘(玩转地球)》, 2017(6), 2-11.
60	冬季偏暖是气候变暖所致吗	1257	吴婷 (2017). 《生命与灾害》, 2017(1), 8-9.
61	福建省极端温度事件对气候变暖的响应	6861	唐宝琪, 延军平, 曹永旺 (2016). 《中国农业大学学报》, 2016(9), 123-132.
62	福州市极端气候变化趋势研究	7209	郑玉萍, 高路, 张江燕, 朱芸 (2017). 《福建师范大学学报：自然科学版》, 2017(2), 96-104.
63	格陵兰冰盖监测模拟及气候影响研究	5320	效存德，陈卓奇，江利明, 丁明虎，窦挺峰 (2019).《地球科学进展》, 2019(8), 781-786.
64	给地球降温看上去很美	3398	泉琳 (2019).《科学新闻》, 2019(4), 43-45.
65	光伏电站对局地气候的影响研究进展	7829	崔杨，陈正洪 (2018).《气候变化研究进展》, 2018(6), 593-601.
66	海南岛 1959—2015 年气候变化特征分析	10516	罗红霞，戴声佩，李茂芬, 谢铮辉 (2018). 《江苏农业科学》, 2018(15), 261-268.
67	海洋：地球最好的“温度计”	2087	夏风 (2019). 《海洋世界》, 2019(4), 64-67.
68	海洋变暖比想象更快	2497	唐琳 (2018). 《科学新闻》, 2018(11), 37-39.
69	海洋对全球变暖的快慢响应与低温升目标	11901	龙上敏，谢尚平，杜岩 (2018). 《科学通报》, 2018(5), 558-570.
70	海洋生物比陆地生物更易受到气候变暖影响	855	《世界环境》编辑部 (2019).《世界环境》, 2019(3), 7.
71	海洋碳汇与温室效应	4992	邱潇涵, 程传东, 赵淑江 (2017). 《管理观察》, 2017(35), 77-81,84.
72	河西西部地区气候变化的时空特征分析	5384	刘琼, 张小平, 张勃 (2018). 《高原气象》, 2018(5), 1353-1363.
73	缓解全球气候变暖的自然对策	2602	钟萃相 (2016). 《科技视界》, 2016(24), 113-113,212.

74	回望上一次全球变暖	887	苏学良 (2018).《中外文摘》, 2018(13), 9.
75	基于 Biome-BGC 模型及树木年轮的太白红杉林生态系统对气候变化的响应研究	7106	李书恒, 侯丽, 史阿荣, 陈兰, 朱显亮, 白红英 (2018). 《生态学报》, 2018(20), 7435-7446.
76	基于区域气候模式未来气候变化研究综述	9133	张磊，王春燕，潘小多 (2018). 《高原气象》, 2018(5), 1440-1448.
77	基于生态网络效用的城市碳代谢空间分析——以杭州为例	3989	夏楚瑜，李艳，叶艳妹，史舟，刘婧鸣，李效顺 (2018). 《生态学报》, 2018(1), 73-85.
78	极端天气——全球变暖与频频发生的热浪、干旱、洪水	19169	《科学世界》编辑部 (2017). 《科学世界》, 2017(1), 16-45.
79	江淮流域梅雨期气候对全球气候变暖的响应	9898	吴楚樵，刘玉芝，贾瑞, 邵天彬, 汪兵 (2019). 《气象学报》, 2019(1), 84-99.
80	将全球变暖限制在1.5℃	189	《气象知识》编辑部 (2019). 《气象知识》, 2019(2), 43.
81	近 2000 年南海北部海表温度变化特征及其对全球变暖的启示	9323	肖杭芳，邓文峰，韦刚健 (2018). 《厦门大学学报：自然科学版》, 2018(6), 748-759.
82	近百年中国气候变化科学问题的新认识	10137	丁一汇，王会军 (2016). 《科学通报》, 2016(10), 1029-1041.
83	警告！全球变暖将超联合国专家预测	545	张梦然 (2018).《广西质量监督导报》, 2018(1), 17.
84	可再生能源可缓解全球变暖	123	《能源与环境》编辑部 (2019). 《能源与环境》, 2019(3), 11.
85	控制气候变暖的要素	3523	杨欣 (2016). 《百科知识》, 2016(1), 44-46.
86	南极 全球变暖导致植物快速生长	206	金凯希 (2017). 《小学时代：奥妙》, 2017(10), 25.
87	南极巨大冰川融化，反而减缓了全球变暖	588	《地球》编辑部 (2016). 《地球》, 2016(2), 9.
88	南极洲东部的冰川也受到了气候变化的威胁	1034	《世界环境》编辑部 (2018). 《世界环境》, 2018(5), 92.
89	报道：南极洲全球变暖南极气温零上天数再增加	231	《中国减灾》编辑部 (2019). 《中国减灾》, 2019(18), 5.
90	南亚热带不同造林模式碳汇林土壤碳积累与碳汇功能	6371	徐英明，虞依娜，李鑫，李昊，何明威，林森 (2019). 《生态学报》, 2019(1), 355-362.
91	欧洲冰川会在 100 年后消失	387	《环球科学》编辑部 (2019). 《环球科学》, 2019(14), 13.
92	七大方案_对抗全球变暖	1065	黄斌 (2018). 《小学生导读》, 2018(1), 52-53.
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199	我国春季短期温度波动规律 1957～2015 年	7059	彭凯，邓建明，张运林，龚志军, 秦伯强 (2019). 《气候与环境研究》, *24*(1), 125-134.
200	想缓解全球变暖种上万亿棵树	320	编辑张梦 (2019). 《科学大观园》, 2019(15), 6.
201	小尺度全球变暖的原因与大尺度气候变化的规律	2030	钟萃相 (2017). 《自然科学(全文版)》, 2017.12, 258.
202	新疆冰川分布现状及变化	4070	揭文辉，付丽华，张策，魏本赞 (2017).《河北遥感》, 2017(2), 22-25.
203	巽他区域地质气候环境演变与陆地生物多样性形成与变化	9271	翁成郁 (2017). 《地球科学进展》[Advances in Earth Science]. *32*(11), 1163-1173. doi: 10.11867/j.issn.1001-8166.2017.11.1163.
204	用太空伞解决地球变暖问题	2376	环科 (2016).《科学大观园》, 2016(12), 41-42.
205	云层加速全球变暖	5422	《厦门科技》编辑部 (2018). 《厦门科技》, 2018(1), 46-49.
206	增加 10 亿公顷的森林将有效遏制全球变暖	611	《上海节能》编辑部 (2019). 瑞士生态学家提出：增加 10 亿公顷的森林将有效遏制全球变暖 (编译自《科学》). 《上海节能》, 2019(8), 718.
207	长江源区河流水温对气候变化的响应	4907	熊明，邹珊，姜彤，李其江 (2018). 《人民长江》, *49*(14), 48-54.
208	长沙城市化发展背景下的气候变化特征	3793	谭诗琪，范嘉智，张弘豪 (2018). 《湖北农业科学》, *57*(16), 47-50, 56.

209	长沙市近 56 年气候变化趋势及突变分析	5765	罗悦，俞文政 (2017). 《安徽农业大学学报》, *44*(2), 302-307.
210	植被活动对气候变化的响应过程研究进展	7107	焦珂伟，高江波，吴绍洪，侯文娟 (2018). 《生态学报》[Acta Ecologica Sinica], 2018, *38*(6), 2229-2238.
211	植树造林在全球气候变暖中的作用及其措施	1840	蒋运辉 (2016) .《现代农业研究》, 2016(12), 64.
212	植树造林在全球气候变暖中的作用及其措施	2113	马关义 (2017). 《现代园艺》, 2017(6), 148.
213	植树造林在全球气候变暖中的作用及其措施	2691	杨立国，李道金，王文明 (2017).《中国科技博览》, 2017(1), 154.
214	中国不同时段气候变暖速率的时空分异研究 (1961-2014)	8248	孔锋，吕丽莉，方建，李曼, 王一飞, 孟永昌, 杨旭 (2017). 《北京师范大学学报(自然科学版)》, 2017，*53*(4), 426-435.
215	中国地表温度对气候变暖响应研究	19817	王磊 (2016). 东北林业大学硕士学位论文, 2016. 6.
216	中国对全球变暖影响到底有多大	625	《中国环境科学》编辑部 (2016). 《中国环境科学》, 2016(4), 999.
217	中国科学家证明二氧化碳会激发次生温室效应	289	《大众科学》编辑部 (2018). 《大众科学》, 2018(6), 9.
218	中国气候变化蓝皮书发布我国受全球变暖影响明显	383	刘强 (2018). 《中国食品》, 2018(9), 170.
219	中国气温变化对全球变暖停滞的响应	8837	杜勤勤，张明军，王圣杰，车存伟，邱雪，马转转 (2018). 《地理学报》, *73*(9), 1748-1764.
220	中国天山冰川生态服务功能及价值评估	8473	张正勇，何新林，刘琳，李忠勤，王璞玉 (2018). 《地理学报:英文版》, *73*(5), 856-867.
221	中国西部大陆性冰川与海洋性冰川物质平衡变化及其对气候响应	6159	牟建新，李忠勤，张慧，徐春海，金爽，梁鹏斌 (2019).《干旱区地理》, *42*(1), 20-28.
222	中美科学家发现全球变暖或比预估快 13%	132	《新疆农垦科技》编辑部 (2017), 《新疆农垦科技》, *40*(4), I0003.
223	种树以阻止气候变暖	392	郭政玺编译 (2017). 《能源评论》[Energy Review], 2017(12), 15.
224	重大气候突变会不会发生？	4673	任国玉 (2017). 重大气候突变会不会发生？——兼评《气候变化突发影响：预见意外》. 《气候变化研究进展》, *13*(2), 181-184.

Appendix 6 The first 42 terms extracted from MCCC by the functionality *Keywords* of Sketch Engine

	Word	Frequency		Relative Frequency		Score
		Focus	Reference	Focus	Reference	
1	变暖 'become warm'	2,412	45,170	3,560.121	2.722	956.72
2	增温 'temperature increases'	754	8,492	1,112.907	0.512	736.82
3	IPCC	422	3,357	622.874	0.202	518.89
4	高信度 'high confidence'	339	39	500.365	0.002	500.19
5	冰川 'glacier'	1,972	99,240	2,910.68	5.981	417.1
6	海平面 'sea level'	337	8,274	497.413	0.499	332.58
7	增暖 'warming'	225	562	332.101	0.034	322.19
8	冰盖 'ice sheet'	292	6,038	430.993	0.364	316.74
9	变率 'variability'	207	1,014	305.533	0.061	288.88
10	海冰 'sea ice'	282	8,758	416.233	0.528	273.09
11	暖化 'warming'	221	3,335	326.197	0.201	272.44
12	CO2	760	54,749	1,121.763	3.299	261.14
13	WGI	169	36	249.445	0.002	249.9
14	温室 'greenhouse'	1,642	145,899	2,423.598	8.793	247.59
15	信度 'confidence'	250	8,592	369.001	0.518	243.77
16	气候 'climate'	7,036	696,697	10,385.163	41.987	241.61
17	km2	206	4,924	304.057	0.297	235.25
18	SST	181	2,440	267.157	0.147	233.78
19	Et	162	1,505	239.113	0.091	220.15
20	海温 'sea temperature'	164	2,414	242.065	0.145	212.19
21	环流 'circulation'	277	17,827	408.853	1.074	197.58
22	WGII	131	2	193.357	0	194.33
23	WGIII	130	2	191.881	0	192.86
24	地表 'the earth's surface'	822	88,384	1,213.275	5.327	191.93

25	冰冻圈 ‘Cryosphere’	131	689	193.357	0.042	186.61
26	格陵兰 ‘Greenland’	157	4,254	231.733	0.256	185.24
27	GHG	128	490	188.928	0.03	184.48
28	距平 ‘anomaly’	132	1,342	194.833	0.081	181.18
29	SPM	133	1,665	196.309	0.1	179.32
30	减缓 ‘mitigate’	703	84,185	1,037.631	5.073	171.01
31	冰期 ‘glacial period’	143	5,728	211.069	0.345	157.65
32	温升 ‘temperature rise’	206	16,503	304.057	0.995	152.94
33	地温 ‘ground temperature’	169	10,638	249.445	0.641	152.61
34	圣婴 ‘holy baby’	117	2,924	172.692	0.176	147.67
35	气溶胶 ‘airosol’	163	11,277	240.589	0.68	143.84
36	日数 ‘days’	162	11,621	239.113	0.7	141.21
37	北半球 ‘the Northern Hemisphere’	190	17,388	280.441	1.048	137.43
38	海表 ‘sea/ocean surface’	93	550	137.268	0.033	133.83
39	平流层 ‘stratosphere’	108	3,553	159.408	0.214	132.12
40	冈底斯山 ‘Gangdisê Range’	94	1,049	138.744	0.063	131.44
41	GMST	87	8	128.412	0	129.35
42	二氧化碳 ‘carbon dioxide’	889	154,697	1,312.167	9.323	127.21

Appendix 7 The first 45 words extracted from MCCC by the functionality *Wordlist* of Sketch Engine

	Word	Frequency
1	的 structural particle	38,571
2	和 'and' conjunction	8,995
3	在 'at/in' preposition	7,036
4	气候 'climate'	7,036
5	变化 'change'	6,425
6	是 'is'	4,899
7	年 'year'	4,589
8	全球 'globe'	4,363
9	了 aspectual particle	3,744
10	对 'for' preposition	3,528
11	影响 'influence'	3,129
12	中 'inbewteen' preposition	3,109
13	与 'and' conjunction	3,082
14	为 preposition 'for'	2,913
15	温度 'temperature'	2,751

	Word	Frequency
16	一 numeral 'one'	2,533
17	会 auxiliary verb 'will'	2,508
18	地区 'region'	2,414
19	变暖 'become warm'	2,412
20	研究 'research'	2,357
21	个 nominal measure word	2,167
22	气温 'air temperature'	2,155
23	将 'will'	2,073
24	有 'have'	2,061
25	增加 'increase'	2,036
26	冰川 'glacier'	1,972
27	系统 'system'	1,918
28	这 demonstrative pronoun 'this'	1,827
29	平均 'average'	1,827
30	趋势 'trend'	1,823

	Word	Frequency
31	也 adverb 'also'	1,799
32	等 'etc.'	1,731
33	地球 'the Earth'	1,699
34	而 conjunction	1,686
35	温室 'greenhouse'	1,642
36	海洋 'ocean'	1,572
37	到 'to' preposition	1,570
38	大气 'atmosphere'	1,550
39	及 'and' conjunction	1,485
40	下 preposition 'under'	1,451
41	上升 'rise'	1,447
42	排放 'emit'	1,438
43	碳 'carbon'	1,422
44	气体 'gas'	1,314
45	不 adverb 'no'	1,308

Appendix 8 Delimitation criteria of Chinese lexical units

This Appendix expounds on the criteria for delimiting Chinese lexical units (including explanation of Chinese morphemes and word-formation, and discussion on methods for differentiating between Chinese words and phrases)

For Chinese, what identifying characteristics do lexical units share? Which criteria can be used to identify lexical units? To answer these questions, let us first look at the delimitation of *word* (词) in Chinese since *word* is the linguistic unit closest to *lexical unit*. Word in Chinese is the smallest meaningful language unit that can stand on its own and freely enter sentences (Liu *et al*, 1983:2).

Determining word boundaries in Chinese is no easy task. No obvious clues can be drawn from the word form. In written Chinese, a sentence seems to be made up of Chinese characters and punctuation marks with no natural boundaries such as spaces between words. Different from Indo-European languages such as English and Roman languages such as French, a word in Chinese never shows inflectional changes of its form regardless of tense, voice, or its syntactic position in sentences. For example, 变 (bian, 'change') never changes its form whether it is in 我变了('I changed'), 你变了('you changed'), 他变了('he changed'), or in 想法已经变了('thoughts have changed'), 想法正在变('thoughts are changing'), 想法会变的('thoughts will change').

Today's disyllabic-word-dominant modern Chinese has evolved from ancient Chinese, in which most words are monosyllabic. In this evolving process, monosyllabic words in ancient Chinese have gradually developed into morphemes, free or bound, in modern Chinese (Zhang, 1985: 28, 31). To illustrate, in ancient Chinese, 海 (hǎi, 'sea') is a one-syllable word, so is 洋 (yáng, 'ocean'); however, 海洋(haiyang, 'ocean') is a word in modern Chinese consisting of two morphemes – 海 and 洋. It is interesting to see that a number of monosyllabic words from ancient Chinese are still present in today's modern Chinese, notably in today's four-character 成语 ('set phrases') and idioms. For instance, in the set phrase 稍纵即逝(shaozòngjishi, 'transient'), 纵(zòng, 'let go')and 逝(shi, 'pass') are one-syllable words from ancient Chinese, meaning 放松 (fàngsōng, 'relax') and

消失 (xiāoshi, ‘disappear’) respectively. It is perhaps this presence of ancient Chinese single-syllable words that hinders the intuition of word boundaries for native Chinese speakers. Questions arise even for native speakers whether 海洋 is a word in itself or two words, or whether 寒冷(hánleng, ‘cold’) is a word or two words.

Furthermore, the inner structure of many words in Chinese resembles much to that of phrases. A free morpheme can enter sentences by itself and stand on its own. A compound disyllabic word composed of two free morphemes and a phrase made up of two words (each word being a free-morpheme word) are not easily distinguishable (Fang, 2019). For example, the linguistic status of lexical items 海洋(hǎiyáng, ‘ocean’), 升温(shengwen, ‘temperature rises’), 降低, 变暖 extracted from corpus MCCC, are not readily ascertained. Determining which one of the four is a word and which one is a phrase is not straightforward even for native speakers. Besides, the existence of special kinds of words called *separable words* (‘离合词’) makes the task of word delimitation much more complicated because separable words in Chinese are words that allow insertion of certain elements and this insertion also leads to difficulties in differentiating separable words and phrases.

Though this research is by no means a study on Chinese word-formation or word segmentation, word delimitation is an insurmountable issue that must be tackled if we want to delimit lexical units since words are linguistic items fairly close to lexical units in Chinese. Once we understand properties of Chinese words, we could transit our discussion from *word* to *lexical unit* and elaborate on characteristics of Chinese lexical units before proposing criteria for identifying Chinese lexical units or Chinese terms. Reasons why it is more preferable to define terms in Chinese as lexical units but not words will also be discussed once we have a full understanding of Chinese lexical units.

To be able to delimit Chinese words, distinguish words from phrases and grasp the exact meaning of words, we need to understand the inner structure of Chinese words and most importantly how words are formed by morpheme(s). Morpheme, the smallest grammatical unit, is the smallest

combination of phonetic sound and meaning (Liu *et al.*, 1983: 1). Chinese is a language of one-syllable morpheme (Fang, 2019) – the majority of morphemes in Chinese are monosyllabic. To illustrate, 变 (*bian*, 'change'), 上 (*shang*, 'up'), 升 (*sheng*, 'rise') and 融 (rong, 'melt/blend'), 增 (*zeng*, 'increase') are one-syllable morphemes – they are meaningful and cannot be further divided. There are also a small number of two-syllable morphemes. For instance, 逍遥 (xiaoyao, 'free and unfettered'), 彷徨 (panghuang, 'hesitate about which way to go'), 徘徊 (paihuai, 'wander up and down'), and 咖啡 (kafei, 'coffee') are two-syllable morphemes that carries no lexical meaning once divided into 逍, 遥, 彷, 徨, 徘, 徊, 咖, or 啡. Morphemes consisting of three or more syllables are only a few, examples including 巧克力 (qiaokeli, 'chocolate'), 舒芙蕾 (shufulei, 'souffle'), 提拉米苏(tilamisu, 'Tiramesu'), 奥林匹克 (aolinpike, 'Olympic').

Chinese is a syllabic language – a one-syllable morpheme is represented by one Chinese character in writing; therefore, the vast majority characters correspond to morphemes (Liu *et al.*, 1983: 1). The character 下 ('down'), 减 ('reduce') and 降 ('fall') each represents a morpheme. However, some characters do not correspond to morphemes. To illustrate, none of the six characters 逍, 遥, 徘, 徊, 彷, 徨 corresponds to a morpheme because none of them carries meaning when appearing as single character.

There are also characters that represent more than one morpheme and carry different meanings in different words. As shown in 现代汉语大词典(*Modern Chinese Dictionary*, 2007), the character 冰 corresponds to three morphemes, each can be associated with a different part of speech : 冰 in the word 冰川 ('glacier') is a noun denoting the solid 冰 ('ice') that water turns into when it falls below zero degree centigrade; 冰 in the sentence 水好冰('the water is so cold') is an adjective describing the state of being cold; 冰 in the context 你把果汁冰上 ('please ice the juice') can also be a verb meaning making something cold by putting it together with ice or putting it into the fridge. The character 川 represents three morphemes, denoting three different entities – river (in 百川归海, 'all rivers flow into the sea'), a flat ground or open countryside (in 一马平川, 'a vast expanse of flat land'), or road (in 我走这条川, 'I will follow this road'). What is interesting is that though 冰 and 川 each carry three meanings when standing alone in contexts,

the word 冰川，the two characters appearing together, becomes the bearer of the sole meaning of “glacier”.

Recognising different categories of morphemes in Chinese is the prerequisite for a clear understanding of the differences between simple words (单纯词), synthetic words（合成词） and compound words（复合词）. Morphemes can be divided into four types, namely free morphemes, bound morphemes (morphemes that are not free), half-free morphemes, morphemes that are generally not free (Lv, 1980: 4).

- Free morphemes – morphemes that can either stand as words by themselves or combine with other morphemes to form compound words. For example, 冰(bīng, ‘ice’), 海 (haǐ, ‘sea’) and 变 (bian, ‘change’) are free morphemes. They can stand alone in sentences or combine respectively with morphemes 川(chuān), 水(water) and 化 (hua) to form compound words 冰川(bīngchuān, ‘glacier’), 海水 (‘sea water’) and 变化(‘change’).
- Bound morphemes – morphemes that cannot stand on theirown in sentences, but must combine with other morphemes to form words. 融(róng), for instance, is a bound morpheme that cannot enter sentences by itself. It must combine with other morphemes: 消（xiao）, 解(jiě) or 化(huà) to form words 消融(xiaorong, ‘melt’), 融解(róngjiě, ‘melt’) and 融化 (rónghuà, ‘melt’).
- Half-free morphemes – morphemes that can not only combine with morphemes words, but also phrases and sentences. Examples that Lv (1980) enumerates include 着(zhe), 了(le), 还 (hai).
- Morphemes that are not free in most cases– morphemes that are generally recognised as morphemes that are not free, but can act as free morphemes under certain circumstances. One particular example is the morpheme 氧(yǎng, ‘oxygen as a chemical element’), which generally speaking cannot stand on its own as a word, but has to combine with 气(qì, ‘gas’) to form 氧气 (yǎngqì, ‘oxygen’). Nevertheless, in specialised texts from the domain of chemistry, 氧 is observed to become a free morpheme that functions as a word by itself.

Free morphemes and bound morphemes are the most relevant and the most important for word delimitation (Fang, 2019:29) as well as for distinguishing words from phrases. Words in Chinese are mainly constructed through the following four types of combination (Fang, 2019: 28), example words taken from MCCC.

a	Bound morpheme + Bound morpheme (B+B)	影 响('influence')、 发 生 ('happen')
b	Bound morpheme + Free morpheme (B+F)	累 积('accumulate')、 突 变 ('mutate')、结果('result')
c	Free morpheme + Bound morpheme (F+B)	暖 化('warming')、 升 温 ('temperature rise')、 消 融 ('melt')
d	Free morpheme + Free morpheme (F+F)	升 高('rise high')、 减 弱 ('attenuate')、退缩('retreat')

Words whose inner structure conform to *a*, *b* or *c* are called synthetic words("合成词") whereas words conforming to *d* are referred to as compound words ("复合词") (Fang, 2019: 28). Because a bound morpheme cannot stand alone as a word, any two-character combination is a word if at least one character is a bound morpheme (Yi, 2007:40; Wang, 2008:32). This confirmation provides firm linguistic grounds for the differentiation of words from phrases when validating candidate terms proposed by Sketch Engine, especially for a number of problematic cases. To clarify, candidate term 升温(shengwen, 'temperature rises') on the Keyword list is by intuition a word rather than a phrase. However, doubts arise when we try to divide this word into 升 and 温. It appears that 升 can act as a word as in, for example, 温度升了 ('the temperature rises'), and that 温 is also capable of being a word as in, for instance 水是温的('the water is lukewarm'). This seemingly compositionality questions the status of 升温 as a word. Nevertheless, it should be noted that the meaning of 温 in 升温 is 温度('temperature') whereas 温 in 水是温的('the water is lukewarm') bears a different meaning of being warm or lukewarm. When expressing the

meaning of 'temperature', 温 must be attached to 度 to form the word 温度 (wendu, 'temperature'); 温 cannot stand on its own to mean 'temperature' 温度. Therefore, we know that 温 corresponds to two morphemes – a free morpheme meaning warm and a bound morpheme meaning temperature. The meaning of 升 in 升温 is 'rise' and when expressing the very meaning of 'rise', 升 can stand as a word by itself as in 温度升了('the temperature rises'). Ultimately, 升温, conforming to structure c, is a word composed of a free morpheme 升 and a bound morpheme 温.

Free morphemes account for the majority of morphemes in Chinese. Su (1995) investigates 1000 characters that are most frequently used in Chinese and found that 983 out of 1000 characters are free morphemes whereas the rest 17 characters are bound morphemes or single syllables carrying no substantial meaning. Because free morphemes can act as words by themselves, some Chinese words whose internal structure accord with structure *d* (F+F) are not readily distinguishable from phrases. To illustrate, candidate term 升高 (shenggao, rise high) on the Keyword list is composed by a free morpheme 升(sheng, rise) and a free morpheme 高(gao, high). It is intuitively a word rather than a phrase. However, the fact that 升高 can be extended to have elements inserted in between 升 and 高 as in the phrase 升得很高 ('rise to very high') seems to validate its status as a phrase. Other candidate terms extracted from MCCC that share the same F+F internal structure with 升高 include 上升、降低、下降、减弱、增强.

In order to determine whether these two-character lexical combination with F+F internal structure such as 升高 are phrases or compound words, we must resort to some methods and tests that confirm our intuition. Scholars researching in Chinese word-formation have recommended various methods for testing words from phrases. Now we will investigate three methods that are employed when validating candidate terms from phrases in this research.

Drawing support from the definition of *word* is the first method for validating the status of word in this research. As pinpointed by Cruse (1986: 35), words are "the smallest mobile units". Word in Chinese is the smallest form that can enter sentences without being associated with certain

elements (Fang, 2019: 23). One particular example of a word in Chinese is 冰川(bingchuan, 'glacier').

(1) a. 冰川融化了吗？Have glaciers melted?

b. 全球冰川正在加速消融。Global glaciers are melting in an accelerating rate.

(2) 小玉：南极的什么正在因为气候变暖而融化?

What is now melting in Antarctica because of climate warming?

小雨：冰川。 *Glacier.*

It can be easily seen from (1) and (2) that the lexical form '冰川' is a word that can be used freely in sentences, and can be the answer to a question by itself. Although 冰川 is comprised of two characters – two morphemes 冰 and 川 and we thus can divide 冰川 into even smaller units – 冰 and 川, neither 冰 nor 川 could express the meaning of the word 冰川. Though 冰 and 川 is capable of each being a smallest meaningful unit, when they combine to form 冰川, a new free meaningful unit is formed that can stand on its own to denote the large solid ice that is formed as a result of years' recrystallization of snow. With the help of the definition of *word* in Chinese, we can validate certain about the status of word of a number of candidate terms in this research including 退缩(tuisuo, 'retreat'), 吸收(xishou, 'absorb'), 波动.

The definition of Chinese words as "the smallest mobile units" proves to be genuinely useful when validating candidate terms in this research, especially for some problematic cases such as 变暖 (biànnuan, become warm) and 变冷 (biànlěng, 'becomes cold'). 变暖 (biànnuan, become warm) is the first candidate term proposed by Sketch Engine on the Keyword list. Though intuitive judgement may lead us to believe that 变暖 is a word, the following three examples question whether 变暖 is a smallest free unit.

(3) 气候变暖。*Climate becomes warm.*

(4) 气候变冷。*Climate becomes cold.*

(5) 气候变热。*Climate becomes hot.*

Suppose 变暖 is a word, then it must be a smallest free unit in sentences. Nevertheless, 暖 can be substituted with 冷（leng, 'cold'） as in (4) and 热(re, 'hot') as in (5). Therefore, 变暖 is not

the smallest free unit in sentence (3); rather, 变(bian, 'change') and 暖(nuan, 'warm') is each a smallest free meaningful form. Other evidence supporting that 变暖 is a phrase rather than a word is that we could expand it by inserting other elements in-between 变 and 暖. For instance, by inserting 得 and 很, 变暖 becomes 变得很暖, which makes perfect sense meaning 'become very warm'. Similarly, 变冷 can be expanded into 变得非常冷('becomes very cold'). The fact that adding more elements into 变暖 and 变冷 is also possible further proves that 变暖 and 变冷 are verb-complement phrases (动补短语) where 暖 and 冷 are respectively the complement(补语) of the verb 变. To illustrate, we could say 今年气候变得比前些年都要冷一些 ('Climate of this year becomes colder than that of previous years'). Given these points, 变暖 is a phrase, but not a word.

The second method used in this research to validate word status is the *insertion criteria* proposed by Wang (1943) and expanded by Lu (1957). According to this criterion, a combination is a word if it does not allow any insertion in the combination, and if it does allow, the combination is highly probably a phrase. One particular example is 变化. 变化 is a word since any insertion between 变 and 化 is not allowed. To clarify, it is impossible that we insert elements such as 着, 过, 得, 不 in between 变 and 化. *变着化, *变过化, *变得化, *变不化 do not make any sense. Using this method, we could validate word status of candidate terms extracted including 融化, 暖化, 排放, 释放 吸收, 改变, 蒸发 etc. However, as pinpointed by Fang (2019), this method can only ascertain word status of synthetic words containing bound morphemes, but not effective for verifying compound words. Indeed, compound words such as 降低, 升高, 减弱 are words though they do allow insertion of certain elements in-between. These words, named as Separable Verbs （离合词）in Chinese grammar, are exceptions for the Insertion Criteria. Overall, a two-character combination must be a word if it does not allow any insertion; however, if it does allow, it does not necessarily lead to the confirmation that it cannot be a word.

The third method is to evaluate whether a verb is a separable word（ '离合词'）. The concept of 离合动词('separable verb') was first advanced by Zhang (1957). Separable verbs in Chinese

refer to a group of Chinese verbs that behave as words when used with its constituents unseparated, but act as phrases when its constituents are separated (Zhang, 1957: 8). To clarify, 唱歌(chànggē, sing) is a separable verb that can function as a verb when the two characters are bind together and seen as a whole. For instance, in the sentence 她唱歌了('She sang'), 唱歌, but not 唱 acts as the sentence predicate while 歌 is not the object of 唱. Because the inner structure of separable verbs like 唱歌 resembles very much that of a phrase, 唱歌 can also be a Verb-Object phrase when its constituents 唱 and 歌 appear separately as in the sentence 她唱了一首歌('She sang a song'). In this sentence, 唱 is the predicate with 歌 as its direct object.

Regarding different types of separable verbs, Chinese scholars have put forward six kinds of separable verbs, namely 动宾型 Verb-Object separable verbs (Jin, 1984; Nie & Wang, 1994; Duan, 1994; Wang, 1999; Cao & Feng, 2003), 动补型 Verb-Complement separable verbs (Jin, 1984; Nie & Wang, 1994; Wang, 1999; Cao& Feng, 2003) 联合型 Coordinative separable verbs (Jin, 1984; Nie & Wang, 1994 Duan, 1994; Wang, 1999) , 主谓型 Subject-Predicate separable verbs (Wang, 1999; Cao& Feng, 2003).

- 动宾型 Verb-Object e.g. 操心, 理发, 洗澡
- 动补型 Verb-Complement e.g. 提高, 降低
- 联合型 Coordinative e.g. 尊敬, 修改
- 主谓型 Subject-Predicate e.g. 头疼, 眼红
-

降低(jiangdi, 'reduce'), composed by two free morphemes 降(jiang, 'fall') and 低(di, 'low') is included as an example for verb-complement separable verb in Jin (1984) and Cao & Feng (2003). To clarify, 降低(jiangdi, 'reduce') behaves as verb when the two characters are bond together as in sentence 气温逐渐降低 'Air temperature gradually falls'. In comparison, when the two character appear separately as in sentence 气温降得极低('Air temperature has fallen to a very low level'), 降得极低('fall to a very low level') is a phrase with 低(di, 'low') being the complement of the predicate verb 降. As mentioned earlier, lexical items extracted from MCCC such as 升高

(shenggao, ‘rise high’), 降低(jiangdi, ‘reduce’), 减弱(jianruo, ‘weaken’) are quite problematic cases because the intuitive judgement that these lexical forms are words is challenged by the fact that they can expand into verb-object phrases 升得非常高(‘rise very high’), 降得极低(‘fall to a very low level’) and 减到很弱(‘attenuate to a very low level’). As a matter of fact, 升高(shenggao, ‘rise high’), 降低(jiangdi, ‘reduce’), and 减弱(jianruo, ‘weaken’) are compound words as their status as separable words is confirmed in Chinese linguistics (Pan, Ye, Han, 1993).

Appendix 9 The screenshot of the *Concordance* page of Sketch Engine