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Towards a New Typology of Meteorological Events: A Study Based on Synchronic and Diachronic Data

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Abstract

In this article, we expand the typological studies on weather expressions by bridging linguistic and meteorological ontologies. Based on our investigations into weather words of Sinitic languages from both synchronic and diachronic perspectives, we propose a new weather event typology, typology of meteorological events (TyME), with two binary features, [±Process] and [±Material]. We argue that this typology covers more weather phenomena in a systematic and ontologically transparent way and can benefit synchronic and diachronic studies on weather and language. In addition, a cross-linguistic investigation is conducted on previously less studied meteorological expressions: fog, dew and frost. The results show that fog, dew and frost can be said to fall in the majority of the languages, which seems to contradict their meteorological formation behaviours, but in fact conforms to natural laws. Based on the new weather event typology and analysed data, we discover that fog, dew and frost all correlate with precipitation in terms of directionality and encoding types. The two binary features we propose account for these formerly overlooked weather events as well as others and can provide effective assistance in analysing the mechanisms underlying those seemingly scientifically infelicitous expressions.

Keywords: Weather Event Typology; Sinitic languages; Directionality; Fog; Dew; Frost

1 Introduction

A conversation can always start with 'What's the weather like today?' but the question may get a full range of different answers. It could be sunny or cloudy, snowy or rainy, windy or calm, hot or cold, dry or damp, or simply 'lousy'. This shows that weather is so important and closely related to our lives that we cannot ignore any type of it. On the other hand, weather remained one of the most mysterious phenomena for a long time in human history. People without scientific knowledge might wonder who pours down the heavy rain, what forces the wind to blow, where the thunder comes from, why there is dew on grass in the morning, or how the fog comes out, gets thicker and then disappears. Being important and mysterious at the same time, weather offers many possibilities of conceptualisation (in the sense of cognitive semantics), thus bringing about the linguistic diversity of meteorological expressions. As Langacker (1991: 365) pointed out, it rains differently in different languages: the same phenomenon may be expressed as (literally) *Rains*, *It rains*, *Rain falls*, *It falls rain*, *Rain is*, *Rain goes* and *Rain rains*.

Weather expressions have long been drawing linguists' attention and have posed challenges for semantic and grammatical studies, e.g., participants in weather events can be hard to identify and weather verbs being unaccusative or unergative is highly debatable (Levin & Krejci, 2019). In recent years, more research on weather expressions has been conducted from cross-linguistic or typological perspectives. Based on the results of previous cross-linguistic studies such as Ruwet (1991), Bartens (1995), Saarinen (1997), Mettouchi & Tosco (2011) and Salo (2011), a more influential framework was proposed by Eriksen et al. (2010, 2012). Following the previous research's focus on argument structure, they put forward a three-fold typology of weather constructions, predicate type ('*It rains*'), argument type ('*Rain is*') and argument-predicate type ('*Rain rains*'), depending on the element which was primarily responsible for encoding the meteorological event. Furthermore, Eriksen et al. (2012) added a semantically based typology of weather events to the formal one. Weather phenomena were then divided into dynamic and static events, with the former consisting of precipitation (e.g., rain, snow, hail) and non-precipitation (e.g., thunder, lightning, wind), and the latter consisting of atmospheric conditions (e.g., warm, humid, darkness) and light emitting (e.g.,

sunshine). With the two typological systems of weather constructions and events, it is possible to establish a typology of languages. Because different types of weather events may tend to be associated with a specific encoding type, and different languages vary in terms of selecting the encoding type for a given event type (Eriksen et al., 2012). For example, Eriksen et al. (2012) argued that all precipitation events were encoded with either the argument, predicate or argument-predicate type in a specific language, thus leading to three language types. This model can serve as a useful tool in studying meteorological expressions in different languages. Recent studies such as Van Hoey (2018) and Andrason (2019) have looked into weather sentences in Mandarin Chinese and the Polish language with the help of such typology.

Also, studies of the historical development of weather words have been conducted. Eriksen et al. (2010) presumed that the encoding type of precipitation events might change following the pathway of argument type to argument-predicate type, and further to predicate type, since the predicate type was argued to be the most 'customised' pattern for meteorological expressions, i.e., it was a special structural application in this semantic field, while the argument type was considered the most 'trivial' encoding method. Further support for such hypothesis can be found in Bleotu (2012), who mentioned that verbs for falling in Finnish and Hungarian had lost the original meaning and could only mean raining or precipitating. Andrason & Visser (2017) argued that the synchronic variation of cognate objects of weather verbs exhibited in six African languages had a diachronic explanation, and might be represented as a grammaticalisation path. Most recently, Ren & Dong (forthcoming) examined 19 weather events in Old Chinese and Middle Chinese, and found that the encoding methods for these events had undergone a shift from predominantly predicate type to predominantly argument type during such period.

There are two possible approaches to classify meteorological expressions. The first approach takes linguistic categories as the starting point, such as the studies introduced above, and proposes typologies of weather expressions in terms of grammatical structures. On the other hand, the second one takes meteorological taxonomy as the starting point, and looks at how different weather phenomena in the system of meteorology are encoded in languages. The second approach has the potential benefit of being able to shed light on the relation between language and weather. For example, three types of

atmospheric water, i.e., precipitation (e.g., rain), condensation (e.g., dew) and suspension (e.g., fog), are encoded differently in terms of directionality and parts-of-speech (PoS) of weather expressions in Sinitic languages (Huang & Dong, 2020). To the best of our knowledge, very little research on typology of weather words has been conducted taking the second approach. In this article, we aim to explore the meteorology-driven approach in order to build a new typology of weather expressions that can well combine and bridge linguistic and meteorological ontologies.

Note that since previous studies focused on how languages encoded weather events in their grammatical systems, it is possible to overlook some meteorological phenomena. For example, weather phenomena such as fog, dew and frost were rarely accounted for in previous studies. Such phenomena are common to most societies, and may play a considerable part in agriculture and transportation, thus certainly deserve careful consideration. Besides, several of the latest studies have shown that the weather words for these phenomena in Sinitic languages have quite intriguing grammatical and semantic behaviours (e.g., Dong, 2018, 2019; Dong et al., 2020). More importantly, as we will see later in this article, a closer cross-linguistic investigation on fog, dew and frost may have significant implications for the typology of meteorological events at issue. In the current study, therefore, we will also examine how the three weather phenomena are expressed in various languages, and provide analysis based on our suggested typology of weather expressions.

The article is structured as follows. In Section 2 we explicate why Sinitic languages offer a unique opportunity for the study of language and weather, and provide insights into typological research of weather expressions gained from Sinitic languages. In Section 3, we make several suggestions on improving the typological study at issue. Most importantly, we propose a new typology of meteorological events and argue for its advantages in terms of coverage and explanatory power. With this established, in Section 4 we conduct a cross-linguistic investigation on the previously less studied weather events fog, dew and frost; in Section 5 we discuss the results of this investigation and offer accounts based on our proposed typology. In Section 6, we reclassify linguistic expressions for weather events with the new typology, which further illustrates its principles and adds more arguments for its usefulness. In Section 7, we further elaborate on the nature of the two features we use to build the new typology and why they can help with the study of language and weather.

Section 8 concludes and states possible future work.

2 Insights from Sinitic Languages

Previous typological research on weather expressions typically relies on eclectic data collection guided by pre-existing descriptions and research and constrained by availability of typological data. That is, it has been quite difficult, if not impossible, for a single study to systematically cover a clearly defined range of meteorological or linguistic variations. We explore the possible theoretical and methodological implications by comprehensive research of language variation and change data in Sinitic languages.

Sinitic languages exhibit a full range of linguistic differences through both language change and language variations and are synchronically *bona fide* languages by the linguistic definition of mutual intelligibility, in spite of the long tradition to refer to them as dialects in Chinese literature. They can benefit the typological research as the language family has more than 1,000 well documented languages and dialects (Tian & Yi, 2019) and has unbroken written documentation containing meteorological data for over 3,000 years (Huang & Shi, 2016: 8). Based on Sinitic languages, we can easily compare differences of meteorological expressions to other attested morphosyntactic differences across languages, and we can apply a proposed typological framework to diachronic changes and also verify its validity. In addition, Sinitic languages are spoken over an extremely wide range of climates. Due to the vast territory and complex landforms of China, all climate classifications demonstrate an exceptionally large scale of climate types and regions valid for it: from tropical to boreal zones, from rainy to dry and to ice-snow climates (Domrös & Peng, 1988: 230). The confluence of these facts offer a unique opportunity for the study of typology of weather expressions.

With access to both diachronic and synchronic data from Sinitic languages, we propose to explore the following three aspects of typological research on weather expressions.

First, improving and supplementing the typology of encoding methods for precipitation. Eriksen et al. (2012: 392) claimed that every language tended to stick to one encoding type for expressing precipitation events. In Old Chinese, things seem to be the exact opposite: all encoding types can be used for precipitation. According to Ren (2018), 雨 *yǔ*, 雪 *xuě* and 雹 *báo* can function as both nouns and verbs in Old Chinese, denoting rain, snow and hail, or to rain, to snow and to hail respectively. In other words, precipitation events can be

encoded with argument type and predicate type. Moreover, Ren & Dong (forthcoming) have also found in Old Chinese examples of argument-predicate type, and the 'generalised predicate type' as well, where the verb had undergone a semantic shift to denote precipitating (Eriksen et al., 2012). For example, as cited from Ren & Dong (forthcoming), 澍 *shù* in Old Chinese can be used as a noun meaning rain, or as a verb meaning to rain. Thus, 澍雨 *shù yǔ* in (1) demonstrates a case of the argument-predicate type where both the argument (雨 *yǔ*) and the predicate (澍 *shù*) denote the weather event. In addition, except for the meaning of rain and to rain, 雨 *yù* (bearing a different tone) in Old Chinese has another verbal usage to denote the process of objects falling from the sky like raining. That is to say, 雨 *yù* is a verb with a specific meaning 'to precipitate' when used in this sense, as shown in (2) and (3) below. Therefore, 雨雪 *yù xuě* 'to snow' and 雨雹 *yù báo* 'to hail' in these two sentences should fall into the generalised predicate type. It can be seen from the above analysis that precipitation events are not encoded with one type only, as predicted by Eriksen et al. (2012), but employ all the encoding types in Old Chinese.

(1) 须臾澍雨
xūyú__shù__yǔ
moment__to-rain__rain
'It started to rain a moment later.' (Biographies of loners, in *Book of the Later Han*)

(2) 今我来思, 雨雪霏霏
jīn__wǒ__lái__sī__yù__xuě__fēifēi
now__I__come__SI__fall__snow__snowflake-sifting-alike
'Now when I am coming back, the snowflakes are sifting all over the sky.' (Cai wei, in *Shi Jing*)

(3) 秋, 大雨雹, 为灾也
qiū__dà__yù__báo__wéi__zāi__yě
autumn__heavily__fall__hail__be__disaster__YE
'It hailed heavily in autumn, which was a disaster.' (Xigong, in *Zuo Zhuan*)

Second, to explore the pathways of language change in terms of encoding types. Eriksen et al. (2010) hypothesised that the encoding method for precipitation followed a single pathway: argument type → generalised predicate type/argument-predicate type → predicate type. This hypothesis also meets

challenges posed by Sinitic languages. We have mentioned above that 雨 *yǔ* 'rain/to rain', 雪 *xuě* 'snow/to snow' and 雹 *báo* 'hail/to hail' have verbal usage in Old Chinese, as illustrated in (4)-(6) below, quoted from Ren (2018). This means that Old Chinese has the predicate encoding type for precipitation, as noted by Van Hoey (2018) and Dong et al. (2020). Furthermore, Ren & Dong (forthcoming) stated that predicate type was the predominant encoding type for precipitation among all the available methods in Old Chinese. On the other hand, modern Chinese, whether Mandarin or other Sinitic languages, has predominantly adopted the argument type to encode raining (下雨 *xià yǔ* fall-rain), snowing (下雪 *xià xuě* fall-snow) and hailing (下冰雹 *xià bīngbáo* fall-hail). Hence, it can be observed in Sinitic languages that the direction of encoding type change is just the opposite of the prediction in Eriksen et al. (2010).

(4) 是日, 饮酒乐, 天雨
shì__rì__yǐn__jiǔ__lè__tiān__yǔ
this__day__drink__wine__merry__sky__rain
'On this day, it rained when (they) were making good cheer.' (Wei ce, in *Zhan Guo Ce*)

(5) 癸巳雪
guǐ__sì__xuě
Gui__Si__snow
'It snowed on the day of Gui Si.' (*Oracle Bone Script Collection*)

(6) 壬子, 夕雹
rén__zǐ__xī__báo
Ren__Zi__nightfall__hail
'It hailed at nightfall on the day of Ren Zi.' (*Oracle Bone Script Collection*)

Third, to extend the coverage of the typology of weather expressions to cover additional types of weather events such as fog, dew and frost. These three phenomena are important to human society but are scarcely discussed in Eriksen et al. (2010, 2012). It is also unclear how they would be accounted for in the weather event typology of Eriksen et al. (2012). Meteorological studies (e.g., Ahrens, 2012) observe that dew and frost are commonly formed on cold surfaces by changing water vapour into dewdrops or ice via cooling, and fog is usually formed by cooling or by mixing of relatively dry air with moist air caused by evaporation. It can thus be seen that dewing and frosting are not dynamic

events, but rather static ones. Nevertheless, to dew and to frost are different from the static events in Eriksen et al.'s (2012) typology, because they are neither atmospheric conditions such as warm, humid or darkness, nor light emitting events like sunshine, and they have tangible weather substances while the other static events do not. Therefore, dew and frost cannot be put into the dynamic or the static event group, i.e., Eriksen et al.'s (2012) event typology. Fog, on the other hand, is special in that it seems to be both static and non-static, but in a rather complex way. As pointed out by Ren & Dong (forthcoming), when viewed from outside, if possible, the foggy air may sometimes be observed moving to the effect of wind, but normally not as dynamic as precipitation or lightning, since fog is not likely to happen in windy conditions (Ahrens, 2012). However, when people are in the foggy area, what they can perceive is a vast expanse of whiteness with low visibility, which resembles the static events such as being light or dark, regardless of if the fog actually moves or not. In addition, not only can the viewing position, either being inside or outside of a foggy area, affect a person's perception of fog as static or not, it also has influence on whether a tangible substance can be recognised in such a weather event. From a distance, fog may have a clear-cut shape similar to clouds, but no palpable substance is easy to identify when people are surrounded by suspended fog droplets. As we can see from above, it is difficult to find fog, dew and frost suitable positions within the existing weather event typology. Additionally, Eriksen et al. (2012) stated that the supportive verbs for precipitation events with argument encoding type were rarely extended to the expressions of other weather events in one given language. Fog, dew and frost in Sinitic languages seem tricky again. Dong et al. (2020) and Huang & Dong (2020) have shown that 霧 *wù* 'fog', 露 *lù* 'dew' and 霜 *shuāng* 'frost' can share the same verbs such as 下 *xià* 'to fall' and 降 *jiàng* 'to fall' with 雨 *yǔ* 'rain', 雪 *xuě* 'snow' and 雹 *báo* 'hail' in Mandarin and other Sinitic languages, which serves as another challenge for previous generalisations.

3 Typology of Meteorological Events: A New Proposal

Previously published typologies of meteorological expressions, especially the ones in Eriksen et al. (2010, 2012), provide solid and reliable foundations for further cross-linguistic studies on weather phenomena. However, such typologies were not tested over languages spoken over a wide range of meteorological diversity, neither over diachronic changes. We propose several

minor revisions, in the spirit suggested in Eriksen et al. (2010, 2012), to address the challenges we have stated previously.

We have claimed that the prediction about the precipitation encoding method in a given language is too strong. However, there is still a tendency to express precipitation events with a specific encoding type in Sinitic languages, be it Old Chinese, Middle Chinese or Modern Chinese varieties, i.e., predominant though not exclusive encoding methods can be found in different stages of Sinitic languages. For example, predicate type is the predominant encoding type among the four existing ones in Old Chinese (Ren & Dong, forthcoming). Therefore, it might be more reasonable to revise the prediction at issue to the connection between precipitation events and predominant encoding types.

In terms of the change of encoding types, the case of Sinitic languages has suggested that there may not be a universal pathway for such diachronic changes and cross-linguistic comparison must be conducted based on investigations into different languages with historical data, since evidence has shown that the encoding type changes are likely to be influenced by language-specific factors. For example, the fact is clear in Sinitic languages that predicate type has changed to argument type, which can be well accounted for within the language family itself. It is mentioned previously that 雨 *yù* in Old Chinese can denote the process of objects falling from the sky like raining, and can take 雪 *xuě* 'snow' and 雹 *báo* 'hail' as objects when used in this sense, as shown in (2) and (3). The utilisation of this semantically versatile verb is argued by Dong et al. (2019) to be more productive and regularised, and can lower the chance of ambiguity caused by polysemous weather words with both verbal and nominal usages, thus leading to the substitution with a more uniform argument encoding type for precipitation. Ren & Dong (forthcoming) further argued that the shift of predominating predicate type in Old Chinese to predominating argument type in Middle and Modern Chinese, should be treated in a bigger context of the essential change of vocabulary that happened during the late Old Chinese and Middle Chinese, i.e., from implying to presenting (Hu, 2005). According to Hu (2005), formerly implied modifiers may become presented, such as the change of 泪 *lèi* 'tears' to 眼泪 *yǎnlèi* eye-tear 'tears'; implied objects of an act may also be presented, such as 钓 *diào* 'to angle' changing to 钓鱼 *diàoyú* angle-fish 'to angle'; implied act could be presented as well, such as 誓 *shì* 'to vow' to 发誓 *fāshì* express-vow 'to make a vow'. Therefore, in the case of weather word changes, for example, the action to fall

is implied in 雨 *yǔ* 'to rain' in Old Chinese while presented in Modern Mandarin in 下雨 *xià yǔ* fall-rain 'to rain'.

Last and most importantly, the expressions about fog, dew and frost have quite intriguing linguistic behaviours that deserve closer investigation, and the neglect of which has already revealed some inadequacies in the existing typologies of weather events. Thus, we need to (1) reconsider the way to classify weather events, and (2) explore more weather phenomena across languages from a typological perspective.

In fact, the reason why fog, dew and frost cannot be well incorporated into the weather event typology of Eriksen et al. (2012), is that such a typology is not systematically constructed. According to Eriksen et al. (2012: 391), the four major types of weather events are classified as such because each of them tends to select specific encoding types, and there are semantic distinctions which are claimed to give rise to the differences in their encoding. This shows that the standards for the classification are not purely semantically based, but more like a generalisation about the meaning denoted by each group of weather phenomena which have similar encoding behaviours according to the languages investigated by Eriksen et al. (2012). In other words, such an event typology is parasitic on the existing typological work of weather and language and its validity may be challenged when more data are collected and analysed. Moreover, inconsistencies can be found in this event typology. The sub-group of non-precipitation events in Eriksen et al. (2012: 395), i.e., thunder, lightning, wind, etc., is claimed to not have consistent encoding patterns across languages, which deviates from the basic principles of their classification. Besides, it takes three seemingly arbitrary criteria, i.e., dynamic/static, precipitation/non-precipitation and sunshine/non-sunshine, to get the four event types, which is not ontologically transparent. Hence, the types of weather events classified within this system can be too diverse in nature to be comparable among themselves, and it may not be able to cover some weather phenomena such as fog, dew and frost. As we have already indicated, we ought to also focus on meteorological taxonomy to improve the classification of weather events.

Ren (2018) first proposed a framework with two binary features for describing various weather events to account for data in Old Chinese: [±Process] and [±Material]. A weather event with a tangible process is [+Process], otherwise [-Process]; and a weather event with tangible products is [+Material], otherwise [-Material]. For instance, the falling rain and blowing wind are [+Process], while

the former has tangible raindrops, thus [+Material], but the latter lacks such products, hence [-Material]; dew and coldness, on the other hand, are [-Process] since there is no observable dynamic process during their formation or appearance, while the former with dew droplets is [+Material] and the latter is obviously [-Material]. We can see that the two features not only describe the semantics of weather words, but also reflect the perception and experience of weather phenomena which chiefly consist of weather process and weather products in conceptualisation, i.e., they can transparently and systematically combine language and meteorology. In this article, therefore, we build on the insight and initial analysis of Ren (2018) to expand such a framework to typological studies of weather expressions.

We propose the incorporation of these two features in our new typology of meteorological events (TyME). TyME is a typology specifically developed based on the mapping between weather expressions and weather phenomena using concepts shared by linguistic and meteorological ontologies through the features of [±Process] and [±Material]. This typology is expected to provide better tools to account for how languages encode weather, as well as how weather shapes languages. Its potential contributions to the study of weather and language are based on the following characteristics of the system: First, the two features correspond to the fundamental conceptual elements of meteorological events: weather processes as Process and weather products as Material. Hence all sub-types of weather events can be covered. Second, the two features are conceptually linked to the linguistic features [±V] and [±N], which has been crucial in the account of the distribution of grammatical categories of weather words both synchronically and diachronically in Sinitic languages (see Dong et al., 2020; Huang & Dong, 2020). Third, the prediction of PoS variations and changes showed that these two features can contribute to accounting for predicate and argument encoding types, making the semantic typology of weather events and formal typology of weather constructions highly comparable. Finally, the typology constructed with [±Process] and [±Material] is in fact compatible with the event typology of Eriksen et al. (2012), whose results can thus be incorporated, as will be shown later in Section 6. A good example to illustrate the strength of these characteristics is the contrast between rain and wind. Labelling them 'precipitation' and 'non-precipitation' respectively does not provide any useful information for linguistic encoding. TyME, on the other hand, makes verifiable prediction on

encoding based on the weather process and the weather material it produces (see more details in Section 6). TyME allows more weather phenomena to be investigated, especially those events that were neglected in previous studies. In the following sections, preliminary typological research on fog, dew and frost will be conducted.

4 A Cross-linguistic Investigation on Fog, Dew and Frost Expressions

As stated previously, the ways to express fog, dew and frost may exhibit grammatical and semantic characteristics that deserve closer investigation. For example, Dong et al. (2019, 2020) reported that Sinitic languages tended to describe the occurrence of fog, dew and frost as moving downwards, which contradicted the fact that these phenomena do not evolve downward movement during formation or appearance. Such seemingly scientifically infelicitous expressions, as argued by Dong et al. (2019, 2020), are the results of Chinese people' s inference from daily experience and primitive beliefs, i.e., they regard fog, dew and frost as kinds of precipitation which does fall under gravity. Furthermore, with the help of Hantology (Chou & Huang, 2010), a linguistic ontology based on Chinese characters, directionality shown in those weather expressions was found in Dong et al. (2019, 2020) to be closely related to their encoding types and PoS of weather words: downward movement expressions can be linked to nominal weather words and argument encoding type. On the other hand, Meulleman & Paykin (2016) showed that fog, dew and frost could be encoded as weather verbs in Dutch and Spanish, and such expressions did not convey any vertical movement meaning, as demonstrated in (7) and (8) respectively quoted from them. This indicates that the three weather phenomena may be represented quite diversely across languages.

(7) Het dauwt / Het ijzelt / Het rijmt / Het mist
it__dew (V) / it__black-ice (V) / it__hoarfrost (V) / it__fog (V)
'There is dew / black ice / hoarfrost / fog'

(8) Rocía / Escarcha
dew (V) / hoarfrost (V)
'There is dew / hoarfrost'

Previous studies have provided helpful starting points on this subject, and also left several questions for further discussion. For example, do fog, dew and frost in other languages have similar associations with precipitation as in Sinitic languages? How to account for the relation between directionality and encoding types or PoS in expressions of fog, dew and frost? Besides, fog exhibits

uncertainty in terms of directionality and PoS in Modern and Old Chinese. According to Dong (2019), fog can be expressed as moving downwards as well as moving upwards; it can function as both a noun and a verb in Old Chinese, while dew and frost are strongly inclined to 'fall' and can only be weather nouns in Old Chinese. Thus, another two questions arise: how can we analyse the idiosyncrasies of fog expressions in Chinese? Does fog show akin idiosyncratic linguistic behaviours in other languages? To work out the above questions and other related issues, it is necessary to conduct a cross-linguistic investigation on such weather phenomena, with a focus on indicated directions and encoding types. We also hope to exhibit how TyME can help with the analysis in this case study.

By consulting native speakers with questionnaires, we have examined the ways to denote the occurrence or formation of fog, dew, frost and precipitation (including rain, snow and hail) in 7 languages from different language families or branches: Nuosu (Butuo County, China), Thai (Thailand), Malay (Malaysia), English (America), Spanish (America), Japanese (Japan) and Korean (China). The full results are shown in the Appendix. We will briefly analyse the directionality and encoding types demonstrated in such data below.

In Nuosu, all precipitation phenomena are encoded with the argument type, i.e., rain, snow and hail function as nouns and need the verb *dʑɯ*^{33} 'to fall', which has a downward meaning, to indicate the appearance of them. Likewise, fog, dew and frost are also nouns in Nuosu, but no vertical movement is presented in related expressions.

The Thai language, on the other hand, encodes the 6 weather events quite uniformly: all the phenomena are encoded as nouns, and all but frost are expressed with downward meanings by using verbs such as *tok*^{1} 'to fall' and *loŋ*^{0} 'to fall'.

As for Malay, rain and snow, as well as fog and dew are encoded as verbs without explicit directionality, while hail adopts the argument type and combines with a verb with downward meaning, i.e., *me-nurun* realise-fall 'to fall'. There is no expression to state the occurrence of frost in Malay, to the best of our informants' knowledge, which is in line with the finding of Huang & Dong (2020) that Singaporean Mandarin's lacking such frost-related phrases is due to the scarceness of frost in the tropical areas.

All precipitation events in English are represented by weather verbs, whilst fog adopts the predicate type with a verb (i.e., *fog*) or an adjective (i.e., *foggy*),

dew the argument type, and frost both types.

More complex situations can be found in Spanish. Unlike rain and snow being encoded with the predicate type, the other form of precipitation, hail, is phrased with the argument type, accompanied by a verb with downward meaning, e.g., *está callendo granizo* is-falling-hail 'it is hailing'. The occurrence of fog can be realised as both argument and predicate types without directional meanings, while dew and frost, contrary to Meulleman & Paykin (2016) as mentioned above, are encoded with the argument type in our investigation and convey downward movement meanings. This may be related to the variety differences among world Spanishes. For example, our informant mentioned that the verb *neblinear* in Chilean Spanish states the occurrence of mist, which also adopts predicate type yet differs from the predicate type using an adjective in our data.

Japanese and Korean behave similarly in encoding such weather phenomena. Arguments are primarily responsible for encoding all fog, dew, frost and precipitation events, and downward movement is expressed when stating the occurrence of precipitation and frost, e.g., Japanese *furu* 'to fall' and Korean *naeri* 'to fall' are used to denote raining, snowing or hailing. The only difference between the two languages is that fog can be said to 'fall' in Korean but not in Japanese. Table 1 is a summary of the encoding and directional properties analysed above, together with related behaviours of Sinitic languages based on the data of Dong et al. (2019, 2020).

		Nuosu	**Thai**	**Malay**	**English**	**Spanish**	**Japanese**	**Korean**	**Chinese**
Encoding Type	Fog	A	A	P	P	Both	A	A	A
	Dew	A	A	P	A	A	A	A	A
	Frost	A	A	——	Both	A	A	A	A
	Precipitation	A	A	P(rain&snow) A(hail)	P	P(rain&snow) A(hail)	A	A	A
Downward Directionality	Fog	-	+	-	-	-	-	+	+
	Dew	-	+	-	-	+	-	-	+
	Frost	-	-	——	-	+	+	+	+
	Precipitation	+	+	-(rain&snow) +(hail)	-	-(rain&snow) +(hail)	+	+	+

Table 1. Encoding types and directionality of 6 weather events in different languages (A = argument type; P = predicate type)

5 Discussion on the 'Falling' of Fog, Dew and Frost

Fog, dew and frost, as shown in Table 1, tend to adopt the argument encoding method across languages, and scientifically infelicitous descriptions of them 'falling' can be found in 5 out of 8 languages (Sinitic languages counted as one). Even though the English data we collected does not show downward movement being conveyed, such cognitive manner could be identified elsewhere. According to *Oxford English Dictionary* (Dew, n., 2019), for example, dew was formerly supposed to fall or descend from the heavens, hence sentences such as 'The dew was falling fast' could be uttered more than 200 years ago. This is in consonance with Dong et al.'s (2019, 2020) explanations for the 'falling' fog, dew and frost in Sinitic languages as briefly introduced in Section 4. Reasonable assumptions can thus be made that weather events fog, dew and frost that do not move downwards in the physical world can be widely said to 'fall' in human languages, and the cognitive processes behind such linguistic behaviours may have much in common from culture to culture.

More cross-linguistic data will certainly be needed to draw a comprehensive picture of this subject. Our investigation, however, is already sufficient for a preliminary probe into the mechanisms of such weather expressions, especially given the implicit information existing in the data. In light of earlier studies, linguistic behaviours of fog, dew and frost could be better observed if we take precipitation into account. After examining the patterns demonstrated in Table 1, three implications concerning encoding types and directionality of these weather events can be generalised among the languages, which can be well explained and might cast light on the current issue.

First, if fog, dew and frost are encoded with the argument type, precipitation events are entirely or partly encoded with the argument type. Precipitation events are all [+Process, +Material], i.e., they consist of tangible weather products (raindrops, snowflakes, hailstones, etc.) and dynamic weather processes (the falling of those weather products). Both constituents of precipitation are possible to be encoded as the representative of a certain event: a focus on the product leads to the argument type, and a focus on the process might lead to the predicate type. Such linking between constituents of weather events and encoding types have been attested by Dong et al. (2019, 2020) based on large-scale data of Sinitic languages. Therefore, it could be inferred that if one language disallows the argument type for encoding precipitation, then weather products are probably much less salient than weather processes amid language users' cognition on such events. Since the products of precipitation

are generally most common, palpable and tangible among weather events. Once they cannot acquire enough salience to be lexicalised as weather nouns, other weather products such as fog and dew droplets are even less likely to become the semantic representatives of the corresponding weather phenomena. Hence, when nouns for fog, dew and frost exist in one language, it should be highly probable that precipitation nouns can also be found there.

Second, if fog, dew or frost expressions convey downward movement meanings, precipitation expressions entirely or partly convey downward movement meanings. Fog, dew and frost are all [-Process], meaning they do not conspicuously move, so the reason for their being expressed as going downwards must lie in people's cognition. Dong et al. (2020) argued that the concept of 天 *Tiān* in traditional Chinese culture, a divine power up in the sky and the aloft source and controller of various meteorological phenomena, played an important part in making fog, dew and frost perceived in the same way as precipitation by Chinese people, i.e., fog, dew and frost, like precipitation events rain, snow and hail, were all believed to be given by 天 *Tiān* from above, hence in the manner of 'falling'. Moreover, fog, dew and frost often appear near ground in the morning without any obvious change of directions, which would cause people who wake up and notice such water around to naturally infer that it had 'fallen' during their sleep (Dong et al., 2019). On the basis of such observations about Sinitic languages, we propose that similar mechanisms also account for akin linguistic behaviours elsewhere. Different languages are surely subject to diverse sociocultural influencing factors, but one thing they have in common on this issue is that fog, dew and frost must be deemed in the same group with precipitation by language users, to gain the capability of 'falling'. In the physical world, precipitation products are practically the only weather substances that fall onto the ground under gravity, thus analogies between precipitation and fog, dew or frost are necessary if the latter events are to be described as moving downwards. It is therefore required that at least one of the precipitation phenomena can be expressed with downward movement meanings, otherwise fog, dew or frost could find no source to copy or adopt such semantics.

Third, if one of these weather events, be it precipitation or non-precipitation, is expressed as moving downwards, such an event is encoded with the argument type in the particular language. Raindrops, snowflakes and hailstones fall wherever they appear, yet they are not necessarily said to fall. In languages

where precipitation events are encoded with the predicate type, such phenomena are semantically represented by weather verbs, which means that there is no place left for verbs with directional meanings. For instance, although the English sentence 'It rains' indeed connotes downward movement because people have abundant experience of how rain moves, but it does not express such meaning explicitly. Thus, argument type encoding should be a necessity for delivering downward movement.

The three implications mentioned above are in fact very closely related, which together can aid us in understanding the current issue more thoroughly. For example, implication 2 and 3 are both generalised from the results of our investigation, but the latter can in fact be inferred from the former. Our discussion on implication 2 suggests that fog, dew and frost are deemed to belong in the same group as precipitation event types, thereby 'inherit' the ability to fall. However, such 'inheritance' will fail to assign fog, dew and frost any particular verbs of downward movement when precipitation events are encoded with the predicate type and are not explicitly said to fall. One possibility for resolving this dilemma, as shown, is for the weather events to be encoded with the argument type. Moreover, by linking the three implications, one linguistic property of a certain weather phenomenon may be deduced from another property of a different phenomenon, e.g., if fog is said to fall in one language, we can infer that fog must be encoded with the argument type (by implication 3), and further that there must be at least one precipitation event that is encoded with the argument type (by implication 1). The same result can be obtained via another path: if there is 'falling' fog in one language, then there must be at least one precipitation event that can be expressed as falling (by implication 2), and we can further infer that, again, at least one precipitation event is encoded with the argument type (by implication 3).

It can be further found that the three implications are deeply intertwined in a systematic and orderly manner. Two major principles underlie the implications and account for those scientifically infelicitous expressions: (1) directionality correlates with encoding types; (2) fog, dew and frost correlate with precipitation in terms of directionality and encoding types. In other words, in order to scrutinise the falling of fog, dew or frost, we should also examine precipitation events, with foci on which direction they are said to move and which type they are encoded with.

We defined the feature [+Material] for weather events involving tangible

weather products, so dew and frost are both [+Material] while fog is [±Material] due to the complexity of perceiving this phenomenon which will be further elaborated on later. Based on the values of this feature, we can better analyse the tendency of fog, dew and frost to adopt the argument encoding type and the correlation between the three weather events with precipitation in regard to directionality and encoding types. Feature [+Material] has been argued to be related to the feature [+N] in grammatical studies (Dong et al., 2020; Huang & Dong, 2020, among others), and [+N], or the 'nouniness' of words, underlies the argument encoding method employed by weather expressions. Thus, the tendency of fog, dew and frost towards argument encoding type may be attributed to the [+Material] feature they share. Since fog can be [-Material] in some cases, it is encoded with the predicate type in more languages than dew and frost as exhibited in Table 1. In addition, the [+Material] feature implies tangible forms, which may contribute to the analogy between precipitation and fog, dew and frost, when they are encoded as nouns. The feature also implies mass and suggests that they are subject to gravity and hence the downward movement encoding for expressions of fog, dew and frost (see Section 7 for more details).

6 Reclassifying Weather Events with TyME

The seemingly idiosyncratic correlation between precipitation and fog shown in our data can be accounted for with another TyME based generalisation. Among the languages we studied, fog could be encoded with the predicate type in Malay, English and Spanish, while precipitation events are entirely or partly encoded with the predicate type in such languages too. That is to say, the predicate type encoding of fog seems to be highly correlated with the predicate type encoding of precipitation. Although the actual typological generalisation is pending and requires data from more language families, we can be certain now that encoding methods of fog and precipitation could correlate in both argument type and predicate type. Such relation also adds to the idiosyncrasies of fog expressions. As mentioned earlier, Dong (2019) has argued that fog behaved quite uniquely in Sinitic languages: it can be realised as nouns and verbs in Old Chinese; it can 'fall' as well as 'rise' in Old and Modern Chinese. Such uncertainties could be due to the fickle nature of the fog events such that they might be perceived as tangible or intangible, static or not static, depending on various natural circumstances.

The idiosyncrasies of fog expressions come from the complex physical

properties of fog. It has been elaborated in Section 2 that the positions of foggy areas relative to the speaker and the environmental wind conditions jointly decide how fog is perceived. Such complexity makes it quite difficult to place fog into the event typology of Eriksen et al. (2012). However, by adopting the binary features we suggested in this article, [±Process] and [±Material], we show that TyME can account for the full range of variations of linguistic behaviours of fog expressions.

In the new typology, fog should be [-Process, ±Material], i.e., two places in this system are reserved for fog, which is in accordance with its diverse perceived natural appearances. When the observer is within the foggy environment, then fog is [-Process, -Material] to them, similar to brightness or darkness. However, fog could be [-Process, +Material] if the observer is observing the fog from a distance. We have mentioned that fog might occasionally move to the effect of wind but not in the same dynamic manner as rain or lightning, since normally fog does not exist in windy conditions. Hence the feature [+Process] is not assigned to fog in TyME, similar to clouds which may also move slowly if the air is not so calm. In Old Chinese, therefore, its [-Process, -Material] feature facilitates fog's verbal usage as stative predicate similar to weather verbs 晴 *qíng* 'to be sunny' and 阴 *yīn* 'to be cloudy' at that time, and the [-Process, +Material] feature enables its argument type encoding with the downward movement (Ren & Dong, forthcoming).

The full typology of TyME is given in Table 2, demonstrating how the new typology and the one proposed by Eriksen et al. (2012) classify weather events.

Eriksen et al. (2012)		Examples	TyME
Dynamic	Precipitation	Rain, Snow, Hail, Sleet	[+Process, +Material]
	Non-precipitation	Thunder, Lightning, Wind	[+Process, -Material]
Static	Temperature and atmosphere and light conditions	Cold temperature, Warm temperature, Hot temperature, Humid atmosphere, Daylight, Darkness, (Fog)	[-Process, -Material]
	Sunshine	Sunshine	
	——	Dew, Frost, Cloud, Rainbow, (Fog)	[-Process, +Material]

Table 2. Comparison of Eriksen et al.' s (2012) weather event typology and TyME

Note that in reality it is not possible for weather products to remain immobile forever, yet we do not assign the [+Process] feature to every weather phenomenon. Like the analysis of fog and cloud above, we only use this feature to indicate weather events with tangible and conspicuous movement, since the two features link semantics to the perception and experience of weather phenomena, not to purely physical mechanisms. Similarly, [+Material] indicates a perceptually observable weather product, i.e., people can see or touch it and deem it an object. For example, a rainbow is a phenomenon of light, but people would call it a bow, an arch, etc. (Dong, 2019: 9), i.e., it is perceived as a tangible object. Lightning, however, can also be seen, but it moves so fast via unfixed paths and lasts such a short time that people are less likely to perceive it as a stable object, hence having the feature of [-Material].

One obvious and major difference between the two typologies is that events such as fog, dew, frost, cloud, rainbow, etc. which were missed out in Eriksen et al. (2012) can now be accommodated in TyME, mostly under the subclass [-Process, +Material]. Unlike fog being [-Process, ±Material], other weather phenomena only occupy one place each in the typology. As clearly shown in Table 2, apart from the newly incorporated events, the two typologies are compatible to a great extent in terms of the classifying results.

We mentioned in Section 5 that the feature [+Material] could be linked to the grammatical feature [+N]. It is necessary, however, to clarify that the features [±Process] and [±Material], though being useful in grammatical analysis, cannot alone predict the specific PoS or encoding type of a weather event in a particular language. For example, fog, dew and frost are not uniformly nouns in the languages we investigate, although they all share the [+Material] feature. Such grammatical behaviours are influenced by various factors, among which the two binary features only predict tendencies or imply possible strategies. Another example comes from 雷 *léi* 'thunder' and 电 *diàn* 'lightning'. They are described as [+Process, -Material] in our typology, but function as both verbs and nouns in Old Chinese. Based on evidence from syntactic positions and modifier diversity, Dong et al. (2019) argued that their nominal usages were in fact the nominalisation of the weather processes but not weather products. That is, [+Material] is neither necessary nor sufficient for nominal usage, but just offers tendency or possibility of being nouns.

In addition, due to the historical changes explained in Section 3, most weather

verbs in Old Chinese, regardless of their features, have become weather nouns in modern Sinitic languages since the act in a weather event is presented. TyME can also predict and explain this diachronic change. In this framework, only weather events with [+Process, +Material] or [+Process, -Material] features can undergo such a change, because the [+Material] feature can enable nominal realisation of weather products, while the [+Process] feature allows both verbal and nominal usages of weather processes. That is, [+Process, +Material] weather events (e.g., rain and snow) and [+Process, -Material] weather events (e.g., thunder and lightning) are possible to act as both verbs and nouns, which is necessary for the change from verbs to nouns. Actually, words of these weather events do exhibit such a grammatical change from Old Chinese to modern Sinitic languages (Dong et al., 2020). However, the other two subtypes, i.e., [-Process, -Material] and [-Process, +Material], are unlikely to undergo such a change, since [-Process, -Material] (e.g., sunny and cold) tends to lack the ability of nominalisation of weather products or processes, and [-Process, +Material] (e.g., dew and frost) tends to lack the ability to function as verbs. According to the diachronic investigation of Ren & Dong (forthcoming), such a prediction matches the exact change in the history of Sinitic languages: only the weather events of the former two subtypes, e.g., rain, snow, thunder and lightning, have both nominal and verbal usages in Old Chinese and can only function as nouns now.

It is also noteworthy that TyME can offer further support for previous generalisations on encoding methods for particular events. Eriksen et al. (2012) found that languages tended to express static events with the predicate type. Such weather phenomena, i.e., coldness, warmth, brightness, etc., fall into the category of [-Process, -Material] in our framework, and such features can actually account for their tendencies on encoding types. The feature [-Material] indicates that they do not have tangible products, while the feature [-Process] means that such events do not have tangible processes. Thus they are not likely to be nominalised in the same way with dew or frost that has weather products, nor are they likely to be nominalised like thunder or lightning that involves weather processes. Being predicates seems to be their only way of lexicalisation. Furthermore, they do not tend to function as dynamic verbs similar to raining, also due to their lack of tangible processes. So, it can be inferred that, like the mentioned 雾 *wù* 'to fog', 晴 *qíng* 'to be sunny' and 阴 *yīn* 'to be cloudy' in Old Chinese, such weather events are most likely to be static verbs

or adjectives.

7 Moving Downwards: Scientifically Infelicitous or Felicitous?

Directionality has been used as a key factor when recent studies (Dong et al., 2020; Huang & Dong, 2020, among others) and the current one investigate meteorological expressions. It works rather well in such studies: idiosyncratic morphosemantics of weather expressions can be depicted using directionality; different types of weather phenomena may be linguistically represented differently in terms of directionality; PoS of weather words are found to correlate with directionality. Although the results turn out to be satisfying, the underlying reason for the usefulness of directionality in weather expression studies has not been looked into yet. In fact, the helpfulness of directionality in research comes from its importance in weather perception. Humans pay attention to weather events essentially because such events have impact on people' s lives and the environment around them: the falling rain can wet hair and clothes, while a flash of lightning may dart down and strike people or livestock to death; a southeasterly wind during summer will bring abundant rainfall to coastal China, but a northwesterly wind during winter will make Chinese people living inland feel cold and dry. That is, meteorological events are perceived and observed in terms of how they affect human beings, hence the directionality towards people is crucial. Further, we claim that the law of gravity underlies the directionality in the perception and conceptualisation of weather phenomena, and also underlies the binary features we use in this study to classify meteorological events.

The only constant force that applies in all weather events is gravity. The law of gravity states that as a force, gravity will act on any object to create downward movement, and that the downward moving object will have identical acceleration regardless of its mass/weight, as proven by Galileo' s well-known experiments. In addition, gravity also plays an important role in perception of vertical directions. According to Schöne (1964), human spatial perception relies both on vision and on gravity. Especially the sense of verticality, i.e., the directions of up and down, is influenced by the direction and strength of gravity, and by visual cues from the environment (Jörges & López-Moliner, 2017). Therefore, the gravity of mother earth calls for every weather product to fall, and we rely on sensory organs responding to gravity when we perceive directionality of weather events.

Nevertheless, we do not live in vacuum. Any falling object will encounter

resistance by the air. As a result, some water may be suspended as the falling is cancelled by air resistance (e.g., fog and mist), or it may not be able to fall by the fact that the water has already been positioned on fixed surfaces (e.g., dew and frost). Neither case, however, can resist the gravity forever. Either suspended fog or condensed dew will eventually fall when (1) the suspended water mass becomes too big for the counter-force of the air friction to 'suspend' it, or (2) the condensed water mass becomes too big for the friction of the surface of condensation to keep it in one position. In other words, in either case, it is the accumulated water mass that will eventually allow gravity to work and the water to fall or drop. Therefore, the falling of fog, dew and frost is inevitable according to natural laws, instead of being scientifically infelicitous. Gravity and mass together decide the vertical directionality of atmospheric water: gravity requires water in any form to fall, while the falling or not falling is controlled by the mass or density (mass/size) of the water.

The intertwined directionality and mass, can actually be considered as alternatives to the two binary features, [±Process, ±Material], that we propose to construct TyME. Logically, the two pairs imply each other. Weather processes have directionality, and directionality can only be demonstrated in processes; materials have mass, and mass must be carried by materials. Moreover, as discussed above, directionality and mass can provide a more relevant account for meteorological expressions in the sense that directionality is crucial to the perception of weather, and mass controls the realisation of vertical movement of weather events. The mass of weather products has been argued by Dong et al. (2019, 2020) to have an impact on the PoS and selection of weather words in Sinitic languages, thus another benefit of applying features [±Directionality, ±Mass] is that we can give better explanations for such linguistic behaviours based on the suggested typology.

The use of weather verbs denoting the movement of falling or dropping should correlate with the perceived propensity for downward moment of the weather events. However, such propensity cannot be found or inferred from the event typology in previous studies, which does not contain any information about the primary physical factors governing directions of weather events, i.e., gravity and mass. Based on the implications we generalised from our data, on the other hand, it could be discovered that directionality can indeed be predicted by the two features we propose. To be articulated as falling, our data shows that it is necessary for a weather event to be encoded as a noun. And the

'nouny' property of weather events has been proven by Dong et al. (2019, 2020) to have links with the feature [±Material] or [±Mass], so for downward movement, [+Material]/[+Mass] is important.

Mass controls the falling of water required by gravity, but how it controls and how likely the falling is, both leave plenty of room for conceptualisation. Different languages in fact assign different tendencies of possible falling depending on the conceptualisation of mass for each weather type, and as shown in Dong et al. (2019, 2020), the history and diversity of Sinitic languages allow us to test our hypothesis with a wide range of data.

8 Conclusion and Future Work

To describe and analyse the formerly overlooked fog, dew and frost and other weather events in a more systematic way, we suggested a new event typology, TyME. This typology is built with two binary features [±Process] and [±Material], which can also be interpreted as [±Directionality] and [±Mass], and can assist us in typological studies on weather and language with wider coverage of various weather events, and with better tools to account for diachronic changes.

We found in our investigation that even though fog, dew and frost do not fall in the physical world, they are said to fall across languages and time. Precipitation events, at the same time, must also be explicitly stated as falling in the same languages. Moreover, the 'falling' precipitation and non-precipitation have to be weather nouns, but not verbs. Such rules generalised from our investigation reveal the mechanisms underlying those seemingly scientifically infelicitous expressions: directionality correlates with encoding types, and fog, dew and frost correlate with precipitation in terms of directionality and encoding types. With the help of TyME, we also offered analysis for such linguistic behaviours of weather expressions.

Our analyses also have implications for studies on basic lexicon, such as the Swadesh list. In one of its early versions, Swadesh (1950) listed 225 meanings, which include 5 weather events (but 6 weather words with 'freeze' and 'ice' referring to the same event) related to atmospheric water: cloud, fog, freeze, ice, rain and snow. However, in the final 100-word version (Swadesh, 1972), only two are included: cloud and rain (noun). The items of the list are supposed to be as universal as possible, but according to our research, such universality seems arguable. For example, some languages might only have verbs for raining but no nouns. Since how weather phenomena are conceptualised and linguistically encoded vary across languages, there is no consensus about a

shared or default ontological system of weather, nor is there clear consensus about the default grammatical constructions for weather events. Therefore, in order to prevent biases and to provide an adequate universal account, the items of core vocabulary should be selected based on more deliberate typological investigations in future studies.

We can make one more important observation about the typology of weather words in terms of meteorological taxonomy. Most of the time, fog, dew and frost are treated as a whole in our study, largely because of their counterintuitive directionality displayed in expressions. However, they are by no means the same in meteorology: fog, water droplets suspended in the air with rather wide spatial distributions, is classified as suspension; dew, formed by the cooling water vapour changing to liquid form on some surfaces, is called condensation; frost, on the other hand, could be a mixture of multiple meteorological events. For example, cooling water vapour changing directly to ice without becoming a liquid first will form delicate and white crystals of ice that are called *hoarfrost*, *white frost* or simply *frost*; the loss of heat to or below the freezing level by the atmosphere and surface objects in dry air and without reaching saturation creates a frost known as *black frost* or *freeze*, which has no visible frost forms and can severely damage certain crops (Oliver, 2005: 382; Ahrens, 2012: 96). Therefore, how they are encoded differently in languages should be interesting. Some preliminary discoveries have already been made. We have shown several times in this article that fog and fog expressions exhibit a number of idiosyncrasies compared to dew and frost. In fact, Huang & Dong (2020) used directionality to demonstrate that fog is encoded differently from dew and frost in Sinitic languages and Old Chinese. More specifically, fog tends to be expressed as 'rising' while dew and frost as 'falling' in standard Mandarin Chinese; fog is much more likely than dew and frost to be described as 'rising' in Sinitic languages; fog shows directional uncertainty in Old Chinese but dew and frost tend to 'fall'. Moreover, findings in the current and previous research imply that dew and frost are also represented differently in certain aspects of languages, e.g., frost can be said to 'fall' in more languages than fog and dew, and can be encoded with the argument type in all languages that have frost expressions while fog or dew cannot, as shown in Table 1; according to Dong et al. (2020), unlike fog and dew, frost cannot be solely said as moving upwards in any Sinitic language, and is expressed with more non-directional meanings than directional ones. This is surely an intriguing topic that the

authors of this article aim to further investigate with the proposed TyME in the near future.

Appendix. Results of Cross-linguistic Investigation on 6 Weather Phenomena

	Rain	Snow	Hail
Nuosu	m˧³³fa³³ dʑɯ³³ rain__fall It rains.	vo³³ dʑɯ³³ snow__fall It snows.	dzo³³ dʑɯ³³ hail__fall It hails.
Thai	fon⁴ tok¹ rain__fall It rains.	hiʔ¹maʔ³ tok¹ snow__fall It snows.	lu:k²hep¹ tok¹ hail__fall It hails.
Malay	Semalam hujan ·lebat past-night__rain__dense It was raining heavily overnight.	ber-salji realise-snow It is snowing.	me-nurun hujan ais batu realise-fall__rain__ice__stone It hails.
English	It is raining.	It is snowing.	It is hailing.
Spanish	Está lloviendo. is__raining It is raining.	Está nevando. is__snowing It is snowing.	Está callendo granizo. is__falling__hail It is hailing.
Japanese	ame-ga furu rain-GA__fall It rains.	yuki-ga furu snow-GA__fall It snows.	hyou-ga furu hail-GA__fall It hails.
Korean	bi-ga o-da/naeri-da rain-GA__come-DA/fall-DA It rains.	nun-i o-da/naeri-da snow-I__come-DA/fall-DA It snows.	ubag-i chi-da/naeri-da/tteoreoji-da hail-I__hit-DA/fall-DA/drop-DA It hails.
	Fog	**Dew**	**Frost**
Nuosu	m˧³³ȵo⁵⁵ v ʊ̈ ⁵⁵ fog__grind It fogs.	tʂɯ³³ ʐ˧³³ ti⁵⁵ dew__water__adhere Dew forms.	vo³³ȵi³³ dʑo³³/ti⁵⁵ frost__exist/adhere It frosts up.
Thai	m ɔ:k¹ loŋ⁰ fog__fall It fogs.	na:m³kha:ŋ³ loŋ⁰ dew__fall Dew forms.	na:m³kha:ŋ³khɛŋ⁴ k ɔ ʔ¹ dew-freeze__adhere It frosts up.

Malay	ber-kabus have-fog It is foggy.	meng-embun become-dew Dew forms.	——
English	It is fogging. It got foggy.	Dew formed on the grass.	The window frosted up/over. Frost formed on the window.
Spanish	Hay niebla. / Se puso nublado. has__fog/ itself__put__cloudy It is foggy.	Hubo rocío esta mañana. / Cayó un rocío en la mañana. / Se formó rocío en la grama. had__dew__this__morning/ fall__a__dew__in__the__morning/ itself__formed__dew__on__the__grass There was dew this morning. / There was dew in the morning. / There was dew on the grass.	Cayó una helada en la mañana. / Se formó escarcha en la ventana. / La ventana se cubrió de escarcha. fall__a__frost__in__the__morning/ itself__formed__frost__on__the__window/ the__window__itself__covered__of__frost It frosted over in the morning. / The window frosted over. / The window frosted over.
Japanese	kiri-ga kakaru fog-GA__hang It fogs.	tsuyu-ga oku dew-GA__put Dew forms.	shimo-ga oriru frost-GA__fall It frosts over.
Korean	angae-ga naeri-da/kki-da fog-GA__fall-DA/cover-DA It fogs.	iseul-i maechi-da dew-I__form-DA Dew forms.	seori-ga naeri-da frost-GA__fall-DA It frosts over.

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