

# Directionality and Momentum of Water in Weather: A Morphosemantic Study of Conceptualisation based on Hantology\*

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**Abstract.** We present in this paper a study of the conceptualisation of meteorological events involving water in Chinese based on Hantology, a SUMO-based ontology of Chinese orthography. Our comprehensive investigation of the morphosemantic behaviours of these weather words in both Mandarin and Sinitic languages reveals that they are predicted by the directionality and momentum of their formation and movement. We studied events involving water in both liquid and solid forms: such as rain, snow, hail, fog, dew and frost. They share the radical 雨, which can be linked to two SUMO nodes according to Hantology. This ontological bifurcation can be shown to bring about not only the diversity of direction expressions referring to these words for water, but also the differences of semantic features and PoS between them in Archaic Chinese. Moreover, the momentum of different water forms is proposed to be the physical basis for the differences of PoS, semantic features and node linking.

**Keywords:** Weather and Language · Directionality · PoS · Mandarin Chinese · Sinitic Languages · Old Chinese

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# 1 Introduction

## 1.1 Scientific Felicity of Weather Verbs

Weather verbs are often verbs of movement or appearance but used in highly conventionalised and typologically different ways [1, 2, etc.]. Hence whether these weather verbs embody or metaphorically represent the actual weather events are highly debated. For instance, a common expression in weather forecast to describe fogs is 普降大雾 *pǔ jiàng dà wù* ‘widely-fall-big-fog’ in Chinese, which uses the verb 降 *jiàng* ‘to fall’ to report that certain areas are covered in dense fogs. Interestingly, however, fog does not fall. According to Ahrens [3], fog is usually formed by cooling or by evaporation and mixing of moist air with relatively dry air. Different types of fog (e.g., radiation fog, advection fog or upslope fog) either do not have a vertical movement, or move upwards, but never go downwards. Hence it seems that this particular use of the weather verb is scientifically infelicitous and does not directly represent the actual movement of fog.

In fact, 降 *jiàng* ‘to fall’ can also be used with other weather events such as 降露 *jiànglù* ‘to dew’ and 降霜 *jiàngshuāng* ‘to frost’. As stated by Ahrens [3], dew is formed when air cools to the dew point due to contact with cold surfaces, and frost is produced on the ground and other surfaces by direct change of water vapour into ice via cooling. Therefore, there is no downward movement during the formation of fog, dew and frost, which is also in accordance with our life experience. Unlike rain or snow, fog, dew and frost do not fall down from the sky. Thus, it seems that the use of the weather verb 降 *jiàng* ‘to fall’ is highly conventionalised and neither embodied nor scientifically felicitous. Then a question arises: why does the Chinese language use verbs with downward movement meaning to represent such water-related weather events without downward movements? Interestingly, besides Mandarin Chinese, many Sinitic languages<sup>1</sup> also exhibit such morphosemantic convention. One thing various Sinitic languages have in common is that they all use Chinese characters. It is worth mentioning that the characters for the aforementioned weather phenomena, together with 雨 *yǔ* ‘rain’, 雪 *xuě* ‘snow’ and 雹 *báo* ‘hail’, share the same radical 雨. Rain, snow and hail are also forms of water, and belong to precipitation that does fall under gravity which can co-occur with 降 *jiàng* ‘to fall’, too. So, a further question we want to address is: is the fact of radical sharing just a coincidence, or a key for us to explain such idiosyncratic usage?

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<sup>1</sup> Sinitic languages are traditionally referred to as Chinese dialects. Both terms are used interchangeably in our study.

## 1.2 Ontology and Hantology

Borrowed from philosophy, ontology refers to the ‘explicit specification of a conceptualisation’ [4]. Ontology generally concerns two questions [5]: 1) What are the basic concepts for knowledge representation? and 2) How are the concepts organised?

Recent studies show that the Chinese orthography has conventionalised a system of semantic relations of basic concepts [6, 7] and such ontology has its psychological reality among Chinese people [8]. Following this line of research, the current study investigates the directions in the expressions of different weather phenomena in various Sinitic languages based on Hantology.

## 2 Method

Corpora and dictionaries were consulted to obtain comprehensive information of how Chinese people describe the formation and/or appearance of water (both in liquid and solid forms) in weather events, all with the radical 雨 in Chinese characters. After analysing the results, we provided an account from Hantology for the distribution of directional meanings. Further supporting evidence from Archaic Chinese and physics was also discussed.

The BCC Corpus [9] and the CCL Corpus [10] were consulted for the usage of weather expressions in Mandarin Chinese. As for the former, the balanced and diachronic corpora were used. We have searched combinations of verbs with directional meanings and weather phenomena 雾 *wù* ‘fog’, 露 *lù* ‘dew’ and 霜 *shuāng* ‘frost’ respectively in these corpora, and calculated the frequencies after manual check. The verbs include 降 *jiàng* ‘to fall’, 下 *xià* ‘to fall’, 起 *qǐ* ‘to rise’ and 上 *shàng* ‘to rise’. In total, there were 12 possible forms of compounds (‘降/下/起/上 + 雾/露/霜’).

Besides Mandarin Chinese, related usage in other Sinitic languages was also investigated. We collected the expressions of eight weather phenomena from the dictionaries of Li [11], Xu and Miyata [12], Tao [13] and Zhang and Mo [14], which are usually represented by characters 雨 *yǔ* ‘rain’, 雪 *xuě* ‘snow’, 雹 *báo* ‘hail’, 雾 *wù* ‘fog’, 露 *lù* ‘dew’, 霜 *shuāng* ‘frost’, 雷 *léi* ‘thunder’ and 电 (traditional form: 電) *diàn* ‘lightning’, all containing the radical 雨. Compared to Mandarin, five more phenomena were added for Sinitic languages, since we planned to conduct a comparative study with the diverse expressions in these languages. Verbs that co-occur with weather nouns to indicate the occurrence of such phenomena were examined and grouped into four major types according to directional meanings: upward, downward, both, and no obvious vertical direction.

In our study, the verbs involving upward movement are 起 *qǐ* ‘to rise’ and 上 *shàng* ‘to rise’. The ones referring to downward movement are 降 *jiàng* ‘to fall’, 落 *luò* ‘to fall’, 下 *xià* ‘to fall’ and 压 *zhé* ‘to press down’. It needs to be mentioned that most of the verbs are polysemes. Those implicating the downward direction clearly indicate a downward movement towards the ground, while the others, i.e., 起 *qǐ* and 上 *shàng*, may have differ-

ent interpretations about which sense they are used in. For instance, 起 *qǐ* means to rise, to start or to occur, etc.; as a result, 起雾 *qǐwù* could be interpreted as fog rising, fog appearing, or both. Similarly, 上 *shàng* can mean to rise or to add, so 上雾 *shàngwù* may also indicate a non-directional meaning as fog being added.

### 3 Results

Distribution of the 12 forms (‘降/下/起/上 + 雾/露/霜’) in the BCC and CCL corpora (accessed 8 and 13 Dec 2018, respectively) is shown in Table 1.

**Table 1.** Corpus search results

	BCC balanced	BCC diachronic	CCL
降雾 <i>jiàngwù</i>	11	2	8
下雾 <i>xiàwù</i>	174	18	10
起雾 <i>qǐwù</i>	352	32	22
上雾 <i>shàngwù</i>	5	0	0
降露 <i>jiànglù</i>	7	0	2
下露 <i>xiàlù</i>	7	1	4
起露 <i>qǐlù</i>	1	0	0
上露 <i>shànglù</i>	0	1	0
降霜 <i>jiàngshuāng</i>	66	66	13
下霜 <i>xiàshuāng</i>	119	87	26
起霜 <i>qǐshuāng</i>	14	1	0
上霜 <i>shàngshuāng</i>	16	1	2

Among the fog-related compounds, the upward direction constitutes 65.9%, 61.5% and 55%, respectively in each corpus, which is larger than the downward direction, but there is no disparity. However, downward meanings are much more frequently expressed when describing the occurrence of dew and frost. The number of dew-related compounds is quite small, compared to the other two phenomena. It may be due to the fact that the visibility of dew is lower than fog and frost. Also, dew is not as relevant to human beings as fog and frost, because fog and frost could have an impact on transportation, agriculture and people’s daily life.

Related expressions in 229 dialects/subdialects have been investigated. As previously mentioned, verbs were classified based on directional meanings and the percentage under each category was calculated. Since our focus is the directions the expressions denote, we did not consider the order of the verbs and the weather nouns. Besides, not all the eight weather phenomena in every dialect are included in the dictionaries, so instead of frequencies, percentages by directions concerning each phenomenon are provided in Table 2.

**Table 2.** Distribution of directions in Sinitic languages (%)

	Down	Up	Both	None
Snow	100	0	0	0
Rain	98.3	0	0	1.7
Hail	97.0	0	0	3.0
Fog	51.7	24.7	13.5	10.1
Dew	50.0	15.2	4.5	30.3
Frost	45.5	0	2.0	52.5
Thunder	0	6.8	0	93.2
Lightning	0	0	0	100

The eight phenomena exhibit three directional tendencies. Rain, snow and hail, which belong to precipitation, are highly inclined to be expressed with downward meanings. Thunder and lightning also show a clear tendency that they are seldom used with directional meanings. Fog, dew and frost, however, show more complicated patterns. First, downward meanings have greater proportions than upward ones. Secondly, both directions co-exist in some languages, which cannot be found in expressions of other phenomena. Thirdly, frost-related compounds or phrases cannot be solely expressed as moving upwards, and have more non-directional meanings than directional ones.

Please note that the two verbs we counted as with upward meanings may have ambiguous interpretations, as has been mentioned. Based on the results, we might state that not only can fog, dew and frost ‘fall’ in Mandarin and other Sinitic languages, they even ‘fall’ more than they ‘rise’. This is in line with Dong’s [15] brief observation on 雾 *wù* ‘fog’.

## 4 Discussion

### 4.1 One Radical, Two Ontological Concepts

Hantology is the integration of both ontological and linguistic information [6]. In particular, morphosyntactic cues, such as word and compound formation generalisations, are preserved when mapped to formal ontological representations. As such, Hantology is a linguistic ontology which integrates shared world views of the speakers of Chinese. Thus the conceptual representation of the radical 雨 in Hantology reflects Chinese people’s perception of the water-related weather phenomena and how it influences the morphosemantic behaviours of the different characters sharing this radical.

In Hantology, the radical 雨 represents both the ontology node of ‘water’ and that of ‘weather process’ in SUMO [16]. We propose that characters 雾 *wù* ‘fog’, 露 *lù* ‘dew’ and 霜 *shuāng* ‘frost’ are linked to the ‘water’ node, 雷 *léi* ‘thunder’ and 电/電 *diàn* ‘lightning’ are linked to the ‘weather process’ node, and 雨 *yǔ* ‘rain’, 雪 *xuě* ‘snow’ and 雹 *báo* ‘hail’ are linked to both. The reason why fog, dew and frost can share the same verbs with rain, snow and hail is that they share the same ontology node in the conceptual structure,

which reflects that people would regard the former ones as kinds of precipitation. Also, the fact that fog, dew and frost appear near ground and rarely involve any obvious vertical direction change has facilitated such analogy, because their ground-level positions match the ‘fallen’ status and they do not show typical symptoms of ‘rising’. Our claim can be bolstered by the following arguments.

First, similar ‘atypical’ taxonomical classifications are well attested in Chinese radical systems [17]. For example, 鱿 *yóu* ‘squid’, 鲸 *jīng* ‘whale’, 鳄 *è* ‘crocodile’, 鲍 *bào* ‘abalone’, 鲵 *ní* ‘giant salamander’, and 鳖 *biē* ‘softshell turtle’ are not fishes, yet all the characters have the component of 鱼 ‘fish’, indicating that they are deemed to belong to the conceptual class of fishes. That is, these characters share most functional characteristics with the class of fishes.

Secondly, some Sinitic languages use both types of verbs with opposite directions to describe the occurrence of fog, dew and frost. For example, fog can both ‘fall’ and ‘rise’ in 13.5% of the languages. This means that speakers of those languages must have independent inference for each directional expression, otherwise they would conflict with each other. Fog in some cases does involve upward movement, as noted earlier, which may contribute to the usage of 起 *qǐ* ‘to rise’ and 上 *shàng* ‘to rise’. On the other hand, the reason for using verbs with downward meanings is most likely that those phenomena are deemed as precipitation, since they do not actually move downwards.

Thirdly, the distributions of 降 *jiàng* ‘to fall’ and 下 *xià* ‘to fall’ in the CCL Corpus demonstrate differences in terms of text style. As illustrated in Table 3, 降 *jiàng* tends to be used in formal texts, while 下 *xià* in informal ones. The ‘降/下’ contrast is a method to make a distinct style difference when they take rain, snow and hail as objects. When such method is applied to fog, dew and frost, we can infer that they should also be regarded as precipitation. Another piece of evidence is that, all the six cases of 降雾 *jiàngwù* are from newspapers after 2003, while cases of 下雾 *xiàwù* have a much wider time range, suggesting that 降雾 *jiàngwù* may be an emerging copy of 降雨 *jiàngyǔ*, 降雪 *jiàngxuě*, etc. As for the cause for the only exception 降霜 *jiàngshuāng*, its reverse form 霜降 probably plays a role. 霜降 is one of the traditional solar terms (节气), and the common use of which in daily life is likely to have rendered 降霜 more informal.

**Table 3.** Distributions of 降 *jiàng* and 下 *xià* (CCL)

	降雾	下雾	降霜	下霜	降露	下露
Formal	6	1	6	7	2	0
Informal	2	9	7	19	0	4

## 4.2 Evidence from Archaic Chinese

Further evidence can be obtained from Archaic Chinese with the Hantology link to the radical 雨. The morphosemantic and grammatical differences of the characters sharing the

radical in fact can be predicted according to the differences in the conceptualisation of perception of ‘water’ vs. ‘weather process’.

First, the expressions of directional meanings concerning those weather phenomena have the same distribution in three different groups in both Archaic and Modern Chinese. According to Ren [18], 雨 *yǔ* ‘rain’, 雪 *xuě* ‘snow’ and 雹 *báo* ‘hail’ can function as weather verbs in Archaic Chinese, denoting to rain, to snow and to hail, respectively. They hence express downward movement themselves. The second group of weather nouns, namely 露 *lù* ‘dew’ and 霜 *shuāng* ‘frost’, need to combine with verbs with downward meanings, such as 降 *jiàng* and 陨 *yǔn* in (1) and (2) below, to indicate their occurrence.<sup>2</sup> The last group, 雷 *léi* ‘thunder’ and 电/電 *diàn* ‘lightning’, are not found to convey any directional meanings.

(1) 凉风至, 白露降, 寒蝉鸣

liáng fēng zhì bái lù jiàng hán chán míng  
cool\_wind\_arrive\_white\_dew\_fall\_cold\_cicada\_chirp

*Cool wind arrives. White dew appears. Winter cicadas chirp.* (Yueling, in *Liji*)

(2) 駟见而陨霜

sì xiàn ér yǔn shuāng  
Star-Si\_appear\_then\_fall\_frost

*There will be frost when Star Si appears.* (Zhouyuzhong, in *Guoyu*)

Secondly, of the eight weather phenomena, the three groups can be attributed to their denotational differences. A weather phenomenon can be viewed as consisting of weather event and weather product. We can view the ontological class of ‘water’ as specifically the weather product of such phenomena. As analysed previously, in Hantology, 雾 *wù* ‘fog’, 露 *lù* ‘dew’ and 霜 *shuāng* ‘frost’ are linked to ‘water’ and refer to weather products exclusively. 雷 *léi* ‘thunder’ and 电/電 *diàn* ‘lightning’ refer to ‘weather process’ as events. And lastly, 雨 *yǔ* ‘rain’, 雪 *xuě* ‘snow’ and 雹 *báo* ‘hail’ refer to both. Based on ancient scholars’ annotations and semantic facets of the words in actual use, Ren [18] argues that 雾 *wù*, 霜 *shuāng* and 露 *lù* are [+material], and have almost no verbal usage; 电/電 *diàn* and 雷 *léi* are [+process], and can be used as nouns and verbs; 雨 *yǔ*, 雪 *xuě* and 雹 *báo* are [+material, +process], and can also function as nouns and verbs. It shows that the ontology nodes and semantic features have one-to-one correspondence on this issue and can thus have mutual corroboration. Note that although the thunder group seems to be exceptional to have both N/V categories, their nominal usages are different from the rain group. In Mandarin Chinese, the rain group has deep unaccusative behaviours in appearing as subjects of intransitive constructions. However, the thunder group cannot typically appear in subject position. This indicates the strong referentiality and ‘nouniness’ of the

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<sup>2</sup> No expression describing the occurrence of fog was found in the ancient documents we investigated.

rain group; while it is likely that the nominal usage of the thunder group is in fact nominalisation of the weather process. This difference can also be underlined by the wider range of modifiers the rain group can take, vs. the restricted group of manner-related modifiers allowable for the thunder group.

We can make one important observation about these three groups of linguistic representation with regard to Eriksen et al.’s [1] typology of weather and language. They propose that weather events are encoded in three types of linguistic representations: Predicate type, Argument type, and Argument-Predicate type. They also observe that precipitation events tend to be encoded by only one type in any language. We found that the three groups of weather words with radical 雨 *yǔ* attest the first two types of representation. However, true precipitation events are represented by either Predicate or Argument types, contrary to their prediction. This should be accounted for with closer examination of types of weather events in the future. In addition, recent study [19] shows that fog, dew and frost expressions exhibit intriguing typological behaviours across languages in terms of encoding type and directionality, thus also deserve further investigation.

According to Huang’s [5, 20] research, a concept which can be defined independent of time is *endurant*, and a concept which must be defined dependent of time is *perdurant*. Furthermore, Huang claims that [+N] feature stands for *endurant* properties, and [+V] feature represents *perdurant* properties. Since a process is dependent of time, while material is not, we can now connect the *endurant/perdurant* dichotomy with semantic features proposed by Ren [18], together with the ontology node linking and the directions of those weather phenomena, as illustrated in Table 4.

**Table 4.** Connection of related aspects concerning weather words in Archaic Chinese

	雾露霜	雨雪雹	雷电
Direction	Down	Down	None
Node	Water	Both	Weather Process
PoS	N.	N./V.	N./V.
Feature	+Material	Both	+Process
Temporal Dichotomy	Endurant	Both	Perdurant

### 4.3 A Momentum Account

We can know from the mechanisms of fog, dew and frost, as introduced before, that they involve a formation process, and some types of fog even involve movement. Then why can’t they be linked to ‘weather process’ node, or be used as verbs, or have [+process] feature in Archaic Chinese? The answer may lie in physics.

In physics, momentum is a quantity expressing the motion of a body, which equals to the product of its mass and velocity, and is defined as below.

$$p = mv \text{ [21]}$$



We propose that the momentum of the weather phenomena is positively correlated with its activity. Large momentum brings about high activity, and high activity leads to more ‘verby’ properties. Based on the research of Houghton [22], Hughes and Brimblecombe [23], Matzner [24], Libbrecht [25] and Ahrens [3], fog droplets are around 0.01-0.02 mm in diameter; dew droplets at initial stage are about 0.035 mm in diameter, and their mean diameter at sunrise is about 0.2 mm; rain drops are equal to, or greater than 0.5 mm in diameter; most of the snow crystals are much larger than rain drops, e.g., the famous multi-branched stellar dendrite crystal could be 3 mm from tip to tip; hailstones are greater than 5 mm in diameter. We have not found data on frost size, but since it comprises ice crystals as snow and is usually in clusters, there are reasonable grounds to presume that frost crystals are not smaller than rain drops. Thus, the mass of the six phenomena can be roughly divided into two groups, fog and dew being ‘smaller’, and frost, rain, snow and hail being ‘bigger’. Now we count in velocity. The velocities of fog, dew and frost are very small, even close to zero; therefore, their momentum is much smaller than the falling rain, snow and hail. It can thus be seen that the phenomena with smaller momentum have lower activity, lacking the capacity for being verbs in Archaic Chinese. In addition, momentum is also linguistically represented in other respects.

We just mentioned that frost has big mass but small velocity, which makes its momentum smaller than rain, snow and hail. On the other hand, this also makes its momentum greater than fog and dew. Such physical difference is reflected in two aspects. First, as shown in Table 2, for expressions describing frost, there is no Sinitic language with the ‘upward’ direction only, while there are 24.7% for fog and 15.2% for dew. In this regard, frost resembles rain, snow and hail. Second, 霜 *shuāng* can compound with verbs with high activity in 55.6% of the Sinitic languages, e.g., 打 *dǎ* ‘to hit’/扯 *chě* ‘to pull’/拉 *lā* ‘to pull’. The percentage is 31.8% for 露 *lù* and 5.6% for 雾 *wù*. The results are in direct proportion to their momentum. In addition, more evidence can be obtained from our data of Sinitic languages that verbs with high activity also tend to take other high momentum weather phenomena as objects. For example, languages may use 打雨 *dǎyǔ* hit-rain to denote raining a heavy rain (e.g. Xingyi Chinese), use 打风 *dǎfēng* hit-wind to denote blowing strong wind (e.g. Guangzhou Cantonese), or use 打闪 *dǎshǎn* hit-lightning to mean lightning flashing (e.g. Harbin Chinese). Please see Dong [19] for more discussions on the relation between momentum and activity.

## 5 Conclusions

In this paper, we examined the correlation between eight weather phenomena and their linguistic representations in Mandarin and other Sinitic languages, aiming to account for two observations: that they share the radical 雨 in Chinese orthography, and that the Chinese language somehow contradicts science and allows fog, dew and frost to ‘fall’. We argue that weather events consist of weather process and weather object; hence the radical 雨 is shown by Hantology to represent two corresponding ontology nodes. Such concep-

tual structure gives rise to the distribution of directional meanings, and also the differences in semantic features and PoS in Chinese. Their momentum is argued to be the physical basis for the differences in PoS, semantic features and node linking.

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