

CONTRIBUTION TO WEATHER SCIENCE IN ANCIENT INDIA  
VIII—OBSERVATION AND MEASUREMENT OF METEOROLOGICAL  
PARAMETERS IN ANCIENT INDIA

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The post-Vedic scholars fully recognised the need for collection of meteorological data for understanding the performance and vagaries of the monsoon. We find in the literature a rich variety of observations described here and there. Wherever possible, they made actual measurements also. All these were skilfully used by them in the development of rainfall forecasting techniques. A survey of these observations and measurements is made in this paper.

INTRODUCTION

Varāhamihira commences his chapters on weather science with the following verse<sup>1</sup>

*Annam jagataḥ prānah prāvṛt kalasya cānnamāyattam ;  
Yasmādataḥ pañkṣyah prāvṛt kālah prayatnena.*

'The living beings depend on food for their existence. The availability of food depends on the monsoon. Therefore, the rainy season deserves careful investigation.'

From the above verse, it is clear that the post-Vedic scholars were extremely result-oriented when they investigated the monsoon and its vagaries. Every observation, however remote it may be, mattered for them if they were convinced that it has some relation to monsoon performance. In other words, they also collected many observations on things, which were not strictly meteorological in character and used them for forecasting rainfall. In this

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paper, we shall mainly deal with the observations and measurements of meteorological parameters.

#### OBSERVATIONS AND MEASUREMENTS

##### A. Wind

That the winds have an important role on the weather was known to even Vedic seers. The replacement of the westerlies by moist easterlies ushering in the monsoon in their region was eagerly awaited by them and whenever it was delayed they performed rituals to propitiate the rain god.<sup>2</sup> They had a general rule that wind from the east brings rains, wind from the west drives away rain, wind from the north favours rain and wind from the south does not produce any rain. They were also familiar with the hot and dust raising winds from southwest and because of the bad effects, the southwest direction itself was considered inauspicious.

It is during the post-Vedic period that wind observations were intensified. The post-Vedic scholars classified the wind into three types ; viz., *Bhāvaka*, *Sthāpaka* and *Jñāpaka*. The *Bhāvaka* wind was defined as that which produces clouds. It produces rain immediately or a few days later. *Sthāpaka* wind is one which was believed to favour formation and nourishment of rain foetuses and its direction is characterised according to the season in which it is observed. In other words, it establishes the rain foetuses and protects them. *Jñāpaka* wind is characteristic of the particular time of observation and reminds one of the season to follow.

The post-Vedic scholars were familiar with observation of the strength and direction of the wind by the movement of clouds. They also used the surer method of measuring wind direction with the help of a pole of 12 cubits in length, at the top of which a flag of black colour 4 cubits in length was attached.<sup>3</sup> When the wind was not steady, the wind direction was taken as the one from which the wind was strongest.

The details we get in the literature regarding interpretation of wind direction in terms of weather that was likely to occur later show that almost daily observations of wind at each place should have been made and some sort of a diary kept on the same. It is almost certain that our ancients were as familiar with local wind as the present day meteorologist whose knowledge is mostly based on measurement by instruments.

The post-Vedic scholars had also carefully observed changing wind directions especially when rain occurred due to a moving system. Many rules involving change of wind directions were framed by them. For example, the following rule obviously refers to a moving system.

When the wind from the north is stopped and the wind from the east blows, it portends rain for five days. When the wind from the east stops

and the wind from the south blows, there will be rain for three more days. When the wind from the west is stopped and the wind blows from the southwest, the rain decreases.

In fact, they had such a good weather sense that they were able to foresee the occurrence of heavy rain days ahead purely based on wind observations.

Our ancients had also studied the seasonal winds which would ensure good monsoon rains and knew well which were beneficial and which were harmful in every month or season. Many details of seasonal winds and their effects are available in literature. But, unfortunately, unless one can fix the region in which they are applicable, there is the danger of mix up of the details pertaining to different regions. In fact, in later literature, the authors themselves have thoroughly mixed up information of different regions. However, people were quite knowledgeable and, therefore, they knew what rules were valid for their region. Some details of the utilisation of wind information in forecasting have already been given in previous papers.<sup>4</sup>

### B. Clouds

Observation of clouds and their varied nature formed an important component of rainfall forecasting practices in ancient India. The shape, colour, and nature of the cloud provided rich information for them and they carefully collected every detail and related it to expected rainfall. The following extracts from *Bṛhatsaṃhitā* are typical examples.

1. Clouds that resemble pearls, silver, *kamala* flower, lily or collyrium in colour and which are in the shape of aquatic animals will contain abundant water in their embryo. Those clouds which have been scorched by the burning rays of the sun and fanned by a gentle breeze will at the time of delivery pour torrents of water as if they were angry.<sup>5</sup>
2. If the clouds are formed in the east, there will be growth of good crops ; in the southeast, there will be raging fires ; in the south, decay of crops ; in the southwest, destruction of half the crops ; in the west, ample rain ; in the northwest, stormy rain in some places ; in the north, very good rain and if in the northeast, bumper crops. The same effects should be predicted of the wind also arising in several directions.<sup>6</sup>

In *Kṛṣi Parāśara*<sup>7</sup> we find four broad divisions of clouds viz., 1) *Āvarta* 2) *Samvarta* 3) *Puṣkara* 4) *Droṇa*. While *Āvarta* rains in particular areas only, *Samvarta* rains everywhere. Rainfall will be scanty during the predominance of *Puṣkara*. *Droṇa* cloud on the other hand, gives plenty of rain over a wide area. It is not very difficult for a modern meteorologist to infer what clouds they represent. According to Madhusūdan Ojha<sup>8</sup>, the word *Abhra* means low spreading clouds (like what we see in hill areas). Cumulus clouds seen here and there are called *Varddala*, spreading cumulus (like *Alto cumulus*) are called *Ghana*, and clouds covering the sky like a sheet (*stratus* type) are called *Ghata*.

*Meghamālāmañjarī*<sup>9</sup> enumerates eighty types of clouds, ten each in Mandāra, Kailāsa, Trikūṭa, Jaṭhara, Sṛṅgavera, Paryanta, Himavat and Gandhamadana mountains and the author even names them. Kautilya,<sup>10</sup> who deals with clouds in the plains, however, says that there are three types which rain continuously for seven days, eighty that pour minute drops, and sixty accompanied with sunshine. Another classification of the clouds names them as *Naga*, *Parvata*, *Vṛyabha*, and *Arbuda*. The clouds that are found in hill regions during winter giving solid precipitation are said to belong to the *Diggaja* class. Description of clouds according to their visual shape was most common. They found elephants, bulls, pigs, trees, castles, cities, *etc.* in the clouds and attached importance to them. This happened especially in the case of cumulus clouds with some vertical development. Some were identified as capable of giving rain while the others were said to bring no rain. Our ancients were also quite familiar with the type of clouds associated with a moving system when it approaches their region. Some details of the use of clouds in forecasting are already given in previous papers.<sup>11</sup>

Picturesque description of clouds is very common in literature. Verses 13-24 of chapter 24 of *Bṛhatsaṃhitā* gives description of clouds by our ancients. Description of seasonal clouds is also available in literature.

### C. Lightning

Many of the treatises deal with lightning extensively. In fact, most of them have a sole chapter on lightning. The observations on lightning were used by our ancients for forecasting rainfall as well as forecasting good or bad days ahead. We give below some details available in *Bhadrabāhu Saṃhitā*<sup>11</sup> as an illustration.

1. If the sky is cloudy and at that time lightning is seen in the east and its colour is white or yellow, it surely brings rain the next day.
2. If there is intense lightning in the east and its colour is red and at the same time there is wind, there will be only light rain.
3. If lightning of low intensity is accompanied by quick thunder and clouds move already, there will be good rain and sometimes hails will occur.
4. If the colour of lightning is that of saffron, it will be hot the next day and there will be heavy rain in the afternoon.
5. If in the midnight there is lightning in the west, it will be hot the next day.
6. If the sky is filled with dark clouds and looking dark everywhere and at that time there is lightning with blue colour and heavy thundering, it

indicates of an approaching storm with strong winds. There will be rain after three days.

7. If there is intense lightning in the north and the sky is overcast, there will be heavy rain in the morning.
8. If the clouds are reddish in colour and at that time during the day there is lightning, it indicates drought conditions ahead.

There are many more such observations and forecasts in this work. All these show the care with which the observations have been made though one would hesitate to accept all the interpretations as given by the author because of the tinge of astrology in some of them.

#### D. Thunder

*Meghamālāmañjarī* gives interesting details about observations on thunder.<sup>12</sup> Thunder heard in the morning brings immediate rain. If it is heard in the noon, it destroys rain. Thunder heard in the evening brings lot of rain. If thunder is heard in the previous night and rain follows, it will last for three days. If it is heard at midnight it will bring very heavy rain and if it is heard towards the end of night it will rain for a week. The author also gives forecasts of rain based on the nature of sound of thunder as heard by us. If it sounds *Ghumu Ghumu* it portends heavy rain and prosperity. If it sounds *Kat pata* it will give only scanty rain. If it sounds *Dha Dha Dha* it will destroy rain. If an explosive sound is heard there will be hardship to people. But in all cases, whenever thunder is heard and if lightning is also seen, it is considered auspicious.

#### E. Rain

Observations of rainfall date back to Vedic period. While the initial observation during the *R̥gvedic* period were purely qualitative, some classification emerged during the period of *Yajurveda*. The *kārīrīṣṭi* mentions eight types of rainfall, viz., (1) *Jinvarāvṛt*—rain produced by east wind, 2) *Ugrarāvṛt*—rain with winds, 3) *Bhaumarāvṛt*—thundering and raining, 4) *Tveṣārāvṛt*—thundering with lightning and raining, 5) *Purtirāvṛt*—raining overnight, 6) *Srutarāvṛt*—famed as raining much, 7) *Virādāvṛt*—raining while the sun shines, 8) *Bhūparāvṛt*—thundering, lightning, raining.

Quantitative measurements of rainfall seems to have commenced around the beginning of the Christian era. Pāṇini in his *Aṣṭādhyāyī* under the chapter *Varṣapramāṇa* (III 4.32) mentions *goṣpada* as a measure of rainfall.<sup>12</sup>

Regarding the time when one should start measuring the rain for estimating the total rainfall of the rainy season different views were held at that time. Varāhamihira says<sup>13</sup> that it should be commenced after the full moon day of the

month Jaiṣṭha, when it has rained in the asterisms commencing with pūrvāsāḍha. He also quotes another view<sup>14</sup> that the quantity of rainfall should be gauged when for the first time in the season it rains sufficiently enough to make the ground free from dust or when drops of water are visible on the tips of blades of grass.

According to Varāhamihira, the units of measurement of rainfall prevalent during his time (600 A.D.) were *pala*, *ādhaka*, and *drona*.<sup>\*</sup> The rain gauge<sup>15</sup> was round with a diameter of one *hasta* (18 inches) and had marks of *pala*. When it is full it indicated one *ādhaka* of rainfall. Based on the knowledge we have of *pala*, Madhusūdan Ojha<sup>16</sup> infers that one *drona* would mean two and a half inches of rain. This seems to be reasonable since according to Kautilya<sup>17</sup> the annual rainfall is 16 *dronas*, i.e., 40 inches in the Jangla areas, 24 *dronas* in moist areas, 13½ *dronas* in *Asmāka* country, 24 *dronas* in *Avantī* and a large quantity in the *Himālayan* region and in the regions where water channels are made use of in agriculture. Kautilya also says<sup>18</sup> that the superintendent of treasure house was entrusted with the duty of measuring rainfall with a gauge which was also 18 inches (one *aratni*) in diameter. *Sāmasaṃhitā*, an earlier work of Varāhamihira, describes the *ādhaka* measurement as *Mahgadha Māna*. This would support the hypothesis that the system of measurement of rainfall as given by Kautilya and Varāhamihira was prevalent in North India for a long time (3rd century B.C. to 6th century A.D.).

However, according to Parāśara<sup>19</sup> the height and diameter of the rain gauge should be 8 *āṅgulas* (6 in) and 20 *āṅgulas* (15 in), respectively and when it is filled to the brim it measures one *ādhaka*. Parāśara<sup>20</sup> also gives a method of measuring rainfall on the ground. If it measures four cubits on the ground, it amounts to one *drona*.

*Kṛṣi Parāśara*<sup>21</sup> gives a different definition of *ādhaka*. According to the author, the quantity of water spreading over 100 *yojanas* and extending to a height 30 *yojanas* is equivalent to one *ādhaka*.

According to Kautilya, if one-third of the total annual rainfall came from the beginning and ending month of the rainy season and two-thirds in the middle, it augured good and prosperous crops.

#### F. Solid precipitation

The post-Vedic scholars had also observed precipitation in the form of snow in the hilly regions. They knew that thick fog becomes dew when the temperature decreases. Dew was called *avaśyāya*. thick fog was called *dhūmika*. *Kujhaṭi* is another name for mist or fog. *Tuśāra* is heavy snowfall. *Prāleya* is fern (old ice) *Hima* is the general term for snow. They were also familiar with the occurrence of hail which was called by them as *karaka*.

\* 50 *palas* make one *ādhaka* and 4 *ādhakas* make one *drona*.

### G. Observations of atmospheric optical phenomena

Halos round the sun and the moon, different shapes and colours of the illuminated region around the sun, rainbows, comets, meteors, *etc.* were all carefully observed by our ancients and correlations were established with impending weather. Conditions of the sky and colour just before sunset and just before sunrise were also observed and correlated with rainfall. According to Nārada, the colour of the halo around the sun is indicative of rain. However, so many colours have been included in this rule that one doubts whether the forecast has any meaning at all. The halo round the sun is of two kinds, *Paridhi* and *Pariveṣa*.<sup>22</sup> The dull circular cloud-like structure round the sun's disc was associated with rain. Seasonwise changes in the structure of the halos were also studied by our ancients. Every author has a whole chapter on *Pariveṣa*.

Observations of rainbow were also made in the past. The shape and orientation, the direction of its appearance, the apparent point of contact with the ground, *i.e.*, whether it is water, plain ground, or a tree mattered for them and rules were framed accordingly. Some details of the use of the above optical phenomena are given in paper VI.<sup>23</sup>

The meteoric showers were objects of intense observation for our ancients. Several types were identified and meanings were attached to them. Fiery skies and dust-borne skies were also observed and interpreted by them in their own way.

### H. Agricultural meteorology

From very early times, the effect of certain meteorological parameters on the crops was known to man, whose main occupation was agriculture. The sowing seasons for the various foodgrains were carefully chosen keeping in view the characteristics of weather in the region. In the literature, we find several statements describing the effect of weather on crops. We present below a collection<sup>24,25</sup> of some that are of interest to us.

1. If thundering clouds appear in the east on the 9th and the 11th days of the bright half of Pausa, the crops will be damaged.
2. If there is rain on the 5th day of dark half of Pausa and if that happens to be a Tuesday, the crops will be very good that year.
3. If there is heavy rain on the 9th day of bright half of Āṣāḍha, there will be very little produce that year.
4. If it is raining at the time of the sun's entry into the asterism Ārdrā, drought will occur later and crops will be destroyed.
5. If there is wind from the east during the Śarat season, and the wind is from north during the Vasanta season, flowers of fruit-bearing trees will fail to produce good crop.

6. If the wind is from the northwest in Āśāḍha, from the east in Śrāvaṇa, from the north in Bhādrapada, the crops will fail that year.
7. If the wind is from the northwest in Śrāvaṇa, from the east in Bhādrapada from the west in Āśvina, the crops will come very well in the month of Kārttika.
8. If in the rainy season trees like *Ūntkantel* (a bushy tree which camels eat), *Ringni*, or *Sankhapuṣpi* flower, there will be no crops that year.
9. If lightning appears in the south there will be drought.
10. The wind from the northwest may bring rain but it brings pests like locusts with it.
11. If there is wind from the west in Śrāvaṇa, from southwest in Bhādrapada, or from the east in Āśvina, the crops will wither that year due to pest attack.
12. If the wind is from the east or the southeast in Bhādrapada, the crops of that period will be affected by pests.
13. If the wind is from the south in the *Hemanta ṛtu*, if it is from the southwest in the winter, from the west in *Vasanta* as well as *Sarat ṛtus*, the crops will prosper.
14. Wind from the northwest in Śrāvaṇa, from the east in Bhādrapada, and from the west in Āśvina, are good for the crops of rainy season.
15. Wind from the northwest in Āśāḍha, from the south in Śrāvaṇa, and from southeast in Āśvina, will result in withering of crops for want of rain.

In conclusion, it should be said that our ancients were very keen observers and showed a very high skill in the utilisation of the observations even though one would still think many of these associations may be based on scanty data.

#### REFERENCES

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- <sup>12</sup> Garga. *See ref 9*.
- <sup>13</sup> Varāhamihira, *Bṛhatsamhitā*, Ch.23-1, p.221.
- <sup>14</sup> —————, *Ibid.*, Ch.23-3, p.221.
- <sup>15</sup> —————, *Ibid.*, Ch.23-2, p.221.
- <sup>16</sup> Madhuśudan Oja, *Ķādambinī*, p.274.
- <sup>17</sup> Kautilya, *Arthaśāstra*, II, 24.5, p.127.
- <sup>18</sup> —————, *Ibid.*, II, 5-7.
- <sup>19</sup> Varāhamihira, *Bṛhatsamhitā*, p.217 (Notes).
- <sup>20</sup> —————, *Ibid.*, p.217 (Notes).
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