

## CHAPTER 14 — PRESENT AND PAST WEATHER; STATE OF THE GROUND

|            | <i>Page</i>                                                                                |
|------------|--------------------------------------------------------------------------------------------|
| 14.1       | General ..... I.14-1                                                                       |
| 14.1.1     | Definitions ..... I.14-1                                                                   |
| 14.1.2     | Units and scales ..... I.14-1                                                              |
| 14.1.3     | Meteorological requirements ..... I.14-1                                                   |
| 14.1.4     | Methods of observation ..... I.14-1                                                        |
| 14.2       | Observation of present and past weather ..... I.14-2                                       |
| 14.2.1     | Precipitation ..... I.14-2                                                                 |
| 14.2.1.1   | Objects of observation ..... I.14-2                                                        |
| 14.2.1.2   | Instruments and measuring devices ..... I.14-2                                             |
| 14.2.2     | Atmospheric obscurity and suspensoids ..... I.14-3                                         |
| 14.2.2.1   | Objects of observation ..... I.14-3                                                        |
| 14.2.2.2   | Instruments and measuring devices for obscurity and suspensoid characteristics..... I.14-3 |
| 14.2.3     | Other weather events ..... I.14-3                                                          |
| 14.2.3.1   | Objects of observation ..... I.14-3                                                        |
| 14.2.3.2   | Instruments and measuring devices ..... I.14-3                                             |
| 14.2.4     | State of the sky ..... I.14-4                                                              |
| 14.2.4.1   | Objects of observation ..... I.14-4                                                        |
| 14.2.4.2   | Instruments and measuring devices ..... I.14-4                                             |
| 14.3       | State of the ground ..... I.14-4                                                           |
| 14.3.1     | Objects of observation ..... I.14-4                                                        |
| 14.3.2     | Instruments and measuring devices ..... I.14-4                                             |
| 14.4       | Special phenomena ..... I.14-4                                                             |
| 14.4.1     | Electrical phenomena (electrometeors)..... I.14-4                                          |
| 14.4.2     | Optical phenomena (photometeors) ..... I.14-4                                              |
| References | ..... I.14-4                                                                               |



## PRESENT AND PAST WEATHER; STATE OF THE GROUND

## 14.1 General

## 14.1.1 Definitions

The term *weather* in observational practice is regarded as covering those observations of the state of the atmosphere, and of phenomena associated with it, which were initially not intended to be measured quantitatively. These observations are qualitative descriptions of phenomena observed in the atmosphere or on the Earth's surface, such as precipitation (hydrometeor falling through the atmosphere), suspended or blowing particles (hydrometeors and lithometeors), or other specially designated optical phenomena (photometeor) or electrical manifestations (electrometeor). Detailed descriptions may be found in WMO (1975).

A *hydrometeor* is an ensemble of liquid or solid water particles suspended in or falling through the atmosphere, blown by the wind from the Earth's surface, or deposited on objects on the ground or in free air.

A *lithometeor* is an ensemble of particles most of which are solid and non-aqueous. The particles are more or less suspended in the air, or lifted by the wind from the ground.

A *photometeor* is a luminous phenomenon produced by the reflection, refraction, diffraction, or interference of light from the Sun or the moon.

An *electrometeor* is a visible or audible manifestation of the atmospheric electricity.

In meteorological observations, weather is reported in two forms. *Present weather* is a description of the weather phenomena present at the time of the observation. *Past weather* is used to describe significant weather events occurring during the previous hour, but not occurring at the time of the observation.

This chapter also describes the methods of observing a related item: the state of the ground. *State of the ground* refers to the condition of the Earth's surface resulting from the recent climate and weather events, in terms of amount of moisture or description of any layers of solid, or aqueous or non-aqueous particles covering the normal surface.

## 14.1.2 Units and scales

The observations identified as present weather, past weather, and state of ground are reported together with quantitative data. Such observations have been standardized on scales that enable the observer to select an appropriate term from a large number of descriptions derived from the perceptions of human observers and laid down in WMO (1995).

Only quite recently the development of automated meteorological stations and the use of unmanned stations have created the need to quantify the functions so far performed by observers. Efforts in this field have been

reported from many countries. In order to accommodate the varying levels of sophistication and effectiveness of automated meteorological stations in observing present and past weather, specific coding directives have been included in WMO (1995), which are separate from the more complete reporting from manned stations.

## 14.1.3 Meteorological requirements

Present and past weather, as well as the state of the ground, are primarily meant to serve as a qualitative description of weather events. They are required basically because of their impact on human activities and transportation safety, as well as for their significance as regards the understanding and forecasting of synoptic weather systems. It should be noted that several other chapters in this *Guide* deal with related topics. The quantitative measurement of precipitation amounts is described in Chapter 6, Part I and cloud observations in Chapter 15, Part I. Part II treats topics which are specific to aeronautical and marine observations, automated systems, radar, and atmospheric.

Weather observations of interest in the determination of present and past weather are categorized in this chapter into three types: precipitation (falling hydrometeors), atmospheric obscurity and suspensoids (lithometeors and suspended or blowing hydrometeors), and other weather events (such as funnel clouds, squalls, and lightning). Liquid precipitation or fog which leave frozen deposits on surfaces are included in the appropriate precipitation and suspended hydrometeor category.

Other phenomena, such as those of an optical nature (photometeors) or electrometeors other than lightning, are indicators of particular atmospheric conditions and may be included in the running record maintained at each station of the weather sequence experienced. However, they are of no significance in the determination of present and past weather when coding standard meteorological observations, and are included here only for completeness.

## 14.1.4 Methods of observation

The only current capability for observing all of the different forms of weather are the visual and auditory observations of a trained human observer. However, given the high cost of maintaining a significant staff of trained observers, a number of services are increasing their use of automated observing systems in primary observing networks, as well as continuing their use for supplementing manned networks with observations from remote areas.

Basic research (Bespalov, *et al.*, 1983) has confirmed the possibility that weather phenomena may be determined by the logical analysis of a group of data variables. No single sensor is currently available which

classifies the present weather; rather, data from a variety of sensors are used (such as visibility, temperature, dew point, wind speed, and differentiation of rain versus snow) to make such determinations. Computerized automated observing systems have the capability to perform this logical analysis, but they vary in their ability to observe the required weather phenomenon, based on the instrumentation included in the system and the sophistication of the algorithms. While automated systems cannot observe all types of weather event, those of significance can be observed, making them cost-effective alternatives to the fully-trained human observer.

## 14.2 Observation of present and past weather

The observations to be recorded under the headings present weather and past weather include the phenomena of precipitation (rain, drizzle, snow, ice pellets, snow grains, diamond dust, and hail), atmospheric obscurity and suspensoids (haze, dust, smoke, mist, fog, drifting and blowing snow, dust or sandstorms, dust devils), funnel clouds, squalls, and lightning.

The observation of present weather necessitates noting the various phenomena occurring at the station or in sight of the station at the time of observation. In synoptic reports, if there is no precipitation at the time of observation, account is taken of the conditions during the last hour in selecting the code figure.

### 14.2.1 *Precipitation*

#### 14.2.1.1 OBJECTS OF OBSERVATION

The character of precipitation can be defined as being one of three forms, namely showers, intermittent precipitation, and continuous precipitation. Showers are those precipitation events associated with physically-separated convective clouds. Observers (or instruments replacing humans) also have to classify precipitation into the three intensity categories: slight, moderate, and heavy, according to the rates of precipitation fall or other related factors (such as visibility).

The precipitation character (intermittent, continuous, showery) and type (rain, drizzle, snow, hail) affect the definition of scales of precipitation intensity. Until now, no internationally-agreed definition had been laid down for those terms used in describing precipitation intensity. But when instrumental measurement of the intensity of precipitation becomes more universal it should be possible to specify intensity ranges to correspond with those terms. Presently, it is left to each Service to define the terms in the light of local conditions and experience.

Observations of rain or drizzle at low temperatures should distinguish whether the precipitation is freezing or not. Frozen rain or drizzle is that which causes glazed frost by freezing on coming into contact with solid objects.

Solid precipitation can occur in the form of diamond dust, snow grains, isolated star-like snow crystals, ice pellets, and hail, full descriptions of which are given in WMO (1975).

#### 14.2.1.2 INSTRUMENTS AND MEASURING DEVICES

The classification of rainfall into the three intensity categories can be done with the help of an analogue recording raingauge from the slope of the actual rainfall trace made by the pen on the recording drum of the instrument.

Digital precipitation-measuring devices sense both amount and duration of precipitation. The intensity can be determined from the time dependence of precipitation if the sampling frequency is of the order of one minute. For information on exposure, sources of error, and calibration, see Chapter 6, Part I.

One major area of instrumentation involves the identification of the type of precipitation. Systems which are currently under evaluation for operational use involve either optical methods or radar. Recent field tests have shown that all of these systems are capable of detecting most precipitation — except for the very lightest snow or drizzle — in over 90 per cent of the occurrences. The percentage of detection of very light precipitation is usually much lower. Sophisticated algorithms are required to differentiate between several of the precipitation types. For example, wet or melting snow is difficult to distinguish from rain.

A precipitation occurrence sensor system (Wiggins and Sheppard, 1991; WMO, 1985*b*) using Doppler radar has been found to distinguish snow from rain or from hail by measuring the falling speed. The amount is estimated from the total backscattered power. The precipitation-occurrence sensor system detects the start of most precipitation — except for the very lightest snow or drizzle — and can recognize the end of precipitation.

Optical present-weather sensors detect precipitation occurrence, type of precipitation, and in some cases, amount. These instruments are based on a variety of techniques which measure the effects of precipitation particles on light emitted from a transmitter. One such instrument analyses the fluctuation of an infrared light beam while precipitation is falling (WMO, 1989). Others use either forward or backscattering (Gaumet, Salomon and Paillisse, 1991*b*) light, similar to methods of measuring visibility. In all of the optical devices, the size, shape, fall-speed, and concentration of precipitation particles result in different characteristics. These characteristics are usually related to signal strength and signal variability or frequency. The precipitation type determined by these instruments is often compared with the measurements from other sensors, such as temperature and dew point, to determine the precipitation type when the instrument output is indeterminate, and as a form of quality control. The instruments require periodic calibration and/or alignment, as well as more frequent lens cleaning.

Optical devices using laser technology have proved to be more expensive to install and difficult to maintain. Alignment drift problems are characteristic of these instruments, which have longer baselines between the transmitting and receiving apparatus.

A sensor which has been designed specifically to detect freezing rain or glaze is also currently under evaluation for operational use (Starr and Cauwenberghe, 1991). It senses the amount of ice accumulation on a probe. The probe vibrates at a frequency which is proportional to the mass of the probe. When ice freezes on the probe, its mass changes and the vibration frequency decreases. A heater is built into the sensor to de-ice the probe when required. The sensor has also been found to be effective in identifying wet snow.

#### 14.2.2 *Atmospheric obscurity and suspensoids*

##### 14.2.2.1 OBJECTS OF OBSERVATION

In reports which take into account the atmospheric conditions during the last hour, haze should be distinguished from mist or water fog. With haze, the air is relatively dry, whereas with mist or water fog, there is usually evidence of high humidity in the form of water droplets or rime on grass, leaves, etc. If the station is equipped with measuring instruments, it is fairly safe to assume that the obscurity is haze if the relative humidity is less than a certain percentage, e.g. 80 per cent and if the visibility is within certain limit values, e.g. greater than 1 km in the horizontal, and greater than 2 km in the vertical. Mist is to be reported at high humidity values and at a visibility of 1 km or more. In synoptic reporting, fog is regarded as applying to water or ice fogs, generally reducing the horizontal visibility at the Earth's surface to less than 1 km.

Rime deposit is caused by solidification into ice of water droplets in fog on coming into contact with solid objects at a temperature below freezing point. The present and past weather codes do not distinguish between different types of rime.

Wherever the term fog occurs in the present weather and past weather codes it should be read in this sense. In climatological summaries, however, all occasions of visibility less than 1 km are regarded as fog.

Drifting or blowing snow is snow blown off the ground into the air after it has already fallen. In the present weather code, drifting and blowing snow are separately distinguished, the former referring to snow not raised more than below the observer's eye level.

Other meteorological phenomena to be identified include widespread dust in suspension in the air, dust or sand raised by wind, a dust and sandstorm caused by turbulent winds raising large quantities of dust or sand into the air and reducing visibility severely, dust whirls or sand whirls, and, occasionally, funnel clouds.

WMO (1975) should be at the observer's disposal as an auxiliary means.

##### 14.2.2.2 INSTRUMENTS AND MEASURING DEVICES FOR OBSCURITY AND SUSPENSOID CHARACTERISTICS

A possible approach for the identification of obscurity and suspensoid characteristics is the complex processing

of measured values that can act as predictors. The approach requires researching meteorological quantities, which accompany the formation, intensification, and disappearance of the phenomenon, as well as determining the limiting conditions. The problem of identifying fog, mist, haze, snowstorm, and duststorm is reported in Goskomgidromet (1984) and in WMO (1985a). The meteorological visual range serves as the most important indicating element. Of the remaining variables, wind velocity, humidity, temperature, and dew point have proved to be important identifying criteria.

Optical devices measuring the backscattering of light, similar to those which measure visibility, have also been shown to be effective in identifying fog (Gaumet, Salomon and Paillisse, 1991b). The light scattering by fog droplets produces a signal of high-intensity and low-intensity variance.

#### 14.2.3 *Other weather events*

##### 14.2.3.1 OBJECTS OF OBSERVATION

One event of critical importance in the protection of life and property is the recognition and observation of funnel clouds. This phenomenon consists of an often violent whirlwind, revealed by the presence of a cloud column or inverted cloud cone (funnel cloud), protruding from the base of a Cumulonimbus. The cloud may extend all the way down to the Earth's surface, in which case water, dust, sand, or litter may be raised, producing a "bush" around the tip of the funnel.

The strong wind that rises suddenly, lasts for a few minutes, and then passes away is called a squall. Squalls are frequently associated with the passage of cold fronts. In such circumstances, they occur in a line and are accompanied, typically, by a sharp fall of temperature, veer of wind, a rise in relative humidity, and a roll-shaped cloud with horizontal axis (line squall).

The definition of a thunderstorm (WMO, 1992) is an example of the exclusive derivation of the description from the perception of human observers. The occasion should be counted as a thunderstorm when thunder is heard (even if lightning is not observed).

##### 14.2.3.2 INSTRUMENTS AND MEASURING DEVICES

The presence of funnel clouds, or tornadoes, can often be determined with the use of weather radar (see Chapter 9, Part II). Modern Doppler weather radars have become quite effective in the recognition of mesocyclones, thus providing more detailed and advanced information about this severe weather phenomenon than visual observation alone.

Squalls can be determined out of the discrete succession of measured values of wind velocity. If the output of a wind velocity measuring device is combined with those of a wind direction sensor, of a thermometer, or of a humidity sensor, then the identification of a line squall seems to be possible.

Thunderstorms are mainly detected through the use of lightning counters. On the basis of the instruction

provided to observers and issued by different Services, a certain numbers of lightning strokes per interval of time must be selected which may be used in combination with precipitation rates or wind speeds to define slight, moderate, and heavy thunderstorms (see Chapter 7, Part II).

#### 14.2.4 *State of the sky*

##### 14.2.4.1 OBJECTS OF OBSERVATION

The specifications of the state of the sky are used to describe the progressive changes that have occurred in the sky during a previous time. Changes in the total amount of clouds, in the height of the cloud base, and in the type of cloud are to be considered likewise.

##### 14.2.4.2 INSTRUMENTS AND MEASURING DEVICES

Cloud amount characteristics (total cloud cover in oktas, height of cloud base, and total cloud cover in various cloud layers) can be approximated from the variation of cloud-base height measured by a cloud-base optical measuring system by the application of statistical methods. Obviously, this is limited to cloud layers within the vertical range of the cloud-base measuring system (Persin, 1987; US NOAA, 1988).

#### 14.3 *State of the ground*

##### 14.3.1 *Objects of observation*

Observations of the state of the ground (symbolic letters E and E') should be made in accordance with the specifications given in Code tables 0901 and 0975 in WMO (1995), which are self-explanatory.

##### 14.3.2 *Instruments and measuring devices*

Research has shown that it is possible to discriminate main states of soil by means of reflecting and scattering phenomena (dry, humid, wet, snow-covered, rimed or iced) (Gaumet, Salomon and Paillisse, 1991a).

#### 14.4 *Special phenomena*

##### 14.4.1 *Electrical phenomena (electrometeors)*

Electrometeors either correspond to discontinuous electrical discharges (lightning, thunder) or occur as more or less continuous phenomena (Saint Elmo's fire, polar aurora). Full descriptions of electrometeors are given in WMO (1975).

Special records of lightning should include information regarding the type, intensity, frequency of flashes, and the range of azimuth over which discharges are observed; the lapse of time between lightning and the corresponding thunder should be noted. Care should be taken to distinguish between the actual lightning flash and its possible reflection on clouds or haze. Automatic detection systems for lightning location are in operational use in many countries. Chapter 7, Part II contains more information on this topic.

Exceptional polar aurora should be described in detail. Light filters, where available, may be used as a

means of increasing the sensitivity of the observations, and theodolite or clinometers (alidades) may be used to increase the accuracy of the angular measurements.

##### 14.4.2 *Optical phenomena (photometeors)*

A photometeor is a luminous phenomenon produced by the reflection, refraction, diffraction, or interference of light from the Sun or Moon. Photometeors may be observed in more or less clear air (mirage, shimmer, scintillation, green flash, twilight colours), on or inside clouds (halo phenomena, corona, irisation, glory) and on or inside certain hydrometeors or lithometeors (glory, rainbow, fog bow, Bishop's ring, crepuscular rays).

Observers should take careful note of any optical phenomena that occur. A written description should be accompanied by drawings and photographs, if possible. Full descriptions of these phenomena are given in WMO (1975); concise instructions for observing the more common phenomena are given in some observer's handbooks, e.g. (the United Kingdom Meteorological Office (1994).

A theodolite is a very suitable instrument for precise measurements, but when it is not available, a graduated stick held at arm's length is useful; with the occurrence of a mock Sun, the position may be determined by noting its relation to fixed landmarks. The diameter of a corona may be estimated by taking the angular diameter of the Sun or Moon as approximately half a degree.

#### References

- Bespalov, S. M., et al., 1983: *Osnovnyje voprosy razrabotki setevoj avtomaticeskoj gidrometeorologiceskoj stancii* (Main aspects of designing a network of automatic hydrometeorological stations), Trudy GGO, 473, pp. 3-12, Gidrometeoizdat, Leningrad.
- Gaumet, J. L., Salomon, G. and Paillisse, R., 1991a: Automatic observations of the state of the soil for meteorological applications. *Preprints of the Seventh Symposium on Meteorological Observations and Instrumentation: Special Sessions on Laser Atmospheric Studies*, American Meteorological Society, New Orleans, 13-18 January 1991, pp. J191-J194.
- Gaumet, J. L., Salomon, P. and Paillisse, R., 1991b: Present weather determination by an optical method. *Preprints of the Seventh Symposium on Meteorological Observations and Instrumentation: Special Sessions on Laser Atmospheric Studies*, American Meteorological Society, New Orleans, 13-18 January 1991, pp. 327-331.
- Goskomgidromet, 1984: *Opređenije atmosfernih javlenij po dannym avtomaticeskich stancij, soveqanije gruppy ekspertov GMS/MS socialisticeskich stran po teme 9.1. KR GMS/MS* (Identification of atmospheric phenomena from the data from automatic weather stations, meeting of the panel of socialist countries HMS/MS on theme 9.1), Obninsk 24-28 August 1984, Moscow.

- Persin, S. M., 1987: *Izmerrenije vysoty niznej granicy oblakov i karakteristika oblacnosti kak zadaca paspoznavanija obrazov* (Measuring cloud ceiling and characterizing cloudiness as a task of image identification), *Trudy GGO*, 512, pp. 49-91, *Gidrometeoizdat*, Leningrad.
- Starr, K. M. and Cauwenberghe, R. V., 1991: The development of a freezing rain sensor for automated surface observing systems. *Preprints of the Seventh Symposium on Meteorological Observations and Instrumentation: Special Sessions on Laser Atmospheric Studies*, American Meteorological Society, New Orleans, 13-18 January 1991, pp. 338-343.
- United Kingdom Meteorological Office, 1984: *Observer's Handbook*. Fourth edition, Her Majesty's Stationary Office, London.
- United States National Oceanic and Atmospheric Administration, 1988: *Federal Standard Algorithms for Automated Weather Observing Systems Used for Aviation Purposes*. Office of the Federal Coordinator for Meteorological Services and Supporting Research, United States Department of Commerce, FCM-S5-1988, Washington, D.C.
- Wiggins, W. L. and Sheppard, B. E., 1991: Field test results on a precipitation occurrence and identification sensor. *Preprints of the Seventh Symposium on Meteorological Observations and Instrumentation: Special Sessions on Laser Atmospheric Studies*, American Meteorological Society, New Orleans, 13-18 January 1991, pp. 348-351.
- World Meteorological Organization, 1975: *International Cloud Atlas: Manual on the Observation of Clouds and Other Meteors*. Volume I, WMO-No. 407, Geneva.
- World Meteorological Organization, 1985a: Algorithms for automatic coding of the present and past weather by unmanned meteorological stations (M. Mezösi, *et al.*). *Papers Presented at the Third WMO Technical Conference on Instruments and Methods of Observation (TECIMO-III)*, Ottawa, 8-12 July 1985, Instruments and Observing Methods Report No. 22, WMO/TD-No. 50, Geneva, pp. 255-259.
- World Meteorological Organization, 1985b: An improved AES precipitation occurrence sensor system (B. E. Sheppard and K. K. Wu). *Papers Presented at the Third WMO Technical Conference on Instruments and Methods of Observation (TECIMO-III)*, Ottawa, 8-12 July 1985, Instruments and Observing Methods Report No. 22, WMO/TD-No. 50, Geneva, pp. 103-108.
- World Meteorological Organization, 1987: *International Cloud Atlas*, Volume II, Geneva.
- World Meteorological Organization, 1989: The next generation of sensors of ASOS (F. W. Gallagher, III). *Papers Presented at the Fourth WMO Technical Conference on Instruments and Methods of Observation (TECIMO-IV)*, Brussels, 4-8 September 1989, Instruments and Observing Methods Report No. 35, WMO/TD-No. 303, Geneva, pp. 105-109.
- World Meteorological Organization, 1992: *International Meteorological Vocabulary*, WMO-No. 183 Geneva.
- World Meteorological Organization, 1995: *Manual on Codes*, Volumes I.1 and I.2, WMO-No. 306, Geneva.
- 
-

