

Chapter 2

Weather Observations

Weather observations are the basic ingredients of weather analysis. These observations define the current state of the atmosphere, serve as the basis for isoline patterns, and provide a means for determining the physical processes that occur in the atmosphere. A working knowledge of the observation process is an important part of weather analysis.

Source-Based Observation Classification

Weather parameters are determined directly by human observation, by instruments, or by a combination of both.

Human-based Parameters: Traditionally the human eye has been the source of various weather parameters. For example, the amount of cloud that covers the sky, the type of precipitation, or horizontal visibility, has been based on human observation.

Instrument-based Parameters: Numerous instruments have been developed over the years to sense a variety of weather parameters. Some of these instruments directly observe a particular weather parameter at the location of the instrument. The measurement of air temperature by a thermometer is an excellent example of a direct measurement.

Other instruments observe data remotely. These instruments either passively sense radiation coming from a location or actively send radiation into an area and interpret the radiation returned to the instrument. Satellite data for visible and infrared imagery are examples of the former while weather radar is an example of the latter.

Hybrid Parameters: Hybrid observations refer to weather parameters that are read by a human observer from an instrument. This approach to collecting weather data has been a big part of the weather observing process for many years.

Proper sensing of atmospheric data requires proper siting of the sensors. This is particularly critical for instruments located at the Earth's surface. The placement must ensure that the sensor is sampling the atmosphere while not being adversely affected by nearby energy sources or other factors. For example,

if a thermometer is placed in the sun, it will not only sense air temperature but be influenced by solar radiation hitting on the instrument. Both the Office of the Federal Coordinator for Meteorology (OFCM) and the World Meteorological Organization (WMO) provide siting requirements for most instruments.

The collection of various weather parameters into a formal weather observation has evolved over the years. The human observer was a major factor in the process for many years. In recent years, the process has become automated.

Human-Produced Observations

Prior to 1990 surface weather observations across the United States were taken by human observers. Each hour a weather observer went outside, examined the sky, checked a series of instruments, and prepared a report of the current weather for the observation site. The observer used visual observation of the sky to determine the number of cloud layers, the amount of sky covered by each layer, the height of each layer above the Earth's surface, the visibility, and the presence of any precipitation or obstruction to vision. The observer also read instruments to determine the current temperature, dew point temperature, pressure, wind direction and wind speed. The data gathered were then coded into a standard format and transmitted to a variety of users.

Automated Observations

During the early 1990s the observation process became automated. Two automated systems were installed across the United States: the Automated Surface Observing System (ASOS) and the Automated Weather Observing System (AWOS). Essentially, the human observer's part in the process was eliminated or significantly reduced. A combination of sensors and computer processors took over the observation process.

The observations produced by both ASOS and AWOS satisfy most of the weather requirements for aviation operations. Some elements, like thunderstorm occurrence, have not been fully automated and are added to the observation by human observers at larger, high-traffic airports.

Figure 2-1 is a conceptual representation of the automation process. Each weather element has a primary sensor designed to observe that particular element. At specified time intervals,

the primary sensor provides an output value for the element in question. The sensor interval depends upon the instrument and the element it is designed to observe. The sensor output is fed into an algorithm for processing. For some weather elements, information from more than one sensor is used by the algorithm. The algorithm output is the basis for what is reported on the weather observation. The reportable value may differ slightly from the algorithm output value due to the reporting code rules.

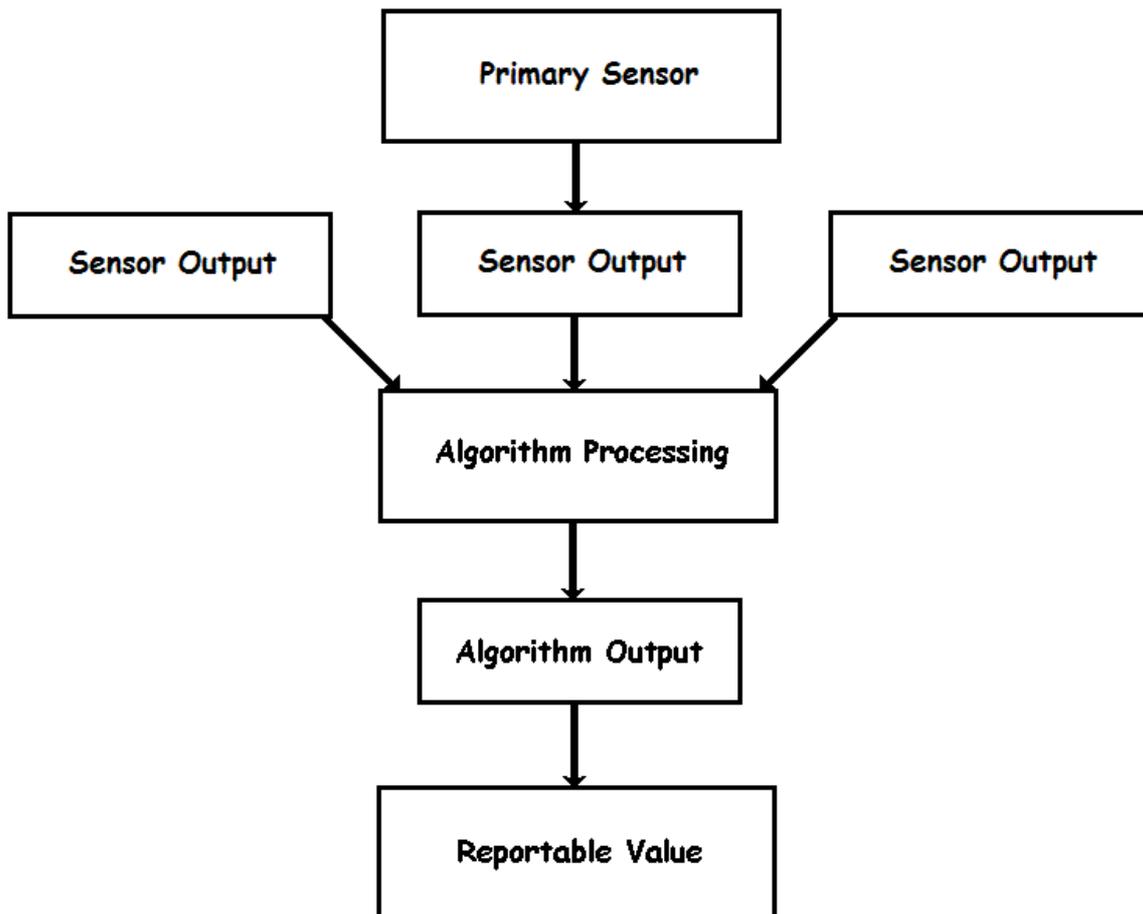


Figure 2-1: Conceptual Representation of the Automated Observing Process.

Determination of temperature and dew point temperature is a relatively simple example. The hygrothermometer (sensor) produces a temperature and dew point temperature value once each minute. Five sensor values from a five minute period are averaged by the algorithm to produce the algorithm output value

in degrees Fahrenheit. This value is converted to degrees Celsius for coding on the actual observation (METAR code).

A more complex example is cloud cover. The laser beam ceilometer (sensor) reports the height of a cloud base every 30 seconds. The algorithm uses 30 minutes of data, or 60 data points, to statistically process these sensor output values into sky cover. The algorithm provides the height of the cloud base and amount of sky covered by clouds for up to three layers. The algorithm assumes that the clouds are moving at a uniform rate across the vertically pointing laser beam.

The Table 2-1 shows the sensor output interval and algorithm averaging period used by ASOS.

Parameter	Sensor Output Interval	Algorithm
Temperature, Dew Pt	1 minute	5 minute average
Wind Speed/Direction	5 seconds	2 minute average
Visibility	1 minute	10 minute harmonic mean
Laser Ceilometer	30 seconds	30 min statistical sort
Present Weather	1 minute	1 minute data
Freezing Rain	1 minute	1 minute data
Rain Gage	1 minute	1 minute data

Table 2-1: ASOS Sensor/Algorithm Information

Types of Observations

There are four types of weather observations based on the location of the observation or type of instrument used. These include: surface observations; upper air observations; radar observations; and satellite observations.

Surface Observations: When the point of observation is at the Earth's surface, the observation is called a surface observation. These observations include the standard airport-based reports from ASOS and AWOS, local networks that are often used by television weathercasters, and temperature and precipitation data from National Weather Service cooperative observers.

Standard airport-based observations always include values for wind direction, wind speed, surface visibility, present weather or obstructions to vision (if occurring), sky condition, temperature, dew point temperature, altimeter setting, and sea level pressure. Additional data on peak wind speed and

direction, precipitation amount, maximum/minimum temperature, and 3-hour pressure change, among other parameters, are included when they occur or at specified times. These data are coded into METAR format for transmission to a wide variety of users. METAR code can be found in Federal Meteorological Handbook, Number 1 (FMH-1), available (for download) from the OFCM web site.

Upper air Observations: When the point of observation is above the Earth's surface, somewhere in the atmosphere, the observation is called an upper air observation. These observations routinely include balloon-borne radiosondes and commercial aircraft data (ACARS). Radiosonde data include temperature, dew point temperature, pressure, and wind as a function of height. Upper level wind data are also available from the weather radar network (VAD winds), the experimental profiler network, and satellite data.

Radar Observations: The National Weather Service (NWS) operates a network of Doppler radars that are the primary source of weather radar data across the United States. Each radar unit has a nominal range of 250 nm from the radar location. The two primary data types from these radars are reflectivity (a measure of the strength of the return signal) and Doppler velocity (a measure of the motion along the beam). These data types are discussed in more detail in Chapter 8.

Each radar unit emits energy at a series of elevation angles in order to sense what is happening in a volume of the atmosphere above the Earth's surface. These data are fed into a set of algorithms that produce a variety of interpretative parameters. Some of these parameters are described in Chapter 8.

All data produced by the NWS radar network are digital and are available to anyone. There are companies that process these data into products that are often seen on television weathercasts. One example of what can be done with these digital data is the regional radar composite where data from several sites are combined into a product covering several states or the entire nation. Sometimes radar data are combined with digital satellite to produce a combination display.

Some television stations have their own radars. Coverage from these radars is limited to 250 nm from the radar location. The algorithm processing varies among units.

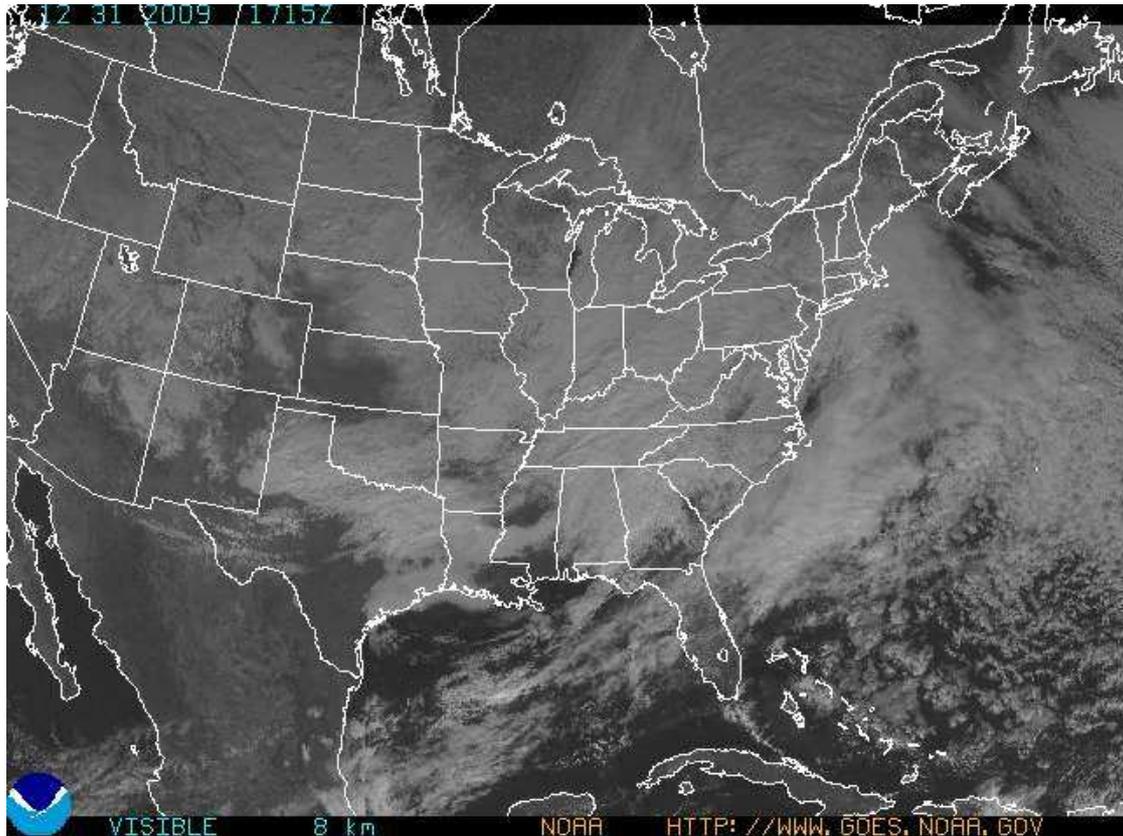


Figure 2-2: Example of a Visible Satellite Image

Satellite Observations: Although there are active sensors on satellite platforms, the satellite imagery most used by weather analysts are passive in nature. These include visible images, infrared (IR) images, and water vapor images (WV).

Visible images show the solar radiation reflected from the Earth's surface. Higher intensity reflections are shown in white with lower reflections toward the darker end of the scale. As a result, clouds are white while shadows are black, with varying shades of gray in between. Visible imagery is routinely available during daylight hours. Figure 2-2 is an example of a visible satellite image.

IR images show the thermal infrared radiation emitted by the Earth and clouds below. These data are converted to a brightness temperature and shaded in either black-and-white or color. For black-and-white imagery, colder clouds are shaded white with warmer areas shown in darker shades. Because all data are digital, any band of temperature may be shaded or set to one color to highlight (or enhance) that particular cloud features. Some of these features are discussed in more detail in Chapter

7. Figure 2-3 is an example of a colored-enhanced IR satellite image.



Figure 2-3: Enhanced Infrared Satellite Image

WV imagery represents the emission of electromagnetic energy by the water vapor in the middle to upper troposphere. Higher moisture values are usually shown at the white end of the scale with drier areas depicted by the darker end of the scale. Color enhancement is common, as shown in Figure 2-4.

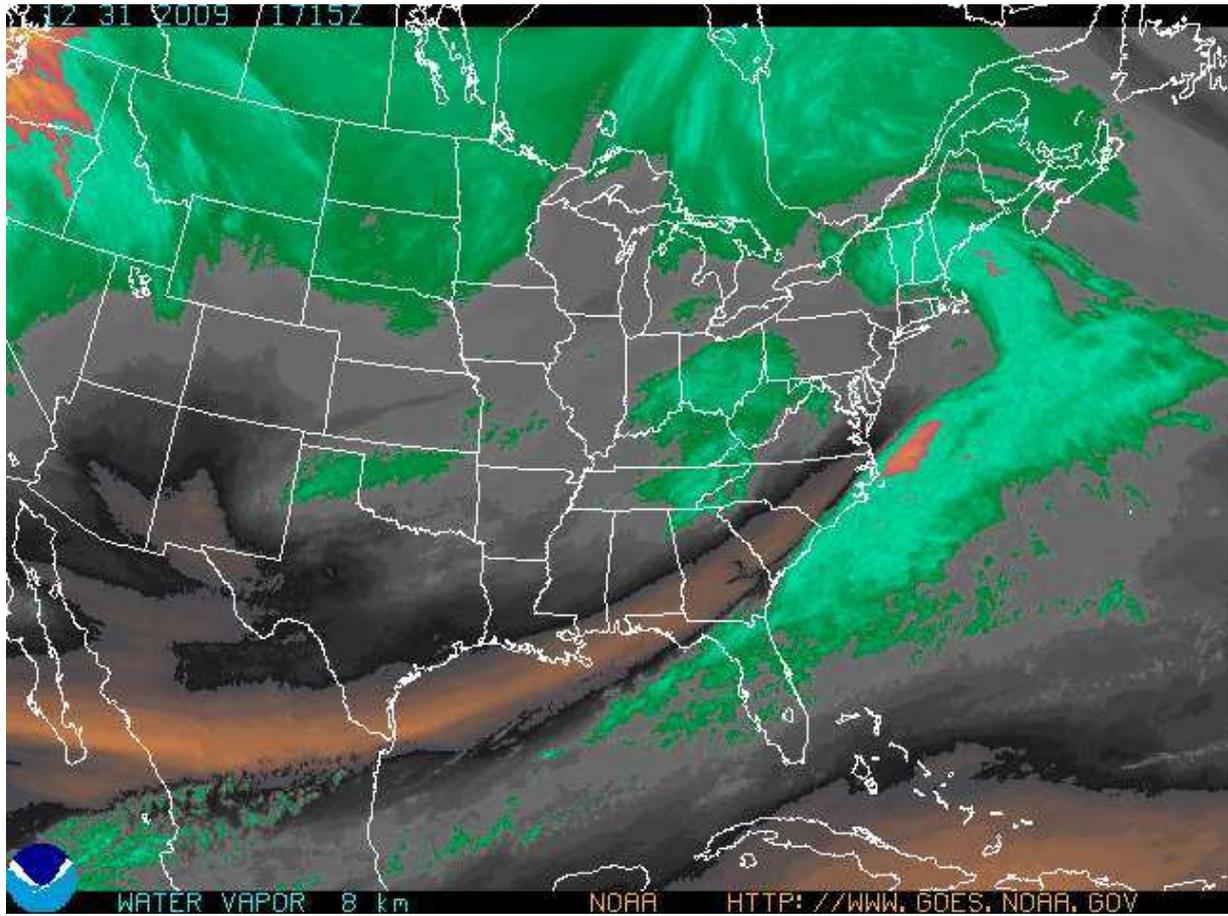


Figure 2-4: Enhanced Water Vapor Image

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