2. SITING

This document describes the stations where Global Atmosphere Watch (GAW) precipitation chemistry and deposition measurements are made. It states the criteria for siting these stations and the requirements for properly locating and installing the precipitation gauge and precipitation chemistry sampler. It addresses the need to document the on-site placement of instruments and site surroundings.

2.1 General Considerations

Selecting the location of stations for monitoring the amount and chemistry of precipitation is of ultimate importance in designing a precipitation chemistry network. Emissions of particles or gases near a station can affect the chemistry of precipitation collected there, resulting in measurements that are unrepresentative of the region where the station is located. Obstructions that interfere with the free fall of rain or snow can increase or decrease the amount of precipitation captured in a standard rain/snow gauge. The goal is to locate a station where the composition of airborne pollutants represents the geographical region of the station and where the physical setting and site surroundings do not bias the precipitation catch. In short, proper site selection is critical to representative precipitation chemistry and wet deposition measurements.

The GAW Programme has promulgated guidelines for monitoring on regional and global scales. These guidelines have been further refined for making representative precipitation chemistry and wet deposition measurements. While specific siting criteria can be difficult to meet, there is some latitude for countries in selecting sites. For example, if a site that is part of an existing network is to be designated as a GAW precipitation chemistry station, it must be carefully assessed as to how well it meets the siting criteria in this chapter. If the desire is to locate a new station, then these criteria should be used to select the best possible site. In all cases, how well a station meets the siting criteria must be documented. This documentation is an important part of the metadata that describes and characterizes the station.

2.2 Categories of Stations

A network of measurement stations is the backbone of the GAW programme. This network consists of global, regional, local, and mobile stations. Complementing measurements from GAW-designated stations are measurements from stations in contributing networks. GAW stations are operated by their host countries, either by their National Meteorological and Hydrological Services or by other national scientific organizations. Contributing networks may be operated by consortiums of governmental, nongovernmental, and private organizations. For precipitation chemistry and wet deposition measurements, it is important that both GAW-designated stations and stations in contributing networks follow the siting criteria and guidelines in this chapter, since both contribute data to the World Data Centre for Precipitation Chemistry.

Global and regional GAW stations, described below, make precipitation chemistry and wet deposition measurements, while local and mobile GAW stations do not report these measurements.

Global stations are the flagship of the GAW programme. These stations provide atmospheric measurements for addressing global issues, such as climate change and stratospheric ozone depletion, as well as measurements of other core GAW parameters. Global stations generally are remote and have low or background levels of air pollutants, representative of a large atmospheric regime. Notably, these stations regularly submit data to GAW data centers.

Regional stations provide atmospheric measurements for assessing regional environmental issues, such as acidic wet and dry deposition, long-range transport of pollutants, biogeochemical cycles, biomass burning, biogenic sources and sinks of greenhouse gases, and others. A regional station is considered less remote than a global station with levels of pollutants that are representative of the surrounding few hundreds of km.

Annex B of *The WMO Global Atmosphere Watch (GAW) Implementation Plan: 2016-2023* provides a detailed list of the requirements and recommendations for GAW stations (WMO GAW Report 228).

2.3 Siting Criteria for GAW Stations

The GAW Programme established siting criteria for a broad suite of measurements at its global and regional stations (WMO GAW Report No. 99). These criteria were set despite the difficulty of finding locations where suitable conditions could be met on an ongoing basis. In principle, depending on the measurement:

1) Global stations should be in remote areas, e.g., islands, mountain ranges, forest preserves:
   a) where no significant changes in land-use practices are expected within 30-50 km in all directions for up to 50 years;
   b) away from major populations, industrial centers, major highways, and airports;
   c) where effects of major natural phenomena such as volcanic eruptions, forest fires, and dust storms do not exist or are very infrequent;
   d) where it can be reasonably assumed that ambient air
      - is free of local pollution,
      - is free of the influence of regional pollution at least 60% of the time evenly distributed over the year, and
      - contains only diluted vestiges of chemical species carried to the site by the long-range transport from sources located at least 30-50 km away;
   e) where a full suite of surface meteorological measurements is reported.

   Global stations should measure at least two variables in at least three of the six GAW focal areas and fully comply with GAW quality assurance requirements. In principle, when occasional effects of local or regional pollution occur at these stations, the data should be filtered appropriately to extract background concentrations and submit both filtered and unfiltered data to the GAW data centers. (Annex B of WMO GAW Report 228).

2) Regional stations should be located:
   a) in rural areas, sufficiently distant from population and industrial centers so the effect of these sources of air pollution is absent most of the year;
   b) in areas normally free of nearby agricultural or other land-use sources, e.g., highways and unpaved roads, construction activities, mining and mineral extraction operations;
   c) at or close to meteorological/climatological stations that make surface observations and perhaps rawinsonde measurements.

For both station types, particular care must be taken that each represents the region of interest in terms of the natural and anthropogenic emissions and topographic features.

Some additional considerations in siting global and regional stations include availability and interest of scientists, existence of a suitable infrastructure, relevance to national and/or regional issues and objectives (especially in developing countries), and the long-term commitment of all parties involved, including laboratories. **Stations are expected to operate for at least ten years.**

2.4 Siting Guidelines and Requirements for GAW Precipitation Chemistry and Wet Deposition Measurements

2.4.1 Regional Guidelines

Sites selected for precipitation chemistry and wet deposition measurements should represent the region where they are located. Areas immediately outside of urban and industrial areas are to be avoided. Table 2.1 provides a detailed list of minimum distances that global and regional stations should be from various sources of anthropogenic and natural emissions. Treat these as guidelines.

Ideally, one would conduct a rigorous assessment of the influence of local emissions on the air and precipitation chemistry at a site before locating a GAW station. The appraisal would consider meteorological and topographic conditions, along with estimated emissions from the activities mentioned in Table 2.1. In practice, such an appraisal may be conducted using data collected at a station over the course of at least a year to assess the representativeness of the station.

Here are some general considerations:

- Representative exposure to air masses is important. Locate a station in flat or moderately undulating terrain. Avoid valleys. If this is not practical, locate a site above the nighttime temperature inversion that typically forms in valleys. Avoid coastal locations with pronounced land-sea breeze effects. Also avoid being too close to trees or towers that not only can alter windspeeds/directions affecting the catch of precipitation but also can be a source or sink of certain air pollutants.
- Stations should not be located near emission sources. Avoid natural sources such as geothermal areas, volcanoes, and areas subject to excessive windblown dust. Avoid sea spray by locating the station sufficiently inland from the coastline.
- Pay special attention to industrial operations and suburban/urban related sources. Power plants, chemical plants, and manufacturing facilities should be at least 50 km from the station, preferably farther. Increase this separation to 100 km, if in the general upwind direction from the station. These same criteria apply to suburban/urban areas with populations of 25,000. For populations greater than 100,000, the station should be no closer than 100 km or 200 km, if in the general upwind direction. Beyond 100 km to 200 km, industrial and urban sources are assumed to blend sufficiently with the air mass characteristics of the region. In highly populated continental regions such as the northeastern United States, portions of western Europe, or southeastern China, it may not be possible to meet all distance guidelines for regional stations.

2.4.2 On-Site Requirements

The site should be accessible in both summer and winter and have a low risk of vandalism. Placement of the precipitation chemistry sampler and standard precipitation gauge should conform as nearly as possible to the following:

1) Install the sampler and gauge over undisturbed land. Naturally vegetated, level areas are preferred, but grass-covered areas and slopes up to ±15% are acceptable. Sudden changes in slope within 30 m of the sampler should be avoided. Ground cover should surround the sampler for approximately 30 m. In agricultural areas, a vegetated buffer strip must surround the sampler, separating it from crops or tilled soil by at least 30 m.
2) Maintain the height of vegetation at the site to less than approximately 0.5 m and no higher than half the height of the precipitation chemistry sampler or gauge, measured from the ground to the sampling orifice.
3) Ensure that structures do not project onto the sampler or gauge at an angle greater than 45 degrees from horizontal; 30 degrees is considered optimal, but 45 degrees is the highest angle acceptable. As shown in Figure 2.1, the distance from the sampler to the object must be at least equal to the height of the object and preferably twice the height of the object. Residential dwellings are to be twice their height from the sampler, as well; and should be no closer than 30 m from the sampler when they are in the prevailing upwind direction. Anemometer towers, poles, and overhead wires are considered as structures and must meet these same on-site requirements.
4) To reduce wind turbulence, do not enclose the base of the sampler. Any object over 1 m high that can deflect the wind should not be located within 5 m of the sampler or gauge.

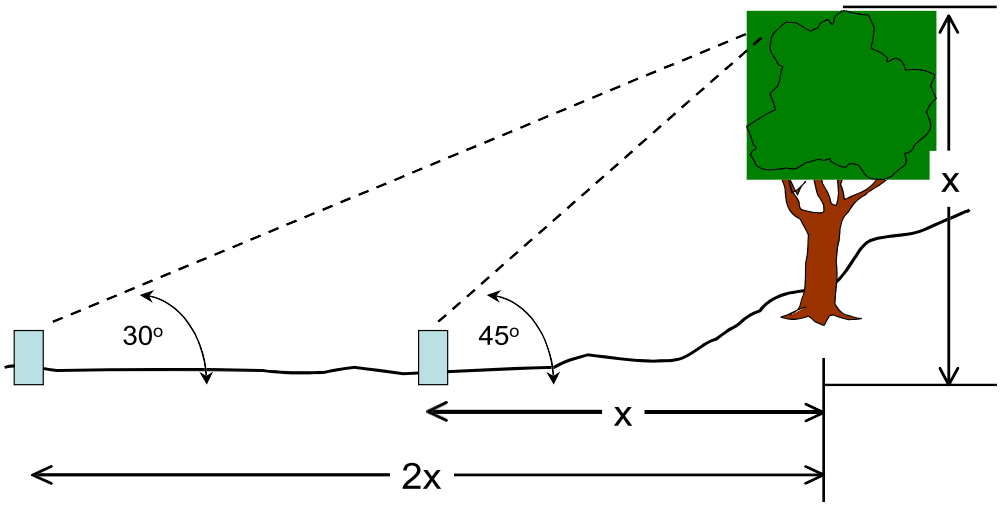

Figure 2.1: How to locate sampler and gauge away from nearby objects.

5) Install the precipitation gauge 5 to 30 m from the precipitation chemistry sampler in accordance with National Meteorological and Hydrological Service (NMHS) standards. In general, the gauge orifice should be located no higher than the sampler orifice; and for some gauges, placement should be as close to the ground surface as possible but high enough to avoid ground splash.
6) In areas where more than 20% of annual precipitation is in the form of snow, equip the gauge with a suitable wind shield. **It is recommended that the wind shield be installed by a meteorological expert**.
7) In areas having an annual accumulation of more than 0.5 m of snow, the sampler and gauge may be raised off the ground on a platform (or platforms). Platforms should be no higher than the maximum anticipated snowpack. Equip the sampler with a properly counterweighted snow roof in areas where snow is 10% or more of the annual precipitation depth. If installed, leave the roof on year-round.
8) Install fencing, if needed, to reduce vandalism or encroachment by animals. An open mesh, galvanized chain link fence is recommended. The placement of the fence must meet requirements in items 3) and 4), above.

See Chapter 3 for a detailed discussion of site facilities and operation of precipitation samplers and gauges. Bigelow (1984) and Dossett and Bowersox (2001) provide examples of siting manuals.

It is recommended that a precipitation chemistry station be located at a standard meteorological station, so long as that station successfully meets the siting requirements identified in this chapter. This enhances the value of the precipitation chemistry data by making collocated meteorological measurements available for data interpretation. Meteorological data are especially useful when unusual precipitation measurements are reported.

Table 2.1: Minimum-Distance Guidelines for GAW Precipitation Chemistry and Wet Deposition Measurement Stations.

Potential Interference	Minimum Distance to Site (km) Global	Regional	Examples, Notes and Local Considerations
SO_2 or NO_x Point Source			
>100 tonnes per year	50	20	If emission sources (such as power plants, refineries, chemical plants, smelters, or other major industrial facilities) are in the general upwind direction from the collector, then the regional distances should be doubled.
>1000 tonnes per year	100	50	
Major Industrial Complex	150	50	
Town, population 1,000-10,000	25	10	Future population growth and associated land development should be considered carefully, especially for towns and villages near a station. If population centers are in the general upwind direction from the collector, then the regional distances should be doubled.
Town, population 10,000-25,000	50	20	
City, population 25,000-100,000	100	50	
City, population >100,000	200	100	
Major highway, airport, railway, shipping lane, harbor	25	5	Moving sources of pollution, such as air, ground, or water traffic or the medium on which they traverse (e.g., runway, taxiway, road, tracks, or navigable river), should not be within 500 m of the collector.
Secondary road, heavily travelled	5	1	The local road network around the site is of particular concern. Traffic volume and type as well as road surface will largely determine the impact at the site.
Secondary road, lightly travelled	1	0.5	
Feedlot operations	50	2	Acceptable distances will vary greatly depending on size of the operation. Even small concentrations of animals should be housed no closer than 500 m. If the feedlot, dairy barn, or animal waste pile can be smelled at the collector, it is too close.
Intensive agricultural activities	10	2	Surface storage of agricultural products, fuels, vehicles, or other source materials should be kept at least 500 m from the collector.
Limited agricultural activities	1	0.4	Storage of small amounts of agricultural products, fuels, or other source materials should be kept at least 200 m from the collector and well-sealed.
Parking lot or large paved area	0.5	0.2	On-site parking lots and maintenance yards also need to be kept at least 300 m from the collector.
Building with fuel combustion	1	0.4	
Sewage treatment plant	20	2	
Active volcano, fumarole, etc.	100	20	Geothermal sites including geysers and springs may have significant emissions and should be avoided.
Natural salt, dust, alkali sources	2	2	Windswept materials from salt and alkali flats as well as sea spray from coastlines can contaminate samples.
Tree line, building	0.05	0.05	

2.5 Site Documentation

A record that documents every station that participates in precipitation chemistry and wet deposition measurements should be available on file with the NMHS or other sponsoring agency. Appendix B (GAW Precipitation Chemistry and Wet Deposition Station Description) provides forms for documenting a GAW station on regional, local, and on-site scales. Periodically completing these forms makes available a temporal history that may be useful for interpreting data from a station. Tracking changes also enables a sponsoring agency to evaluate whether siting criteria are being met. The list, below, provides additional valuable documentation that complements the written description in Appendix B:

1) A map of the region, preferably a topographic map (1:24,000 scale or similar), with the station location identified with a circled X. Include adjoining map(s) if the site is near the map border. If a map is not available, prepare sketches of the region and local area. Sketches should show the location of air pollution sources and land use and land cover surrounding the station.
2) On-site sketch showing placement of all instruments and the location of structures, fences, and other real or potential obstructions to airflow and the free fall of precipitation.
3) Color or black and white photographs of the site showing the area surrounding the sampler in 8 directions (i.e., photos taken facing N, NE, E, SE, S, SW, W, NW). The pictures should be taken from 5 to 7 m from the sampler with the sampler and precipitation gauge in the foreground. Label the back of each photo with the station name, date, and direction.

Station personnel should keep a copy of all documentation for their own records and to use for periodic evaluation of the site.

The GAW Station Information System (GAWSIS) provides the official catalogue of GAW stations and contributing networks. Sponsored by the Federal Office of Meteorology and Climatology MeteoSwiss in collaboration with the WMO GAW Secretariat and other GAW organizations, GAWSIS provides users with a searchable database that documents:

- stations, including descriptions and status
- lists of measurement programs and data availability
- contact people
- bibliographic references and supporting documents

Information on new or closed stations should be reported to GAWSIS and to the WDCPC.

The WDCPC does not maintain a record of GAW precipitation chemistry and wet deposition measurement station documentation (i.e., photos, maps and sketches, site histories, site quality assurance information, etc.). It is the responsibility of each NMHS and sponsoring agency to maintain an archive of this documentation and make relevant information available to interested data users.

2.6 Ongoing Site Evaluation and Changes

Ideally, each station should be inspected by network personnel every year and audited independently every 5 years (Martini and Mohnen, 1994). Any changes should be documented and station description forms, maps, and sketches (as described in the preceding section) should be updated. Copies of the original and updated documentation should be maintained by the sponsoring (NMHS) agency. This includes changes at regional and local scales, as well as on-site. Examples of changes which should be documented include: a new industrial complex being constructed many kilometers away; urban and suburban growth near the site; new agricultural activity being initiated adjacent to the site; and new (interfering) instrument towers being placed near the precipitation sampler or gauge at the site. Where changes are deemed to have compromised the chemical and spatial representativeness of the site, corrective actions must be taken to return the site to compliance. If this is not possible, a site may lose its global or regional status or in the extreme, it may discontinue involvement in the GAW programme.

Follow these guidelines when documenting changes at a station.

- Moving the precipitation chemistry sampler or gauge more than 30 m from the previous location requires new site sketches and pictures. Mark the new placement on the topographic map where the station is located.
- If the station is moved more than 1 km it is considered a new station. A new station identifier will be assigned. New station coordinates and start dates must be provided (refer to Chapter 5 for data submittal).
- The reason(s) for changes in placements of equipment or moves of the station should be described in writing.

Documentation of all site changes must be kept by the NMHS or other sponsoring agency and made available to interested data users upon request. Information on site changes or closures should be reported to the WDCPC and GAWSIS.

2.7 References

Bigelow, D. S. (1984) Instruction Manual, NADP/NTN Site Selection and Installation. July 1984, National Atmospheric Deposition Program, Illinois State Water Survey, 2204 Griffith Drive, MC-674, Champaign, IL 61820-7463.

Dossett, S. R. and Bowersox, V. C. (2001) Instruction Manual, NADP/NTN Site Selection and Installation. Revisions of Chapter 3 and Appendix A. National Atmospheric Deposition Program, Illinois State Water Survey, 2204 Griffith Drive, MC-674, Champaign, IL 61820-7463.

Martini, L. and Mohnen, V. (1994) GAW QA/QC, Wet Deposition System, Audit Questionnaire. Annex E. In *Report of the Workshop on Precipitation Chemistry Laboratory Techniques*, Hradec Kralove, Czech Republic, 18-21 October 1994. WMO GAW Report No. 102. WMO, Case postale No. 2300, CH-1211 Geneve 2.

WMO GAW Report No. 99. (1995) Status of the WMO Global Atmospheric Watch Programme, as of 31 December 1993. WMO, Case postale No. 2300, CH-1211 Geneve 2.

WMO GAW Report No. 228. (2017) Global Atmosphere Watch (GAW) Implementation Plan: 2016 – 2023. World Meteorological Organization (WMO), 7 bis, avenue de la Paix, Box 2300, Geneva 2, Switzerland (https://library.wmo.int/doc_num.php?explnum_id=3395).