2. SITING

This chapter describes the global and regional sites that currently make up the GAW Precipitation Chemistry Programme, and states the criteria and specifications that should be used in locating these sites. Guidelines for precipitation chemistry sampler and rain/snow gauge placement at the site are given, and required site documentation is shown.

2.1 General Considerations

Site characteristics can seriously impact the quality of sampled precipitation. As a result, site selection is a critical part of a monitoring network's design.

The GAW Programme has established guidelines for monitoring on a regional and global basis. The GAW Precipitation Chemistry Programme has further refined the guidelines for siting to monitor precipitation chemistry. While specific siting criteria can be at times difficult to meet, there is some latitude for countries in selecting sites. If a site that is part of an existing network is to be designated as a GAW precipitation chemistry site, 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 the siting criteria can be used to select the best possible site.

2.2 Categories of Stations

In the GAW Programme, there are two categories of monitoring stations, where a wide range of measurements may be taken, including precipitation:

- *Global stations* provide measurements needed to address atmospheric environmental issues of global scale, such as climate change, stratospheric ozone depletion, tropospheric ozone increases and changes in the oxidizing capacity of the atmosphere. A global station is considered remote, with low (background) levels of pollutants, representative of a large atmospheric regime.
- *Regional stations* provide measurements primarily to help assess regional aspects of global atmospheric environmental issues, such as acidic wet and dry deposition, long range transport of pollutants, biogeochemical cycles, exchange of pollutants between the atmosphere and the sea, biomass burning, biogenic sources and sinks of greenhouse gases and others. A regional station is considered less remote than a global station, with medium levels of pollutants, representative of the surrounding few hundreds of kilometres.

A *contributing partner station* is one that is not a Global or Regional GAW Programme station but it contributes data to a GAW World Data Centre. Contributing partner stations are being defined at the time of this manual's writing and will be described in a future GAW report.

2.3 Network Density

The current guideline for GAW network density is that there should be a minimum of one global station per principle climatic zone and per major biome (e.g., Bailey, 1989 and Bailey and Hogg, 1986). This has not yet been achieved. For regional stations, the density should allow regional aspects of global environmental issues and environmental problems of interest to the regions or country(ies) concerned to be adequately addressed.

2.4 Siting Criteria for GAW Stations

The GAW Programme established siting criteria for its global and regional monitoring stations (WMO GAW Report No. 99) that apply to the broad suite of measurement components (i.e., not just to precipitation chemistry measurements). These siting criteria have been established despite the difficulty of finding locations where suitable conditions are met often enough and evenly enough through the year and on a long-term basis.

In principle, and depending on the measurement component:

1) Global stations preferably should be located in remote (if possible pristine) areas where:

   a) no significant changes in land-use practices are expected for at least 50 years within a reasonable distance (30-50 km) in all directions from the stations; away from major populations and industrial centres, away from major highways and airports; if possible on islands, mountain ranges and major forest reserves;
   b) effects of major natural phenomena such as volcanic eruptions, forest fires and dust storms are not frequently experienced;
   c) it can be reasonably assumed that the ambient air at the station is entirely free of the influence of local pollution sources, nearly free of the influence of regional pollution sources 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 kilometres away;
   d) a full programme of surface meteorological observations is carried out.

2) Regional stations should be located:

   a) in rural areas, at any rate sufficiently far away from population and industrial centres, so that the effect of local sources of air pollution is absent at the station most of the year;
   b) on, or close to meteorological/climatological stations making surface and rawindsonde observations.

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

Other siting considerations 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.

GAW global stations are considered as research centres and are expected to monitor all or most of the variables of the GAW measurement programme listed in the WMO GAW Report No. 99, whereas regional stations have a more flexible observational programme. Global stations also serve as reference stations for regional stations. **Stations are expected to operate for at least ten years.**

2.4.1 Siting Guidelines for GAW Precipitation Chemistry Programme Stations

Sites chosen for precipitation sampling should be representative of larger areas. Areas immediately outside of urban and industrial areas are to be avoided. To aid in site identification, Table 2.1 gives the minimum distance that a station should be from various emissions sources.

The distances given in Table 2.1 are guidelines only. It is recommended that an appraisal of the influence of local emissions on the air and precipitation chemistry at a site be made during the site selection process. Such an appraisal should consider meteorological and topographic conditions, along with estimated emissions from the activities mentioned in Table 2.1.

Sites must be representative with respect to their exposures to air masses. The ideal is a well-exposed site in a flat or moderately undulating terrain. If valleys cannot be avoided, the site should be located on the side of the valley above the most pronounced nighttime inversion layer. Coastal sites with pronounced diurnal wind variations due to land-sea breeze effects are also not recommended. Since vegetation is a sink for many air pollutants, it is important to avoid situations where precipitation sheltering by vegetation (e.g., a stand of trees) results in lowered precipitation amounts or sample concentrations when the wind is blowing from a particular direction. In general, sampling sites should not be located around strong natural sources of interfering species, such as geothermal areas,

volcanoes, and areas subject to excessive windblown dust. Sea spray contamination should be avoided by locating the sampler sufficiently inland from the coastline.

Specific attention should be directed to industrial operations and suburban/urban area related sources. Large industrial operations such as power plants, chemical plants and manufacturing facilities should be at least 50 km away from the sampler, preferably further. If the emission sources are located in the general upwind direction (i.e., the mean annual west-east flow in most cases) from the sampler, then its distance should be increased to 100 km. This same criterion also applies to suburban/urban areas whose population approximates 25,000 people. For larger population centres (i.e., greater than 100,000) the sampler should be no closer than 100 km. This distance is doubled to 200 km, if the population is upwind of the sampler. Beyond 100 to 200 km both industrial and urban sources are generally assumed to blend in sufficiently with the air mass characteristics of the region. In highly populated continental regions (e.g., NE United States, portions of western Europe, SE 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 grassed areas and slopes up to ±15% are acceptable. Sudden changes in slope within 30 metres of the sampler should be avoided. Ground cover should surround the sampler for a distance of approximately 30 metres. In farm areas, a vegetated buffer strip must surround the sampler for at least 30 metres.
2) Maintain the height of vegetation at the site to less than approximately 0.5 metres 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 the horizontal (30 degrees is considered optimal, but 45 degrees is the highest angle acceptable). Therefore, 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 away from the sampler (30 degrees) and should be no closer than 30 metres from the sampler when they are in the prevailing upwind direction. Anemometer towers, poles and overhead wires are considered to be structures and must meet these on-site requirements.

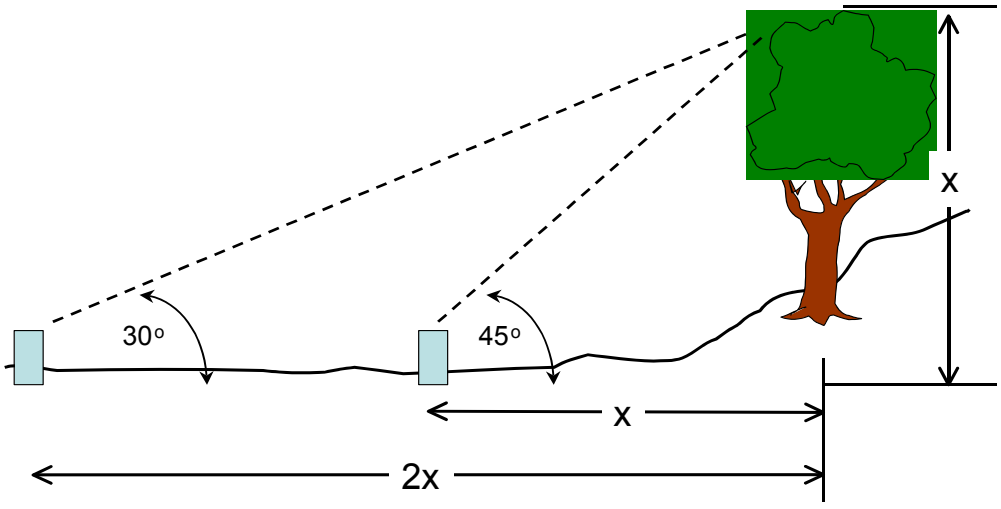

Figure 2.1: How to locate sampler and gauge away from nearby objects.

Table 2.1: Minimum-Distance Guidelines for GAW Precipitation Chemistry Stations.

Potential Interference	Minimum Distance to Site (km) Global	Regional	Examples, Notes and Local Considerations
SO_2 or NO_x Point Source			If emission sources (such as power plants, refineries, chemical plants, smelters or other major industrial facilities) are located in the general upwind direction from the collector, then the regional distances indicated should be doubled.
>100 tonnes per year	50	20	
>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 centres are located in the general upwind direction from the collector, then the regional distances indicated 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, harbour	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 metres 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 metres. 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 metres 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 metres 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 metres 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	

4) To reduce wind turbulence, do not enclose the base of the sampler. Any object over 1 metre high that is capable of deflecting wind should not be located within 5 metres of the sampler.
5) Install the precipitation gauge 5 to 30 metres from the precipitation chemistry sampler in accordance with National Meteorological and Hydrological Service (NMHS) standards. In general, the gauge mouth 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 accumulation of over 0.5 metres of snow per year, the sampler and gauge may be raised off the ground on a platform (or platforms). Platforms should be no higher than the maximum anticipated snow pack. 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, but not required, that the precipitation station be located at a standard meteorological station (GAW or other), if that station successfully meets the siting requirements stated in this chapter. This enhances the value of the precipitation chemistry data by making other collocated meteorological parameters available for data interpretation. Meteorological data are especially useful when unusual precipitation measurements are reported.

2.5 Site Documentation

Each station (or its designated agency or NMHS) is required to maintain written descriptions of the site (on regional, local, and on-site scales) and a history of all changes made to the station. The following items will aid NMHSs in tracking site changes and evaluating if siting criteria and site requirements are being met:

1) The GAW Precipitation Chemistry Programme Site Description Form (Appendix B).
2) Regional, local, and on-site sketches.
3) Colour or black and white photographs of the site showing the area surrounding the sampler in 8 directions at 45 degree intervals (i.e., photos taken facing N, NE, E, SE, S, SW, W, NW). The pictures should be taken at a distance of 5 to 7 metres from the sampler, with the sampler and rain gauge showing in the foreground. Clearly label the back of each photo as to the site, date, and direction.
4) 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.

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

Information about the GAW ground-based stations is available from the GAW Station Information System (GAWSIS), an initiative by the QA/SAC Switzerland in collaboration with the WMO Secretariat, the GAW World Data Centres and other GAW representatives. The goal of GAWSIS is to provide the GAW community and other interested people with an up-to-date, searchable data base of site descriptions, contact people, measurement programmes and available data. The GAWSIS website is now in use at:

http://www.empa.ch/gaw/gawsis/

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

NOTE: At this time, the WDCPC is not maintaining an archive of the GAW precipitation chemistry site documentation (i.e., photos, site histories, site quality assurance information, site maps, etc.). It is the responsibility of each GAW Precipitation Chemistry Programme participant to make their site documentation available to interested data users, via the Internet, if possible.

2.6 On-Going Site Evaluation and Siting Changes

Ideally, each site should be inspected by network personnel every year and independently audited every 5 years (Martini and Mohnen, 1994). Any changes to the site should be documented and corrected forms and maps (as described in the preceding section) should be maintained by the NMHS. This includes changes at regional and local scales as well as at the site. Examples of changes which should be documented include: a new industrial complex being constructed many kilometres away; urban and suburban growth near to 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 invalidated the chemical and spatial representativeness of the site: 1) changes must be made to bring the site back into compliance (if possible), 2) the site must be eliminated as a GAW site, or 3) the site must be reclassified as to the representativeness of its data (e.g., from a global to a regional site).

Changes in site location must be documented so that data users have the ability to determine if measurement changes correlate with physical changes at the site.

1) All site moves greater than 30 metres from the original location require new site sketches, and pictures. A new map is required only if the site moves off the old map.
2) If the station equipment is moved more than 1 kilometre, it is considered to be a new site. A new station ID number will be assigned to the site by the WDCPC. New station coordinates and start dates must be provided (refer to Chapter 5 for data submittal).
3) The reason(s) for the site change should be described in writing.

The documentation of all site changes is to be kept by the GAW Precipitation Chemistry Programme participant (i.e., the NMHS or its designate), 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

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