

Review of Global Atmospheric Watch Sites at Valentia and Mace Head, Ireland

Environmental Research Centre Report

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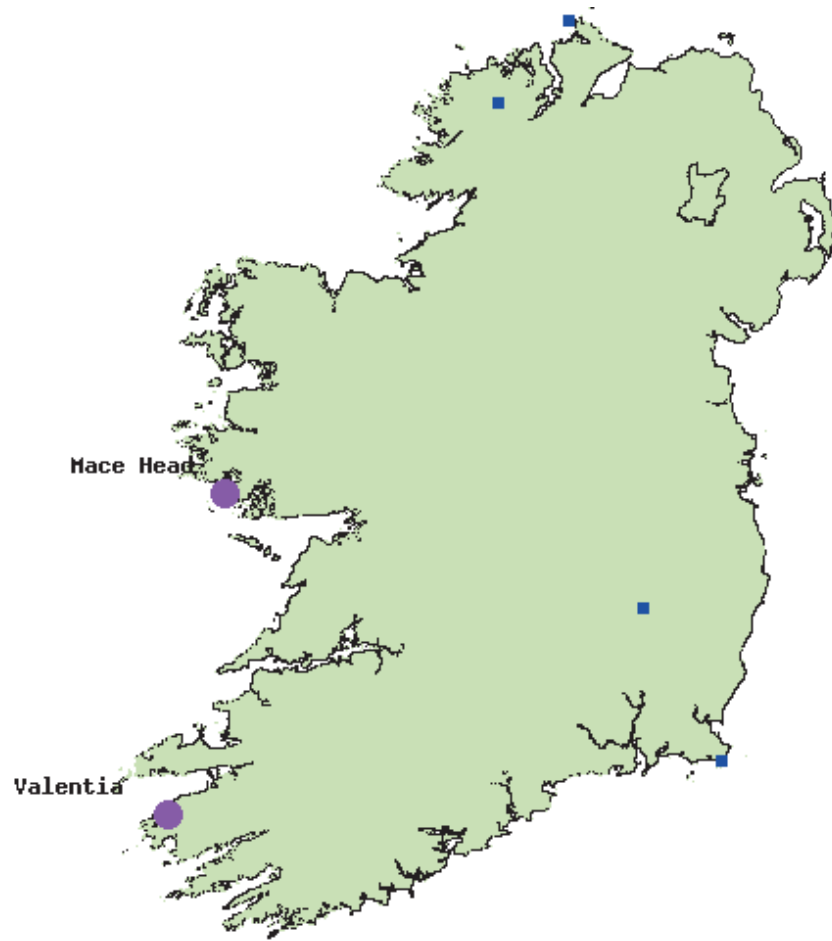
Len Barrie, WMO, Keith Puckett, Environment Canada and Frank McGovern, EPA, at Valentia during the review of Irish GAW sites.



A view of the Valentia Observatory Building, Co. Kerry.



A view of the Mace Head Atmospheric Research Station, Co. Galway .



Map of Ireland showing the Valentia and Mace Head sites.

1 Introduction

The Global Atmosphere Watch (GAW) programme¹ of the World Meteorological Organization (WMO) was established by the WMO Congress in 1989. The WMO Global Ozone Observing System and the global Background Air Pollution Monitoring (BAPMoN) programme were merged into one programme, GAW. GAW is advised by the Working Group on Environmental Pollution and Atmospheric Chemistry (Chair Oystein Hov) of the WMO Commission for Atmospheric Science (President Anton Eliassen). It is coordinated by the Environment Division (Chief, Leonard Barrie) of the Atmospheric Research and Environment Programme (AREP), Department of WMO (Director, Elena Manaenkova) in Geneva.

The mission of GAW is threefold:

1. Systematic global monitoring of atmospheric chemical composition and related physical parameters on a global to regional scale
2. Analysis and assessment in support of environmental conventions and future policy development
3. Development of a predictive capability (e.g. needs real-time delivery of ozone and aerosol observations to forecast centres via the WMO Global Telecommunication System (GTS)).

The emphasis of GAW monitoring as defined in the *Strategic Plan: 2001–2007* (GAW Reports 142 and 156) is on six groups of variables: ozone, UV radiation, greenhouse gases, aerosols, selected reactive gases (CO, NO_y, VOCs, SO₂) and precipitation chemistry. In addition, GAW shares responsibilities at WMO with the World Weather Watch (WWW) programme for the global solar radiation measurement network. For each variable, the GAW system includes a world reference standard (if necessary maintained by a Central Calibration Laboratory), world and regional calibration centres, quality assurance activities, a detailed accounting of

network stations and configuration (through the GAW Station Information System GAW SIS²), a world data centre and oversight through one of six Scientific Advisory Groups (SAGs). Through a network of Global and Regional stations operated by WMO Members as well as contributing stations operated by partners, global coverage of adequate density for the particular variable is maintained. Irish GAW stations make a critical contribution to GAW and the Integrated Global Atmospheric Chemistry Observations (IGACO) strategy that WMO is implementing.

The Irish Meteorological Service (Met Éireann) and the Irish Environmental Protection Agency (EPA) are collaborating to support GAW observational and analysis activities at the GAW Regional station, Valentia (described by responsible managers in Annex 1) and, with the National University of Ireland, Galway (NUI, Galway), the GAW Global station, Mace Head (described by responsible managers in Annex 2). A review of these two stations was co-sponsored by these two agencies in collaboration with the Valentia Station and Mace Head groups. The former was comprised of Met Éireann meteorological staff, the latter of scientists from NUI, Galway. Leonard Barrie of WMO (mentioned above) and Keith Puckett, Director of Air Quality Research Branch of the Canadian Meteorological Service were the reviewers.

The objectives of the review were to:

- evaluate ongoing activities in the context of requirements of the GAW programme
- consider operational issues and challenges and identify realistic options to address them
- identify areas in which improvements or investments may be needed
- provide feedback on opportunities for further development of the sites both individually and in tandem.

1. http://www.wmo.ch/web/arep/gaw/gaw_home.html

2. <http://www.empa.ch/gaw/gawsis/>

2 Review Summary and Recommendations

2.1 Valentia

Valentia is a master station in the Met Éireann network with a history dating back to 1862. The site was inspected in the context of the WMO guidelines for a GAW regional site. Observations related to four of six groups of GAW variables were evident: ozone (column, surface-*in situ* and profile), spectral UV, aerosol chemistry EMEP style (major ions) and bulk precipitation chemistry (major ions). Currently, Valentia does not measure the suite of five GAW core aerosol variables recommended in GAW Report No. 153 (aerosol optical depth, scattering, absorption, mass in two size ranges and chemistry in two size ranges).

It was clearly evident that comprehensive meteorological measurements and some air chemistry observations were being made carefully, that the operations were under control and that they were linked to acknowledged WMO world reference standards. A data management policy was clearly evident and a priority of the programme. The data are regularly transmitted to appropriate agencies that maintain archives and foster use of the data. For example, the column ozone data are transmitted to the GAW World Ozone and UV Data Centre at the Meteorological Service of Canada in Toronto. The role of Valentia as the master station in a larger Irish network is an important part of the programme. There is a well-designed calibration and data delivery strategy that is closely linked to WMO standards.

The current suite of measurements planned or already in place is for the most part complementary and not duplicative of those at Mace Head, and with one exception, the siting was consistent with those of a GAW regional site. Whereas the GAW siting criteria are met for many GAW variables, recent housing and local business developments in the nearby town of 1000 people have put these criteria in jeopardy for *in situ* aerosols and gases. Alternative sites are being considered. The review included a visit to the proposed location of the new remote-sampling site for surface-*in situ* aerosols and gases on Valentia Island nearby. The new location was well situated as a regionally representative site unaffected by local sources and for sampling the clean marine atmosphere.

Valentia is the centre of the Irish solar radiation measurement programme and regularly submits data to the GAW World Radiation Data Centre in St. Petersburg. It is responsible for ensuring that the Irish solar radiation measurements conform to WMO requirements.

The station is well manned with 15 professionals making around-the-clock meteorological and atmospheric chemistry observations. All observations are made by human observers including for example radiosondes four times a day. It should be noted that there are other observations associated with geophysical and phenological programmes. It was pointed out that, given current obligations, there was limited scope for expanding the suite of measurements using the existing staff number or training. Nevertheless, the staff interviewed seemed receptive to accommodating a limited additional number of carefully chosen measurements related to the GAW programme.

In this context, given the availability of effort,

- *the reviewers recommend the installation of automated sun-tracking sunphotometer AOD measurements, to complement those in place at Mace Head, and in addition, to extend chemical analyses of existing samples to describe levels of MSA, using well-developed ion chromatographic techniques.*
- *It is suggested that the current 'bulk' precipitation collector be replaced by a wet-only precipitation chemistry collector conforming to the recently released measurement guidelines in GAW Report No. 160.*

At Valentia, there is a comprehensive capability for total column, vertical profile and surface-based observations of ozone which is appropriate in the context of the growing interest by WMO/GAW and WMO Members in issues related to the Vienna Convention on Protection of the Ozone Layer, ozone as a greenhouse gas (IPCC assessment, UNFCCC convention) and the role of ozone in human health and air quality (UN-ECE LRTAP convention).

- *It is recommended that the ozone sonde measurement programme at Valentia be extended to a year-round programme.*

These ozone sonde observations would be the only measurements in Ireland and the Atlantic seaboard of Europe characterising import of air pollution from North America. They also fill a gap in the stratospheric balloon sonde network. Currently, ozone sondes are released once per week during the late winter/spring period. Ozone sonde measurements are important for characterising the total atmosphere and will become increasingly useful as Ireland and WMO Members add ozone to weather forecast models for improvement of dynamics and prediction of chemical weather (GAW Strategic objective c). The GAW Secretariat in Geneva as well as its World Calibration Centre for Ozone Sondes (H. Smit, FZJ, Juelich, Germany) and Scientific Advisory Group for Ozone (Chair J. Staehelin) are available to assist this effort.

The reviewers were impressed by the Valentia facility, its historical and present significance in the Met Éireann, European and global network and the length of its observational record.

- *It is recommended that a popular communications brochure and website are produced for Valentia and updated periodically. It should introduce interested public, scientists, policy makers and decision makers to the observatory and to its importance in an Irish, European and global GAW network addressing local, regional and global weather, climate and air quality issues.*

2.2 Mace Head

The station at Mace Head (described in Annex 2) became one of 23 WMO/GAW global observatories in 1994. This recognised the long-term observational activities at the station for greenhouse gases (1987) and aerosols (1958) as well as the excellent facilities and support provided by the NUI, Galway, and partners nationally (Met Éireann, EPA), regionally (EU researchers) and internationally (global NASA-funded AGAGE and NSF-funded AEROCE programmes) for long-term atmospheric chemistry programmes and shorter-term research measurement campaigns. The reviewers found the facilities at the station to be well maintained but solid institutional support missing (see recommendation in [Section 2.3](#)).

The location of the site on the western tip of Ireland fulfils the GAW siting criteria and fills a gap in the GAW global network for the compounds measured. The location on the coast in the westerlies downwind of North America and the biogenically active North Atlantic Ocean makes it an ideal place to study the long-range transport of air pollution, marine biogenic gases and sea-salt aerosol production and chemistry.

Mace Head is world renowned for the many atmospheric chemistry research campaigns with exciting new discoveries that have been conducted in parallel with the baseline air chemistry measurements over the past 11 years. Despite this, it does not have a solid footing as a Met Éireann station. The recent addition of an automated meteorological station by Met Éireann is an important improvement bringing meteorological observations at Mace Head into the WMO network and laying the groundwork for further collaboration with Met Éireann. In return, the atmospheric chemistry programme benefits because of having meteorological observations that conform to standards.

Of the six groups of GAW variables, Mace Head has a strong record in the measurement of greenhouse gases, aerosols and two reactive gases (CO, surface ozone) and to a lesser extent UV radiation. It does not measure routinely the total column or vertical profile of ozone, the vertical profile of aerosols or precipitation chemistry.

The aerosol programme at Mace Head is very strong for physical and optical aerosol measurements at the surface. Excellent intellectual and technical leadership is provided by the NUI, Galway, and continuous real-time observations at the surface are made for size distribution, aerosol scattering and absorption and aerosol mass. It has one of two long-term records of cloud condensation nuclei (CCN) in the world. The other is at the Global GAW station, Cape Grim, Tasmania, Australia. Aerosol optical depth is measured routinely using the GAW precision filter radiometer. It was designed and built by the GAW World Optical Depth Research and Calibration Centre, Davos, Switzerland (C. Wehrl). Mace Head is thereby part of the WMO coordinated long-term AOD network (GAW Report No. 162) that is proposed. It will be a key network in aerosol satellite validation and in real-time aerosol observations for next generation forecast models.

The GAW SAG for Aerosols (GAW Report No. 153) recommends that at least five core aerosol parameters

are measured routinely at GAW stations (i.e. aerosol optical depth, scattering, absorption, mass in two size ranges and chemistry in two size ranges). This is fulfilled for the first three variables but not yet for the last two. Due to the proximity to marine sea-salt sources, there is great advantage to be gained in making size-fractionated scattering and absorption observations as well as chemistry (this is an option to be considered by the principal investigators). With regard to mass and aerosol chemistry, we have two recommendations:

- *It is recommended that routine mass and aerosol chemistry in two size ranges are added to the surface measurement programme at Mace Head.*

Continuous mass is currently being done in sub-10- μm particles but needs to be augmented by 1- μm particles according to the GAW guidelines. Aerosol chemistry observations at Mace Head are currently being conducted on bulk samples on a project basis. This is a project in which the EPA is funding the former US AEROCE partner to analyse samples that it had collected.

- *It is recommended that the EPA consider the initiation of a size-fractionated aerosol chemistry programme at Mace Head, possibly by upgrading the funding to Met Éireann's analytical laboratory and the sampling system.*

Due to the strategic location of Mace Head next to the North Atlantic Ocean in the westerlies, the principal investigators should consider adding measurements of total particulate bromine and iodine to the routine aerosol chemistry observations in two size fractions using relatively inexpensive instrumental neutron activation analysis (INAA). This is a prime candidate for a university postgraduate student programme.

In addition, the absence of observations of aerosols in the vertical is a significant deficiency since observations in the surface boundary layer are not always representative of the troposphere aloft. The Japan Meteorological Agency at the Regional GAW station, Ryori, north-east of Tokyo, has instituted a routine operation aerosol LIDAR programme run by meteorological agency staff.

- *It is recommended that vertical profiling alternatives for clouds and aerosols are considered and implemented at Mace Head. Possibilities include LIDAR (several alternatives from simple micro-pulse*

to heavy-duty Raman aerosol systems) and routine light aircraft profiling.

The greenhouse gas programme at Mace Head is well supported by AGAGE partners in the UK, by NOAA/CMDL in the United States and by LSCE/CEA in France. WMO/GAW support for technical personnel to attend biennial workshops such as the 12th WMO/IAEA Meeting of Experts on Carbon Dioxide Concentration and Related Tracer Measurement Techniques in Toronto Sept 2003 (GAW Report No. 161) or its successor the 13th meeting in Boulder Colorado 19–22 September 2005 is often available.

2.3 An Approach for Improved Integration and Support for the Irish Air Chemistry Observational Programme Related to Weather, Climate, Ozone Depletion and Air Quality

The capability of both stations to measure the composition of Irish, European and North Atlantic air in a complementary way strengthens the Irish contribution to the European EMEP and the WMO/GAW programmes. As the incorporation of aerosol and ozone mass conservation equations into weather forecast models moves from research to operational phases in the next 10 years (e.g. the EU-funded GEMS project centred on ECMWF), there will be a need for real-time delivery of observations of aerosol, ozone and their gaseous precursors, with Ireland filling an important gap in western Europe downwind of North America. The ozone and aerosol measurement programmes at Valentia, Mace Head and the rest of Ireland have the potential to evolve in this direction at a minimal cost if foresight in introducing new observational and data management systems is exercised and links to GAW and IGACO are maintained.

In the sections above, recommendations were made on ways to improve the measurement programmes at each observatory while keeping an eye on the whole Irish observational scene related to GAW. With regard to the latter, the following approach to better support an integration of Irish observations related to atmospheric chemistry and the GAW programme is offered by the reviewers:

1. It is essential that the GAW Global station at Mace Head be placed on a solid footing of operational

support that is customary at all other GAW Global stations (e.g. Cape Grim, Australia; Alert, Canada).

- *It is recommended that the EPA, Met Éireann and NUI, Galway, develop a memorandum of understanding for the technical support and life-cycle management of observational equipment and facilities at Mace Head.*
2. The atmospheric aerosol and precipitation chemistry analytical laboratory at Met Éireann is a key facility in Irish air and precipitation chemistry observations. It is currently responsible for analysis of daily samples of aerosols from Valentia and three EPA/Met Éireann sites, operated under the EPA Centre of Excellence (COE) project on transboundary air pollution, as well as daily precipitation chemistry at Valentia. There are currently no long-term aerosol-chemistry in two size-ranges observations at Mace Head and a need exists for a refined approach to EMEP and GAW aerosol measurements at Valentia.
- *Thus, it is recommended that the current aerosol chemistry project at Mace Head is replaced eventually by a long-term programme at both sites with the appropriate support to the analytical laboratory and the sampling equipment in achieving this.*
 - *It is also suggested that the Met Éireann analytical laboratory develop a twinning partnership with larger analytical aerosol and precipitation chemistry facilities such as those at the EMEP Chemical Synthesizing Centre (NILU, Norway) or at the Air Quality Research Branch of the Meteorological Service of Canada (Toronto, Canada). (This takes advantage of costly R&D research on routine analytical systems that is performed elsewhere by much larger laboratories.)*
3. In response to benefits gained from the solid footing of Mace Head described in 1 above:
- *It is recommended that scientists from the NUI, Galway, responsible for aerosol measurements at Mace Head support, with the assistance of the EPA and Met Éireann, the development of a GAW*

core aerosol observation programme at the Valentia Island observatory in cooperation with the Meteorologist and the Principal Meteorological Officer at Valentia.

GAW core aerosol observational systems operating at Mace Head would be duplicated at Valentia and the data shared by both institutions. This arrangement expedites technology transfer from an R&D institution in the country to an operational facility. Since Valentia and Mace Head are in very different parts of the country the measurements are **not** redundant. (*A seasonal 5-day back-trajectory climatology analysis superimposed on the gridded emissions inventory map of SO₂ for Europe and North America would be useful in illustrating this. The German Weather Service's GAW Global station at Hohenpeissenberg has trajectories for all GAW global stations including Mace Head.*) This would also strengthen the Irish commitment to EMEP.

4. Given the uniqueness of Mace Head and Valentia and the need for technology transfer between them,
- *it is suggested that the EPA, Met Éireann and the NUI, Galway, consider holding annually a national GAW technical workshop on "The Role of Atmospheric Chemistry Observations in Climate, Weather and Air Quality Issues" alternately at the two observatories.*

This would have several benefits for the atmospheric meteorological and air chemistry measurement community in Ireland. It would ensure that: (i) Irish data would be reported on a regular basis, (ii) Met Éireann staff would be exposed to the significance of their efforts, (iii) an exchange of views would occur between the research and operational communities, (iv) the observatories would be brought into national focus, and (v) by judicious selection of guest speakers, the European and global GAW and air chemistry community would become aware of the R&D potential of the sites. The association with WMO/GAW would strengthen the link to European and global observations and bring the help of the GAW Secretariat at WMO to bear in planning. There is a precedent for a GAW-based approach by multi-agencies in Switzerland led by MeteoSwiss.