An Integrated Global Atmospheric Chemistry Observations Strategy and WMOs Leading Role: GAW & IGACO

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1. WMO/GAW and IGACO: An International Programme Coordinating Aerosol Observations

The Global Atmosphere Watch (GAW) Programme of the World Meteorological Organization (WMO) was established in 1989 merging the Global Ozone Observing System and Background Monitoring of Air Pollution (BAPMoN) programmes It is focused upon the role of atmospheric chemistry in global change (Strategic Plan, 2001; Strategic Plan Addendum, 2004). Consisting of a partnership of managers, scientists and technical expertise from 80 countries, GAW is coordinated by the WMO Secretariat in Geneva and the Working Group on Environmental Pollution and Atmospheric Chemistry (WG-EPAC) of the Commission for Atmospheric Science (CAS).

WMO/GAW coordinates research and observations contributing to international conventions in which atmospheric chemistry processes are important. For the Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer, GAW supports the WMO/UNEP quadrennial Scientific Assessment of Ozone Depletion and the WMO /UNEP triennial meeting of the Ozone Research Managers of the Parties to the Convention. It also produces regular Ozone Bulletins during the Antarctic Depletion season and is exploring ways to inform the public about severe aerosol events. GAW has been actively involved in supporting the United Nations Framework Convention on Climate Change (UNFCC) through contributions to the Strategic Implementation Plan of the Second Report on the Adequacy of the Global Observing Systems for Climate by the Global Climate Observing Strategy (GCOS). This plan was recently accepted by the Parties to the Convention. Defined in that Strategic Implementation Plan are Essential Climate Variables (ECVs) that need to be systematically measured globally in order to address major issues. Greenhouse gases, ozone and aerosols are the main air chemistry ECVs. WMO/GAW is recognized as the lead international programme in furthering the observational requirements of UNFCC through GCOS. GAW also supports the UN-ECE Long Range Transboundary Air Pollution (LRTAP) Convention signed in 1979.

WMO/GAW has taken the lead in a scientific assessment of the past, present and future state of global air composition observations, the measurement requirements and priorities in the next 15 years for Integrated Global Atmospheric Chemistry Observations (IGACO, 2004). The IGACO Atmospheric Chemistry Theme Report (IGACO, 2004) produced for the partners of the Integrated Global Observing Strategy (IGOS) recommends an approach for integration of ground-based, aircraft and satellite observations of IGACO of 13 classes of atmospheric chemistry variables including aerosol optical properties using atmospheric forecast models that assimilate not only meteorological observations but also chemical constituents. There are four major focii in the planned implementation: IGACO-Ozone, IGACO-Greenhouse Gases, IGACO- Air Quality Long Range Transport of Air Pollution and IGACO-Aerosols. The latter will shape the next generation WMO/GAW aerosol programme of 2008-2015 and will be implemented under the leadership of

WMO/GAW in collaboration with many partners including the ECMWF-based EC-project GEMS, AERONET, GCOS and the Global Earth Observations System of Systems (GEOSS) with its secretariat at WMO. There exist a hierarchy of systems anchored by the WMO GAW programme that clearly integrates and links measurements to applications to the 10 societal benefit areas of GEOSS, namely, disasters, climate, weather, water, health, energy, ecosystem, agriculture, biodiversity.

2. The Global Atmosphere Watch (GAW)

The focus, goals and structure of GAW are outlined in detail in the Strategic Implementation Plan (Strategic Plan, 2001; Addendum 2004). Recognizing the need to bring scientific data and information to bear in the formulation of national and international policy, the GAW mission is threefold:

a. Systematic monitoring of atmospheric chemical composition and related physical parameters on a global to regional scale

b. Analysis and asessment in support of environmental conventions and future policy development

c. Development of a predictive capability for future atmospheric states.

The components of the GAW monitoring programme are summarized in Figure 1. Global GAW networks focus on six measurement groups: greenhouse gases, UV radiation, ozone, aerosols, major reactive gases (CO, VOCs, NO_y and SO_2), and precipitation chemistry. The GAW Station Information System (GAWSIS) was developed and is maintained by the Swiss GAW programme. It is the host of all GAW metadata on observatory managers, location and measurement activities. According to GAWSIS there are 23 Global, 640 Regional and 73 Contributing stations operating or that have submitted data to a GAW World Data Centre. GAW Scientific Advisory Groups (SAGs) for each of the six measurement groups establish measurement standards and requirements while calibration and quality assurance facilities ensure valid observations. Five GAW World Data Centres collect, document and archive data and quality assurance information and make them freely available to the scientific community for analysis and assessments. Note the linkages of GAW to partner networks and to satellite observations that contribute to the global air chemistry observations system.

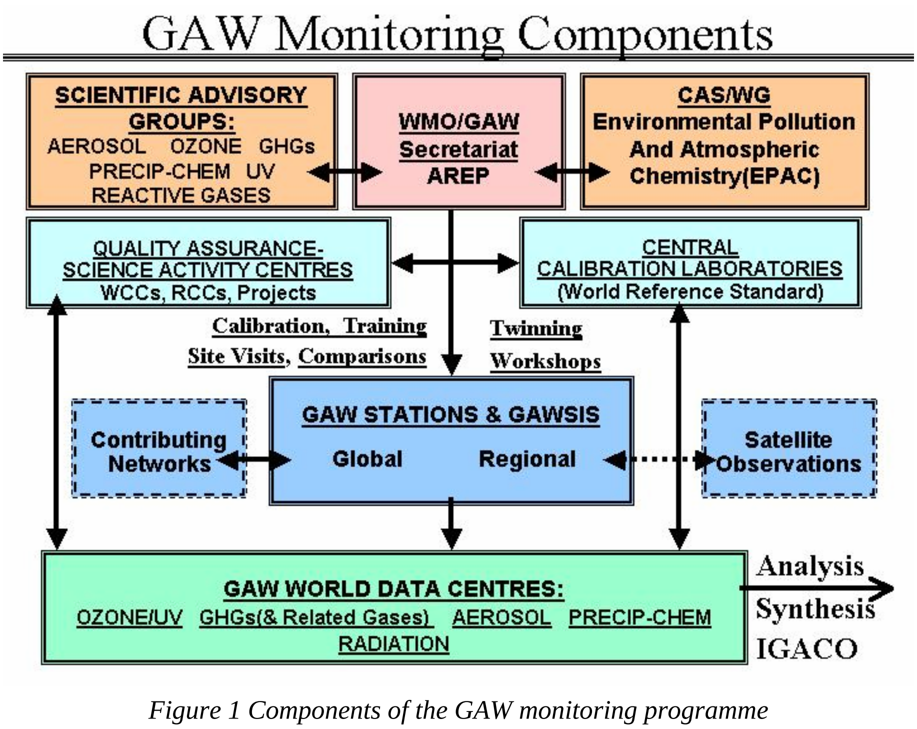

Figure 1 Components of the GAW monitoring programme

Table 1 Summary of GAW calibration, quality assurance and data archiving facilities (as of December 2003). The world central facilities have assumed global responsibilities, unless indicated (am: Americas; e/a: Europe and Africa; a/o: Asia and the South-West Pacific). From the addendum to the GAW strategic implementation plan (strategic plan addendum, 2004).

Species	**QA/SAC**	**World Calibration Centre**	**Central Calibration Laboratory (CCL) World Reference Standard)**	**World Data Centre**
CO_2	JMA (A/O)	CMDL	CMDL	JMA
CH_4	EMPA (Am, E/A) JMA (A/O)	EMPA (Am, E/A) JMA (A/O)	CMDL	JMA
N_2O	UBA	IMK-IFU	CMDL	JMA
CFCs				JMA
Total Ozone	JMA (A/O)	CMDL[1], MSC[2], MGO[3]	CMDL[1], MSC[2]	MSC
Ozone Sondes	FZ-Jülich	FZ-Jülich	FZ-Jülich	MSC
Surface Ozone	EMPA	EMPA	NIST	JMA
Precipitation Chemistry	ASRC-SUNY	ASRC-SUNY	ISWS	ASRC-SUNY
CO	EMPA	EMPA	CMDL	JMA
VOC	UBA[5]	IMK-IFU[5]		JMA
SO_2				JMA
NO_x				JMA
Aerosol		IfT (Phys. Properties)		JRC
Optical Depth		PMOD/WRC	PMOD/WRC[4]	JRC
UV Radiation	ASRC-SUNY (Am)	SRRB (Am)[5]		MSC
Solar Radiation		PMOD/WRC	PMOD/WRC	MGO
^{85}Kr, ^{222}Rn		EML		JMA
^{7}Be, ^{210}Pb		EML		EML

ASRC-SUNY Atmospheric Sciences Research Centre, State University of New York (SUNY), Albany NY, USA, hosting the World Data Centre for Precipitation Chemistry (WDCPC)

BSRN Baseline Surface Radiation Network, Federal Institute of Technology (ETH), Zürich, Switzerland

CMDL Climate Monitoring and Diagnostic Laboratory, National Oceanographic and Atmospheric Agency (NOAA), Boulder CO, USA

EML Environmental Measurements Laboratory, Department of Energy (DoE), New York City NY, USA

EMPA Swiss Federal Laboratories for Materials Testing Research and ResearchTesting, Dübendorf, Switzerland

FZ-Jülich Forschungszentrum Jülich, Jülich, Germany

IMK-IFU Institut für Meteorologie und Klimatologie Atmosphärische Umweltforschung, Forschungs-zentrum Karlsruhe in der Helmholtz-Gemein-schaft, Garmisch-Partenkirchen, Germany

ISWS Illinois State Water Survey, Champaign IL, USA

IfT Institute for Tropospheric Research, Leipzig, Germany

JMA Japan Meteorological Agency, Tokyo, Japan, hosting the World Data Centre for Greenhouse Gases (WDCGG) and the Quality Assurance/Science Activity Centre for Asia and the South-West Pacific

JRC Environment Institute, Ispra, Italy, hosting the World Data Centre for Aerosols (WDCA)

MGO A.I. Voeikov Main Geophysical Observatory, Russian Federal Service for Hydrometeorology and Environmental, St. Petersburg, Russia, hosting the World Radiation Data Centre (WRDC)

MSC Meteorological Service of Canada – formerly Atmospheric Services (AES), Environment Canada, Toronto, Canada, hosting the World Ozone and UV Data Centre (WOUDC)

NIST National Institute for Standards and Testing, Gaithersburg MD, USA

PMOD/WRC Physikalisch-Meteorologisches Observatorium Davos/World Radiation Centre, Davos, Switzerland

SRRB Surface Radiation Research Branch of NOAA's Air Resources Laboratory, Boulder CO, USA

UBA German Environmental Protection Agency, Berlin, Germany

[1] Dobson only

[2] Brewer only

[3] Filter instruments

[4] Precision Filter Radiometers (PFR)

In the past decade, the emphasis of the GAW community on standardization, calibration, quality assurance, data archiving/analysis and building the air chemistry monitoring networks has resulted in major advances. Table 1 summarizes the facilities related to quality assurance and archiving in GAW for the GAW target variables as well as some critical ancillary variables. Over 80% of these facilties have been established under GAW since 1989 while the rest that preceded GAW have been strengthened through membership in the programme. In addition to these facilities, 7 regional calibration centres for total ozone are in operation.

For each variable for which GAW maintains a global network, the triangle of world reference standard (primary standard), calibration and quality assurance, network description , data archiving and network oversight needs to be in place.

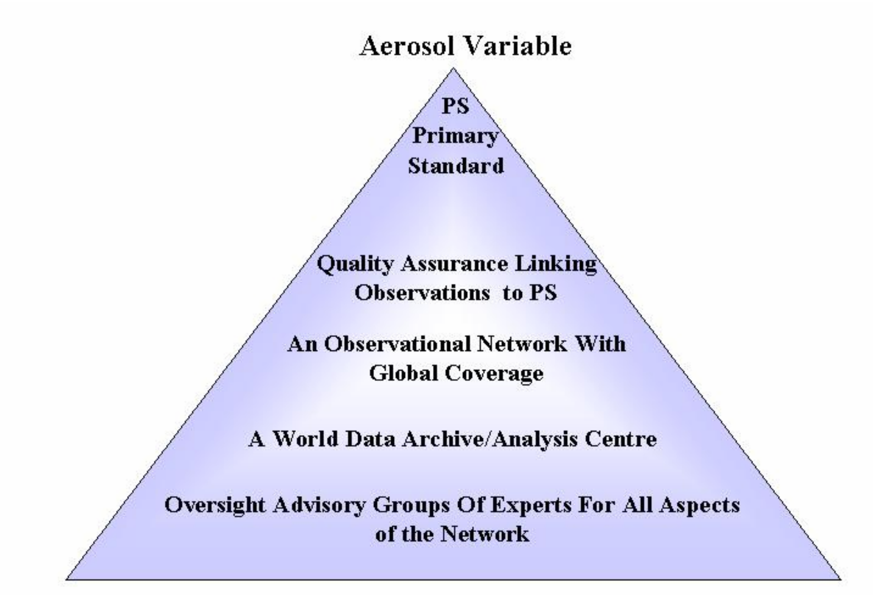

Figure 2 The GAW network triangle: essential components of an aerosol network

There are GAW Global, Regional and Contributing stations that support the monitoring of GAW target variables in each of the six groups. Global and Regional stations are operated by a WMO Member and are defined by Technical Regulations adopted by the WMO Executive Council in 1992 (EC XLIV; 1992) as well as the GAW Strategic Implementation Plan (Strategic Plan, 2001; Strategic Plan Addendum, 2004). Contributing stations are those that conform to GAW measurement guidelines, quality assurance standards and submit data to GAW data centres. They are mostly in partner networks that fill major gaps in the global monitoring network. The difference between a Global and a Regional GAW station lies in the facilities available for long term measurements, the number of GAW target variables measured, the scientific activity at the site and the commitment of the host country. The location of the 23 GAW Global stations is shown in Figure 3. Jungfraujoch in Switzerland is the latest addition to the network.

To monitor global distributions and trends of a particular variable with sufficient resolution to address outstanding gaps in understanding of environmental issues requires not only Global but also Regional and Contributing stations. An example of a mature global GAW network is show in Figure 4 for total column ozone. There are also global networks for other variables such as balloon sonde ozone, surface ozone, carbon dioxide, methane, nitrous oxide, reactive gases and precipitation chemistry that involve different combinations of the three types of stations and network configurations (e.g. GAW Activities, 2003). An important goal of this workshop is to identify the location of all long term aerosol optical depth stations that are currently operated by various organizations and to find ways that they can be knit together into a global network such as that for total ozone in Figure 4.

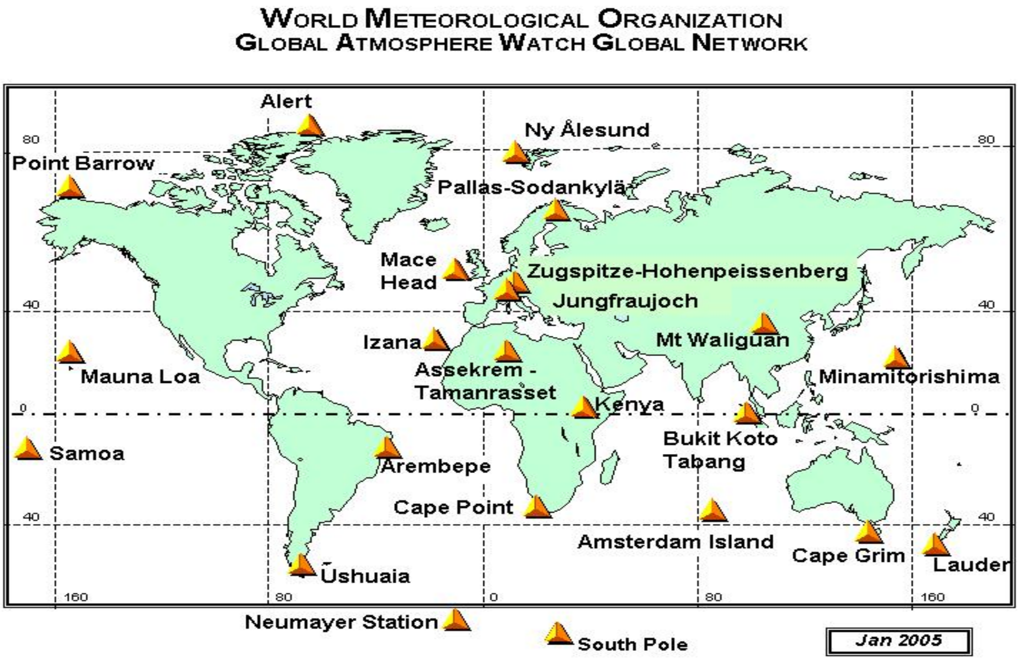

Figure 3 Global stations in the GAW network

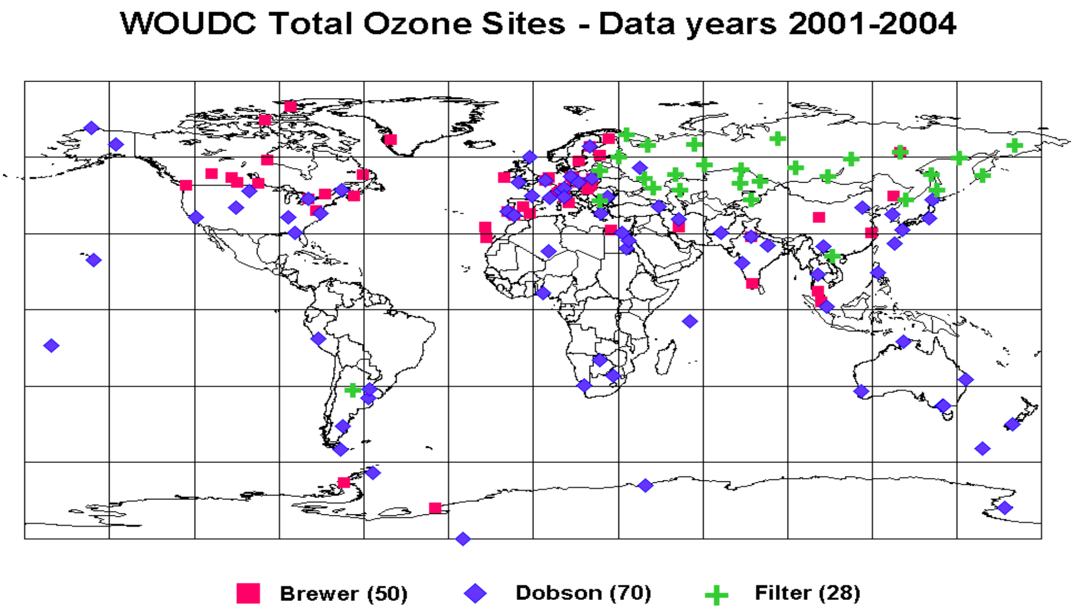

Figure 4 GAW Global network for total column ozone based on data submitted to the World Ozone and UV Data Centre (compliments of Ed Hare Meteorological Service of Canada). The network is comprised of three sub-networks of different instruments and is maintained through regional calibration centres.

3. The Integrated Global Atmospheric Chemistry Observation Strategy For Aerosols (IGACO-aerosol)

WMO/GAW is the designated lead in the implementation if an Integrated Global Atmospheric Chemistry Observations (IGACO) strategy (Fig. 5) within which the next generation GAW will evolve to meet the observational need and challenges of climate change, ozone depletion, air quality and long range transport of air pollution. It is essential that the groundwork laid in the past 16 years for global surface-based monitoring of aerosols is maintained and strengthened. This is no mean feat considering the pressures on WMO Members supporting GAW and partners such as AERONET and national monitoring agencies. In the next decade, technological advances in measurement methodology and data exchange will shape the evolution of GAW monitoring. Merging ground-based in situ and remote sensing observations with routine aircraft and satellite measurements through the use of "smart interpolators" that are under development by the research and modelling community is at once a daunting and exciting challenge.

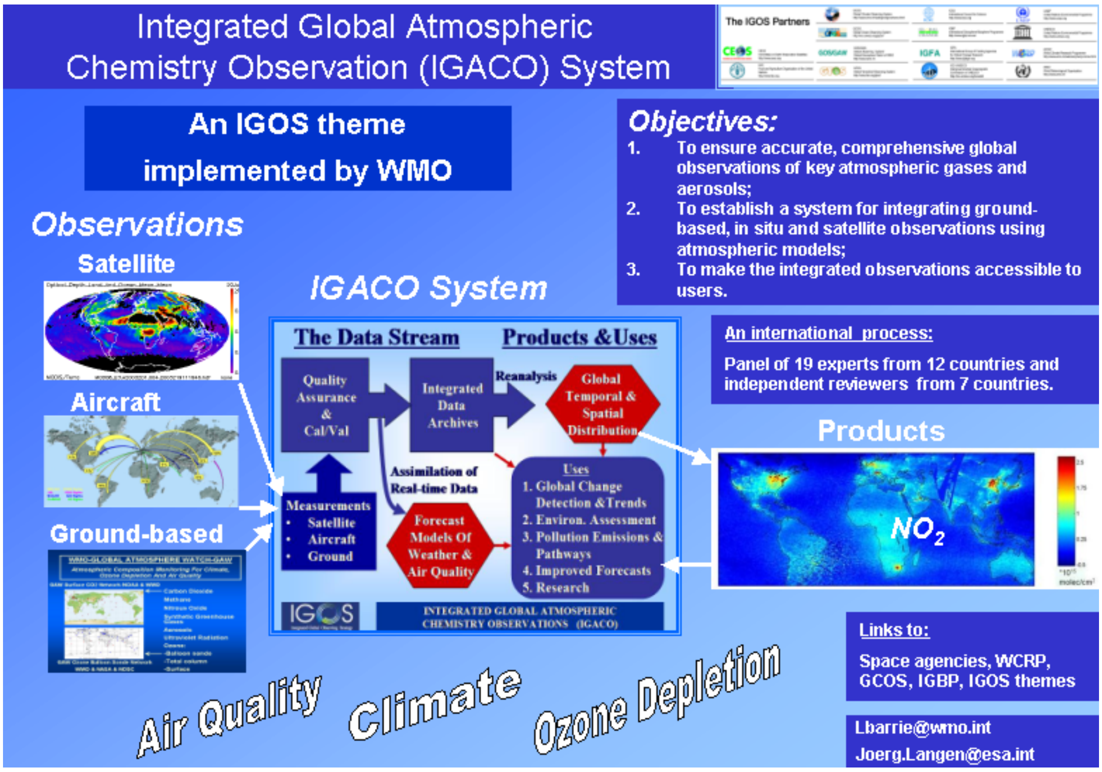

Figure 5 A schematic of the IGACO partners, system and links societal needs and issues.

IGACO will build upon GAW networks and quality assurance facilities as cornerstones while bridging to other observational programmes for commercial aircraft and satellites as well as to the modelling and research community. It will enhance support for the existing observational programmes while filling gaps in data integration/synthesis and application of results, services and products to meet the needs in the nine societal benefit areas (SBAs) of the new GEOSS programme with its secretariat at WMO.

In a recent report on aerosol measurement procedures guidelines and recommendations (GAW Aerosol Guidelines, 2003), five core aerosol observables (aerosol optical depth AOD), scattering, absorption, mass {two size ranges} and chemical composition {two size ranges}) were recommended as a priority for a global surface-based network. In addition, a comprehensive set of other aerosol measurements were recommended that include vertical profiles by LIDAR. In Figure 6 the global long term network for aerosol optical depth is shown. It consists of a 90 stations operated by 8-10 agencies. Half are part of the NASA based AERONET group and half are comprised of WMO partners. The GAW World Optical Depth Research and Calibration Centre (WORCC) in Davos Switzerland will anchor the quality assurance programme of a WMO/GAW coordinated global AOD network that will provided systematic surface-based AOD observations for real time data assimilation by models such as ECMWF and for calibration/validation of aerosol satellite observations.

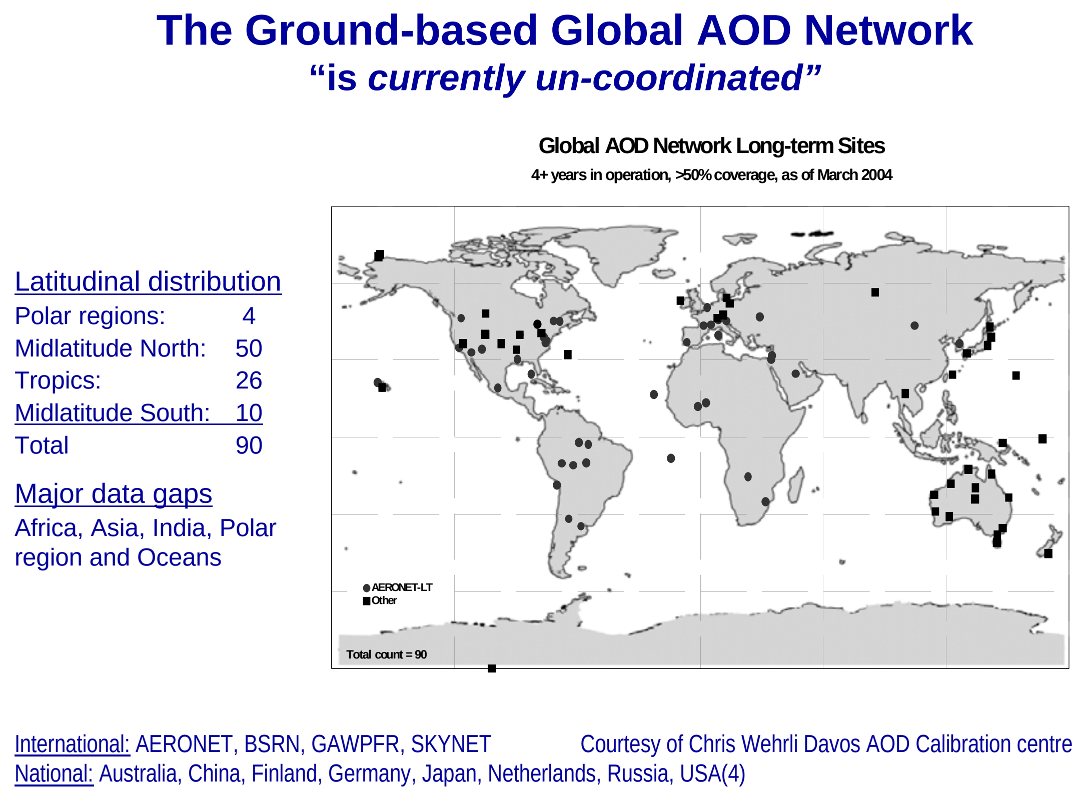

Figure 6 The global long term network for aerosol optical depth (AOD) as of March 2004 (GAW Report #162)

4. References (see GAW home page www.wmo.ch/web/arep/gaw/gaw_home.html)

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