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MEETINGS

Air Quality Remote Sensing From Space

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Recent advances in tropospheric remote sensing have opened the way for measuring, monitoring, and understanding processes that lead to atmospheric pollution. As part of an integrated observing strategy, satellite measurements provide a context for localized observations and help to extend these observations to continental and global scales. The challenge for future space-borne missions will be directly accessing the local scale and facilitating the use of remotely sensed information for improving local- and regional-scale air quality (AQ) forecasts. Achieving this goal could provide important societal dividends for public health, for policy applications related to managing national AQ, and for assessing the impact of daily human activity on the distributions of important trace gases and aerosols and their short-timescale variability—known as 'chemical weather'—as well as on climate.

To address these issues, a recent workshop was held at the National Center for Atmospheric Research (NCAR), in Boulder, Colo., entitled Air Quality Remote Sensing From Space: Defining an Optimum Observing Strategy (AQRS). The primary goal of this community meeting was to examine the key measurement characteristics required for the successful use of satellite remote sensing in measuring environmentally significant pollutant trace gases and aerosols. The meeting engaged over 150 scientists and AQ stakeholders, primarily from North America and Europe, but also had some representation from Asia and Australia.

The workshop sessions were arranged around the following specific objectives:

- Provide an overview of current and future operational requirements for AQ satellite observations;
- Review the current space-based capabilities for measuring tropospheric trace gases and aerosols and assess the benefits and limitations for AQ applications;
- Further the development of techniques for combining space-based measurements with models, particularly at the regional scale, for estimating sources and sinks, and for separating the contributions of local production and transported pollution;
- Examine the horizontal, vertical, and temporal measurement resolutions required to capture the variation of the important atmospheric constituents and processes determining AQ; and
- Explore future mission concepts and detail the parameters of an optimum observation system for AQ studies from space.

After participants heard talks and viewed posters addressing these issues, the last day of the workshop was devoted to lively general discussion sessions aimed at identifying the key observational requirements for AQ science and operational needs, and assessing the relative capabilities of the proposed remote sensing approaches for meeting these challenges. It was recognized that if any mission related to atmospheric composition is to become a reality within the next decade, it is imperative that the atmospheric chemistry community establish its own set of key measurements

At the encouragement of Rick Anthes—co-chair of the National Research Council decadal survey, *Earth Science and Applications from Space*, which is charged with determining the priorities for the next round of space-borne missions—the workshop participants agreed that a statement of community consensus as to the priorities for a future AQ mission should emerge from the meeting. After soliciting input from the participants, a statement document was developed by the organizing committee, which subsequently submitted the document to the decadal survey process. The conclusions of this statement, as expressed in its executive summary, are detailed below.

Air quality measurements are urgently needed to understand the complex consequences of increasing anthropogenic emissions, the biogenic response to changing temperature and humidity, and the escalating incidence of fire. The workshop identified four principal areas in which satellite observations are crucial for future AQ basic research and operational needs: (1) AQ characterization for retrospective assessments and forecasting to support air program management and public health advisories; (2) quantification of emissions of ozone and aerosol precursors; (3) long-range transport of pollutants extending from regional to global scales; and (4) large puff releases from environmental disasters.

The recent advances in tropospheric remote sensing from low-Earth orbit (LEO) instruments such as Measurements of Pollution in the Troposphere (MOPITT), Global Ozone Monitoring Experiment (GOME), Moderate Resolution Imaging Spectroradiometer (MODIS), Multiangle Imaging Spectroradiometer (MISR), Scanning, Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY), Ozone Monitoring Instrument (OMI), and Tropospheric Emission Spectrometer (TES), have demonstrated the value of using satellites for scientific studies as well as environmental applications. Workshop participants agreed that the measurement capabilities for tropospheric ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), formaldehyde (HCHO), sulfur dioxide (SO_2), and aerosols need to be continued and, at the same time, instrument capabilities and measurement algorithms for these species need to be improved.

Ideally, the AQ community envisions a scientific and observing framework for atmospheric composition that is analogous to the framework achieved for weather forecasting. In particular, the U.S. national weather prediction system relies on the combination of observations from geostationary Earth orbit (GEO), LEO, and from suborbital and surface platforms to derive a four-dimensional view (three spatial dimensions plus temporal) of the physical state of the atmosphere. Similar capability for AQ constituents will be required for AQ characterization and 'chemical weather' forecasting.

Workshop participants reached a consensus that multispectral sentinel missions (at GEO or Lagrangian (L-1) orbit, the latter indicating an orbit at the stationary point created by the combined gravitational pull of the Sun-Earth system) that have high spatial and temporal resolution, and which are able to measure the concentrations of some gas species within the boundary layer, would be most beneficial to the AQ community.

At the present time, GEO meets this measurement capability with the least amount of risk, and the greatest societal benefit from a U.S. perspective would be derived from placing such a satellite in an orbit capable of observing North America. The U.S. National Oceanic and Atmospheric Administration's (NOAA) GOES-R operational suite of measurements from geostationary Earth orbit will have some AQ-relevant capability for O_3, CO, and aerosols. However, since NOAA's primary objective is the improvement of weather forecasting, observations currently are not optimized for AQ applications, and critical multispectral measurements in the ultraviolet (UV) and near-infrared (IR) are not planned.

Workshop participants stated the need for a new generation of dedicated AQ satellite missions that also will be part of an integrated observing system that includes air monitoring networks, in situ research campaigns, and three-dimensional chemical transport models. The continued collaboration with NOAA to determine the most efficient and synergistic use of resources to meet AQ observational objectives from GEO and LEO was emphasized by workshop participants. This is particularly important since GEO AQ observations will need to be complemented by operational global measurements of tropospheric gases and aerosols from National Polar-orbiting Operational Environmental Satellite System (NPOESS) and other NOAA and European satellite systems.

Over the longer term, global measurements for AQ with a sentinel capability could be obtained from L-1 orbit, but this approach requires more technical development to ensure the essential multispectral measurements and to mitigate risk. Other approaches for AQ measurements discussed at the workshop included multiple satellites flying in LEO formation and satellites perched in mid-Earth orbit (MEO). The latter can provide time-resolved observations (about five per day at midlatitudes for all longitudes) but with UV/visible measurements switching monthly between north and south. Each of these approaches has value and may harmonize well with measurement objectives put forth by other Earth system science disciplines. The LEO formation and multiple MEO instruments with limb-viewing capability provide better measurement vertical resolution in the middle and upper troposphere which is needed for understanding the impact of tropospheric and stratospheric chemistry on climate. Improved vertical resolution capability is also important in the stratosphere to monitor the stability of the atmospheric ozone layer.

Workshop participants also concurred that a satellite in LEO would be the best platform to help scientists gain an understanding of the composition and size characteristics of atmospheric aerosols throughout the troposphere. This could be achieved by means of multi-angle, spectropolarimetric, and stereoscopic-imaging techniques in conjunction with active (high spectral resolution lidar) measurements.

The workshop, entitled Air Quality Remote Sensing From Space: Defining an Optimum Observing Strategy (AQRS), was held at the NCAR, in Boulder, Colo., on 21–23 February 2006.

Further information about the workshop and the proceedings and presentations are available at http://www.acd.ucar.edu/Events/Meetings/Air_Quality_Remote_Sensing/index.shtml

Acknowledgments

The meeting organizing committee comprised representatives from the different constituencies interested in air quality remote sensing. The committee included David Edwards (NCAR), Philip DeCola (NASA Headquarters, Washington D.C.), Jack Fishman (NASA Langley Research Center, Hampton, Va.), Daniel Jacob (Harvard University, Cambridge, Mass.), Pawan Bhartia (NASA Goddard Space Flight Center, Greenbelt, Md.), David Diner (Jet Propulsion Laboratory, Pasadena, Calif.), John Burrows (University of Bremen, Germany), and Mitch Goldberg (NOAA National Environmental Satellite Data and Information Service, Camp Springs, Md.). Special funding from the U.S. National Science Foundation, NASA, and NCAR supported the workshop participation of 18 early career scientists.

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GEOPHYSICISTS

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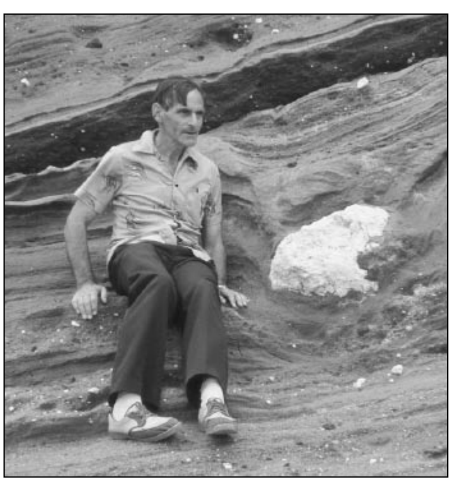
James A. Van Allen, (1914–2006)

James A. Van Allen, who served as president of AGU from 1982 to 1984, died on 9 August. Van Allen was president of the Planetary Sciences Section from 1964 to 1968 and president of the Solar-Planetary Relationships Section (now the Space Physics and Aeronomy Section) from 1976 to 1978. He was awarded the John Adam Fleming Medal in 1963 and the William Bowie Medal in 1977. Van Allen joined AGU in 1948.

George Walker, 1926–2005

George Patrick Leonard Walker, an outstanding and multi-faceted geologist and one of the most influential volcanologists in the world, died on 17 January 2005, at the age of 78. He was born in London on 2 March 1926 and grew up mainly in Northern Ireland. He read geology for B.Sc. honors and M.Sc. degrees at Queens University in Belfast, Northern Ireland, and completed his training with a Ph.D. in mineralogy from Leeds University in England, which he received in 1956. By then, he had already been appointed, in 1954, to a lectureship at Imperial College London.



Walker's earliest scientific achievements were in mineralogy. As part of his doctoral studies at Leeds, he recognized and mapped secondary, zeolite-dominated mineral zones in the Tertiary lava flows of northeastern Ireland. This work resulted in a classic series of papers on the burial and alteration of lavas, which were published between 1951 and 1960. Through these papers, he developed a reputation as an outstanding mineralogist. Walker also discovered new zeolite minerals during this period, including garronite and a variety of gismondine.

In the 1960s, Walker turned his interests to the volcanic rocks of eastern Iceland, of which he mapped a considerable portion. From mineral zones in lavas, he went on to discover welded ash deposits between the lava flows, to describe whole volcanic centers, and to be one of the first to investigate subglacial volcanic deposits. His work included several groundbreaking insights, including contributing to the growing picture of plate tectonics by showing how dyke swarms in eastern Iceland were produced during crustal spreading. His research revolutionized the understanding of the geology of Iceland, and in 1980 he was one of the rare foreign citizens to be awarded the Order of the Falcon, conferred by the president of Iceland in recognition of Walker's contributions to concepts that culminated in his classic 1964 paper, with Gudmundur Bödvarson, on crustal drift in Iceland, the first account of crustal spreading by dyke injection.

By the mid-1960s, Walker was working on Mount Etna in Italy, a frequently active, lava-producing volcano. He proposed radical views on the importance of viscosity to flowing lava, including the first attempt to explain what processes limited the lengths of flows. A visit to India in 1969 to study the much older Deccan Trap lavas led to the concept of compound lava flows, which was adopted as a major concept in volcanology.

Around 1968, Walker began to expand his interests to explosive volcanism, using the whole world as his laboratory. He was much influenced by the work of field volcanologists such as Sigurdur Thorarinsson in Iceland, Robert L. Smith in the United States, and Shigeo Aramaki and Hisashi Kuno in Japan, all of whom had pioneered a quantitative and systematic approach to the documentation of pyroclastic deposits. It is perhaps in this field that Walker made his greatest contributions. His classic papers on the fundamentals of modern quantitative volcanology are numerous, and during the 1970s, he essentially revolutionized the standard approach to studying and understanding explosive volcanism, turning it from a qualitative and descriptive enterprise to a quantitative science. During this