ESRL Global Monitoring Division Science Review

Science Themes and Proposed Reviewers for Approval

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Boulder, Colorado

Vision of the Global Monitoring Division (GMD)
A society that has access to and uses the best possible information on atmospheric constituents that drive climate change, stratospheric ozone depletion and baseline air quality.

Mission of GMD
To acquire, evaluate and make available accurate, long-term records of atmospheric gases, aerosol particles, and solar radiation in a manner that allows the causes of the change to be understood.

Calibrations and Standards
GMD measurements require accuracy and traceability to standards over long periods; some GMD measurements have been in continuous operation for over half a century. As such, GMD maintains the WMO world standards for CO_2, CH_4, CO, N_2O and SF_6, the WMO world standard for total column ozone and the International Calibration Facility for broadband, IR and UV solar radiation instruments. In addition, GMD maintains primary standards for 42 halocarbons (CFCs, HFCs) and hydrocarbons such as benzene, butane, acetylene etc.

Key Products
GMD produces long-term, continuous, global records of the known atmospheric constituents that cause climate change in the Earth system. From these data GMD produces the Annual Greenhouse Gas Index (AGGI), annual Ozone Depleting Gas Index (ODGI), Carbon Tracker, Interactive Data Visualization tool, Arctic (Barrow) annual snowmelt date and the global Solar Calculator.

Science Themes for Review

1. Climate Forcing:
Earth's climate is changing largely because of increasing greenhouse gases in the atmosphere; modified to some extent by the distribution of aerosols and aerosol properties. To understand the influence of changing atmospheric composition on climate change and to minimize its eventual magnitude, societies need the best possible information on the trends, distributions, sources, and sinks of atmospheric substances that influence climate. For effective management of climate-forcing atmospheric species, a solid scientific understanding of their natural cycles and the processes that influence these cycles is necessary. Atmospheric measurements are the touchstone of models and theories describing these cycles. Providing a sound basis for important societal decisions requires a global effort that involves studying numerous gases, particles, and atmospheric radiation on appropriately designed spatial and temporal scales.

NOAA measurements of climatically important substances in the atmosphere began in the late 1950s and expanded in the mid-1970s for carbon dioxide (CO_2), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), and ozone (O_3). Over the years other gases have been added, including methane (CH_4), carbon monoxide (CO), hydrogen (H_2), numerous hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), methyl halides, and sulfur hexafluoride (SF_6). GMD produces and maintains global standards for most of the climate-relevant gases.

The original objective of GMD "baseline" aerosol measurements was to detect a response to changing conditions on a global scale. Since the 1970s our understanding of the behavior of atmospheric aerosols has improved considerably. In response to the finding that anthropogenic aerosols create a significant perturbation in the earth's radiative balance on regional scales, GMD expanded its aerosol research program (1992) to include stations for monitoring aerosol properties in regions where significant aerosol forcing was anticipated.

2. Ozone Depletion:
Research by GMD has been critical in determining the degree of depletion of stratospheric ozone, measuring the trends of the compounds causing this depletion, and understanding the causes and consequences of stratospheric ozone loss. GMD conducts year-round, balloon-borne vertical structure and total column optical measurements of ozone over the South Pole. During the winter preceding the early springtime Antarctic ”ozone hole”, satellites are unable to measure polar ozone without sunlight. GMD also monitors stratospheric ozone in the Arctic and at lower latitudes, monitors the gases responsible for depletion of the stratospheric ozone, and monitors changes in ultraviolet radiation. As such, understanding the production and fate of ozone and the ozone-depleting compounds is a focal point of GMD research.

Ground-based measurements of total-column ozone have been made for over 40 years with the Dobson spectrophotometer; the 16-station GMD Cooperative Dobson Network is a significant portion of the global Dobson network, as are the fourteen GMD balloon-borne ozonesonde stations. These stratospheric ozone measurements, along with the GMD greenhouse gas, surface ozone, aerosols, radiation and halocarbons measurement networks are linked to the world calibration standards maintained by GMD, as are a preponderance of the stations in other international global networks.

Three gases that make a significant contribution to stratospheric ozone depletion, CFC-11, CFC-12 and N_2O, have been monitored by GMD since the mid-1970s. Since then, numerous additional CFCs, HCFCs, and other halogenated gases have been incorporated into the measurement program as the number of monitoring sites increased. Most of the gases that are responsible for depleting stratospheric ozone are anthropogenic, but some, such as methyl bromide and methyl chloride, have natural contributions as well.

3. Baseline Air Quality:
Although much of GMD's effort has focused on obtaining global long-term measurements of the remote atmosphere, scientifically it has been necessary to make some observations at sites that are regionally influenced. This allows GMD to investigate the linkage between global and

regional distributions and sources of climatically important gases. Examples include carbon cycle sampling surface sites at Harvard Forest, Massachusetts, and Niwot Ridge, Colorado, and on ~500 meter tall towers in Wisconsin, Iowa and Texas.

In recent years, it has become even more apparent that air masses can carry pollution long distances, over which compounds can be transformed during transport. For instance, large-scale pollution and dust from Asia is transported across the Pacific Ocean in a matter of days and impacts sites in the United States. Fires in Central America send smoke plumes across Mexico and the south-central U.S., and dust from Africa regularly reaches the southeastern U.S.

GMD added a baseline station at Trinidad Head, California, in 2002 to help monitor incoming air pollution from Asia. At about the same time, an observatory was established at Summit, Greenland in cooperation with the National Science Foundation, to monitor pollution entering the Arctic from lower latitudes and to serve as the sole high-altitude Arctic atmospheric observatory documenting changes in the Arctic free troposphere.

Review Panel Members

Review Chair
Dr. Kenneth W Jucks
Program Manager, Upper Atmosphere Research Program
NASA, Earth Science Division
NASA HQ
300 E Street
Washington, DC 20546
(202) 358-0476
kenneth.w.jucks@nasa.gov
Primary Expertise**: Ozone Depletion**
Secondary Expertise**: Climate Forcing**

Dr. Ken Jucks is the Program Manager for the Upper Atmosphere Research Program. He came to NASA HQ as an IPA detailee from the Smithsonian Astrophysical Observatory (SAO, part of the Harvard-Smithsonian Center for Astrophysics) in Cambridge, MA. He has been an HQ NASA Civil servant since 2009.

The Upper Atmosphere Research Program (UARP) concentrates on processes that control ozone concentrations in the upper troposphere and stratosphere, and therefore surface ultraviolet radiation. The program funds numerous laboratory and field campaigns that contribute to quantifying our scientific understanding of ozone changes. Typical laboratory studies include kinetics studies of key reactions that either directly or indirectly destroy and create ozone or the precursors to ozone destroying compounds, as well as spectroscopic studies required to accurately monitor the key atmospheric constituents. Typical field studies include airborne in situ and remote sensing instrumentation for focused aircraft field campaigns, high altitude

balloon remote sensing and in situ observations, and long term ground based in situ and remote sensing programs.

Dr. Jucks was with the FIRS-2 Atmospheric remote sensing research group, 1990-2009 and PI of the program from 2003-2009. From 2001-1006 he was with the FIRST (Far Infrared Spectroscopy of the Troposphere) instrument and science team and a member of the HITRAN molecular spectroscopy working group. Ken currently is the NASA HQ Program Scientist for the NASA EOS Aura, Orbiting Carbon Observatory (OCO-2 & OCO-3), Active Sensing of CO_2 Emissions over Nights, Days, and Seasons (ASCENDS), CLARREO satellite missions, Earth Venture Instrument Announcement of Opportunity solicitations, numerous airborne mission, and GSFC DISC.

Dr. Jucks has authored over 90 publications in journals.

Dr. Øystein Hov
Research Director
Norwegian Meteorological Institute
PO Box 43, Blindern
0313 OSLO
Norway
Tel: +47 22 963360
Email: oystein.hov@met.no
Primary Expertise: **Air Quality**
Secondary Expertise: **Climate Forcing**

Dr. Øystein Hov is Director of Research at the Norwegian Meteorological Institute. He has been active in the World Meteorological Organization Global Atmospheric Watch Programme (WMO/GAW), which coordinates observing systems for atmospheric composition, including greenhouse gases, ozone, ozone-depleting gases, aerosols, precipitation, and reactive gases. He is a member of the WMO Commission for Atmospheric Sciences, which oversees and coordinates activities of GAW and the World Weather Research Programme (WWRP).

Dr. Hov was recently selected to lead a European working group on "Impacts of extreme weather" under the Norwegian Academy of Science at the behest of the European Academies Science Advisory Council (EASAC). EASAC consists of (natural) scientific academies from all EU countries plus Switzerland and Norway. Its purpose is "building science into EU policy" by giving advice to European policy-makers. EASAC operates extensive scientific reporting activities within the three main areas of energy, life sciences and the environment. The framework of EASAC includes mitigating and adapting to climate change.

Dr. Hov has published scientific articles in the fields of climate, air quality, atmospheric trace gases and biosphere-atmosphere interactions among others.

Professor Michael B. McElroy
Gilbert Butler Professor of Environmental Studies
Harvard School of Engineering and Applied Sciences
Pierce Hall
29 Oxford Street
Cambridge, MA 02138
(617) 495-4359
mbm@seas.harvard.edu
Primary Expertise: **Climate Forcing**
Secondary Expertise: **Ozone Depletion**

Professor McElroy leads atmospheric science and policy work at two major universities, Harvard and Columbia. He is Gilbert Butler Professor of Environmental Studies at Harvard, heads Harvard University's Center for the Environment and chairs the Interfaculty Initiative on the Environment. He served as Founding Chair of Harvard's Department of Earth and Planetary Sciences and has focused his research especially on effects of human activities on the global environment.

Some of the many awards Professor McElroy has received are the James B. Macelwane Award by the American Geophysical Union (1968), The American Association for the Advancement of Science "Newcomb Cleveland Prize" (1977), NASA Public Service Medal (1978), Eire Society Gold Medal Award (1987), The George Ledlie Prize at Harvard University; Research and Development Award from the National Energy Resources Organization (1989), and an Honorary DSc., Queen's University of Belfast, N. Ireland (1991) among many others.

Committees Professor McElroy has served on include NASA's Stratospheric Research Advisory Committee, Space and Earth Science Advisory Committee, and the Weather, Climate, and Oceans Advisory Subcommittee. For the U.S. Congress they include the Space Program Advisory Panel and the Office of Technology Assessment. For the National Academy of Sciences he has served on the Committee on Climate Energy and National Security, Committee on Science, Engineering and Public Policy, Panel on Global Tropospheric Chemistry, Committee on the Atmospheric Effects of Nuclear Explosions, Board on Atmospheric Sciences and Climate and the Committee for the International Geosphere/Biosphere Program. He has also served on the Intelligence Science Board the primary source of external advice to the U.S. Director of National Security.

Professor McElroy has published in excess of 260 scientific publications on a wide range of atmospheric topics and authored 2 books.

Professor Anne M. Thompson
Professor of Meteorology
Penn State University
510 Walker Building
University Park, PA 16802
Phone: (814) 865-0479
anne@met.psu.edu
Primary Expertise: **Ozone Depletion**
Secondary Expertise**: Air Quality**

Professor Thompson has been a Professor of Meteorology at Pennsylvania State University since 2005 and prior to that a scientist at NASA's Goddard Space Flight Center from 1984 to 2004. She has observational and modeling interests in: air-sea exchange and biogeochemical cycling; early studies of chemical-climate links, pollution, oxidizing capacity; remote sensing; and trace gas variability from natural and anthropogenic causes (aviation, biomass burning).

Professor Thompson is known for leadership in aircraft programs, research cruises, international field experiments and the SHADOZ and IONS ozonesonde networks. She is the recipient of COSPAR's Nordberg Medal for Space Science, the Women in Aerospace International Achievement Award, NASA Honor Award (SHADOZ), NASA/DOI Wm T. Pecora Award (TOMS), Penn State's Wilson Research Excellence Award.
Professor Thompson is a fellow of the American Association for the Advancement of Science (AAAS) and a member of the American Geophysical Union (AGU) and American Meteorological Society (AMS). She is president of the Commission on Atmospheric Chemistry and Global Pollution (2002-2006), Vice-President of IAMAS (2007-) and Chair-elect of the AAAS Atmospheric and Hydrospheric Sciences Section.

Professor Thompson has over 150 refereed scientific publications and is an ISI highly-cited author (Geosciences).

Professor Beverly Law
Forestry Department
328 Richardson Hall
Oregon State University
Corvallis, OR 97331
(541) 737-6111
bev.law@oregonstate.edu
Primary Expertise: **Climate Forcing**
Secondary Expertise: **Air Quality**

Dr. Law is Professor of Global Change Biology & Terrestrial Systems Science within the Department of Forestry, Oregon State University. She studies ecosystem processes, including carbon and water cycling (e.g. photosynthesis, transpiration by trees and shrubs, autotrophic and heterotrophic respiration) as influenced by climate and disturbance, processes contributing to whole ecosystem CO2 and water vapor exchange measured by the eddy covariance method and remote sensing of canopy structure and modeling ecosystem processes in response to climate and disturbance.

Professor Law is on the advisory boards of the European Integrated Carbon Observation System (ICOS) and GHG-Europe; PI on a NOAA project that runs the Oregon CO_2 Observation Network focused on $CO/CO_2/H_2O$ measurement profiles on tall towers; contributor to NACP, Fluxnet and AmeriFlux synthesis publications on terrestrial carbon and water cycling; PI on an AmeriFlux project on the effects of climate anomalies on physiology of mesic and semi-arid forests; and AmeriFlux Science Chair for 10 years.

Professor Law is an Aldo Leopold Leadership Fellow (since 2004) and has received the World Meteorological Organization Norbert Gerbier-MUMM International Award (2004), Oregon State University's Provost Award for Excellence in Research (2002) and the College of Forestry Dean's Award for Outstanding Achievement in Research (2000).

Professor law has in excess of 168 scientific publications and is in the top 1% in the ISI Essential Science Indicators (ESI) for citations in Agricultural Sciences in the past decade.

Primary Expertise**: Climate Forcing**
Secondary Expertise**: Ozone Depletion**

Dr. Carl Brenninkmeijer
Max Planck Institute for Chemistry
Hahn-Meitner Weg 1
55128 Mainz, Germany

Tel.: +49 6131-305 305
E-mail: carl.brenninkmeijer@mpic.de

Dr. Brenninkmeijer holds a PhD from the University of Groningen (1983) on the development and application of isotope paleo-climatology tools. He was a junior Research Fellow at the Institute of Nuclear Sciences, Department of Scientific and Industrial Research, Lower Hutt, New Zealand, 1976-1978 And a research Fellow University of Groningen, the Netherlands, 1978 -1983. He was acting Head of the stable isotope geochemistry laboratory at the Institute of Nuclear Sciences, DSIR, Lower Hutt, New Zealand, 1983-1994 where he was the co-developer of an atmospheric chemistry program at NIWA-IGNS.

Dr. Brenninkmeijer has been Group leader of "Global Observations" at the Max Planck Institute for Chemistry, Atmospheric Chemistry Division, Mainz, Germany from 1994 to the present. As such, he has been the coordinator of the passenger aircraft-based research project CARIBIC (Large European project, 11 science partners, www.caribic-atmospheric.com) since 2001. He is

an adjoint professor, Marine and Atmospheric Sciences, (Somas), University of New York at Stony Brook, USA and Miller Professor, Spring 2011, UC Berkeley, CA. Carl is a member of the science advisory committee and professor at the European Research Course on Atmospheres, ERCA, Grenoble, France.

Dr. Brenninkmeijer has been an advisor to the IAEA (1984-1989), World Meteorological Organization GAW-UNEP (1994-1995) and WMO GAW Science Advisory Group member on reactive gases (1998-2002). He has been editor of the Journal of Atmospheric Chemistry and Physics Discussions.

Dr. Brenninkmeijer has in excess of 250 publications in reviewed scientific journals covering a wide range of subjects in atmospheric composition, climate forcing, ozone depletion and isotope chemistry, among others.