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Article on **Workshop on Spanning Regional-to-Global Pollution**

For Eos, August 2, 2002

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In May 2002, NASA Goddard Space Flight Center's (GSFC) Laboratory for Atmospheres sponsored a Workshop on the topic "Interactions of Urban Pollution with the Regional and Global Environment." The Workshop, attended by 80 researchers in atmospheric chemistry, air quality and remote sensing, was held at the NASA Goddard Visitor's Center in Greenbelt, Maryland. The Organizing Committee consisted of Anne Thompson, Paul Newman and James Gleason (all at GSFC), William Brune (Penn State) and Russell Dickerson (University of Maryland-College Park).

Atmospheric chemistry and the study of pollution are at a crossroads. Traditionally, communities have investigated distinct issues, e.g., regional air quality, intercontinental transport, micro-scale and molecular processes, global remote sensing, and gas-particle-climate connections. Within each area, knowledge has deepened by advances in basic science and technology. Modeling has evolved rapidly, because of faster computers, improved parameterizations, and a better knowledge of many of the processes required for credible simulations. Experimentally, sensitive, accurate instrumentation has been developed to measure hundreds of trace species in gas and aerosol phases. Satellite remote sensing can track the intercontinental transport of smoke, dust, haze and of ozone and several of its precursors (CO, NO_2) and related gases. Researchers in remote field situations can forecast pollution, view near-real-time satellite imagery, and predict the history of air parcels that may be sampled from aircraft or other platforms. A schematic is shown in Figure 1.

At the same time, the links between climate change and atmospheric chemistry and microphysics have become clearer. Changing climate - perturbed temperatures, cloud properties, aerosol distributions, precipitation patterns - will affect the earth's chemical composition, just as changes in trace gases (e.g. ozone) and aerosol distributions are among the major forcings on the earth's radiation budget. Thus, isolated research in subdisciplines is inadequate for addressing pressing scientific and societal issues. These issues bridge local, regional and global scales and require integrated observing and interpretive-predictive (modeling) strategies (Figure 2). The purpose of the Workshop was to bring together elements of the community to survey progress to date in our measurement and modeling capabilities, to identify the most pressing uncertainties and research needs, and to connect various communities in formulating strategies for the coming decade. A framework is provided by environmental regulations and several documents prepared by an inter-Agency Commission on Environmental Needs Research (CENR, 2001) and the National Academy of Sciences (2001).

Progress in a number of areas was noted in four plenary talks with shorter presentations on related topics. The first two plenary talks and associated presentations were "regional" and the focus was on multi-disciplinary experiments conducted in the US. Spyros Pandis (Carnegie-Mellon University) described measurements and models - primarily for aerosol composition, source evaluation and transformation - as they were used in a regional air quality experiment, the Pittsburgh Air Quality Study (PAQS). Most aerosol composition and nucleation events could be explained by current models but on some mornings explosive growth in the number of new particles was observed. Regional foci on Atlanta (Ted Russell, Georgia Tech) and the mid-Atlantic (Russ Dickerson) presented similar issues to the PAQS study but with greater emphasis on the role of biogenic chemicals and region-to-region tracking of pollution transport. A plenary talk by James Meagher (NOAA/Aeronomy Laboratory) included an overview of the 1999 Nashville Southern Oxidants Study and the massive TexAQS2000 experiment, with measurements from ground, balloon, and aircraft. TexAQS2000 showed that, in addition to regional sources that have some characteristics similar to those in Nashville, Pittsburgh, New York and Atlanta, Houston's latitude, coastal meteorology and prominence in the petrochemical industry introduce factors that make it the current "ozone capital" of the US. This study also revealed a potentially serious underestimate of the emissions of highly reactive VOCs in Houston [Kleinman et al., 2002].

Recent advances in aerosol composition and sizing have enabled the observations of particle formation and particle growth events and of chemically speciated size distributions, with local urban aerosols (< 200nm) being composed mainly of hydrocarbons, and regional aerosols (> 200nm) being composed mainly of sulfate and oxygenated organics (Manjula Canagaratna, Aerodyne). A reminder that eastern US aerosols and trace gas mechanisms are not representative of the country as a whole came from William Stockwell (Desert Research Institute) who reported on models and measurements of ozone, nitrogen oxides and nitrate aerosols from western US experiments. Danny McKenna (National Center for Atmospheric Research) description of the airborne TOPSE (Tropospheric Ozone Production about the Spring Equinox) experiment conducted in Canada in 2000 emphasized the role that stratospheric and upper tropospheric ozone play in lower-level ozone over North America during the March-April period.

Moving to larger scales, international campaigns with multiple platforms, state-of-the art measurements and models have confirmed the role of transboundary (country-to-country) and intercontinental transport. Examples were shown from last year's TRACE-P (Transport and Atmospheric Chemical Evoltuion-Pacific) and ACE (Aerosol

Characterization Experiment)-Asia by Gregory Carmichael (University of Iowa), James Crawford (NASA/Langley Research Center) and Mian Chin (Georgia Tech/NASA-Goddard). Strong regional impacts from India were observed in the 1999 INDOEX (Indian Ocean Experiment) campaign, described by Russell Dickerson (University of Maryland). Very long-range transport of pollution vented out of the boundary layer leads to near-global pollution in the tropics (Robert Chatfield, NASA/Ames). The large database from ozone-instrumented commercial aircraft can be used to examine profiles from landings and take-offs at major cities world-wide (more than 12000 from 1995-2001). Ozone profiles at Johannesburg, South Africa, a city with alternations of low ozone and pollution from industry and biomass burning, can be classified into six populations, with distinctive profile shapes and origins (Roseanne Diab, University of Natal-Durban). Satellite data displaying source regions, eg NO2 and formaldehyde from GOME (Global Ozone Monitoring Experiment; Randall Martin, Harvard) and transport of CO (from MOPITT, Measurements of Pollution in The Troposphere; David Edwards, NCAR) point to the future when, it is hoped, a geostationary satellite with pollution detection can track megacity and large-scale pollution minute by minute. Annmarie Eldering of the Jet Propulsion Laboratory described NASA's next generation ozone, NO_2 and aerosol observing systems (AURA in 2004).

The aforementioned results showed that distinguishing sources, sinks, transport and ozone precursor-production relationships has become easier in the past 5-10 years with better instrumentation for dozens of key constituents and with process and regional-scale models. However, it is still a challenge to capture urban and regional-scale transport and chemical transformations in global models. One of the most persistent inadequacies is how to represent sub-grid microphysical, photochemical and dynamical processes. Kenneth Pickering (University of Maryland) showed a stretched-grid model in which a meso-scale mesh can be imbedded into a global coupled-chemical-transport model without the boundary problems typically found in a nested approach. Another challenge is adequate knowledge of emissions. Global models resolve typically 2-5 degrees of latitude and longitude, gross in comparison to the domain used by urban-regional modelers and regulators keeping an eye on point sources. Prasad Kasibhatla (Duke University) showed that inverse modeling is one approach to identifying potential inaccuracies in emissions.

In a summarizing presentation, William Brune used OH and HO_2 data and models to emphasize the fact that uncertainties affect the full matrix of issues (urban-regional-global-period of climate change projections) and the processes shown in Figure 2. Petrochemical emissions in Houston, for example, produce high nighttime concentrations of the oxidant HO_2. Such a detail is probably not considered in regional and global models, yet may be essential to determining the global impact of megacities with high refining and chemical manufacturing activity. The nonlinearity of oxidant formation (OH, HO_2, ozone) has long been a challenge in predictive models. Instruments to measure the OH and HO_2 radicals have been an important breakthrough but the agreement between observations and models vary greatly in different regimes, e.g. high NO_x, low NO_x. Questions remain: Are the differences real? An instrumental artifact? incorrect theory? Do they matter? At the same time, measurements of acetone and other oxygenated species in the free troposphere are surprisingly high in the southern as well as northern hemisphere.

The differences that appear between observations and models are a reminder that while we have concentrated on experimental technology and scaling issues in models, fundamental mechanisms are still not understood well enough to ensure that interpretation of measurements and predictive capabilities are accurate. An integrated strategy, with observations and models interacting with one another and spanning local to global scales, is a necessity for the scientific and policy communities, but one that will take more focused planning. A follow-on Workshop will refine strategies further.

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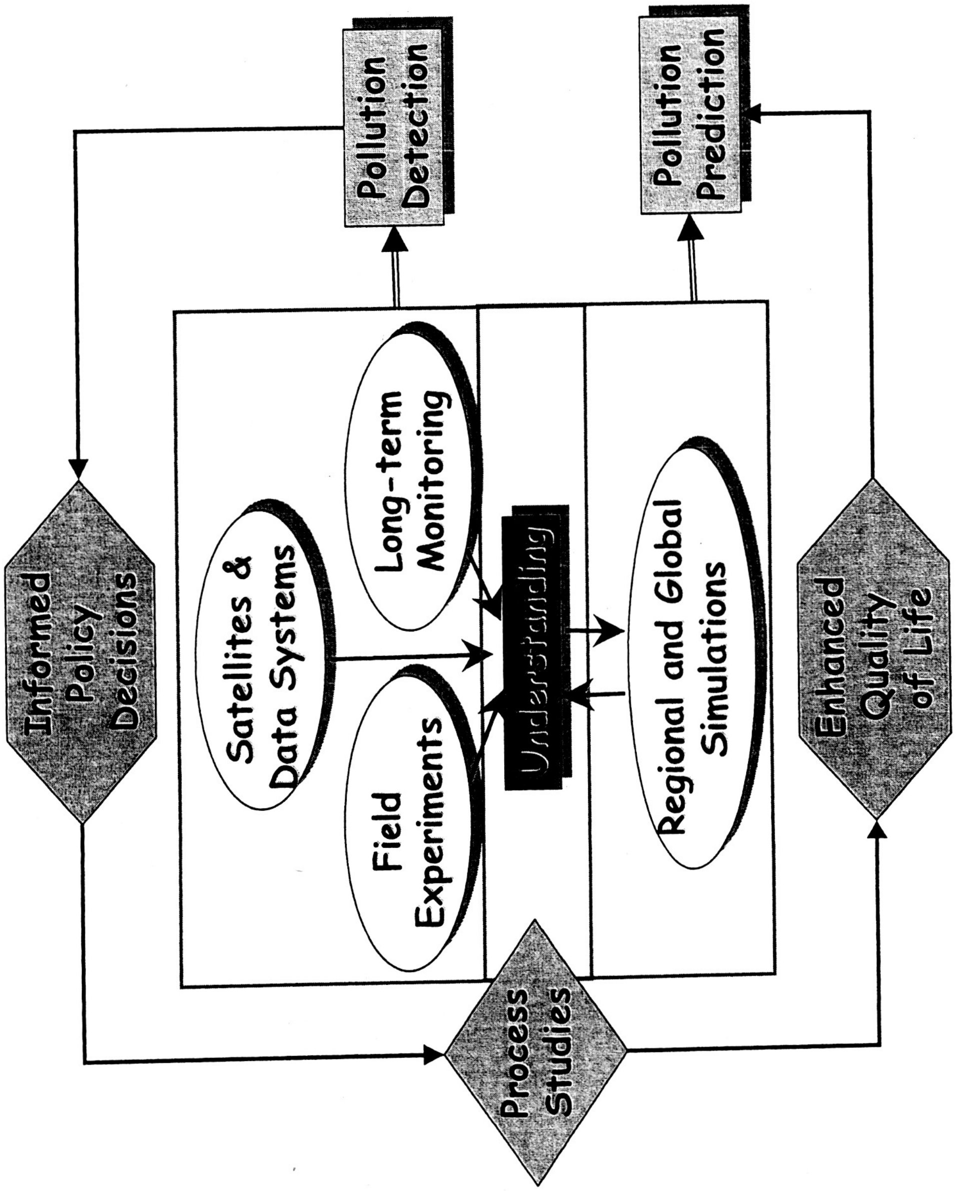

Informed Policy Decisions
Pollution Detection
Pollution Prediction
Satellites & Data Systems
Long-term Monitoring
Field Experiments
Understanding
Regional and Global Simulations
Enhanced Quality of Life
Process Studies

FIG 1.

Uncertainties in process for issue?

- urban ozone
- urban PM2.5
- regional pollution
- regional haze
- carbon balance
- global pollution
- atmospheric oxidation
- climate

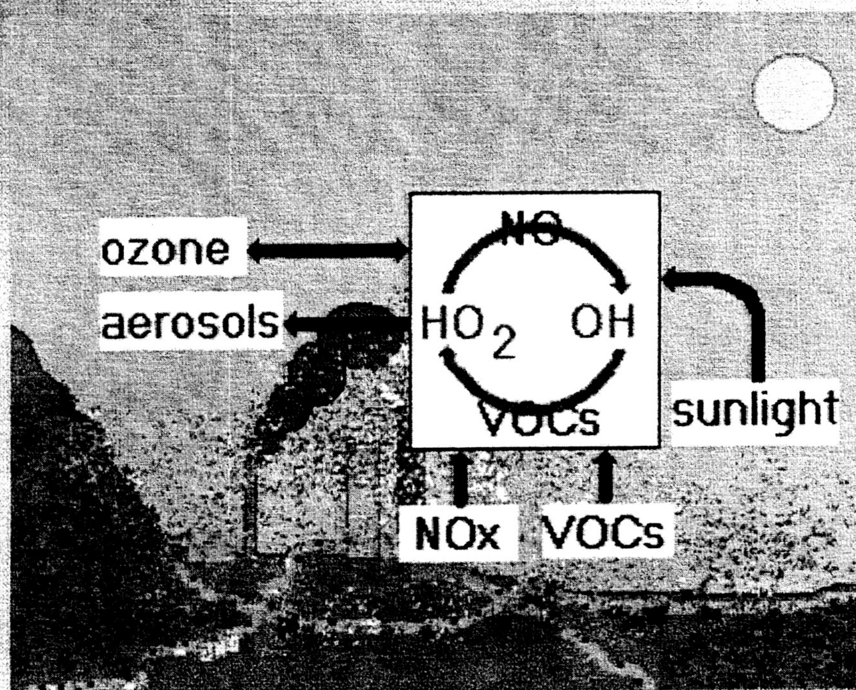

FIG 2

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