Assimilation of Chemical Data from NASA’s EOS Instruments:

- Experiences from the GMAO
- Thoughts for planning

Steven Pawson, Ivanka Stajner, Andrew Tangborn, Krzysztof Wargan of NASA’s Global Modeling and Assimilation Office

Daniel Jacob, Solène Turquety and the Harvard University Intex Team

Kevin Bowman and the TES Team

Nathaniel Livesey, Lucien Froidevaux and the MLS Team

Community Workshop on Air Quality Remote Sensing from Space: Defining an Optimum Observing Strategy

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Objectives of Presentation

✓ To illustrate some impacts of different types of satellite data on assimilation of ozone and carbon monoxide (OSEs)
✓ To promote discussion about the role of OSSEs in future mission design
Impact of Aura OMI and MLS ozone data: realistic profile shape in lower stratosphere because of information content of MLS

Comparisons at SAGE III measurement locations on January 11-13, 2005.

Similar results obtained by assimilating MIPAS (limb IR) and POAM/ILAS (limb occultation) data for different years and locations.
OMI data have a beneficial impact on total tropospheric ozone columns from assimilation: Spatial and temporal variability are captured.
Towards an OMI+MLS+TES assimilation: Potential capabilities of the model to isolate layering not evident with “smooth” nadir data

A dynamically driven low-ozone feature over the Atlantic on Feb. 17 present in the assimilated (OMI+MLS) field is smoothed out in the TES retrieval. This shows that OMI+MLS+TES assimilation has the potential to resolve vertical features that are obscured in the TES retrievals.
Summary of EOS-Aura ozone assimilation

- OMI+MLS assimilation yields accurate representations of stratospheric profile and (generally) tropospheric column
- Optimism that TES retrievals can be incorporated, with appropriate weight given to information content (a priori, averaging kernel)
- Concept of OSEs (Observation Sensitivity Experiments) - combining several data types
- Basis for other constituent assimilation (e.g., carbon species) in GMAO
… but, how well can present tropospheric data be utilized for Air Quality?

✓ Need near-surface analyses and (say) 24-hour forecasts, yet most present space-based constituent data constrain upper-middle troposphere - address pollution export issues, with less immediate relevance to air quality (aerosols somewhat different)

✓ Source estimates determined from space-based instruments can play an important role, as demonstrated clearly in summer 2004 (Intex-NA):
  ✓ Alaskan/Canadian emissions calculated from MODIS fire observations included in GEOS-4 helped link this burning to degraded air quality in Houston (Morris et al., JGR submitted)
  ✓ Layering of air masses exposed to various sources of pollution transported over the Eastern US
Global contributions to East-Coast USA pollution modeled during Intex-NA

Using global atmospheric models, with representations of dynamics, physics and chemistry, GMAO is able to simulate distributions of atmospheric trace gases for studies of pollution and impacts on climate.

The example shows CO pollution forecasts the Intex-NA (Intercontinental Transport Experiment) mission in Summer 2004. The 2-day forecasts (along a proposed DC-8 flight track) reveal CO pollution throughout the troposphere (above), with contributions (left) from local Fossil-Fuel emissions (bottom), forest fires in the western USA (middle) and Asia (top).

Figure produced by Harvard group as part of Intex-NA mission planning
The following questions arise (maybe more):

- What is the value of nadir IR (MOPITT CO, AIRS/IASI CO/ozone) measurements for Air Quality forecasting?
- How adequately do space-based estimates of biomass-burning emissions constrain pollutant concentrations?
- Are we exploiting present-day satellite observations (e.g., emissions, precursors)?
- ...
- What do the demands of AQ forecasting really imply for observational requirements?
- What are the limitations of the models used in assimilation and prediction?
What might be wrong with the models (specifically, the transport)?

- Integrity of the meteorological analysis impacts the value of the assimilation and forecast.
- Model error is much more complex in the troposphere than in the stratosphere:
  - Have some confidence in large-scale advection.
  - Aware of uncertainties in sub-grid processes (e.g., existence of clouds) and associated transport (e.g., outflow), but do not possess a full understanding of these issues.
- What type of observations will help us correct for detrainment occurring at the wrong level?
- Value of cloud observations?

MOPITT averaging kernels

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The importance of OSSEs (Observing System Simulation Experiments)

✓ A planning tool - what impact will a new data type “really” have on our ability to forecast air quality?
  ✓ Typical application: “instrument X will be launched in orbit A - what impact will the data have?”
  ✓ Better: “what would be the optimum orbit for instrument X?”
  ✓ Best: “what is the observational requirement for Air Quality and can any combination of proposed instruments meet this?”

✓ Should be wary of model limitations on interpretation
✓ OSSEs require much infrastructure and planning, but potentially help the community and funding agencies make wise choices