Stratospheric Analyses in MERRA & Atmospheric Constituent Capabilities

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Themes

• The stratosphere in GEOS-5/MERRA analyses
• Chemistry simulations using MERRA analyses:
  – On-line (i.e., chemistry modules in GEOS-5)
  – Off-line (i.e., MERRA analyses driving CTMs)
The Stratosphere in GEOS-5/MERRA

- GEOS-5 GCM extends to 0.01hPa (~80km)
- Temperature constraints to 0.4hPa (~55km):
  - Sonde measurements to about 10hPa
  - “Dense” satellite radiances in lower stratosphere
  - SSU Channels 1-3 (1979 onwards, to 2006)
  - AMSU-A Channels 12, 13, 14 (after 1997)
- V8 SBUV retrievals constrain ozone
  - Total columns
  - Partial profiles for p<64hPa (~20km)
- No suitable stratospheric moisture data
- Other trace gases not assimilated
Temperature Validation

Good performance in the stratosphere; some uncertainty near the stratopause

- Validation is performed against various independent datasets
- This comparison is with NASA’s Microwave Limb Sounder (MLS) retrievals for February 2008
- Similar results are evident with sparse lidar data (e.g., Table Mountain, Mauna Loa) and other satellite instruments

Emily Liu, Nicole McKee
Use of AMSU-A Channel 14

Variational bias correction (VBC) is not applied to AMSU-A Channel 14 radiances

Temperature differences with bias correction on or off on August 15, 2008. Values reach ±14K.

PDFs of O-F $T_B$ (K) for two high-peaking AIRS channels: model bias propagates into the analyses when AMSU-A Ch. 14 VBC is turned on (left) and there is better agreement without VBC (right). These AIRS channels are not assimilated.
Transport – CTM Products

• Chemistry-transport models driven by:
  – Analyzed winds, temperature, etc.
  – Sub-grid quantities, such as cloud mass fluxes

• Products are archived as “chem” stream
  – Resolution reduced to 1°×1.25°L72
  – Mass fluxes as well as winds
  – Will provide GEOS-5-compatible transport core

• Downsides: impact of averaging and I-O cost
On-Line Constituents

• Cost-effective and more accurate than CTM
• Uses constituent packages built into GEOS-5:
  – Stratospheric Ozone Chemistry
  – GOCART Aerosol
  – GMI COMBO
  – Carbon species
  – Idealized trace gases (e.g., $^{222}$Rn, age of air, ...)
• So-called “replay” mode reproduces time series of analyses with accurate (time resolved) transport and less I-O than CTM
Schematic of “replay”

Max Suarez
N$_2$O simulations with GEOS-5.2.0

Stratospheric transport appears well represented in the MERRA analysis system

- Simulations use meteorology from 2°×2.5°L72 MERRA “SCOUT” runs
- Stratospheric chemistry package (Code 613.3) turned on for “replay”
- Comparison here is with in-situ data from SOLVE ER-2 flights on Jan 20 and Jan 27, 2000
- GEOS-5 (red) in much better agreement with SOLVE N$_2$O data than is GEOS-4 (blue)
- GEOS-5 somewhat better at resolving individual peaks (better spatial gradients)
- Will be re-done using MERRA runs

Craig Benson
CO simulations using GEOS-5.2.0

Examining uncertainty due to "true" and "approximate" sub-grid cloud transport

- GEOS-5 meteorology from 2°×2.5°L72 MERRA "SCOUT" runs
- CO module implemented using prescribed sources and linearized loss
- Plots show MOPITT observations and two simulations over N. America/Atlantic for September 2002
- First simulation (middle) uses the "true" convective transport (RAS) from GEOS-5.
- Second simulation (bottom) uses same cloud mass fluxes but a different (diffusive) numerical algorithm.
- Interestingly, CO columns values are closer to MOPITT when "diffusive" transport algorithm is used

Zhengxin Zhu
Summary

• Have given a “sample” of the work being done
• Stratosphere in MERRA has some integrity – some uncertainty near the stratopause
• Don’t trust the mesosphere – we did not try to analyze it!
• Stratospheric transport shows promise
• Transport by sub-grid processes in the troposphere remains a very interesting research question!