UTLS Ozone Assimilation in GEOS-5: EOS-MLS Results and NPP-OMPS Planning

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Why UTLS Ozone is Important

Passive space-based ozone data include:

- "Total" columns (e.g., SBUV, OMI, TOMS, GOME, …)
- Weighted partial columns in the upper troposphere (e.g., AIRS, IASI)
- Stratospheric Profiles (e.g., SBUV, MLS, MIPAS, NPP limb profiler)

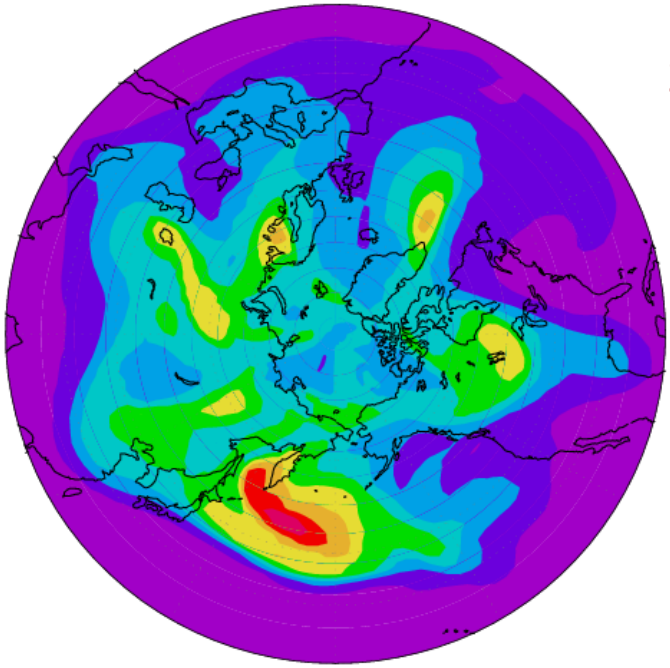
From an operational analysis and forecasting perspective:

- Upper tropospheric and stratospheric ozone impacts radiance assimilation and (very weakly) forecast skill
- Near-surface ozone is an important component of air quality forecasts

Present space-based observations are not optimal for analysis and forecasting of near-surface ozone in air-quality studies

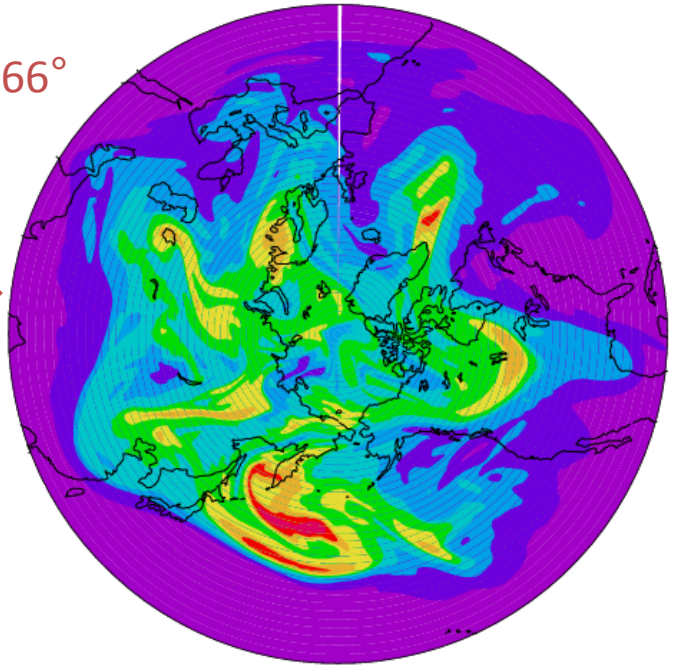
Total columns and stratospheric profiles can constrain tropospheric partial column – the model then infers the profile (with surface obs.)

Ozone at 192hPa in GEOS-5



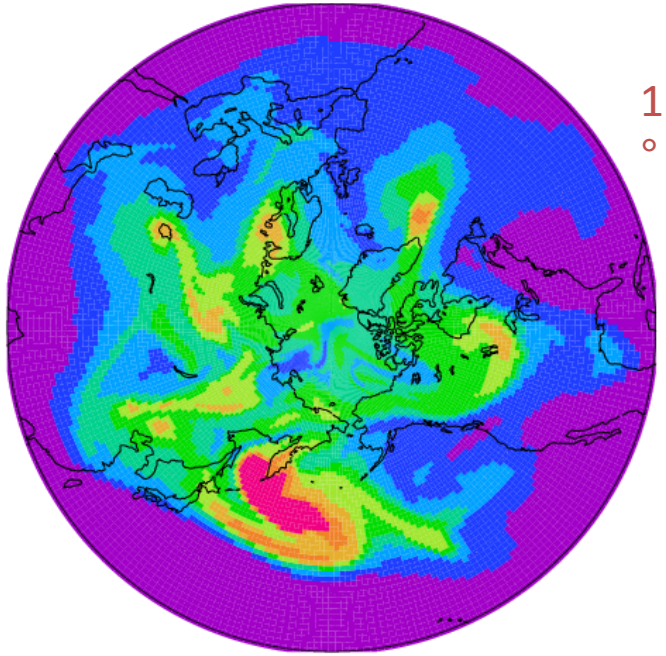
2°×2.5°

0.5°×0.66°



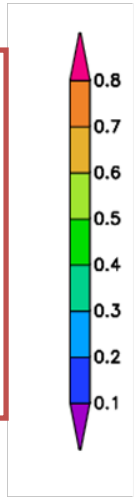
MLS T & O_3 assimilation into GEOS-5

Ozone at 192hPa on January 14, 2005



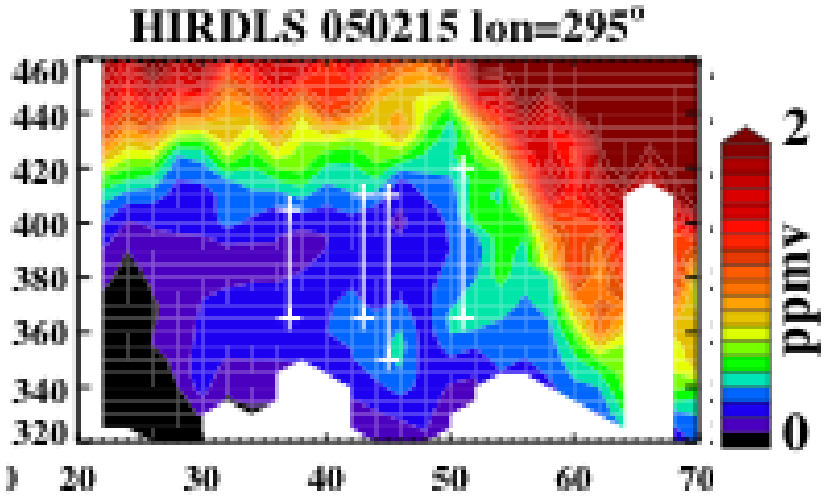
1°×1.25°

MLS & OMI O_3 assimilation into GEOS-5, omitting SBUV

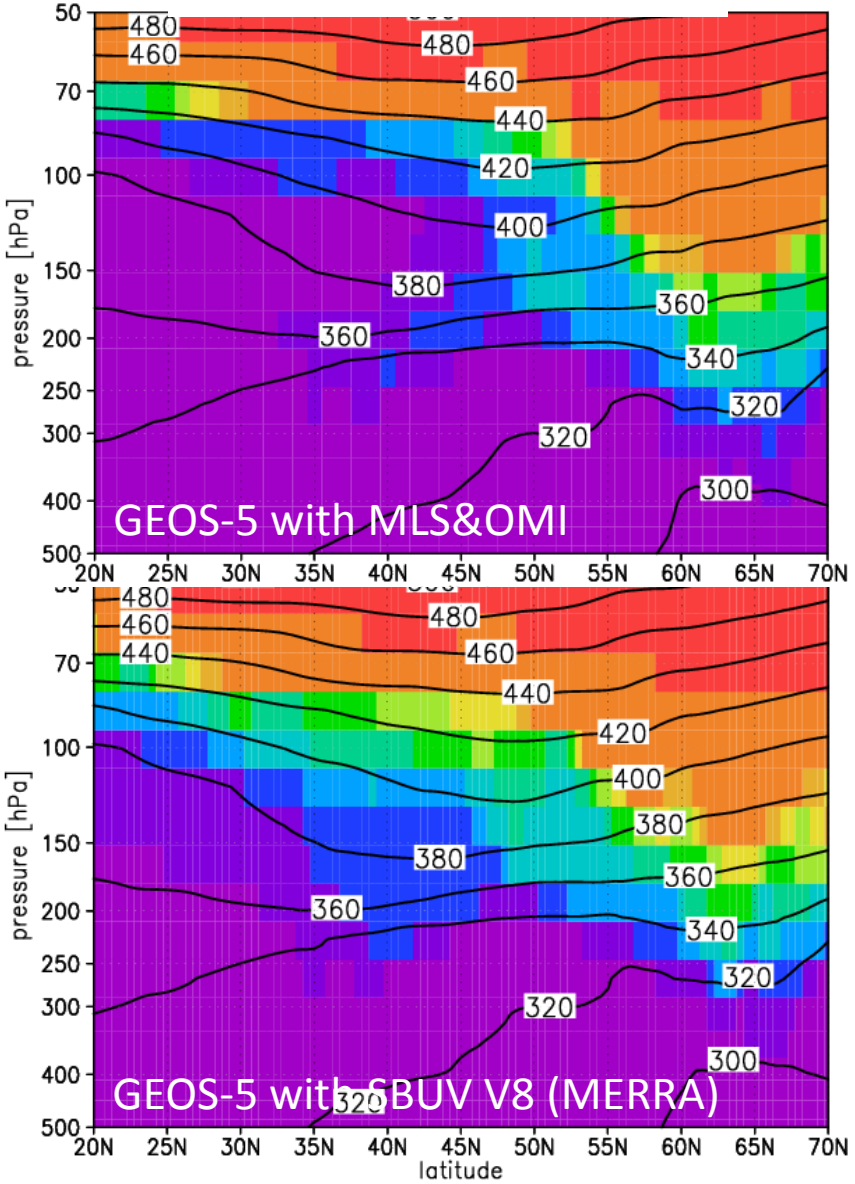


Indication that filaments are better captured as resolution increases – a typical result

UTLS Ozone Structure in GEOS-5



295°E on Feb 15, 2005



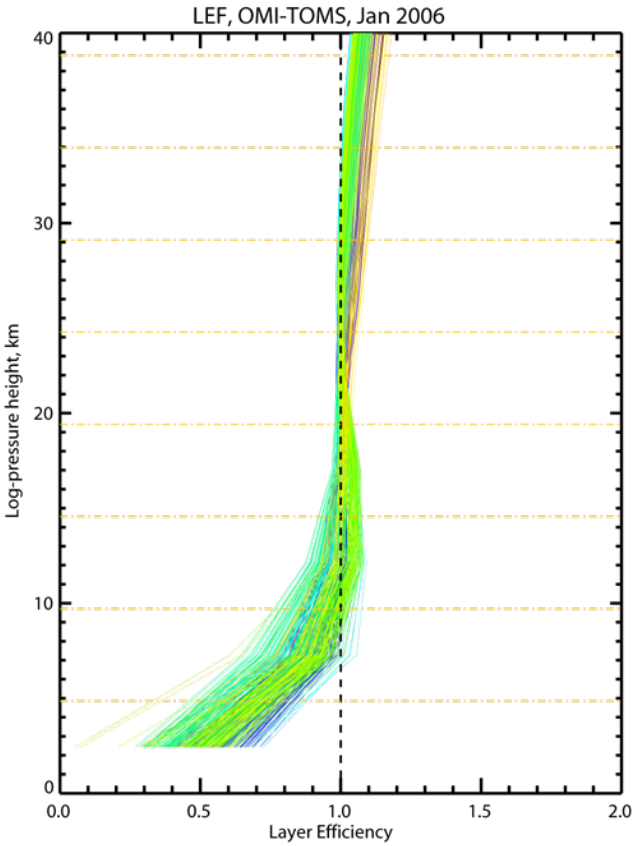
With SBUV observations, GEOS-5 analyses do not capture the rich spatial ozone structure in the UTLS. This means that the tropospheric ozone column is unrealistic. Adding MLS profiles leads to much more realistic features.

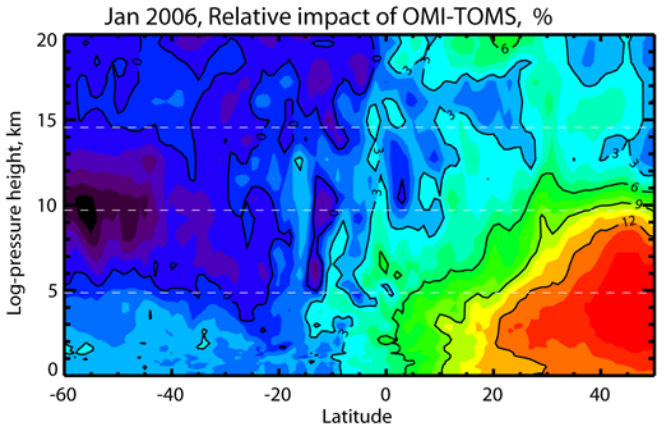
Ozone Assimilation

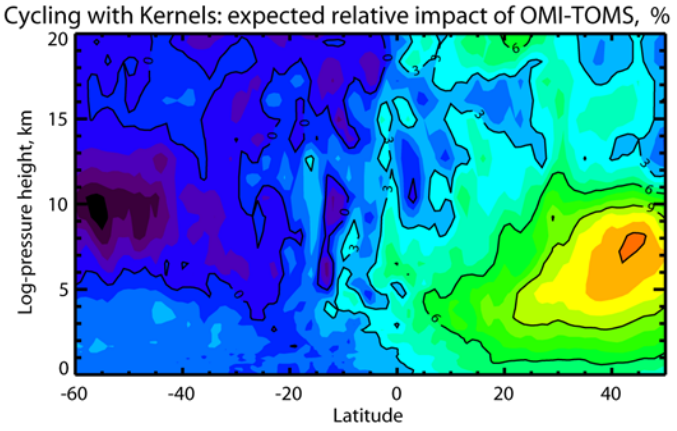
GEOS-5/GSI includes ozone assimilation:

- Standard system assimilates of SBUV total column ozone and deep stratospheric layers
- Ozone impacts infrared radiances (e.g., ATOVS, AIRS) in temperature and moisture assimilation
- Extended system includes OMI total columns and MLS ozone profiles down to cloud top
- Simple tropospheric ozone chemistry (derived from GEOS-Chem) – working on a new, internal implementation
- Improving observation operators (OMI)
- Simple background covariance model – working on a new model (e.g., concentration gradients more important than concentrations)
- Impacts of MLS assimilation on AIRS radiance biases
- Development of assimilation capabilities for OMPS – an OMPS/LP OSSE

OMI Averaging Kernels







Standard version of GSI assumes no height dependence in OMI weighting function. However, there is a substantial decrease in sensitivity to ozone at high pressures. This has been included in the observation operator. Preliminary results (right) suggest that there will be a much smaller increment of OMI observations on tropospheric ozone fields when this is implemented in GEOS-5.

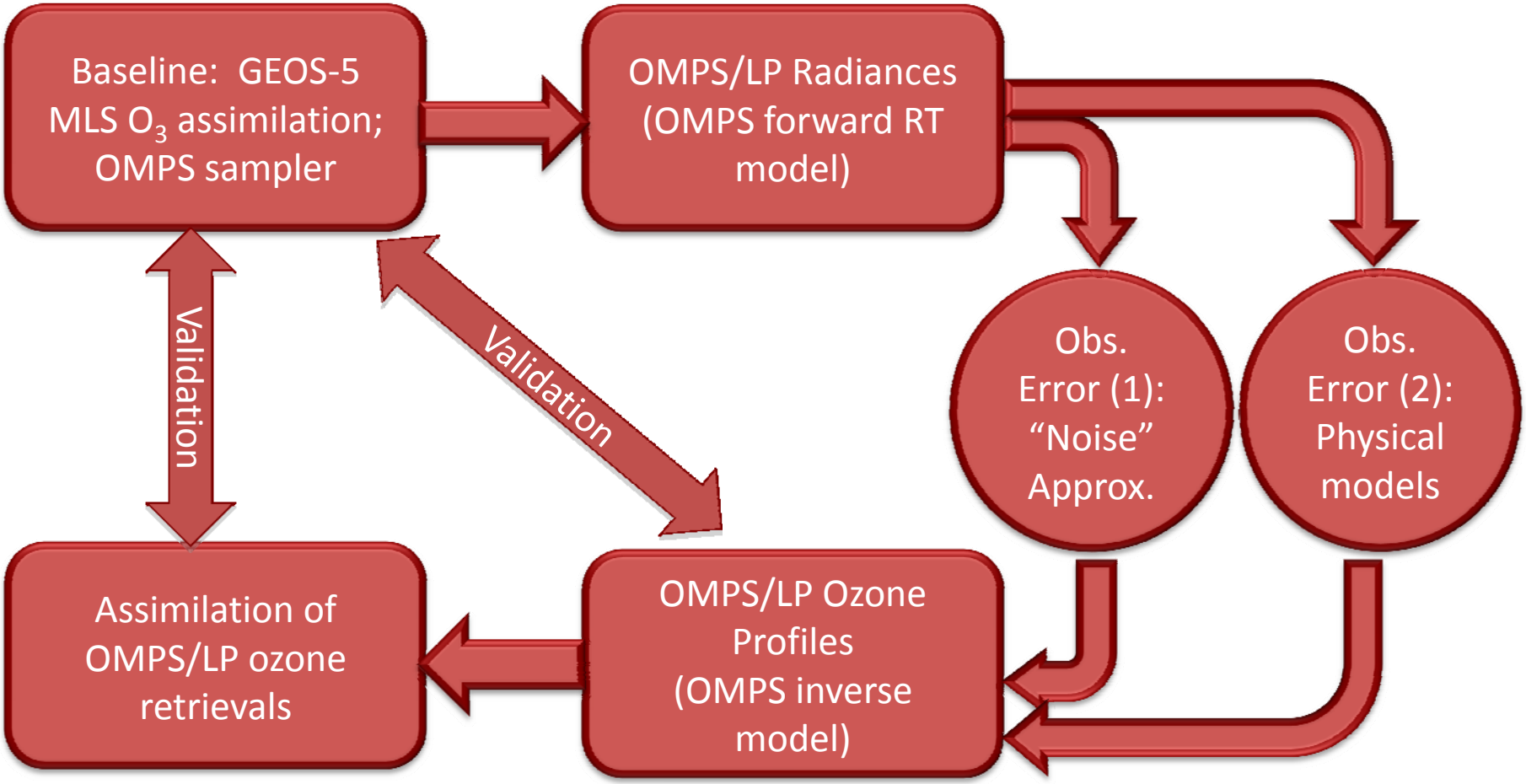
OMPS Limb Profiler - Utility

- Unlike previous operational instruments, OMPS/LP offers profile information down to cloud top
- Supplements an SBUV-like nadir-viewing instrument
- Limb-profiling concept proven with space-borne instruments (e.g., SAGE-III, Osiris, SCIAMACHY)
- Offers potentially better vertical resolution than MLS
- Around 7,000 profiles per day in daylight, compared to >3,000 day-night MLS profiles

OMPS/LP offers the potential to constrain UTLS ozone in GEOS-5 and in operational assimilation systems – we are collaborating with OMPS/LP scientists to implement these data in GSI

OMPS Limb Profiler - OSSE

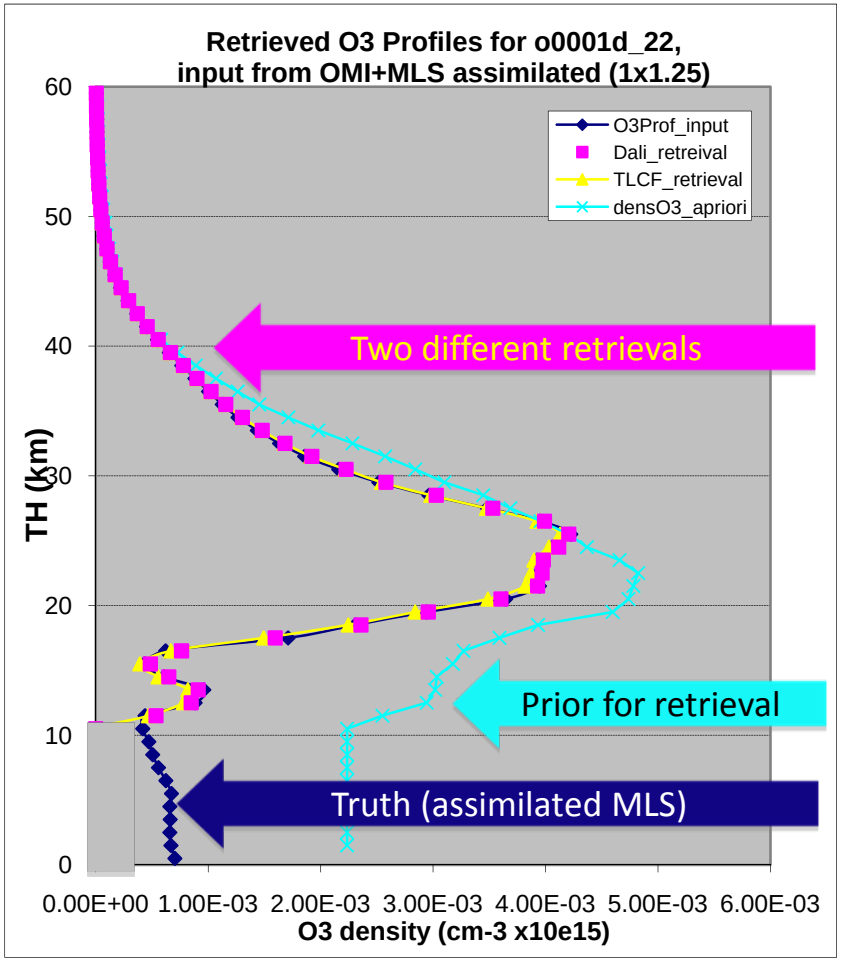
With what fidelity can OMPS/LP reproduce assimilated EOS-MLS ozone?

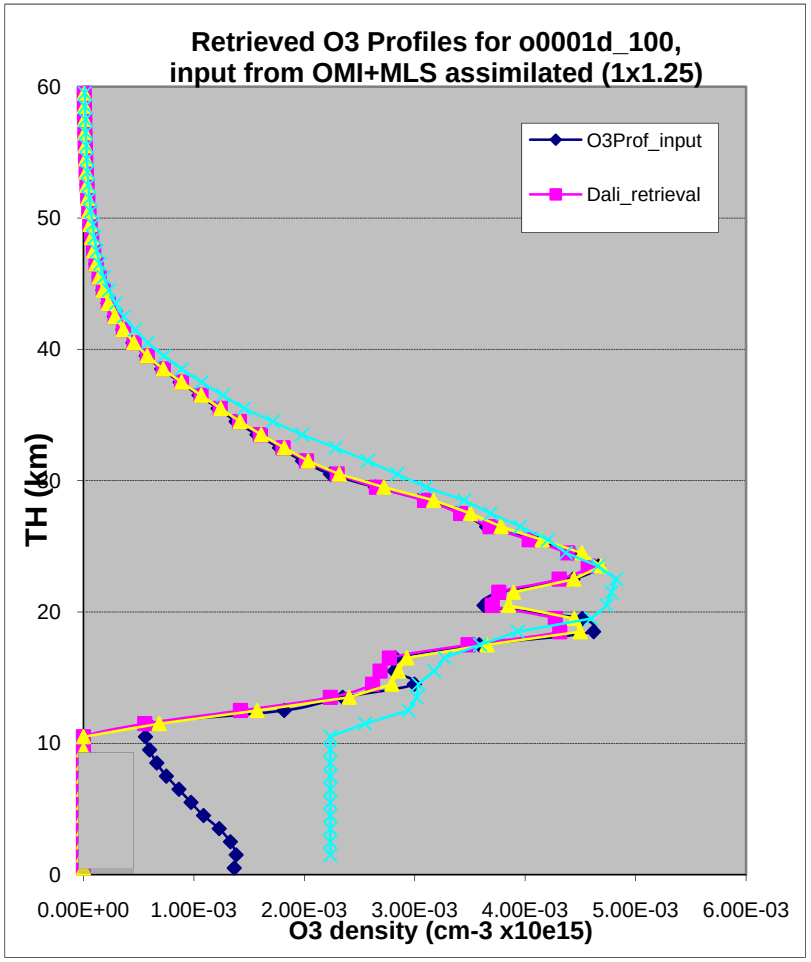


Work performed with Didier Rault and Ghassan Taha from the OMPS LP Team

Example 1: “Simple Error Model”

Comparison of OMPS retrievals with MLS assimilation, adding noise to radiances



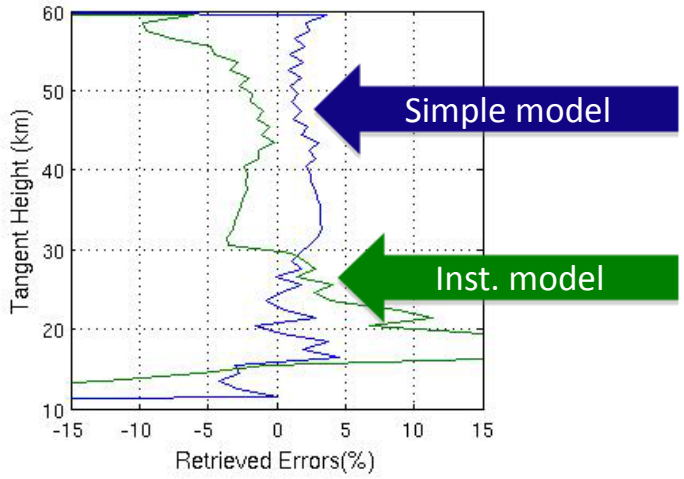


Retrievals beginning with very unrealistic priors are able to derive very accurate profiles from the radiances (with idealized noise) in both cases

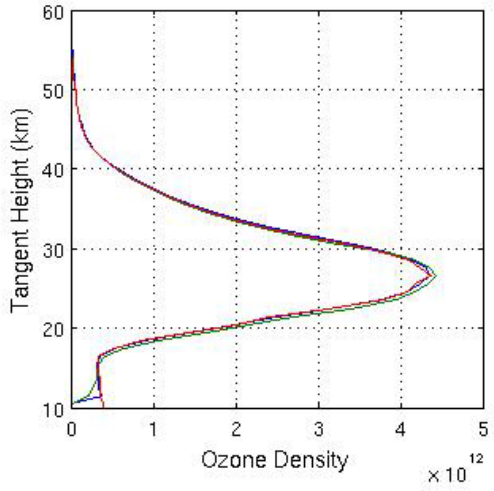
Example 2: Physical Error Modeling

Comparison of OMPS retrievals with MLS assimilation, adding noise to radiances

Relative Errors



Absolute Values



Several instrument noise sources were used to more realistically account for errors (i.e., stray light, smile effect, etc):

- Instrument gridded model
- Deconvolution model
- Gain Consolidation model

Performance is worse in the low stratosphere than with the simple error model (ongoing)

Working to complete the end-to-end OSSE. This will give capability for immediate assimilation of OMPS/LP data after launch.

Summary

- Ingesting EOS-Aura observations (OMI and MLS) into GEOS-5
- Use of MLS profiles leads to well constrained ozone field in UTLS
- Various improvements to the assimilation system are underway (e.g., observation operator for OMI)
- Systematically building an OSSE for OMPS/LP that allows evaluation against MLS assimilation system

Have tried to illuminate some of the development pathways for ozone assimilation in GMAO, with emphasis on JCSDA work