



Aura Science Team Meeting



Modeling Analysis of TES Observations to Characterize the Global Distributions of Tropospheric CO and O₃

Qinbin Li, Nigel Richards, Line Jourdain

and the **TES** and **MLS** teams

Kevin Bowman (one of the TES guys)

Jet Propulsion Laboratory, California Institute of Technology

November 8, 2005



Objective



Overall objective: improve the quantification of precursor emissions, chemical processes, and transport that determine the distributions (in space and time) of tropospheric CO and O₃.

Outline of talk:

- Assimilation of TES tropospheric CO retrievals in the GEOS-CHEM global 3D CTM. (Work by Nigel Richards)
- Interpreting TES observations of tropical tropospheric O₃. (Work by Line Jourdain)

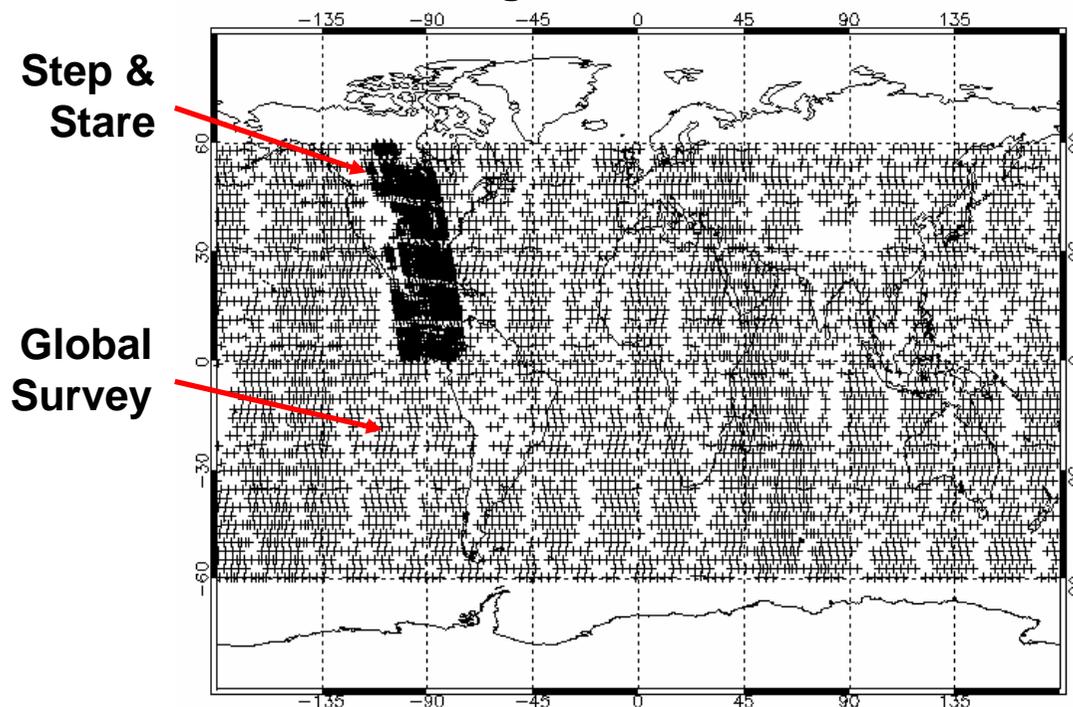


Assimilation of TES CO in GEOS-CHEM



Approach

Coverage of TES data used



Sequential assimilation:

- A sub-optimal Kalman filter method [Khattatov et al., 2000].
- GEOS-Chem 4°x5° simulation of CO with archived OH fields from a full-chemistry simulation.
- Initial model variance set to 20%.
- Model the time evolution of error covariance by treating the diagonals as a passive tracer in GEOS-CHEM. The off-diagonals are parameterized.

TES data used in the assimilation:

- 6 global surveys and 10 step & stare special observations during Nov. 1-15, 2004.
- Data filtered according to quality flags; retrievals with surface pressure < 825 hPa removed; data north and south of 60 degrees removed.
- CO profiles and averaging kernels mapped down from 87 to reduced 14 vertical levels for computational consideration.

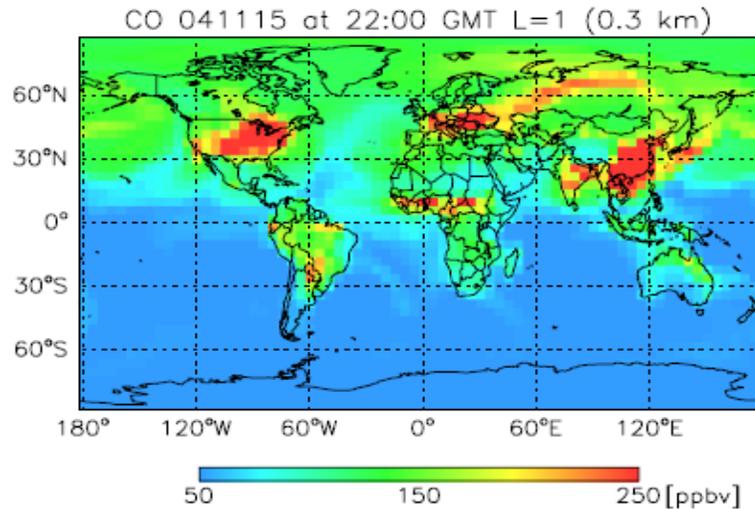


Assimilation of TES CO in GEOS-CHEM

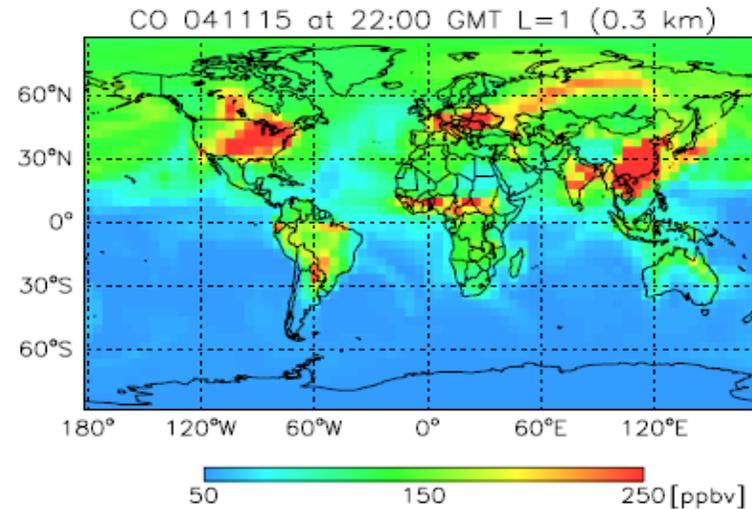


Simulation vs Assimilation @Surface

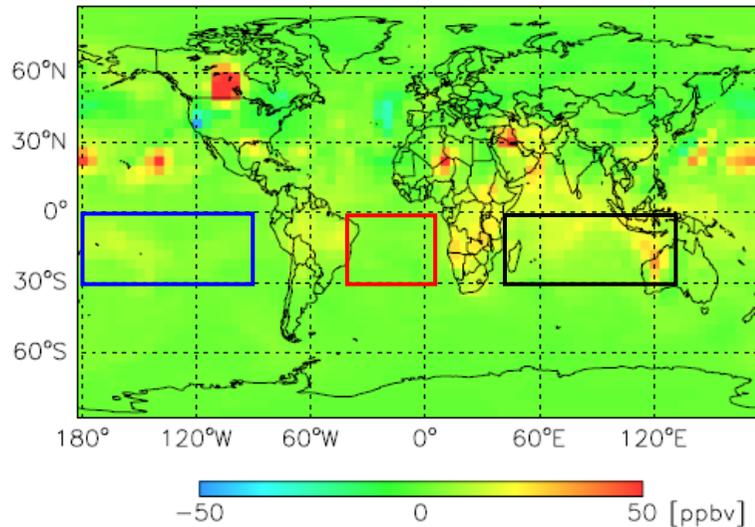
Without Assimilation



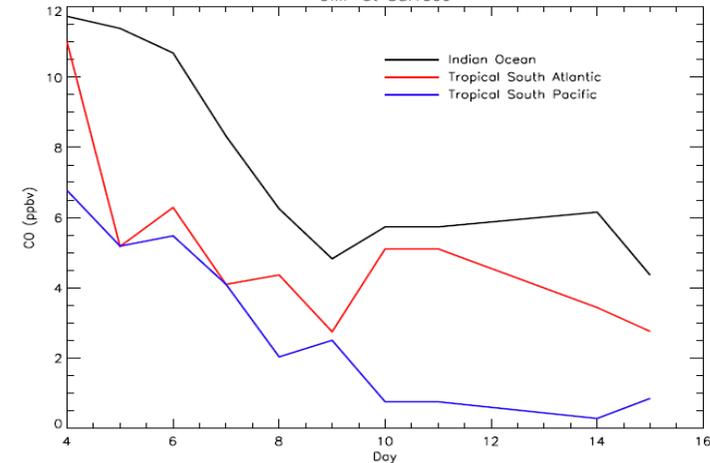
With Assimilation



Absolute Difference



OMF at Surface



A 2-week simulation/assimilation for Nov. 1-15, 2004. Results for Nov. 15 are shown.

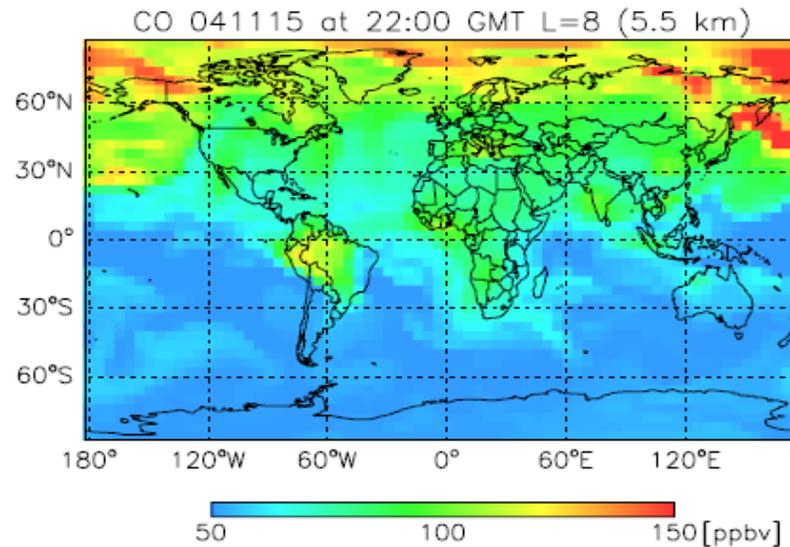


Assimilation of TES CO in GEOS-CHEM

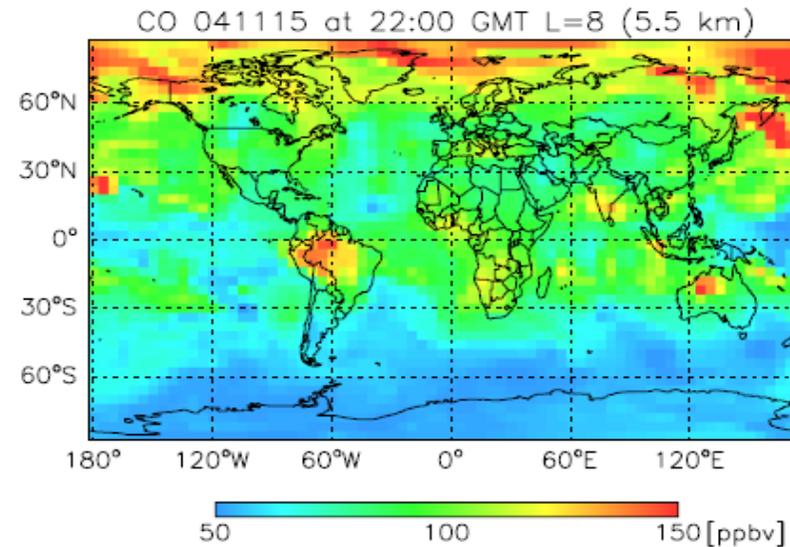


Simulation vs Assimilation @ 5.5 km

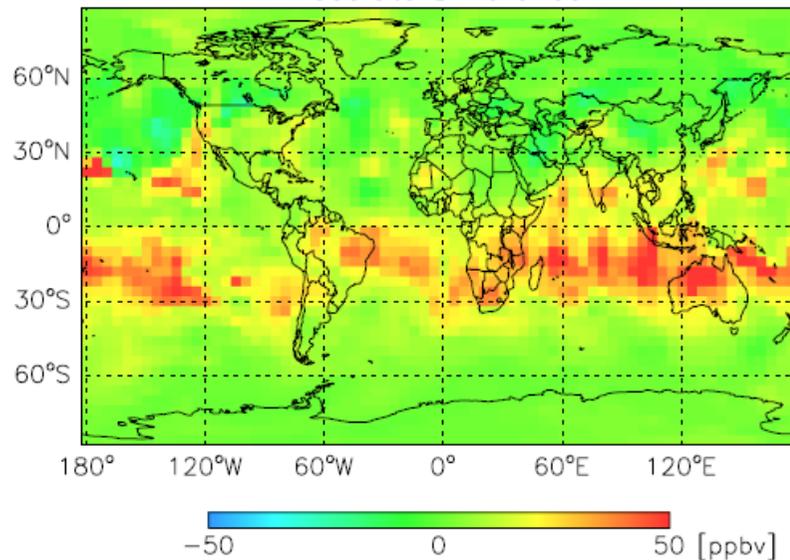
Without Assimilation



With Assimilation



Absolute Difference



Largest difference seen between equator and 30°S in the southern hemisphere, likely due to underestimated biomass burning emissions in Southern Africa and South America.

The simulations use a climatological biomass burning emission inventory (not year-specific).

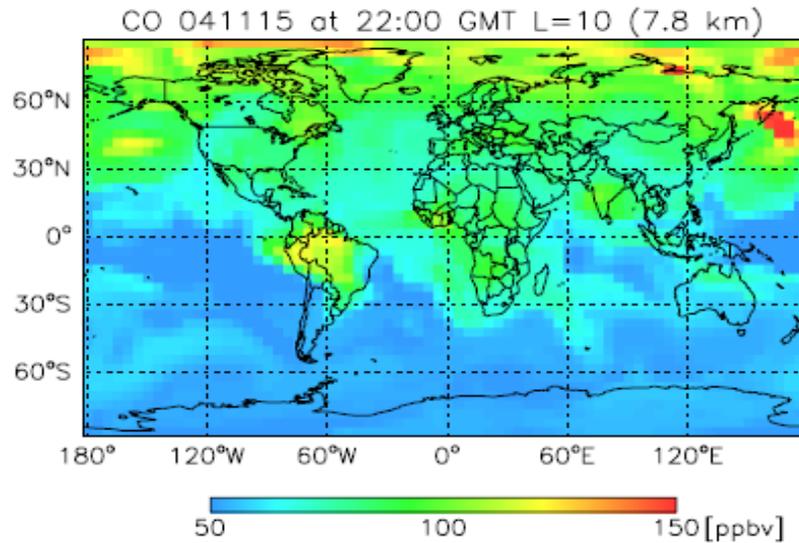


Assimilation of TES CO in GEOS-CHEM

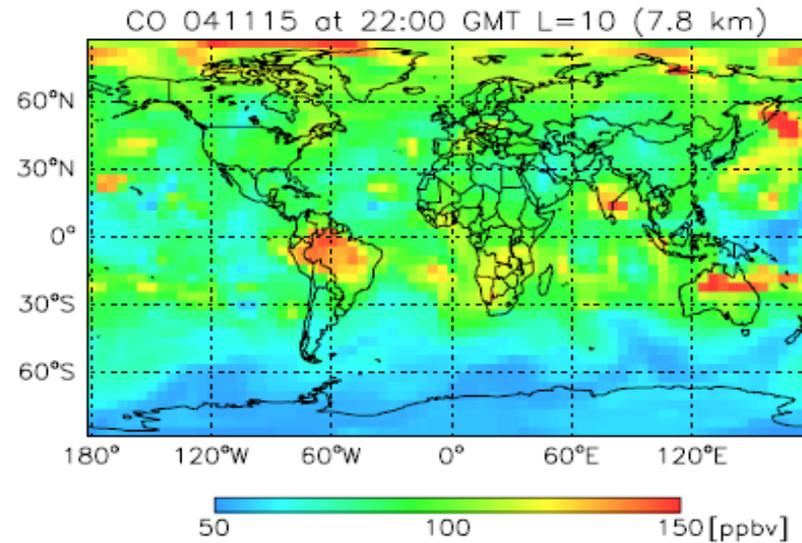


Simulation vs Assimilation @7.8 km

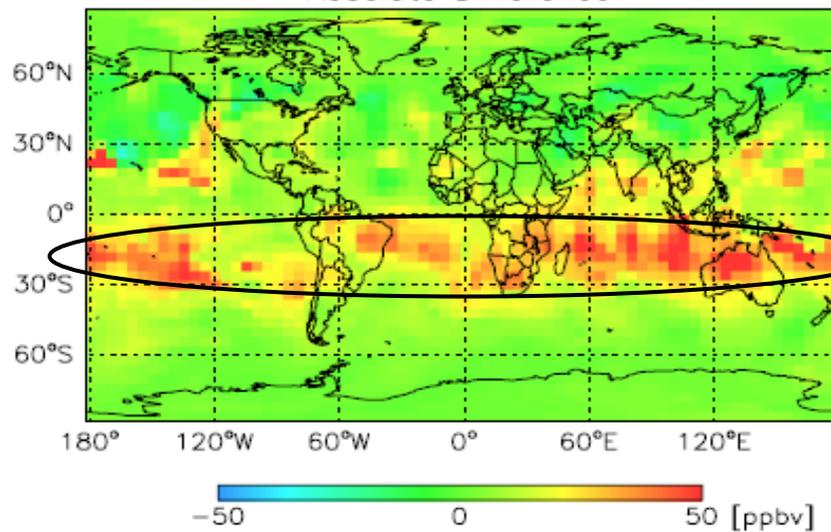
Without Assimilation



With Assimilation



Absolute Difference



Large difference due to model underestimating biomass burning emissions.

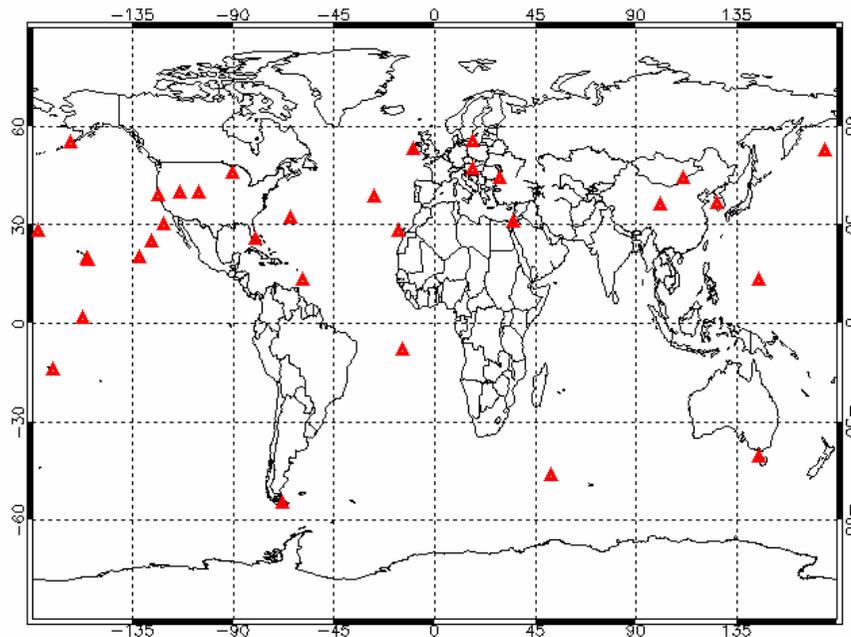


Validation of the Assimilation

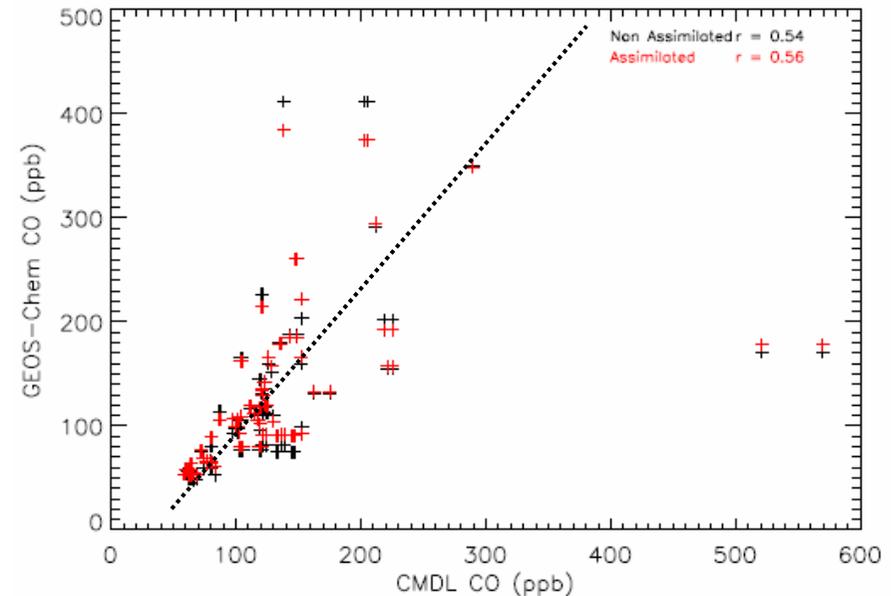


Comparison with CMDL surface CO measurements

CMDL sites used in the comparison



Black: no assimilation Red: assimilation



Results from the simulation and assimilation runs are compared with CMDL CO measurements. Values are for Nov. 15, 2004.

At the surface the assimilation shows no apparent improvement compared to the simulation (without assimilation).

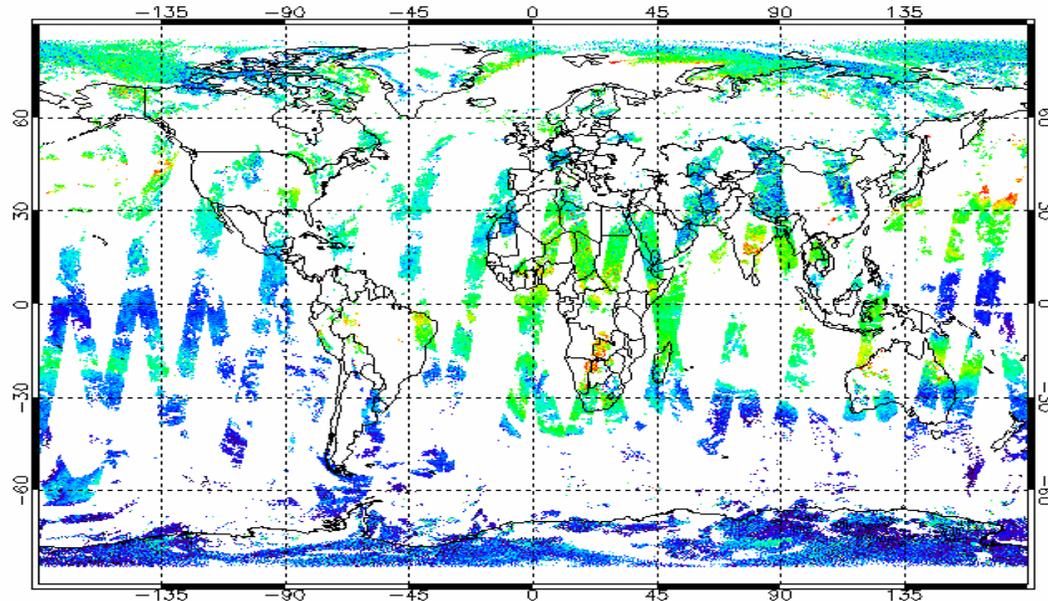


Validation of the Assimilation

Comparison with MOPITT CO retrievals



500 hPa MOPITT CO, Nov. 15, 2004



- Comparison is for the final day of the assimilation run, Nov. 15, 2004.
- GEOS-CHEM CO profiles extracted at the time and location of MOPITT measurements.
- MOPITT averaging kernels were applied to both assimilated and non-assimilated GEOS-CHEM profiles.
- Transformed model and MOPITT profiles binned to GEOS-CHEM 4°x5° grid.

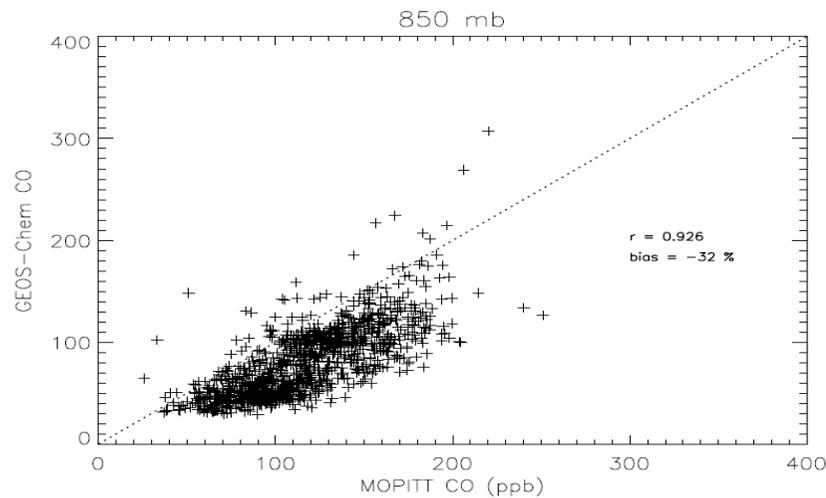


'Validation' of the Assimilation

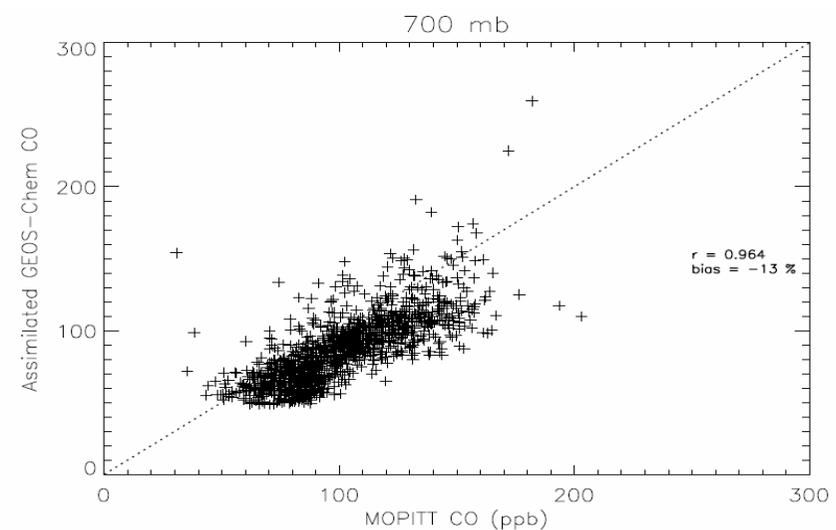
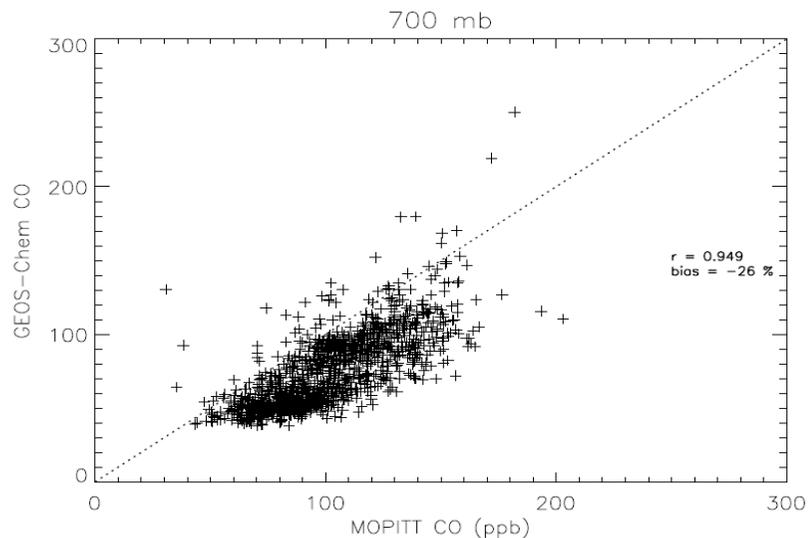
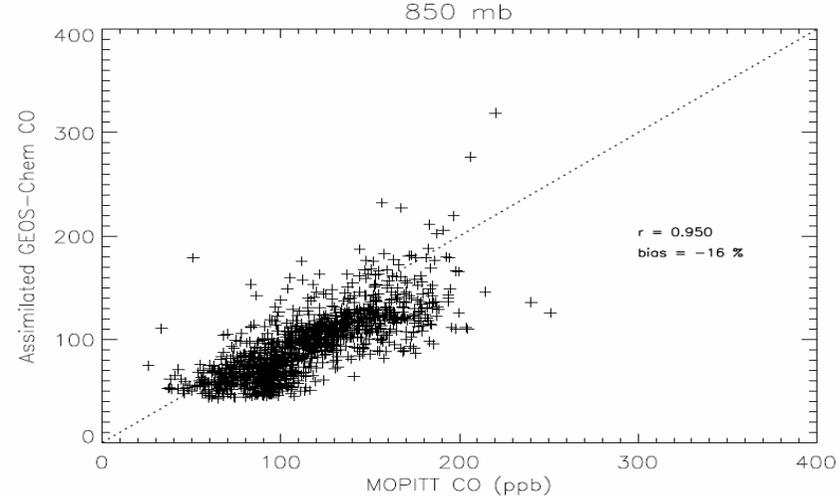
Comparison with MOPITT CO @850 & 700 hPa



Without Assimilation



With Assimilation



Compared with MOPITT retrievals, the assimilation results show much smaller biases, defined as $(\text{model} - \text{MOPITT}) / \text{MOPITT}$ than the non-assimilation values.

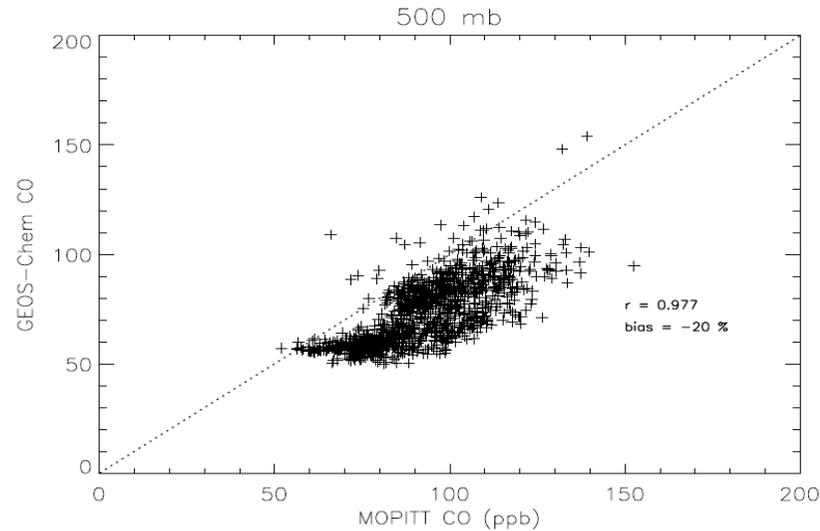


Validation of the Assimilation

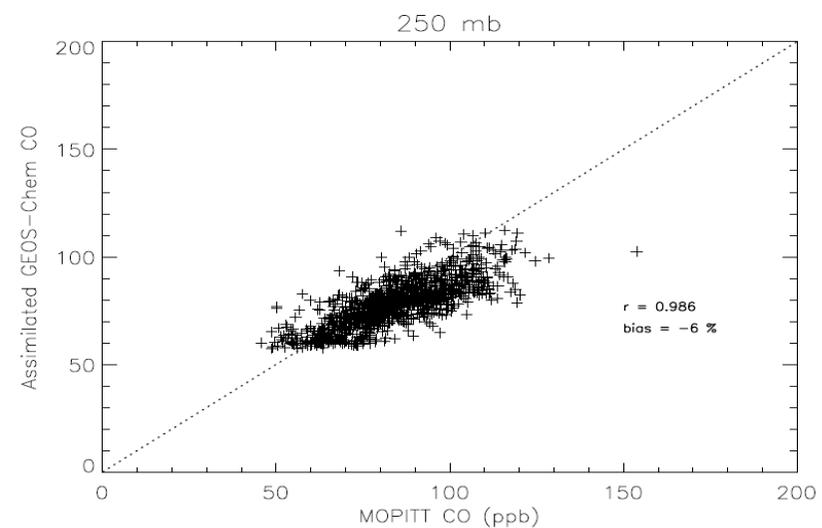
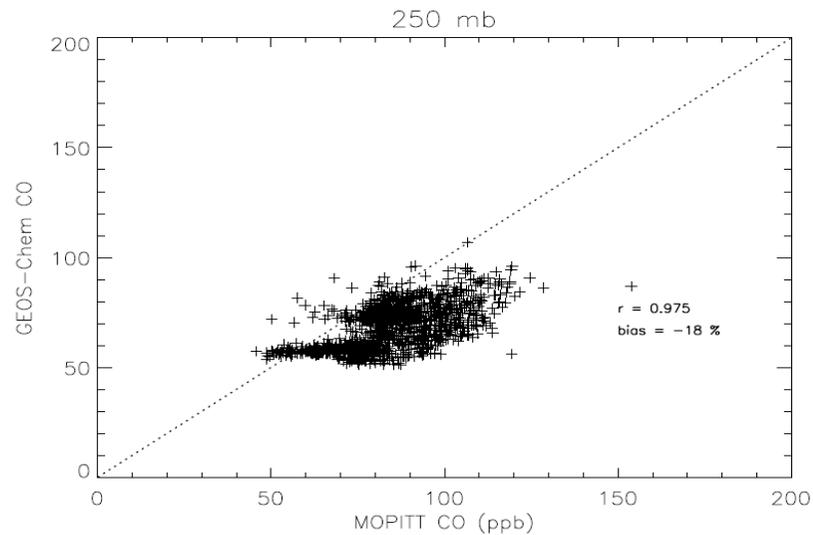
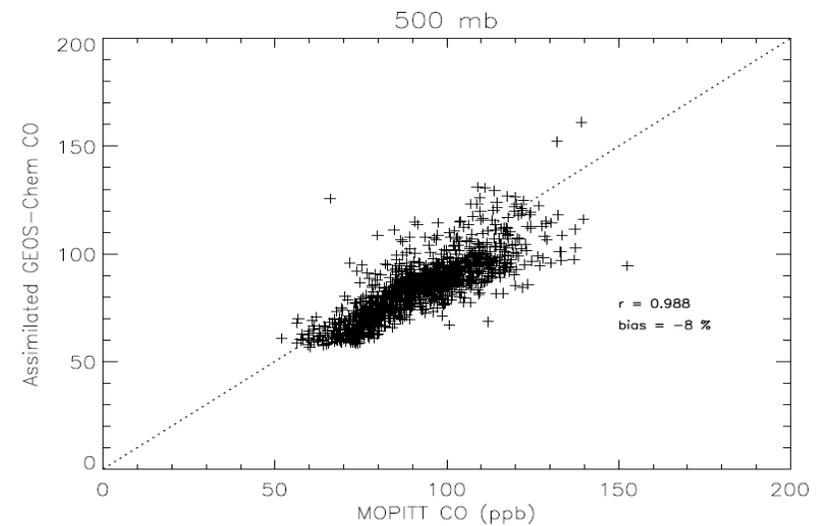


Comparison with MOPITT CO @500 & 250 hPa

Without Assimilation



With Assimilation



Even larger improvements in the middle/upper troposphere where TES is most sensitive.



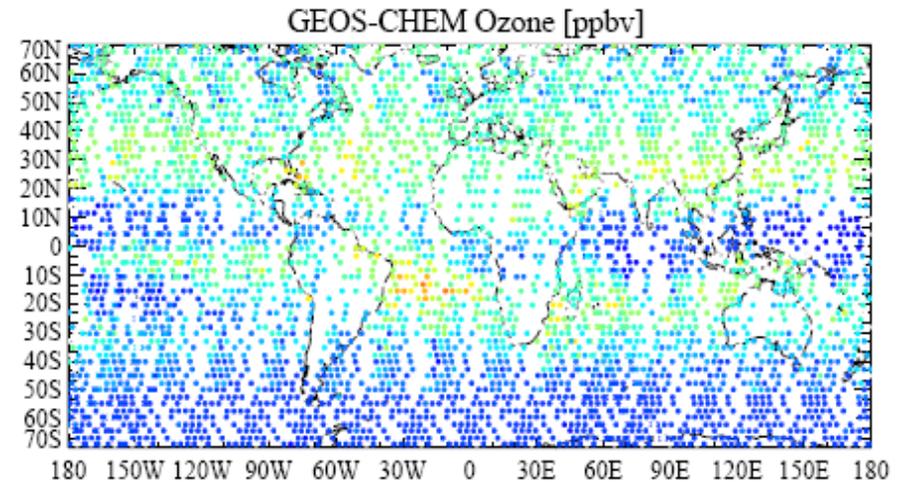
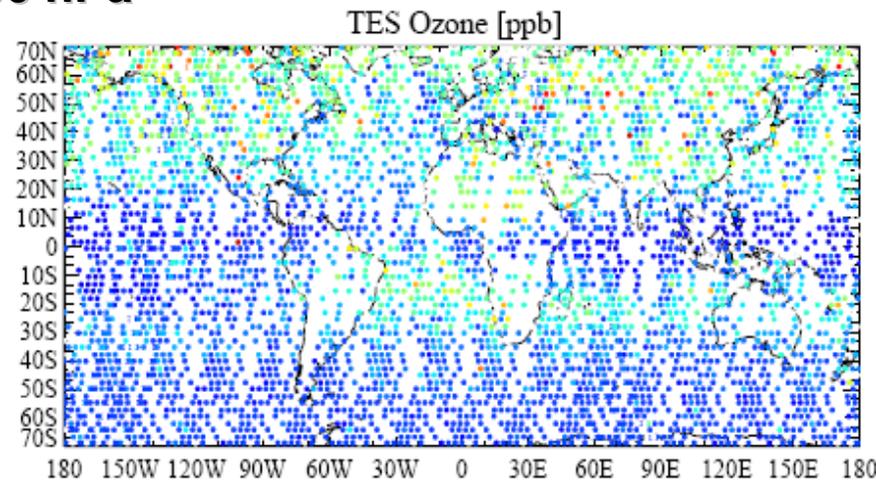
TES Tropospheric Ozone

Comparison with GEOS-CHEM results

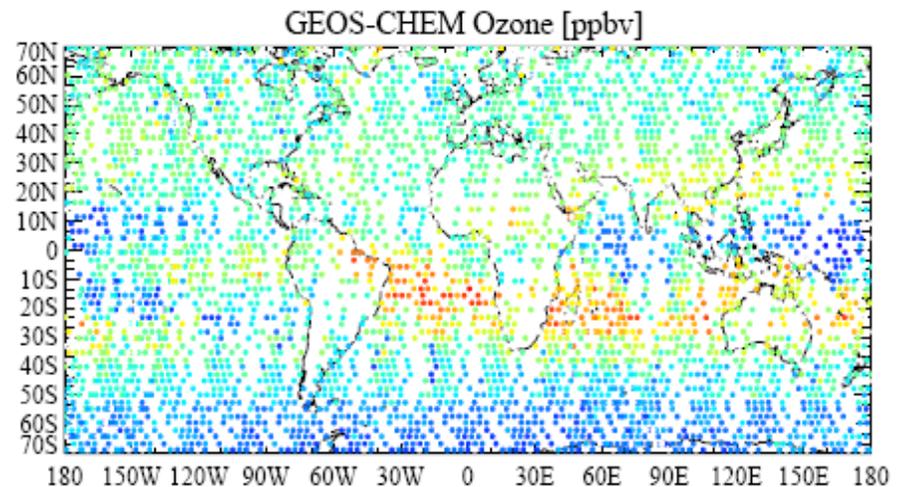
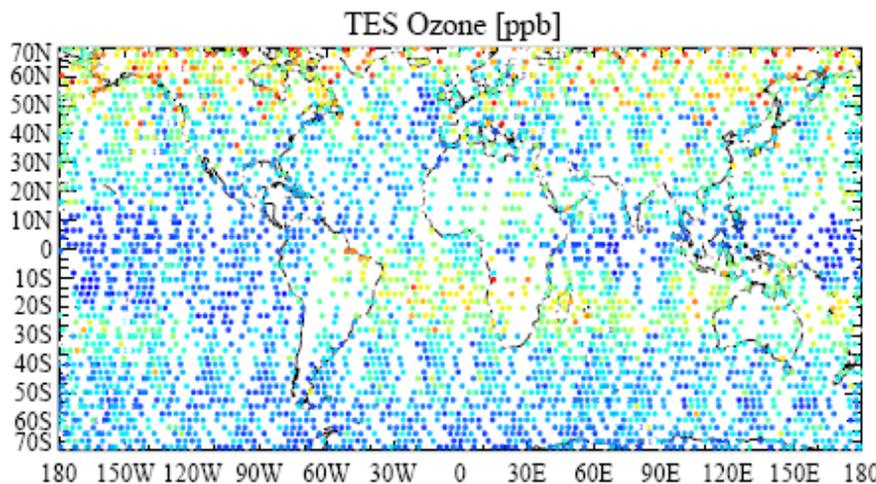


November 2004

700 hPa



500 hPa



TES retrievals: 6 global surveys from November 2004. Model results sampled along TES orbital tracks. TES averaging kernels applied to model simulated O₃ profiles.



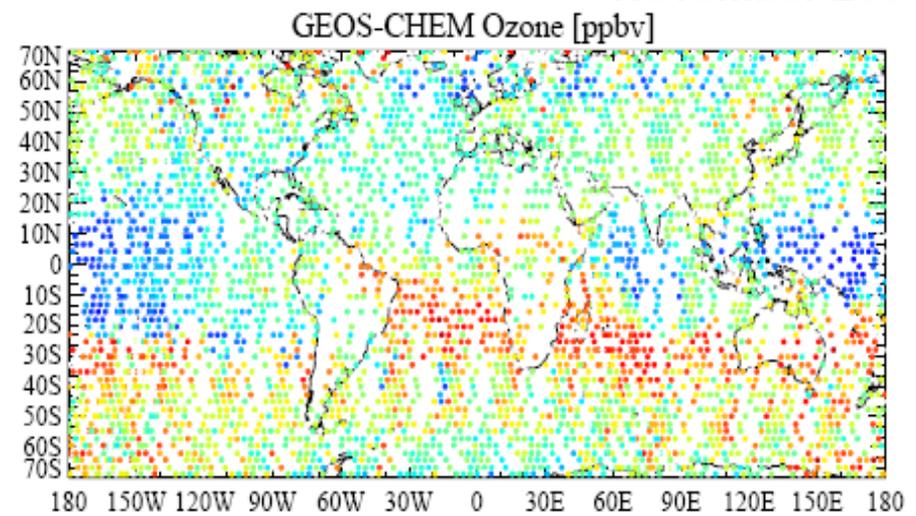
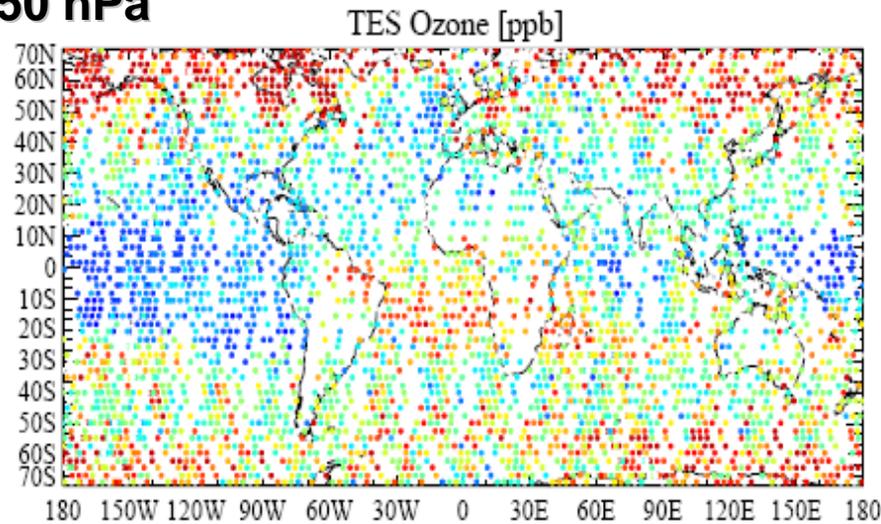
TES Tropospheric Ozone

Comparison with GEOS-CHEM results

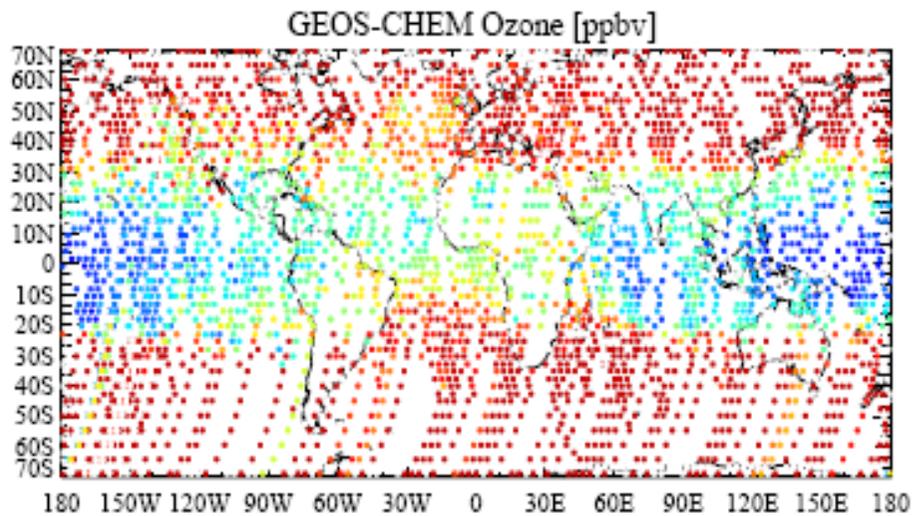
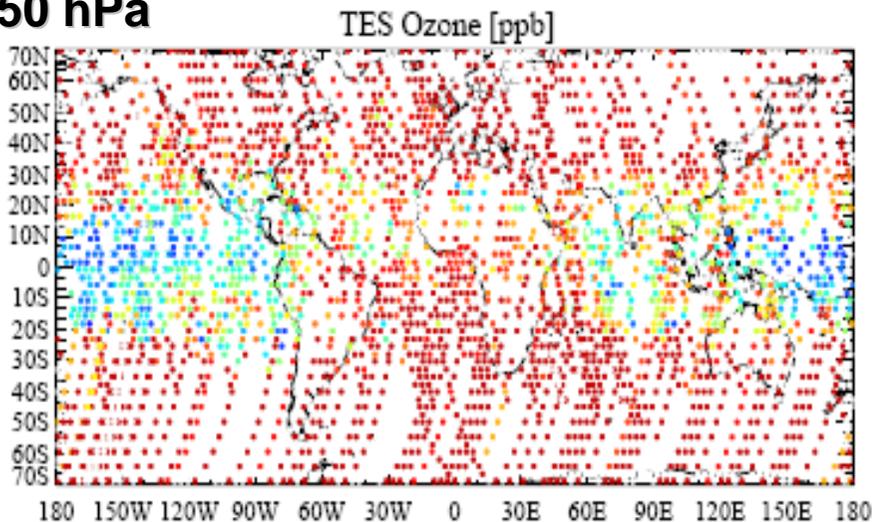


November 2004

350 hPa



250 hPa



In the tropical upper troposphere, much lower O_3 concentrations in the model than TES.

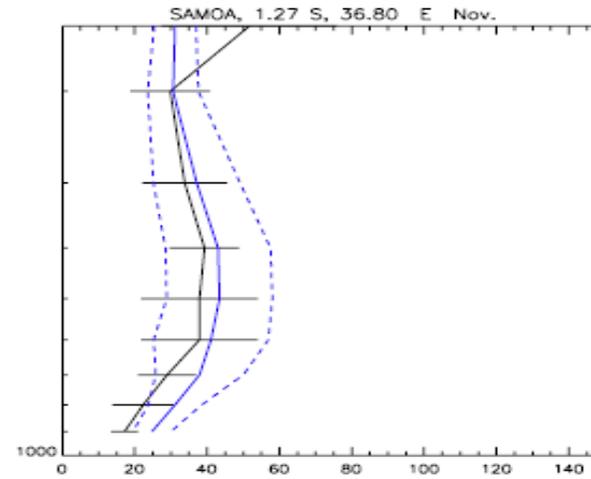
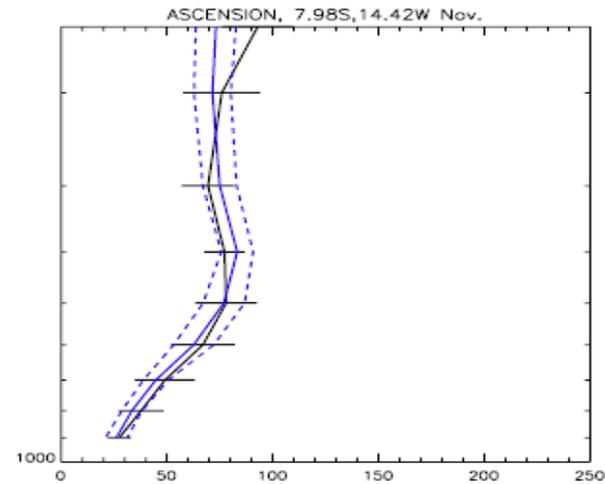


GEOS-CHEM Simulated Tropospheric Ozone

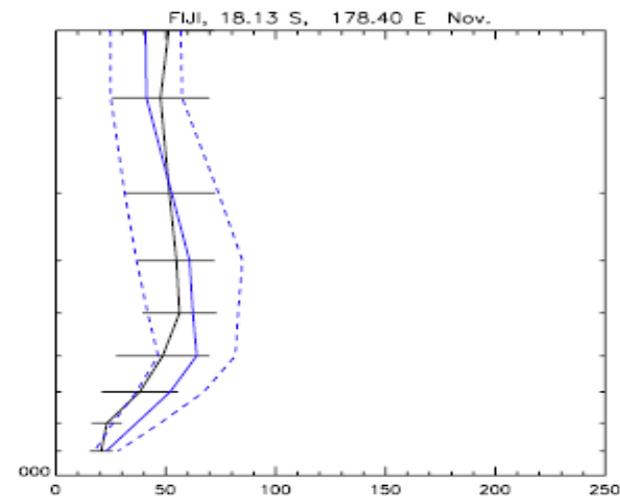
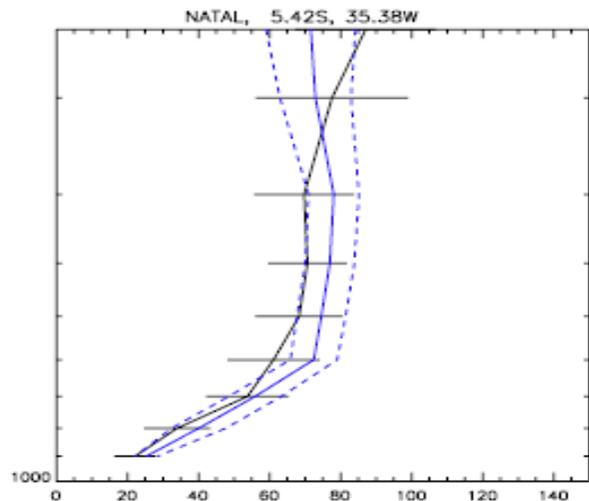


Comparison with SHADOZ ozonesonde data

Monthly mean GEOS-CHEM tropospheric ozone profiles (November 2004)
compared SHADOZ ozonesonde data (monthly mean for November 2000-2004)



— SHADOZ
— GEOS-CHEM

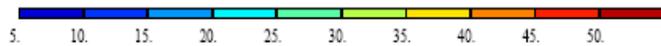
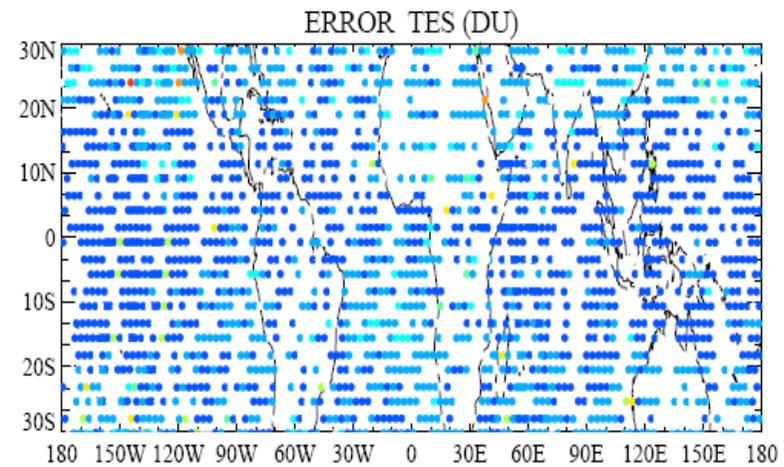
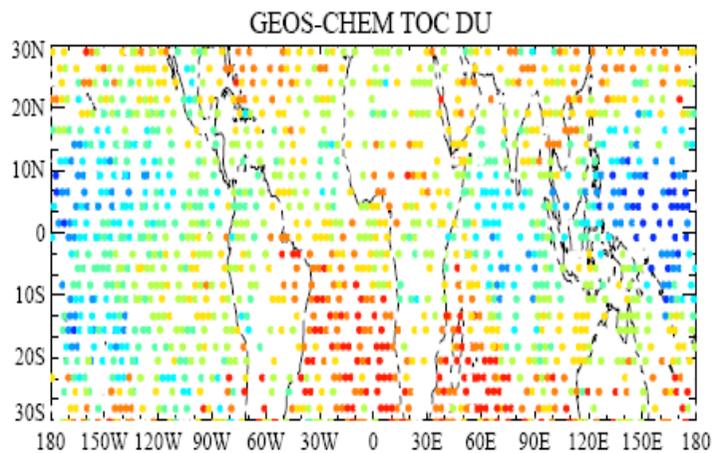
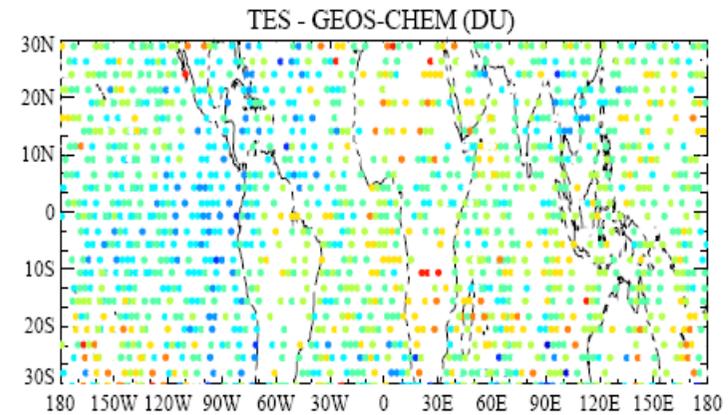
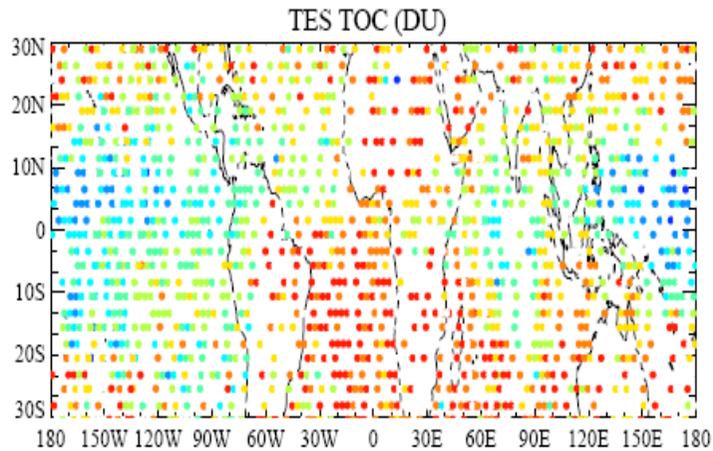




TES Tropospheric Ozone Columns Comparison with GEOS-CHEM



Tropospheric Ozone columns (TOC) Nov. 2004 (6 Global Surveys)



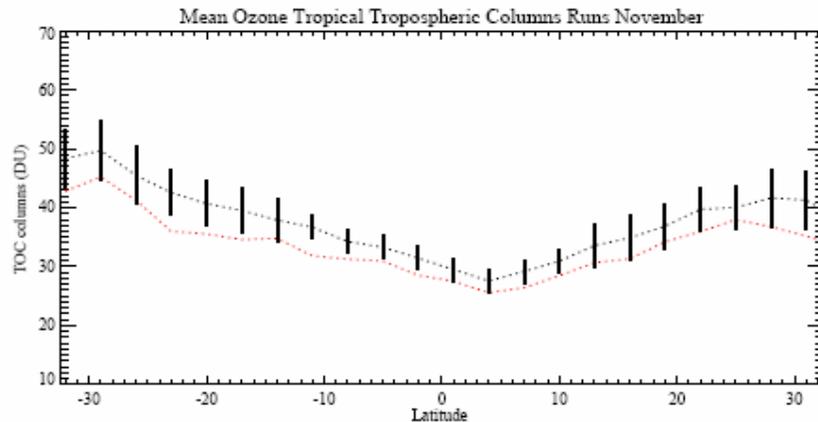
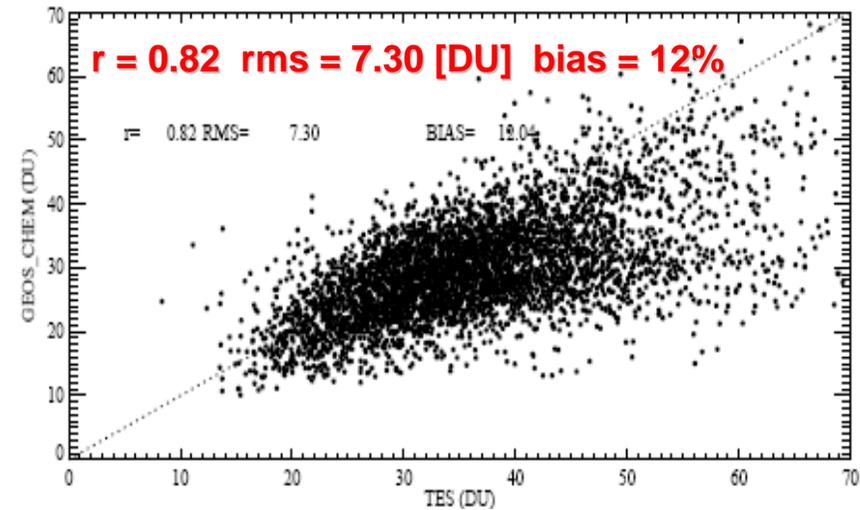
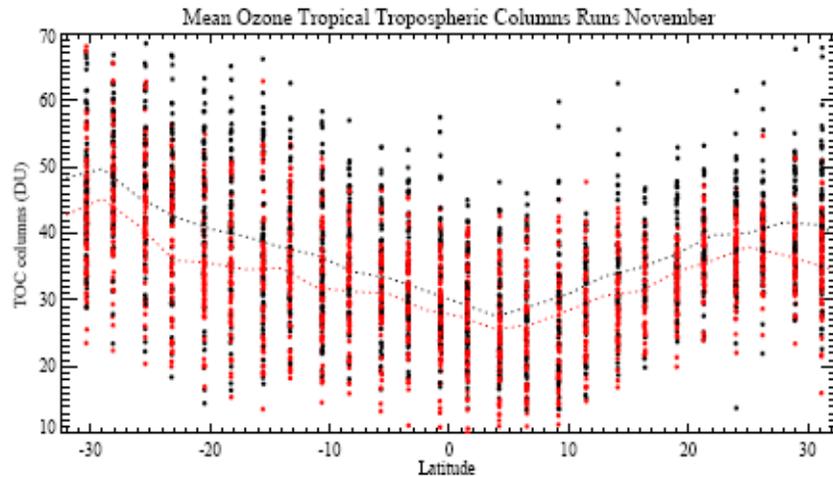


TES Tropospheric Ozone Columns

Comparison with GEOS-CHEM



November 2004



6 November GS global surveys
Bias: $(\text{TES} - \text{Model}) / \text{Model}$

..... TES zonal mean

..... GEOS-CHEM zonal mean



Future Work



-
- **Continue validation of assimilated CO with independent observations such as MOZAIC.**
 - **Assimilation of TES ozone in GEOS-CHEM; validation of the assimilation results with ozonesonde and MOZIAC observations.**
 - **Seasonal variation of tropical tropospheric ozone.**
 - **Quantify the relative influence of biomass burning, lightning NO_x emissions, convective transport, and long-range transport on tropical tropospheric ozone.**