Assimilation of TES observations for the analysis of processes governing the chemistry of the troposphere

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Tropospheric models

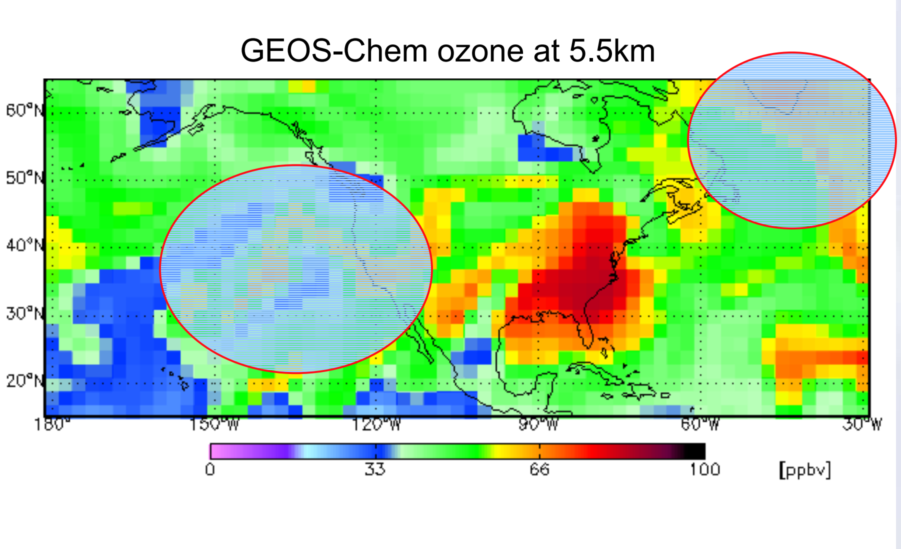
- AM2-Chem
  - GCM developed at NOAA GFDL.
  - B-grid model, 2.0° latitude x 2.5° longitude, 24 vertical levels (top level approx. 45km).
  - Chemistry scheme based on MOZART-2 [Horowitz et al., 2003; Tie et al., 2004].
  - Model dynamics constrained by Newtonian nudging to NCEP reanalyses.

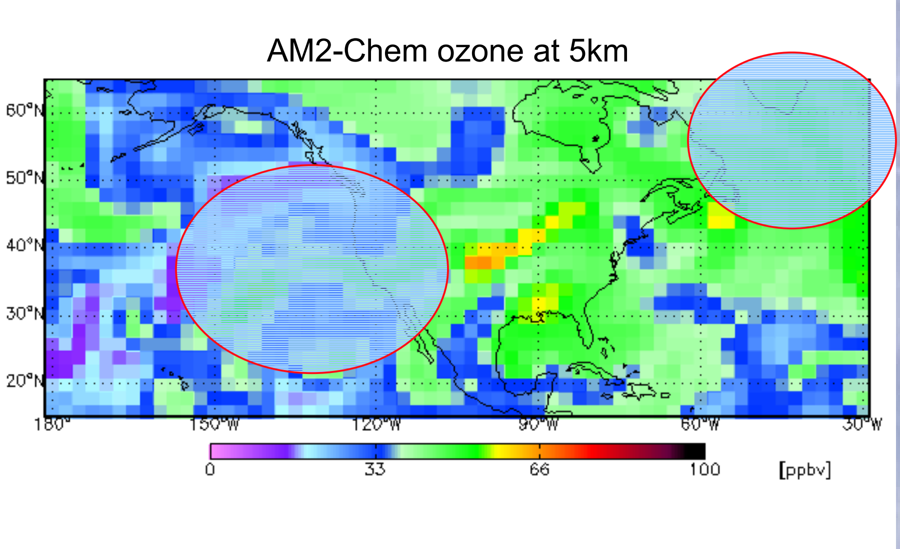
- GEOS-Chem
  - CTM.
  - 2.0° latitude x 2.5° longitude, 30 vertical levels (top level approx. 80km).
  - Model transport driven by GEOS-4 GMAO analyses.

Sequential Kalman filter approach to the assimilation of TES ozone and carbon monoxide profiles.

TES data assimilated for July 2005.

Tropospheric Ozone

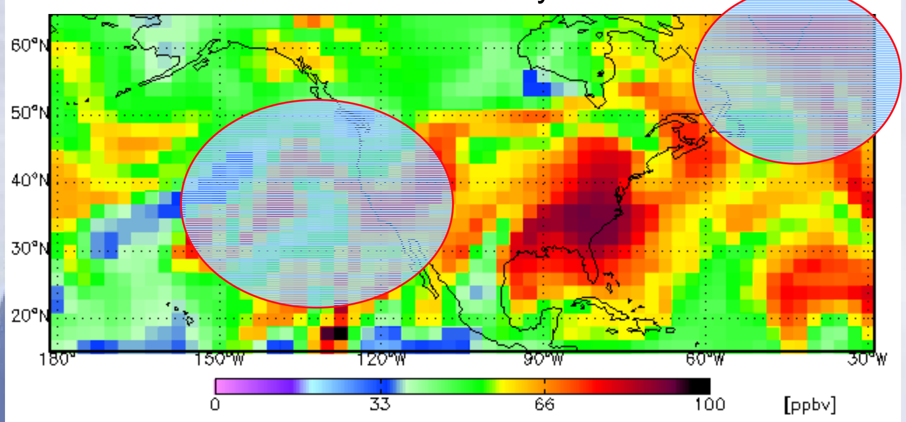




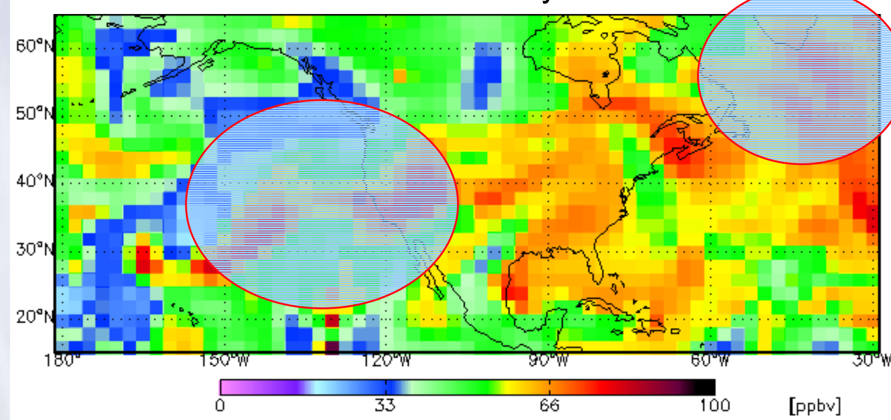
- Ozone field over North America at approx. 5km on 26th July 2005.
- Dynamical features correlate in both models.
- Ozone abundance is generally much greater in GEOS-Chem compared to AM2-Chem.
- Large discrepancy over SE USA due to more NO_x in GEOS-Chem, possibly due to lightning source in mid-troposphere.

Impact of TES data

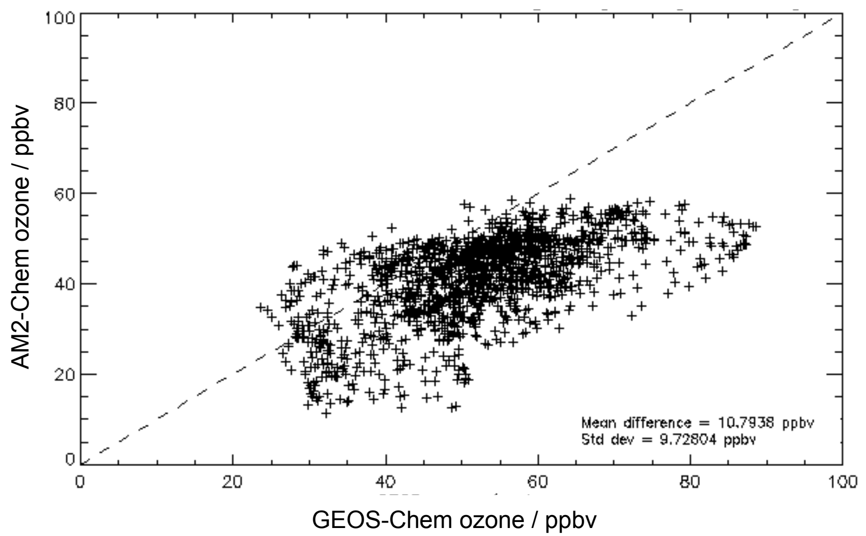
GEOS-Chem ozone analysis at 5.5km



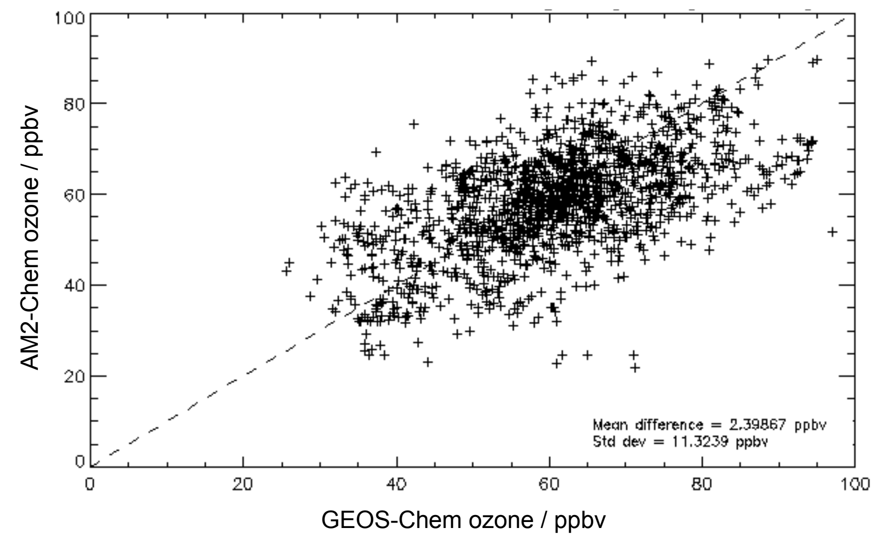
AM2-Chem ozone analysis at 5km



Scatter of model ozone fields at 5km

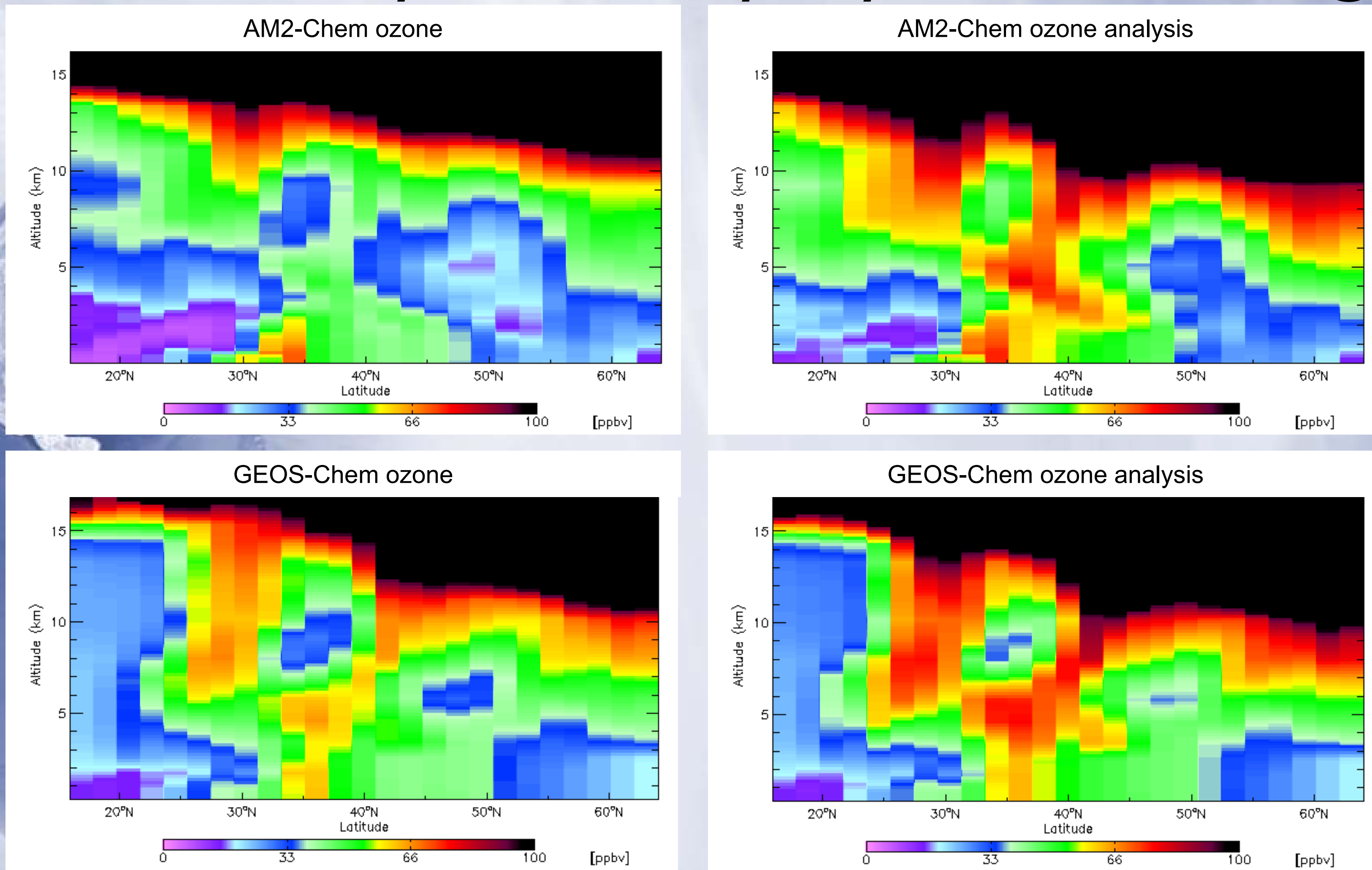


Scatter of model ozone analysis fields at 5km



Model ozone analyses “converge” with a reduction in the mean difference from 10.7 ppbv to 2.4 ppbv.

Stratosphere-Troposphere Exchange



Altitude-latitude cross-sections at 120°W, 21:00 GMT.

Stratospheric intrusion at 40N more pronounced in both models following assimilation.

Partitioning of NO_x

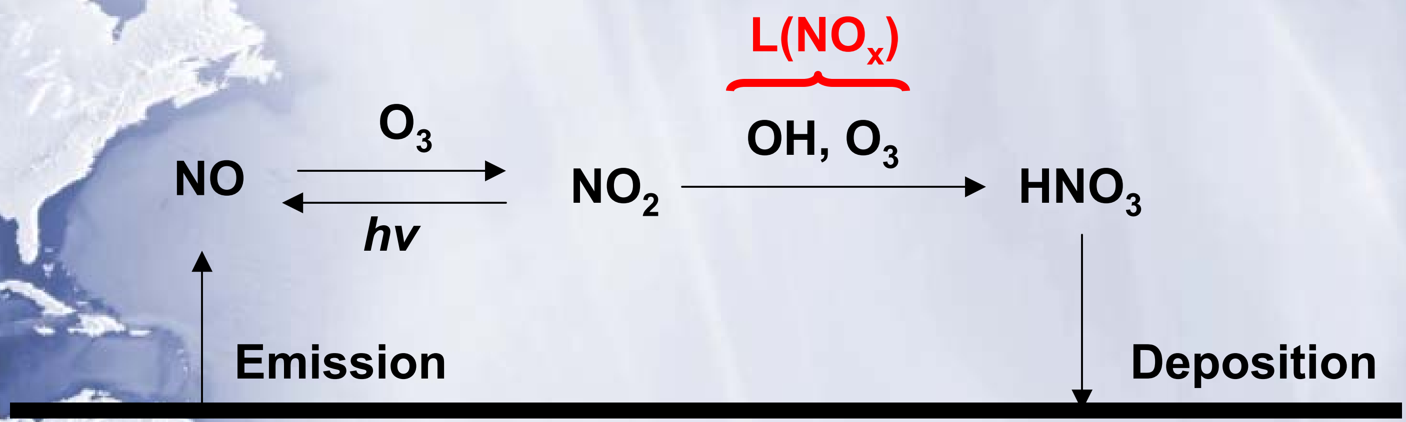
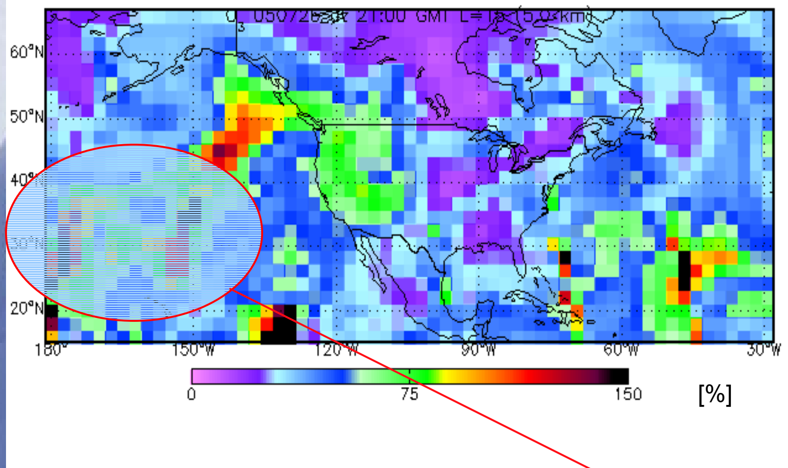


Figure adapted from Jacob [1999]

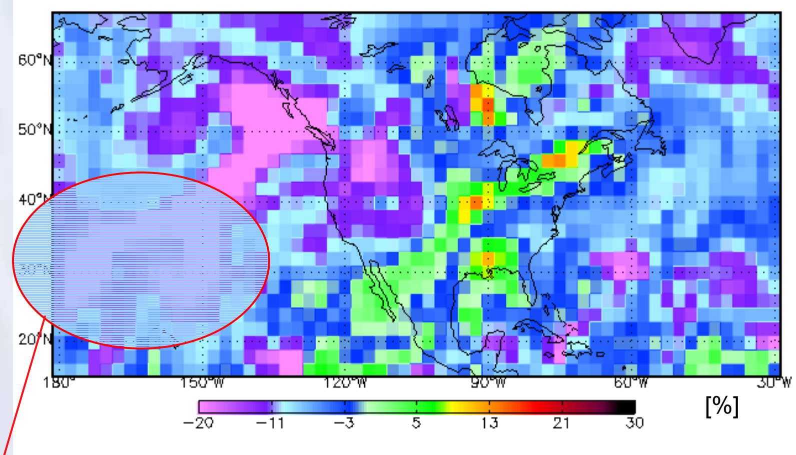
- The NO_x cycle in the troposphere implies that the balance of $NO:NO_2$ is sensitive to the ozone abundance.
- Assimilation of TES data significantly increases the ozone tracer field in the models.
- Increased ozone in the model will decrease the NO_x lifetime.

Impact of assimilation on NO_x chemistry

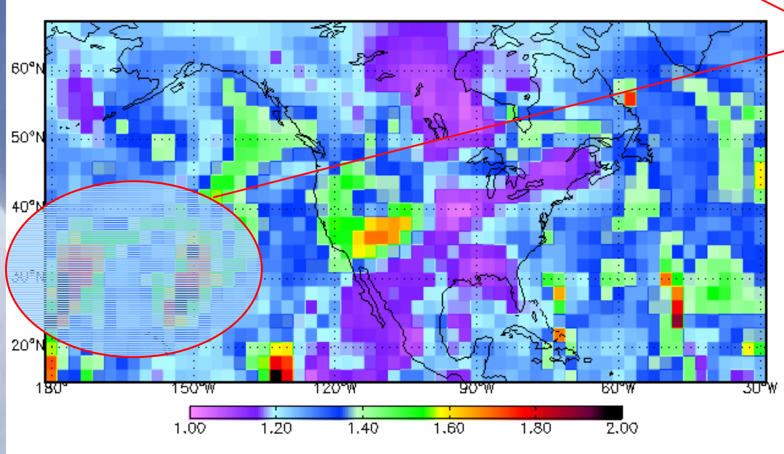
Percent change in AM2-Chem O_3



Percent change in AM2-Chem NO_x



$[NO:NO_2]_{noassim}/[NO:NO_2]_{assim}$



- Increases in ozone lead to a shift in the partitioning of $NO:NO_2$ and an increase in NO_2 reflected by high values in the ratio of $[NO:NO_2]_{noassim}/[NO:NO_2]_{assim}$
- NO_2 increase leads to a decrease in the lifetime of NO_x and subsequent decrease in NO_x abundance.

z = 5km, Time = 21:00 GMT

Conclusions and outlook

- Tropospheric ozone
  - The AM2-Chem and GEOS-Chem models show significant differences in tropospheric ozone abundances. Assimilation of TES data brings the ozone abundances closer together in both models.
  - Dynamical features (e.g. stratospheric intrusion) are better represented in the ozone distribution in both models.
- NO_x chemistry
  - Large changes in NO_x chemistry correspond to changes in the ozone distribution.
  - Assimilation of NO_x observations (OMI) will further constrain model chemistry.
  - Chemical data assimilation has the potential to provide a powerful tool for understanding the processes controlling chemistry in the troposphere.