Comparison of Aura-MLS CO measurements with global chemical models

Jonathan H. Jiang and Hui Su

Jet Propulsion Laboratory

California Institute of Technology, Pasadena, California

Bryan Duncan

Goddard Space Flight Center, Greenbelt, Maryland

Jack McConnell

York University, Toronto, Canada

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Daniel Jacob and Jennifer Logan

GEOS-CHEM group, Harvard University, Cambridge, MA

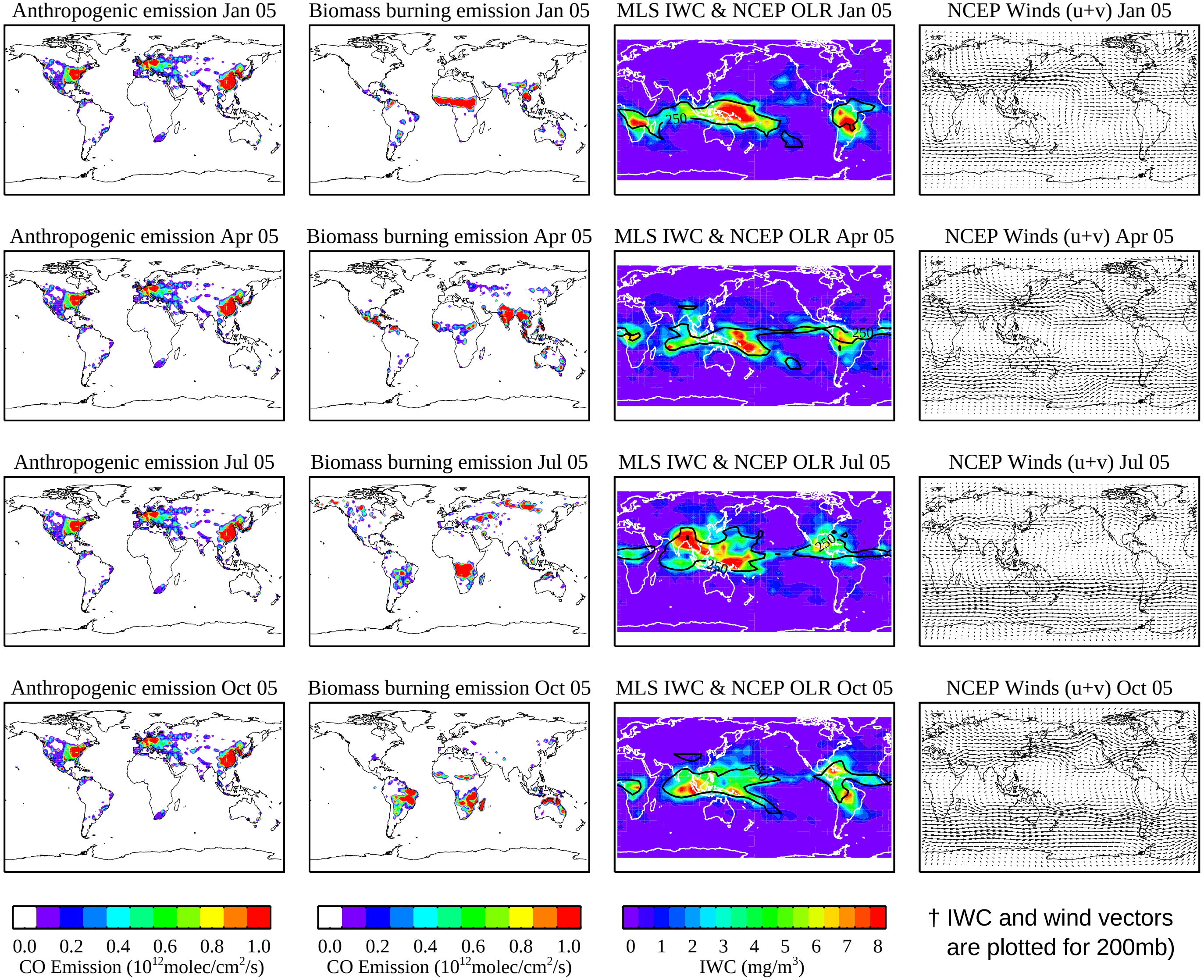
Objectives

- To use MLS measurements of carbon monoxide (CO) and other satellite observations to study the physical and dynamical processes that control the CO distribution in the upper troposphere

- To evaluate and cross-compare observations and models, to further understand their differences, assess and improve model parameterizations

Factors that control CO distribution in the upper-trop

Surface Emissions | Convection | Winds



Black-contour: OLR<240 (W/m^2)

† IWC and wind vectors are plotted for 200mb)

- **Surface Emission**

  Anthropogenic: Has little seasonal variation; located in population centers.
  Bio-mass burning: has strong seasonal variation and yearly dependence.

- **Convection**

  Deep-convection is the major mechanism that injects the surface CO missions into the upper-troposphere.

  Deep-convection also has a strong seasonal variations.

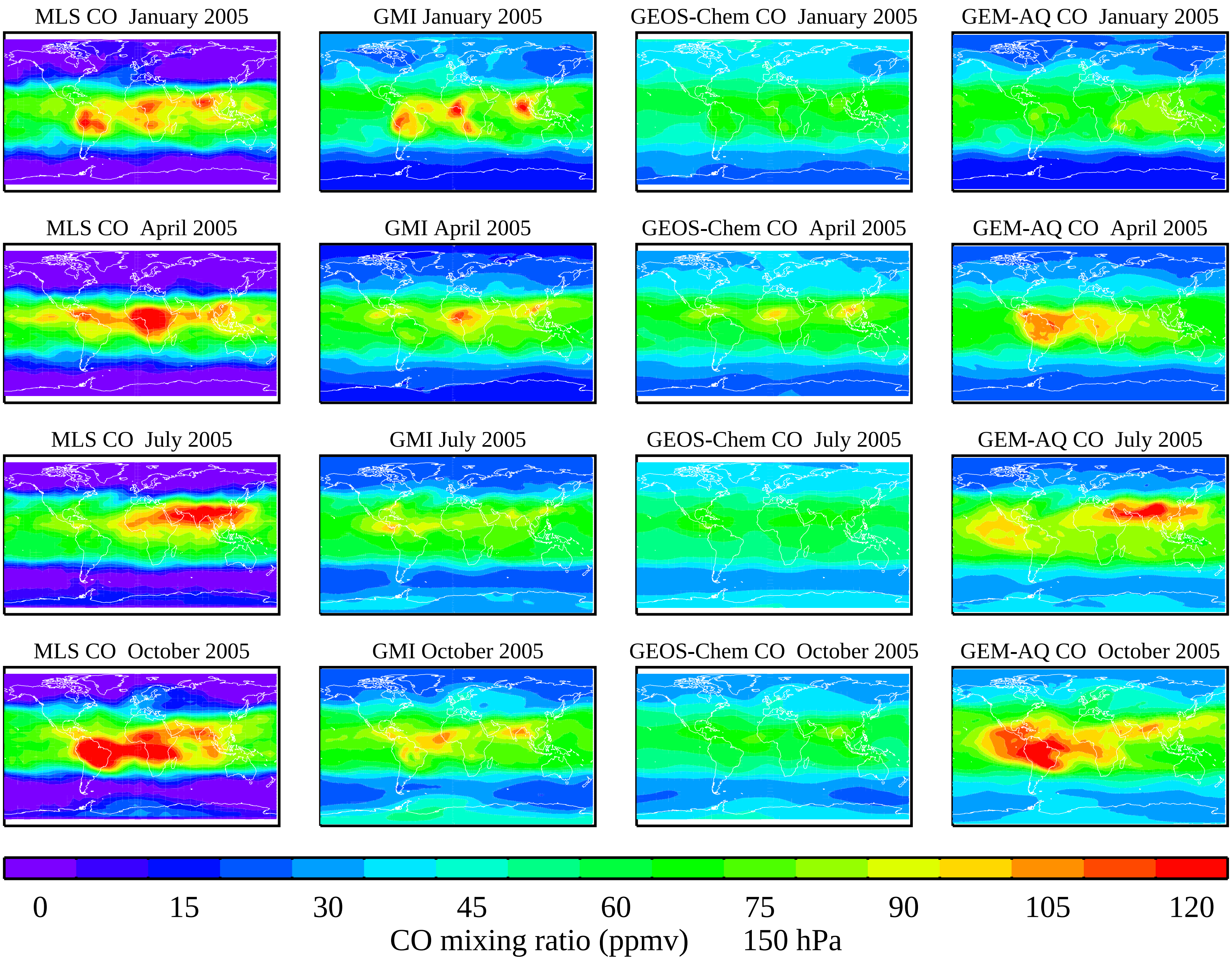
- **Winds**

  Once deposited into to the upper troposphere, CO is also influenced ed by winds: e.g. mid-latitude westerlies, upper level anti-cyclones.

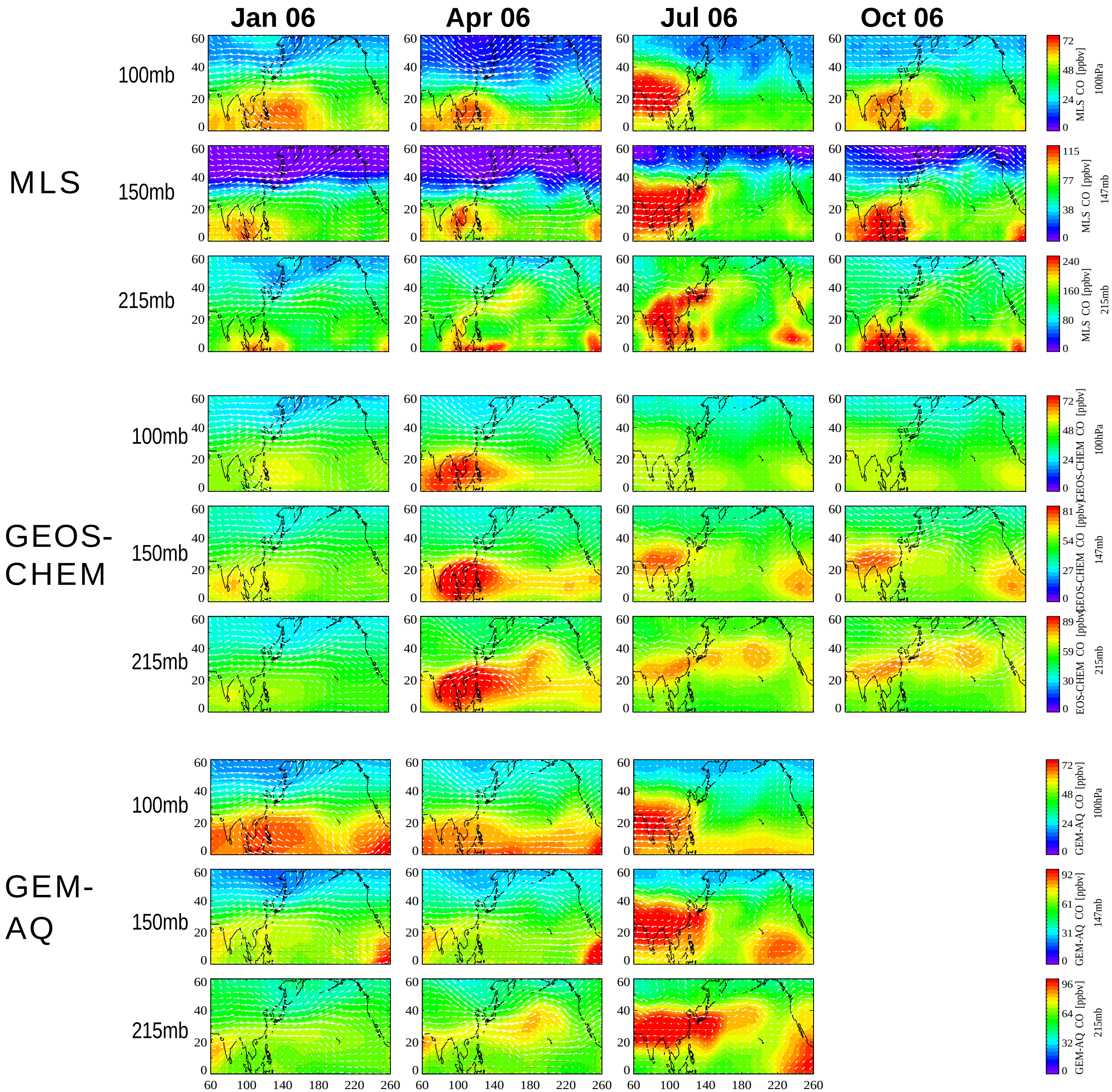
- **Other Factors**

  Chemistry

Seasonal variation of CO in the upper-trop (150mb)



MLS compares with GEOS-CHEM and GEM-AQ



- **Significant differences exist between the two models. For example, both MLS and GEM-AQ show maximum CO loading over SE Asia in summertime, while the GEOS-CHEM produces the maximum CO in spring over maritime continent.**

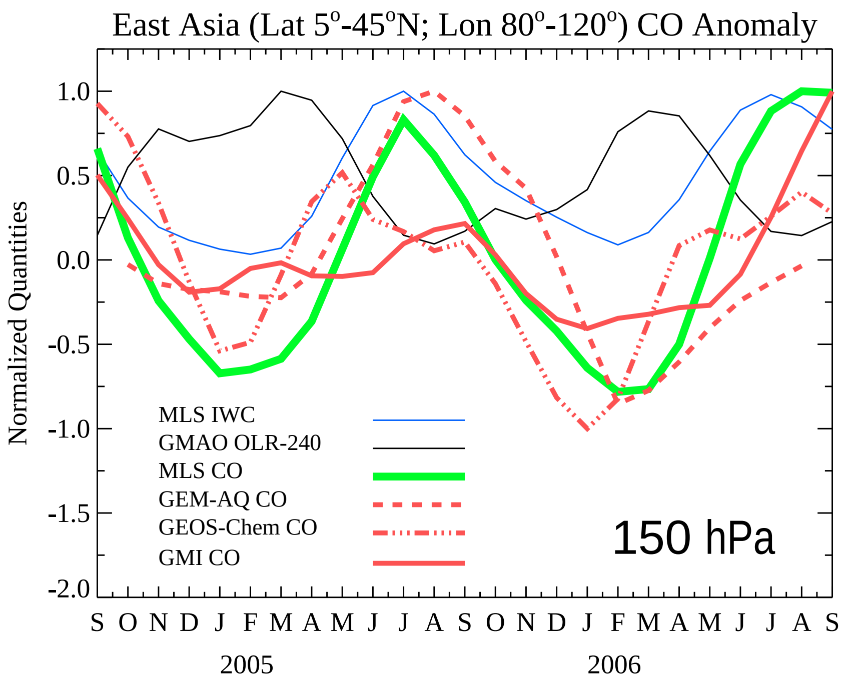
GEOS-CHEM:

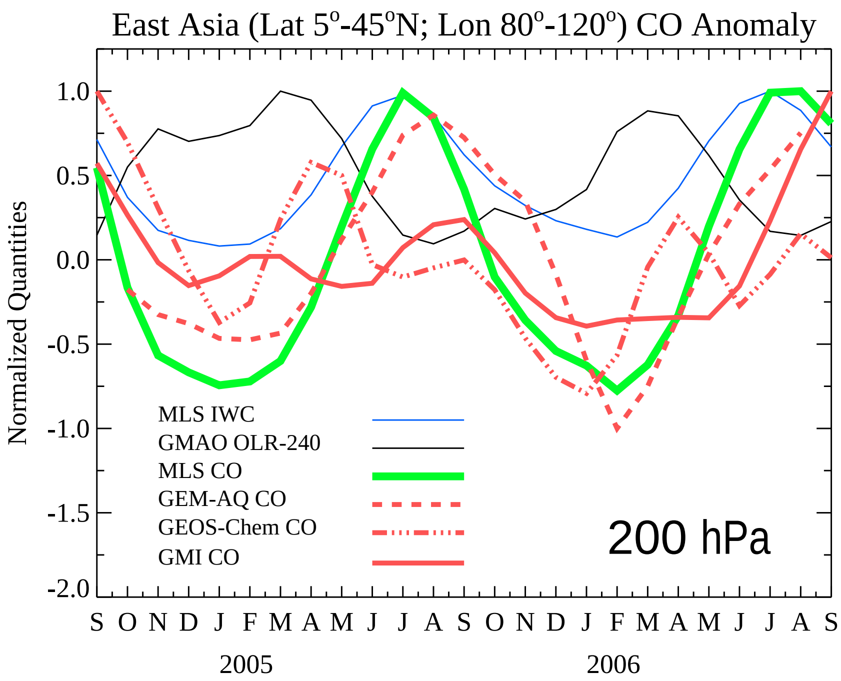
Dynamics: GEOS4 assimilated meteorological data;

GEM-AQ:

Dynamics: CCC GEM analysis [Cote et al. 1998]
Convection: Bulk scheme [Zhang & McFarlane 1997]
Chemistry: [Gauthier et al. 1999], developed at York U.

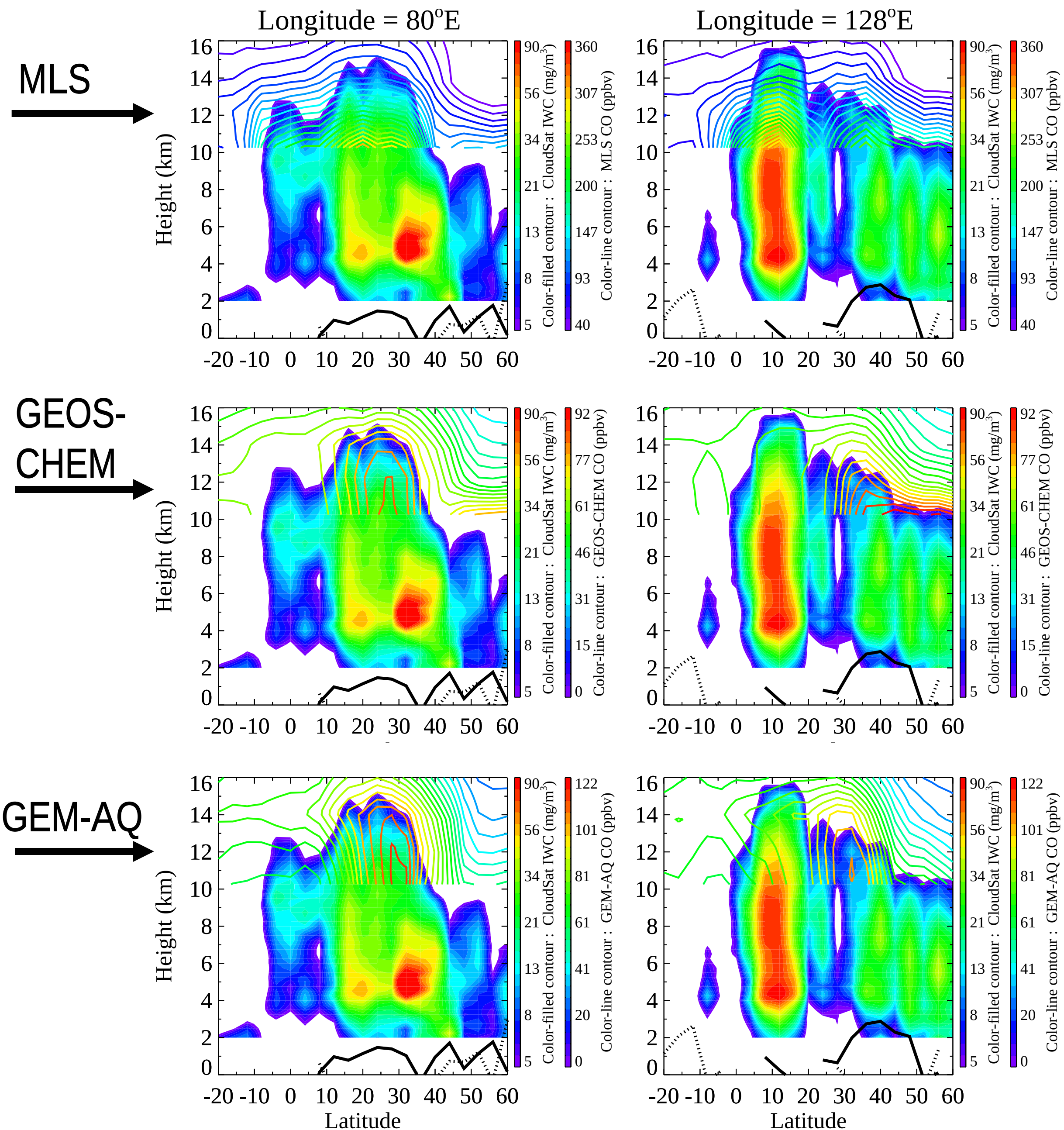
Time series of observed and modeled CO in East Asia





- Observed upper tropospheric (UT) CO variations over in East Asia are generally in-phase with convection, with peaks in summer (JJA).
- GMI and GEOS-CHEM simulated UT CO have weaker seasonal cycle than observed, especially over summer – modeled CO is lower than MLS CO. GEM-AQ has similar amplitude to MLS.
- GMI CO peaks in September, later than MLS. GEOS-CHEM CO has peaks in late spring, earlier than MLS. GEM-AQ has similar phase to MLS.

Do the models capture the convection correctly?



- CloudSat provides information on how the surface emitted CO is deposited into upper troposphere. The strength of convection may be measured by the total amount of CloudSat observed cloud water condensates in an air column.
- The figures show the Aura MLS observed, GEOS-CHEM and GEM-AQ simulated upper-trop CO loading (line-contours) and the CloudSat measured cloud water contents in the troposphere (color-filled contours) at 2 latitude versus height cross-sections.
- At 80°E, both models show high CO roughly correlated with the convection. At 128°E, however, both models fail to capture the deep-convection at 10°N latitude.
- CloudSat and MLS data could be used to improve convective parameterization in the models.

(Plots are 8 Jul - 14 Aug 2006 averages.)

Summary

- Aura MLS observations provides important information of the upper tropospheric CO distributions and transport.

- Comparison of the MLS observed CO against 3 chemistry models (GMI, GEOS-CHEM and GEM-AQ) found:
  - ♦ The data and models exhibit the same general morphology in high upper tropospheric CO loading near the tropics;
  - ♦ However, there are considerable differences between the MLS observation and models.

- There are also significant differences among the three models.
  - ♦ These differences, which need further study, may be due to:
    - Convection in three models may not be adequately represent the real atmosphere.
    - Differences in assimilated/analysis meteorological data used by the models.
    - Difference in treatment of chemistry?

Future Work

- Identify the relative contributions of emission source (I), dynamics (II) and chemistry (III) to model-data differences
- Analyze I and II and then obtain the chemistry contribution by subtracting I and II from total model-data differences
- Provide insights for model improvements
- Variables to be examined: emission inventory, convective mass flux (and CloudSat IWC/LWC), horizontal winds, etc