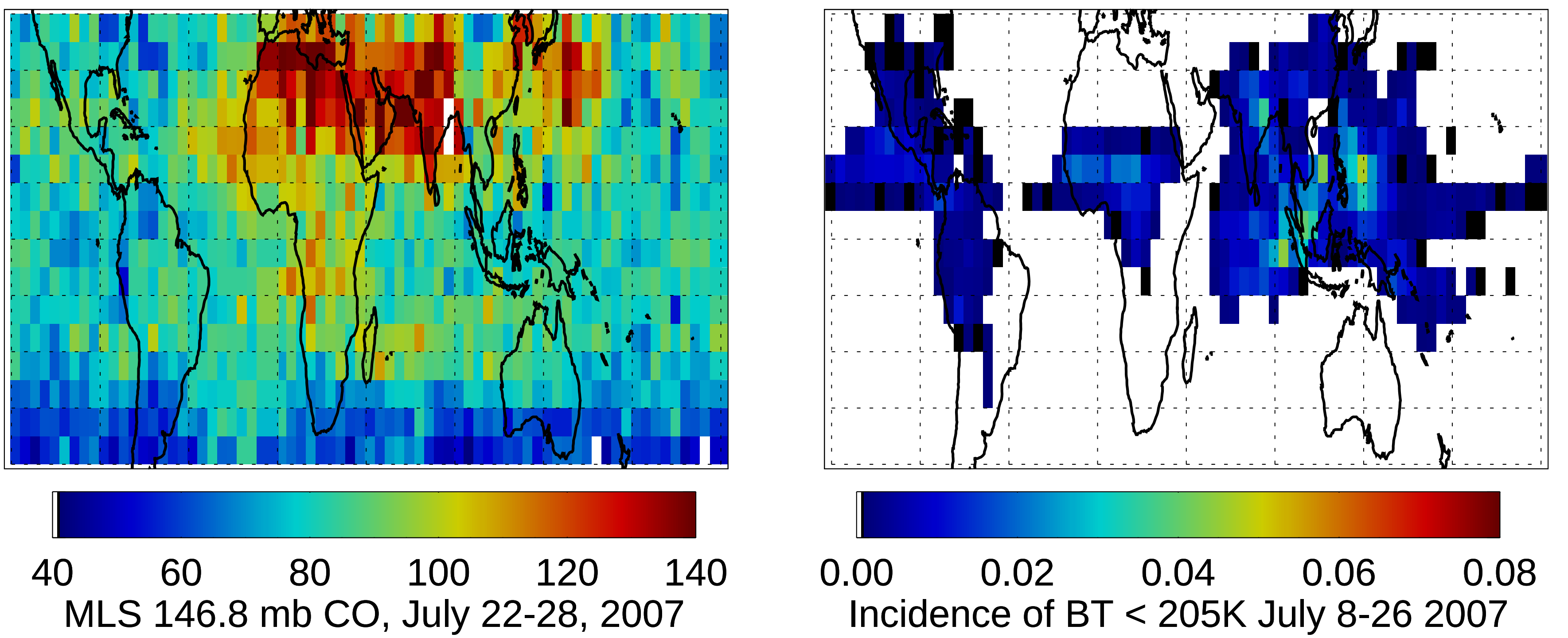
The Effect of Convection on the Composition of the Tropics at 150mb as observed by MLS

Leonhard Pfister, NASA Ames Research Center

- Upper tropospheric ozone and water are important greenhouse gases and are strongly affected by convection
- 150mb is the bottom of the TTL and drives the stratospheric entry value of many gases (NOT water)
- Recent work (Jiang et al) shows relationship of 150mb CO to convection on a bulk statistical basis
- Models do poorly in realizing convection, especially in the tropics
- Can we explain water and CO at 150mb with trajectories and **really** simplified yet accurate convection?

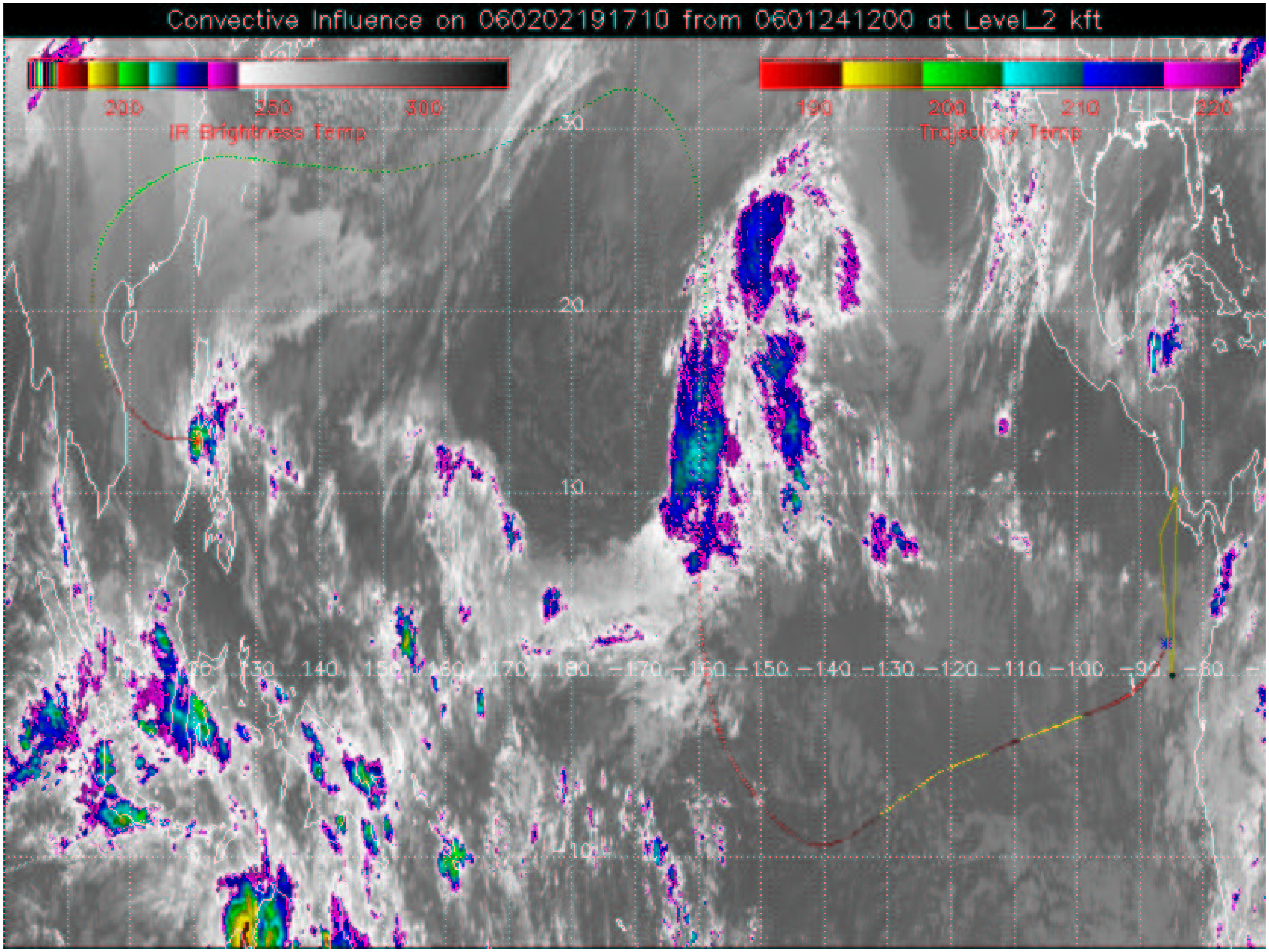
CO at 146.8mb and incidence of convection reaching 146.78mb, July 22-28, 2007.



Model Formulation

- Perform 14 day back trajectories from a cluster of points (15) surrounding each tropical (-35 to 35 degrees) 150 mb MLS observation for 5 days (July 23-27, 2007) – about 110000 trajectories.
- Both adiabatic trajectories and diabatic trajectories (based on clear sky heating rates).
- Run trajectories through 3-hourly global meteorological IR window channel satellite imagery.
- Establish when and where each trajectory intersects convection (as determined by comparing trajectory altitude to cloud altitude). Some trajectories never intersect convection.

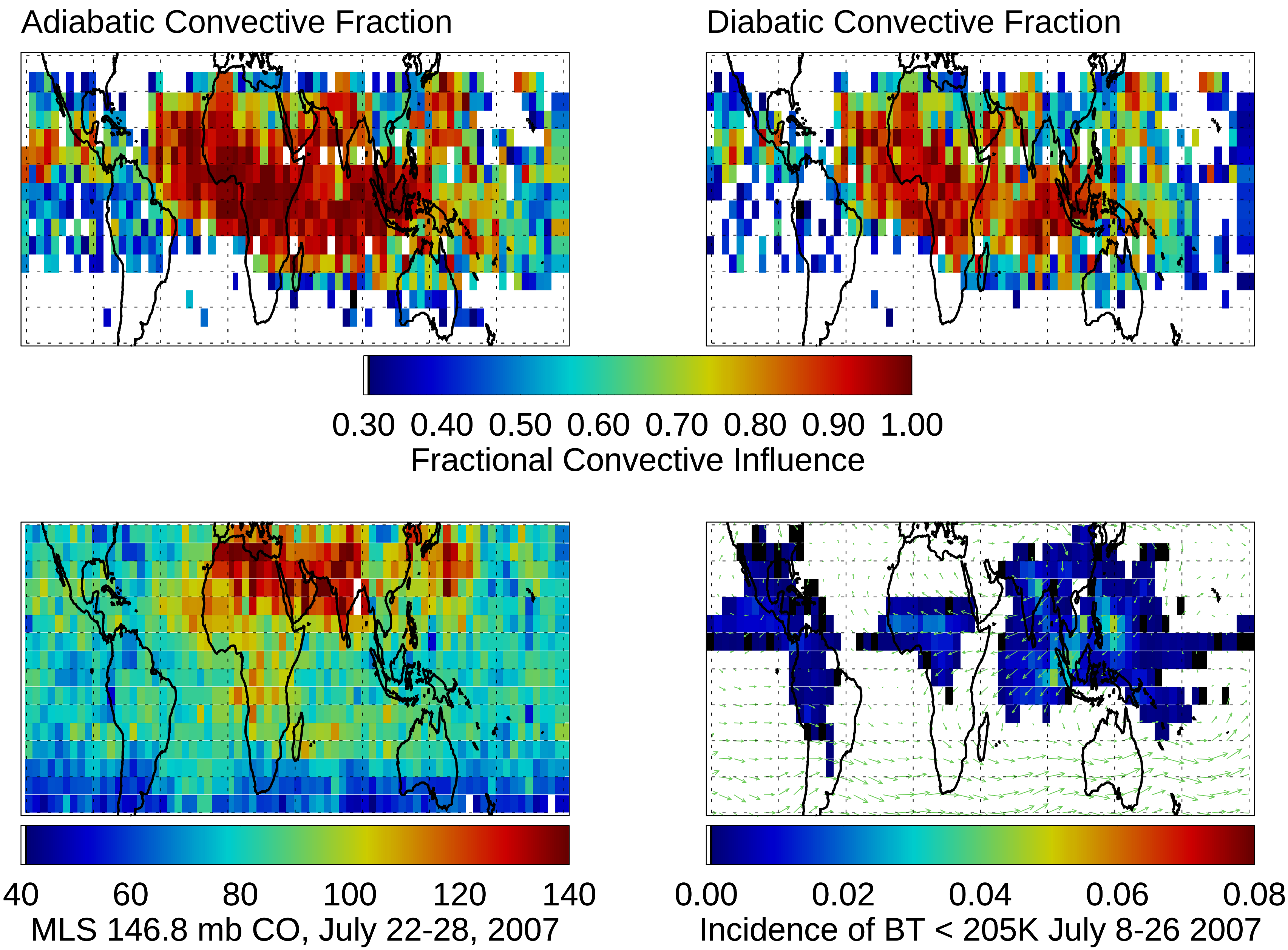
Convective influence on an air parcel



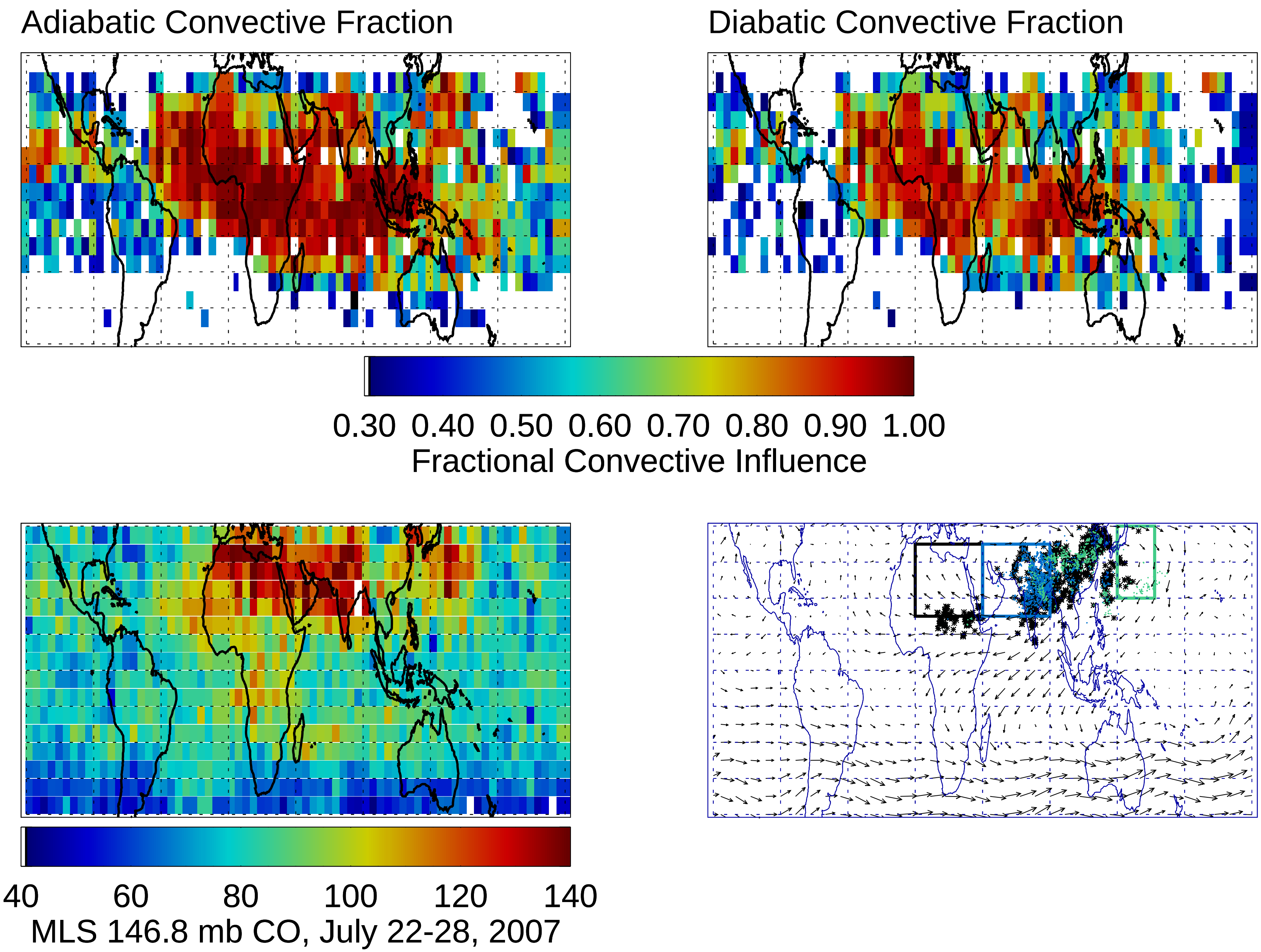
Model Formulation (continued)

- Calculate Convective Fraction (fraction of [15] cluster points that are convectively influenced)
- Can clearly establish the location of convection affecting certain MLS points.
- Calculate CO by convolving surface CO (based on emissions) at location of convection with fractional convective influence and mixing with ”clean” background.
- Calculate water based on the minimum ice saturation mixing ratio (ISMR) since the most recent convection. Use NCEP for initial water (and minimum ISMR) for parcels with no convection.

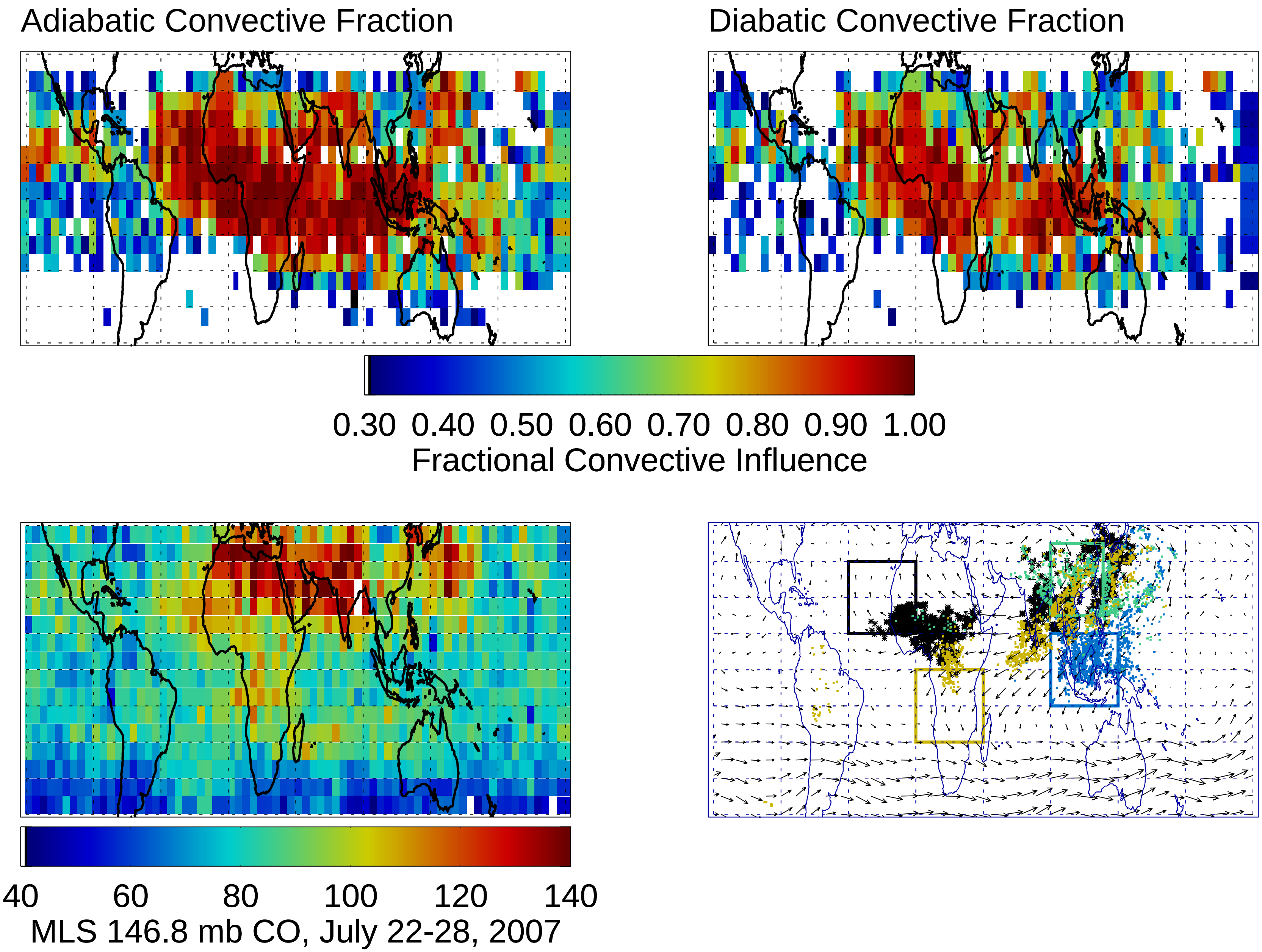
Convective Fraction, CO, and Convection



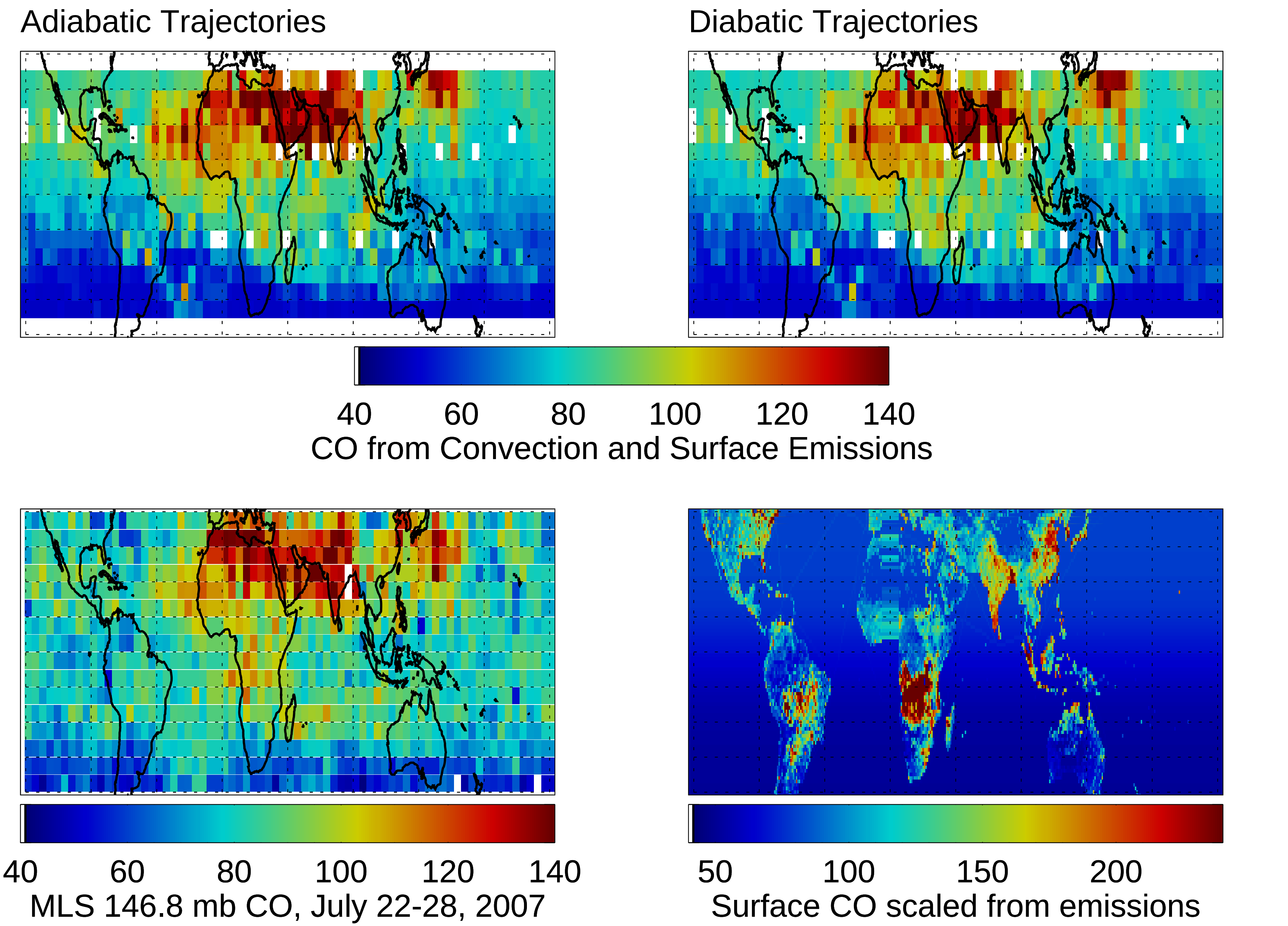
Location of convection for High CO regions



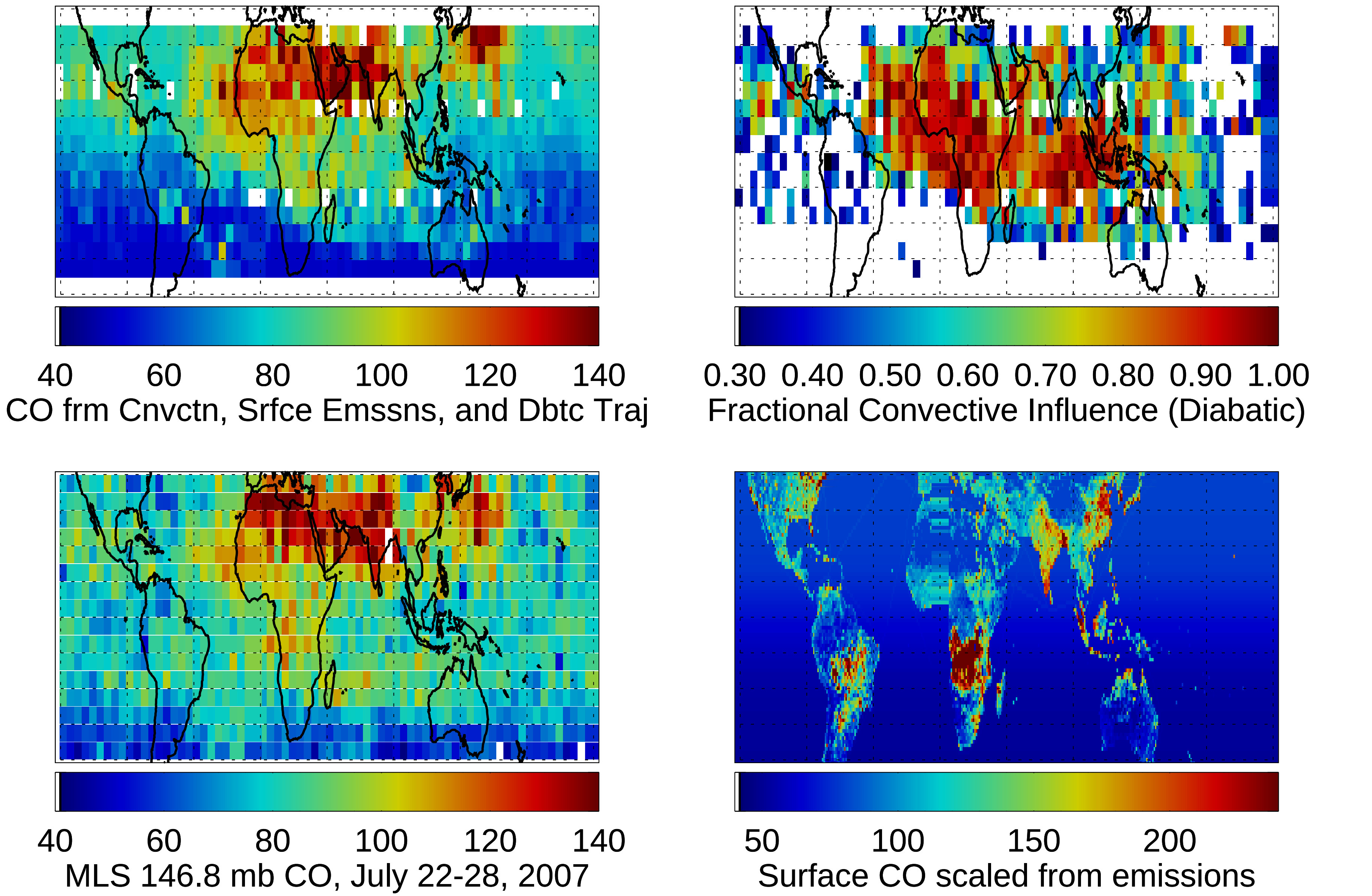
Location of convection for Lower CO regions



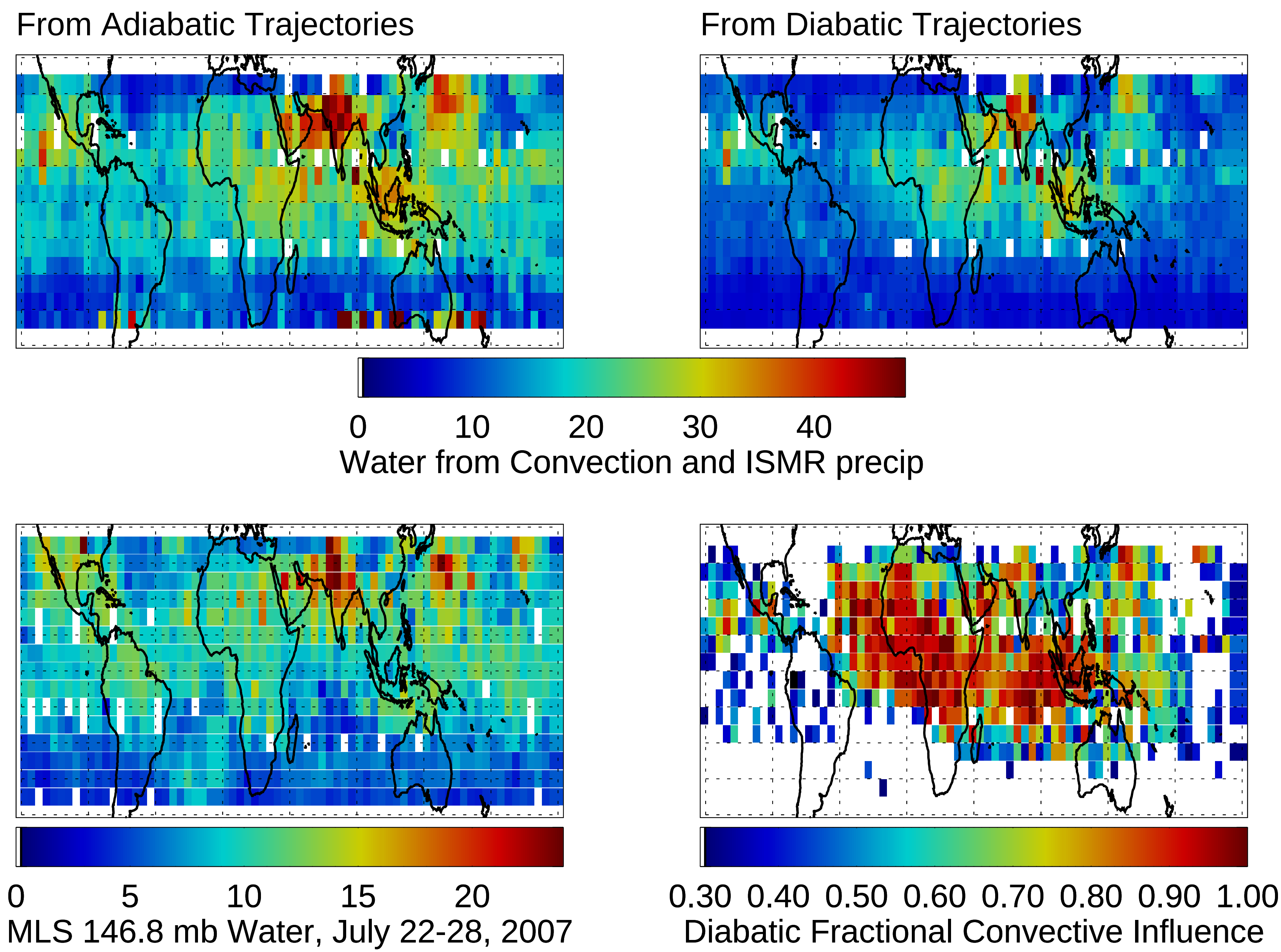
Convolved CO using Diabatic and Adiabatic Trajectories



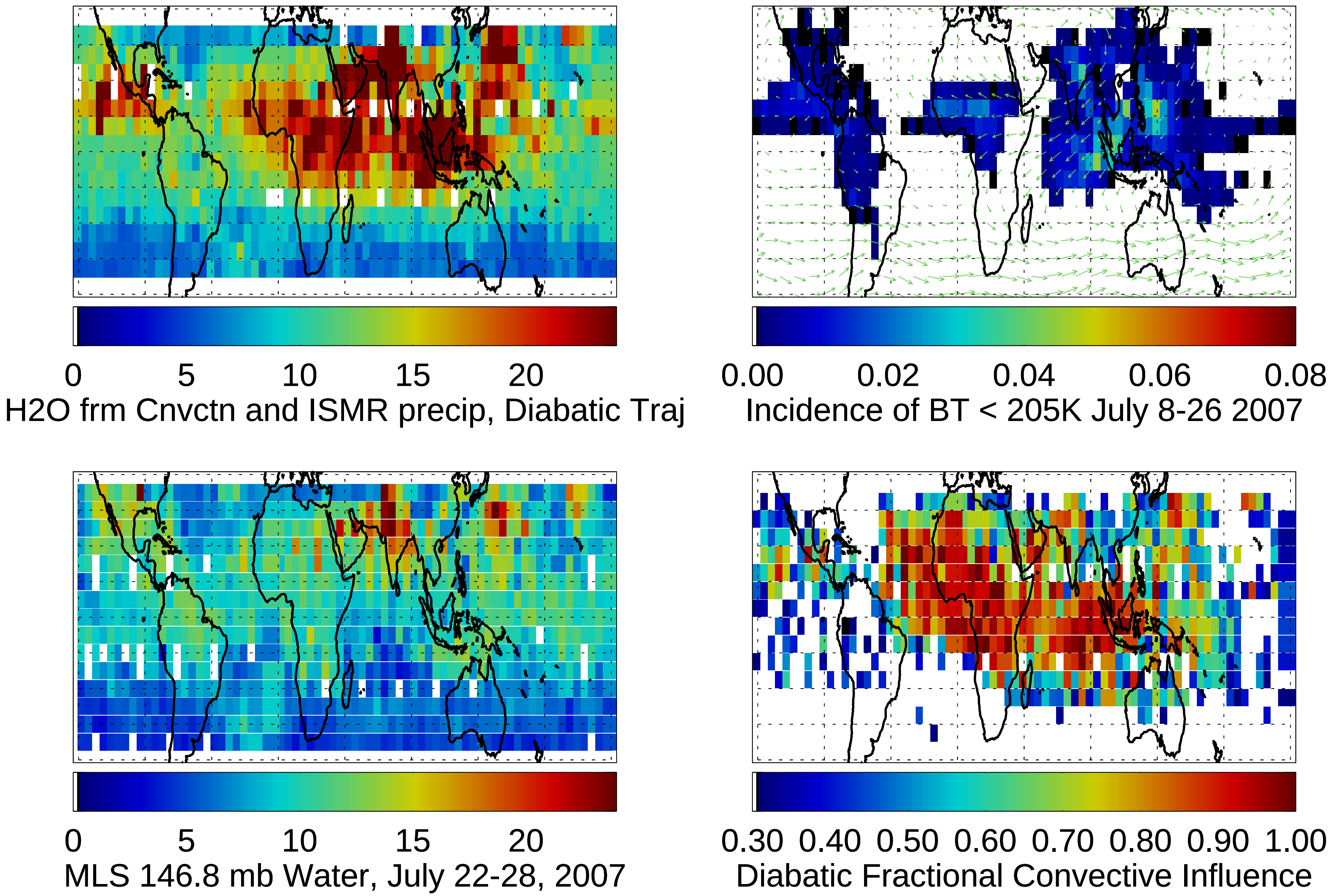
Convolved CO using Diabatic Trajectories with Convective Fraction



Convolved Water using Adiabatic and Diabatic Trajectories



Convolved Water using Diabatic Trajectories



Conclusions(1)

- Have used satellite imagery and trajectories to calculate CO and H2O at 150mb
- Satellite imagery is probably the most accurate information we have on globally locating convection on the appropriate time scale and getting the altitude right
- CO simulation is quite successful – this does not depend on using adiabatic or diabatic trajectories.
- Note that we are scaling the surface convective input by the log of emissions, so the success is in the pattern and not the quantity.
- At least during this period, the biomass burning peak in Africa does not appear to be driving the bulk of the CO at 150mb.

Conclusions(2)

- Water is not as well simulated, but we learn something
- Simulation too wet, indicating that the back trajectories are not going high enough (thus not squeezing out enough water). A more careful formulation of the diabatic heating is called for.
- Encounter with convection may not mean full replacement of air mass or full saturation.
- Thickness of outflow layer may need to be specified – some clouds may detrain above 150mb and not affect this layer as much.
- Future work to use MLS water and CO to improve the parameterization, thus improving understanding of how convection impacts the Upper Tropical Troposphere.