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GESTAR

Coupling CASA CO_2 with NASA Unified WRF (NU-WRF)

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Motivation

✗ The magnitude, location, and mechanism of CO_2 terrestrial biosphere sinks are not well characterized and remain among the leading sources of uncertainty in carbon-climate interactions.

✗ Global model is difficult to resolve key processes controlling CO_2 fluxes, e.g., photosynthesis, respiration, and boundary layer transport.

✗ This on-going effort will integrate the observation-constrained CASA CO_2 vegetation flux model into the NU-WRF framework to study CO_2 spatial-temporal distribution at higher resolution (1~10 km) to:

- ✓ better understand mechanisms controlling CO_2 fluxes and local mixing ratio variability – e.g., convection, boundary layers, and frontal interaction
- ✓ Improve processes that control sources and sinks of carbon in the terrestrial biosphere in the model

Model Development

Built on WRF, NU-WRF integrates the new Goddard cloud microphysics scheme, Goddard radiative transfer processes (and explicit interaction between cloud and radiation), Goddard Land Information System, Goddard Satellite Data Simulator Unit, and GOCART.

CASA-GFED treats carbon uptake by photosynthesis and carbon release through respiration and fires. CASA-GFED conserves carbon mass balance and is highly constrained by the satellite observed vegetation cover and activities. CASA-GFED carbon fluxes are applied to both NU-WRF and global carbon transport model PCTM.

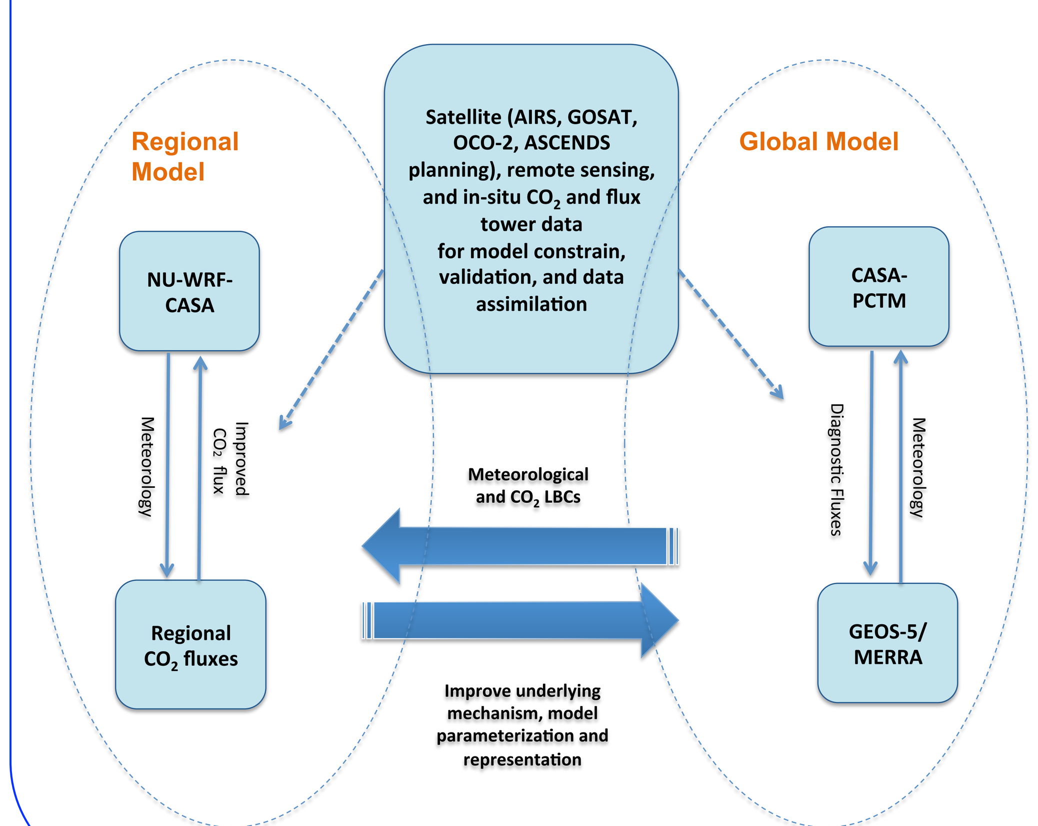

Figure 1. Coupled NU-WRF-CASA modeling system is expected to resolve small scale CO_2 sources and sinks, reduce transport uncertainties, and contribute to improving global CO_2 modeling.

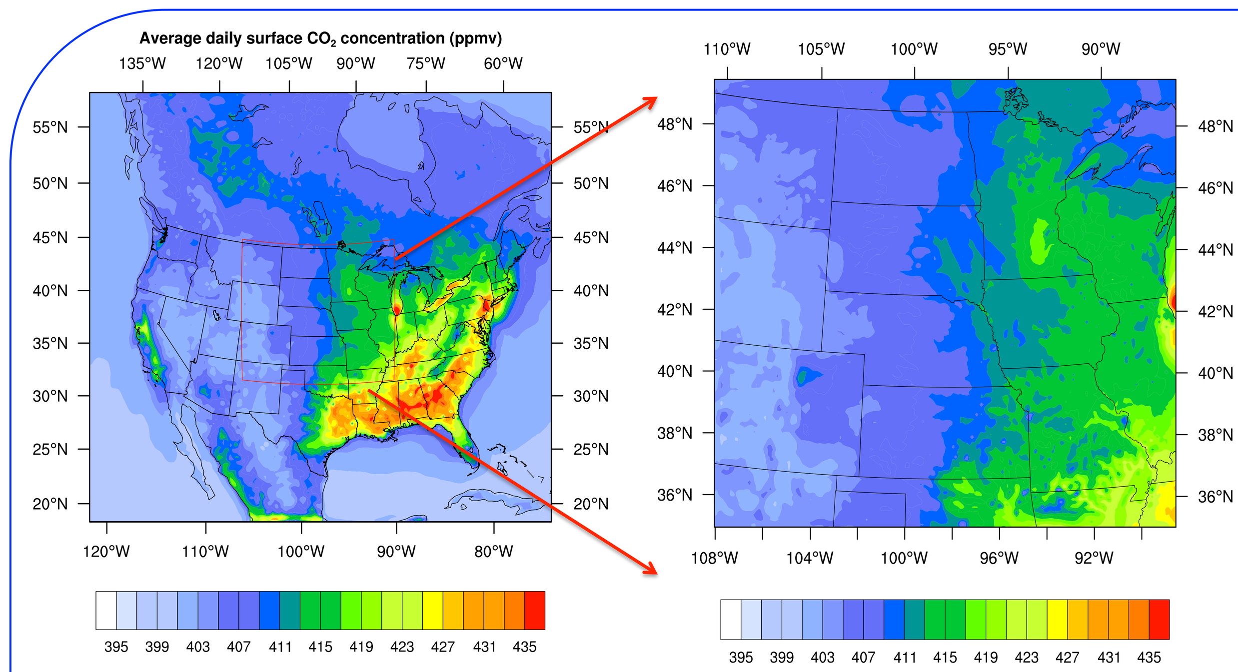

Figure 2. Monthly (3/22/2010~4/20/2010) average CO_2 concentration at surface: 27 km grid (left) and the nested 9 km grid (right). CASA-GFED provides CO_2 net fluxes and PCTM provides initial and boundary conditions (IC/BC). NU-WRF system works properly to project global IC/BC and fluxes to regional model speciation. Fine resolution simulation shows more detailed features.

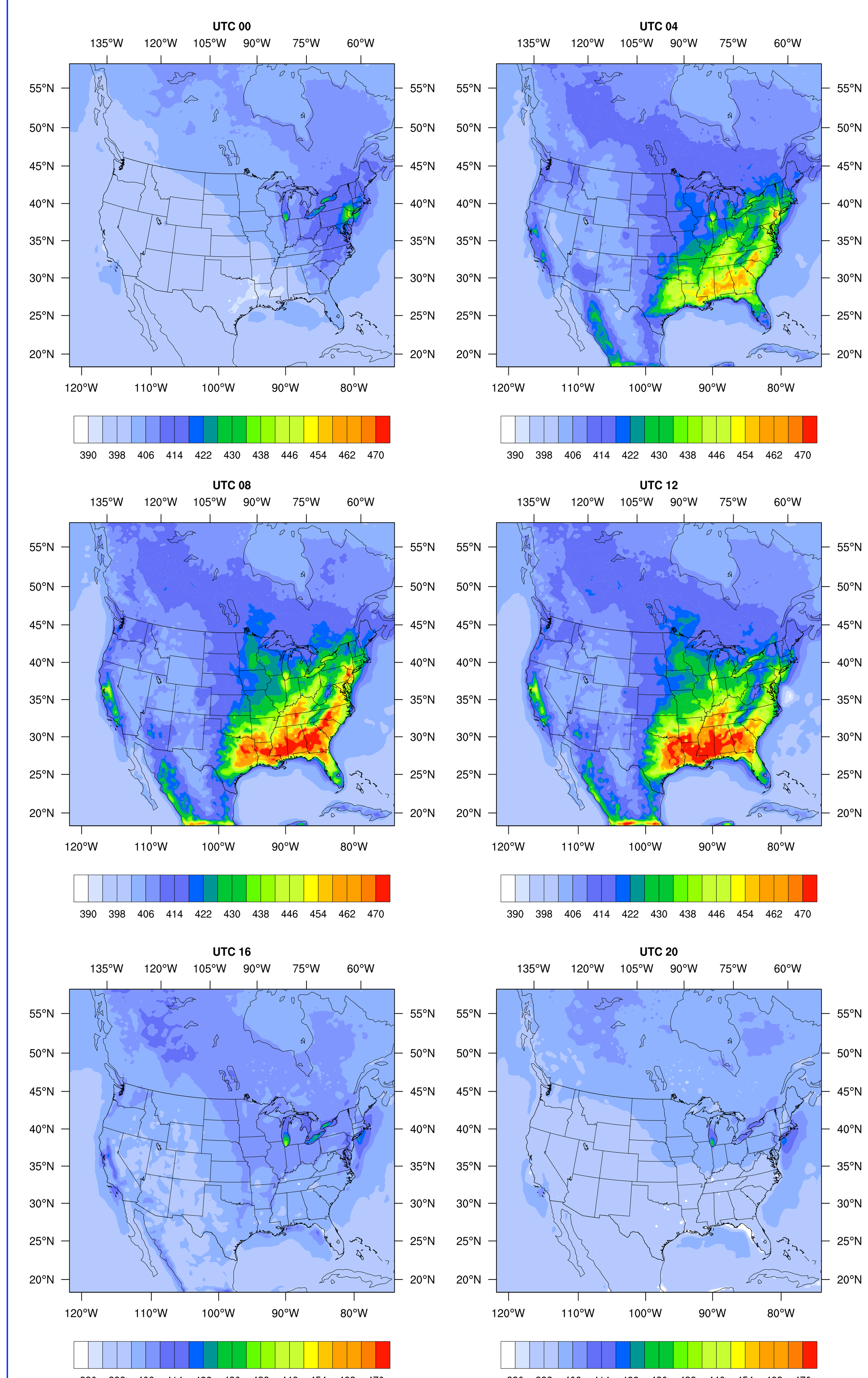

Figure 3. Monthly average diurnal cycle of CO_2 concentrations at surface. Strong diurnal variation over the southeast US, where plant vegetation dominates the landscape, is the result of the cycle of plant photosynthesis/respiration and mixing processes. Over urban and developed land areas, mixing processes largely determines the diurnal cycle of surface CO_2 concentrations.

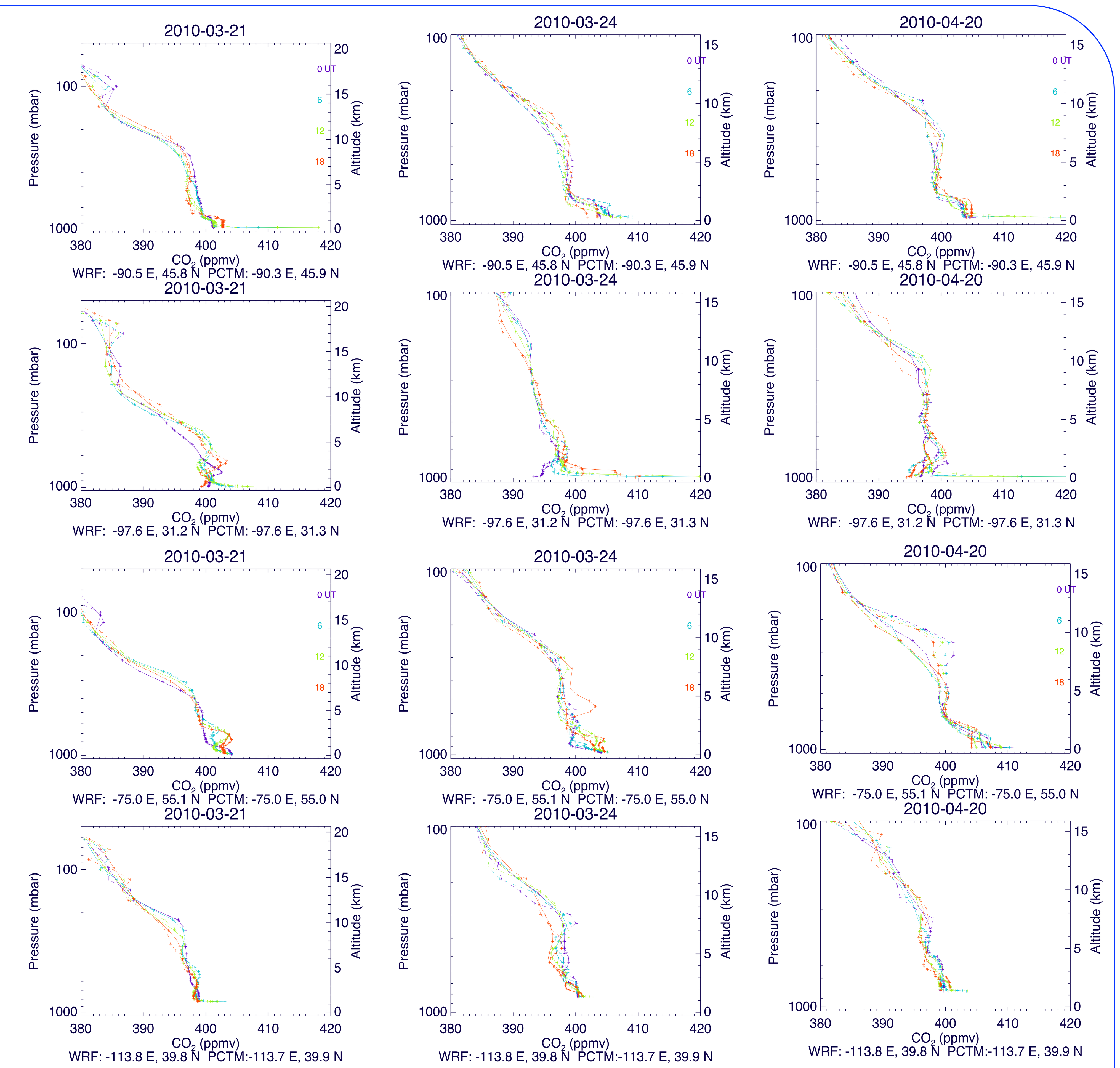

Figure 4. Comparisons of NU-WRF (solid line) vs. PCTM (dashed line) CO_2 over time and altitude for 4 selected locations. Color indicates UTC hour of each day. At the initial time (0 UTC of 3/21/2010), NU-WRF and PCTM results match each other well indicating a proper projection and interpretation of the global results to NU-WRF speciation. With time moving on, noticeable differences between models (up to 5 ppmv in some cases) are observed, likely because of the treatment of boundary layer transport and horizontal/vertical resolution.

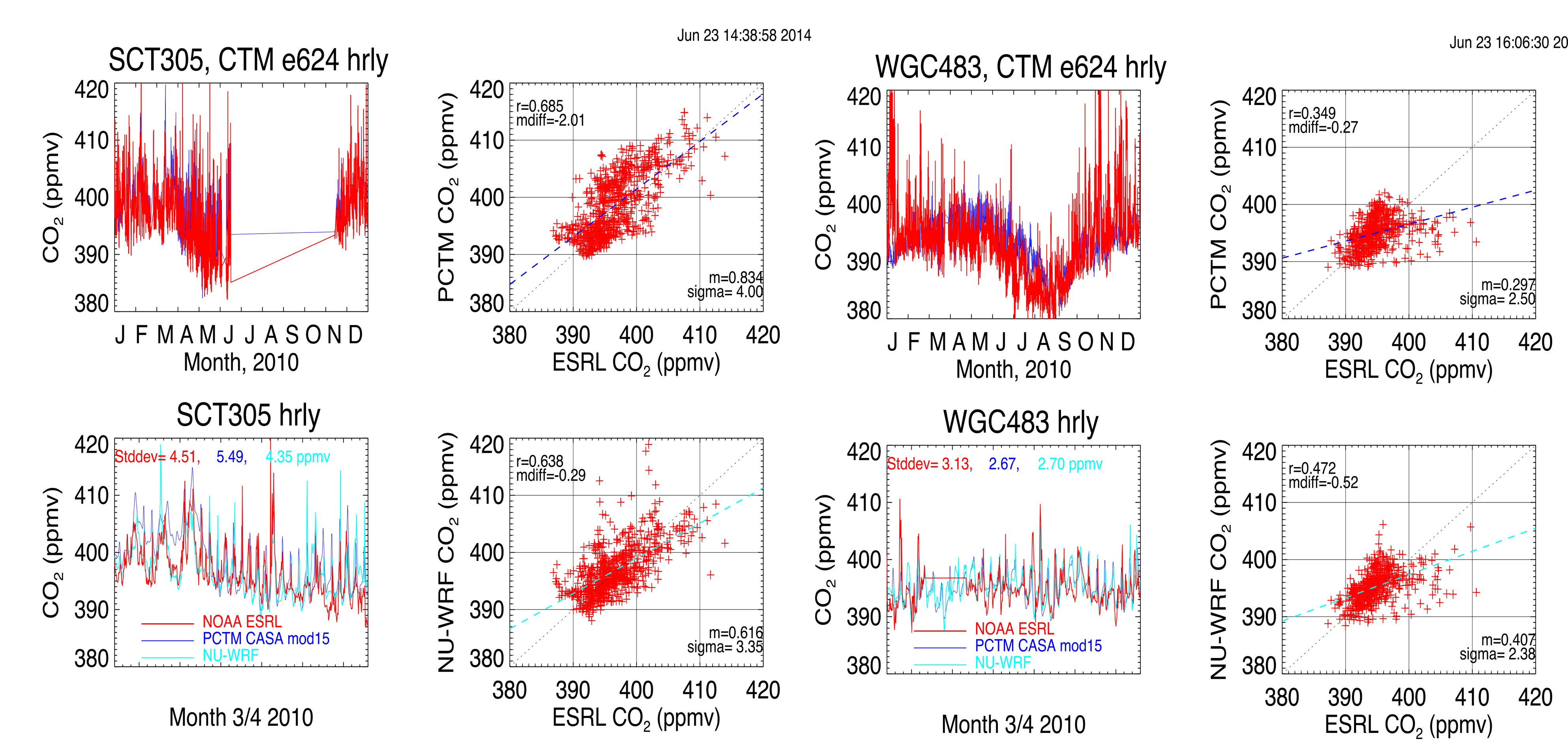

Figure 5. Comparisons of NU-WRF/PCTM CO_2 concentrations vs. ESRL observations at SCT (South Carolina) and WGC (California) sites. NU-WRF generally catches diurnal carbon cycles well. Statistically NU-WRF performs as well as PCTM but its standard deviations more closely follow those of the respective observations.

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