The Role of the WRF-Chem Mesoscale Model

The goal here is to make use of the PSU WRF-Chem version of the Weather Research and Forecasting model (Skamarock et al., 2005; Lauvaux et al., 2012) to quantify errors due to atmospheric transport in the CMS-Flux 4D-Var inversion system products. We transport surface fluxes from CMS-Flux (optimized biosphere fluxes plus surface fluxes for ocean, biomass burning, fossil fuel, biofuel and ship bunker fuel emissions (see Liu et al., 2014; Nasser et al., 2010; Nasser et al., 2011)). Boundary conditions are the CMS-Flux posterior CO2 fields. Ultimately, we will produce an ensemble of WRF simulations over North America using different model physics, comparing the atmospheric output to CO2 and meteorological observations. Shown here are preliminary results from an initial run of WRF-Chem at 30 km resolution for 2010.

As part of the initial testing of this experimental setup, we created simulated XCO2 observations (pseudo-satellite observations) at the locations of the ACOS-GOSAT v3.3 samples for 2010 (O’Dell et al., 2012; Crisp et al., 2012; Wunch et al., 2011), applying the ACOS averaging kernel for each sample to the WRF column CO2 at each sample location.

Figure 2: North American domain for WRF simulations. Also shown are locations of ACOS v3.3 GOSAT xCO2 samples for June 2010 within the WRF domain.

Using WRF XCO2 in CMS-Flux Inversions

Two 4D-Var inversions with the GEOS-Chem (4° x 5°) adjoint model for 2010 using the pseudo-satellite observations: 1) assimilate only the WRF XCO2 simulated for North America and 2) assimilate the WRF XCO2 for North America and GEOS-Chem XCO2 for the rest of the world. Prior fluxes are the same as the true fluxes used to generate the pseudo-observations in this OSSE.

Figure 6: Note that the WRF XCO2 observations are biased high relative to the GEOS-Chem XCO2 simulations.

Next Steps

- Refine the WRF-Chem model setup.
- Create ensemble of WRF simulations for 2010 using ‘best’ parameterizations (see work of Diaz Isaac).
- Compare simulated XCO2 and CO2 to TCCON, aircraft, and surface observations.
- Compare both WRF and GEOS-Chem meteorology to observations.
- Quantify uncertainty estimates due to transport for North America based on ensemble results.
- Contribute these uncertainty estimates to the development of CMS-Flux products.

References


Lauvaux et al., 2012. Constraining the CO2 budget of the corn belt: exploring uncertainties from the assumptions in a mesoscale inverse system. ACP, 12, 337-354, doi:10.5194/acp-12-337-2012


Nasser et al., 2010. Modeling global atmospheric CO2 with improved emission inventories and CO2 production from the oxidation of other carbon species, GMD, 3, 889-816, doi:10.5194/gmd-3-889-2010

Nasser et al., 2011. Inverse modeling of CO2 sources and sinks using satellite observations of CO2 from TES and surface flask measurements, ACP, 11, 6029-6047, doi:10.5194/acp-11-6029-2011


Skamarock et al., 2005, NCAR Technical Document

Wunch et al., 2011. A method for evaluating bias in global measurements of CO2 total columns from space, ACP, 11, 12317-12337. doi:10.5194/acp-11-12317-2011

The ACOS v3.3 data were produced by the ACOS/COSCATO-2 project at the Jet Propulsion Laboratory, California Institute of Technology from GOSAT column CO2 spectra.