Improving air quality modeling on process level via better representing the land surface states

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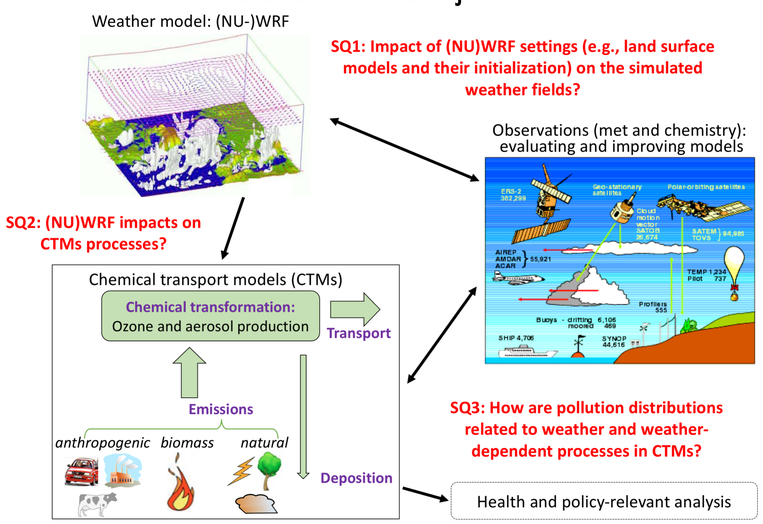
1. Introduction and Objectives

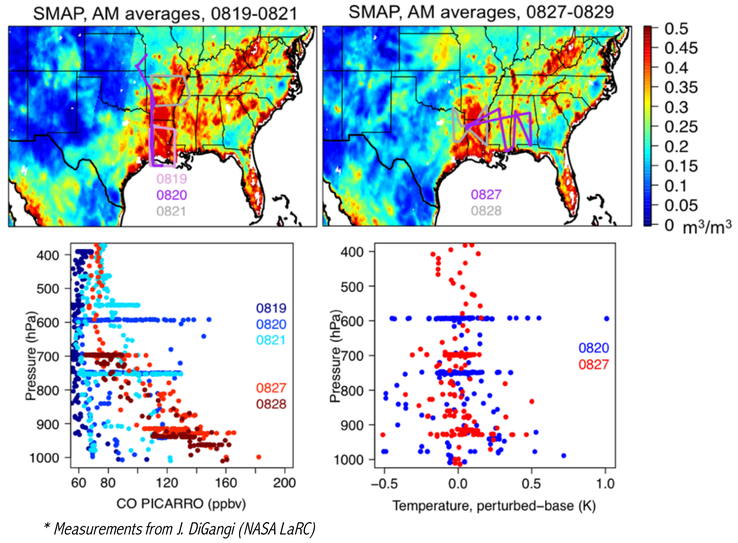


Chemical transport models (CTMs) simulate and attribute air pollution in support of policy decisions. They focus on the chemical cycle of the pollutants, including emissions from anthropogenic and natural sources, chemical transformation, transport and deposition.

CTMs are driven by meteorological models. How well the CTMs represent the atmospheric processes that control the pollution distributions highly depend on the quality of the used meteorological inputs.

We explore how chemical transport modeling can be improved on process level (in this poster, pollution transport and biogenic emissions driven by the WRF model) by alternating the representation of land surface (soil and vegetation) states.

2. Day-by-day variability of carbon monoxide (CO) and SMAP soil moisture under different weather conditions during the ACT-America campaign



** Measurements from J. DiGangi (NASA LaRC)*

(Upper) Morning time surface soil moisture from SMAP during convective (August 19-21, 2016) and fair weather (August 27-29, 2016) conditions over the southeastern US. Flight paths during ACT-America were overlaid.

(Lower left) Day-by-day observed CO vertical profiles along the ACT-America flight paths.

(Lower right) Air temperature differences between the WRF perturbation and base simulations along the flight paths. In the perturbation run, WRF initial soil moisture was reduced by a constant value of 0.01 m^3/m^3 in all soil layers.

During the convective period, SMAP indicates wetter soil conditions, and elevated CO concentrations were observed above the boundary layer. Under fair weather conditions, SMAP indicates drier soil conditions, and CO shows distinct decreasing vertical gradient with altitude. Larger temperature responses to a same amount of the soil moisture perturbation are shown under convective conditions within and above the boundary layer than on fair weather days. Such results suggest possibilities of using SMAP data to adjust the model initial soil moisture fields and therefore to improve the simulations of atmospheric moisture/pollution transport on regional/hemispheric scales. This would be an extended work from our recent contribution to Task Force on Hemispheric Transport of Air Pollution.

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Research article 08 May 2017

Impact of intercontinental pollution transport on North American ozone air pollution: an HTAP phase 2 multi-model study

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3. Biogenic isoprene emissions driven by WRF simulations using different land initialization methods during the SEAC⁴RS campaign

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Model evaluation paper

Linkages between land initialization of the NASA-Unified WRF v7 and biogenic isoprene emission estimates during the SEAC⁴RS and DISCOVER-AQ airborne campaigns (revised)

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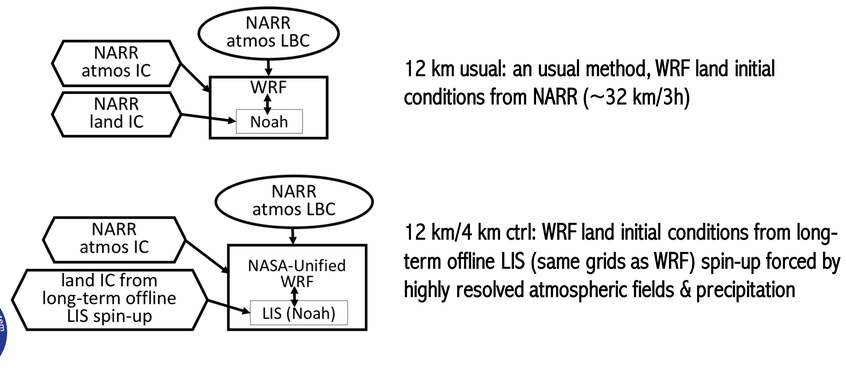
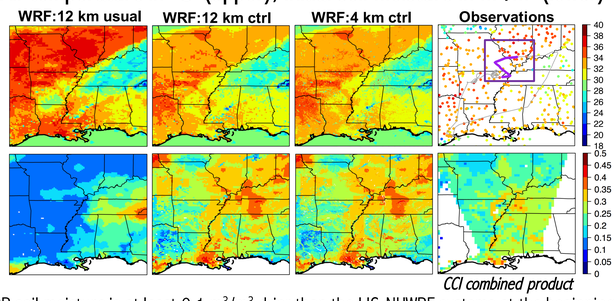


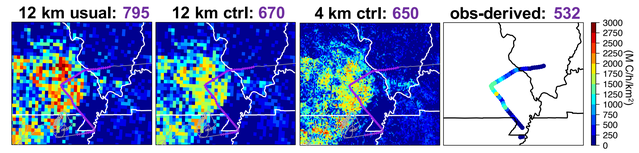
Case study of September 11, 2013

Air temperature in ℃ (upper); Initial soil moisture in m^3/m^3 (lower)



NARR soil moisture is at least 0.1 m^3/m^3 drier than the LIS-NUWRF systems at the beginning of the simulation. As a result, the 12 km usual run shows 2-4 °C positive biases in Missouri, which were dramatically reduced in the ctrl runs. Lower temperature resulted in thinner boundary layer heights.

Isoprene (an ozone/aerosol precursor) emissions



MEGAN v2.1 net primary isoprene emissions: rely on source type, source density (leaf area index), weather (e.g., temperature, radiation, soil moisture…), CO_2
Aircraft derived: rely on isoprene and hydroxyl radical concentrations, boundary layer heights..

- WRF/MEGAN isoprene emissions in all three cases are higher than the obs-derived
- The isoprene emissions based on the WRF ctrl runs are closer to the obs-derived, with the 4 km ctrl run based the closest to the obs-derived

Conclusions and ongoing/future work

(NU)WRF simulated atmospheric weather fields were sensitive to its initial soil moisture conditions. The sensitivity differed by location and time.

Initializing (NU)WRF with LIS land fields produced more accurate weather fields than initializing it directly with a coarse dataset.

The better (NU)WRF atmospheric weather fields helped improve air quality modeling on process level, which are relevant to policy decisions.

We are using SMAP data, along with other satellite land products and in-situ measurements, to:
-inform weather and air quality modeling on continental/hemispheric scales
-interpret variability in the observed and modeled pollutants' distributions

Check out 2018 AMS session of "land surface conditions and atmospheric composition", at the "20th Conference on Atmospheric Chemistry"

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