Demonstration of Satellite-Chemical Transport Model Framework to Estimate Near-Real-Time PM Composition

Tessa Clarizio (tessac2@illinois.edu), Dr. Hannah Horowitz, Dr. Vishal Verma, Dr. Lei Zhao
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Department of Civil & Environmental Engineering, Grainger College of Engineering, University of Illinois at Urbana-Champaign

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

MOTIVATION

Improve forecasting of particulate matter air pollution health risks in true near-real-time.

RESEARCH OBJECTIVE

Establish a link between near-real-time satellite AOD measurements and chemical transport modeling to predict $PM_{2.5}$ composition.

BACKGROUND

Air pollution causes millions of premature deaths each year globally.

Air pollution mortality is largely due to particulate matter (PM) exposure.

Fine PM (diameter <2.5 microns, $PM_{2.5}$) pose the greatest risk to health because they can travel deeper into the lungs.

$PM_{2.5}$ can be composed of different chemicals such as sulfate, nitrate, ammonium, black carbon and organic aerosol.

$PM_{2.5}$ chemical composition can affect adverse health impacts.

$PM_{2.5}$ levels (but not composition) can be estimated from satellite aerosol optical depth measurements (AOD).

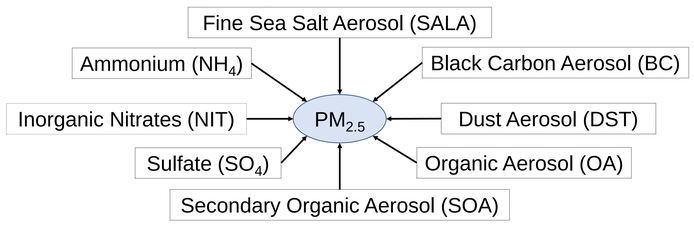
Atmospheric chemical modeling tools can be used to predict $PM_{2.5}$ composition.

STEP 3: MET FIELD SENSITIVITY ANALYSIS

In order to carry out research task #3, first must carry out a **sensitivity analysis** between the different meteorological fields available in GEOS-Chem: MERRA-2 & GEOS-FP.

MERRA-2	GEOS-FP
The Modern-Era Retrospective analysis for Research and Applications, Version 2	Uses most recent validated GEOS system, "forward processing"
Reanalysis	Operational
0.5° x 0.625°	0.25° x 0.3125°

Main $PM_{2.5}$ Components Simulated in GEOS-Chem



METHODS

Terra Satellite – MODIS, MISR

Suomi NPP Satellite – VIIRS

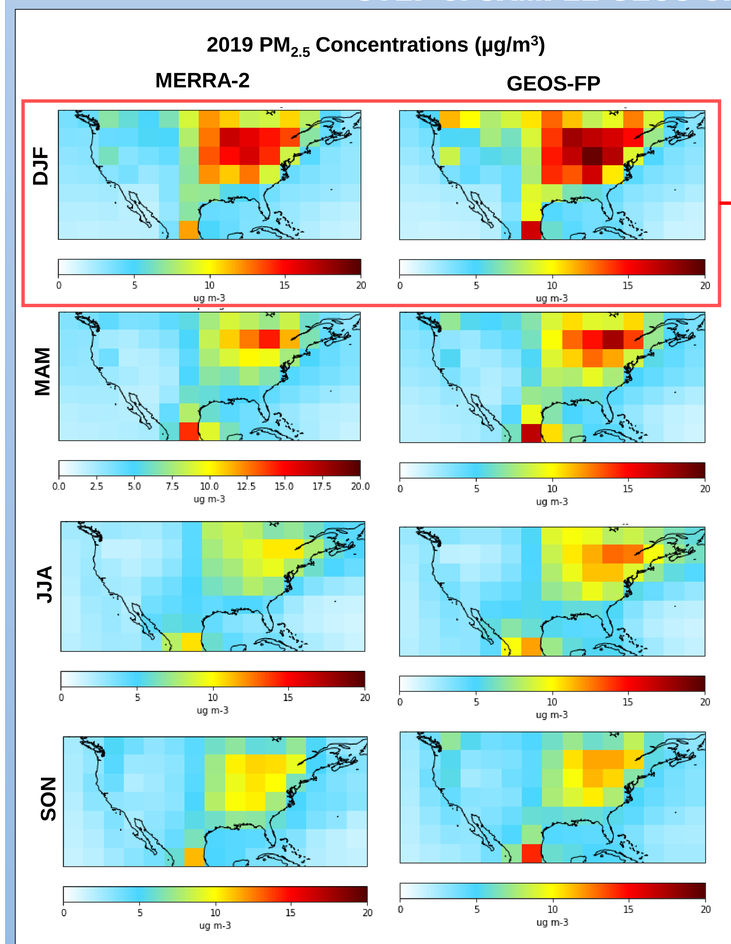
Aqua Satellite – MODIS

1. Collect NRT satellite data
2. Combine satellite AOD products
3. Use combined products and chemical transport model to get initial estimate of $PM_{2.5}$ composition
4. Interpolate the model estimates to a 10km grid
5. Multiply satellite-adjusted total $PM_{2.5}$ to get chemical concentrations of each species

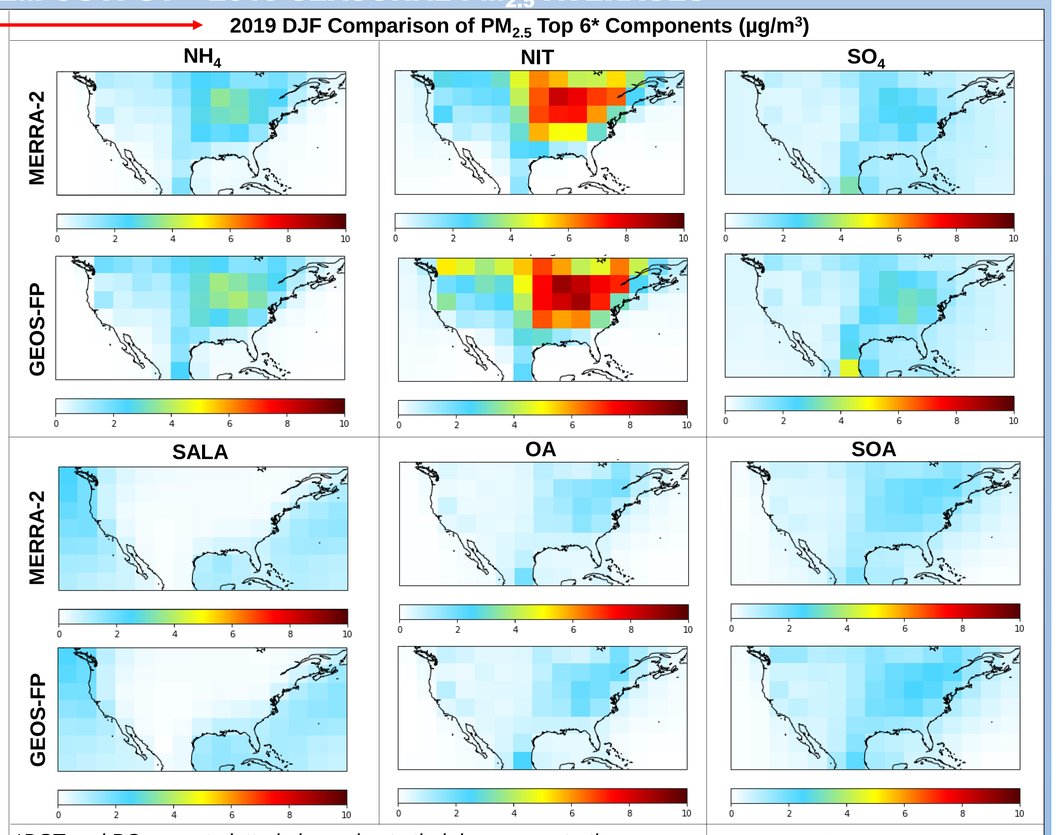
GEOS-Chem

$PM_{2.5}$ Components

STEP 3: SAMPLE GEOS-CHEM OUTPUT – 2019 SEASONAL $PM_{2.5}$ AVERAGES

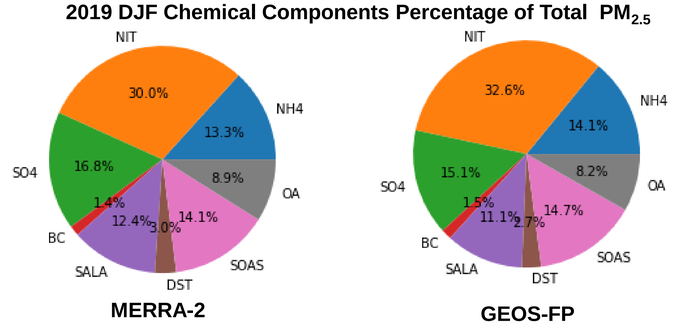


- Overall, using GEOS-FP results in higher $PM_{2.5}$ concentrations at all locations compared to MERRA-2.
- The spatial distribution of $PM_{2.5}$ concentrations are similar for both MERRA-2 and GEOS-FP.
- Winter (DJF) had the highest $PM_{2.5}$ concentrations. Therefore, the 8 main $PM_{2.5}$ components were examined to see how different species contributing to $PM_{2.5}$ differ between MERRA-2 and GEOS-FP.
- Future work will examine differences between the remaining seasons.



*DST and BC are not plotted above due to their low concentrations

2019 DJF Chemical Components Percentage of Total $PM_{2.5}$



SUMMARY

- NIT, SO_4 and NH_4 were the largest contributors to $PM_{2.5}$.
- GEOS-FP resulted in higher concentrations of all $PM_{2.5}$ components compared to MERRA-2.
- MERRA-2 and GEOS-FP had similar chemical component fractions, demonstrating consistency on the relative amount of each aerosol species across both met fields.