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

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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, 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.

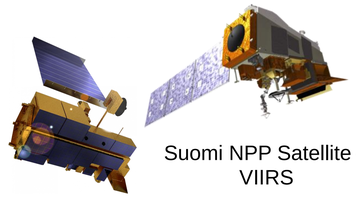
$PM_{2.5}$ can be composed of different chemicals such as sulfate, nitrate, ammonium, black carbon and organic aerosol.

$PM_{2.5}$ levels can be estimated from satellite aerosol optical depth measurements (AOD).

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

METHODS

1. Collect NRT satellite data
2. Combine satellite AOD products
3. Use chemical transport model to get initial estimate of $PM_{2.5}$ composition
4. Interpolate the model estimates to a 10km grid
5. Scale simulated total $PM_{2.5}$ by satellite-model AOD ratios for final estimate of concentration of each species



Terra Satellite – MODIS, MISR

Suomi NPP Satellite – VIIRS

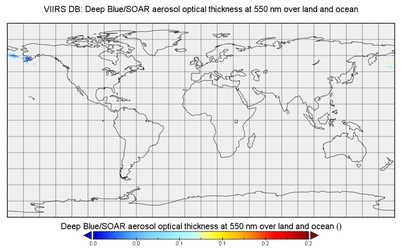
Aqua Satellite – MODIS

+ GEOS-Chem

$PM_{2.5}$ Components

STEP 2: COMBINE SATELLITE AOD PRODUCTS

Collect Near-Real-Time Satellite AOD
- L2 MODIS Terra and Aqua, VIIRS-Atmosphere and MISR aerosol products



Map individual AOD measurements → Map daily 10km AOD for each satellite product → Map combined daily 10km AOD

STEP 3: 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
Reanalysis	Operational
0.5° x 0.625°	0.25° x 0.3125°

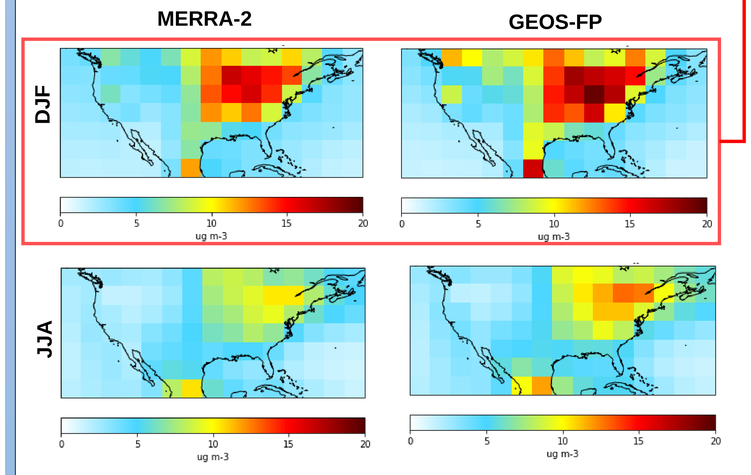
Sensitivity analysis GEOS-Chem run details:
- 4.0 x 5.0 resolution
- Spin up for 1 year (2018), run over 2019
- Full chemistry
- 72 vertical levels
- Troposphere + stratosphere

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

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

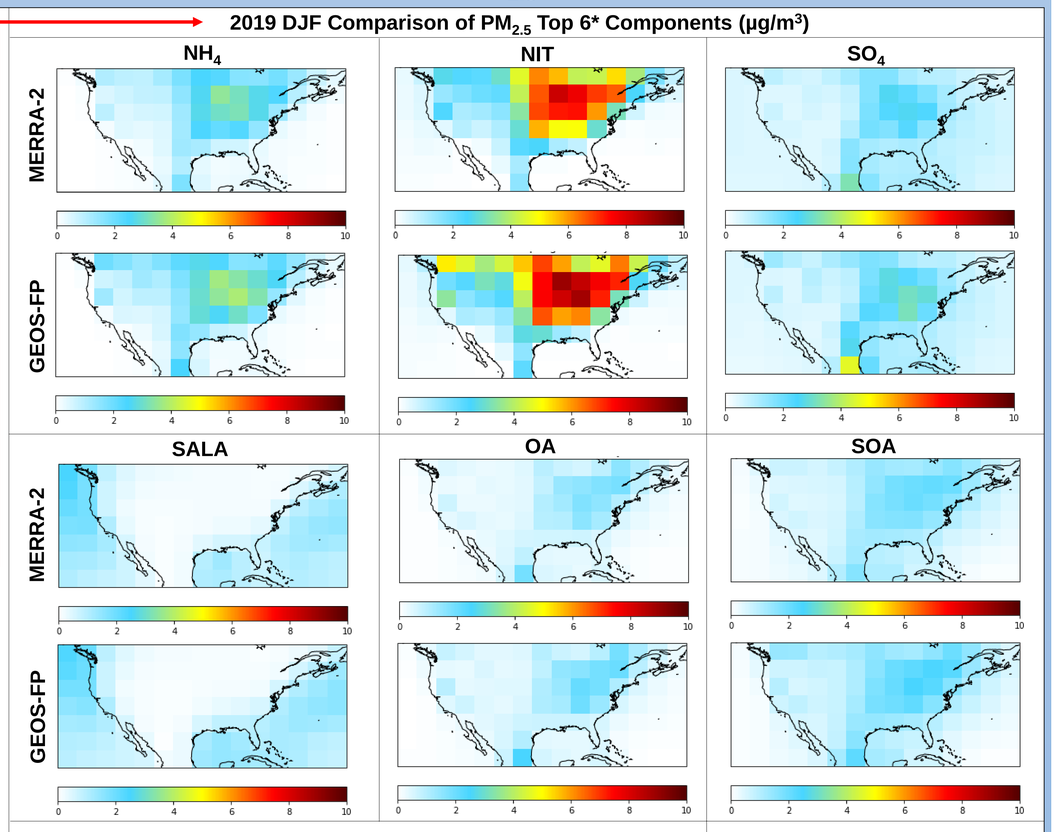
** DST is DST1. DST2 is not considered because the amount is negligible.*
*** OA is calculated by multiplying the sum of the hydrophobic (OCPO) and hydrophilic (OCPI x 1.05) carbon aerosol by the OA/OC ratio.*

2019 $PM_{2.5}$ Concentrations (μg/m³)

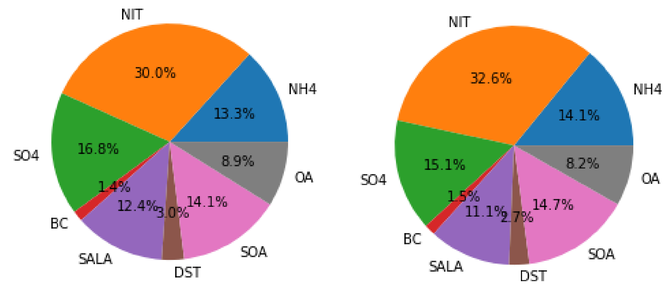


- Winter (DJF) and Summer (JJA) had the greatest seasonal differences
- Overall, using GEOS-FP results in higher $PM_{2.5}$ concentrations at all locations compared to MERRA-2.
- The spatial distribution of $PM_{2.5}$ concentrations are similar for both MERRA-2 and GEOS-FP.
- Winter (DJF) had the highest $PM_{2.5}$ 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.

2019 DJF Comparison of $PM_{2.5}$ Top 6* Components (μg/m³)



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 GEOS-FP can be used for nested grid simulations for this study.