



# Fires, Smoke, and Air Quality

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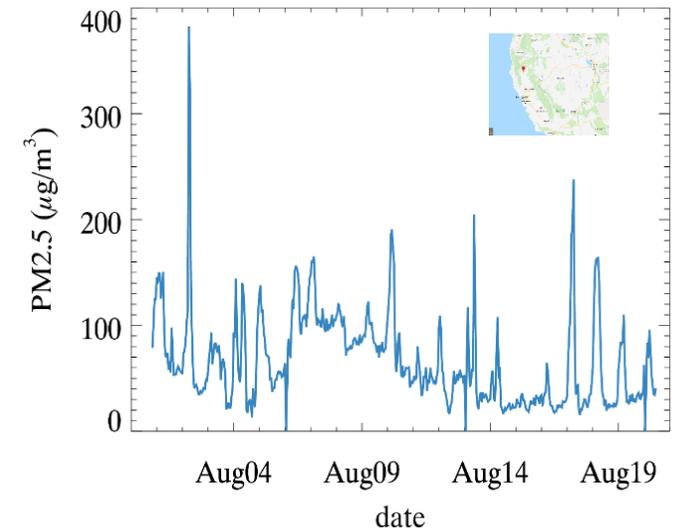
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IMSG

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NOAA/ESRL





# Biomass Burning

- Fires release large amounts of aerosols into the atmosphere that have adverse effects on human health and economy
  - Long range transport of smoke from fires impacts air quality in downwind regions. **Worldwide 250,000 premature deaths per year (Jacobson, JGR, 2014).**
  - Impacts national parks, monuments, and transportation due to reduced visibility.

## ***Ft. McMurray Fire, Canada, May 2016***



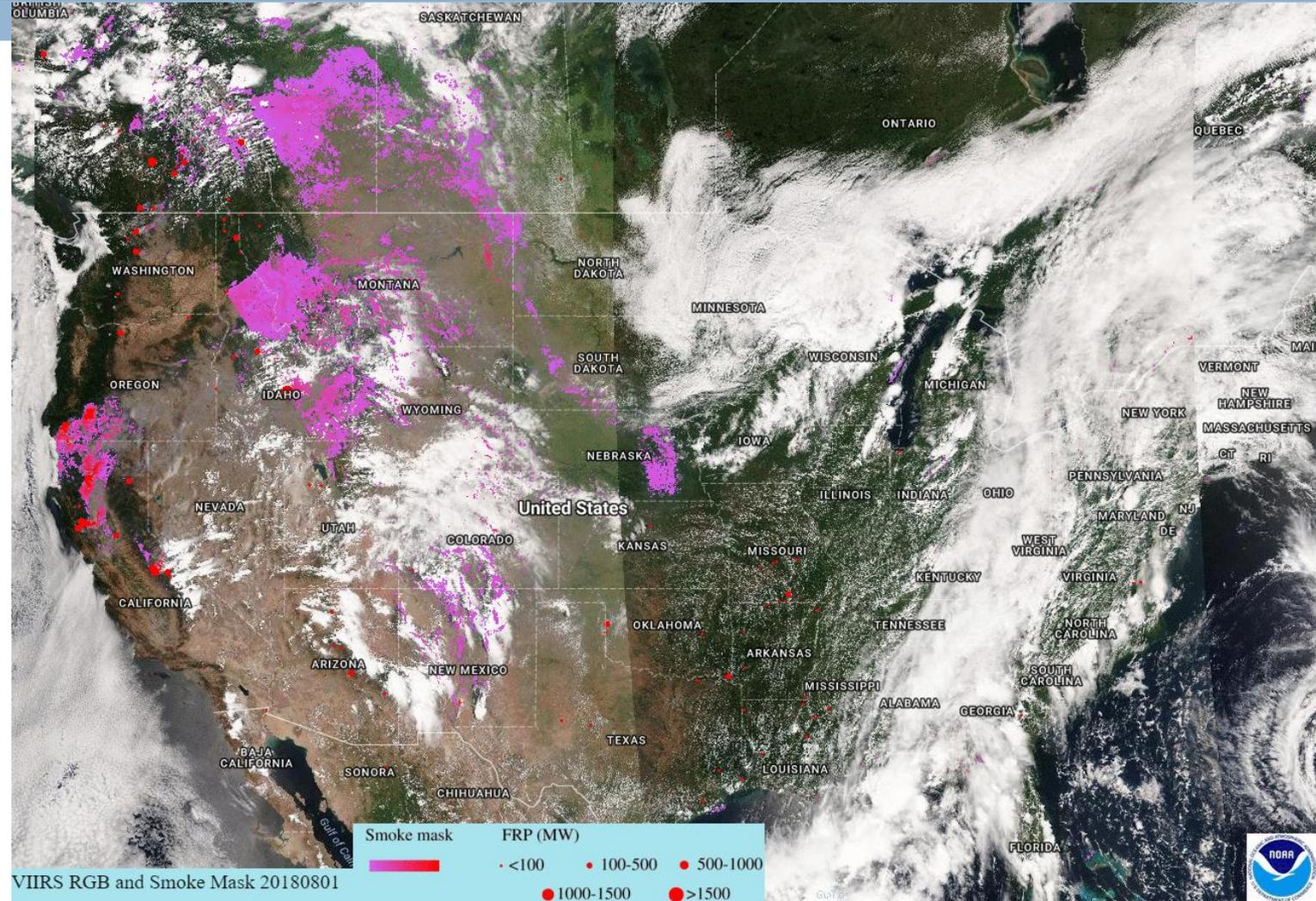
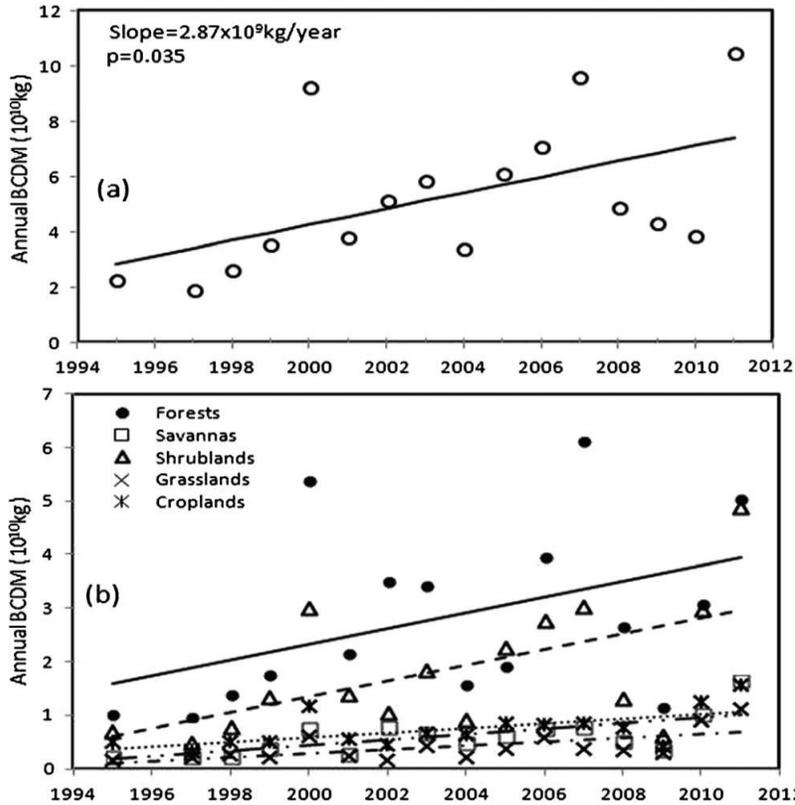


# Types of Fires

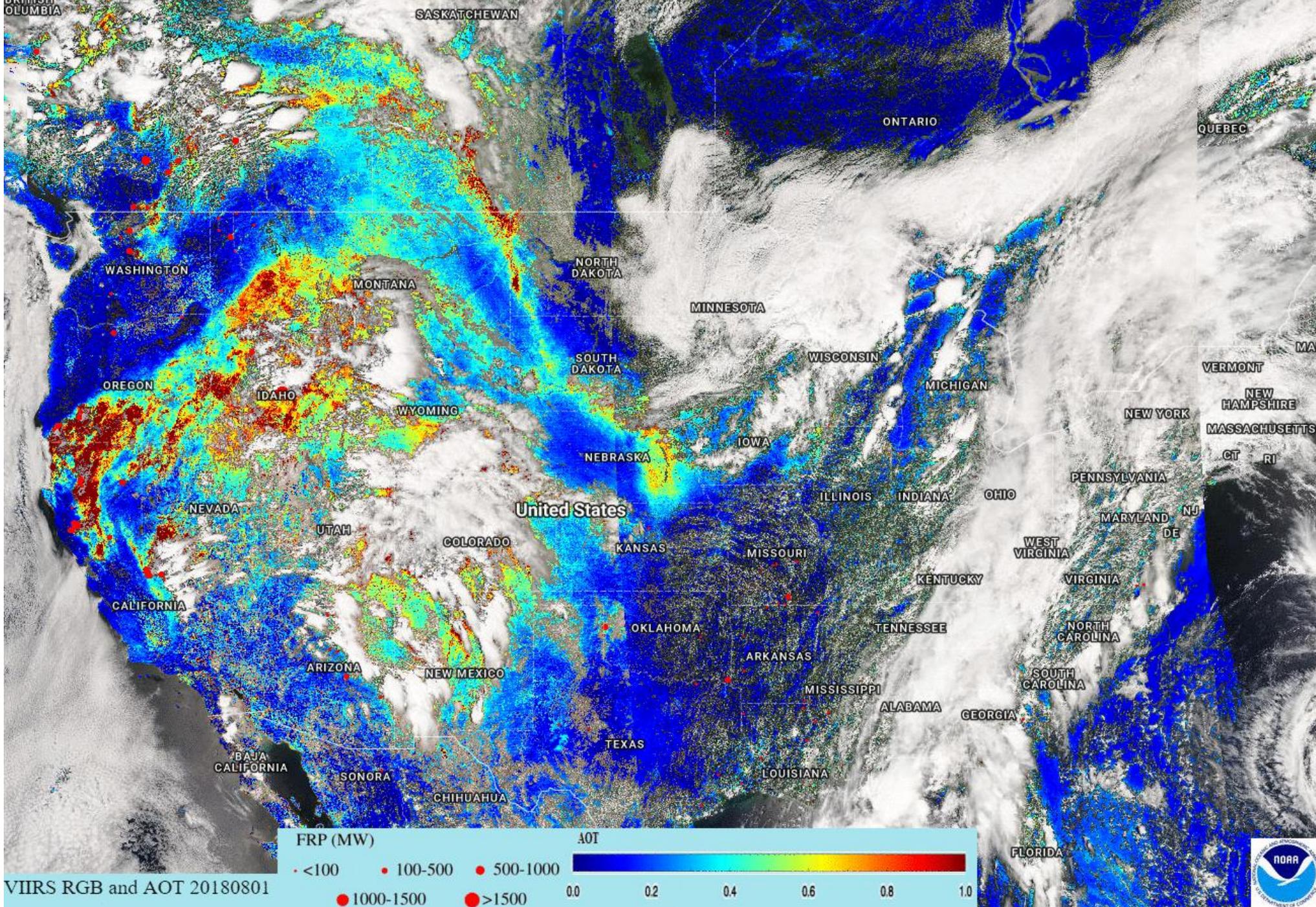




# Trends in Fire Activity



Zhang, X., Kondragunta, S., and Roy, D.P., 2014. Interannual variation in biomass burning and fire seasonality derived from geostationary satellite data across the contiguous United States from 1995 to 2011. *Journal of Geophysical Research-Biogeosciences*, <http://dx.doi.org/10.1002/2013JG002518>.





# Air Quality Predictions

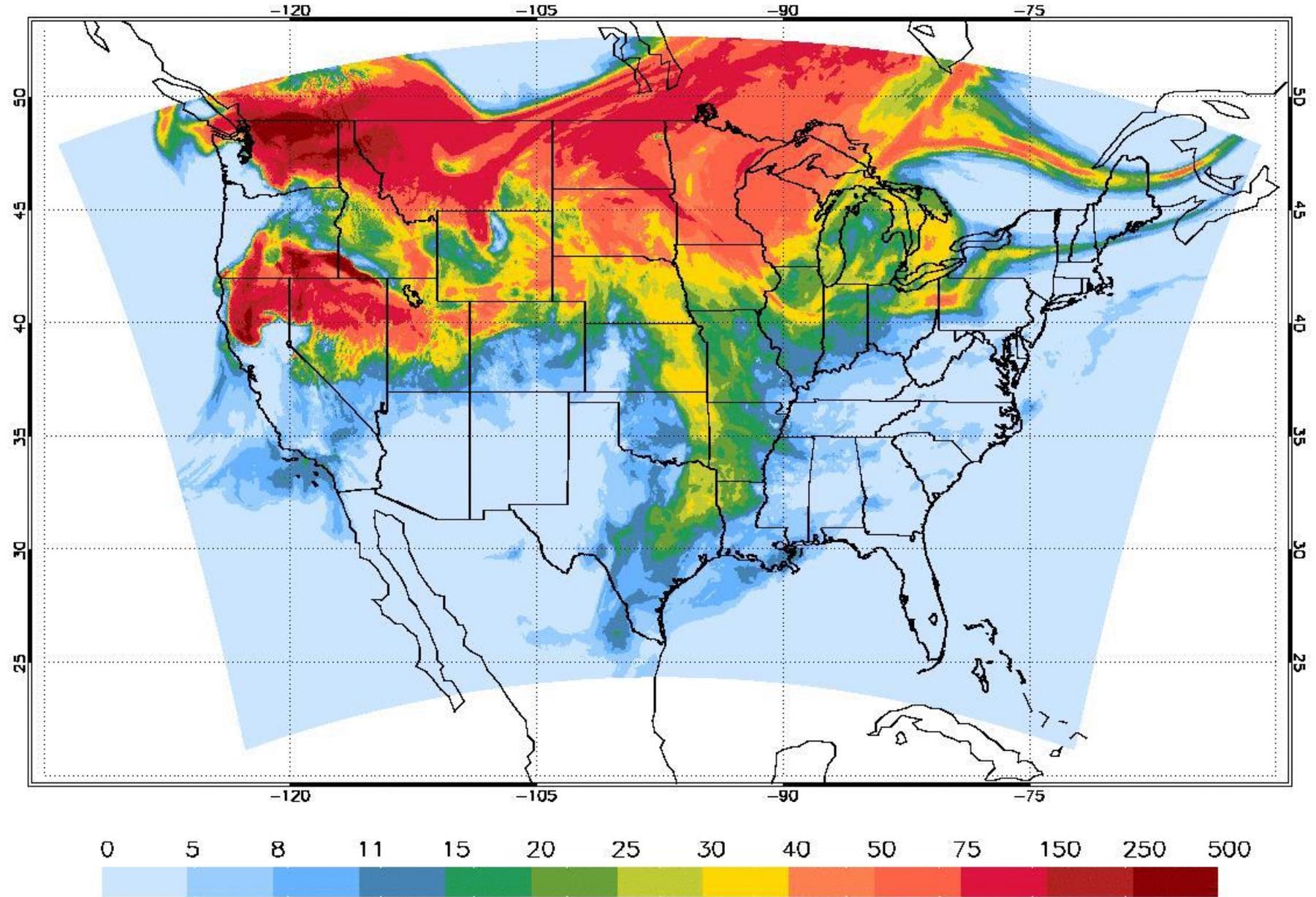
- Numerical models that predict air quality (ozone and PM2.5) need to know where the fires are located, how high is the aerosol loading being emitted, at what height is the plume injection, and the duration of the fire.
- Near real time information from satellites that models need
  - Fire location - **yes**
  - Fire Radiative Power (a proxy to calculate emissions) - **yes**
  - Fire duration (if satellite is in geostationary orbit) - **yes**
  - Plume injection – **no**
  - Aerosol composition - **no**





HRRR Vertically Intergrated Smoke (mg/m<sup>2</sup>) 08-19-2018 06:00

Forecast time: 01



**High  
Resolution  
Rapid  
Refresh  
(HRRR-  
Smoke)  
Model**

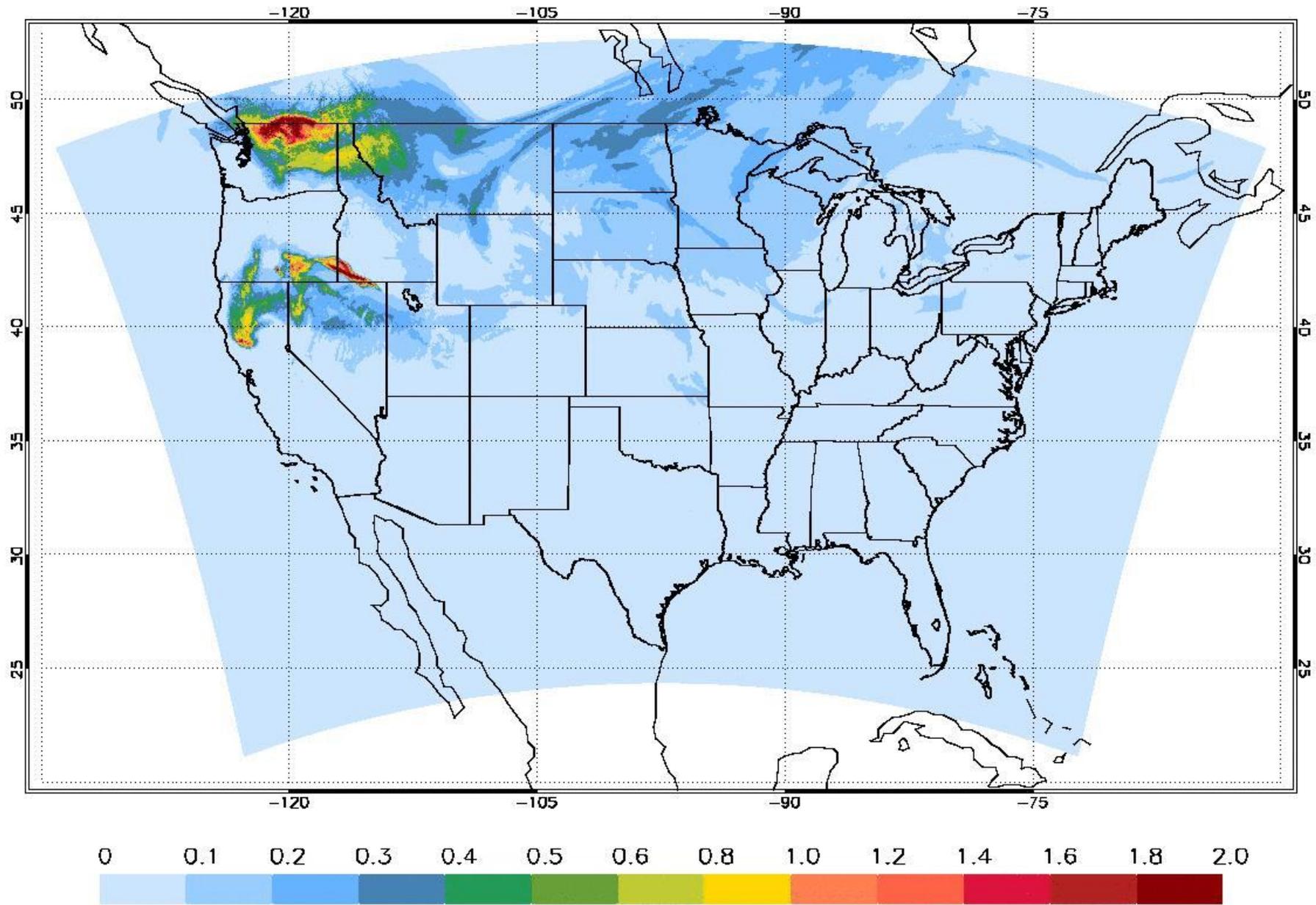


HRRR Smoke AOD 08-19-2018 06:00

Forecast time: 01

$$\text{AOD} = n_c \times \beta$$

$n_c$  is column concentration ( $\text{mg}/\text{m}^2$ );  $\beta$  is mass extinction efficiency ( $\text{m}^2/\text{g}$ )





# Evaluation of HRRR-Smoke using VIIRS AOD

## Caveats – VIIRS AOD

- VIIRS AOD has gaps
  - Clouds
  - Very thick smoke
    - Cloud mask calls smoke confidently cloudy
    - AODs are out of range ( $> 5.0$ )
- VIIRS smoke mask is qualitative indicator of smoke and only 80% accurate

## Caveats – HRRR Smoke

- Simple scaling of particle concentration to AOD
- No secondary aerosol formation
- No hygroscopic particle growth

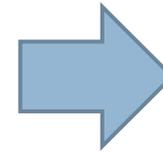
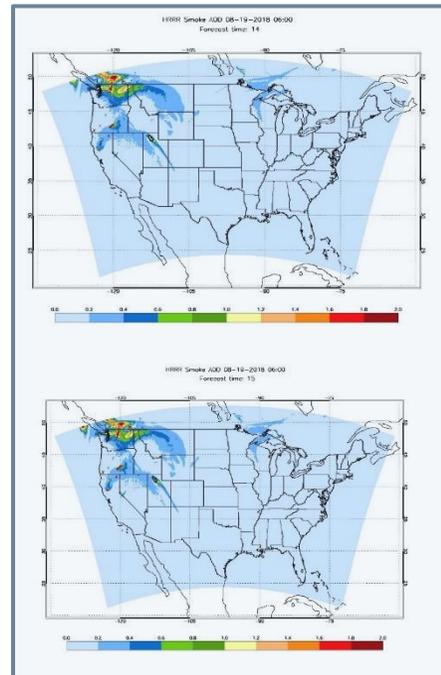
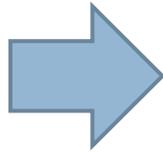
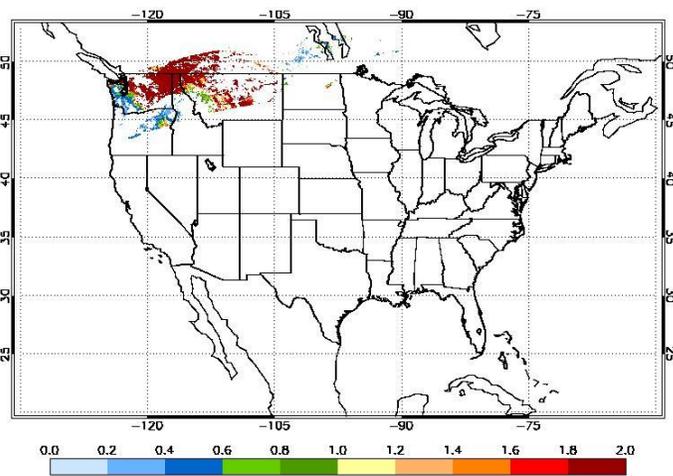


# Match-Up Criteria

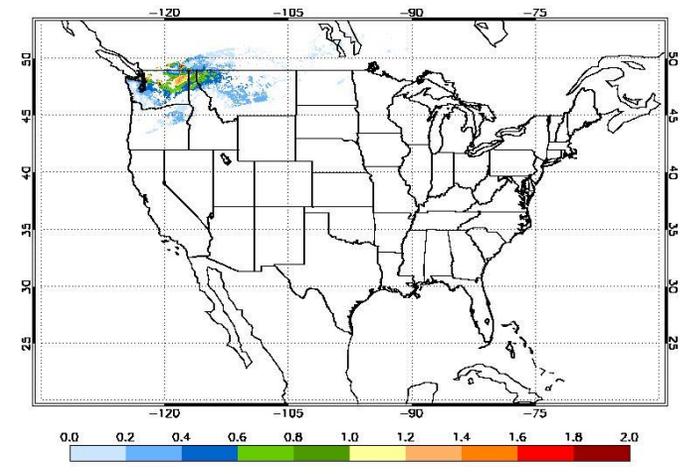
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- ❑ VIIRS AOD pixels in a granule with co-existing VIIRS smoke mask are retained as “smoke AOD”
- ❑ VIIRS smoke AOD re-mapped to  $0.05^\circ \times 0.05^\circ$
- ❑ HRRR smoke AOD re-mapped to  $0.05^\circ \times 0.05^\circ$
- ❑ Each VIIRS granule matched to HRRR-Smoke  $\pm 30$  minutes of VIIRS overpass time

VIIRS Smoke AOD 20180819Z010



HRRR Smoke AOD 20180819Z010

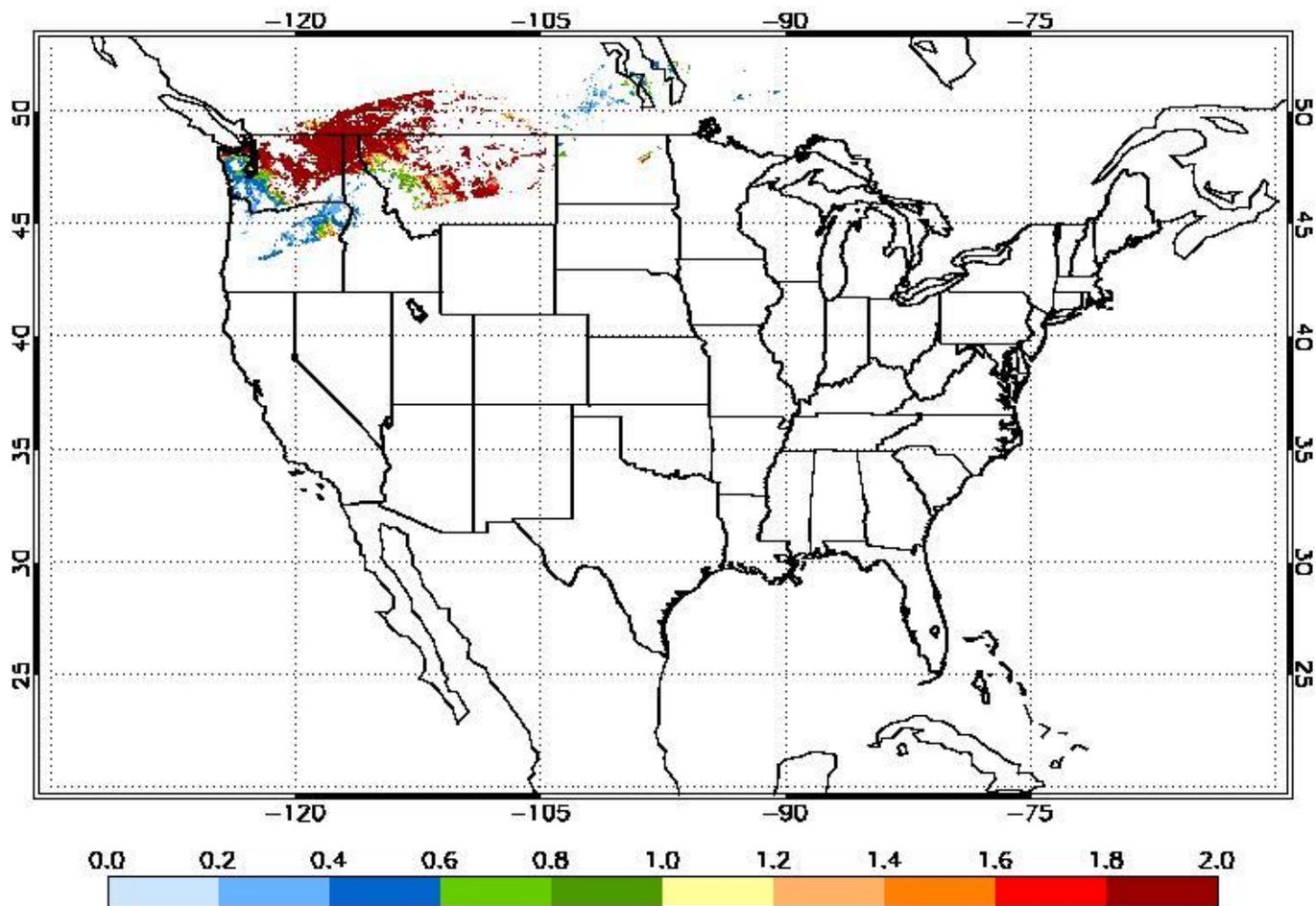




# Match-Up Criteria

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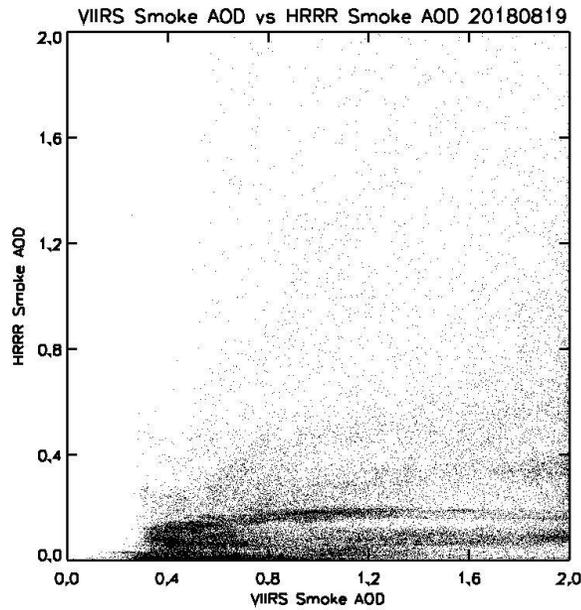
VIIRS SMOke AOD 201808192010





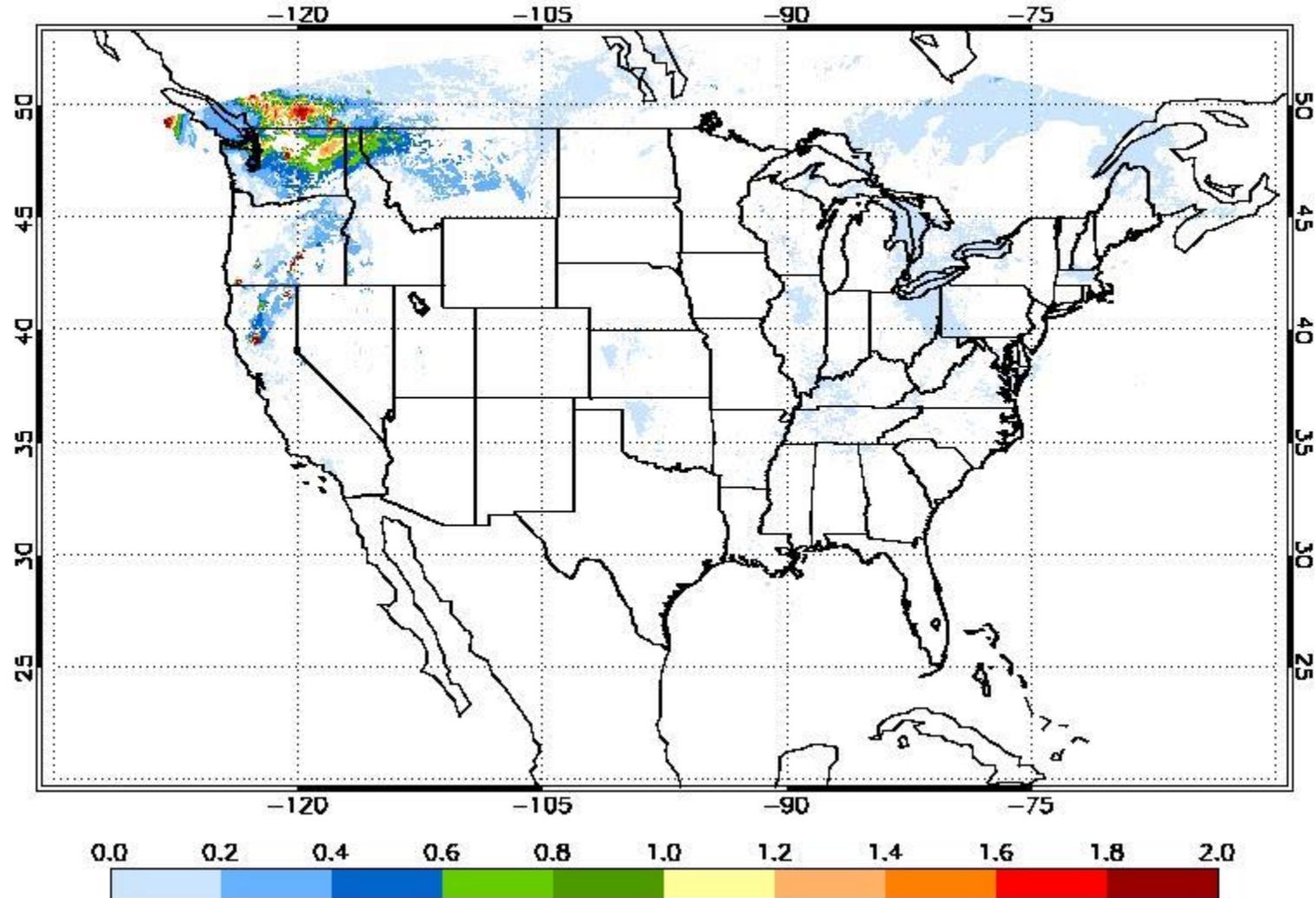
# HRRR-Smoke vs. VIIRS Smoke AOD

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- Likely source of bias:
- Transported smoke
  - Fire emissions
  - Matchup method

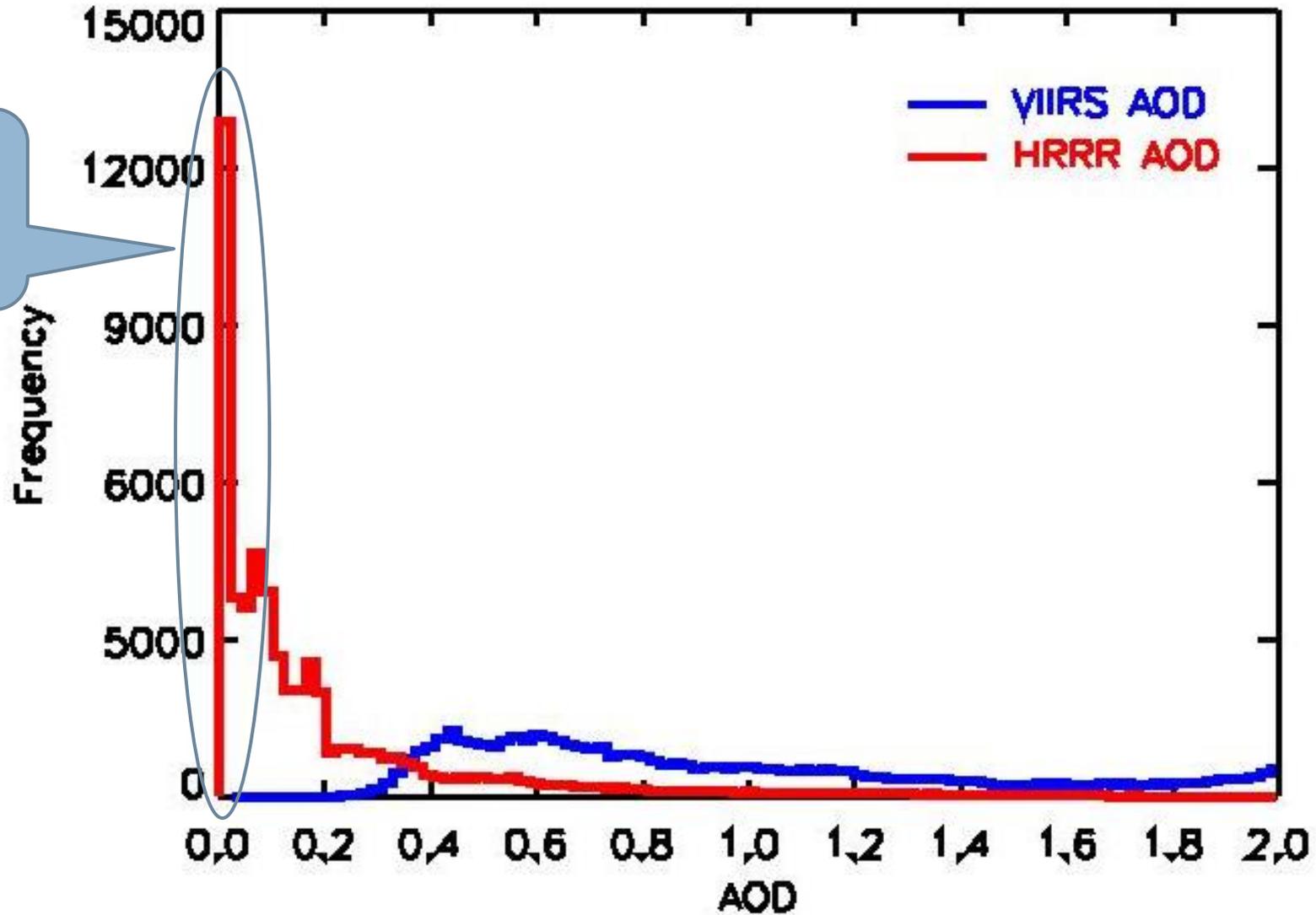
HRRR Smoke AOD 20180819



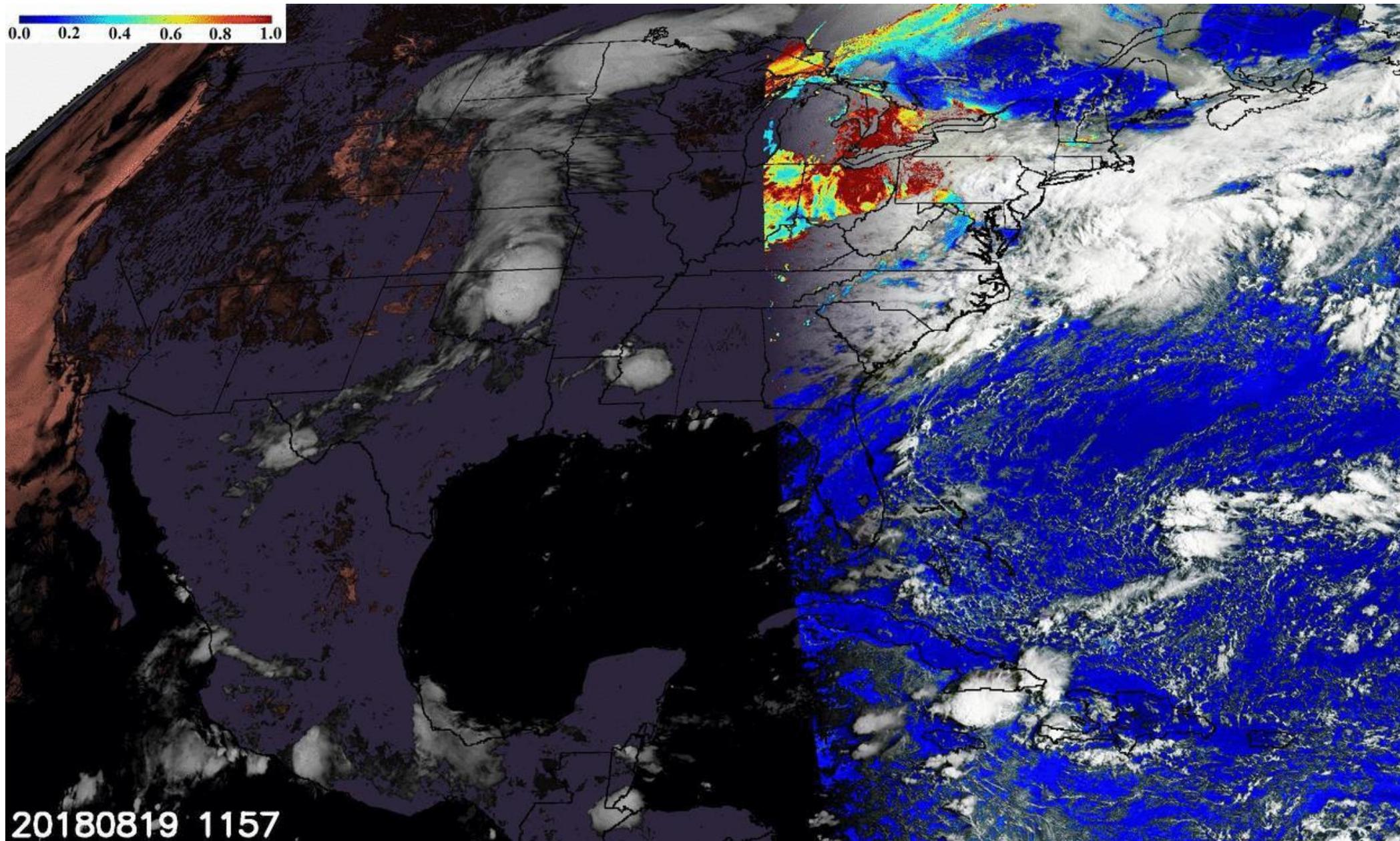


# HRRR-Smoke vs. VIIRS Smoke AOD

Model background AOD



0.0 0.2 0.4 0.6 0.8 1.0



20180819 1157



# Summary

- Analyzed one week of data but presented only one day of comparisons
- HRRR-Smoke model spatial patterns of smoke agree well with VIIRS observations matched up in space and time;
  - For qualitative applications such as informing field forecasters, IMETs et al. about locations of smoke, the model is performing very well.
- HRRR-Smoke model **column** aerosol concentrations are under-predicted and therefore AOD. HRRR-Smoke surface PM2.5 concentrations are likely correct
- The entire month of August data will be analyzed and stratified statistics will be generated to understand model performance for smoke events with smoke generated locally vs. transported smoke from Canada into the US domain;
- GOES-16 ABI AOD shows that smoke plume spatial patterns change rapidly
- Better matchups with GOES-16 ABI AOD expected to improve the matchups and results