Dispersion Modeling to Estimate Wildfire Smoke Transport During the Yosemite Rim Fire

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Motivation

Fire emissions inventories are currently the only method to model fire emissions. Because each fire emissions inventory uses a different approach to model emissions, the estimation of emissions from a single fire is different. There is no validation dataset to determine which method is correct. We aim to understand how these differences affect atmospheric modeling using these inventory estimates of fire emissions as model inputs.

Approach

- Aggregate daily emissions estimates from each fire emissions inventory.
  - The inventories and products used are FINN, GFED, MFLEI (250 m pixel and 10 km spatially aggregated products), and WFEIS (MODIS and MTBS burned area products). We omitted GFED emissions because it reported no daily emissions on either day.
  - The total emissions estimates from that day of the Rim Fire were summed. Averaging each pixel location weighted by the amount of burned area in that each pixel determined a single fire location for the day. WFEIS (MTBS) did not report a daily progression, so total emissions were averaged equally over fire length.
- Use daily aggregated results from emissions inventories for August 22 and August 31, 2013, as inputs.
  - August 22 is a clear day with an intense smoke plume. August 31 has strong wind shear in the Central Valley of California and over the Sierra Nevada Mountains.[1]
- Run a 24-hour HYSPLIT concentration using the aggregated location, $PM_{2.5}$ emissions amount, and burned area from each fire emissions inventory.
  - NAM 12km meteorological data drives these HYSPLIT runs.
  - Plume concentration is averaged for 0-5000 m above ground level.
  - Emissions are assigned temporally using the default HYSPLIT temporal profile.
  - No plume injection height was used.
- Use visible images from MODIS as an evaluation dataset.
  - Aqua overpass occurs at 20:30 UTC locally.
  - HYSPLIT results show the average concentration between 20:00 and 21:00 UTC.

Summary + Future Work

- Dispersion results from each fire emissions inventory show drastically different concentrations.
- The method used by a fire emissions inventory to estimate emissions impacts how a dispersion model estimates the transport of a smoke plume through the atmosphere.
- The plume from each inventory differs in size, amount of PM2.5 emissions, and plume location after transport.
- None of the results closely match the visible plume results from MODIS, though many capture a general shape close to the visual image. This discrepancy may result from the averaging HYSPLIT results over the entire hour of the overpass and vertically in the atmosphere.
- These results highlight the impact of fire emissions inventory choice and the differences the inventory method creates in dispersion modeling, even after aggregating inventory results.
- **Future work**: combining WFEIS (MODIS) and WFEIS (MTBS) data to utilize several sources of remote sensing information in a fire emissions inventory, assign a temporal profile that better captures the temporal profile of fires in the western United States, apply accurate plume injection height information.

References

1. Loría-Salazar, S. M., et al., (2021). *Journal of Geophysical Research: Atmospheres*, *126*(11).

Results

August 22, 2013

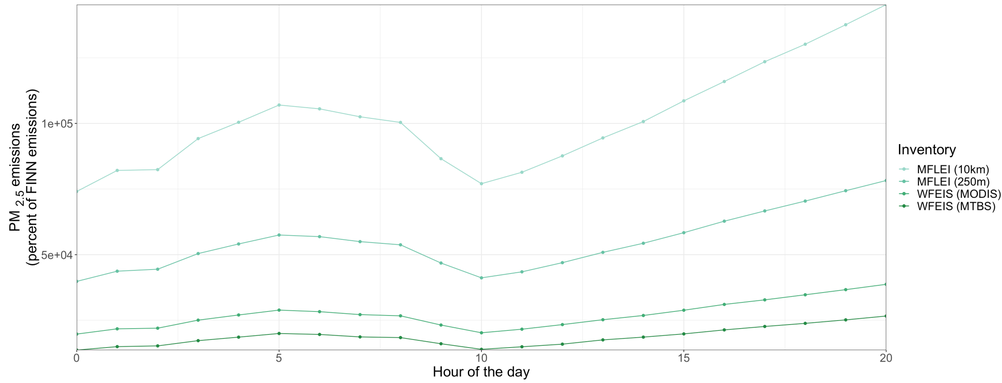

Figure 1: The hourly amount of $PM_{2.5}$ emitted on August 22, 2013, by the Rim Fire, as estimated by each fire emissions inventory. The results are represented as the percentage of FINN emissions estimates, which had the lowest emissions, to best show the different magnitudes of emissions estimates from each inventory.

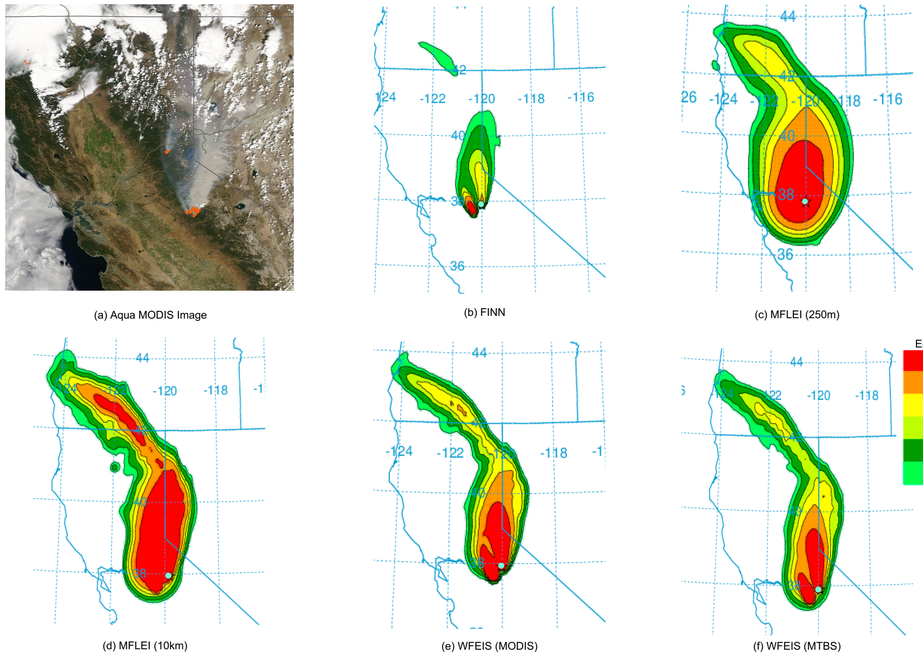

Figure 3: HYSPLIT dispersion results averaged over the hour corresponding to the Aqua satellite overpass, seen in figure (a), for August 22, 2013. The orange dots on the Aqua image represent thermal anomalies (i.e., fires), and the teal dots on the HYSPLIT images represent emissions release location. These figures show how drastically the amounts and locations of the different emissions can vary between emissions inventories and how this impacts the smoke plume dispersion results in HYSPLIT modeling.

August 31, 2013

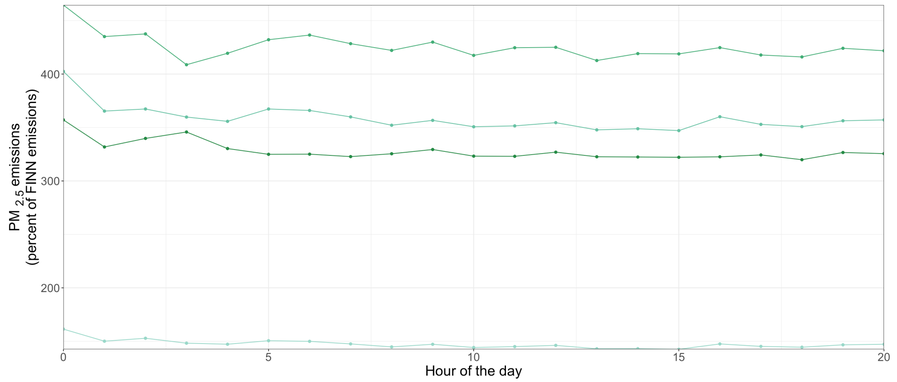

Figure 2: The hourly amount of $PM_{2.5}$ emitted on August 31, 2013, by the Rim Fire, as estimated by each fire emissions inventory. The results are represented as the percentage of FINN emissions estimates, which had the lowest emissions, to best show the different magnitudes of emissions estimates from each inventory.

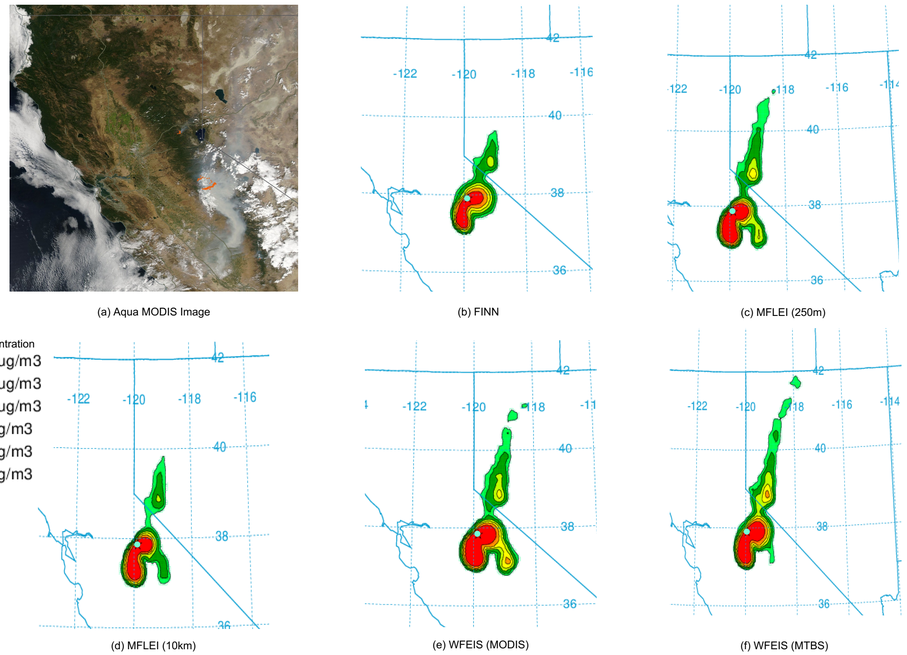

Figure 4: HYSPLIT dispersion results averaged over the hour corresponding to the Aqua satellite overpass, seen in figure (a), for August 31, 2013. The orange dots on the Aqua image represent thermal anomalies (i.e., fires), and the teal dots on the HYSPLIT images represent emissions release location. The high wind shear on this day creates difficult conditions to model, and this further emphasizes how the differences between each emissions inventory impact HYSPLIT modeling.

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