Simulating wildfire smoke transport in the western U.S.: Differences between emission inventories

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BACKGROUND

- **Soberanes Fire**: The Soberanes Fire, caused by an illegal campfire, occurred in Soberanes Creek, Garrapata State Park, Monterey County, California starting on July 22nd and lasted for around 82 days until October 12th in 2016.
- **Yosemite Rim Fire**: The fire started on August 17, 2013 in a remote canyon in Stanislaus National Forest, in California caused by a hunter's illegal fire that got out of control. This fire grew to be (at the time) the third-largest wildfire in California's history.
- **FINN:** FINN uses thermal anomalies and land cover products from satellite remote sensing to estimate burned area and fuel loading, respectively. FINN uses emissions factors, for many chemical species, and vegetation estimates to provide fire emissions inputs to chemical transport models in near real-time.
- **NEI-SMARTFIRE:** The NEI has point source day-specific fire emissions obtained from SMARTFIRE (Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation) with the estimated fire activities (fire locations, duration and size) serving as the initial data for the BlueSky framework. This framework is implemented in the Sparse Matrix Operator Kerner Emissions (SMOKE) modeling system to generate fire emissions.
- **GFED**: Global Fire Emissions Database, a monthly emission inventory with 27 km resolution, focuses primarily on the interactions of climate and fire at the global scale.
- **MFLEI**: Missoula Fire Lab Emission Inventory, a fire emission inventory for contiguous U.S. with updated emission factors and wildland fuels map.
- **WFEIS**: Wildland Fire Emission Information System, has higher greenhouse gas emissions and fuel consumption.

METHODS

Soberanes Fire

- **Community Multiscale Air Quality (CMAQ)** simulates atmospheric dynamics and chemical processes.
- **Sparse Matrix Operator Kernel Emissions (SMOKE)** modeling system is used to generate CMAQ emission inputs based on NEI.
- **FINN** is converted to SMOKE/CMAQ model ready format.
- **Weather Research and Forecasting Model** generates meteorological conditions for CMAQ inputs.

Rim Fire

- **FINN, GFED, MFLEI, WFEIS** fire emissions inventory evaluation and selection for long term smoke transport modeling.
- **Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) s**imulates atmospheric transport.

RESULTS/DISCUSSION: 2016 Soberanes Fire

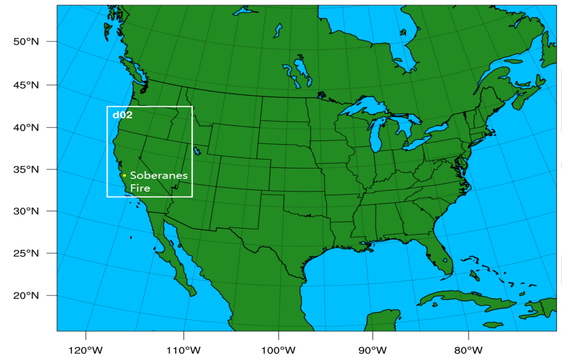

Figure 1. Domains for CMAQ simulations. 12km horizontal resolution outer domain and 4km nested domain in the western US. Yellow dot represents the location of the Soberanes Fire.

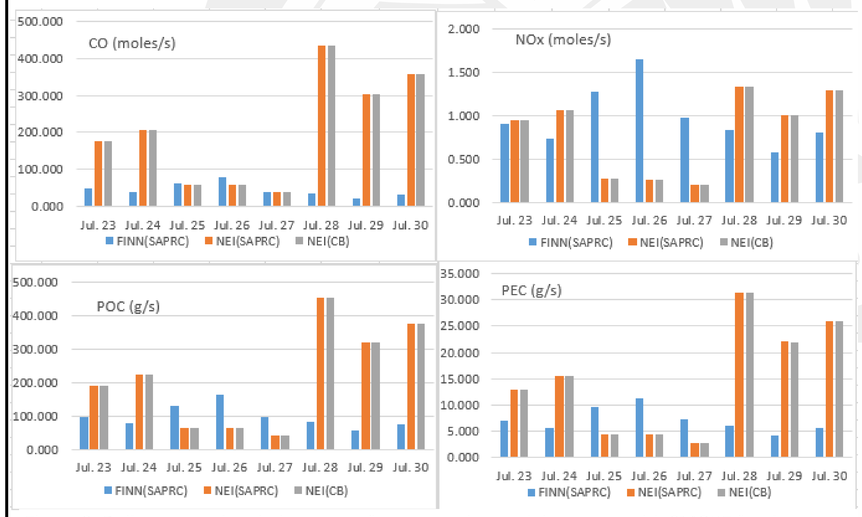

Figure 2. Daily averaged emission rates after processing each inventory with SMOKE for the Soberanes Fire, two inventories (FINN and NEI) and two chemical mechanisms (SAPRC and CB05).

EMISSIONS SUMMARY

- FINN has less day-to-day variability than the NEI
- Six days into the fire, NEI emissions are greater than FINN
- Emissions are less sensitive to the chemical mechanism chosen than the inventory selected
- Because FINN is developed for near real time applications, less input data is used to estimate the emissions
- SMARTFIRE (NEI) uses both ground and satellite-based data to estimate fire activity and emissions

FUTURE WORK

- Simulate air pollution concentrations and evaluate CMAQ results
- Evaluate the CMAQ using observations and satellite retrievals
- CMAQ simulation with brute force, DDM, and source apportionment to quantify the impacts from wildfire smoke downwind of fires

RESULTS/DISCUSSION: 2013 Rim Fire

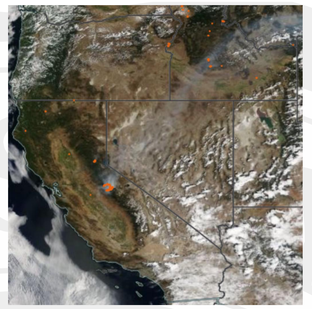

Figure 3. Terra MODIS visible image from 30 Aug 2013 showing the geographic boundary for the 2013 emissions evaluation. Thermal anomalies (red dots) and smoke from the Rim Fire. *Image from NASA Worldview.*

Table 1. Details of the four wildfire emissions inventories for 2013 study.

	MFLEI	FINN	GFED 4s	WFEIS
Resolution	10 km x 10 km Daily	1 km x 1 km Daily	0.25° x 0.25° Monthly	1 km x 1 km Daily
Available to	2015	2019	2016 (beta up to 2020)	2018 - 2020
Advantages	Updated fuel parameterizations	Near real time data	Incorporation of small fires	Combined burn area product using MODIS and MTBS
Disadvantages	Data latency	Relies heavily on MODIS data	Large error in small fire product	High fuel consumption

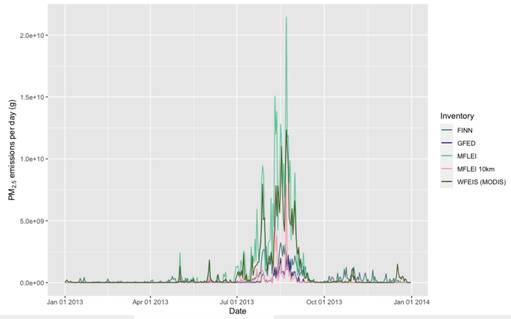

Figure 4. Domain averaged, daily $PM_{2.5}$ emissions (g/day) for FINN, GFED, MFELI 250m, MFLEI 10km, and WFEIS emissions inventories for 2013. The Rim Fire occurred from 17 Aug – 4 Nov. *Note: y-axis is scaled linearly with a break near zero to better represent the large numbers.*

EMISSIONS SUMMARY

- All 5 inventories have similar temporal variability but the magnitude of emissions, especially during Rim Fire is significantly different
- They also differ significantly outside of fire season (e.g., Oct-Jan)
- Difficult to determine inventory accuracy without measurements
- Direct comparison and Bayesian modeling can provide insights
- Based on this, FINN underestimates and MFLEI 250m overestimates

FUTURE WORK

- Use WFEIS MODIS inventory to estimate daily wildfire emissions
- Simulate smoke transport for 2007-2020 using HYSPLIT
- Combine HYSPLIT results and ambient concentrations from regulatory monitoring networks to calibrate smoke concentrations
- Estimate the health impacts associated with wildfire smoke exposure in Reno, Nevada