Evaluating Fire Emissions Inventories with Bayesian Statistics

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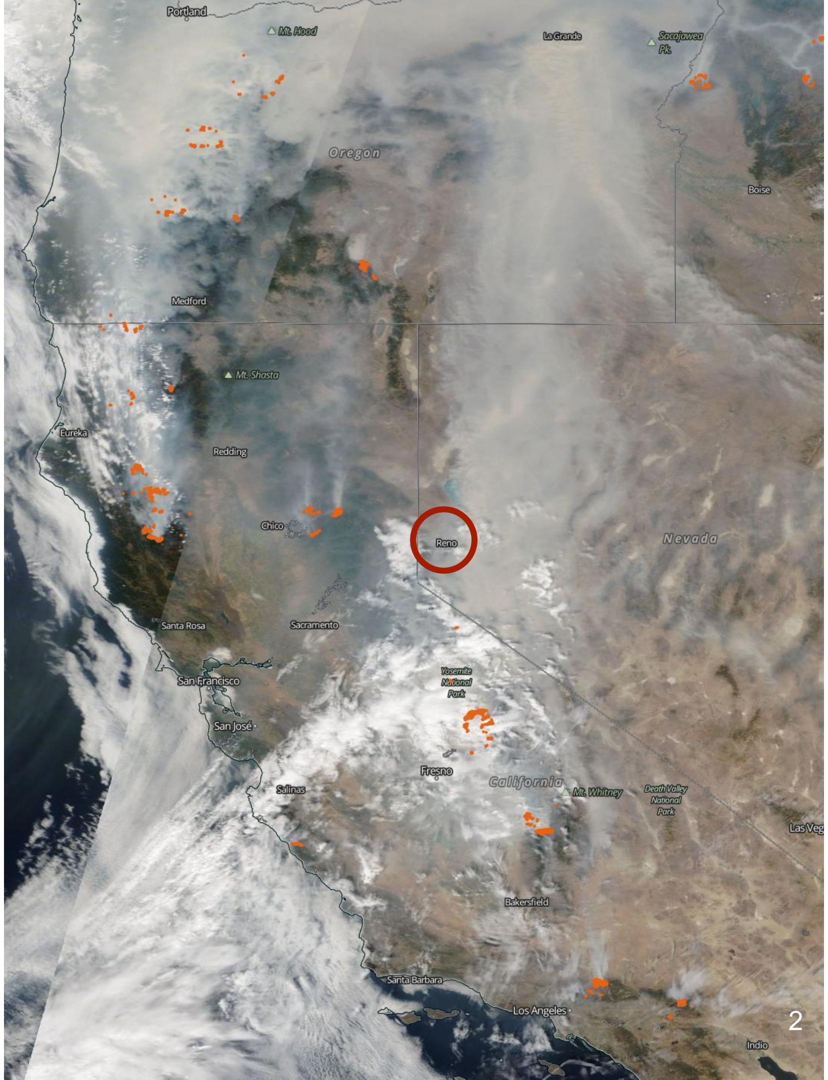
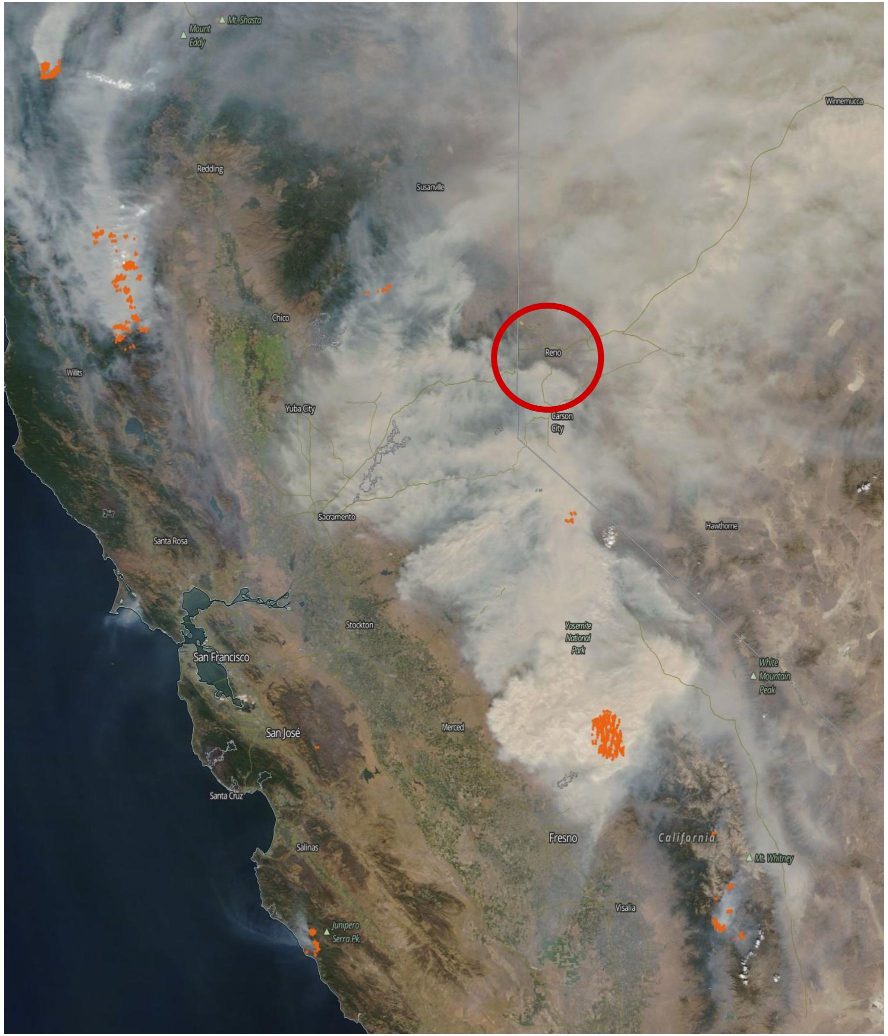
Overarching Research Goal

- NIH project looking to determine the health effects of wildfire and prescribed burn smoke on humans in the Reno, Nevada area.
- Focus on plume-specific aerosol mixtures in wildfire smoke from different wildfires with different fuel types



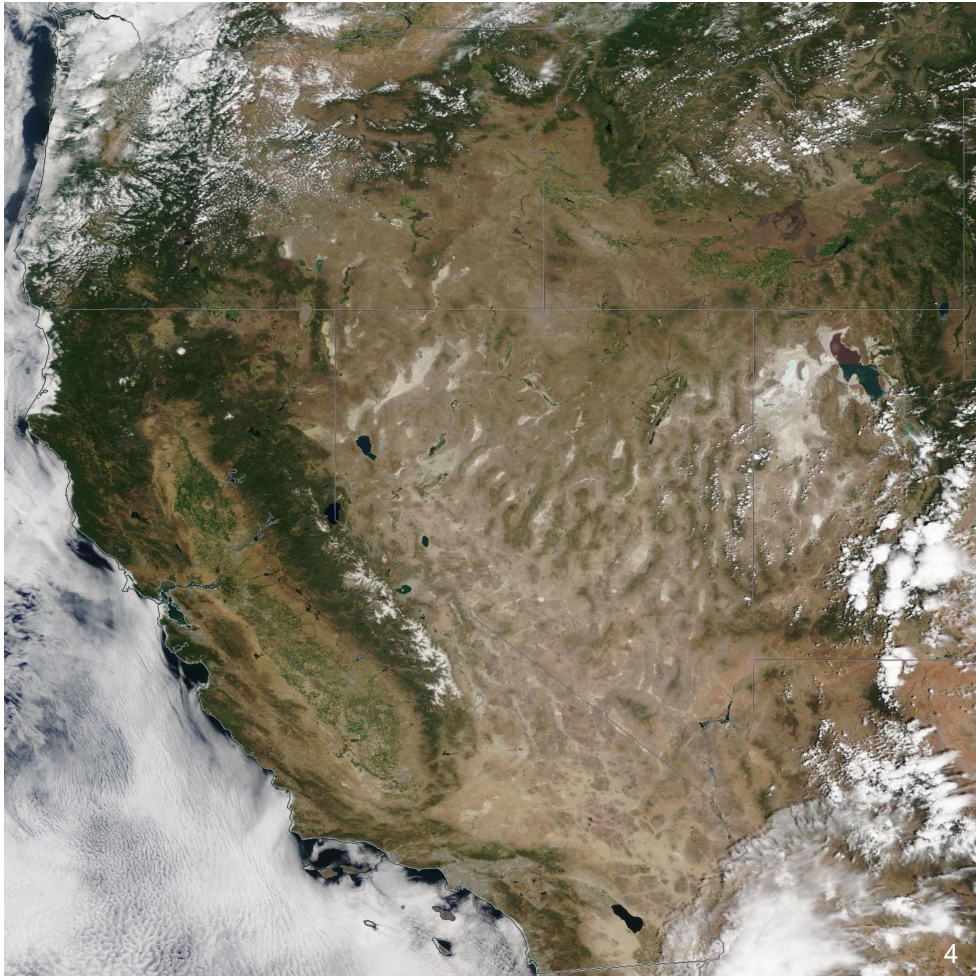
Objectives

- Determine the inventory that can best provide multi-year, daily smoke exposure estimates for individual smoke plumes in Reno.



Project Requirements

- Temporal domain: 2007-2020
  - Consistent methodology
  - Daily smoke exposure estimates
- Modeling Domain
  - Western United States including Oregon, California, Nevada, and parts of Idaho, Utah, Washington, and Arizona

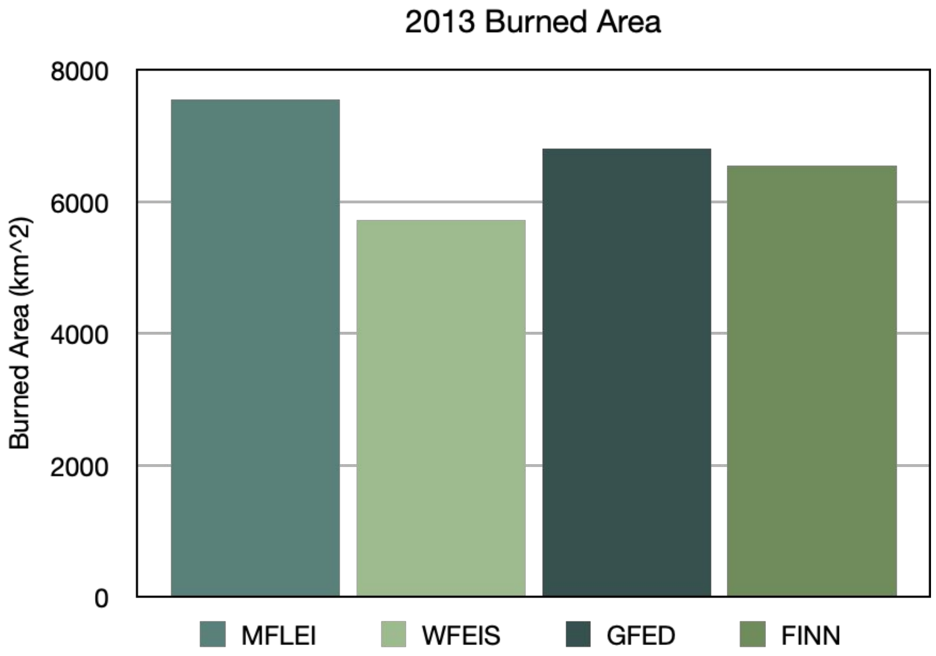


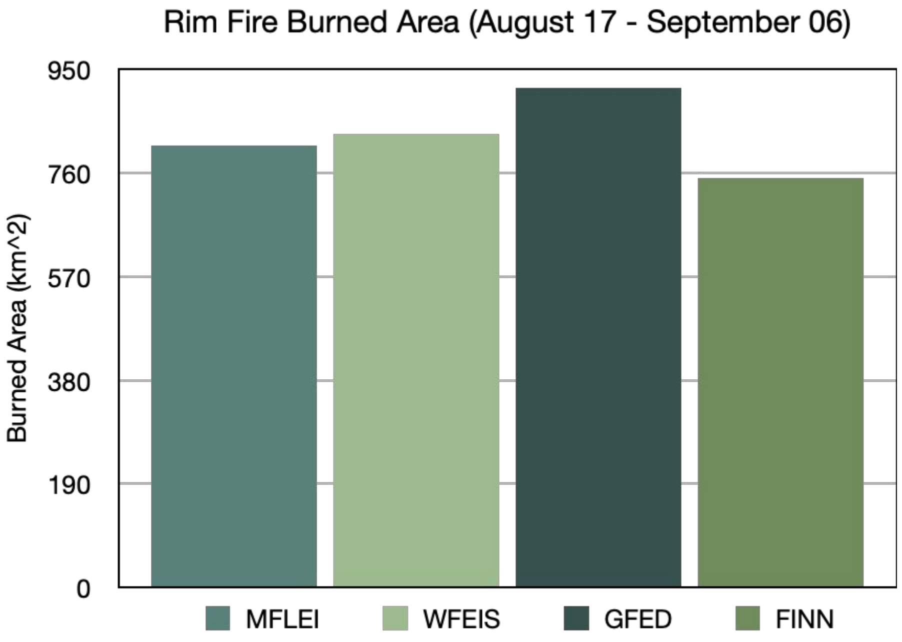
Fire Emissions Inventory Summary

	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

Direct Comparison

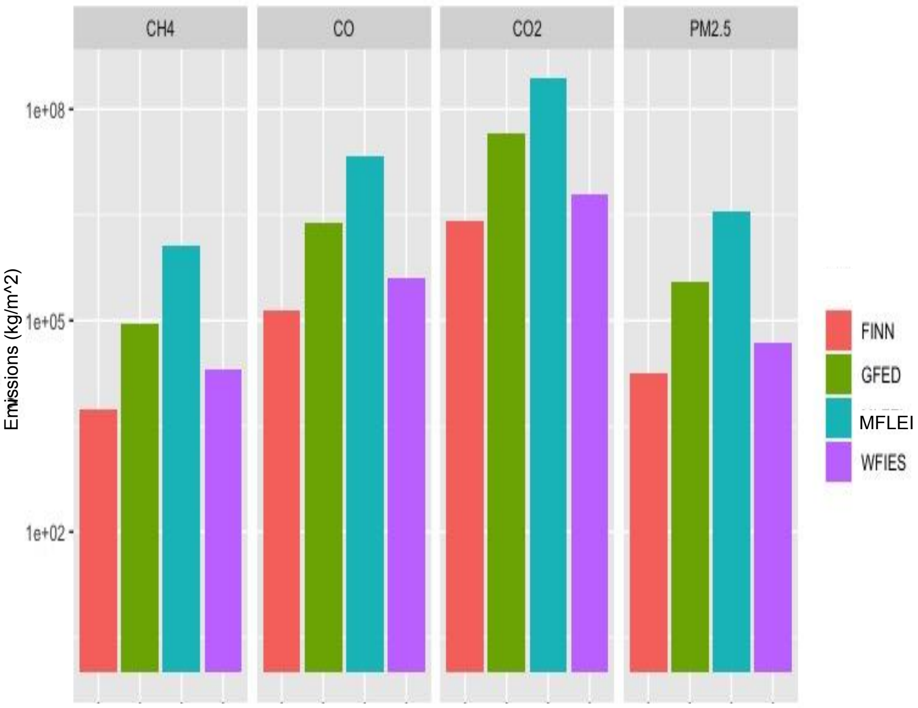
Burned Area Comparison



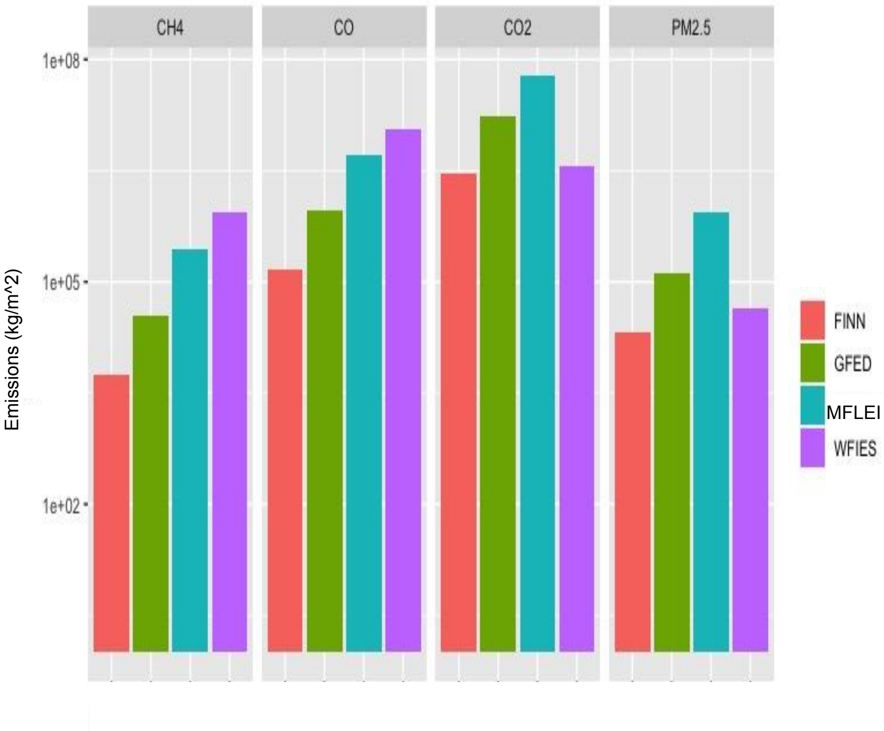


Emissions Comparison

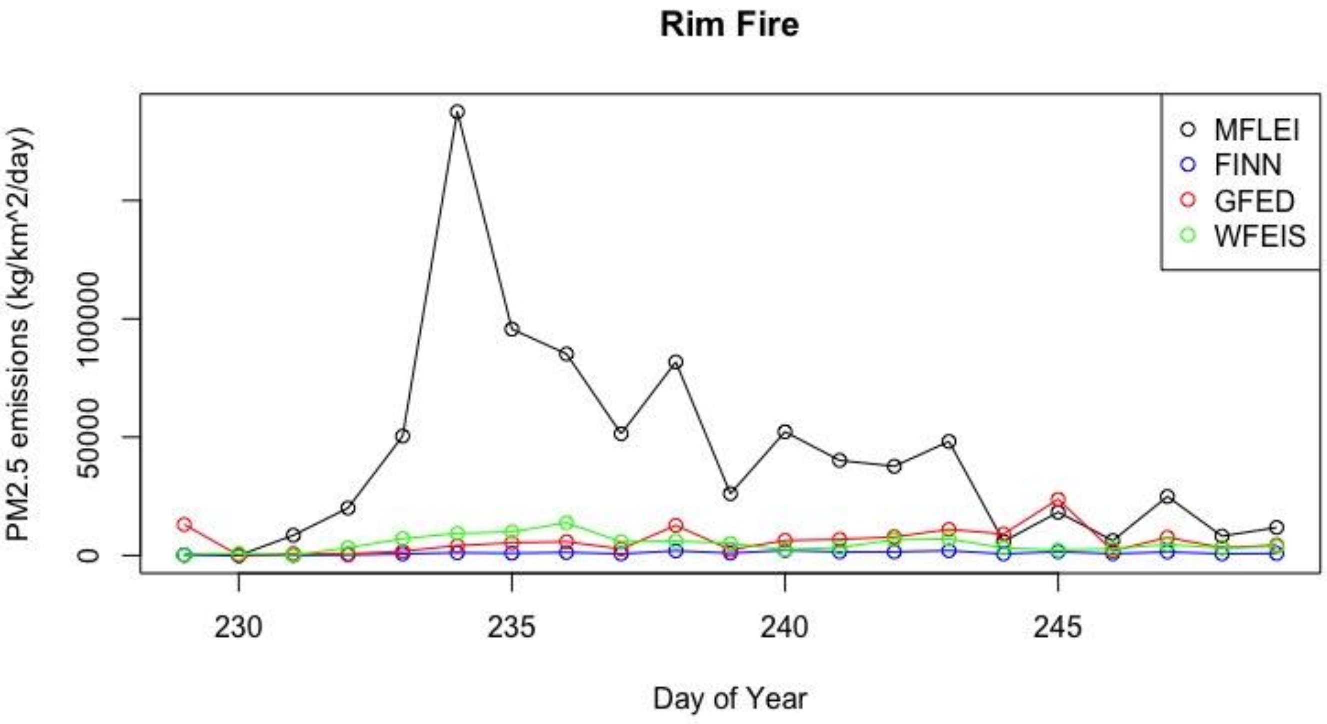
2013 Total Emissions

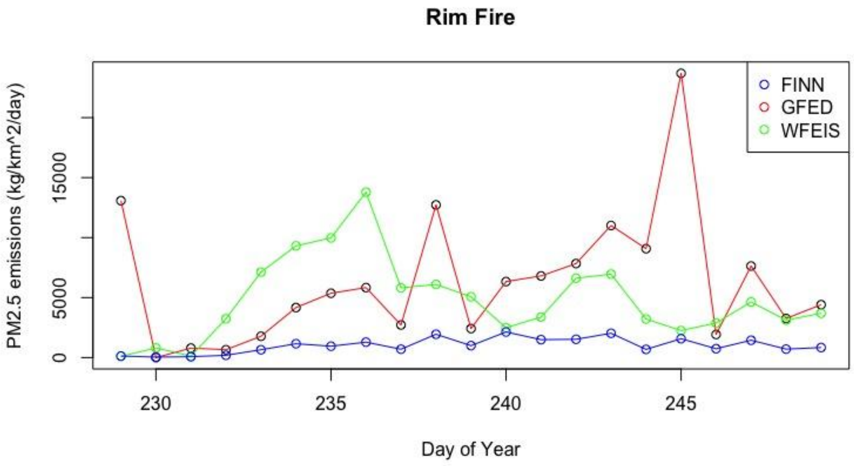


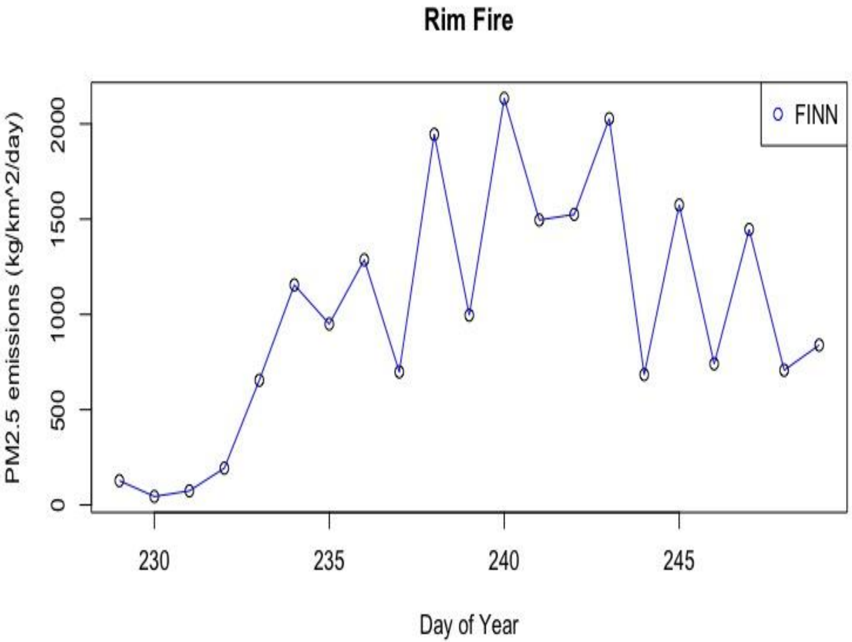
Rim Fire Total Emissions



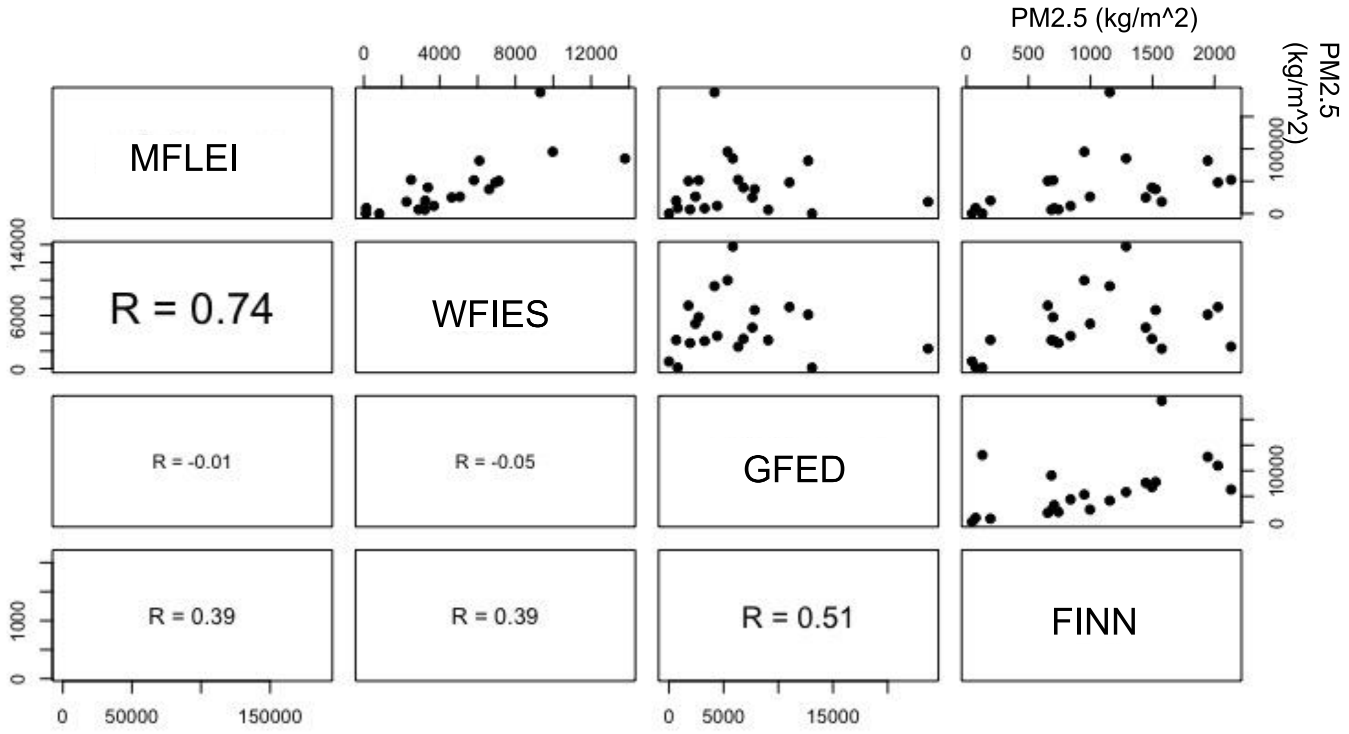
Rim Fire Daily Emissions




Rim Fire
PM2.5 emissions (kg/km^2/day)
0
5000
15000
230
235
240
245
Day of Year
FINN
GFED
WFEIS


Rim Fire
PM2.5 emissions (kg/km^2/day)
0
500
1000
1500
2000
230
235
240
245
Day of Year
FINN

Correlation Between Inventories

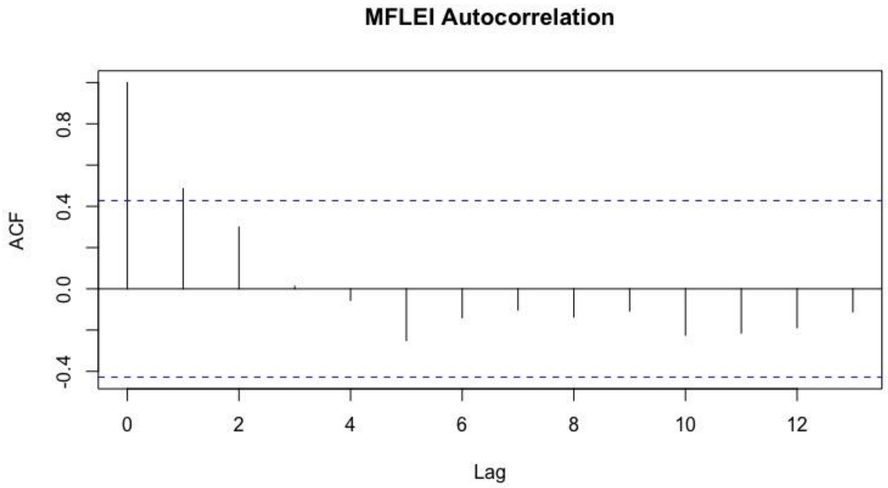


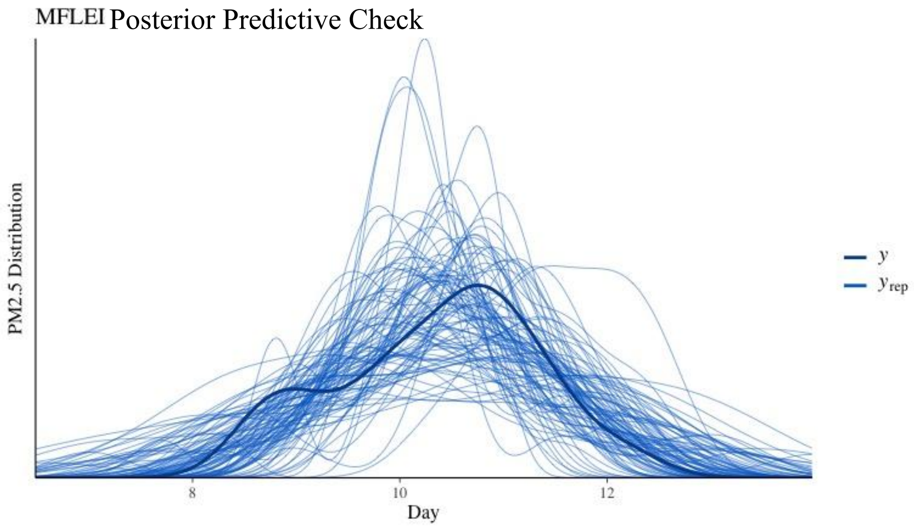
Bayesian Analysis

Model Description

- Single level model
- PM2.5 emissions per day of the Rim Fire
- MCMC sampling used to obtain information from the posterior distribution
- $y \sim \text{normal}(\alpha + \beta y_{n-1}, \boldsymbol{\sigma})$
  - α ~N(0, 10)
  - β ~ N(0, 2.5)
  - $\boldsymbol{\sigma}$ ~ exponential(rate = 1)

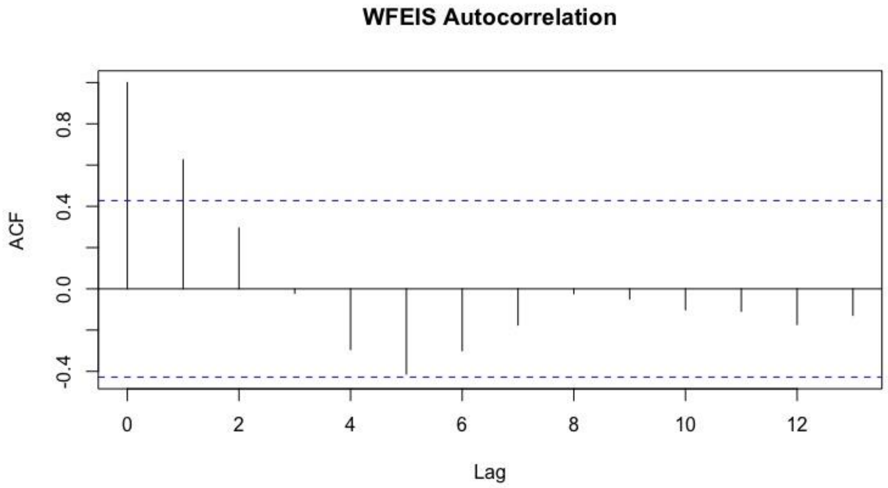
MFLEI

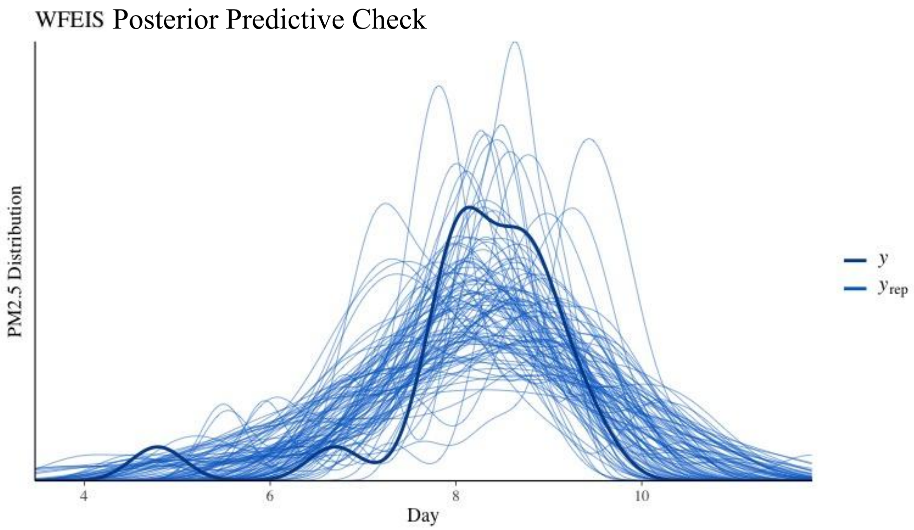




- Autocorrelation at day 1.
- Posterior summary statistics show a slope of 0.49 with a standard deviation of 0.23

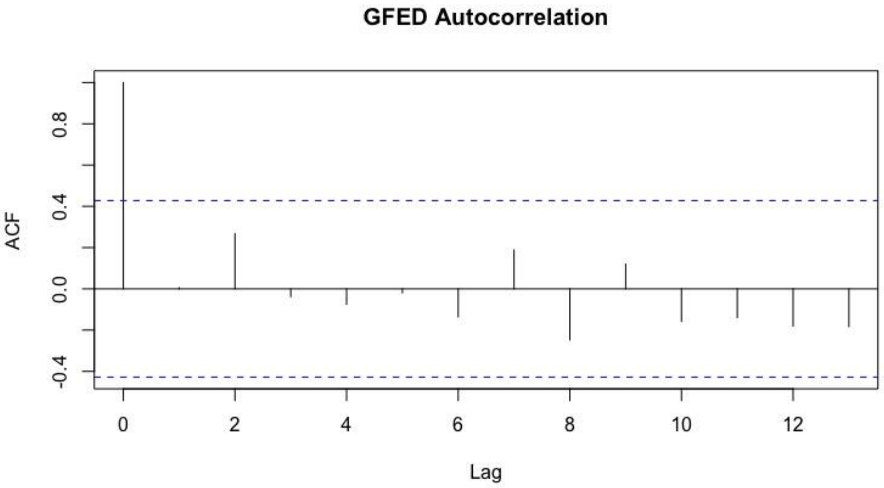
WFEIS

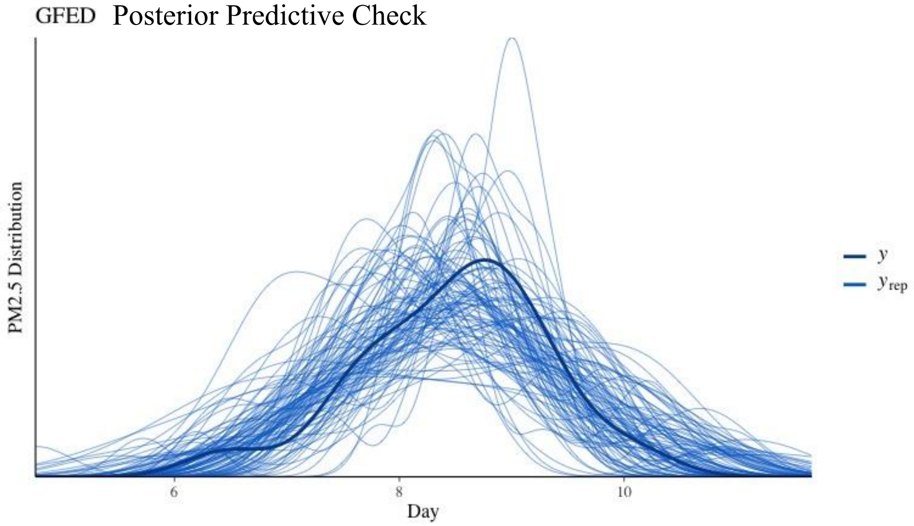




- Autocorrelation at day 1.
- Posterior summary statistics show a slope of 0.47 with a standard deviation of 0.16

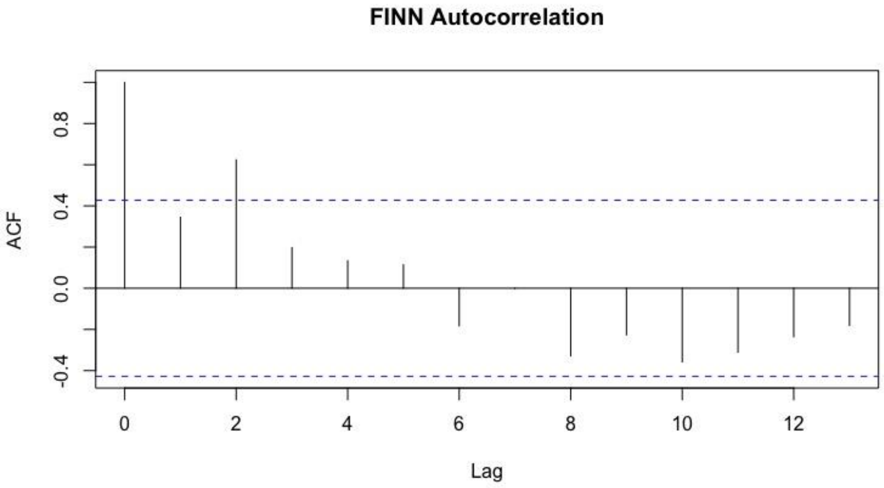
GFED

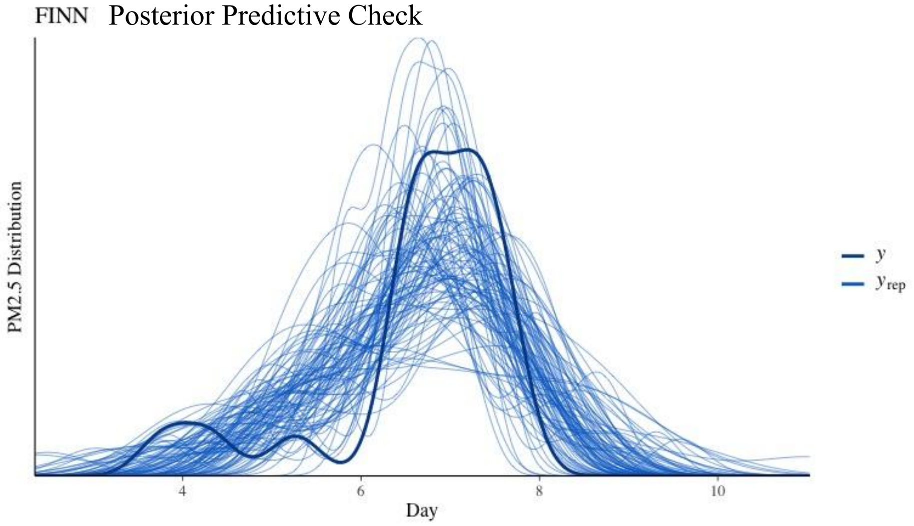




- No autocorrelation.
- Posterior summary statistics show a slope of 0.29 with a standard deviation of 0.22

FINN





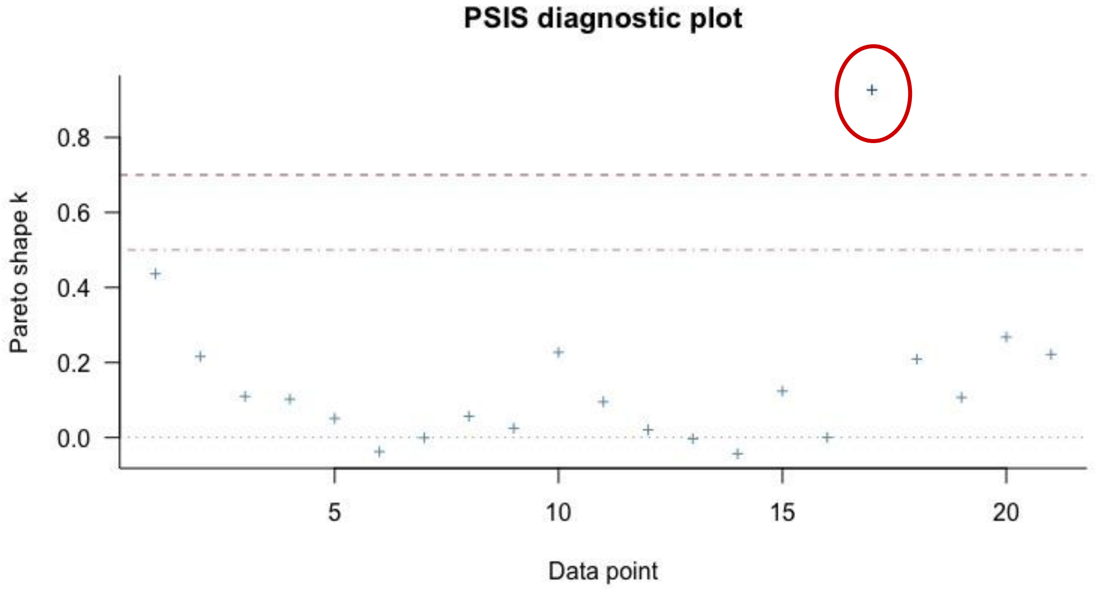
- Autocorrelation at day 2.
- Posterior summary statistics show a slope of 0.72 with a standard deviation of 0.15

Conclusions

- Based on my direct comparison and Bayesian analysis, WFEIS is most suitable for the project.
- Direct comparison shows FINN likely underestimates and MFLEI likely overestimates
- WFEIS has lowest posterior predictive standard deviation of the “reasonable” fire emissions inventories
  - High fuel consumption will be addressed in future updates

Future Work

- Use Bayesian analysis to evaluate measurement error for each model
- Use cross validation techniques to determine influential points in the distribution



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