Exceptional Events Study

Air Quality in Utah: Science for Solutions II

Derek V. Mallia[1*], Adam Kochanski[1], and Dien Wu[1], and John Lin (PI)[1]

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COLLEGE OF MINES AND EARTH SCIENCES | THE UNIVERSITY OF UTAH
DEPARTMENT OF ATMOSPHERIC SCIENCES

UTAH DEPARTMENT OF ENVIRONMENTAL QUALITY

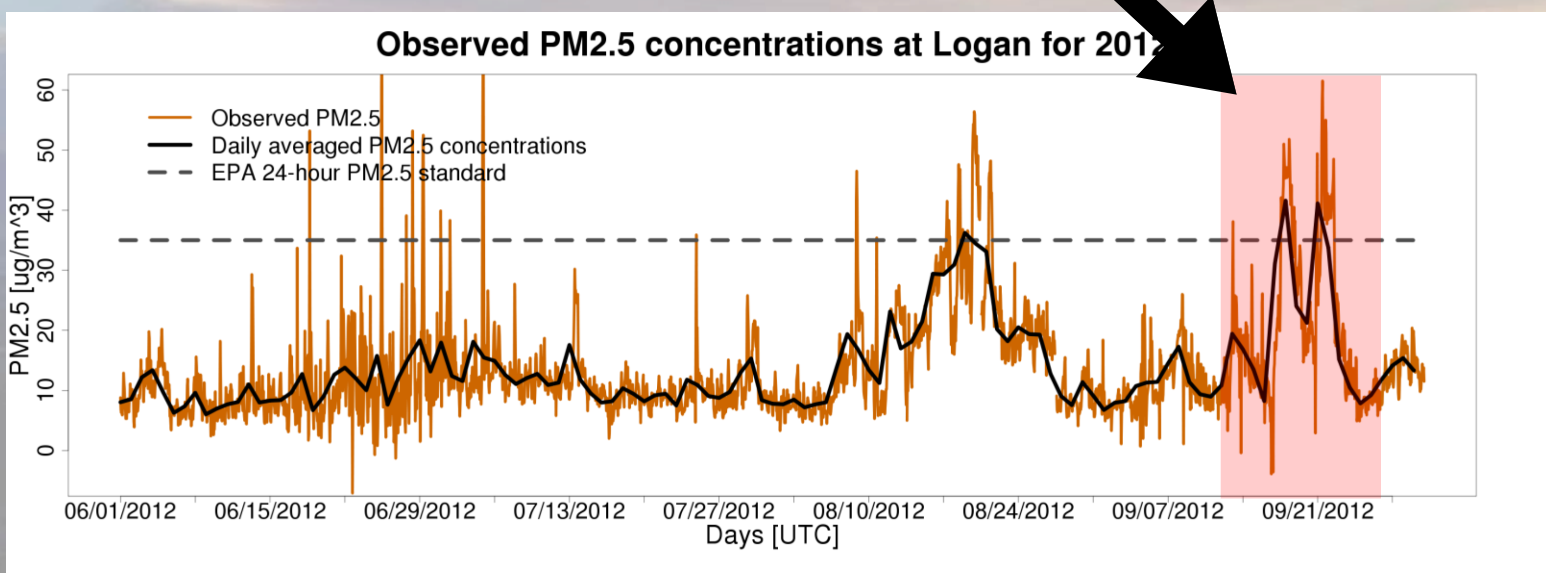
*Corresponding E-mail: Derek.Mallia@utah.edu

Motivation

- **Wildfires and dust storms can have significant impacts on regional air quality**

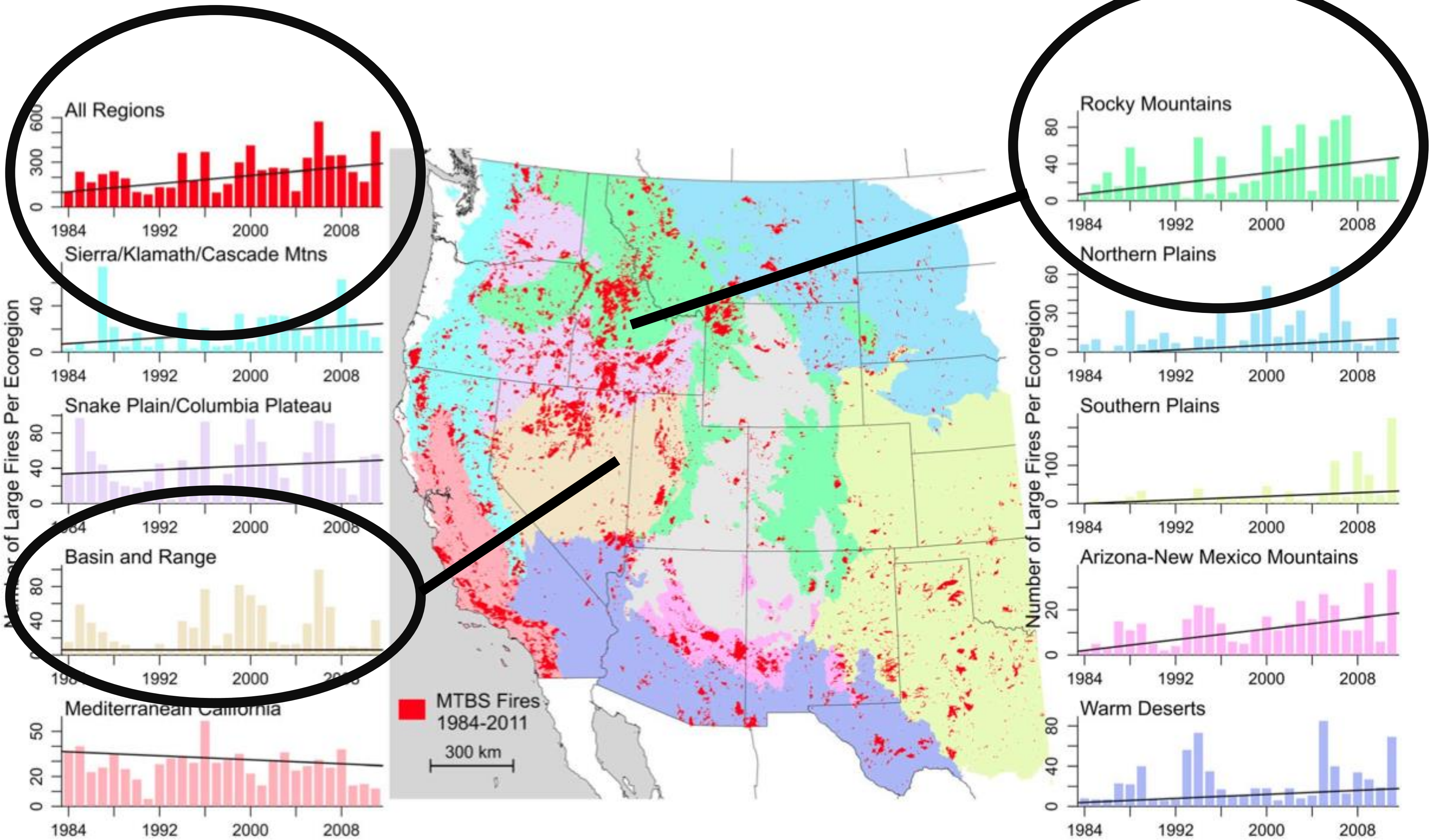
- **However, wildfires and dust storms are considered *exceptional events* as they are not reasonably controllable or preventable**

- **Our objective for this project is to *help the Utah Division of Air Quality identify days when the air quality in SLC is in non-attainment with respect to National Ambient Air Quality Standards due to wildfires and/or dust storms***

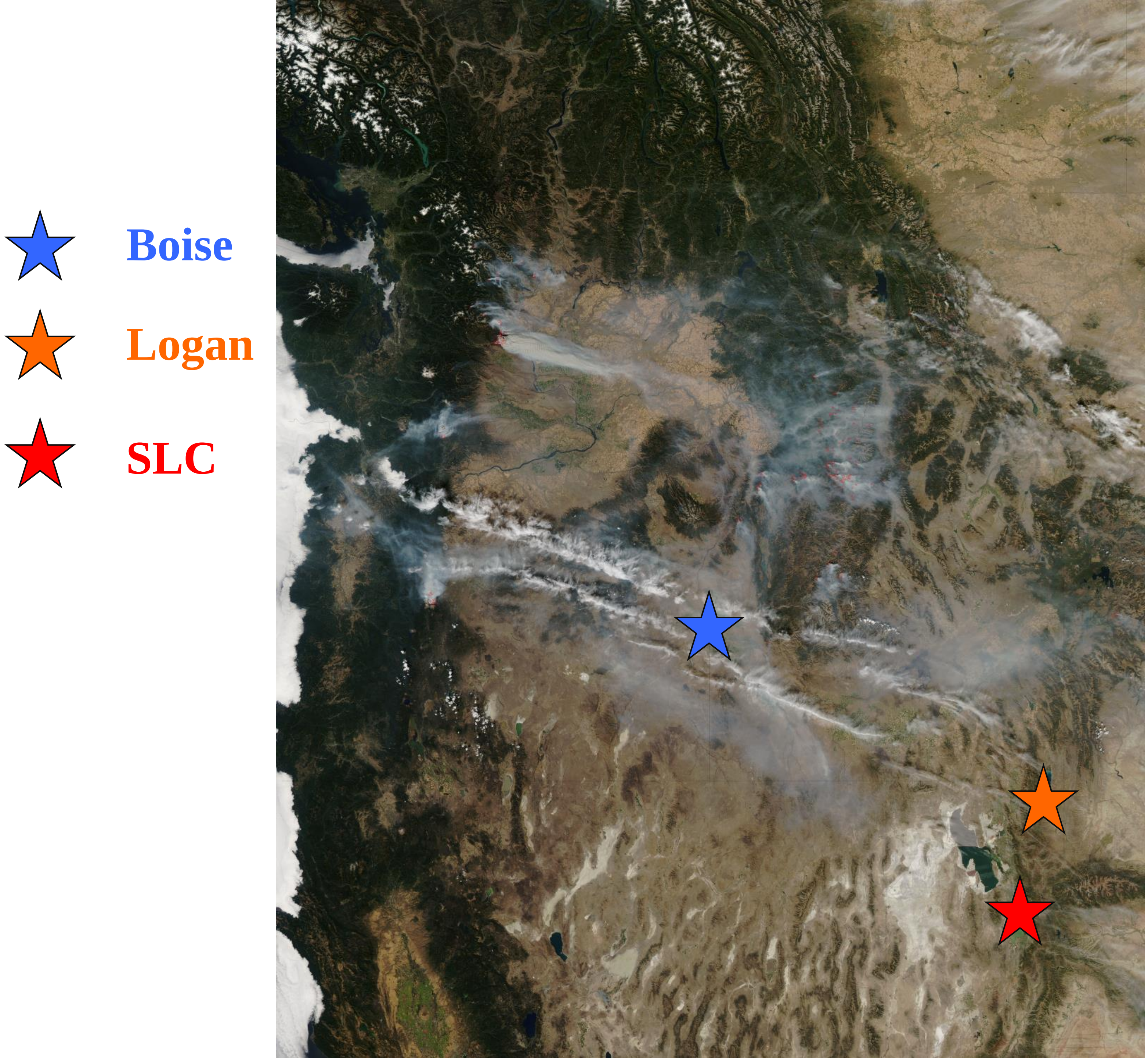


Wildfires

Western U.S. wildfire trends

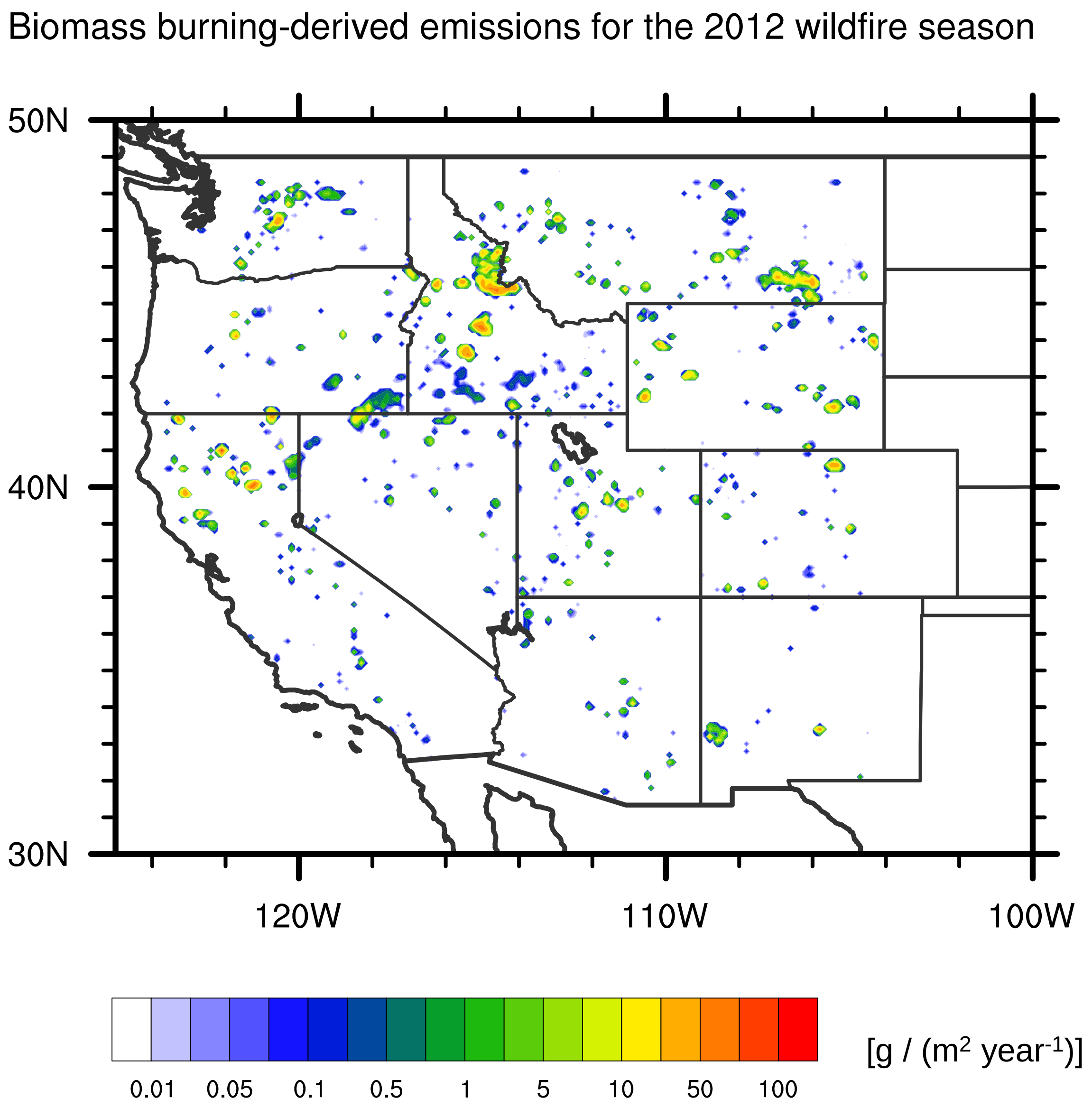


Source: Dennison, P. E., S. C. Brewer, J. D. Arnold, and M. A. Moritz (2014), Large wildfire trends in the western United States, 1984–2011, Geophys. Res. Lett., 41, 2928–2933, doi:10.1002/2014GL059576.


Boise
Logan
SLC


2012 western US Wildfire Season was one of the largest on record…

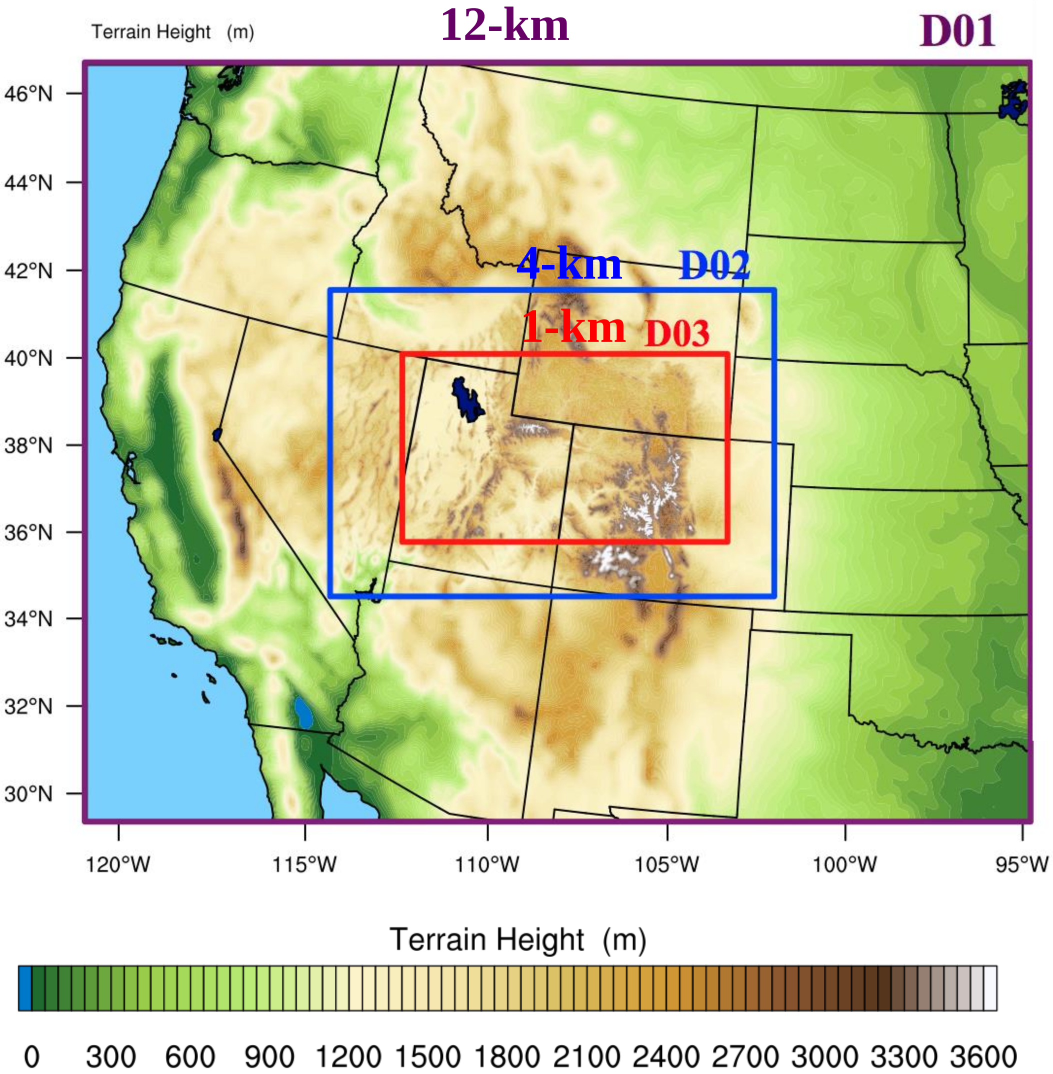
Where did most wildfire emissions occur during the 2012 wildfire season?



Emissions for [CO]

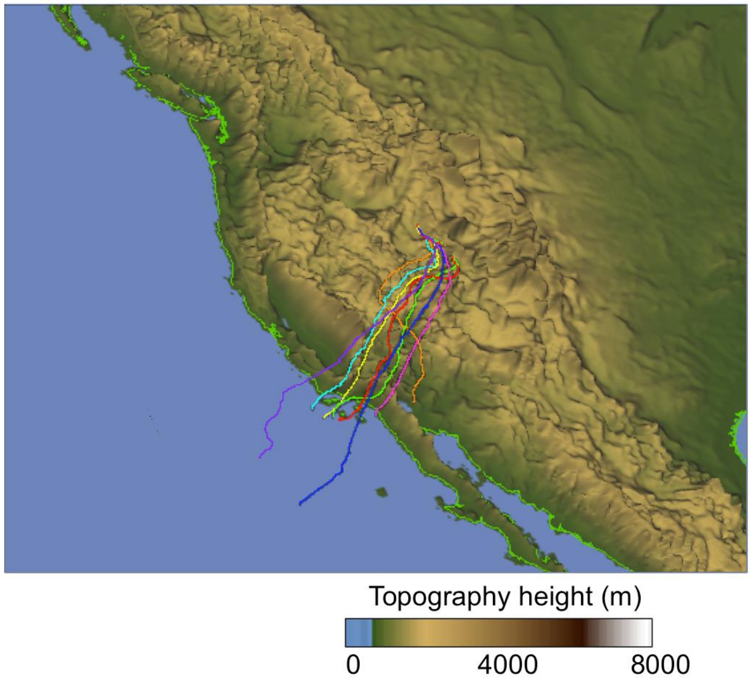
*Based on the Wildland Fire Emissions Inventory (*Urbanski et al.*, 2011)

Weather Research and Forecasting (WRF) model



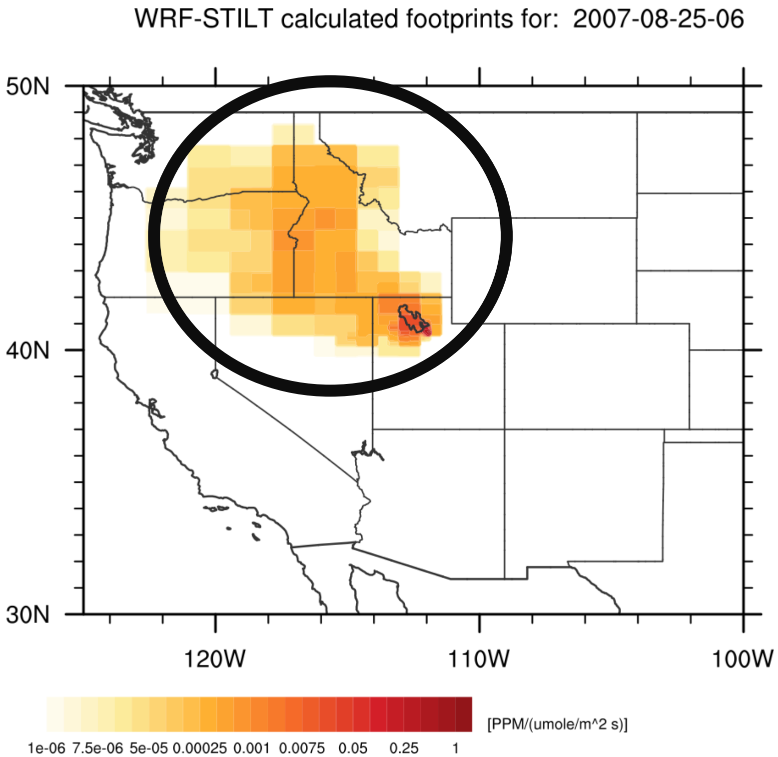
Skamarock et al., 2007

Stochastic Time-Inverted Lagrangian Transport (STILT) model [*Lin et al.*, 2003]



Using our trajectories, we can determine whether air that arrived at the Wasatch front passed over any wildfires!

Footprint x Emissions = Contribution of emission source



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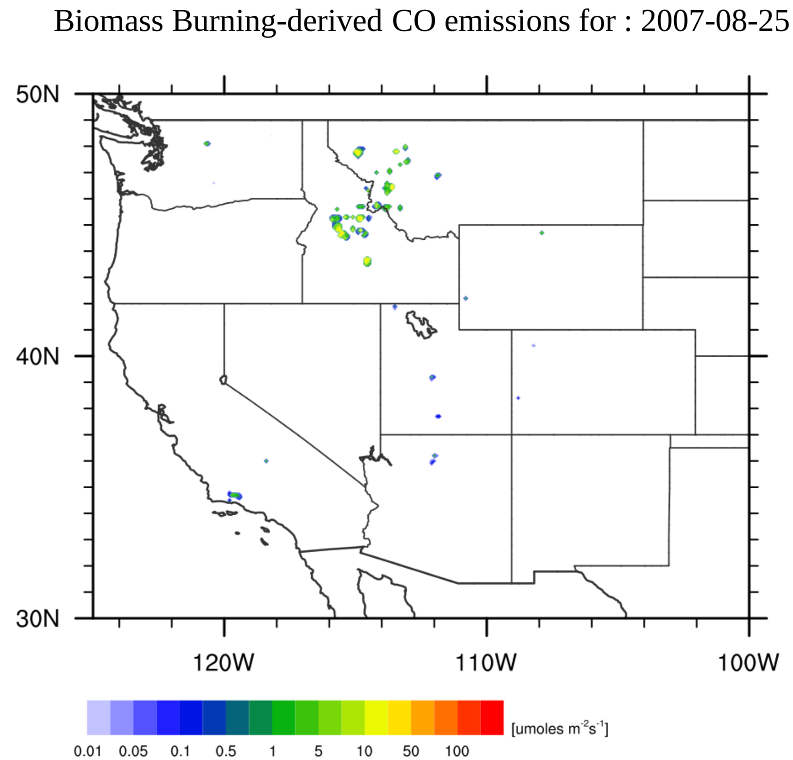

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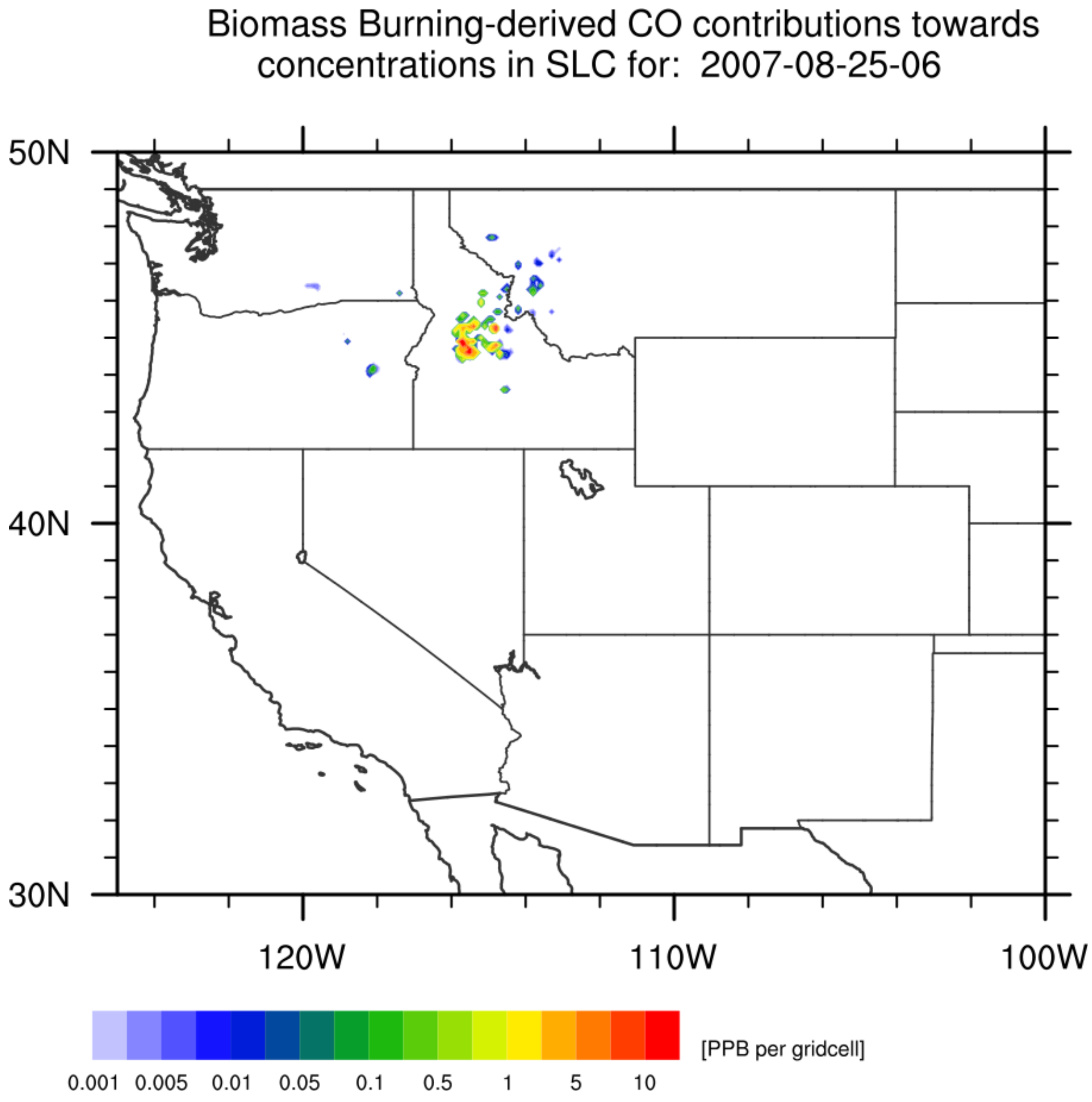
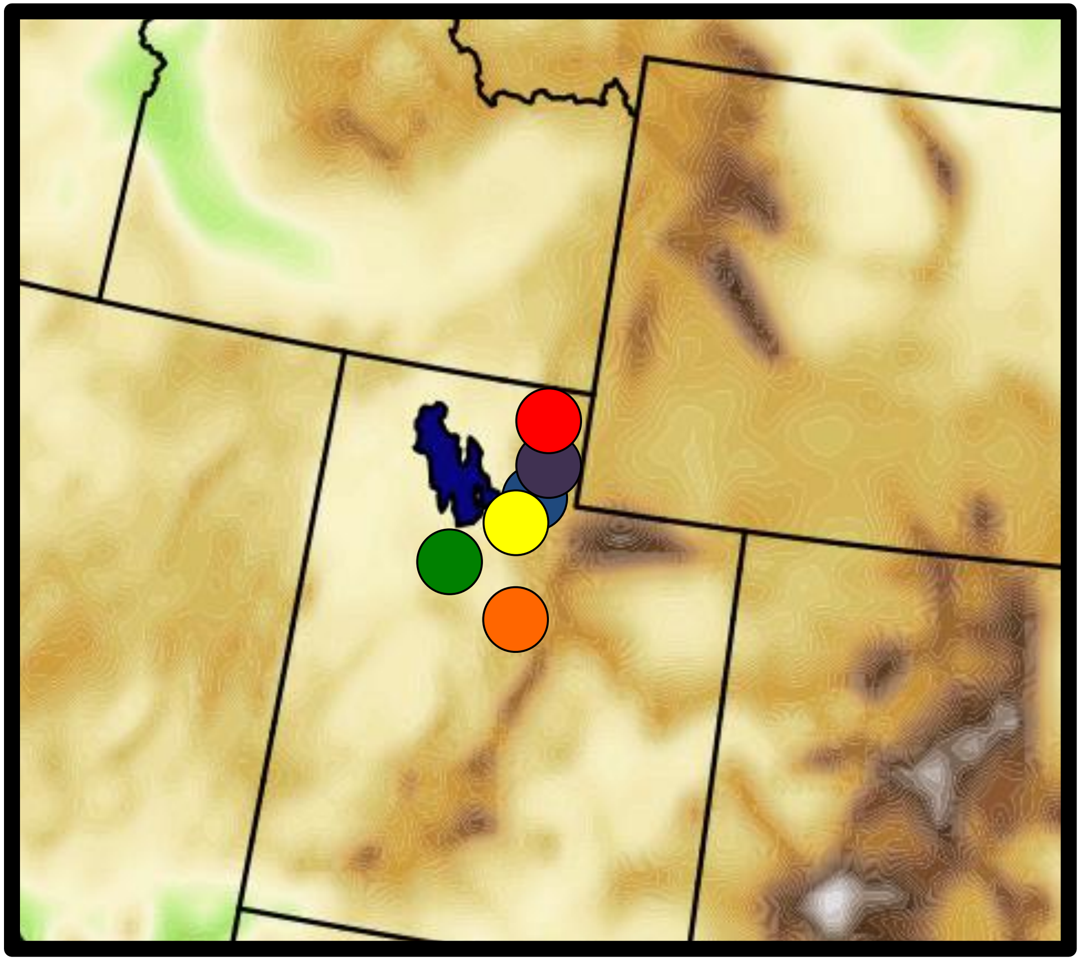
The orange/red areas indicate the source regions for air that is arriving at SLC

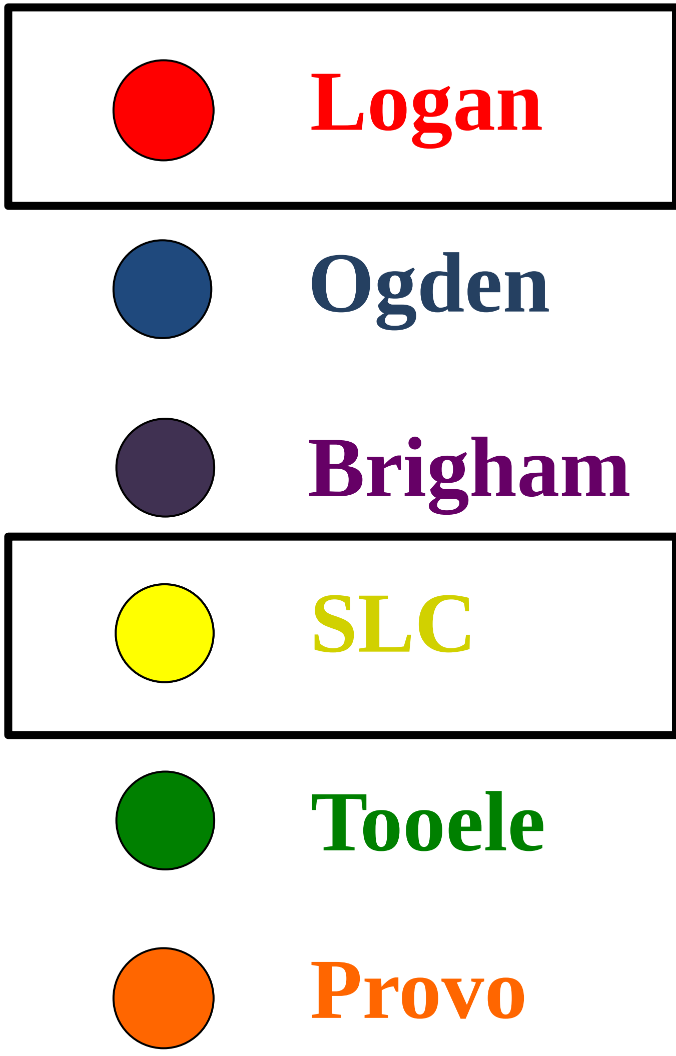
Warmer colors indicate wildfires with more emissions (and likely larger wildfires)

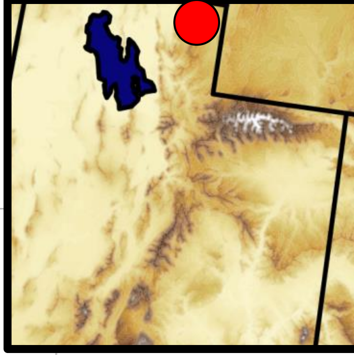


You can then sum up all of the contributions to determine the total contribution of "stuff" from *ALL* wildfires

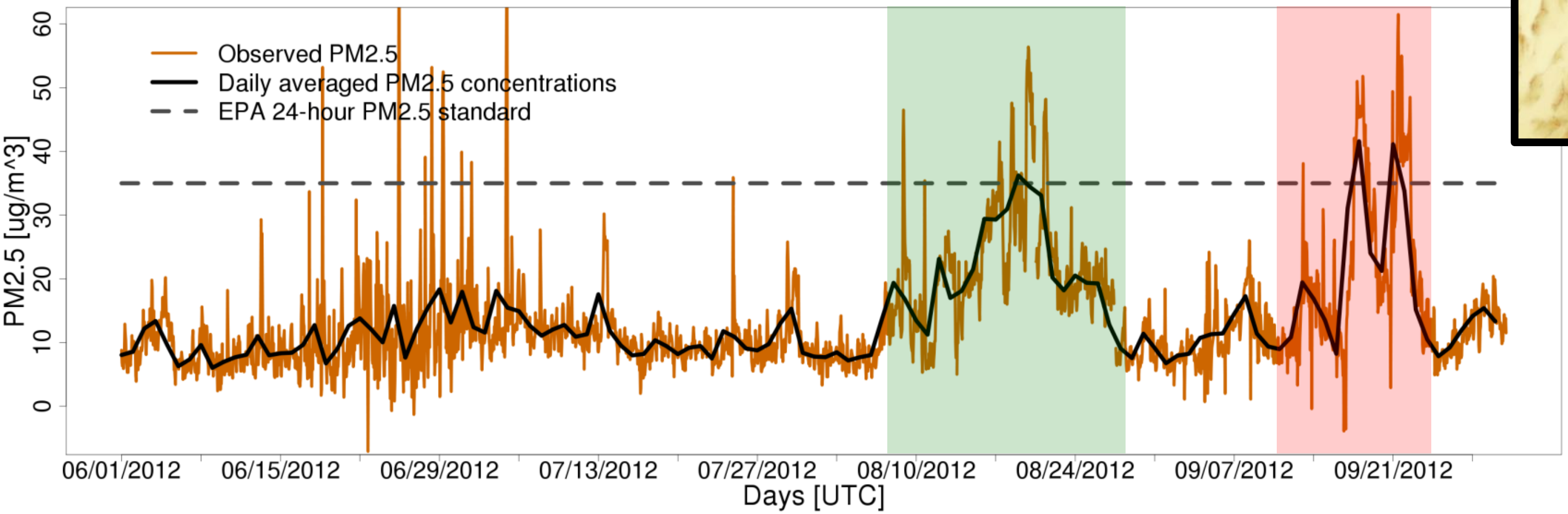
Study locations



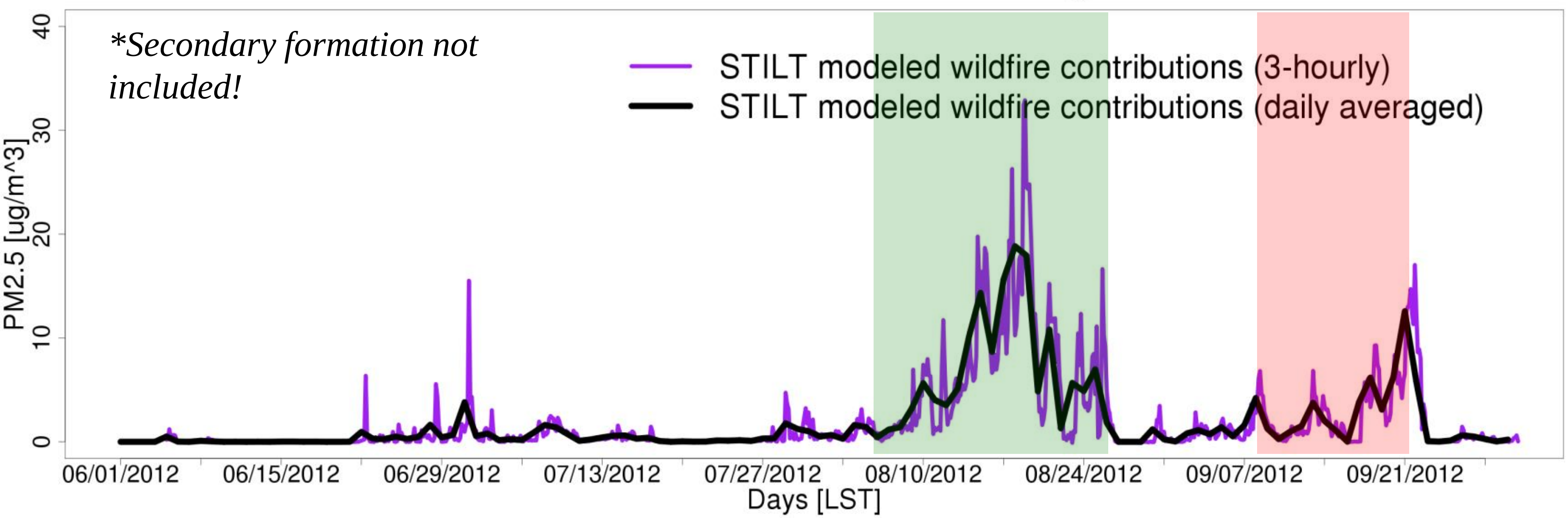




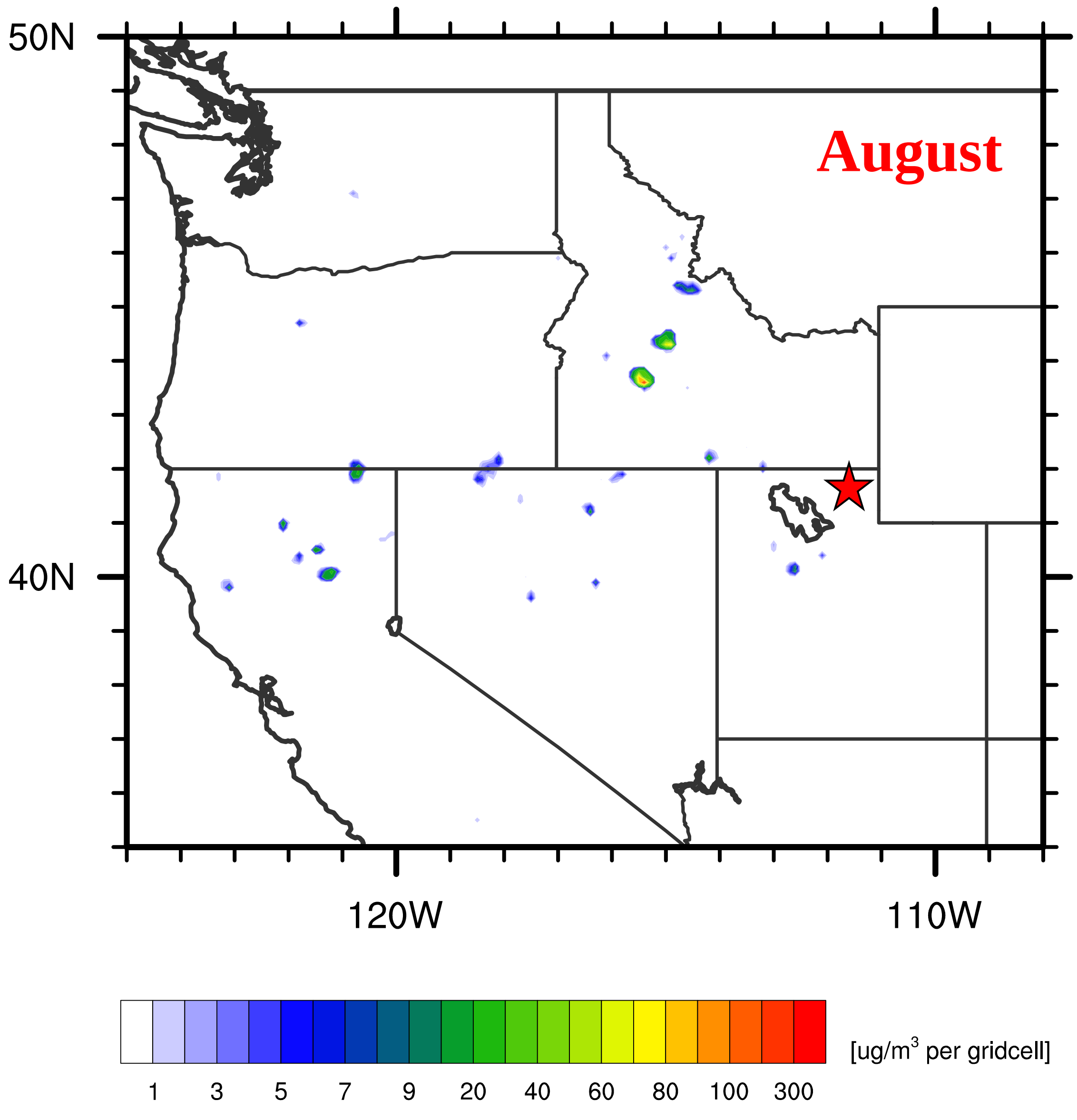
Observed PM2.5 concentrations at Logan for 2012



STILT modeled PM2.5 concentrations at Logan for 2012



Biomass Burning-derived PM2.5 contributions towards concentrations in Logan for August 2012



AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE
10.1002/2014JD022472

Key Points:
- WRF-STILT model used to determine impacts of wildfire emissions
- Wildfire emissions had episodic impacts in Salt Lake City
- Impacts of wildfires confirmed by observations

Correspondence to:
D. V. Mallia,
Derek.Mallia@utah.edu

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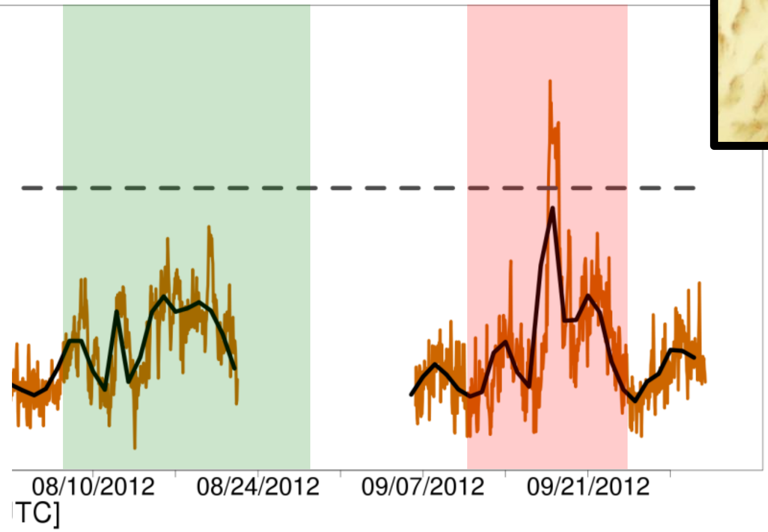
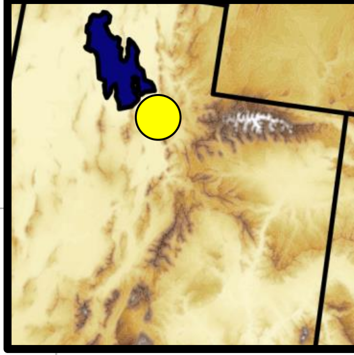
Impacts of upwind wildfire emissions on CO, CO_2, and $PM_{2.5}$ concentrations in Salt Lake City, Utah

D. V. Mallia[1], J. C. Lin[1], S. Urbanski[2], J. Ehleringer[3], and T. Nehrkorn[4]

[1]Department of Atmospheric Sciences, University of Utah, Salt Lake City, Utah, USA, [2]Missoula Fire Sciences Laboratory, Rocky Mountain Research Station, United States Forest Service, Missoula, Montana, USA, [3]Department of Biology, University of Utah, Salt Lake City, Utah, USA, [4]Atmospheric and Environmental Research Inc., Lexington, Massachusetts, USA

Abstract Biomass burning is known to contribute large quantities of CO_2, CO, and $PM_{2.5}$ to the atmosphere. Biomass burning not only affects the area in the vicinity of fire but may also impact the air quality far downwind from the fire. The 2007 and 2012 western U.S. wildfire seasons were characterized by significant wildfire activity across much of the Intermountain West and California. In this study, we determined the locations of wildfire-derived emissions and their aggregate impacts on Salt Lake City, a major urban center downwind of the fires. To determine the influences of biomass burning emissions, we initiated an ensemble of stochastic back trajectories at the Salt Lake City receptor within the Stochastic Time-Inverted Lagrangian Transport (STILT) model, driven by wind fields from the Weather Research and Forecasting (WRF) model. The trajectories were combined with a new, high-resolution biomass burning emissions inventory—the Wildfire Emissions Inventory. Initial results showed that the WRF-STILT model was able to replicate many periods of enhanced wildfire activity observed in the measurements. Most of the contributions for the 2007 and 2012 wildfire seasons originated from fires located in Utah and central Idaho. The model results suggested that during intense episodes of upwind wildfires in 2007 and 2012, fires contributed as much as 250 ppb of CO during a 3 h period and 15 $\mu g/m^3$ of $PM_{2.5}$ averaged over 24 h at Salt Lake City. Wildfires had a much smaller impact on CO_2 concentrations in Salt Lake City, with contributions rarely exceeding 2 ppm enhancements.





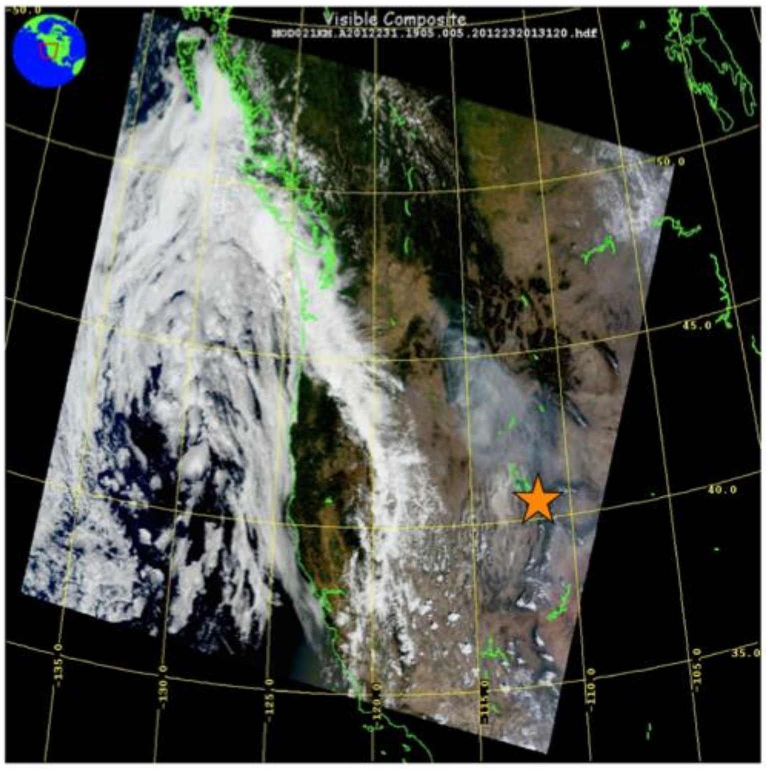
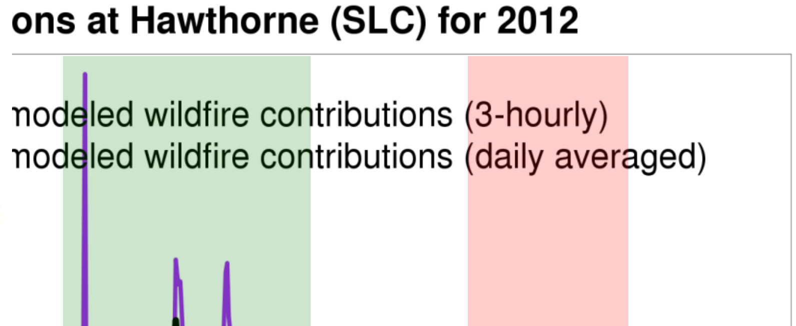
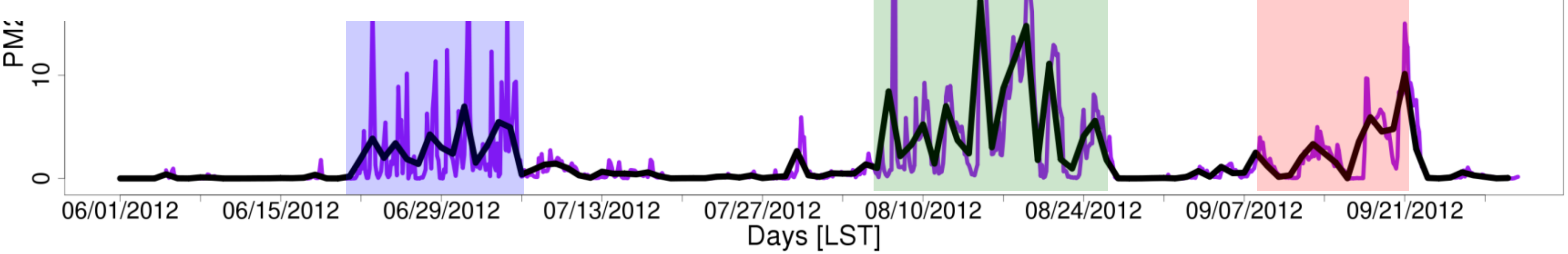
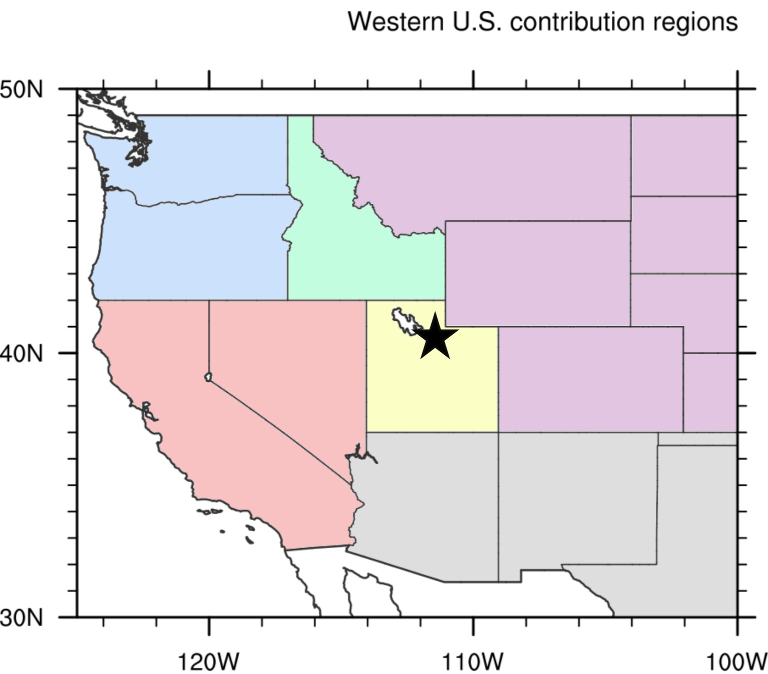


Figure 13. MODIS scan from the TERRA polar-orbiting satellite of the visible light spectrum on 18 August 2012 at 1905 UTC. The star indicates the location of SLC. Credit: NASA.

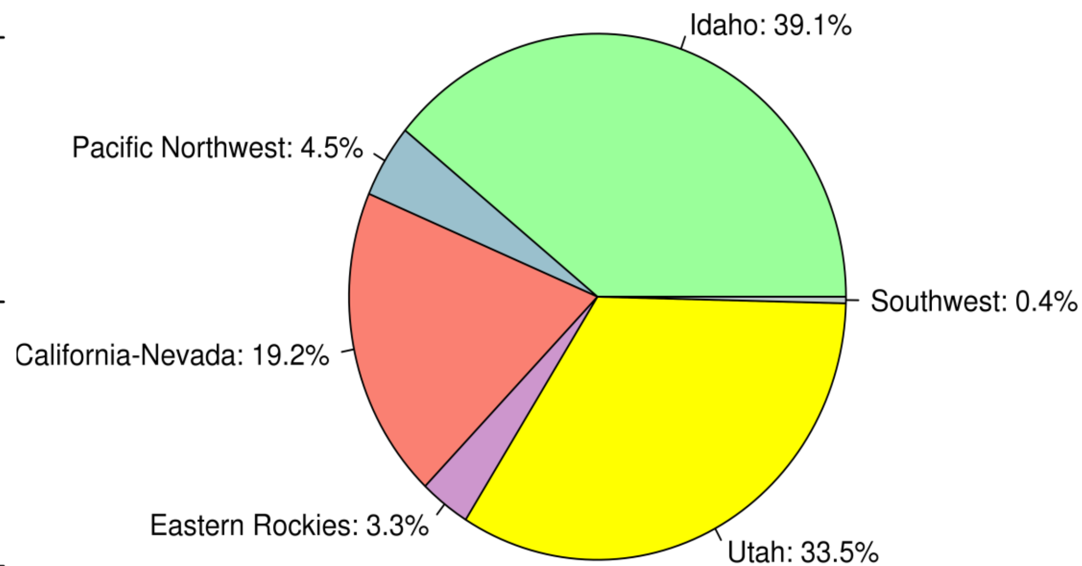




For Salt Lake City



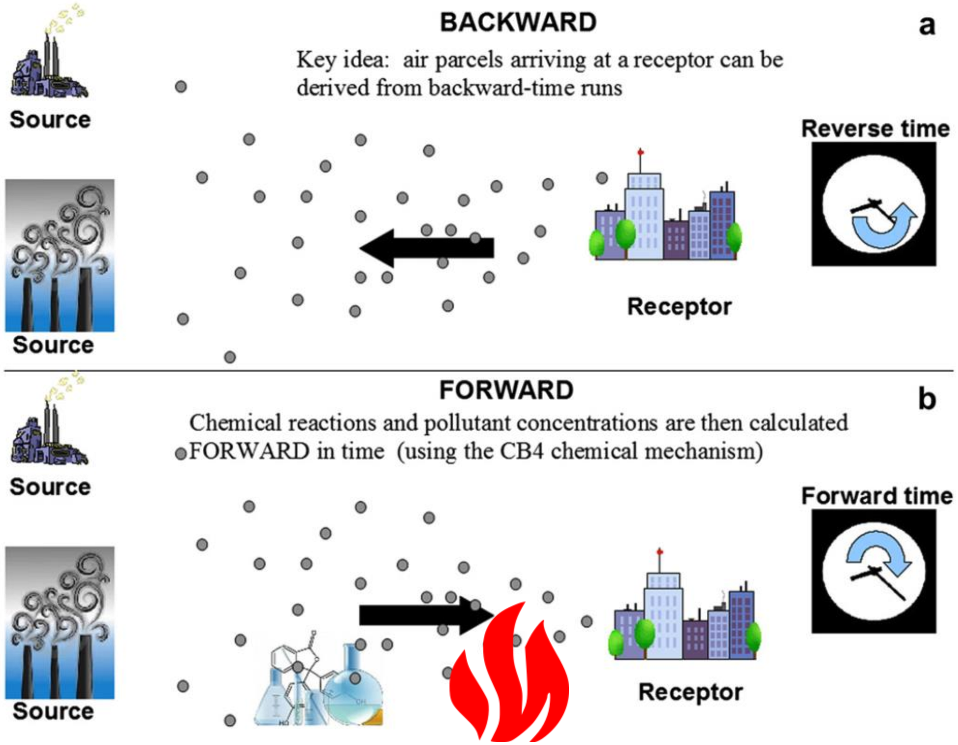
2012 Wildfire Contributions by Region for CO



Mallia, D. M., J. C. Lin, S. Urbanski, and J. Ehleringer , and T. Nehrkorn (2015), Impacts of upwind wildfire emissions on CO, CO_2, and $PM_{2.5}$ concentrations in Salt Lake City, Utah, J. Geophys. Res. Atmos., 119.

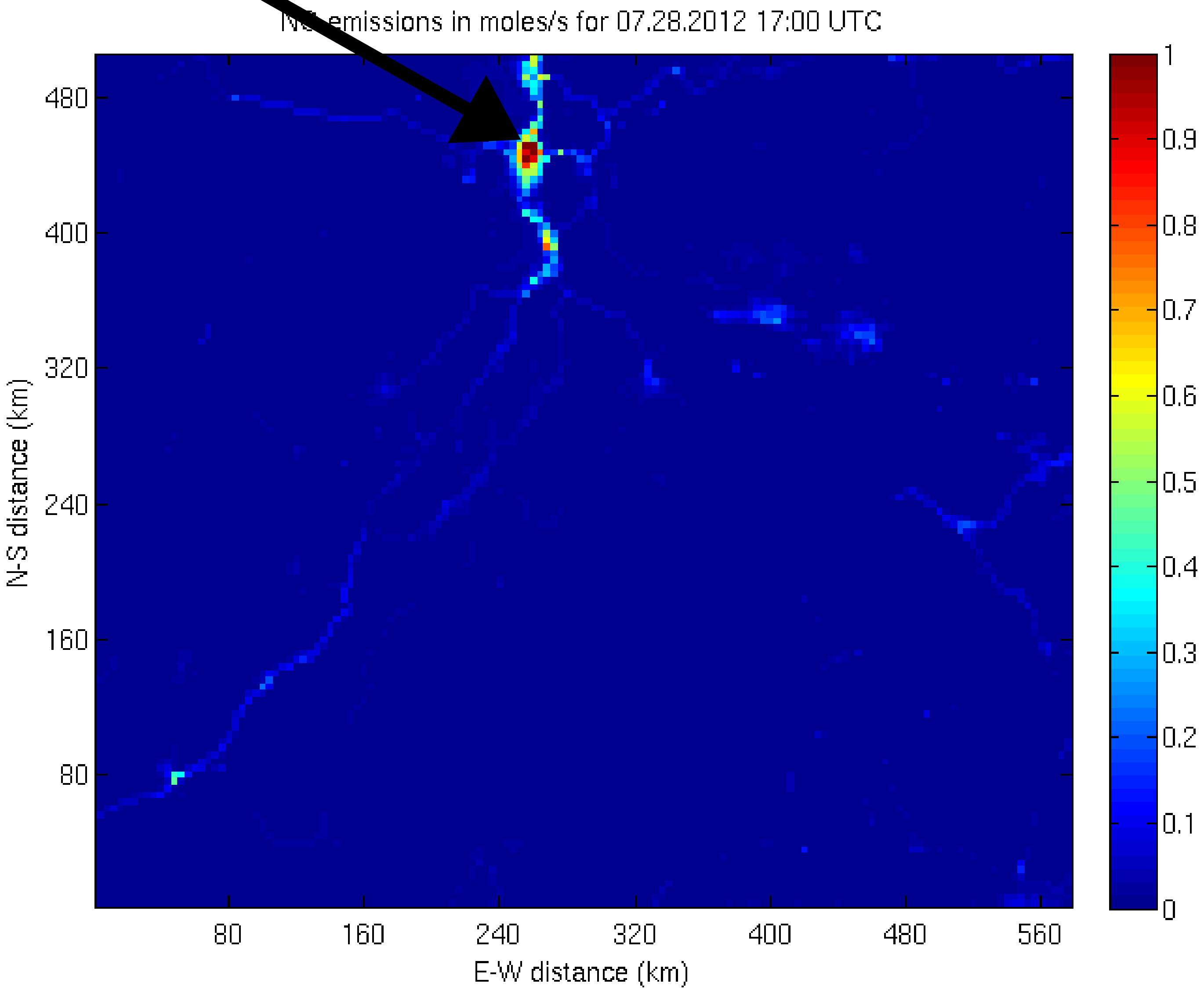
STILT-Chem *[Wen* et al., 2012]

- While primary $PM_{2.5}$ from wildfires can be modeled reasonably without chemistry, ozone is a bit trickier as there are many chemical reactions that impact ozone concentrations which will require implementing the STILT-Chem model

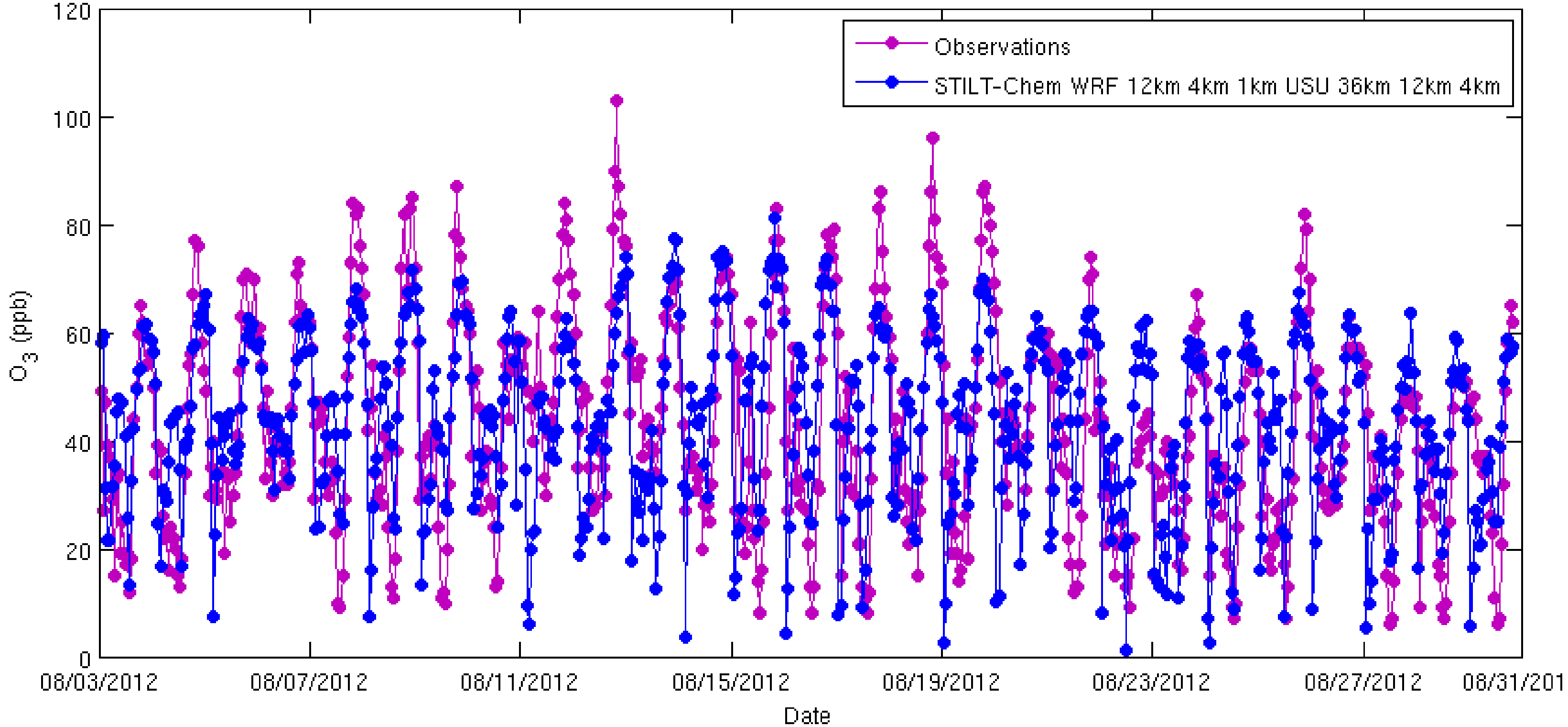


Salt Lake City

USU Vernal Emissions (NO_x)



Modeled vs. observation ozone concentrations for SLC



- Initial simulations show that STILT can reasonably model the diurnal cycle of ozone within the Salt Lake Valley

- The next step will be to include wildfire emissions (from the WFEI) to see how simulated ozone concentrations are modified by these emissions

Dust storms

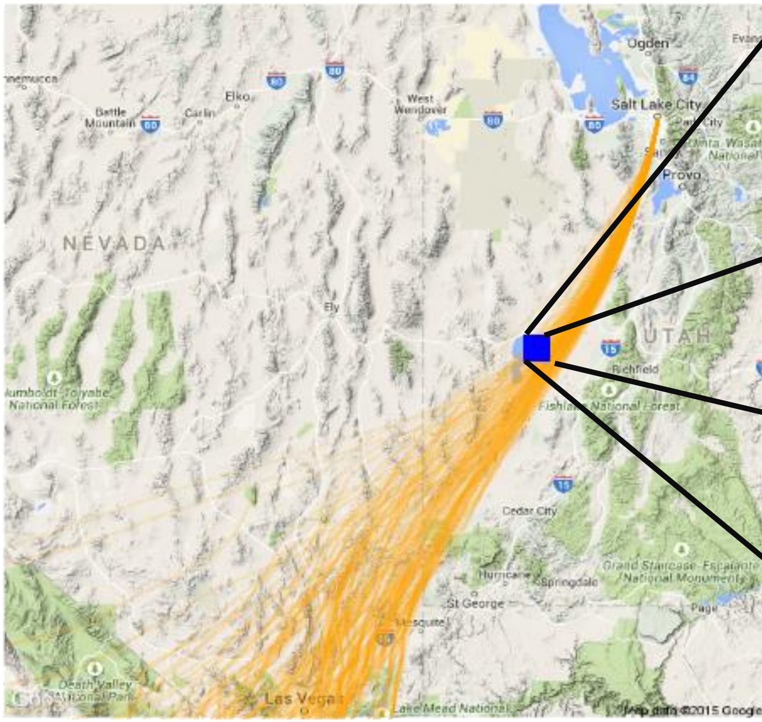
- First step for modeling dust events will to construct dust emission model in collaboration with DAQ which can accurately determine the flux of dust into the atmosphere

$$F = \sum_{i,j} K \times A \times \frac{\rho}{g} \times S_i \times \mathrm{SEP} \times u_* \times (u_*^2 - u_{*ti,j}^2) \text{ for } u_* > u_{*t}$$

Fu et al., [2014]

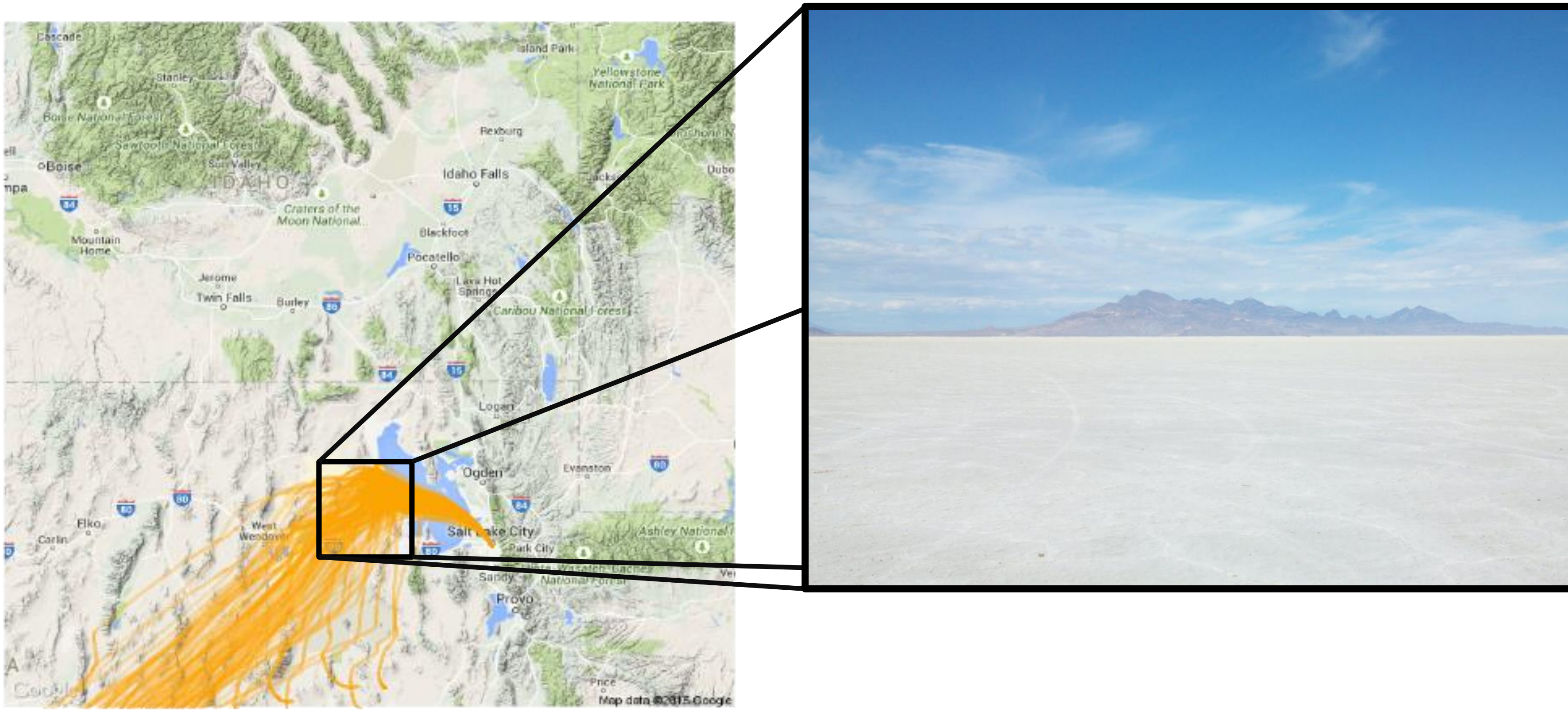
- The following equation measures to flux of dust (F), which is essentially dependent on the landuse/soil type (I.E salt flats vs urban sprawl), wind speed, soil moisture, and the amount of erodible soil available

Trajectories arriving at SLC (April 27th 2010)



- Similar to the wildfire modeling study, we will combine the “footprint” with our dust emission model to determine how dust contributed towards suspected exceptional events

Trajectories arriving at SLC (May 21st 2008)



- Dust event possibly originating from the Salt Flats

Conclusions/future work

- It has been demonstrated the WRF-STILT model can accurately replicate periods of enhanced $PM_{2.5}$ simulations for the Wasatch front, suggesting that wildfires were responsible for $PM_{2.5}$ exceedances along the Wasatch Front

- Many of these contributions came from wildfires that were out-of-state!

- Initial model results show that STILT-Chem can reasonably replicate ozone concentrations across the Wasatch front

- Next goal is to re-run STILT-Chem with wildfire emissions

- Modeling framework has been laid out for dust events, which should hopefully be implemented by this fall--

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