Development of A Forest Fire Smoke Emission and Dispersion Model Using Real-time MODIS Data

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Outline

- Overview of goal
- Background
  - MODIS DB
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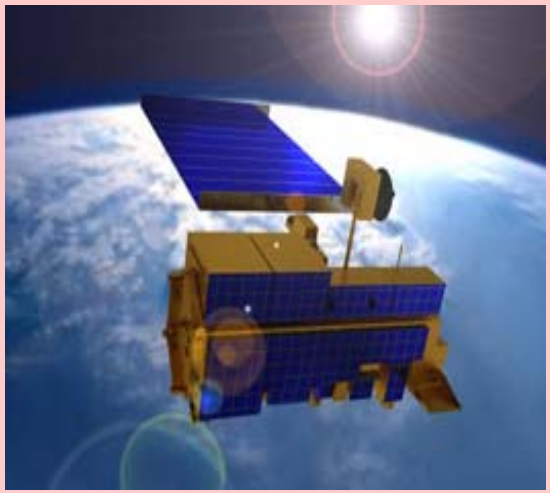
- Emissions calculations
- Hayman Fire results
- Conclusions and future work

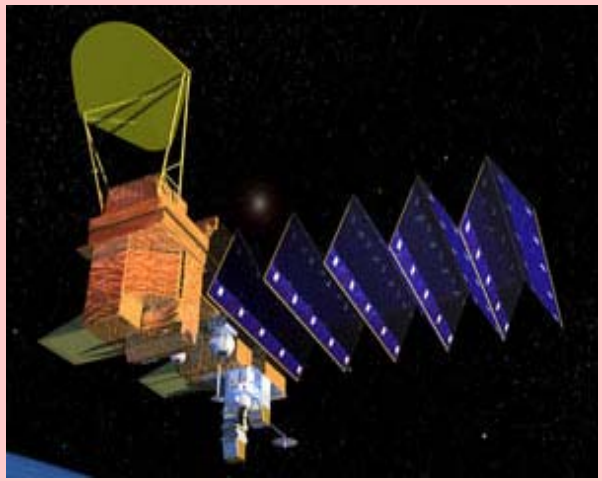
Objectives

- Develop a nationwide emissions inventory of trace gases and aerosol particles from fires, with 1-km resolution, at 10:30 a.m. and 1:30 p.m. daily.
- Integrate the emissions inventory into the NOAA Weather Research and Forecasting (WRF) model and HYSPLIT-4 dispersion model to forecast smoke dispersion and pollutant concentrations.
- Automate the WRF and HYSPLIT forecast models and improve forecast accuracy by comparing forecast results with satellite measurements of CO and particulate concentrations.
- Train air quality managers to use the forecast model.

Background - MODIS

The NASA Earth Observing System (EOS) satellites Terra and Aqua (shown at left) each carry a MODIS (**MOD**erate resolution **I**maging **S**pectroradiometer) instrument onboard. Each MODIS instrument collects 36 spectral bands of information over the globe twice daily. These bands range from 0.4 to 14.4 μm.



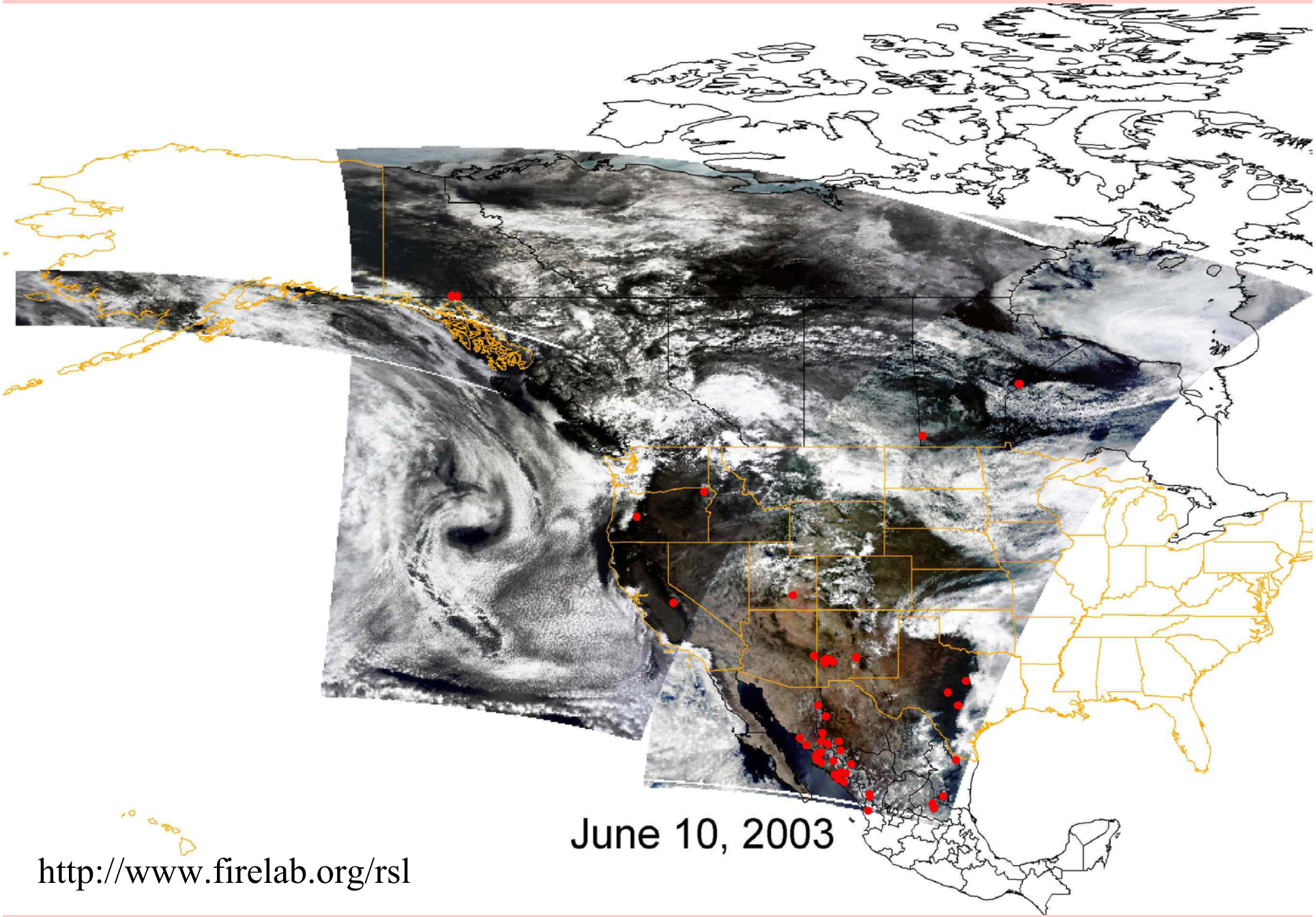


Background – MODIS DB

•The satellites transmit the data collected by the MODIS instruments in real time.

•At the Fire Sciences Laboratory, real-time data is collected with a Direct Broadcast (DB) station.

•Processing consists of georegistration, atmospheric correction, hot spot (active fire) detection, and a newly added burn scar detection algorithm.



http://www.firelab.org/rsl

Background – Burned Area Algorithm

- When satellite overpass is cloud-free, use preliminary near infrared (NIR) spectral burn area algorithm from NASA Goddard Space Flight Center.
- When clouds or thick smoke block the NIR wavelengths, use the hull of accumulated hot spot detections from all passes during the duration of fire, up to last overpass image clear in the thermal spectral range (often the previous evening).

Background – Burned Area Algorithm

- The *convex hull* is the shape produced by stretching a rubber band around the points
- The *alpha shape* is a generalization of the convex hull
- The parameter *alpha* is adjusted to vary between the extreme cases of the point set itself and the convex hull

Convex Hull

1.5km Alpha Hull

Emission Calculations

- Burned area converted from units of projection (m^2) to hectares
- Total fuel loading obtained by multiplying by Kg/ha for fuel type (from previous field data or NFDRS)
- Percent of fuel consumed based upon fuel type and area burned
- Emission factors chosen from field work done previously in similar fuel types

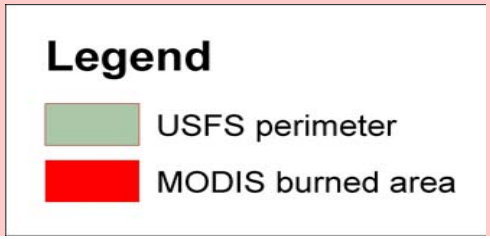
$$m^2 * \frac{ha}{m^2} * \frac{Kg}{ha} * \% * \frac{g}{Kg} = g$$

Hayman Fire Results

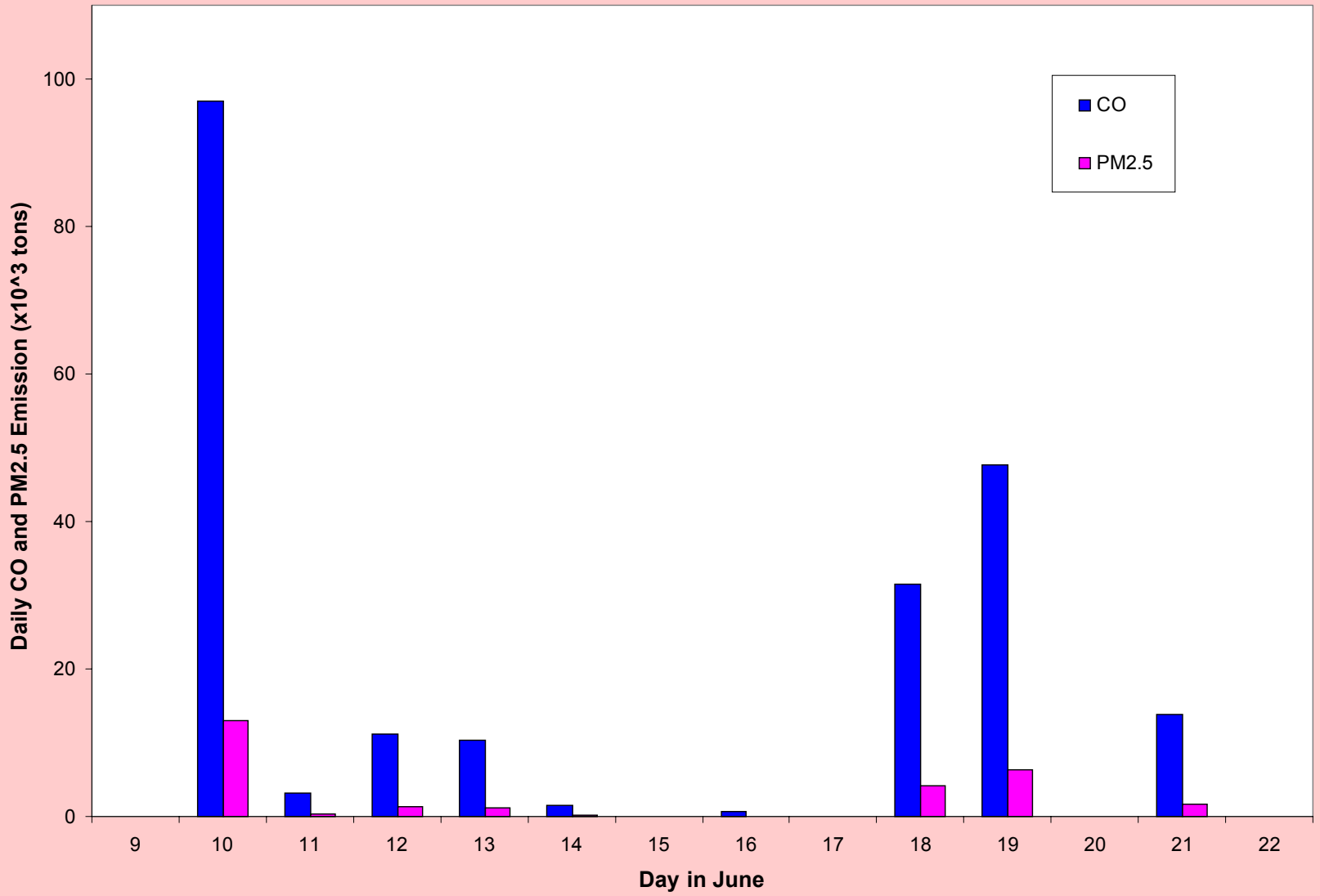
June 14

June 19

Final



Hayman Fire Results



Hayman Fire Results

Conclusions

- The majority of CO and PM2.5 was emitted during the period of June 9-13 and June 18-21 when fires propagated extensively.
- Approximately 2.2 x 10^5 tons of CO and 2.9 x 10^4 tons of PM2.5 were emitted during the entire period of the Hayman Fire.
- The amount of CO emitted by Hayman Fire is about five times of the amount of CO produced annually by industrial sources in Colorado.
- The amount of particles less than 2.5 μm emitted by the Hayman Fire is about twice of that produced annually by industries in Colorado.

Future Work

- Currently validating burn scar algorithm across fuel types and elevation-slope-aspect combinations found in Western U.S. and Canada
- Automate emissions estimation and integrate into MODIS DB processing stream
- Use emission inventory as input to WRF and HYSPLIT forecast models
- Validate results with MODIS AOT and MOPITT CO
- Train air quality managers (technology transfer)

Acknowledgements

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References

- Li, Rong-Rong et al. Remote Sensing of Burn Scars Using MODIS Near-IR Channels. Remote Sensing of Environment. Submitted 2003.
- Alpha Shapes Software website: http://www.alphashapes.org/alpha/index.html