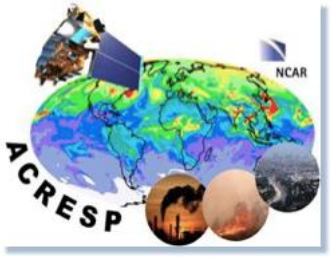

Gabriele Pfister
NCAR/ACD

Wildfires
From Alaska to California and From Global to Regional

Case Studies

- Boreal Fires in Alaska & Canada in Summer 2004
  - Inverse Modeling of CO Emissions
  - Ozone Production and Transport

MOZART
MOPITT CO
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MOZART = Model for Ozone and related Chemical tracers (global offline CTM)
WRF-Chem = Weather and Research Forecast Model with Chemistry (regional CTM)

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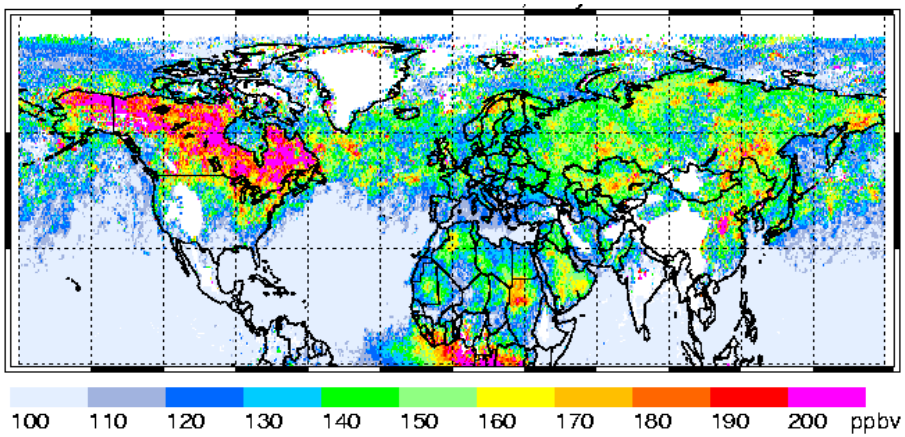
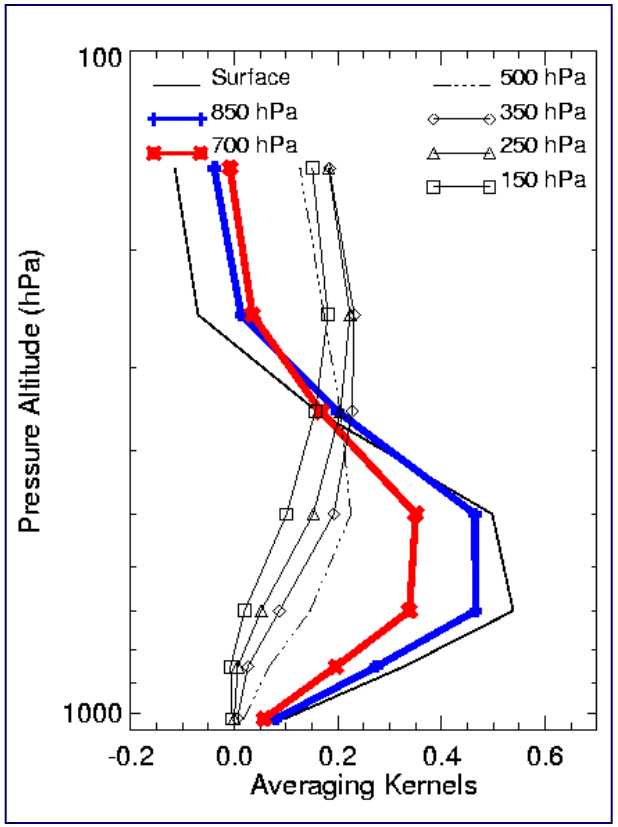
Inverse Modeling: Boreal Fires in Alaska and Canada in Summer

MOPITT (Measurements Of Pollution In The Troposphere)

- IR Gas Correlation Radiometer
- Launched in 1999 on EOS Terra
- Sun-Synchronous Orbit
- FOV: 22 x 22 km^2
- Data for March 2000 – Present,
- V3: CO at 7 Retrieval Levels (DFS ≤ 2)
- Highest sensitivity in mid-troposphere
- *www.eos.ucar.edu/mopitt*

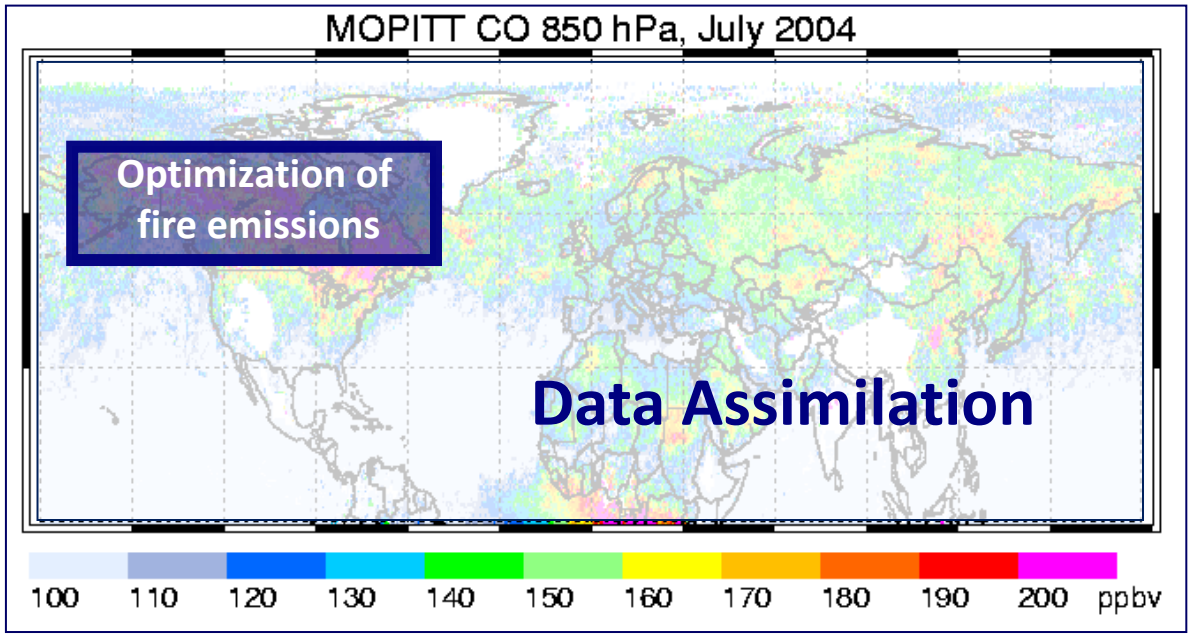
MOPITT CO @ 850 hPa for July 2004





Pfister et al., 2005

Inverse Modeling: Boreal Fires in Alaska and Canada in Summer 2004



Contribution from

Sources outside Region ⇔ Other Local Sources

- assimilation of MOPITT into MOZART globally
- no update of CO fields over defined region

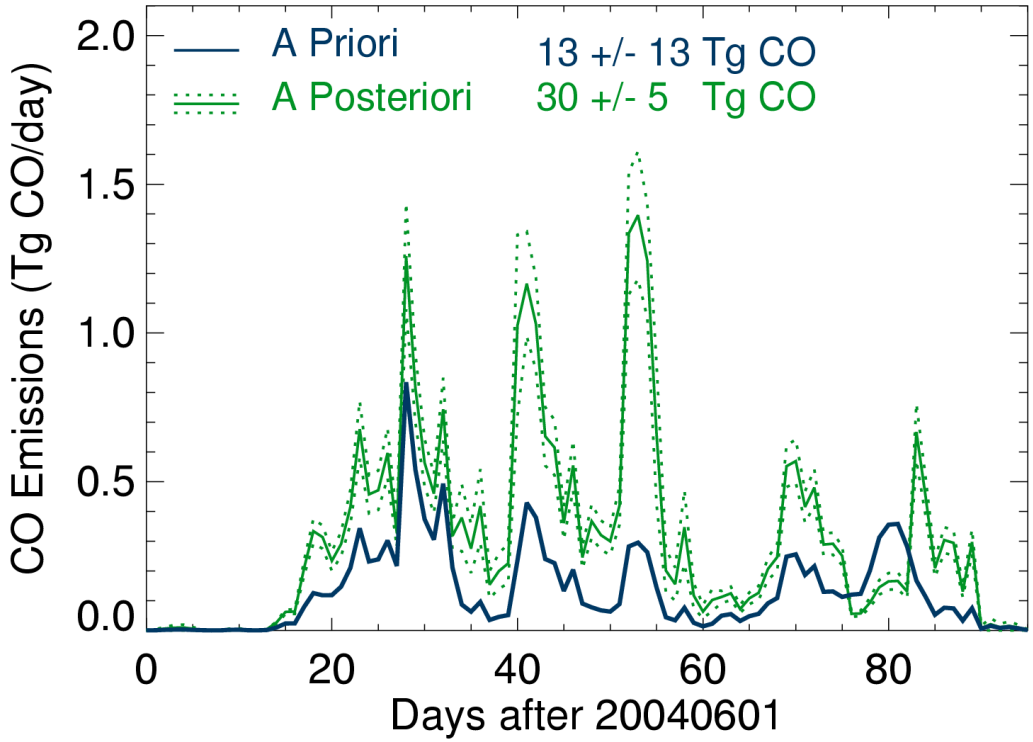
⇒ OmF (Observation *minus* Forecast)
≈ adjustment to a priori fire emissions

- anthropogenic, biogenic, methane oxidation,...
- small compared to wildfires and/or reasonably well known

- 14 CO tags included in MOZART (weekly fire emissions)
- Inversion is iterated three times
- 11 independent pieces of information

Pfister et al., 2005

Inverse Modeling: Boreal Fires in Alaska and Canada in Summer



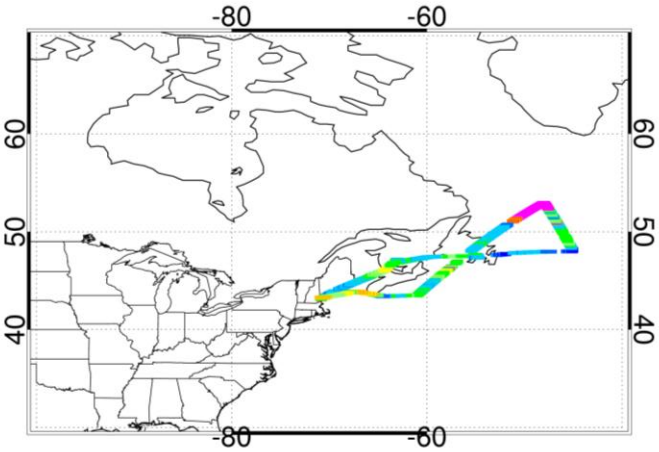
Anthropogenic Emissions
for US for June-August
~25 Tg CO

Sensitivity to emission injection height:

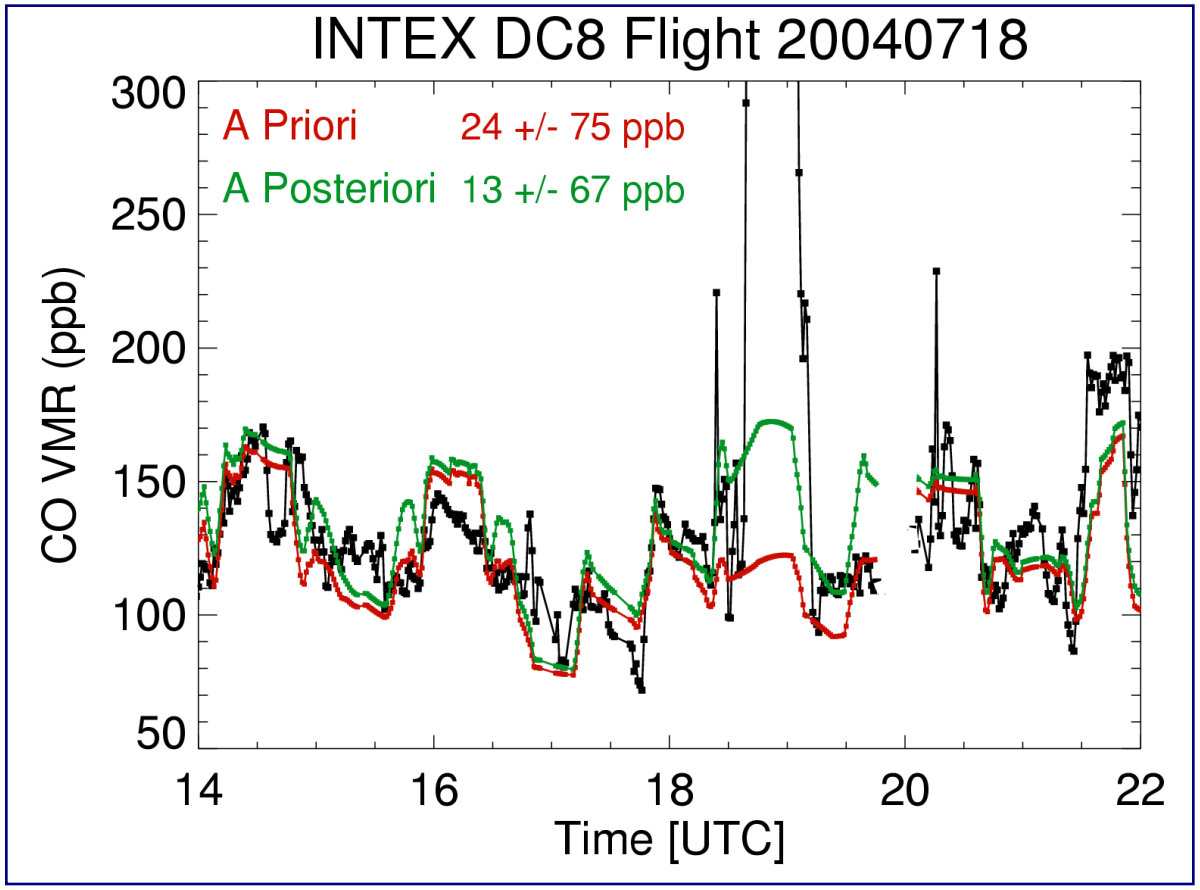
Model injection height [surface] ⇒ [surface - 400hPa]

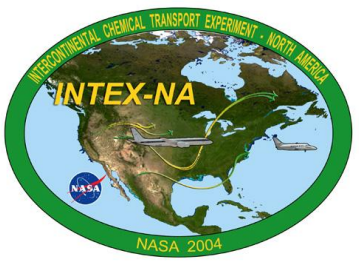
Even though the CO fields change with injection height,
the impact on the emissions strength in this study was small

Inverse Modeling: Boreal Fires in Alaska and Canada in Summer



Evaluation with aircraft data





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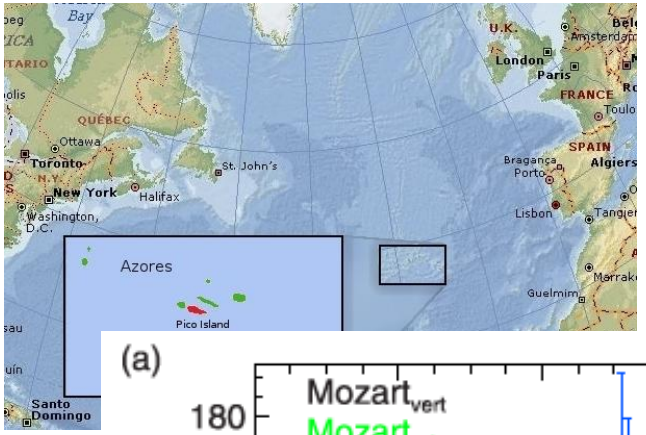
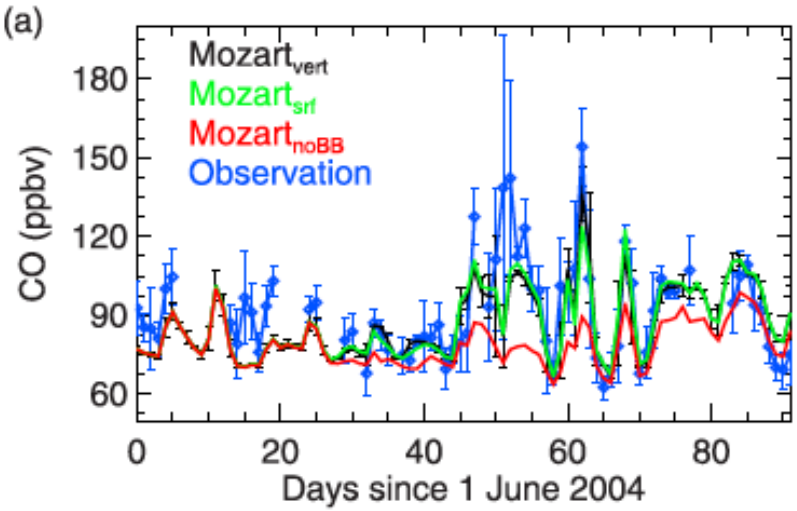
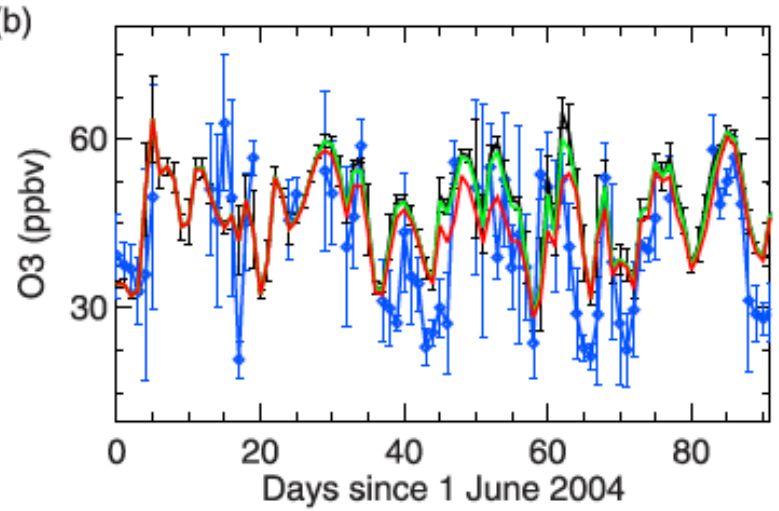
Ozone Production: Boreal Fires in Alaska and Canada in Summer 2004

Pfister et al., 2006



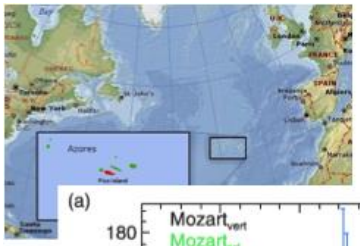
Modeled and Observed CO and O_3 at PICO-NARE





Ozone Production: Boreal Fires in Alaska and Canada in Summer 2004

Pfister et al., 2006



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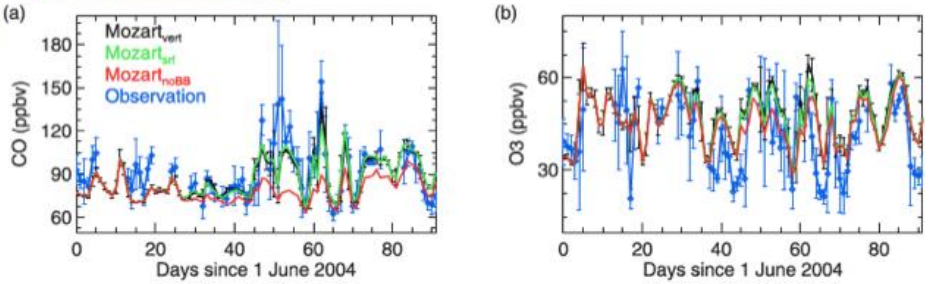
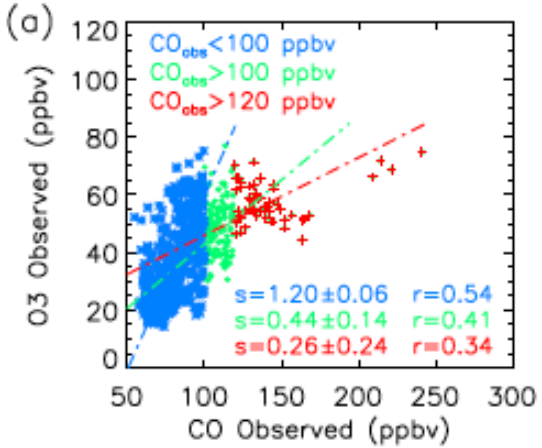
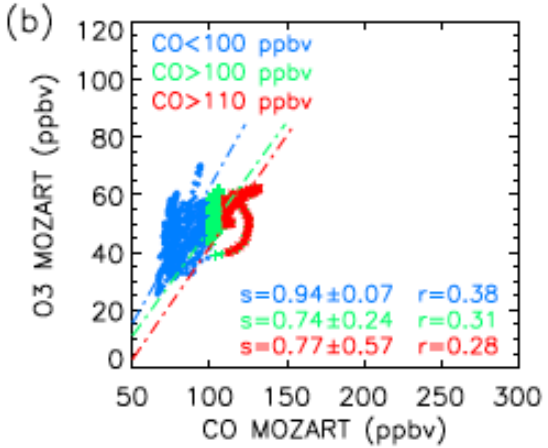
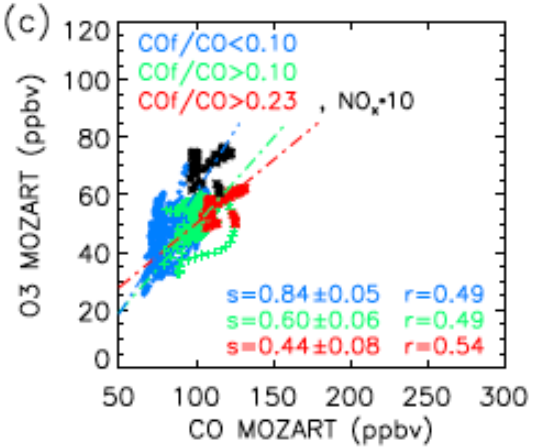
CO and O_3 at PICO-NARE



Calculate O_3 Enhancement Ratios

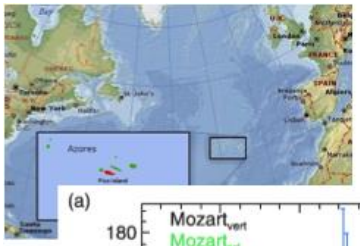




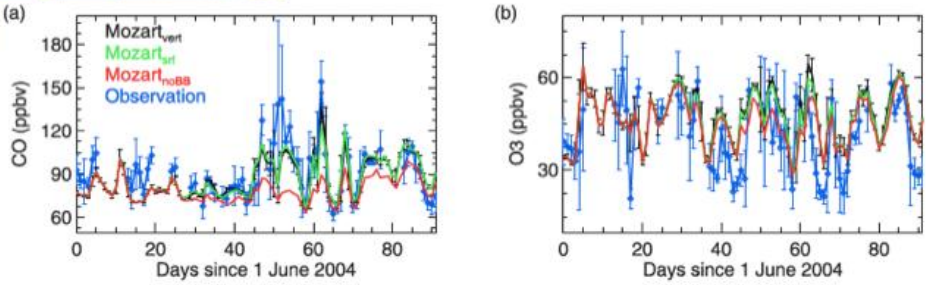


Ozone Production: Boreal Fires in Alaska and Canada in Summer 2004

Pfister et al., 2006



Modeled and Observed
CO and O_3 at PICO-NARE



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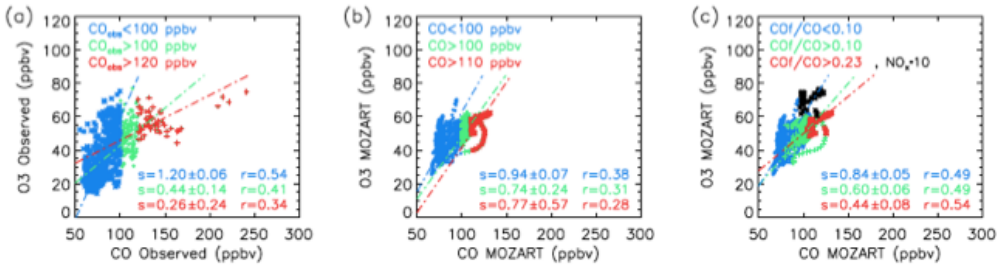

Derive Ozone Production

O_3 from Enhancement Ratios: 10.7 – 15 Tg

Global Modeled O_3 from Fires (BB minus noBB): 6 Tg

Regional Modeled O_3 from Fires (BB minus noBB): 9-11 Tg

Global O_3 from Model O_3^{FIRE}: 9 Tg

O_3^{FIRE}: model tracer for tracking O_3 from the fires in the model

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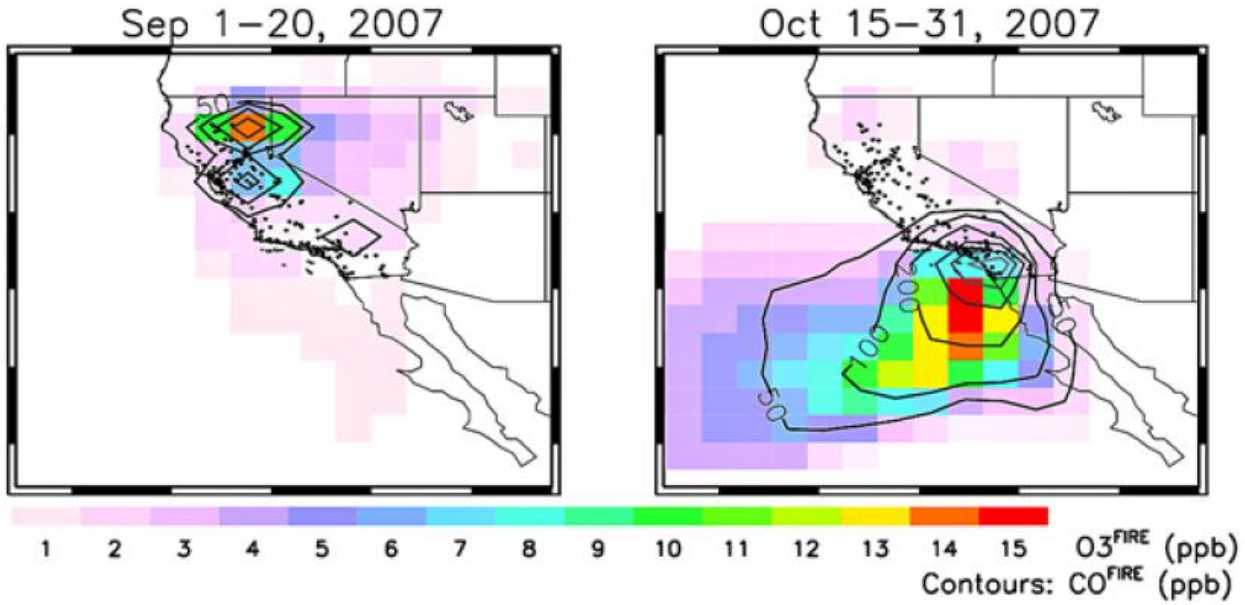
Wildfires in California in Fall 2007

- Intense late season wildfires
- Two Fire Periods:
  - Northern California – September 2007
  - Southern California – October 2007

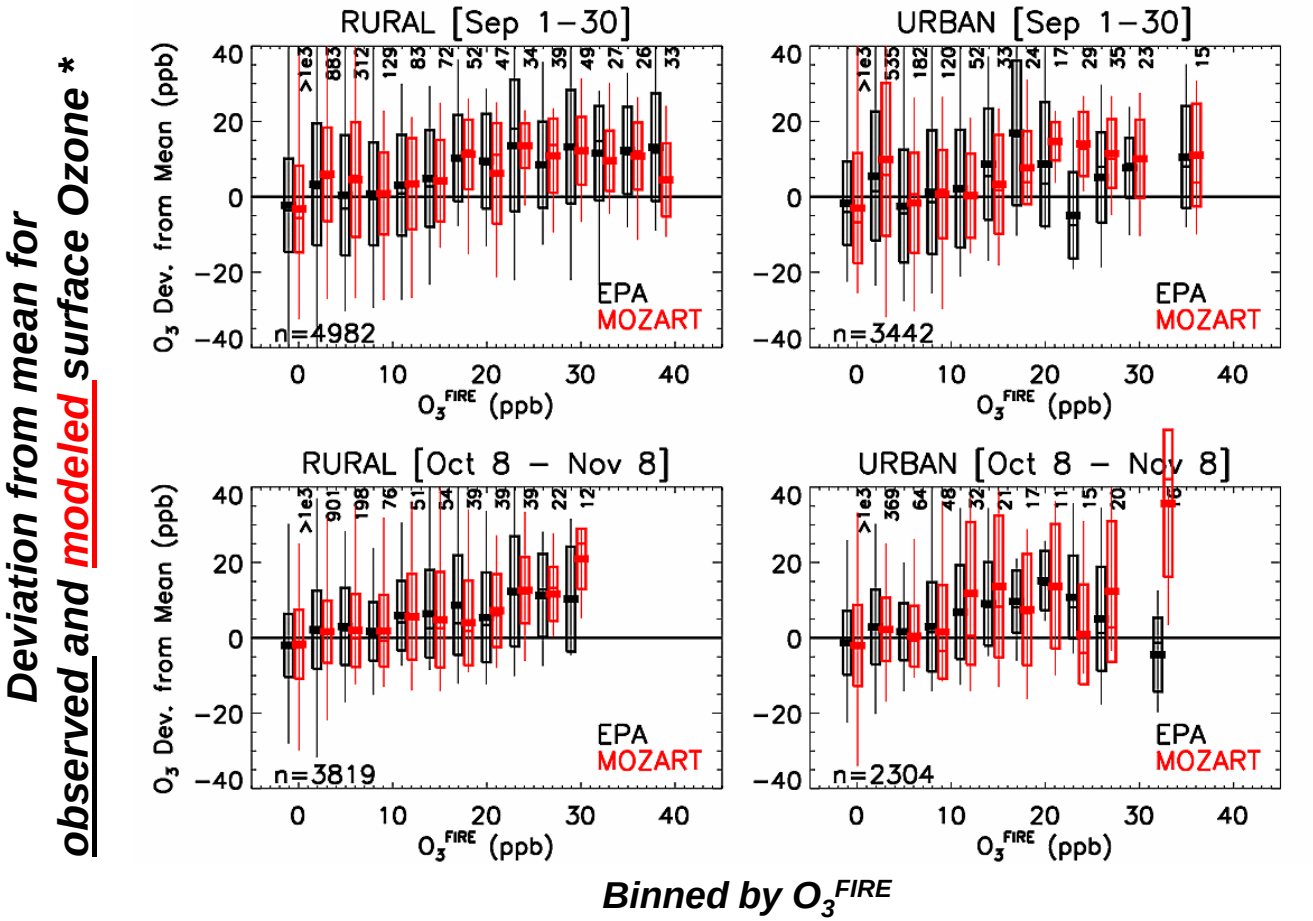
MOZART Tracers CO^{FIRE} and $O_3{}^{FIRE}$



Pfister et al., GRL, 2008

Wildfires in California in Fall 2007

Extracting Fire impact from surface observations of O_3 using MOZART with O_3^{FIRE}



Rural Sites: Mean observed (modeled) enhancement:

$O_3^{FIRE} > 20$ ppb 12 ± 14 ppb $(10 \pm 10$ ppb) September

10 ± 13 ppb $(12 \pm 9$ ppb) October

NAAQS Violations three times more likely

Pfister et al., GRL, 2008

* 8-hour afternoon concentrations

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ARCTAS/CARB – AQ over California

Collaboration between NASA and California Air Resources Board
dedicated to California Air Quality and Climate Change Objectives

Campaign: 4 DC-8 and 2 P-3 Science Flights plus ground-based; June 18-26, 2008

- ☑ Characteristics of AQ in California: How well do we understand and model it and what datasets are needed for evaluation?
- ☑ Importance of:
  Pollution Inflow – Local FFBF Emissions – Biogenic VOCs – Fires
- ☑ Modeling Tools: MOZART-4 and WRF-Chem

WRF-Chem/MOZCART

- **MOZART gas phase chemistry scheme included in WRF-Chem V3.2 (WRF-Chem/MOZART) and linked to GOCART aerosols (WRF-Chem/MOZCART). WRF-Chem V3.2 was released April 2010**

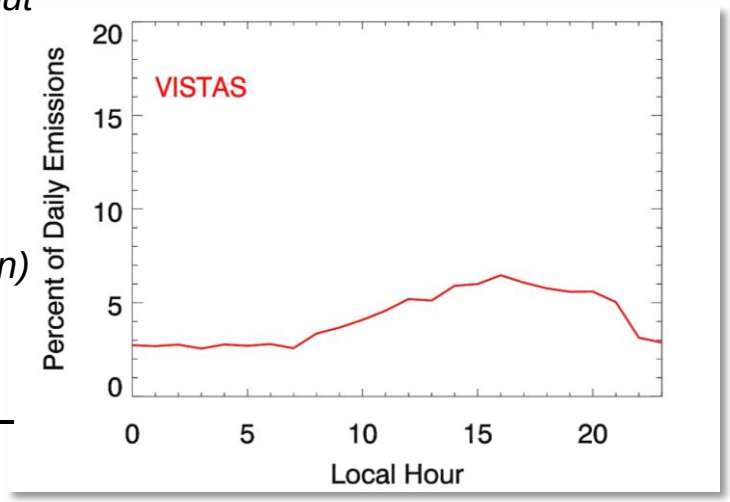
- Updates to photolysis (FTUV) and dry deposition (Wesely), including:
  - Climatological overhead O_3 and O_2 columns for FTUV calculations
  - Seasonality in dry deposition
  - Preprocessors to produce the required additional inputs are provided.

- Works with MEGAN online biogenic emissions (Guenther et al., 2005) and plume rise module (S. Freitas).

➢ **Ensure chemical compatibility, support consistent analysis across spatial scales, & enable use of common data assimilation capabilities**

Modeling Setup

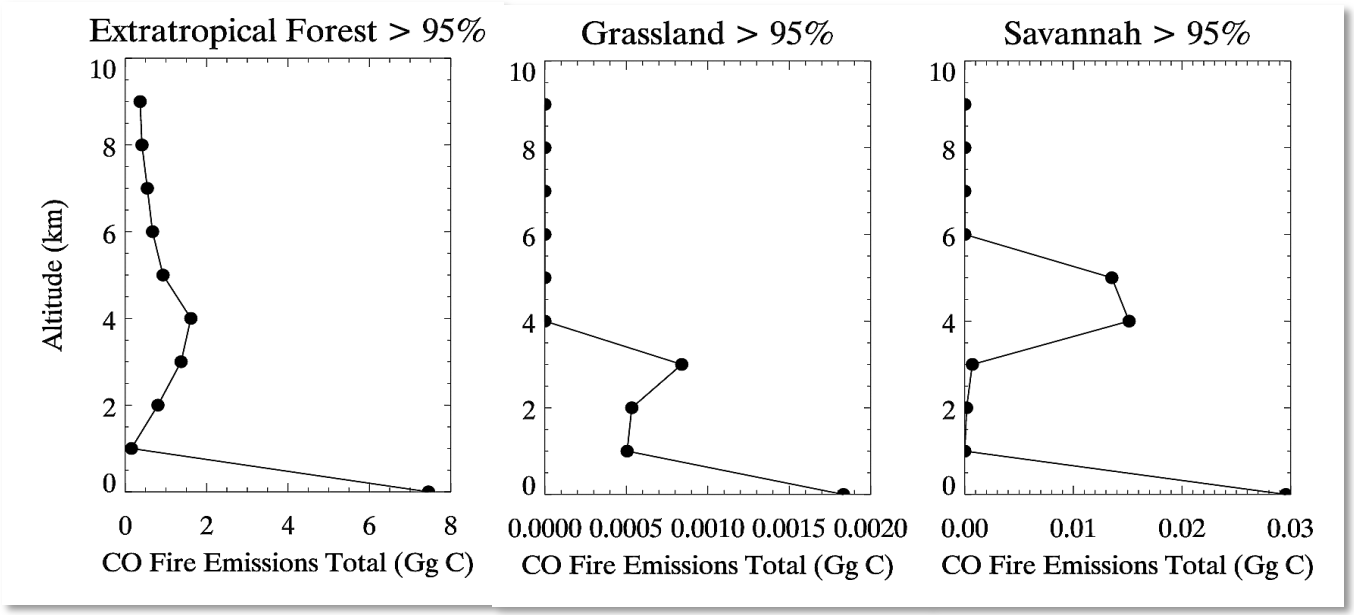
Simulation Period:	*14-30 June, 2008; 20-hour output*
Spatial Resolution:	*12 x 12 km^2*
PBL Scheme:	*BouLac, multi-layer BEP urban physics*
FF&BF Emissions:	*EPA NEI 2005*
Biogenic Emissions:	*MEGAN online*
Fire Emissions:	*C. Wiedinmyer (NCAR)*
Meteorological IC&BC:	*NAM (3-hours, 40 km resolution)*
Chemical IC&BC:	*MOZART T170L64*



WRF-Chem Run 41

Fire plume rise calculation

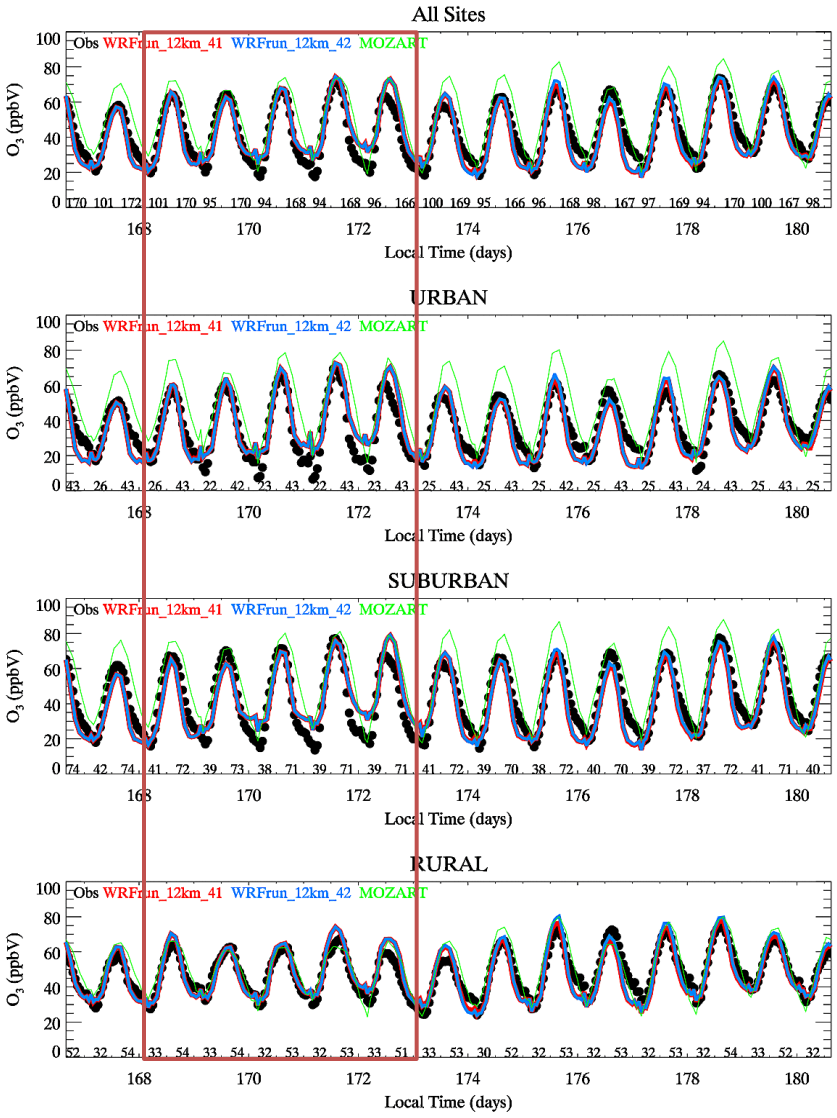
VISTAS diurnal proflle

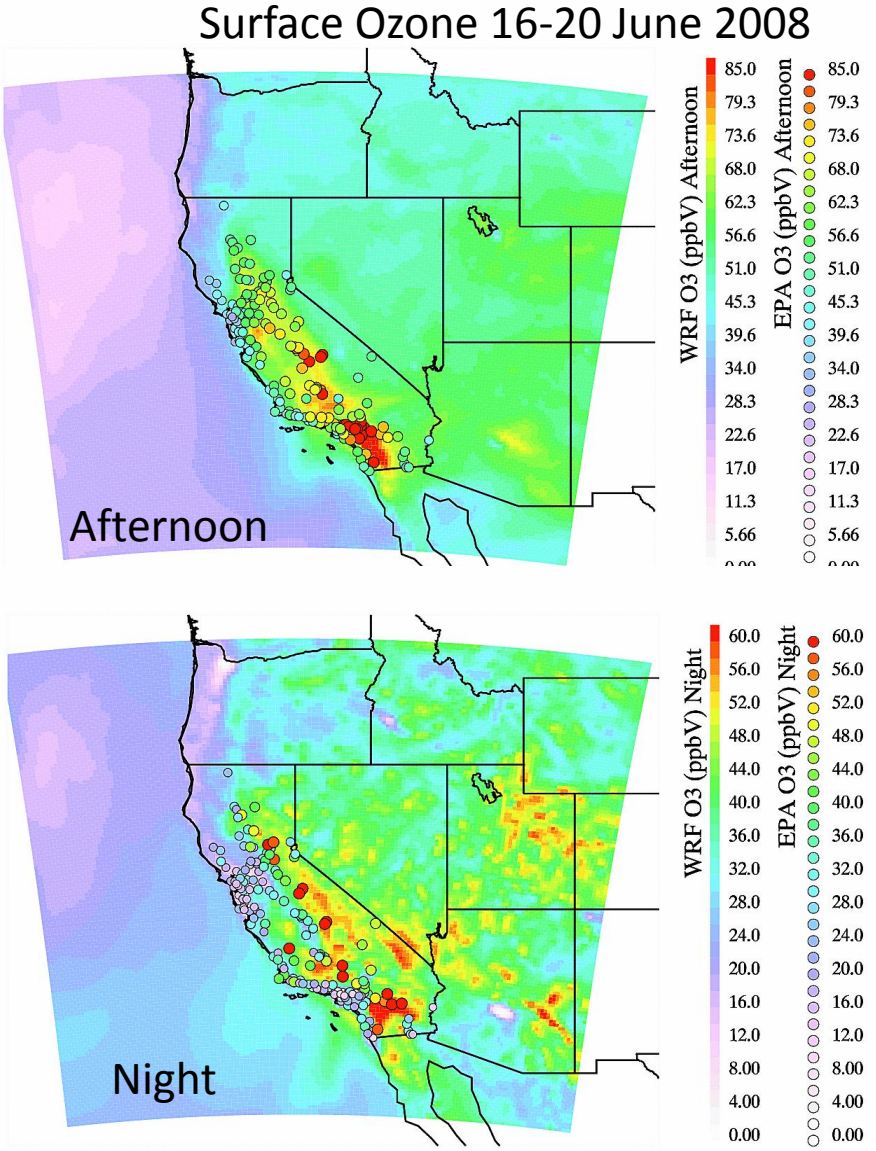


Wildfires in California in June 2008

A few results – How well do we compare to Surface Sites?

Ozone @ EPA Monitoring Sites





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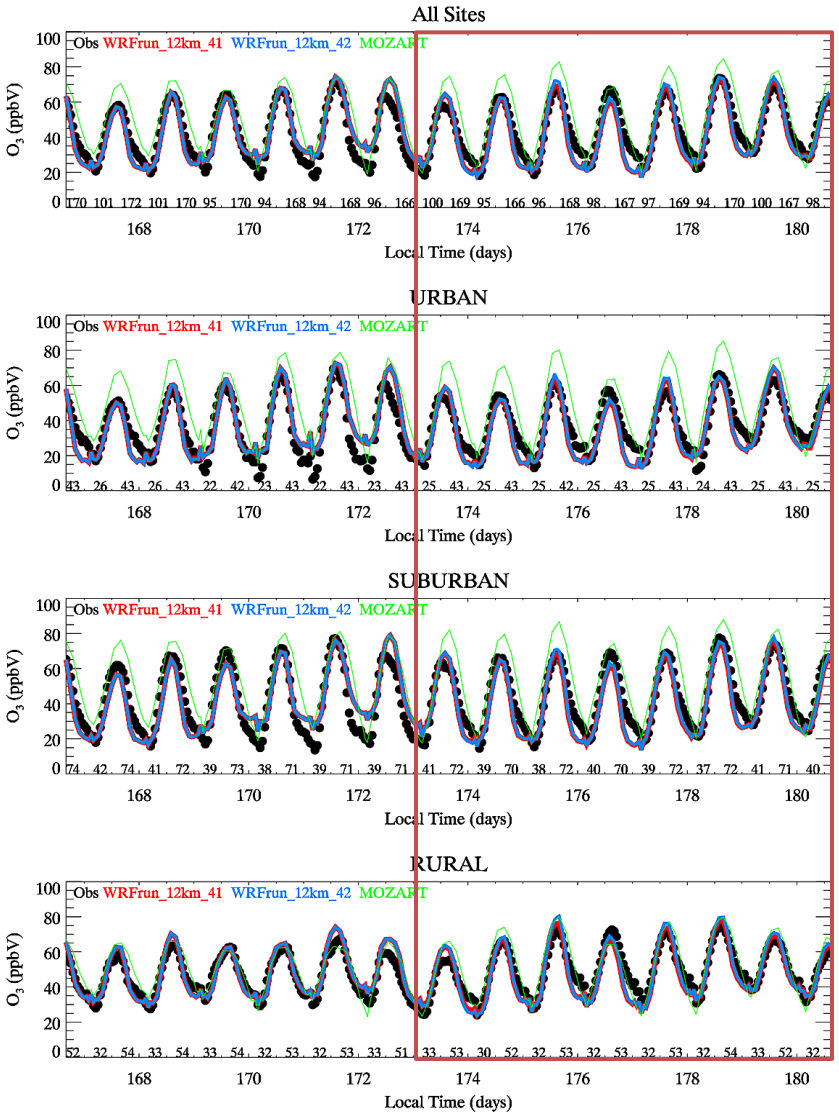
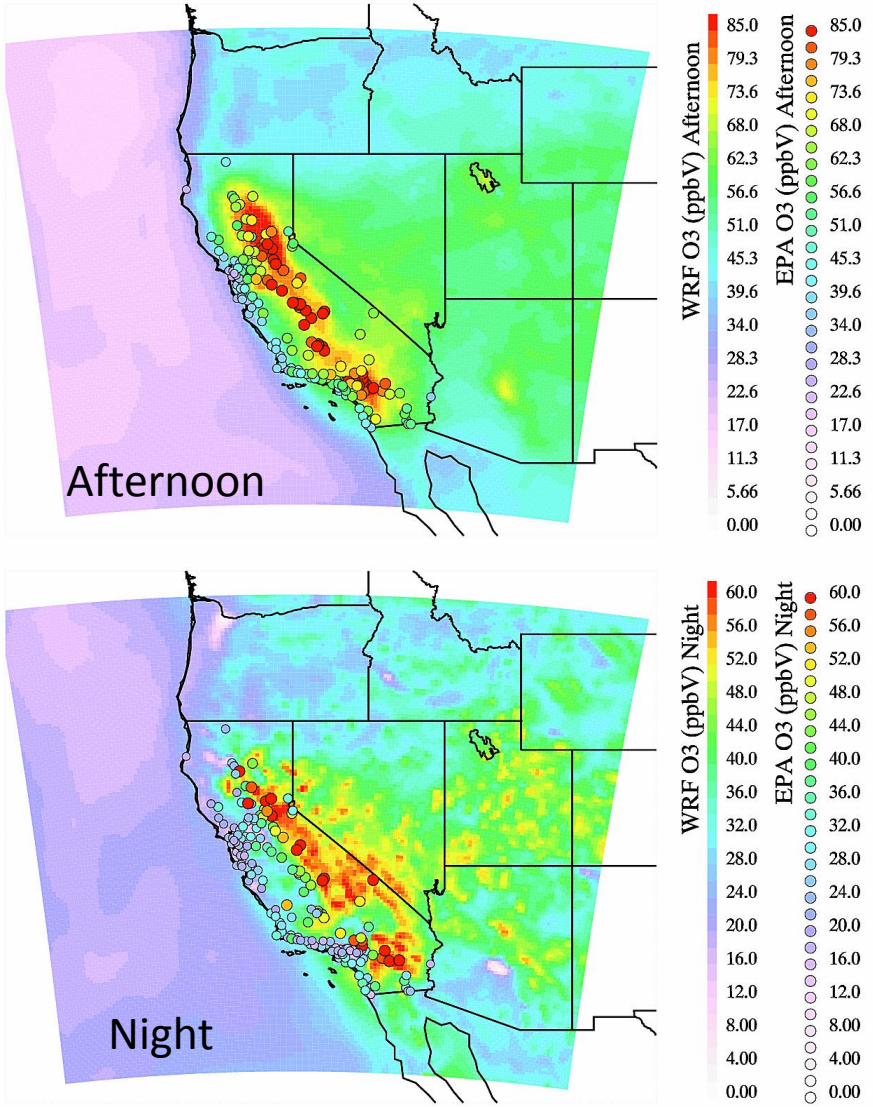


Surface Ozone 21-29 June 2008



Wildfires in California in June 2008

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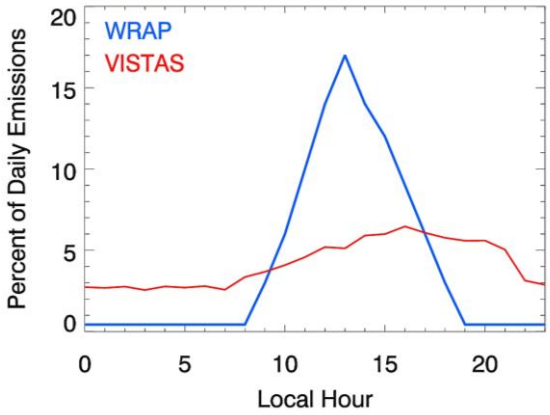


WRF-Chem Run 41

Fire plume rise calculation

VISTAS diurnal profile

WRF-Chem Run 42

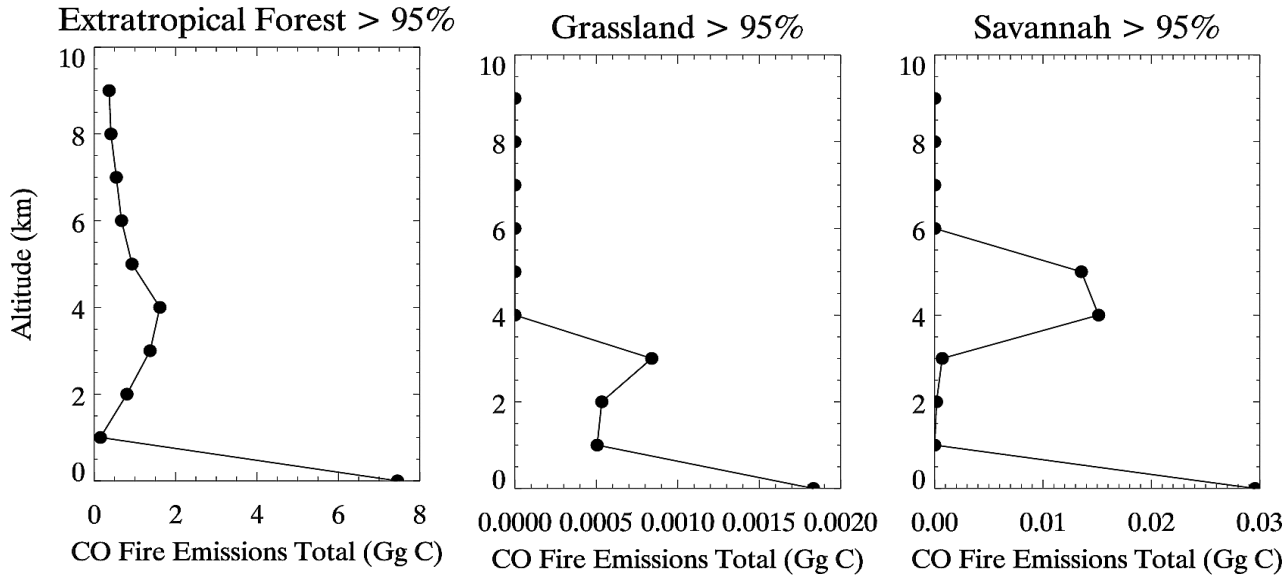
Fire emissions at surface

VISTAS diurnal profile

WRF-Chem Run 45

Fire Plume rise calculation

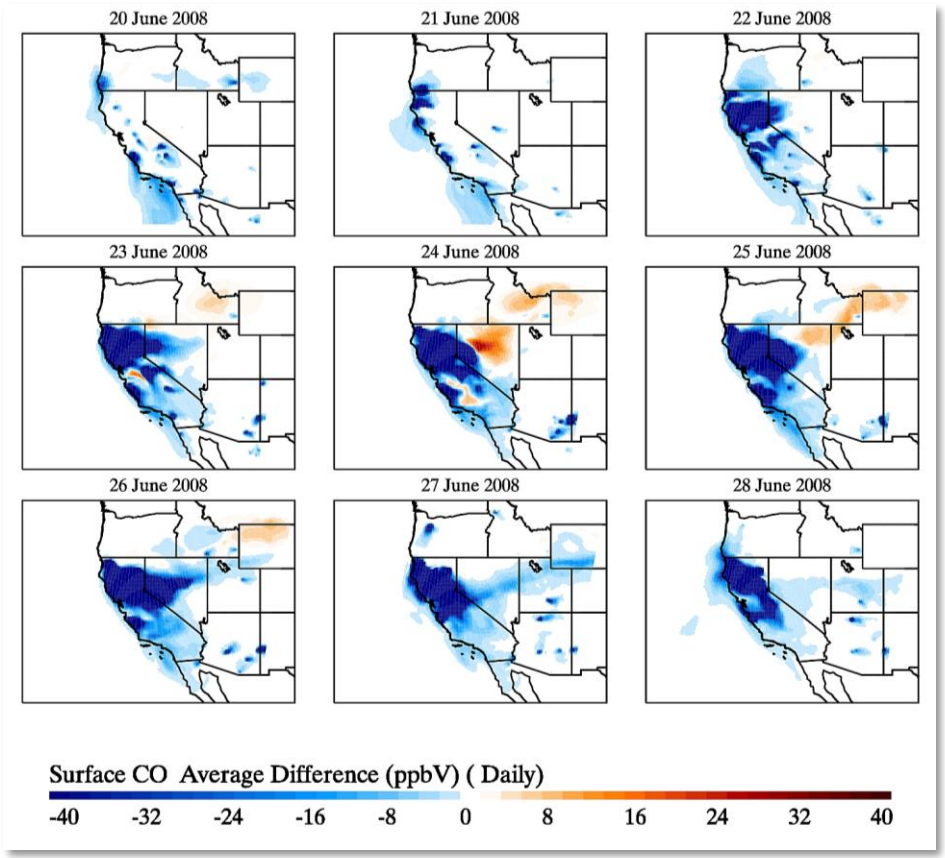
WRAP diurnal profile



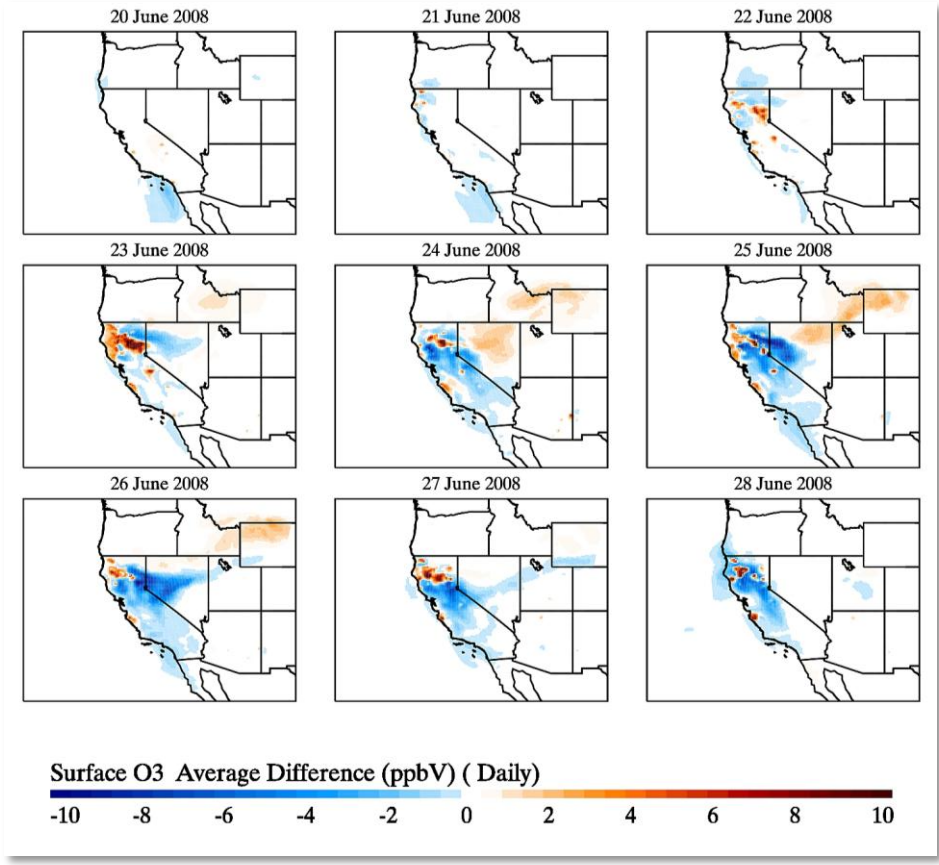
Wildfires in California in June 2008

Plumerise vs. Surface Inj.

Surface CO



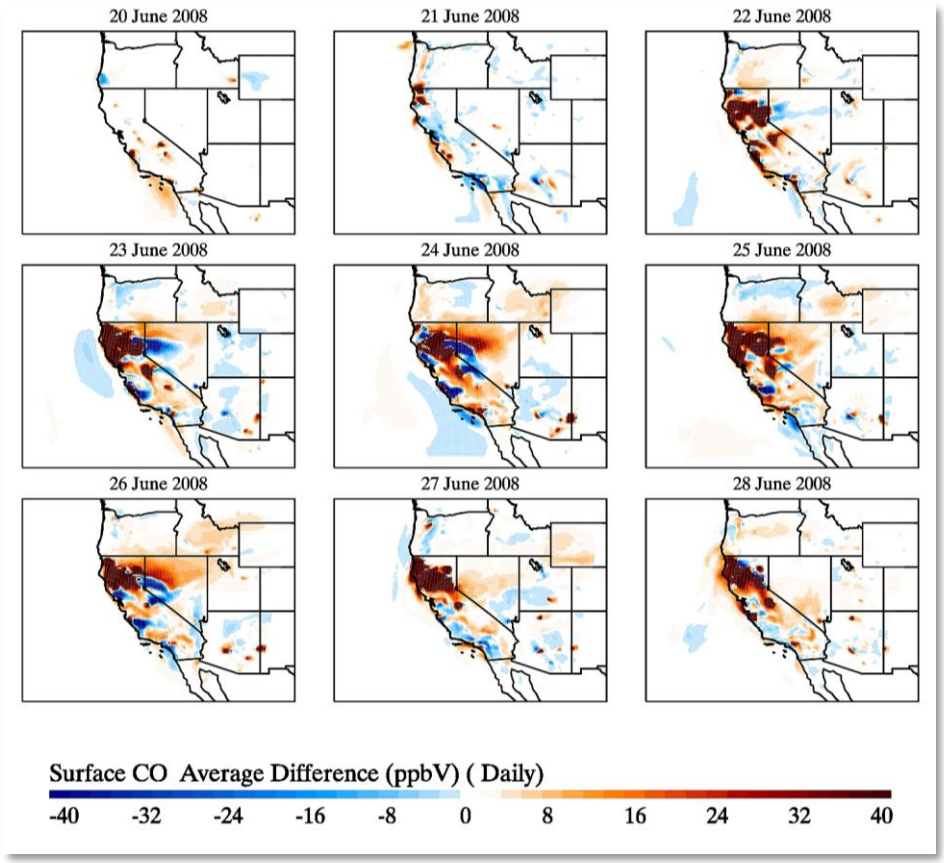
Surface O_3



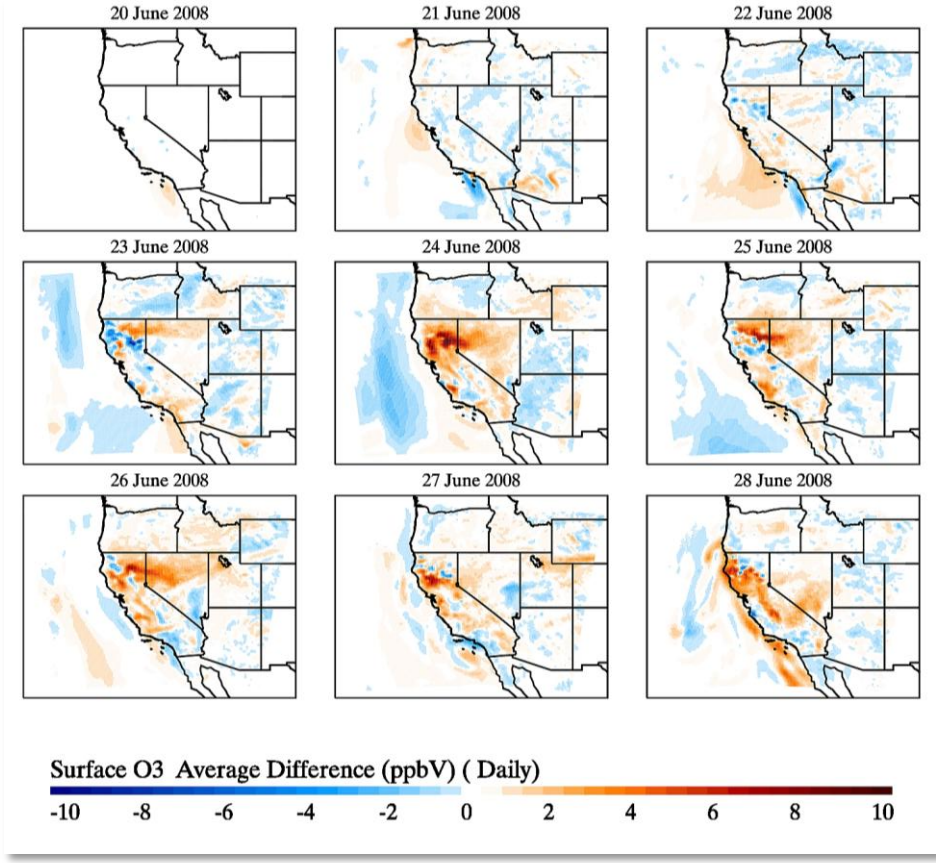
Wildfires in California in June 2008

VISTAS vs. WRAP

Surface CO



Surface O_3

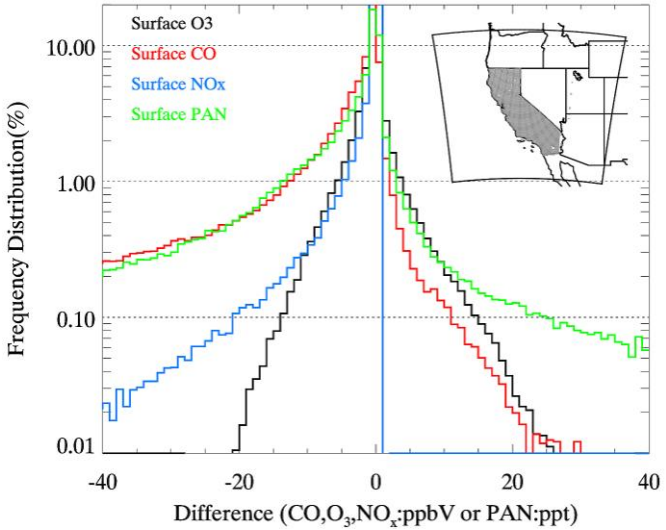


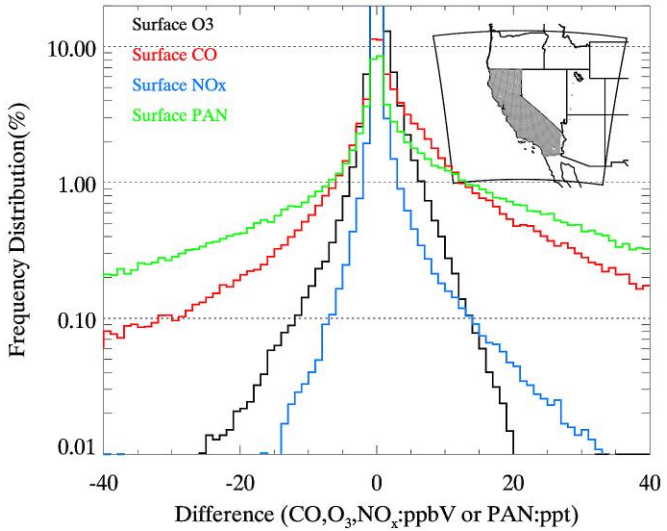
Wildfires in California in June 2008

Plumerise vs. Surface Inj.

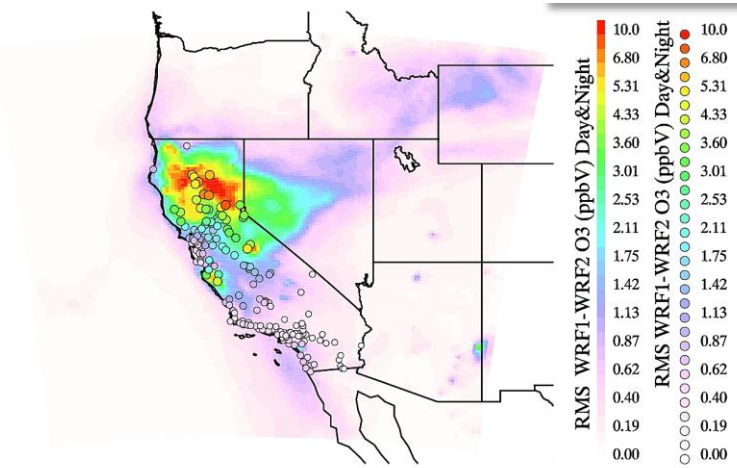
VISTAS vs. WRAP

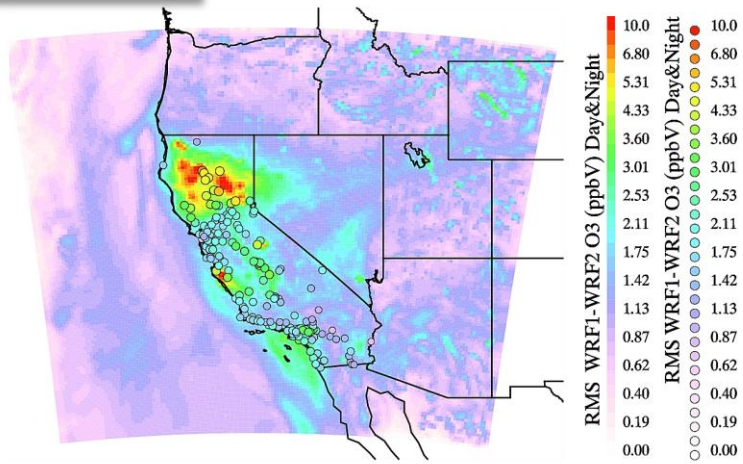
Frequency Distribution of Differences





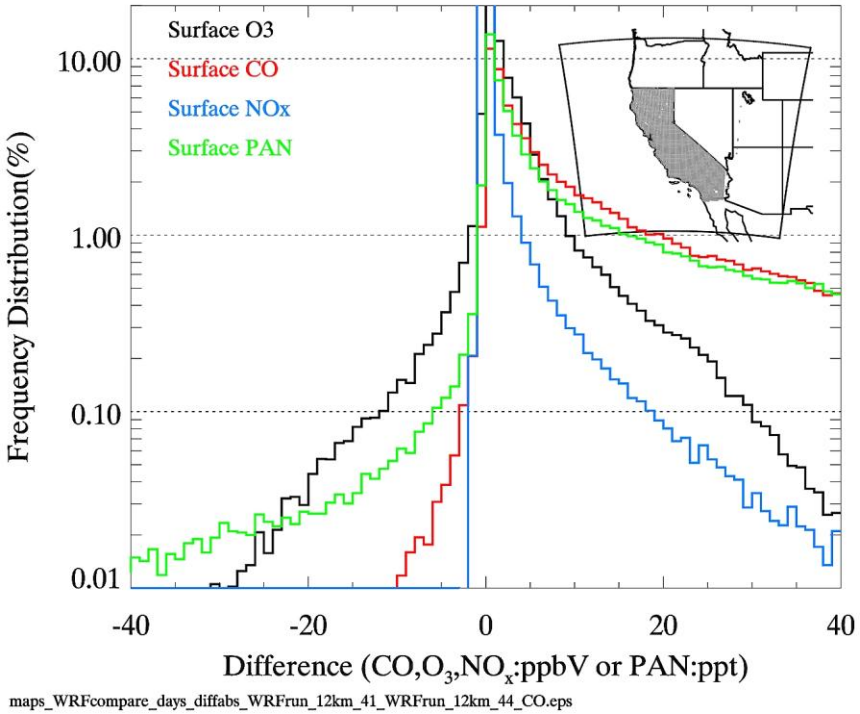
RMS difference in Surface O_3



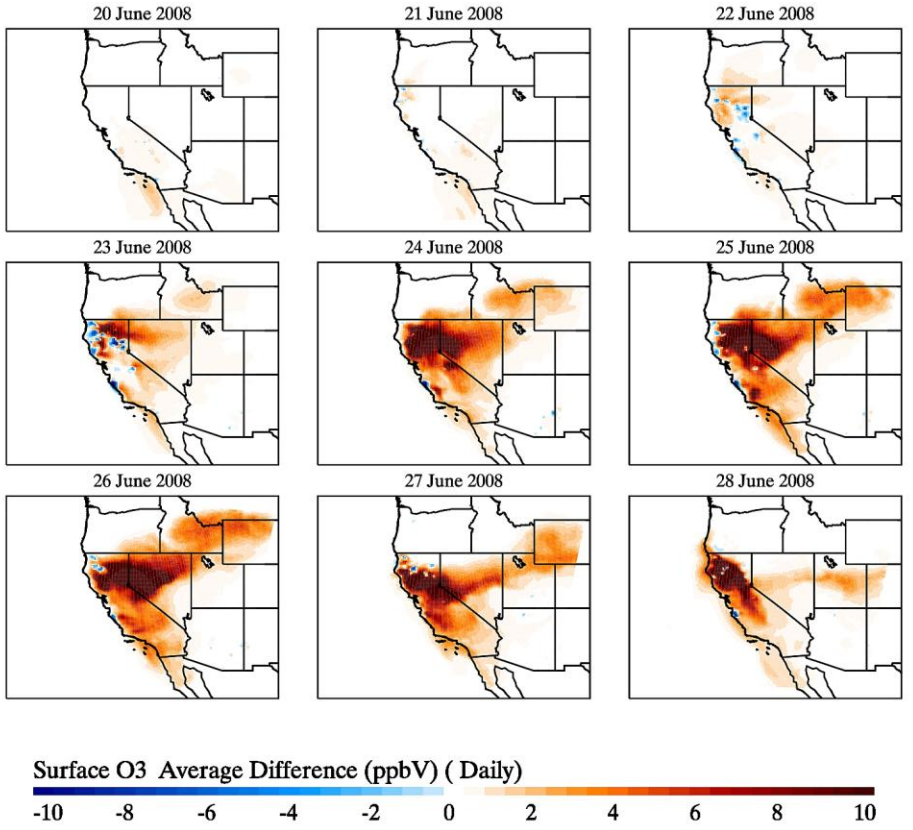


To be continued…

Wildfires in California in June 2008 – fire vs. nofire

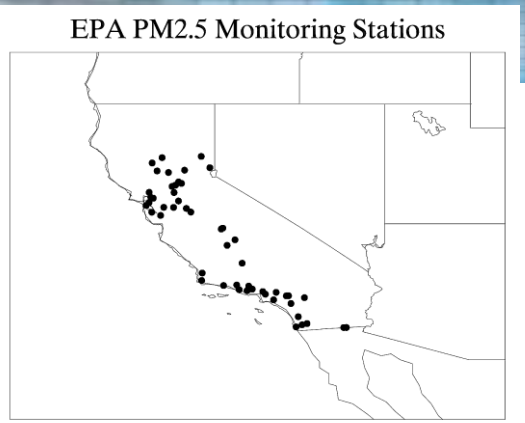


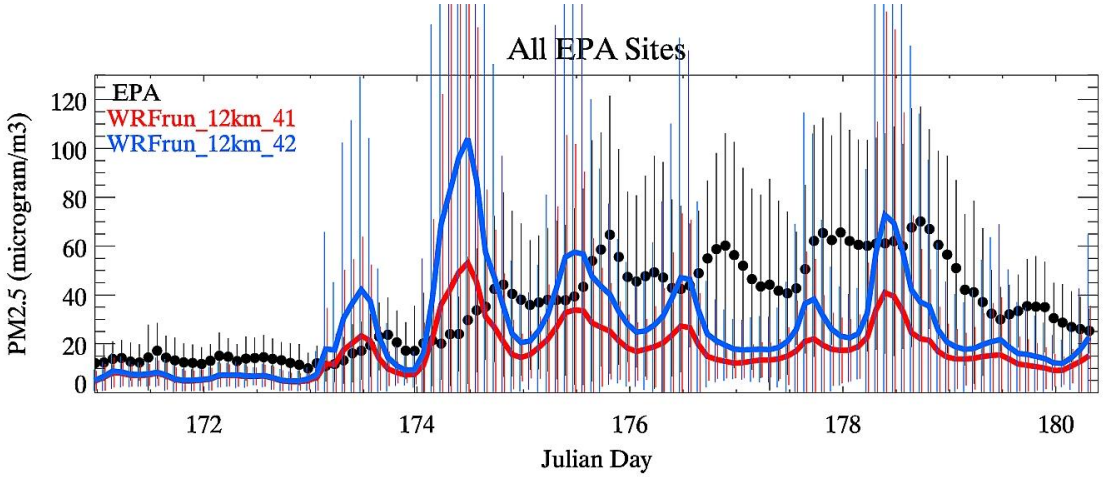
maps_WRFcompare_days_diffabs_WRFrun_12km_41_WRFrun_12km_44_CO.eps



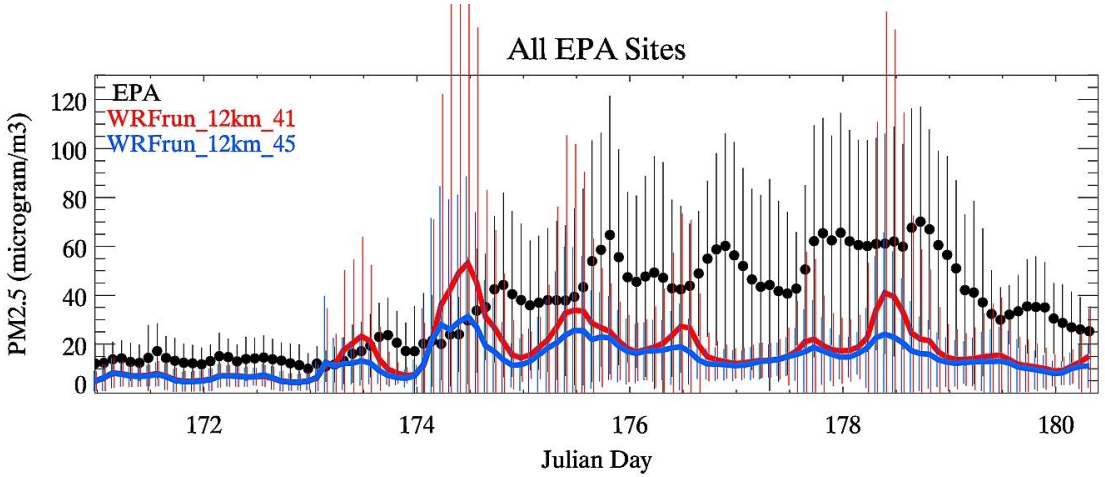
maps_WRFcompare_days_WRFrun_12km_41_WRFrun_12km_44_O3.eps

Wildfires in California in June 2008 – PM2.5





Plumerise vs. Surface Inj.

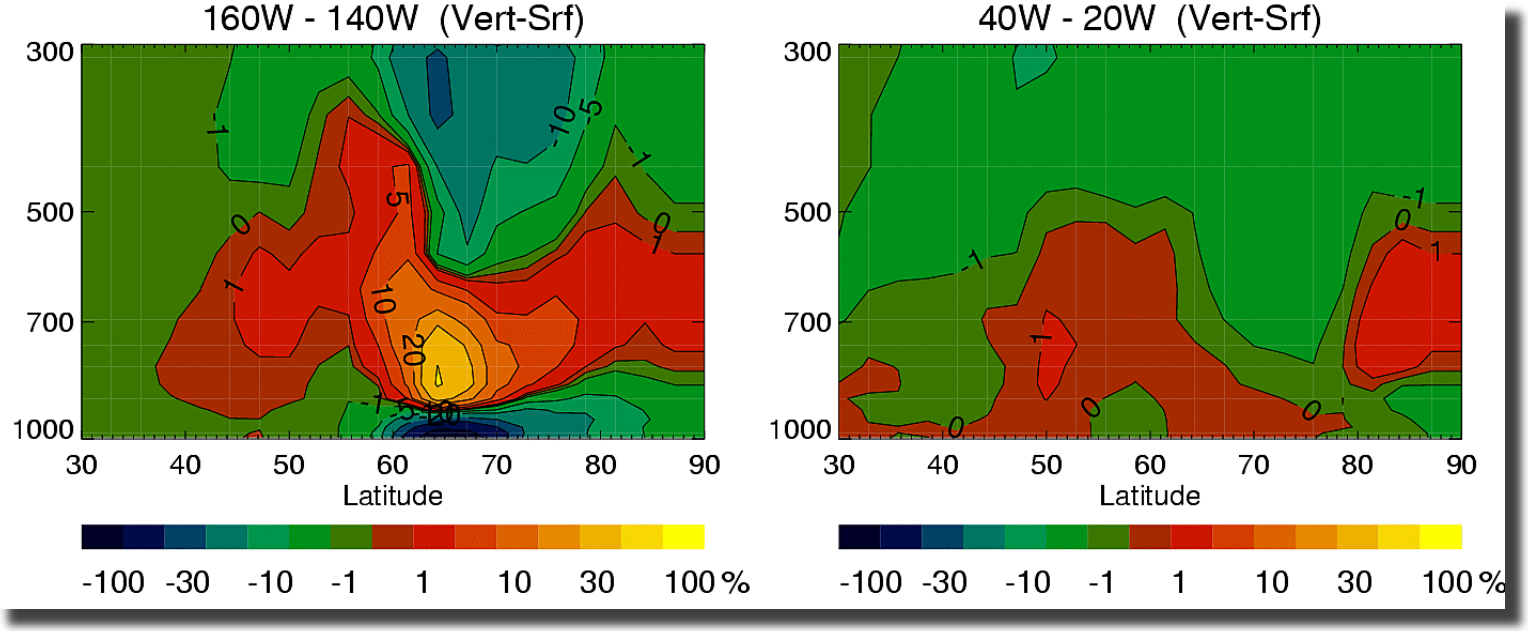


VISTAS vs. WRAP

Inverse Modeling: Boreal Fires in Alaska and Canada in Summer

Emissions Injection Height

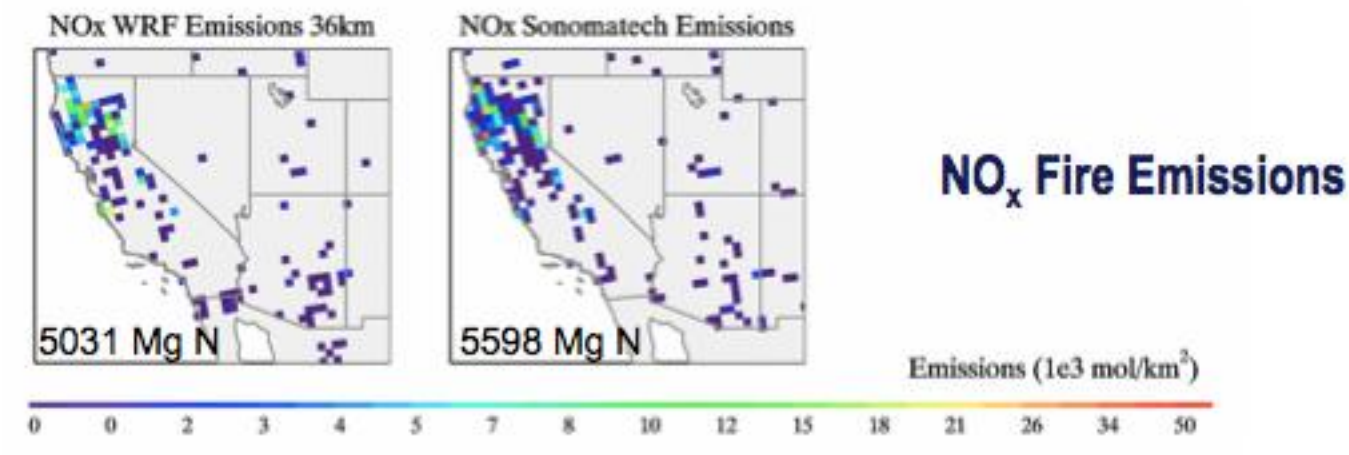
Over the emissions regions and during single transport events, the differences between **BBsrf** and **BBvert** can be large, but, on average, are small further downwind from source regions.



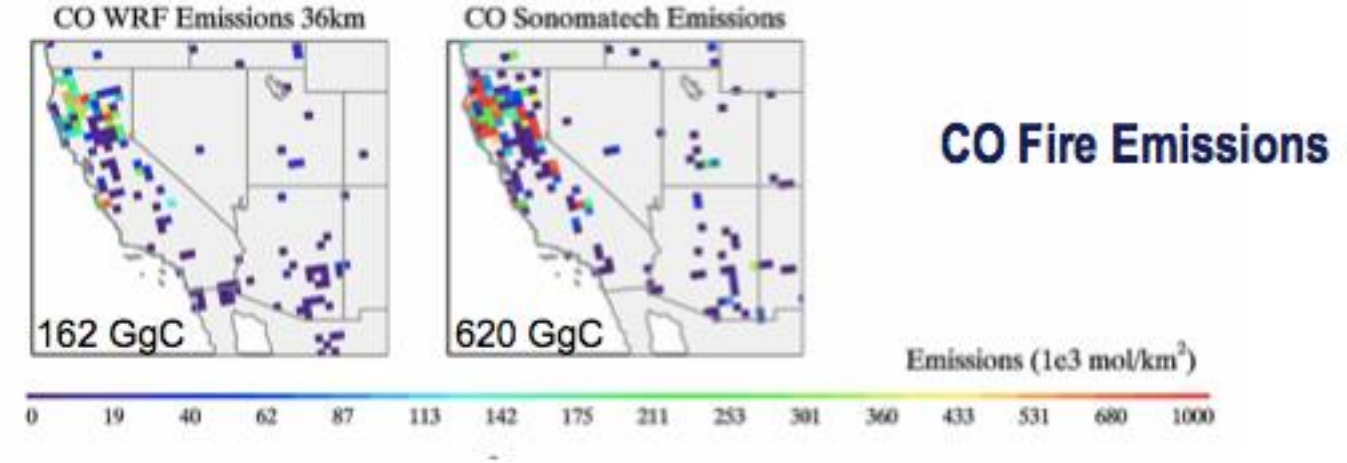
Zonal averaged difference (%) in the CO mixing ratio for BBvert and BBsrf. July 2004.

CA Fires 2008 - Emissions

WRF-Chem Fire Emissions ↔ Sonoma Technology EI
(C. Wiedinmyer) *(BlueSky Framework)*



NO_x Fire Emissions



CO Fire Emissions