The Alpha Jet Atmospheric eXperiment (AJAX): Three years of airborne ozone and greenhouse gas measurements over California and Nevada

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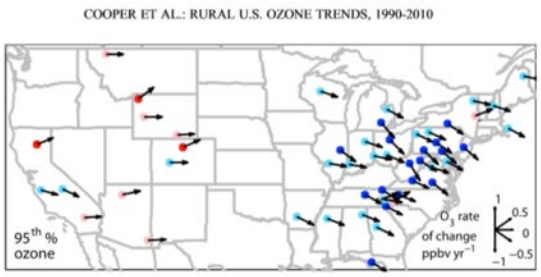
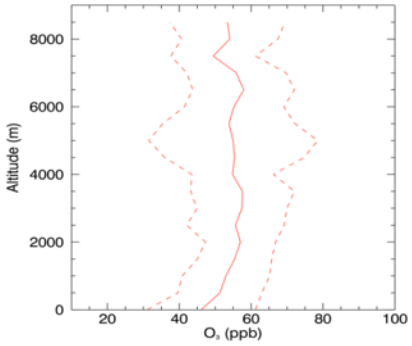
Background

- **US EPA NAAQS** is **75 ppbv**, with a decision on the **proposed reduction** to 60-70 ppbv is due.
- **Modeled background O_3 in western US is 15-60 ppbv** (Fiore et al., 2003; Jaffe et al., 2003; Lefohn et al., 2011; Lin et al., 2012; Zhang et al., 2011).
- O_3 is only regulated pollutant with **positive vertical gradient**. The Mountainous western US is influenced by isentropically driven subsidence (Cooper et al., 2011).
- O_3 trends in the western US (Cooper et al., 2012):
  - **Urban sites have decreased** (precursor control)
  - **Rural sites have increased** (increasing tropospheric baseline O_3)
  - **Large gaps in surface data**: monitor density much less than in eastern US



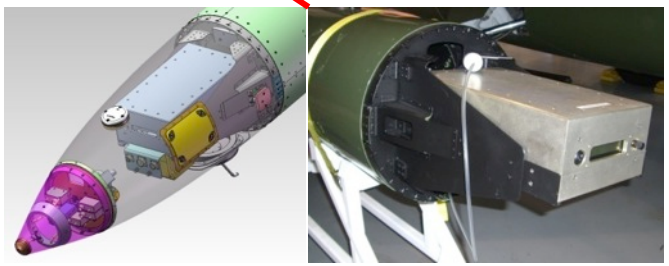


Average O_3 profile plotted for offshore AJAX profiles during 2012

Experimental set-up

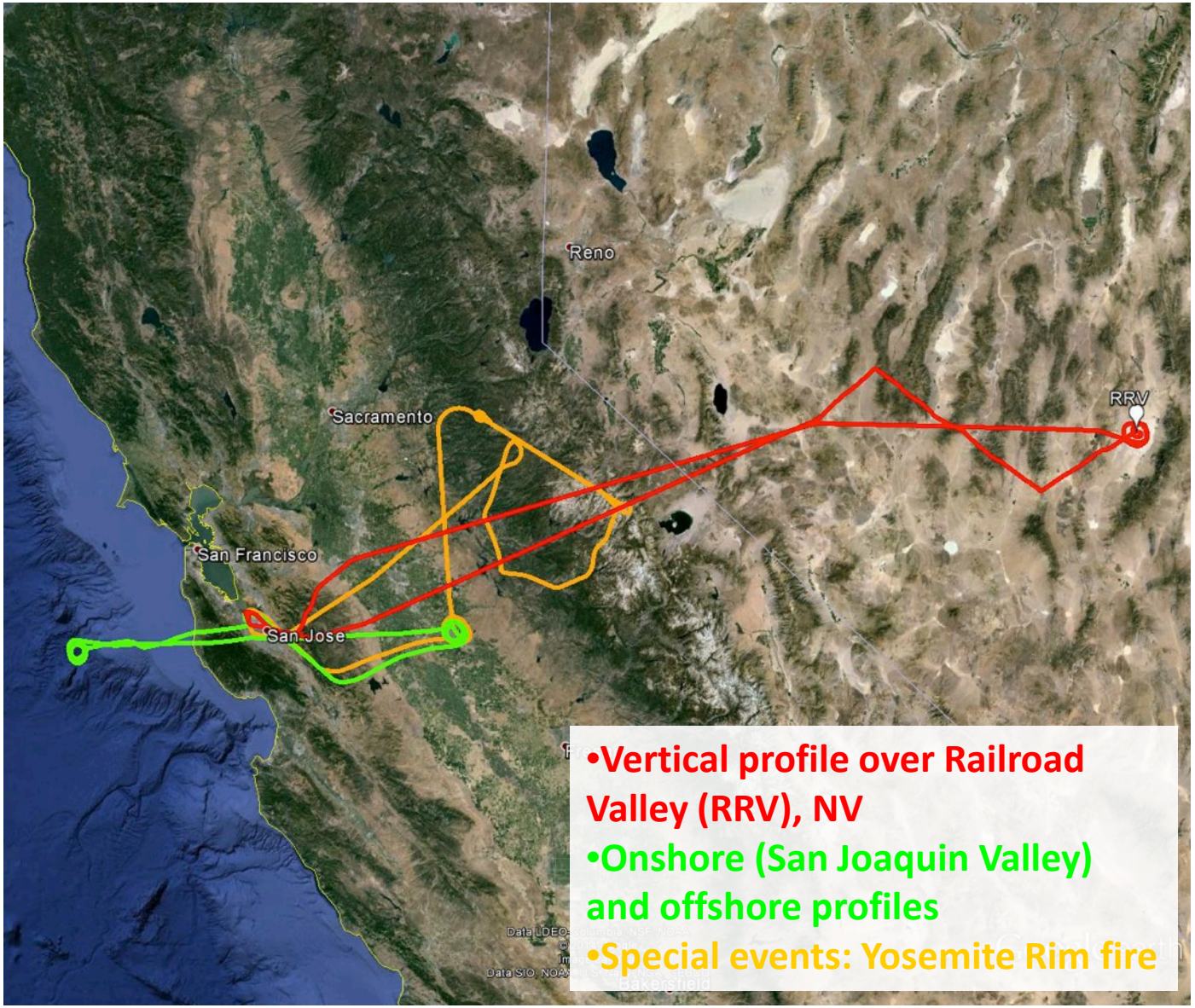
NASA Ames Alpha Jet Atmospheric eXperiment (AJAX)

Modified Picarro (2301-*m)* measures CO_2 and CH_4 located in center- and tail- sections of the wing-pod

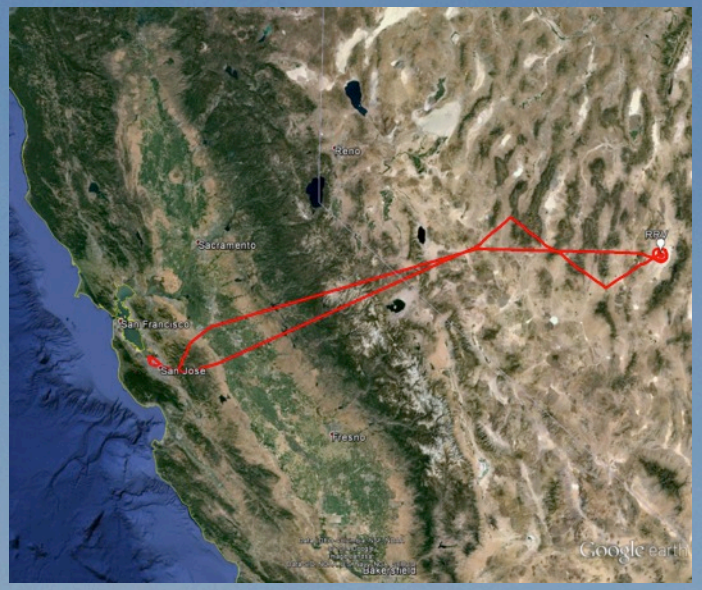


Modified 2B technologies (model 205*)* measures O_3 and Meteorological Measurement System (MMS) located in the front/nose section of the wing-pod

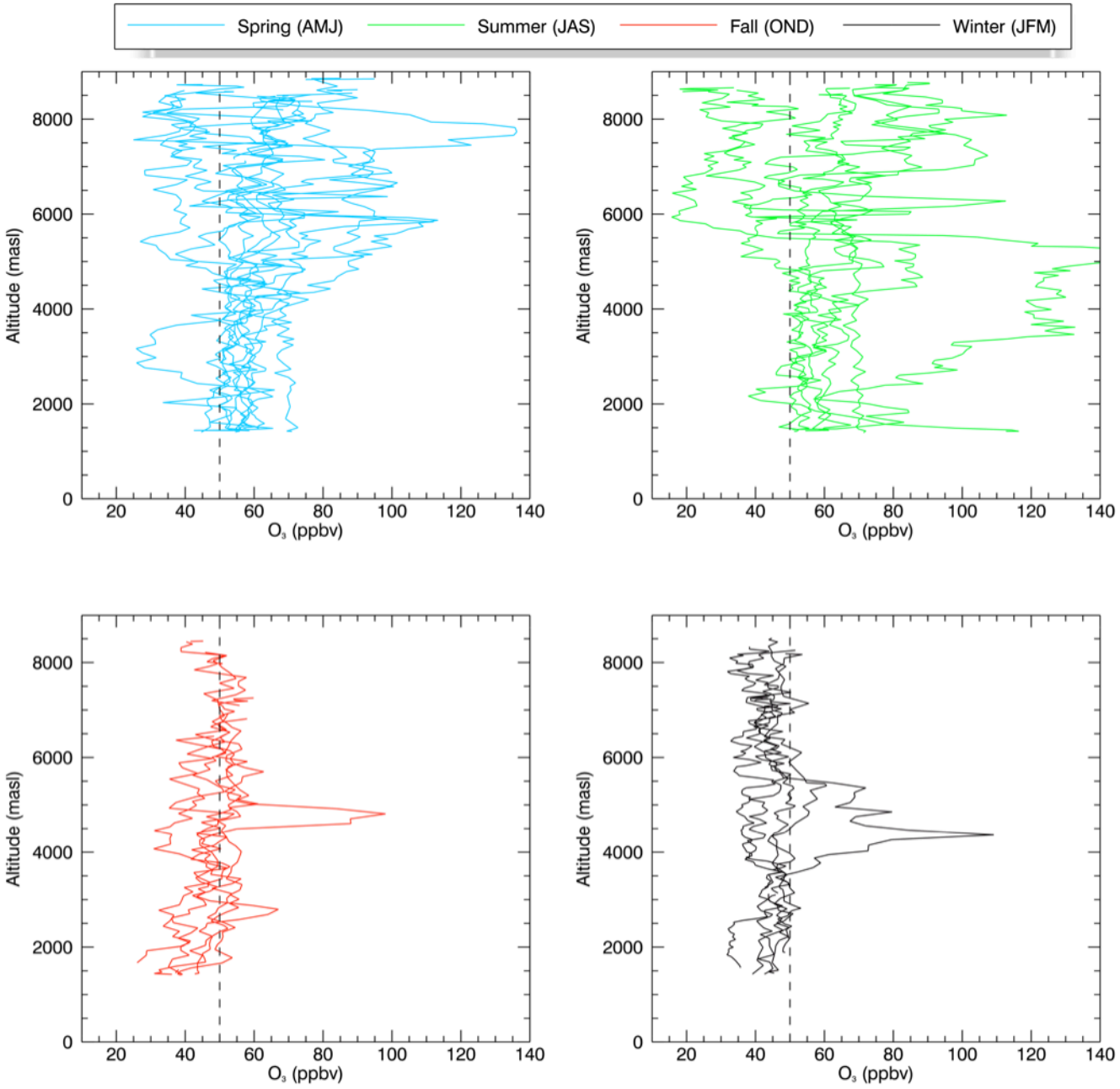
Where we fly


Reno
Sacramento
RRV
San Francisco
San Jose
•Vertical profile over Railroad Valley (RRV), NV
•Onshore (San Joaquin Valley) and offshore profiles
•Special events: Yosemite Rim fire

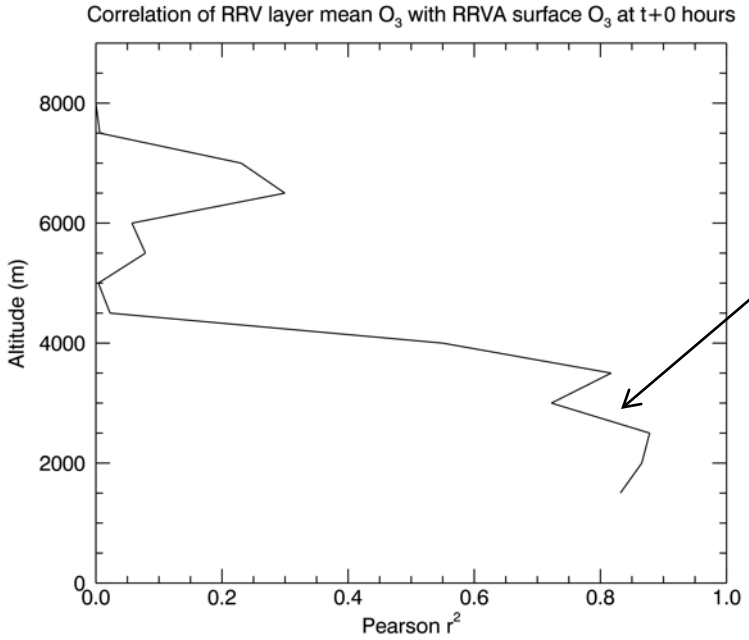
Railroad Valley (RRV)



Flights: Once a month since May 2011, plus intensives every year at summer solstice


Spring (AMJ)
Summer (JAS)
Fall (OND)
Winter (JFM)
Altitude (masl)
0
2000
4000
6000
8000
20
40
60
80
100
120
140
O₃ (ppbv)

Correlations between RRV profiles and RRV surface site

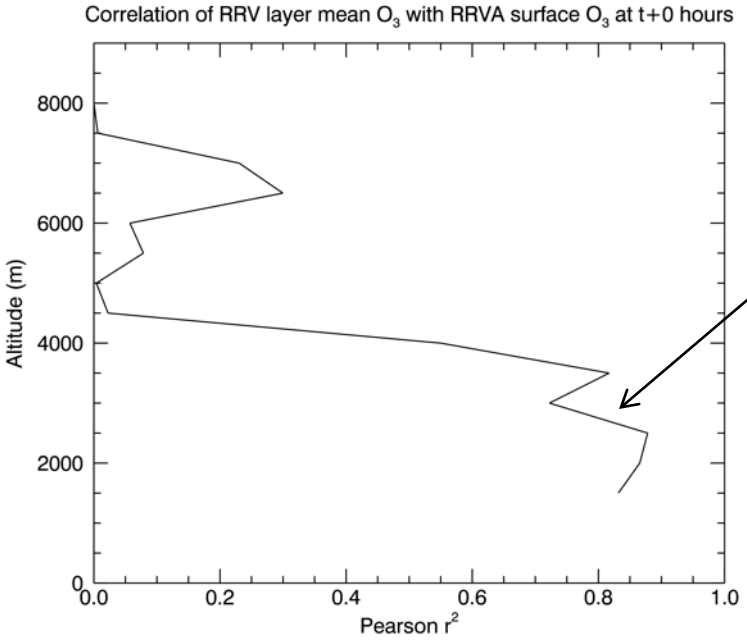


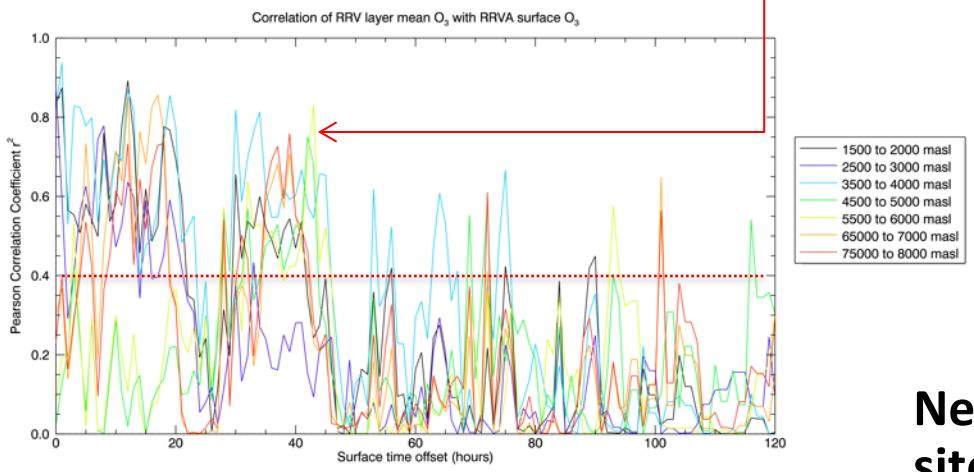
Parrish et al. (2010)

- High correlation **below 4 km represents the typical extent of the boundary layer** over RRV

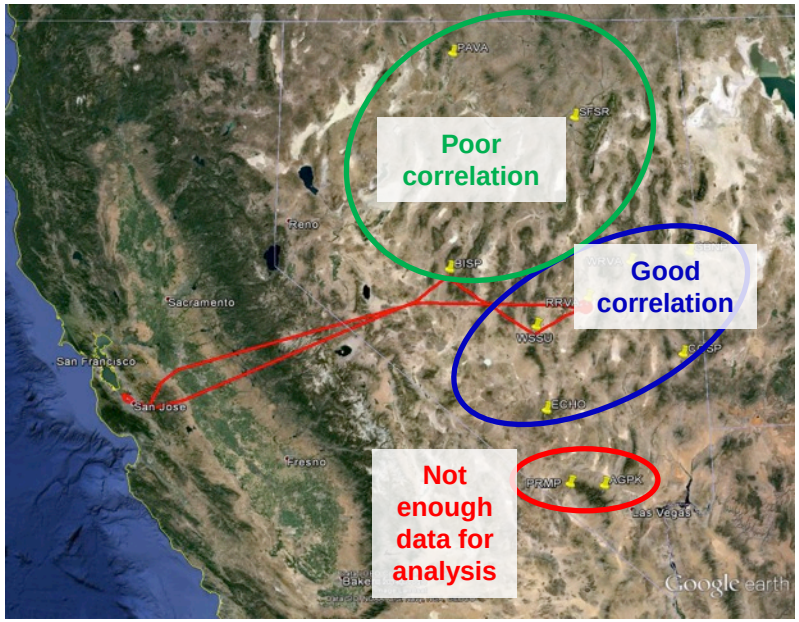
Nevada Rural Ozone Initiative surface O_3 sites (Mae Gustin & Rebekka Fine, UNR)

Correlations between RRV profiles and RRV surface site



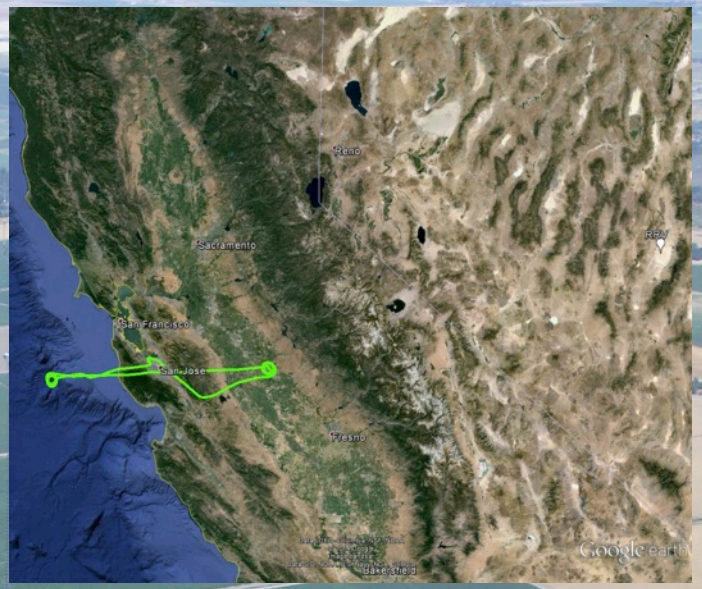


- High correlation **below 4 km represents the typical extent of the boundary layer** over RRV
- Correlation **remains high for 2 days** after the time of the RRV profile, *t*



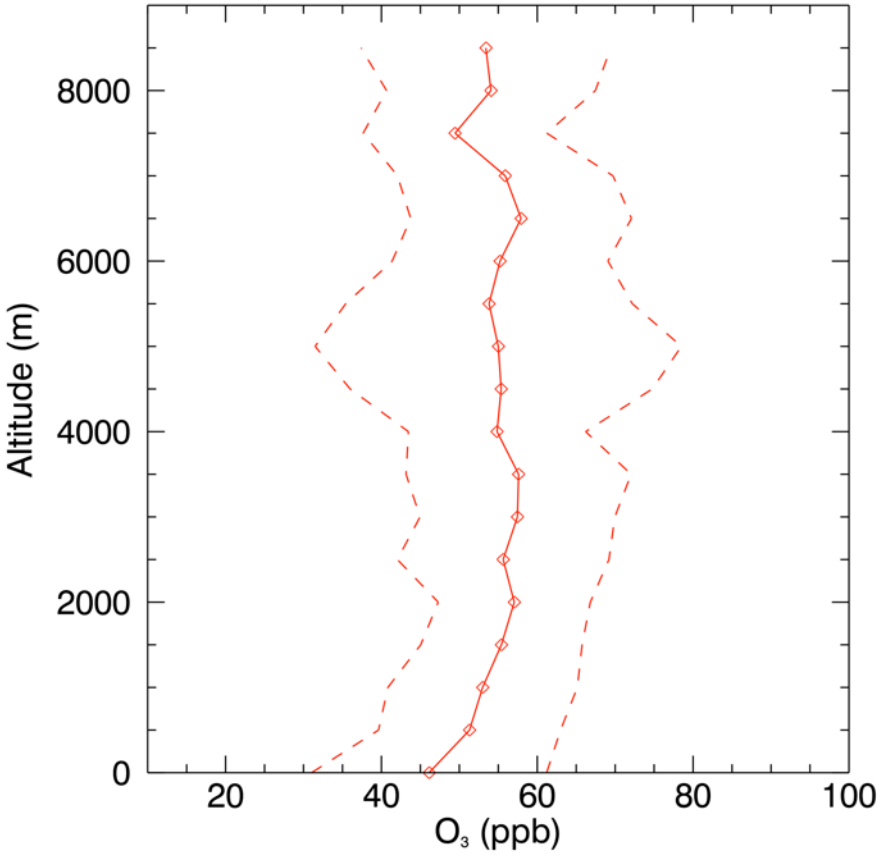
Nevada Rural Ozone Initiative surface O_3 sites (Mae Gustin & Rebekka Fine, UNR)

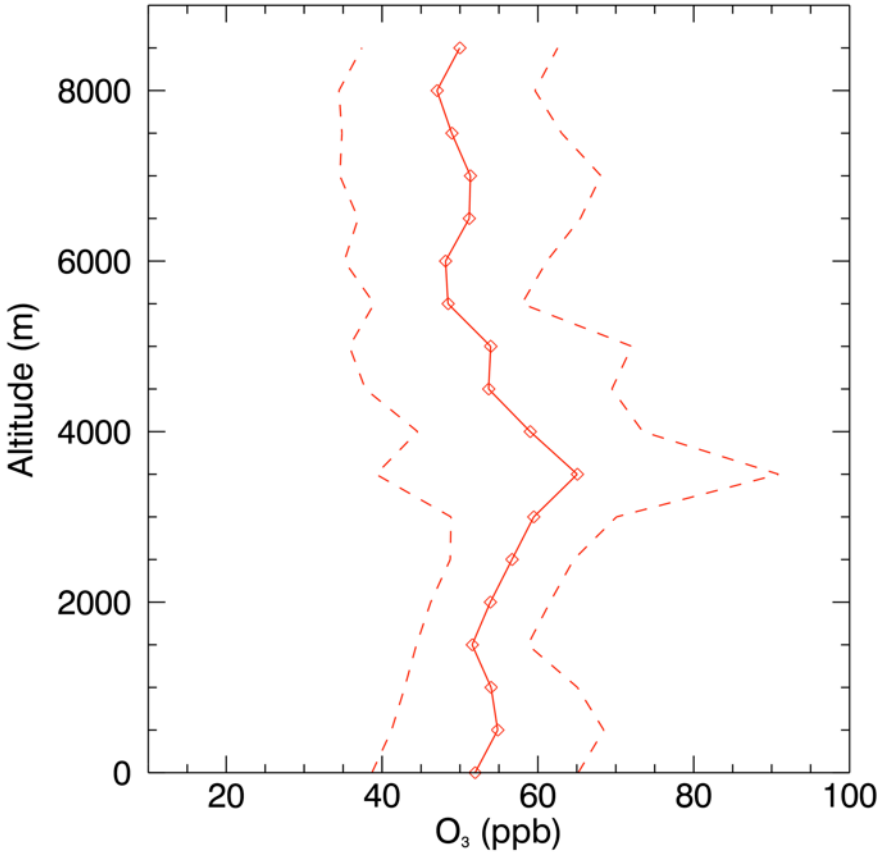
Onshore-offshore flights



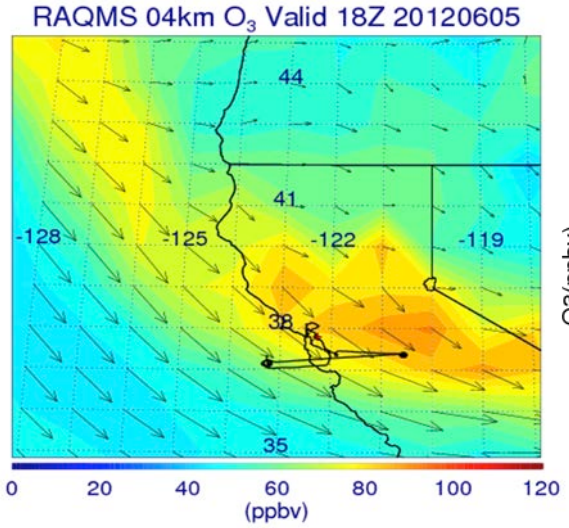
Flights: Once a month during 2012, since then during spring (April-June)

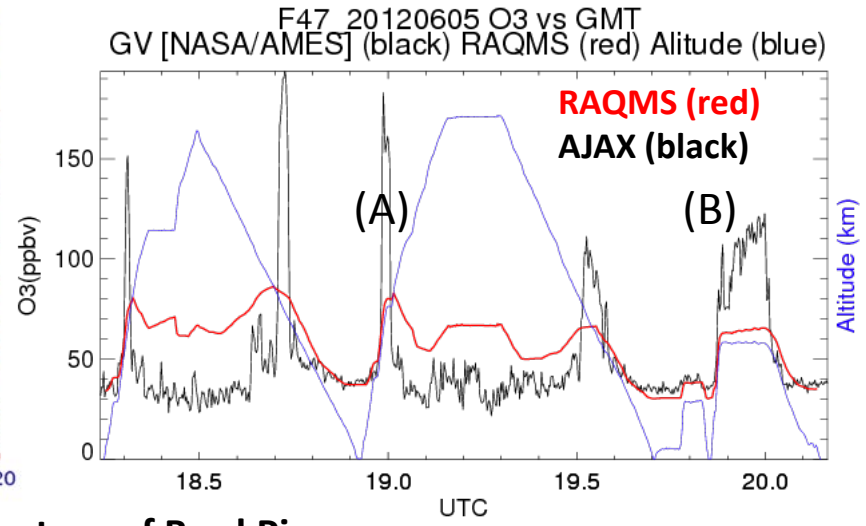
Average O_3 profiles: Offshore (left) and inland (right).

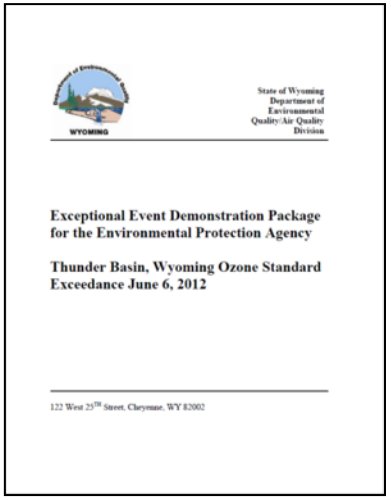




Stratosphere-to-troposphere transport (STT): AJAX flight 5 June 2012





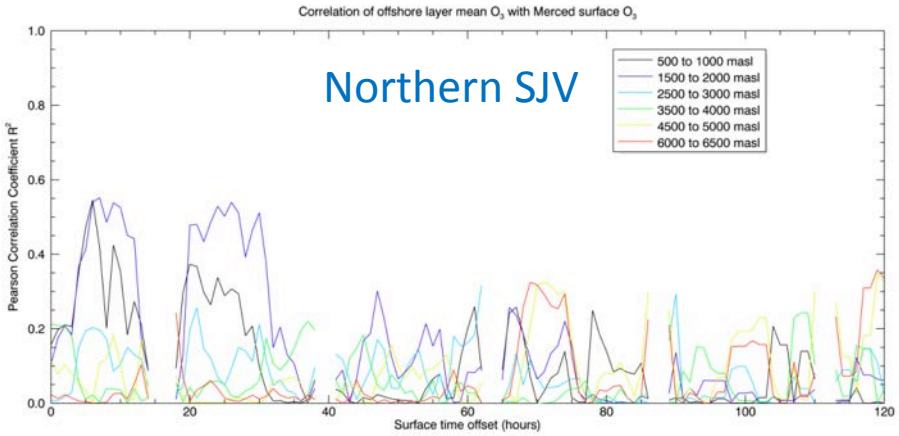


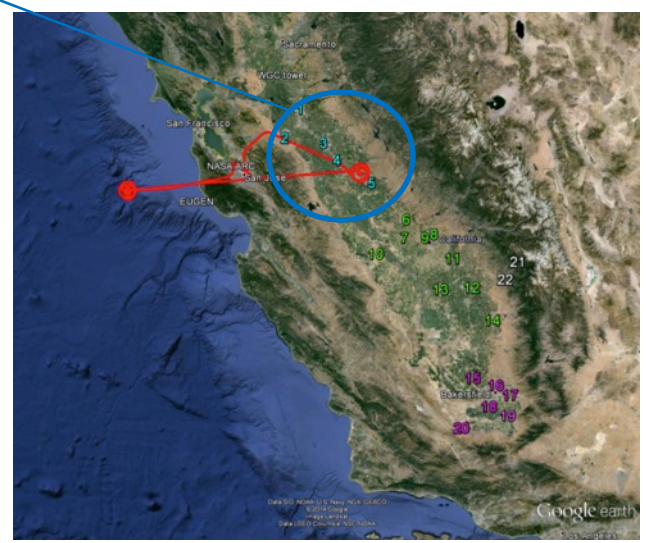
Figures courtesy of Brad Pierce

- AJAX measurements show a narrow (<1km) filament of high (>180ppbv) ozone during the profile over San Joaquin Valley (A) and a broader filament during the off-shore profile (B)
- RAQMS global ozone analysis underestimates the ozone mixing ratio within the fold for both onshore and offshore spirals but captures the timing and location fairly well.

Yates et al., 2013, Atmos. Chem. Phys., 13, 12481-12494

Correlations between offshore O_3 profile and SJV surface O_3





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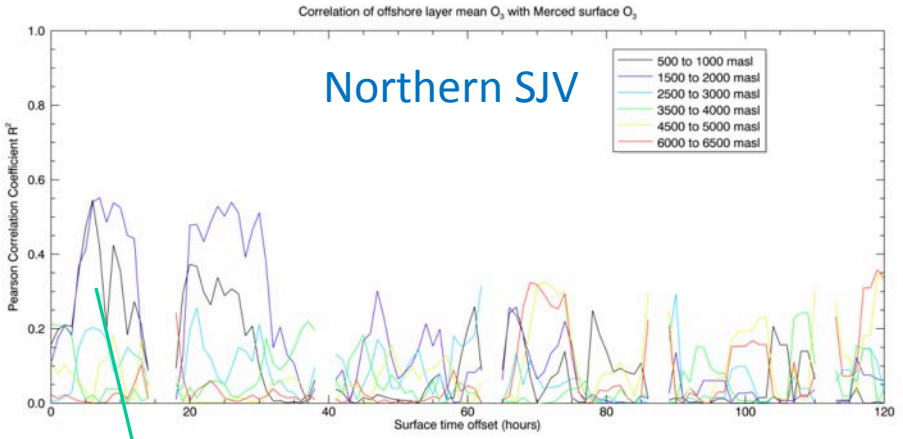

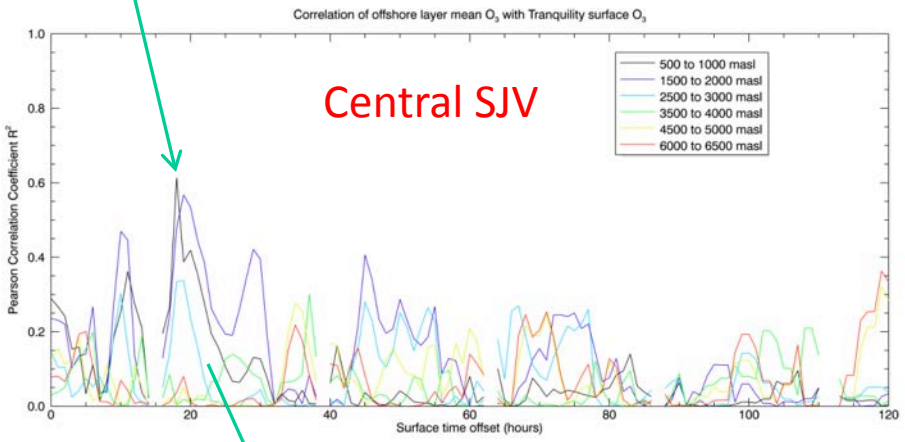

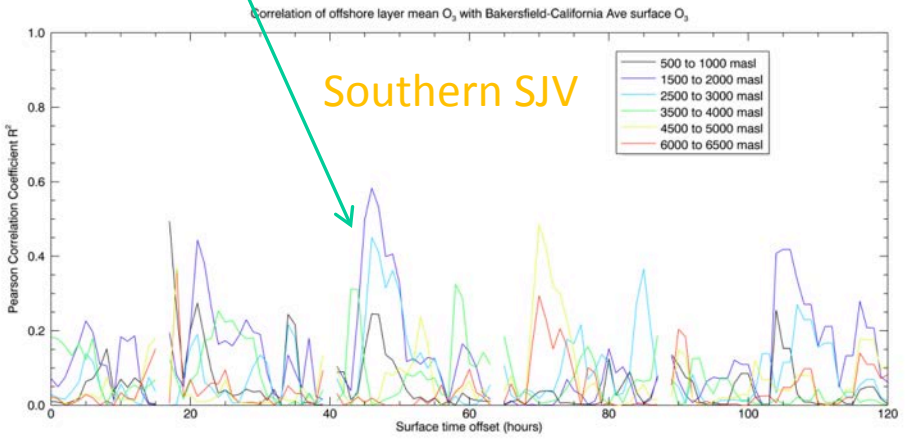

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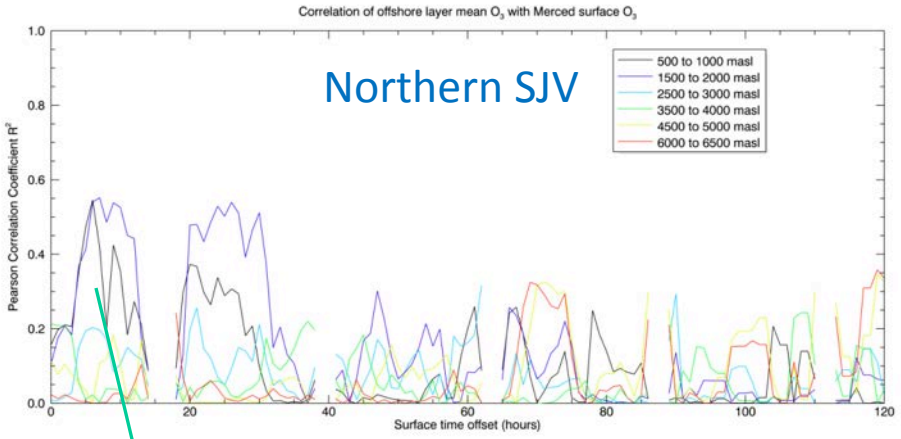
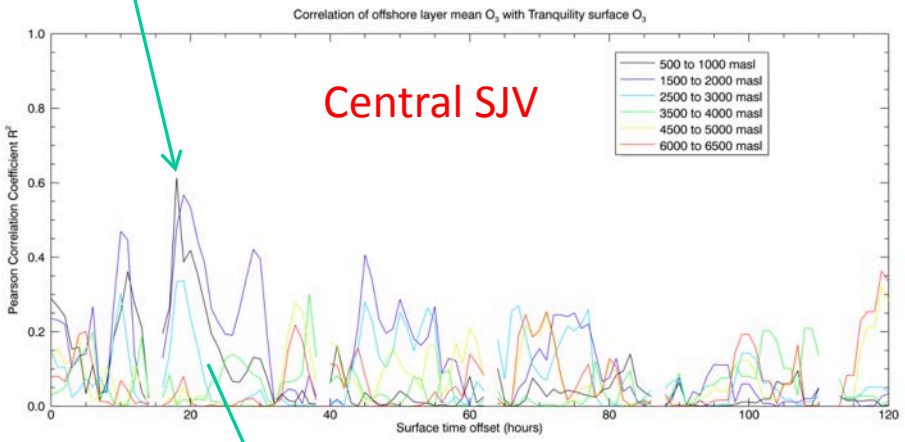
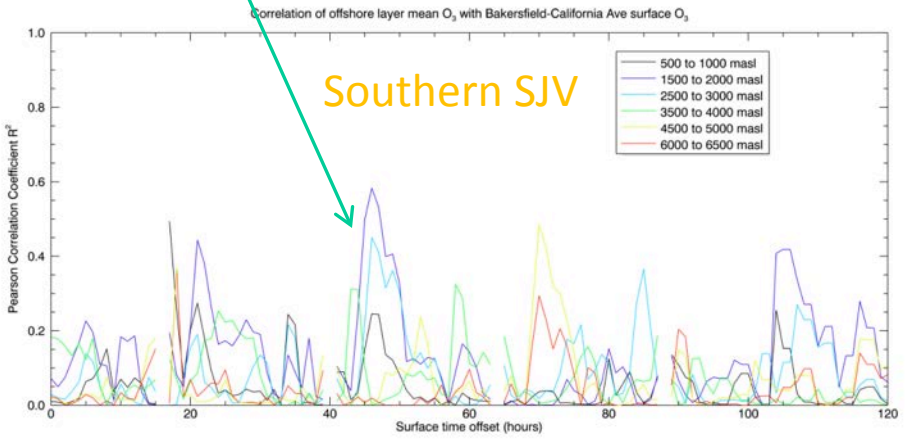
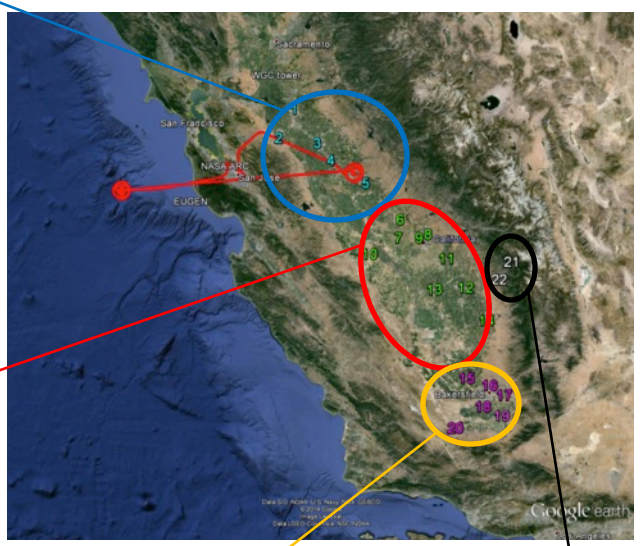
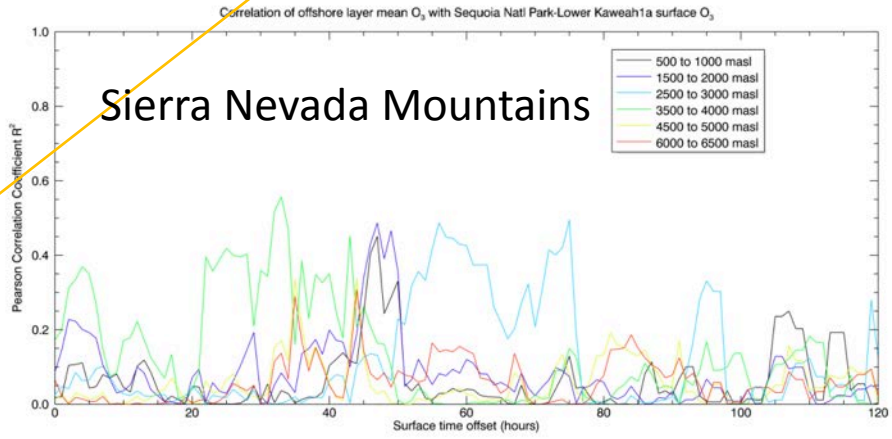






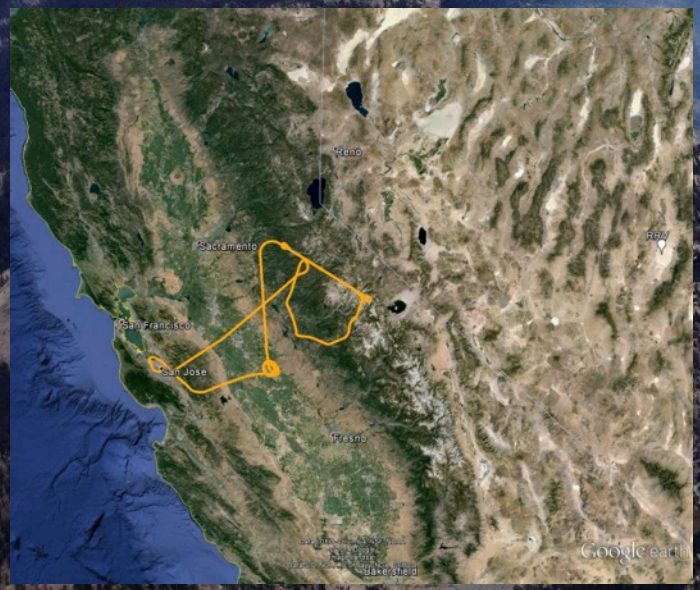




Yosemite Rim fire

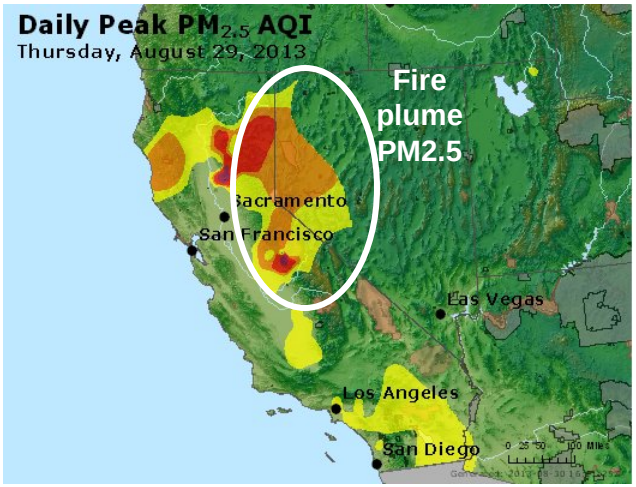
Main smoke plume

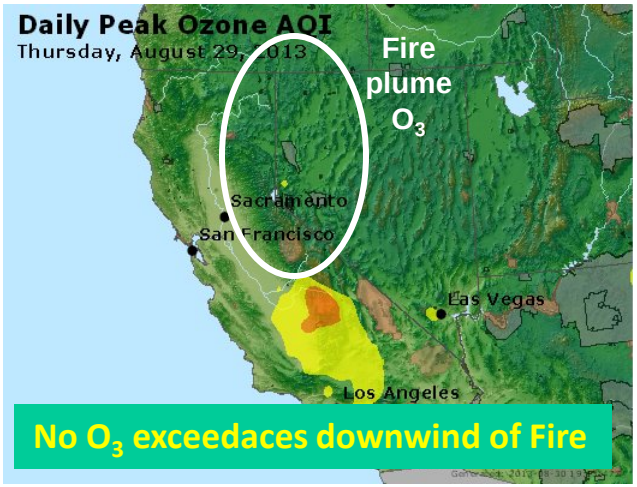
Valley Haze



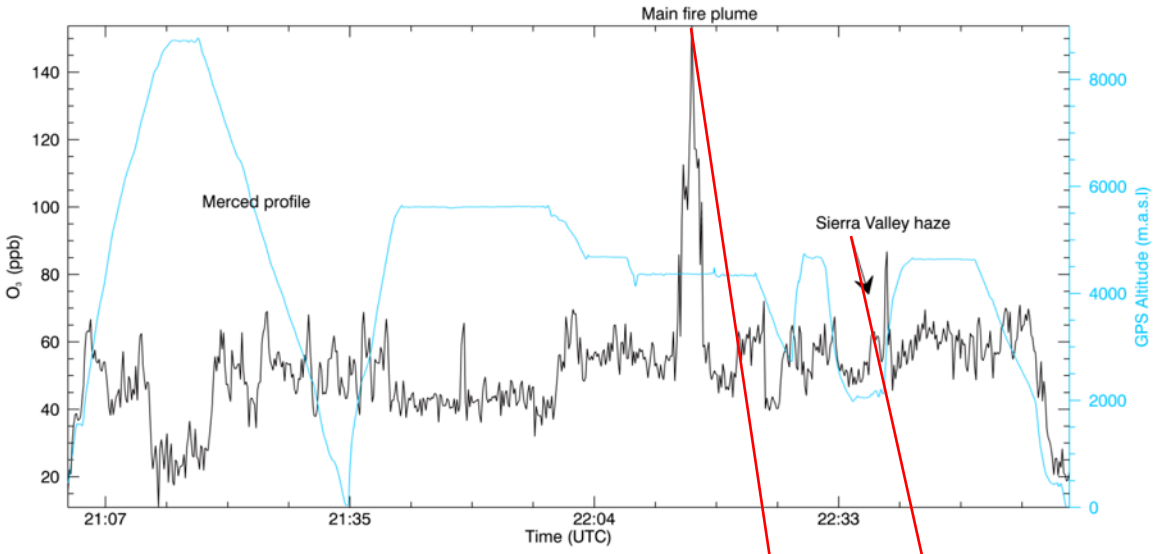
(Photo credit: Rob Simone)

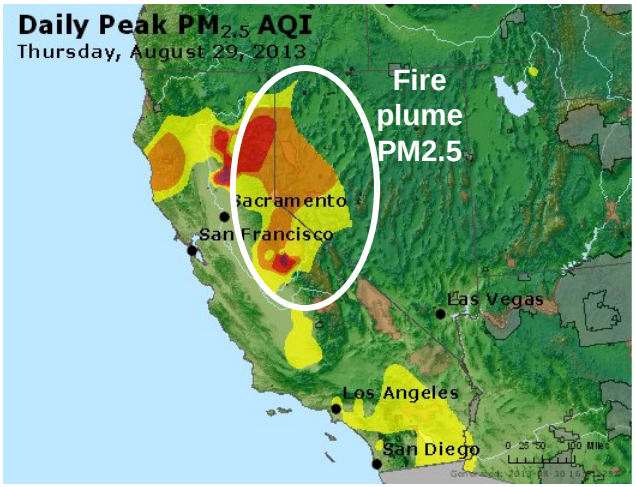
Yosemite Rim fire 29 Aug 2013

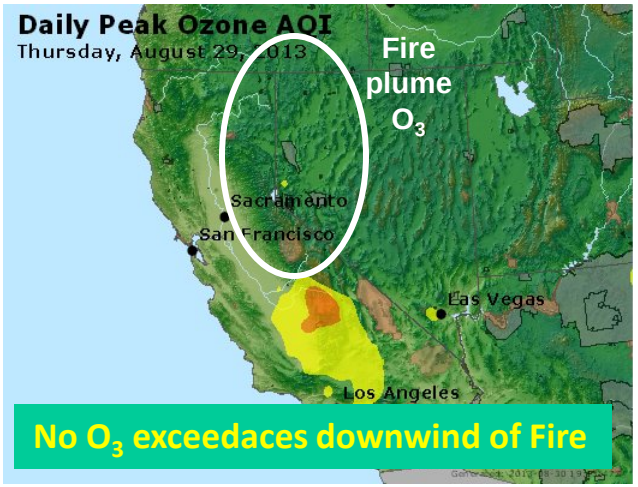




Yosemite Rim fire 29 Aug 2013







Conclusions & Future Work

- Regular sampling of O_3, and targeting key events, above CA and NV can address key questions in current Western US O_3 knowledge:
  - Provide evidence to support theories of vertical mixing and transport in a complex mountainous region
  - Used to assess regional contributions through sampling upwind (clean) and downwind (polluted) profiles.
  - Uniquely flexible to target key events (e.g. Yosemite Rim Fire, targeting stratospheric intrusions etc)

- **New Instrumentation**: AirCore (GHG satellite validation to 13 km) & Formaldehyde (Tom Hanisco, NASA GSFC)

Thank you

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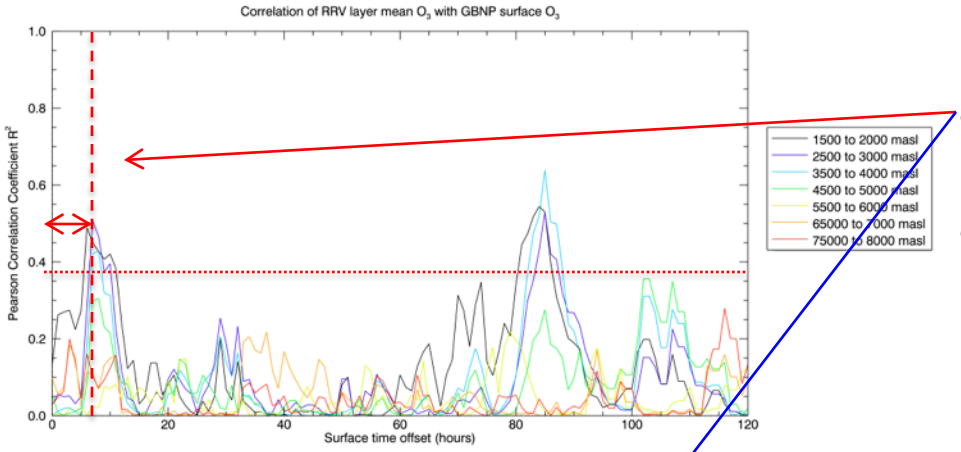
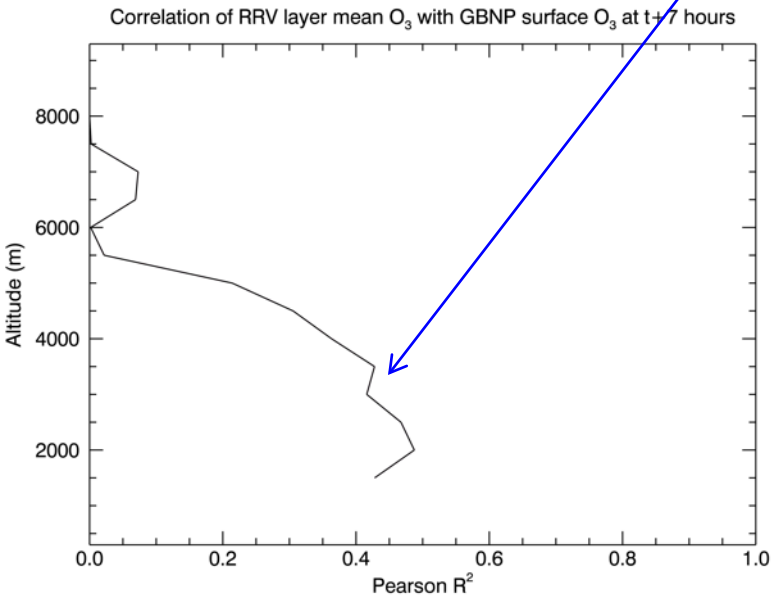
Tomoaki Tanaka	Rebekka Fine
Warren Gore	Brad Pierce
Matt Roby	Owen Cooper
Chris Camacho	Ryan Walker
David Austerberry	Jimena Lopez
Tony Trias	Craig Clements
Emmett Quigley	Zion Young
Matthew Johnson	Roy Vogler
Ed Sheffner	Peter Tong
Pat Hamill	Pilots & Crew of H211, LLC

http://www.youtube.com/watch?v=brvhCnYvxQQ

Extra Slides

Correlations with Great Basin National Park surface site





- **Good correlation** (R^2 >1/e) at *t*+6-12 hrs (& 85 hrs) at altitudes below 3.5 km
- Time offset (*t*+6-10 hrs**) implies** GBNP and RRV profile < 3.5 km are influenced by common transport/production mechanisms with a brief time lag