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 O₃ 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).

- O₃ is only regulated pollutant with **positive vertical gradient**. The Mountainous western US is influenced by isentropically driven subsidence (Cooper et al., 2011).

- O₃ trends in the western US (Cooper et al., 2012):
  - **Urban sites have decreased** (precursor control)
  - **Rural sites have increased** (increasing tropospheric baseline O₃)
  - **Large gaps in surface data**: monitor density much less than in eastern US

Average O₃ profile plotted for offshore AJAX profiles during 2012
Experimental set-up

NASA Ames Alpha Jet Atmospheric eXperiment (AJAX)

Modified Picarro (2301-m) measures CO₂ and CH₄ located in center- and tail- sections of the wing-pod

Modified 2B technologies (model 205) measures O₃ and Meteorological Measurement System (MMS) located in the front/nose section of the wing-pod
Where we fly

- Vertical profile over Railroad Valley (RRV), NV
- Onshore (San Joaquin Valley) and offshore profiles
- Special events: Yosemite Rim fire
Flights: Once a month since May 2011, plus intensives every year at summer solstice
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 O₃ 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 \( \text{O}_3 \) 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

- 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 O₃ profile and SJV surface O₃

Northern SJV
Correlations between offshore O₃ profile and SJV surface O₃

Northern SJV

Central SJV

Southern SJV
Correlations between offshore O$_3$ profile and SJV surface O$_3$

Northern SJV

Central SJV

Southern SJV

Sierra Nevada Mountains
Yosemite Rim fire

Main smoke plume

Valley Haze

(Photo credit: Rob Simone)
Yosemite Rim fire 29 Aug 2013

No $O_3$ exceedances downwind of Fire
Yosemite Rim fire 29 Aug 2013

No O₃ exceedances downwind of Fire
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)
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http://www.youtube.com/watch?v=bryhCnYvxQQ
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