Springtime high surface ozone events over the western United States: Quantifying the role of stratospheric intrusions

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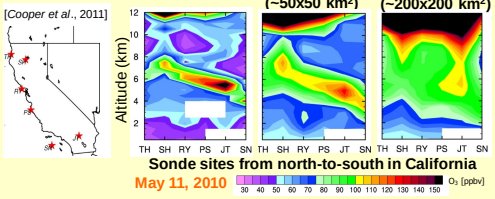
1. Introduction

The most active region at northern mid-latitudes for deep stratosphere-to-troposphere ozone transport (STT) in winter and spring is located off North American west coast, with strong influence extending into the western USA [*Sprenger and Wernli*, 2003]. Understanding STT is crucial for setting attainable ozone standards for this region. Quantifying STT in space and time is a long standing issue in current models due to limitations in model resolution, the representation of atmospheric circulation and chemistry both in the stratosphere and in the troposphere, the definition of tropopause, and tracking stratospheric ozone in the troposphere [e.g. *Stohl et al.*, 2003; *Prather et al.*, 2011].

We focus on the CalNex campaign period (**May-June 2010**) to:

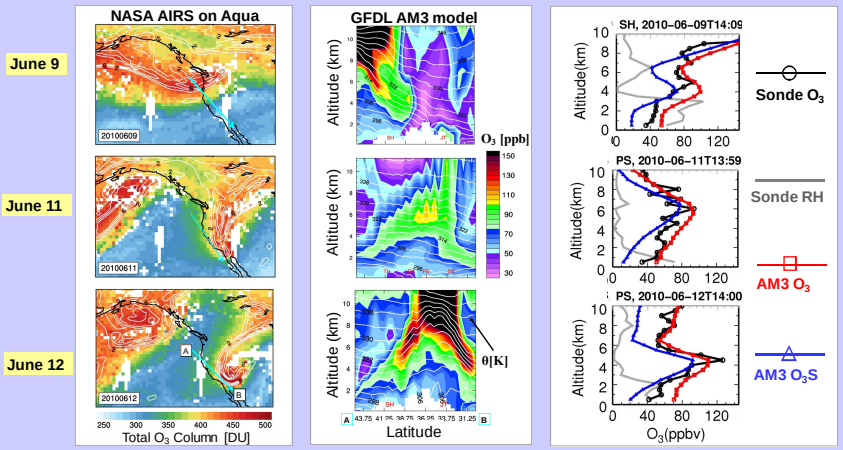
- Improve process understanding of regional STT variability on multiple spatial (50 to 200 km horizontal) scales
- Quantify the role of STT on springtime high surface ozone events
- Develop space-based criteria to aid in identifying the exceptional events for regional air quality management

2. High-resolution GFDL AM3 better captures structure of stratospheric intrusions



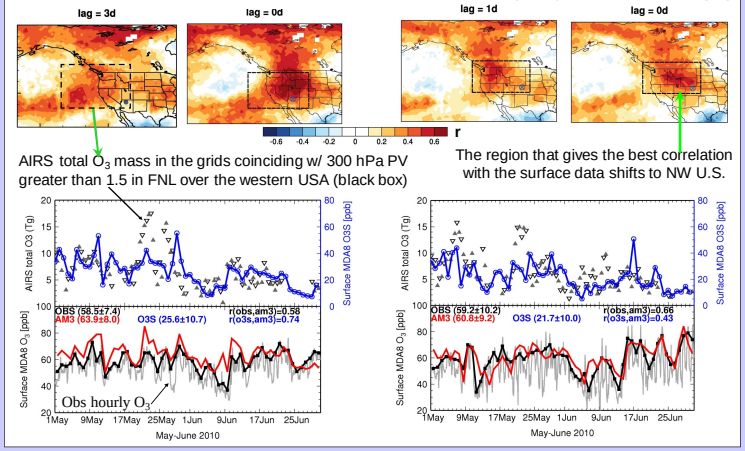
- **Full stratosphere-troposphere-aerosol chemistry** [*Donner et al.*, 2011]
- **Nudged to NCEP GFS U and V (Weaker strength with decreasing pressure)** [*Lin et al., 2011*]
- **Stratospheric ozone tracer (O_3S)**
  - Label O_3 above thermal tropopause as "stratospheric"
  - Transport driven by meteorology
  - Subject to chemical and depositional loss in the troposphere
  - Better for diagnosing variability than absolute magnitude

3. A proof-of-concept approach to forecast deep stratospheric intrusions impacting ground-level ozone using space-based column measurements of O_3



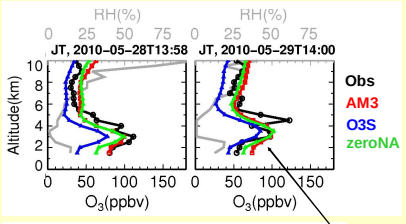
- **AIRS total O_3 retrievals (color)** [*Susskind et al, 2003*] **capture southeastward intrusions of polar strat. air**
- **Consistent with 300 hPa PV (contour, PVU) from FNL analysis**
- **Model O_3 profiles and stratospheric O_3 tracer confirm injections of stratospheric O_3 into the mid- and lower troposphere**
- **Consistent with ozonesonde observations along the California coast**
- **Six events verified by daily ozonesondes during May 10-June 19, 2010**

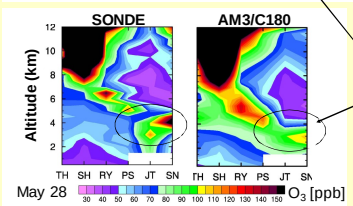
Correlation of AIRS total O_3 at each 1°x1° grid with stratospheric enhancement to surface daily max 8-hr O_3 (MDA8) at western U.S. high-elevation sites in AM3 lagged by 1-3 days



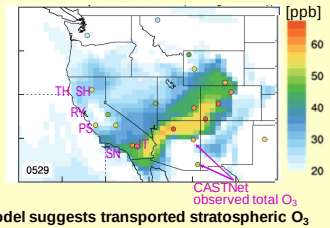
- **Only very deep intrusions traversing California are likely to influence the SW US surface (Section 4)**
- **Injection of stratospheric O_3 is a key driver of high-O_3 events in the intermountain regions**

4. Deep stratospheric ozone intrusions may affect surface air quality in densely populated regions (e.g. LA area)



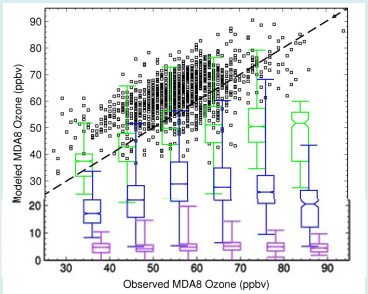


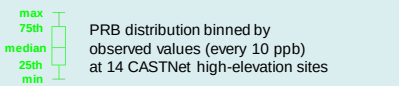
Stratospheric enhancement to MDA8 O_3 in the model surface layer on May 29



- **Model suggests transported stratospheric O_3 contributes ~80% to enhanced O_3 at 2-4 km on May 28-29, consistent with the low observed humidity (marker for air of stratospheric origin). The recirculation of NA anthrop emissions is NOT a major source.**
- **At the surface, the model estimates a 50-60% contribution from stratospheric O_3 on May 29**

5. Summary of the results for the U.S. Mountain West (Apr-Jun 2010)





- **PRB** (*estimated with NA anthrop. emissions off*)
- **Stratospheric contribution** (*likely an upper limit, Section 2*)
- **Asian enhancement** (*Lin et al., 2011*)

- **AM3 captures some observed high-O_3 events (>70 ppb), but overestimates the lower tail of observed O_3**
- **PRB is largest in the EPA 60-70 ppb range of O_3 proposed for reconsideration (not adopted)**
- **Significant contributions of stratospheric O_3 at high end**
- **Challenges for this high-altitude region to attain 60 ppb standards**

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