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Informing North American Background Ozone from Observations: Characterizing Ozone Levels in North America from Ozonesonde and Surface Observations

Sam Oltmans
Boulder, Colorado

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What can observations tell us about background ozone?

- We don't measure North American Background (NAB) ozone

  So what do we measure?
- Can we measure "background" ozone at a North American location like Trinidad Head, California?
- What are the characteristics of North American "background" ozone?

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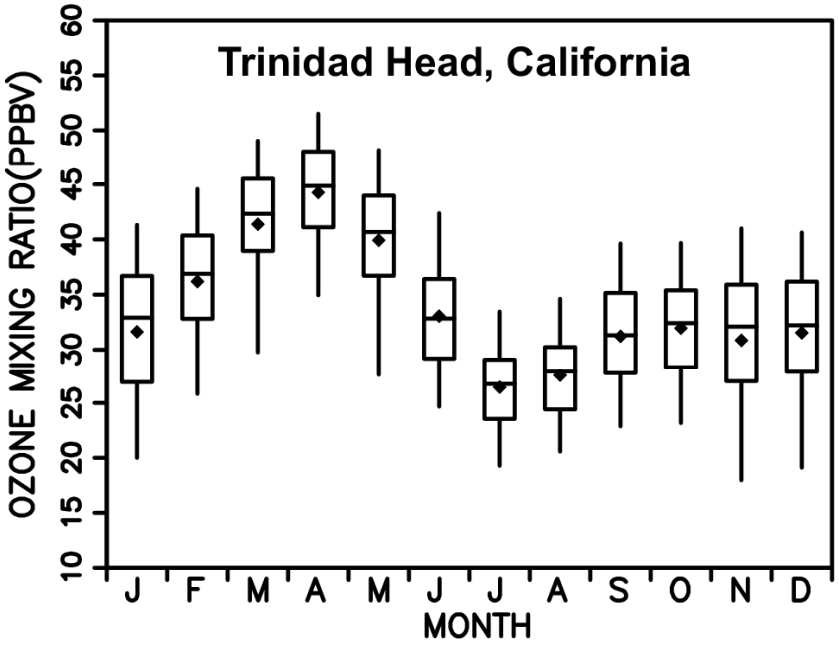
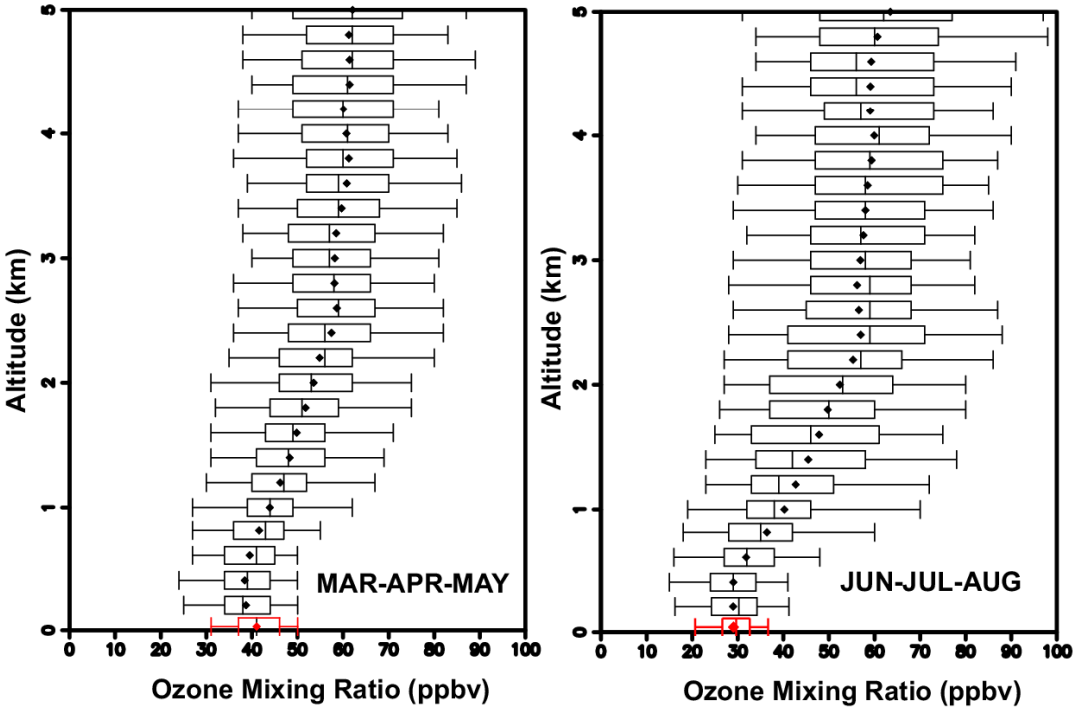
Location of the NOAA Trinidad Head Observatory

Conclusion: Trinidad Head is a well exposed site in a relatively remote location.





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Surface (daytime) and profile ozone at Trinidad Head

Diamond = Mean
Horizontal/Vertical Line Inside Box = Median
Box = Inner 50th Percentile (25th & 75th)
Whiskers = Inner 90th Percentile (5th & 95th)
Red = Surface Values Superimposed on the Profile.

Conclusion:

1) Average spring daytime (or 8-hr max) surface ozone at Trinidad Head is ~43 ppb. 25% of the hourly avgs. >45 ppb.
2) Above the boundary layer (~2 km) avg. O_3 is ≥50 ppb in spring and summer.

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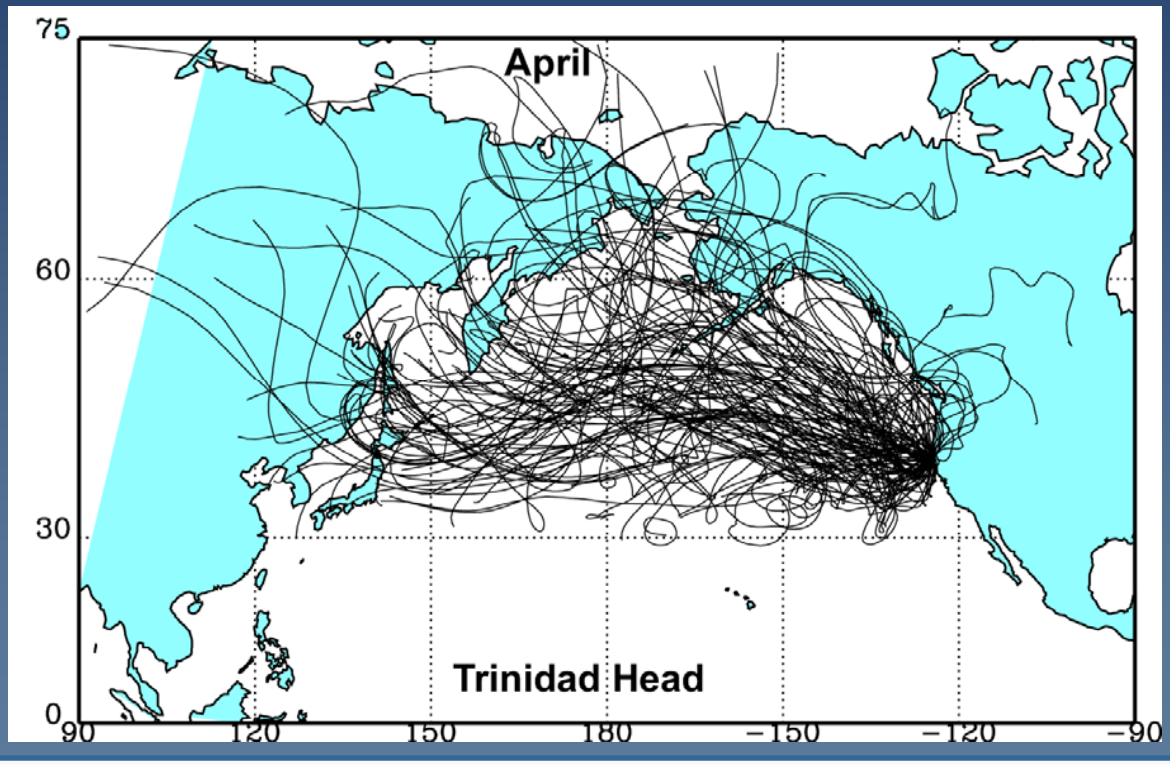
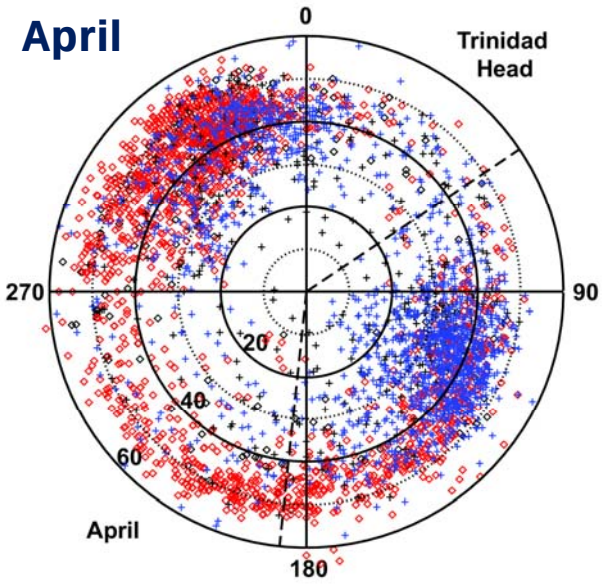
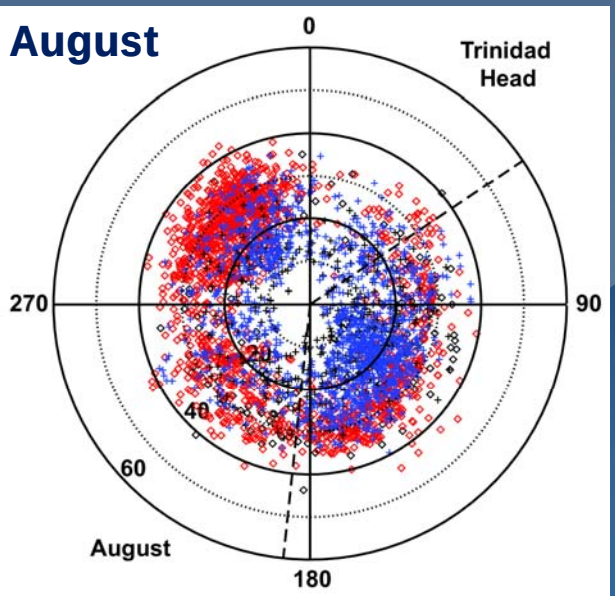
Is ozone measured at Trinidad Head Representative of PRB conditions?

Back trajectories (10-day) to Trinidad Head for days in April with hourly avgs. ≥50 ppbv





Trinidad Head surface ozone separated by day (10-21 LST - red) and night (22-09 LST - blue).



Conclusion: During the daytime – Very frequently.
At night – Some of the time.

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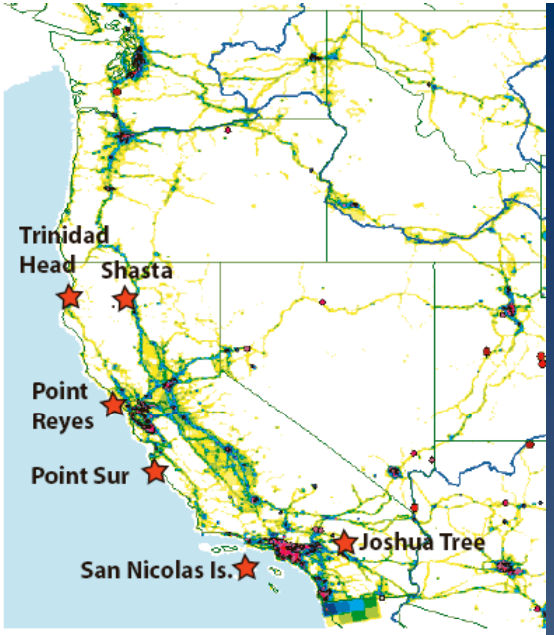
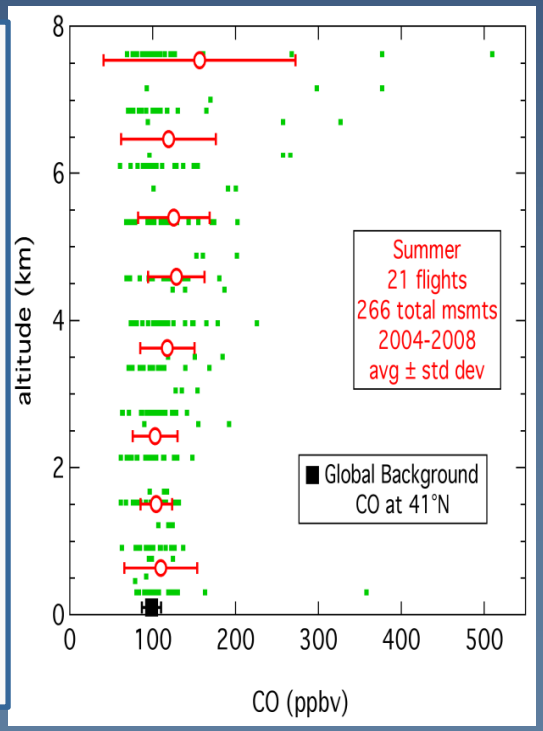
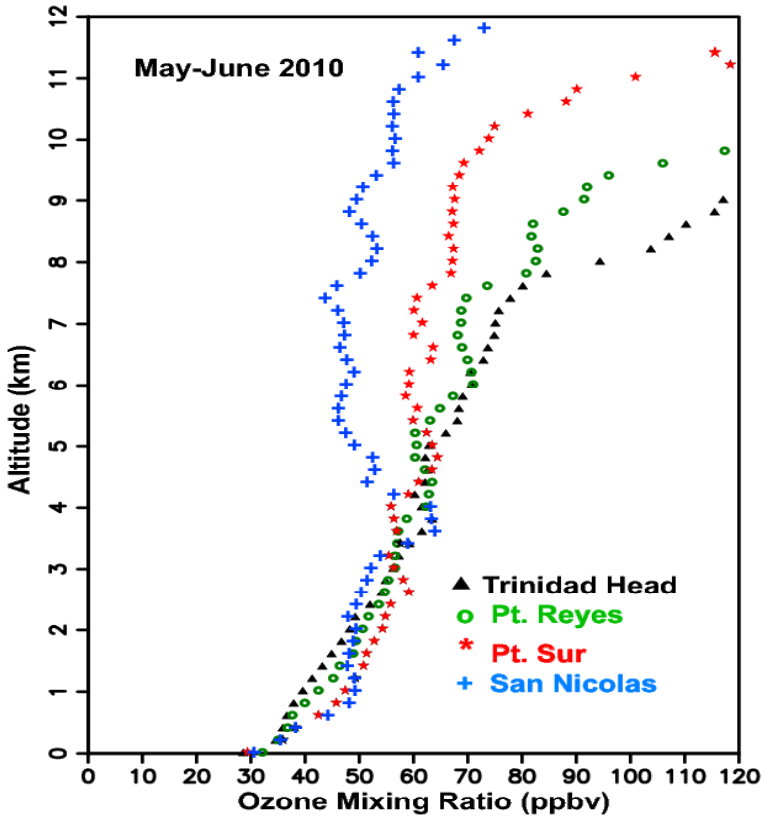
What do vertical profiles say about ozone reaching the California coast?



Vertical profiles of carbon monoxide measured in flasks collected on aircraft flights above Trinidad Head CA. The green pts give the individual obs and the red circles indicate avgs and standard deviations .

Conclusion: Air flowing into Trinidad Head represents the Pacific "background".





Average ozone mixing ratio profiles at four sites making ozonesonde observations during the IONS 2010-CalNex Campaign in May-June 2010.

Conclusion: In the lower troposphere (<4 km) average ozone amounts are similar along the California coast.

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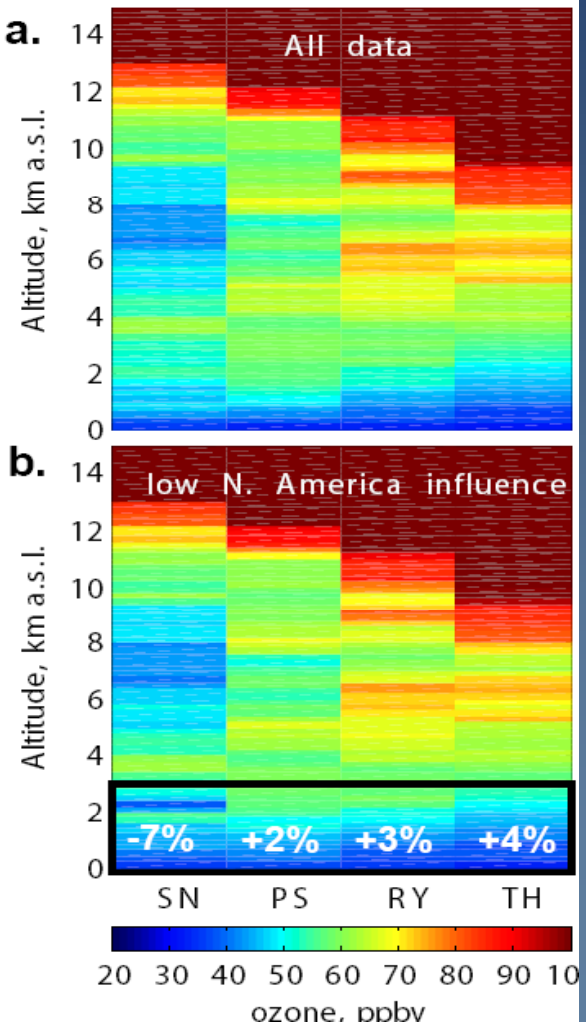
What influences tropospheric ozone levels at the California coast?

TH = Trinidad Head
RY = Point Reyes
PS = Point Sur
SN = San Nicolas Isl.

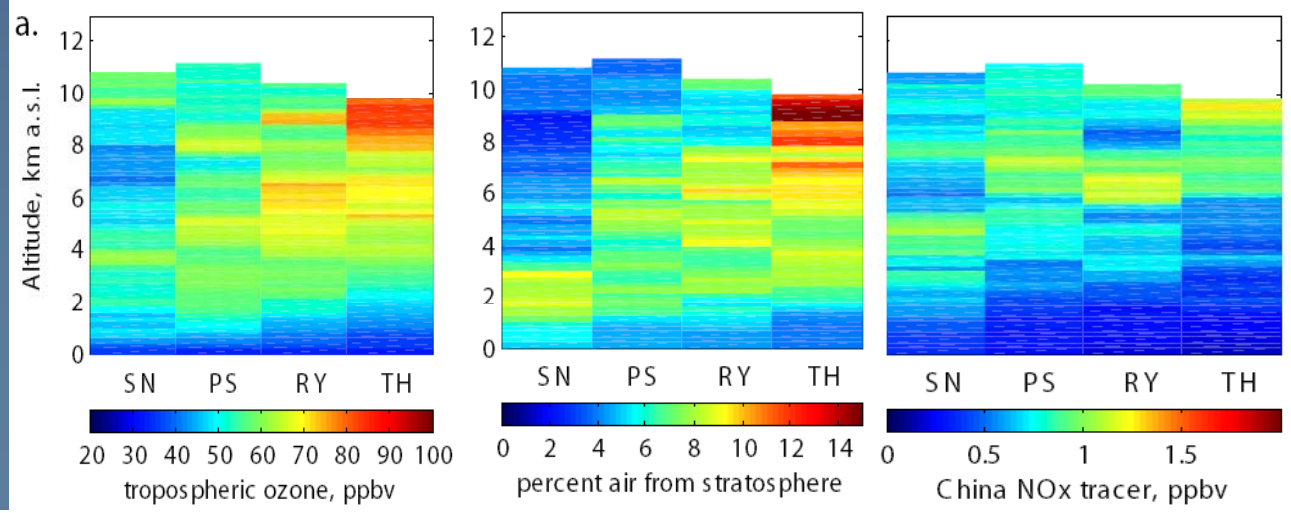


Conclusion (left panel): North American influence has an insignificant impact on lower trop O3 levels along the coast of CA.

Conclusion (below):

1) **Strat contribution increases at lower levels moving south.**
2) **Asian transport is felt most strongly above the boundary layer (~2 km)**

Tropsopheric Ozone (ppbv) | **Stratospheric Contribution (%)** | **Asian Transport (NOx Tracer – ppb)**



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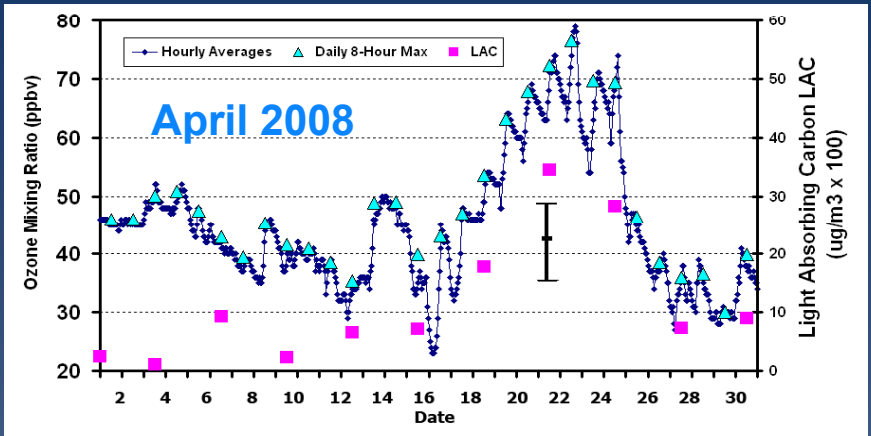
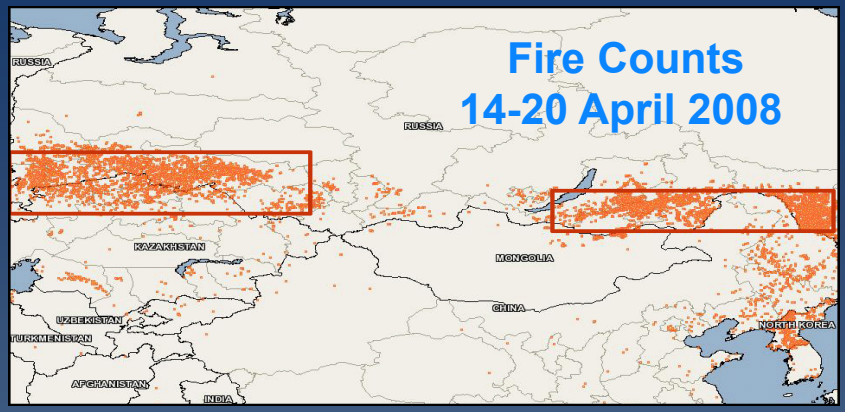
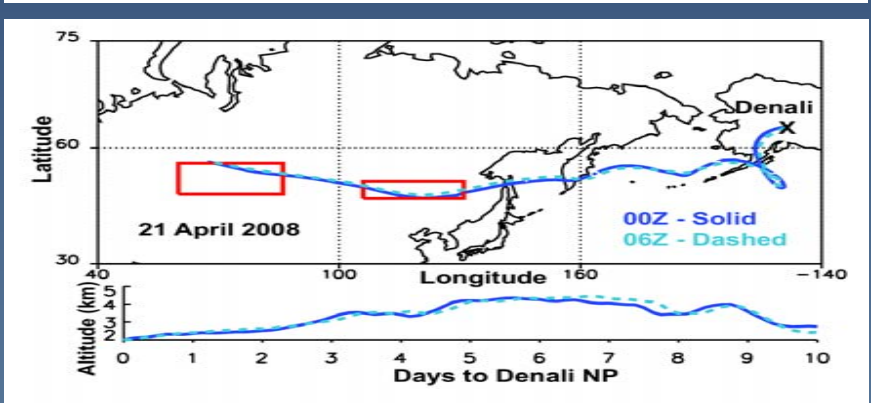
What can interior sites in North America tell us about NAB?

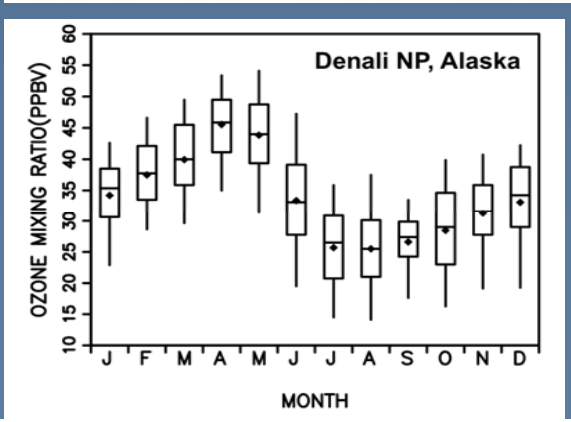






Influence of Eurasian Biomass Burning

Surface ozone at Denali NP, AK in April 2008. Peak hourly avg 78 ppb, 8-hr max of 75 ppb, 5-day avg >65 ppb associated with trajectory and ancillary constituents showing likely cause as major early fires in Eurasia.



Conclusion: During spring Asian transport can have significant influence on lower trop O3 levels. Higher spring ozone amounts (April avg. ~45 ppb) have little North American influence and likely represent ozone levels of air flowing into North America.

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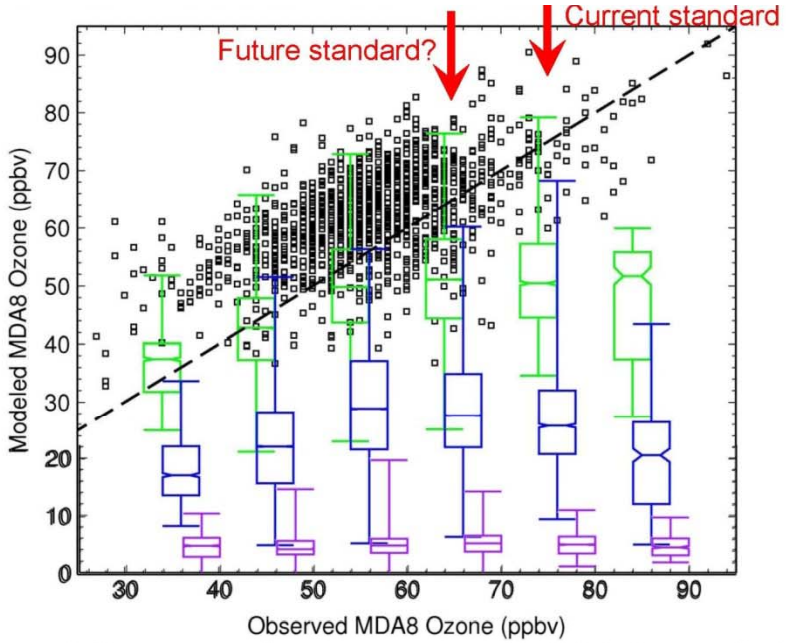
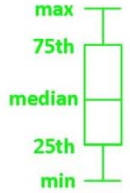
Comparison of Observations with Model Results

Comparison of model results from the GFDL AM3 with observations over the western US in May-June 2010.

Note the important contribution from the stratosphere, especially relative to the Asian contribution and the contribution from NAB to the observed O_3 above 50 ppb.





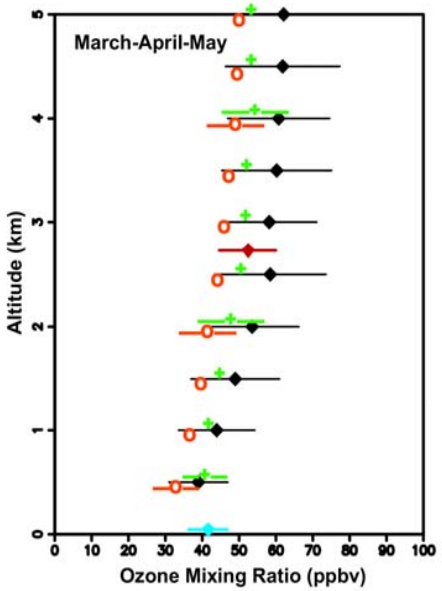
NAB distribution binned by observed values (every 10 ppb)

O_3-Strat (*upper limit*)

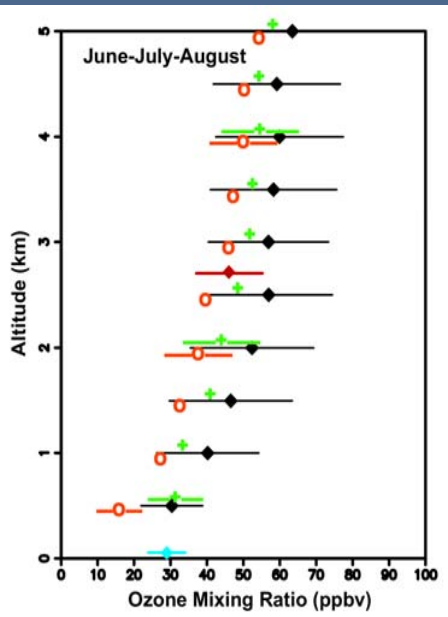
O_3-Asian

From Lin et al. (in preparation)

- **AM3 model captures some observed high-O_3 events (>70ppb)**
- **NAB (including stratospheric and Asian components) is largest in the 50-80 ppb range of observed total O_3**



Diamonds are Trinidad ozonesondes. Blue symbols are the seasonal surface ozone average at Trinidad Head. Red symbols are the Mt. Bachelor seasonal average plotted at the altitude of the observatory. Profile results from the GEOS-Chem model for 2006 are shown as green pluses. The contribution from PRB the model profile is shown by orange circles. (McDonald-Buller et al., 2011).



Comparison of model results from the high resolution GEOS Chem Model (Zhang et al., 2011) and observations at Trinidad Head and Mt. Bachelor, OR (McDonald-Buller et al., 2011).

The modeled O_3 and background O_3 are generally less than the observed value.

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Conclusions

- Trinidad Head Observatory in N. California is a well located site for monitoring air entering the west coast of the U.S.
- Monthly average background ozone concentrations entering the west coast of the U.S. in the spring are >43 ppbv with daily 8-hour average amounts ≥50 ppbv. The number of hourly average concentrations ≥50 ppb for April varies from 30 to 187. The range of maximum hourly average concentrations is 54 to 65 ppb. This suggests background ozone levels may be somewhat higher than models predict.
- Intensive ozonesonde measurements confirm that Trinidad Head is representative of ozone levels entering the west coast of the U.S. and North America has minimal influence on levels at the coast.
- Biomass burning can produce large ozone enhancements that contribute to "background" ozone on an episodic basis and elevate average background values. Ozone data from relatively remote locations along with ancillary constituent data suggests that such ozone observations are often representative of background.
- Recent model results suggest that background ozone has a greater contribution from stratospheric sources than earlier model results suggest, especially relative to the Asian transport component.
- Background ozone makes a substantial contribution to observed ozone at concentrations ≥50 ppb.
- A broader perspective on "background" ozone can be provided using observations along with the modeled background ozone.