The Importance and Frequency of STE Processes in Affecting North American Background (NAB) O_3

Comments to the CASAC Ozone Review Panel

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Why Background (NAB) is Important

Correctly estimating hourly averaged NAB O_3 concentrations is important because characterizing PRB O_3 levels that are too low can result in

- Overestimated human health risk predictions; and
- Optimistic policy expectations of the levels to which hourly average O_3 concentrations can be lowered as a result of emission reduction requirements.

The Stratosphere - An Important Contributer to NAB O_3

- Sufficient evidence exists to illustrate that the stratosphere contributes to NAB O_3 concentrations at the surface at both high and low-elevation monitoring sites.
- A key question is how frequently do stratosphere-to-troposphere to the surface (STT-S) events enhance ozone concentrations at both high- and low-elevation monitoring sites?

Lefohn et al. (2001)

- STE processes contribute frequently to hourly average O_3 concentrations ≥ 50 ppb during the winter and spring at rural high- and low-elevation monitoring sites across southern Canada and the northern US.

- STE processes can contribute to violations of the US 8-h O_3 standard.

Recent Findings

- Langford et al. (2009) documented STE episodes in Colorado resulting in exceedances of the US O_3 standard during the springtime.
- Cooper et al. (2011) report that descending stratospheric intrusions and Asian pollution plumes play an important influence on the O_3 concentration distributions along the California coast.
- Langford et al. (2011) report that STT processes enhance surface O_3 concentrations at the Crestline (CA) O_3 monitoring site. The site experiences some of the highest O_3 exposures in the US.

Recent Findings

- Emery et al. (2011) modeling results indicate that PRB was well over 60 ppb in the West and Intermountain West due to event-oriented phenomena, such as stratospheric intrusion and wildfires.
- Ambrose et al. (2011) indicate that STE processes together with long-range transport from Asia were the most important mechanisms for delivering enhanced O_3 levels to the lower free troposphere in the Pacific Northwest.
- Lin et al. (2012-in preparation) report that the stratospheric contribution to North American background (NAB) in the spring is larger than that from Asian transport.

The Frequency of STT-S Enhancements

- Lefohn et al. (2011) investigated the frequency of STE events and their associated enhancements at 12 surface O_3 monitoring sites in the western and northern tier of the US.
- The authors concluded that the STT-S contributions were frequent during specific months and appeared to enhance the surface O_3 concentrations at both high- and low-elevation monitoring sites.

Predictions by Ludwig et al. (1977)

- Ludwig et al. (1977), using data from radioactive debris injected into the stratosphere during nuclear weapons testing in the 1960s, concluded the stratosphere contributed to ground level O_3 concentrations with a maximum occurring in the springtime at both high- and low-elevation surface-monitoring sites.

- The areas of greatest stratospheric contribution was estimated to be along the eastern slope of the Rocky Mountains, Upper Midwest, and in a band stretching from Texas into the northeastern US.

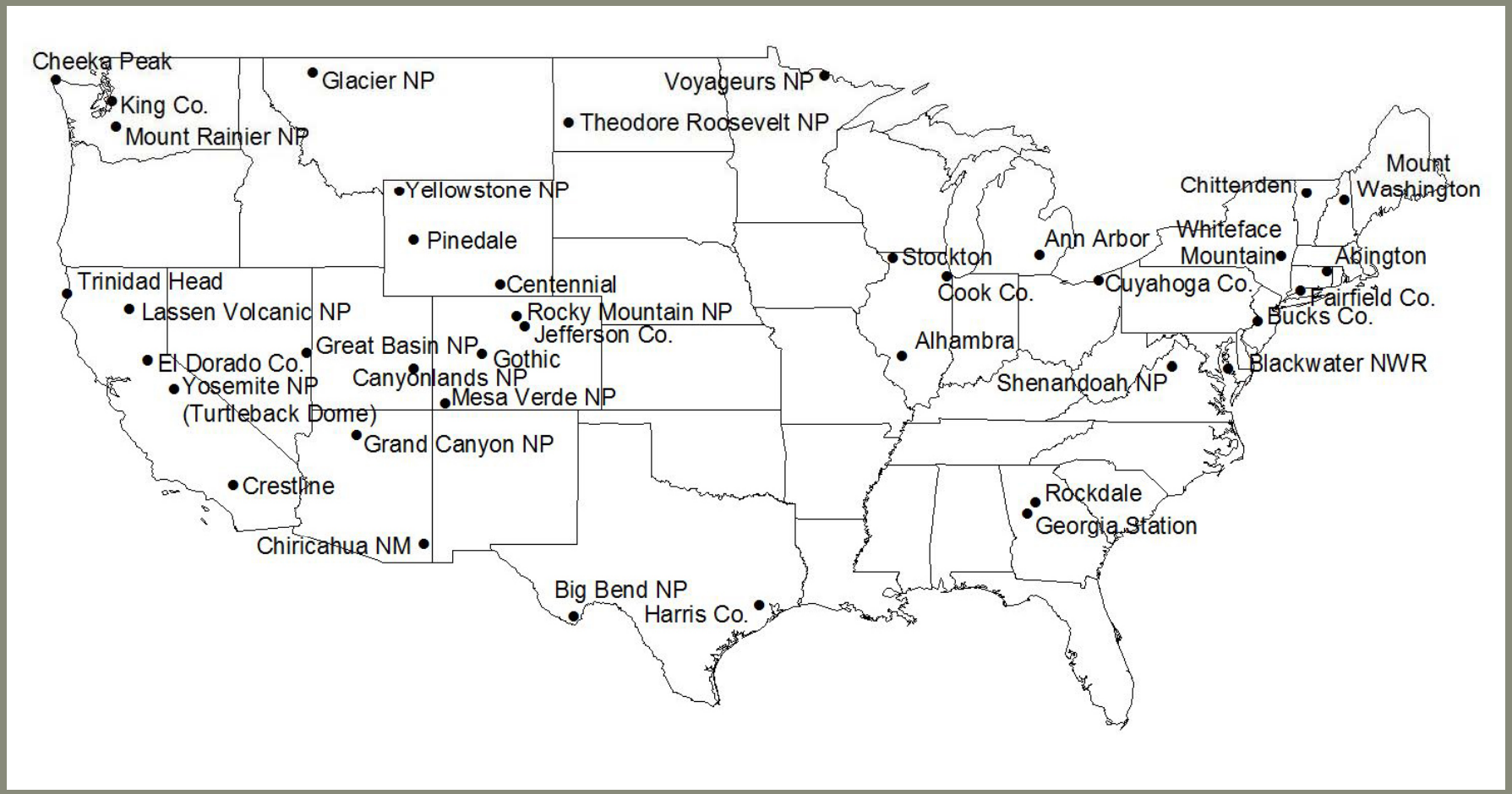
Most Recent Research Results by Lefohn et al. (2012)

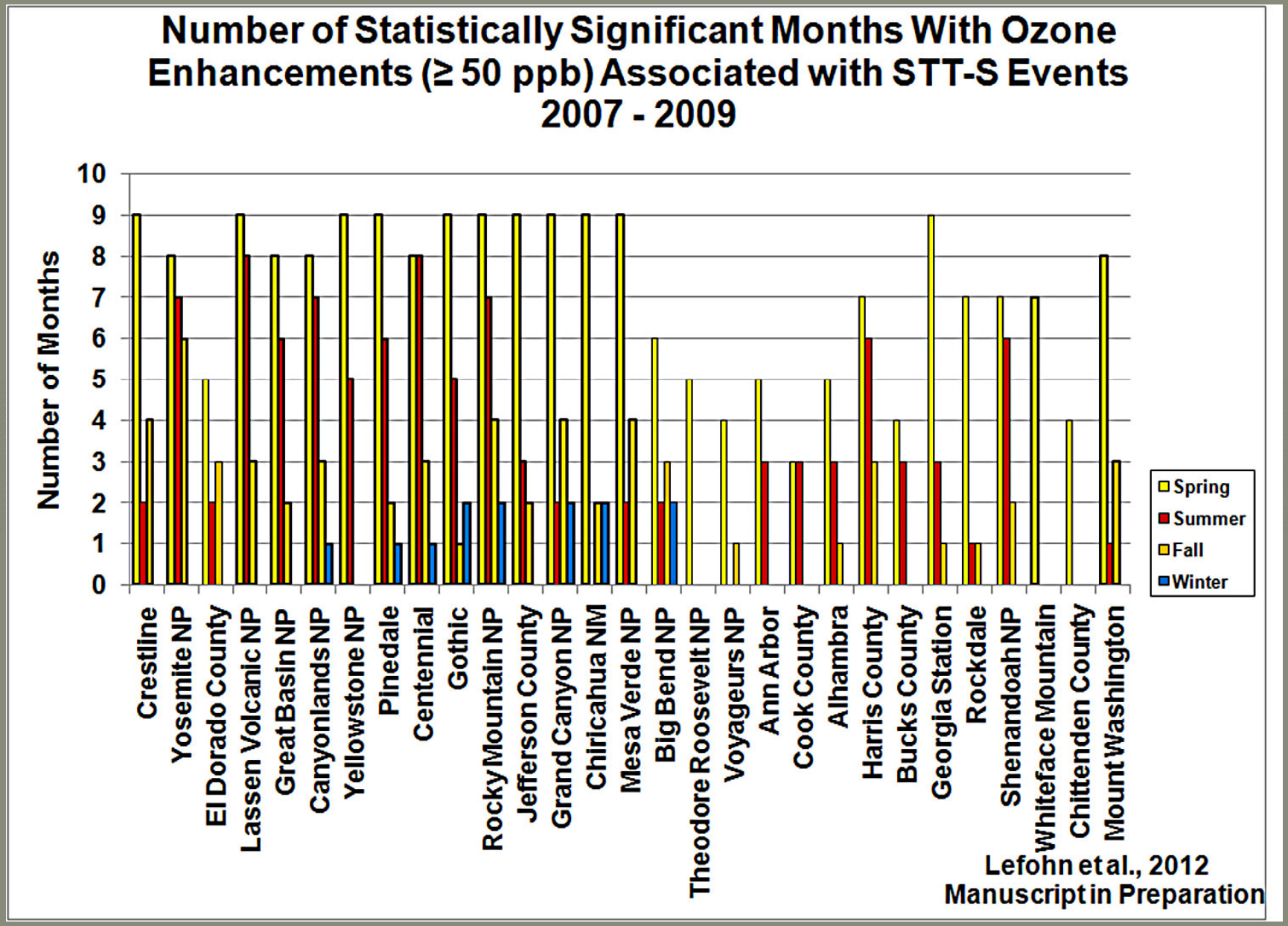
- Lefohn et al.* (2012-in preparation) investigated 39 monitoring sites across the US using a methodology similar to that used in Lefohn et al. (2011).

- Our results indicate that the stratosphere contributes to enhanced O_3 hourly averaged concentrations (≥ 50 ppb) at both high and low-elevation monitoring sites across the many areas in the US and our initial analysis indicates that the spatial pattern generally agreed with the predictions of Ludwig et al. (1977).

*Authors: Lefohn, Wernli, Shadwick, Oltmans, and Shapiro

Location of the 39 Ozone Monitoring Sites




Number of Statistically Significant Months With Ozone Enhancements (≥ 50 ppb) Associated with STT-S Events 2007 - 2009
Number of Months
0
1
2
3
4
5
6
7
8
9
10
Crestline
Yosemite NP
El Dorado County
Lassen Volcanic NP
Great Basin NP
Canyonlands NP
Yellowstone NP
Pinedale
Centennial
Gothic
Rocky Mountain NP
Jefferson County
Grand Canyon NP
Chiricahua NM
Mesa Verde NP
Big Bend NP
Theodore Roosevelt NP
Voyageurs NP
Ann Arbor
Cook County
Alhambra
Harris County
Bucks County
Georgia Station
Rockdale
Shenandoah NP
Whiteface Mountain
Chittenden County
Mount Washington
Spring
Summer
Fall
Winter
Lefohn et al., 2012
Manuscript in Preparation

Observations

- The high-elevation sites in the West, Intermountain West, and East experience O_3 concentration enhancements frequently occurring during the spring, summer, and fall that are statistically associated with STT-S events; and

- The frequency of STT-S events is greater at higher-elevation than at lower-elevation sites but both are frequent during the springtime.

Concluding Remarks

- The stratosphere frequently contributes to North American Background O_3 concentrations at the surface at both high and low-elevation monitoring sites.

- Modeling results reported indicate that the background contribution is largest in the 50-80 ppb range. GEOS-Chem models appear to underestimate the frequently occurring hourly average NAB O_3 concentrations $\geq$ 50 ppb.