SHADOZ (Southern Hemisphere Additional Ozonesondes): Classification of Ozonesonde Profiles using Self-Organizing Maps

Anders Jensen[1], Anne Thompson[1], F. J. Schmidlin[2]
[1]The Pennsylvania State University
Department of Meteorology, *anders@psu.edu*
[2]NASA, Goddard Space Flight Center, Wallops Flight Facility

PENNSTATE 1855

SHADOZ Southern Hemisphere Additional Ozonesondes

Introduction

- Stratospheric ozone absorbs ultraviolet radiation from the sun, but surface ozone is a pollutant.
- Tropospheric ozone concentrations are influenced by advection, stratospheric influence, photochemical production, biomass burning, and other anthropogenic sources.
- Ozone concentrations should be low in the tropics, especially over oceans.
- Pollution in the southern Atlantic is enhanced by biomass burning in southern Africa.

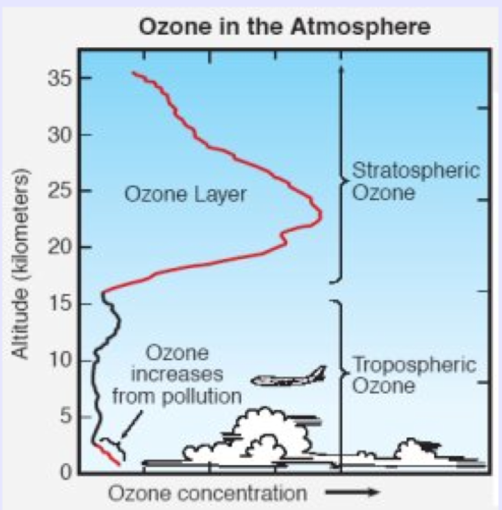
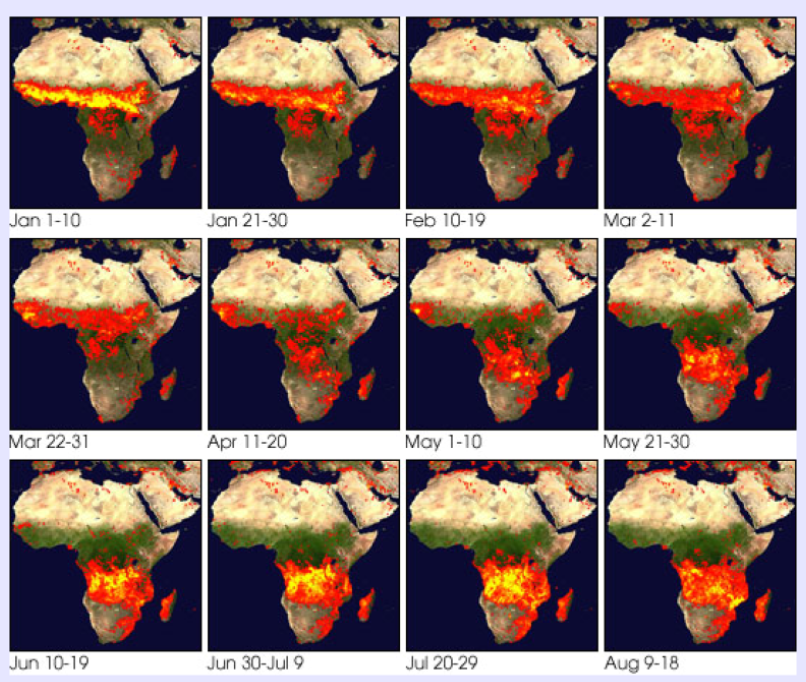


Figure 1 (right). Ozone in the Atmosphere. Image courtesy NASA.

- Seasonal biomass burning leads to a large increase in ozone in the southern Atlantic.
- To what extent does biomass buring affect tropical ozone values?

Problem



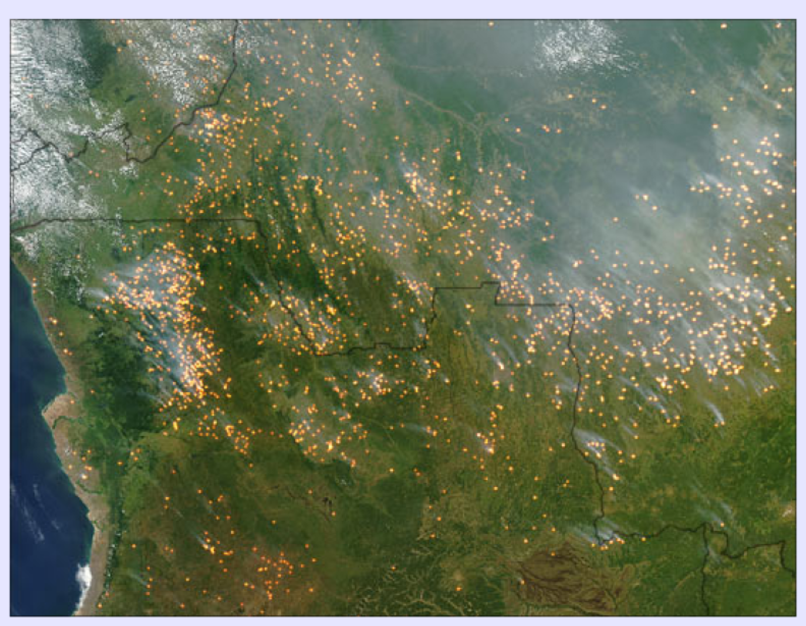


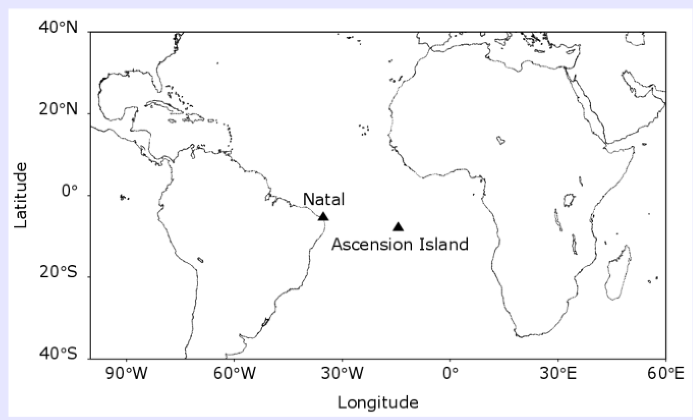
Figure 2 (top). Fire counts from MODIS in 2005 from January to August. Image courtesy NASA.

Figures 3 (middle). Fire counts and smoke in Angola and The Democratic Republic of the Congo. Image courtesy NASA.

Figure 4 (above). Biomass burning. Image courtesy NASA.

Goal & Methods

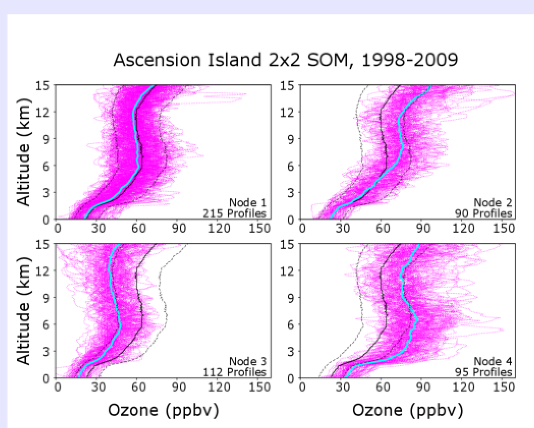
- Ozonesondes were launched at Ascension Island and Natal from 1998 - 2009
- We cluster ozonesonde profiles using self-organizing maps (SOMs) and compare the cluster maps to meteorology.
- We hypothesize that ozonesondes will cluster according to influences from meteorology and anthropogenic sources.
- Comparing clusters with the meteorology and seasonality should lead to insight on the major influences of tropical ozone.



Figures 5 (upper right). Ascension Island and Natal locations.
Figures 6 (above). Ascension Island. Image courtesy www.ascension-island.gov.ac

Figure 7 (right). An ozonesonde luanch from Hampton, VA.

Analysis



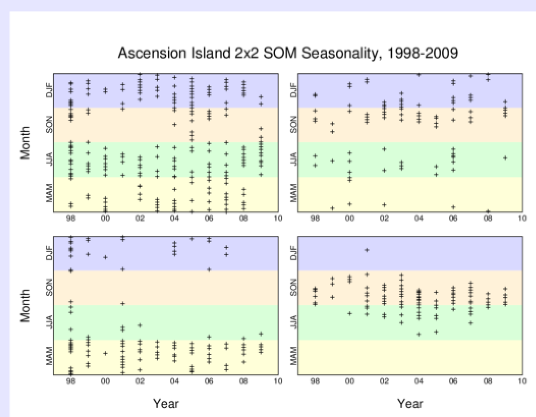
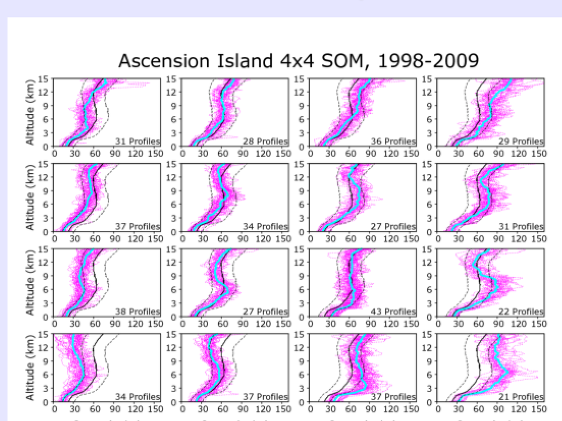
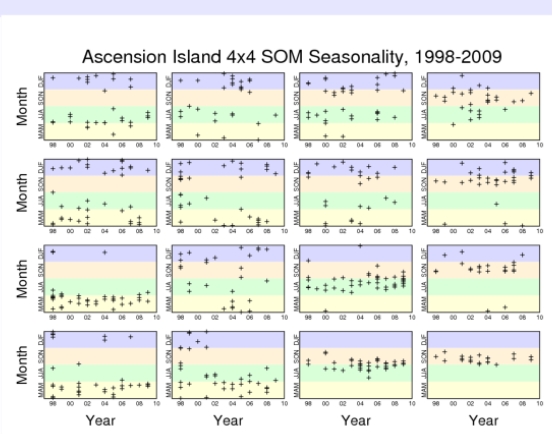


Figure 8 (above left). A 2x2 SOM for Ascension Island. The SOM nodes are plotted in cyan, the ozonesonde profiles are plotted in magenta, and the mean and one standard deviation for the entire period is plotted in solid black and dashed black respectively.

Figure 9 (above right). The launch time of year of each ozonesonde profile in each cluster. Note the seasonality for nodes 3 and 4.





Figures 10, 11 (above left, above right). Same as figures 8 and 9, but for a 4x4 SOM.

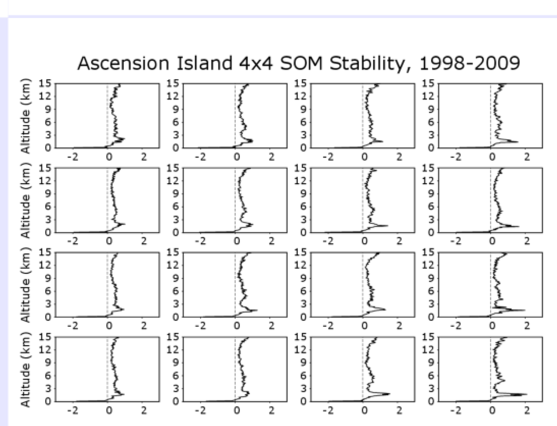


Figure 12 (right). Average stability of the profiles that went into each node. Positive values denote stable layers.

Analysis

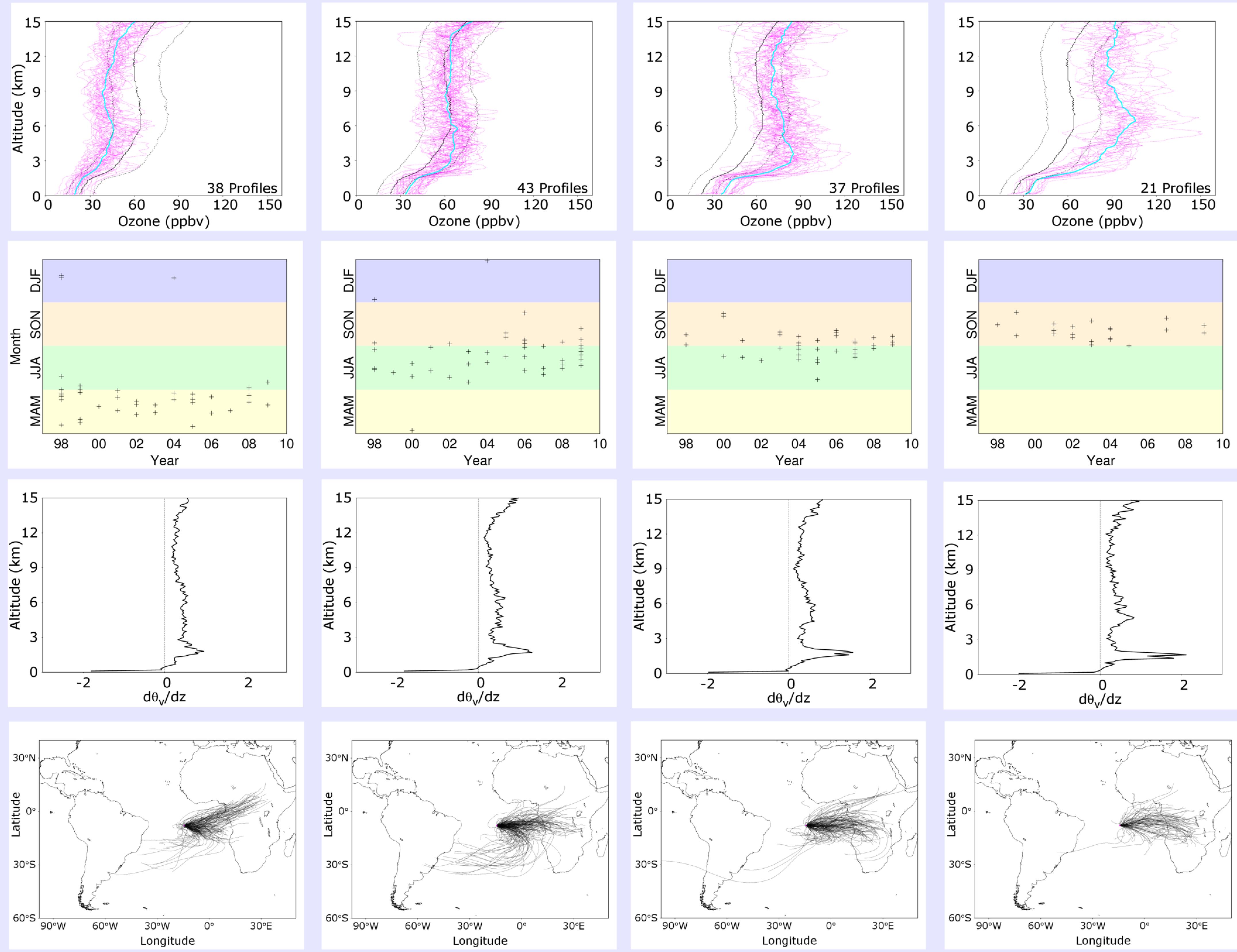
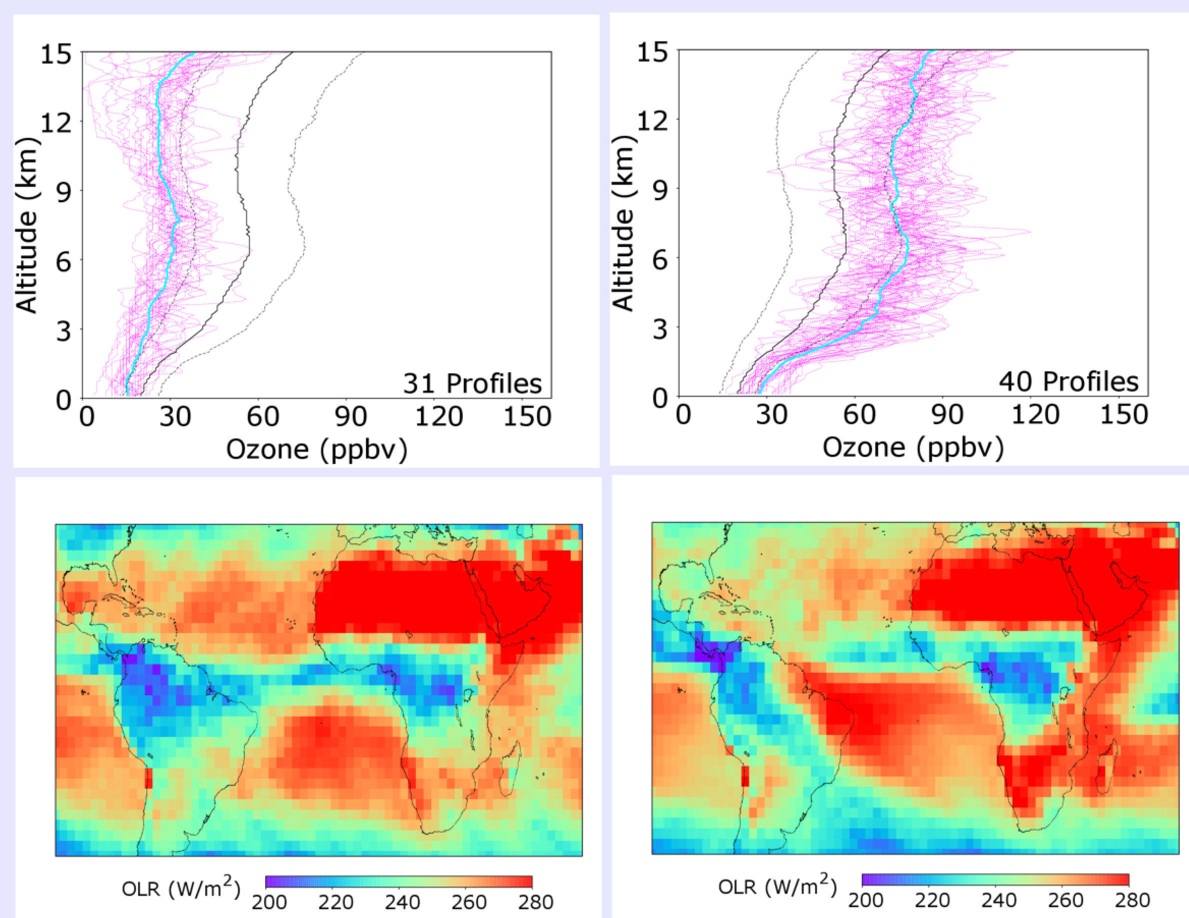


Figure 13 (above). A yearly cycle of ozone at Ascension Island taken from the 4x4 SOM. Influences from biomass burning are apparent. Row 1 shows the individual SOM nodes (cyan) and the ozonesonde profiles (magenta). Row 2 shows the seasonality of the profiles. Row 3 shows the stability and row 4 shows the 7-day back trajectory clusters ending over Ascension Island at an altitude of 2.5 kilometers.



- In March, April, May (MAM) ozone values at Ascension Island are below average. As the year progresses to June, July, August (JJA), increased stability and flow mainly from the African continent leads to increased ozone at Ascension Island. The main burning season in southern Africa is in September, October, November (SON). This is when ozone at Ascension Island is significantly increased from the mean. The pronounced atmospheric stability in this season leads to the large vertical ozone gradient seen above about 1.5 kilometers. Also flow patterns during this time of year have Ascension Island downwind of the African continent.

Figure 14 (left). The influence of convection on ozone seen at Natal. Row 1 shows two different SOM nodes from the 4x4 Natal SOM where the node on the left shows significantly lower ozone than the mean and the node on the right shows significantly higher ozone than the mean. Row 2 shows the corresponding average outgoing longwave radiation (OLR) corresponding to each day that went into the nodes. OLR data was provided by National Centers for Environmental Protection (NCEP) reanalysis. OLR is significantly lower at Natal corresponding to the lower ozone case, suggesting convection is vertically mixing ozone.

Conclusions

- Self-organizing maps are an effective way to cluster ozonesonde profiles and link ozondesonde profile cluster to meteorological phenomena.
- Ascension Island ozonesonde profiles are influenced by seasonal biomass burning and convective mixing. Also, atmospheric stability plays an important role.
- Self-organizing maps pick out a yearly cycle of ozone at Ascension Island.
- Ozone over Natal shows influence from seasonal convection.
- Results from self-organizing maps can be used to improve regional and global chemical transport models.

Acknowledgments

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