Contributions of Atmospheric Dynamics and Chemistry to Total Ozone Variability and Trends Across the United States: A Case Study Based on Long-term Ground Based Data Sets

I. Petropavlovskikh[1], R. Evans[2], G. McConville[1] and H.E. Rieder[3]

[1]Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO 80309; 303-497-6279, E-mail: irina.petro@noaa.gov
[2]NOAA Earth System Research Laboratory, Boulder, CO 80305
[3]Columbia University, Lamont-Doherty Earth Observatory, Palisades, NY 10964

Measurements of total ozone (by Dobson spectrophotometers) across the continental United States (U.S.) have been made starting in the early 1960s. Here, we analyze temporal and spatial variability and trends in total ozone from the observational record. While long-term ozone changes are detected by all stations, we find different patterns in ozone variability on shorter time scales. In addition to standard evaluation techniques of ozone variability we utilize STL-decomposition (Seasonal Trend decomposition of the time series based on LOcally wEighted Scatterplot Smoothing (LOESS)) methods to address temporal variability and trends in the Dobson data. The decomposition shows a clear seasonal cycle in total ozone, with maxima in spring and minima in late fall/early winter. The LOESS-smoothed trend component shows the decline of total ozone between the 1970s and 1990s and 'stabilization' in recent years. In particular, the effects of the two major volcanic eruptions of El Chichón (1982) and Mt. Pinatubo (1991) are clearly visible in the STL trend component. The residual component of the STL-decomposition shows a high degree of short- to medium-term variability which can be attributed to synoptic-scale meteorological variability. Further, we apply methods from Extreme Value Theory (EVT) to characterize days with high and low total ozone (termed HOs and ELOs, respectively) on station level and analyze temporal changes in the frequency of these extremes. From these records, we derive 'fingerprints' of dynamical features such as the North Atlantic Oscillation and El Niño Southern Oscillation and analyze the contribution of dynamics to ozone trends and variability. Finally, we compare results from EVT modeling with standard metrics (i.e., mean values) and compare results from the ground based network with recent results from satellite data.

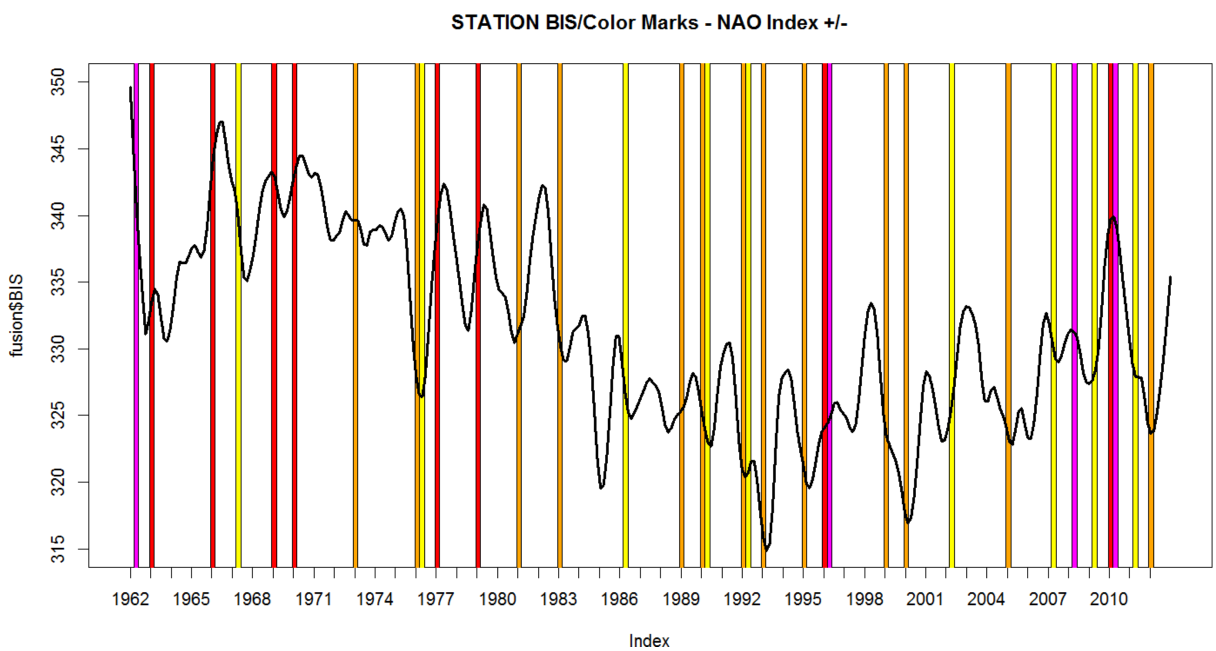

Figure 1. STL-Trend Component (black solid line) of the Dobson total ozone measured at Bismarck station over 1962-2012 period. Colored bars mark 'fingerprints' of the North Atlantic Oscillation (NAO) during winter (DJF) and spring (MAM). Orange bars mark positive NAO phase (NAO > 1) while blue bars mark negative NAO phase (NAO < -1), respectively.