Harvard Forest regional-scale airmass composition by PATH (Patterns in Atmospheric Transport History)

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J. Geophys. Res., in press, 1998

Abstract

We calculated four years (1990-1993) of back trajectories arriving at Harvard Forest and used them to define patterns in atmospheric transport history (PATHs), which describe significant differences in regional-scale motion. This information has been used to assess the degree to which regional-scale transport modulates the chemical composition of air masses sampled at Harvard Forest. We illustrate that significantly different seasonal signals in trace-gas concentration are derived for different flow patterns. Throughout the year, high-speed transport of relatively cool, dry, cloud-free air from the north and northwest delivered air which on the average, represents background conditions for the Harvard Forest site. These synoptic conditions describe the atmosphere after passage of a cold front. The most polluted conditions (highest concentrations of anthropogenic trace gases) in each season occurred under SW flow with generally warmer temperatures, higher water-vapor mixing ratios, relatively low mixed-layer depths at the site, and a higher frequency of cloudy conditions. These regional-scale air-mass characteristics are consistent with synoptic conditions describing warm sector transport or flow ahead of an advancing front. To move beyond the general or average air-mass characteristics described by these results, we have analyzed the covariation of species (e.g.; O_3 versus NO_y-NO_x; O_3 versus CO) to address differences in ozone production efficiency (OPE) based on regional-scale atmospheric transport history. Based on these analyses for summer daytime measurements, we show that relatively fresh pollutants arrive in the SW flow pattern while the most aged air masses with higher OPE arrive in W-flow under deep mixed layers and coincident with high isoprene mixing ratios, suggesting a mid-western contribution to large regional high oxidant episodes. These observations of patterns in chemical characteristics related to patterns in transport have been corroborated with probability maps which indicate the likelihood of transport from upwind regions using the trajectories selected for chemical distribution end members (10th and 90th percentiles).