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Influence of wildfires on the variability and trend of ozone concentrations in the U.S. Intermountain West

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Wildfires are important sources of ozone by emitting large amounts of NO_x and NMVOC, main ozone precursors at both global and regional scales. Their influences on ozone in the U.S. Intermountain West have recently received much interest because surface ozone concentrations over that region showed an increasing trend in the past two decades likely due to increasing wildfire emissions in a warming climate. Here we use the Lagrangian particle dispersion model (FLEXPART) as well as the GEOS-Chem chemical transport model to estimate wildfires' contribution on summer (June, July and August; JJA) ozone concentration variations, trends, and extremely high ozone events over the US Intermountain West for the past 22 years (1989-2010).

We combine the resident time estimated from the FLEXPART 5-day backward trajectories and a high-resolution fire inventory to define a fire index representing the impact of wildfires on ozone concentration at a particular site for each day of summers 1989-2010. Over 26,000 FLEXPART back-trajectories are conducted for the whole time period and for 13 CASTNet surface monitoring sites. We build a stepwise multiple linear regression (SMLR) model of daily ozone concentrations using fire index and other meteorological variables for each site. The SMLR models explain 53% of the ozone variations (ranging from 12% to 68% for each site).

We show that ozone produced from wildfires (calculated from SMLR model) are of high variability at daily scale (ranging from 0.1 ppbv to 20.7 ppbv), but are averaged to lower values of about 0.25-3.5 ppbv for summer mean. We estimate that wildfires magnify inter-annual variations of the regional mean summer ozone for about 32%, compared to the result with wildfires impact excluded from the SMLR model. Wildfire ozone enhancements increase at a rate of 0.04 ppbv per year, accouting for about 20% of the regional summer ozone trend during 1989-2010. Removing wildfires' impact would reduce 35% (46%) of the high-ozone days with measured daily ozone concentrations exceeding 65(75) ppbv, indicating their significant influence on ozone exceptional events.

We further compare the wildfire ozone enhancements estimated by the statistical and Lagrangian approach with those estimated from a Eulerian model (GEOS-Chem). Despite highly-correlated results, GEOS-Chem largely overestimates wildfire ozone influences near the source regions and fails to capture ozone production from wildfires at long distance, reflecting deficiencies in current Eulerian models to capture small-scale emissions.