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Model study of the cross-tropopause transport of biomass burning pollution

B. N. Duncan[1], S. E. Strahan[1], Y. Yoshida[1], S. D. Steenrod[1], and N. Livesey[2]

[1]Goddard Earth Sciences and Technology Center, University of Maryland, Baltimore County, Baltimore, Maryland, USA & The Atmospheric Chemistry and Dynamics Branch, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

[2]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, USA

Abstract. We present a modeling study of the troposphere-to-stratosphere transport (TST) of pollution from major biomass burning regions to the tropical upper troposphere and lower stratosphere (UT/LS). TST occurs predominately through 1) slow ascent in the tropical tropopause layer (TTL) to the LS and 2) quasi-horizontal exchange to the lowermost stratosphere (LMS). We show that biomass burning pollution regularly and significantly impacts the composition of the TTL, LS, and LMS. Carbon monoxide (CO) in the LS in our simulation and data from the Aura Microwave Limb Sounder (MLS) shows an annual oscillation in its composition that results from the interaction of an annual oscillation in slow ascent from the TTL to the LS and seasonal variations in sources, including a semi-annual oscillation in CO from biomass burning. The impacts of CO sources that peak when ascent is seasonally low are damped (e.g. Southern Hemisphere biomass burning) and vice-versa for sources that peak when ascent is seasonally high (e.g. extra-tropical fossil fuels). Interannual variation of CO in the UT/LS is caused primarily by year-to-year variations in biomass burning and the locations of deep convection. During our study period, 1994–1998, we find that the highest concentrations of CO in the UT/LS occurred during the strong 1997–1998 El Niño event for two reasons: i. tropical deep convection shifted to the eastern Pacific Ocean, closer to South American and African CO sources, and ii. emissions from Indonesian biomass burning were higher. This extreme event can be seen as an upper bound on the impact of biomass burning pollution on the UT/LS. We estimate that the 1997 Indonesian wildfires increased CO in the entire TTL and tropical LS (>60 mb) by more than 40% and 10%, respectively, for several months. Zonal mean ozone increased and the hydroxyl radical decreased by as much as 20%, increasing the lifetimes and, subsequently TST, of trace gases. Our results indicate that the impact of biomass burning pollution on the UT/LS is likely greatest during an El Niño event due to favorable dynamics and historically higher burning rates.

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