Transport Rates and Age of Air in the TTL during Boreal Winter

Jasna Pittman[1], Steve Wofsy[1], Bruce Daube[1], Eric Hintsa[2,3], Fred Moore[2,3], Jim Elkins[3], Ru-Shan Gao[3], Troy Thornberry[2,3], Andrew Rollins[2,3], Laurel Watts[2,3], Ed Dlugokencky[3], Lenny Pfister[4], Qing Liang[5,6], Tao Wang [7]

[1]*Harvard University, Cambridge, MA, USA*
[2]*CIRES / University of Colorado, Boulder, CO, USA*
[3]*NOAA ESRL, Boulder, CO, USA*
[4]*NASA AMES, Moffett Field, CA, USA*
[5]*NASA Goddard, Greenbelt, MA, USA*
[6]*Universities Space Research Association, Greenbelt, MA, USA*
[7]*NASA JPL, Pasadena, CA, USA*

The tropics serve as the main gateway for surface air to enter into the stratosphere. Pollutants and ozone-depleting substances (ODS) reaching the stratosphere via the tropics have shown to have an adverse effect on the chemical and radiative properties of this layer of the atmosphere and hence Earth's climate. Within the tropics, the Western Pacific has been previously identified as the dominant region for stratospheric entry. This study focuses on data collected in the Tropical Tropopause Layer (TTL) aboard the NASA Global Hawk aircraft during the ATTREX campaign. This campaign achieved extensive sampling between 14 and 19 km in altitude over the Central and Eastern Tropical Pacific in Feb – Mar 2013 and over the Western Tropical Pacific in Feb – Mar 2014. The goals of this study are twofold: (i) to quantify transport rates in the TTL and (ii) to evaluate age spectra and mean age of air derived from aircraft observations and models in the TTL. Aircraft data, complemented by NOAA's surface measurements, show comparable ascent rates above the 380 K isentrope, but different mean ages at the top of the TTL over the Eastern and Western Pacific regions. Within the Western Pacific, we also find comparable ascent rates, but different sources of air feeding the Northern and Southern Hemispheres. While vertical ascent dominates, there are other transport pathways that can affect the chemical composition and radiative properties of the TTL. During the deployment to the Western Pacific for instance, we encountered isolated events such as an early season typhoon and convectively injected air over Africa as evidenced by distinct signatures in CO_2, CH_4, CO, H_2O, and O_3. We also expanded our latitudinal coverage by crossing the Northern Hemisphere subtropical jet over both the Western and Eastern Pacific in order to assess the extent of horizontal mixing between tropics and subtropics during boreal winter. These special cases allow us to explore the effect of these transport pathways on transport rates in the TTL. Under all conditions, we also investigate age spectra and mean age of air using aircraft measurements, trajectory analysis driven by ERA-interim circulation and simulations from the NASA GEOS-5 atmospheric global climate model. Several general circulation models predict an acceleration of the Brewer-Dobson circulation under scenarios of increased concentrations of greenhouse gases in the troposphere. A consequence of this acceleration is a shorter residence time, hence a decrease in the mean age of air in the stratosphere. This study provides an opportunity to test models at the shortest transport time scales and at the start of the stratospheric journey over the tropics.