Low Ozone in the Tropical Tropopause Layer (TTL) Over the Western Pacific

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The tropopause over the western tropical Pacific is thought to be one of the primary entry points of air from the troposphere into the stratosphere. In this region, temperatures are low enough in the tropical tropopause layer (TTL) ~14-18.5 km to dehydrate air to the low values observed in the stratosphere. The NASA Airborne Tropical Tropopause Experiment (ATTREX) mission was designed to study the transport of water vapor and other trace gases in the TTL over the Pacific Ocean, in order to better understand how dehydration occurs and how ozone-depleting gases reach the lower stratosphere. Field campaigns included flights of the NASA Global Hawk unmanned aircraft system (UAS), with more than 100 vertical profiles in the TTL over the western Pacific from Guam in January-March 2014 (ATTREX-3). This followed the ATTREX-1 and 2 deployments with flights from California to the central and eastern tropical Pacific. During ATTREX-3, the Global Hawk was joined in Guam by the NSF/NCAR GV and British BAe-146 research aircraft, which provided coverage of the atmosphere from the boundary layer to 19 km. Coincident balloon measurements of ozone and water vapor were also obtained for the February Global Hawk flights. As expected, very cold conditions were encountered and ice saturation was frequently observed. Ozone was consistently low (10-40 parts per billion [ppb]) in the lower part of the TTL, with low values extending up to the thermal (cold point) tropopause, particularly in March 2014. While ozone as low as 20 ppb was occasionally observed over the central and eastern Pacific in February-March 2013 during ATTREX-2, it more often averaged 40-50 ppb, and typically increased slowly with height from about 14 km to the tropopause. In ATTREX-3, long-lived tracers such as nitrous oxide (N_2O) were very close to their tropospheric values in the TTL over the western tropical Pacific. Sulfur hexafluoride (SF_6) data suggested that sampled air masses had very recently originated at the surface, with little in-mixing of stratospheric air from midlatitudes. Methane and carbon monoxide often peaked just below or near the local tropopause. These results indicate frequent deep convection, bringing air from the marine boundary layer (with low ozone and high values of long-lived trace species) directly to the upper troposphere. The origins and transport of air in the TTL during ATTREX-3 will be discussed, as well as the reasons for and implications of the very low ozone observed.

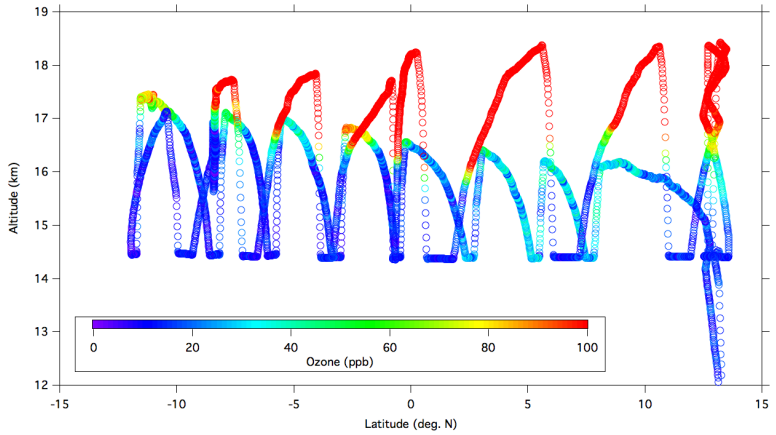

Figure 1. Altitude-latitude curtain plot for the Global Hawk on March 9, 2014 over the western Pacific (145-175°E), color-coded by ozone. Ozone on this flight was often below 20 ppb in the lower part of the TTL, and increased rapidly with altitude above the tropopause (16-17 km).