Observational estimation of the 'cold trap' dehydration in the tropical tropopause layer: The water vapor MATCH

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Stratosphric water vapor is controlled by the degree of dehydration the air parcels experience on their entry into the stratosphere. Randel et al. (2006) showed the correspondence between the stratosphric water vapor and the tropopause temperature on seasonal and interannual time scales. The dehydration takes place in the tropical tropopause layer (TTL) over the western Pacific, where the air parcels encounter the lowest temperature during horizontal advection (cold trap hypothesis (Holton & Gettelman, 2001)). The hypothesis is supported by GCM studies such as those by Hatsushika & Yamazaki (2003). Simplified treatment of the dehydration processes combined with trajectories reproduce water vapor variations reasonably well (Fueglistaler et al., 2005). On the other hand, extreme super saturation was often observed in the TTL (Peter et al., 2006). Thus we need observational data to verify the efficiency of dehydration.

We have been conducting the project Soundings of Ozone and Water in the Equatorial Region (SOWER) using chilled-mirror hygrometers in the western Pacific. Hasebe et al. (2007) suggested that the water content in the observed air parcels on many occasions was about twice as much as that expected from the minimum saturation mixing ratio during horizontal advection prior to sonde observation. However, it is necessary to estimate changed amount of water vapor by repeated observation of the same air parcel to quantify dehydration. The MATCH method, proposed by Rex et al. (1997) for the estimation of ozone depletion in the arctic region, is effective for this purpose.

The MATCH pairs were sought from the network of SOWER campaign observations with the use of isentropic trajectories. For those pairs identified, screening procedures are performed to cope with the fact that vertical shear may not be well represented in the analysis field, and that deep convection system could reach the altitude of the TTL. The MATCH pairs are removed when the air parcels encountered deep convection found in the satellite infrared images, the sonde-observed temperature does not agree with spatio-temporary interpolated temperature of the ECMWF analysis field within a reasonable range, or the ozone mixing ratio is not conserved between the paired observations. Among these survived, we found a MATCH in which an air parcel advected from Ha Noi (Viet Nam) to Tarawa (Kiribati) at 367K potential temperature indicating a dehydration from about 6.0 ppmv to 3.5 ppmv. This air parcel experienced super saturation for about 1 day.