A Lagrangian Description on the Troposphere-to-Stratosphere Transport Changes Associated with the Stratospheric Water Drop Around the Year 2000

Taisuke Noguchi[1] and Fumio Hasebe[1,2]

[1]*Graduate School of Environmental Science, Hokkaido University, Sapporo, Japan*
[2]*Faculty of Environmental Earth Science, Hokkaido University, Sapporo, Japan*

The cause and effect of the sudden drop of stratospheric water vapor (SWV) after 2001 (e.g., Randel et al., 2006; Rosenlof and Reid, 2008) need to be fully understood since SWV is an important driver of decadal scale global climate change (Solomon et al., 2010). While some difficulty in constructing a reliable long-term SWV record is still a concern (Hegglin et al., 2014), the understanding of a possible stepwise change in SWV is quite important in assessing the age of stratospheric air with its long-term trends as well. In the light of great role of TTL dehydration in SWV, here we present a Lagrangian description on the changes in the minimum saturation mixing ratio of water (SMR_{min}) along the trajectories with its geographical location (Lagrangian Cold Point; LCP) for the air parcels advected in the Tropical Tropopause Layer (TTL) before entering the stratosphere. The backward kinematic trajectories initialized on 400 K potential temperature surface in the tropics similar to those of Fueglistaler et al. (2005) are used relying on the ERA interim meteorological fields. The calculations are started on the 5th, 15th, and 25th of every month during the period 1997 to 2002. The statistical features of the SMR_{min} and LCP are analyzed for the 90-day trajectories in which the air parcels experienced LCP in the TTL (spanning from 355 K to 400 K in the vertical and within 30 degree latitudes from the equator).

The decrease of SMR_{min} in the 2000 to 2001 period has been found most remarkable in boreal summer. The stepwise change in the ensemble mean SMR_{min} is identified for the air parcels initialized in September 2000. Thereafter, the horizontal projection of trajectories in the layer between 360 K and 370 K exhibits eastward expansion of the anticyclonic branch circulating the Tibetan high. Eastward spread of the area of maxima in the frequency distribution of LCP accompanies this expansion. The SMR_{min} averaged in each latitude-longitude bin accumulated on the occasion of LCP events shows significant decrease in the central Pacific where the LCP population increase takes place. These results do not give insights into the driving mechanism such as the eddy heat flux on TTL cooling (Fueglistaler et al., 2014). However, they may imply that the drop has resulted from a response of the TTL circulation to modulated boreal summer monsoon combined with intensified extratropical pump and thermal forcing at the bottom boundaries. It is quite interesting to investigate further how these changes have interacted between each other.

References

Fueglistaler, S., Abalos, M., Flannaghan, T.J., Lin, P., Randel, W.J. *ACP* **2014**, 14, 13439-13453.

Fueglistaler, S., Bonazzola, M., Haynes, P.H., and Peter, T. *J. Geophys. Res.* **2005**, 110, D08107.

Hegglin, M.I., Plummer, D.A., Shepherd, T.G. et al., *Nature Geosci*. **2014**, 7, 768-776.

Randel, W.J., Wu, F., Voemel, H., Nedoluha, G.E., and Forster, P. *JGR* **2006**, 111, D12312.

Rosenlof, K.H., and Reid, G.C. *J. Geophys. Res*. **2008**, 113, D06107.

Solomon, S., Rosenlof, K.H., Portmann, R.W., Daniel, J.S. et al., *Science* **2010,** 327, 1219-1223.