Water vapor variation around the tropical tropopause during the CEPEX campaign

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Understanding water vapor variation in the atmospheric system is important to grasp the climate conditions of our planet. To estimate the radiative and chemical effects on the climate change, we have to clarify factors contributing to water vapor variation around the tropical tropopause region where water vapor acts as a very sensitive minor constituent. Because water vapor content at the tropopause is about 4 to 5 order less than that at the surface, the tropical tropopause region is supposed to be one of the data sparse areas where we cannot get the routine observation data. Recently, many researches using models and satellite data have actively discussed about the cause of controlling the stratospheric water vapor content. However, there are many uncertainties in the models and satellite data so that none of interpretation explains all the observational facts synthetically. Thus, in this study we use data from the NOAA water vapor sonde that has little estimation error owing to its measurement principle. Then we focus on how the large scale circulation field and the water vapor variation are connected with each other. The water vapor, ozone and meteorological sonde data used in this study were obtained from the campaign called CEPEX (Central Equatorial Pacific Experiment). ECMWF 40 year reanalysis (ERA40) wind and temperature data, NOAA OLR (outgoing long-wave radiation) and UARS/MLS water vapor mixing ratio were also used for investigating the large-scale circulation features.

A mean water vapor mixing ratio observed on a voyage during the CEPEX campaign was about 1.9 ppmv at 16.5 km where the cold point tropopause lies, and it was about 3.3 ppmv when observations were done on Christmas Island where the voyage ended up. The mean difference with 1.4 ppmv is quite large in comparison with the standard stratospheric water vapor content. In the former case on a voyage the water vapor content at the tropopause level shows a minimum mixing ratio, indicating that some significant mechanism should work to keep the water vapor less than the usual value. We tried to understand how this significant change in water vapor content depends on space or time variations of the circulation structure. By showing longitude-time sections of the ERA40 temperature and the NOAA OLR around the equatorial (5S to 5N) tropopause level we found that there appear cold regions often in the east of the low OLR and warm regions in the west of the low OLR during the northern winter time including the 20-day CEPEX observation period. The temporal change in the temperature was much more distinguished than the spatial gradient. We also found the temporal change in the MLS water vapor data in a longitude-time section. While seeing their relationships in the equatorial longitude-height sections averaged over the former half (7 to 17 March) and the latter half (20 to 26 March) of the observation period, we found there was cold anomaly distribution inclined eastward with increasing altitude in the east of the low OLR and wind divergence distribution around the cold anomaly. In this period, horizontal sections for the horizontal wind at 100 hPa showed anticyclonic gyres with cold anomalies over the western and central Pacific region, which is supposed to be a Rossby response due to the tropospheric heating. This observational evidence suggests that the coldest region enhanced by this response makes water vapor around the tropopause lower, which was first pointed out observationally by Eguchi and Shiotani [2004]. The same mechanism could be applied to water vapor decrease particularly during the former half of the CEPEX period. This is supposed to be caused by the intensification of the coldest region and the large-scale horizontal wind structure at the tropopause level. On the contrary during the latter half of the observation period, this large-scale circulation structure becomes weak, and comparatively warm region contains rather rich water vapor. Hence we can conclude that the disturbance around the tropopause level with a time scale of a few weeks is one of the most important factors controlling the temperature and horizontal wind field and consequently water vapor variations during the CEPEX period.

REFERENCE

[1] Eguchi and Shiotani (2004) J. Geophy. Res., 109, doi:10.1029/2003JD004314 .