Stratosphere-troposphere exchange over the northern Pacific Ocean using chemical reanalysis data

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Stratosphere-troposphere exchange (STE) is one of the important factors that determine the distribution of constituents in the troposphere and stratosphere. Two-way airmass exchange between the lower stratosphere and the troposphere occurs in association with mid-latitude weather disturbances, with the net transport from the stratosphere to troposphere. Among various mid-latitude disturbances, explosive cyclones are those with very rapid surface pressure drops and cause severe weather phenomena. In this study, we investigate the role of explosive cyclones over the northern-hemisphere Pacific Ocean in the STE. We analyze ozone and carbon monoxide (CO) data from a chemical reanalysis data set called the Tropospheric Chemical Reanalysis data (TCR-1).
TCR-1 is a 10-year chemical reanalysis data set for the period from 2005 to 2014. TCR-1 assimilates satellite chemistry data from the Ozone Monitoring Instrument (OMI), Aura Microwave Limb Sounder (MLS), Tropospheric Emission Spectrometer (TES), and Measurement of Pollution In The Troposphere (MOPITT), by using a global chemical transport model CHemical AGCM for Study of atmospheric Environment and Radiative forcing (CHASER) driven with NCEP-DOE reanalysis data and the ensemble Kalman filter technique. NCEP-DOE reanalysis data are also used to calculate potential vorticity (PV) and to obtain TCR-1 ozone and CO data on isentropic surfaces. The definition of explosive cyclones used in this study is the one used by the Japan Meteorological Agency, that is, extra-tropical cyclones whose center-pressure drop rate is more than 24 hPa $\times \sin(\phi)/\sin(60^\circ)$ (where ϕ is latitude) within 24 hours. Both monthly mean and instantaneous 2-pvu PV curves on isentropic surfaces are used to define the tropopause. Indices for irreversible Stratosphere-to-Troposphere Transport (STT) and Troposphere-to-Stratosphere Transport (TST) are further defined using ozone and CO data to investigate quantitative impact of explosive and non-explosive cyclones over the northern-hemisphere Pacific Ocean. Explosive cyclones over the northern Pacific Ocean are observed in winter, with the maximum activity in January and February. It is found that about half of the explosive cyclones cause significant STE. In January, the average amount of STT per cyclone due to explosive cyclones is significantly greater than that due to other cyclones. It is also found that the amount of STT (TST) in years 2005-2009 is significantly smaller (greater) than that in years 2010-2014. In the presentation, we will discuss possible causes of this interannual change.

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