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ENSO influence on the Asian summer monsoon anticyclone as derived from the satellite observations, reanalysis and model simulations

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El Nino and La Nina are opposite phases of El Nino–Southern Oscillation (ENSO). The extremes of ENSO patterns have impacts not only on ocean processes, but also on global weather and climate. The ENSO activities typically show pronounced features in boreal winter time, but some prolonged events may last for months or years. In this study we analyze the influence of ENSO on the atmospheric composition in the tropical and extra-tropical UTLS region in the months following strong ENSO events. In particular, we are interested in the impact of ENSO on the Asian summer monsoon (ASM) anticyclone.

Using the Multivariate ENSO Index (MEI), we define two composites starting from strong El Nino and La Nina winters (|MEI|>0.9) and analyze the anomalies caused by them in the following months. To quantify the differences in dynamics, the velocity potential (VP) and the stream function (SF) are calculated based on ERA-Interim reanalysis from 1979 to 2015. SF shows that during winter the horizontal flow in the tropical UTLS is dominated by two equatorially symmetric anticyclones resembling the well-known Matsuno-Gill solution. In summer, the anticyclone in the North Hemisphere is shifted to the ASM region. VP shows that the centers of the divergent part of the flow lie in the West Tropical Pacific and Central Pacific for La Nina and El Nino winters, respectively. These centers move northwestwards during spring and summer. The anticyclone, subtropical jet and the divergent part of the flow after La Nina winters are significantly stronger than after El Nino winters.

Based on the MLS measurements of CO, H_2O and O_3 from 2004 to 2015, we also discuss the respective anomalies at the tropopause level for the El Nino/La Nina composites. EL Nino composite of CO shows higher values in the tropical region not only during winter but also during spring and summer. La Nina composite of H_2O shows low anomaly over Maritime Continent which spread over the whole tropics until summer. The H_2O anomalies are consistent with the respective composites of the outgoing longwave radiation (OLR). O_3 composites show more zonally symmetric features during and after strong El Nino than La Nina events. We also discuss the distribution of the mean age, H_2O and O_3 from the CLaMS simulation during 1979-2015. The distributions of mean age and O_3 are well-correlated. The patterns of H_2O and O_3 distributions from CLaMS show similar features comparing with those from MLS. The difference between the El Nino/La Nina composites becomes insignificant in late summer.

El Nino episodes which last until the next winter are also selected (1987, 1992 and 1993). The SF and VP distributions show strongest anomalies during these three years comparing with all El Nino results. In particular, ASM anticyclone is weak during these periods. Accordingly, O_3 and H_2O concentrations in the tropics show weak intrusions from the subtropics during summer. This indicates that if El Nino does not decay until the following summer, the ASM anticyclone will be significantly weaker.