The Relationship between Stratospheric Flow Regimes and Multi-decadal Variation in Tropospheric Circulation

Dr. Hua Lu

British Antarctic Survey

Hua Lu*, Lesley J. Gray**, Patrick Martineau***, John C. King*, and Thomas J. Bracegirdle*

* British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, England, U.K.

** NCAS-Climate, Department of Atmospheric Physics, Oxford University, Clarendon Laboratory, Parks Road, Oxford, OX1 3PU, UK

*** Research Center for Advanced Science and Technology (RCAST) at the University of Tokyo

Downward influence of the stratosphere on the tropospheric circulation have been a subject of active research in recent years. The mechanisms fundamentally involve planetary-scale Rossby waves (PRWs) and their interaction with the winter stratospheric polar vortex, but the details remain obscure.

Here this downward coupling is examined in terms of flow regime behaviour in the upper stratosphere. We have found that the winter stratospheric polar vortex becomes wider and stronger during certain winters but narrower and more upright during other winters. We demonstrate that these two flow regimes differ dynamically in terms of wave meanflow interaction, wave-wave interactions, and their seasonal development. They are also associated with different tropospheric forcing and responses. The narrow-jet regime is associated with persistent, low frequency wave disturbances from the troposphere and anomalous radiative cooling the subtropical stratosphere. Such combination leads to weakened westerlies at the equatorward flank of the polar vertex with enhanced wave breaking/absorption near the polar vortex edge. The effect can be linked to Matsuno-type of wave mean-flow interaction, which often results in stratospheric sudden warmings and downward movement of zonal mean anomalies. The tropospheric response is marked by an equatorward shift of the mid-latitude westerly jet. Conversely, the wide-jet regime favours nonlinear wave-wave interaction. The nonlinearity starts in the upper stratosphere due to localized, nonlinear wave breaking. Poleward wave reflection results in significant changes in atmospheric transience, which can be linked to “self-tuning” whereby downward reflecting wave-1 are followed by enhanced quasi-stationary wave-2 forcing. These changes in the stratosphere are projected onto the tropospheric westerlies. Over the North Atlantic sector, it is marked by enhanced jet strength in late winter.