International Max Planck Research School on
EARTH SYSTEM MODELLING

# Climatological analysis of planetary wave propagation in Northern Hemisphere winter

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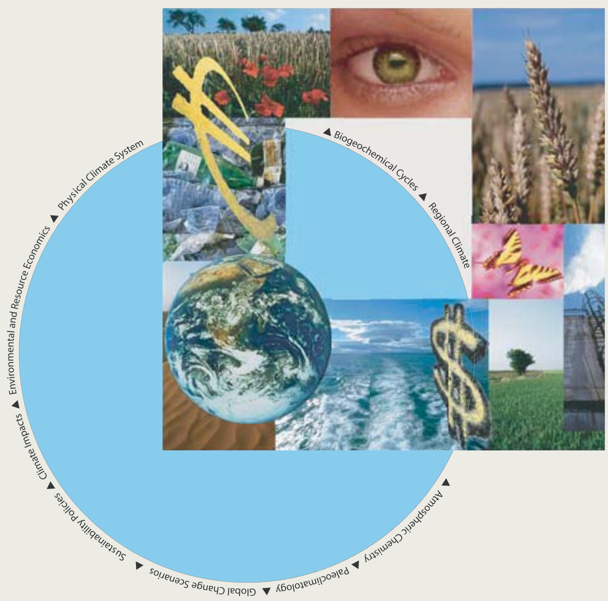

# Abstract:

The atmospheric control on planetary wave propagation, and planetary wave activities and eddy forcing on mean flow in the troposphere and stratosphere in Northern Hemisphere (NH) winter, has been investigated by the new introduced analysis - frequency of negative refractive index squared ( $f\,(n_k^2<0)$), and E-P flux and its divergence by using the NCEP/NCAR reanalysis data from 1958 to 2002. It was found that the atmospheric zonal mean zonal wind (ZMZW), vertical shear of ZMZW and atmospheric stability can control the planetary wave propagation. On the other hand, the planetary waves can also affect atmospheric circulation by wave–mean flow interactions. The interannual and intraseasonal anomalies of the polar and subpolar stratospheric circulation, which can be defined as the strong polar vortex regime (SVR) and weak polar vortex regime (WVR) by applying the zonal wind at 50hPa, $65^{o}$N as a diagnostic, have been explored. It was found that the planetary waves contribute significantly on the constructing and maintaining of the stratospheric polar vortex regimes. On the other hand, the regime itself also has effects on the planetary wave propagation. Furthermore, the different contributions of stationary waves and transient waves on atmospheric mean flow have been investigated, respectively.

The violent tropical volcanic eruptions can induce impacts on climate system by injecting a huge amount of aerosols into the lower stratosphere, which can spread to globe and disturb the radiative balance. The stronger polar vertex, weaker tropical jet, tropical stratospheric warming and polar stratospheric cooling in NH winter can be observed after the violent tropical volcanic eruptions. By choosing three cases (Agung 1963 eruption, El Chichon 1982 eruption, and Pinatubo 1991 eruption), the impacts of volcanic eruptions on atmosphere and their influences on planetary wave propagation have been studied. The “dipole” structures of anomalies of ZMZW and zonal mean temperature were found in both volcanic winters and SVR. Moreover, it was found in volcanic winters, the stationary planetary waves can propagate more from the troposphere to the stratosphere and, these waves can continuously transport more eddy heat fluxes upward from the lower stratosphere to the middle and higher stratosphere than in other winters.

The general circulation models’ (GCMs) performance on atmospheric circulation and planetary wave propagation has also been studied. The bias of a stronger stratospheric polar vortex was found in the simulation of the GCM (ECHAM5_AMIP2) possibly due to the low upper boundary level (10hPa). The bias can be modified in the simulation of the middle atmospheric GCM (MAECHAM5_AMIP2) with higher upper boundary level (0.01hPa), although the stratospheric polar vortex is becoming too weak. The influences of ocean on planetary wave propagation have also been investigated by analyzing the simulation of atmosphere-ocean coupled GCM (MAECHAM5_MPIOM). The stratospheric polar vortex is still too weak in MAECHAM5_MPIOM. In the simulations of all these three GCMs, the wave activities and zonal easterly momentum forcing are weaker for stationary waves in both the troposphere and stratosphere but stronger for transient waves in the troposphere compared with observations. The major differences between MAECHAM5_AMIP2 and MAECHAM5_MPIOM were mainly located in the

troposphere, which implies that the influences of ocean on planetary wave propagation cannot reach up to the stratosphere.