Blocking Formations by the Upscale Energy Cascade

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In this study, nonlinear numerical simulations of amplification of low-frequency planetary waves and concurrent blocking formations were demonstrated. The simulations are conducted by a barotropic spectral model derived from three-dimensional spectral primitive equations with a basis of vertical structure functions and Hough harmonics. The model is truncated to include only barotropic Rossby components of the atmosphere with simple physics of biharmonic diffusion, topographic forcing, baroclinic instability, and zonal surface stress. These four physical processes are found to be sufficient to produce a realistic and persistent dipole blocking with a sharp transition from zonal to meridional flows on a sphere.

Analyzing energetics of blocking formations in the model (see Figs. 1 and 2), we showed that an amplification of the meridional dipole mode was caused by the upscale energy cascade from synoptic disturbances under an environment of persistently amplified wavenumber 2. When the persistent wavenumber 2 exists, synoptic disturbances contribute to amplify the dipole mode of wavenumber 1. In contrast, when the persistent wavenumber 2 is absent, synoptic disturbances contribute to accelerate zonal flow with enhanced wave-mean flow interactions, and wavenumber 1 is not amplified. Therefore, it is found that the persistent wavenumber 2 plays a catalytic role in drawing synoptic wave energy and feeding wavenumber 1. The topographic forcing in amplifying wavenumber 2 appears to be necessary for the blocking system in the model, although it is not the main energy source for the system.

Reference: Tanaka, H. L., 1991: *Mon. Wea. Rev.*, **119**, 2919-2935.

00Z 9 Jan 1979 500mb

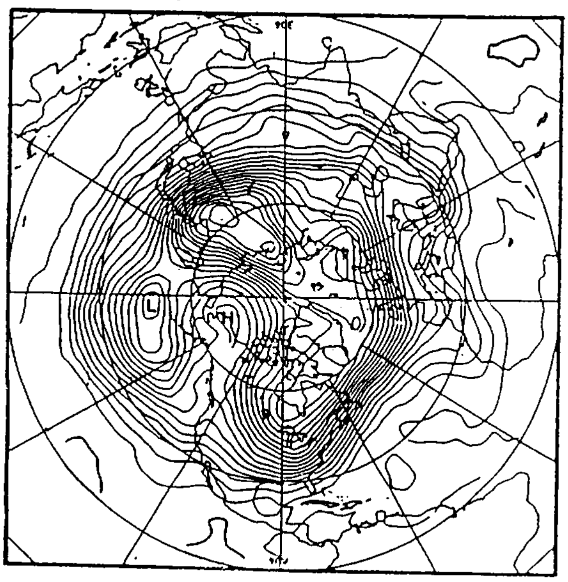

Fig. 1: Observed 500 mb geopotential field on 9 January 1979 during the FGGE. The largest-scale dipole blocking is seen with its high-pressure center over Alaska.

Day 60

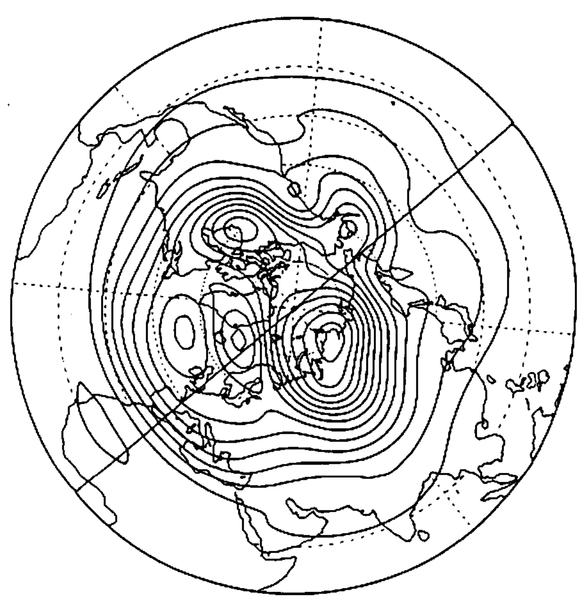

Fig. 2: Barotropic geopotential field of the model atmosphere when a dipole blocking occurred. The contour interval corresponds to 100 m. Coastal line is drawn for the reference of the scale.