A Two-Dimensional Dynamical Model for the Subseasonal Variability of the Asian Monsoon Anticyclone

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Background

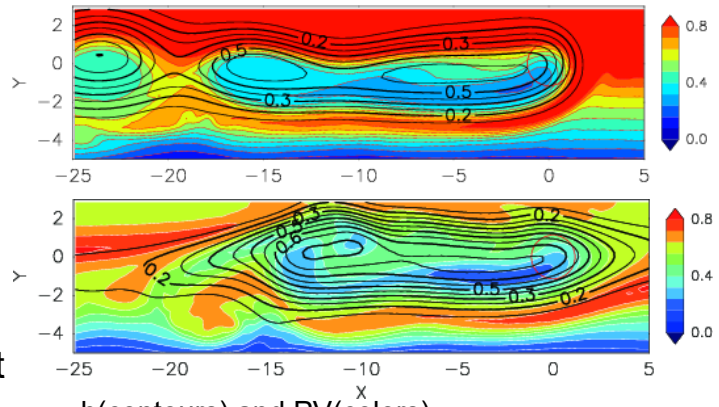
The Asian monsoon anticyclone (South Asian high / Tibetan high) exhibits significant subseasonal variability. The formation of 'eddy shedding' due to dynamical instability is one possible explanation for a generation mechanism of such variability, as demonstrated by a shallow water model by Hsu and Plumb (2000). However, their model has not sufficiently reproduced the realistic structure, in which the air inside the anticyclone is largely trapped within a finite longitudinal domain. This structure is important in characterizing tracer transport between the troposphere and stratosphere.

Modified shallow water model

A set of experiments are performed using a modified version of the shallow water model. The governing equations are beta-plane shallow water equations with a localized steady forcing at the subtropics and a linear relaxation. To incorporate the latitudinal tropopause structure around the subtropical jet, the shallow water model in this study allows the latitudinal dependence of the mean depth. The estimation of latitudinally-dependent equivalent depth is performed using ERA-Interim reanalysis data on isentropic coordinates and revealed the significant positive latitudinal gradient to the north of 30N, corresponding to the vertical structure change associated with the subtropical jet. Based on this, the mean depth with a positive latitudinal gradient is prescribed in experiments with a modified shallow water model. Realistic ranges of parameters, such as forcing location, intensity and relaxation time, are estimated from the reanalysis data.

Results

In experiments with sufficiently strong mean depth gradient and forcing intensity, an unsteady quasi-periodic final state is attained. The westward 'eddy shedding' occurs but with a structure in which vortices are trapped within the entire anticyclone. The change of spatial structure can be explained by the background topographic-beta effect. This structure is more realistic than that of the conventional model. This result supports the possibility of the internal dynamics driving the subseasonal variability of the Asian monsoon anticyclone.



h(contours) and PV(colors)
top: constant mean depth
bottom: latitudinally dependent mean depth