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Selective Absorption Mechanism for the Maintenance of Blocking

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Atmospheric blocking is one of the most influential phenomena in global atmospheric environments. The understanding of its dynamical processes is important to clarify weather extremes and the stratosphere-troposphere coupling and to extend forecast periods. In the dynamics of blocking, especially, its maintenance mechanism has been a stimulating topic for many meteorologists.

About the maintenance mechanism of blocking, Shutts (1983) evaluated the effect of synoptic eddies in his numerical model and proposed the Eddy Straining Mechanism (hereafter, referred to as ESM). Using simple numerical models, he demonstrated that synoptic eddies strained in the north-south direction by blocking provide negative/positive vorticity to a blocking high/low and this vorticity forcing, i.e., the second-order flow maintains the blocking dipole structure against dissipation.

Some pieces of evidence, however have shown that the ESM does not work well in several real cases of the block maintenance. For example, Arai and Mukougawa (2002) performed a similar experiment to Shutts (1983) and indicated the strong sensitivity of the ESM against a small meridional shift of the stormtrack (strictly speaking, wavemaker), or a small change of the size of high-frequency eddies. This is a very adverse constraint in the real atmosphere because the relative positions of blocking to the stormtrack tend to fluctuate from case to case so that they do not necessarily exist in the same latitude band.

Thus, we propose a more realistic mechanism of the block maintenance named as the Selective Absorption Mechanism (hereafter referred to as SAM), in which a blocking anticyclone selectively and exclusively absorbs synoptic anticyclones. This mechanism is essentially the same mechanism as the Fujiwhara effect, which qualitatively explains that binary eddies with the same polarity merge and eddies with the opposite polarity separate. In this study, we verify the effectiveness of the SAM by observational analyses and simple numerical experiments.

Ten episodes of blocking that occurred in the mid-North Pacific and the eastern North Atlantic between 1990 and 2005 are investigated. Trajectories of synoptic anticyclones and cyclones during blocking persistent periods are analyzed and show the selective absorption of anticyclonic eddies by the blocking highs.

We also perform numerical experiments using the nonlinear barotropic vorticity equation on a beta-plane channel. The maintenance rate of blocking is quantitatively evaluated by using an areal averaged method. The result supports the block maintenance by the SAM.

From the above two results, we can conclude that the SAM is more adaptive as the block maintenance mechanism than the ESM, because the essence of the SAM is absorption of eddies, not but eddy straining.