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A Nonlinear Multi-Scale Interaction Model for Atmospheric Blocking: The Eddy-Blocking Matching Mechanism

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In this paper, a nonlinear multi-scale interaction (NMI) model is used to propose an eddy-blocking matching (EBM) mechanism to account for how synoptic eddies reinforce or suppress a blocking flow. It is shown that the spatial structure of the eddy vorticity forcing (EVF) arising from upstream synoptic eddies determines whether an incipient block can grow into a meandering blocking flow through its interaction with the transient synoptic eddies from the west. Under certain conditions, the EVF exhibits a low-frequency oscillation on timescales of 2-3 weeks. During the EVF phase with a negative-over- positive dipole structure, a blocking event can be resonantly excited through the transport of eddy energy into the incipient block by the EVF. As the EVF changes into an opposite phase, the blocking decays. The NMI model produces life cycles of blocking events that resemble observations.
Moreover, it is shown that the eddy north-south straining is a response of the eddies to a dipole- or Ω-type block. In our model, as in observations, two synoptic anticyclones (cyclones) can attract and merge with one another as the blocking intensifies, but only when the feedback of the blocking on the eddies is included. Thus, we attribute the eddy straining and associated vortex interaction to the feedback of the intensified blocking on synoptic eddies. The results illustrate the concomitant nature of the eddy deformation, whose role as a PV source for the blocking flow becomes important only during the mature stage of a block. Our EBM mechanism suggests that an incipient block flow is amplified (or suppressed) under certain conditions by the EVF coming from the upstream of the blocking region.