Geophysical Research Abstracts
Vol. 21, EGU2019-211, 2019
EGU General Assembly 2019

An extended nonlinear multi-scale interaction model of atmospheric blocking in a slowly varying basic flow

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In past years, the second author and his collaborators proposed and developed a nonlinear multiscale interaction (NMI) model to describe life cycles of blocking and North Atlantic Oscillation (NAO) events based on the zonal scale separation assumptions of blocking or NAO and eddies. Here, we extended the NMI model to include a slowly varying basic flow. The amplitude of the blocking anomaly is described by a forced nonlinear Schödinger equation (NLS). In this equation, while the blocking amplitude can be amplified by preexisting incoming synoptic eddies, the nonlinearity and dispersion of blocking depend on the coefficients of this NLS, which are related to the spatial distribution of basic flow.

The eddy-driven blocking will have long lifetime greater than 20 days and not within the range of 10-20-day timescale, if the positive feedback of incoming synoptic-scale eddies is only considered. However, the blocking can have a 10-20-day timescale when the positive and negative feedbacks of incoming synoptic-scale eddies are considered. Thus, the 10-20-day timescale of blocking events is a result of the combination of the positive and negative feedbacks of incoming synoptic-scale eddies.

On the other hand, when the basic current is spatially varying in the extended NMI model, the changes in the strength and meridional distribution of background zonal wind can be combined into the meridional gradient of potential vorticity (PVy). The results showed that when PVy is small, the subsequent blocking will have strong nonlinearity and weak dispersion. In this case, the blocking can be intense and maintain for long duration. In contrast, the blocking is weak and has short duration.