Geophysical Research Abstracts
Vol. 13, EGU2011-1610-2, 2011
EGU General Assembly 2011
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Extreme dynamic conditions for 2010 blocking in European Russia as compared with earlier episodes

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The blocking anticyclone which caused the heat wave in European Russia in June to August 2010 is studied from the point of view of blocking generation through a Rossby-type wave instability. The NCEP/NCAR Reanalysis 2 and UK Met Office objective analysis are used to calculate diagnostic characteristics of the process and to compare the latter against earlier, weaker episodes observed in the same region and season (2002, 2007). In the 2010 episode a planetary wave with zonal wavenumber 4 started growing in the middle of June: two ridges – in Europe and East Siberia – developed into blockings and caused extremely hot and dry weather.

The PV-θ criterion of blocking (as introduced by Pelly and Hoskins, 2003; PV and θ standing for Ertel potential vorticity and potential temperature, respectively) is calculated for every 12 h to determine the onset and decay times for every episode of blocking. The ridge of high tropopause in the 2010 episode reached especially high latitudes (to about 80 N). At the 2 pvu level, reversal of potential temperature gradient is well-expressed during the whole period of blocking (55 days), which exceeds significantly those for other episodes. Also, at this level, a secondary ridge of high θ (also with reversal of θ gradient) is observed to the west of primary one. Fast incipient growth of blocking represents another specific feature of 2010 summer. In the total ozone field, a closed minimum ($<$275 DU) is located near 67 N, the 300 DU contour lying near 80 N, in a general agreement with the dynamic tropopause topography.

To estimate effects of synoptic-scale eddies in the blocking onset and maintenance, the quasi-vector $\vec{E}$ (by Hoskins, James and White, 1983) is calculated from the time series of wind velocity components at 200, 250, 300 hPa levels. In order to separate the synoptic eddies from the motions of larger scales, filtration is applied to the time series in every point of 2.5x2.5 grid over the mid-latitude (30-70 N) zone. Considering the transition band of the Lanczos filter characteristics equal to several days (5 to 7), the boundary frequency between large and synoptic scales is chosen as corresponding to zonal wavenumber 7, by making use of the Taylor hypothesis. The boundary frequencies are slightly varied. The resulting $\vec{E}$-divergence is obtained after moving averaging the filtered out synoptic-scale quantities over 10-12 day periods in order to discern time changes in the synoptic-scale feeding of the growing wave. It is found that the $\vec{E}$-divergence field contains well-expressed areas of positive values, which imply energy transfer from the eddies to the larger-scale flow. Also, areas with opposite direction of energy transfer are obtained. Horizontal distribution of the areas, as well as their height changes (from 300 to 200 hPa levels) depend on tropospheric jet stream position, their entrance and exit regions. This result corresponds as well to 2010 episode, as to two other blockings under consideration. The comparison shows that in the case of extreme intensity of blocking (2010), feeding from synoptic eddies is especially well-developed and localized. Features of space and time distribution of feeding are displayed for the episodes under consideration.