Geophysical Research Abstracts, Vol. 9, 04033, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-04033

Identification of regions of rapid cyclone development from the large-scale flow properties

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It is well-known that weather regimes which are quasi-stationary configurations of the large-scale atmospheric circulation have a strong influence on the life cycle of extra-tropical cyclones. However, at the present time, no theory is able to determine for a given weather regime the location of their explosive growth stage. For example, even if a strong large-scale baroclinicity is a prerequisite condition for the formation of European storms as the Christmas 1999 storms, it fails to represent the area where they have grown most rapidly. In my presentation, the question of the preferred regions where synoptic transient eddies, namely surface cyclones and upper-tropospheric disturbances, rapidly intensify will be addressed.

The methodology consists in decomposing the atmospheric flow issued from various (re)analysis (operational analysis from Météo-France, reanalysis of the FASTEX campaign as well as the ERA40 reanalysis database) into a high- and a low-frequency part. Our aim is to localize the most likely regions where high-frequency eddies will rapidly develop by analyzing the low-frequency flow configuration. Two types of such regions, called barotropic and baroclinic critical regions, are identified.that involve very distinct mechanisms.

Barotropic critical regions are regions where a transient barotropic growth can occur and appear quite often on looking at the ERA40 database. It is identified from the deformation tensor of the low-frequency flow and more specifically from a diagnostic called effective deformation that involves the low-frequency deformation magnitude and the low-frequency vorticity. After an illustration of this barotropic regeneration process, it will be shown how in some cases a barotropic critical region can also trigger a baroclinic development phase.

Baroclinic critical regions by contrast involve a pure baroclinic mechanism and their appearance seem to be quite exceptional. The formation of these regions is due to the presence of a strong zonal upper-level jet and a lower-level jet that are meridionally far from each other in areas where they reach their maximum amplitude but close to one another further eastward in their exit regions. Baroclinic critical regions are precisely regions where these two low-frequency jets converge. Illustration of such regions will be given by analyzing the Christmas 1999 and mid-December 2004 large-scale circulations that lead to very strong storms over Europe.