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Study of the flood events in the Carpathians and along the Elbe river with aid of the numerical models

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Catastrophic floods caused by heavy prolonged rainfalls in the Ukrainian Carpathians in November 1998 and along the Elbe river in Germany and Czech Republic in August 2002 are under consideration in the presented study. Obviously, the flood events were connected with global atmospheric processes and the analysis of the synoptic situations has showed that the main factors led to the catastrophic floods were: a) the blocked cyclones; b) contraction between the polar and the arctic atmospheric fronts resulted in a sharpening of the frontal zones; c) very high liquid water content and the strong income of a warm moist air from the south; d) additional orographic lifting; e) and finally in both cases the already deeply water saturated ground and the relatively high water levels of many rivers due to the heavy rainfalls just in a few days prior to the flood events.

A new approach is proposed for the study of the flood events in Europe. It is based on a complex of different numerical models: (1) REgional MOdel (REMO) developed in MPI-M (Hamburg); (2) Combined Model of the Cloudy Troposphere (CMCT) and (3) 1-D spectral cloud model both developed in UHRI.

The regional climate model REMO is based on the Europamodell, the former numerical weather prediction model of the German Weather Service (Majewski, 1991). Further development of the model took place at the MPI-M, where the physical parameterizations from ECHAM4/T106 were implemented into the Europamodell code (Jacob and Podzun, 1997). Here, the limited area model is double nested into the ECMWF Analyses data using a sponge zone of 8 grid points to harmonize the fields

with updates of the lateral boundaries every 6 hours. REMO was used in both a climate mode when was initialized 7½ months and ½ month for the Elbe case and 12 hours for the Carpathians prior the start of the rainfalls and in a forecast mode with restart every midnight and run for just 30 hours every day of the events. The better results in a representation of the space and time distribution of precipitation was obtained in the forecast mode in a whole. But the precipitation intensity and sums were 2-3 times less then the measured ones.

The hourly outputs from REMO were used for initializing of CMCT that is the 3-D mesoscale diagnostic model with possibility to calculate vertical motions from the continuity equation and, hence, to determine developments of clouds by positive thermodynamic rate of condensation. The vertical integral of this characteristic (E) corresponds to the possible maximum of precipitation rate:

$$E = -\int_0^H \rho w \frac{\partial q_s}{\partial z} dz \quad ,$$

where ρ and q_s are the density and specific humidity of the air respectively; z is the height; $H$is the z-maximum; $w$is the vertical component of the wind velocity.

The maxima of the integral thermodynamic condensation rate in the presented simulations reached 20 mm/h for the Carpathians and 30 mm/h for the Elbe flood events and were comparable with measured ones. CMCT was used to obtain trajectories of cloud systems over the places of interest that is the stations with measured maxima of precipitation. Than 1-D spectral cloud model was initialized by thermodynamic characteristics obtained from REMO and CMCT on these trajectories named tracks. These tracks crossed maxima of precipitation determined from REMO and CMCT and allowed to analyze microphysics of clouds and precipitation with spectral cloud model. This model includes droplets, raindrops and ice crystals (every category of 41 bins) and the main microphysical processes in clouds: condensation (sublimation) on activated CCN (IN), collision-coalescence of precipitation particles for droplets, freezing, etc. The runs with spectral microphysics revealed the importance of cold processes in the clouds in particular over the Carpathians where obtained in the simulations intensities of snow was comparable with rain rates. Note, that sleet was really observed in the Carpathians.

The presented approach and obtained first results are pretty encouraging. The space distributions of precipitation and their maxima were got close to the observed ones at least. Further development and improvement will be done in the ice processes representation in REMO and 1-D spectral cloud model that should to improve the representation of precipitation quantitatively.