A complex of the numerical models in the study of the catastrophic flood along the Elbe river in August 2002

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The catastrophic flash flood caused by heavy prolonged rainfalls in August 2002 along the Elbe river in Germany and Czech Republic is under consideration in the presented study. A new approach was proposed recently by the authors for the study of the flood events in Europe which 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. Further development of the proposed method particularly with more fine resolution will be presented.

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 7 months and half of month prior to 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. A new ice scheme was implemented in REMO recently that improved representation of precipitation formation processes in the model. But the precipitation intensity and sums were still 1.5-2 times less then the measured ones for this extreme case.

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 maximum of the integral thermodynamic condensation rate for the studied case reached 30 mm/h and was comparable with measured precipitation intensity. CMCT was used to obtain trajectories of cloud systems over the places of interest that is the stations with measured maxima of precipitation – Dresden and Zinnwald. 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 microphysical model has allowed to obtain a time development of precipitation rates far more close to observed ones, particularly for Dresden in simulation with more fine resolution.

The presented approach and obtained results are pretty encouraging. The space distributions of precipitation and their maxima were got close to the observed ones at least. Further simulations with horizontal resolution down to 2 km will be done for this case and other flood cases in Europe to find optimal strategy and maybe some physical predictors for probable forecasting of flash floods.