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Local Cloudiness Development Forecast Based on Simulation of Solid Phase Formation Processes in the Atmosphere

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Nowadays numerical simulation of thundercloud formation processes is of great interest as an actual problem from the practical point of view. Thunderclouds significantly affect airplane flights, and mesoscale weather forecast has much to contribute to facilitate the aviation forecast procedures. An accurate forecast can certainly help to avoid aviation accidents due to weather conditions.

The present study focuses on modelling of the convective clouds development and thunder clouds detection on the basis of mesoscale atmospheric processes simulation, aiming at significantly improving the aeronautical forecast.

In the analysis, the primary weather radar information has been used to be further adapted for mesoscale forecast systems. Two types of domains have been selected for modelling: an internal one (with radius of 8 km), and an external one (with radius of 300 km).

The internal domain has been directly applied to study the local clouds development, and the external domain data has been treated as initial and final conditions for cloud cover formation. The domain height has been chosen according to the civil aviation forecast data (i.e. not exceeding 14 km).

Simulations of weather conditions and local clouds development have been made within selected domains with the WRF modelling system. In several cases, thunderclouds are detected within the convective clouds. To specify the given category of clouds, we employ a simulation technique of solid phase formation processes in the atmosphere.

Based on modelling results, we construct vertical profiles indicating the amount of solid phase in the atmosphere. Furthermore, we obtain profiles demonstrating the amount of ice particles and large particles (hailstones). While simulating the processes of solid phase formation, we investigate vertical and horizontal air flows. Consequently, we attempt to separate the total amount of solid phase into categories of small ice particles, large ice particles and hailstones. Also, we strive to reveal and differentiate the basic atmospheric parameters of sublimation and coagulation processes, aiming to predict ice particles precipitation. To analyze modelling results we apply the VAPOR three-dimensional visualization package.

For the chosen domains, a diurnal synoptic situation has been simulated, including rain, sleet, ice pellets, and hail. As a result, we have obtained a large scope of data describing various atmospheric parameters: cloud cover, major wind components, basic levels of isobaric surfaces, and precipitation rate. Based on this data, we show both distinction in precipitation formation due to various heights and its differentiation of the ice particles.

The relation between particle rise in the atmosphere and its size is analyzed: at 8-10 km altitude large ice particles, resulted from coagulation, dominate, while at 6-7 km altitude one can find snow and small ice particles formed by condensation growth. Also, mechanical trajectories of solid precipitation particles for various ice formation processes have been calculated.