“Numerical simulation of tornadic supercell using a convective cloud model”

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Introduction: On 10th of July 2017 in the afternoon a Tornado occurred in Lower Austria between Schwechat and Rauchenwarth, which also hit the international Airport in Schwechat. This tornado reached strength of category F2. It caused hail with a diameter off up to 8cm and flooding around Schwechat. In Vienna 3715 lightnings were observed, what corresponds to the sum of lightnings in the last three years. This poster should discuss the results of a numerical simulation of this supercell, using a convective cloud model.

Method: In order to capture the initiation of supercell storm and evolution of tornado we have conducted also a three-dimensional simulation using a cloud resolving model with fine horizontal grid resolution and small domain which covers the tornadic storm area of 61x61x60 km^3. The present version of the model contains ten prognostic equations: three momentum equations, the pressure and thermodynamic equations, four continuity equations for the water substances, and a subgrid-scale kinetic energy equation. The cloud model is initialized using a warm ellipsoid thermal bubble with the maximum temperature perturbation of 2.0 ℃ in the bubble centre as suitable for highly unstable atmosphere to trigger severe convective storm. The initial meteorological conditions were taken from upper air sounding from Wyoming University (attached on Moodle). A three-dimensional (3-D) runs were performed within small domain with size 51x51x20 km^3 that covers the central part of Vienna City area and its southern part where supercell storm and tornado occurred.

Discussion and Conclusion: To conclude, the supercell from 10th July 2017, can be well described with the made graphics and simulations. It is also very useful to understand the different processes within a supercell.

Case Analysis: Western Europa was influenced by a trough, which caused southwesterly winddirections in Austria. That led to advection of energy-rich air mass from the south. Moisture was high, and the sounding showed a very unstable stratification of the atmosphere. These ingredients led to development of a supercell with a tornado in the south of Vienna. On the thunderstorm spectrum, supercells are the least common type of thunderstorm, but they have a high propensity to produce severe weather, including damaging winds, very large hail, and sometimes weak to violent tornadoes. What makes a supercell unique from all other thunderstorm types is that it contains a deep and persistent rotating updraft called a mesocyclone. If the environment is favorable, supercell thunderstorms can last for several hours.

Results: The development of the destructive supercell near Schwechat can be well described with the convective cloud model. According to some results of the model, the cloud also contained hail, what is very typical for a supercell. Figure 1 shows a typical structure of a supercell with the updraft in the left part of the cell, followed by the wallcloud. In the right part of the cell, downdraft with heavy precipitation can be seen. At the right end of the cell, there is the typical inflow band.

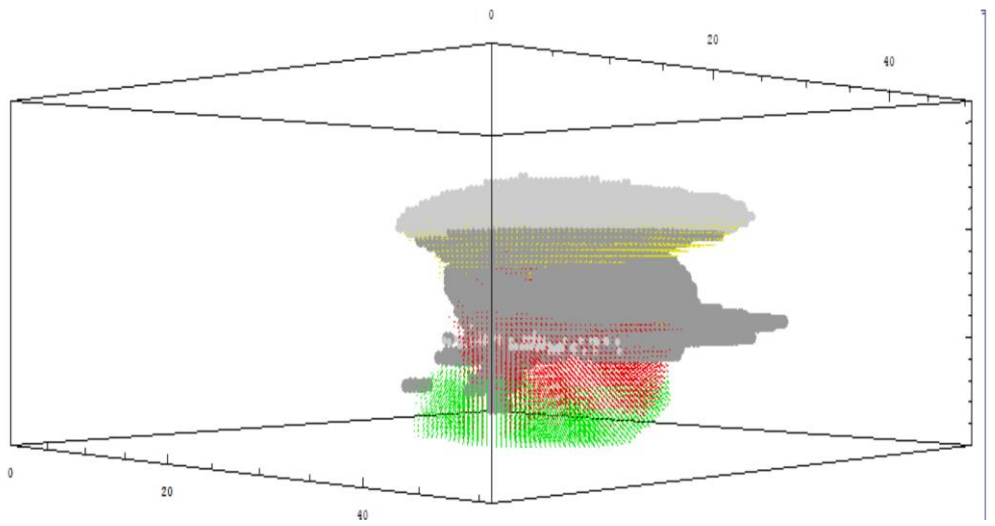

Figure 1 Supercell with typical structur of a supercell with up- and downdrafts, wallcloud and inflow band.

References:

Barth, M.C., S.-W. Kim,, C. Wang, K. E. Pickering, L. E. Ott, G. Stenchikov, M. Leriche, S. Cautenet, J.-P. Pinty, Ch. Barthe, C. Mari, J. H. Helsdon, R. D. Farley, A. M. Fridlind, A. S. Ackerman, V. Spiridonov, and B. Telenta, 2007: Cloud-scale model intercomparison of chemical constituent transport in deep convection, Atmos. Chem. Phys., 7, 4709–4731.

Klemp, J.B., R.B.Wilhelmson,1978: The simulation of three-dimensional convective storm dynamics. J. Atmos. Sci.35, 1070–1096.

Lin, Y.L., R.D. Farley, and H.D. Orville, 1983. Bulk water parameterization in a cloud model. J. Climate Appl. Meteor. 22, 1065–1092.

Orville, H.D., and F.J.Kopp, 1977: Numerical simulation of the history of a hailstorm, J. Atmos. Sci., 34, pp. 1596–1618.

Spiridonov V, Dimitrovski Z, Ćurić M. 2010. A Three-Dimensional Simulation of Supercell Convective Storm, Advances in Meteorology. 2010: 15.

Spiridonov, V., and M. Curic, 2015: A Storm Modelling System as an Advanced Tool in Prediction of Well Organized Slowly Moving Convective Cloud System and Early Warning of Severe Weather Risk. Asia Pac. J. Atmos. Sci., 51(1), 1-15, DOI: 10.1007/s13143-000-0000-0.

Spiridonov, V., and M.Curic, 2018: Evaluation of Supercell Storm Triggering Factors Based on a Cloud Resolving Model Simulation. Asia-Pac. J. Atmos. Sci., 00(0), 0-00, DOI: 10.1007/s13143-018-0070-7 (in press).

Telenta, B., and N. Aleksic, 1988: A three-dimensional simulation of the 17 June 1978 HIPLEX case with observed ice multiplication, 2nd International Cloud Modeling Workshop, Toulouse, 8-12 August 1988. WMO/TD No. 268, 277–285.

https://www.weather.gov/ama/supercell

https://www.skywarn.at/index.php/superzelle-und-mesozyklone.html