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Satellite-based study and numerical simulation of mesoscale convective systems with tornadoes in Russia for 2017-2018

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The study is carried out to estimate the capability of using Meteosat-8 SEVIRI satellite data for the detection of tornado-generating mesoscale convective systems (MCSs) and supercell storms. We consider the cloud top temperature, overshooting tops, cold-rings, and cold U-V shaped features as signatures of tornado formation. The study is performed for 2017-2018, on the example of several tornado outbreaks in the European Russia and Ural region. The tornado events are identified by witness and media reports and by satellite-based analysis of tornado-induced forest damage tracks.

For the first time in this region, overlapping of actual tornado tracks with Meteosat-8 images allows to detect the features of MCSs and supercell storms that yielded tornadoes. It is found, that the extremely low cloud top temperature and overshooting tops have a relatively weak correlation with tornado events. Whereas, the cold-rings and cold U-V shaped features are related more tightly with strong tornadoes, and hence can be considered as the signatures of strong mesocyclones.

The importance of convective instability conditions is highlighted. Particularly, Meteosat data show good capability to detect tornado-generating MCSs and supercell storms that are formed in the environments with strong convective instability (and strong updrafts). However, the local supercell storms which generate tornadoes in the conditions with weak or moderate convective instability, have no typical signatures on the cloud top. Consequently, their satellite-based detection is difficult.

Also two strong tornado events in the Ural region, occurring 3 June 2017 and 18 June 2017, were simulated with WRF-ARW atmospheric model. We used GFS model forecasts and ERA-5 reanalysis data as WRF model input. The simulated MCS characteristics were compared with Meteosat-8 data, and simulated mesocyclone tracks were overlapped with observed tracks of tornadoes. In both cases, the simulated tracks of mesocyclones are within 50 km of the observed tracks of tornadoes, but the intensity of mesocyclone 3 June 2017 was significantly underestimated.

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