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Heavy rainfall event on 30th June 2017 in Moscow: physical drivers and statistical background

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The extreme rainfall on June 30, 2017 in the central part of the European territory of Russia is one of the strongest precipitation events ever observed in this region. According to ground observations, it caused the record precipitation amount per day for June in Moscow (65 mm) since 1970.

Our study considers physical and synoptic drivers of the extreme rainfall on June 30, 2017 as well as statistical estimates of such phenomena's repeatability for the Moscow region. The degree of extremality of this phenomenon has been assessed using long-term observational time series since second half of the 20th century. Based on meteorological observations, radar data and ERA5 reanalysis we demonstrate that rainfall was associated with three mesoscale convective systems (two squall lines [Markowski, Richardson, 2010] and one meso-beta scale convective system) which appeared in the warm sector of a cyclone. The main cause for their development was an anomalously high total moisture content for the region which reached 41.5 kg / m^2 and exceeded 0.995 percentile in the sounding data over Moscow [Durre et al., 2006] for the period 1957 – 2017. An analysis of the water vapor balance components using ERA5 reanalysis showed that advection of water vapor was the main factor in the appearance of the quasilinear region of an extremely high moisture content ("atmospheric river"). A smaller but very noticeable role was played by evaporation from the earth surface, largely controlled by the soil moisture.

Besides evaporation, another local factor which may intensify precipitation are the physical effects induced by a big city [Han et al., 2014]. To test the role of the Moscow city and soil moisture in the June 30 case the mesoscale non-hydrostatic model COSMO 5.05 with 3 km grid was used. The simulation result confirmed an idea of the significant role of evaporation from the earth's surface in precipitation intensity: a 10-times decrease in soil moisture in the initial conditions led to a 3-times decrease in the daily amount of precipitation in the study area. Urban-induced effects of the Moscow megacity were studied by running sensitivity model experiments with COSMO where bulk urban canopy model TERRA_URB was switched on or off. The account for urban surface effects did not provide any noticeable increase in the amount of precipitation in the Moscow

region, but led to redistribution of the daily precipitation sum and its increase at the leeward side of the megacity.

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