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Study and forecast of convection phenomena over the territory of the south of Russia using lightning location data network

Introduction

In recent years, the number of lightning detection networks deploy worldwide. The networks provide information on the coordinates, time, type of discharge, as well as some physical characteristics of a lightning. For instance, there are Worldwide Lightning Location Network (WWLLN) and Russian regional networks. Gathering lightning data is necessary for storm climatology, validation of forecasts, finding solutions of lightning protection problems and improving the prediction of convection using data assimilation technique. The main goals of this study are storm climatology and simulation of severe storms using data assimilation technique over southern part of Russia during the convective season of 2017. WWLLN data, WRF-ARW and LTNGDA are used for the research [1-3].

Methodology

Well-known that the south of Russia is “the most lightning” region of Russian Federation. This research is devoted to the statistical analysis of thunderstorm data in 2013-2017. It includes identifying the number of days with thunderstorms, determining the total duration of every thunderstorm events, identification of areas with the highest thunderstorm activity and study of the spatial distribution of the density of lightning discharges.

Also, this work presents simulation results of seven case studies of the most destructive convective storms observed in 2017 over Krasnodar region of Russia. In current research we computed BASE experiment (without lightning assimilation) and LTNGDA experiment (with assimilated lightning data gathered from Worldwide Lightning Location Network [1,4]. Both experiments are computed using WRF-ARW v. 3.9.1 with 2 km resolution and 30 vertical levels. The advance time is 48 hours. The domain of interest is (45.5-46.4 N; 37-41 E). Some used parameterizations: cu convection – Kain-Fritsch, microphysics - NSSL 2–moment Scheme with CCN Prediction. Then the difference in vertical profiles of the air temperature and cloud water content in points with observed lightning for both experiments is analyzed. The convection thunderstorm evolution is also studied. But the main goal of the research is the accuracy of the surface air temperature, relative humidity, pressure and rains evaluated for BASE and LTNGDA experiments. Bias, abias and rmse are obtained. The WWLLN data are used for the comparison.

Conclusions

According to this statistical analysis three areas in south of Russia were found with the highest thunderstorm activity – Starominskaya , Psebaj and Krymsk statations. In 2013-2017 the average number of thunderstorms there is 30.2, 45.4, 28.8 respectively. Maximum of days with thunderstorms, thunderstorm duration (hours) and lightning density (km2/year) are found in summer months – for June, July and August. Remarkably that these values gathered from WWLLN and Russian regional networks are different. For instance, the average number of days with thunderstorms gathered from WWLLN in June, July and August are 8.6, 9.8 and 9.0 respectively, according for data from Russian networks – 6.9, 7.8 and 7.2 respectively. Average thunderstorm duration (hours) for the same months are 59.3, 69.6 and 76.5 (WWLLN) respectively; 47.5, 55.7 and 61.2 (Russian networks) respectively. Average lightning density (km2/year) for the same months are 4.0, 4.7 and 5.1 (WWLLN) respectively ; 3.2, 3.7 and 4.1 (Russian networks) respectively.

According to the preliminary of simulation results it was found that lightning assimilation helps to improve the short-term forecast of air temperature, pressure, relative humidity and rain. It concerns not only its forecast estimations. The LTNGDA technique makes the cumulus precipitation localization more accurate. This is especially pronounced in estimates of precipitation. The forecast scores in LTNGDA experiment are more accurate for seven case studies.

Acknowledgments

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