Interannual Variability in Cyclone Activity in Different Reanalyses: Comparative Assessment

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Interannual variability in cyclone activity represents an important feature of climate dynamics providing insights on the mechanisms of the observed and projected climate variability and change. At the same time, estimates of cyclone activity are highly uncertain, being dependent on the methods of cyclone identification and tracking and on the data sets used to quantify cyclone activity. In order to establish more truth in understanding interannual variability of characteristics of cyclone activity in the Northern Hemisphere in the present climate we analyze cyclone characteristics in seven different reanalyses (NCEP1, NCEP2, ERA-40, ERA-Interim, JRA, MERRA, CSFR) for the period from 1979 onwards. These products represent wide spectrum of model formulations, resolution and data assimilation systems and overlap with each other for the last 3 decades. For cyclone identification and tracking we used a numerical tracking algorithm developed at P.P. Shirshov Institute of Oceanology, RAS. The tracking scheme identifies cyclone locations, builds cyclone trajectories and allows for the quantitative estimation of cyclone numbers and cyclone life cycle characteristics (lifetime, migration, intensity, deepening rate, propagation velocity, etc.). Main issues to be addressed in our analysis are: (i) the extent to that interannual variability of characteristics of cyclone activity are similar in different reanalyses (geographical and temporal distribution), (ii) qualitative and quantitative differences in the magnitudes of trends in the characteristics of cyclone activity in different reanalyses, and (iii) consistency of trends and variability patterns in the number of cyclones and in cyclone lifecycle characteristics in different products. We suggest that the resolution is the major factor of differences between different products. There is a general tendency of the growing number of cyclones with the spatial resolution of the reanalysis. The highest number of cyclones (2600 per year) is found in MERRA (non spectral model) and the lowest count of 1315 cyclones per year identified in NCEP DOE reanalysis. At the same time many characteristics of cyclone life cycle (e.g. intensity, deepening rates) potentially depend on the model formulation used in reanalyses. For instance MERRA being comparable with CSFR in resolution shows much higher occurrence of extremely deep and rapidly intensifying cyclones. Spatially, the highest comparability between datasets is observed over oceans with the strongest regional differences being identified over the continents and in the Arctic, where differences between different data sets may amount to 100%. In our analysis we make a special emphasis on the comparison of extremely deep events and rapidly intensifying cyclones. Analyzing long-term temporal variability in cyclone activity, we separately considered linear trends on interdecadal time scales and shorter period interannual variability. In winter all reanalyses show statistically significant linear trends in the number of cyclones over the Eastern US, in the North-West Atlantic and in the North-East Pacific with a lesser consistency of linear tendencies over Mediterranean storm track and in the Arctic. In summer estimates of regional trends are less robust compared to the winter season. Analysis of temporal evolution of the characteristics of cyclone life cycle shows a positive anomaly in the occurrence of deep cyclones over the NH in 1990s, however, during the last decade all products show a robust tendency of the increasing occurrence of moderate and shallow cyclones. Among different reanalyses, MERRA shows a slight increasing in the number of rapidly intensifying cyclones in both Atlantic and Pacific. Analysis of shorter period interannual variability shows that MERRA, NCEP-CFSR and ERA-Interim are stronger correlated with each other than the other reanalyses. The highest correlation is observed in the eastern parts of the Atlantic and Pacific, where it amounts to 0.7-0.8 and drops below the level of statistical significance over the continents (especially over the regions with elevated topography).

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