Extratropical Cyclones over North Atlantic based on ERA-5 and NCEP-NCAR-DOE Reanalysis for 1979-2020

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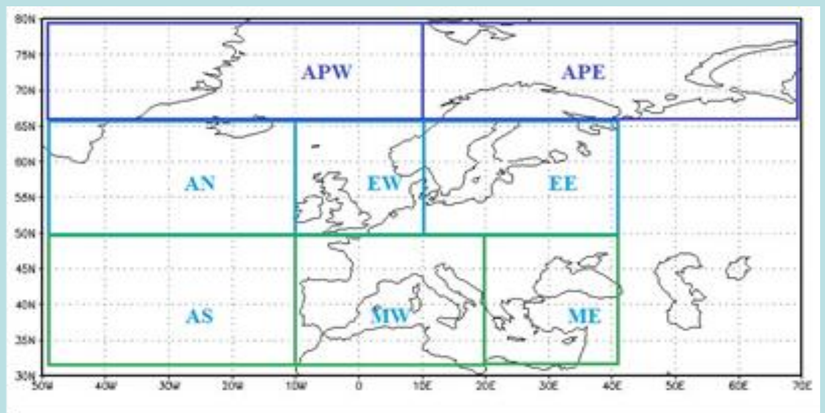

Fig.1. Regions, selected for calculation of cyclone characteristics

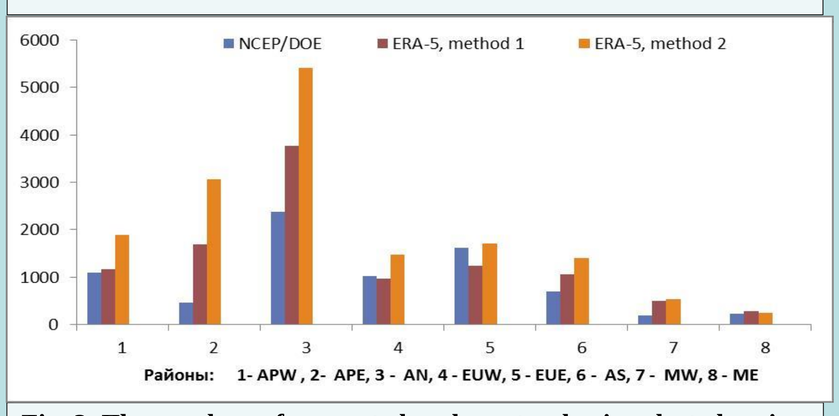

Fig. 2. The number of generated cyclone tracks in selected regions during winter season based on NCEP/NCAR/DOE and ERA-5/ECMWF reanalyses for all period 1979/80-2020/21.

Introduction

The goal of study is the comparison the characteristics of cyclone activity in different regions of North Atlantic and European seas (fig. 1) during winter half of year for 197980-2020/21 based on:

1) one method and different reanalyses, ERA-5/ECMWF and NCEP/ NCAR/DOE;
2) different modification of cyclone centers identification for one reanalysis, ERA-5/ECMWF.

1. Data and Methodology

The cyclone centers and cyclone tracks were identificated based on automated cyclone detection/tracking algorithm [1] based in 6-hourly MSLP data in grid points of NCEP/NCAR/DOE and ERA-5 reanalyses [2]. Cyclone center identification based ERA-5 reanalyses made using tow modification of method: 1) with step 2.5°x2.5° by analogy with step of data in NCEP/NCAR/DOE, and 2) with step 1.25° x 1.25° .

Cyclones are identified in North Atlantic region [30°n-80°n, 50°w-70°e]. For analysis the cyclone trajectories with life more 12 hours were selected.

The density of generated cyclone tracks, the number of cyclone centers and cyclone activity index were calculated as main cyclonic activity characteristics in selected regions. The density of generating cyclone tracks was calculated as the number of cyclone tracks, having start in region during winter season. The cyclone activity index was calculated as the summa of pressure anomalies in cyclone centers points of region for season.

To analyze and compare the climatology of generated extratropical cyclones in different selected regions of the North Atlantic, the number of generated cyclones in the winter half of the year from October to March was calculated for all period 1979/80-2020/21 based on both reanalyses. Analysis of the interannual variability of the number of cyclone centers and the cyclonic activity index carried out for the selected regions of Icelandic minimum [55°n-65°n, 50°w-10°w] and Barenz sea [66°n-80°n, 10°e-70°e]. Barenz sea region named marked on the map (fig.1) with letters APE. The cyclone characteristics were calculated as for all cyclones, as separately for extreme cyclones with central pressure from 980 gPa and less.

2. The number of cyclones tracks generated in the regions

Figure 2 shows the significant differences between reanalyses in quantity of generated cyclones in selected regions during period of study. Systematically in all regions more cyclones were identified by ERA-5 reanalysis data with modification 2. The maximum number of cyclones for both reanalysis is generated in mid-latitude of North Atlantic (region AN) and polar latitudes (regions APW and APE). The maximum differences between reanalyses are also observed in same regions (AN, APW, APE).

3. On number of cyclones based on period of Life

Figure 3 shows that the significant part of all cyclones over North Atlantic are cyclone with life less then 8 srokes or two days: near 70% based on NCEP/DOE and more 80% based on ERA5 reanalysis. The significant increase of number cyclone track in ERA5 reanalysis during winter seasons is associated with an increase primarily in the number of short-lived cyclones.

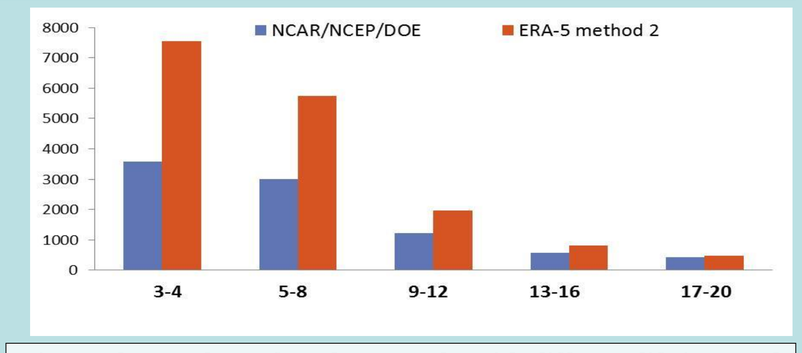

Fig. 3. The number of cyclone tracks with different life in North Atlantic during winter season based on NCEP/NCAR/DOE and ERA-5/ECMWF reanalyses for all period 1979/80-2020/21.

4. On number cyclone centers in regions

Figure 4a. The first version of cyclone identification according to ERA-5 data in the Icelandic minimum area allows to obtain, on average, about 400 identified cyclone centers per season, the second version - already from 400 to 650 cyclone centers, which is significantly more compared to the first version of calculations, and almost two times more than NCEP/NCAR/DOE reanalysis. The share of deep cyclones in the Icelandic minimum area is higher according to ERA-5 data using the first version of calculations focused on identifying larger cyclones, in contrast to the second version.

Figure 4b. In the area of Barenz Sea the use of the second version of cyclone identification according to ERA-5 data gives on average about 400 cyclone centers for the winter season, which is four times more compared to the NCEP/NCAR/DOE reanalysis. This significant increase in the centers of cyclones can be assumed that cyclones with a horizontal radius near 400 km, identified by the second version, may constitute a significant part of the total number of cyclones detected in the Barents Sea region.

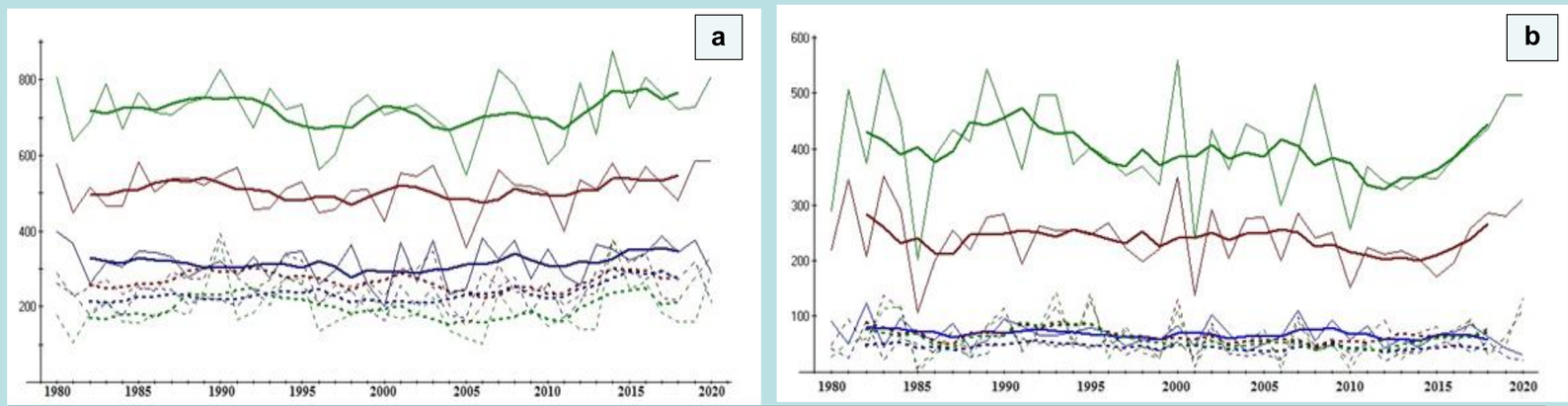

Fig. 4. The number of cyclone centers during winter season regions: a) Icelandic minimum region, b) Barenz region. The color of line: blue NCEP/NCAR/DOE реанализ, brouw - ERA-5/ECMWF , modification 1, green – modification 2. Solid line – all cyclones, points – deep cyclones, bold line - moving average over five years.

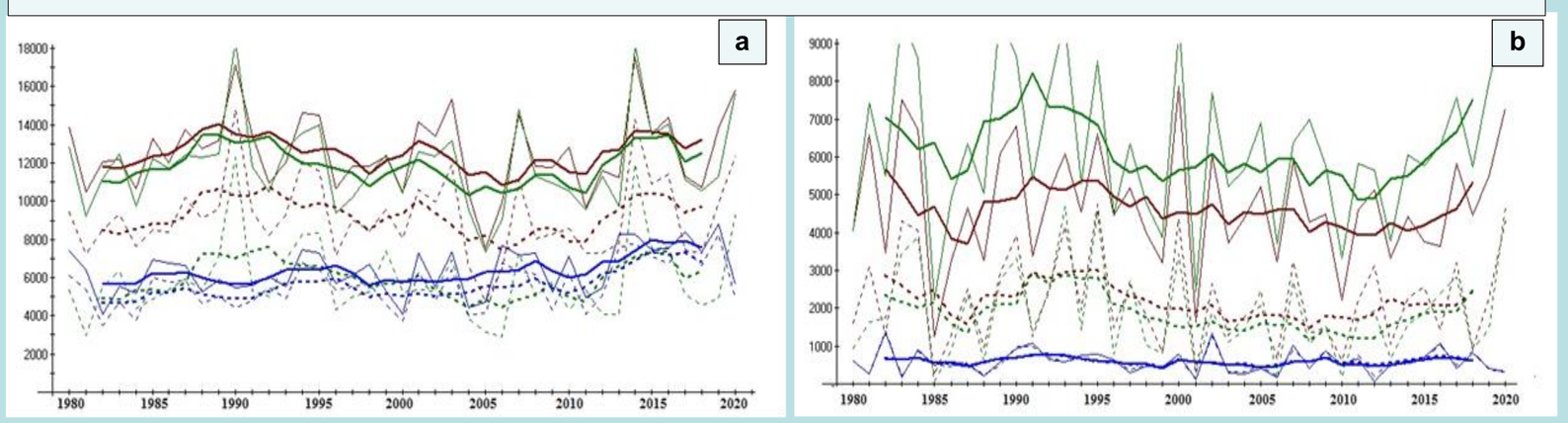

Fig. 5. The cyclone activity index during winter season in regions: a) Iceland region, b) Barenz region. The color of line: blue NCEP/NCAR/DOE реанализ, brouw - ERA-5/ECMWF , modification 1, green – modification 2. Solid line – all cyclones, points – deep cyclones, bold line - moving average over five years.

5. On cyclone activity index in regions

Figure 5 shows, that the values of the cyclonic activity index, both in the Icelandic minimum area and in the Barents Sea area, calculated from the ERA-5 reanalysis data, turned out to be significantly higher compared to the index values obtained from the NCEP/NCAR/DOE reanalysis data: in the Icelandic minimum area, on average, in twice, in the Barents Sea region - more than 4 times. In the area of the Icelandic minimum, the maximum values of the cyclonic activity index were obtained using the first version of cyclone identification according to ERA-5 data. In the Barents Sea region, with a relatively equal number of deep cyclones obtained from the data of both reanalyses, the second version of cyclone identification gives higher values of the cyclonic activity index according to ERA-5 data for each winter season.

6. On the tendency of interannual variability of cyclonic activity

Moving averages, calculated for the analyzed parameters for every 5 years, show the consistency between the trend of interannual variability in the number of cyclones and the variability of the cyclonic activity index in the study areas (Fig. 4, Fig.5). However, the periods of increase and decrease in the tendency of the cyclonic activity index variability stand out more clearly in comparison with the variability of the number of cyclones.

7. Conclusion

The use of the ERA-5 reanalysis data and second version of the cyclone center identification method gives the highest number of generated cyclone trajectories in almost all areas of North Atlantic in the winter half of the year compared to the first version and reanalysis of NCEP/NCAR/DOE. This increase is associated with an increase primarily in the number of short-lived cyclones. The maximum differences in number of cyclone trajectories between reanalyses are observed in the temperate and subpolar latitudes of North Atlantic.

The analyses of cyclone characteristics in Icelandic and Barenz regions also shows the significant increase in the number of centers of cyclones and cyclone activity index according to the ERA-5 reanalysis during all period of study compared to NCEP/NCAR/DOE reanalysis.

The comparison of two versions of cyclone identification according to one reanalysis ERA-5 shows the differences in the annual values of the characteristics of cyclonic activity in selected regions, associated with differences of calculation versions. At the same time the course of the trend of variability of characteristics, were calculated with different versions based on ERA-5, in the selected regions of the North Atlantic in winter seasons from 1979/80 to 2020/21 independent of the selected cyclone identification criteria.

References

1. Viazilova N.A. Cyclonic activity and fluctuations in circulation in the North Atlantic. – Russian J. “Meteorology and Hydrology”, 2012, N 7, pp. 5-14.
2. Hersbach H. et. al. The ERA5 global reanalysis. Quart. J. Royal Meteor. Soc., 2020, vol.146, pp.1999-2049.