

Variability of planetary high-altitude frontal zones in the Northern Hemisphere from 1990 to 2019 in the summer and their location during extreme weather events

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The main objectives

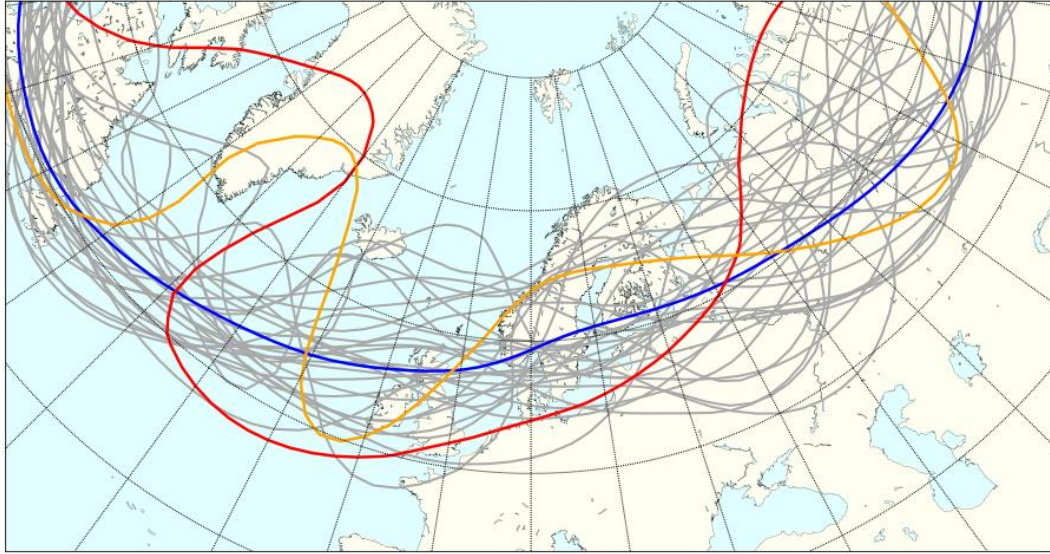
- The analysis of mean monthly location of planetary high-altitude frontal zones in Euro-Atlantic sector in summer period during 1990-2019;
- The identification of characteristic positions for summer months – June, July and August and maximum deviations from climatological norm of 1961-1990 in years with the formation of blocking regime in the atmosphere;
- The calculation of the values of the standard deviations of displacements relative to the climatological position for each year both for the North Atlantic region, Europe and the European part of Russia, and for the Euro-Atlantic sector as a whole.

Data and method

- The mean monthly isobaric surfaces 500 hPa of data reanalysis NCEP NCAR $2.5^\circ \times 2.5^\circ$ were analyzed from 1990 to 2019 years every summer month – June, July and August.
- For each summer months was defined one isohyps which characterizes the middle location of planetary high-altitude frontal zone.
- For June this isohyps equals **560 hPa**, for July and August **572 hPa** (method of Khrabrov Y., *Khrabrov Y, 1957 in Russian*).
- Isohyps of each months has compared with climatological norm (1961-1990 years).

Planetary high-altitude frontal zones in June 1990-2019

a) Planetary high-altitude frontal zones in June 1990-2019



Blue line – climatological norm of 1961-1990

Red line – position in June 2012

Yellow line – position in June 2019

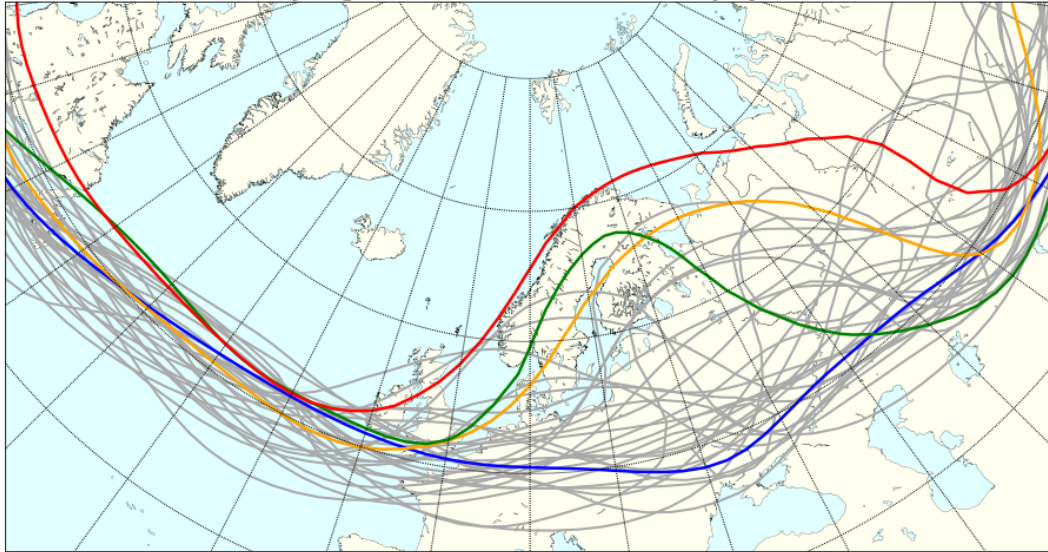
High-altitude frontal zone in June has a non-uniform location from year to year both over the North Atlantic region and over Europe, the European part of Russia and Western Siberia.

- The most northerly location and also the maximum deviation from the climatic norm up to 21°N was noted in June 2012 over Greenland and Kara Sea coast.
- The second largest northern location up to 16°N was noted in June 2019 over Greenland.
- In other years deviations were noted both to the north and south of the climatic position within $6\text{-}12^{\circ}\text{N}$.

The synoptic situation with the spreading of the high-altitude ridge northwards and the deviation of the high-altitude frontal zone has favored to the blocking west-eastern flow in the atmosphere, formation stationary anticyclone and surface anomalies in the form of record ice melting in Greenland and high temperatures and fires in the regions of Western Siberia.

Planetary high-altitude frontal zones in July 1990-2019

b) Planetary high-altitude frontal zones in July 1990-2019



Blue line – climatological norm of 1961-1990

Yellow line – position in July 2010

Green line – position in July 2014

Red line – position in July 2018

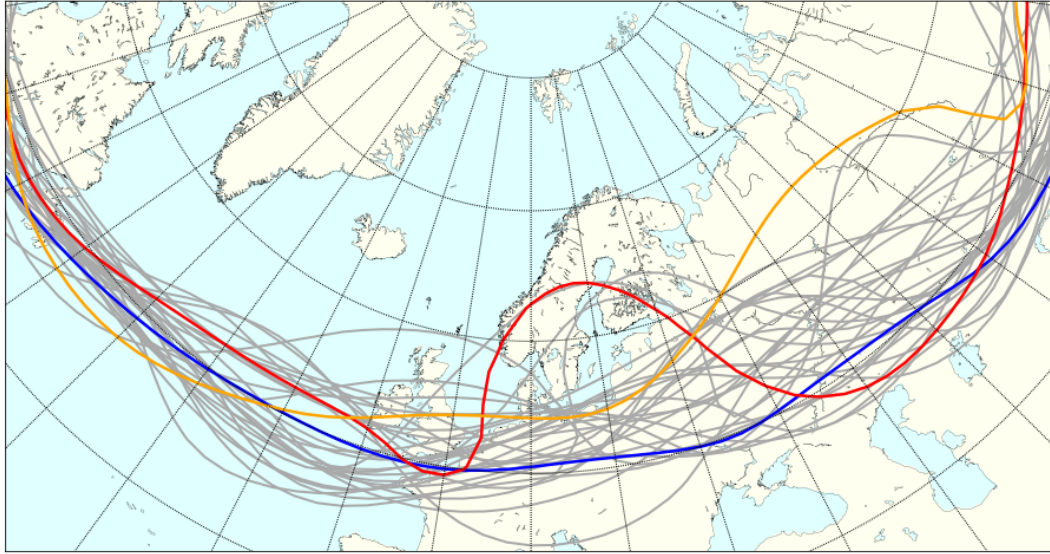
High-altitude frontal zone in July is more evenly located within 45-53° N over the North Atlantic region with slight deviations from its climatic position. In the area of the continental part deviations from the norm were noted in most cases to the north.

- The most northerly location and also the maximum deviation from the climatic norm up to 23°N was noted in July 2018 over North Europe and Scandinavia.
- The second largest northern location up to 18°N was noted in July 2010 over European part of Russia.

The anomalous circulation with stationary anticyclone in the summer of 2010 had disastrous effect both in terms of economic damage in the form of extreme drought in Russia, and human losses - an increase in mortality compared to previous years during this period. In 2018 - record positive anomalies of surface air temperatures in the Netherlands, Belgium, and in Scandinavian countries droughts and forest fires.

Planetary high-altitude frontal zones in August 1990-2019

c) Planetary high-altitude frontal zones in August 1990-2019



Blue line – climatological norm of 1961-1990

Red line – position in August 2002

Yellow line – position in August 2016

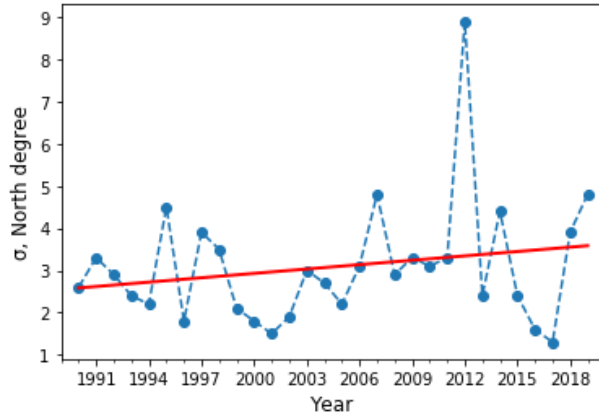
High-altitude frontal zone in August has a similar distribution to July, but with the smallest deviations from the climatic norm over the continental part. Over the North Atlantic, the position remains within the climatic norm, over the continental part with a deviation to the north within 5-10°N and maximum up to 12-15°N in some years.

- The most northerly location and deviation from the climatic norm up to 15°N was noted in August in 2016 over European part of Russia and Western Siberia and in 2002 over North Europe.

Throughout the August 2016 anomalous hot weather was observed in most of the European part of Russia and the Urals, new daily air temperature maximums were recorded and at the end of the month, August 2016 became the hottest in Russia since 1891.

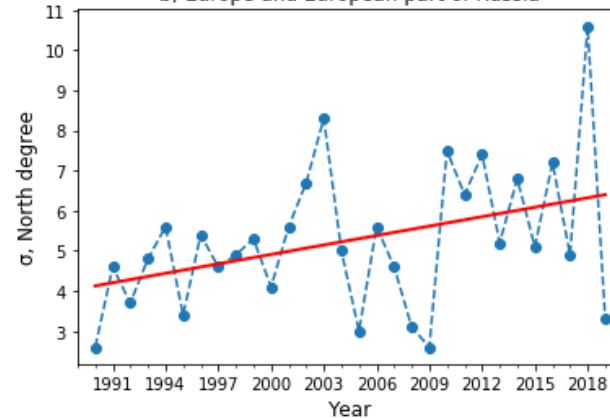
Standard deviations of displacements relative to the climatological position 1961-1990

a) North Atlantic



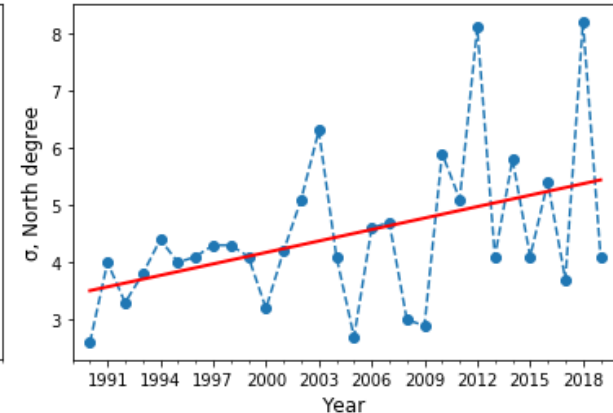
For the North Atlantic region the standard deviations are within 1-5°N with maximum to 9°N in 2012.

b) Europe and European part of Russia



For the Europe and European part of Russia from 1990 to 2010 3-6°N, with maximum to 8°N in 2003, for the period 2010-2019 values of standard deviations has increased to 5-8°N with maximum to 11° in 2018.

b) Euro-Atlantic sector



In Atlantic-European sector from 1990 to 2000 the values of standard deviations were within 2-4°N, for the period 2000-2010 3-6°N, from 2010 to 2019 4-8°N.

Summary

- As can be seen in general for the thirty-year period from 1990 to 2019 there is a tendency for the increase in the meridional deviations of the planetary high-altitude frontal zones in the summer. The main contribution was made by the maximum deviations observed over the past ten years: in June 2012 and 2019 in the North Atlantic; in July 2010, 2014 and 2018 and in August 2016 over Europe and the European part of Russia.
- Thus with a high degree of probability should expect the appearance of new summer extreme weather events in the Atlantic-European region, associated with the spreading of high-altitude ridges and the shifting of the planetary high-altitude frontal zone far to the north.