Features in spatial distribution of higher order cumulants of meteorological anomalies in the Northern Hemisphere

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<u>Purpose:</u> to assess the frequency of extreme weather events formation and to identify areas with a significant contribution of nonlinear interactions to the general dynamics of arising atmospheric instability. The solution of this goal will help to answer the question about unprecedented current increase in the frequency of extreme weather events.

Atmospheric (meteorological) variability is subdivided into components corresponding to different time scales: a) synoptic (SV, 2-7 days) and low-frequency (LV, 10-30 days). The calculations were carried out for warm and cold seasons over the Northern Hemisphere. Samples, constructed for each value, took into account the scale of variability and the season of the year.

The spatial distributions in the characteristics of fluctuations variability (cumulants - asymmetry and excess) of air humidity (Q), temperature (T), geopotential height (Z) and components of the wind velocity (zonal (U), meridional (V) and vertical (W) in isobaric coordinates) were calculated at the level of 850 hPa.

Comparison

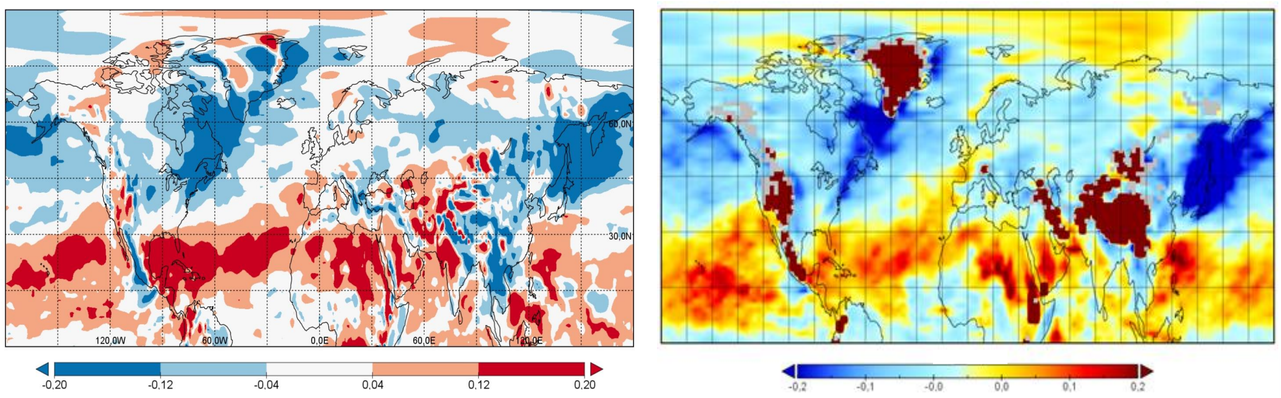
ERA-Interim reanalysis data (6-h) for the period of 1979–2017 with a spatial resolution of 1.125×1.125° were used, as well as CMIP6 daily data with resolution of 2.5°. CMIP6 data (IPSL CM6ALR midHolocene r1i1p1f2 gr) model middle Holocene climate (Boucher O. et al., 2018), and main factors are: small gas components, orbital parameters, dust (direct influence, as well as taking into account the feedback if the dust cycle was represented in the model).

SV in cold season

Skewness coefficient

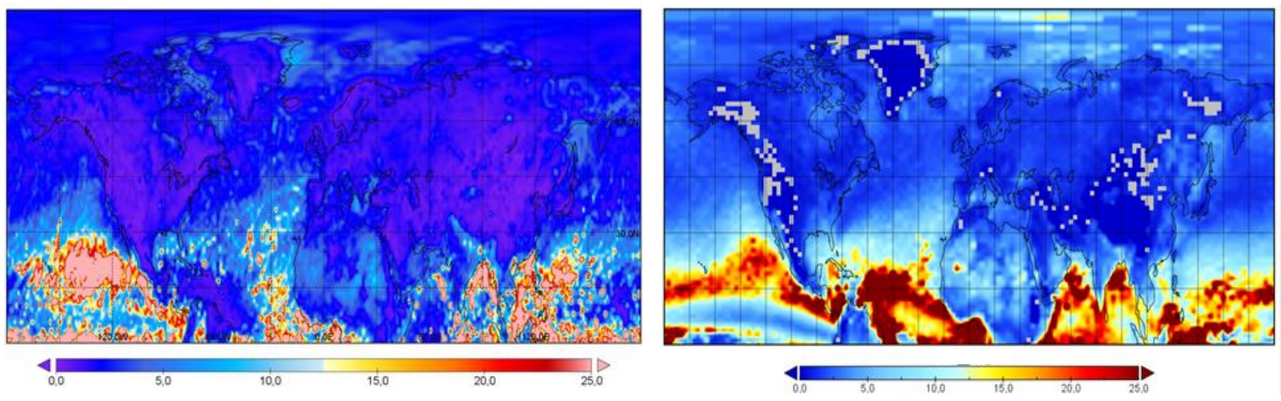
of zonal wind speed

Reanalysis data | **CMIP6**



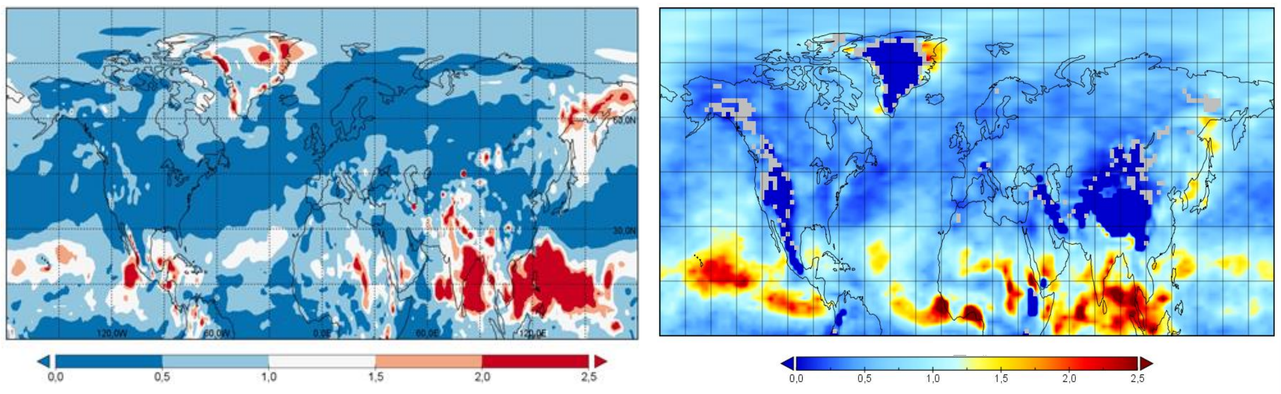
Kurtosis coefficient

of vertical wind speed



Kurtosis coefficient

of zonal wind speed



The maximum differences in the characteristics were revealed for the kurtosis of the zonal component of the wind speed, which manifests itself mainly in the change in the areas of manifestation of nonlinear disturbances (large values of cumulants): at present time, in contrast to the Holocene, there has been a shift in areas from the eastern part of the Pacific Ocean to the western one, disappearing in the Atlantic Ocean. and amplification in high latitudes.

Experiments

CMIP6

Model calculations were carried out for three 50-year time intervals:

- the historical time interval (Historical)
- the interval with a constant atmospheric carbon dioxide concentration (PiControl)
- the period, started since 2016 - numerical experiment under anthropogenic impact scenario (SSP5-8.5).

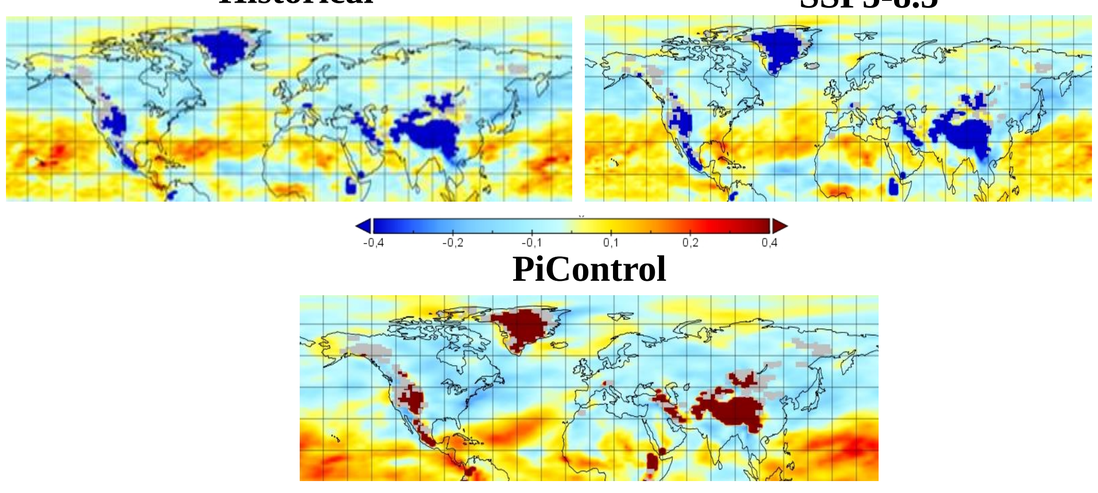
A statistical model of the frequency of extreme weather events formation was used. It based on the cumulative expansion of the probability distribution function.

LV in warm season

Skewness coefficient

of zonal wind speed

Historical | **SSP5-8.5**

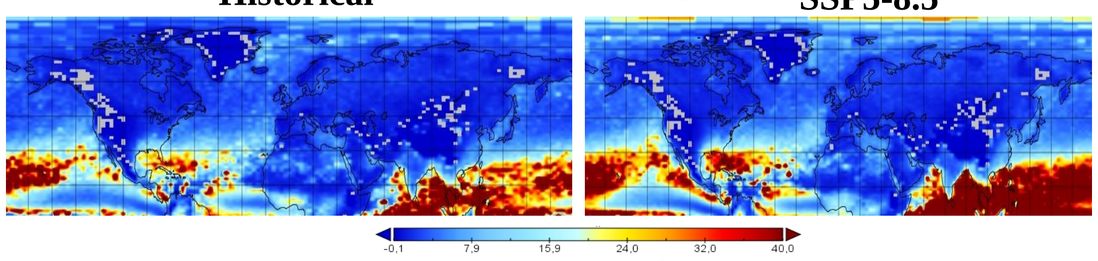


PiControl

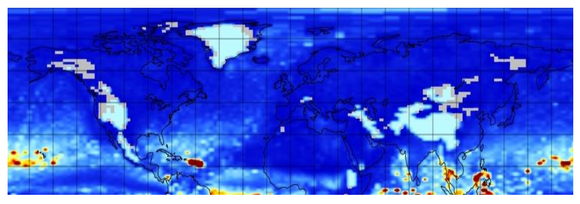
Kurtosis coefficient

of vertical wind speed

Historical | **SSP5-8.5**



PiControl



Results

- ❑ For the first time, a comparison was made of the characteristics of extreme weather events in the Holocene and in the modern period.
- ❑ In general, the spatial distributions of skewness and kurtosis in the middle Holocene are similar to those in the late 20th and early 21st centuries, especially over the oceans. It was also found that the probability of extreme events at high latitudes increased.
- ❑ Under anthropogenic warming in cold season, the probability of Q anomalies occurrence decreases (for SV in high latitudes and in the energy active zones of the Pacific and the Atlantic oceans, and in the oceans over the equator and the tropics). The probability of the anomalies development increases for T and W (for LV over Siberia) and decreases for U. From the analysis of the spatial distribution in kurtosis, it follows that the amplitude range of W disturbances increases in the equatorial and tropical zones of the oceans.
- ❑ Thus, it was found that in climatic projections the intensity of nonlinear horizontal processes decreases, while an increase in the intensity of the vertical air flows was revealed under the anthropogenic warming.

Acknowledgments

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