

Severe convective weather events in Russia: statistics, interannual variability, formation risks in the 21st century

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Motivation

Considerable threat to society under the observed global climate change comes from the changes in frequency and magnitude of weather extreme events.

Severe convective events among the most destructive weather events: tornadoes, heavy showers, squalls, hail.

However, a little is known about statistics of such event in Russia and about connection of its activity with the climate change





Tornadoes in Northern Eurasia: the new database



Why are we interesting?





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Sources for new climatology

Sources for tornado (and waterspouts) climatology:

•Scientific literature: papers and books (overviews and case-studies);

•Databases of state hydrometeo services (Soviet, Russian, Ukranian etc.), database of All-Russian Institute of hydrometeorological information.

•Station observations (45 years, 508 stations: only 28 cases);

•ESWD (European severe weather database, contains many erroneous cases for fUSSR countries).

- •Scanned newspapers (from the mid. 19th century).
- •Ancient Russian chronicles (word 'vikhor').
- •Web overviews, web news, web forums etc.
- •Social networks (eyewitnesses photo and video).
- •Satellite information
- Radar data (for verification)



New database



Annual and diurnal cycle





Year to year changes





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Looking for tornado tracks from space

 Looking for candidates for being tornado track – elongated and narrow forest disturbances (Landsat Global Forest Change base: Year Loss product).

2. Detailed analysis of these tracks with high-resolution images (fallen trees lies in CCW (or CW) direction).

> Features of forest disturbances due to windstorm (a) and tornado (b) on a high-res. satellite images

Example of narrow and elongated track of forest disturbances







'Unknown' tornadoes: climatology



For 2000-2014 we found more than 160 tornadoes (with intensity >F1) in forested regions, that were not reported by eyewitnesses (105 – in the European part of Russia, 55 – in the Asian part).

Shikhov and Chernokulsky, 2018, RSE



Satellite data for well-known tornadoes





Landsat data were used to disentangle **1984 Ivanovo tornado outbreak:** 8 tornadoes with precise location and path width and length were discovered.

Chernokulsky and Shikhov, 2018, AR



Heavy convective showers



Data processing

Computation of showery (convective), non-showery (largescale) and drizzle precipitation based on routine observations on total precipitation, weather conditions and cloud types.

Remove of errors that come from punch-card digitizing (e.g. 100.2 -> 1.2 mm)

Remove stations with gaps and artificial discontinuities (instant reversals of weather types that associated with showery and nonshowery precipitation). 538 stations -> 326 stations

Chernokulsky et al, 2018 (RMH), 2019 (ERL)





Climatology of precipitation of different genesis



MODA

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Long-term changes of precipitation of diff. genesis

2000

2000

years

2010

2010



Contribution of 95th percentile to total precipitation R95pTOT_{Conv} а 135° E 75°, R95pTOT_{Strat} 600 135° E 75° F





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b

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Indices of convective instability



Ingredient-based approach

Ingredient-based approach (for diagnostics of severe weather events): shear, lift, instability, moisture Ingredients can be presented in form of convective instability indices (CAPE, SRH, DLS, MLS, LLS, 3D, SWEAT, WMAXSHEAR, etc.) Ingredients Based Approach



Apples Sugar Flour Egg Shear of the vertical wind Lift Instability Moisture

Doswell, C.A. III, H.E. Brooks and R.A. Maddox (1996): Flash flood forecasting: An ingredientsbased methodology. *Wea, Forecasting*, **11**, 560-581.

Doswell et al., 1996



Defining indices thresholds for tornadoes



KOA.

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Changes of indices in the recent decades



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Projected changes



Normalized changes of occurrence of critical values of 3D index



Can we attribute a single extreme weather event to climate change? An example of Krymsk



Precipitation in Krymsk







Meredith et al, 2015 (Nat Geosci)







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Meredith et al, 2015 (Nat Geosci)



Take-home messages

- The datasets for tornadoes and heavy showers are compiled. It is shown that the threat of tornadoes is sufficiently underestimated in Russia
- An increase of convective precipitation rate (and contribution of heavy showers) is revealed.
- Indices of convective instability have positive trend in the recent decades. This trend likely remains in the 21st century
- The Black Sea surface warming amplified precipitation that lead to Krymsk flashflood.



The Tornado over Khanty-Mansiysk: An Exception or a Symptom?

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Thank you for your attention!

