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First hints for the influence of planetary waves on extreme temperature events (with a focus on Bavaria and the Alpine Region)

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Motivation

- The meridional temperature gradient at the surface between the Arctic and the midlatitudes is decreasing [e.g. Serreze & Barry, 2011].
- A change in the meridional temperature gradient at the Earth‘s surface should have an effect on the vertical propagation of planetary waves [e.g. Francis & Vavrus (2012)]
- A change in planetary wave activity is expected to influence the occurrence of extreme weather events [e.g. Coumou et al. 2014; Kornhuber et al. 2017]

- **Is there a long-term change regarding the occurrence frequency of extreme temperature events?**
- **What does this change look like?**
- **Why does the occurrence frequency change? Is there a relation to a change in planetary wave activity?**

Identification of extreme temperature events in mid latitudes on the Northern Hemisphere

Data basis:

ERA5 daily temperature data (Jan. 1979 – Feb. 2020, averaged over the latitudinal region 30°N to 70°N)

Definition “extreme day“:

$$T_x(\lambda) \gtrless \overline{T_{x[1979-2018]}(\lambda)} \pm 2\sigma\left(T_{x[1979-2018]}(\lambda)\right)$$

$T_x(\lambda)$: mean temperature at day x at longitude λ
σ: standard deviation

Definition “extreme temperature events”:

Spatial and temporal clusters of extreme days

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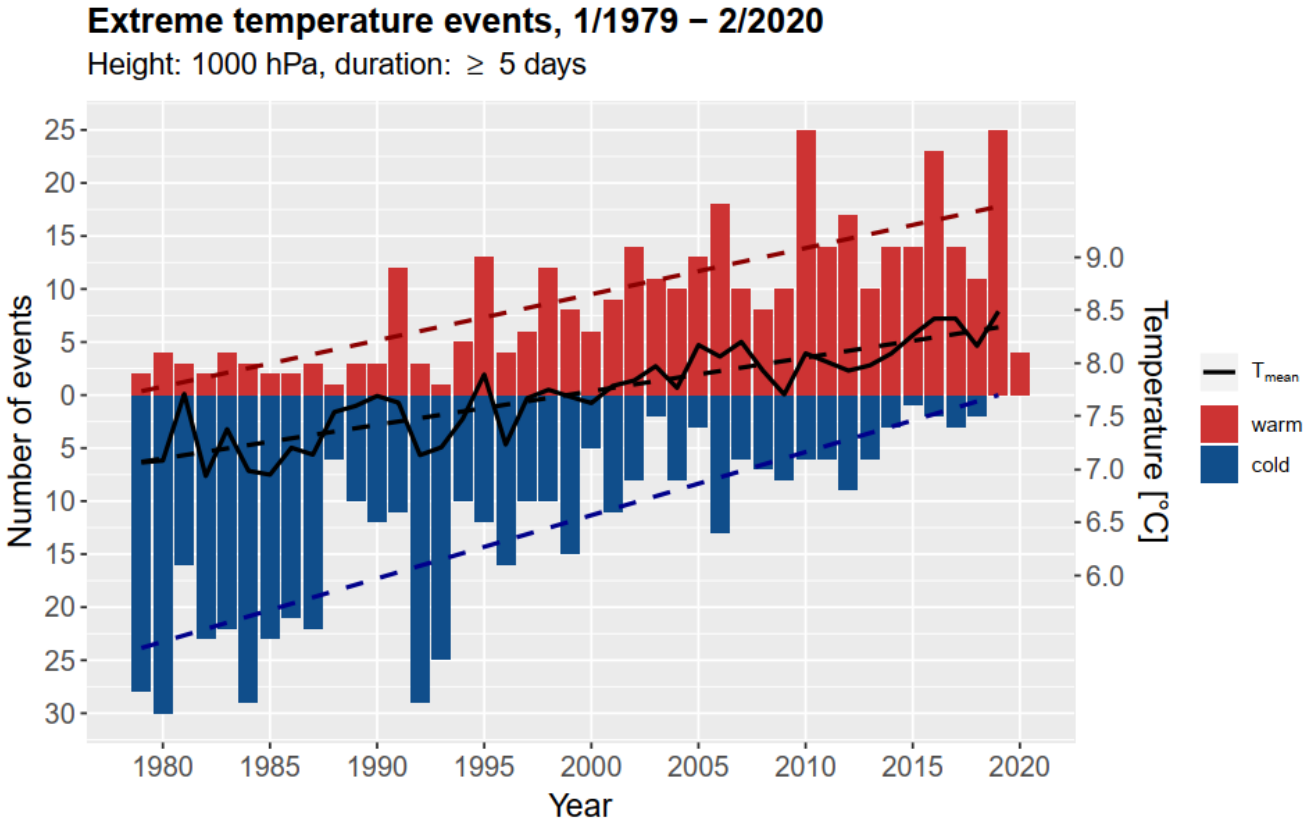
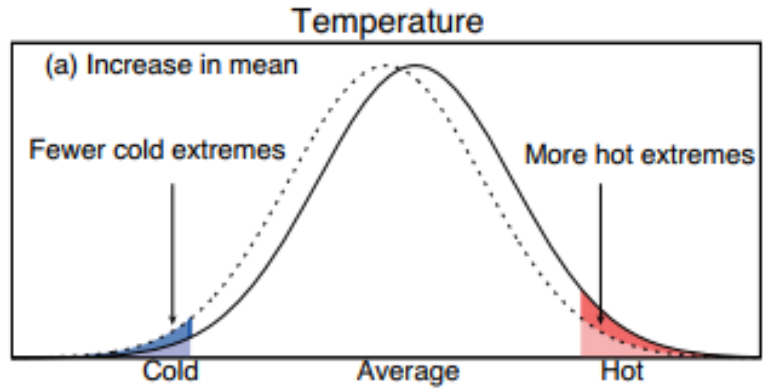
Occurrence of extreme temperature events near the surface (1000 hPa) [30°N-70°N]





[IPCC, 2013]

- The occurrence frequency of near surface heat events increases, whereas the opposite holds for cold events.
- This is consistent with the expected effect of increasing average temperatures on the occurrence frequency of extreme temperature events.

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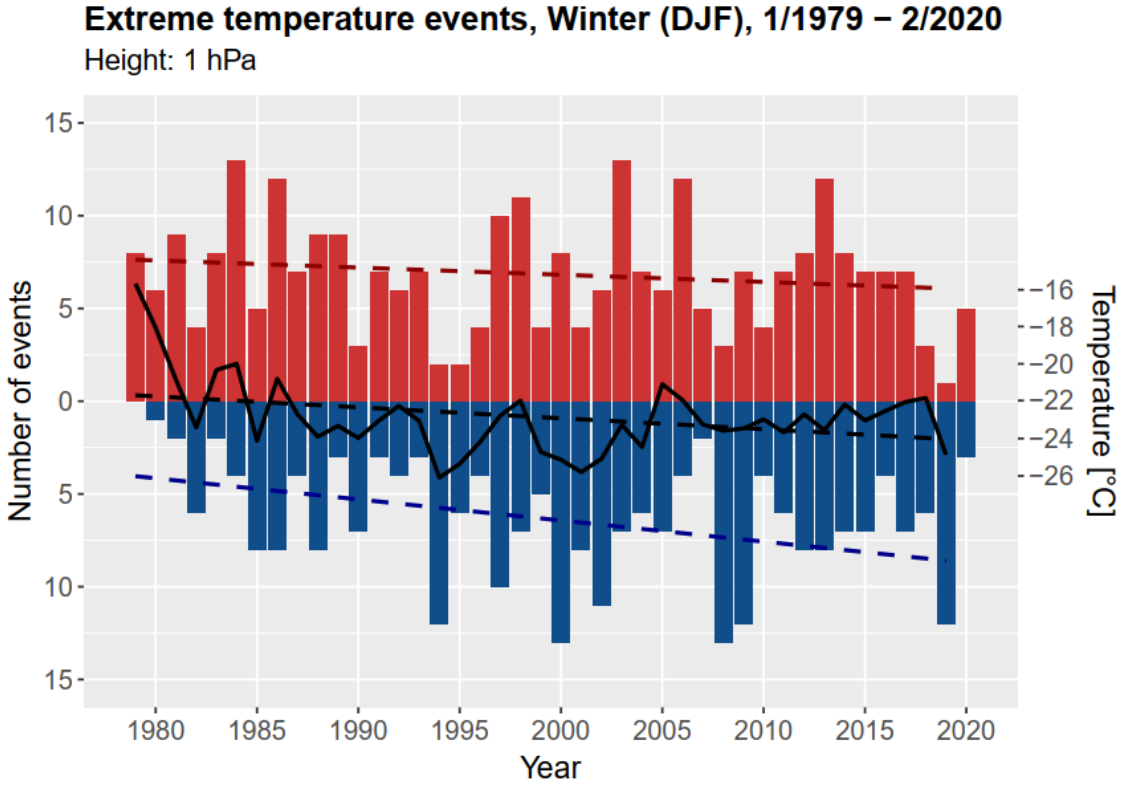
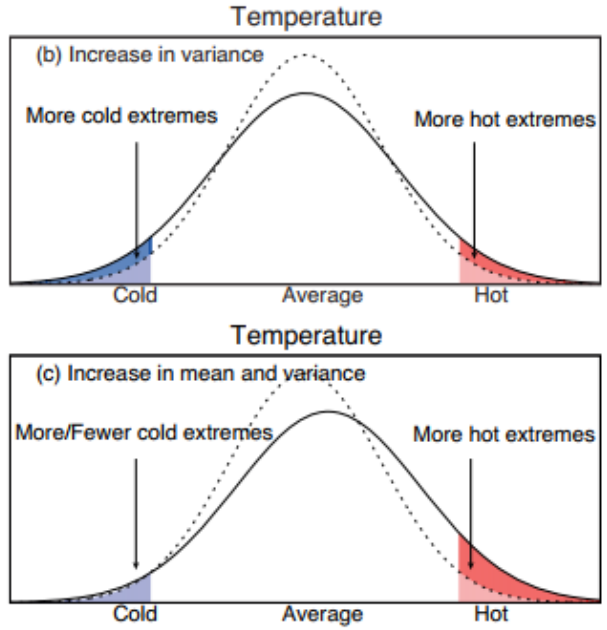
Occurrence of extreme temperature events in the stratosphere in winter





[IPCC, 2013]

Stratosphere:

- A focus on the winter season reveals the influence of atmospheric dynamic on the temperature distribution.
- Decrease of heat events less strong than increase of cold events.
- This indicates the superposition of an increasing variance of the occurrence of extremes due to an increasing planetary wave activity, and a shift in mean due to the decreasing average stratospheric temperature.

Summary

- We developed an algorithm that identifies extreme temperature events in ERA5 temperature data from 1979 to February 2020 in different height levels (1000hPa – 1hPa).
- We analyze how the occurrence frequency of extreme temperature events in mid latitudes of the Northern Hemisphere has changed, and how this change can be related to possible changes of the planetary wave activity.
- In the troposphere the occurrence frequency of heat events increases whereas the opposite holds for cold events. This is consistent with the expected effect of increasing average temperatures on the occurrence frequency of extreme temperature events.
- In the stratosphere, however, we observe an increase of cold events and a very slight decrease of heat events. This indicates a superposition of an increasing variance of the occurrence of extremes due to an increasing planetary wave activity, and a shift in mean due to the decreasing average stratospheric temperature.