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A comprehensive study of the extreme heat and drought of the 2018 European summer

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2018 was the TOP5 warmest European summer in the last years.

Heat as extreme as 2018 could occur in 2 out of every 3 summers in a 1.5C world, virtually every summer in a 2C world.

Probability distributions of Cumulative Excess Heat [1] in ERA5 (1979-2021; black) versus in MPI-GE simulations under recent climate (1979-2021; gray), and future 1.5 °C (2020-2049; orange), and 2 °C (2050-2079; red) warmer climates.

[1] Perkins-Kirkpatrick and Lewis, 2020, Nat. Comm

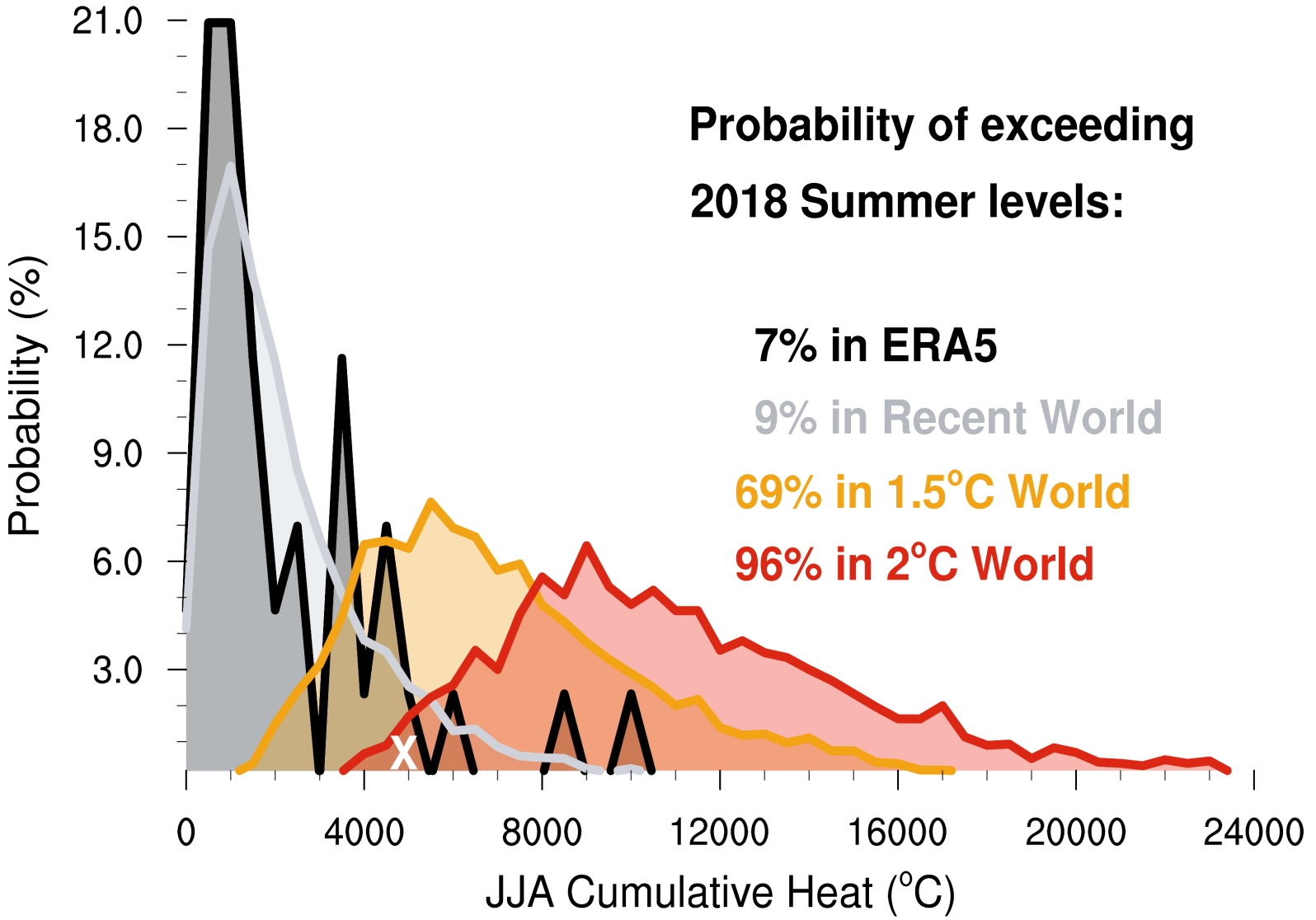

Fig: Laura Suarez-Gutierrez

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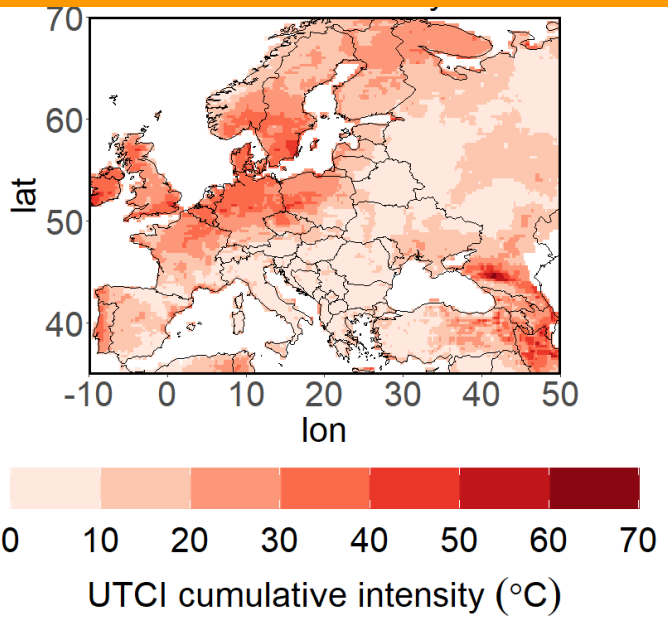
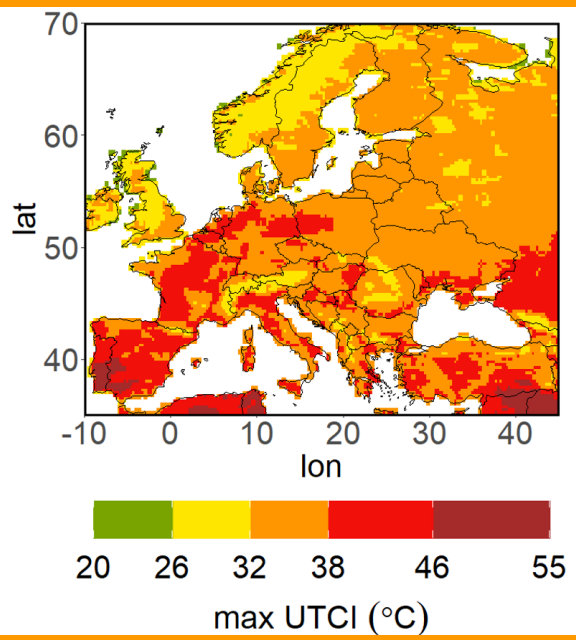
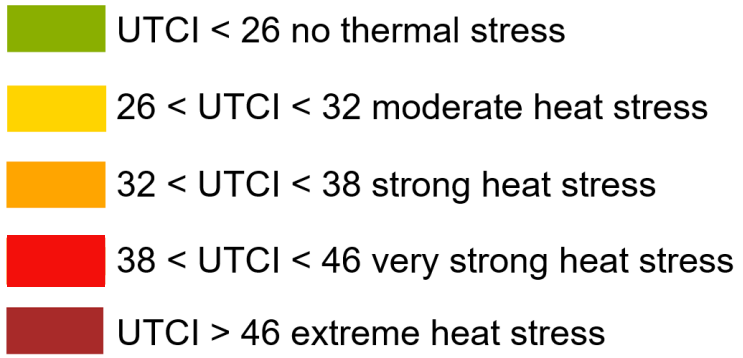
The 2018 European Summer: extreme heat on top of severe drought

Cumulative Thermal Comfort

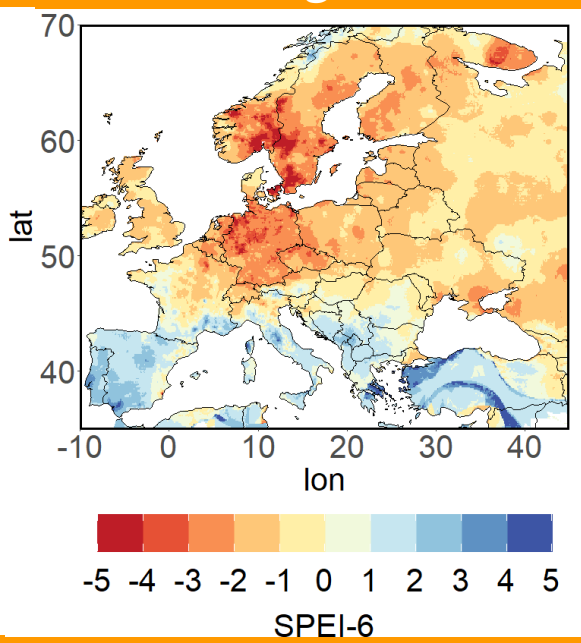


Maximum Thermal Comfort





Drought Index



Figs: Florian Becker, Dragan Petrovich

2018 summer did not exhibit the most extreme heat, but due to the concurrent severe drought it lead to devastating impacts:

- **Forest mortality of unprecedented scale** [Schuldt et al., 2020; Senf and Seidl, 2021]
- **50% reduction in agricultural yields** [Toreti et al., 2019; Beillouin et al., 2020]
- **Increased forest fire occurrence** [San-Miguel-Ayanz et al., 2019]

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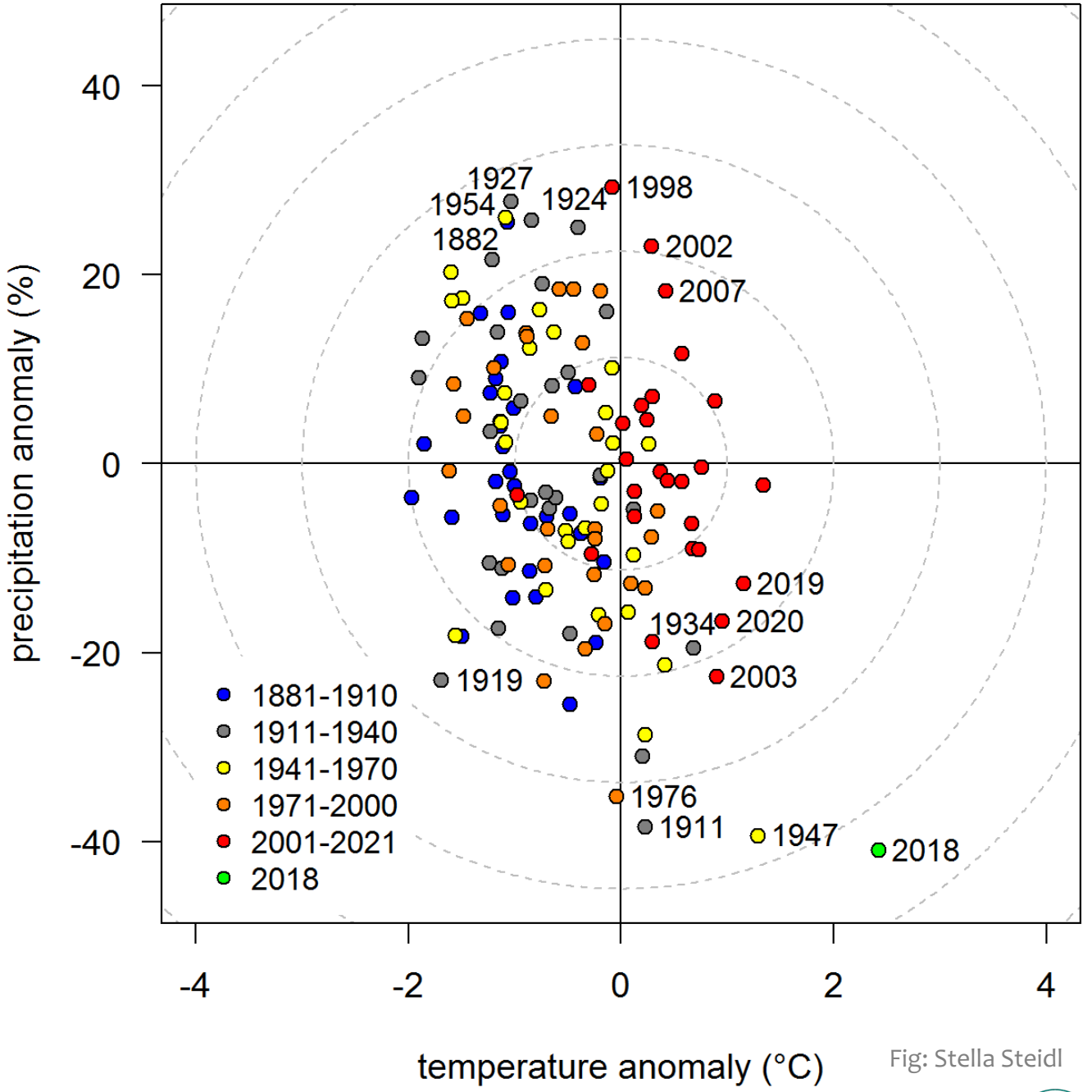
In Germany, the period of April to October 2018 was the warmest and driest on record since 1881.



Thermopluviogram for the April – October period, for 1881-2021 for Germany. DWD Station data for temperature and precipitation anomalies wrt. the climatological mean period of 1981-2010

Fig: Stella Steidl

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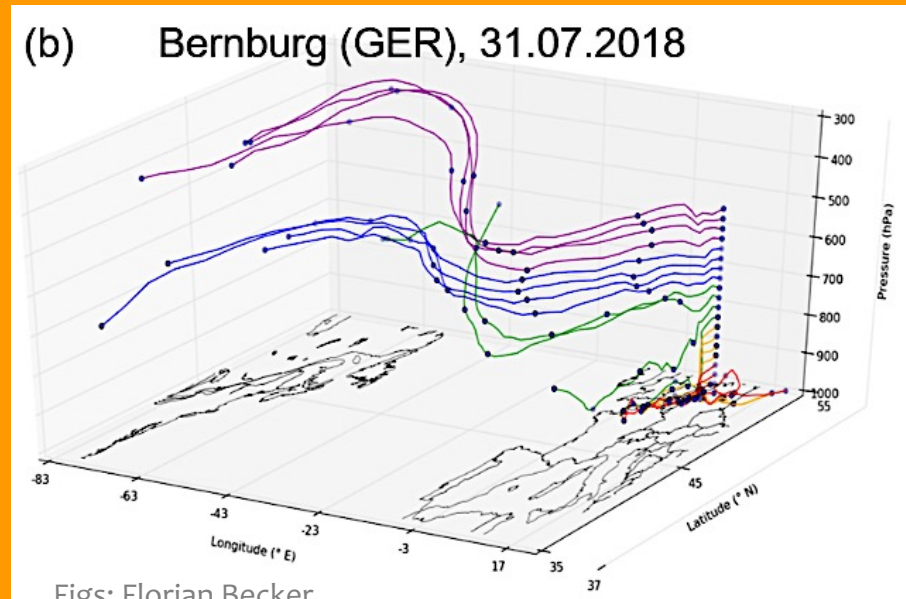
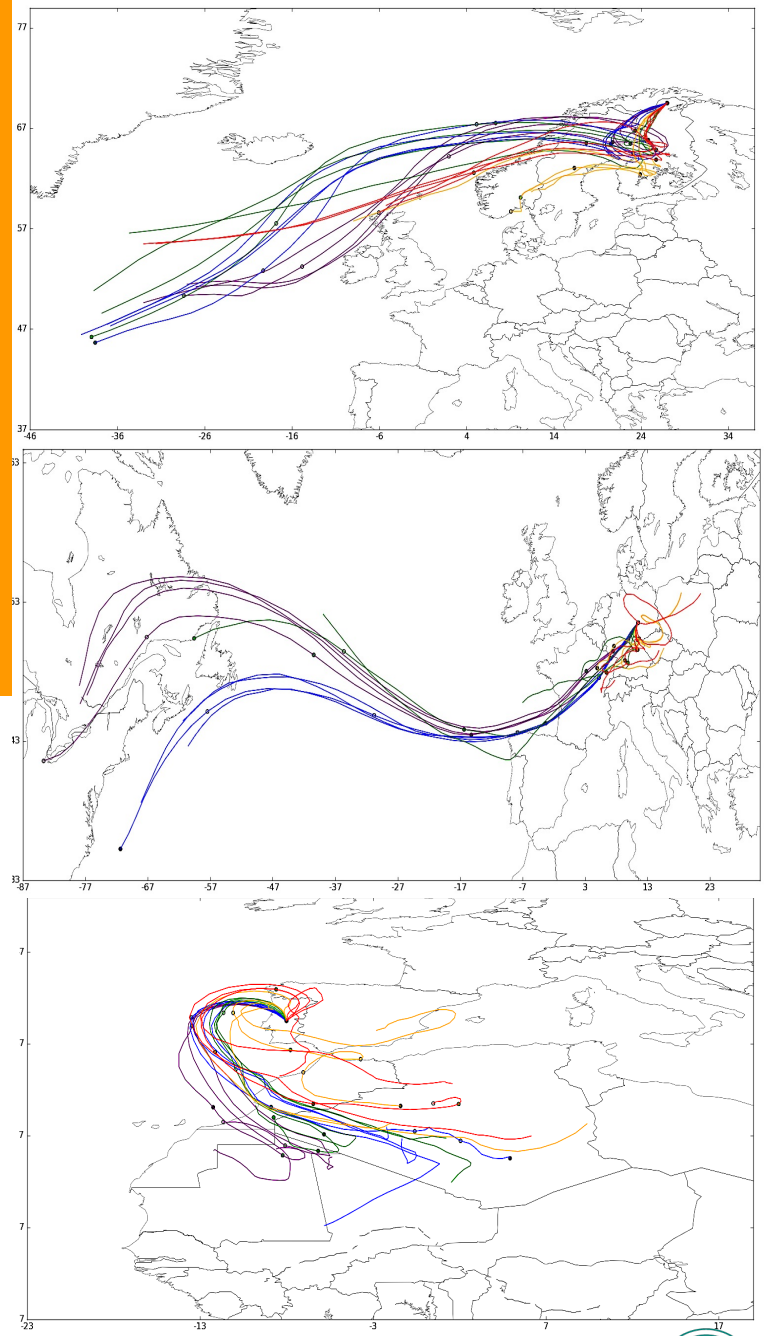
Dynamical drivers: Remote upper-atmosphere air masses, stagnant air at lower layers

Northern and Central Europe received upper- to mid-troposphere air masses originating over the North Atlantic, indicating Rossby wave propagation and the role of upstream warm conveyor belts.

Central and Eastern Europe received air masses from nearby regions to the east, indicating stagnant air masses facilitated by localized convection.

Southern Europe in contrast received warm-air advection from the Saharan region.





Backward trajectories of air masses over (a) Utsjoki, Finland, 18.07.2018. (b) Bernburg, Germany, 31.07.2018. (c) Alvega, Portugal, 04.08.2018. Each black dot represents of a 24-hour time step.

Figs: Florian Becker

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Dynamical drivers: Persistent blocking and double jet stream

Eurasian double jet stream developed in mid-May and persisted until July, one of the longest such events on record [Rousi et al. accepted in Nat. Comms.], which occurred together with persistent blocking conditions in the region of weak winds between the two jets.

Zonal wind anomalies at 250hPa during July 2018 (colors) and climatology (dashed contours).
Hovmöller diagram of the 2018 zonal mean zonal wind anomalies (5-day running means).

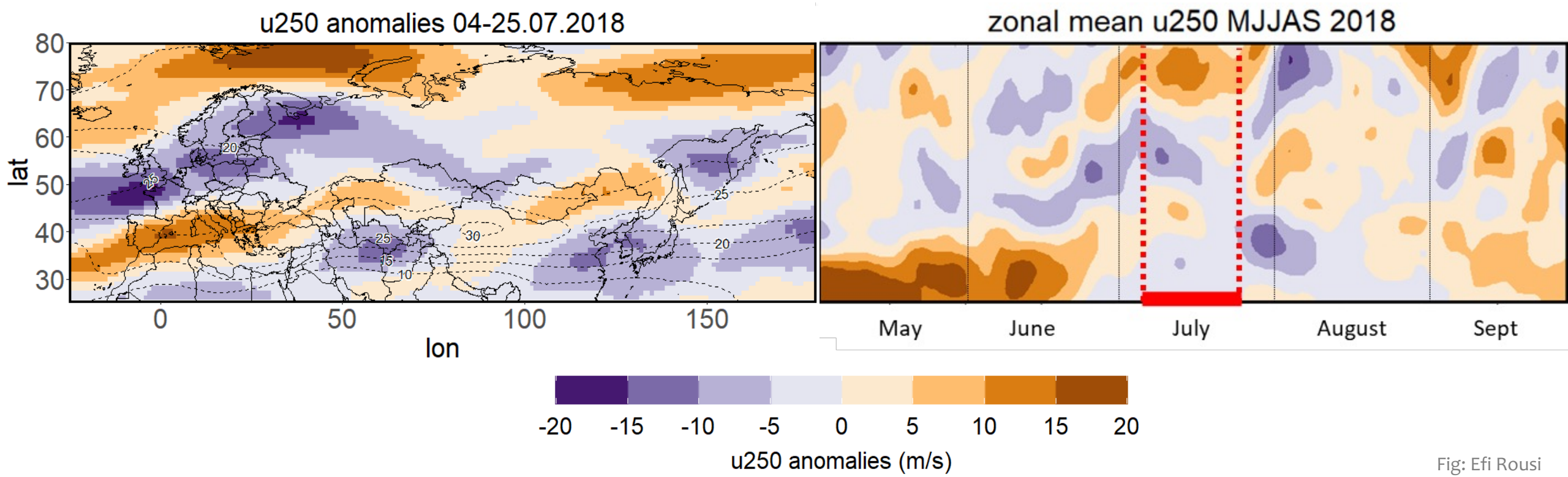

Fig: Efi Rousi

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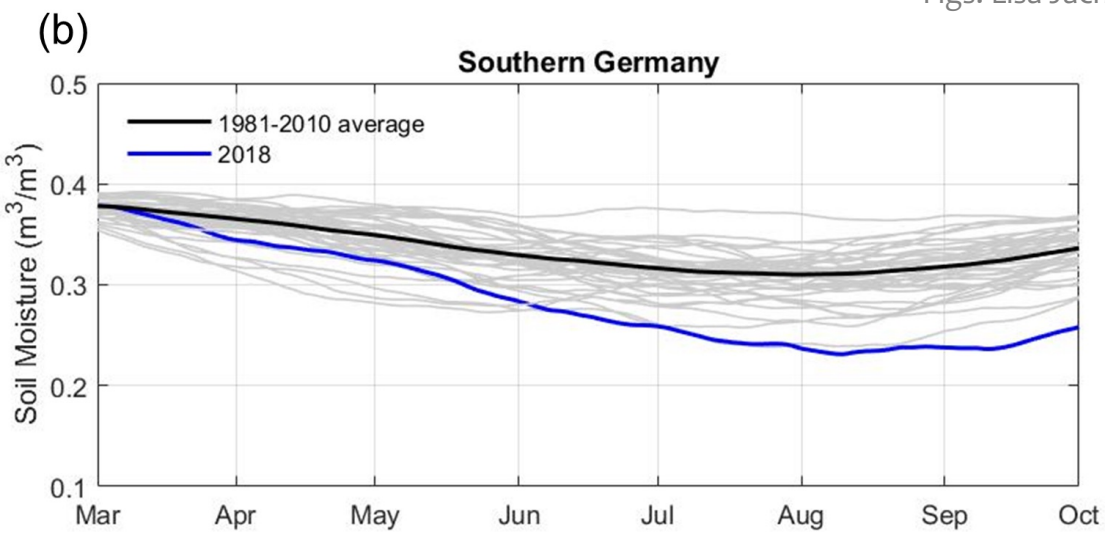
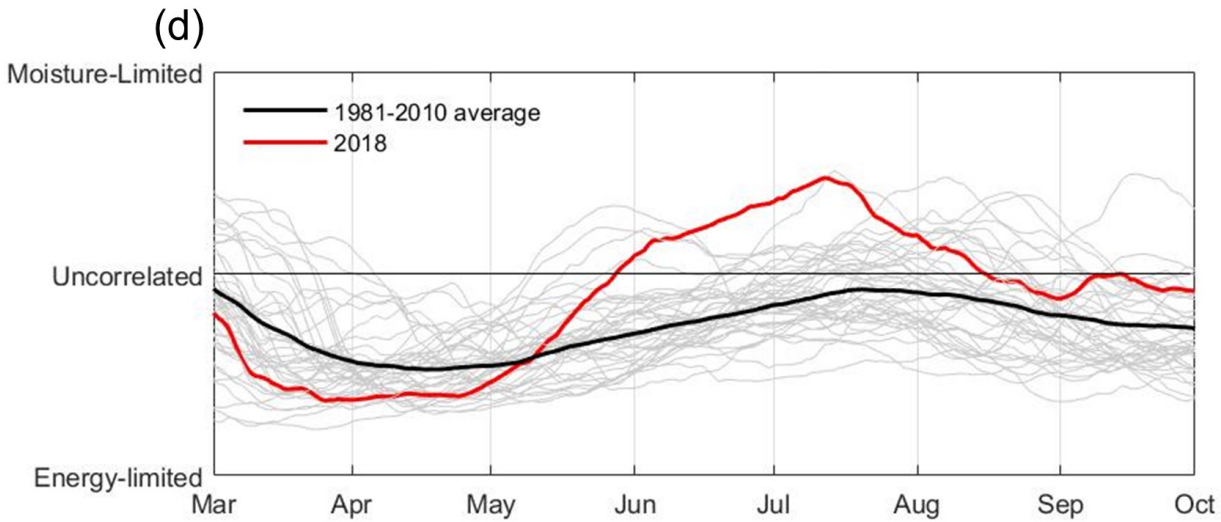
Low-frequency precursors – soil moisture regime in Germany

Germany transitioned from an average/slightly dry state in spring towards driest summer on record.

Spring moisture evaporation limited by sensible heat, but strong transition towards moisture-limited regime from May.

Figs: Lisa Jach





Soil moisture 92-day mean over Southern Germany (48 °N-51 °N and 4 °E – 16 °E) for March-September of 2018 (blue) and 1981-2020 individual years (gray) and average (black).

Correlation between 92-day mean soil moisture and latent heat flux for March to September of 2018 (red), and 1981-2020 individual years (grey) and average (black).

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Summer 2018 was a unique example of persistent heat and drought in large parts of Europe unadapted to this kind of compound hazard.

Extreme 2018 Heat and Drought key players:

- Rossby wave activity and remote vs. local air masses
- Persistent Double Jet and Blocking
- Spring and summer precipitation and soil moisture deficits
- Strong evaporative moisture depletion

Open Questions:

- Cause-effect relationship between atmospheric and soil moisture states?
- Spring North Atlantic SST tripole: long-memory precursor of jet stream state?

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