POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Weakened Flow, Persistent Circulation and Prolonged Heat Waves in Boreal Summer

Dim Coumou

coumou@pik-potsdam.de

Understanding, modelling and predicting weather and climate extremes

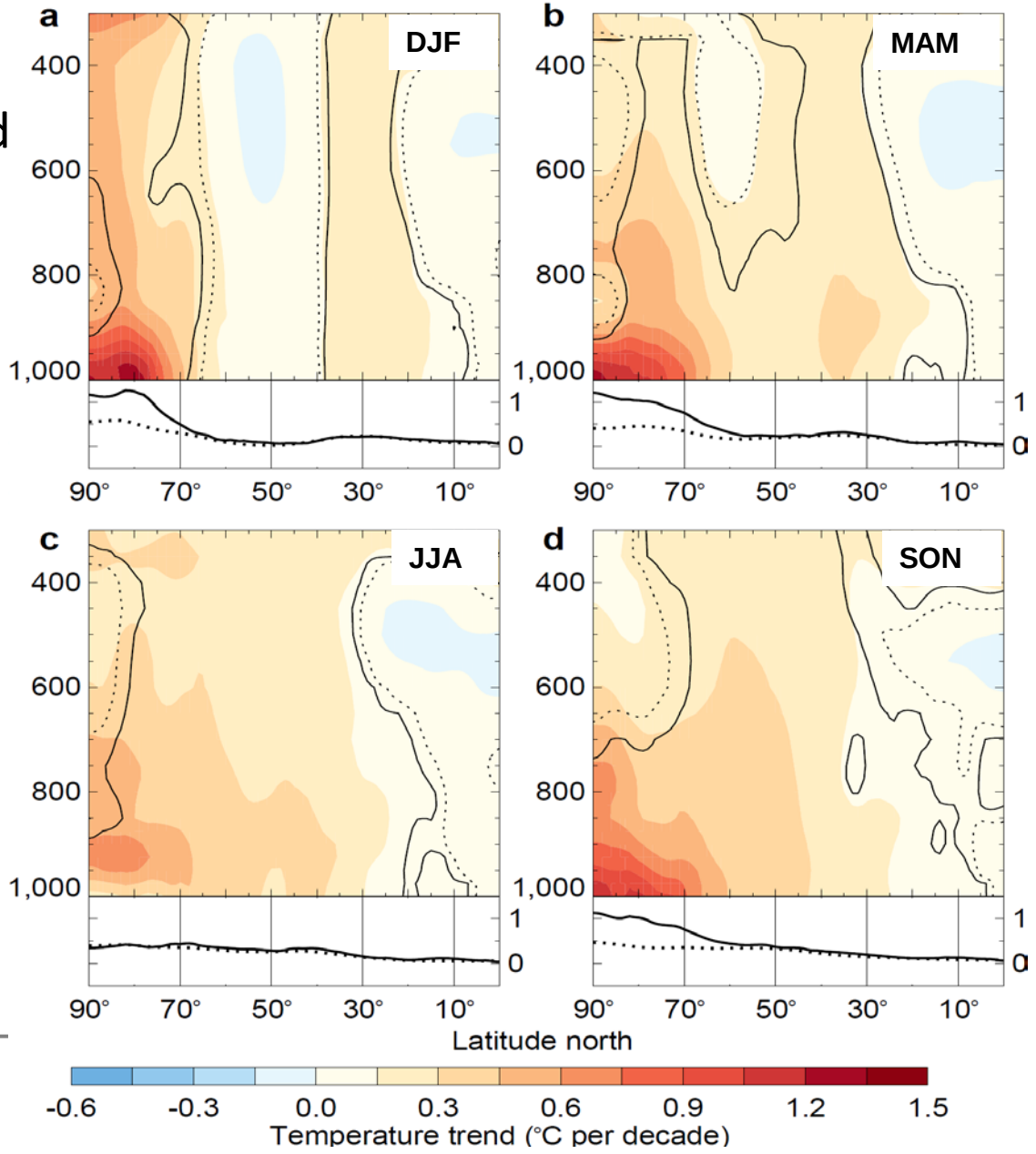
WCRP workshop, Oslo, 5-7 October 2015

Leibniz Gemeinschaft

Arctic Amplification

Strongest amplification in cold seasons

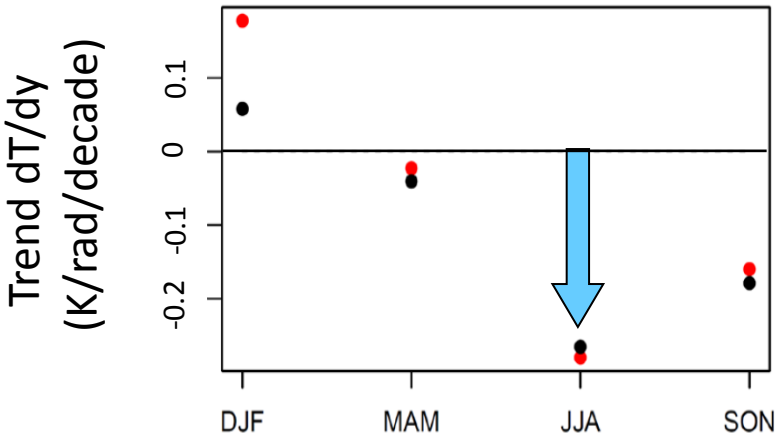
Temperature trends 1979-2014



Cohen et al, *Nat Geo* (2014)

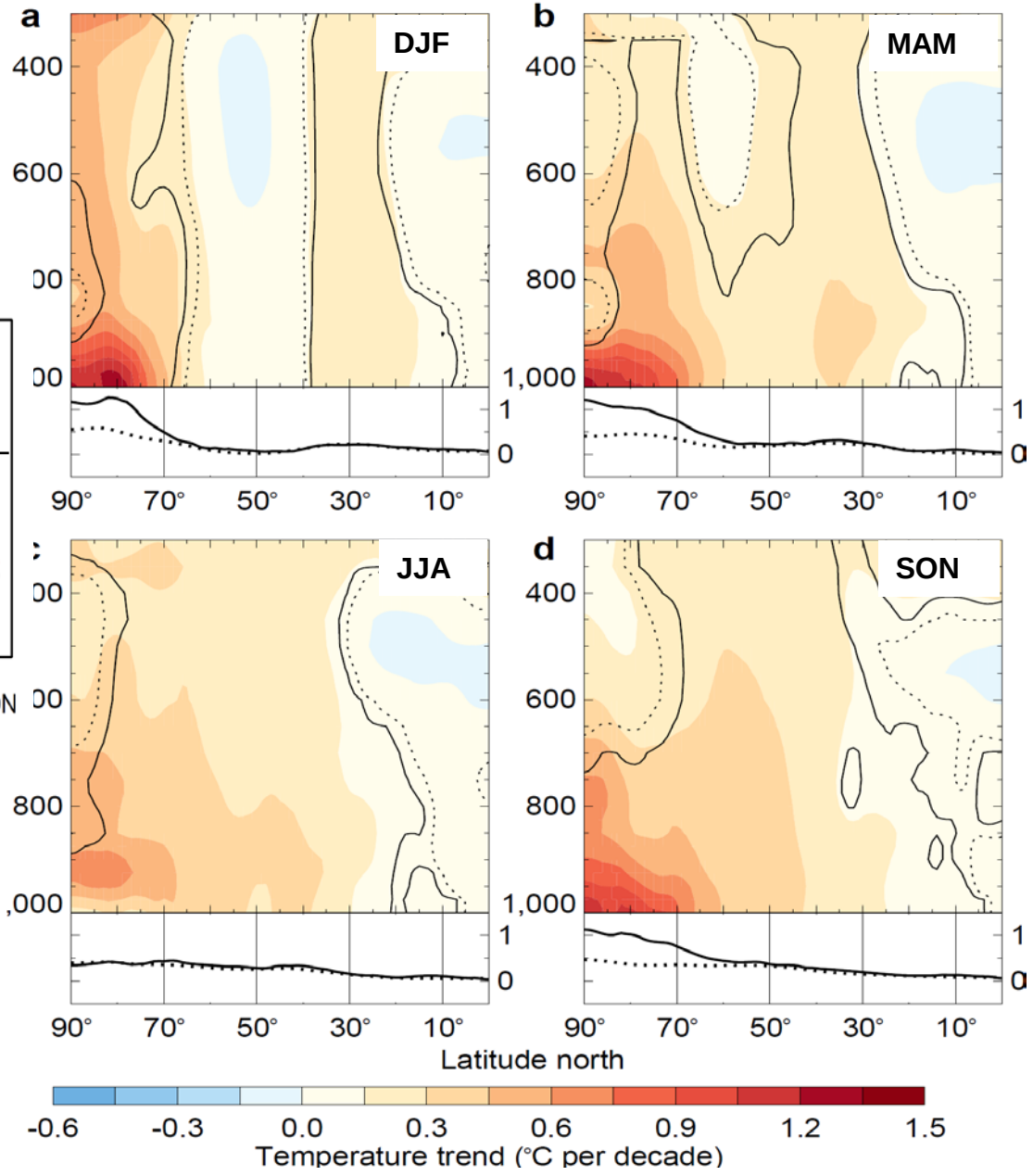
Arctic Amplification

Strongest amplification in cold seasons



Mid-latitude temperature gradient reduced most in summer

Temperature trends 1979-2014

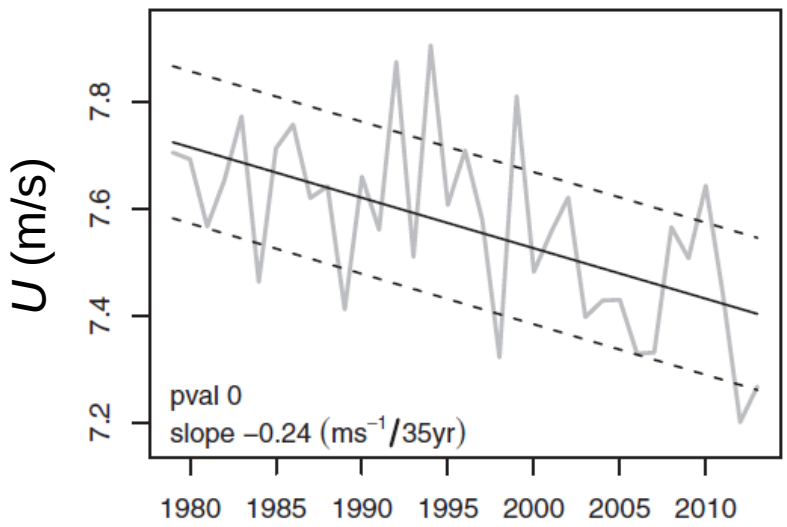


Cohen et al, *Nat Geo* (2014)

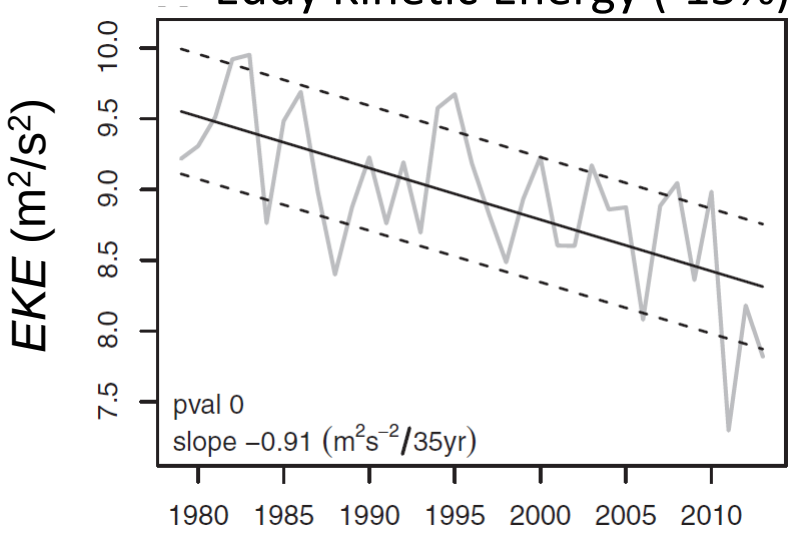
Weakening Mid-latitude Summer Circulation

Observed

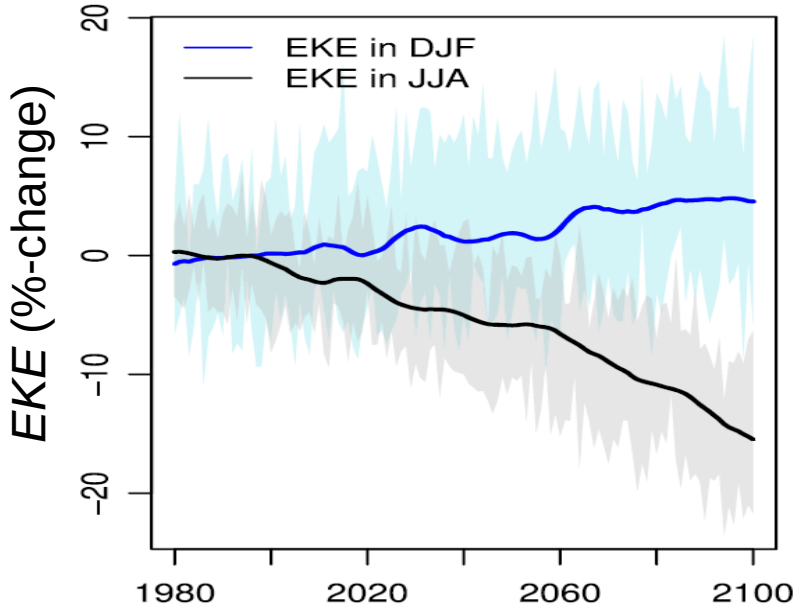
Zonal Wind (-5%)

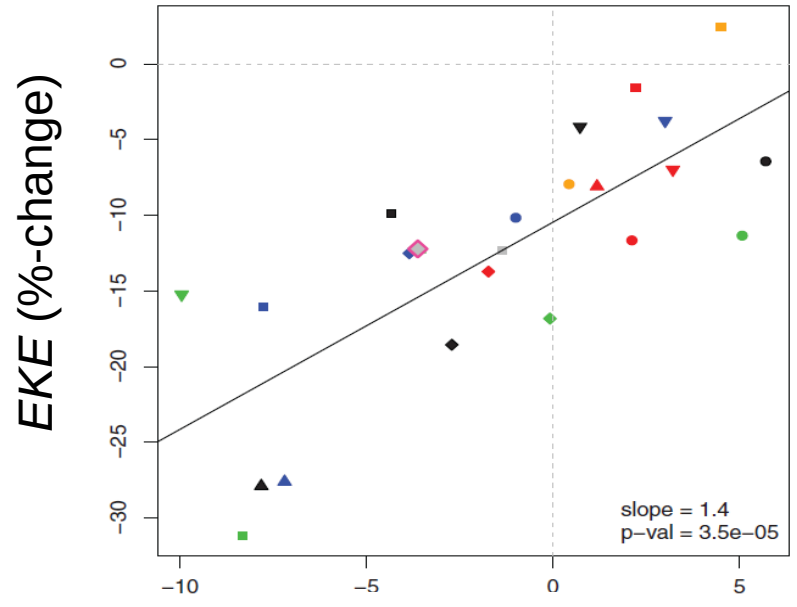


Eddy Kinetic Energy (-15%)



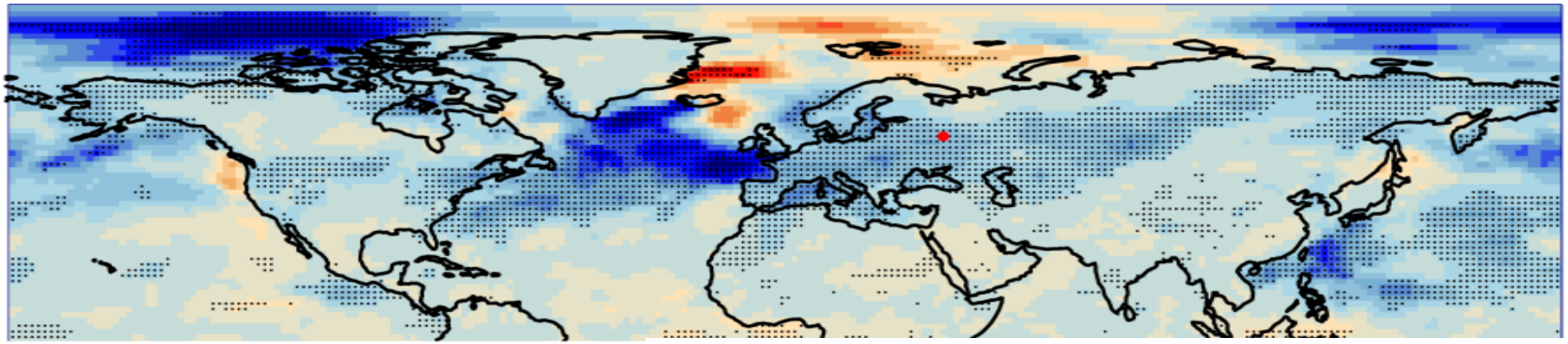
Projections

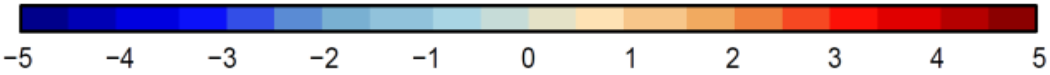




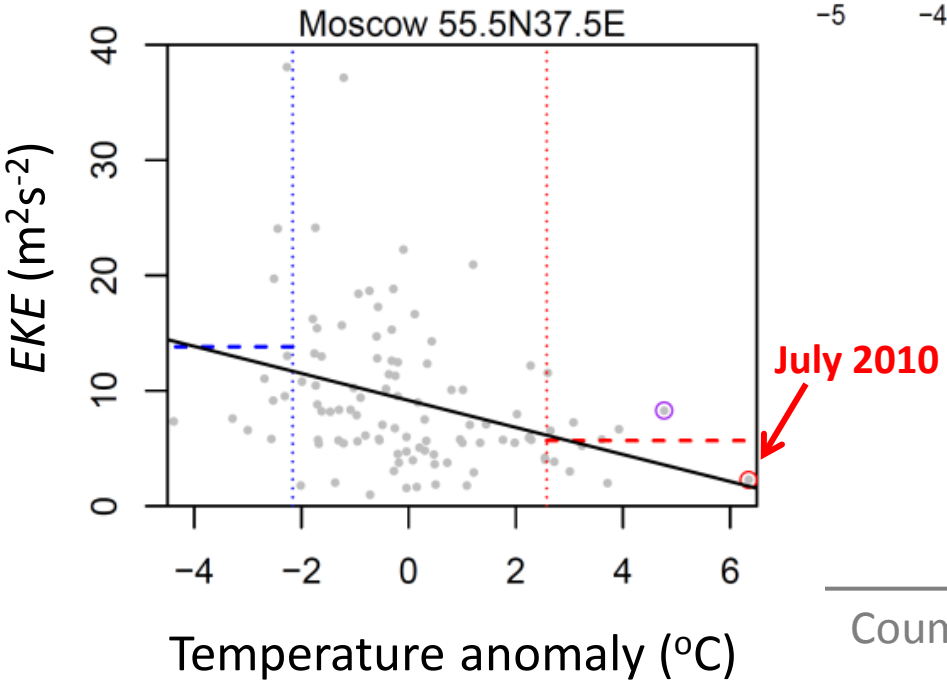
Coumou et al, *Science* (2015), Lehmann et al, *ERL* (2014)

Weak *EKE* associated with monthly heat extremes





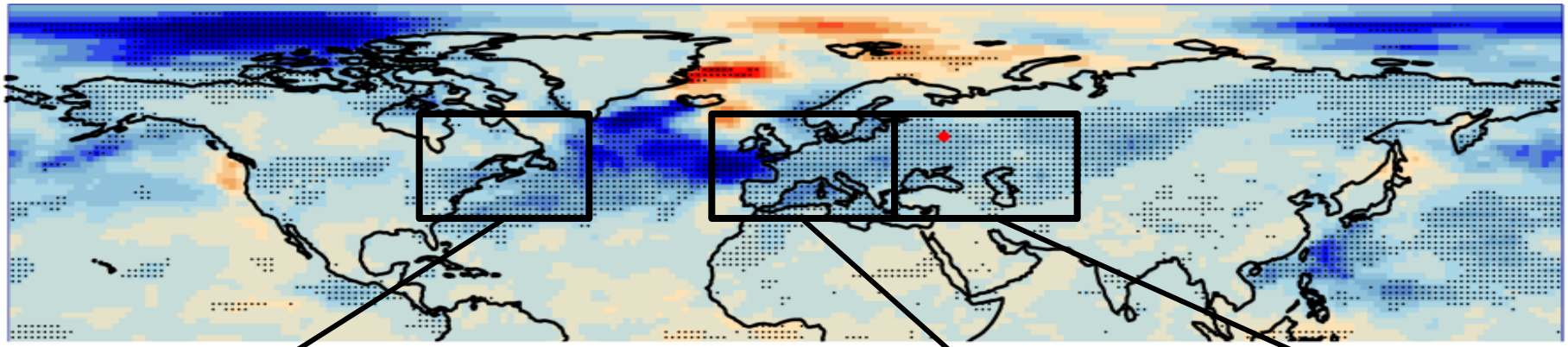
Regression slope ($m^2s^{-2}/^oC$)



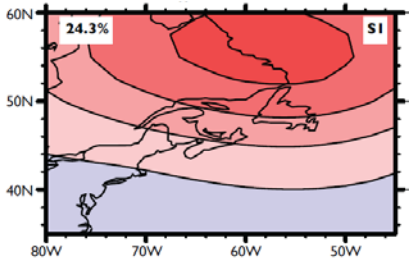
Correlation analysis consistent with notion of summer-storms bringing cooling

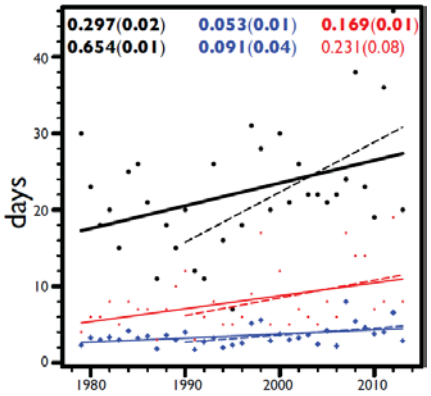
Coumou et al, *Science* (2015)

Increased blocking in Storm track affected regions



Eastern America





Horton et al, *Nature*, 2015

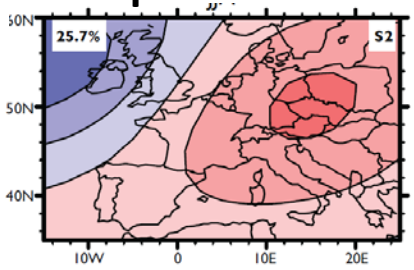
Upward trends in **anticyclonic summer circulation**, both in frequency and in persistence

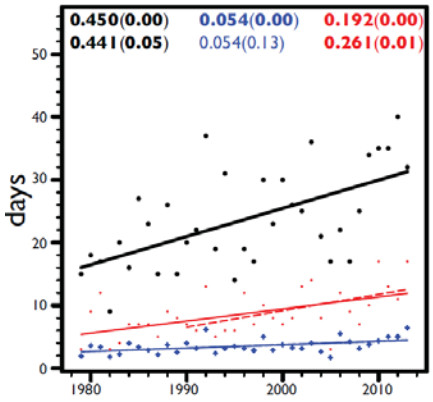
Frequency (days)

Maximum Duration (days)

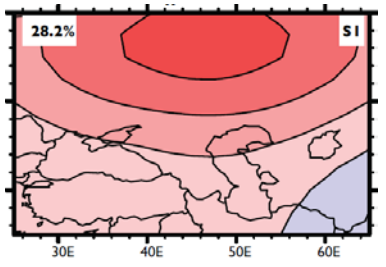
Persistence (days)

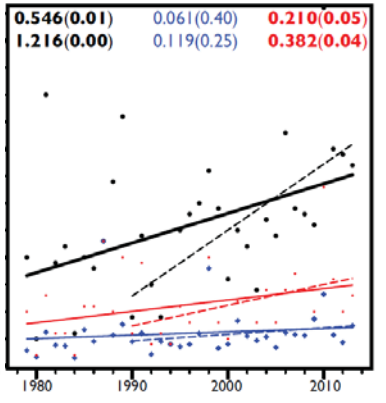
Europe





Western Asia





Wave-Resonance:

Dynamical Mechanism to create High-Amp Quasi-Stationary Waves in Summer

Waveguide:

Trapping of synoptic-scale wave in mid-lats

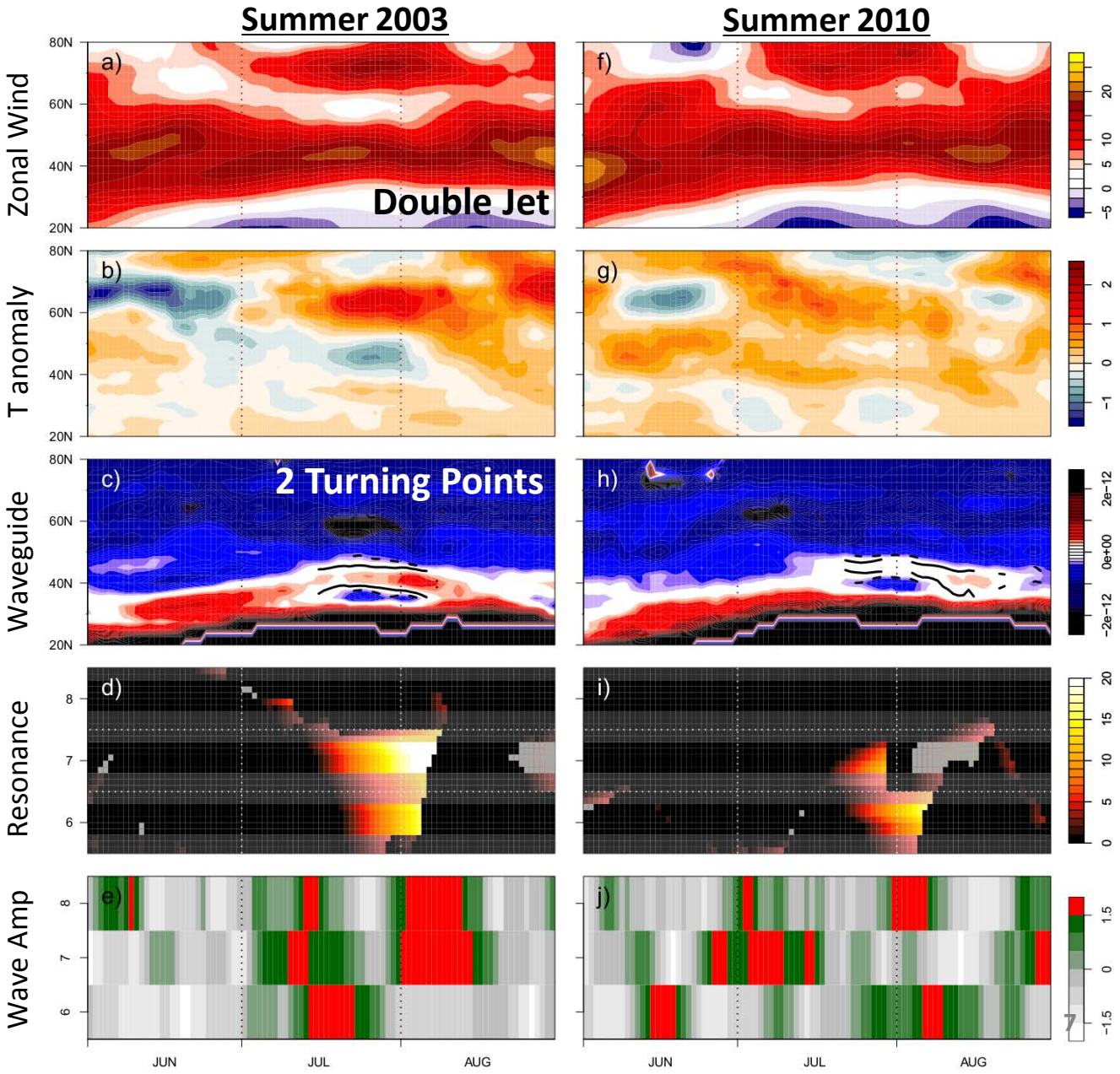
+

Right forcing:

High-amp, quasi-stationary waves (6, 7 or 8).

Often associated with summer extremes

Zonal-mean Hovmöller diagrams

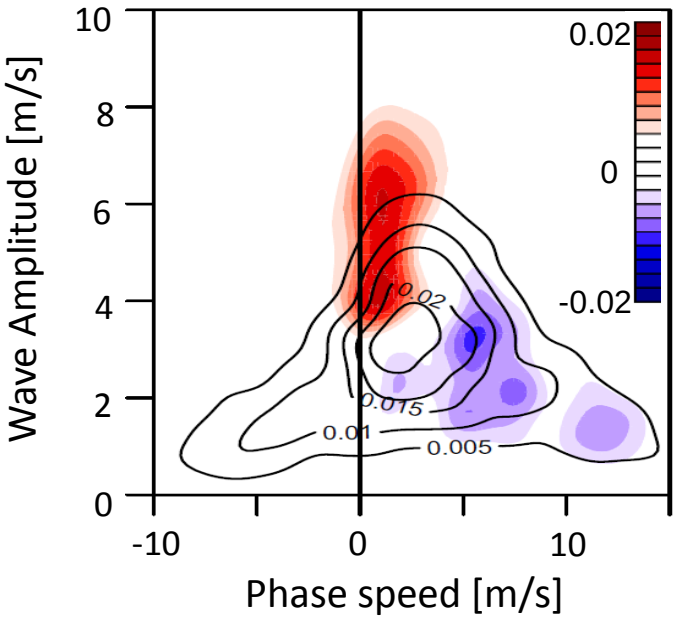


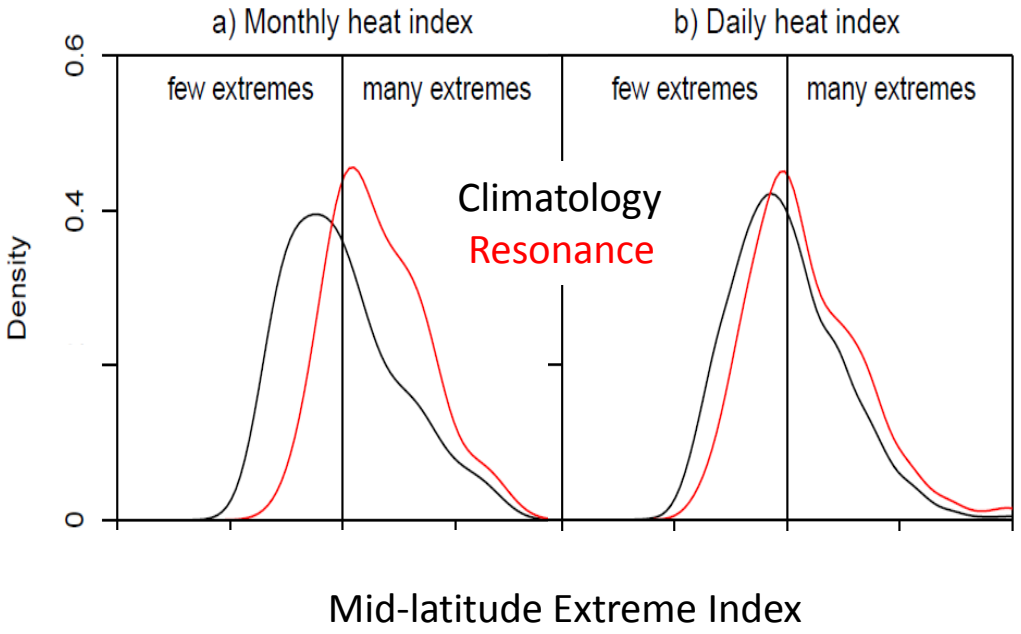
Petoukhov et al., *PNAS* (2013)
Coumou et al., *PNAS* (2014)
Kornhuber et al. (in review)

Statistics: Resonance vs Summer Climatology

High-altitude circulation dominated by *high-amplitude quasi-stationary* waves

Surface weather *more extreme*, especially on multi-day timescales





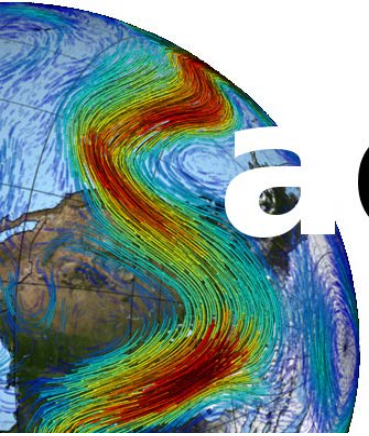
Summary

Changes in large-scale summer circulation indicate:

- Weakened jet and weakened transient wave activity (*EKE*)
- Cluster of high-amplitude quasi-stationary wave events linked to resonance
- Enhanced anti-cyclonic flow regimes in some regions

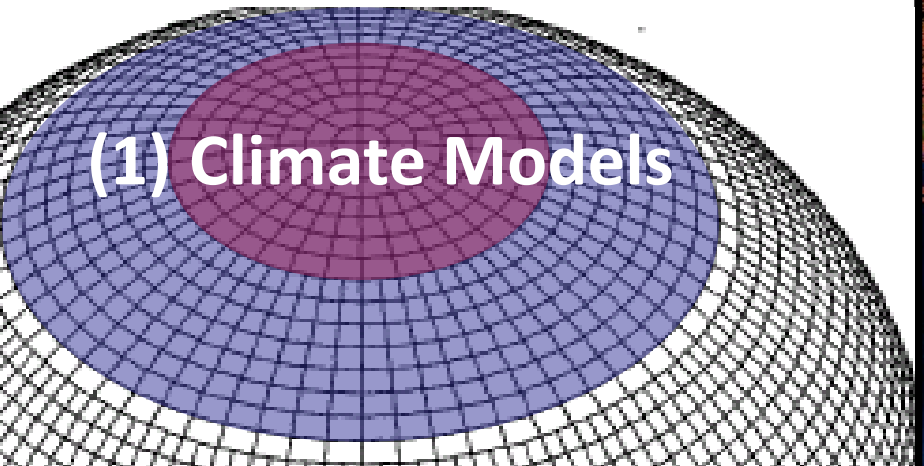
This likely made summer weather more persistent and suggests that changes in dynamics played a role in some recent extremes

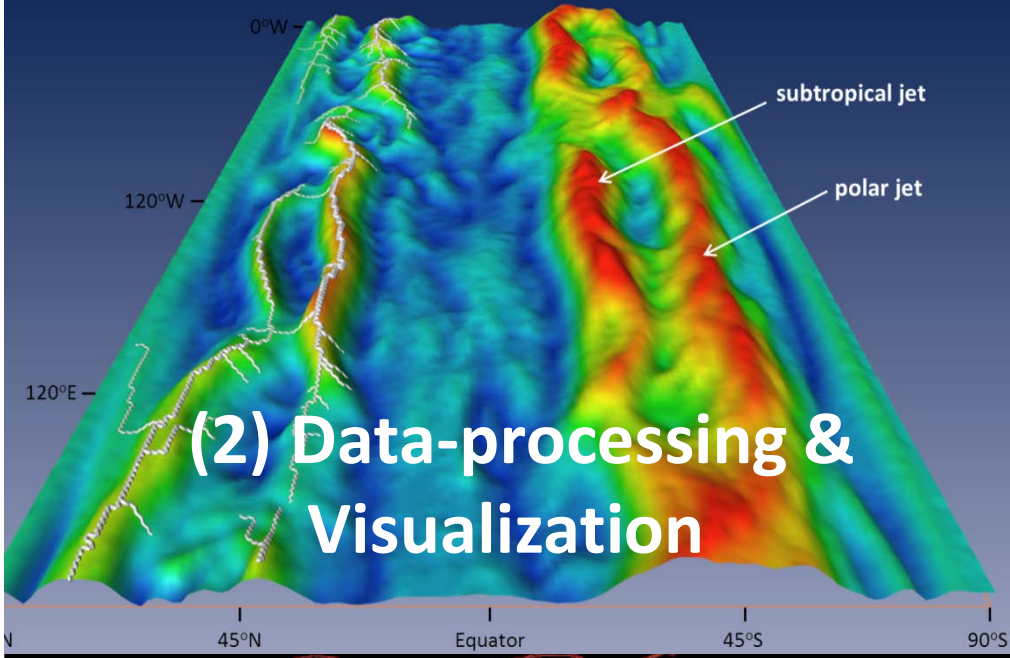
More research is needed to understand the drivers behind these changes: *Causal Effect Networks / Modeling*

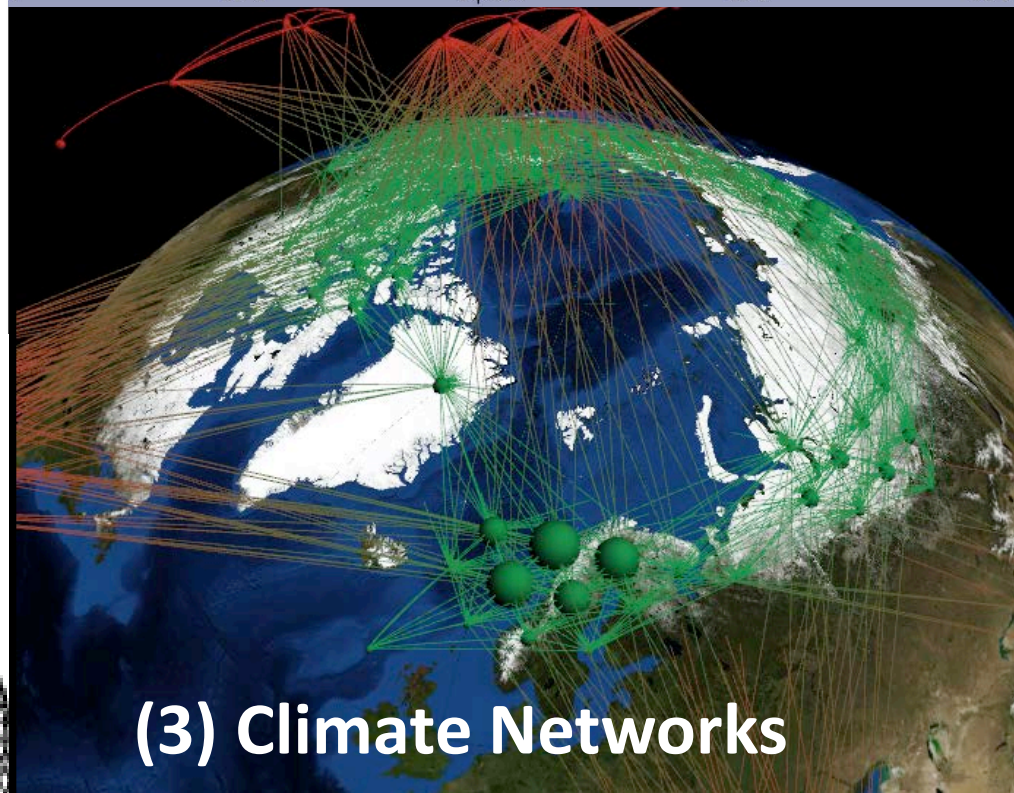


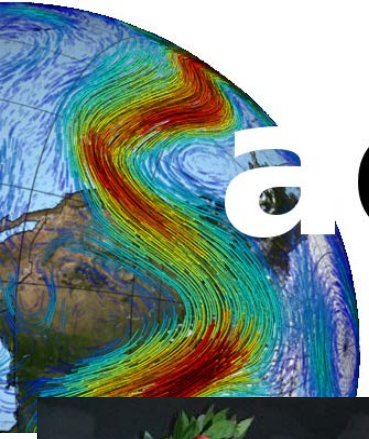
acreX

"Model- and observation-based analysis of the drivers behind the variability in **large-scale atmospheric circulation** patterns and their influence on **extreme weather events**."



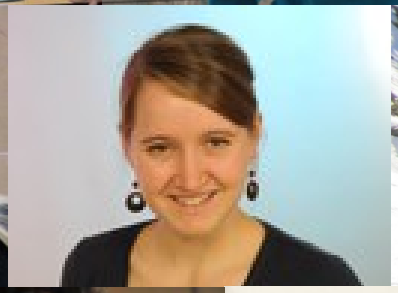


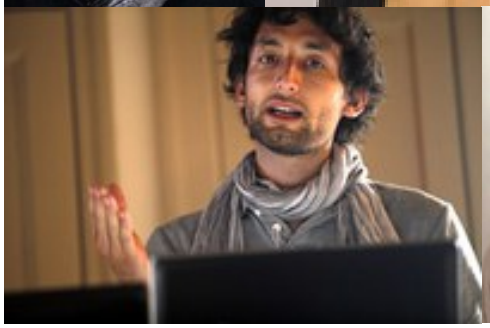


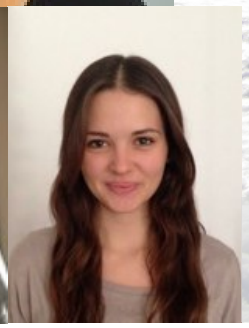


acreX

BMBF-Funded Junior Research Group







European Research Course on Atmospheres
January 2015