Freie Universität Berlin

The role of upper vs. lower tropospheric baroclinicity on severe storms over Central Europe and Iceland: Observational results and climate scenarios

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Motivation

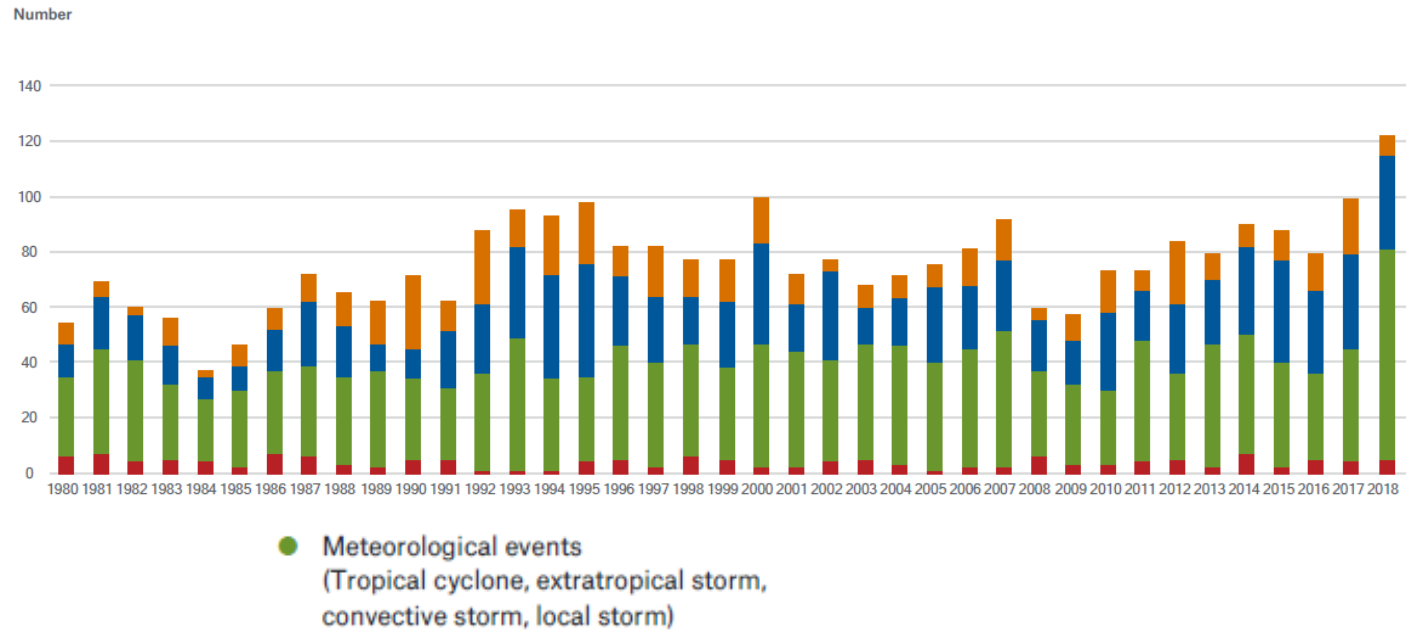


Fig. 1: Number of relevant natural loss events in Europe from 1980 until 2018 for geophysical events (red), meteorological events (green), hydrological events (blue) and climatological events (orange) (Munich RE, 2019).

Motivation

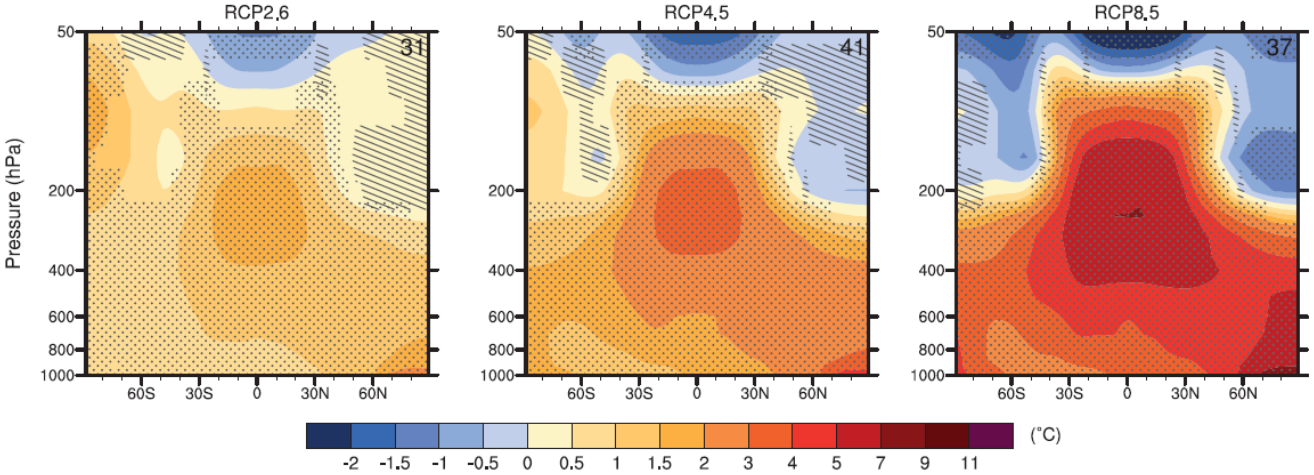


Fig. 2: Ensemble mean for zonal atmospheric mean temperature changes [°C] for RCP2.6 (left), RCP4.5 (middle) and RCP8.5 (right) for 2081-2100 in comparison to 1986-2005 (see IPCC (2013) Fig. 12.12).

Motivation
Study Questions

a) How do severe **storms change in future climate** in the used data sets?

b) Are there significant **connections** between **baroclinicity** and **severe storm** parameters and different are they in the **upper and lower troposphere**?

c) Does the **connection** between baroclinicity and severe storms various in the **future climate** compared to present climate?

Data

- Winter season for storms October to March (ONDJFM)

Reanalysis: ERA-interim

- 1979/80 to 2009/10
- Resolution: 0.75°
- 6hr: psl, ua, va, ta, zg

Model: MPI-ESM-LR

- historical: 1969/70 to 1999/2000
- RCP 4.5: 2069/70 to 2099/2100
- Resolution: 1.875°
- 6hr: psl, ua, va
- daily: zg, ta, ua, va

Sensitivity analysis
→ Storm tracking in 850hPa
→ Daily EADY

Methodology – Tracking of Storms/Cyclones

- Wind Storm tracking algorithm like *Leckebusch et al. (2008)*
- Exceedance of 98th percentile of wind speed

$$SSI_{T,K} = \sum_{t}^{T} \sum_{k}^{K} \left[\left(max(0, \frac{v_{k,t}}{v_{Perc,k}}) \right)^3 \cdot A_k \right]$$

- Cyclone tracking with algorithm of *Murray and Simmonds (1991)*
- max. $\nabla^2 p$

Methodology – Eady Growth Rate

- Eady growth rate as indicator for baroclinicity

(Hoskins and Valdes, 1990)

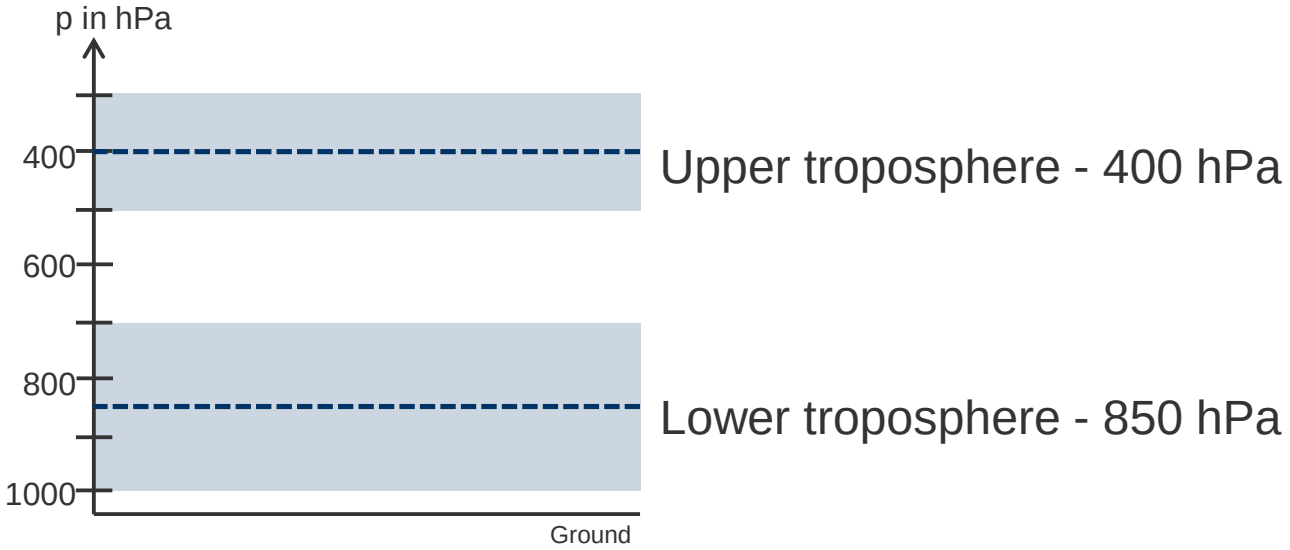
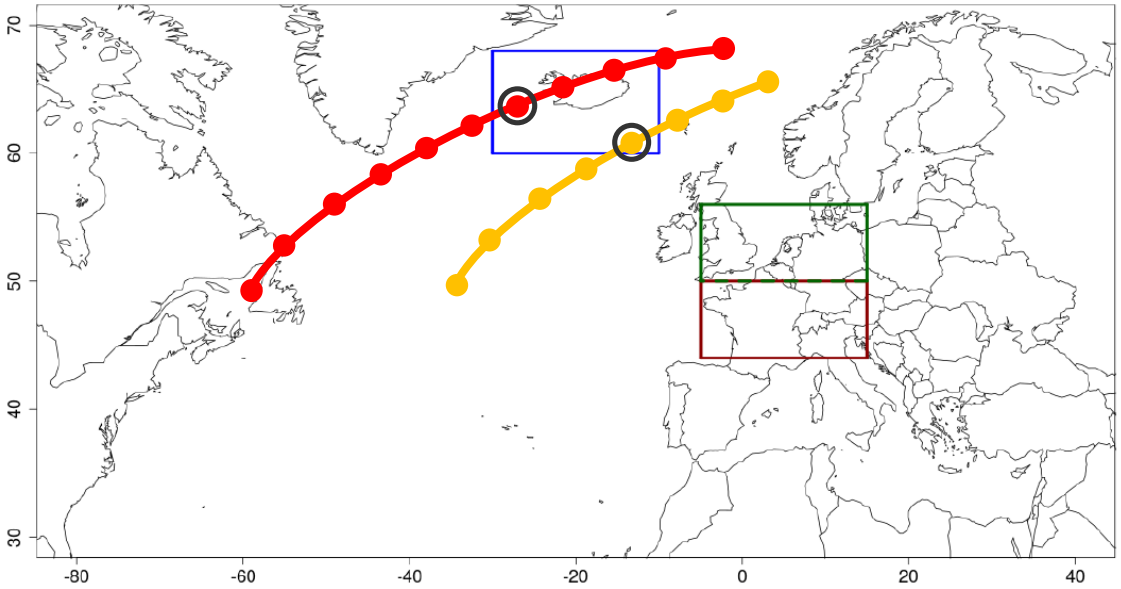


Fig. 3: Scheme of used EADY levels with total regions (color shaded) and resulting mean (dashed line).

Methodology – Eady Growth Rate Composite



Eady growth rate mean of previous 3 days

Fig. 4: Scheme of used time steps for EADY composite on the example box Iceland with two example storm tracks (red and orange) and the first time step in the box (marked with black circle).

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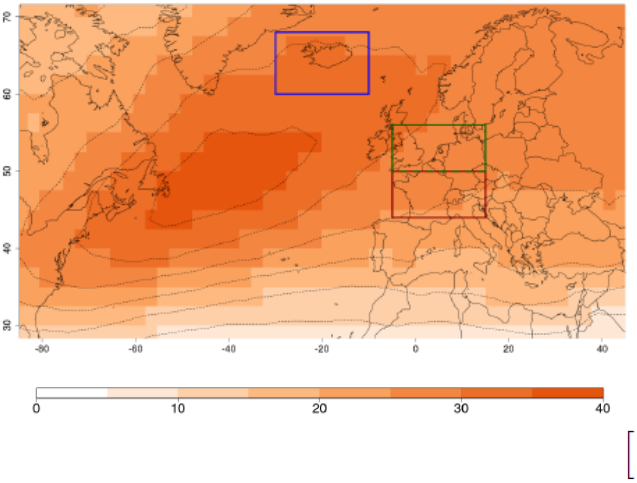
Results – Track Density

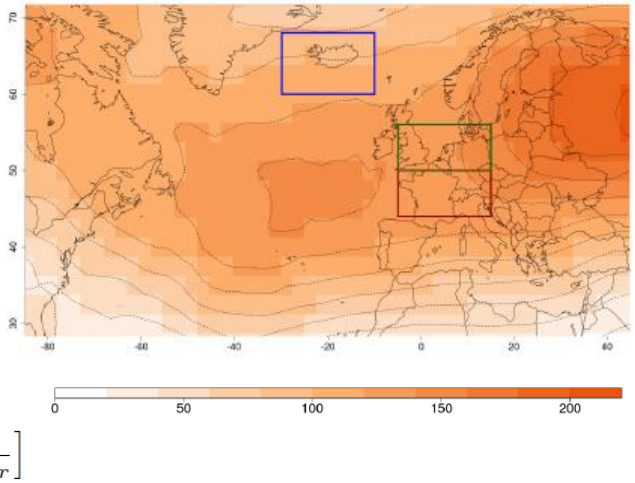
Wind Storm Tracks

ERA tracked at 850hPa



Cyclone Tracks

ERA near surface/ at sea level



$\left[\frac{\#}{year}\right]$

Fig. 5: Track density of storms (left) and cyclones (right) within a radius of 1000km for ERA tracked in near surface.

Results – Track Density Differences

Wind Storm Tracks

Cyclone Tracks

(MPI-ESM HIST) - (ERA)

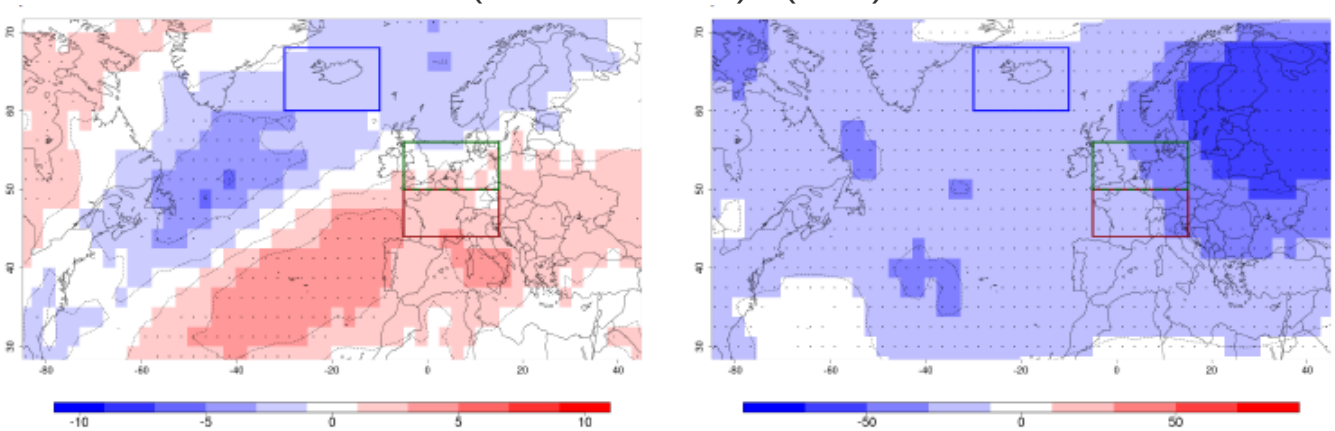


Fig. 6: Difference of track density of storms (left) and cyclones (right) between ERA and MPI-ESM HIST, significance at 5% level marked by dots.

Results – Track Density Differences

Wind Storm Tracks

Cyclone Tracks

(MPI-ESM RCP4.5) - (MPI-ESM HIST)

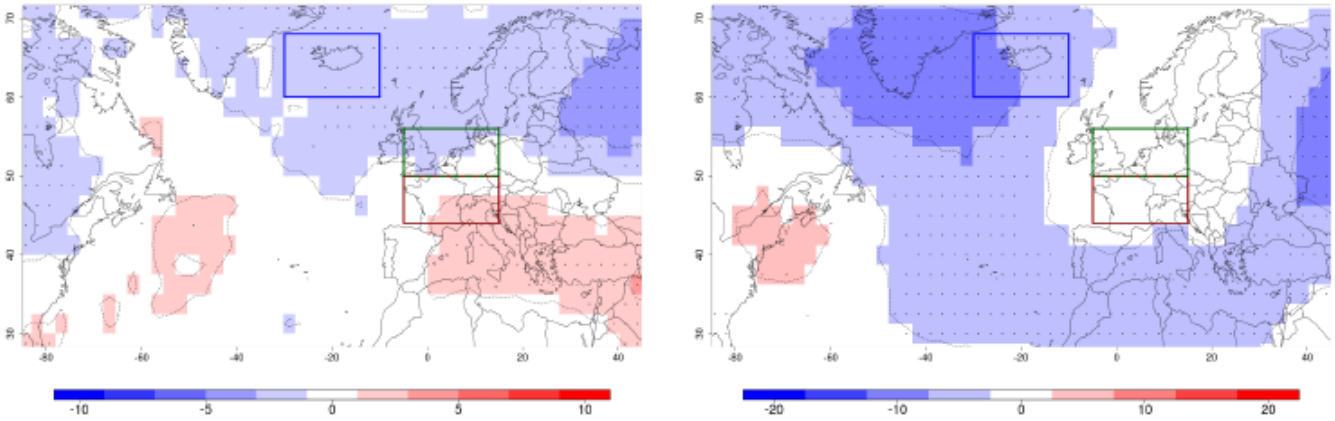


Fig. 7: Difference of track density of storms (left) and cyclones (right) between MPI-ESM RCP4.5 and HIST (bottom), significance at 5% level marked by dots.

Results – Eady Growth Rate Climatology

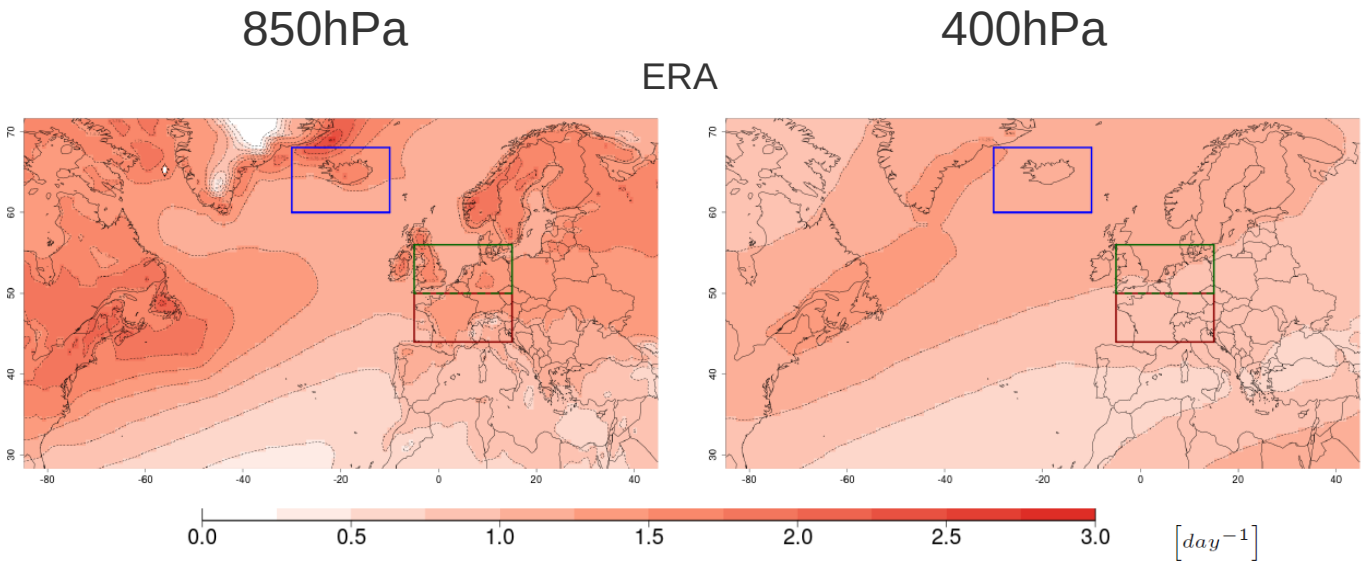


Fig. 8: EADY [day^{-1}] winter climatology of ERA for 850hPa (left) and 400hPa (right).

Results –
Eady Growth Rate Climatology

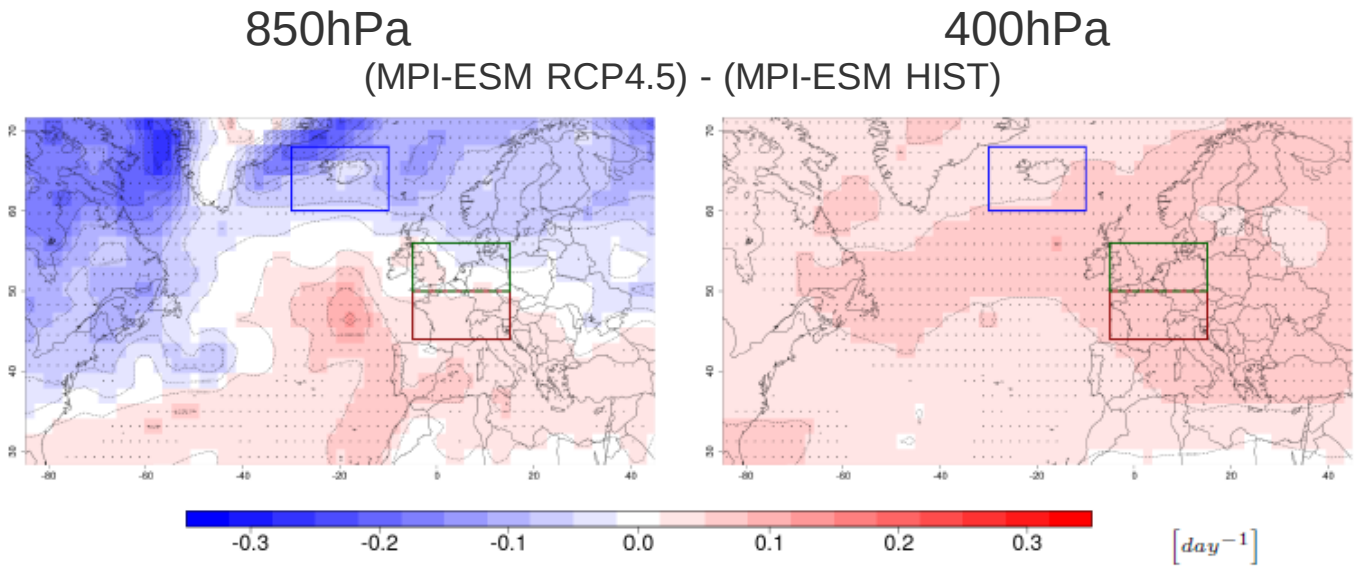


Fig. 9: Difference of EADY [day^{-1}] winter climatology between MPI-ESM RCP4.5 and HIST (bottom) for 850hPa (left) and 400hPa (right), significance at 5% level marked by dots.

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Results – Eady Growth Rate Anomalies

Europe-North

Composite: 3-day mean of first timestep inside box

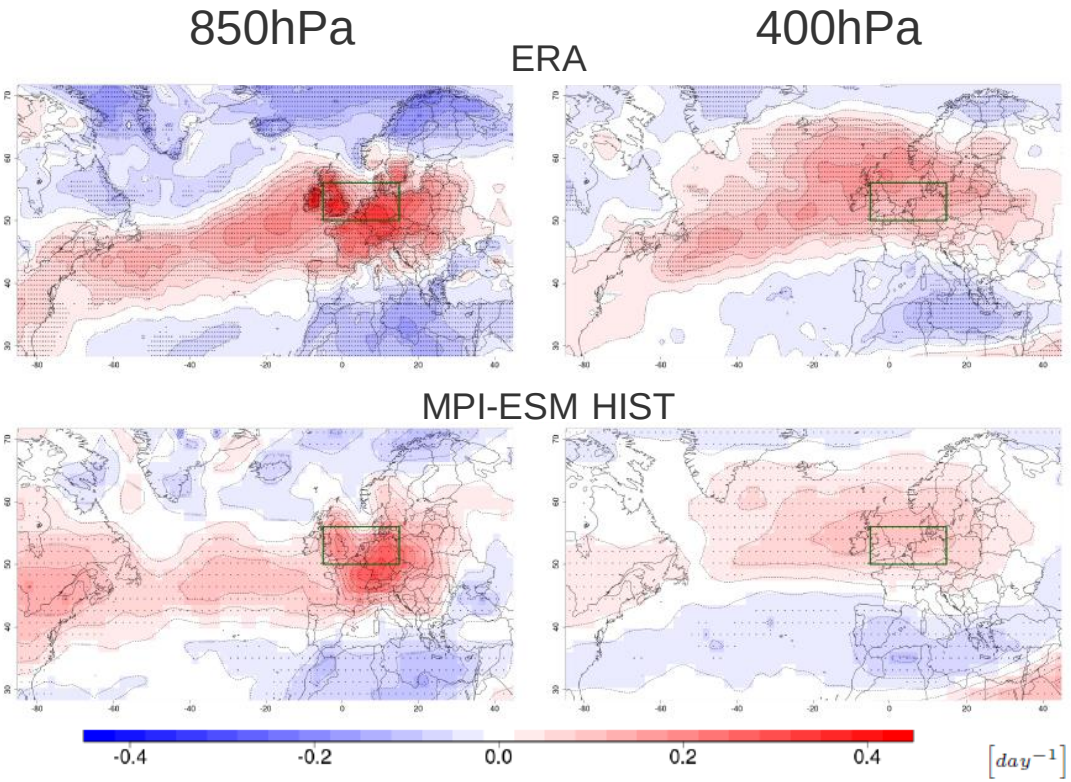

Fig. 10: Anomaly between EADY composite in **Europe-North** and winter climatology in 850hPa (left) and 400hPa (right) for ERA (top) and MPI-ESM HIST (bottom), significance at 5% level marked by dots.

Study Questions

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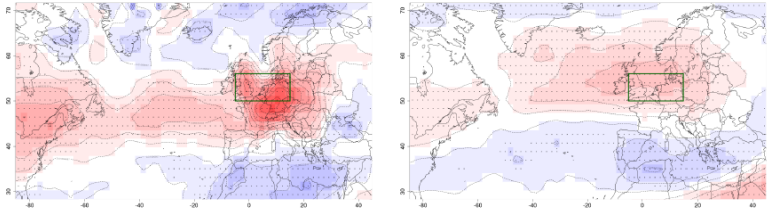
Results – Eady Growth Rate Anomalies

Europe-North

Climate Signal

MPI-ESM HIST



850hPa

400hPa

MPI-ESM RCP4.5

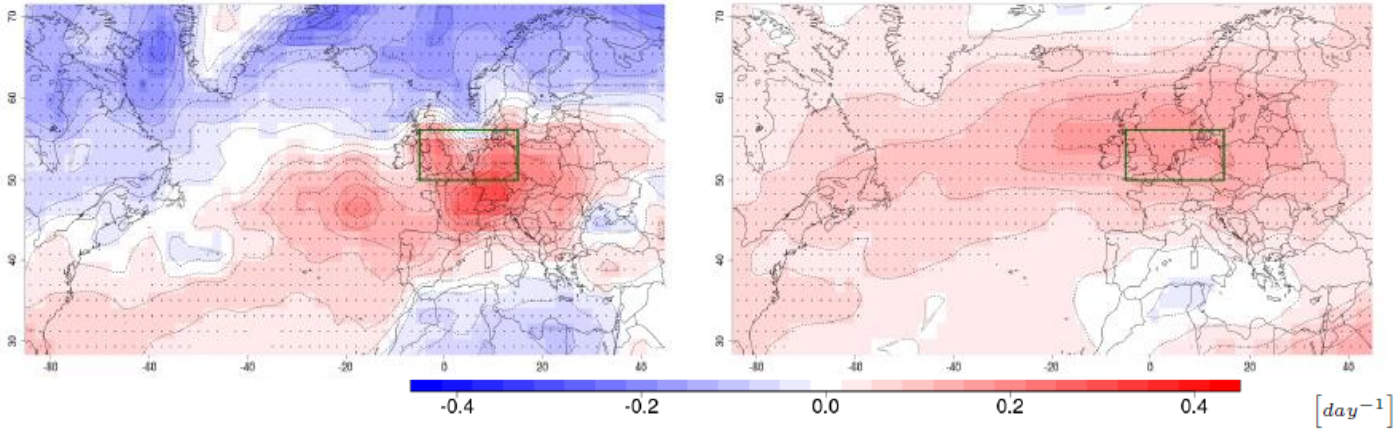


Fig. 11: Anomaly between EADY composite in **Europe-North** and winter climatology in 850hPa (left) and 400hPa (right) for MPI-ESM RCP4.5, significance at 5% level marked by dots.

Conclusion

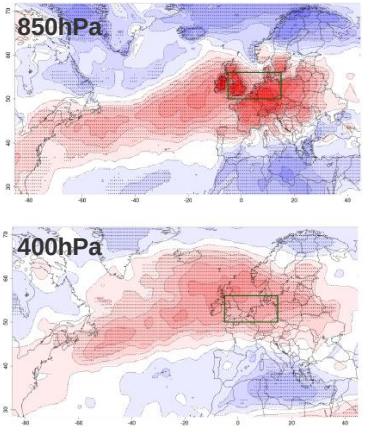
- ~ 25 % increase of Eady in lower troposphere

  In observation and historical run
- Northwards shift from lower to upper

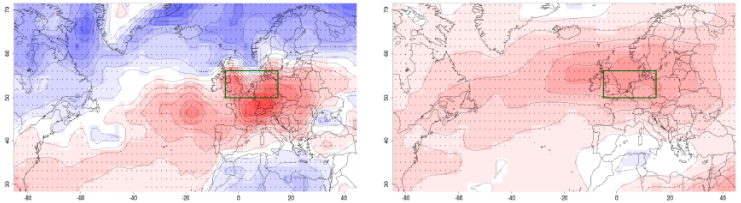
  troposphere
- Extended signals over North Atlantic
- Clear positive anomaly in upper tropospheric

  baroclinicity in

  climate scenario



MPI-ESM RCP4.5



Thank you for your attention!

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