Sensitivity of proxies on non-linear interactions in the climate system

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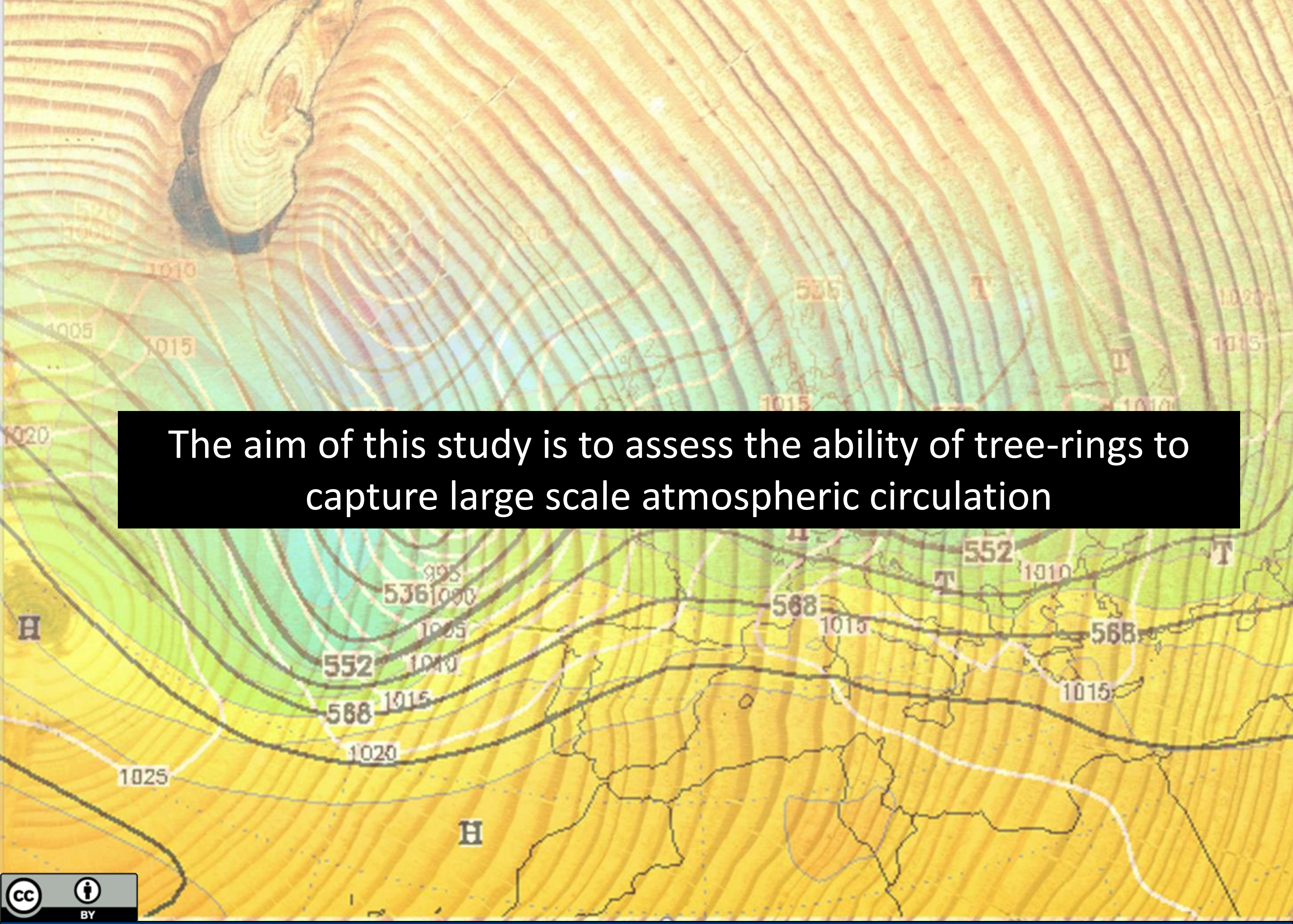
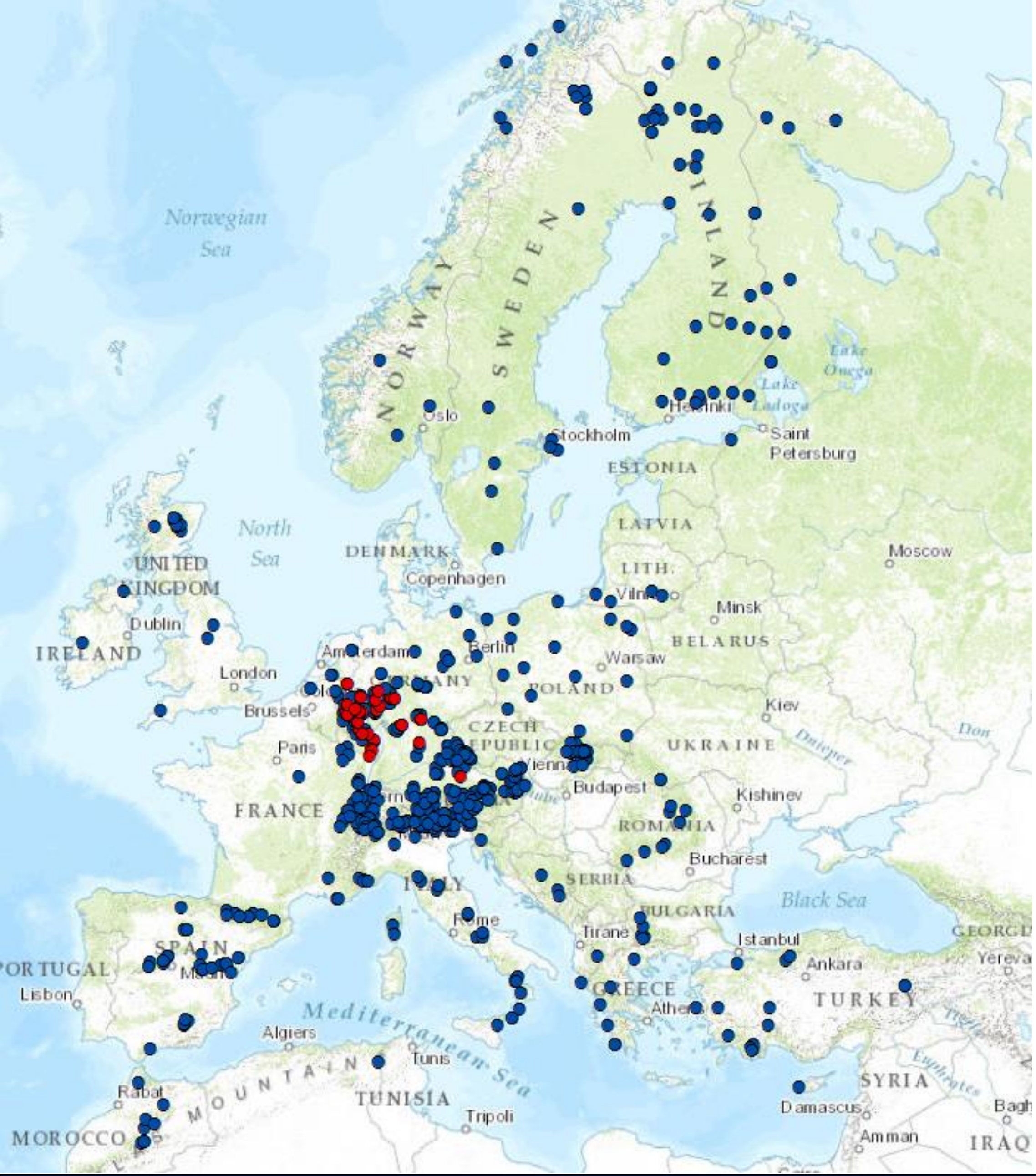
Schultz et al. 2015 Scientific Reports: www.nature.com/articles/srep18560



The aim of this study is to assess the ability of tree-rings to capture large scale atmospheric circulation

Tree-ring width data (TRW)



Tree-ring dataset-1 •

- 50 chronologies, 2 species (beech, oak)
- 32-year cubic smoothing splines with a 50% frequency-response cutoff
- investigation period 1891–1990

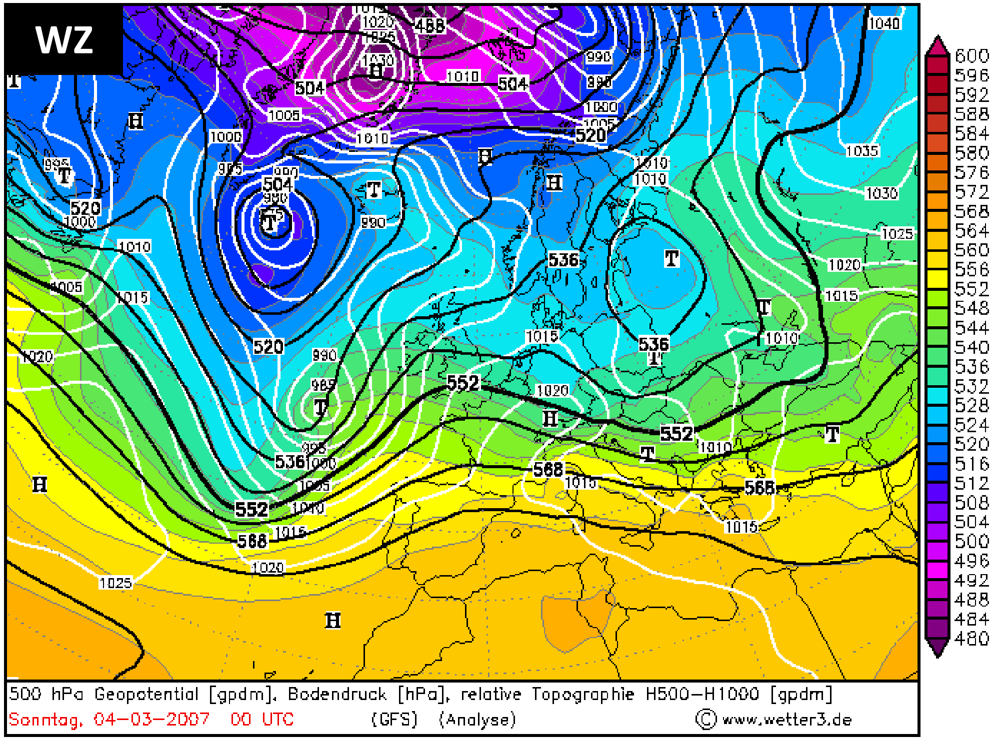
Tree-ring dataset-2 •

(Babst, et al. (2013), Biogeogr.)

- 726 chronologies, 36 European tree species
- adaptive power transformation (stabilize the heteroscedastic variance structure)
- 32-year cubic smoothing splines with a 50% frequency-response cutoff
- investigation period 1881–1980

Weather-types

- Weather-types are the leading factor for local and regional climate conditions
- Subjective (manual) Hess Brezowsky classification with 29 types *(Hess und Brezowsky 1952)*
- Eight objective, circulation-type classifications (cost733class classification software, spatial domain 54 °W to 70 °E/30 °N to 76 °N) *(Philipp, et al. 2010 Phys. Chem. Earth.)*
  - Century Reanalysis data; 1000 hPa and 500 hPa geopotential height
  - two variants 18 and 27 classes / types
  - two classification approaches GWT (Großwettertypen) and k-means clustering



In total: Nine weather-type classifications

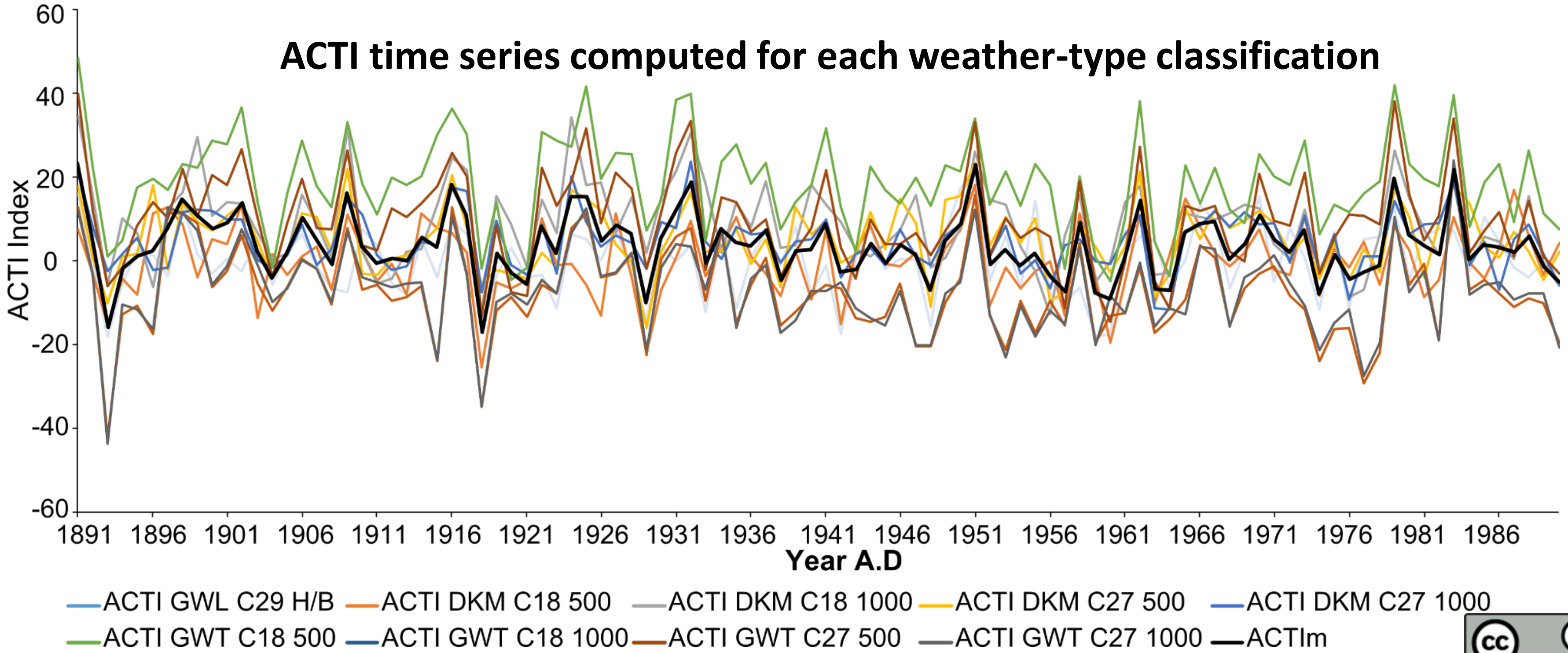
Atmospheric circulation tree-ring index (ACTI)

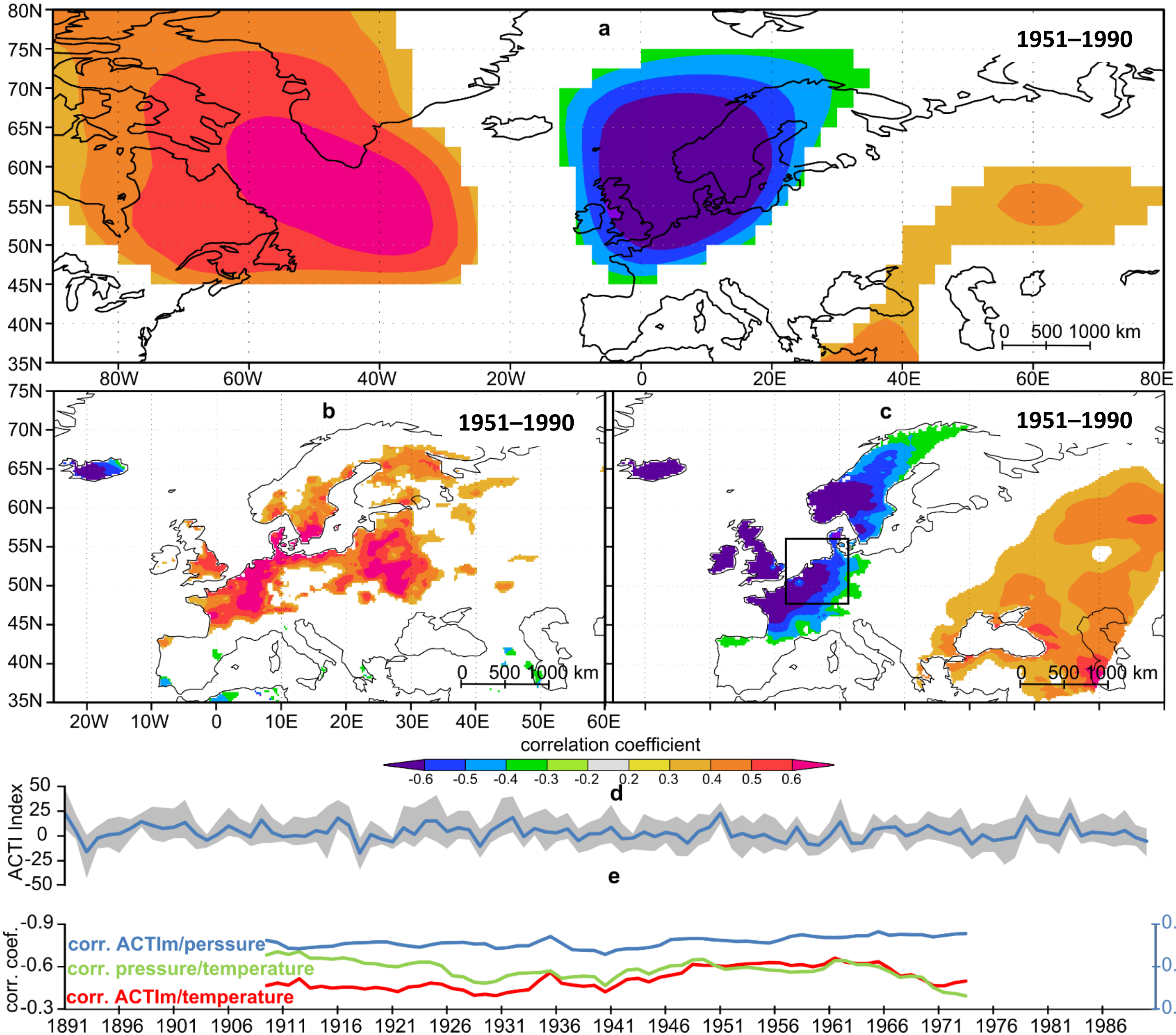
- The values of the ACTI time series are defined as springtime sums of the weighted weather-type frequencies during the period 1891 to 1990 (for tree-ring dataset-1)

- Weather-type weights are computed, based on a Monte Carlo simulation with 1 million simulation runs

$$ACTI_y = \sum_{j=1}^{w} (h_{yj} \times g_j)$$

Schultz & Neuwirth (2012), Agricult Forest Metero





Spatial (a-c) and moving (e) correlation computed between gridded climate datasets and ACTIm

(a) *NCEP/NCAR Reanalysis 1, pressure (500 hPa)*

(b) *E-OBS 10, precipitation*

(c) *E-OBS 10, maximum temperature*

(d) ACTIm (blue) with the fluctuation range (gray) of all ACTI time series.

(e) Moving correlation analyses in 35-year window between ACTI and climate datasets

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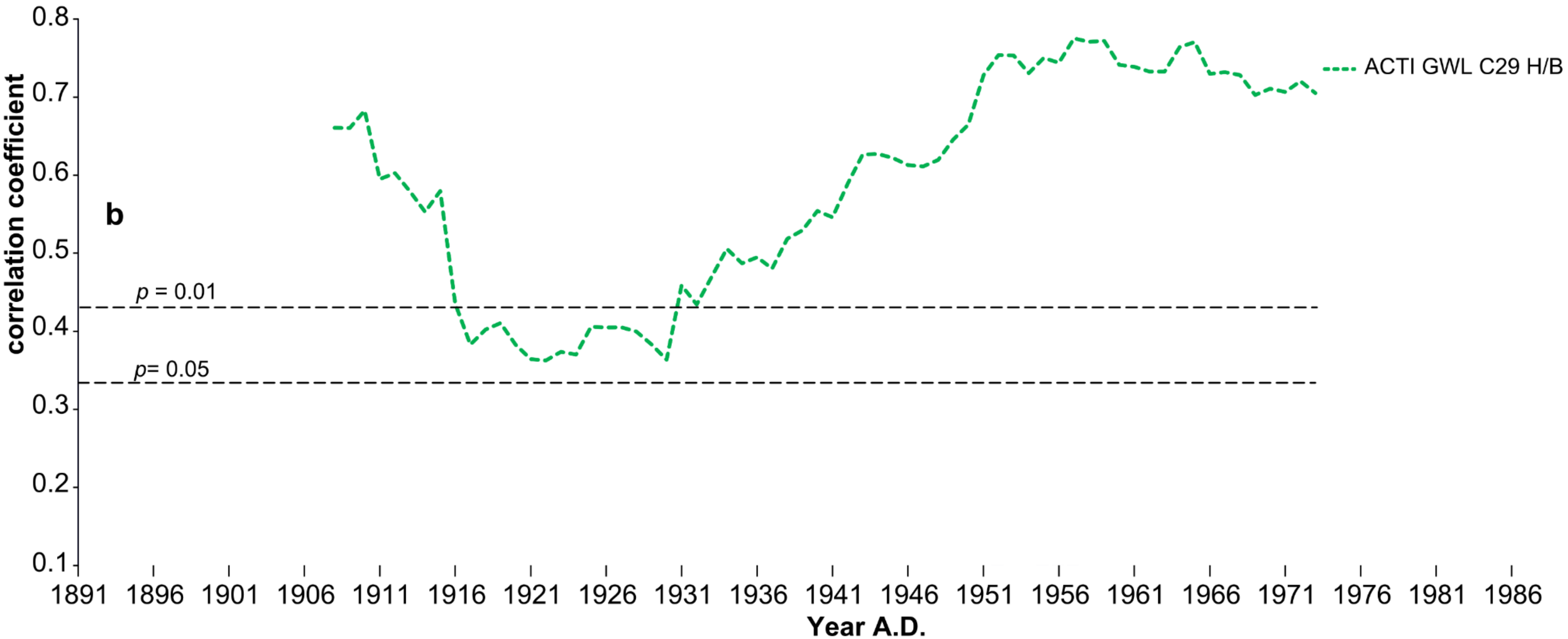
Temporal stability (ACTI TRW)



(**b**) Moving correlation analyses in 35-year window between ACTI and TRW

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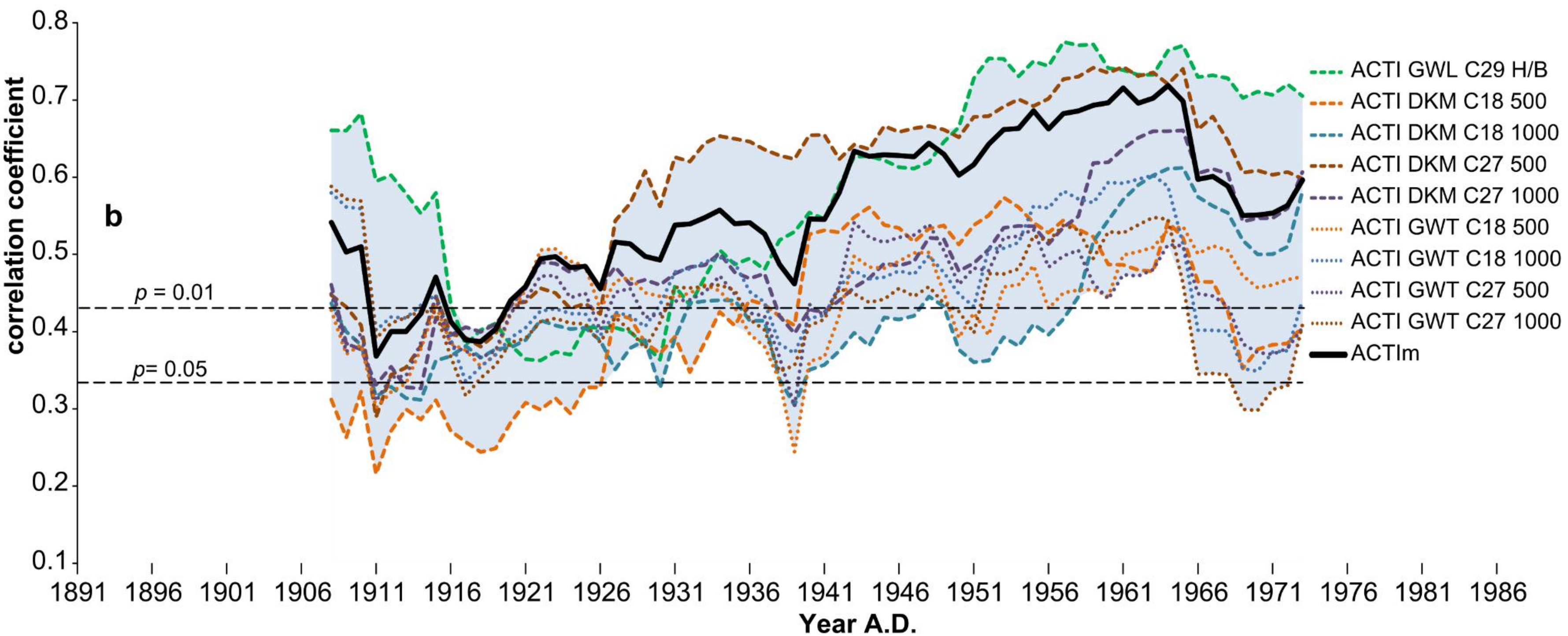
Temporal stability (ACTI TRW)



(**b**) Moving correlation analyses in 35-year window between ACTI and TRW

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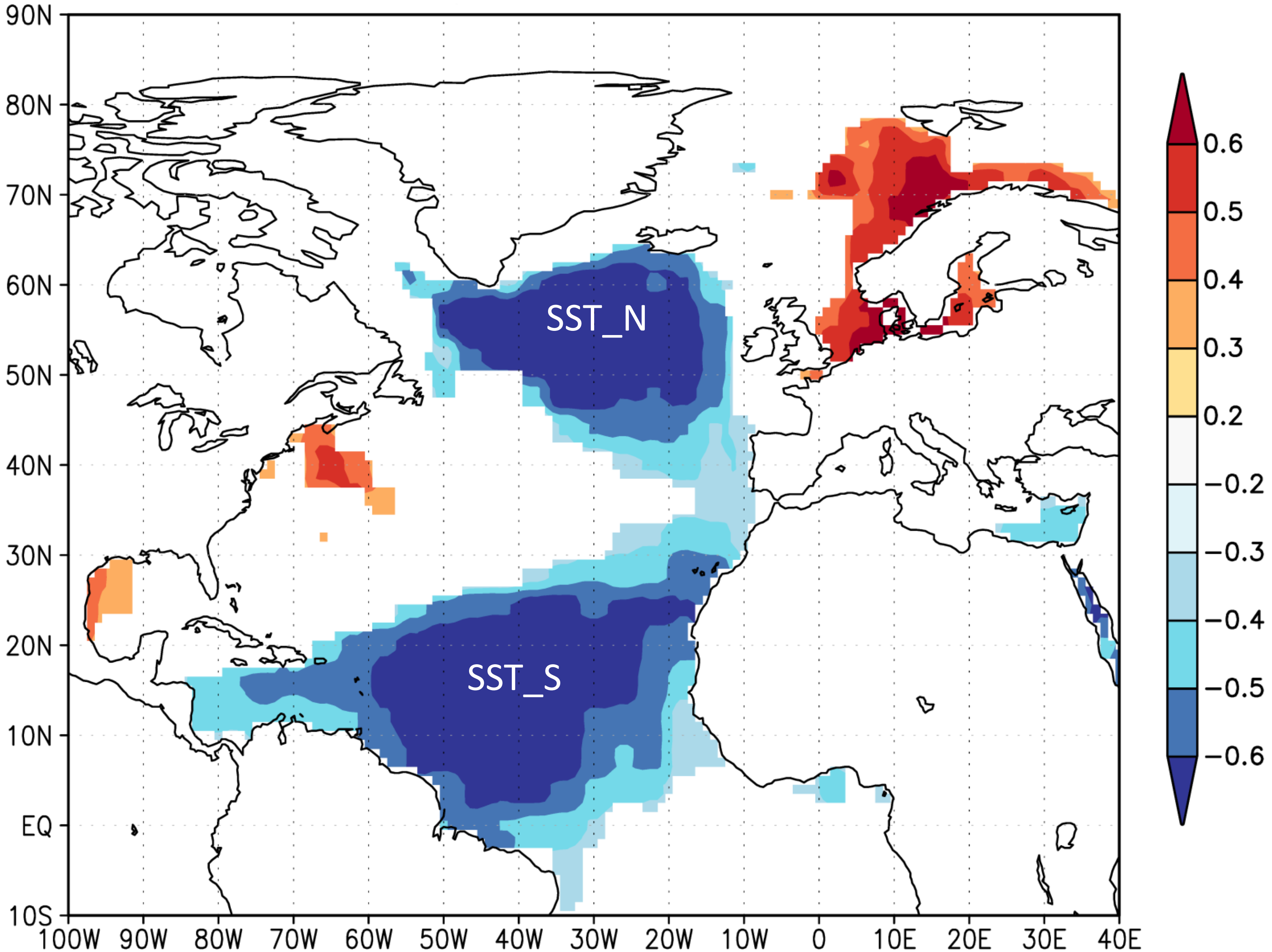
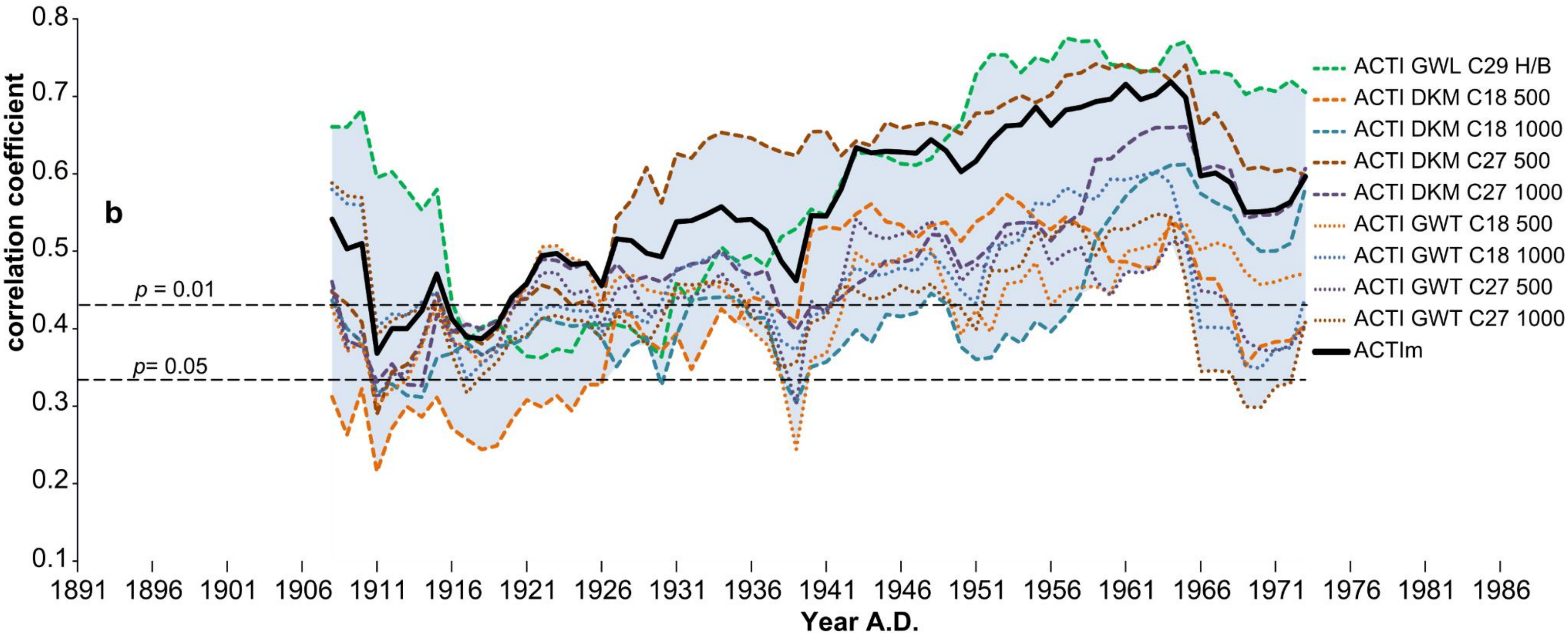
Correlation between HadSST and NAO (Azores) 1899-1933



SST_N average 50°W 15° E /40°-60 °N **SST_S** average 70°W 15°E /0°-30 °N

Temporal stability (ACTI TRW)



(**b**) Moving correlation analyses in 35-year window between ACTI and TRW

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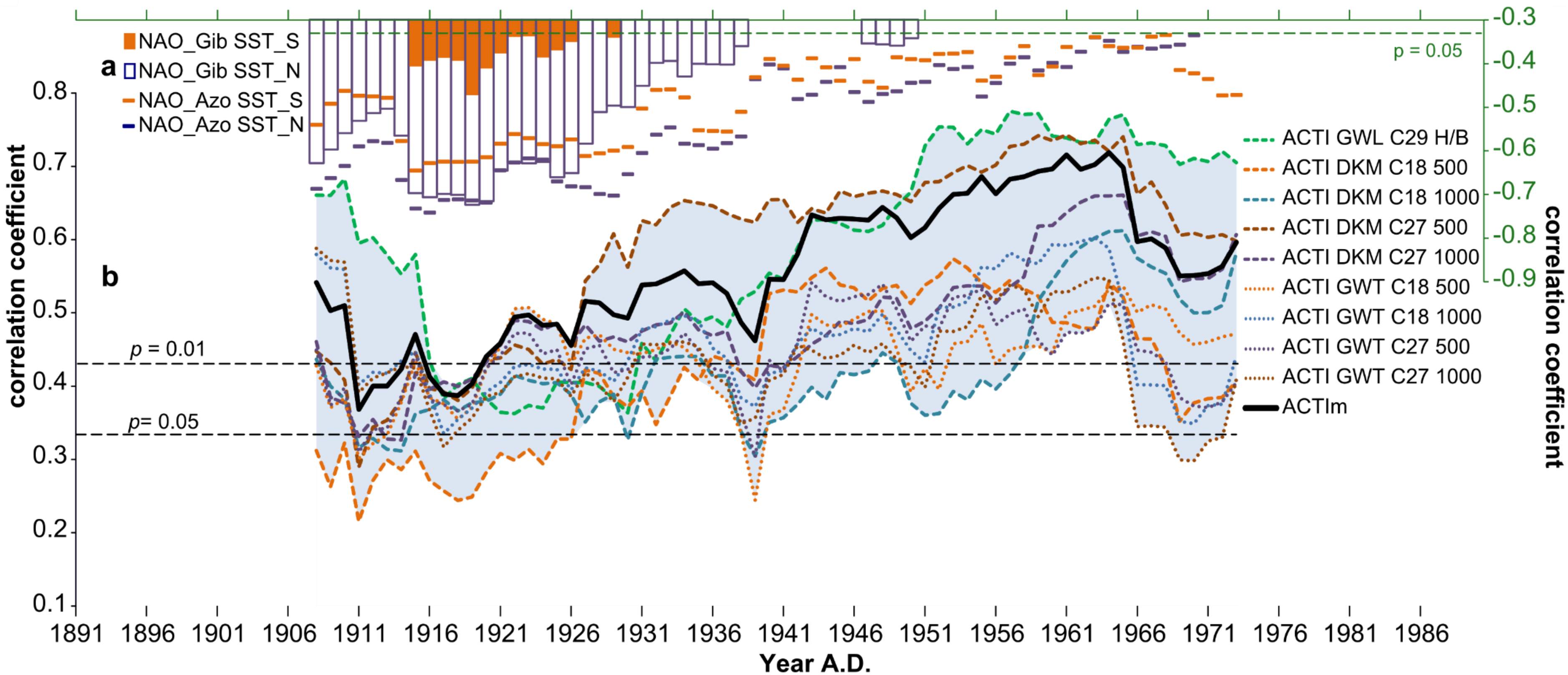
Temporal stability (SST NAO)



(**a**) Moving correlation analyses in 35-year window between SST and NAO

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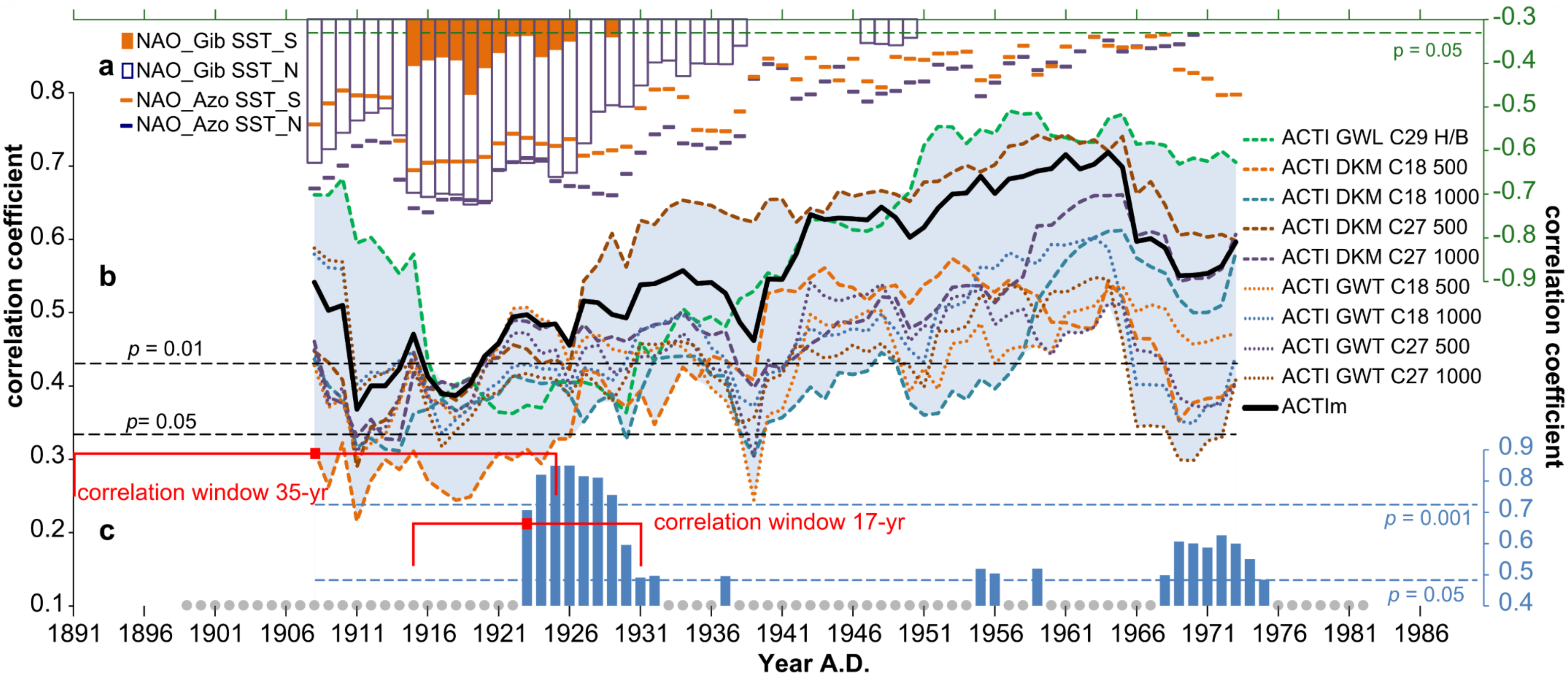
Temporal stability (SST TRW)



(**c**) Moving correlation analyses in 17-year window between SST and TRW

- In the beginning of the 20th century and at the end of the time series the weather-type sensitivity of the tree-ring-width network decreases, whereas a significant statistical relationship with SST occurs

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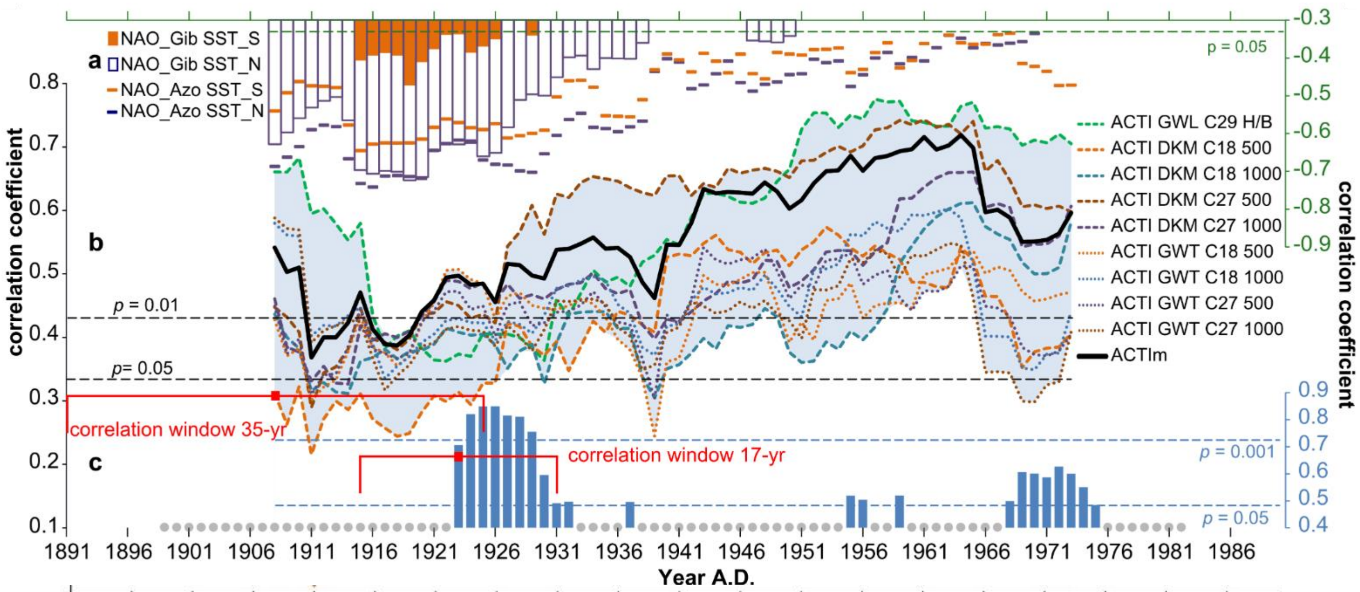
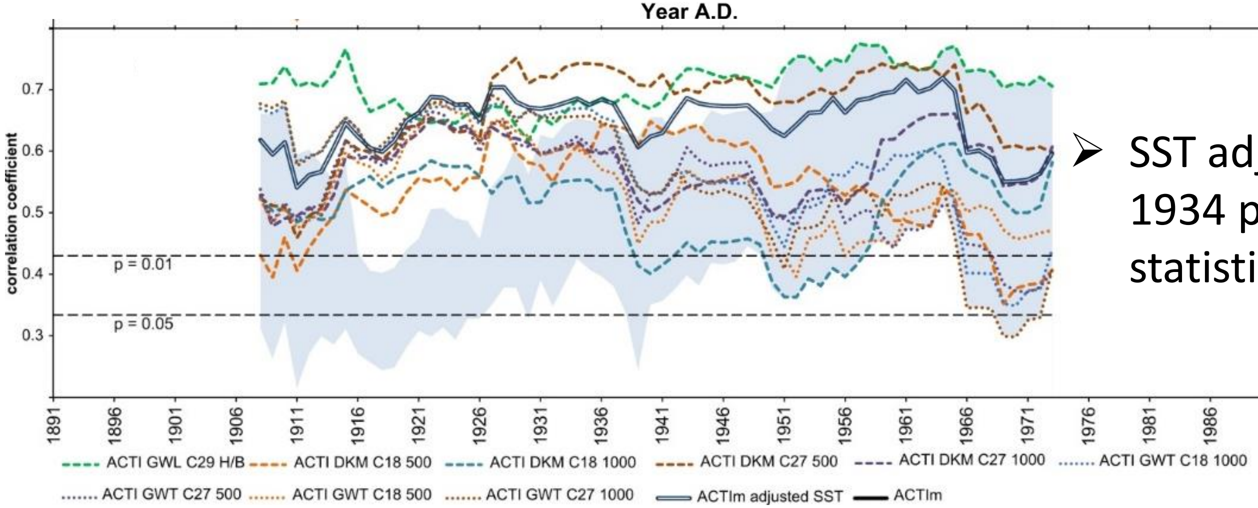
Temporal stability after SST adjustment





- SST adjustment for the 1917-1934 period, indicating stable statistical relation ships

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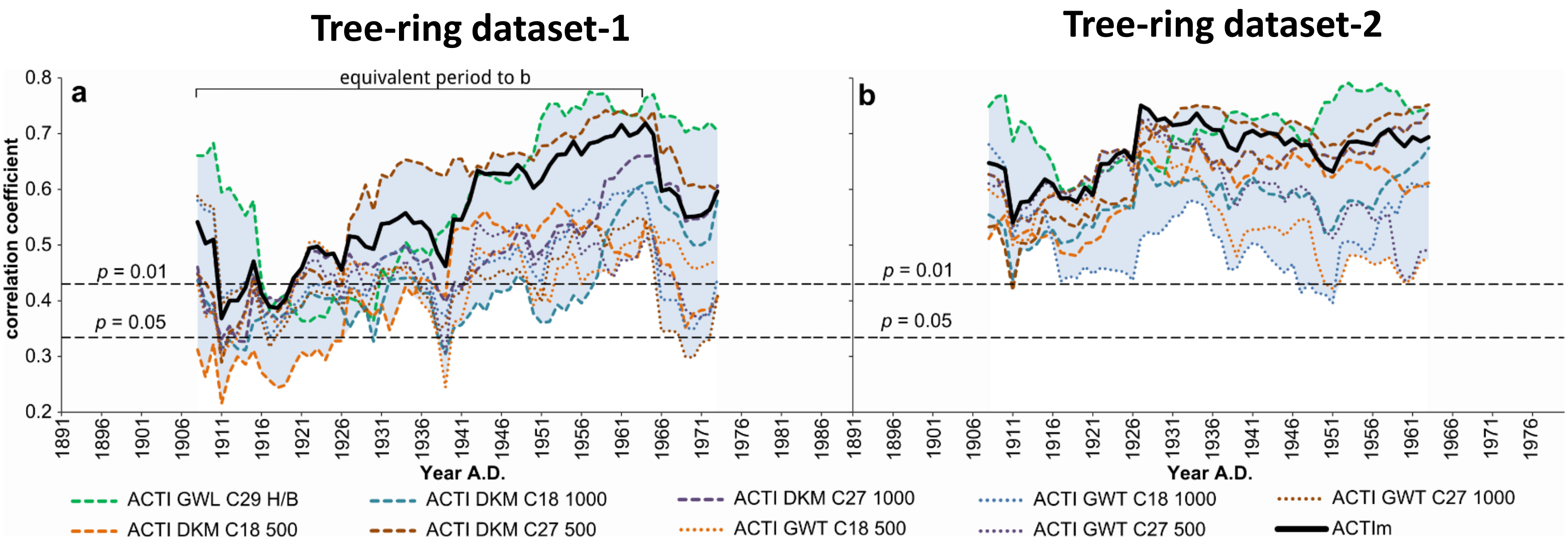
Temporal stability for TRW dataset 1 and 2



- Scale bias effect can be generally defined as a reduced climate sensitivity of proxies for phenomena in subordinate levels of the climate system, caused by nonstationarities / nonlinearities in superordinate scales of the climate system

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Conclusion

- Our results indicate that nonstationarities in superordinate space and time scales of the climate system (here synoptic- to global scale, NAO, AMO) can affect the climate sensitivity of tree-rings in subordinate levels of the system (here meso- to synoptic scale, weather-types)

- More attention is needed to understand scale effects and interdependencies between processes and phenomena acting on different scales of the climate system

- The climate sensitivity of tree-rings can appear unstable, but in reality this is only caused by predictor sets which are incomplete and do not consider interdependencies between the predictors

- Further research is needed to understand the impact of spectral biases (Franke et al. 2013) and scale biases on climate reconstructions and their interrelation universitätbonn Geographie

Thank you for your attention and thanks to all colleagues for providing data

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