NCAS Climate
Department of Meteorology

Indecis
Sectorial Climate Services
www.indecis.eu

University of Reading

WP5 - INDICES TIME EVOLUTION AND RELATIONS WITH THE ATMOSPHERE

ERA4CS
European Research Area for Climate Services

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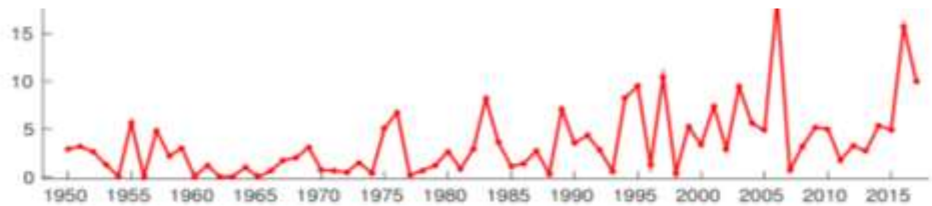
Albert Osso, Philip Craig (also Len Shaffrey, Emily Black, Ed Hawkins)

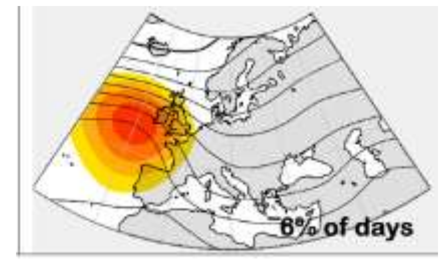
WP5 - Indices Time Evolution & Relations with Atmosphere

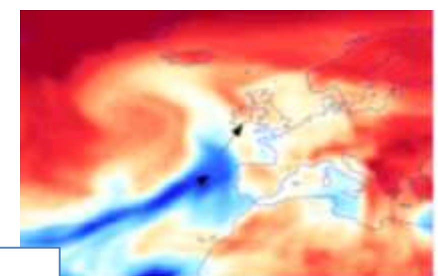
Aim: quantify variability/change in indices and establish link to atmospheric circulation patterns



Deliverables:

- Inventory and Catalogue of Indicators of circulation variability for comparison with the INDECIS-ISD
- Report on temporal evolution of the INDECIS-QCHDS and INDECIS-ISD, including the time-emergence of climate-change signals and relation with atmospheric patterns
- Report on the relation between INDECIS-QCHDS and INDECIS-ISD and atmospheric patterns





Compile teleconnection indices

Evaluate physical linkages between atmospheric variability, extremes & sectorial indices

Analyse temporal evolution of INDECIS-QCHDS/ISDs

WP 2,3,4

Investigate time-emergence of observed climate change signal

WP 6,7

Observed and thermodynamically driven total precipitation (RT) tendency (Osso et al, Univ Reading)

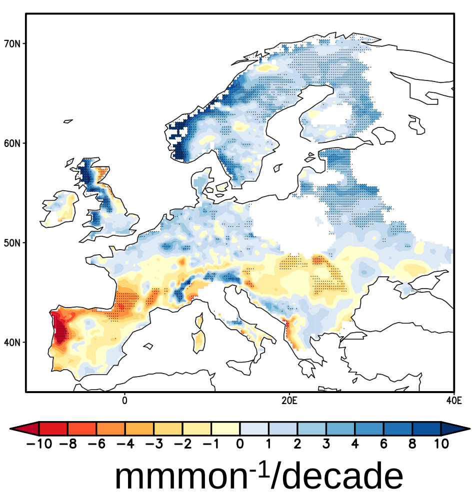
- WP5.2 delivered; WP5.3 under development (Osso)
- Atmos circulation precursors to extreme UK rainfall (Allan)Time of emergence of INDECIS variables and comparison with climate models (paper) (Osso, Hawkins, All)
- Links between INDECIS variables and atmospheric circulation patterns: thermodynamic/dynamic components (Osso, All)
- New plans based on this meeting (Craig/Osso/All)

$$Iobs(t) = \sum_{i=1}^{i=8} \beta_i \, PC_i(t) + \varepsilon(t)$$

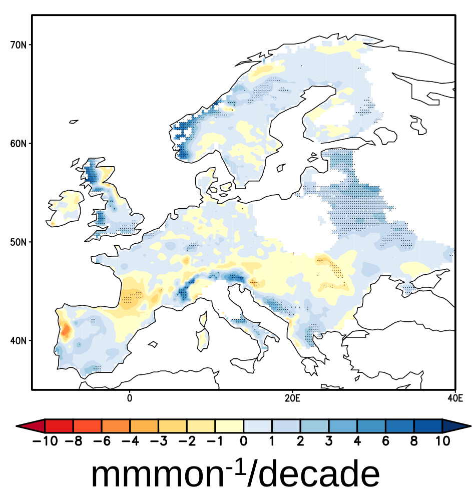
Iobs(t) ➔ Indices anomalies.
PCi(t) ➔ Modes of atmospheric variability.
ε(t) ➔ Error term ~non-dynamic contributions to Iobs(t).

(1) **(2)** **(3)**

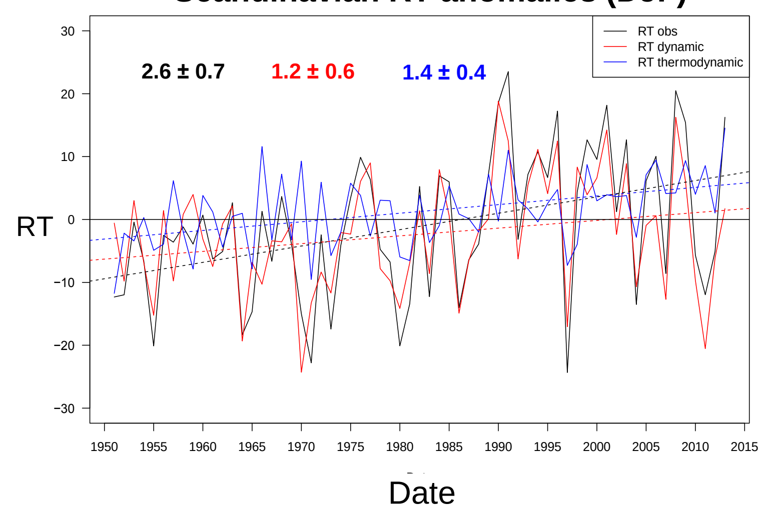
Observed tendency (DJF)



Thermodynamic tendency (DJF)



Scandinavian RT anomalies (DJF)



UC/ICH – trends and links with atmospheric teleconnections

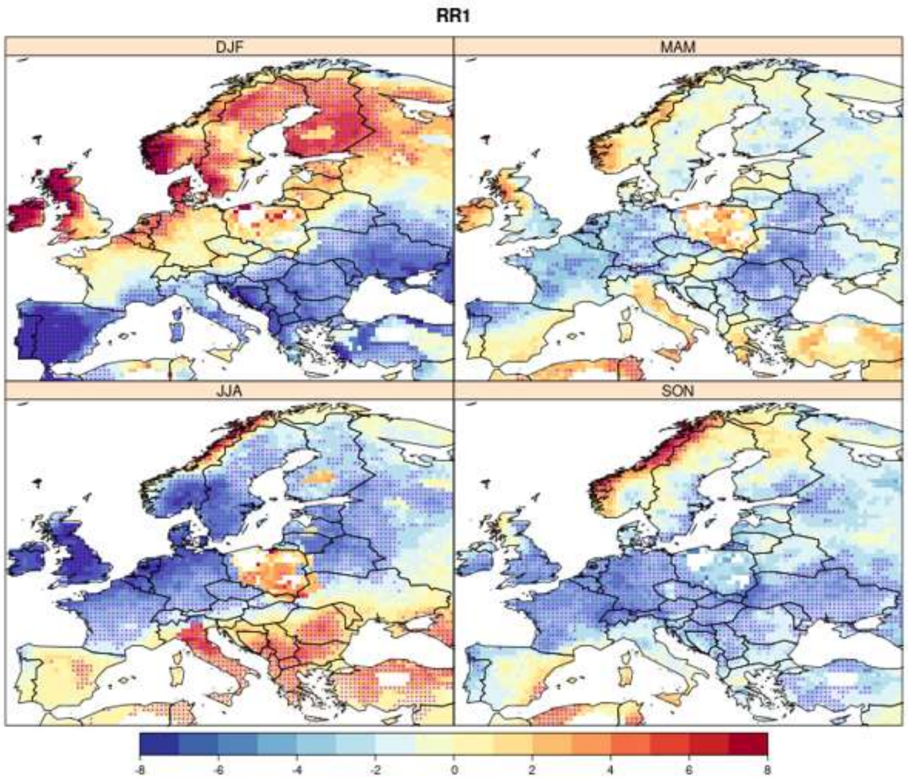
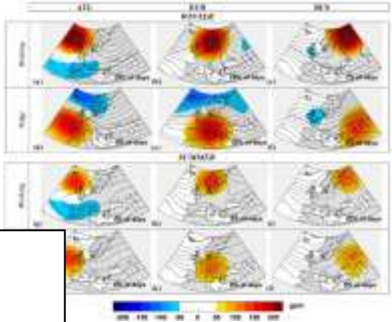


Fig.7 Regression coefficients for RR1 ~ NAO (days/season). Statistically significant values (p-value < 0.05) are depicted in purple.

The most important relationships between RR1 and EA are found in western Europe in winter, in the Atlantic watershed in spring and in the British Isles and southern Norway in summer (Fig.8). Some negative correlations are found in the eastern Mediterranean area.

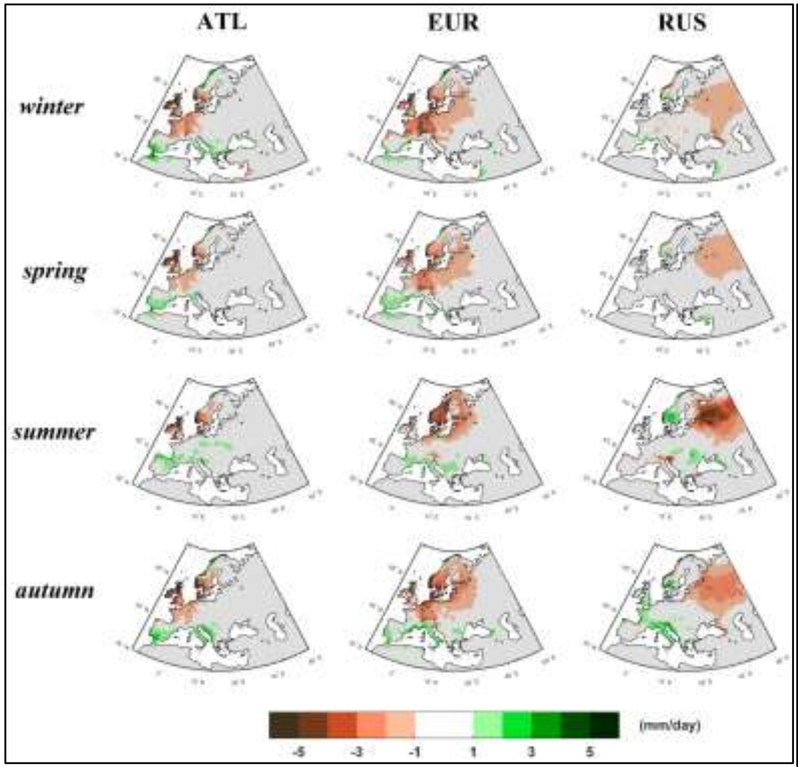
FFCUL: Surface responses for blocking and ridge regimes
Heat extremes and atmospheric patterns (Aug 18, Jun/Jul 19) (Sousa, Trigo)
Ongoing: New automated blocking – ridge detection scheme

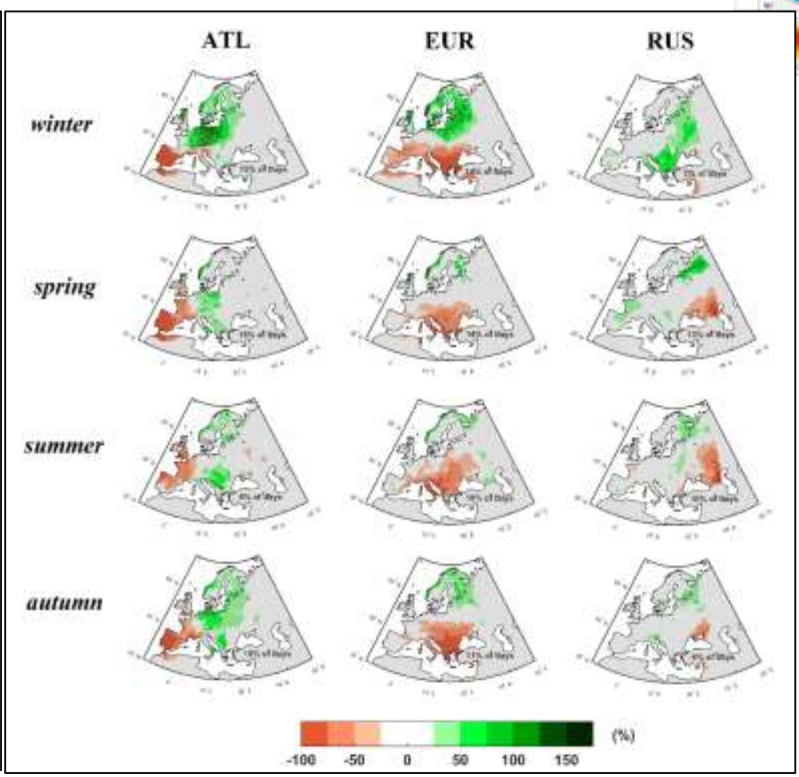


Surface responses for blocking and ridge regimes

Rainfall

blocks **ridges**





Opposite responses all year round:

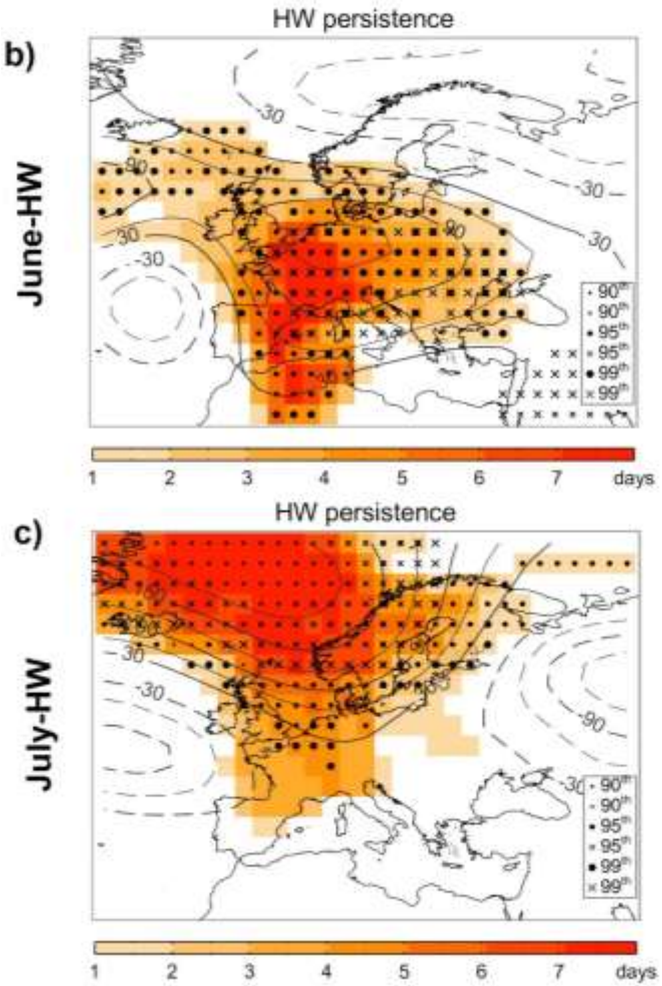
Ridge- wet north

dry south

Block- dry north

wet south

Extreme heat episodes in Central Europe – June/July 2019

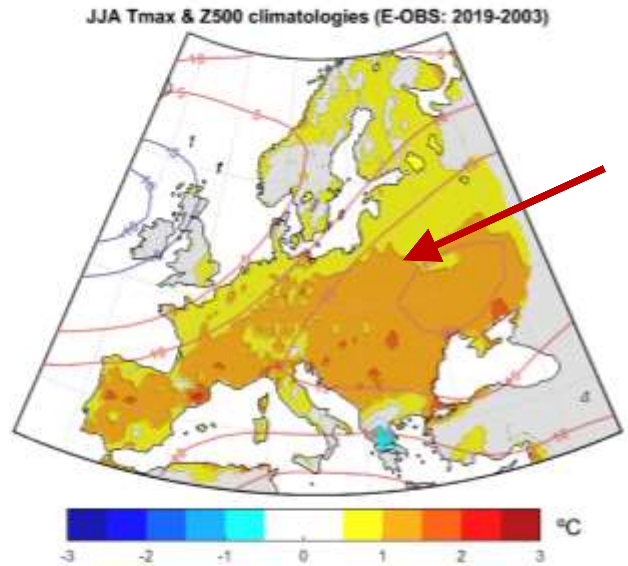


June 2019

First time ever that France registered >45°C

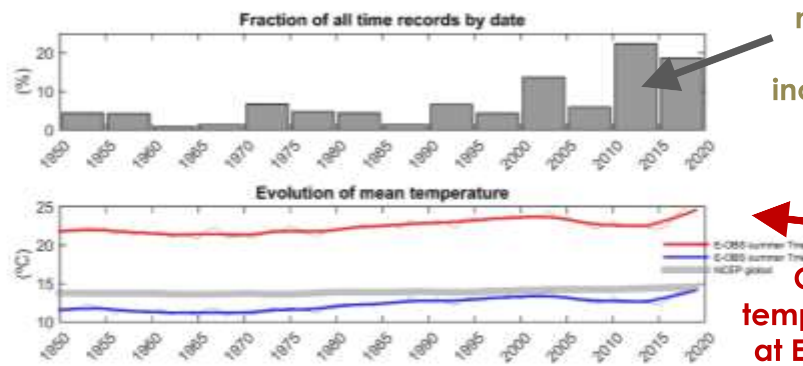
July 2019

First time ever that Belgium & Netherland s registered >40°C



Since the historical 2003 heatwave, summer mean temperatures have increase > 1°C in Europe.

In just 15 years!!!

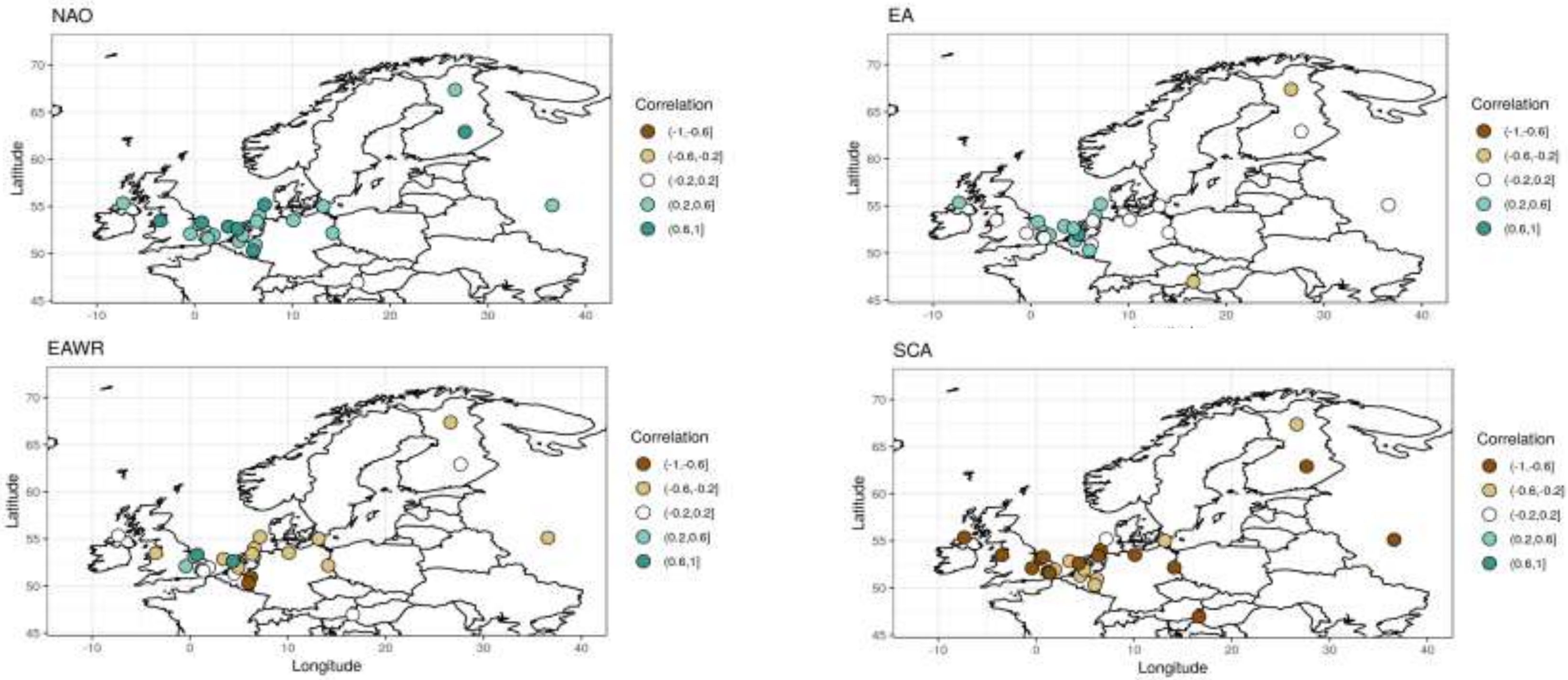


Frequency of new records has been increasing over and over

Continuous temperatures rises at European and Global scales!

BSC: Indices relationship with the Euro-Atlantic circulation patterns (Capacity Factor at tall towers) (Soret et al)

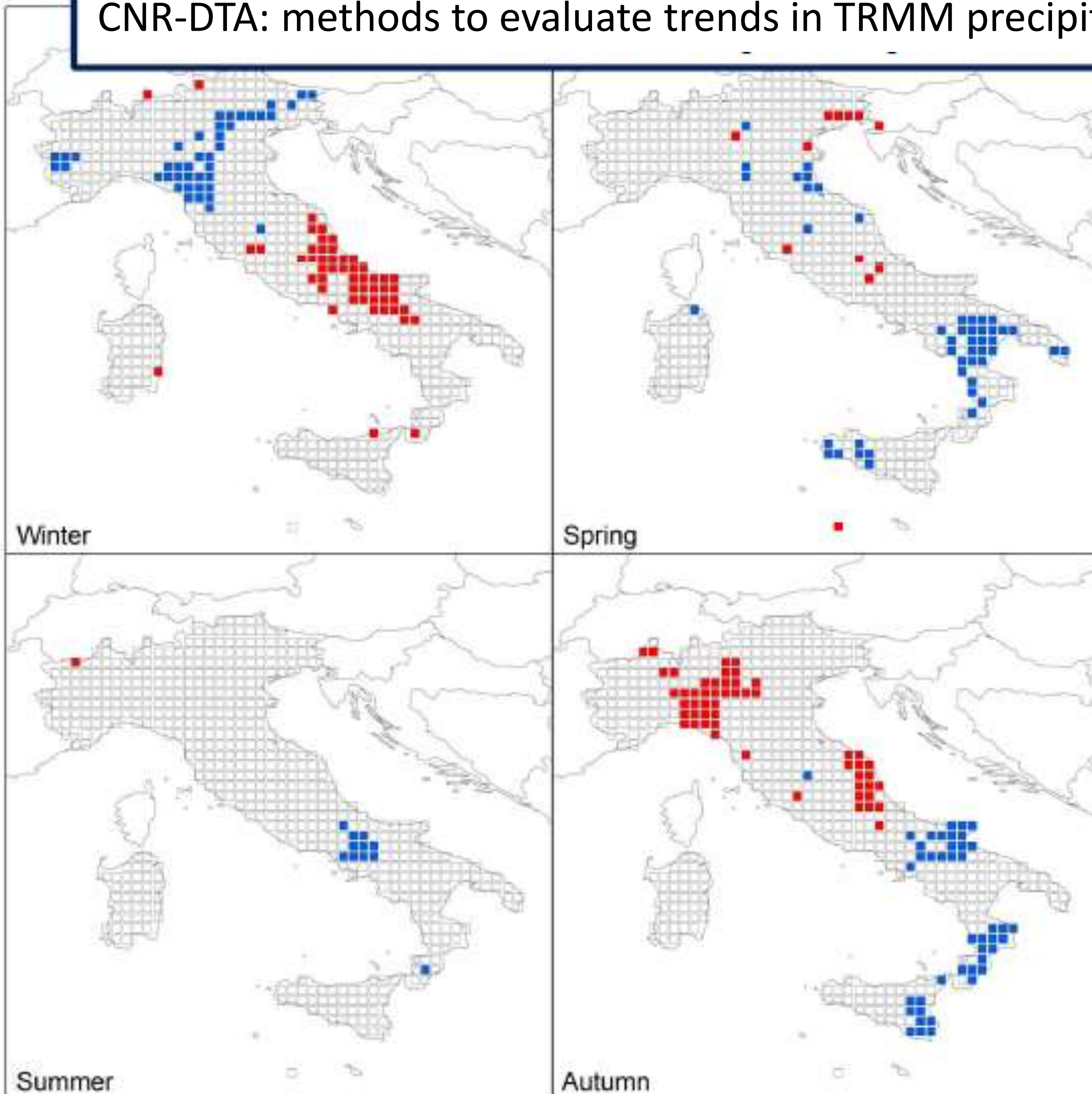
Indices relationship with the Euro-Atlantic circulation patterns (Capacity Factor at tall towers)



Indecis
Sectorial Climate Services

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

CNR-DTA: methods to evaluate trends in TRMM precipitation over Italy



Negative trend of precipitation in central-eastern Italy

Shift from Autumn to Winter for north-western Italy

Tommaso Caloiero, Giulio N. Caroletti & Roberto Coscarelli

Further studies: changes in precipitation response to teleconnections through time

E.g., comparing correlation results from 1951-1980 with those from 1981-2010

	1951-1980	1981-2010
NAO	12 (1)	17 (0)
MOI	9 (2)	16 (2)
ONI/ENSO	16 (0)	10 (0)
WeMOI	17 (0)	15 (0)
EA	16 (1)	12 (0)
EA/WR	17 (1)	13 (0)
SCAND	21 (1)	11 (1)

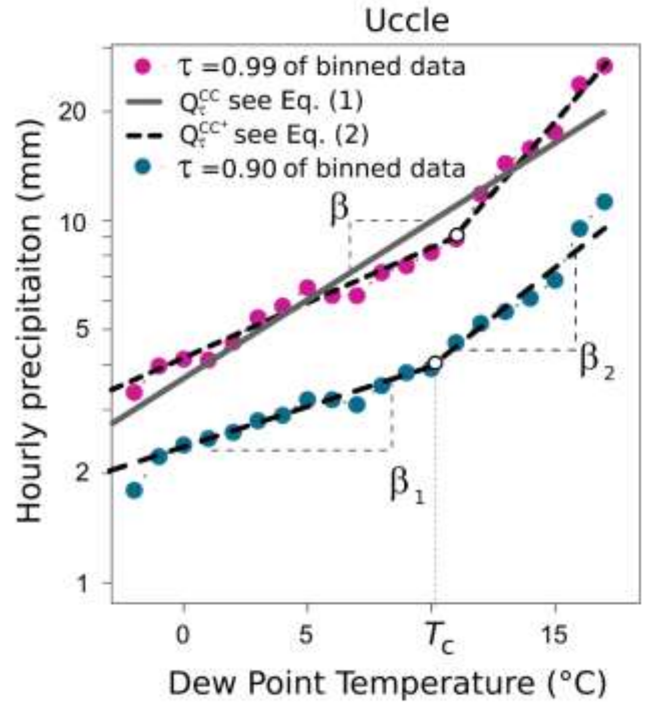
Number of months (#) when a teleconnection (left) has the strongest correlation with monthly precipitation (and, in brackets, the number of months when this correlation is equal or above 0.4). **Tirreno 2 rain zone**; 1951-1980 (center), 1981-2010 (right).

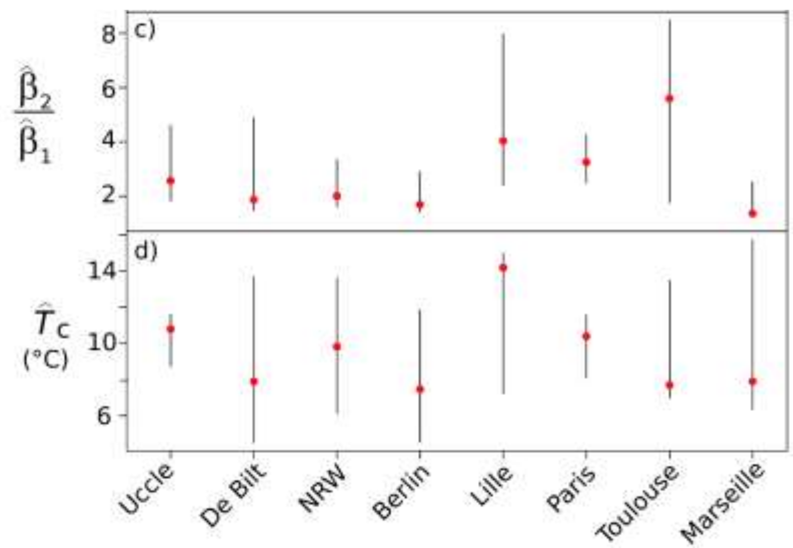
Giulio N. Caroletti, Roberto Coscarelli
& Tommaso Caloiero

RMI plans for WP5

Van de Vyver, Van Schaeybroeck

- So far:
  - Methodology to study sub-hourly rainfall extremes (IDF & relation with temperature, based on observations)
- Next step 1:
  - Validation based on methodology of sub-hourly rainfall extremes of convective-permitting models (WIP)
- Next step 2:
  - Projected trends in modeled sub-hourly rainfall extremes





Publications

- Coscarelli, R.; Caloiero, T.; Caroletti, G.N. : Valutazioni di condizioni di siccità in Calabria, Technologies for Integrated River Basin Management, 40, 777-790, 2019
- Caloiero, T.; Caroletti, G.N.; Coscarelli, R.: TRMM-based rainfall temporal analysis over Italy, Springer Nature Applied Sciences - special issue on "Natural hazards and hydrological risks"

- Sousa PM, Trigo RM, Barriopedro D, Soares PMM, Ramos AM, Liberato MLR (2017a) Responses of European precipitation distributions and regimes to different blocking locations. Clim. Dyn. doi: 10.1007/s00382-016-3132-5
- Sousa PM, Trigo RM, Barriopedro D, Soares PMM, Santos JA (2017b) European temperature responses to blocking and ridge regional patterns. Climate Dynamics. doi: 10.1007/s00382-017-3620-2

- Van de Vyver, H., Van Schaeybroek, B., De Troch, R., Hamdi, R., Termonia, P. (2019) Modeling the scaling of short-duration precipitation extremes with temperature. Earth Space Sci. https://doi.org/10.1029/2019EA000665

- M. Iturbide, J. Bedia, S. Herrera, J. Baño-Medina, J. Fernández, M.D. Frías, R. Manzanas, D. San-Martín, E. Cimadevilla, A.S. Cofiño, J.M. Gutiérrez, The R-based climate4R open framework for reproducible climate data access and post-processing, Environmental Modelling & Software, 111, 42-54, https://doi.org/10.1016/j.envsoft.2018.09.009, 2019.

- Allan, R.P., Blenkinsop, S., Fowler, H.J., Champion, A.J. (submitted): Atmospheric precursors for intense summer rainfall over the UK. *Int. J. Clim.*
- *Hawkins et at. Submitted paper on Time of Emergence*

WP5 ongoing work/plans

- **UREAD:** WP5.2 delivered; WP5.3 under development (Osso)
  - Atmos circulation precursors to extreme UK rainfall (Allan)
  - Time of emergence of INDECIS variables and comparison with climate models (paper) (Osso, Hawkins, All)
  - Links between INDECIS variables and atmospheric circulation patterns: thermodynamic/dynamic components (Osso, All)
  - New plans based on this meeting (Craig/Osso/All)
- **BSC:** Indices relationship with the Euro-Atlantic circulation patterns (Capacity Factor at tall towers) (Soret et al)
- **CNR:** Time evolution/trends in precipitation-Italy (Caroletti/Coscarelli/Caloiero)
  - changes in precipitation response to teleconnections through time
- **UC/IHC:** trends and links with atmospheric teleconnections Casanueva/Bedia/Herrera/Frías/Fernández/Cofiño/Gutiérrez/del Jesús/Espejo/Izaguirre/Bueno
- **FFCUL:** Surface responses for blocking and ridge regimes, heat extremes and atmospheric patterns (Aug 18, Jun/Jul 19) (Sousa, Trigo)
  - Ongoing: New automated blocking – ridge detection scheme
- **RMIB:** Methodology to study sub-hourly rainfall extremes (IDF & relation with temperature, based on observations) (Van de Vyver, Van Schaeybroeck)
  - Validation based on methodology of sub-hourly rainfall extremes of convective-permitting models (WIP)
  - Projected trends in modelled sub-hourly rainfall extremes

Summary/Actions

- D5.2 on time variability and time of emergence ready
- D5.3 on links with atmospheric circulation well advanced, can be updated to final datasets
- Albert Osso leaves Reading for Graz but continues in WP5; hiring of new researcher Philip Craig underway
- Focus on key publications: emphasis on opportunities for collaborative work
  - e.g. UoReading/UCR to on variability in sectoral indices and atmospheric circulation including blocking/weather typing
  - Link WP5/WP6 by including reanalysis products (e.g. dynamic/thermodynamic components of change; time of emergence of extremes in observations and models
  - Agree on set of standard and non-standard/sectorial relevant metrics to analyse (extreme precipitation, fire, snow, …)
  - How can WP5 more toward what sectors want? Need input
  - Coordinated analysis of wind power (WP4/5/6)?

Extra WP5 slides from University of Reading

Albert Ossó, Richard Allan, Len Shaffrey,Ed Hawkins and Emily Black

Observed emergence of the climate change signal of extreme events

Motivation

- Changes in climate are usually considered in terms of trends or differences over time. However, for many impacts which will require adaptation, it is the amplitude of the change relative to the local amplitude of climate variability which is more relevant.

- Signal-to-noise (S/N) is important for climate impacts, especially for ecosystems which have a limited ability to adapt and so large changes outside past experience could be particularly harmful.

Methodology

$$L(\mathrm{t}) = \alpha \mathrm{TsG}(\mathrm{t}) + \beta$$

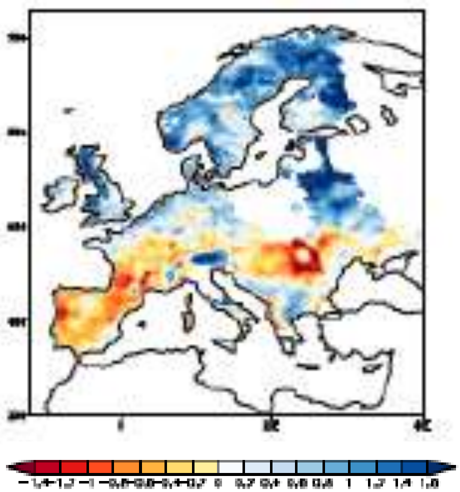
L(t) is the local change over time, TsG(t) is a smoothed version of GMST change over the same period, α defines the linear scaling between L and TsG, and β is a constant.

The ‘signal’ of global temperature change is defined as the value of the smoothed GMST in 2017, the component of local climate change explained by GMST is αG and the ‘noise’ is defined as the standard deviation of the residuals ($L - \alpha G$).

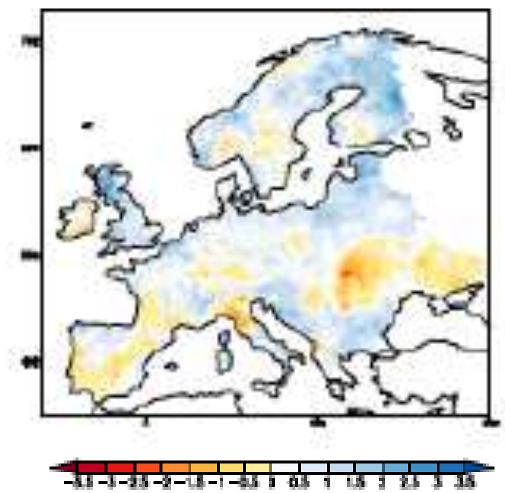
We use the INDECIS indices, HadCRU4 and CMIP6 (historical + rcp4.5) for the period (1950-2017).

Signal to noise ratio (examples)

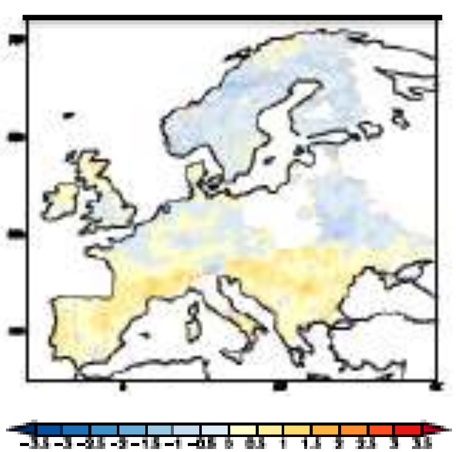
TP



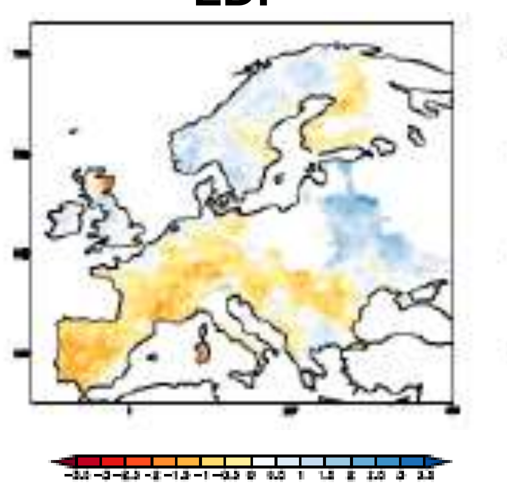
PVWD



LWP



LDP



We adopt the language of *Frame et al.* [2017]:

S/N<2 Familiar climate.

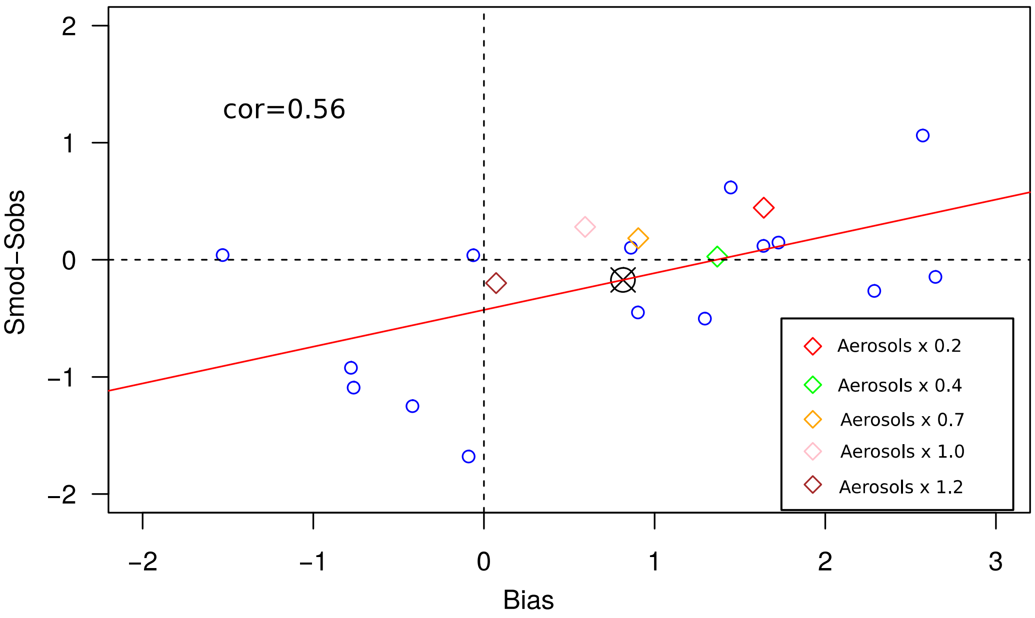
S/N>2 Unusual climate.

S/N>3 Unknown climate.

S/N>5 Inconceivable climate

Time of Emergence in summertime

Relationship between the simulated and observed temperature signal and model bias over Southern Europe



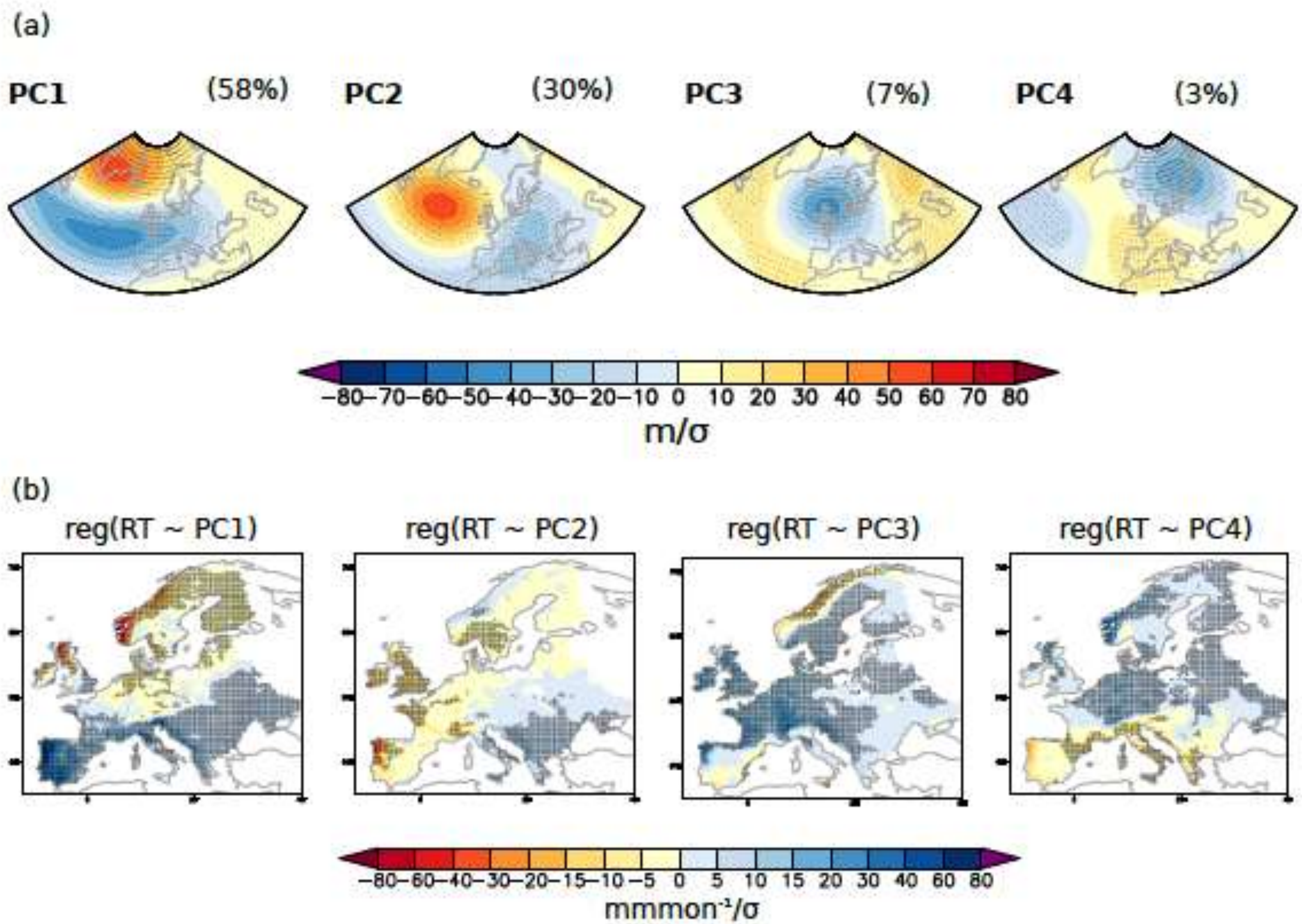
Based on the CMIP5 set and the SMURPHS ensemble

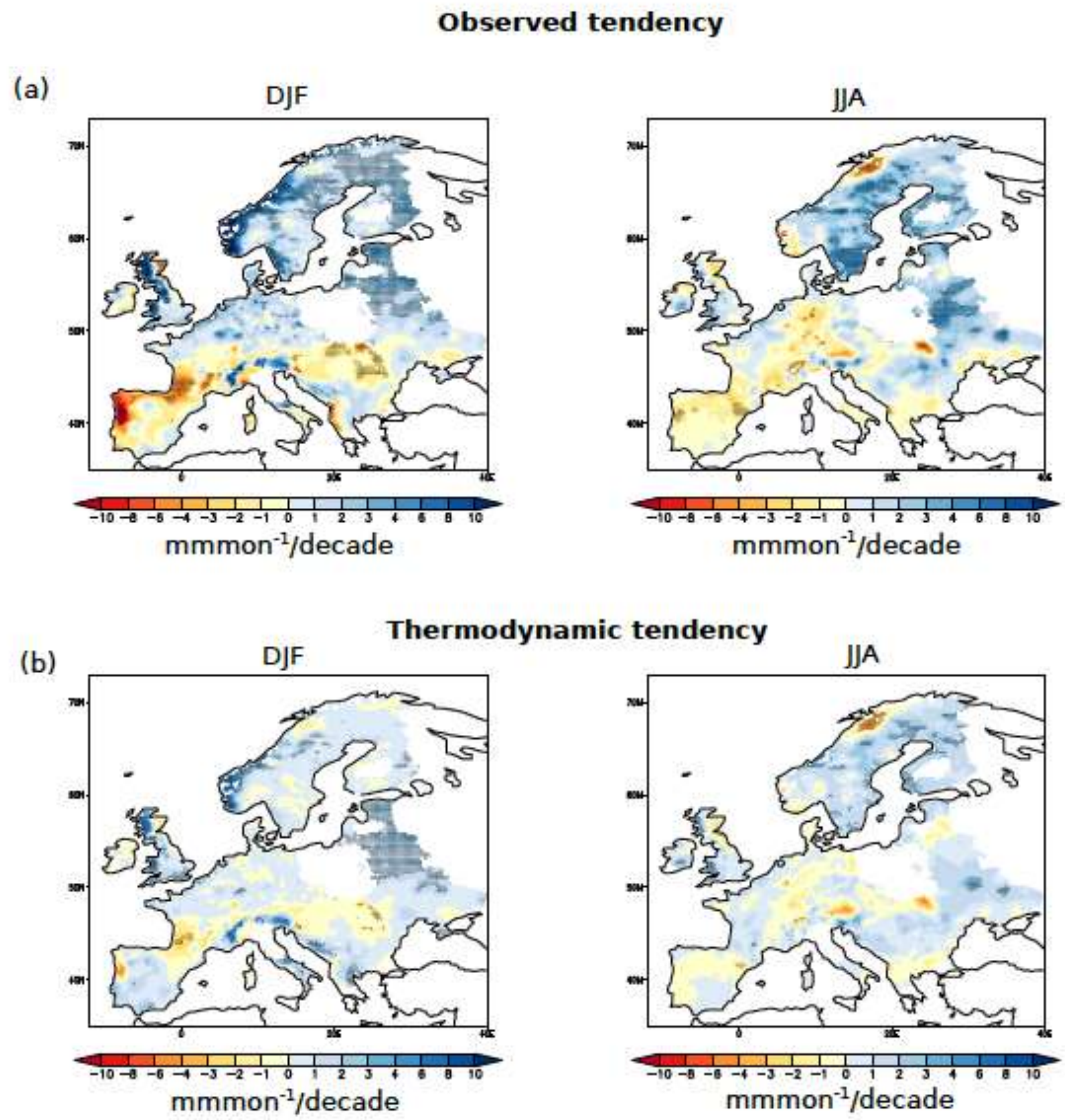
Thermodynamic vs Dynamic change

We quantify the thermodynamically driven trend by removing by linear regression the contribution of atmospheric circulation to the indices temporal evolution.

If we assume that the temporal changes in the atmospheric circulation can be represented with PCs of Z500, the regression model can be described as follows (similarly with Ceppi et al. 2012):

$$Iobs(t) = \sum_{i=1}^{i=8} \beta_i \, PC_i(t) + \varepsilon(t) \qquad (1)$$

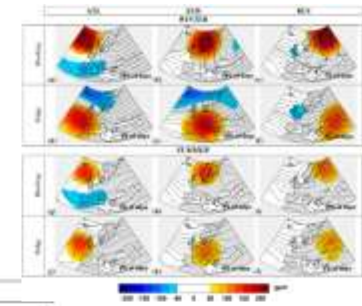

(a)
PC1
(58%)
PC2
(30%)
PC3
(7%)
PC4
(3%)
−80 −70 −60 −50 −40 −30 −20 −10 0 10 20 30 40 50 60 70 80
m/σ
(b)
reg(RT ~ PC1)
reg(RT ~ PC2)
reg(RT ~ PC3)
reg(RT ~ PC4)
−80 −60 −40 −30 −20 −15 −10 −5 0 5 10 15 20 30 40 60 80
mmmon⁻¹/σ


Observed tendency
(a)
DJF
JJA
−10 −8 −6 −4 −3 −2 −1 0 1 2 3 4 6 8 10
mmmon-1/decade
Thermodynamic tendency
(b)
DJF
JJA
−10 −8 −6 −4 −3 −2 −1 0 1 2 3 4 6 8 10
mmmon-1/decade

Extra slides from Pedro Sousa/Ricardo Trigo FFCUL

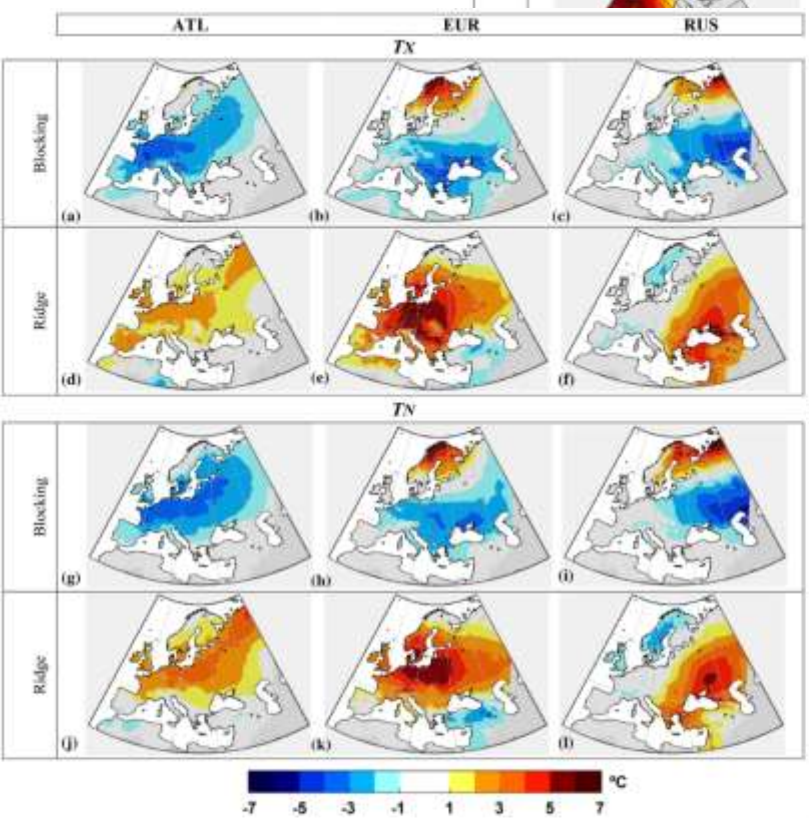
Surface responses for blocking and ridge regimes

2m temperature

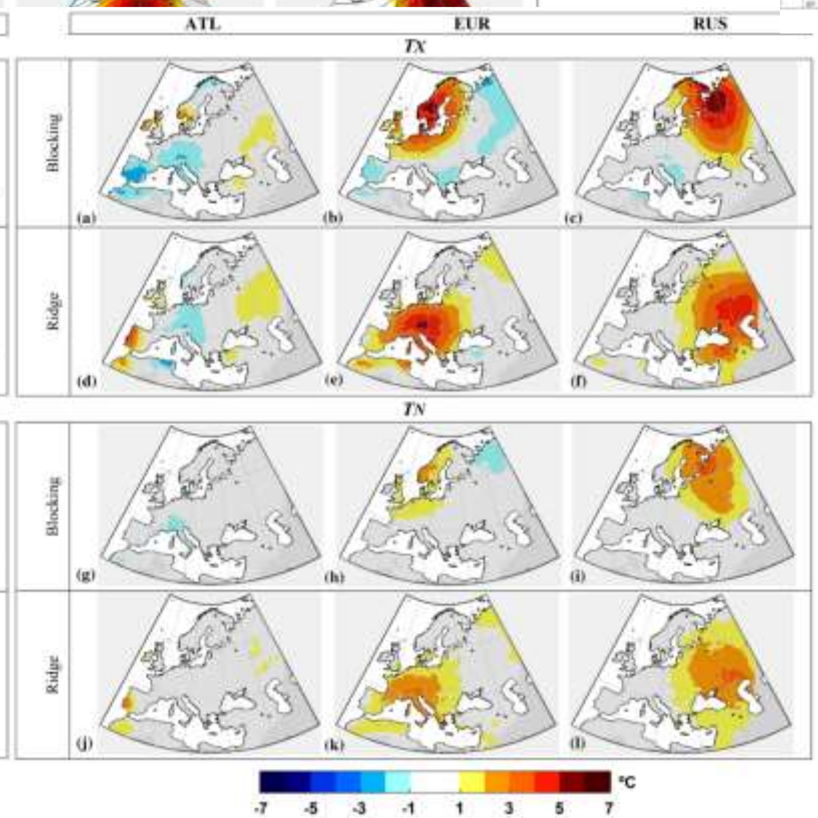


Z500 composites

winter



summer



i) Opposite responses in winter:

Ridge- mild

Block – cold

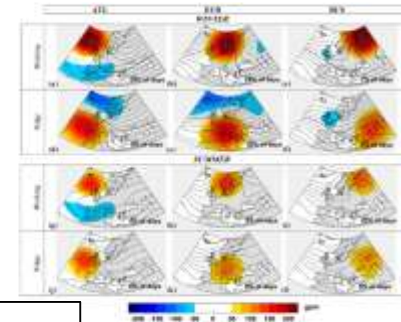
ii) More similar responses in summer:

Block - hot north

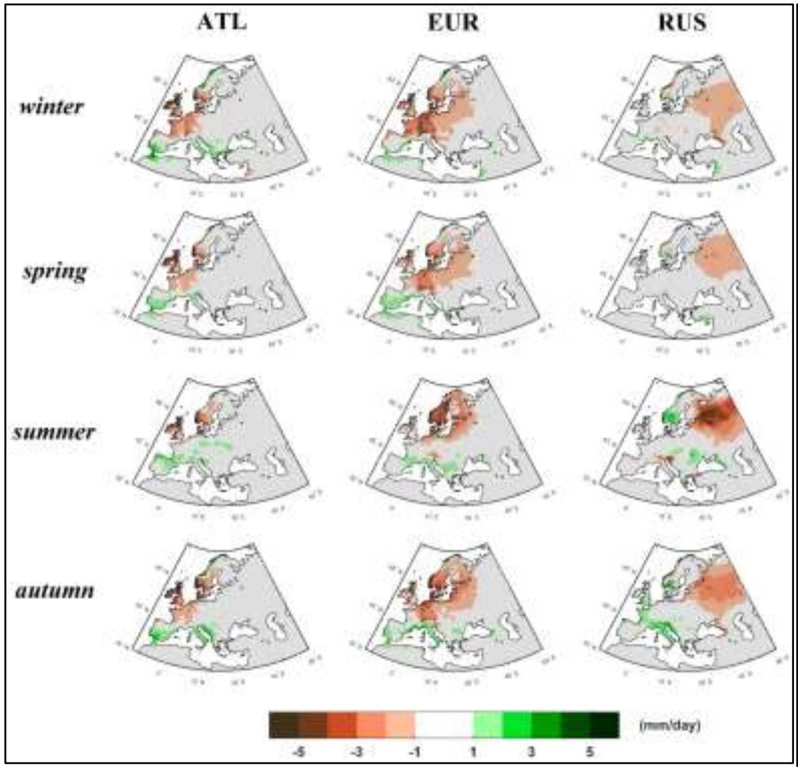
Ridge - hot south

Surface responses for blocking and ridge regimes

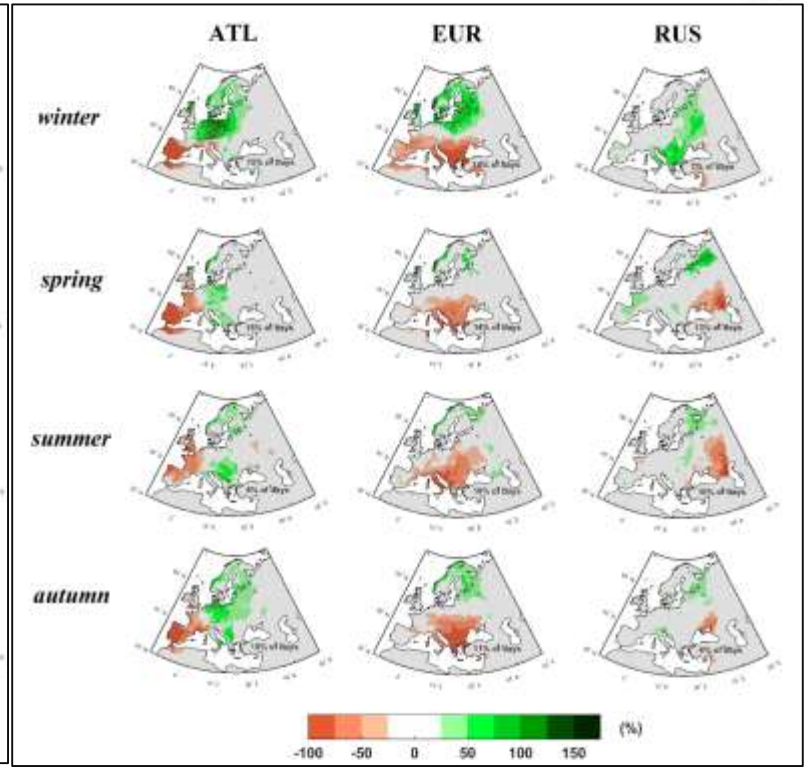
Rainfall



blocks



ridges

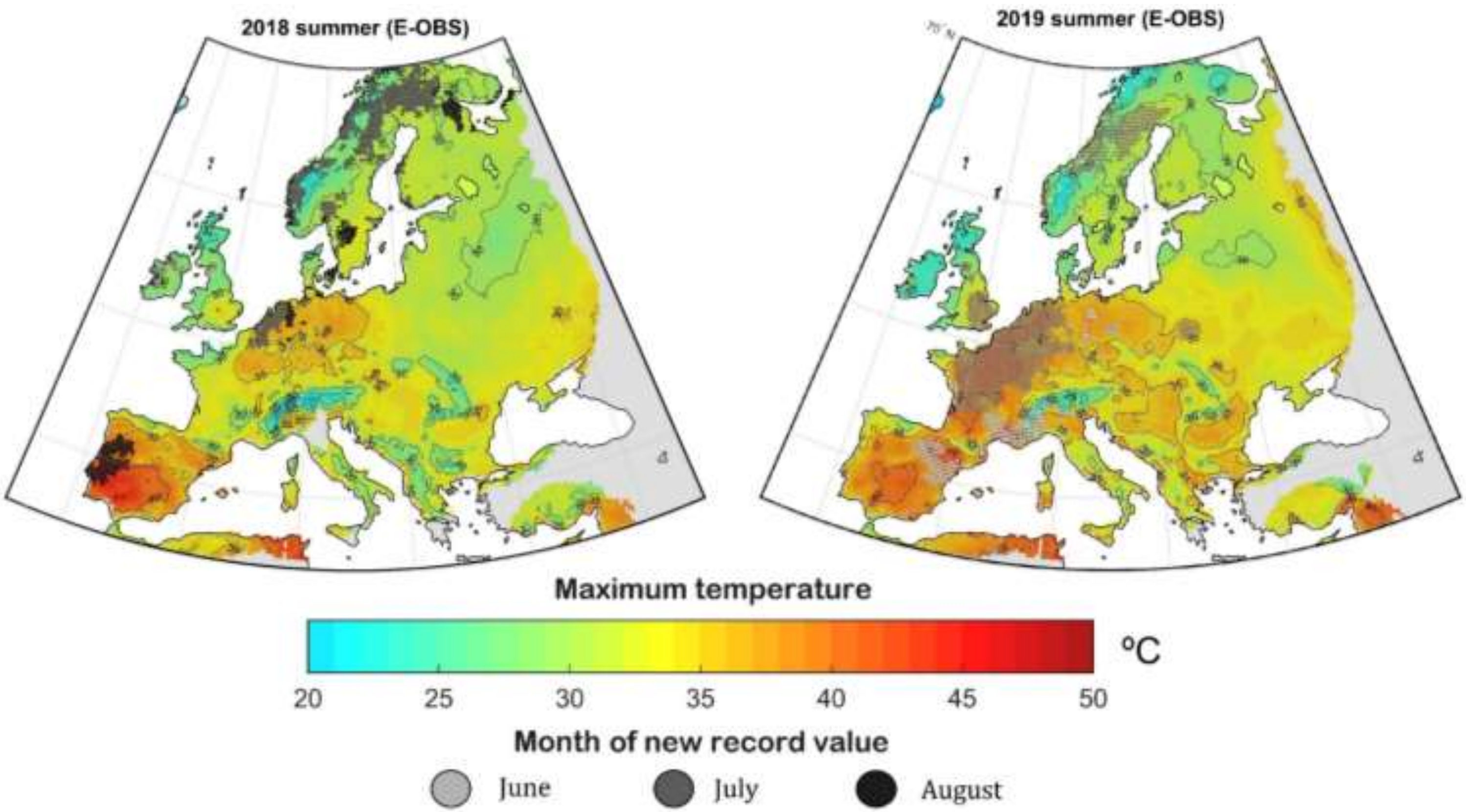


Opposite responses all year round:

Ridge- wet north
dry south

Block- dry north
wet south

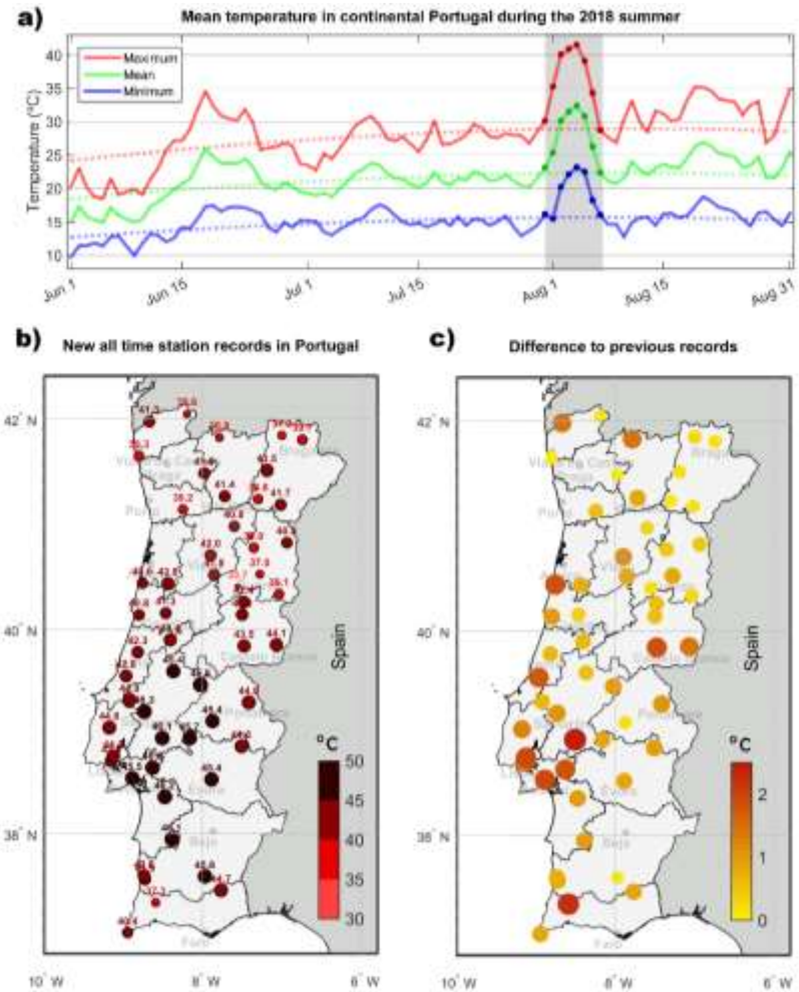
Recent record-breaking temperature events in Europe



Sousa et al. (2019)

Weather and Climate Extremes

Extreme heat episode in Portugal – August 2018

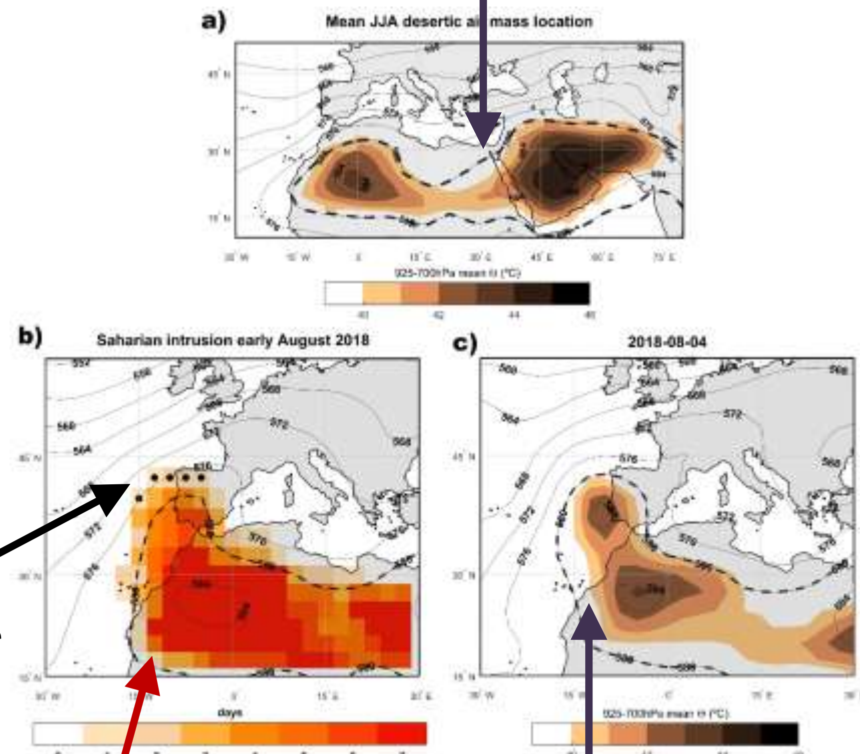


i) More than 50% of the country with Tmax>40°C

ii) 17 stations with Tmax>45°C

iii) 40% of stations broke all-time records

Typical location of desert air masses

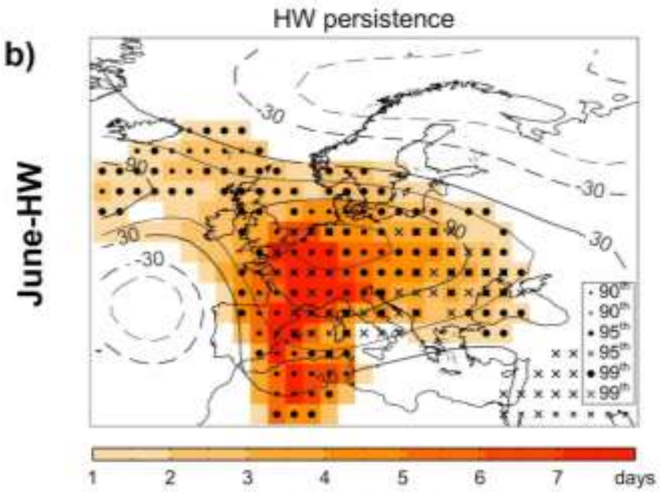


First time ever here

Intrusion persistence

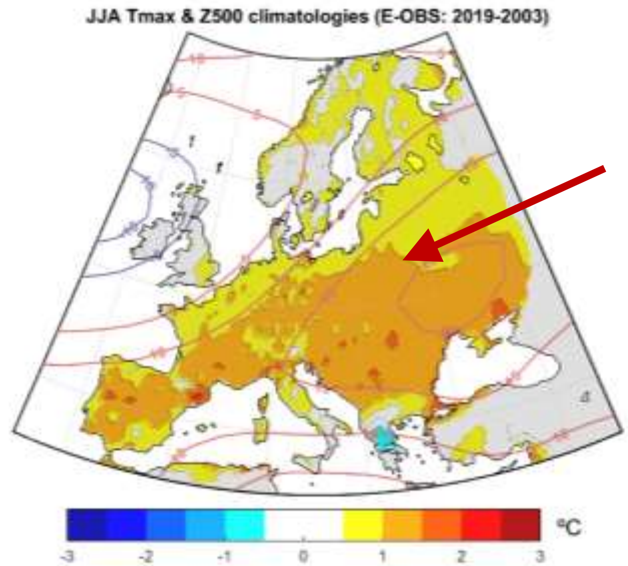
Subtropical ridge with Saharan intrusion

Extreme heat episodes in Central Europe – June/July 2019



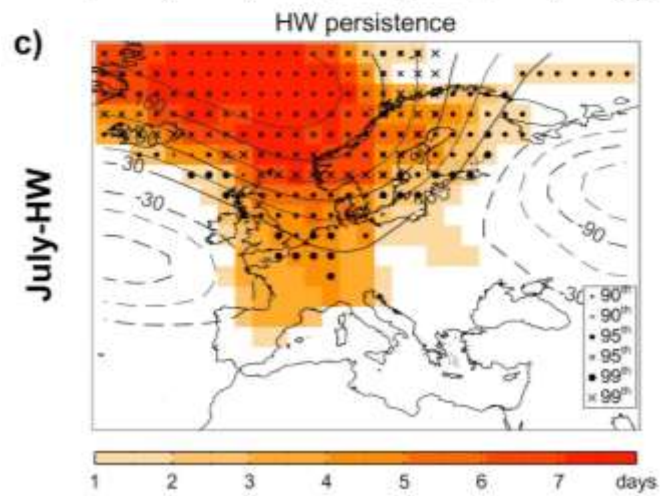
June 2019

First time ever that France registered >45°C



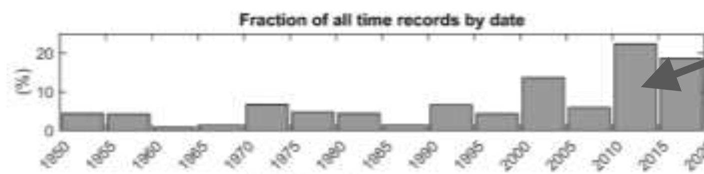
Since the historical 2003 heatwave, summer mean temperatures have increase > 1°C in Europe.

In just 15 years!!!

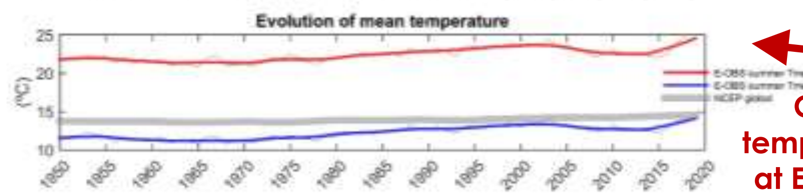


July 2019

First time ever that Belgium & Netherlands registered >40°C

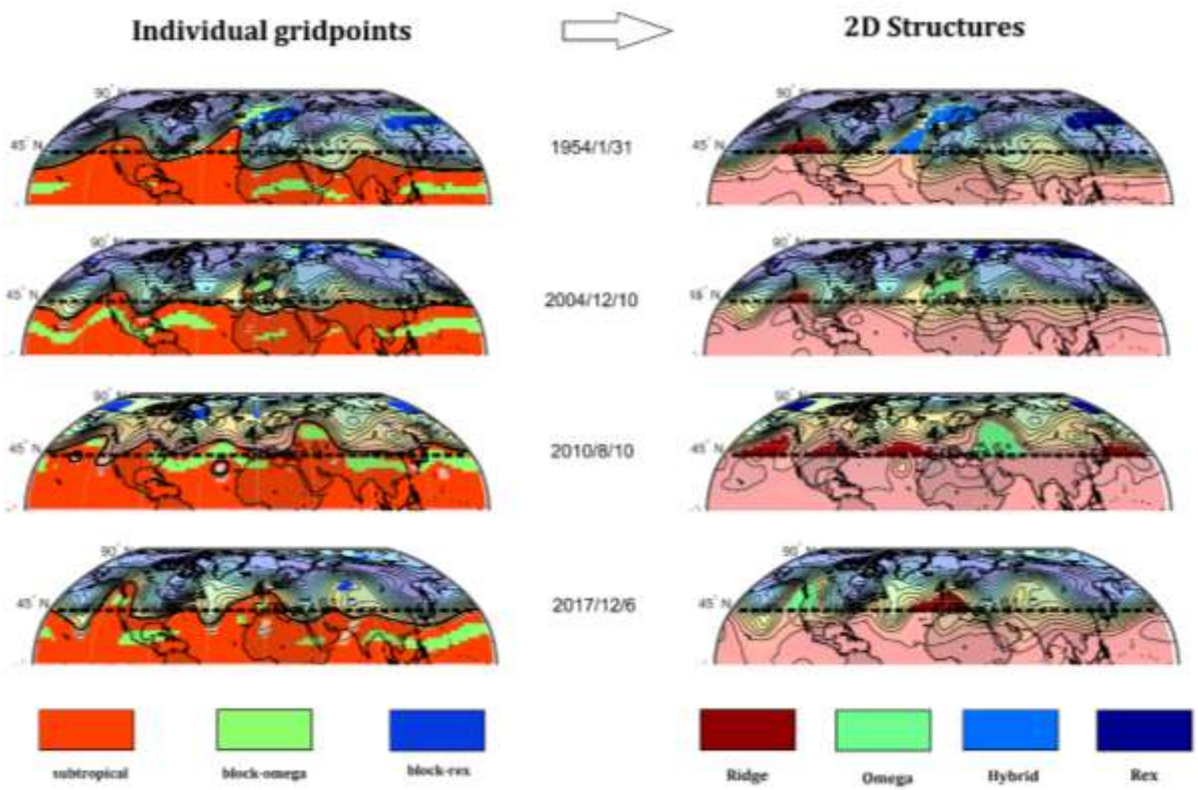


Frequency of new records has been increasing over and over



Continuous temperatures rises at European and Global scales!

Ongoing work: **New automated blocking – ridge detection scheme**



Sousa et al. (2019)

in preparation

i) New dynamical methodology

ii) Captures Blocks (distinguishing Omega and Rex types)

iii) Captures the extent of subtropical ridges (subtropical intrusions)

iv) Auto-calibrated, so usable for different models and <u>different climate scenario</u>s