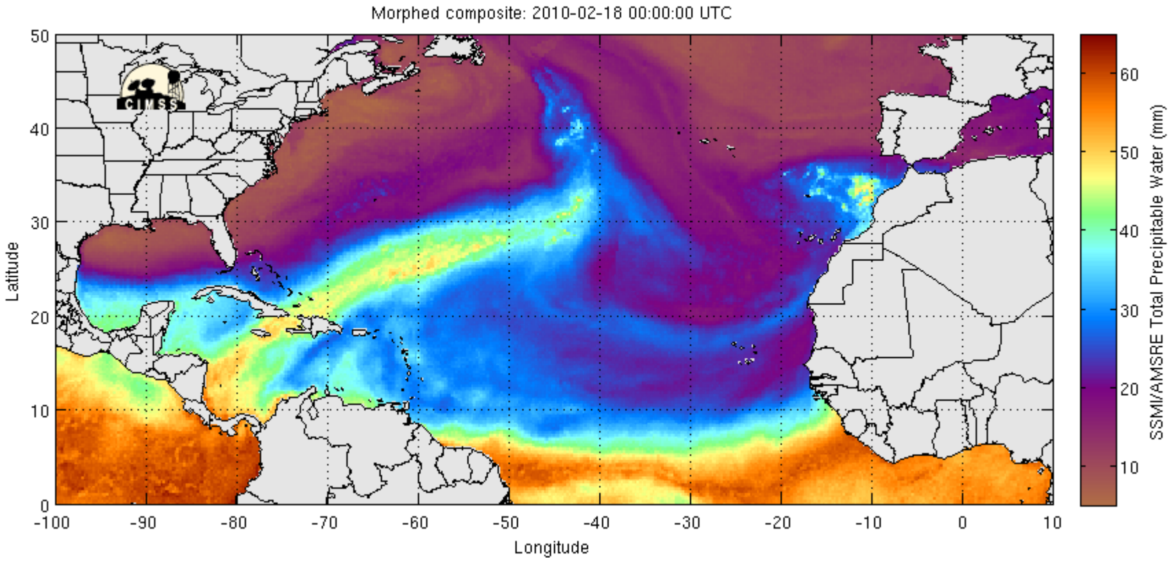
Long-term variability regional changes in precipitation since 850 and the role of the water vapor transport



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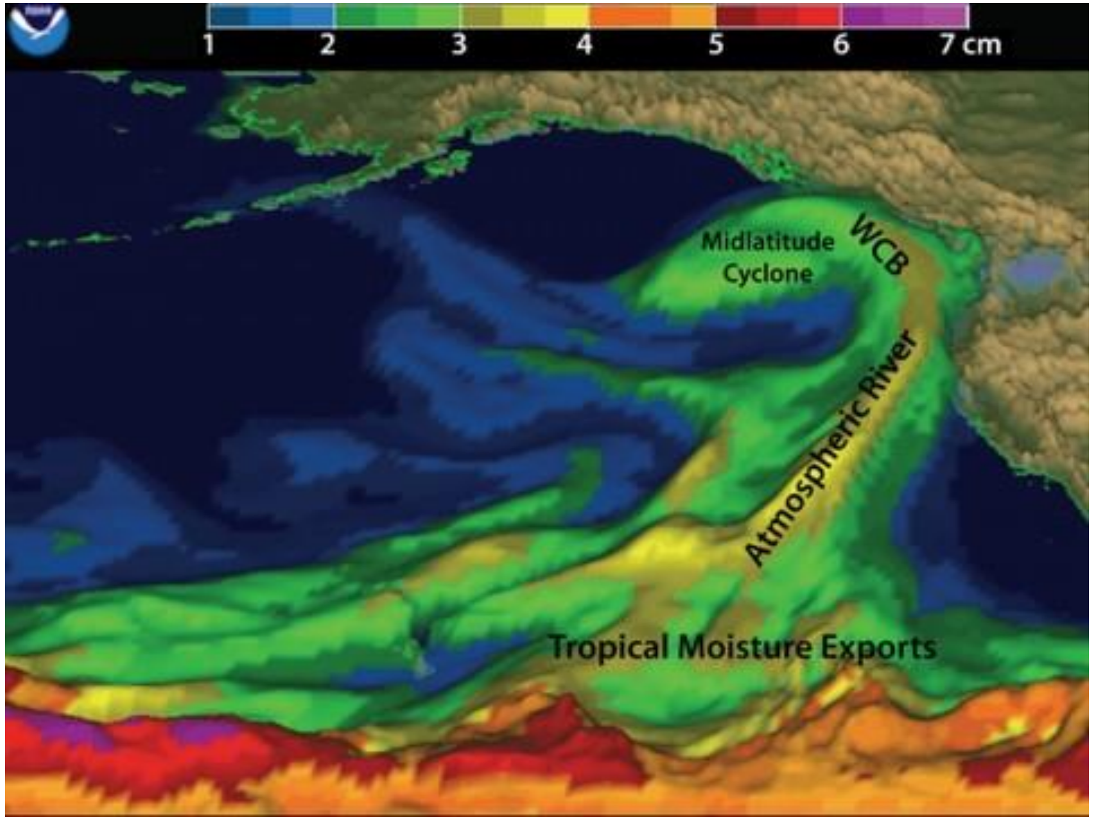
Outline

- ARs influence areas in Europe and impacts
- Integrated water vapor transport and ARs Detection
- ARs– CIMP5 Future Scenarios
- Long-Term simulation

1) ARs influence areas in Europe and impacts

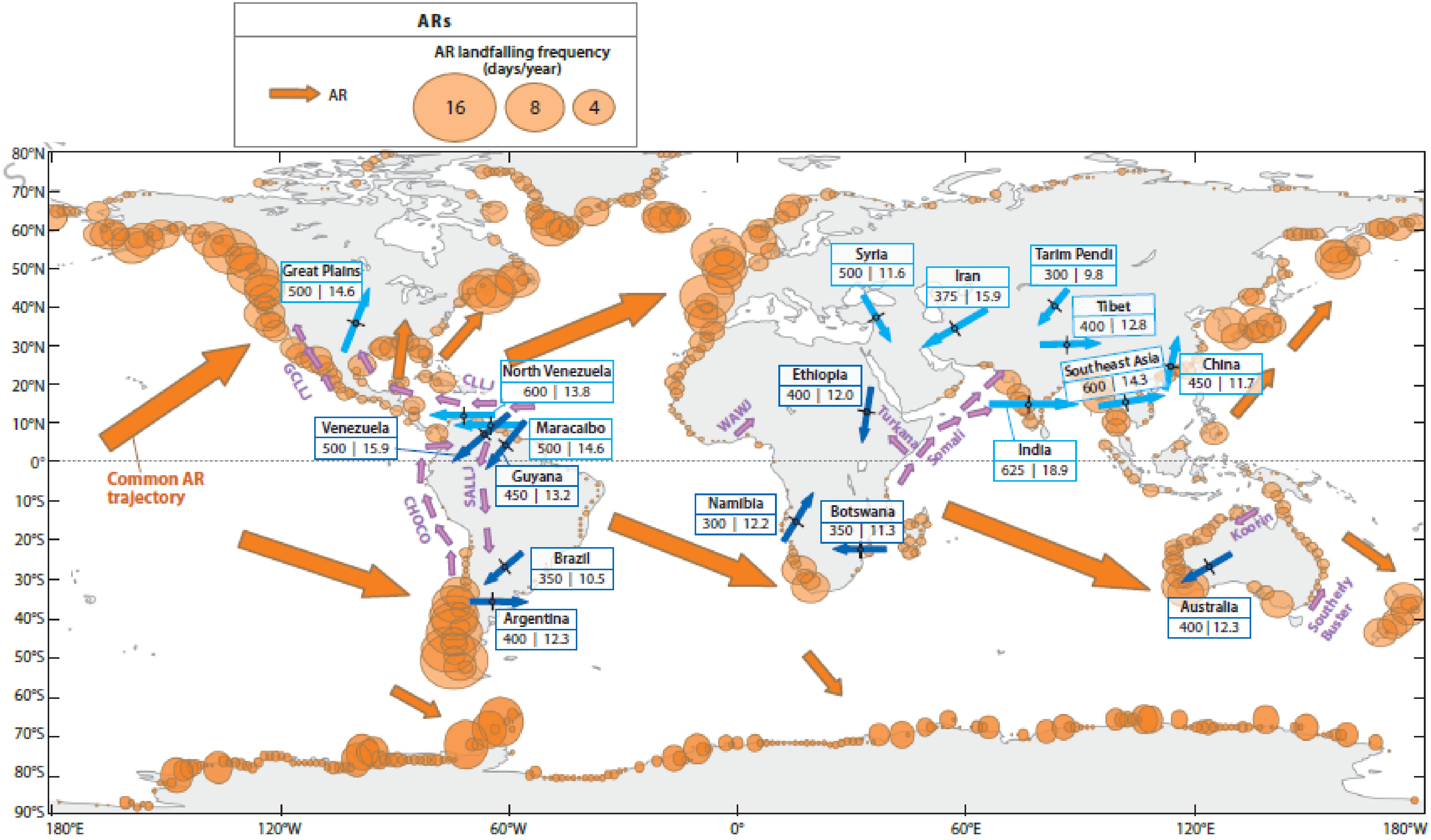
Atmospheric Rivers



A long (~2000km), narrow (~850km), and transient corridor of strong horizontal water vapor transport that is typically associated with a low-level jet stream ahead of the cold front of an extratropical cyclone. The water vapor in atmospheric rivers is supplied by tropical and/or extratropical moisture sources. Atmospheric rivers frequently lead to heavy precipitation where they are forced upward—for example, by mountains or by ascent in the warm conveyor belt.

AMS, Glossary

1) ARs influence areas in Europe and impacts



ARs climatology provided by Guan and Waliser, 2015.

Adapted from Gimeno et al., 2016, Annu. Rev. Environ. Resour

1) ARs influence areas in Europe and impacts

Average AR fraction in (%) in each month

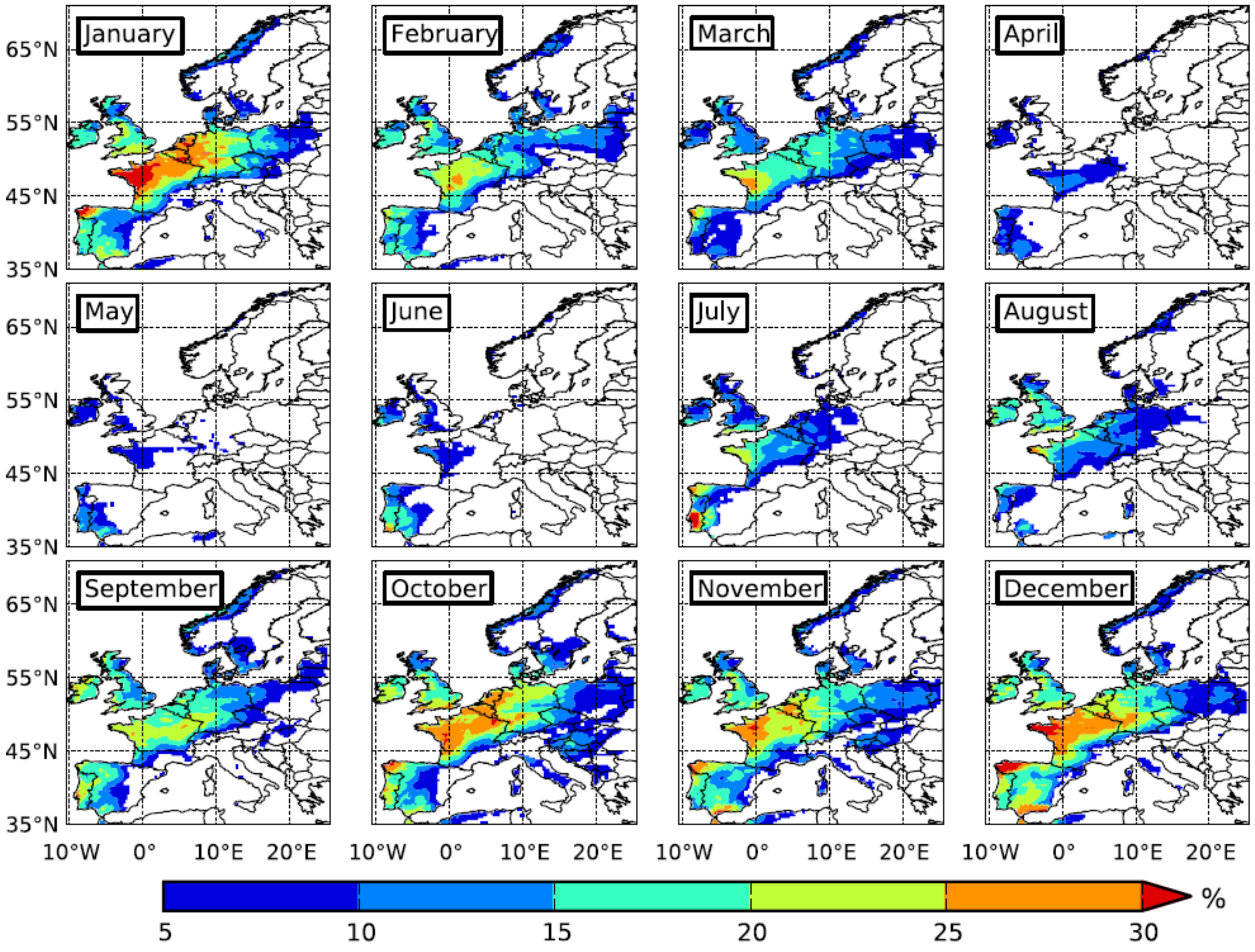
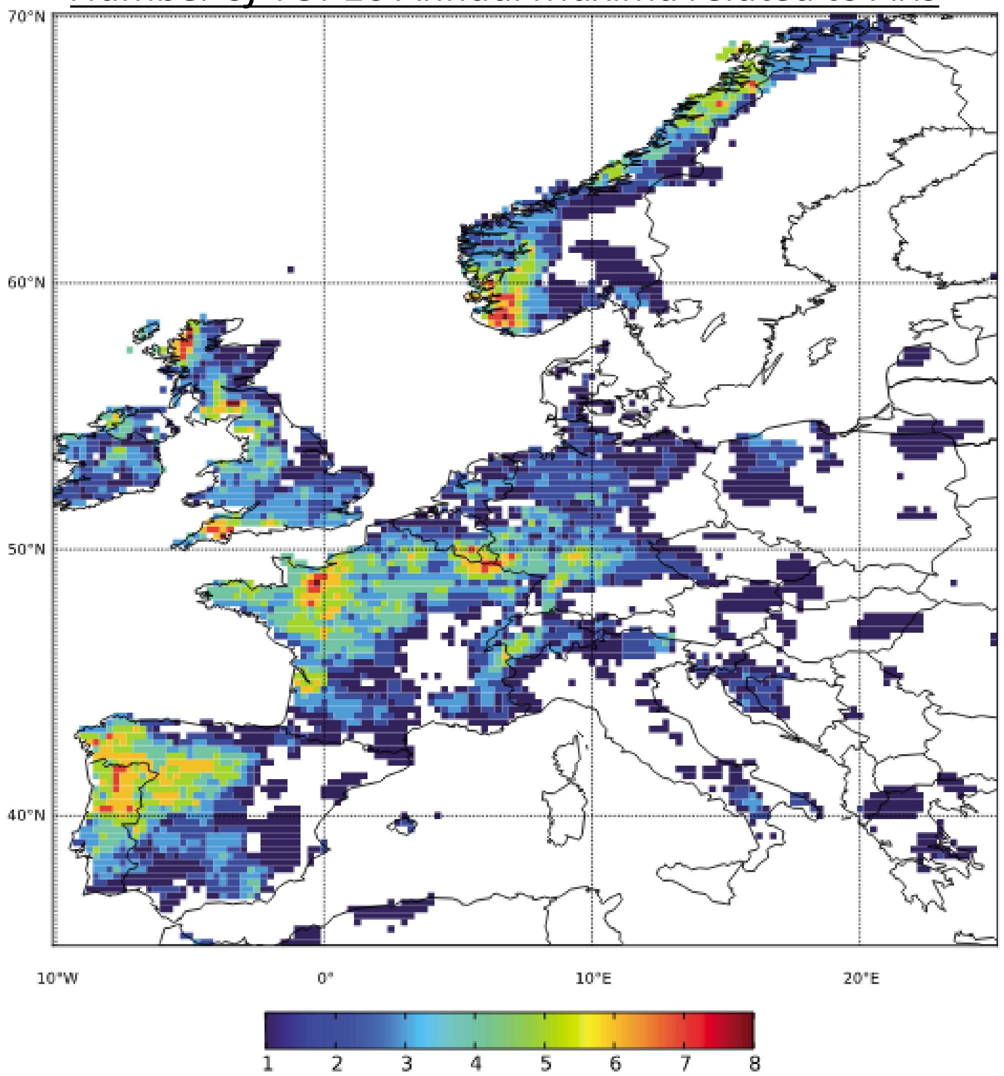


Fig. 2. The average AR fraction (in%) in each month from Europe over the period 1979–2012.

Lavers and Villarini, 2015

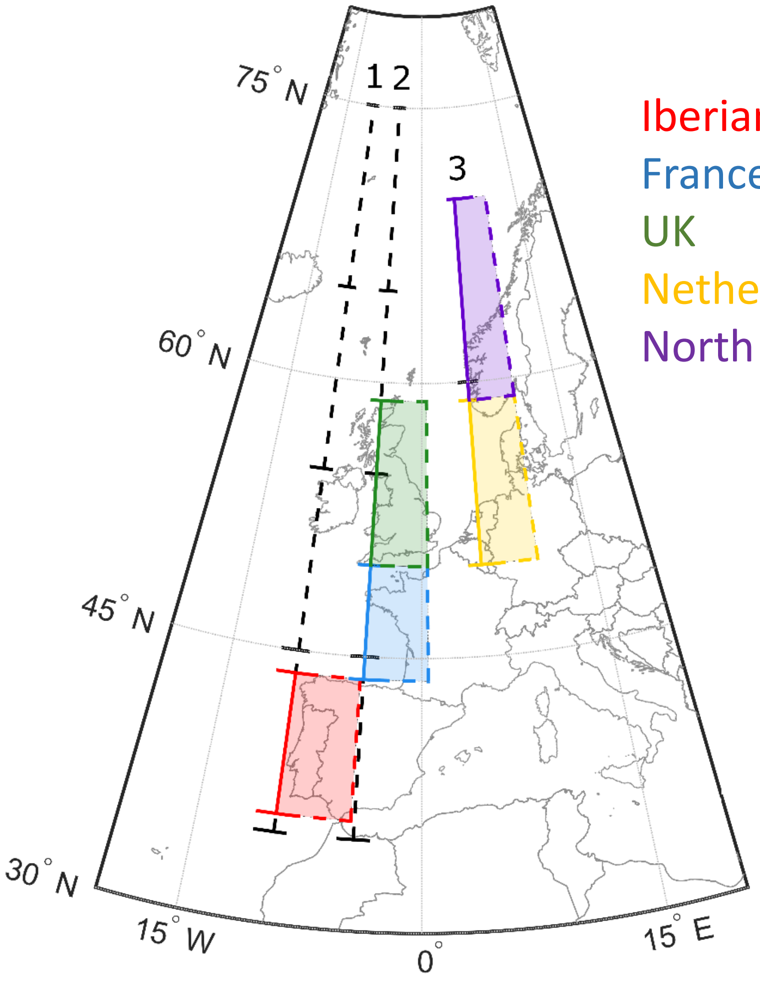
Number of TOP10 Annual Maxima related to ARs



Lavers and Villarini, 2013

2) Integrated water vapor transport and ARs Detection

ARs detection scheme (based on Ramos et al., 2015, using vertically integrated water vapor transport (IVT) as input variable for the detection scheme) was applied to 3 reference meridians leading ultimately to 5 domains.



Iberian Peninsula
France
UK
Netherlands and S. Scandinavia
North Scandinavia

- Moisture Sources of the ARs impacting Europe (Ramos et al., 2016a)
- Future Climate scenarios ARs impacting Europe (Ramos et al., 2016b)
- Catalogue of hydro-geomorphological events and their atmospheric forcing (Pereira et al., 2018)
- Predictability of the ARs (ongoing work)
- ARTMIP Project (ongoing work)

$$IVT = \sqrt{\left(\frac{1}{g}\int_{1000hPa}^{300hPa} qu\,dp\right)^2 + \left(\frac{1}{g}\int_{1000hPa}^{300hPa} qv\,dp\right)^2}$$

Ramos et al. 2015, J. Hydrometeorology
Ramos et al., 2016a, Earth Syst. Dynam
Ramos et al., 2016b, Geo Res Lett
Pereira et al., 2018, Adv. Water Res

3) ARs– CIMP5 Future Scenarios

RCP4.5 and RCP8.5 Climate Change Scenarios

6 Climate Models

	Resolution	Consecutive grid points	Minimum Length	Past Present Climate	RCP4.5 RCP8.5
ERA-Interim (ERA)	*0.75 x 0.75*	*36*	*1728*	***1980-2005***	-
BCC-CSM (**BCC**)	~2.812 x ~2.812	10	1800	***1980-2005***	***2074-2099***
CAN-ESM (**CAN**)	~2.812 x ~2.812	10	1800		
GFDL-ESM2G (**GFD**)	2.5 x 2.5	11	1760		
NOR-ESM1 (**NOR**)	2.5 x 2.5	11	1760		
CNRM-CM5 (**CNR**)	~1.406 x ~1.406	19	1710		
EC-Earth (**ECE**)	1.125 x 1.125	24	1728	1850-2009	2006-2099

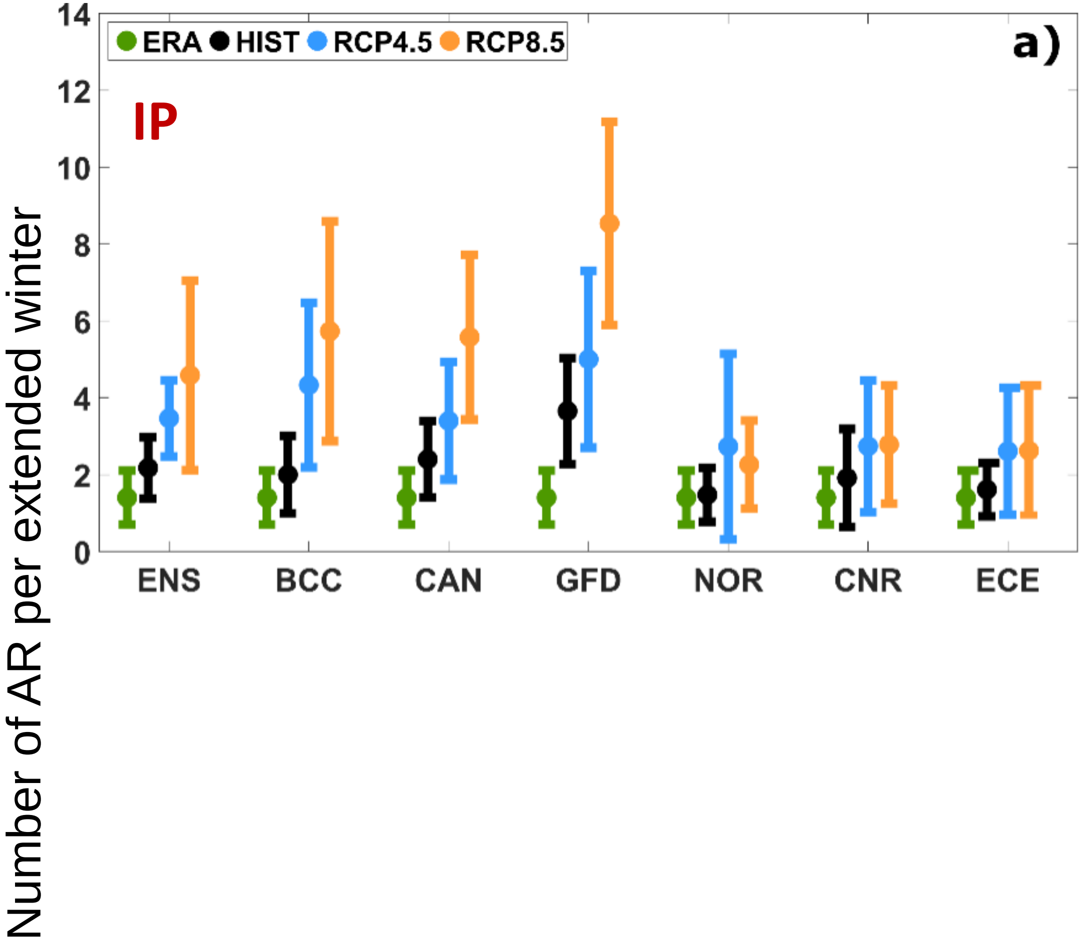
High temporal resolution 6h

Model levels between 1000 hPa to 300 hPa

Ramos et al., 2016b, Geo Res Lett

3) ARs– CIMP5 Future Scenarios

ARs frequency



Iberian Peninsula

Historical 1980-2005

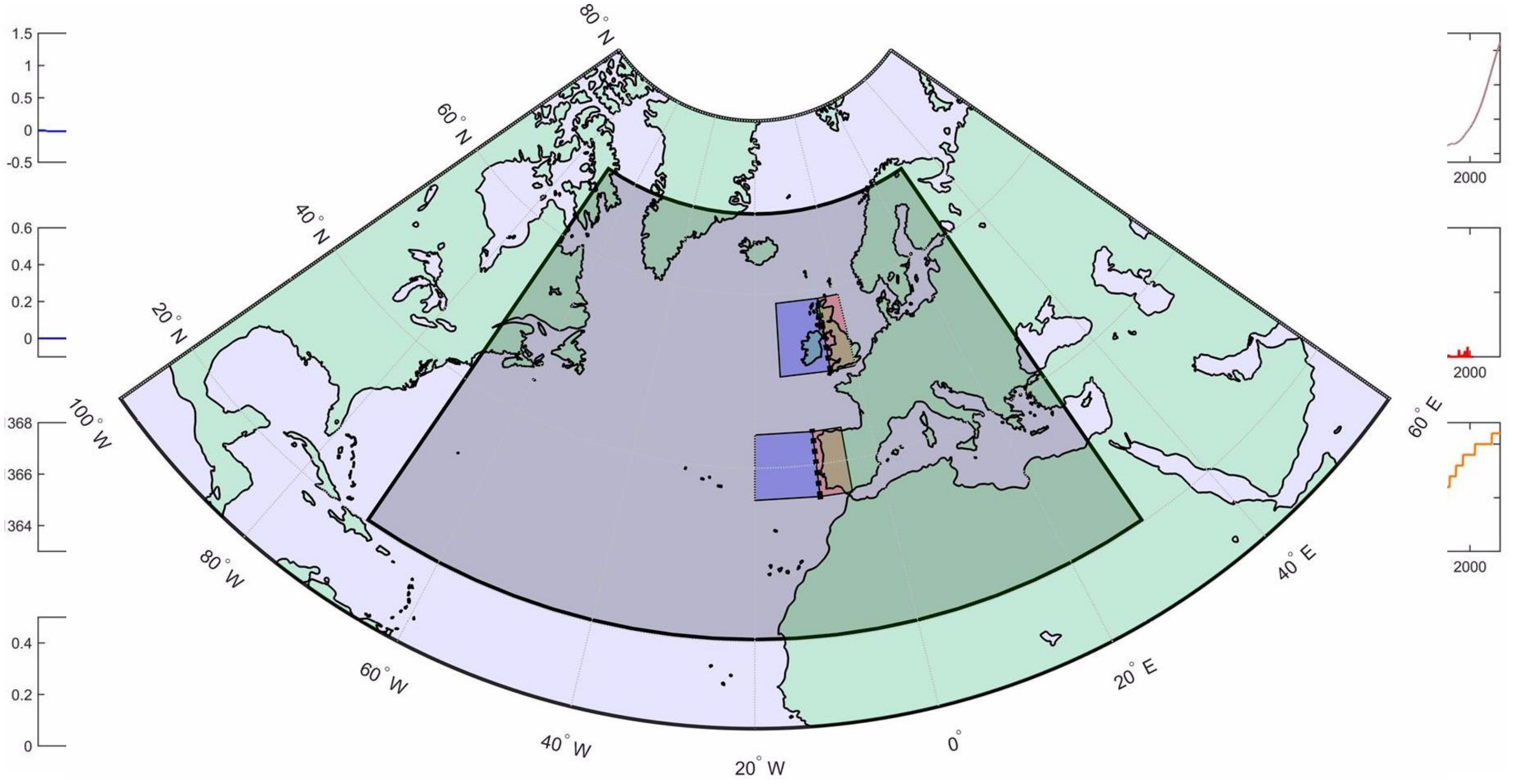
Future 2074-2099

Threshold for the computation of the ARs was the **historical** one for both periods.

Ramos et al., 2016b, Geo Res Lett

4) Long-Term simulation

Will the increase in the number of ARs and higher values of IVT in Future scenarios produce more precipitation?



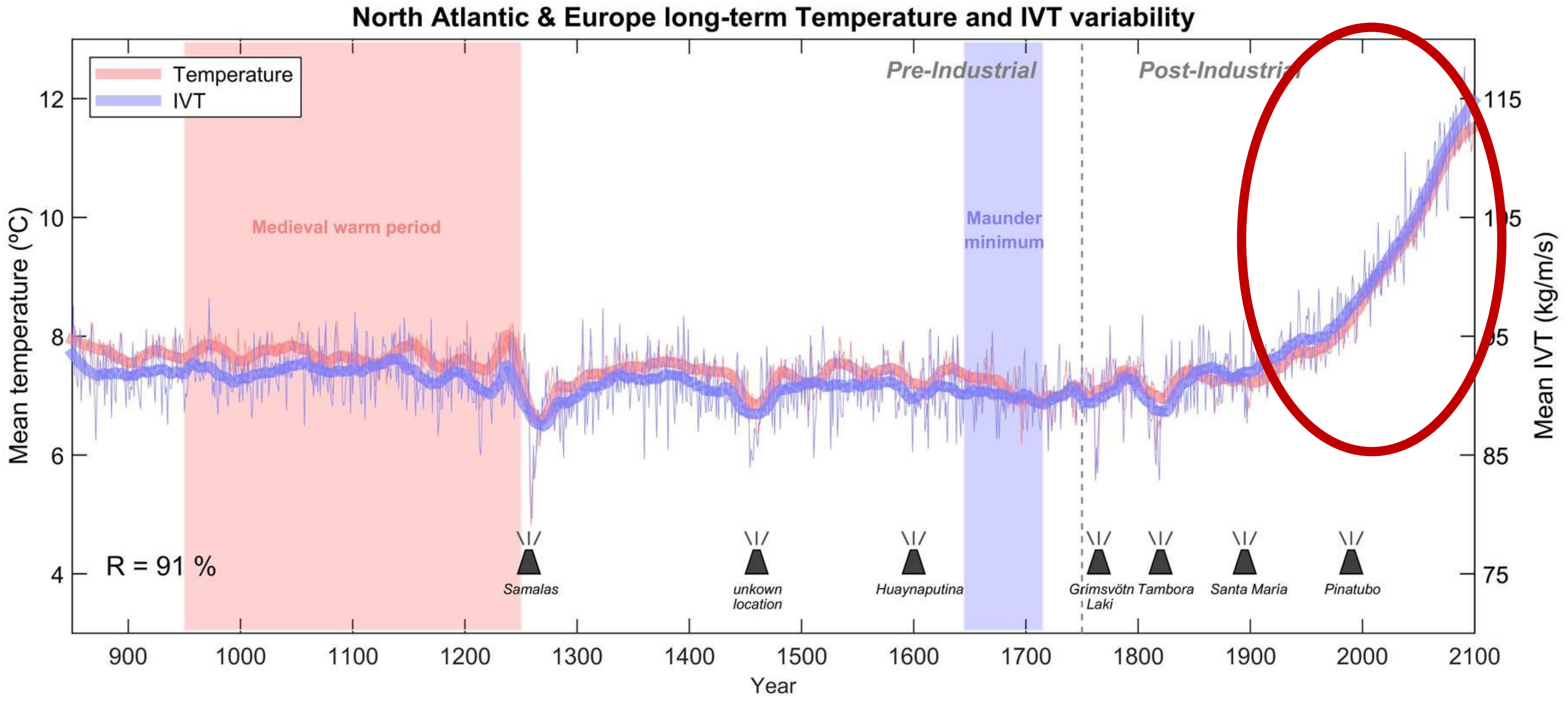
CESM 1.0.1 ([Community Earth System Model]):
•0.9x1.25 grid box

Experiment (**Lehner et al., 2015, Earth Syst. Dynam**)
•Transient simulation from 850 to 2100 with **RCP8.5 with 12 h output data**

4) Long-Term simulation

Will the increase in the number of ARs and higher values of IVT in Future scenarios produce more precipitation?

North Atlantic & Europe domain



CESM 1.0.1 (Community Earth System Model):
•0.9x1.25 grid box

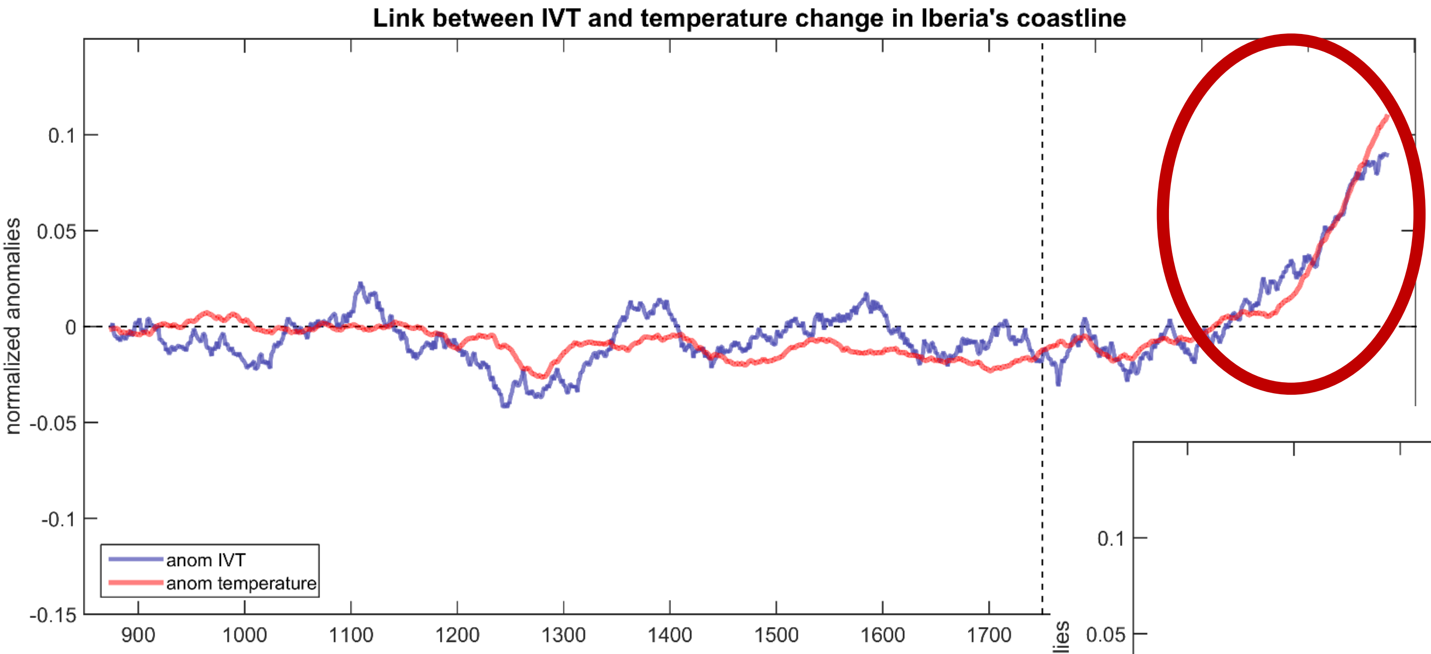
Experiment (**Lehner et al., 2015, Earth Syst. Dynam)**
•Transient simulation from 850 to 2100 with **RCP8.5 with 12 h output data**

4) Long-Term simulation

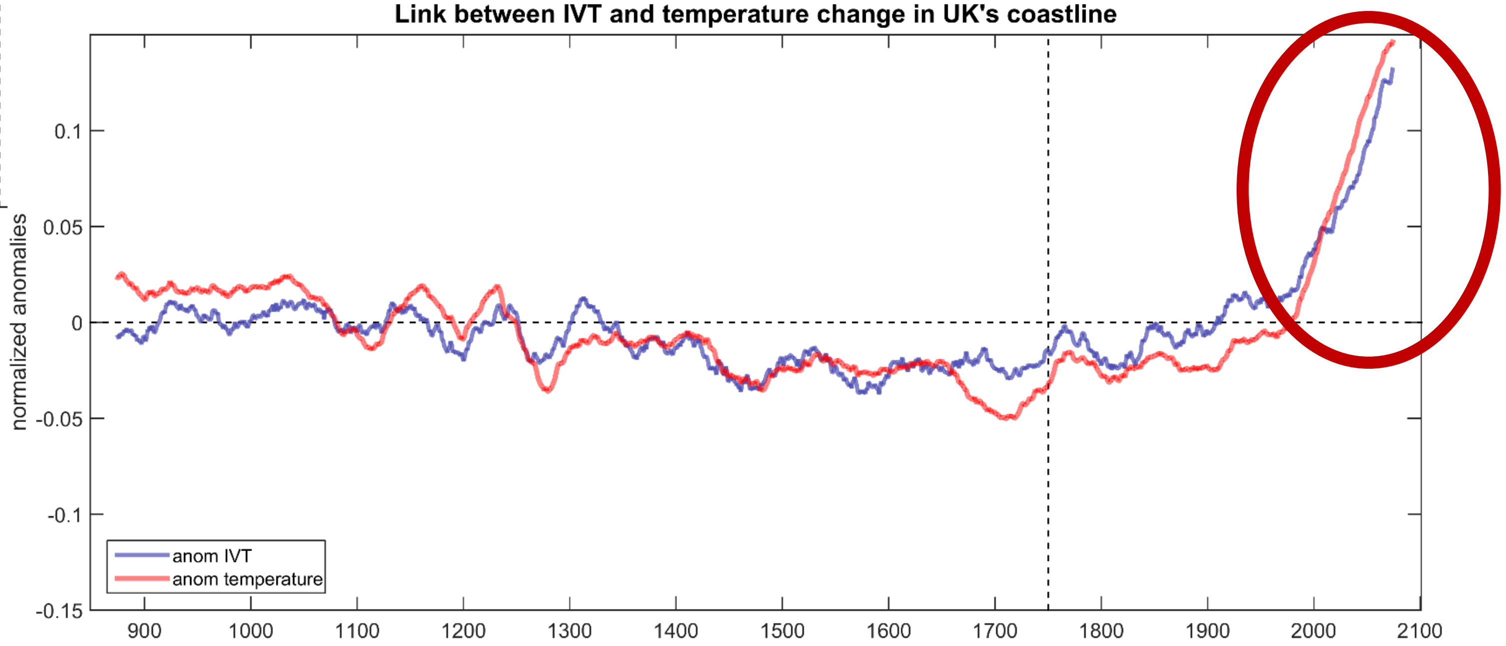
Will the increase in the number of ARs and higher values of IVT in Future scenarios produce more precipitation?

IVT vs Temperature

Iberian Peninsula



UK

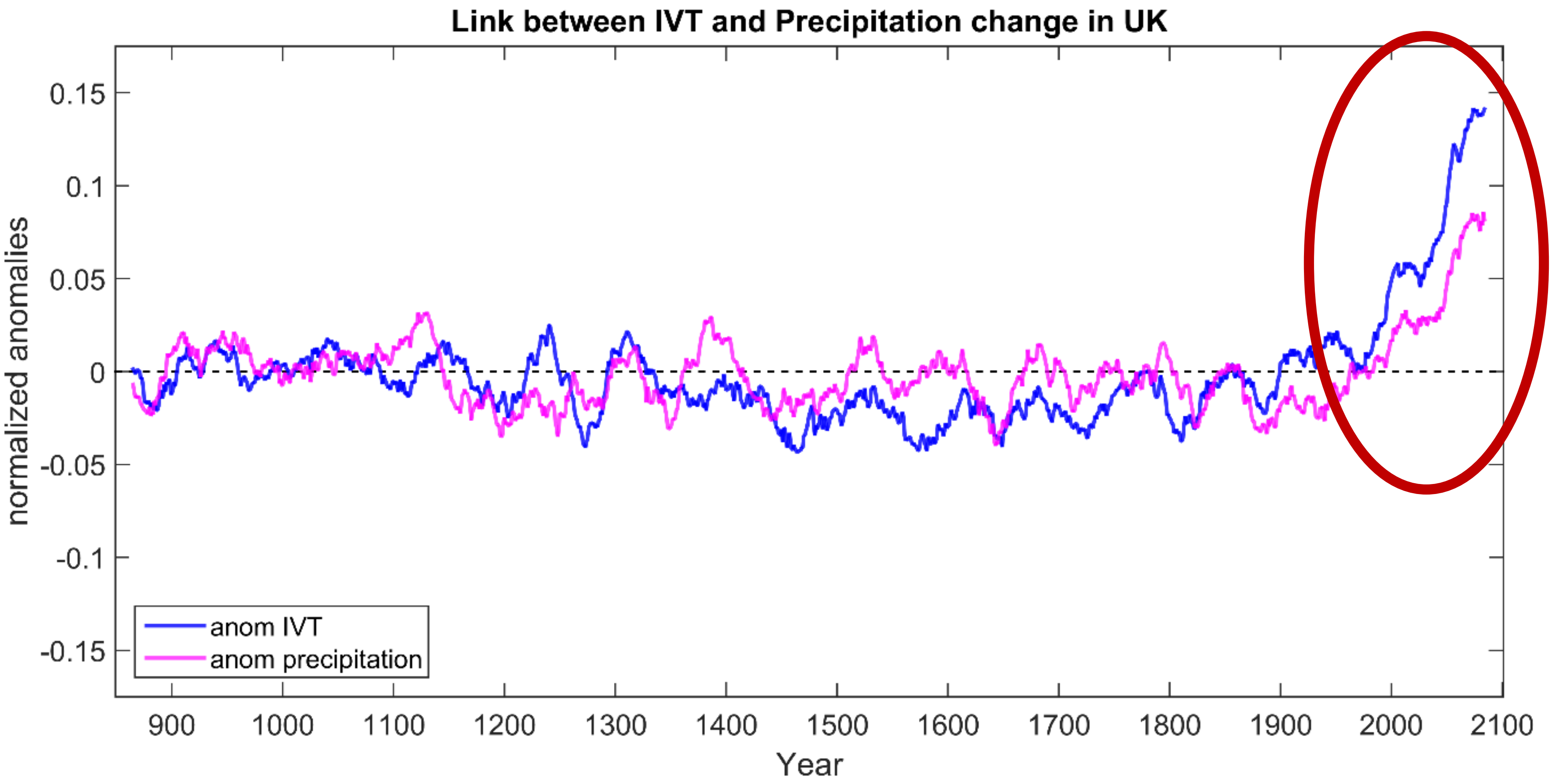


4) Long-Term simulation

Will the increase in the number of ARs and higher values of IVT in Future scenarios produce more precipitation?

IVT vs Precipitation

United Kingdom

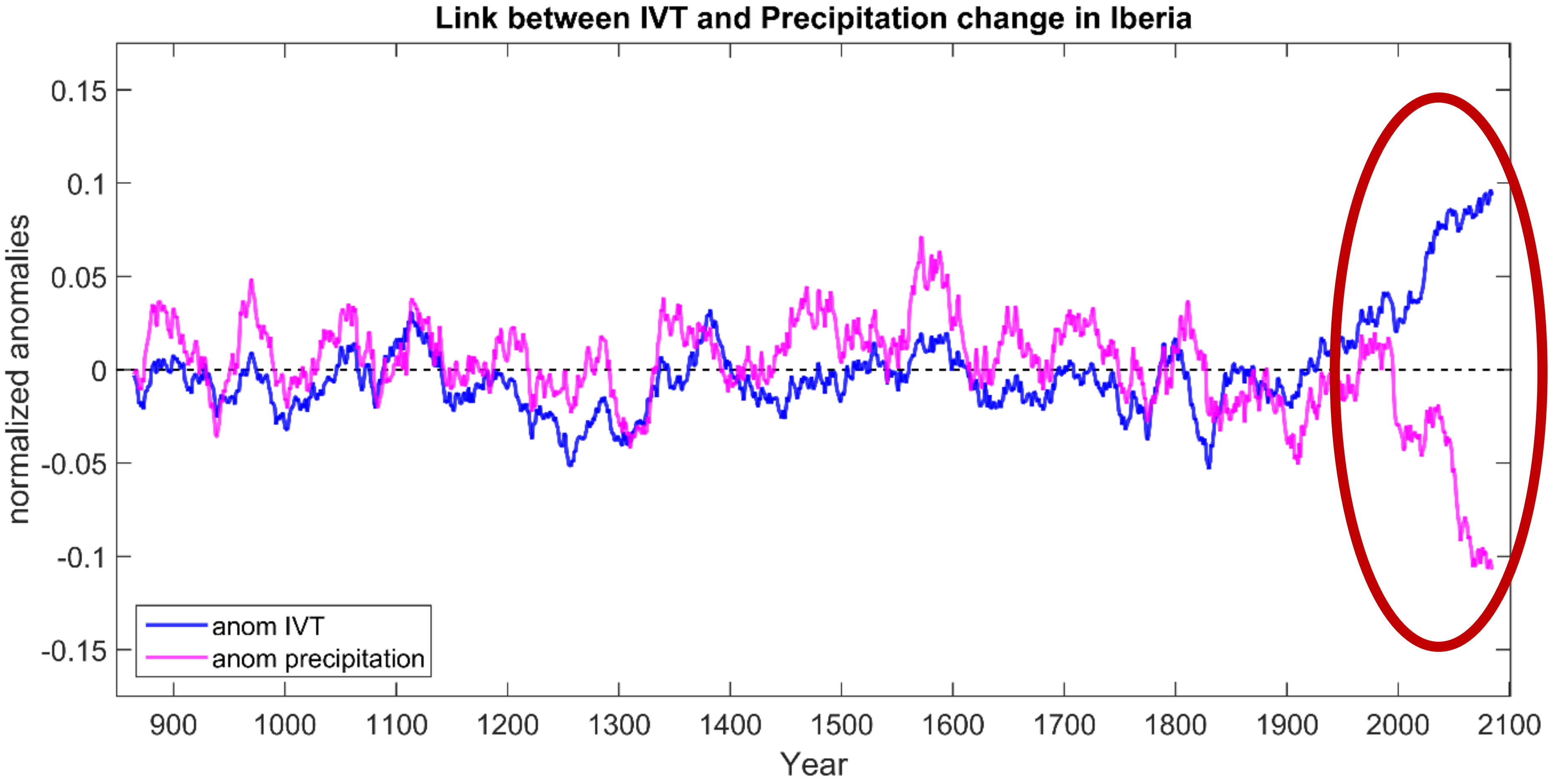


4) Long-Term simulation

Will the increase in the number of ARs and higher values of IVT in Future scenarios produce more precipitation?

IVT vs Precipitation

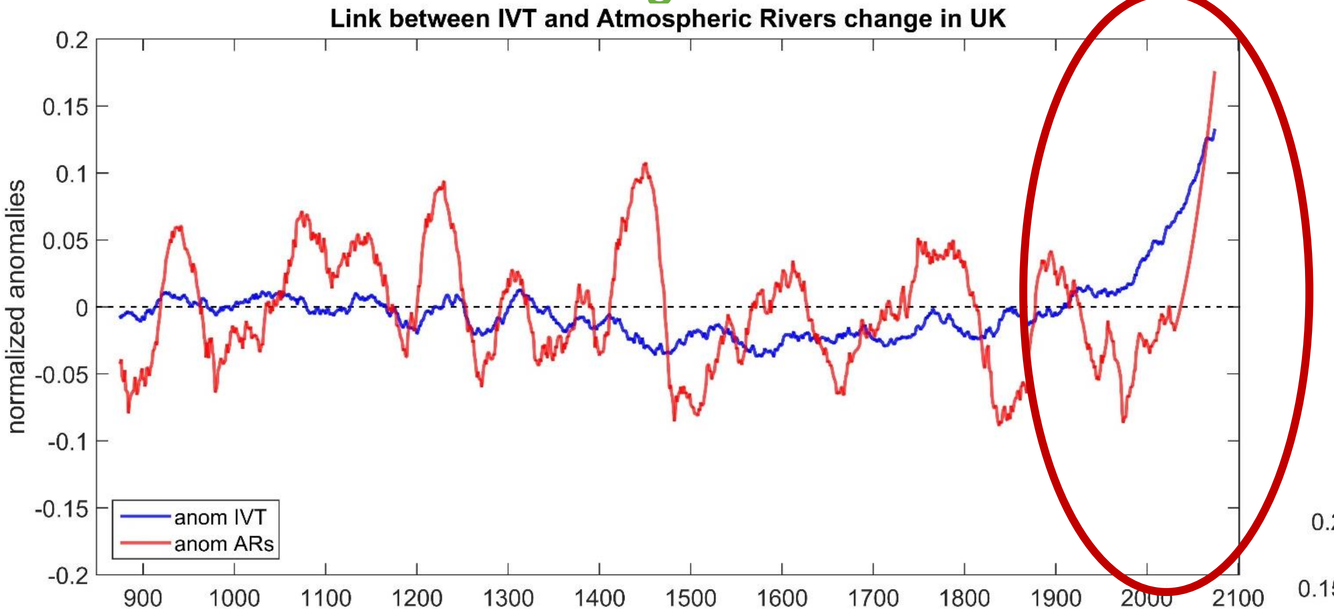
Iberian Peninsula



4) Long-Term simulation

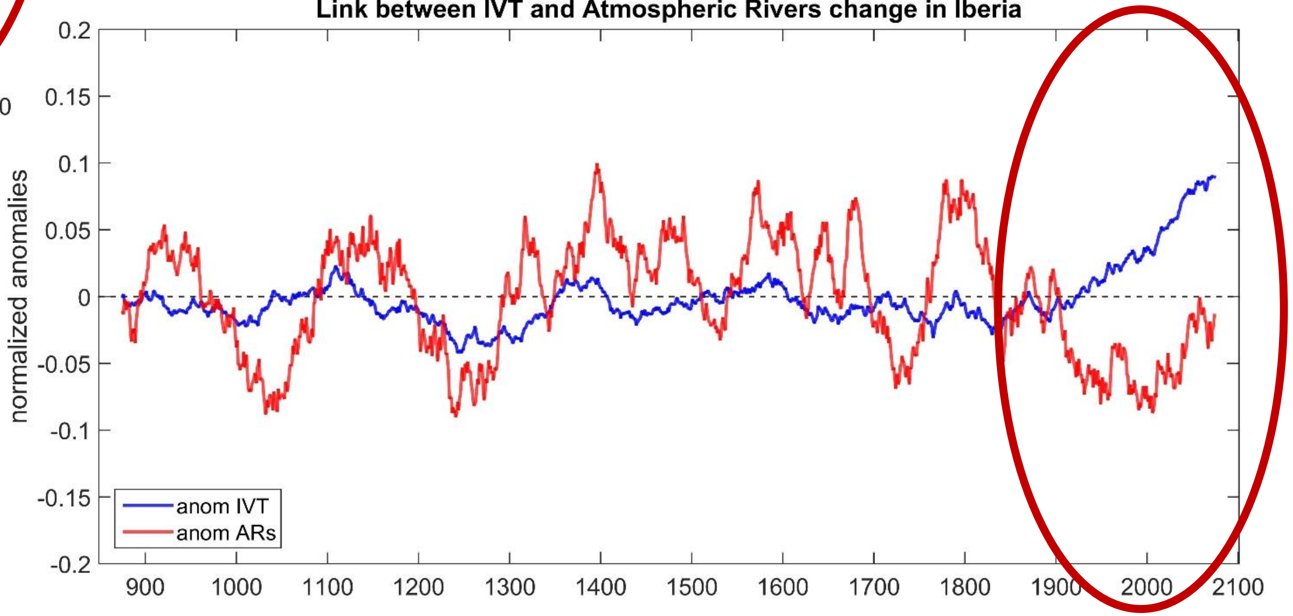
Dynamical changes in a future warmer climate

United Kingdom



IVT vs ATMOSPHERIC RIVERS

Iberian Peninsula

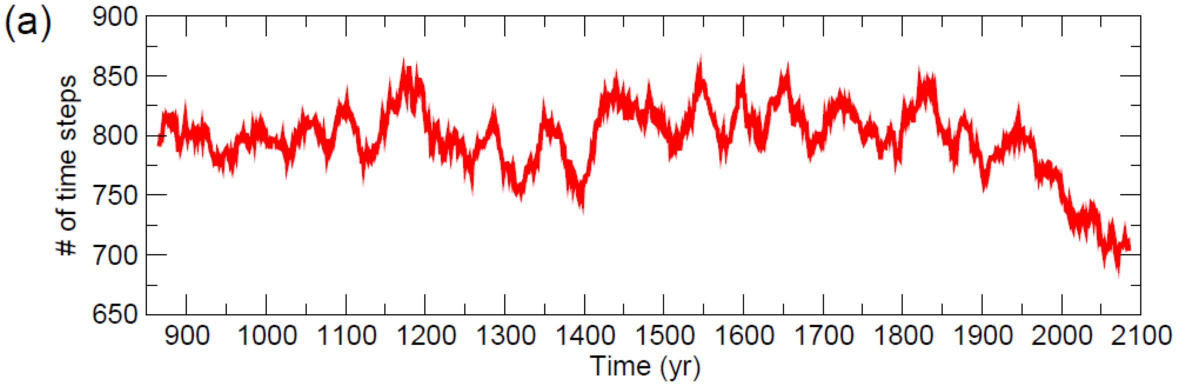


ARs are computed taking into account a **IVT 30-year moving threshold** over the **850-2100** period in order to remove the **thermodynamical** effect.

4) Long-Term simulation

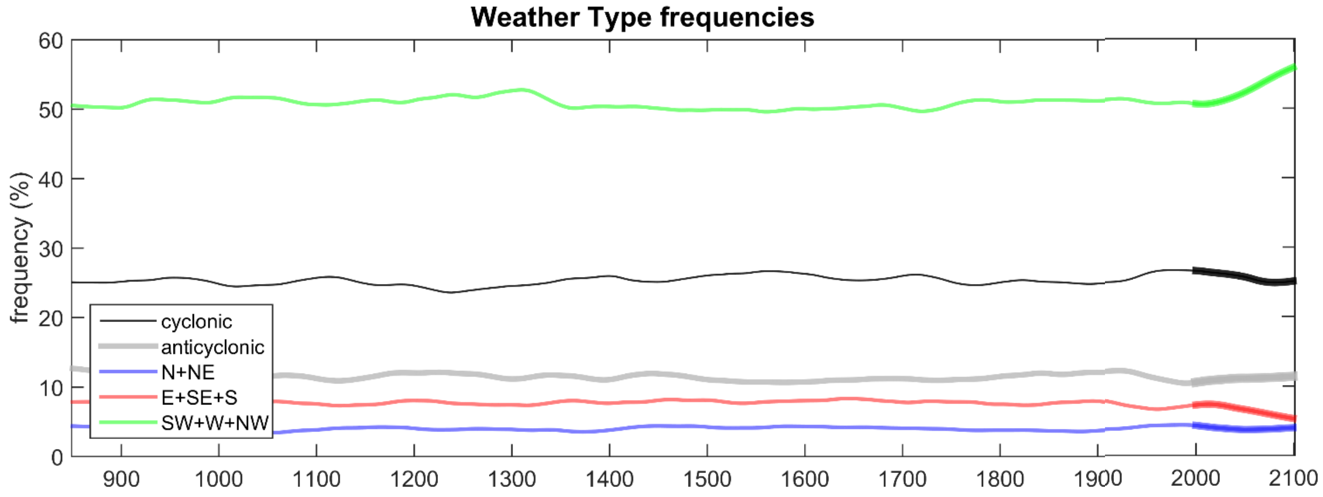
Dynamical changes in a future warmer climate

30-yr running window cumulative cyclone presence

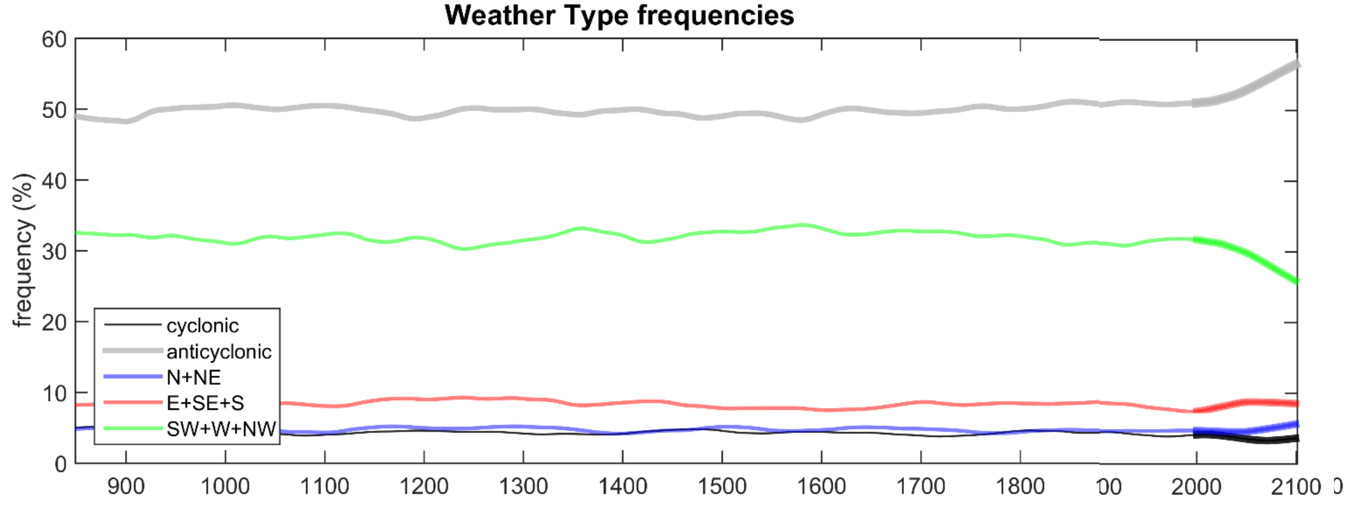


Raible et al., 2018 Clim. Past Discuss

United Kingdom



Iberian Peninsula



Conclusions

- ARs have different areas of influence in Europe **with major socio-economic impacts** <u>specially in western Europe</u>;

- The **frequency and intensity** of ARs <u>increases along the European Coast in both RCP scenarios</u>, particularly for RCP8.5; The increase in the number of ARs is robust and is **projected to double on average** in the northern domains compared to the historical period;

- The connection between the increase in the IVT and precipitation in future climate scenarios it´s not trivial. It is on phase in the Northern domains and off-phase in the Iberian Peninsula;

- In the case of the UK there is: an increase in moisture transport, ARs frequency, and wet CWTs, and consequently in precipitation.

- For the Iberian Peninsula, there is <u>no clear increase in ARs frequency</u>, despite moisture transport increase. Furthermore, there is an increase in the anticyclonic type with a decrease in wet CWTs. Additional moisture content retaining capacity in a warmer atmosphere probably relevant too (Clausius-Clayperon relation) without relevant forcing to force moisture to precipitate.

Thank you for your attention!

Acknowledgments

This work is supported by Fundação para a Ciência e a Tecnologia (FCT), Portugal through the project "Expert Crowdsourcing for Semantic Annotation of Atmospheric Phenomena" - eCSAAP (CMU/CS/0012/2017).

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unDerstanding And Modeling cOmpound CLimate and weather EventS (DAMOCLES)

COST Action CA17109

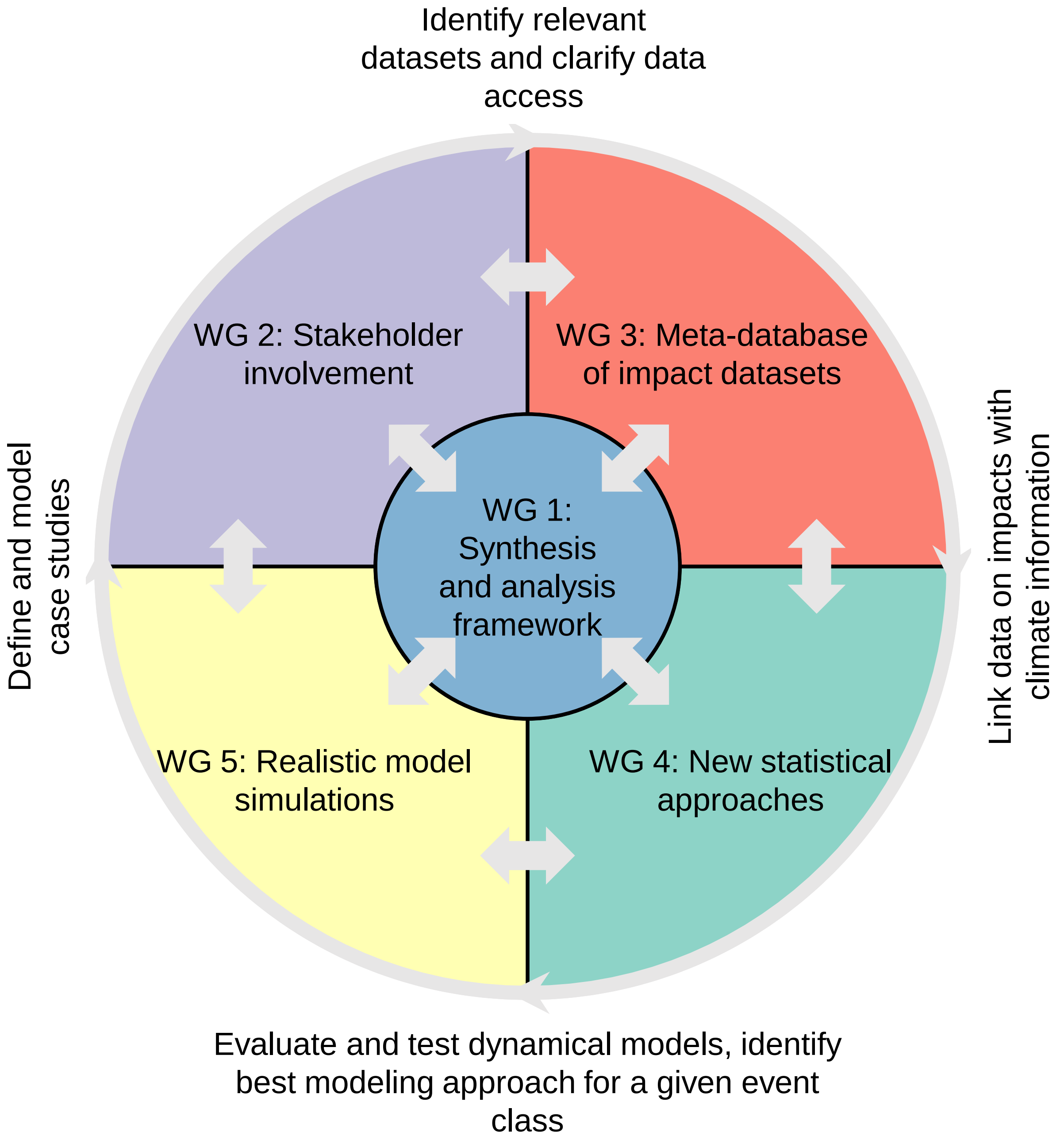
PI: Jakob Zscheischler, ETH Zurich

Started October 2018

What is a compound event?

Compound weather/climate events refer to the combination of multiple *drivers* and/or *hazards* that contributes to societal or environmental *risk*.

Zscheischler et al. (*Nature Climate Change*, 2018), based on workshop “Addressing the challenges of compound events” held in April 2017 at ETH Zürich, Switzerland



First WG meeting in Prague in 17 / 18 December

WG2: Stakeholder involvement

Objectives

- Add relevance to the science of Compound Events through stakeholder involvement
- Enable collaboration between scientists and stakeholders on Compound Event risk management
- Promote best practices of Compound Event risk management.

Deliverables

- Publish working paper on stakeholder and stakeholder needs with respect to compound events (M9)
- Publish plans on case studies on compound events online on DAMOCLES' project website (1-2 pages each) (M15)
- Publish white paper on case studies on compound events and lessons learnt (M48)

4) Atmospheric Rivers – Long-Term simulation

Changes in rainfall regimes (different percentiles)