ASPECT
FACILITATING SEAMLESS CLIMATE ADAPTATION

Funded by the European Union

This project has received funding from the European Union's Horizon Europe – the Framework Programme for Research and Innovation (2021-2027) under grant agreement No. 101081460.

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Forecast quality assessment of multi-annual predictions of mean and extreme temperature and precipitation: multi-model evaluation and impact of model initialisation

Carlos Delgado-Torres, Markus G. Donat, Panos J. Athanasiadis, Pierre-Antoine Bretonnière, Louis-Philippe Caron, Nick J. Dunstone, Nube Gonzalez-Reviriego, An-Chi Ho, Dario Nicolì, Klaus Pankatz, Andreas Paxian, Núria Pérez-Zanón, Margarida Samsó-Cabré, Balakrishnan Solaraju-Murali, Albert Soret, and Francisco J. Doblas-Reyes

15IMSC
Toulouse, June 2024

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Objectives

- Evaluate the **forecast quality** of the decadal predictions contributing to CMIP6/DCPP in predicting near-surface air **temperature**, **precipitation**, the **AMV** index and the **GSAT** anomalies.

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- Estimate the **impact of model initialisation** by comparing the skill of the decadal predictions and historical forcing simulations multi-model ensembles.

- Estimate how much skill is lost for not having all the predictions available in real-time by comparing a **research multi-model ensemble (13 forecast systems)** against an **operational multi-model ensemble (4 forecast systems)**.

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Data and methods

- **Forecast period:** forecast years 1-5
- **Evaluation period**: 1961-2014
- **Variables**: temperature and precipitation
- **Indices**: AMV index and GSAT anomalies
- **Reference forecasts:**
  - Climatological forecast
  - Individual forecast systems
  - Historical simulations
  - Operational multi-model

Forecast system	DCPP members	HIST members	Initialisation month
BCC-CSM2-MR	8	3	January
CanESM5	20	40	January
CESM1-1-CAM5-CMIP5	40	40	November
CMCC-CM2-SR5	10	1	November
EC-Earth3-i1	10	10	November
EC-Earth3-i2	5	-	November
HadGEM3-GC3.1-MM	10	4	November
IPSL-CM6A-LR	10	32	January
MIROC6	10	10	November
MPI-ESM1.2-HR	10	10	November
MPI-ESM1.2-LR	16	10	November
MRI-ESM2-0	10	5	November
NorCPM1	10	30	October
	169 members	**195 members**	

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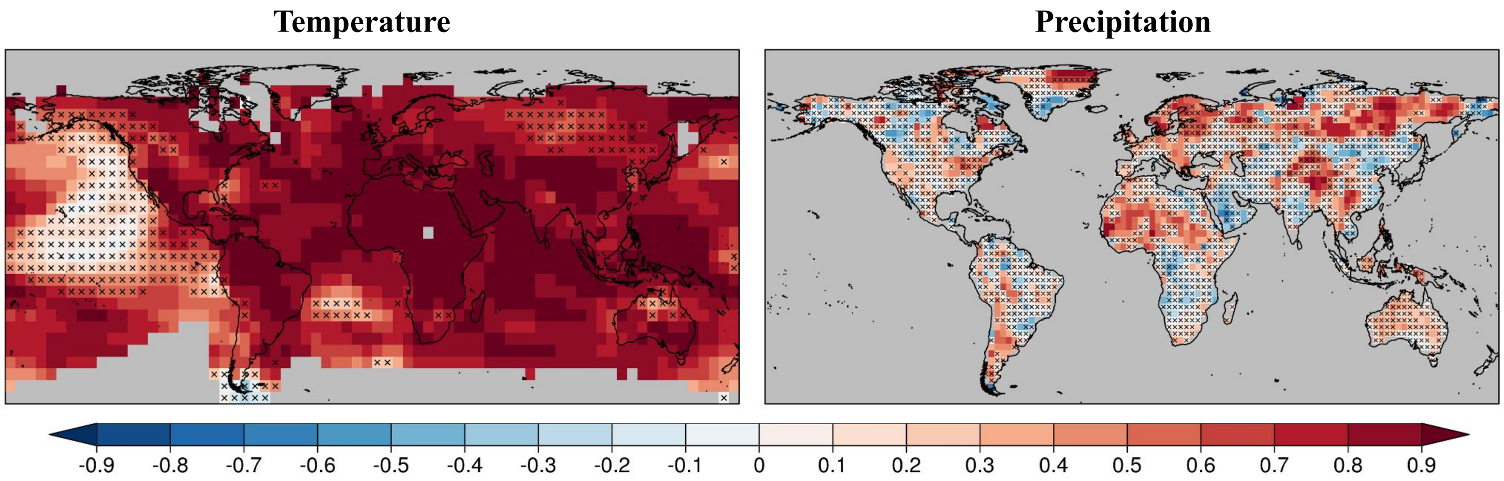
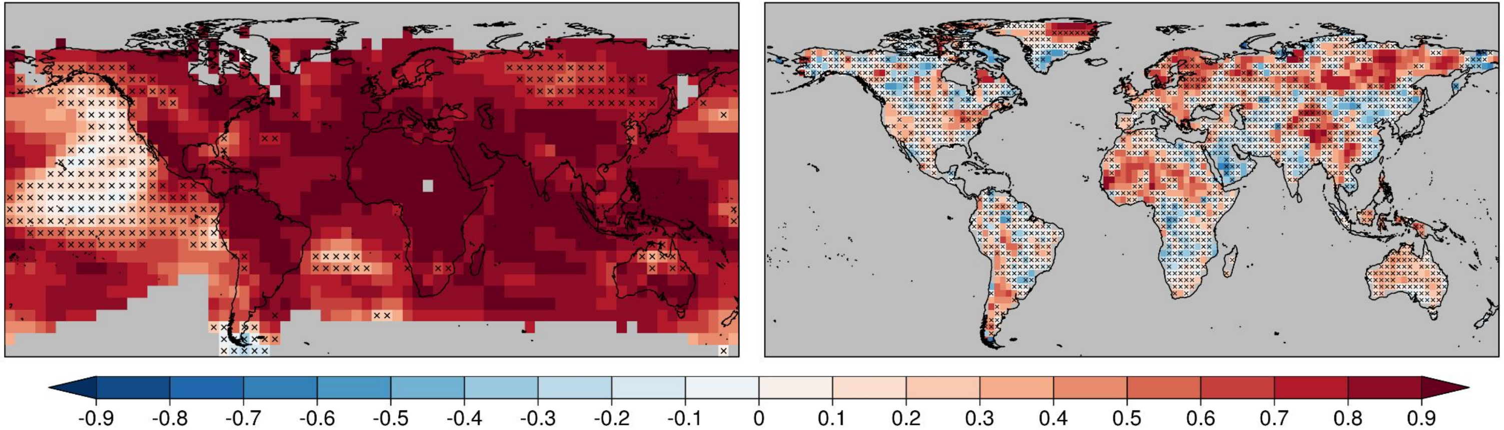
DCPP multi-model skill



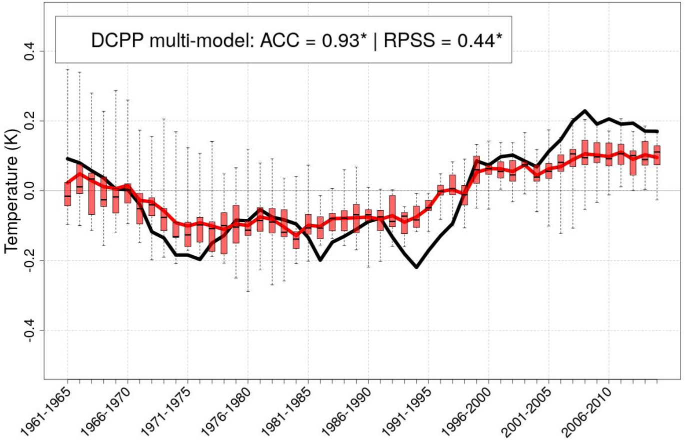
ACC for **forecast years 1-5**
DCPP multi-model ensemble: **169 members** from **13 forecast systems**

DCPP multi-model skill

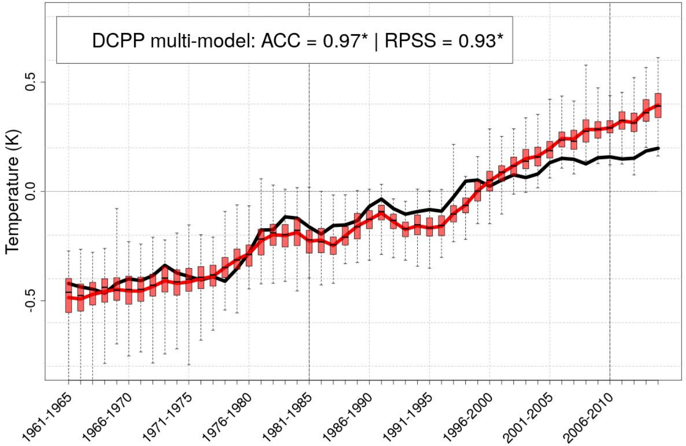
Temperature | **Precipitation**



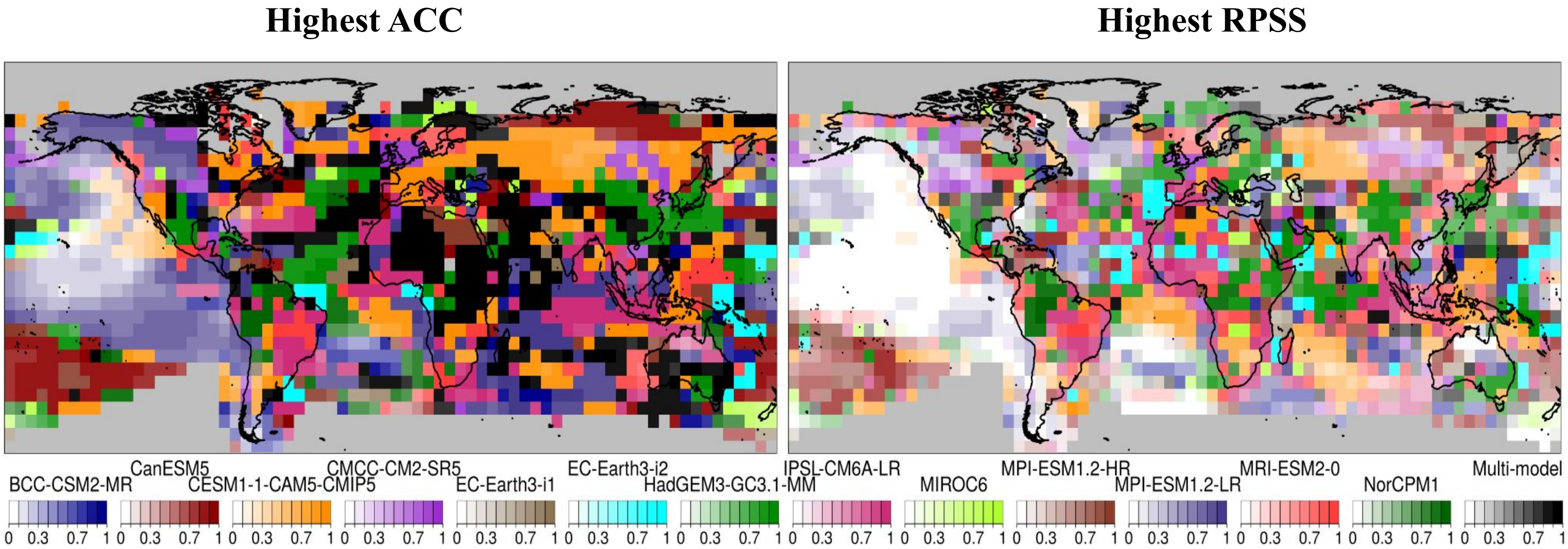
Atlantic Multidecadal Variability



Global Surface Air Temperature



Multi-model vs individual forecast systems



Forecast system or multi-model with the **highest skill** in predicting temperature for the **forecast years 1-5**

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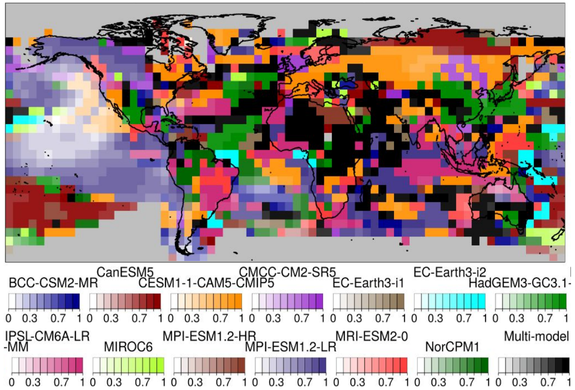
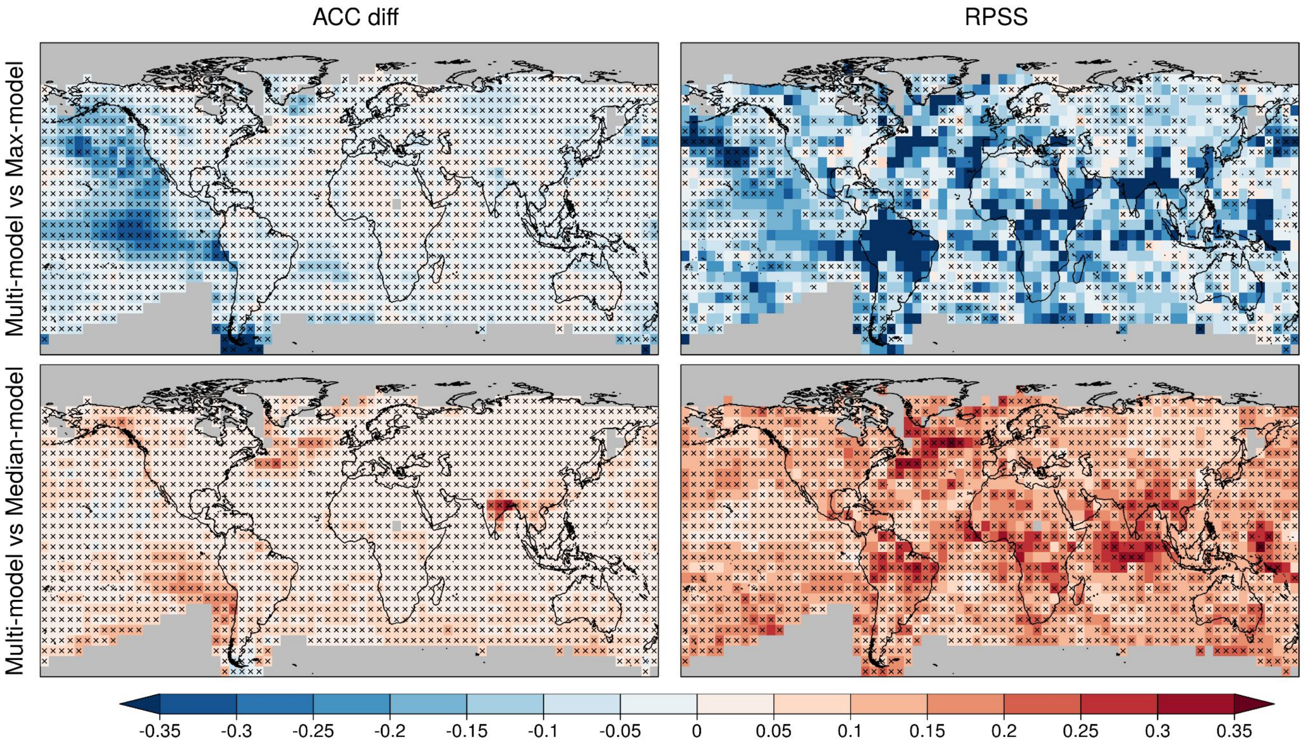
Multi-model vs individual forecast systems

Highest ACC - Temperature





- Multi-model generally **worse** than the best forecast system.
- Multi-model generally **better** than the 50% of the forecast systems.

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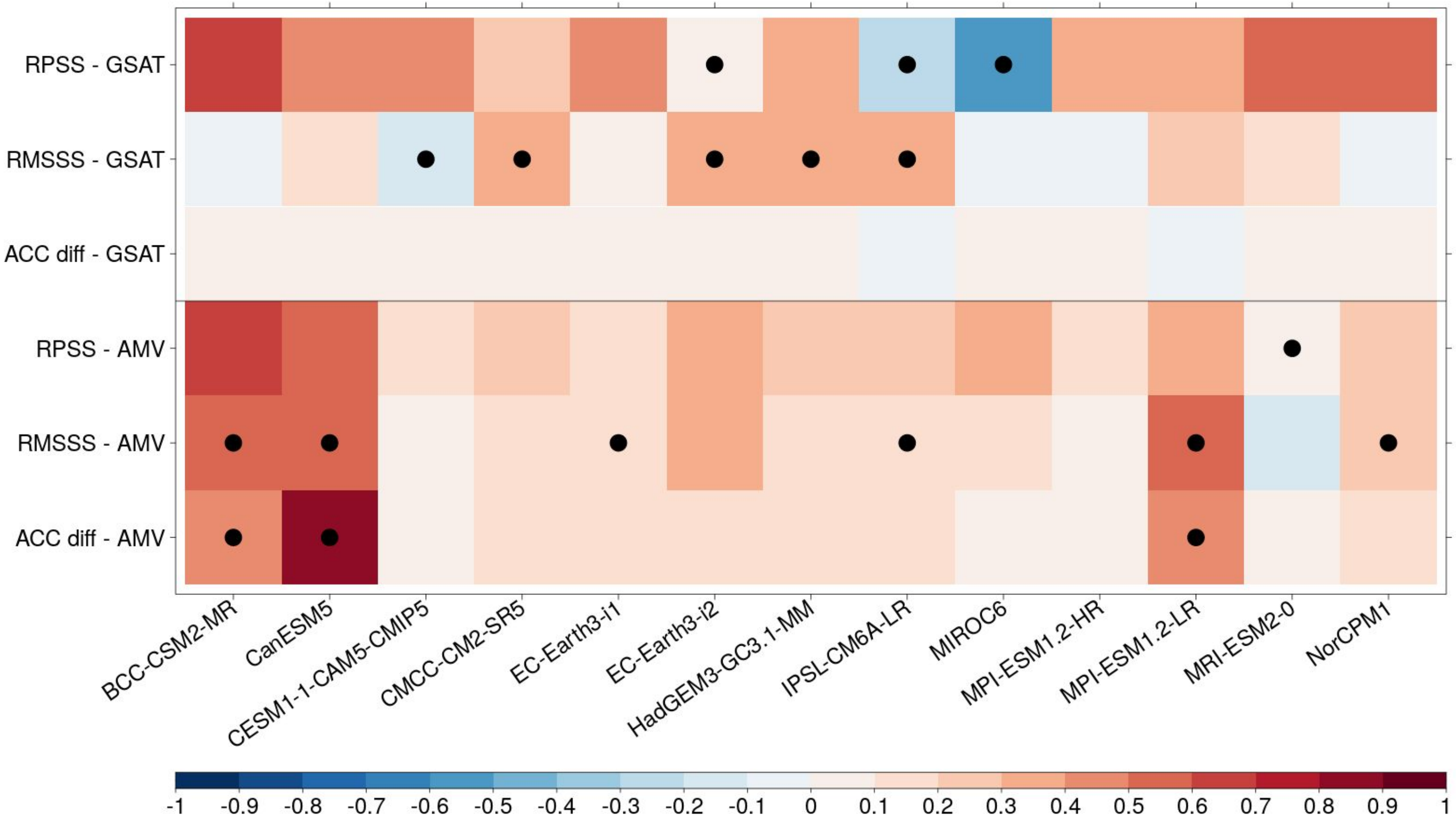
Multi-model vs individual forecast systems



Multi-model **worse** than forecast system ← | → Multi-model **better** than forecast system

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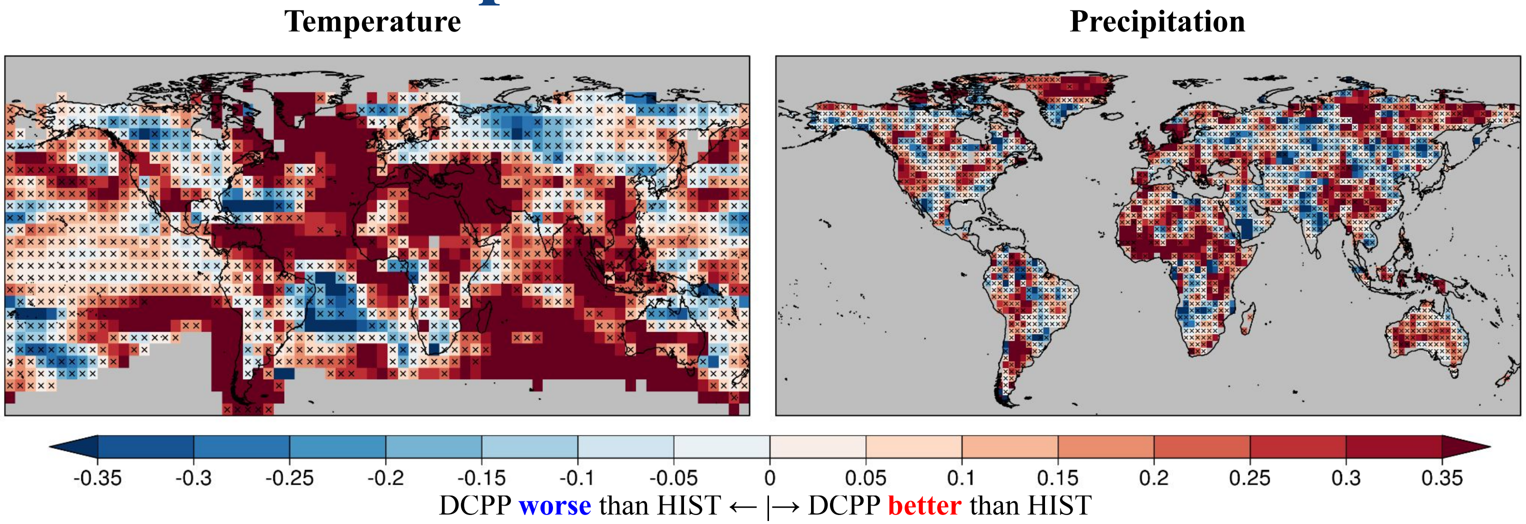
Impact of initialisation



Residual correlation for **forecast years 1-5**
DCPP multi-model ensemble: **169 members** from **13 forecast systems**
HIST multi-model ensemble: **195 members** from the same forecast systems

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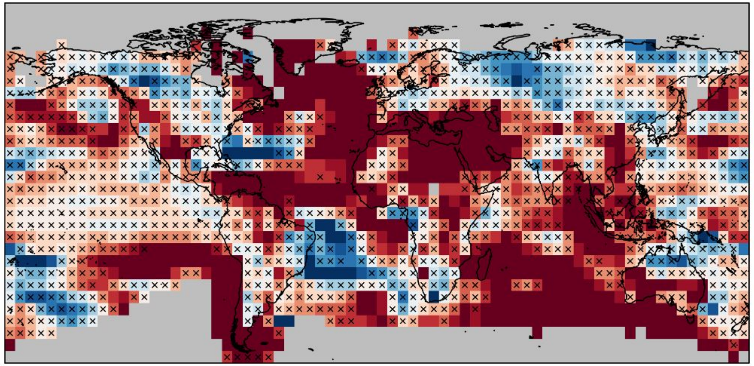
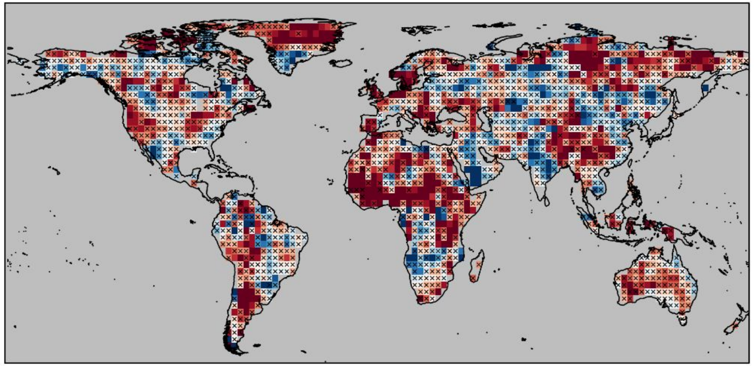
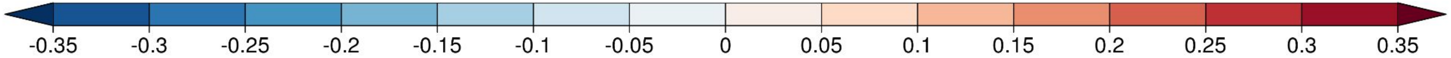
Impact of initialisation

Temperature



Precipitation





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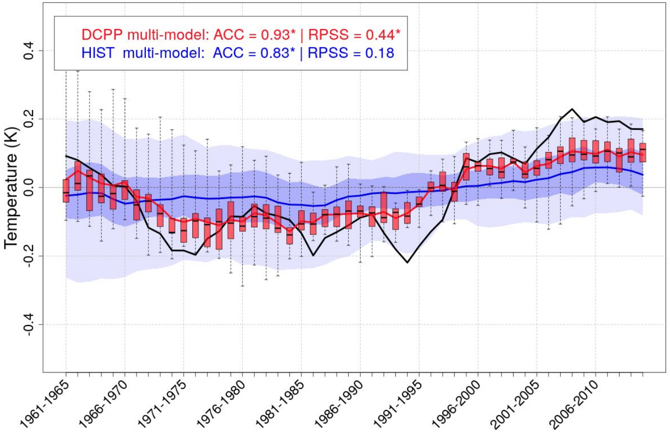

Index	Residual ACC	RPSS
AMV	0.75*	0.32*
GSAT	0.45*	-0.06

- **DCPP** multi-model ensemble: **169 members**
- **HIST** multi-model ensemble: **195 members**

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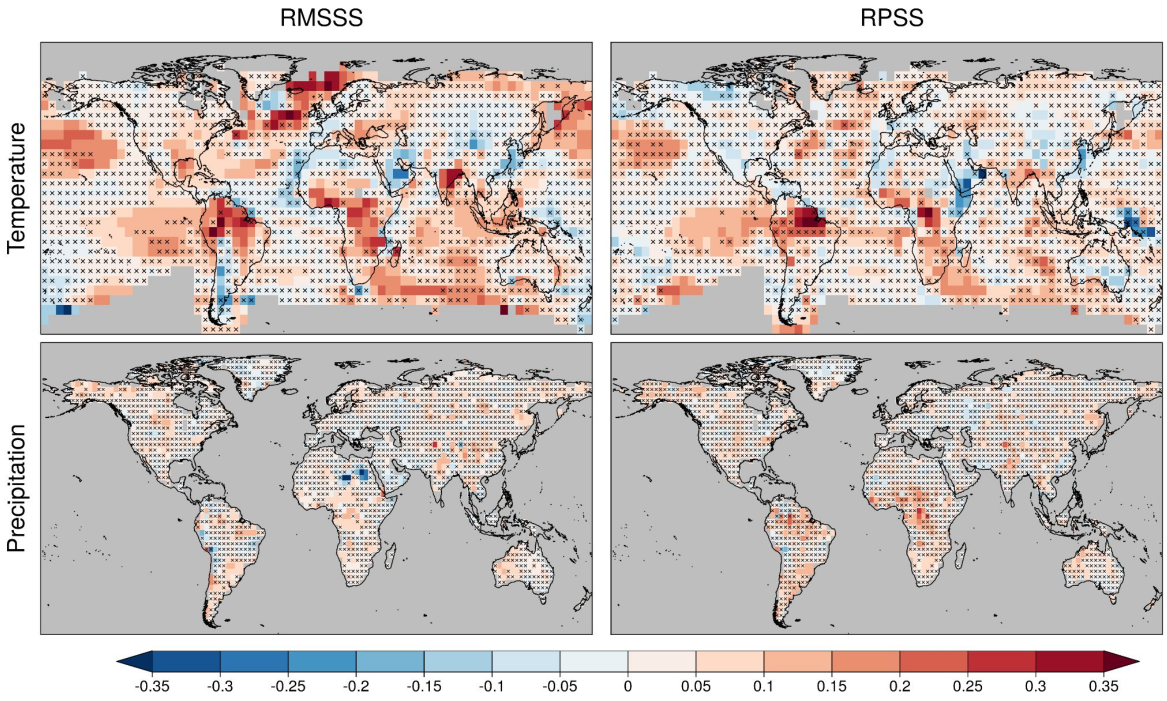
DCPP vs C3S_34c multi-model (13 vs 4 systems)



DCPP multi-model **worse** than C3S_34c multi-model ← | → DCPP multi-model **better** than C3S_34c multi-model

- DCPP multi-model: **169 members** from **13 forecast systems**.
- C3S_34c multi-model: **40 members** from **4 forecast systems** (CMCC-CM2-SR5, EC-Earth3-i1, HadGEM3-GC3.1-MM and MPI-ESM1.2-HR).

Importance of having more real-time predictions!

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Main findings

- **DCPP multi-model skill**:
    - Generally high for temperature, particularly over land regions.
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  - The best system generally provides the highest skill for a particular location, variable and forecast period.
    - Highest forecast quality for a particular climate service.
  - The multi-model provides higher skill than, at least, the 50% of the systems.
    - More straightforward operational forecast generation.
  - More real-time predictions would allow selecting the best forecast system or multi-model (sub)ensemble for each specific region, variable and forecast period.

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    - More straightforward operational forecast generation.
  - More real-time predictions would allow selecting the best forecast system or multi-model (sub)ensemble for each specific region, variable and forecast period.
- **DCPP vs HIST multi-models**:
  - Added value of initialisation over some ocean and land regions for temperature and precipitation.
  - Added value for AMV and GSAT.

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Thank you!

15IMSC
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Data and methods

- **Forecast period:** forecast years 1-5
- **Evaluation period**: 1961-2014 (start dates 1960-2009)
- **Variables**: monthly temperature (TAS) and precipitation (PR)
- **Extreme indices (ETCCDI)**
  - Daily maximum temperature: TXx and TX90p
  - Daily minimum temperature: TNn and TN10p
  - Daily precipitation: Rx5day and R95p

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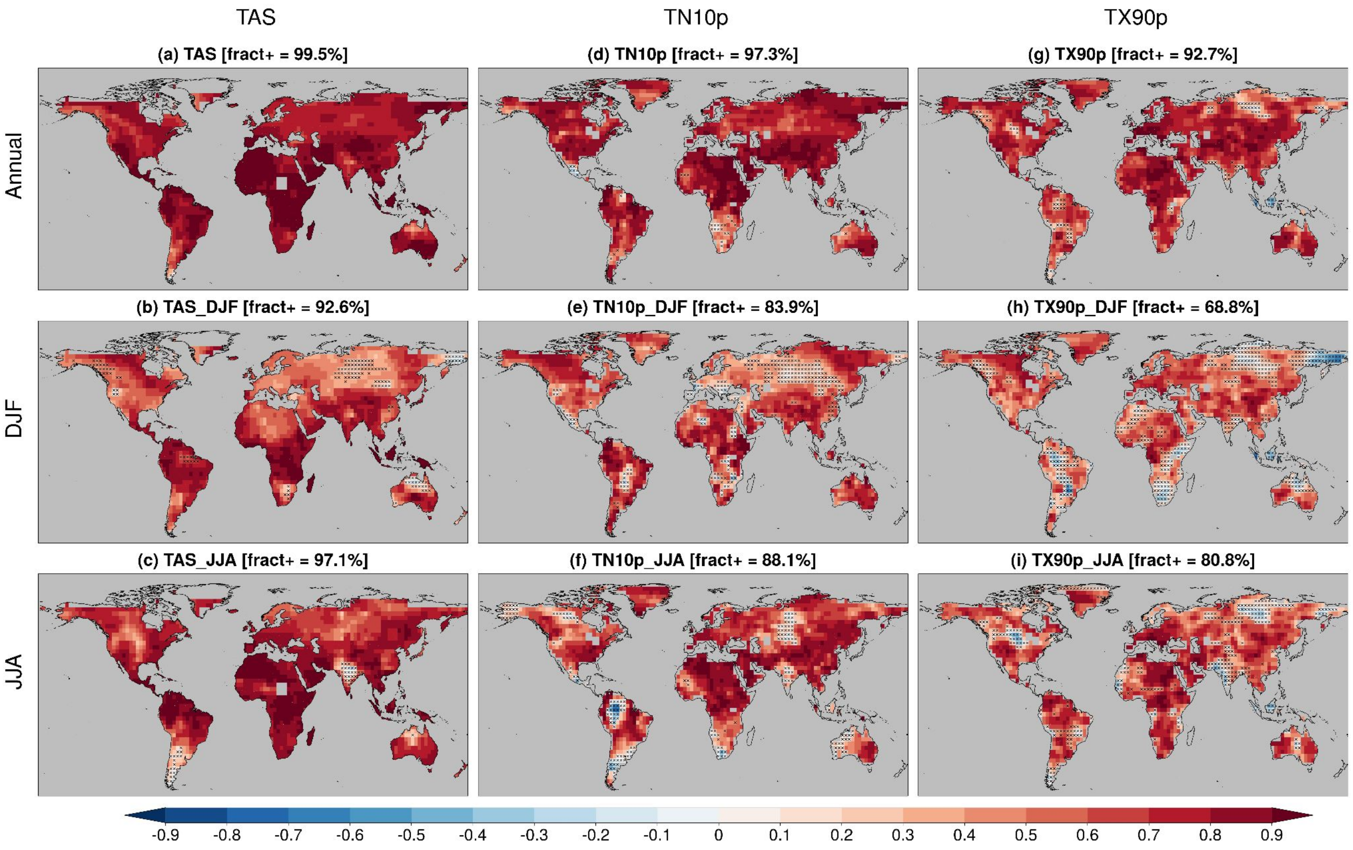
Multi-model skill - Temperature extremes

The DCPP multi-model ensemble **skillfully predicts** variations in the **temperature extremes** over most land regions.

The **extreme indices are predicted with lower skill** than the mean quantities.



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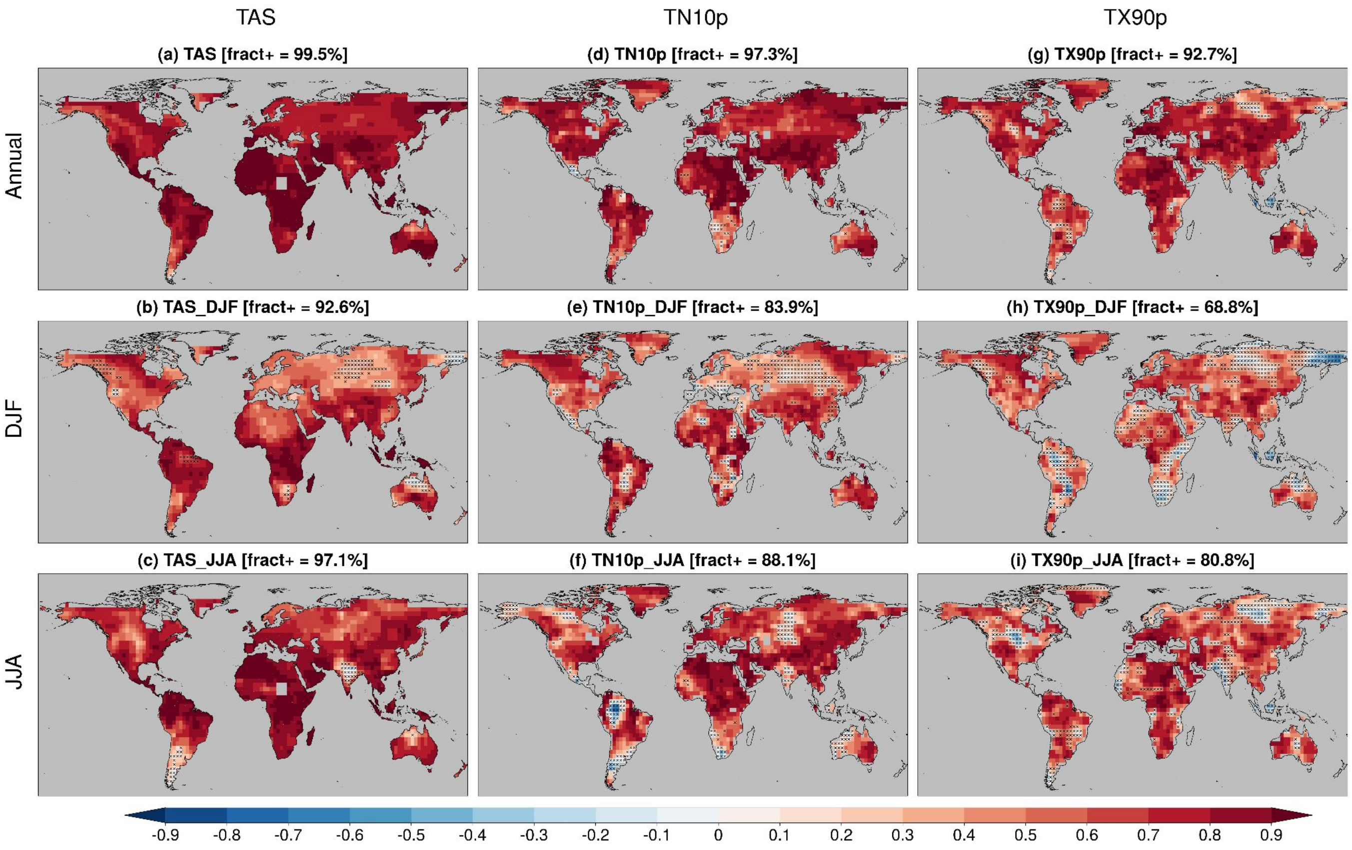
Higher skill for indices based on minimum temperature than those based on maximum temperature.

Generally higher prediction skill in **summer** than in winter.



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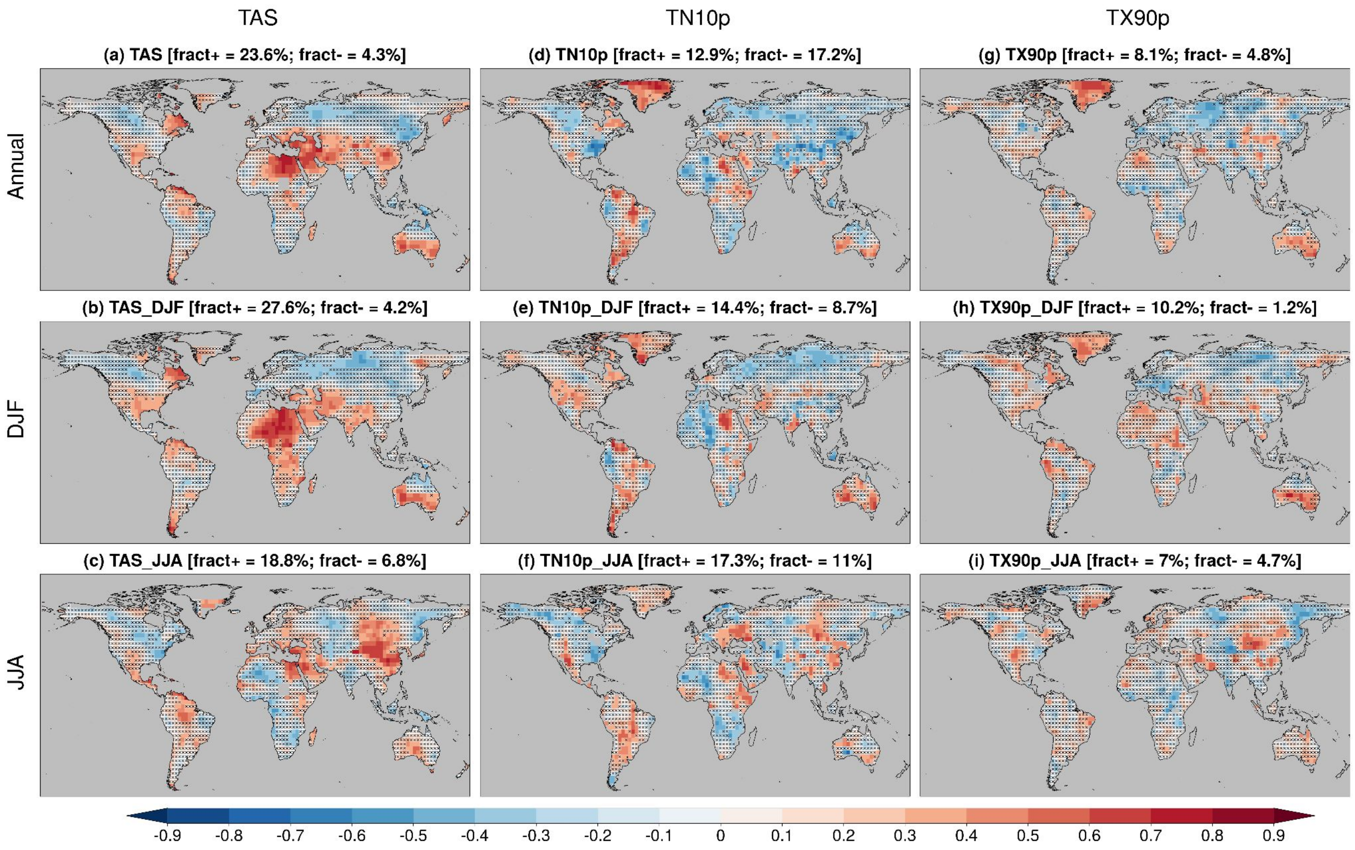
Impact of initialisation - Temperature extremes

Different impact of model initialisation depending on the season.

Some regions show **added value** for predictions of **mean temperature**.



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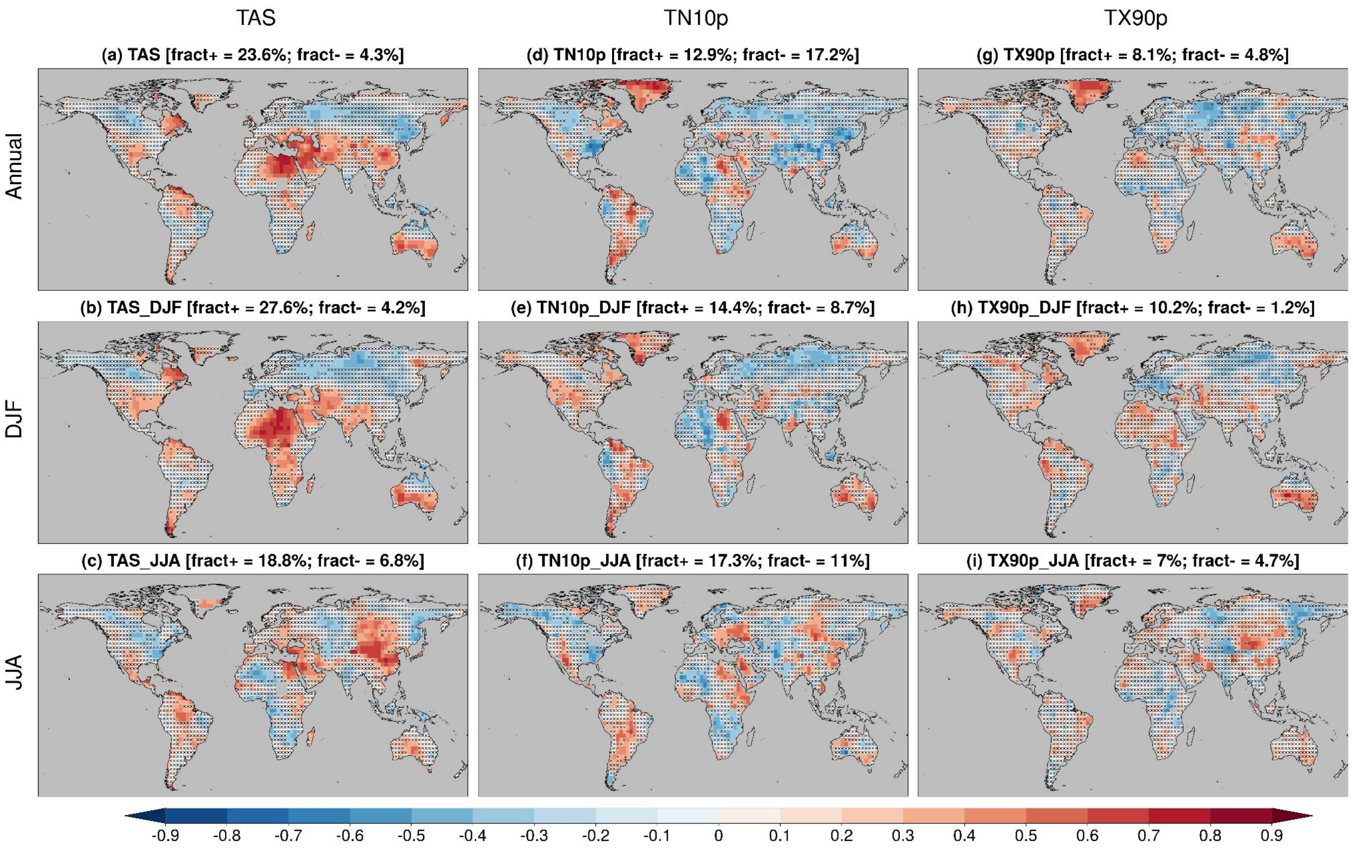
For **extreme temperature**, the impact of initialisation is **generally low** and highly **region-dependent**.



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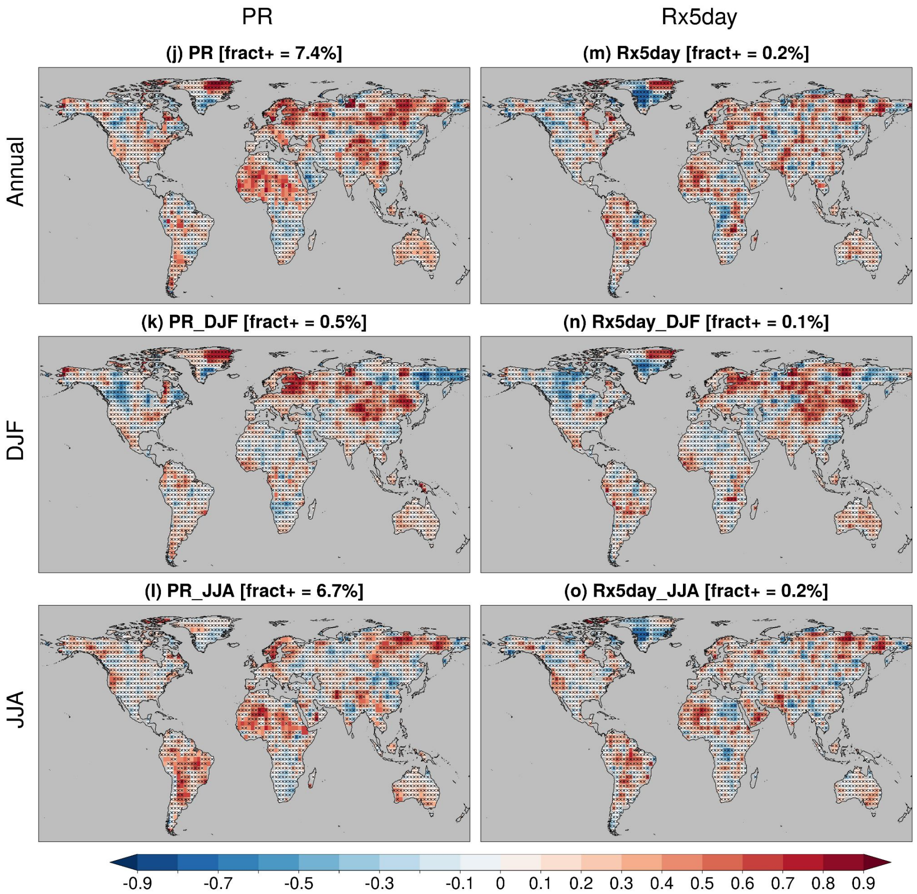
Multi-model skill - Precipitation extremes

The prediction skill for **precipitation extremes is much more limited** than for temperature extremes.

Different regions where the multi-model is skillful for **summer and winter**.

Generally **similar patterns for mean and extreme precipitation**.



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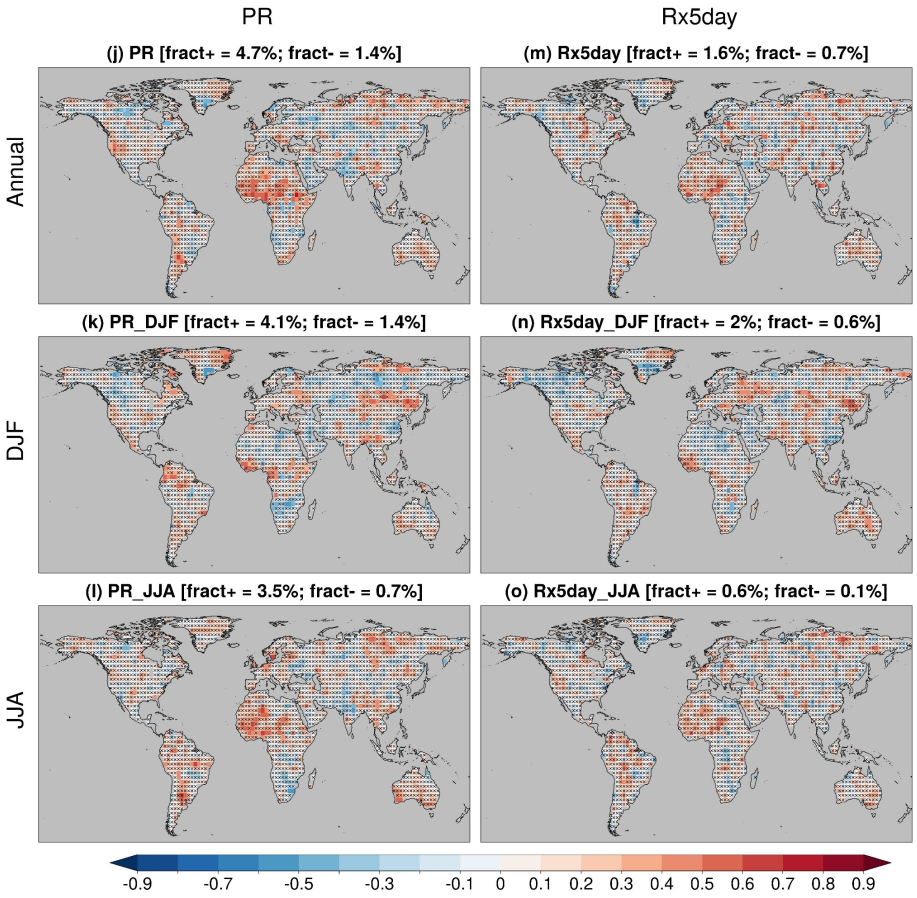
Impact of initialisation - Precipitation extremes

Low added value from model initialisation for prediction of mean and extreme precipitation.



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Main findings

- The multi-model ensemble provides **skillful predictions of temperature extremes** over most land regions, while the **prediction skill is more limited for precipitation extremes**.

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- The **added value from model initialisation** for predictions of extremes is generally **low and highly region-dependent**.

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