Climate Change Service

EUCP
European Climate Prediction system

ASPECT
FACILITATING SEAMLESS CLIMATE ADAPTATION

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Predicciones multianuales de temperatura y precipitación media y extrema: evaluación multimodelo e impacto de la inicialización

Carlos Delgado-Torres, Markus G. Donat, Albert Soret, 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 y Francisco J. Doblas-Reyes

XIII Congreso Internacional AEC
Madrid, enero de 2025

carlos.delgado@bsc.es

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.

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.

- Compare the **multi-model ensemble against the individual forecast systems** to assess the benefit and drawbacks of combining predictions from different forecast systems.

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.

- Compare the **multi-model ensemble against the individual forecast systems** to assess the benefit and drawbacks of combining predictions from different forecast systems.

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

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.

- Compare the **multi-model ensemble against the individual forecast systems** to assess the benefit and drawbacks of combining predictions from different forecast systems.

- 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)**.

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.

- Compare the **multi-model ensemble against the individual forecast systems** to assess the benefit and drawbacks of combining predictions from different forecast systems.

- 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)**.

- Assess the multi-model forecast quality for **extreme indices based on daily minimum and maximum temperature and precipitation**, and comparing it to that for mean temperature and precipitation.

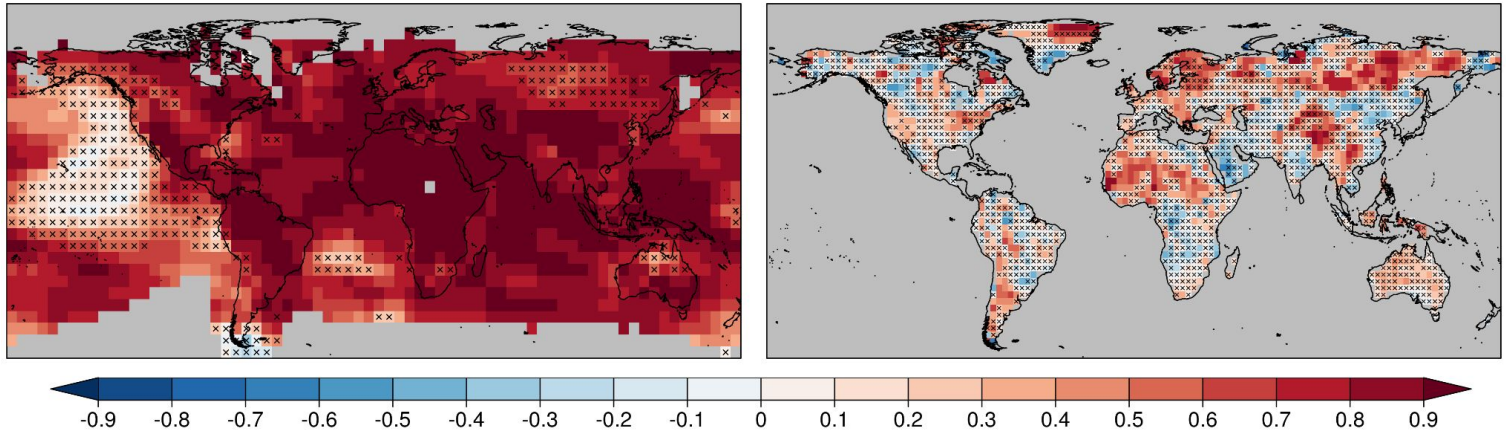
Data and methods

- **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 forcing 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-CMIP 5	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**	

DCPP multi-model skill

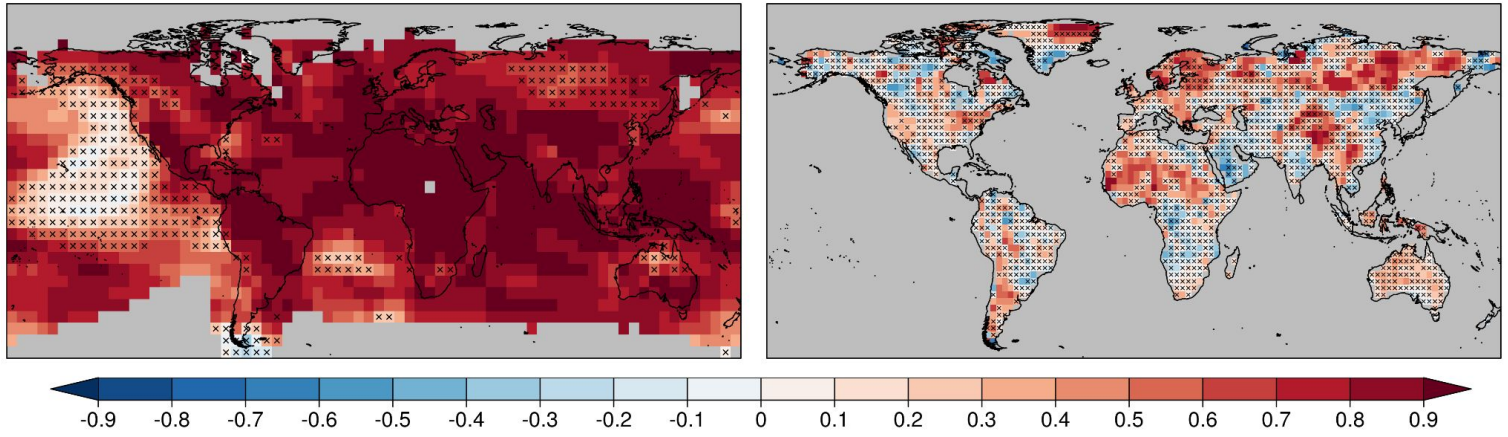
Temperature **Precipitation**



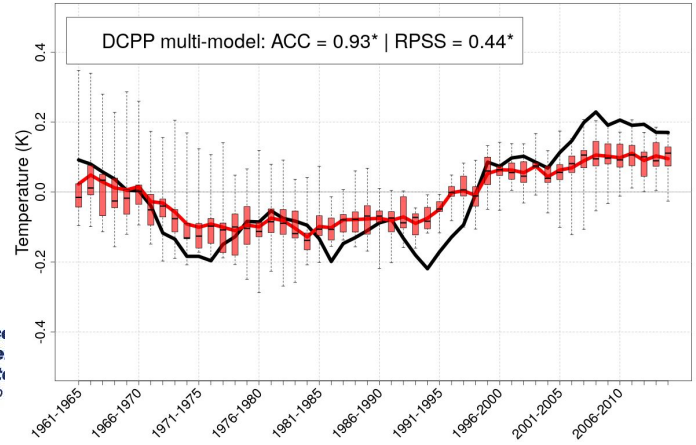
ACC for **forecast years 1-5**
DCPP multi-model ensemble: **169 members** from **13 forecast systems**

DCPP multi-model skill

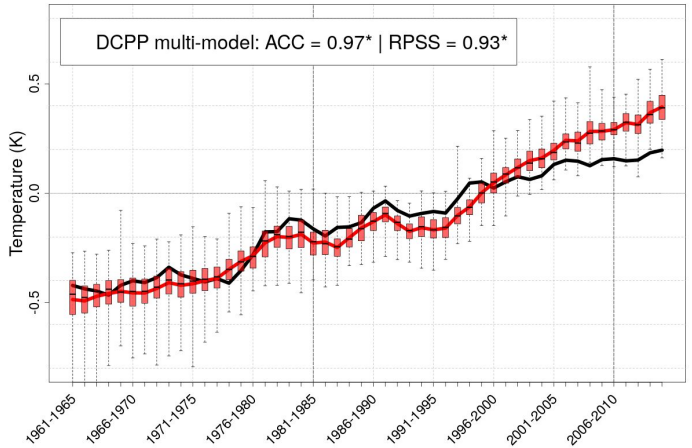
Temperature | **Precipitation**



Atlantic Multidecadal Variability

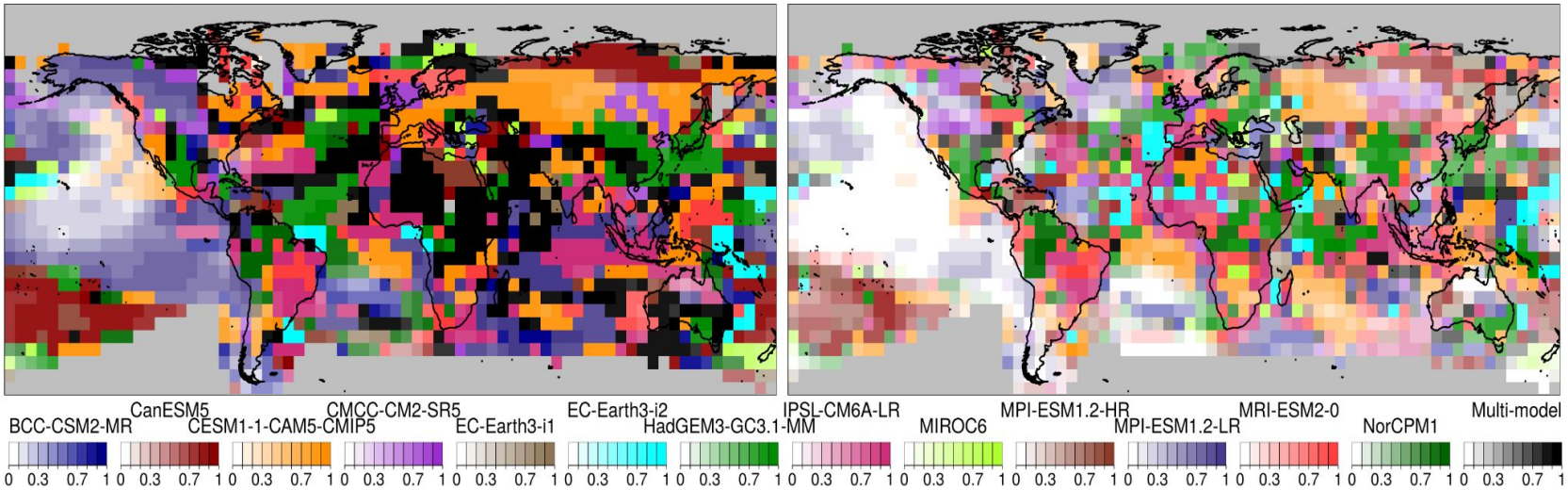


Global Surface Air Temperature



Multi-model vs individual forecast systems

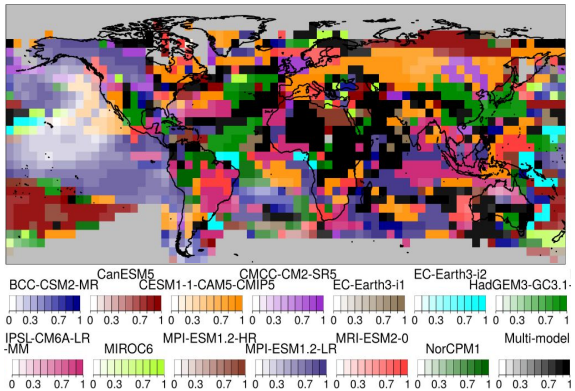
Highest ACC | **Highest RPSS**

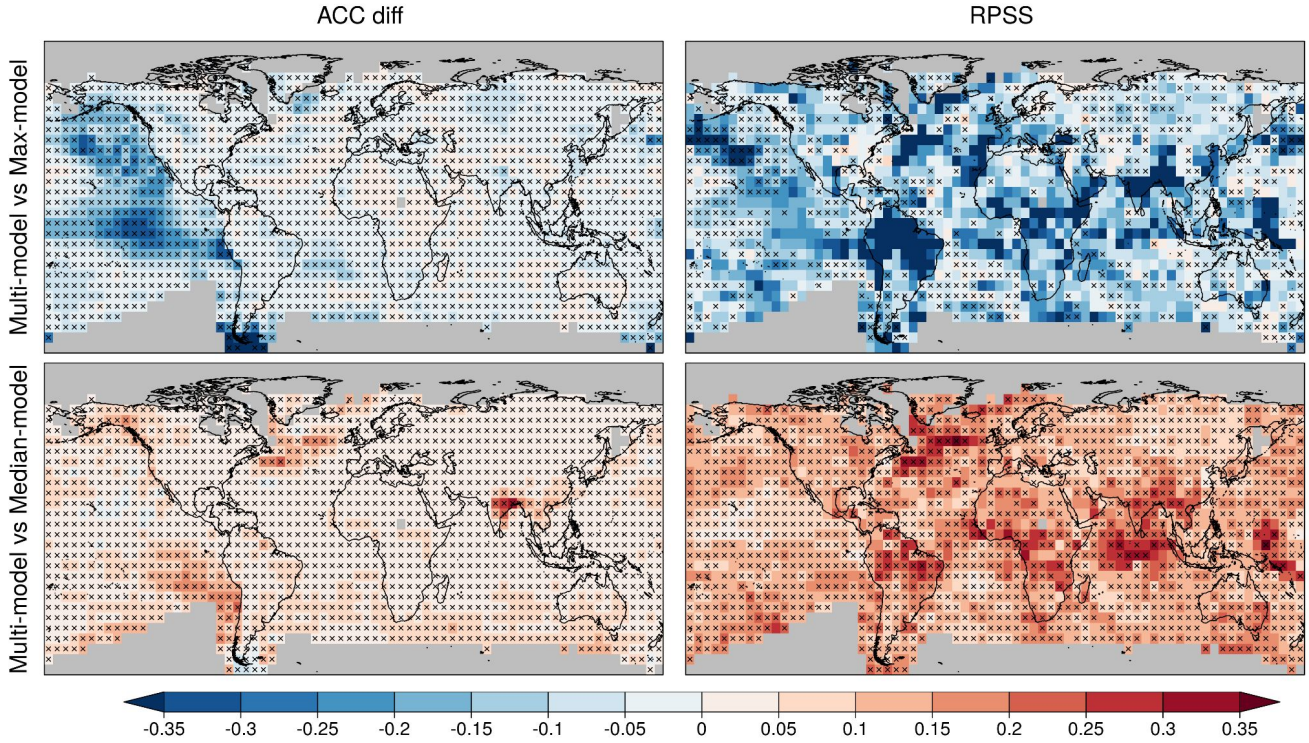


Forecast system or multi-model with the **highest skill** in predicting temperature for the **forecast years 1-5**

Multi-model vs individual forecast systems

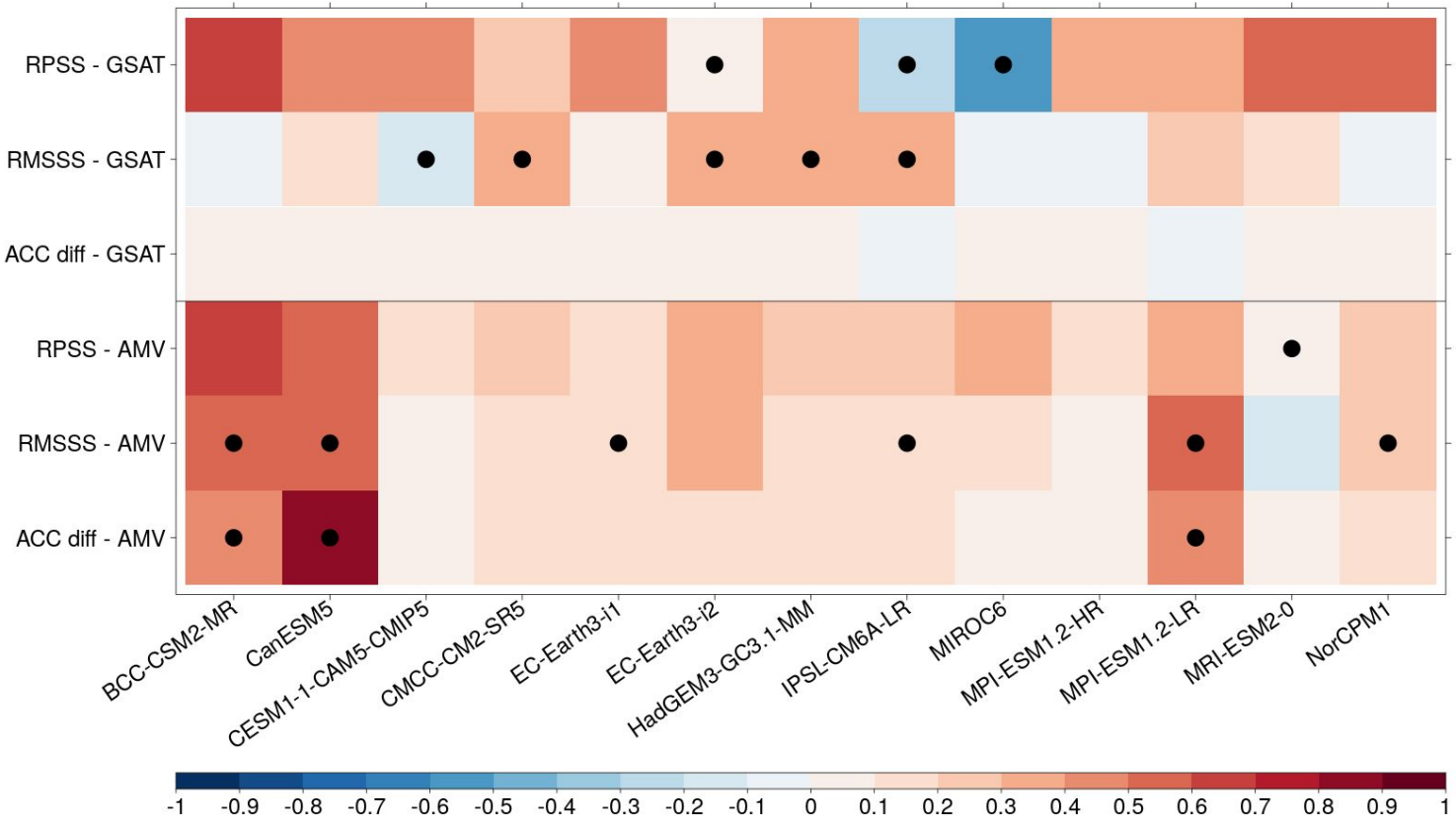
Highest ACC - Temperature





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

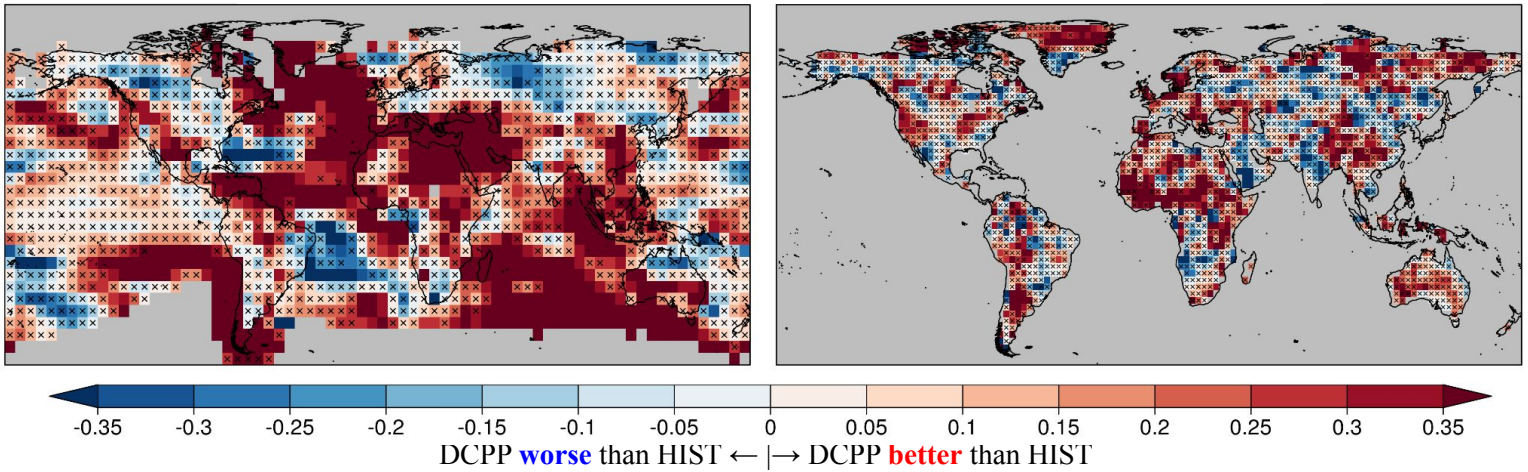
Multi-model vs individual forecast systems



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

Impact of initialisation

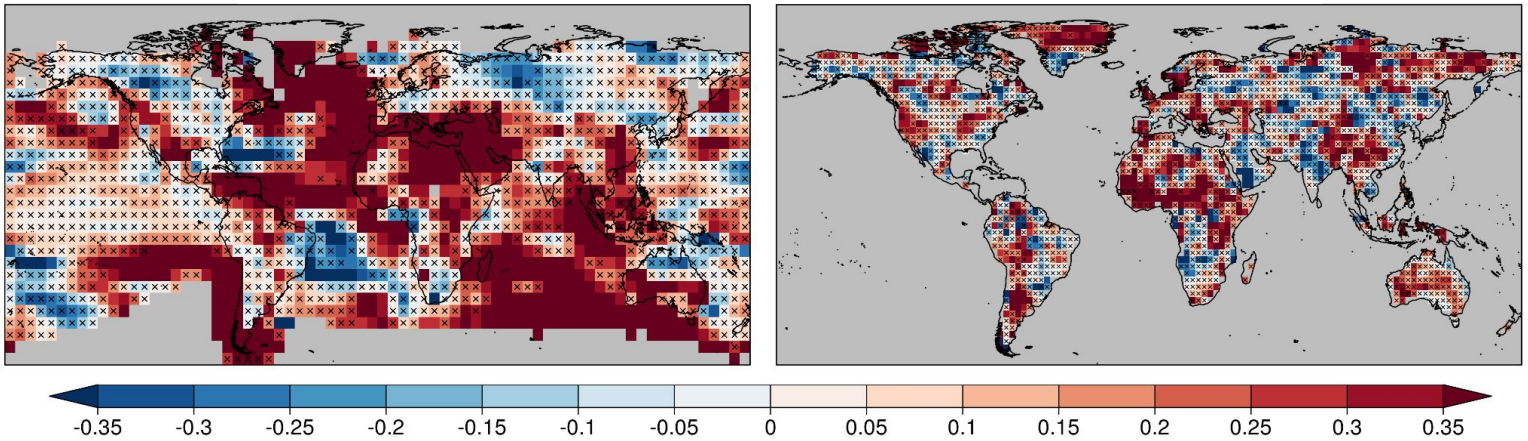
Temperature **Precipitation**



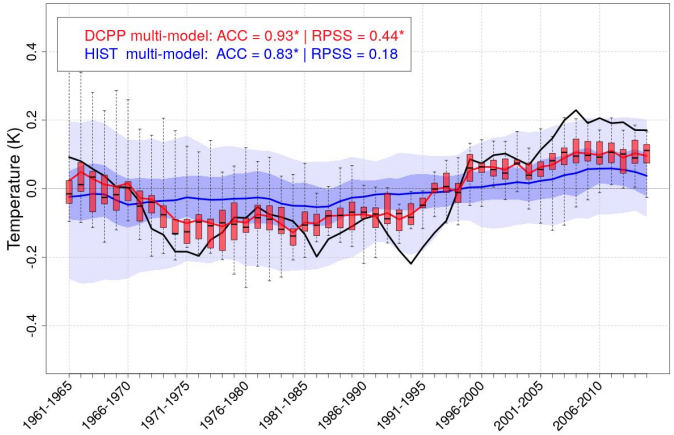
Residual correlation for **forecast years 1-5**
DCPP multi-model ensemble: **169 members** from **13 forecast systems**
HIST multi-model ensemble: **195 members** from the same forecast systems

Impact of initialisation

Temperature **Precipitation**



Atlantic Multidecadal Variability

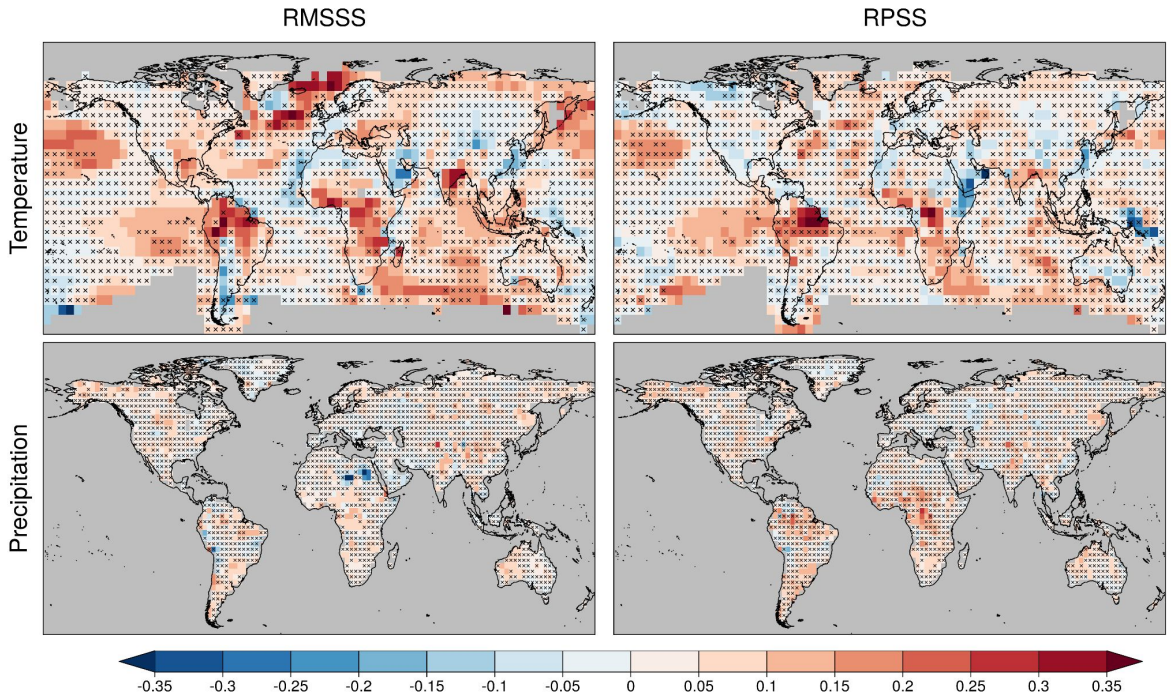


Index	Residual ACC	RPSS
AMV	0.75*	0.32*
GSAT	0.45*	-0.06

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

Barcelon
Supercon
Center
Centro Nacio

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!

Extreme indices - 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

Forecast system	DCPP members	HIST members	Initialisation month
BCC-CSM2-MR	8	2	January
CanESM5	20	25	January
CMCC-CM2-SR5	10	6	November
EC-Earth3-i1	10	10	November
EC-Earth3-i2	5	-	November
EC-Earth3-i4	10	-	November
HadGEM3-GC3.1-MM	10	4	November
IPSL-CM6A-LR	10	31	January
MIROC6	10	10	November
MPI-ESM1.2-HR	10	10	November
MRI-ESM2-0	10	6	November
NorCPM1-i1	10	30	October
NorCPM1-i2	10	-	October
	133 members	**134 members**	

Extreme indices - Data and methods

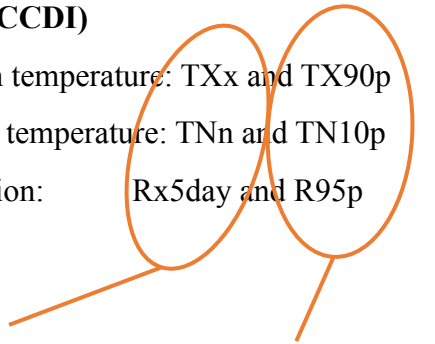
- **Forecast period:** forecast years 1-5
- **Evaluation period**: 1961-2014 (start dates 1960-2009)
- **Variables**: monthly temperature (TAS) and precipitation (PR)
- **Extreme indices (ETCCDI)**
  - Daily maximum temperature: TXx and TX90p
  - Daily minimum temperature: TNn and TN10p
  - Daily precipitation: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

Related to **intensity**

Forecast system	DCPP members	HIST members	Initialisation month
BCC-CSM2-MR	8	2	January
CanESM5	20	25	January
CMCC-CM2-SR5	10	6	November
EC-Earth3-i1	10	10	November
EC-Earth3-i2	5	-	November
EC-Earth3-i4	10	-	November
HadGEM3-GC3.1-MM	10	4	November
IPSL-CM6A-LR	10	31	January
MIROC6	10	10	November
MPI-ESM1.2-HR	10	10	November
MRI-ESM2-0	10	6	November
NorCPM1-i1	10	30	October
NorCPM1-i2	10	-	October
	133 members	**134 members**	

Extreme indices - 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



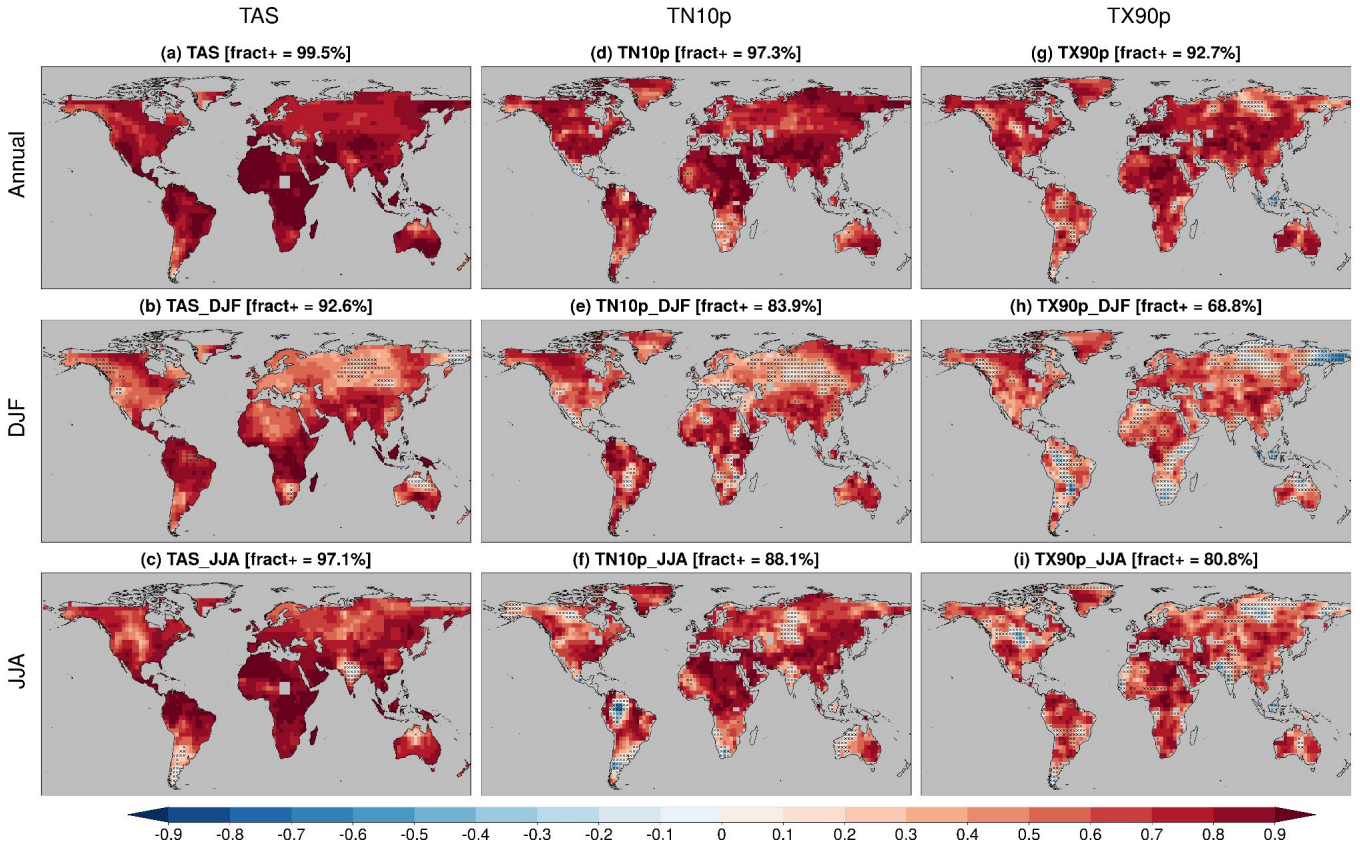
Forecast system	DCPP members	HIST members	Initialisation month
BCC-CSM2-MR	8	2	January
CanESM5	20	25	January
CMCC-CM2-SR5	10	6	November
EC-Earth3-i1	10	10	November
EC-Earth3-i2	5	-	November
EC-Earth3-i4	10	-	November
HadGEM3-GC3.1-MM	10	4	November
IPSL-CM6A-LR	10	31	January
MIROC6	10	10	November
MPI-ESM1.2-HR	10	10	November
MRI-ESM2-0	10	6	November
NorCPM1-i1	10	30	October
NorCPM1-i2	10	-	October
	133 members	**134 members**	

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

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.



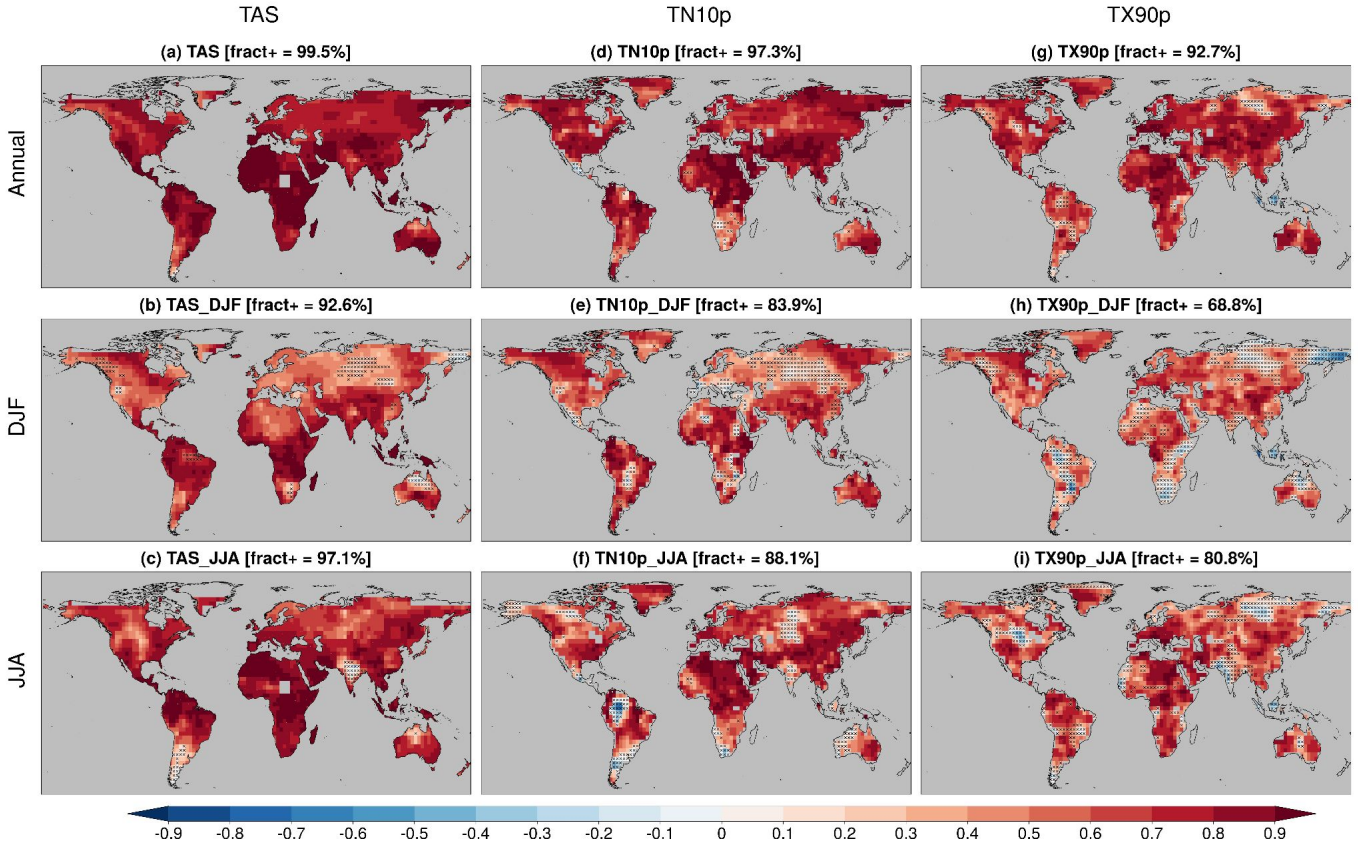
Multi-model skill - Temperature extremes

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.

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

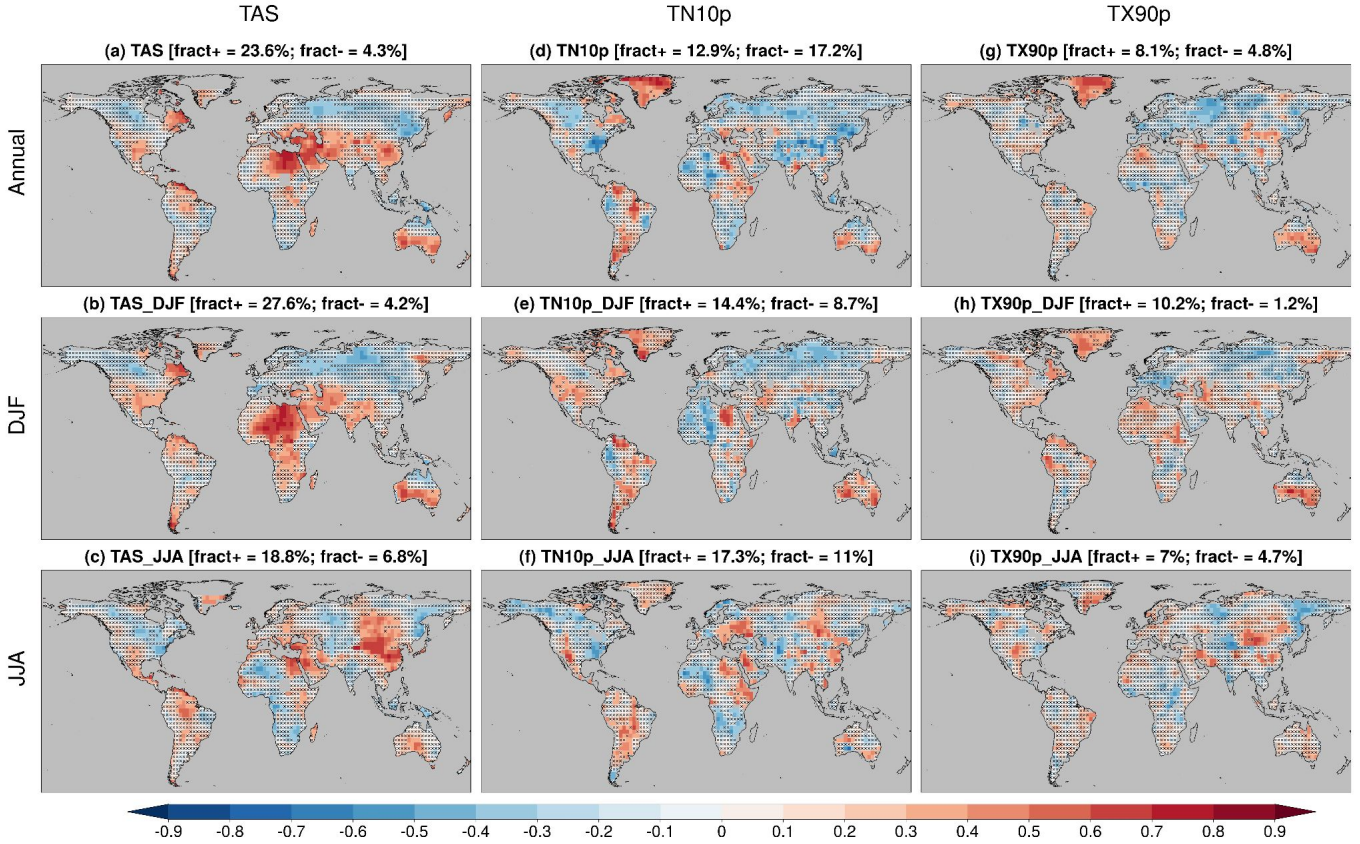
Generally higher prediction skill in **summer** than in winter.



Impact of initialisation - Temperature extremes

Different impact of model initialisation depending on the season.

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

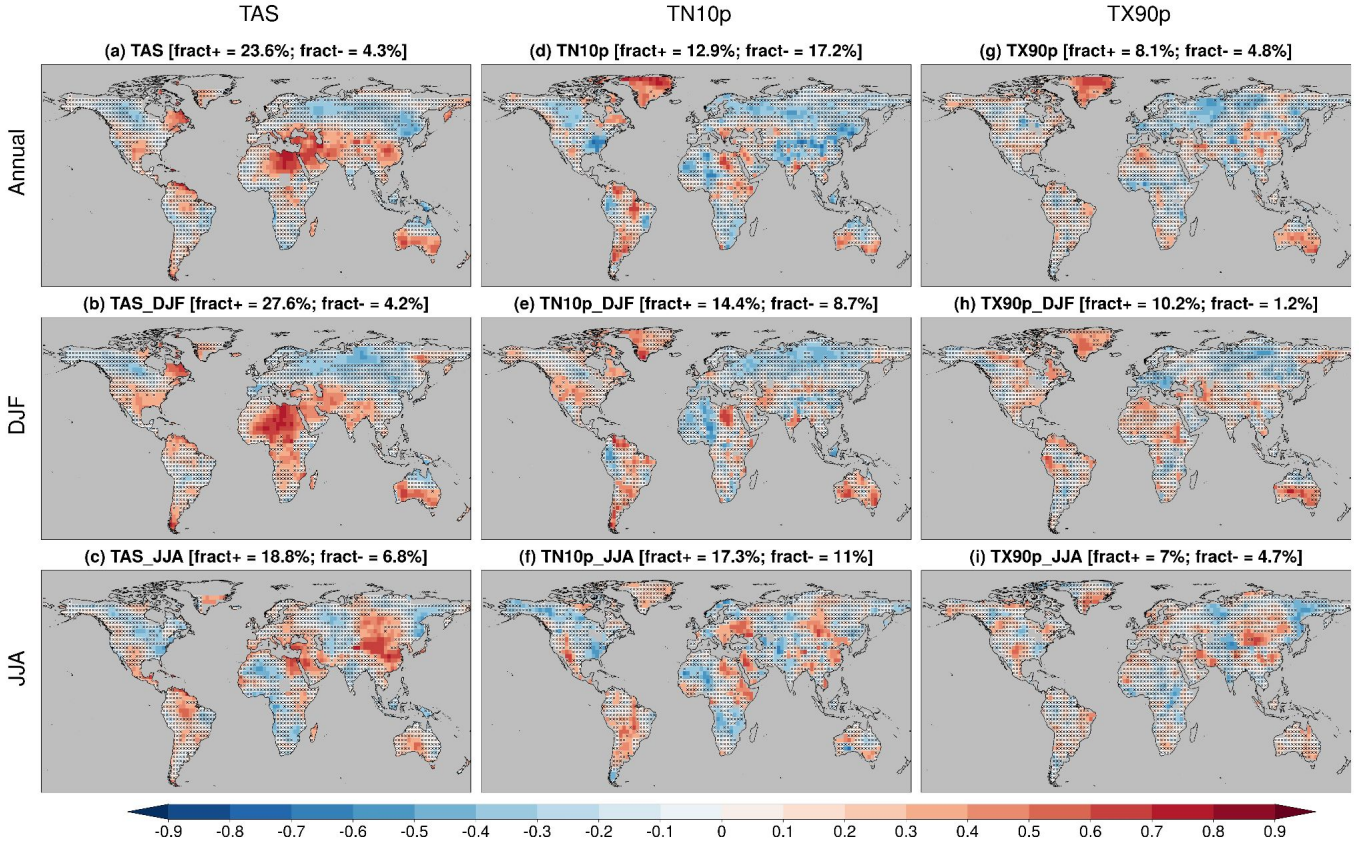


Impact of initialisation - Temperature extremes

Different impact of model initialisation depending on the season.

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

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

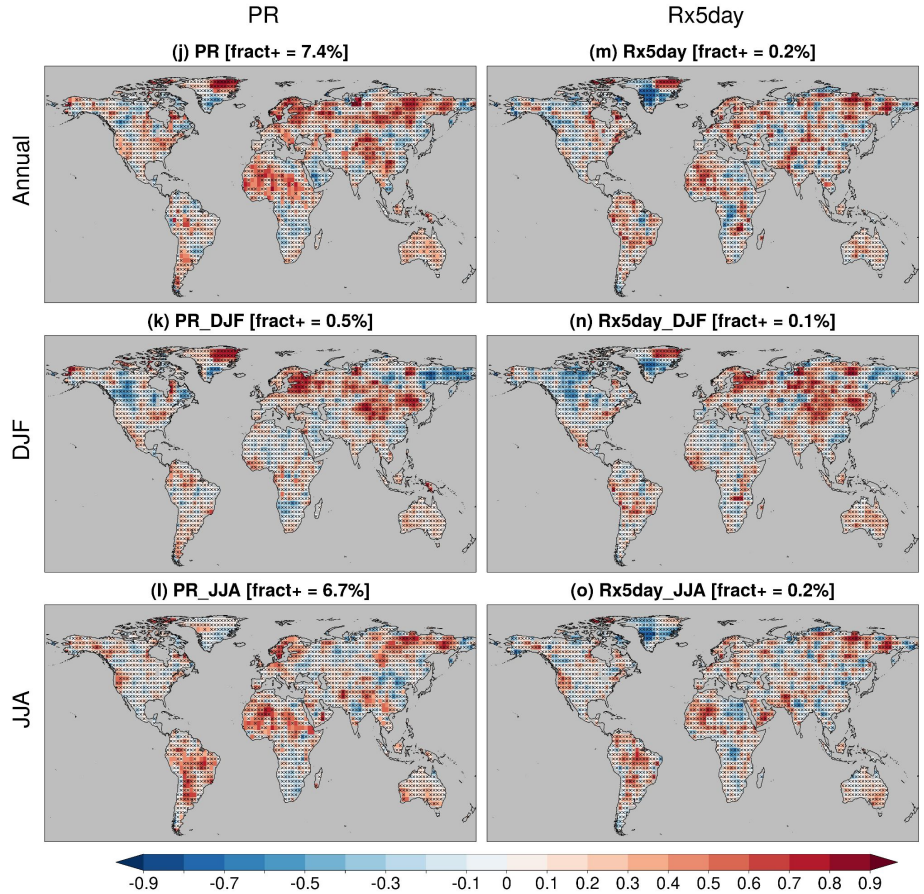


Multi-model skill - Precipitation extremes

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

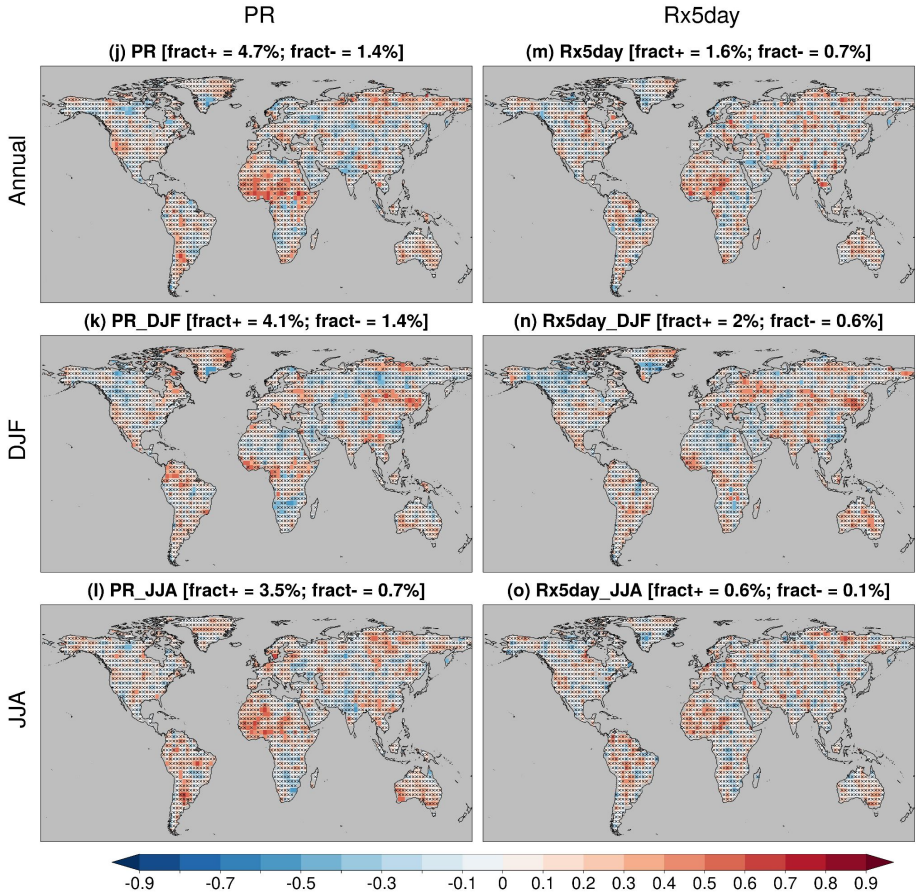
Different regions where the multi-model is skillful for **summer and winter**.

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



Impact of initialisation - Precipitation extremes

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



Main findings

- **DCPP multi-model skill**:
  - Generally high for mean and extreme temperature, particularly over land regions
  - Lower for mean and extreme precipitation (limited to regions over Central Africa, Europe, and Asia)

Main findings

- **DCPP multi-model skill**:
  - Generally high for mean and extreme temperature, particularly over land regions
  - Lower for mean and extreme precipitation (limited to regions over Central Africa, Europe, and Asia)

- **Mean vs extreme predictions:**
  - Lower skill for extremes than for mean quantities
  - Higher skill for extremes based on minimum temperature than for maximum temperature
  - Higher skill for the frequency-related extremes (TX90p, TN10p, R95p) than for the intensity-related extremes (TXx, TNn, Rx5day)
  - Higher prediction skill in summer than in winter.

Main findings

- **Multi-model vs forecast systems**:
  - 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

Main findings

- **Multi-model vs forecast systems**:
  - 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

- **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
  - Generally low and highly region-dependent for predictions of extremes

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.

Madrid
Enero 2025

Barcelona Supercomputing Center
Centro Nacional de Supercomputación

Delgado-Torres, C., Donat, M. G., Gonzalez-Reviriego, N., Caron, L., Athanasiadis, P. J., Bretonnière, P., Dunstone, N. J., Ho, A., Nicoli, D., Pankatz, K., Paxian, A., Pérez-Zanón, N., Cabré, M. S., Solaraju-Murali, B., Soret, A., and Doblas-Reyes, F. J. (2022). Multi-Model forecast quality assessment of CMIP6 decadal predictions. Journal of Climate, 35(13), 4363-4382. https://doi.org/10.1175/JCLI-D-21-0811.1

Delgado-Torres, C., Donat, M. G., Soret, A., Gonzalez-Reviriego, N., Bretonnière, P.-A., Ho, A.-C., Pérez-Zanón, N., Samsó Cabré, M., and Doblas-Reyes, F. J. (2023). Multi-annual predictions of the frequency and intensity of daily temperature and precipitation extremes. Environmental Research Letters, 18 034031. https://doi.org/10.1088/1748-9326/acbbe1

¡Muchas gracias!

carlos.delgado@bsc.es