Workshop on Objective Seasonal Forecast (OSF) production over MedCOF region.
2-4 July 2024 Madrid, Spain

POTENTIAL IMPROVEMENTS THROUGH CALIBRATION AND DOWNSCALING: BLENDING ANALOGS AND MLR

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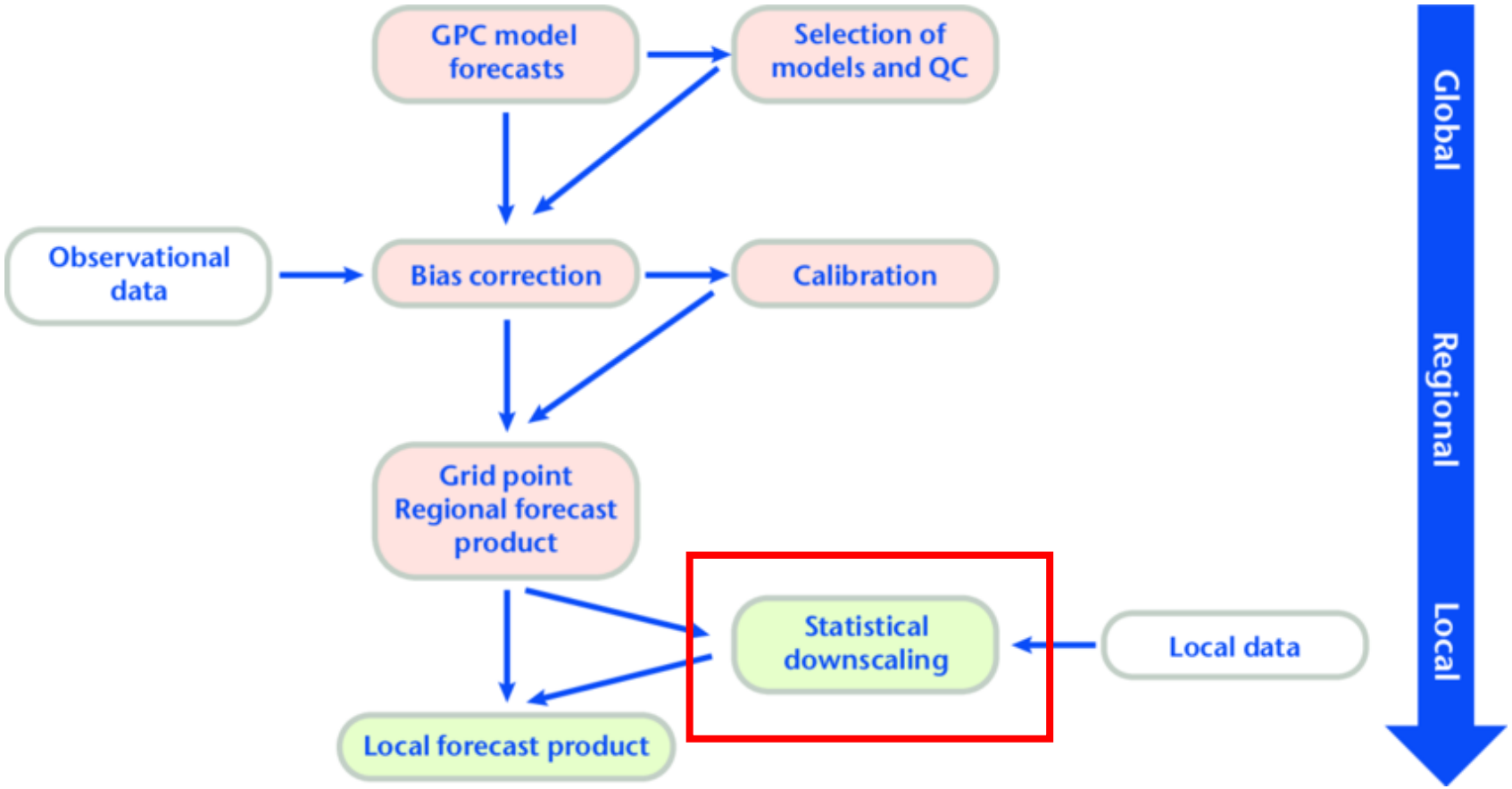
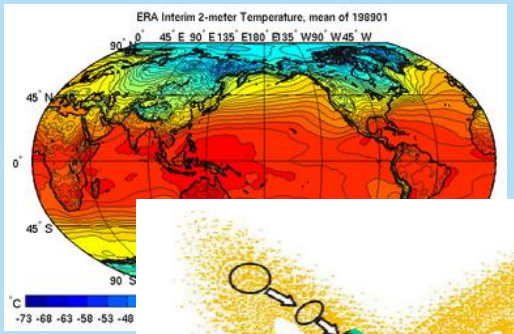
Outline of the recommended procedure to develop an objective seasonal forecast

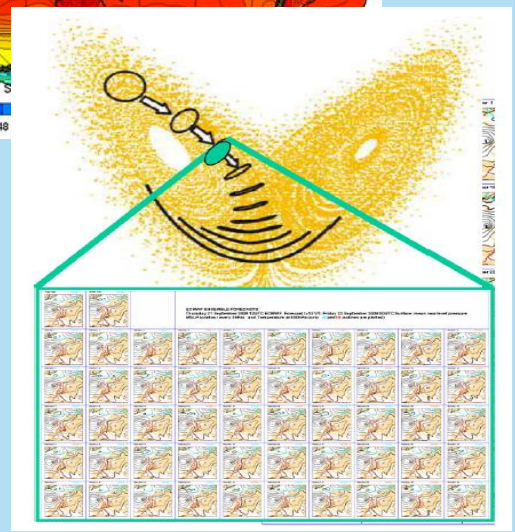


Kumar et al., 2020

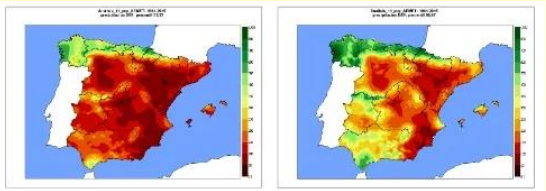
Important aspects of downscaling process

Select **representative predictors** from Seasonal Forecast Systems (low resolution, e.g. SEAS5.1 1º)





Have **quality observational dataset** (high resolution, e.g. 5km)



Serie de precipitación diaria en rejilla con fines climáticos

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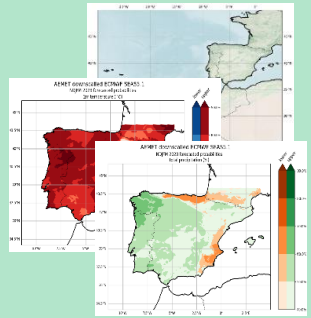
Petra Ramos Calzado

Select **statistical downscaling methods**

1. Analogs/Weather typing
2. MLR
3. QM
4. ML techniques (RF, XGB, ANN…)
5. …

Analogs + MLR + Weather types from AEMET algorithm



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Analogs downscaling algorithm from AEMET

(Petisco et al. (2008a), Petisco et al. (2008b), Amblar et al. (2017))

What it does: Downscaling of precipitation and maximum and minimum temperature of the seasonal forecast on a grid. It uses analogous synoptic situations in a past reference period based on Euclidean distances. Also uses regression and weather types.

Input data:

- Reanalysis (ERA Interim, ERA 5,...) and seasonal forecasting (Hindcast and Forecast (SEAS5.1))

- Observational High resolution data (ROCIO_IBEB 5km AEMET grid).

Output data:

- Temperature and precipitation data on a 5Km grid

Domain: centered on IP

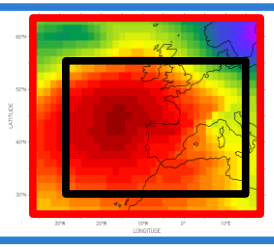
ANALOGS + MLR downscaling algorithm from AEMET: TEMPERATURE

CALIBRATION and VALIDATION PERIOD (1981-1996)
REANALYSIS + OBSERVATIONS

1. Obtain a set of analogs associated with an estimation day

DATA

- **ERAInterim (1.5º x 1.5º)**
- **Geostrophic wind components 1000-500 hPa from geopotential (12h)**
- **Domain: wider than IP**



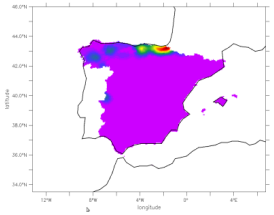
2. Regression model
(with a set of selected analogs)

PREDICTANDS (Yn) (ROCIO_IBEB 5km):
- Tmax y Tmin

PREDICTORS (Xn) (ERAInterim 1.5º):
- geopotential (1000/500 hPa)
- Insolation
- 2 m temperature
- Geostrophic wind components (1000/500 hPa)
- Vorticity (1000/500 hPa)

ESTIMATION PERIOD (Hindcast (1997-2016) Forecast (2023-2024))
SEASONAL FORECAST SYSTEMS

- **Domain: IP**

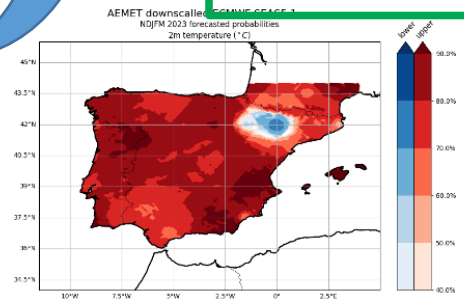


- **PREDICTORS (Xn) (SEAS5/SEAS5.1 from ECMWF (1º x 1º)**:
- geopotential (1000/500 hPa)
- Insolation
- 2 m temperature
- Geostrophic wind components (1000/500 hPa)
- Vorticity (1000/500 hPa)

Yn=f(Xn)

PREDICTANDS (Yn)

Maximum and Minimum Temperature



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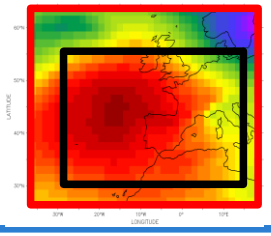
WEATHER TYPES + ANALOGS downscaling algorithm from AEMET: PRECIPITATION

CALIBRATION and VALIDATION PERIOD (1981-1996)
REANALYSIS + OBSERVATIONS

1. **Weather types:** seeds (Lund, 1963) + k-means (Anderberg, 1973)
2. **Synoptic analogs** for each weather type

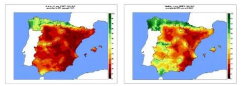
DATA

- **ERAInterim (1.5º x 1.5º)**
- **Geostrophic wind components 1000-500 hPa from geopotential (12h)**
- **Domain: wider than IP**



3. Stepwise regression: Significance of each predictor in a linear regression model, for each weather type

PREDICTAND (ROCIO_IBEB 5km):
Precipitation
Potential PREDICTORS:
- geopotential (1000,500hPa)
- Relative humidity (700hPa)
- Relative vorticity (1000hPa)
- Geostrophic wind components (1000, 500hPa)
- Temperature (1000, 850, 700, 500hPa)



Serie de precipitación diaria en rejilla con fines climáticos

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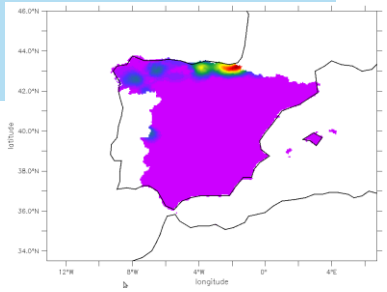
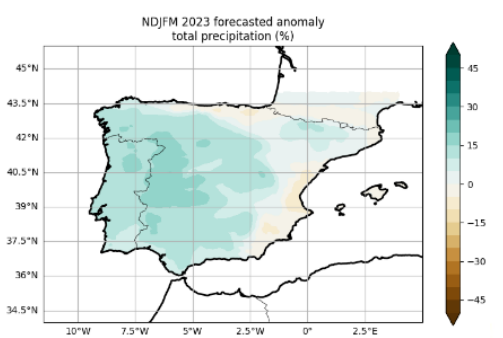
$Yn = f(Xn)$

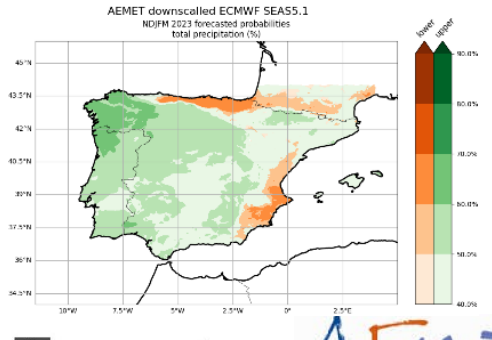
ESTIMATION PERIOD (Hindcast (1997-2016) // Forecast (2023-2024))
SEASONAL FORECAST SYSTEMS

1. **Obtain synoptic analogs**
2. **Determine to which synoptic type it belongs -> significant predictors**
3. **Local similarity using significant predictors**



Precipitation





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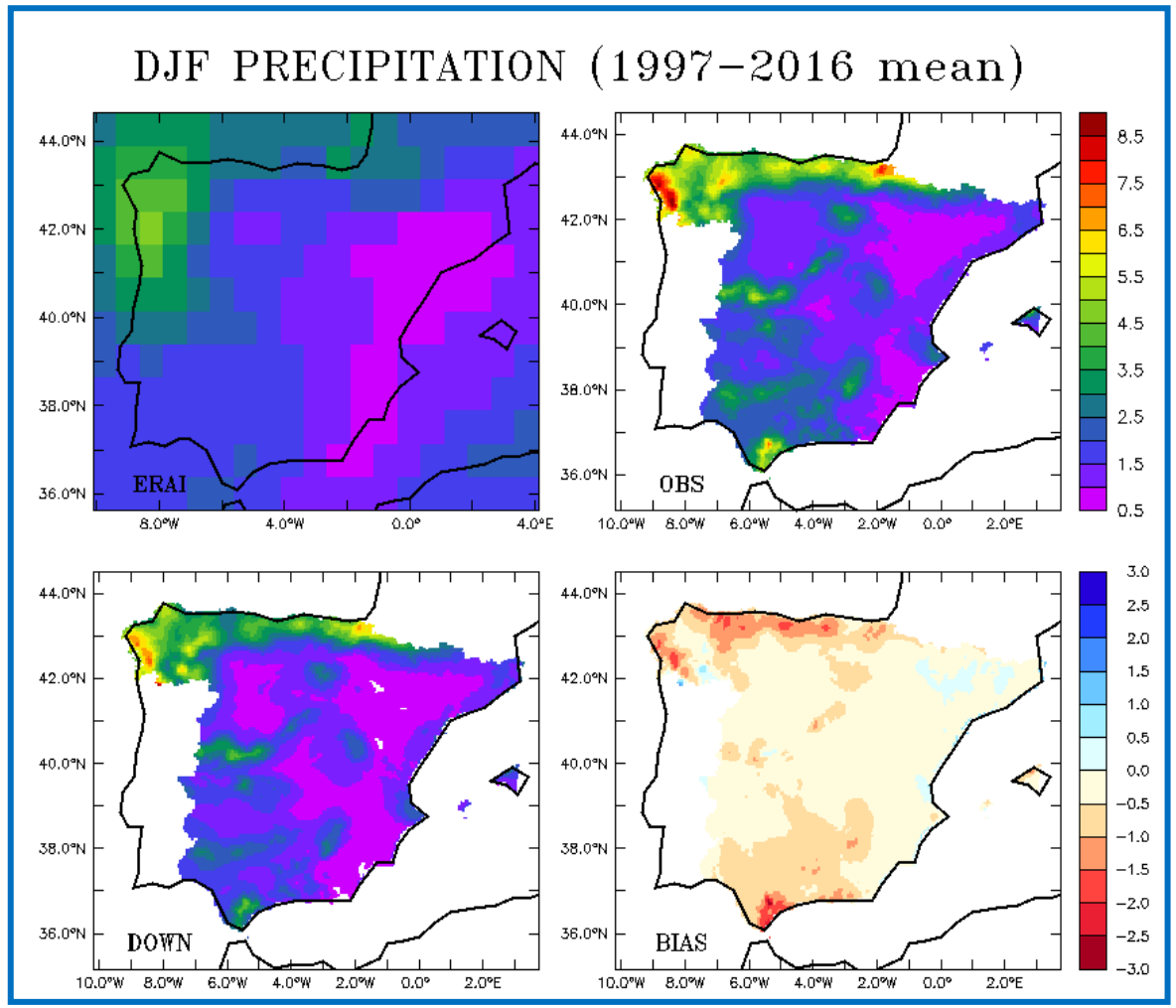
PRECIPITATION ERAInterim evaluation



- Example of the spatial distribution of the downscaling daily winter precipitation (mm/day) of ERA Interim (ERAI, upper-left panel), AEMET observational database (OBS, upper-right panel), downscaling ERA Interim-based (DOWN, lower-left panel) and of the bias (BIAS (DOWN-OBS), lower-left panel), average over the period 1997-2016.

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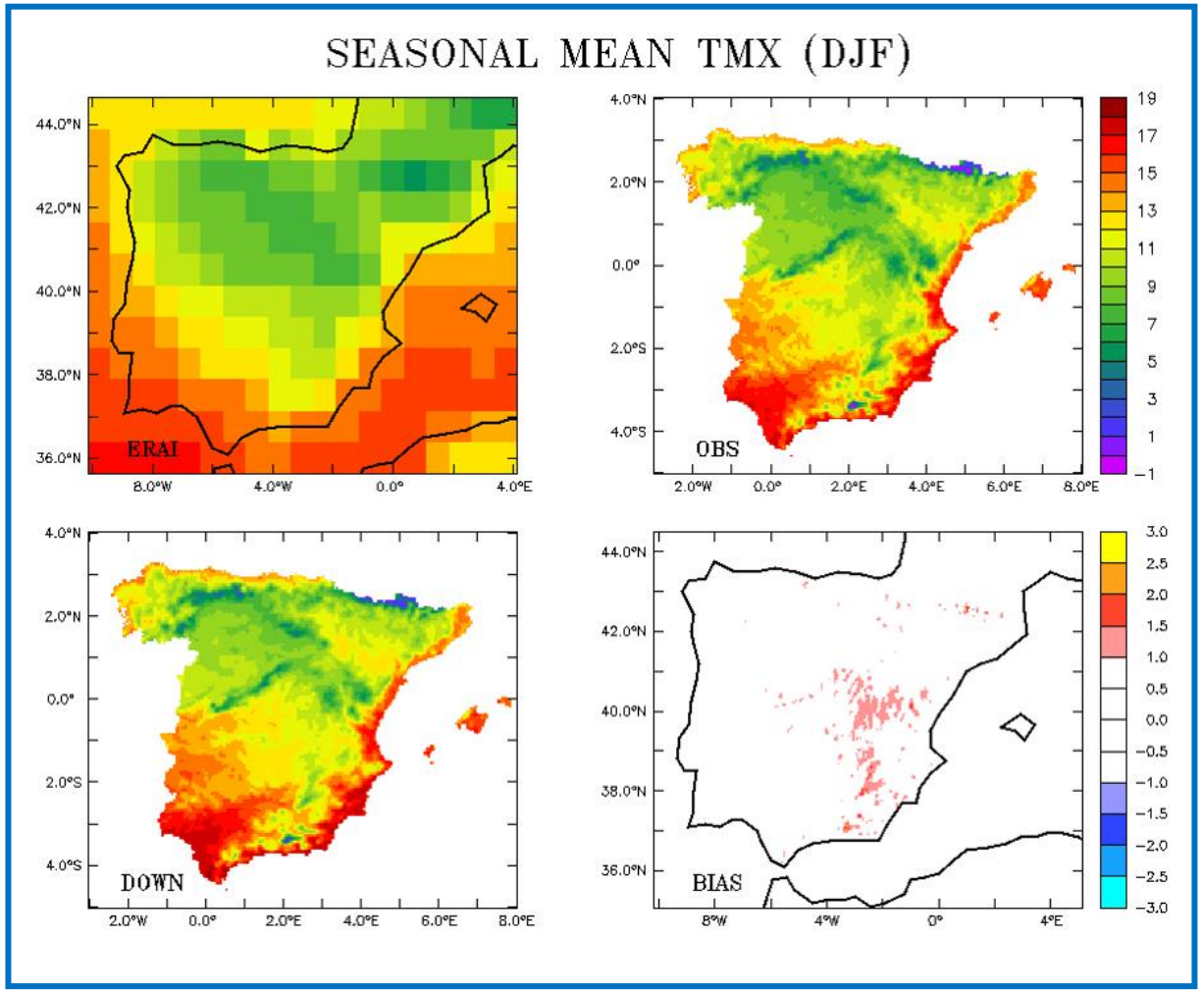
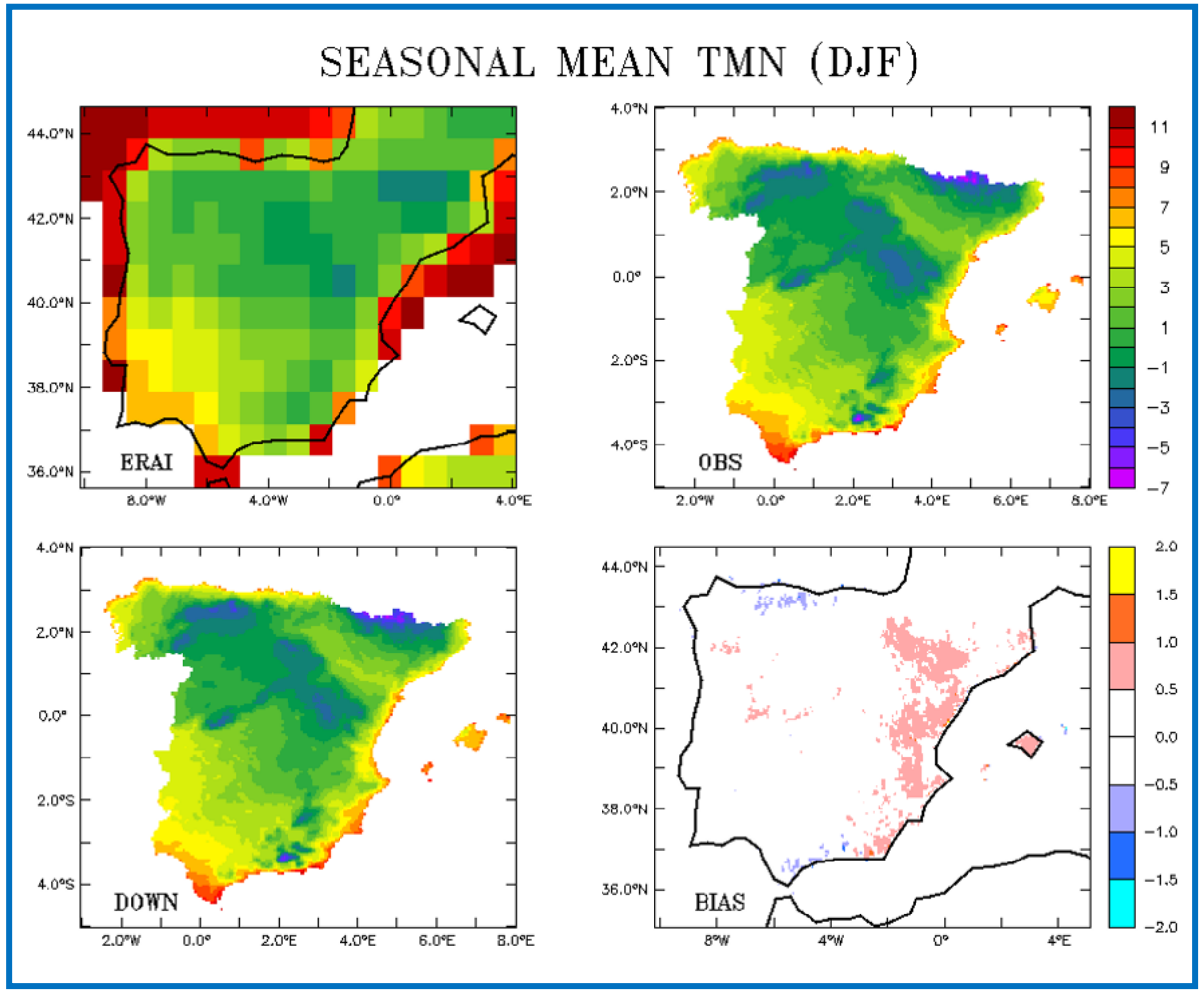
MAXIMUM and MINIMUM TEMPERATURE ERAInt evaluation





- Example of the spatial distribution of the downscaling daily winter maximum and minimum temperature (ºC) of ERA Interim (ERAI, upper-left panel), AEMET observational database (OBS, upper-right panel), downscaling ERA Interim-based (DOWN, lower-left panel) and of the bias (BIAS (DOWN-OBS), lower-left panel), average over the period 1997-2016.

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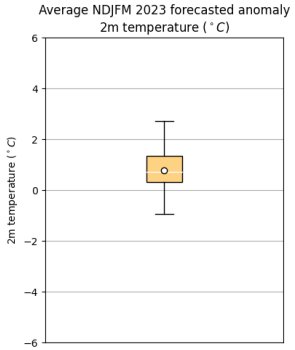
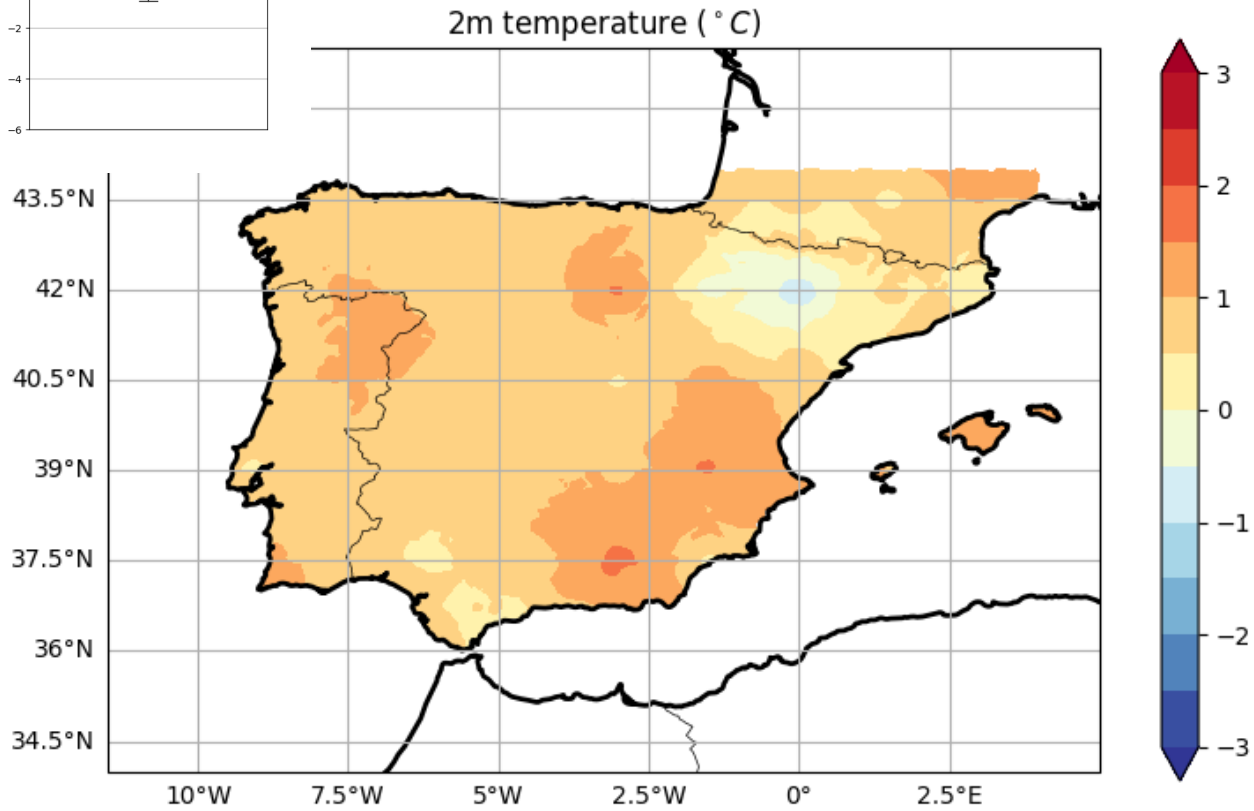
Downscaling of extended winter (NDJFM) seasonal forecast 2023-2024

Uncertainty associated with SEAS5.1 members

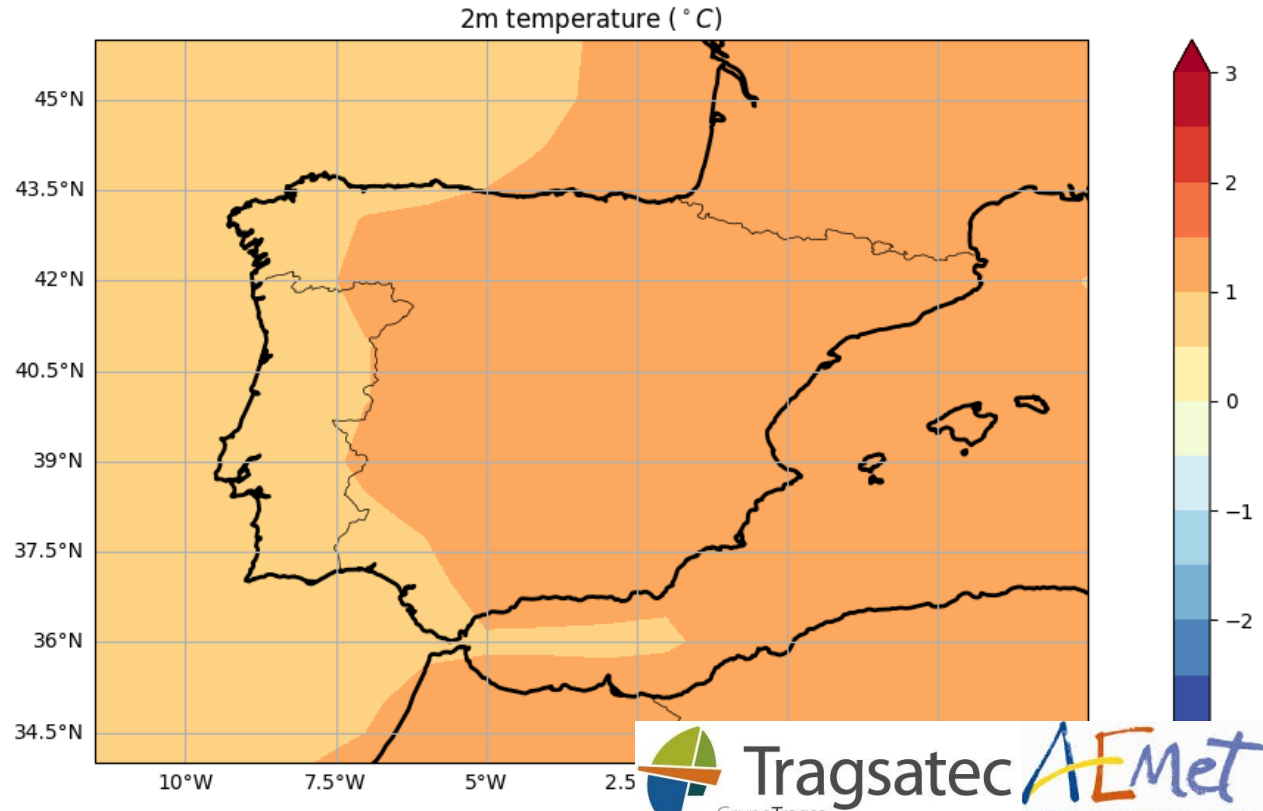


Mean TEMPERATURE anomaly regarding to HINDCAST (1997-2021)
DOWN vs RAW

DOWN SEAS5.1



RAW SEAS5.1



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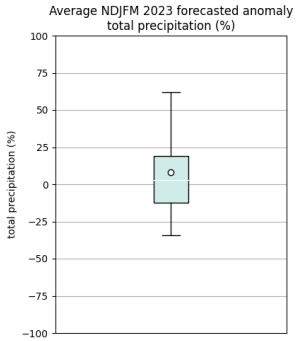
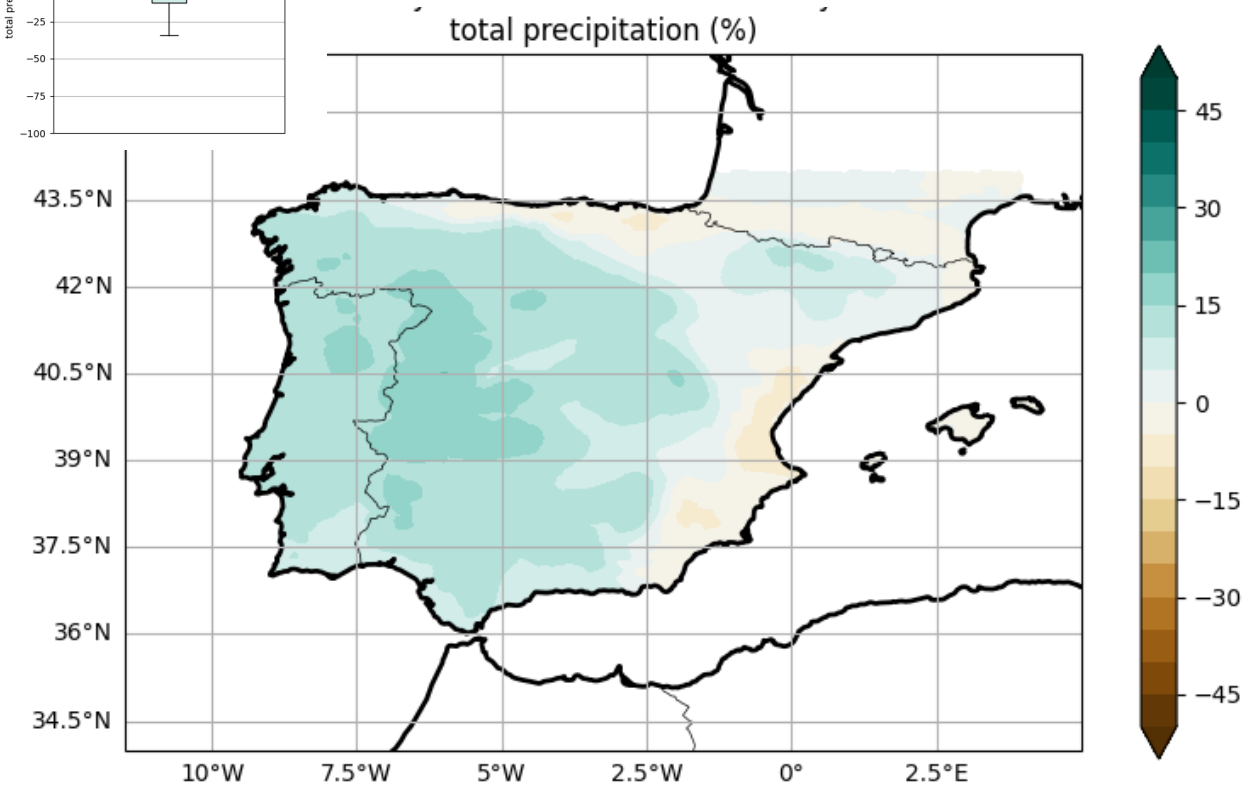
Downscaling of extended winter (NDJFM) seasonal forecast 2023-2024

Uncertainty associated with SEAS5.1 members

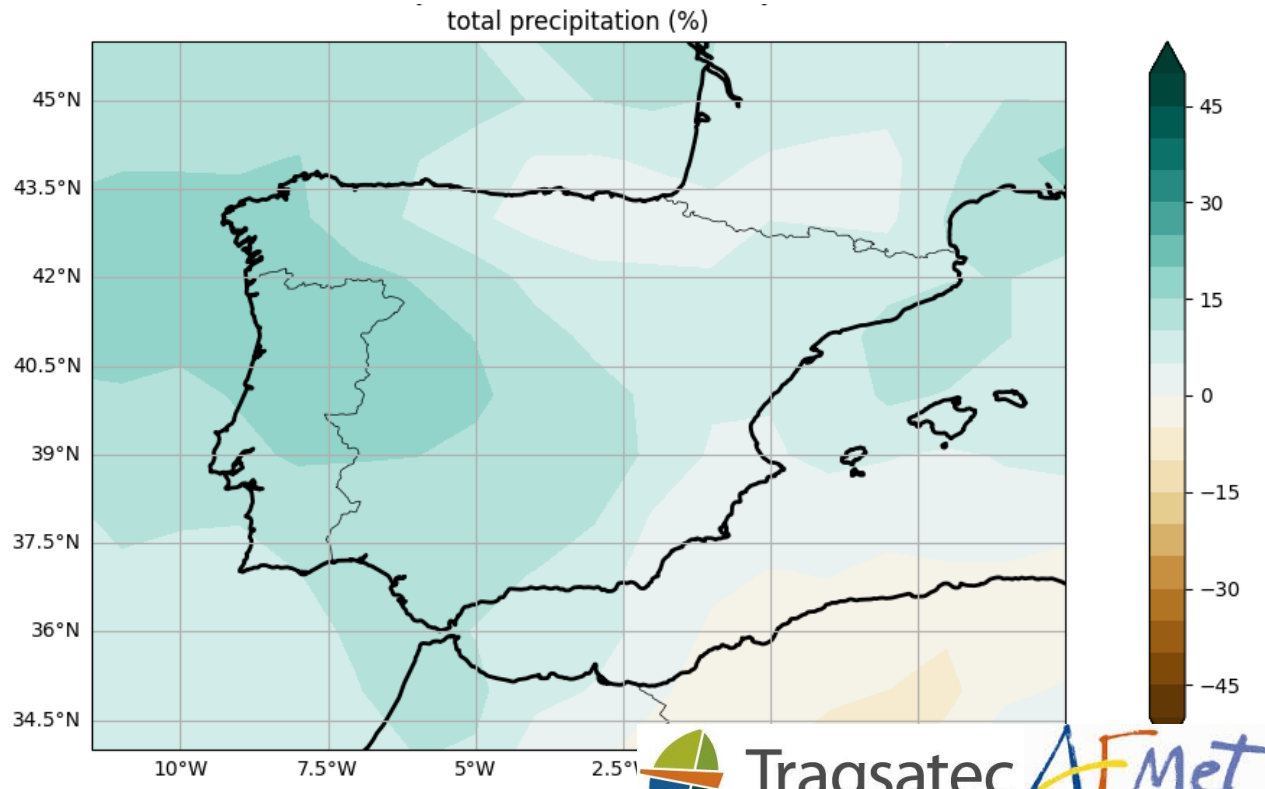


PRECIPITATION anomaly regarding to HINDCAST (1997-2021)
DOWN vs RAW

DOWN SEAS5.1



RAW SEAS5.1



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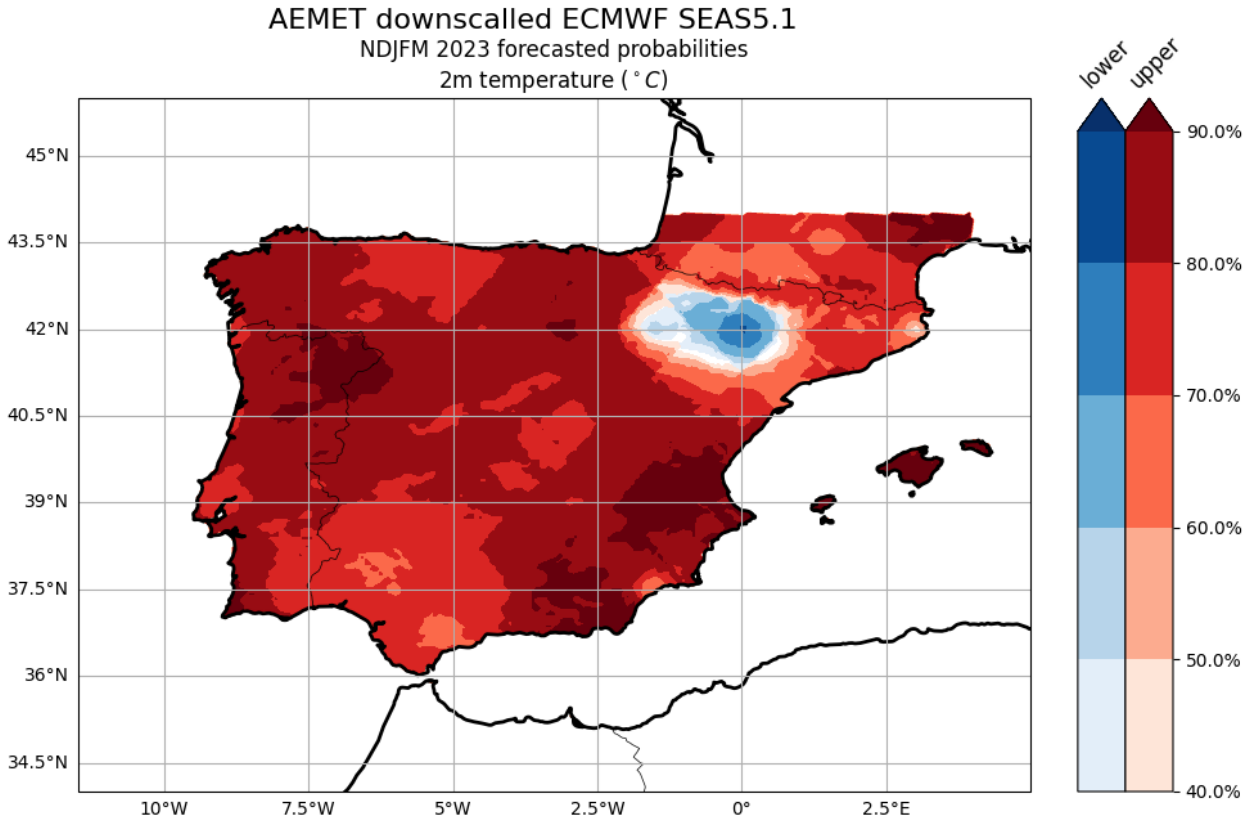
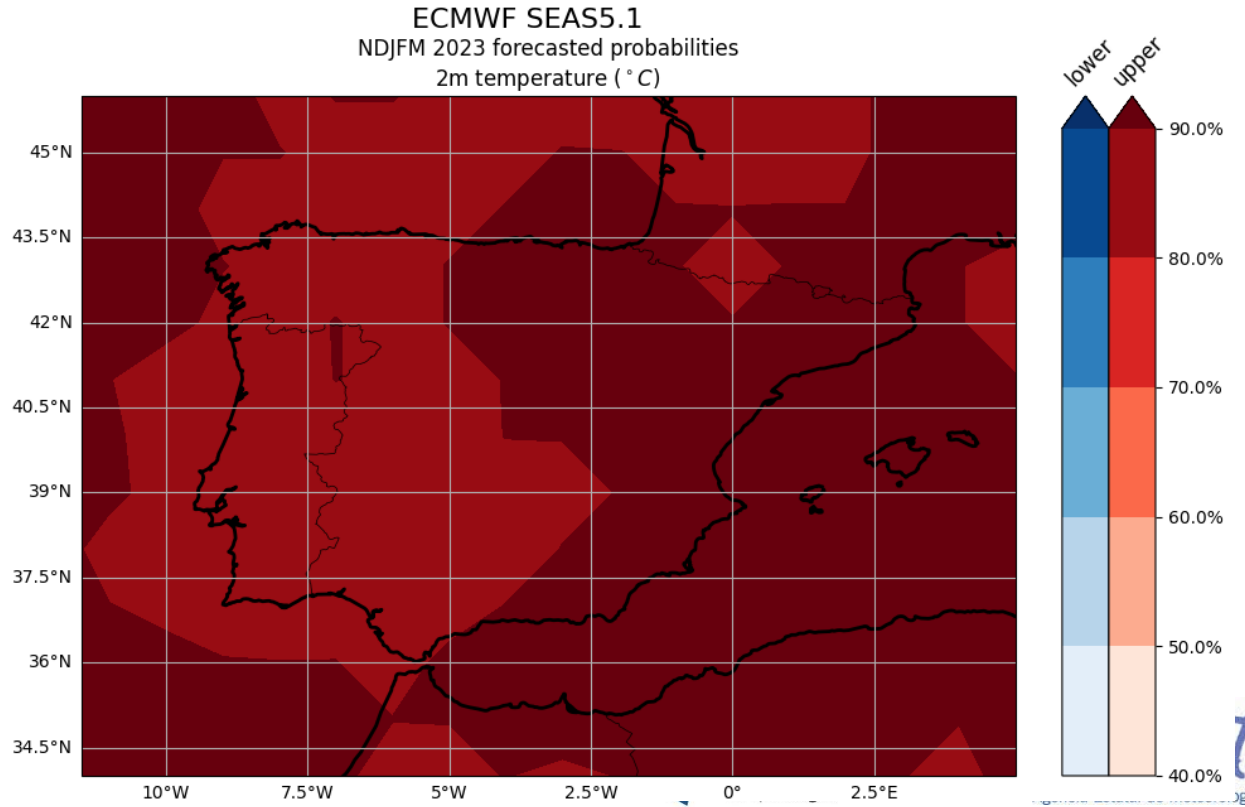
Dowscaling of extended winter (NDJFM) seasonal forecast 2023-2024

Most likely upper and lower terciles probability for mean
TEMPERATURE
DOWN vs RAW

DOWN SEAS5.1



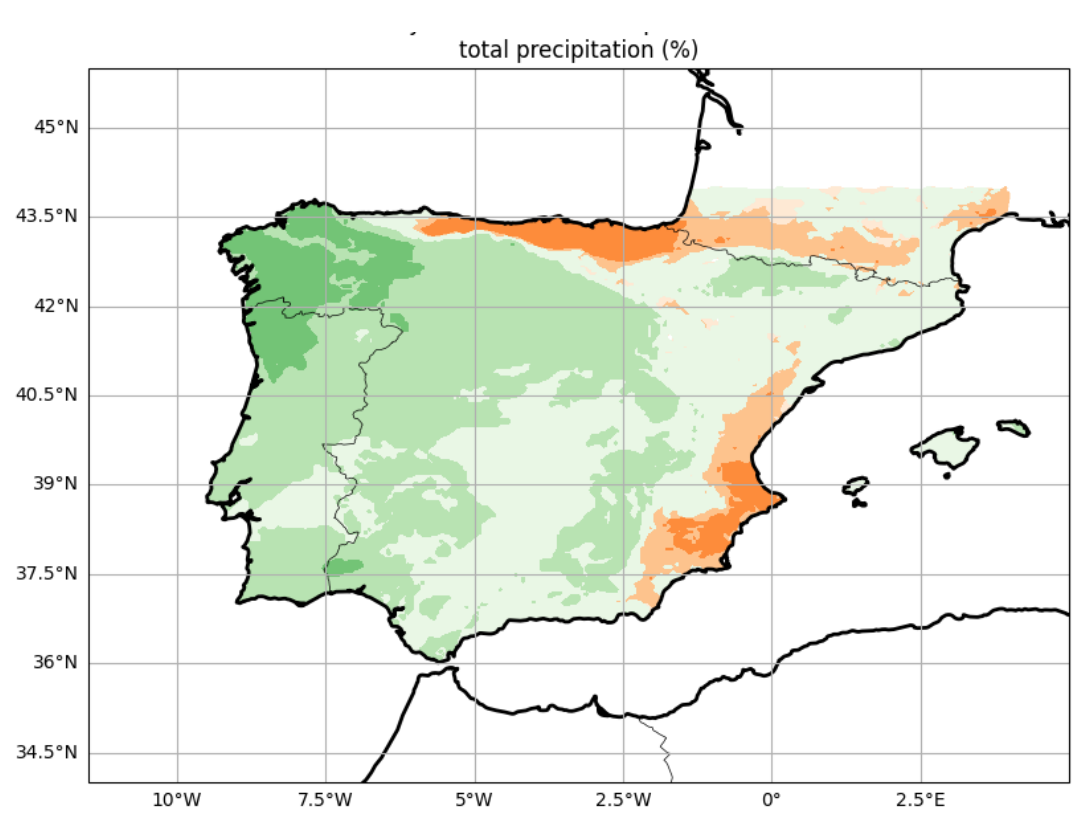
RAW SEAS5.1

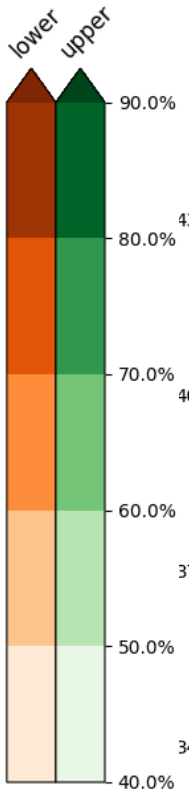


Downscaling of extended winter (NDJFM) seasonal forecast 2023-2024

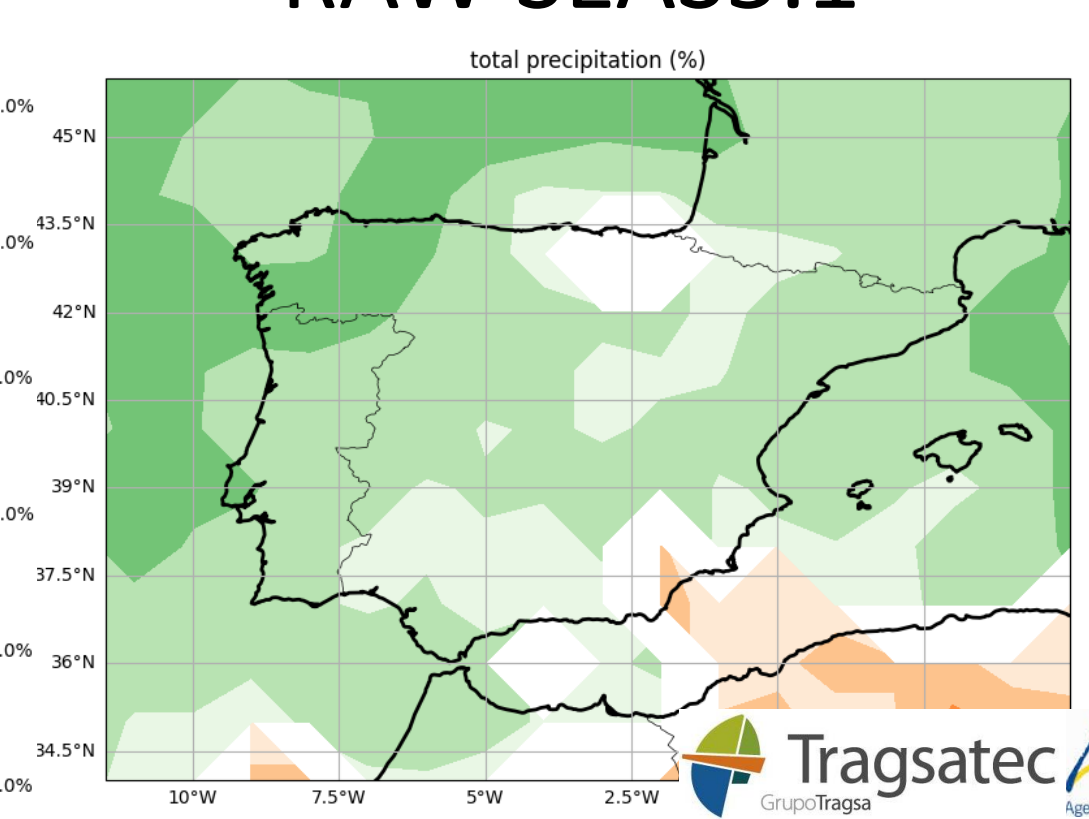
Upper/Lower terciles Probability of occurrence for
PRECIPITATION
DOWN vs RAW

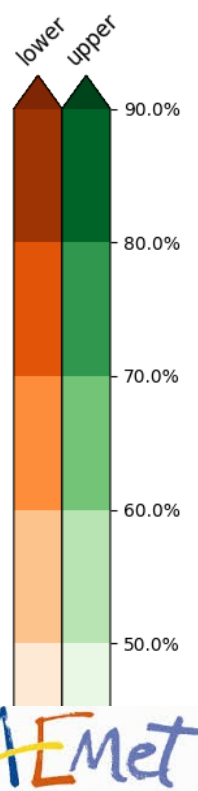
DOWN SEAS5.1





RAW SEAS5.1





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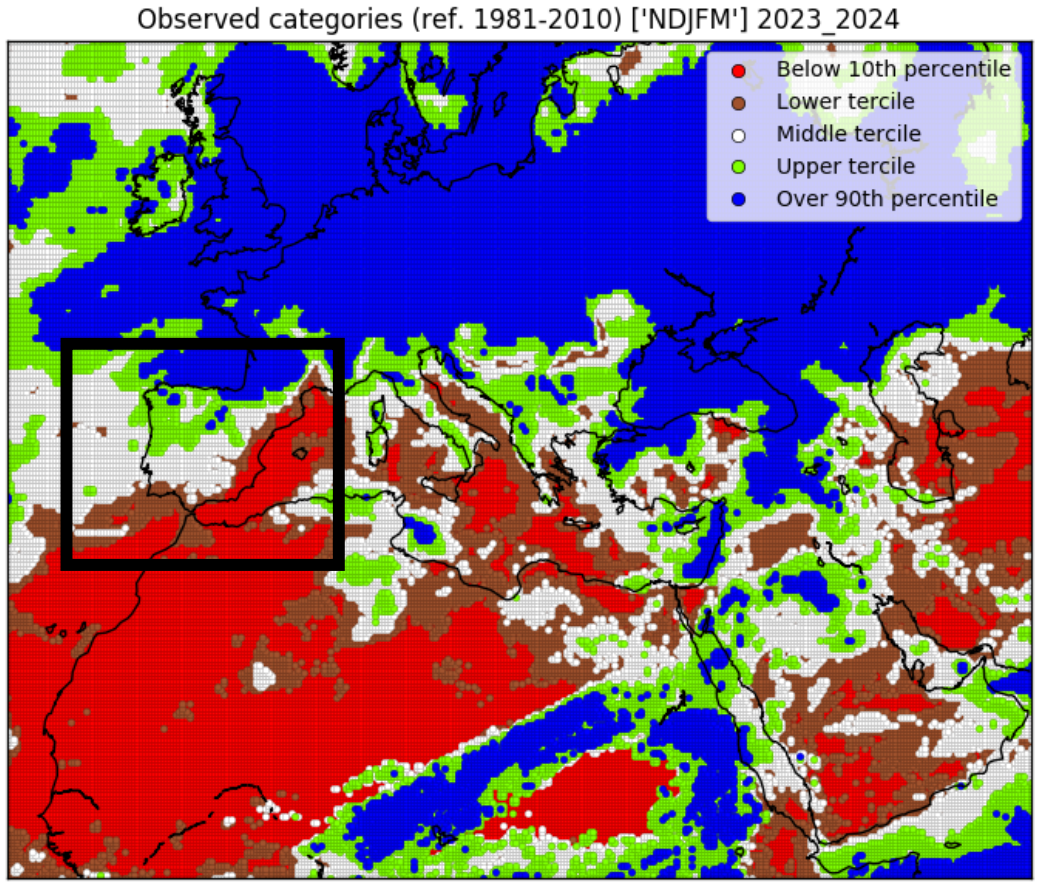
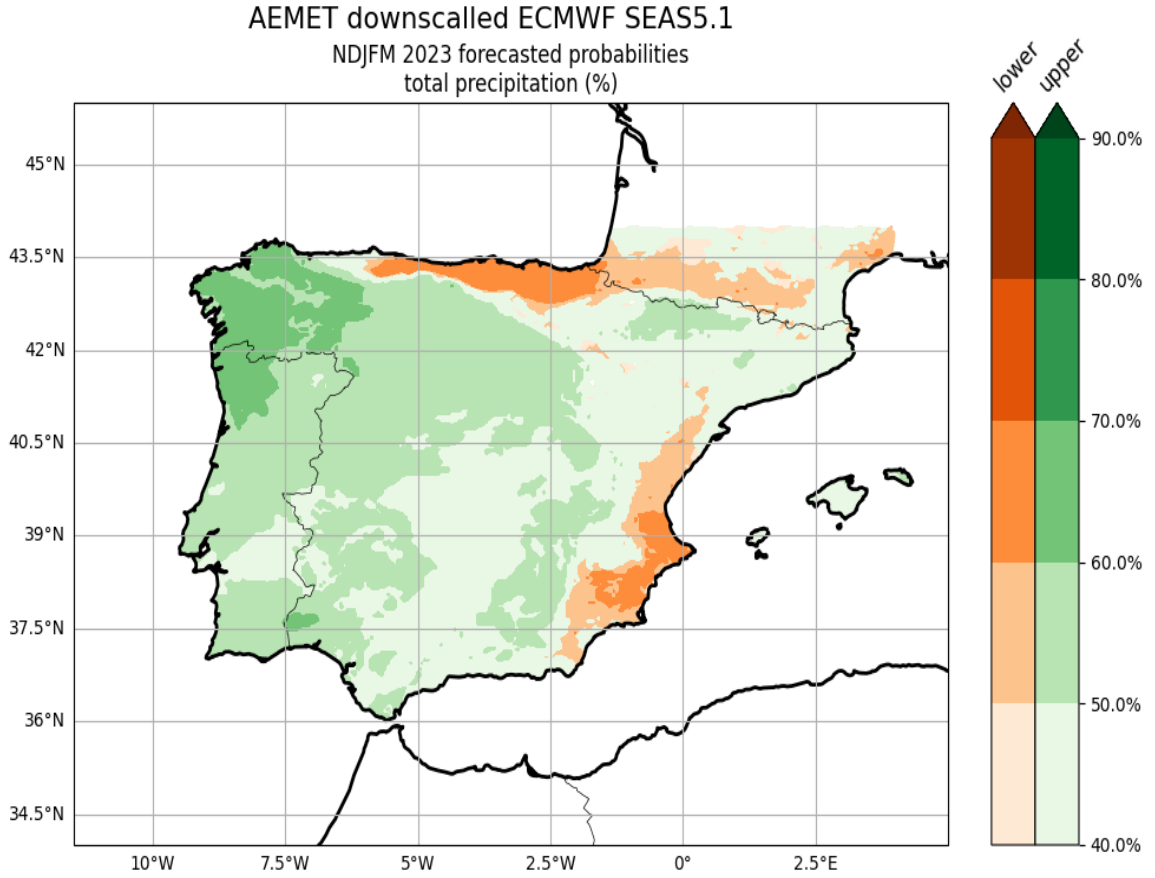
NDJFM 2023-2024 verification

ERA5



DOWN SEAS5.1



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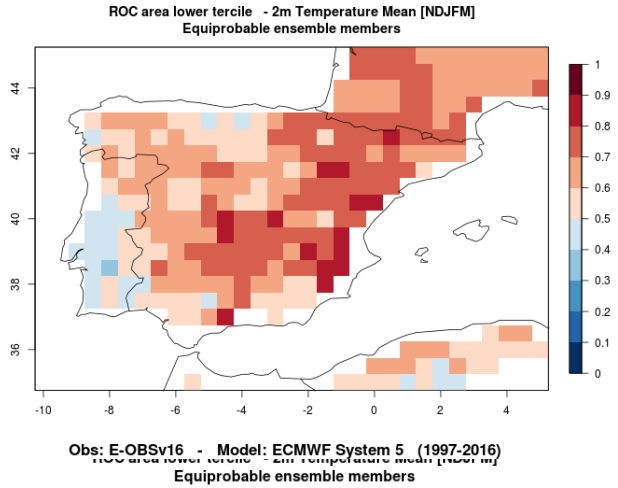
Downscaling of extended winter (NDJFM) seasonal forecast 2023-2024

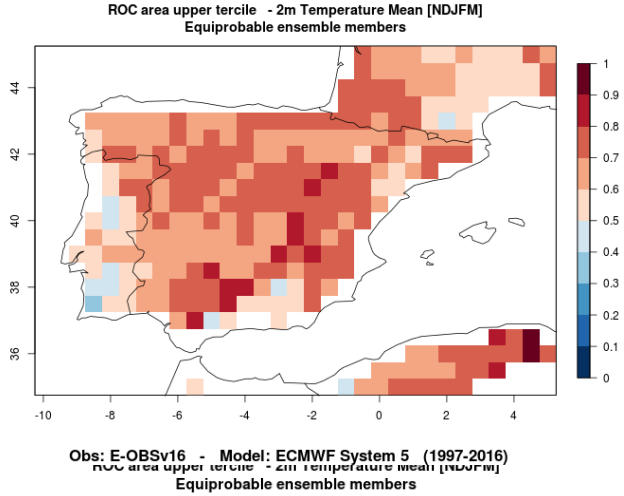
Skill (ROCArea) of lower/upper terciles for mean TEMPERATURE
RAW vs DOWN

LOWER

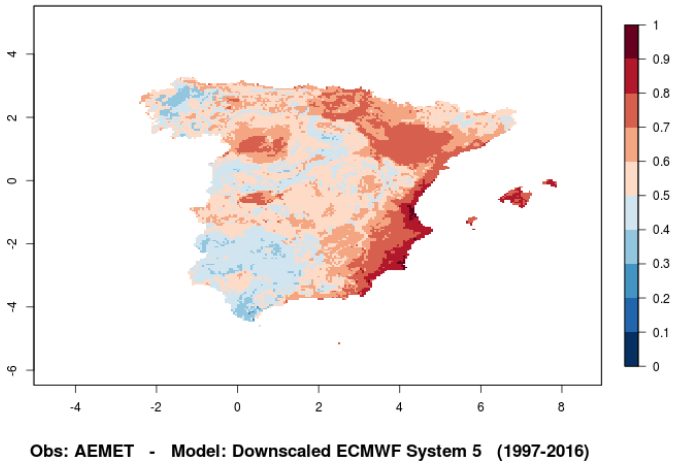
UPPER

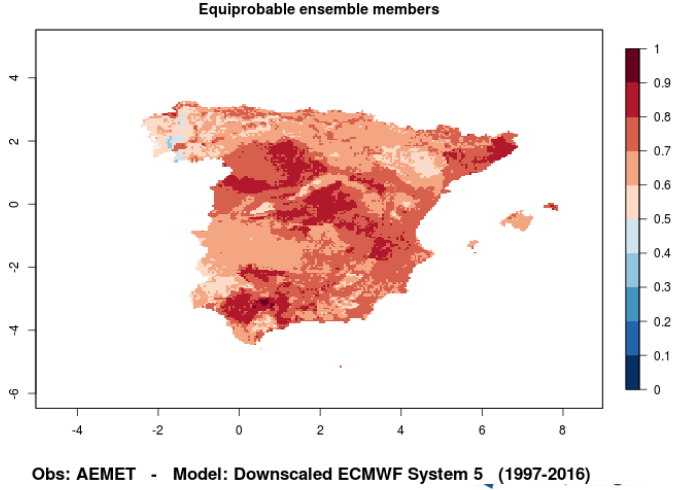
RAW SEAS5.1





DOWN SEAS5.1





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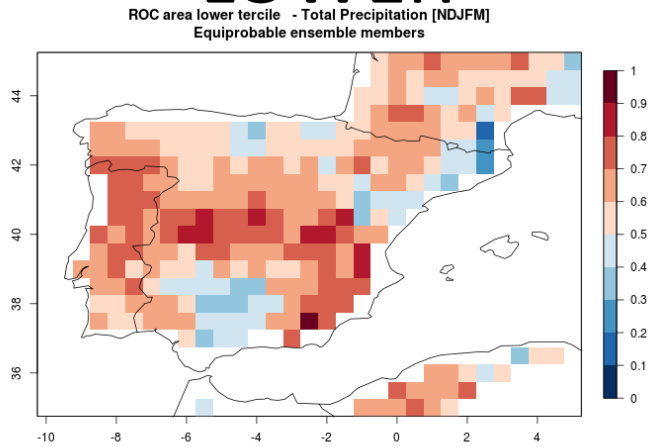
Downscaling of extended winter (NDJFM) seasonal forecast 2023-2024

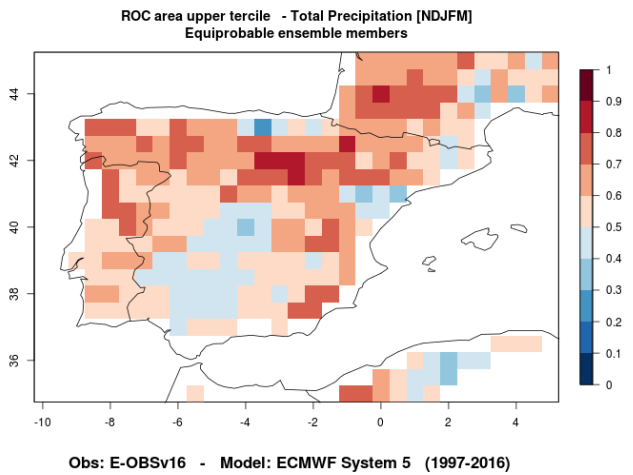
Skill (ROCArea) of lower/upper terciles for PRECIPITATION
RAW vs DOWN

LOWER

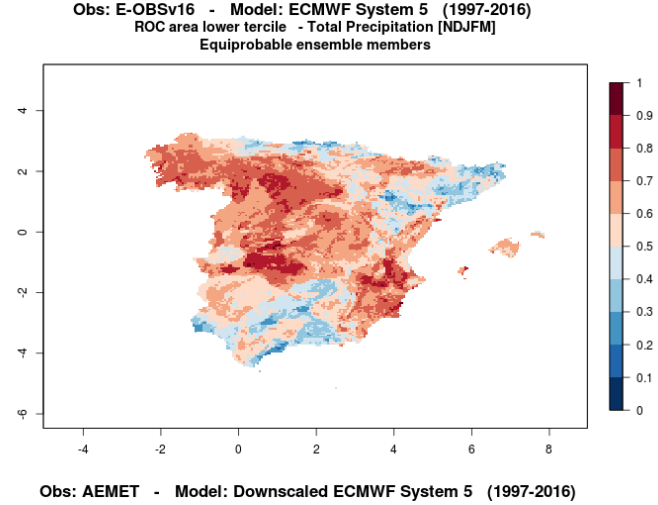
UPPER

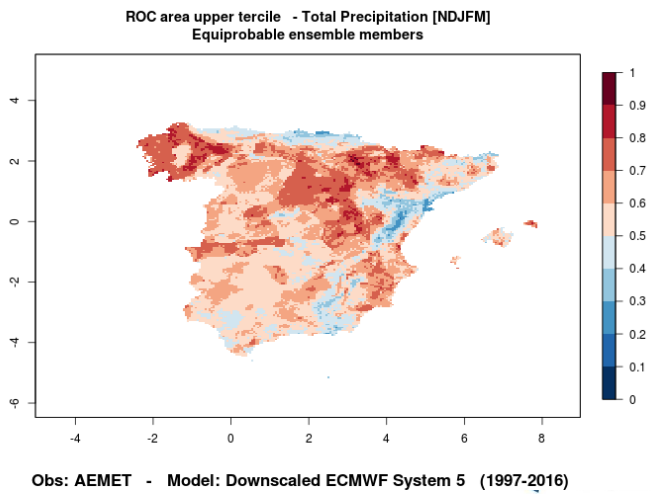
RAW SEAS5.1





DOWN SEAS5.1





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Conclusions

- It is important to take account representative predictors from Seasonal Forecast Systems, quality observational dataset and a proper downscaling method.
- The evaluation (1997-2016) of precipitation and maximum and minimum temperature estimated by the AEMET analog method shows that the methodology can provide geographical detail compared to ERAInterim, showing a very accurate spatial pattern concerning the AEMET observational dataset.
- During the extended winter, for both precipitation and mean temperature, the downscaling provides added value compared to the raw SEAS5.1 data in the following points:
    - The increased resolution of the seasonal forecast allows it to be used by resource management models in sectors such as hydrology or agriculture.
    - The greater spatial detail of the probability of occurrence allows a more realistic prediction to be made.
    - The seasonal prediction skill (ROC area) is improved both spatially and in terms of the number of occurrences.

References

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- Petisco de Lara, S. (2008a). Método de regionalización de precipitación basado en análogos: Explicación y validación. AEMET, Madrid.
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Thank you for your attention!

La distancia euclídea entre los campos tipificados de cada componente c de dos elementos m y n, donde c representa una componente cualquiera $(u_{1000}, v_{1000}, u_{500}, v_{500})$ del viento geostrófico, vendría dada por la expresión [1].

$$d_c = \sqrt{\frac{\sum_{1}^{n} w_i (c_{mi} - c_{ni})^2}{\Sigma w_i}} \qquad [1]$$

en donde:

c_{mi} y c_{ni} representan el valor de la componente c tipificada de viento geostrófico en el punto de rejilla i para dos situaciones sinópticas m, n cualesquiera cuya distancia se quiere calcular;

w_i es la ponderación correspondiente al punto de rejilla i;

$n = 198$ es el número total de puntos de rejilla del campo.

Una vez calculadas las cuatro distancias d_c correspondientes a cada uno de los cuatro campos de componentes de viento geostrófico, se toma la media de ellas como distancia D_s entre los elementos considerados.

Analogs downscaling algorithm from AEMET

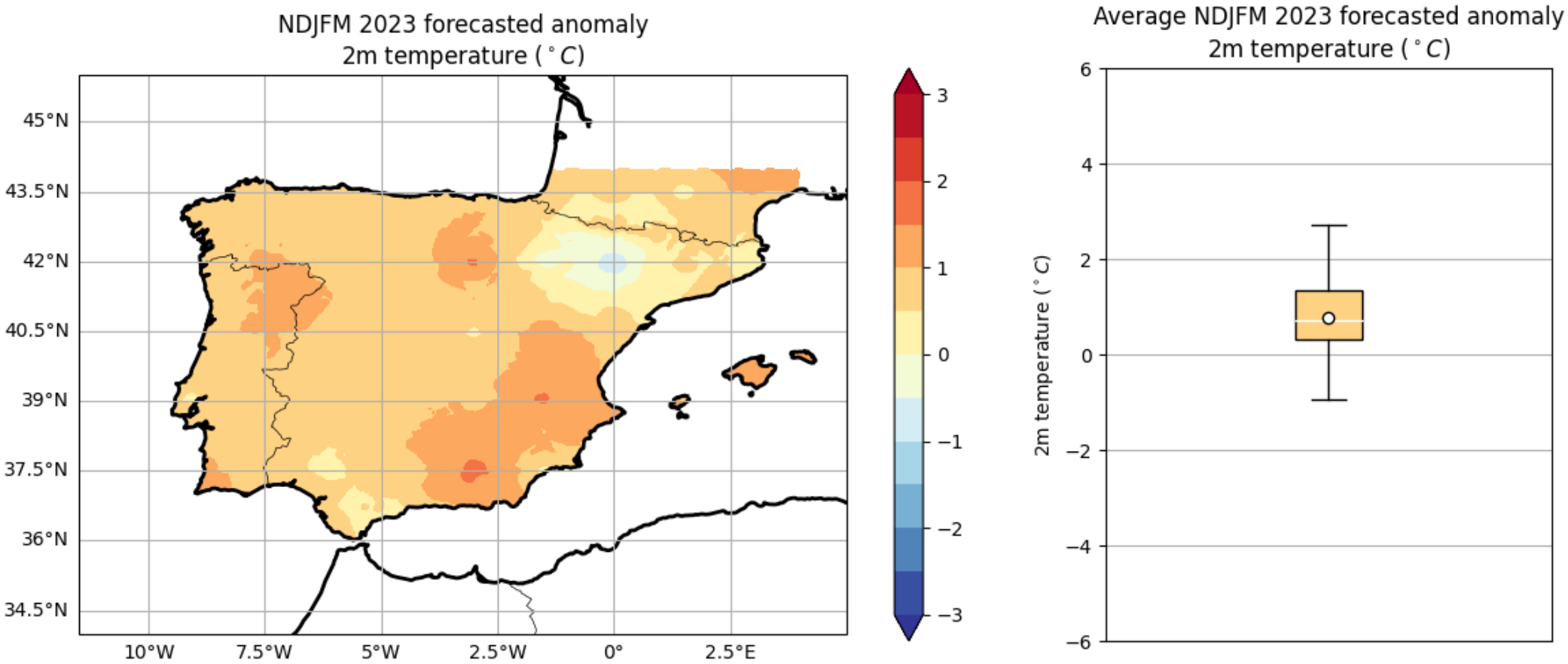
Depending on variable, methodology is different:

Precipitation: reanalysis synoptic regimes are classified according to weather types (k-means, [Anderberg1973]) and significant predictors are determined for each of them. Finally, the group to which our problem day belongs is assigned, and rainfall is estimated by regression with the significant predictors for its weather type.

Tmax and Tmin: a multiple linear regression is carried out between some predictor variables of the reanalysis and the temperature data of the observational grid. Once the adjustment has been made, the temperature estimate is made by substituting, in the adjusted equation, the values that the predictor variables take on the problem day of the model.

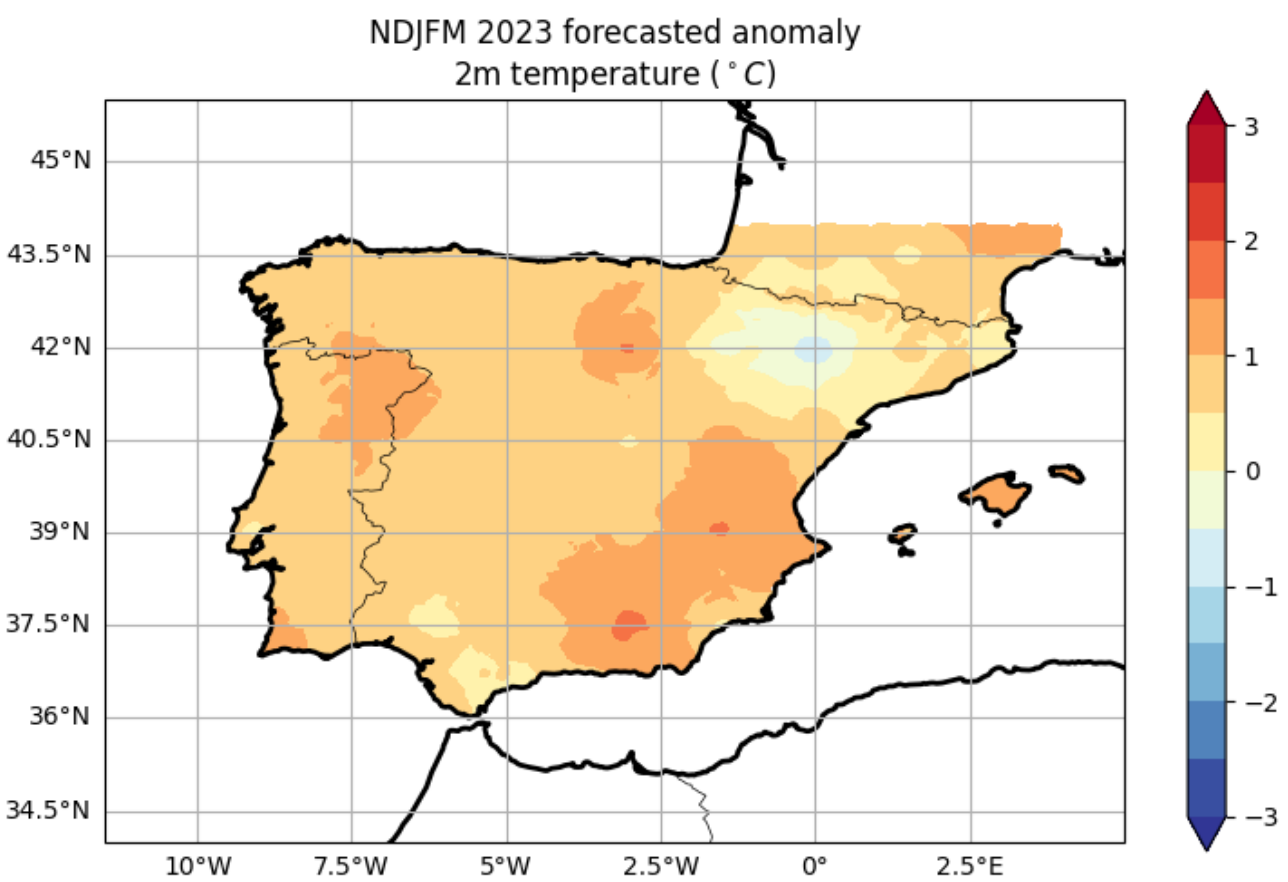
Downscaling of extended winter (NDJFM) seasonal forecast 2023-2024

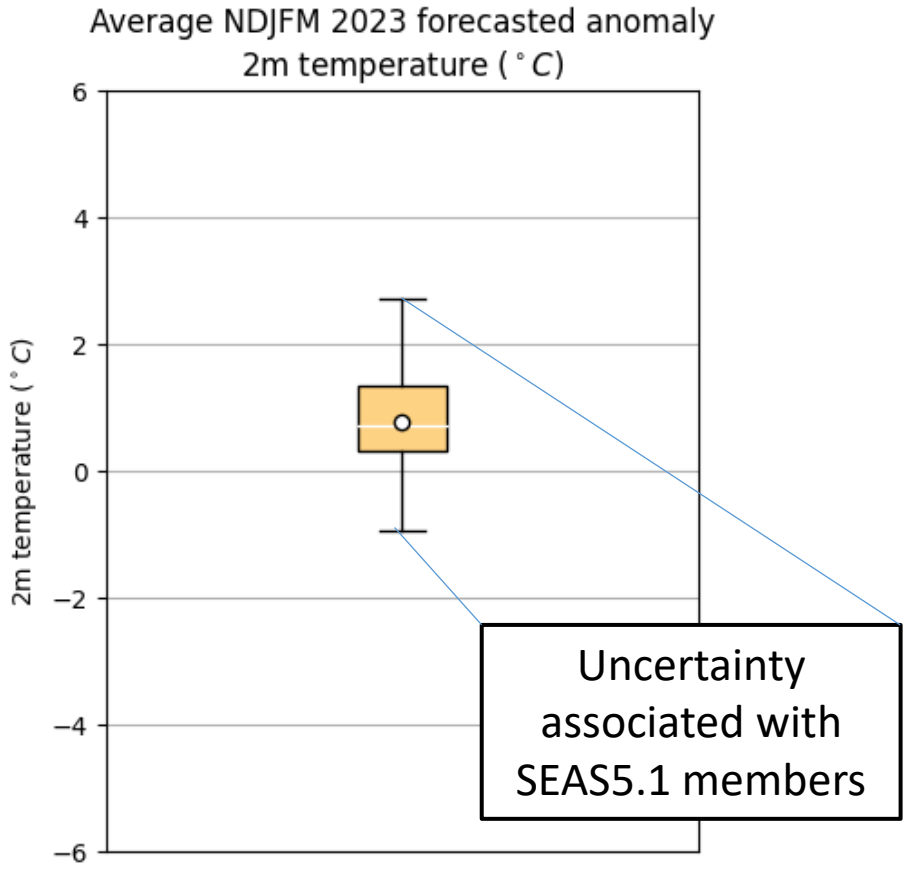
AEMET downscalled ECMWF SEAS5.1 NDJFM 2023



Downscaling of extended winter (NDJFM) seasonal forecast 2023-2024

AEMET downscalled ECMWF SEAS5.1 NDJFM 2023





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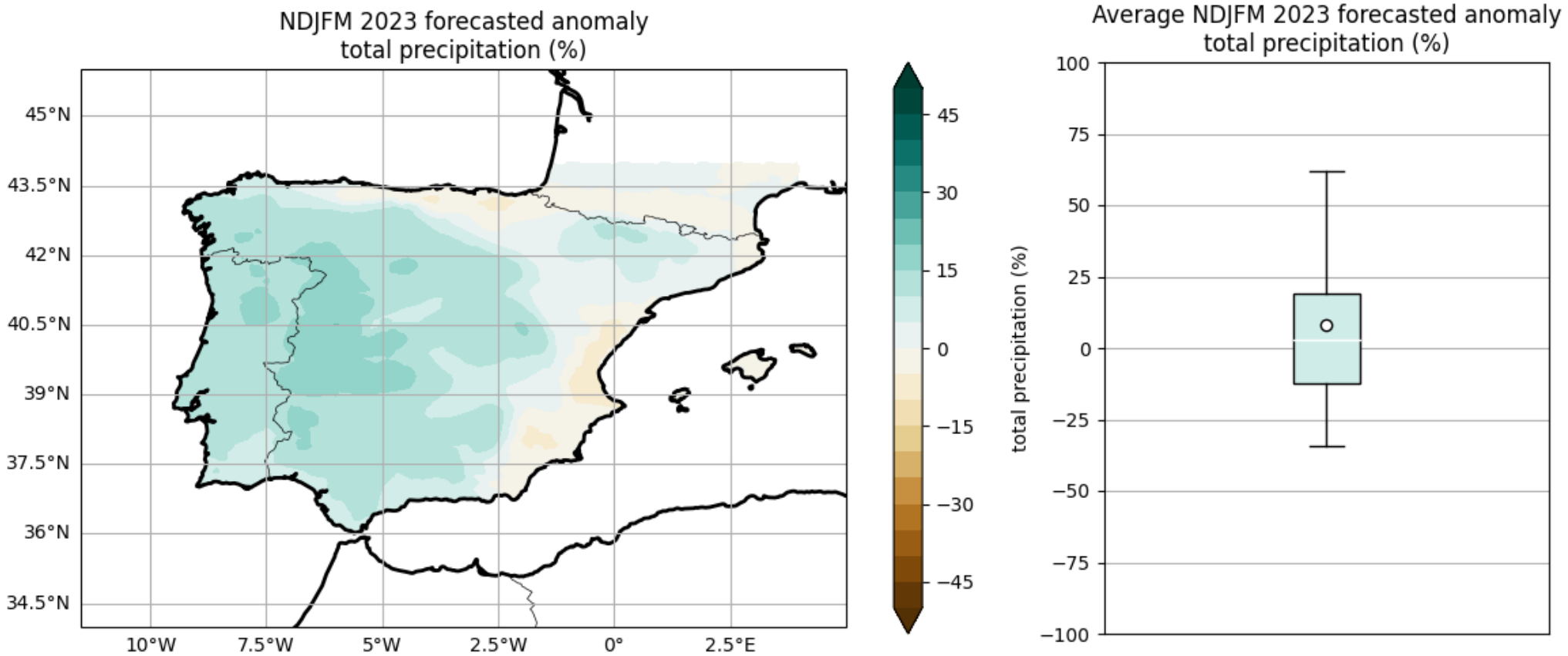
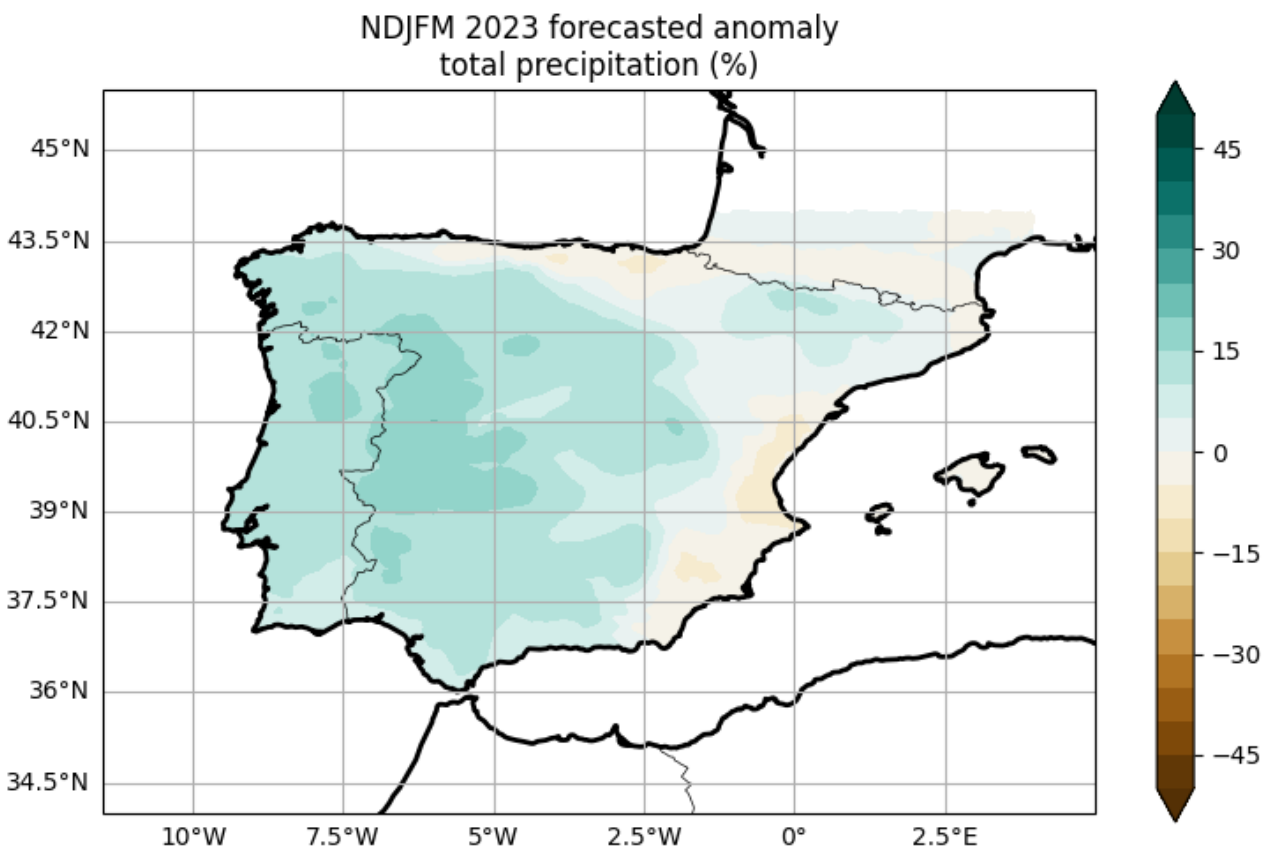
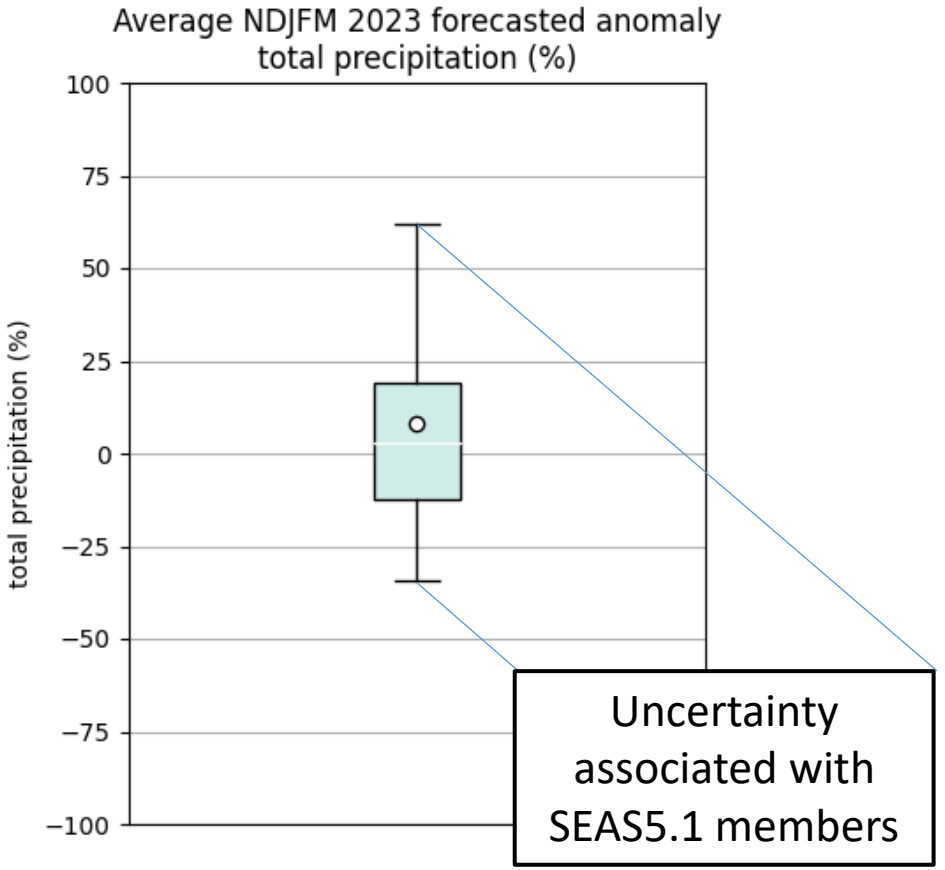


Downscaling of extended winter (NDJFM) seasonal forecast 2023-2024

AEMET downscalled ECMWF SEAS5.1 NDJFM 2023





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