

# ***Modelización climática en AEMET: contribuciones a modelos, predicciones y proyecciones***

Congreso Asociación Meteorológica Española

E. Rodríguez-Guisado, A. Hernanz-Lázaro, C. Correa-Guinea, J.C. Sánchez-Perrino, I. Prieto-Rico, A. Fernández-Andrade, J.A. Parodi-Perdomo, A. Martínez-Ferrer, J.J. González-Alemán, F. Franco-Manzano, M. Domínguez-Alonso, S. Sanfiz, J. Gutiérrez-Fernández, I. Rodríguez-Muñoz, M. Ortega-Camacho

[erodriguezg@aemet.es](mailto:erodriguezg@aemet.es)



GOBIERNO  
DE ESPAÑA

VICEPRESIDENCIA  
TERCERA DEL GOBIERNO

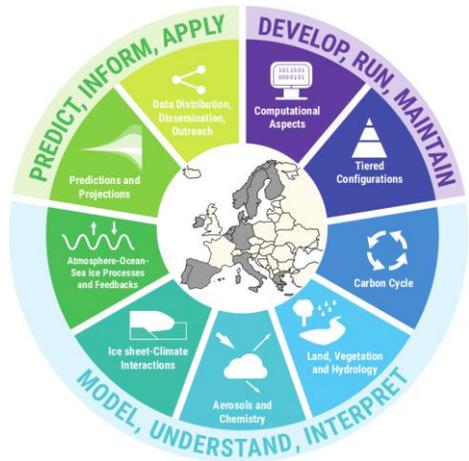
MINISTERIO  
PARA LA TRANSICIÓN ECOLÓGICA  
Y EL RETO DEMOGRÁFICO



Agencia Estatal de Meteorología

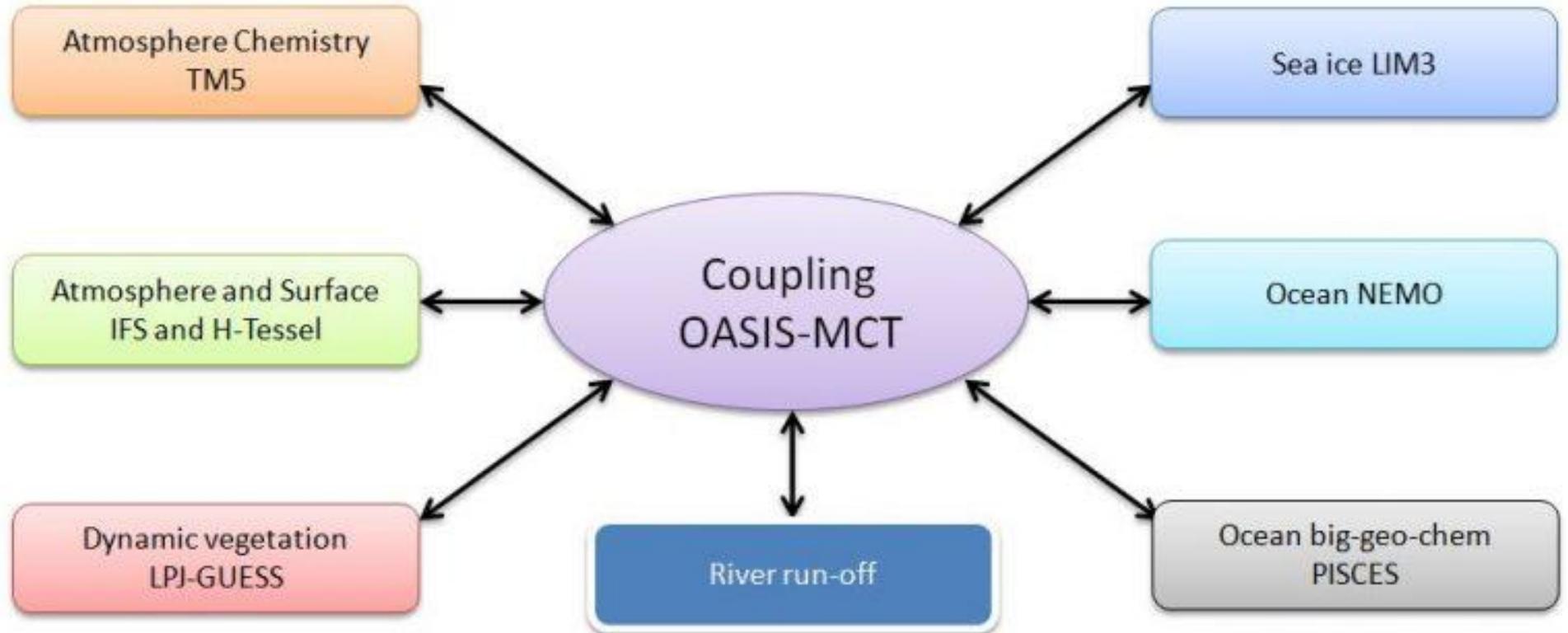
1. Climate Modelling
2. Downscaled climate projections for Spain
3. Climate Predictions
4. Climate Services

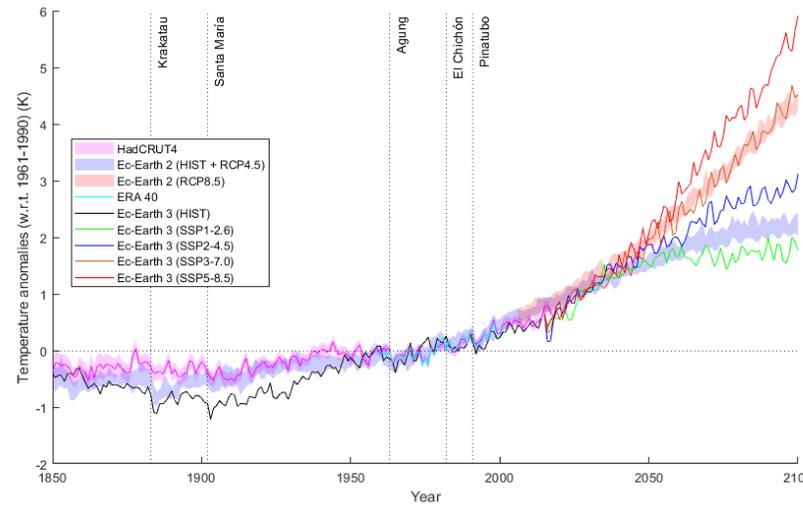
1. **Climate Modelling**
2. Downscaled climate projections for Spain
3. Climate predictions
4. Climate Services



**GCM**  
Global Climate Model

The EC-Earth global climate coupled model consists of the atmospheric IFS model developed at ECMWF coupled to the NEMO LIM3 ocean / sea ice model developed at University of Louvaine-la-Neuve. It also has vegetation, air chemistry, and bio-geo chemistry models and can be coupled to a Greenland ice sheet





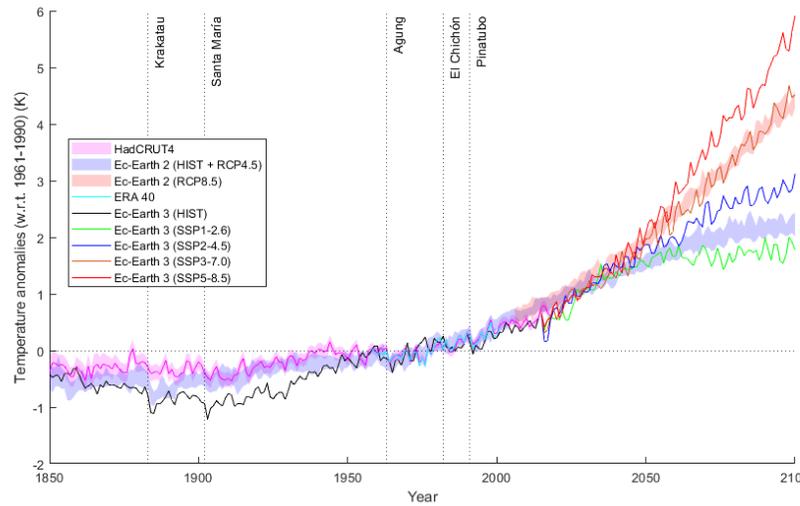
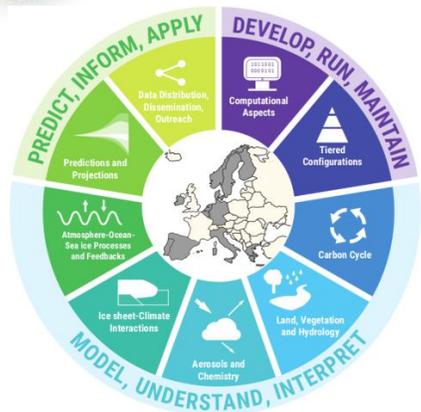
- AEMET is member of EC-EARTH ESM consortium, and has contributed with several simulations to CMIP6, including covid-MIP and ICE-MIP experiments.
- Currently, model version for AR7 is being finished, and first simulations will start shortly.

Póster día 25 16:45-17:15

*EC-EARTH4: Nueva versión del modelo climático global europeo.*

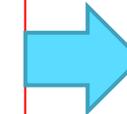
*J.A. Parodi-Perdomo, E. Rodríguez-Guisado*

**First results**



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IPCC ([link](#)): **“Climate models are one of the primary means for scientists to understand how the climate has changed in the past and may change in the future. These models simulate the physics, chemistry and biology of the atmosphere, land and oceans in great detail, and require some of the largest supercomputers in the world to generate their climate projections”**

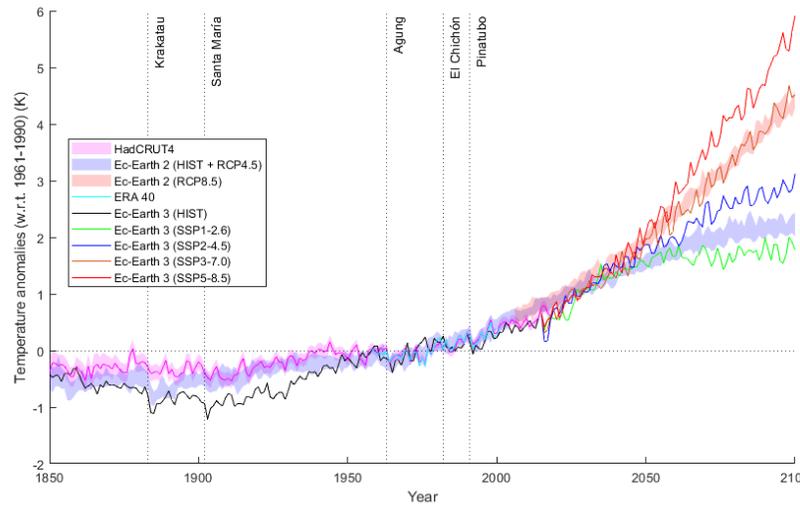


Current international context puts CMIP (and data for next IPCC

CORE EC-EARTH consortium members pay an anual fee, but there are many associated members that can use the model for research and contribute with no cost but their commitment.

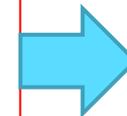
**WE NEED YOU!**





- AEMET is member of EC-EARTH ESM consortium, and has contributed with several simulations to CMIP6, including covid-MIP and ICE-MIP experiments.
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Current international context puts CMIP (and data for next IPCC report) at risk



CORE EC-EARTH consortium members pay an anual fee, but there are many associated members that can use the model for research and contribute with no cost but their commitment.

WE NEED YOU!





AEMET is member of HCLIM (Harmonie-CLIMate) consortium, which develops a regional climate model based on Harmonie, sharing code and systems with ACCORD/HIRLAM/UWC.

Which contributes to CORDEX and has a CPM version.

AEMET contributes with development on:

**Soil humidity:** improved representation of water table

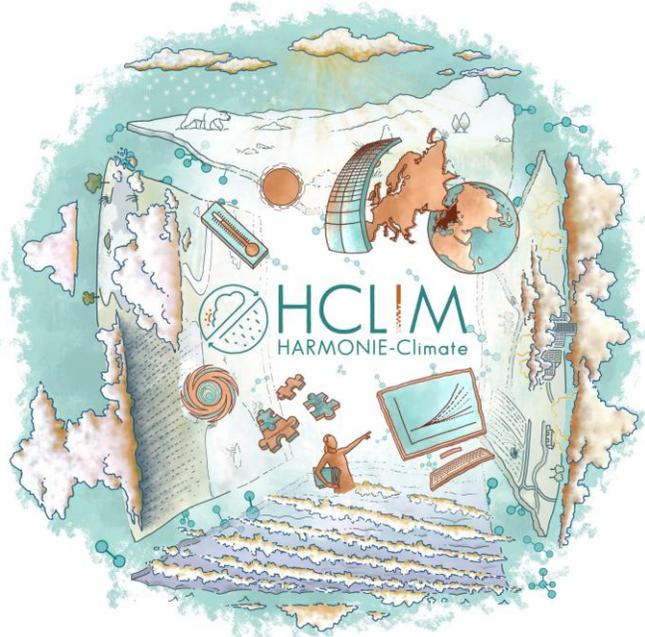
**Aerosols:** improved representation of aerosols (jointly with NWP)

**Ocean coupling:** AEMET leads the working group seeking to have a reliable version of the model coupled with ocean, particularly relevant for Spain.

**AI/ML:** participation in the group developing hybrid methods and emulators based on HCLIM.

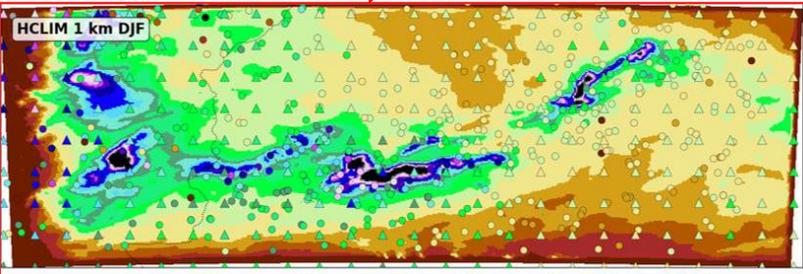
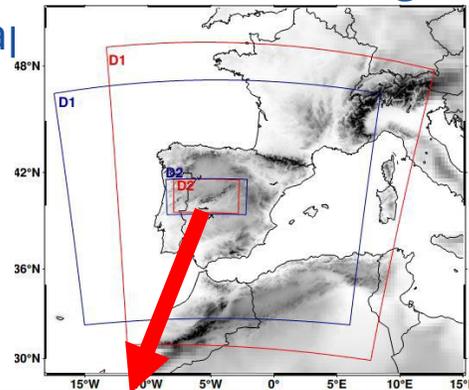
<https://www.hclim.org/>

More has been showed X25@13:30: *DANAS en clima presente y futuro: downscaling híbrido con machine learning y modelos regionales de alta resolución. I. Prieto, A. Fernández, J.C. Sánchez, E. Rodríguez*



## CIMAS:

Very high resolution modelling over mountain areas, aiming at providing projections and services filling existing gaps



J26 13:45 (biblioteca) Proporcionando información de impactos del cambio climático para adaptación en zonas de orografía compleja: la iniciativa CIMAS.

## CORDEX FPS:

Very high resolution modelling over macaronesian Islands. Aiming at evaluate models performance at very high resolution setting the ground for specific projections for islands.

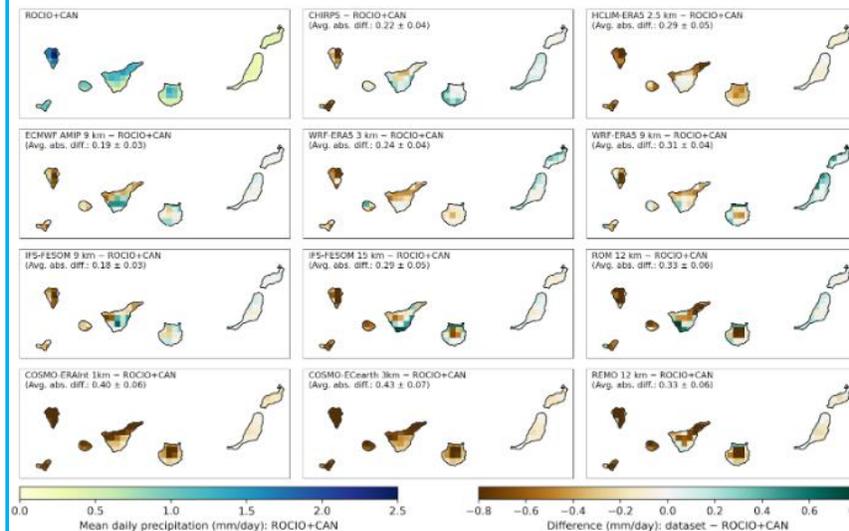
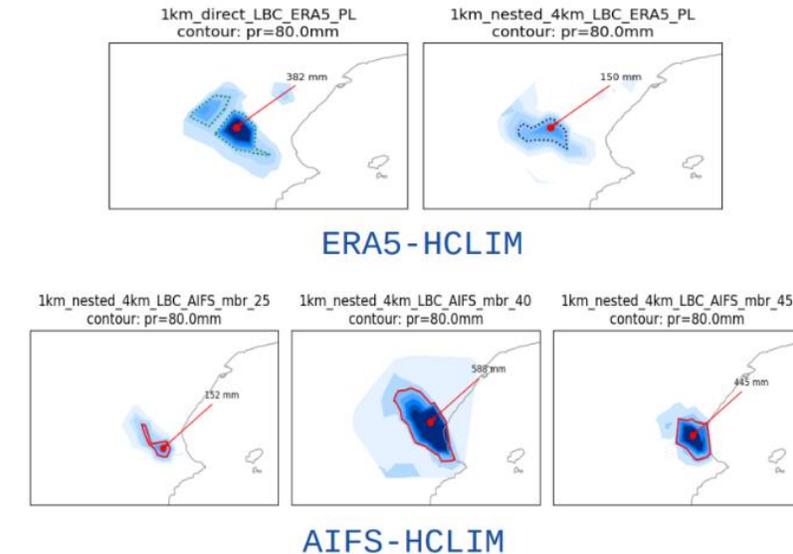


Fig. 6. Mean daily precipitation. The indicated mean absolute differences correspond to averages over all land grid points, and confidence intervals at the 95% level were estimated via bootstrap resampling.

## PSEUDOGLOBAL WARMING:

Event-based attribution and CC impact.

AI: combination of HCLIM and AI for exploring plausible scenarios before



X25@13:30: DANAS en clima presente y futuro: downscaling híbrido con machine learning y modelos regionales de alta resolución. I. Prieto, A. Fernández, J.C. Sánchez, E. Rodríguez

**CIMAS:**

Very high resolution modelling over mountain areas, aiming at providing projections and services filling existing gaps

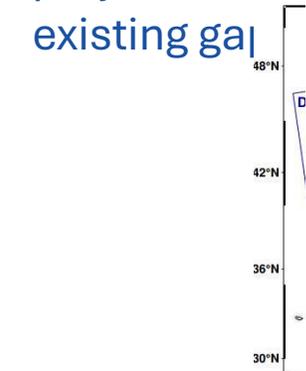
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Very high resolution modelling over macaronesian Islands. Aiming at evaluate models performance at very

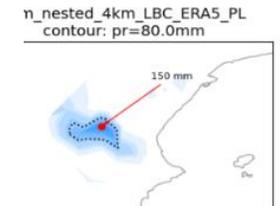
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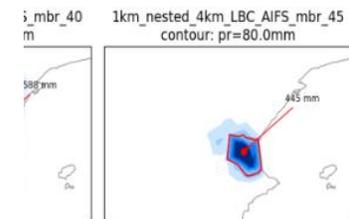
Es posible participar en el consorcio como asociados, y usar el modelo para todo tipo de estudios. Invitación a colaborar.



enarios before



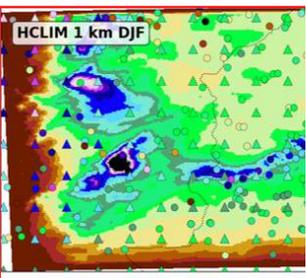
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n clima presente híbrido con modelos

regionales de alta resolución. I. Prieto, A. Fernández, J.C. Sánchez, E. Rodríguez



J26 13:45 (bibliografía de información de climático para adaptación en zonas de orografía compleja: la iniciativa CIMAs.

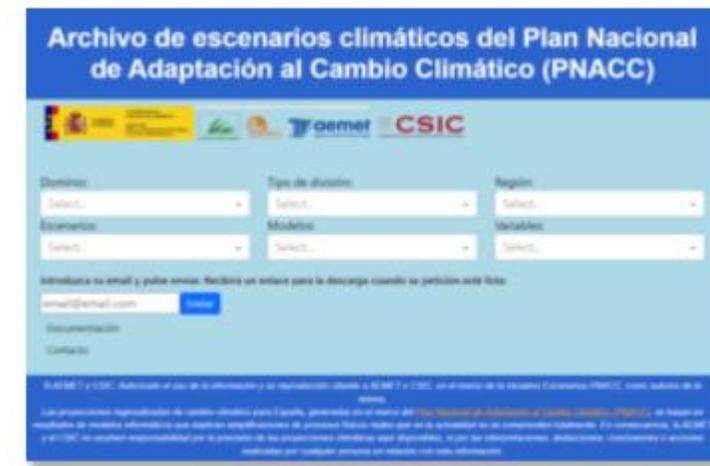


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AEMET Works together with Spanish Office fo Climate Change and other institutions (CSIC, FB...) to make available downscaled climate scenarios in two different ways:

- A dynamic visor (including derived indices and variables statistics, both for mean values and extremes) that eases exploring the main outcomes for Spain
- A public repository, allowing advanced users accesing the data and develop their own applications, with AEMET support



Archivo proyecciones climáticas AR6  
DESCARGA MASIVA.

Visualización: <https://escenarios.adaptecca.es/>

[https://www.aemet.es/es/serviciosclimaticos/cambio\\_climat](https://www.aemet.es/es/serviciosclimaticos/cambio_climat)

RESEARCH ARTICLE  Open Access  

**Evaluation of statistical downscaling methods for climate change projections over Spain: Present conditions with perfect predictors**

Alfonso Hernanz  Juan Andrés García-Valero, Marta Domínguez, Petra Ramos-Calzado, María A. Pastor-Saavedra, Ernesto Rodríguez-Camino

First published: 26 June 2021 | <https://doi.org/10.1002/joc.7271> | Citations: 16

<https://doi.org/10.1002/joc.7271>

RESEARCH ARTICLE  Open Access  

**On the limitations of deep learning for statistical downscaling of climate change projections: The transferability and the extrapolation issues**

Alfonso Hernanz  Carlos Correa, Juan-Carlos Sánchez-Perrino, Ignacio Prieto-Rico, Esteban Rodríguez-Guisado, Marta Domínguez, Ernesto Rodríguez-Camino

First published: 28 November 2023 | <https://doi.org/10.1002/asl.1195>

<https://doi.org/10.1002/asl.1195>

RESEARCH ARTICLE  Full Access

**Evaluation of statistical downscaling methods for climate change projections over Spain: Present conditions with imperfect predictors (global climate model experiment)**

Alfonso Hernanz  Juan Andrés García-Valero, Marta Domínguez, Ernesto Rodríguez-Camino

First published: 18 March 2022 | <https://doi.org/10.1002/joc.7611>

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RESEARCH ARTICLE  Open Access  

**A critical view on the suitability of machine learning techniques to downscale climate change projections: Illustration for temperature with a toy experiment**

Alfonso Hernanz  Juan Andrés García-Valero, Marta Domínguez, Ernesto Rodríguez-Camino

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**Evaluation of statistical downscaling methods for climate change projections over Spain: Future conditions with pseudo reality (transferability experiment)**

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**Comparison of machine learning statistical downscaling and regional climate models for temperature, precipitation, wind speed, humidity and radiation over Europe under present conditions**

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**pyClim-SDM: Service for generation of statistically downscaled climate change projections supporting national adaptation strategies**

Alfonso Hernanz   Carlos Correa  Juan Andrés García-Valero  Marta Domínguez  Esteban Rodríguez-Guisado  Ernesto Rodríguez-Camino 

 Spanish Meteorological Agency (AEMET), Madrid 28040, Spain  
 AEMET, Murcia 30107, Spain

Received 4 August 2022, Revised 11 July 2023, Accepted 19 September 2023, Available online 24 September 2023, Version of Record 24 September 2023.

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**Evaluación de métodos de regionalización estadística para la generación de proyecciones climáticas en el marco del PNACC-2 2021-2030**

Nota técnica 41 de AEMET

Autores:

Carlos Correa Guinea (AEMET, Servicios centrales)

Alfonso Hernanz Lázaro (AEMET, Servicios centrales)

Esteban Rodríguez Guisado (AEMET, Servicios centrales)

Reseña:

La Agencia Estatal de Meteorología (AEMET) es responsable de la elaboración de las proyecciones climáticas regionalizadas sobre el territorio de España según lo establecido en el segundo Plan Nacional de Adaptación al Cambio Climático (PNACC-2). Las proyecciones climáticas regionalizadas suponen un aumento de la resolución espacial con respecto a las proyecciones climáticas proporcionadas por los modelos climáticos globales. AEMET elabora las proyecciones climáticas regionalizadas sobre España aplicando métodos de regionalización empírico-estadísticos a las proyecciones climáticas de un conjunto de modelos climáticos globales. Las proyecciones climáticas regionalizadas son necesarias para la realización de estudios de impacto y vulnerabilidad que requieren datos en alta resolución espacial.

Esta nota técnica tiene dos objetivos: 1) evaluar y seleccionar un conjunto de modelos climáticos globales cuyas proyecciones serán regionalizadas; 2) comparar diferentes métodos empírico-estadísticos de regionalización a fin de elegir un método para regionalizar los datos diarios de las siguientes variables climáticas de interés: temperatura máxima, temperatura mínima y

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pyClim-SDM: Service for generation of statistically downscaled climate change projections supporting national adaptation strategies

*V 12:15 La nueva generación de escenarios de cambio climático nacionales Escenarios PNACC y el visor de AdapteCCa. A. Hernanz, C. Correa, E. Rodríguez, M.Y. Luna, A. Morata, M. Iturbide, J.M. Gutierrez, M. Sánchez, R. Labad, J. F. Heras, A. Lancho*

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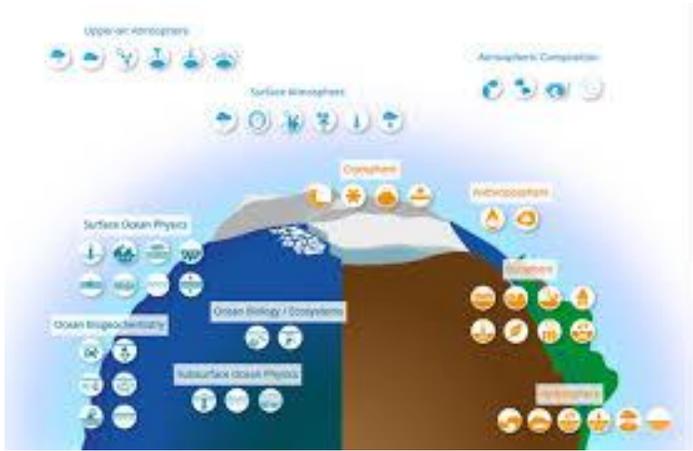
Esteban Rodríguez Guisado (AEMET, Servicios centrales)

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## Application of ESD to other variables **Extremes information**



X25@18:00 (biblioteca) -  
*Regionalización de escenarios de cambio climático para las principales variables climáticas, parte I: evaluación y metodologías novedosas de aprendizaje profundo.*  
M. Ortega et al.

*Regionalización de escenarios de cambio climático para las principales variables climáticas, parte II: aplicación a predicción estacional.*

I. Rodríguez-Muñoz et al

Precipitation: Colaboration with DGA, OECC, CSIC y CEDEX for generating information related to extremes, using temporary desagregation (work in progress)

Related Works

(J26@9:45-10:15):

*Estudio comparativo de datos observacionales y reanálisis climáticos para eventos de precipitaciones extremas en la cuenca mediterránea española.*

J. Gutiérrez Fernández, M. Ortega, I. Rodríguez-Muñoz, C. Correa, A. Hernanz, J.J. González-Alemán, E. Rodríguez-Guisado

*Índice de intensidad potencial: un indicador de la probabilidad de fenómenos extremos.*

J. Gutiérrez-Fernández, J.J. González-

Support and specific information generation: hidrological planning, biodiversity, Koppen climate distribution.

EUROCLIMA+

Collaboration with NMSs from Central America for generating downscaled scenarios and projections web visor.



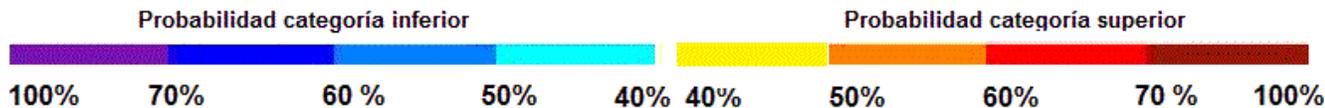
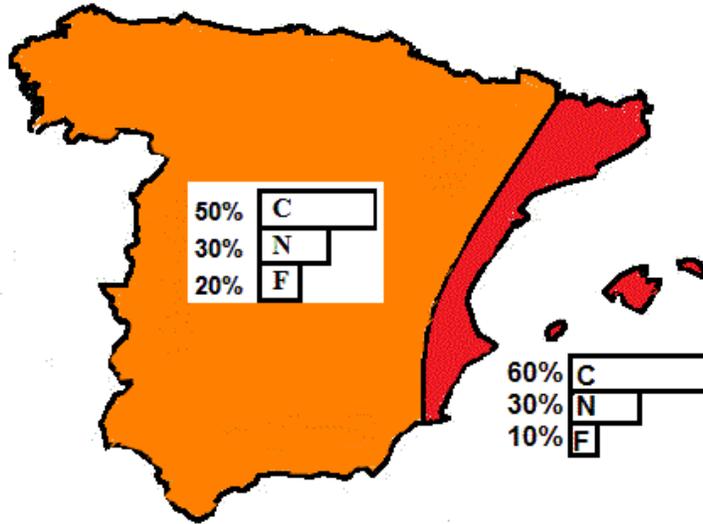
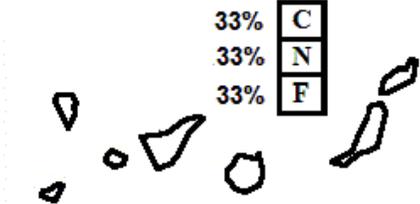
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# Operational Seasonal forecast

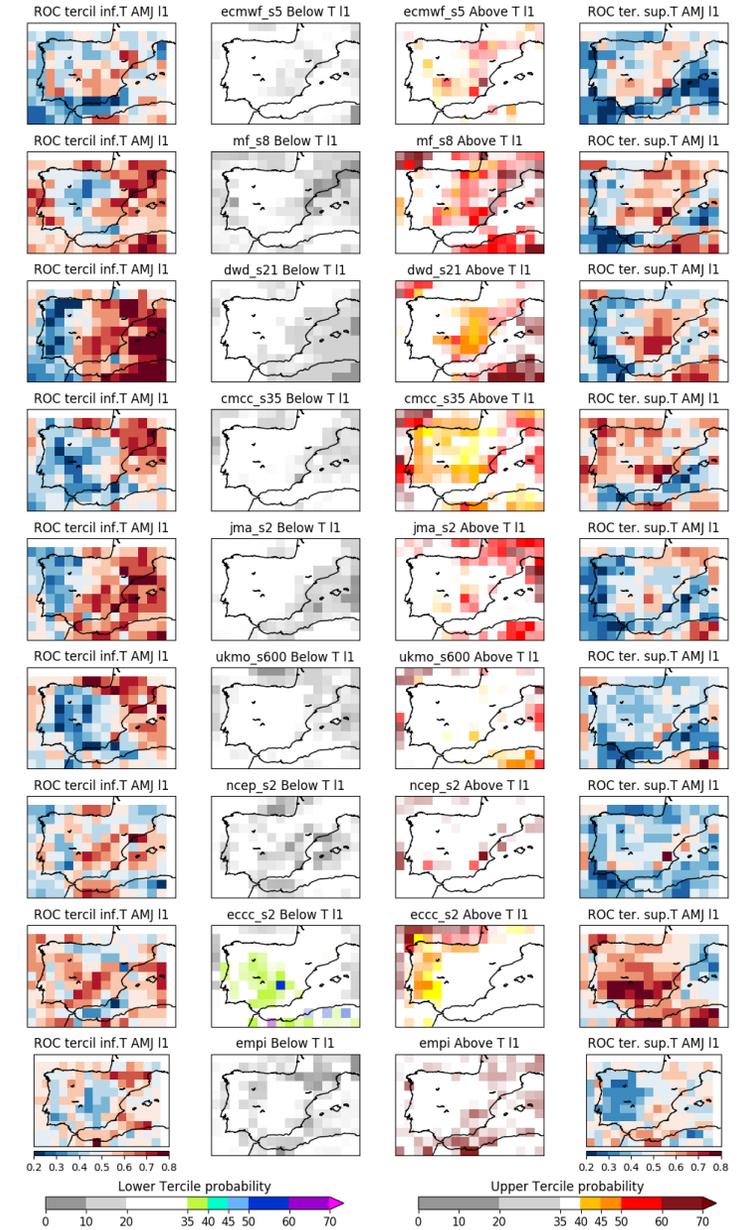
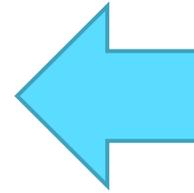
## PROBABILIDAD DE LA CATEGORÍA MÁS PROBABLE DE TEMPERATURA DICIEMBRE-ENERO-FEBRERO 2019 - 2020

- C** Probabilidad tercil superior
- N** Probabilidad tercil central
- F** Probabilidad tercil inferior

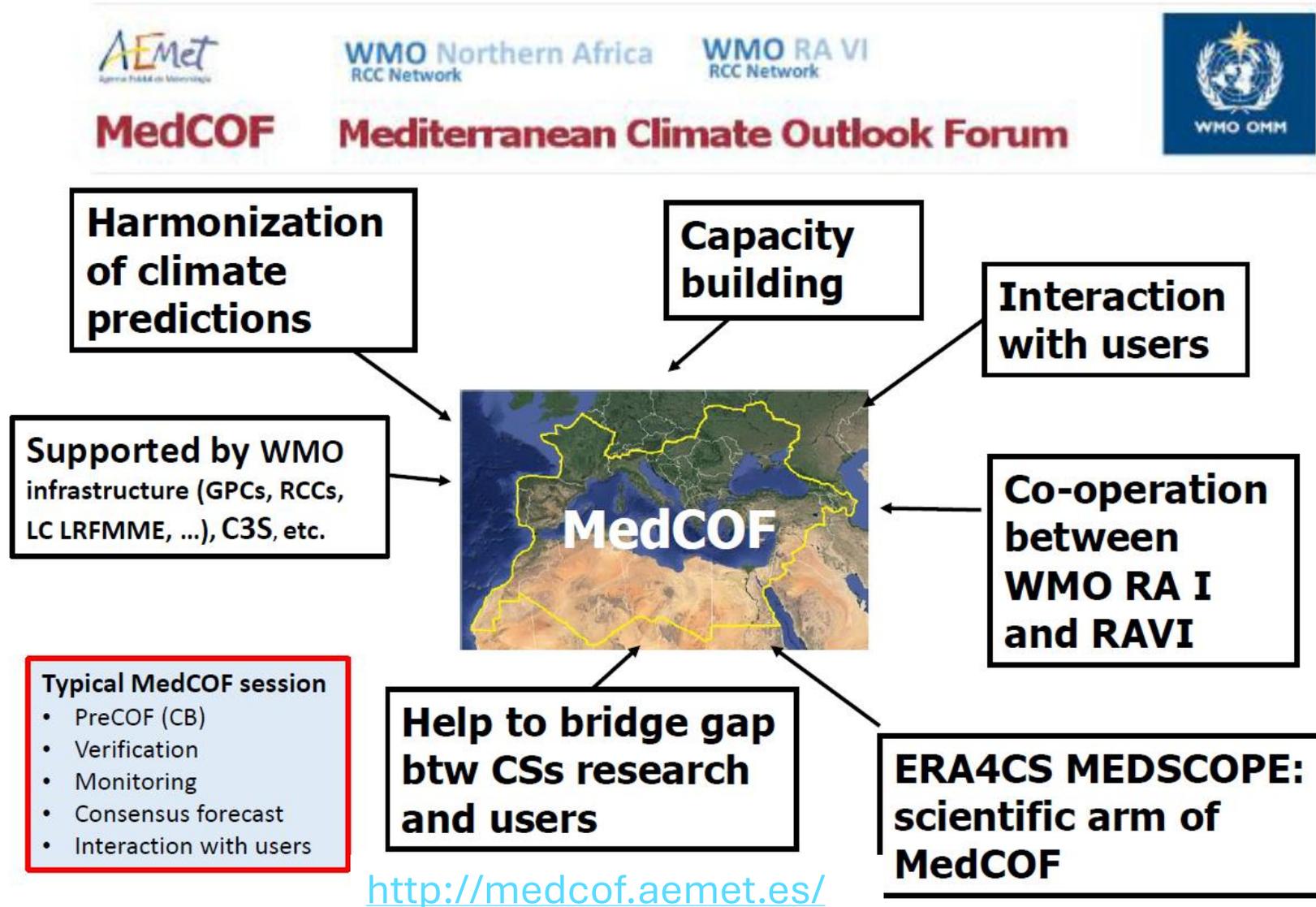
Los colores muestran la probabilidad de la categoría más probable.  
El color blanco indica la climatología



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# AEMET coordinates Mediterranean Climate Outlook Forum (MedCOF)



### Selecing and weighting members

Due to high internal variability, skill from dynamical seasonal forecast models is limited in mid latitudes. Some Works has shown potential weighting or selecting members from the ensemble according empirical forecasts or variability patterns information. This methodology is used operationally for reservoirs climate servic:

([https://www.aemet.es/es/serviciosclimaticos/apoyo\\_gestion\\_embalses](https://www.aemet.es/es/serviciosclimaticos/apoyo_gestion_embalses))

<https://dx.doi.org/10.5194/asr-16-165-2019>

V@10:15 salón actos *De la Ciencia a la Operatividad: Servicios Climáticos de Predicción Estacional de Tragsatec para AEMET.*

S. Sanfiz, M. Domínguez, M.

Sanchez, E. Rodríguez-Guisado

### Downscaling

Dynamical models lack the spatial resolution to properly reproduce the complex patterns on climate variables due to orography. This is key for providing Climate Services and useful information. We explore several downcaling methods  
J26@16:15 salón actos  
¿Pueden las técnicas de regionalización estadística mejorar la pericia de la simulación de la precipitación intensa a escala estacional?

M. Domínguez-Alonso, S. Sanfiz, E. Rodríguez-Guisado

X25@18:00 (biblioteca)

Regionalización de escenarios de cambio climático para las principales variables climáticas, parte II: aplicación a predicción estacional.

I. Rodríguez-Muñoz et al

### Specific indicators and visualization

We are exploring generating information of specific indicators, as in climate projections (CLIMPACT-like) at seasonal timescale, and specific visualization for seasonal products. More in S. Sanfiz and M. Dominguez-Alonso, and in:

X 25@10:30 S. actos *Verificación de la predicción estacional regionalizada de extremos meteorológicos en la península Ibérica.* M. Hernández Calleja, M.

Dominguez Alonso, E. Rodríguez Guisado  
V27@10:00 S. actos *Predicción estacional de índices climáticos combinando modelos dinámicos y métodos estadísticos.* P.

Fernández Castillo, E. Rodríguez Guisado, T. Losada Doval, B. Rodríguez de Fonseca  
V27 Póster *La Plataforma Estatal de Servicios Climáticos de la AEMET y el CSIC.* A. Morata, Y. Luna, E. Rodríguez, J.M. Gutiérrez, S. Vicente, S. Beguería, D. Barriopedro, C. Azorín, R. García

1. Climate Modelling
2. Downscaled climate projections for Spain
3. Climate Predictions
- 4. Climate Services**

# Plataforma Estatal de Servicios Climáticos

 Evaluación del estado y evolución del clima  
● ▲ ■ ◆

## Servicios climáticos temáticos

 Sequía meteorológica  
● ▲ ■

 Extremos térmicos y olas de calor  
● ▲

 Información eólica  
● ▲

 Información agrometeorológica  
● ▲ ■ ◆

 Precipitaciones extremas  
● ▲

 Riesgo meteorológico de incendio  
● ▲ ■ ◆

 Radiación solar  
● ▲ ■

 Atribución de temperaturas extremas al cambio climático  
● ▲

## Almacén de datos climáticos y herramientas para usuarios

 Visor de predicción estacional  
■

 Escenarios PNACC (Visor AdapteCCa)  
◆

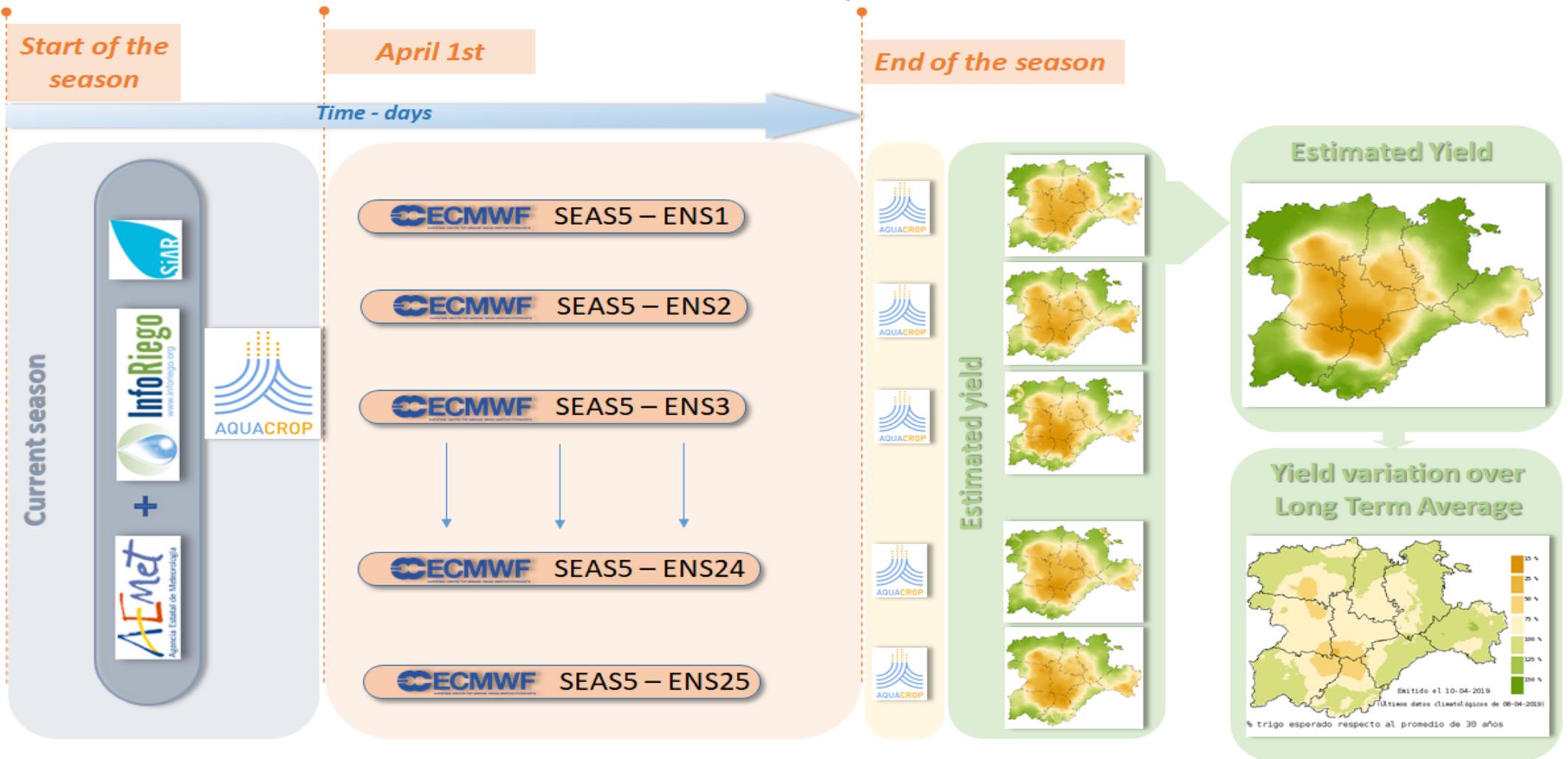
## Escala temporal



# Crop yield seasonal forecast



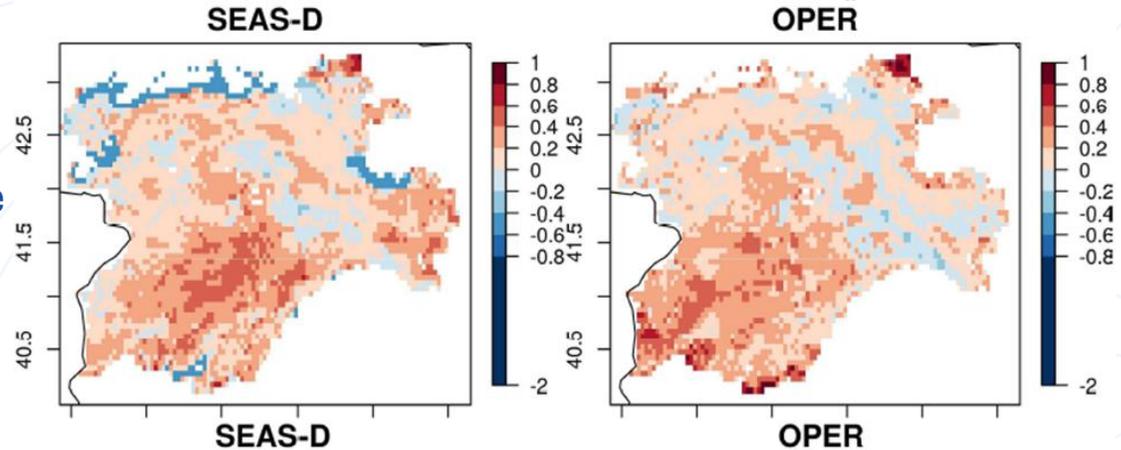
November June



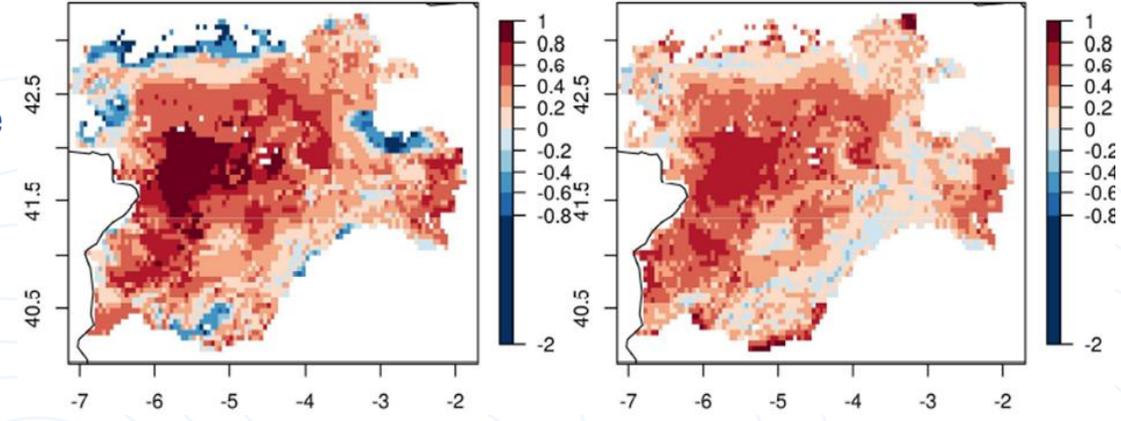
# Crop yield seasonal forecast



Upper tercile



Lower tercile



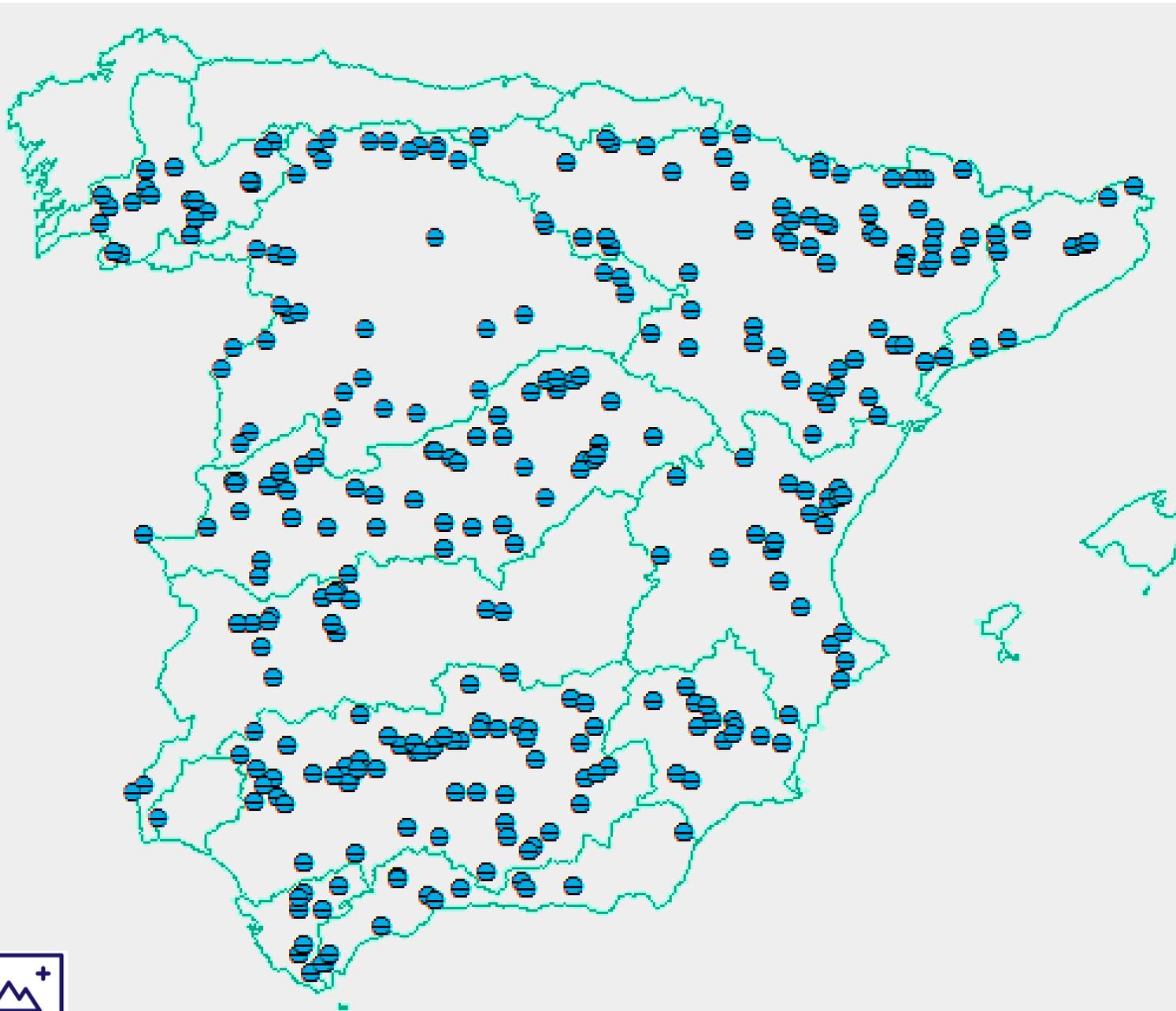
**SEAS-D:** from April 1<sup>st</sup>, couples ECMWF SEAS5 for AMJ to aquacrop

**OPER:** uses ECMWF Medium range forecast for April 1<sup>st</sup>-10<sup>th</sup>, and then an ensemble based on April 10<sup>th</sup> – June observations over last 30 years

WORK to automatize, extend to national level and to climate projections

Brier Skill Score of Crop Yield (Climatology as a reference)





- Highly regulated basins.
- Drought periods means planning 3-4 years in advance
- High intensity intervals
- Most rain from November to March



Need to know inflow for upcoming winter.  
Collaboration with water authorities from 2013.



VIEWER



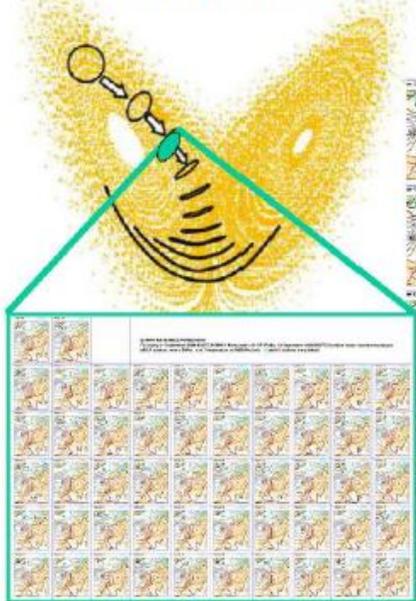
EVALUATION AT BELESAR RESERVOIR



BEST NAO weighting and combination

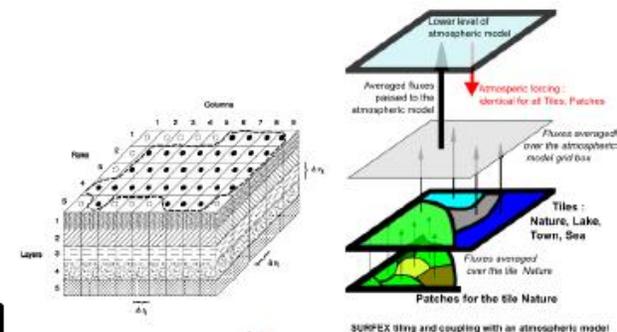
SIMPA SURFEX

ECMWF S5



- **Domain of application:** All water reservoirs in Spain
- **Potential user(s):** dam managers
- **Decision making process:** Partition of water resources among main users: agriculture, energy, public supply

Downscaling based on ANALOGS

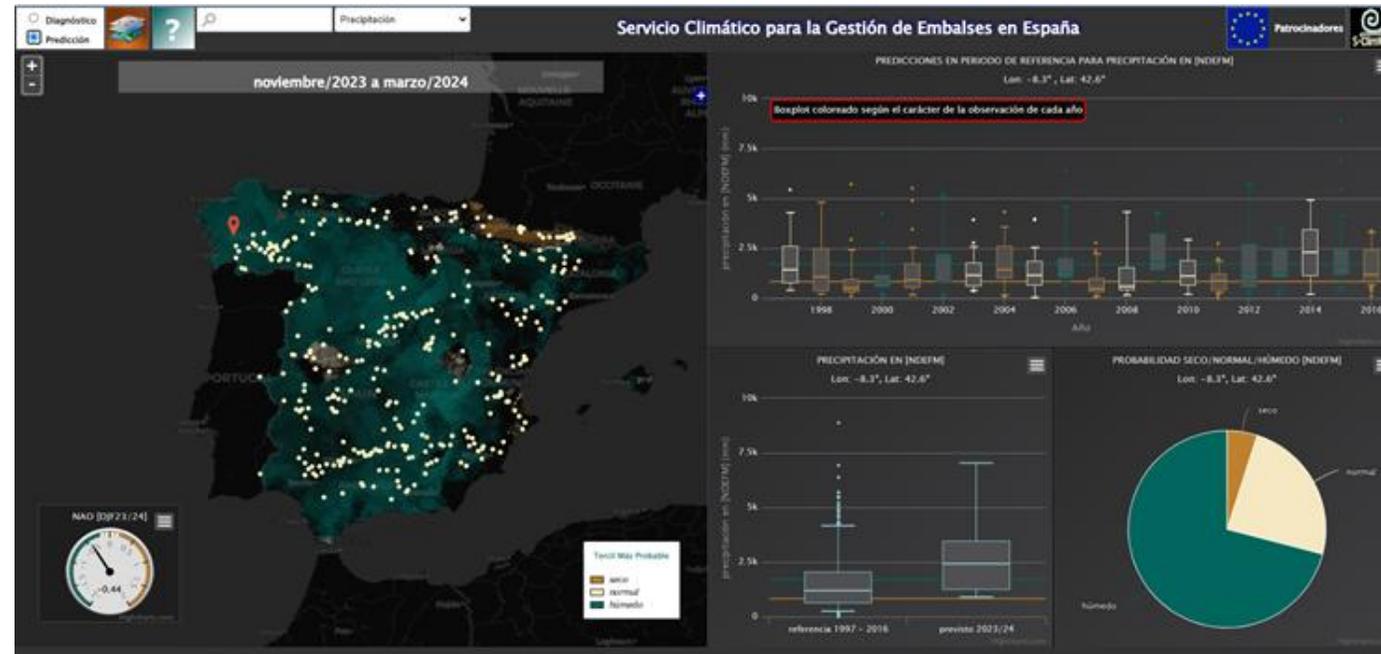


The service is currently available through AEMET web.

The visor has been developed jointly with Water authorities at Spain



Work to extend to the whole year and to climate projections



[https://www.aemet.es/es/serviciosclimaticos/apoyo\\_gestion\\_embalses](https://www.aemet.es/es/serviciosclimaticos/apoyo_gestion_embalses)

V@10:15 salón actos *De la Ciencia a la Operatividad: Servicios Climáticos de Predicción Estacional de Tragsatec para AEMET.*  
S. Sanfiz, M. Domínguez, M. Senande, E. Rodríguez-Guisado

J26@16:15 salón actos  
¿Pueden las técnicas de regionalización estadística mejorar la pericia de la simulación de la precipitación intensa a escala estacional?  
M. Domínguez-Alonso, S. Sanfiz, E. Rodríguez-Guisado

J26@16:00 biblioteca *Predicción de aportaciones a embalses en España a través de modelos climáticos de proyecciones de precipitación regionalizadas del CMIP6.*  
J. Gutierrez-Fernández, S. Sanfiz, E. Rodríguez-Guisado



GOBIERNO  
DE ESPAÑA

VICEPRESIDENCIA  
TERCERA DEL GOBIERNO

MINISTERIO  
PARA LA TRANSICIÓN ECOLÓGICA  
Y EL RETO DEMOGRÁFICO



**aemet**

Agencia Estatal de Meteorología