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Assessing drought risk in West Mediterranean basin from regional climate multimodel ensemble

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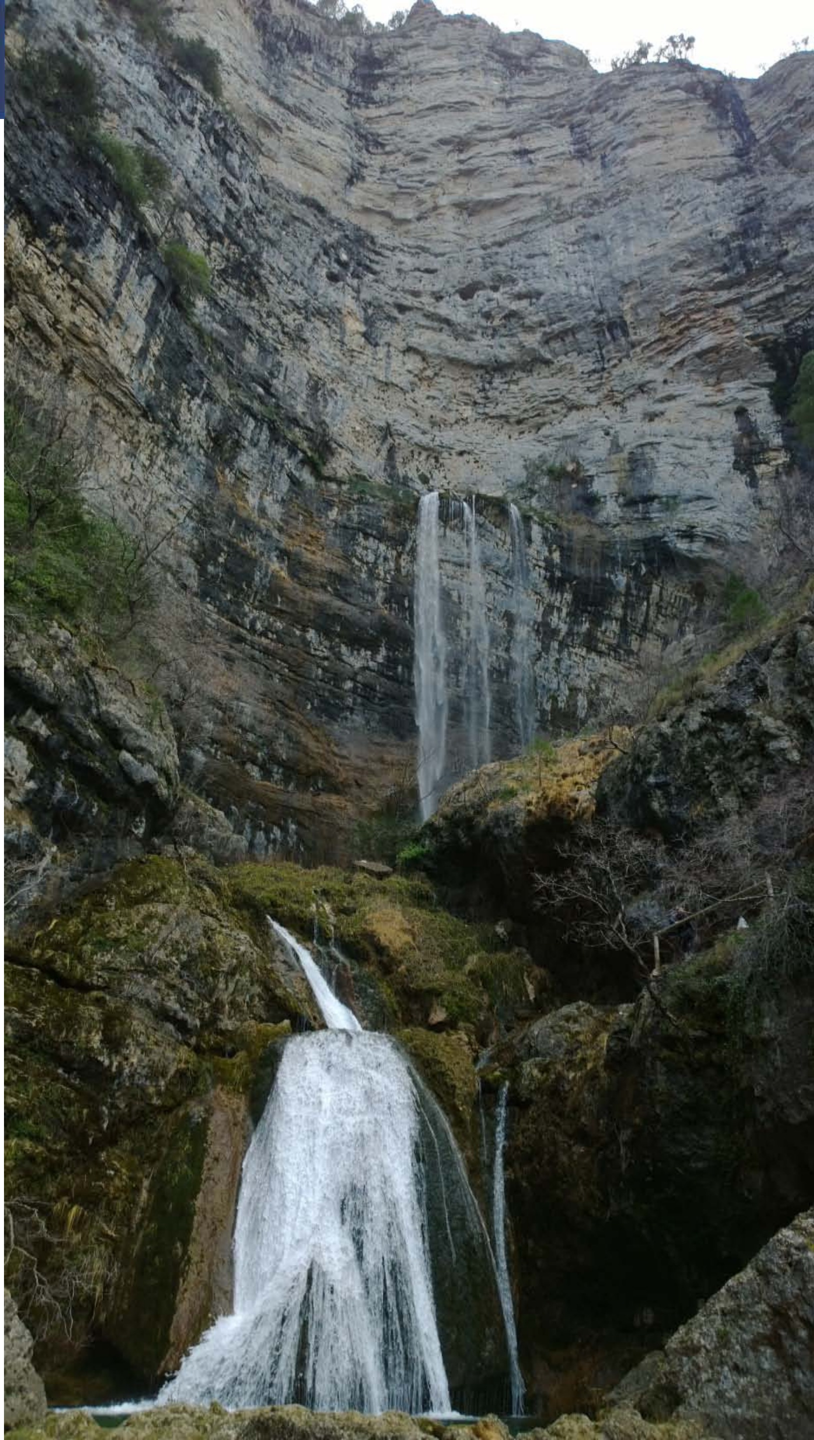


Mundo River springs, February 2014

Motivation: Segura River Basin study area

General Characteristics

Europe

Spain

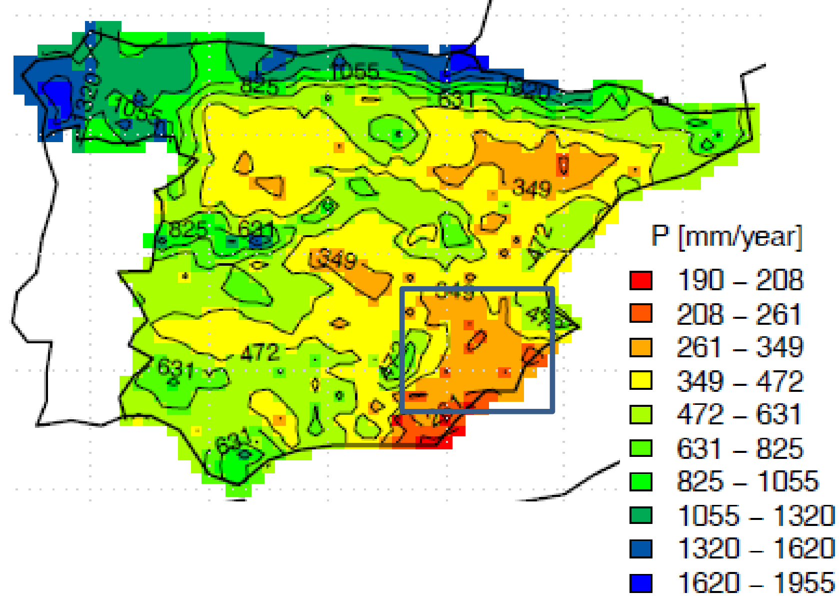
SURFACE (Km^2)	**18 815**
POPULATION THAT DEMANDS RESOURCES FROM SEGURA RIVER BASIN (inhabitants). Year 2009	**1 969 370**
SUMMER POPULATION (inhabitants). Year 2009	**> 2 500 000**
TOTAL LENGHT OF CHANNEL NETWORK (Km)	**1 470**
IRRIGATION SURFACE (ha)	**269 029**
SOURCES OF WATER RESOURCES (Hm^3)	**Surface water ; Groundwater Reutilization ; Desalinisation; Water Transfers from ohter basins (Tajo-Segura and Negratín transfers)**

Source: CHS

Motivation: Segura River Basin (SRB) main characteristics

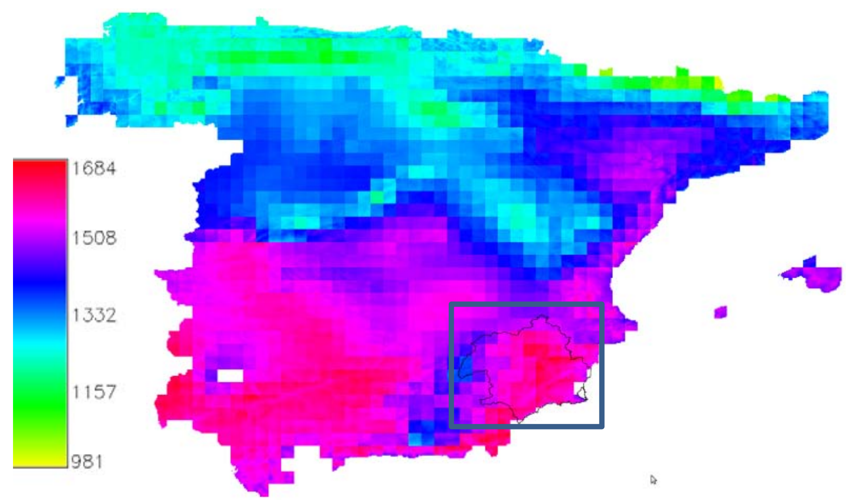
- The South East of Spain receives less Rainfall than the rest of Iberian Peninsula. SRB: Mean annual Rainfall = 300 mm.
- SRB: Mean annual Potential Evapotranspiration ETp = 1500 mm.
- Most of the area is classified as semi-arid, while the coastal areas are considered ´arid´.

Mean annual rainfall 1961-1990 (Spain02)



- Available water resources per inhabitant in the SRB: only 442 m³/inhabitant/year → **The SRB presents the least renewable water resources of all the Spanish river basins.**

Mean annual ETp 1961-1990*



	Surface (km²)	Ratio per inhabitant
SRB	18 870 (3.7%)	442 m³/inhab/year
Spain	506474	2460m³/inhab/year

Source: CHS, 2007

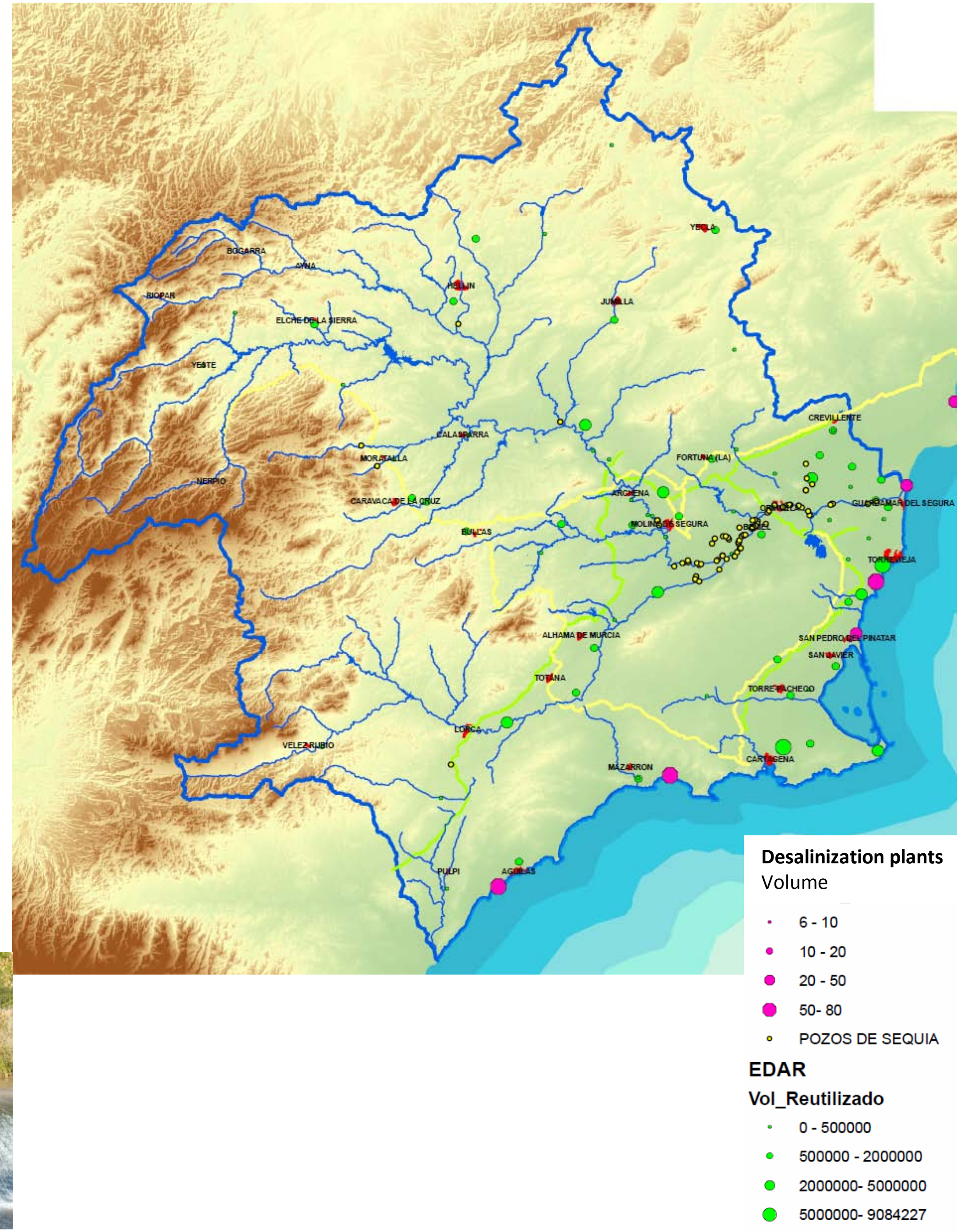
*ETp from Hargreaves modified method considering Spain02 dataset.

Motivation: SRB's main characteristics

- Agriculture area: more than 43 % of the basin surface, of which one-third is brought under irrigation (269 000 ha).
- Irrigated agricultural water demand : 85 % of the total water demand in 2007 in the entire basin.
- Water scarcity is a major issue in the Segura River Basin.

Fuensanta reservoir

Segura river donwstream Talave reservoir (Lietor. Albacete)



Motivation: about uncertainties

- On the oher hand, several authors highlights
  - there is a current and future intensification of water cycle, and
  - the need for improvement the ability of monitoring and predicting the impacts associated with the change of hydrologic regime → considering the presumption of <u>hydroclimatic non stationarity.</u>

▪ Then, the Regional Climate Models (RCMs) improve the understanding of climate mechanism , however projections of **climate change in extreme rainfall events** exhibit <u>great divergence between RCMs</u>.

▪ The RCMs are still sensitive to physical parameterization, spatial-temporal resolution and internal variability → uncertainties → multimodel ensemble !

▪ In conclusion, approaches should be applied,taking into account both
  - ▪ the variability provided by different RCMs, and
  - ▪ the non-stationary nature ot time series for the building of hazard maps of extreme water events .

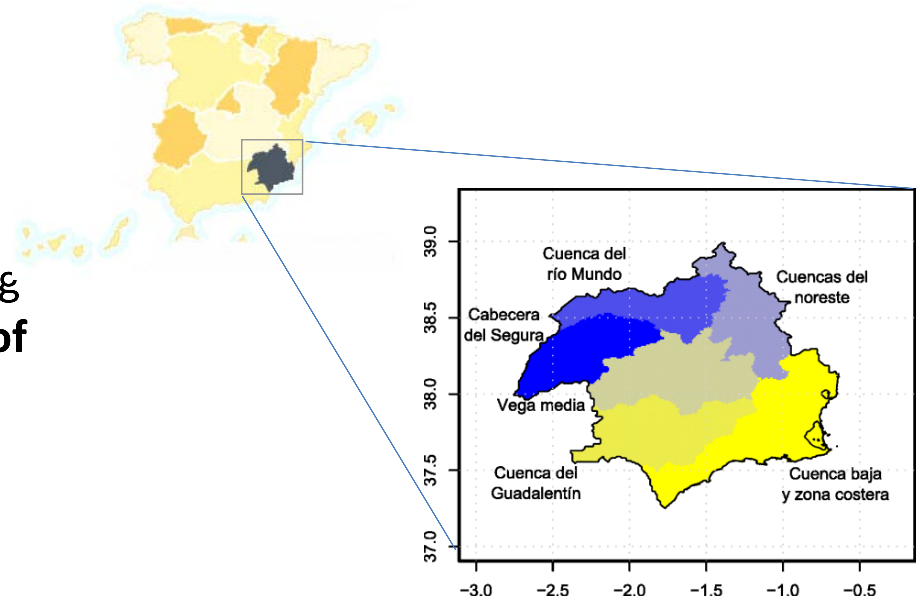
non-stationary PDF ensembles

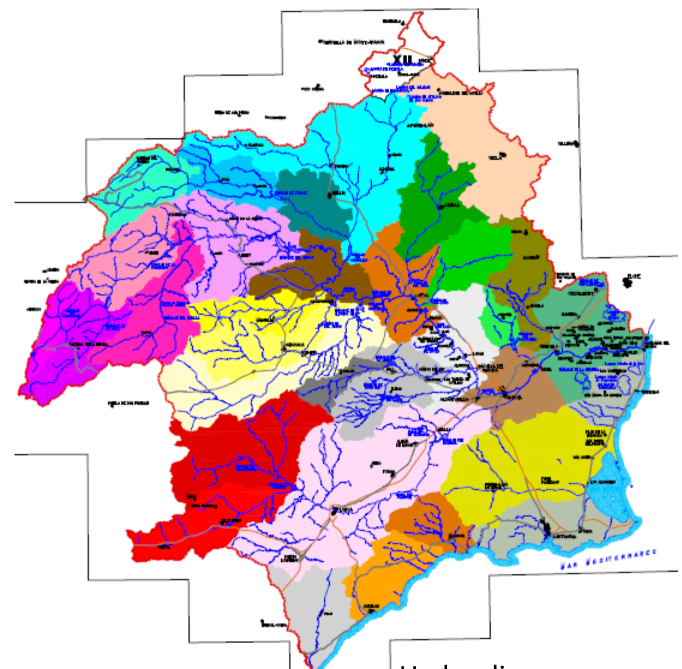

Main aim

- The work focuses in the **probability density functions (PDFs)-based evaluation**, considering bias analysis, **of skills of RCMs for simulation of <u>maximum dry spells lengths (MDSL)</u> series** at basin scale.

- The **MDSL** are considered as the *maximum number of consecutive days without rainfall, or days with rainfall below a threshold*. MDS have major impacts on agriculture due to their influence on soil moisture content.

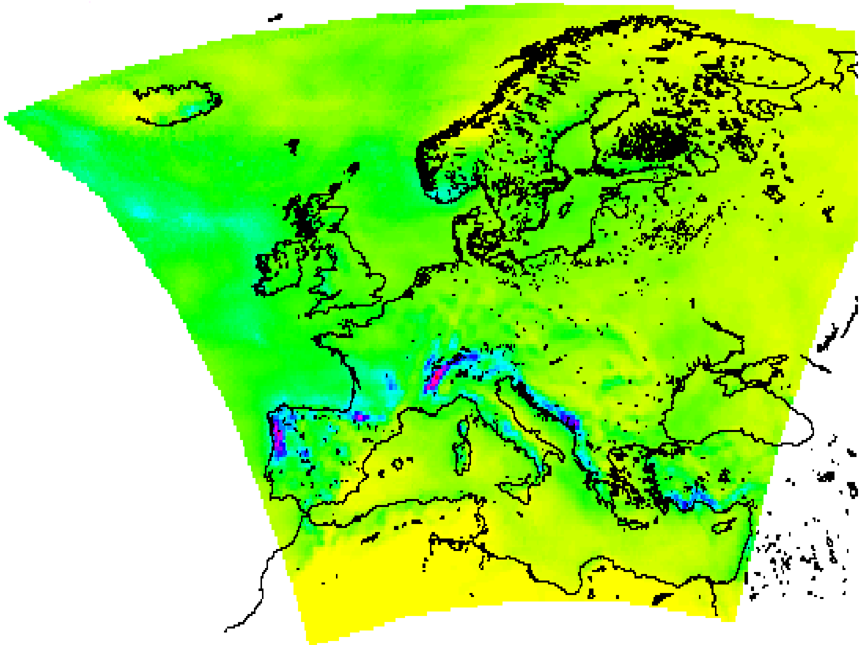
- **The main aim is the assessment of change in PDFs of maximum dry spells lengths on Segura River Basin (southeast of Spain), and the spatial pattern associated with the change.**





Hydraulic zones

Datasets



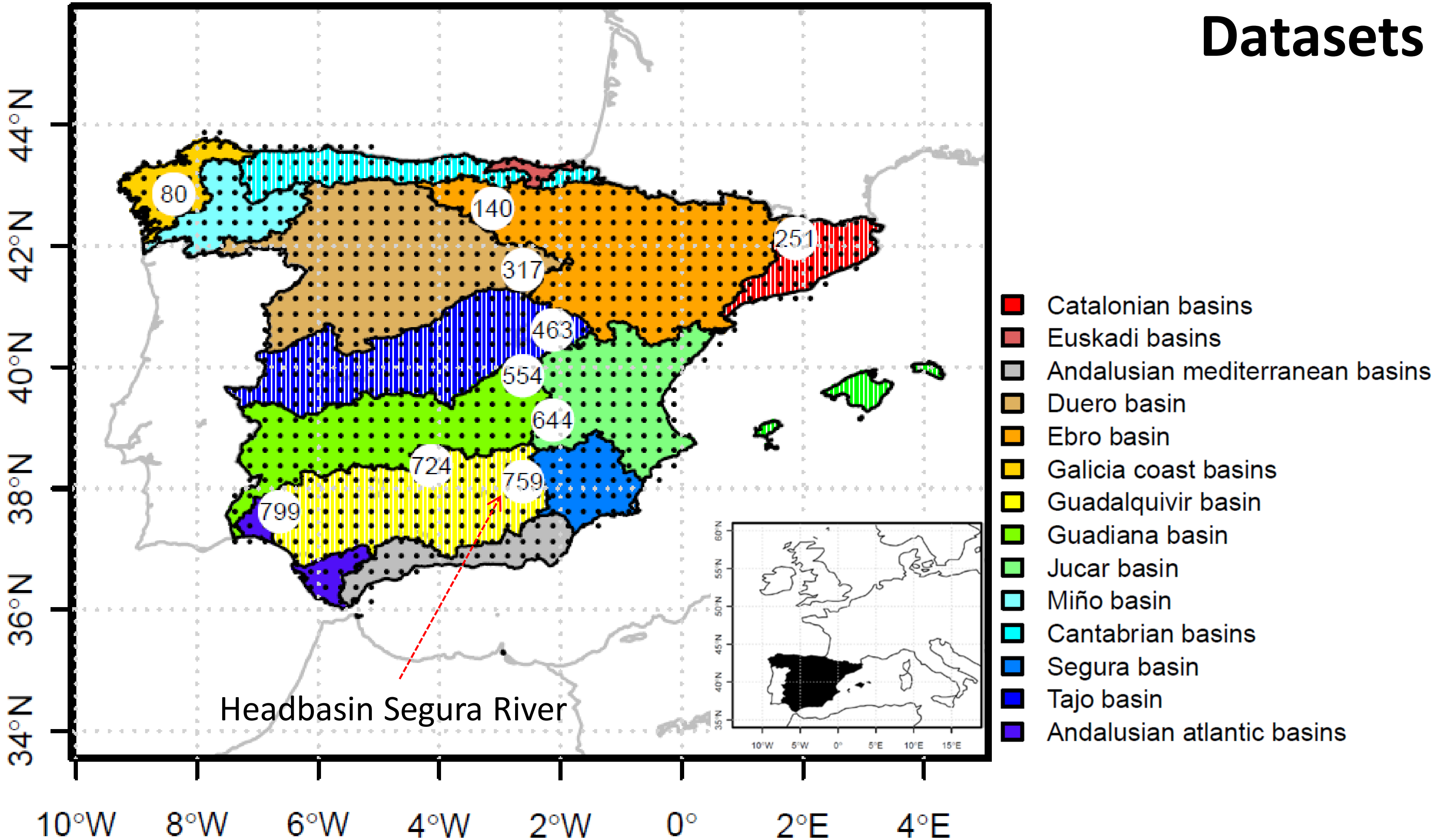
- Working with **regular daily gridded rainfall dataset** of 0.2 º (approx. 20 km) horizontal resolution spanning the period from *1950 to 2007*, named **Spain02**/v2.1 (or Spain02) is used, derived from a very dense network of 2756 quality-controlled stations [Herrera et al., 2010].

- The results provided by **seventeen RCMs driven by GCMs, from the European ENSEMBLES Project** [Christensen et al., 2009] for the time period **1950–2050** under SRES **A1B** are considered:

1. C4IRCA3 (HadCM3Q16),
2. CNRM/RM5.1 (ARPEGE RM5.1),
3. DMI/ARPEGE (ARPEGE),
4. DMI/BCM (BCM),
5. DMI/ECHAM5-r3 (ECHAM5-r3),
6. ETHZ/CLM (HadCM3Q0),
7. METO_HC/HAD (HadCM3Q0),
8. ICTP/REGCM3 (ECHAM5-r3),
9. KNMI/RACMO2 (ECHAM5-r3),
10. METNO/BCM (BCM),
11. METNO/HadCM3Q0 (HadCM3Q0),
12. MPIM/REMO (ECHAM5-r3),
13. OURANOS/MRCC4.2.1 (CGCM3),
14. SMHI/BCM (BCM),
15. SMHI/ECHAM5-r3 (ECHAM5-r3),
16. SMHI/HadCM3Q3 (HadCM3Q3), and
17. UCLM/PROMES (HadCM3Q0).

http://ensemblesrt3.dmi.dk/

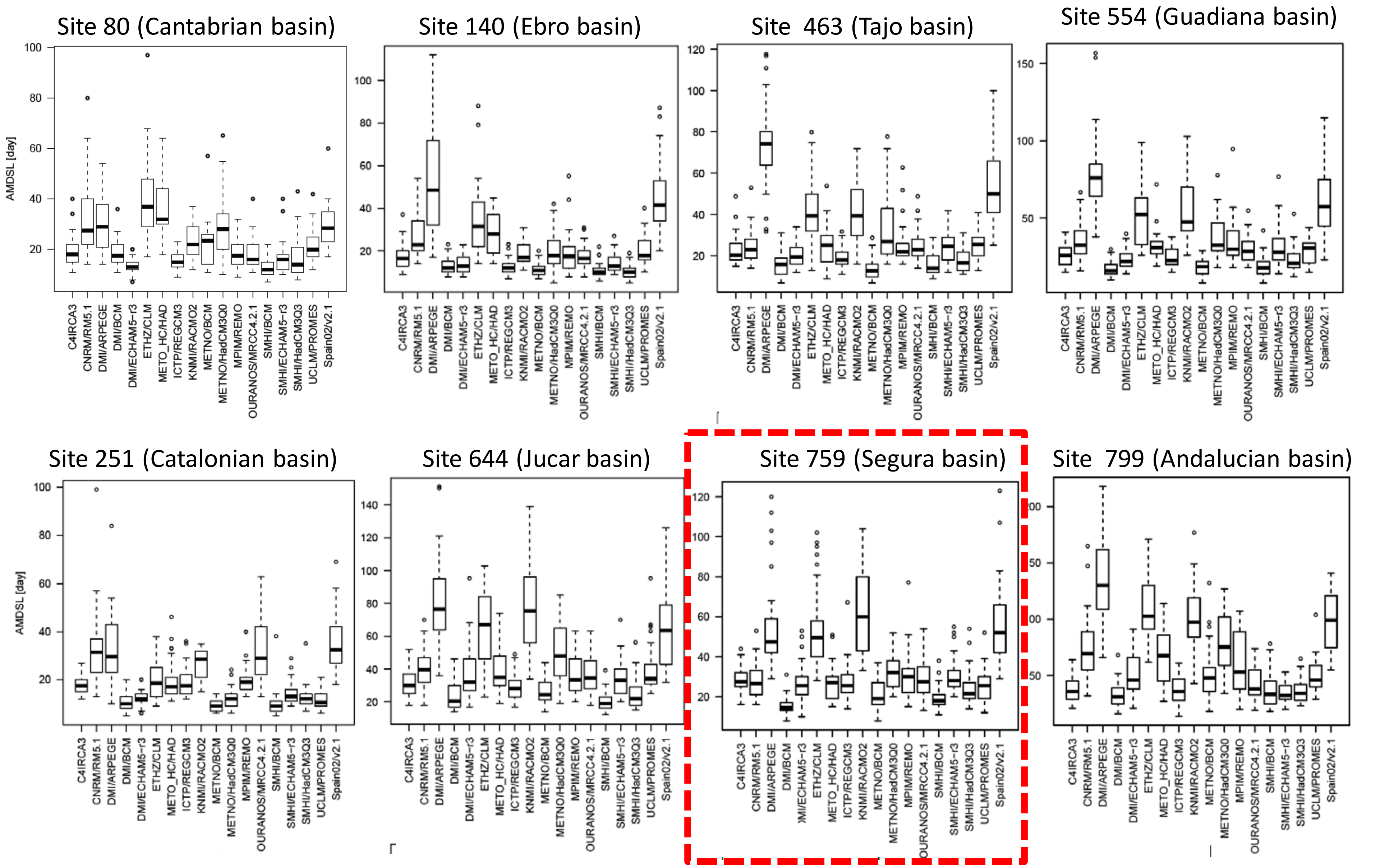
Datasets



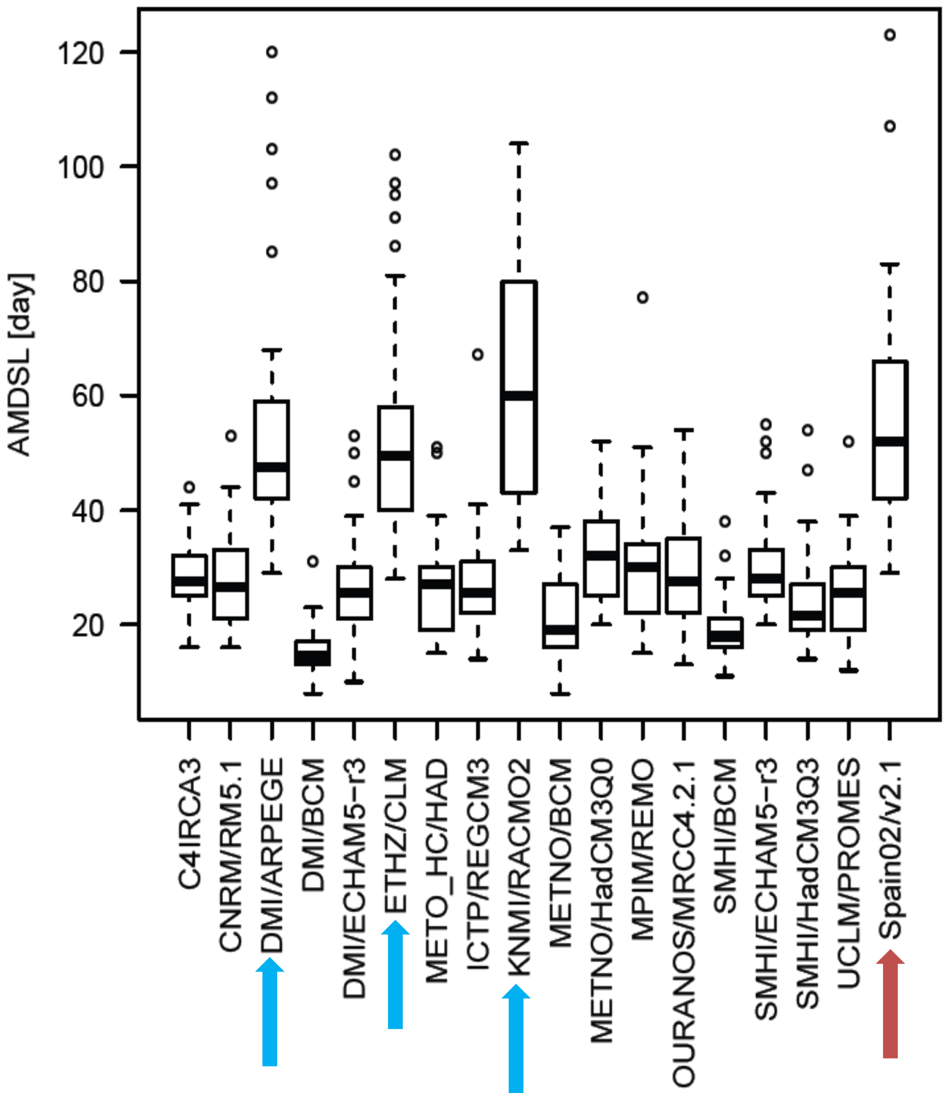
- Based on the grid provided by the RCMs dataset, 906 sites for analysis were set up.
- Ten grid sites were selected for headwaters of main river basins: Galicia coast basin (site 80), Ebro River basin (140), Catalonian basin (251), Duero River basin (317), Tajo River basin (463), Guadiana River basin (554), Jucar River basin (644), Guadalquivir River basin (724), Segura River basin (759), and Andalusian Atlantic basins (799).

Assessing distributional similarity between observed dataset and RCMs

Boxplot of AMDSL for threshold 1 mm/day in the control period



Boxplot of AMDSL for threshold 1 mm/day in the control period

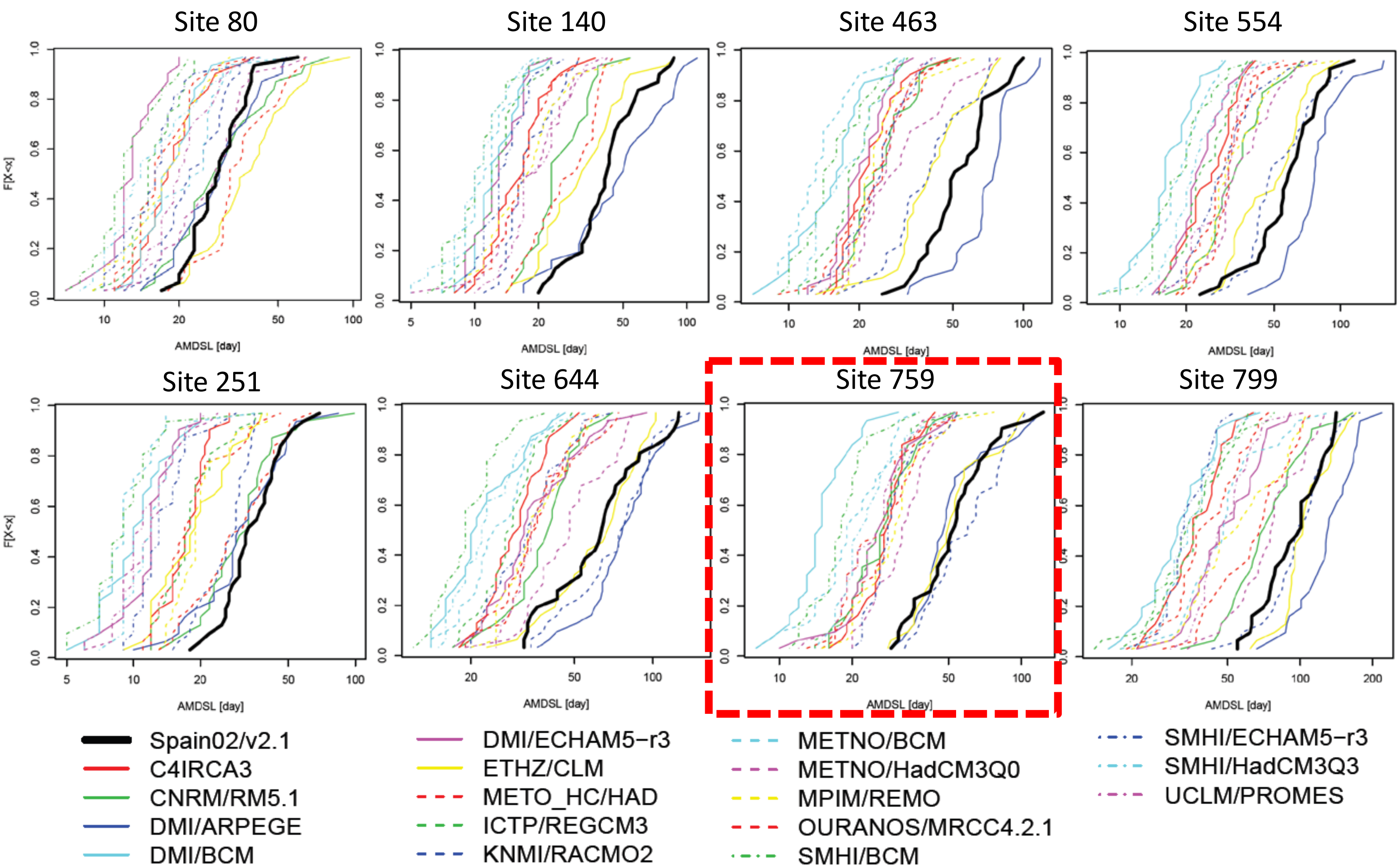


Headbasin Segura River. Site 759

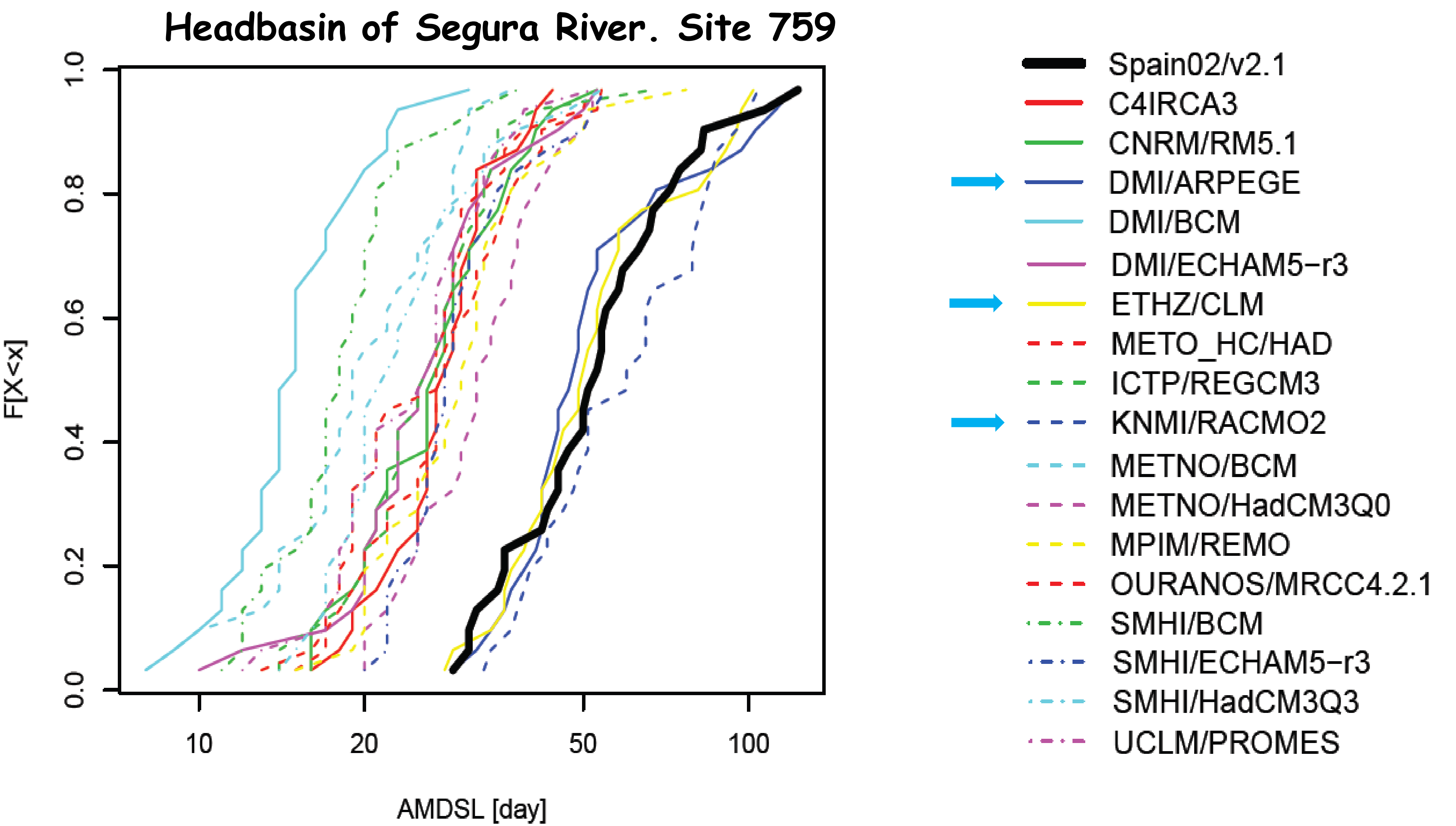
- By visual inspection, the DMI/ARPEGE, ETHZ/CLM and KNMI/RACMO2 RCMs present the greater values of AMDSL and more similarity (median, etc,) to those corresponding from the observed dataset.

Assessing distributional similarity between observed dataset and RCMs

CDFs of AMDSL for theshold 1 mm/day in the control period



CDFs of AMDSL for theshold 1 mm/day in the control period



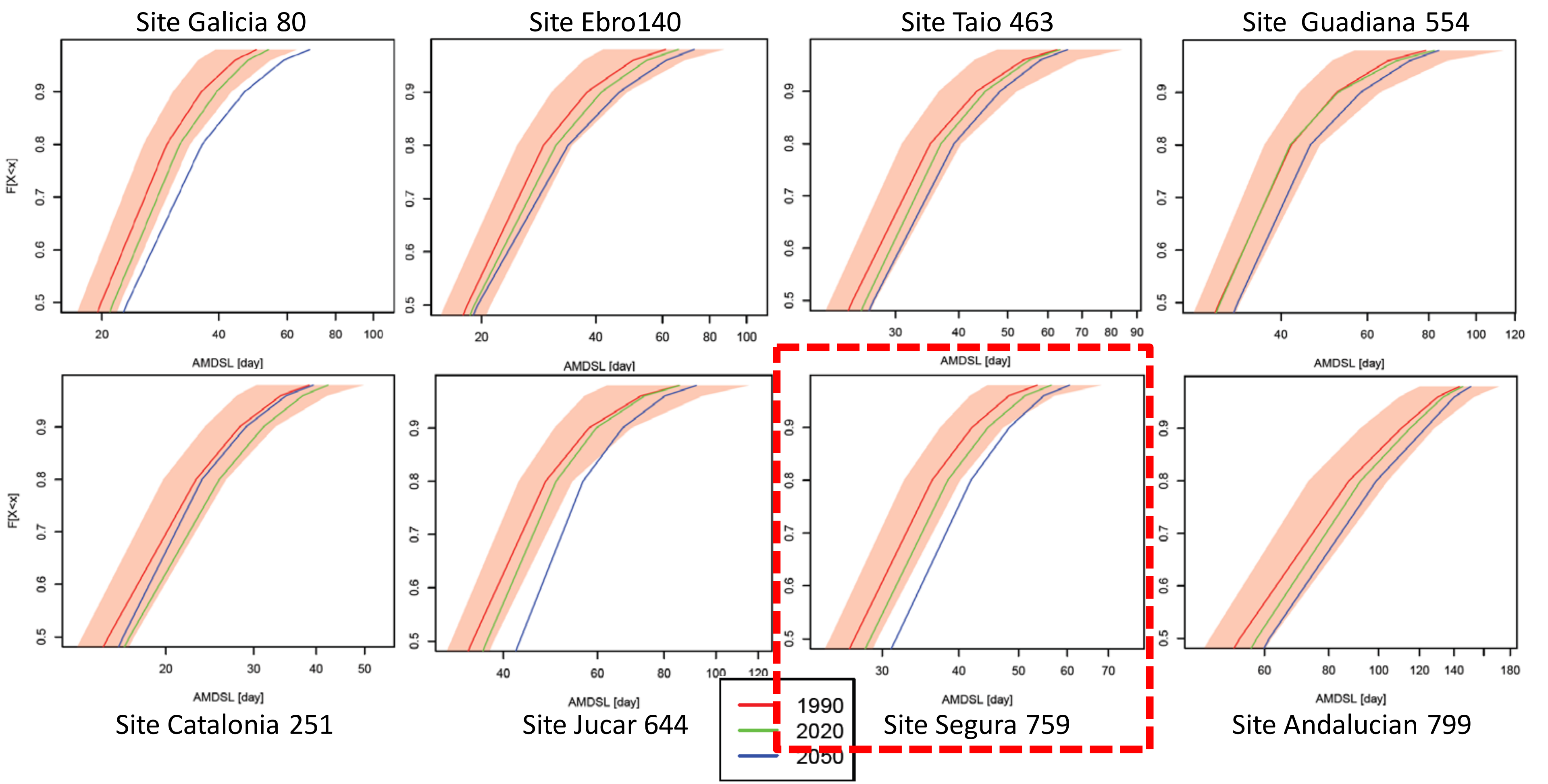
How we can build PDF ensemble at grid site and AMDSL risk maps, considering non stationarity ?

- **In the analysis of trends of MDSL series** in the SRB, **GAMLSS (Generalized Additive Models for Location, Scale and Shape), has been applied** (Stasinopoulos & Rigby, 2007). GAMLSS consists of semi-parametric regression models, since they allow relating the parameters of a PDF as a function of an explanatory variable through non-parametric smoothing functions [*Stasinopoulos and Rigby*, 2007]. In the present work, **four PDFs of two parameters are considered** when applying GAMLSS: Gumbel (GU), Gamma (GA), Lognormal (LN) and Weibull (WEI).

- To analyse plausible trends in AMDSL, **a PDF ensemble was built for each site. The skill score applied to each RCM was defined according to the performance in the Reliability Ensemble Average (REA, Giorgi and Mearns, 2002) analysis**. Greater weight was given to RCMs with a high value of *Pm* using bootstrapping techniques.

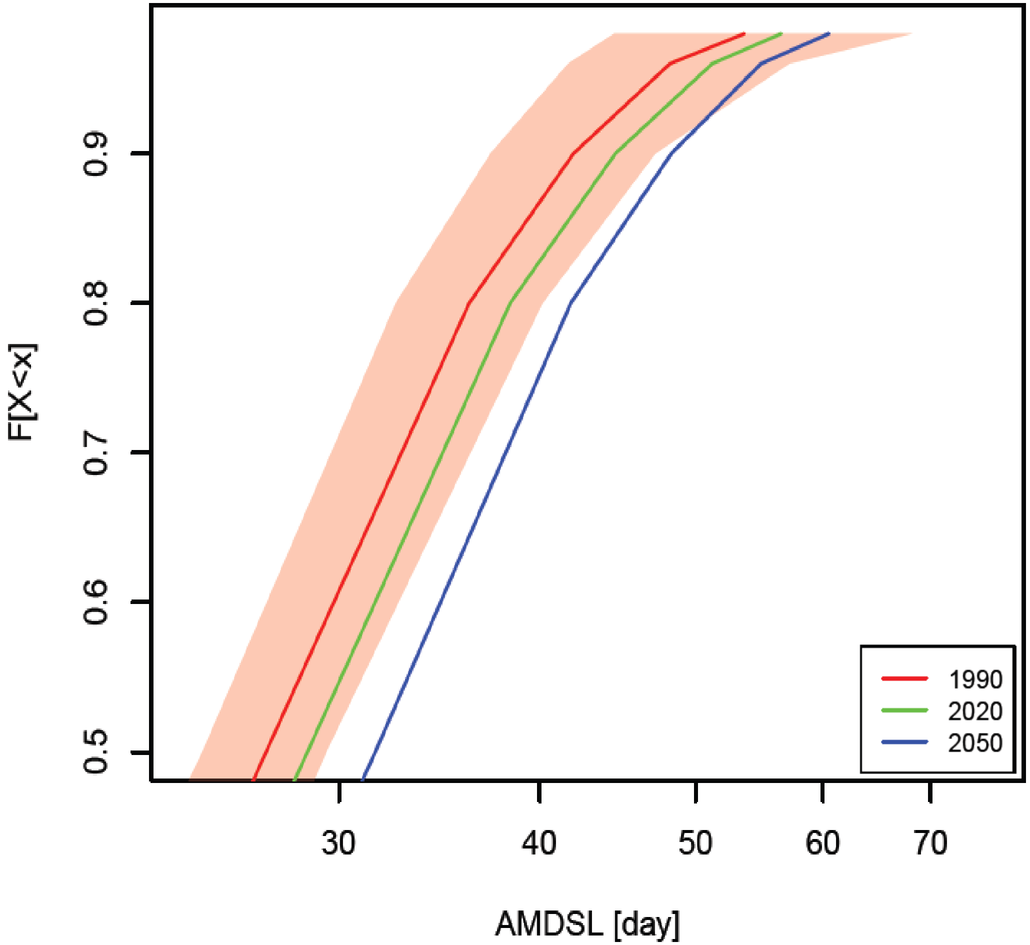
- **Then the ensemble of PDF, with non-stationary parameters, was constructed** for each ten years **for the period 1961-2050**. **From the PDF ensemble,** several statistics (mean, standard deviation, and **AMDSL for several *Tr*)** with their respective 95 % confidence intervals (CI), could be estimated using bootstrapping techniques. Then, **these values were interpolated to generate the spatio-temporal evolution** of statistics..

CDFs ensemble of AMDSL for threshold 1 mm/day from RCMs



CDFs ensemble of AMDSL for threshold 1 mm/day from RCMs

Headbasin Segura River. Site 759



CDF ensemble on site 759 for 1990 (red); 2020 (green); and 2050 (blue). (CI 95 % for 1990 year of reference).

PDF ensemble* with non stationary parameters were built on site, for the analysis of plausible trends of AMDSL.

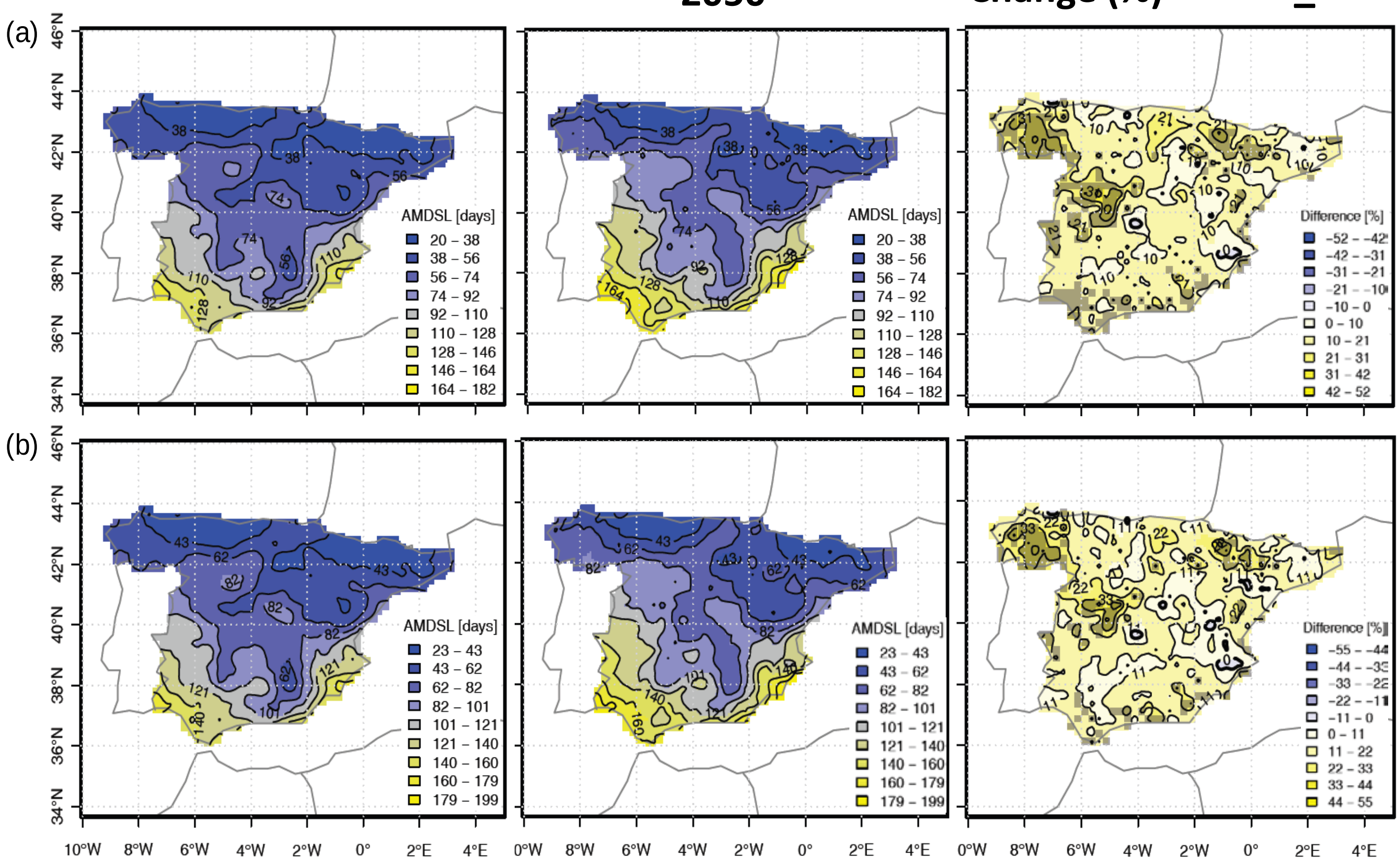
*The skill scores for each RCM, were defined according the Reliability Ensemble Average (REA), proposed by Giorgi and Mearns (2002). The two samples Test of Smirnov-Kolmogorov was considered for the assessment of the bias.

Spatial distributions of AMDSL (threshold 1 mm/day) associated to return periods, over Spain

1990 | **2050** | **Change (%) 2050 _1990**

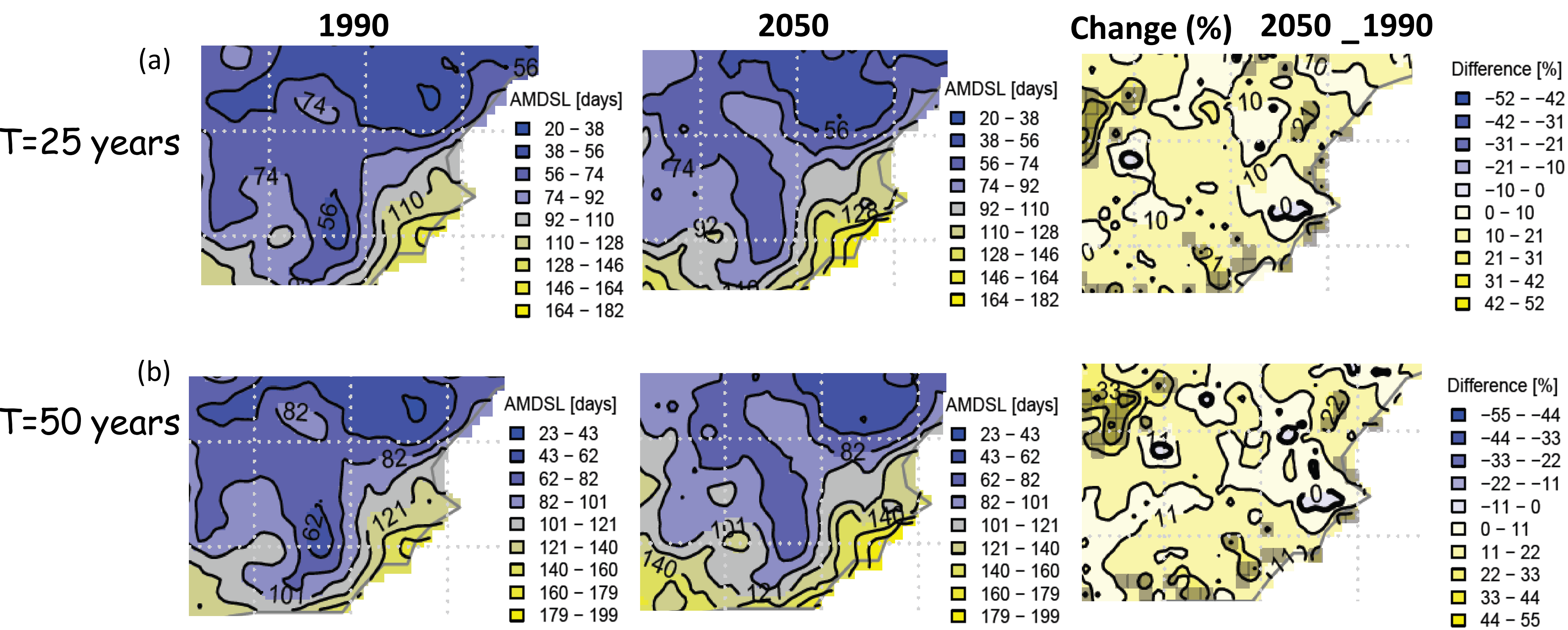
T=25 years

T=50 years



Maps of AMDSL for 1990 in the first column. 2050 in the central column, and their percentage of change (%) evaluated as [$100\times(\text{map}_{2050}-\text{map}_{1990})/\text{map}_{1990}$] in the last column: (a) *Tr* = 25 years and (b) *Tr* = 50 years. The shaded areas represent a significant change (95 % CI).

Spatial distributions of AMDSL (threshold 1 mm/day) associated to return periods. Southeast of Spain



Maps of AMDSL for 1990 in the first column. 2050 in the central column, and their percentage of change (%) evaluated as [$100\times(\text{map}_{2050}-\text{map}_{1990})/\text{map}_{1990}$] in the last column: (a)*Tr* = 25 years and (b)*Tr* = 50 years. The shaded areas represent a significant change (95 % CI).

Conclusions

- From the evaluation of spatio-temporal pattern of AMDLS, plausible trends associated to Tr (return periods) could be considered by the responsible of taking decision (stakeholders) in order to reach a better balance between mitigation and adaptation.

- *Taking into account a PDF ensemble from RCMs, a general increase of MDSL is expected for 2050 on SRB* (about 15 % in the headbasin for Tr=50 years).

-This methodology is independent of the variable and the study region → therfore it could be applied to other regions, such as Latin America.

- On going research,
    - *Application of concept of return period in the framework of nonstationary hydrologic extreme events* → analysis of the work of Salas and Obeysekera (2014).
    - *Building ensemble for several variables* (rainfall, maximum, minimum and mean temperature) *as input to hydrological models, considering several approaches* → *for improving projections of components of water cycle* (runoff, evapotranspiration, etc.).

Thanks for your attention !

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