SWIM and Horizon 2020 Support Mechanism

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Recent advances in drought hazard monitoring and climate change impact assessment over Spain

Presented by:

Ms. Sandra GARCIA GALIANO, PhD Civil Engineer

Department of Civil Engineering, Universidad Politécnica de Cartagena

sandra.garcia@upct.es http://www.upct.es/~agua

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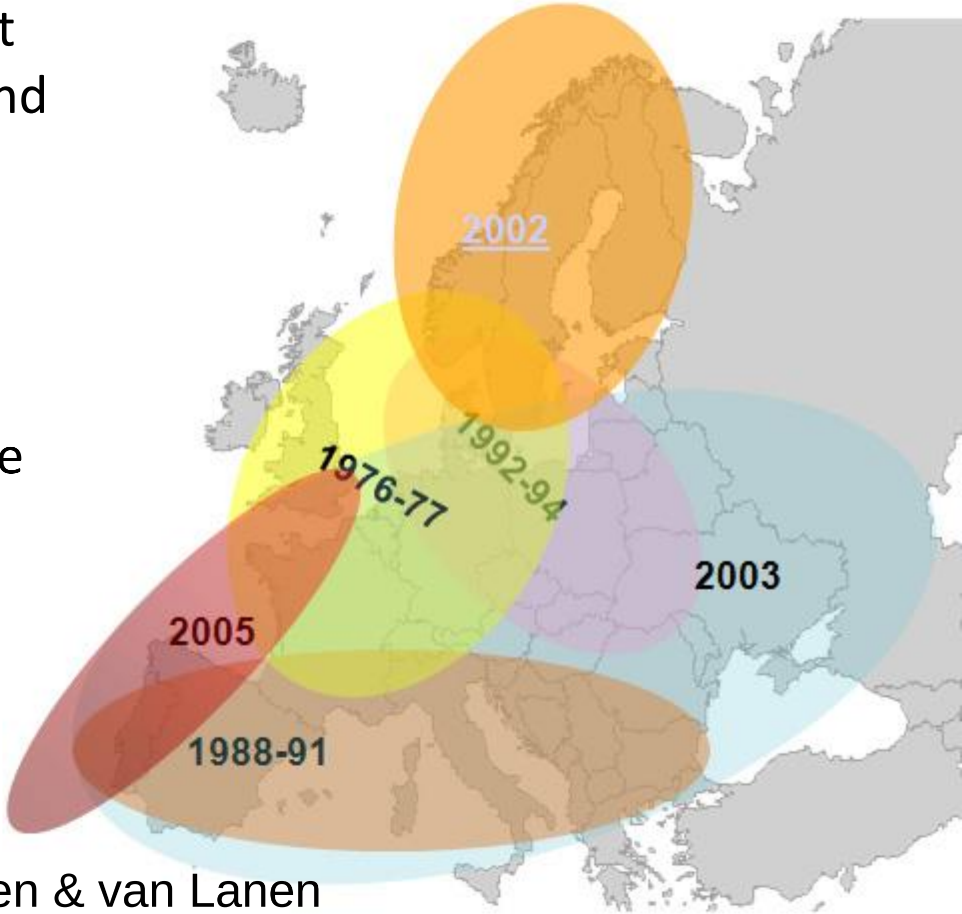
Introduction

- Spain is one of the European countries with most environmental problems related to water scarcity and droughts.

- Additionally, several studies suggest trends of increasing temperature and decreasing rainfall, mainly for the Iberian Peninsula, due to climate variability and change.

- Southern and south-eastern Europe are most prone to an increase in drought hazard.



Tallaksen & van Lanen

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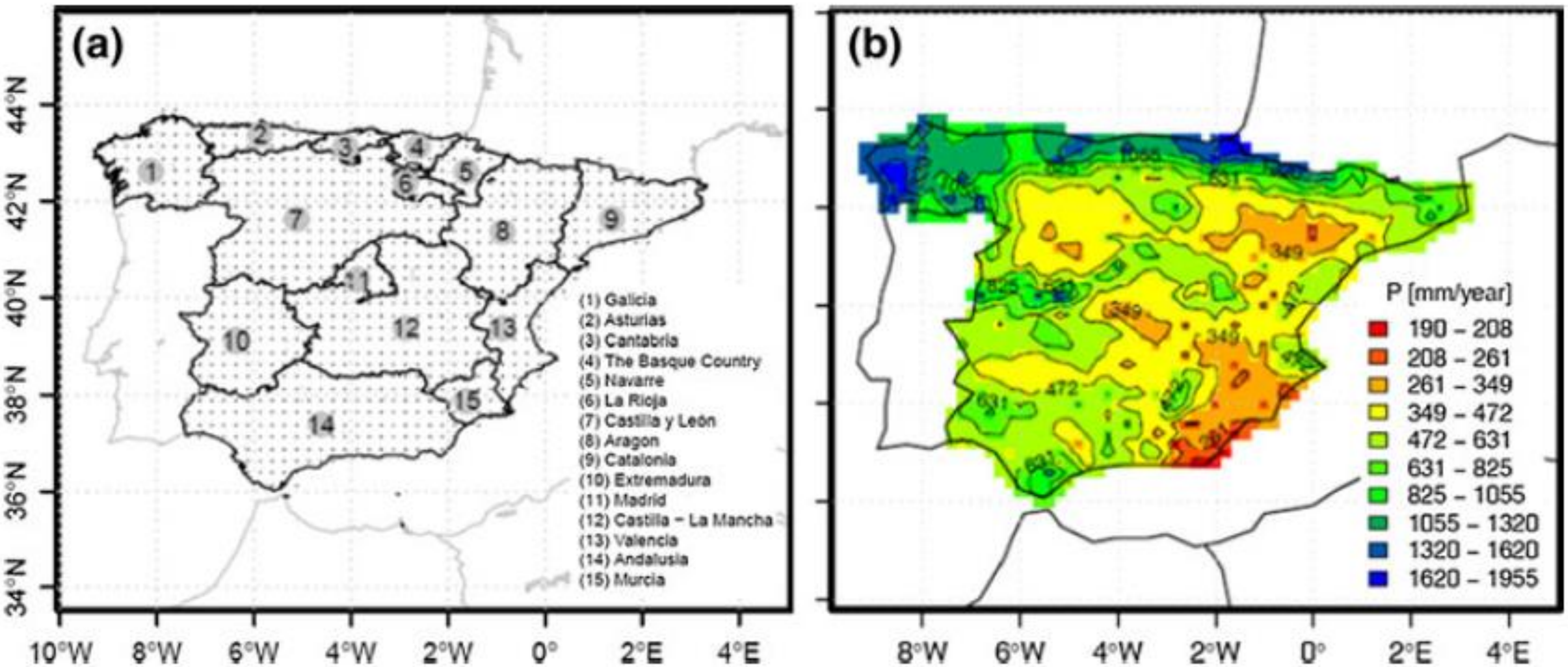
Introduction

- While Regional Climate Models (RCM) are a valuable tool for understanding climate processes, the causes and plausible impacts on variables and meteorological extremes present a wide range of associated uncertainties.

- The multi-model ensemble approach allows the quantification and reduction of uncertainties in the projections. The combination of models (RCM in this case), generally increases the reliability of the predictions, although there are different weighting methodologies.

- The main objective of this work is to identify the trends of maximum droughts over Spain for horizon 2050, considering an ensemble approach.

Study area



Zone of study: a) Location of 906 sites and administrative limits (autonomous regions) of continental Spain; and b) Mean annual rainfall for time period 1950–2007, from Spain02/v2.1 dataset

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Material and Methods

- Considering **high-resolution grids of observed daily rainfall** and information provided **by latest-generation RCMs**, the changes in the spatio-temporal patterns of annual maximum dry spells lengths (AMDSL) in continental Spain are assessed.

- AMDSL corresponds to maximum consecutive days without rainfall, or with rainfall below a threshold. AMDSL have major impacts on agriculture due to their influence on soil moisture content for low return periods (*Tr*).

Material and Methods

- A 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

- The results provided by seventeen latest-generation **RCMs driven by GCMs**, from the European ENSEMBLES Project for the time period 1950–2050 under SRES A1B greenhouse gas and ozone recovery forcing scenarios are considered.

•**Table 1**. Datasets of daily rain: observed data (Spain02/v2.1) and selected RCMs from ENSEMBLES Project.

Name	Institute	GCM	RCM	Temporal cover
Spain02/v2.1	UC[(1)]	Observed data		1950-2007
C4IRCA3	C4I[(2)]	HadCM3Q16	RCA3	1951-2099
CNRM/RM5.1	CNRM[(3)]	ARPEGE RM5.1	Aladin	1950-2100
DMI/ARPEGE	DMI[(4)]	ARPEGE	HIRHAM	1951-2100
DMI/BCM	DMI	BCM	DMI-HIRHAM5	1961-2099
DMI/ECHAM5-r3	DMI	ECHAM5-r3	DMI-HIRHAM5	1951-2099
ETHZ/CLM	ETHZ[(5)]	HadCM3Q0	CLM	1951-2099
METO_HC/HAD	HC[(6)]	HadCM3Q0	HadRM3Q0	1951-2099
ICTP/REGCM3	ICTP[(7)]	ECHAM5-r3	RegCM	1951-2100
KNMI/RACMO2	KNMI[(8)]	ECHAM5-r3	RACMO	1950-2100
METNO/BCM	METNO[(9)]	BCM	HIRHAM	1951-2050
METNO/HadCM3Q0	METNO	HadCM3Q0	HIRHAM	1951-2050
MPIM/REMO	MPI[(10)]	ECHAM5-r3	REMO	1951-2100
OURANOS/MRCC4.2.1	OURANOS[(11)]	CGCM3	CRCM	1951-2050
SMHI/BCM	SMHI[(12)]	BCM	RCA	1961-2100
SMHI/ECHAM5-r3	SMHI	ECHAM5-r3	RCA	1951-2100
SMHI/HadCM3Q3	SMHI	HadCM3Q3	RCA	1951-2100
UCLM/PROMES	UCLM[(13)]	HadCM3Q0	RRCM	1951-2050

[(1)] Universidad de Cantabria, Spain. [(2)] Community Climate Change Consortium for Ireland. [(3)] Météo-France, Centre National de Recherche Météorologiques. [(4)] Danish Meteorological Institute. [(5)] Swiss Federal Institute of Technology Zurich.[(6)] Hadley Centre, UK. [(7)] International Centre for Theoretical Physics, Italy. [(8)] Royal Netherlands Meteorological Institute.Spain. [(9)] Norwegian Meteorological Institute. [(10)] Max-Planck-Institut für Meteorologie, Germany. [(11)] Canada. [(12)] Swedish Meteorological and Hydrological Institute. [(13)] Universidad de Castilla La Mancha, Spain.

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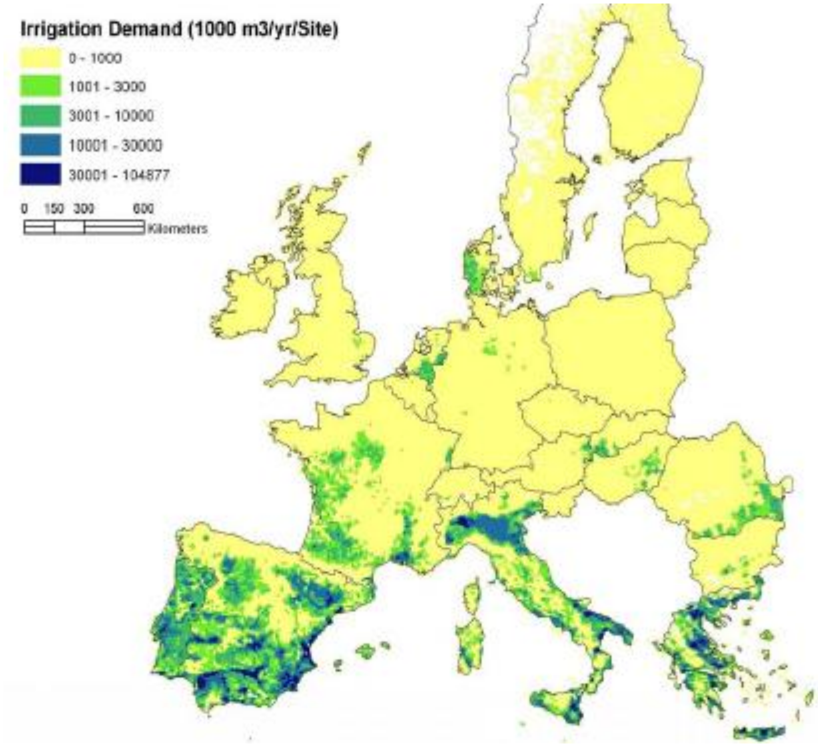
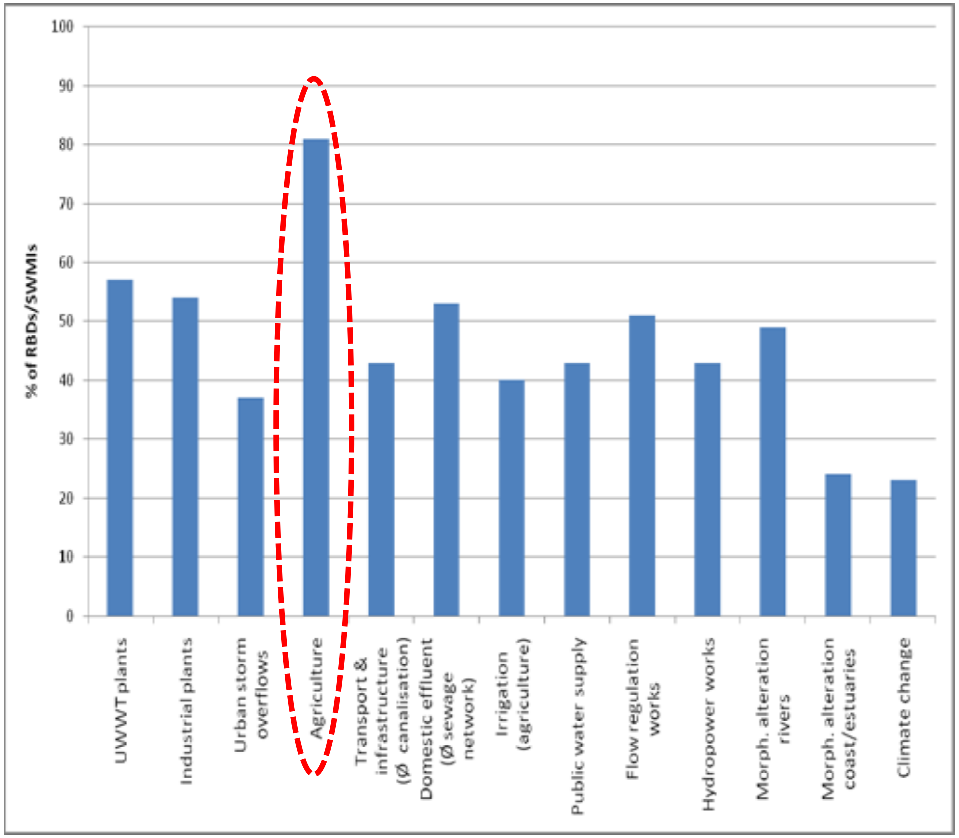
Material and Methods

- **Agriculture is one of the main abstracting sector in Europe** (Source: EEA, 2009 water resources in Europe – confronting water scarcity and droughts).
- Irrigation up to 80 % in South of Spain, and others parts of Europe.



Source: Wriedt et al., 2008, in Rouyer N. EC presentation April 2010



- AMDSL have major impacts on agriculture due to their influence on soil moisture content for low return periods (*Tr*).

WFD: agriculture is identified as the major significant water management issue. *Source: WFD Plunge into the debat conference (2009), in Rouyer, N presentation April 2010*

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Material and Methods

- PDF (probability density functions) were adjusted to AMDSL obtained from the observed rainfall and simulated rainfall by the RCMs dataset.
- A strategy is applied for the building of non-stationary PDF ensembles with the aim of evaluating the spatial pattern of future risk of drought for an area.
- Based on the Reliability Ensemble Averaging (REA) method, the assessing of its factors is done by a performance measure → Kolmogorov-Smirnov test.
- The reliability and skills of RCMs are assessed, for building the **PDF ensemble**, at grid site for the study area.

Material and Methods

Therefore, by adjusting PDF to series of AMDSL, applying GAMLSS and bootstrapping techniques, the assessment of regional changes and trends associated to high returns period, is assessed.

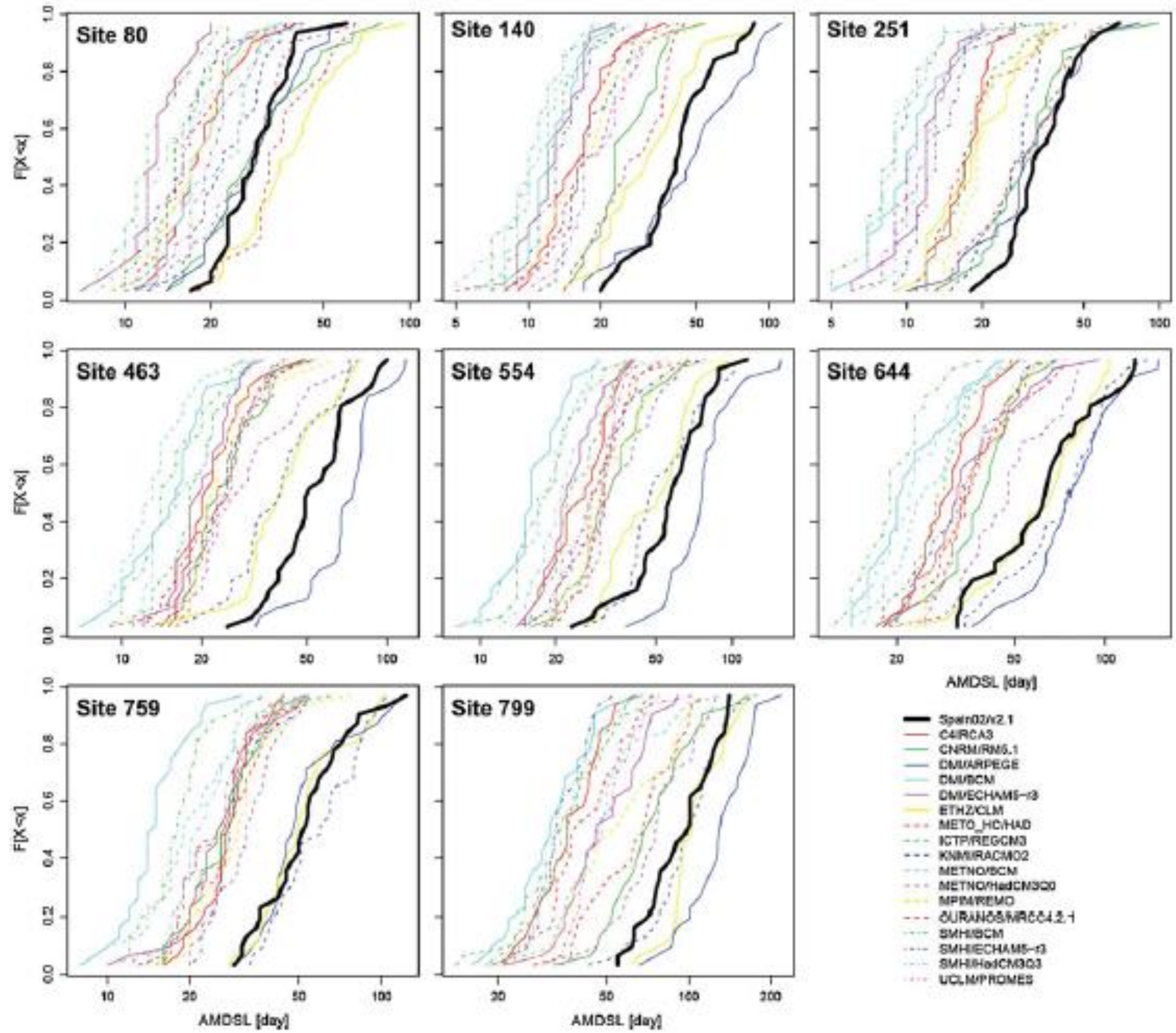

Fig. 3 CDFs of AMDSL from both observed dataset (*in black*) and RCMs (*in colour*), for 1961–1990 period

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Material and Methods

- The AMDSL time series from RCMs were modelled by GAMLSS tools. 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.
- Four PDFs of two parameters were considered for the GAMLSS application (Gumbel (GU), Gamma (GA), Lognormal (LN) and Weibull (WEI)).
- From the spatial patterns of plausible AMDSL associated with several *Tr*, and the time frame selected, quantitative predictions of climate change impacts on extreme drought risk at basin scale are assessed.
- Fig. 1 presents the maps constructed of AMDSL for the 96 % quantile (*Tr* =25 yrs.) and 98 % (*Tr*=50 yrs.) for the years 1990 and 2050, and their percentage difference.

Results

1990 2050

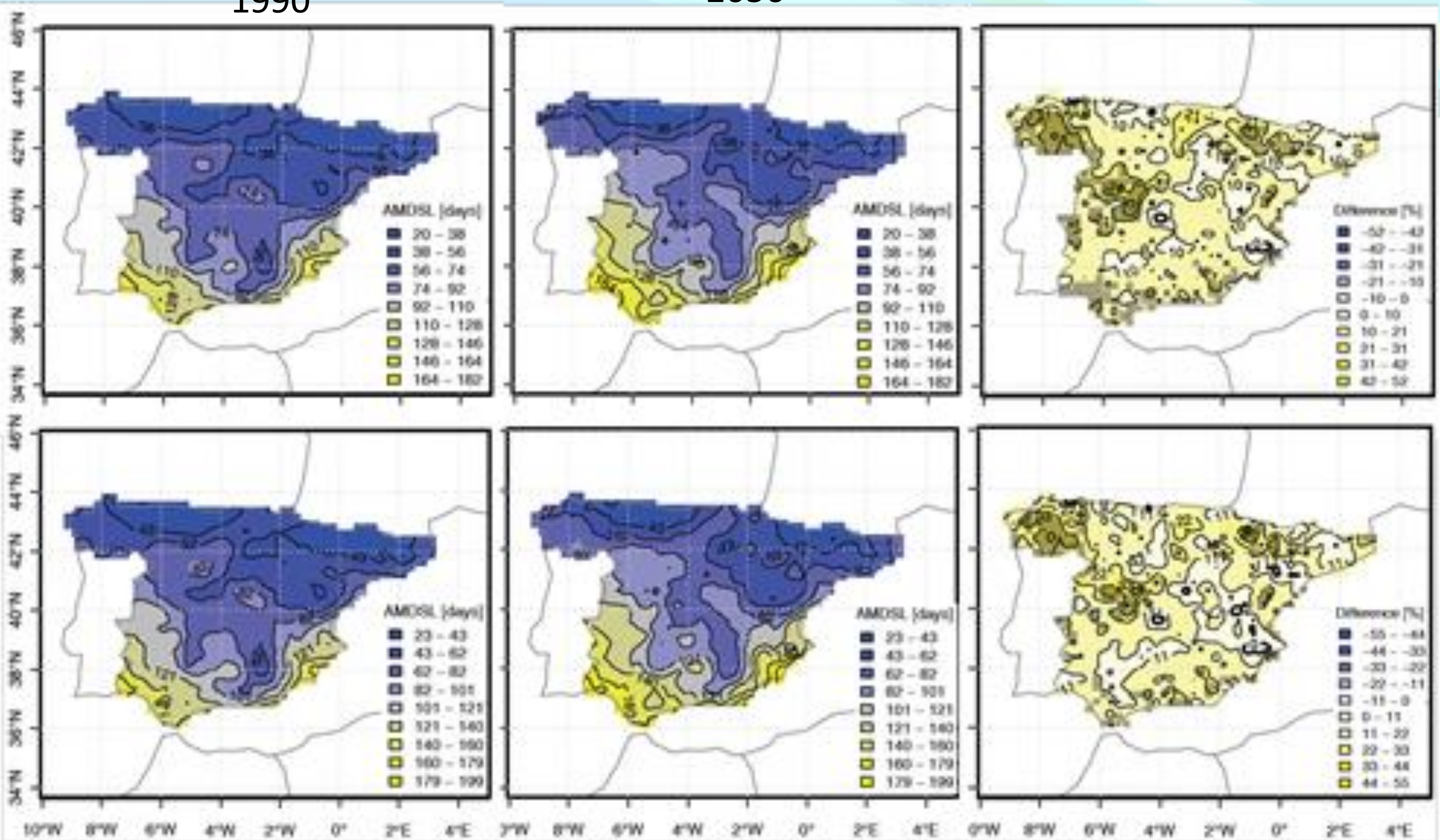

Fig. 1 Maps of AMDSL for 1990 in first column, 2050 in central column, and their percentage change (%) assessed as $[100\times(map_{2050}-map_{1990})/map_{1990}]$ in last column: (a) ***Tr* = 25 yrs**., and (b) ***Tr* = 50 yrs**. The shaded areas represent significant change/difference (95 % confidence interval).

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Results

AMDSL mean

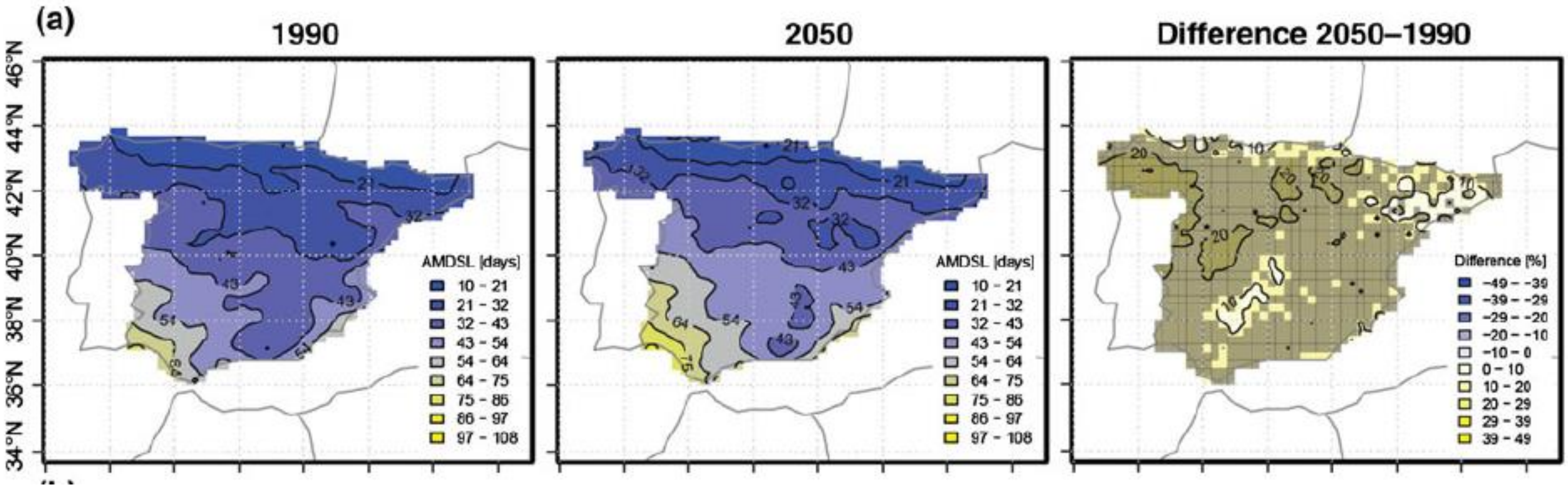

Fig. Maps of **AMDSL mean** for years 1990 (left) and 2050 (center), and their percentage change (right), assessed as [100 . (map2050 - map1990)/map1990].

A plausible significant and widespread increase throughout continental Spain of the mean value of annual maximum dry spell lengths (AMDSL) between the years 1990 and 2050, is identified

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Discussion and conclusions

- This study describes the variability and discontinuities detected in the spatial patterns of annual extreme dry spells in peninsular Spain, by non-stationary modelling and ensemble techniques of RCMs.
- Improving the knowledge regarding expected trends of AMDSL at basin scale, contributes to design more effective drought contingency preparedness and recovery operations.
- In order to exploit all the information provided by the RCMs available, a PDF ensemble is built at grid site based on the distributional similarity and bootstrapping techniques, via REA methodology.
- In general, an intensification of drought events for 2050 horizon, in contrast with 1990, is expected. The areas prone to extreme droughts in mainland Spain are identified.

Discussion and conclusions

- A plausible significant and widespread increase throughout continental Spain of the mean value of annual maximum dry spell lengths (AMDSL) between the years 1990 and 2050, is identified.
- The AMDSL maps associated with *Tr* = 25 and 50 yrs., from the PDF ensemble, present an appreciable general increase in the spatial pattern for the horizon 2050 in contrast with 1990.

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For further information

Website

www.swim-h2020.eu E: info@swim-h2020.eu

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Giraldo Osorio, J.D., and **García Galiano, S.G.** 2012. Assessing uncertainties in the building of ensemble RCMs over Spain based on dry spell lengths probability density functions. *Climate Dynamics*. doi: 10.1007/s00382-012-1381-5

Thank you for your attention.

sandra.garcia@upct.es http://www.upct.es/~agua

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