Universitat Autònoma de Barcelona

IMPRESSIONS

Potsdam Institute for Climate Impact Research

Explorando escenarios climáticos más allá de los dos grados en Iberia. El caso de la cuenca del Tajo

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Seminario del GRUP DE RECERCA EN AIGUA TERRITORI I SOSTENIBILITAT (GRATS)

Universitat de Girona, 22.09.2016

Funded by the 7th Framework Programme of the European Union
Contract Number: 603416

SEVENTH FRAMEWORK PROGRAMME

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Outline

I. Introduction:

- The IMPRESSIONS project
- ‘High-End Climate Change’ (HECC) and current emission trends
- From SRES to SSP and RCP scenarios

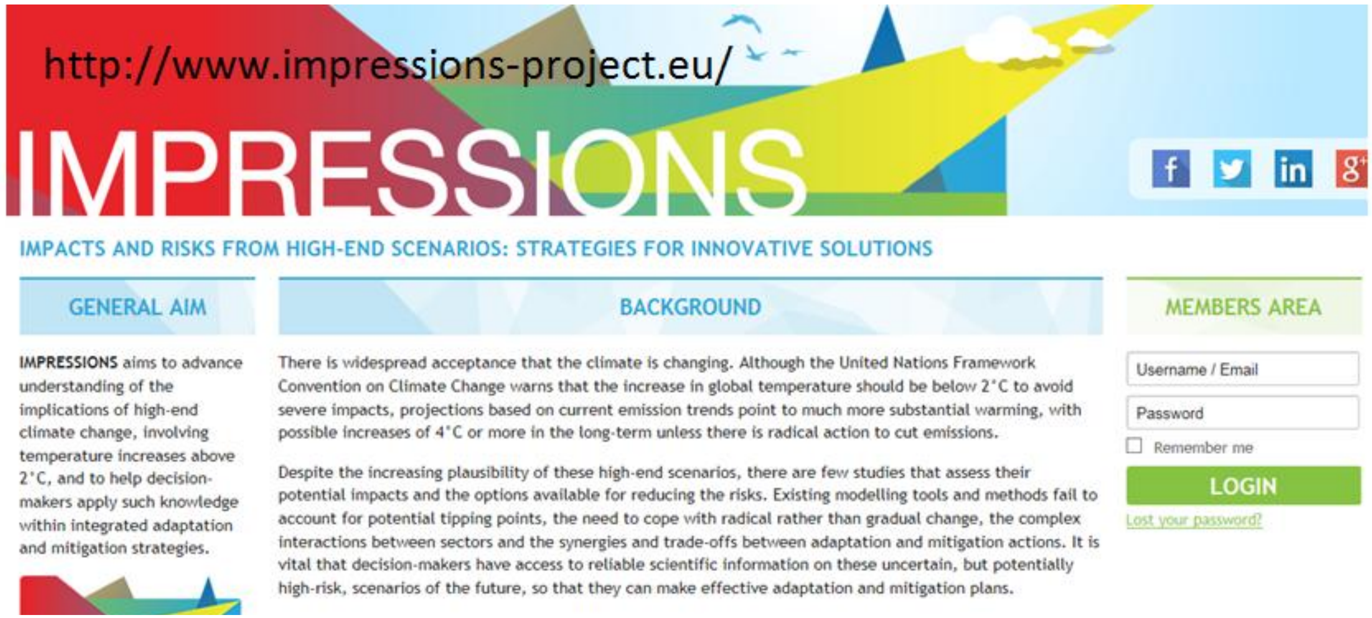
II. The Iberian case study:

- Context: Iberian climate trends
- The Tagus river basin and the SWIM model

III. Discussion and limitations of the study

I. Introduction

The IMPRESSIONS project



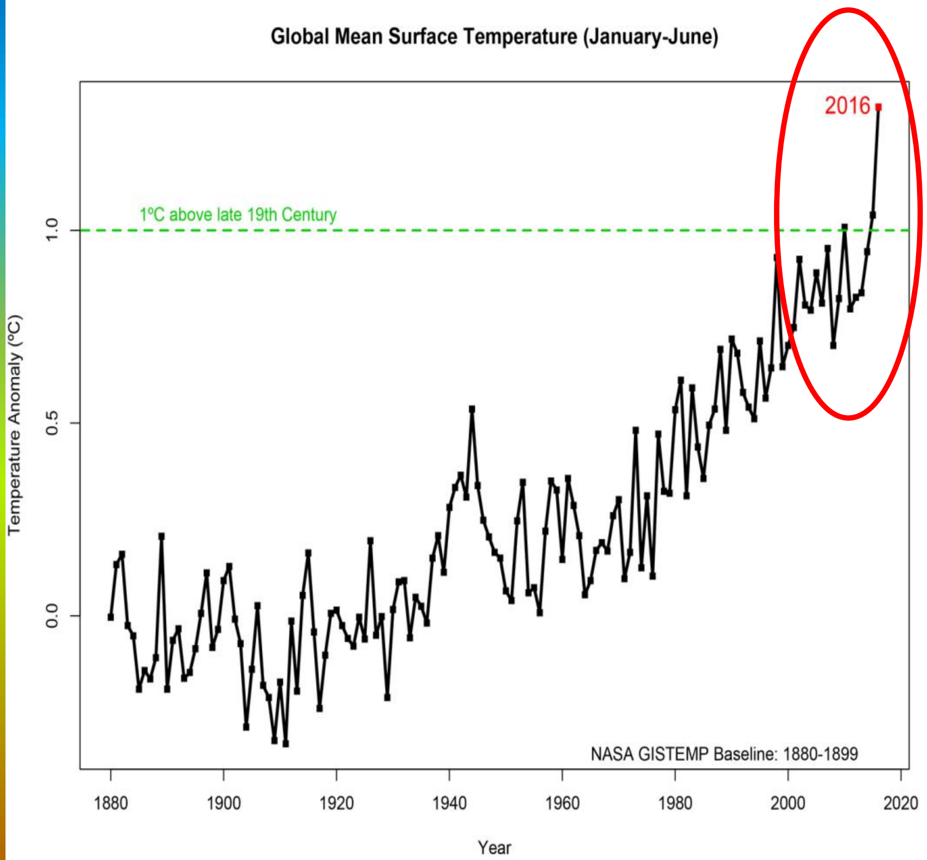
Multi-scale:
5 case studies

Global and central Asia case studies

European case study

▲ 3 regional/local case studies (Scotland, 2 Iberian catchments, 2 Hungarian municipalities)

High-End Climate Change…

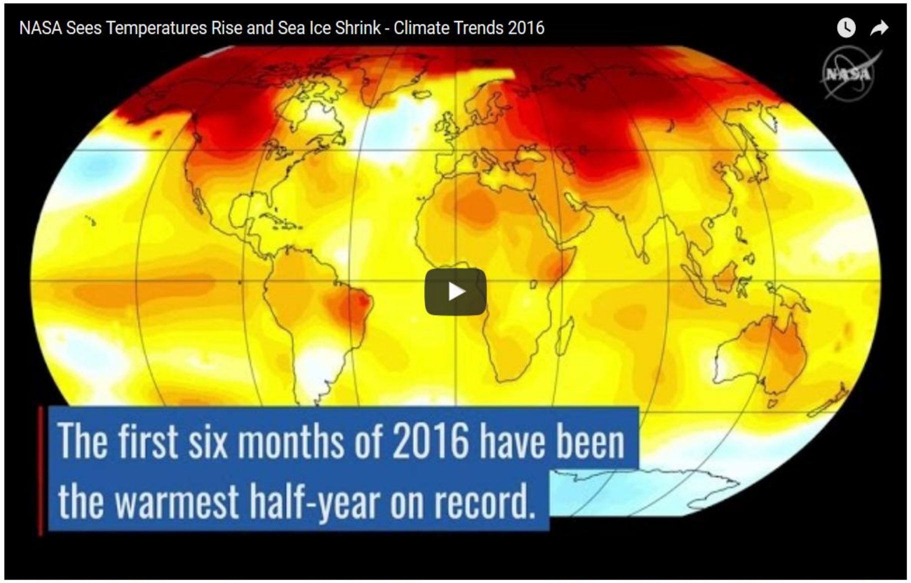


July 19, 2016

2016 Climate Trends Continue to Break Records

Two key climate change indicators -- global surface temperatures and Arctic sea ice extent -- have broken numerous records through the first half of 2016, according to NASA analyses of ground-based observations and satellite data.

Each of the first six months of 2016 set a record as the warmest respective month globally in the modern temperature record, which dates to 1880, according to scientists at NASA's Goddard Institute for Space Studies (GISS) in New York. The six-month period from January to June was also the planet's warmest half-year on record, with an average temperature 1.3 degrees Celsius (2.4 degrees Fahrenheit) warmer than the late nineteenth century.

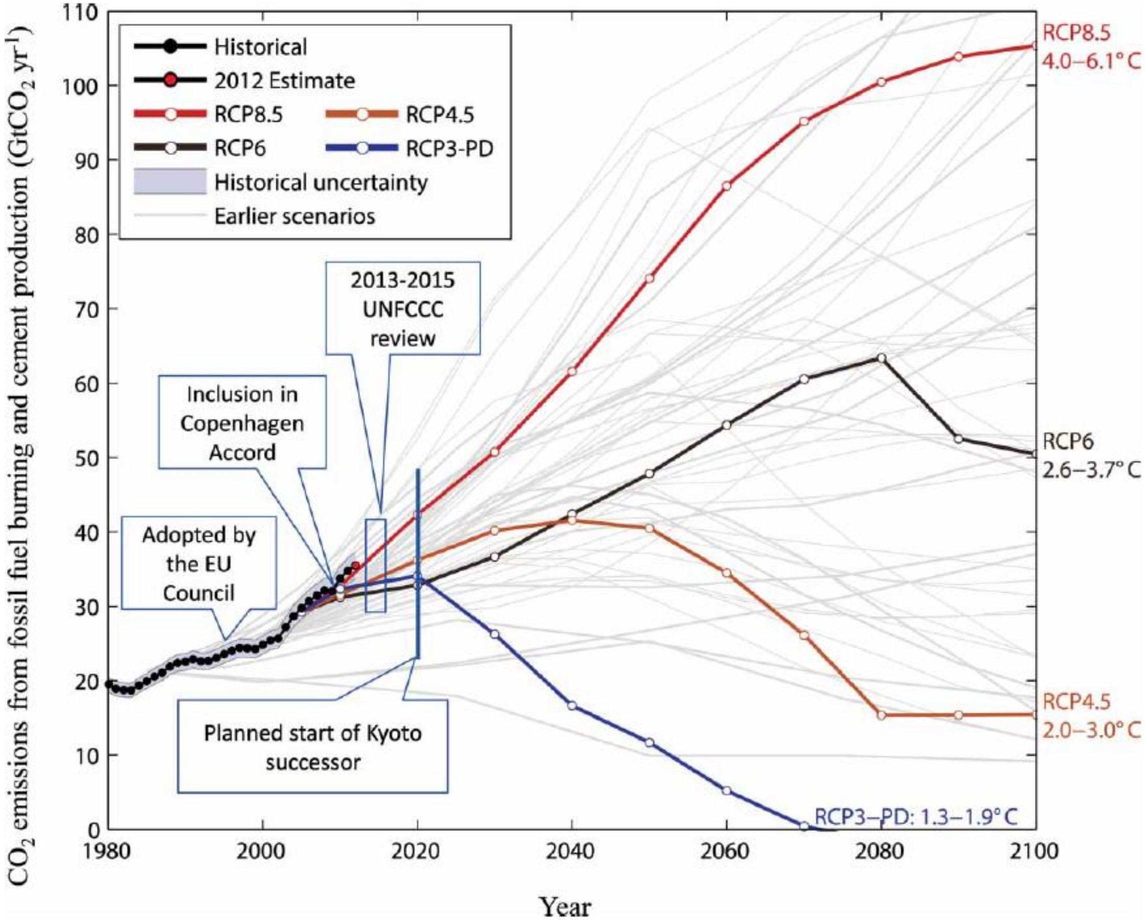


http://www.nasa.gov/feature/goddard/2016/climate-trends-continue-to-break-records

- NASA: "Each of the first six months of 2016 set a record as the warmest respective month globally in the modern temperature record, which dates to 1880".

Current emissions trends

- Recent research on mitigation indicates that the increasing growth in CO_2 emissions that has occurred since 2000 has significantly reduced the probability of limiting warming to 1.5 or 2^{o}C.

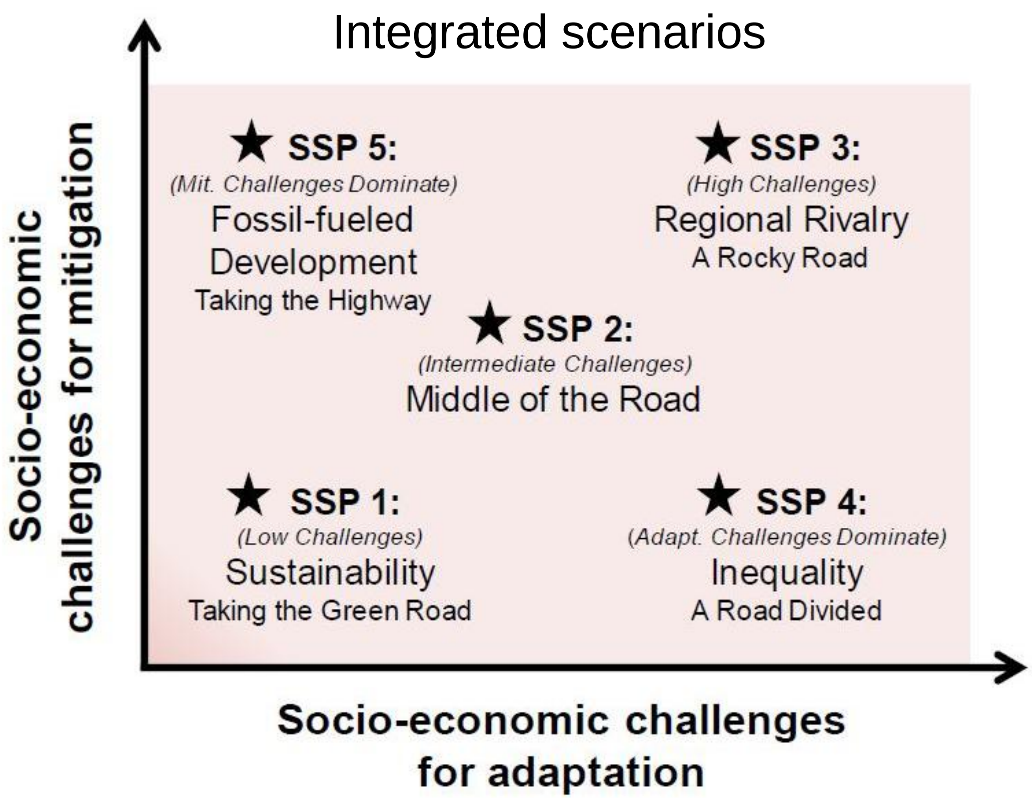


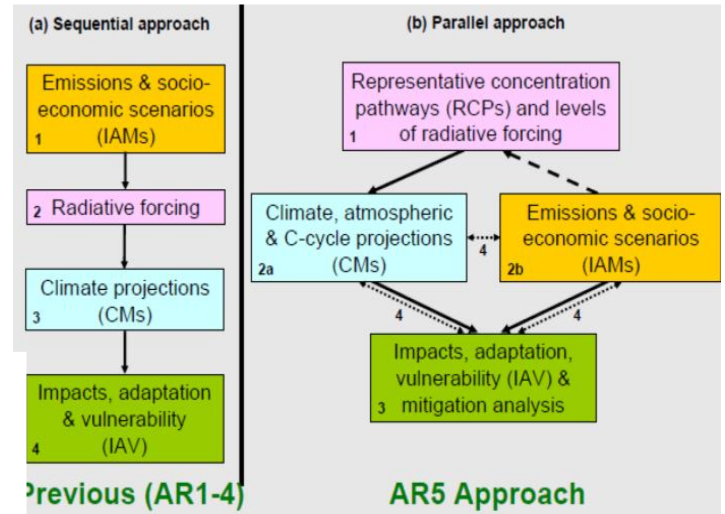
The new **Representative Concentration Pathways (RCP)** of the last IPCC report (AR5) refer the level of radiative forcing (global energy imbalances), measured in watts per square metre, by the year 2100 and replaces the former SRES scenarios category.

Jordan et al. (2013). Going beyond two degrees? The risks and opportunities of alternative options. Climate Policy, 13: 751-769.

From SRES scenarios to SSP

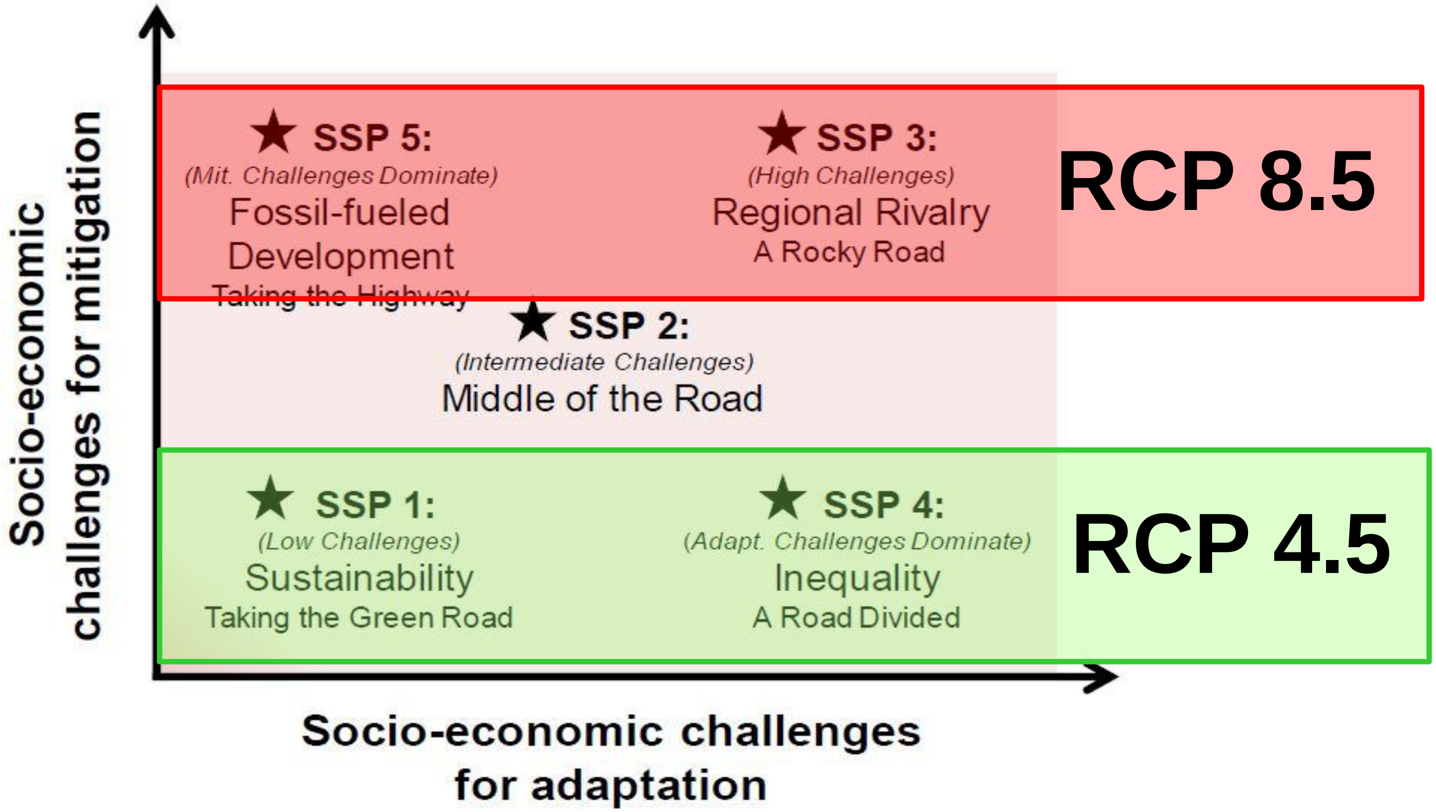
- **Shared Socio-economic Pathways (SSP)** are plausible alternative global scenarios in the evolution of society and ecosystems over a century in the absence of climate change or climate change policies.





SSP Scenario	Challenges	SRES equivalent
SSP1	Low for adaptation Low for mitigation	B1, A1T.
SSP3	High for adaptation High for mitigation	A2
SSP4	High for adaptation Low for mitigation	No analogue
SSP5	High for mitigation Low for adaptation	A1FI

Combining climate & socio-economics scenarios in IMPRESSIONS



	Low adaptation challenges	High adaptation challenges
High mitigation challenges	RCP8.5x SSP5	RCP8.5 x SSP3
Low mitigation challenges	RCP4.5x SSP1	RCP4.5x SSP4

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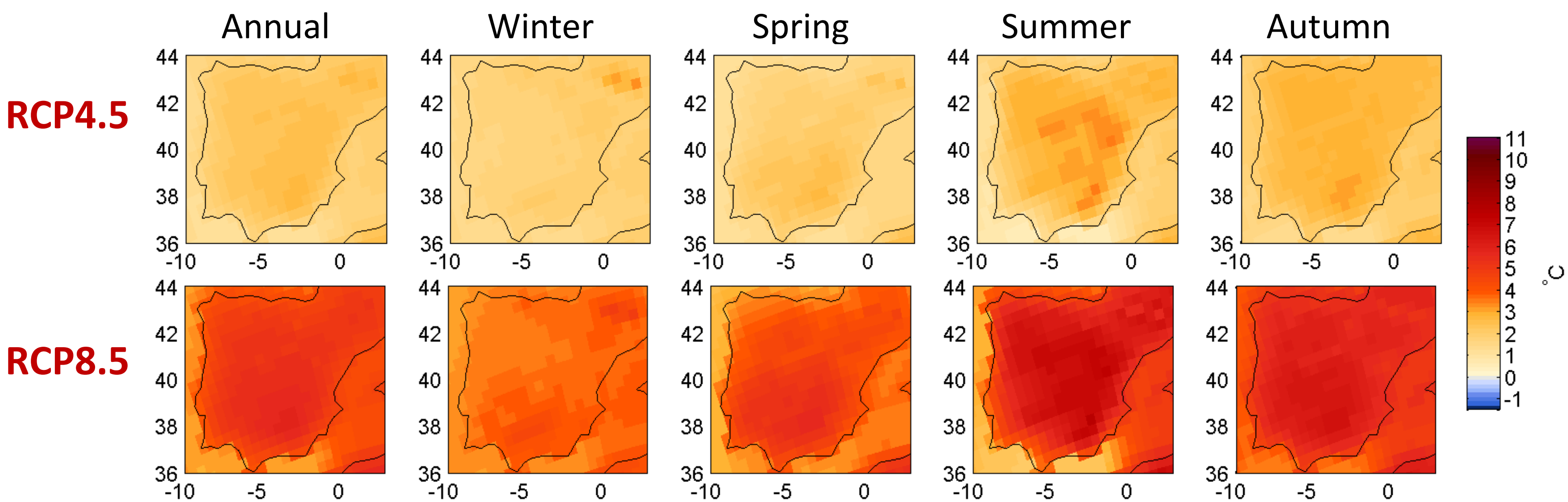
II. The Iberian case study

Temperature change in Iberia (2071-2100)

Seasonal temperature change from HadGEM Earth System Model downscaled with the RCA regional model at a spatial resolution of 50km (changes relative to 1981-2010):

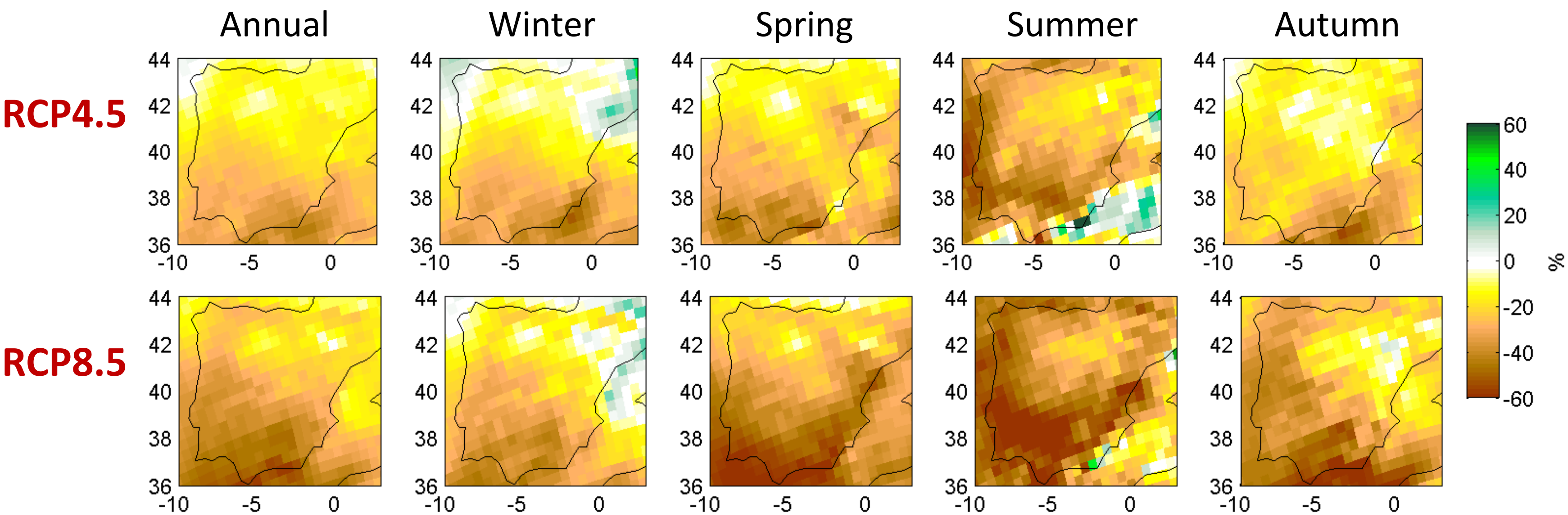


Annual temperature change (°C) from a large sub-set of climate models in CMIP5:

	25%	50%	75%	Max
RCP4.5	1.6	2.1	2.5	3.7
RCP8.5	3.5	4.3	5.0	6.9

Precipitation change for Iberia (2071-2100)

Seasonal precipitation change from HadGEM Earth System Model downscaled with the RCA regional model at a spatial resolution of 50km (changes relative to 1981-2010):

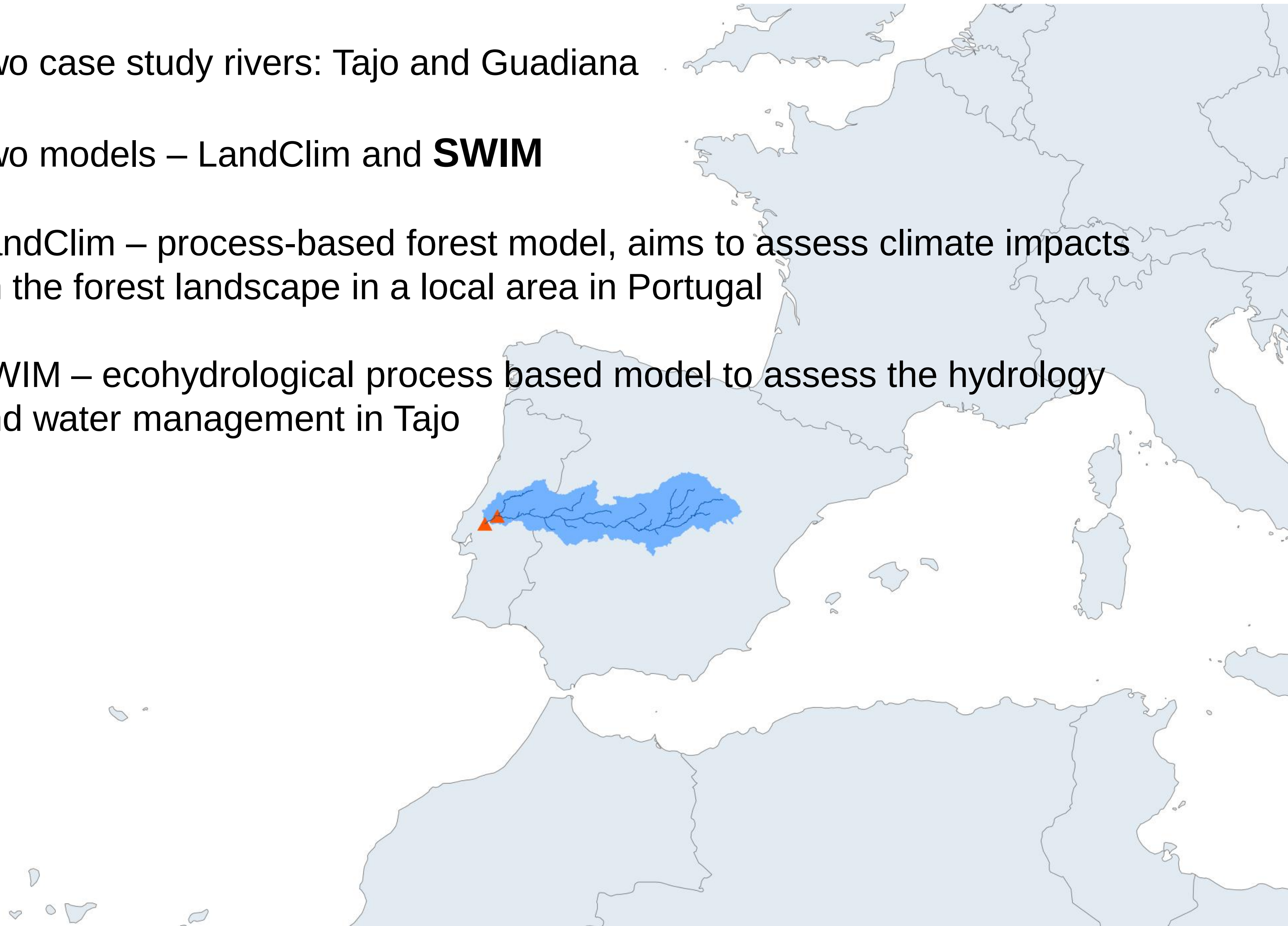


Annual precipitation change (%) from a large sub-set of climate models in CMIP5:

	25%	50%	75%
RCP4.5	-16	-11	0
RCP8.5	-30	-26	-12

Iberian Case Study

- Two case study rivers: Tajo and Guadiana
- Two models – LandClim and **SWIM**
- LandClim – process-based forest model, aims to assess climate impacts on the forest landscape in a local area in Portugal
- SWIM – ecohydrological process based model to assess the hydrology and water management in Tajo



SWIM: Soil and Water Integrated Model

Eco-hydrological process-based semi – distributed model

Assemblage of three main components - hydrological, vegetation and pedosphere modules, simulates discharge, crop growth, sediment and nutrients flow at the daily time step

Pedosphere

- **Nitrogen cycle**
- **Carbon cycle**
- **Phosphorous cycle**

Vegetation

- **Wetland module**
- **Crop**
- **Forest**

Water Allocation Module

- **Water management**
- **Irrigation processes**

Reservoir Module

- **HPP**
- **Reservoir processes**

Hydrology

- **Soil profile**
- **River network**
- **Deep/shallow groundwater**
- **Percolation**

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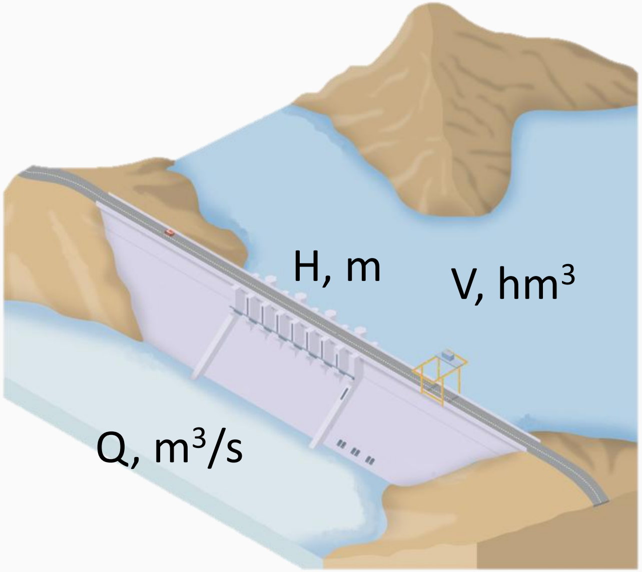
Reservoir module

1 minimum daily discharge max and min volumes

2 discharge depending on the water level and electricity production demands

3 discharge depending on the water level



- Conceptual representation of the reservoirs processes for the

Environmental targets

Calculates HPP from water discharge and fall

Withdrawal module

Seepage and evaporation

Flood protection

Water Allocation Module

01

subbasin subbasin

efficiency of the transfer, added to subbasin on the next day

02

subbasin reservoir

efficiency of the transfer, replaces the withdrawal rates at the reservoir ctrl file

03

subbasin out/in

the transfer is happening either from the basin or to outside of the basin

04

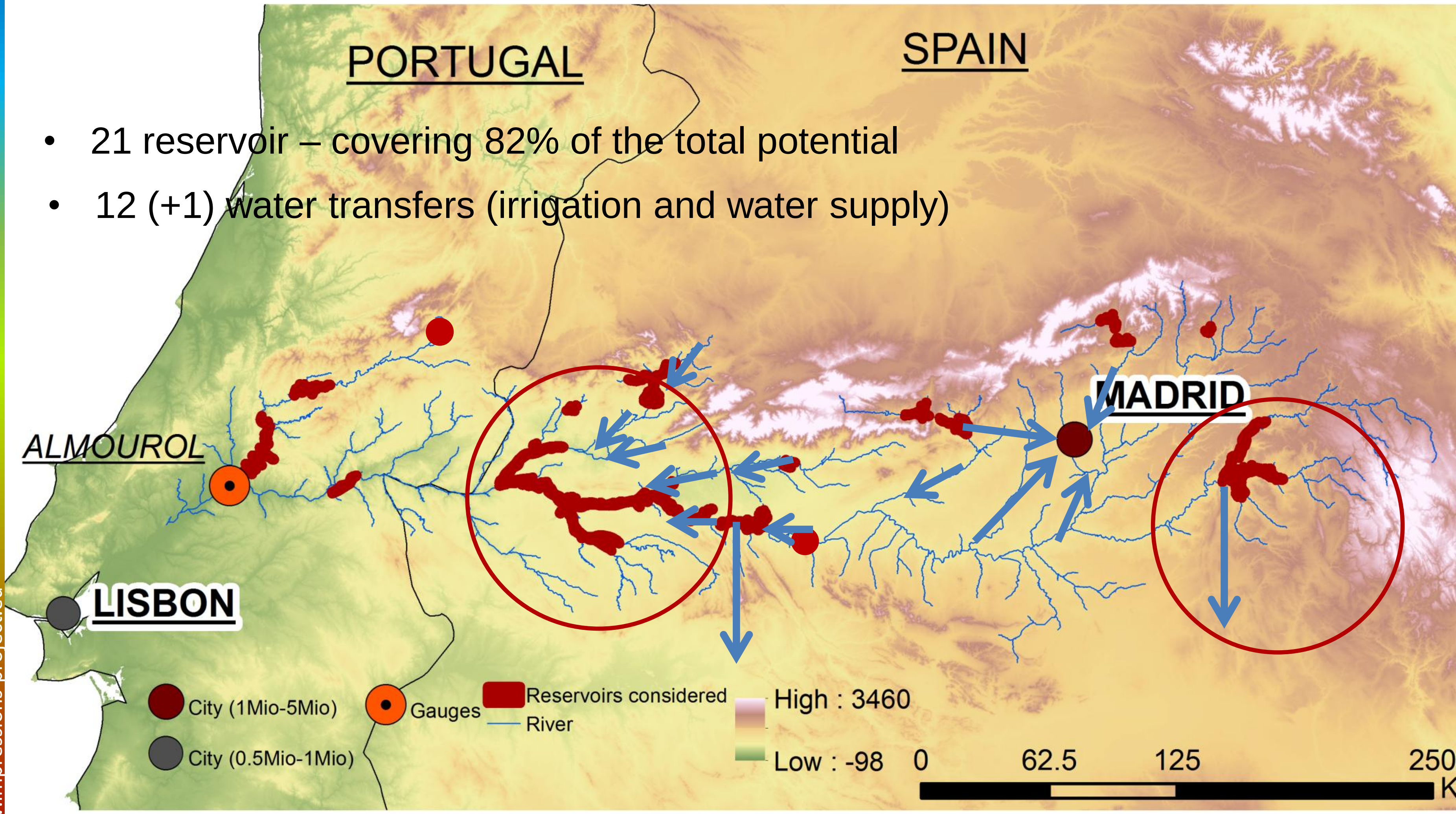
subbasin irrigation

adds water to hydrotopes

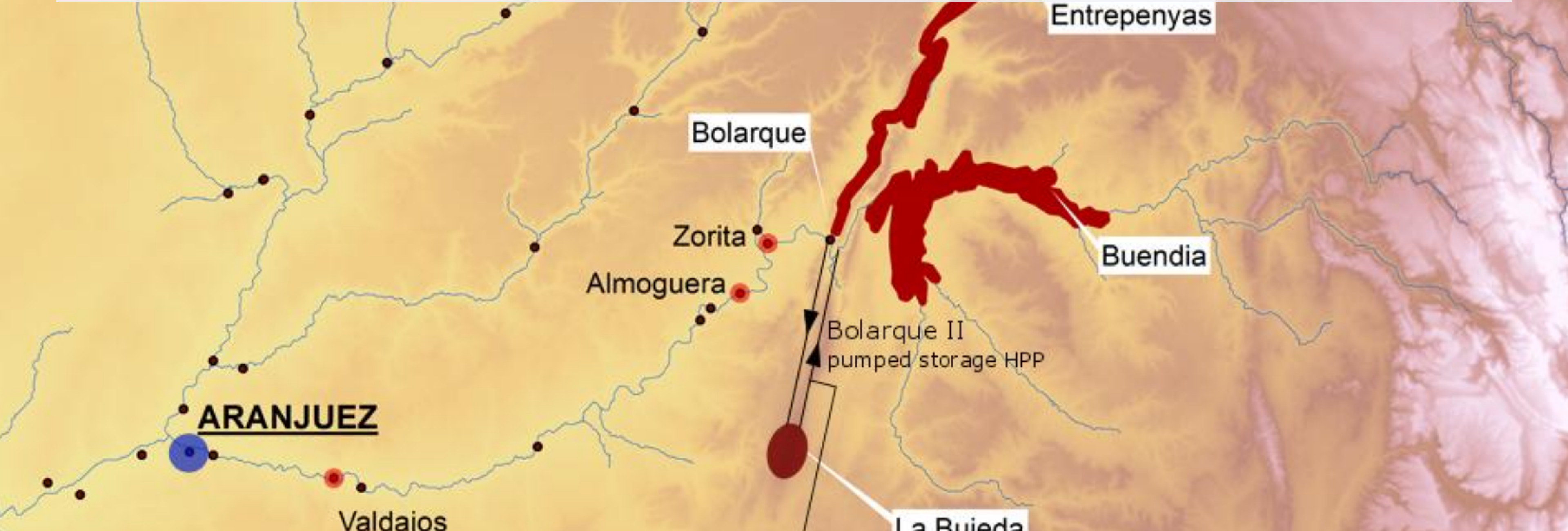
- Allows to simulate inter and intra basin water transfers and irrigation processes

SWIM model of the Tajo River Basin

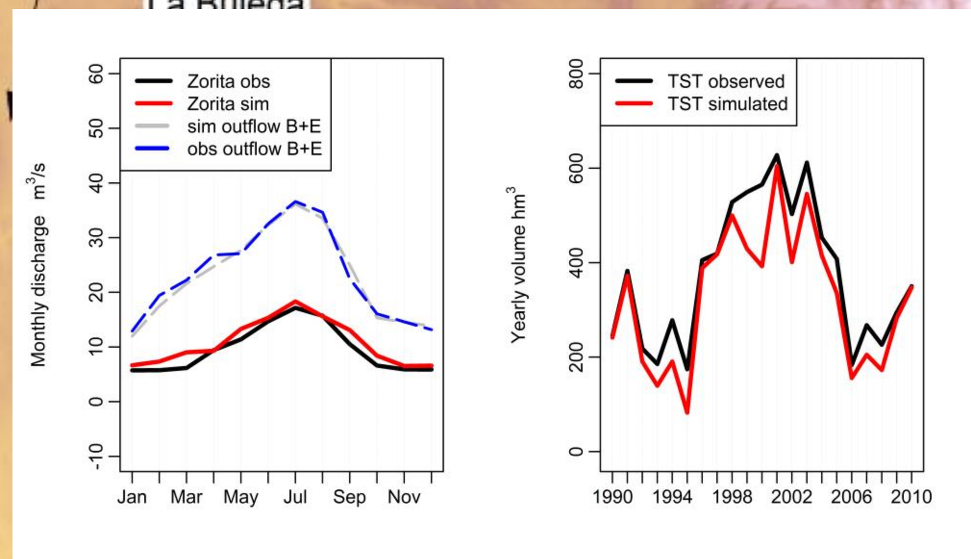
- 21 reservoir – covering 82% of the total potential
- 12 (+1) water transfers (irrigation and water supply)



Buendía – Entrepeñas system. SWIM, Reservoir and Water Allocation Module



- 2 water transfers to represent TST and HPP, 2 reservoirs to alter reservoir management



Iberian narratives

SSP1- Sustainability

- growing social participation in environmental, social, and economic issues
- creation of European social-oriented political framework
- ‘learning cycles’ in many sectors
- joint Portuguese-Spanish Agency on environmental protection and natural resource use and social welfare
- cooperation between water users
- reduction of water and energy demand (behaviour+ tech change)
- Population is stable because of low natural growth and a balanced migration.
- Iberia exports technology and renewable energy and green quality services to other EU member states

SSP5- fossil-fuelled development.

- Investment in cheap and plentiful fossil fuel-based energy resources
- Technological focus for socioeconomic development
- large-scale intensively managed and mechanized agriculture and commercial forestry.
- Decrease unemployment – social mobility
- Technological fixes to environmental problems (e.g. drought)
- Start relocating people from very dry areas
- Iberia totally depends on technology, fossil fuels, subsidies from the EU and gas from northern Africa, and investments of large corporations.
- Economic crises
- Financial bubbles and food shortages
- Emigration to Northern Europe

SSP4- Inequality

- Unemployment and immigration to Iberia
- Exclusive development
- Low social cohesion and stratification
- Investments in wind and solar technology through taxes and EU funding -> in line with EU policy
- Limited access to resources to majority
- Rivalry between social and ethnic groups are maintained and increased by the elite policies.
- Trade agreements with North Africa
- Limited migration

SSP3- Regional Rivalry

- Exclusive economic development. Rivalries between and within Iberia
- Separatism increases; difficulties to govern and cooperate
- 'Club Med' to (only partly) counteract water and resource scarcity
- Iberia: Portugal, Spain, Catalonia,Basc country
- Population flows are mostly leaving Iberia and the remaining Iberian population concentrates more and more in large cities
- 'Desertified Iberia'

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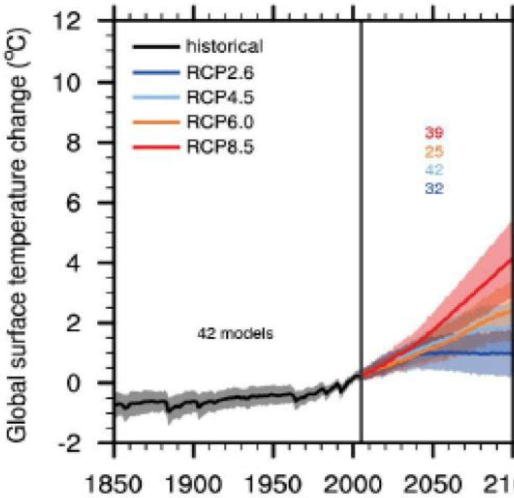
Modelling Integrated Scenarios in the Tajo (1)

SSP1 x RCP4.5

	Low adaptation challenges	High adaptation challenges
High mitigation challenges	RCP8.5x SSP5	RCP8.5 x SSP3
Low mitigation challenges	RCP4.5x SSP1	RCP4.5x SSP4



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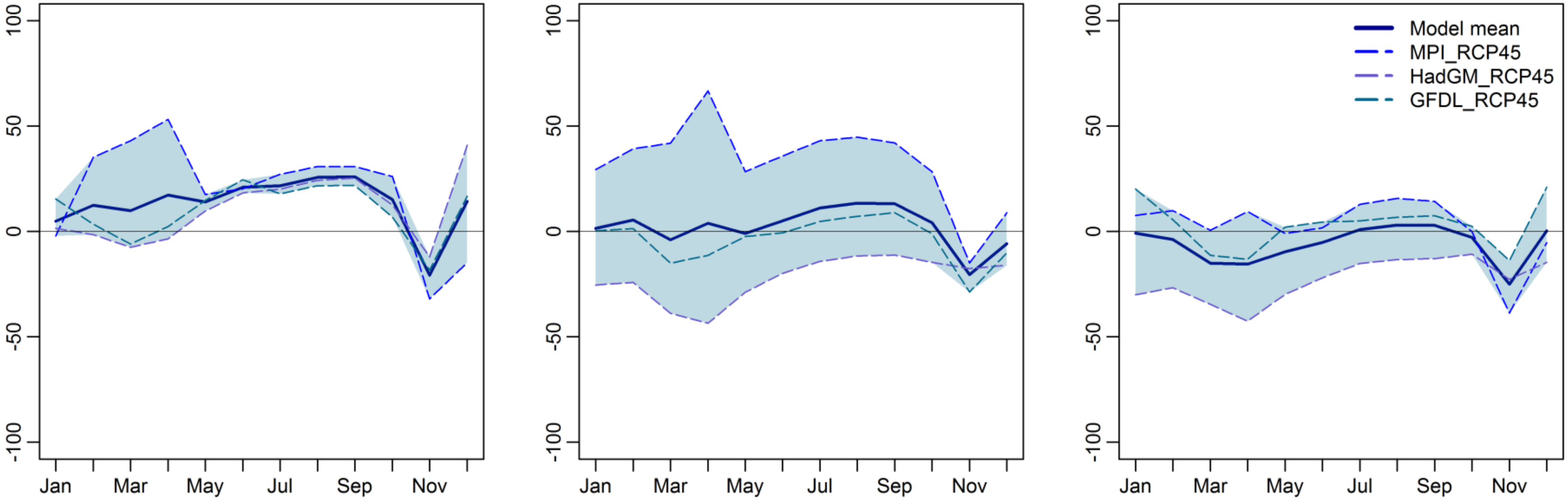
Modelling assumptions

- Tagus-Segura water Transfer has secondary importance over the real environmental flows in Tagus (resembling the natural conditions)
- Withdrawls for irrigation and urban water transfer in the catchment are decreasing (and their efficiencies increasing, by 40% with respect to 2001-2010, very little water lossess)
- Alcantara dam is managed as now (implicitly taking into account the Albufeira agreement)

Modelling results – Water availability Entire Tagus River SSP1



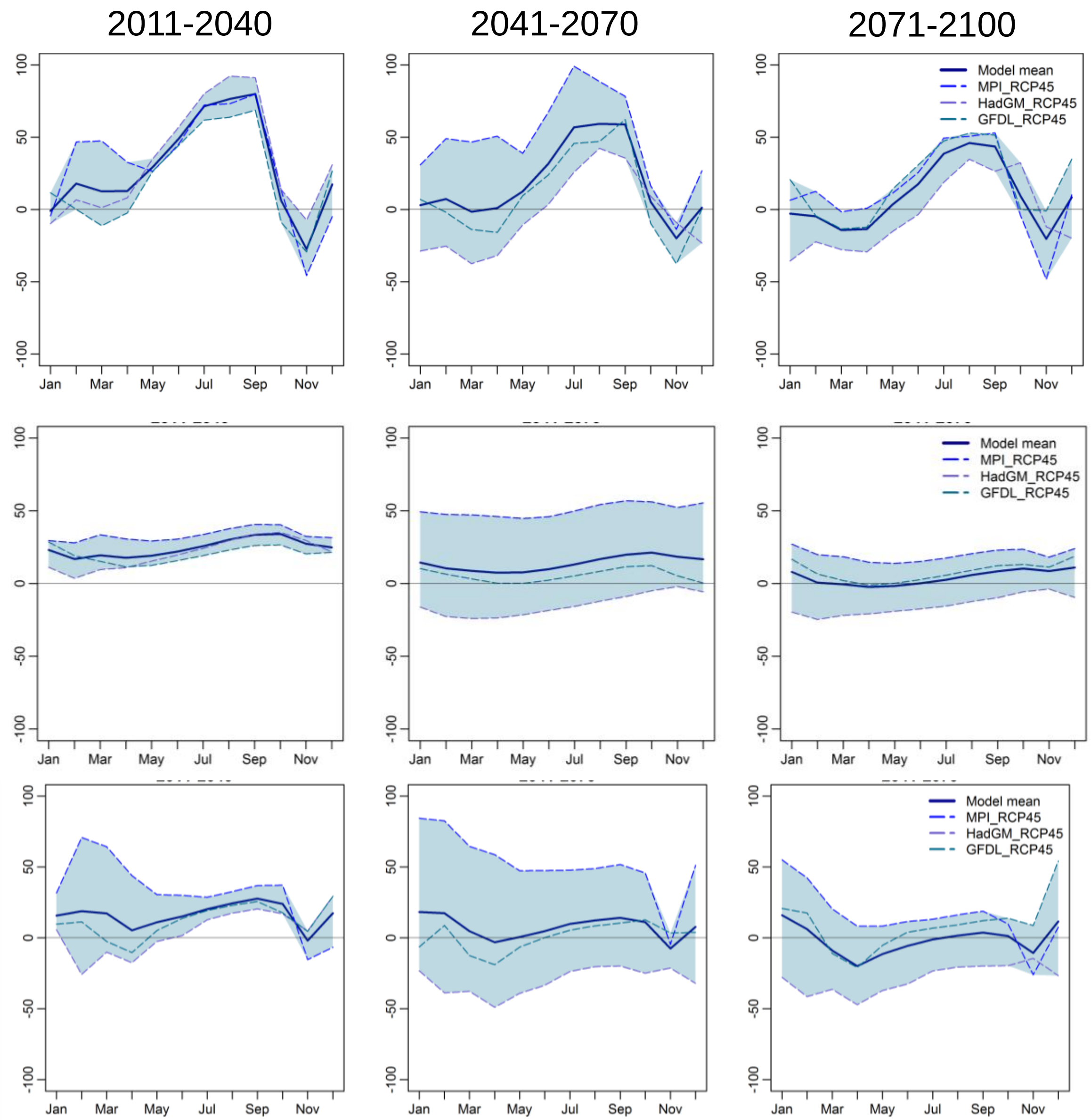
2011-2040

2041-2070

2071-2100

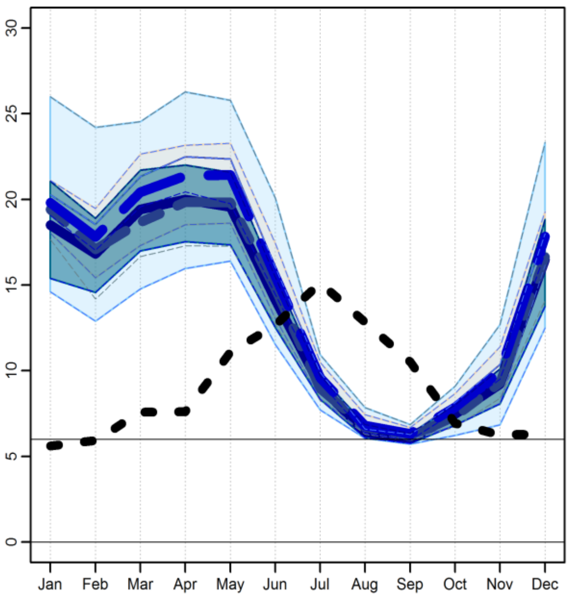
Modelling results – Alcantara Dam SSP1

Percentage deviation in inflow (top), volume (middle) and outflow (bottom) from the Alcantara dam (relative to current conditions 1981-2010)

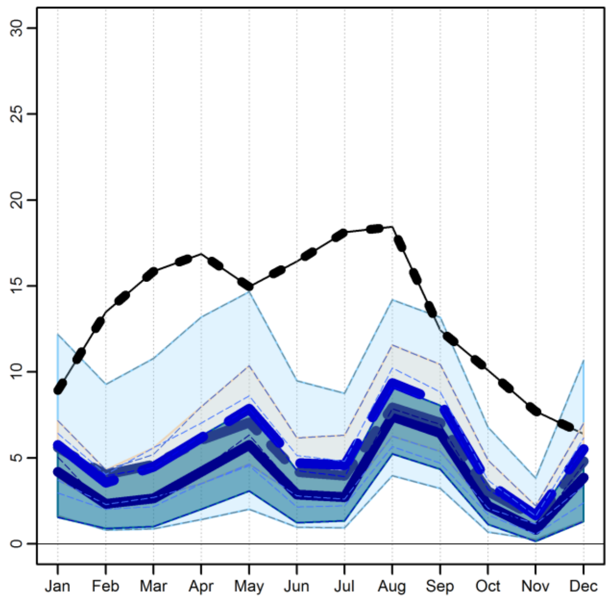


Increase in the summer inflows reflects the increased efficiency in the water transfers, as well as decrease in the withdrawals with respect to the current situation

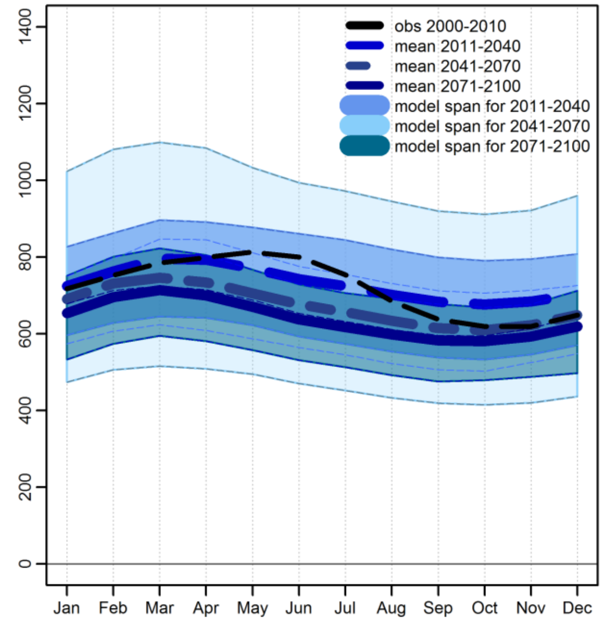
Tagus-Segura Water Transfer SSP1



Discharge in Tagus (m3/s) (e.g. Aranjuez)



Discharge supplied to Segura (m3/s)



Volume of B+E (hm3)

- The Buendia and Entrepenyas reservoirs are managed in a sustainable way – more discharge in winter and less in summer, to resemble natural conditions
- The discharge in Tagus downstream of both reservoirs and withdrawal to Tagus-Segura Transfer is set to “real” environmental flows (according to IHA)
- Under RCP4.5, total volume supplied to Segura (average among models): 169 hm3, 155 hm3, 117 hm3 (versus 350 hm3 average demand specified in the Segura Basin Management Plan)

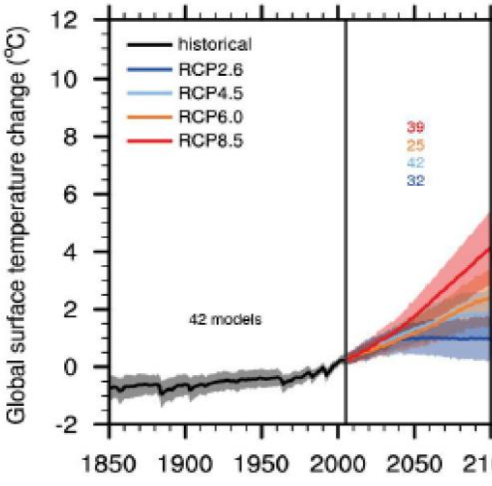
Results SSP1 x RCP4.5

- Amount of water volumes to be transferred to Segura obviously decreases
- Water supplied to society decreases aswell, because of increase in efficiencies of transfers and infrastructure according to the SSP storyline
- Water avilability is projected to experience little change according to the multi-model mean *(important to note that maybe during this time the flows are relatively low, e.g. -50% in summer-spring is not the same as 50% in winter, when the discharges are really high)*
- Important to notice, that the volumes of the Buendia and Entrepenyas reservoirs are preserved better when the “sustainable” way of operation is introduced

Modelling Integrated scenarios in the Tajo (2)

SSP5 x RCP8.5

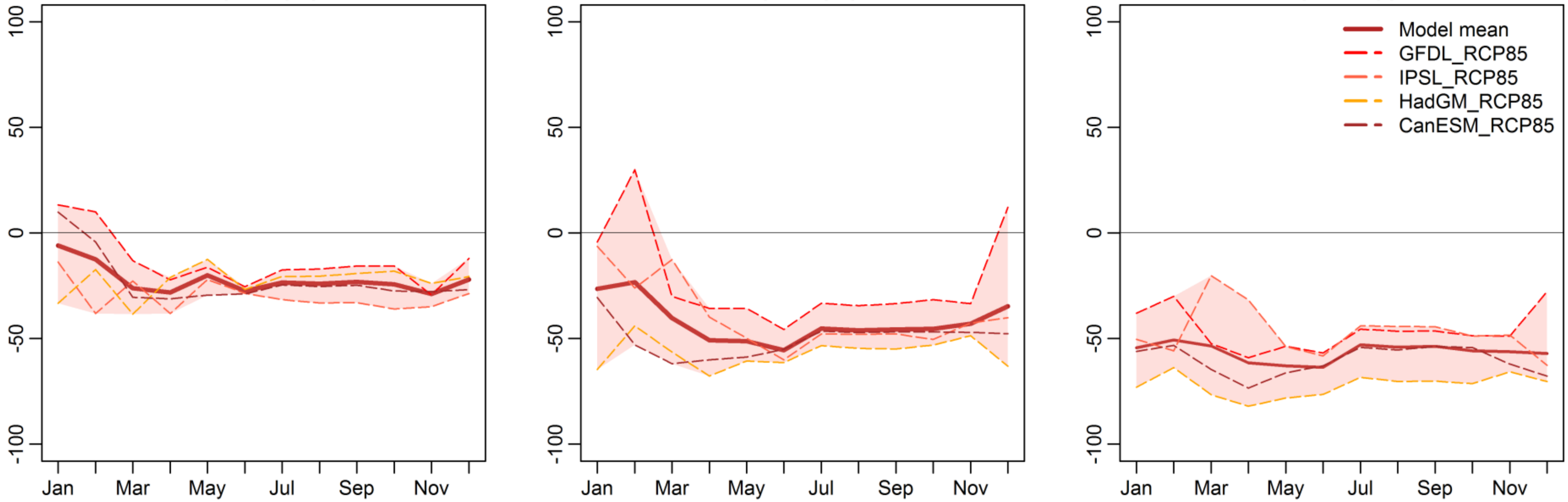
	Low adaptation challenges	High adaptation challenges
High mitigation challenges	RCP8.5x SSP5	RCP8.5 x SSP3
Low mitigation challenges	RCP4.5x SSP1	RCP4.5x SSP4



Modelling assumptions

- Tagus-Segura water Transfer has primary importance over the real environmental flows in Tagus (resembling the natural conditions). The demands of the downstream beneficiaries are completely ignored, discharges are set to the overall minimum, and all water is sent to the Segura Basin
- Another large water transfer to satisfy growing need of the South is organized, from the Valdecanays reservoir (just upstream of the Alcantara dam)
- Withdrawls for irrigation and urban water transfer in the catchment are strongly increasing, especially the water supply to Madrid area
- Alcantara dam is storing more water as a response to lowering water availability (e.g. This “behaviour” of reservoir mangers was observed in several river basins in Spain (e.g. Duero) – when the inflows have decreased, the outflows from the reservoirs have decreased as well)

Modelling results – Water availability
Entire Tagus River

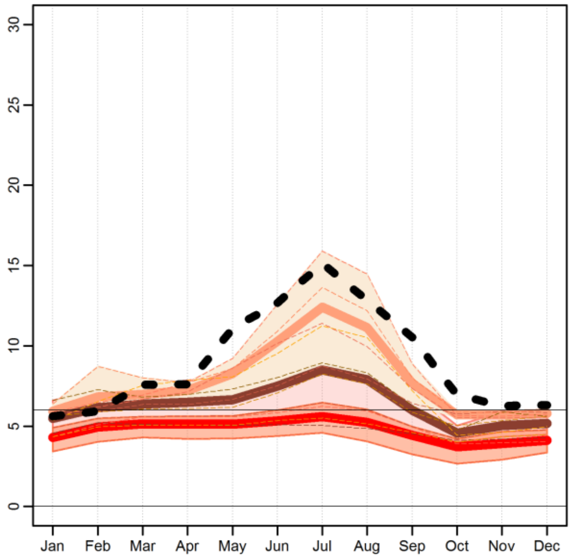


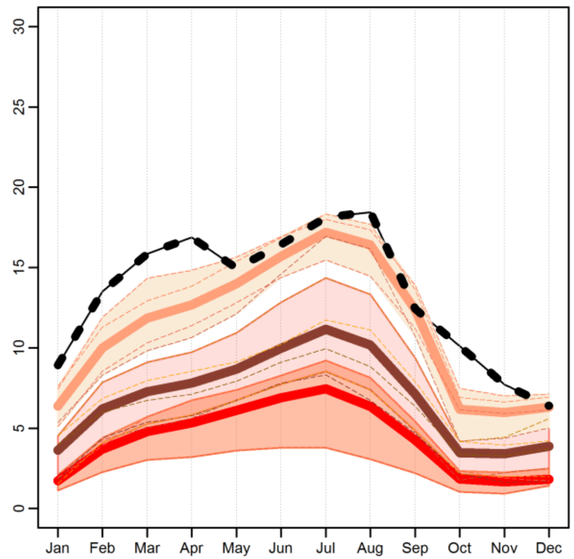
2011-2040

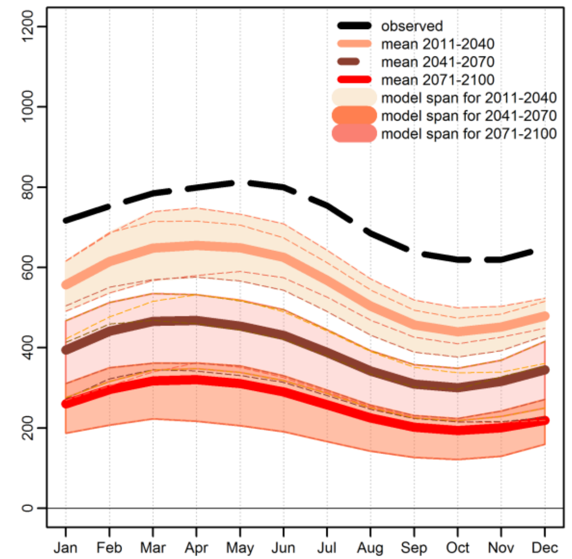
2041-2070

2071-2100

Modelling results – Tagus-Segura Water Transfer







Discharge in Tagus (m3/s) (e.g. Aranjuez)

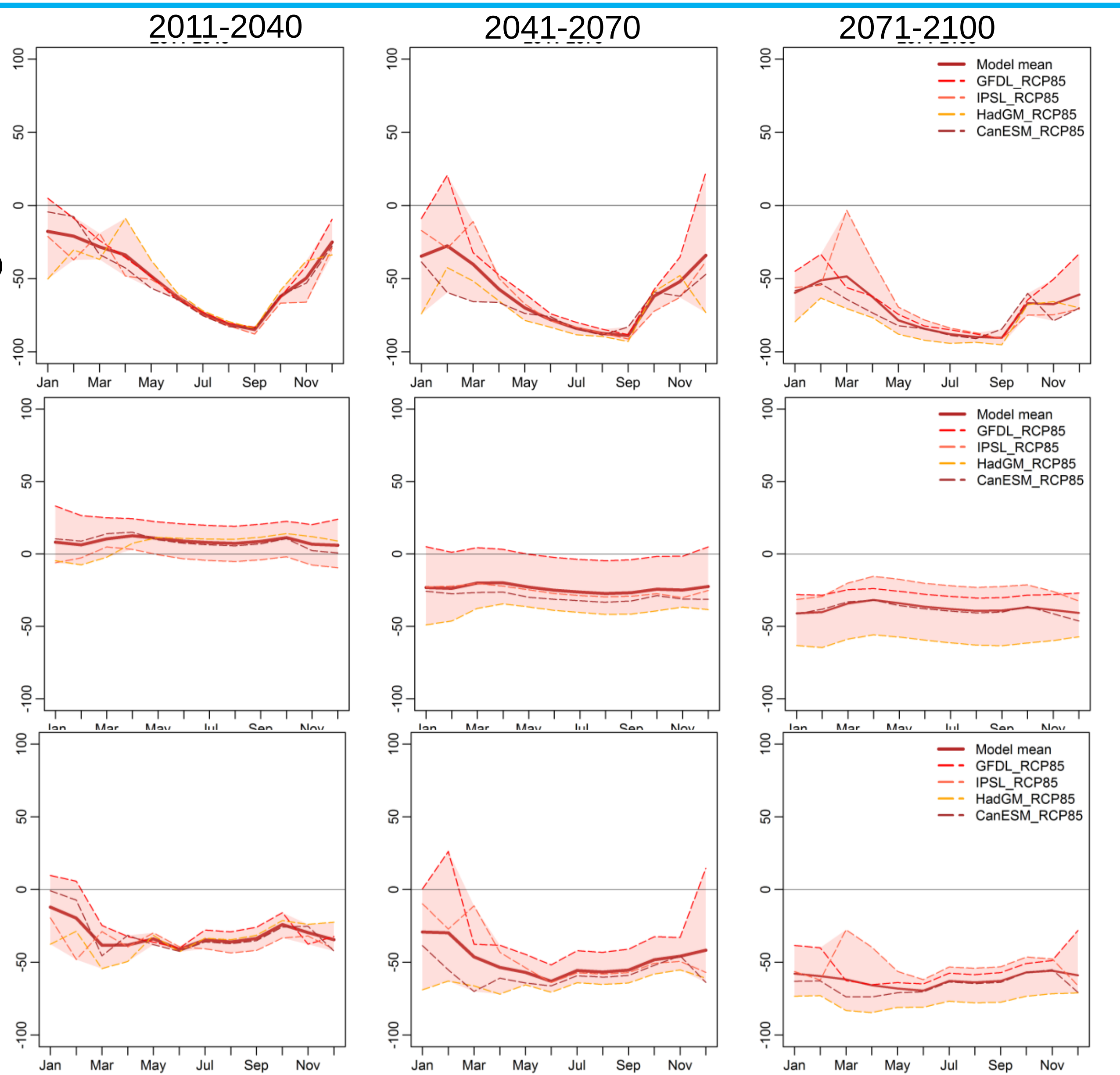
Discharge supplied to Segura (m3/s)

Volume of B+E (hm3)

- The Buendia and Entrepenyas reservoirs are managed in a business-as-usual way – no resembling of natural conditions
- The discharge in Tagus downstream of both reservoirs and withdrawal to Tagus-Segura Transfer equals 6m3/s, throughout the year – strong environmental degradation
- Under RCP4.5, total volume supplied to Segura (average among models): 349 hm3, 314 hm3, 134 hm3 (versus 350 hm3 average demand specified in the Segura Basin Management Plan)

Modelling results – Alcantara Dam

Percentage deviation in inflow (top), volume (middle) and outflow (bottom) from the Alcantara dam (relative to current conditions 1981-2010)



III. General conclusions and limitations of the study

General conclusions

- Amount of water volumes to be transferred to Segura decreases, but still can be kept on the average levels of 2001-2010 until mid-century
- The overall Tagus discharge decreases drastically – especially under RCP8.5, the high flows in winter are stored by the reservoirs to increase the water flows during summer to satisfy growing agricultural and urban water demands
- Drastic drecrease in summer is due to increased withdrawals
- Buendia and Entrepenyas Reservoirs are reaching critical volume levels of 400 hm3 during the second future slice

Limitations of the methodology

- Albufeira agreement is not just a threshold but a more complex policy tool - neccesary to evlaute it in the future
- Not all water withdrawals are included in the model (yet). As usula time as a constraint – at least 38 channels that should be potentially included in the model
- For the SSPs – no “real”, or stakeholders defined, numbers for the e.g. efficencies of the water transfers or operation of the Alcantara dam – own assumptions, verified with project partners responsible for the SSPs downscalling
- Not forgetting about gereal uncertainty sources – hydrological modelling, climate projections and climate models (though bias-corrected)!

Outlook AC - SWIM

- Couple the Agent-Based Modelling approach with conventional Hydrological modelling, to explore co-evolution of human-hydrological system of the River Tagus headwaters (or Alcantara Dam?)
- Employ the model to:
    - explore the impacts of different climate-change scenarios on the dynamics of the socio-hydrological system
    - study the effects of different possible transformative policies to ease existing and projected water stress of the Tagus area