Vulnerability of Mediterranean water resources under high-end climate change. Recent development and challenges ahead, from regional to local scales.

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Manolis Grillakis, Kostas Seiradakis, Ioannis Tsanis

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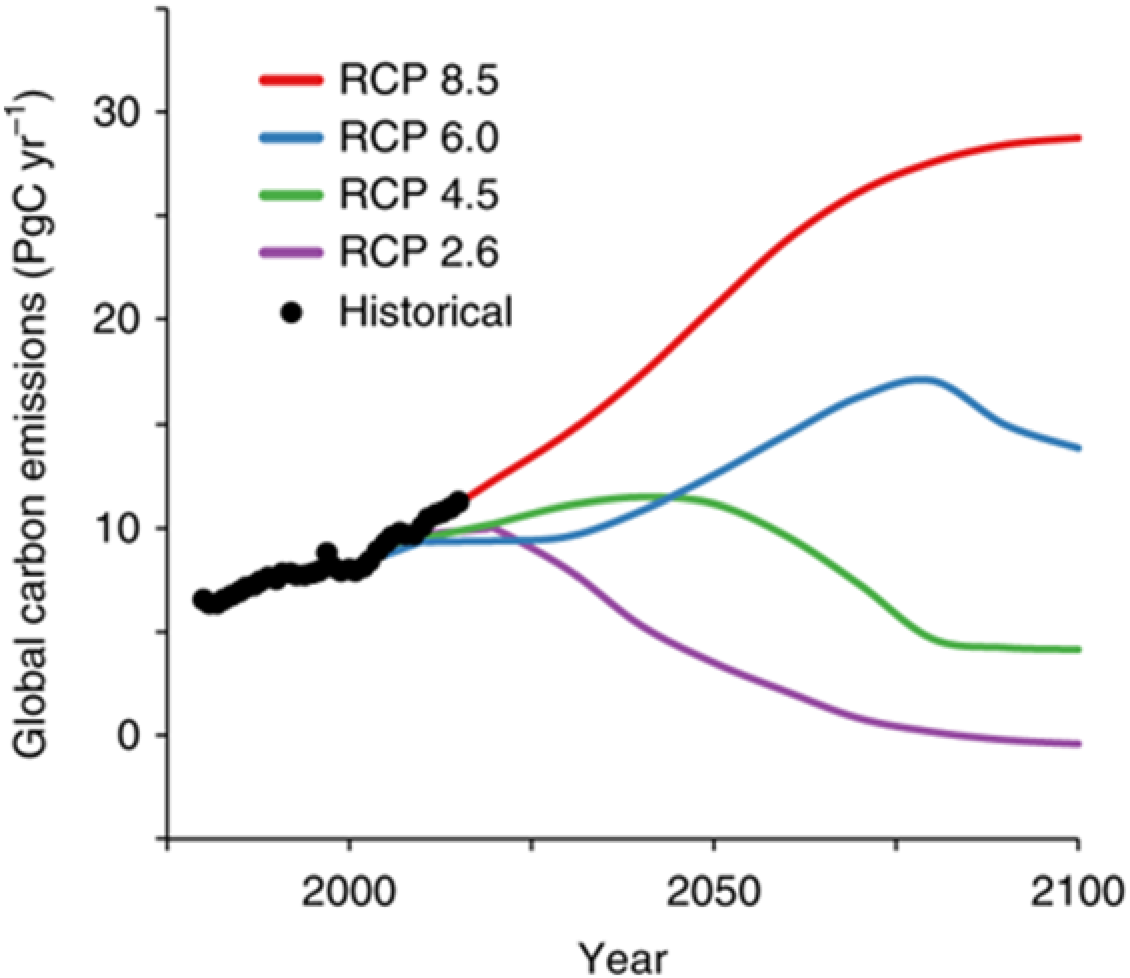
High end climate change - Why is it



The current global level of emissions aligns with the most extreme model forecast RCP 8.5

Smith & Myers (2018) Nature Clim.

Major research questions

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SEVENTH FRAMEWORK PROGRAMME

High-End cLimate Impacts and eXtremes

How much larger are the impacts at 4°C compared to 2°C and 1.5°C?

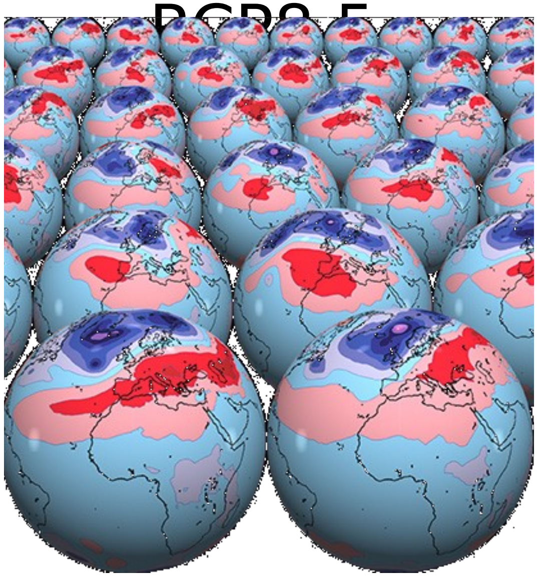
What is the level and the range of changes of physical and socio-economic circumstances?

physical socio-economic

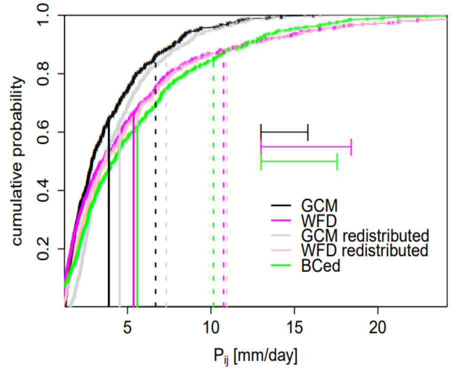
Water sector

Methodology

High resolution climate simulations RCP8.5

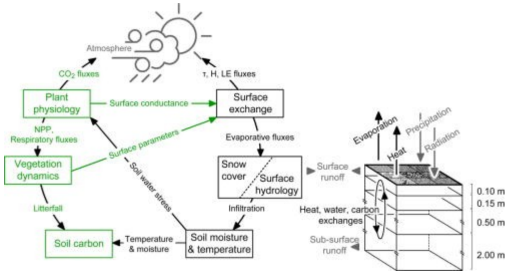


better information on future climate extremes



Trend preserving Bias adjustment

Hempel et al., 2013. Earth Syst. Dyn.



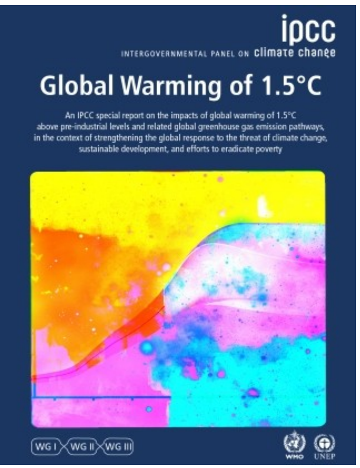
JULES (Joint UK Land Environment Simulator)

Best et al., 2011

Clark et al., 2011. Geosci. Model Dev.

Results supported the production of IPCC SR

3



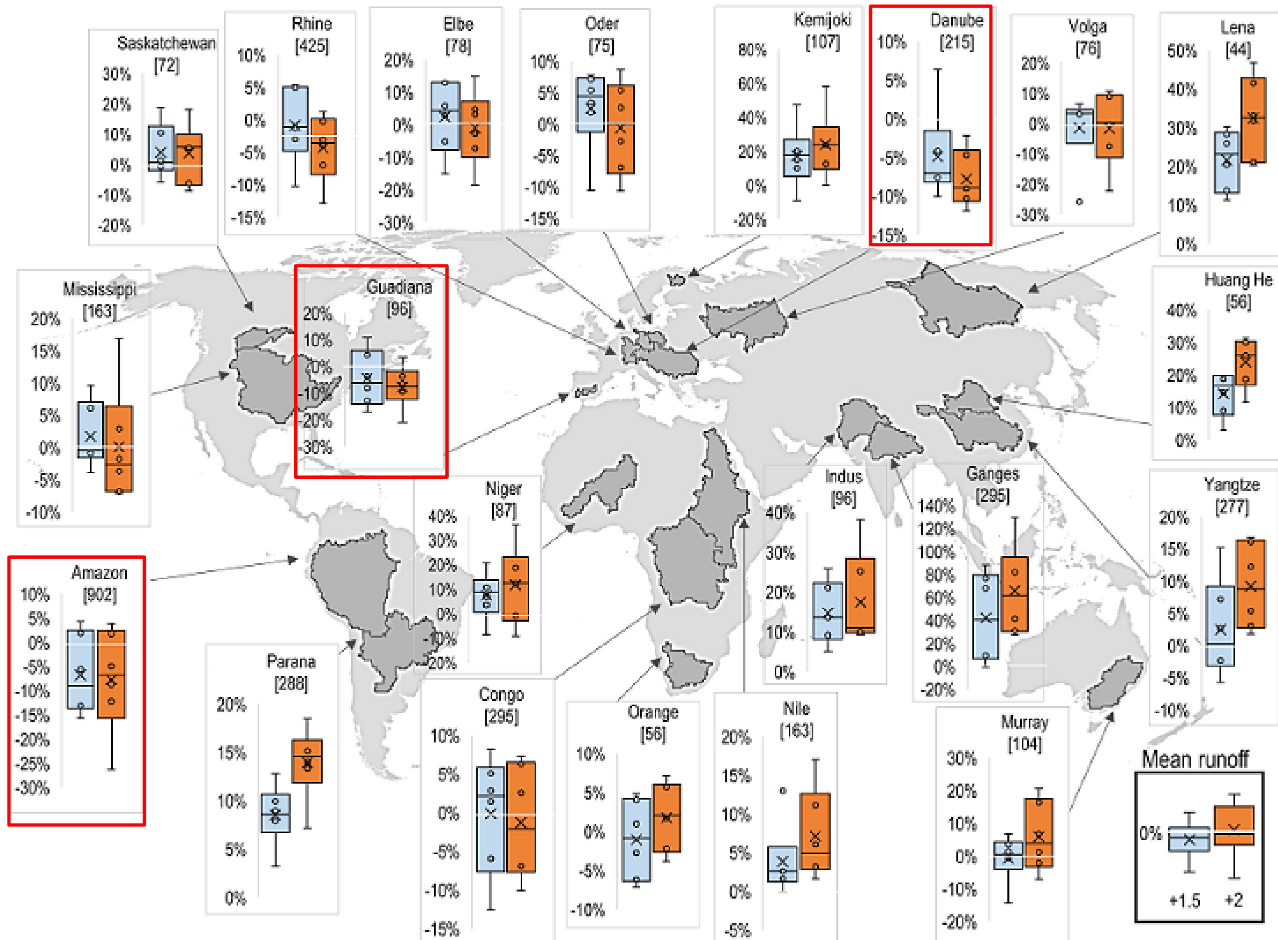


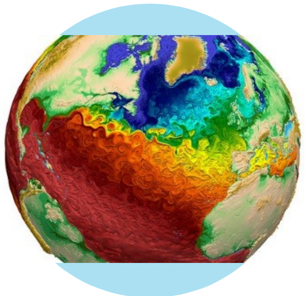
Figure 3.15 | Runoff changes in twenty-one of the world's major river basins at 1.5°C (blue) and 2°C (orange) of global warming, simulated by the Joint UK Land Environment Simulator (JULES) ecosystem–hydrology model under the ensemble of six climate projections. Boxes show the 25th and 75th percentile changes, whiskers show the range, circles show the four projections that do not define the ends of the range, and crosses show the ensemble means. Numbers in square brackets show the ensemble-mean flow in the baseline (millimetres of rain equivalent) (Source: Betts et al., 2018).

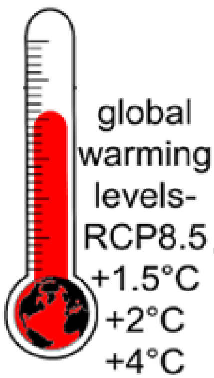
202 **Chapter 3:Impacts of 1.5°C of Global Warming on Natural and Human systems**

Betts et al (2018) Philosophical Transactions of the Royal

Major research questions

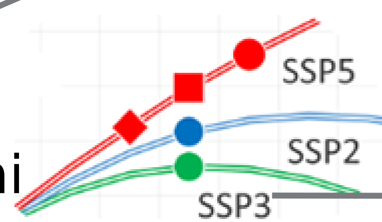
What is the level and the range of changes of physical and socio-economic circumstances?



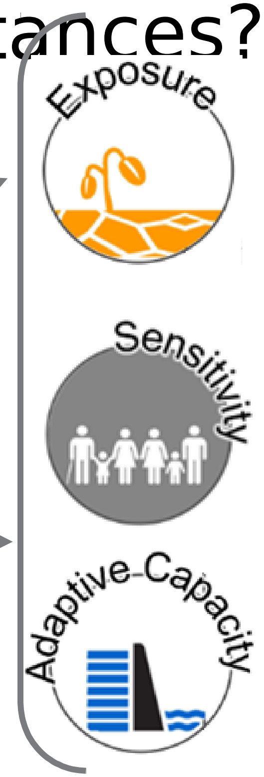


Hydrologic modeling

Socio economic



Population density
Water Demand
GDP
Human Capital
Technological developments



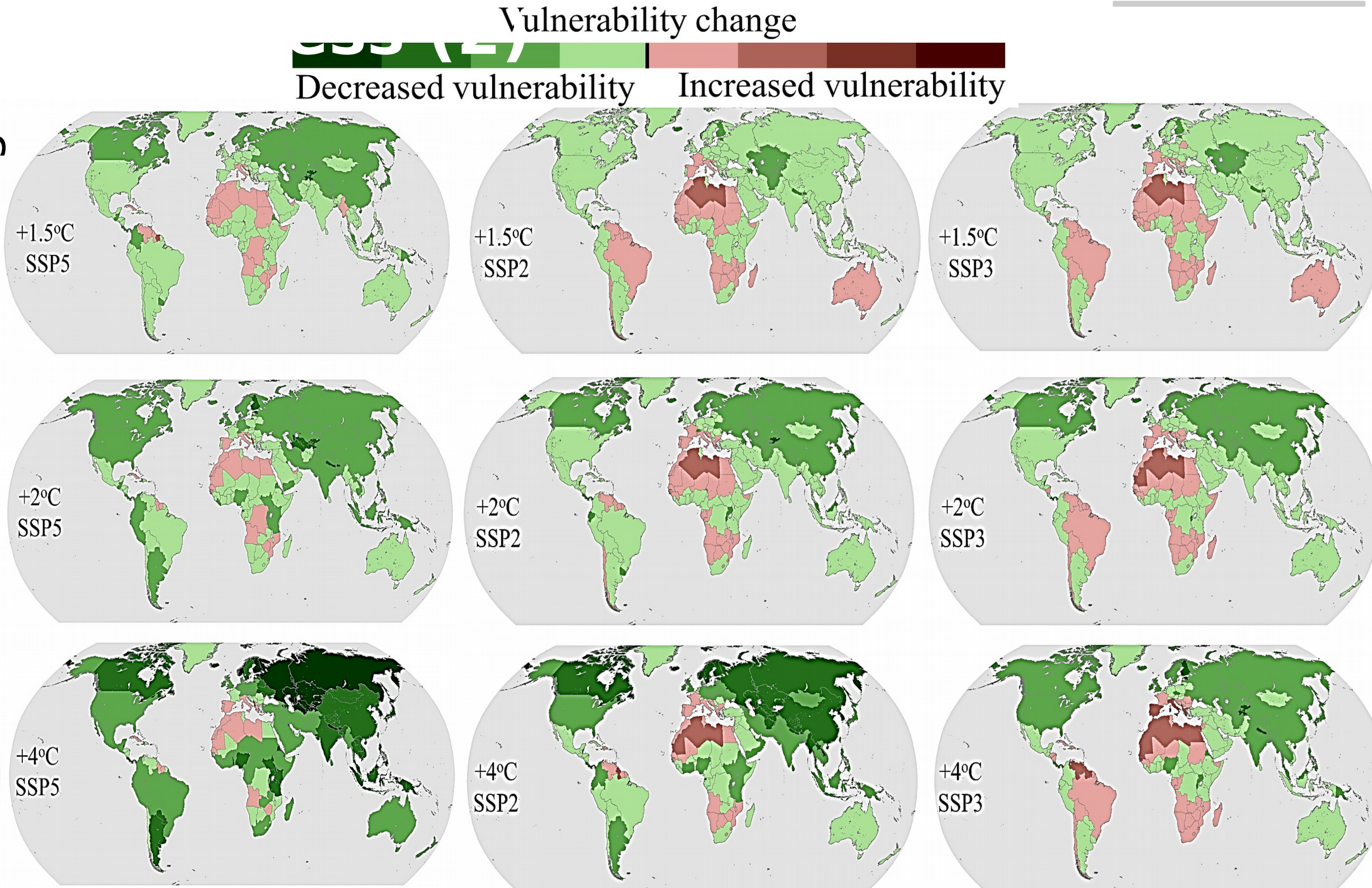
composite index

Vulnerability to freshwater stress

Koutroulis et al (2019) Global and

Vulnerability to freshwater

Warming



Increased challenges for adaptation

Mediterranean countries are projected to face increase in water vulnerability regardless the level of adaptation and the level of warming

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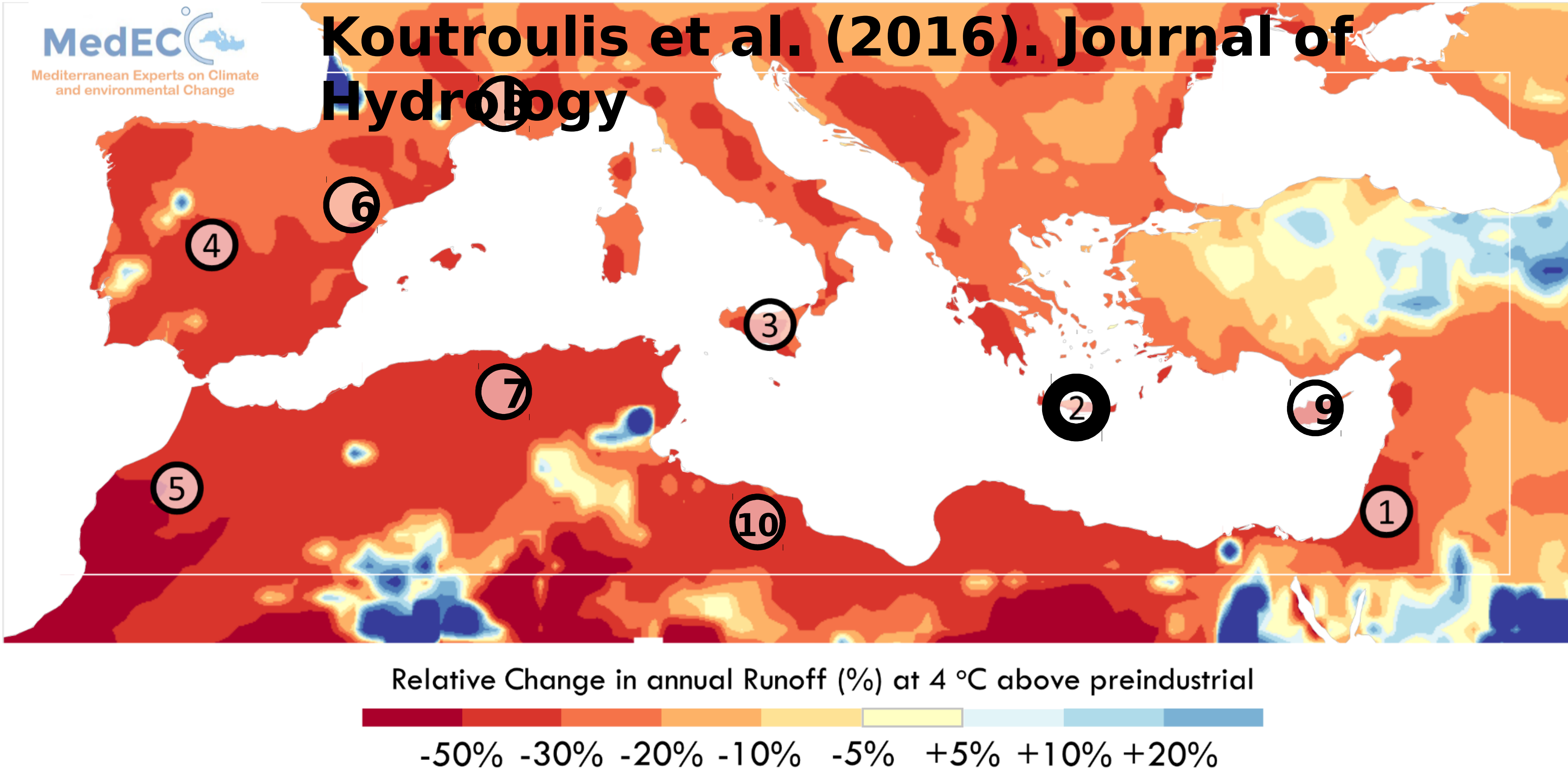
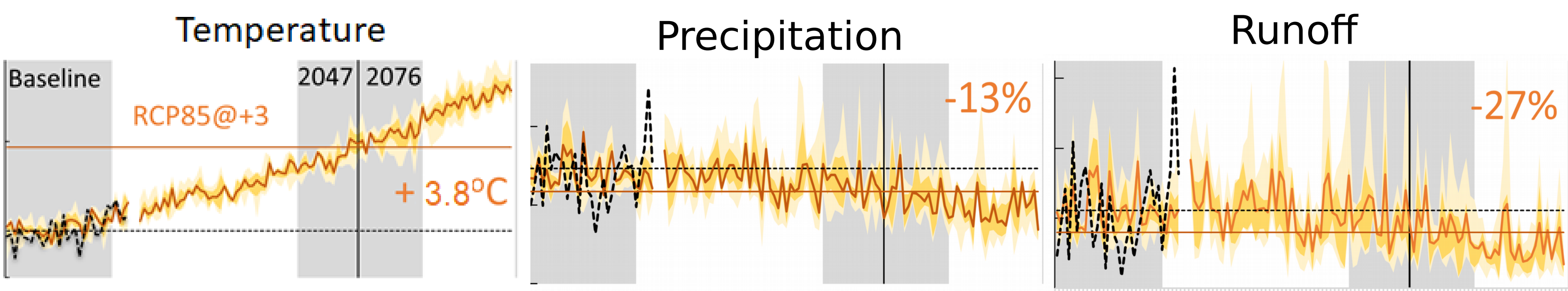
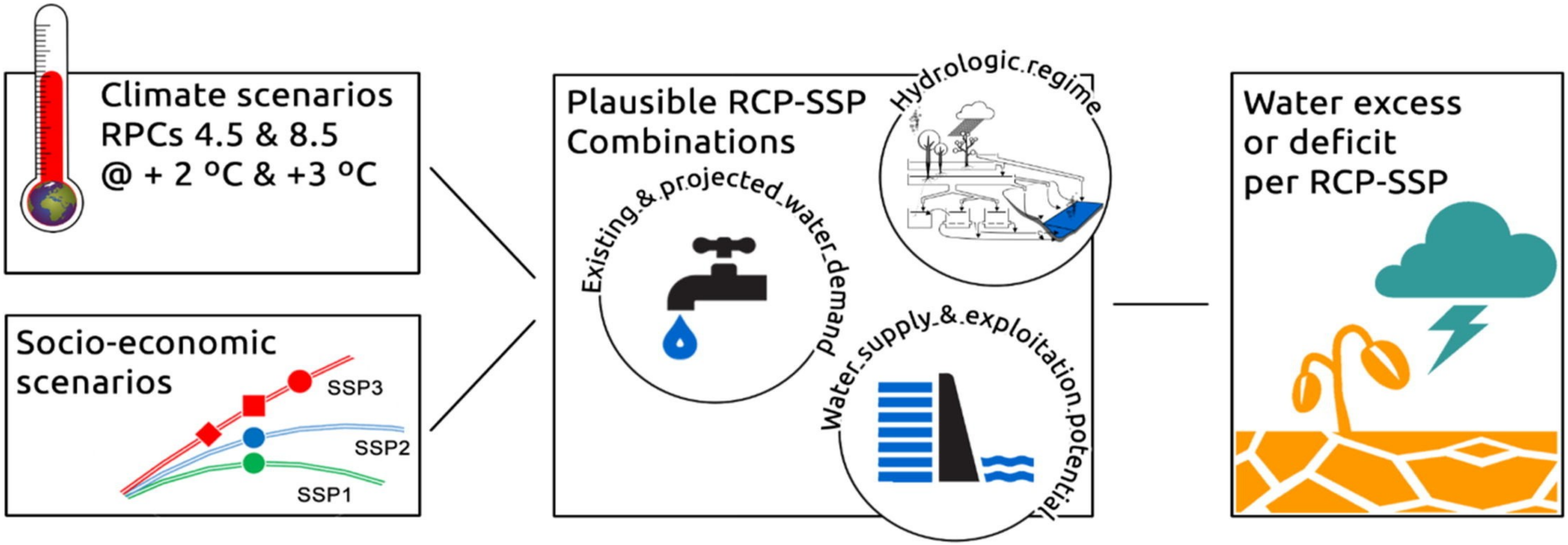
Focus on the regional scale

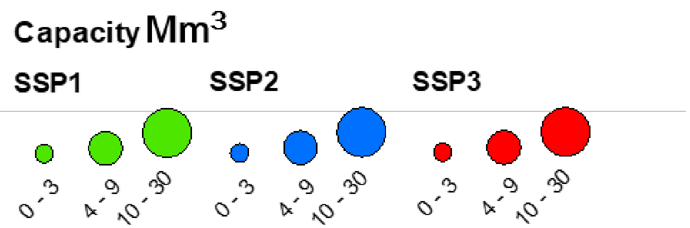
Koutroulis et al. (2016). Journal of Hydrology

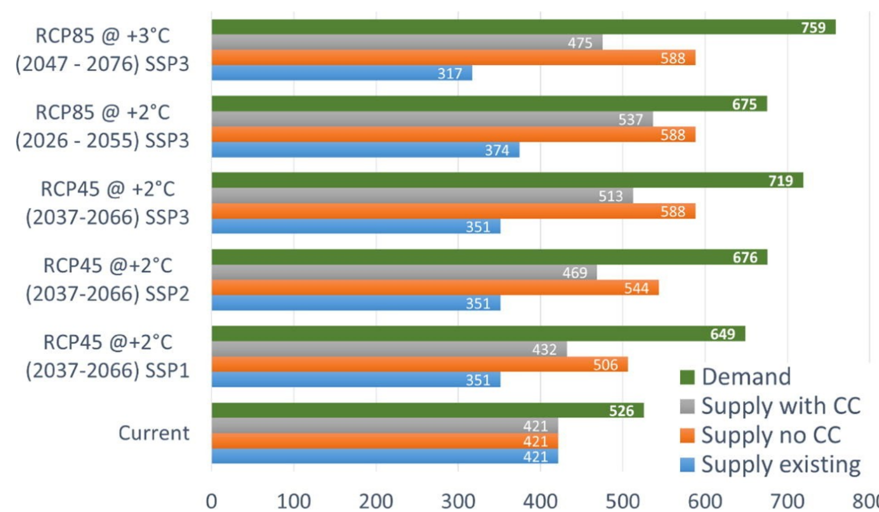




Focus on the local scale

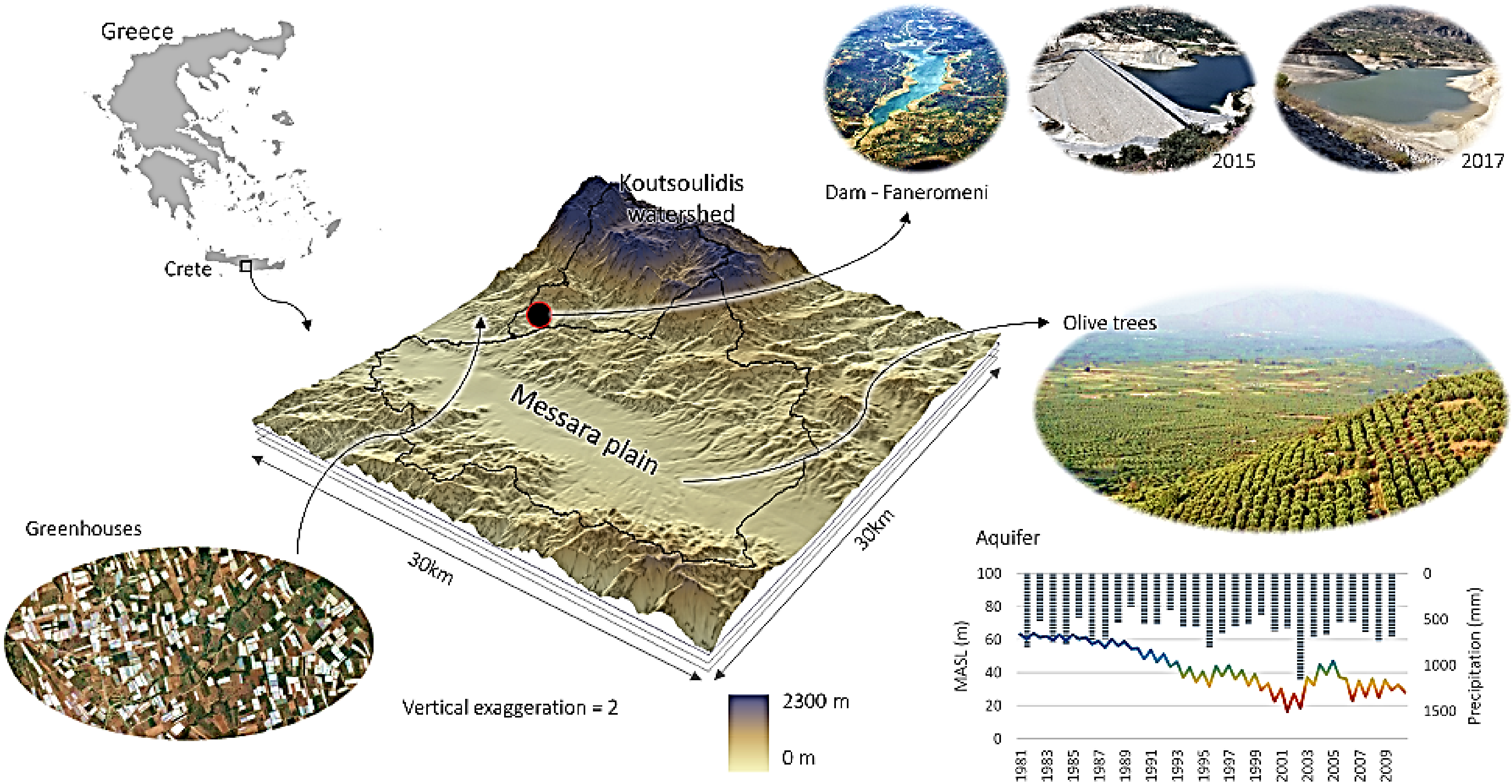






Koutroulis et al (2016) Journal of Hydrology

Focus on the basin scale

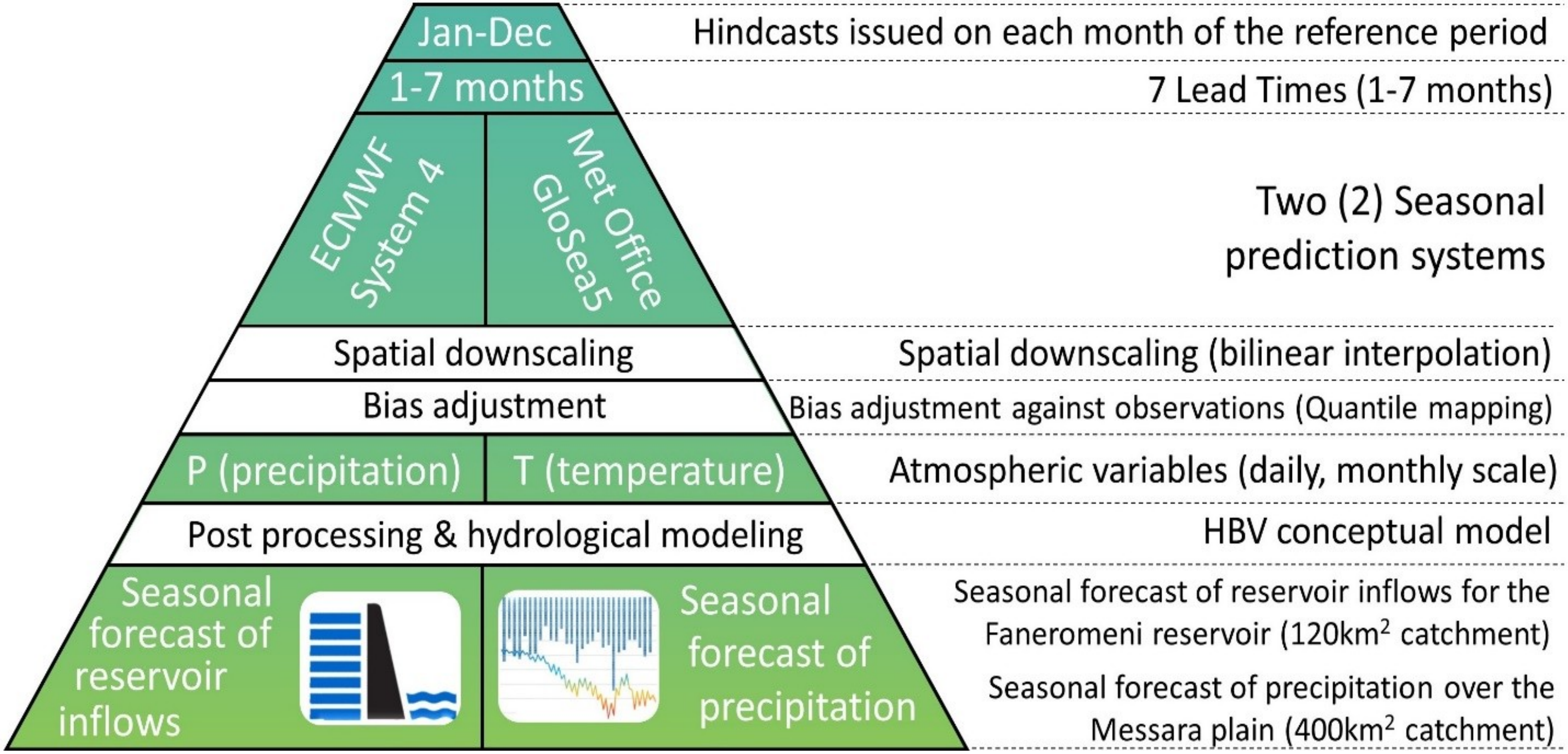


Grillakis et al (2018) Water

Focus on the basin scale

imprex
Learn from today to anticipate tomorrow

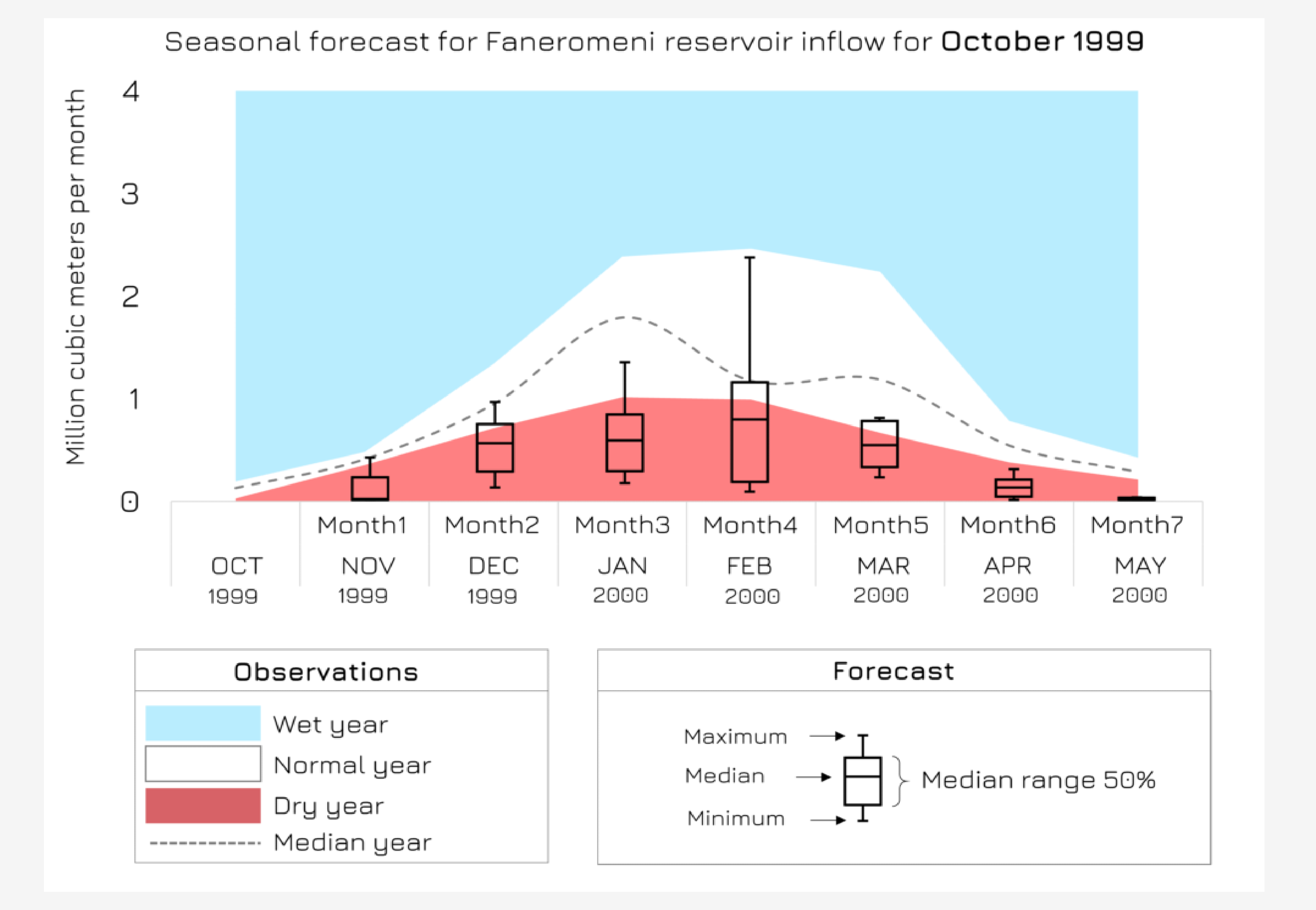
AIM TO BRING SEASONAL HYDRO-METEOROLOGICAL FORECASTS IN LOCAL WATER MANAGEMENT.



Grillakis et al (2018) Water

Focus on the basin scale

Focus on the basin scale



Conclusions

- Measurable impacts are avoided at 1.5^{o}C vs 2^{o}C and substantial at 1.5^{o}C and 2^{o}C vs 4^{o}C.
- Socioeconomic changes may, in some regions, have greater impact on water availability compared to climatic
- Emerging scientific developments can support adaptation in practice.
- Communicate proper information of climate change outside the scientific

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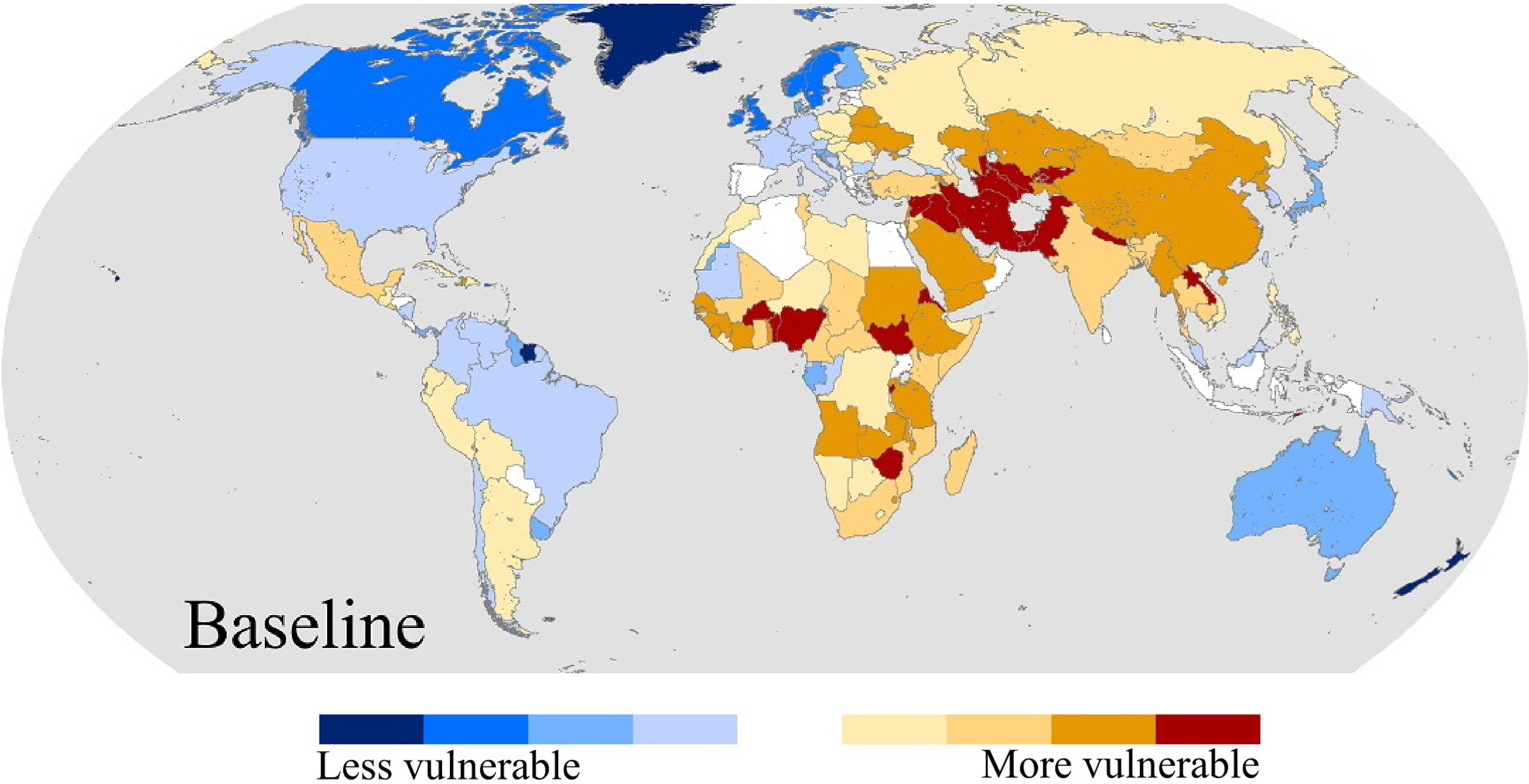
Thank you

Backup slides...

Vulnerability to freshwater

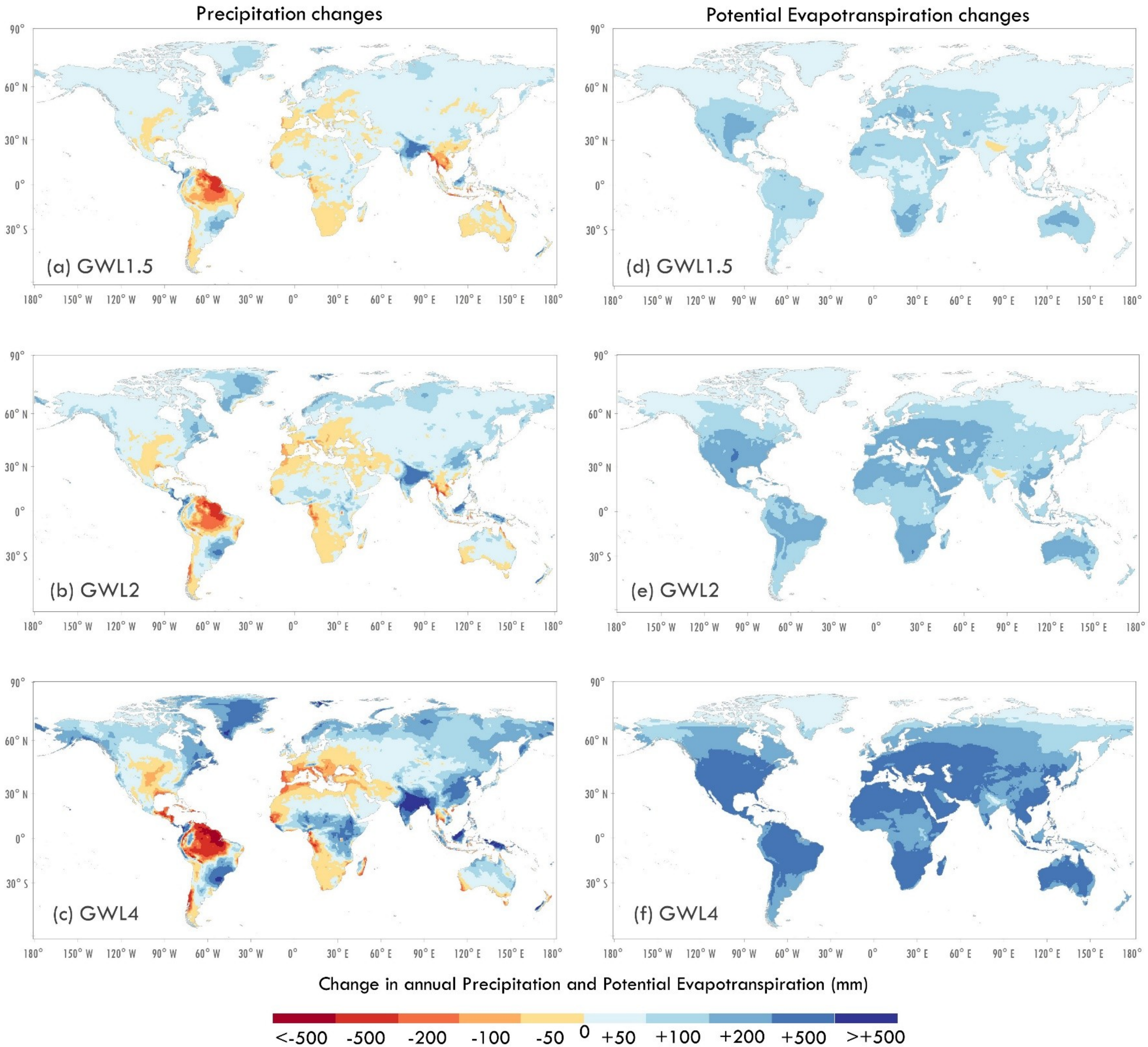


Koutroulis et al. (2019). Global and

Methodology

High resolution climate scenarios - RCP8.5

AGCM	Model providing driving SSTs &SICs	1.5°C		2°C		4°C	
		Time of passing	**CO_2 (ppm)**	**Time of passing**	**CO_2 (ppm)**	**Time of passing**	**CO_2 (ppm)**
EC-EARTH3-v3.1	IPSL-CM5A-LR	**2025**	431.5	**2036**	472.0	**2074**	708.9
	GFDL-ESM2M	**2038**	480.5	**2054**	564.3	**n/a**	n/a
	HadGEM2-ES	**2021**	418.8	**2035**	467.9	**2075**	717.0
	EC-EARTH	**2028**	441.7	**2043**	503.5	**2090**	844.8
	GISS-E2-H	**2031**	452.5	**2047**	523.9	**n/a**	n/a
	IPSL-CM5A-LR	**2024**	428.2	**2038**	480.5	**2072**	692.9
	HadCM3LC	**2026**	434.8	**2040**	489.4	**2088**	827.2
HadGEM3-GA6.0	IPSL-CM5A-LR	**2024**	428.2	**2035**	467.9	**2071**	685.0
	GFDL-ESM2M	**2036**	472.0	**2051**	546.3	**n/a**	n/a
	HadGEM2-ES	**2019**	412.8	**2033**	460.0	**2071**	685.0
	IPSL-CM5A-MR	**2023**	425.0	**2036**	472.0	**2069**	669.3
	MIROC-ESM-CHEM	**2020**	415.8	**2032**	456.2	**2068**	661.6
	ACCESS1–0	**2026**	434.8	**2040**	489.4	**2081**	766.6

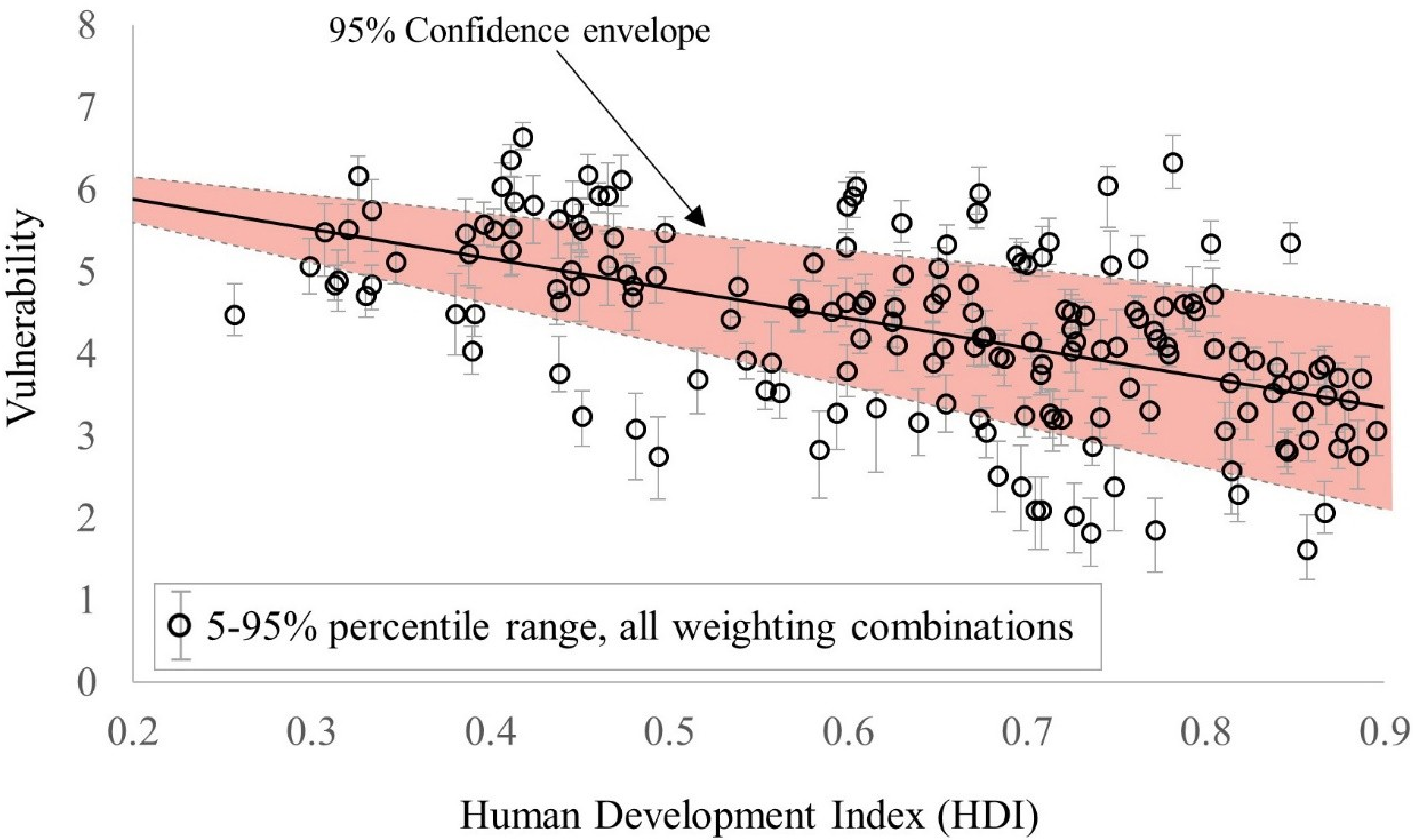

Precipitation changes
Potential Evapotranspiration changes
(a) GWL1.5
(b) GWL2
(c) GWL4
(d) GWL1.5
(e) GWL2
(f) GWL4
Change in annual Precipitation and Potential Evapotranspiration (mm)
<-500 -500 -200 -100 -50 0 +50 +100 +200 +500 >+500

Composite index: A vulnerability based

Indicator	Expressed by	
Exposure	Water availability on average	Relative changes in mean annual runoff production
	Low flows	Relative changes in 10th percentile runoff production
	Duration and severity of extreme events relevant to water availability (short and long term droughts)	Change in duration of short and long term meteorological droughts (SPI6 – SPI48)
		Change in duration of short and long term hydrological droughts (SRI6 – SPI48)
Sensitivity	**Population density**	**Number of people totally affected by freshwater stress**
	Total withdrawal	Consumptive and non-consumptive use
	Total cropland area	Arable land and permanent crops
	Water Demand sectoral	**Gridded dataset of water demand per sector**
Adaptive capacity	**Economic resources available to adapt**	**GDP per capita (PPP)**
	Law enforcement	World Governance Indicators (WGI) – World Bank
	Human Capital	**Percent of highly educated working population**
	Groundwater Resources	Extent of productive aquifers and inland water bodies for freshwater storage
	Upstream storage	Water storage capacity available upstream of a location relative to the total water

Bold marked = SSP varying

Vulnerability to freshwater stress (2)



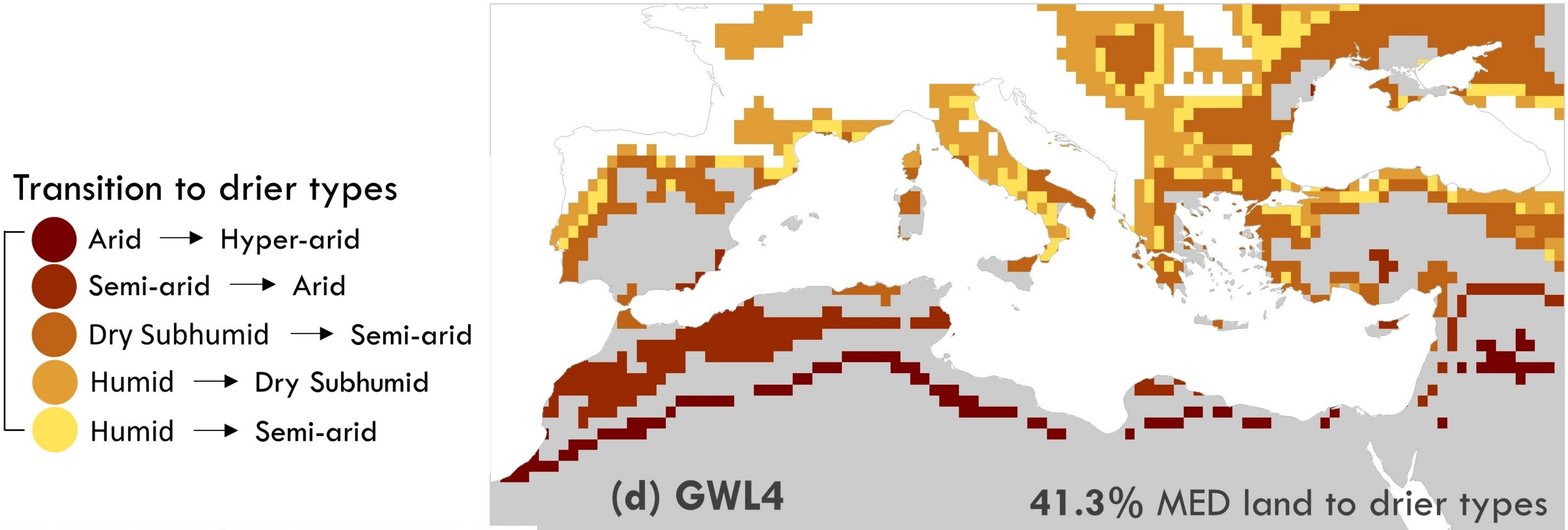
UNDP, 2013

	Indicator	W1 (equal)	W2	W3	W4	W5	W6
Exposure	Water availability on average	25%	20%	20%	20%	40%	25%
	Low flows	25%	20%	20%	40%	20%	25%
	Duration and severity of extreme events relevant to water availability (short and long term droughts)	25%	20%	40%	20%	20%	25%
		25%	40%	20%	20%	20%	25%
Sensitivity	Population density	25%	20%	20%	20%	40%	30%
	Total withdrawal	25%	20%	20%	40%	20%	20%
	Total cropland area	25%	20%	40%	20%	20%	20%
	Water Demand sectoral	25%	40%	20%	20%	20%	30%
Adaptive capacity	Economic resources available to adapt	20%	17%	33%	17%	25%	29%
	Law enforcement	20%	17%	17%	25%	17%	14%
	Human Capital	20%	17%	17%	25%	25%	29%
	Groundwater Resources	20%	25%	17%	17%	17%	14%
	Upstream storage	20%	25%	17%	17%	17%	14%

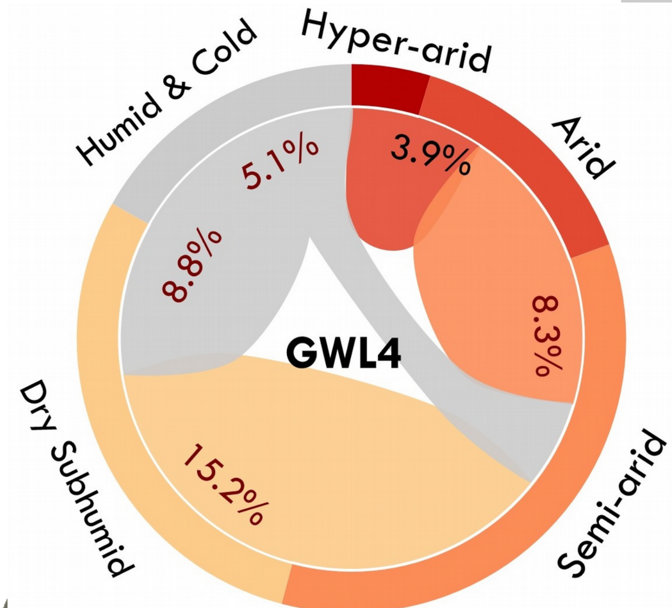
The use of atmosphere-only models provides four advantages:

(i) it enables us to focus limited computational resources on the critical issue of increased atmospheric resolution for improved representation of extreme weather events;
(ii) it allows us to use prescribed SSTs to constrain the models to simulate similar patterns of climate change to those in the CMIP5 models;
(iii) it provides the facility to examine particular regional climate responses of interest, such as particular shifts in monsoon circulations where these are influences by SSTs, and
(iv) it allows for bias-correction of SSTs from coupled models, for increased realism of control

Dryland changes in the MED SREX



Distribution of dryland changes in the Mediterranean



MedECC

Mediterranean Experts on Climate and environmental Change