Sponge Scapes

Evidence and Solutions for improving **SPONGE** Functioning at Land**SCAPE** Scale in European Catchments for increased Resilience of Communities against Hydrometeorological Extreme Events

How to model the impacts of climate change?

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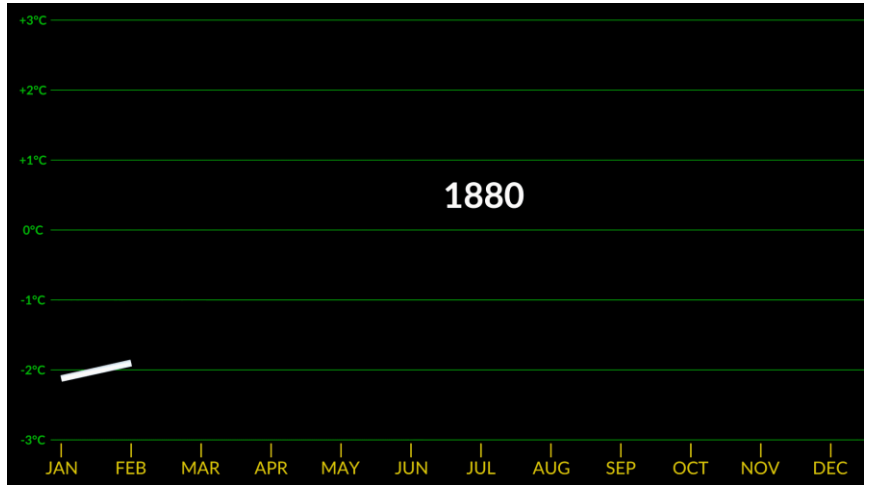
Changing water cycle



Source: Goddard Institute for Space Studies, NASA

Valencia flood, 2024

Vistula drought, 2015

POLICYFORUM

www.sciencemag.org SCIENCE VOL 319 1 FEBRUARY 2008

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CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1]* Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Impacts

Q1: What effect will climate change have on water resources in terms of quantity and quality?

Resilience

Q2: Will the existing and planned measures (technical, NbS, „sponge”, etc.) effectively offset the effects of projected climate change?

Gaps in evidence and recommendations: role of modelling under climate change

GAPS

Reported sponge measures are often not evaluated for a range of hydro-meteorological events under current and future conditions

RECOMMENDATIONS

Evaluate sponge functioning and the impact of suggested measures for a wide range of hydrometeorological events, taking a variation in pre-event conditions into account, using a pre-defined set of indicators and scenarios

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Historical background

Future hydrology derived directly from a GCM

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 85, NO. C10, PAGES 5529–5554, OCTOBER 20, 1980

Sensitivity of a Global Climate Model to an Increase of CO_2 Concentration in the Atmosphere

SYUKURO MANABE AND RONALD J. STOUFFER

Geophysical Fluid Dynamics Laboratory/NOAA, Princeton University, Princeton, New Jersey 08540

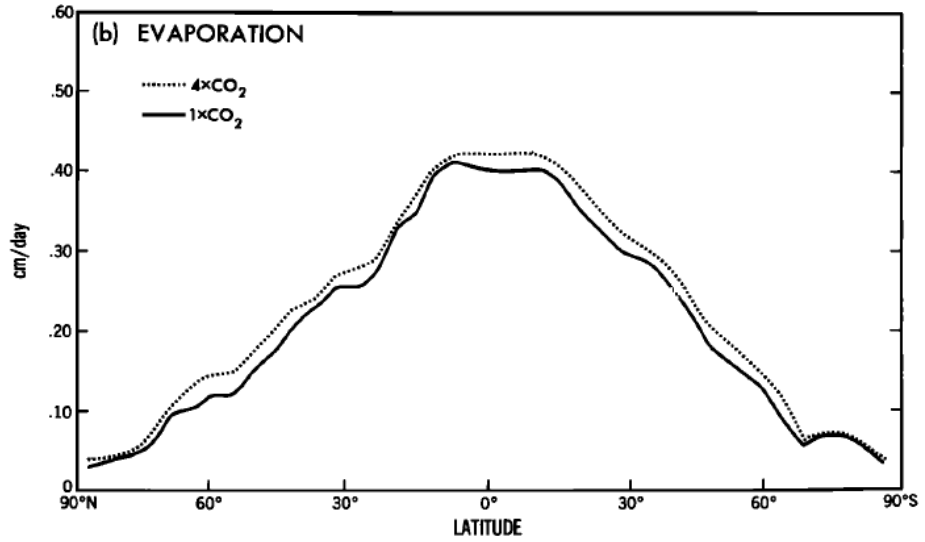


Fig. 24. Latitudinal distributions of (*a*) zonal mean precipitation rate and (*b*) zonal mean evaporation rate in units of centimeters/day. Solid line and dotted line indicate the results from the 4 × CO_2 and 1 × CO_2 experiment, respectively.

Future hydrology derived from a conceptual model forced with a GCM

ELSEVIER

Journal of Hydrology 183 (1996) 397–424

Journal of Hydrology

The effects of climate change due to global warming on river flows in Great Britain

N.W. Arnell[a,*], N.S. Reynard[b]

[a]*Department of Geography, University of Southampton, Southampton SO17 1BJ, UK*

[b]*Institute of Hydrology, Wallingford OX10 8BB, UK*

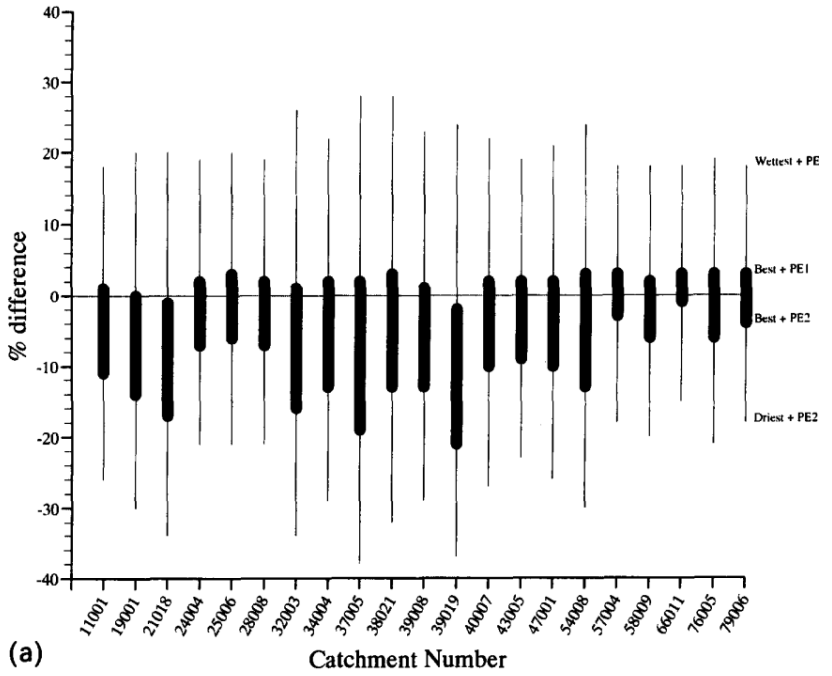
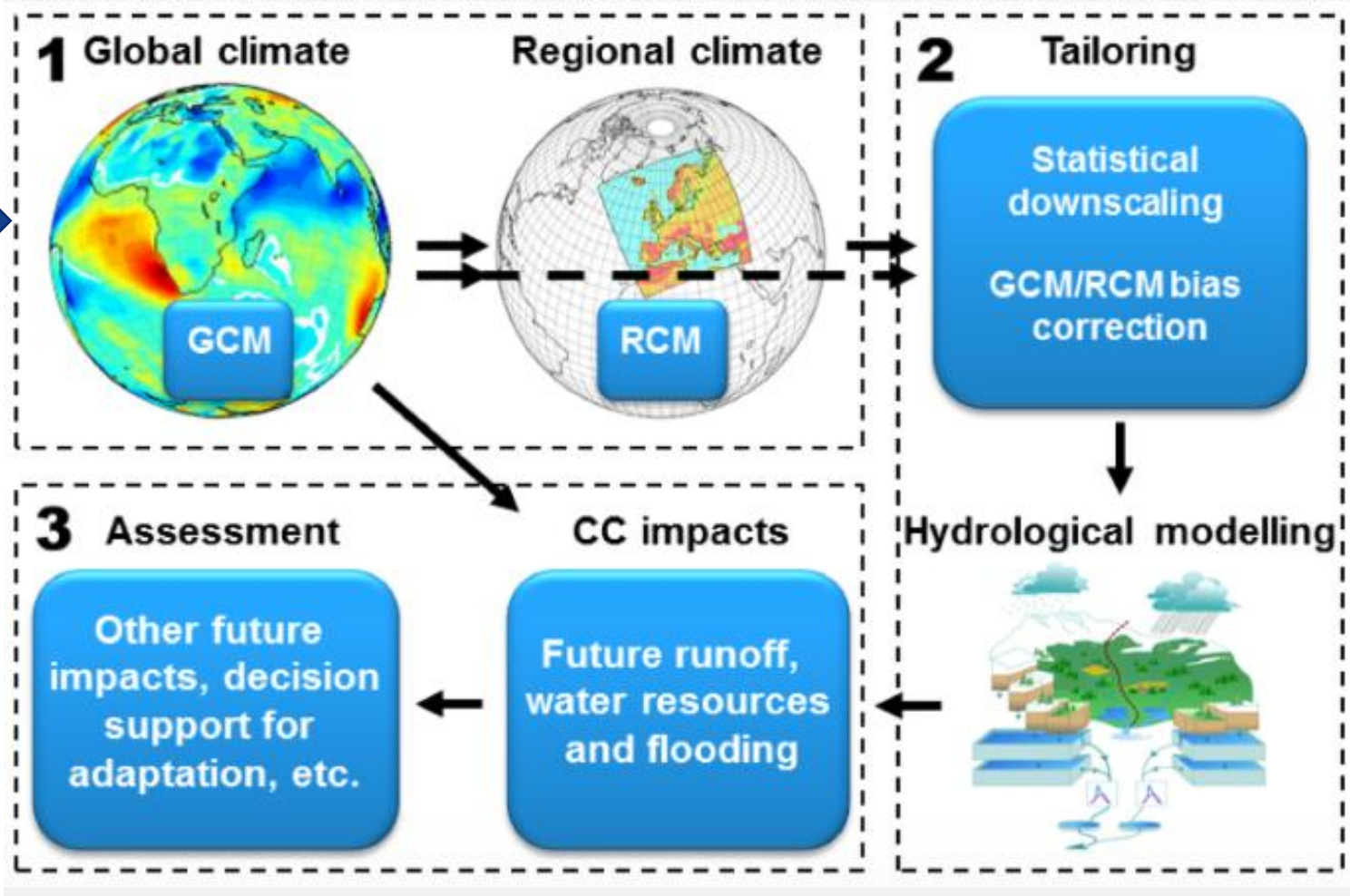


Fig. 5. Percentage and absolute change in average annual runoff (by 2050) by catchment.

How can we use hydrological models to understand how climate change affects the water cycle?

GHG emission scenarios

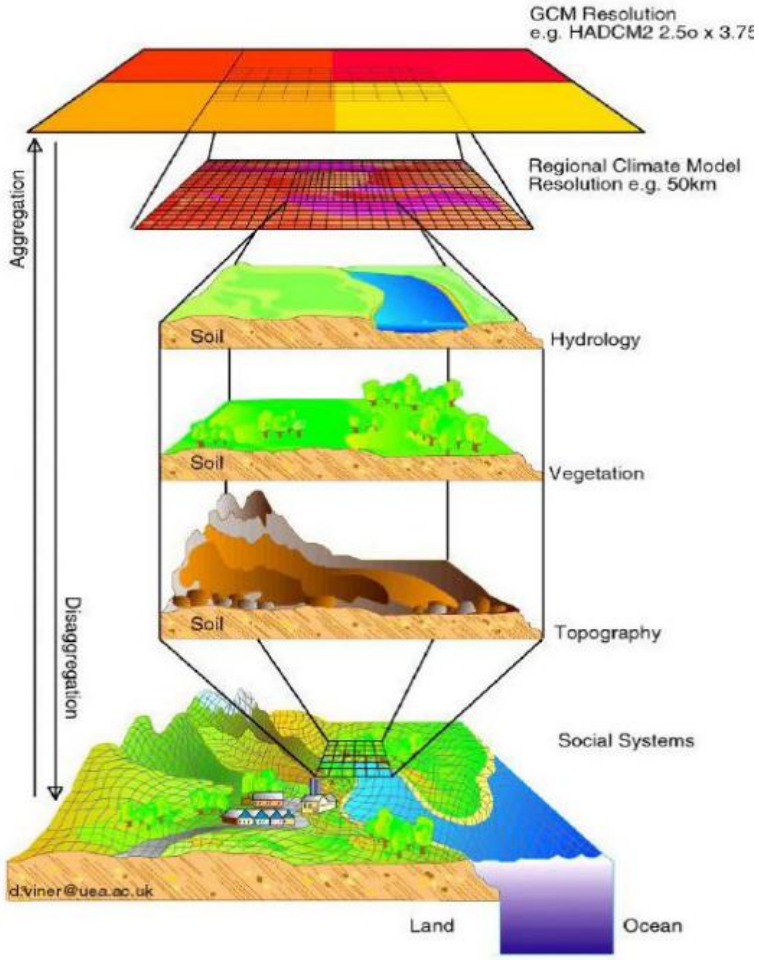


E.g. wflow, SWAT, HYPE, VIC, etc.

Olsson *et al.*, 2015, Climate

Climate forcing and downscaling

- Climate downscaling approaches
  - Dynamical downscaling (RCMs, e.g. CORDEX)
  - Empirical-statistical downcaling
    - Transfer-function models (regression, analog)
    - Stochastic generators (e.g. LARS-WG)
    - Bias adjustment methods (delta change, quantile mapping)



Viner, 2012

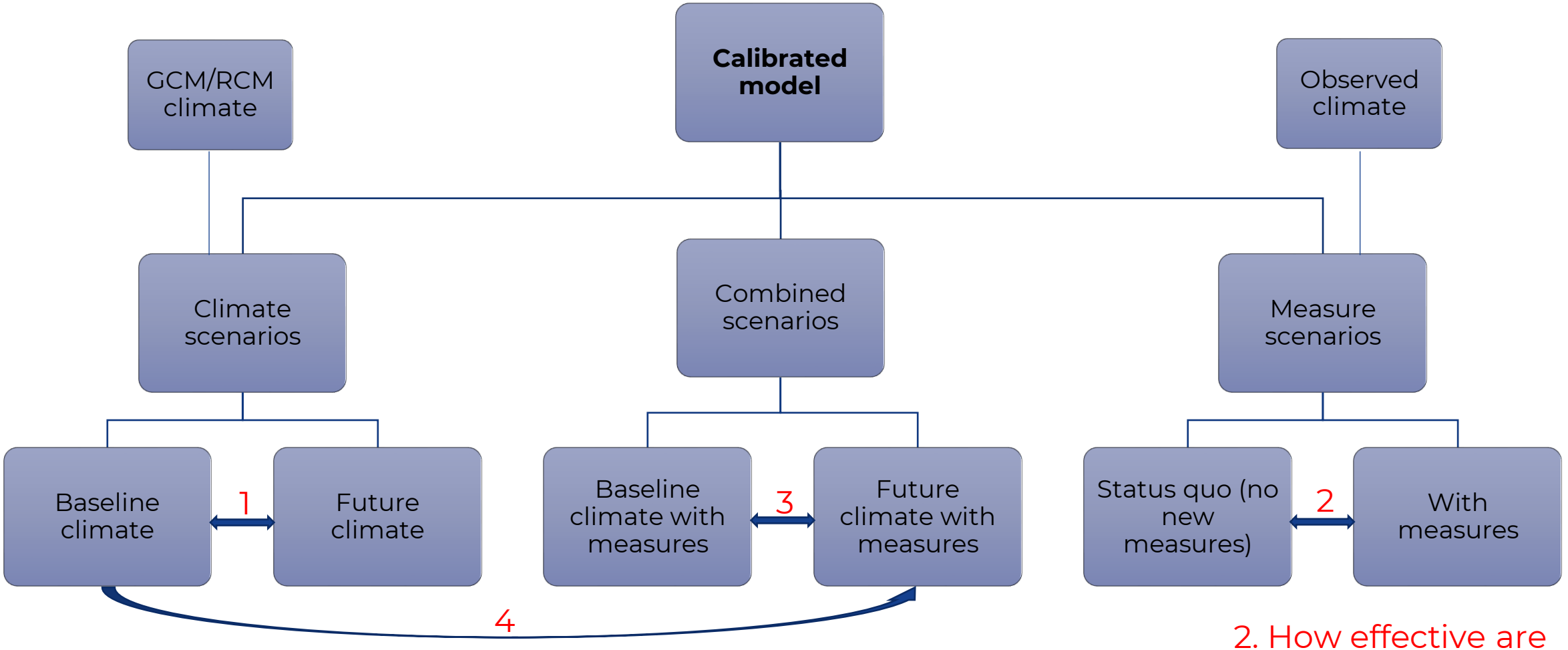
State-of-the-art climate change datasets

Dataset name	Temporal resolution*	Spatial resolution	GHG scenarios	Bias adjustment
NEX-GDDP-CMIP6	Daily	0.25 degrees (~25 km)	Various SSP-RCPs (CMIP6)	Yes
ISIMIP3b	Daily	0.5 degrees (~50 km)	Various SSP-RCPs (CMIP6)	Yes
CHELSA (V2.1)	Monthly	30 arc sec (~1 km)	Various SSP-RCPs (CMIP6)	Yes
EURO-CORDEX	Daily	0.11 degrees (~12 km)	Various RCPs (CMIP5)	Raw - No** JRC version – Yes

*** Bias-corrected future climate projections at sub-daily resolution are rare. Users must apply disaggregation / downscaling tools based on daily projections**

**** Various bias-adjusted CORDEX-based climate products are also available for most European countries**

Example modelling workflow



1. What is the effect of climate change?

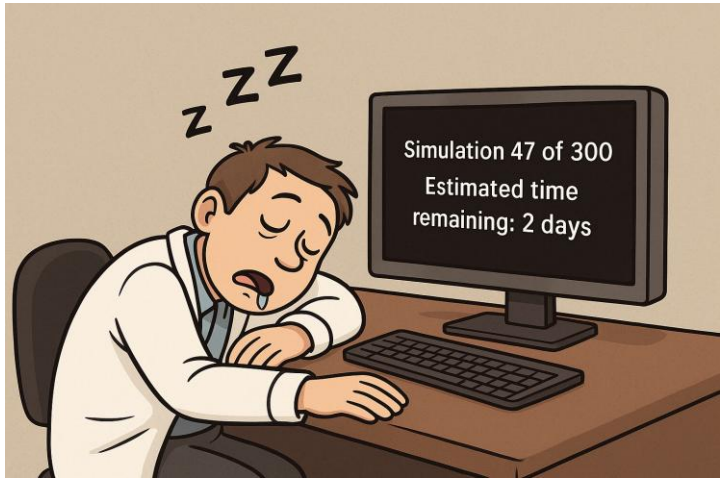
4. What will the combined effect of climate change and the measures be?

3. How effective will the measures be under climate change?

2. How effective are the measures?

Example scenario matrix for a combined (climate change & measures) impact assessment

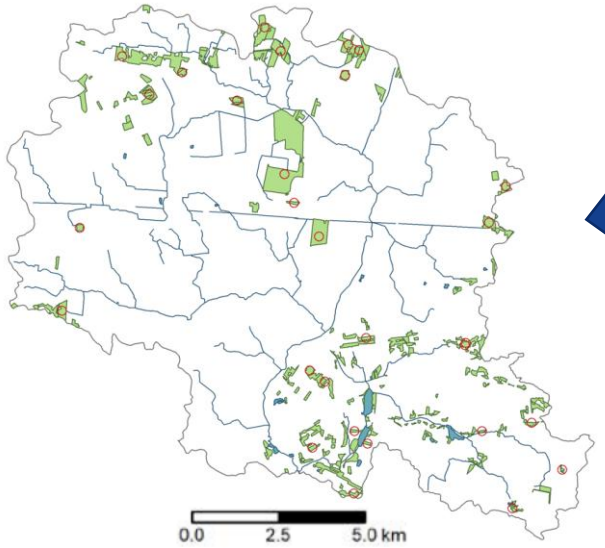
Scenario type	RCPs	Climate models	Simulation periods	Measures	Total # runs
Climate change	3	6	3	-	54
Measures	-	-	-	6	6
Climate change & measures	3	6	3	6	324



Quantifying combined effects – OPTAIN project example (PL case study)

Measure implementation in SWAT+

Measure scenario	Area [%]
Cover crops + low tillage	81.6 %
Controlled drainage	53.8 %
Crop rotations	30.6 %
Afforestation	5.1 %
Pond	0.06 %
All	87.3 %

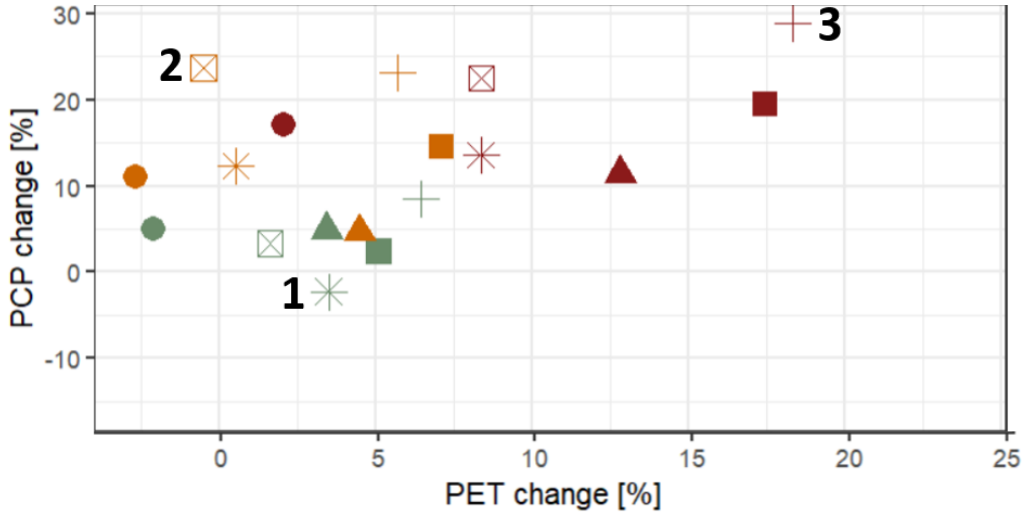


Climate change

Bias-adjusted EURO-CORDEX simulations

Full ensemble of 18 simulations (3 RCPs x 6 RCMs) for the 2071-2100 horizon

Three contrasting scenarios selected for the „combined" simulations: 1) „Cool & dry" (RCP2.6), 2) „Cool & wet" (RCP4.5) and 3) „Warm & wet" (RCP8.5)



OPTAIN

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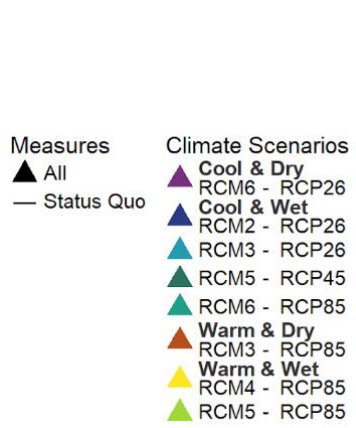
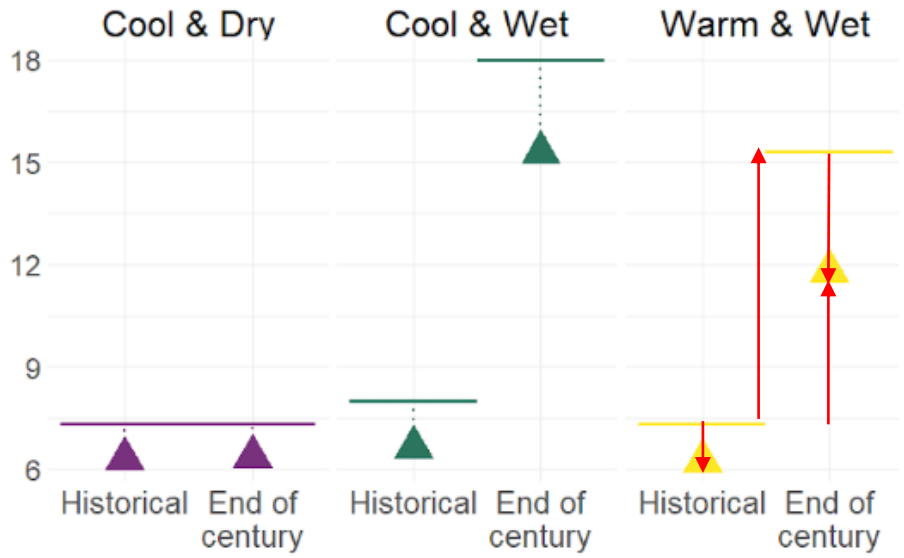
Einikarimkandi *et al.*, in prep.

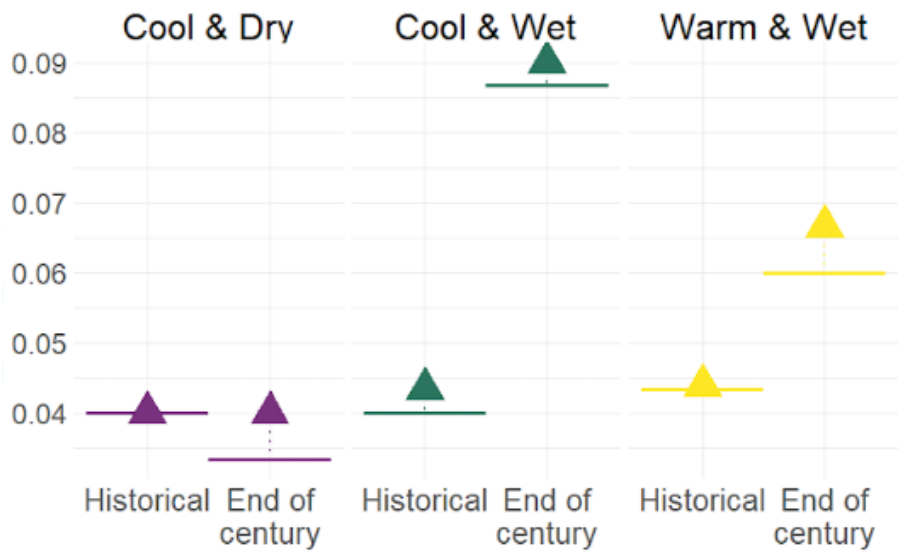
Quantifying combined effects – OPTAIN project example



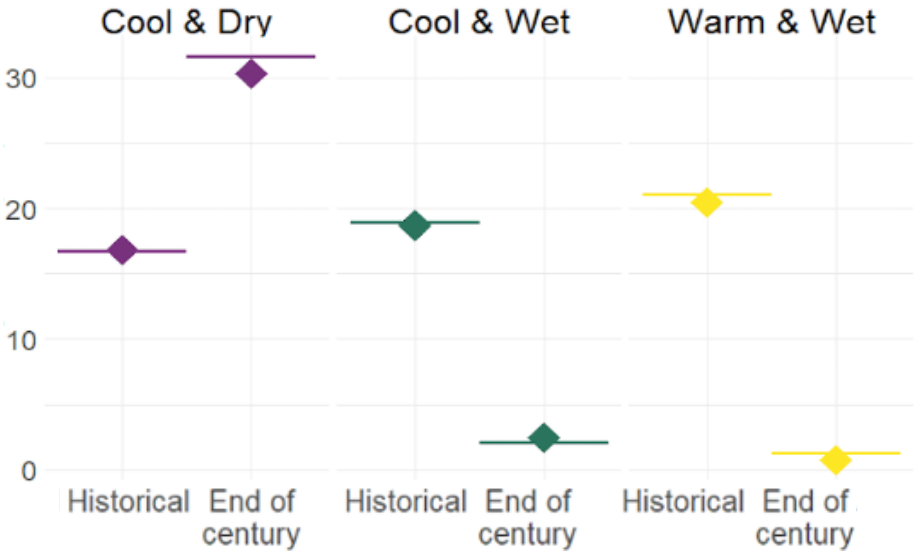
Annual maximum flows [$m^3/s/km^2$]



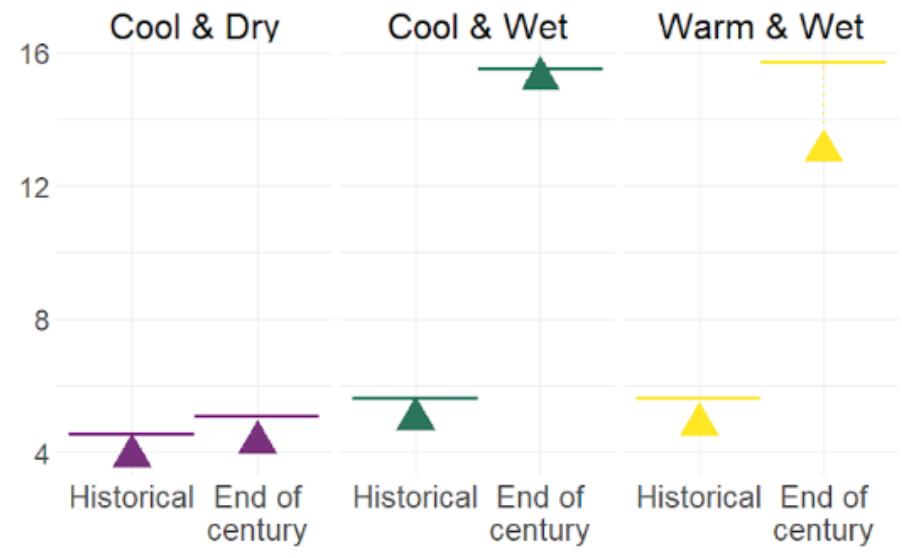
Annual minimum flows [$m^3/s/km^2$]



Soil moisture drought magnitude [-]



Total Nitrogen loads [kg N/ha/year]



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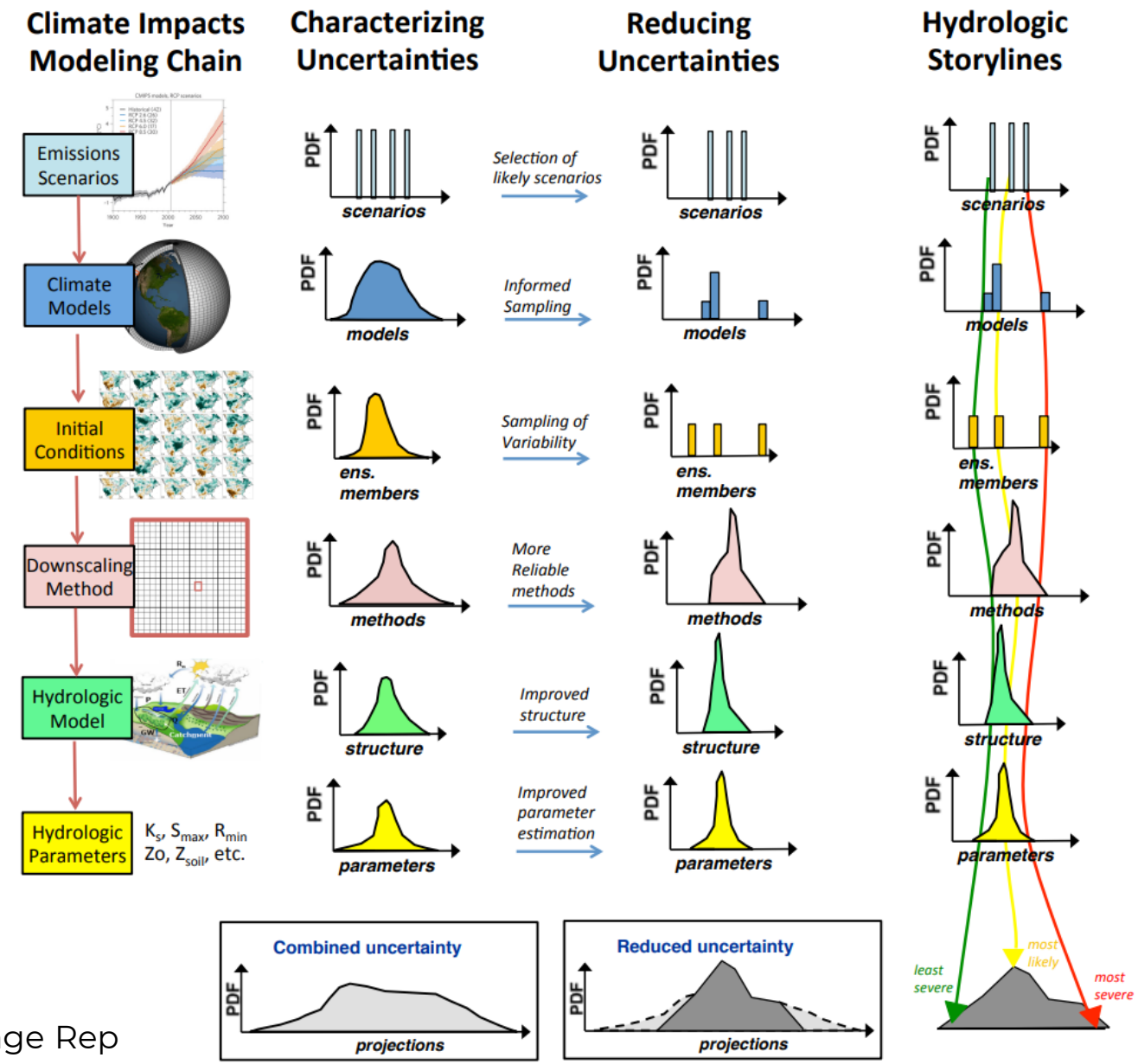
Characterizing and reducing uncertainties



Clark *et al.*, 2016, Curr Clim Change Rep

Take home messages

All the necessary methodologies, tools and data are in place to conduct model-based climate change impact assessments on water resources

This task can be complex, so don't underestimate the time and data storage requirements

Uncertainty is unavoidable, but sometimes reducible. It should always be communicated clearly

Some CC applications (e.g. event-based flood modelling or groundwater modelling) may require slightly different approaches (e.g. coupling with hydrological models)

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