Global assessment of water policy challenges under uncertainty in water scarcity projections

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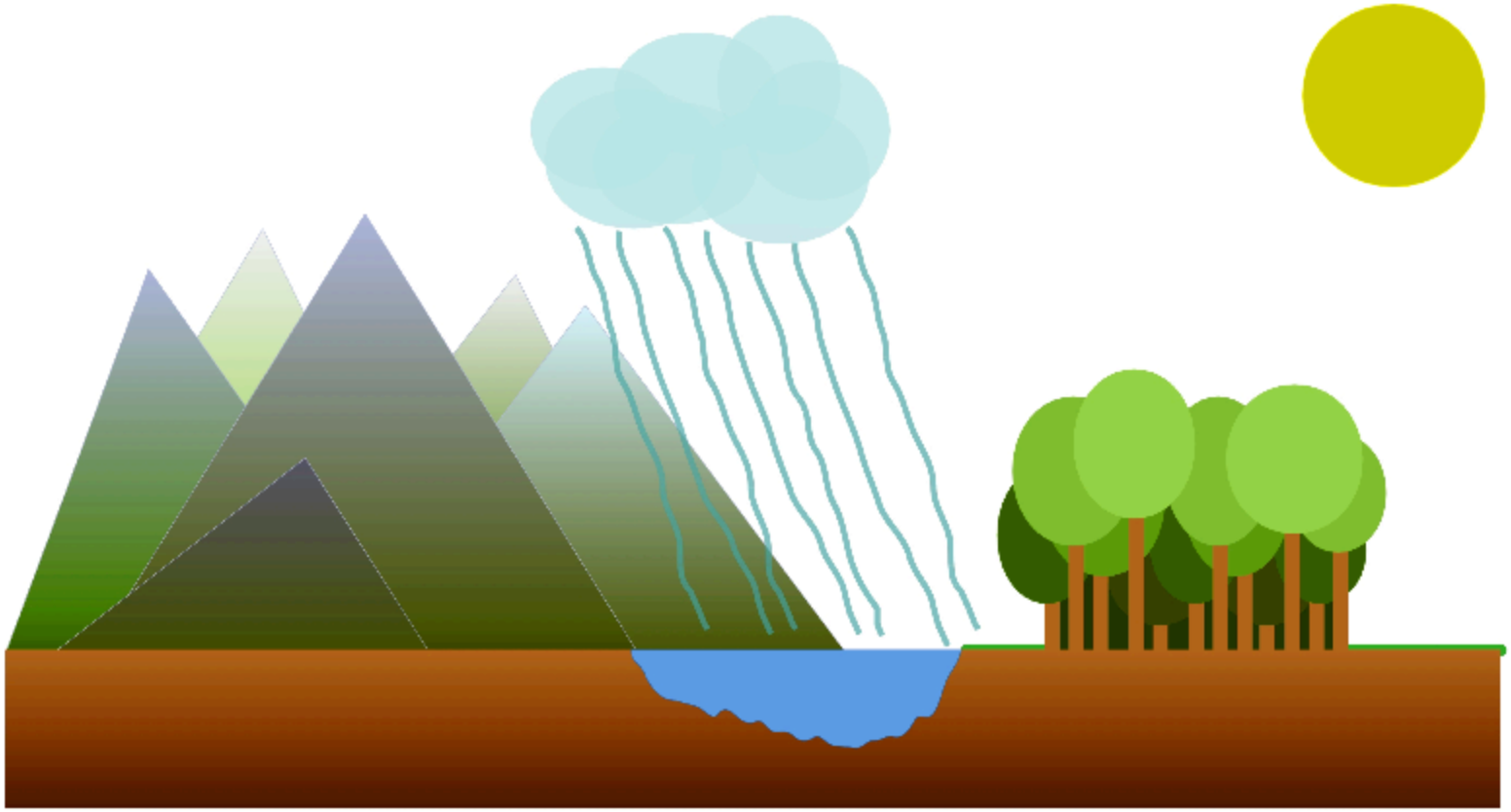
Water at the land surface



Water at the land surface

Water scarcity

$$\frac{\text{water demand}}{\text{water supply}}$$

Water Scarcity Index (WSI)

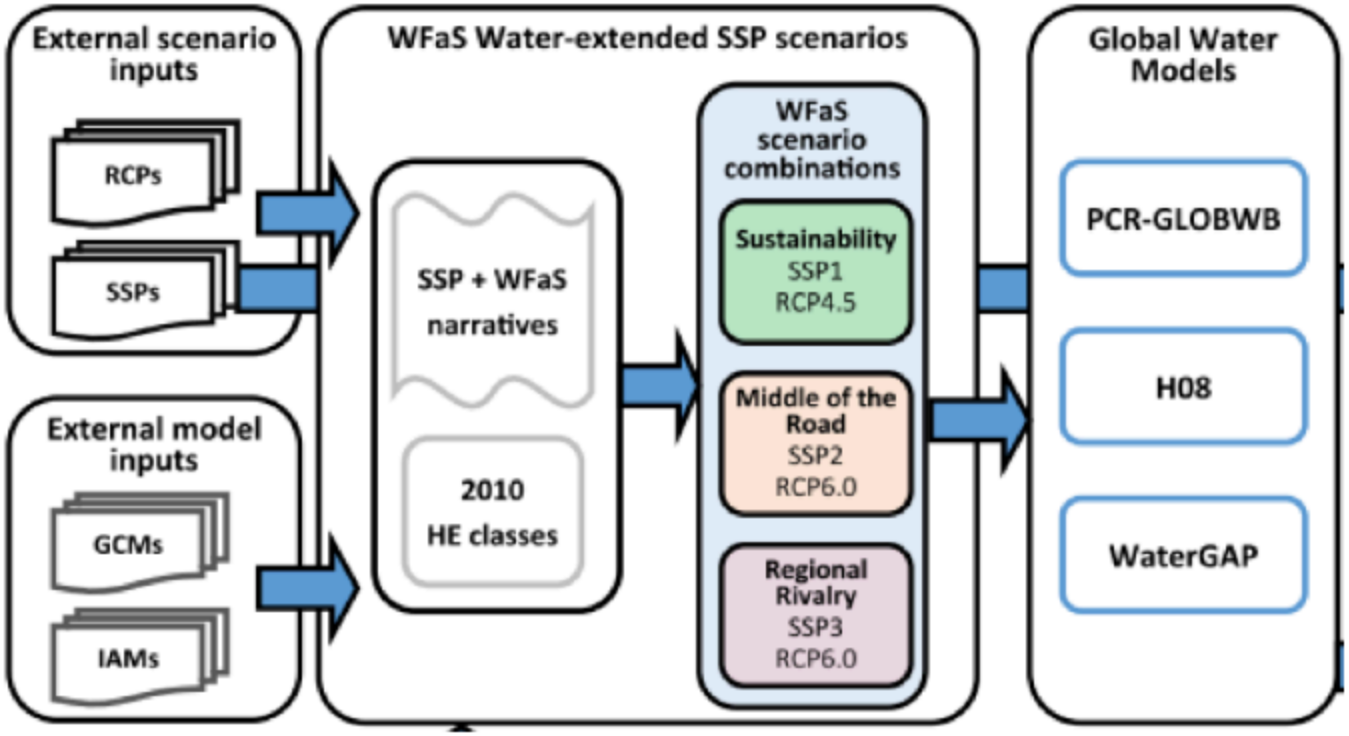
Objectives

Water scarcity is projected to change (increase)!

- What **drives** the change?
- What is the associated **uncertainty**?
- How does this **uncertainty change**?

Resulting policy implications?

Data



Time: 2006-2055

Res: 0.5deg

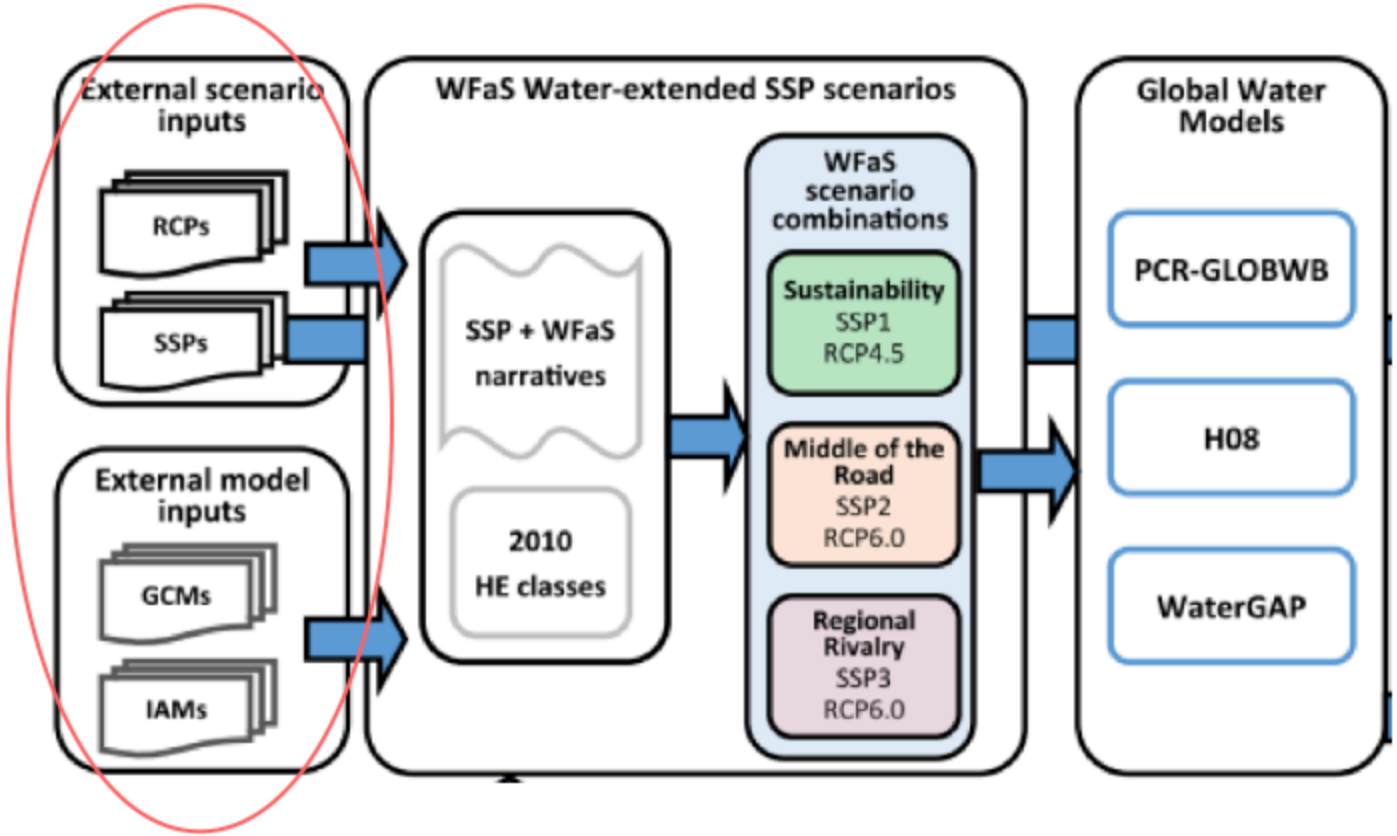
5 Global Climate Models (GCMs) to force

3 Global Hydrological Models (GHMs) under

3 different water scenarios

Satoh et al., Earth's Future

Data



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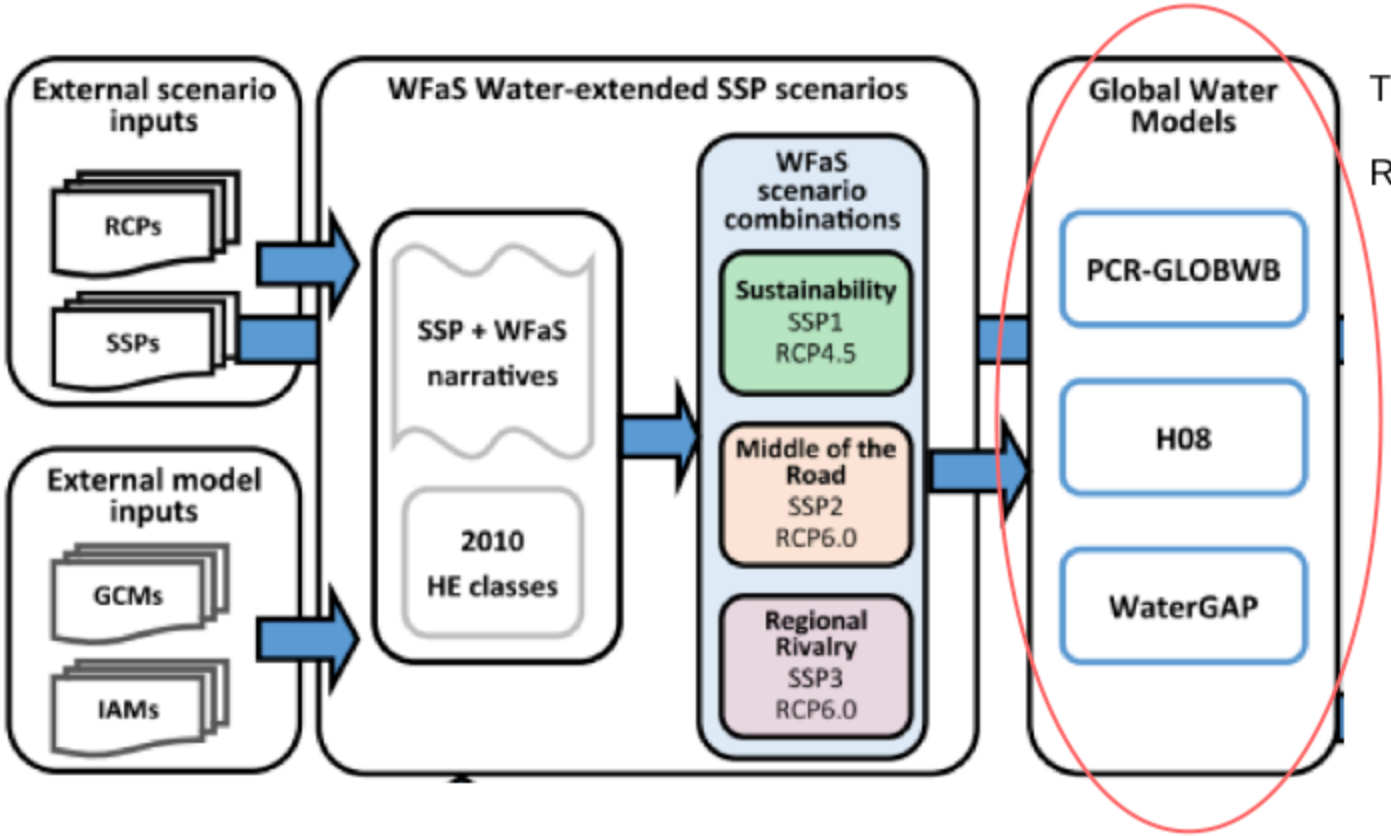

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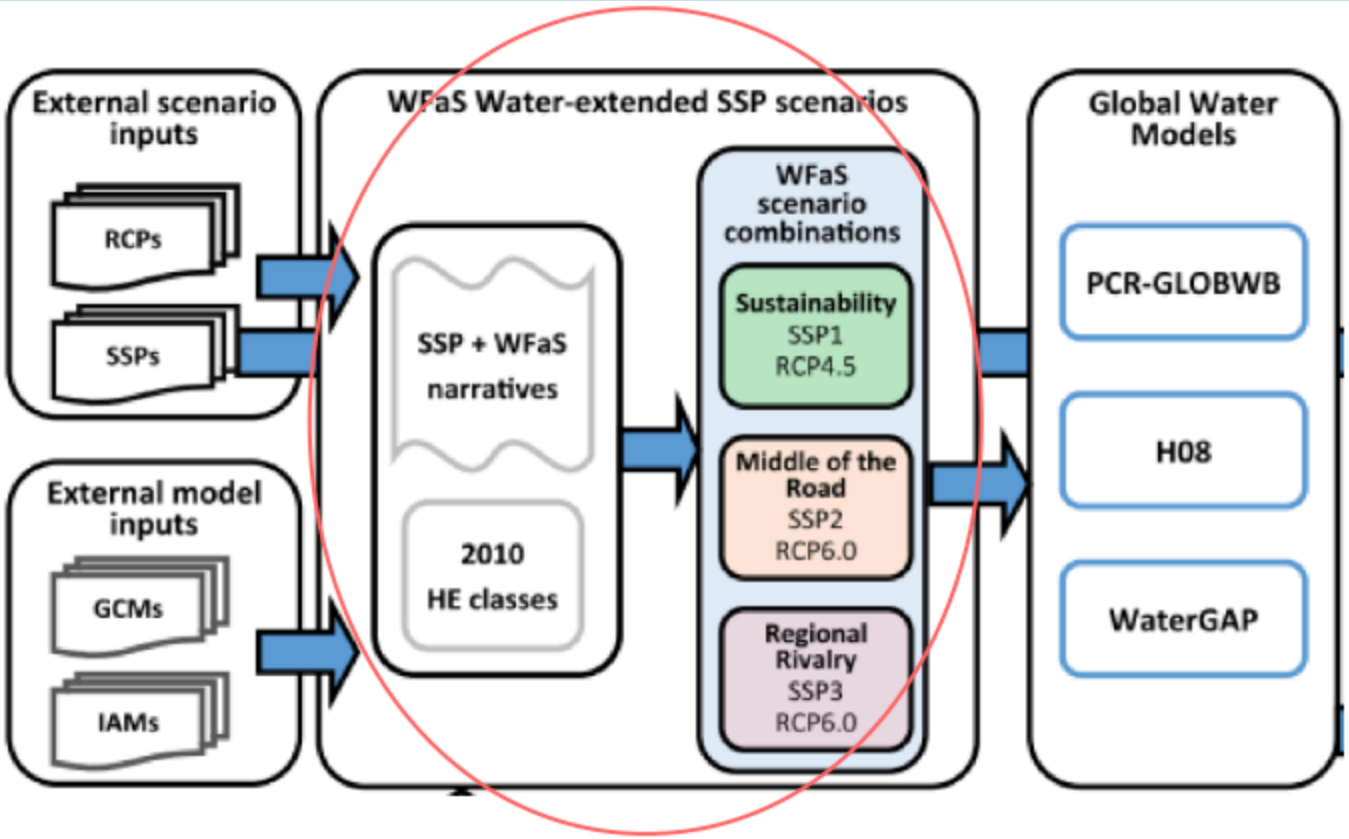

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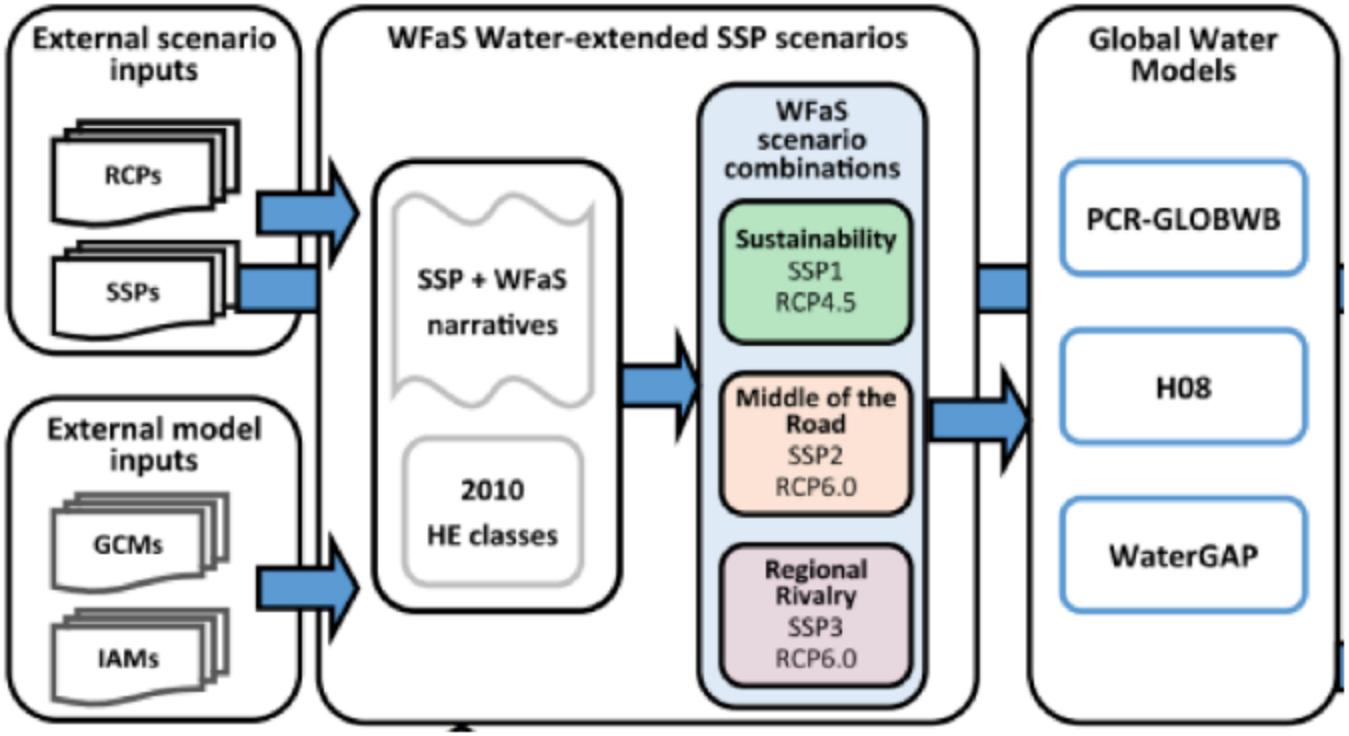

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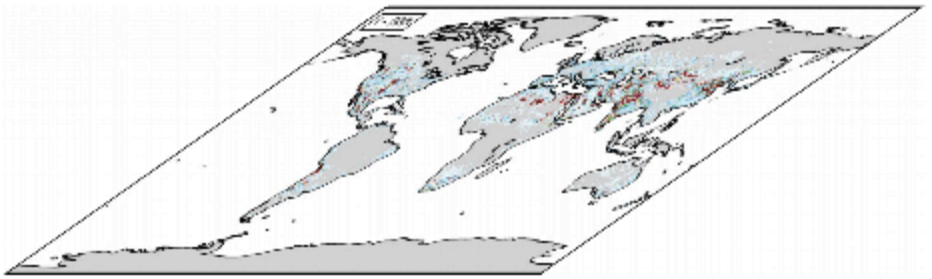

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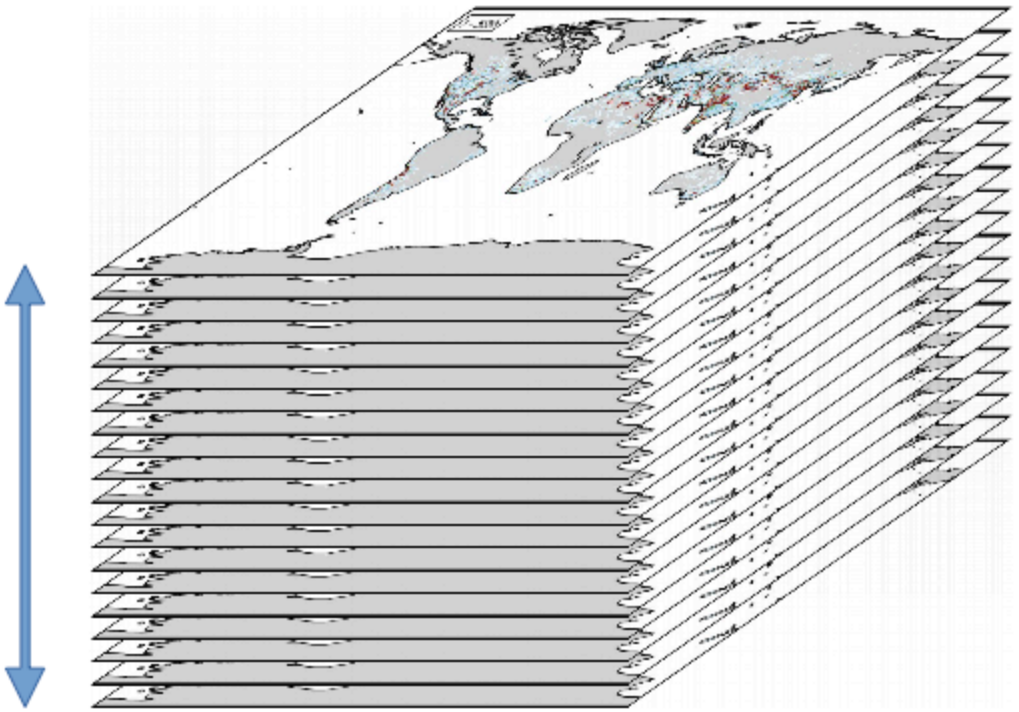
Data

45 global estimates of projected water scarcity



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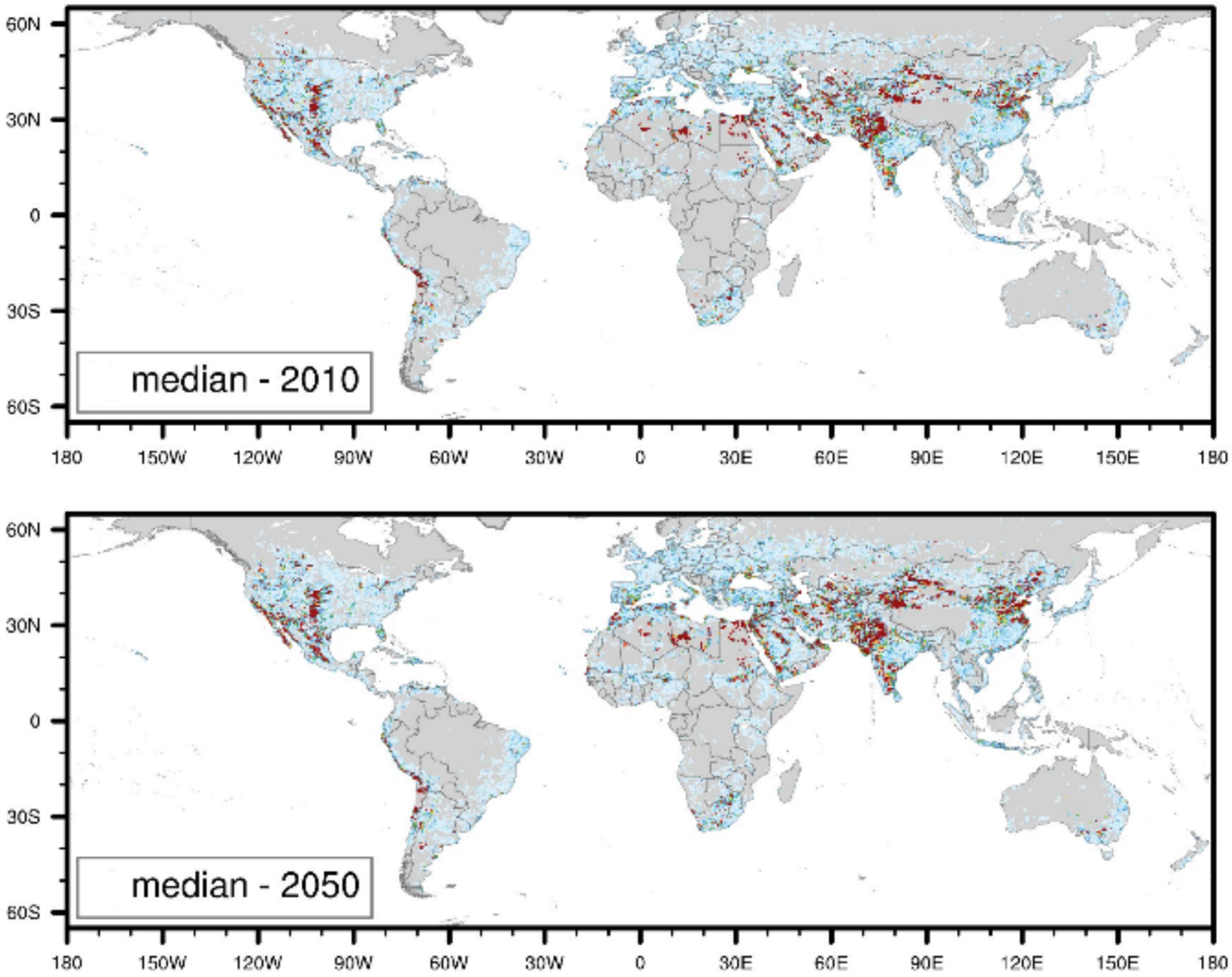
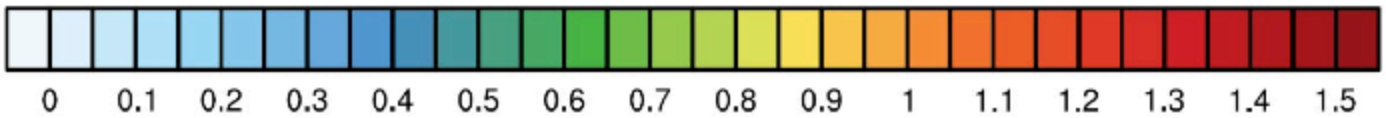
Water scarcity change

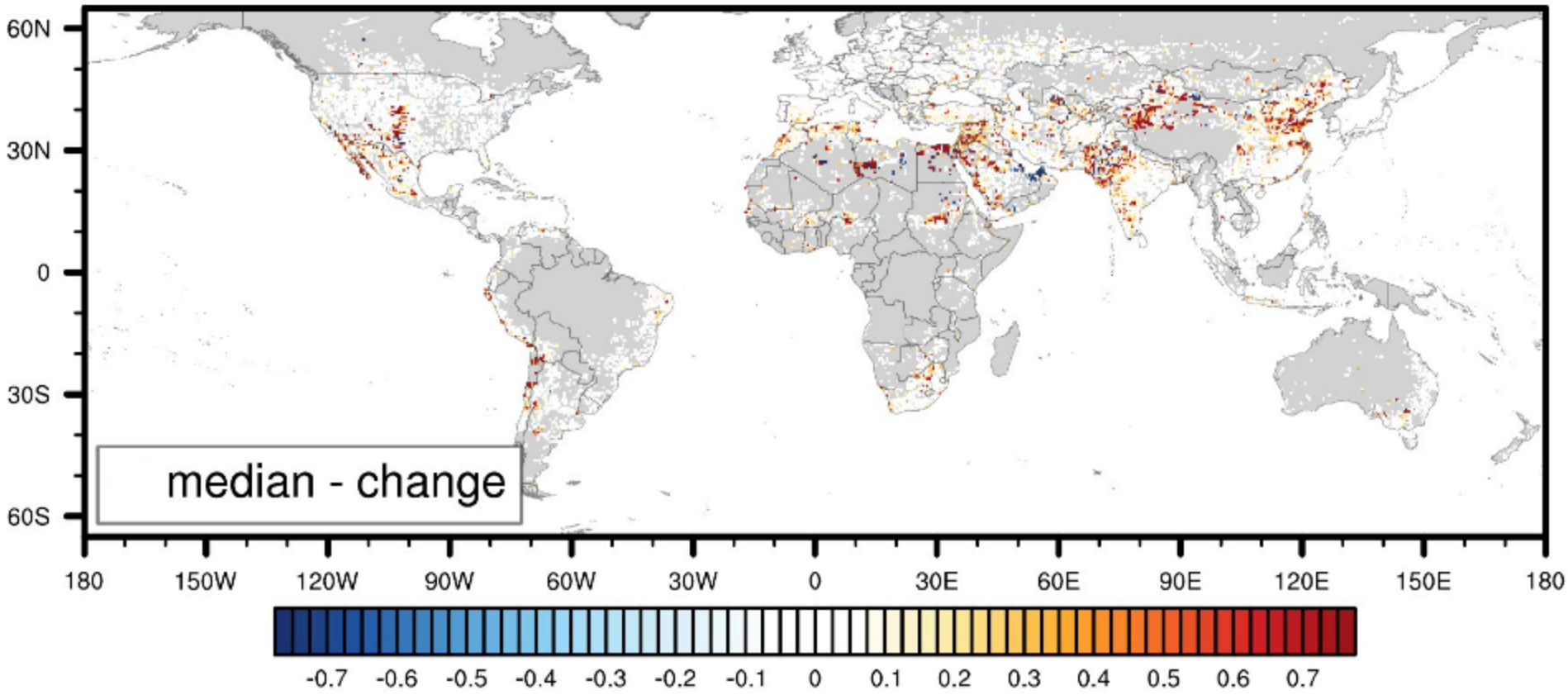




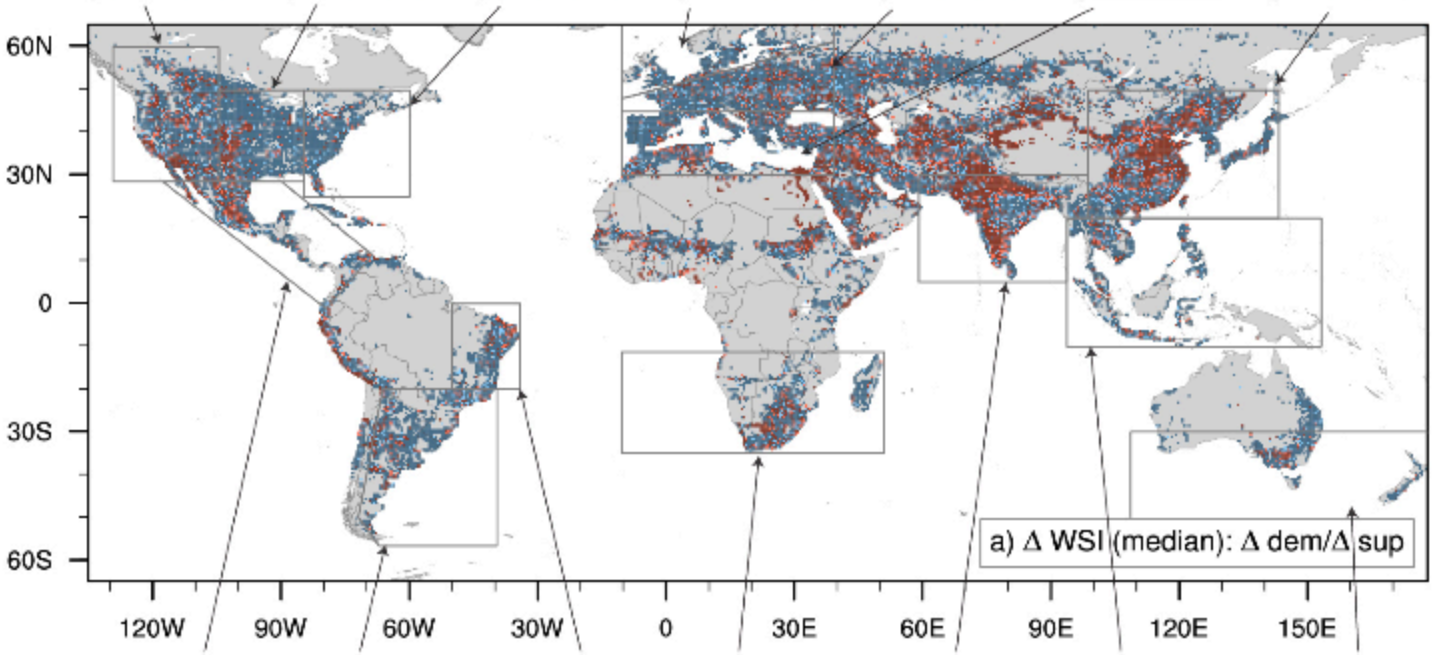
WSI

masked: WSI < 0.1

Water scarcity change



Demand vs. Supply



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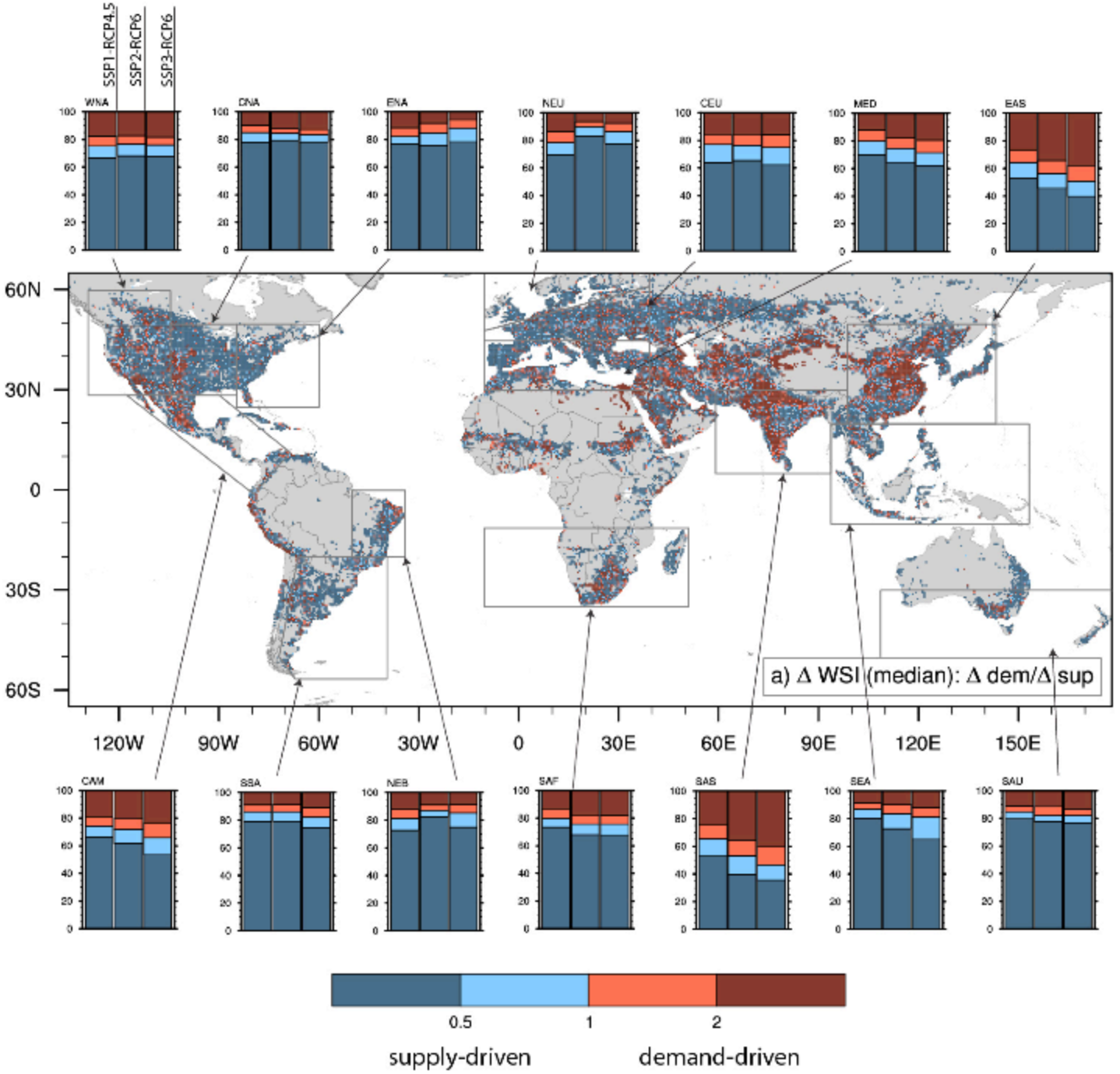

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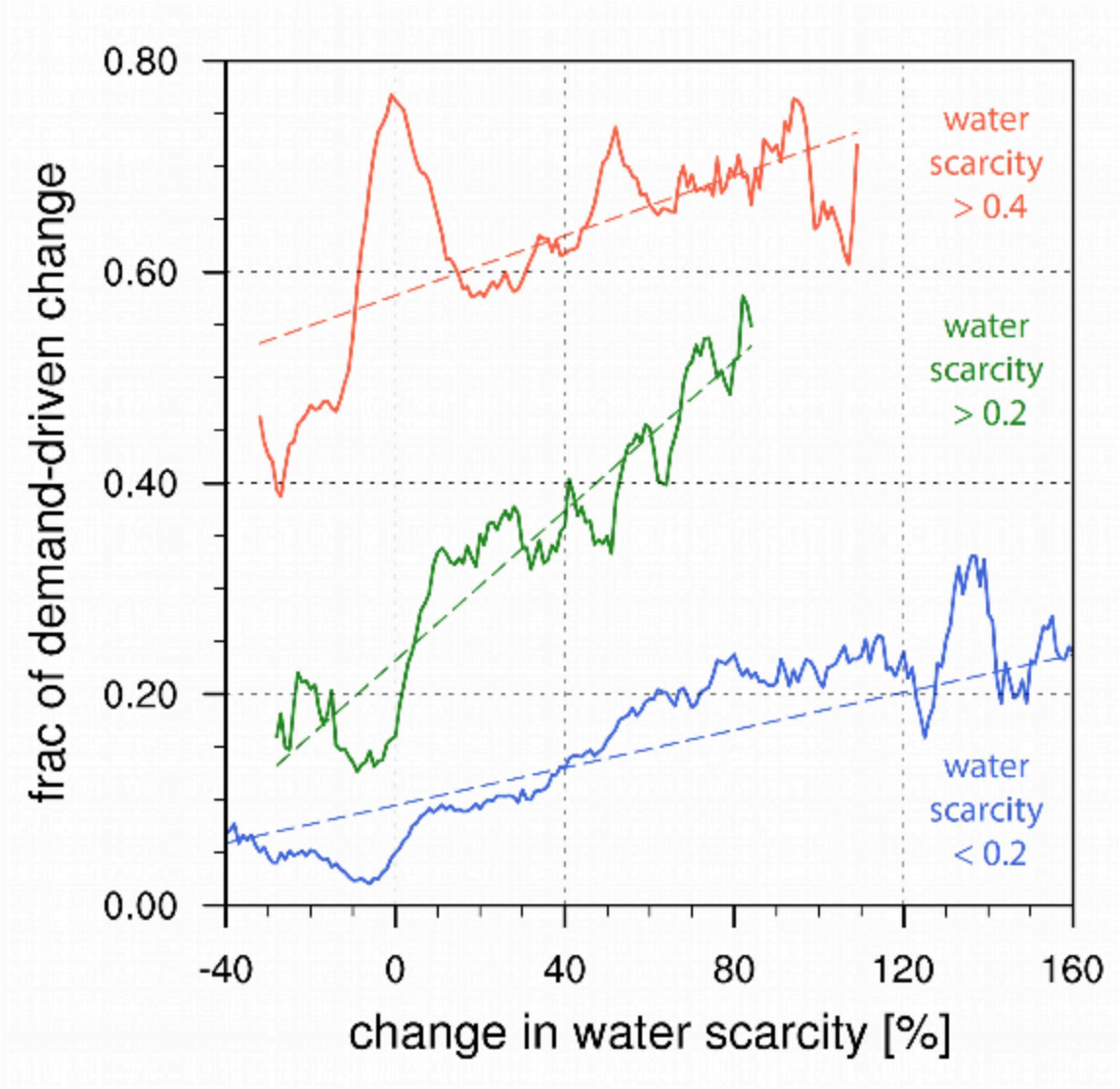
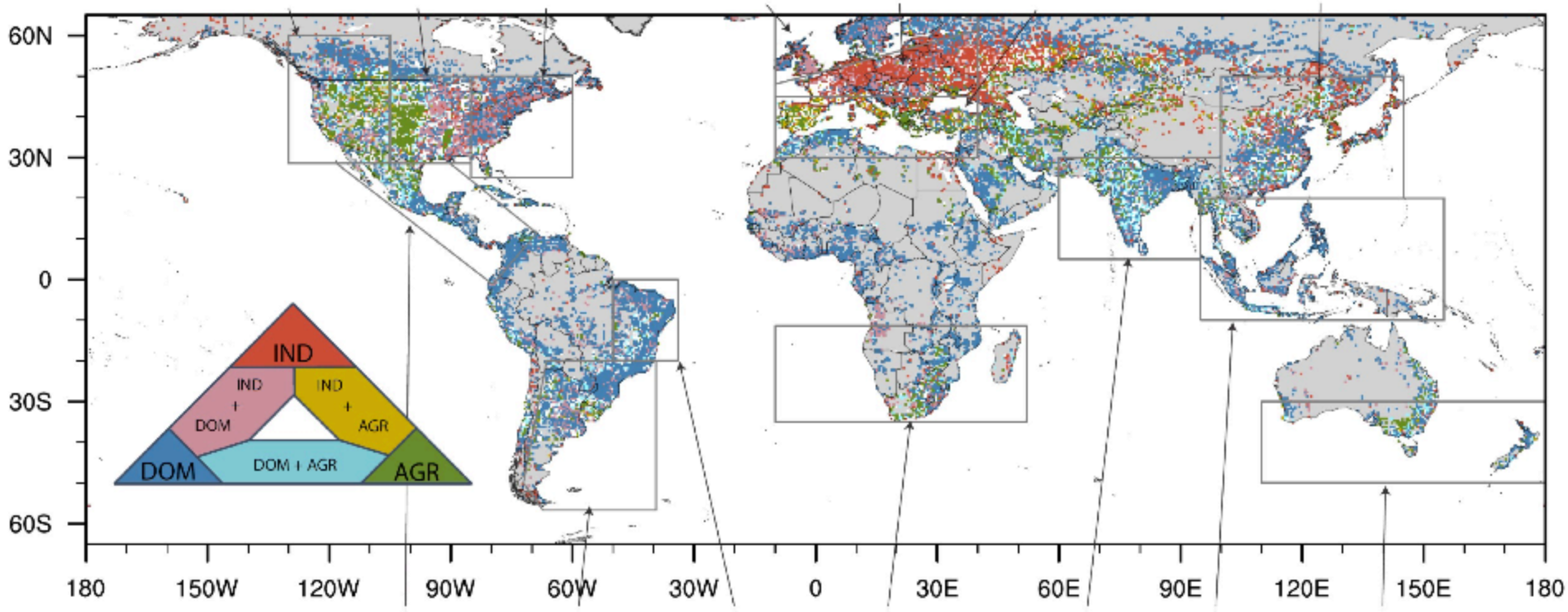
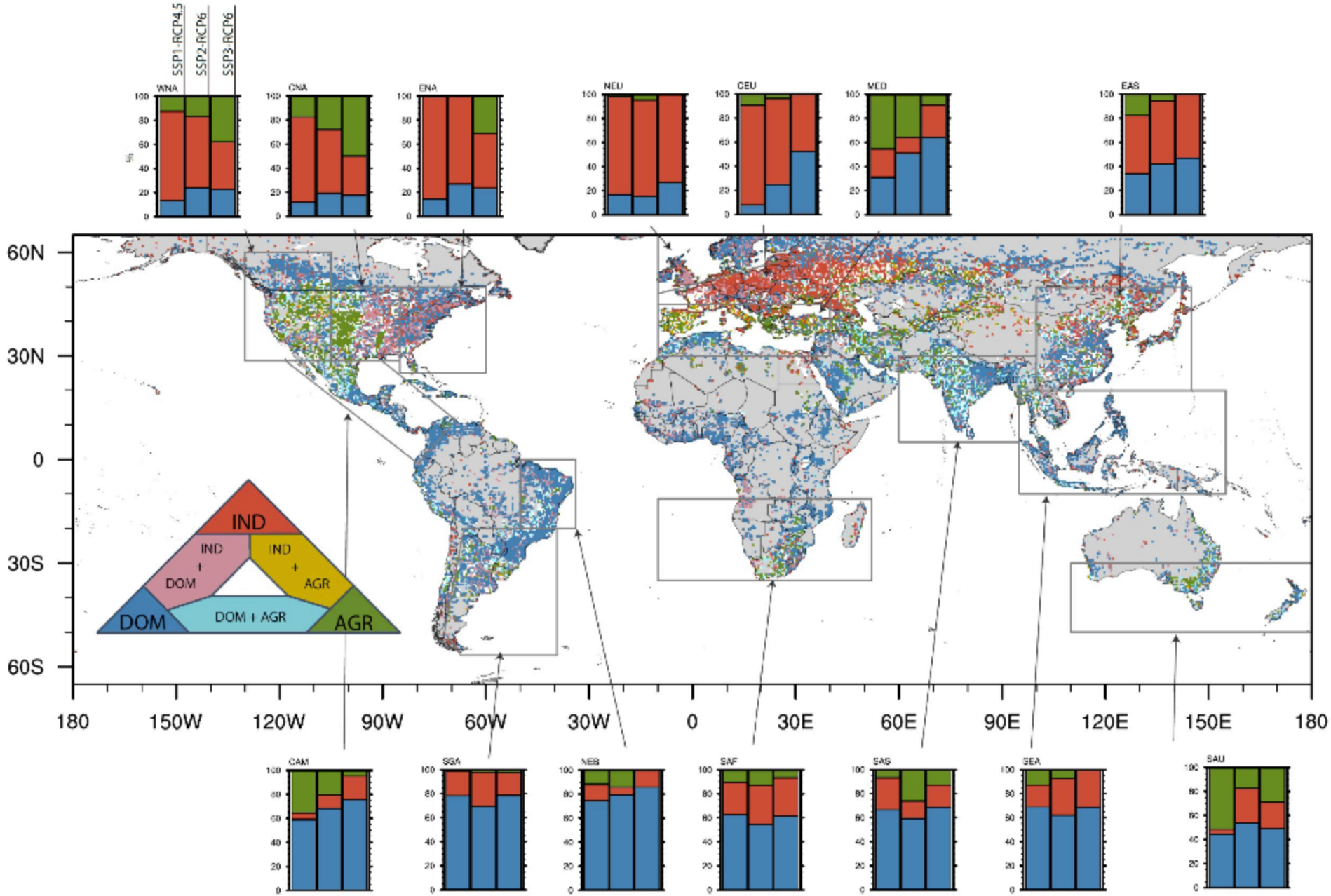


Demand change - sectors

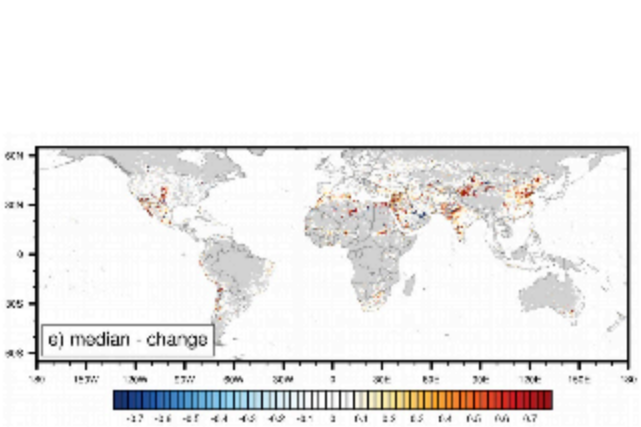
- **IND - industrial water use** (growth in GDP, energy production, energy consumption per capita and infrastructural area, etc.)
- **DOM - domestic water use** (population density and GDP per capita)
- **AGR - irrigation** (irrigation area, climate change)

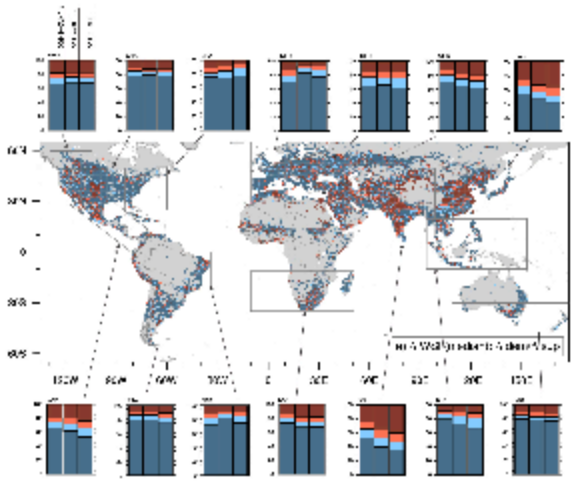


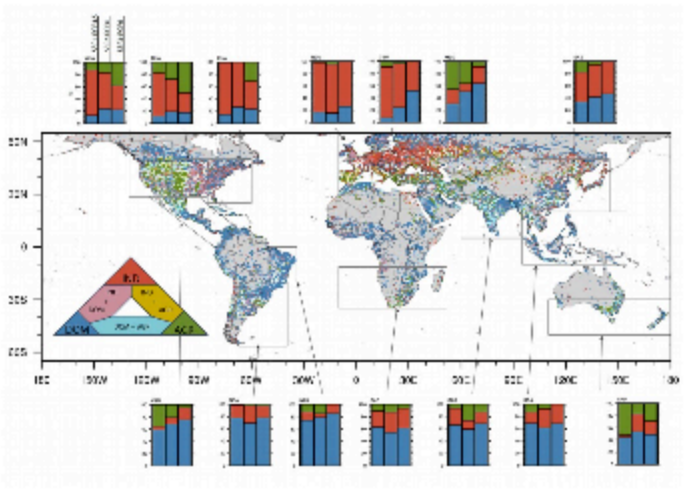
Demand change - sectors



Implications







Supply-driven change:

adaptation measures directly increasing water availability, including e.g.

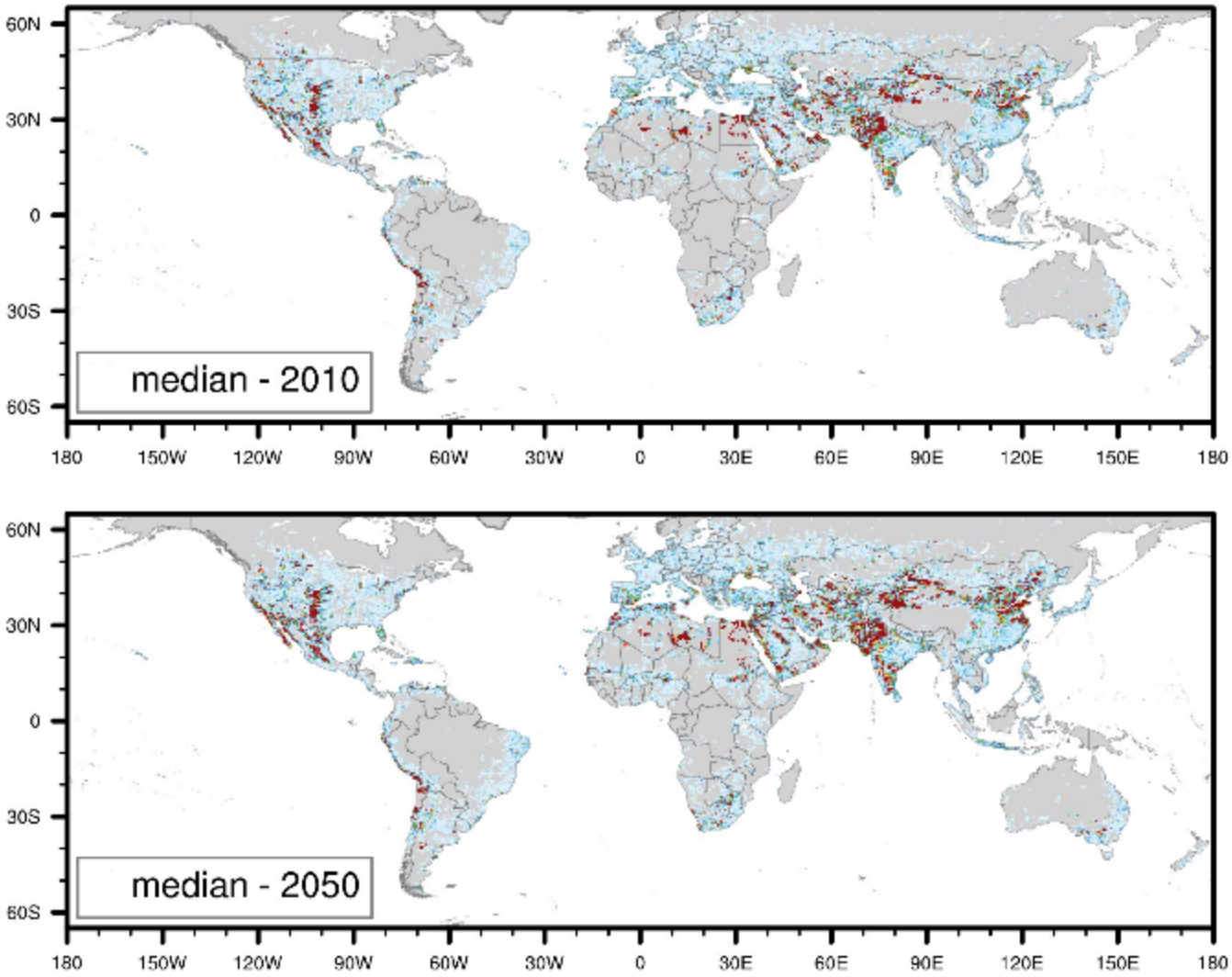
- infrastructure investments (reservoirs, water transfer systems, desalination, etc.)
- sustainable water allocation policies

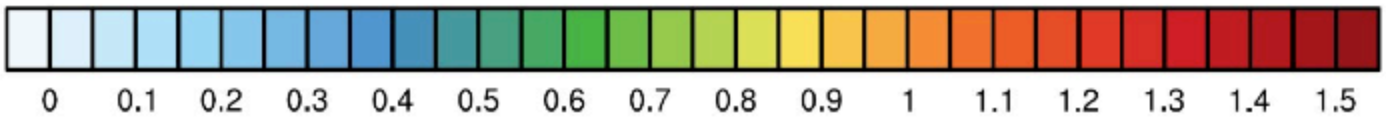
Demand-driven change:

additional soft-measures can be effective, including e.g.

- market-based water allocation system
- increased irrigation efficiencies
- use of water-efficient crops

Water scarcity change





WSI

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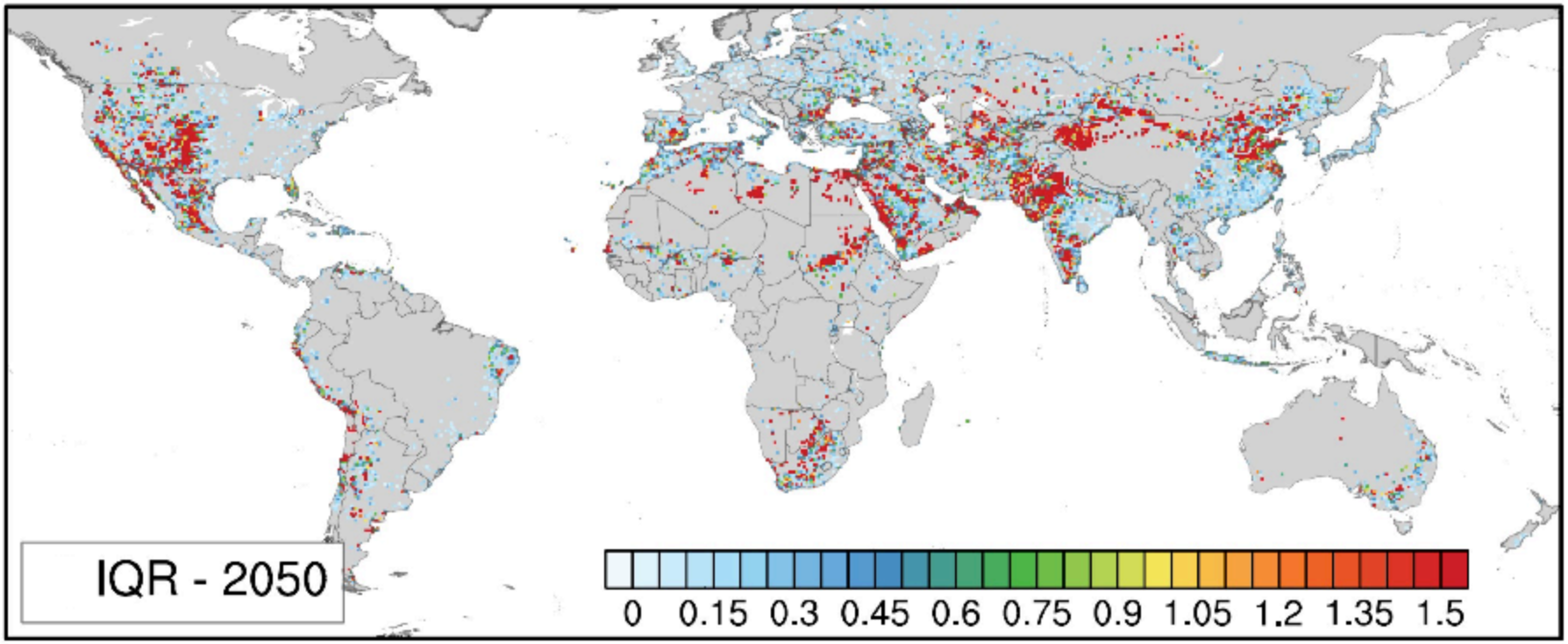
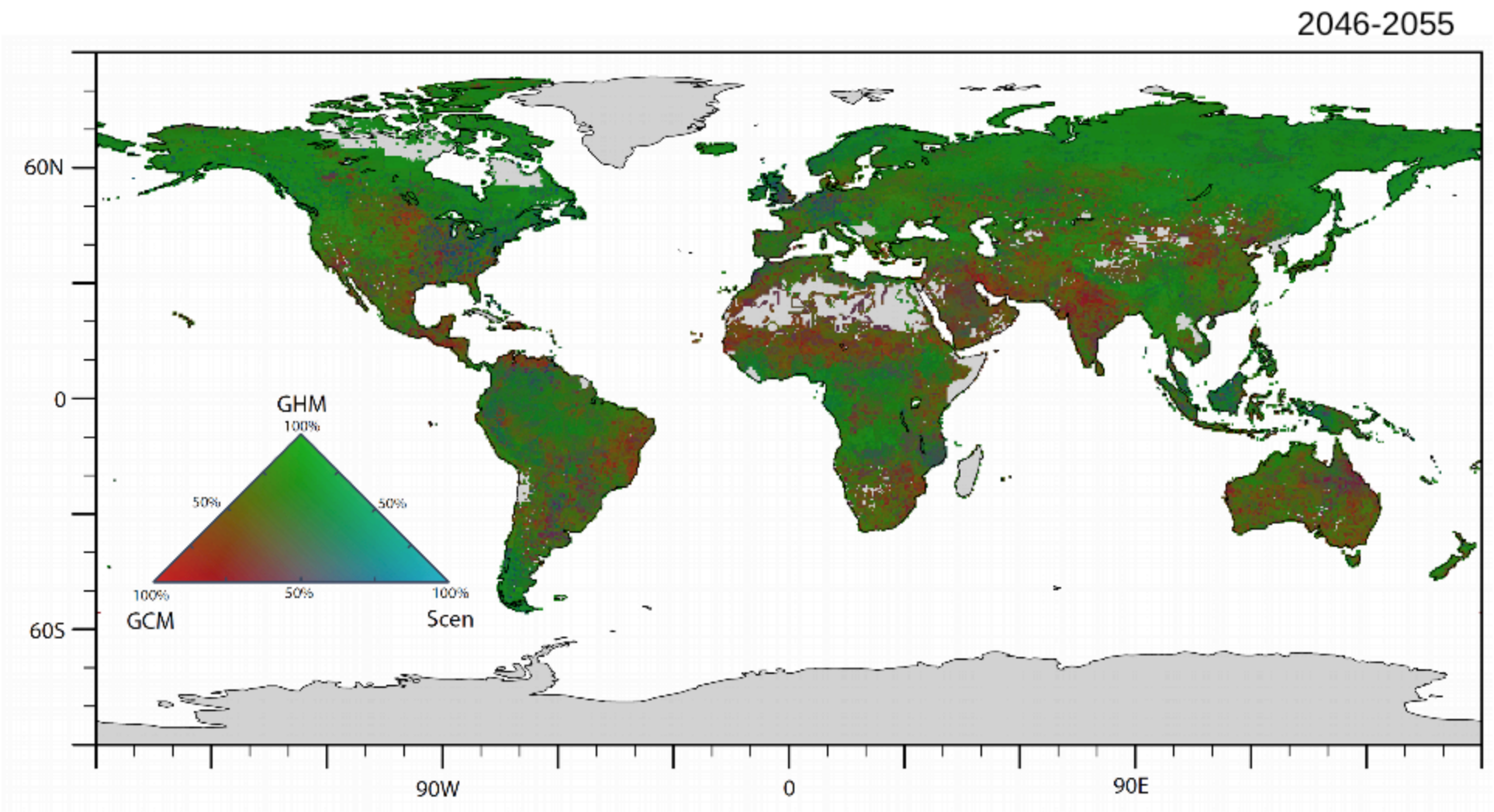
Uncertainties?

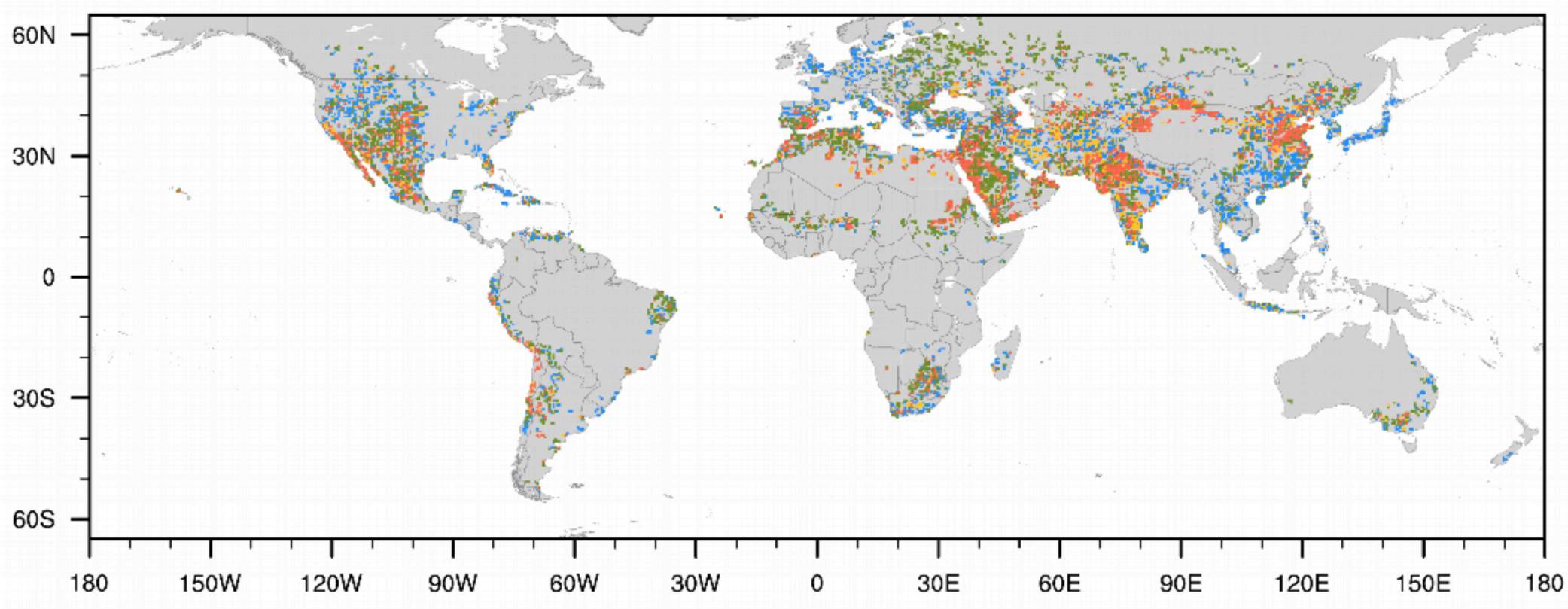


Sources of uncertainty



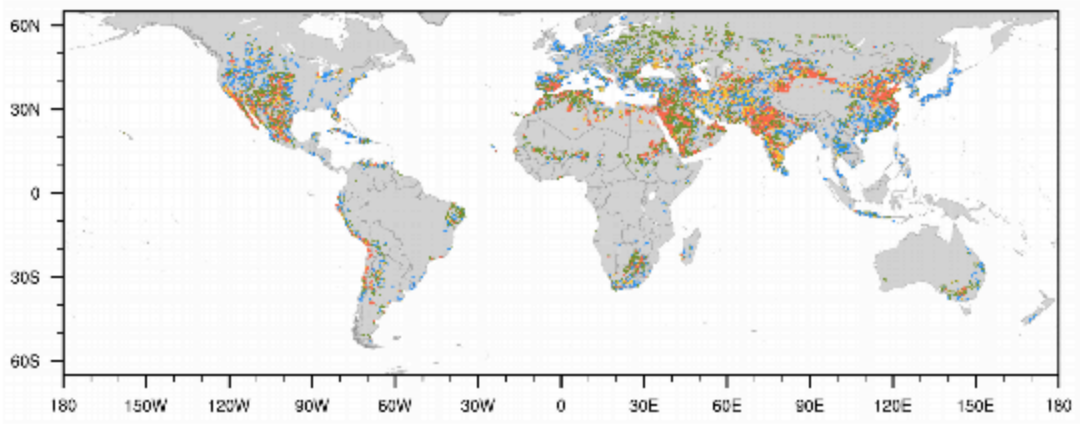
- **Global Hydrological Models (GHM)** are the main source of uncertainty in most regions
- **Climate Models (GCM)** are the main driver of uncertainty in many subtropical regions
- Uncertainty stemming from **water scenarios (Scen)** is less important

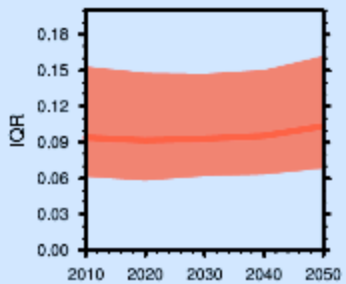
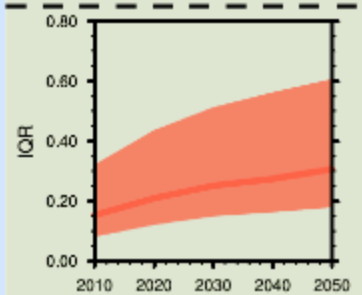
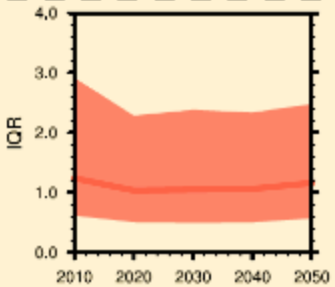
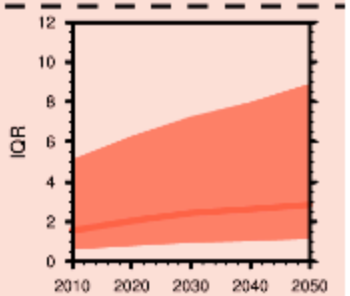
Management challenges



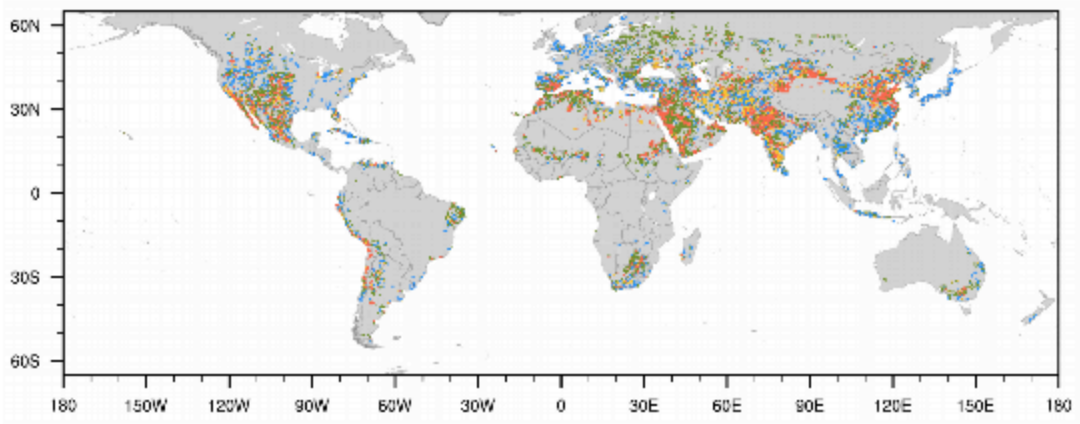
Challenges

Management challenges



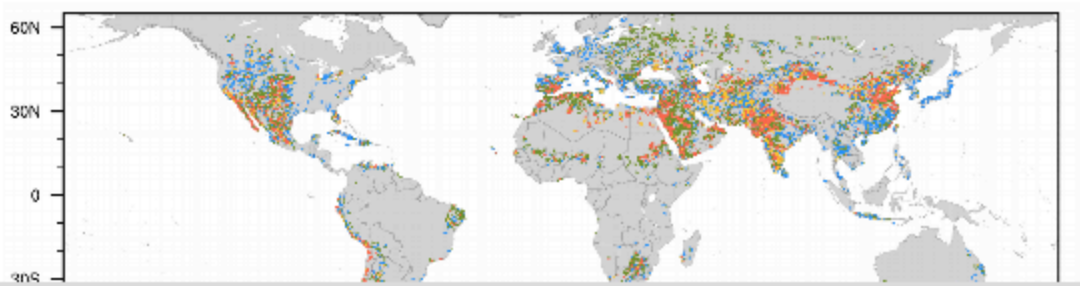
Challenges	low	medium	medium	high
median **water scarcity** (in 2050)	< 0.4 non-, slightly water scarce	< 0.4 non-, slightly water scarce	> 0.4 severely water scarce	> 0.4 severely water scarce
within-area **range of uncertainty** (2010-50)				
uncertainty (2010)	low IQR < 0.15	low to medium IQR < 0.35	medium to high IQR > 0.6	medium to high IQR > 0.6
uncertainty changes (2010-50)	relatively stable	medium to high increase	relatively stable	medium to high increase

Management challenges



Challenges	low	medium	medium	high
Policy actions	monitoring and reviewing risks	transitional changes	transitional/ transformational changes	transformational changes
Decision-making frameworks	conventional approaches such as e.g., cost benefit analysis	iterative processes and robust-decision making beginning with low-regret options	evaluating potential for both transitional and transformational options	evaluating transformational options
		sprinklers and drips instead of surface irrigation, irrigation scheduling, etc.	Water infrastructure, broad water management	Water infrastructure - **modular options,** alternative livelihoods

Management challenges



- Implementation of these policies must account for environmental needs and is challenged by governance structure and socio-political barriers.
- Successful adaptation requires:
  - robust institutional infrastructure
  - enhanced local institutional capacities
  - functioning rules
  - improved water governance

Chall

Policy

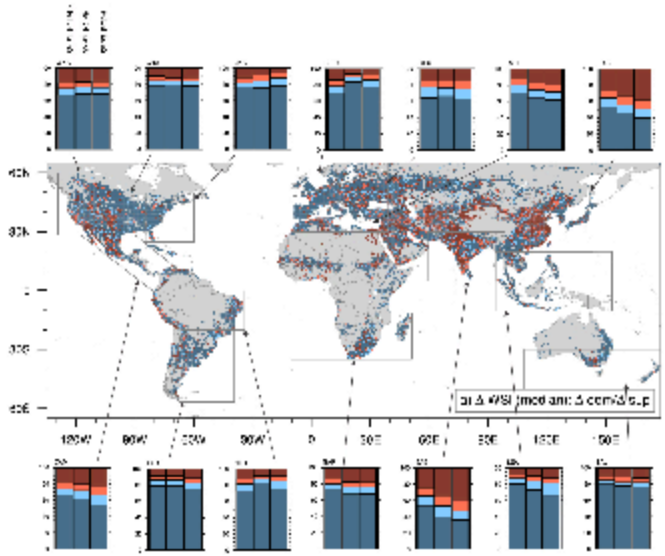
Decisi
framew

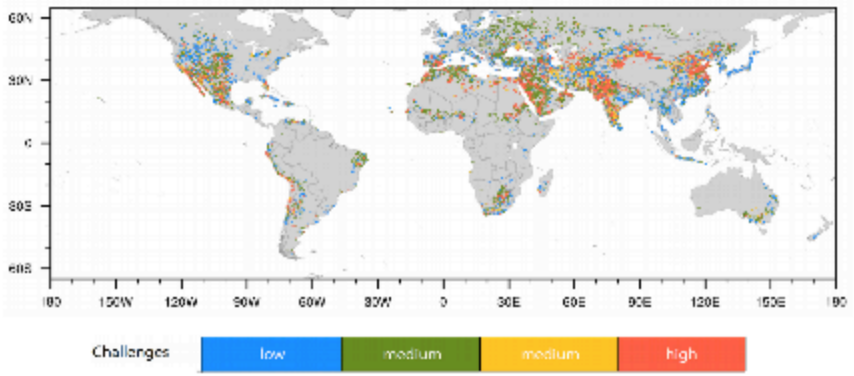
such as e.g., cost benefit analysis	beginning with low-regret options	both transitional and transformational options	transformational options
	sprinklers and drips instead of surface irrigation, irrigation scheduling, etc.	Water infrastructure, broad water management	Water infrastructure - **modular options,** alternative livelihoods

Concluding remarks

Assessing **demand vs. supply-driven changes in water scarcity** has important **implications for policy-making.**

Uncertainties in future projections are **substantial**





Adequate policy-making should **recognize drivers and uncertainties** in future projections.

Evaluating **alternative scenarios** beyond the average projection helps avoid **maladaptation, adverse path dependencies** and **large costs of error.**

Our results call for a **careful and deliberative design of water policy interventions**

Thanks!

Peter Greve

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Generic policy implications

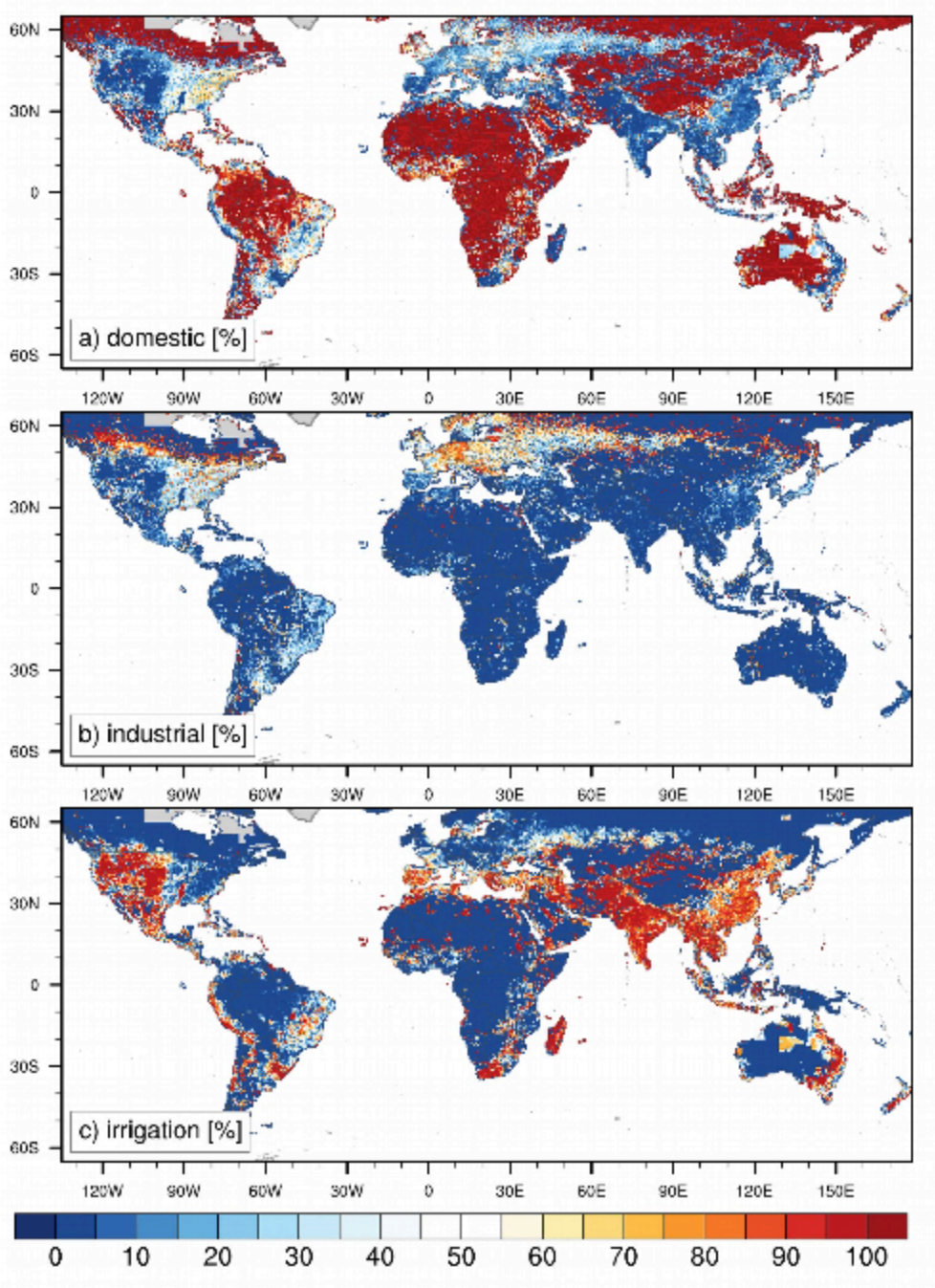
- **Low challenge areas** (no/limited water scarcity, low & stable uncertainty)
  - no immediate actions required - regular monitoring activities and risk reevaluations are advised

- **Medium challenge areas** (no/limited water scarcity, low & increasing uncertainty)
  - **immediate actions may be advisable - transitional changes will likely suffice**
  - start from implementing **low or no-regret (soft path) transitional options** (beneficial in any case)
  - Implications for farming practice: pressurized systems (sprinklers and drips) instead of surface irrigation, improved crop water productivity (new cultivars), soil management and irrigation scheduling
  - adequate monitoring and early warning systems, diversification of agricultural production, use of crop insurance and compensation schemes

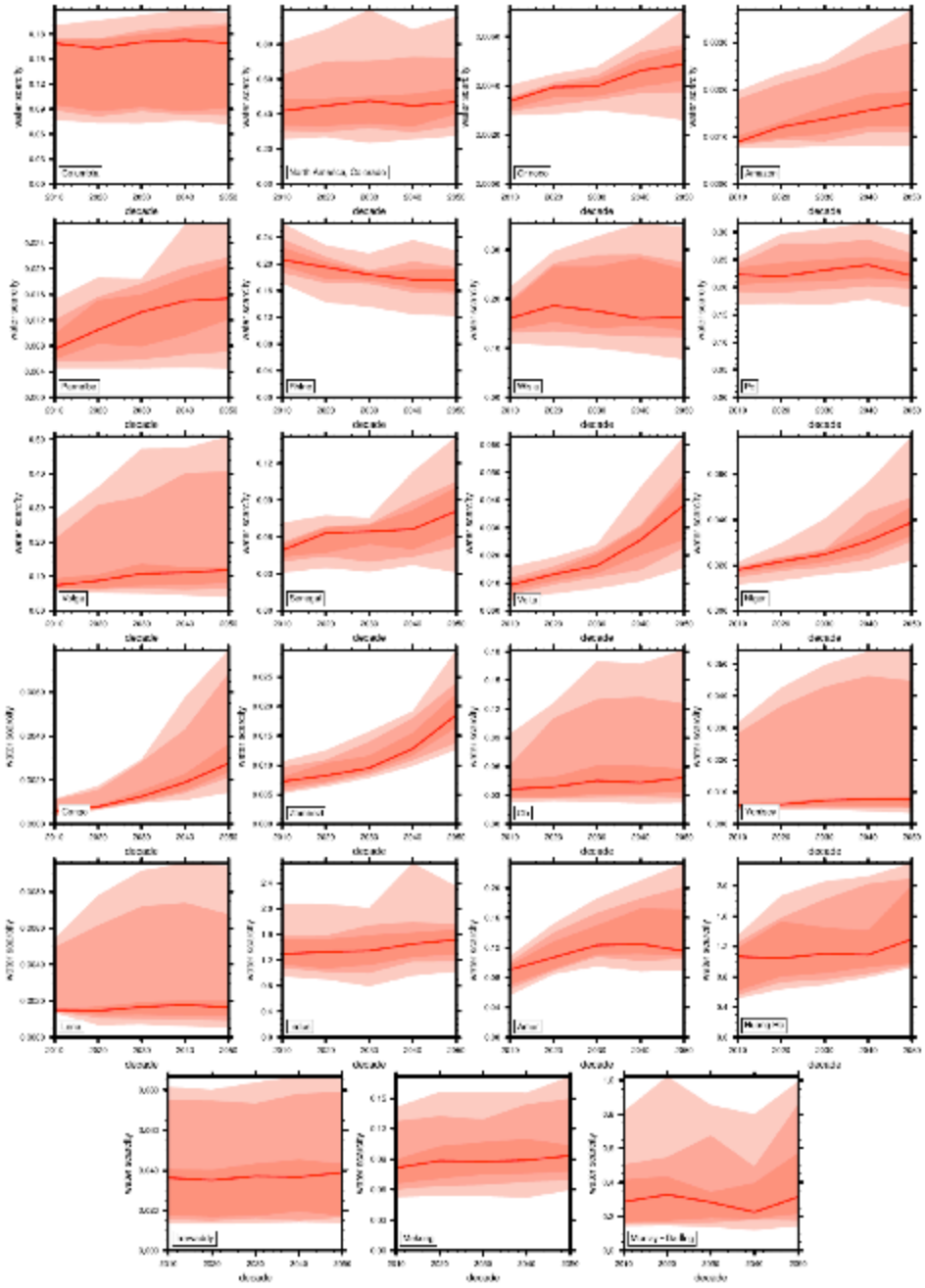
- **Medium challenge areas** (medium/high water scarcity, medium/ high & rel. stable uncertainty)
  - **immediate actions are necessary - transformational changes (hard path) might be necessary**
  - investments in **large water infrastructure** (dams, water transfer, water recycling and reuse, desalination)
  - Broad water management reforms (water buyback – Murray-Darling Basin, efficient wastewater management, rainwater harvesting, etc. - Singapur)

- **High challenge areas** (medium/high water scarcity, medium/high & increasing uncertainty)
  - **immediate actions are necessary - need for transformational changes**
  - investments in **large water infrastructure** (dams, water transfer, water recycling and reuse, desalination) - **modular options that allow for additions and reversals**
  - **Relocation** of industries, development of **alternative livelihoods**
  - risk-reduction strategies and dynamic adaptive policies - flexible water allocation and management rules, clear water use rights and priorities, water exchange in local water markets, virtual water trade in global food markets

Demand by sectors



Changes in uncertainty



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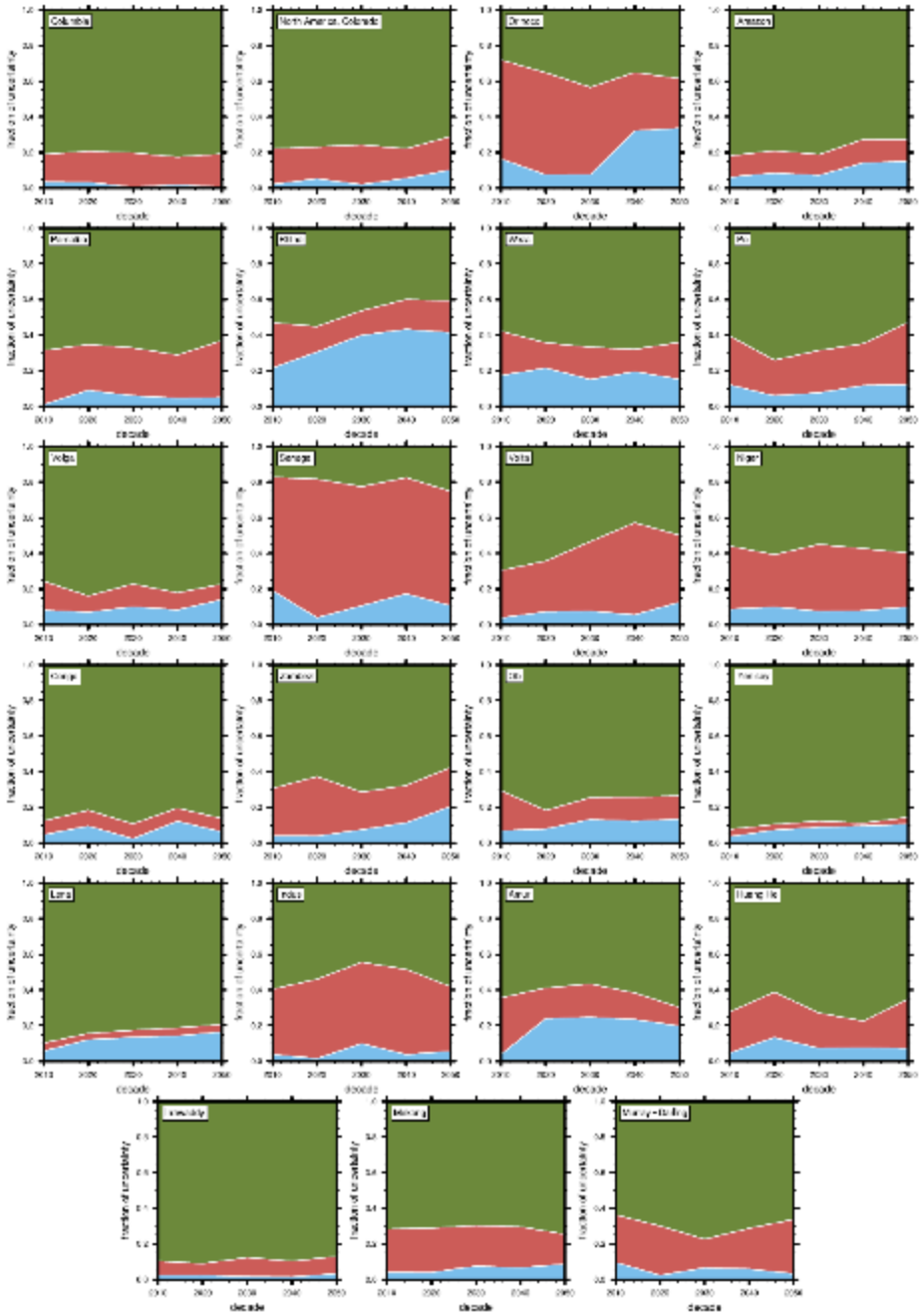

Sources of uncertainty

(i) the average over the variances of all GCMs under each water scenario and for each GHM (**GCM uncertainty**),

(ii) the average of the scenario-specic variances of the averages over all GCMs for each GHM (**GHM uncertainty**) and

(iii) the variance of the averages of all GHMs and GCMs within a specic scenario (**scenario uncertainty**).