



Impacts of Europe's water futures

Mike Acreman (on behalf of WP4)



Many specific questions



How much water is there?

When do we get it ?

Will droughts happen more often?

Will we be able to grow enough food?

Will our wildlife suffer?





General water quantity impacts





Direct water use impacts



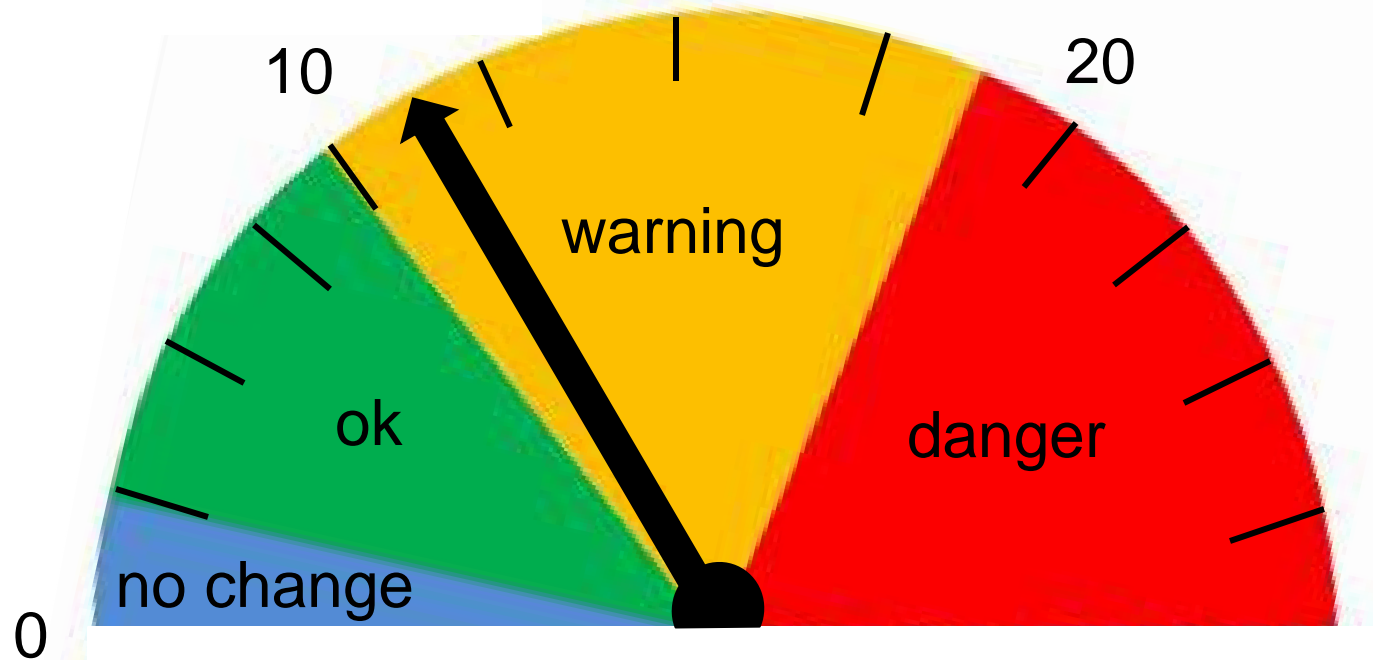


Indirect water use impacts





Impact indicators





ID	Name
Water 1	Water Exploitation Index
Water 2	Water stress index
Water 3	Water scarcity index
Water 4	Change in frequency of flood events
Water 5	Change in flood hazards
Water 6	Change in frequency of river low flow
Water 7	Change in magnitude of river low flow
Water 8	Change in mean annual river flow
Food1	Crop water requirements
Food 2	Agricultural crop production
Food 3	Water resources needed to meet bio-energy targets
Food 4	Potential bio-energy production
Food 5	Economic aspects of agricultural production
Food 6	Water required for irrigation
Food 7	Irrigation water stress
Nature 1	Environmental flows
Nature 2	Floodplain wetlands
Nature 3	Ecosystem services of wetlands
Nature 4	Change in water supply to wetlands
Nature 5	Aquatic macrophyte diversity in lakes
Nature 6	Habitat suitability for river water temperature for fish
People 1	Domestic water stress
People 2	Flood risk
People 3	Risk for harmful algal blooms in shallow lakes and reservoirs
People 4	Domestic water availability
Industry 1	Extra demand for cooling water
Industry 2	Navigability of large rivers
Industry 3	Cooling water stress



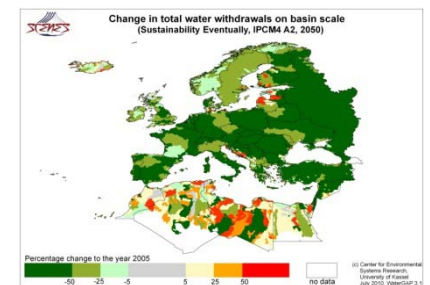
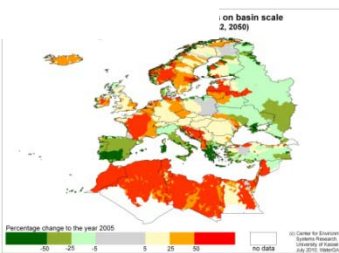
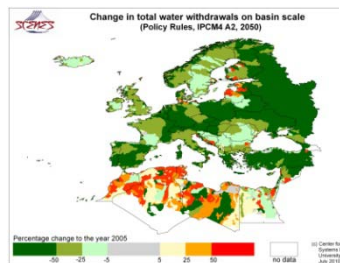
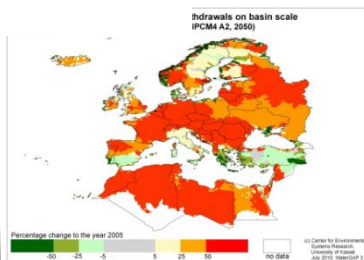
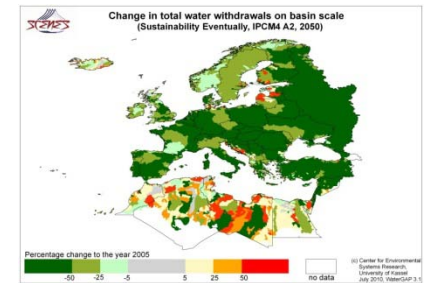
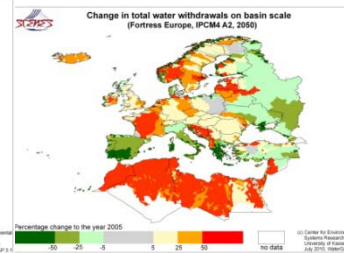
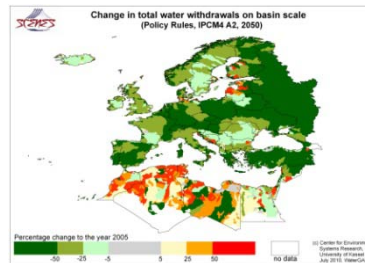
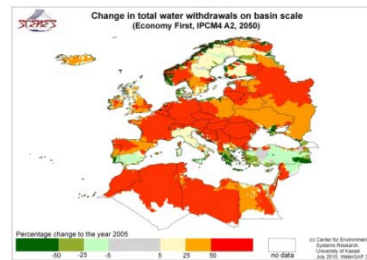


8 maps for most indicators

$$2 \times 4 \times 28 = 224 \text{ maps}$$

IPCM4

MIMR



Economy first

Policy rules

Fortress Europe

Sustainability eventually

only time for a few ...



General water quantity

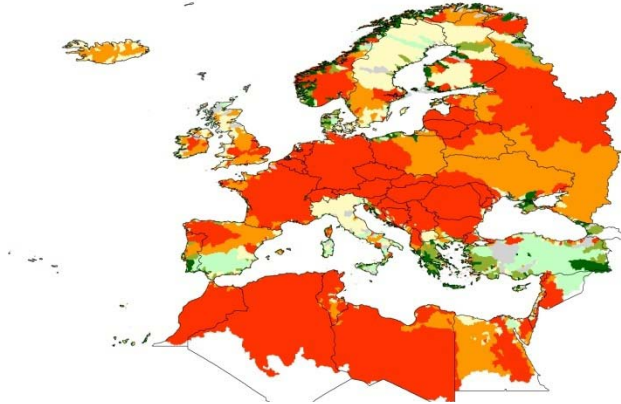


- Water stress = $\frac{\text{water withdrawal}}{\text{water availability}}$
- Water consumption = $\frac{\text{water consumption}}{\text{water availability}}$
- Water scarcity = $\frac{\text{water consumption}}{\text{low flow (Q}_{90}\text{)}}$

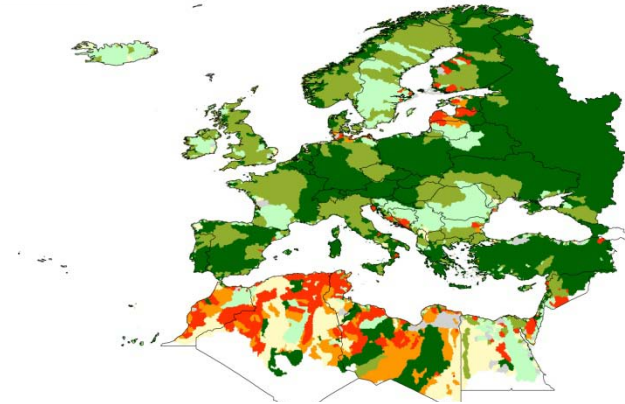


Change in water withdrawals

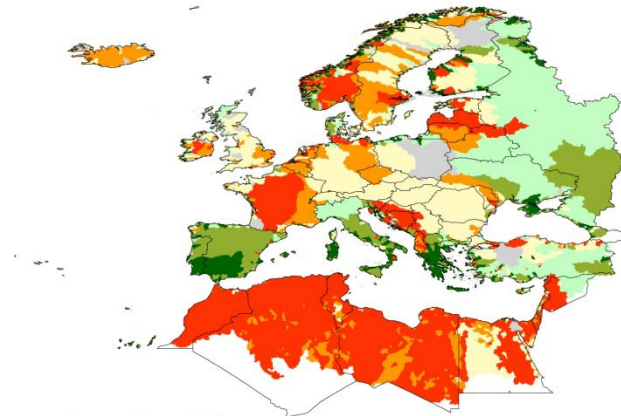
Economy first



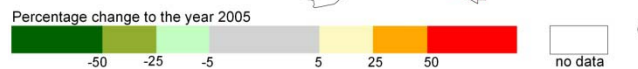
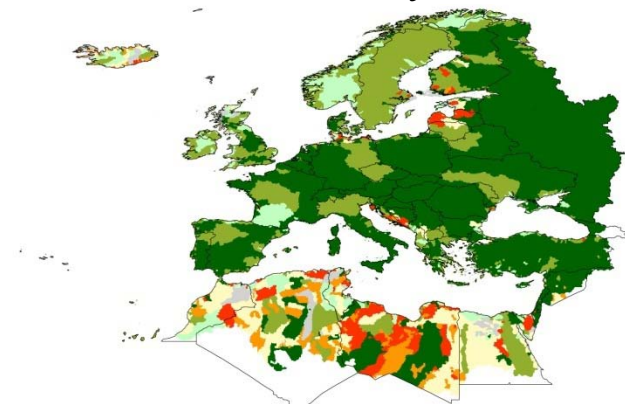
Policy rules



Fortress Europe

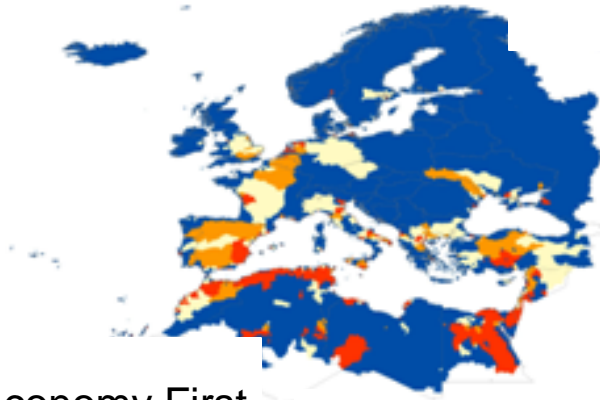


Sustainability eventually

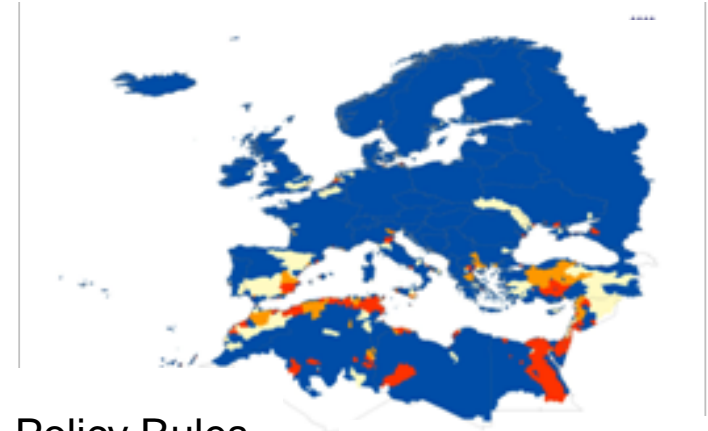




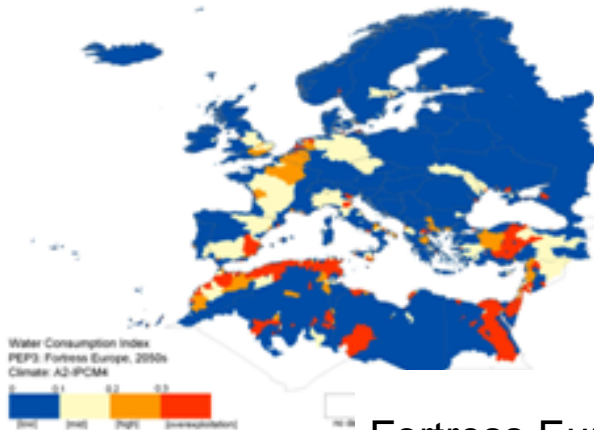
Water consumption index



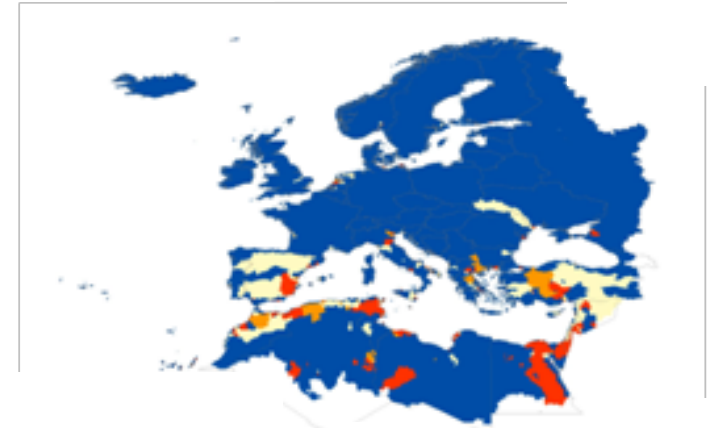
Economy First



Policy Rules



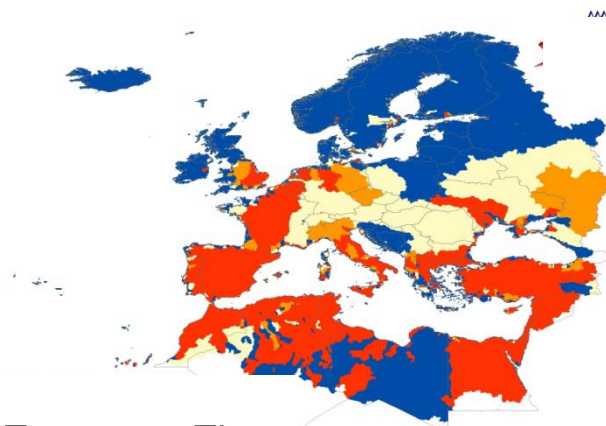
Fortress Europe



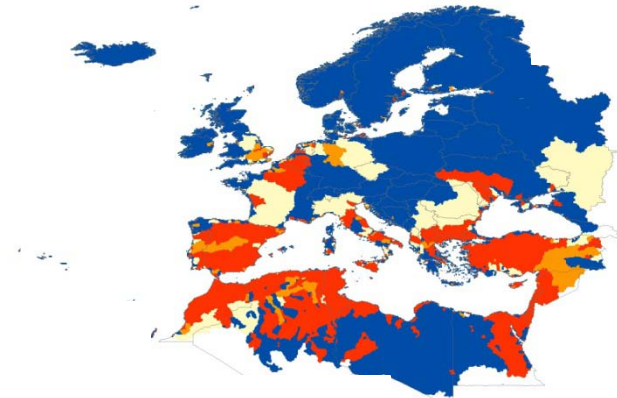
Sustainability Eventually



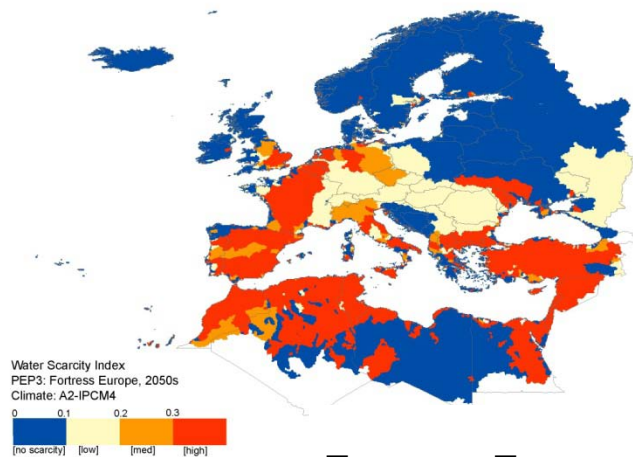
Water scarcity index



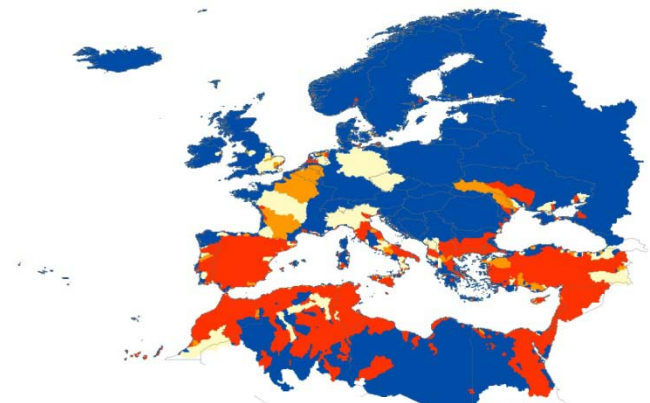
Economy First



Policy Rules



Fortress Europe

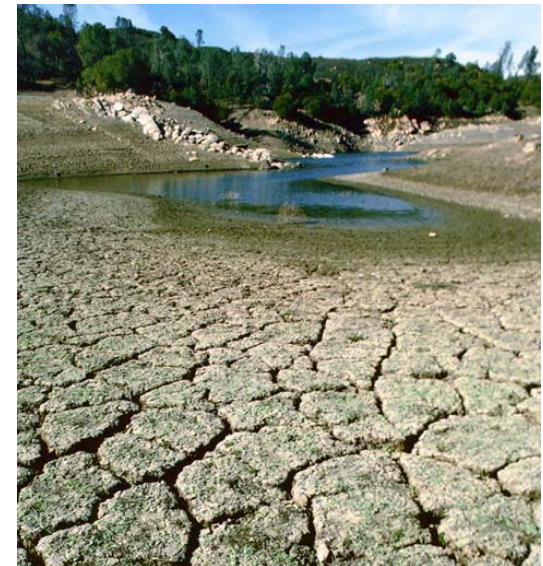


Sustainability Eventually



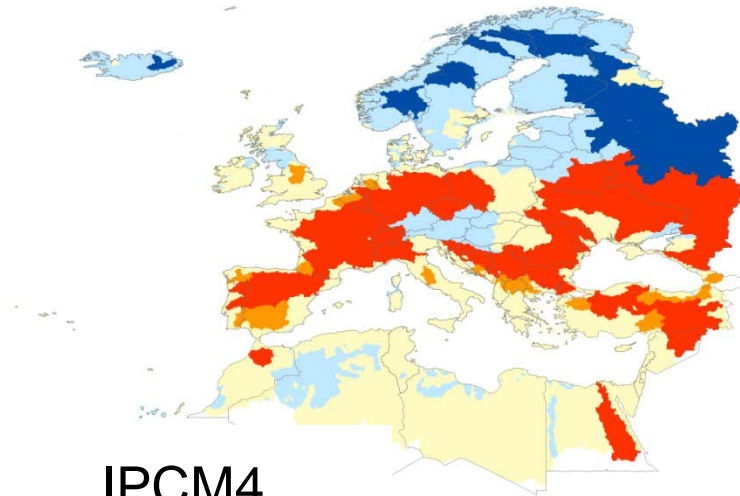
Drought indicators

- Drought frequency low flow (Q_{90})
 → more frequent Q_{85} or less frequent (Q_{95})
- Drought severity
$$\frac{\text{low flow future} - \text{low flow today}}{\text{low flow today } (Q_{90})}$$

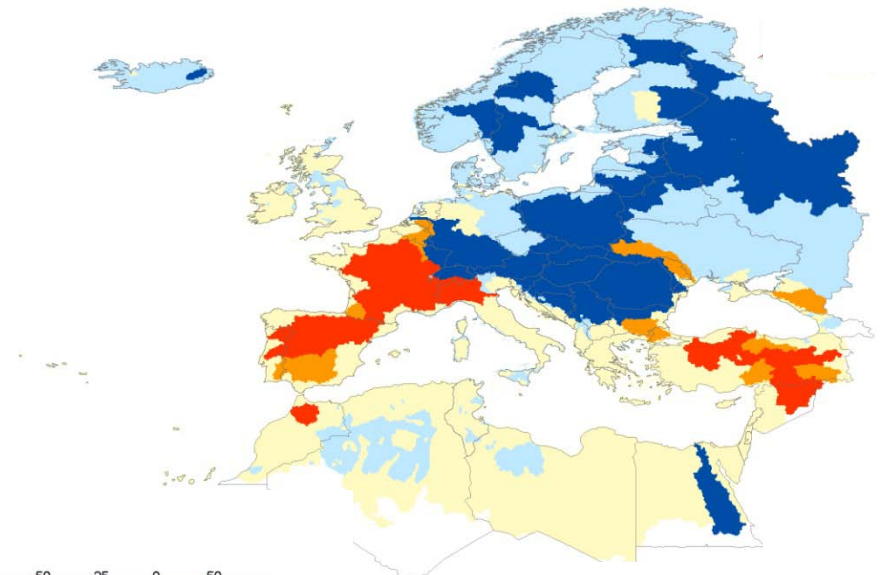




Change in severity of drought



IPCM4



MIMR

based on climate only



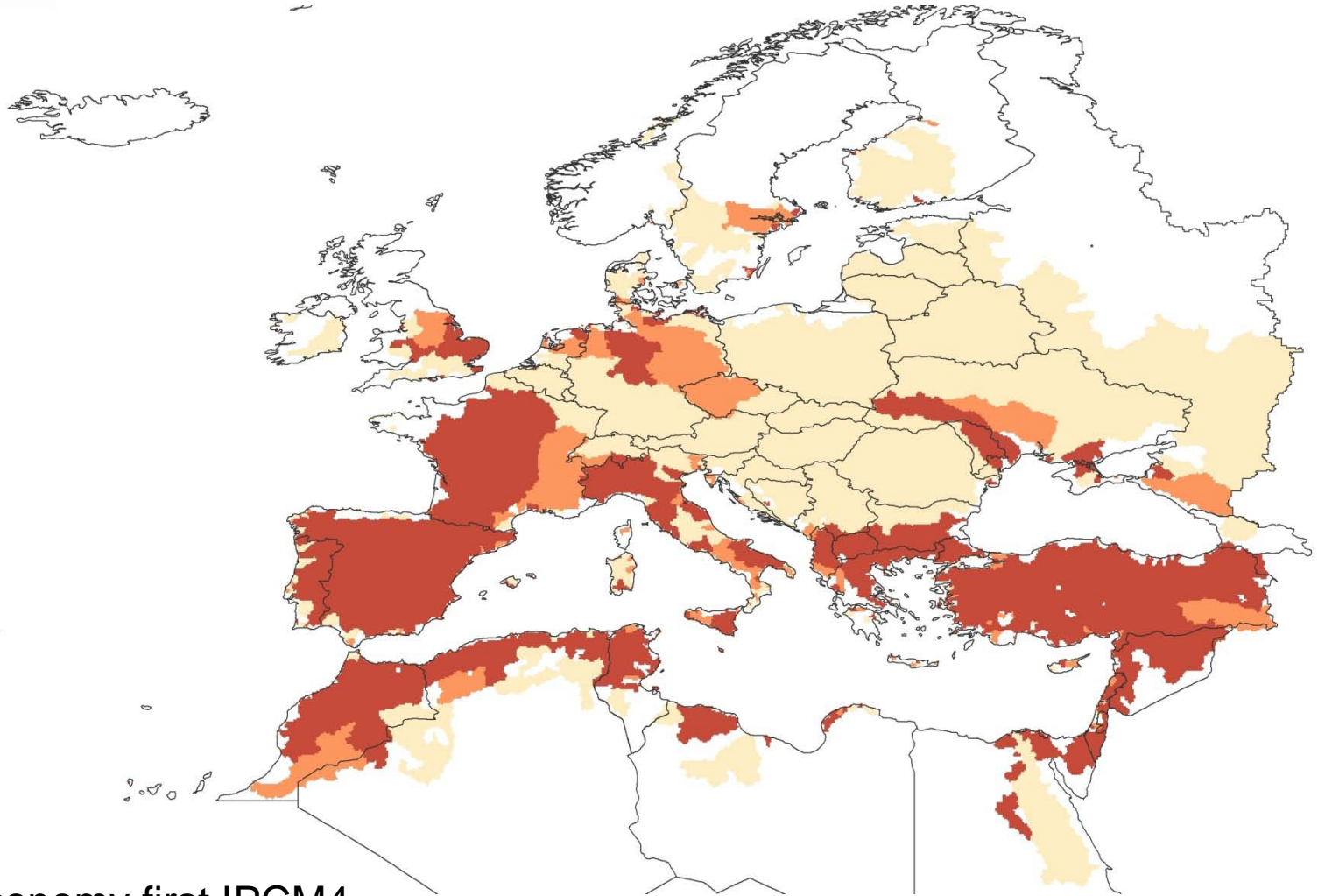
Food indicators

- Irrigation stress = $\frac{\text{water withdrawal}}{\text{water availability}}$





Irrigation water stress summer



Economy first IPCM4

0 - 0.2

[low water stress]

0.2 - 0.4

[mid water stress]

more than 0.4

[severe water stress]



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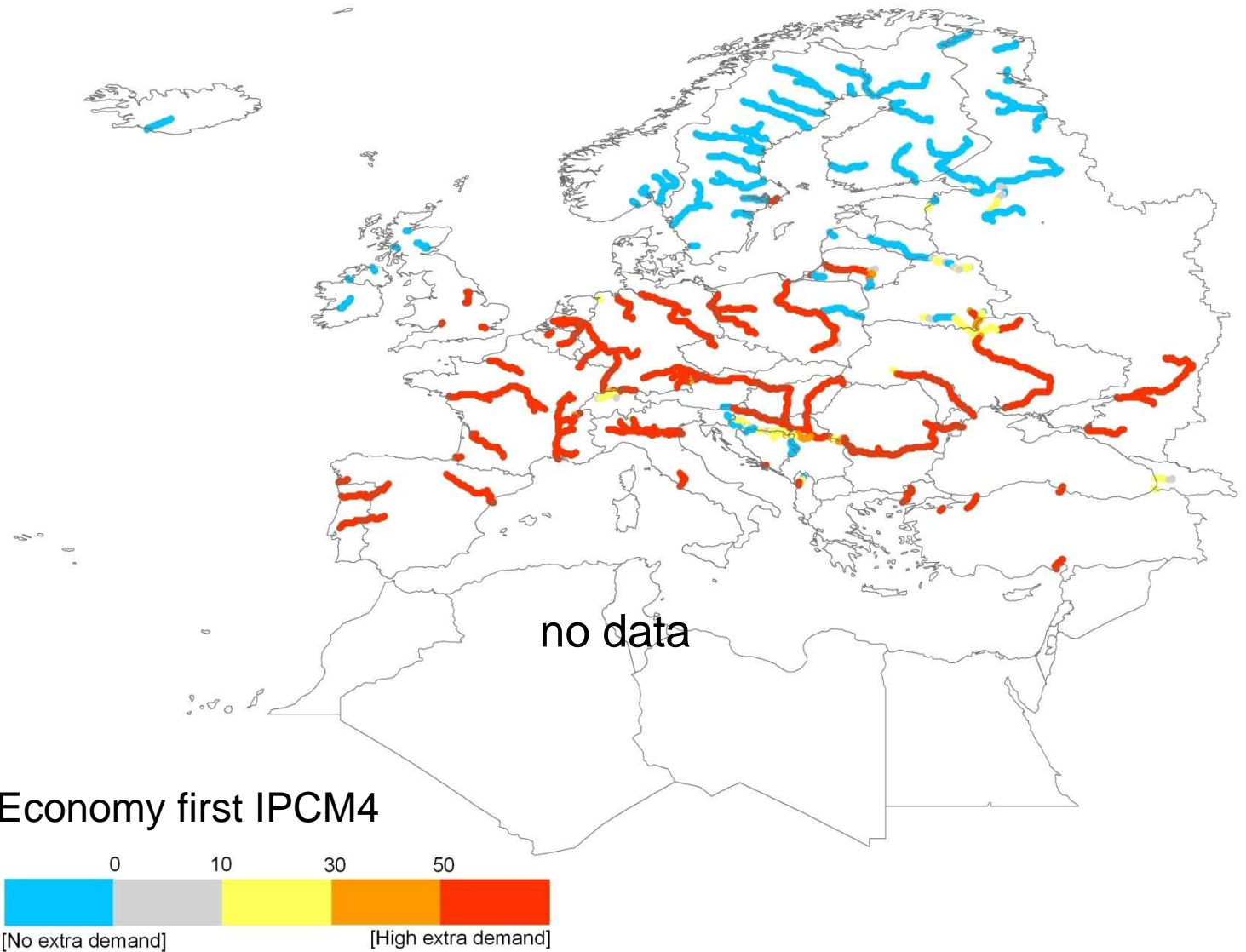
Industry/energy indicators

- % increase in water withdrawal



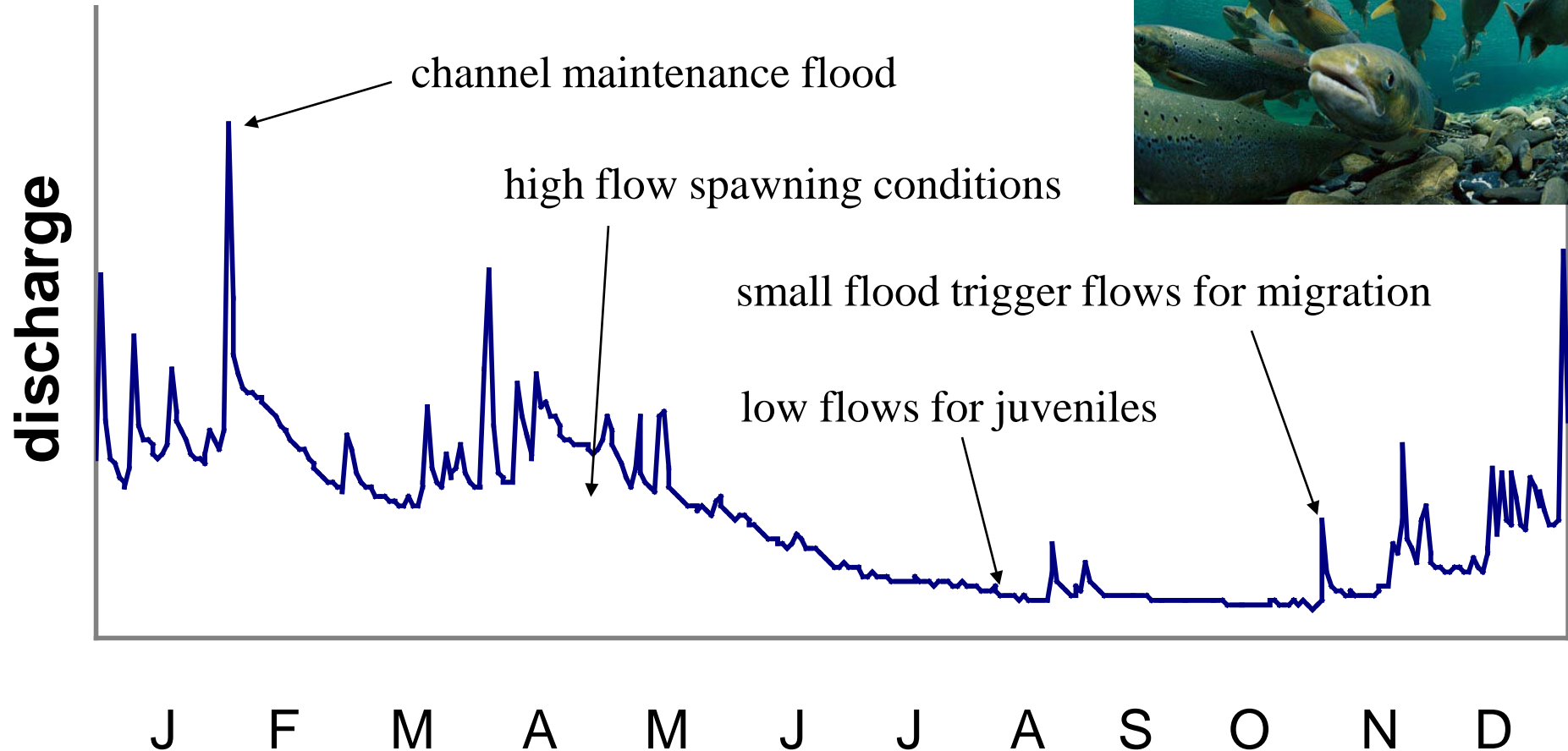


Industrial (cooling) demand





Ecological indicators





Environmental Indicators



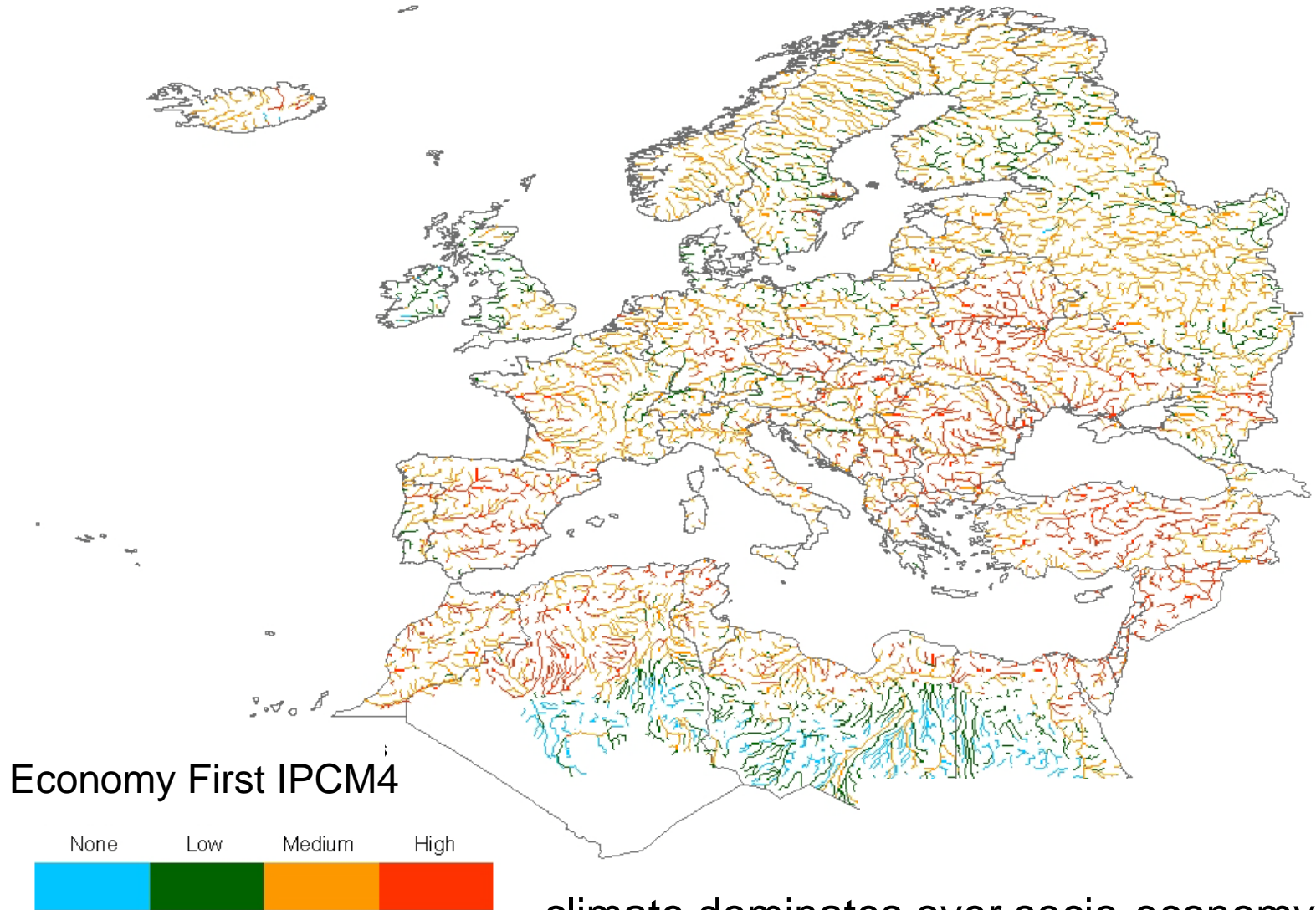
16 elements of flow regime (change + or -)

- No elements of flow change
- 1-5 elements change
- 6-10 elements change
- 10-16 elements change





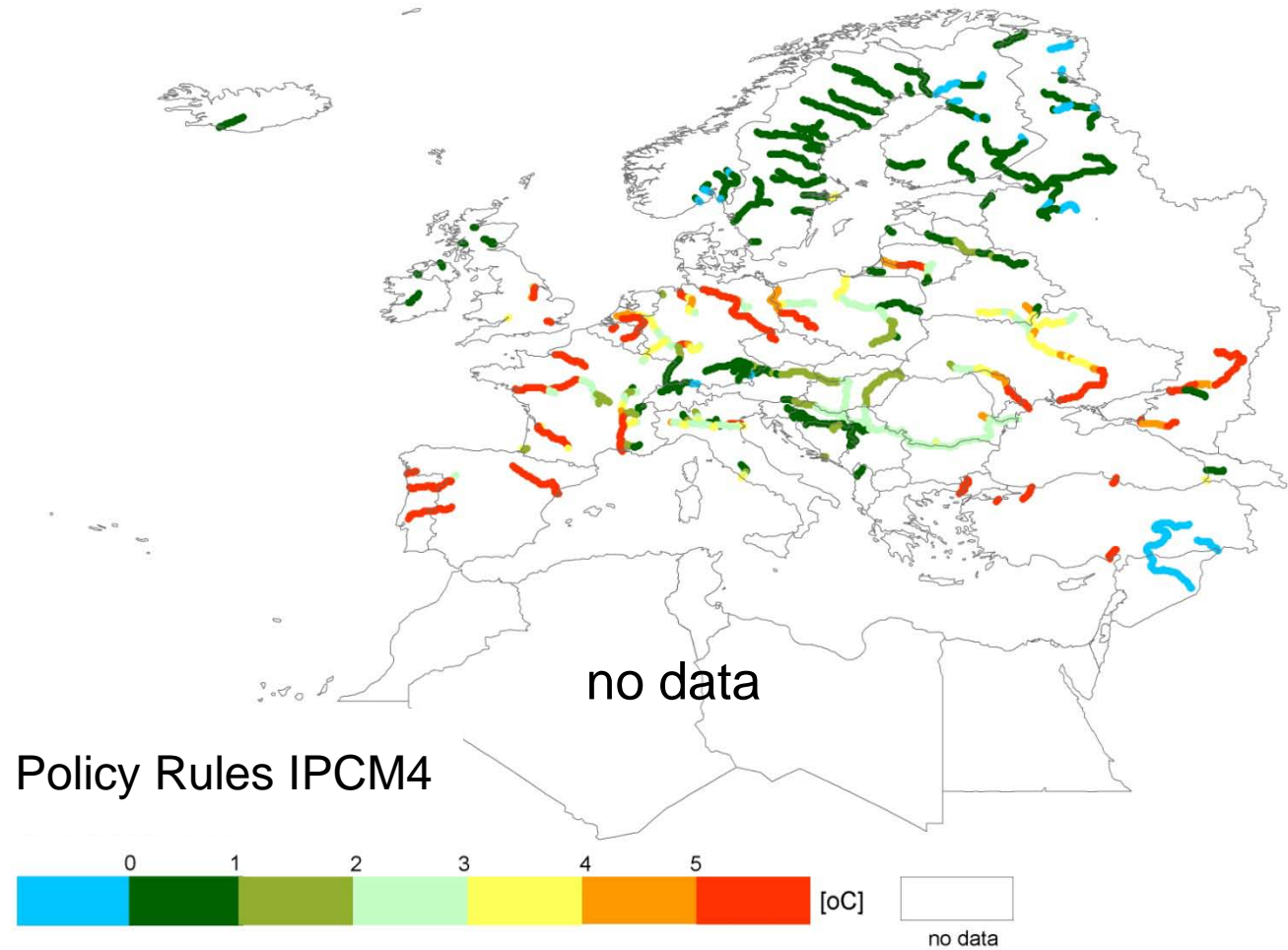
Environmental flows



climate dominates over socio-economy



Water temperature increase



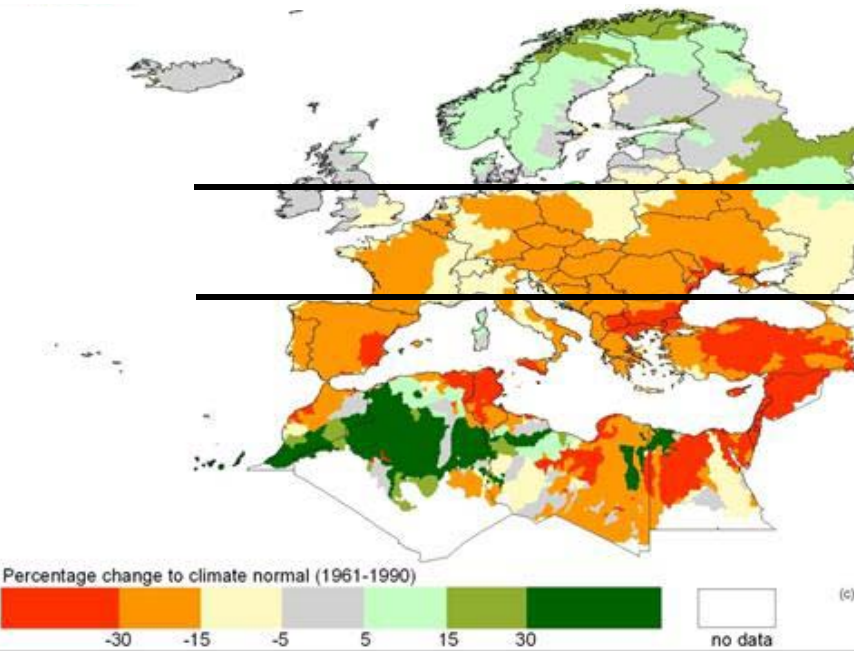
Regional scale



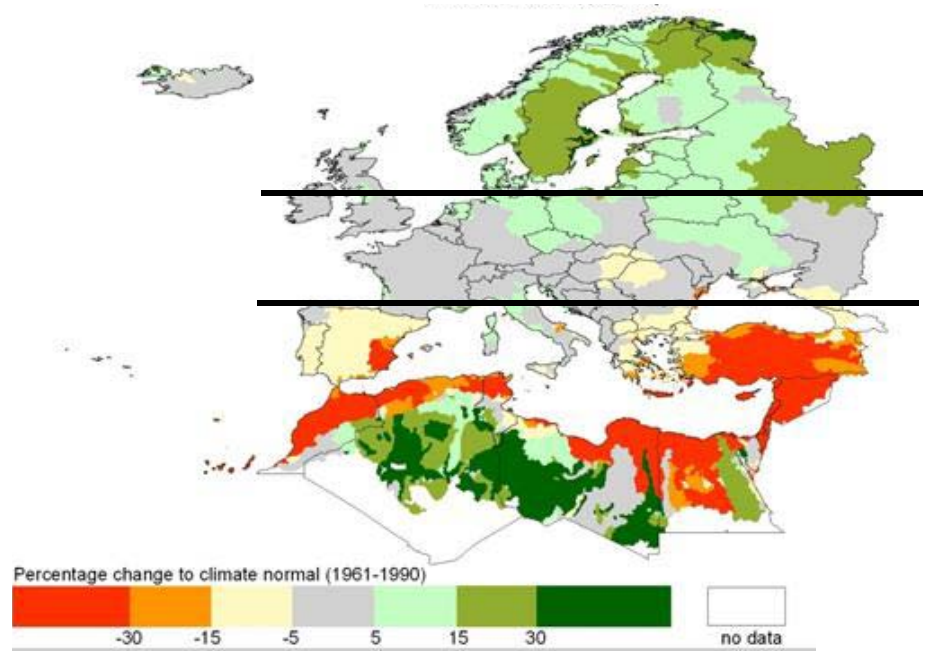


Latitude dominates

IPCM4



MIMR

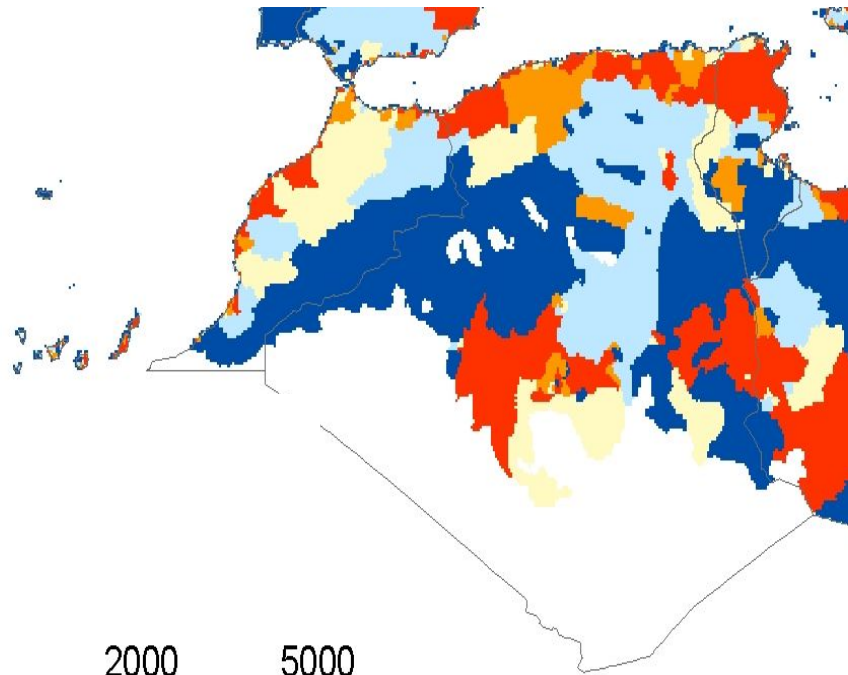


greater reductions in water availability in the south

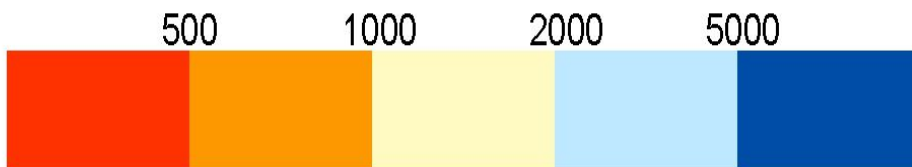


North Africa

low domestic water availability along the coast



PoR MIMR



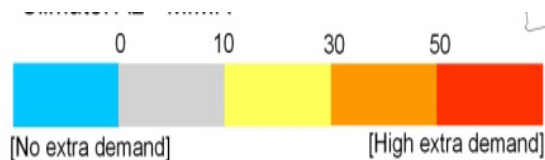
large changes



Western Europe



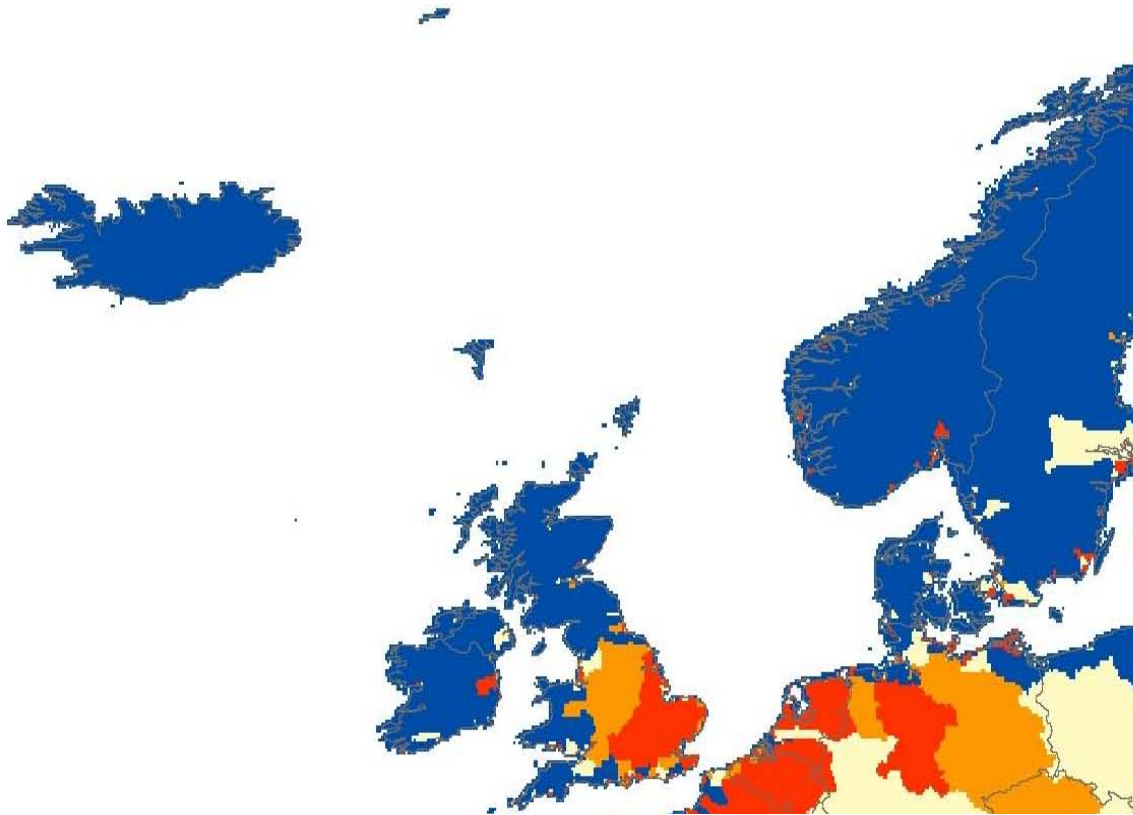
high extra
demand for
cooling water



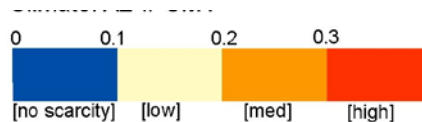
[%] PoR MIMR



Northern Europe



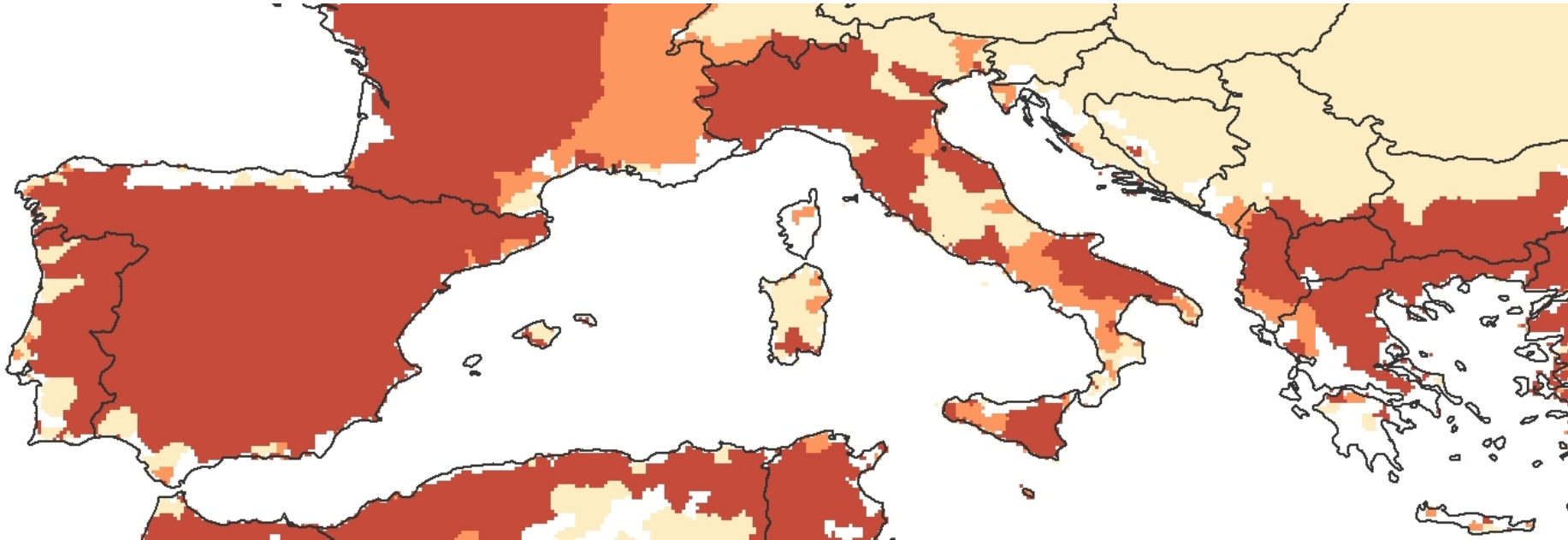
EcF IPCM4



No water scarcity except SE UK



Southern Europe



irrigation-withdrawals-to-availability ratio

0 - 0.2

[low water stress]

0.2 - 0.4

[mid water stress]

more than 0.4

[severe water stress]

EcF IPCM4

Severe irrigation stress in summer



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Eastern Europe east



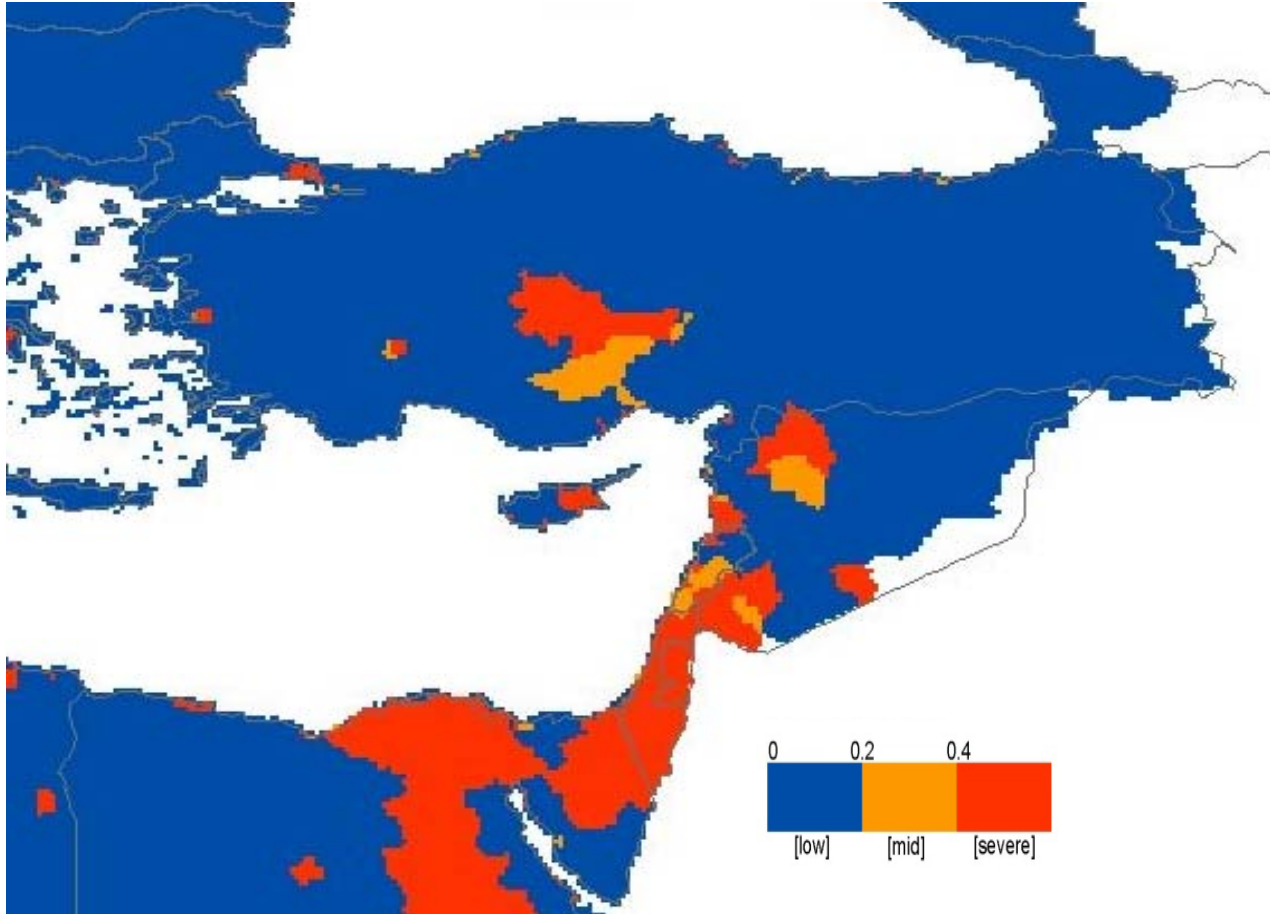
medium to high
impacts on river
ecosystems



SuE IPCM4



West Asia

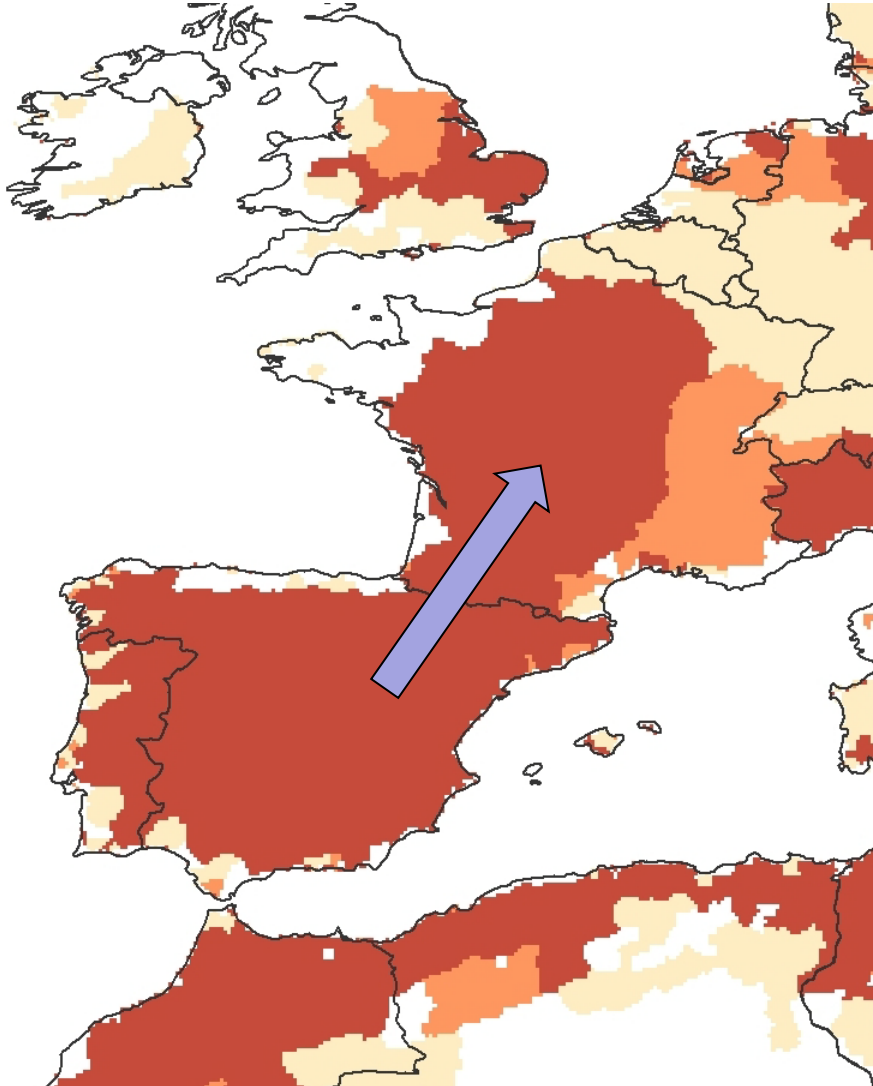


low to severe
domestic water
stress

PoR MIMR



Regional shifts



shift in irrigated
area from
southern Europe
to western Europe.

EcF IPCM4



Summary

- Large differences between regions – direction and severity
- IPCM4 shows more severe impacts than MIMR
- Impacts broadly related to latitude – most negative impacts in the south
- High water stress in north Africa and southern Europe
- Low stress in northern Europe, but “hot spots”
- Northerly shift in agriculture





Implications

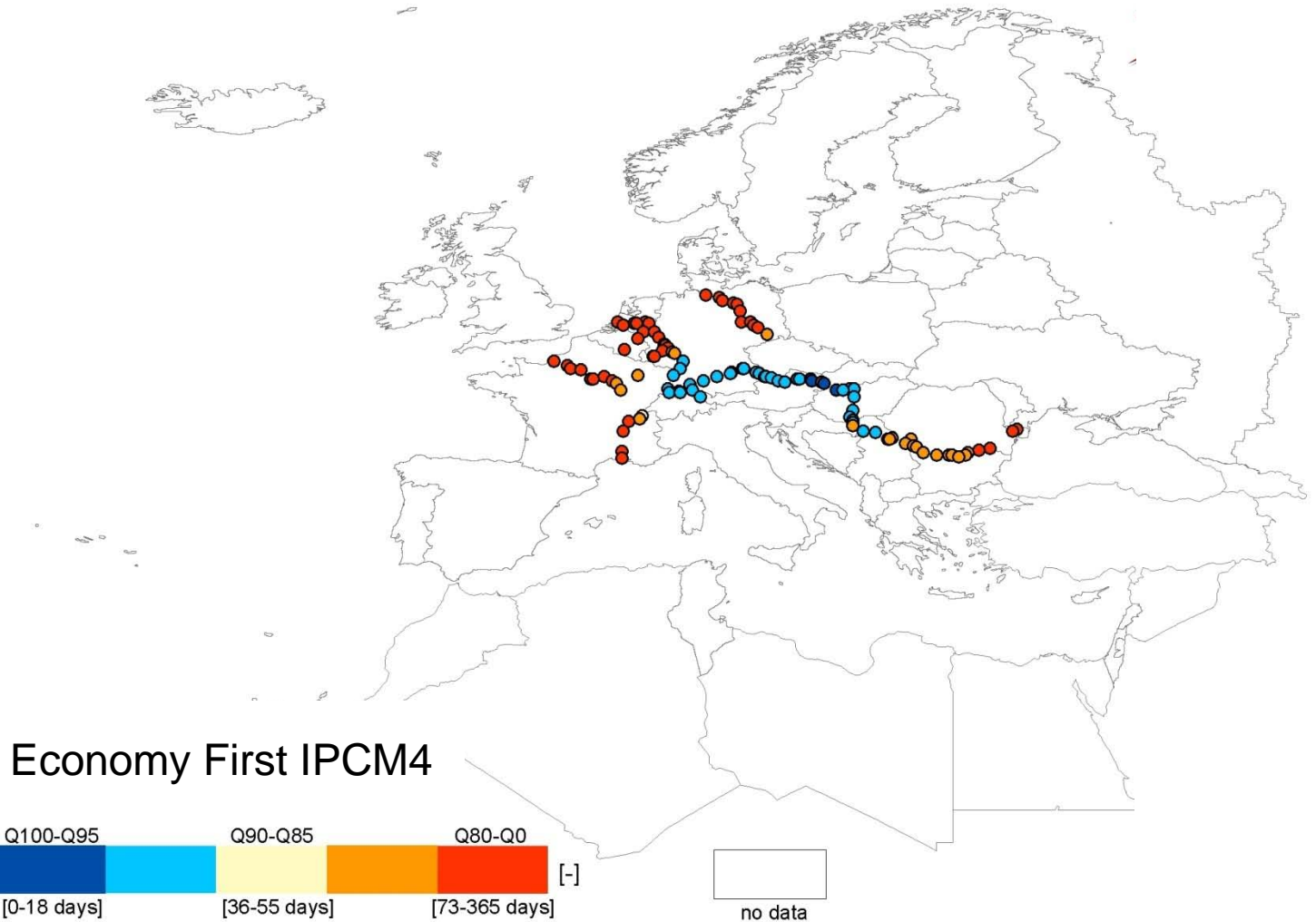
- Understand the indicators
- Stories – not predictions
- Regional patterns – not local detail
- Allocation priority is important
- Process more important than results



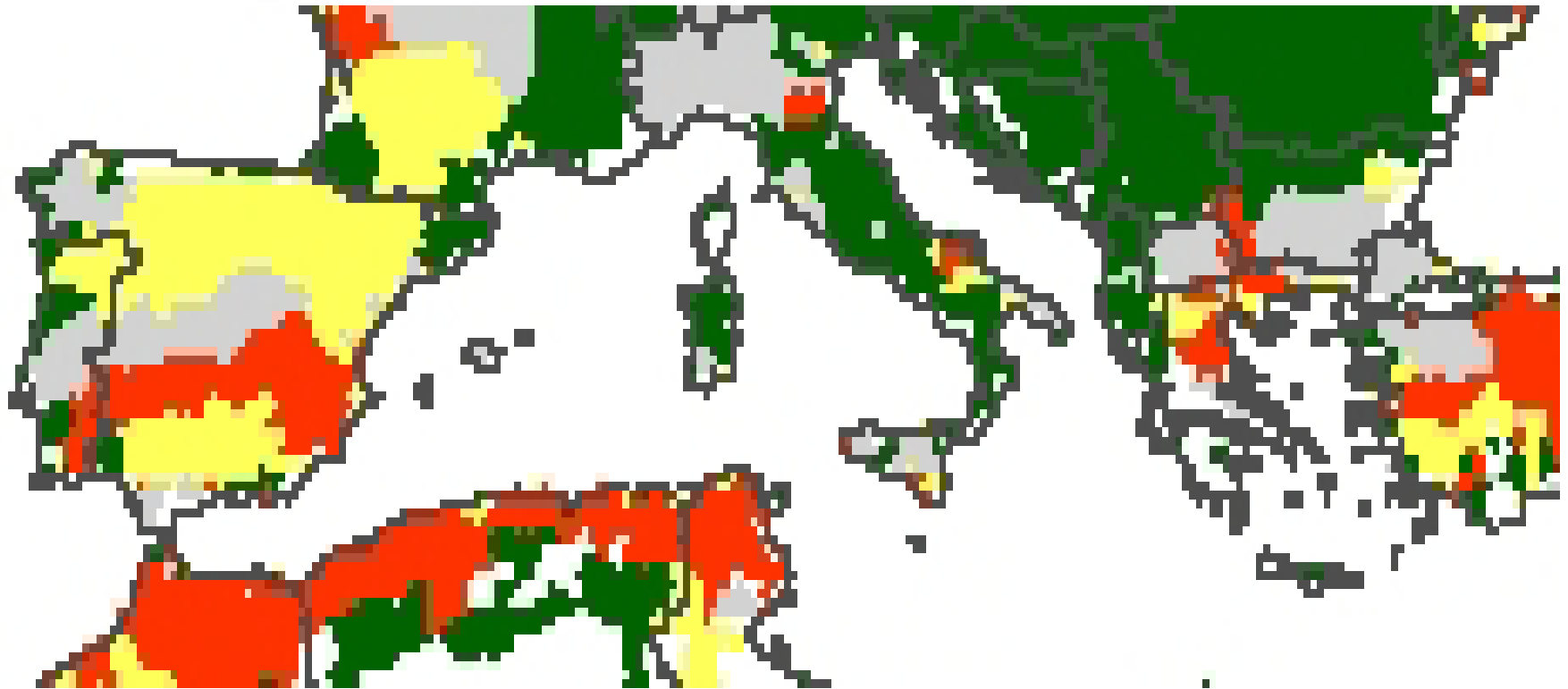




Navigation

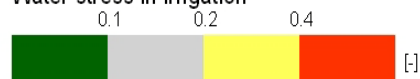


Southern Europe



High water stress for irrigation in Spain

IPCM4 A2, 2050
Water stress in irrigation



EcF IPCM4



Water is essential for all life

**Changes in water availability will impact
on all of us**

and almost everything we do



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