# Future impacts on pan-European environmental flows

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## 1 Introduction

This poster presents a large-scale assessment of a set of climate and socio-economic scenarios for Europe's freshwater futures up to 2050, covering EU countries and neighbours, Mediterranean rim countries of north Africa and the near East. The study aim: (1) to map the severity of potential future impacts of these scenarios on aquatic and riparian ecosystems in the region; and (2) to identify which scenarios have most/least influence. The methodology is based conceptually on the Range of Variability Approach (RVA) using the Indicators of Hydrological Alteration (IHA): a desk-top technique for assessing environmental flow requirements. Major rivers and their tributaries are represented as ~35,000 contiguous cells (0.5' longitude x 0.5' latitude) within the WaterGAP (Water - Global Assessment and Prognosis) model. For each cell, monthly flows were generated for an ensemble of 10 future change scenarios consisting of combinations of two climate scenarios (IPCM4 and MIMR) and four socio-economic water-use scenarios for 2040-2069. Given the high number of sites and scenarios, the IHA/RVA was adapted to use monthly flows and results aggregated using a simple colour coding system to aid mapping and interpretation.

**Table 1** Environmental flow indicators

| *Regime characteristic* | *Parameter monthly (one value per year)* | *Indicator (one value per record)* |
|---|---|---|
| Flood Magnitude & Frequency | Number of times that monthly flow exceeds threshold (all-data naturalised Q5 from 1961-1990) | Median & Interquartile Range |
| Flood Timing | Month of maximum flow (as number 1 to 12) | Mode |
| Seasonal Flow | January flow (mm runoff) | Median & Interquartile Range |
| | April flow (mm runoff) | Median & Interquartile Range |
| | July flow (mm runoff) | Median & Interquartile Range |
| | October flow (mm runoff) | Median & Interquartile Range |
| Low Flow Magnitude & Frequency | Number of months that flow is less than threshold (thresholds = all-data naturalised Q95 from 1961-1990) | Median & Interquartile Range |
| Minimum Flow Timing | Month of minimum flow (as number 1 to 12) | Mode |
| Low Flow Duration | Number of times that two consecutive months are less than threshold (all-data naturalised Q95 from 1961-1990) | Median & Interquartile Range |

**Table 2** Distribution of impact levels per runs (% of cells)

| | | None | Low | Med | High |
|---|---|---|---|---|---|
| IPCM4 | Natural | 5 | 28 | 51 | 15 |
| | EcF | 5 | 21 | 53 | 21 |
| | FoE | 5 | 21 | 54 | 20 |
| | PoR | 5 | 22 | 54 | 19 |
| | SuE | 5 | 23 | 54 | 19 |
| MIMR | Natural | 5 | 29 | 53 | 13 |
| | EcF | 5 | 27 | 53 | 16 |
| | FoE | 5 | 27 | 53 | 15 |
| | PoR | 5 | 28 | 53 | 14 |
| | SuE | 5 | 29 | 53 | 14 |

**Table 3** Differences in impact levels between runs (% of differing cells)

| | IPCM4 Natural | IPCM4 EcF | IPCM4 FoE | IPCM4 PoR | IPCM4 SuE | MIMR Natural | MIMR EcF | MIMR FoE | MIMR PoR | MIMR SuE |
|---|---|---|---|---|---|---|---|---|---|---|
| IPCM4 Natural | | 21 | 20 | 18 | 17 | 35 | 37 | 36 | 36 | 36 |
| IPCM4 EcF | 21 | | 5 | 7 | 9 | 37 | 34 | 35 | 37 | 37 |
| IPCM4 FoE | 20 | 5 | | 5 | 6 | 36 | 33 | 34 | 36 | 36 |
| IPCM4 PoR | 18 | 7 | 5 | | 4 | 35 | 33 | 33 | 34 | 35 |
| IPCM4 SuE | 17 | 9 | 6 | 4 | | 34 | 32 | 33 | 34 | 34 |
| MIMR Natural | 35 | 37 | 36 | 35 | 34 | | 10 | 8 | 5 | 3 |
| MIMR EcF | 37 | 34 | 33 | 33 | 32 | 10 | | 5 | 8 | 9 |
| MIMR FoE | 36 | 35 | 34 | 33 | 33 | 8 | 5 | | 5 | 7 |
| MIMR PoR | 36 | 37 | 36 | 34 | 34 | 5 | 8 | 5 | | 4 |
| MIMR SuE | 36 | 37 | 36 | 35 | 34 | 3 | 9 | 7 | 4 | |

## 2 Data and Method Flow Chart

**Historical climate data**

*Climate Research Unit, University of East Anglia, UK*

Period: 1961-1990;

**Climate Models (x2)**

1. **IPCM4** *IPSL-CM4; Institut Pierre Simon Laplace, France*
2. **MIMR** *GCM MICRO3.2; Center for Climate System Research, University of Tokyo, Japan*

Period: 2040-2069 ('2050s'); IPCC SRES A2 emission scenario (global greenhouse gas emissions to rising steadily and possibly doubling by 2050)

**WaterGAP Model**

Water - Global Assessment and Prognosis

Grid cell size: 0.5' lat x 0.5' long

**Climate model outputs only**

**Socio-Economic Scenarios (x4)**

**Economy First (EcF)**
economy-oriented towards globalisation and liberalisation with intensified agriculture and slow diffusion of water-efficient technologies

**Fortress Europe (FoE)**
closed-border Europe concentrating on common security issues with food and energy independence as the main focus of the European coalition

**Policy Rules (PoR)**
stronger coordination of policies at the European level, driven in part by high energy costs and reduced access to energy supplies, expectation of climate change impacts and increasing water demand

**Sustainability Eventually (SuE)**
transition from globalising, market-oriented Europe to environmental sustainability with quality of life as a central point

Naturalised monthly river flows 1961-1990

**BASELINE**

2 x naturalised monthly river flow series 2040-2069

**IPCM4 Natural**
**MIMR Natural**

8 x monthly river flow series 2040-2069

**IPCM4 EcF, FoE, PoR, SuE**
**MIMR EcF, FoE, PoR, SuE**

**Nine** parameters (one value per year of record per site)
**16 indicators** (one value per period of record per site) as median (magnitude) and interquartile range (variability); (modes for flood and minimum flow timing) ie 7 magnitude indicators + 7 variability indicators + 2 mode indicators
(baseline + 10 modelled series) ***TABLE 1***

Absolute **differences** between **baseline** and **modelled** indicators

Indicators flagged as different from baseline if change > **thresholds**: (30% for median and interquartile range; 1 month for mode)

**Colour-coding system**: blue, green, amber, or red when number of indicators differing from baseline is 0, 1-5, 6-10, or 11-16, respectively

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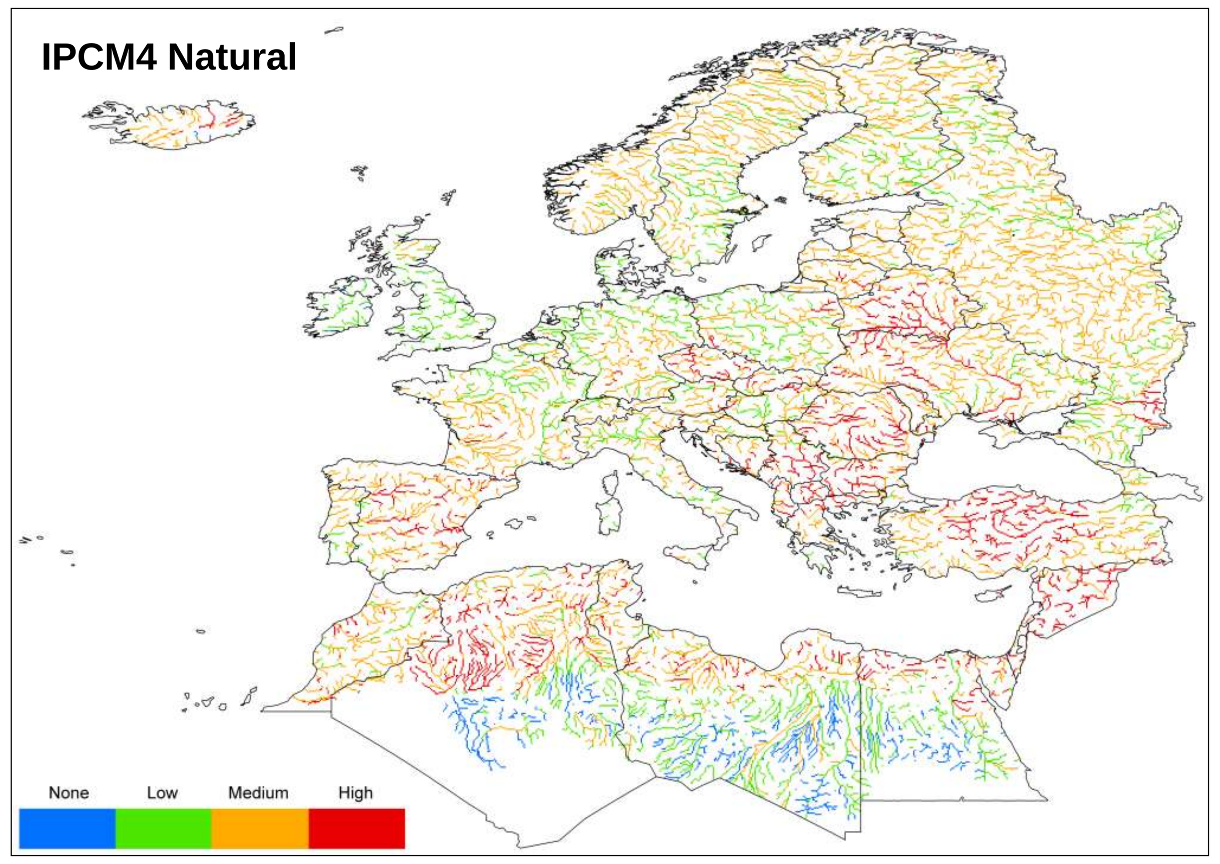


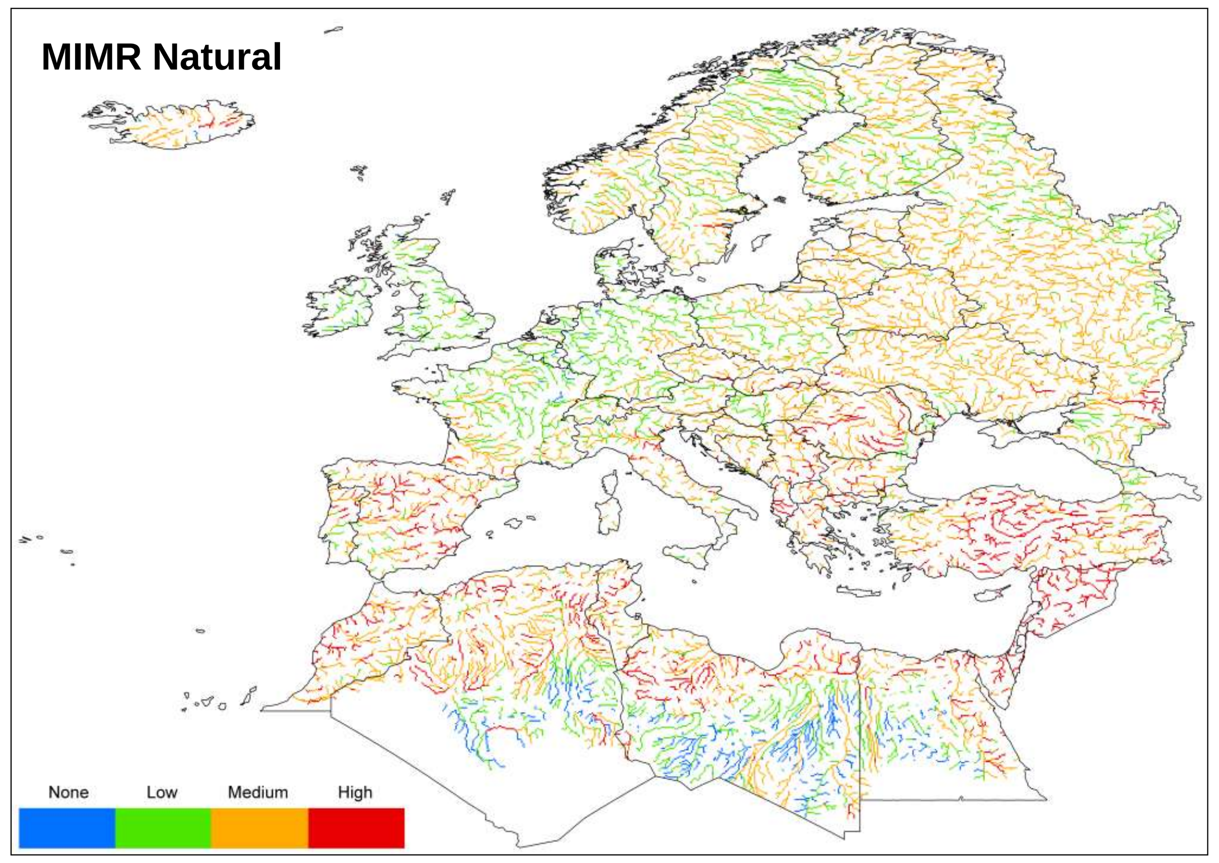


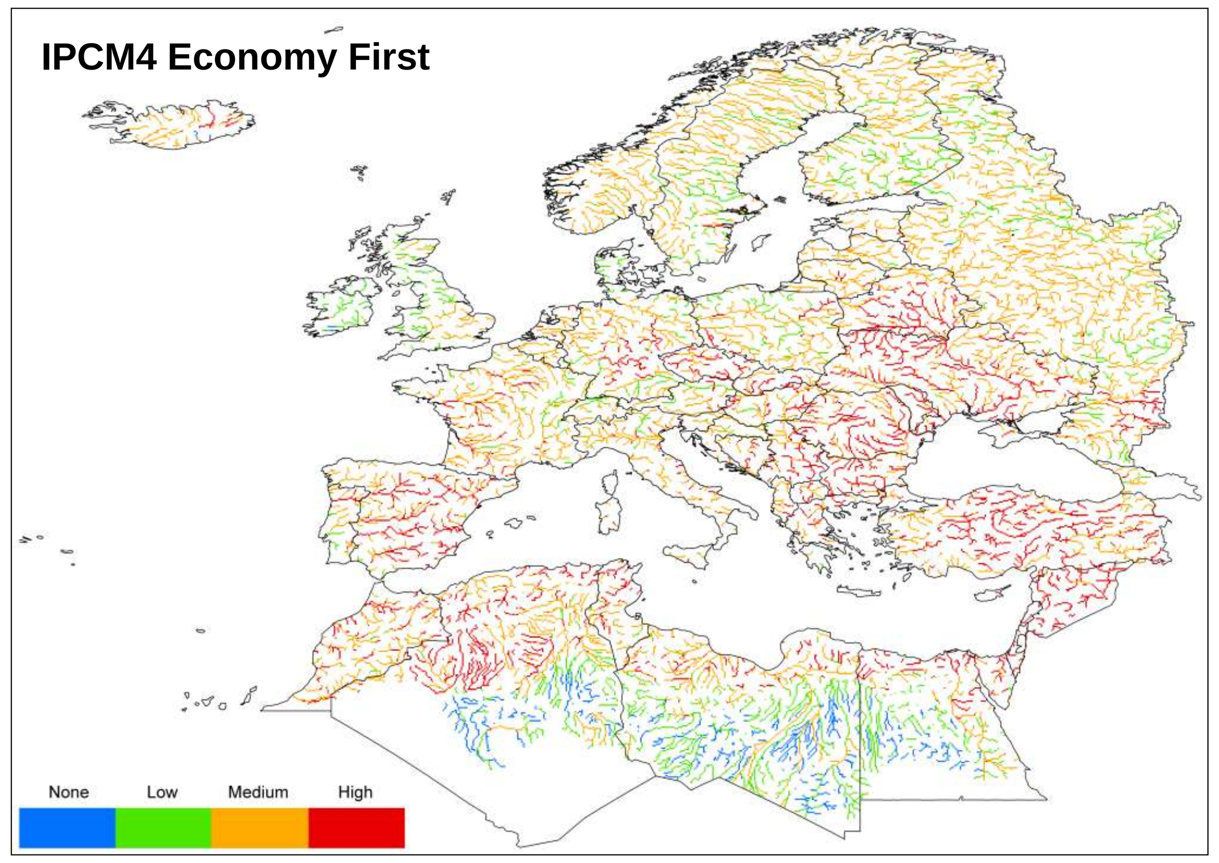


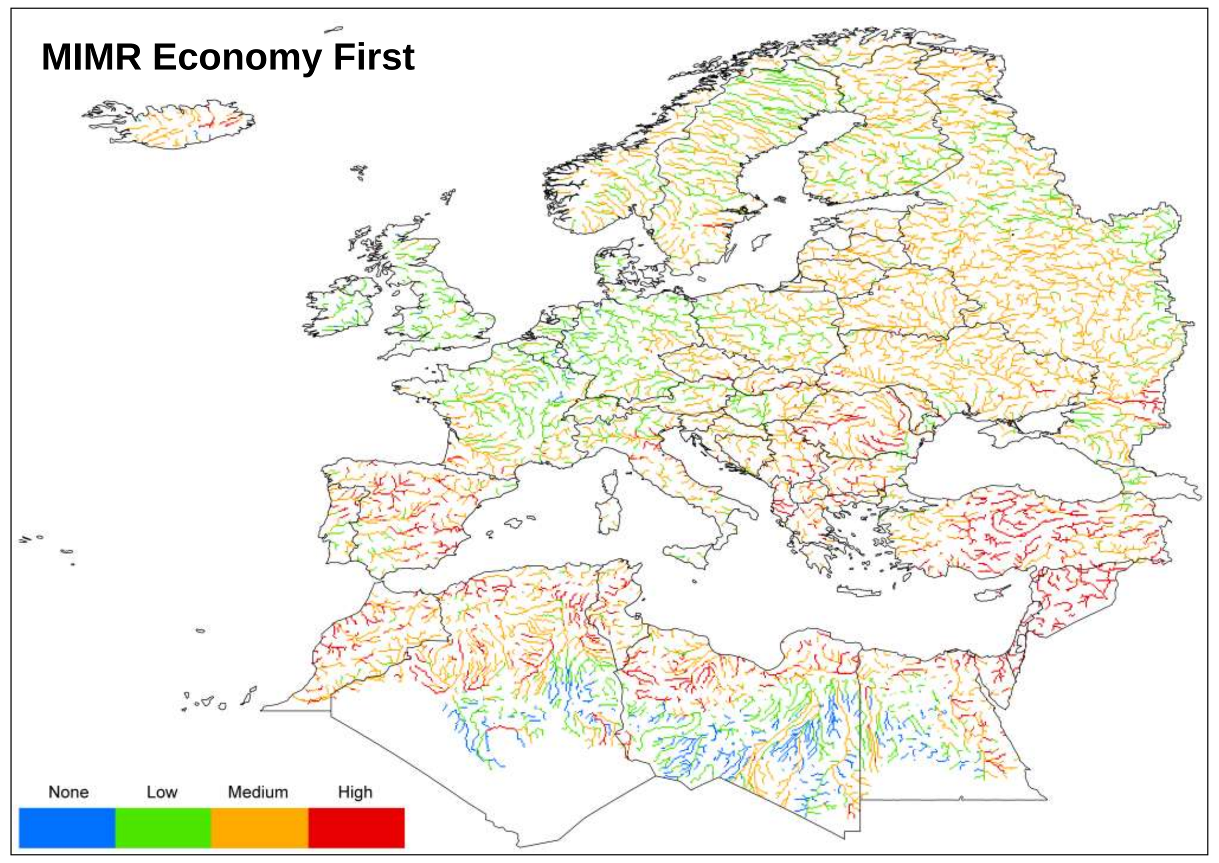


## 3 Results

*Overall future impacts (Table 2 and maps)*
- Under all projections, most rivers are impacted (> 50% of cells medium impact and 15-20% high impact)
- Total numbers of cells in each impact category are very similar for all projections (but MIMR less impacted than IPCM4)

*Differences between climate models and socio-economic scenarios (Table3 and maps)*
- MIMR runs ~30% different from IPCM4 runs
- Socio-economic scenarios ~20% from IPCM4 Natural and up to 10% from MIMR Natural
- Socio-economic scenarios are quite similar (differences within 4-9% under both climate models; note: maps almost identical, hence only EcF featured)

## 4 Conclusions

- Climate models are primary drivers, socio-economic scenarios are secondary drivers
- Differences between models and scenarios relate mainly to the location of impacts