2nd Workshop on

WATER AND ADAPTATION TO CLIMATE CHANGE IN TRANSBOUNDARY BASINS: CHALLENGES, PROGRESS AND LESSONS LEARNED

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Climate change impacts on water resources in Europe - regional and sectoral perspective

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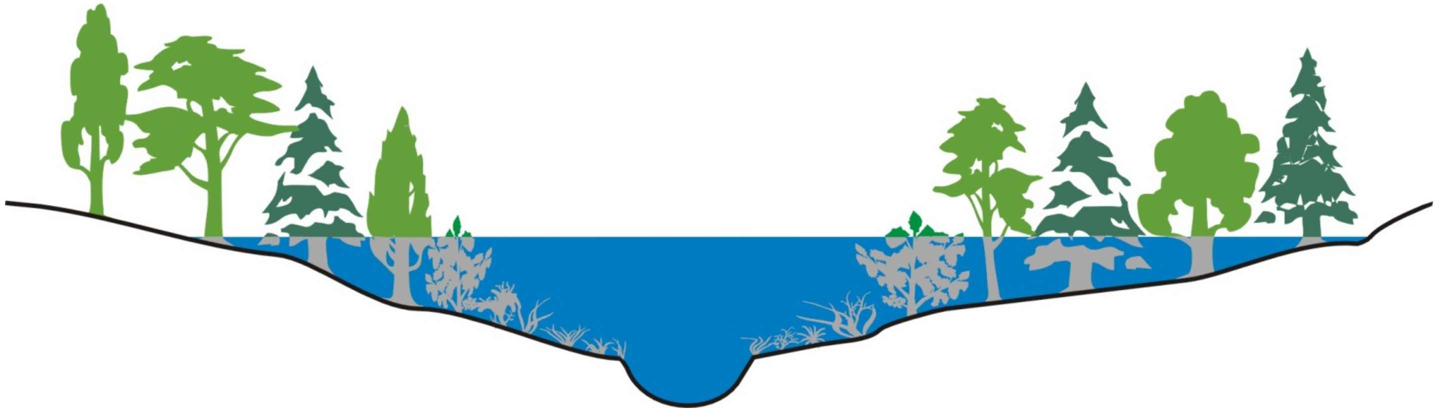
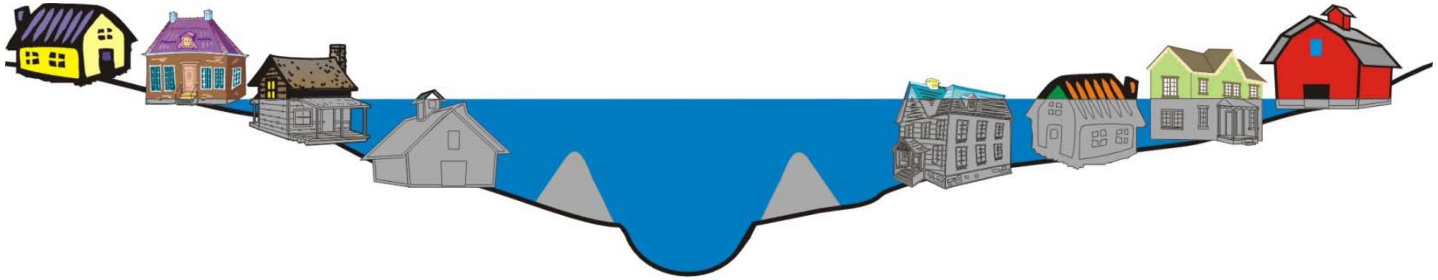
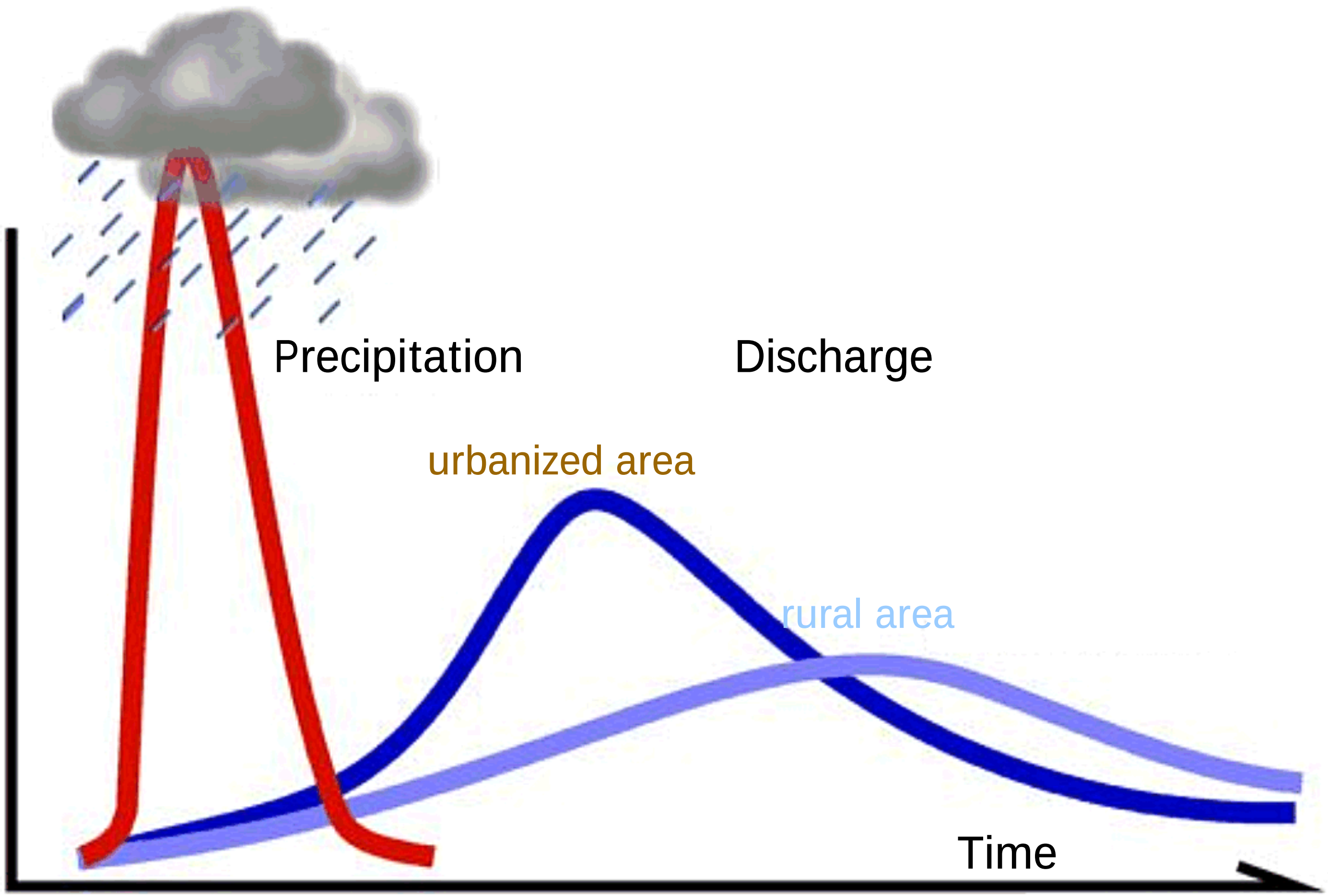
In Europe, all three classes of water-related problems – having **too little water, too much water, or water pollution** – can be exacerbated by climate change.



1000-year flood



Impacts of land-use change on floods



Water holding capacity of the atmosphere

Clausius-Clapeyron equation

$$de_s(T) / e_s(T) = L\, dT / R\, T^2$$

where $e_s(T)$ is the saturation vapor pressure at temperature T,
L is the latent heat of vaporization,
and R is the gas constant.

$T \uparrow \quad e_s(T) \uparrow$

1^{o}C 6-7%

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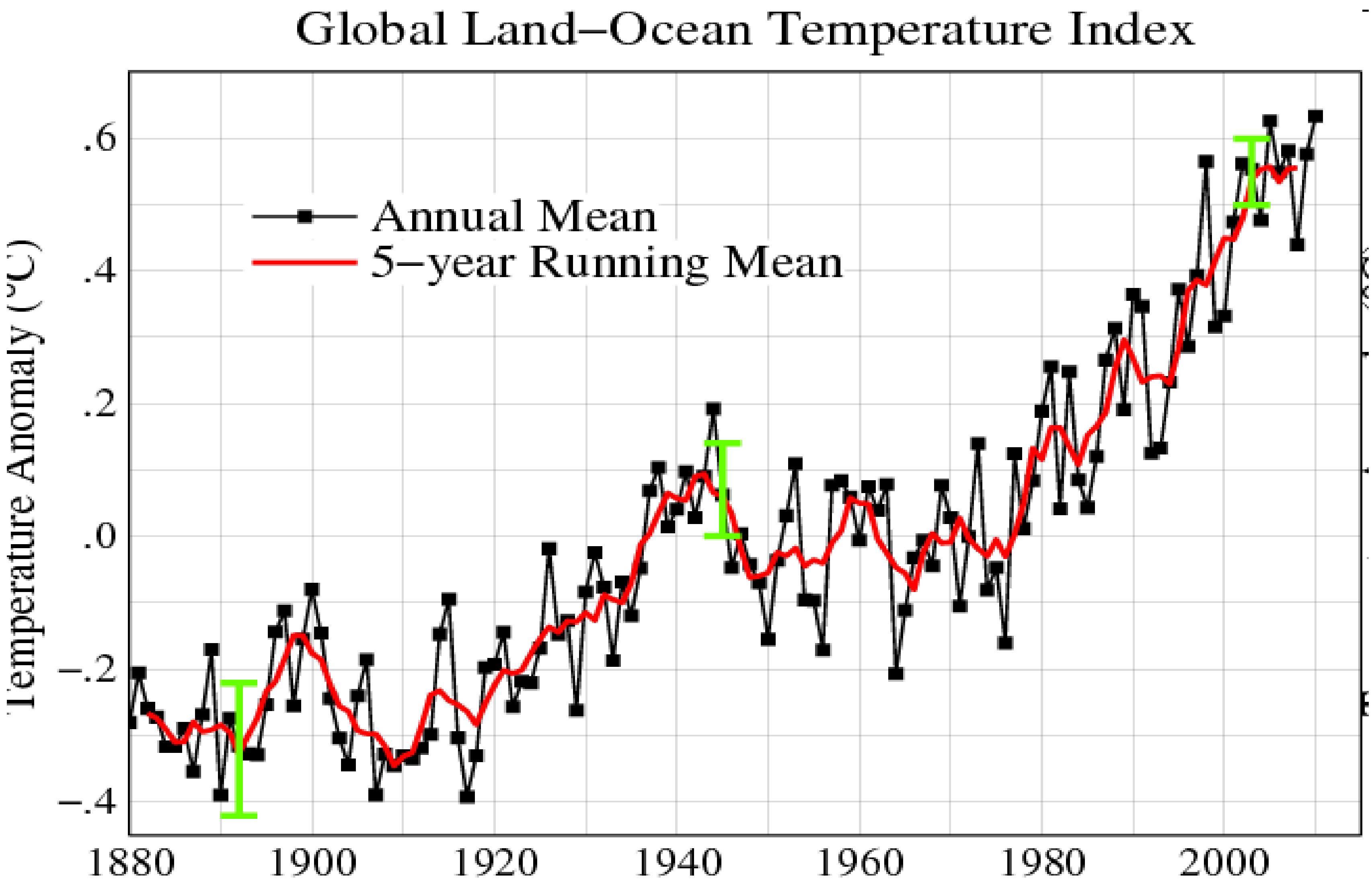
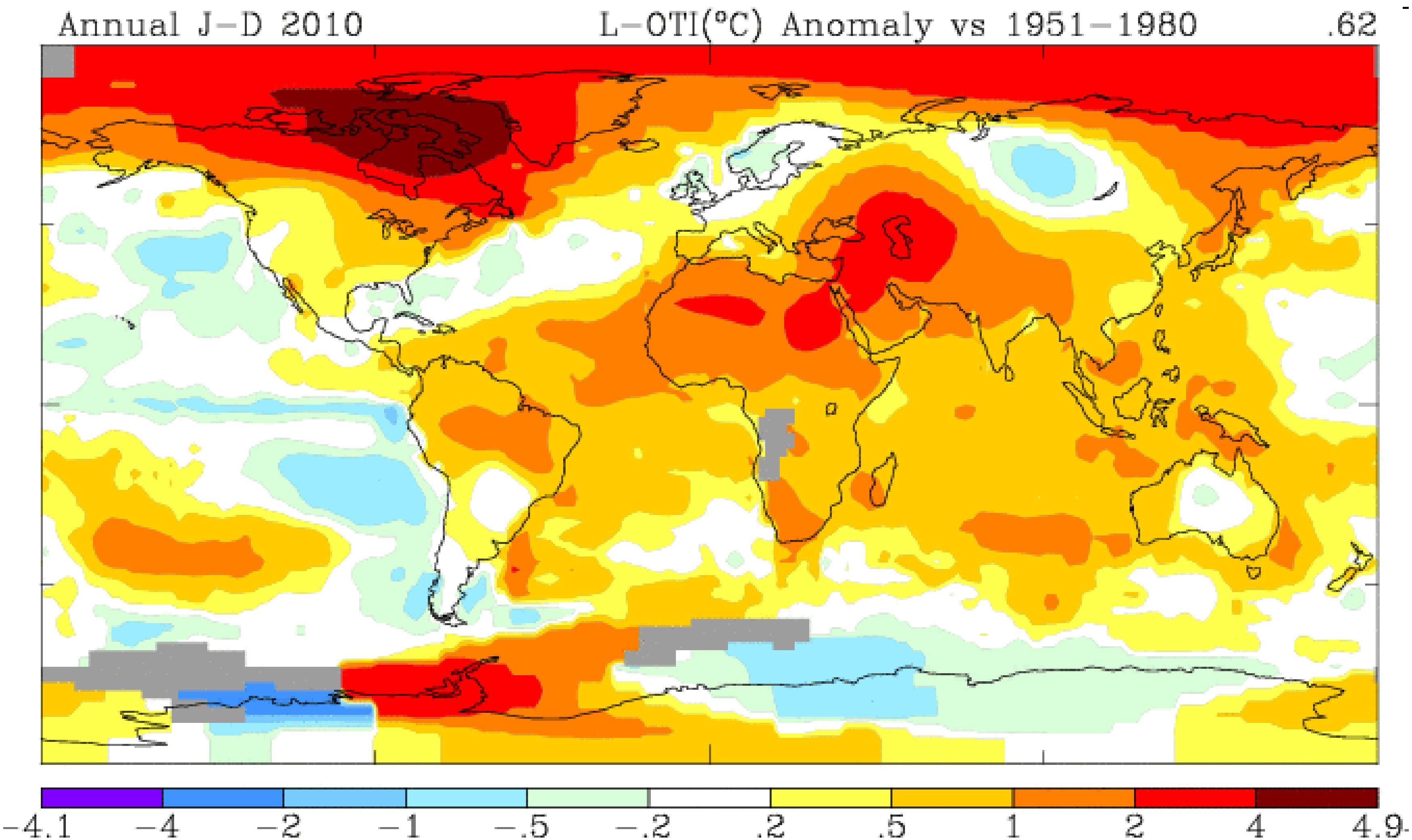
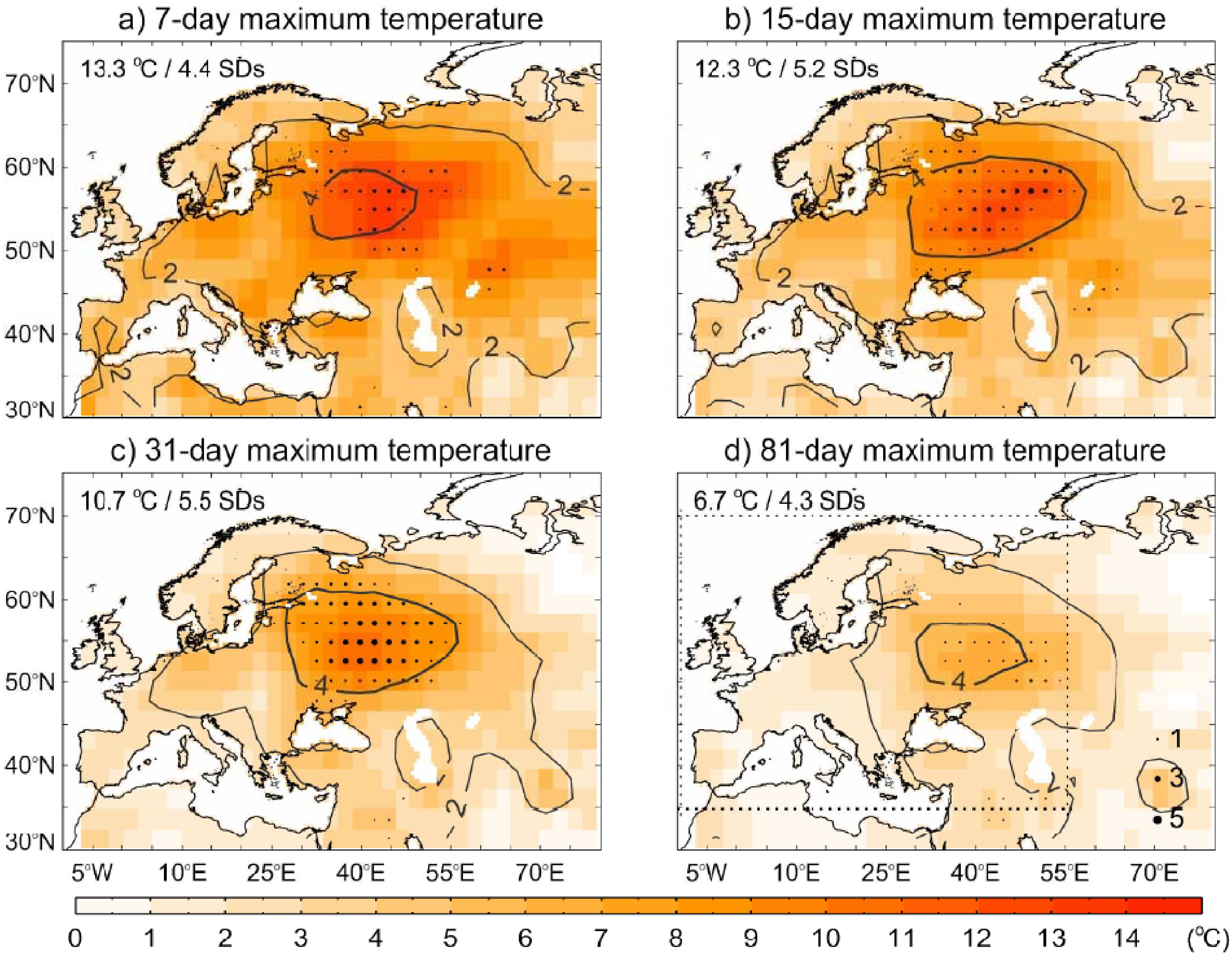


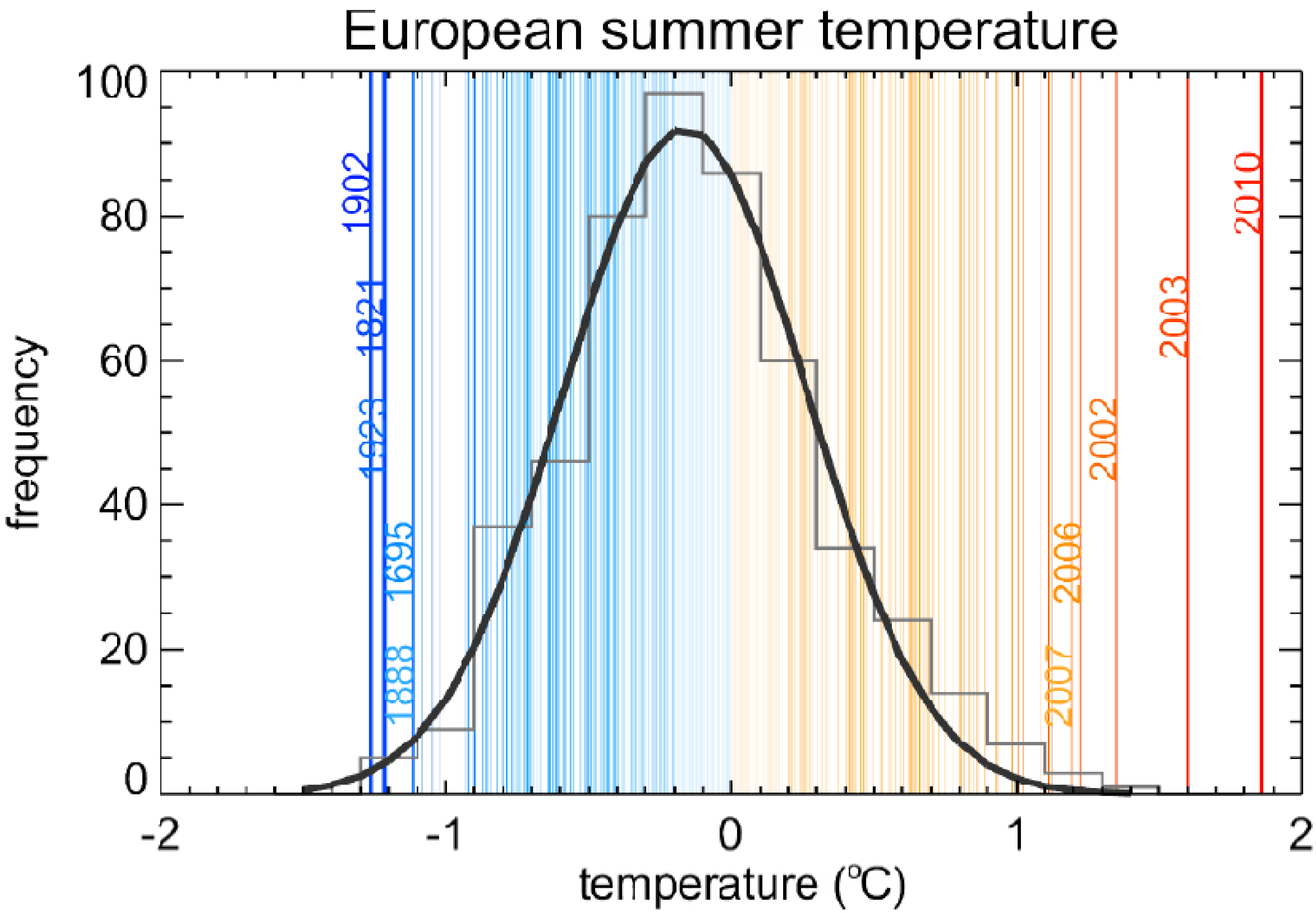
Source: GISS NASA

Temperature anomaly for 2010 (vs 1951-1980) NASA – GISS

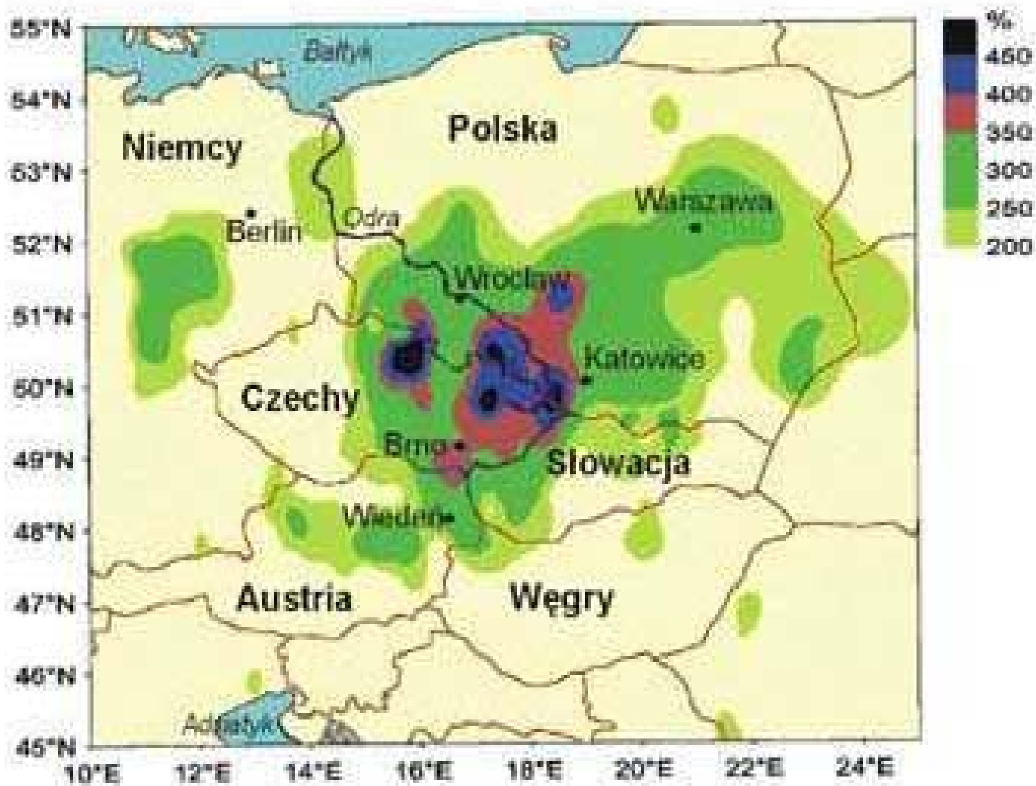




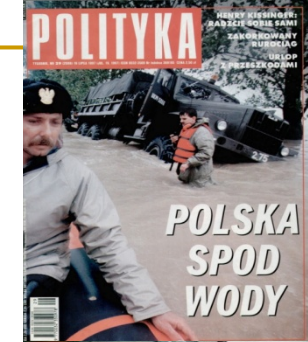
Source: Barriopedro et al., 2011 (2010 relative to 1970-1999)

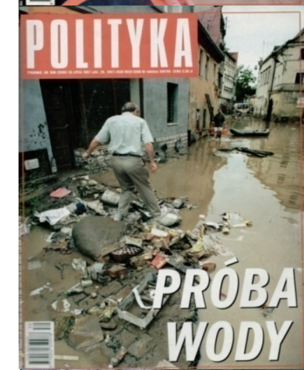


Source: Barriopedro et al., 2011

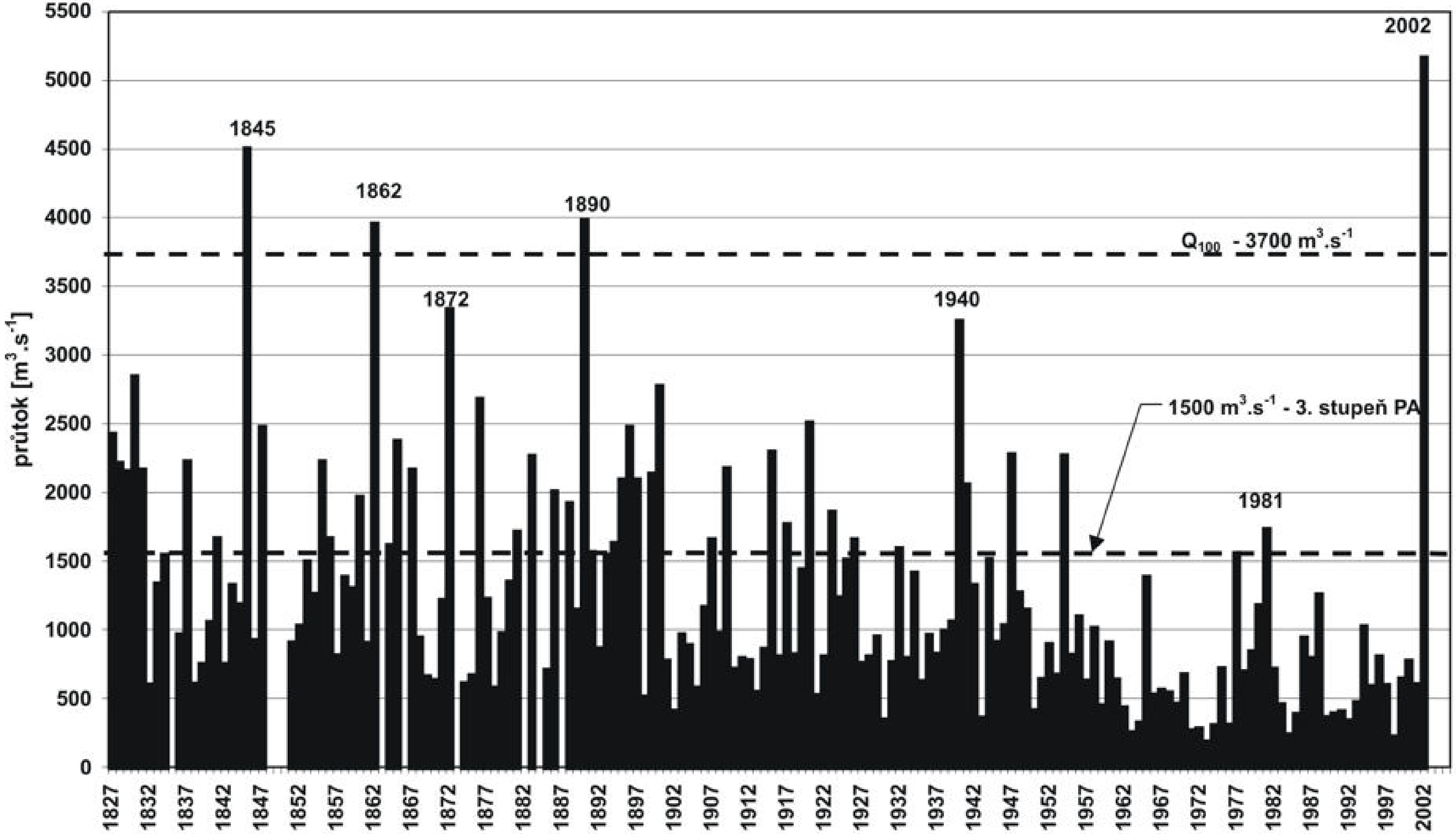


Summer 1997 precipitation compared to long-term mean

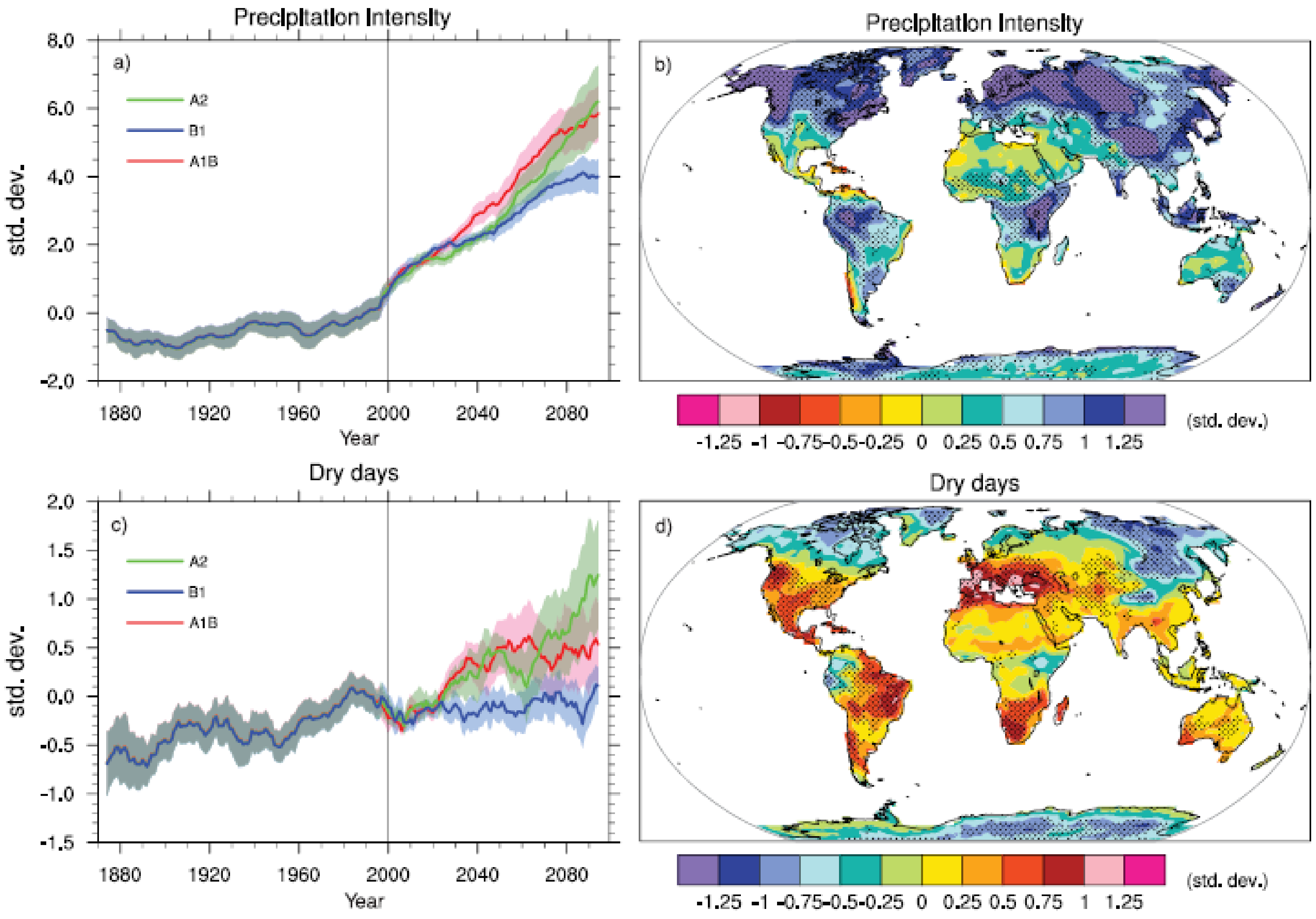




Povodně na Vltavě v Praze



Source: CHMU



Source: IPCC (2007)

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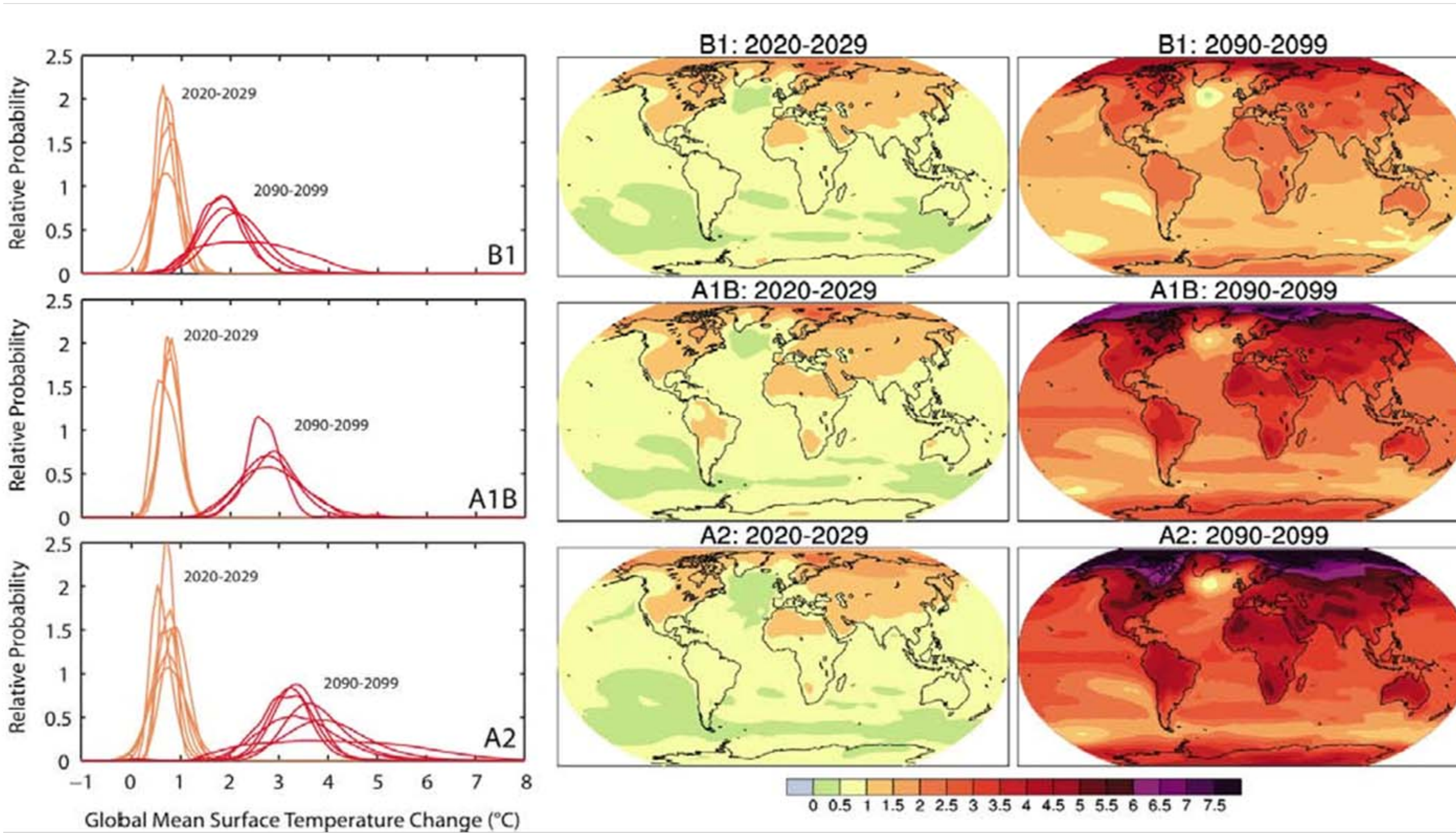
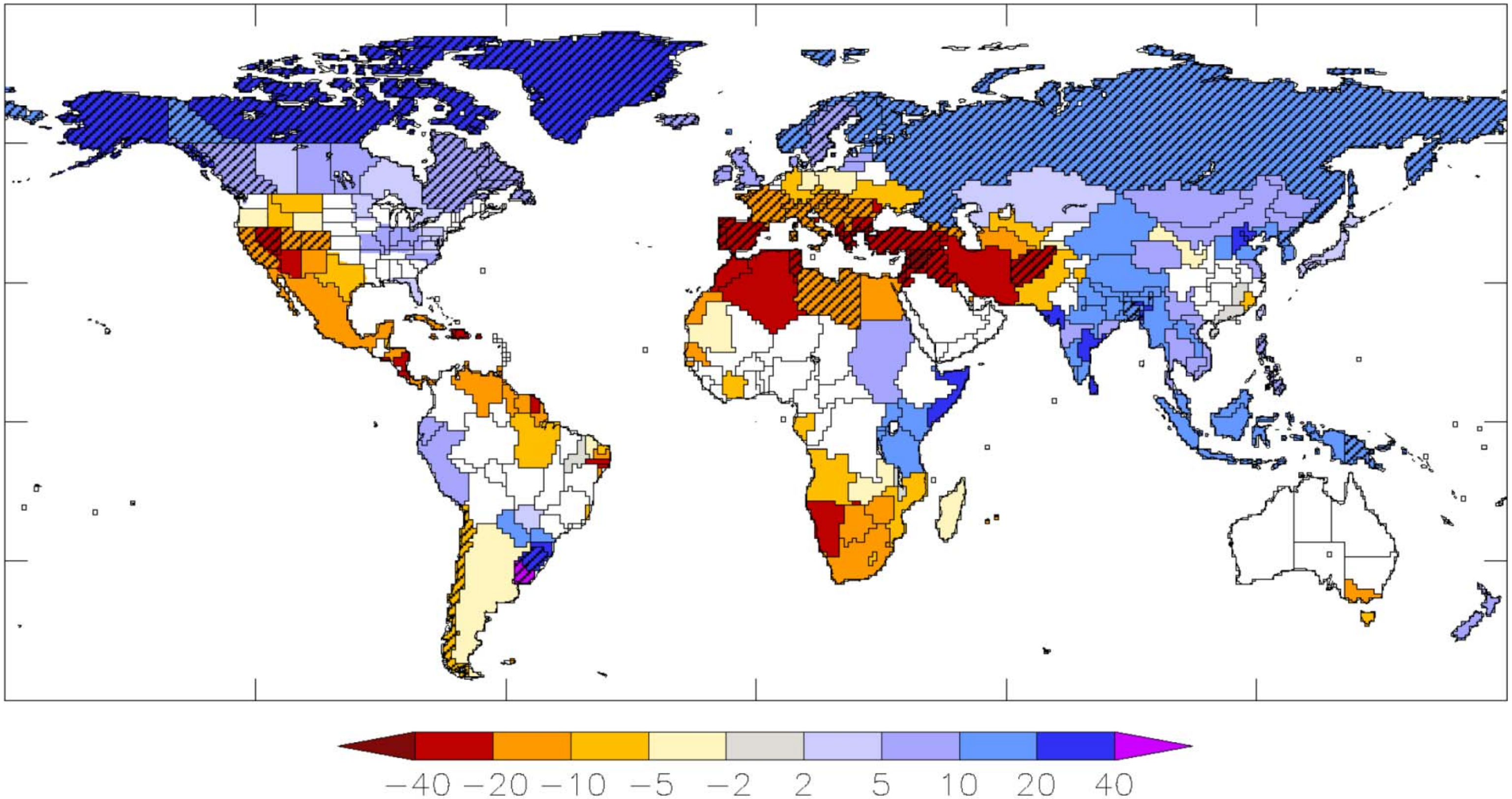
Projected global average temperature changes relative to 1980–1999. Multi-model projections for the B1 (top), A1B (middle) and A2 (bottom) averaged over decades 2020–2029 (center) and 2090–2099 (right). Left - uncertainties (relative probabilities of warming from different studies).

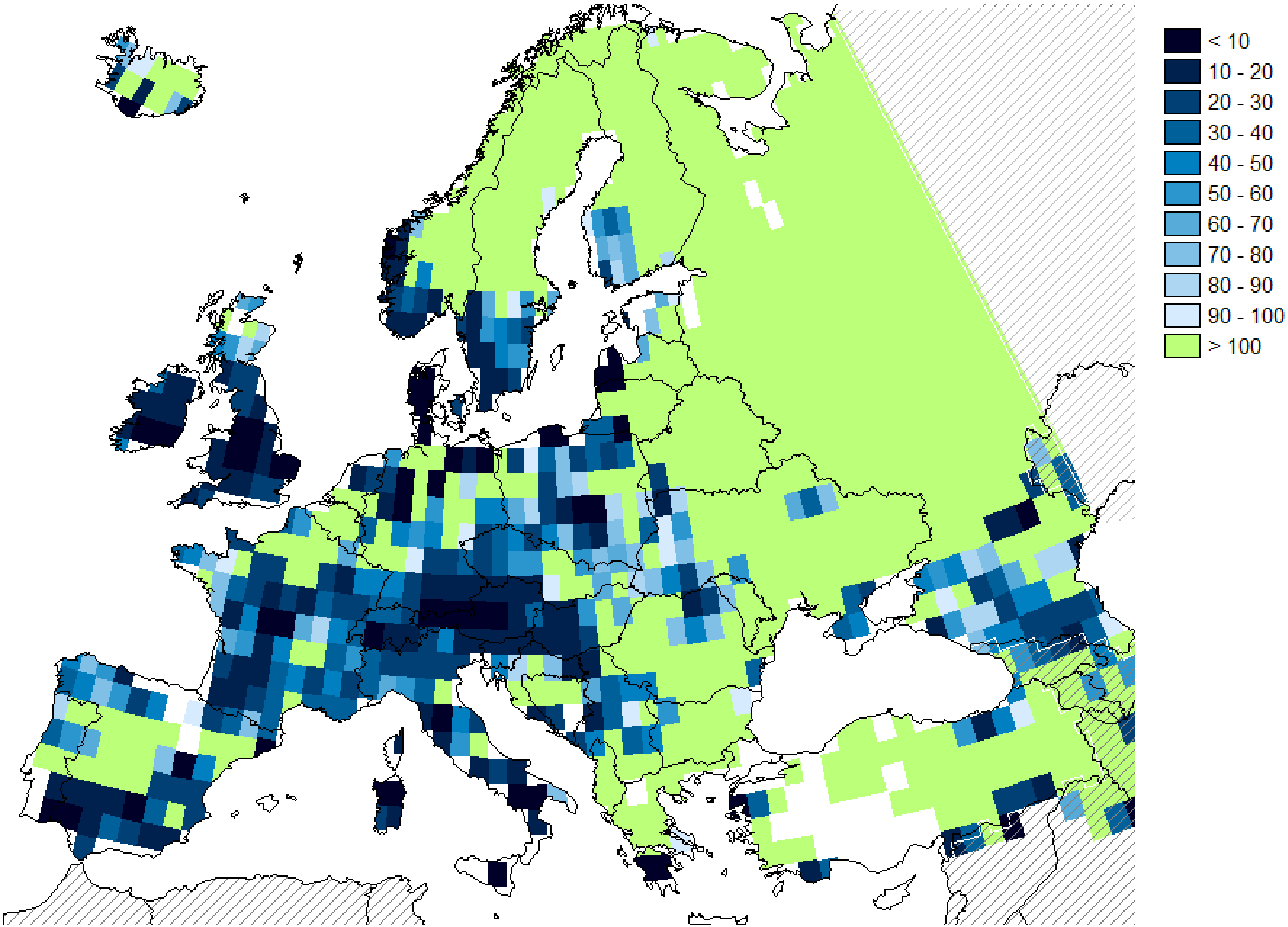


Source: IPCC AR4 WG1 SPM (2007)

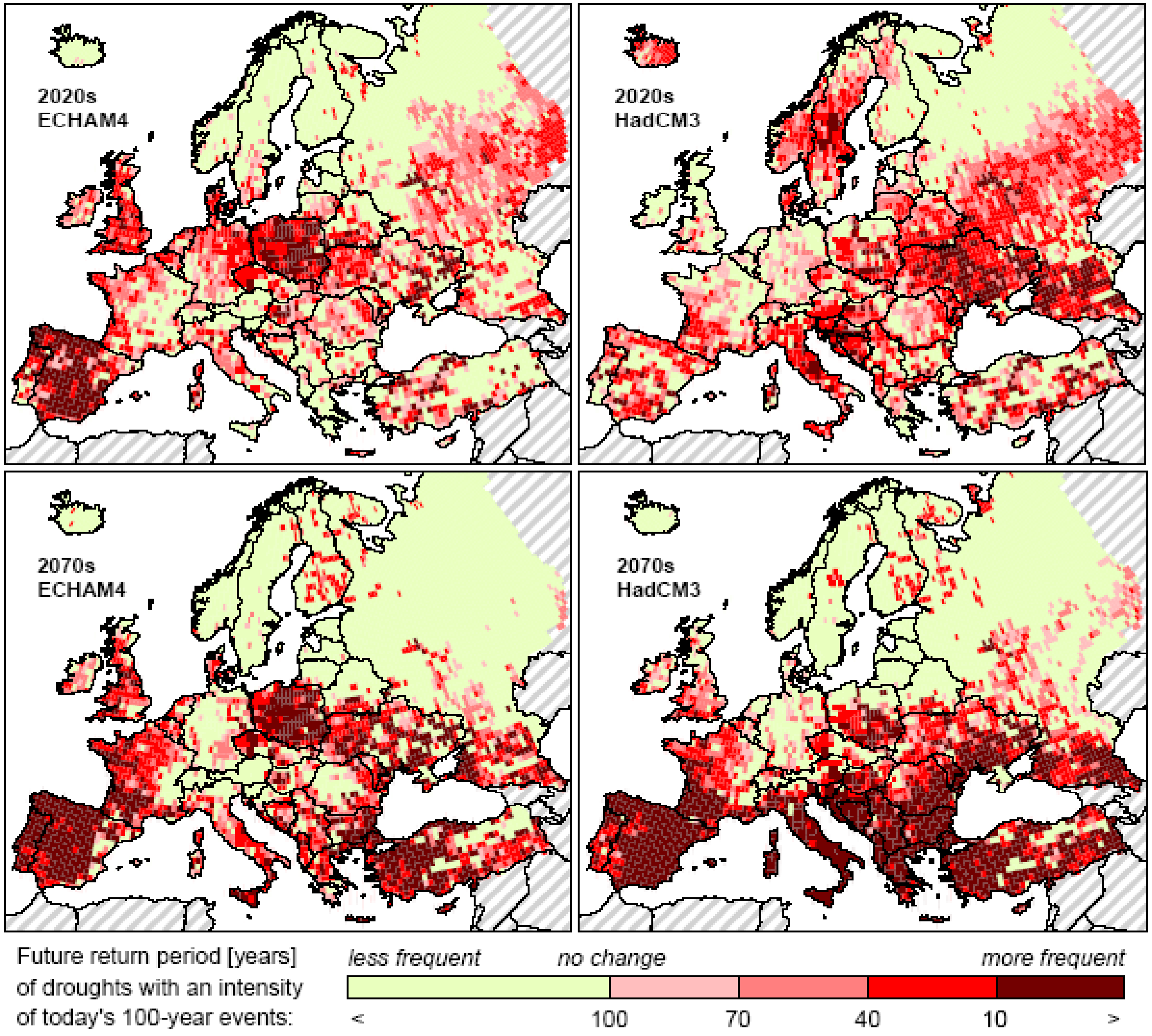
Milly, Betancourt, Falkenmark, Hirsch, Kundzewicz, Lettenmaier & Stouffer Stationarity is Dead: Whither Water Management? ***Science,*** 2008



Projection of changes in annual runoff (2041-2060 vs 1900-1970), for SRES A1B. Colour represents a median from 12 models. Presence of colour means that 8 or more models agree as to the direction of change (hatching: agreement of 11 or 12 models).



Projections of changes in 100-year flood. Source: Hirabayashi



Change in recurrence of 100-year droughts, based on comparisons between climate and water use of 1961-90 and simulations for the 2020s and 2070s (ECHAM4 and HadCM3; WaterGAP 2.1)

Source: Lehner et al., 2005.

Sectors and systems (cf. IPCC TPW)

Agriculture in Europe - Loosers and winners

Agriculture in Europe is basically heat-limited in the north and water-limited in the south, hence the climate change is a good news for the former and bad news for the latter.

Warming will be largely beneficial for mid- and high latitudes (e.g. Scandinavia), extending the length of the growing season. Gains in agricultural area in the North, but shrinking of agricultural area likely in the South of Europe.

Even small warming and reduction in precipitation jeopardize crop yield in the South of Europe, where disadvantages are likely to be predominant.

Sectors and systems (IPCC TPW)

Energy

By the 2070s, hydropower potential for the whole of Europe is expected to decline by 6% (from 20-50% decrease around the Mediterranean to 15-30% increase in N and E Europe).

Health

Both extreme rainfall and droughts can increase the total microbial loads in fresh water and hence the risk of contamination of public and private water supplies and disease outbreaks.

Sectors and systems (IPCC TPW)

Biodiversity

- Some systems, such as the permafrost areas in the Arctic, ephemeral (short lived) aquatic ecosystems in the Mediterranean are projected to disappear.
- During dry years, catastrophic fires are expected on drained peatlands in European Russia.
- Earlier ice melt and longer growing seasons may lead to a higher risk of algal blooms and increased growth of toxic cyanobacteria in lakes.
- Higher precipitation and reduced frost may enhance nutrient loss from cultivated fields, intensify the eutrophication of lakes and wetlands.
- Higher temperatures will reduce dissolved oxygen saturation levels and increase the risk of oxygen depletion.

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Climate change will pose two major water management challenges in Europe:

• increasing water stress mainly in southeastern Europe, and

• increasing risk of floods throughout most of the continent.

To adapt to increasing **water stress**, the most common and planned strategies remain supply-side measures such as impounding rivers to form in-stream reservoirs (but also – despite constrains – wastewater reuse and desalination). Demand-side strategies are also feasible, such as household, industrial and agricultural water conservation, reducing leaky municipal and irrigation water systems, and water pricing. The irrigation water demand may be reduced by introducing crops more suitable to changing climate.

The main structural measures to protect against **floods** are likely to remain reservoirs and dikes in highland and lowland areas respectively. However, other planned adaptation options include expanded floodplain areas, emergency flood reservoirs, preserved areas for flood water, and flood warning systems.

European Union Floods Directive

Preliminary **flood risk assessment** (including assessment of the projected impact of **climate change** trends; forecast of estimated consequences of future floods, …).

• Preparation of **flood maps** and indicative **flood damage maps**, covering the geographical areas which could be flooded with a high probability (e.g. return period of 10 years); with a medium probability (100 years), and with a low probability (extreme events).

• Preparation and implementation of **flood risk management plans**, aimed at achieving the required levels of protection.

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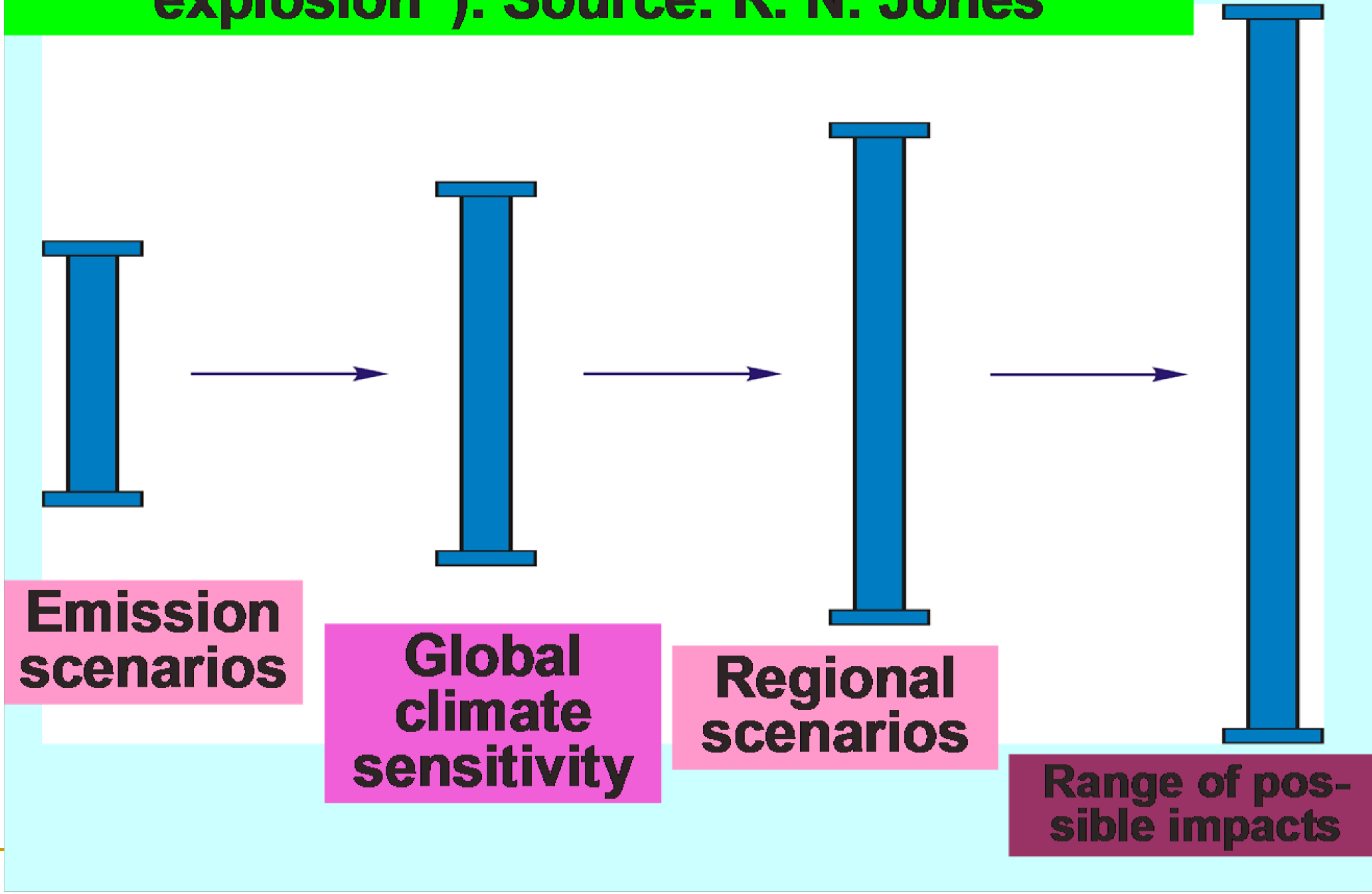
The sensitivity of Europe to climate change has a distinct north-south gradient: southern Europe will be more severely affected than northern Europe.

The already hot and semi-arid climate of southern Europe is expected to become yet warmer and drier, and this will threaten its waterways, hydropower, agricultural production and timber harvests.

However, northern countries are also vulnerable to climate change.

Range of major uncertainties in climate impact assessments („uncertainty explosion”). Source: R. N. Jones



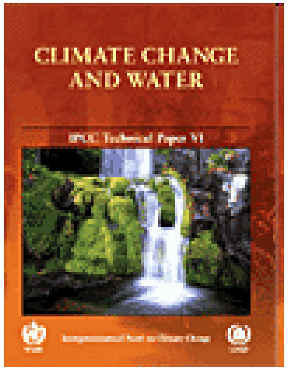
- Under the same emission scenario, different models give rise to different impacts. This difference is often larger than that arising in one model with different emission scenarios.

- Uncertainties in climate change projections increase with the length of the time horizon.

- Uncertainties due to the selection of climate model / emissions scenario dominate in the near term / over longer time horizons.

Robust adaptation procedures, which do not rely on precise projections of changes, need to be developed.

Good adaptation to existing climate and its variability augurs better for adaptation to the future, changed climate. Current **water management practices** may be inadequate to reduce adverse impacts of climate change.



Acknowledgements to co-contributors to IPCC TPW

CLIMATE CHANGE AND WATER, IPCC Technical Paper VI (June 2008) **Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof**, Eds., IPCC Secretariat, Geneva, 210 pp. Available freely at: http://www.ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf

EU 6FP Integrated Project WATCH

WATCH Water and Global Change

Thank you