



EXPO Zaragoza 2008

Semana temática: Cambio Climático y Fenómenos Extremos
(*Climate change and extreme events*)
Zaragoza, Spain, 21-23 July 2008

Heavy precipitation and floods

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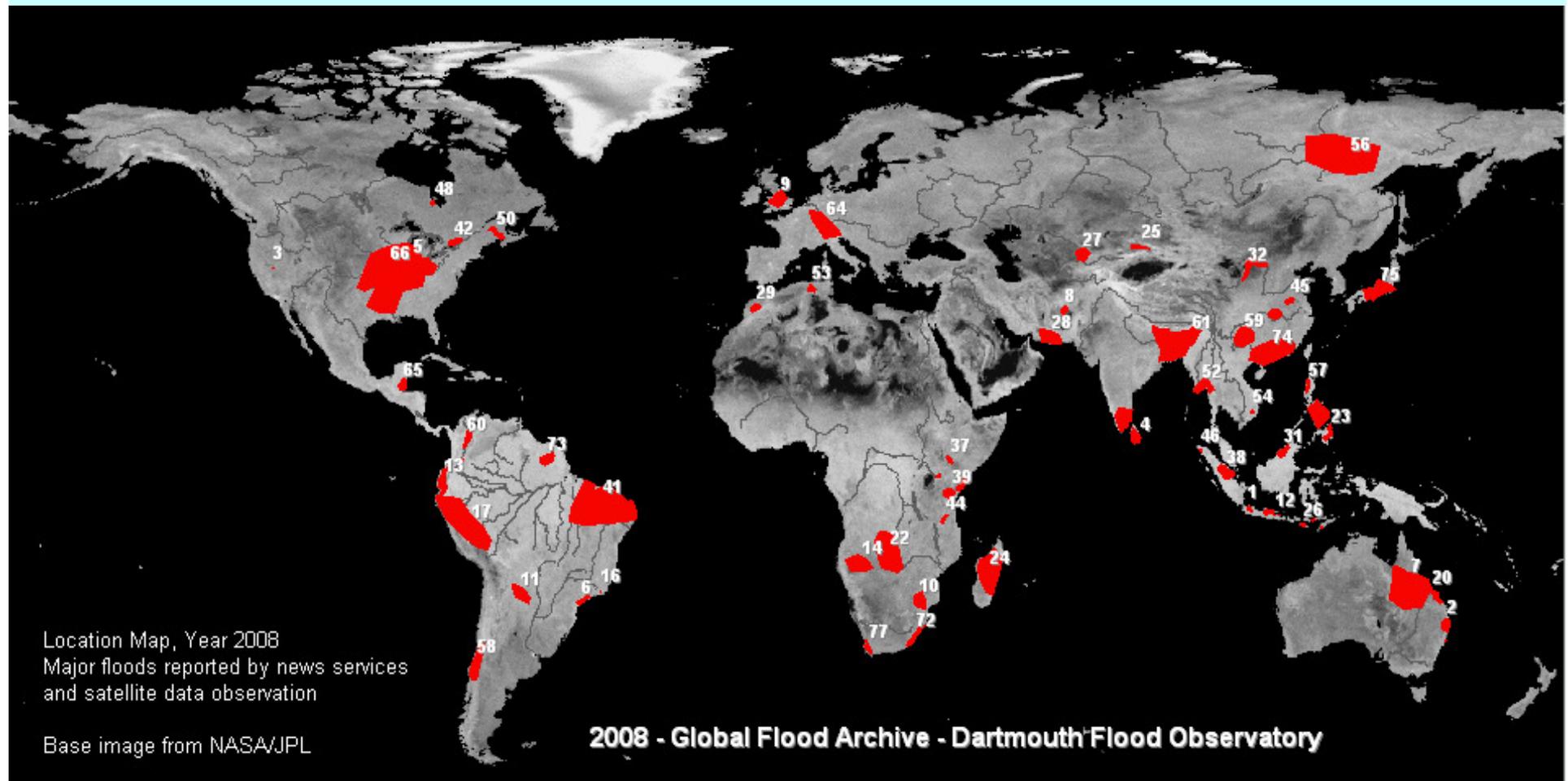


Potsdam Institute for Climate Impact Research
Potsdam, Germany

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Source: Dartmouth Floods Observatory



Data on 1997 floods in Poland (Odra and Vistula):

54 fatalities, **3205 M** Euro damage (Munich Re),

2592 towns and villages flooded (therein 1362 –
totally)

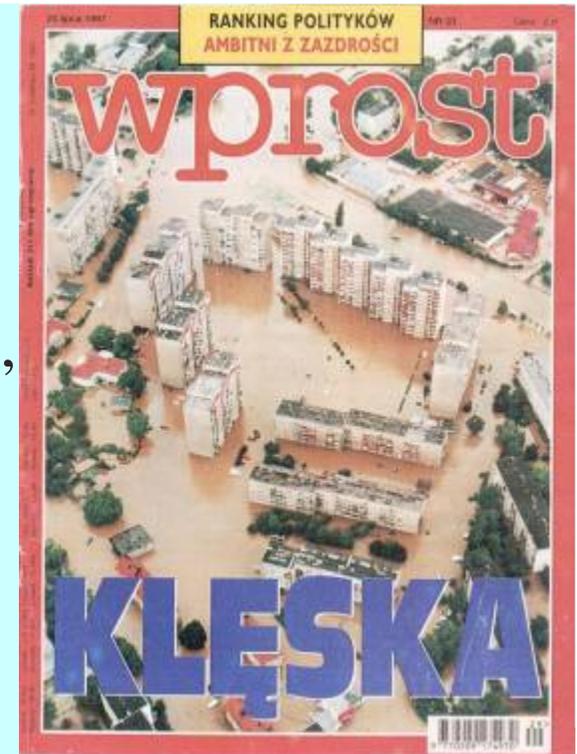
46 000 houses and **725** bridges destroyed /
damaged,

665 000 ha flooded (therein **450 000** ha farmland)

162 000 people evacuated

Action: **25 000** firemen, **45 000** soldiers, **10 000**
police, **100 000** civilians and volunteers

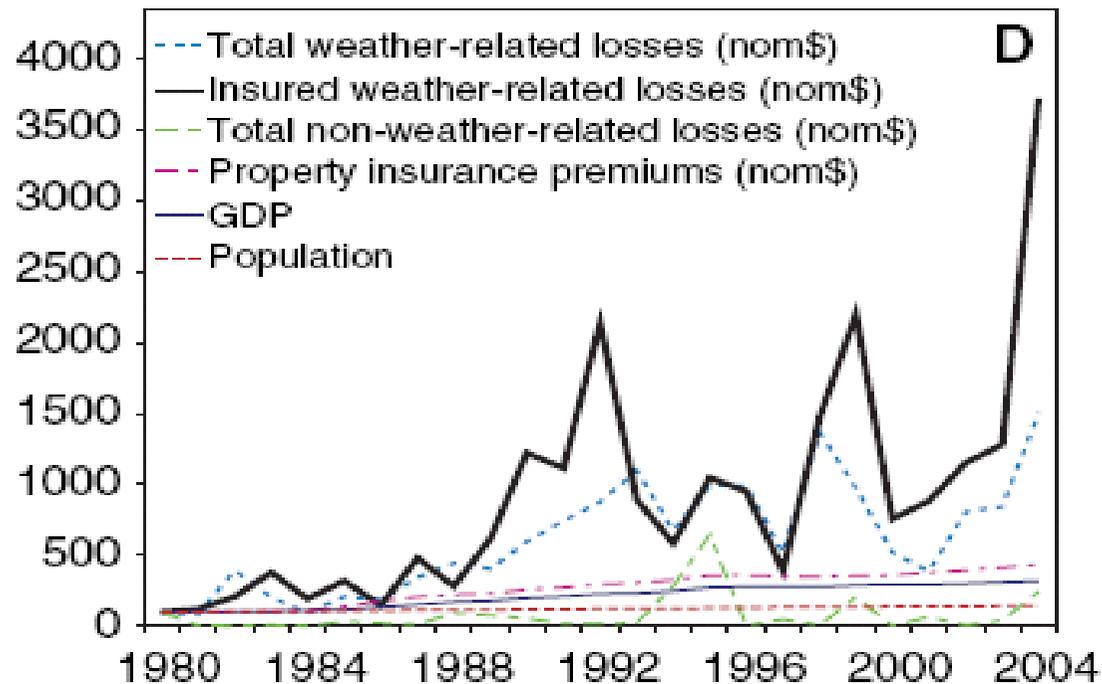
300 000 m³ untreated sewage entered rivers per day



The global decline in aggregate deaths and death rates due to extreme weather events during the 20th century suggest that adaptation measures to cope with some of the worst consequences of such events have been successful.

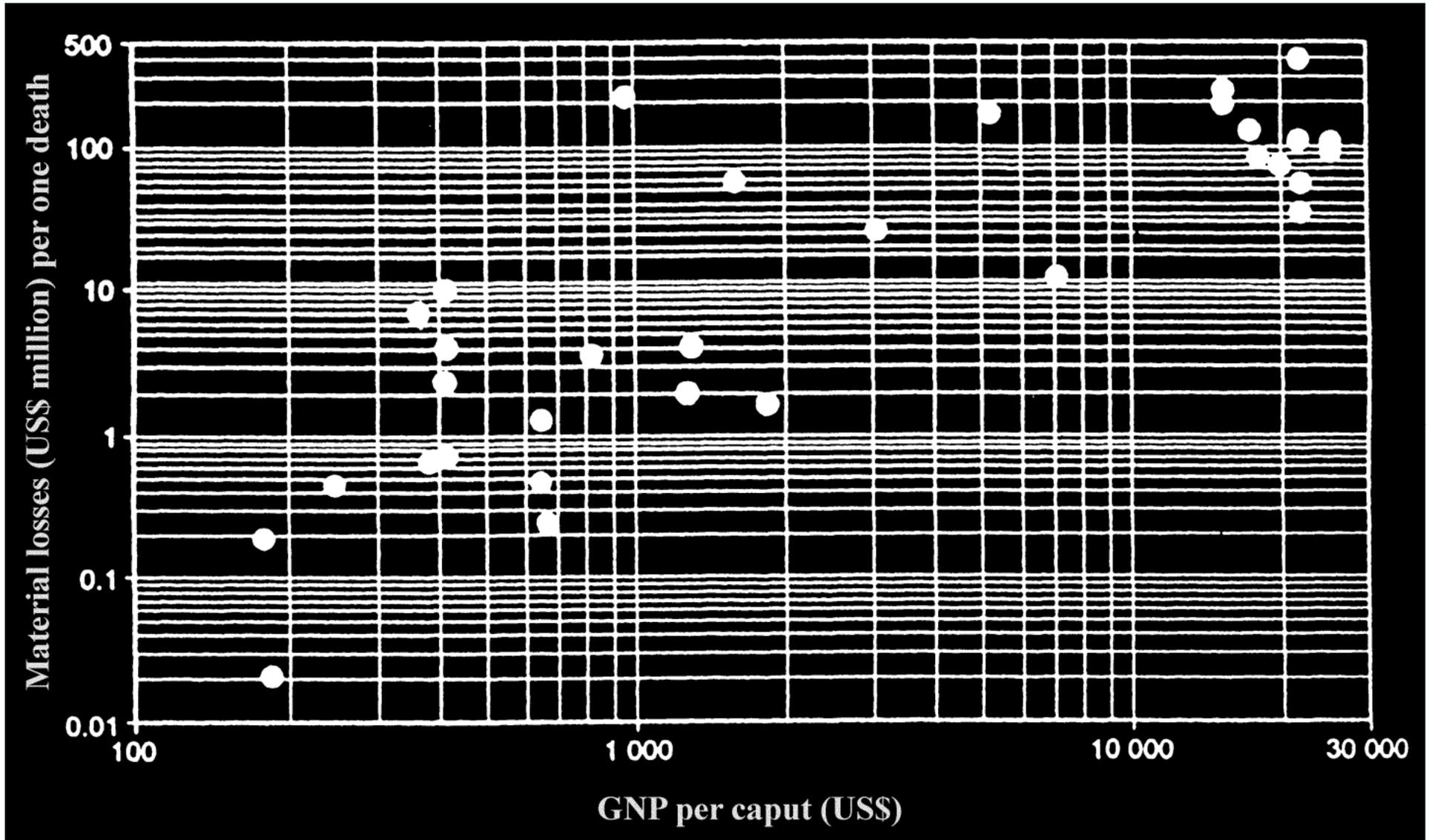
[IPCC AR4 WG II Ch.1]

Loss costs and socioeconomic drivers index: 1980 = 100

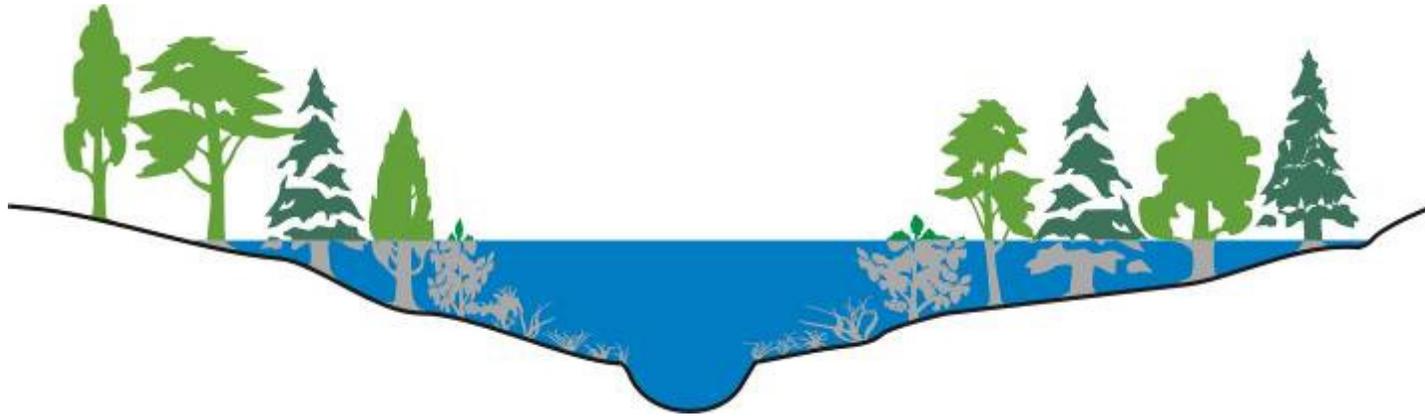


Insured and total property losses caused by weather events (\$45 billion and \$107 billion in 2004, respectively) are rising faster than premiums, population, or economic growth. Data exclude health and life insurance premiums and losses. Inflation-adjusted economic losses from catastrophic events rose by **8-fold** between the 1960s and 1990s and insured losses by **17-fold**.

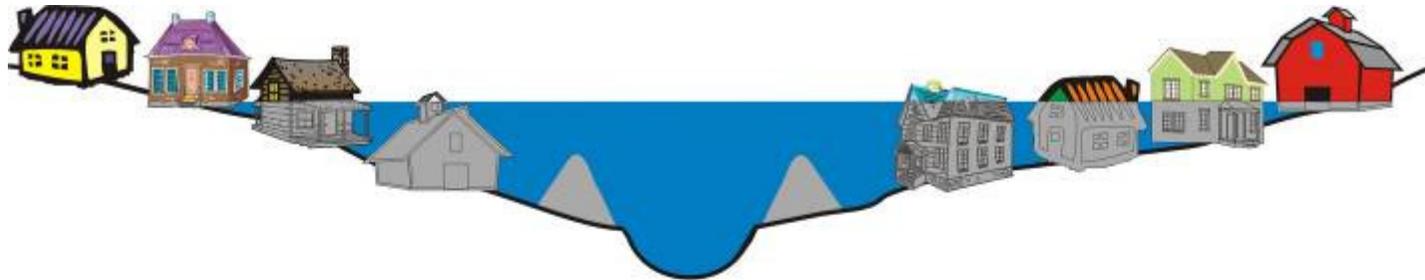
[Mills, 2005]



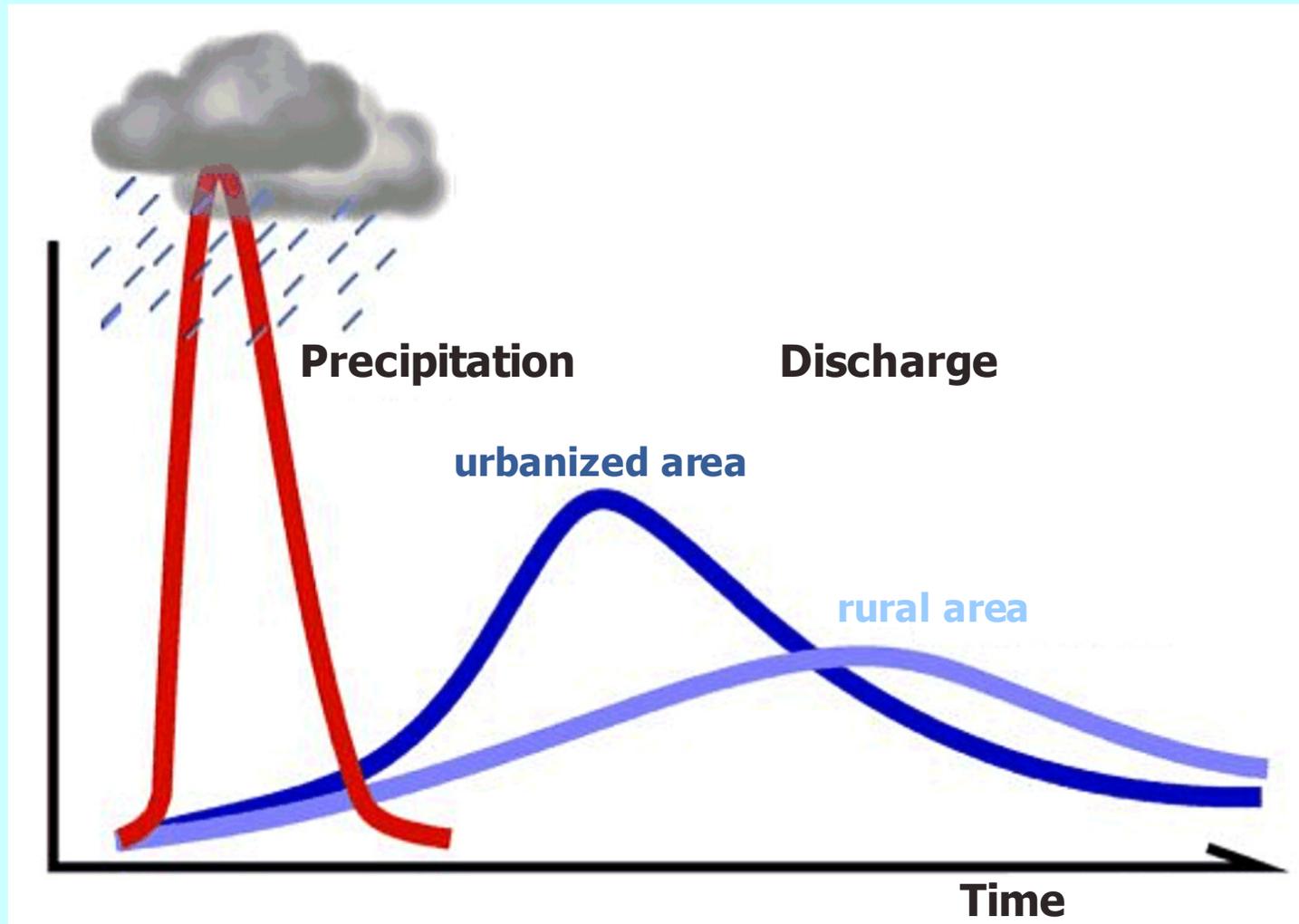
Flood protection efficiency depends on wealth
(Source: Kundzewicz & Takeuchi, 1999)



1000-year flood



Impacts of land-use change on floods



Reasons for changes in flood risk and vulnerability

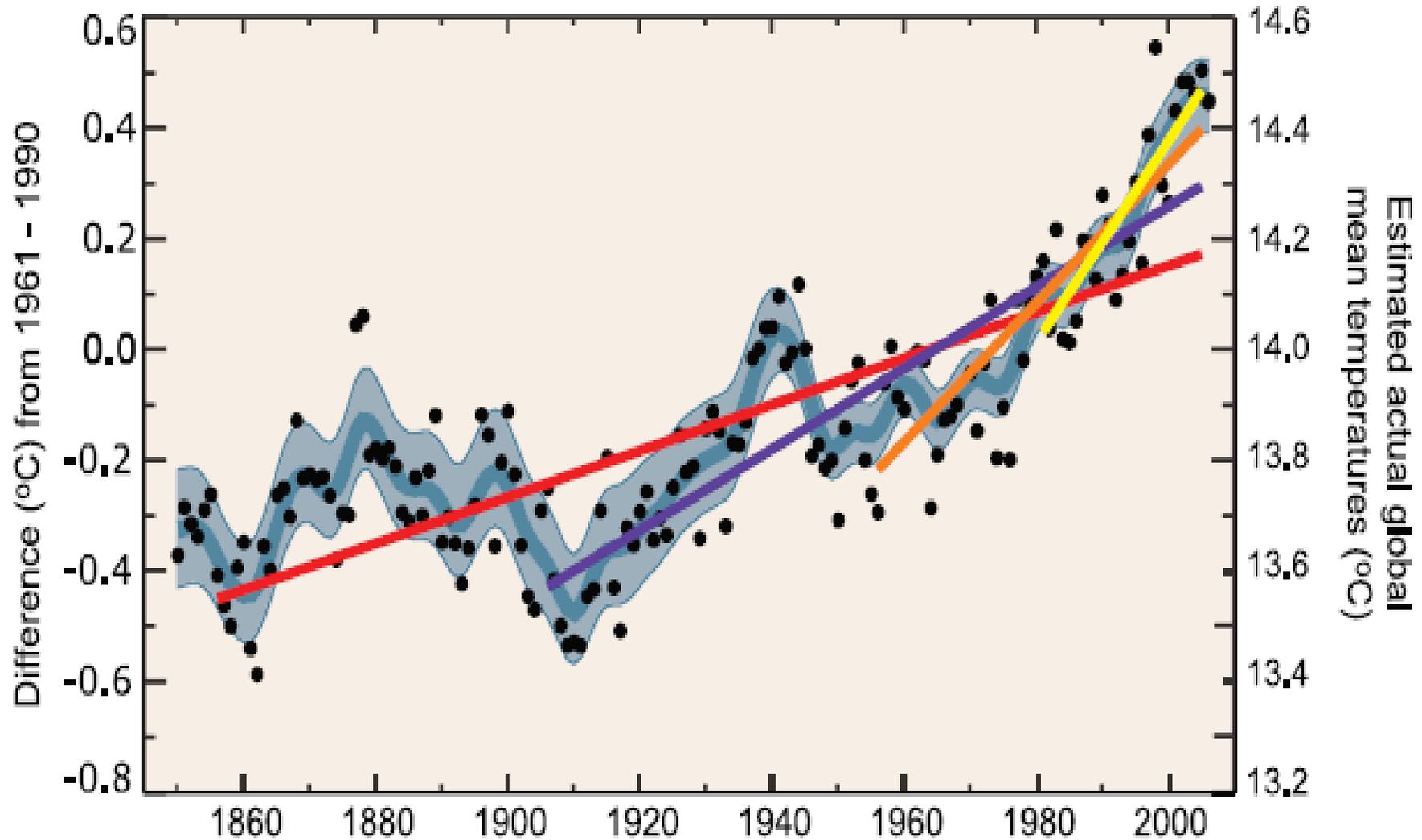
<i>(i) Changes in socio-economic systems</i>	<i>Land-use change, increasing exposure and damage potential – floodplain development, growing wealth in flood-prone areas, changing risk perception</i>
<i>(ii) Changes in terrestrial systems</i>	<i>Land-cover change - urbanization, deforestation, elimination of natural inundation areas (wetlands, floodplains), river regulation – channel straightening and shortening, embankments), damming rivers, adverse changes of conditions of transformation of precipitation into runoff</i>
<i>(iii) Changes in climate and atmospheric system</i>	<i>Holding capacity of the atmosphere, intense precipitation, seasonality, circulation patterns</i>

Source: Kundzewicz & Schellnhuber, 2004

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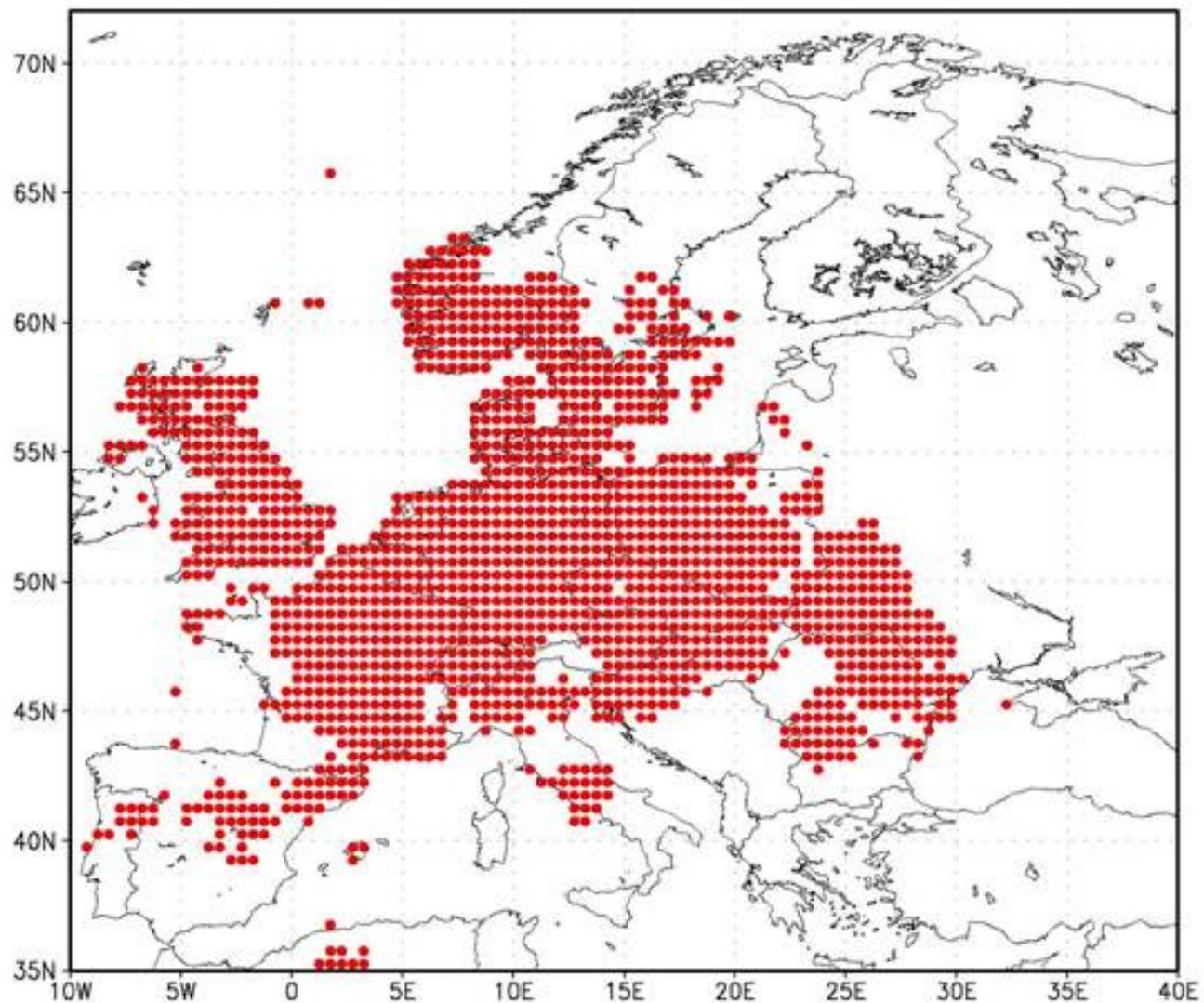
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Patterns of linear global temperature trends. The total temperature increase from the period 1850 to 1899 to the period 2001 to 2005 is $0.76^{\circ}\text{C} \pm 0.19^{\circ}\text{C}$. Source: IPCC (2007)



Mean temperatures of subsequent 12 months in 2006/2007 higher than ever in the history of observations

Source: Kundzewicz et al., 2008



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.

$$T \Rightarrow e_s(T) \Rightarrow$$

$$1^\circ\text{C} \quad 6-7\%$$

Causal mechanisms of floods

Intense / long-lasting precipitation

Snowmelt

Flow obstruction (e.g. ice jam, landslide,
GLOF: Glacial Lake Outburst Flood)

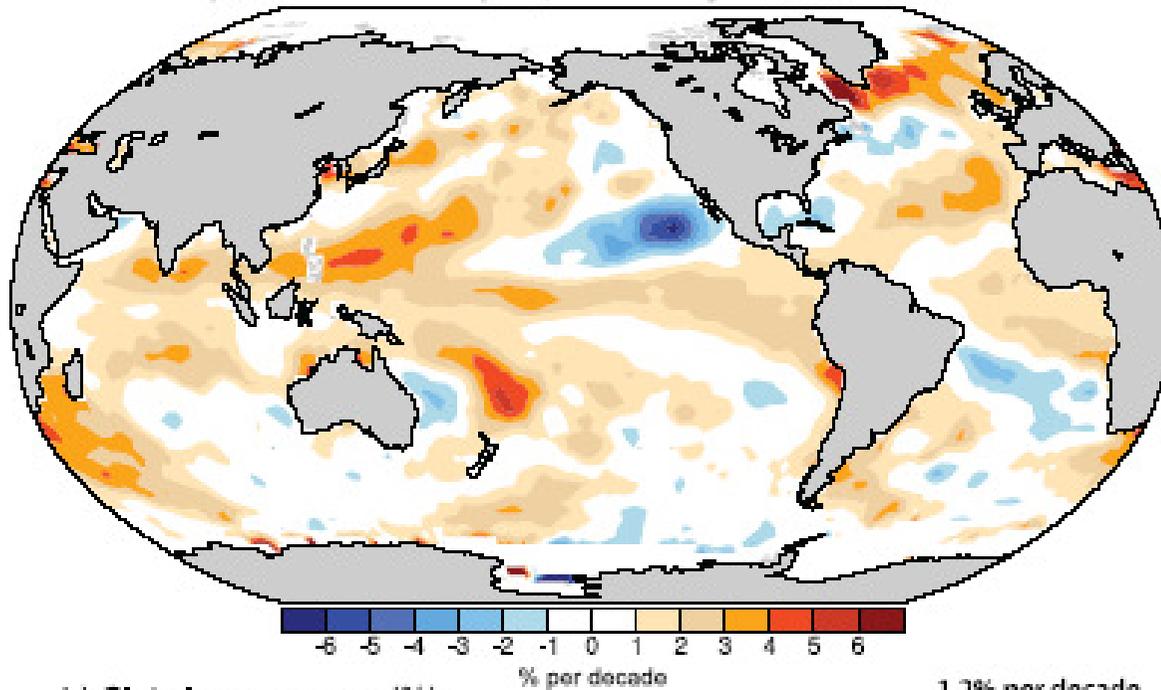
Dam failure

Storm surge

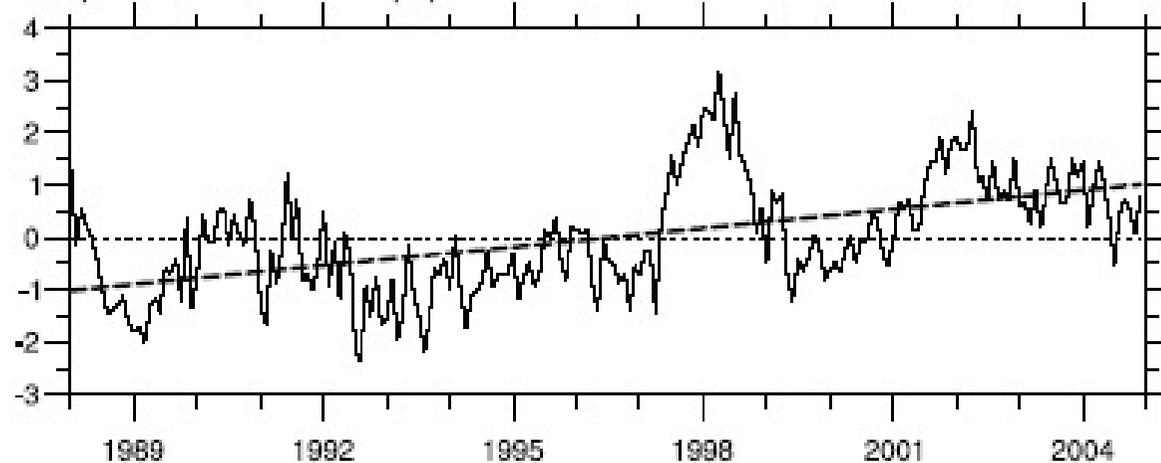
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a) Column Water Vapour, Ocean only: Trend, 1988-2004



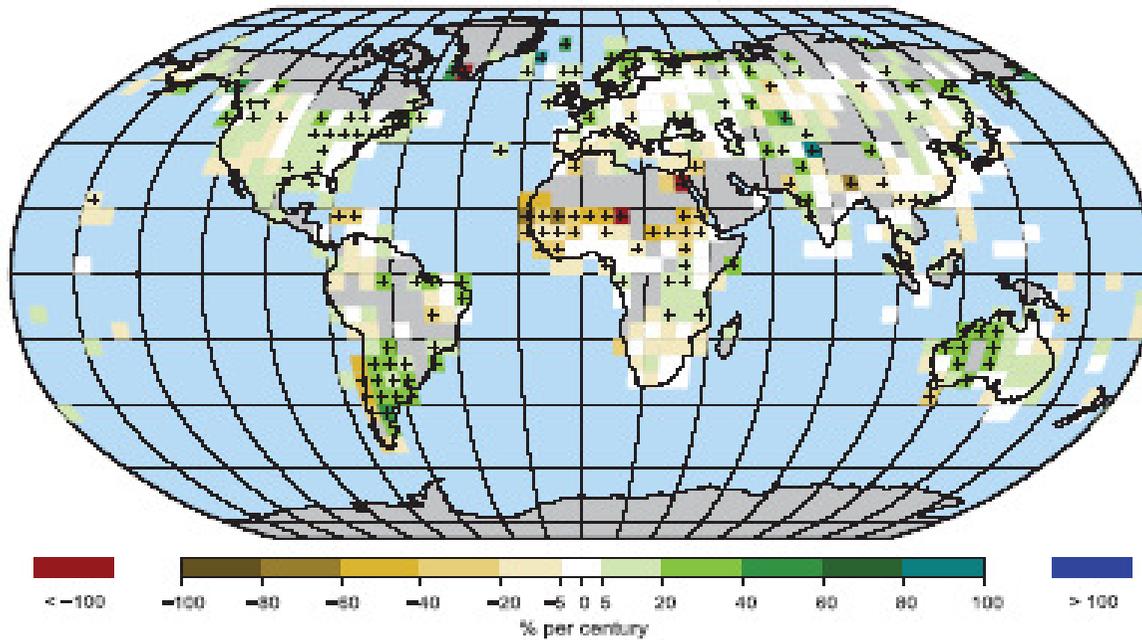
b) Global ocean mean (%)



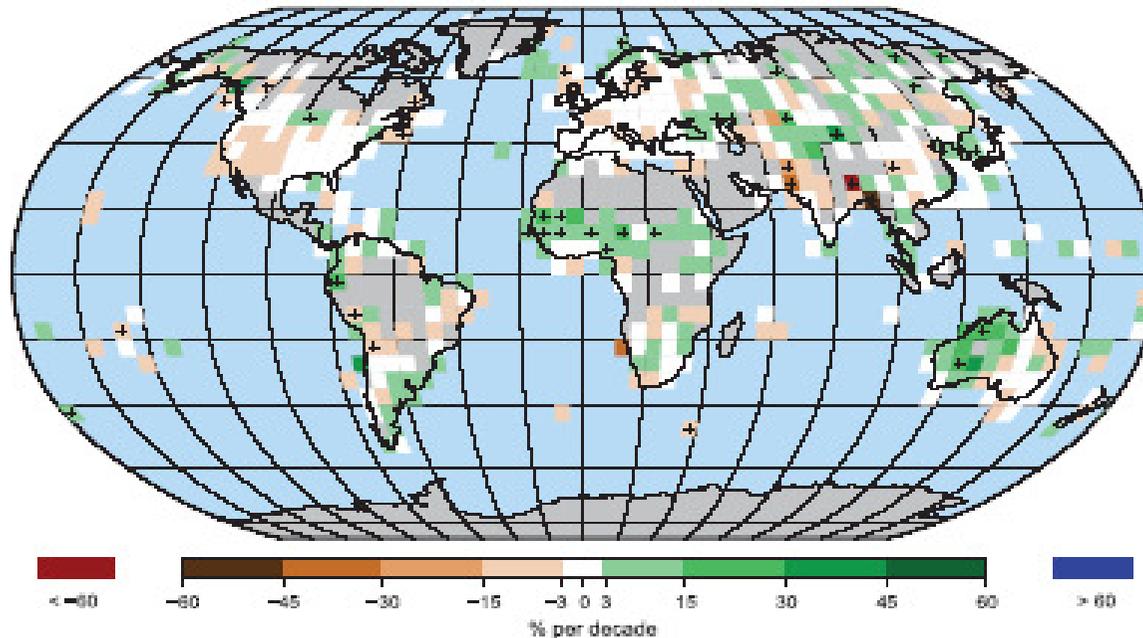
Linear trends in precipitable water (total column water vapour) in % per decade (top) and monthly time series of anomalies relative to the 1988 to 2004 period in % over the global ocean plus linear trend (bottom)

(Source: Trenberth et al., 2007)

Trend in Annual Precipitation, 1901 to 2005



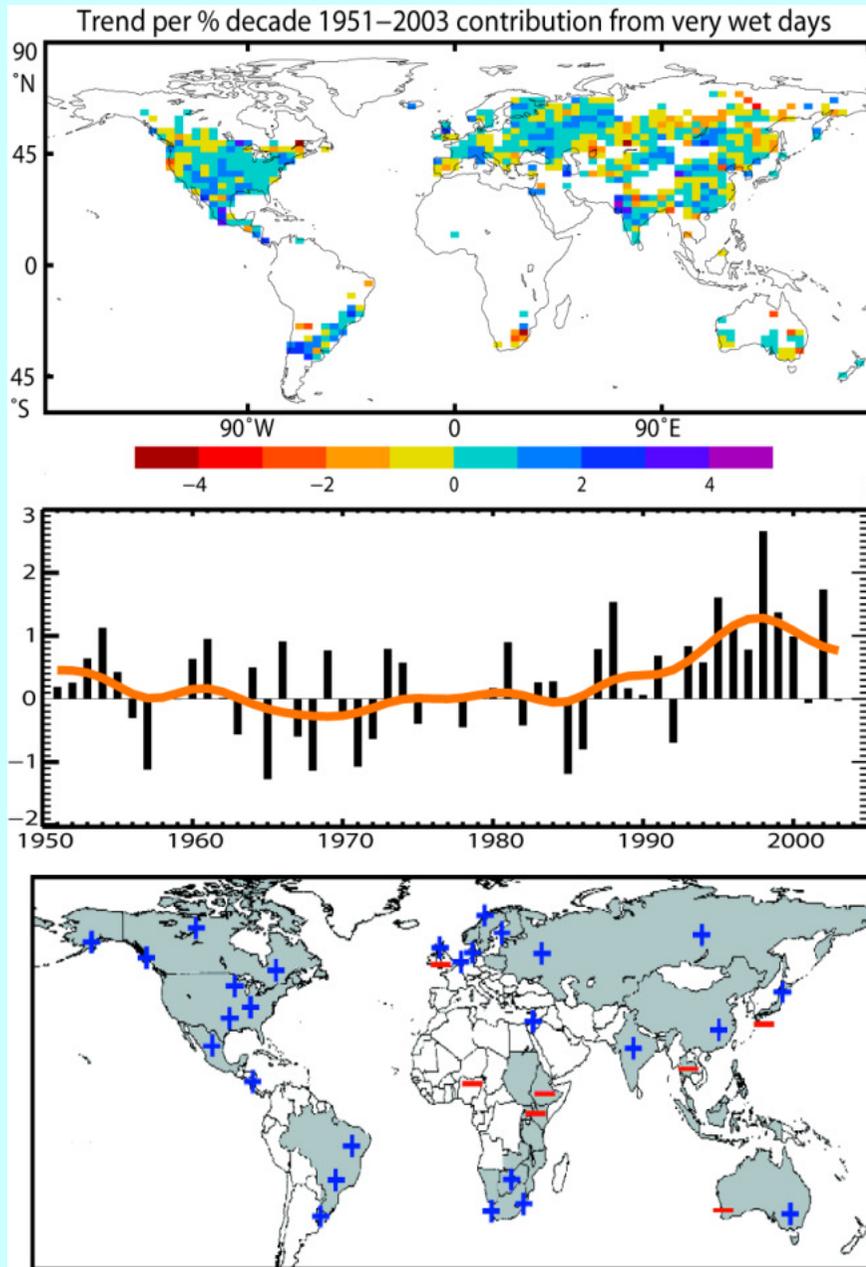
Trend in Annual Precipitation, 1979 to 2005



Trend of annual land precipitation amounts for 1901 to 2005 (top, % per century) and 1979 to 2005 (bottom, % per decade). The percentage is based on the means for the 1961 to 1990 period.

Areas in grey have insufficient data to produce reliable trends. Note the different colour bars and units in each plot. Trends significant at the 5% level are indicated by black + marks.

(Source: Trenberth *et al.*, 2007)



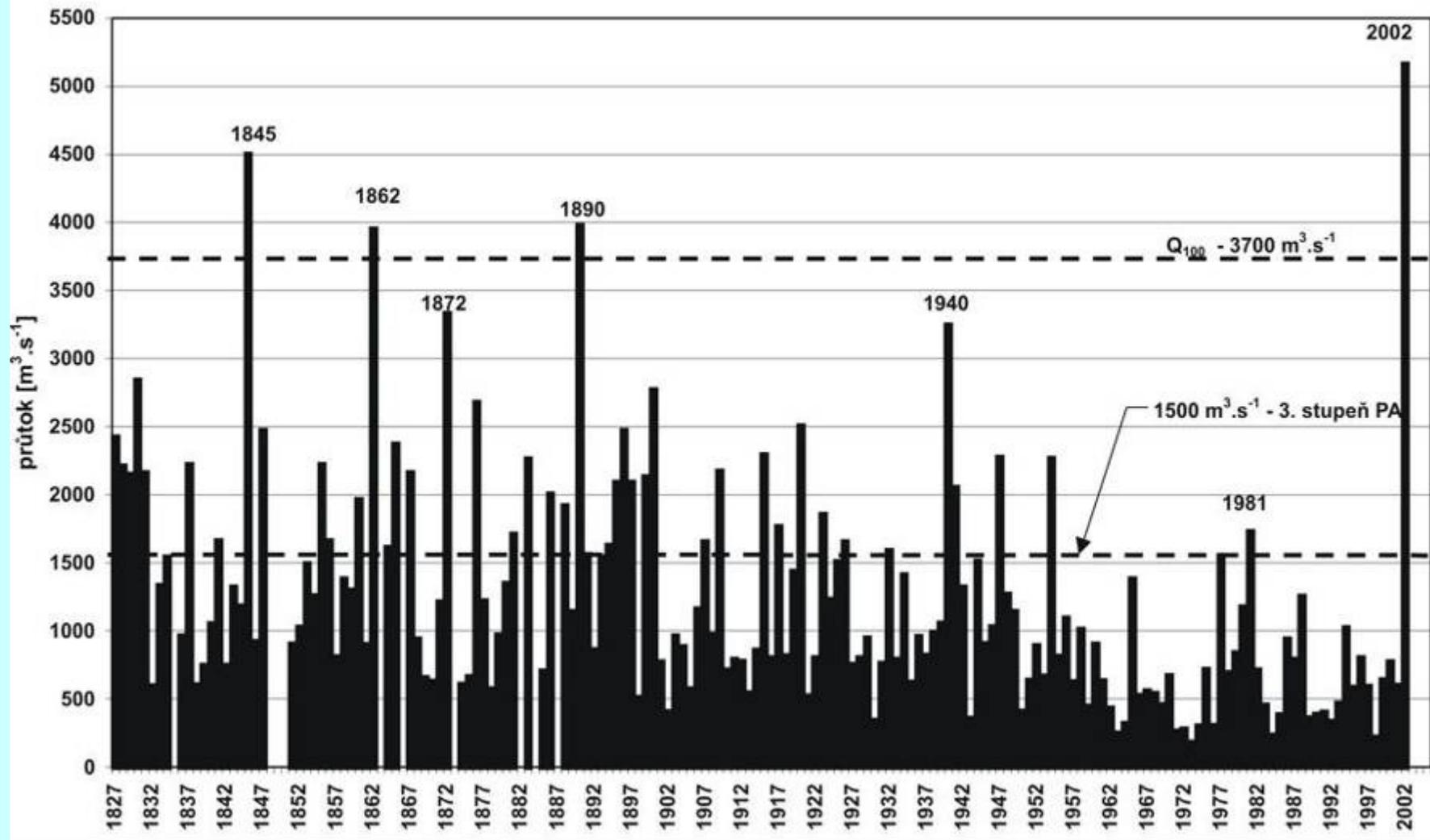
Contribution to total annual precipitation from very wet days (95th percentile and above).

[IPCC WGI AR4, 2007, Groisman et al., 2005, Alexander et al., 2006]

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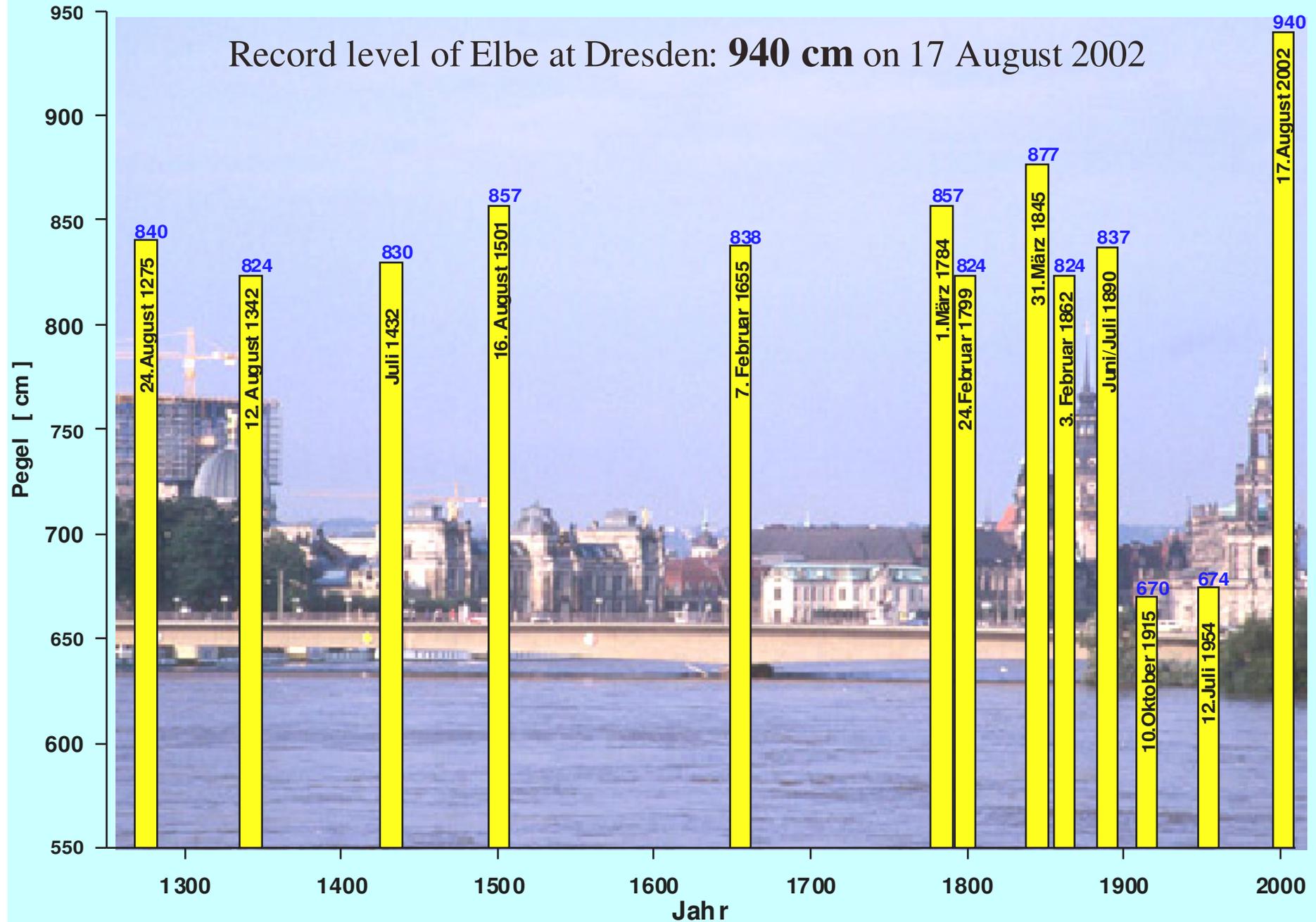
Povodně na Vltavě v Praze



Source: CHMU

Maximum water levels, Elbe at Dresden. Source: Grünewald

Record level of Elbe at Dresden: **940 cm** on 17 August 2002

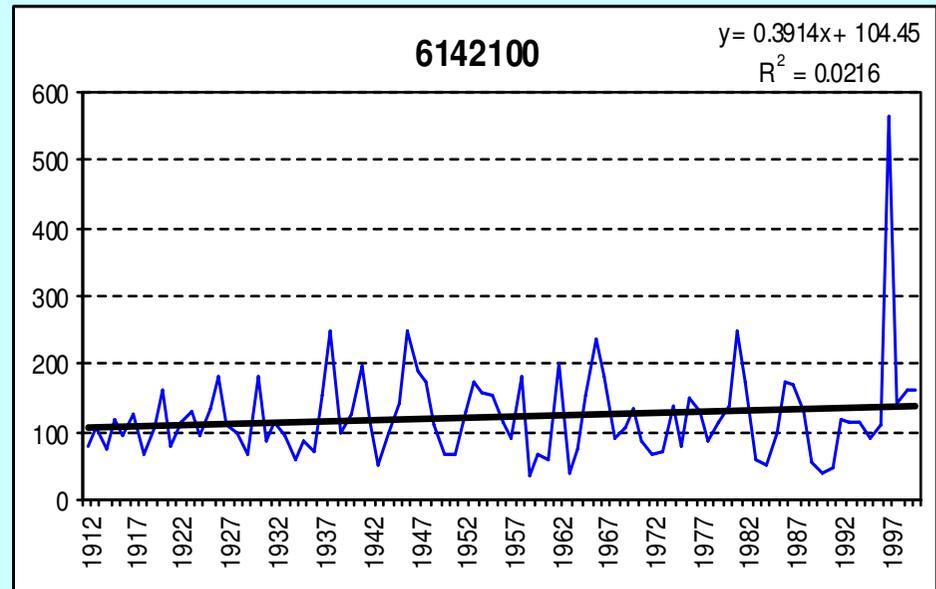
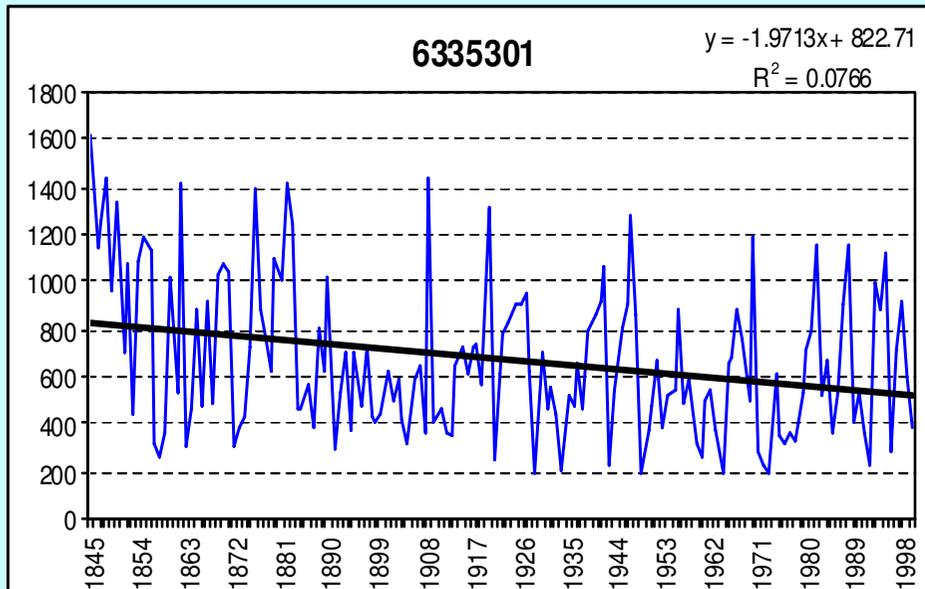
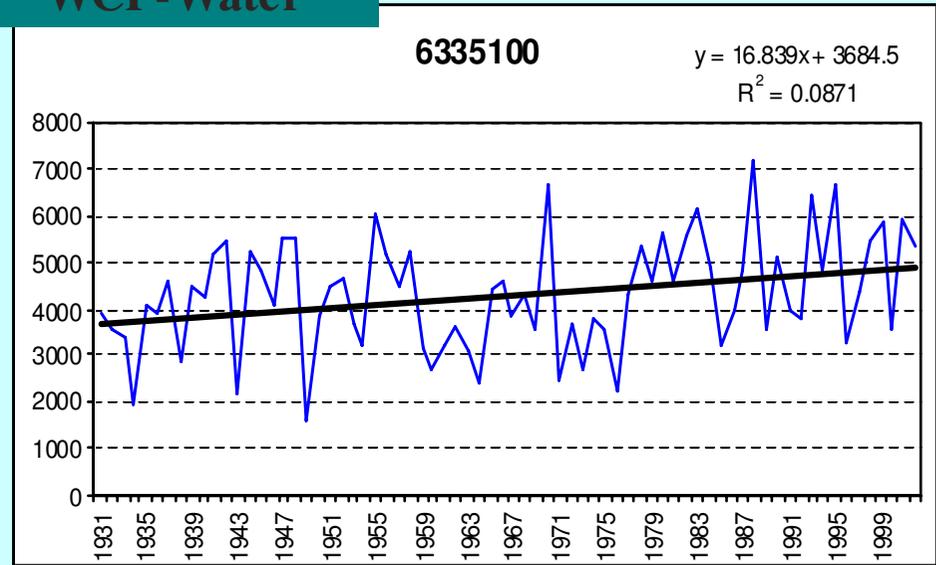
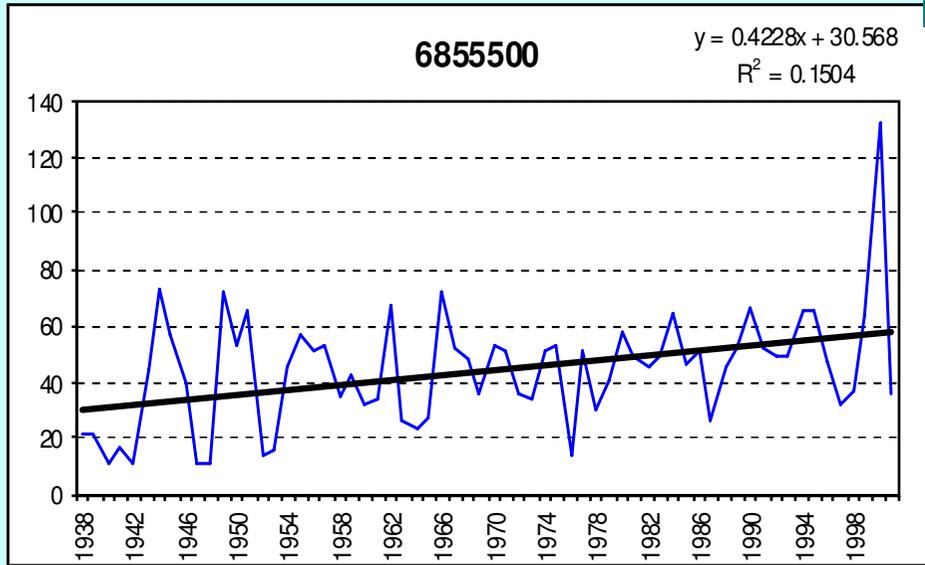


Karjaanjoki, Lohjanjarvi-Peltokoski (SF)

Maximum annual flow

Rhine, Kaub (D)

WCP-Water



Main, Schweinfurt (D)

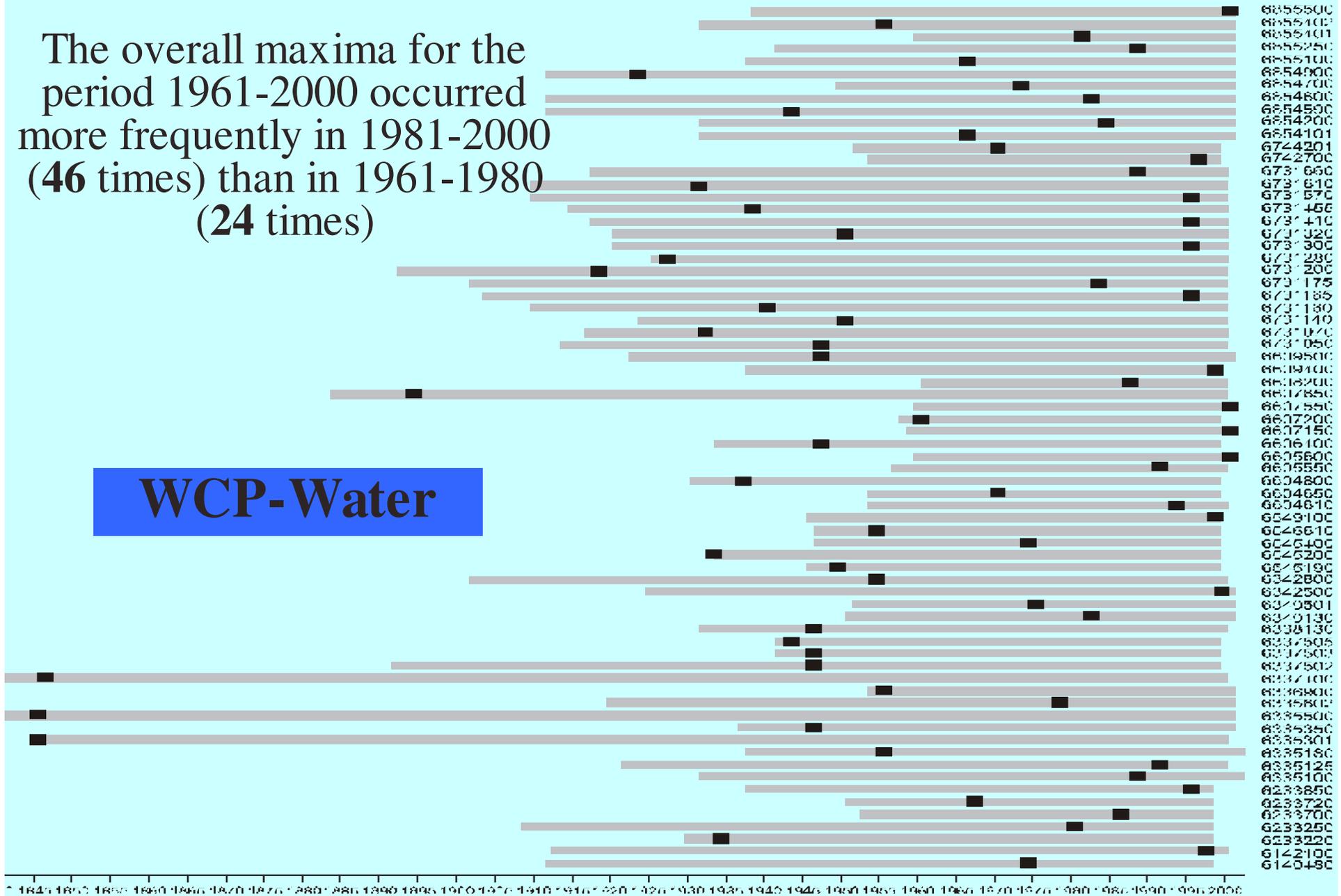
Source: Kundzewicz et al. (2004)

Morava, Moravicany (CZ)

Year of occurrence of maximum flow (Source: Kundzewicz et al., 2005)

The overall maxima for the period 1961-2000 occurred more frequently in 1981-2000 (46 times) than in 1961-1980 (24 times)

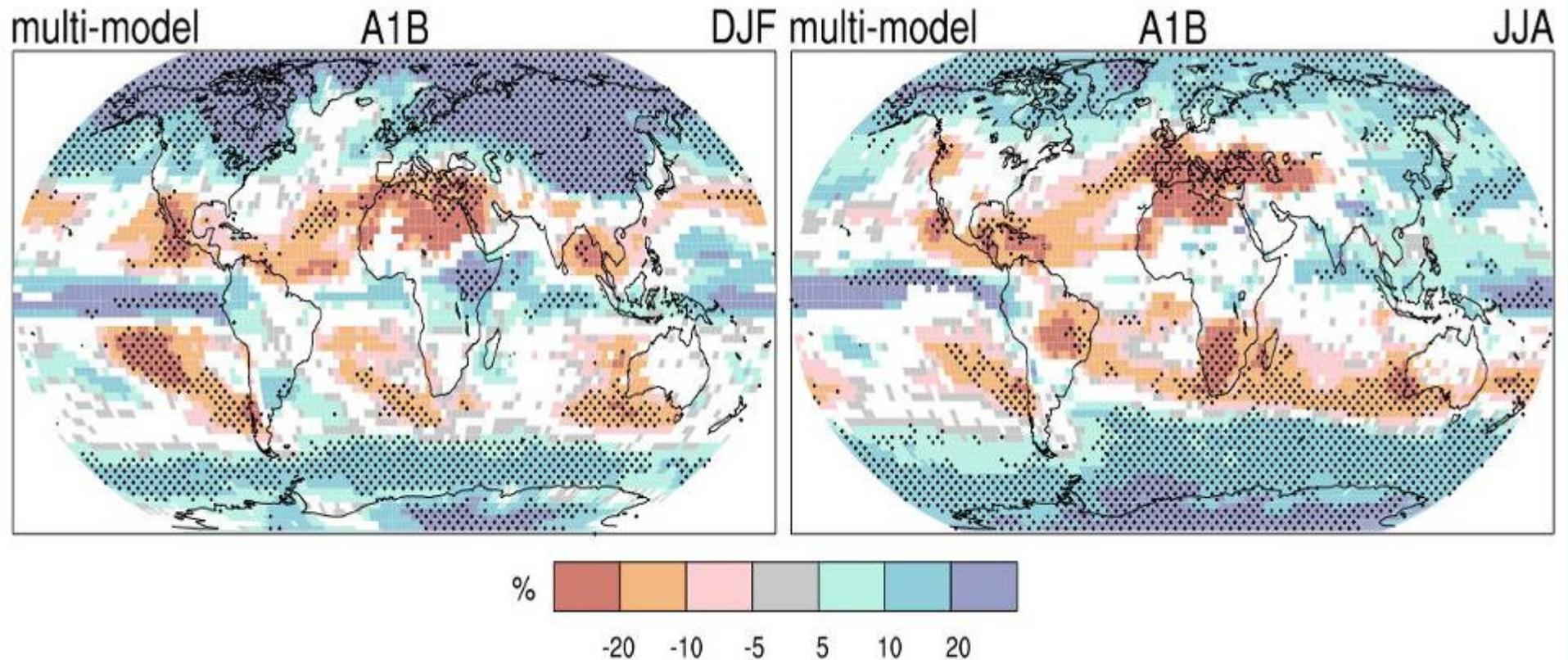
WCP-Water



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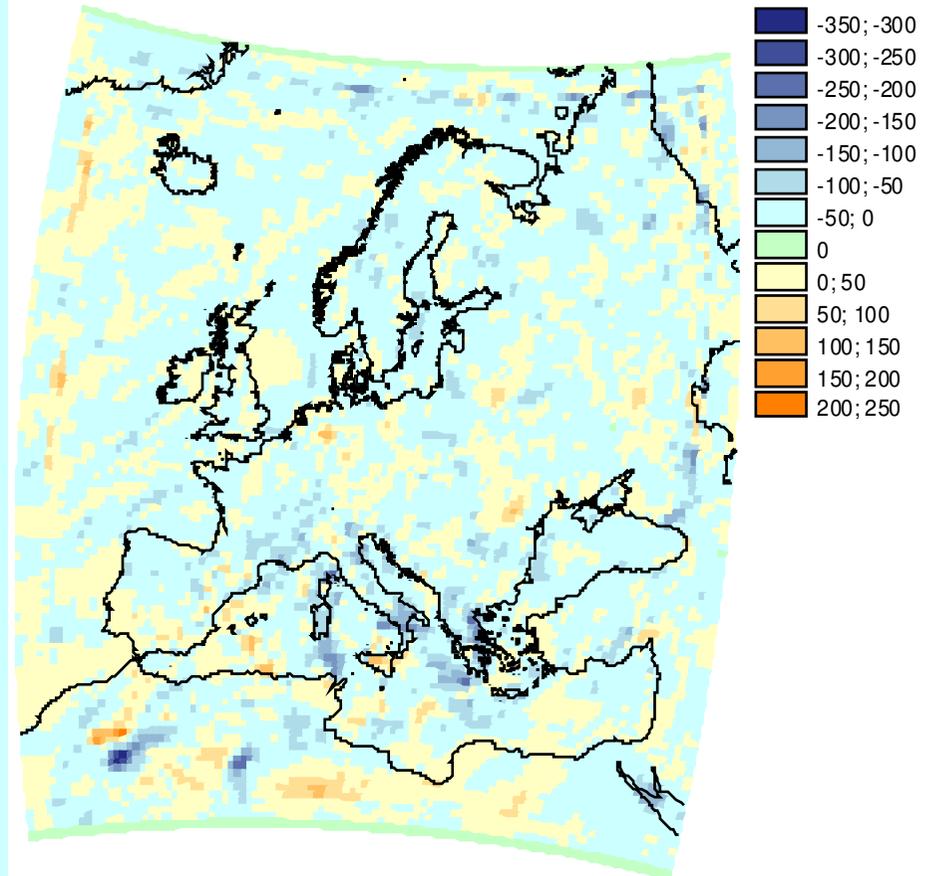
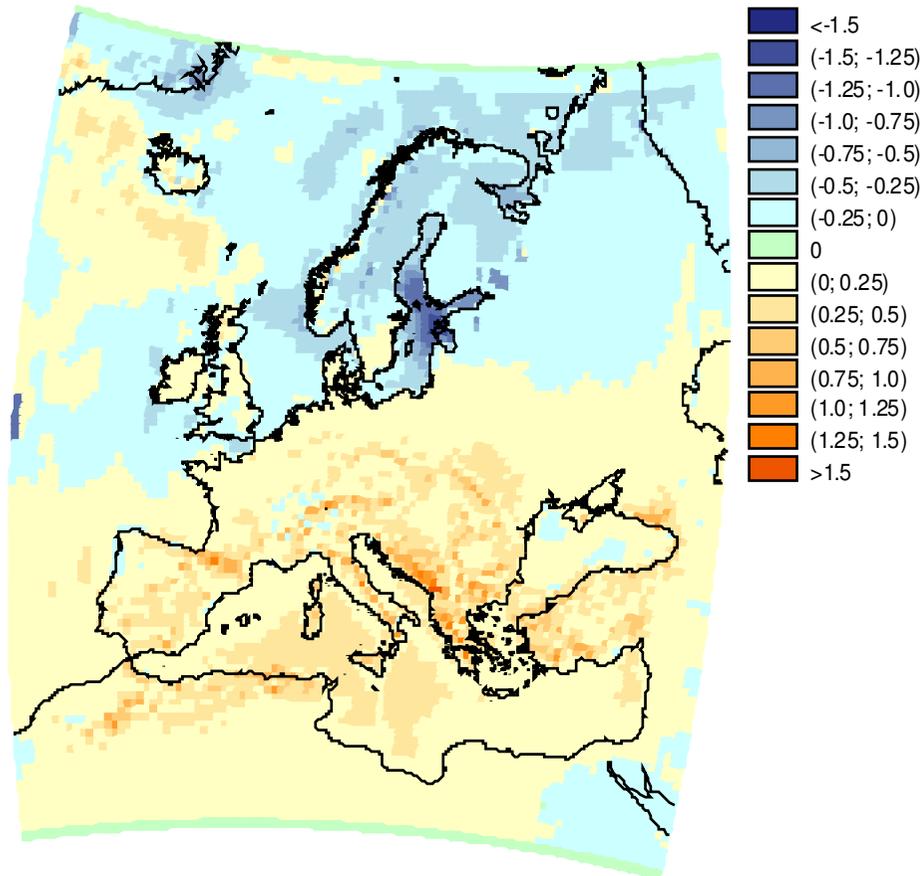
Relative changes in precipitation (in percent) for the period 2090–2099, relative to 1980–1999. Values are multi-model averages based on the SRES A1B scenario for December to February (left) and June to August (right). White areas are where less than 66% of the models agree in the sign of the change and stippled areas are where more than 90% of the models agree in the sign of the change. [IPCC WGI SPM]



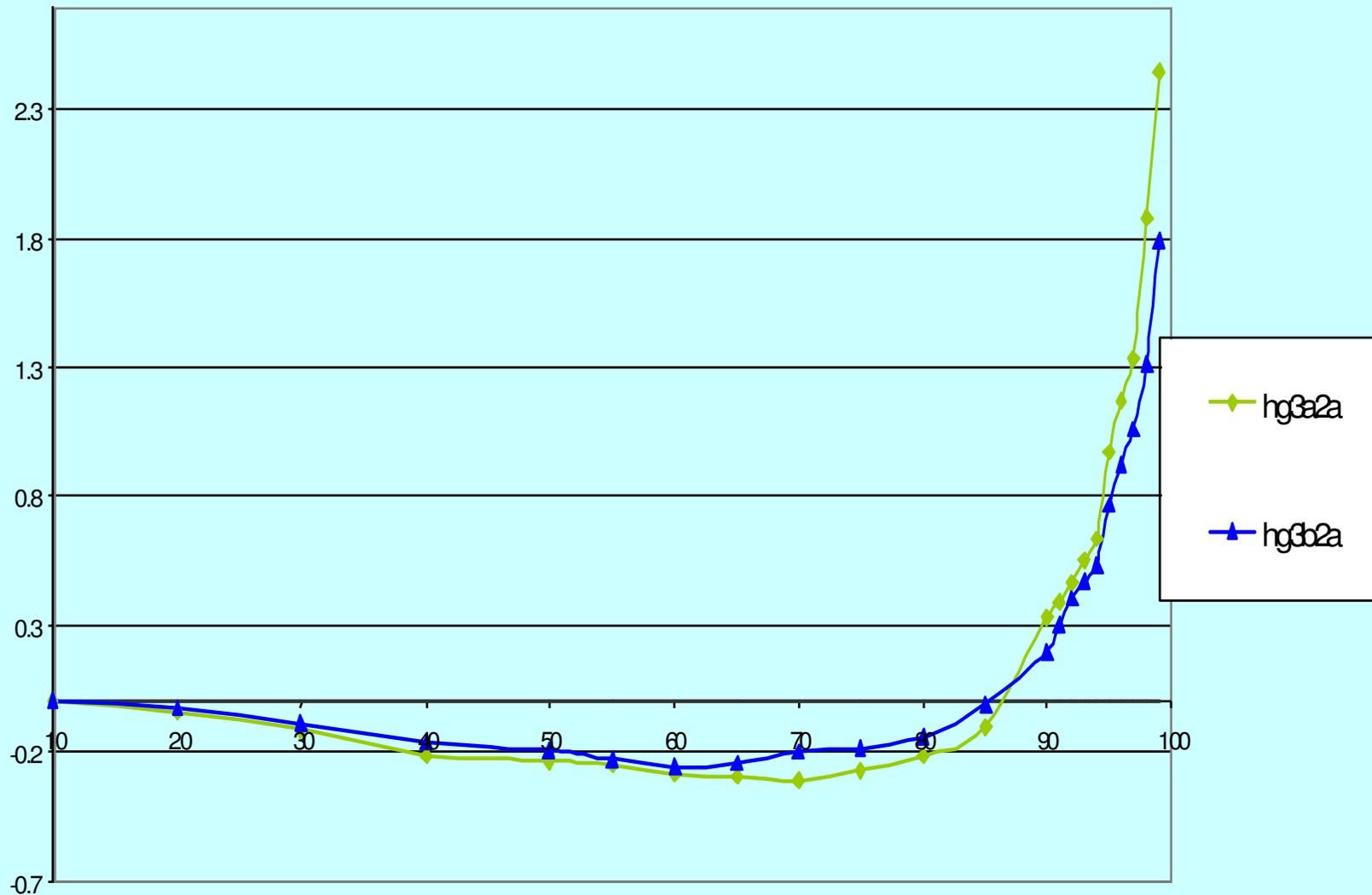
Difference between 1961-1990 and 2070-2099 (A2, HadRM3-P)

Mean precipitation

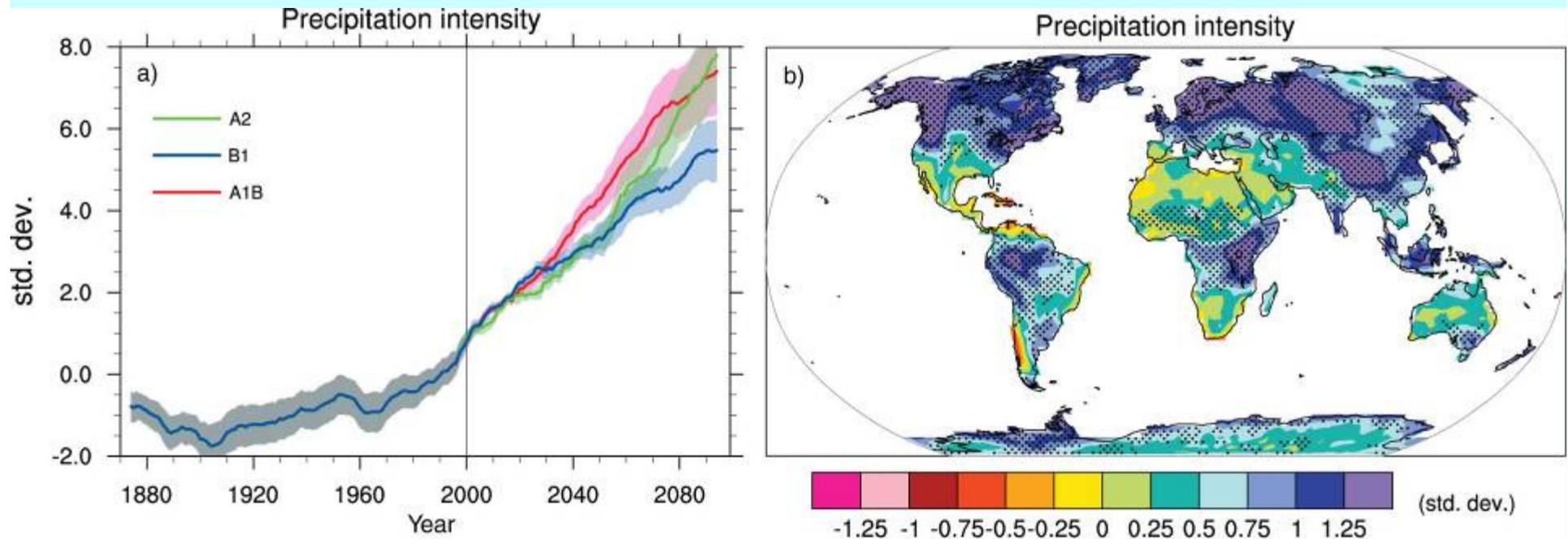
Annual maximum precipitation



Source: Kundzewicz et al. (2004)

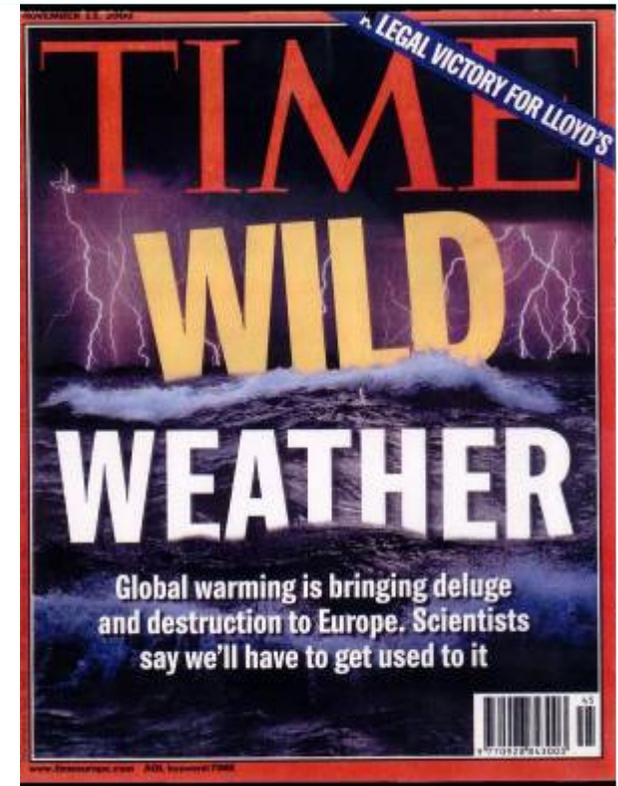
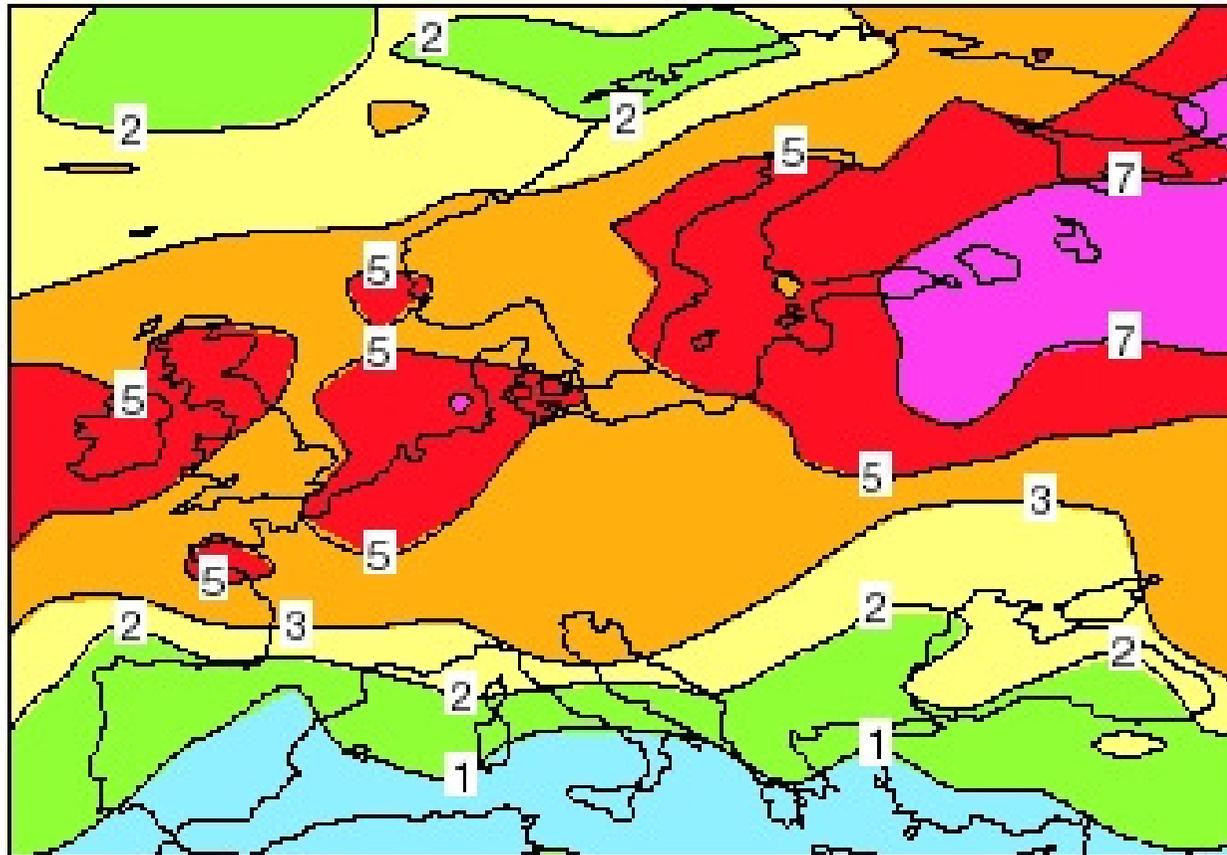


Changes in percentiles of precipitation, Poznań grid, HadRM3 (2070-2099 vs 1961-1990).



Changes in extremes based on multi-model simulations from nine global coupled climate models. L) Globally averaged changes in precipitation intensity (defined as the annual total precipitation divided by the number of wet days) for three scenarios. R) Changes of spatial patterns of precipitation intensity based on simulations between two 20-year means (2080–2099 minus 1980–1999) for the A1B scenario. (IPCC AR4)

c Greenhouse / control



Changing probability of extreme seasonal precipitation in boreal winter. The ratio of probability of a very wet winter for CO2 doubling vs present [Palmer & Räisänen, 2002]

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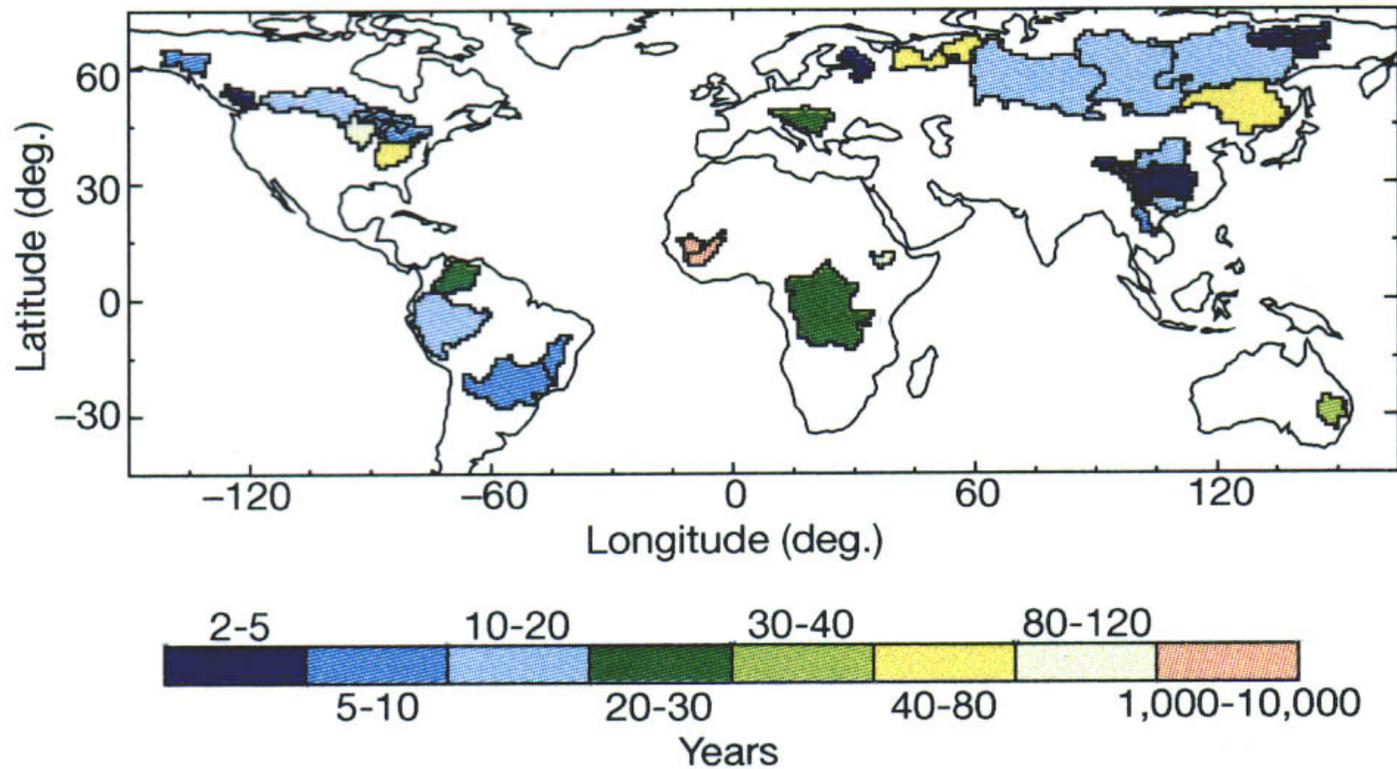
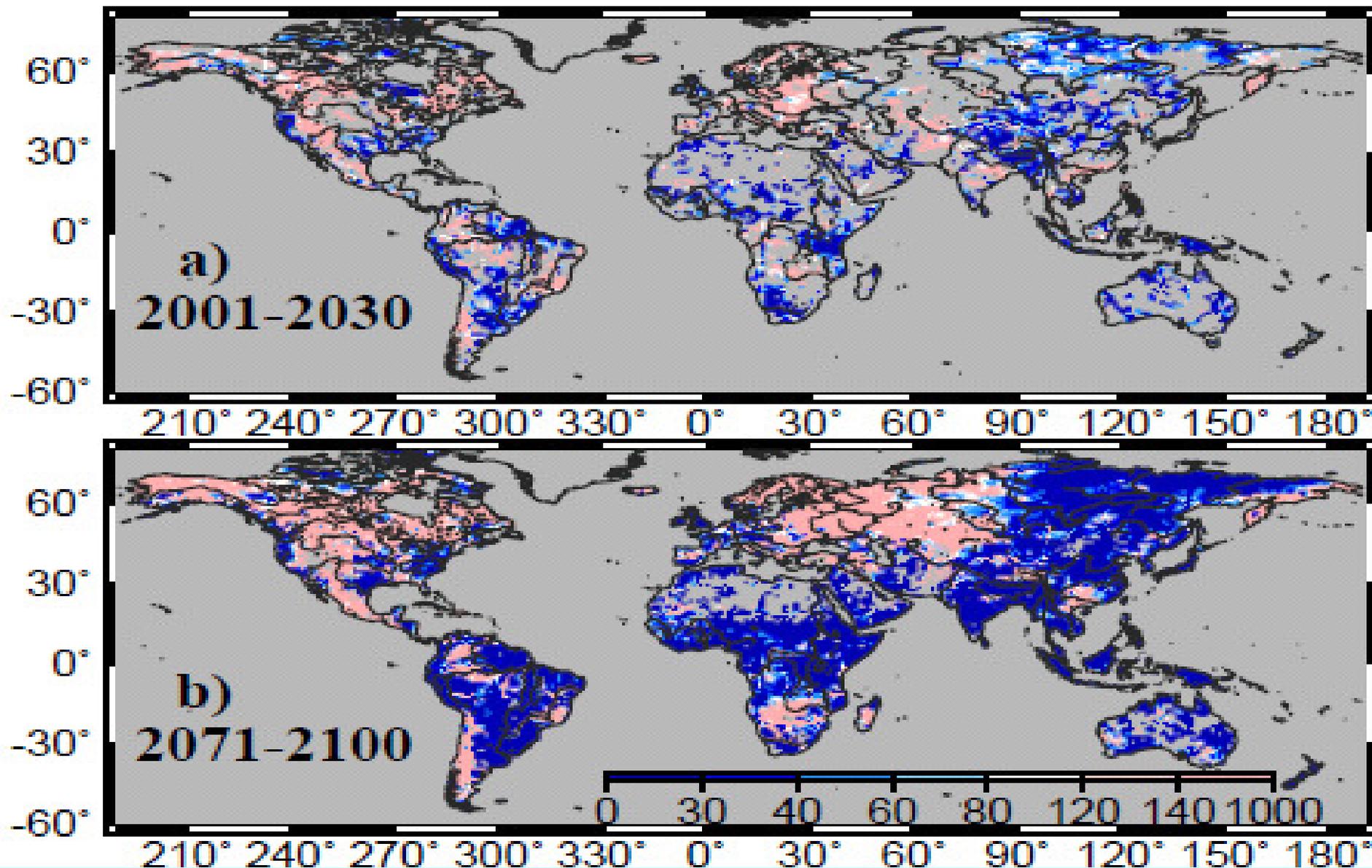
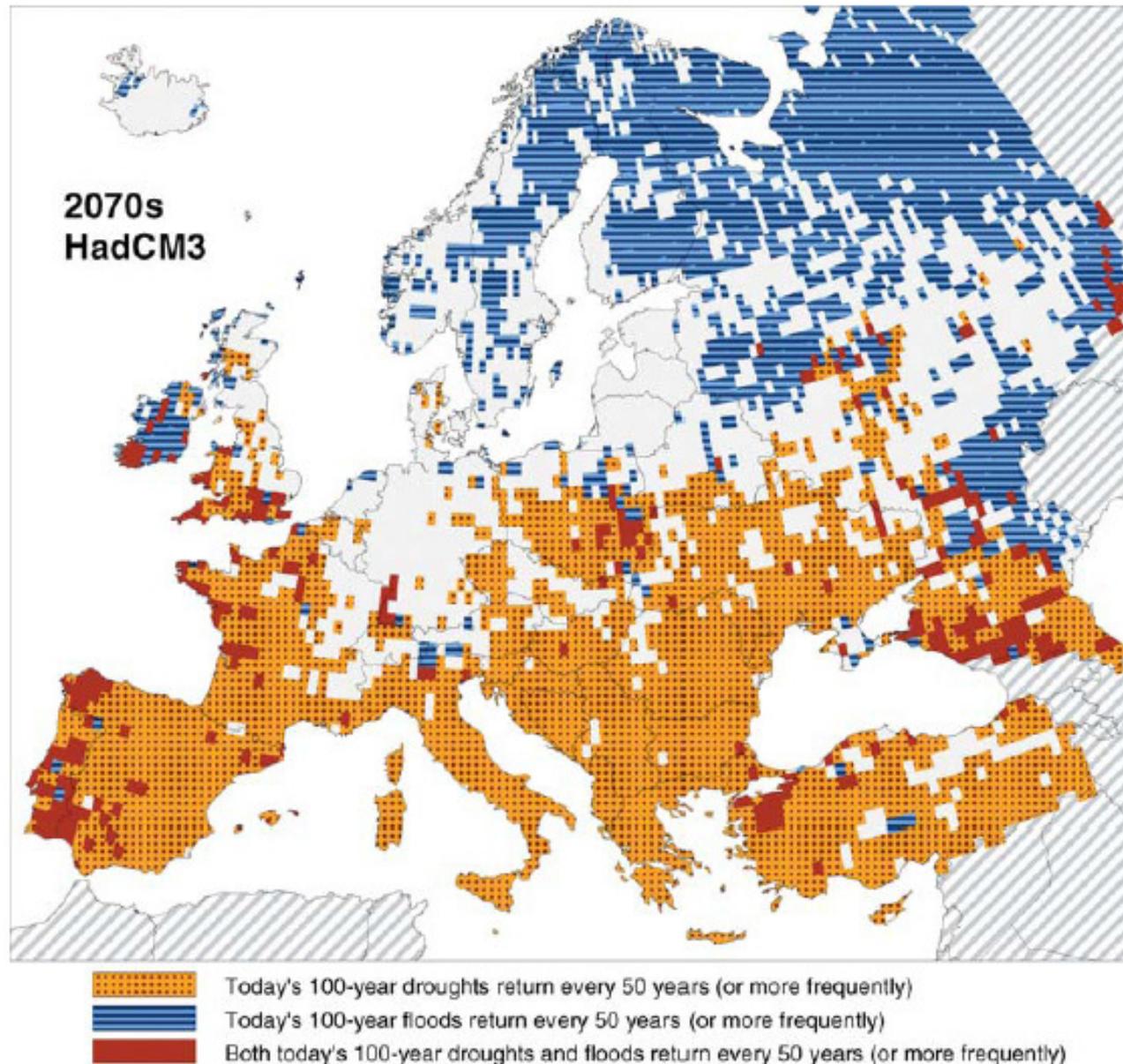


Figure 2 Map showing the gauged drainage areas and flood-risk sensitivities of the 29 river basins in this study. Colour indicates the modelled return period, under idealized quadrupling of atmospheric CO₂ concentrations, of the flood magnitude associated with a 100-yr return period in the control experiment. Although results for low-latitude basins are provided, the poor performance of the model in low latitudes should be kept in mind.

[Milly et al., 2002]



Projected return period (year) of the 20C 100-year floods in the present-day (1901–2000) simulation during (a) 2001–2030 and (b) 2071–2100 estimated by the MIROC. [Source: Hirabayashi et al., 2008]



Source:
Lehner et al.
(2007)

Figure 12. Critical regions as referred to (i) a decrease in the return period of the current 100-year drought to 50 years or less and (ii) a decrease in the return period of the current 100-year flood to 50 years or less. Values calculated with WaterGAP 2.1, based on HadCM3 climate model and Baseline-A water use scenario for the 2070s.

Source: Schreider et al., 2000

The average annual direct flood damage for Queanbeyan, Canberra and the Hawkesbury–Nepean corridor under present day and double CO₂ climates

Catchment	Present day			Double CO ₂ climate		
	Residential	Commercial	Total	Residential	Commercial	Total
Queanbeyan	0.55	0.69	1.24	5.40	6.75	12.15
Canberra	<0.001	0.007	0.007	0.001	0.07	0.07
Hawkesbury–Nepean	3.76	2.34	6.10	14.29	8.91	13.20

All values in million \$AU at mid-1996 prices.

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Water managers in a few countries have begun to consider the implications of climate change explicitly in flood management.

In the **UK** and in **Bavaria** design flood magnitudes have been increased by **20%** and **15%**, respectively, to reflect the possible effects of climate change.

Measures to cope with the increase of the design discharge for the Rhine in the Netherlands from **15 000 to 16 000 m³/s** must be implemented by **2015** and it is planned to increase the design discharge to **18 000 m³/s** in the longer term due to climate change.



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 (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.

Acknowledgements to co-authors of:

IPCC WGII Fourth Assessment Report

Chapter 3: Freshwater Resources and their Management

[www.ipcc.ch]

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