GLOBAL CLIMATE MODELLS AND REGIONAL CLIMATE PROJECTIONS FOR THE 21ST CENTURY

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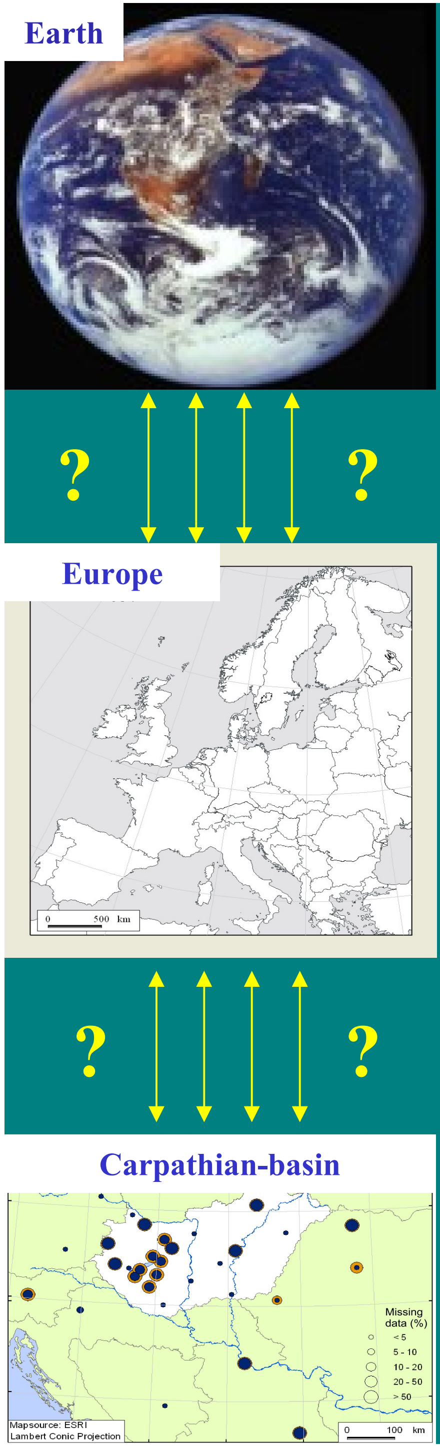


OUTLINE

I. Global climate modelling

II. Historical aspects

III. Regional climate modelling

IV. Joint EU projects on regional climate modelling (PRUDENCE, ENSEMBLES, CECILIA, CORDEX)

V. IPCC – 2007

VI. SREX -2012

VII. Progress and findings of IPCC – 2013-2014

VIII. Perspectives for the Polar region

IX. Perspectives for Central Europe

What is the IPCC?

http://www.ipcc.ch

WMO INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE UNEP

- **Established by:**
  - **World Meteorological Organization (WMO)**
  - **United Nations Environment Programme (UNEP)**
- **Open to all member governments of the UN and WMO**
- **Started in 1988**
- **Full reports in 1990, 1995, 2001, 2007, 2013**

From the IPCC web pages:

"The role of the IPCC is to assess on a comprehensive, objective, transparent basis of the scientific, technical and socio-economic information, wich is relevant to understanding the risk of human-induced climate change and its potential impacts."

What is the IPCC?

Every 5-6 years,
over 1000 scientists
from more than 100 nations
assess the published scientific literature
documenting the state of scientific knowledge
related to climate change issues.

The IPCC reports are ratified by the ~180 member nations.

IPCC- How is it organized?

- Three Working Groups

  I. WG: Physical climate changes

  II. WG: Impacts of physical climate changes on human and natural systems

  III. WG: Mitigation (cost/benefits) of future climate changes

  + Special Reports

IPCC- How is it organized?

- Role of Scientists
  - Assess peer-reviewed literature
  - Find consensus
    - Role of consensus
  - Express uncertainty – calibrated language
  - Write underlying report
  - Write draft of Summary for PolicyMakers

IPCC- Role of consensus

- Finding consensus is very hard
  - Scientists seem much better at finding points of disagreement than points of agreement
- Does a given statement reflect the scientific literature, uncertainties and a wide range of opinions?

IPCC- Role of consensus

- Wording is a big issue
- 2001 WGI bottom line as an example:

"There is new and stronger evidence that *most* of the warming over the last 50 years is attributable to human activities."

  - Plenary turned "much" into "most"
  - Previous disagreement over "substantial" resulted in "much"

- What does substantial mean?
    - Majority?
    - Plurality?

Uncertainty

Different ways to express uncertainty

- Probability (pdf) – likelihood – WG1
  - Virtually certain, Very likely, likely, etc.
- Confidence – high confidence – WG2
  - High, medium, low confidence
- Agreement – high agreement – WG3
  - High, medium, low agreement
- Evidence – much evidence – WG3
  - Much, medium, limited evidence

IPCC- Uncertainty Calibrated Language

- Working Group I definitions:
  - Virtually certain: >99% probability (1:100)
  - Extremely likely: >95% (1:20)
  - Very likely: >90% (1:10)
  - Likely: > 66% (1:3)
  - More likely than not: >50%
  - Unlikely: <33%
  - Very unlikely: <10%

IPCC - Role of governments

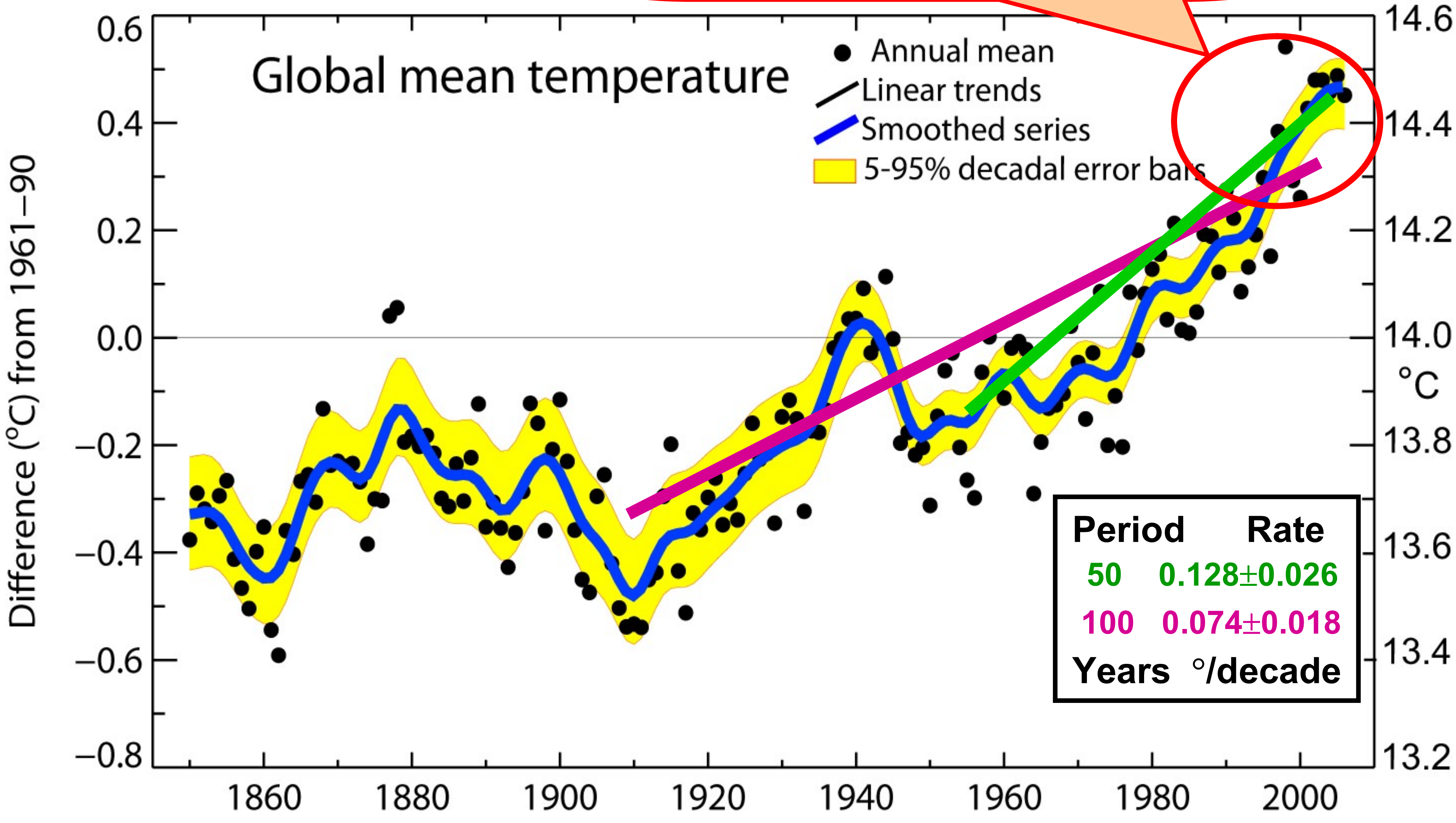
- Must approve SPM (Summary for Policy Makers) line by line (or word by word)
- Scientists must also agree to wording changes
  - Must be consistent with underlying report
  - "Can I live with wording?" question
- Possible to have footnotes saying that a given country or countries did not approve of a part of the text … occasionally used

IPCC- Plenary

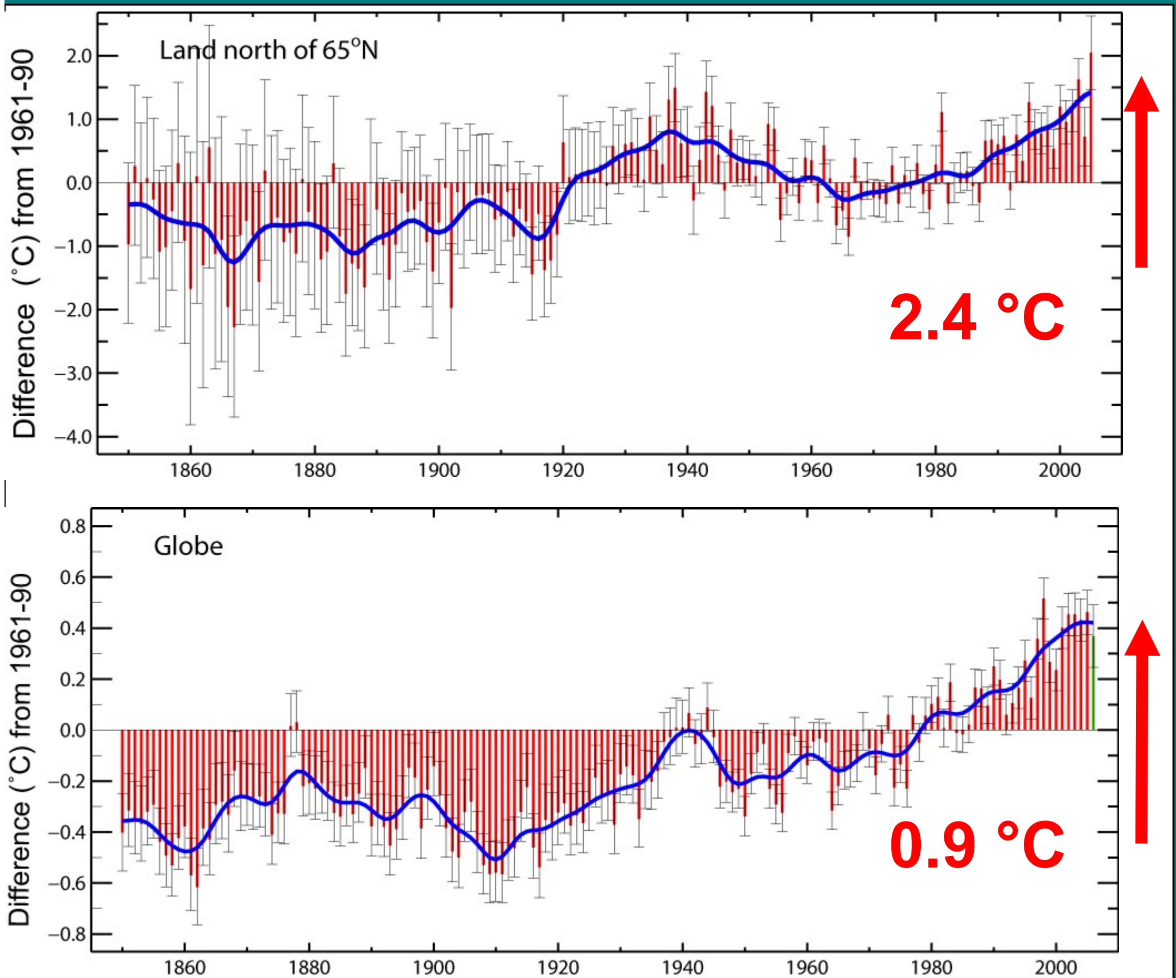
- Typically go very slowly through text in the beginning
- When progress stops on a wording/science/political issue => breakout groups
- Breakout groups meet before/after meeting
  - Focus on a subset of the text
- Last day(s) goes well into night
  - Rush to get things done

Global mean temperatures are rising faster with time

Warmest 12 years:
1998,2005,2003,2002,2004,2006, 2001,1997,1995,1999,1990,2000



Arctic vs Global annual temperature anomalies (°C)

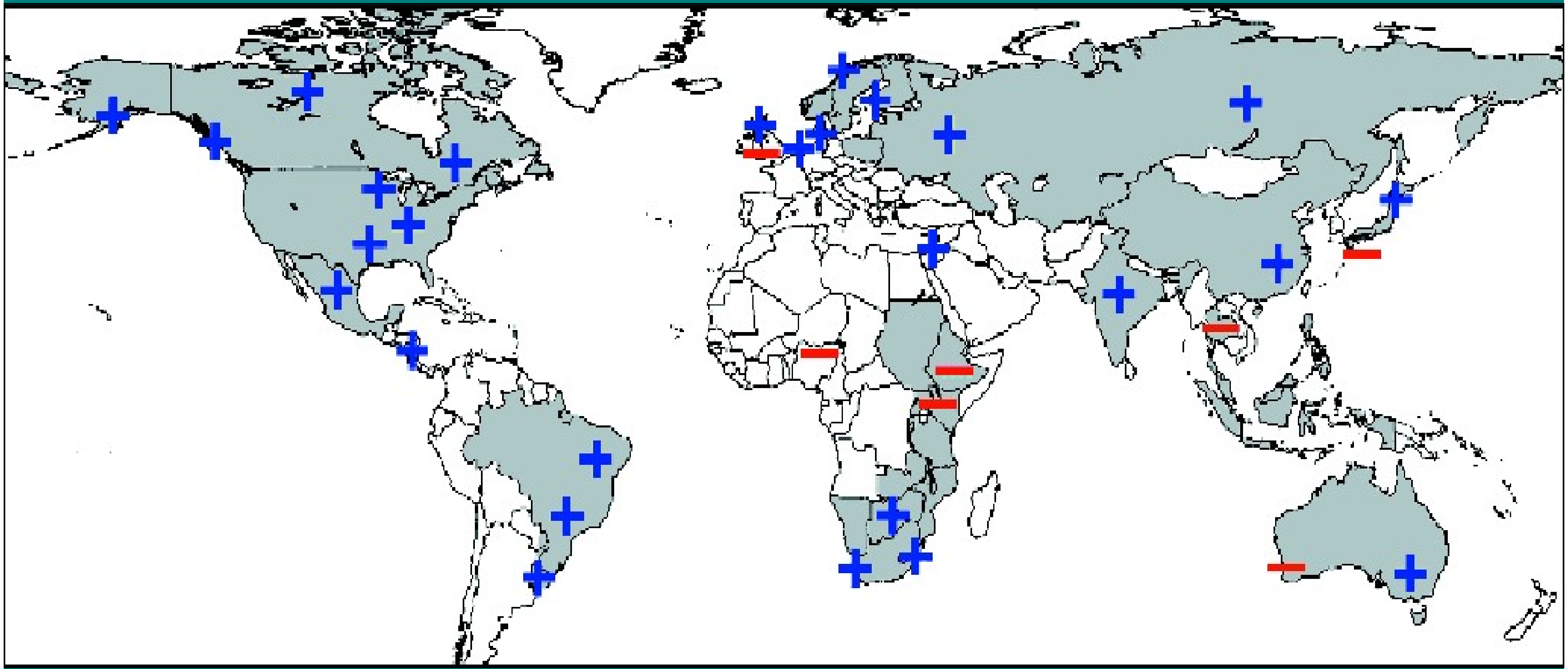


Warming in the Arctic is more than **double** that for the globe from 19th to 21st century and from late 1960s to present.

Warmth 1925 to 1950 in Arctic was not as widespread as recent global warmth.

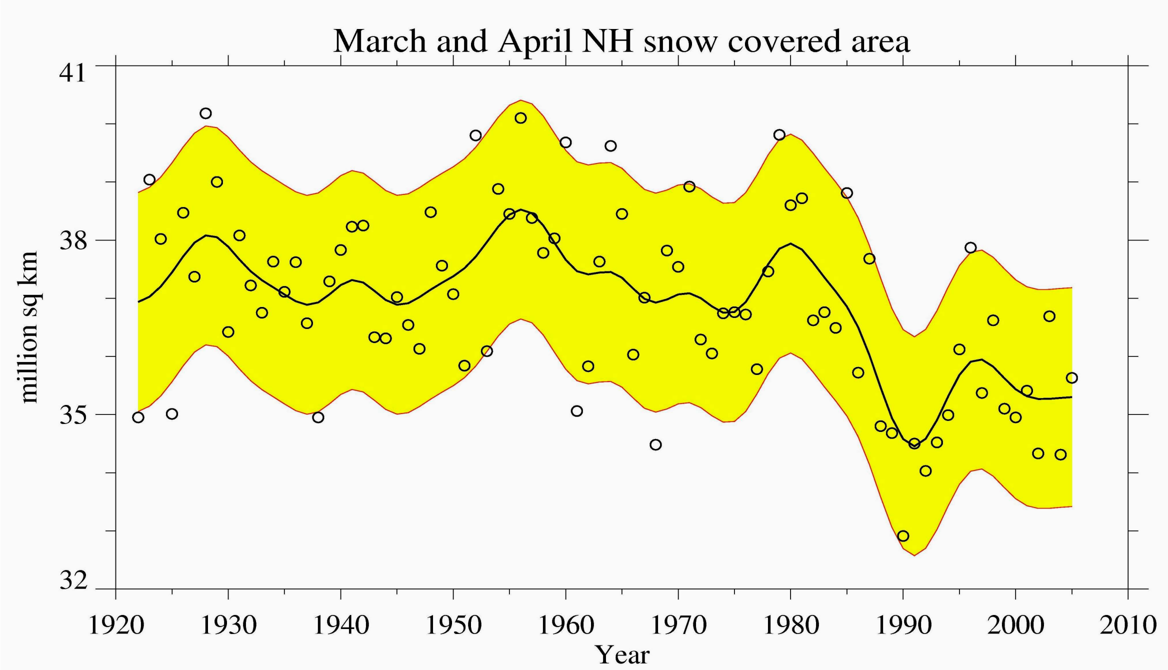
Note different scales

Proportion of heavy rainfalls: increasing in most land areas

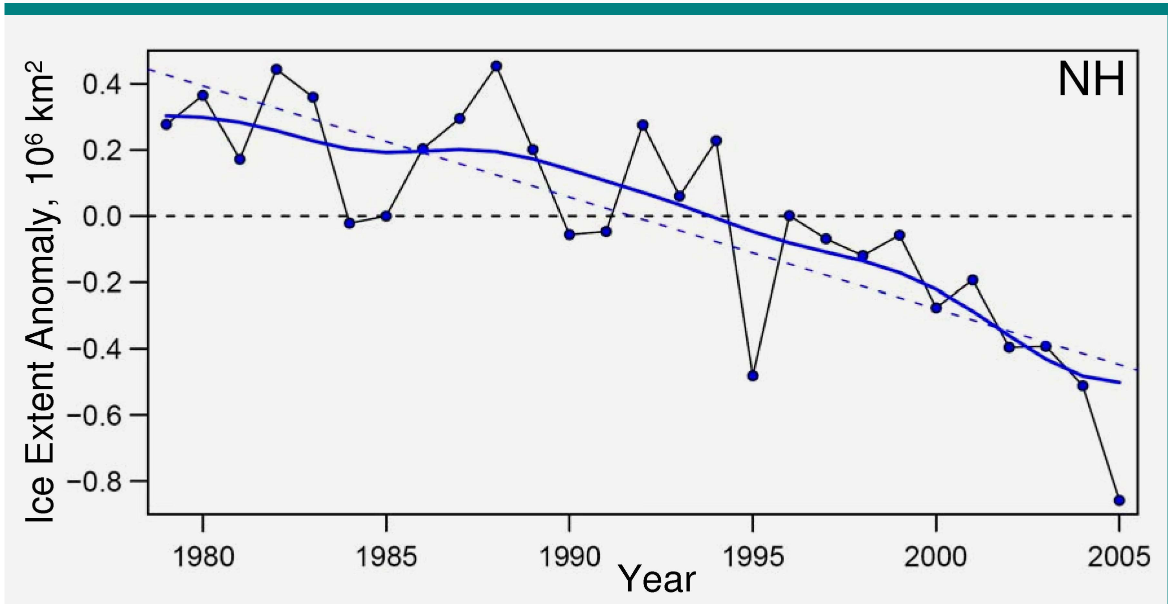


Regions of disproportionate changes in heavy (95th) and very heavy (99th) precipitation

Snow cover and Arctic sea ice are decreasing

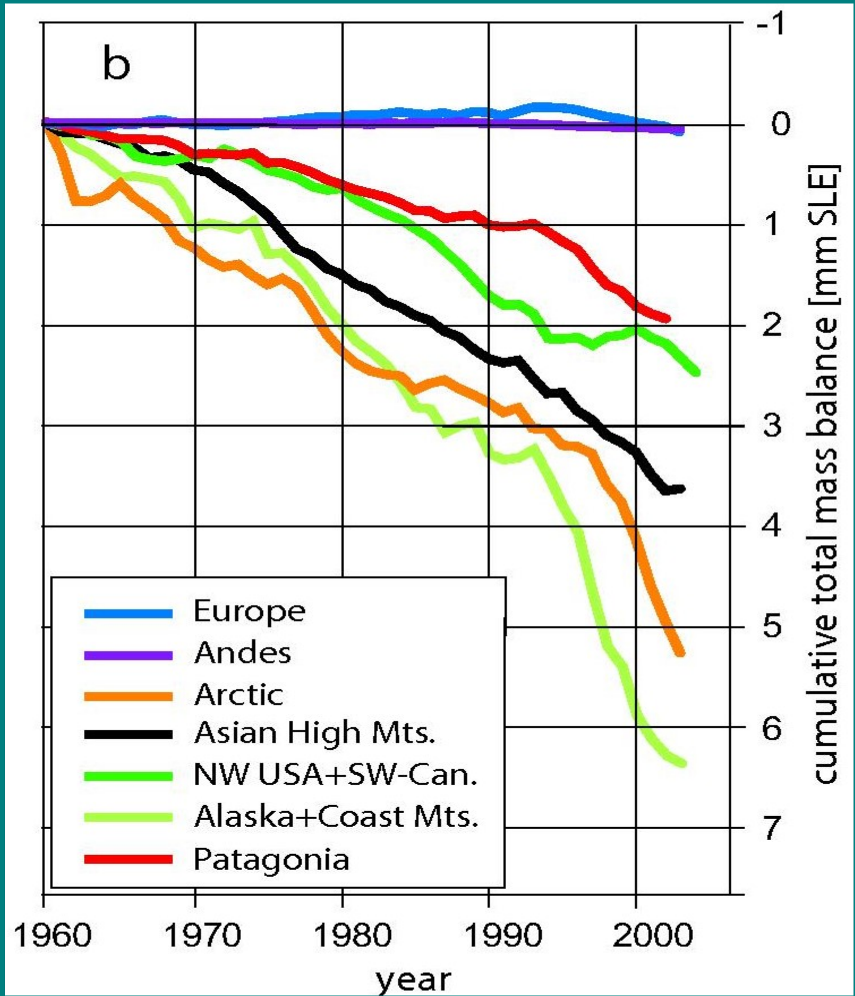


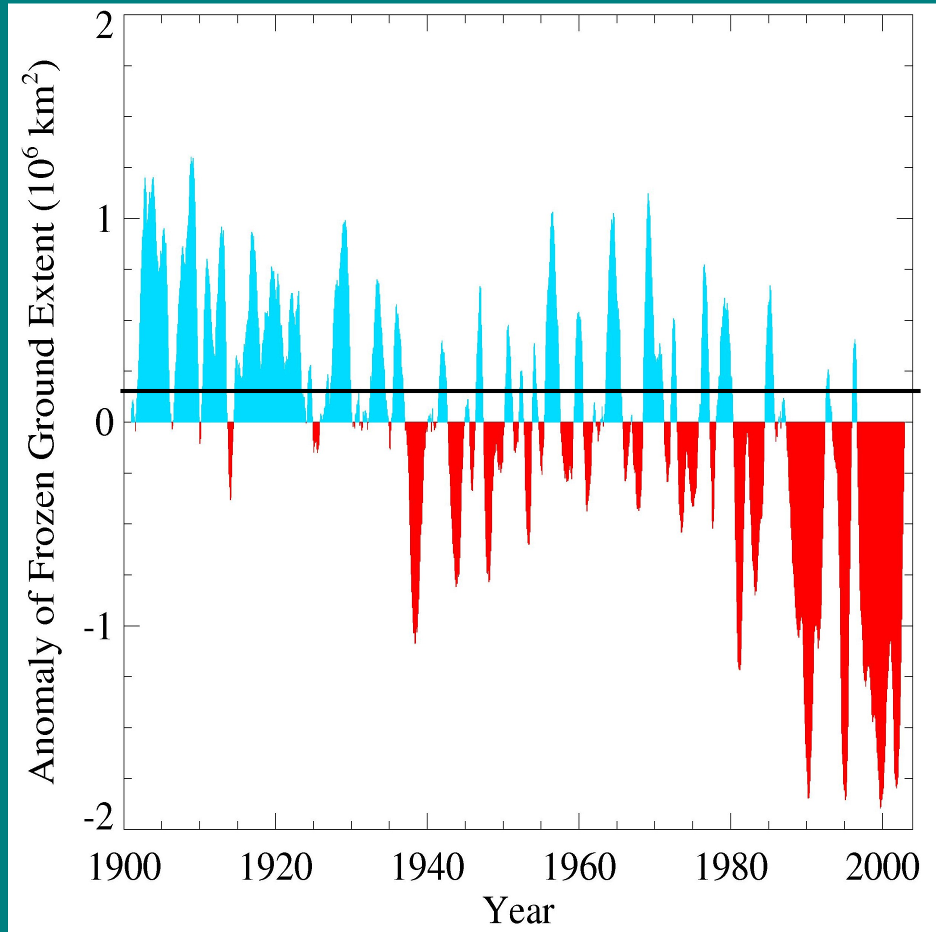
Spring snow cover shows 5% stepwise drop during 1980s



Arctic sea ice area decreased by 2.7% per decade (Summer: -7.4%/decade)

Glaciers and frozen ground are decreasing





Increased Glacier retreat since the early 1990s

Area of seasonally frozen ground in NH has decreased by 7% (1901 – 2002)

Some aspects of climate have not been observed to change:

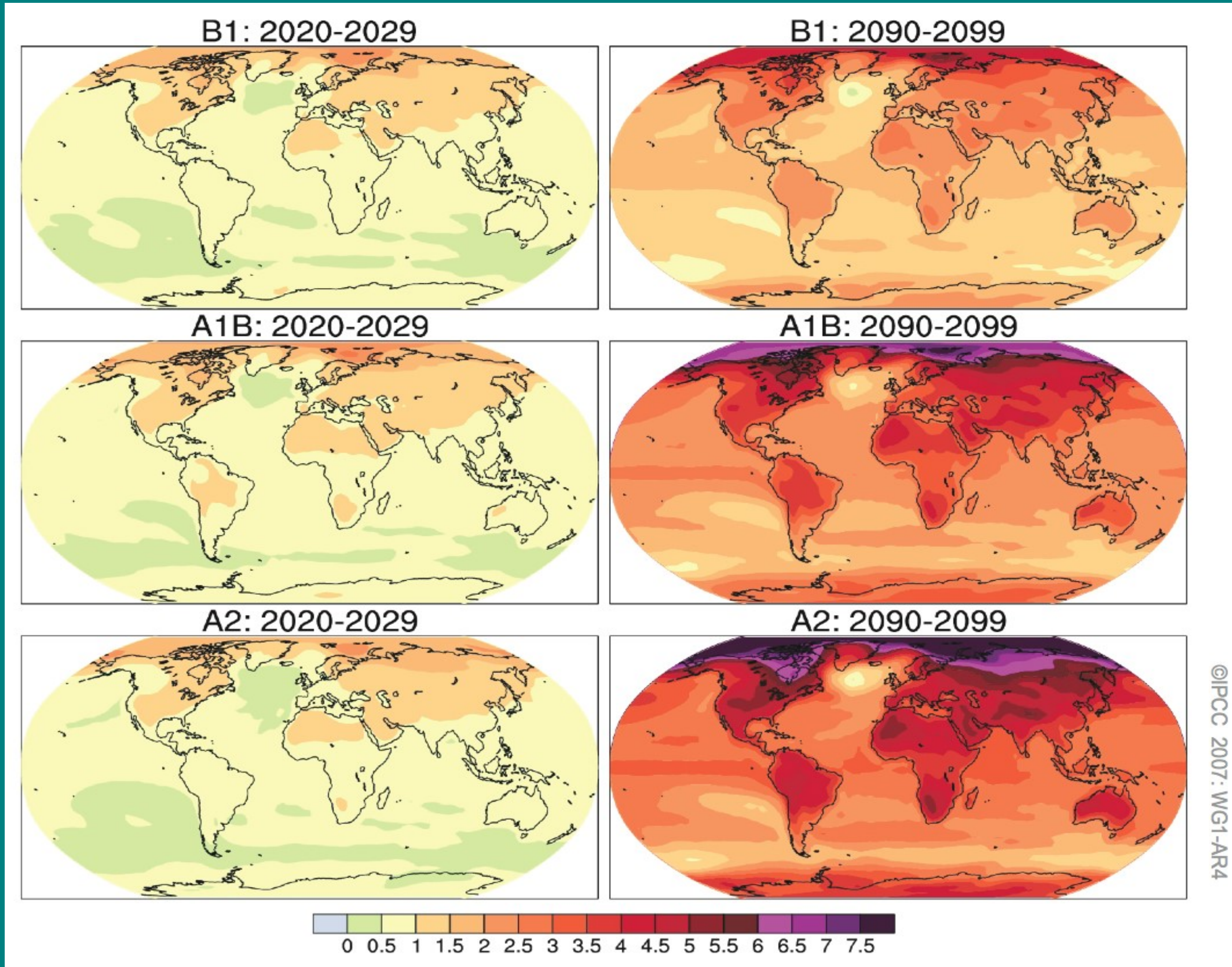
- Tornadoes
- Dust-storms
- Hail
- Lightning
- Antarctic sea ice

Projections of Future Changes in Climate

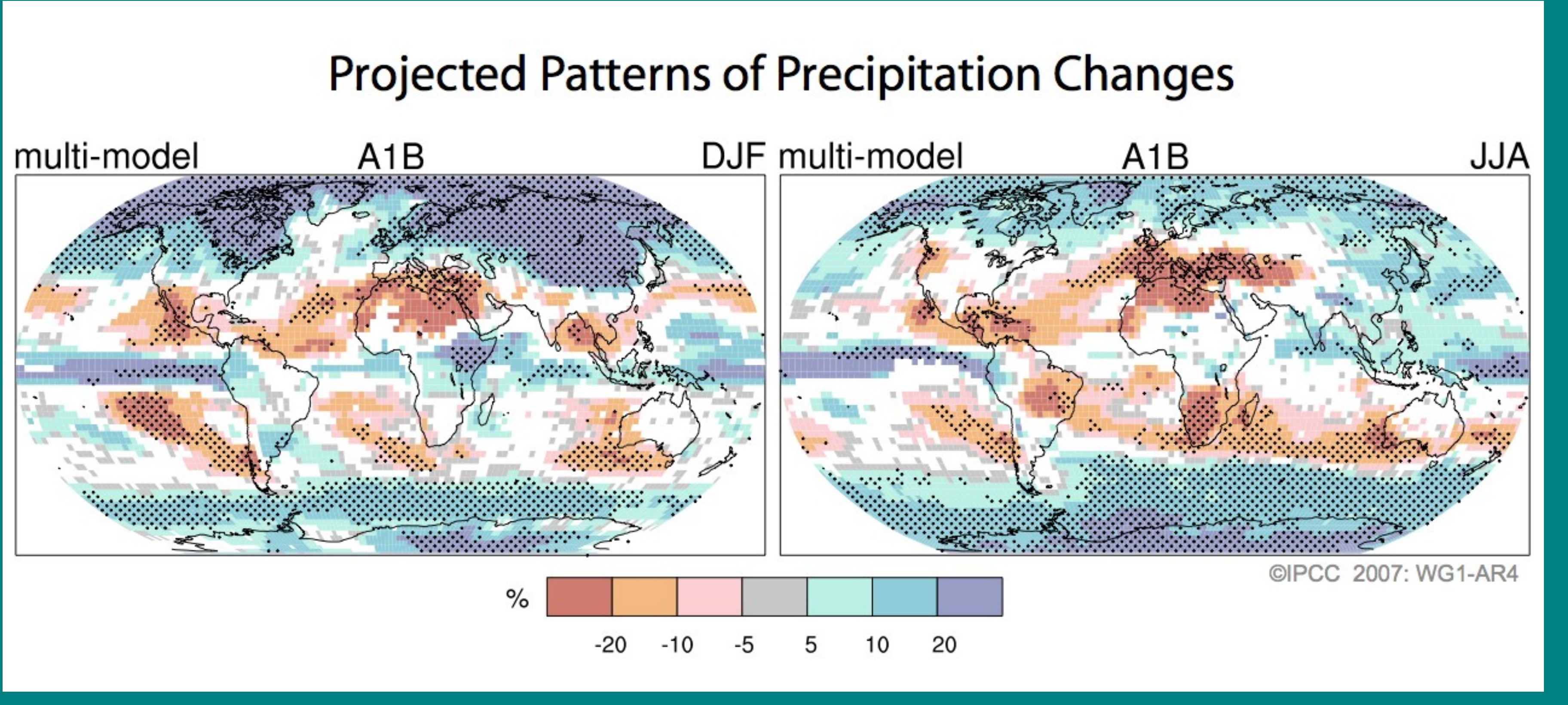
Projected warming in 21st century expected to be

greatest over land and at most high northern latitudes

and least over the Southern Ocean and parts of the North Atlantic Ocean



Projections of Future Changes in Climate



Precipitation increases *very likely* in high latitudes

Decreases *likely* in most subtropical land regions

Projection of future changes in climate – sea level

Case	Sea Level Rise (m at 2090-2099 relative to 1980-1999) Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations[b]	NA
B1 scenario	0.18 – 0.38
A1T scenario	0.20 – 0.45
B2 scenario	0.20 – 0.43
A1B scenario	0.21 – 0.48
A2 scenario	0.23 – 0.51
A1FI scenario	0.26 – 0.59

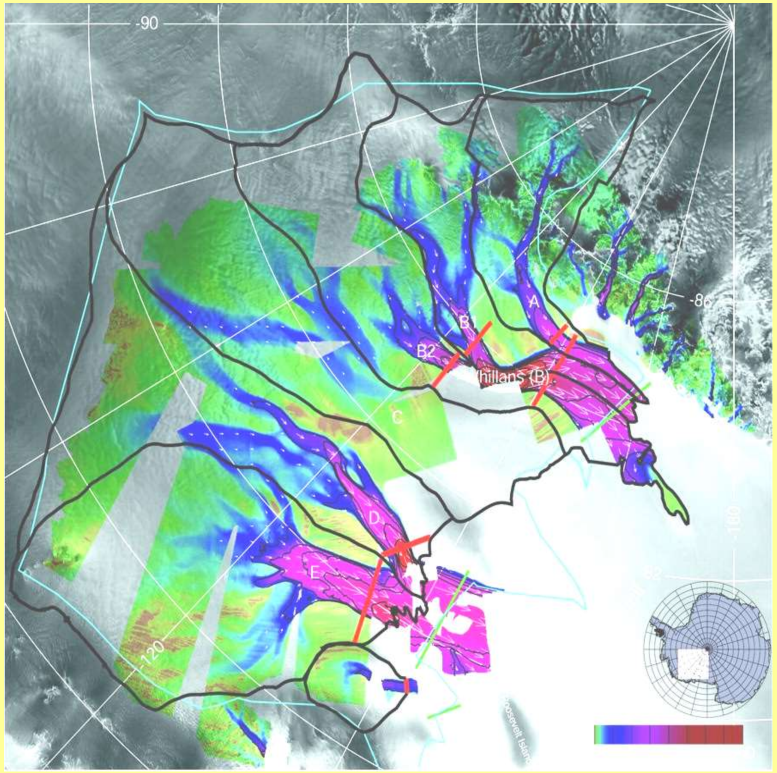
meters

Note:

- No upper bound
- No likelihood
- No best estimate
- Model based estimate only, no expert judgment

IPCC WGI SPM

Sea Level Rise Uncertainty

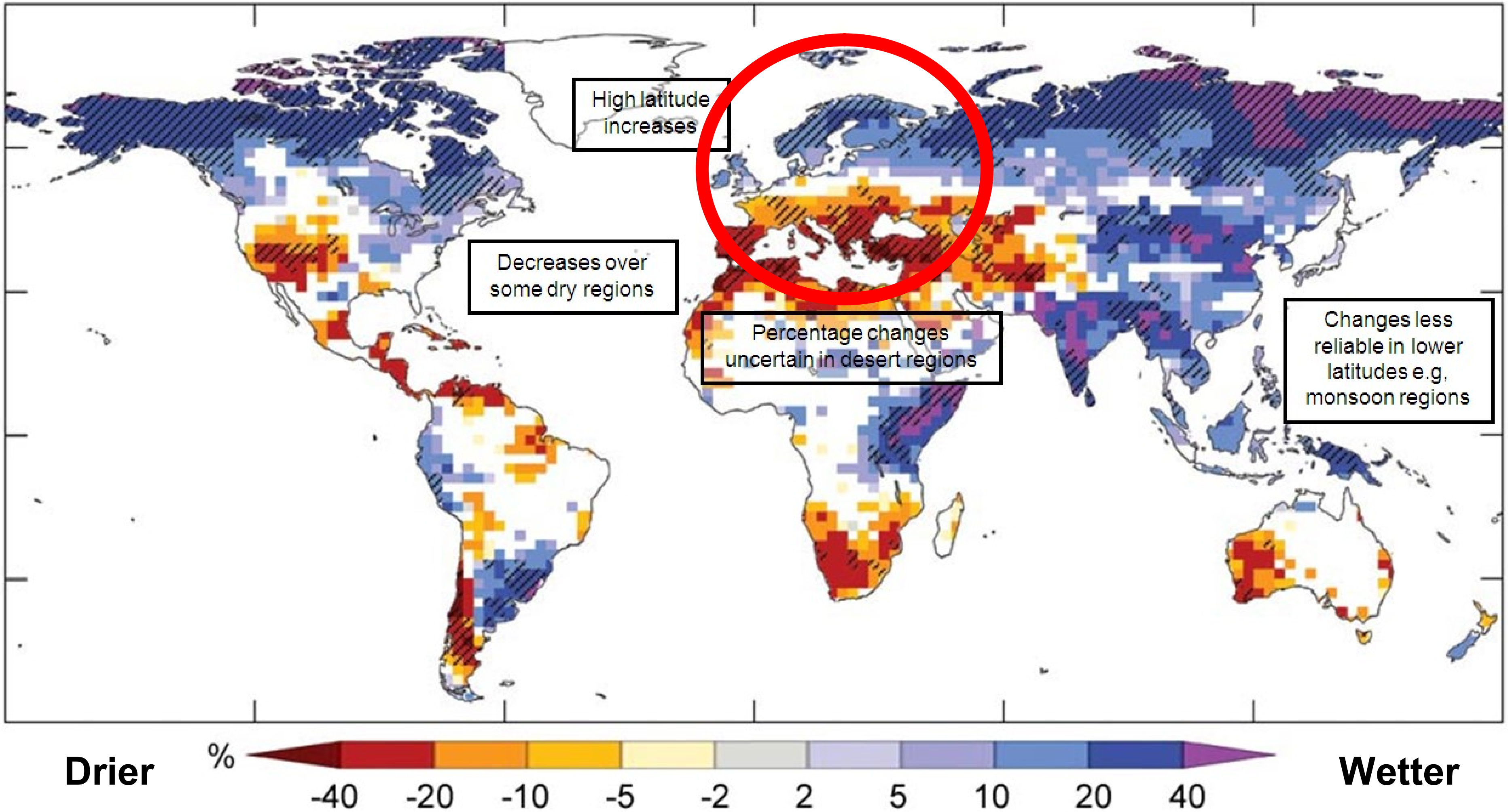


The projections include a contribution due to increased ice flow from Greenland and Antarctica at the rates observed for 1993-2003, but these flow rates could increase or decrease in the future. Therefore the upper values of the ranges given are not to be considered upper bounds for sea level rise.

If this contribution (the observed rates) were to grow linearly with global average temperature change, the upper ranges of sea level rise for SRES scenarios would increase by 0.1 m to 0.2 m.

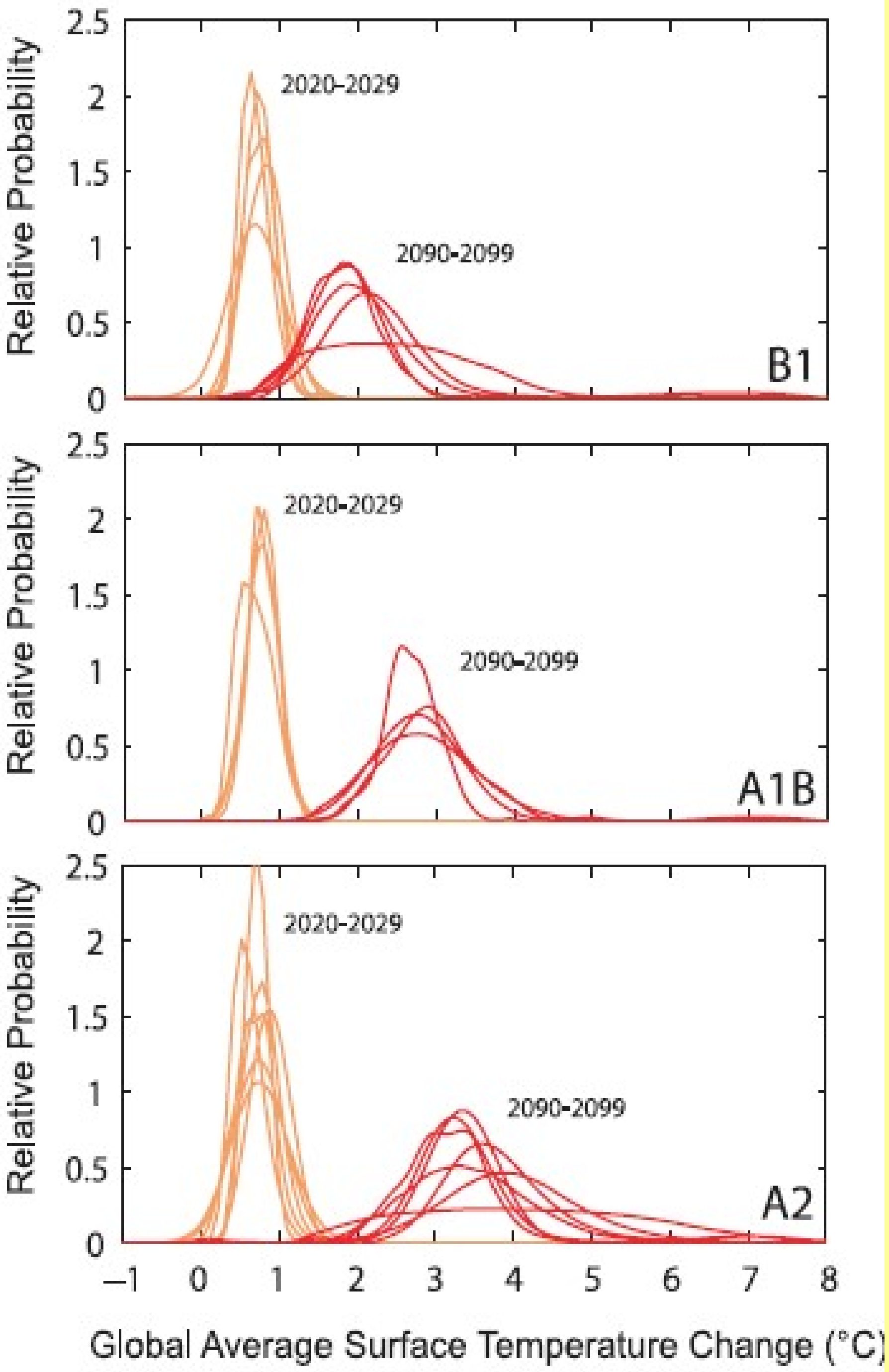
IPCC AR4 Synthesis Report wording

21st Century Water Availability (Runoff) Changes
(Annually averaged)



- *Very likely* runoff will increase in high latitudes.
- *Likely* runoff will decrease over some subtropical and tropical regions.

IPCC AR4 Synthesis



Response time scales

- Note response in 2020's very similar in different emission scenarios.
- Note response in 2090's much more scenario dependent.
- Actions taken today only will have large impacts in climate response in the future.

Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change.

- Partial loss of ice sheets on polar land could imply meters of sea level rise, major changes in coastlines and inundation of low-lying areas, with greatest effects in river deltas and low-lying islands.
- Such changes are projected to occur over millennial time scales, but more rapid sea level rise on century time scales cannot be excluded.

IPCC WGI SPM

Some regions are *likely* to be especially affected

- The Arctic, because of the impacts of high rates of projected warming on natural systems and human communities
- Africa, because of low adaptive capacity and projected climate change impacts
- Small islands, where there is high exposure of population and infrastructure to projected climate change impacts
- Asian and African megadeltas, due to large populations and high exposure to sea level rise, storm surges and river flooding.

IPCC WGI 2007 Findings

- **The planet is warming.** The warming is not uniform. In fact, some small areas are cooling. Other climate and biophysical changes support the idea that the planet is warming. Sea ice and snow edges retreating; increased precipitation; more water vapor in the atmosphere; earlier river thaws; earlier spring migrations; plant blooms; etc.

- **Humans are the cause of increasing greenhouse gases in the atmosphere (CO_2, methane, etc.).** Humans also cause emissions of items that tend to cool the planet (sulfate aerosols for example).

- **Climate models using estimates of past forcings (GHG, aerosols, solar, volcanoes) can simulate much of the past climate variations at the global scale and many regional scales.**

- Using estimates of future emissions, **climate models project relatively large increases in warming** and other associated climate impacts (precipitation, sea level, etc.) over the next century.

Key SPM Messages

19 Headlines

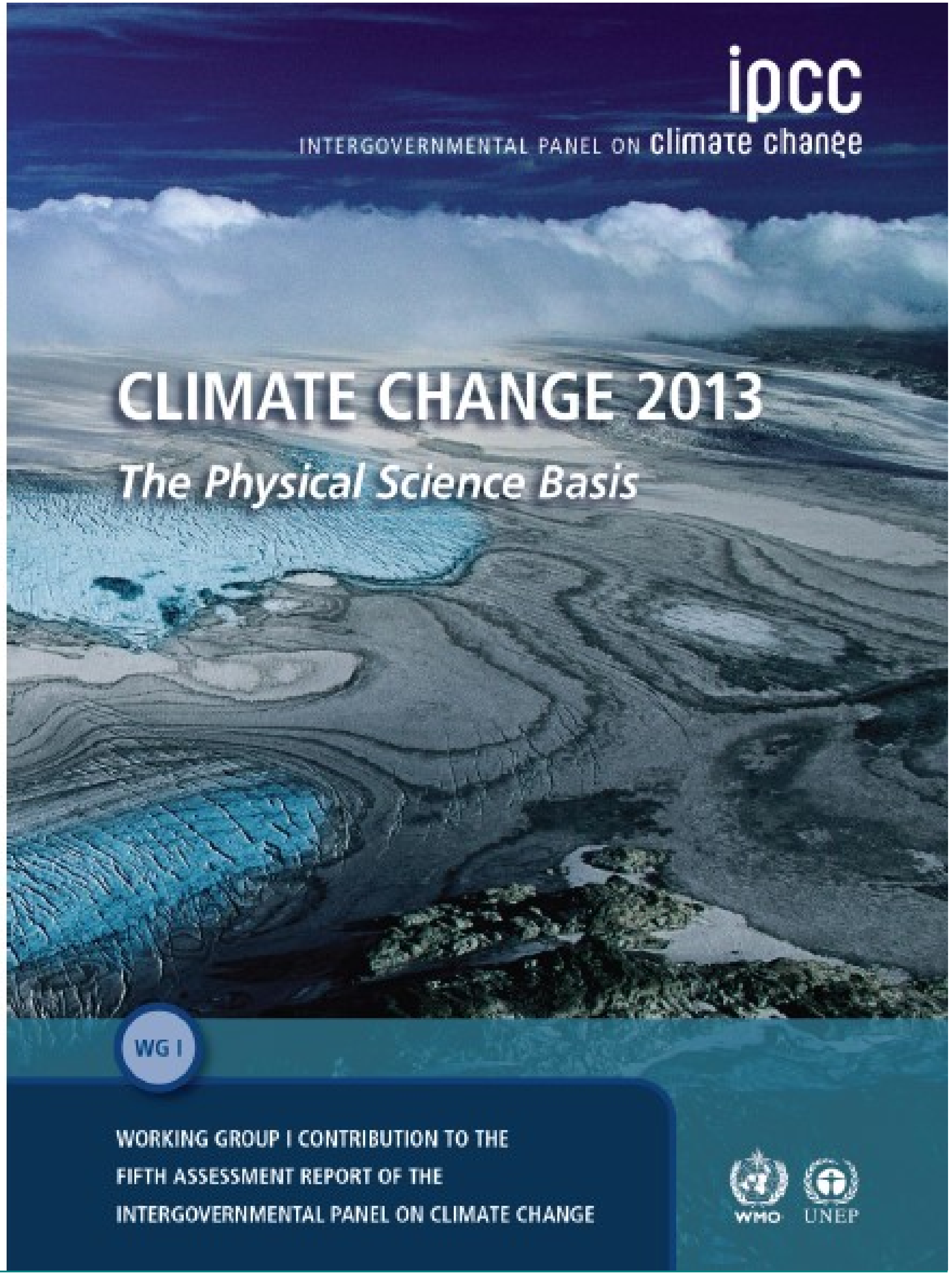
on less than 2 Pages

Summary for Policymakers
~14,000 Words

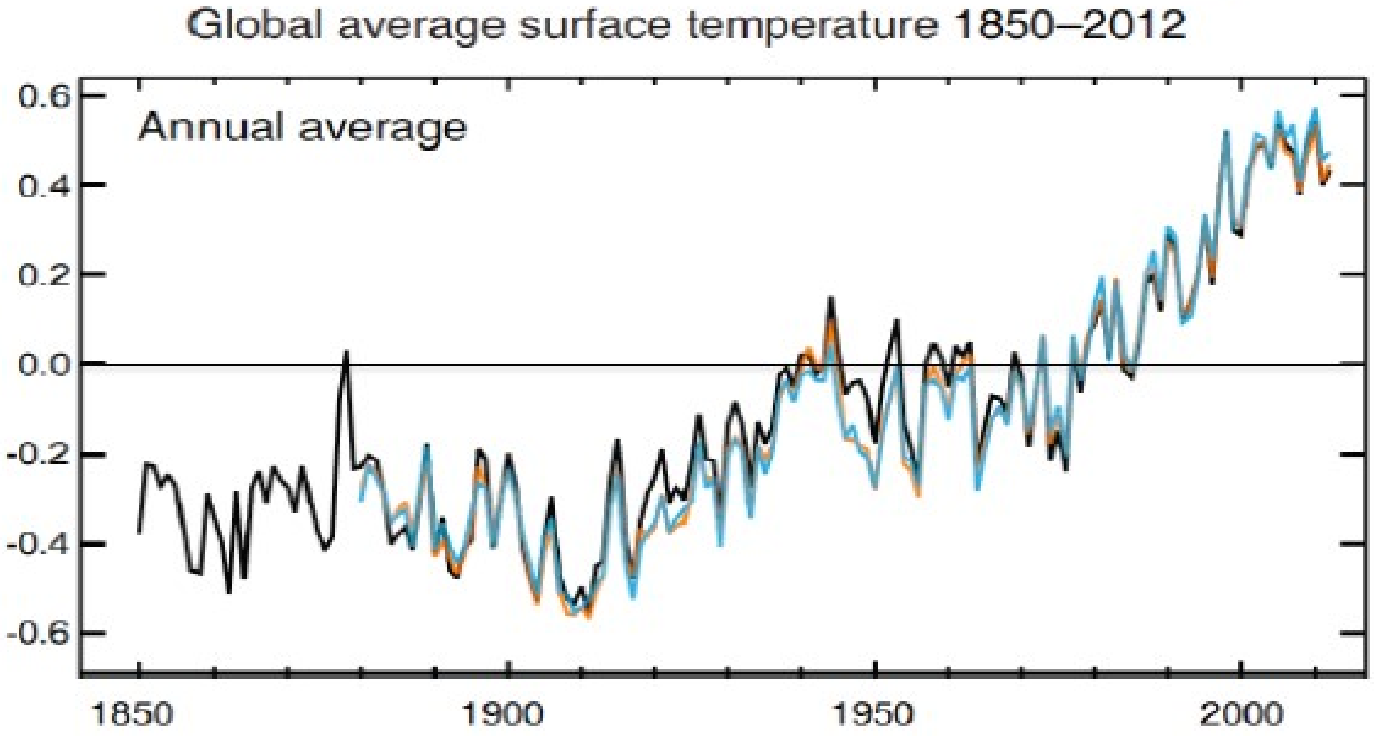
14 Chapters
Atlas of Regional Projections

54,677 Review Comments
by 1089 Experts

259 Authors Selected
from 35 countries



Annual Global Combined Land and Sea Temperature

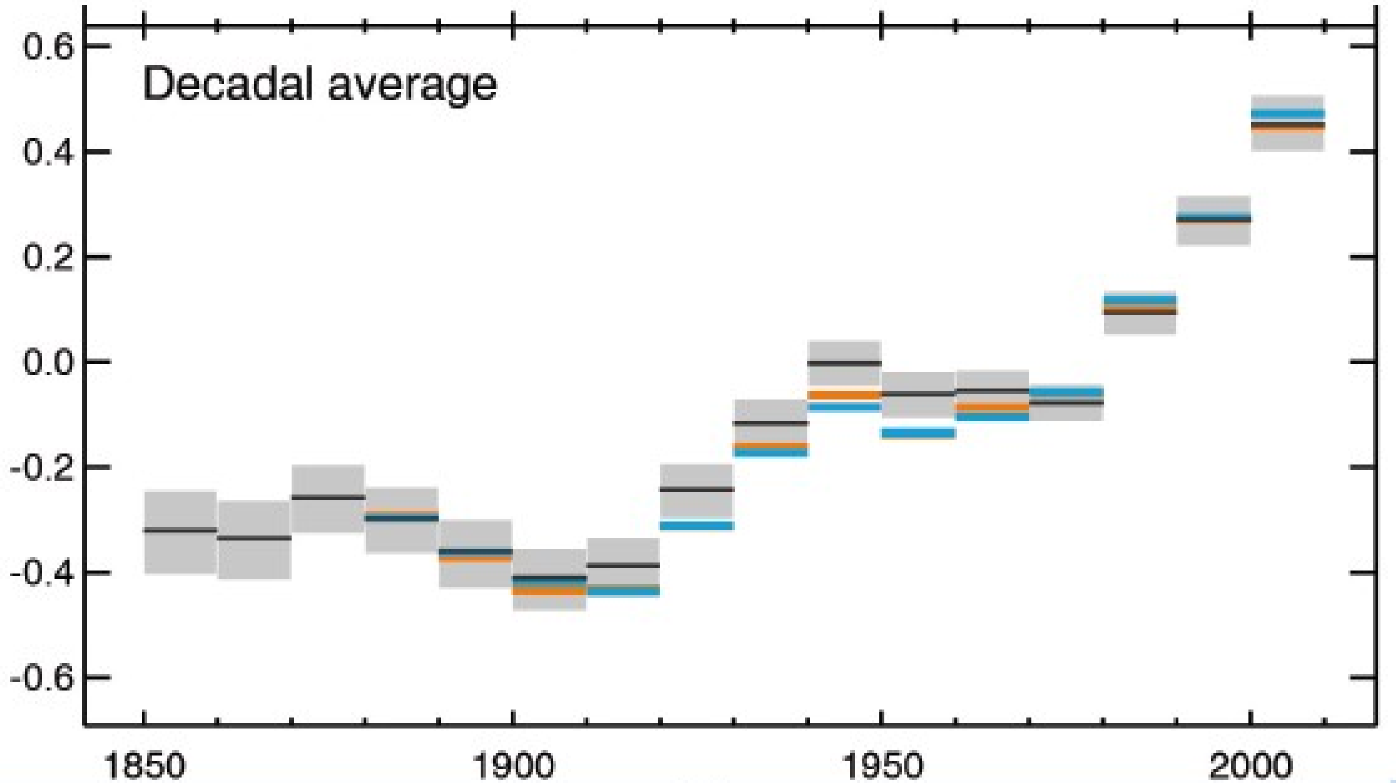


(IPCC 2013, Fig. SPM.1a)

HadCRUT4 (black), MLOST(orange) and GISS (blue) are shown.

The globally averaged combined land and ocean surface temperature data, show a warming of 0.85 [0.65 to 1.06] °C , over the period 1880–2012. The total increase between the average of the 1850–1900 period and the 2003–2012 period is 0.78 [0.72 to 0.85].

Observed globally averaged combined land and ocean surface temperature anomaly1850–2012

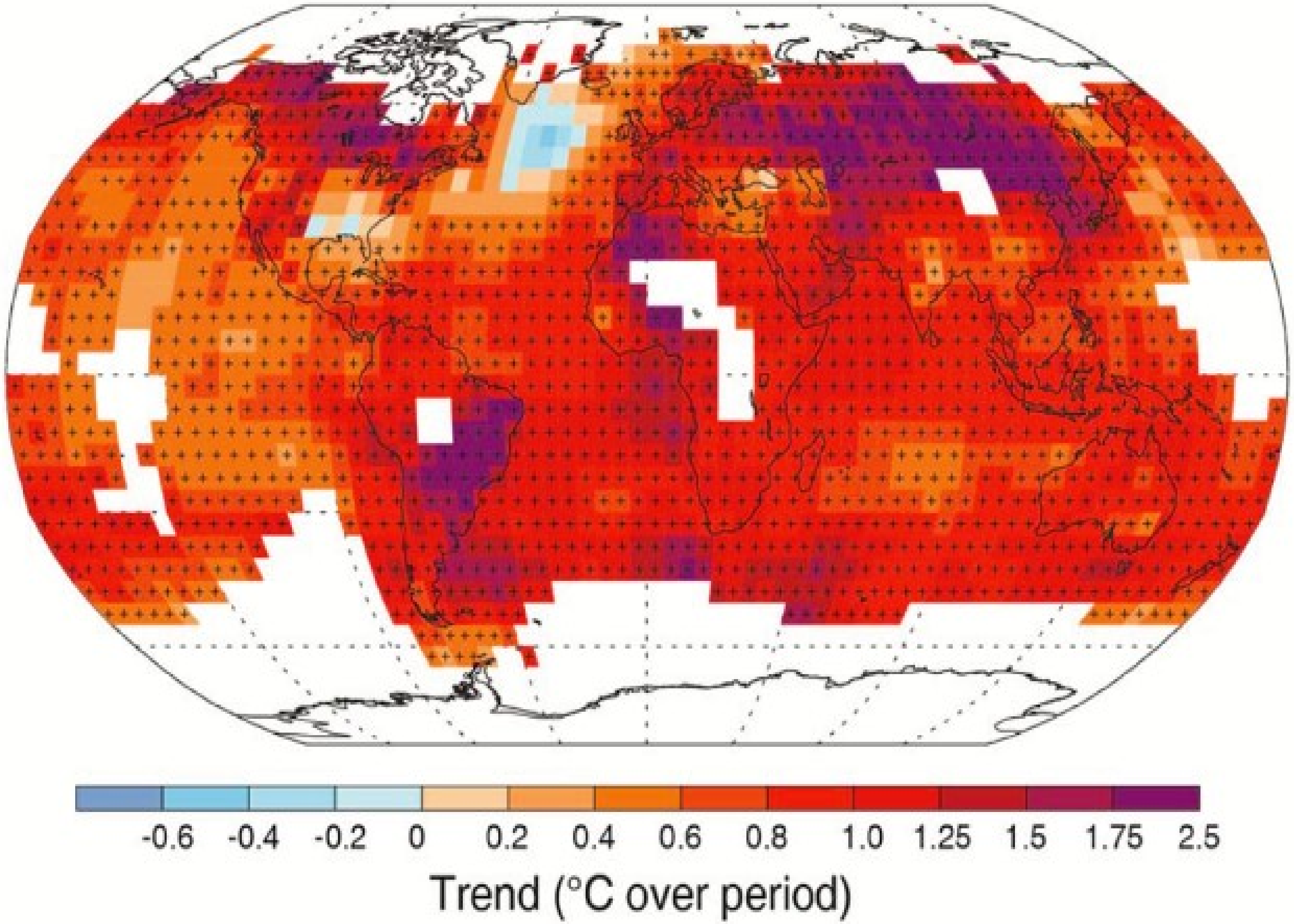


(IPCC 2013, Fig. SPM.1a)

Each of the last three decades has been successively warmer at the Earth’s surface than any preceding decade since 1850.

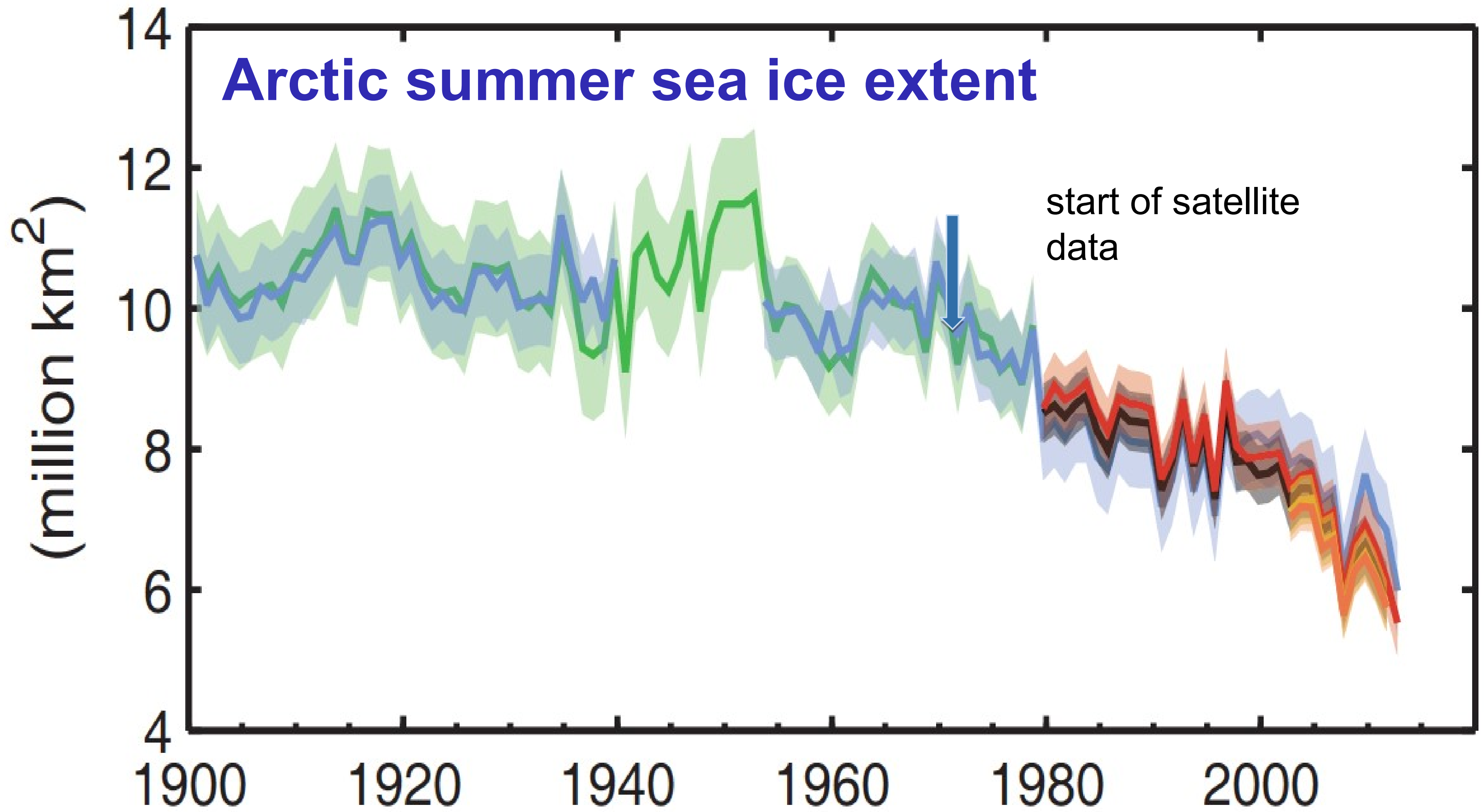
In the Northern Hemisphere, 1983–2012 was *likely* the warmest 30-year period of the last 1400 years (*medium confidence*).

Observed change in average surface temperature 1901–2012



(IPCC 2013, Fig. SPM.1b)

Warming in the climate system is unequivocal



Annual mean Arctic summer sea ice extent decreased *very likely with a rate of* 3.5-4.1% per decade in 1979 – 2012 decrease was most rapid in summer (*high confidence*).
Data normalized to the satellite measured sea ice extent in 1979

Changes since AR4

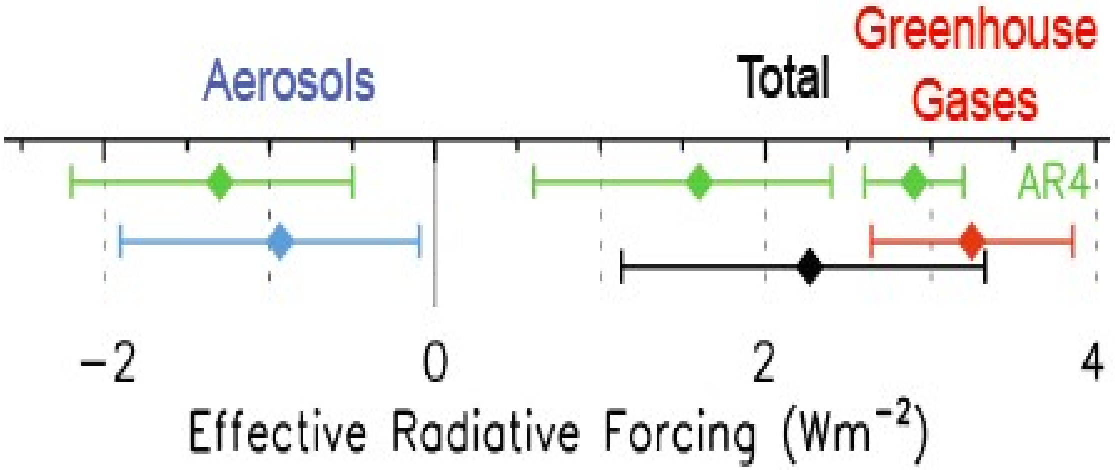
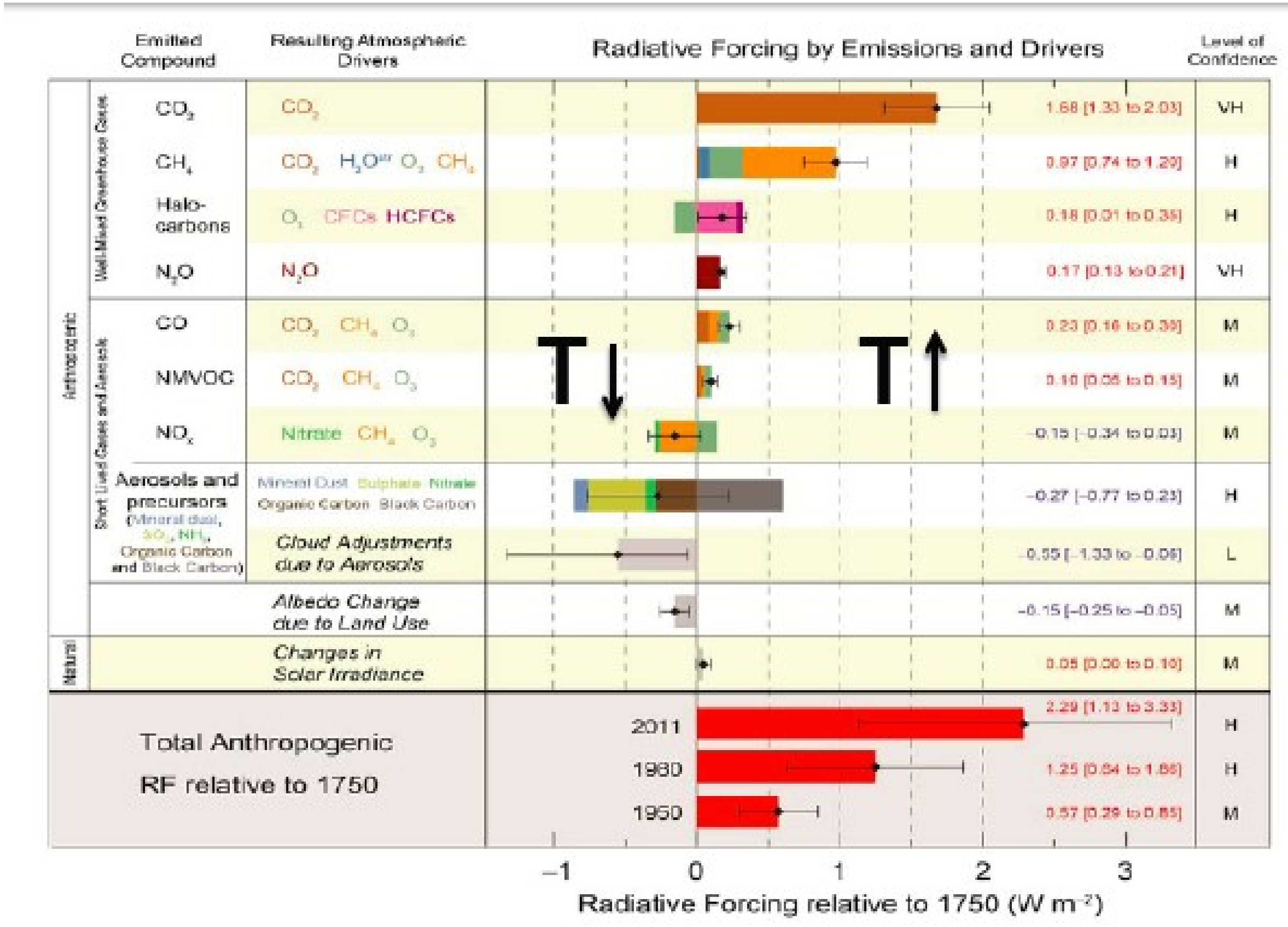


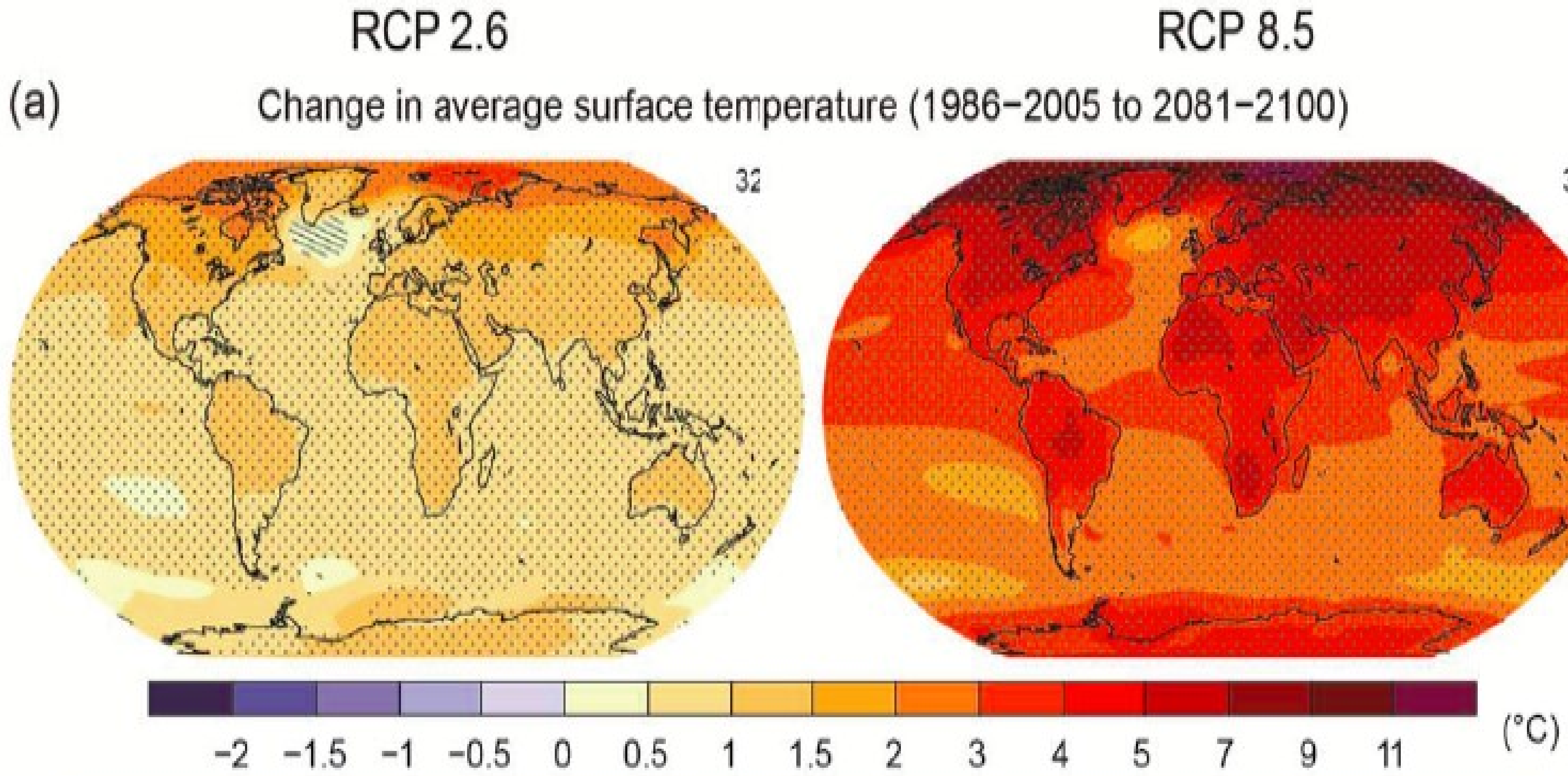
Figure 8.16

- Greenhouse gases continue to increase rapidly
  - Uncertainty ranges increased as now accounting for rapid adjustments to forcing
- Best estimate of net aerosol cooling reduced



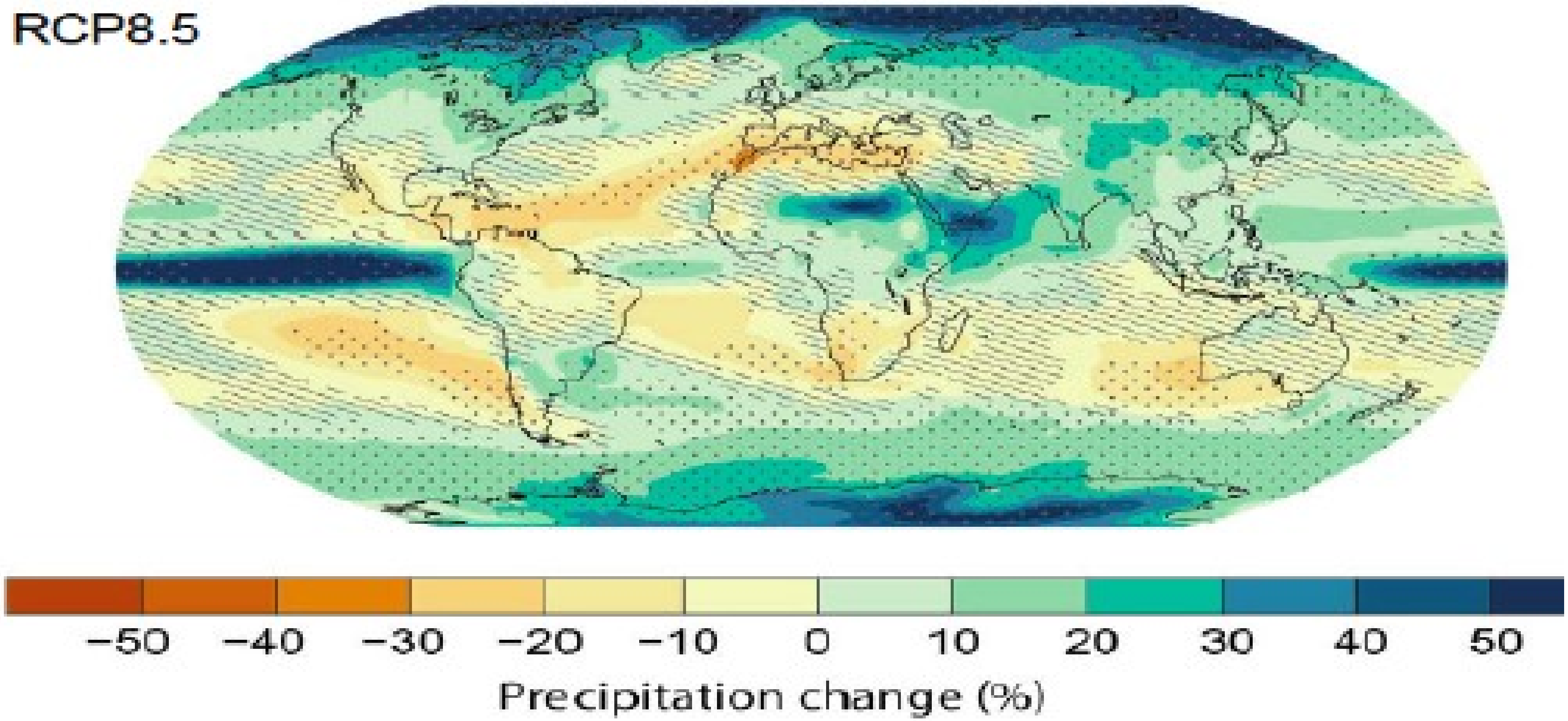
2011 ---- 2.3 W/m^2
1980 ---- 1.2 W/m^2
1950 ---- 0.6 W/m^2

Total radiative forcing is positive, and has led to an uptake of energy by the climate system. The largest contribution to total radiative forcing is caused by the increase in the atmospheric concentration of CO2 since 1750.



(IPCC 2013, Fig. SPM.8)

Increase of global mean surface temperatures for 2081–2100 relative to 1986–2005 is projected to likely be in the ranges derived from the concentration driven CMIP5 model simulations, that is, 0.3°C to 1.7°C (RCP2.6), 1.1°C to 2.6°C (RCP4.5), 1.4°C to 3.1°C (RCP6.0), 2.6°C to 4.8°C (RCP8.5).



The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, although there may be regional exceptions.
Extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions will very likely become more intense and more frequent by the end of this century

AR5 WG I Science Gaps and Questions/1

- Trends and rates of observed climate change
  Has climate change accelerated?
- Large ice sheets in polar regions
  Is the Greenland ice sheet stable?
- Irreversibilities and abrupt change in the climate system
  How robust and accurate is our understanding?
- Clouds and aerosols and their feedbacks
  What is the forcing uncertainty associated with cloud and aerosol processes?

AR5 WG I Science Gaps and Questions/2

- Carbon and other biogeochemical cycles
  Which carbon cycle feedbacks become relevant in the coming decades?
- Near-term and long-term climate projections
  How reliable is decadal prediction, what are the uncertainties beyond 2100?
- Climate phenomena across regions
  How do frequencies and amplitudes of monsoon, ENSO, and others change?

WG II Major Themes

- Framing to support good decisions, including information on risk
- Better integration of climate science with climate impacts
- Broader range of assessed impacts.
- Climate change in the context of other stresses
- Better treatment of extremes and disasters
- Expanded treatment of adaptation
- Better integration of adaptation, mitigation, and development at different regional scales
- Human settlements, industry, and infrastructure

AR5 WG III Outline

I: Introduction	1. Introductory Chapter
II: Framing Issues	2. Integrated Risk and Uncertainty Assessment of Climate Change Response Policies 3. Social, Economic and Ethical Concepts and Methods 4. Sustainable Development and Equity
III: Pathways for Mitigating Climate Change	5. Drivers, Trends and Mitigation 6. Assessing Transformation Pathways 7. Energy Systems 8. Transport 9. Buildings 10. Industry 11. Agriculture, Forestry and Other Land Use (AFOLU) 12. Human Settlements, Infrastructure and Spatial Planning
IV: Assessment of Policies, Institutions and Finance	13. International Cooperation: Agreements and Instruments 14. Regional Development and Cooperation 15. National and Sub-national Policies and Institutions 16. Cross-cutting Investment and Finance Issues

INTERGOVERNMENTAL PANEL ON climate change

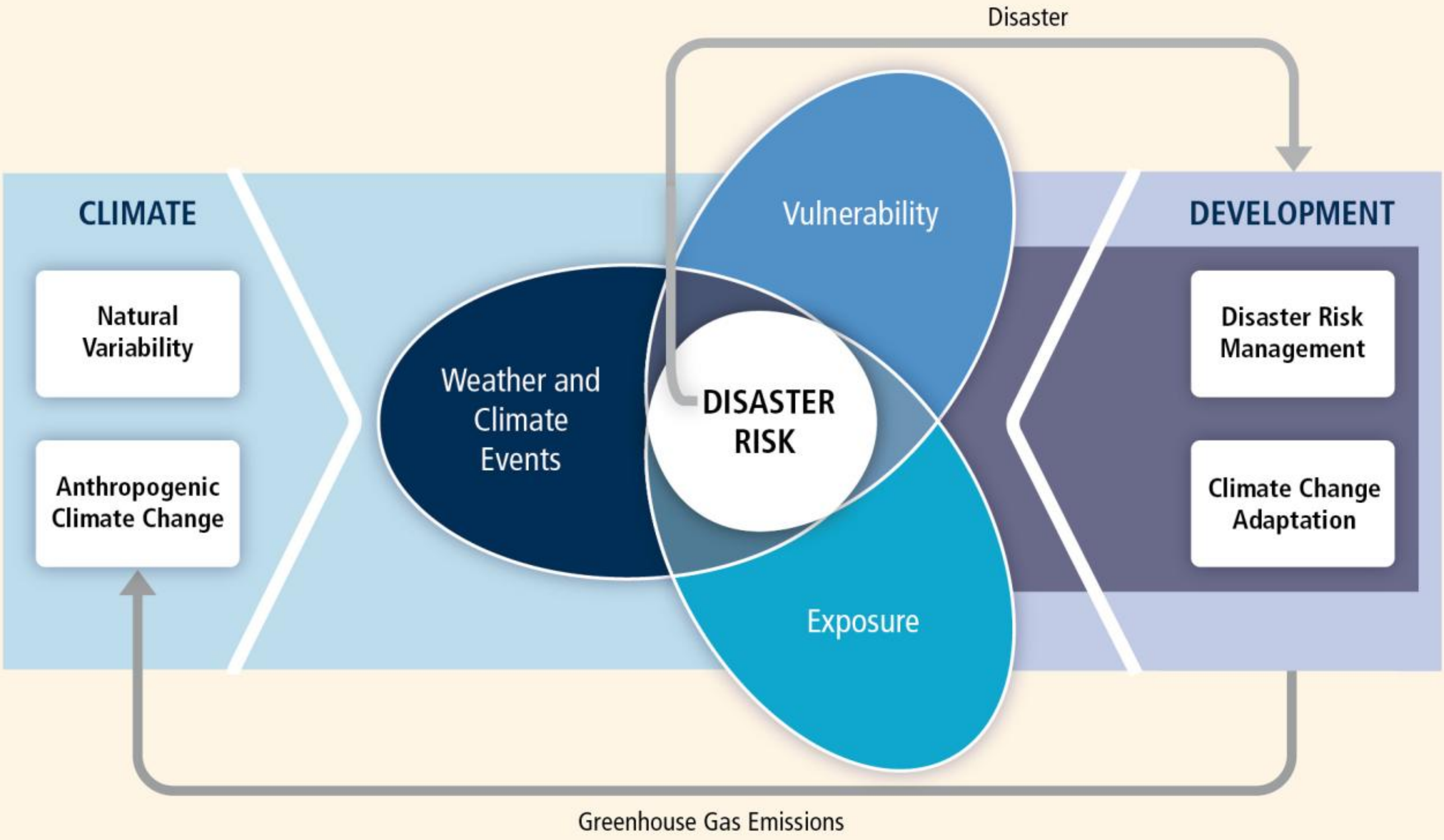
IPCC SREX:

IPCC Special Report on "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation"

IPCC Special Report on “Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation”

- 2.5 years in preparation
- 87 Coordinating Lead Authors (CLAs) and Lead Authors (LAs), across 9 Chapters
- Approval plenary: Kampala, Uganda, November 2012 (*Summary for Policymakers* released 18 November 2012)
- Release of complete report: 28 March 2012

SREX: key concepts and links



SREX: Contents - 9 chapters

1: Climate change: new dimensions in disaster risk, exposure, vulnerability, and resilience

2: Determinants of risks: exposure and vulnerability

3: Changes in climate extremes and their impacts on the natural physical environment

4: Changes in impacts of climate extremes: human systems and ecosystems

5: Managing the risks from climate extremes at the local level

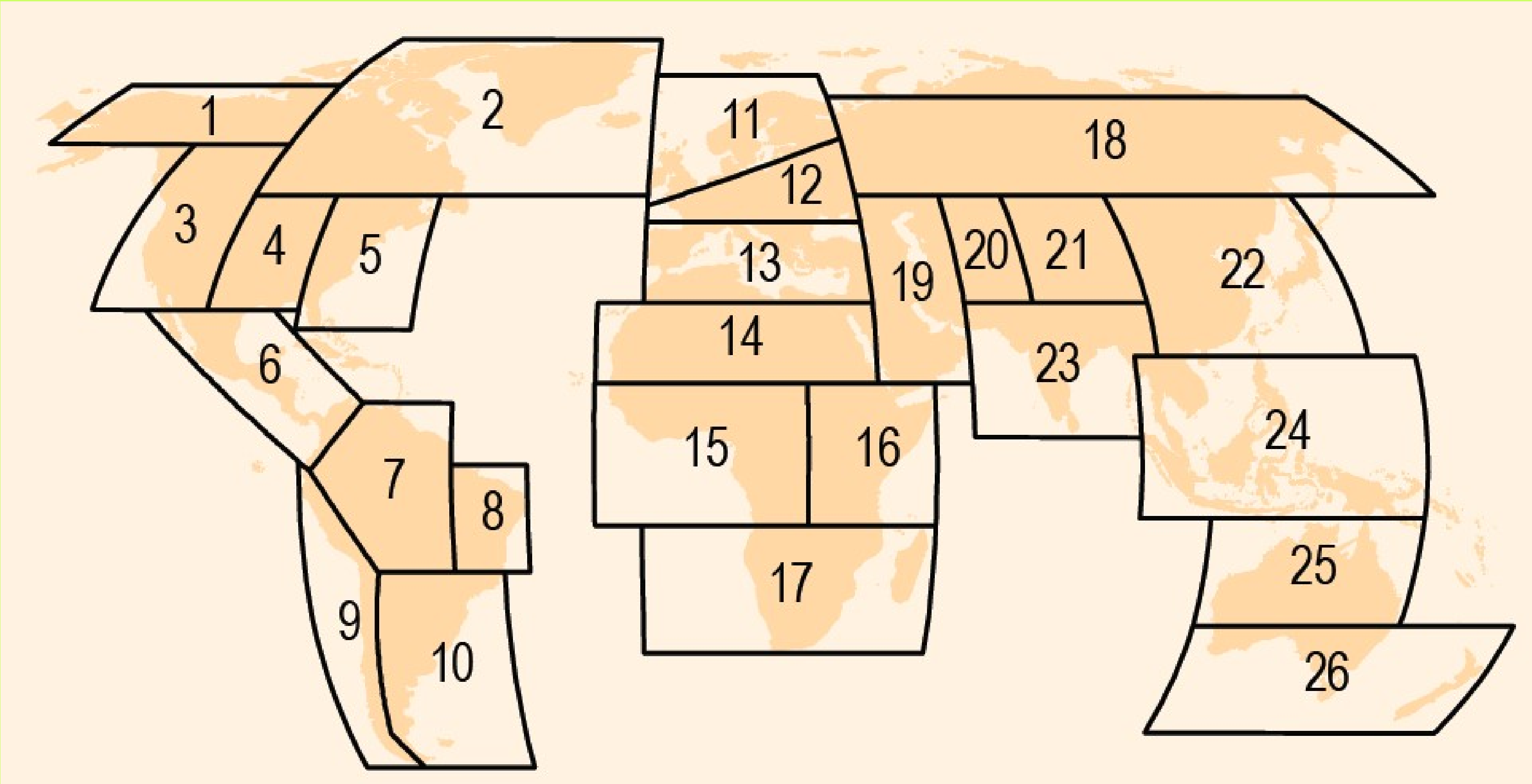
6: National systems for managing the risk from climate extremes

7: Managing the risks: international level and integration across scales

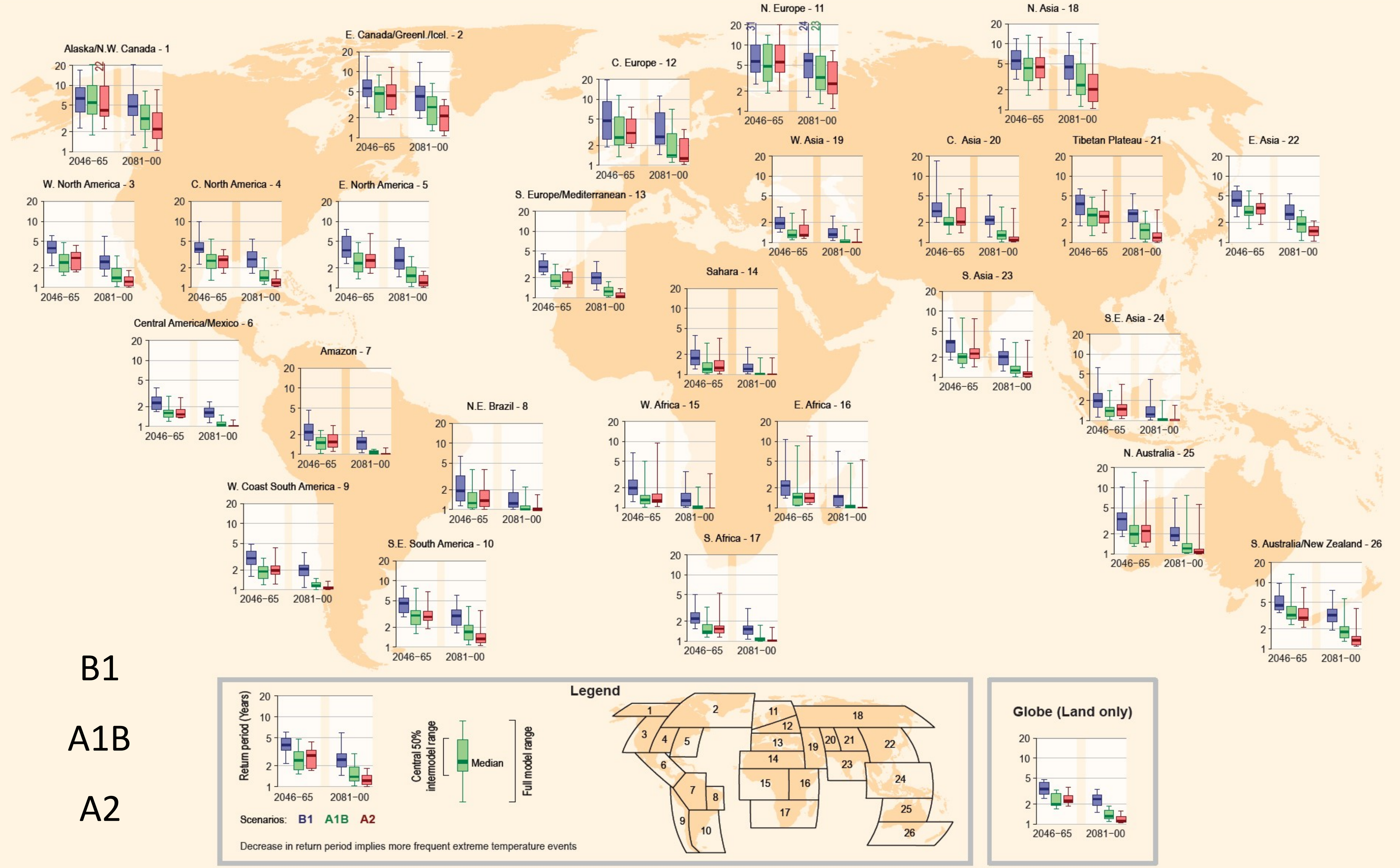
8: Towards a resilient and sustainable future

9: Case studies

Large-scale, land only, regions used for temperature & precipitation extremes (26 sectors)



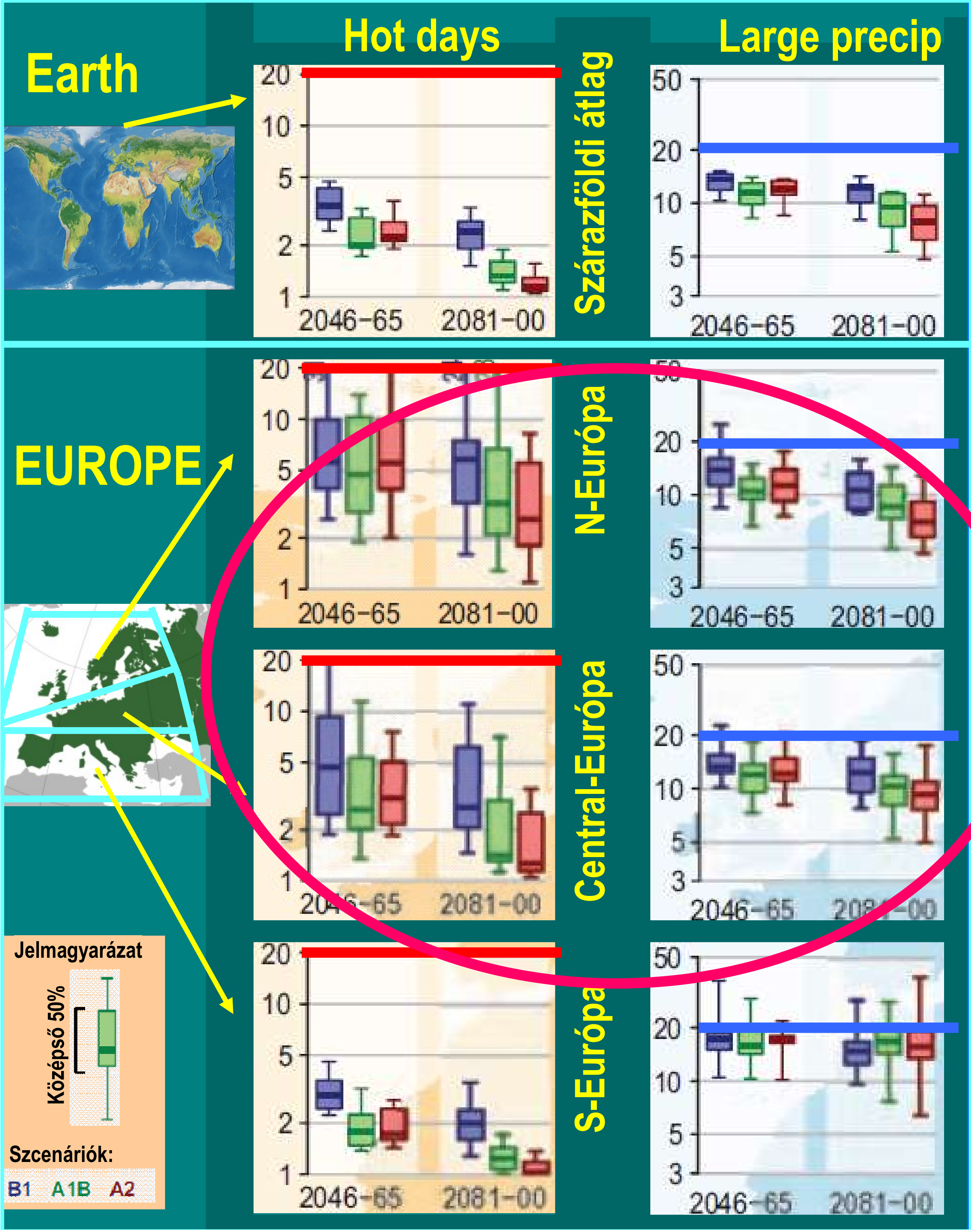
Projected return period
(of hot day with late 20th century return period of 20 years)



B1

A1B

A2



Frequency increase expected for the extremes

Climate simulations
for the XXIst century (B1, A1B, A2):

- more hot days
- more days with large prec

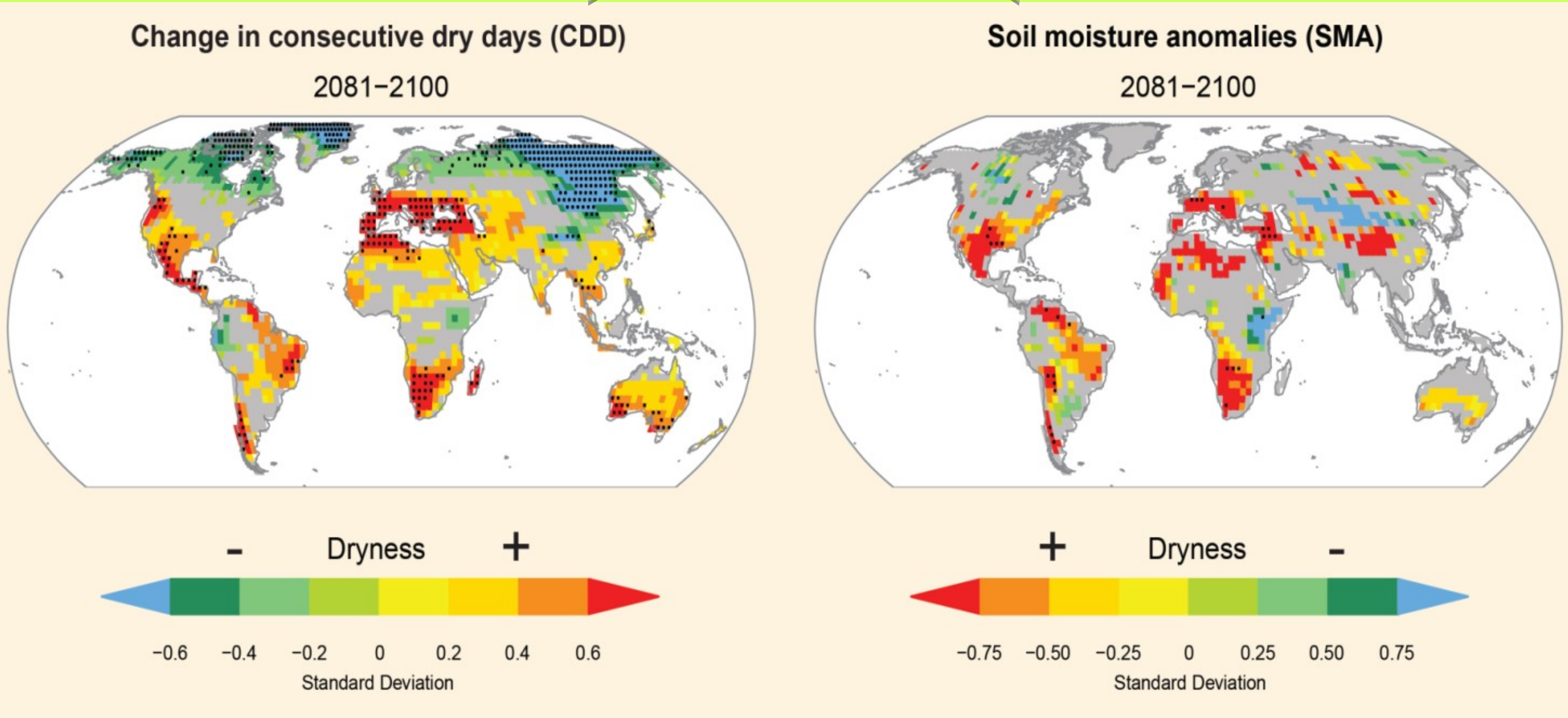
Northern and Central-Europe:
In 20 years 1 event occurs extreme hot temperatute maximum
- in every 2-10 years one (2046-2065)
- in every 1-6 years one (2081-2100)

will occur

In 20 years 1 event occurs extreme large daily precipitation maximum
- in every 10-15 years one(2046-2065)
- in every 8-16 years one (2081-2100)

will occur

Two dryness indices



Gray shading: less than 66% model agreement on sign of change

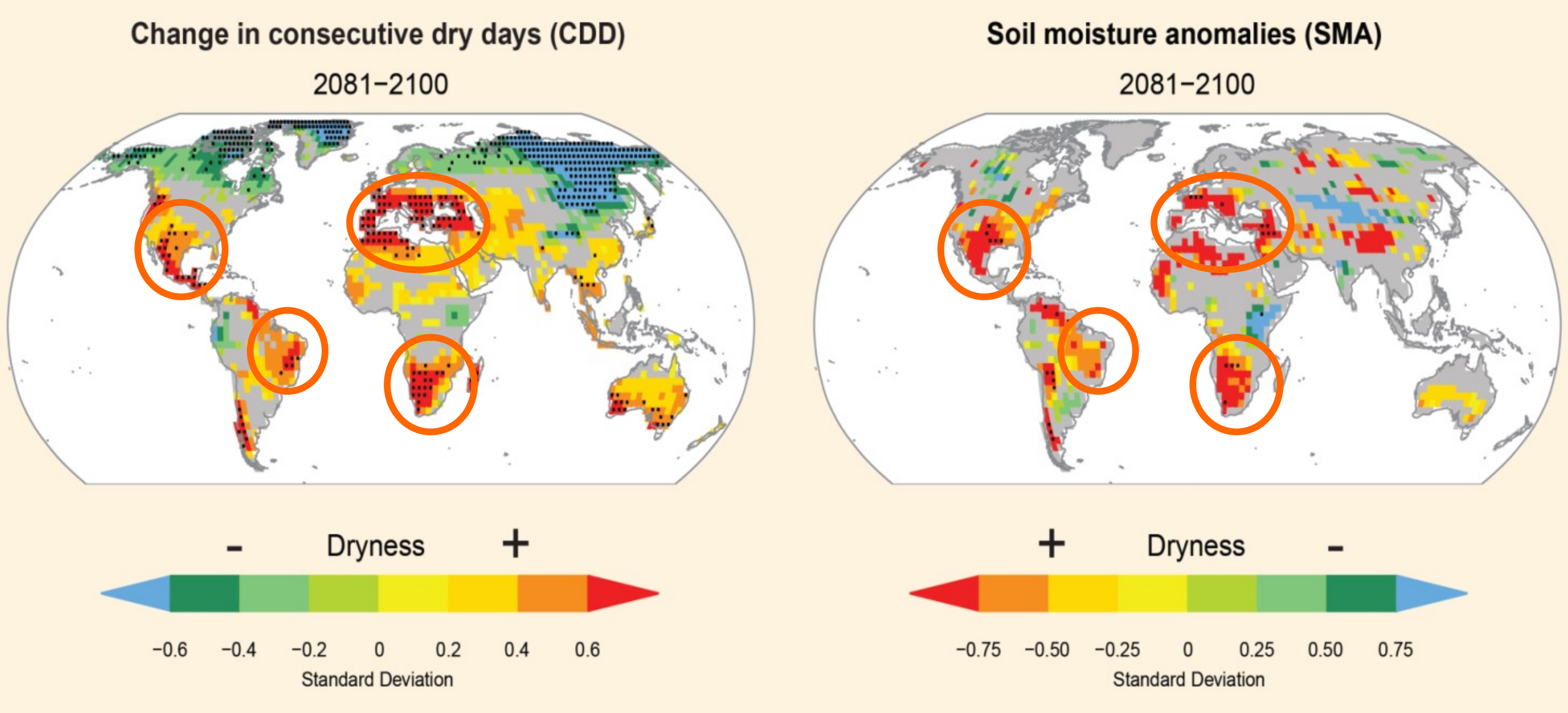
Coloured shading: ≥ 66% model agreement on sign of change

Stippling: ≥ 90% model agreement on sign of change

Problems projecting droughts:

- Inconsistencies between projections of the (many) different drought indices
- Inconsistencies between projections of even a single drought index, between climate models
- Geographical variations in consistency of projections – so it is difficult to make a "global" statement
- Non-climatic factors (eg land use changes) also important complications

Consistency between indices



Consistent projections of increased dryness for these (and other) indices in the Mediterranean region, central Europe, southern North America, northeast Brazil, and southern Africa

Summary of SREX projections

- "…a 1-in-20 year hottest day is *likely* to become a 1-in-2 year event by the end of the 21st century in most regions…"
- "…a 1-in-20 year annual maximum daily precipitation amount is *likely* to become a 1-in-5 to 1-in-15-year event by the end of the 21st century in many regions…"
- "Average tropical cyclone maximum wind speed is *likely* to increase…It is *likely* that the global frequency of tropical cyclones will either decrease or remain essentially unchanged"
- "It is *very likely* that mean sea level rise will contribute to upward trends in extreme coastal high water levels in the future."
- "There is *low confidence* in projections of small spatial-scale phenomena such as tornadoes and hail…"

- “There is *medium confidence* that there will be a reduction in the number of extra-tropical cyclones…there is *medium confidence* in a projected poleward shift of extra-tropical storm tracks.”
- “There is *medium confidence* that droughts will intensify in the 21st century in some seasons and areas…Elsewhere there is overall *low confidence* because of inconsistent projections of drought changes…”
- “Projected precipitation and temperature changes imply possible changes in floods, although overall there is *low confidence* in projections of changes in fluvial floods…There is *medium confidence*…that projected increases in heavy rainfall would contribute to increases in local flooding, in some catchments or regions.”
- “There is *low confidence* in projections of changes in large-scale patterns of natural climate variability” [eg., El Niño]

Important points:

- Our confidence in projecting changes in extremes varies:
  - between extremes
  - geographically
- The expected magnitude of change varies:
  - between extremes
  - geographically
- Confidence is *low* for projections of many extremes…
- …but this does not mean there will be no change in these extremes!

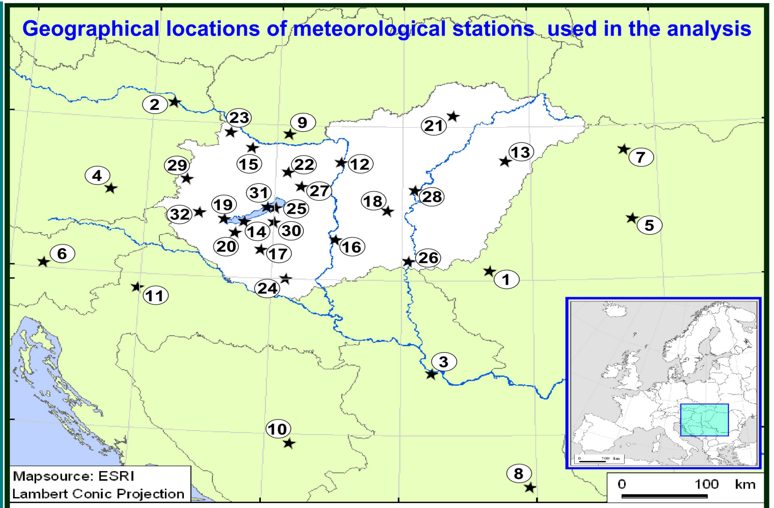
RECENT PAST OF THE TENDENCIES OF THE EXTREME INDECES

(the second half of the 20th century)

DATA USED IN THE ANALYSIS 1901-2001

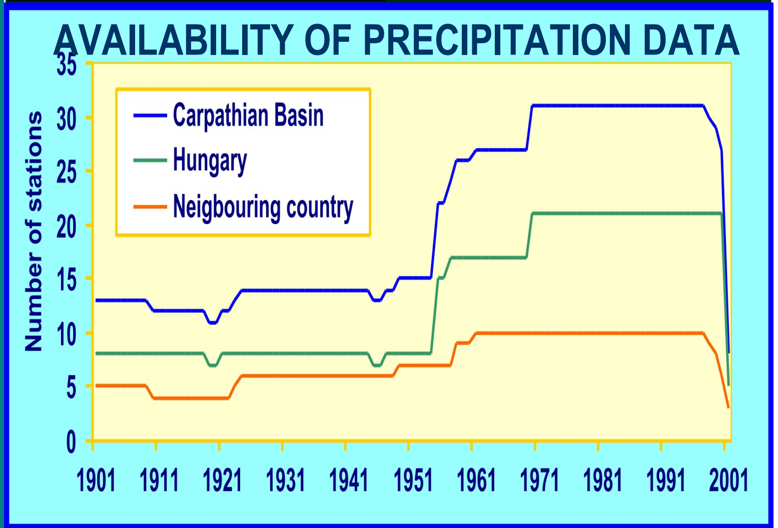
- Meteorological station data (21) from the Hungarian Meteorological Service
  - daily precipitation amount
  - daily max., min., and mean temperature

- Meteorological station data (11) from the ECAD (European Climate Assessment Dataset) internet site
  - daily precipitation amount
  - daily max., min., and mean temperature



	City	N.lat.	E.long.	m
	Stations located outside of Hungary			
1	Arad	46°08'	21°21'	117
2	Vienna	48°14'	16°21'	199
3	Beograd	44°48'	20°28'	132
4	Graz	47°05'	15°27'	366
5	Cluj Napoca	46°47'	23°34'	410
6	Ljubljana	46°04'	14°31'	299
7	Baia Mare	47°40'	23°30'	216
8	Nis	43°20'	21°54'	202
9	Hurbanovo	47°53'	18°12'	115
10	Sarajevo	52°30'	22°30'	211
11	Zagreb	45°49'	15°59'	157
	Stations located in Hungary			
12	Budapest	47°31'	19°02'	118
13	Debrecen	47°33'	21°37'	123
14	Fonyód	46°44'	17°33'	166
15	Győr	47°41'	17°38'	119

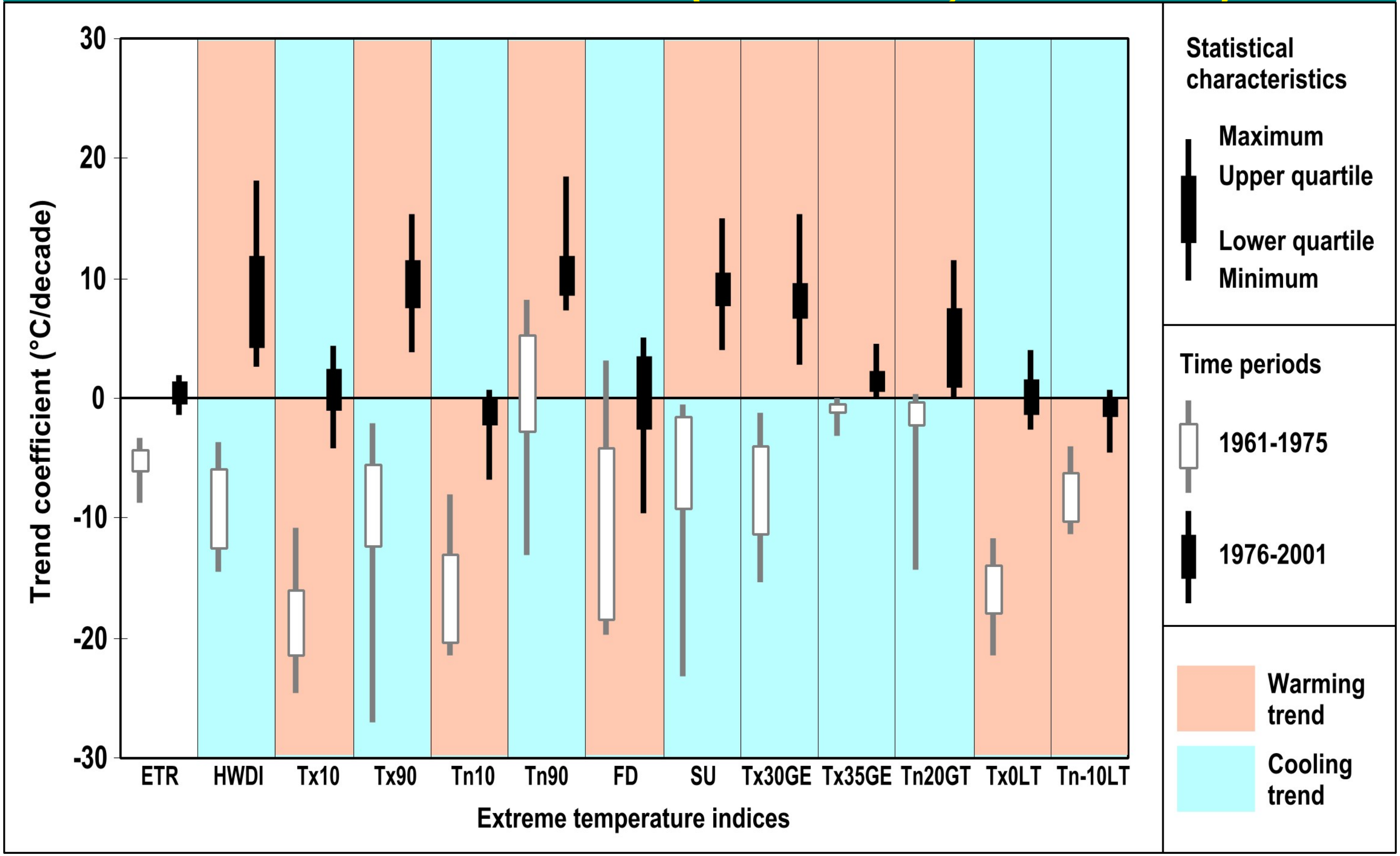
	City	N.lat.	E.long.	m
16	Kalocsa	46°31'	18°59'	92
17	Kaposvár	46°22'	17°50'	152
18	Kecskemét	46°54'	19°46'	114
19	Keszthely	46°45'	17°15'	115
20	Marcali	46°35'	17°25'	128
21	Miskolc	48°08'	20°48'	118
22	Mór	47°23'	18°12'	203
23	Mosonmagyaróvár	47°53'	17°16'	121
24	Pécs	46°00'	18°14'	202
25	Siófok	46°55'	18°02'	108
26	Szeged	46°15'	20°06'	82
27	Székesfehérvár	47°12'	18°25'	111
28	Szolnok	47°10'	20°12'	90
29	Szombathely	47°15'	16°38'	218
30	Tab	46°44'	18°01'	177
31	Tihany	46°55'	17°54'	150
32	Zalaegerszeg	46°50'	16°51'	162



EXTREME INDICES USED IN THE ANALYSIS

No.	Indicator (ECAD)	Definition of the extreme climate index	Unit
1	CDD	Maximum number of consecutive dry days (when $R_{day} < 1$ mm)	day
2	Rx1	Highest 1-day precipitation amount	mm
3	Rx5	The greatest 5-day rainfall total	mm
4	SDII	Simple daily intensity index (total precipitation sum / total number of days when $R_{day} \geq$ 1mm)	mm/day
5	R95T	Fraction of annual total rainfall due to events above the 95th percentile of the daily precipitation for the baseperiod 1961-90 ($\Sigma R_{day} / R_{total}$, where ΣR_{day} indicates the sum of daily precipitation exceeding the $R_{95\%}$)	%
6	RR10	Number of heavy precipitation days ($R_{day} \geq 10$ mm)	day
7	RR20	Number of very heavy precipitation days (when $R_{day} \geq$ 20 mm)	day
8	R75	Number of moderate wet days ($R_{day} > R_{75\%}$, where $R_{75\%}$ indicates the upper quartile of the daily precip. for the baseperiod 1961-90)	day
9	R95	Number of very wet days ($R_{day} > R_{95\%}$, where $R_{95\%}$ indicates the 95th percentile of the daily precip. for the baseperiod 1961-90)	day
10	ETR	Intra-annual extreme temperature range (T_{max}-T_{min})	°C
11	GSL	Growing season length (start: when for >5 days T > 5°C, end: when for >5 days T < 5°C)	day
12	HWDI	Heat wave duration index (for min. 5 consecutive days $T_{max} = T_{N,max}$ + 5 °C, where $T_{N,max}$ indicates the mean T_{max} for the baseperiod 1961-90)	day
13	Tx10	Cold days (percent of time when T_{max} < 10th percentile of daily maximum temperature based on the baseperiod 1961-90)	day
14	Tx90	Warm days (percent of time when T_{max} > 90th percentile of daily maximum temperature based on the baseperiod 1961-90)	day
15	Tn10	Cold nights (percent of time when T_{min} < 10th percentile of daily minimum temperature based on the baseperiod 1961-90)	day
16	Tn90	Warm nights (percent of time when T_{min} > 90th percentile of daily minimum temperature based on the baseperiod 1961-90)	day
17	FD	Number of frost days (T_{min} < 0°C)	day
18	SU	Number of summer days (T_{max} > 25°C)	day
19	RR5	Number of precipitation days exceeding a given threshold ($R_{day} \geq$ 5 mm)	day
20	RR1	Number of precipitation days exceeding a given threshold ($R_{day} \geq$ 1 mm)	day
21	RR0.1	Number of precipitation days exceeding a given threshold ($R_{day} \geq$ 0.1 mm)	day
22	Tx30GE	Number of hot days ($T_{max} \geq$ 30 °C)	day
23	Tx35GE	Number of extremely hot days ($T_{max} \geq$ 35 °C)	day
24	Tn20GT	Number of hot nights (T_{min} > 20 °C)	day
25	Tx0LT	Number of winter days (T_{max} < 0 °C)	day
26	Tn-10LT	Number of severe cold days (T_{min} < -10 °C)	day
27	DD5 - DD11	Degree days (ΣT_{mean} if $T_{mean} > T_{base}$, where T_{base} = 5, 6, 7, 8, 9, 10, 11°C)	°C
28	EDD5 - EDD11	Effective degree days ($\Sigma(T_{mean} - T_{base})$ if $T_{mean} > T_{base}$, where T_{base} = 5, 6, 7, 8, 9, 10, 11°C)	°C

SUMMARY OF THE TREND ANALYSIS OF TEMPERATURE EXTREME INDICES FOR THE CARPATHIAN BASIN (1961-1975, 1976-2001)



SUMMARY OF THE REGIONAL TREND ANALYSIS OF TEMPERATURE EXTREME INDICES

Nr.	Extreme temperature index	1961-2001	1961-1975	1976-2001
1	ETR: Intra-annual extreme temperature range	−	−	+
2	HWDI: Heat wave duration index	−	−	+
3	Tx10: Number of cold days	−	−	+
4	Tx90: Number of warms days	+	−	+
5	Tn10: Number of cold nights	−	−	−
6	Tn90: Number of warm nights	+	+	+
7	FD: Number of frost days	−	−	−
8	SU: Number of summer days	+	−	+
9	Tx30GE: Number of hot days	+	−	+
10	Tx35GE: Number of extremely hot days	+	−	+
11	Tn20GT: Number of hot nights	+	−	+
12	Tx0LT: Number of winter days	−	−	+
13	Tn-10LT: Number of severe cold days	−	−	−

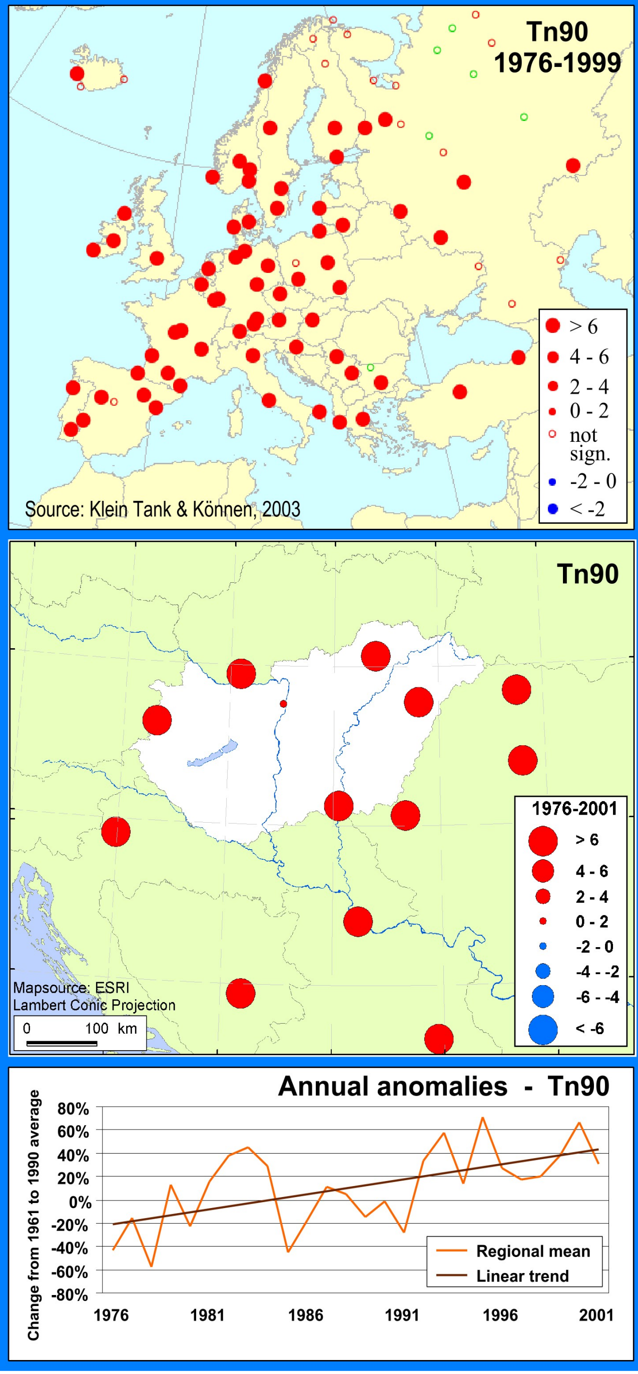
Legend:
+ − Warming
+ − Cooling
+ − Indifferent

1976-2001:

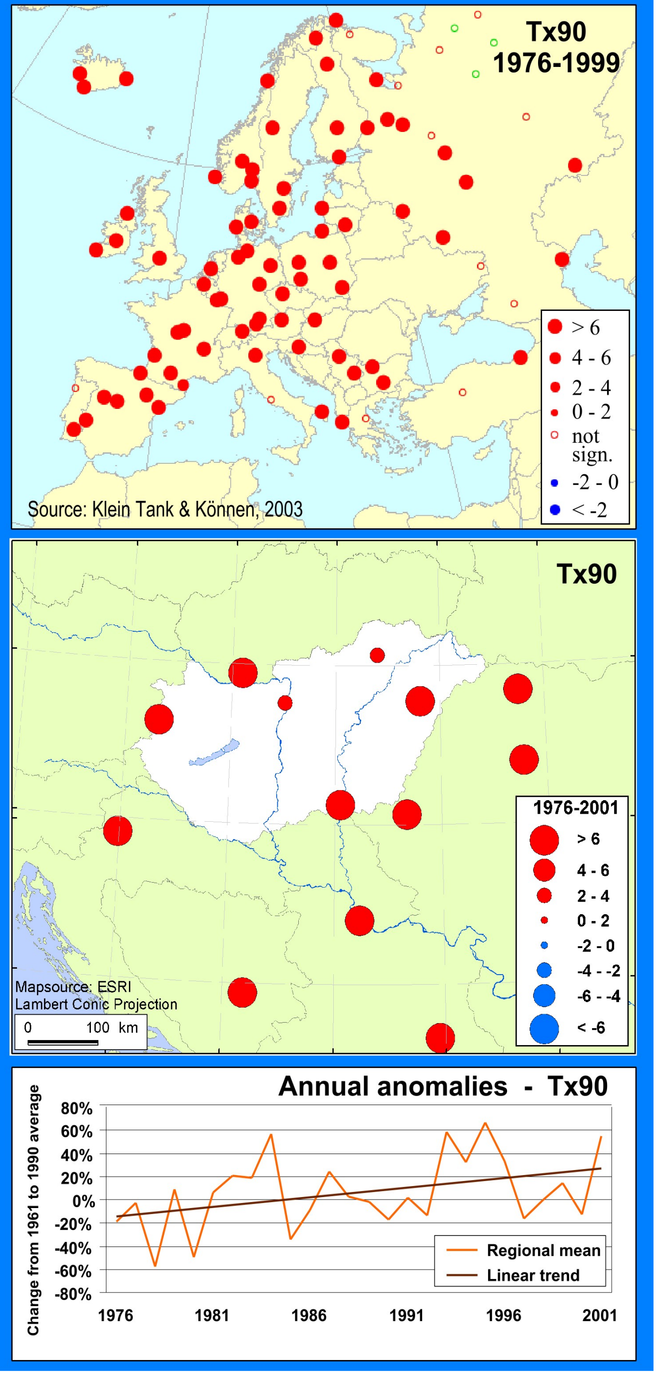
TREND ANALYSIS OF ANNUAL NUMBER OF WARM NIGHTS AND WARM DAYS

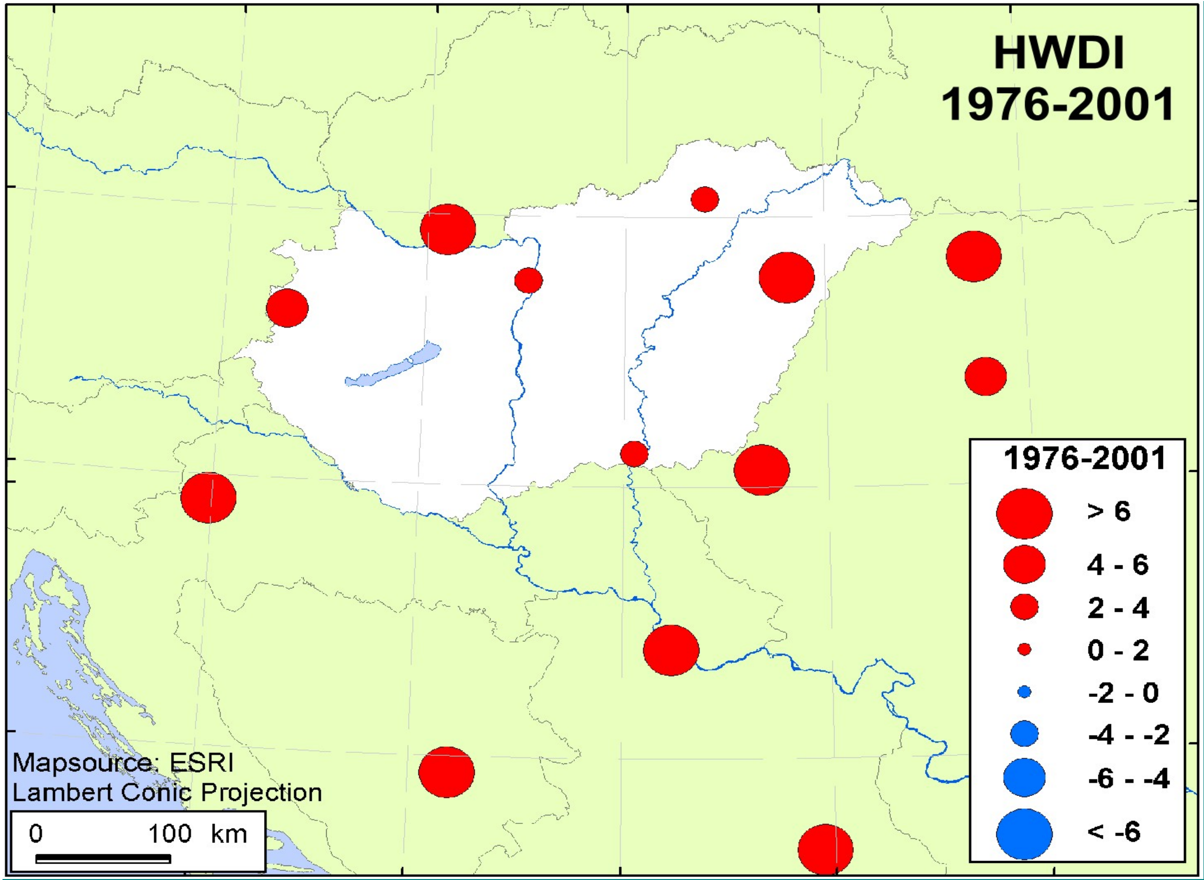
The trend coefficients indicate the number of days per decade

WARM NIGHTS (Tn90)



WARM DAYS (Tx90)

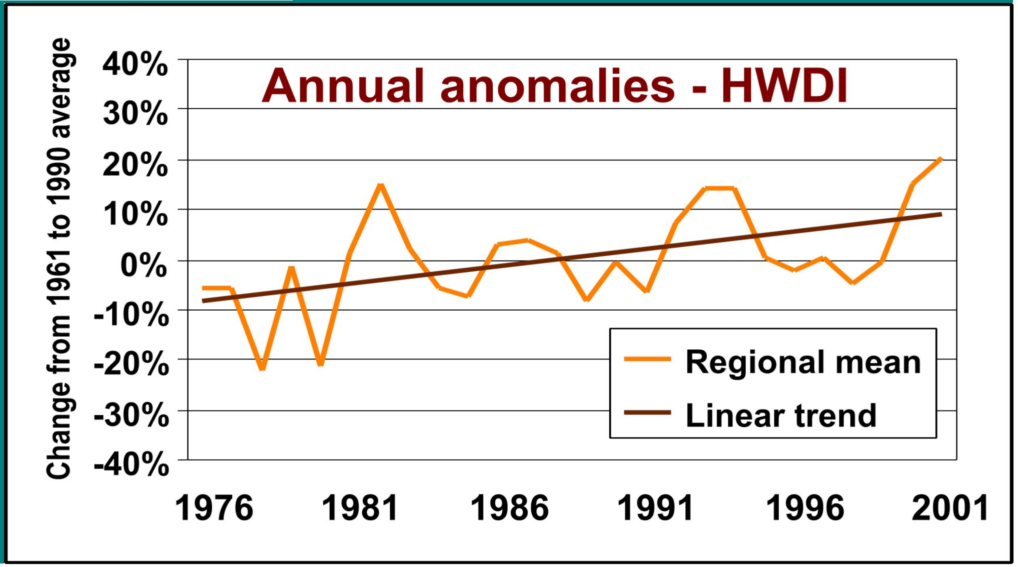




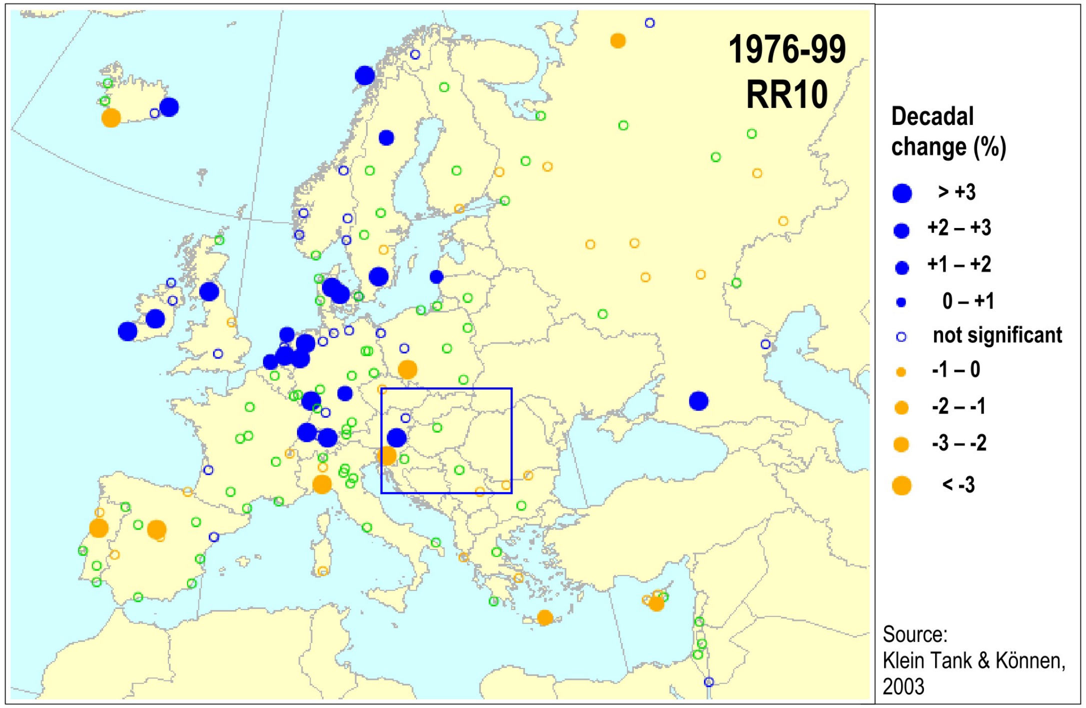
1976-2001:

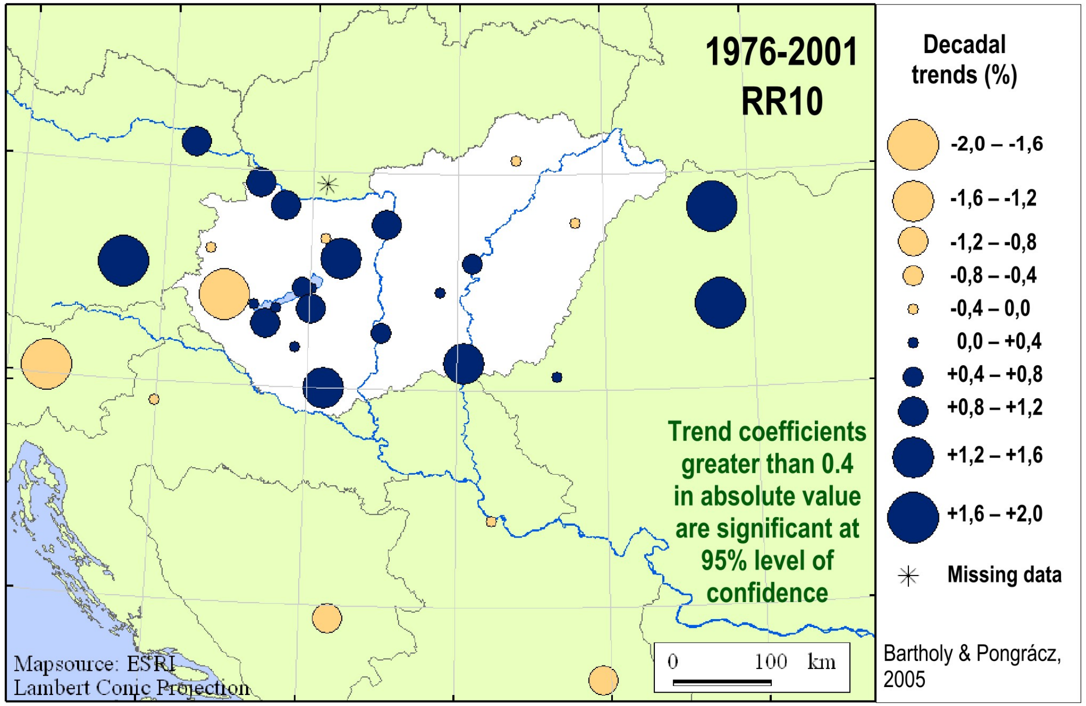
TREND ANALYSIS OF HEAT WAVE DURATION

The trend coefficients indicate the number of days per decade

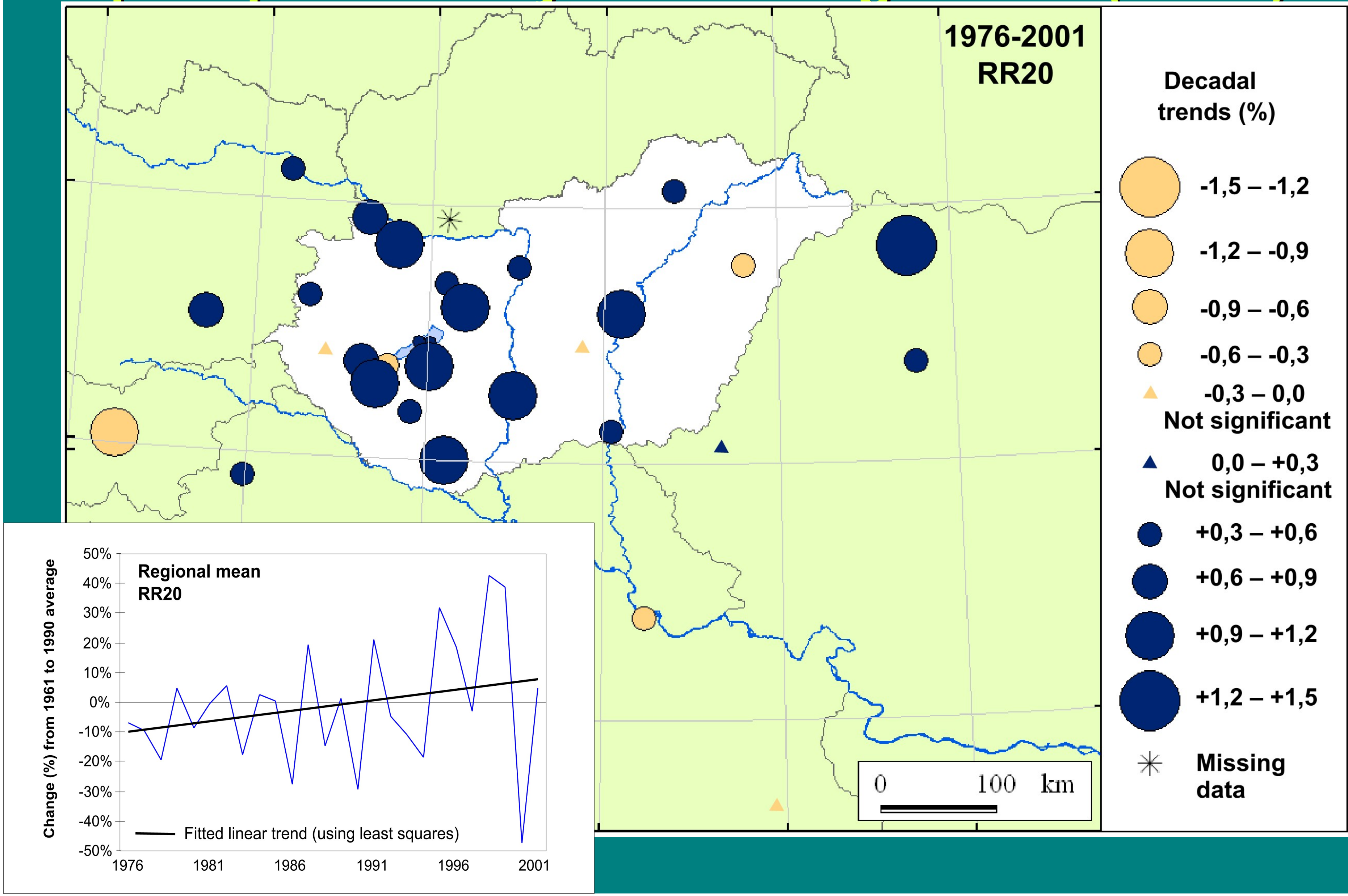


Trend analysis of annual number of heavy precipitation days exceeding 10 mm (RR10)

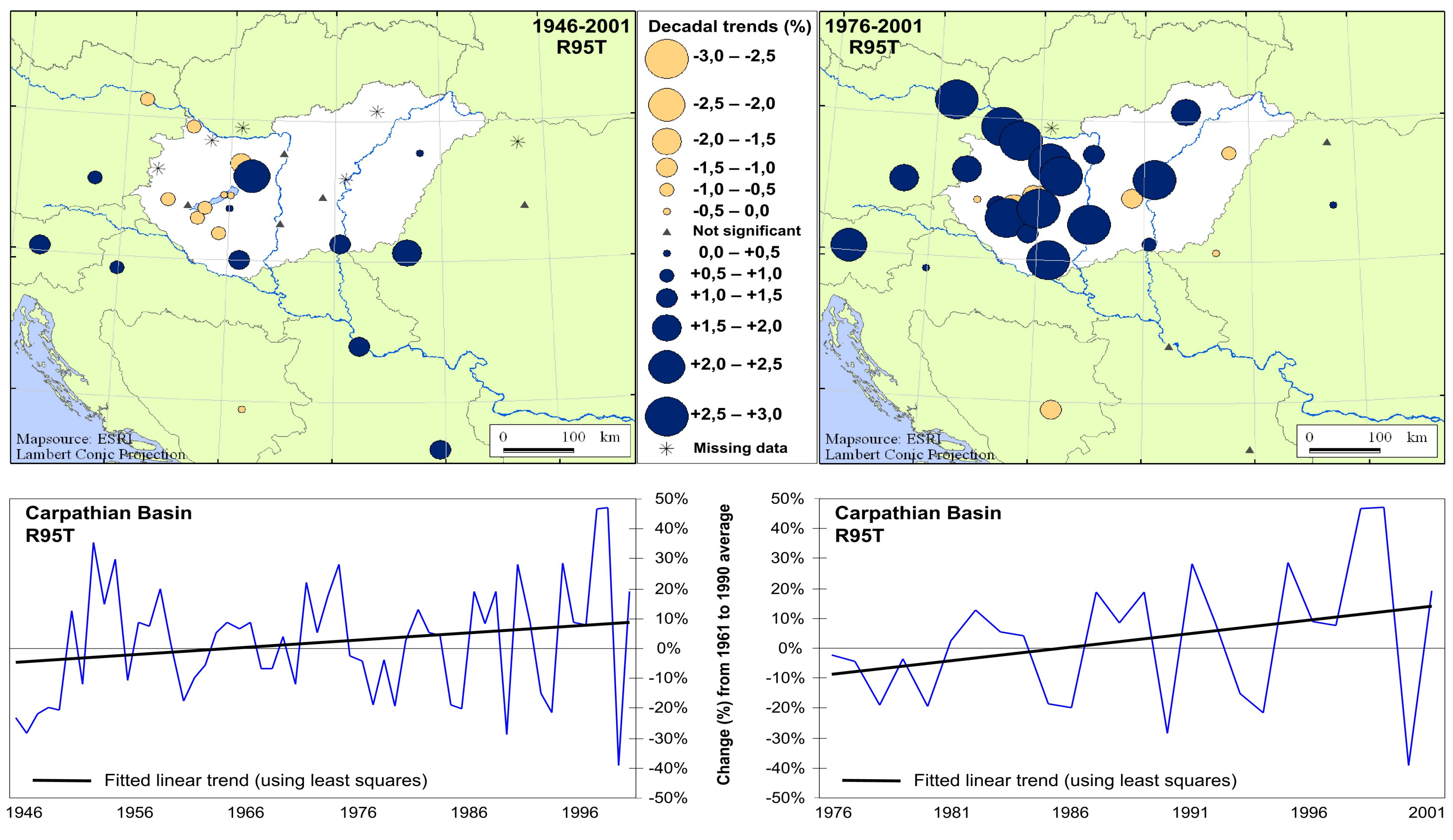




Trend analysis of annual number of very heavy precipitation days exceeding 20 mm (RR20)



Trend analysis of fraction of total annual rainfall due to very wet days (R95T)



1946-2001 - Slight decreasing tendencies in the Transdanubian stations, while increasing trends in other stations

1976-2001 - Strong positive trends

FUTURE TENDENCIES OF THE EXTREME INDEXES

(the last 3 decads of the 21st century)

Estimated frequency changes of extreme temperature indices 1961-1990, 2071-2100 (based on ETH model outputs, A2 scenario)

	Expected change (A2, 2071-2100)	Detected trend (1961-2001)
Summer days ($T_{max}>25°C$)	+39%	+
Hot days ($T_{max}\geq30°C$)	+91%	+
Extremely hot days ($T_{max}\geq35°C$)	> +200%	+
Winter days ($T_{max}<0°C$)	-75%	–
Severe cold days ($T_{min}<-10°C$)	-83%	–
Frost days ($T_{min}<0°C$)	-65%	–
Hot nights ($T_{min}>20°C$)	> +200%	+
Cold days ($T_{max}<T^{1961-90}_{max,10\%}$)	-72%	–
Warm days ($T_{max}>T^{1961-90}_{max,90\%}$)	+116%	+
Cold nights ($T_{min}<T^{1961-90}_{min,10\%}$)	-76%	–
Warm nights ($T_{min}>T^{1961-90}_{min,90\%}$)	+120%	+

Expected changes of annual number of hot days (Tx30GE) and winter days (Tx0LT) in the Carpathian basin

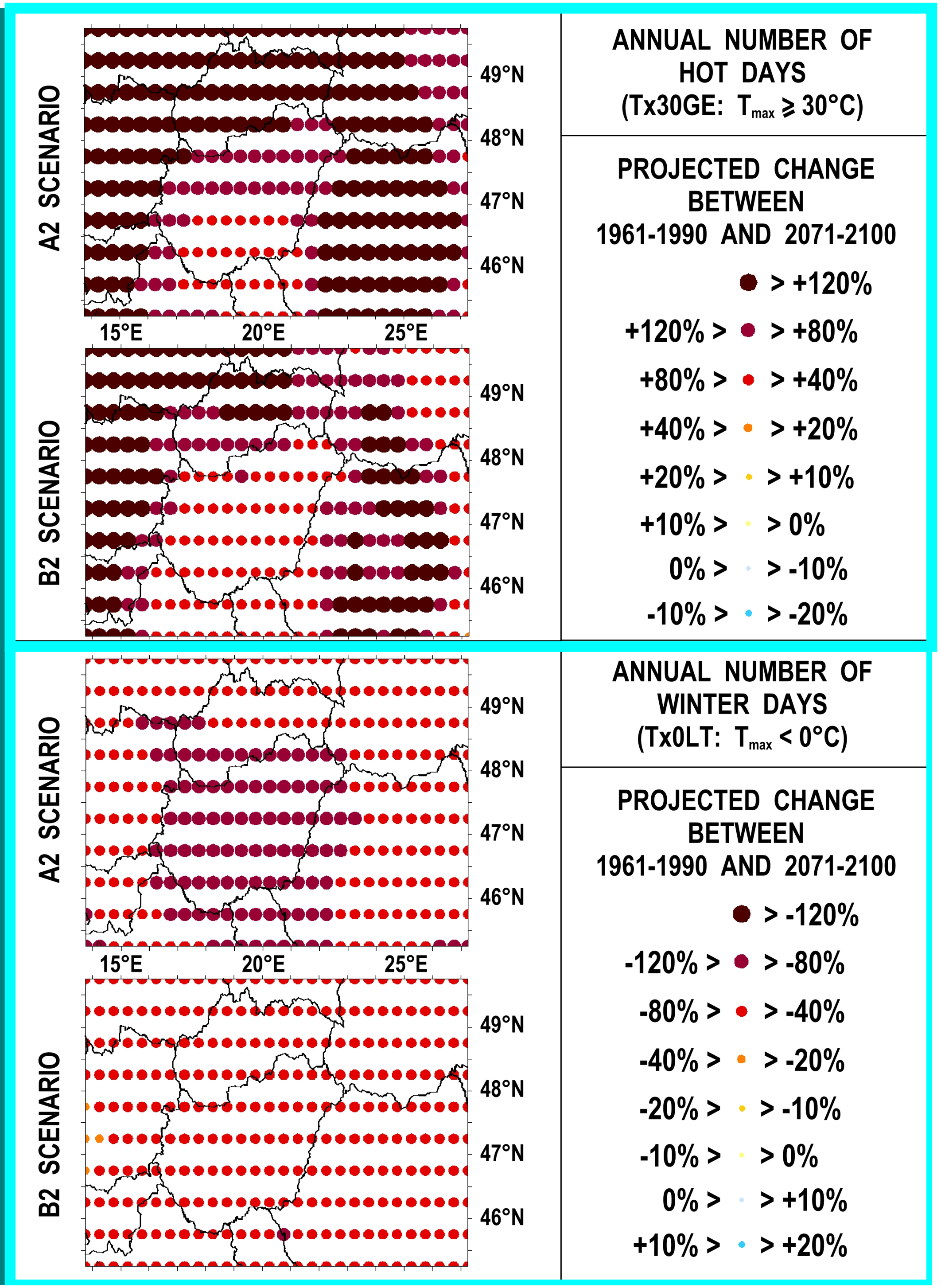
based on ICTP model simulations between 1961-1990 and 2071-2100 for the A2 and B2 scenario

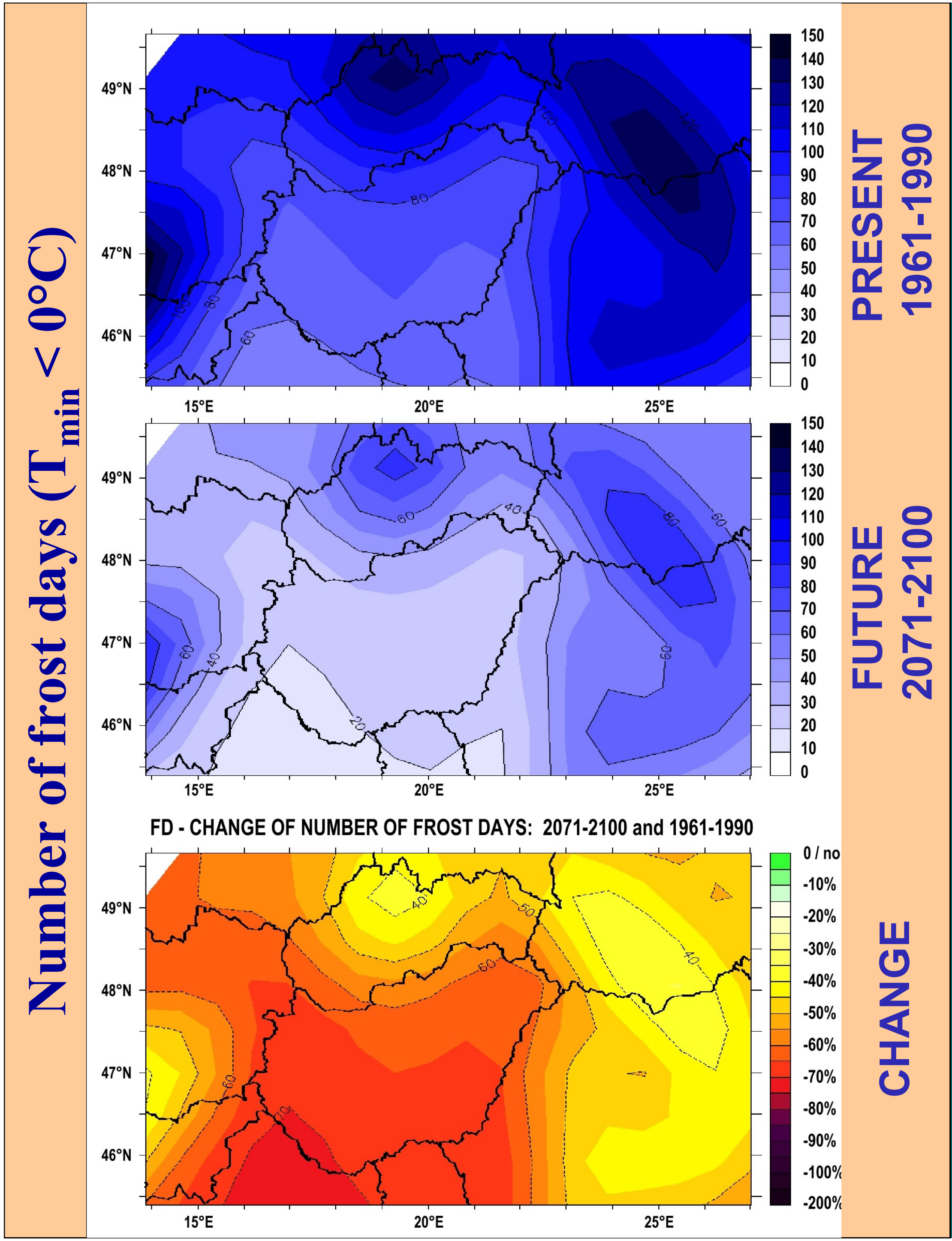
Tx30GE:

increase (+91%)

Tx0LT:

decrease (-75%)

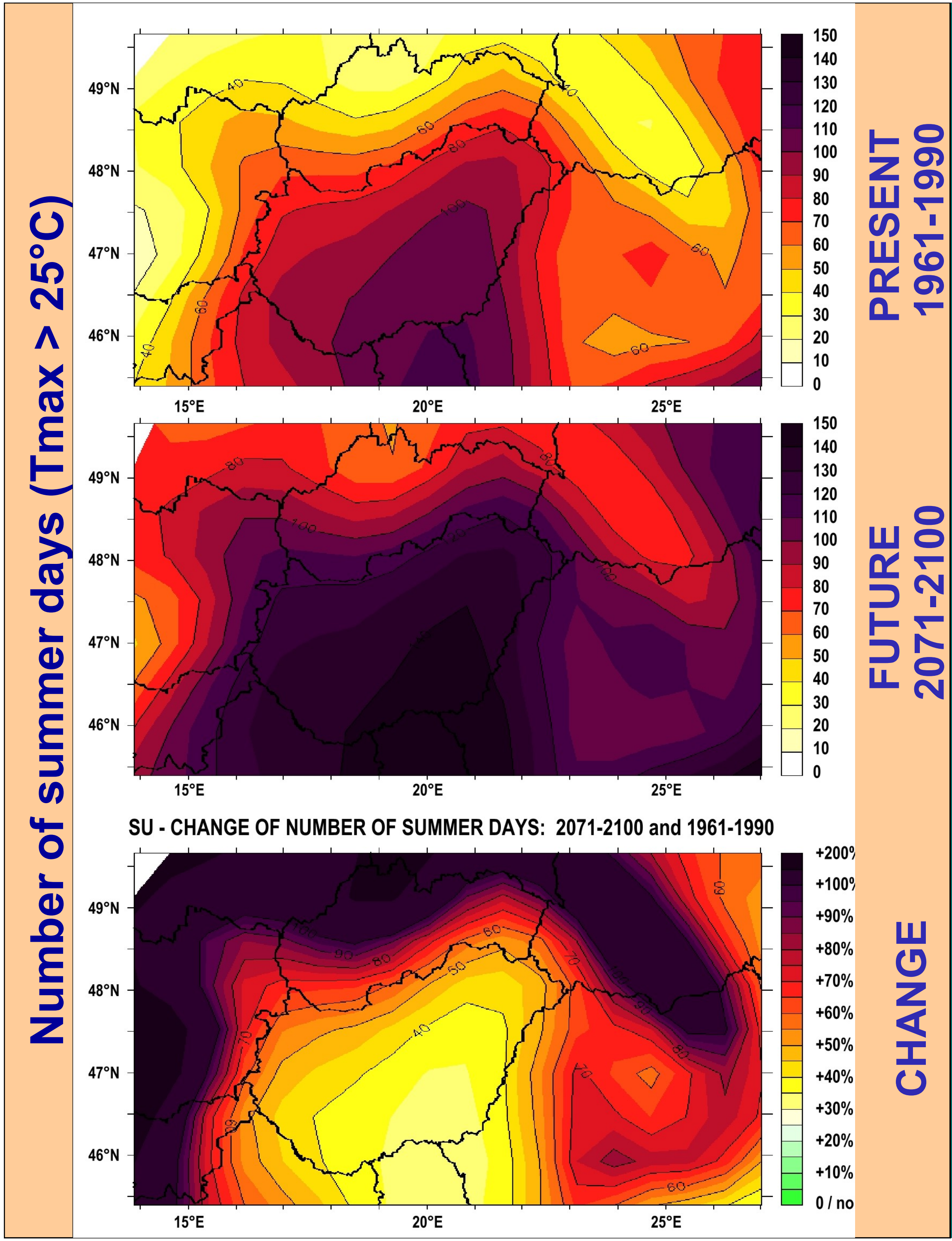




Expected change of the number of frost days and summer days in the Carpathian basin between 1961-1990 and 2071-2100 (using the ETH model outputs, A2 scenario)

DECREASE:

(-40%) – (-70%)



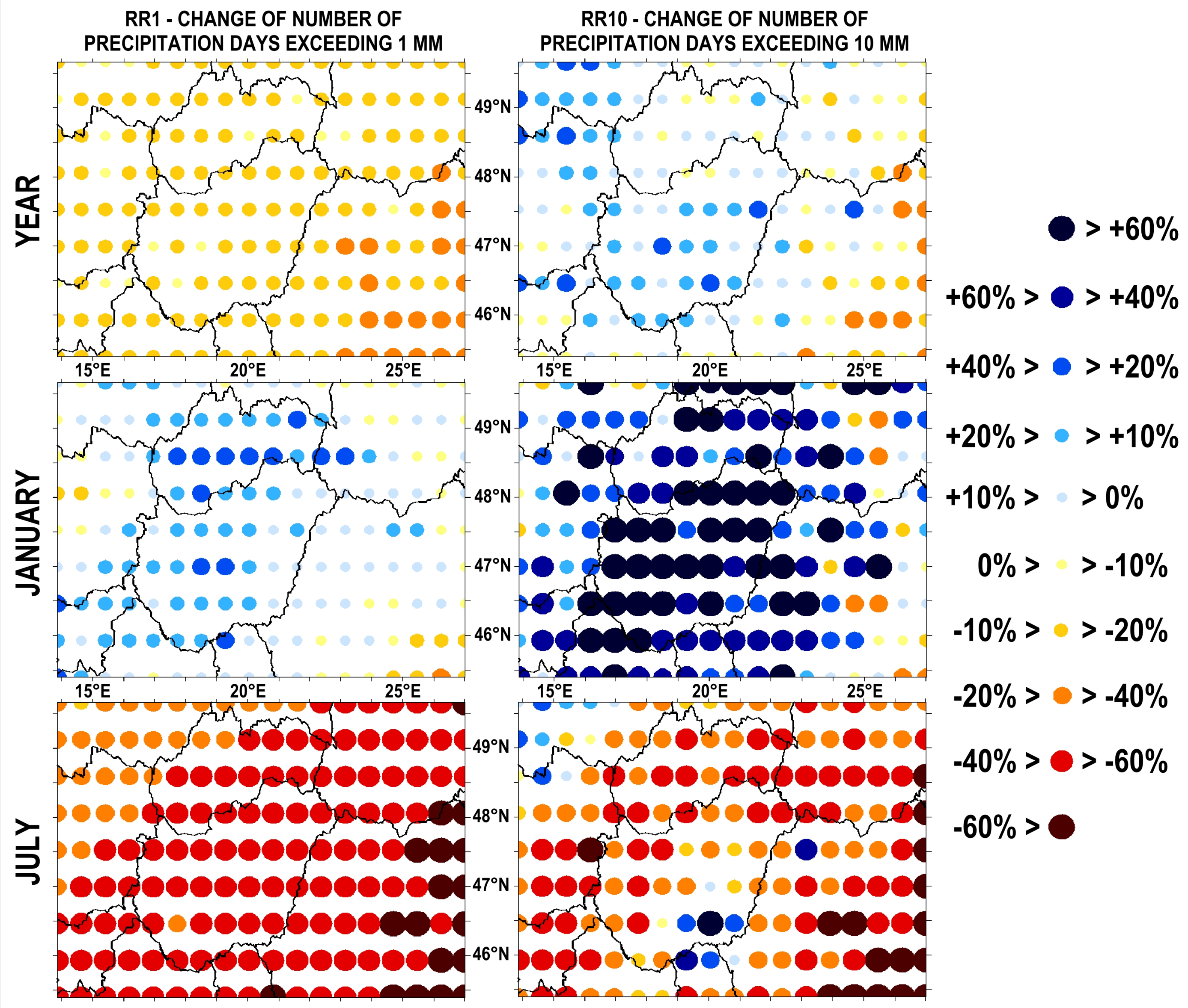
Expected change of summer days in the Carpathian basin between 1961-1990 and 2071-2100 (using the ETH model outputs, A2 scenario)

INCREASE: (+30%) – (+90%)

Estimated frequency changes of extreme precipitation indices 1961-1990, 2071-2100 (based on ETH model outputs, A2 scenario)

	Expected change (A2, 2071-2100)			Detected trend (1976-2001)
	Annual	January	July	
Very heavy precipitation days ($R_{day} \geq 20$ mm)	+37%	> +200%	-5%	+
Heavy precipitation days ($R_{day} \geq 10$ mm)	+13%	+89%	-28%	+
Precipitation days exceeding 5 mm ($R_{day} \geq 5$ mm)	-2%	+38%	-39%	(–)
Precipitation days exceeding 1 mm ($R_{day} \geq 1$ mm)	-13%	+13%	-45%	–
Precipitation days exceeding 0.1 mm ($R_{day} \geq 0.1$ mm)	-15%	+9%	-47%	–
Highest 1-day precipitation (R_{max})	+6%	+27%	-17%	–
Greatest 5-day total precipitation (R_{max})	+0.3%	+18%	-24%	+
Very wet days ($R_{day} \geq R_{95\%,1961-90}$)	+6%	+55%	-39%	+
Moderate wet days ($R_{day} \geq R_{75\%,1961-90}$)	-14%	+13%	-46%	+
Daily intensity (R_{year}/RR1)	+7%	+15%	-5%	(+)
Consecutive dry days ($R_{day}<1$ mm)	+10%	-27%	+26%	–

Expected change of RR1 and RR10 (no. of wet days exceeding 1 mm and 10 mm) in the Carpathian basin between 1961-1990 and 2071-2100 (using the ETH model outputs, A2 scenario)



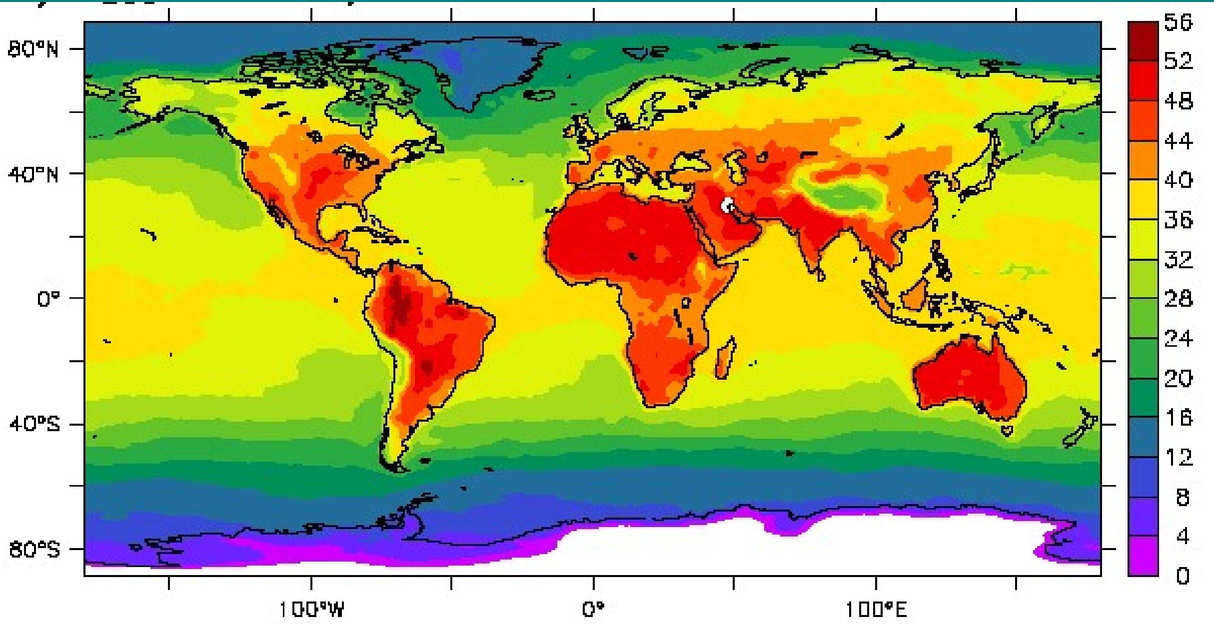
RR1: yearly decrease (-13%), January (+13%), July (-45%)

RR10: yearly increase (+13%), January (+89%), July (-28%)

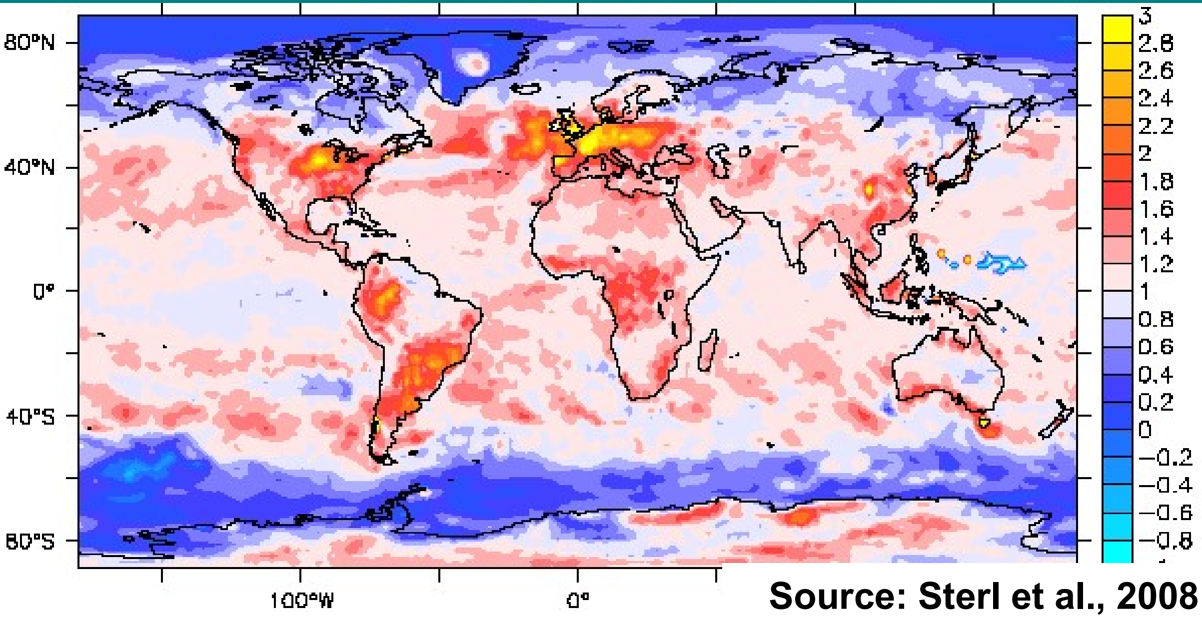
WHAT WILL HAPPEN WITH THE CLIMATE RECORDS (THE EXTREMES OF THE EXTREMES)?

New analysis :
STERL et al, 2008,
Geophisical Res. Letters

T_{100}: 100 years return period temper. (^{0}C)



ΔT_{100}: larger increase than the average (^{0}C)



Source: Sterl et al., 2008

Estimated changes of the temperature values of the 100 year return periods (T_{100}) for 2090-2099.

(reference period: 1990-1999)

TOP -- T_{100} :
Europe > 44 ^{0}C
Africa, Australia > 44 ^{0}C

BOTTOM -- ΔT_{100}:
Pink (blue):
Larger (smaller) increase, than the average

(ESSENCE project, ECHAM5 model, A1B scenario. Max Plack Inst., Hamburg)

CONCLUSION

- **Results of the regional model experiments are essential for the end users.**
  Several international and national projects are working on the regional climate scenarios (ENSEMBLE, CECILIA, CLAVIER)

- **The regional impact studies cannot wait until all results will be available with high resolution.**
  RCM model runs of PRUDENCE project are able to provide valuable, preliminary results.

- **There are strong limitations due to:**
  - **spatial resolution is only 50 km,**
  - **available climate scenarios (only A2, and some B2)**
  - **only for 2071-2100 period, …**