Climate Change: from Global to Local

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CORDEX.be stakeholders meeting,

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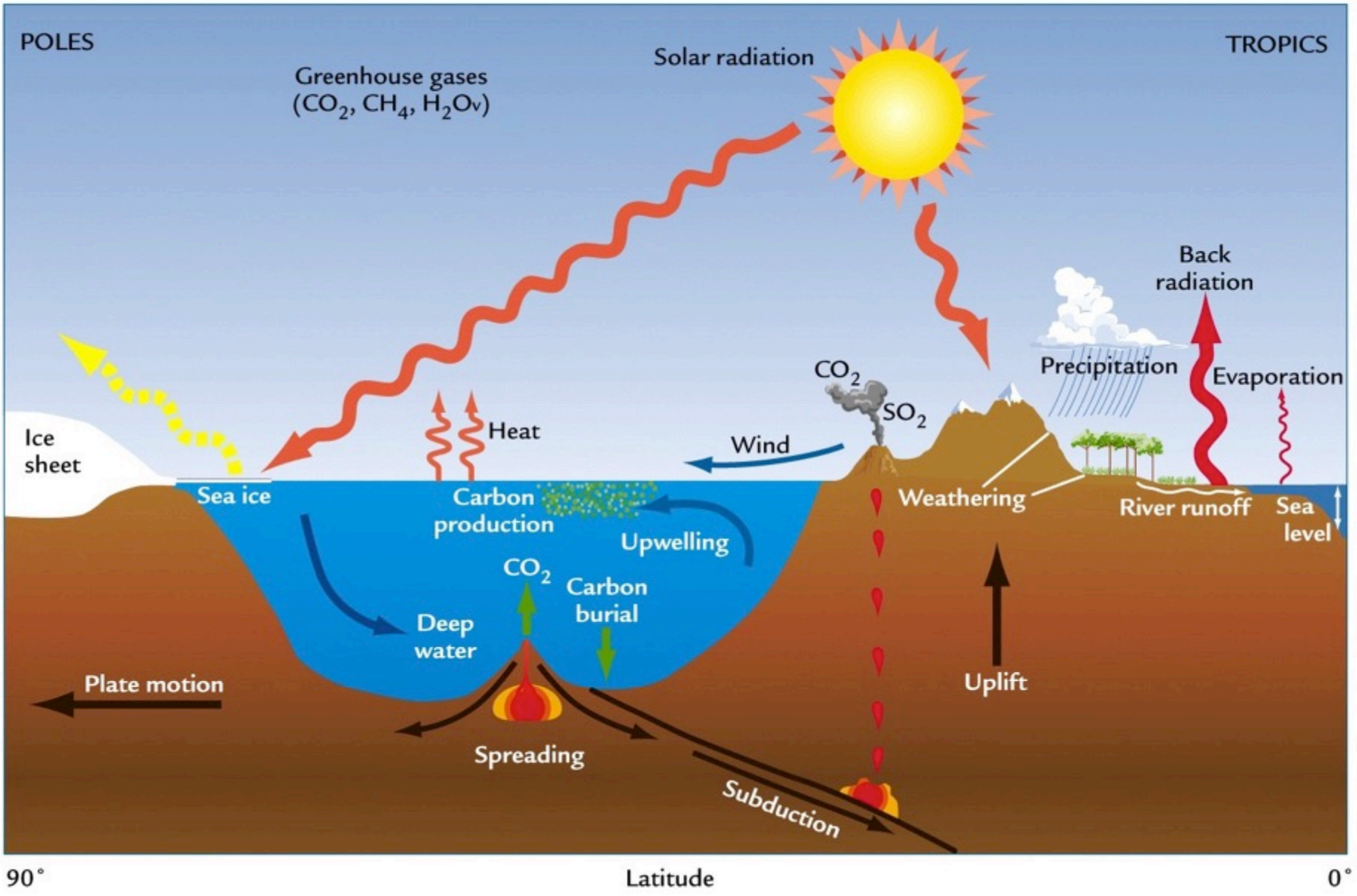
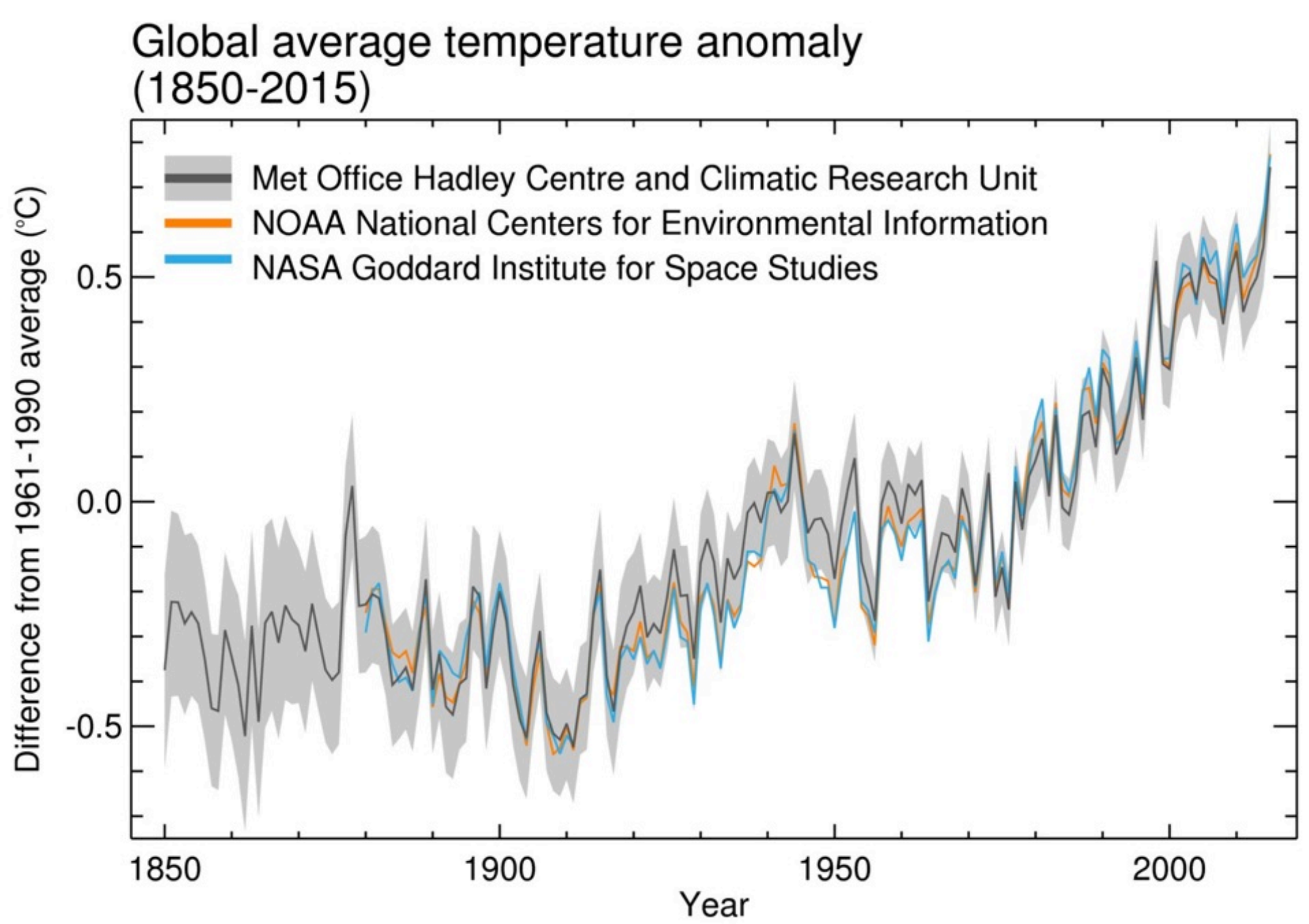
Thanks to the Belgian Federal Science Policy Office (BELSPO), to the Walloon government, and to my team at the Université catholique de Louvain for their support

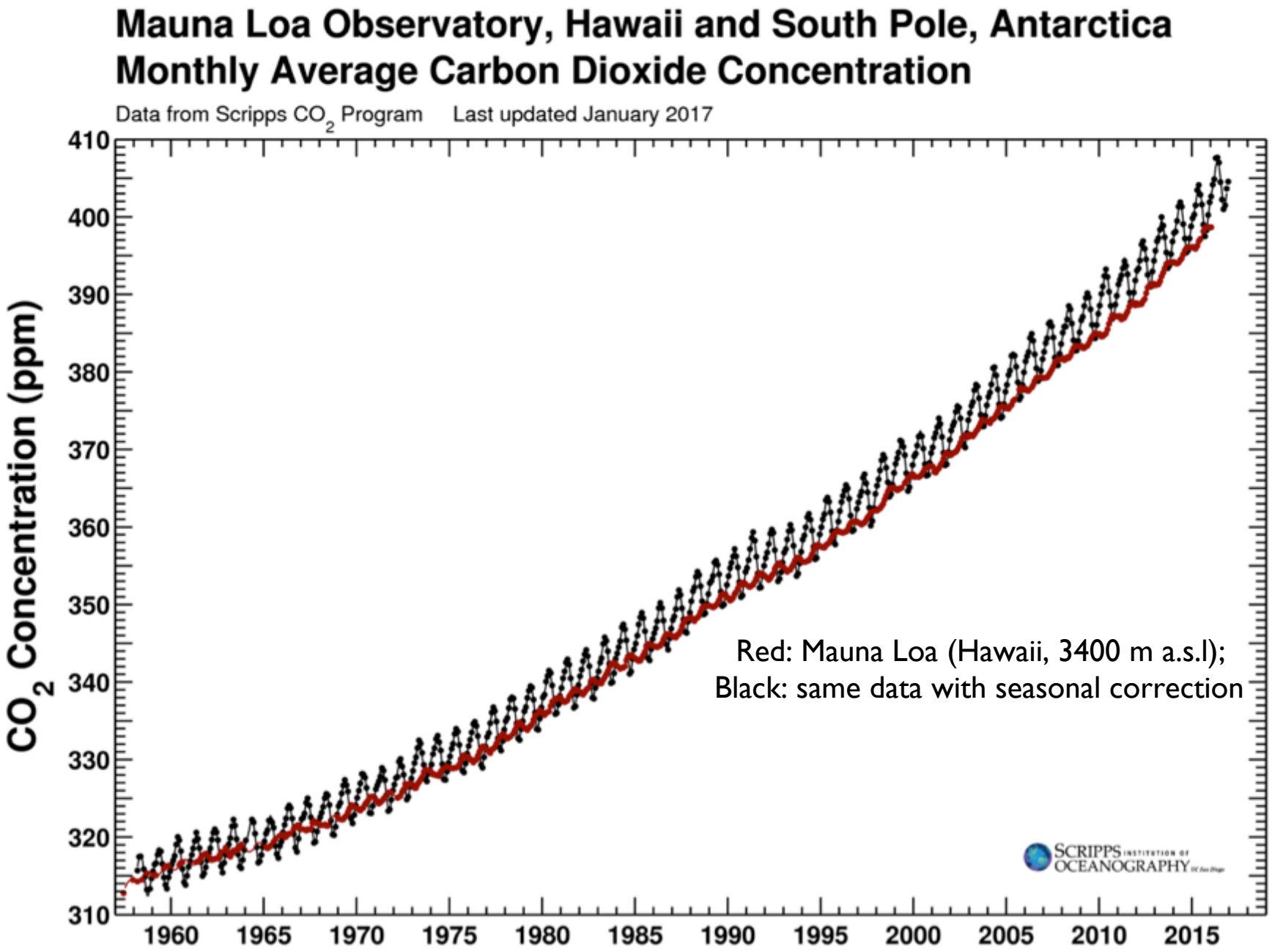


Source: Ruddiman



Source: NASA GISS

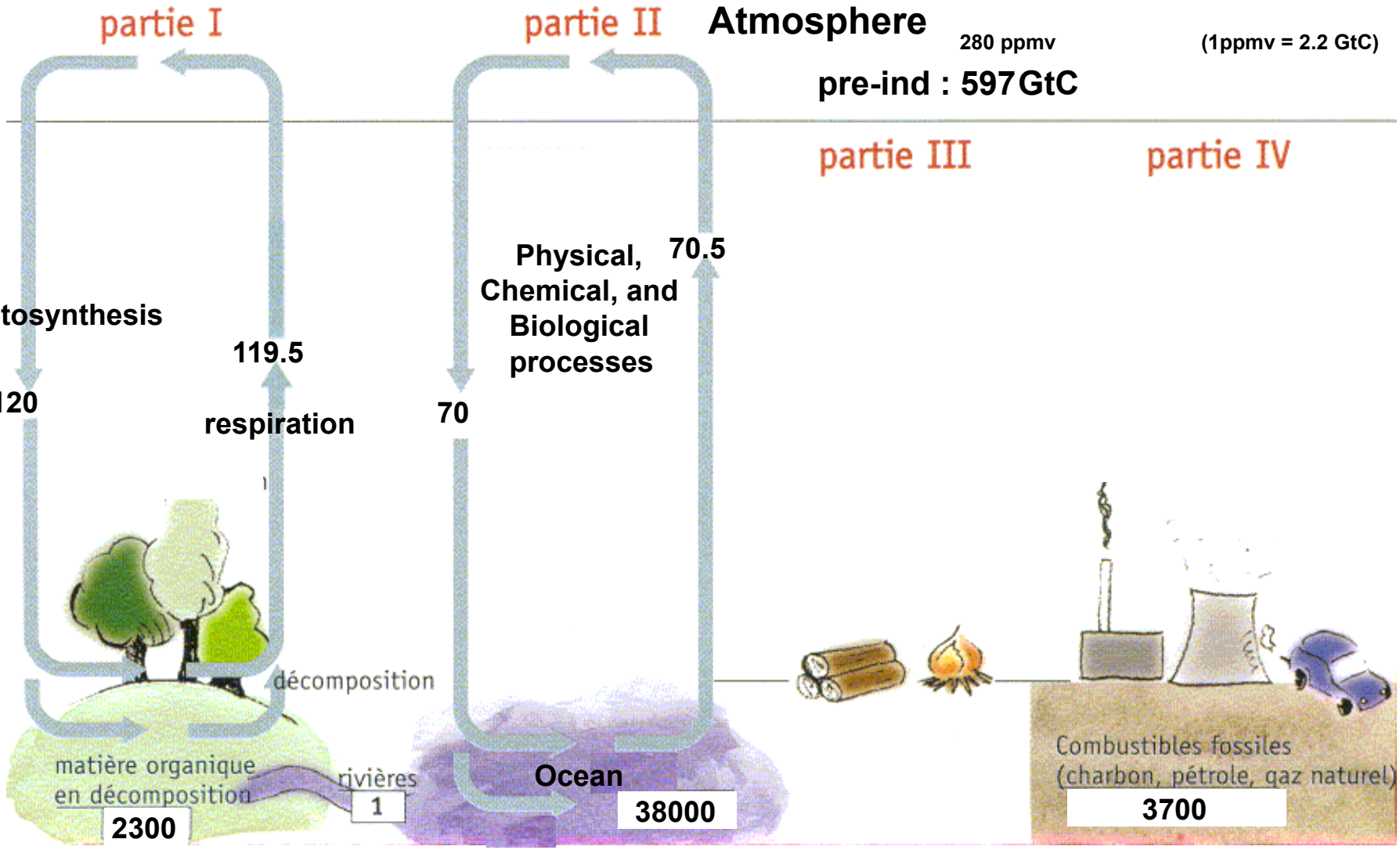
Atmospheric CO_2 concentration



(Lüthi et al.,2008, NOAA)

The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years.

Carbon cycle: unperturbed fluxes

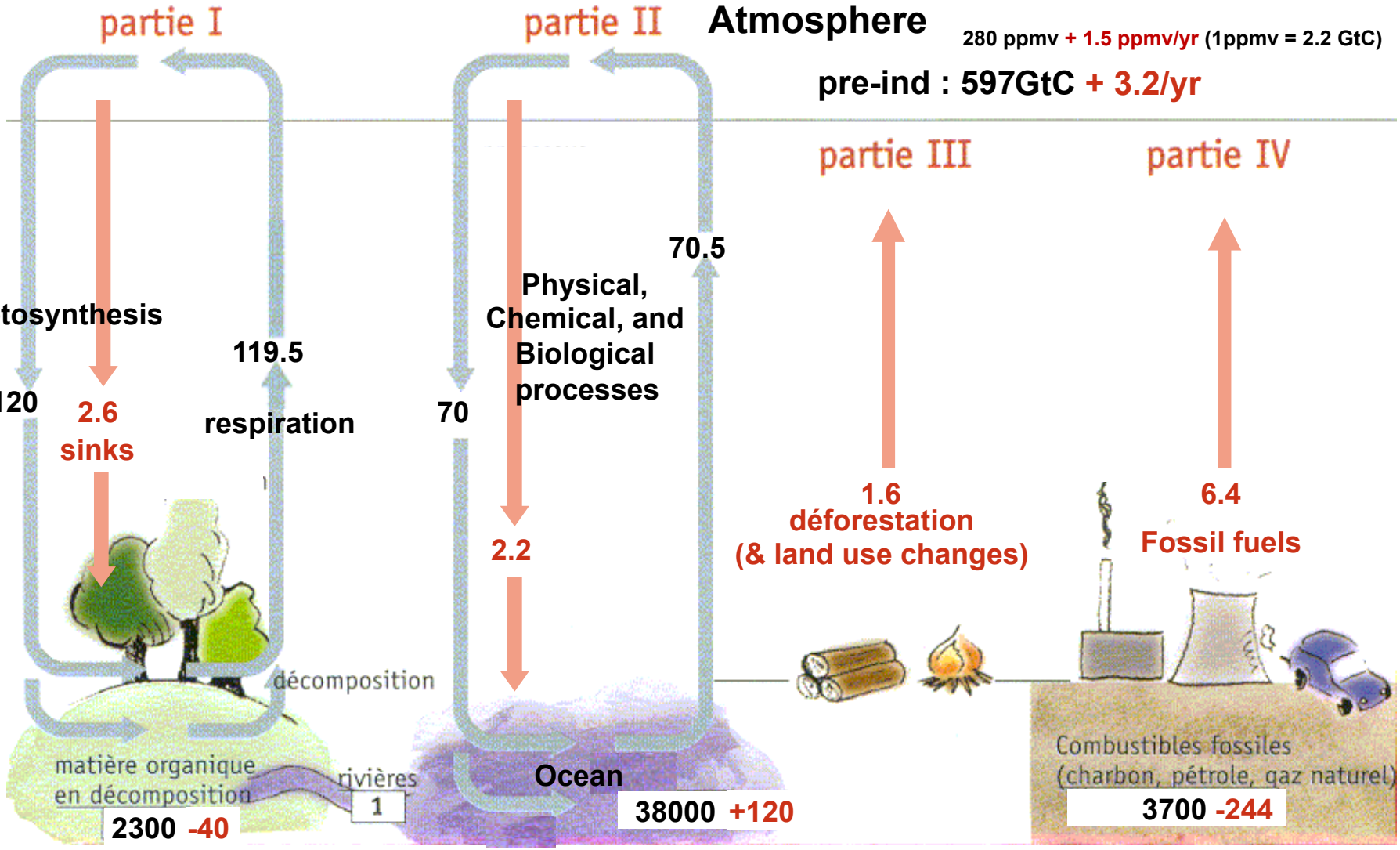


Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get $GtCO_2$)

vanyp@climate.be

Carbon cycle: perturbed by human activities

(numbers for the decade 1990-1999s, based on IPCC AR4)



Units: GtC (billions tons of carbon) or GtC/year

Stocks!

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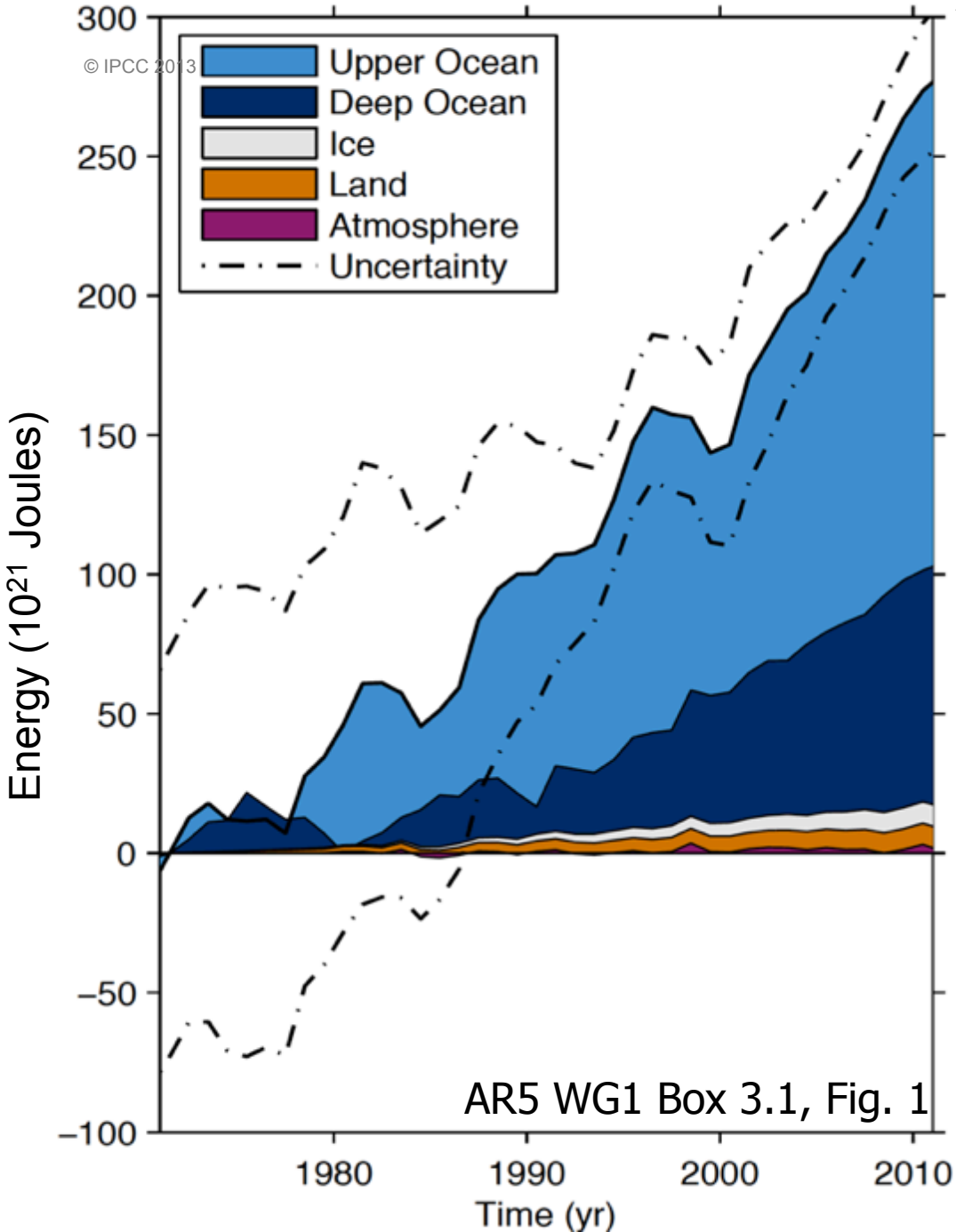
The carbon cycle is policy-relevant

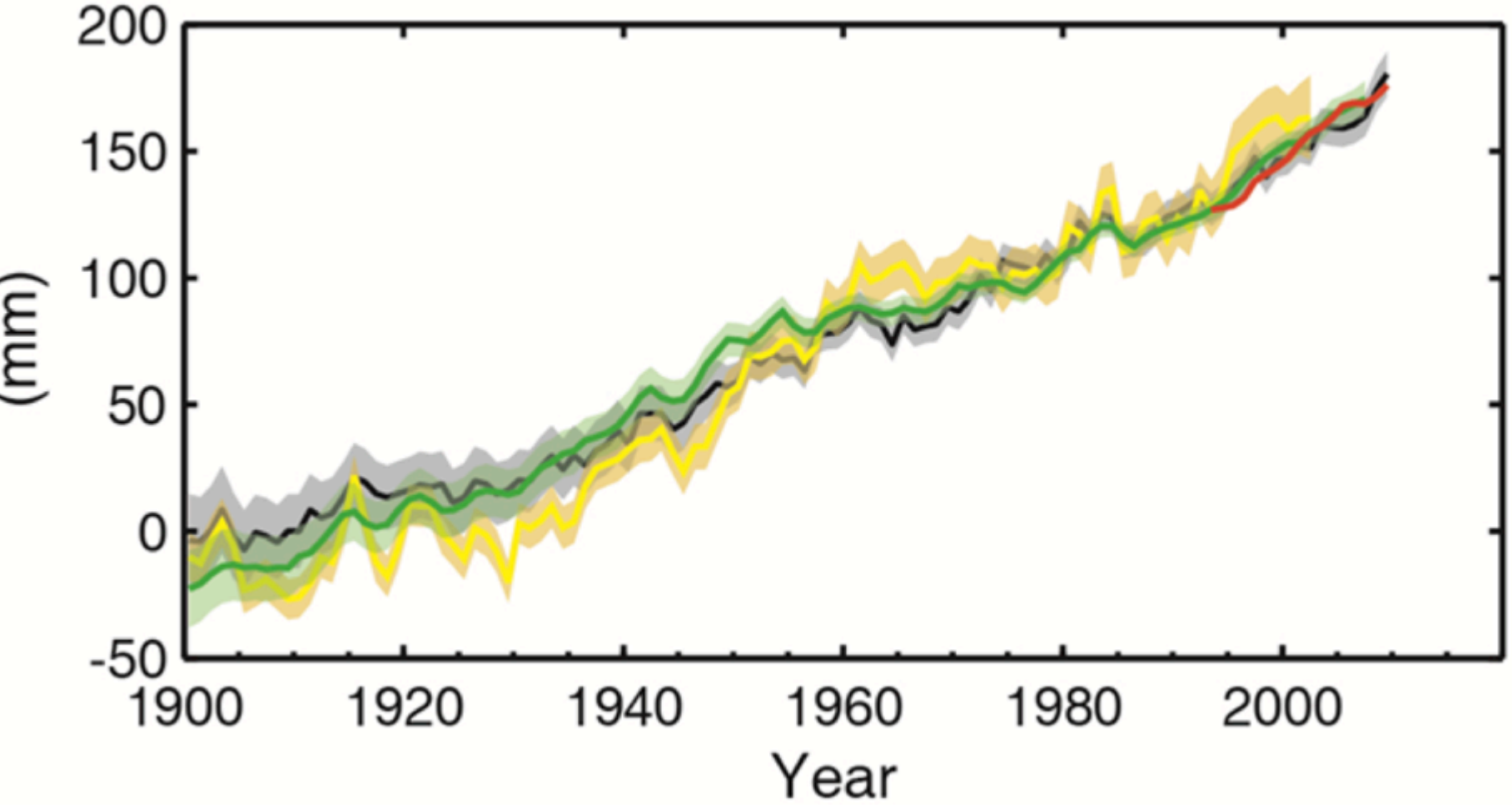
- **CO_2 accumulates in the atmosphere as long as human emissions are larger than the natural absorption capacity**
- **Historical emissions from developed countries therefore matter for a long time**
- **As warming is function of cumulated emissions, the carbon « space » is narrowing fast (to stay under 1.5 or 2°C warming)**

Where does the energy trapped go?



Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010 (high confidence).

Change in average sea-level change



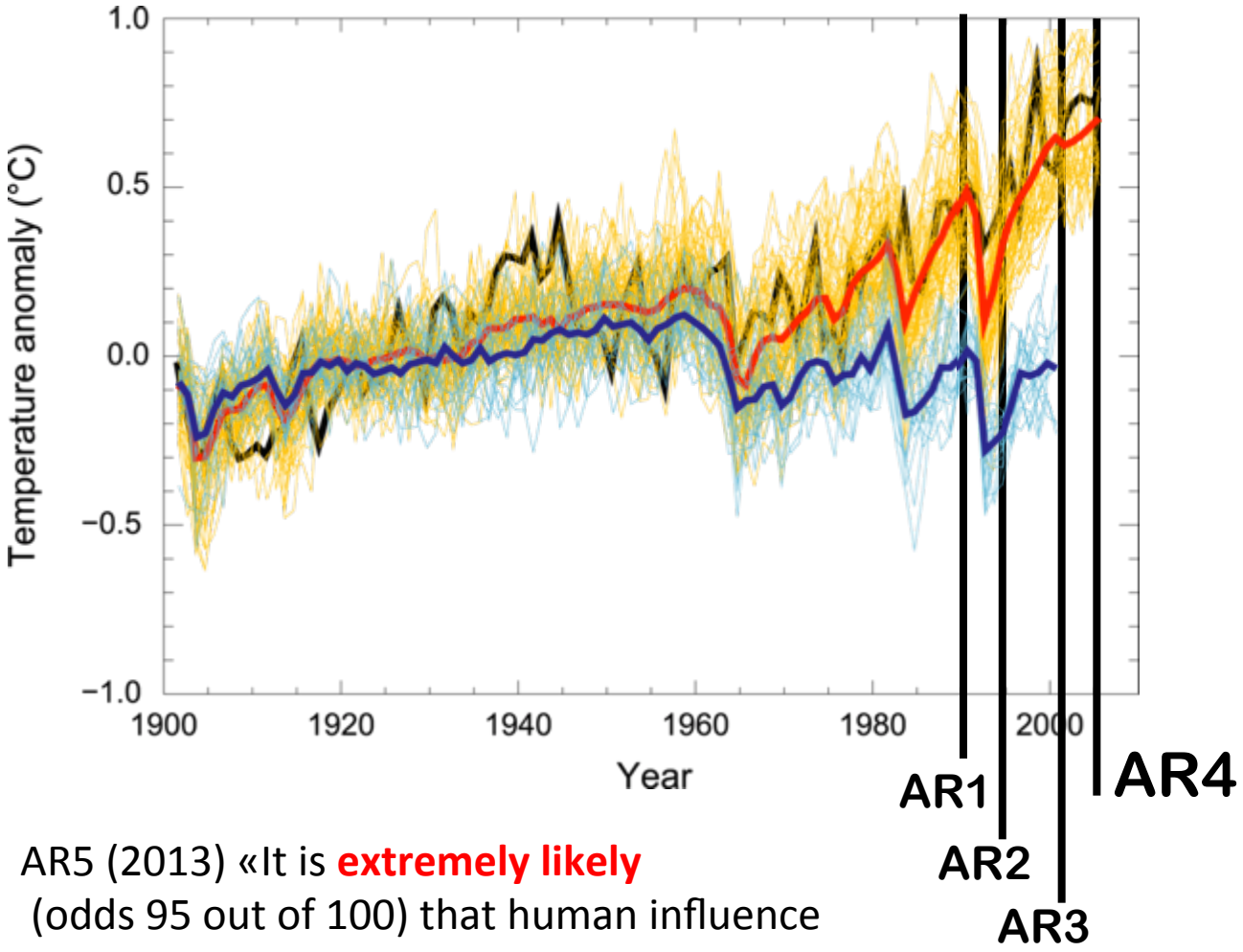
A Progression of Understanding: Greater and Greater Certainty in Attribution

AR1 (1990): "unequivocal detection not likely for a decade"

AR2 (1995): "balance of evidence suggests **discernible** human influence"

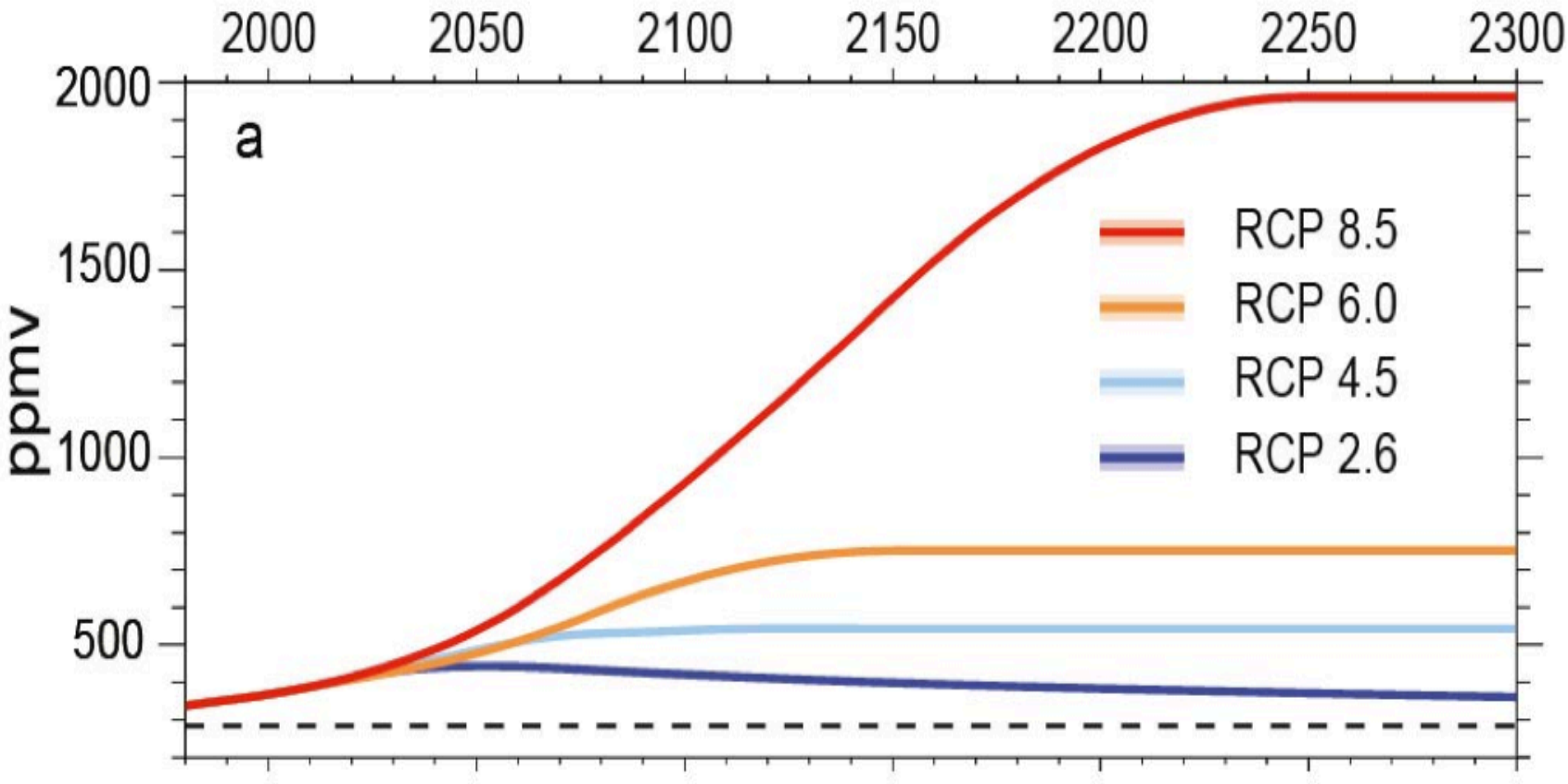
AR3 (2001): "most of the warming of the past 50 years is **likely** (odds 2 out of 3) due to human activities"

AR4 (2007): "most of the warming is **very likely** (odds 9 out of 10) due to greenhouse gases"



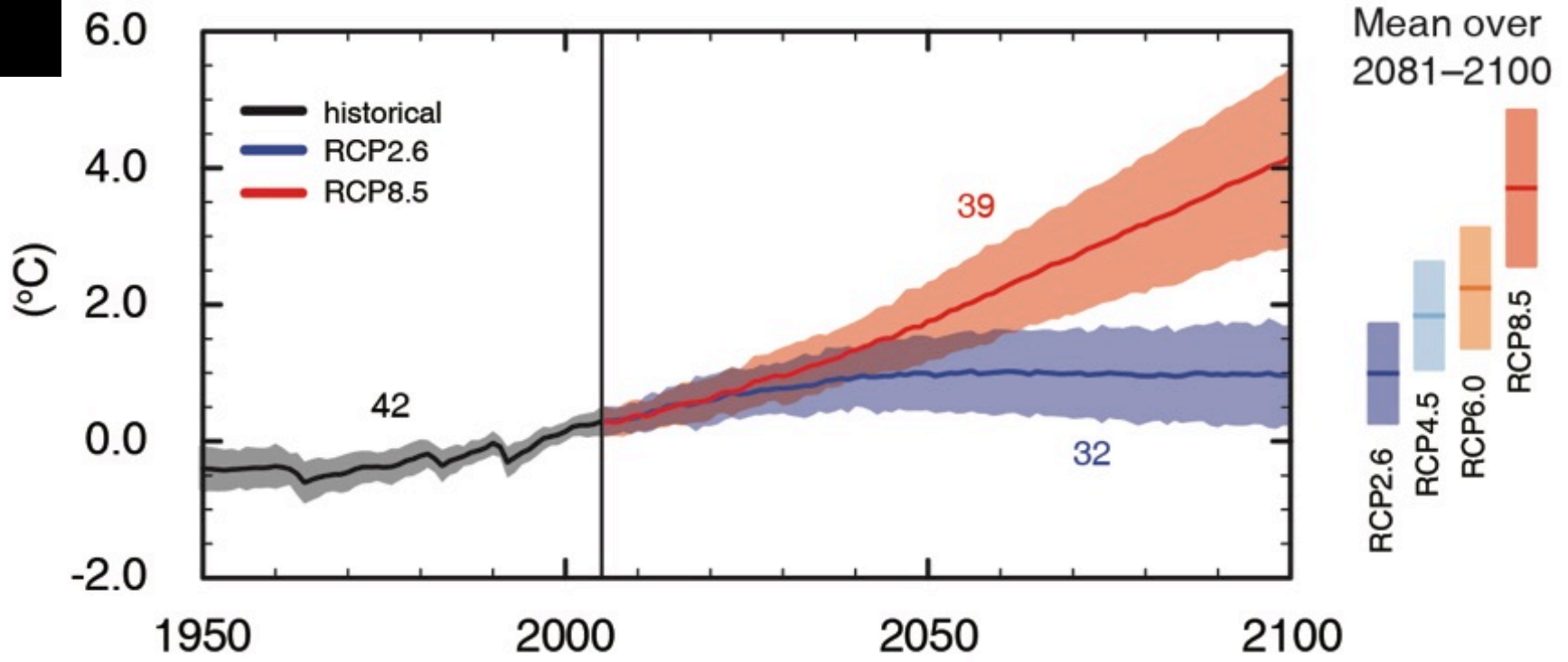
AR5 (2013) «It is **extremely likely** (odds 95 out of 100) that human influence has been the dominant cause… »

RCP Scenarios: Atmospheric CO_2 concentration



Three stabilisation scenarios: RCP 2.6 to 6
One Business-as-usual scenario: RCP 8.5

AR5, chapter 12. WGI- Adopted version / subject to final copyedit



(IPCC 2013, Fig. SPM.7a)

Only the lowest (RCP2.6) scenario maintains the global surface temperature increase above the pre-industrial level to less than 2°C with at least 66% probability

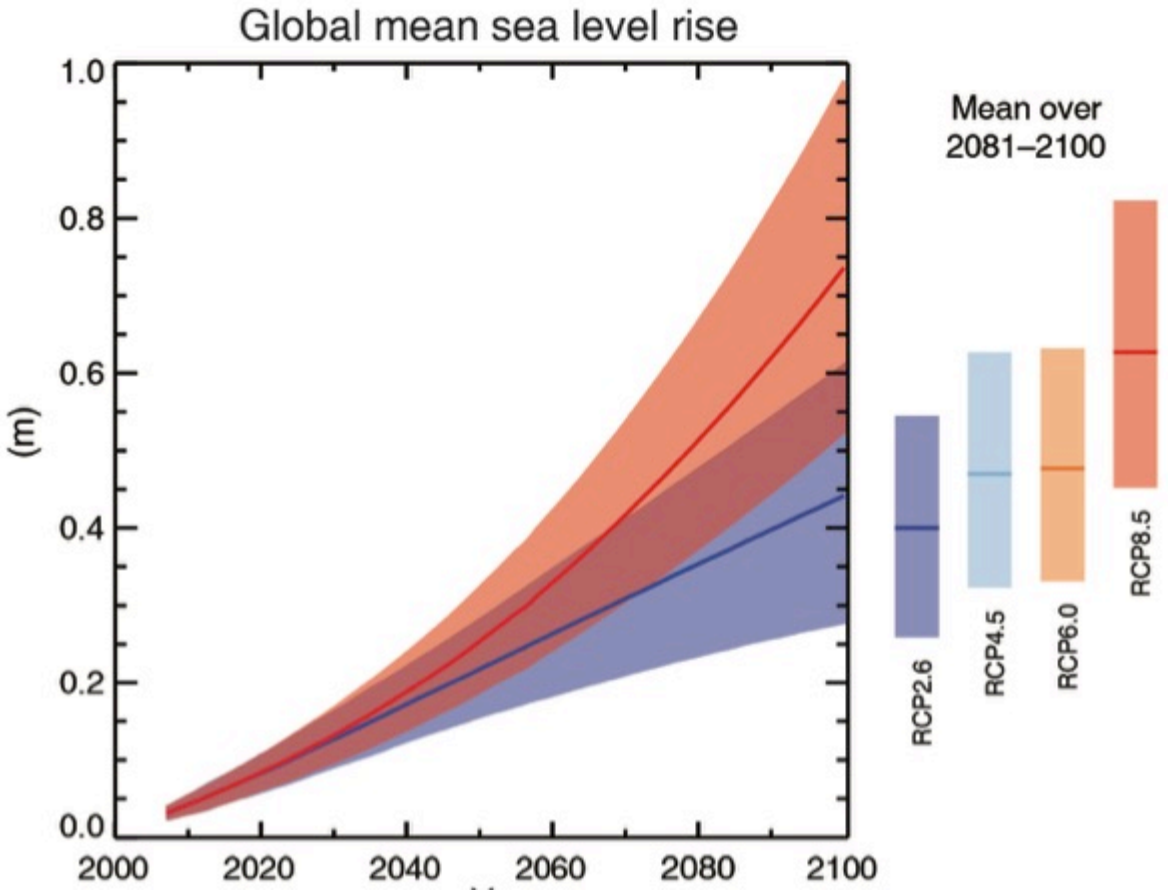


Fig. SPM.9

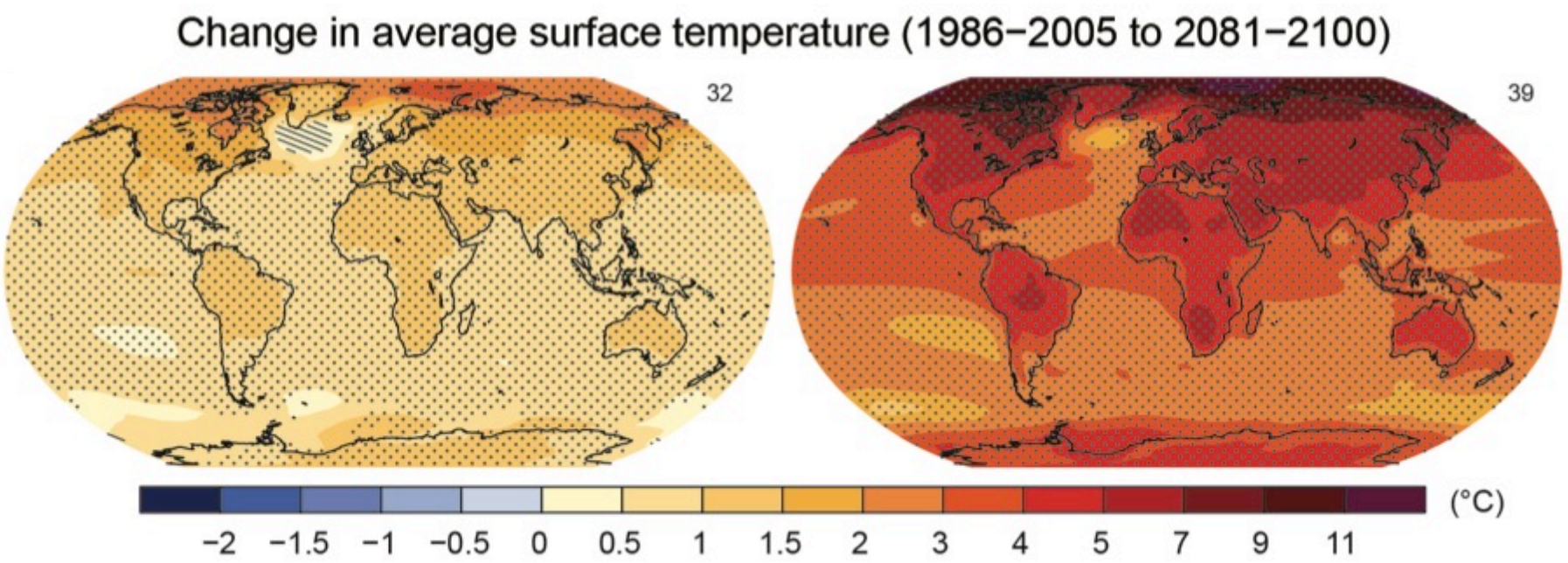
RCP2.6 (2081-2100), *likely* range: **26 to 55 cm**

RCP8.5 (in 2100), *likely* range: **52 to 98 cm**

(Reference level: 1986-2005)

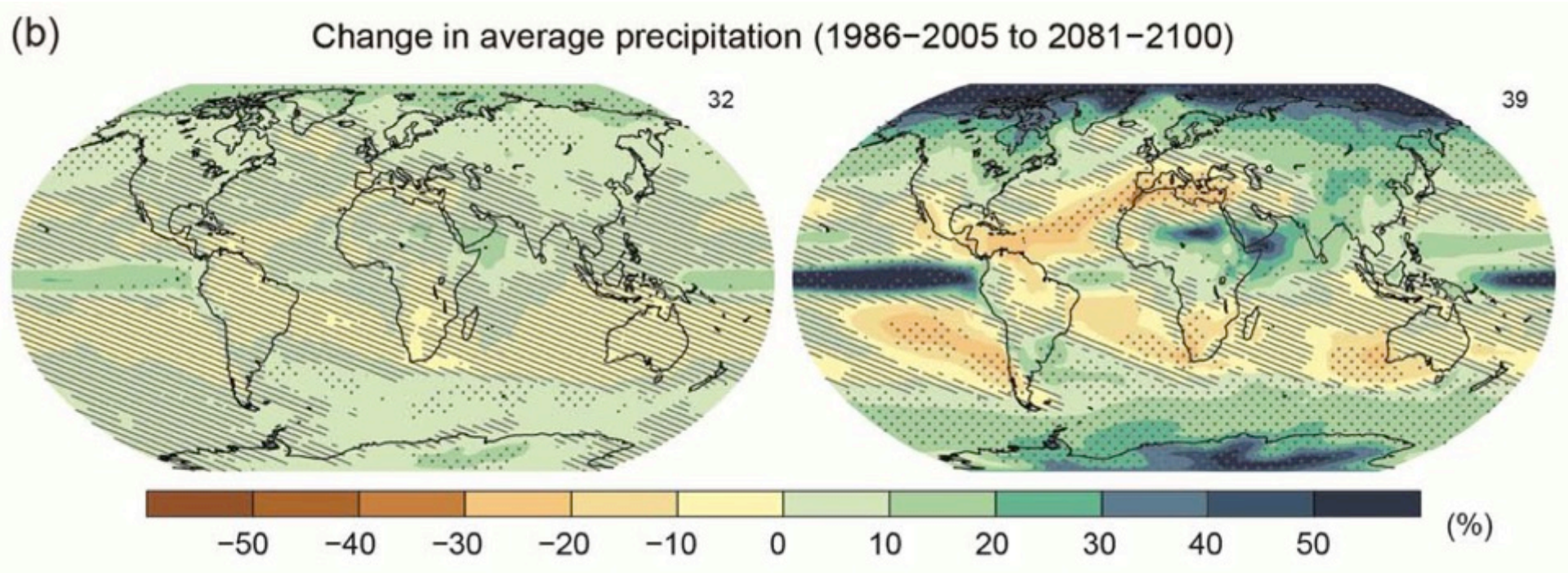
RCP2.6 RCP8.5

Fig. SPM.8



Projected Change in Precipitation

RCP 2.6 **RCP 8.5**



Since 1950, extreme hot days and heavy precipitation have become more common

There is evidence that anthropogenic influences, including increasing atmospheric greenhouse gas concentrations, have changed these extremes

Extreme weather and climate events

Phenomenon and direction of trend	Assessment that changes occurred (typically since 1950 unless otherwise indicated)	Assessment of a human contribution to observed changes	Likelihood of further changes	
			Early 21st century	Late 21st century
Warmer and/or fewer cold days and nights over most land areas	*Very likely*	***Very likely***	*Likely*	***Virtually certain***
Warmer and/or more frequent hot days and nights over most land areas	*Very likely*	***Very likely***	*Likely*	***Virtually certain***
Warm spells/heat waves. Frequency and/or duration increases over most land areas	***Medium confidence*** on a global scale Likely in large parts of Europe, Asia and Australia	***Likely***	Not formally assessed	***Very likely***
Heavy precipitation events. Increase in the frequency, intensity, and/or amount of heavy precipitation	*Likely more land areas with increases than decreases*	***Medium confidence***	*Likely* over many land areas	***Very likely*** over most of the mid-latitude land masses and over wet tropical regions
Increases in intensity and/or duration of drought	***Low confidence*** on a global scale Likely changes in some regions	***Low confidence***	*Low confidence*	***Likely*** *(medium confidence)* on a regional to global scale
Increases in intense tropical cyclone activity	***Low confidence*** in long term (centennial) changes Virtually certain in North Atlantic since 1970	***Low confidence***	*Low confidence*	***More likely than not*** in the Western North Pacific and North Atlantic
Increased incidence and/or magnitude of extreme high sea level	*Likely* (since 1970)	***Likely***	*Likely*	***Very likely***

IPCC, AR5, Table SPM.1

Potential Impacts of Climate Change

Food and water shortages

Increased displacement of people

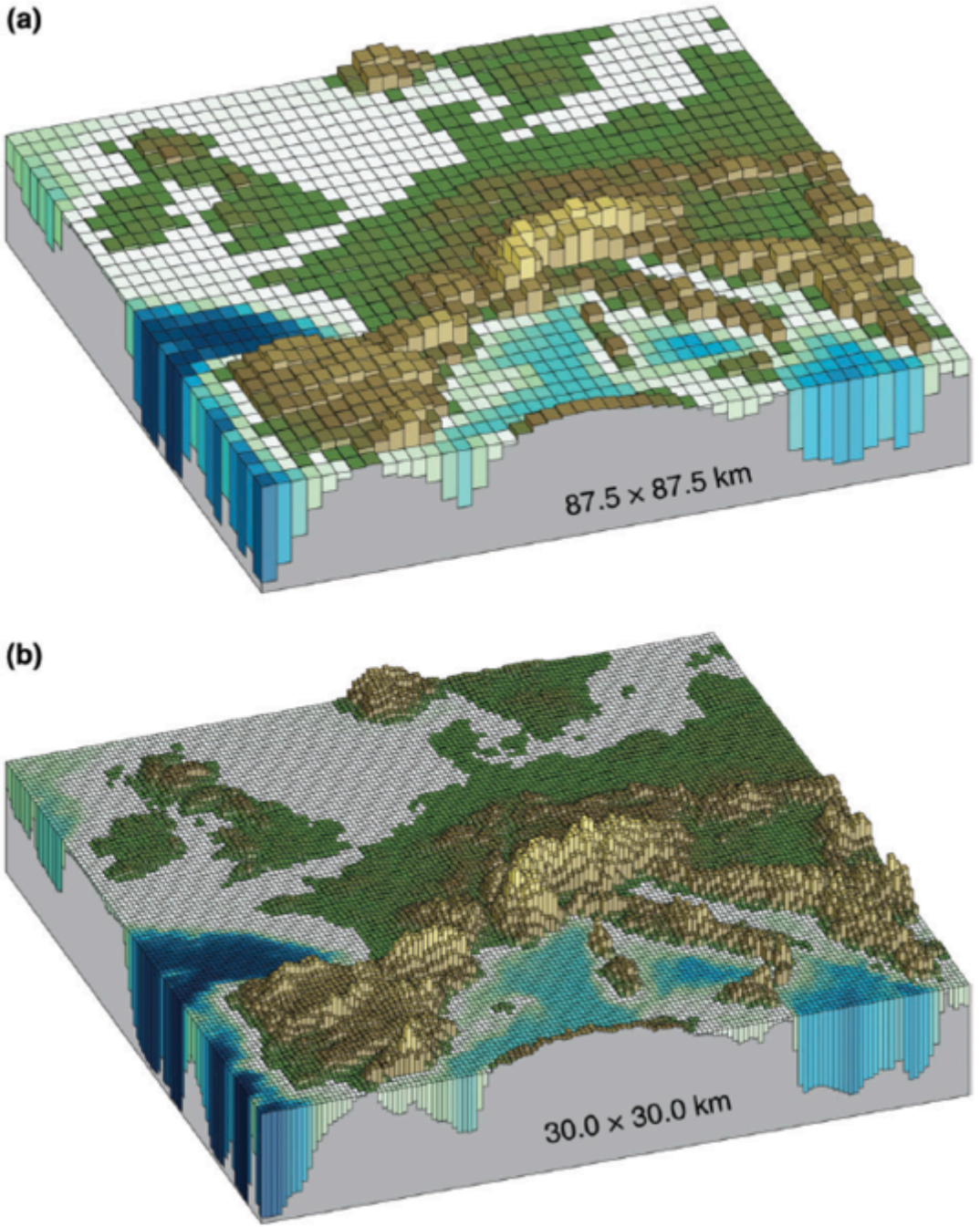
Increased poverty

Coastal flooding

AR5 WGII SPM

More heavy precipitation and more droughts….

The appetite for regional/local information is large



Rummukainen 2016

- Regional climate modelling is a dynamical dowscaling technique applied to the results of a Global Climate Model (GCM) in order to acquire more information on climate simulations and climate change projections
- RCMs operate on higher resolution than GCMs by a factor of 2-10. Some RCMs explore resolutions of 1-5 km.

Source: Rummukainen 2016 WIREs Clim Change

- RCMs add value in regions with variable orography, land-sea and other contrasts
- RCMs are better at capturing sharp, short-duration, and extreme events

Source: Rummukainen 2016 WIREs Clim Change

GCM

RCM + lake model

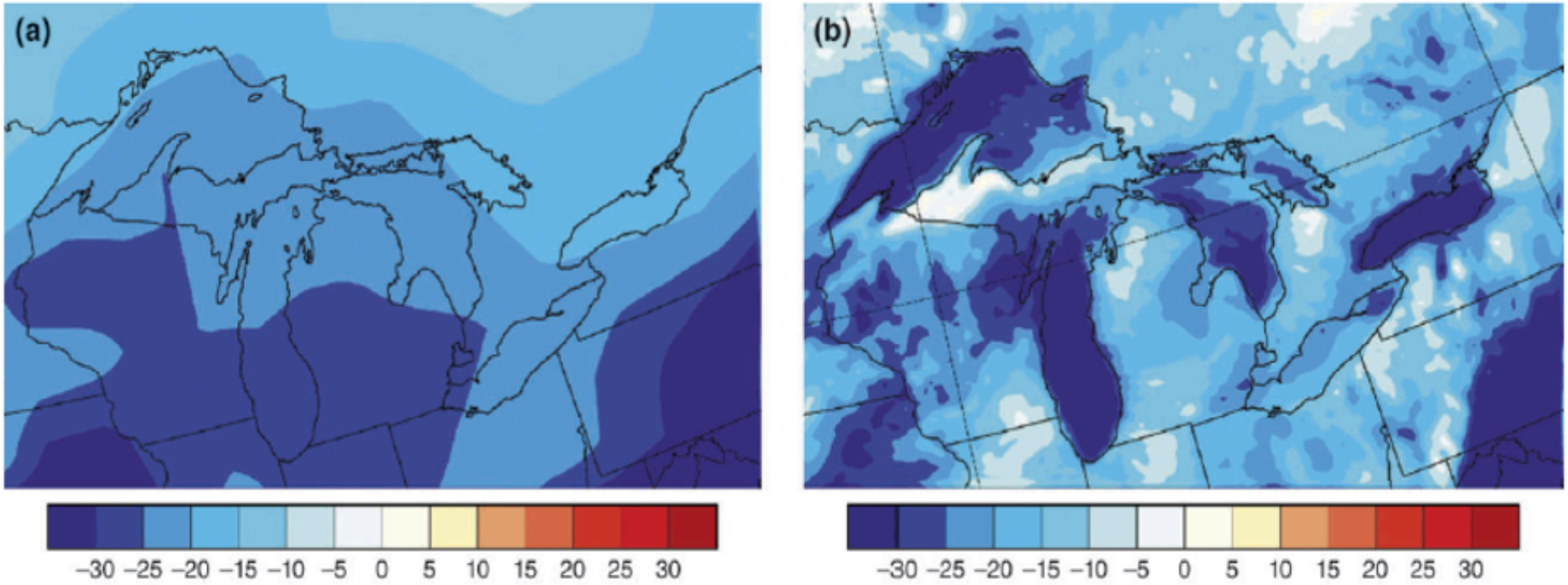


FIGURE 6 | Global climate model (GCM) (a) and regional climate model (RCM) (b) simulated changes (%) in annual mean snowfall over the North American Great Lakes region. (Reprinted with permission from Ref 28. Copyright 2012 American Meteorological Society)

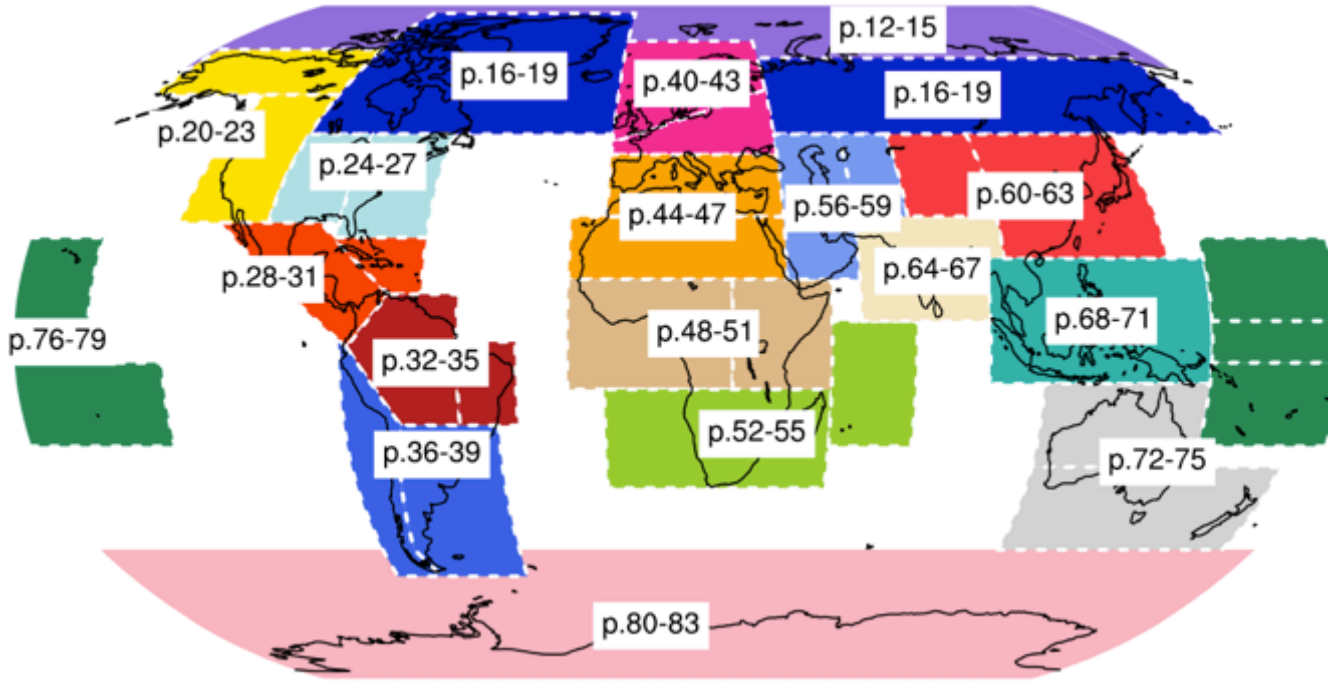
Gula et al. (2012)

Concluding remarks

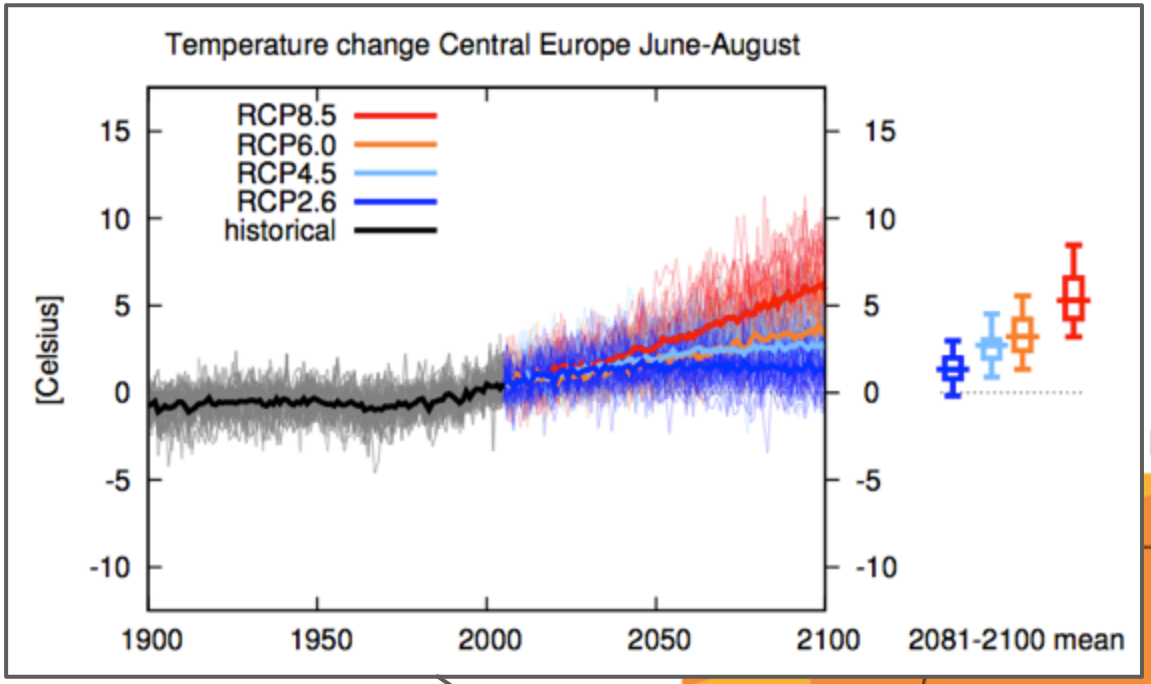
- Resolution matters
- The physics represented by the model must match the resolution increase
- Never « trust » the results of climate projections from a single GCM (see the IPCC AR5 WGI Atlas of regional projections)
- Funding fundamental climate research is still useful!

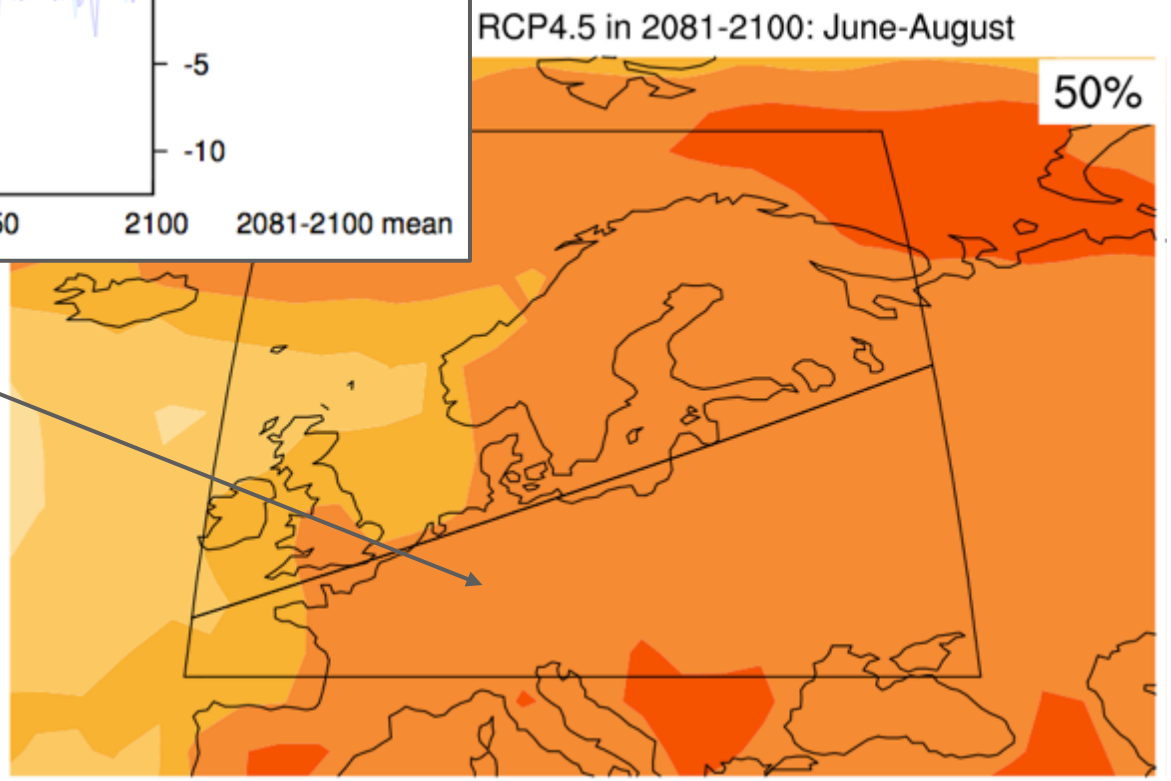
AR5 WGI Regional Atlas

- Addition to previous reports
- > 70 pages of maps, for RCP4.5 only:
  temperature and precipitation changes
  (winter & summer average climate, including model uncertainties)
- Other RCPs & seasons are available as suppl. material

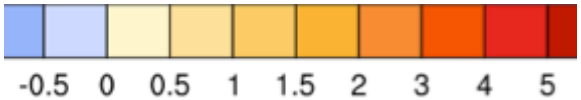


Regional Atlas - «Central Europe», summer temp.



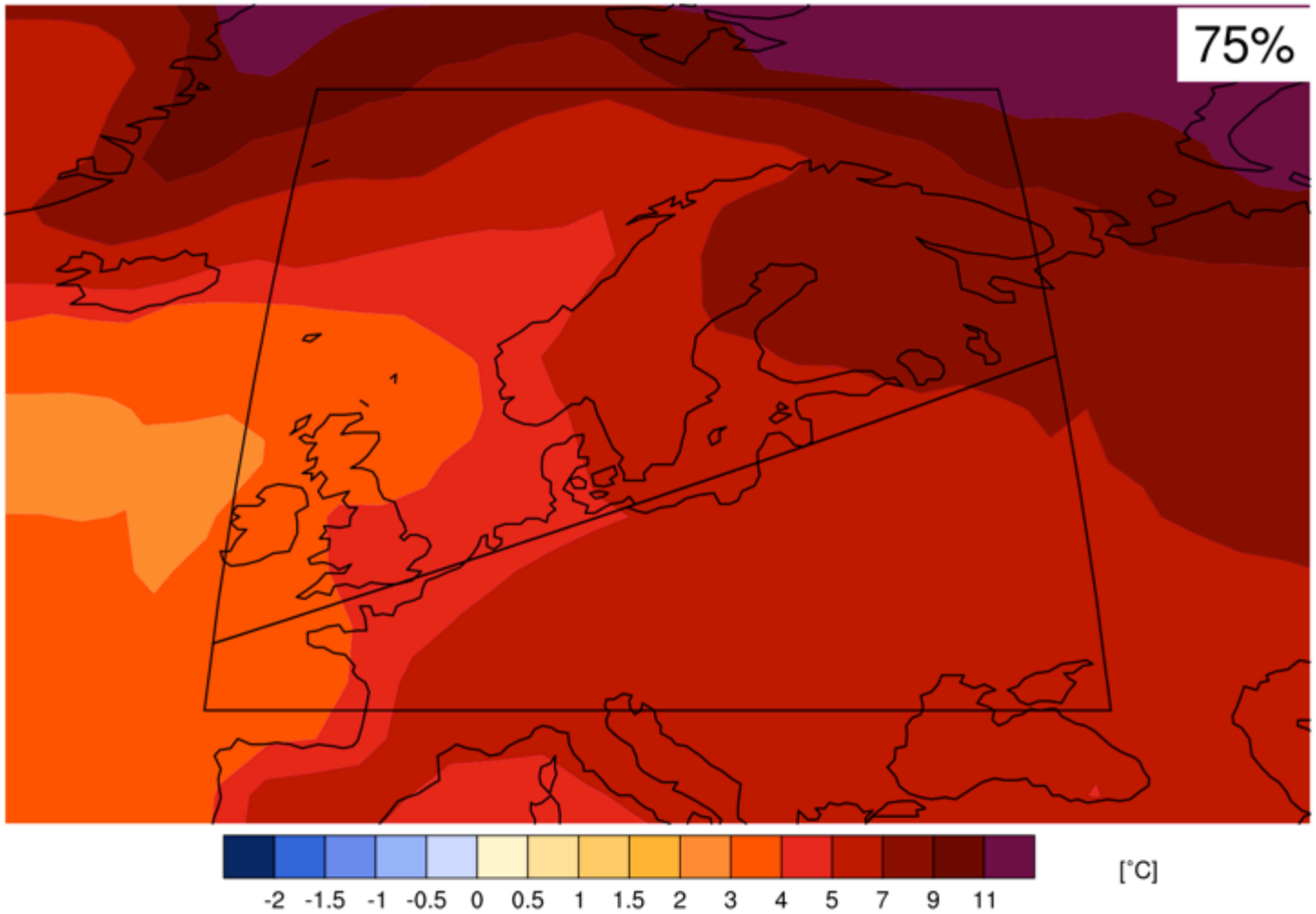


Median of multi-model distribution, average temp change JJA, 2081-2100



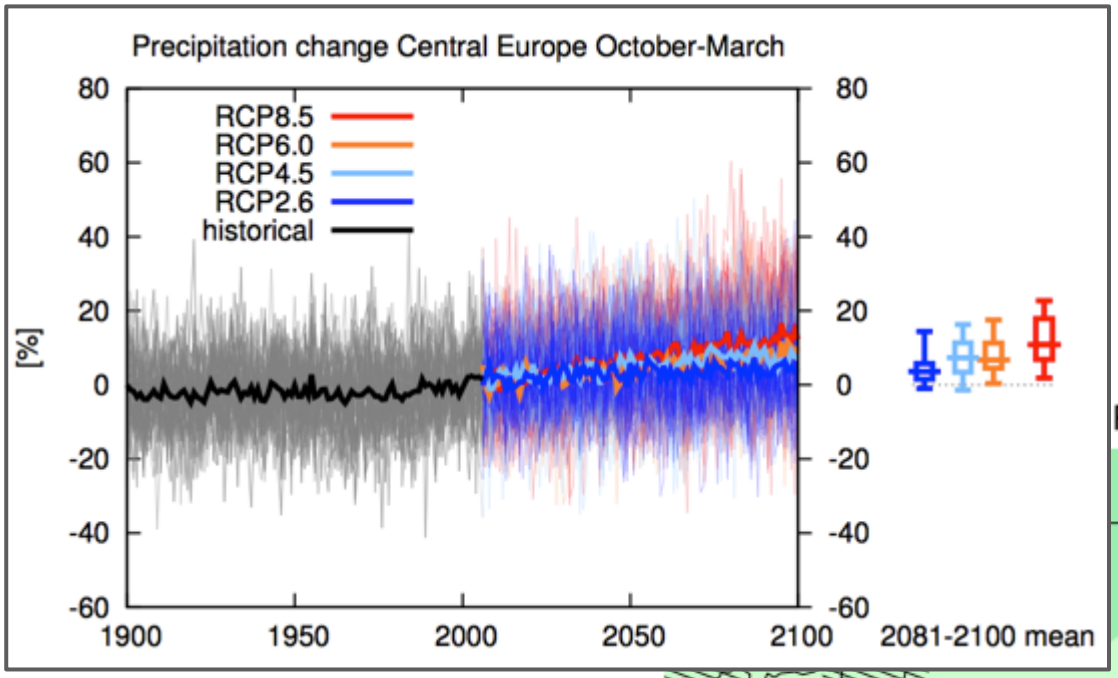
°C / 1985-2005

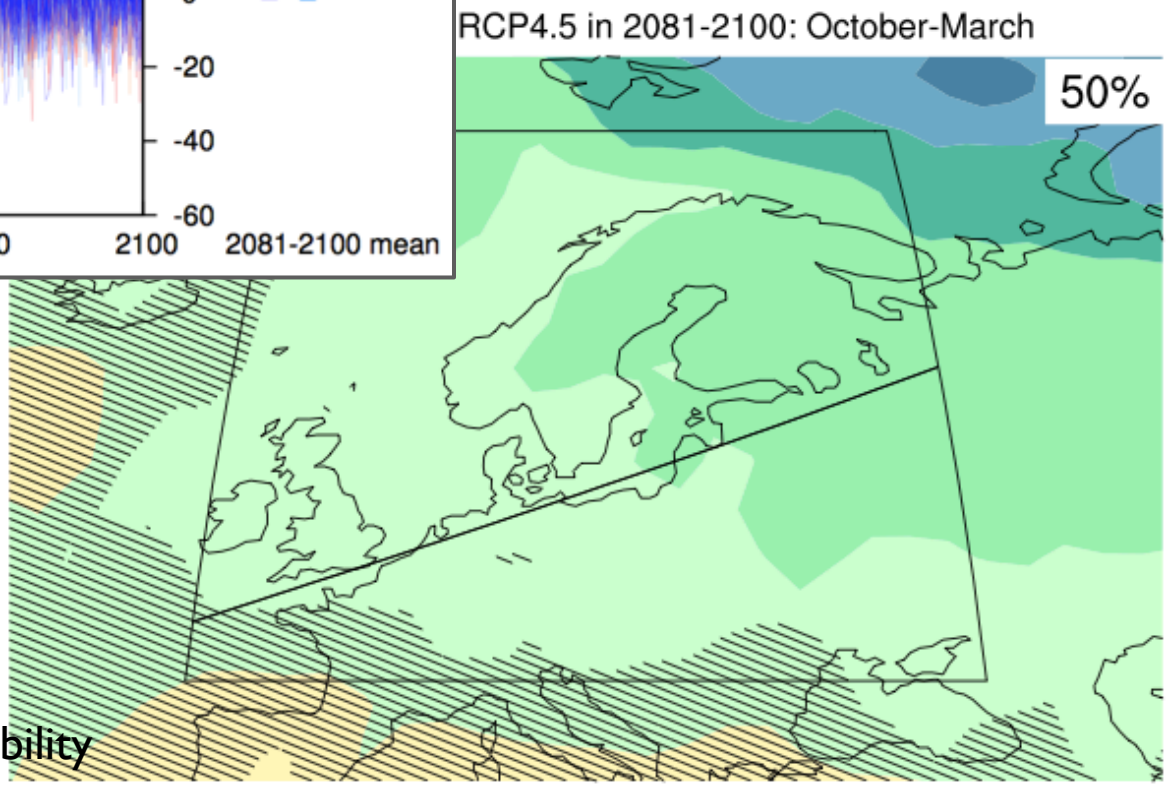
North Europe - Map of temperature changes: 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)



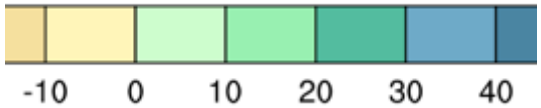
IPCC WG1 Fifth Assessment Report (Final Draft)

Regional Atlas - «Central Europe», precipitation





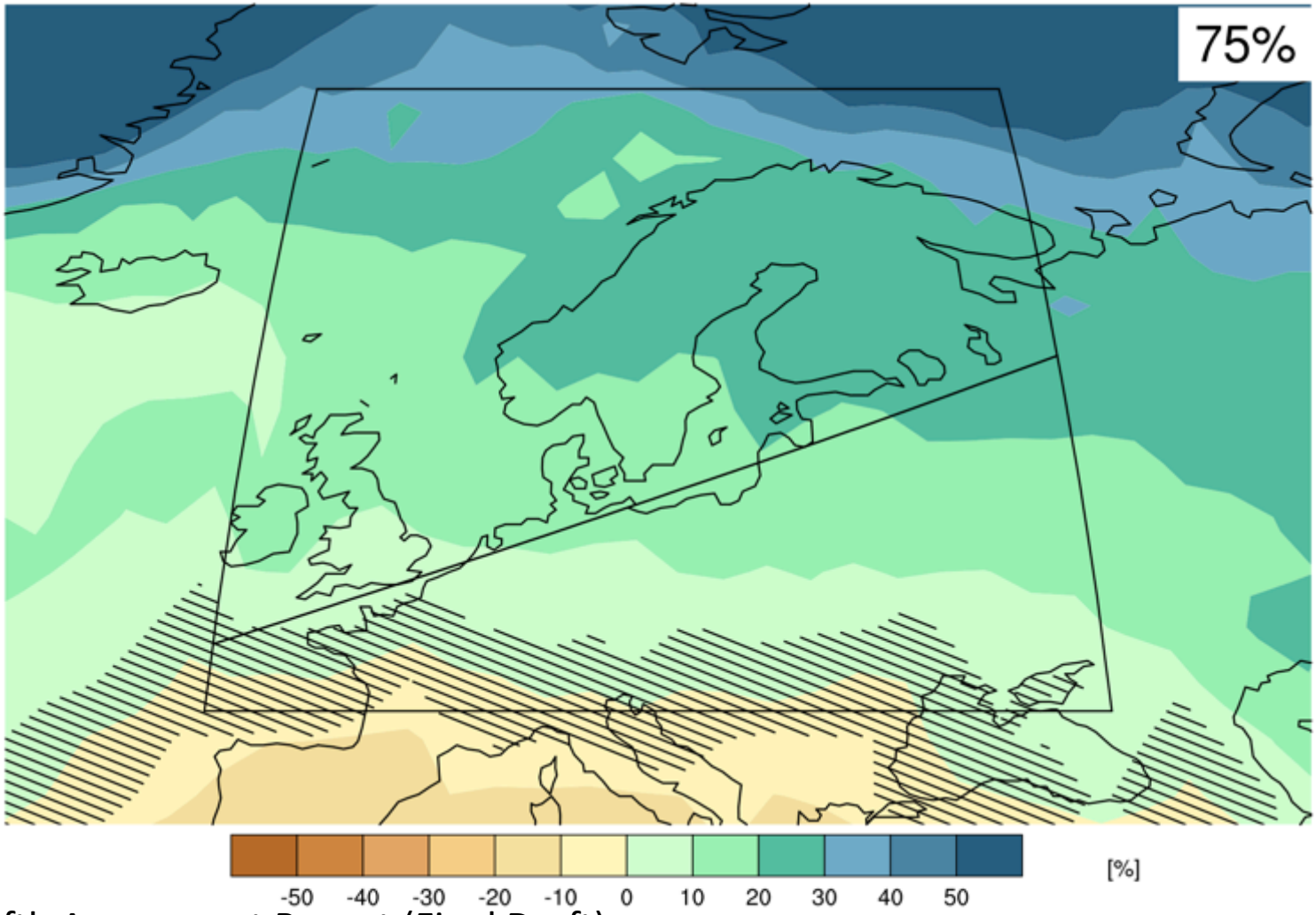
Median of multi-model distribution, average over October-March, 2081-2100



% 1985-2005

(hatching : change < present day variability for 20 years periods)

North Europe - Map of precipitation changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)



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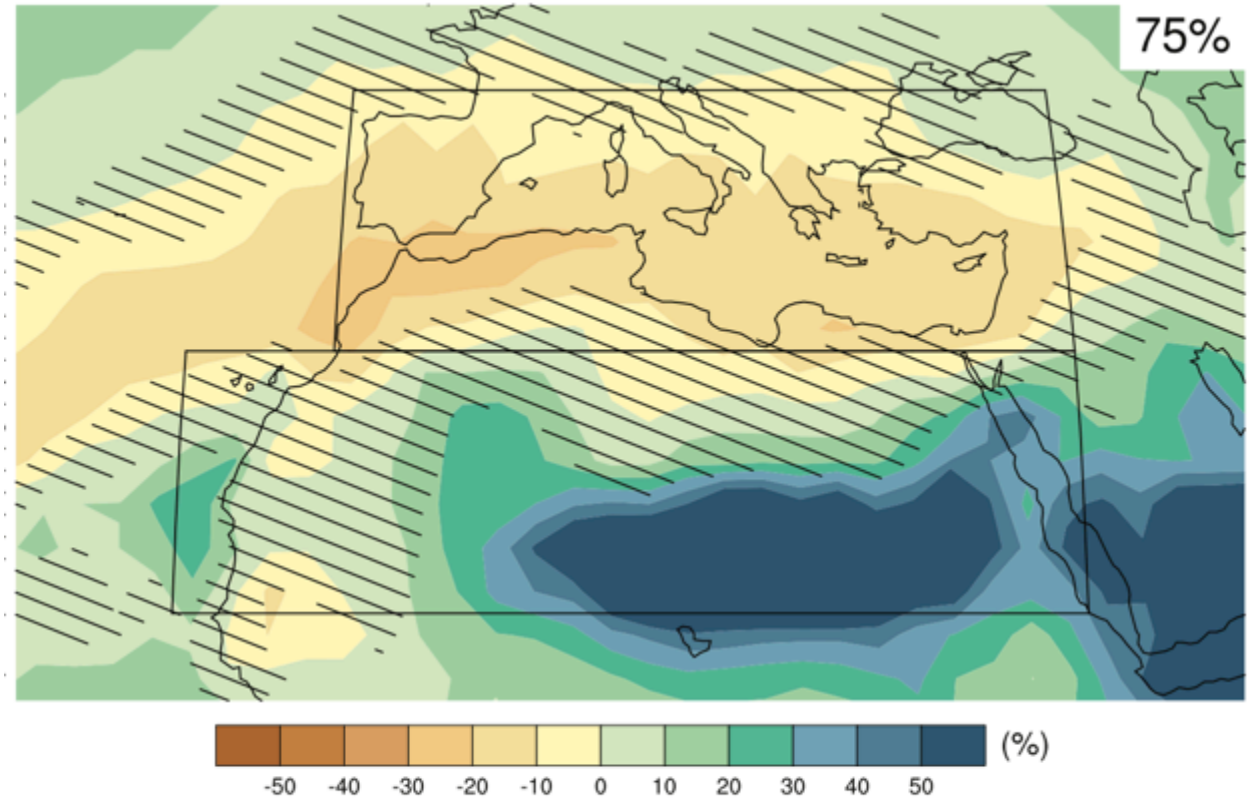
Map of precipitation changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario



Regions where the projected change is less than one standard deviation of the natural internal variability

Regions where the projected change is large compared to natural internal variability, and where at least 90% of models agree on a sign of change

IPCC, AR5, WGI, Annex I: Atlas of Global and Regional Climate Projections Supplementary Material RCP8.5

RCP2.6 RCP8.5

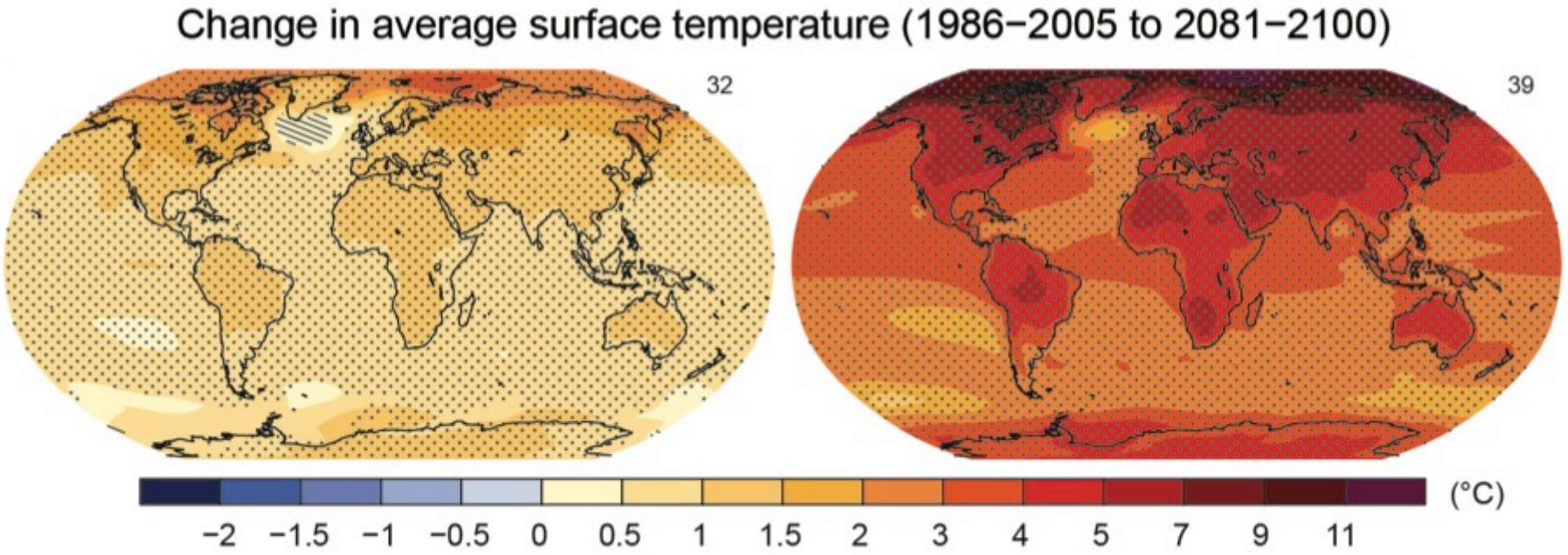


Fig. SPM.8

We have a choice.

Useful links:

- www.ipcc.ch : IPCC
- www.climate.be/vanyp : my slides and other documents
- www.skepticalscience.com: excellent responses to contrarians arguments
- **On Twitter: @JPvanYpersele**