IPCC AR5 (?)

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Intergovernmental Panel on Climate Change (IPCC) Assessment Report 5 (AR5)

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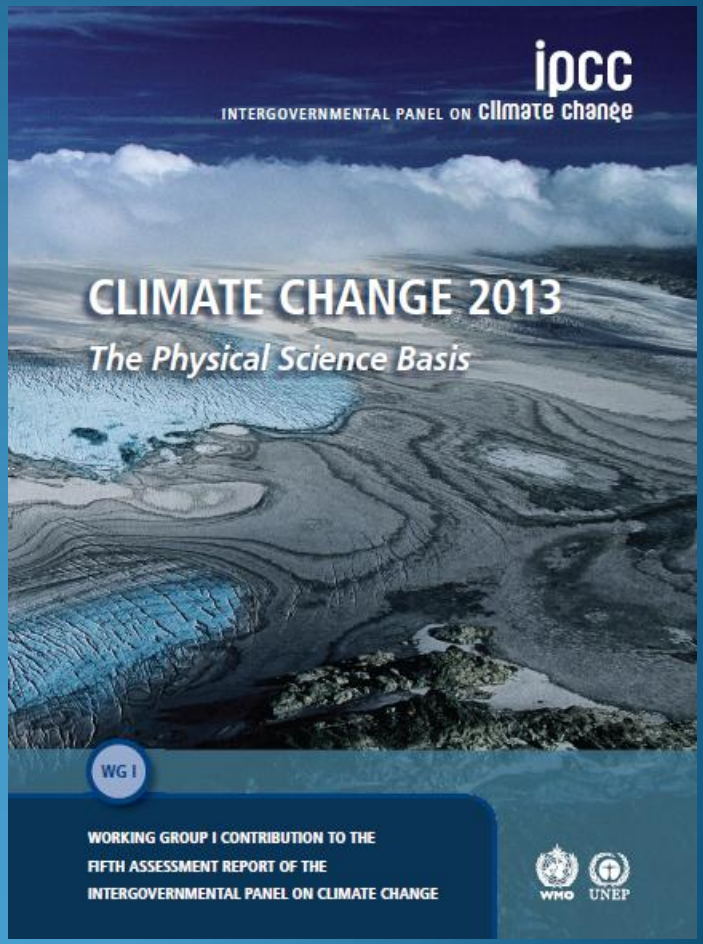


Outline

- IPCC: History, Role and Functions
- Observed Changes in the Climate System
- Drivers of Climate Change
- Understanding the Climate System and its Recent Changes
- Future Global and Regional Climate Change
- Take-home Message

Current knowledge

Future opportunity

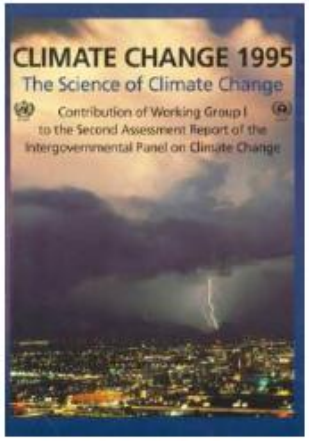
GNSS relevance

Establishment

- Prior to the establishment of IPCC, growing number of literatures indicate the Earth's climate system is warming due to increasing GHG concentration in atmosphere
- Independent, objective, fair and transparent assessment of the state of global climate system is required
- For this reason, United Nations General Assembly (UNGA) 42 proposed the establishment of IPCC and in 1988 IPCC was established under WMO and UNEP
- The IPCC provides such assessment and this becomes the source of information particularly to policy makers and UNFCCC on:
  1. Causes of climate change
  2. Potential impacts on built and natural systems and socio-economic
  3. Possible response options

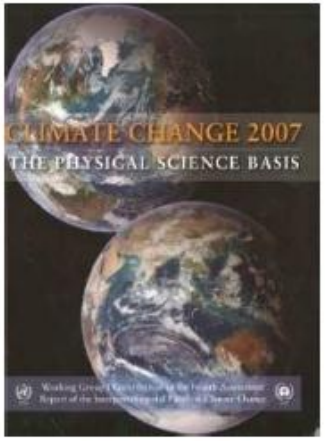
IPCC Reports

FAR 1990

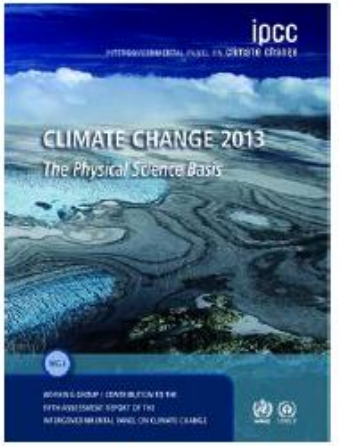


SAR 1995

TAR 2001

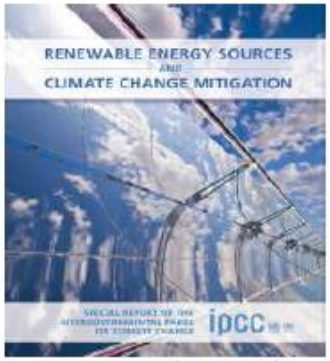


AR4 2007

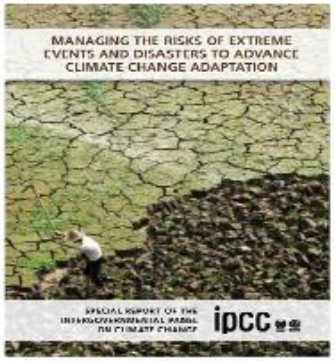


AR5 2013

IPCC had produced 5 Assessment Reports plus several other special reports including the recently released SREX & SRREN.

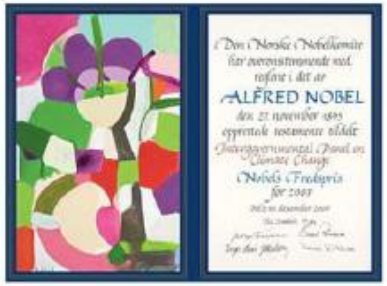


SRREN (2011)



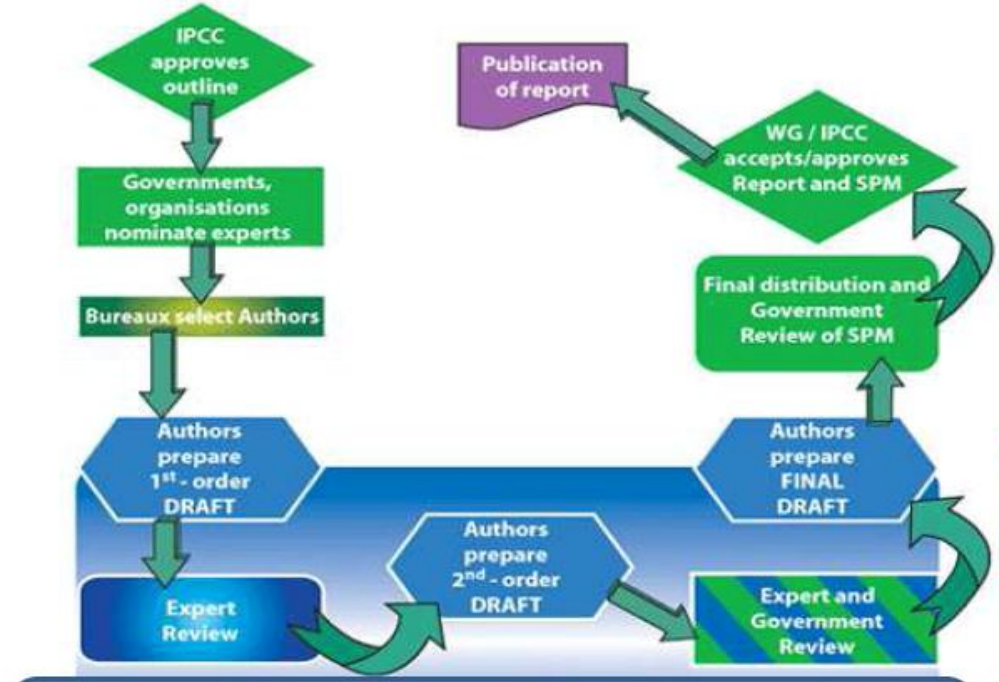
SREX (2012)

Nobel Peace Prize 2007



ipcc
INTERGOVERNMENTAL PANEL ON climate change

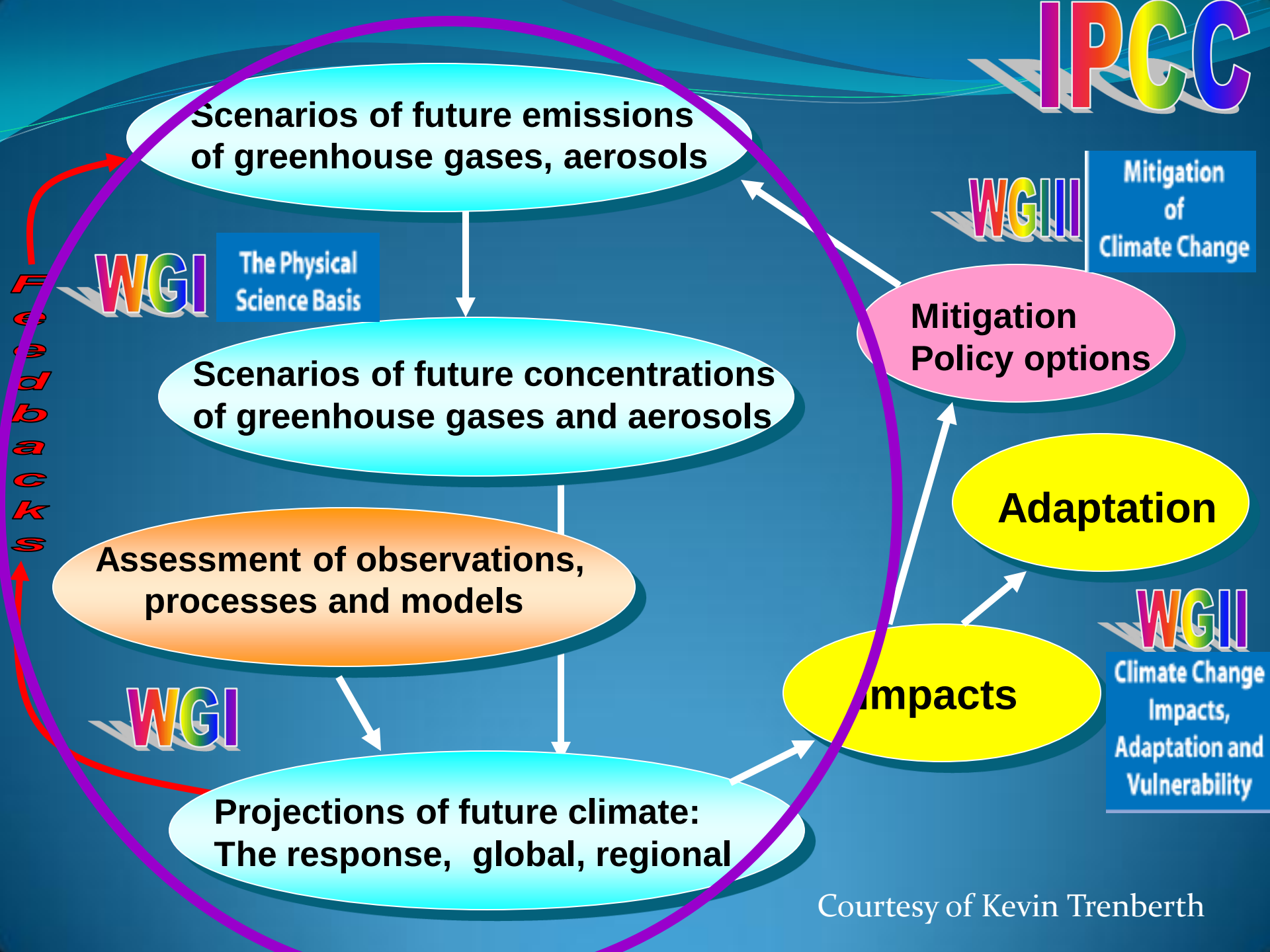
IPCC Assessment Process



IPCC assessment is based on available peer-reviewed publications

Key « Rules » for IPCC Work

- COMPREHENSIVE – all the latest relevant scientific, technical and socio-economic literature published wordwide is assessed
- BALANCED – differring views are reflected in the reports
- OPEN – selection of authors from all countries and relevant discipline, wide review process by experts and governments
- TRANSPARENT – strict clear procedures


IPCC
Scenarios of future emissions of greenhouse gases, aerosols
WGI
The Physical Science Basis
Scenarios of future concentrations of greenhouse gases and aerosols
Assessment of observations, processes and models
WGI
Projections of future climate: The response, global, regional
Feedbacks
WGIII
Mitigation of Climate Change
Mitigation Policy options
Adaptation
WGII
Climate Change Impacts, Adaptation and Vulnerability
Courtesy of Kevin Trenberth

Key SPM Messages

19 Headlines

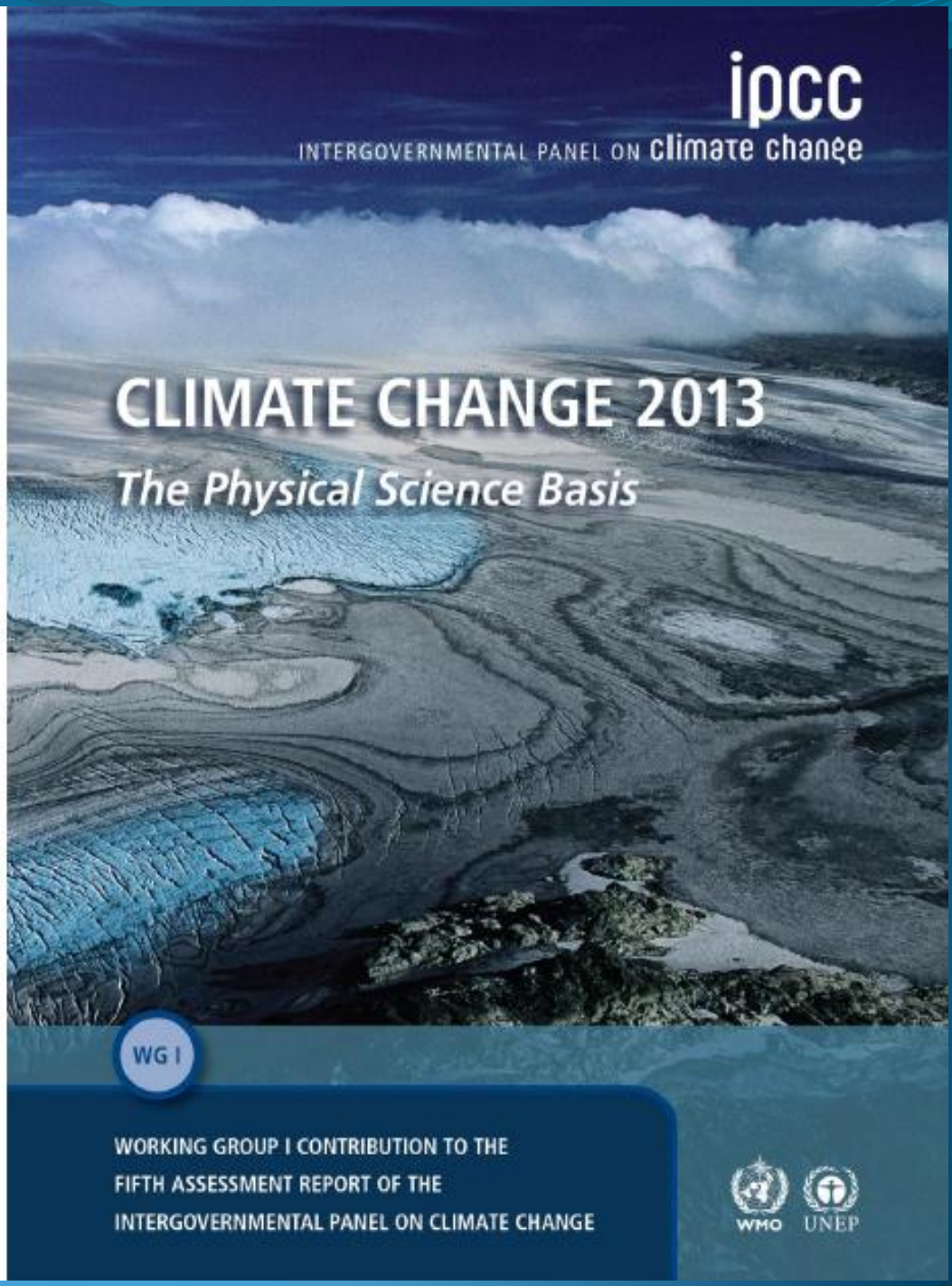
on less than 2 Pages

Summary for Policymakers

ca. 14,000 words

14 Chapters, Atlas

> 1,140,000 words



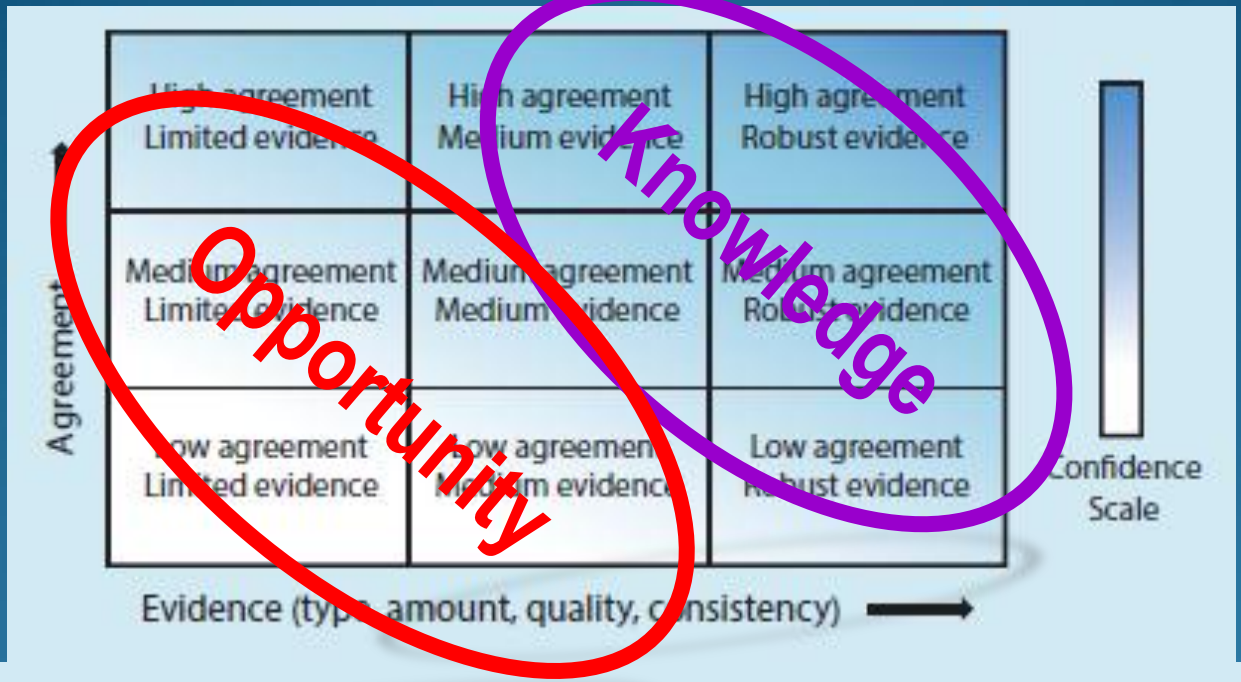
Observation
Ch 2, 3, 4, 5

Drivers
Ch 6, 7, 8

Understanding
Ch 9, 10

Projections
Ch 11, 12, 13, 14

Treatment of Uncertainty

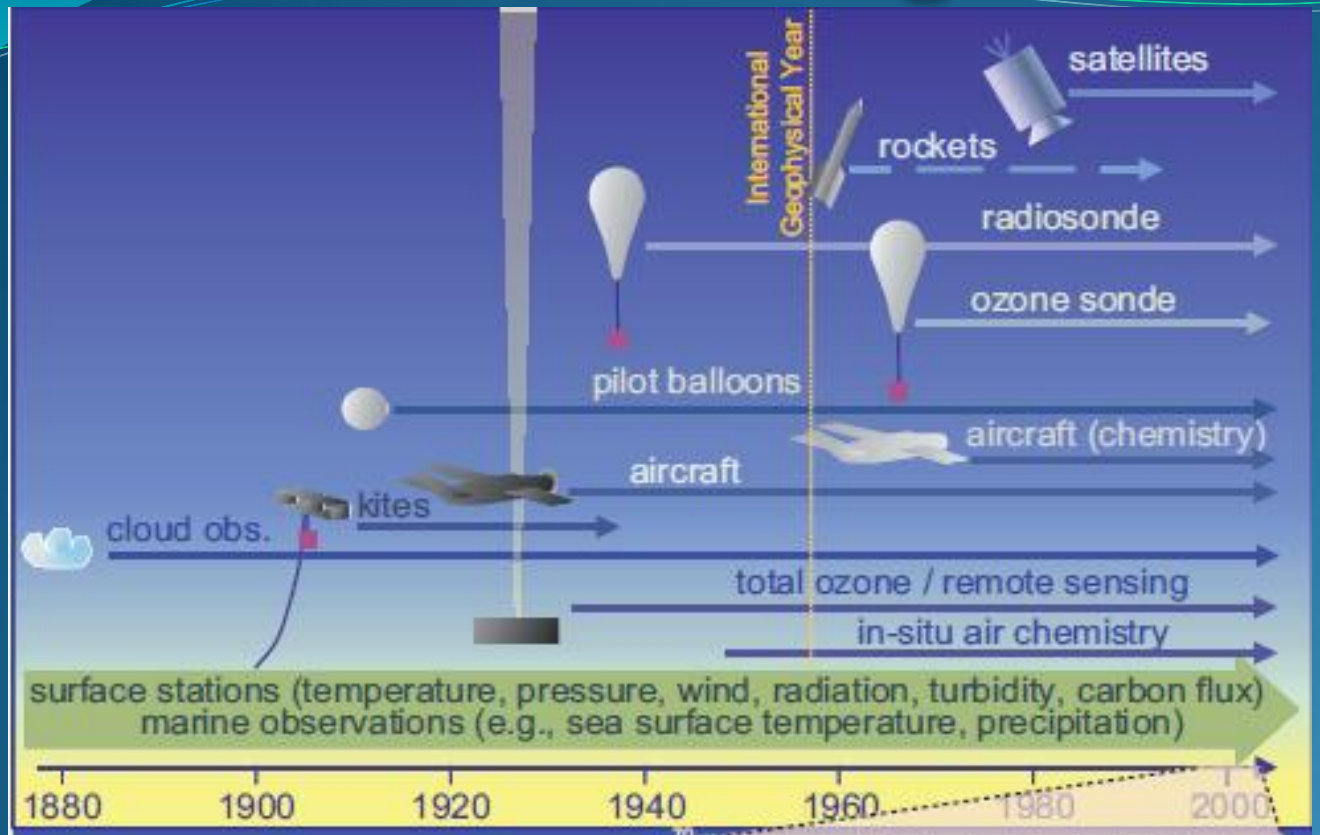


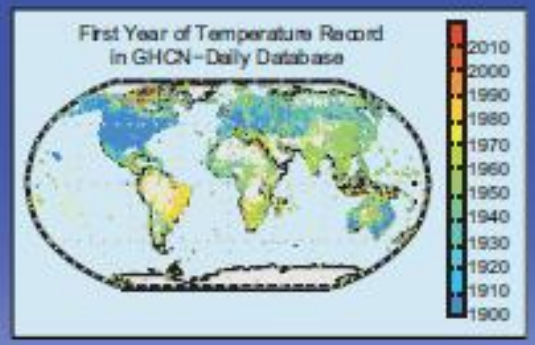
Term*	Likelihood of the outcome
Virtually certain	99–100% probability
Very likely	90–100% probability
Likely	66–100% probability
About as likely as not	33–66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Exceptionally unlikely	0–1% probability

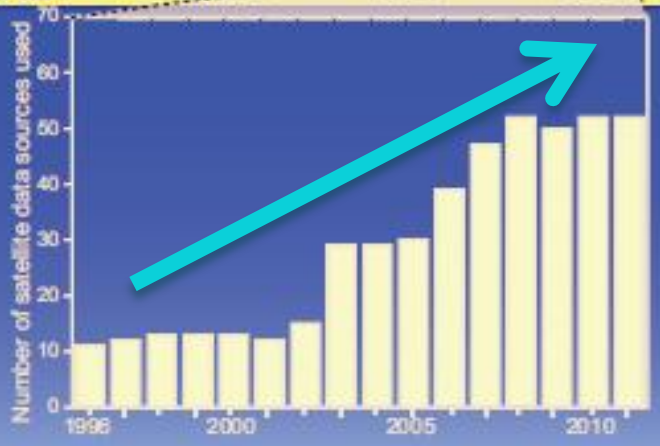
Statement / Headline of IPCC WG1 AR5 SPM

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased

Observed changes: Obs. Capability







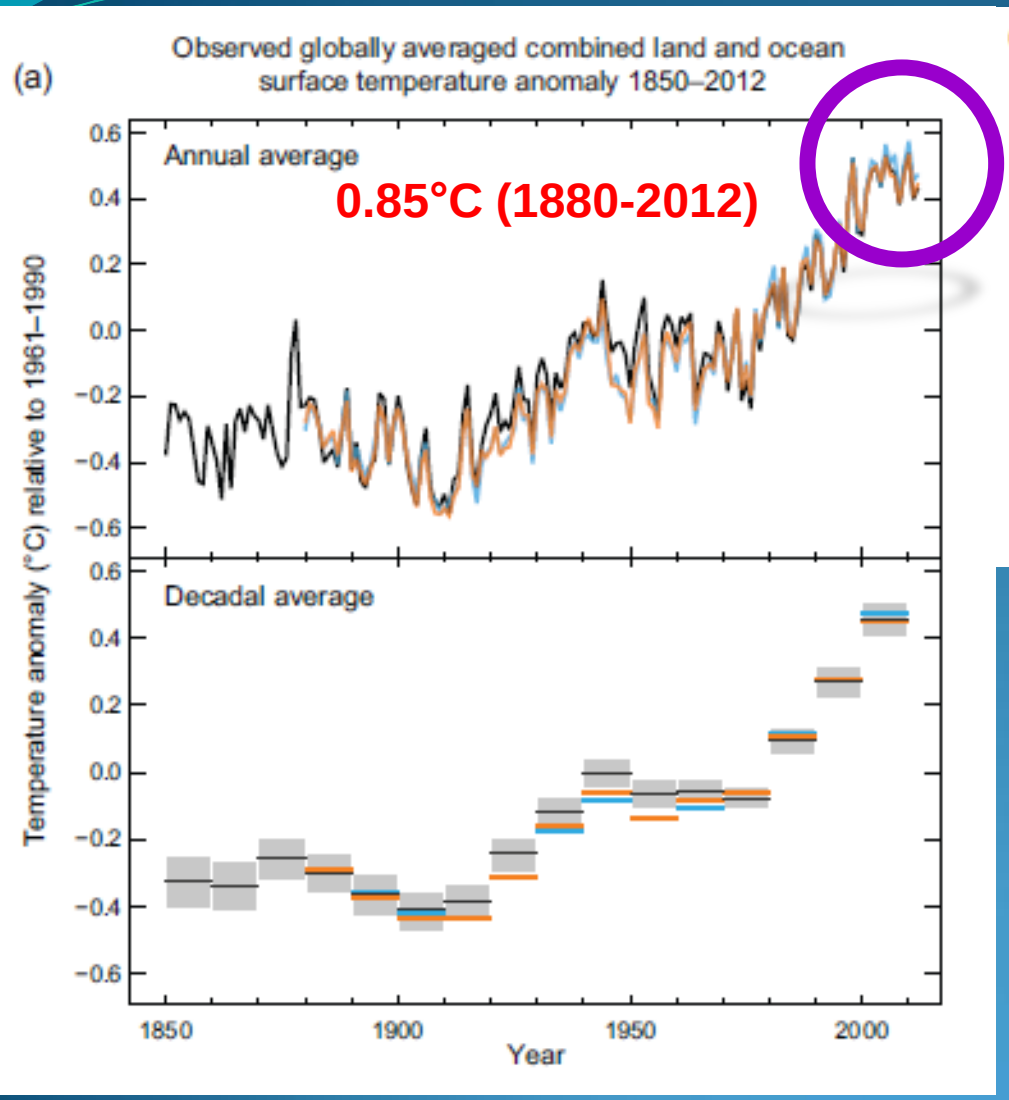
In-situ: new ones, data rescuration, new processing;

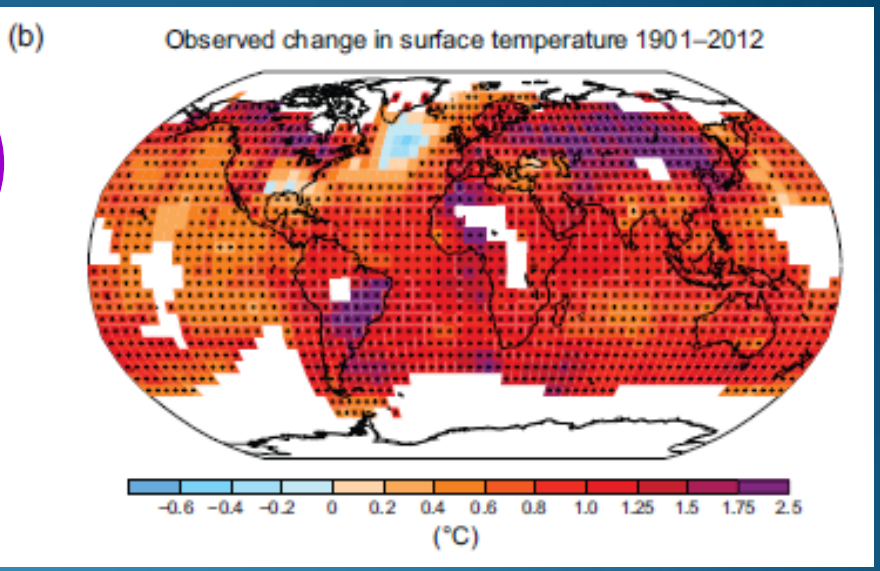
Data gaps in un-developed countries and data continuity in climate record!

Satellite: 5-fold increasing, but reaching the life time!

What is the role of GNSS obs?

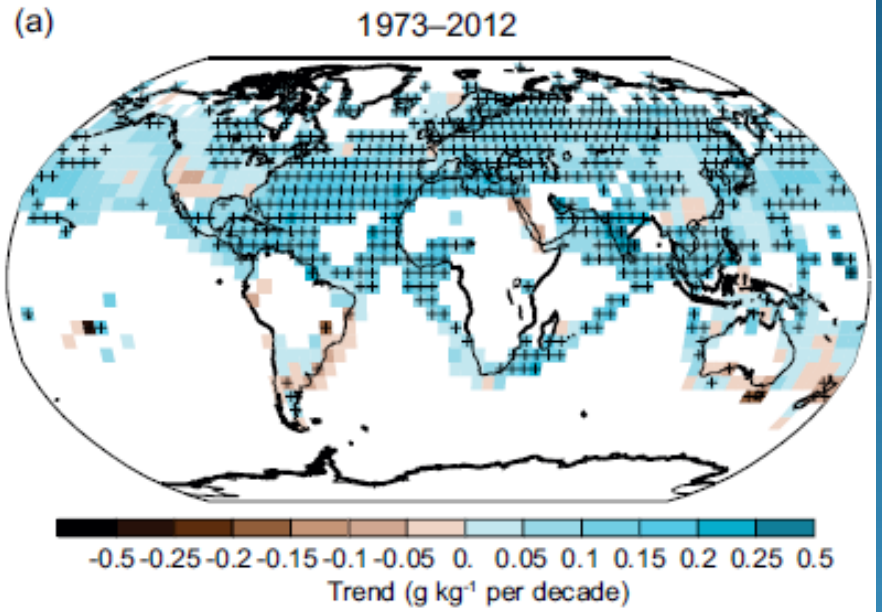
Observed changes: Surface T





- **Global Mean Surface Temperature has increased since the late 19th century.**
- **Each of the past three decades has been successively warmer at the Earth's surface than all the previous decades, and the first decade of the 21st century has been the warmest.**
- **Almost the entire globe has experienced surface warming.**

Observed changes: Humidity



(b) **Surface Specific Humidity**

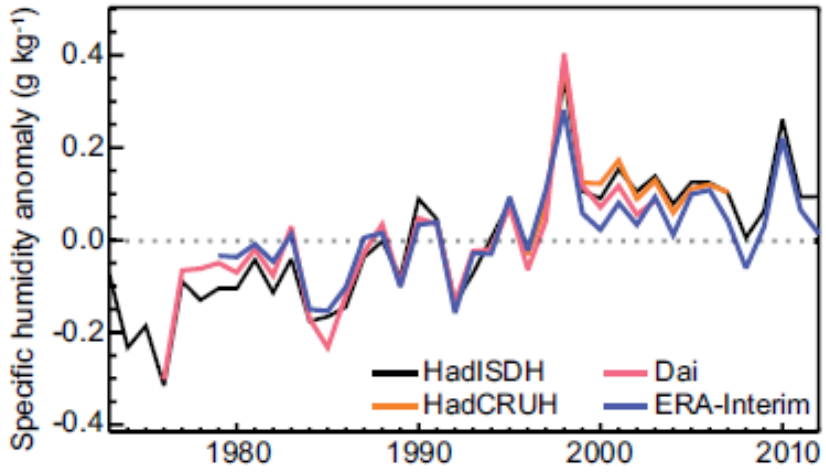
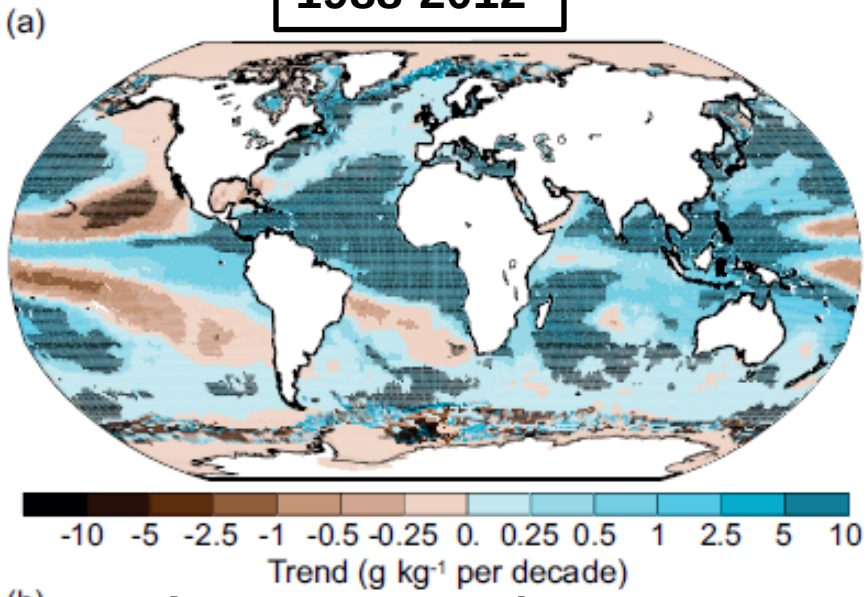


Figure 2.30 | (a) Trends in surface specific humidity from HadISDH and NOCS over 1973–2012. Trends have been calculated only for those grid boxes with greater than 70% complete records and more than 20% data availability in first and last decile

1988-2012



(b) **Column Integrated Water Vapor**

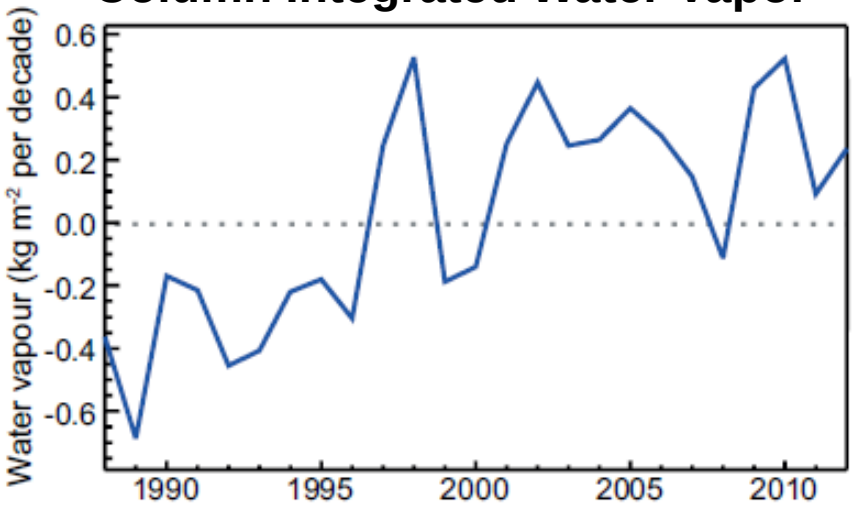
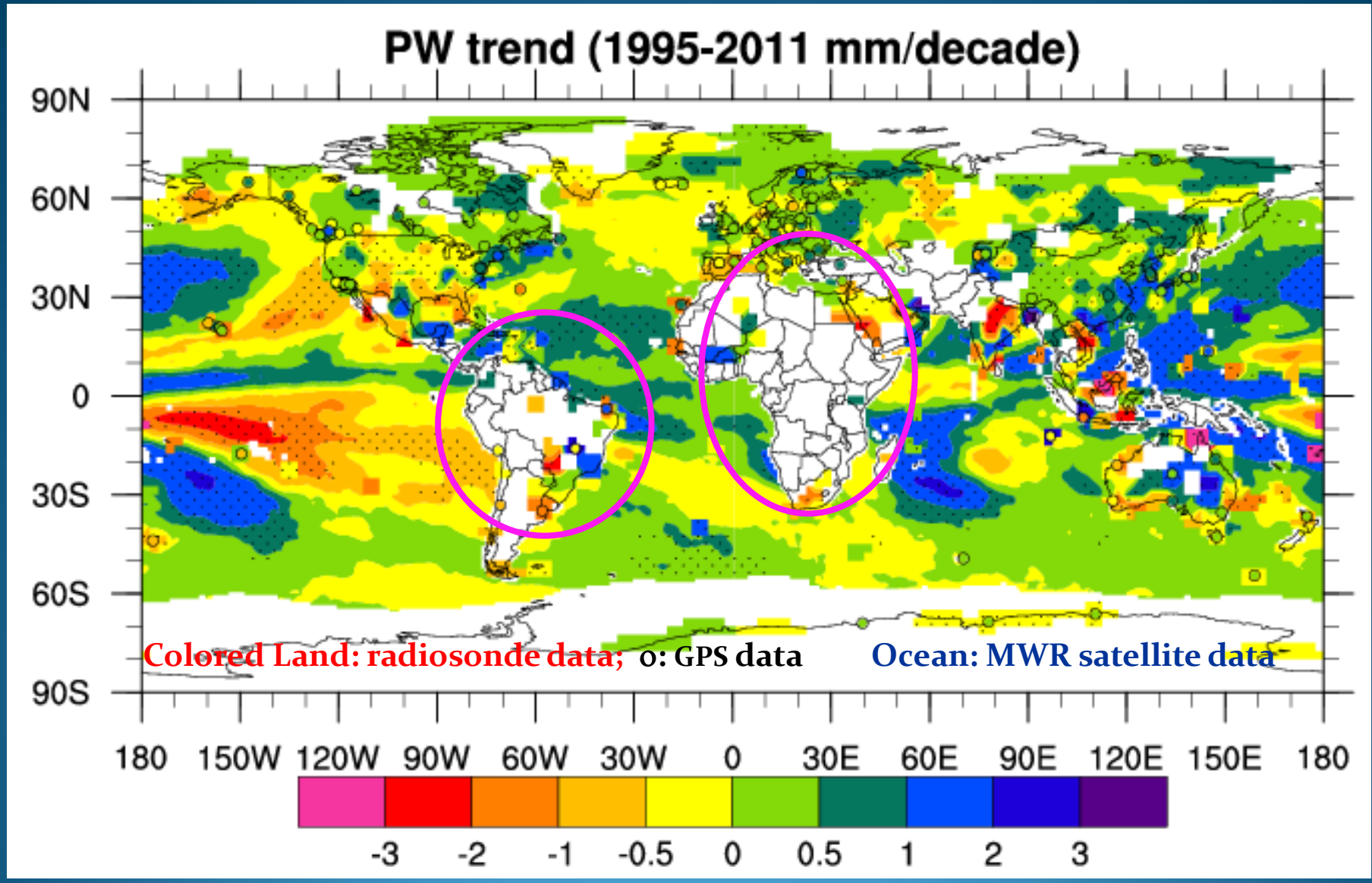


Figure 2.31 | (a) Trends in column integrated water vapour over ocean surfaces from Special Sensor Microwave Imager (Wentz et al., 2007) for the period 1988–2010.



- **Limited number of GNSS stations (~100) for trend!**
- **Data gaps over African and S.A.**

Observed changes: Precipitation

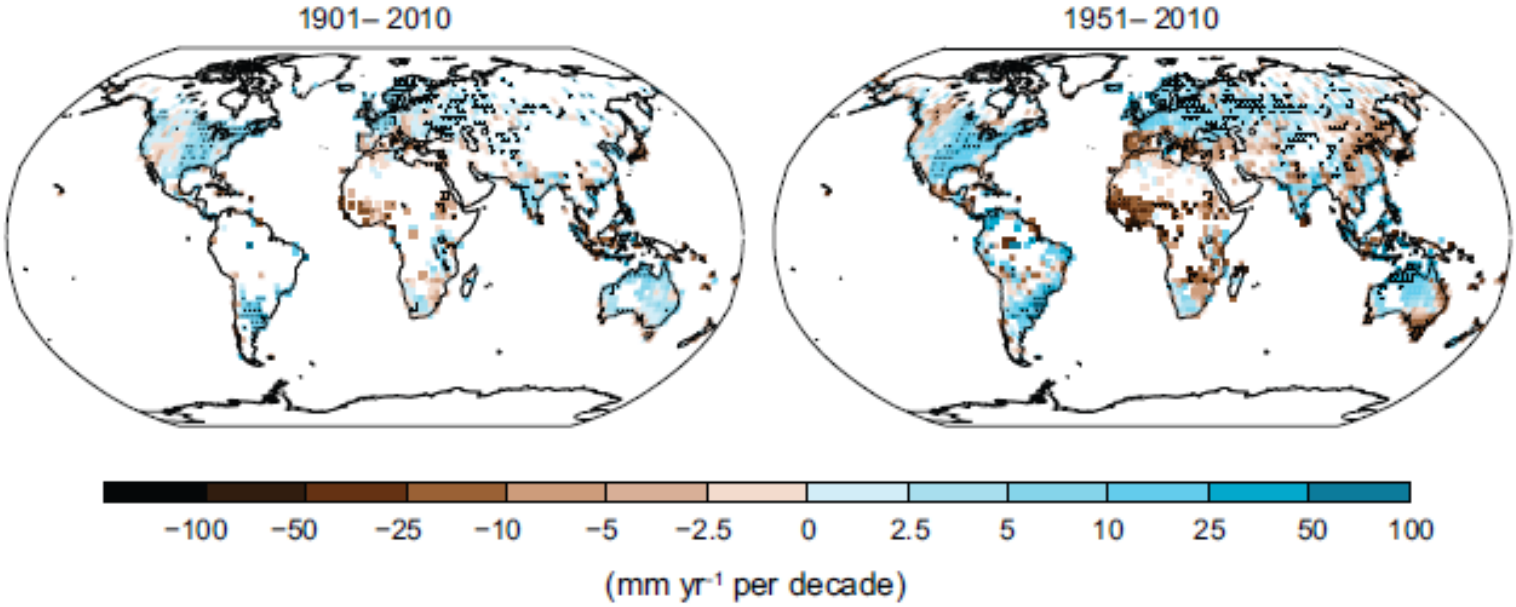
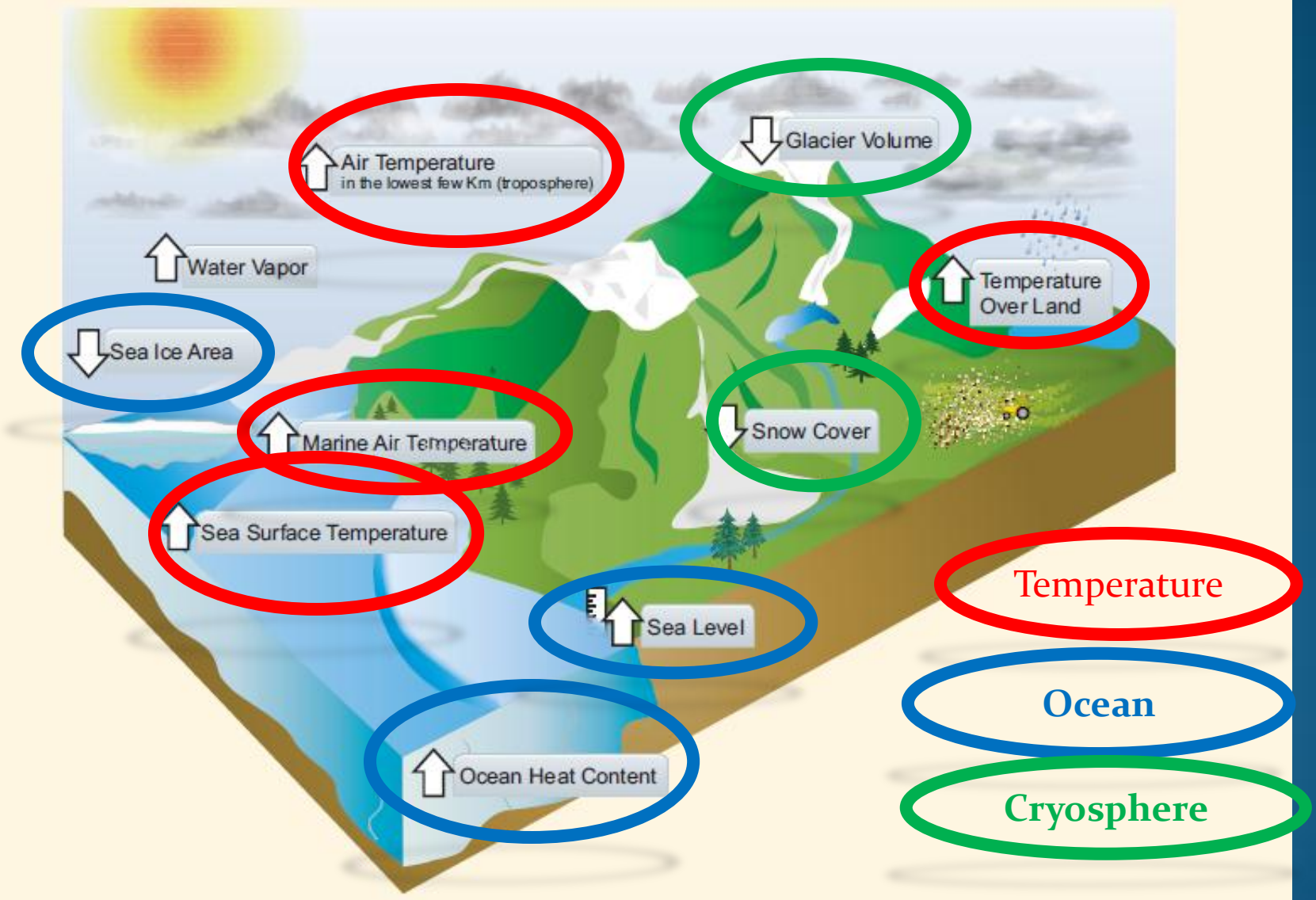


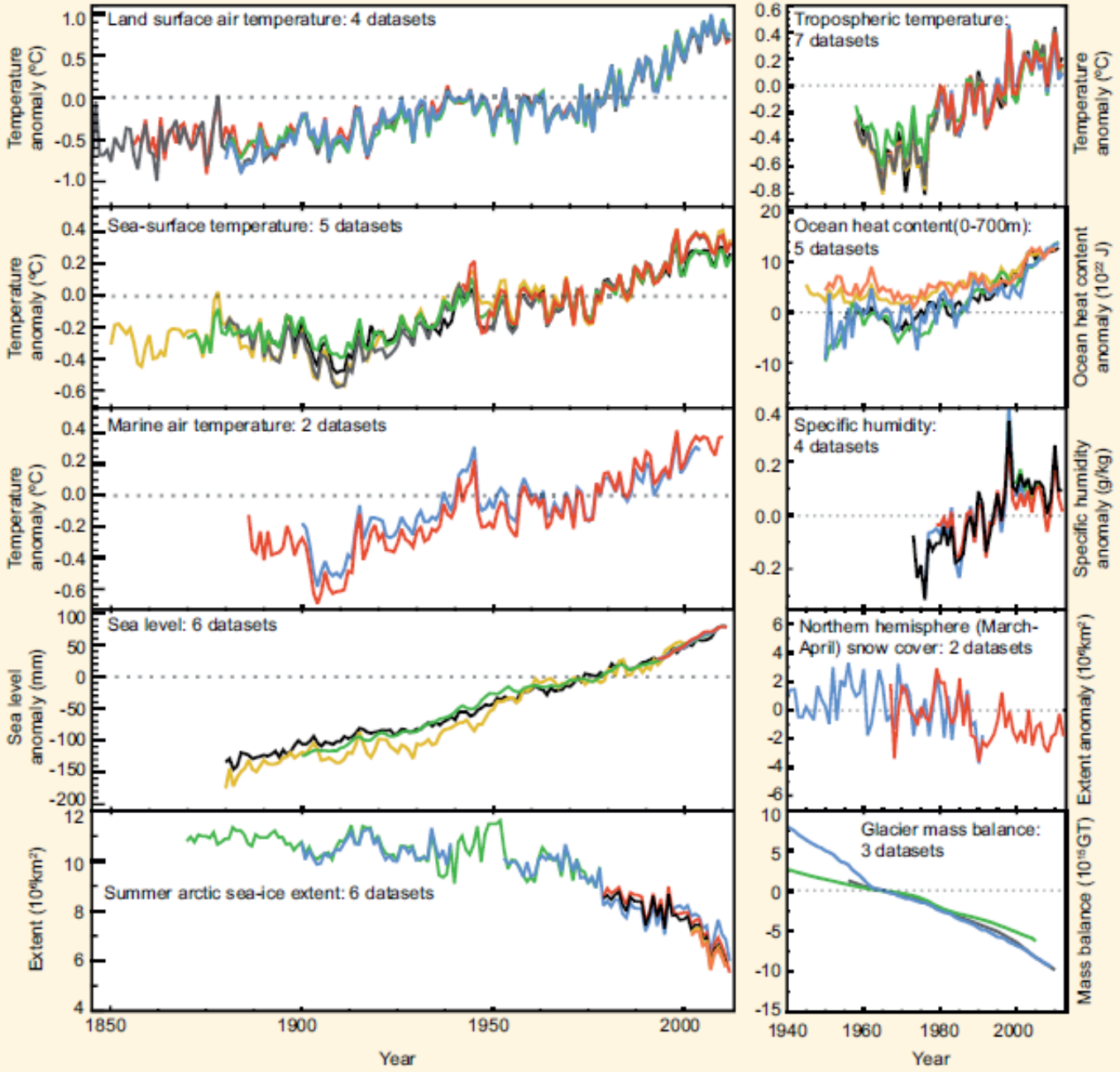
Figure SPM.2 | Maps of observed precipitation change from 1901 to 2010 and from 1951 to 2010 (trends in annual accumulation calculated using the

Wetter region gets more wetter and drier gets more drier since the second half of the 20th century!
("Rich get richer, poor get poorer")

Observed changes: Warming indicators

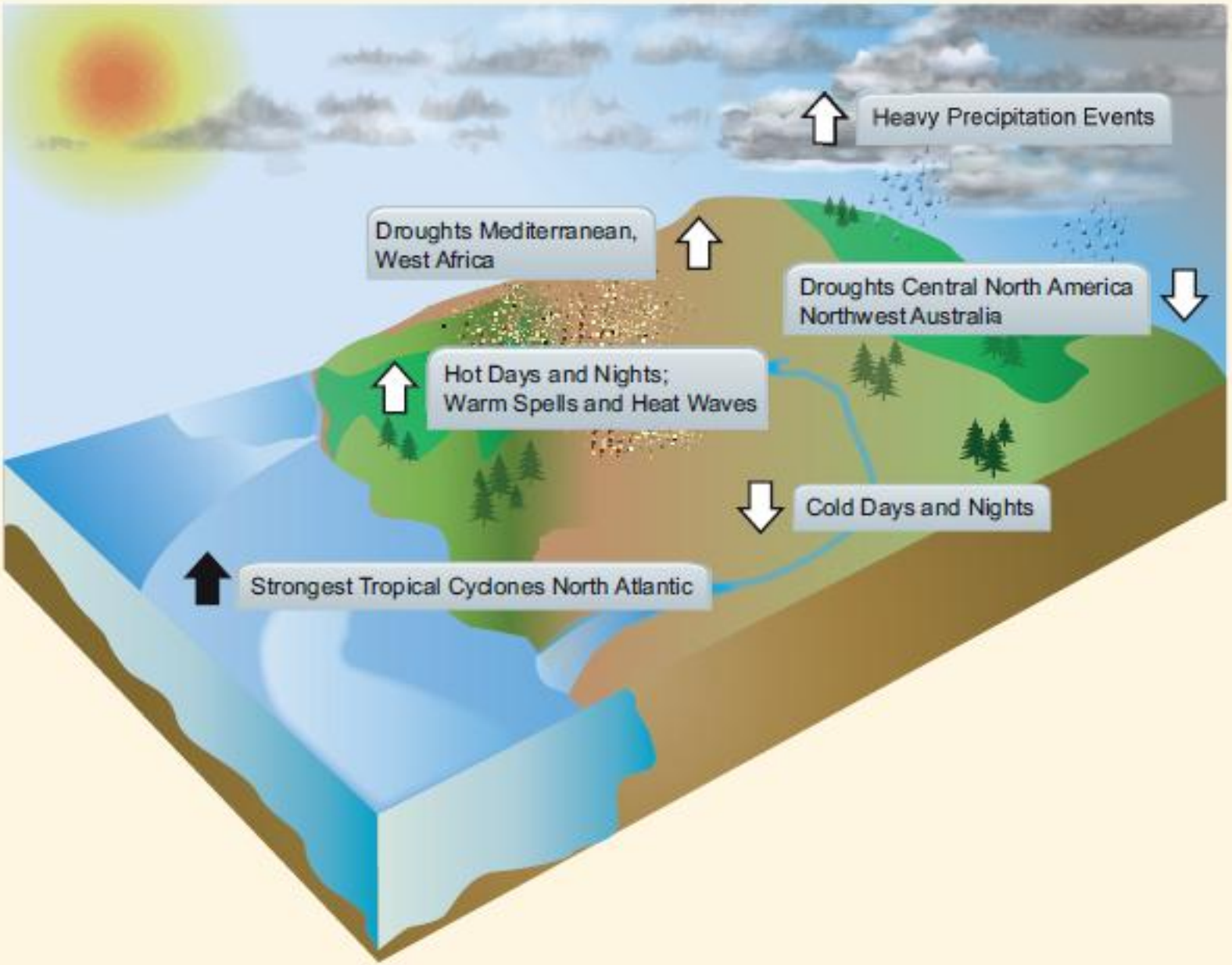


FAQ 2.1, Figure 1 | Independent analyses of many components of the climate system that would be expected to change in a warming world exhibit trends consistent with warming (arrow direction denotes the sign of the change), as shown in FAQ 2.1, Figure 2.



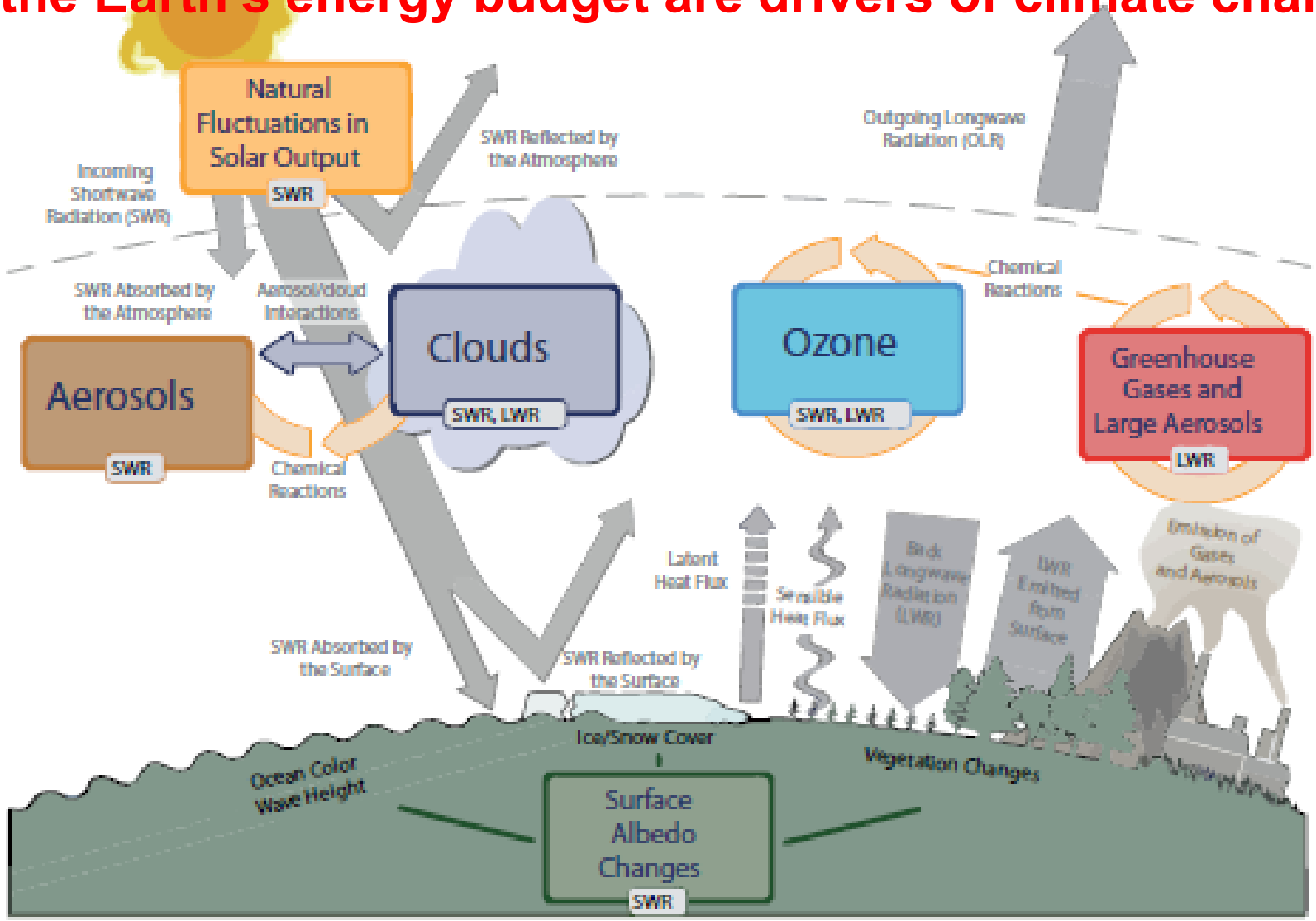
FAQ 2.1, Figure 2 | Multiple independent indicators of a changing global climate. Each line represents an independently derived estimate of change in the climate element. In each panel all data sets have been normalized to a common period of record. A full detailing of which source data sets go into which panel is given in the Supplementary Material 2.SM.5.

Observed changes: Extremes

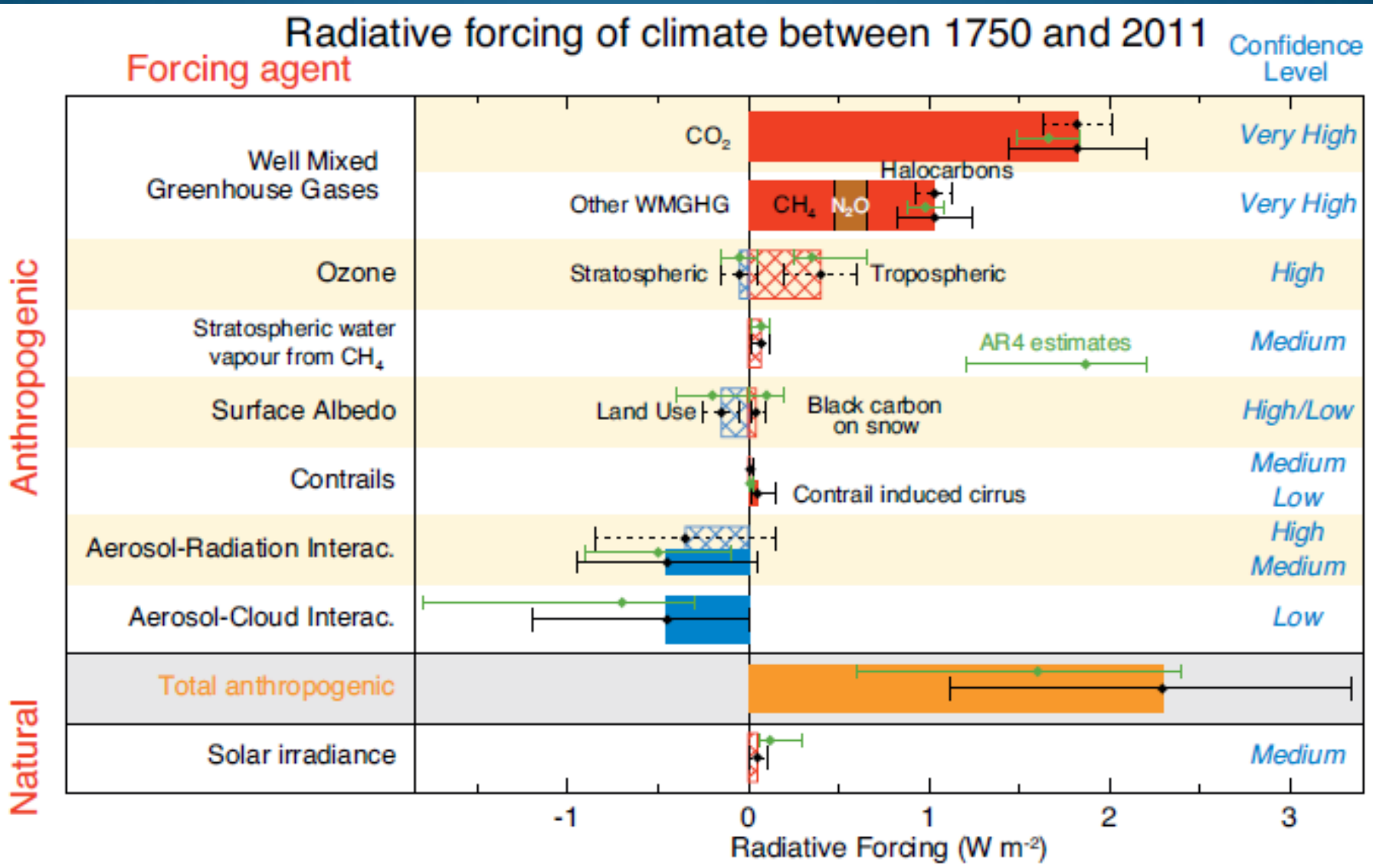


Drivers

Natural and anthropogenic substances and processes that alter the Earth's energy budget are drivers of climate change.



Drivers


Radiative forcing of climate between 1750 and 2011
Forcing agent
Confidence Level
Anthropogenic
Natural
Well Mixed Greenhouse Gases
CO2
Halocarbons
Other WMGHG
CH4
N2O
Very High
Very High
Ozone
Stratospheric
Tropospheric
High
Stratospheric water vapour from CH4
AR4 estimates
Medium
Surface Albedo
Land Use
Black carbon on snow
High/Low
Contrails
Contrail induced cirrus
Medium
Low
Aerosol-Radiation Interac.
High
Medium
Aerosol-Cloud Interac.
Low
Total anthropogenic
Solar irradiance
Medium
-1
0
1
2
3
Radiative Forcing (W m-2)

Drivers

Earth has been in radiative imbalance, with more energy from the sun entering than exiting the top of the atmosphere, since at least circa 1970. It is *virtually certain* that Earth has gained substantial energy from 1971–2010.

Drivers

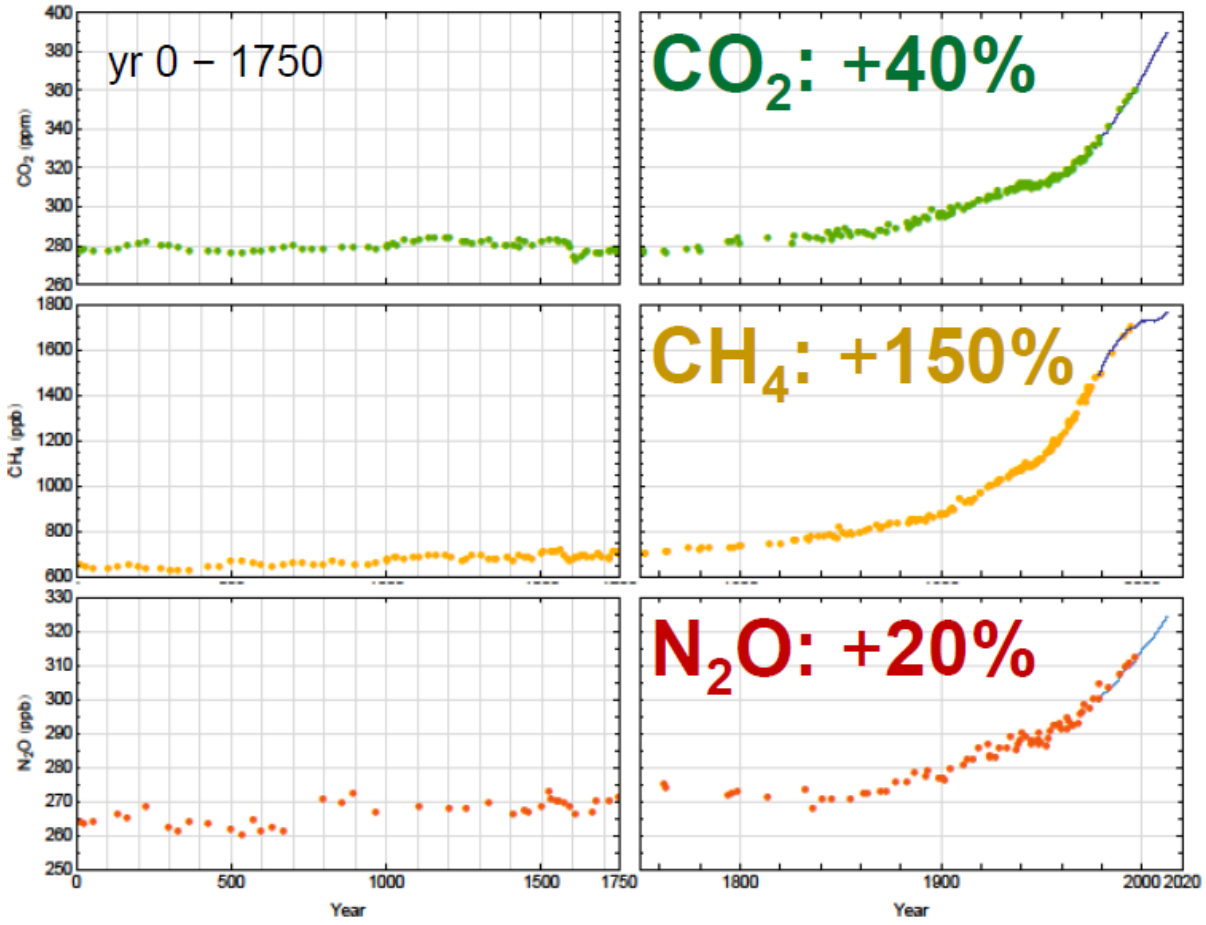


Fig. 6.11

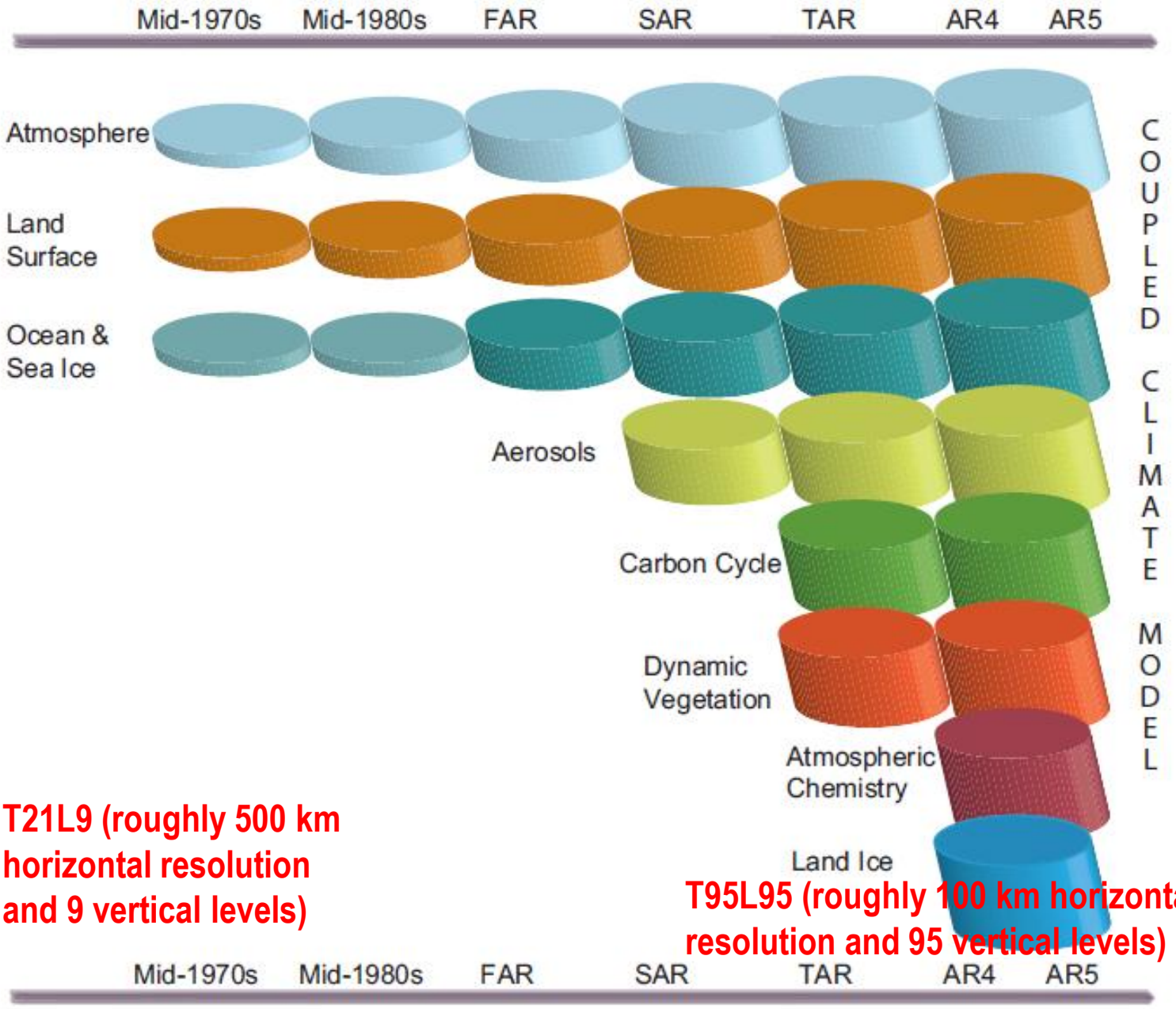
The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have all increased since 1750 due to human activity.

Understanding

- Understanding recent changes in the climate system results from combining observations, studies of feedback processes, and model simulations.

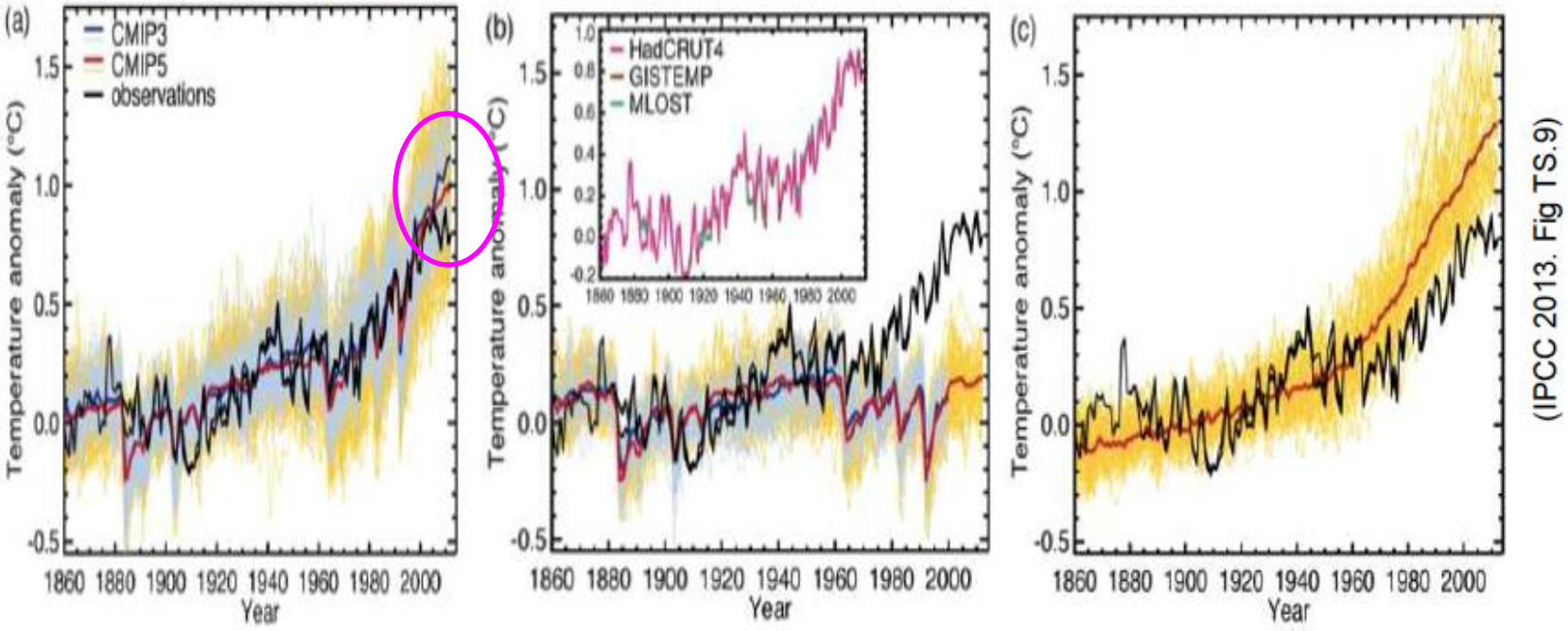
- Evaluation of the ability of climate models to simulate recent changes requires consideration of the state of all modelled climate system components at the start of the simulation and the natural and anthropogenic forcing used to drive the models.

Understanding: Climate Models



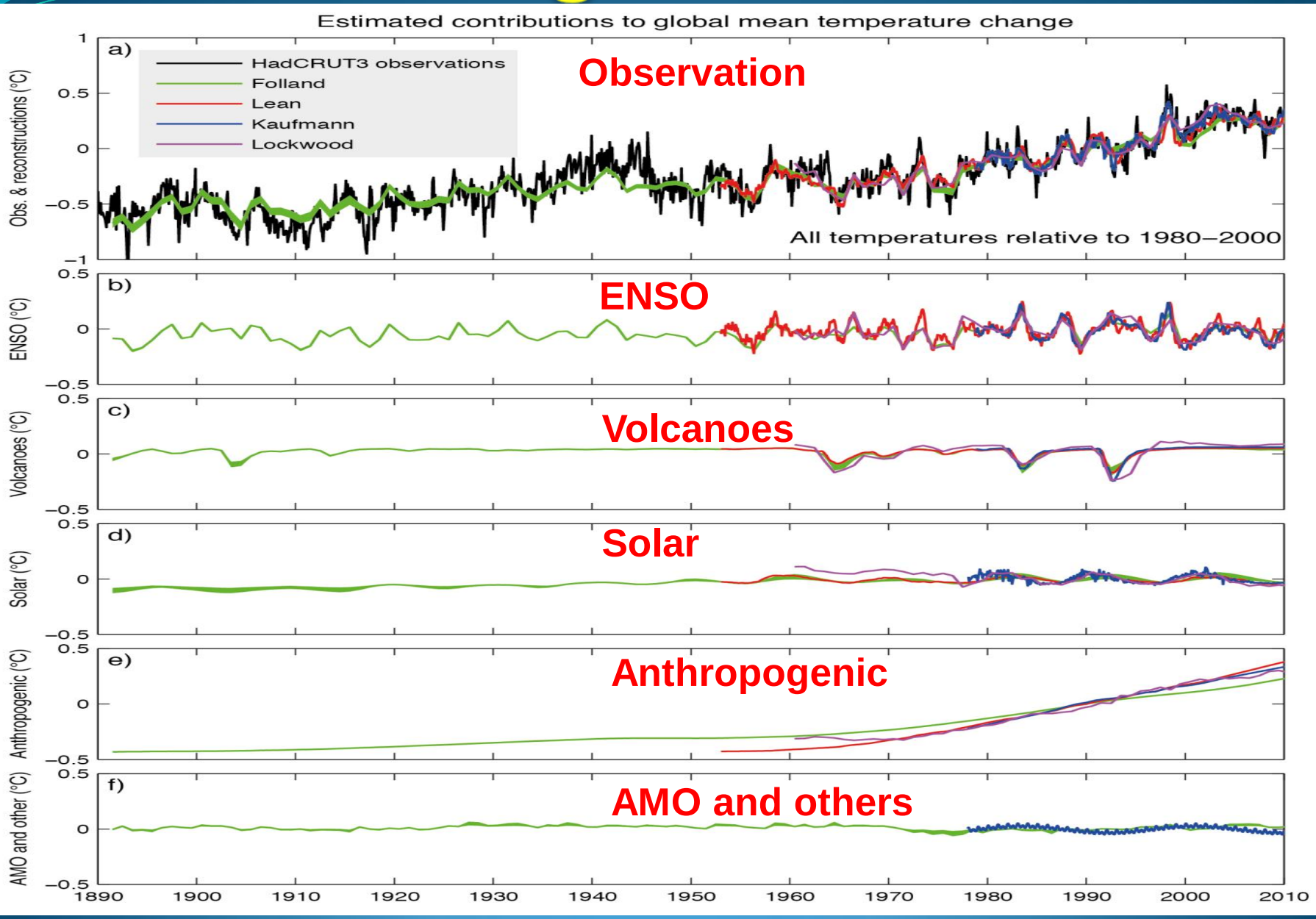
Climate Models Responses to Various Forcings

Natural + Anthropogenic | **Natural** | **CO2 forcing only**

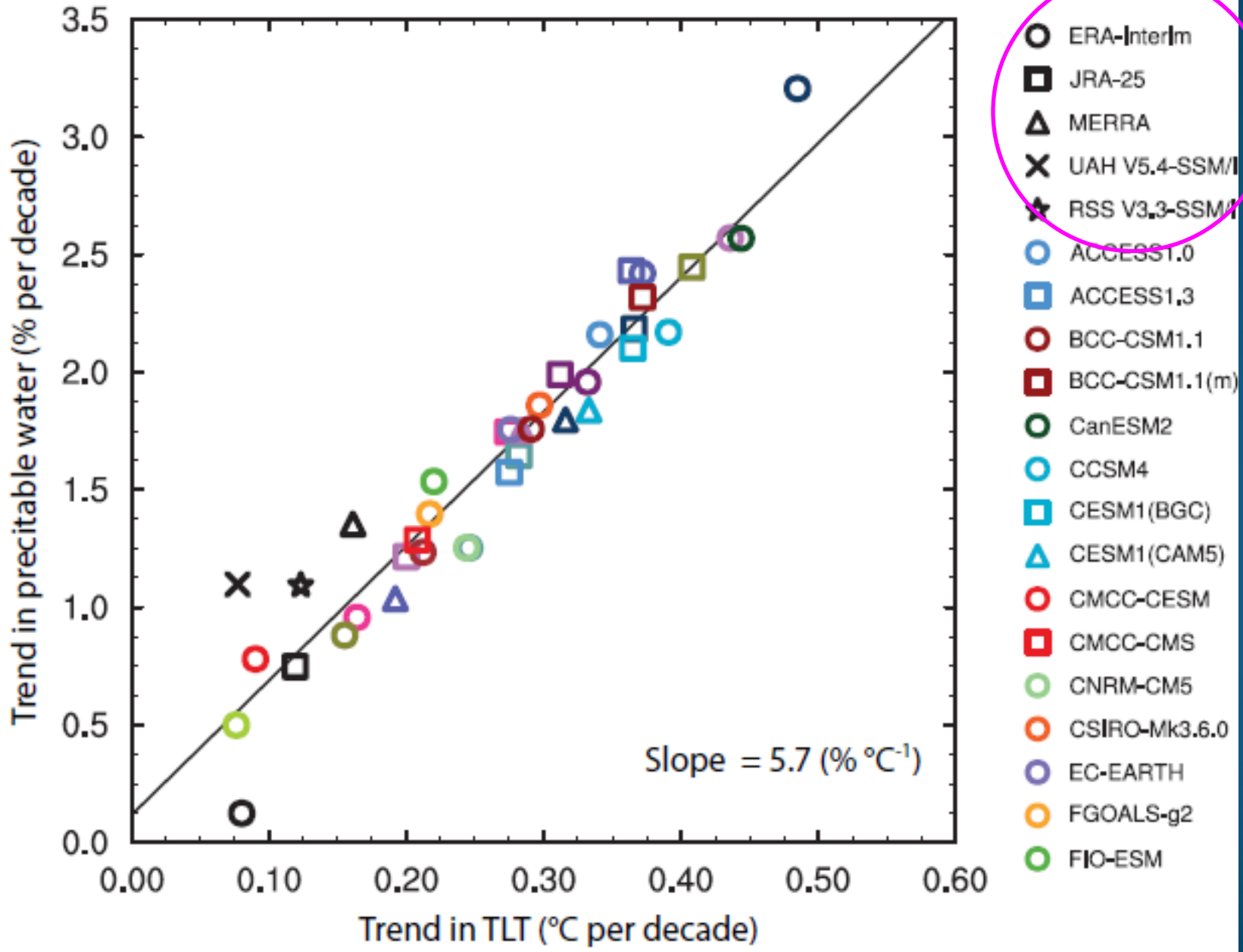


(IPCC 2013. Fig TS.9)

Understanding: Global mean surface T



Understanding: Model evaluation

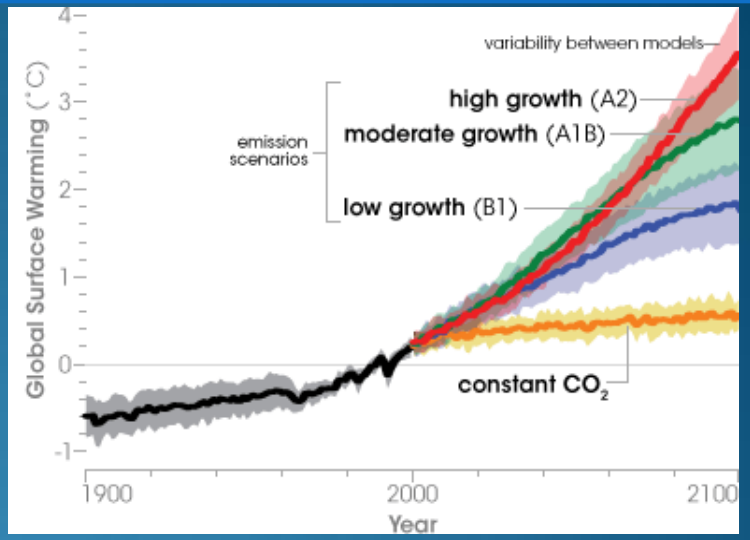


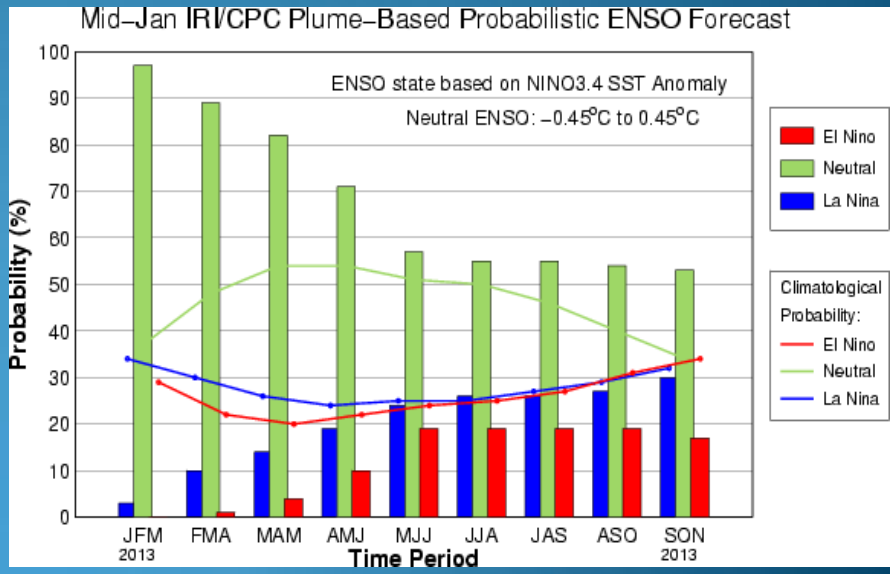
What is a Climate Projection?

- A climate projection is a statement about possible climate changes decades to centuries in the future under certain assumptions, such as those regarding GHG emissions. It is usually made using climate system models forced with projected future GHG emissions.

- Climate projections focus on the forced climate response to future GHG increases. The forcing estimates are very important.

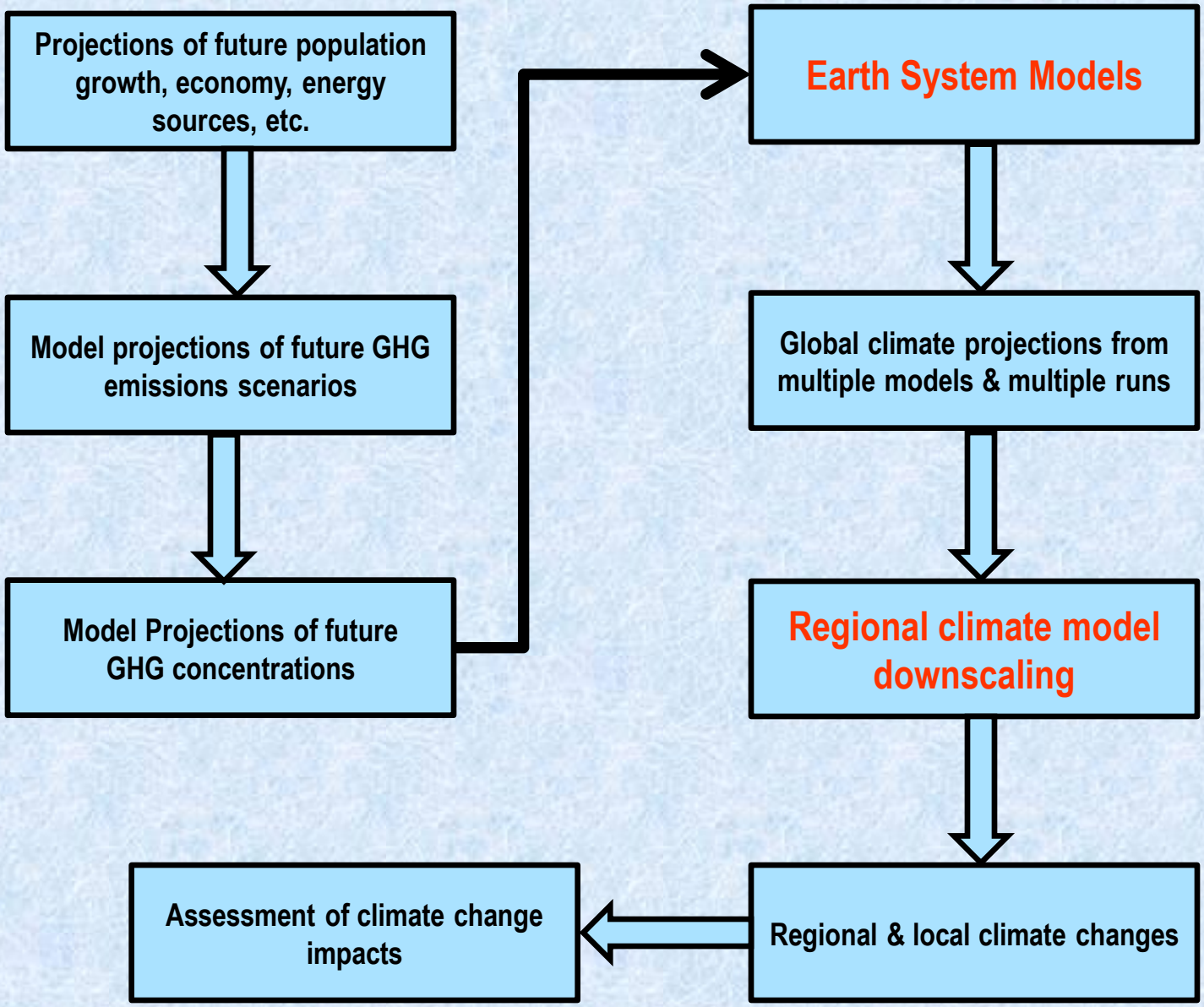
- In contrast, Climate Prediction tends to focus on the natural climate variations, thus the starting conditions are very important.



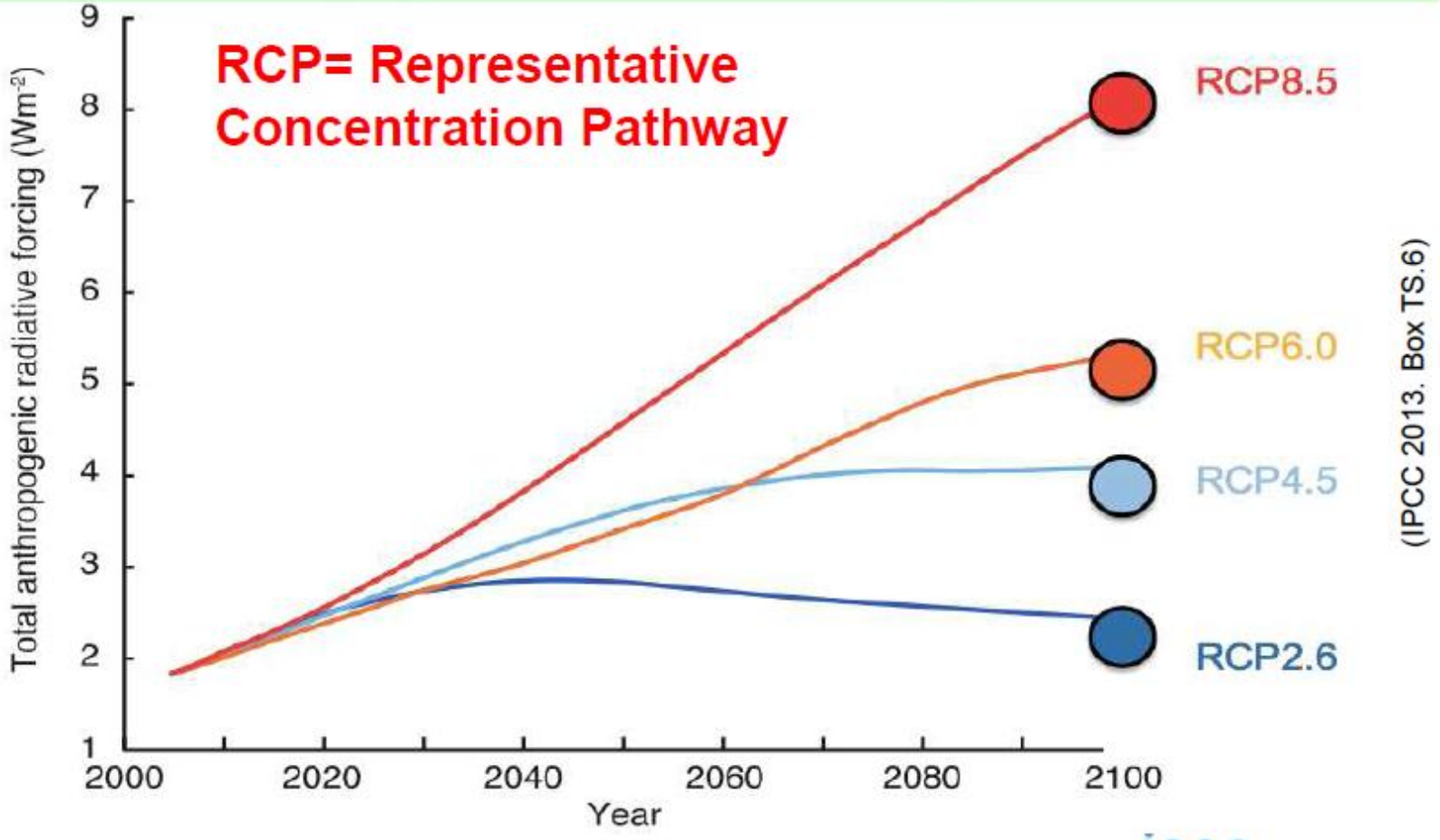


Courtesy of Aiguo Dai

How Do We Make Climate Projections?

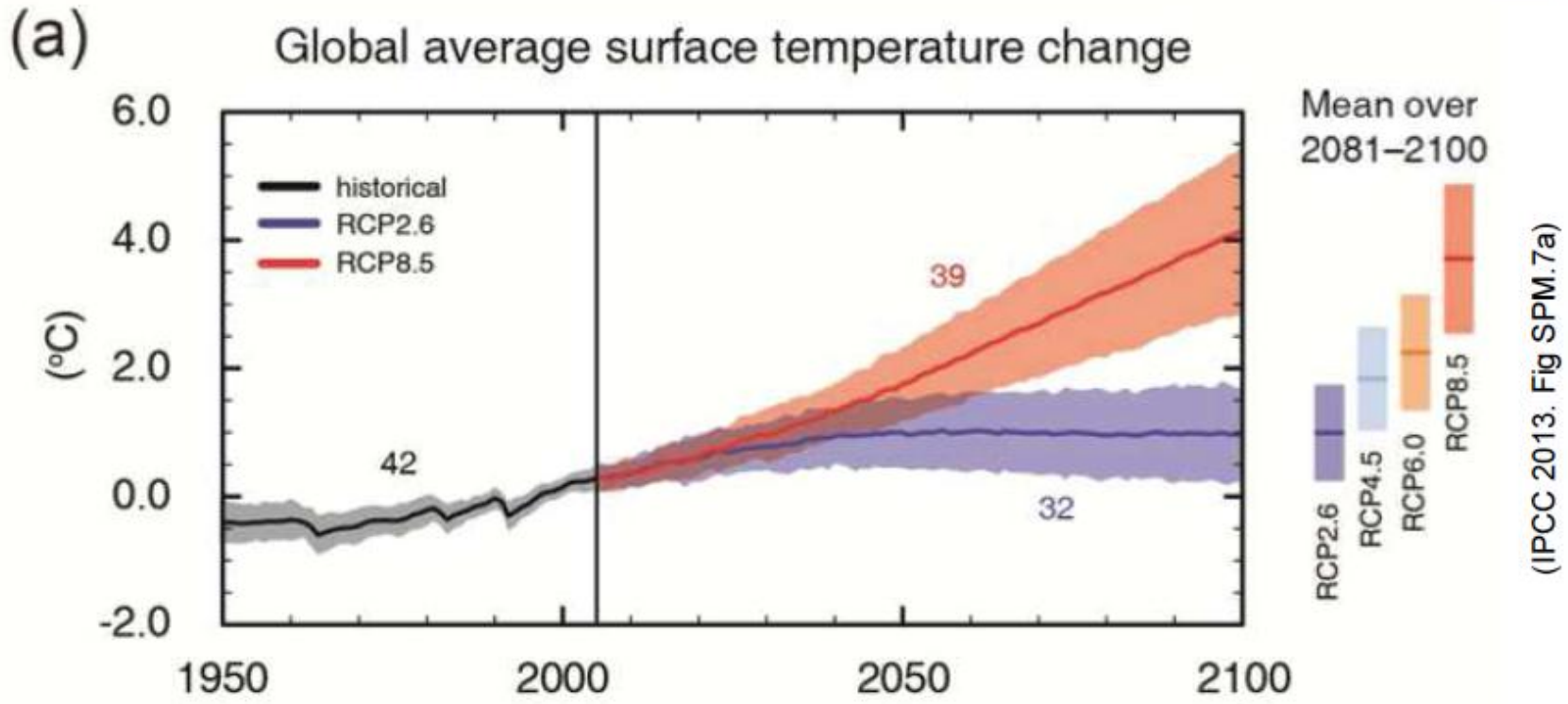


Indicative Anthropogenic Radiative Forcing (RF) for RCPs



(IPCC 2013. Box TS.6)

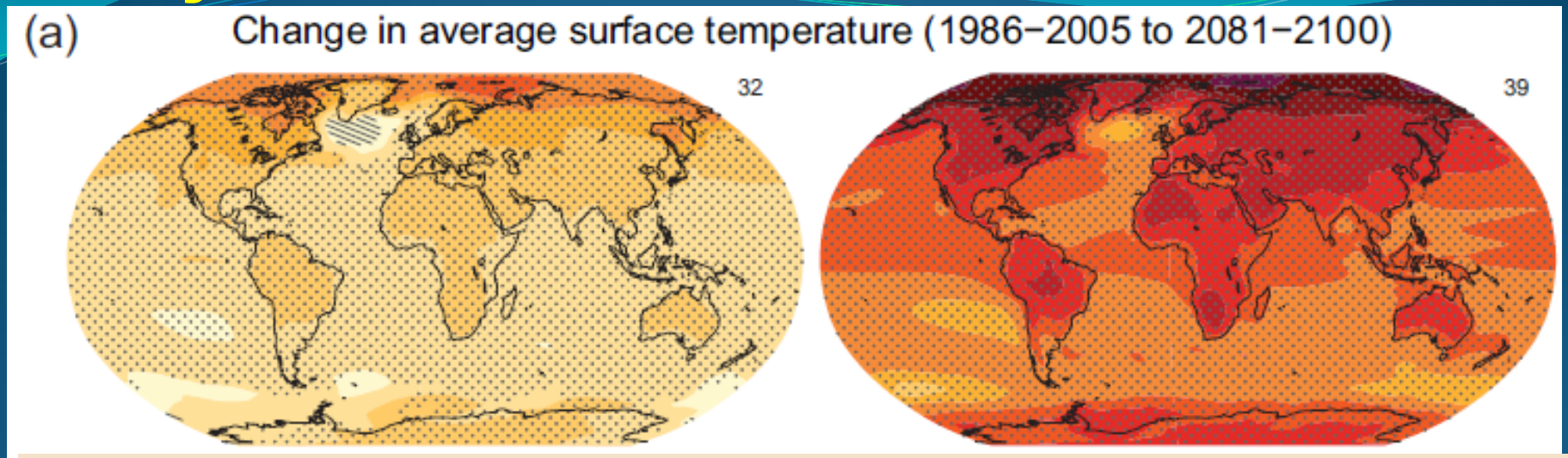
Projected Global Average Temperature Change by end of 21st Century



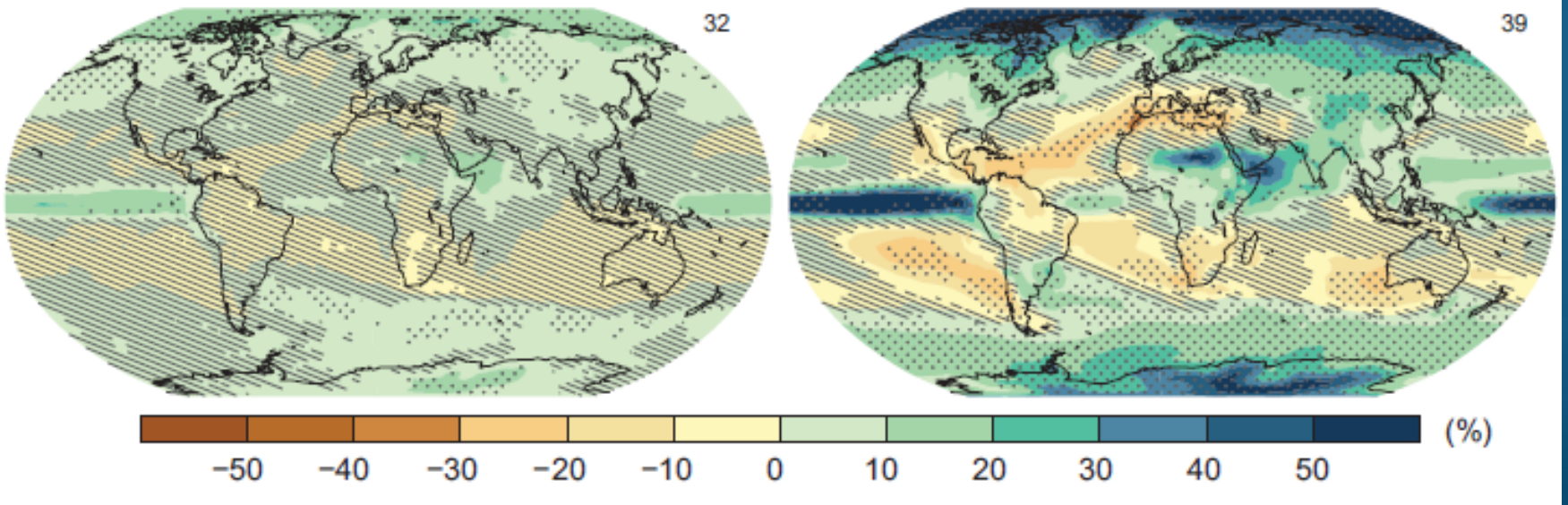
The temperature increase during the last 100 years was only about 0.8°C.

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)

Projections: Temperature & Precipitation

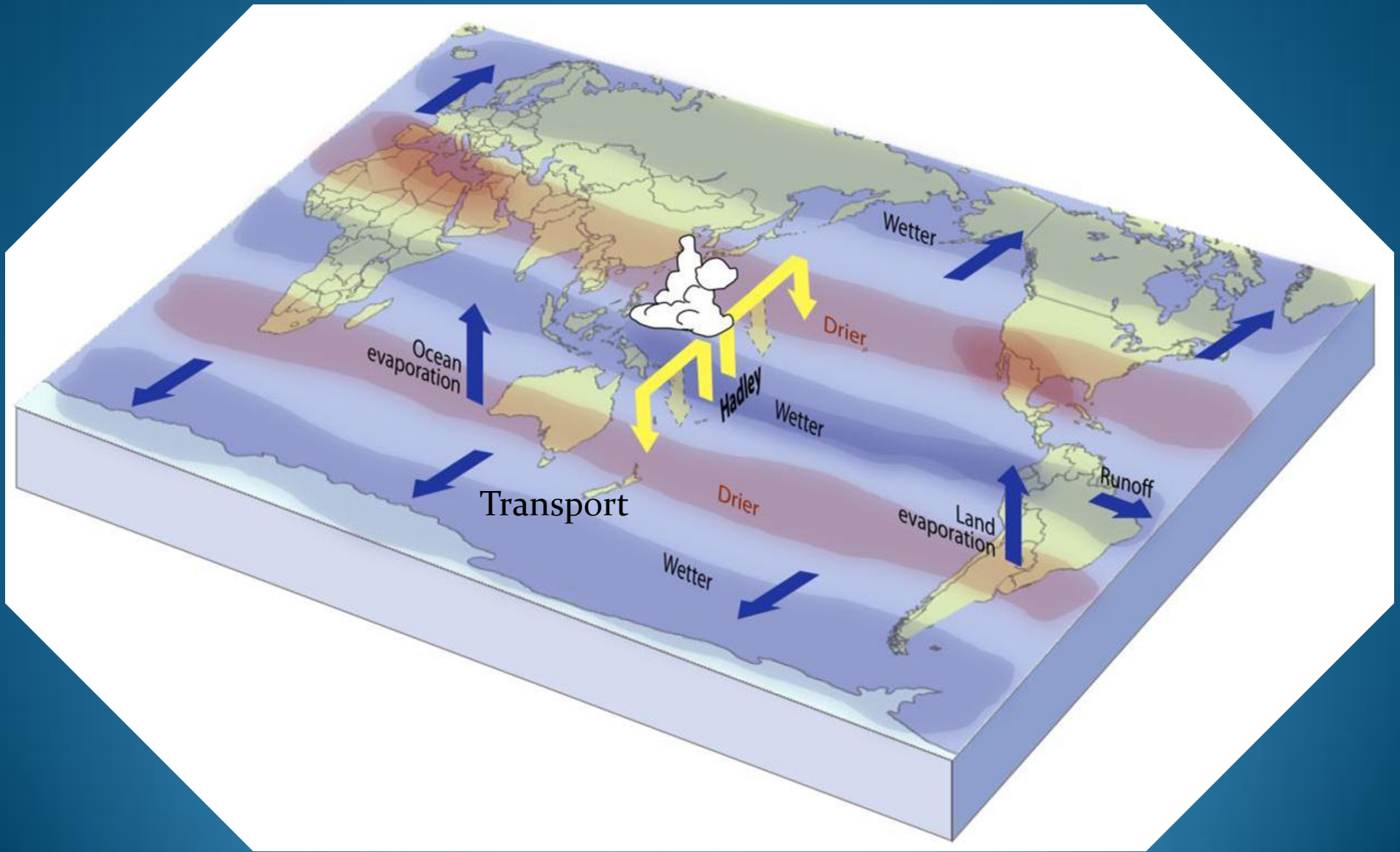


Changes in the global water cycle in response to the warming over the 21st century will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, although there may be regional exceptions (see Figure SPM.8).

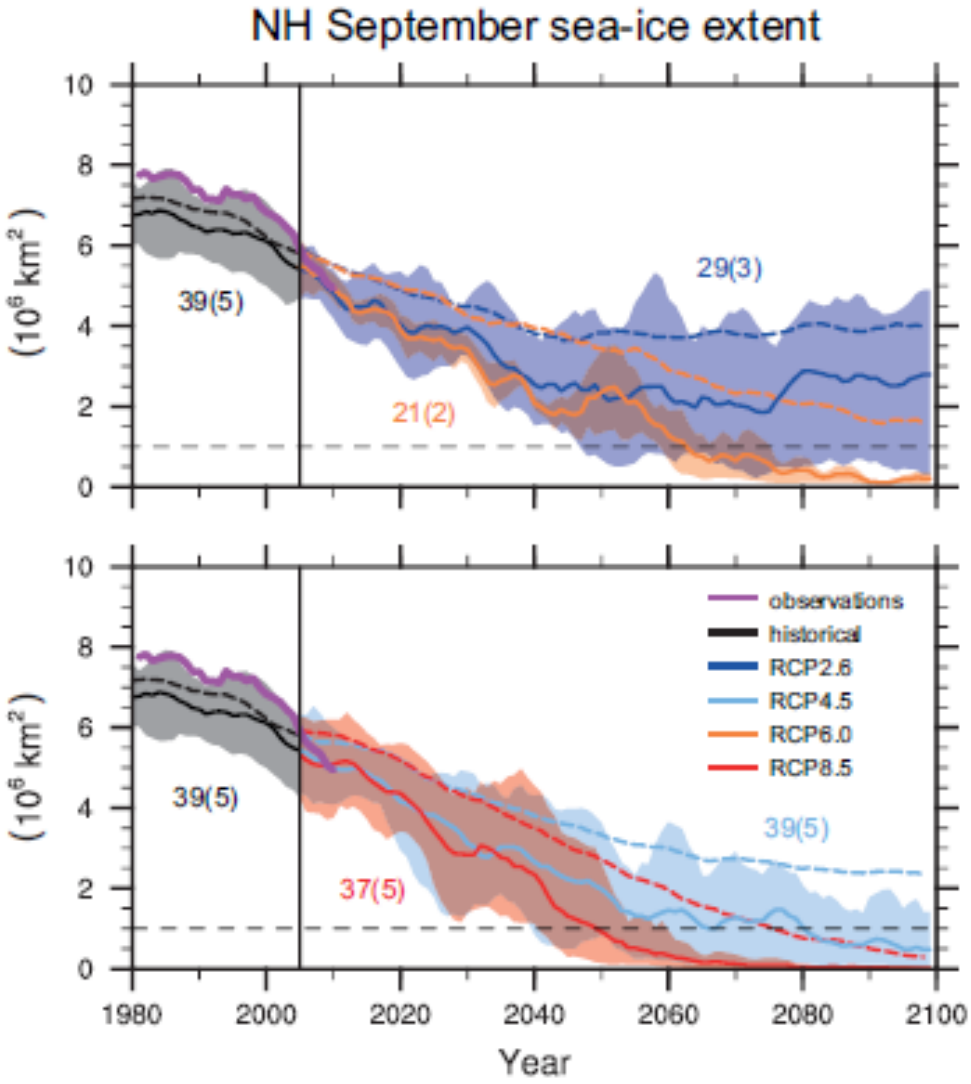


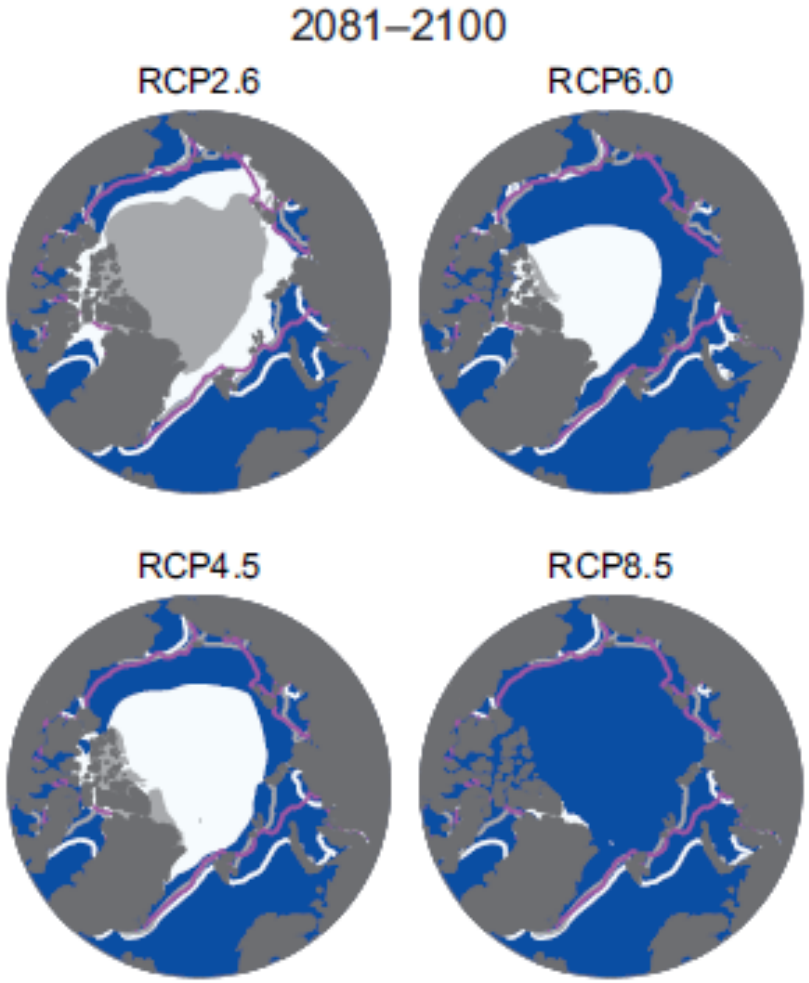
Summary of Projected Changes to the Water Cycle

Change relative to 1986-2005

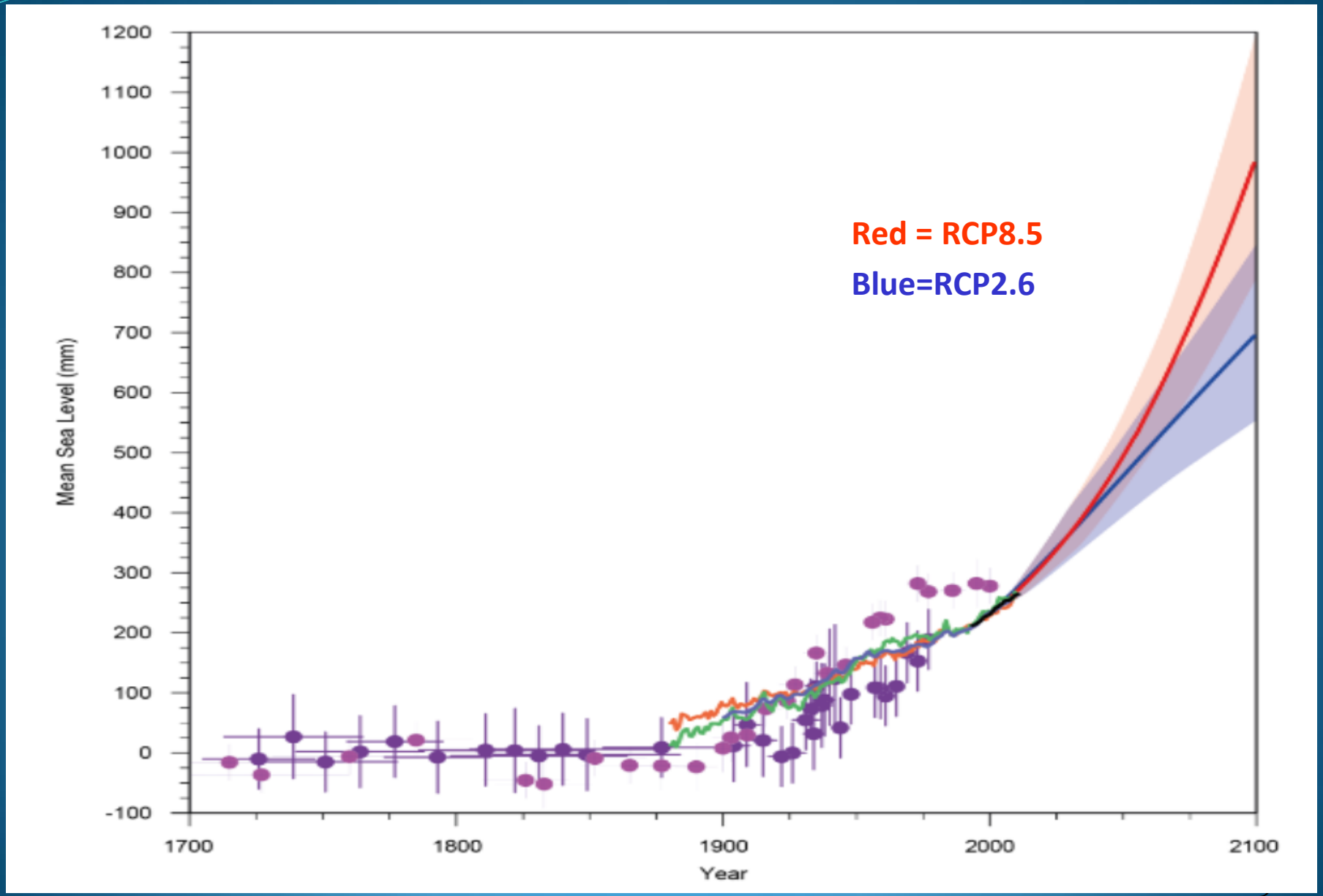


Projections: Sea ice





Historical and Future Sea-level Rise



Take-home Message

Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased.

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.

Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system.

Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.