*iClimate*

Pillar 1: Climate Drivers

# Understanding Climate Change

## – What, Why, Where and When ?

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AARHUS
UNIVERSITY

# Understanding Climate Change
## – What, Why, Where and When ?

- What has, is and will happen?
- Why? Which are the main natural and anthropogenic  mechanisms to impact climate and how do they interact?
- Where will climate change be most prominent and which form will it have in different geographical regions?
- When will we reach a point of no return?

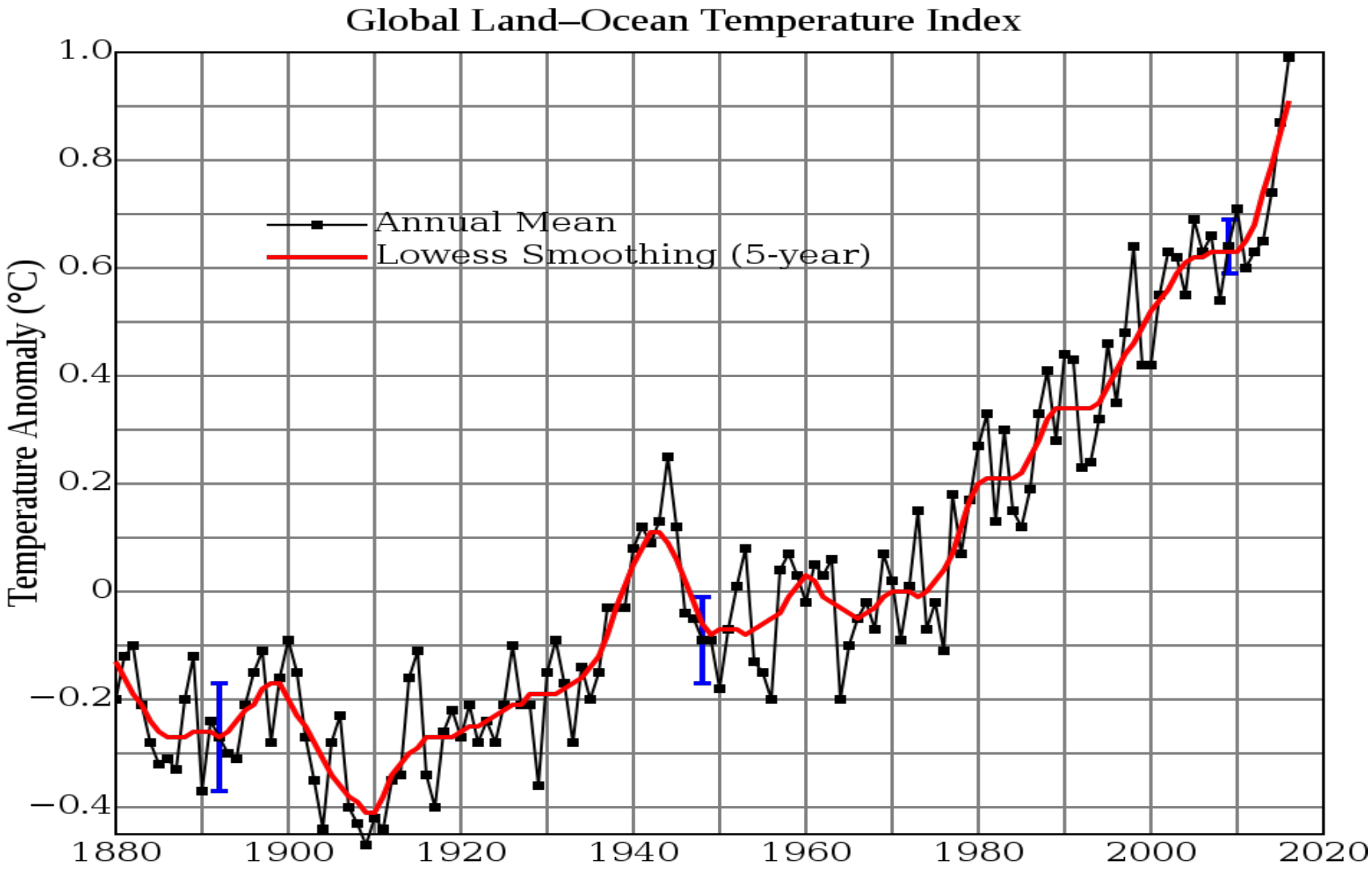
# Objectives of Pillar 1: Climate Drivers

To understand the forcing and drivers of the climate system at global, regional and national scales: anthropogenic and natural origins

- Greenhouse gasses and processes driving the exchange of gasses between atmosphere and ecosystems in the oceans, ice and on land.
- Transport and chemical transformation of gases and aerosols in the atmosphere and feedback to the climate systems
- The interaction between changes in ocean-atmosphere and cryosphere and its impact on key climate parameters.

How: combination of global climate models (incl. atmospheric chemistry models) with results from field and laboratory experiments and monitoring data from a range of research fields.

# Global air temperature 1880-2016



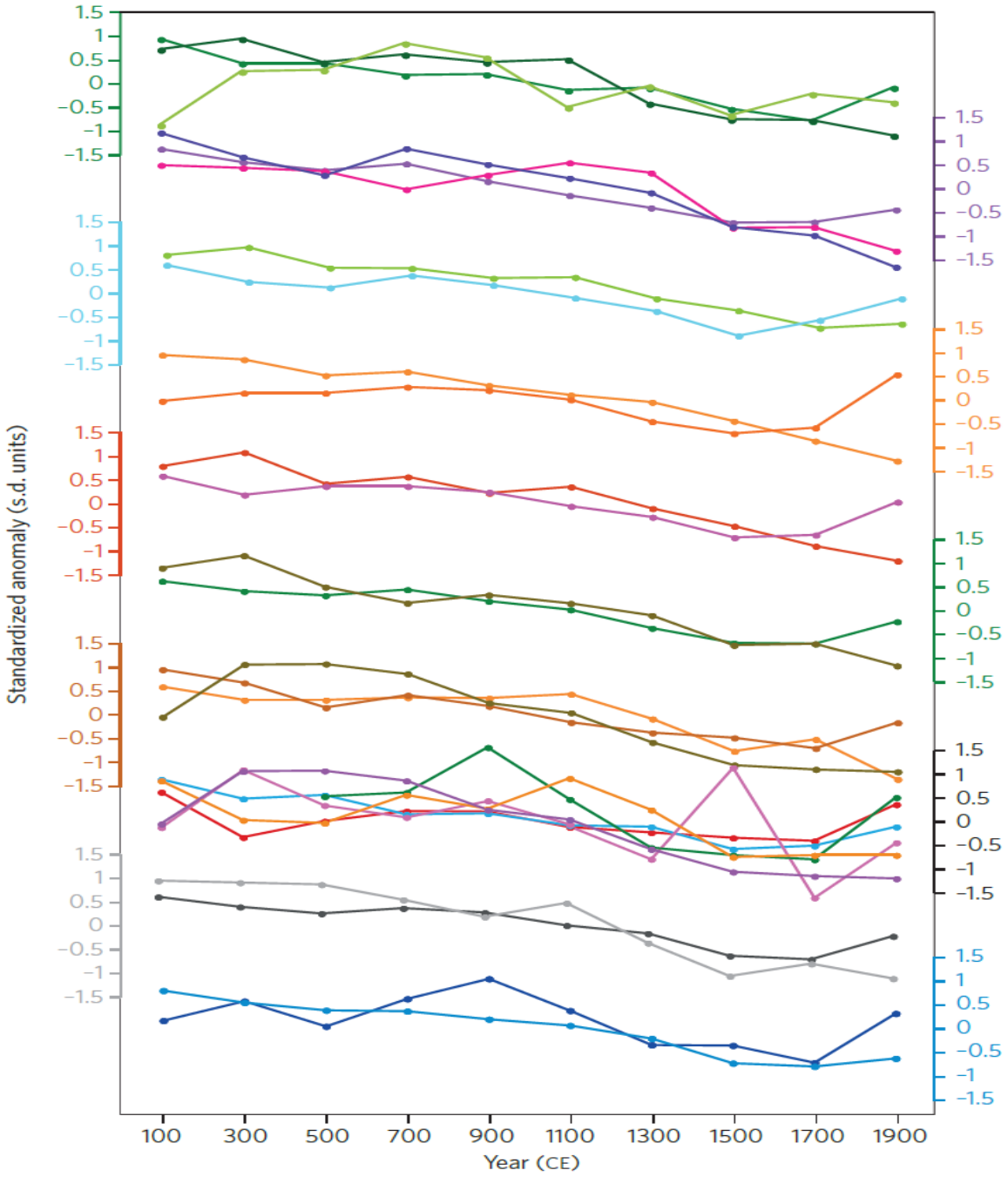

NASA Goddard Institute for Space Studies, 2016

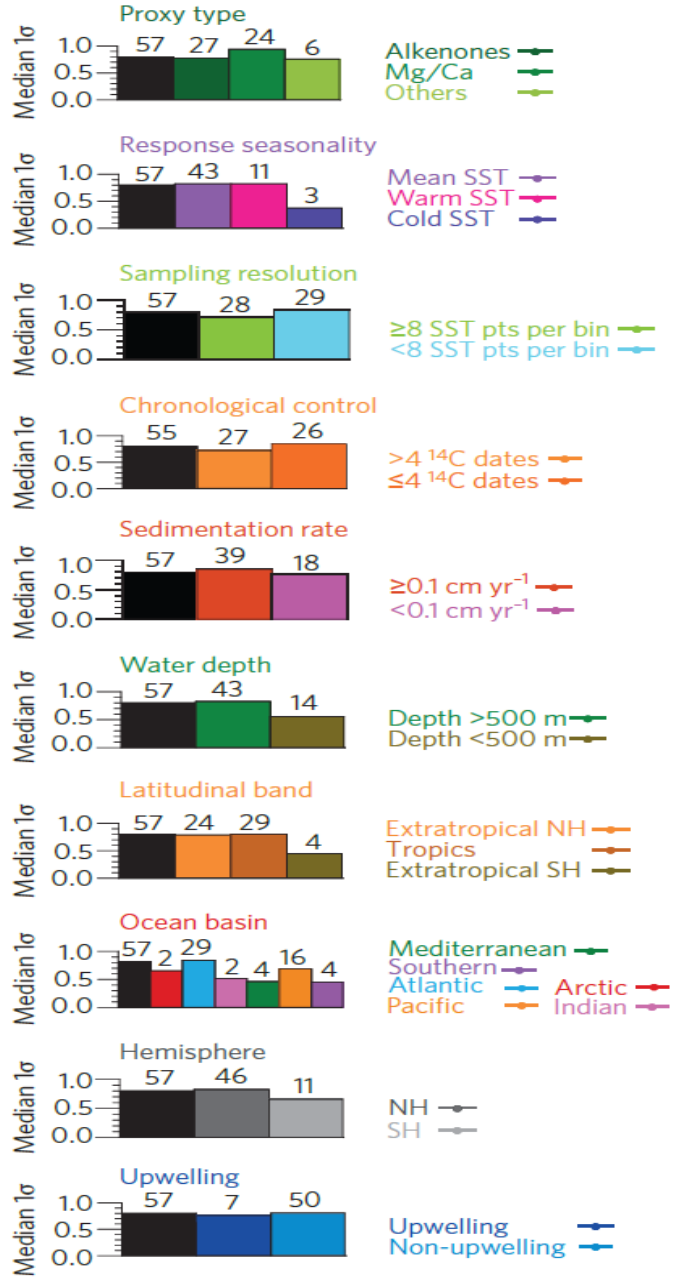
# 2000 years of cooling

Global synthesis of sea surface temperatures derived from 57 individual marine reconstructions

Significant global cooling trend for SST in pre-induscrial Common Era

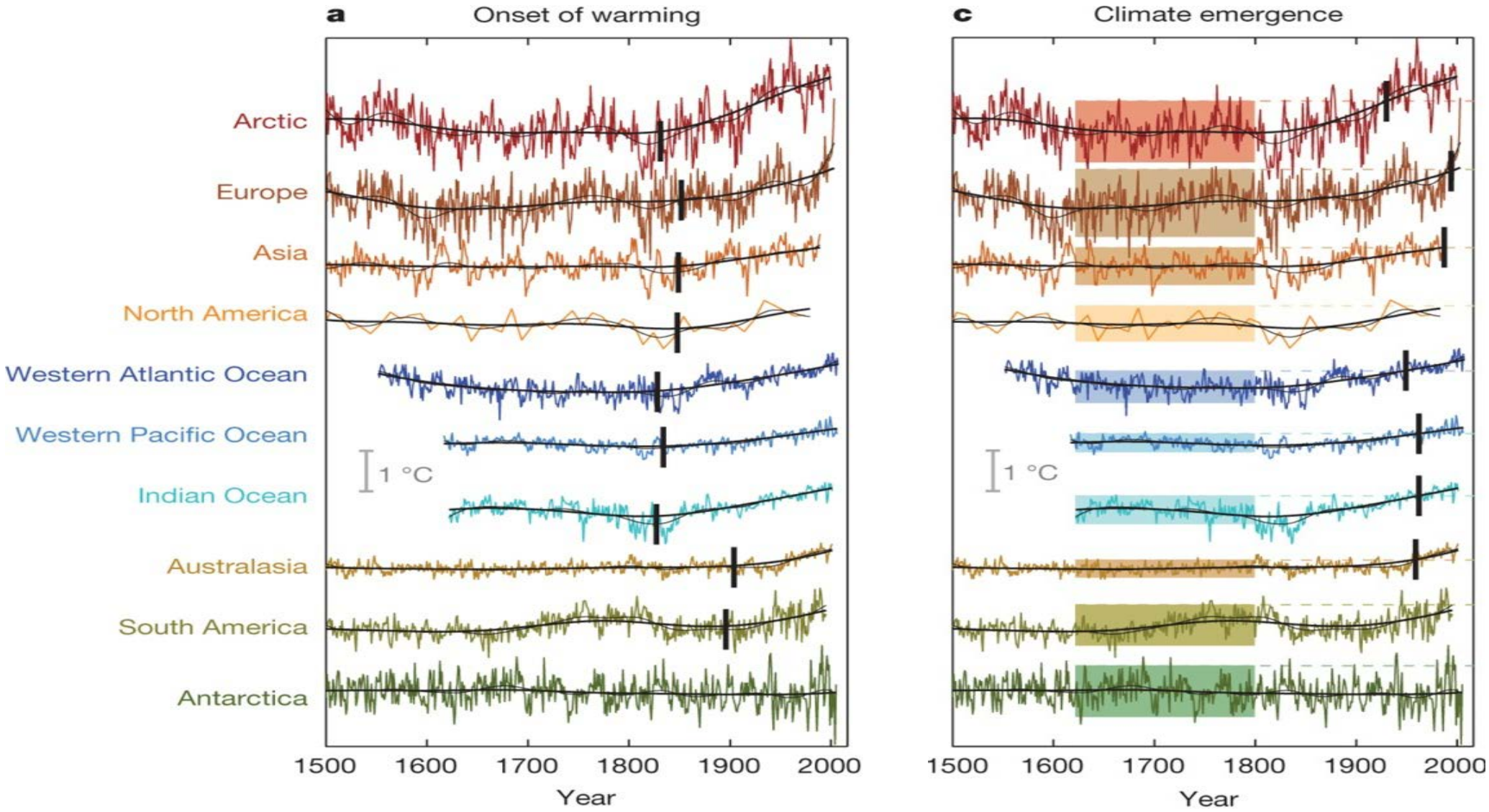
McGregor et al. 2015.
*Nature Geoscience*



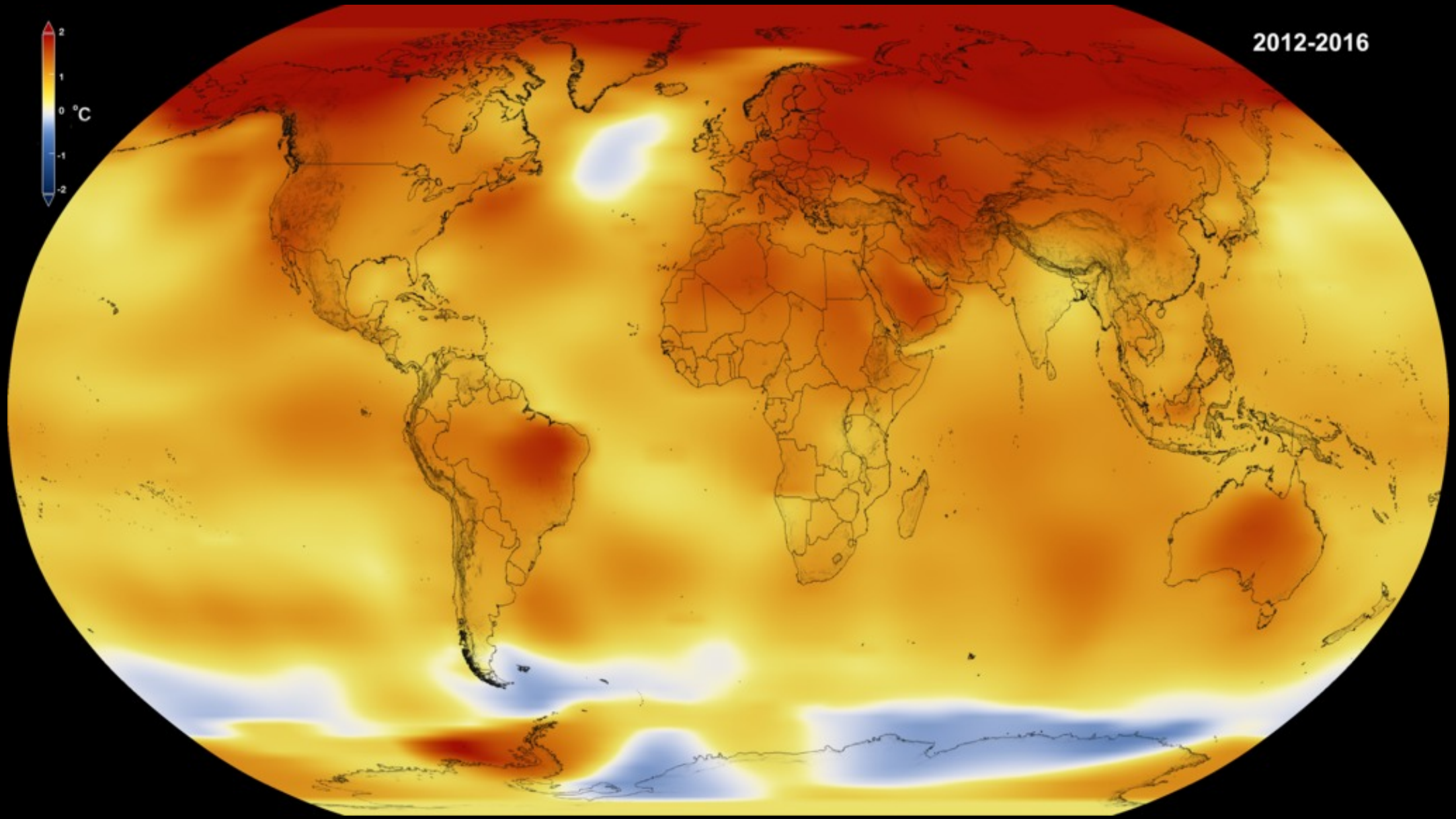




0 CE 1000 CE 2000

# Onset and magnitude of industrial-era warming in regional temperature reconstructions, paleoclimate records

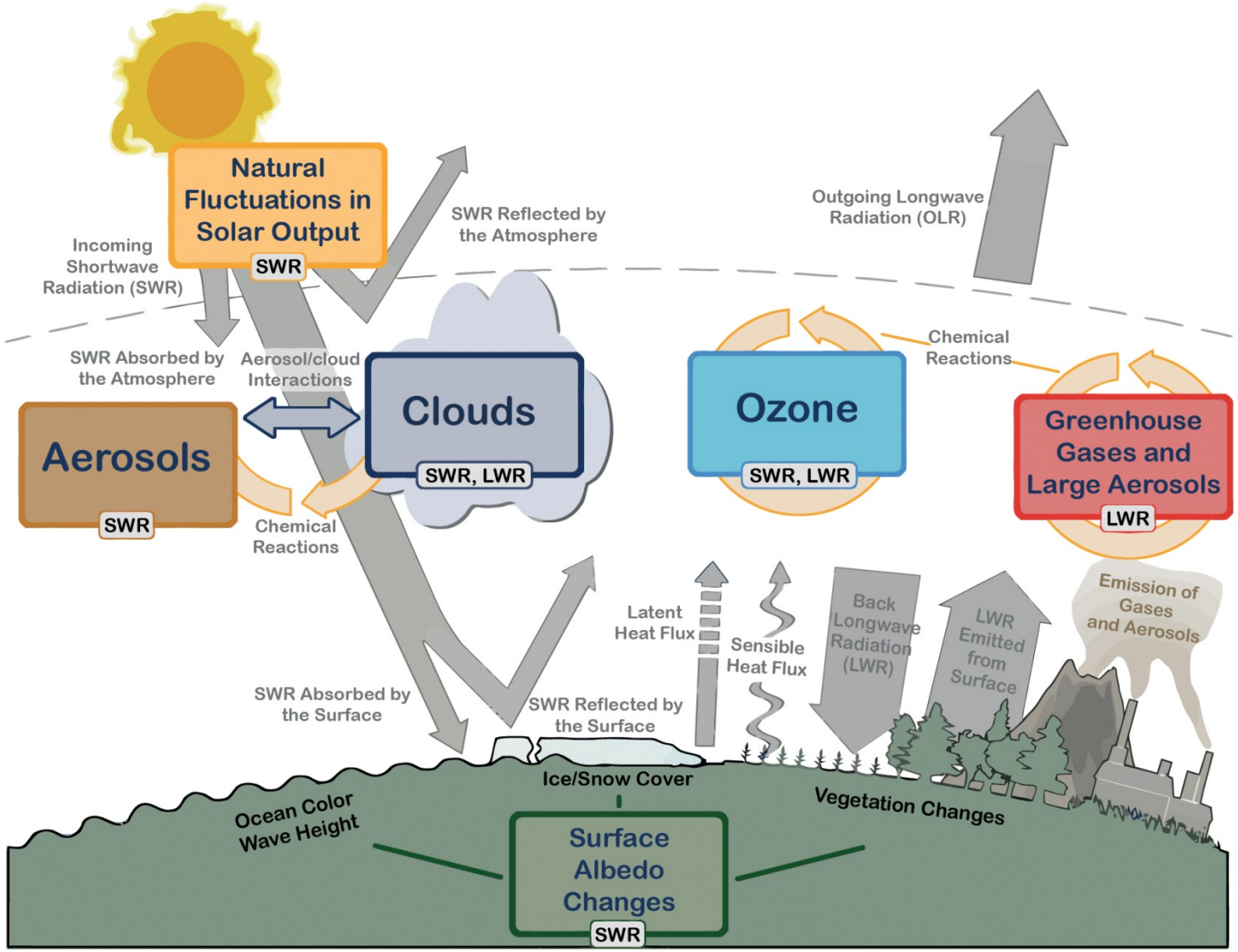



Abram *et al. Nature* 536 (2016) doi:10.1038/nature19082




Global Temperature Anomalies averaged from 2012-2016 in degrees Celsius; baseline period: 1951-1980. (NOAA; Visualizations by Lori Perkins Released on January 18, 2017).

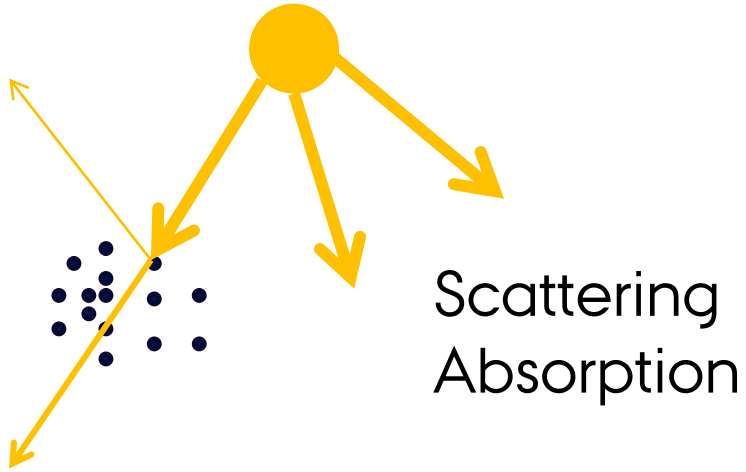
# Significance of the atmosphere:
## winds, clouds, greenhouse gasses, aerosols




IPCC 2013

# Example: aerosol impact on climate

**Direct effect**



# Example: aerosol impact on climate

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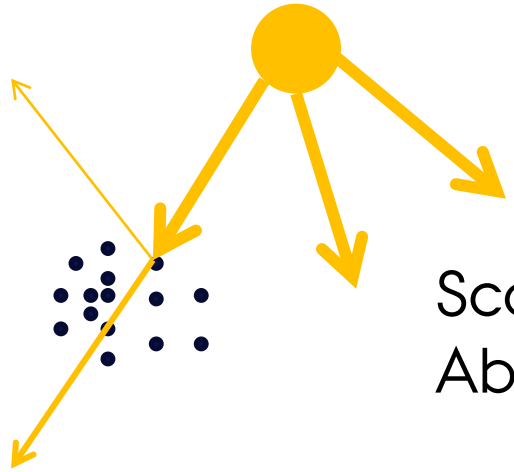
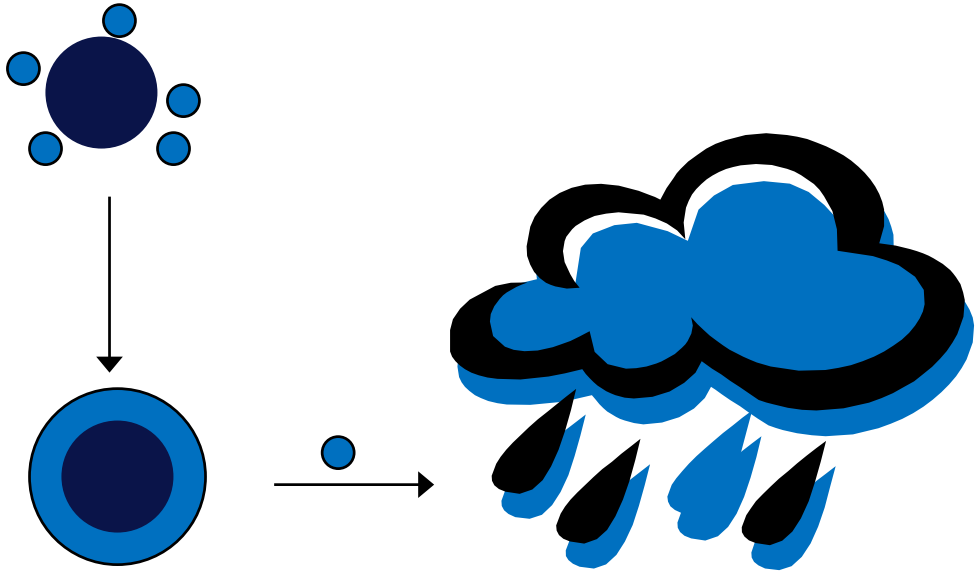


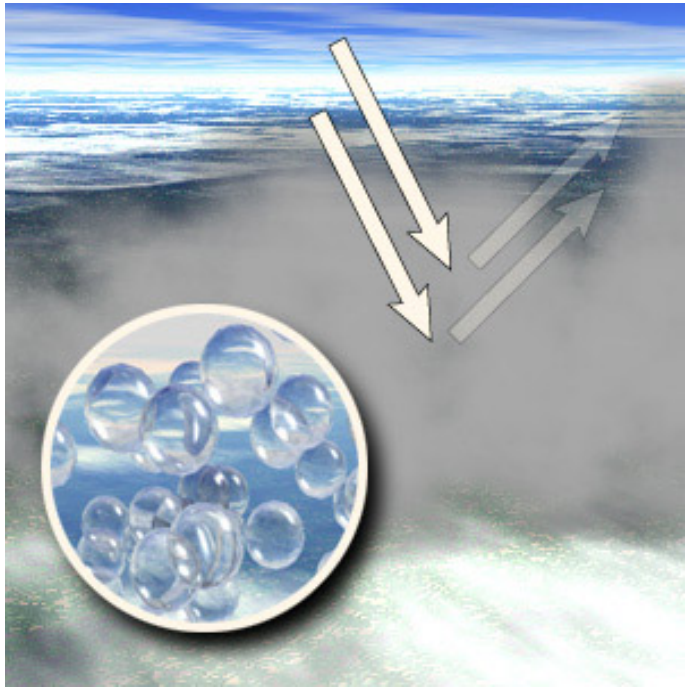
Scattering
Absorption

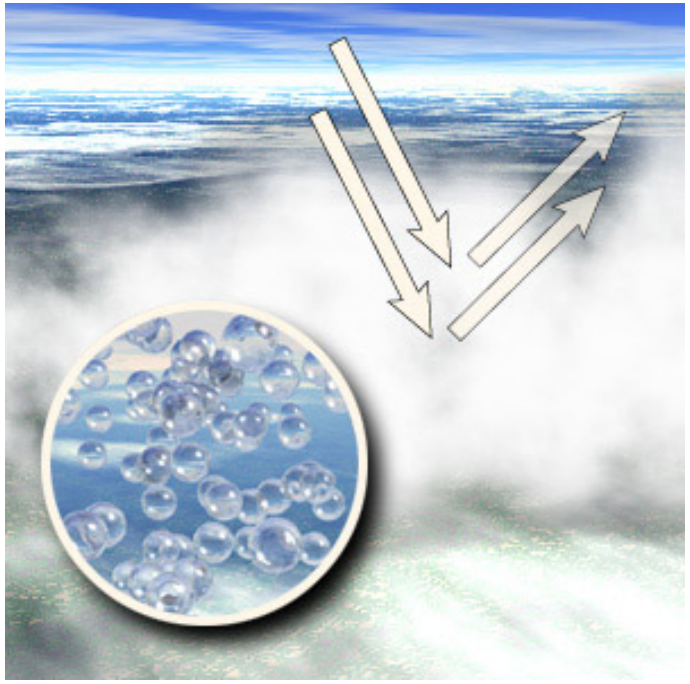
**Indirect effect**



Cloud formation

# Indirect effect

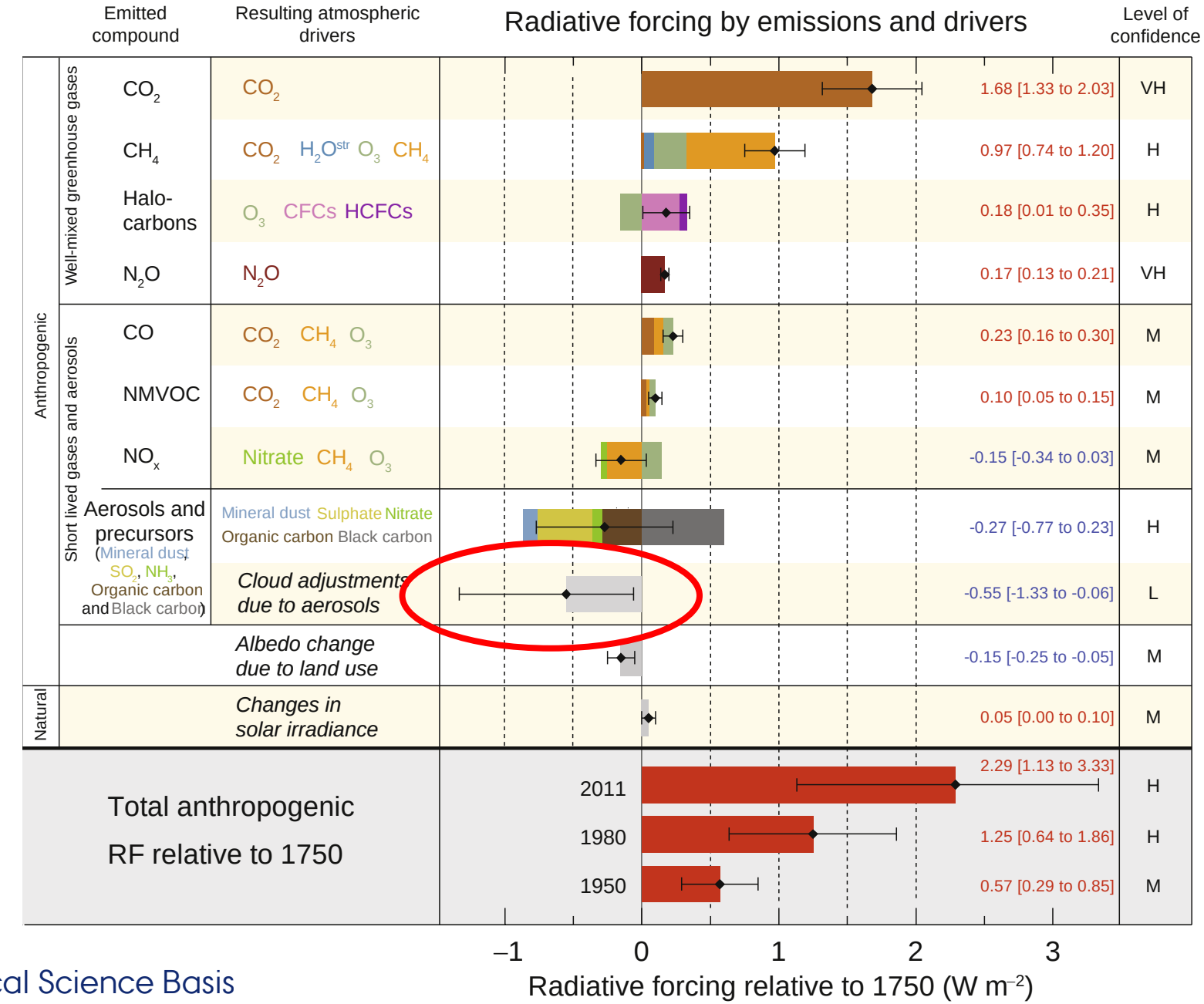




RH>100%

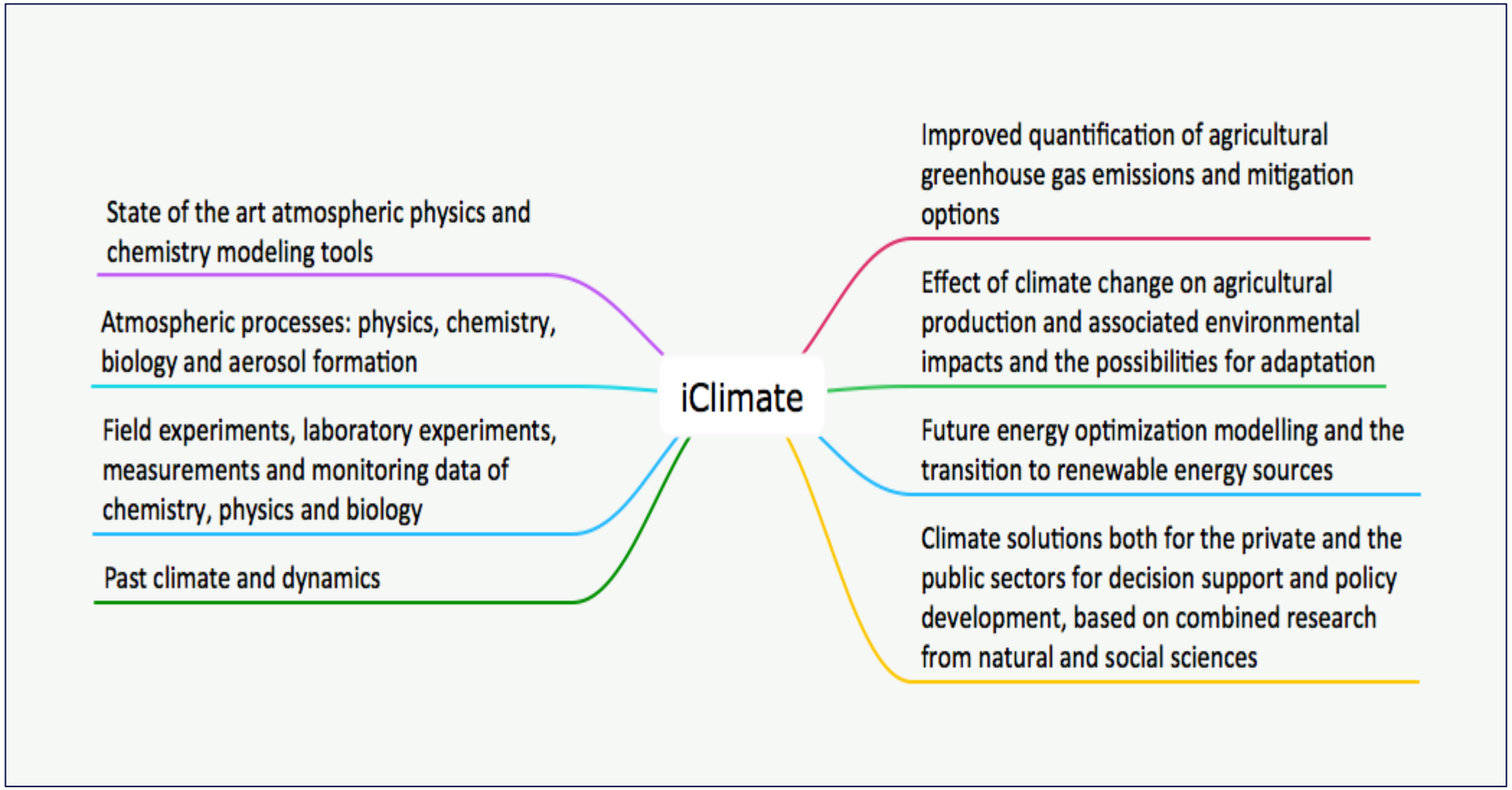
NASA SClence Files™

Radiative properties, cloud lifetime, precipitation

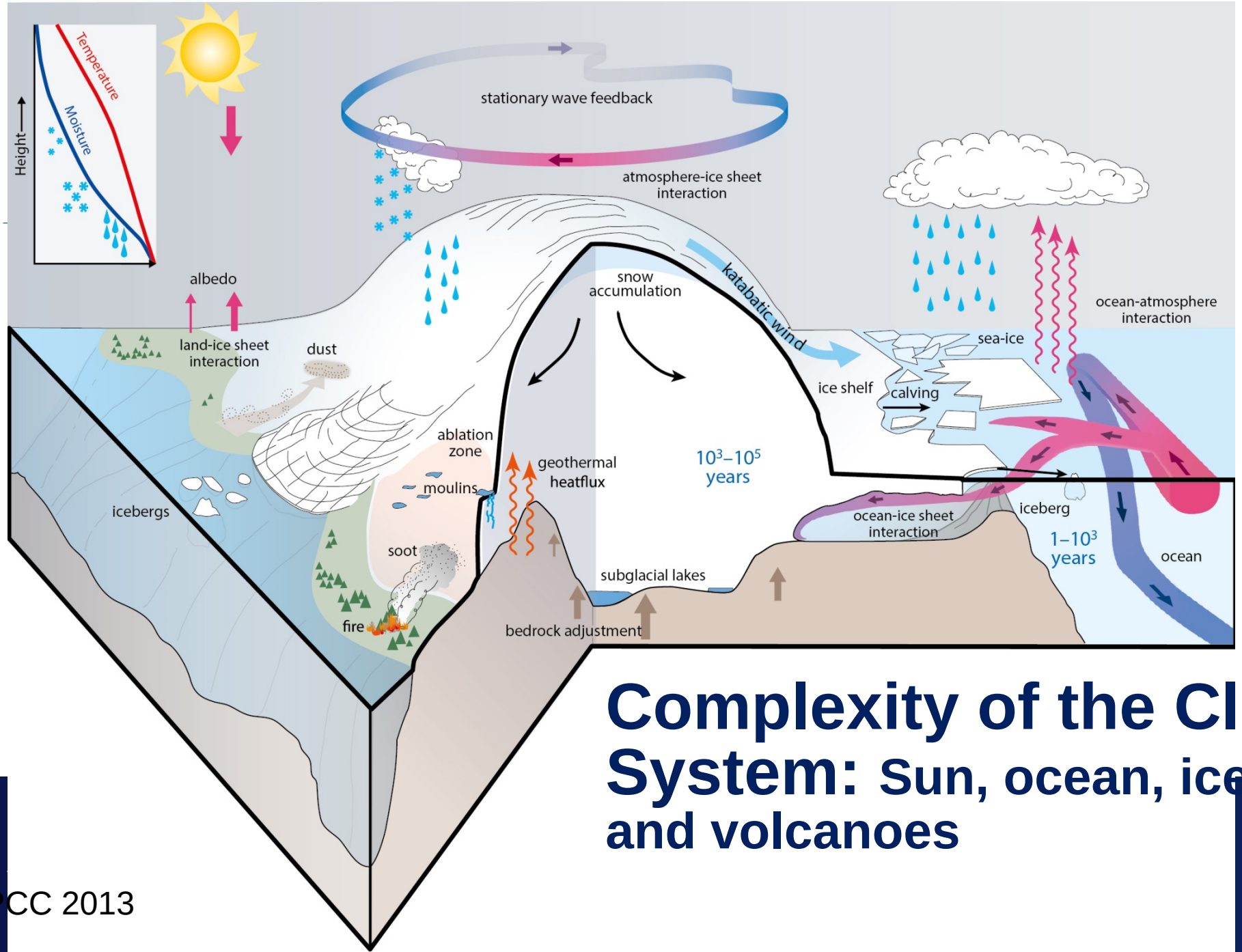



IPCC, 2013: The Physical Science Basis

# Role of Pillar 1 within *iClimate*



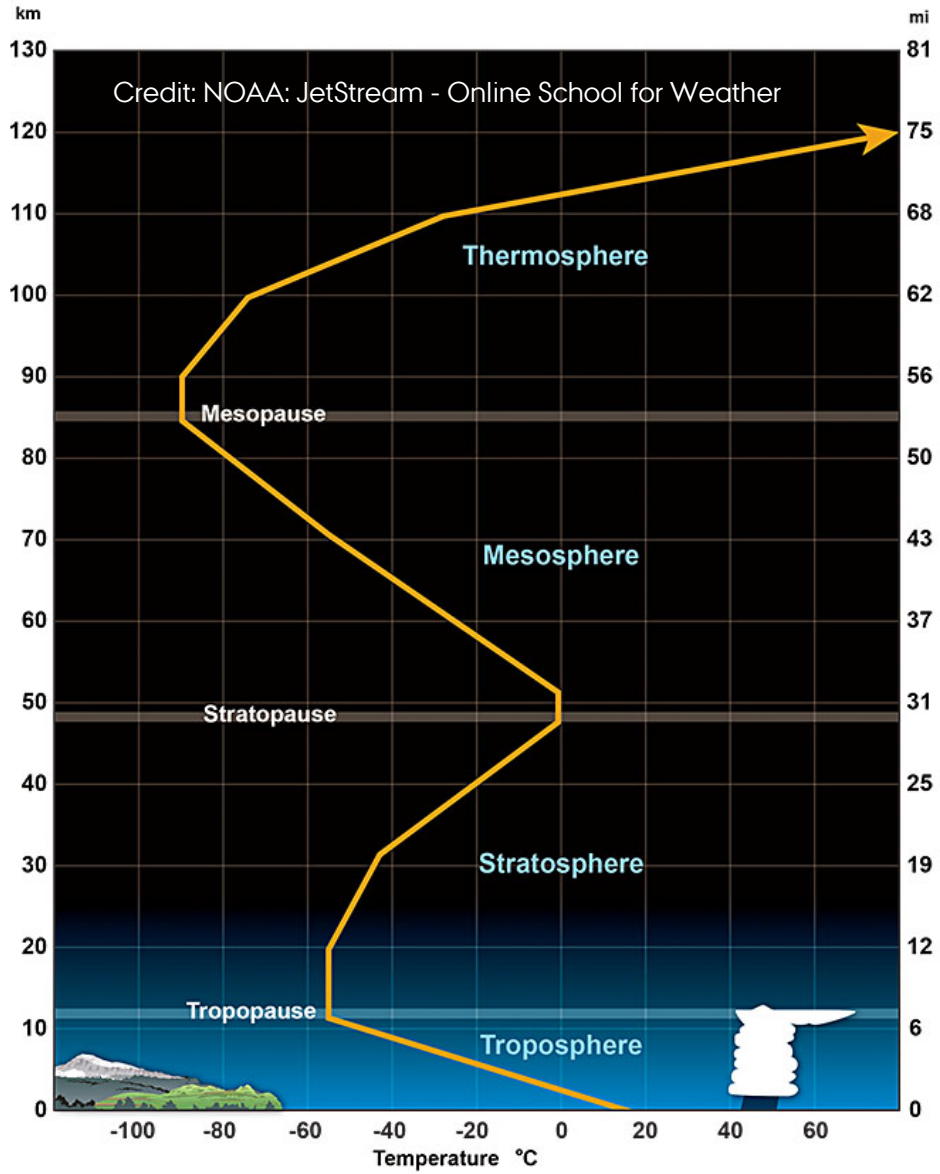
# EXTRA SLIDES, NOT USED

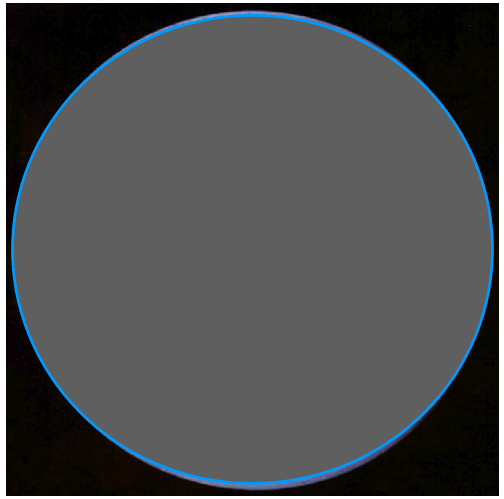



# Complexity of the Climate System: Sun, ocean, ice, atmosphere and volcanoes

IPCC 2013

# The Atmosphere

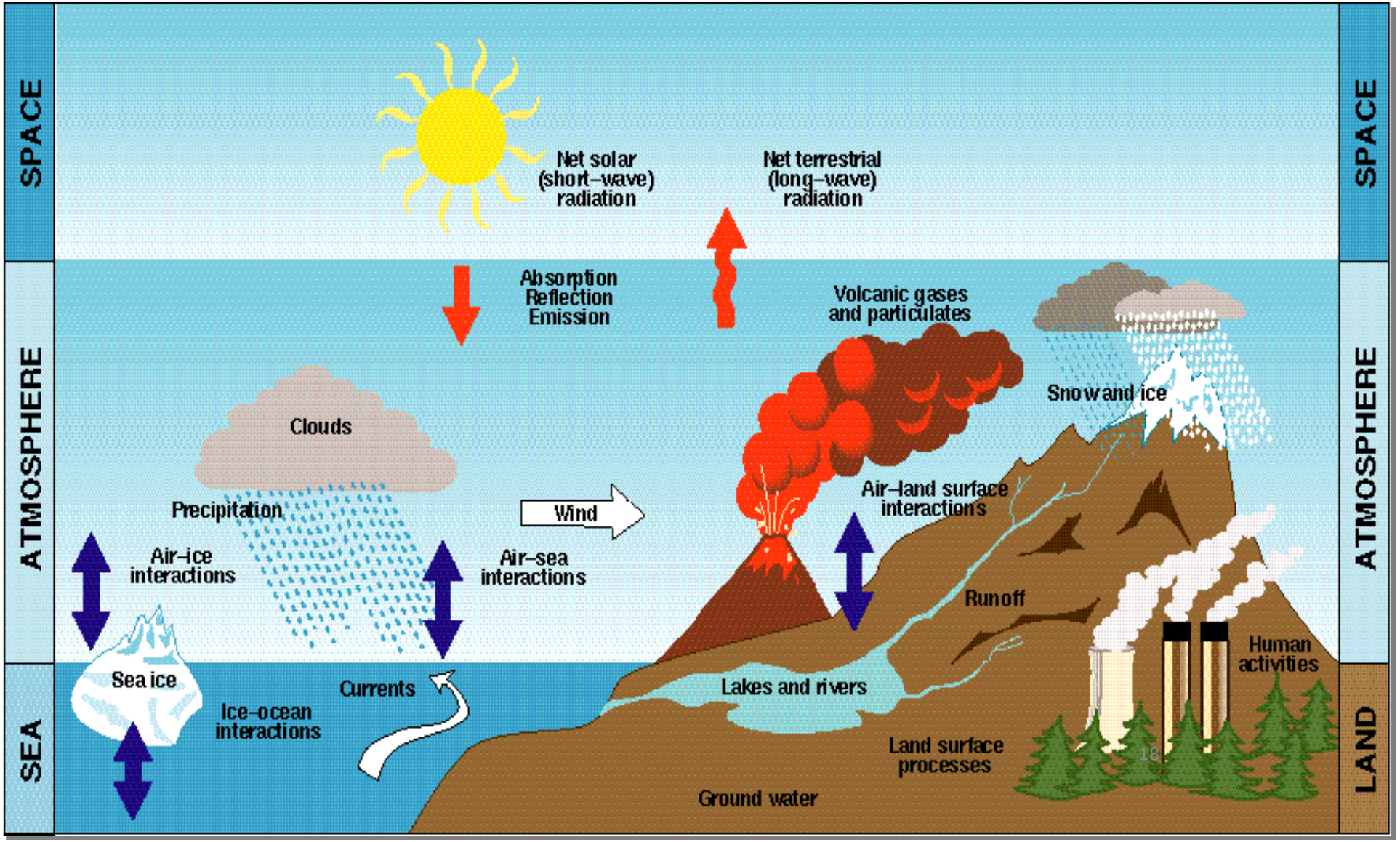


Credit: NASA NSSDC's Photo Gallery

Source: Henry G. Gastineau, ca. 1830. (Wikimedia Commons).

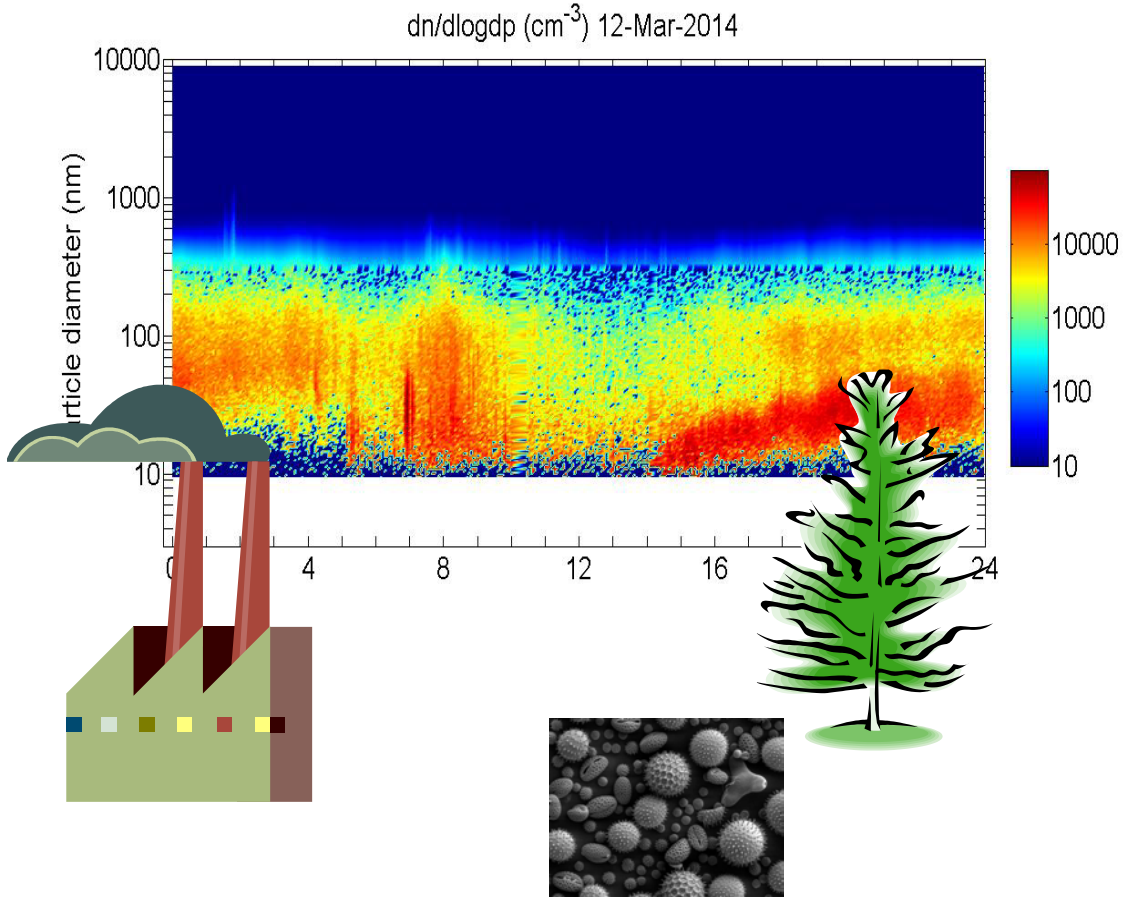
# Interactions in the Climate System

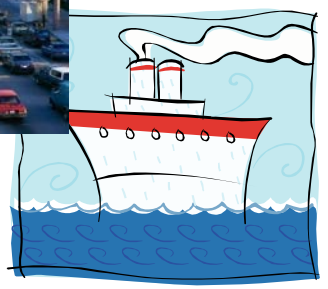



A. Grelle, 2005

# Aerosols

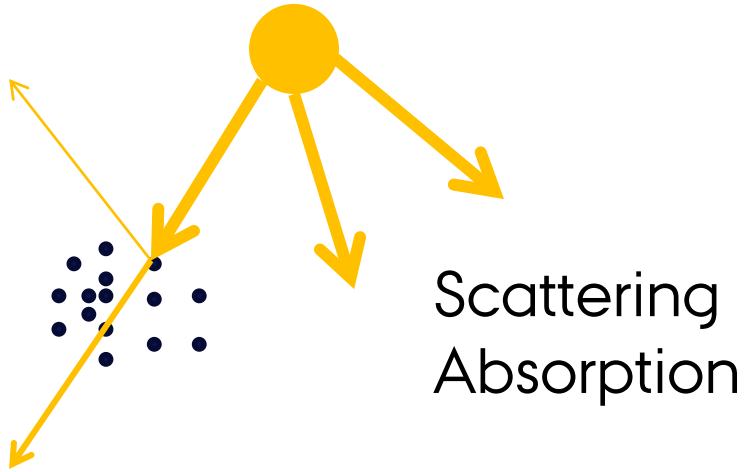
- Primary
- Secondary



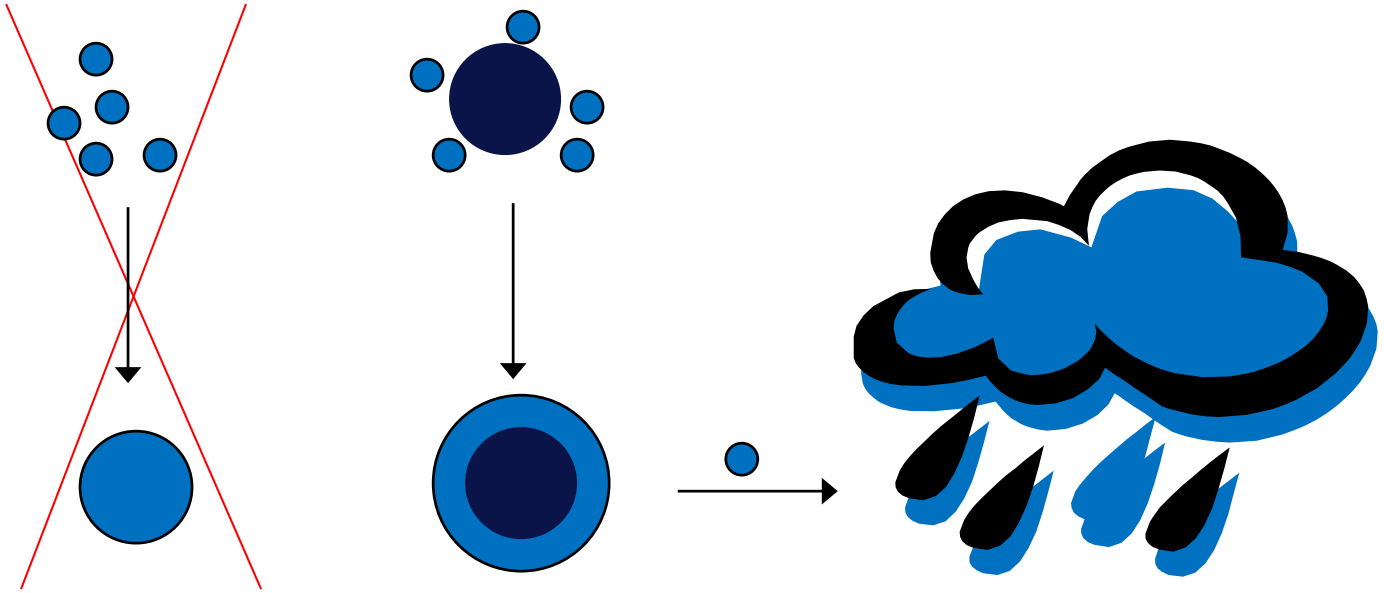



# Impact: Climate

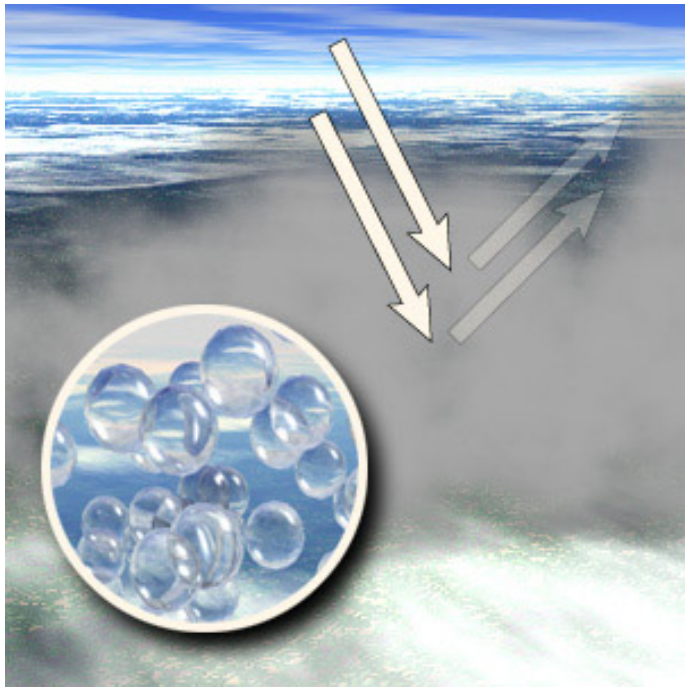
**Direct effect**

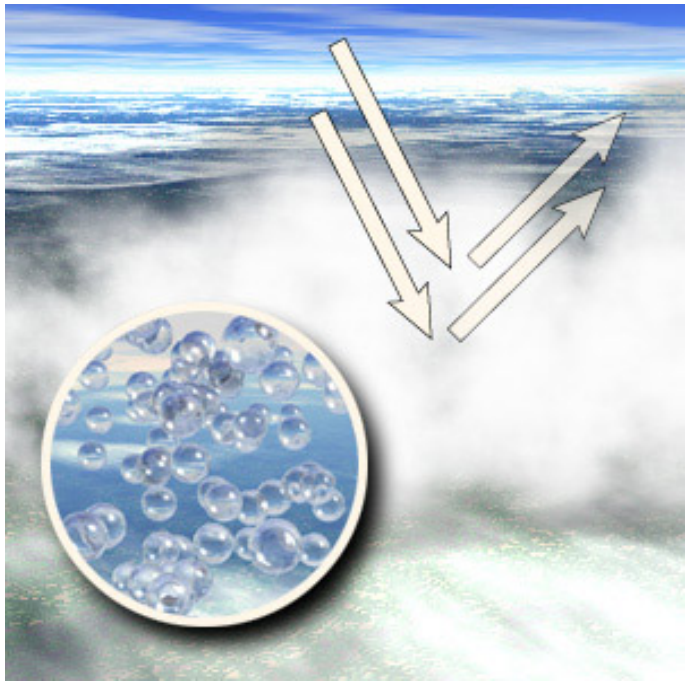



**Indirect effect**



# INDIRECT EFFECT

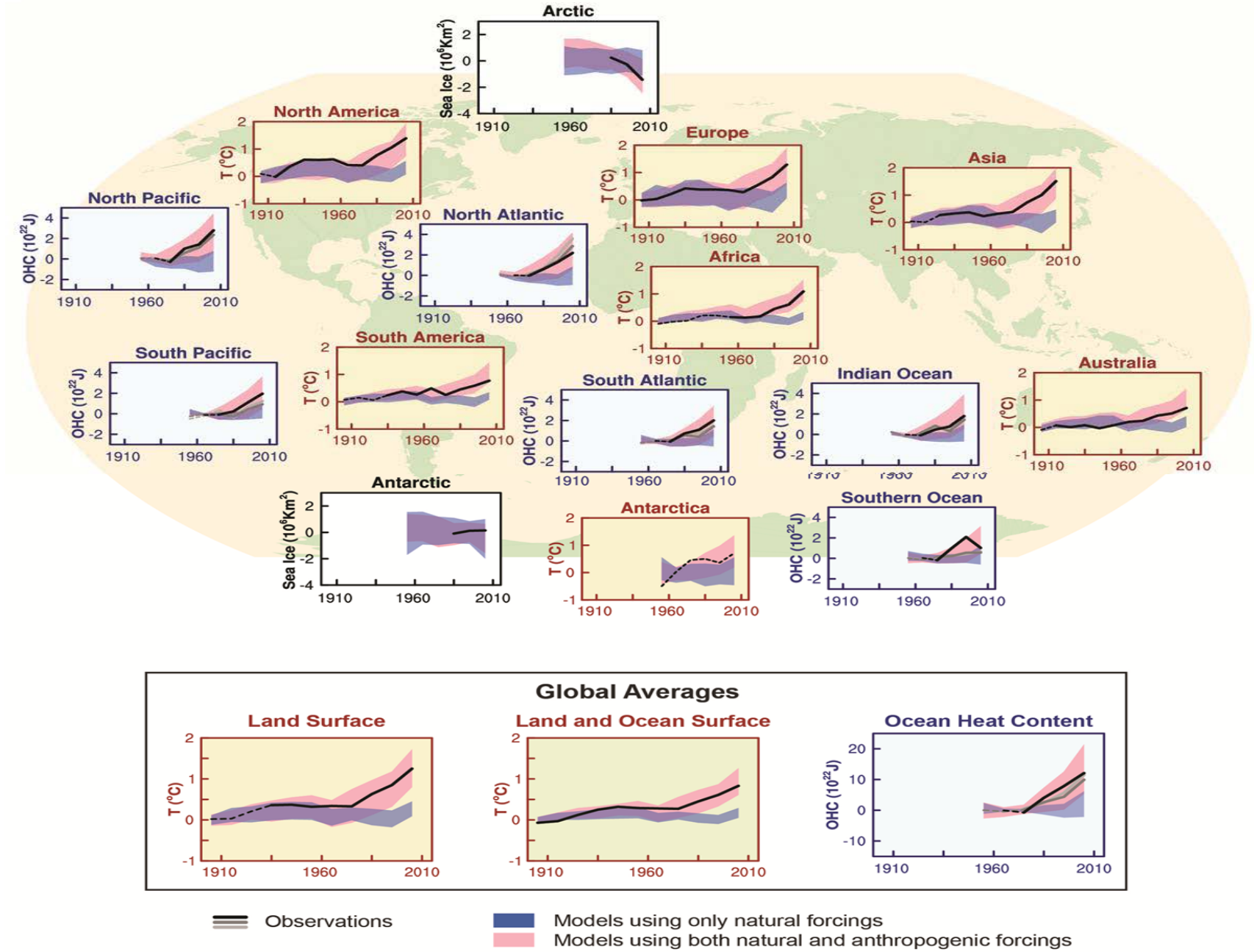




RH>100%

NASA SCIence Files™

Radiative properties, cloud lifetime, precipitation







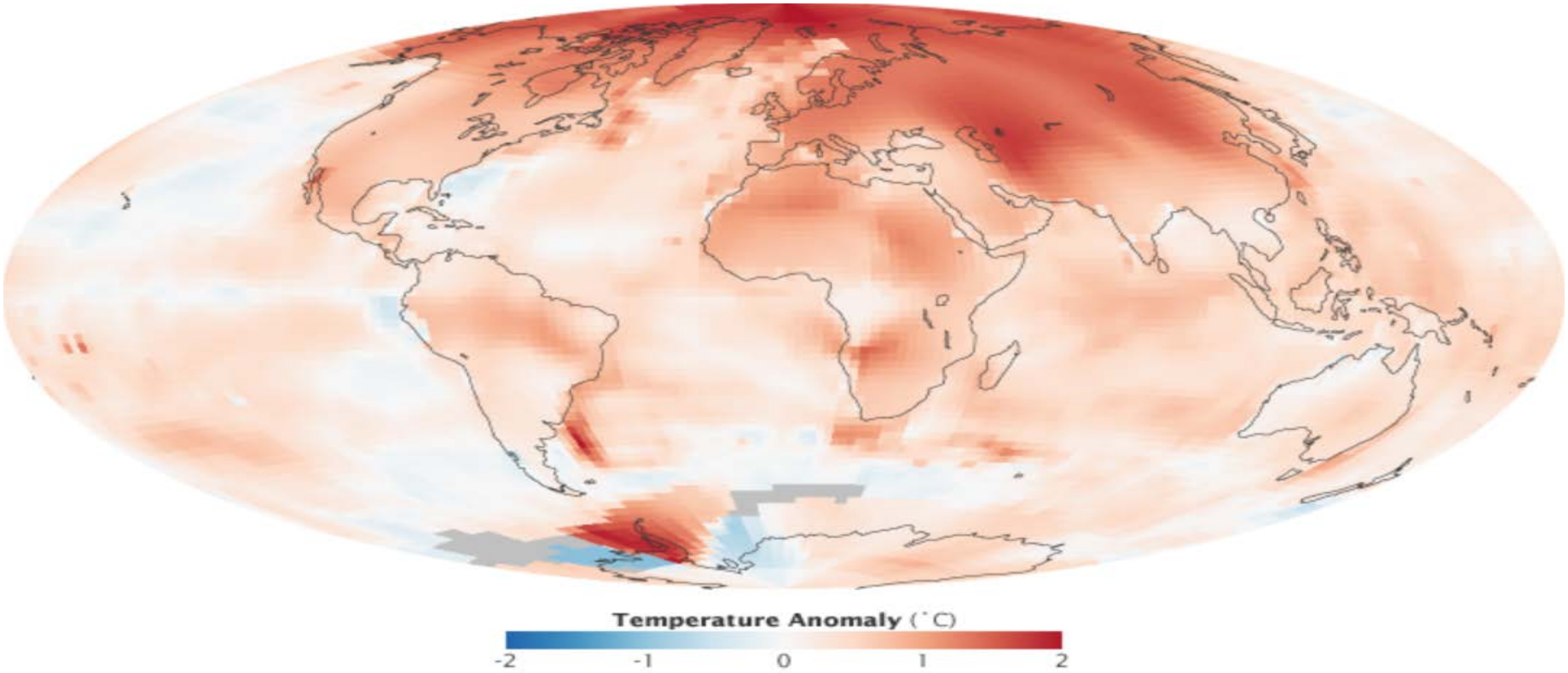
Observations

Models using only natural forcings

Models using both natural and anthropogenic forcings

IPCC 2013

# Arctic amplification

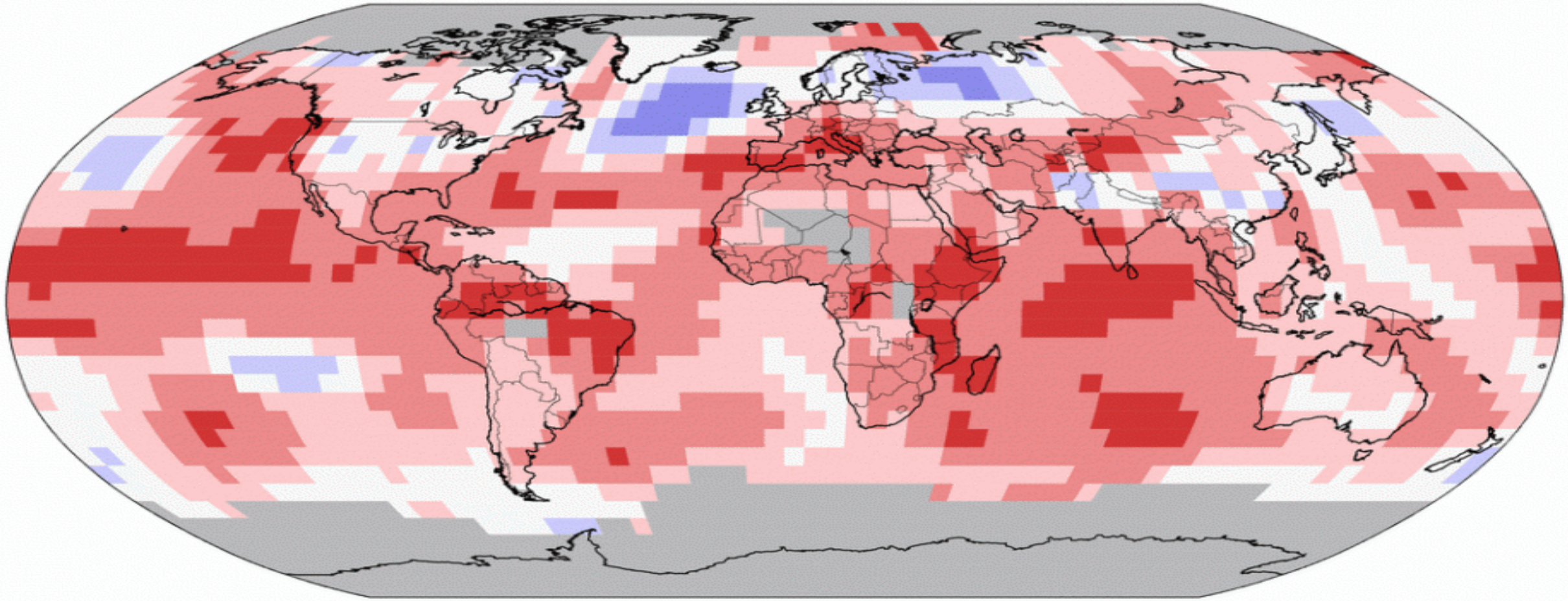



NASA GISS temperature trend 2000-2009, showing strong Arctic amplification

# Land & Ocean Temperature Percentiles Jul 2015

## NOAA's National Centers for Environmental Information

Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0

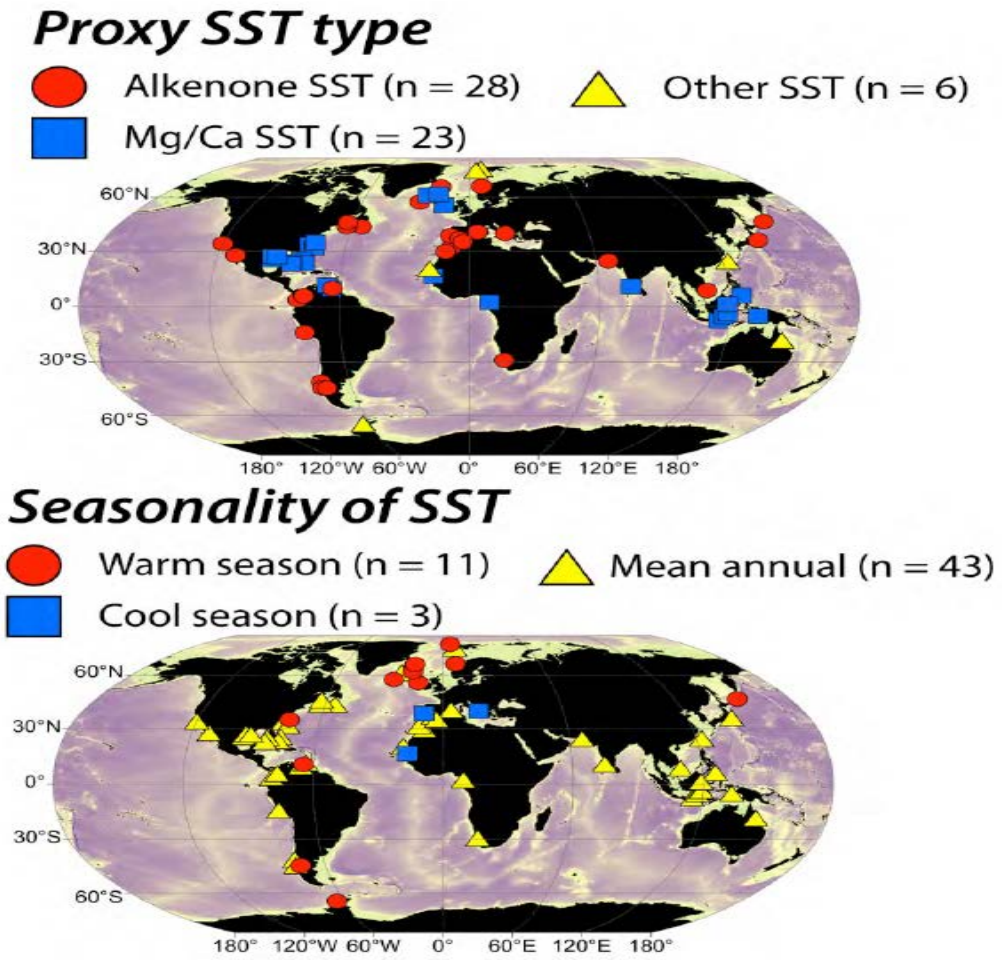


Record Coldest | Much Cooler than Average | Cooler than Average | Near Average | Warmer than Average | Much Warmer than Average | Record Warmest

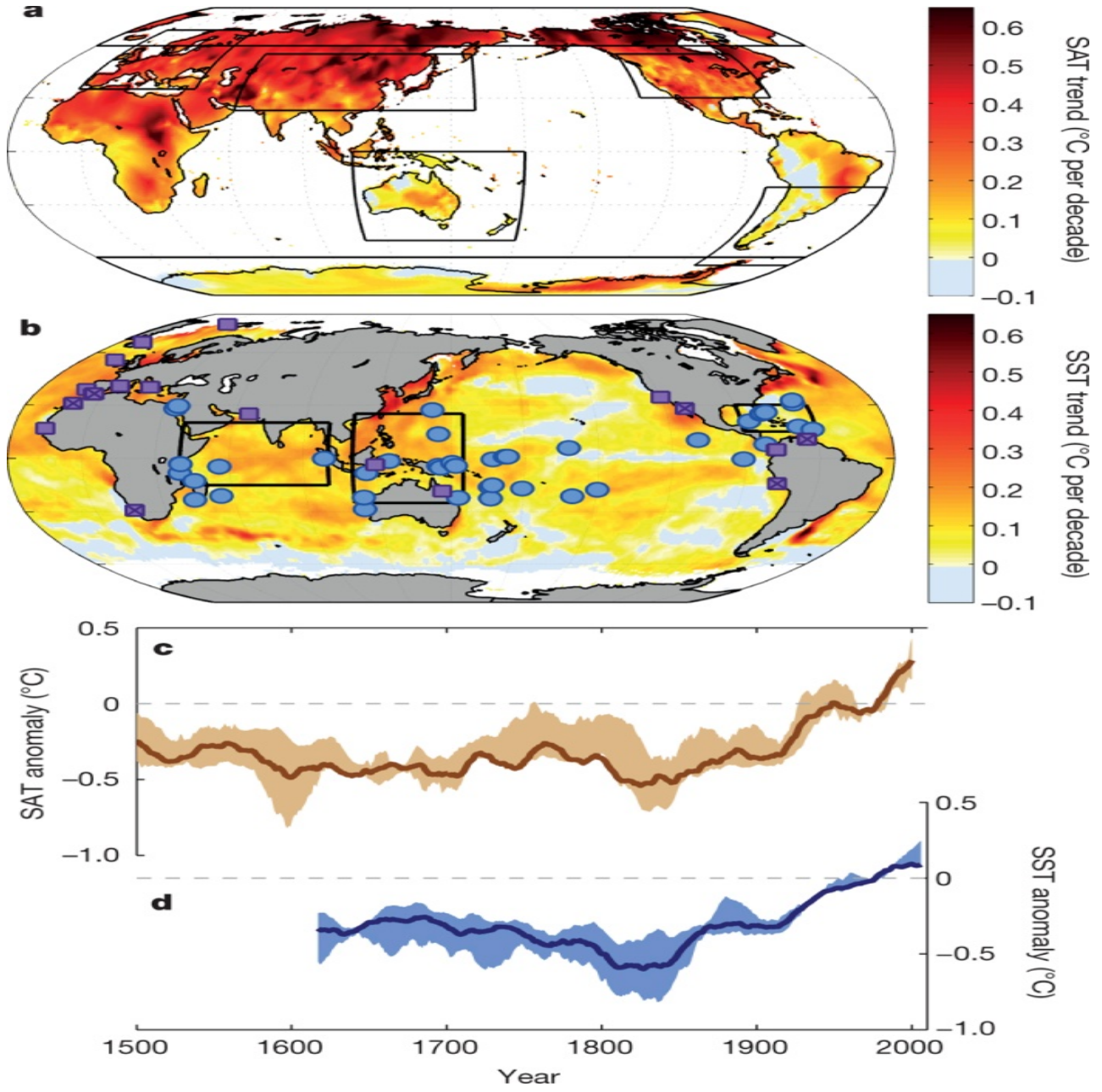
NOAA 2015

Mon Aug 17 06:23:58 EDT 2015

# Arctic and Nordic sites

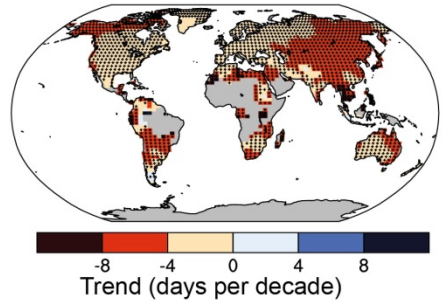


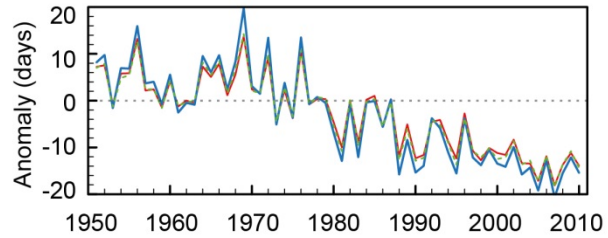

McGregor et al 2015, *Nature Geoscience*



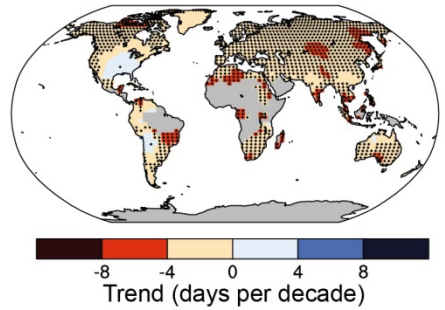

N J Abram *et al. 2016, Nature*

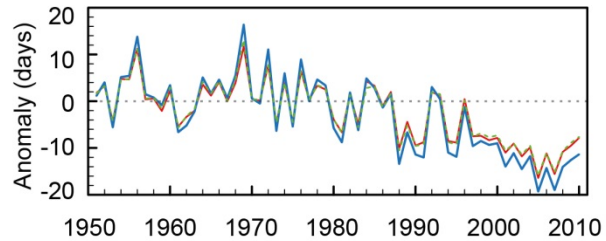
(a) Cold Nights



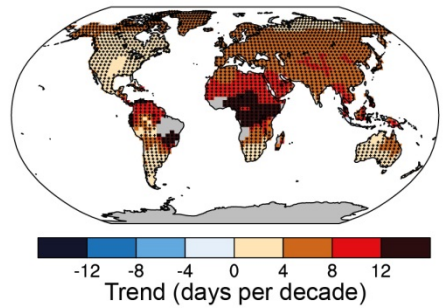



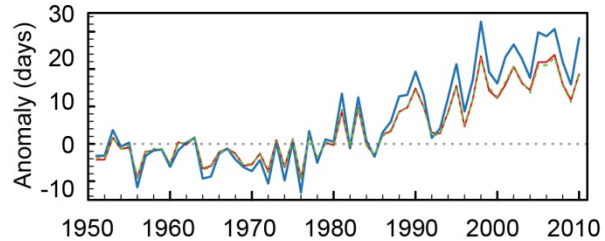

(b) Cold Days



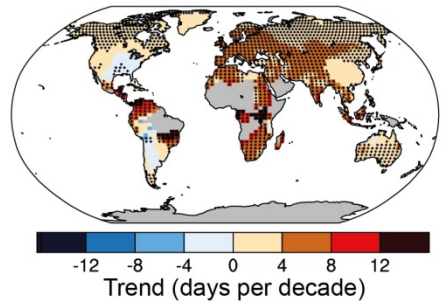



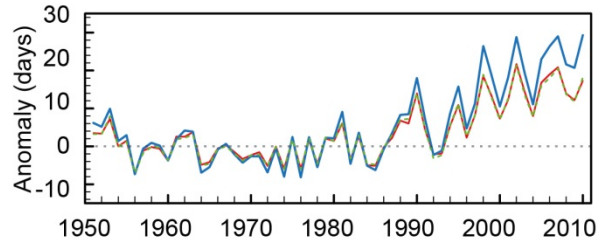

(c) Warm Nights

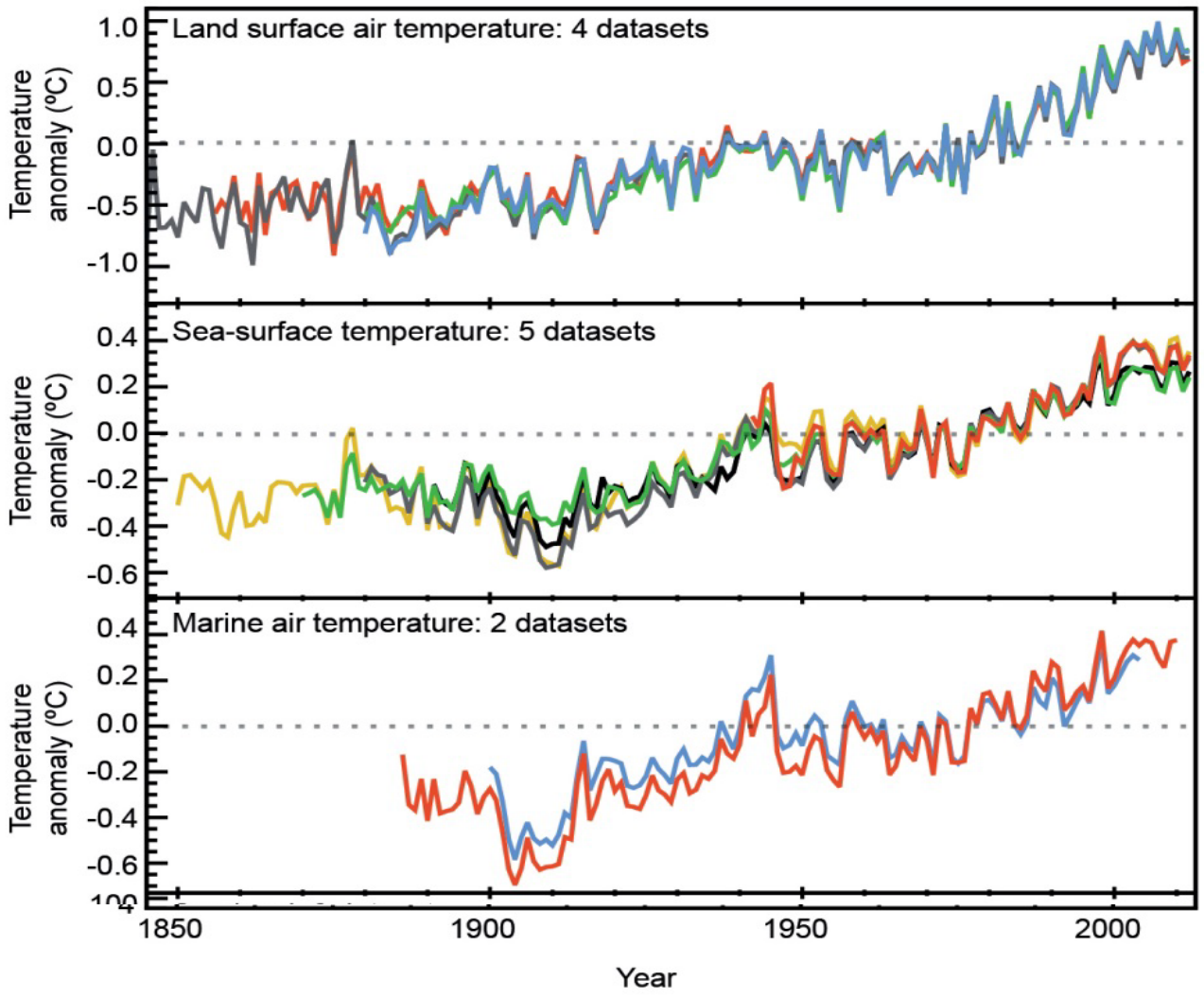


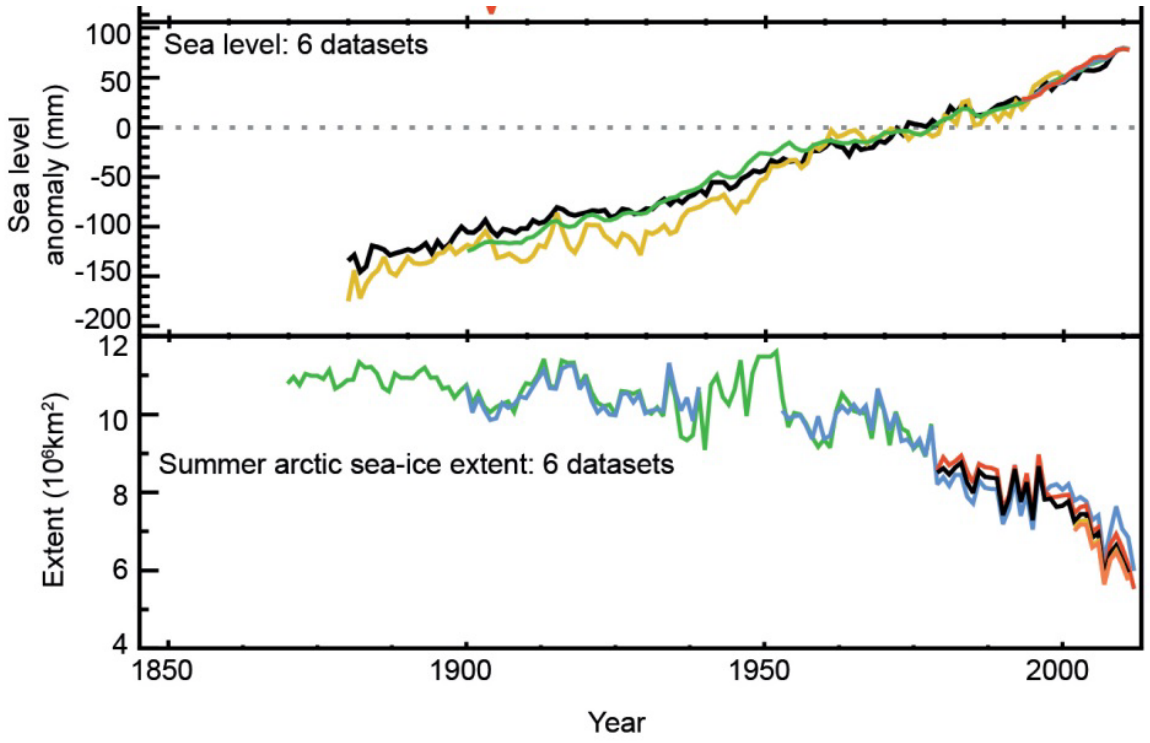




(d) Warm Days

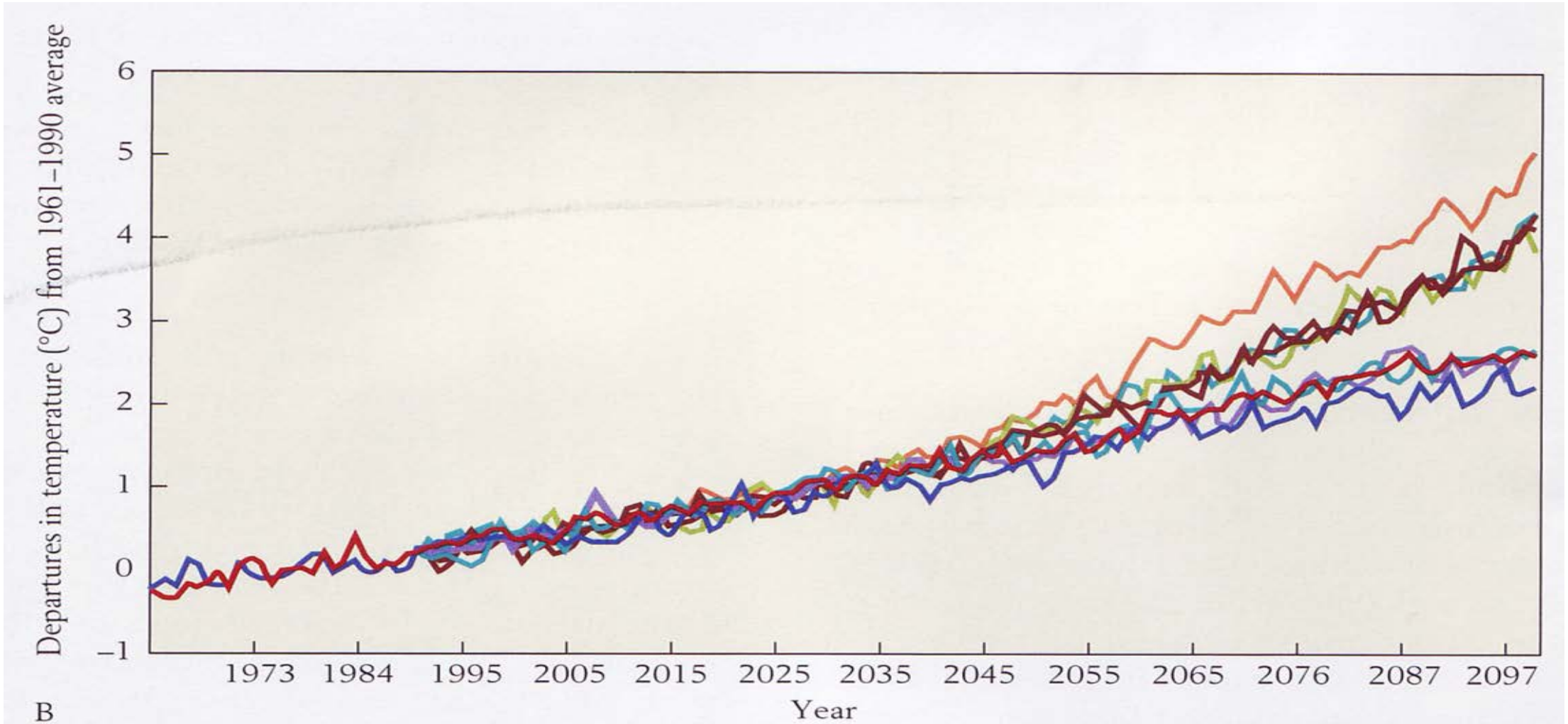


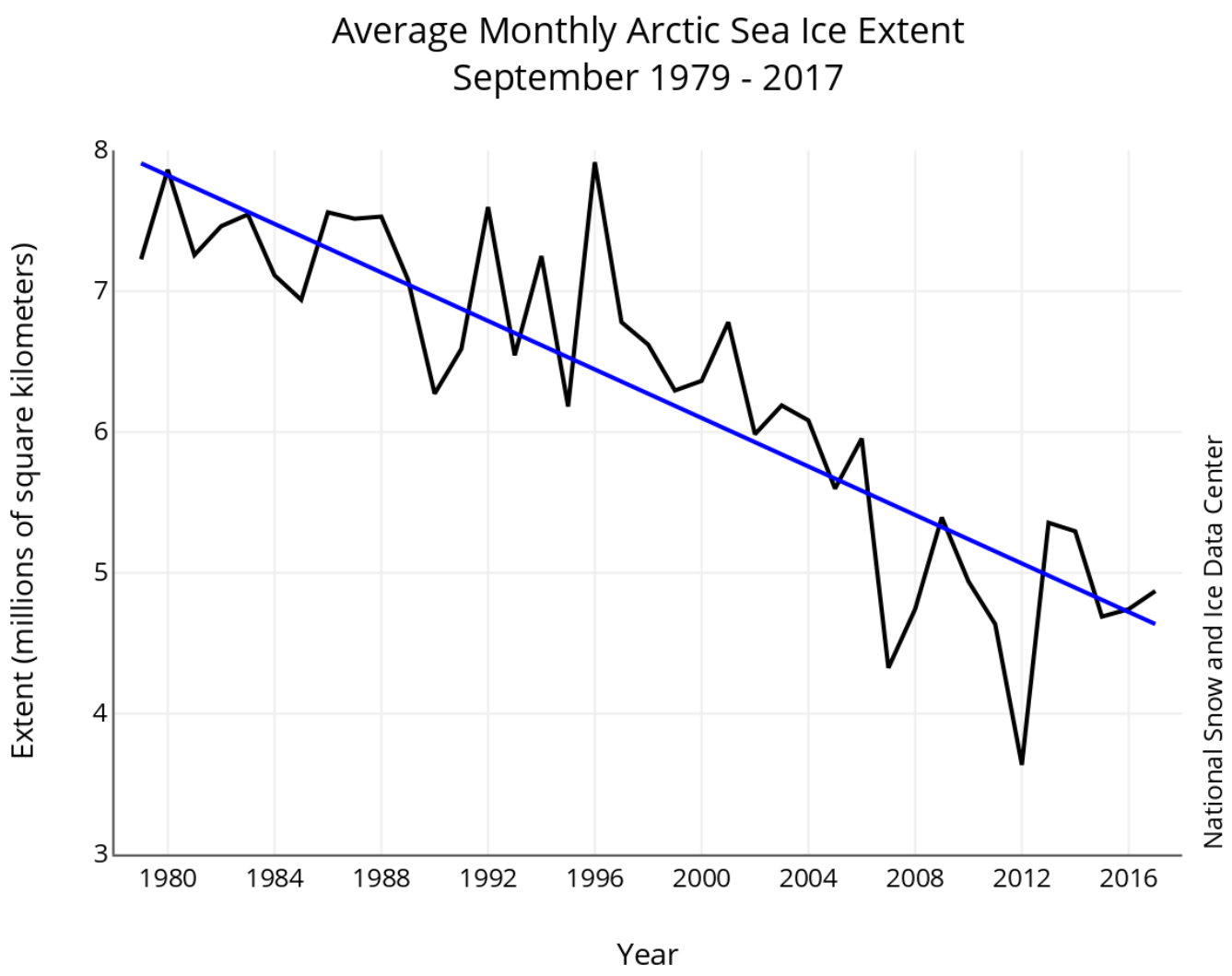

Land surface air temperature: 4 datasets
Sea-surface temperature: 5 datasets
Marine air temperature: 2 datasets
Temperature anomaly (°C)
1.0
0.5
0.0
-0.5
-1.0
0.4
0.2
0.0
-0.2
-0.4
-0.6
1850
1900
1950
2000
Year

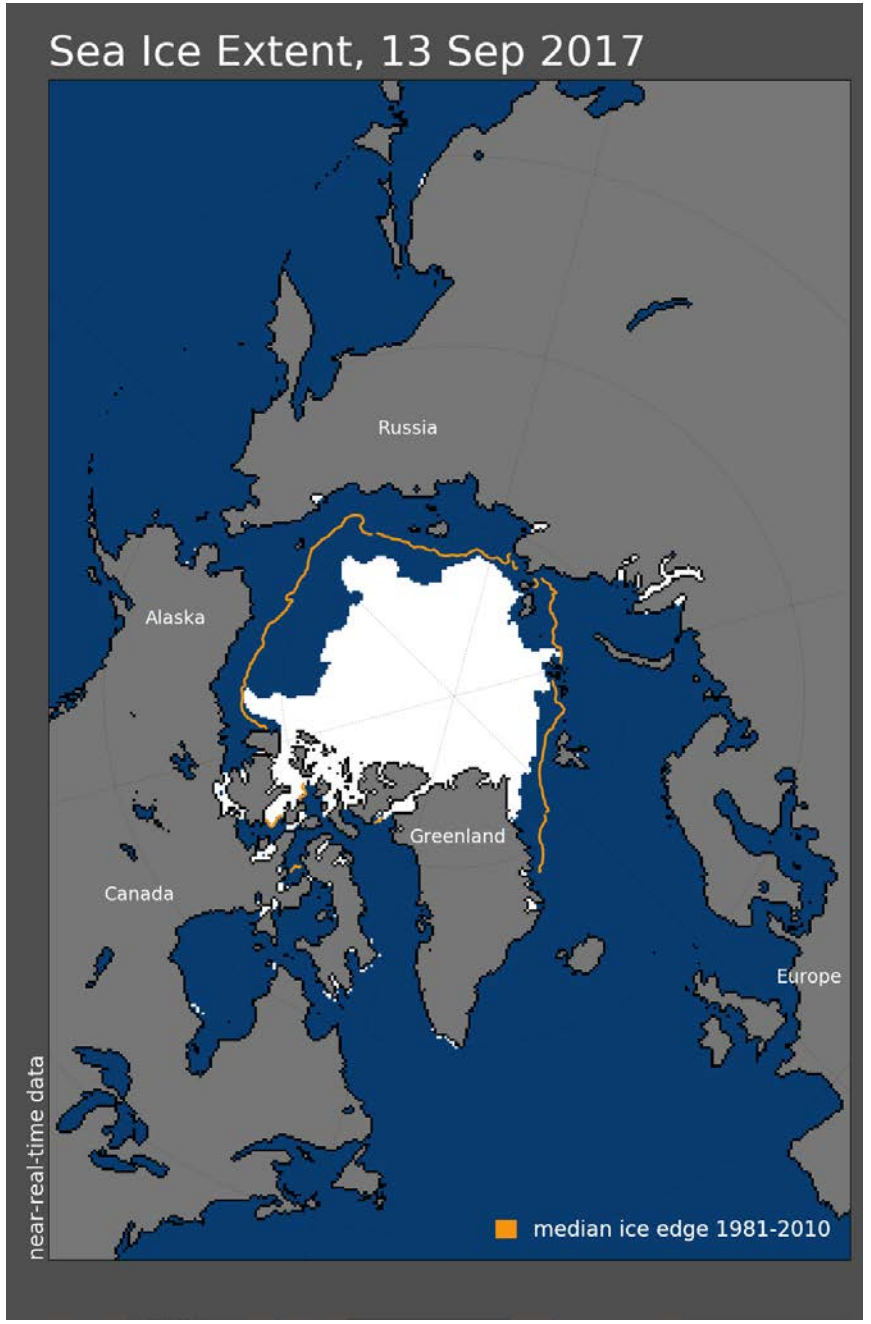

Sea level: 6 datasets
Sea level anomaly (mm)
100
50
0
-50
-100
-150
-200
Summer arctic sea-ice extent: 6 datasets
Extent ($10^6$km$^2$)
12
10
8
6
4
1850
1900
1950
2000
Year

IPCC 2013


Departures in temperature (°C) from 1961–1990 average
6
5
4
3
2
1
0
–1
1973
1984
1995
2005
2015
2025
2035
2045
2055
2065
2076
2087
2097
Year
B

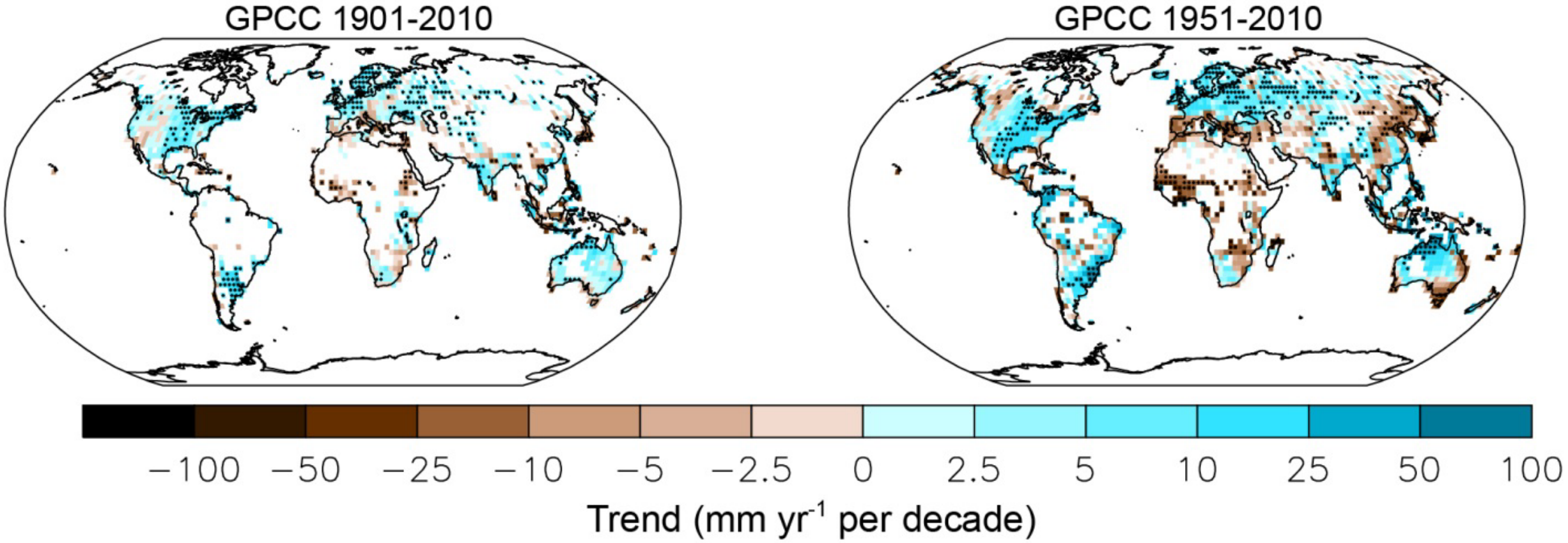
# Sea ice 1979-2017, September



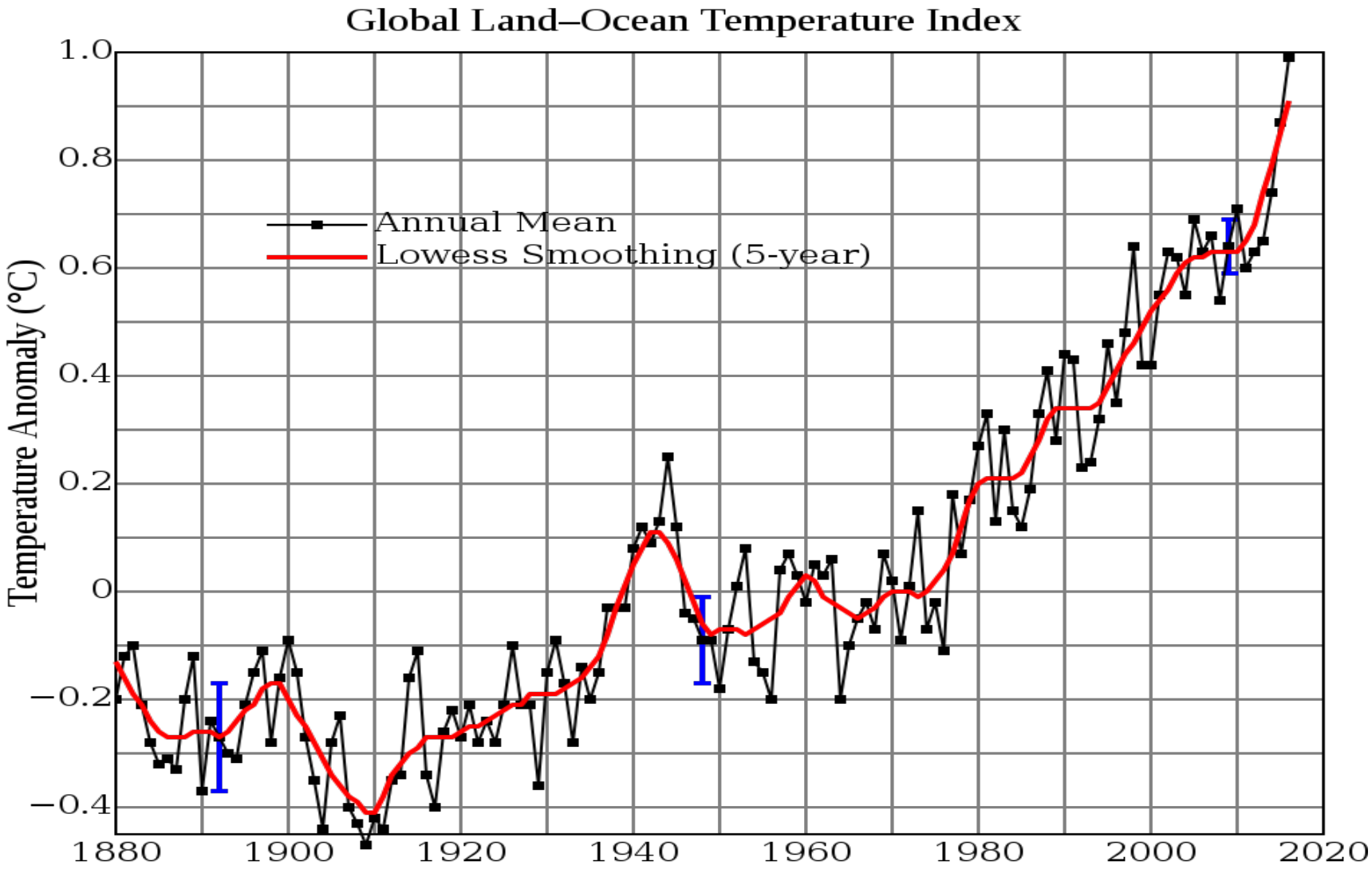

National Snow and Ice Data Center, USA, 2017

# Precipitation




Trends in annual precipitation over land from the GPCC data sets for 1901–2010 and 1951–2010. Source: IPCC 2013.

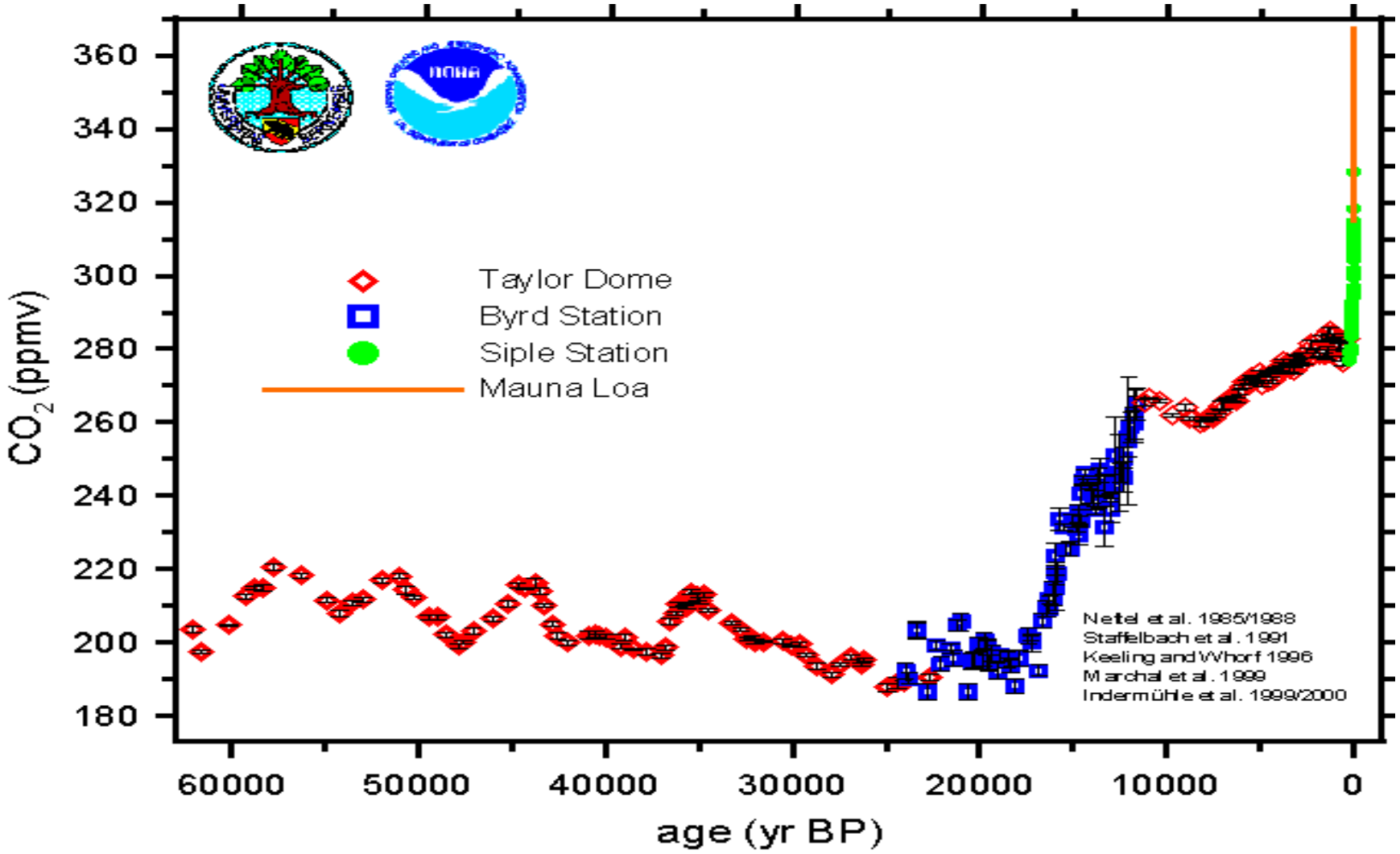
# Global temperature 1880-2016



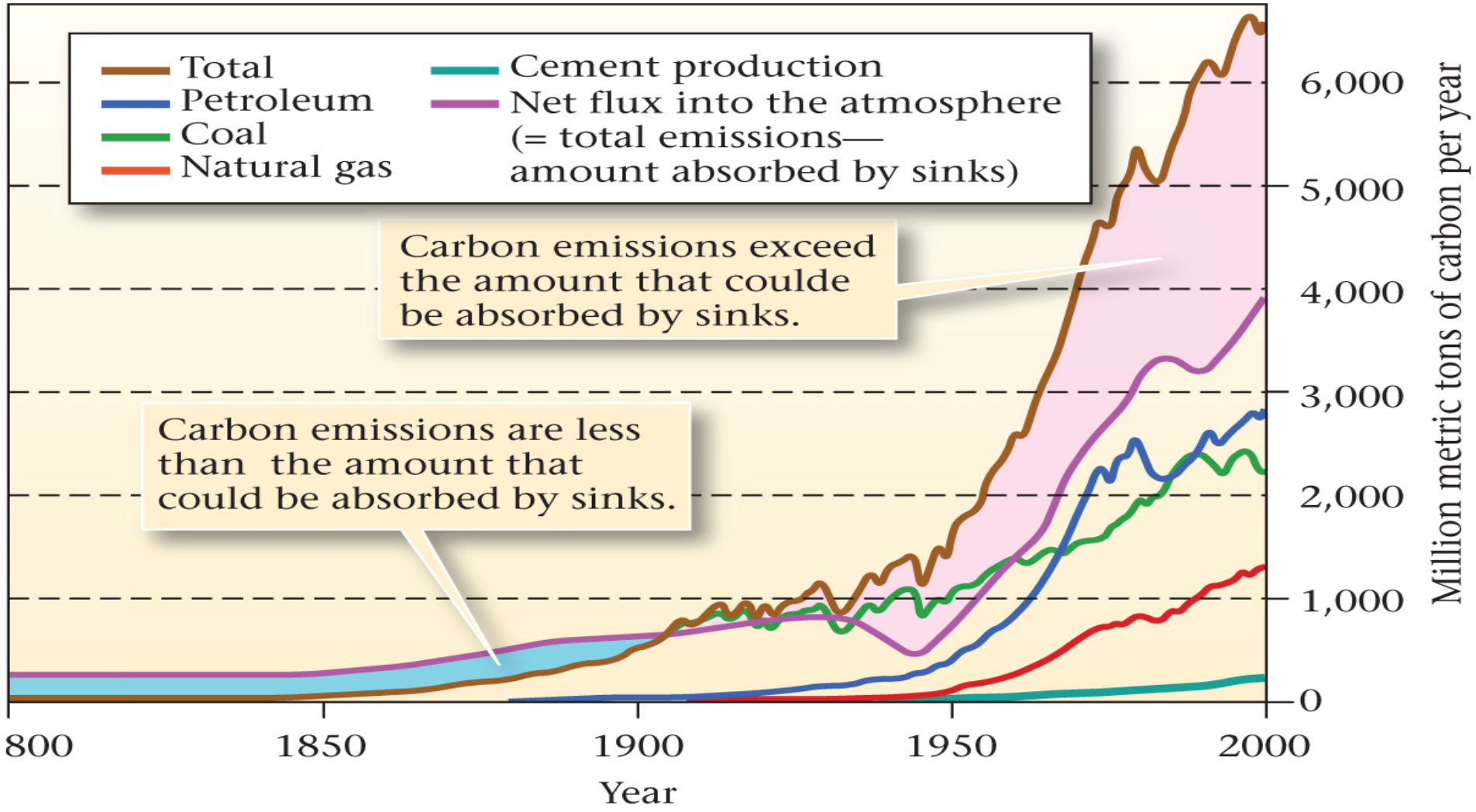

NASA Goddard Institute for Space Studies, 2016

# $CO_2$ i atmosfæren

Data fra Antarktiske iskerner




http://www.climate.unibe.ch/clim_recon/co2.html



# Expected outcome of Pillar 1

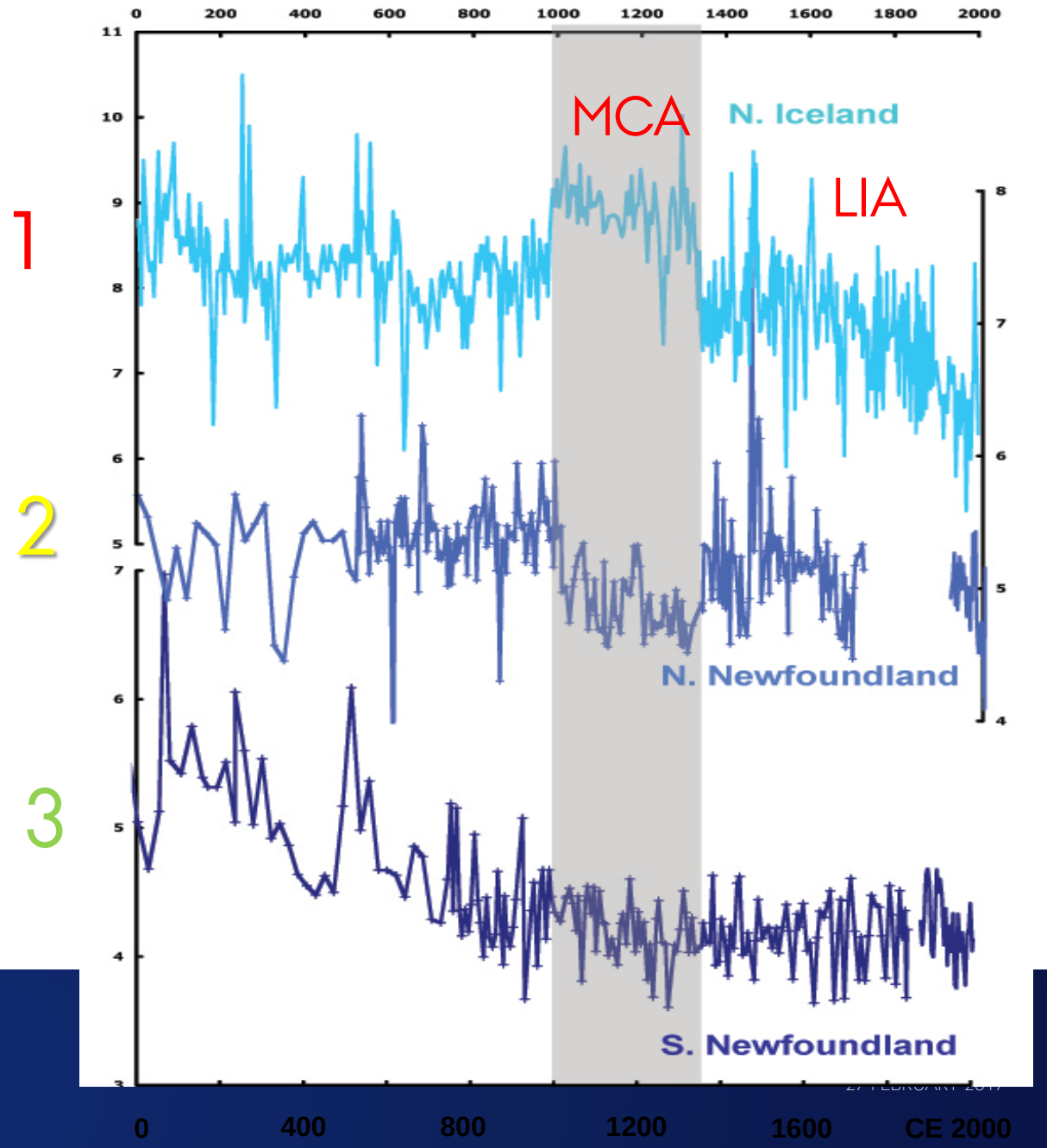
- A new state-of-the-art combined global air pollution and climate model to improve the scientific understanding of the climate change and air pollution interactions; focus on understanding the physics and chemistry of the atmosphere and the air-surface exchange.
- New laboratory and field experiments methods targeted at providing detailed understanding of key processes such as fluxes of climate gases, particle formation in different environments, gas phase oxidation of volatile organic compounds, etc.
- Experimentally based new climate change physical, chemical and (micro-)biological parameterizations for incorporation in climate models and chemistry-transport models.
- New validated model results based on the combined global air pollution and climate model, including new experimentally determined parameterizations concerning the important processes driving climate change.
- Interaction with pillar 4 on the role and importance of Arctic in global change and the possibility for regulation of short-lived climate forcers.
- Detailed maps at global, regional and national scale of climate change related parameters as well as the climate change pace (accelerating, moderate).
- Scenario and sensitivity runs with the combined model showing the importance of the different climate drivers and recommendations to stakeholders.

# Main Objectives of Pillar 1: Climate Drivers

To understand the forcing and drivers of the climate system from anthropogenic and natural origins at global, regional and national scales:

- How much and how fast is climate change evolving and what are the main unknown processes with respect to the drivers of the system?
- How is natural and human-induced forcings interacting?
- Is climate change accelerating or is the development more moderate?
- How big is the climate challenge really for humanity?

# Geographical differences


*Sicre et al., 2014 EPSL*