WHE+ Cherkassy WS, July 2017

Climate change impacts on water resources – adaptation for enhancing resilience

S.B.Weerakoon

Professor, University of Peradeniya

Climate

Climate is a measure of the average pattern of variation in meteorological variables in a given region over long periods of time.

Meteorological variables :
temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other

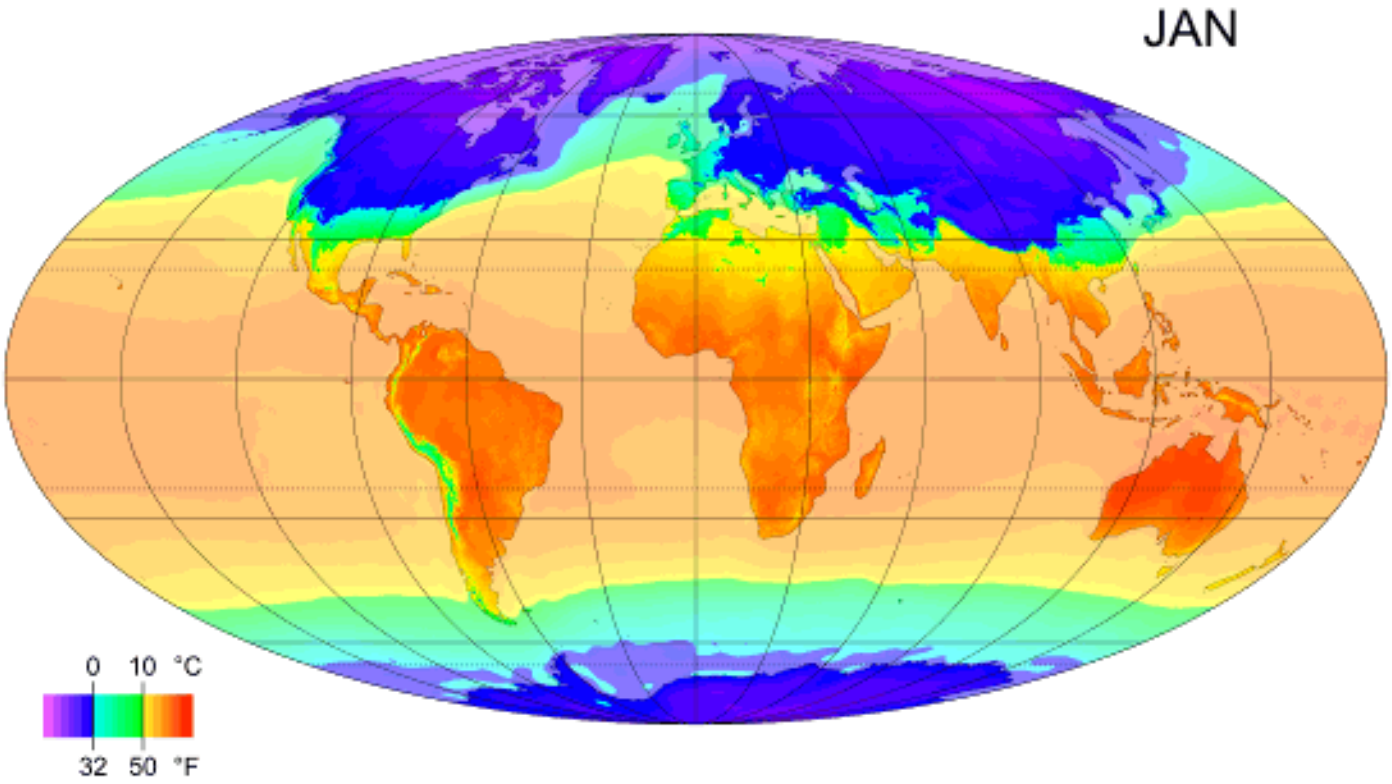
Climate is different from weather. Weather describes the short-term conditions of meteorological variables in a given region.

Climate

The climate of a location is affected by its latitude, terrain, and altitude, as well as nearby water bodies and their currents.

Climates can be classified according to the average and the typical ranges of different variables, most commonly temperature and precipitation.

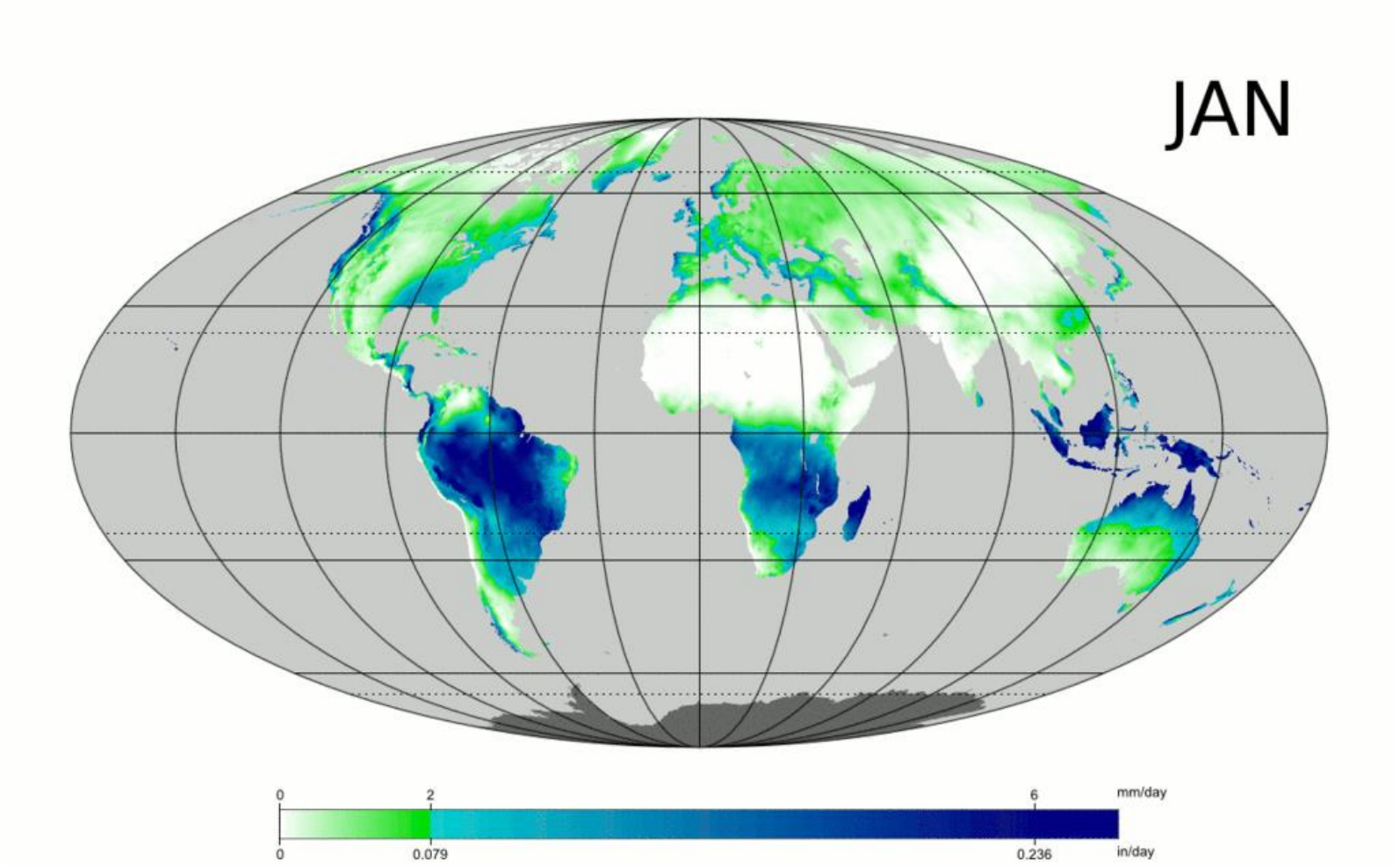
Monthly average surface temperatures from 1961–1990.



This is an example of how climate varies with location and season

http://en.wikipedia.org/wiki/Climate

Precipitation by month



http://en.wikipedia.org/wiki/Climate

Regional Climate

Region's climate is generated by the **climate system**, which has five components:

atmosphere,

Troposphere: 0 to 12 km , Stratosphere: ~to 50 km
Mesosphere: ~to 80 km, Thermosphere: ~ to 700 km
Exosphere: ~ to 10,000 km

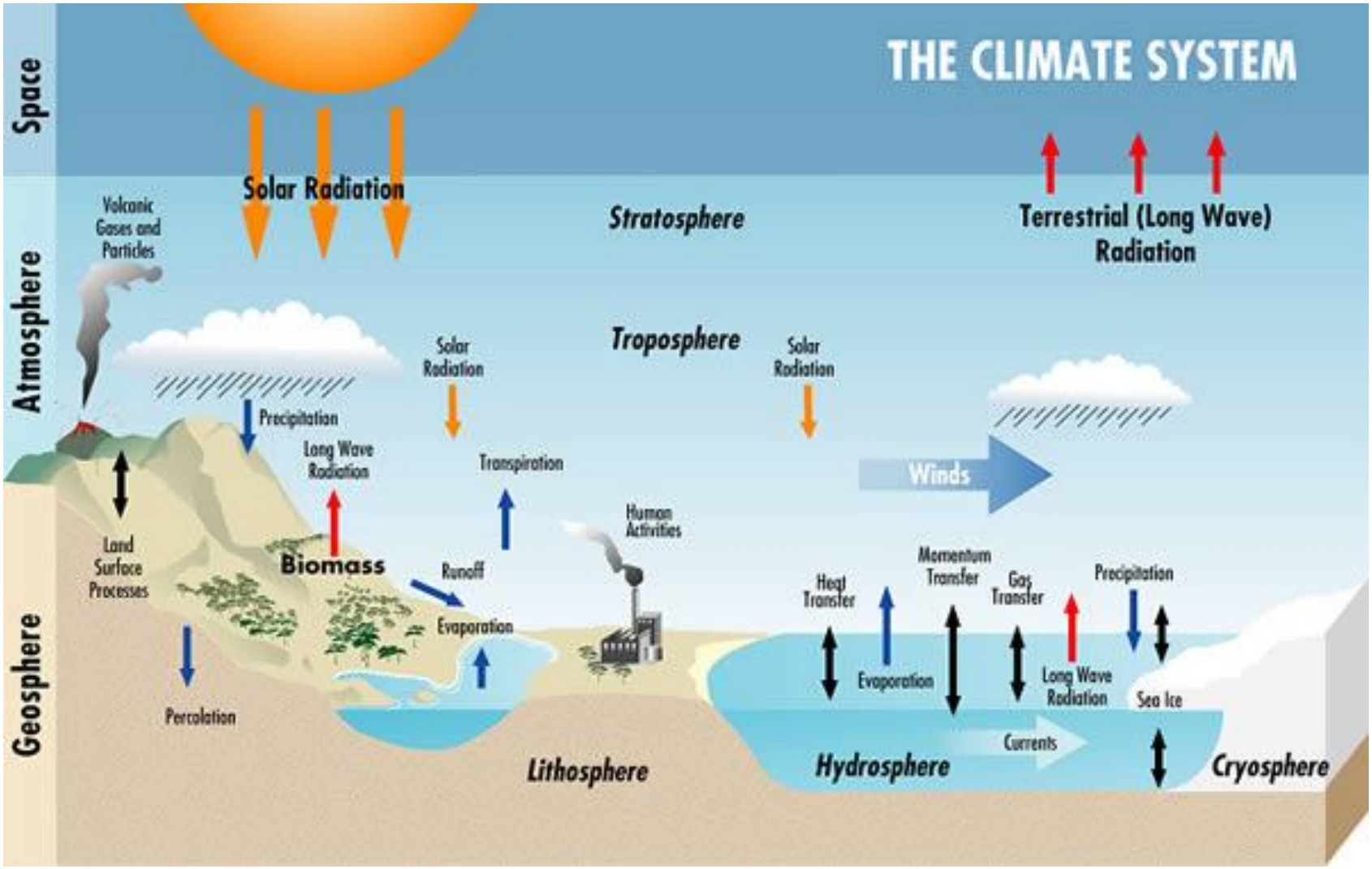
hydrosphere,

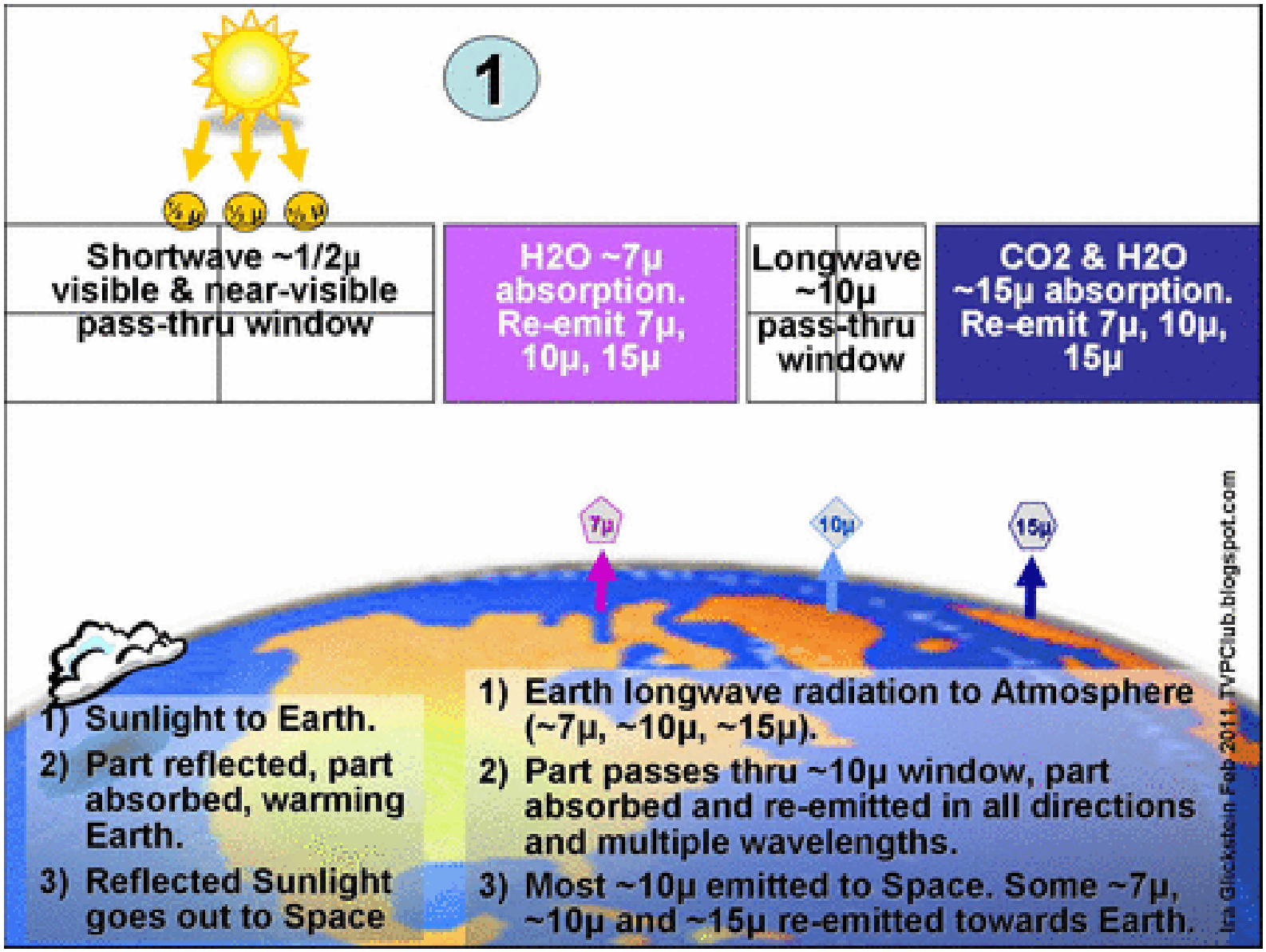
cryosphere, - earth surface where water is in solid form

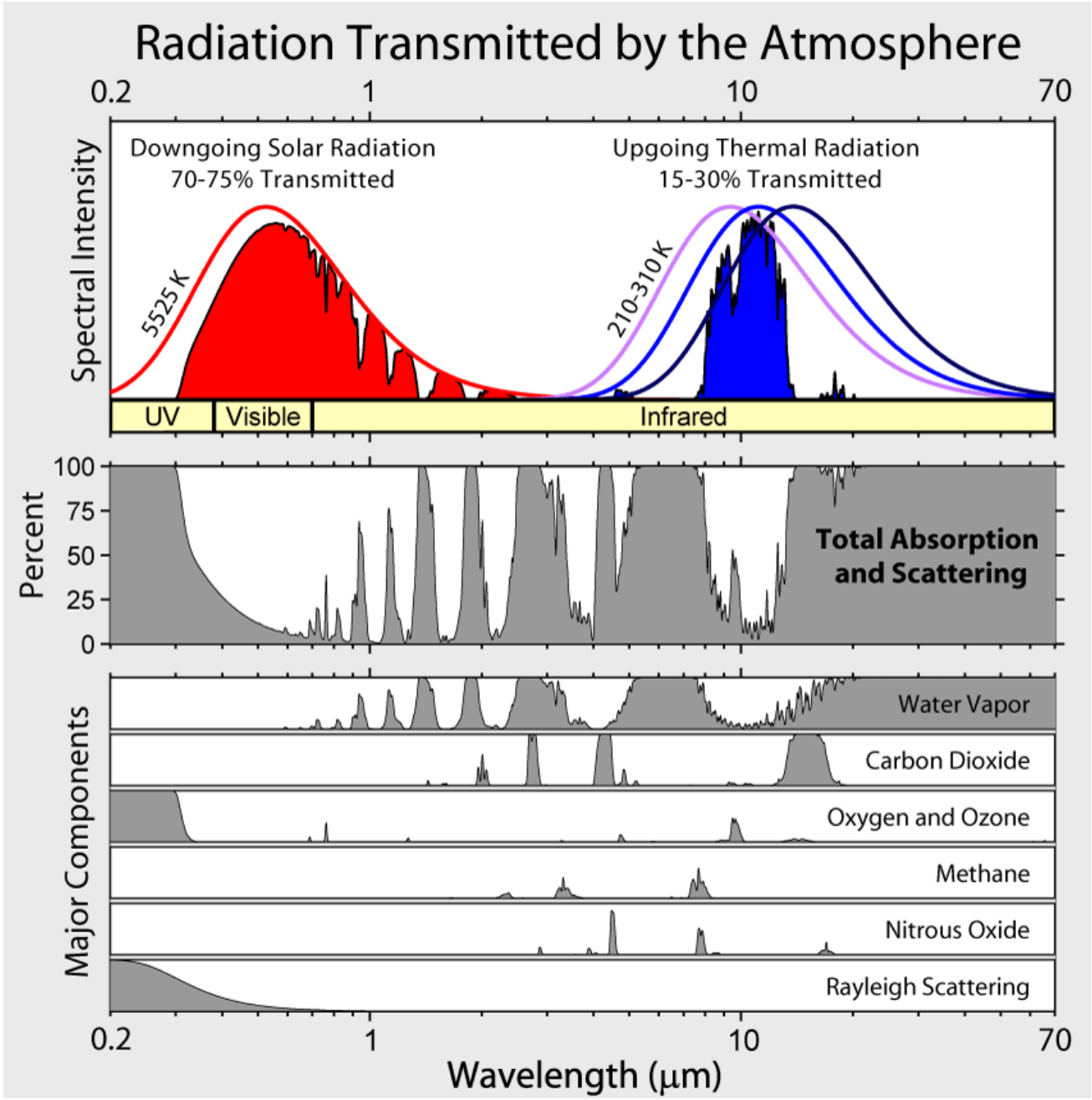
lithosphere, - earth crust and the uppermost mantle

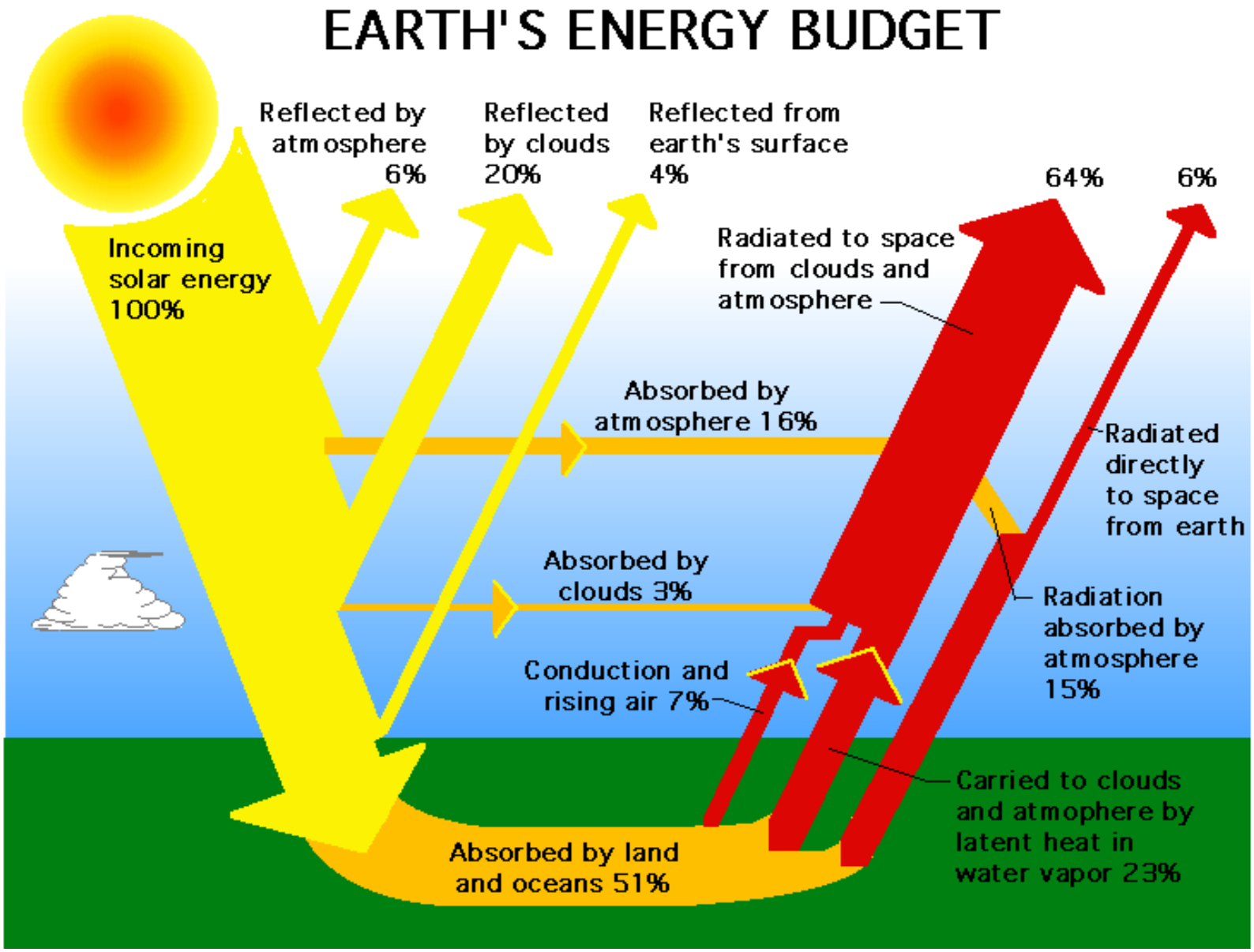
biosphere

Climate System

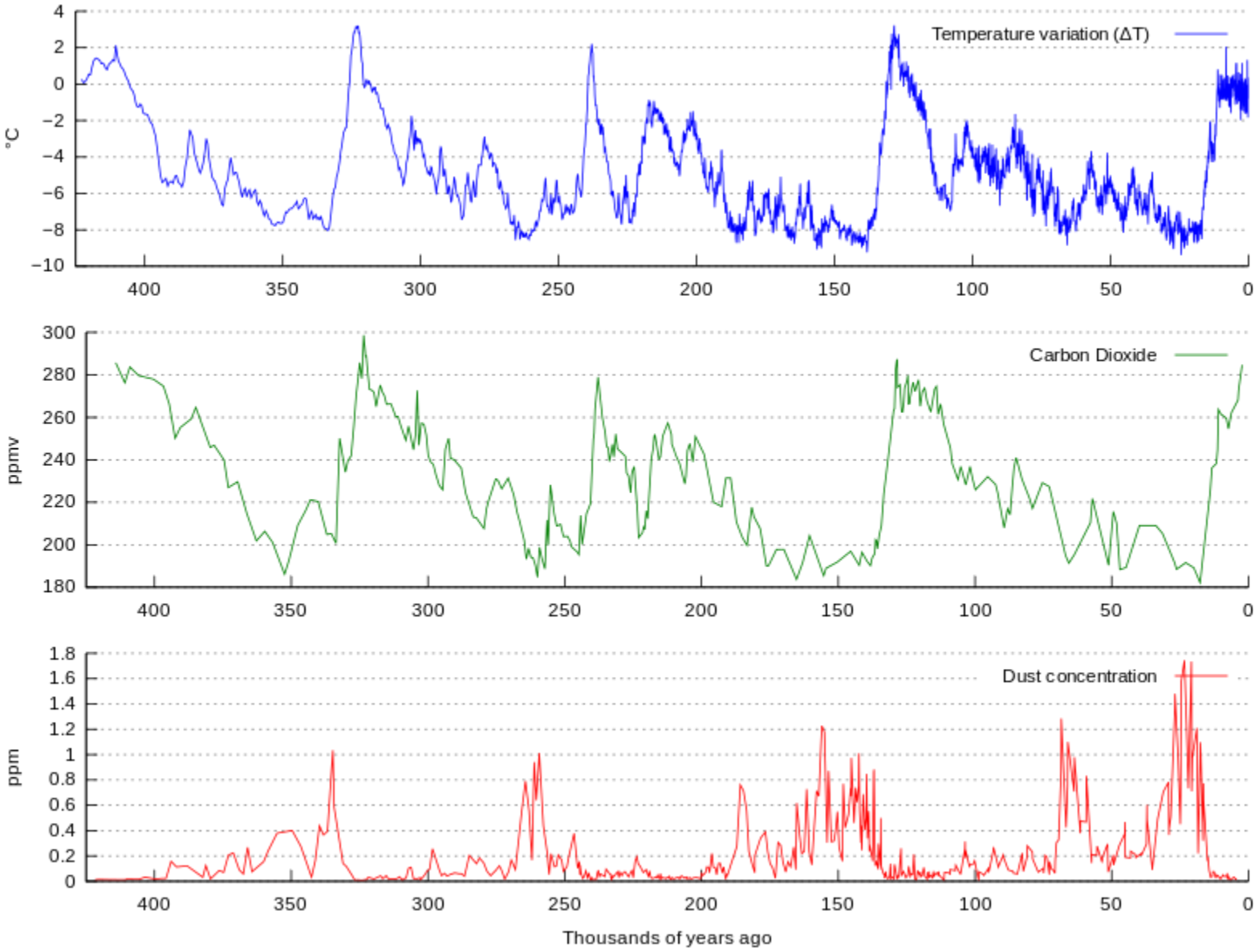



1
Shortwave ~1/2µ visible & near-visible pass-thru window
H2O ~7µ absorption. Re-emit 7µ, 10µ, 15µ
Longwave ~10µ pass-thru window
CO2 & H2O ~15µ absorption. Re-emit 7µ, 10µ, 15µ
7µ
10µ
15µ
1) Sunlight to Earth.
2) Part reflected, part absorbed, warming Earth.
3) Reflected Sunlight goes out to Space
1) Earth longwave radiation to Atmosphere (~7µ, ~10µ, ~15µ).
2) Part passes thru ~10µ window, part absorbed and re-emitted in all directions and multiple wavelengths.
3) Most ~10µ emitted to Space. Some ~7µ, ~10µ and ~15µ re-emitted towards Earth.
Ira Glickstein Feb 2011 TVPClub.blogspot.com


Radiation Transmitted by the Atmosphere
0.2
1
10
70
Spectral Intensity
Downgoing Solar Radiation
70-75% Transmitted
Upgoing Thermal Radiation
15-30% Transmitted
5525 K
210-310 K
UV
Visible
Infrared
Percent
100
75
50
25
0
Total Absorption and Scattering
Major Components
Water Vapor
Carbon Dioxide
Oxygen and Ozone
Methane
Nitrous Oxide
Rayleigh Scattering
0.2
1
10
70
Wavelength (μm)



http://science-edu.larc.nasa.gov/EDDOCS/whatis.html



Variations in temperature, CO2, and dust from the Vostok ice core over the last 400,000 years

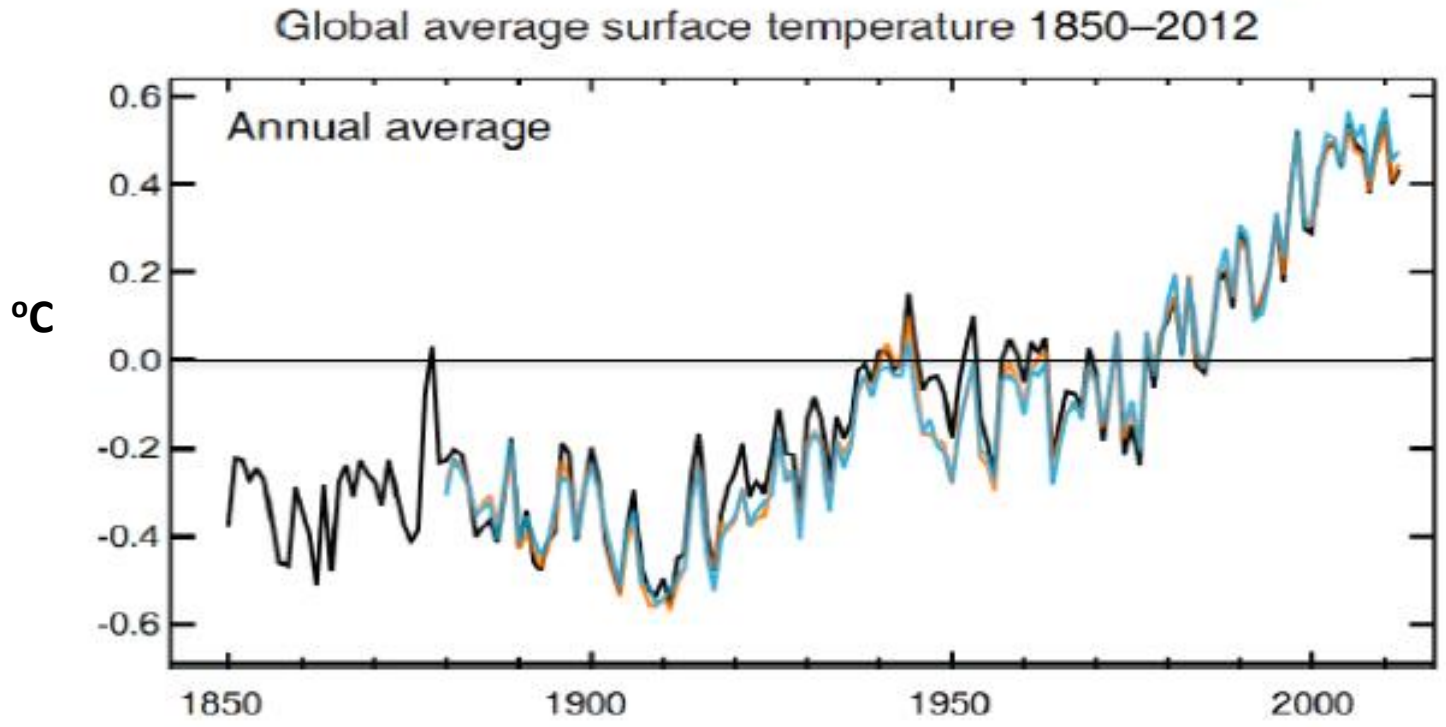
United Nations Framework Convention on Climate Change

"A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods"

Evidence of Global Temperature Increases Since 1900

- Recorded temperature changes
- The observed rise in sea level of 4-8 inches
- The shrinkage of mountain glaciers
- Reduction of northern hemisphere snow cover
- Increasing sub-surface ground temperatures

Annual Global Combined Land and Sea Temperature



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

Fig .1 GMST anomaly (IPCC 2013)

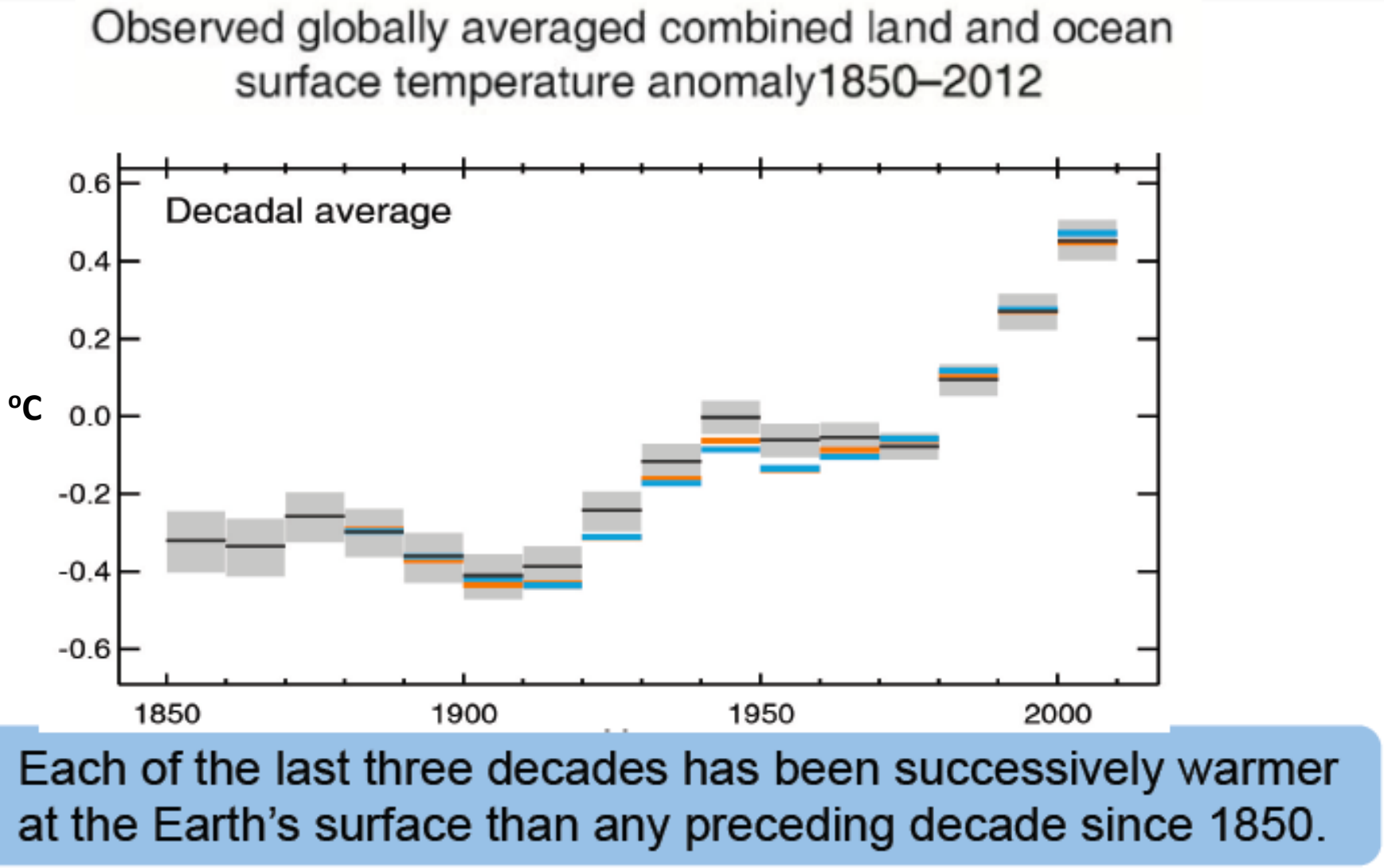
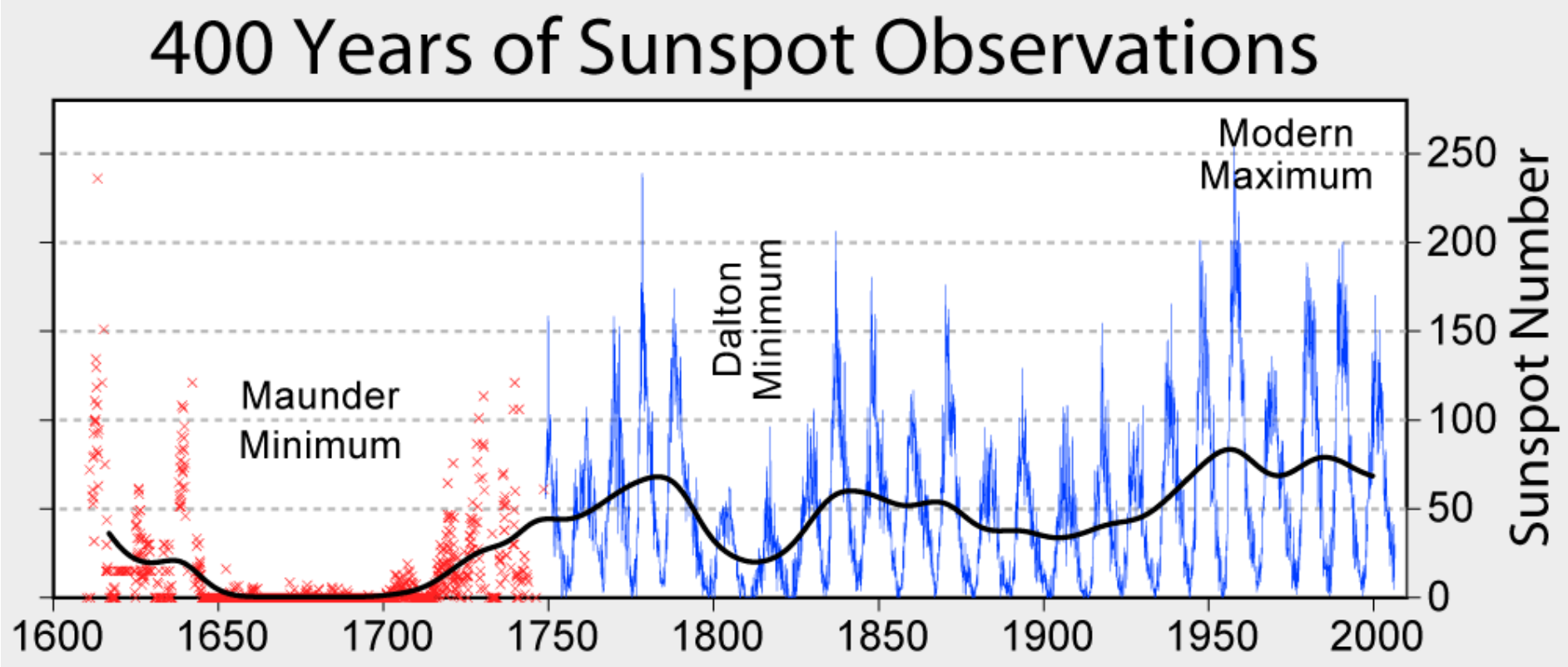


Fig . 2 Decadal averaged GMST anomaly (IPCC 2013)



400 year history of sunspot numbers.

Changes in solar brightness are considered to be too weak to explain recent climate change

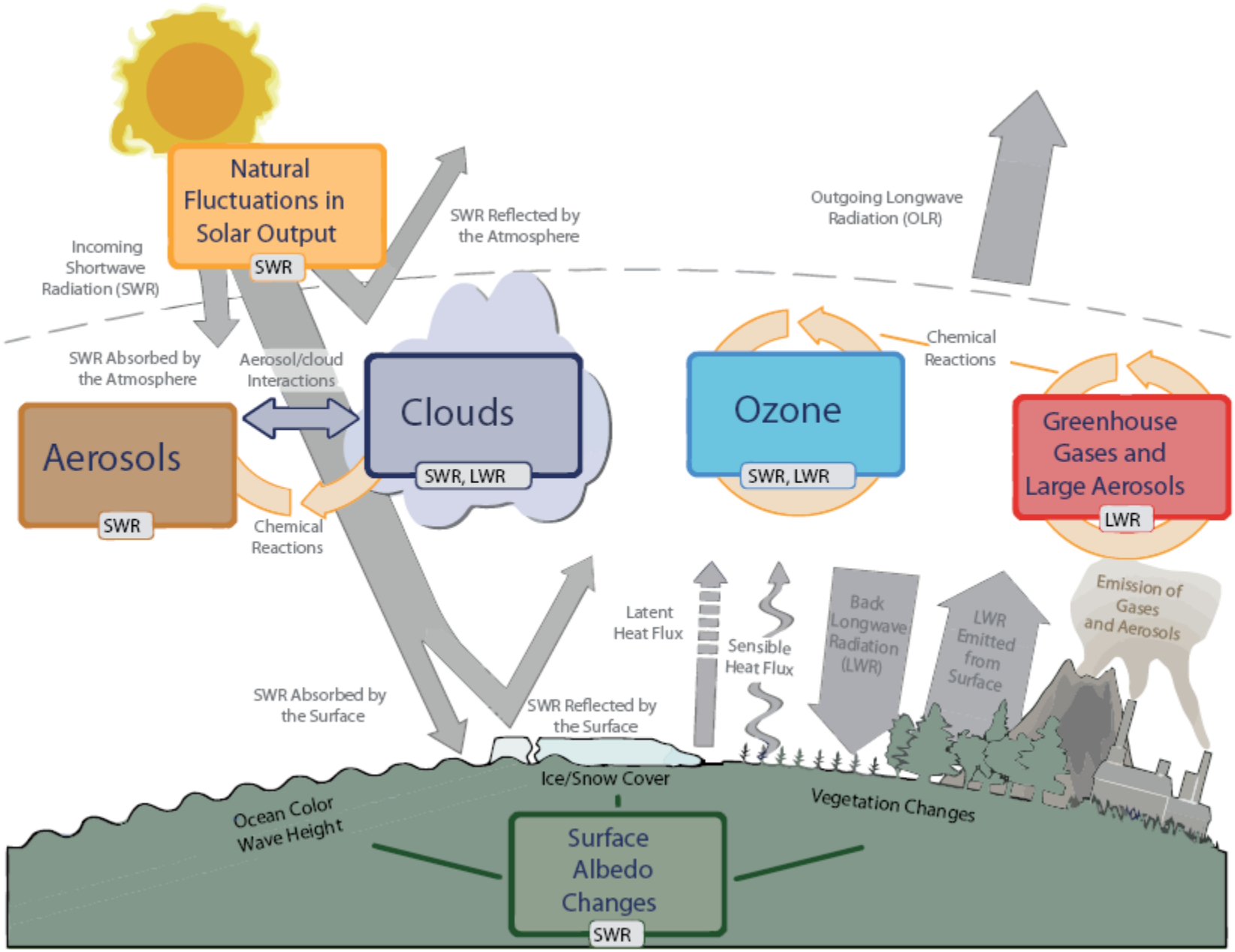


Fig . 3 Transfer of radiative energy (IPCC 2013)

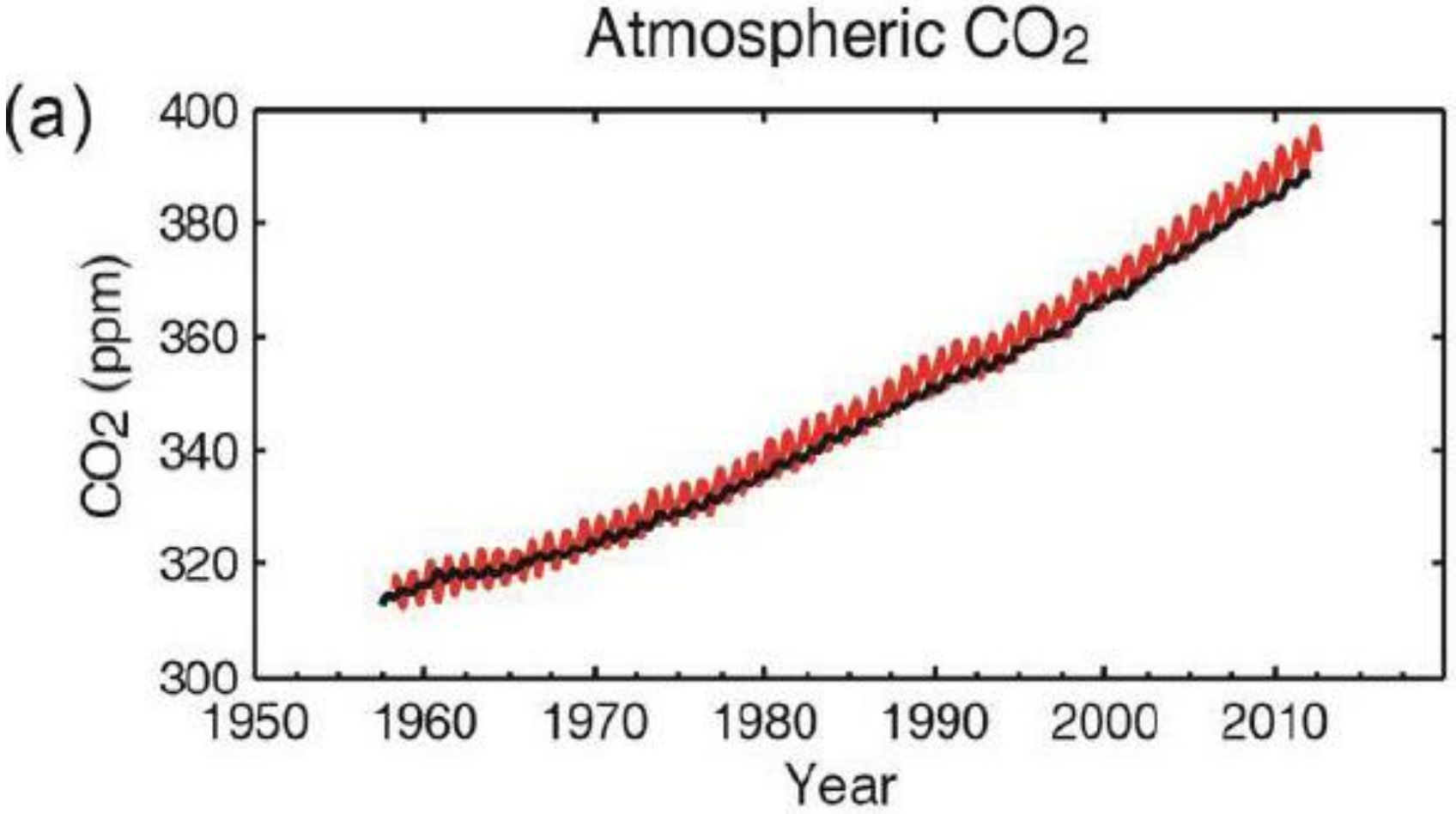


Fig . 6 Anthropogenic CO2 contents in the atmosphere (IPCC 2013)

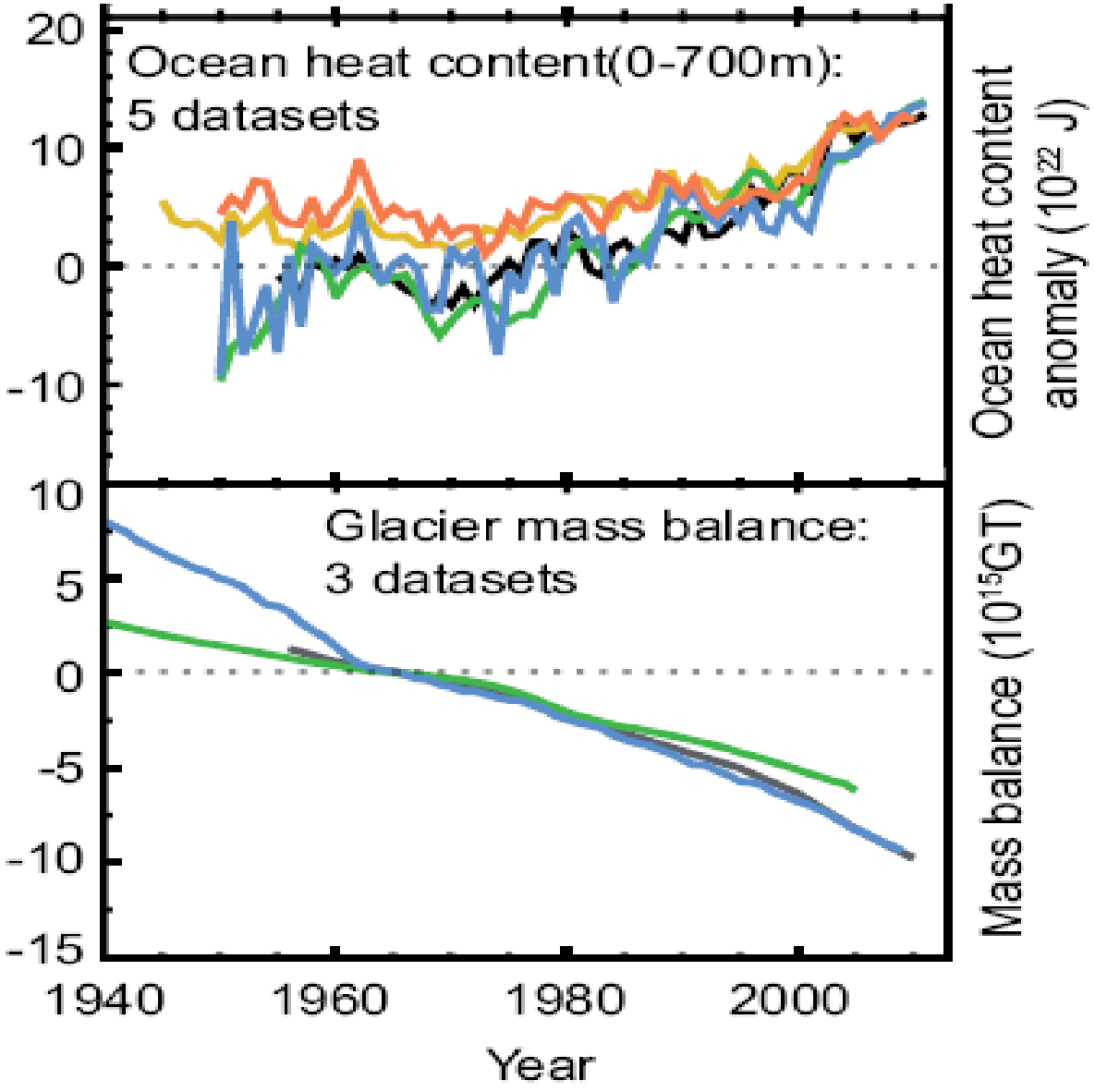
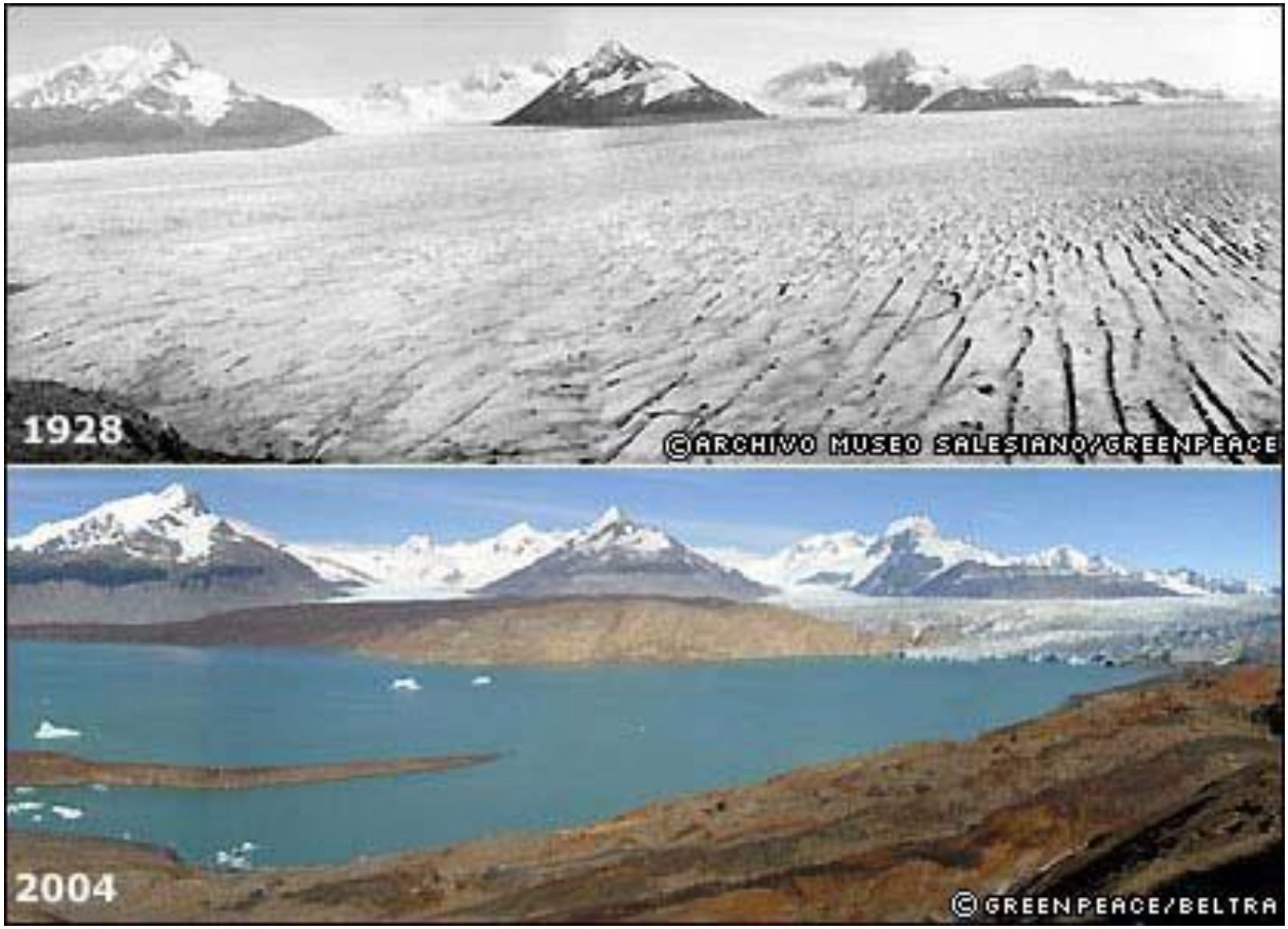
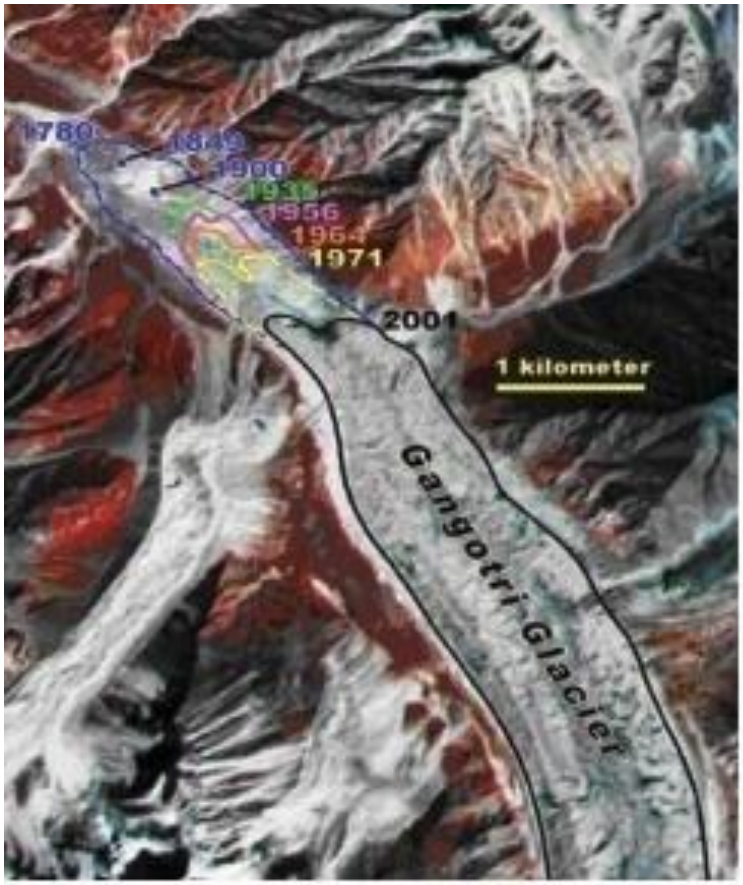


Fig . 7 a) Ocean heat content anomaly
b) Glacier mass balance anomaly (IPCC 2013)



UPSALA GLACIER (Argentina)

Glaciers in Himalaya



Composite satellite image of the Gangotri Glacier terminus has retracted since 1780 (courtesy of NASA EROS Data Center, 9 September 2001).

Glaciers in the Himalaya
- store about 12,000 km^3 of freshwater, are receding and thinning
- supports perennial rivers such as the Indus, Ganga and Brahmaputra which, in turn, are the lifeline of millions of people (IPCC)

Fig . 8 c) Losses of glacier Himalaya (IPCC 2007)

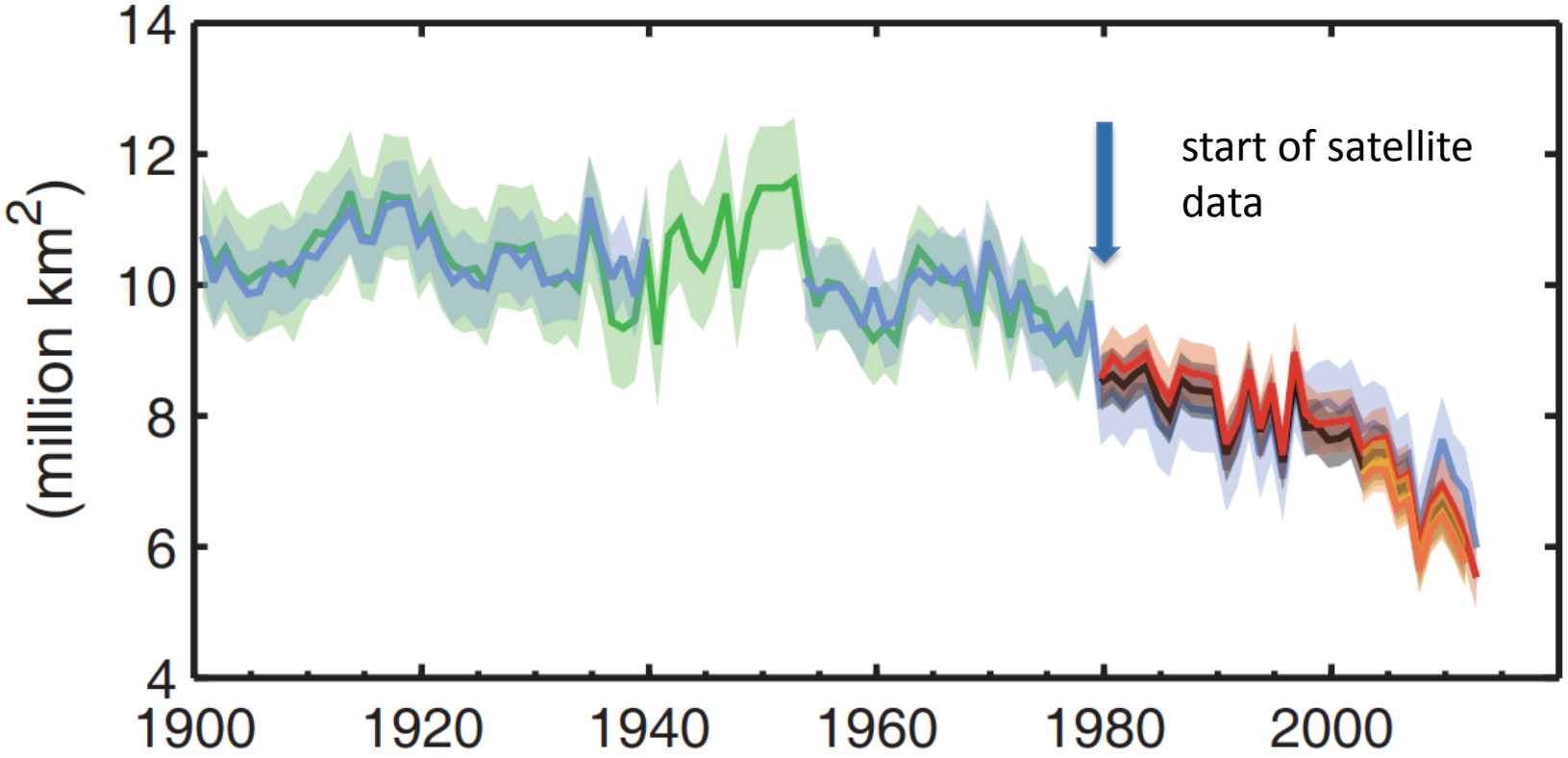


Fig . 9) Annual mean Arctic summer sea ice extent - 3.5-4.1% per decade in 1979 – 2012 decrease (IPCC 2013).

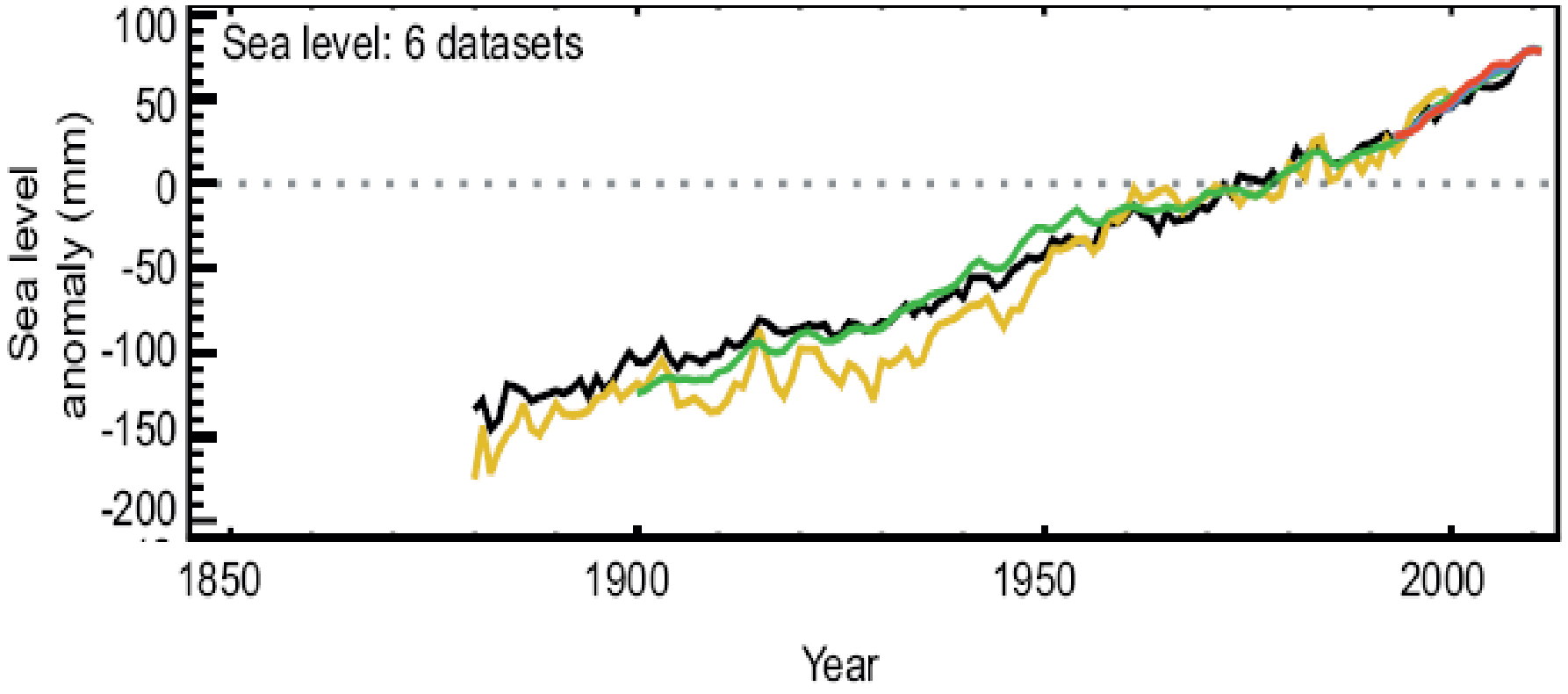


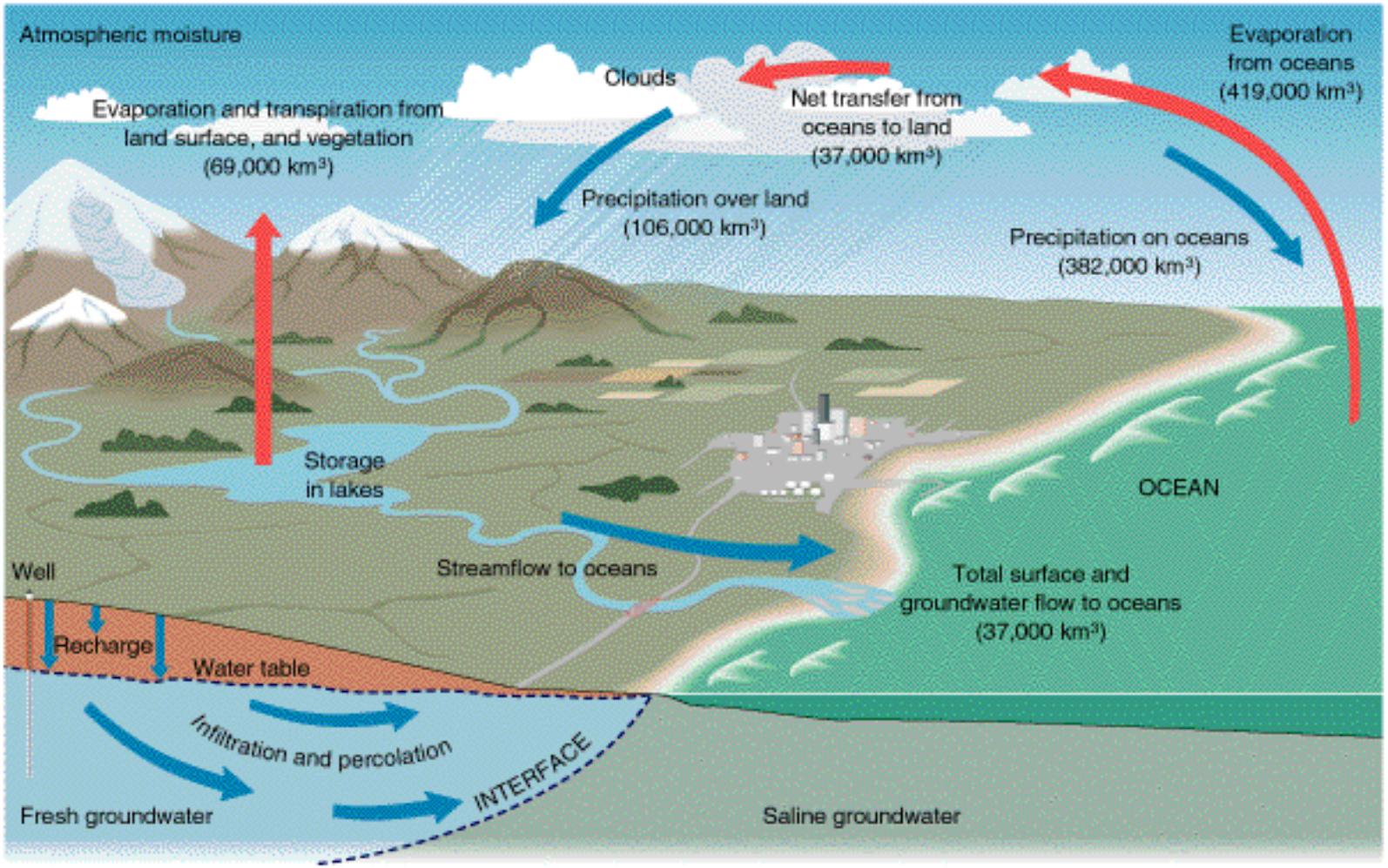
Fig . 9) Mean sea level rise (IPCC 2013)

Climate Change Impacts

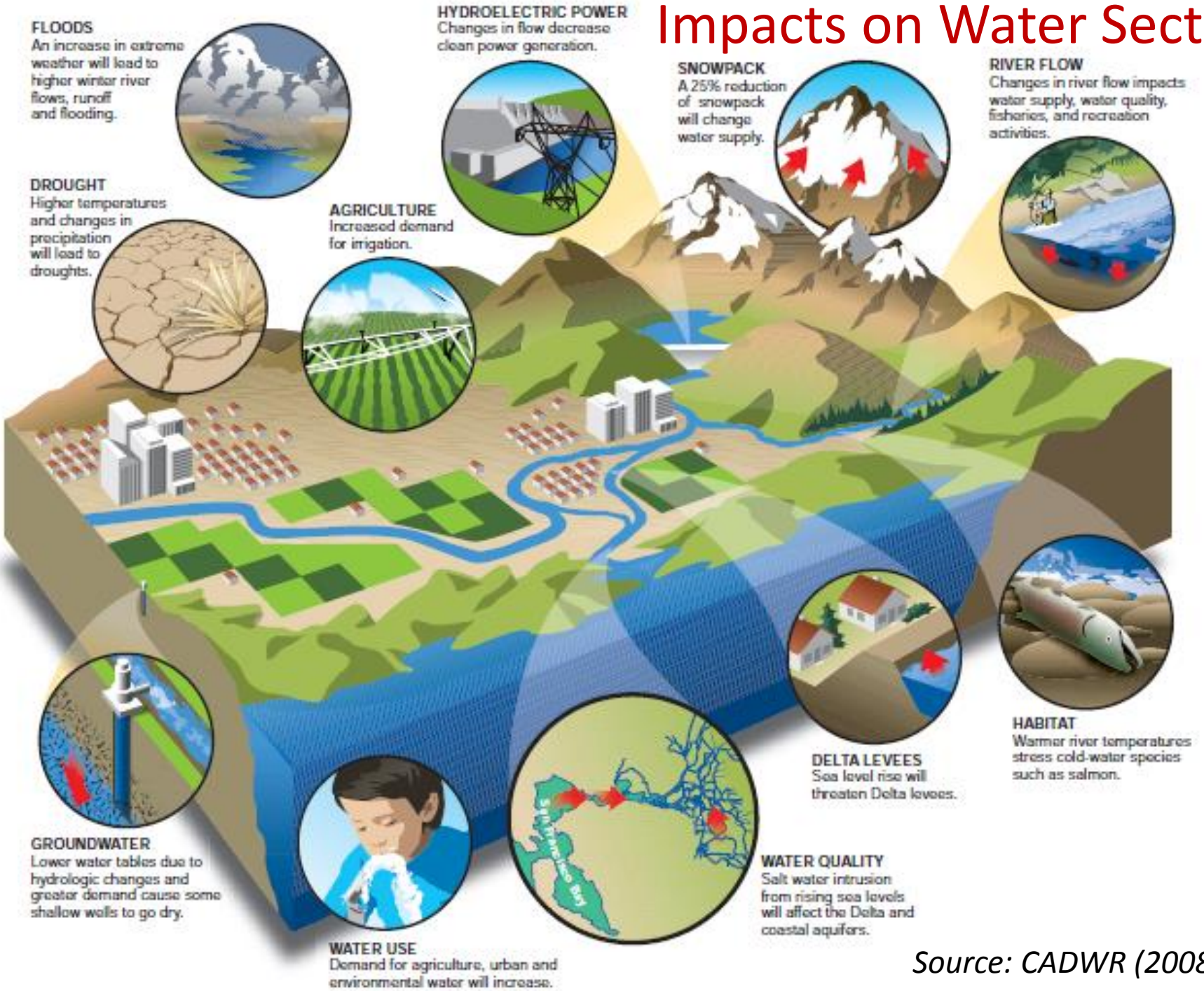
The impacts and risks associated with these changes are real and are already happening in many systems and sectors essential for human livelihood, including water resources, food security, energy security, coastal zones and health

An estimated 200 million people could be displaced as a result of climate impacts climate-related disasters by 2050 (IPCC 2007)

Impacts on Water Resources - Hydrologic cycle



Impacts on Water Sector



Source: CADWR (2008a).

Impacts on Water Sector

Extreme events

Hydrologic extreme events (Floods and droughts) will be more frequent.

Sea level rise

Inundate low lying areas, and increase the salinity of rivers, bays and aquifers.

- The devastating effects of extreme events, temperature increases and sea level rise have consequences for all, particularly the poor, and will only worsen in the future

Impacts on water supply

Impacts on water quantity

Frequent high precipitations lead to

- high discharges in rivers/ higher water levels in reservoirs affecting intake infrastructure
- Increased flooding incidences in facilities
- Increased damages to the distribution systems

Reduce flows due to frequent droughts/low precipitation lead to

- less inflows to sources of water intakes
- restriction of water users caused by increased conflicts over water rights related to base flow in streams

Increased temperatures will result

- higher evapotranspiration rates
- increase demands for landscape, irrigation, human consumption, cooling water

Impacts on water supply

Impacts on water quantity

Increased air temperatures

- biological and chemical degradation of water quality
  - by increased solubility and concentrations of contaminants in fresh water
- enhanced growth of algae, microbes, parasites, and invasive species.

Increased sea level rise

- salt water entrainment to water sources
- mixing of pollutants with fresh water due to inundation

Frequent extremes of precipitations

- High sediment discharges, pollutants accompanied by increased runoff

Impacts on wastewater treatment

- Water courses could have a lower dissolved oxygen content leading to tighter discharge consent standards
- Potential for odour generation in warmer conditions
- Prolonged wet periods may restrict sludge to land recycling route
- Stringent standards for reduction of greenhouse gas emissions
- Increase of investment needs (energy use, processes,) of treatment

Impacts on wastewater treatment

- Warmer weather may have a positive effect on biological treatment processes, which operate more effectively at higher temperatures
- Flooding on wastewater treatment facilities, interruption to service
- Sea water level will make it difficult to discharge treated water under gravity

Climate Change Mitigation and Adaptation

There are two main responses to climate change,

- climate change mitigation
  - cutting the emissions that cause climate change
- climate change adaptation
  - preparing for the impacts of climate change.

IPCC has defined climate adaptation

"adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities”.

Adaptation

UNFCCC Nairobi Work Program

- Climate modelling, scenarios and downscaling–
  Promoting the development of, access to, and use of information and data on projected climate change.

- Climate related risks and extreme events –
  Promoting understanding of impacts and vulnerability, emphasizing current and future climate variability and extreme events, and the implications for sustainable development.

Adaptation – water sector

Adaptation is a local issue

– Depends on geographical, climatic, bio-physical as well as socio-economic characteristics

Adaptation options are many, including:

Structural options :

- Dikes (embankments, levee), sewer networks, drainage
- Retention pond for artificial recharge, dams
- Desalination technology
- Coastal wall, flood proofing
- Green Buildings

Adaptation - water sector

Adaptation options are many, including:

Non-Structural options **:**

- National and sectoral policies
- Demand management, water pricing
- Efficient water use, reuse
- Salt and drought resistance crops
- Watershed management
- Early warning systems, flood mapping
- Insurance
- Awareness campaign

Adaptation of water supply systems for climate resilience

- Proper water supply management.

  Reducing water loss through leakages

  Reduce water usage - proper billing and reducing water theft (unpaid

- Assess the flood levels and make the water intakes/ treatment facilities flood proof/ OR relocate
  - Make structures to be safe against extreme events (floods, coastal storms)

Adaptation of water supply systems for climate resilience

- Risk of failure of operation

  plan for emergency options

- Improve water resources managements:

  catchment management practices

  distributed surface/subsurface water storage

Adaptation of water supply/wastewater system for climate resilience

- Upgrade existing water infrastructure and management practices due to uncertainty of projected hydrological changes

  Statistical parameters of hydro-meteorological data series are not stationary. Historical hydro-meteorological data become not useful to make projection. Modern tools considering climate change projection would be necessary

  Design criteria on stormwater inflows different return periods to be redefined

Improve resilience in water sector

- Improve distributed surface/subsurface water storage , recharge soil moisture

  Distributed storages

  Store seasonal high runoff , increase recharging groundwater, wetlands, to surface storage (from small to larger reservoirs) where possible

- Extreme events will increase soil erosion,

  Siltation

Catchment management practices


Thank you