IWRM as a Tool for Adaptation to Climate Change

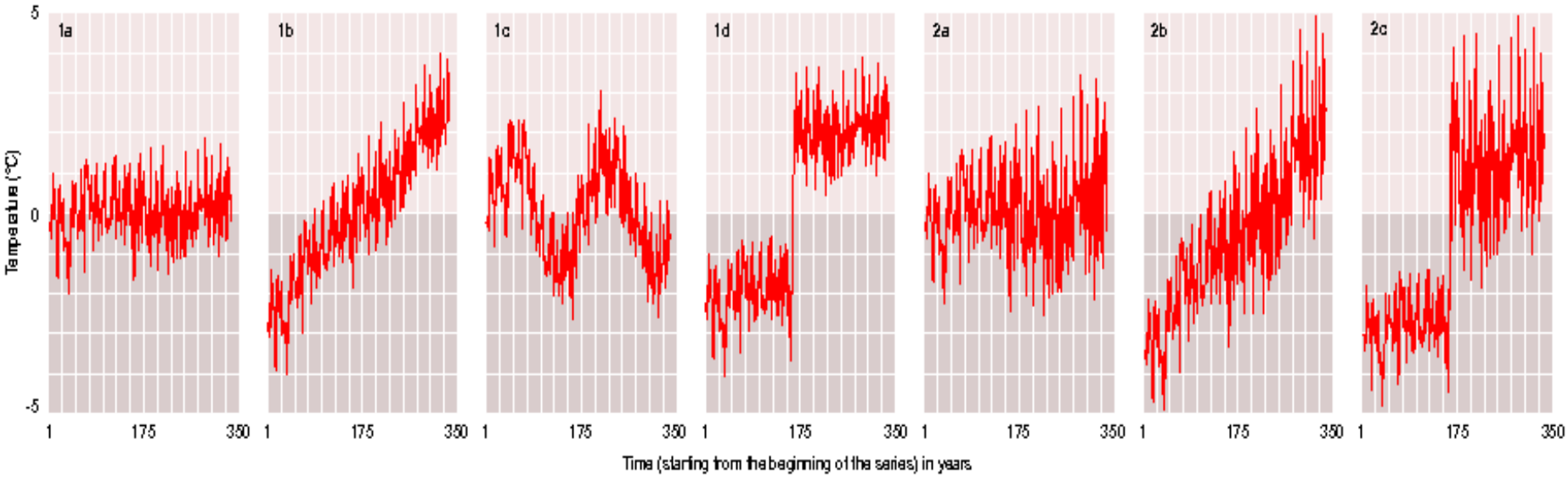
Drivers and Impacts of Climate Change

Outline presentation

This session will address:

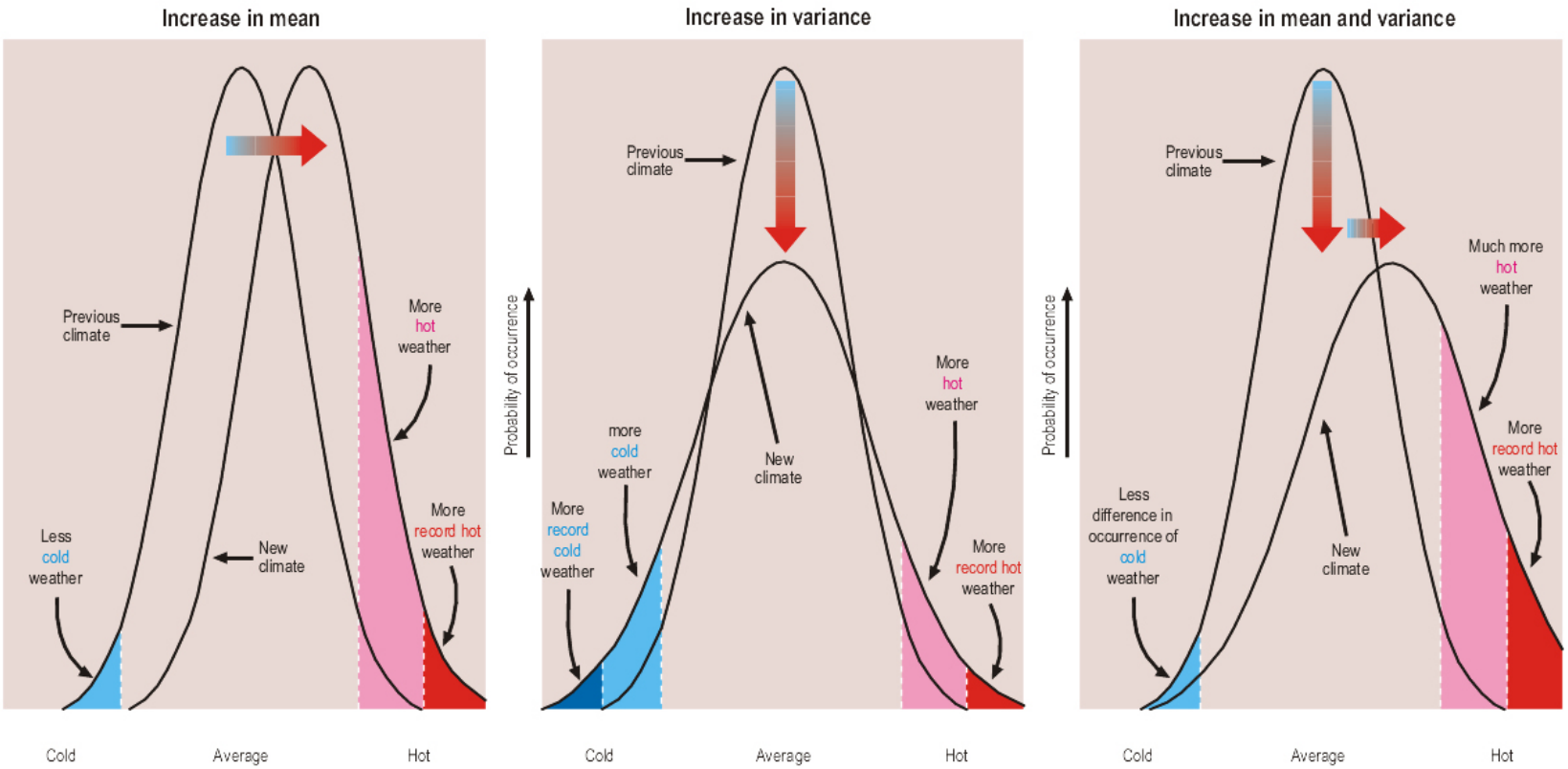
- The drivers/physical science basis of climate change
- The observed and projected impacts on the water cycle
- The consequences for water use and ecosystem functioning.

Climate variability and climate change



- 1a – An example of Temperature variability; fluctuates from observation to observation around a mean value
- 1b to 1d – Combined variability with climate change
- 2a – An increase of variability with no change in the mean
- 2b and 2c – Combined increased variability with climate change.

Impact on probability distributions for temperatures

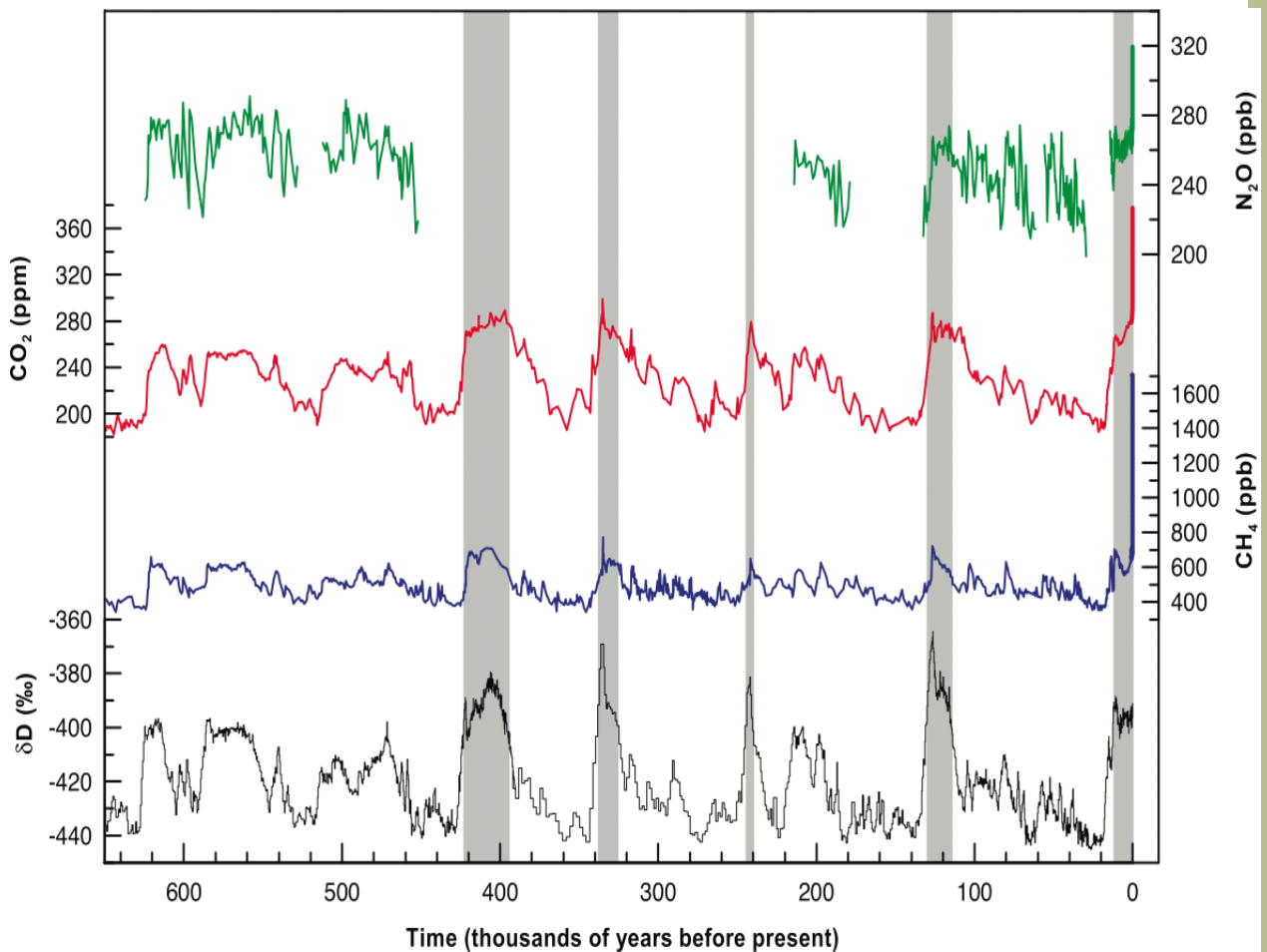


- Increase in the mean
- Increase in the variance
- Increase in the mean and variance.

Variations of deuterium (δD) and greenhouse gases over 650,000 years

Variations obtained from trapped air within the ice cores and from recent atmospheric measurements

- Deuterium (δD) – a proxy for local temperature
- Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) – all have increased over past 10 years.

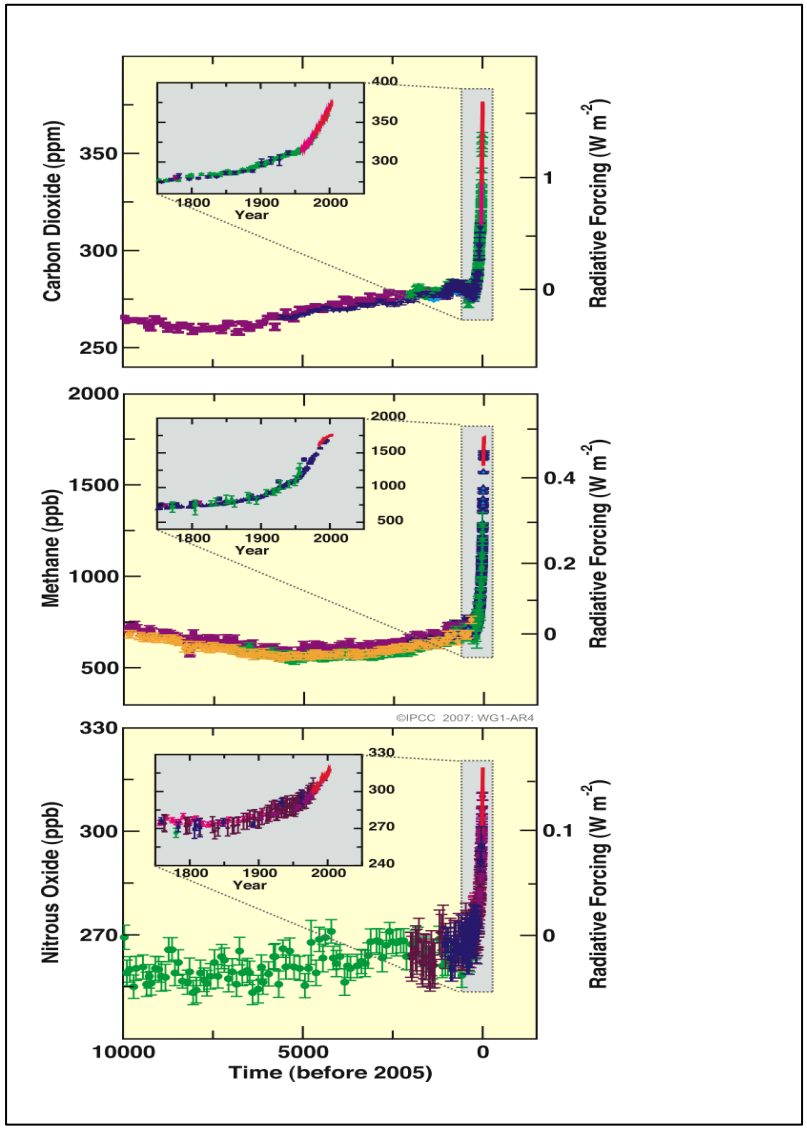


RF due to concentrations of CO_2, CH_4 and N_2O over the last 10,000 years (large panels) and since 1750 (inset panels)

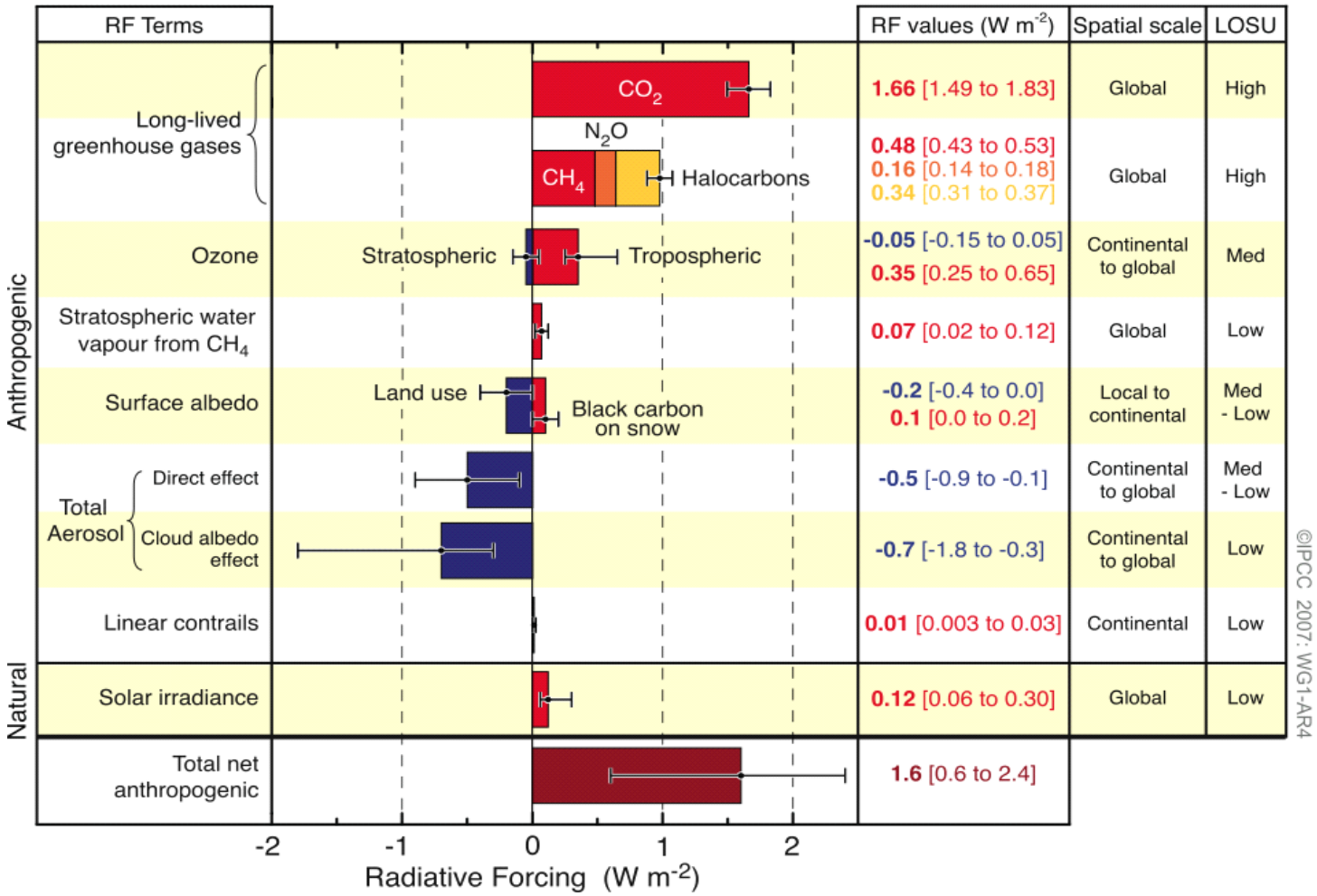
Radiative forcing

- There is a balance between incoming solar radiation and outgoing terrestrial radiation.

- Any process that alters the energy balance of the earth–atmosphere system is known as a radiative forcing mechanism.

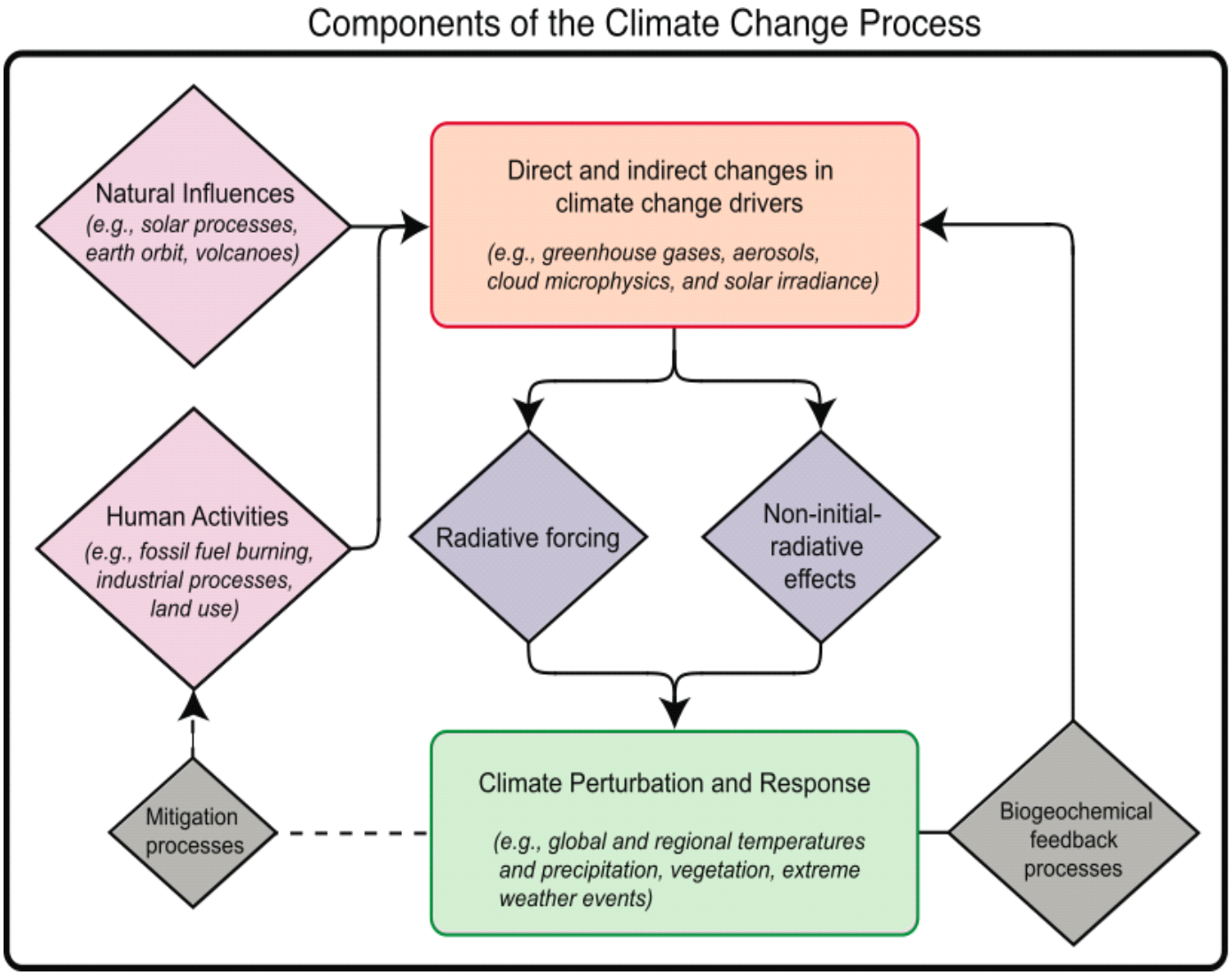


Global RF estimates and ranges in 2005 for anthropogenic CO_2, CH_4, N_2O and other important agents and mechanisms



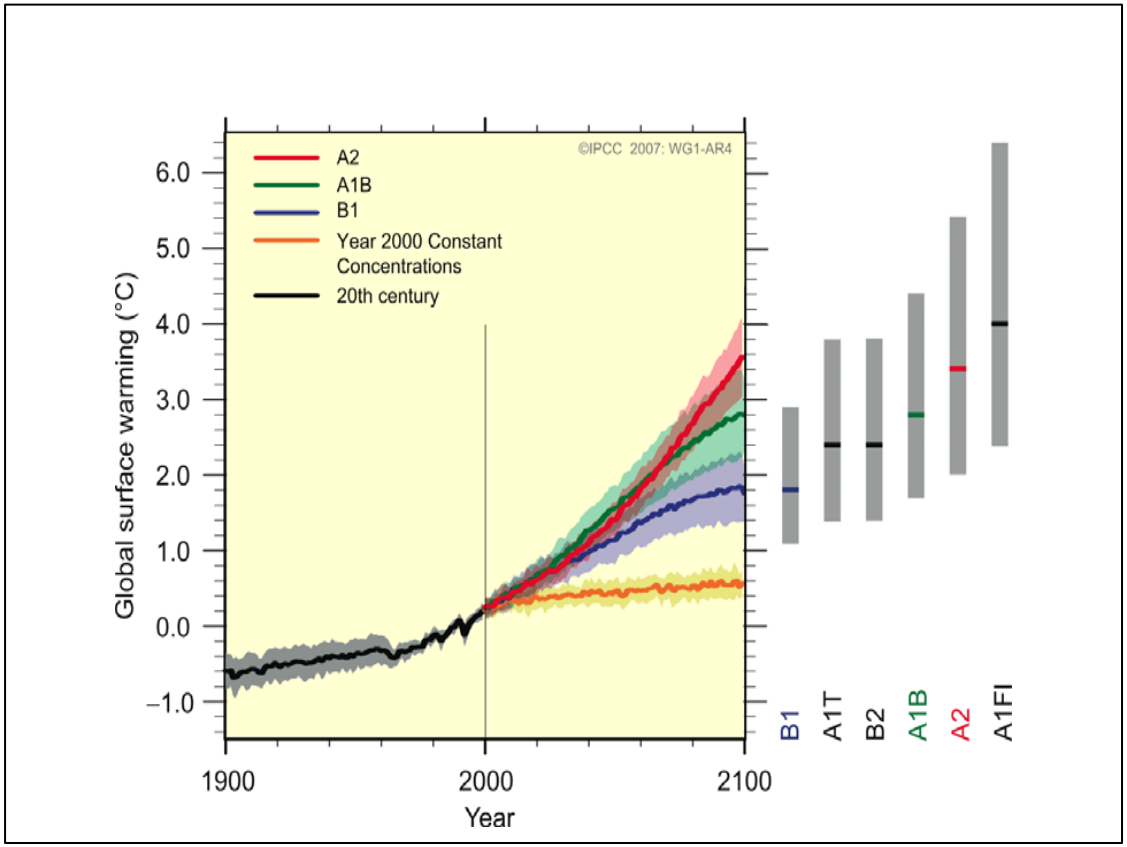
LOSU: Level of scientific understanding

Links of radiative forcing to other aspects of climate change



Observed and projected temperature change

Multi-model global averages of surface warming (relative to 1980–1999) for the scenarios A2, A1B and B1, shown as continuations of the 20th century simulations



Uncertainty characterization

Quantitatively calibrated levels of confidence

Terminology	Degree of confidence in being correct
Very High confidence	At least 9 out of 10 chance
High confidence	About 8 out of 10 chance
Medium confidence	About 5 out of 10 chance
Low confidence	About 2 out of 10 chance
Very low confidence	Less than 1 out of 10 chance

Likelihood scale

Terminology	Likelihood of the occurrence
Virtually certain	> 99% probability of occurrence
Very likely	> 90% probability
Likely	> 66% probability
About as likely as not	33 to 66% probability
Unlikely	< 33% probability
Very unlikely	< 10% probability
Exceptionally unlikely	< 1% probability

Special Report on Emission Scenarios (SRES)

Scenarios considered by the IPCC in their *Third Assessment Report* of 2001

IPCC: Intergovernmental Panel on Climate Change

Economic emphasis →

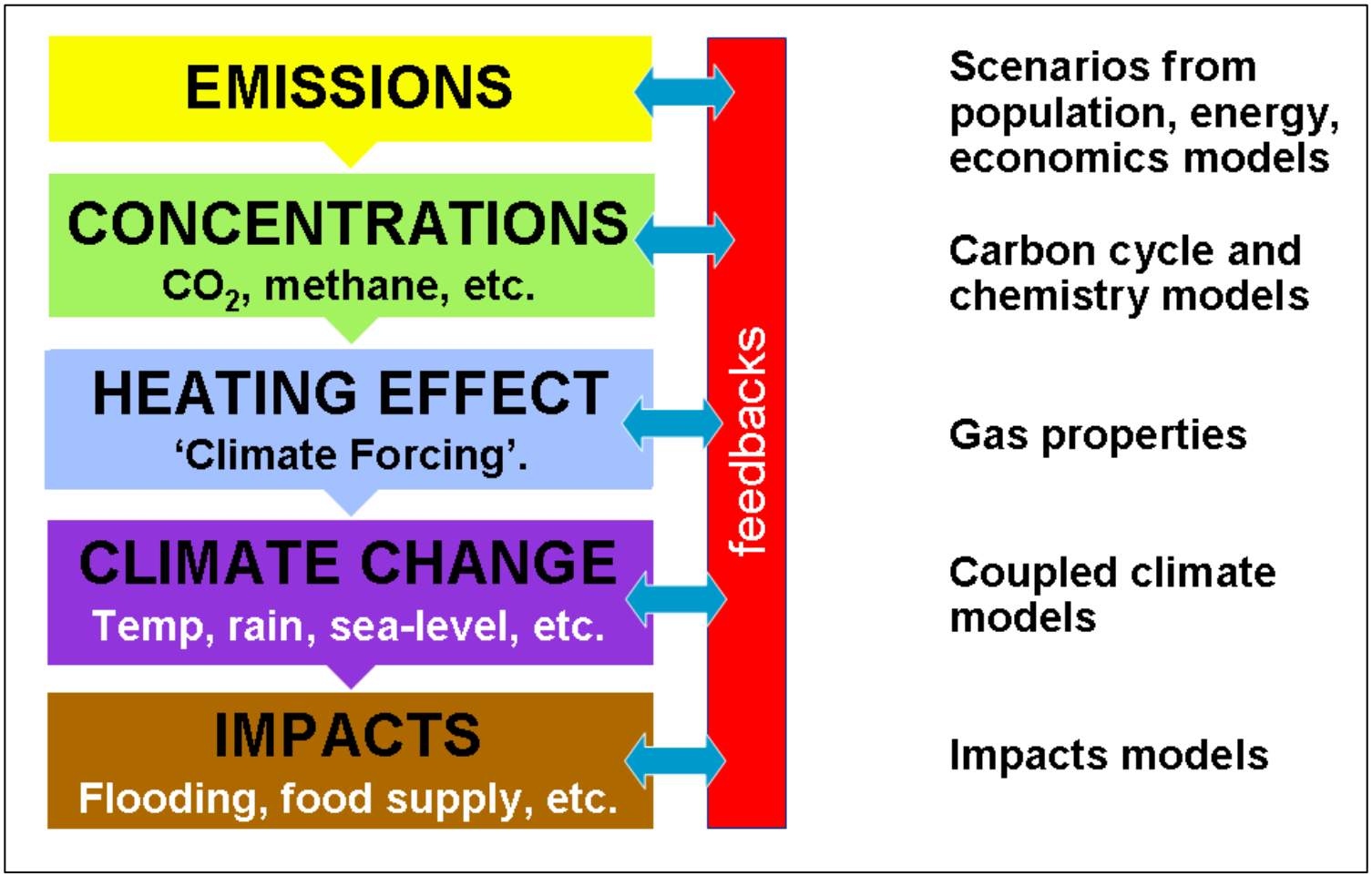
A1 storyline World: market-oriented Economy: fastest per capita growth Population: 2050 peak, then decline Governance: strong regional interactions; income convergence Technology: three scenario groups: • **A1FI**: fossil intensive • **A1T**: non-fossil energy sources • **A1B**: balanced across all sources	**A2 storyline** World: differentiated Economy: regionally oriented; lowest per capita growth Population: continuously increasing Governance: self-reliance with preservation of local identities Technology: slowest and most fragmented development
B1 storyline World: convergent Economy: service and information based; lower growth than A1 Population: same as A1 Governance: global solutions to economic, social and environmental sustainability Technology: clean and resource-efficient	**B2 storyline** World: local solutions Economy: intermediate growth Population: continuously increasing at lower rate than A2 Governance: local and regional solutions to environmental protection and social equity Technology: more rapid than A2; less rapid, more diverse than A1/B1

Global integration ↑

Regional emphasis ↓

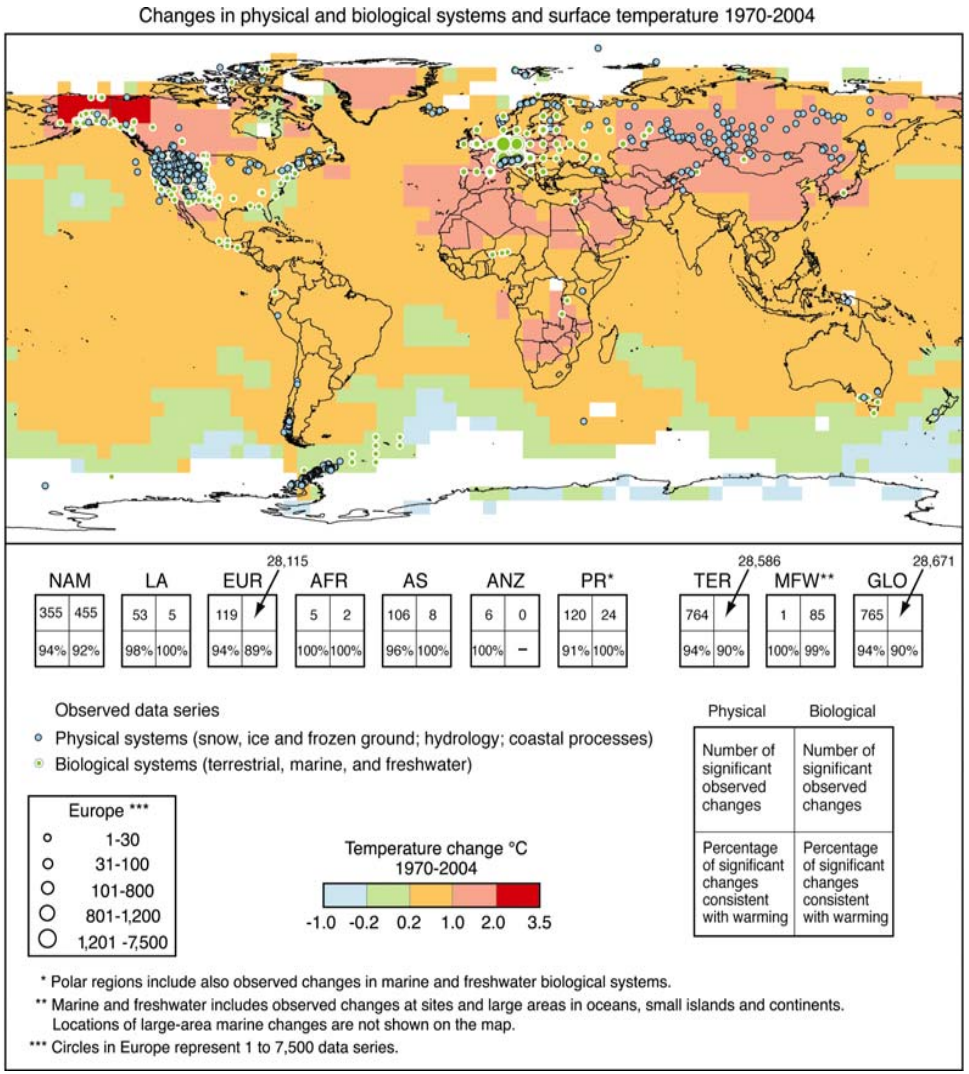
← Environmental emphasis

Scheme of events: From GHG emission to climate change impacts



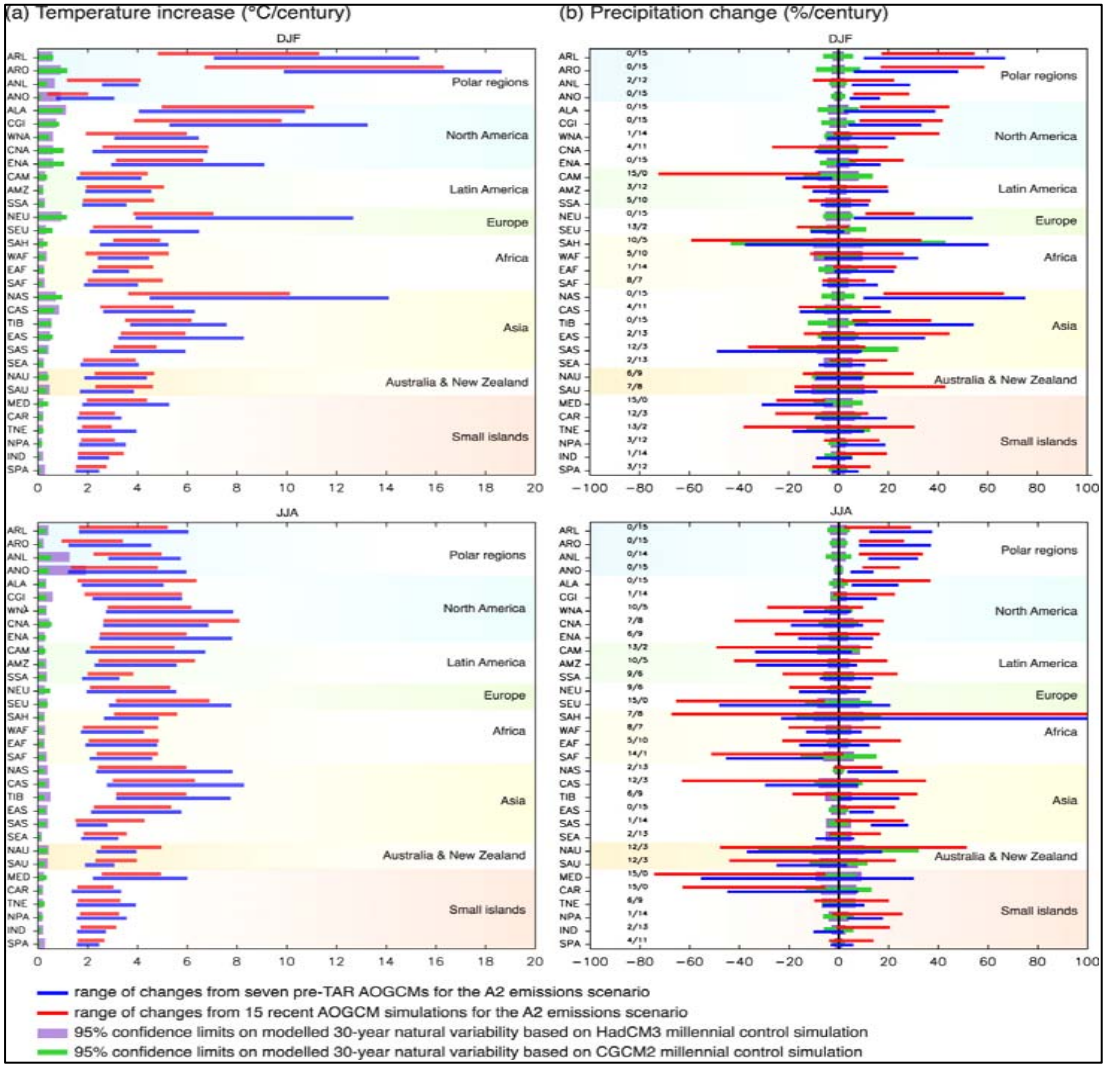
Observed changes and trends in physical systems and biological systems

Locations of significant changes in data series of physical systems and biological systems, together with surface air temperature changes over the period 1970–2004



Regional temperature and precipitation changes

Range of temperature and precipitation changes up to the 21st century across recent (fifteen models – red bars) and pre-TAR (seven models – blue bars) AOGCM projections under the SRES A2 emissions scenarios for 32 world regions, expressed as rate of change per century



Projections of future climate change as they relate to different aspects of water

- Changes in precipitation frequency and intensity
- Changes in average annual run-off
- Impacts of sea level rise on coastal zones
- Water quality changes
- Groundwater changes
- Impacts on ecosystems.

Climate change impacts on water quality

More intense rainfall:

- Increase in suspended solids/turbidity
- Pollutants (fertilizers, pesticides, municipal wastewater)
- Increase in waterborne diseases

Reduced/increased water flow in rivers:

- Less/more dilution of pollution
- Fluctuations in salinity estuaries

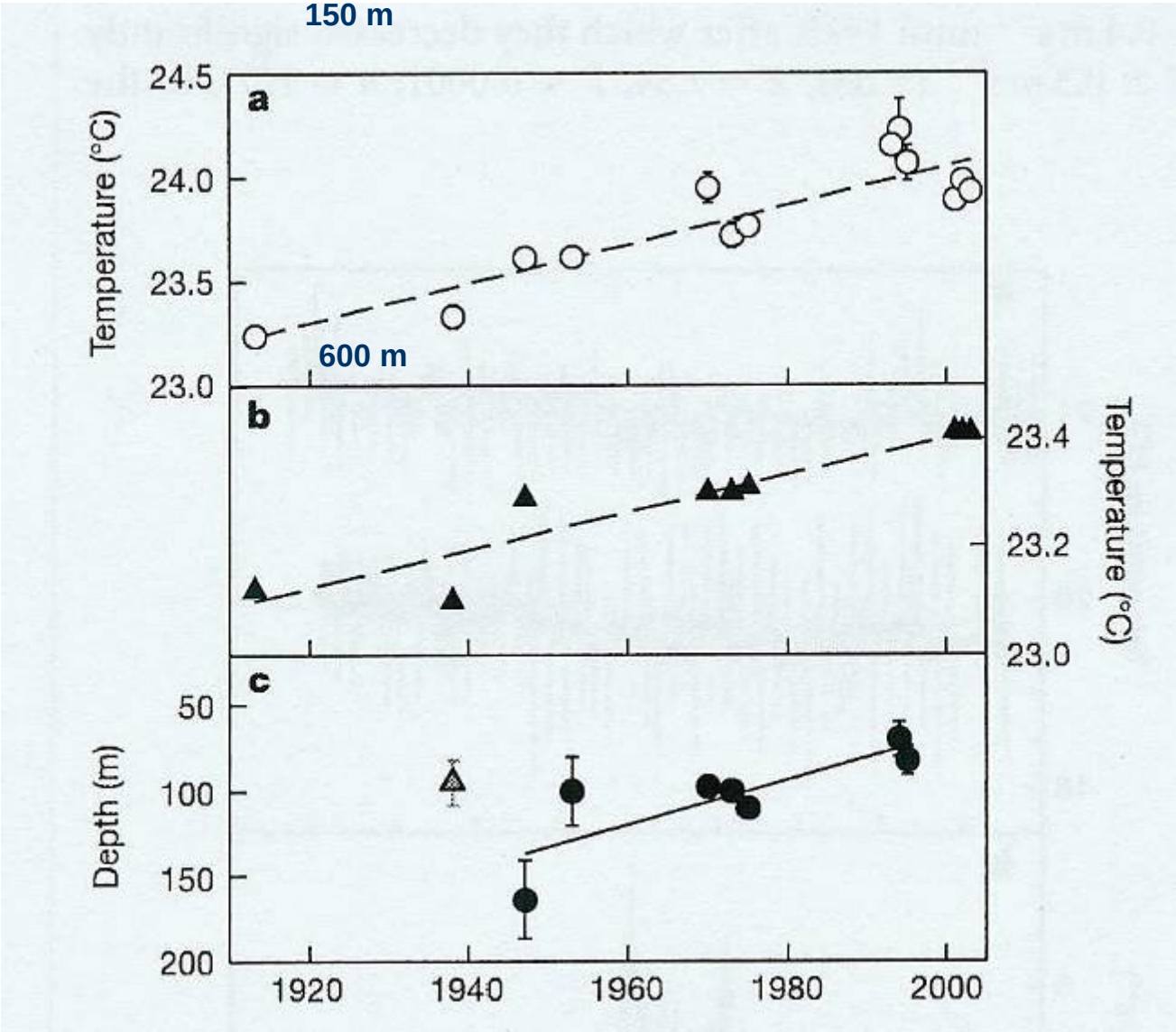
Lowering water levels in lakes:

- Re-suspension of bottom sediments
  - ✓ increased turbidity
  - ✓ liberating compounds with negative impacts

Higher surface water temperatures:

- Algal blooms and increase in bacteria, fungi > toxins
- Less oxygen.

Lake Tanganyika: Trends in temperature and oxygenated depth

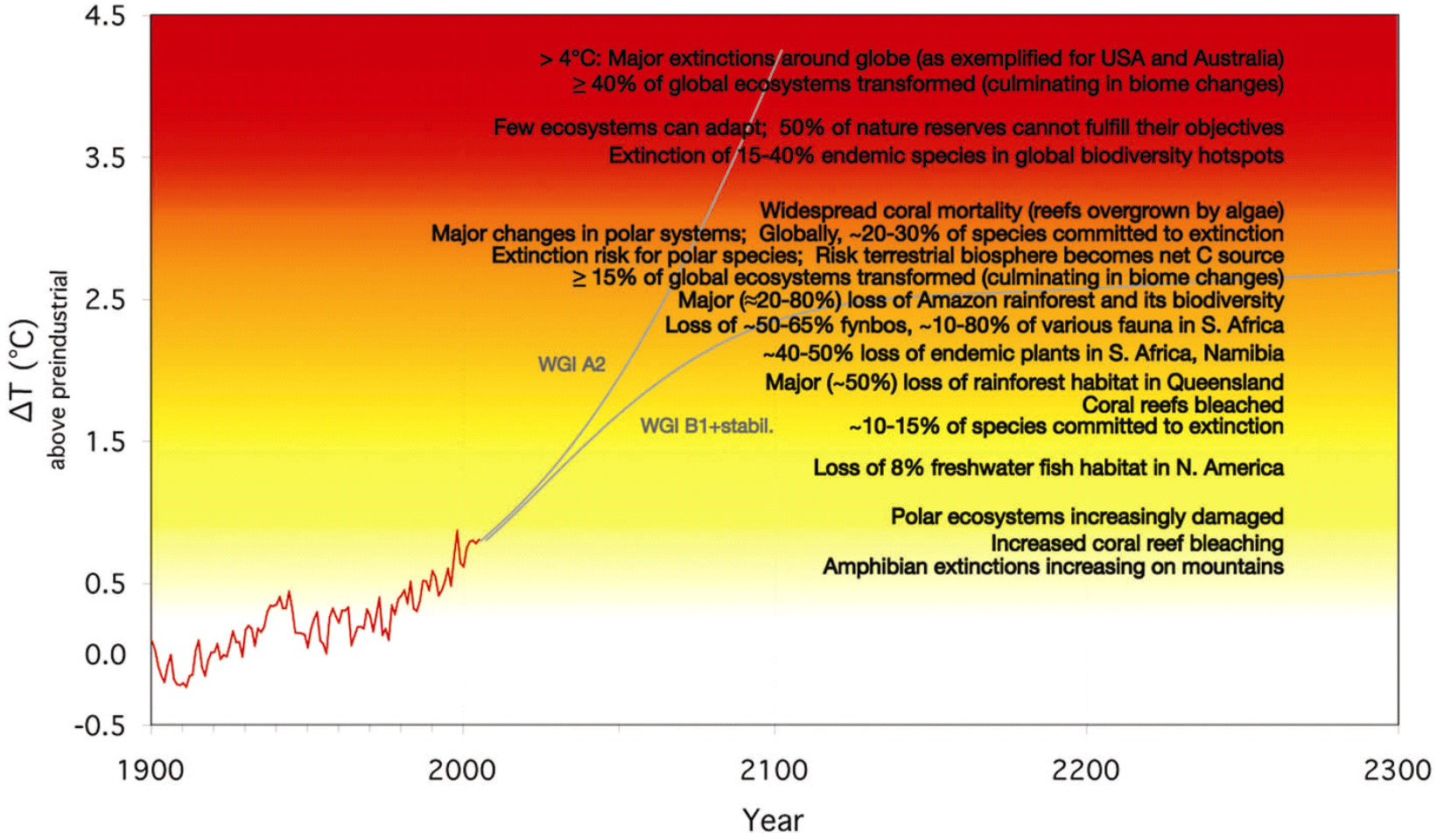


Lake Tanganyika: Impacts of climate change on production

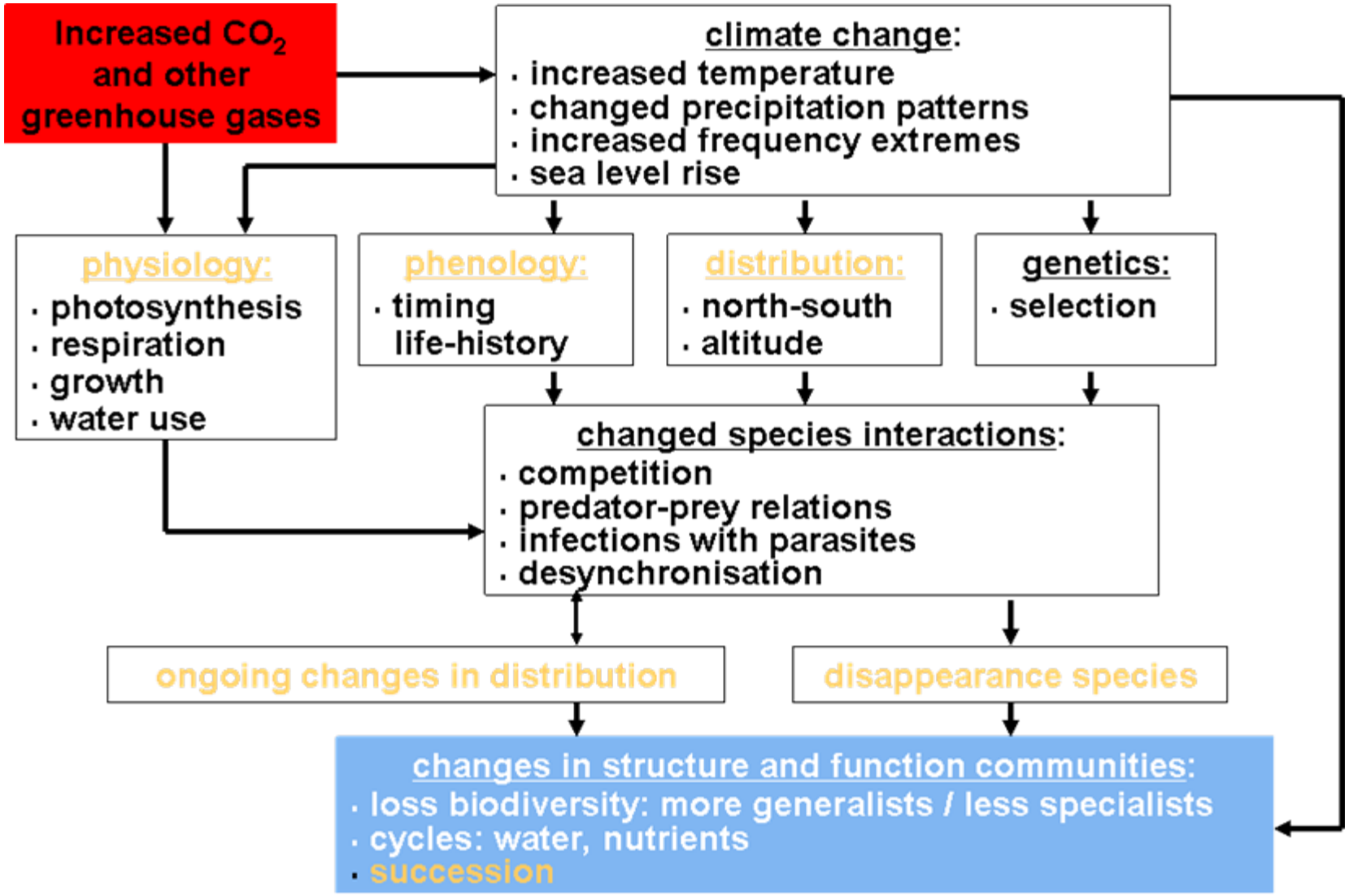
Increased thermal stability and decline in wind velocity:

- Reduced mixing depth
- Diminished deep-water nutrient inputs to surface waters
- Decline in primary productivity
- Decline in pelagic fisheries.

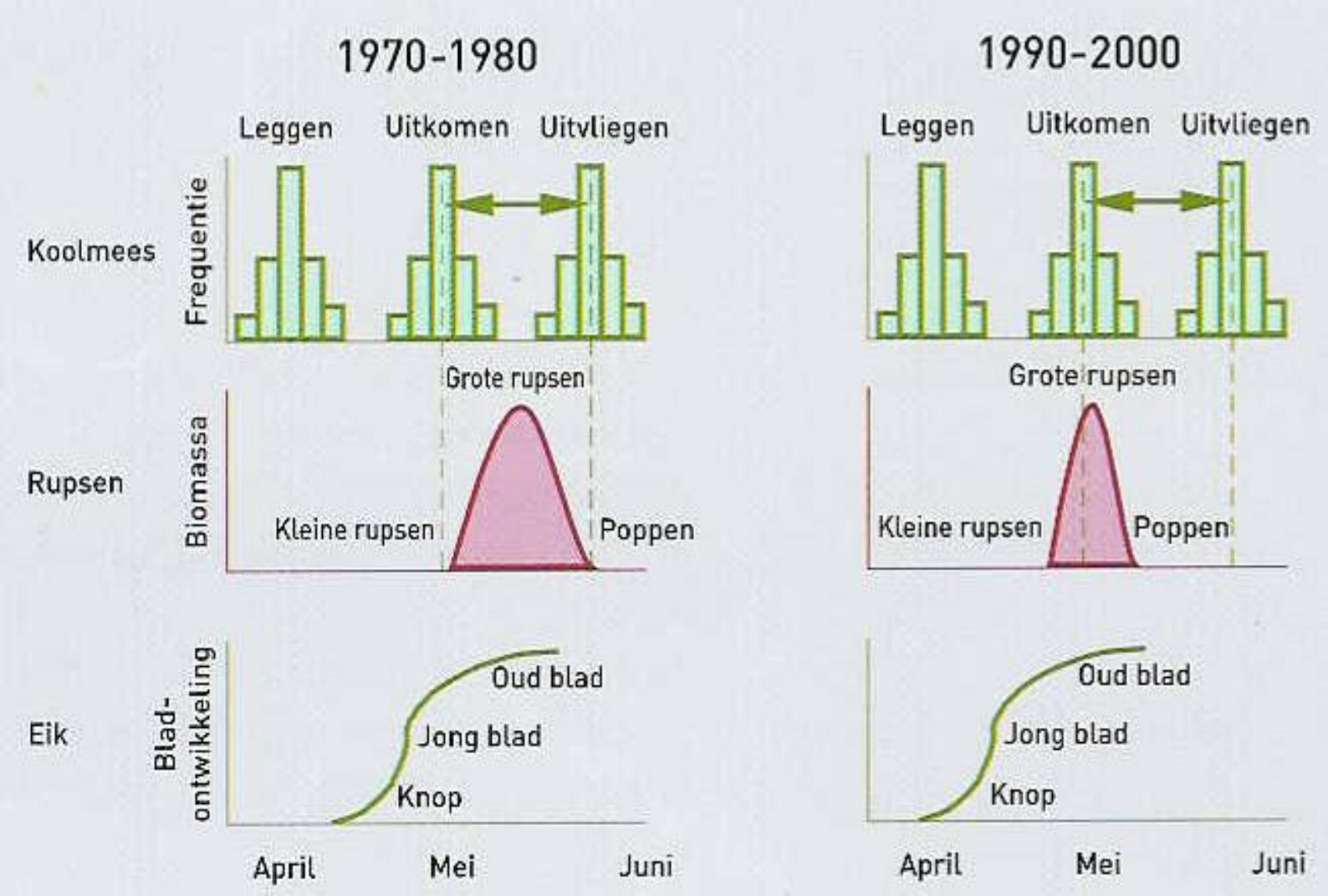
Projected risks due to critical climate change impacts on ecosystems



Climate change impacts on ecological processes



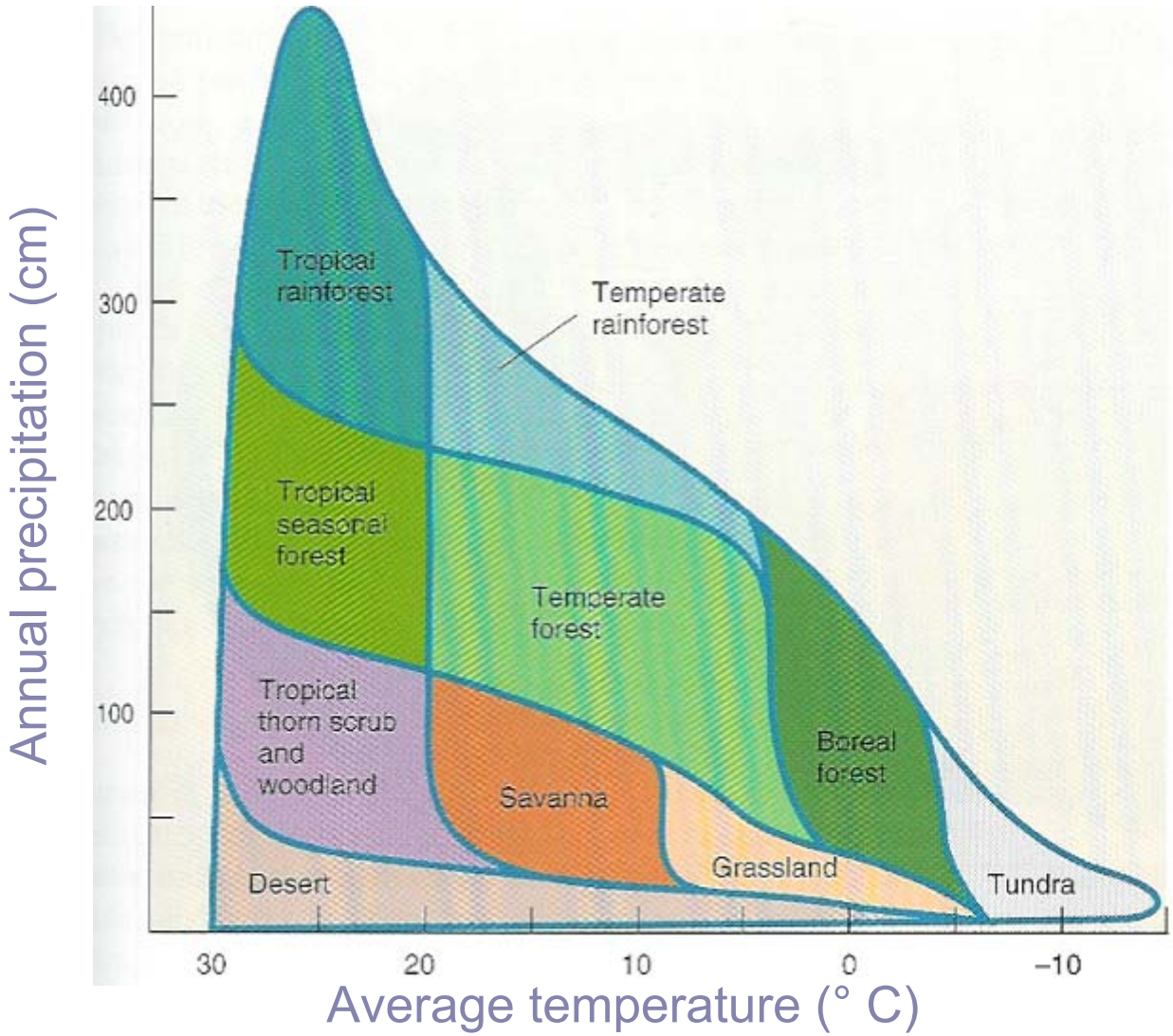
Food chain: Oak – butterfly – great tit



Global warming

1°C temperature rise: 100 km shift in biome

Global distribution biomes



Examples of range shifts and changes in population densities

- Extension of southern species to the north
- Decline in krill in the Southern Ocean
- Occurrence of sub-tropical plankton species in temperate waters
- Changes in geographical distributions of fish species
- Replacement of cold-water invertebrate and fish species in the Rhône River by thermophilic species
- Bird species that no longer migrate out of Europe during the winter
- Extension of alpine plants to higher altitudes
- Spread of disease vectors (e.g. malaria, Lyme disease, bluetongue) and damaging insects.

Key issues facing ecosystems under climate change

- Ecosystems tolerate some level of CC and, in some form or another, will persist
- They are increasingly subjected to other human-induced pressures
- Exceeding critical thresholds and triggering non-linear responses > novel states that are poorly understood
- Time-lags
- Species extinction (global vs local)/invasion exotics.