Integrating vulnerability indicators from natural and social science

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"What is simple is wrong;
What is complicated is useless."
Paul Valéry

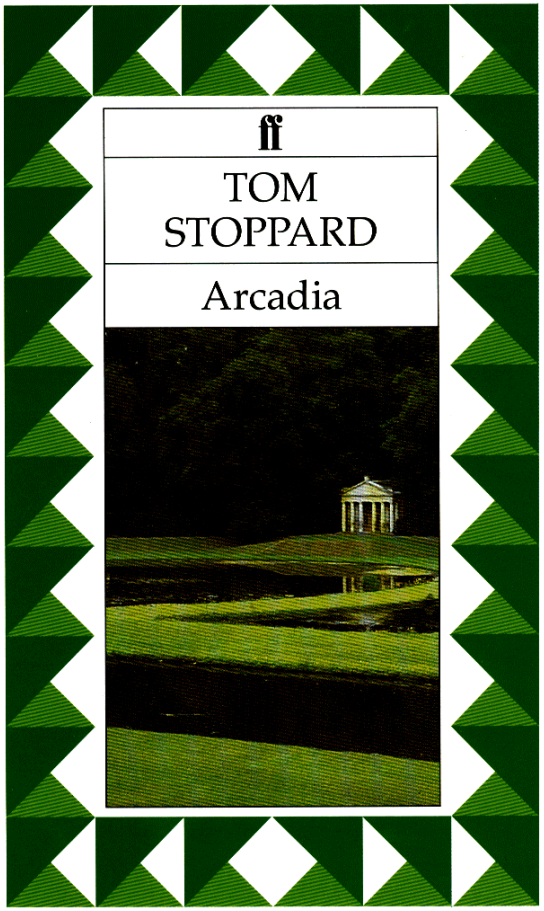
Content:

What are indicators?
The objectives of the conventions
"Safe landing" indicators
The IPCC TAR vulnerability synthesis
Aggregated ecological indicators

Distortions. Interference. **Real data is messy**.

There's a thousand acres of moorland that had grouse on it, always did till 1930. But nobody counted the grouse. They shot them. So you count the grouse they shot. But burning the heather interferes, it improves the food supply. A good year for foxes interferes the other way, they eat the chicks. And then there's the weather. It's all very, very noisy out there. **Very hared to spot the tune.**

Like a piano in the next room, it's playing your song, but unfortunetaly it's out of wack, some of the strings are missing, and the pianist is tone deaf and drunk- I mean, the noise! Impossible! **You start guessing what the tune might be.**



From: *Arcadia. Tom Stoppard, 1993.*

One third of the world's population is now subject to water scarcity

Population facing water scarcity will more than double over the next 30 years

1.6 billion people are without electricity today

Electricity demand in developing countries will increase 3-5 times over the next 30 years

Food production needs to double to meet the needs of an additional 3 billion people in the next 30 years

World Development Goals

- ✔ Half the proportion of people living in extreme poverty between 1990 and2015
- ✔ Enrol all children in primary school by 2015
- ✔ Empower women by eliminating gender disparities in primary and secondary education
- ✔ Reduce infant and child mortality rates by two-thirds between 1990 and 2015
- ✔ Reduce maternal mortality ratios by three-quarters between 1990 and 2015
- ✔ Provide access to all who need reproductive health services by 2015
- ✔ Implement national strategies for sustainable development by 2005 so as to reverse the loss of environmental resources by 2015

The World Developent Indicators: Progress?

Of the world's 6 billion people, 1.2 billion live on less than $1 a day. About 10 million children under the age of five died in 1999, most from preventable diseases. More than 113 million primary school age children do not attend school—more of them girls than boys. More than 500,000 women die each year during pregnancy and childbirth—unnecessarily. And more than 14 million adolescents give birth each year.

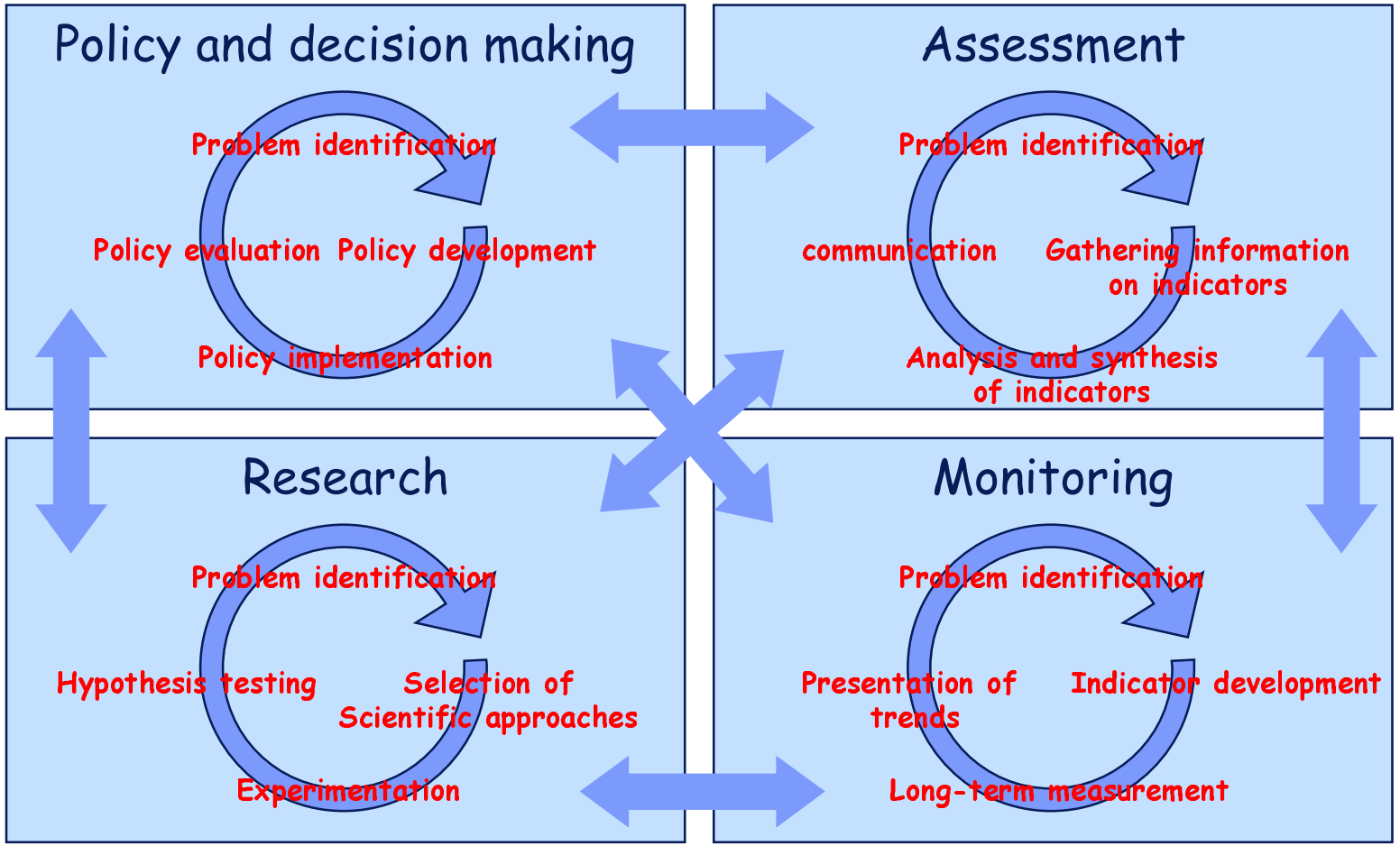
Cause for despair? Or hope?

In 1990 there were 1.3 billion living on less than $1 a day. There were more than 11 million deaths among children under five. There were fewer children out of school, but enrollment rates were also lower.

So there has been progress.

Indicators

A indicator is a measure that quantifies systemic changes of one or more properties of a system, a community or a nation. Indicators are often used to evaluate progress towards planned/desired goals.



Hierarchical indicators framework

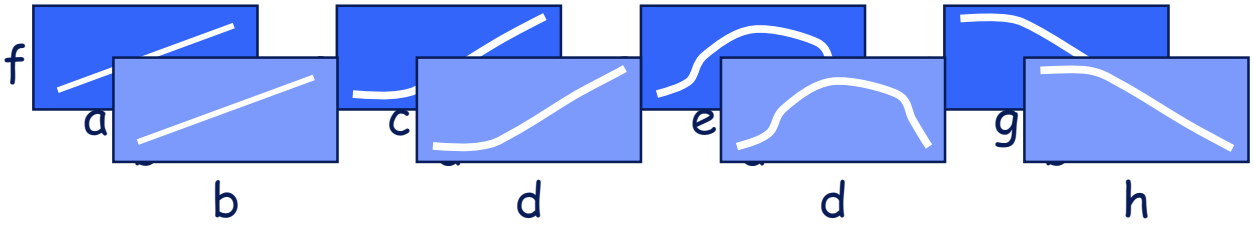
Ultimate indicator

Summary indicators

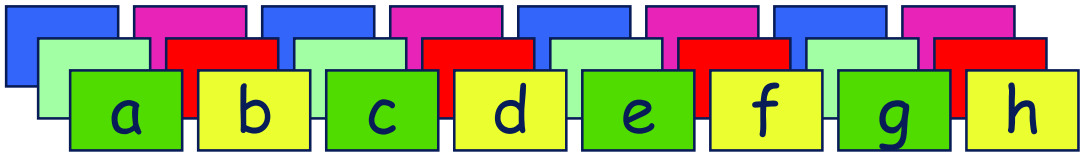
Aggregated indicators

Sectoral, issue oriented or regional indicators

Emperical correlations



Direct observations & measurements



What will the future REALLY be?

What will the future REALLY be?

The objectives of the conventions

The objective of the UN-FCCC

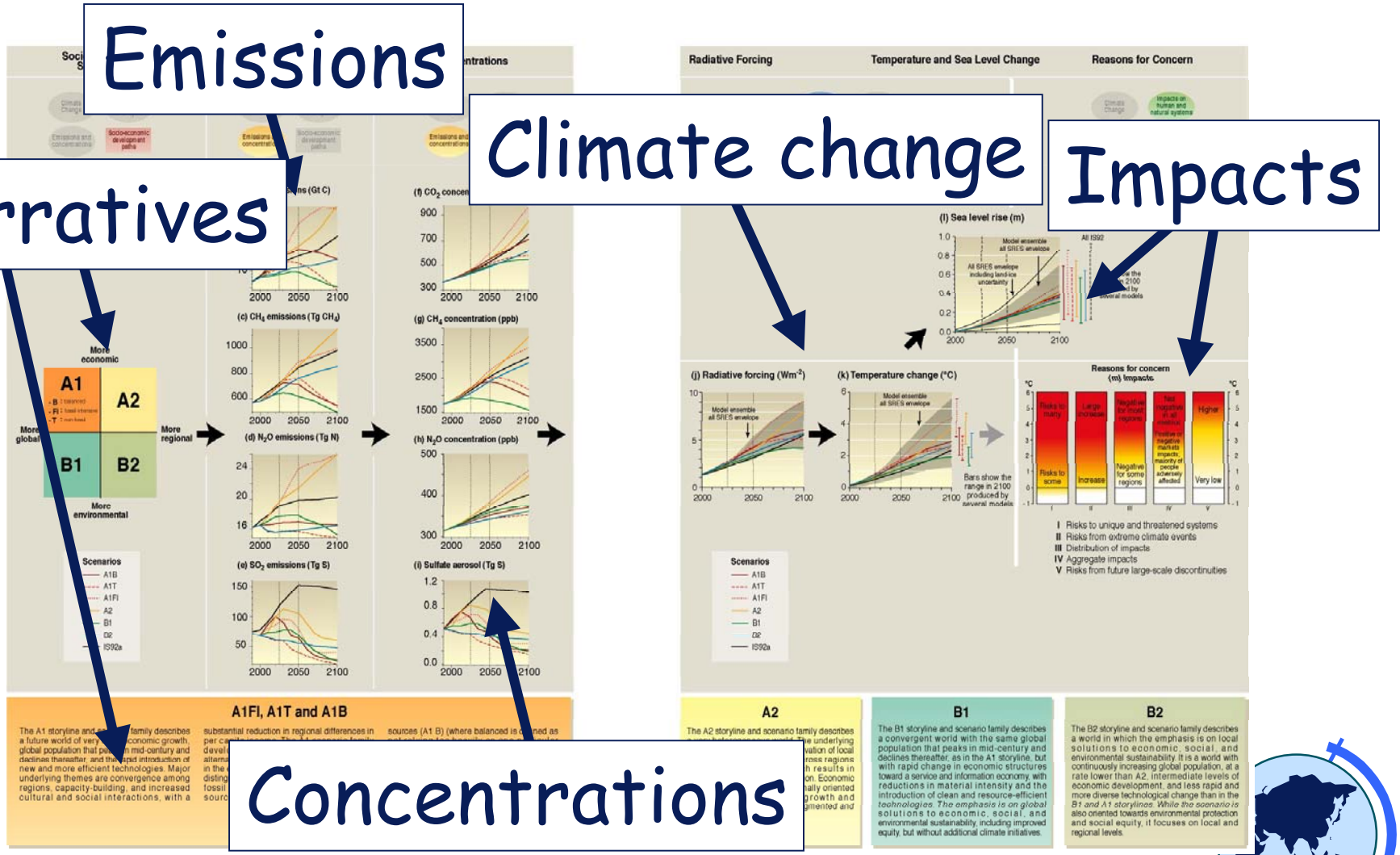
(Article 2 of the Framework Convention on Climate Change)

.... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent **dangerous** anthropogenic interference with the climate system.

Such a level should be achieved within a time frame sufficient:

- ✔ To allow ecosystems to adapt naturally to climate change
- ✔ To ensure that food production is not threatened,
- ✔ To enable economic development to proceed in a sustainable manner.

The summary indicators in IPCC's synthesis report



The Objective of the Biodiversity Convention (Article 1)

… is to conserve biodiversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of its utilisation.

Additional aspects of the CBD

The convention further stimulates parties to:

- ✔ develop national strategies for conservation and sustainable use, which are linked with other environmental and societal issues (Article 6);
- ✔ develop appropriate identification and monitoring systems (Article 7). These monitoring systems should identify and quantify the biodiversity threatening processes and activities.

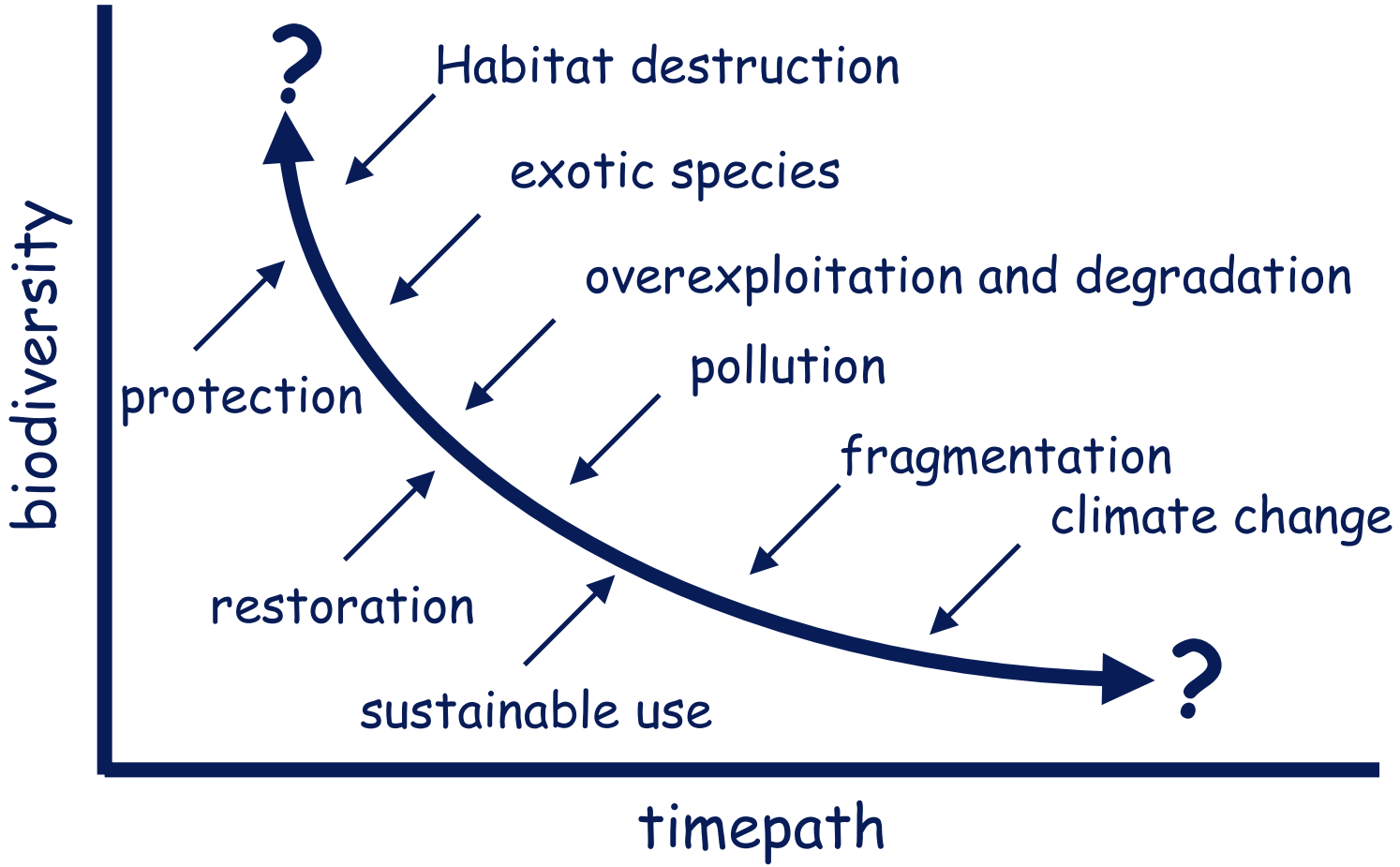
The convention especially focuses on conservation by:

- ✔ establishing protected areas, where natural habitats and viable populations can be maintained and the influence of humans and alien species is reduced (Article 8).
- ✔ the development of research, training, educational and awareness programs (Articles 12 and 13).

And urges urges the parties to develop:

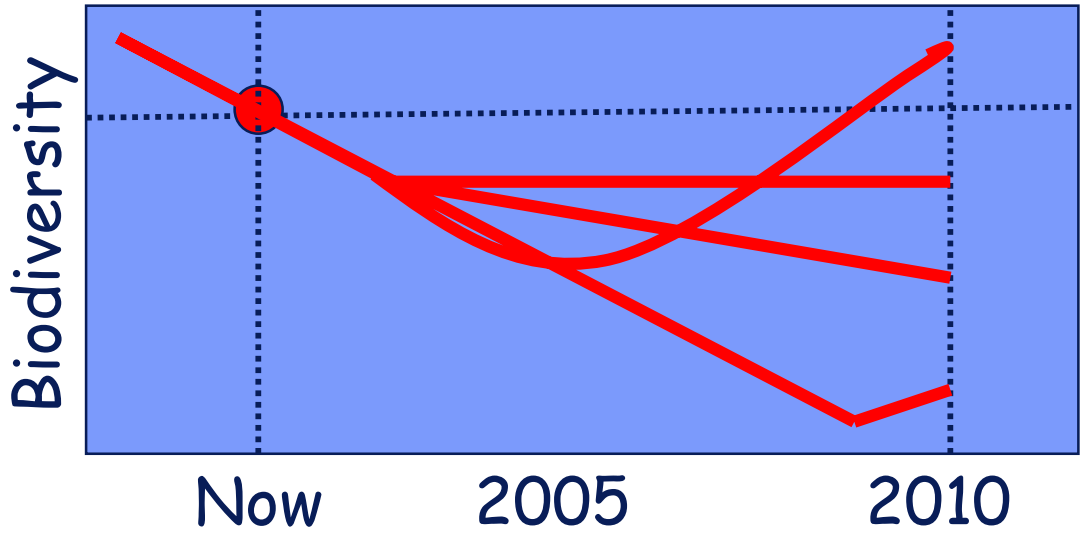
- ✔ the appropriate assessment capacity to evaluate processes and activities that potentially can have an adverse impact (Article 1

Causes of changes in biodiversity



One of the environmental goals of the World Summit on Sustainable Development (WSSD)

..... To significantly reduce the decline of biodiversity by 2010.



"Safe landing" indicators

Targets for Climate Change

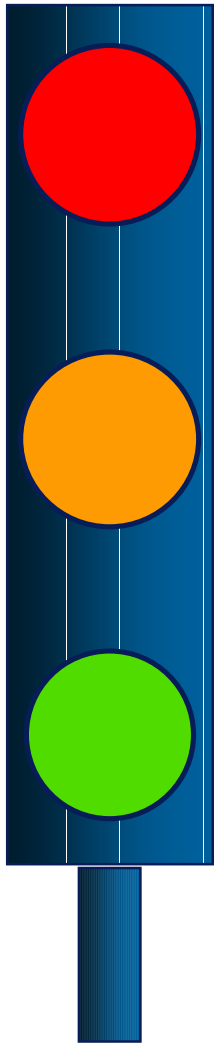
ΔGMT	> 0.2 °C/decade
sea level rise	>0.05 m/decade

Max. ΔT = 2°C
Max. sea level rise = 0.5 m

0.1 °C/dec <	ΔGMT ≤ 0.2 °C/dec
0.02 m/dec <	SLR ≤ 0.05

Max. ΔT = 1°C
Max. sea level rise = 0.2 m

ΔGMT	≤ 0.1°C/decade
sea level rise	≤ 0.02 m/decade



- Social & economic disruption
- Large risk of instabilities

- Large damages to ecosystems
- Risk of instabilities

- Limited damages to ecosystems
- Limited risk of instabilities

From: Vellinga & Swart, 1991. The greenhouse marathon. Climatic Change 18: viii-xii

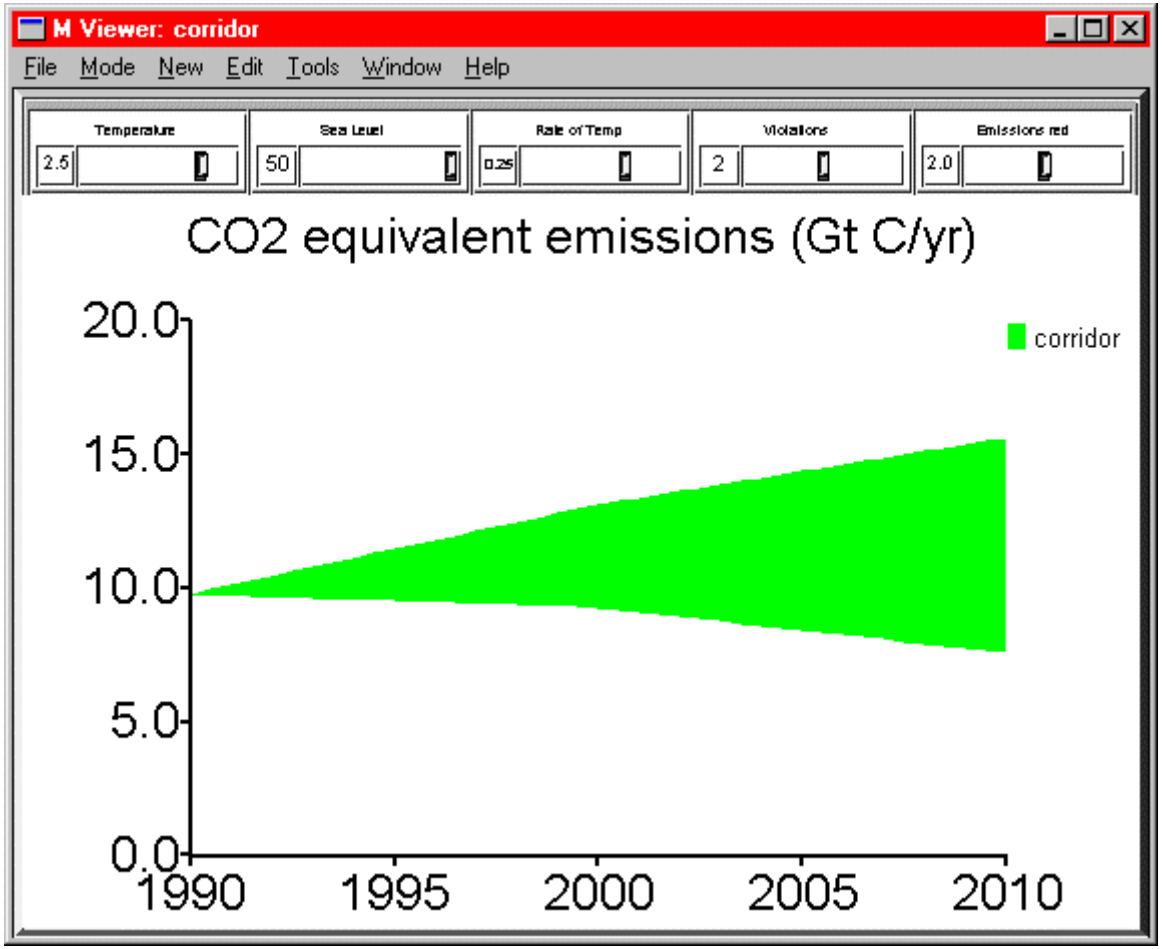
Safe Landing Analysis

- **Science-policy dialogue**
  - development in "Delft-workshops" with FCCC-delegates
  - feedback from FCCC-delegates during AGBM/CoP meetings
- **Aim Safe Landing Analysis:**
  - to determine short-term emission targets compatible with-long term climate protection goals
  - use global indicators to define the long-term climate goals
- **Methodology provides insights, no answers**
  - focus on trade-offs (risks, timing, burden sharing)
  - results subject to scientific uncertainties
  - Selection of climate protection goals is a political choice

What are emission profiles that comply with non-dangerous human interference?

- ✔ Cumulative temperature change – for example, the EU temperature goal of less than 2°C ΔGMT
- ✔ Rate of temperature change - to account for limited adaptation capabilities
- ✔ Maximum sea level rise - relevant for e.g. AOSIS
- ✔ Maximum rate of emissions reduction - to account for technological/economic feasibility

Emission corridor with broad settings



Selected settings:

Max. ΔT is 2.5 °C

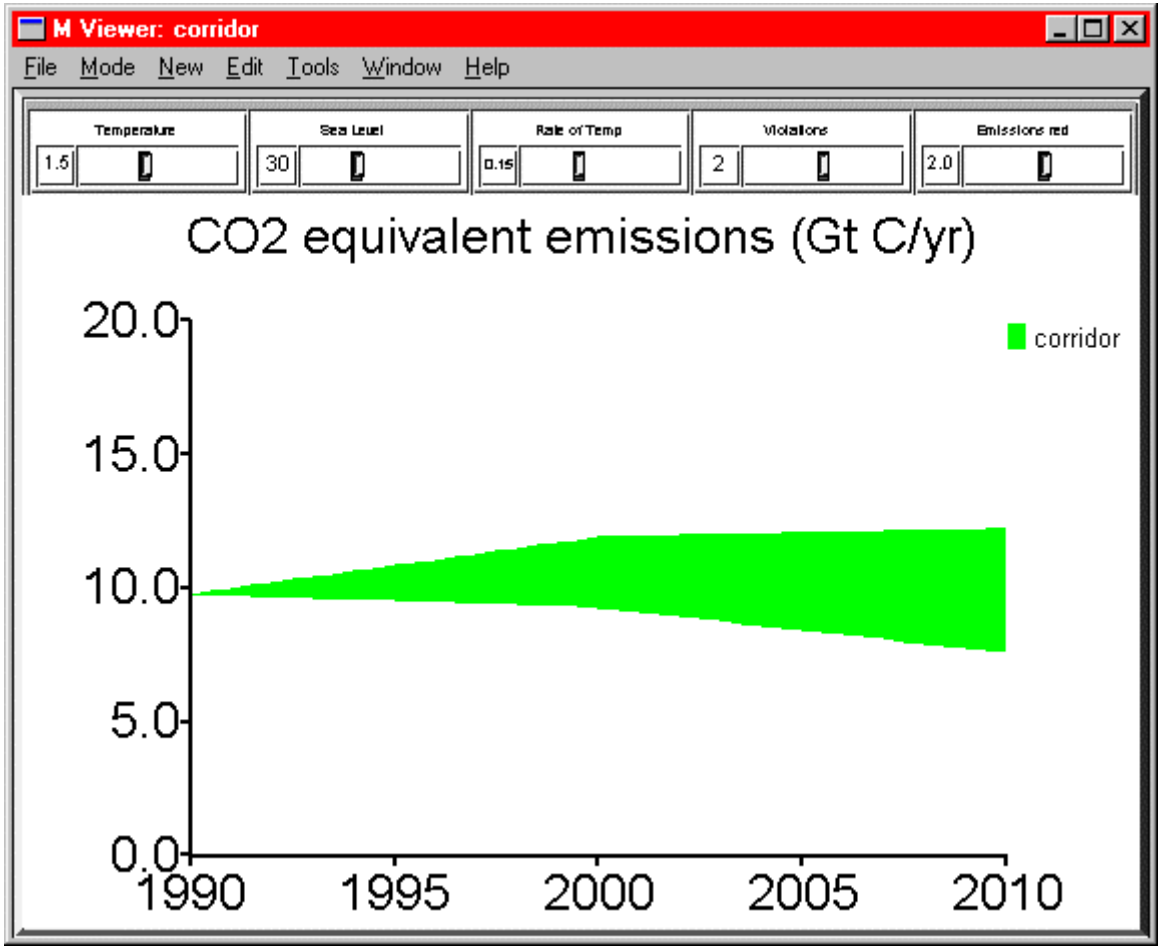
Max. sea-level rise is 50 cm

Max. ΔT/decade is 0.25 °C

Number of violations is 2

Max. emission reduction is 2% year^{-1}

Safe emission corridors with EU objectives



Selected settings:

Max. ΔT is 1.5 °C

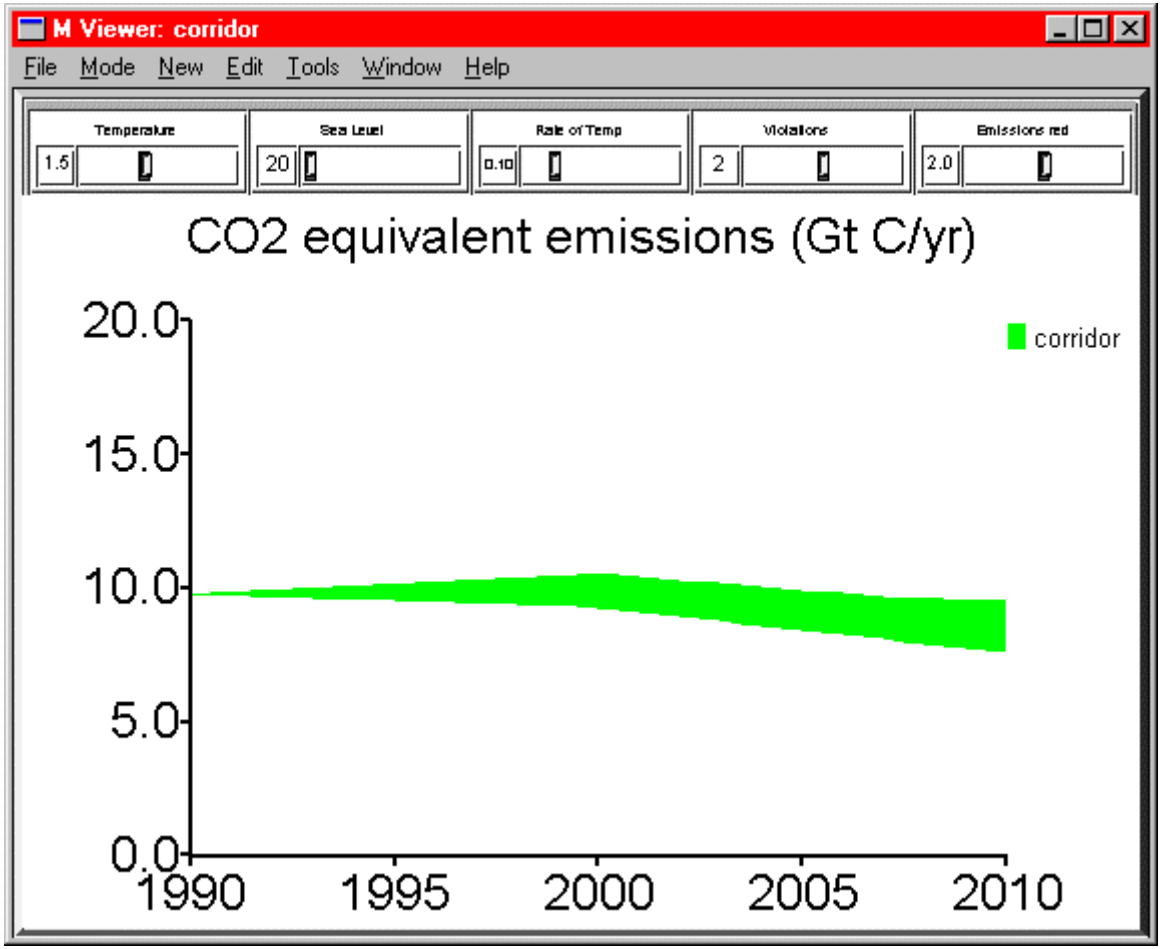
Max. sea-level rise is 30 cm

Max. ΔT/decade is 0.15 °C

Number of violations is 2

Max. emission reduction is 2% year^{-1}

Emission corridor with stringent settings



Selected settings:

Max. ΔT is 1.5 °C

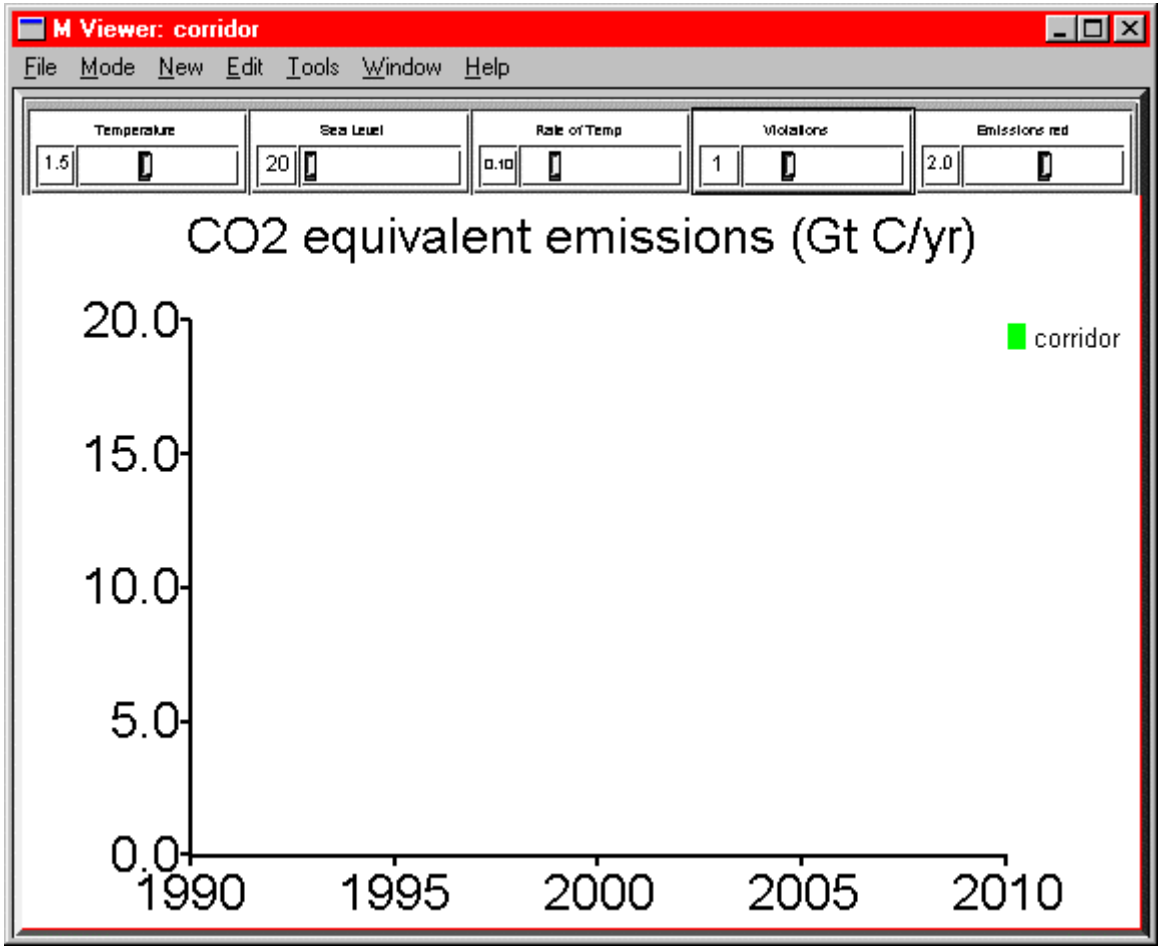
Max. sea-level rise is 20 cm

Max. ΔT/decade is 0.15 °C

Number of violations is 2

Max. emission reduction is 2% year^{-1}

Emission corridor with very stringent settings



Selected settings:

Max. ΔT is 1.5 °C

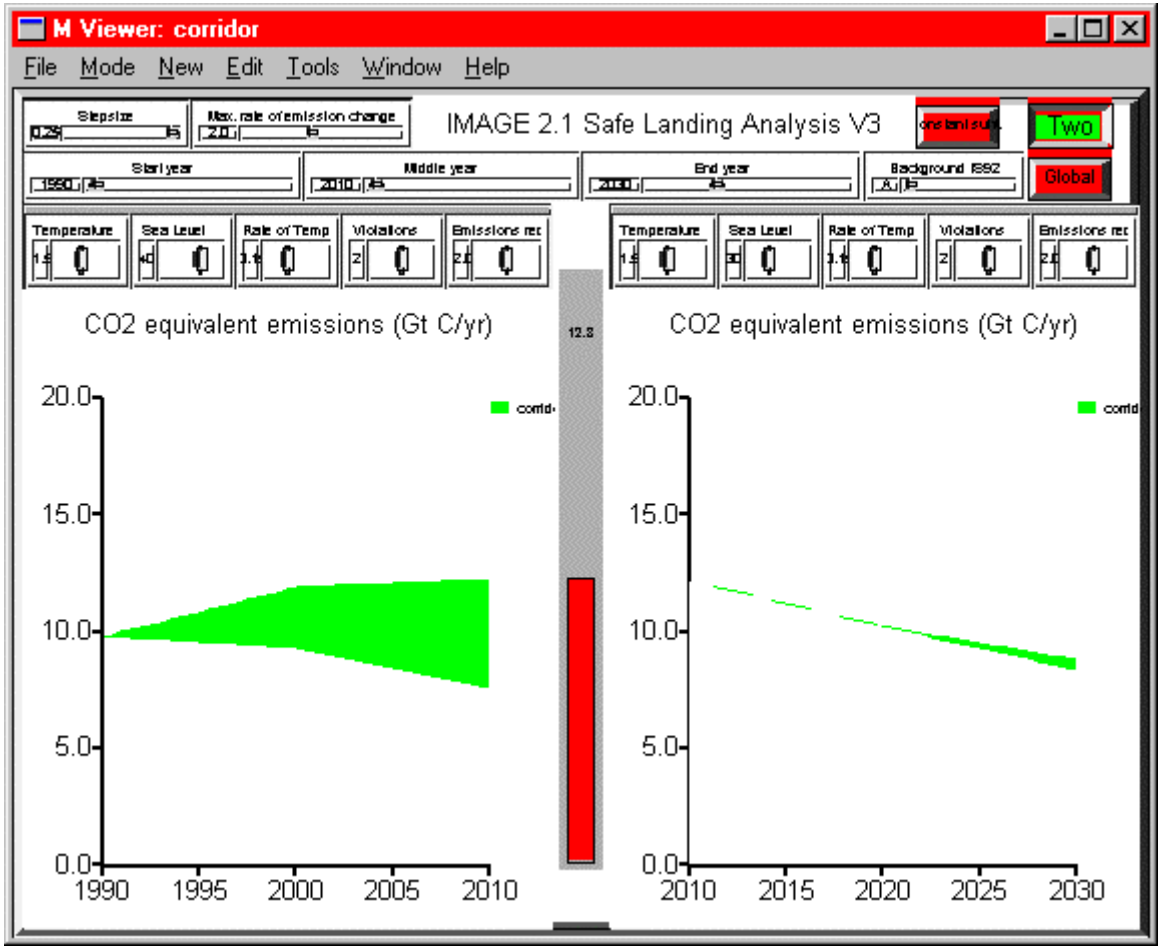
Max. sea-level rise is 20 cm

Max. ΔT/decade is 0.1 °C

Number of violations is 1

Max. emission reduction is 2% year^{-1}

Safe emission corridors with EU objectives



Selected settings:

Max ΔT is 1.5 °C

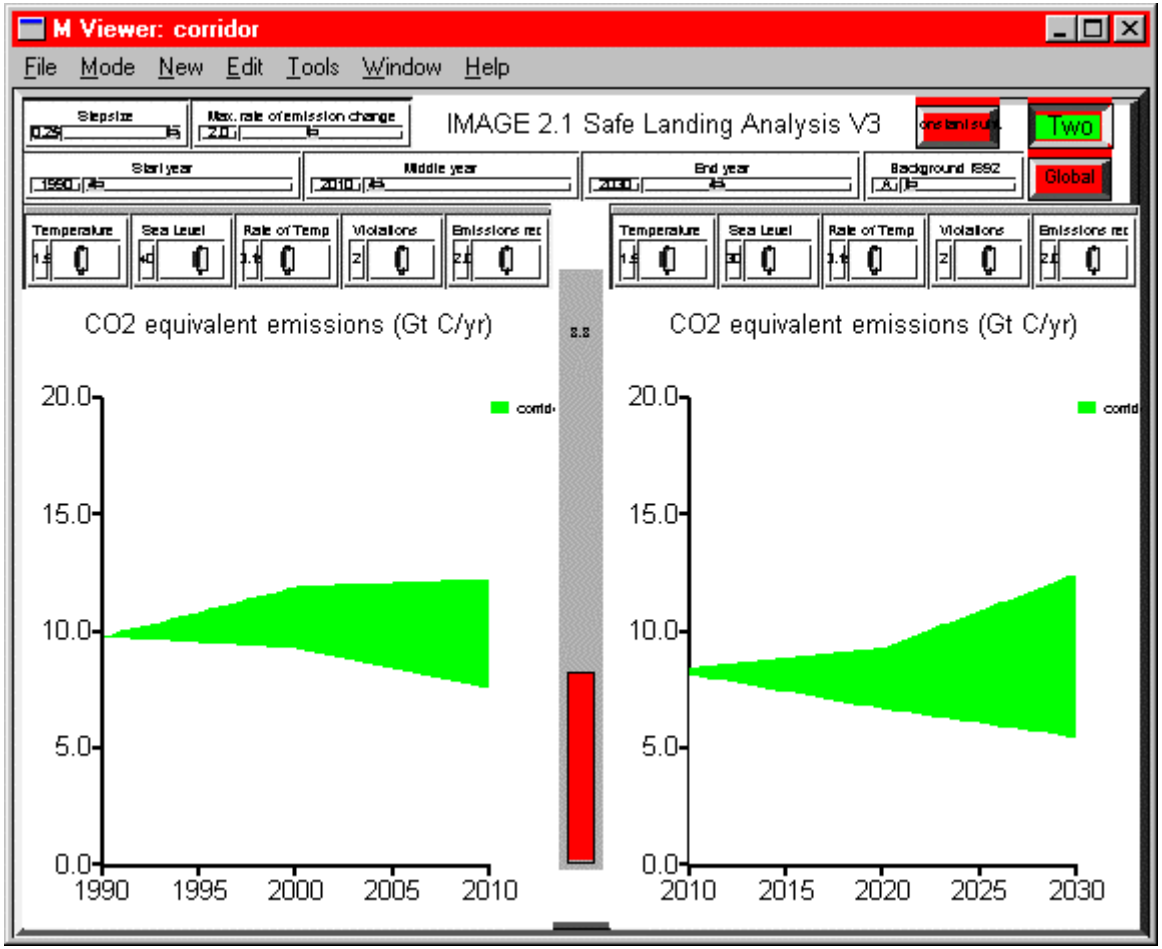
Max sea-level rise is 30 cm

Max ΔT/decade is 0.15 °C

Number of violations is 2

Max emission reduction is 2% year^{-1}

Safe emission corridors with EU objectives



Selected settings:

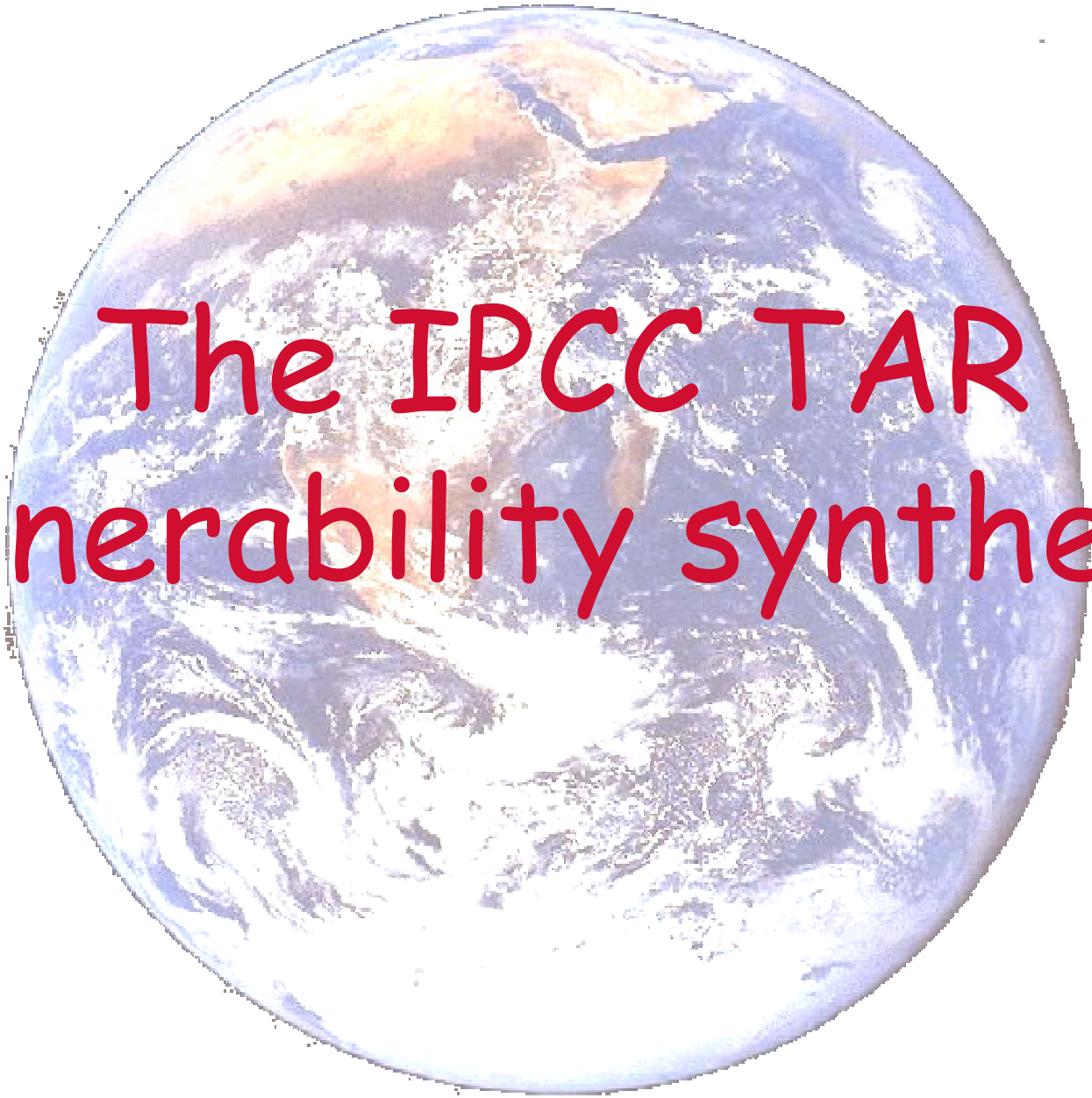
Max ΔT is 1.5 °C

Max sea-level rise is 30 cm

Max ΔT/decade is 0.15 °C

Number of violations is 2

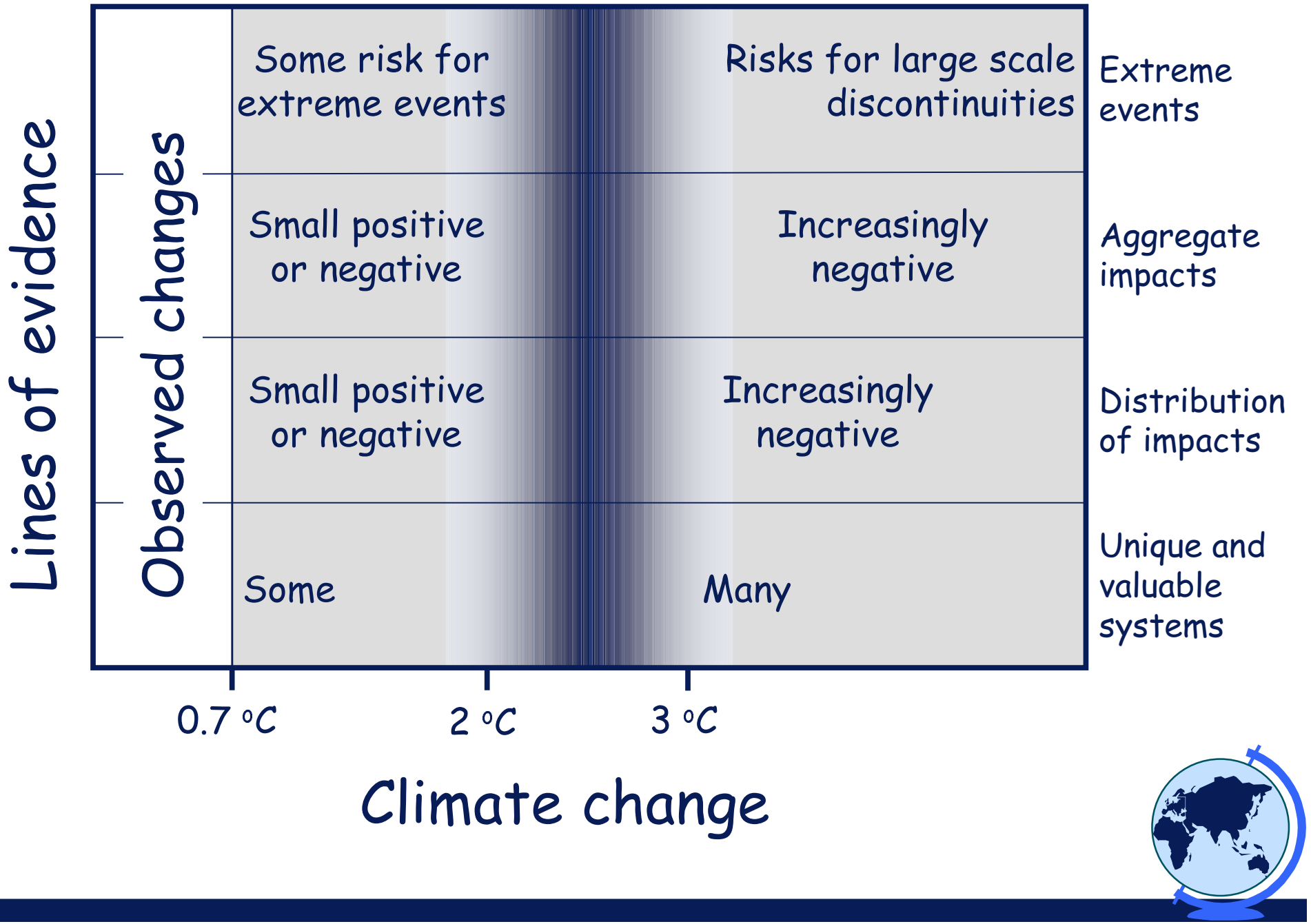
Max emission reduction is 2% year^{-1}



The IPCC TAR vulnerability synthesis

How do we determine "What constitutes dangerous?"

- ✔ Dangerous is a value judgment and not appropriate for analysts to determine
- ✔ We can give information on impacts that may be considered to be dangerous
- ✔ Organized our work along "Reasons for concern" about what may be dangerous


Lines of evidence
Observed changes
Some risk for extreme events
Risks for large scale discontinuities
Extreme events
Small positive or negative
Increasingly negative
Aggregate impacts
Small positive or negative
Increasingly negative
Distribution of impacts
Some
Many
Unique and valuable systems
0.7 °C
2 °C
3 °C
Climate change

Reasons for Concern

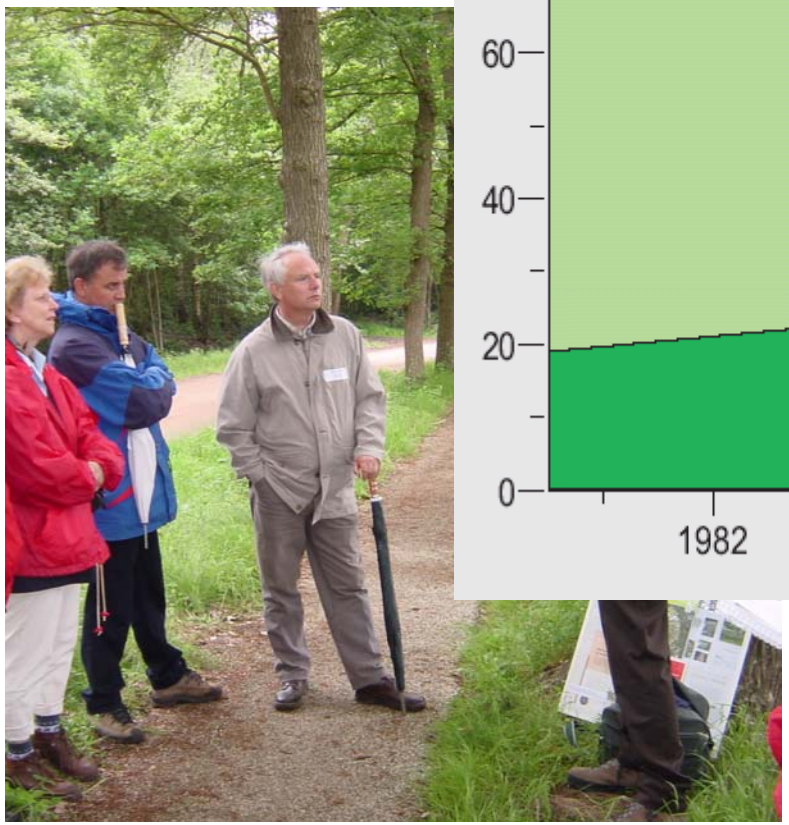
- Relationship between global mean temperature increase and:
  - Unique and Threatened Systems (including observed change)
  - Extreme Weather Events
  - Distribution of Impacts
  - Aggregate (total) Impacts
  - Large Scale Singularities (e.g., NATHC; WAIS)
- Using global mean temperature increase because:
  - It is a widely used indicator for climate change
  - It can be regionalised with GCM-based scenarios for temperature, precipitation and other climate variables
  - It is used by simple globally aggregated models and can be derived from the more complex models
  - It is simple to communicate

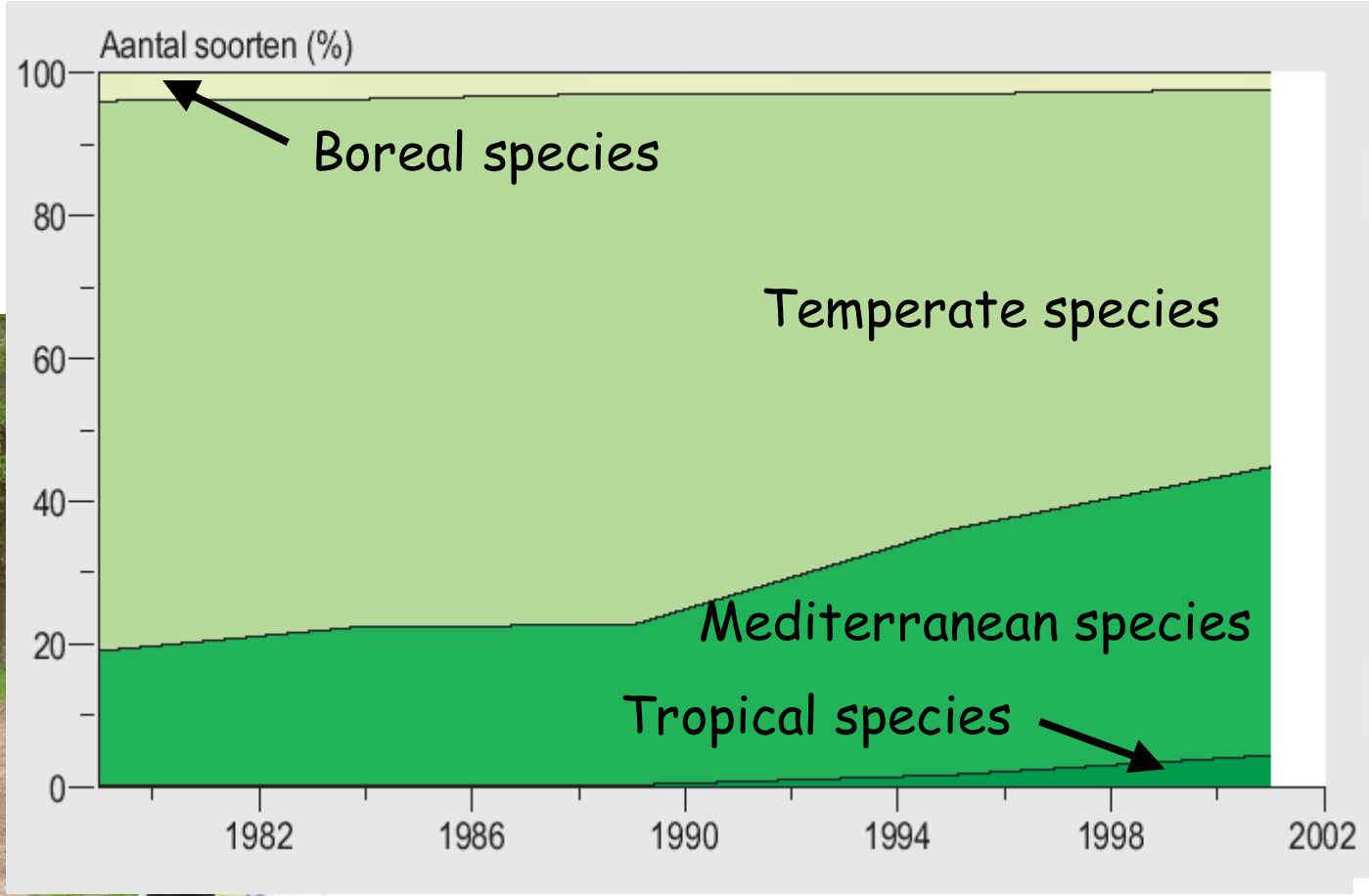
Unique and Threatened Systems

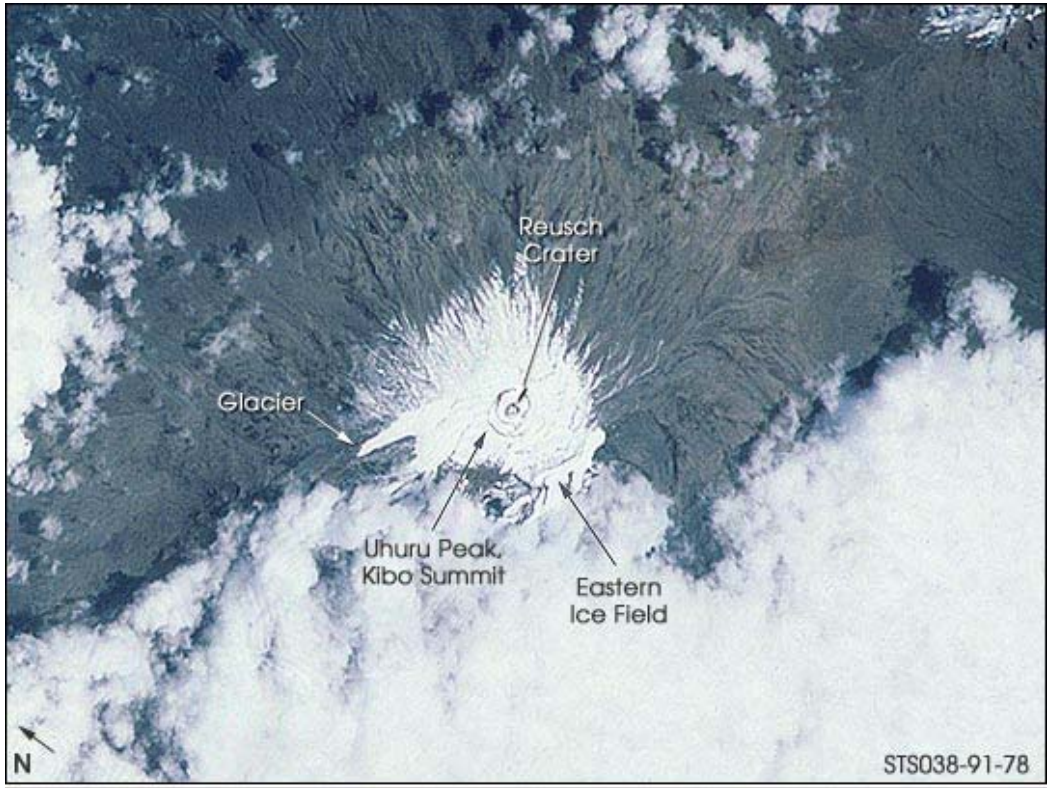
Concern is about unique systems that may be lost or severly damaged, e.g.,

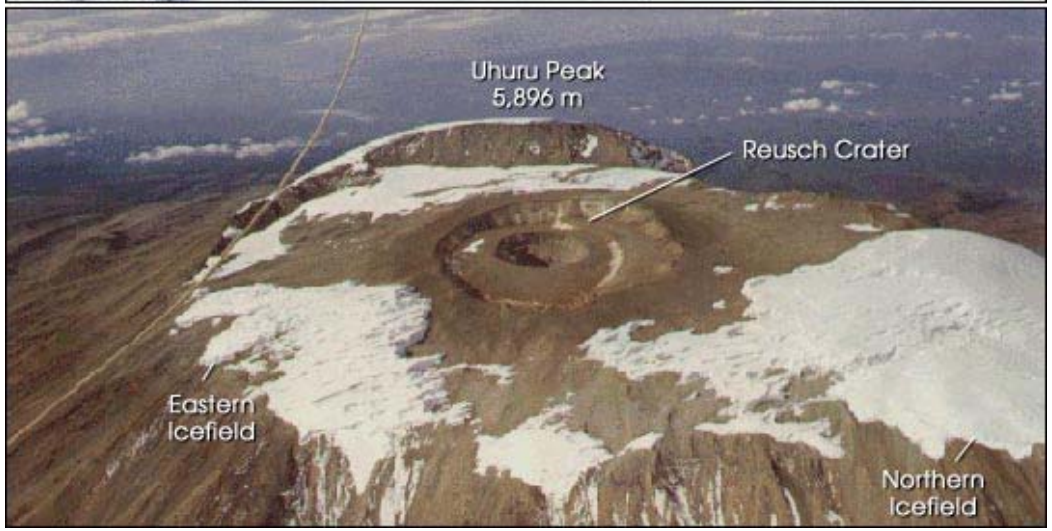
- ✓Coral Reefs
- ✓Polar Bears
- ✓Alpine Ecosystems
- ✓Glaciers
- ✓Small Island States
- ✓and many other ecosystems and species

Changes in Dutch lichen communities









Kilimanjaro: Ice free in 2015?

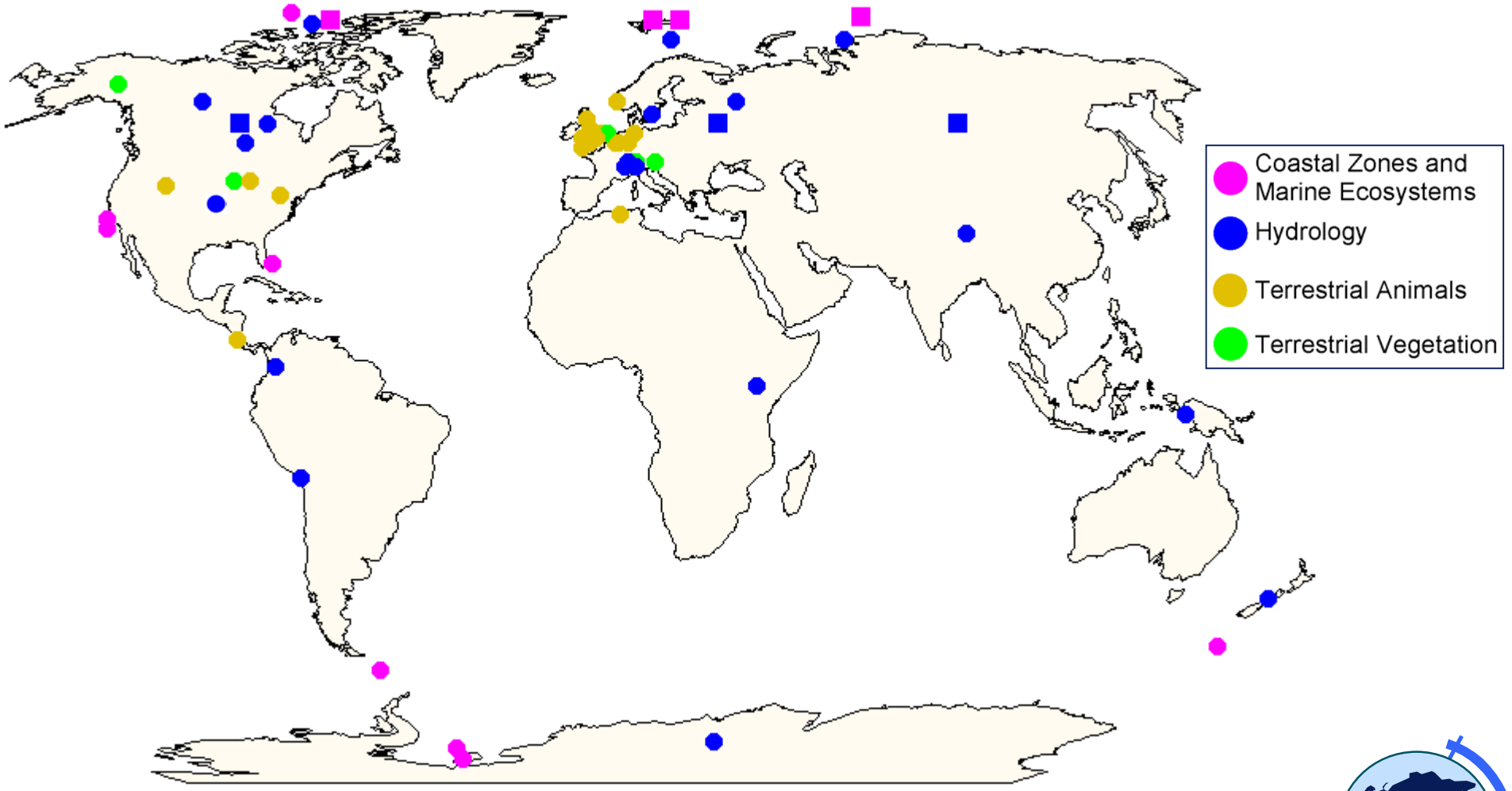
Impacts on hydropower generation and agriculture

1978

2001

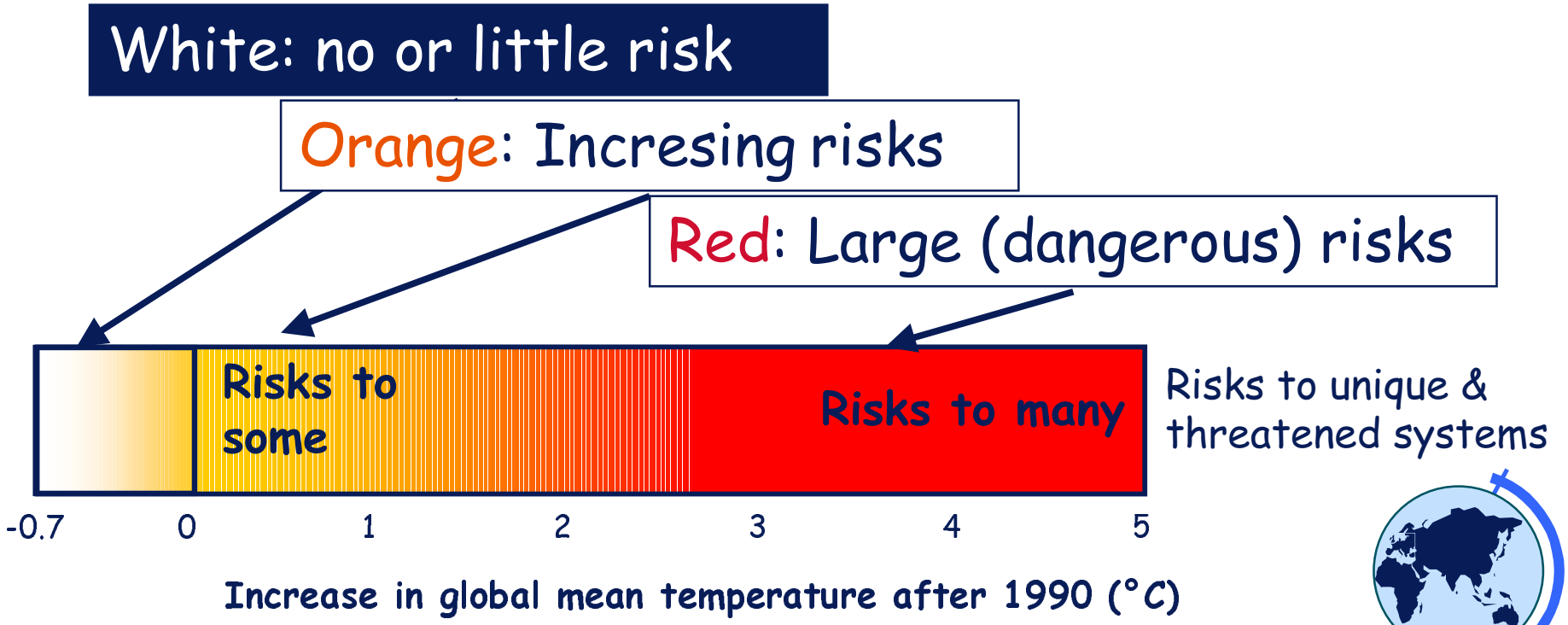
-- NASA space shuttle

Observed impacts of temperature-related regional climate change in the 20th century

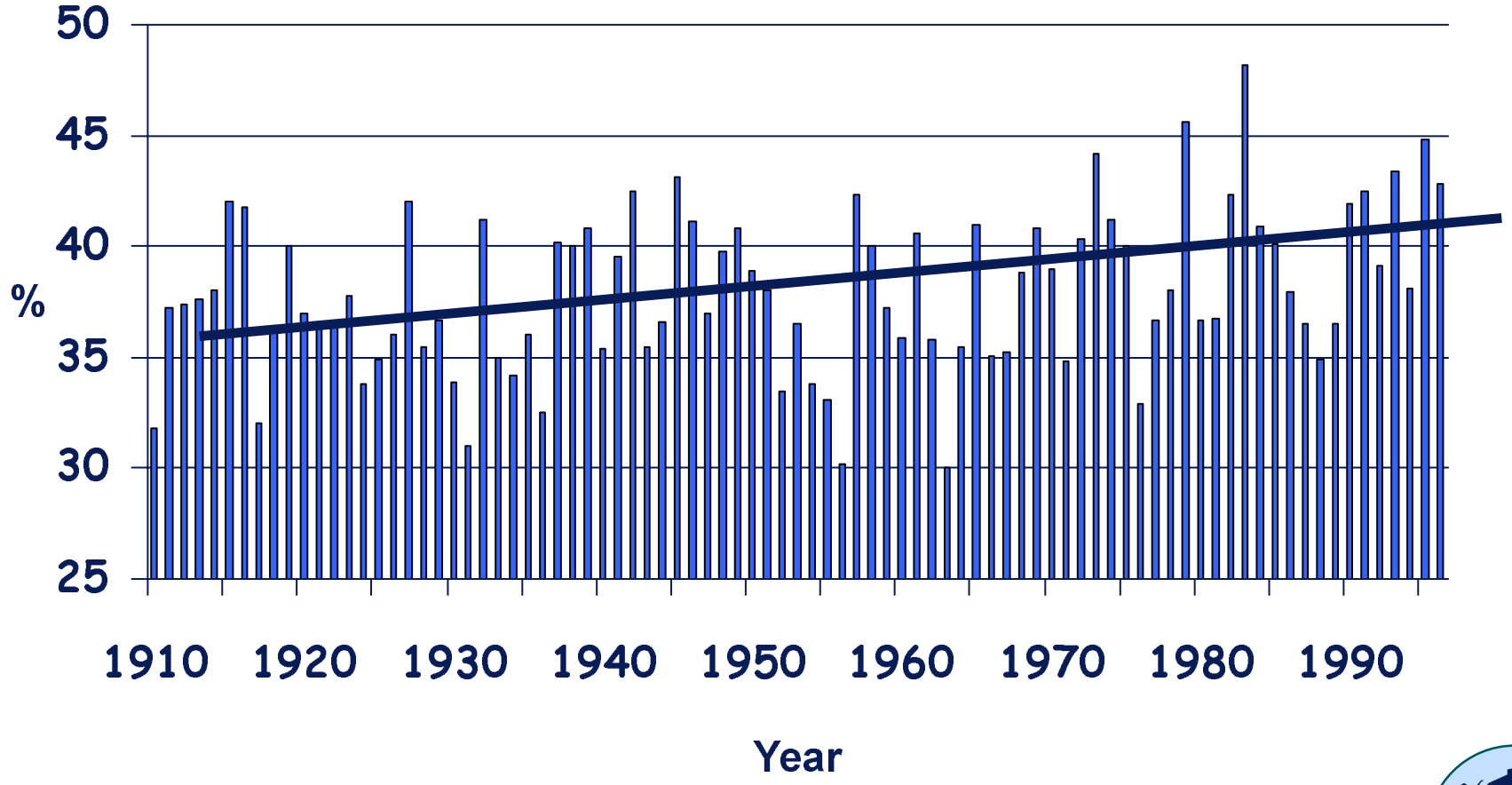


Observation period longer than 20 years

The IPCC vulnerability synthesis: Reasons for Concern



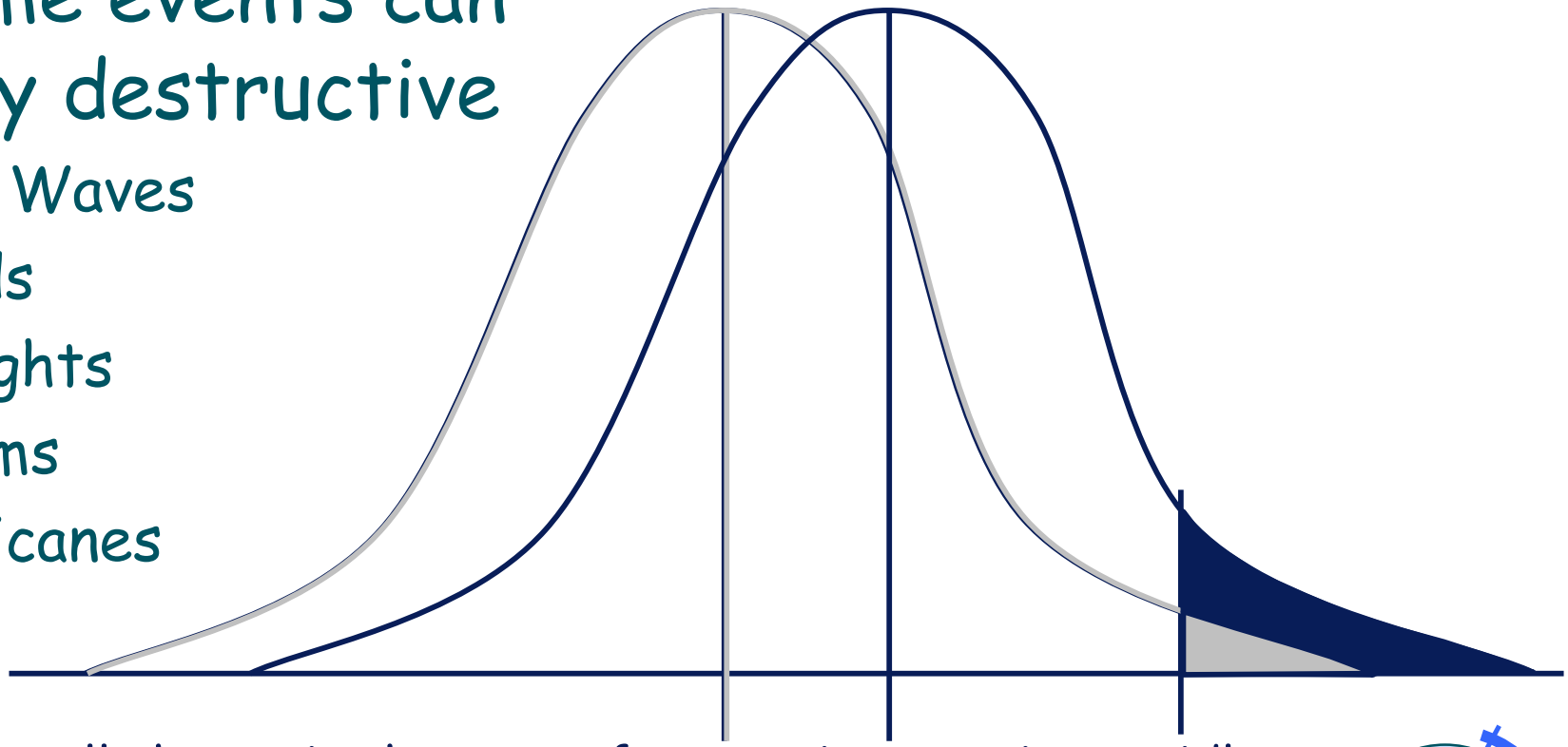
Variations of the percent of U.S. annual precipitation from extreme precipitation events



Changes in Extreme Weather Events

Extreme events can be very destructive

- Heat Waves
- Floods
- Droughts
- Storms
- Hurricanes



With a small change in the mean, frequencies can rise rapidly

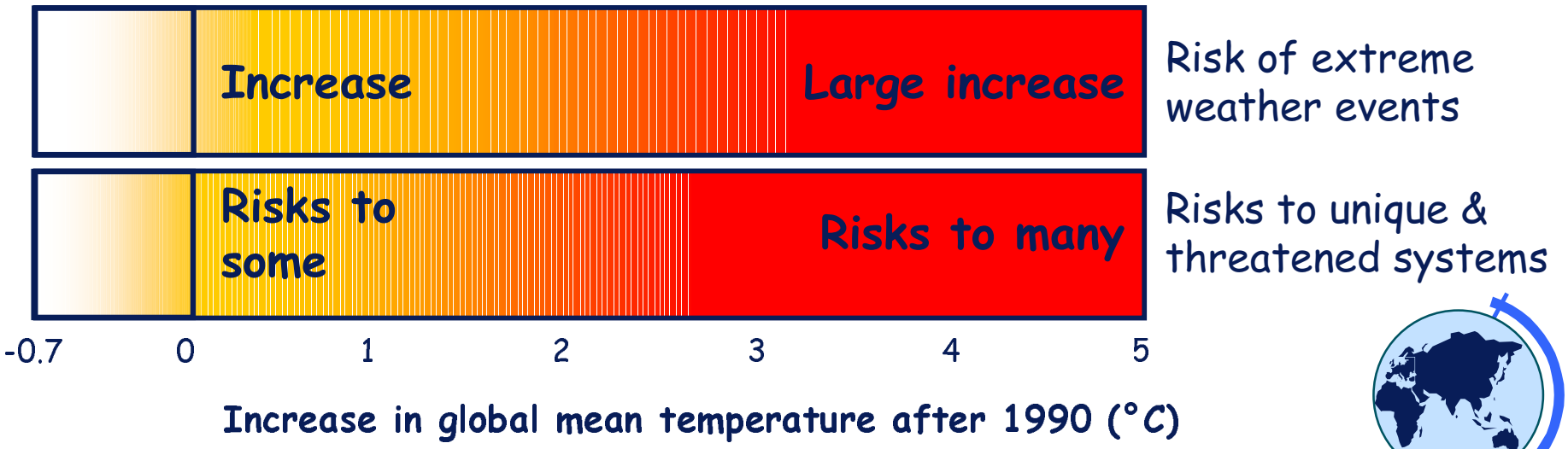
Increased Flooding is Likely

Seasonal moisture actually may increase in springtime

Changing drought frequencies affect soil stability

Changing climatic extremes may be unwelcome

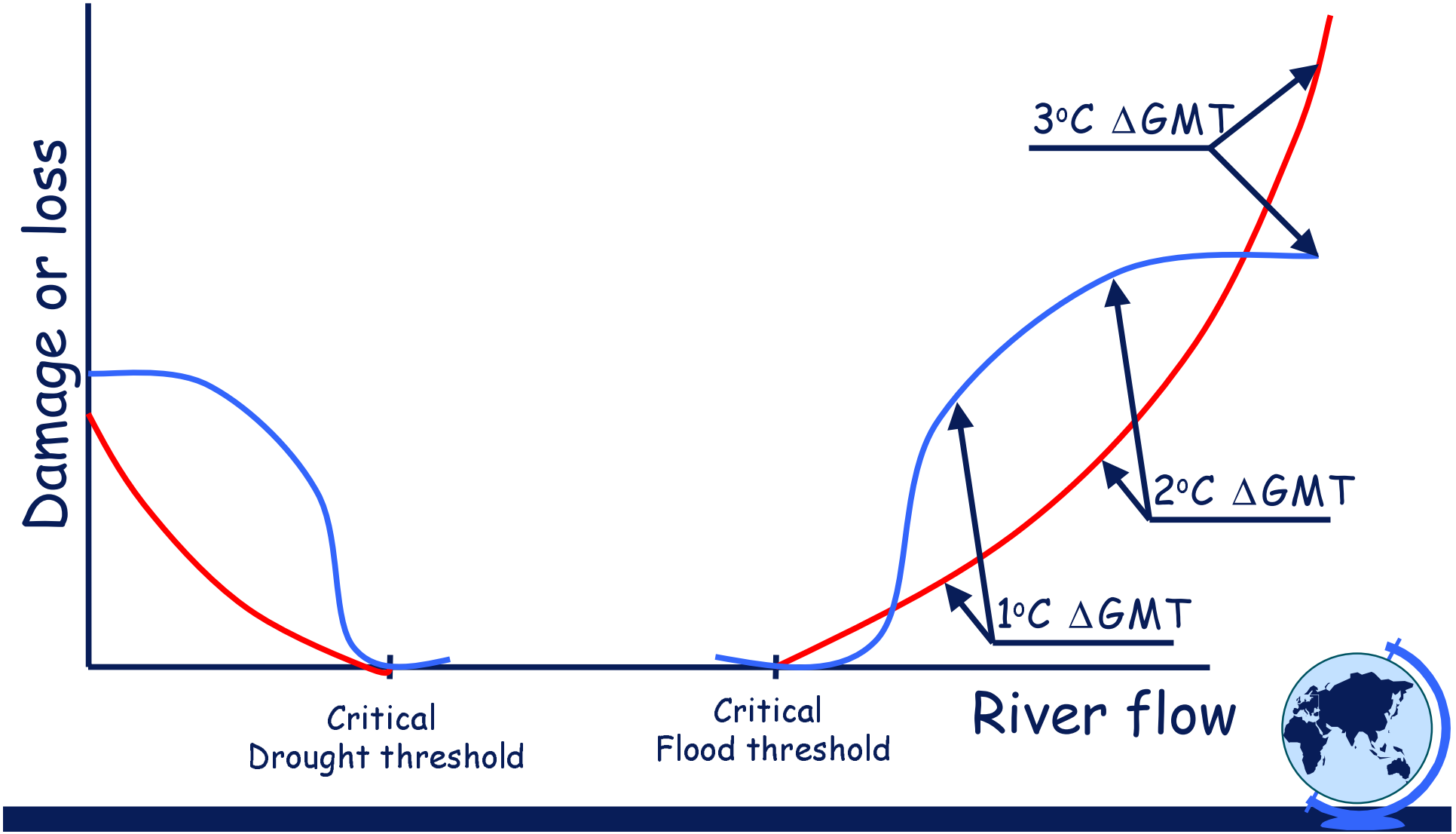
The IPCC vulnerability synthesis: Reasons for Concern



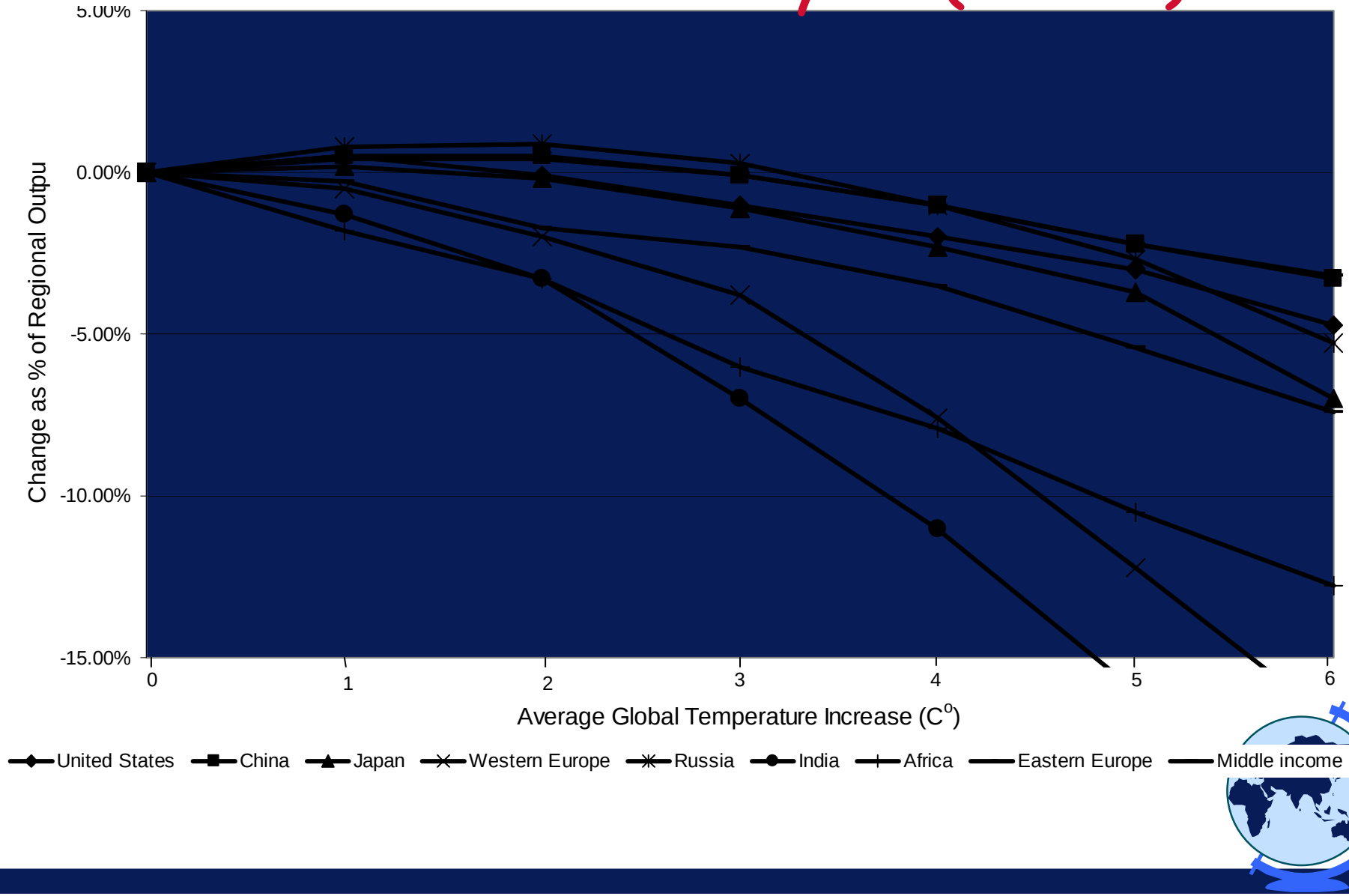
Distribution of Impacts

- ✔ Are Some Regions, Peoples, Systems, More Adversely Affected Than Others?
- ✔ Is it Equitable?

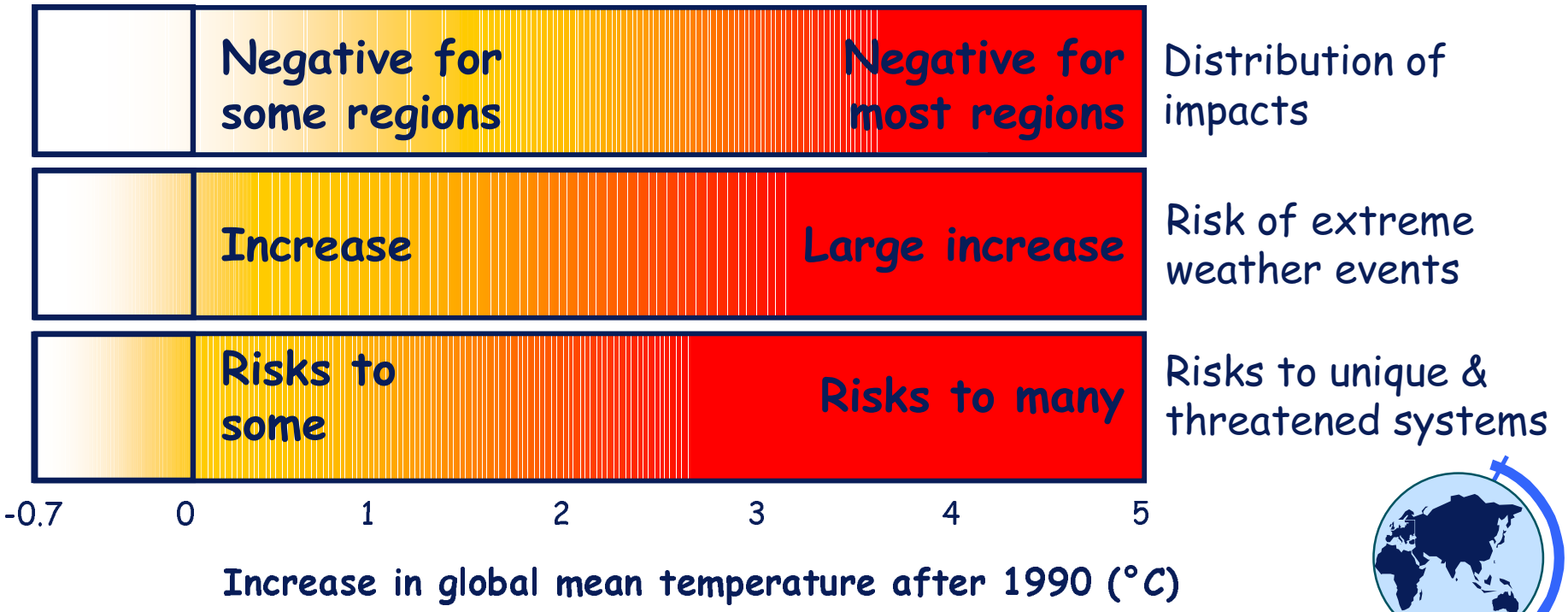
Damage of drought and floods (After Zbyscek Kundzewicz)



Regional damage functions by Nordhaus and Boyer (2000)



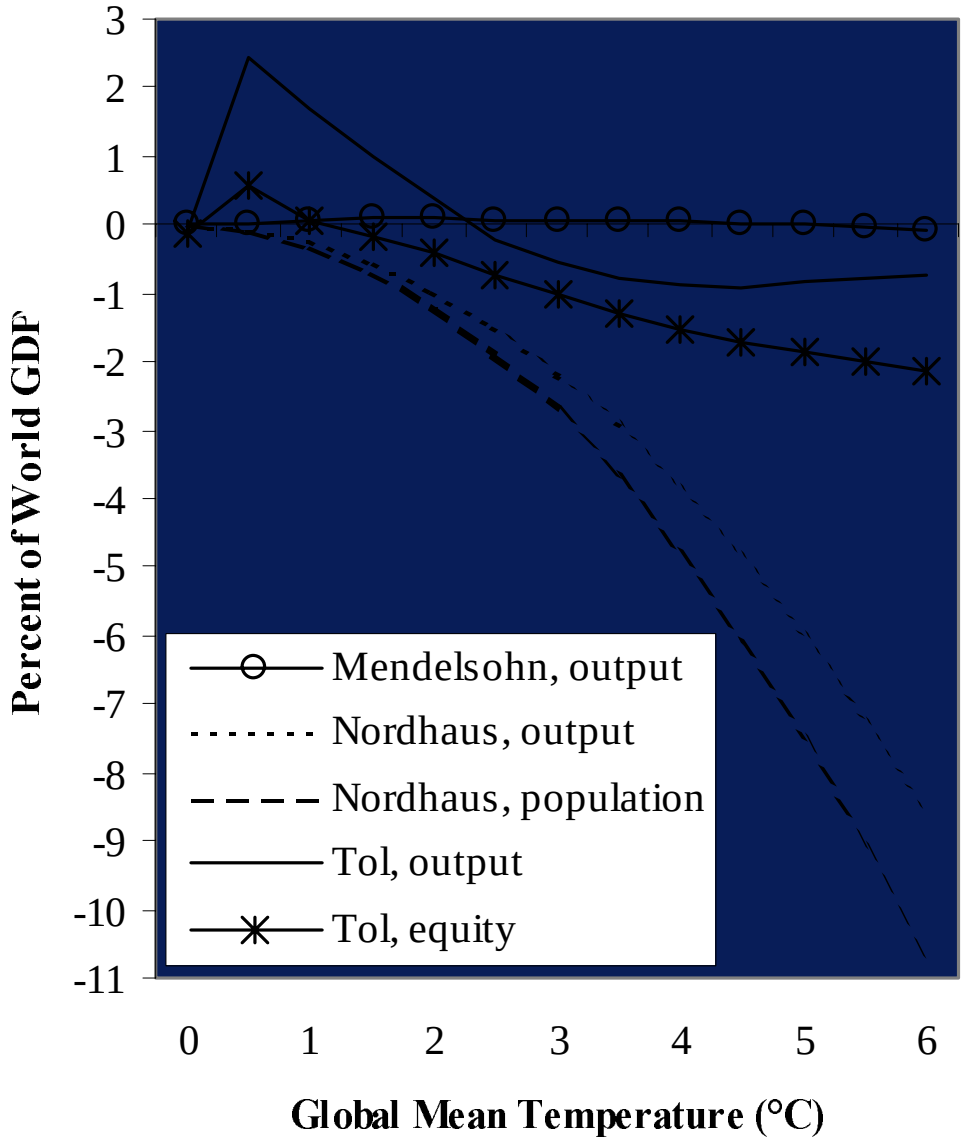
The IPCC vulnerability synthesis: Reasons for Concern



Aggregate Impacts

- ✔ Examines Totality of Impacts, Using a Common Metric
- ✔ Monetization is Most Often Used
- ✔ Monetization is Controversial Because:
  - ✓ Emphasizes Wealthy at Expense of Poor
  - ✓ Hides Inequalities

Global Monetary Impacts



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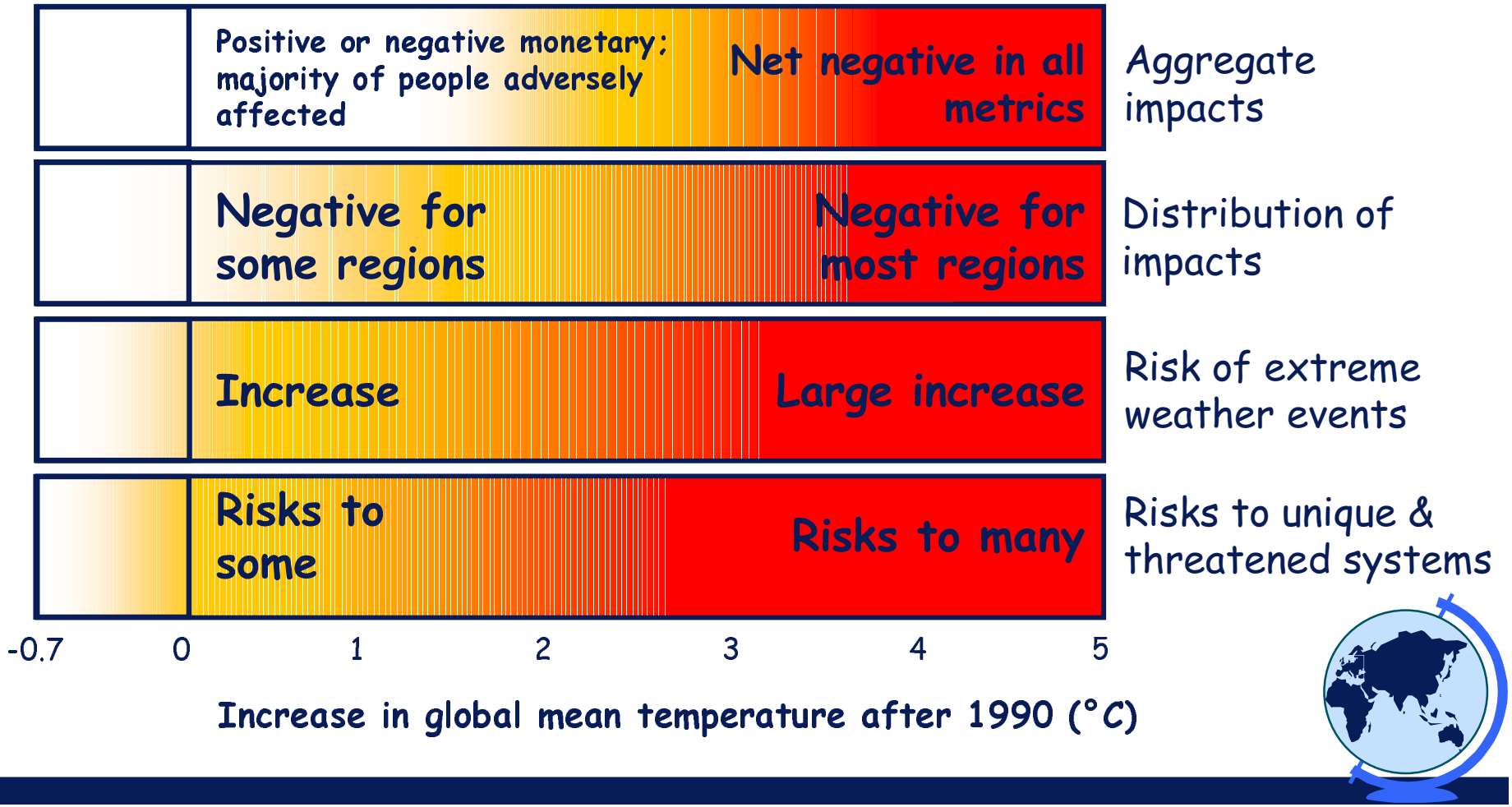
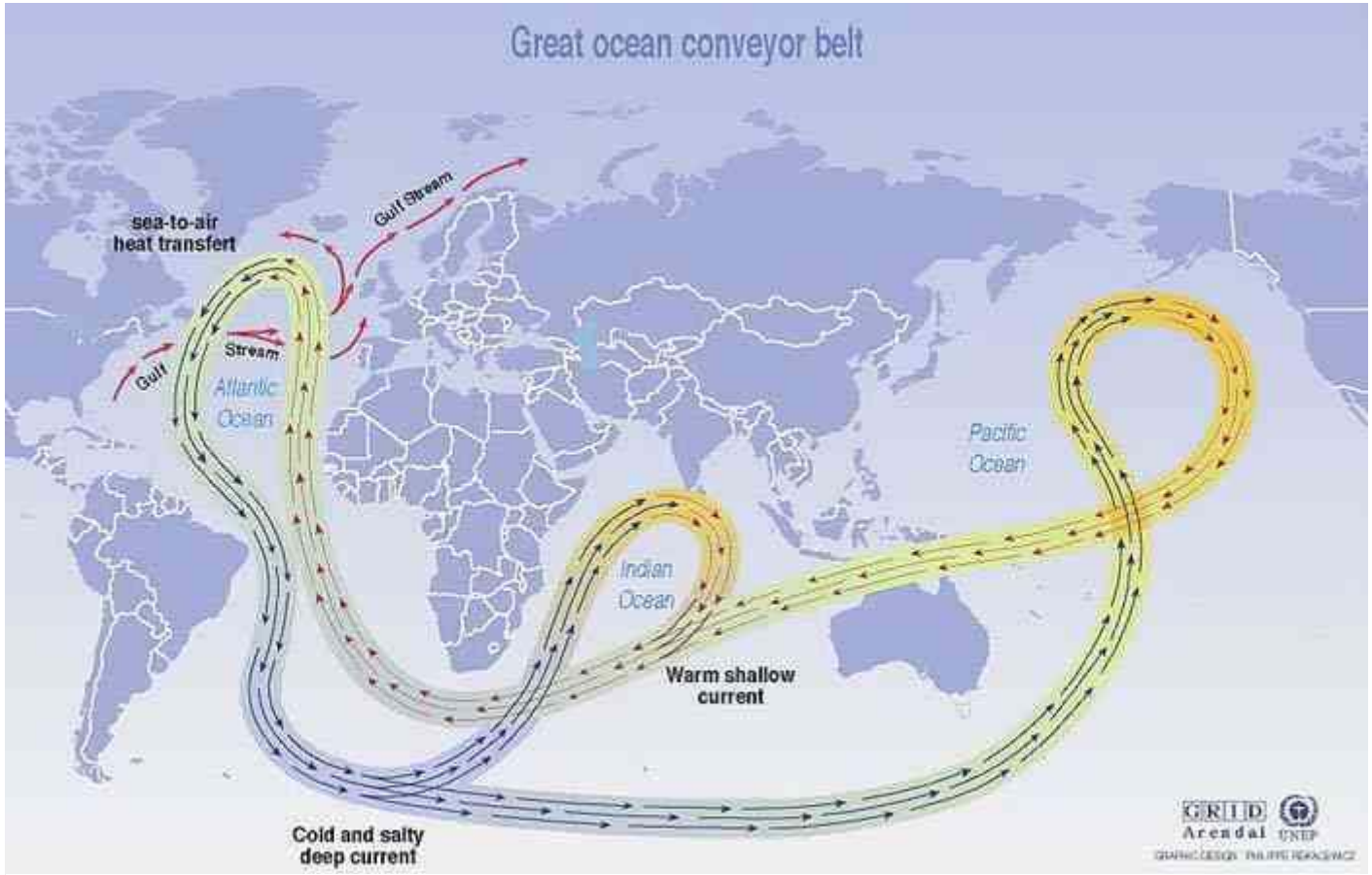


Large Scale Singularities (surprises)

System Changes; Low likelihood but potentially large consequences

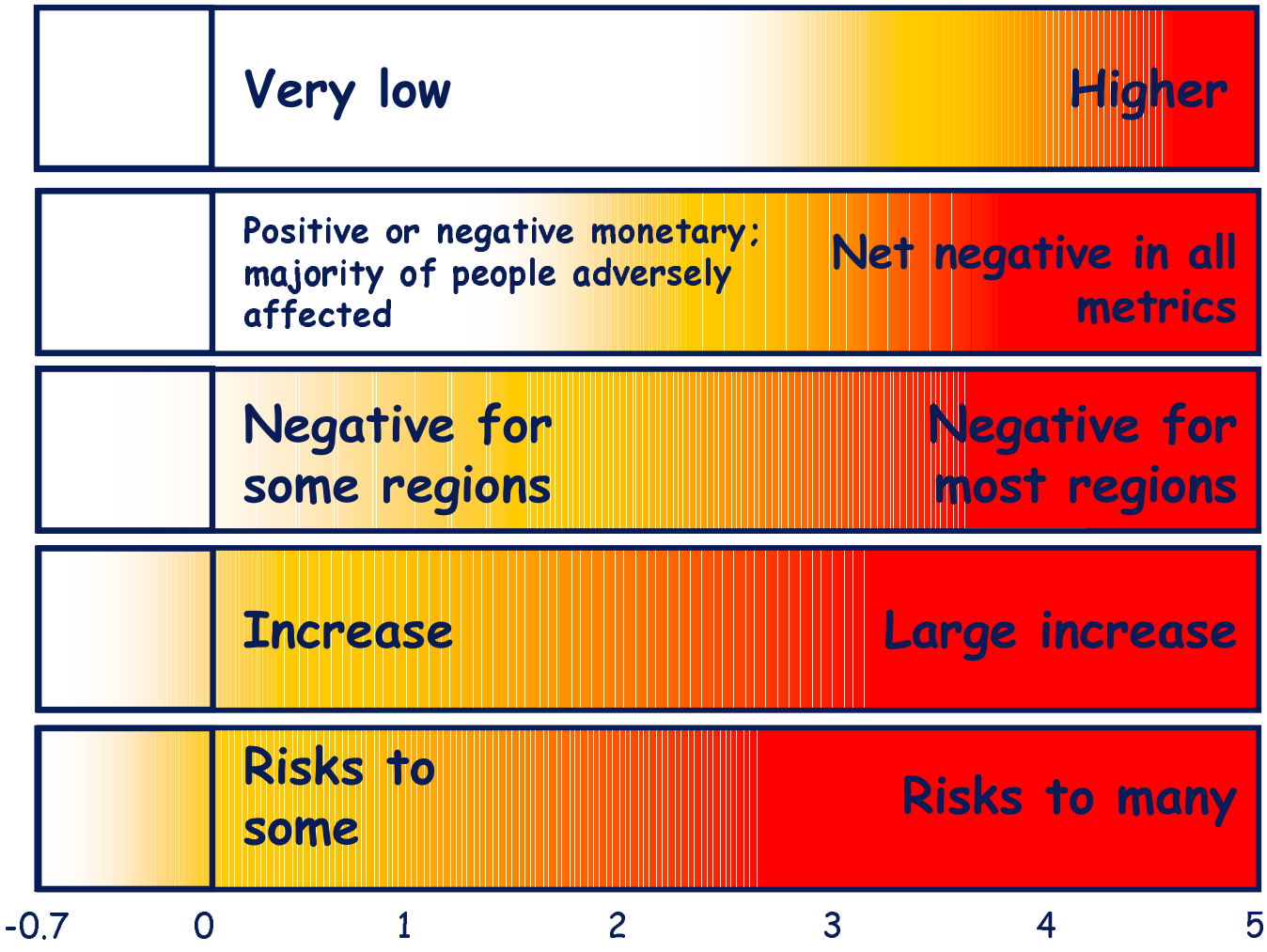
- ✓ West Antartic Ice Sheet disintegration: 4-6 meter sea level rise:
- ✓ ThermoHaline Circulation Collapse: Cooling of North Atlantic
- ✓ Runaway Greenhouse Effect: Positive feedbacks in the carbon cycle

Thermohaline Circulation



Response is a function of the absolute increase in temperature and the rate of temperature increase.

The IPCC vulnerability synthesis: Reasons for Concern



Risks of large scale singularities

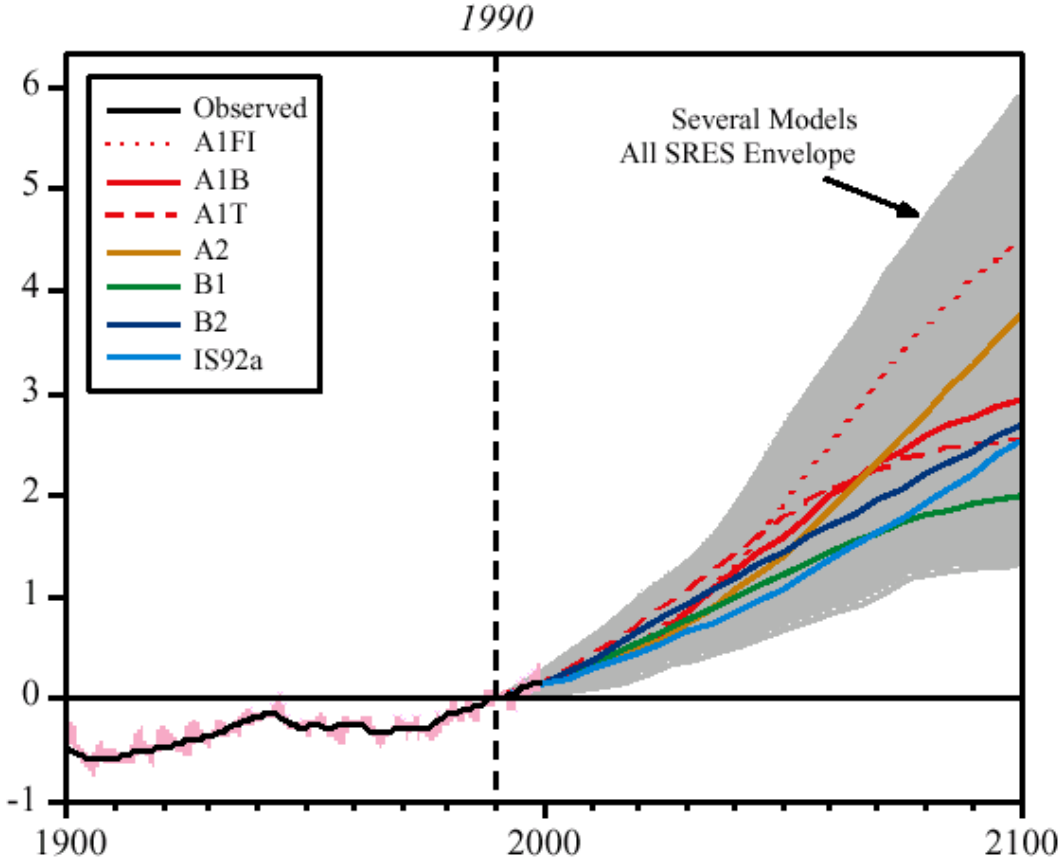
Aggregate impacts

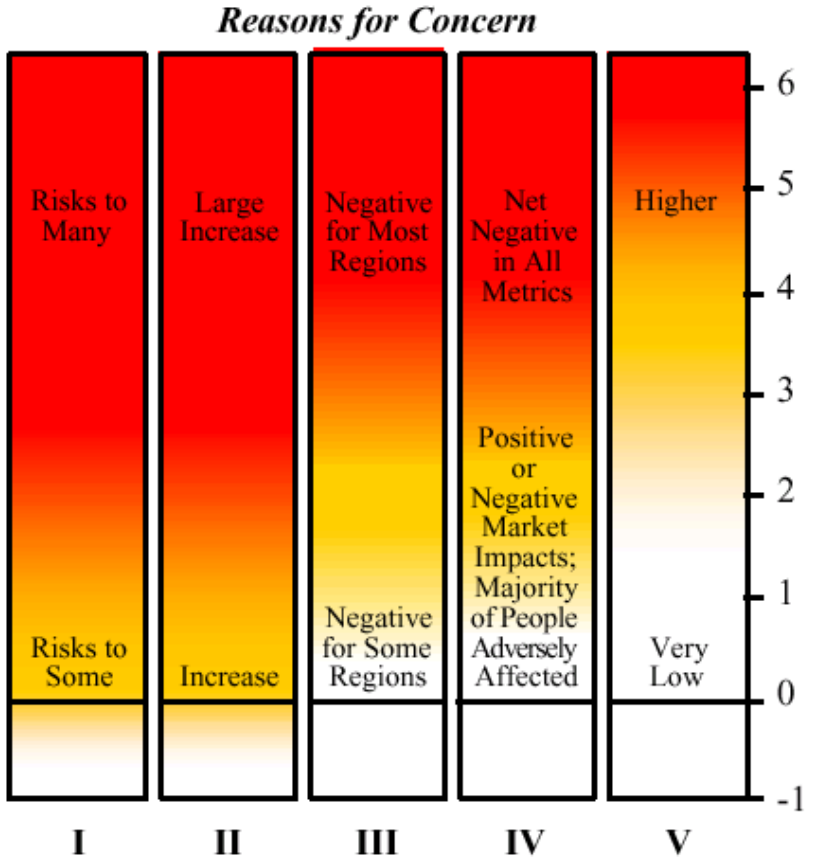
Distribution of impacts

Risk of extreme weather events

Risks to unique & threatened systems

IPCC SRES scenarios and reason for concerns for dangerous impacts



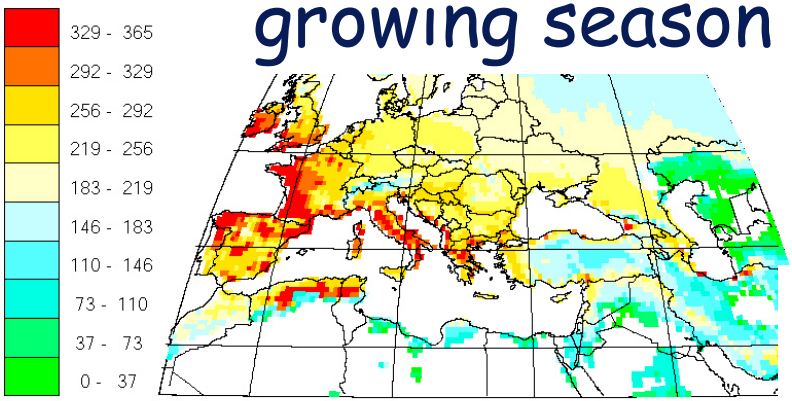


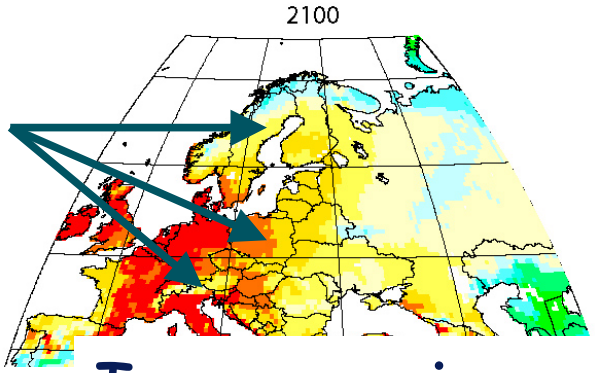
Aggregated ecological indicators

Changes in length and start of season

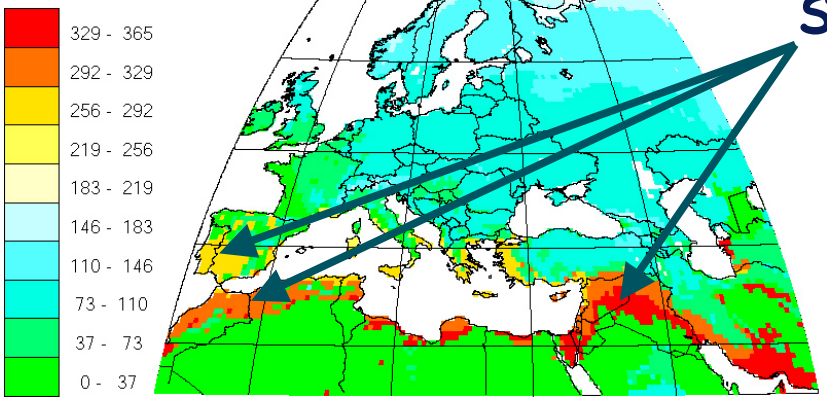
Increase in the length of the growing season

Length



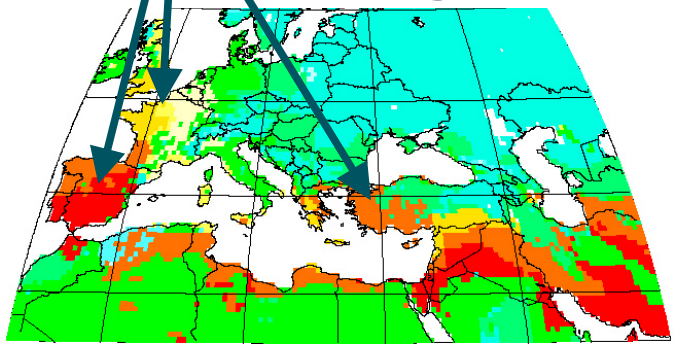


Start



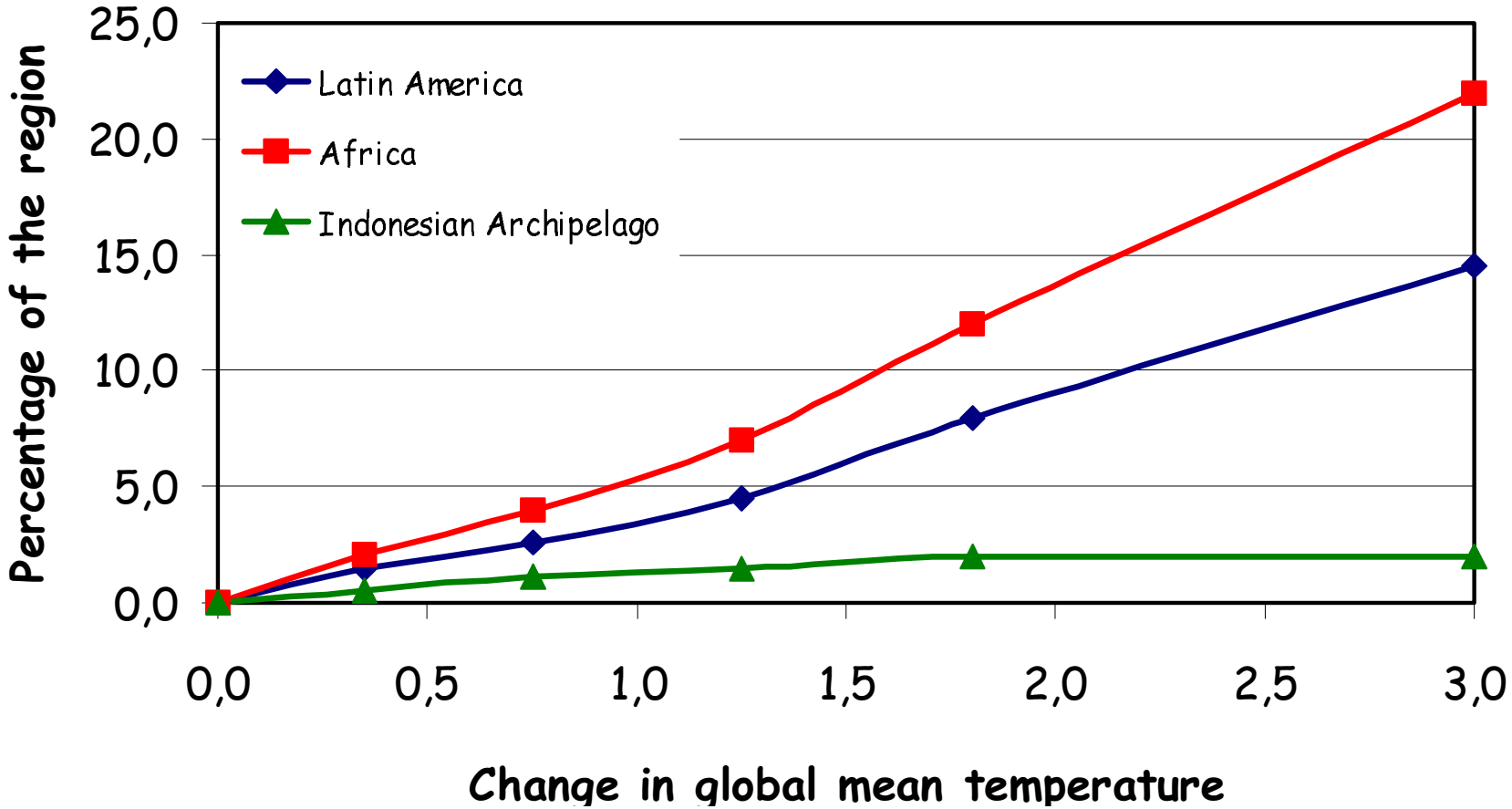
Start of season after the summer drought

Increase in summer droughts

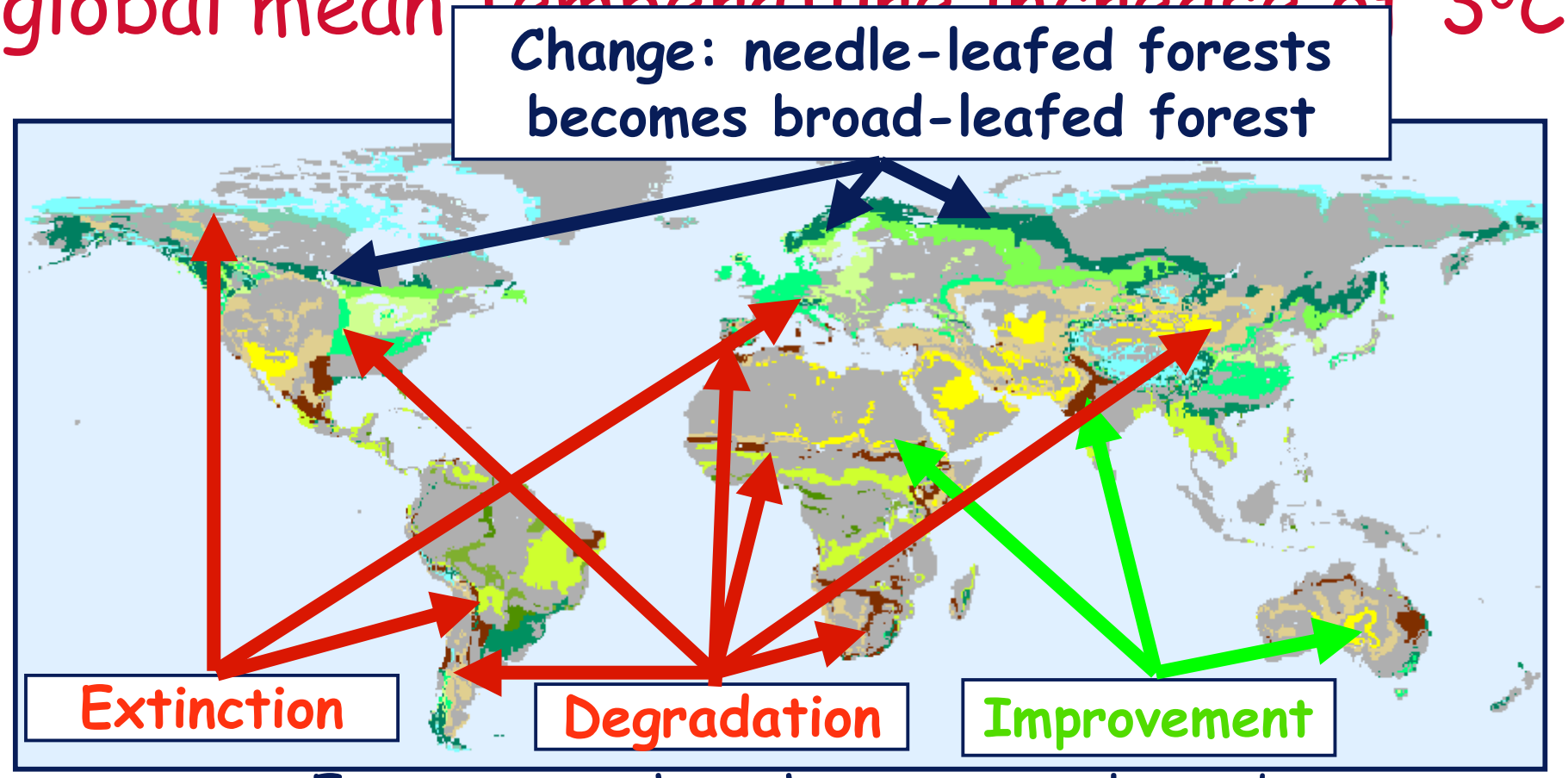


Change in fire-proneness

(i.e. the area without a dry season now but one in the future)



An example: Changing ecosystems at a global mean temperature increase of 3°C

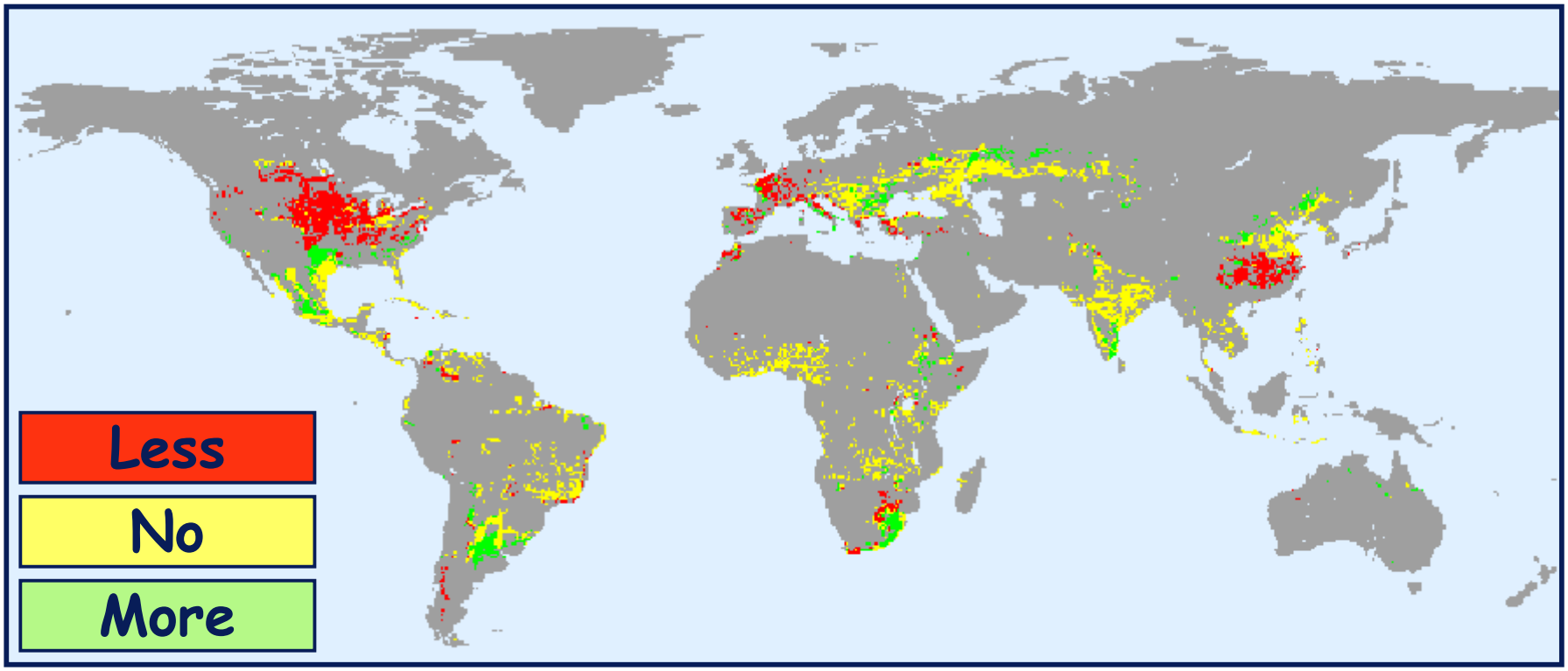


Ecosystems that change are coloured.

Improvement: More trees and higher productivity
Change: Different species composition and landscapes
Degradation: Fewer trees and lower productivity
Extinction: Large habitat decline and irreversible change

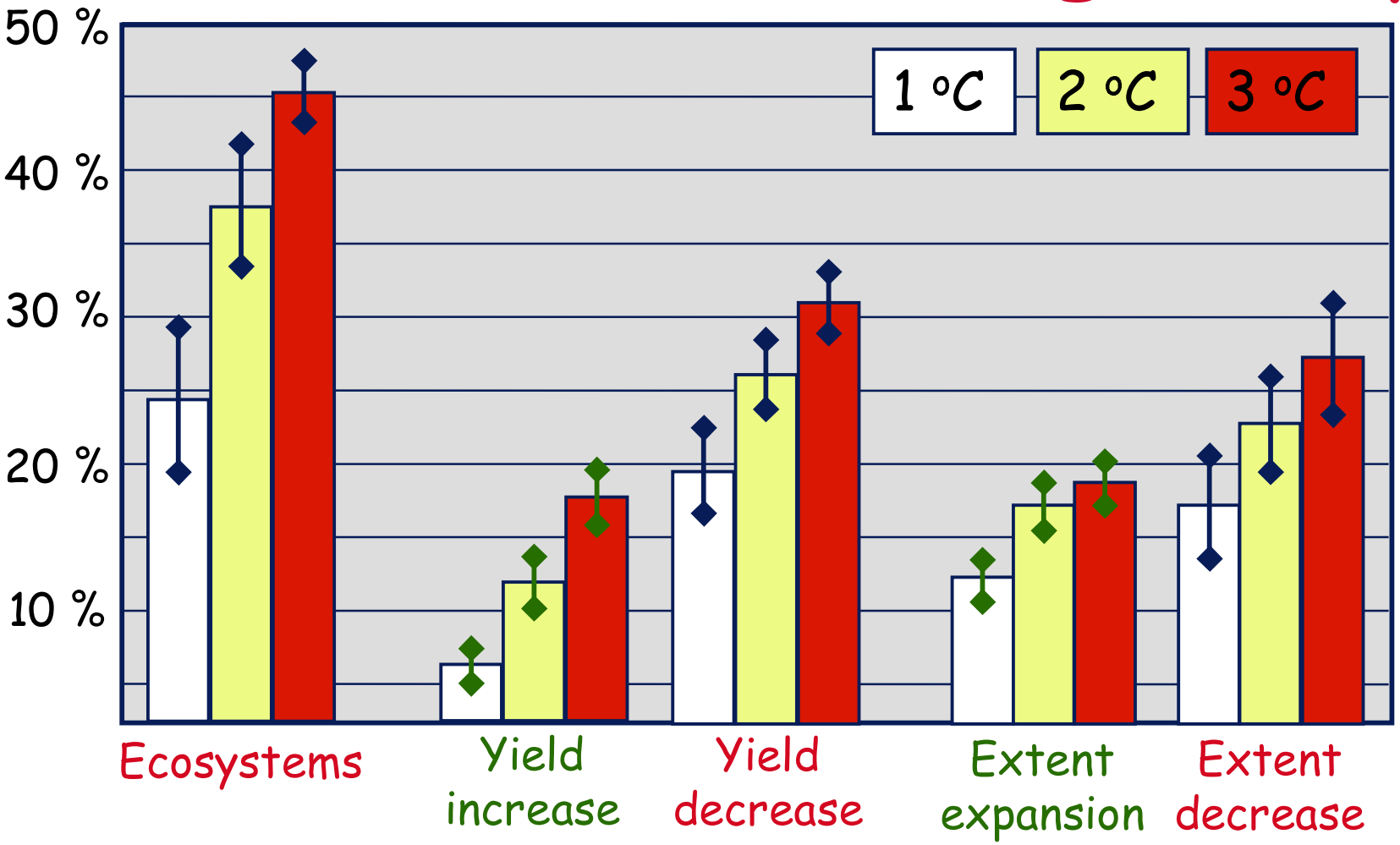
Dieback is fast, regrowth is slow

Impact on the yield of corn



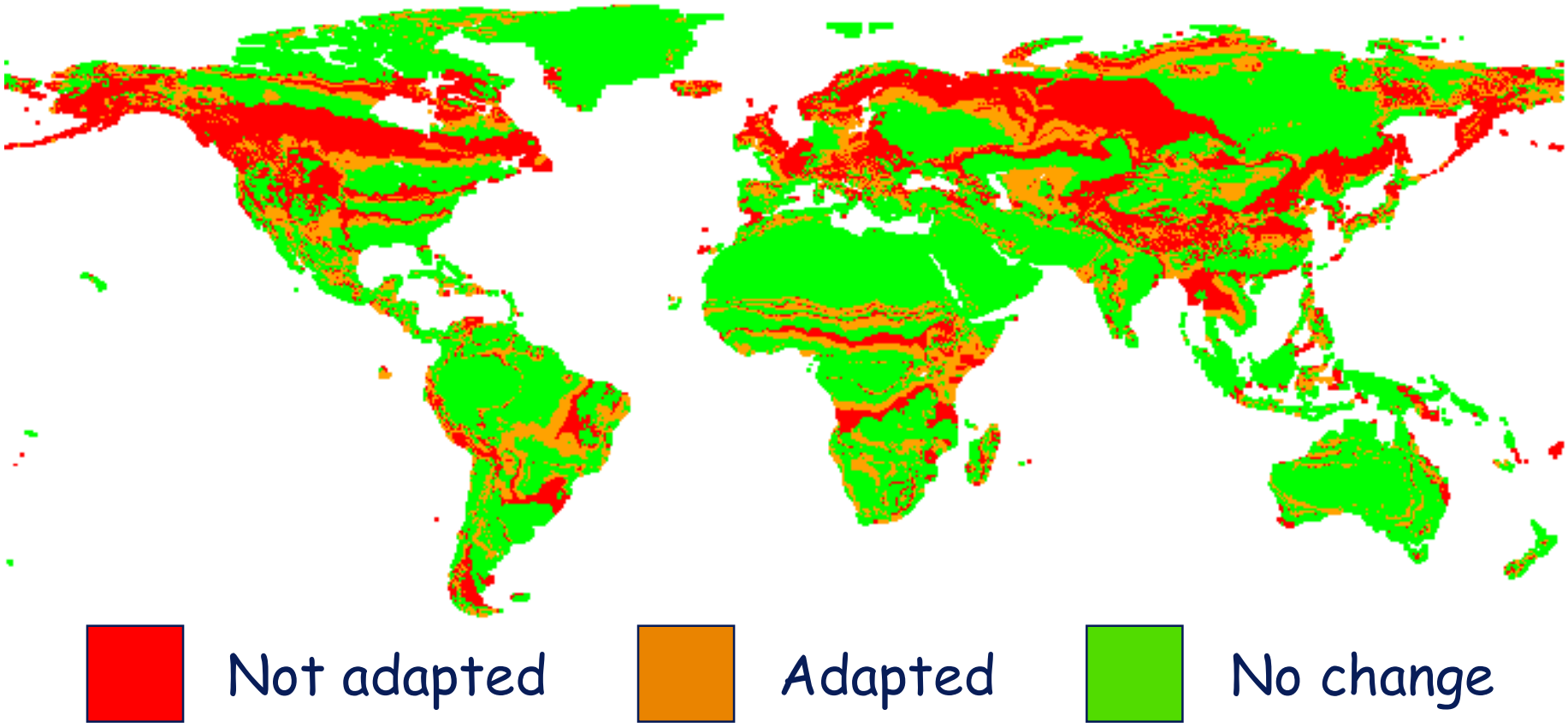
The regional yield can change: some regions improve while others decline (mainly driven by drought)

How do risks evolve globally?



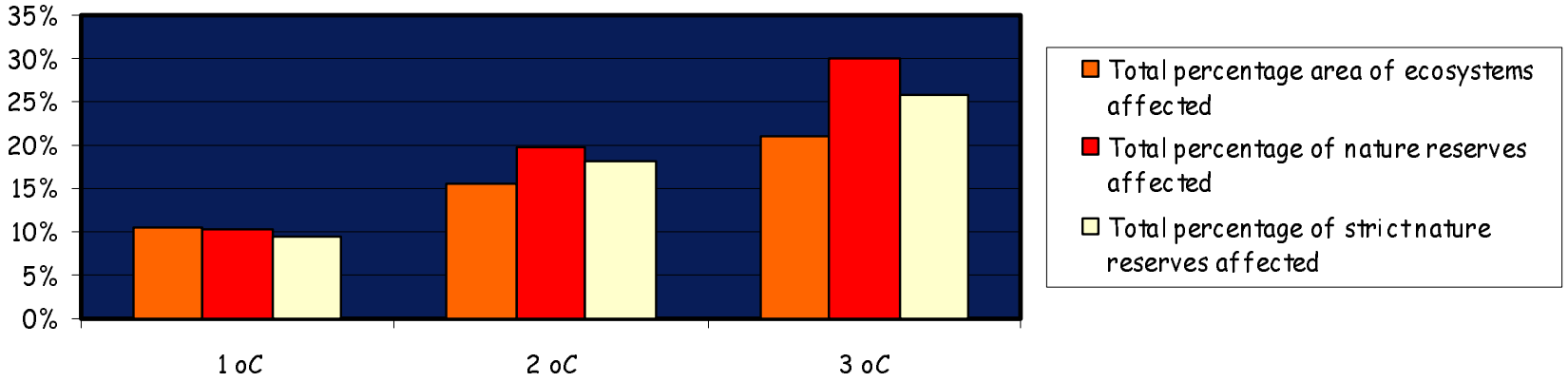
Impacts are expressed as the percentage area affected. The reference is the current area (crops) or the total amount of land (ecosystems).

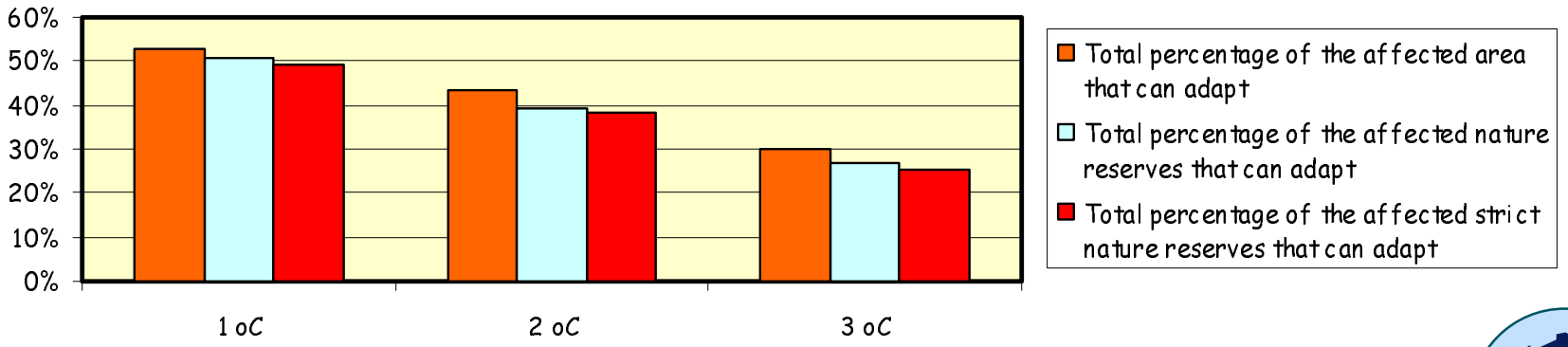
Adaptation at 3 °C in 2100 (Hadcm2)



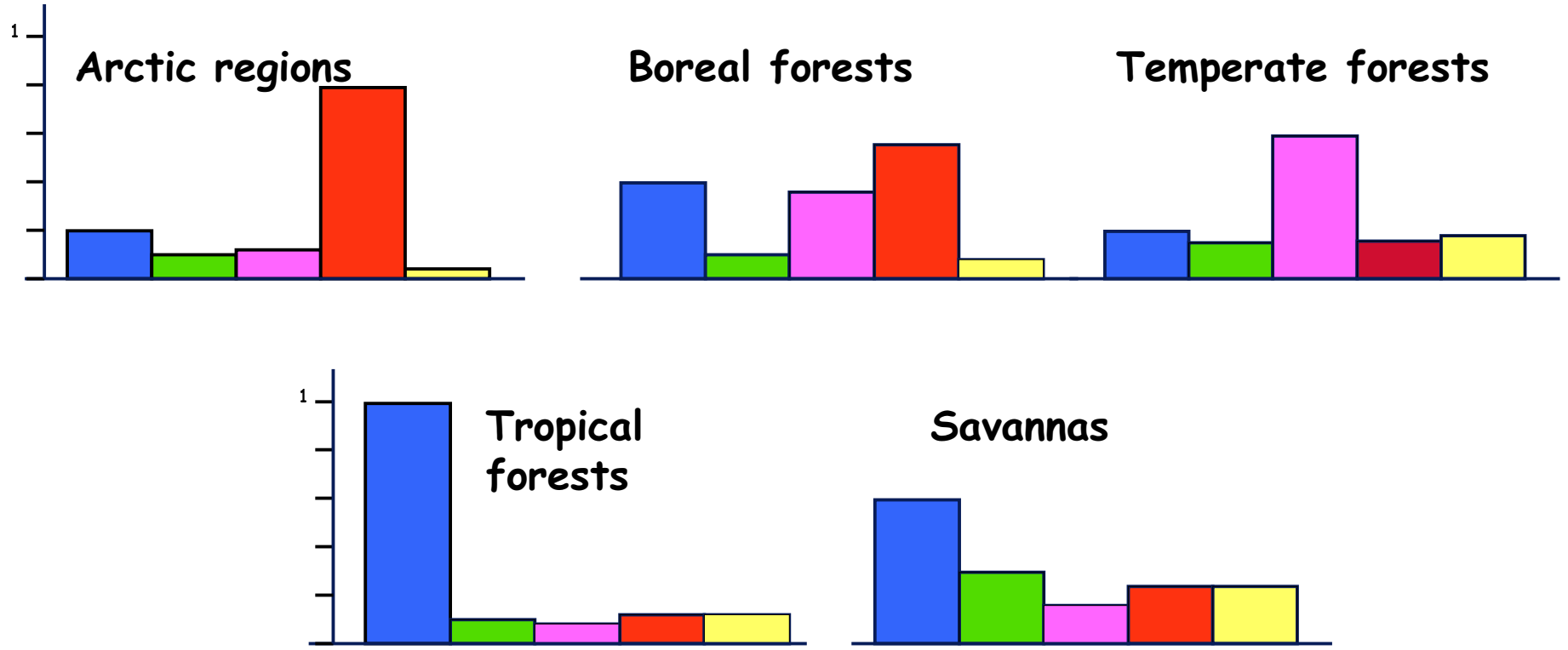
Impacts on nature reserves & adaptation

What area is affected?





Combining climate change and other global change aspects: Impacts on biodiversity



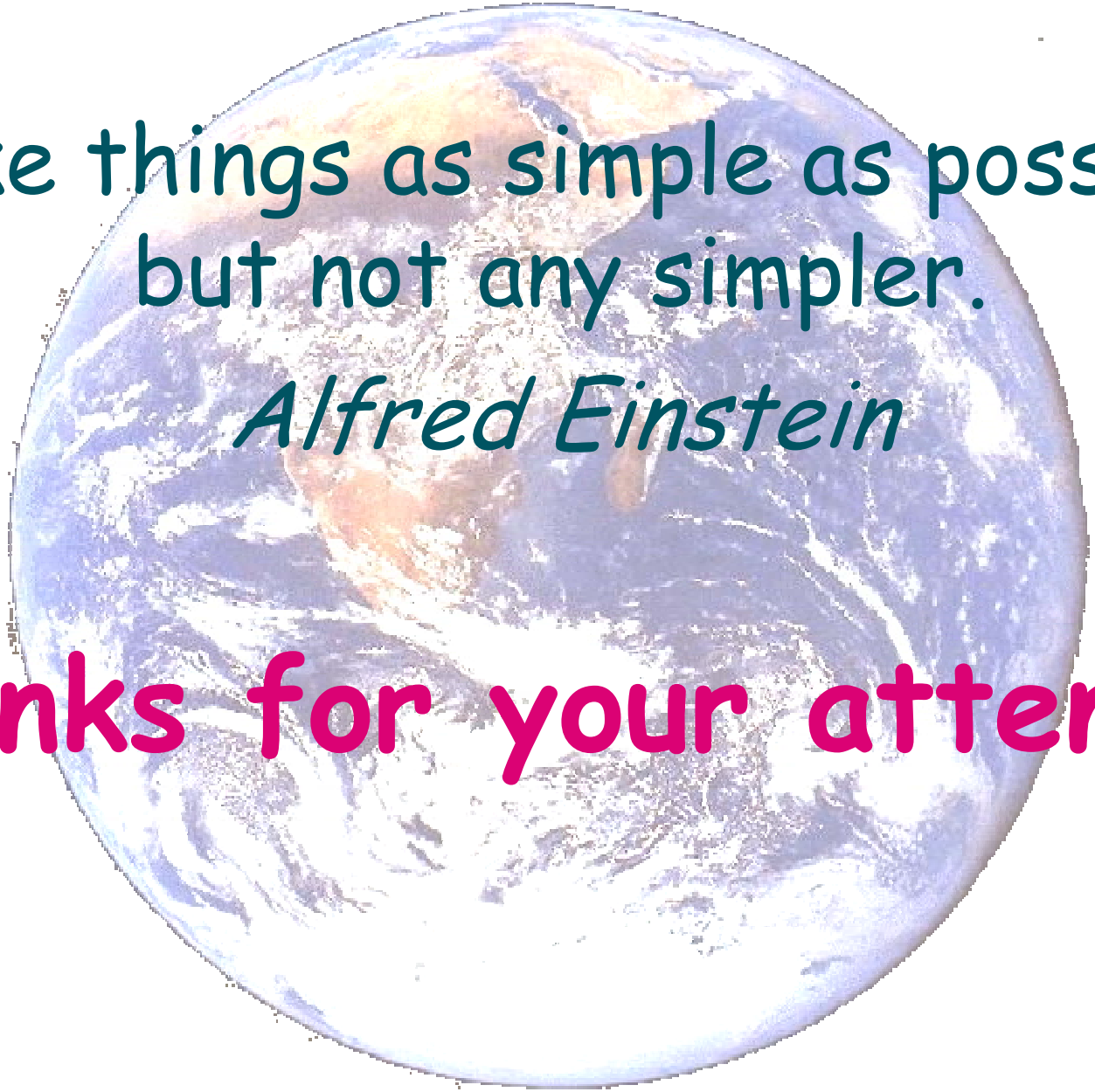
A race of hyper-intelligent pan-dimensional beings built themselves a gigantic supercomputer called **Deep Thought** to calculate once and for all the Answer to the **Ultimate Question of Life, the Universe and Everything**.

For seven and a half million years, Deep Thought computed and calculated, and in the end announced that the Answer was, in fact, **forty-two**.

From: Douglas Adams. The Hitch-hikers Guide to the Galaxy. Guild Publishing, London. (1986).

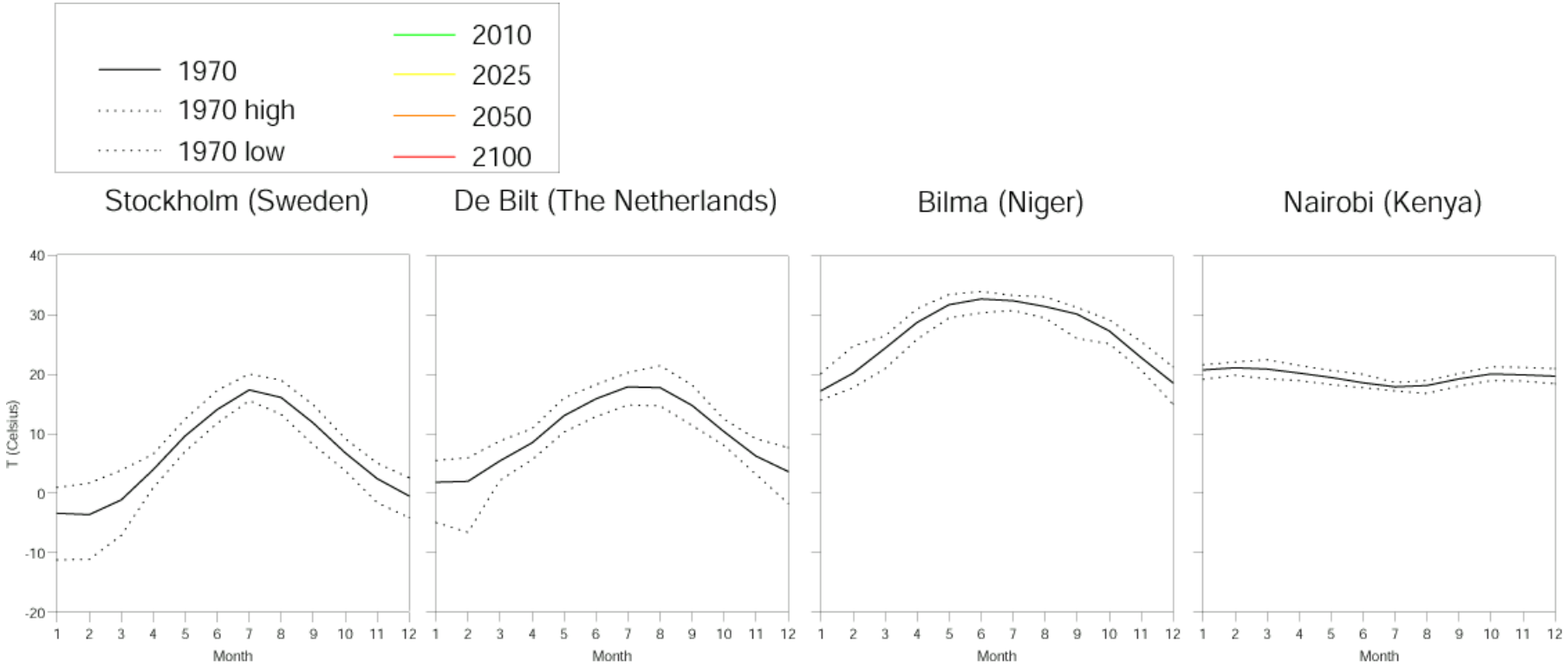
Make things as simple as possible,
but not any simpler.

Alfred Einstein

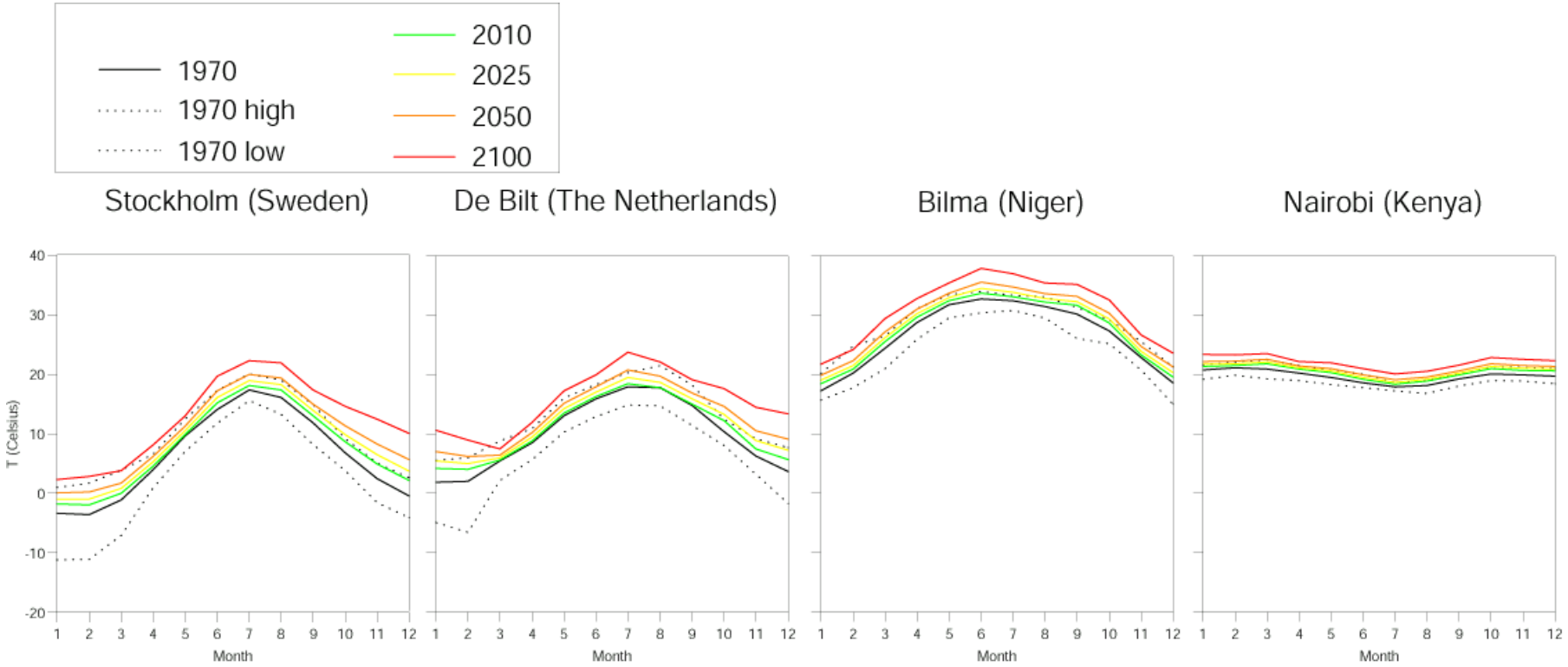


Thanks for your attention

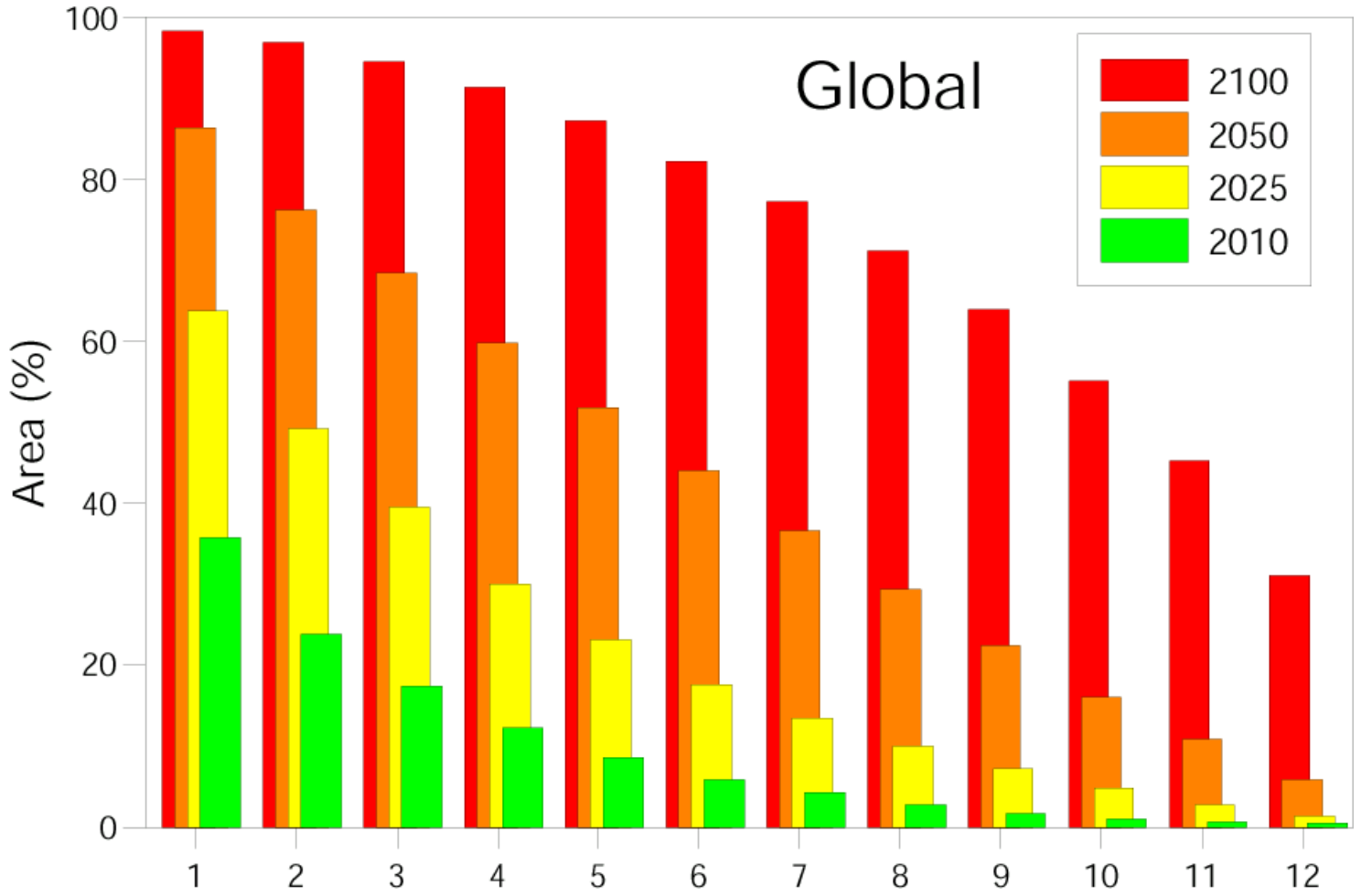
An example of the monthly exceedance indicator



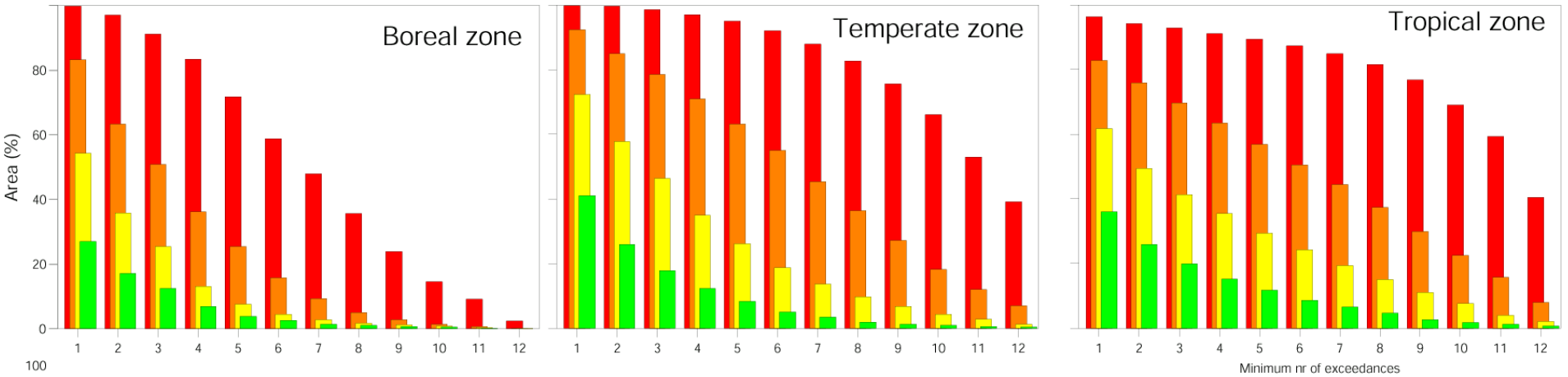
An example of the monthly exceedance indicator



Global exceedance



Regional Exceedance

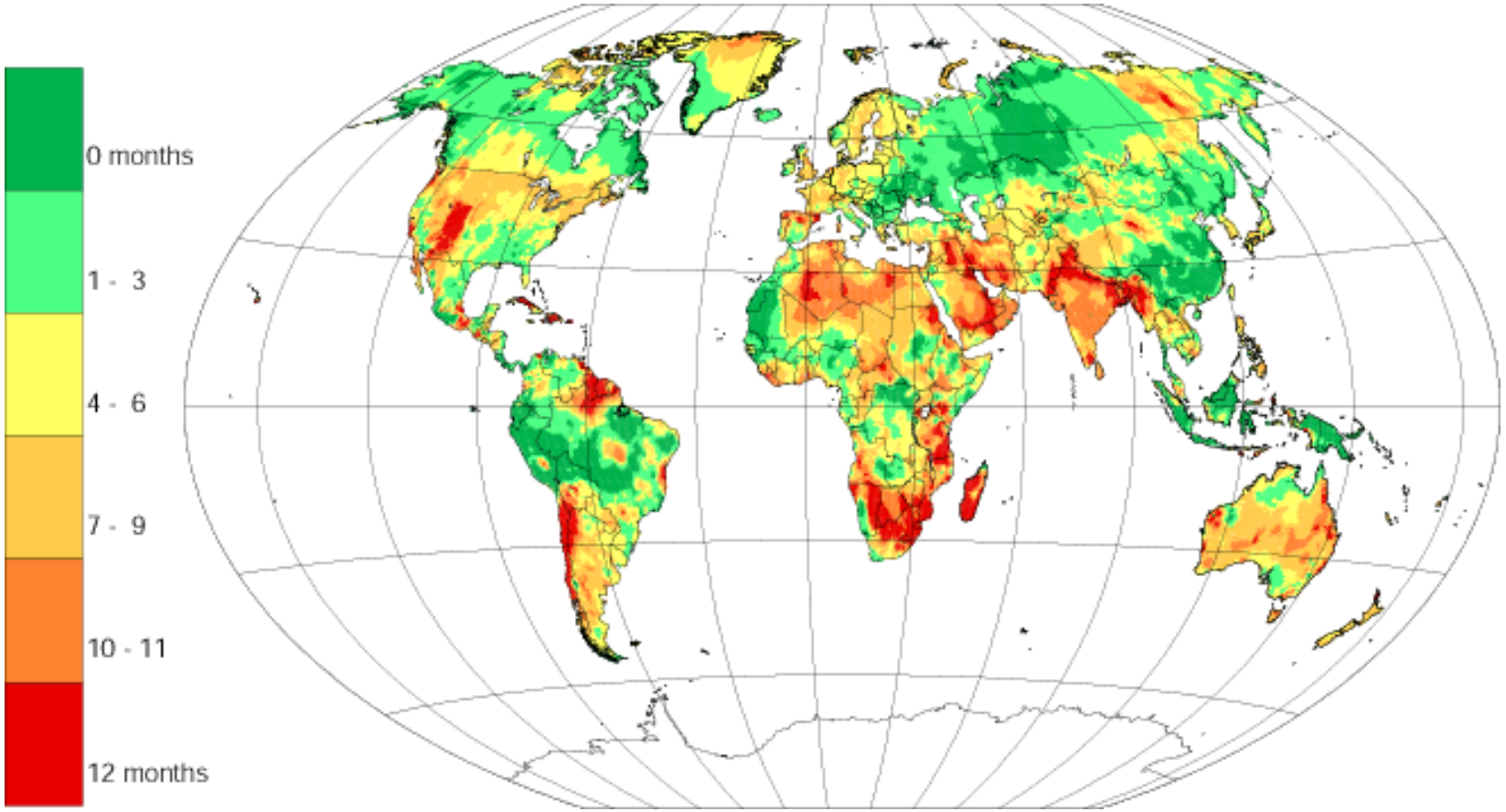


Higher temperature increase but broad temperature ranges (especially in the winter):
all ecosystems affected but not throughout the year

Medium temperature increase but less broad temperature ranges:
all ecosystems affected during most of the year

Small temperature increase but narrow temperature ranges:
almost all ecosystems affected during most of the year

Spatial pattern of exceedance in 2050



Ecosystem services

Provisioning

Goods produced or provided by ecosystems

- food
- fresh water
- fuel wood
- fiber
- biochemicals
- genetic resources

Regulating

Benefits obtained from regulation of ecosystem processes

- climate regulation
- disease control
- flood control
- detoxification

Cultural

Non-material benefits obtained from ecosystems

- spiritual
- recreational
- aesthetic
- inspirational
- educational
- communal
- symbolic

Supporting

Services that maintain the conditions for life on earth

- Soil formation
- Nutrient cycling
- Pollination