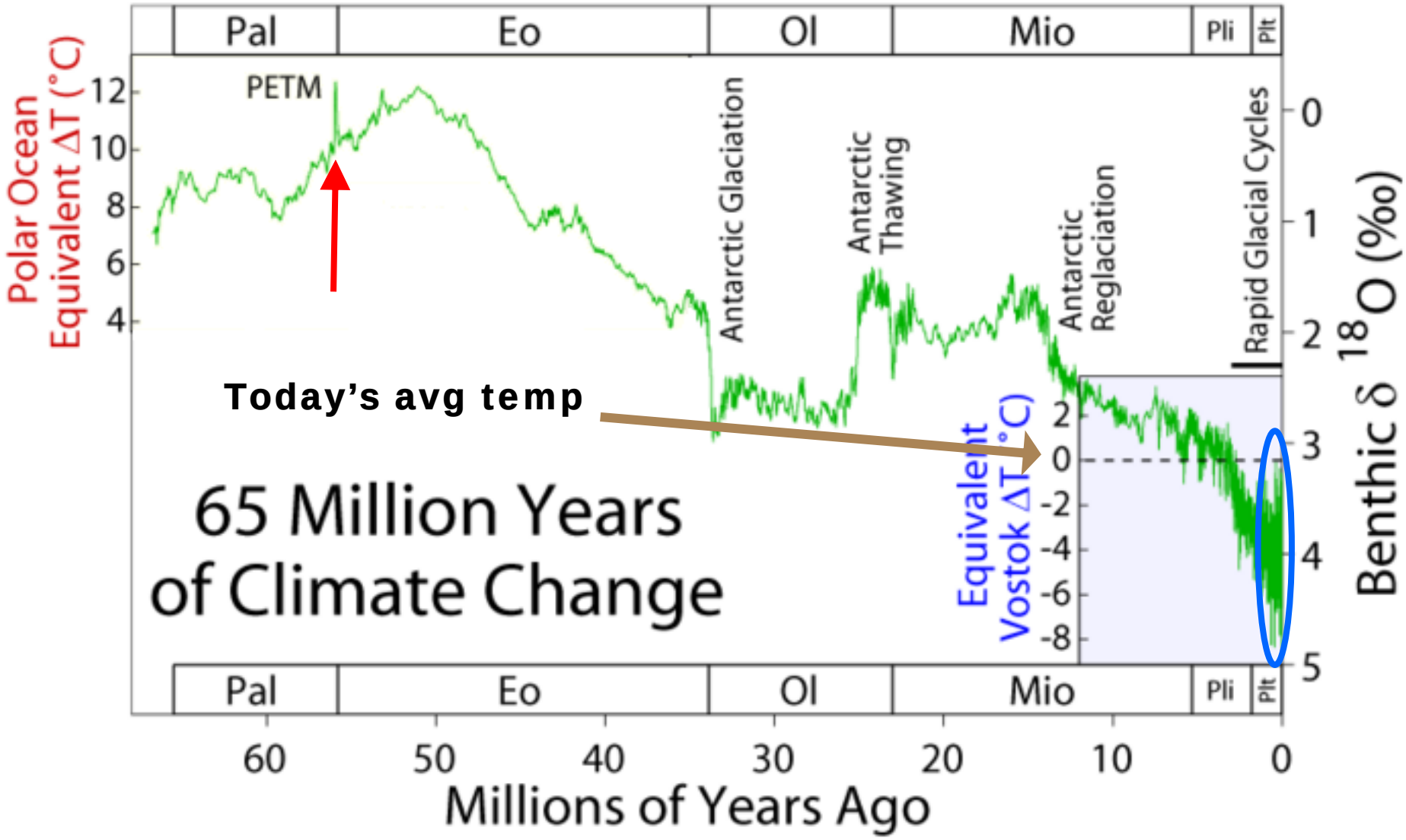
Climate Change and its Implications for Conservation and Policy

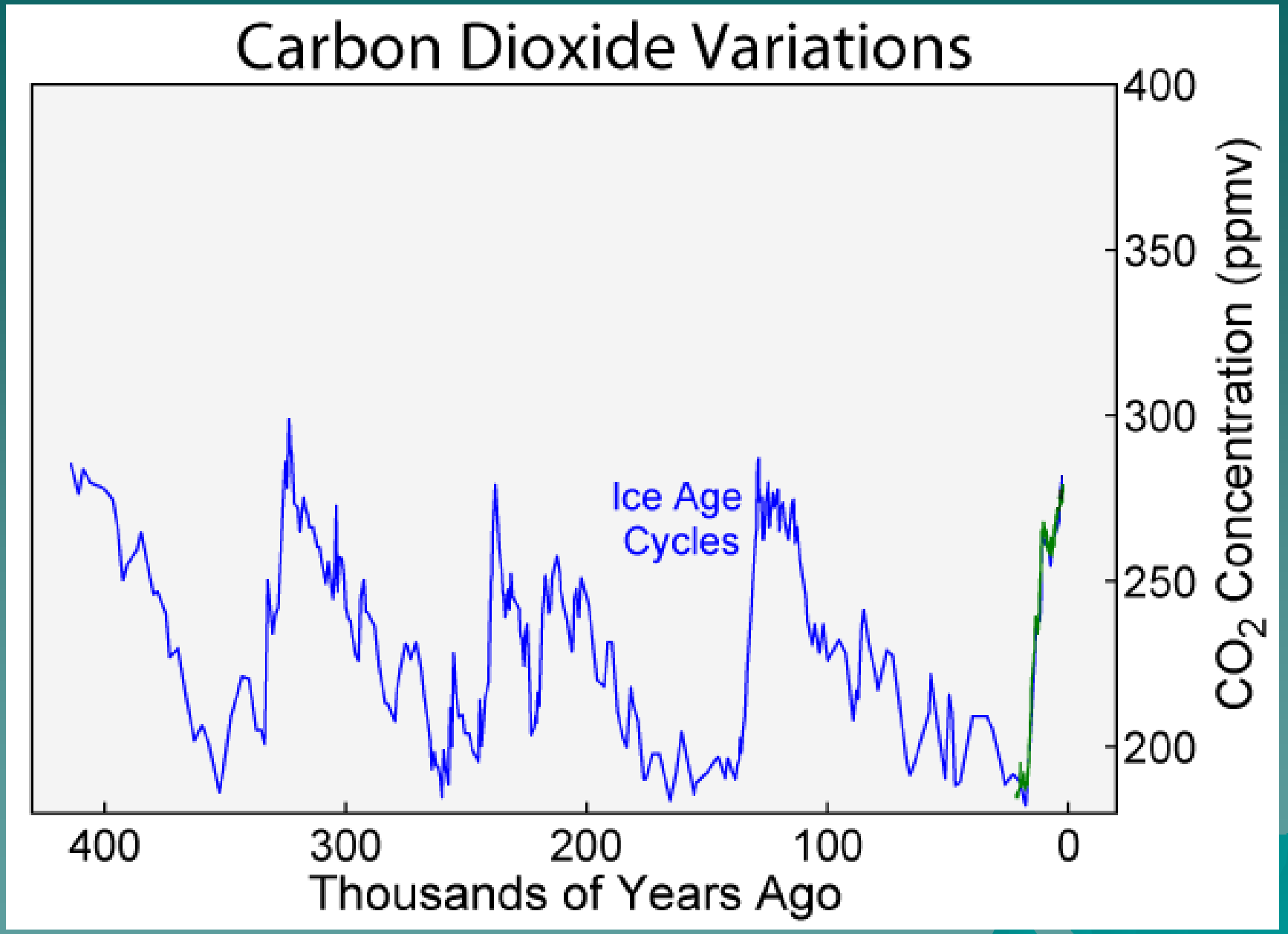
Jeff Burgett, Ph.D.
U.S Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office

Outline

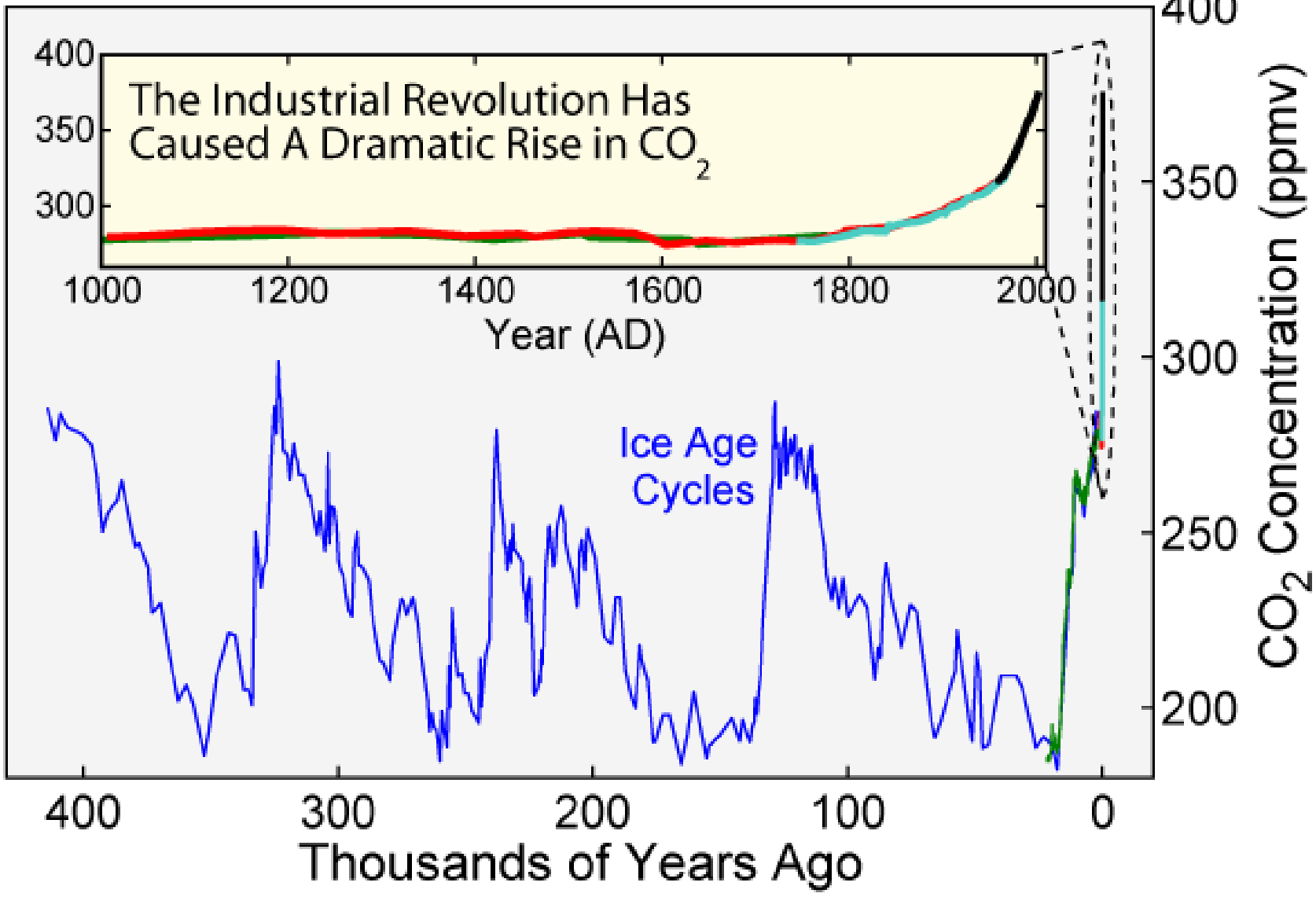
- Quick summary of climate change mechanisms and climate projections
  - Focus on global terrestrial changes
- Ecological ramifications of these changes
- Challenges for resource management and conservation in adapting to climate change

Global Climate Change is Normal (Geologically Speaking)

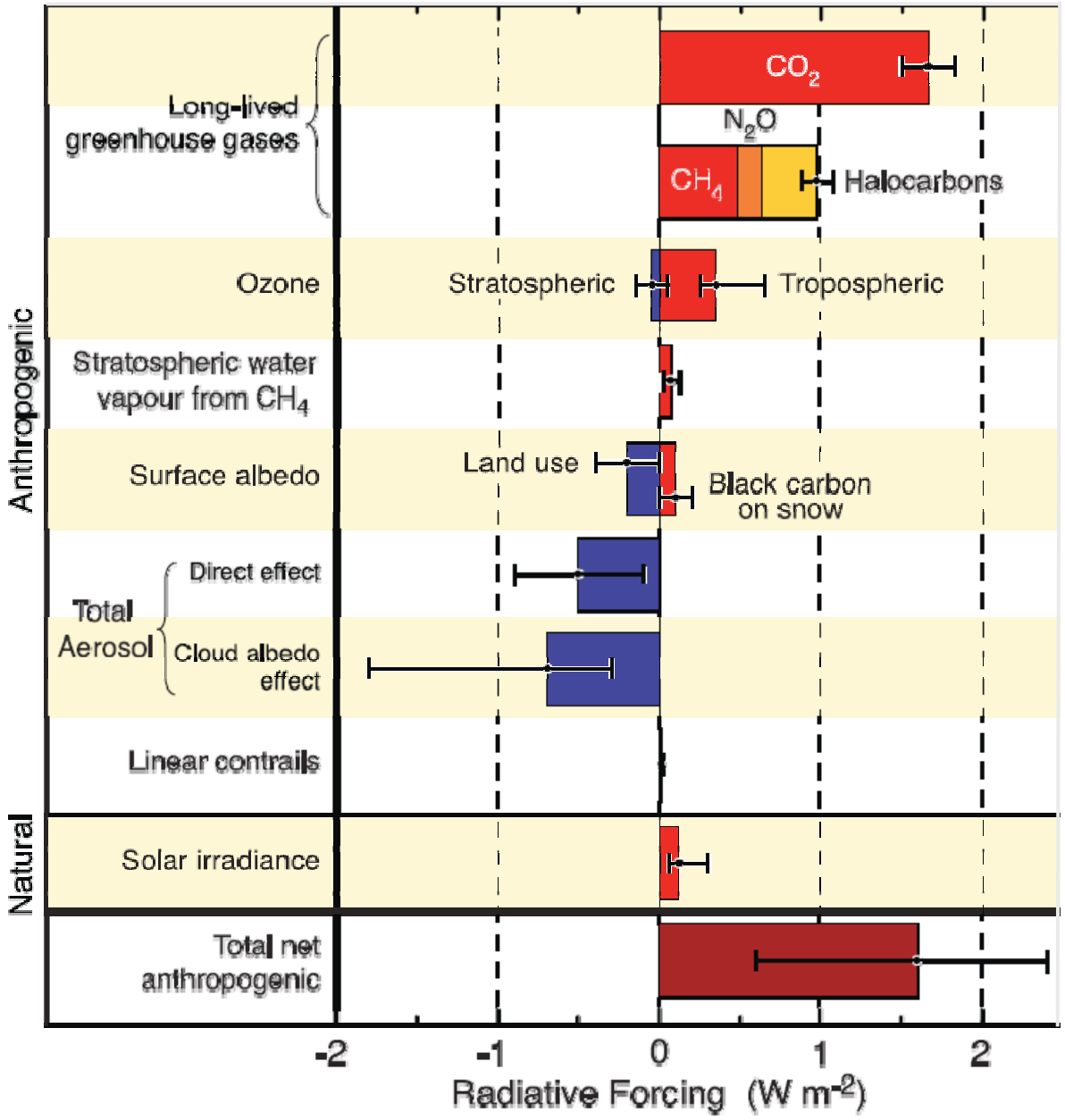




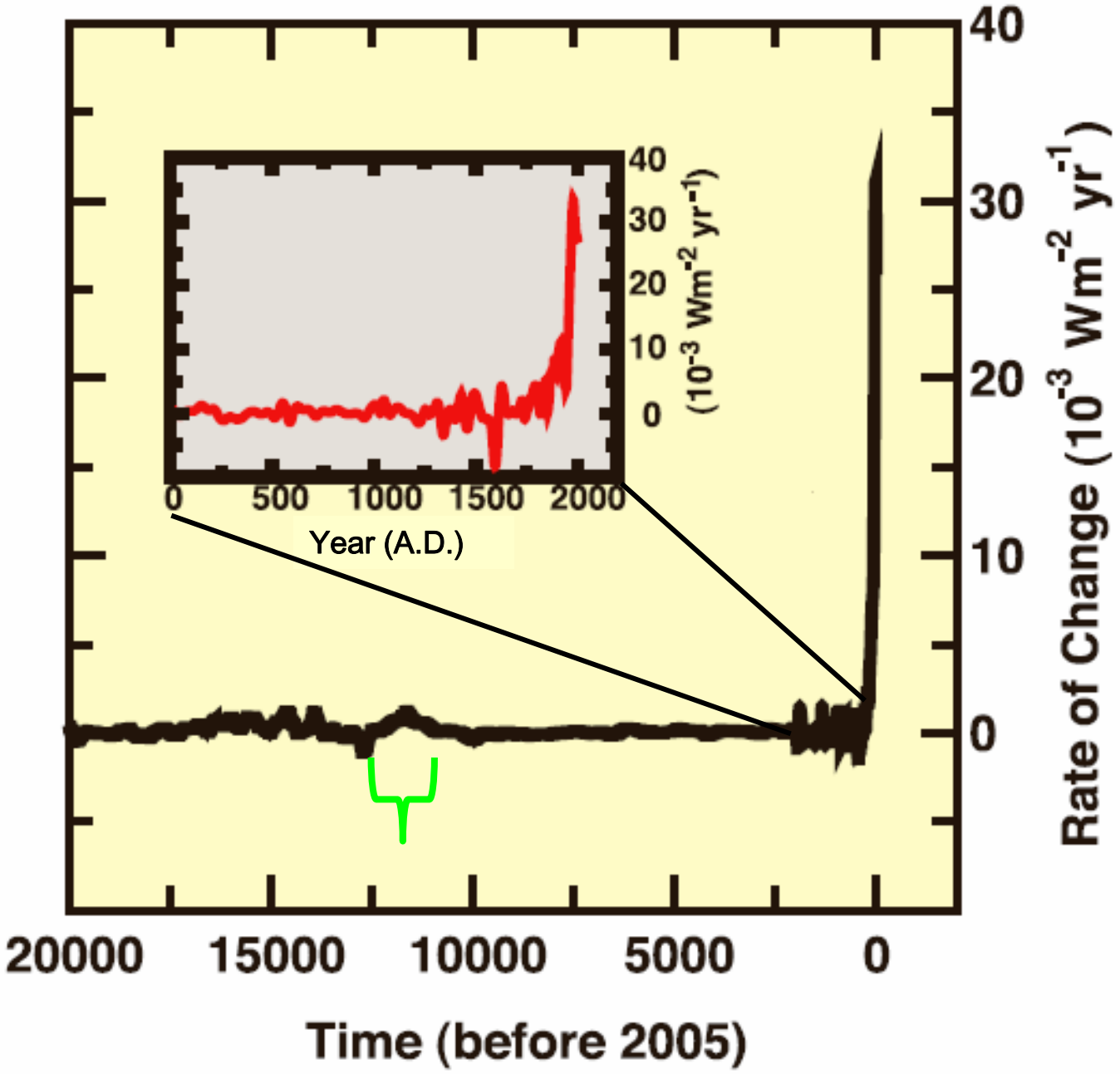
Carbon Dioxide Variations



Radiative Forcing Components of Global Warming



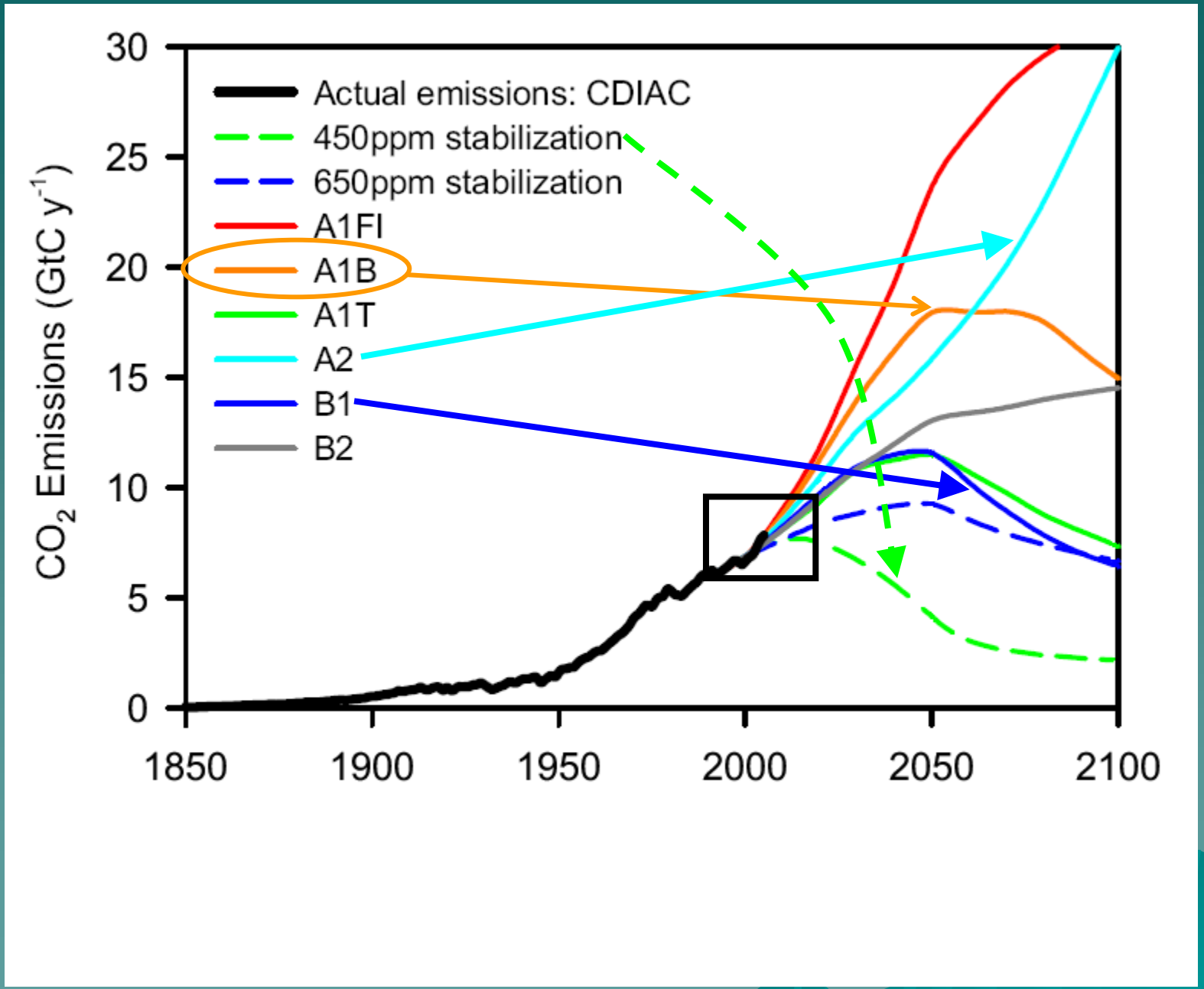
IPCC 2007


40
30
20
10
0
Rate of Change (10^{-3} Wm^{-2} yr^{-1})
40
30
20
10
0
(10^{-3} Wm^{-2} yr^{-1})
0
500
1000
1500
2000
Year (A.D.)
20000
15000
10000
5000
0
Time (before 2005)

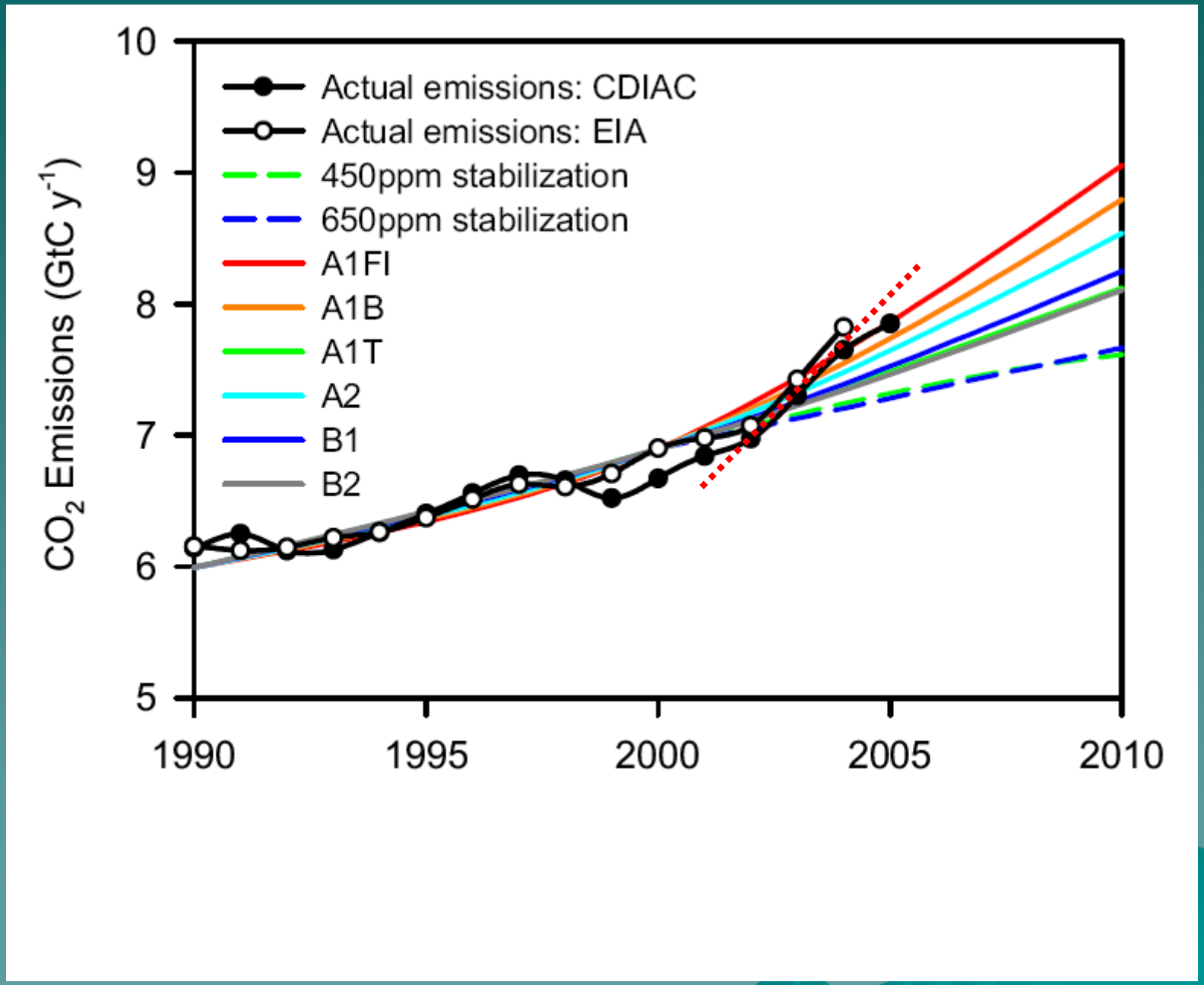
IPCC 2007

Modern Economy = Global Warming

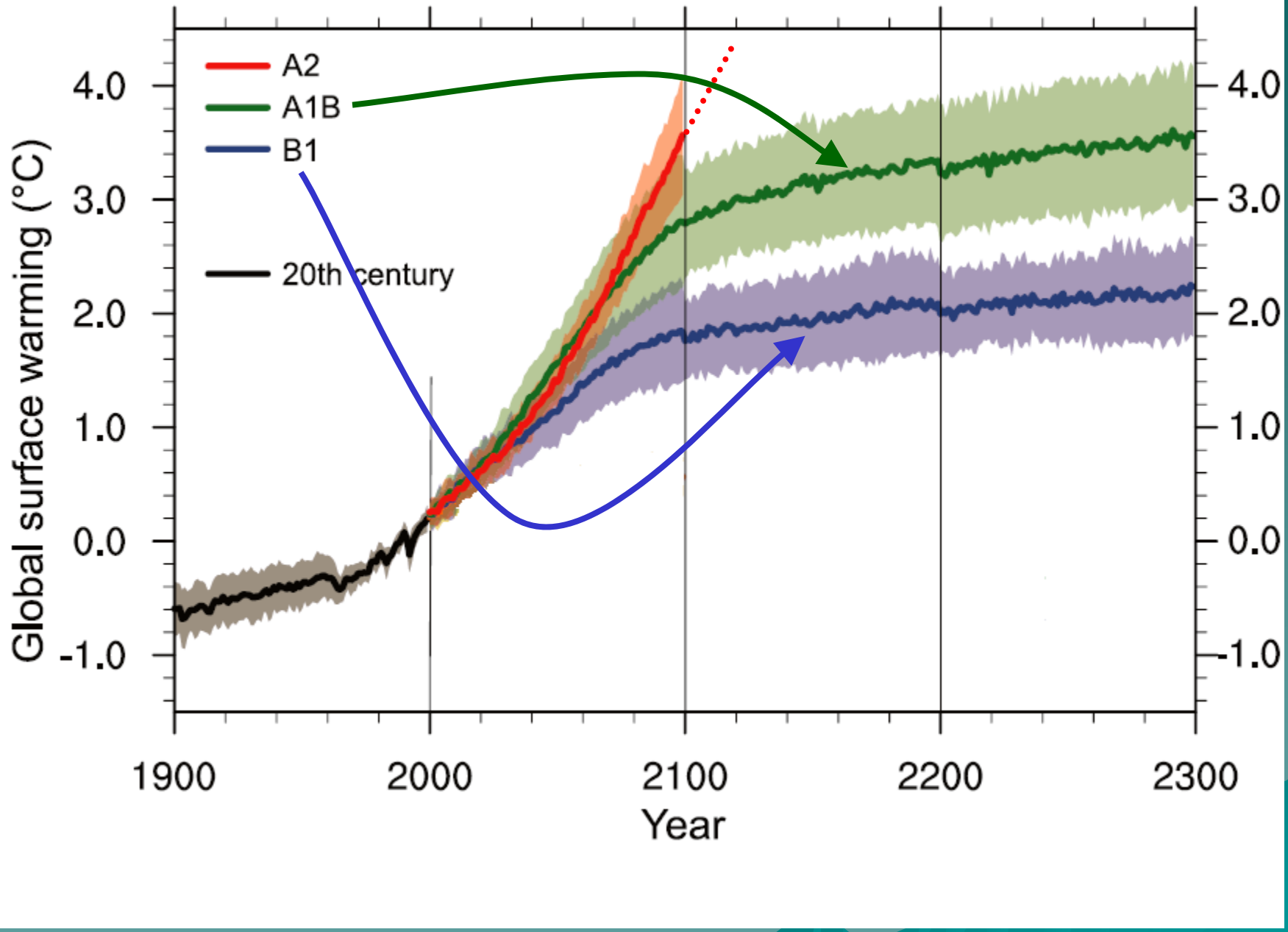
- Industrialization required fossil fuel, still depends upon it
- No current alternatives to satisfy demand
- The global economy is the engine of climate change
  - Growth of one = growth of other w/o changes in energy production or consumption



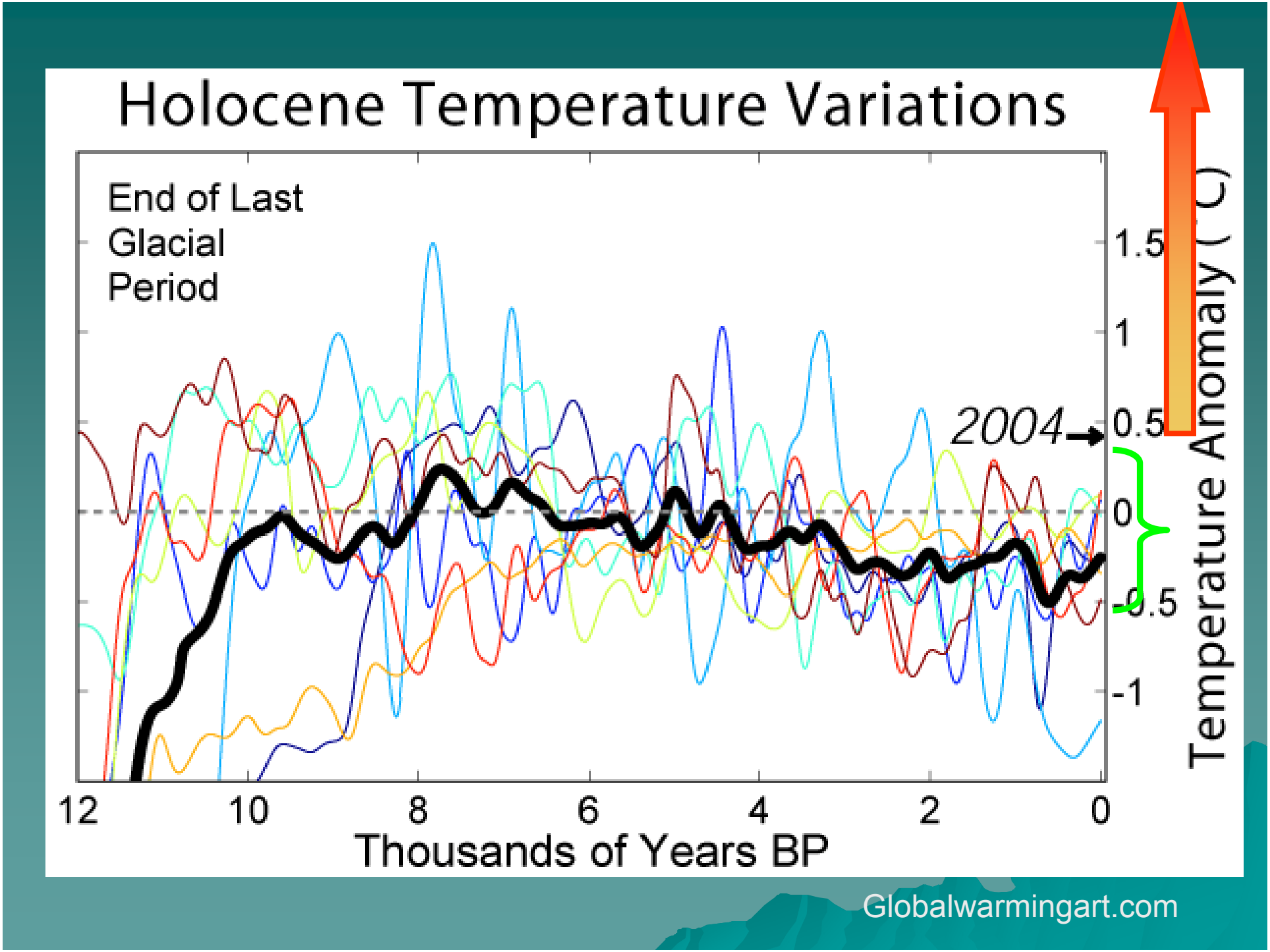
Raupach et al. 2007

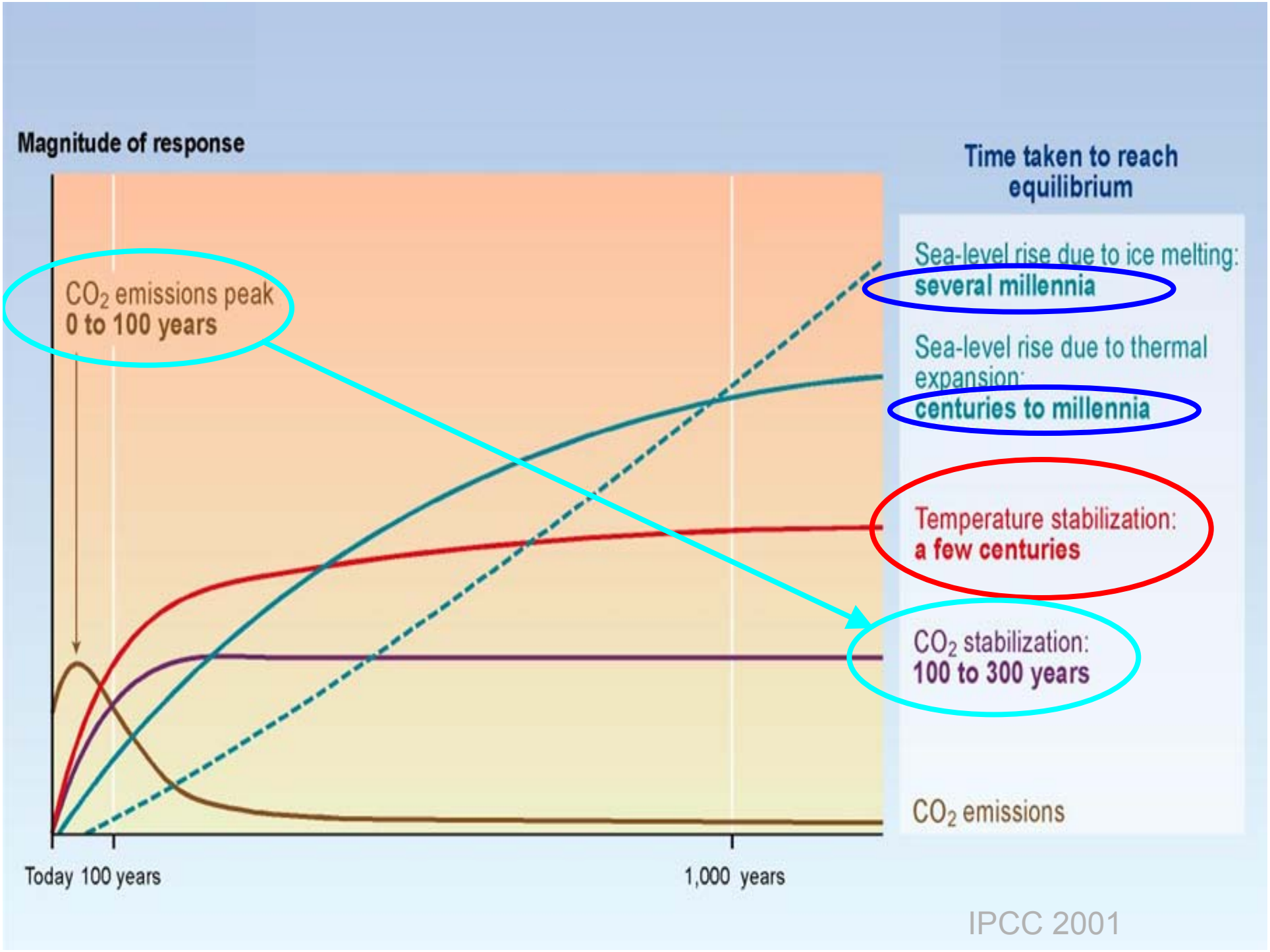


Raupach et al. 2007

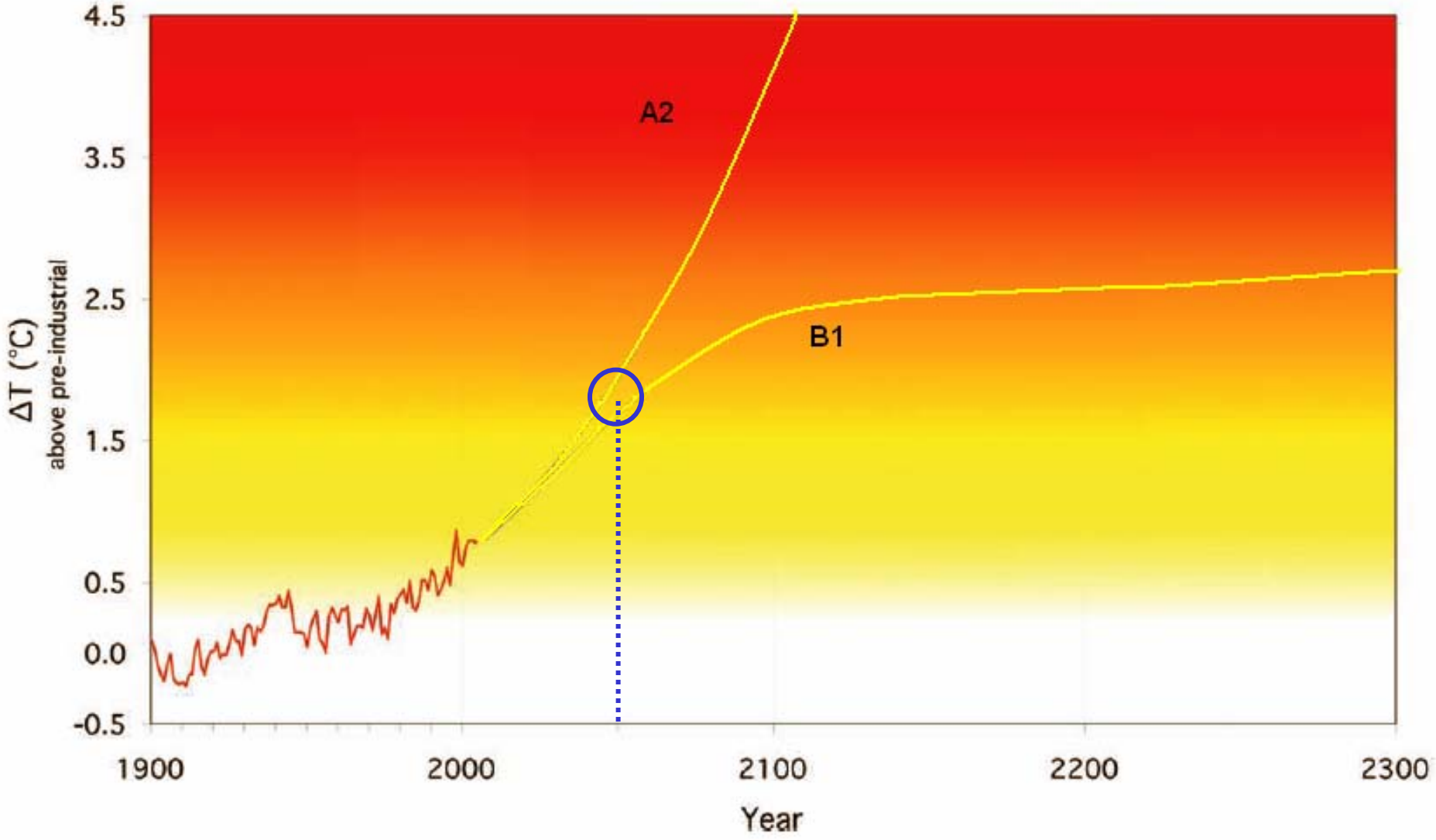

A2
A1B
B1
20th century
Global surface warming (°C)
4.0
3.0
2.0
1.0
0.0
-1.0
1900
2000
2100
2200
2300
Year

IPCC 2007


Holocene Temperature Variations
End of Last
Glacial
Period
2004
1.5
1
0.5
0
-0.5
-1
Temperature Anomaly (C)
12
10
8
6
4
2
0
Thousands of Years BP
Globalwarmingart.com


Magnitude of response
Time taken to reach equilibrium
CO_2 emissions peak 0 to 100 years
Sea-level rise due to ice melting: several millennia
Sea-level rise due to thermal expansion: centuries to millennia
Temperature stabilization: a few centuries
CO_2 stabilization: 100 to 300 years
CO_2 emissions
Today 100 years
1,000 years

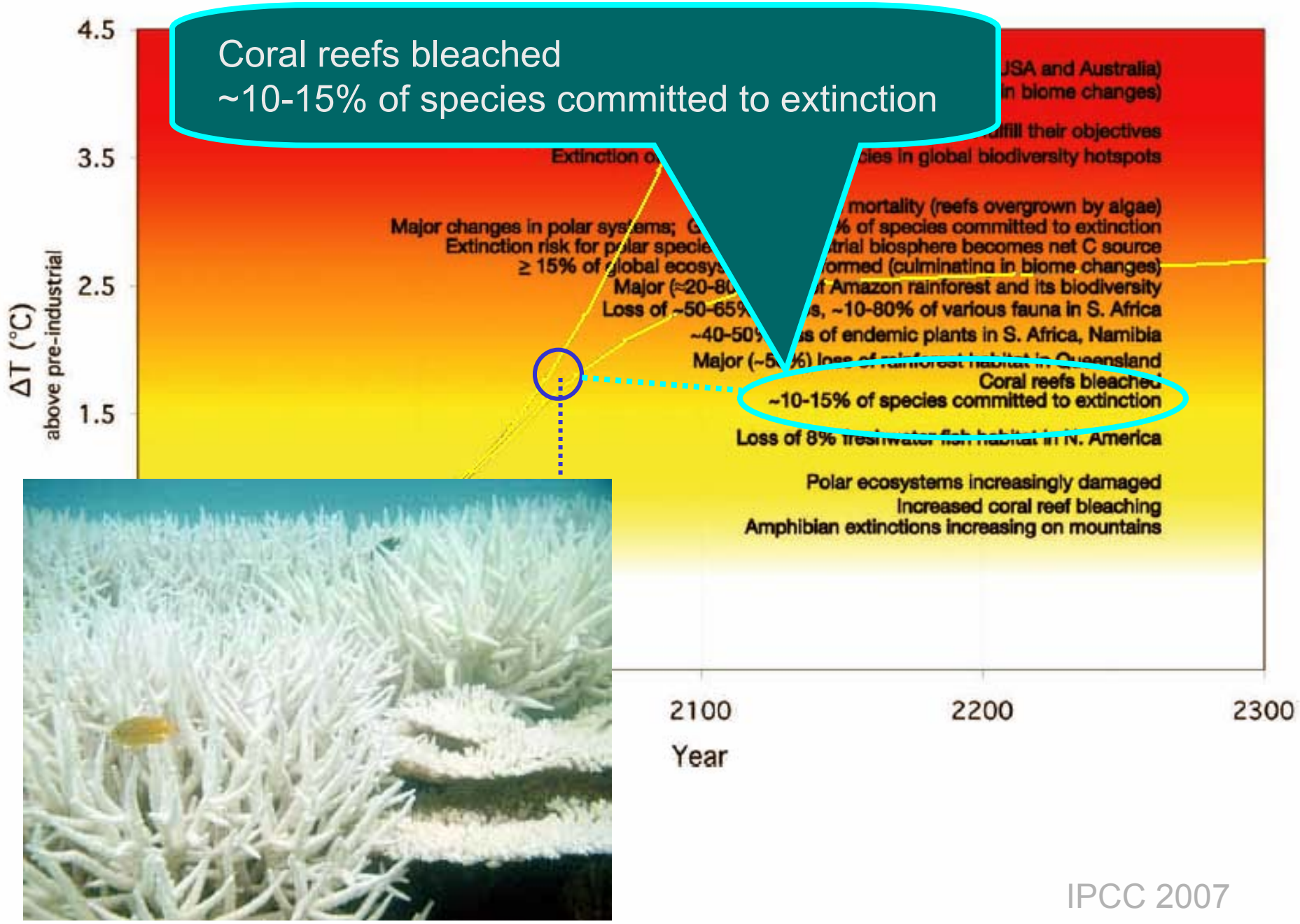
IPCC 2001


4.5
3.5
2.5
1.5
0.5
0.0
-0.5
ΔT (°C)
above pre-industrial
A2
B1
1900
2000
2100
2200
2300
Year

IPCC 2007

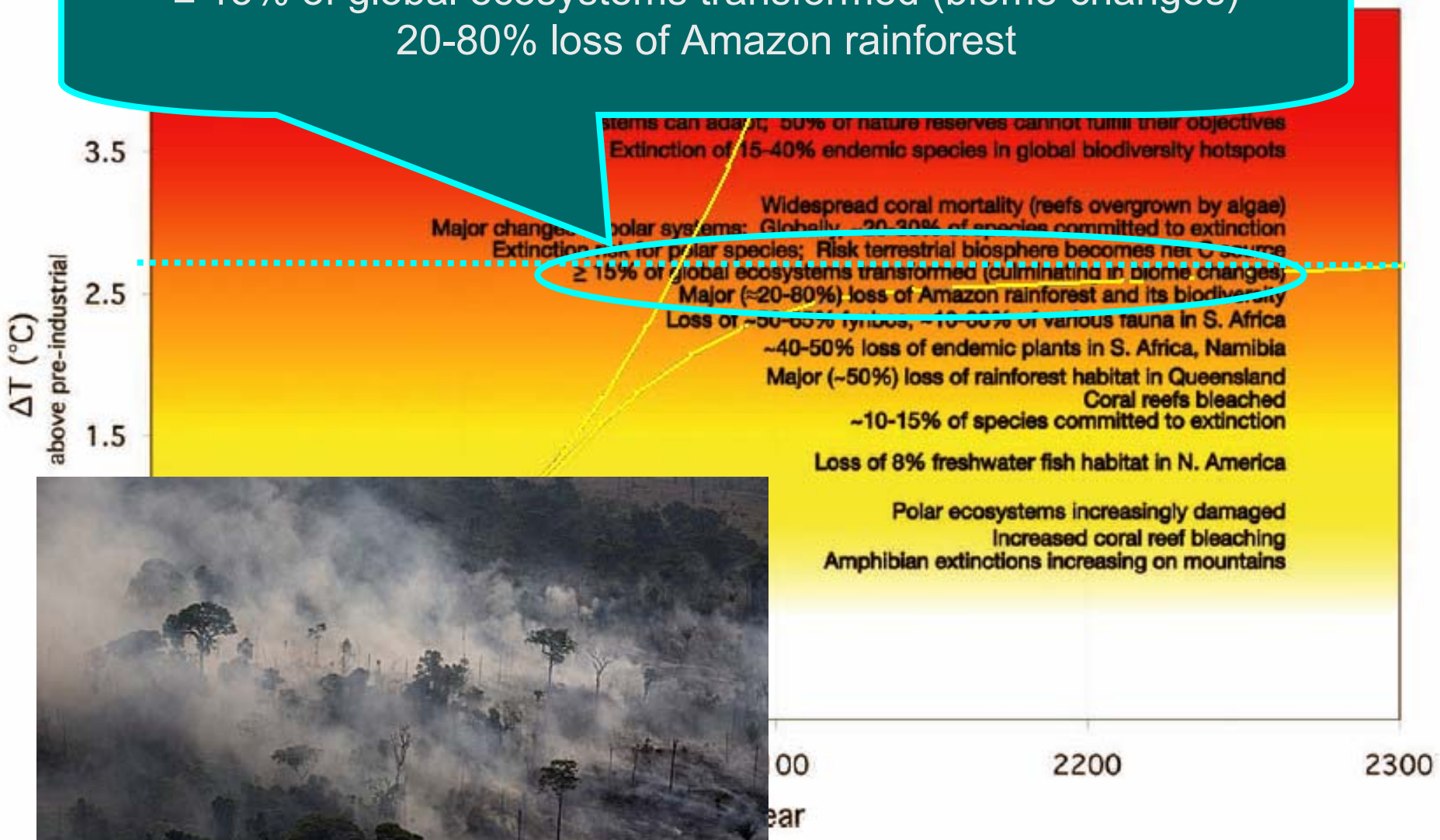
-Polar ecosystems increasingly damaged
-Increased coral reef bleaching
-Amphibian extinctions on mountains

IPCC 2007

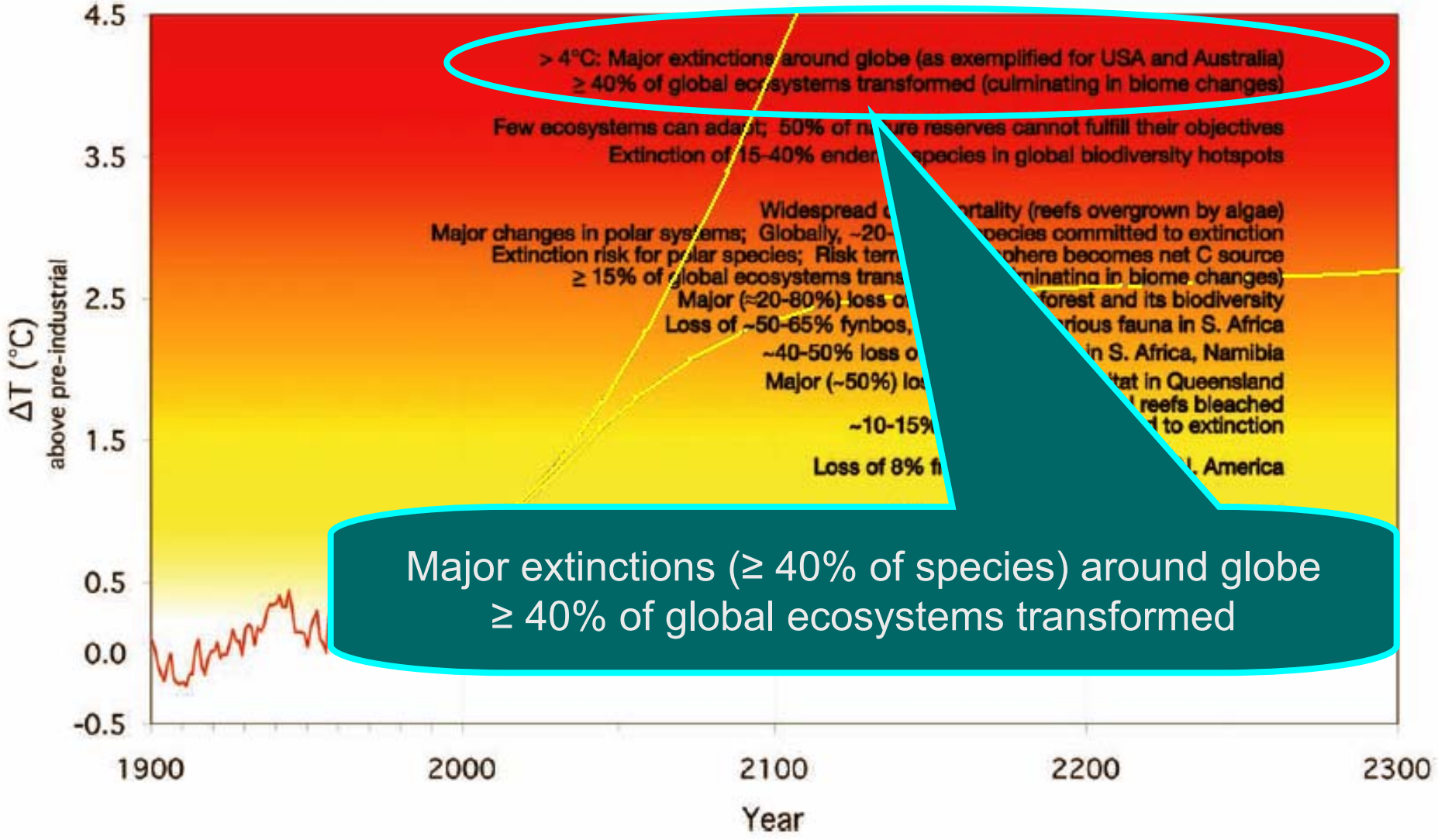

Coral reefs bleached
~10-15% of species committed to extinction
4.5
3.5
2.5
1.5
ΔT (°C)
above pre-industrial
Coral reefs bleached
~10-15% of species committed to extinction
Polar ecosystems increasingly damaged
Increased coral reef bleaching
Amphibian extinctions increasing on mountains
2100
2200
2300
Year

IPCC 2007

≥ 15% of global ecosystems transformed (biome changes)
20-80% loss of Amazon rainforest



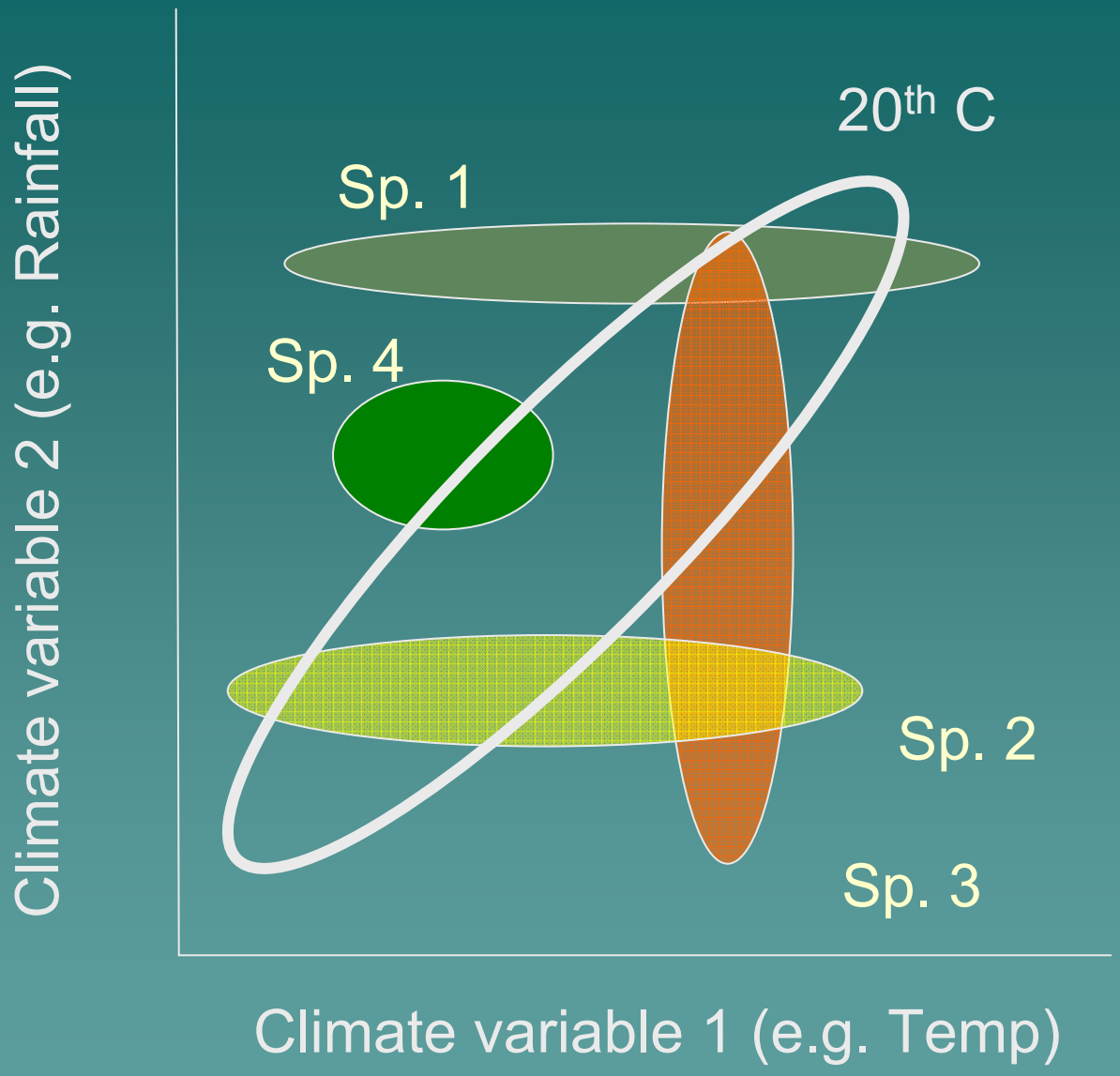
IPCC 2007


4.5
3.5
2.5
1.5
0.5
0.0
-0.5
ΔT (°C)
above pre-industrial
1900
2000
2100
2200
2300
Year
> 4°C: Major extinctions around globe (as exemplified for USA and Australia)
≥ 40% of global ecosystems transformed (culminating in biome changes)
Few ecosystems can adapt; 50% of nature reserves cannot fulfill their objectives
Extinction of 15-40% endemic species in global biodiversity hotspots
Widespread coral mortality (reefs overgrown by algae)
Major changes in polar systems; Globally, ~20-30% species committed to extinction
Extinction risk for polar species; Risk terrosphere becomes net C source
≥ 15% of global ecosystems transculminating in biome changes)
Major (≈20-80%) loss of forest and its biodiversity
Loss of ~50-65% fynbos, various fauna in S. Africa
~40-50% loss of in S. Africa, Namibia
Major (~50%) lostat in Queensland
reefs bleached
~10-15% d to extinction
Loss of 8% fi L. America
Major extinctions (≥ 40% of species) around globe
≥ 40% of global ecosystems transformed

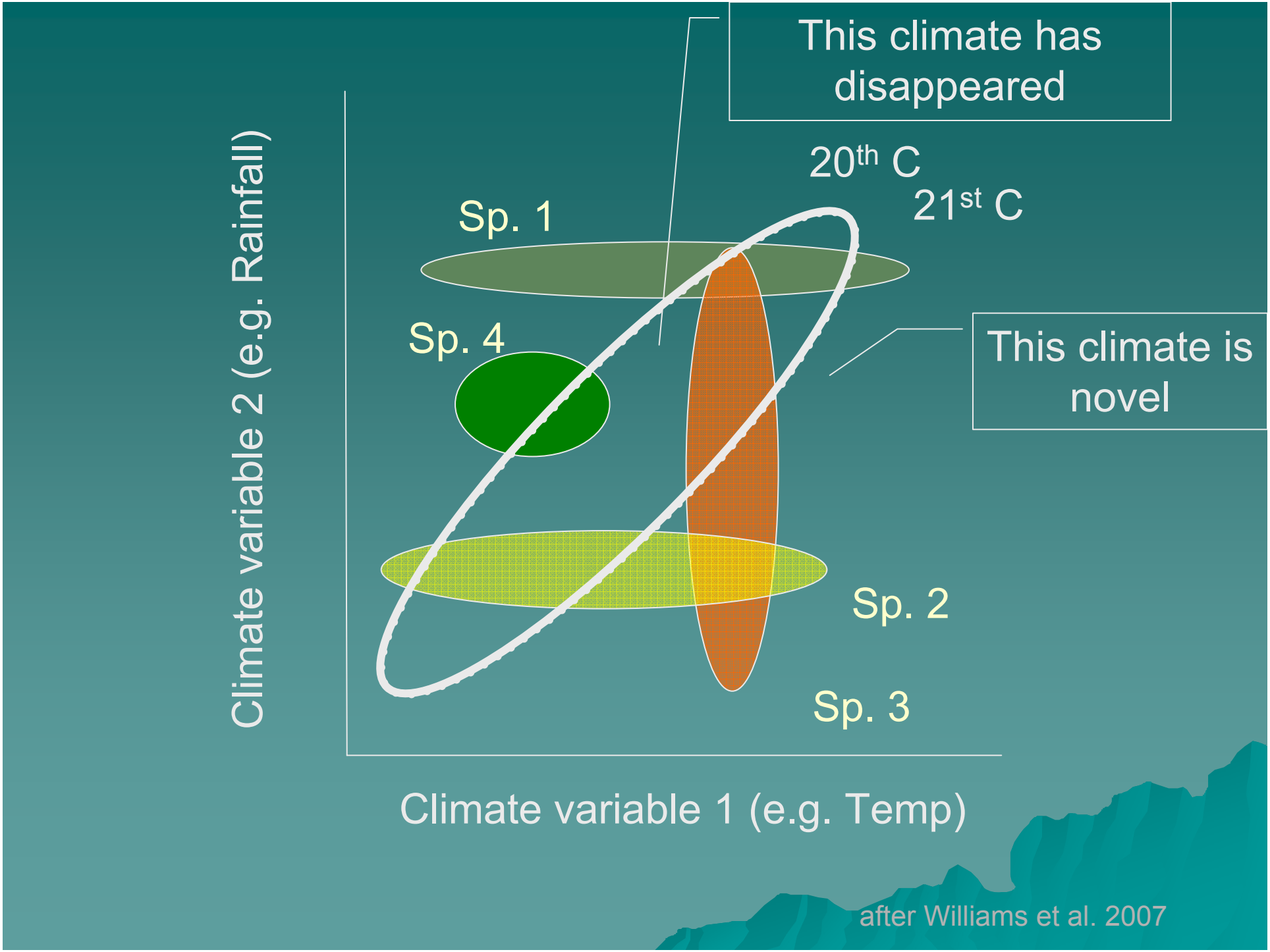
IPCC 2007

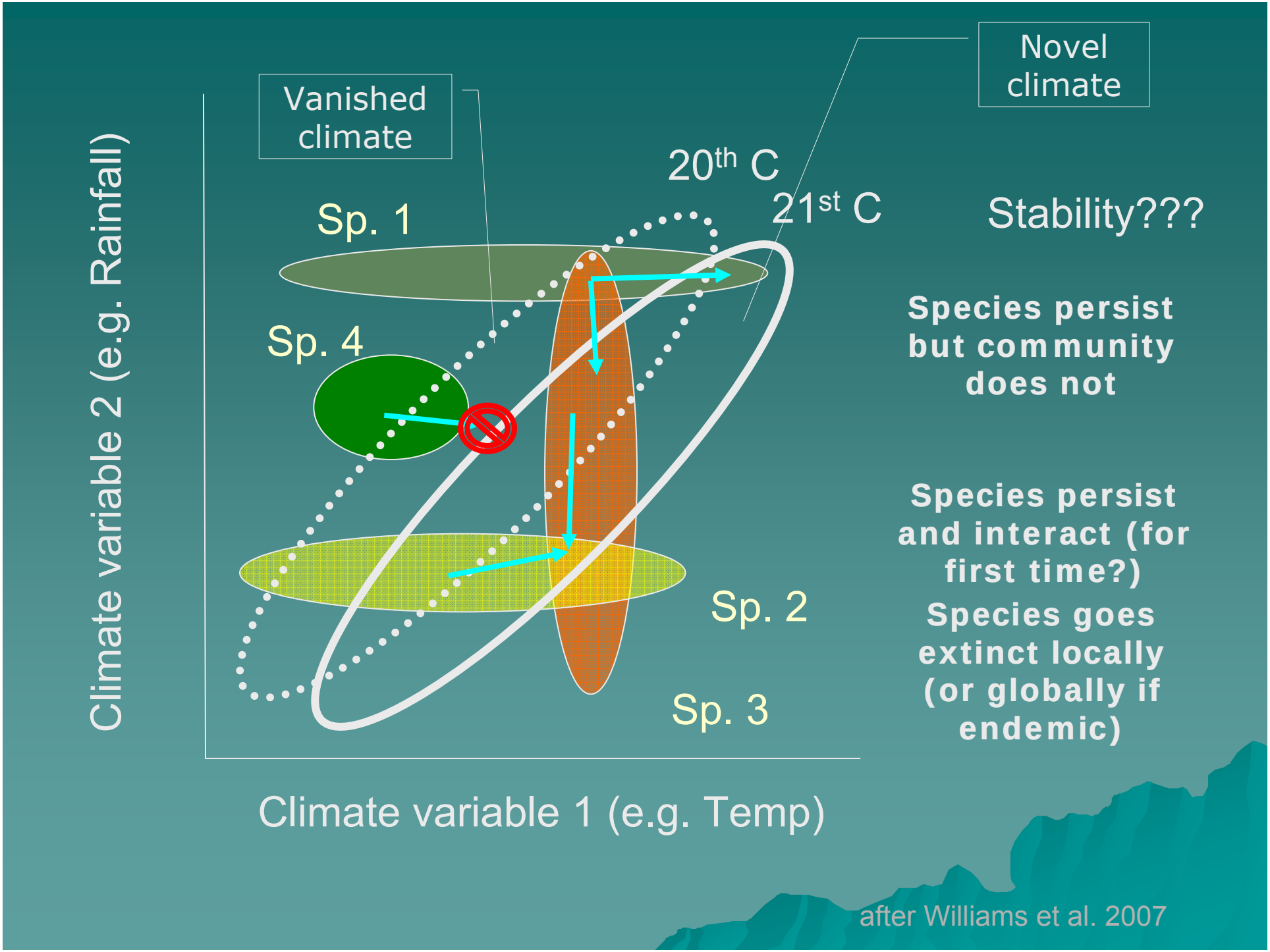
Ecological Responses

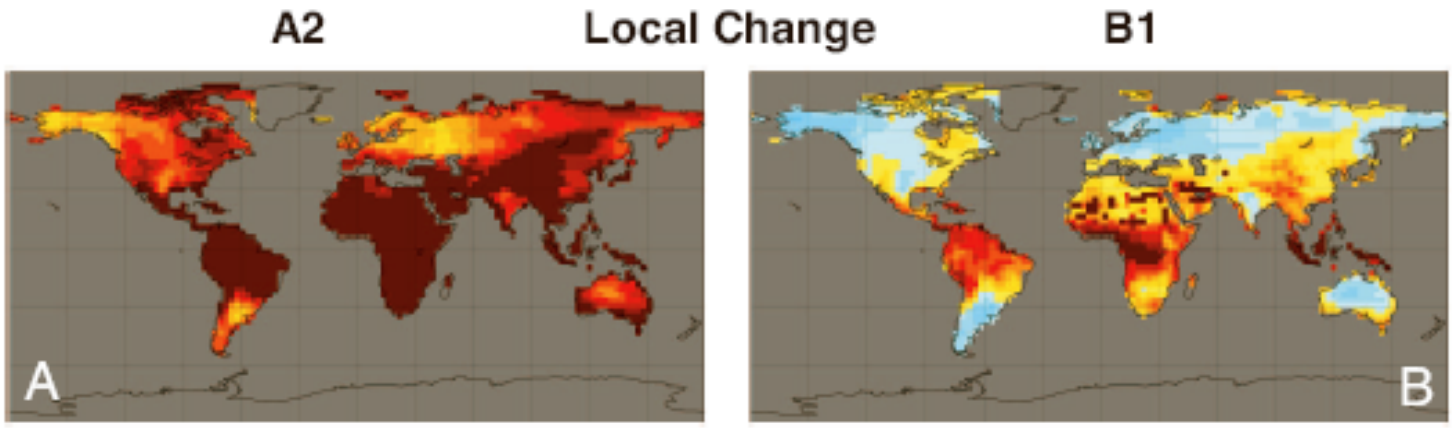
- Change globally, react locally
- Two questions need answers
  - What will happen to the climate in a given region?
  - How will species respond?



after Williams et al. 2007


This climate has disappeared
20th C
21st C
Sp. 1
Sp. 4
This climate is novel
Sp. 2
Sp. 3
Climate variable 2 (e.g. Rainfall)
Climate variable 1 (e.g. Temp)
after Williams et al. 2007


Novel climate
Vanished climate
20th C
21st C
Stability???
Sp. 1
Sp. 4
Sp. 2
Sp. 3
Species persist but community does not
Species persist and interact (for first time?)
Species goes extinct locally (or globally if endemic)
Climate variable 2 (e.g. Rainfall)
Climate variable 1 (e.g. Temp)
after Williams et al. 2007



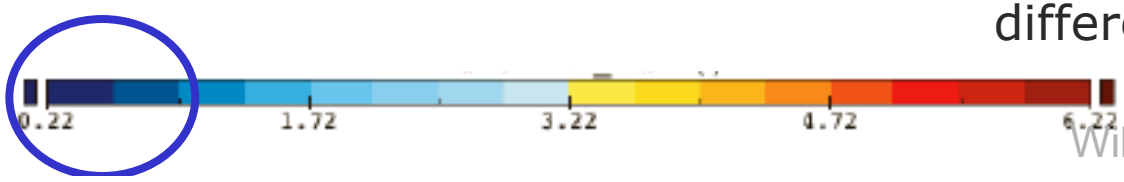
Global change ≥4° C

Global change ~2° C

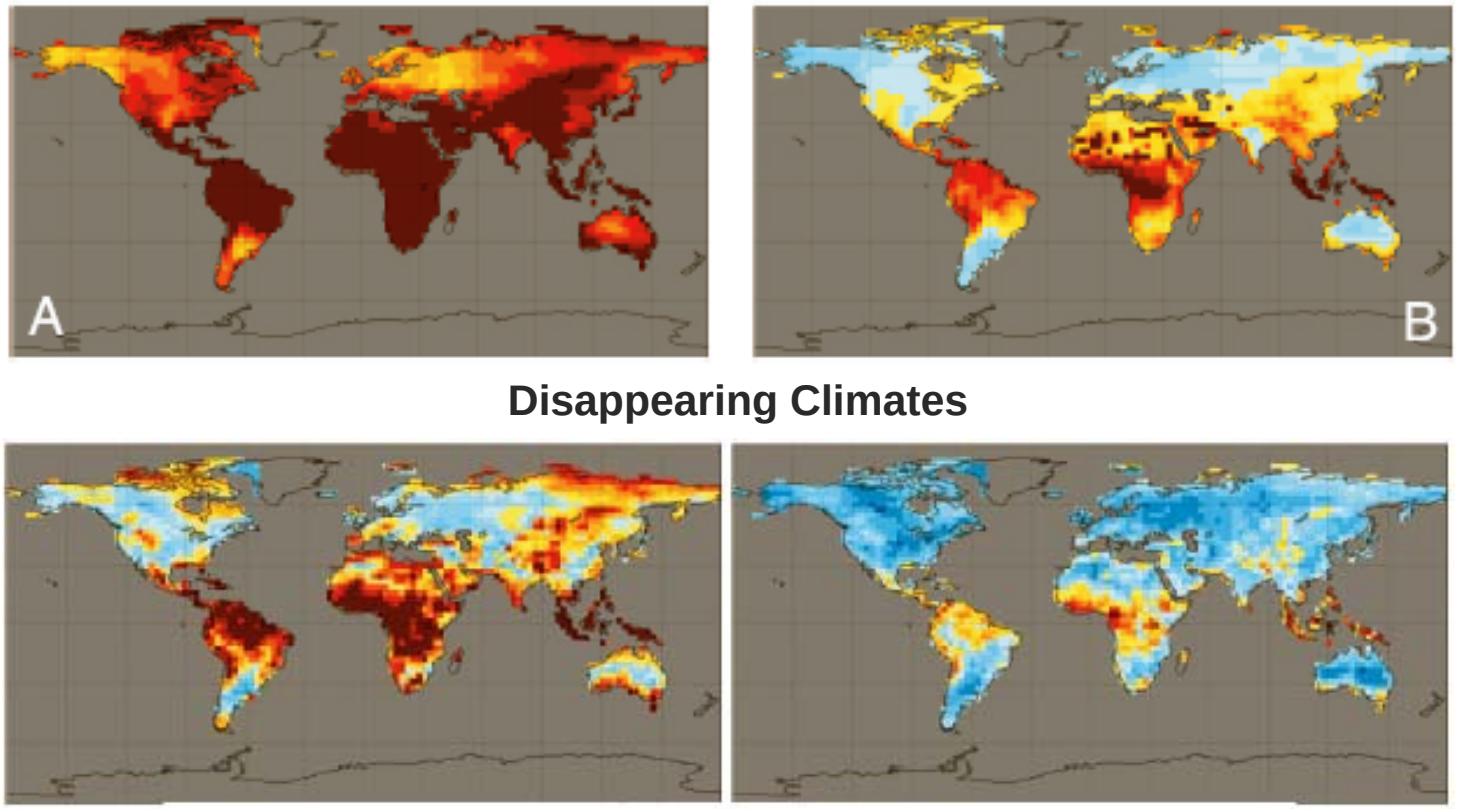
Standardized difference of climate by 2100 from current (2000) climate at each point

21st Cent ≈ 20th Cent.

21st Cent very different

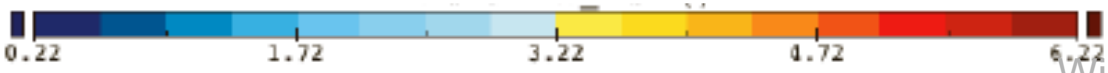


Williams et al. 2007



Difference of 20th century climate from any 21st century climate within 500 km.

Hot colors are likely to be climates that have disappeared from the region.



Williams et al. 2007

Shifting the Conservation Paradigm

- Due to climate change, some basic assumptions underlying conservation practice and management are no longer tenable
  - What are they?
  - How does conservation have to change?

History is…history

- Climate change violates conservation's key assumption: that by controlling threats in a species' historical range, the species can recover and persist where it used to live
  - Underlies virtually all conservation and recovery actions
  - Global change will be permanent, continuous and beyond local control
  - Historical range will lose relevance as climate envelope moves

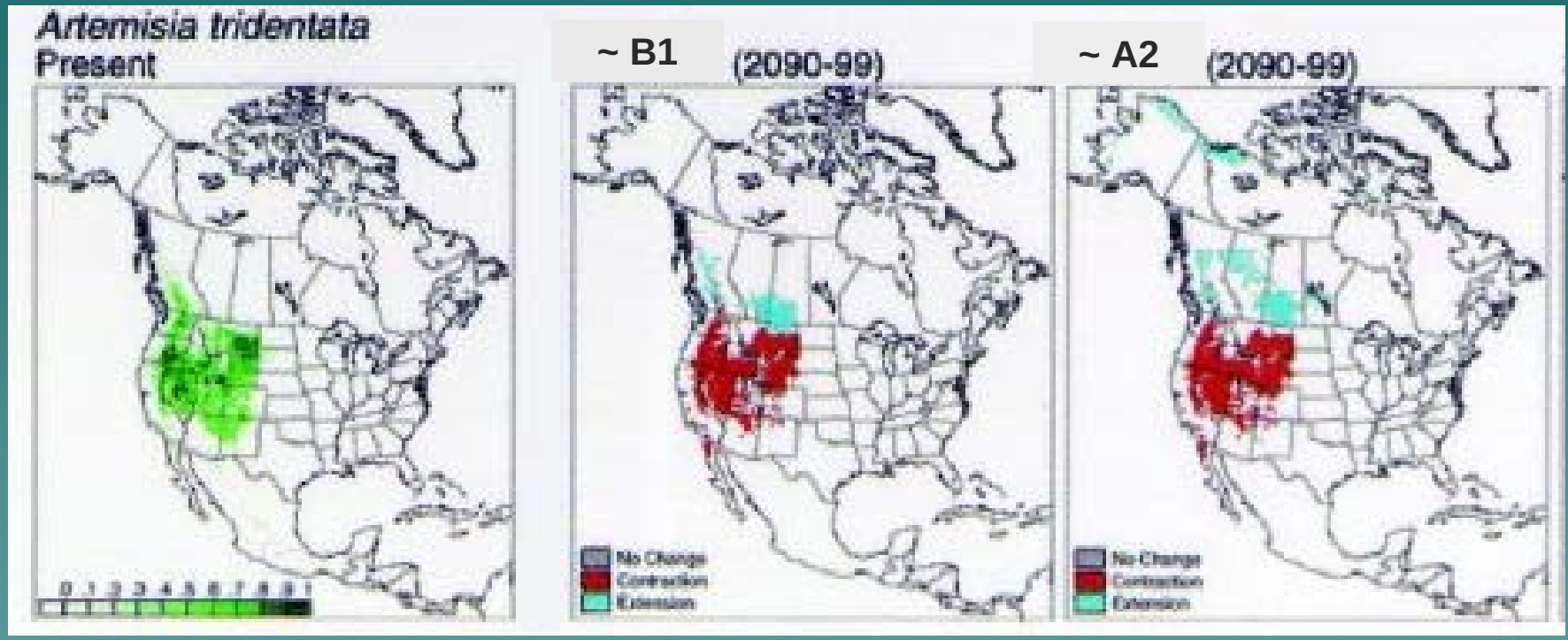
You never step in the same river twice

- In adaptive management, cycles of planning-action-monitoring-planning are assumed to converge on a best solution
  - When climate changes each decade, responses to your management actions will not converge
  - "Communities" will start to change faster than we can learn to manage them by experiment
  - Ecosystem management?

Issue # 1

- Predictions of species' future ranges based on modeling will become fundamental to conservation planning

Climate Envelope Example: Sagebrush



Shift of range (defined by climate & soils) into Canada even under mild warming by 2100

AJ Hansen et al. 2001

Issue # 1

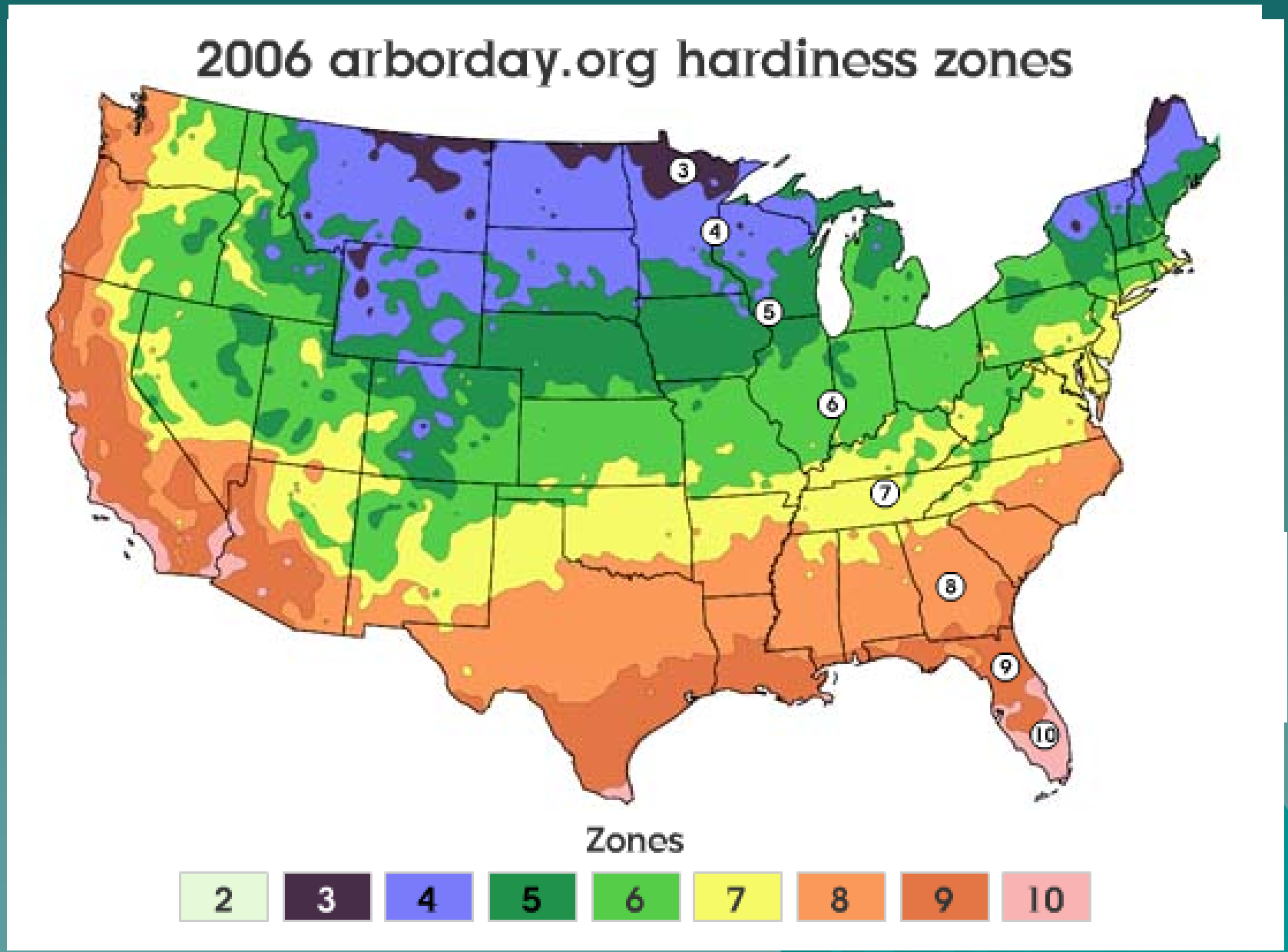
- Predictions of species' future ranges based on modeling will become fundamental to conservation planning
  - Which species? Rare, common, alien pests?
  - Plants easier than animals. Critical resources.
  - What time horizon? Moving target
  - No future equilibrium for > 100 years
  - Models need development
- Institutionalized, funded collaborations that help managers by producing predictions with confidence estimates

Issue # 2

- How to manage lands to maximize species' survival as ecosystems change
  - Look south and down, north and up
  - Plants will move, animals will follow
    - Managing for ecosystems, services in place
    - Managing species must become dynamic
  - Reduce other stresses (e.g. catches, fire) to enhance resilience for currently resident species

Issue # 3

- Determining how, and when, to undertake assisted colonization
  - Rate of change too fast for many species to keep up with climate space


2006 arborday.org hardiness zones
3
4
5
6
7
8
9
10
Zones
2
3
4
5
6
7
8
9
10

Issue # 3

- Determining if, when, and how to undertake assisted colonization
  - Rate of change too fast for many species to keep up with climate space
  - Rate of change favors generalists, weeds over isolated specialists (T&E)
  - How many species at once? Sooner or later?
  - Poor record of deliberate introductions
  - Unintended consequences of success

Issue # 4

- Conflicts between desires of people vs. needs of wild species will escalate
  - Slow climate disasters (SW drought) and abrupt crises likely to become more frequent and severe
  - Dealing with impacts to people, agriculture will dominate funding
  - Reframing the issue in terms of human well-being
    - Rachel Carson effect

- "Polar Bears" will become increasingly common. How will we deal with climate orphans?
  - Recovery planning?
  - Special category?
  - Pull the plug?
  - How much certainty would be enough?

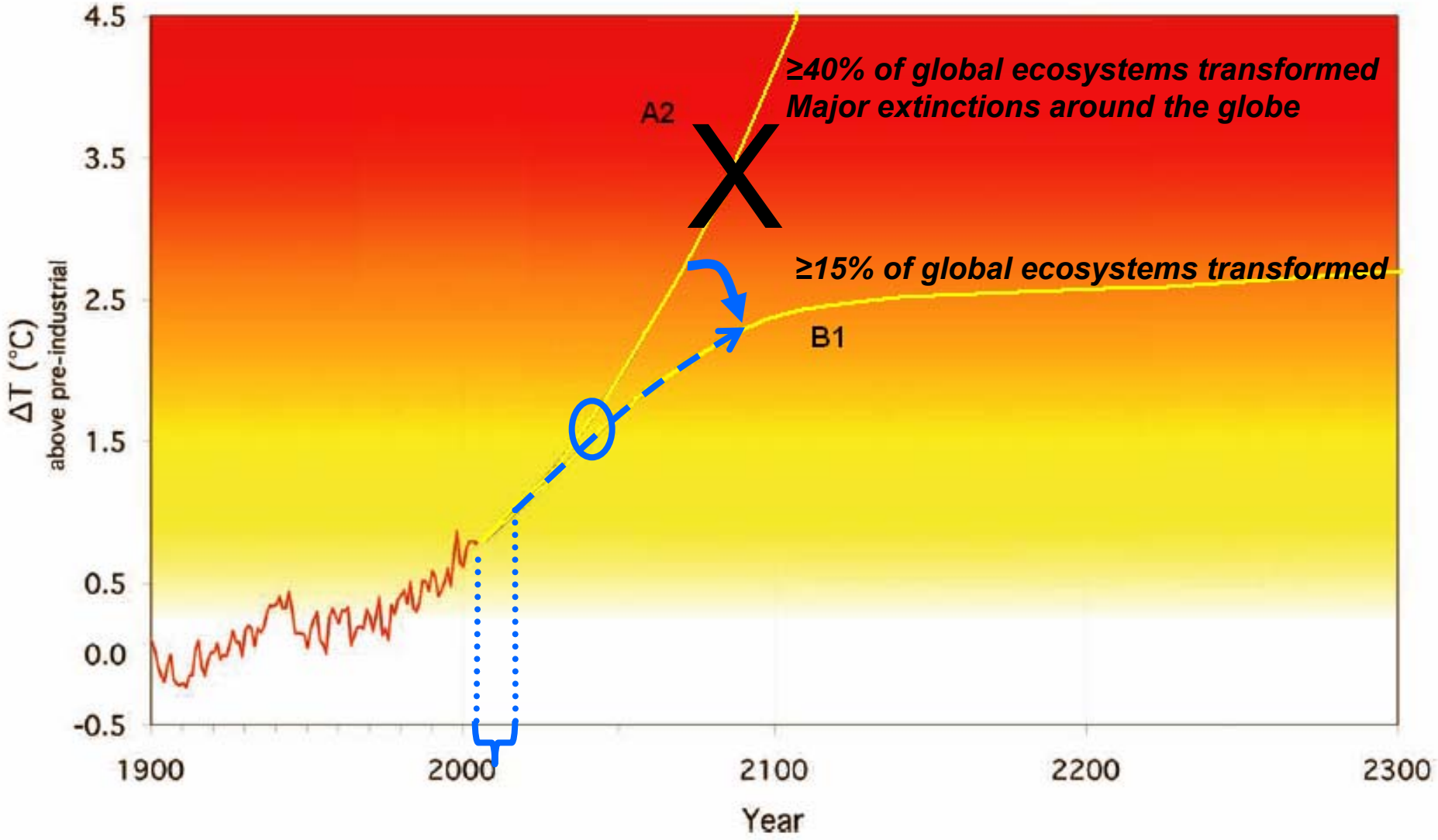
Issue # 6

- Full awareness of the impacts of climate change can lead to despair
  - Negative emotions are normal when reality thwarts our plans
  - People and agencies need to focus on reasonable actions that will make a difference
  - Current goals assume a stable climate that is already gone

Issue # 7

- The challenge to leadership:

  Developing achievable and inspirational goals that incorporate rapid, fundamental change in the natural world


4.5
3.5
2.5
1.5
0.5
0.0
-0.5
ΔT (°C)
above pre-industrial
1900
2000
2100
2200
2300
Year
A2
≥40% of global ecosystems transformed
Major extinctions around the globe
≥15% of global ecosystems transformed
B1


Mahalo
Photo © Jack Jeffrey