# Biogeochemical Cycles:

## Factors Influencing Climate Change

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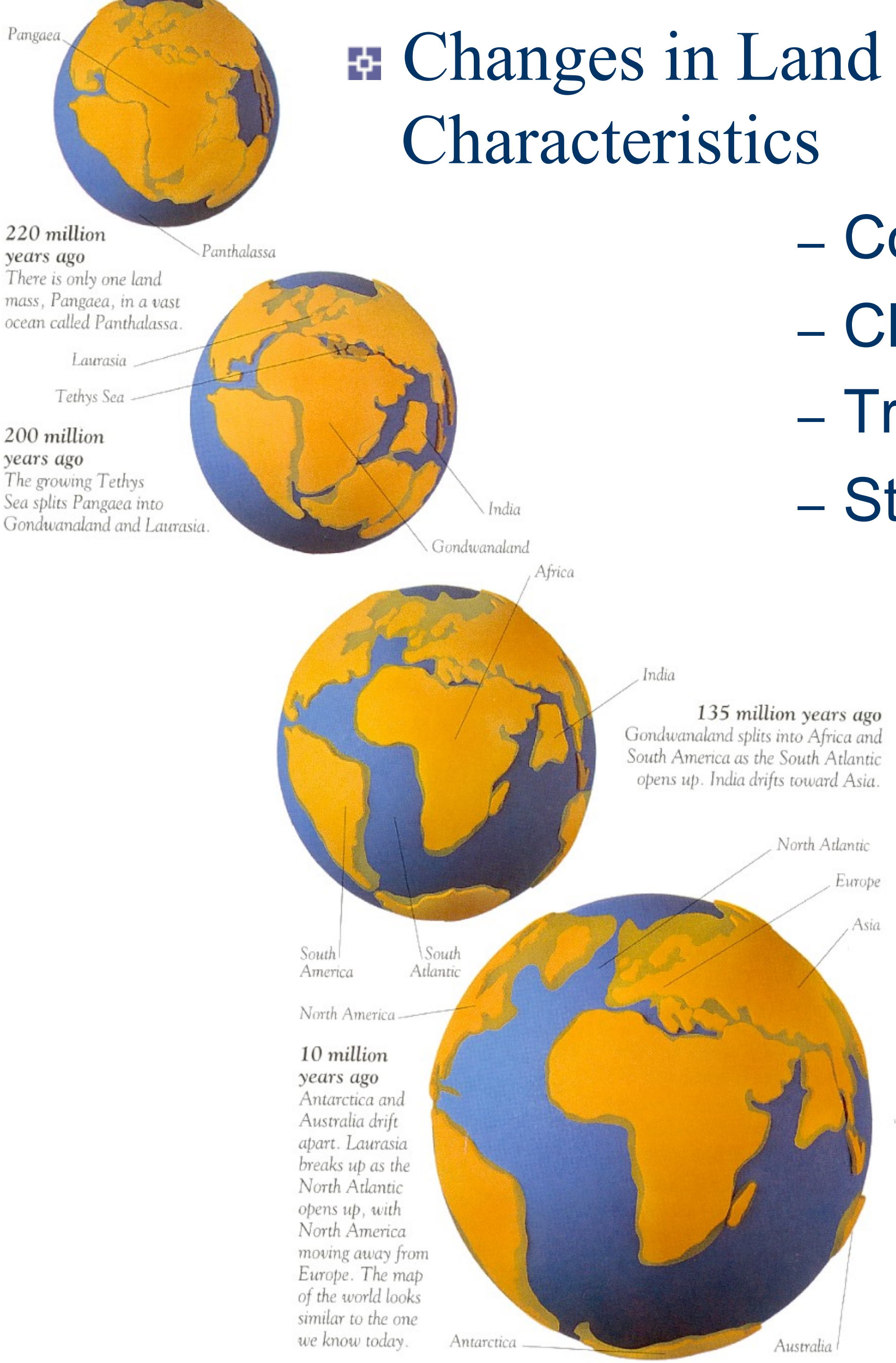
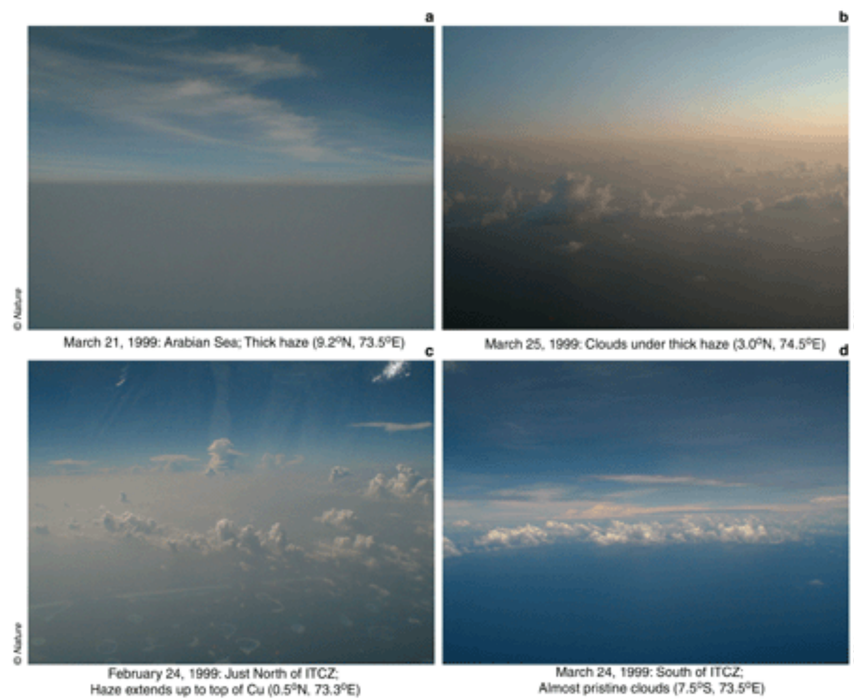
- Changes in Land, Surface and Atmospheric Characteristics
- Methods for Determining Past Climates
- Modeling Climate Change
- Implications and Ecosystem Changes

# Changes in Land Configuration and Surface Characteristics

- Continental drift is a partial cause
- Changes in Atmospheric Turbidity
- Tropospheric Aerosols
- Stratospheric Aerosols



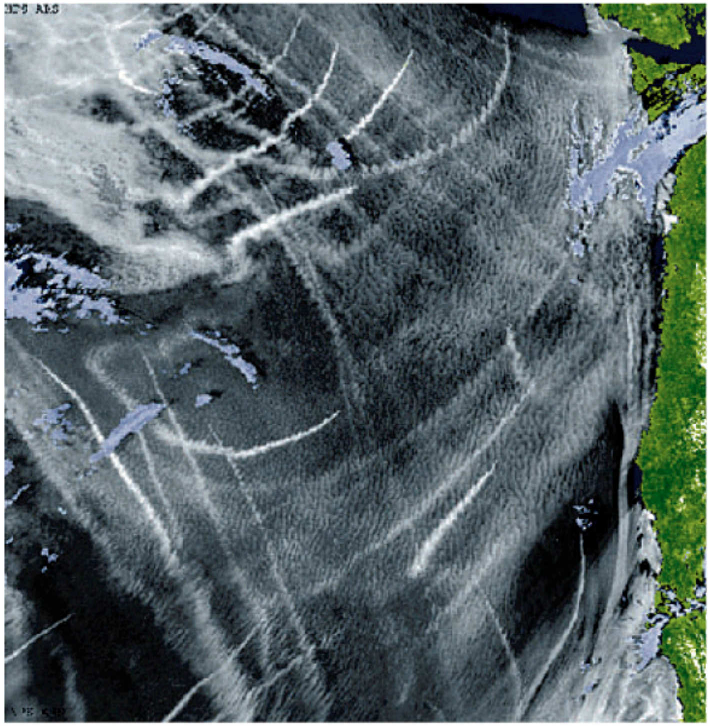




Source: Satheesh and Ramanathan, *Nature*, 2000.

# Changes in Radiation-Absorbing Gases

- Anthropogenic Contributions of $CO_2$
- Exchange of $CO_2$ Between the Atmosphere and Ocean
- Feedback Mechanisms
- Ice-Albedo Feedback
- Evaporation of Water Vapor
- Ocean–Atmosphere Interaction

*for the last 400,000 years CO2 levels did not rise above 280 ppm yet they are already at 381 ppm and rising faster than ever*

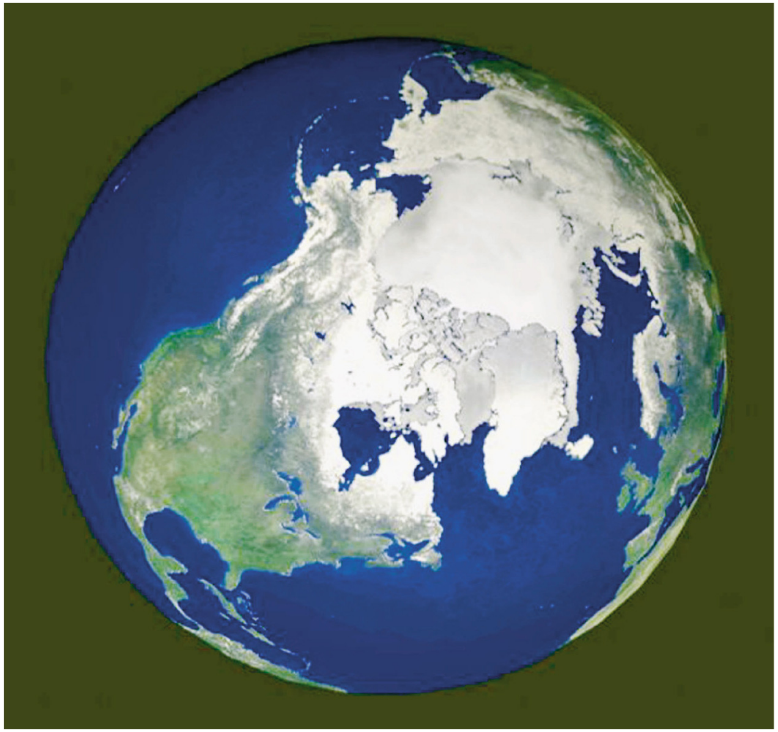


Ship tracks over the Pacific with small amounts of cloud-free ocean (blue)

Pollution

http://news.nationalgeographic.com/news/2006/01/0112_060112_frog_climate.html

# Sea ice



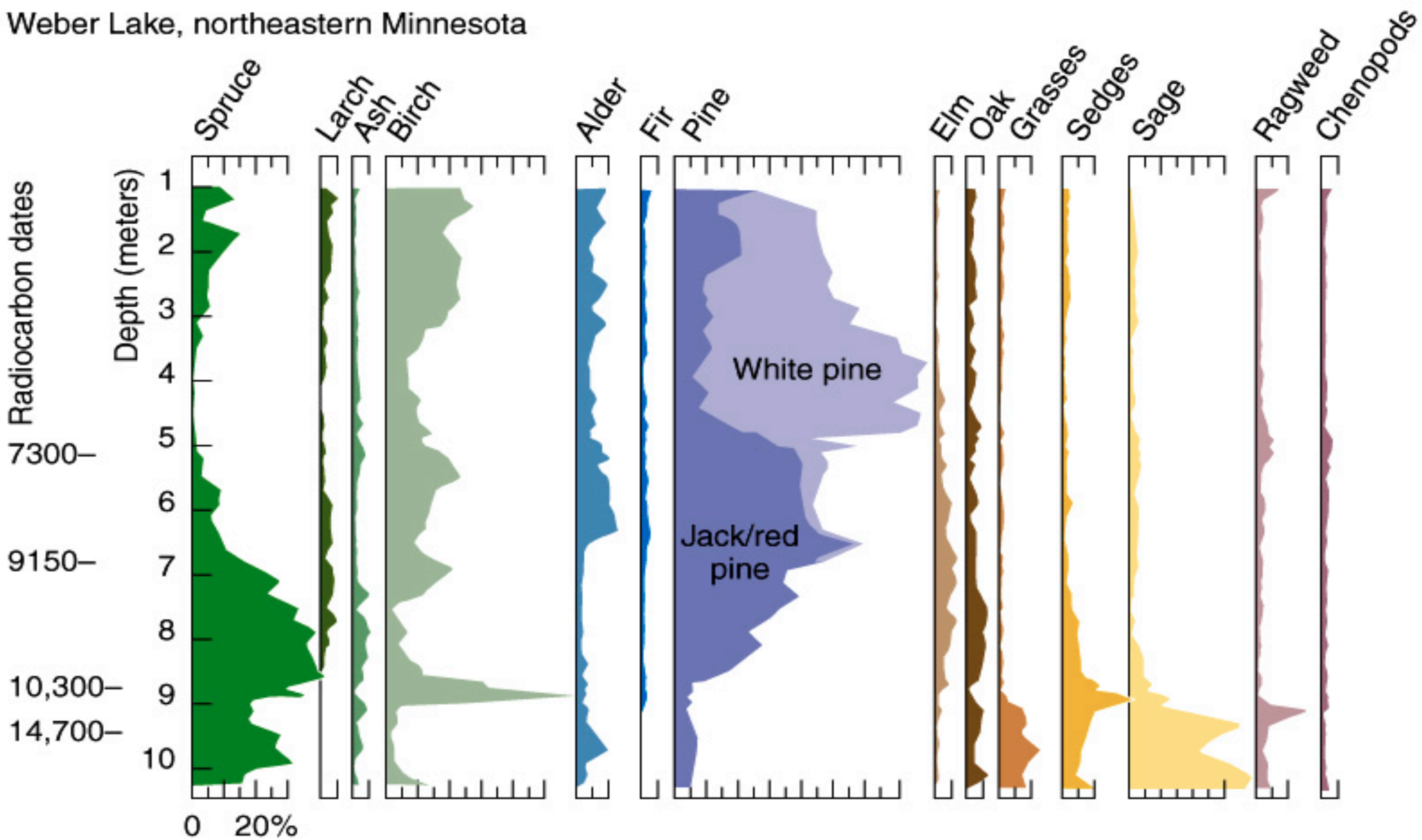
Sea ice distribution for the northern hemisphere

# Methods for Determining Past Climates

- Remnant Landforms
- Features Associated with Ice and Water
- Coral Reefs
- Past Vegetation
- Relic Soils
- Tree Ring
- Ice Cores

# Layers of sediments detail past conditions

# Pollen diagrams detail past vegetation and climate information



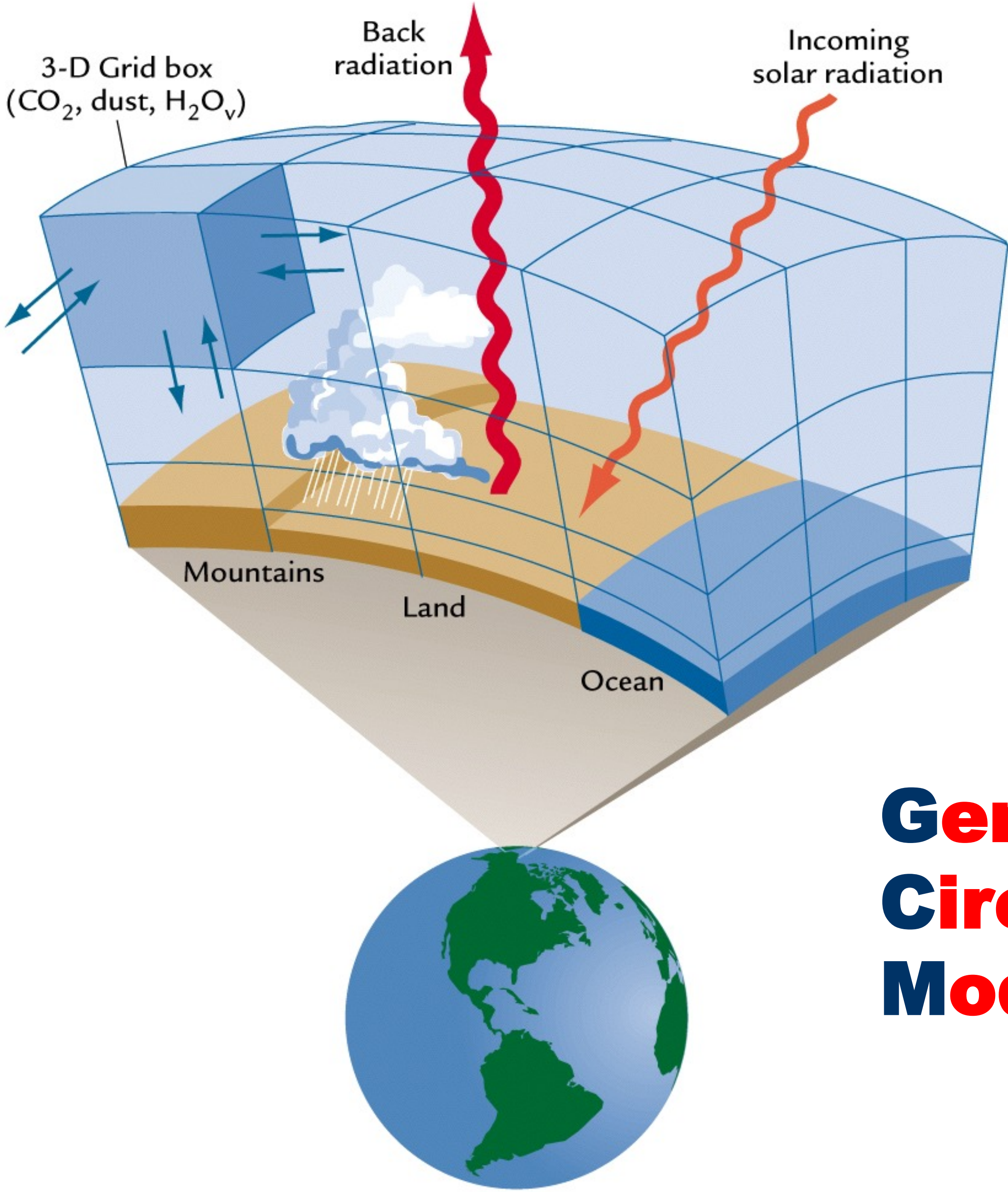

Pollen cycles

## Modeling Climate Change

- One attribute of ‘good science’ is the use of cross-checking data sources to ensure that findings are not unduly influenced by measurement error or limitations of any single data source
- The methods of determining climate change to date has related to temperature, greenhouse gas concentrations, glaciers, snow cover, river and lake ice break-up, permafrost, past vegetation, coral reefs, sea-level rise, and traditional environmental knowledge all indicate that climate change is occurring

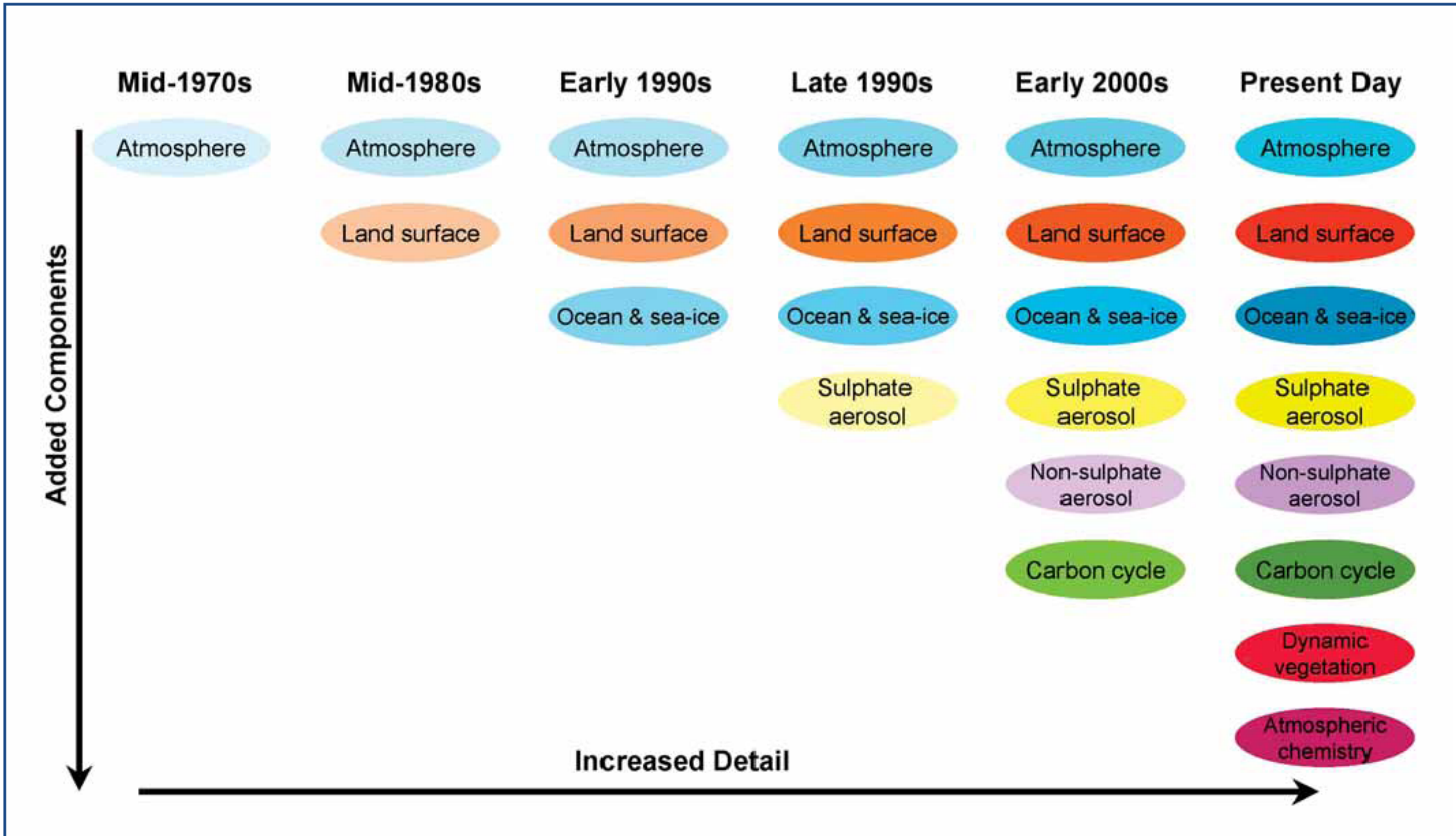
# Modeling Climate Change

- The uncertainty associated with global climate is encouraging scientists to explore many different ways of assessing past and future climates
- One approach is climate modelling
- This is not a new approach—the earliest global climate models date back to the 1950s—but more recent concerns about global warming have pushed the science of climate modelling to the forefront




# General Circulation Models

Evolution of climate model development over the past three decades

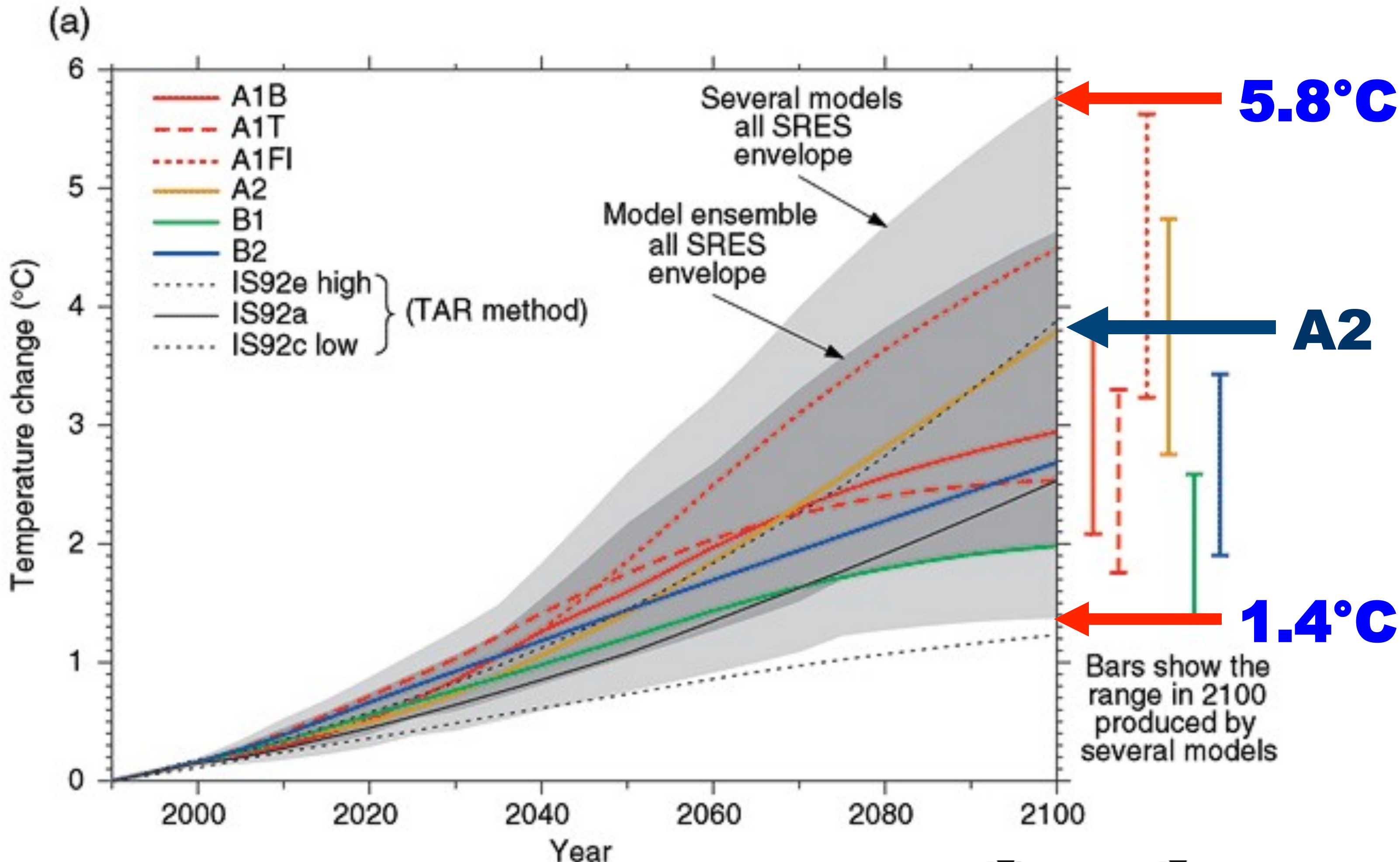



Source: IPCC TAR WG1 2001

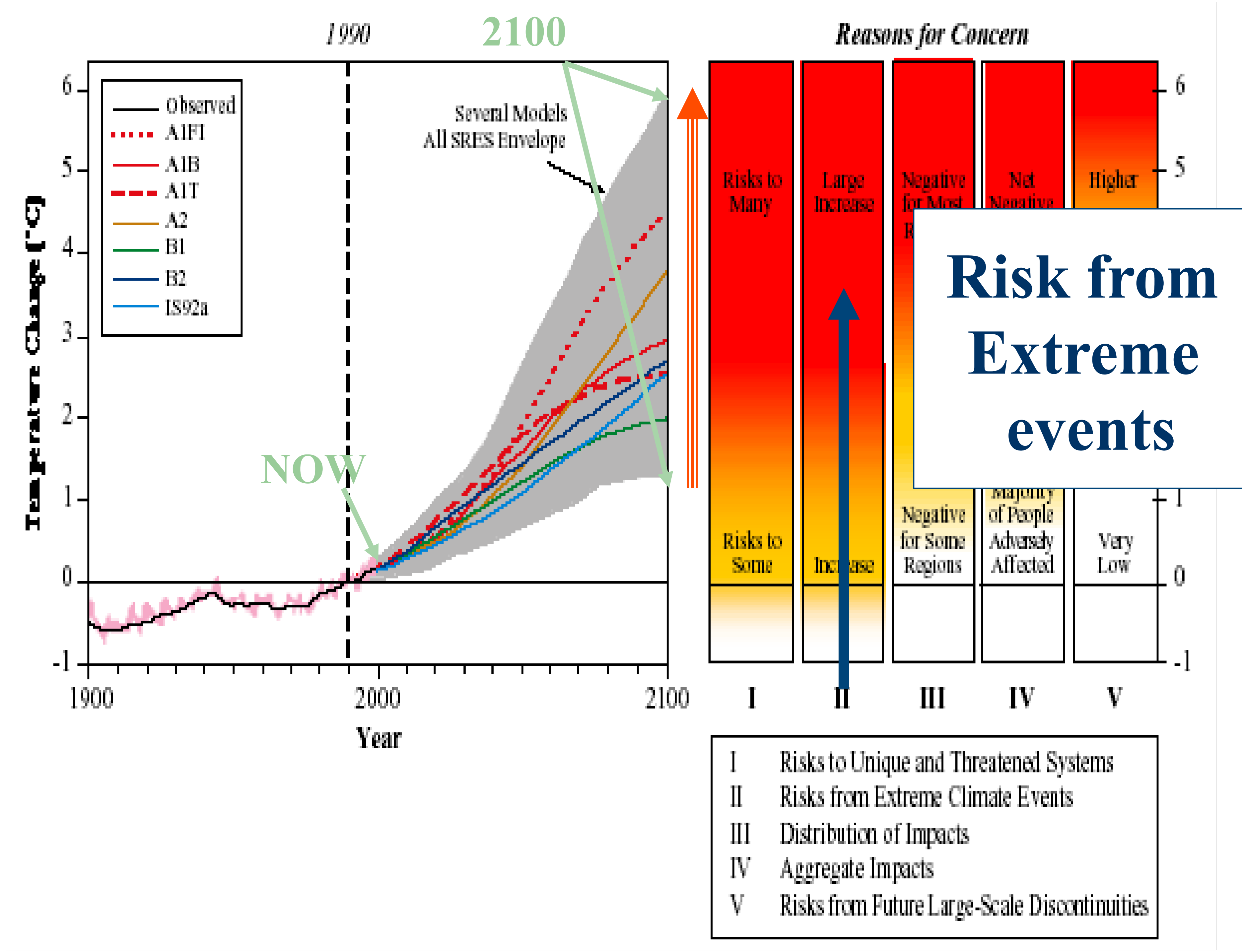
- Climate Models
  - All climate models consider some or all of 5 components in order to predict future climates:
    - radiation
    - dynamics
    - surface processes
    - chemistry
    - time step and resolution

- Limitations of General Circulation Models (GCMs)
  - While GCMs provide overall indications of future climates, their limitations for policy and planning need to be appreciated
  - Many scientists have recognized that the coarse spatial resolution, poor predictive capacity for precipitation, fairly weak simulation of oceans, lack of baseline data, and many other limitations cause GCM outputs to be highly variable

# The Range of Global Temperature Projections (IPCC)




Climate Change 2001
IPCC Third Assessment Report


1990
2100
NOW
Reasons for Concern
Observed
A1FI
A1B
A1T
A2
B1
B2
IS92a
Several Models
All SRES Envelope
Temperature Change (°C)
Year
1900
2000
2100
Risks to Many
Large Increase
Higher
Risks to Some
Increase
Negative for Some Regions
of People Adversely Affected
Very Low
I
II
III
IV
V
Risk from Extreme events
I Risks to Unique and Threatened Systems
II Risks from Extreme Climate Events
III Distribution of Impacts
IV Aggregate Impacts
V Risks from Future Large-Scale Discontinuities

# Scientific Explanations

- In its 2007 report, the Intergovernmental Panel on Climate Change concluded that worldwide trends in the 20th century consistently and strongly reveal an increase in global surface temperature
- There is strong scientific consensus that the increase in greenhouse gases has been caused by human activities
- Natural and human variables both contribute to climate change, but it is hard to figure out their relative contribution, as they both typically operate at the same time

# ▪ Implications of and Ecosystem Change

- Terrestrial Systems
  - It is possible that within your lifetime, many terrestrial systems, along with the associated fauna and flora, will change significantly
  - The consequences of change to terrestrial systems could be dramatic
  - National and provincial parks, which were created to protect representative ecosystems, may disappear or greatly change as the distinctive ecosystems currently protected by such parks evolve into something completely different

- Agriculture
  - One of the major limitations on agricultural activity in most areas of Canada is the climate
  - Canada could actually benefit from global warming, since it would extend the growing season and reduce damage from severe cold
- Freshwater Systems
  - As a result of the changes discussed so far, every part of Canada except the southern Prairies has become wetter
  - These changes may affect tourism in BC, agriculture operations, and shipping patterns on the Great Lakes



- Fisheries
  - Fish are vulnerable to changes in temperature, precipitation, wind patterns, and chemical conditions
  - If water levels drop or there are more periods of lower water levels, the mortality of spawning salmon in BC rivers is likely to increase
- Cryosphere
  - Warmer temperatures in higher latitudes are expected to cause melting of ice, such as the Greenland ice sheet
  - As ice in the Arctic melts, there will be consequences, such as a rise in sea levels

- Ocean and Coastal Systems
  - It appears that both sea temperatures and sea levels will increase
  - This will affect coastal communities, such as those in Prince Edward Island
- Infectious Diseases
  - Given the prediction of the IPCC about climate change in North America, Health Canada has indicated that Canadians can expect to experience a greater incidence of disease
  - This includes infectious diseases such as Lyme disease, dengue fever, West Nile virus, and malaria

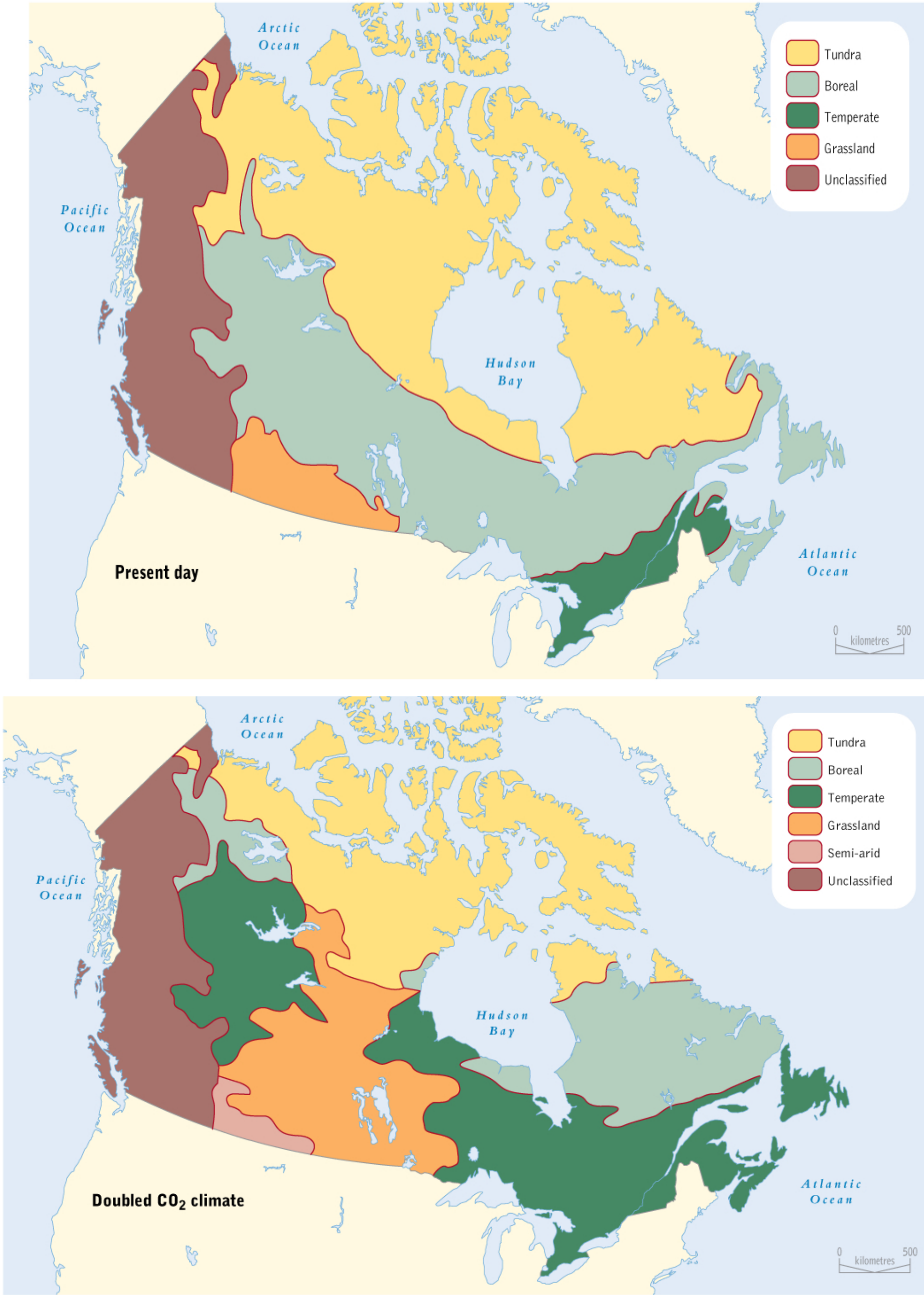



**Figure 7.7 Changes in forest and grassland boundaries resulting from a typical doubled CO2 climate (Hengeveld, 1991)**

- Five types of adaptation are usually recognized:
  - Prevent the loss by adopting measures that reduce vulnerability
  - Tolerate the loss by doing nothing and absorbing the cost of losses when they happen
  - Spread or share the loss by distributing the costs over a larger population, such as through insurance
  - Change the affected activity by ceasing to do certain things or by shifting to other activities; and
  - Change the location of the activity by moving to a less vulnerable location