LECTURE 2_2:

CLIMATE CHANGE

DEFINITIONS AND SCIENTIFIC EVIDENCE RELATED TO …

Text Reference: Dearden and Mitchell (2012), pp. 201-209

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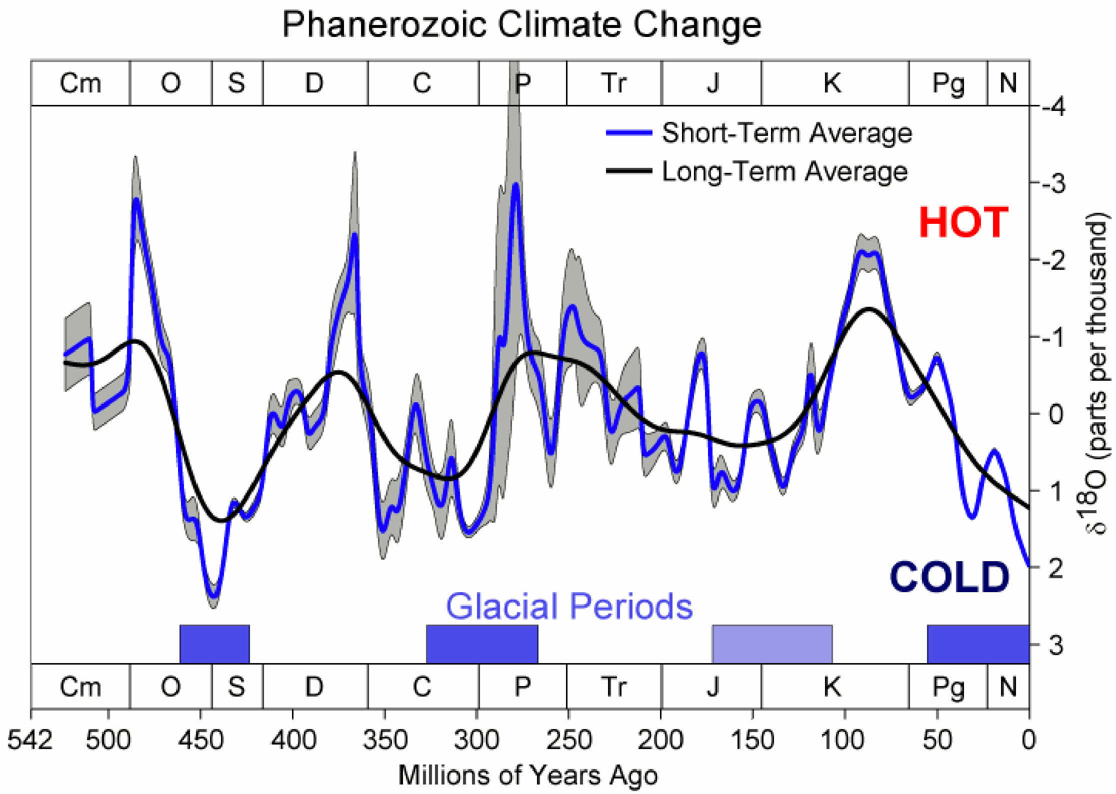
Outline

From: Dearden and Mitchell (2012)

- Definitions:
  - weather, climate, climate change, global warming, greenhouse effect, GCMs,
- Nature of Climatic Change
- Scientific Evidence of Climatic Change

Overview – *Climate is naturally variable*

- Numerous glacial-interglacial periods during Earth's history
- Notable changes observed in the Earth's climate since period of observations (~last 140 years)
- "Climate Change" is now part of the North American "lexicon" – not so prior to 1990



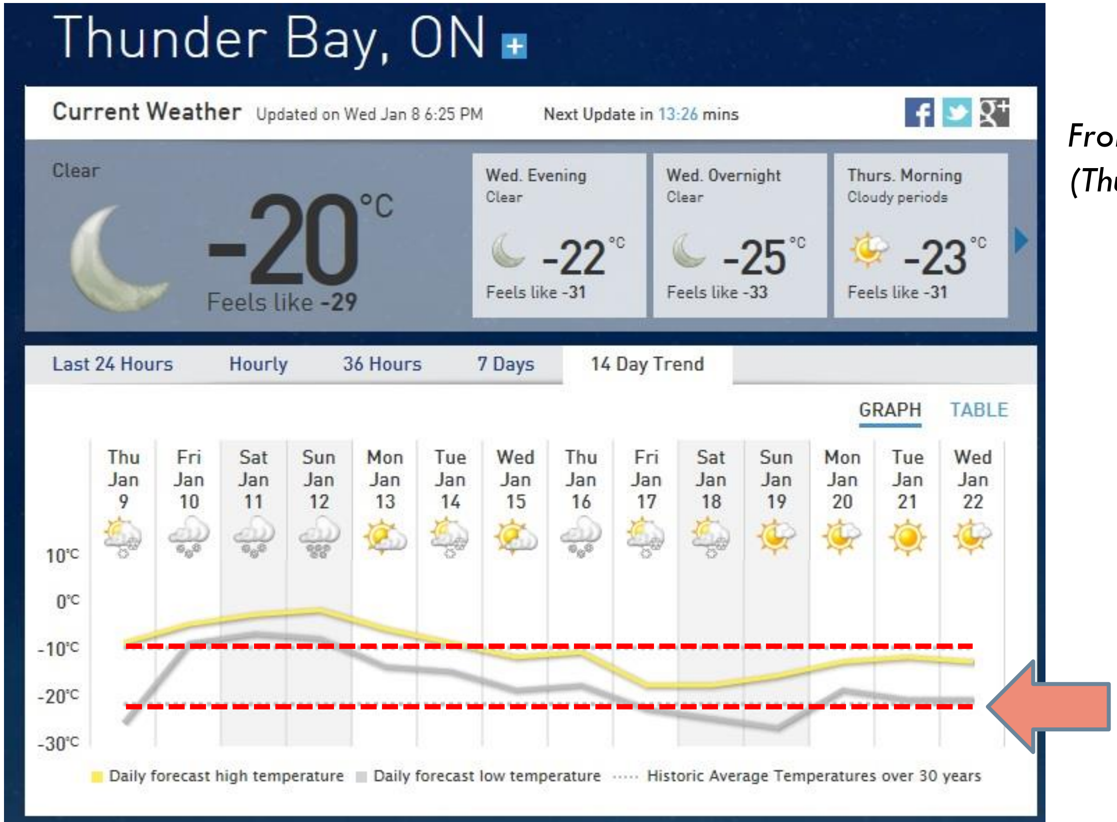
Weather

- **<u>Weather:</u>** "the condition of the atmosphere at any time and place"
- Includes:
  - Temperature
  - Pressure
  - Humidity
  - Winds
  - Air Pressure

From: The Weather Network web site (Thunder Bay, Jan. 8, 2014)

Climate and "Climate Normals"

- **<u>Climate:</u>** "a composite or generalization of the ***variety*** of day-to-day weather observations"
- Compare today's observations with the 'typical"



From: The Weather Network web site (Thunder Bay, Jan. 8, 2014)

"Historic Average Temperatures over 30 years"

OR

CLIMATE NORMALS

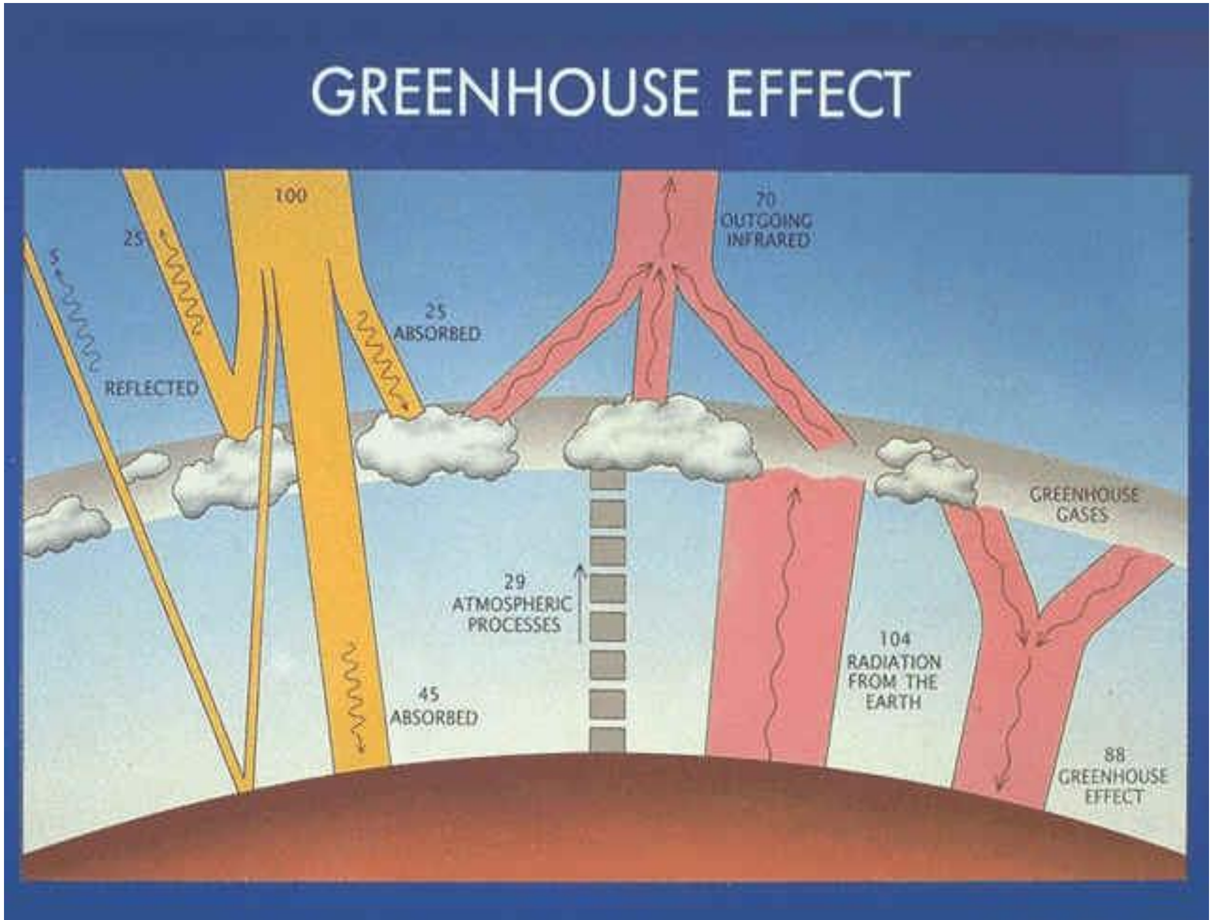
(1961-1990; 1971-2000; etc)

Our activities are universally *weather-dependent* …

From: Meteo France web site (Predictions for Jan. 9, 2014)

Greenhouse Effect

- Balance between incoming Shortwave (SW) radiation and outgoing Longwave (LW) radiation



http://see-the-sea.org/topics/pollution/air/green-house/greenhouse_effect.htm

Natural vs non-natural Greenhouse Effect

- Without the GE, Earth's average temperature would be -18ºC instead of current +15ºC

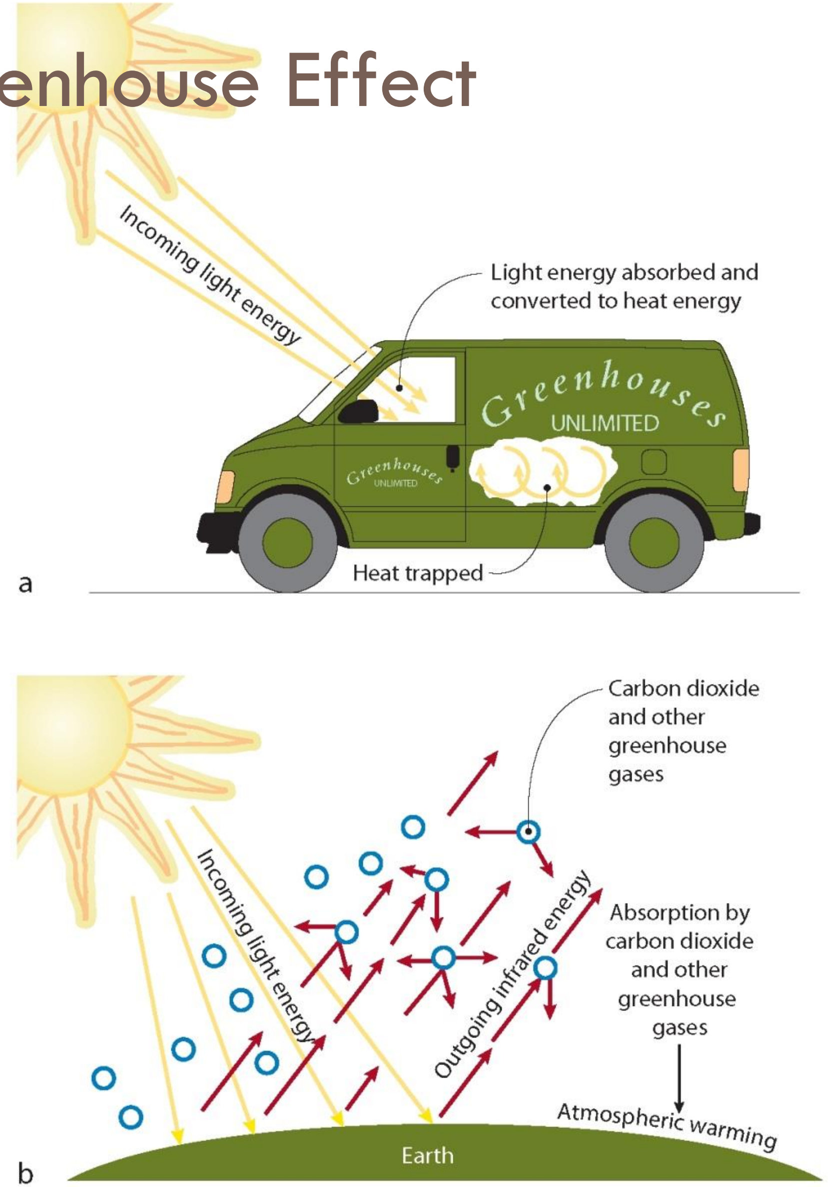
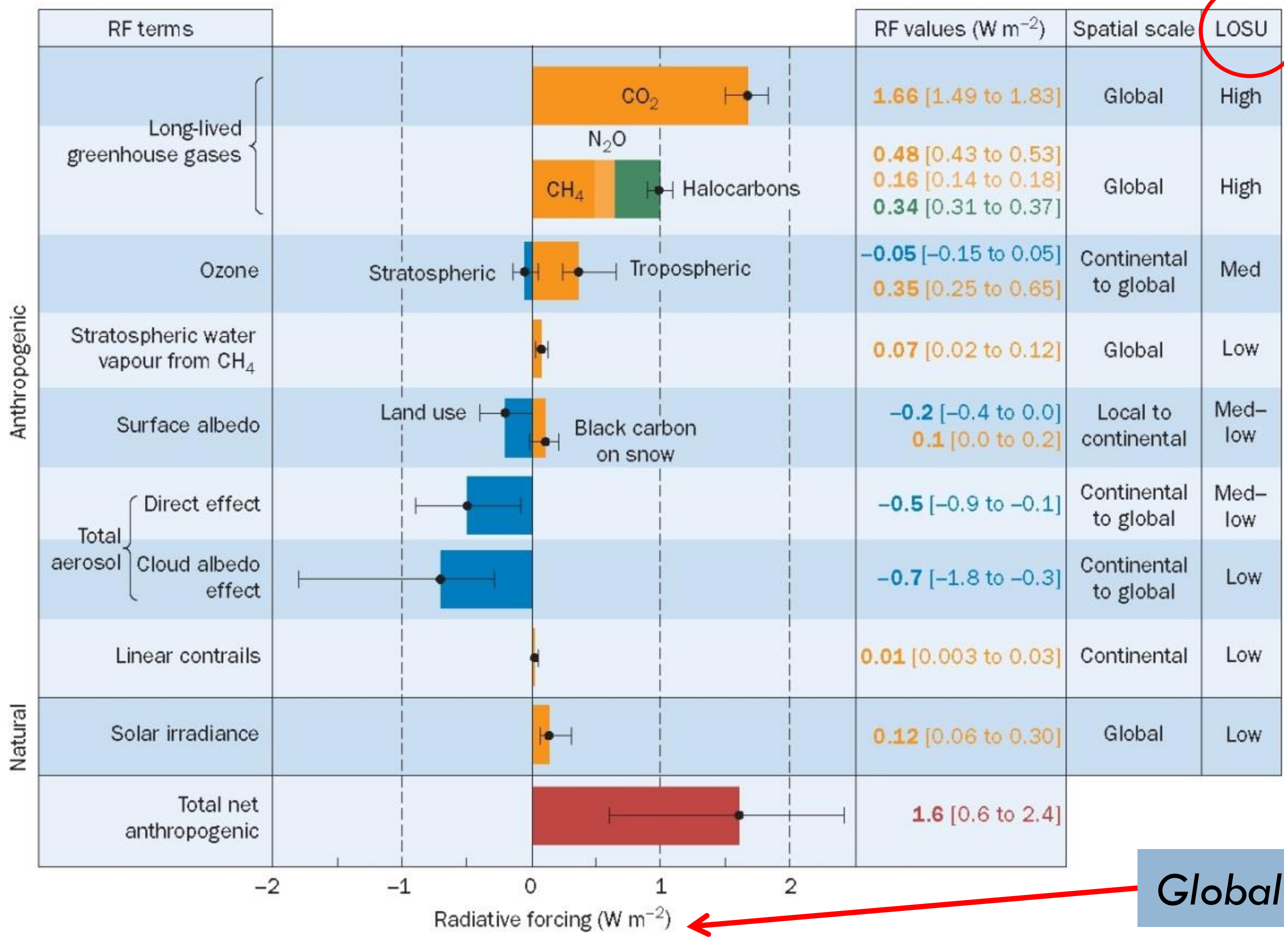


Figure 7.3 | The greenhouse effect.

From: Dearden and Mitchell (2012)

Impact of various *anthropogenic* GG's and 'reliability' of the science …

Level of Scientific Understanding



HIGH

LOW

Note:
Large Error Bars!

Global Avg Radiative Forcing

Figure 7.5 | Global average radiative forcing (RF) estimates and ranges in 2005 for anthropogenic carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and other important agents and mechanisms, together with the typical geographical extent (spatial scale) of the forcing and the assessed level of scientific understanding (LOSU). The net anthropogenic radiative forcing and its range are also shown. They require summing asymmetric uncertainty estimates from the component terms and cannot be obtained by simple addition. Additional forcing factors not included here are considered to have a very low LOSU. Volcanic aerosols contribute an additional natural forcing but are not included in this figure because of their episod
The range for linear contrails does not include other possible effects of aviation on cloudiness. *Source:* IPCC (2007b

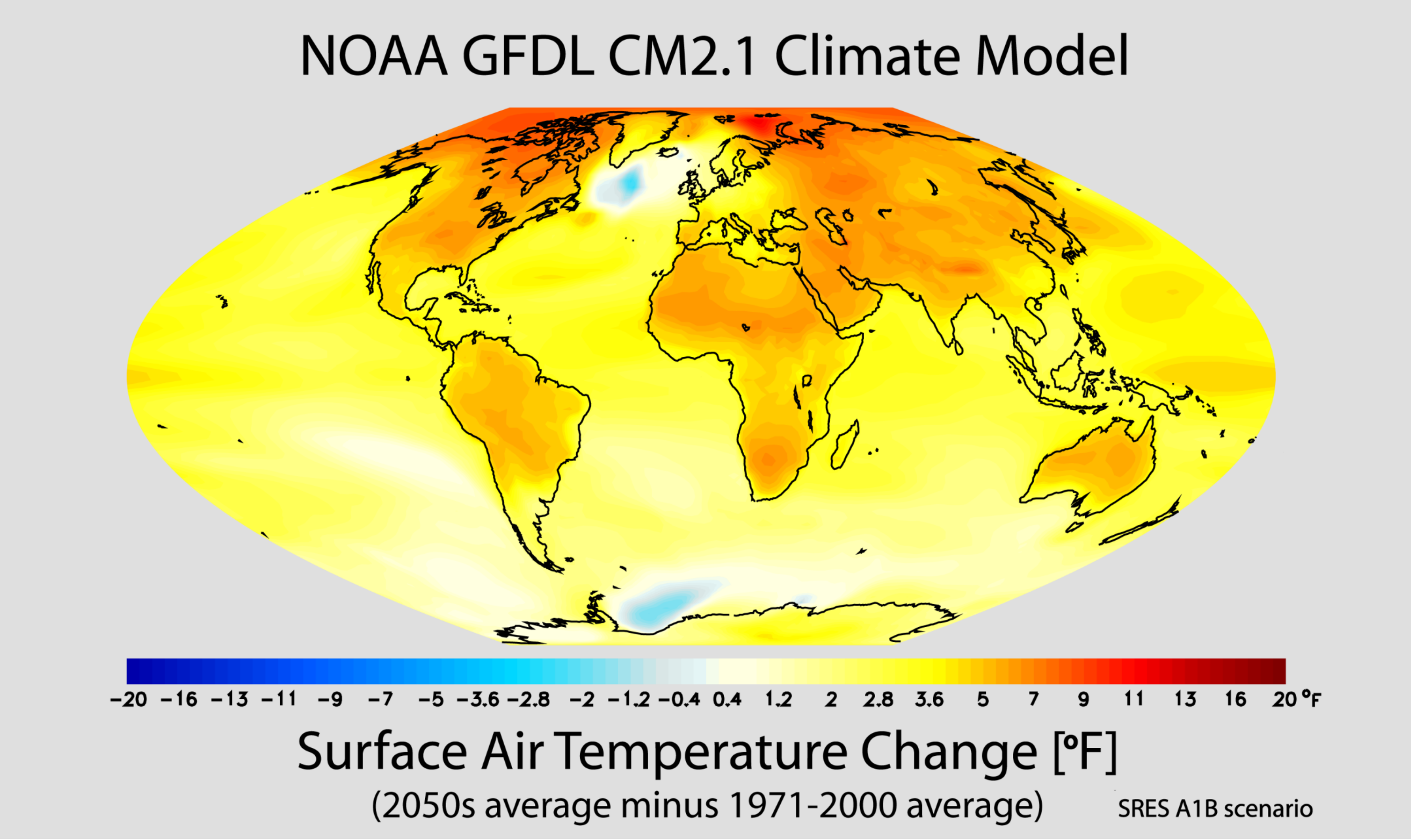
From: Dearden and Mitchell (2012)

Climate Change vs Global Warming

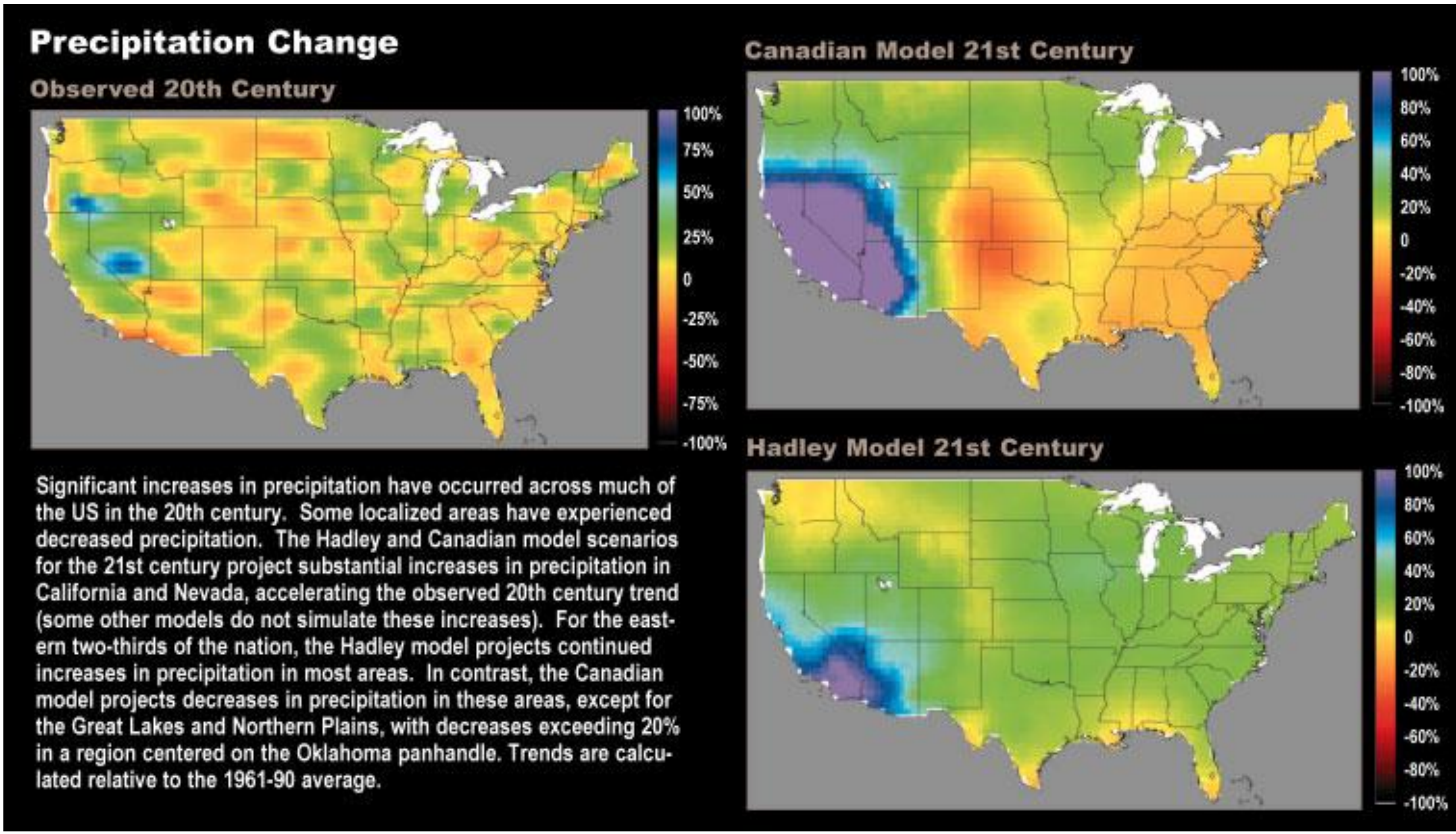
- **Climate Change:**
  - "a long-term shift or alteration of the climate of a specific location, a region, or the entire planet"

- **Global Warming:**
  - "addresses only changes in average surface *temperatures*"

Climate Change vs Global Warming



Climate Change vs Global Warming



Percentage Change in Very Heavy Precipitation

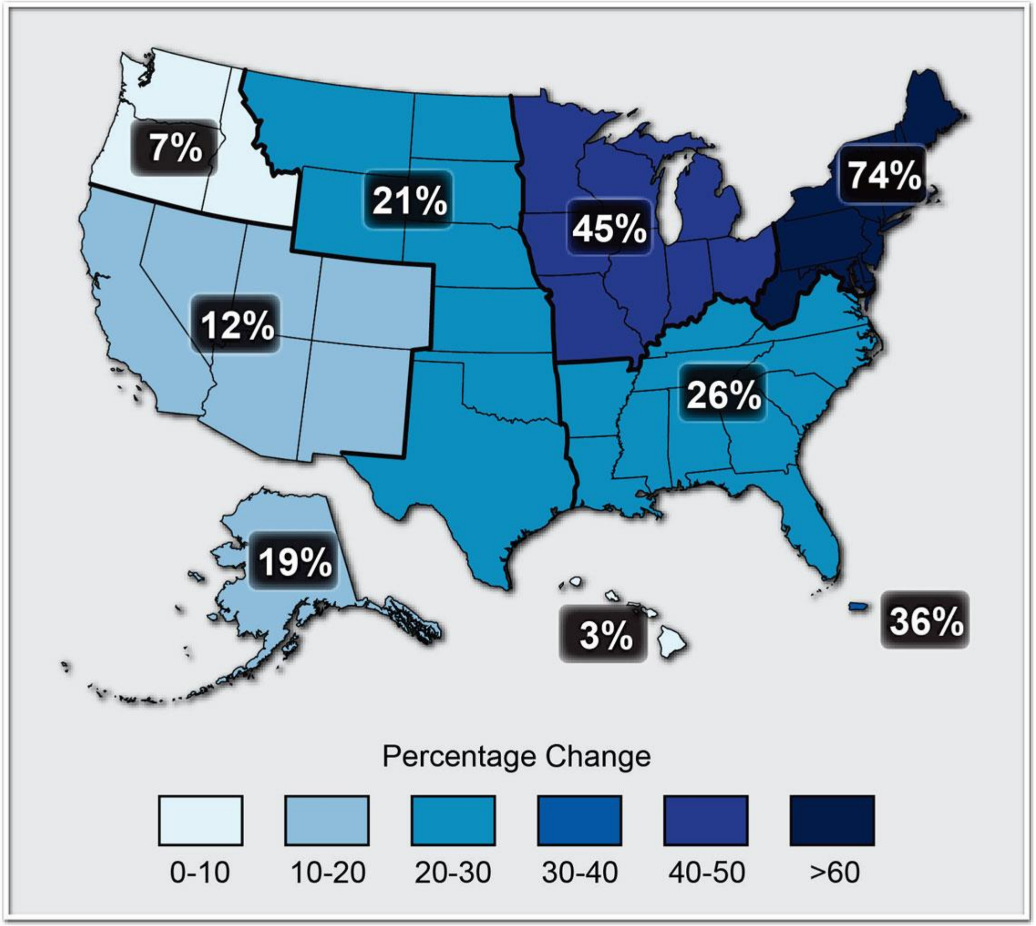
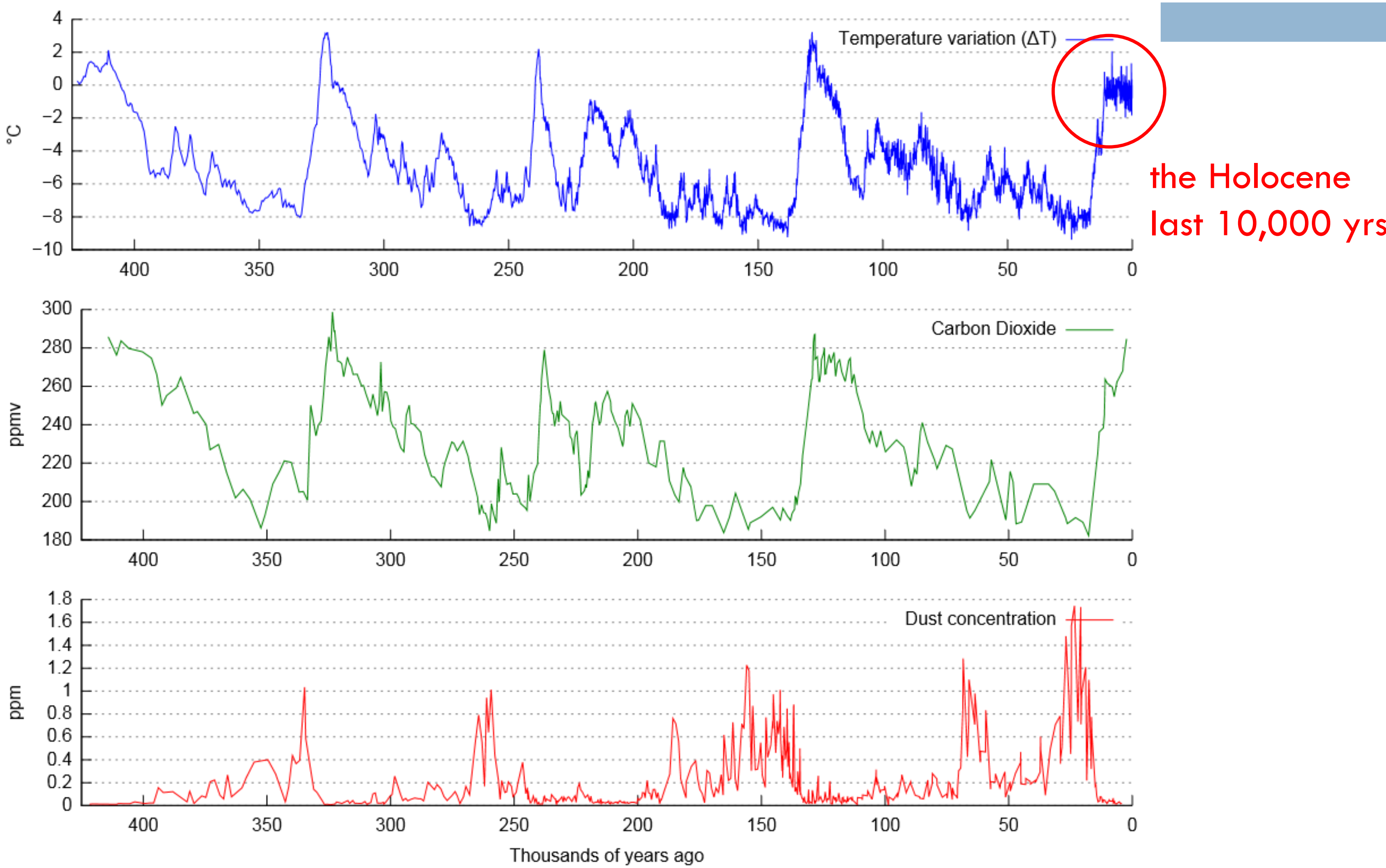


Figure 2.16: Percentage Change in Very Heavy Precipitation
Caption: The map shows percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2011 for each region. There are clear trends toward a greater amount of very heavy precipitation for the nation as a whole, and particularly in the Northeast and Midwest.
(Figure source: updated from (Karl et al. 2009) with data from NCDC)

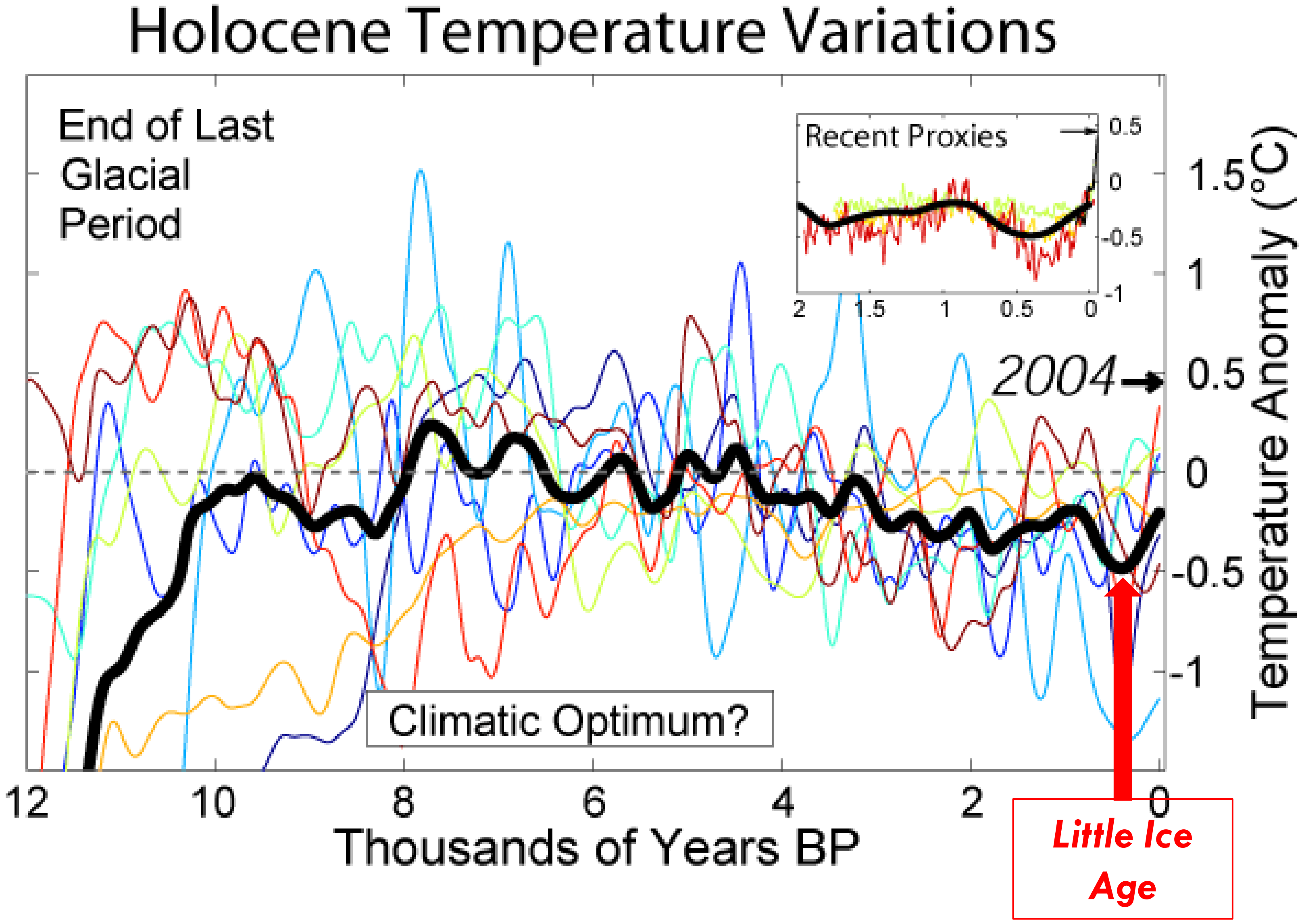
Source: National Climate Assessment Draft January 2013; http://ncadac.globalchange.gov/download/NCAJan11-2013-publicreviewdraft-chap2-climate.pdf

Time Scales: the Quaternary – primarily glacial (last 2 million years)



Reconstructed from Antarctic ice sheet core data; note: co-variation in CO_2 + deltaT.

Holocene → Anthropocene



E's average surface T increased by 0.6°C since 1850s, but not geographically uniform

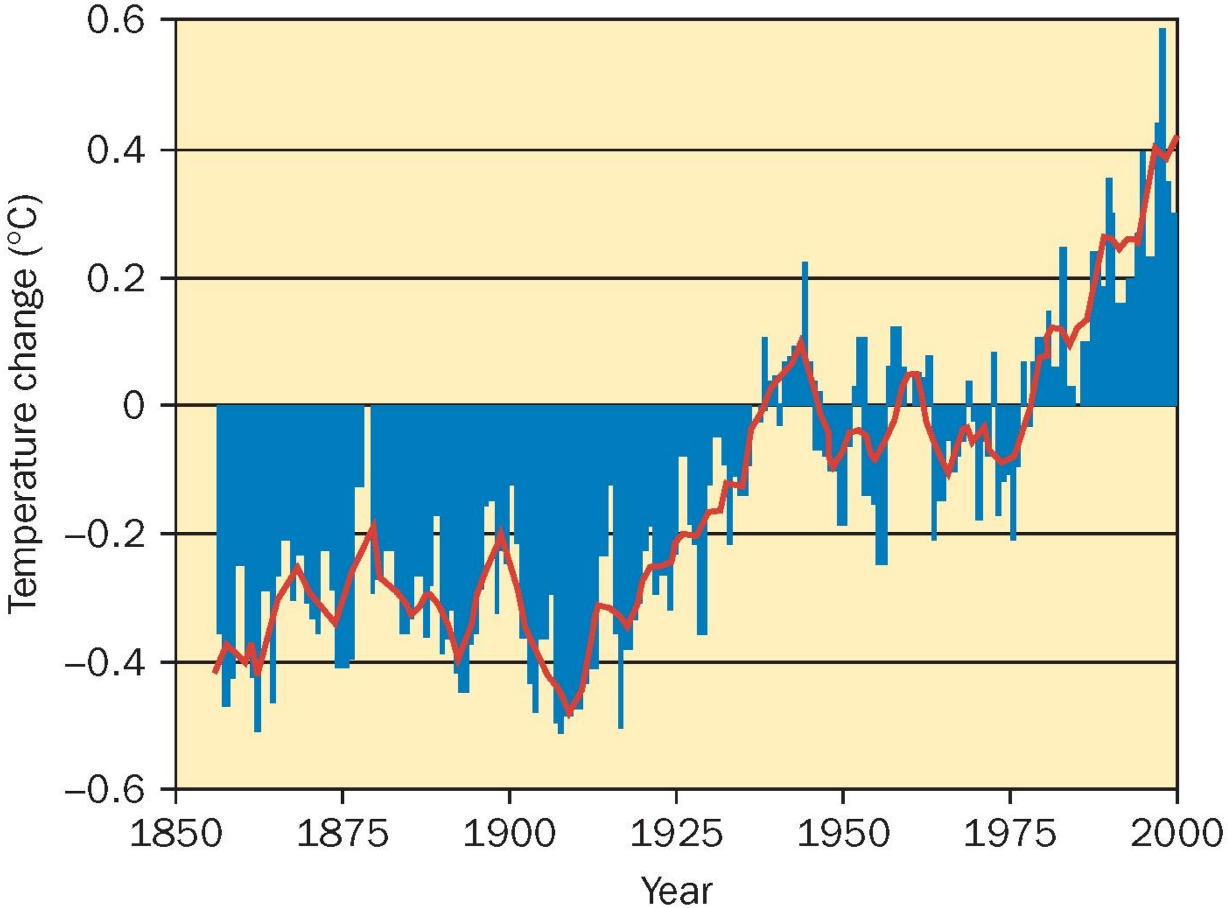


Figure 7.1 | Variation in global average surface temperature between 1856 and 2000. *Source: Miller (2002: A-2),*

From: Dearden and Mitchell (2012)

Key greenhouse gases at highest concentrations observed in past 420,000 years

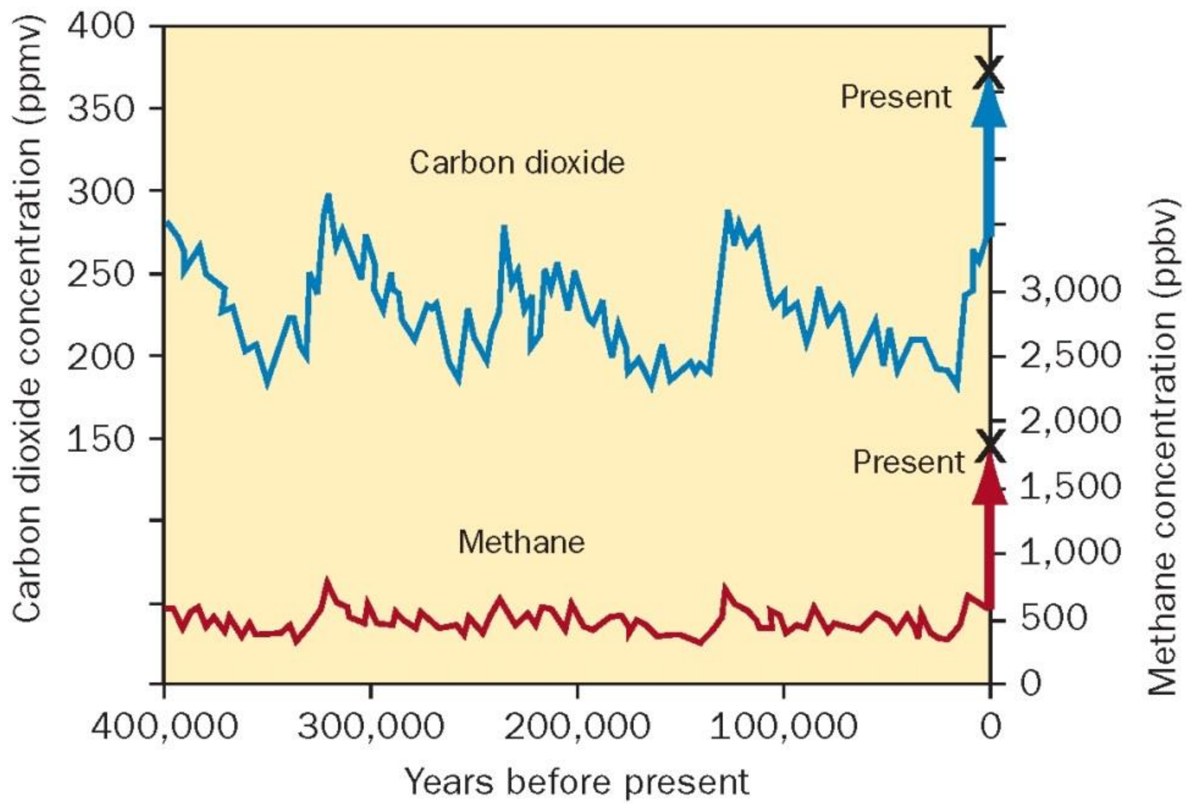
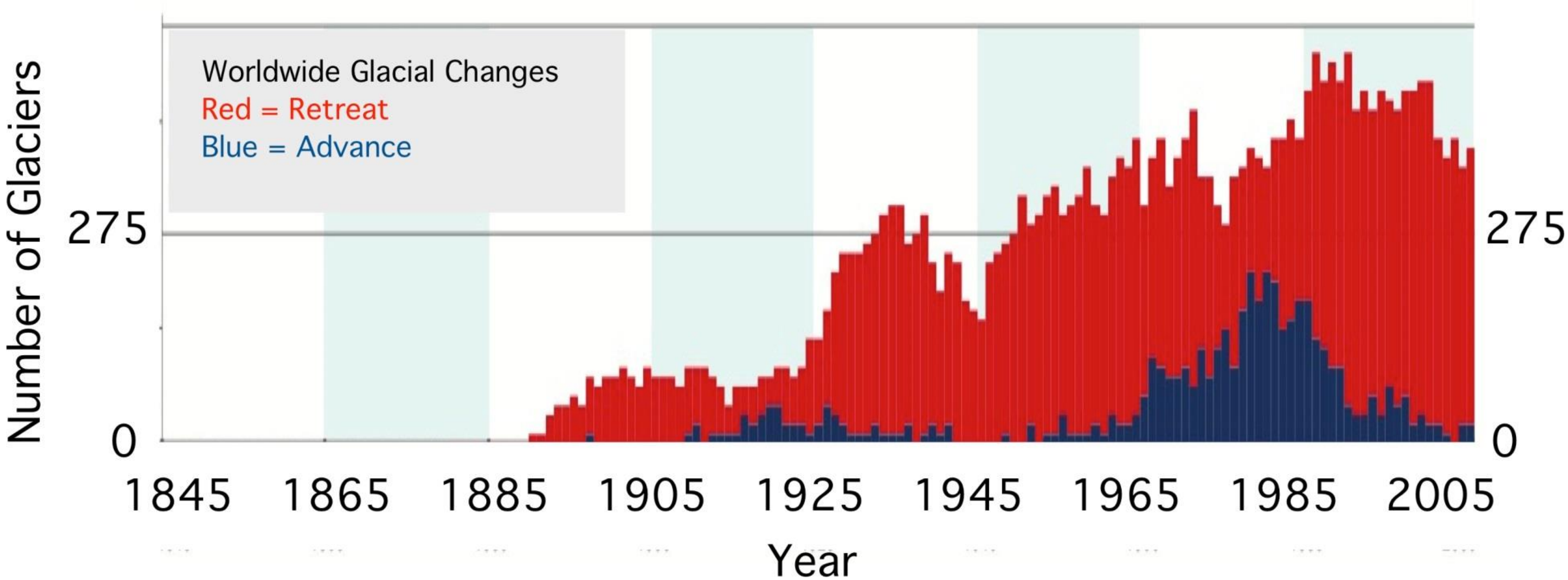


Figure 7.4 | Variation in atmospheric concentrations of carbon dioxide and methane to 400,000 years before present. Measured in the Vostok ice core in Antarctica (thin lines) and during the past 200 years (heavy line). *Source: Miller (2002: A*

From: Dearden and Mitchell (2012)

Other evidence of observed climate change / global warming

- Negative mass balance in most of the world's glaciers and ice sheets



- Reduced snow cover, earlier spring melts

Other evidence of observed climate change / global warming

- Negative mass balance in most of the world's glaciers and ice sheets

Other evidence of observed climate change / global warming

- Permafrost warming and ground ice thawing → potential additional methane release (old methane buried during previous glacial periods)
- Observed sea level rise (~1.8 mm rise per year since 1961) … but one needs to be cautious with respect to interpretation as the landscape in places is still responding to isostatic loading of the last glacial period;

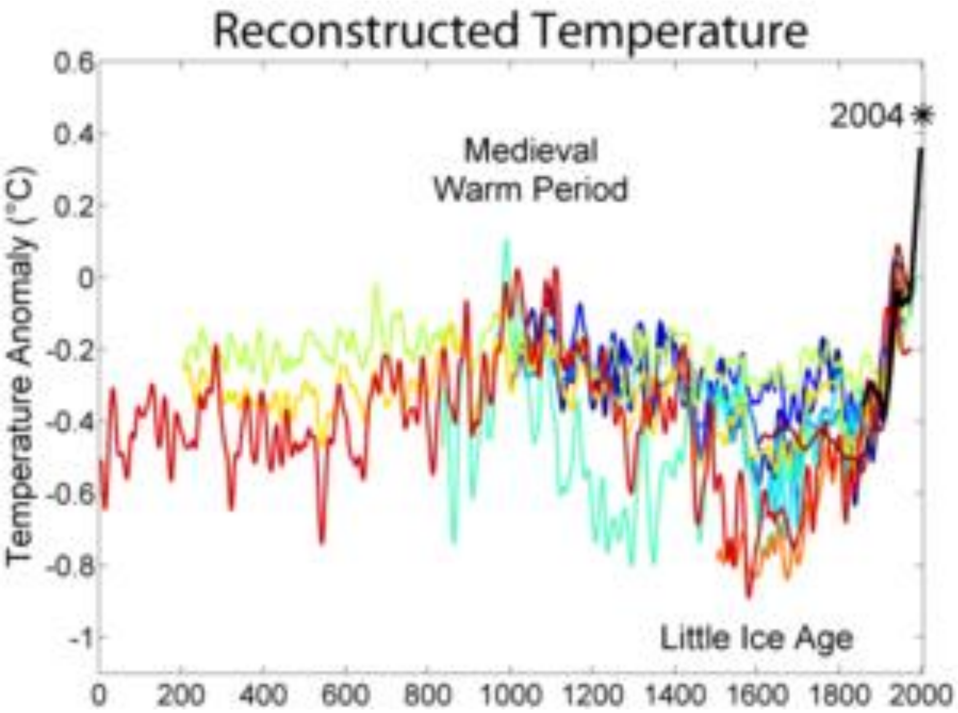
Modeling Climate Change

- A complex undertaking given complexity of earth-atmosphere-oceanic interactions that create climate
- Thus, all climate models simply certain aspects of the actual systems
- Earliest climate models date from the 1950s
- A key step in modeling *future* climate scenarios is to understand how present variations in climate compare with the *past*.

Reconstruction of Past Climates

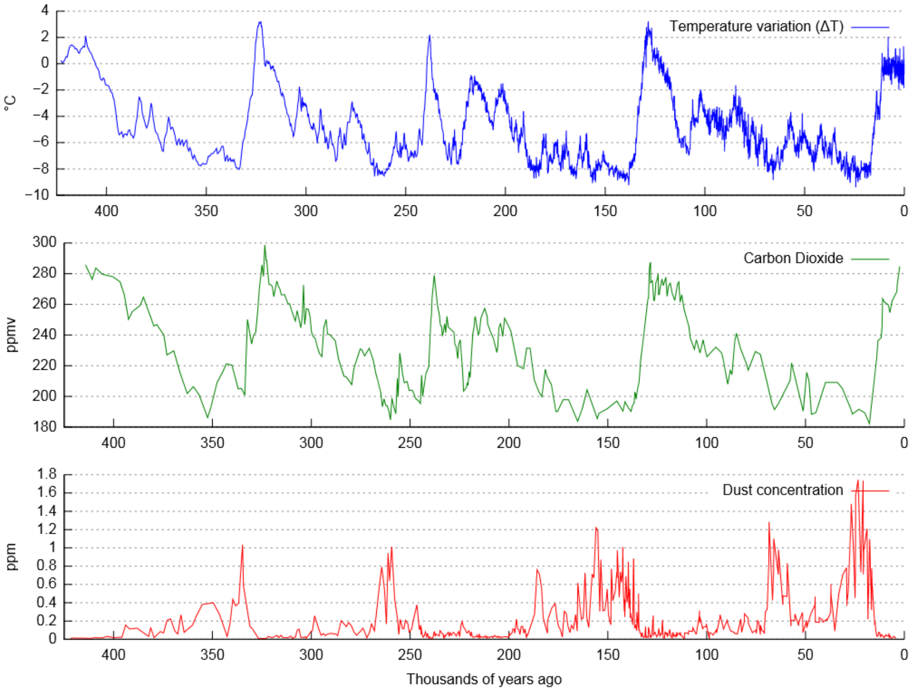
- Last 140 years, temperature (instrumental record)
- Last 35 years, data from upper atmosphere (via satellites)
- Other periods require the use of "proxy data" to build climate histories:

e.g. **<u>Harbour records (ice conditions)</u>** in northern European ports like Reykjavik, Iceland (covers several 100s of years)



Reconstruction of Past Climates

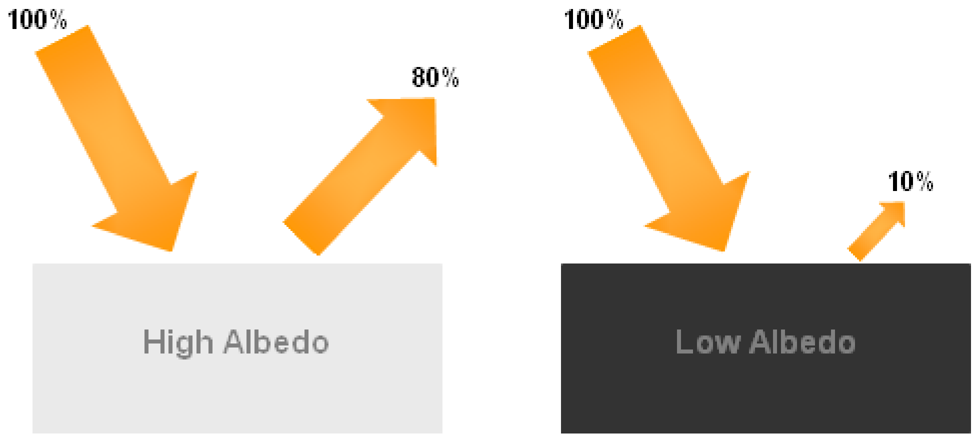
- Also use other climate-sensitive natural indicators such as tree rings and ice cores
  - E.g. ice sheet cores … exceed many 10s of 1000s of years;
  - E.g. tree ring records … some species in coastal BC/Calif. Can go back 1000s



General Circulation Models (GCMs)

- All GCMs use some (or all) of the five following components to model climate change scenarios …

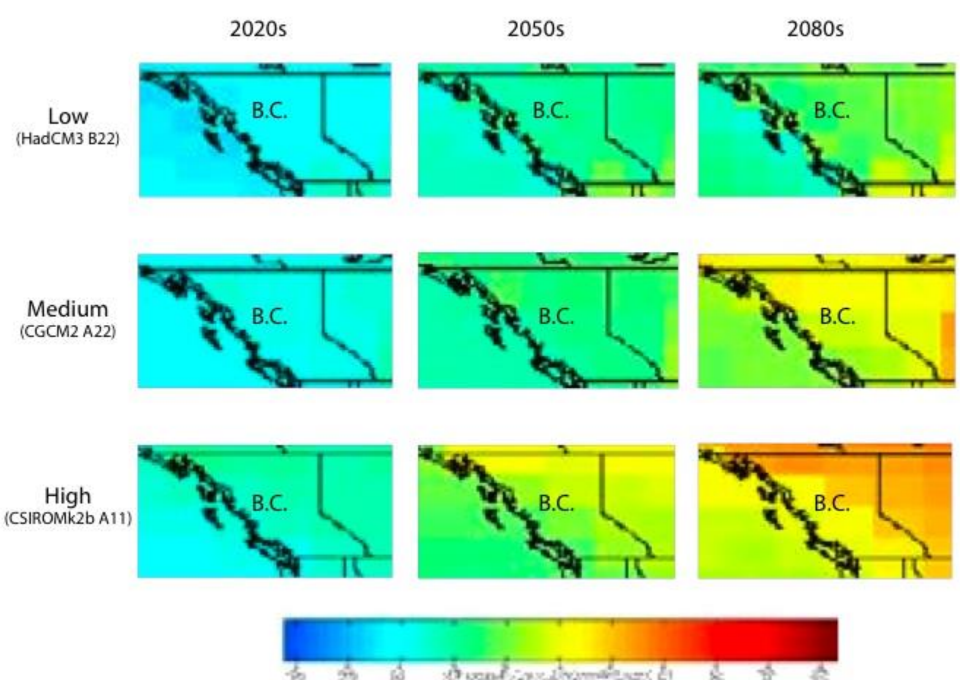
1. radiation – incoming (solar, SW); outgoing (absorbed, reflected, LW)
2. dynamics – horizontal/vertical energy movements
3. surface processes – how E's surface affects climate (e.g., snow cover, vegetation → albedo)



surface	albedo
fresh asphalt	0.04
deciduous forest	0.15 – 0.18
fresh snow	0.80-0.90

General Circulation Models (GCMs)

4. chemistry – chemical composition of the Atmosphere and related interactions with other E processes
5. time step and resolution – time step (minutes or decades); resolution (ie spatial scale … regional vs global)

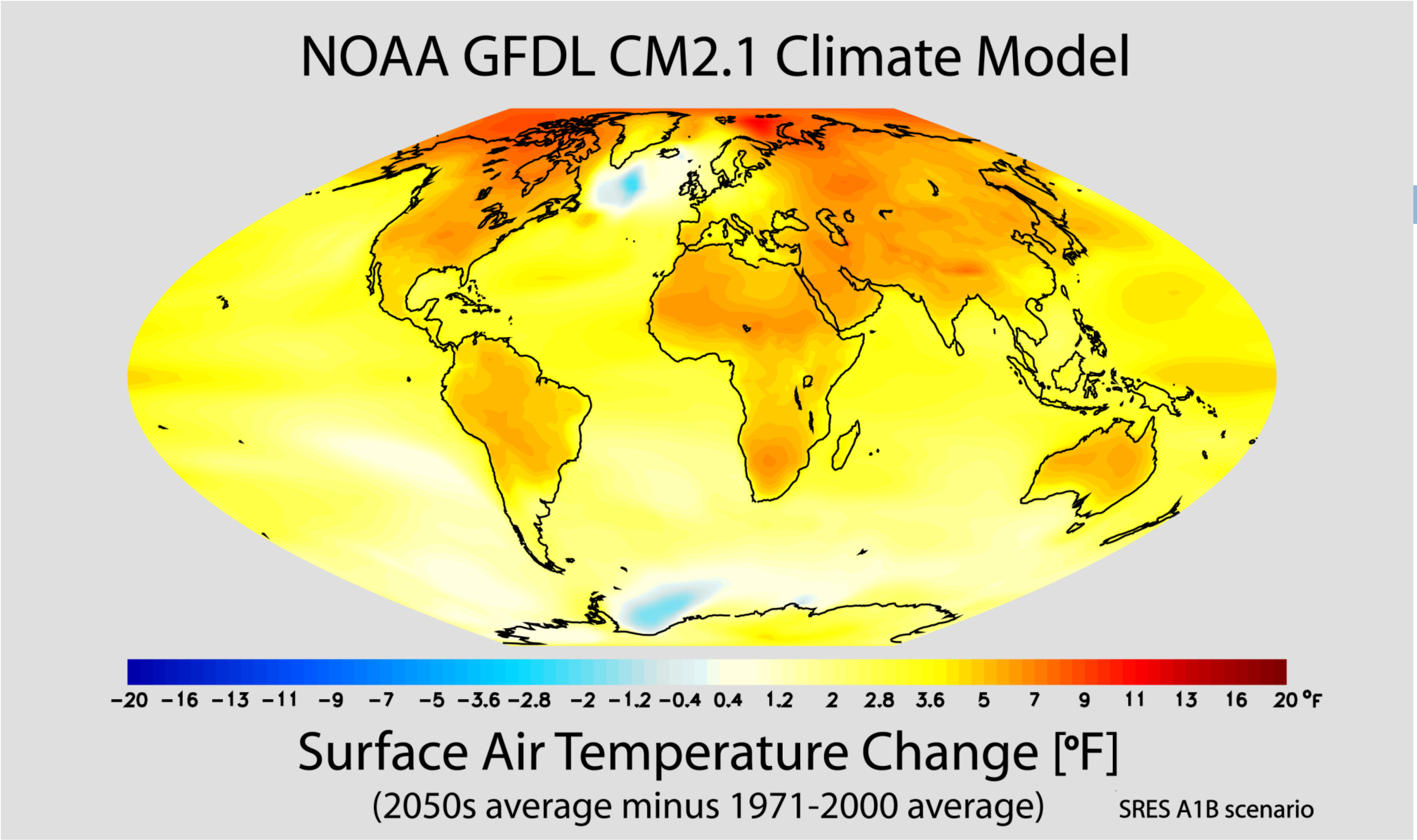


<u>Figure 37:</u> Projected mean annual temperature change for the 2020s, 2050s and 2080s for three climate change scenarios: low, medium and high.

Source: Threats to Biodiversity in British Columbia *(http://www.biodiversitybc.org/EN/main/downloads/tnp-3.html)*

Limitations of 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
- Because of necessary simplifications in modelling climate system, GCMs are most suitable at global scales not for regional representations of climatic change



- little doubt that it will be warmer; the uncertainty is the magnitude of the changes for locations around the world;

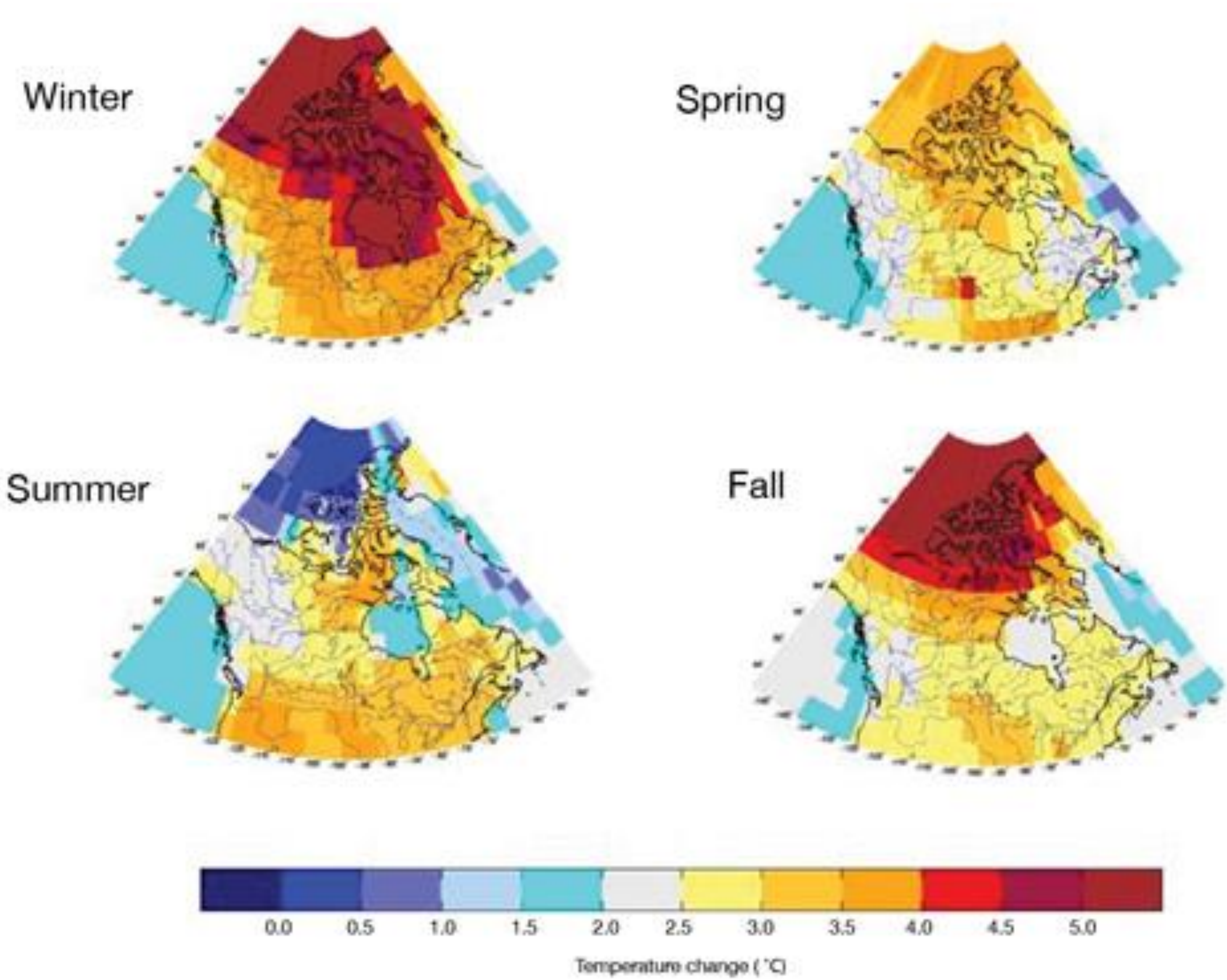


Figure 2.1: Seasonal Change in Temperature across Canada by 2050

Source: NRC 2007

References

- Dearden, P and Mitchell, B. 2012. *Environmental Change and Challenge*, Fourth Edition, Don Mills, Ontario: Oxford University Press {chapter 7}