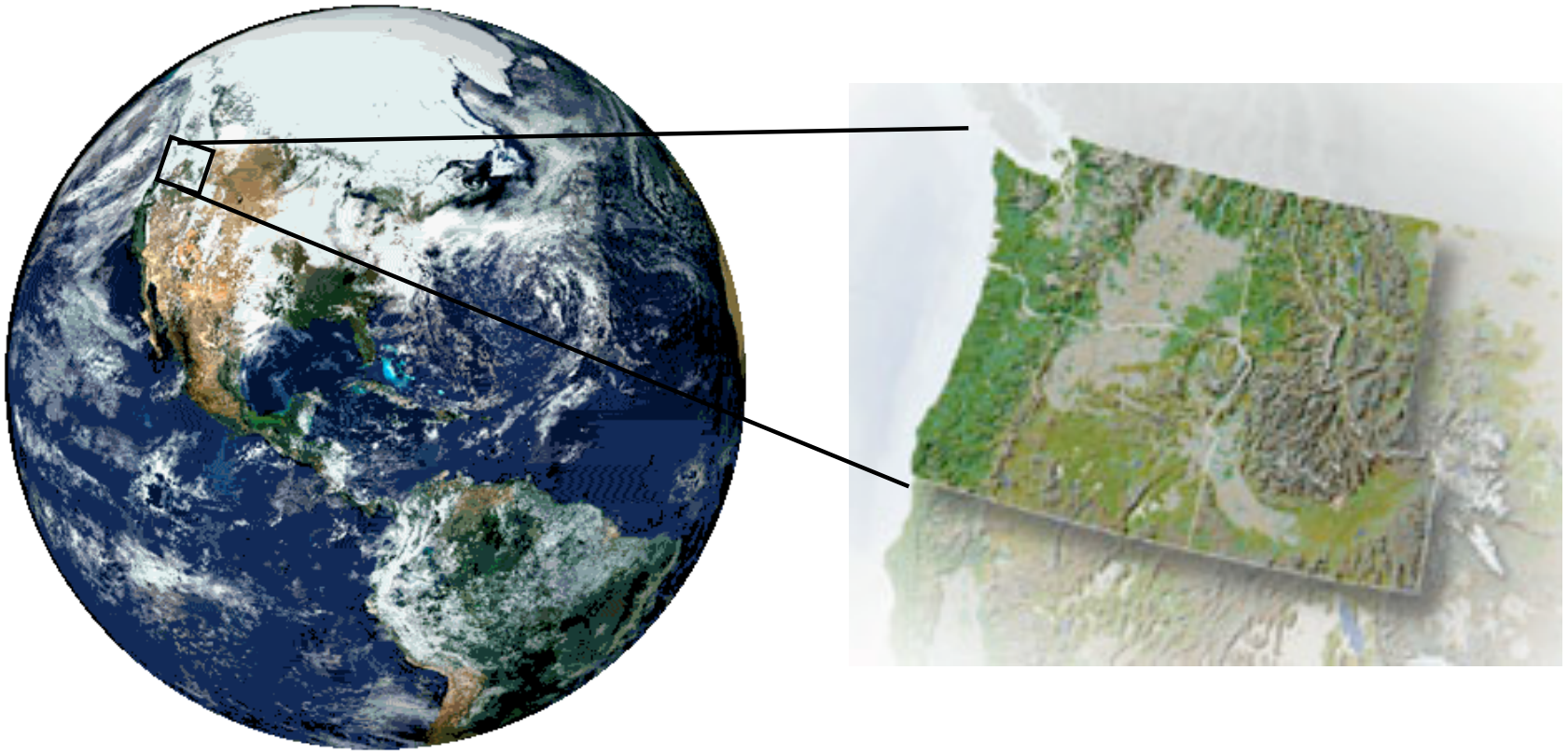
# The Science of Climate Change

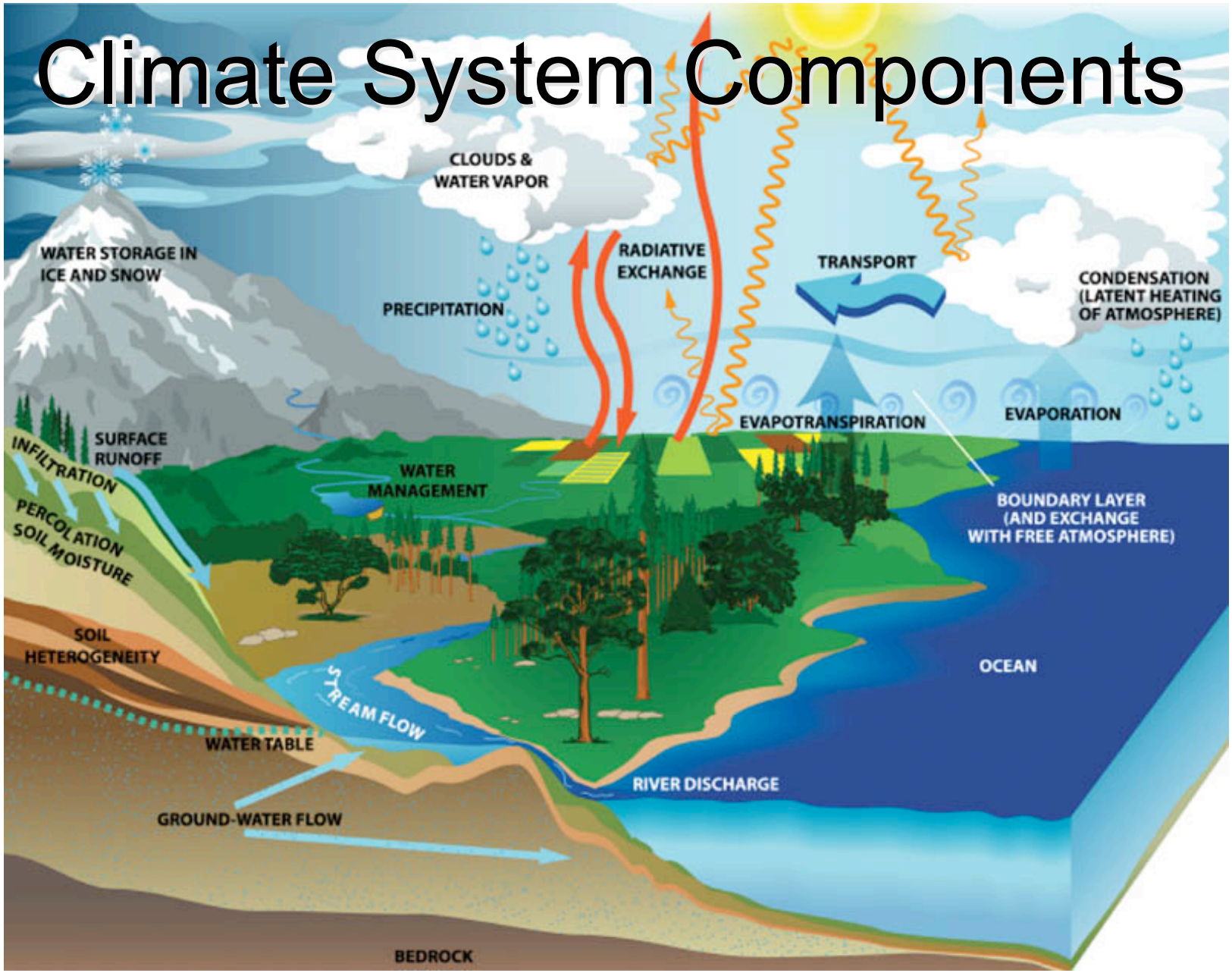


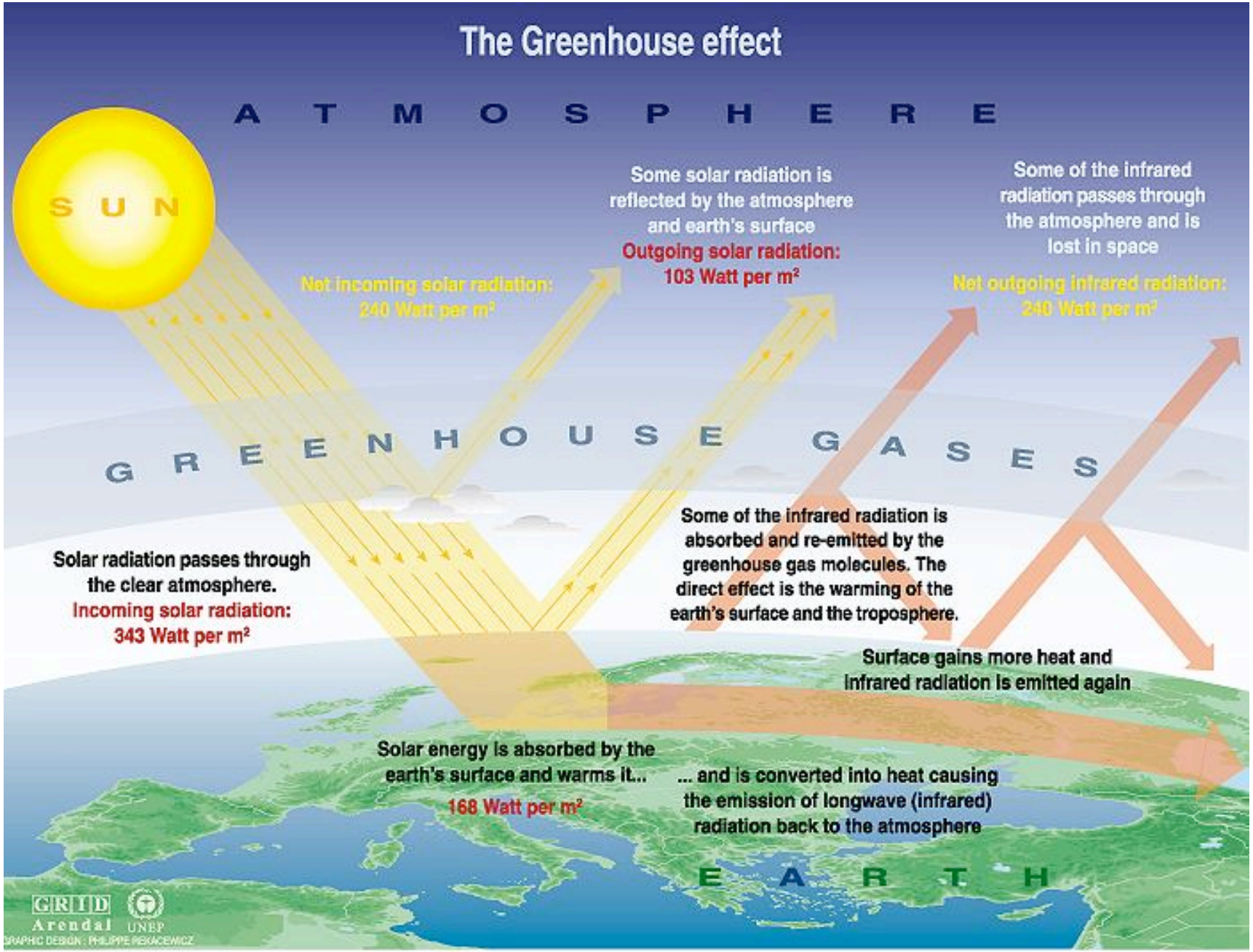
## From the Globe to the Pacific Northwest

*Alan C. Mix, Oregon State University*

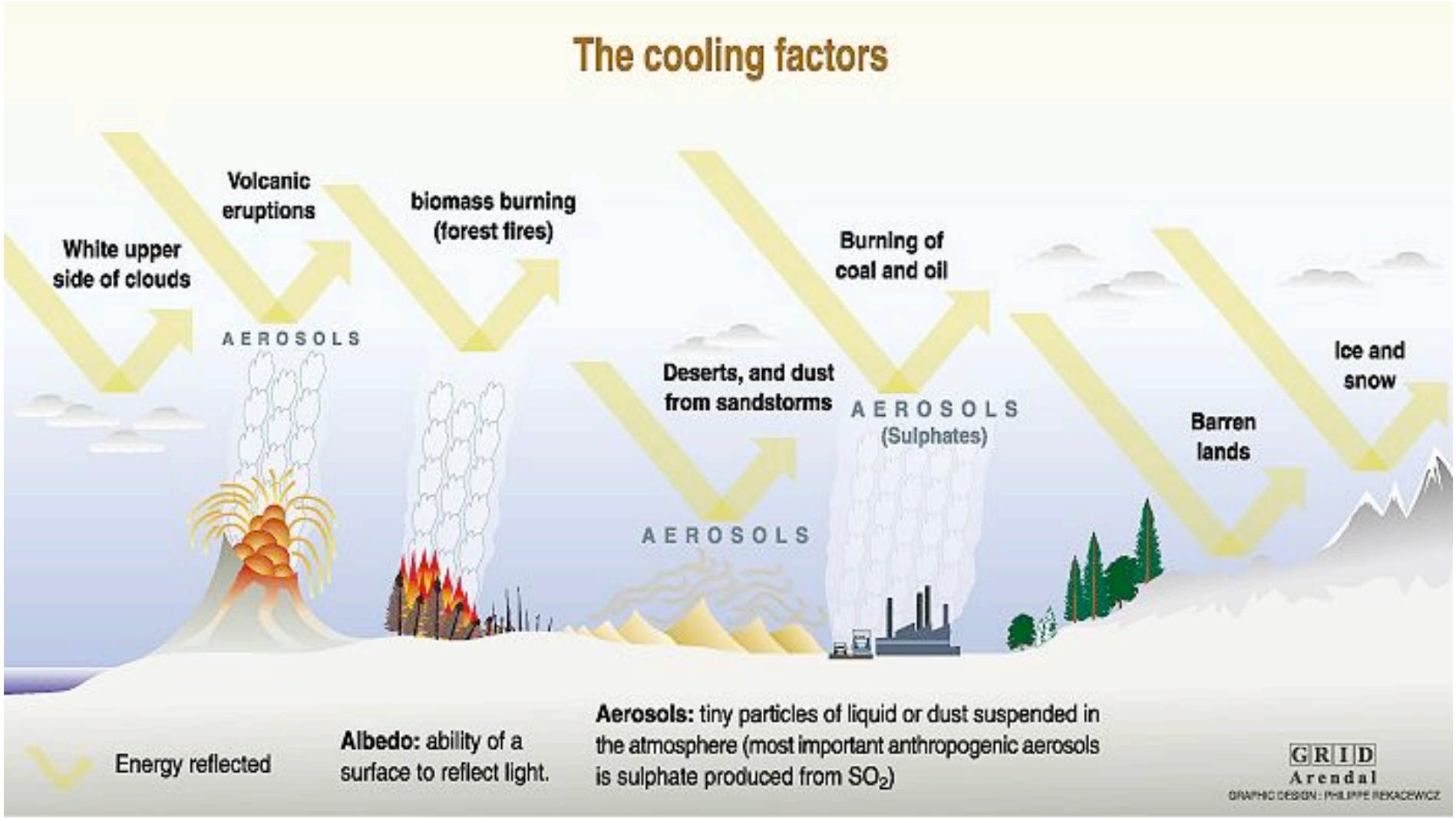
*27 October 2004, WESTCARB, Portland Oregon*

# Climate System Components

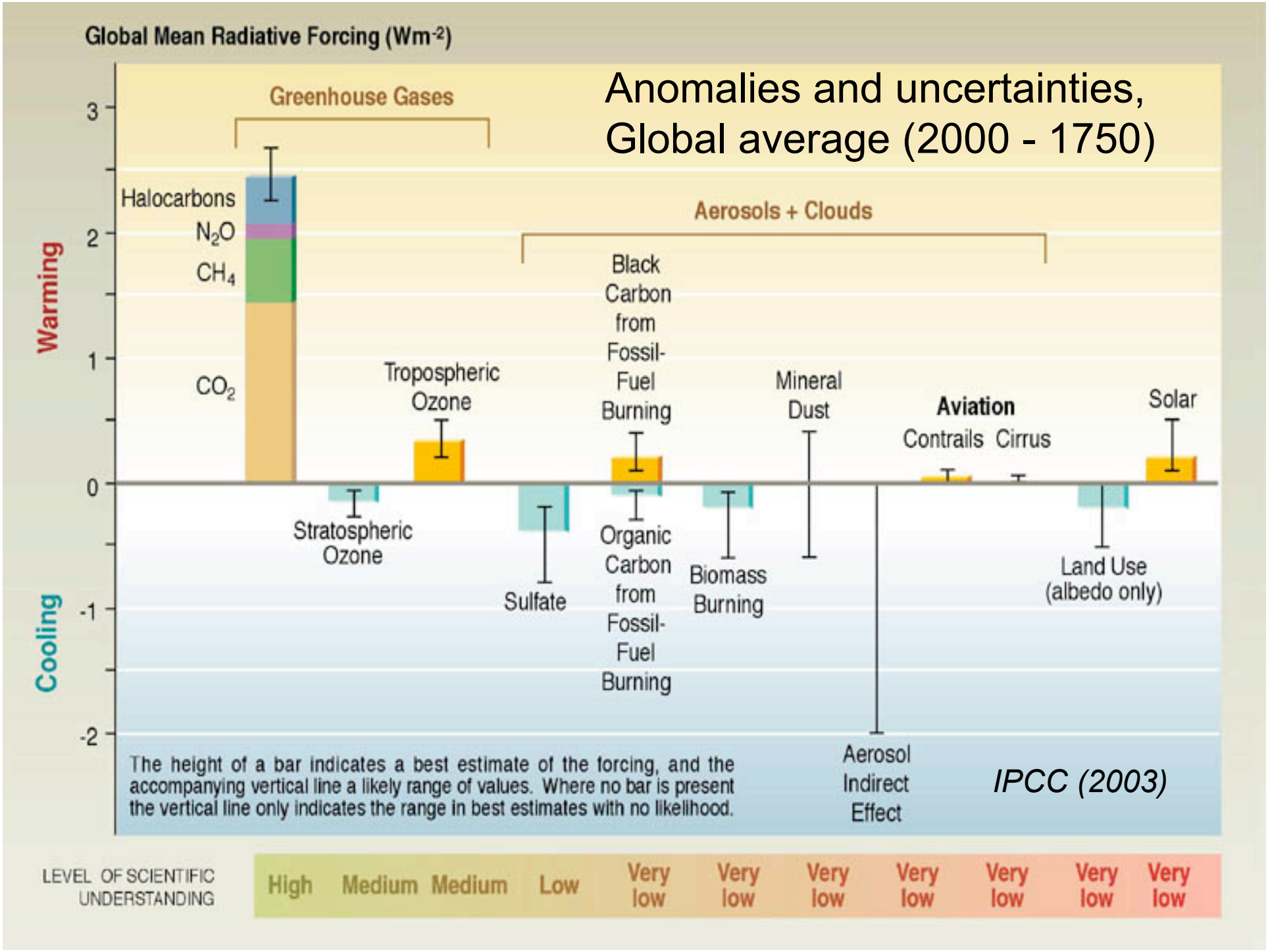




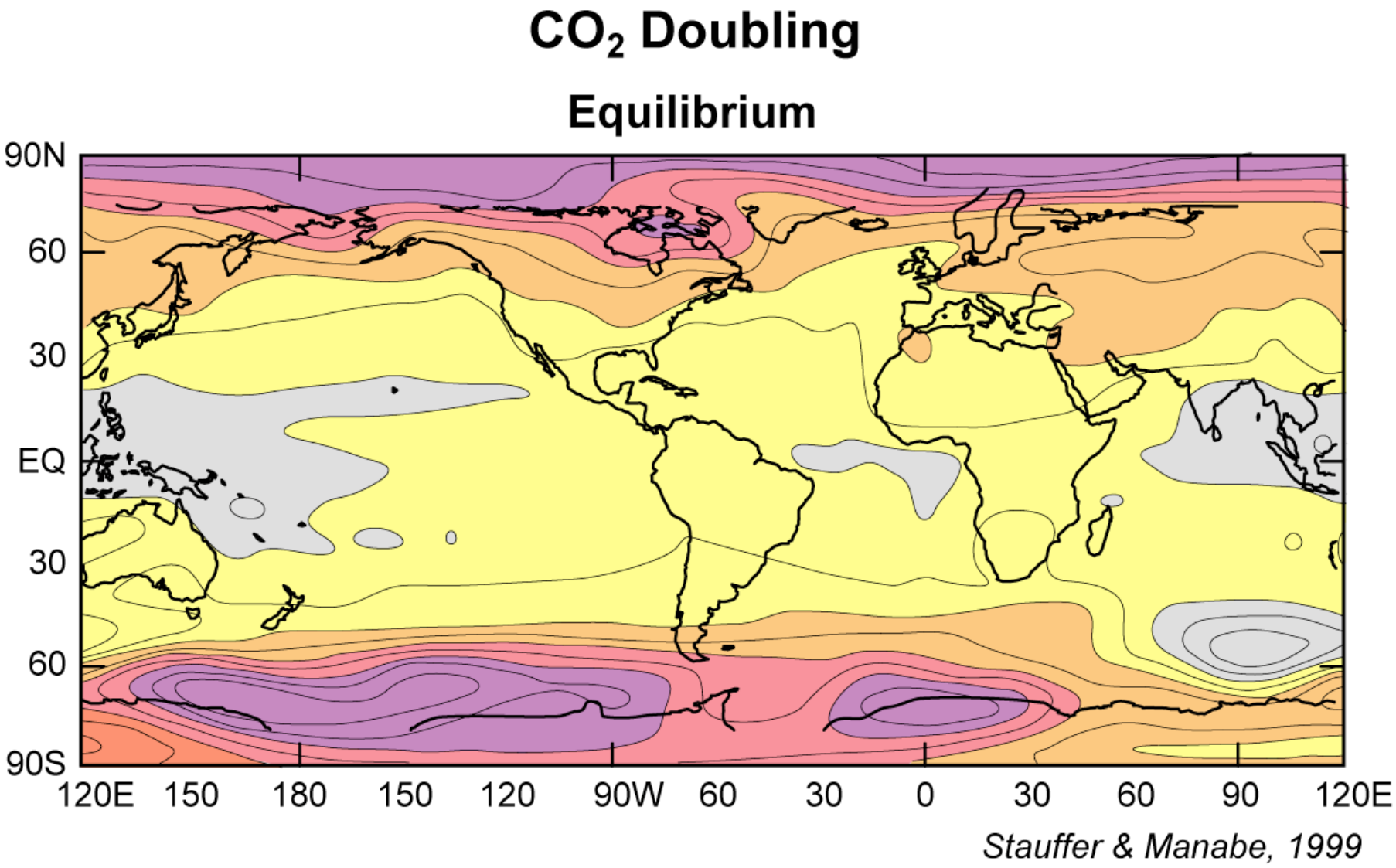

Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.




Sources: Radiative forcing of climate change, the 1994 report of the scientific assessment working group of IPCC, summary for policymakers, WMO, UNEP; L.D. Danny Harvey, Climate and global environmental change, Prentice Hall, pearson Education, Harlow, United Kingdom, 2000.

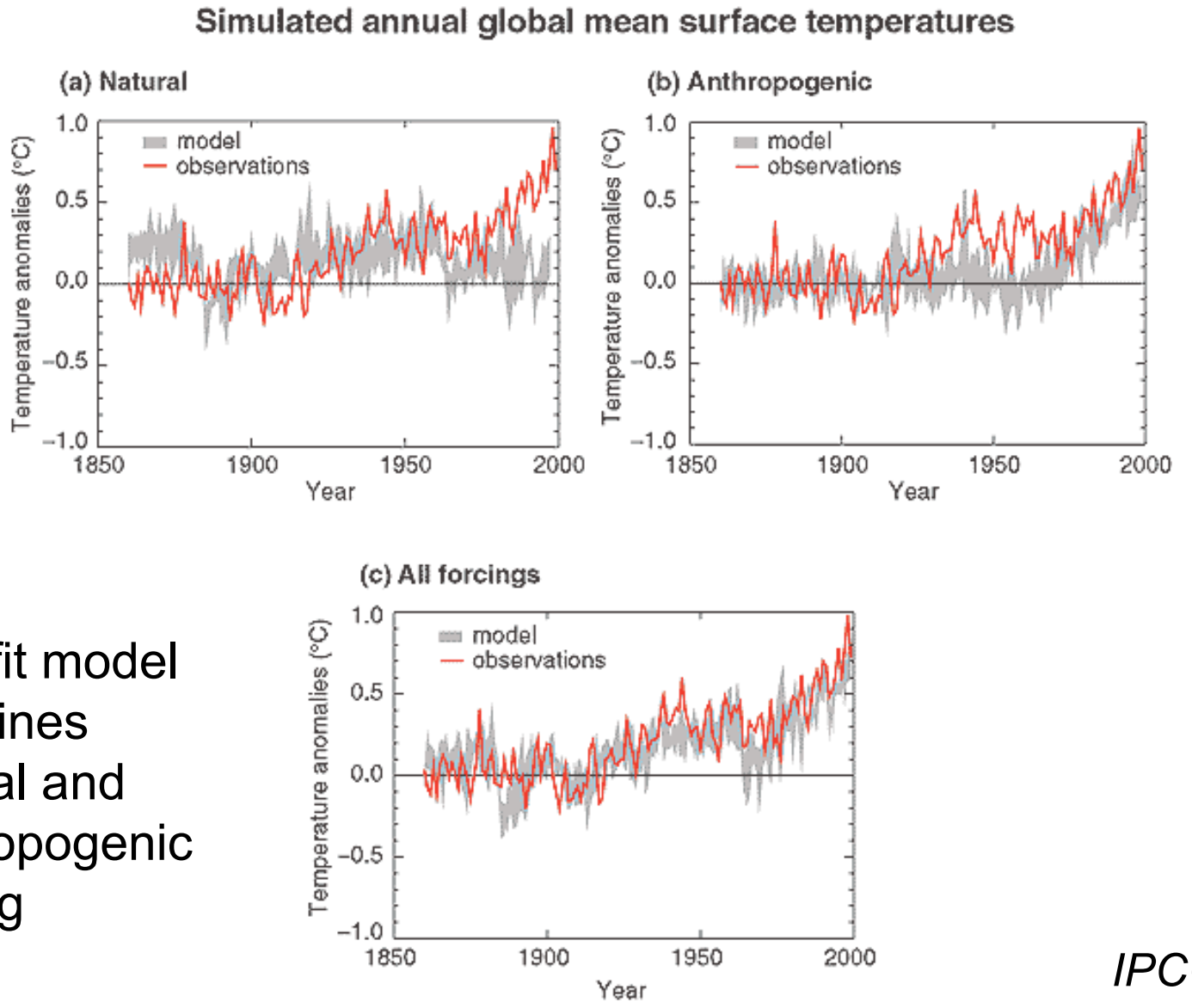

Global Mean Radiative Forcing ($Wm^{-2}$)
Anomalies and uncertainties,
Global average (2000 - 1750)
Greenhouse Gases
Aerosols + Clouds
Warming
Cooling
3
2
1
0
-1
-2
Halocarbons
$N_2O$
$CH_4$
$CO_2$
Tropospheric Ozone
Stratospheric Ozone
Sulfate
Black Carbon from Fossil-Fuel Burning
Organic Carbon from Fossil-Fuel Burning
Biomass Burning
Mineral Dust
Aviation
Contrails
Cirrus
Aerosol Indirect Effect
Land Use (albedo only)
Solar
The height of a bar indicates a best estimate of the forcing, and the accompanying vertical line a likely range of values. Where no bar is present the vertical line only indicates the range in best estimates with no likelihood.
IPCC (2003)
LEVEL OF SCIENTIFIC UNDERSTANDING
High
Medium
Medium
Low
Very low
Very low
Very low
Very low
Very low
Very low
Very low

# Predicted Temperature Changes




*Stauffer & Manabe, 1999*

# Test Models by Simulating History

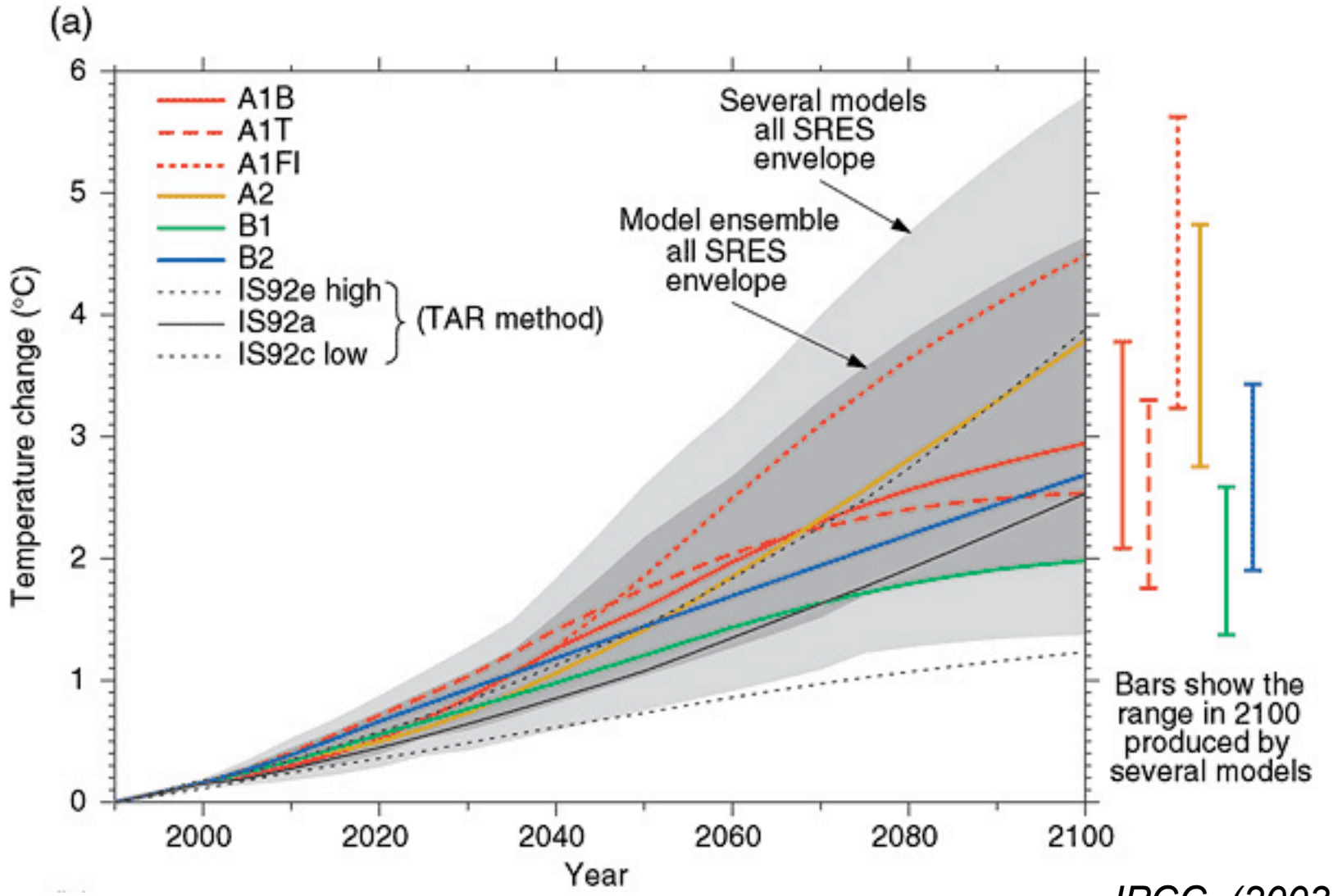



Best fit model combines natural and anthropogenic forcing

*IPCC (2003)*

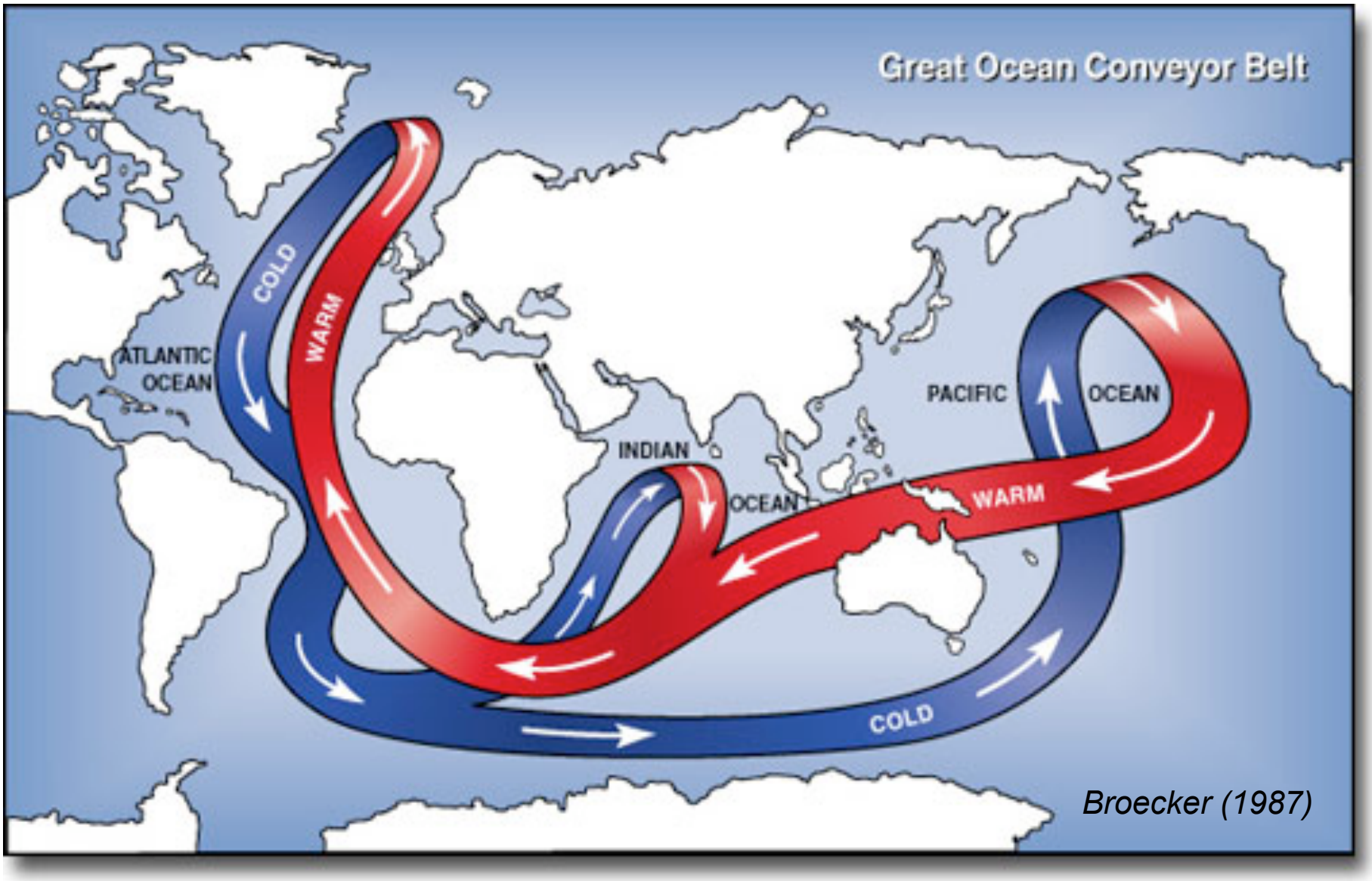
# Future Global Predictions

Uncertainties reflect emissions scenarios and model disagreements.

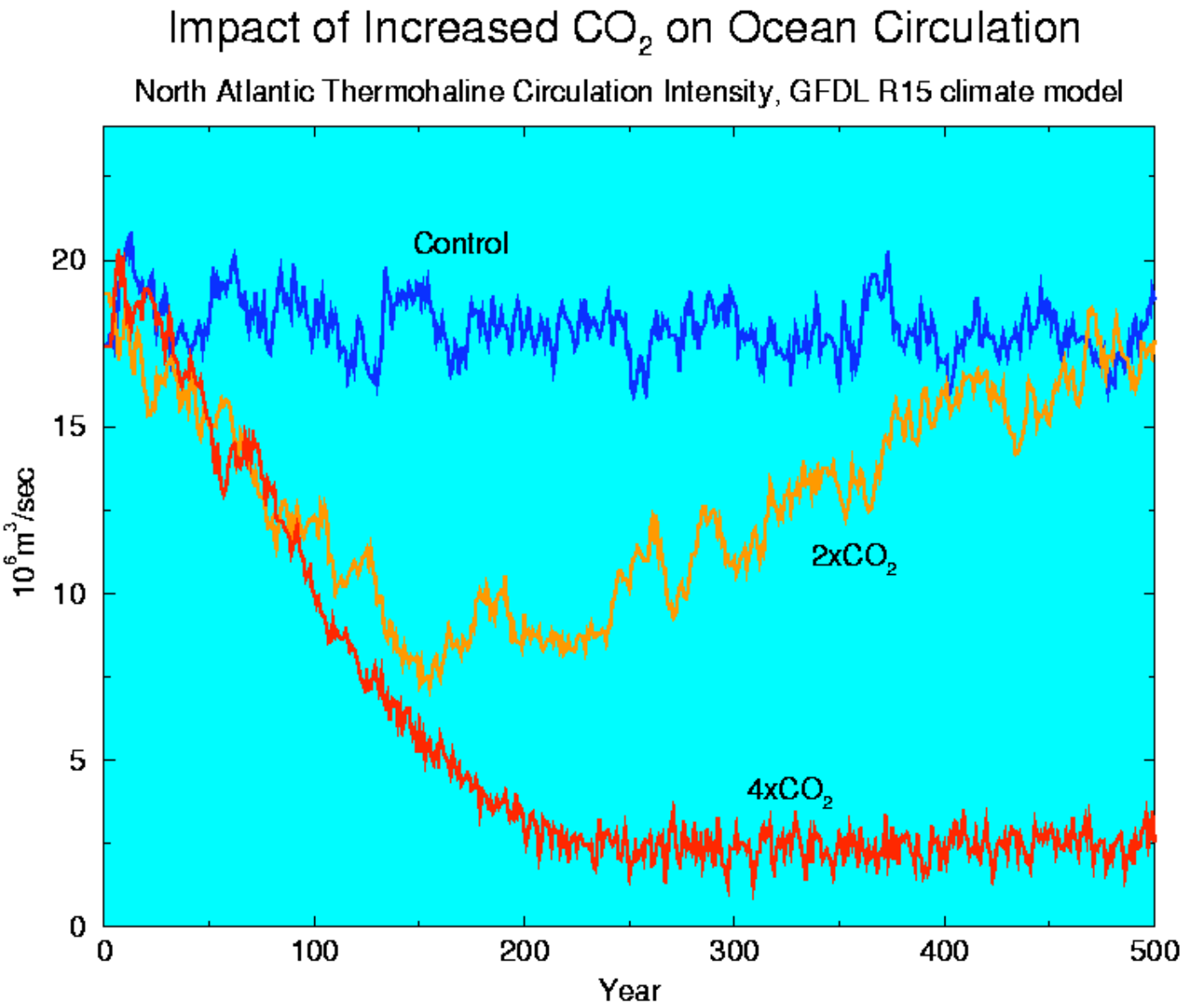



*IPCC (2003)*

# The Oceanic Wild Card



# Is the ocean system stable to $CO_2$ change? Perhaps not.

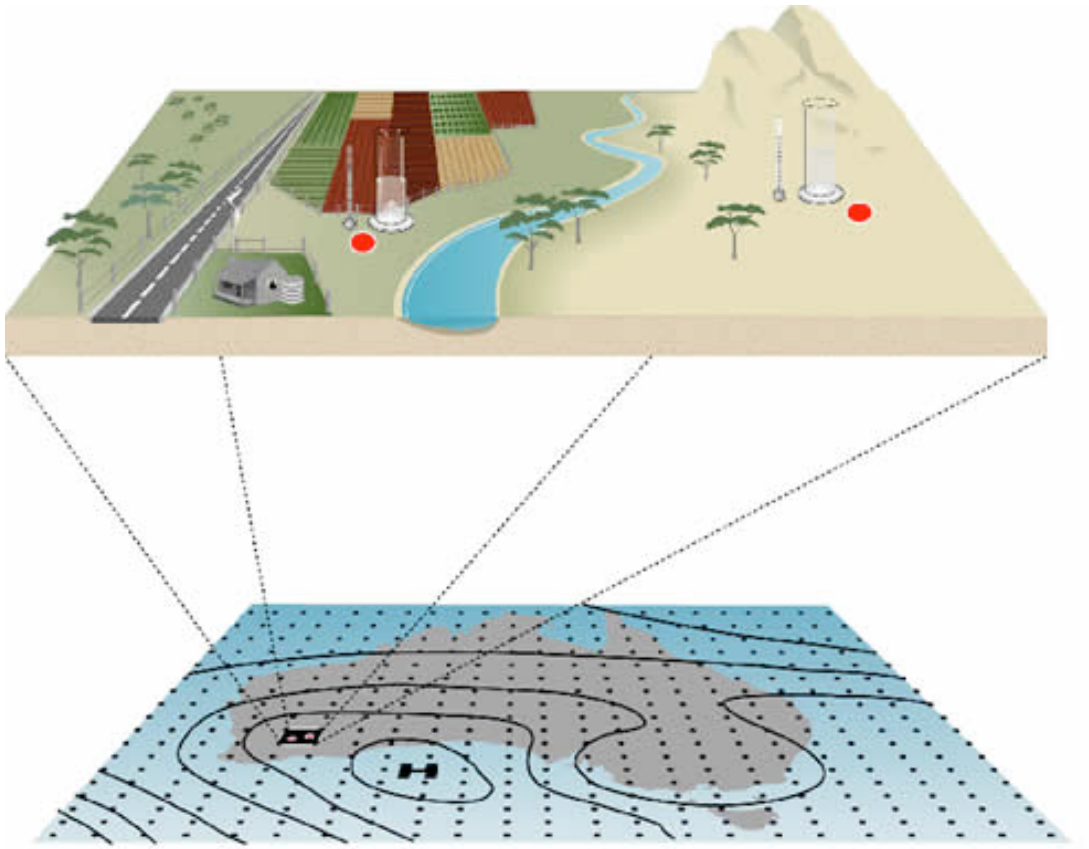



*Manabe & Stouffer, 1994*

# The Challenge of Regional Predictions: "Downscaling" Global Models

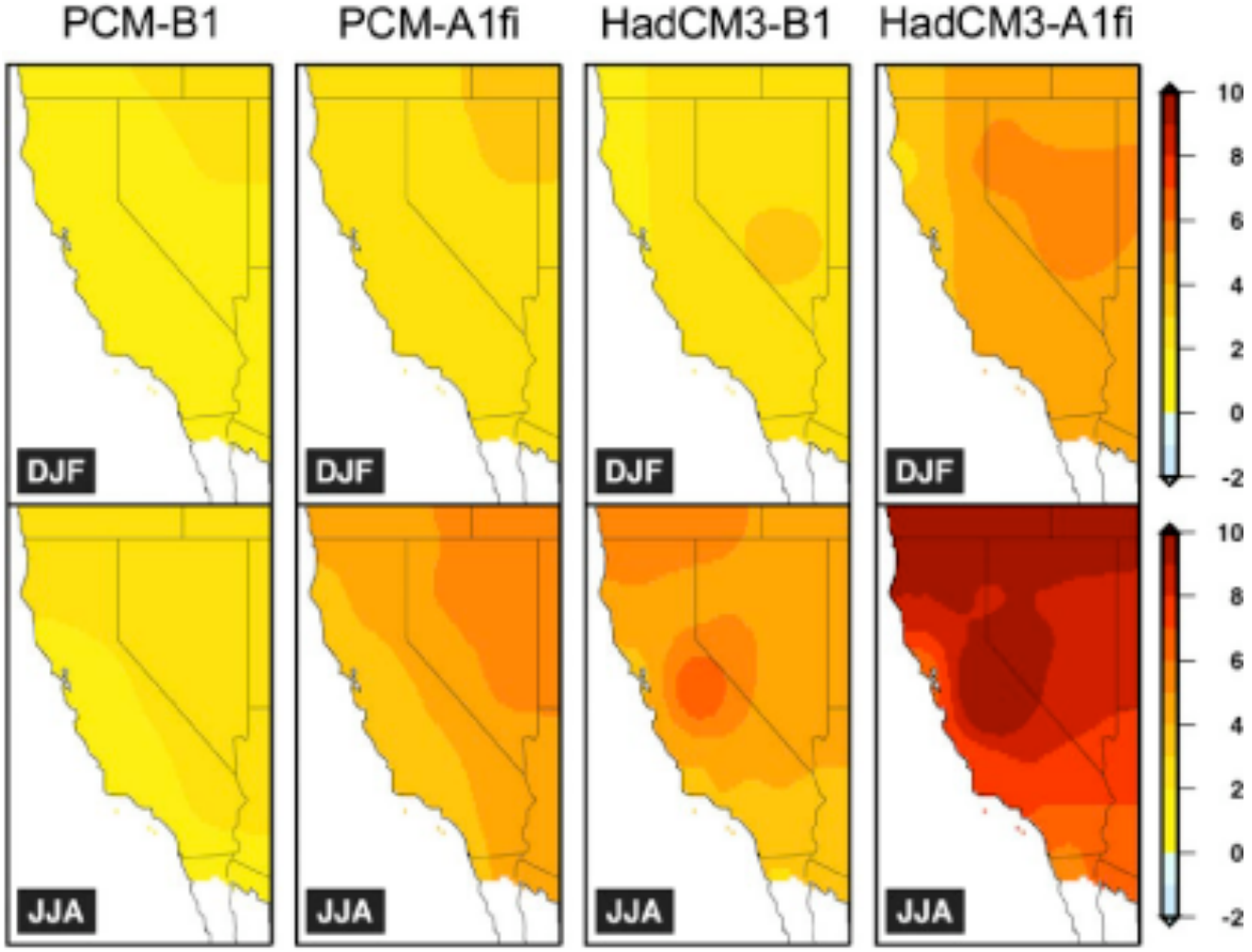
a) Statistical downscaling

b) Embedded regional models



*Charles & Timbal (2004)*

# Downscaled Prediction of 21st Century Warming in California




*Hayhoe et al. 2004*

# Downscaling Pacific Northwest Impacts

Consensus Statement of Climate Change Impacts on the Pacific NW.
http://inr.oregonstate.edu -- download PDF report.

| Variable | Prediction | Uncertainty |
|---|---|---|
| Temperature | 2.7°F by 2030 (average). | intermediate |
| Precipitation | Winter rain, summer drought. | uncertain |
| Snowpack | April-1 snowpack decline. | uncertain |
| Land ecosystems | Drought stress, fire, insects. | uncertain |
| Marine ecosystems | Coastal upwelling increase. | likely |
| | More anoxic events? | uncertain |
| Sea Level | Continued rise - regional | certain |

**Research Priorities**

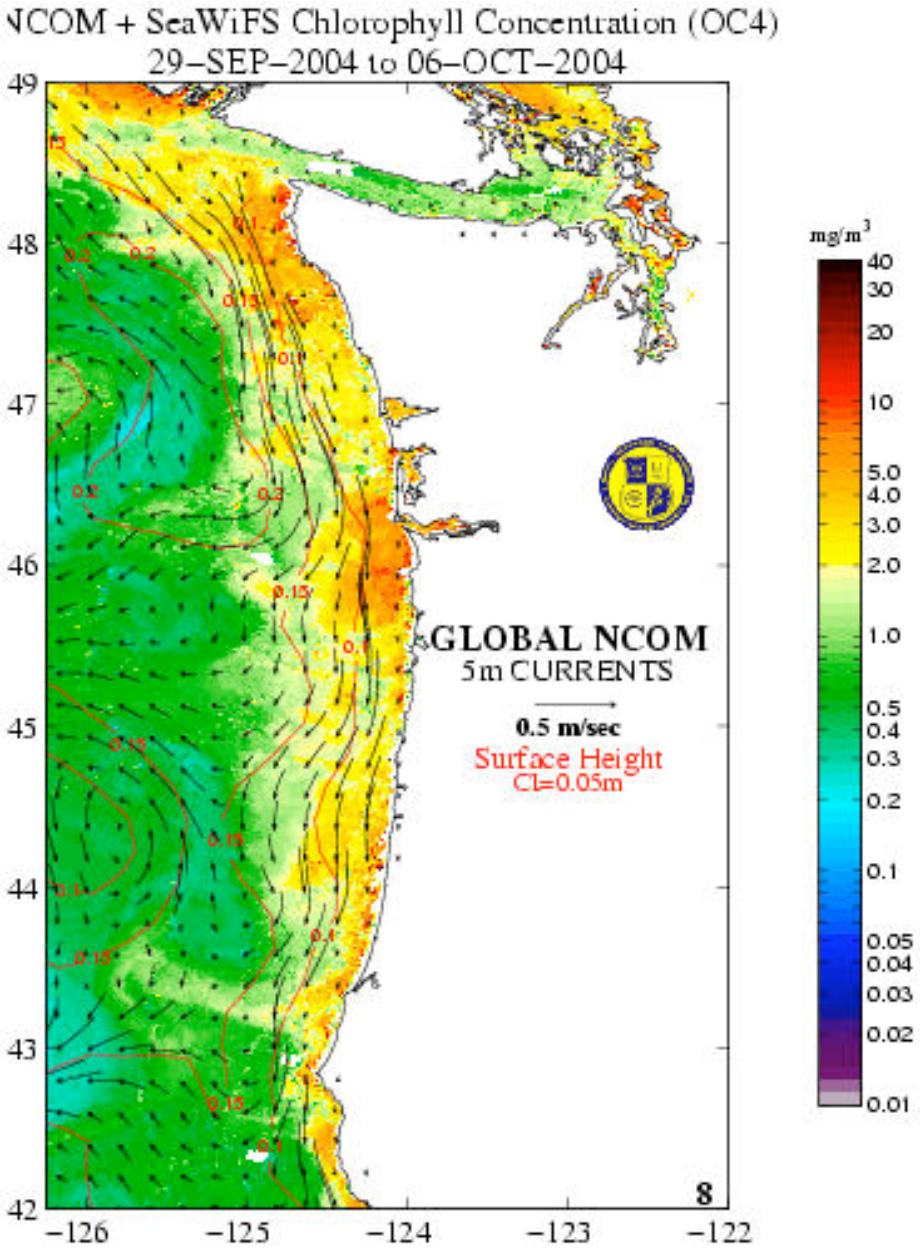
- Improved observations over the long term (paleo, historical, future).
- Experiments to understand processes and dynamic linkages.
- Improved coupled regional models, including ecological responses.
- Science to inform policy analysis, consider economic impacts.

# Pac. N.W. Ocean Impacts

## Possible Feedbacks

- Continental warming…
  leads to…
- Stronger summer winds…
  leads to…
- Stronger coastal upwelling..
  leads to…
- Nearshore cooling
  will this…
- Mitigate Warming?
  will this…
- Increase Bio-Production?
  - Better fisheries?
    or….
  - Anoxic Fish kills?

**We don't know at present.**




*Example of real-time monitoring, Kindle, 2004*

# Summary - What do we know?

- The climate system is complex
  - includes physical, chemical and biological feedbacks
  - some are poorly known.
- Future climate will change - both natural and anthropogenic causes. Surprises possible due to climate "wild cards" - ocean thermohaline circulation, etc.
- Future global-average warming is reasonably certain,
- Some regional climate predictions remain uncertain.
- Regional climate impacts and linkages need study.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