Climate change science

1. Why is climate change science and policy so contentious?

2. Evolution of the climate change science

3. Observed climate change

4. Implications for the biosphere in a changing climate

5. Summary

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Why is climate change science and policy so contentious?

- Deep uncertainty
  No replication – we have one world
  Unfalsifiable science (until the future happens)!
- Cascading uncertainties
  climate-impacts-responses
- Causes are at the heart of modern economy
  Energy addiction
  Growth paradigm
  "Free dump" biosphere
- VESTED INTERESTS

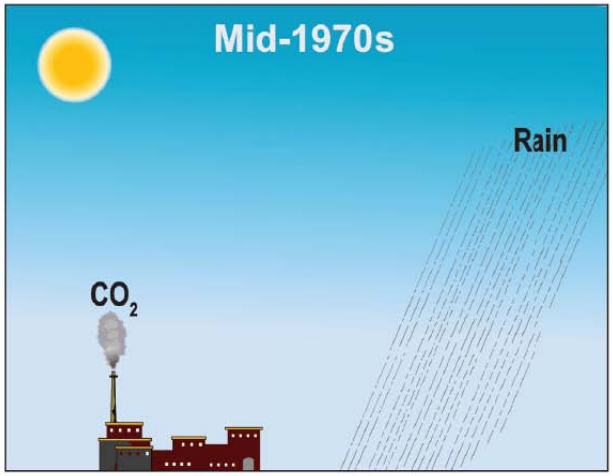
Evolution of the climate science

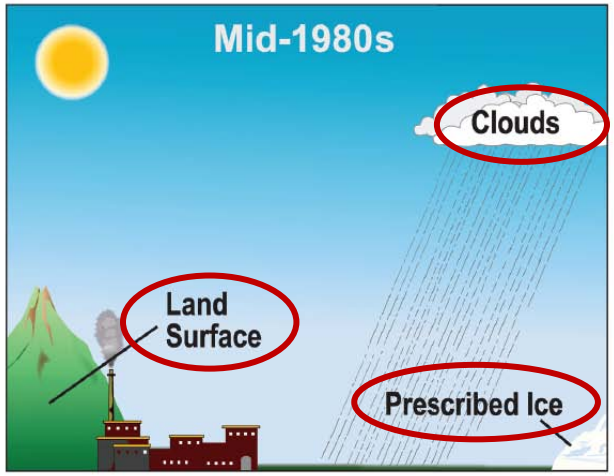
Awareness and partial understanding of the interactive processes that govern climate change predate the IPCC, often by many decades

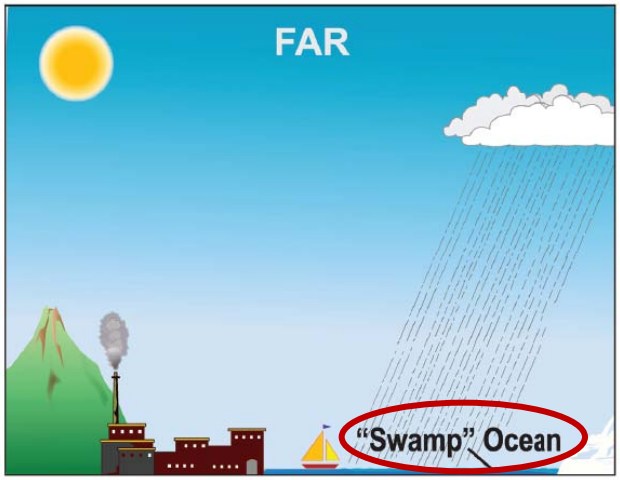
Deeper understanding and quantification of these processes have progressed rapidly since the IPCC First Assessment Report (1990)

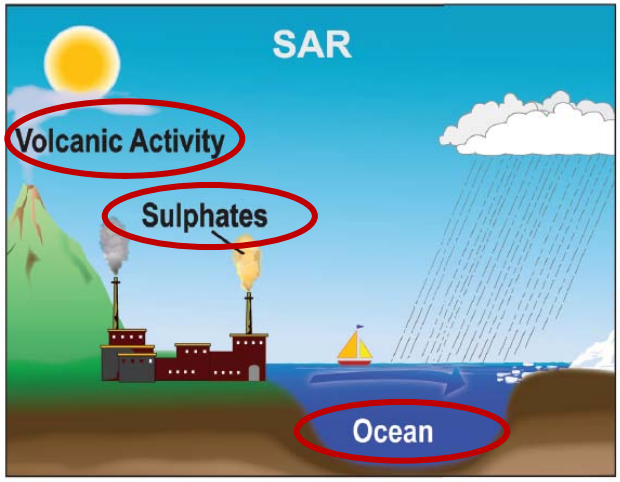
- These advances have arisen from new data, more sophisticated analyses of data, improvements in understanding and simulation of physical processes and more extensive exploration of uncertainty ranges

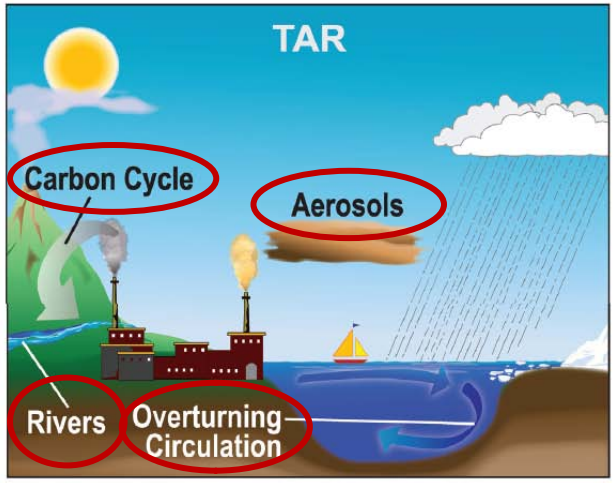
Additional physics incorporated in successive climate models

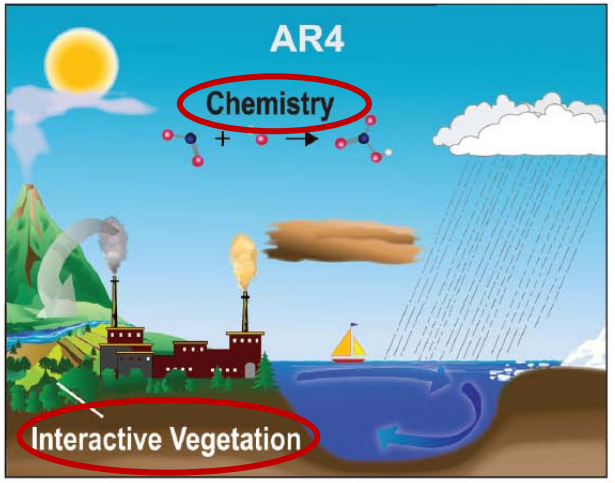








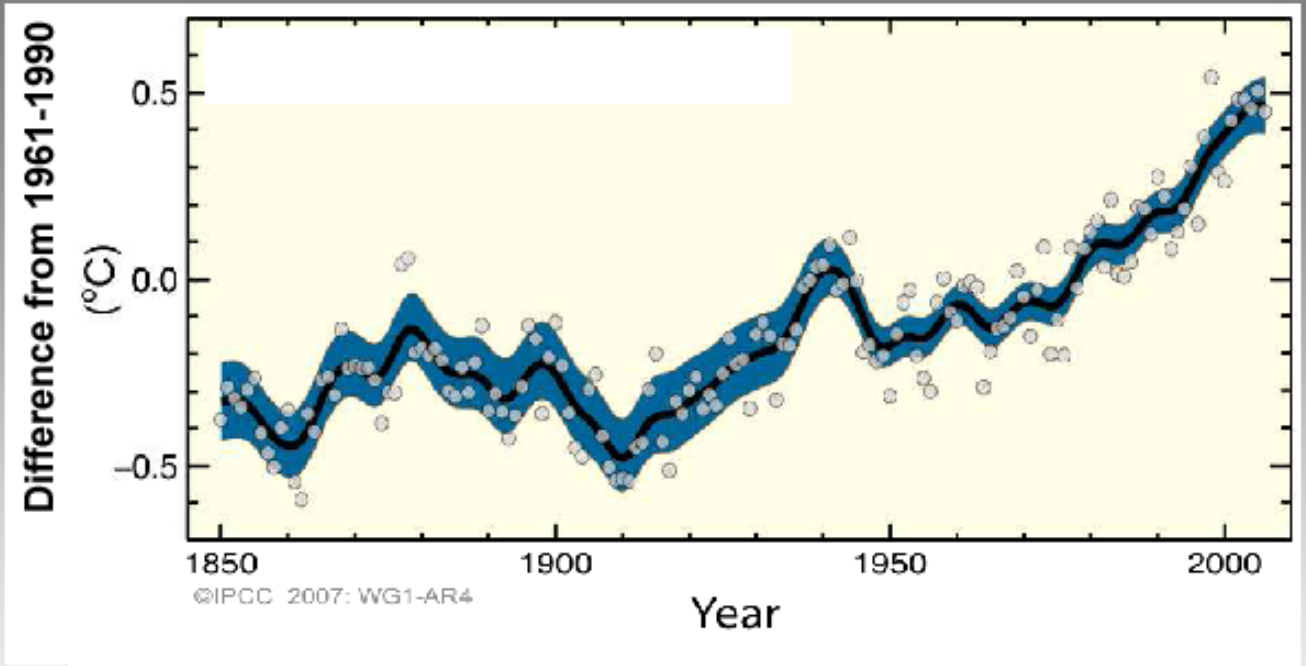




IPCC - A consistent message

- 1990 - The unequivocal detection of the enhanced greenhouse effect is not likely for a decade or more
- 1995 – The balance of evidence suggests a discernible influence of human activity on the climate
- 2001 – New and stronger evidence that most warming observed over the last 50 years is attributable to human activities
- 2007 – *Most of (>50% of) the observed increase in globally averaged temperatures since the mid-20th century is very likely (conf. >90%) due to the observed increase in anthropogenic greenhouse gas concentrations – warming unequivocal*

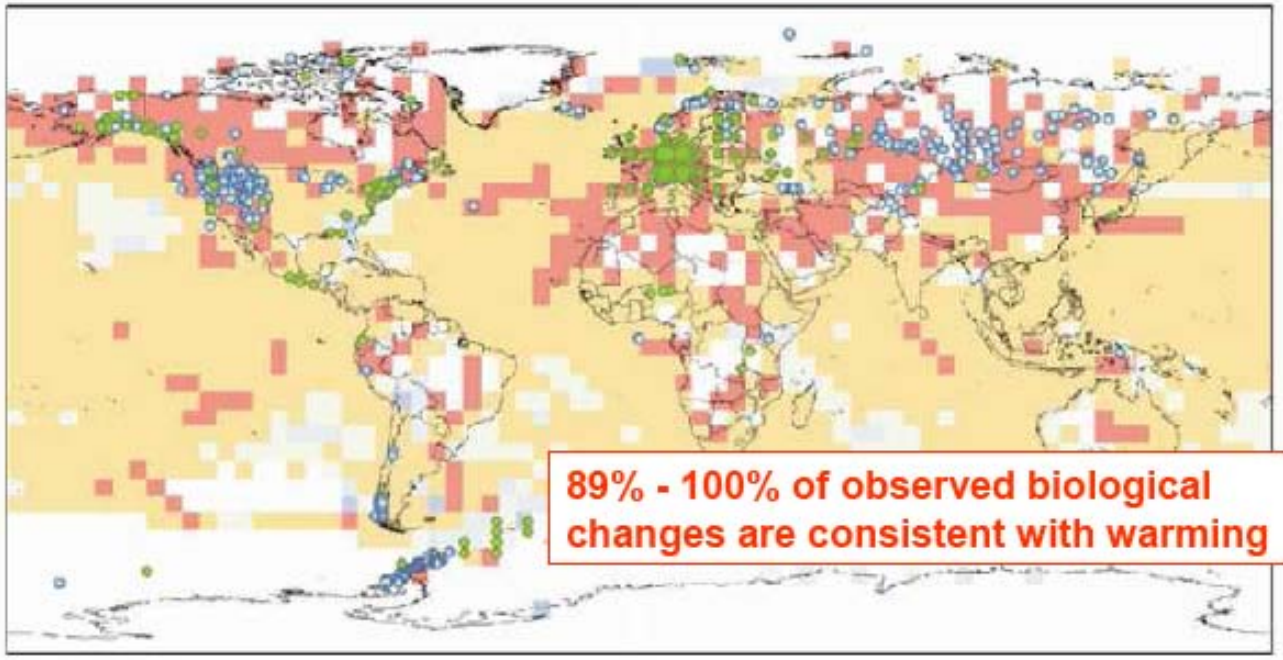
Observed climate change and its causes



"Warming of the climate system is unequivocal" (IPCC 2007)

"Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations" (IPCC 2007)

Changes in physical and biological systems and surface temperature 1970-2004



Trends in atmospheric concentrations for the GHG

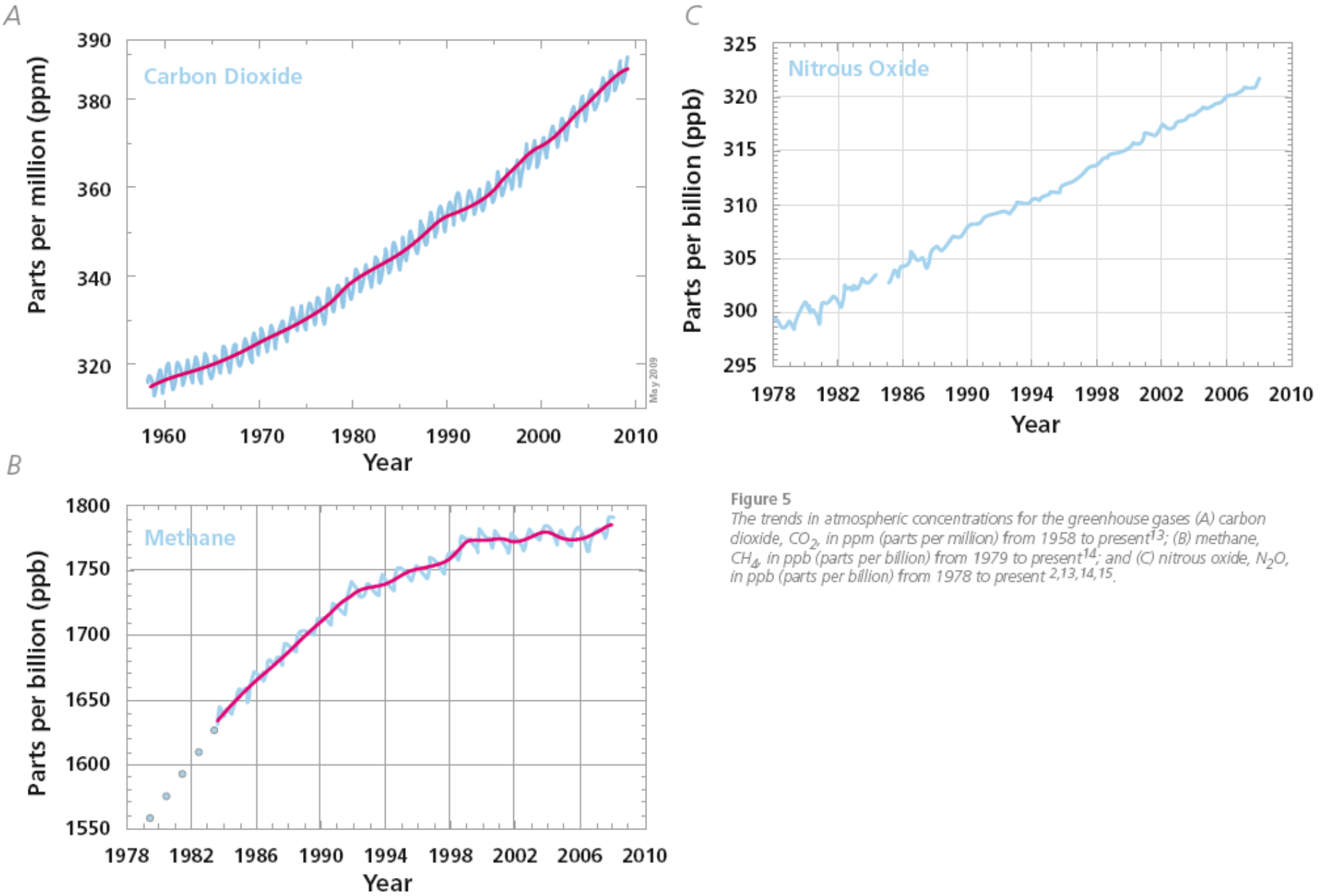


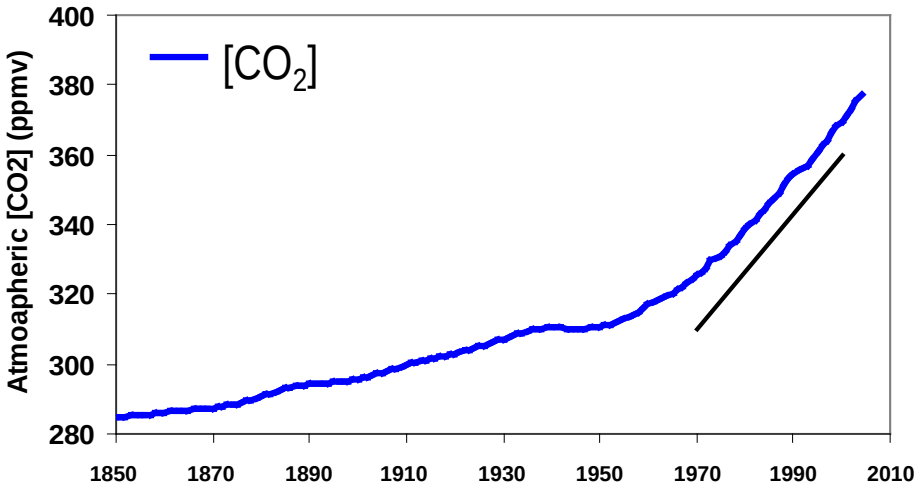
Figure 5
The trends in atmospheric concentrations for the greenhouse gases (A) carbon dioxide, CO_2, in ppm (parts per million) from 1958 to present[13]; (B) methane, CH_4, in ppb (parts per billion) from 1979 to present[14]; and (C) nitrous oxide, N_2O, in ppb (parts per billion) from 1978 to present [2,13,14,15].

Atmospheric CO_2 concentration

Year 2006
Atmospheric CO_2 concentration:

381 ppm

35% above pre-industrial

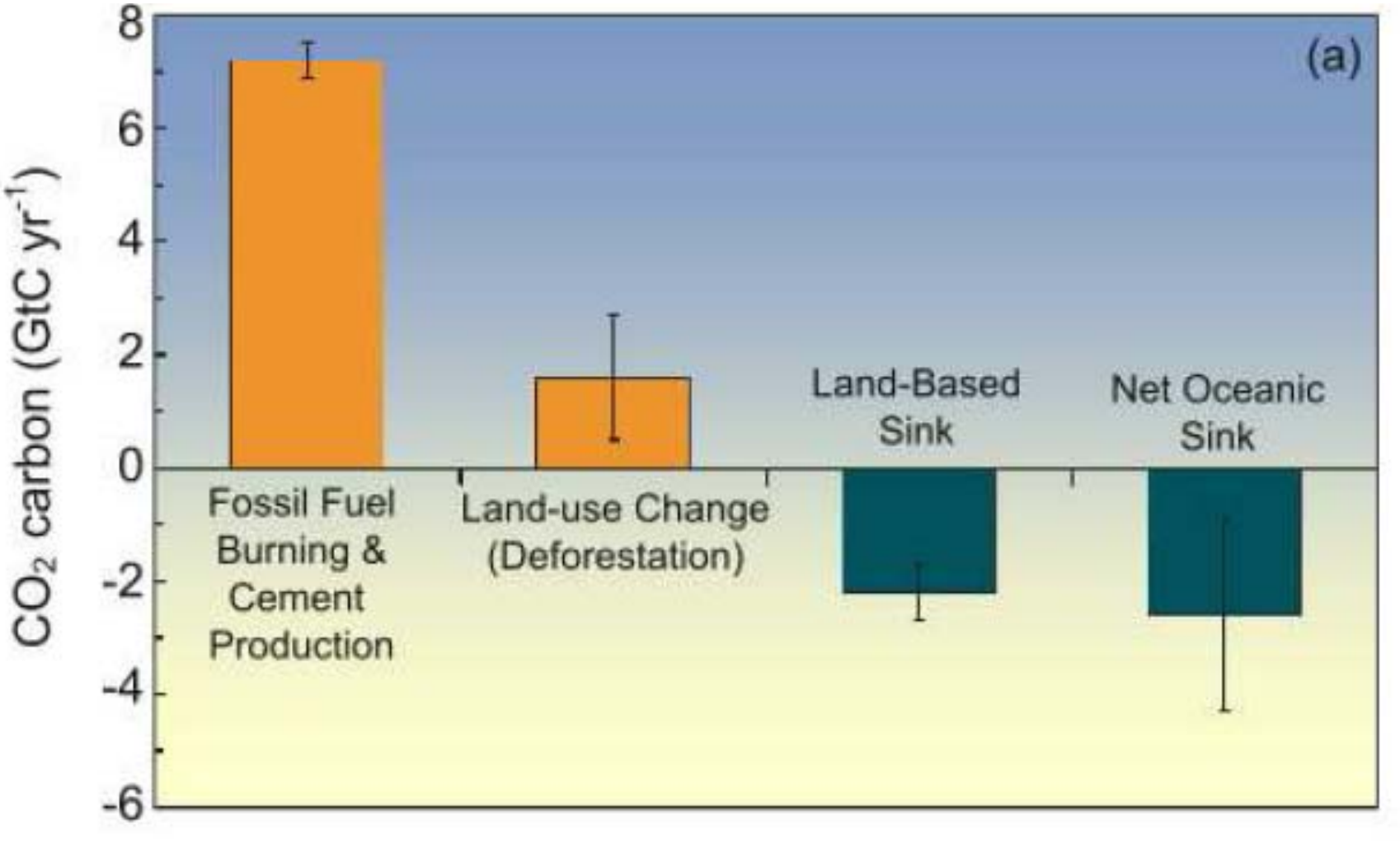


1970 – 1979: 1.3 ppm y^{-1}
1980 – 1989: 1.6 ppm y^{1}
1990 – 1999: 1.5 ppm y^{-1}

2000 - 2006: 1.9 ppm y^{-1}

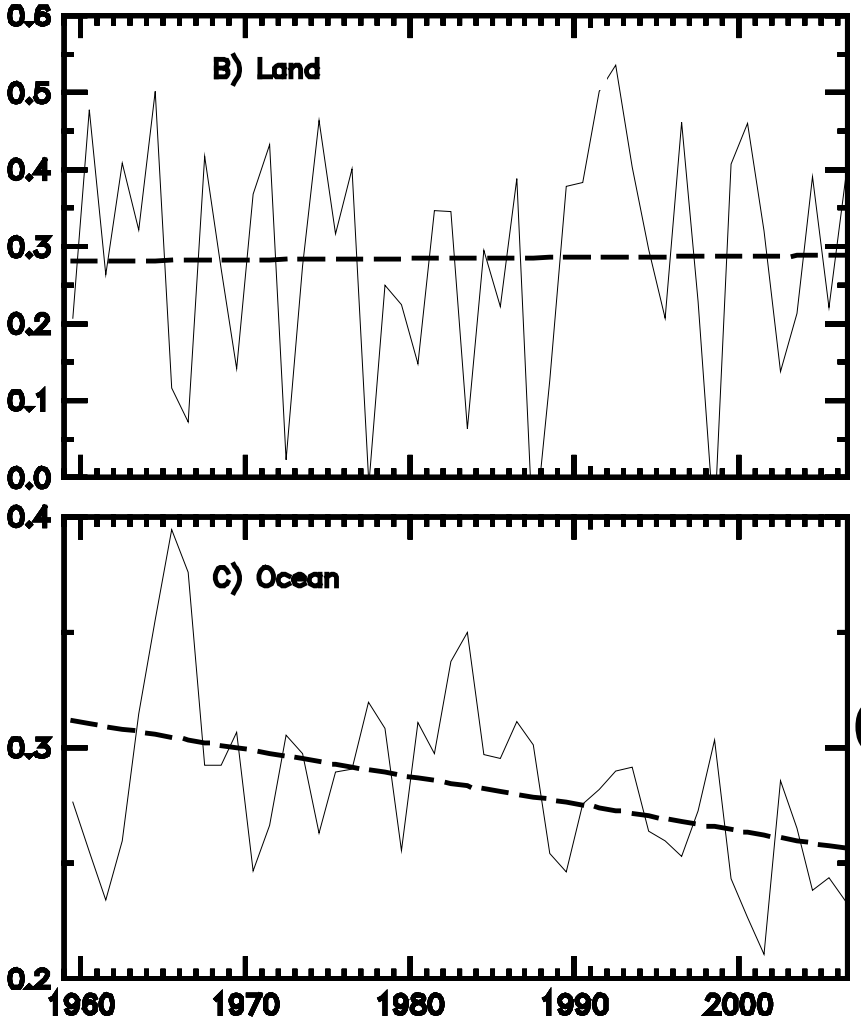
NOAA 2007; Canadell et al. 2007, PNAS

Sources and sinks of CO_2 concentration



Estimated Global Carbon Balance for 2000-2005 (IPCC AR4)

The efficiency of Natural Sinks: Land and Ocean fractions



Land

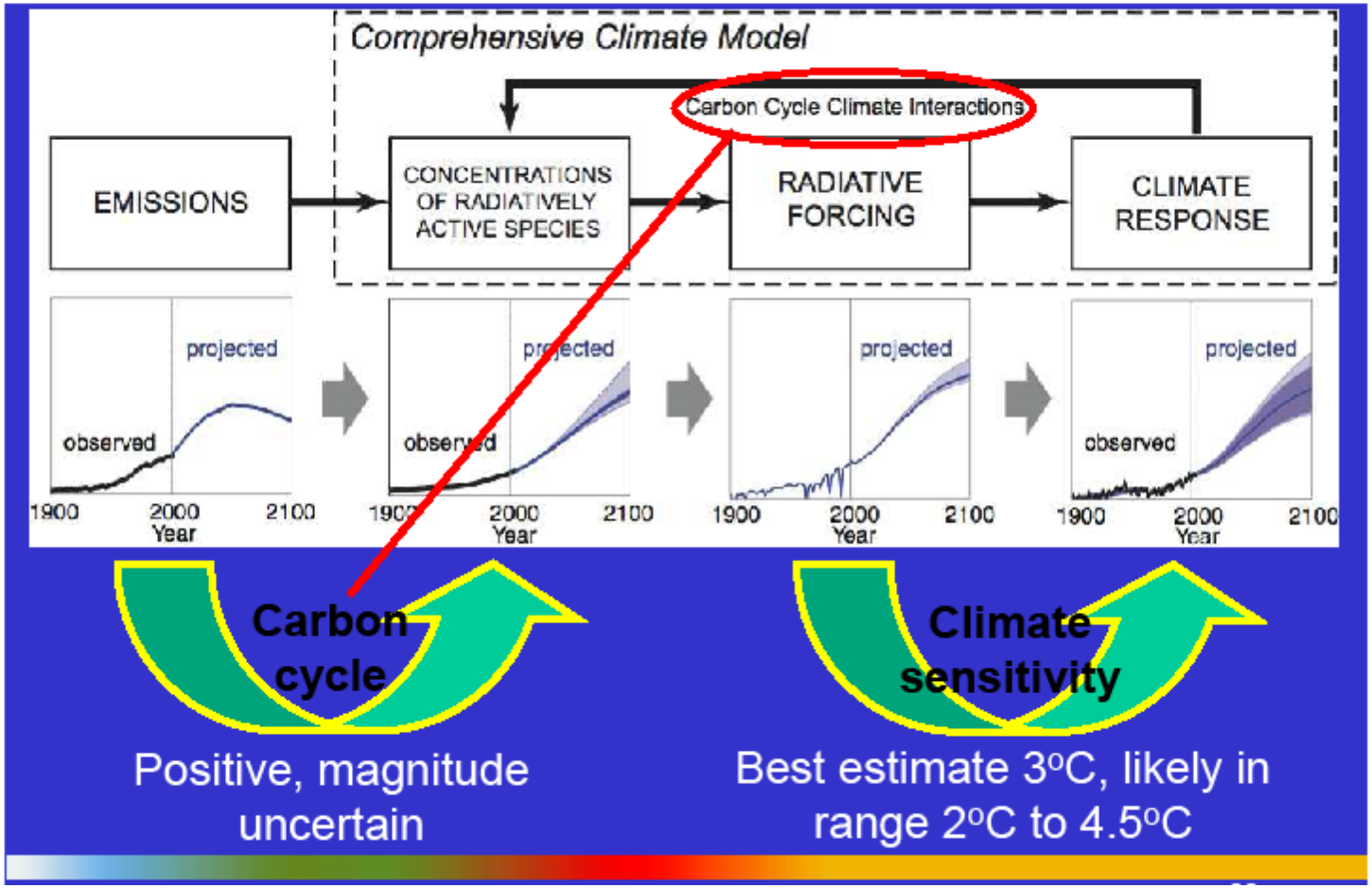
Ocean

In this analysis we don't detect a trend in the fraction of carbon being removed by the land sink; this doesn't exclude the possibility that there is a trend given the large inter-annual variability of the land sink, and the fact that the land sink is not calculated directly but obtained as a residual quantity from closing the carbon budget.

The fraction going into the ocean sink has clearly declined over the last 50 years.

Canadell et al. 2007, PNAS

Science uncertainties affecting policy



Messages so far

- Confidence in climate change science has increased significantly

- Concentrations of CO_2, methane and Nitrous oxide have increased markedly over as a result of human activities and now far exceed pre-industrial values.

- The net effect of human activities since 1750 has been one warming.

- Global warming reduces carbon uptake on land and ocean.

Implications for the biosphere in a changing climate

1. Fire as an earth-system feedback

- Responds to climate change

- Releases CO_2, other greenhouse gases, and aerosols

- Influences landscape character and hence physical properties of land surface (*eg*: albedo and ability to recycle rainfall)

After 3 fires in 12 years: system converted to weed (Prof. H. Mooney)

Implications for the biosphere in a changing climate

2. Species-specific responses to CO_2 fertilization: effects on carbon stores

Figure 5. Resprouting of *Acacia karoo* plants following above ground clipping (to simulate fire) after about 6 months. Plants were grown from seeds in open top chambers under a series of CO_2 regimes ranging from 180 to 1000 ppm. This picture is from the previous experiment that lasted for 2 years.

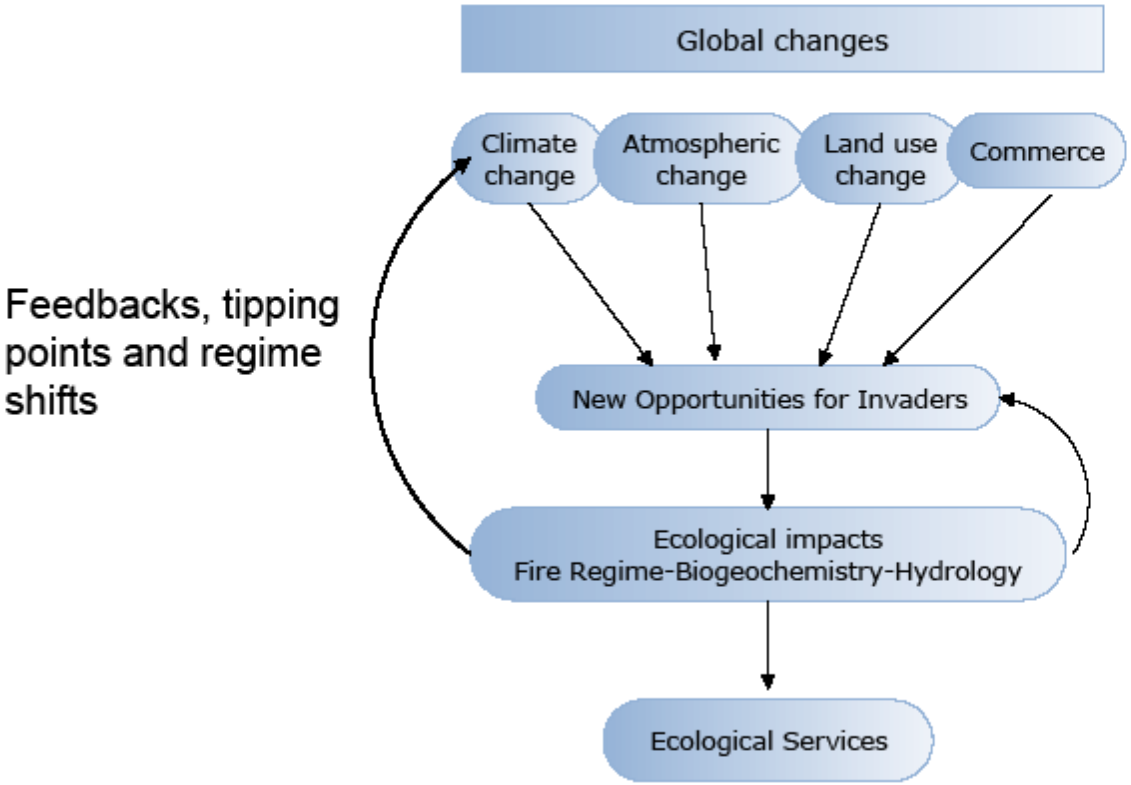
Figure 6. Below ground carbohydrate storage of roots of *Acacia karoo* in response to CO_2 treatment. Also from the previous experiment.

Implications for the biosphere in a changing climate

3. Over-prediction of tree cover in savanna regions by climate-vegetation model

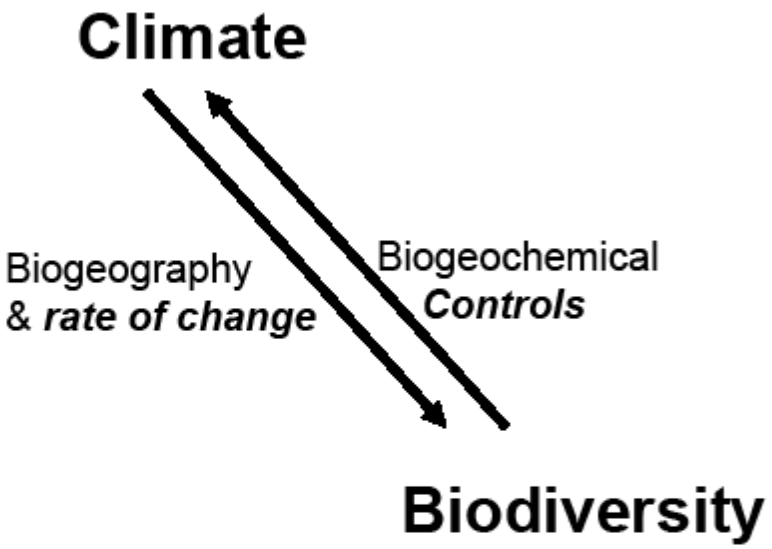
Implications for the biosphere in a changing climate

4. Global changes and the Invasive species



Thuiller, et al. 2007

Summary: The simple view



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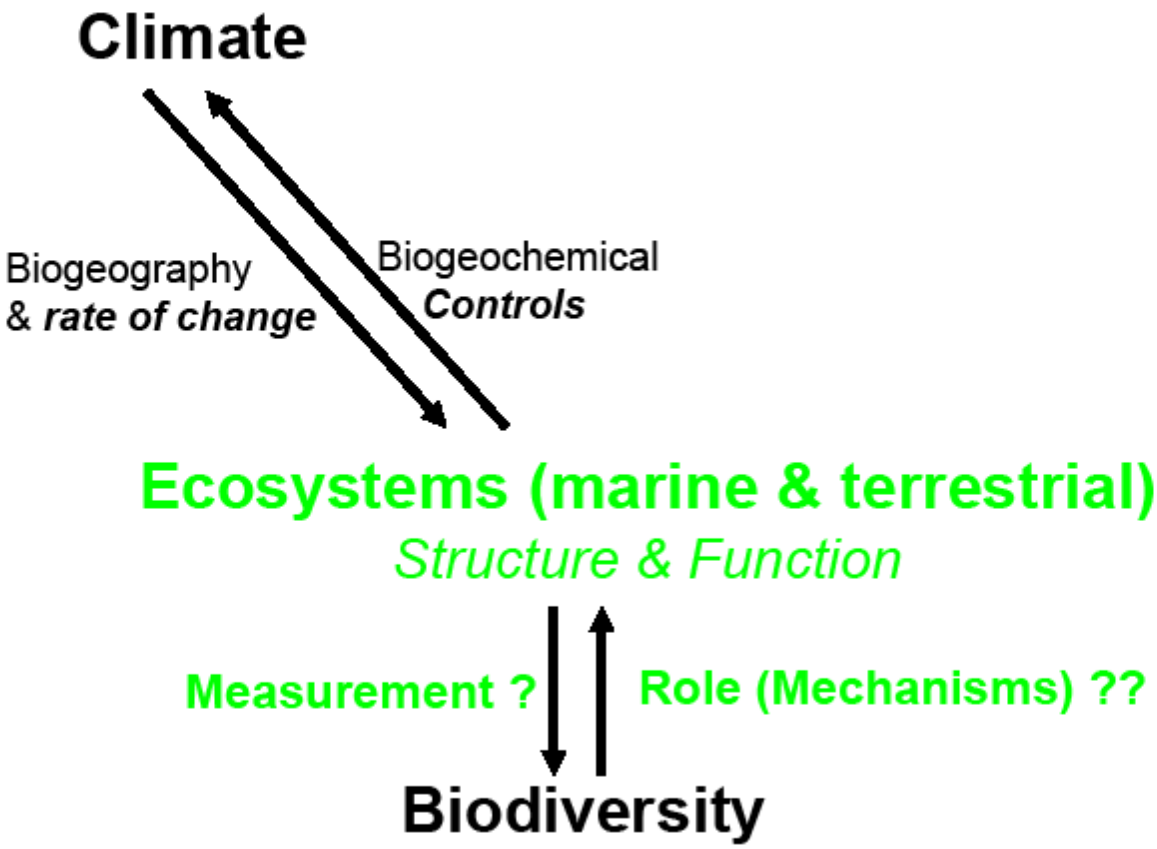
Summary: The scientific challenge



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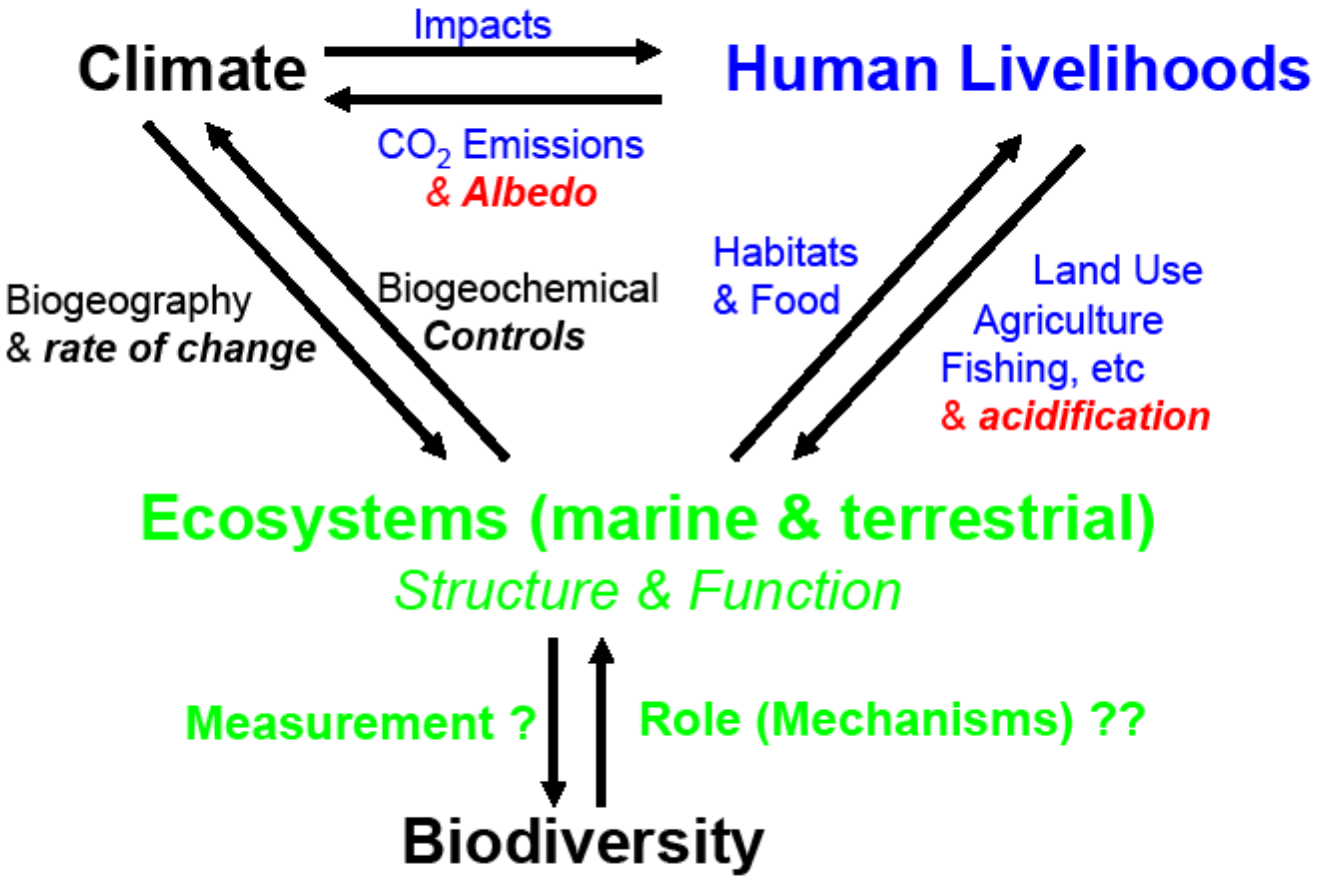
Summary: The whole picture



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