

Working Group I

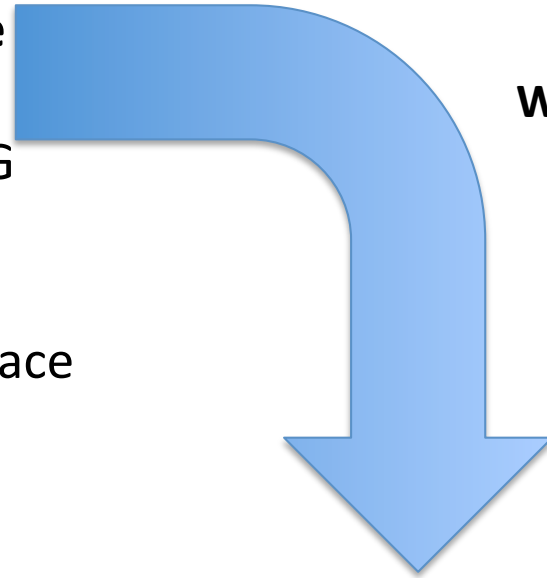
**Radiative  
Forcings**

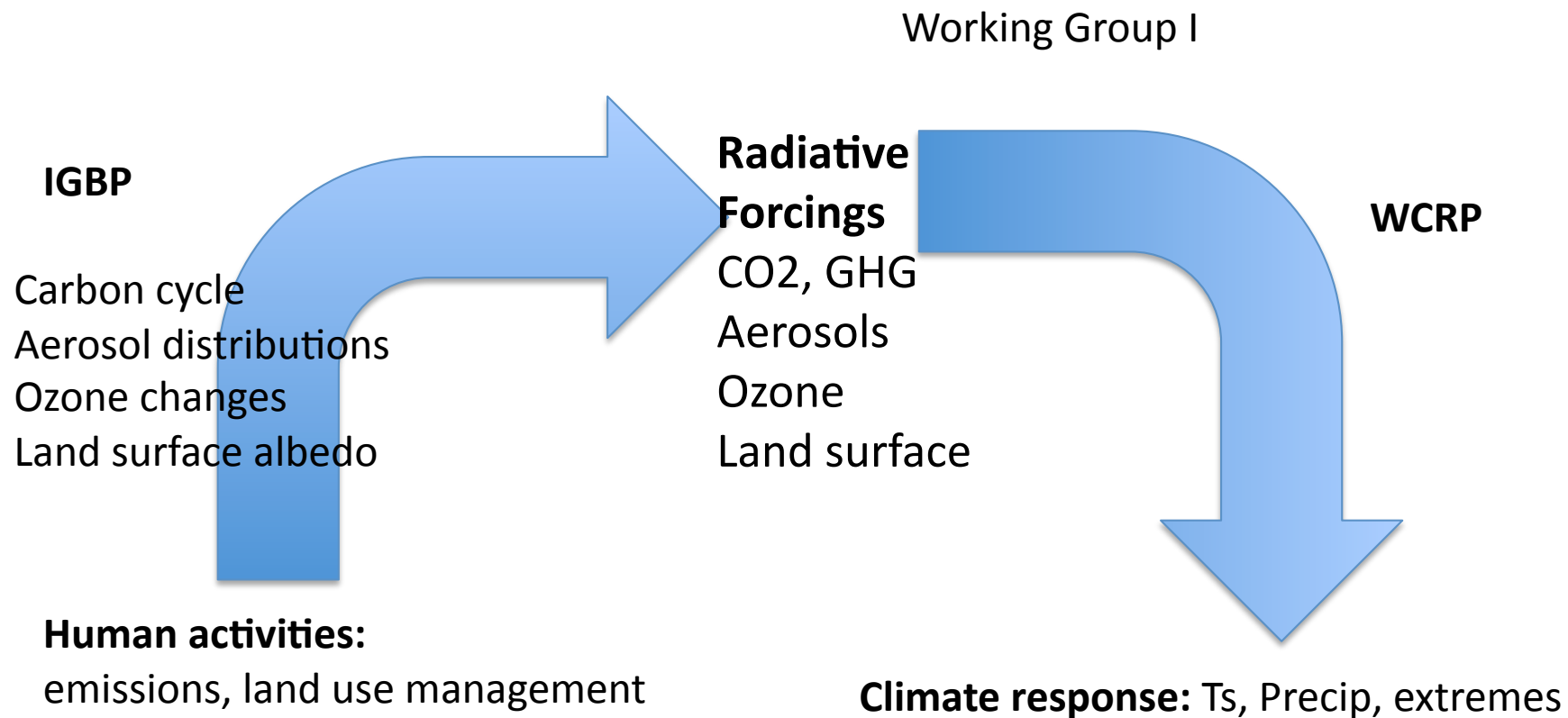
CO<sub>2</sub>, GHG  
Aerosols  
Ozone  
Land surface

**WCRP**

DNA, Climate  
sensitivity, regional  
climate,  
Extremes,  
predictability...

**Climate response:** Ts, Precip, extremes





Arguably, half the uncertainty in going from human emissions and land use management to climate response comes from left hand side

Working Group I

IGBP

**Radiative  
Forcings**

CO<sub>2</sub>, GHG  
Aerosols  
Ozone  
Land surface

WCRP

**Human activities:**

emissions, land use management

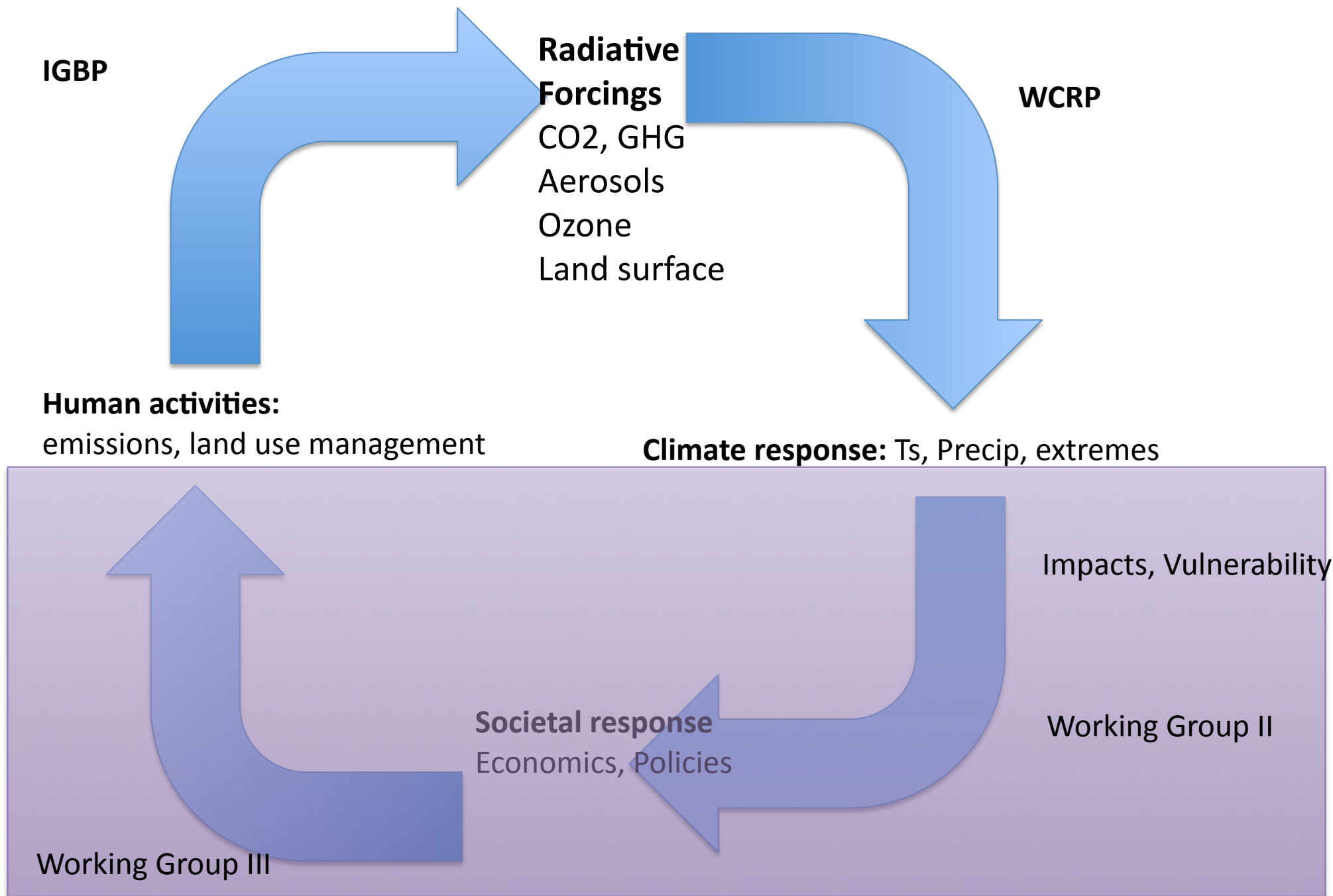
**Climate response:** Ts, Precip, extremes

Impacts, Vulnerability

Working Group II

**Societal response**  
Economics, Policies

Working Group III



# WCRP Grand Challenges structure the science that is advocated in WCRP

- Clouds, circulation and climate sensitivity
  - Changes in cryosphere
  - Climate extremes
  - Regional climate information
  - Regional sea-level rise
  - Water Availability
- 
- Goal: provide actionable information for decision makers
  - Missing half the uncertainty

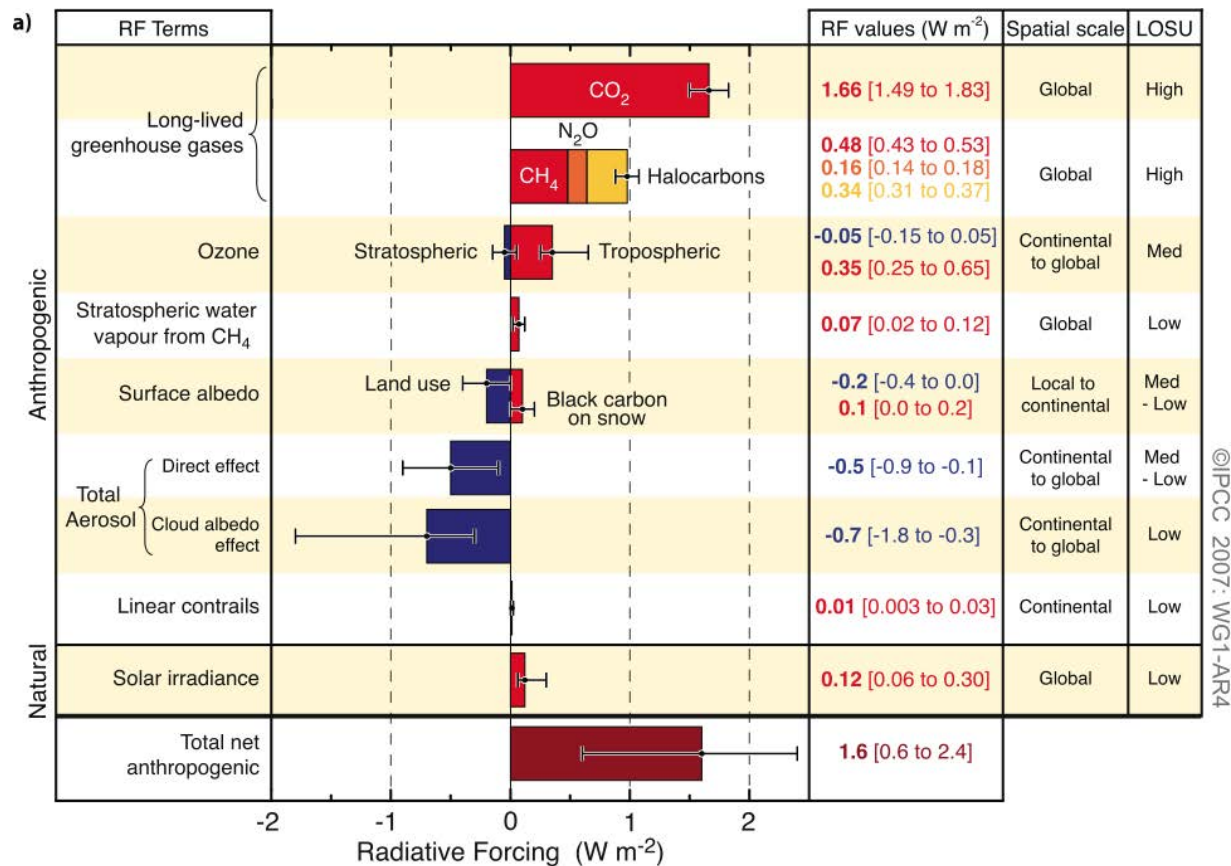
# Gap: From human emissions and management to climate forcing

- Carbon cycle: emissions and management
  - 50% of current co2 emissions are taken up by land and ocean. Will this continue?
  - 40% uncertainty of future temperature in physical climate exists in carbon cycle
  - Both emissions, uptake and land use
- Aerosols: emissions to RF
  - Net negative forcing with large uncertainties?
  - Models had uncertainty of factor of 2-3 in terms of AOD in CMIP5 (models did not match existing observations)
- Land albedo
  - Not assessed in AR5 (fell between cracks)
  - Very different in different models (but could be assessed and improved).
- Other feedbacks, e.g. permafrost melting-->methane and co2, natural wet land methane, biogenic compounds→ozone and aerosols, fires...

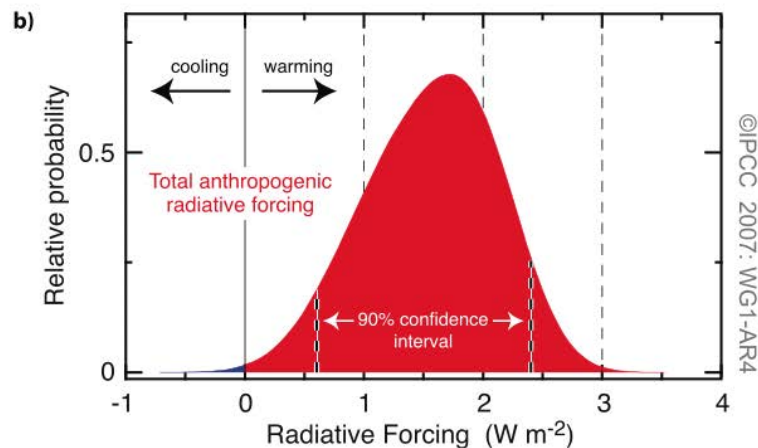
# Forcing workshop

## Forcing estimates 1870 to present

- Focus: provide improved aerosol forcing, land use (biophysical) for DNA
  - Carbon cycle done elsewhere (know co2 time series)
  - Also ozone? Also snow albedo?
- DNA community
  - Claudia Tibaldi, Nathan Gillett, Ben Santer
- Aerosol community
  - AEROCOM:
  - Natural aerosols
  - Observations: satellite and aernet people
  - Olivier Bouchier, Steve Ghan, Stephan Kinne, Michael Schulz, Ken Carslaw, Aiko Voigt, Ralph Kahn, Dave Winker, Francois-Marie Breon
- Land biophysical response
  - Victor Brovkin, , Nathalie de Noblet, David Lawrence, Johannes Feddema, Andy Pittman
- Radiation
  - Piers Forster, Bill Collins,
- Workshop
- Product: (multiple) time series of radiative forcing and uncertainty in two years.

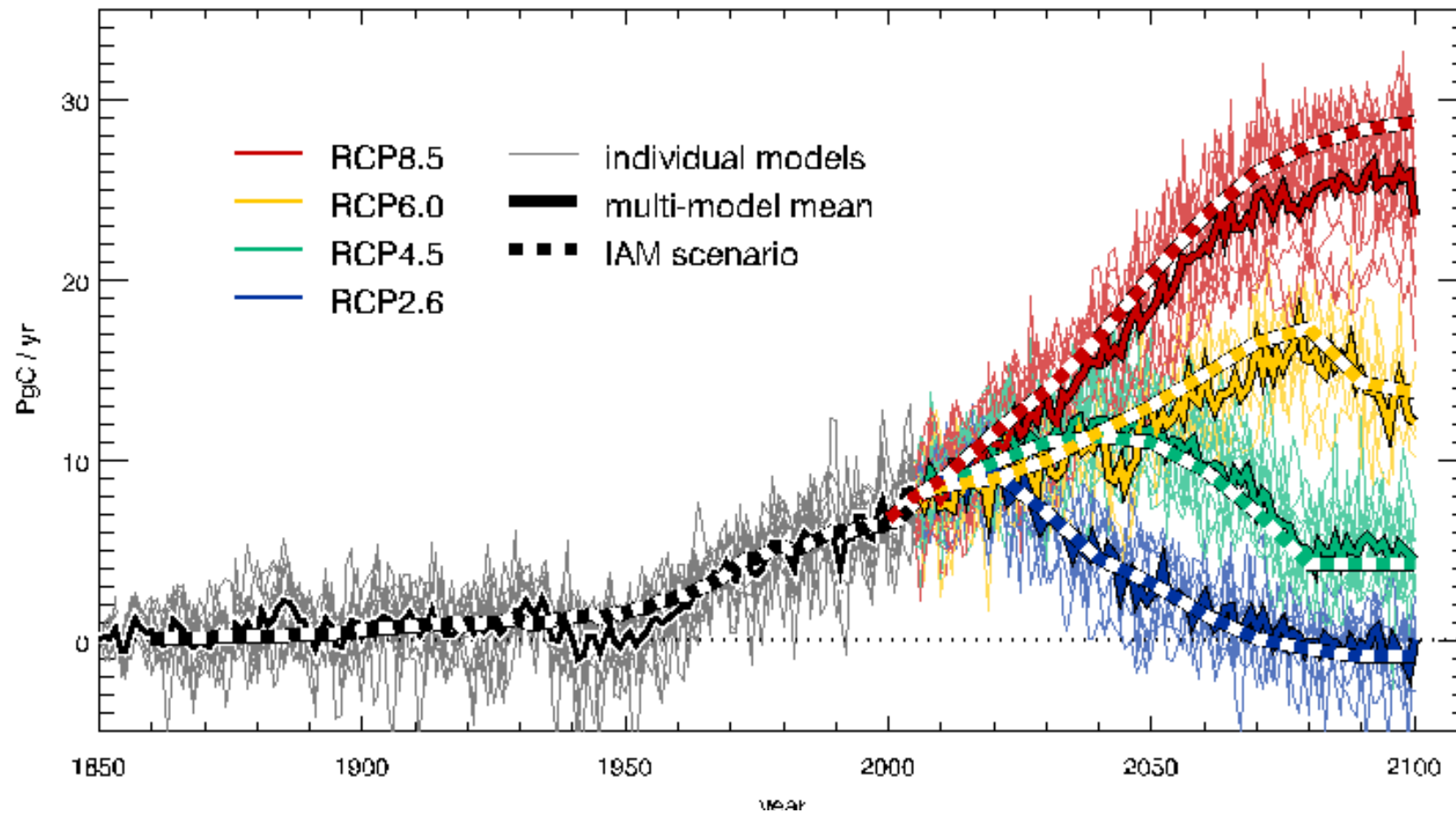


Radiative forcing (RF)  
Estimation of how much the energy budget is perturbed by individual forcings

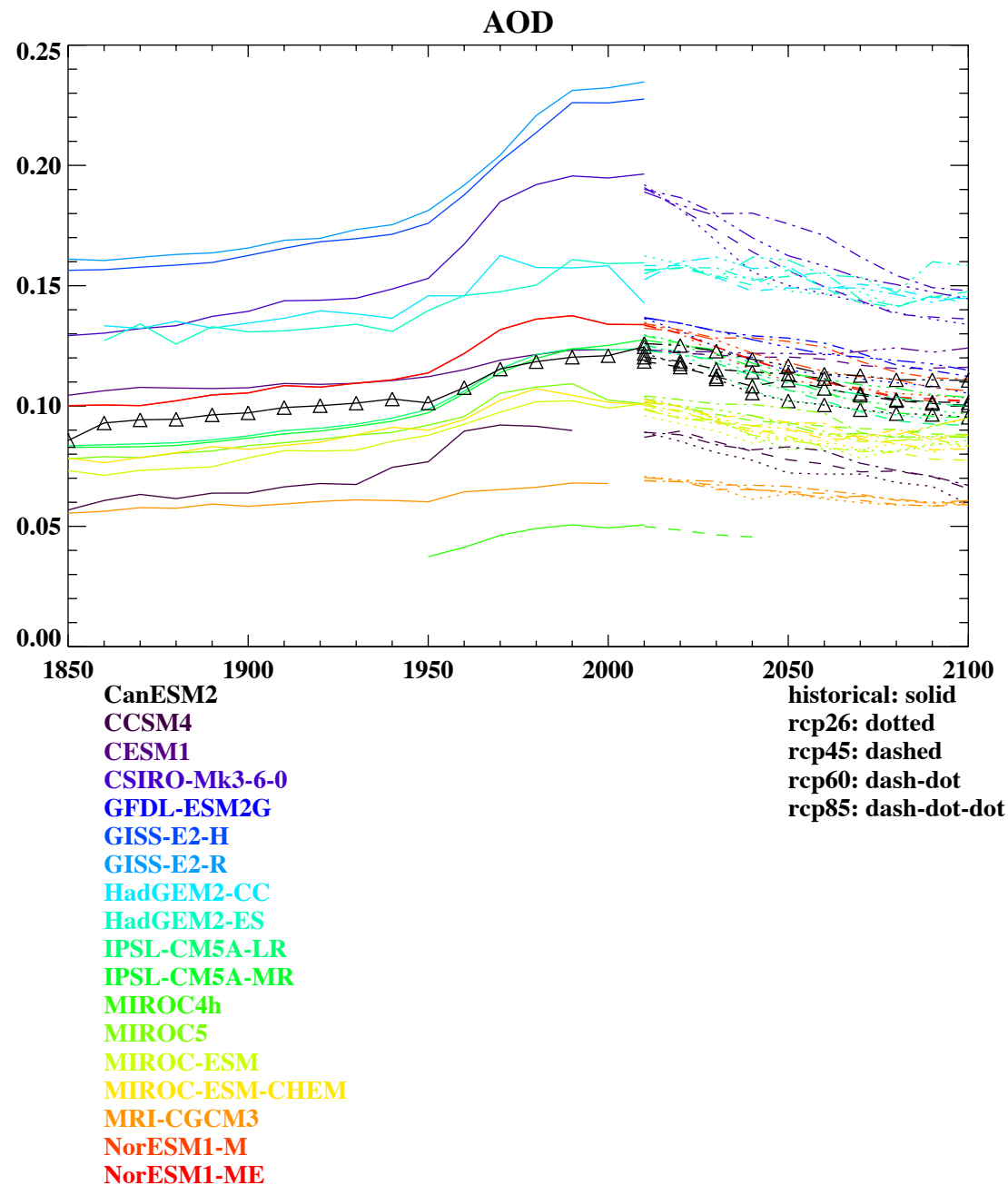


IPCC, 2007

# Allowable C emissions



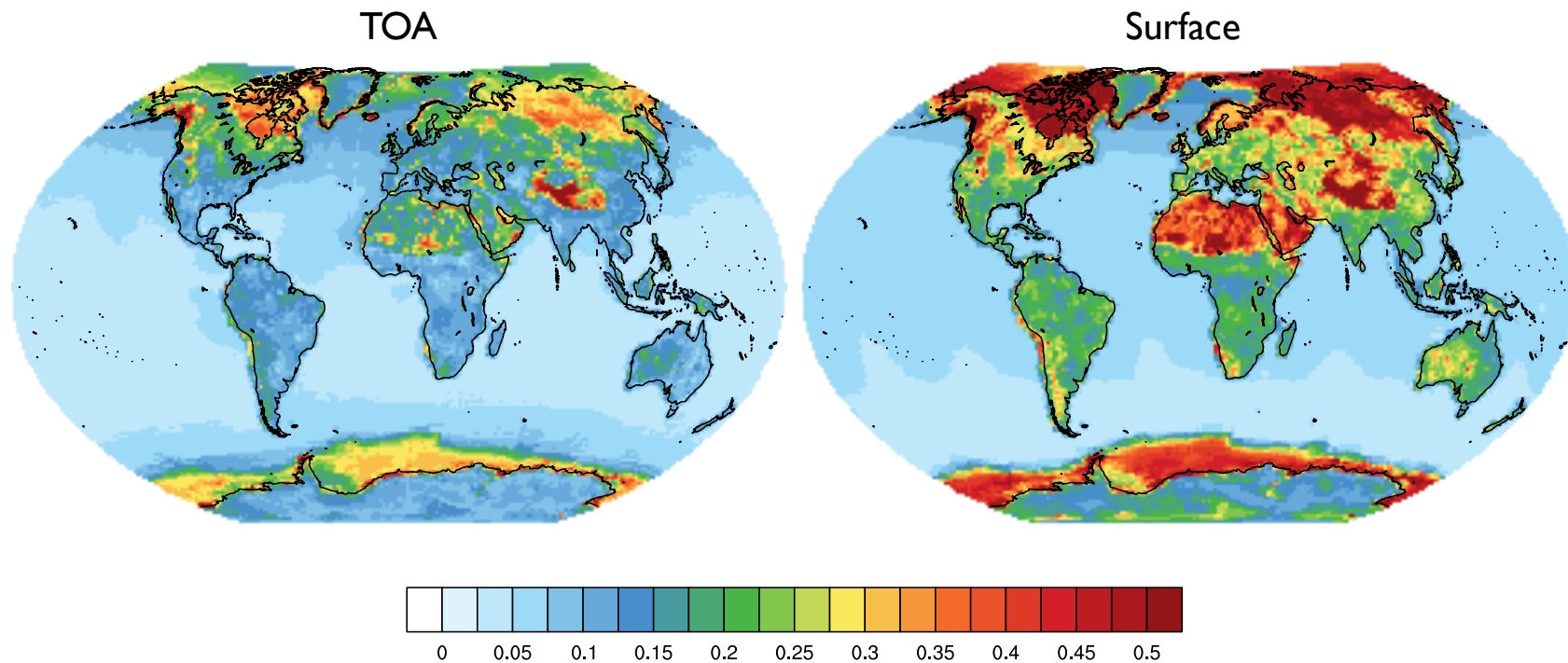




Strong correlation  
between Globally  
averaged AOD and  
aeronet AOD

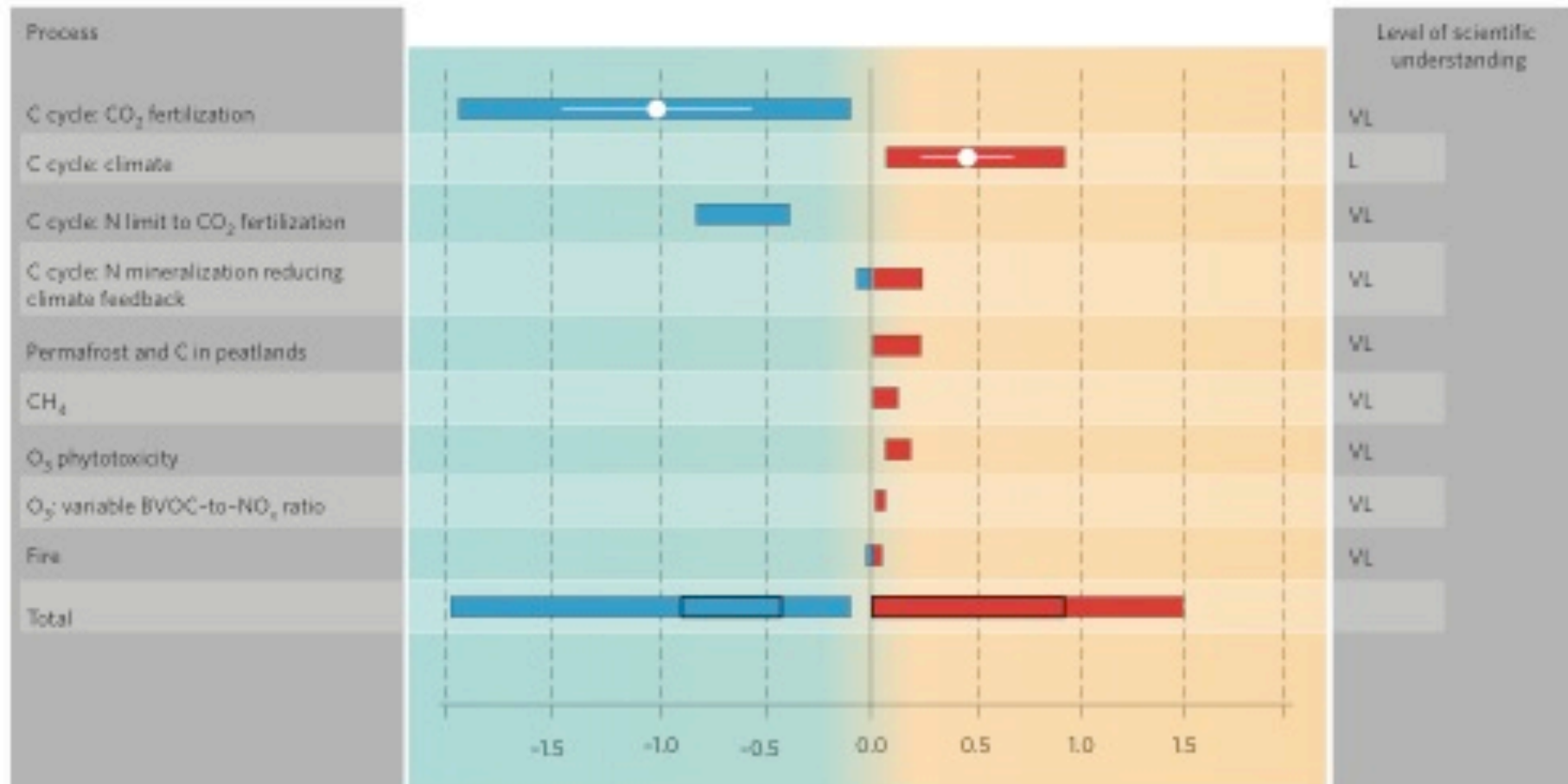
e.g. these differences  
are observed at  
aeronet sites, and  
represent 'fixable'  
errors.

# RMS error in albedo compared to satellite



Slide courtesy of Bjorn Stevesn

# e.g. terrestrial biogeochemical feedbacks on climate



Feedbacks associated with human-mediated changes in the biosphere (W m<sup>-2</sup> K<sup>-1</sup>)

**Figure 1 | Radiative forcing from terrestrial biogeochemistry feedbacks in response to anthropogenic atmospheric and climate changes.** Bars indicate the approximated minimum-to-maximum feedback range over the twenty-first century. The carbon cycle CO<sub>2</sub> and climate feedbacks include average and standard deviations (white). For calculations, adopted from ref. 6, and data sources see Supplementary Information. Totals include top-end estimates, without and with (black rectangle) C-N interactions. Estimates are based on a number of assumptions that had to be made and clearly point to the need for more interdisciplinary research. Scientific understanding is at least low (VL) to medium (L).

Arnell et al., 2010

# Leverage existing projects

- C4MIP
  - Global carbon project, LUCMIP, AEROCOM
  - RFMIP (WGCM)
  - (don't reinvent the wheel)
- 
- But make sure we are going from emissions or land use projections all the way to RF for the climate community.