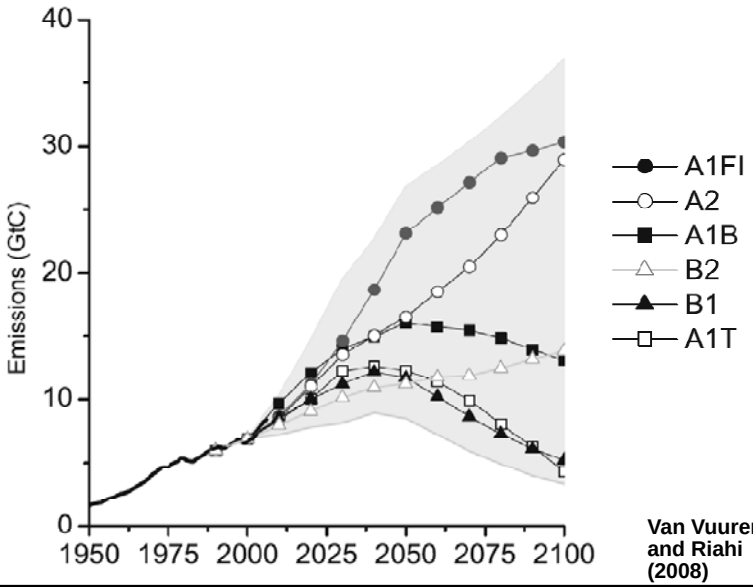
4°C global warming: regional patterns and timing

Richard Betts, Mike Sanderson, Debbie Hemming, Mark New, Jason Lowe, Chris Jones

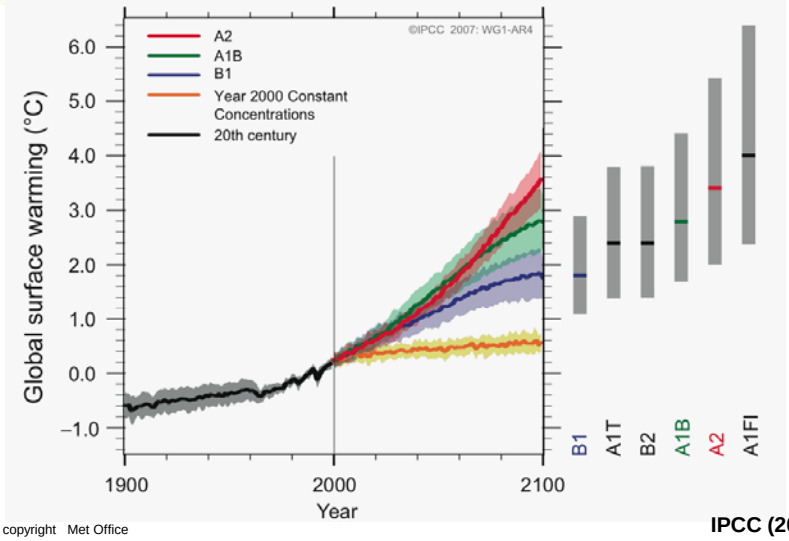
 4°C+ conference, Oxford University, 25.9.09

IPCC SRES emissions scenarios



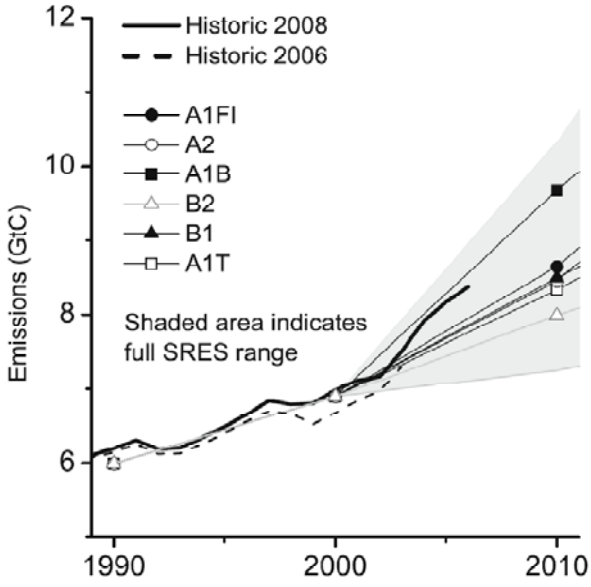
Van Vuuren and Riahi (2008)

Model projections of global warming with IPCC SRES emissions scenarios



IPCC (2007)

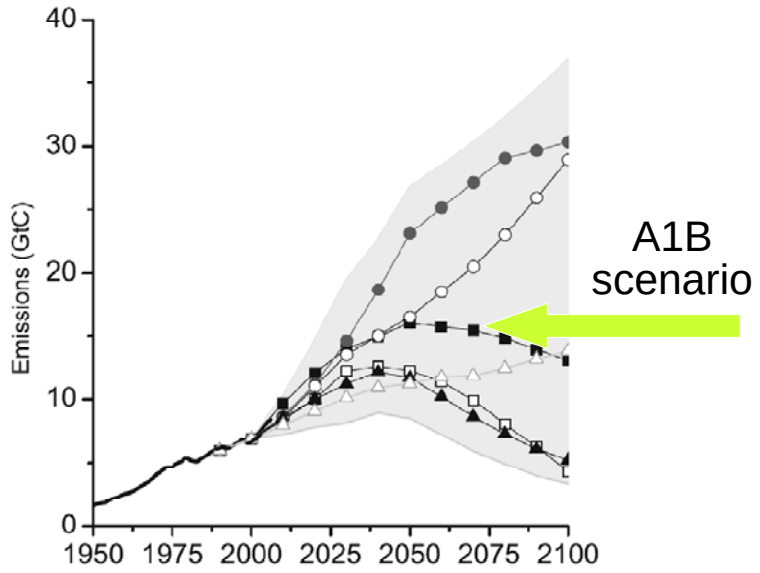
Comparison of SRES scenarios with actual emissions



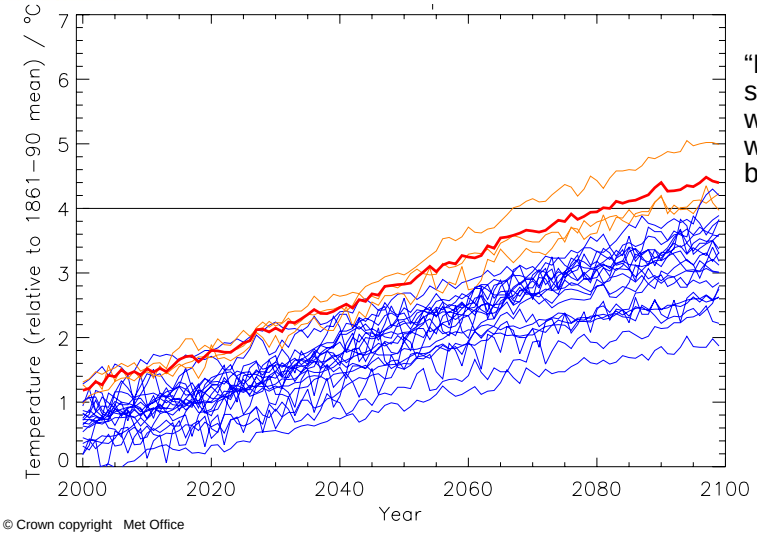
Van Vuuren and Riahi (2008)

Using climate model ensembles to assess confidence in projections

- Multi-model ensemble: set of (mostly) different models
  - IPCC 4th Assessment Report (AR4) – 23 models
- Perturbed physics ensembles: set of variants of one model
  - ClimatePrediction.net – HadCM3 model (1500+ variants)
  - Met Office Hadley Centre (MOHC) "QUMP" project – HadCM3 model (17 variants)
- Simple climate model tuned to the above complex models
  - IPCC "likely range of warming" statements
- Combination of the above
  - UKCP09 – mostly HadCM3, with some input from IPCC AR4 models



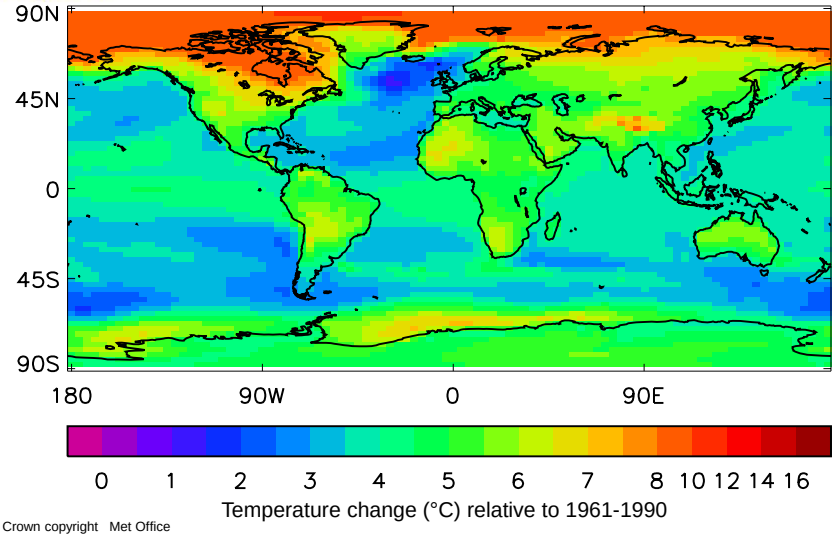
Global warming with A1B scenario: all IPCC models



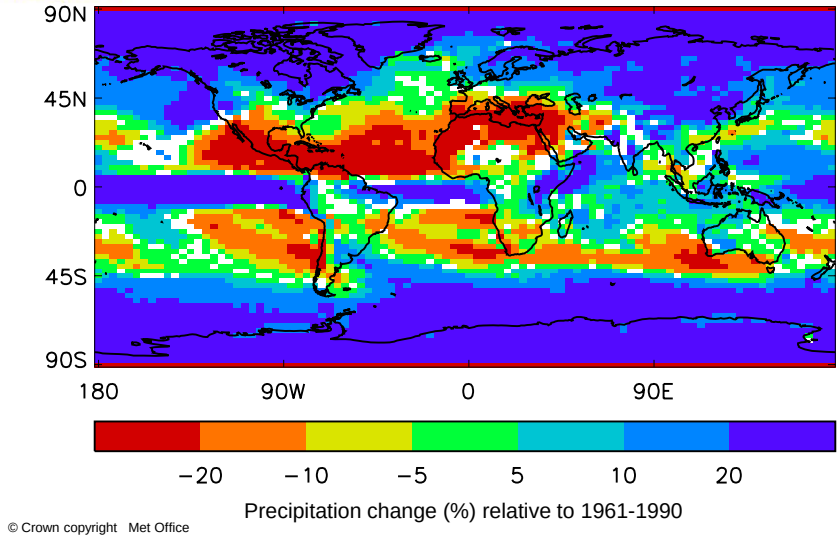
"High-end": simulations with 4°C warming by by 2090s

Pattern of warming by 2090s, A1B

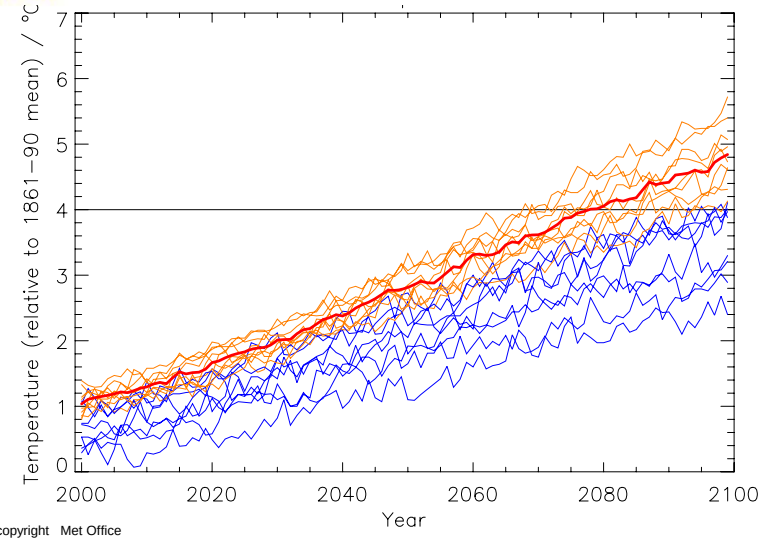
Mean of "high-end" IPCC simulations (3 models, mean global warming 4.3°C)



Precipitation changes by 2090s, A1B
Mean of “high-end” IPCC simulations
(3 models, mean global warming 4.3°C)

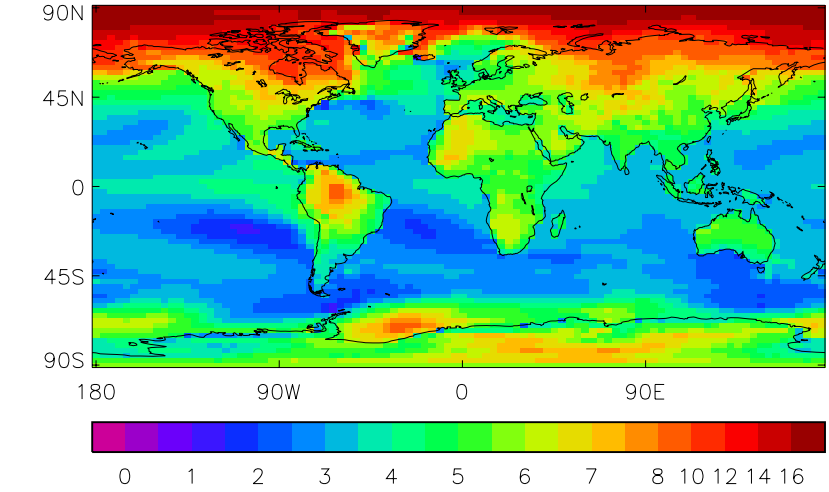


Global warming with A1B scenario: MOHC ensemble



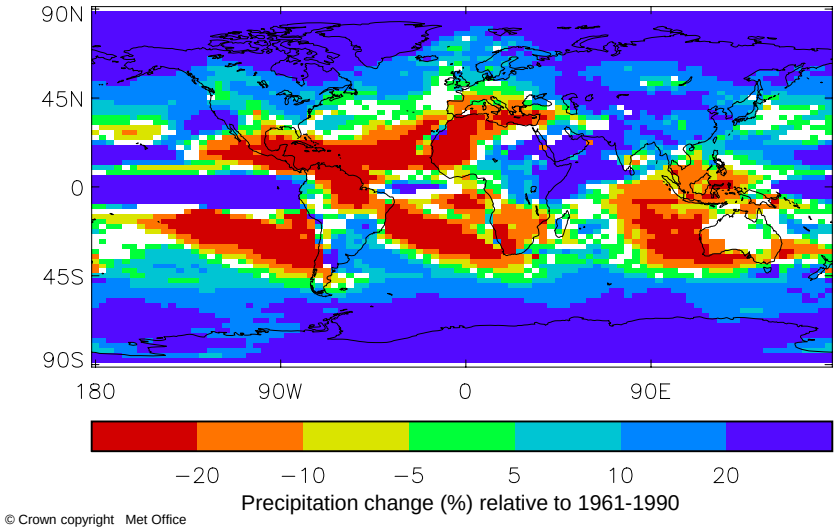
Pattern of warming by 2090s, A1B

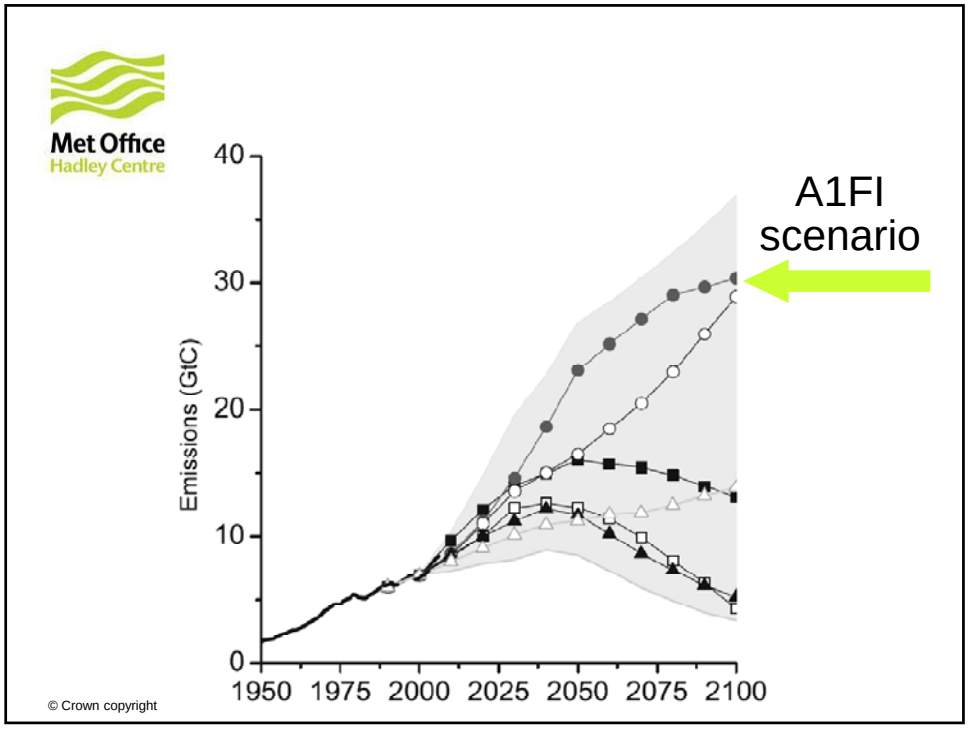
Mean of “high-end” MOHC simulations (9 simulations, mean global warming 4.6°C)

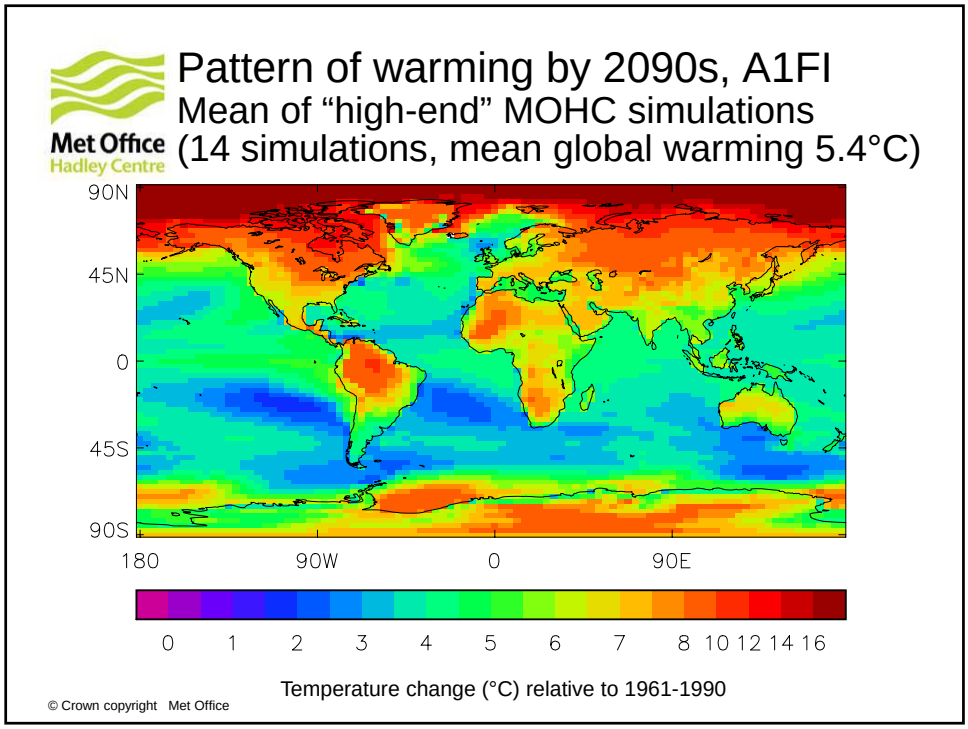


Precipitation changes by 2090s, A1B

Mean of “high-end” MOHC simulations (9 simulations, mean global warming 4.6°C)

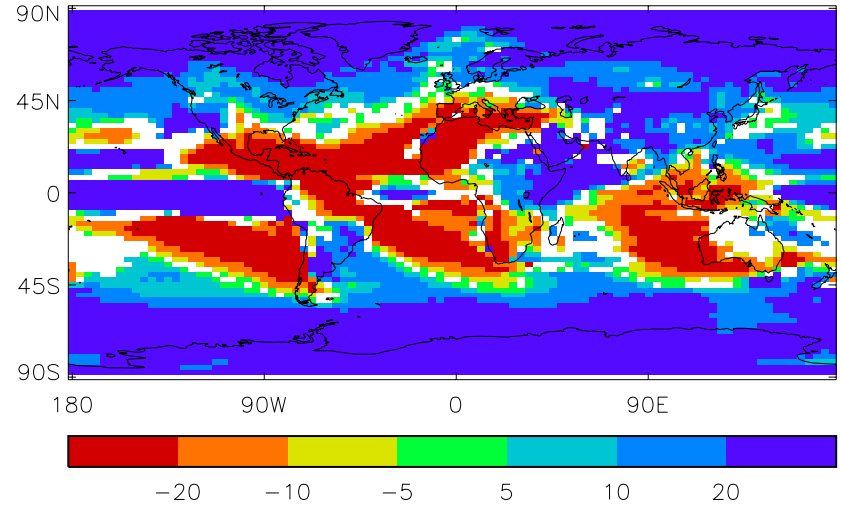



Met Office
Hadley Centre
A1FI
scenario
Emissions (GtC)
40
30
20
10
0
1950 1975 2000 2025 2050 2075 2100
© Crown copyright

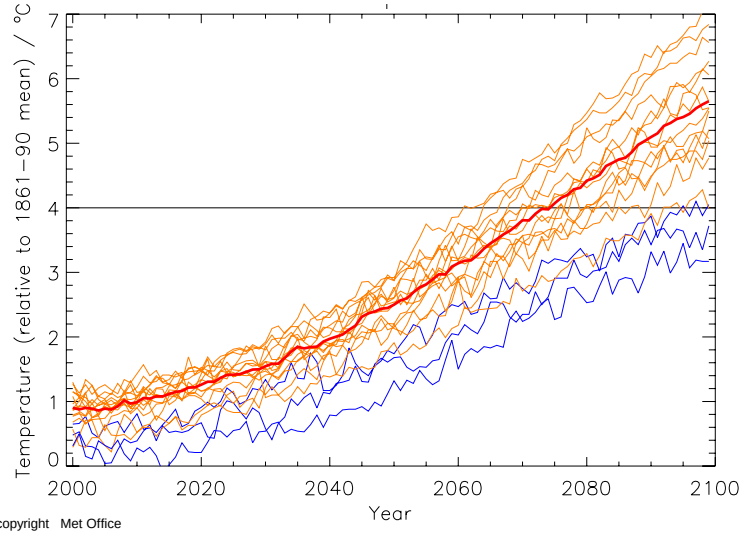

Met Office
Hadley Centre
Pattern of warming by 2090s, A1FI
Mean of "high-end" MOHC simulations
(14 simulations, mean global warming 5.4°C)
90N
45N
0
45S
90S
180
90W
0
90E
0 1 2 3 4 5 6 7 8 10 12 14 16
Temperature change (°C) relative to 1961-1990
© Crown copyright Met Office

Precipitation changes by 2090s, A1FI

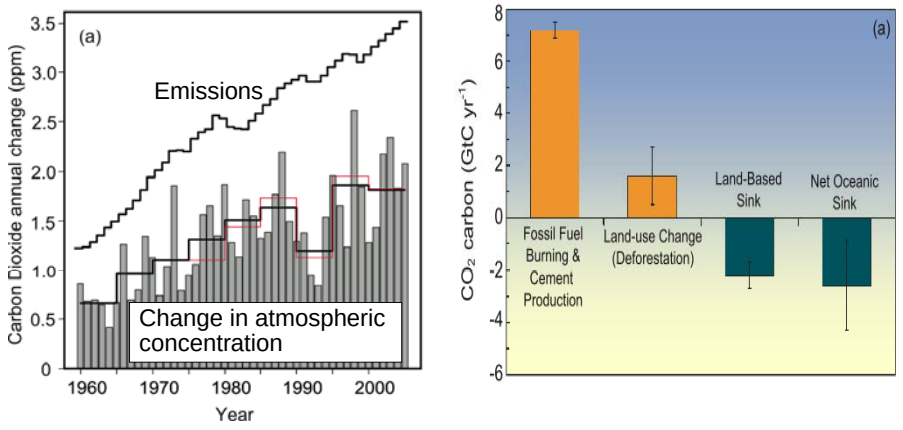
Mean of “high-end” MOHC simulations (14 simulations, mean global warming 5.4°C)



Global warming with A1FI scenario: MOHC ensemble

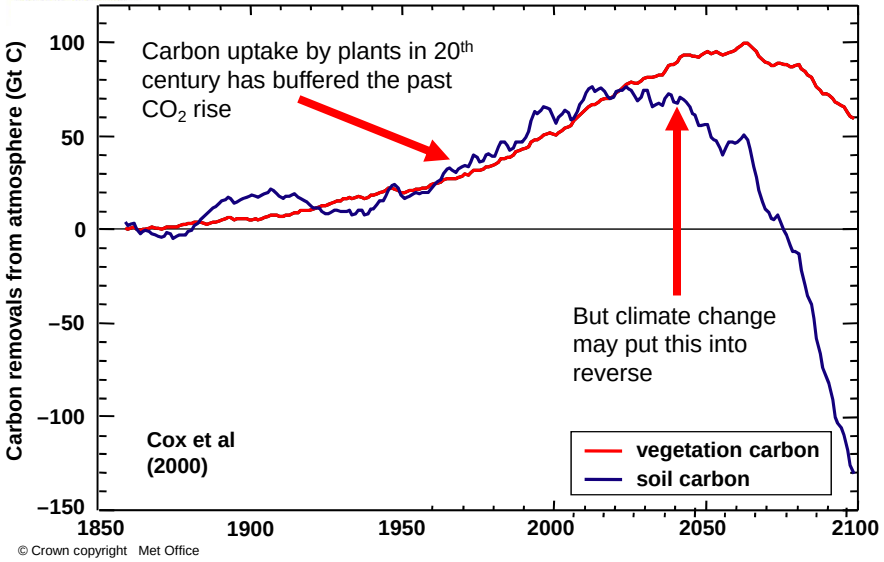


Importance of carbon sinks for slowing CO_2 rise

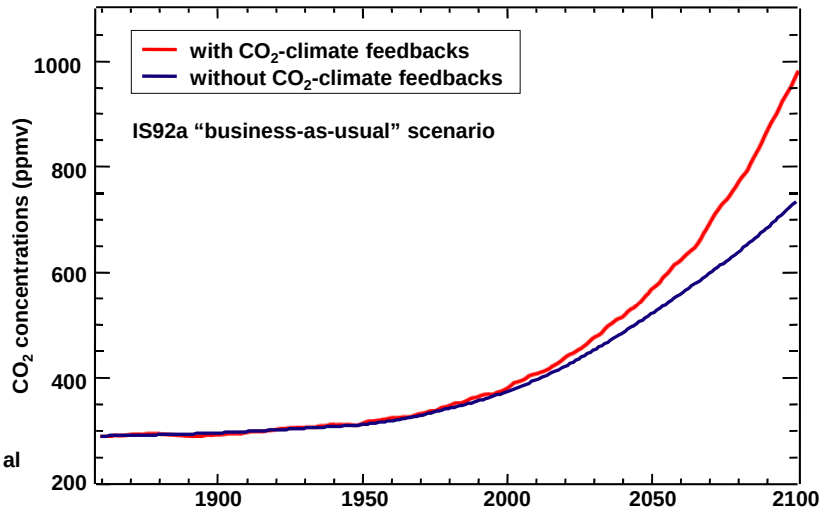


IPCC (2007)

The free ecosystem service that has been buying us time may not last…



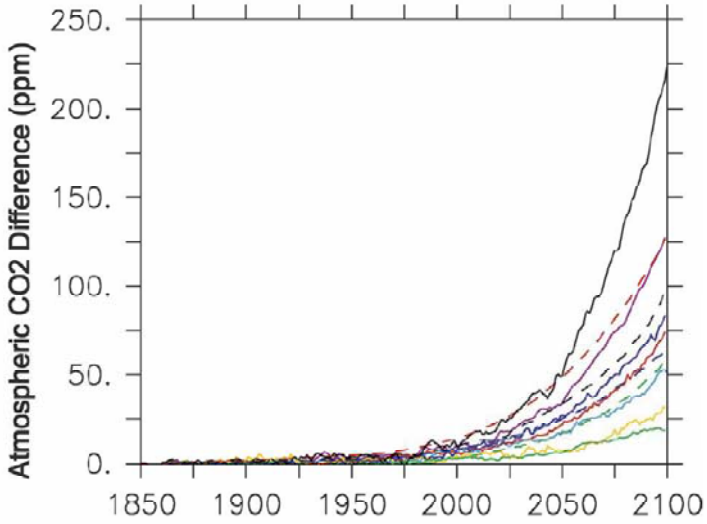
Effects of climate-carbon cycle feedbacks on atmospheric CO_2 rise



Cox et al (2000)

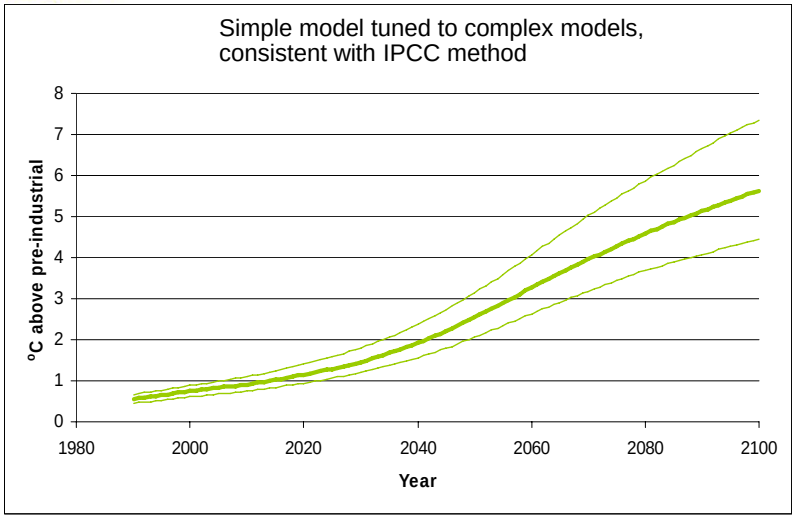
Multi-model assessment of carbon cycle feedbacks (C4MIP):

A2 emissions scenario

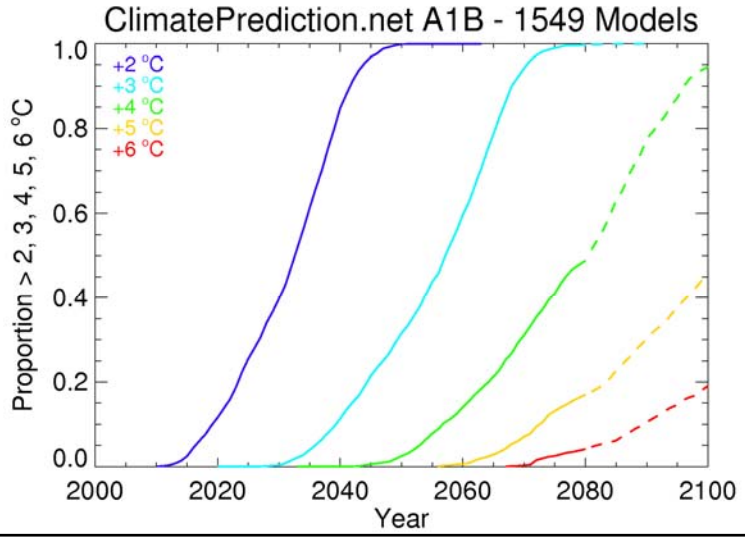


Friedlingstein *et al* (2006)

Range of global warming projections for A1FI (high emissions) scenario, including carbon cycle feedbacks



Exceedance of global warming thresholds, A1B, *no* carbon cycle feedbacks: ClimatePrediction.net



Conclusions

- Current CO_2 emissions are near (but not above) upper end of IPCC scenarios
- 4°C global warming (relative to pre-industrial) is possible by the 2090s, especially under high emissions scenario
- Many areas could warm by 10°C or more
- The Arctic could warm by 15°C or more
- Annual precipitation could decrease by 20% or more in many areas
- Carbon cycle feedbacks expected to accelerate warming
- With high emissions, best guess is 4°C in 2070s
- Plausible worst case: 4°C by 2060