



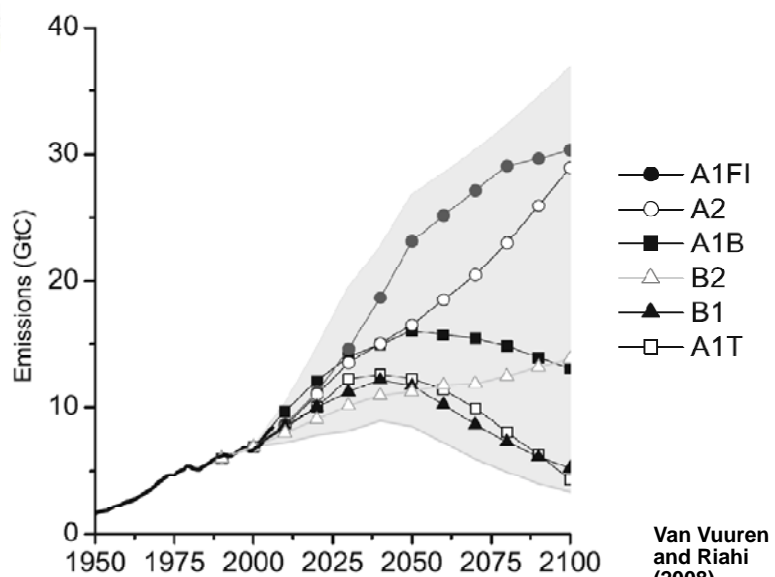
4°C global warming: regional patterns and timing

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

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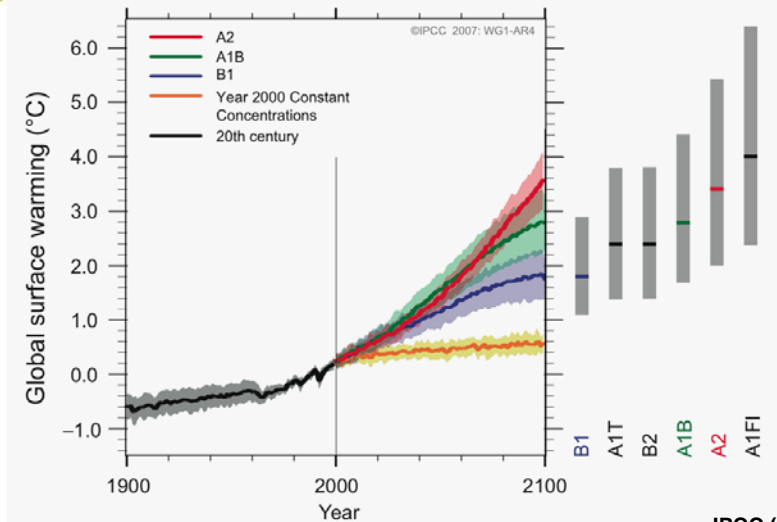
IPCC SRES emissions scenarios



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Van Vuuren
and Riahi
(2008)

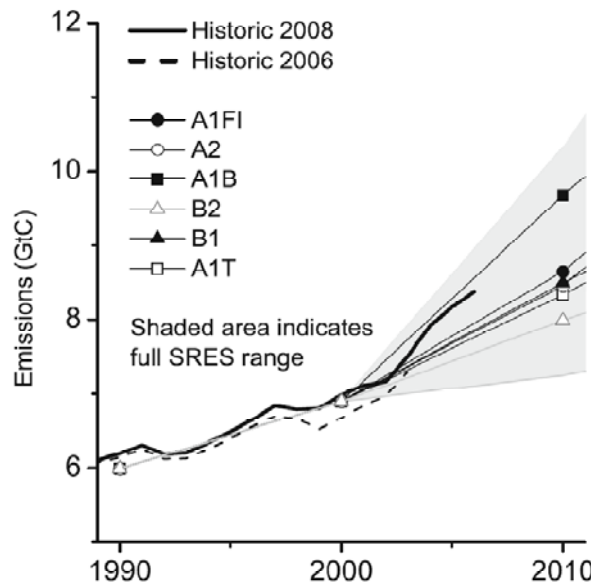
Model projections of global warming with IPCC SRES emissions scenarios



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IPCC (2007)

Comparison of SRES scenarios with actual emissions



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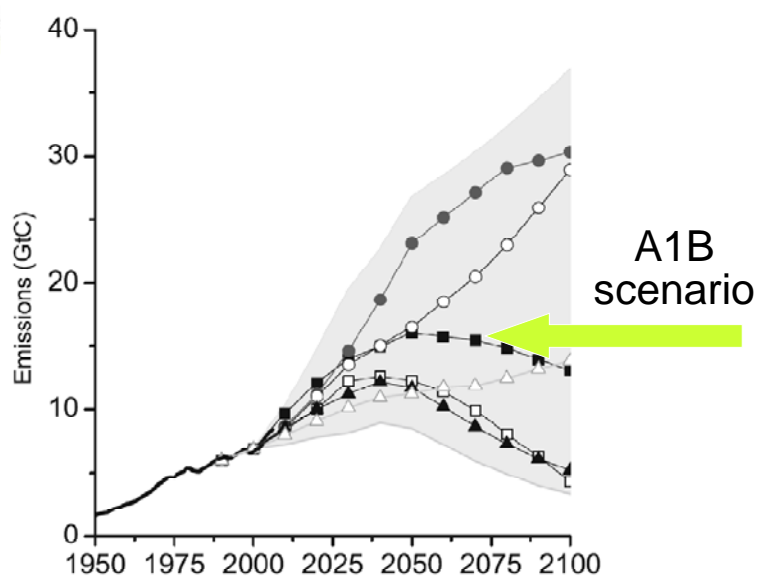
Van Vuuren
and Riahi
(2008)



Using climate model ensembles to assess confidence in projections

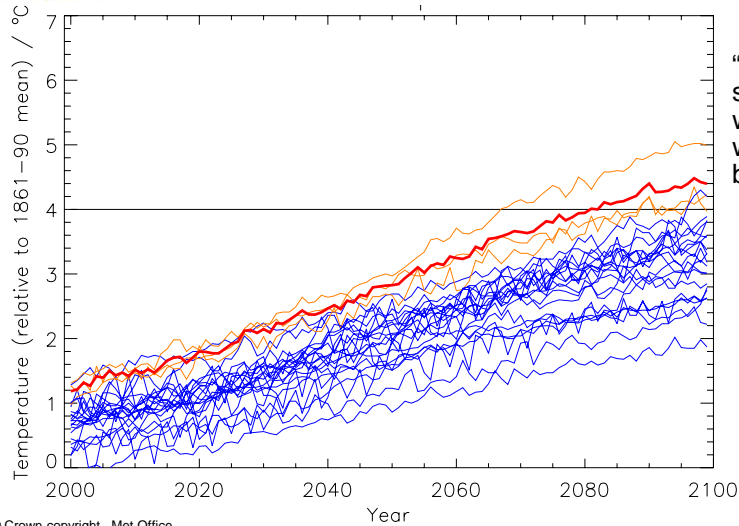
- Multi-model ensemble: set of (mostly) different models
 - IPCC 4th Assessment Report (AR4) – 23 models
- Perturbed physics ensembles: set of variants of one model
 - ClimatePrediction.net – HadCM3 model (1500+ variants)
 - Met Office Hadley Centre (MOHC) “QUMP” project – HadCM3 model (17 variants)
- 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

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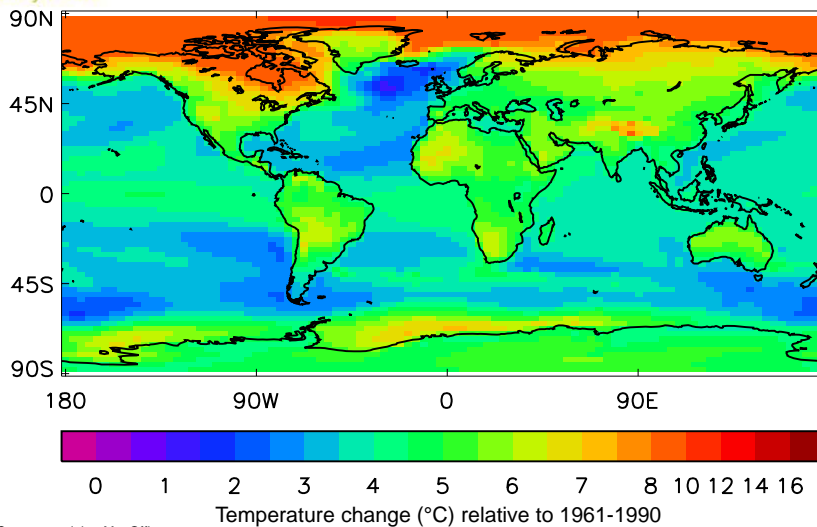
Global warming with A1B scenario: all IPCC models



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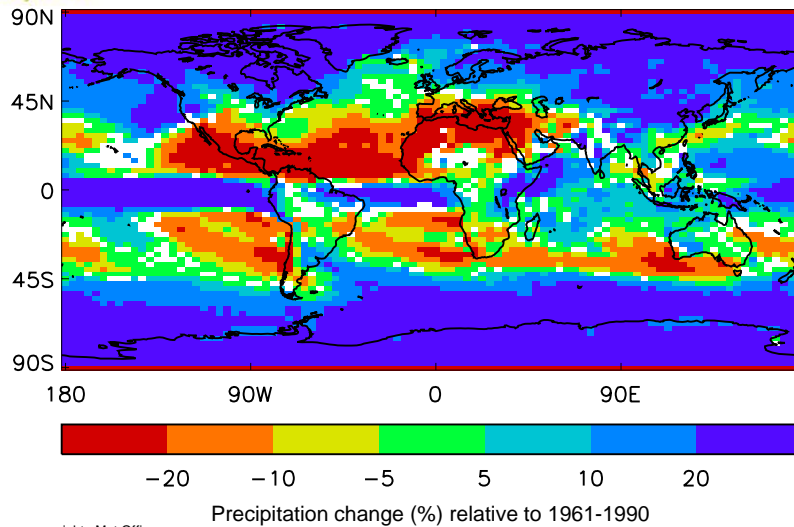
Pattern of warming by 2090s, A1B Mean of "high-end" IPCC simulations (3 models, mean global warming 4.3°C)



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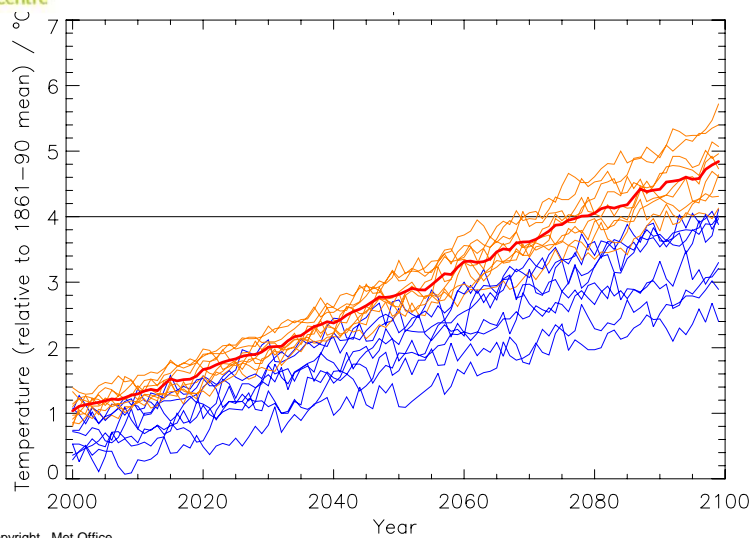
Precipitation changes by 2090s, A1B Mean of "high-end" IPCC simulations (3 models, mean global warming 4.3°C)



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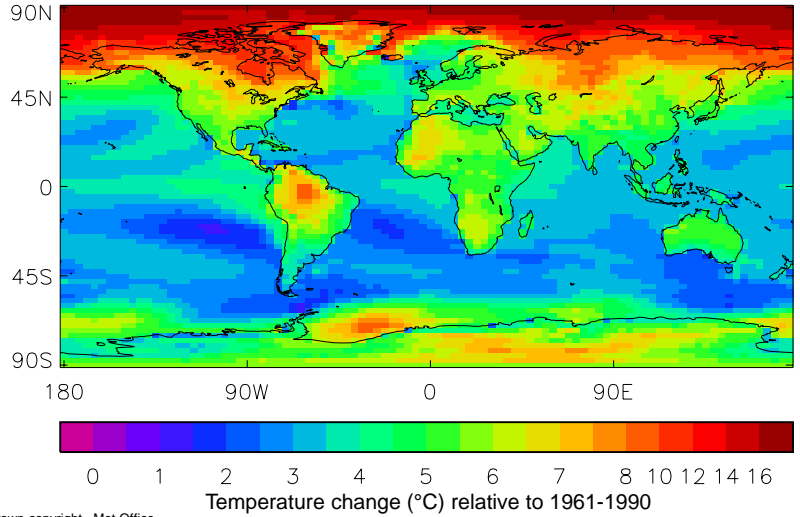
Global warming with A1B scenario: MOHC ensemble



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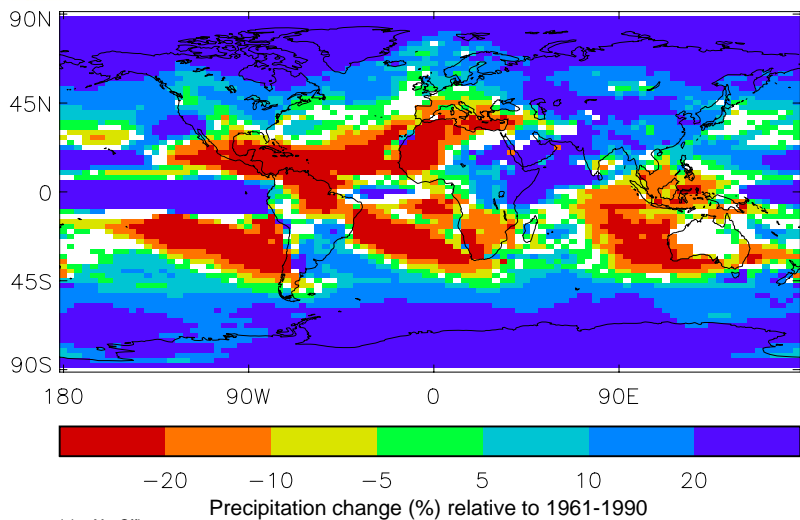
Pattern of warming by 2090s, A1B
Mean of "high-end" MOHC simulations
(9 simulations, mean global warming 4.6°C)



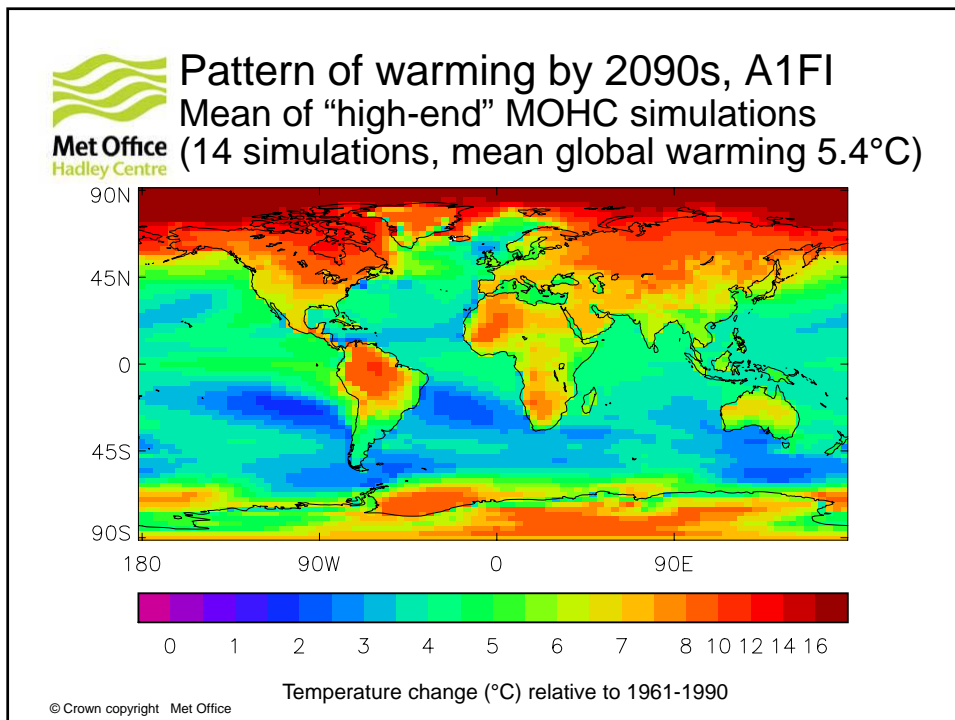
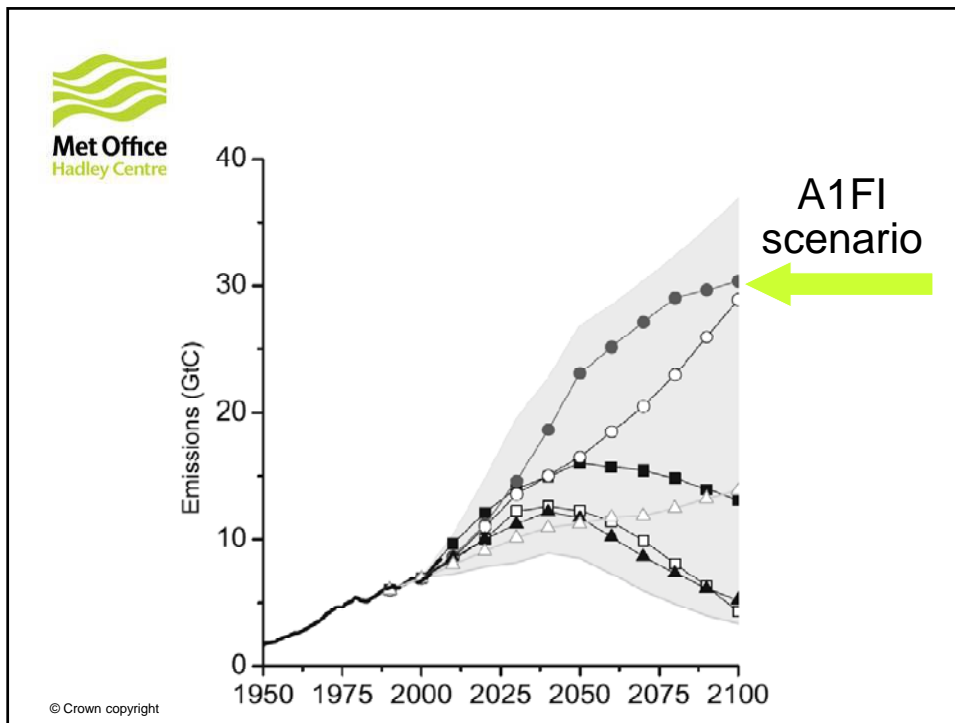
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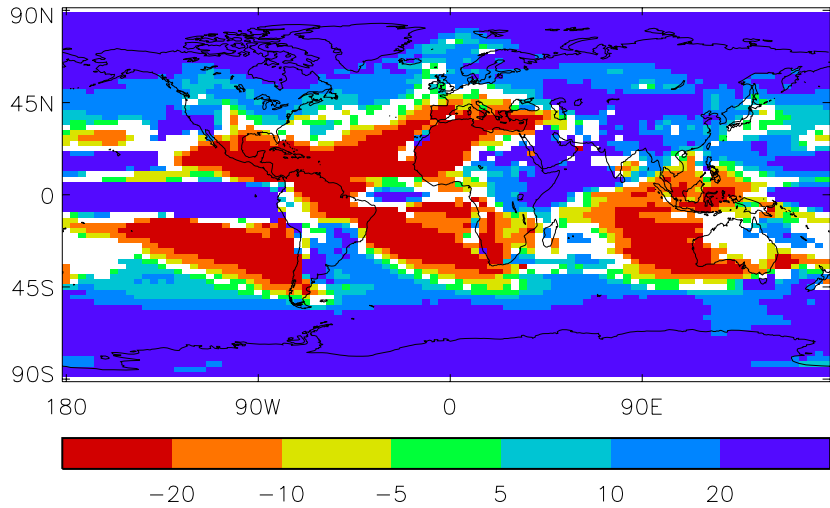
Precipitation changes by 2090s, A1B
Mean of "high-end" MOHC simulations
(9 simulations, mean global warming 4.6°C)




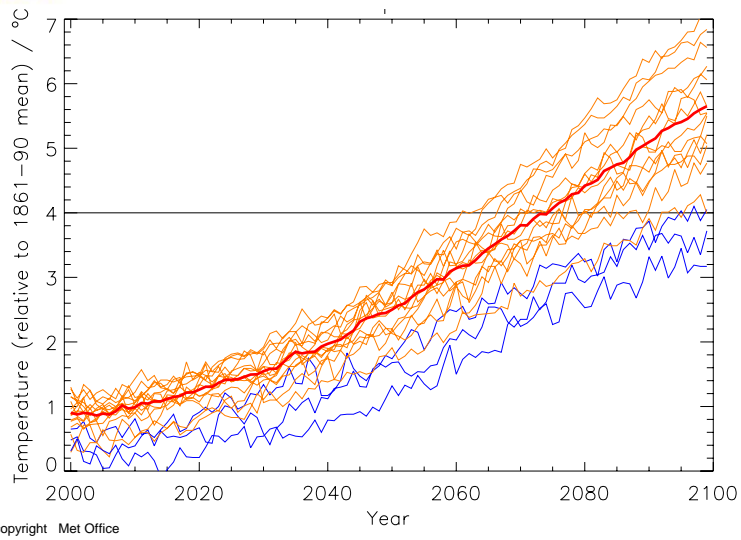
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 **Precipitation changes by 2090s, A1FI**
Mean of “high-end” MOHC simulations
(14 simulations, mean global warming 5.4°C)

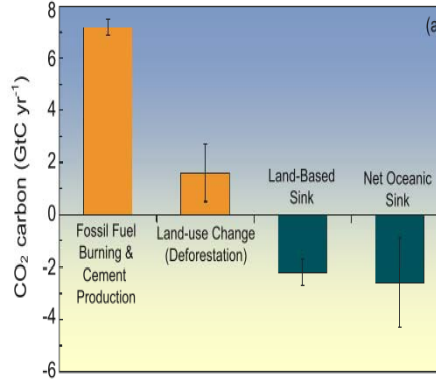
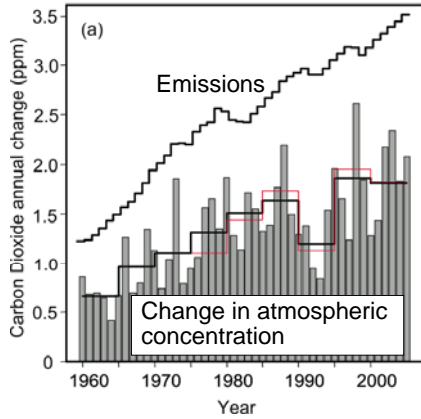


 **Global warming with A1FI scenario:**
MOHC ensemble





Importance of carbon sinks for slowing CO₂ rise

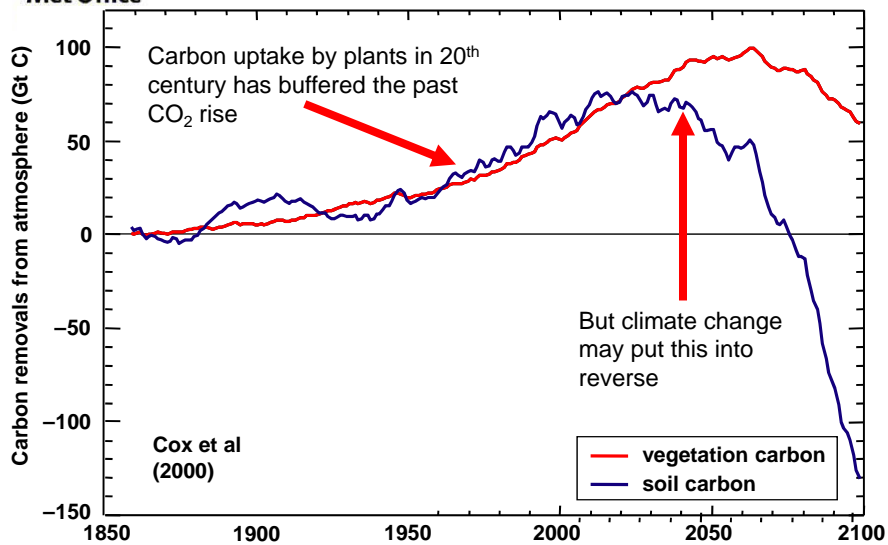


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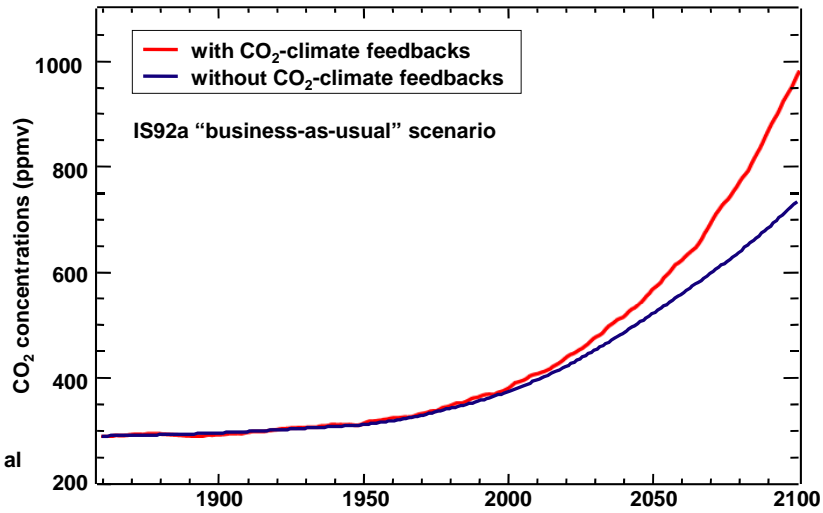
The free ecosystem service that has been buying us time may not last...



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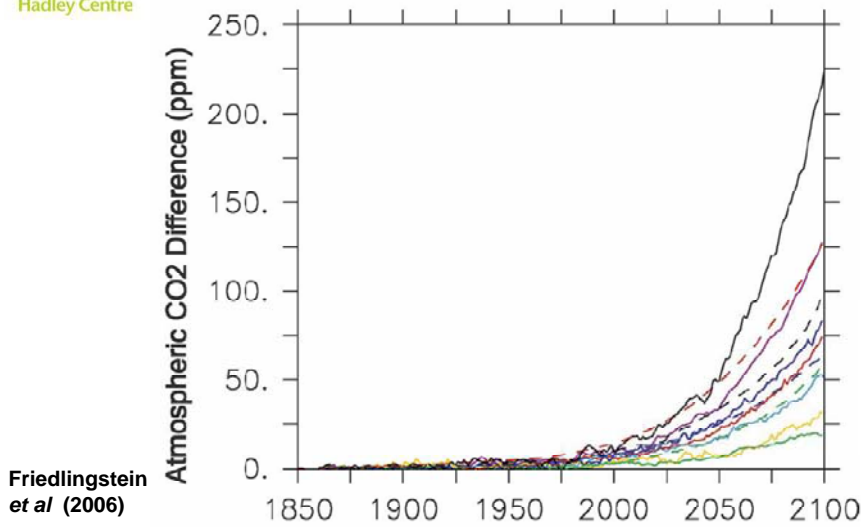
Effects of climate-carbon cycle feedbacks on atmospheric CO₂ rise



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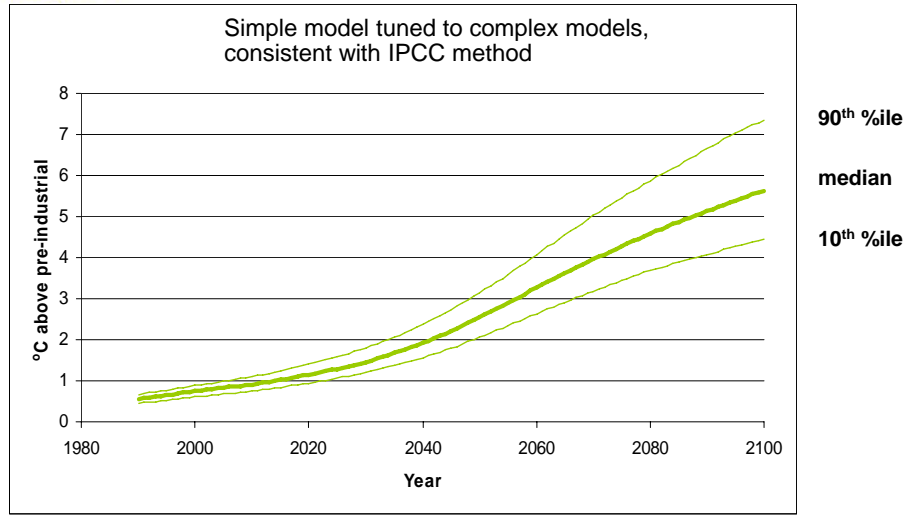
Multi-model assessment of carbon cycle feedbacks (C4MIP): A2 emissions scenario



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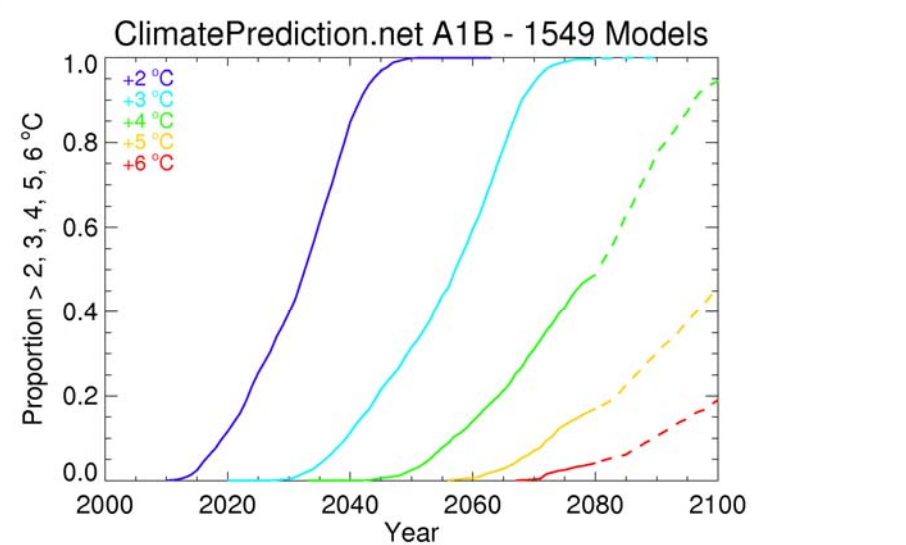
Range of global warming projections for A1FI (high emissions) scenario, including carbon cycle feedbacks



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





Conclusions

- Current CO₂ 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

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