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Does “Amazon die-back” mean it is not worth reducing deforestation?

Richard Betts

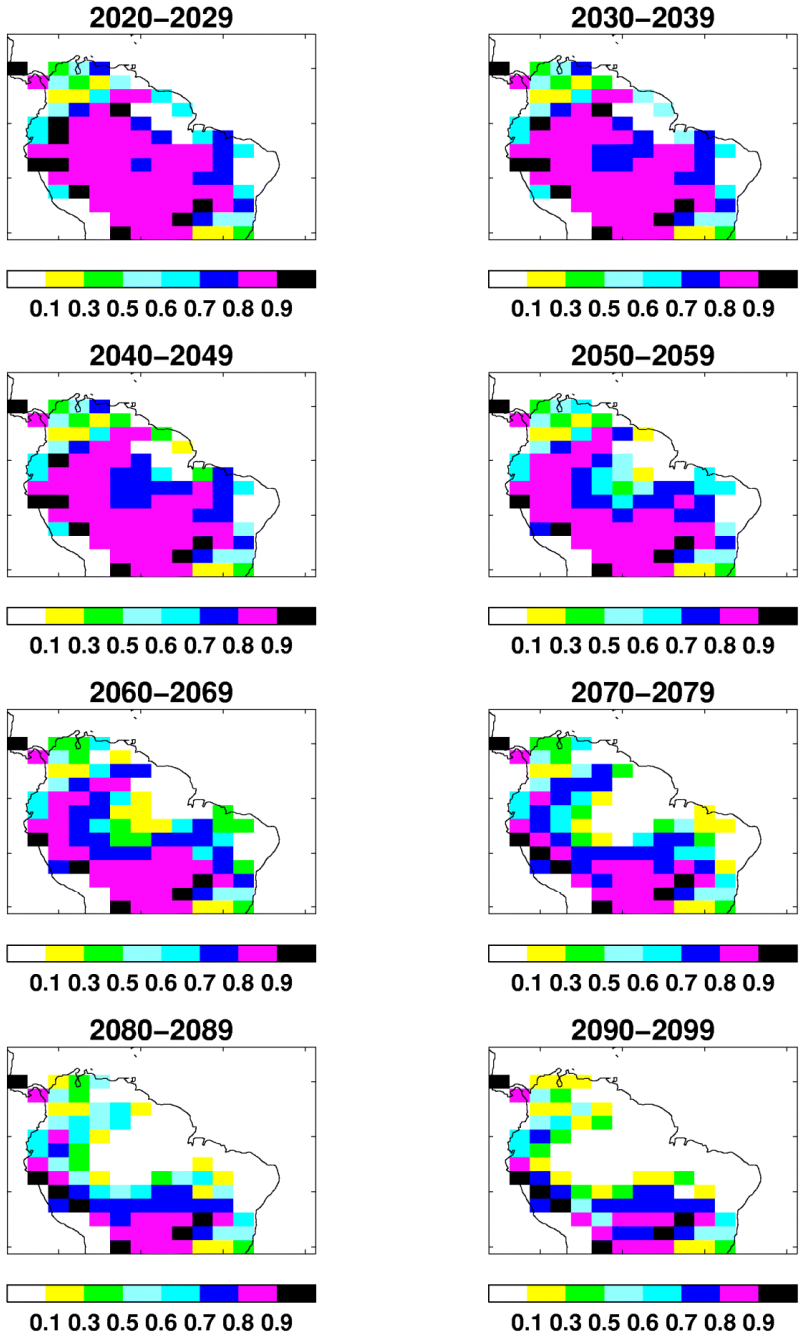
With thanks to: Peter Cox, Wolfgang Cramer, Nicola Golding, John Hughes, Chris Jones, Gillian Kay, Neil Kaye, Yadvinder Malhi, Britaldo Soares-Filho,

JULES science meeting, Edinburgh, 8-9 January, 2009

Projected climate change causes “forest die-back” in Hadley Centre model

Simulated broadleaf tree

(fraction of gridbox covered)



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“So if climate change is going to kill the Amazon, why should we reduce deforestation?”

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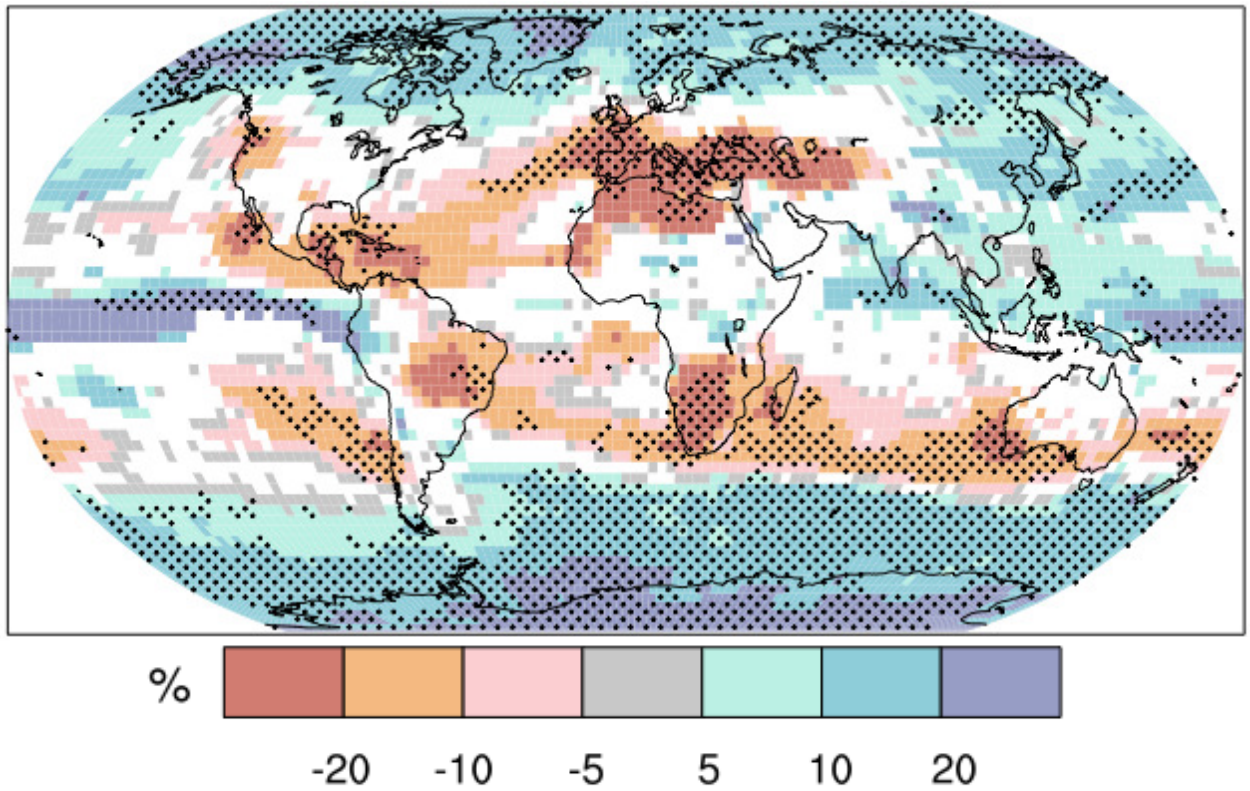
Context: how robust are these predictions?

How well do climate models agree?



Change in precipitation (mm day^{-1}): average of all IPCC models

White: less than 66% agreement. Colours: 66% or more agreement.
Black dots: 90% or more agreement

2090s relative to present-day, A1B scenario: June-July-August

Source: Intergovernmental Panel on Climate Change (IPCC)

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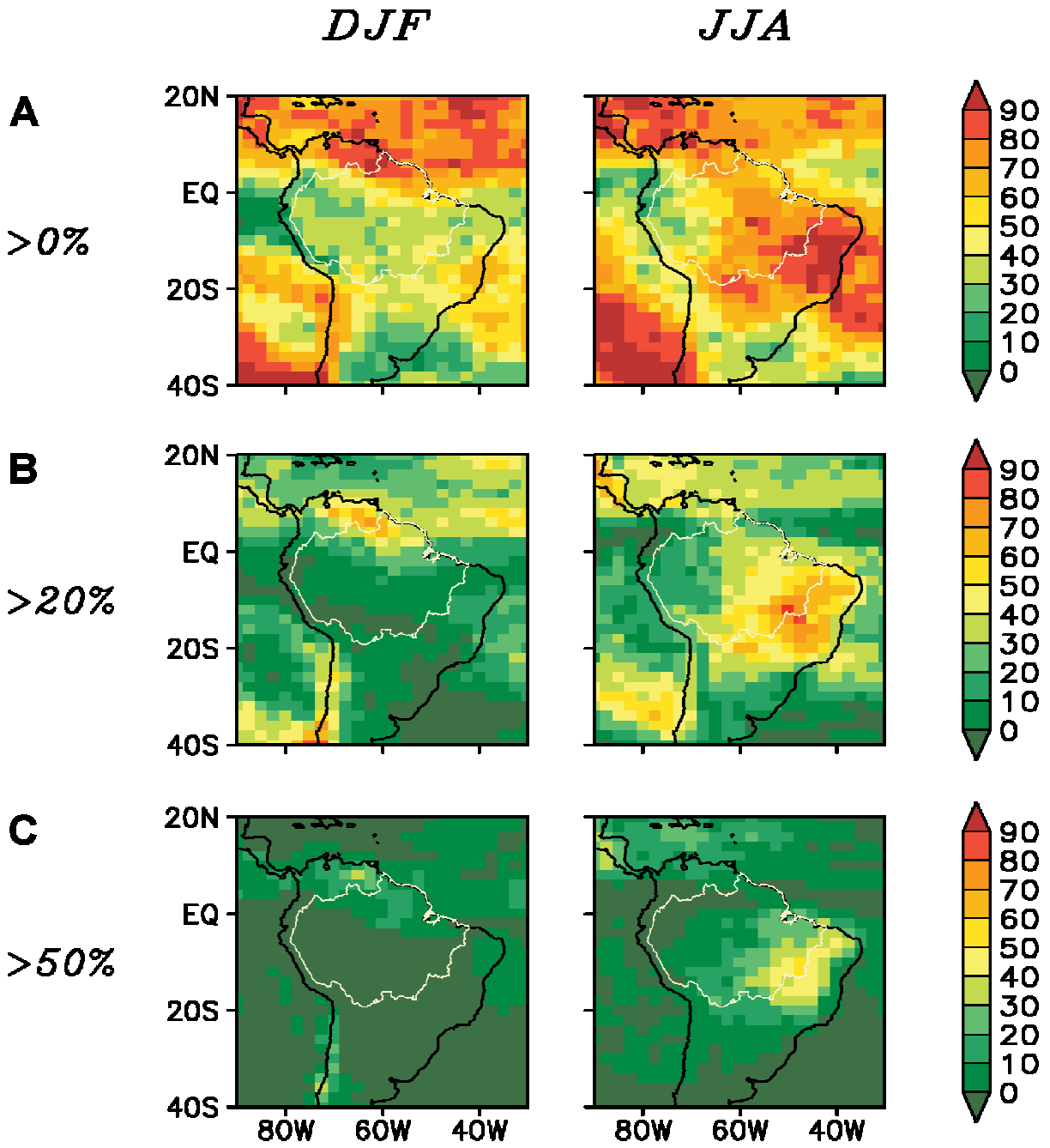
General agreement on drying in Amazonia in JJA – but projections vary in magnitude



Malhi *et al*, 2008

Biases in climate models

Using Koeppen climate classifications to illustrate model biases:

Climate Classes

BWk	Af	Cfa	Csb	EF	Dfc	Dwa
BWh	Am	Cfb	Cwa	ET	Dfd	Dwb
BSk	As	Cfc	Cwb	Dfa	Dsa	Dwc
BSh	Aw	Csa	Cwc	Dfb	Dsb	

Main Classes

A: equitorial
B: arid
C: warm temperate
D: snow
E: polar

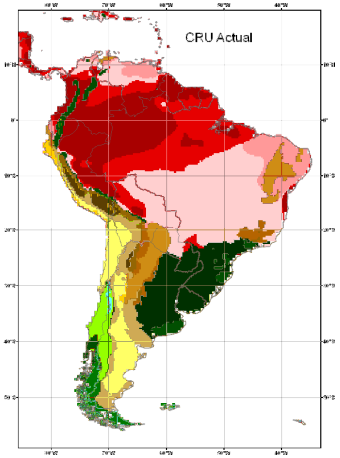
Precipitation

W: desert
S: steppe
f: fully humid
s: summer dry
w: winter dry
m: monsoonal

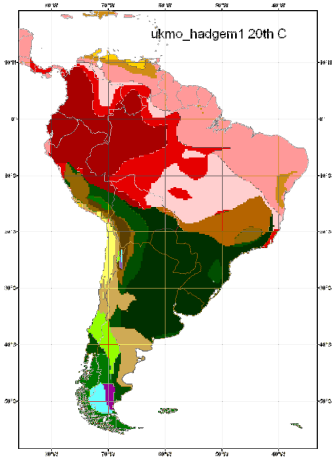
Temperature

h: hot arid
k: cold arid
a: hot summer
b: warm summer
c: cool summer
d: extreme continental
F: polar frost
T: polar tundra

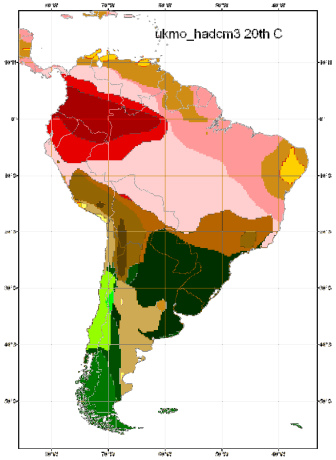
Observed

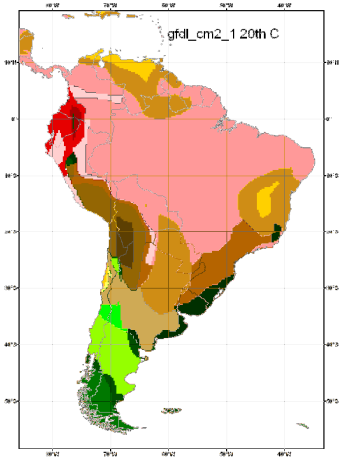


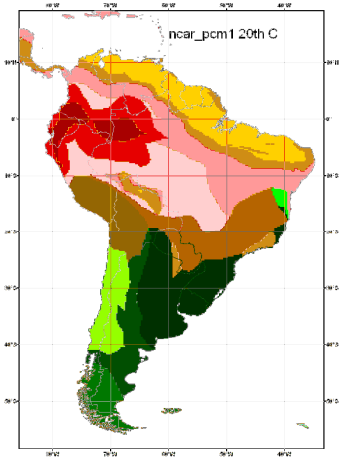
HadGEM1

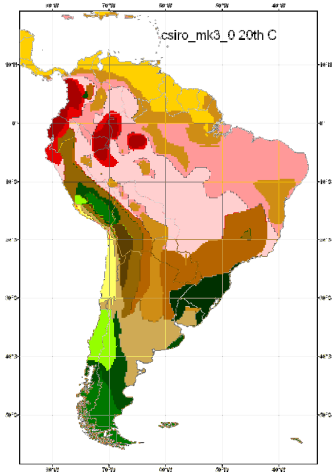


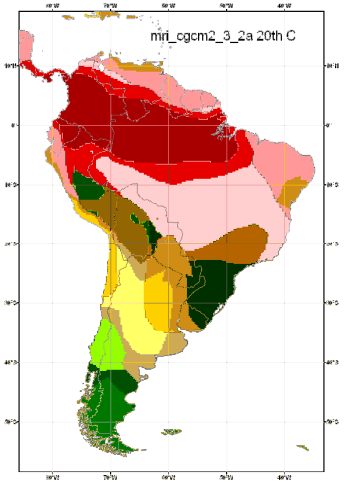
HadCM3

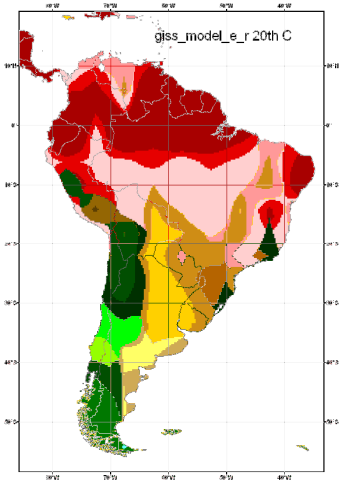


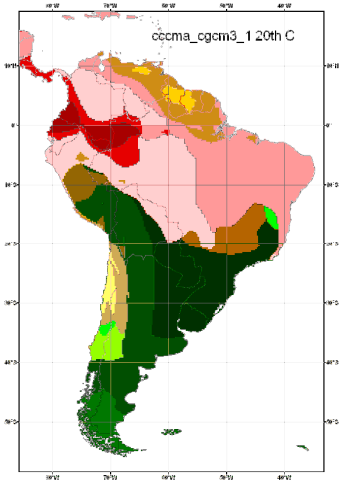


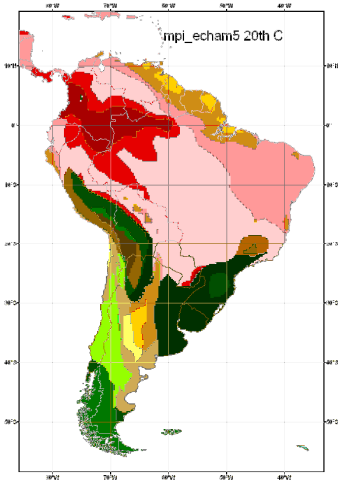












Misleading results from “climatology+anomaly” approach

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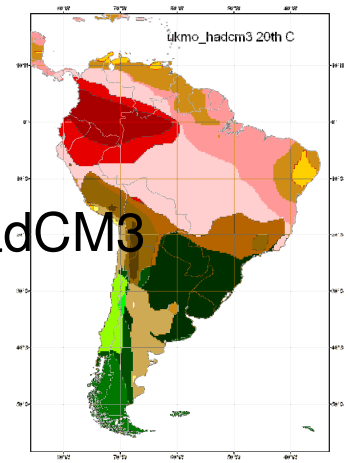
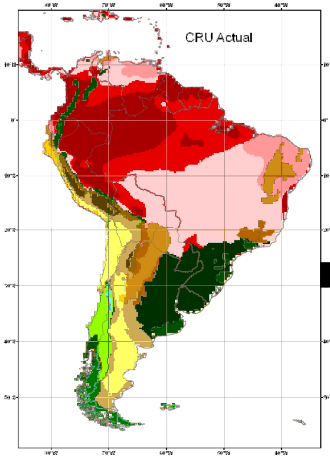
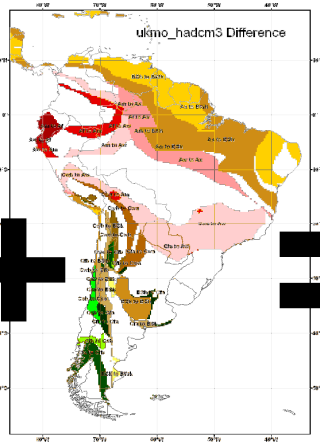
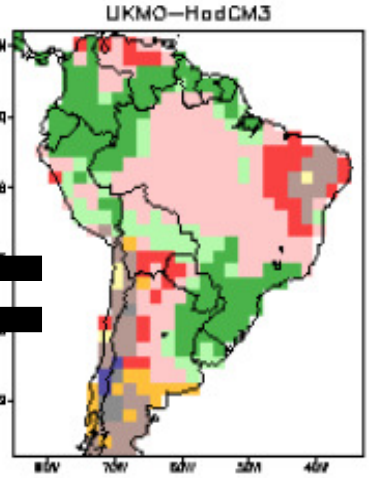
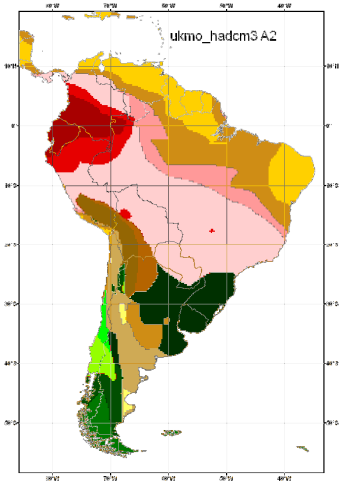
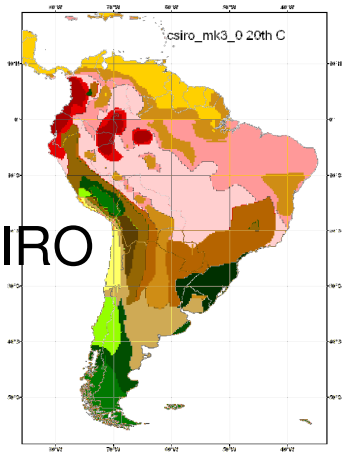
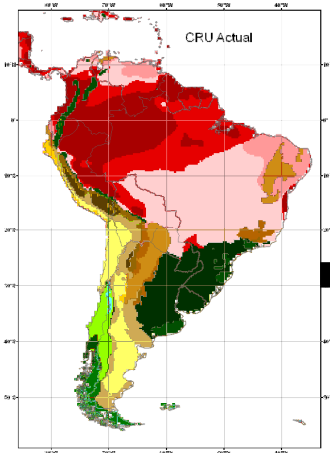
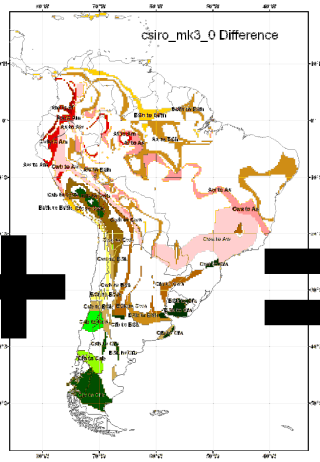
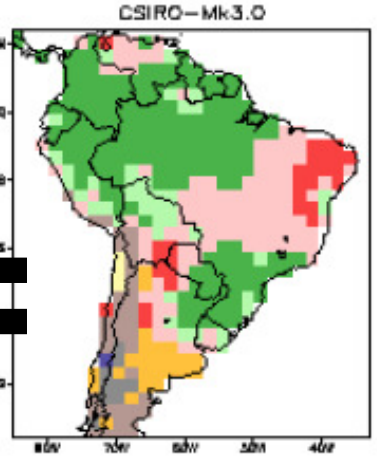
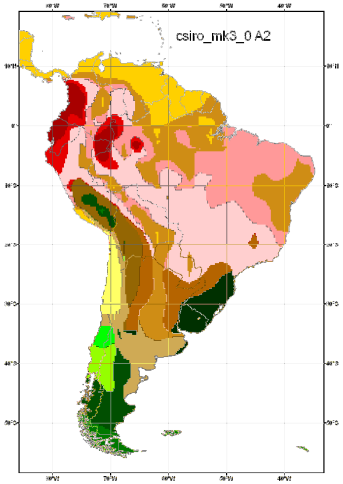
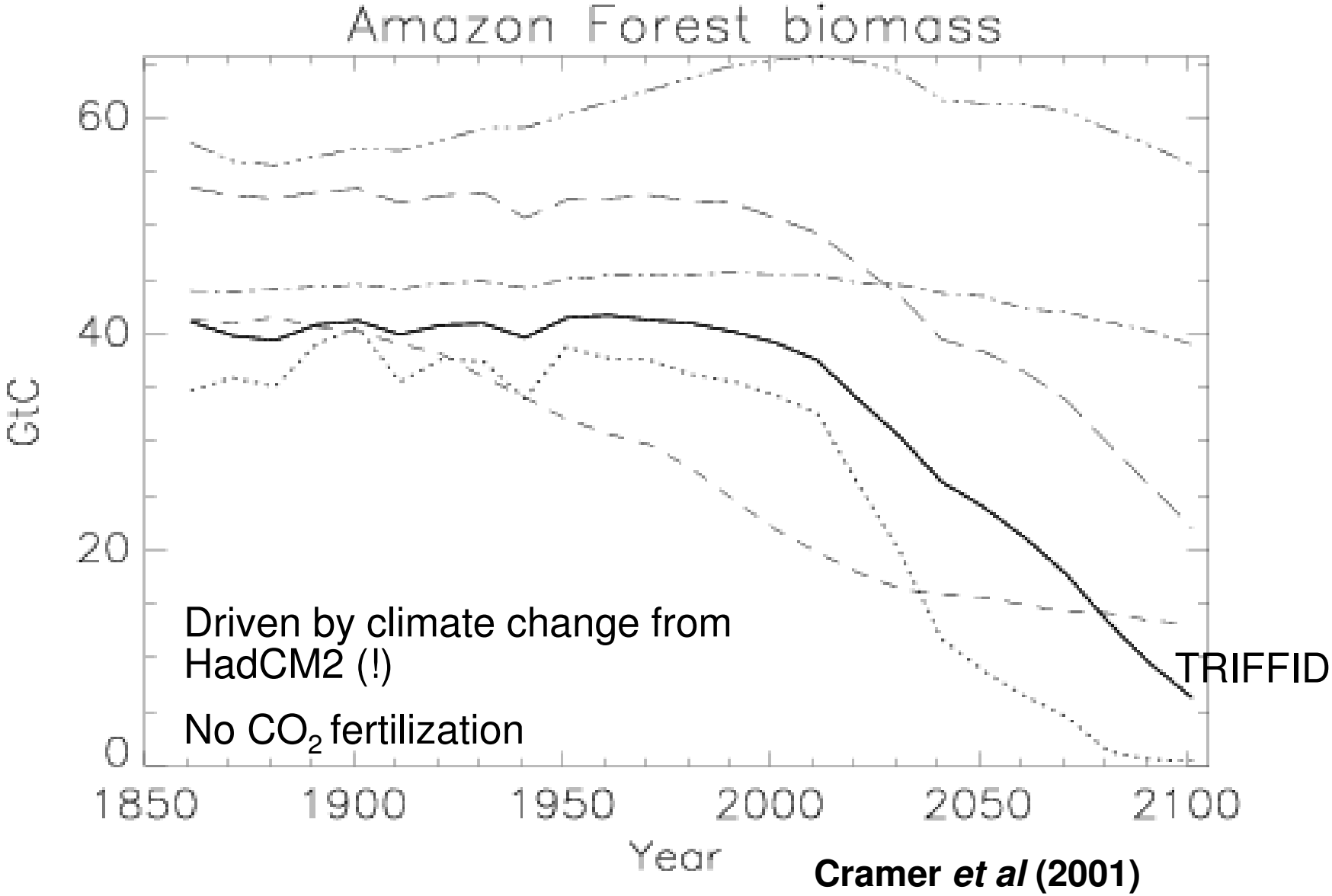
	Control	Observed	Anomaly	Future forest	2100 SRES A2
HadCM3					
CSIRO					

Different vegetation models give different rates of die-back



Cramer *et al* (2001)

So what is to be gained by reducing deforestation?

- Case 1: extreme climate change + dieback scenario
- Case 2: intermediate climate change

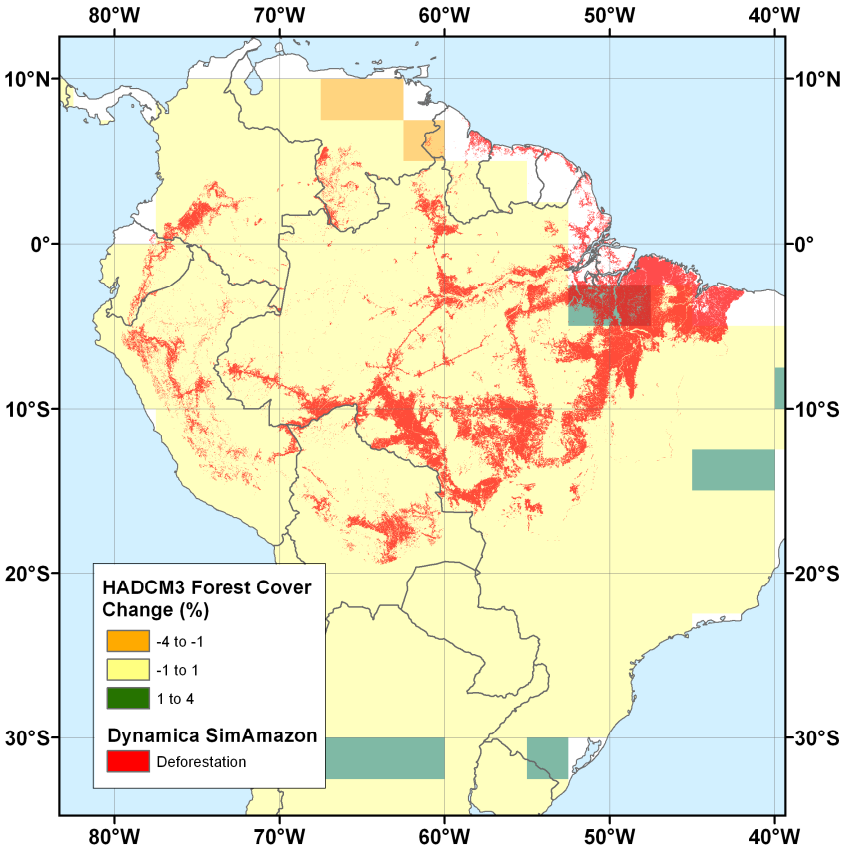
Case 1: extreme climate change + dieback scenario

- HadCM3LC projections with IS92a emissions and climate-carbon cycle feedbacks
- Vegetation change driven by climate change and CO_2 fertilization
- Compare rate of climate-change driven dieback with projected deforestation under business-as-usual (Soares-Filho et al 2006)
- Assess implications for change in vegetation carbon stocks (and hence carbon emissions)

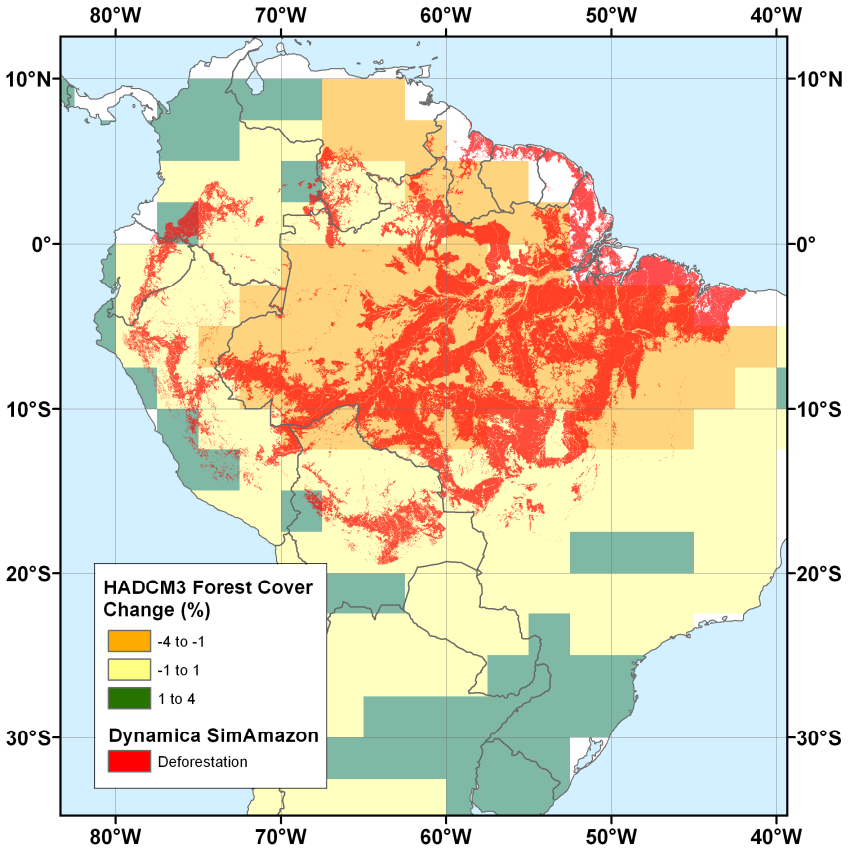
Extreme die-back scenario: still not as fast as direct deforestation

Forest cover change due to HadCM3 climate change (green, yellow, orange) and Soares-Filho *et al* (2006) deforestation (red)

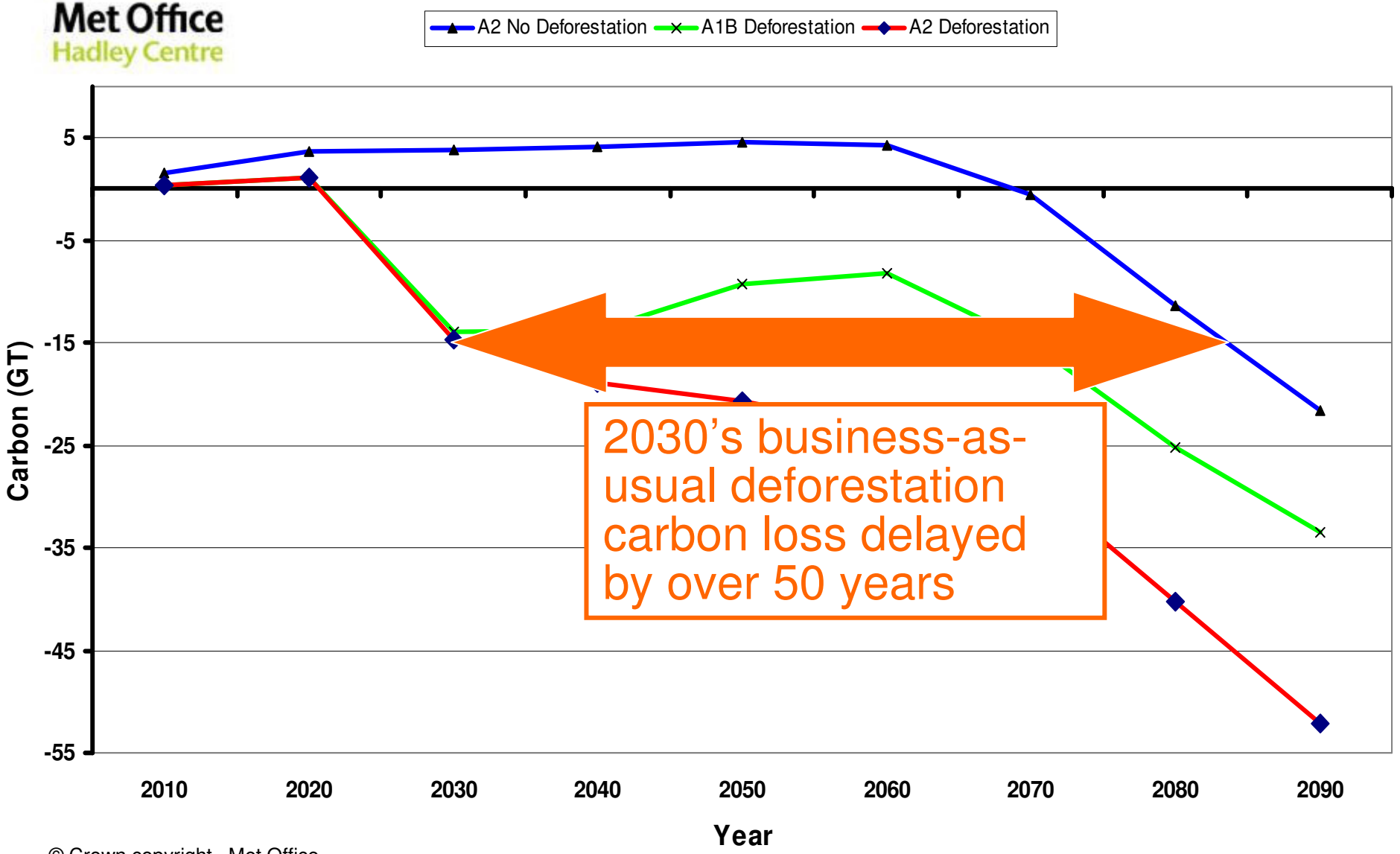
2020



2050



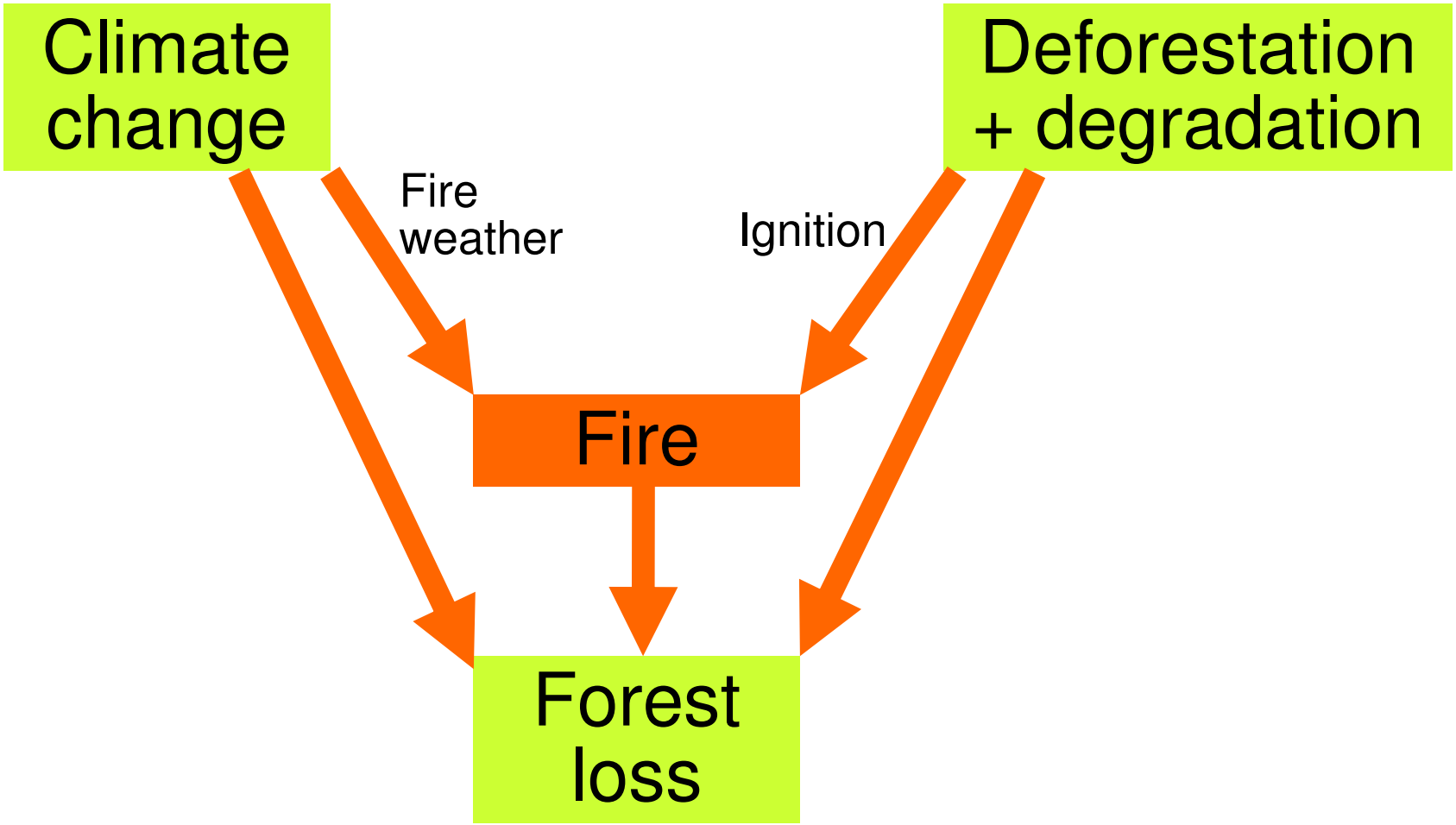
Avoiding deforestation delays carbon loss by decades, *even under extreme climate change scenario*



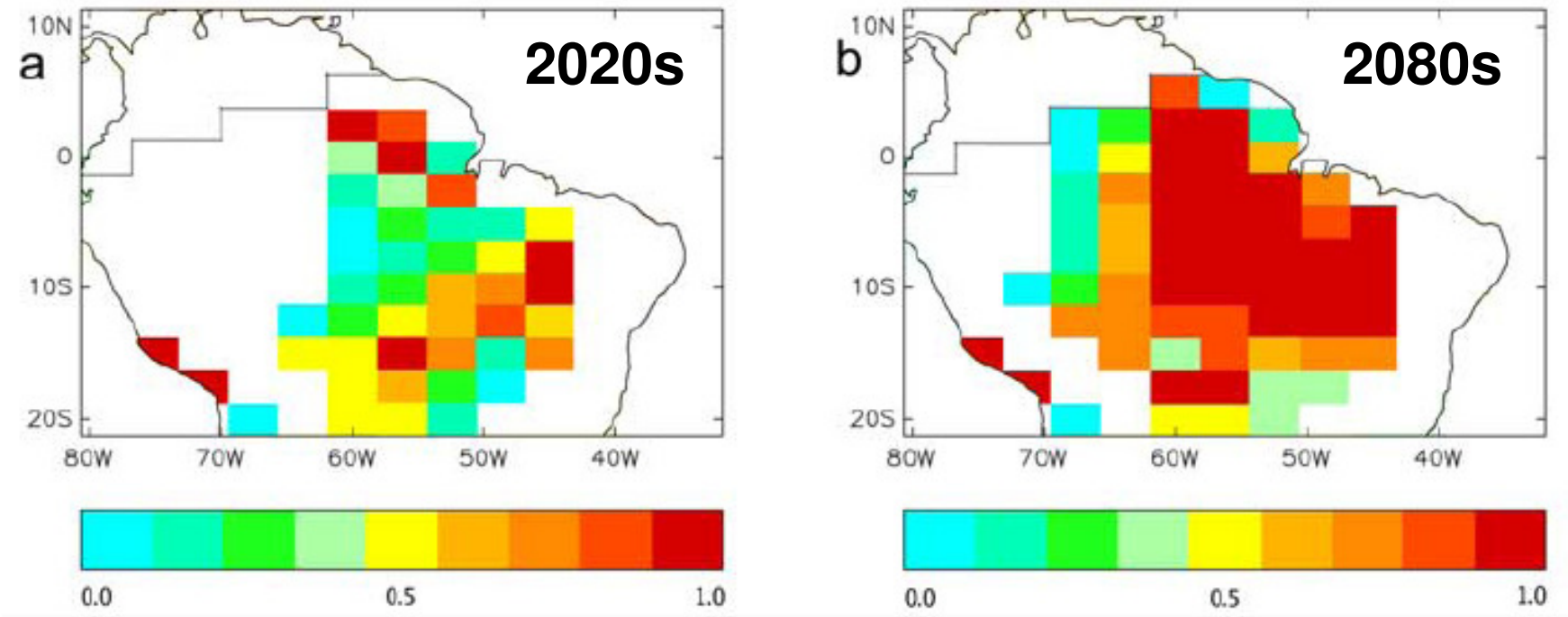
Case 2: intermediate climate change scenario

- HadCM3 projections with SRES A2 emissions and *NO* climate-carbon cycle feedbacks
- Use 17-member perturbed-physics ensemble
- Consider interactions between climate change and deforestation

Interactions between climate change and deforestation / degradation



Projected increase in fire risk due to climate change

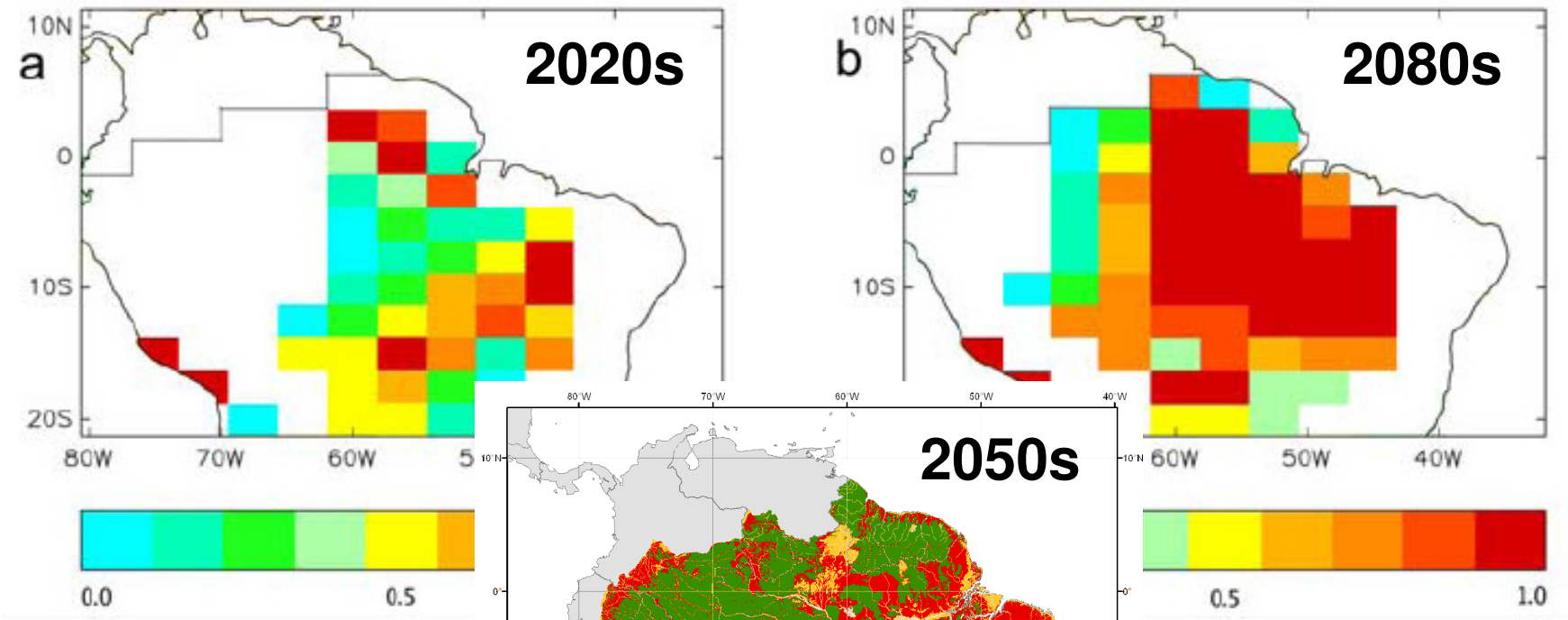


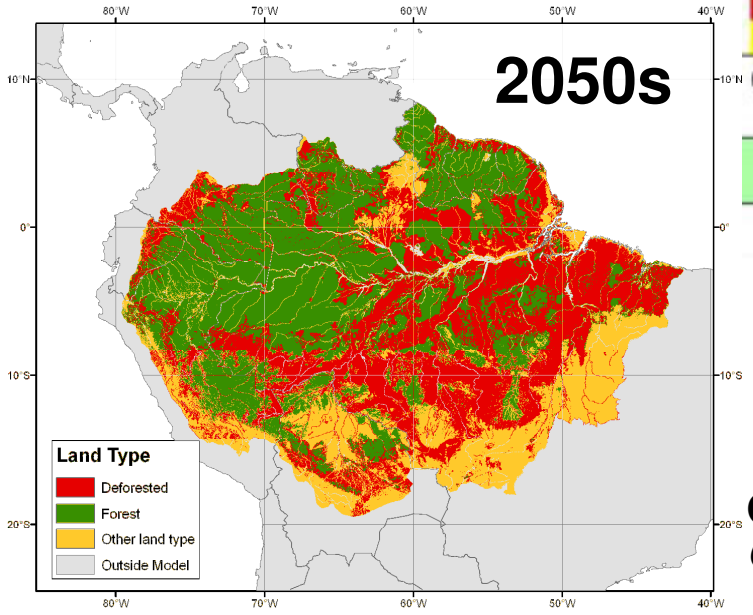
Proportion of climate model simulations projecting “high” fire risk (McArthur fire danger index)

Ensemble of simulations with HadCM3 climate model

Golding and Betts (2008)
Glob. Biogeochem. Cycles

Comparison of projected areas of high fire risk and deforestation





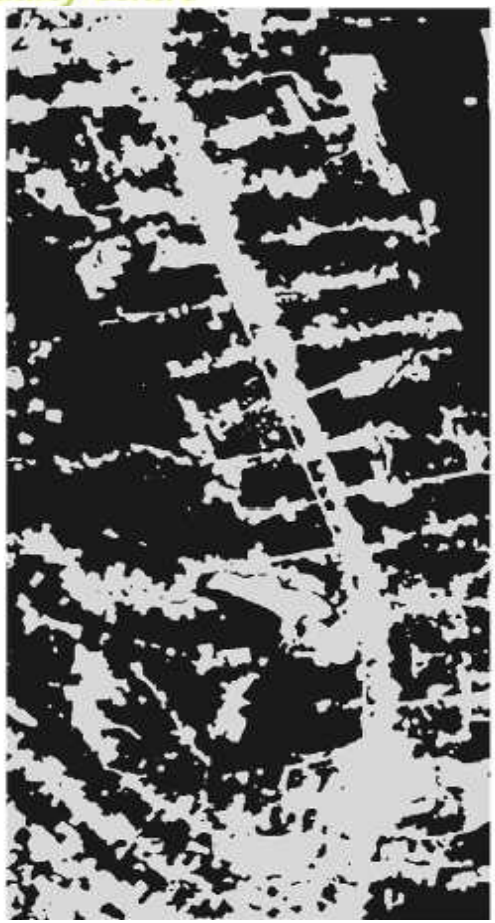
Projected deforestation, business-as-usual (Soares-Filho *et al*, 2006)

Golding and Betts (2008)
Glob. Biogeochem. Cycles

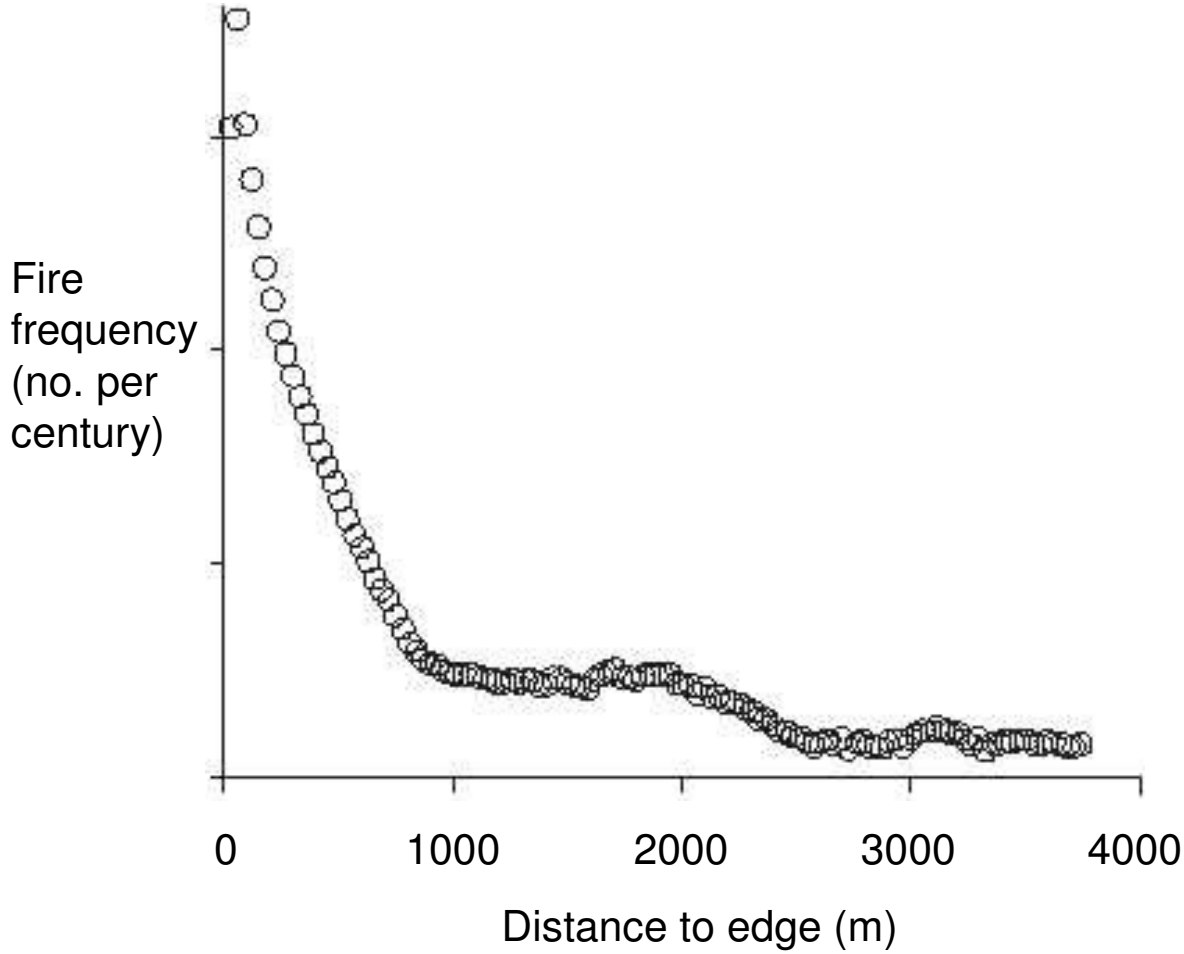
Conclusions

- The Hadley Centre climate model famously predicts warming, drying Amazon climate and “Amazon die-back”
- Other climate models project drying, but not as much
- “Die-back” also depends on sensitivity of forest
- Even in extreme climate scenario, direct deforestation leads to forest loss 50 years earlier than climate change
- Climate change may increase risk impact of deforestation through fire leakage
- Reduced deforestation is still beneficial even under climate change – buys time and reduces impact of climate change

Fragmentation of forest would increase sensitivity to climate change

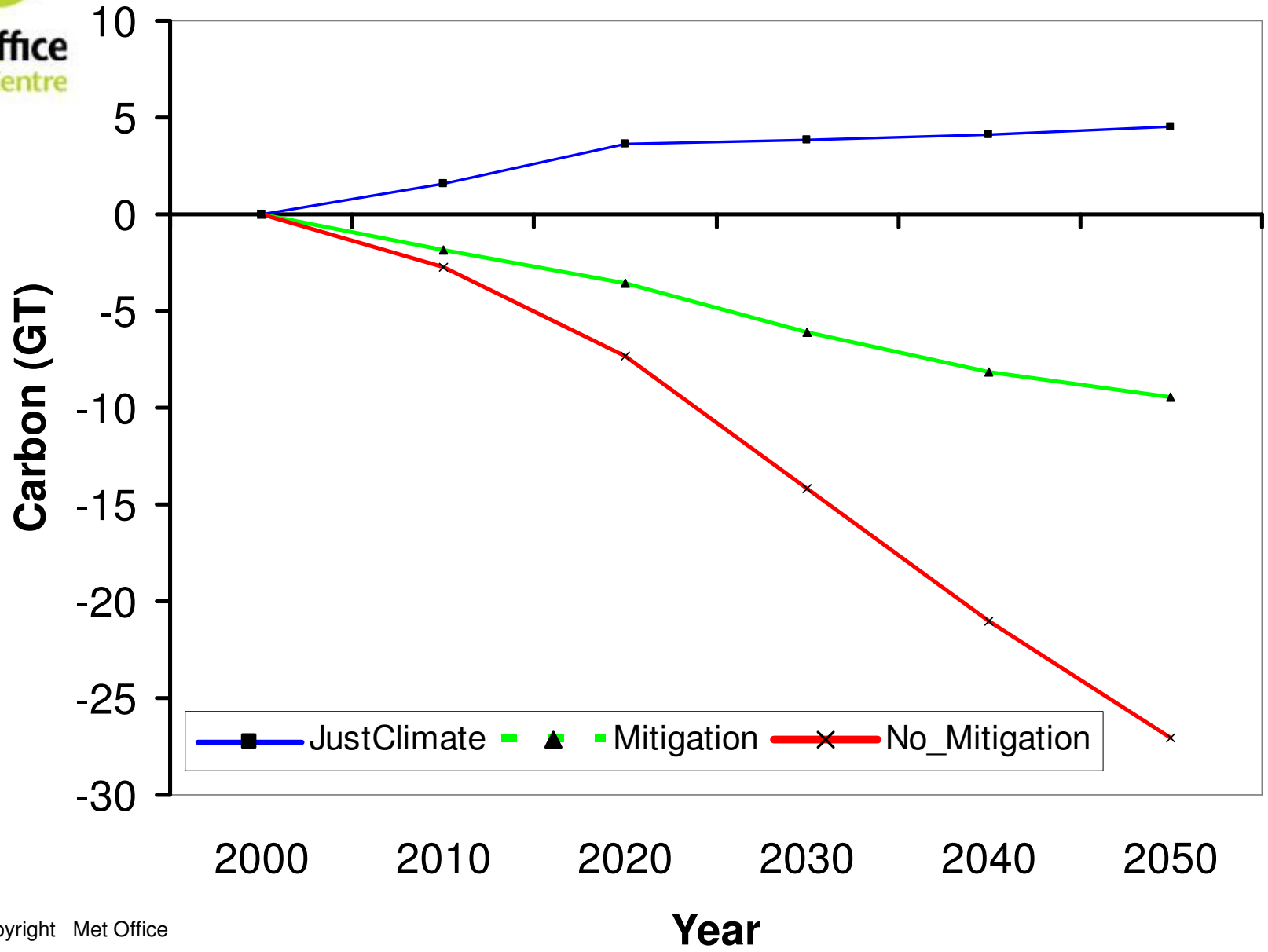


Satellite image of new forest edges due to partial deforestation



Laurence (2004)

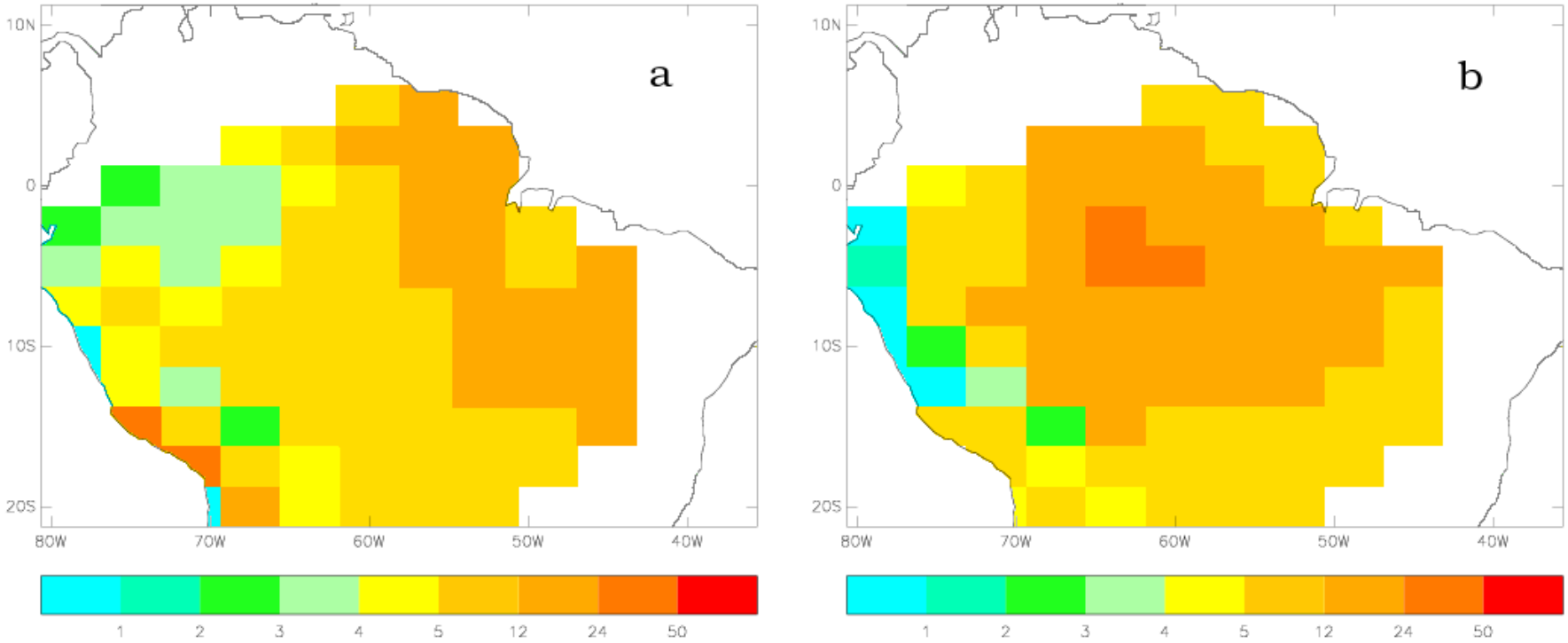
Projected change in South American forest carbon stores



Intermediate drying scenario: change in fire risk

Present day

Change by 2080s

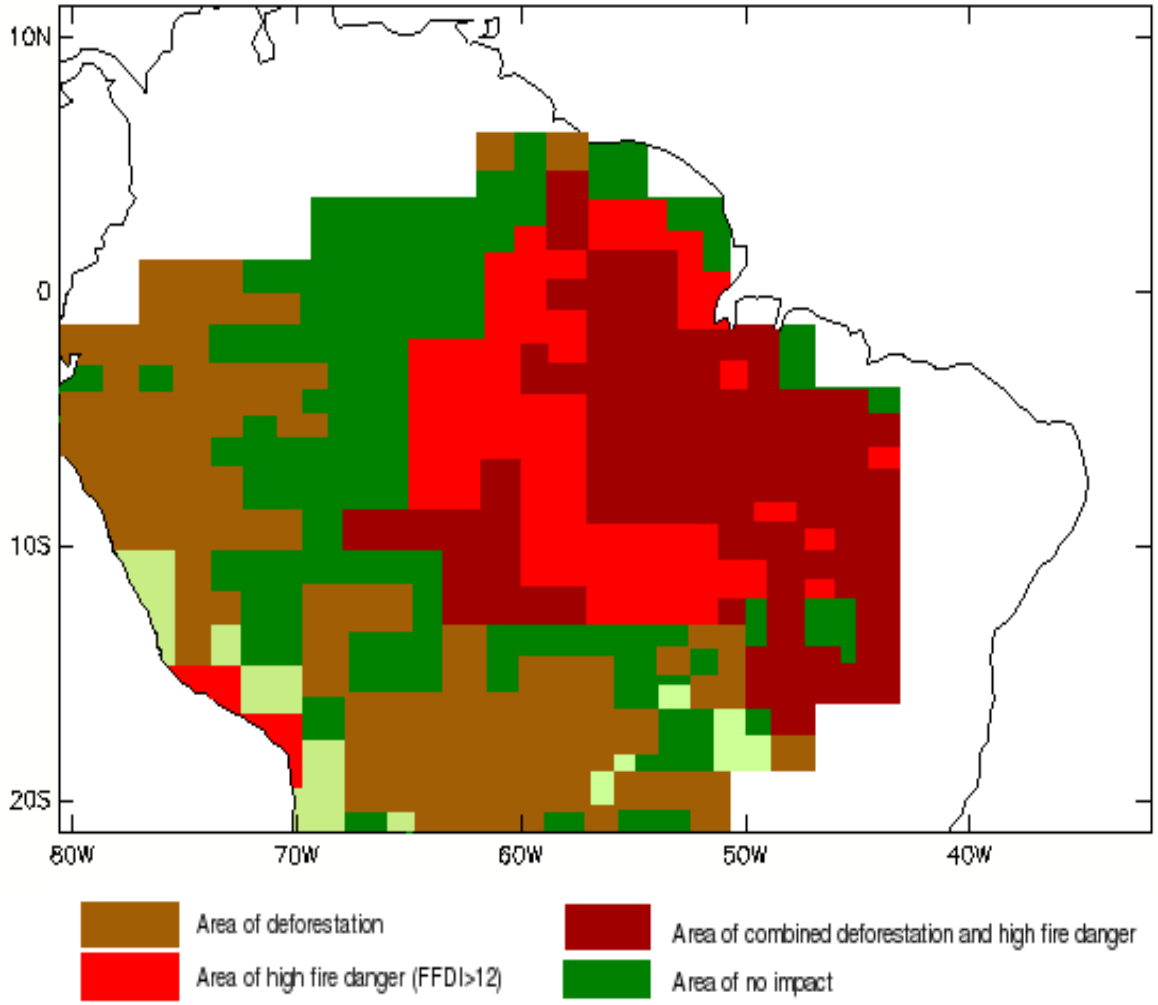


McArthur Fire Danger Index

Golding and Betts (2008)

Overlap between climate change-induced fire risk and deforestation

- Hadley climate models project reduced precipitation in Amazonia
- This would increase the risk of forest fire
- Deforestation activities are an ignition source
- Climate change may increase the impact of deforestation by increasing the risk of fire leakage



Golding and Betts (2008)

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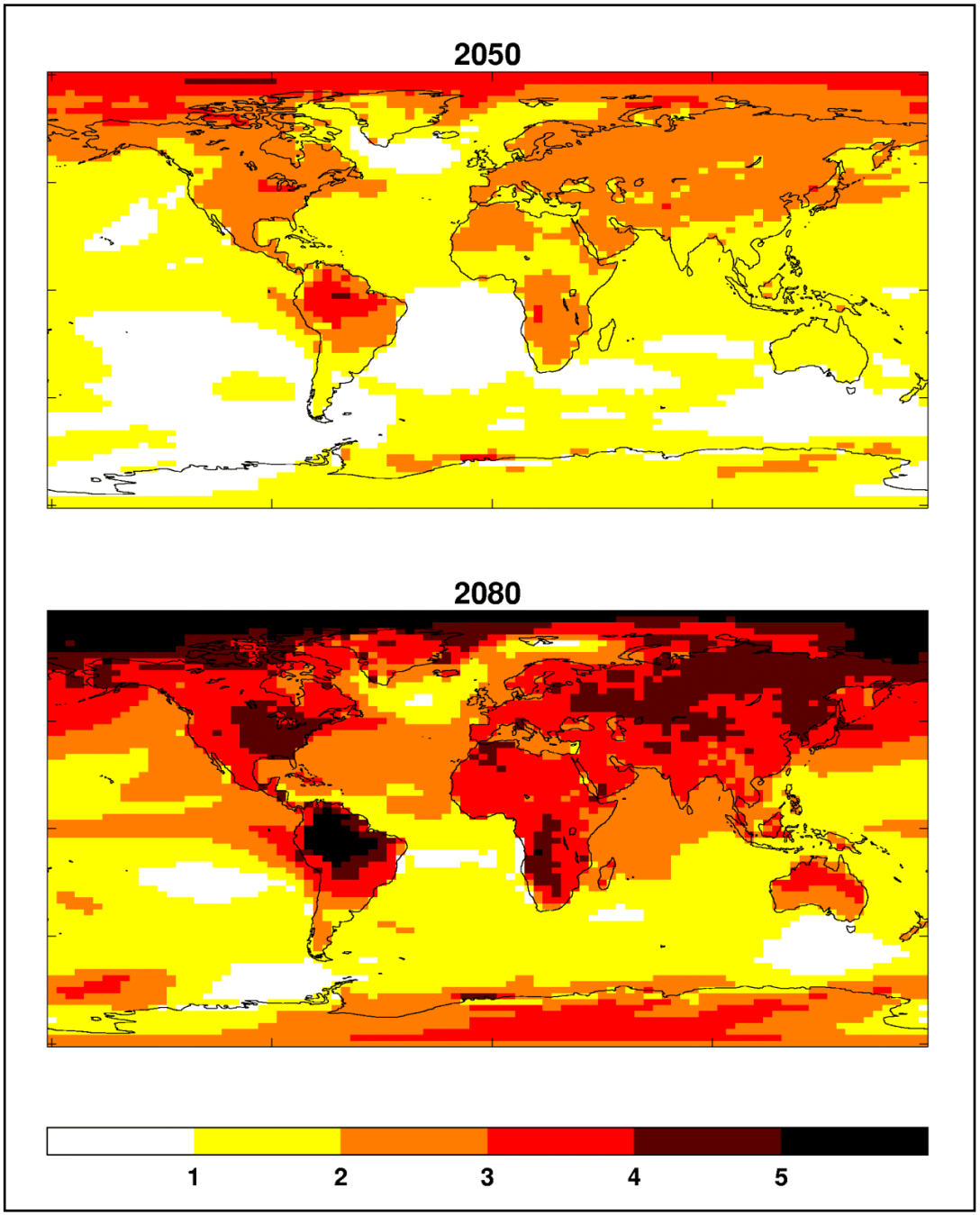
Simulated temperature changes relative to 2000 (ºC)

- Some areas warm faster than others
  - Land warms faster than ocean
  - Faster warming near poles
  - Some ocean areas warm faster than others



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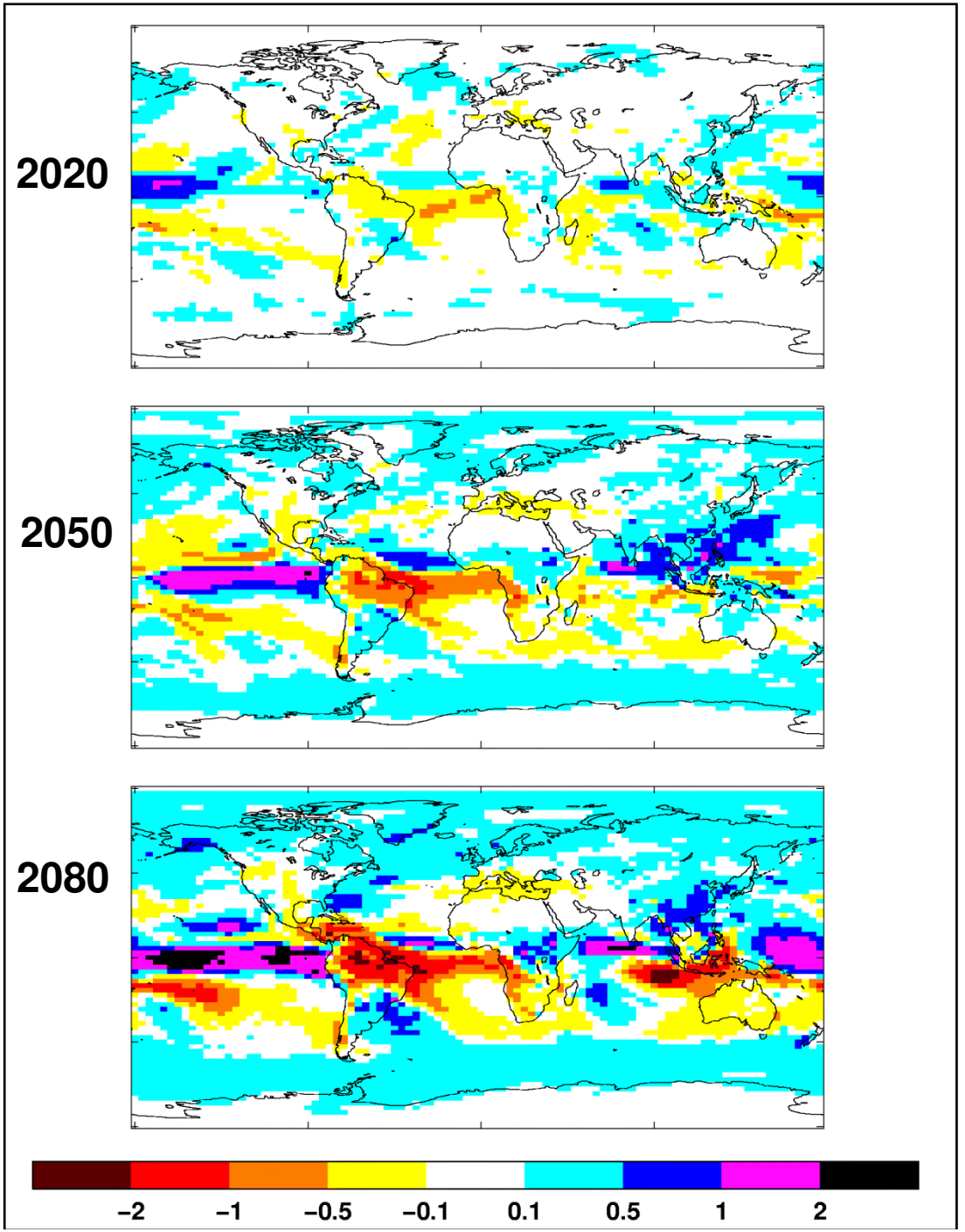
Hadley Centre

Simulated precipitation changes relative to 2000 (mm day^{-1})

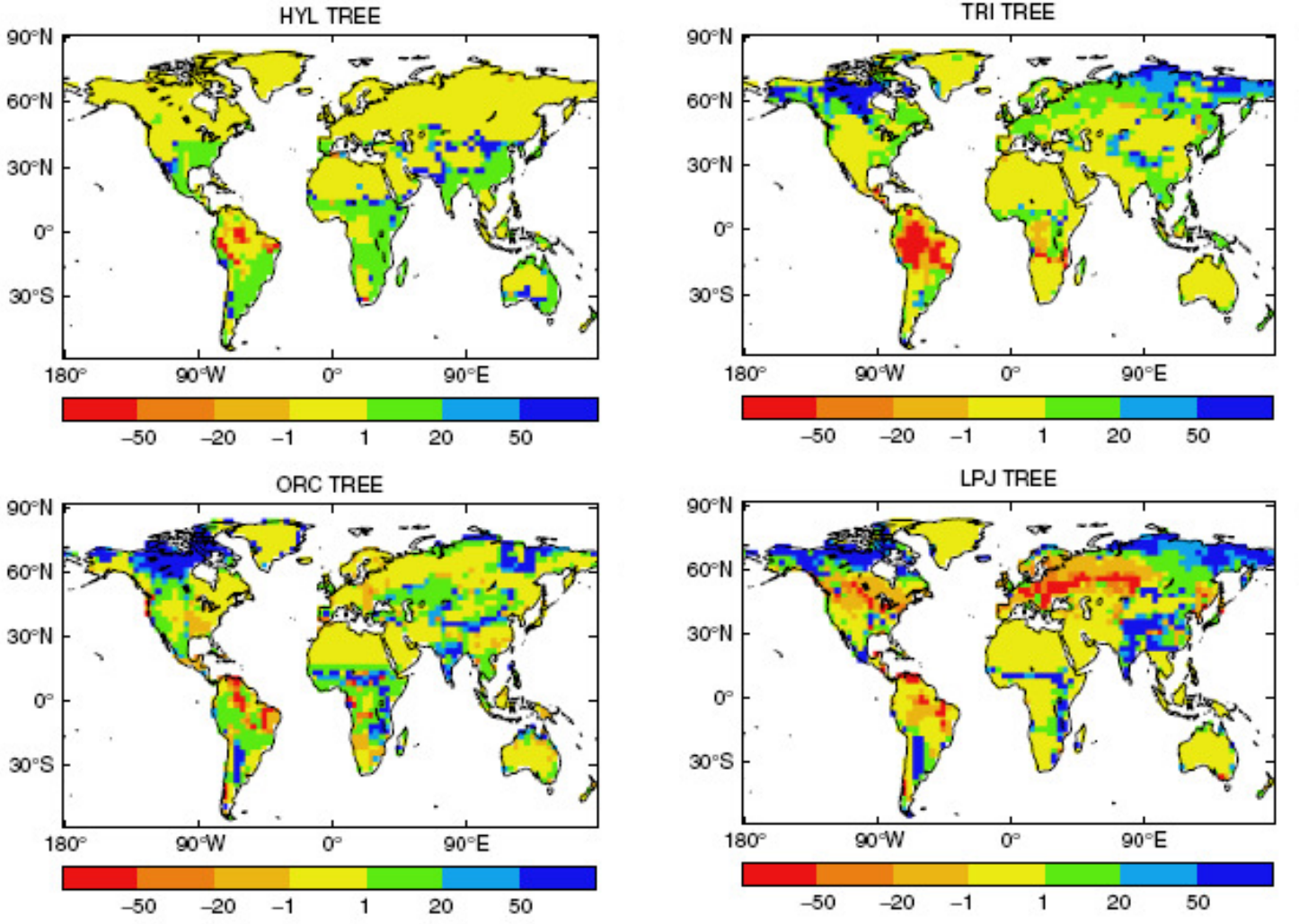
- Differing rates of local warming cause changes in atmospheric circulation
- Amazonian rainfall declines due to responses to sea surface temperature changes in Atlantic and Pacific



Different vegetation models given different levels of die-back

Simulated changes in tree cover from 1860 to 2099 in 4 DGVMs

- driven by HadCM3LC-based climate patterns in IMOGEN



Sitch et al (2008)