Land-use experiments to meet multiple needs for CMIP6

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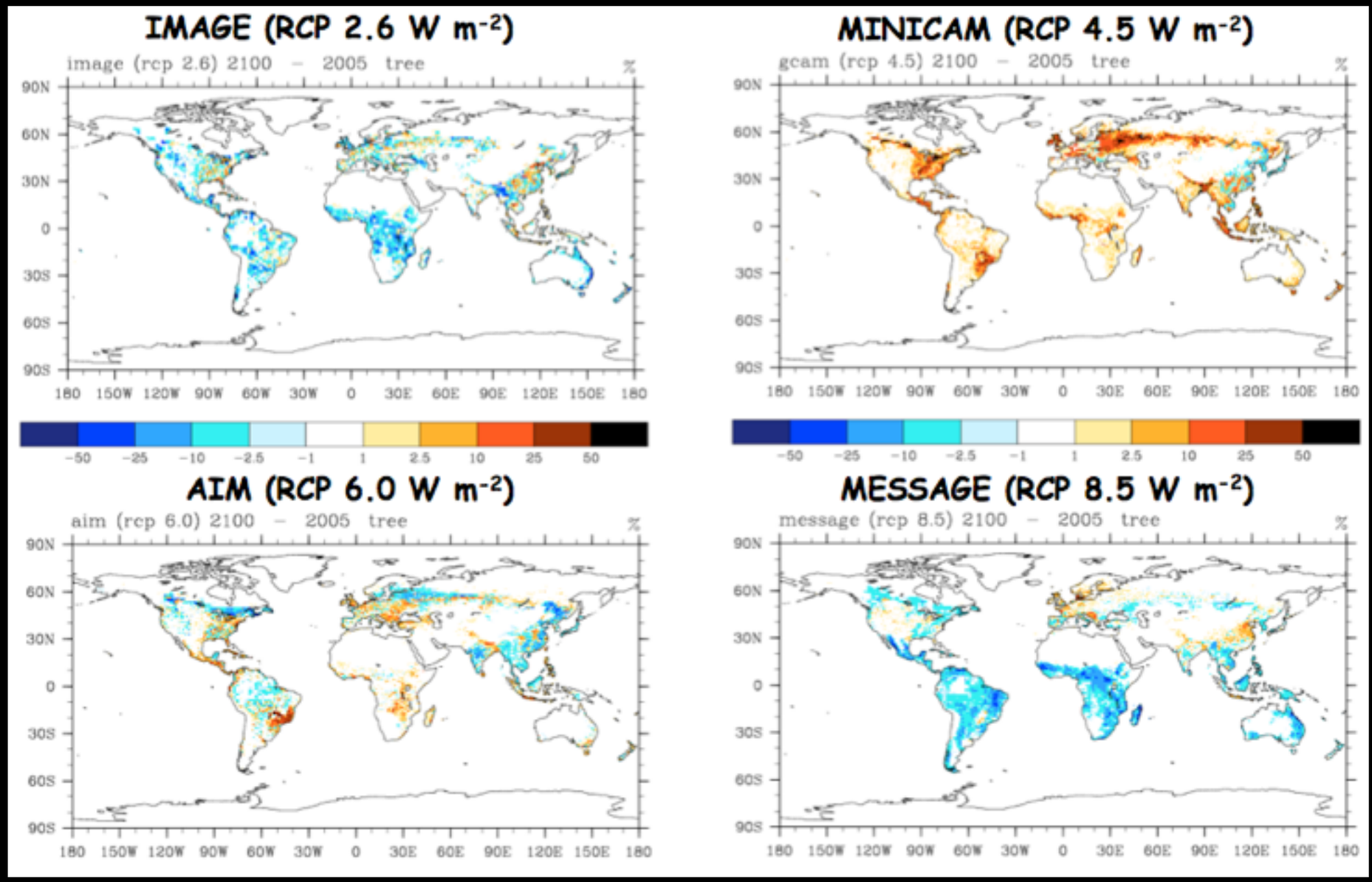
Lawrence Berkeley National Lab

William D Collins, Margaret S Torn, Katherine Calvin, Jae Edmonds, and many more

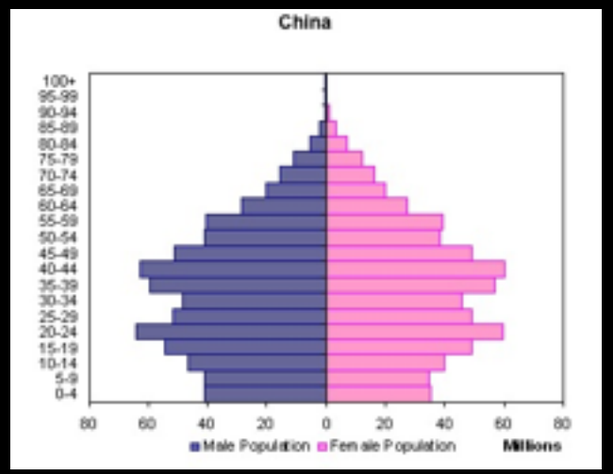
AGCI MIPfest, Aug 5 2014

Future Projections of Land Use Differ Widely



Lawrence, P. J., J. J. Feddema, G. B. Bonan, G. A. Meehl, B. C. O'Neill, S. Levis, D. M. Lawrence, K. W. Oleson, E. Kluzek, K. Lindsay, and P. E. Thornton (2011), Simulating the Biogeochemical and Biogeophysical Impacts of Transient Land Cover Change and Wood Harvest in the Community Climate System Model (CCSM4) from 1850 to 2100, *Journal of Climate*, in review.

Future Projections of Land Use Differ Widely



Demographics

Ag Technology

Climate Adaptation

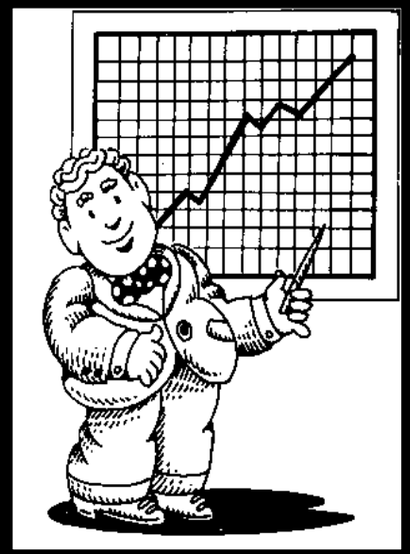
Dietary Preferences

Mitigation Policy (e.g. biofuels, afforestation)

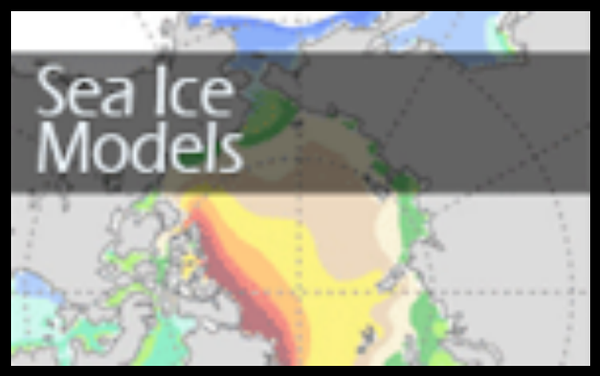
	SSP1	SSP2	SSP3	SSP4	SSP5	SRES
RCP8.5						X
RCP6.0						X
RCP4.5						X
RCP2.6						X

The Integrated Earth System Model (iESM)

GCAM and GLM



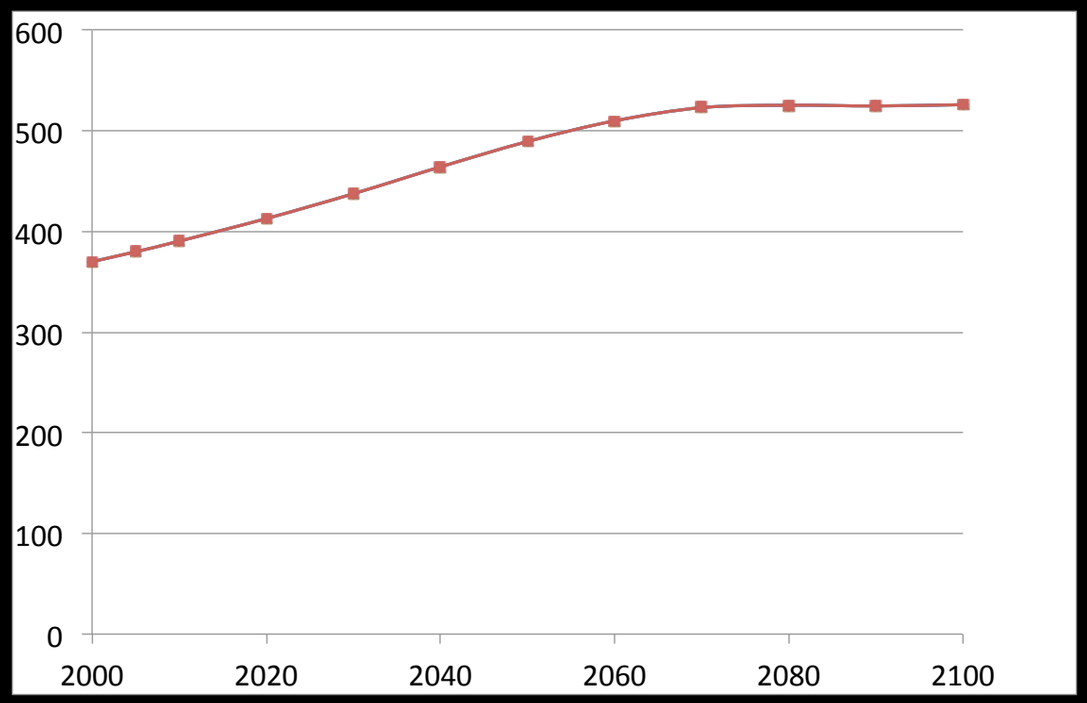
Economics
Demographics
Energy System
Ag System



Do all RCP4.5 policies lead to same climate?

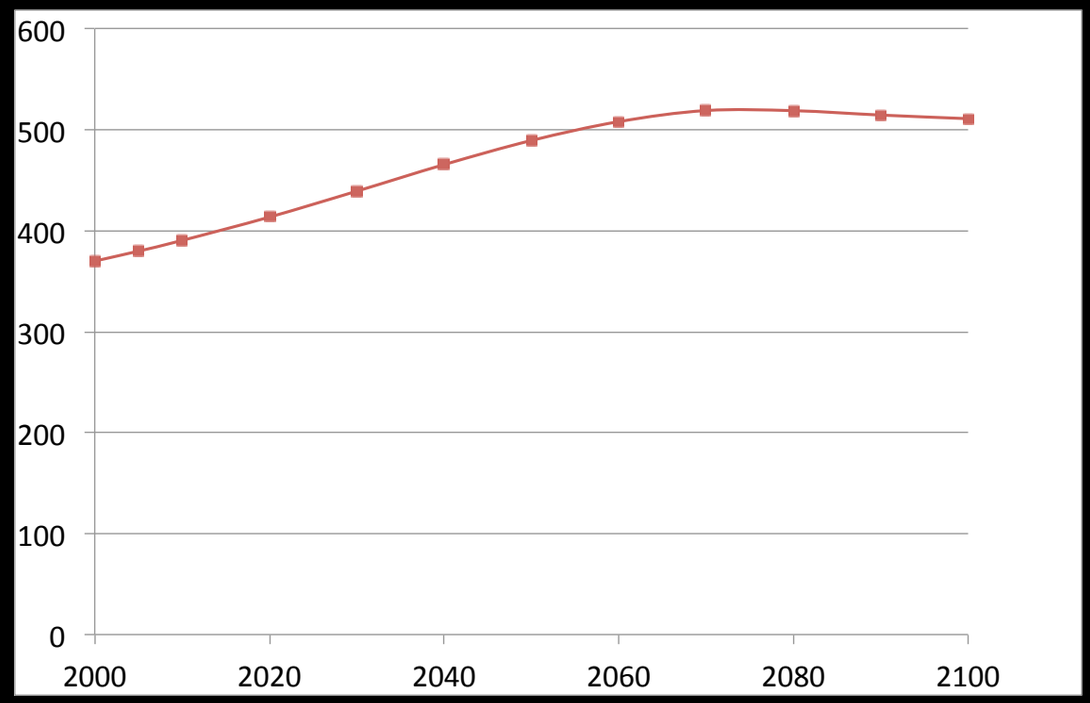
Two Scenarios: 2005-2100

Universal Carbon Tax (UCT)



CO_2 Concentration (ppm)

Fossil Fuel and Industrial Carbon Tax (FFICT)



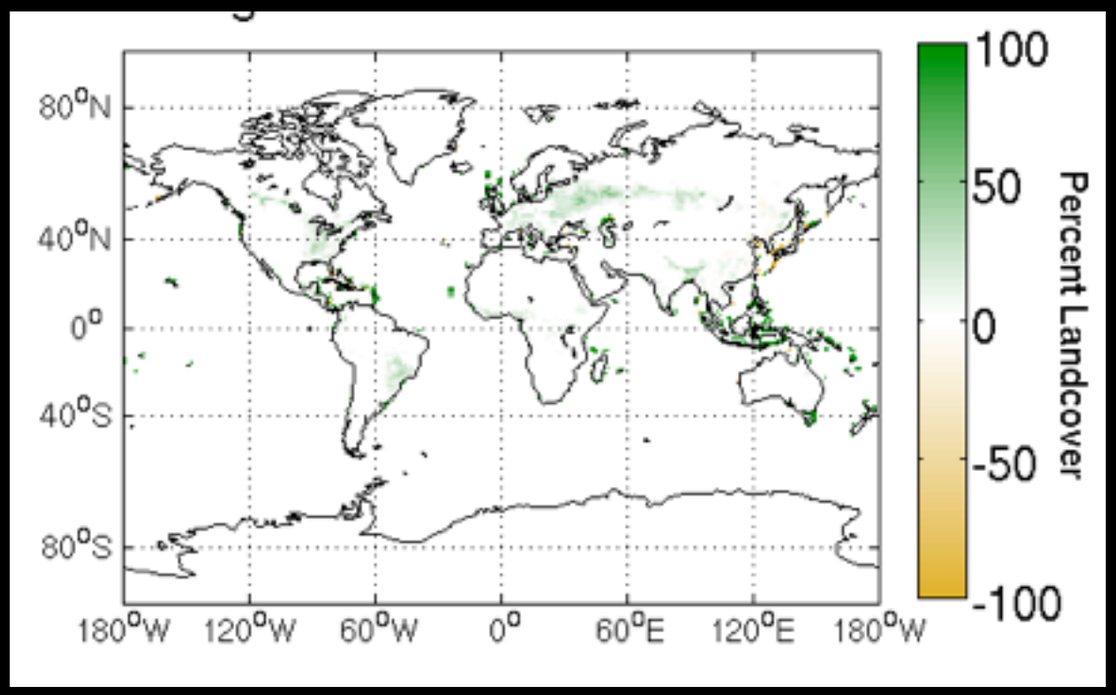
Identical forcing from greenhouse gases and aerosols

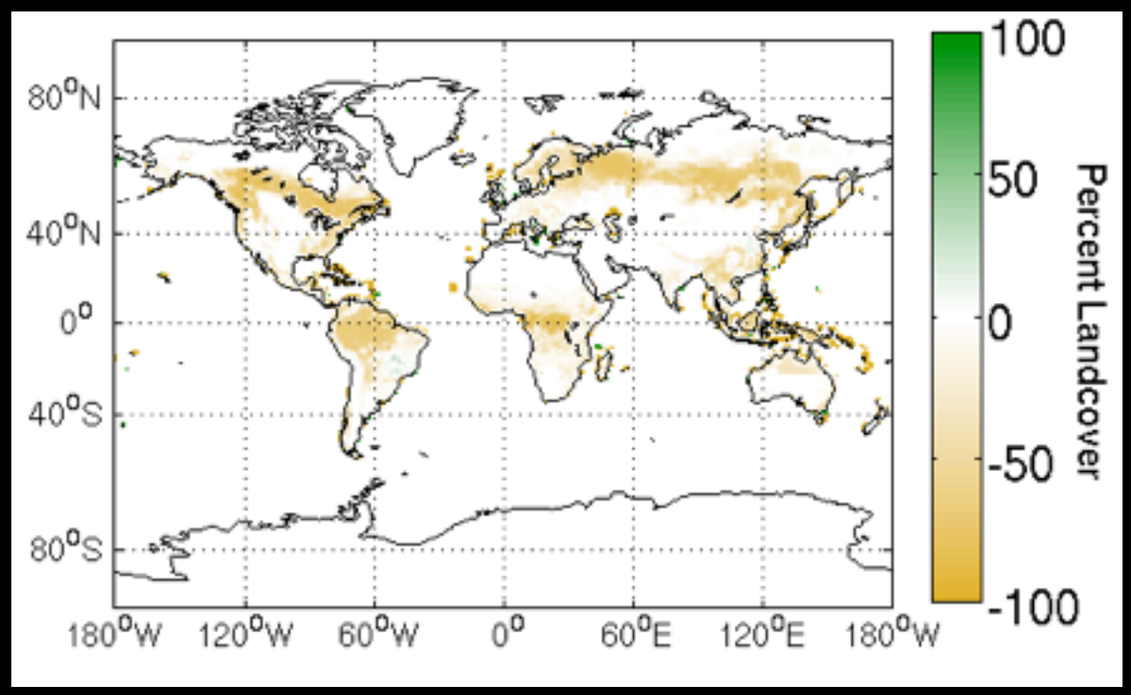
Do all RCP4.5 policies lead to same climate?

Two Scenarios: 2005-2100

Universal Carbon Tax (UCT)

Fossil Fuel and Industrial Carbon Tax (FFICT)

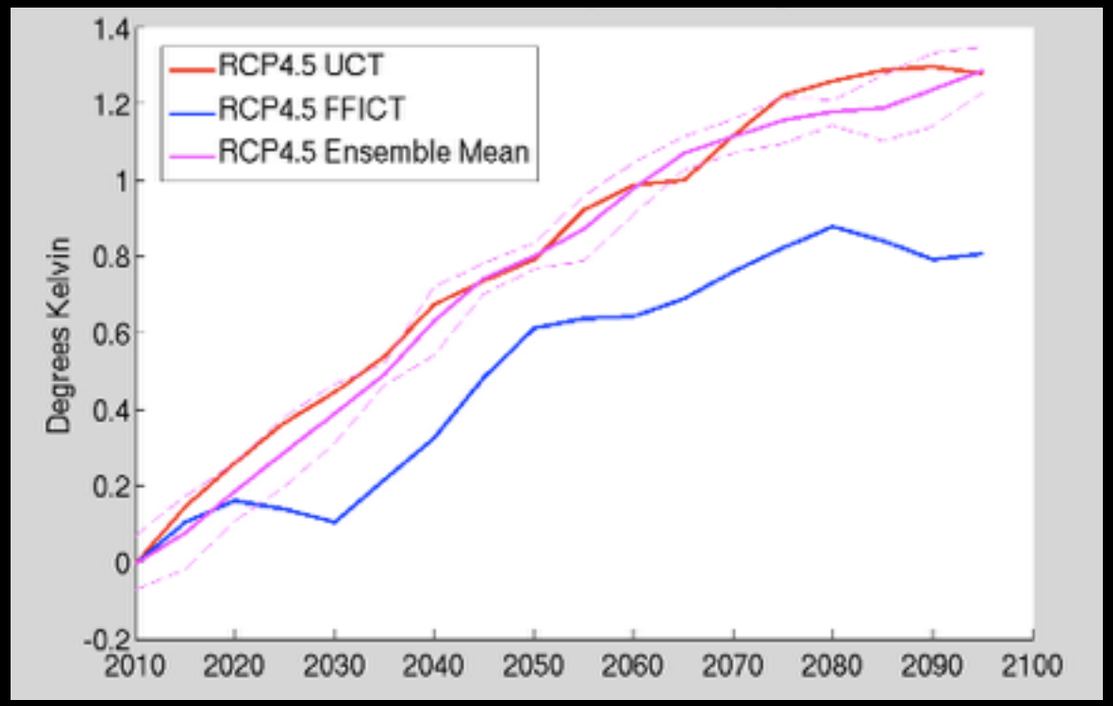




Change in Forest Cover from 2005 to 2100

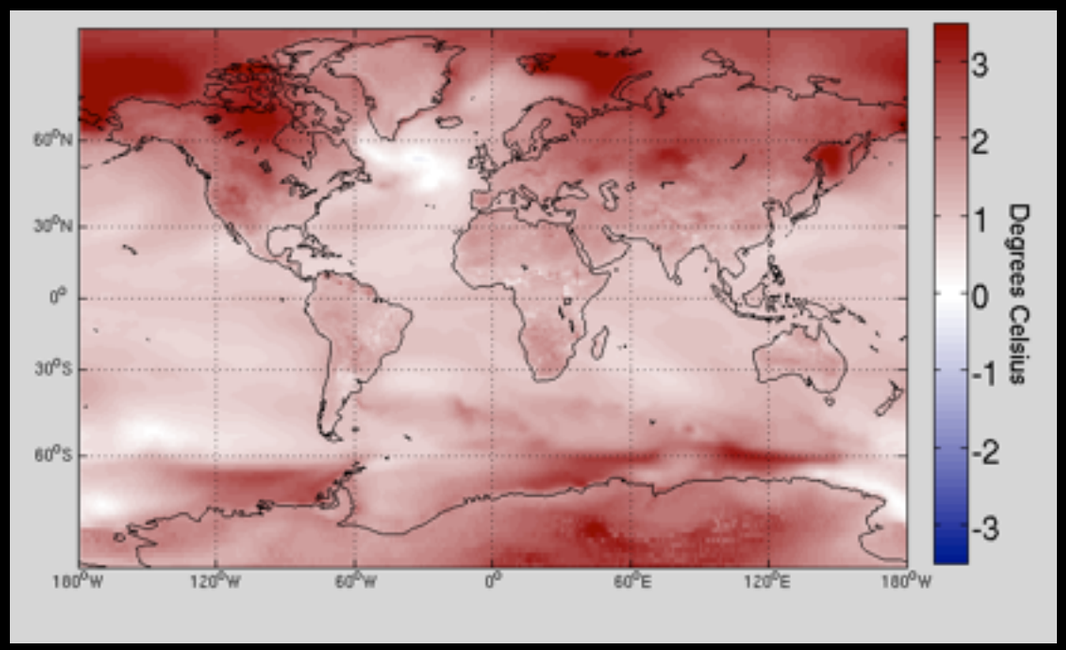
Very different patterns of land use change

Global Mean Temp Change

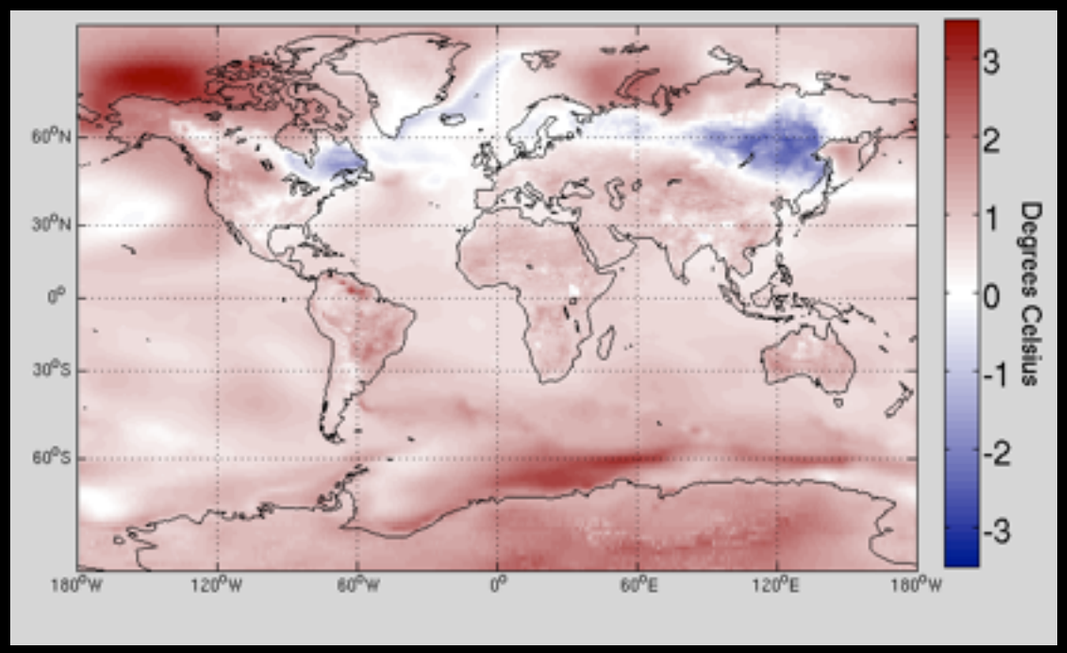


Temperature change from first (2005-2015) to last (2091-2100) decade

RCP4.5 UCT

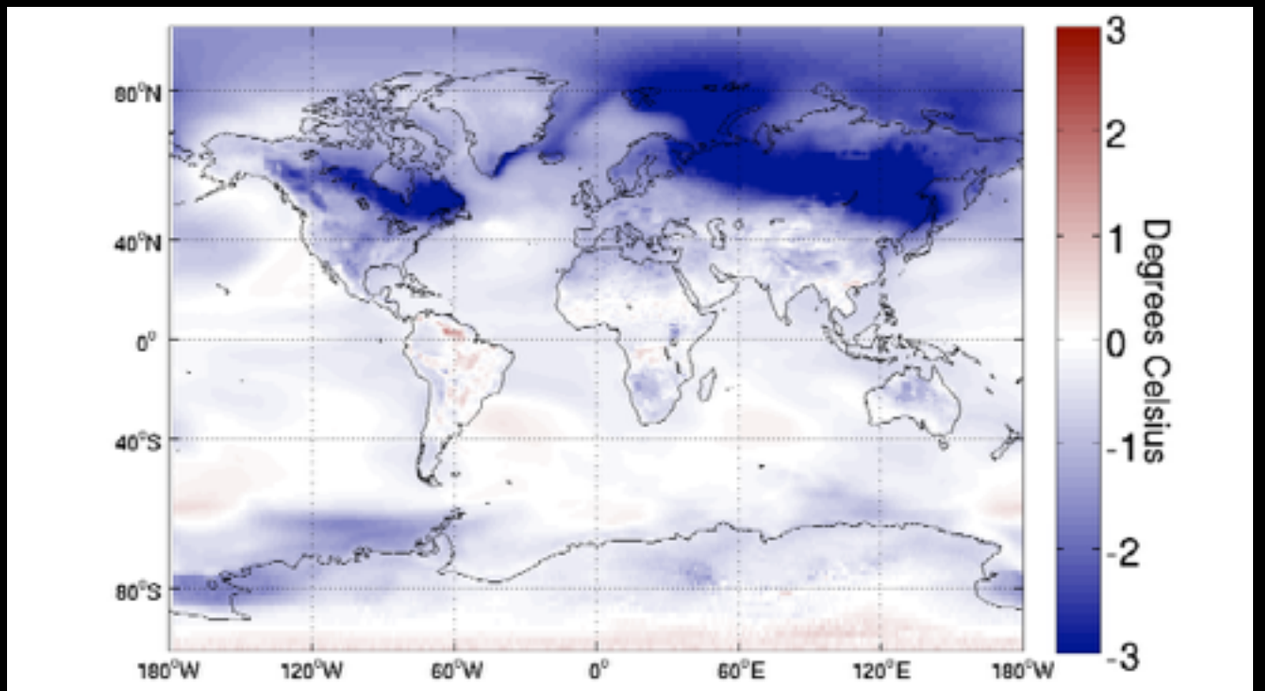


RCP4.5 FFICT

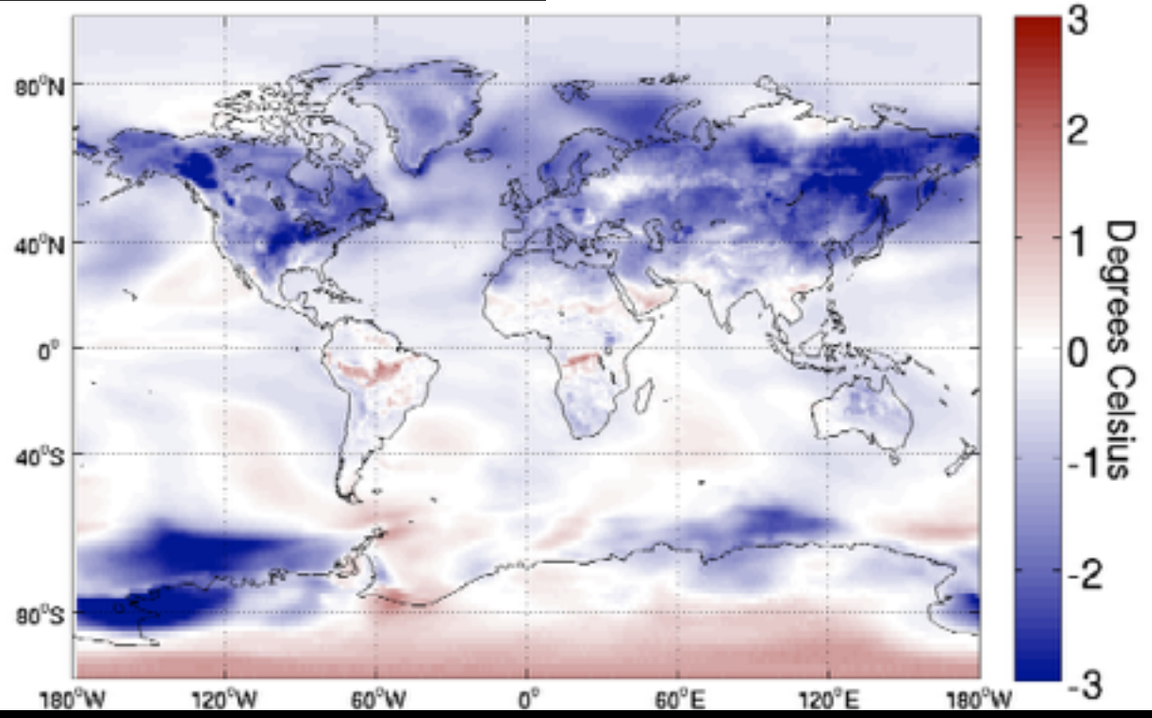


Temperature difference *FFICT-UCT*
(decadal mean, 2090-2100)

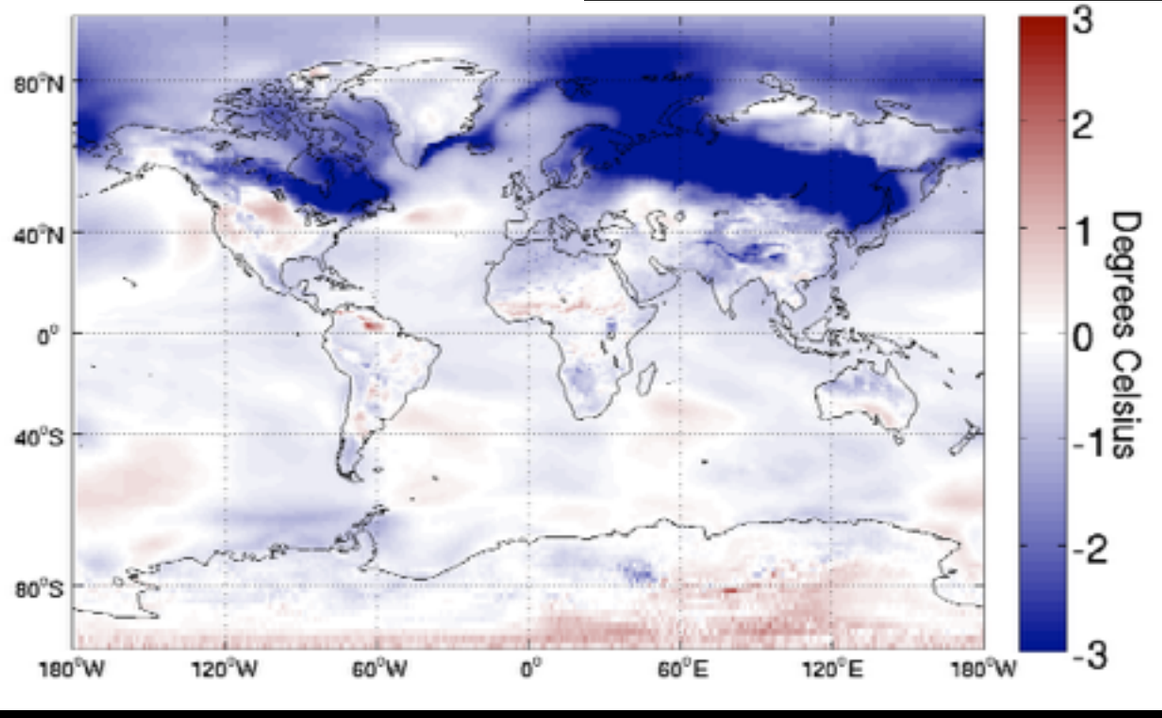
Annual Mean



NH Summer



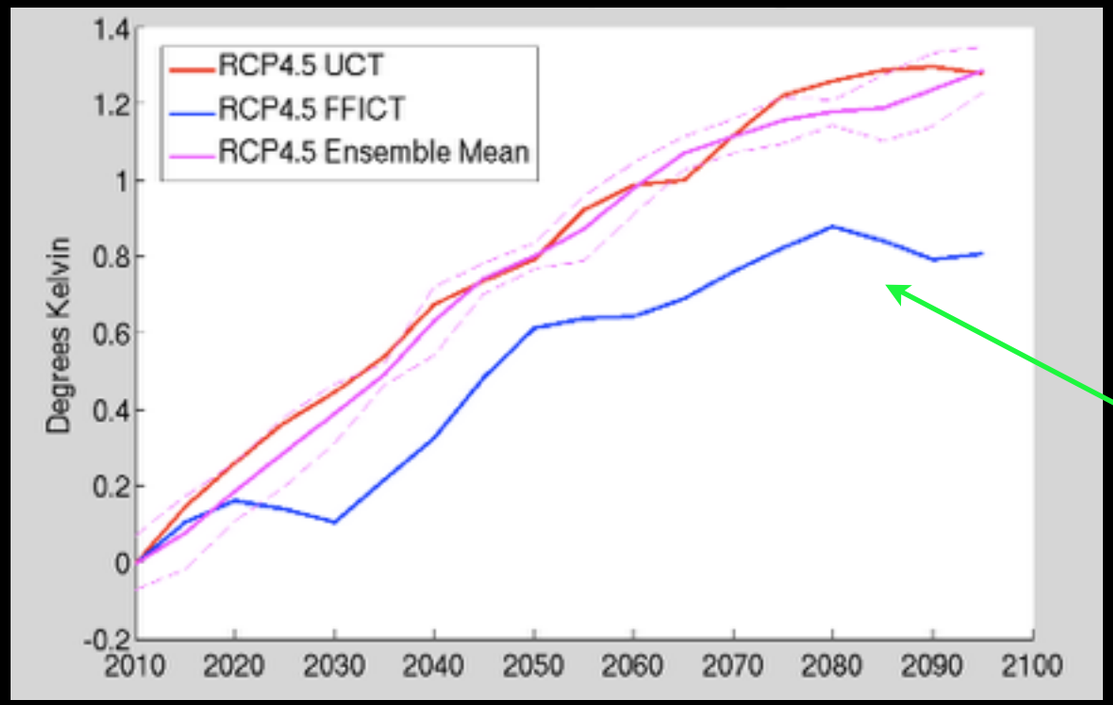
NH Winter



Important Notes

- Concentrations forced
  - Therefore isolates biophysical effects
- Range forest cover may exceed SSP range
- Only one IAM, one ESM

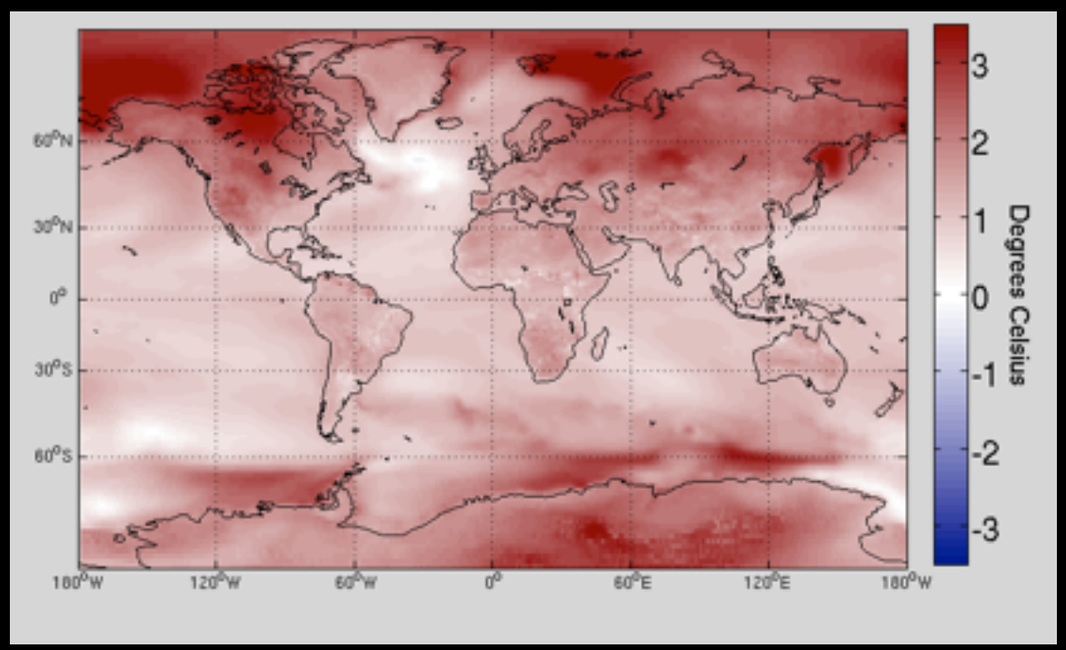
Global Mean Temp Change



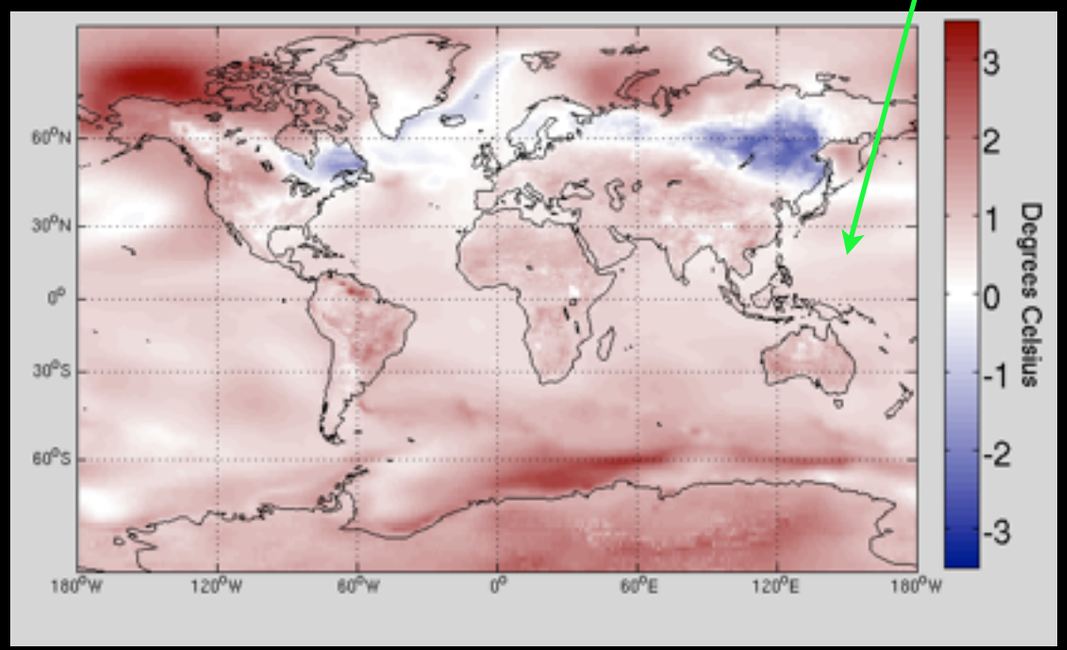
Actually RCP 3.9 !

Temperature change from first (2005-2015) to last (2091-2100) decade

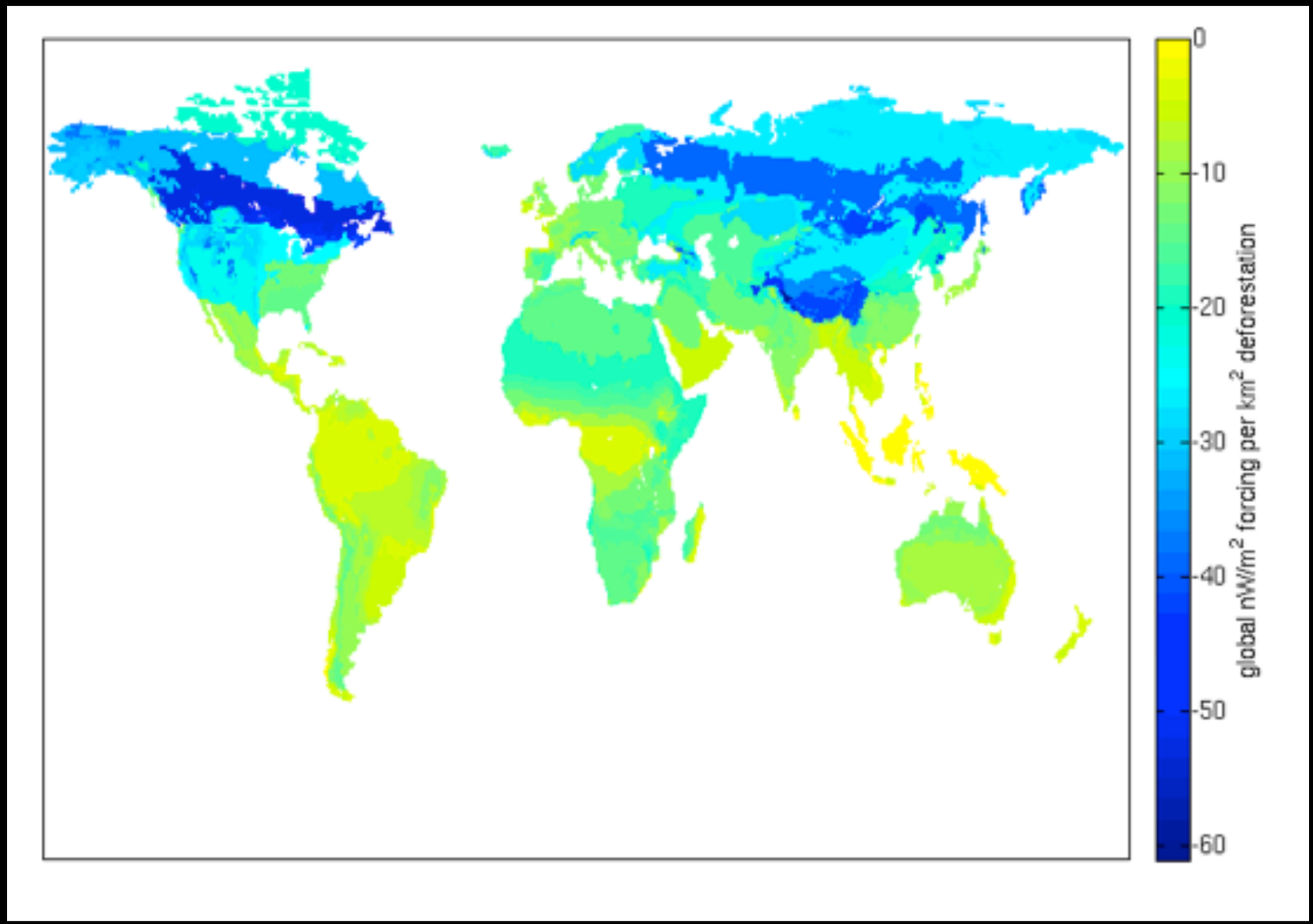
RCP4.5 UCT



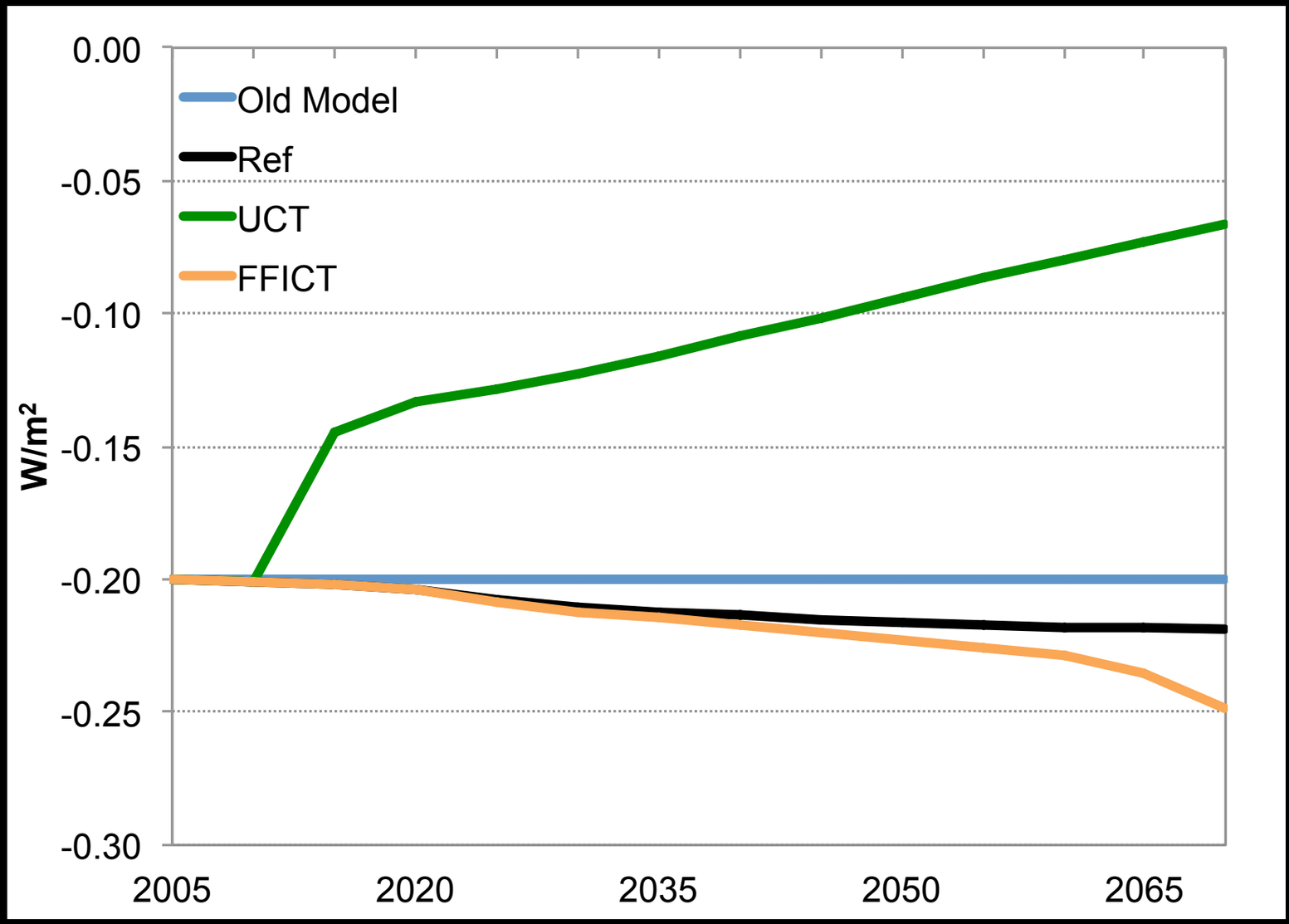
RCP4.5 FFICT



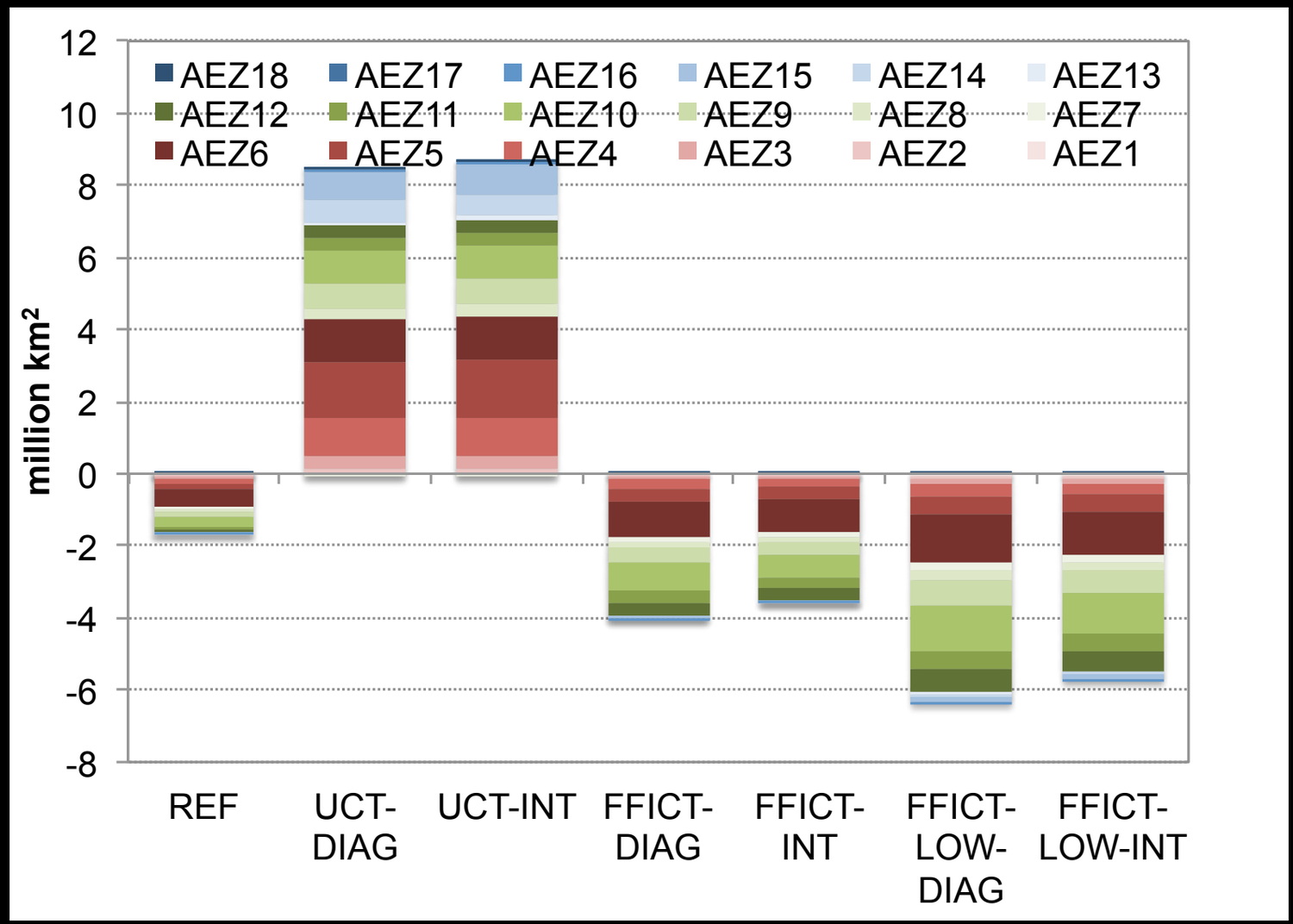
Accounting for land-use forcing within GCAM



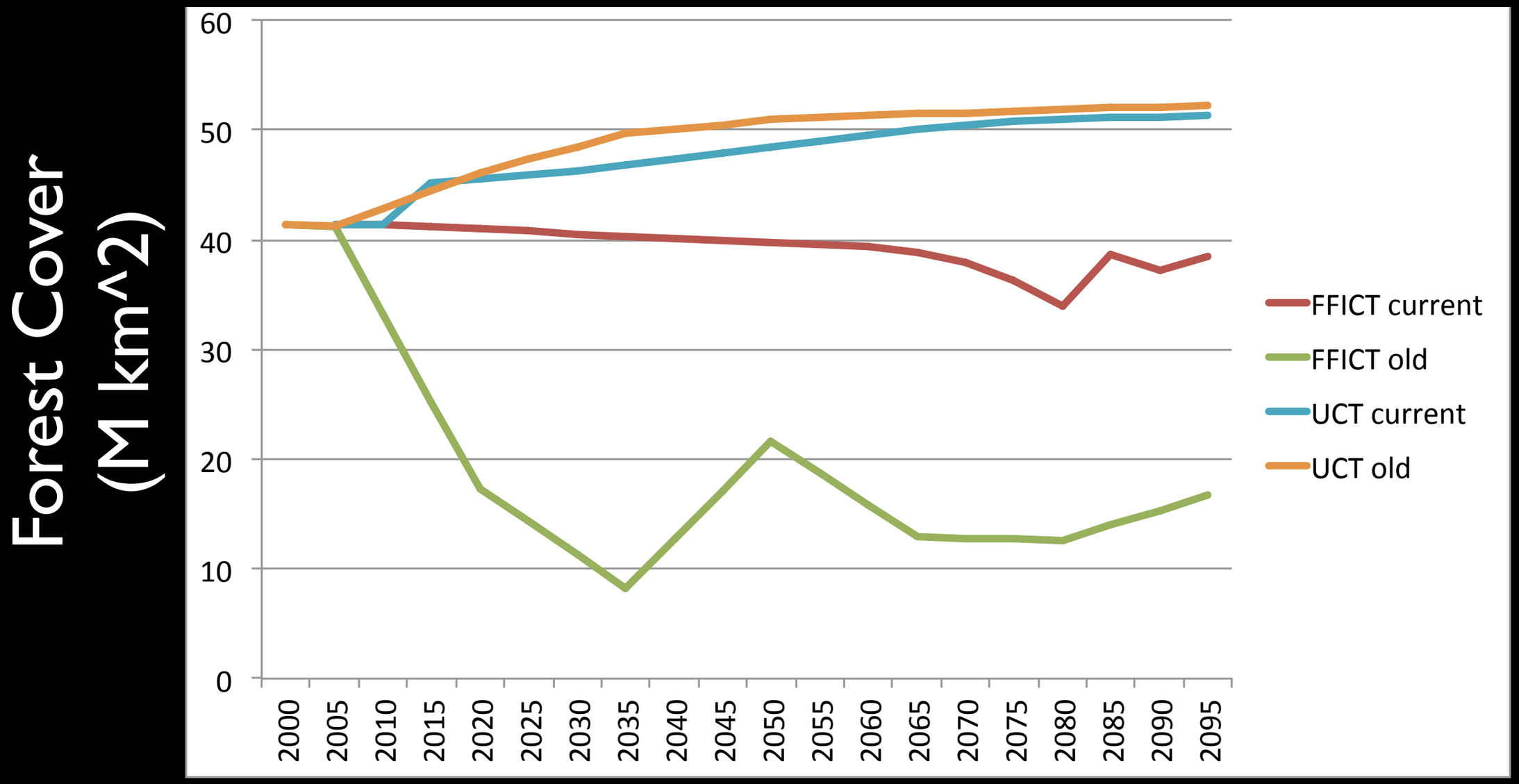
Forcing from Land-Use Change



Regional Differences Matter

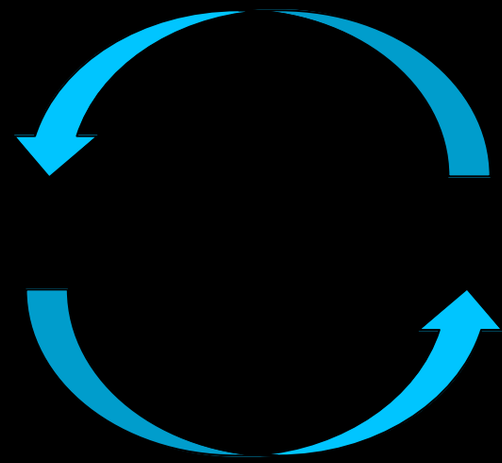


Forcing range is smaller in new GCAM



To what extent is land-use forcing equivalent to GHG forcing ?

Photographer: Roman Makhmutov



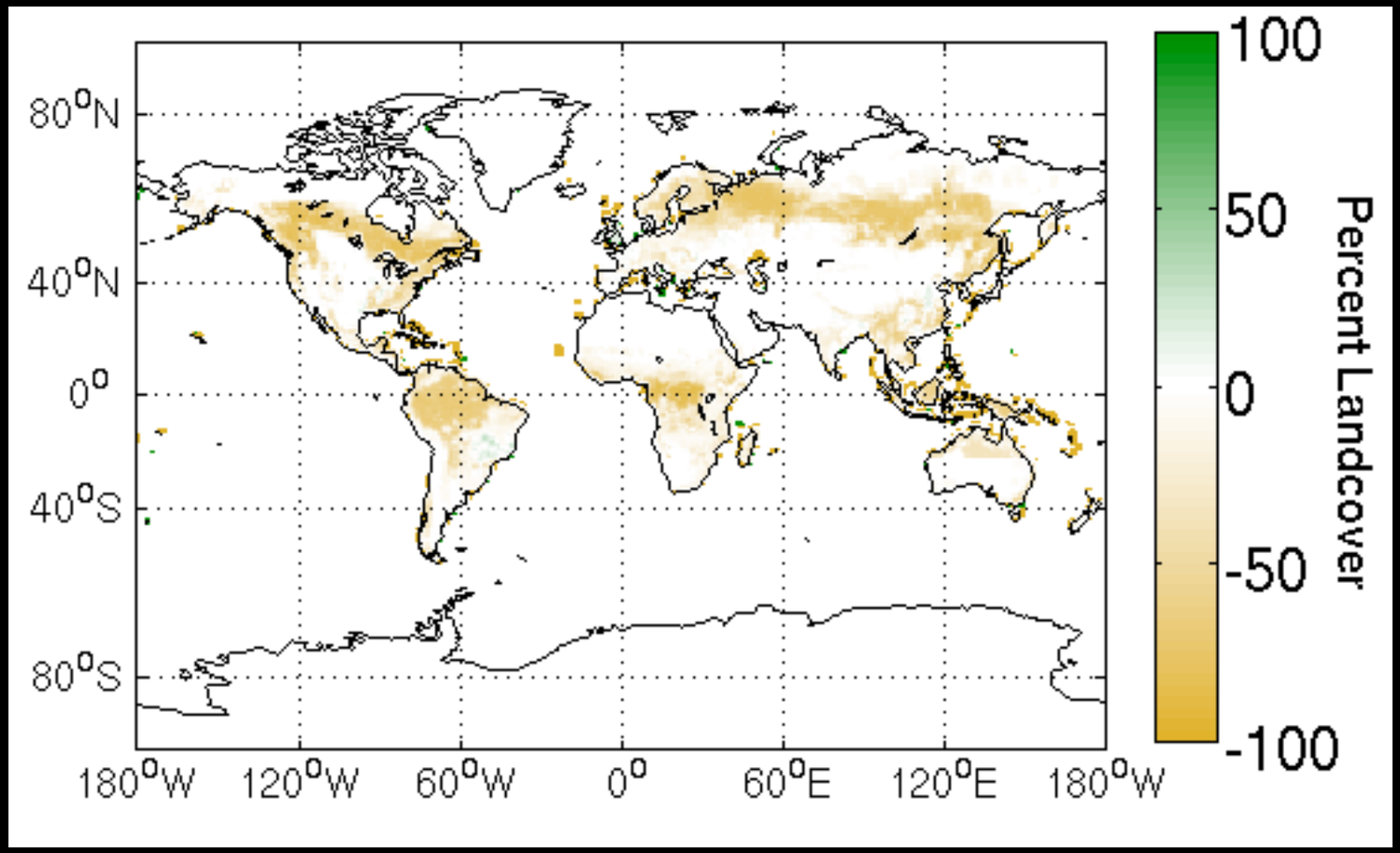
- non-radiative (e.g. hydro) effects
- spatially concentrated effects

Three Simulations

Equilibrium response relative to pre-industrial

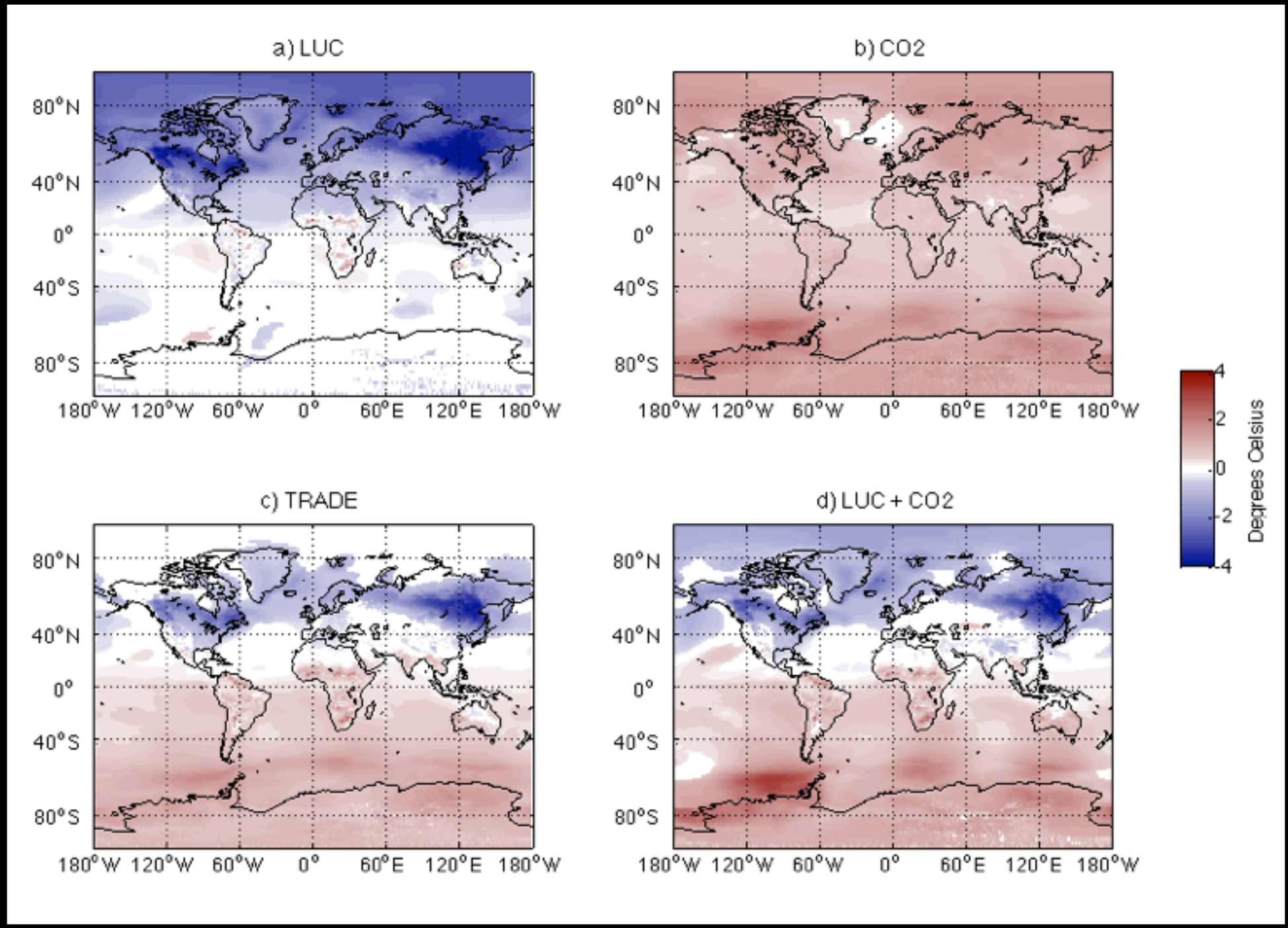
	land forcing	CO forcing	net forcing
	W/m	W/m	W/m
Land Use Change Only	-1		-1
Equivalent CO		+1	+1
Land Use Change and Equivalent CO	-1	+1	0

Pattern of Deforestation

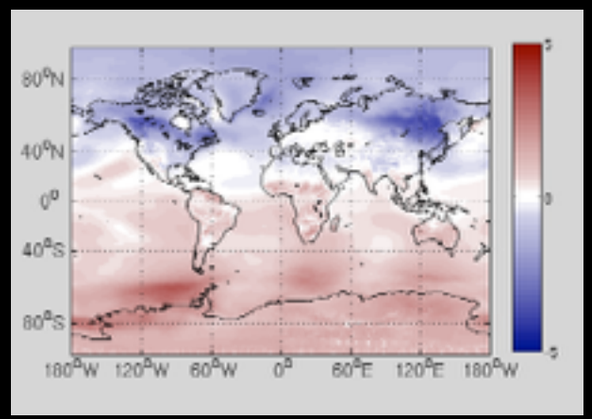


Widespread deforestation of approximately 50% based on Integrated Assessment Model (GCAM)

Temperature Effects



Pattern Scaling of Land Use Effects



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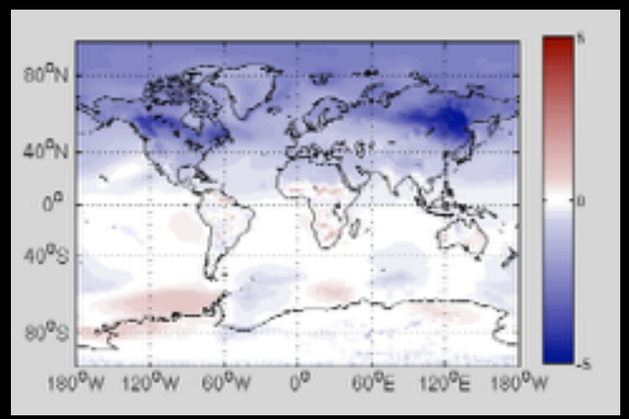

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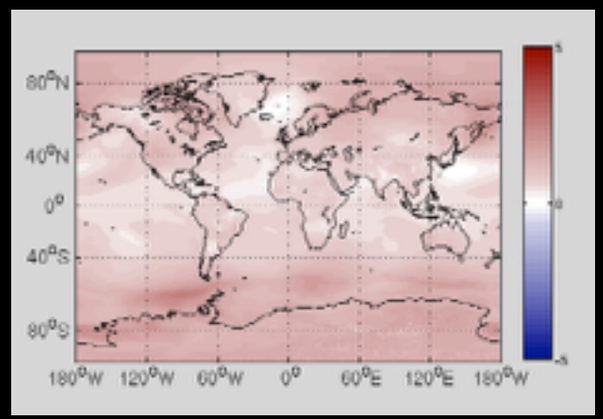


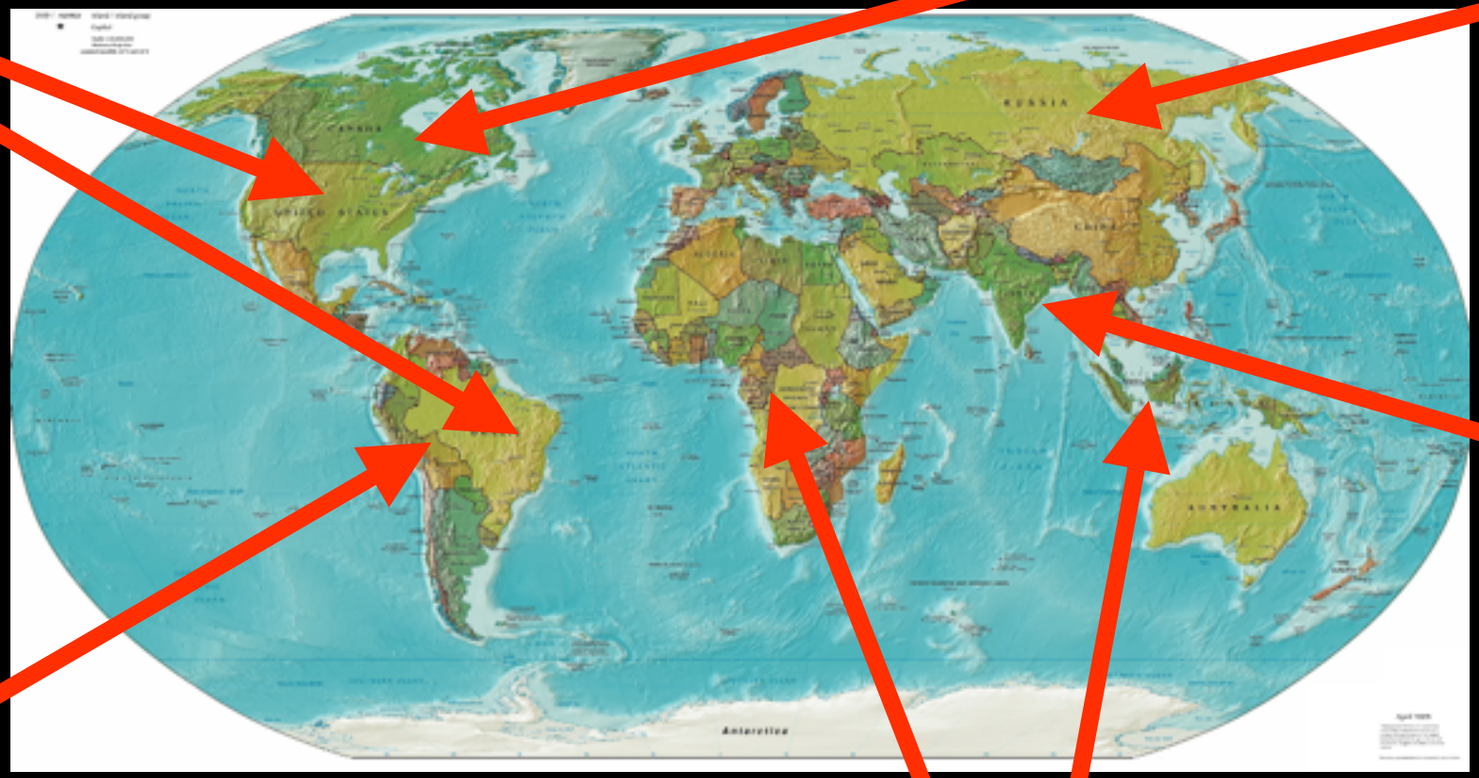
Requires:

- response additivity
- linear scaling of responses
- knowledge of the responses

Need an Atlas of Land-use Climate Response Relationships

biofuels

deforestation



irrigation

fragmentation

degradation

Key Questions for Land-use Pattern Scaling

- How resolved in space is sufficient?
- How resolved in process is sufficient?
- Which teleconnections scale?
- When does linearity break down?
- Which interactions are most important?
- Does scaling hold for metrics of extremes?
- Does it work for multi-model ensembles?

- How would we design a simulation protocol to support emulation / p-scaling?

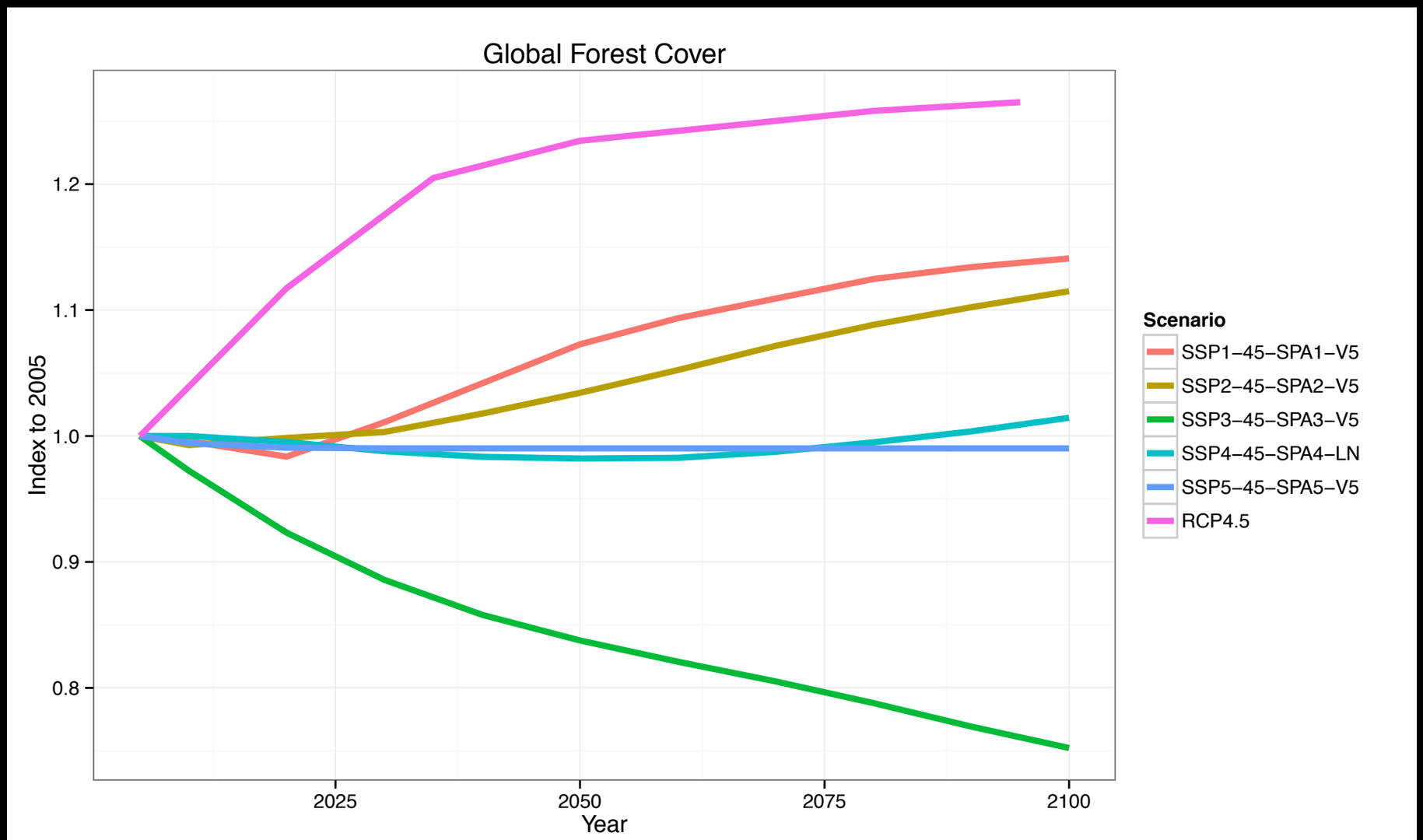
Plausible Land and Aerosol Scenarios

- ScenarioMIP
  - how much do different SSPs matter?
- LUMIP
  - how much do plausible land ranges matter?
- AerChemMIP
  - how much do plausible emissions ranges matter?

Plausible Land and Aerosol Scenarios

	SSP1	SSP2	SSP3	SSP4	SSP5
RCP8.5					
RCP6.0					
RCP4.5		X		X	
RCP2.6					

Forest Cover across SSPs and original RCP4.5



Plausible Land and Aerosol Scenarios

	SSP2	SSP2 / SSP4 land	SSP2 / SSP4 land+chem	SSP4
RCP8.5				
RCP6.0				
RCP4.5	X	o	o	X
RCP2.6				

Plausible Land and Aerosol Scenarios

	SSP2	SSP2 / SSP4 land	SSP2 / SSP4 land+chem	SSP4
RCP8.5				
RCP6.0	X?	o?	o?	X?
RCP4.5	X	o	o	X
RCP2.6				

Thank You!

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