

Climate Implications of Alternative Scenarios of Future Land Use Change: An Application of Integrated Earth System Modeling



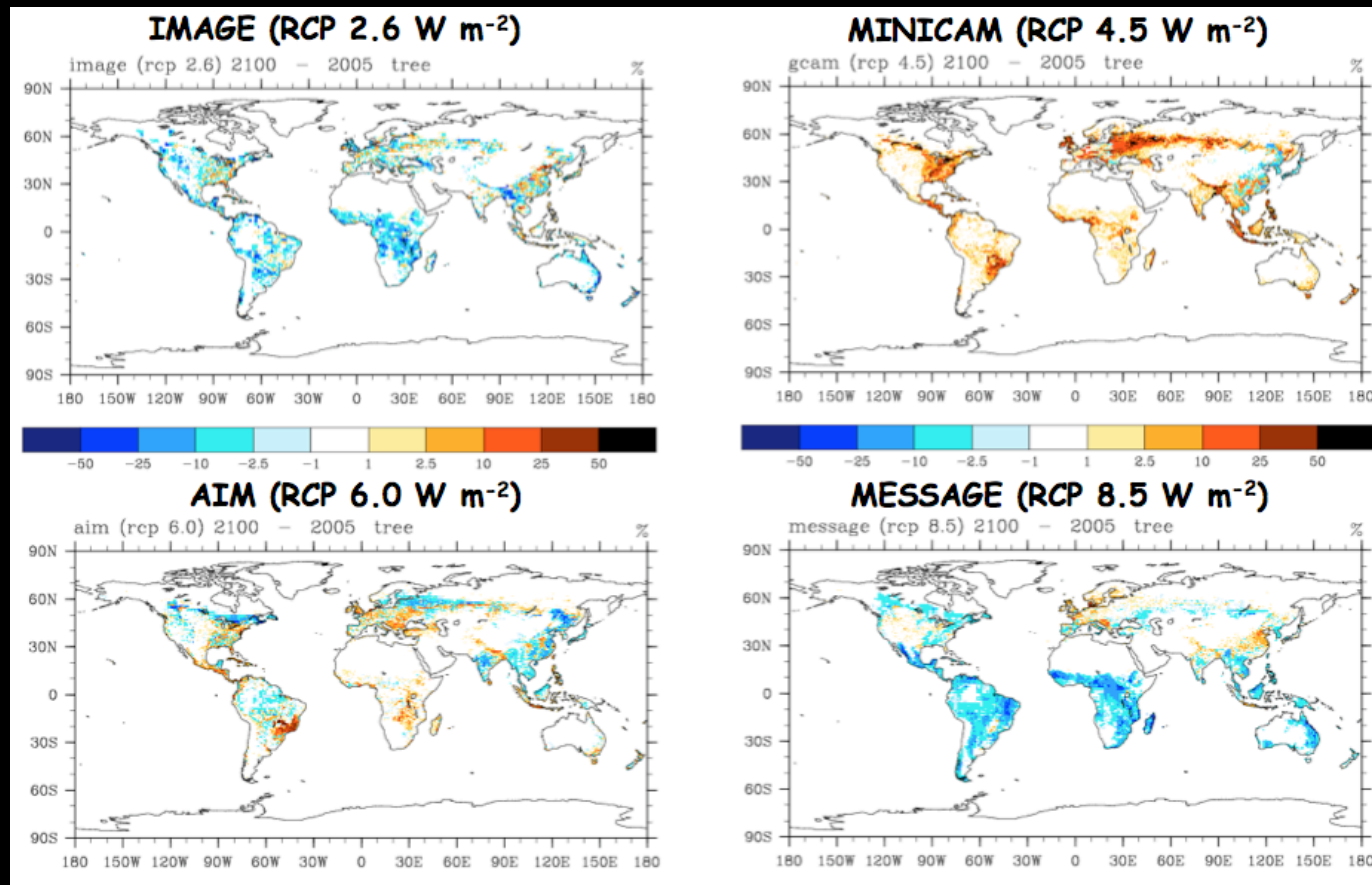
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Motivation

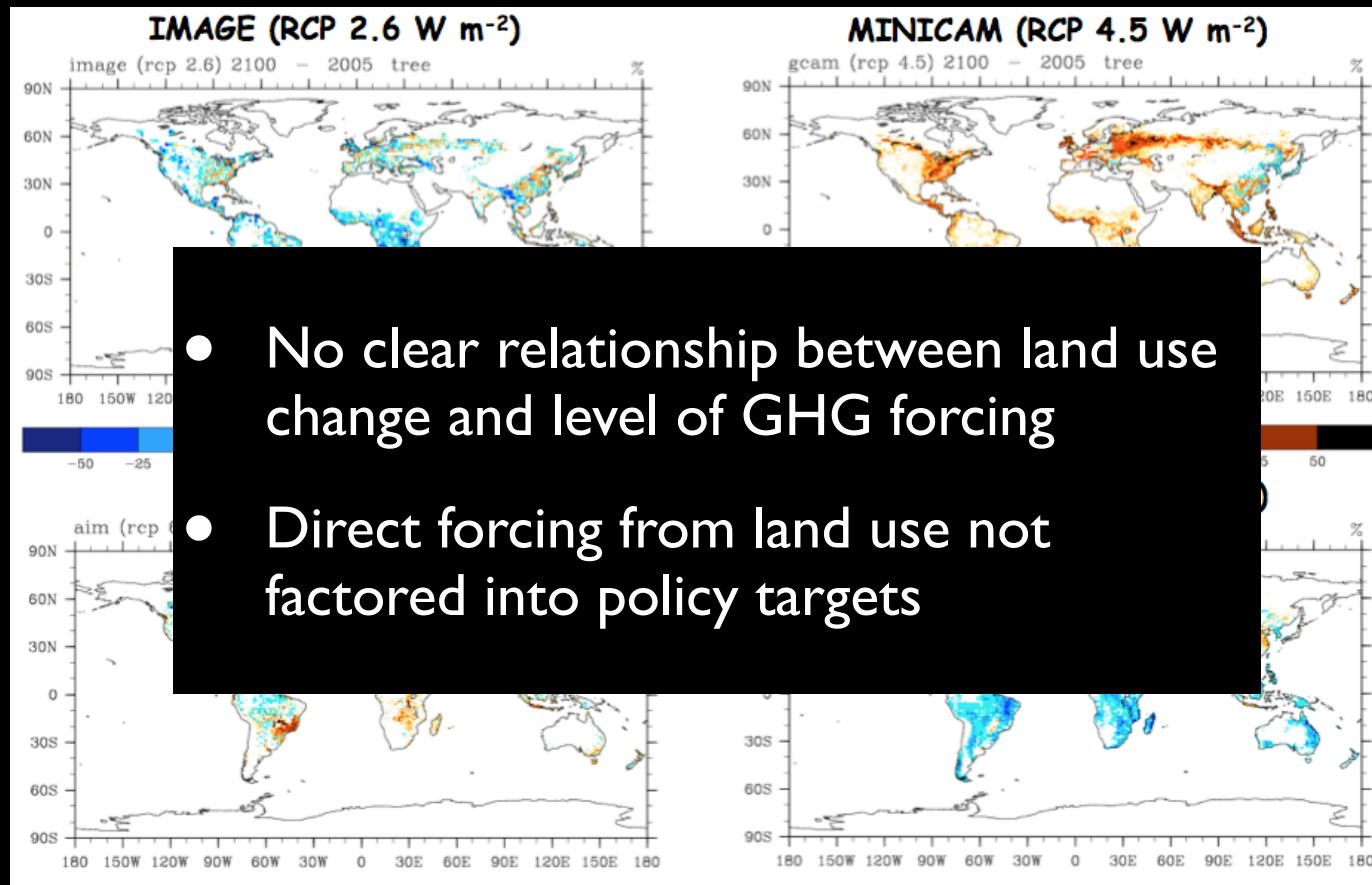
- New policies address GHG sources and sinks from land use change
- However, these policies (and the fictitious ones modeled for IPCC) ignore biogeophysical effects
- Not clear whether plausible scenarios of future land use change induce significant biogeophysical climate perturbations
- If so, not clear that radiative forcing metric is convenient or appropriate

Future Projections of Land Use Differ Widely



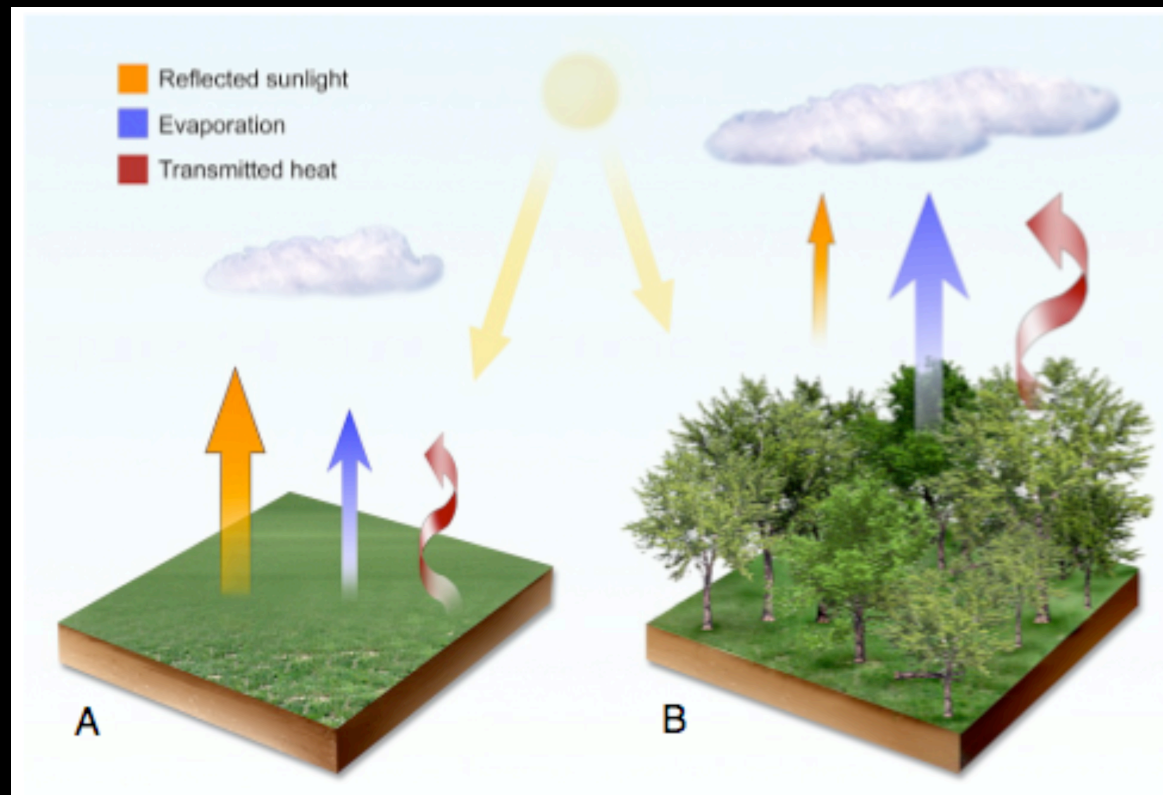
Lawrence, P. J., J. J. Feddema, G. B. Bonan, G. A. Meehl, B. C. O'Neill, S. Levis, D. M. Lawrence, K. W. Oleson, E. Kluzek, K. Lindsay, and P. E. Thornton (2011), Simulating the Biogeochemical and Biogeophysical Impacts of Transient Land Cover Change and Wood Harvest in the Community Climate System Model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

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Biogeophysical Effects of Land Use Change



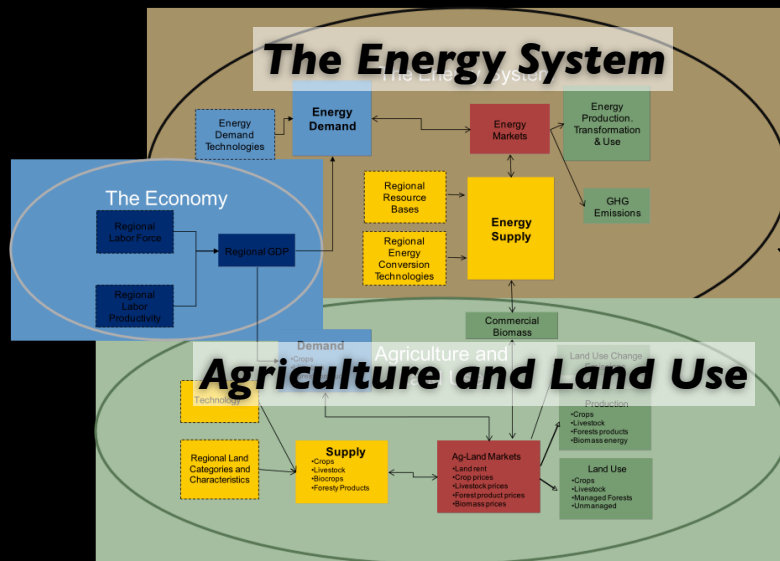
Source - Jackson et al. Environ. Res. Lett.3 (2008) 044006

Objectives

- Examine climate implications of two future scenarios of anthropogenic activity that reach the same GHG forcing target with very different LUC.
- Use offline land and radiative transfer simulations to isolate forcing and feedback mechanisms operating in different regions
 - Understanding mechanisms helps to validate model, identify uncertainties, and identify generalizability
 - Also, current metric paradigm relies on forcing concept

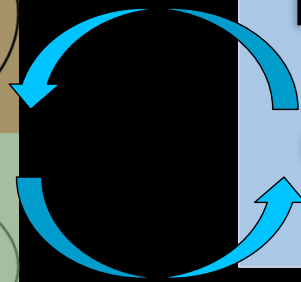
Do all RCP4.5 policies lead to same climate?

GCAM and GLM



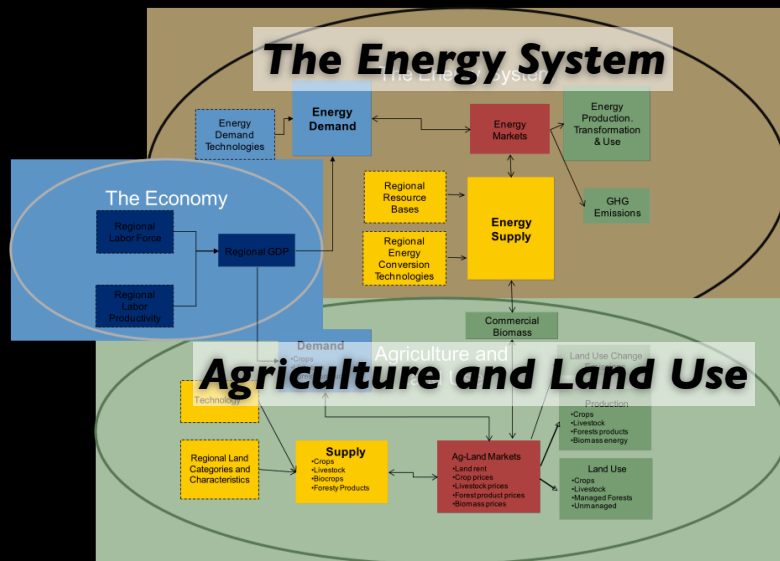
CESM

NCAR Community Earth System Model
(GCM with Land Surface Model)



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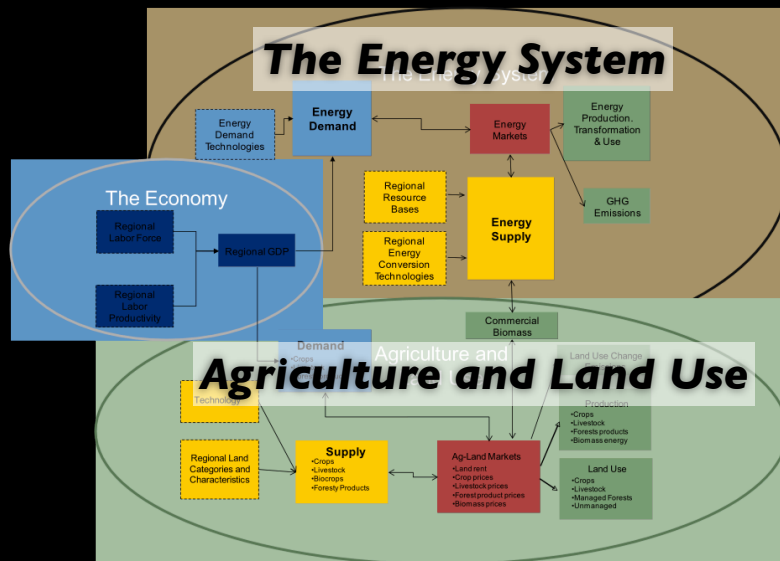
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Two Scenarios: 2005-2100

- RCP4.5 UCT (x6 ensemble)
- RCP4.5 FFICT (x1 ensemble)
- Biofuel and crop expansion
- ~50% forest cover loss

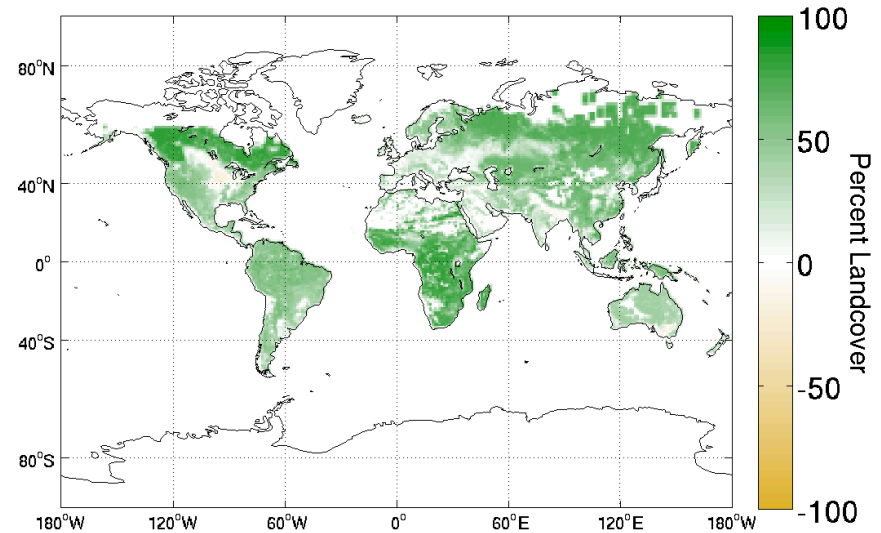
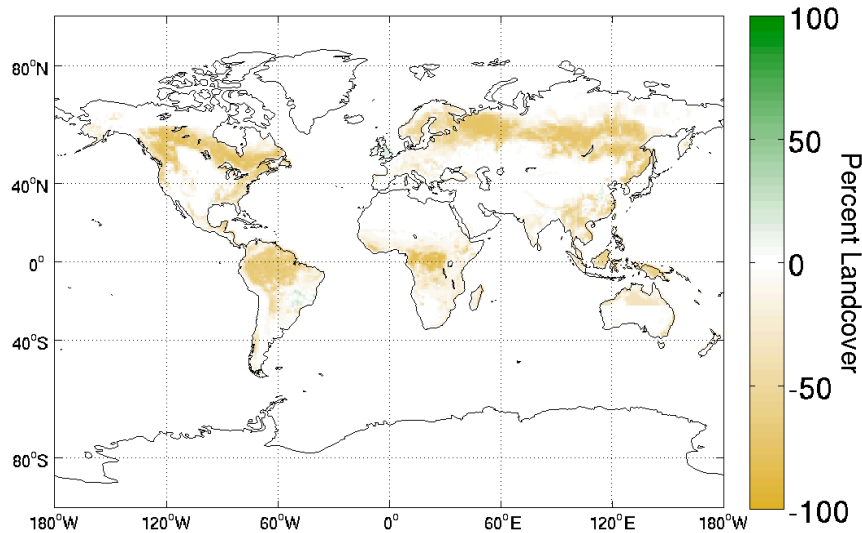
- Fully-Coupled Transient
- 1 degree resolution
- CN model active
- Simple crop model
- Prescribed Atm GHG levels

Fossil Only Tax → Deforestation

Change in Landcover from 2005 to 2100

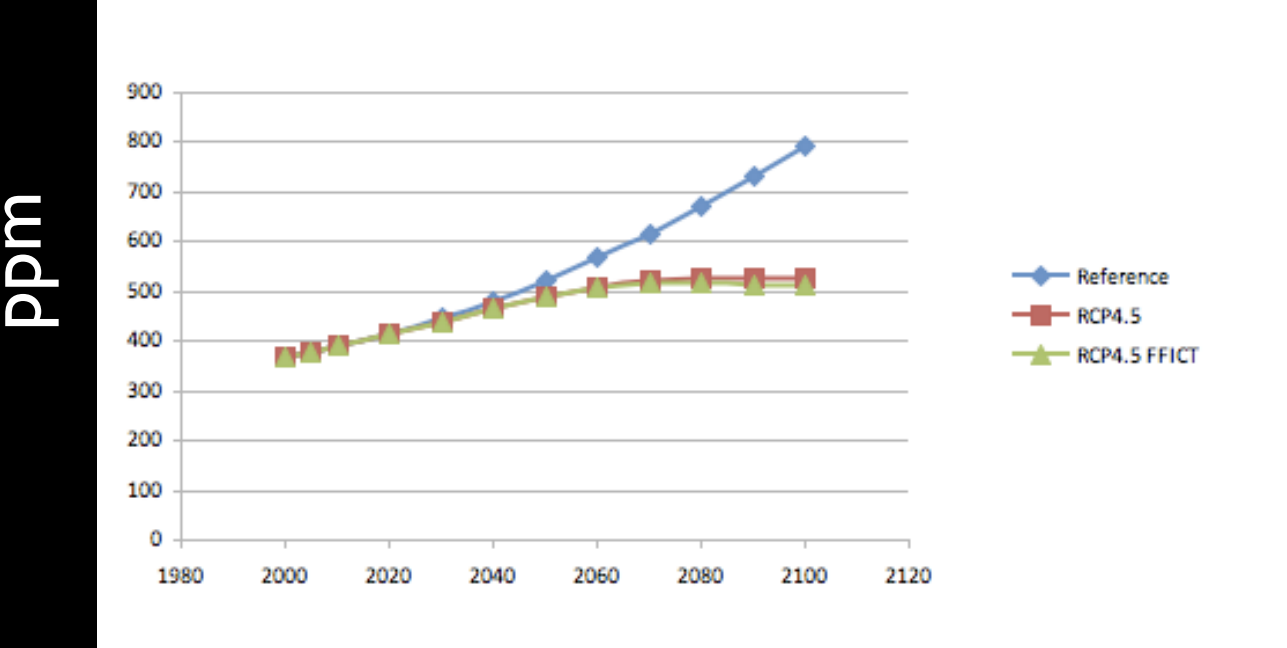
FFICT: Change in Forest Cover

FFICT: Change in Crop Cover



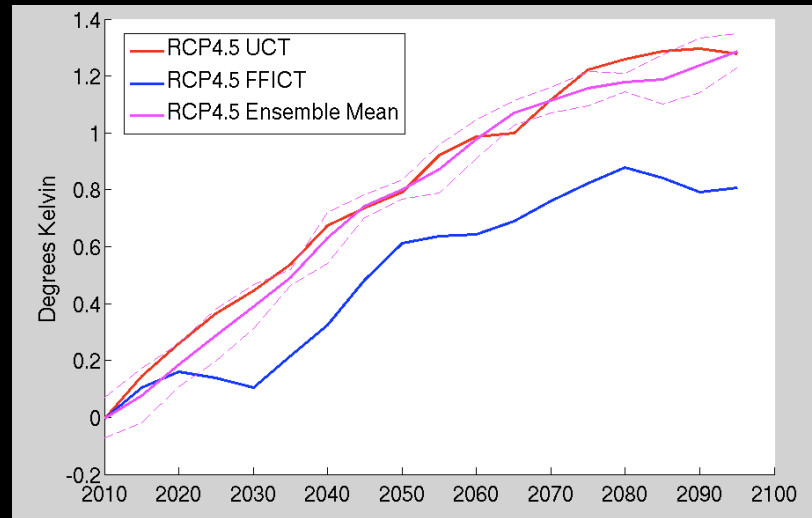
**50% Forest Conversion
to Bioenergy & Croplands**

CO2 Concentration

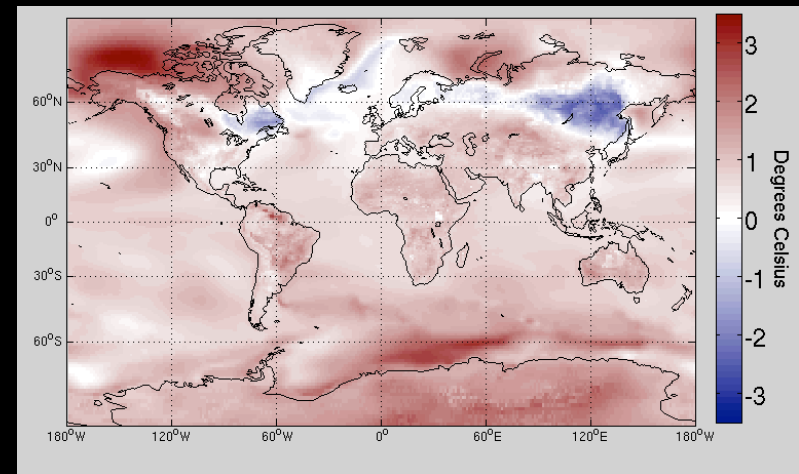
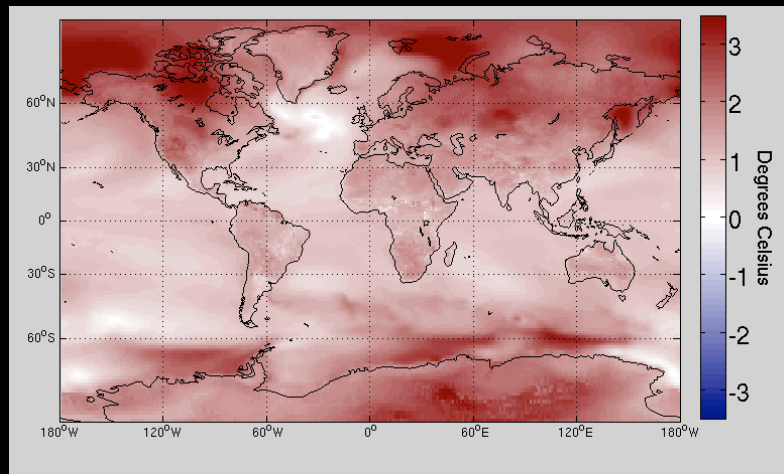


year

Global Mean Temp Change



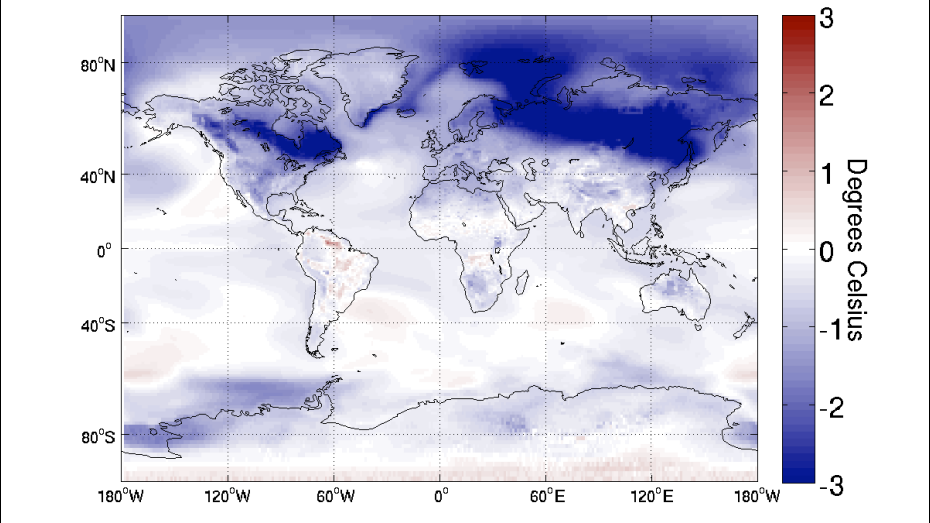
Temperature change from first (2005-2015) to last (2091-2100) decade
RCP4.5 UCT RCP4.5 FFICT



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

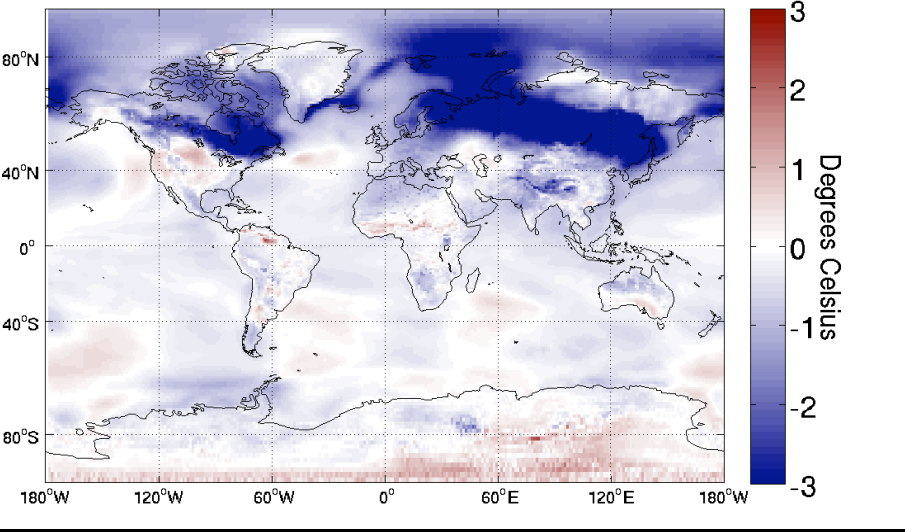
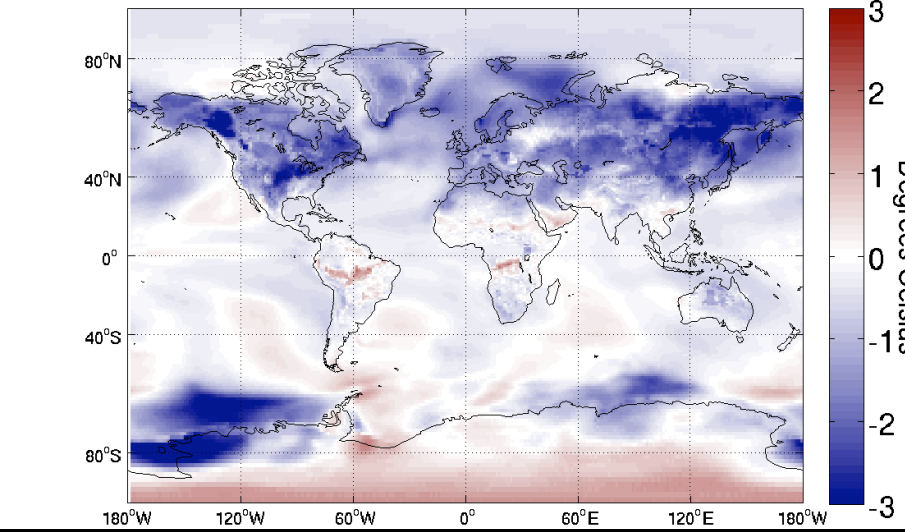
50% Forest loss

Annual Mean



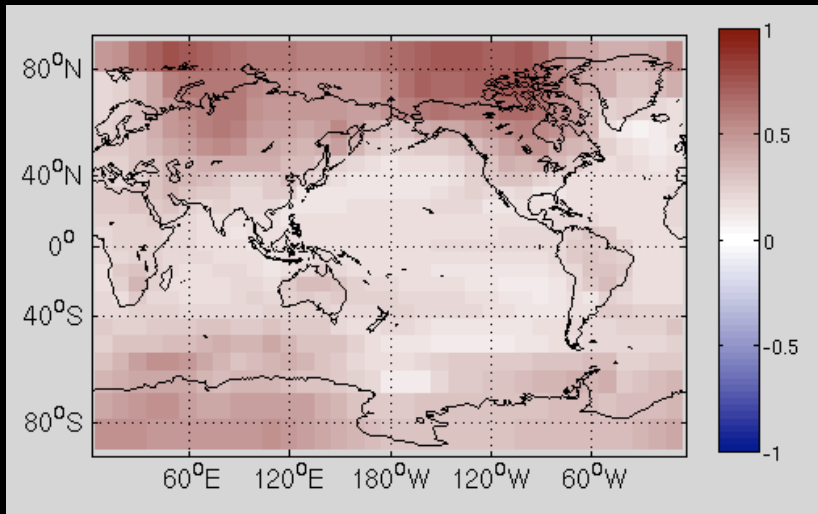
NH Summer

NH Winter

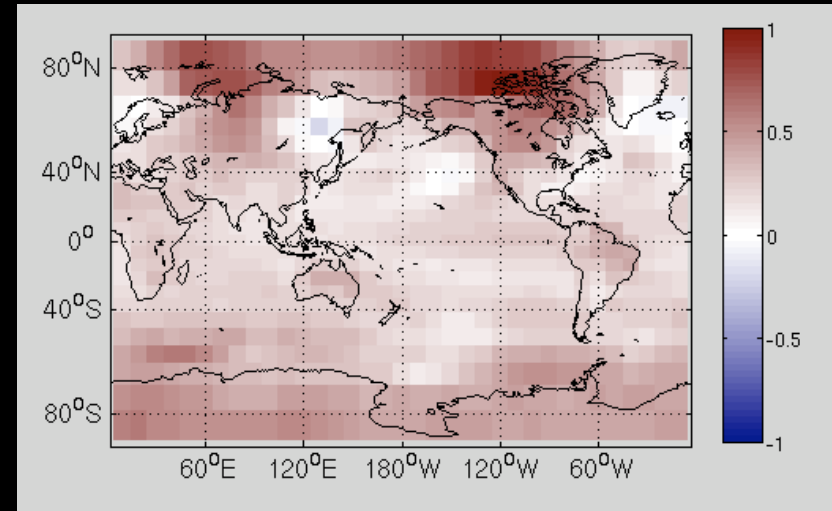


Spatial Fingerprint Analysis

RCP4.5 UCT Fingerprint



RCP4.5 FFICT Fingerprint



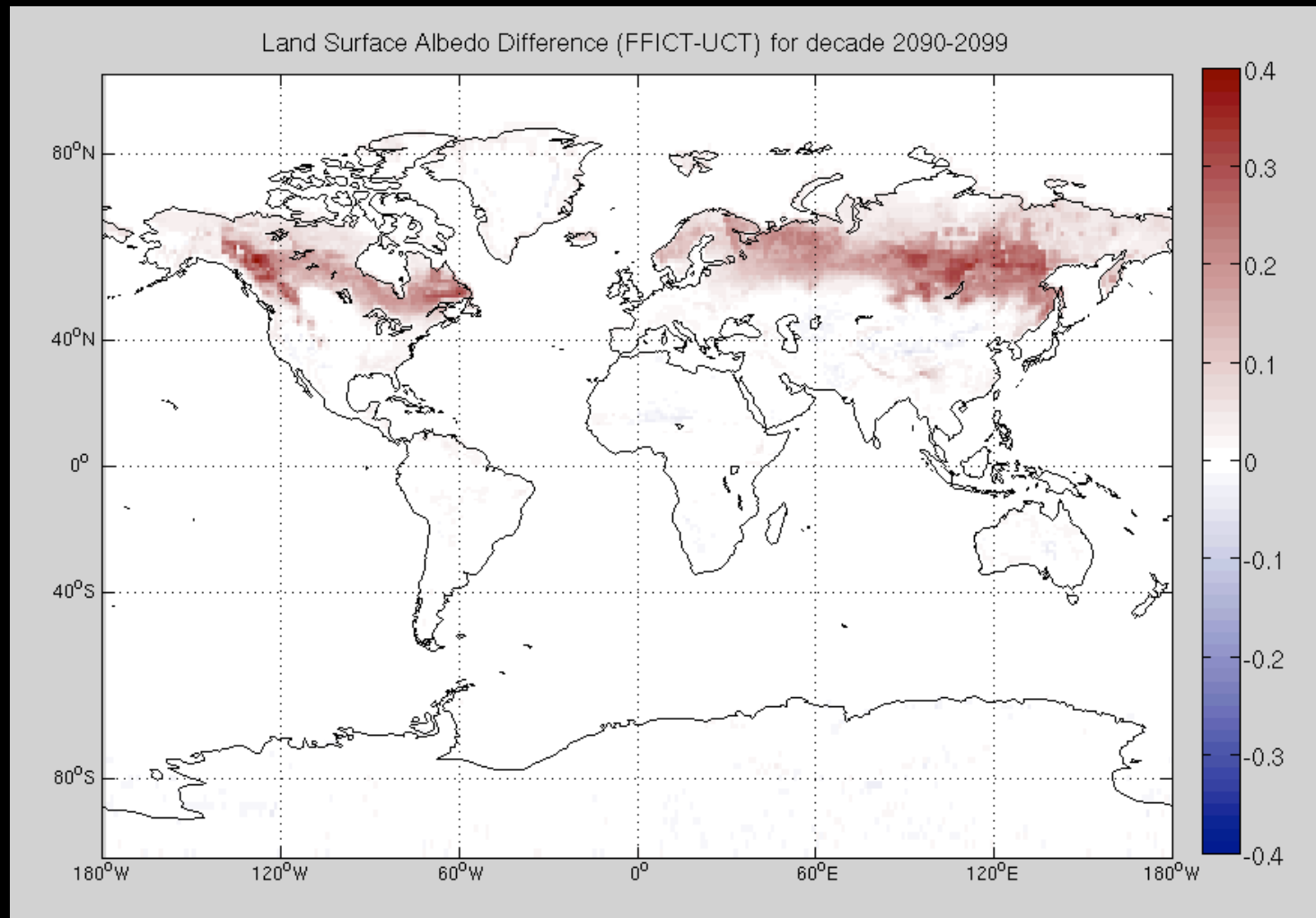
Is FFICT fingerprint distinctive from UCT ensemble members?

What drives the regional differences?

Forcing vs. Feedback



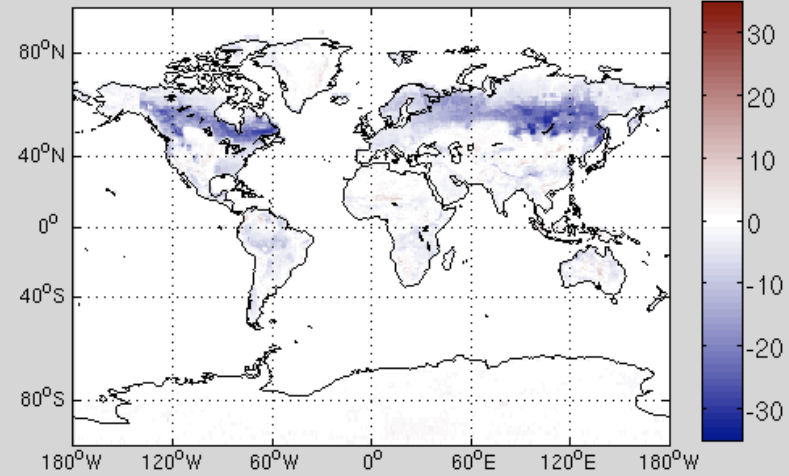
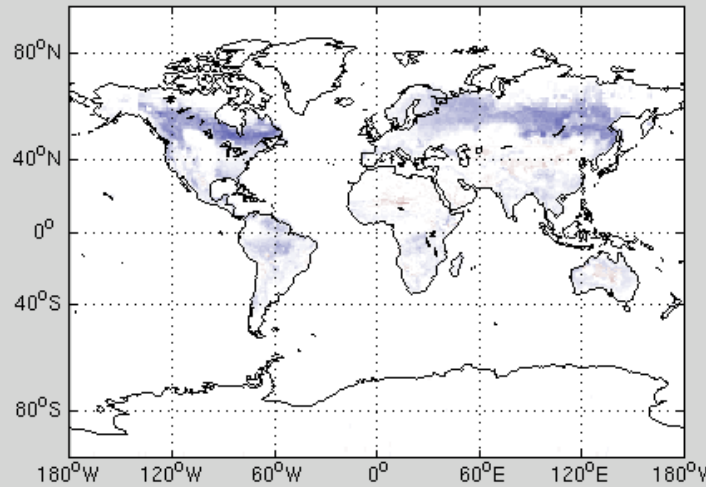
Surface Albedo difference *FFICT-UCT* (decadal mean, 2090-2100)



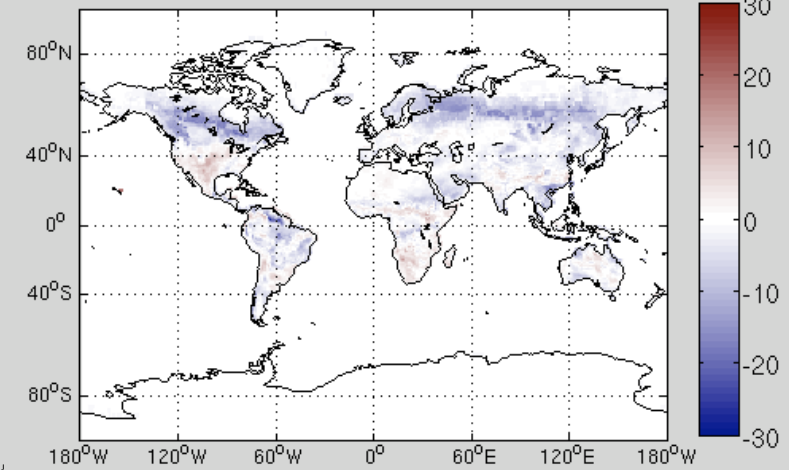
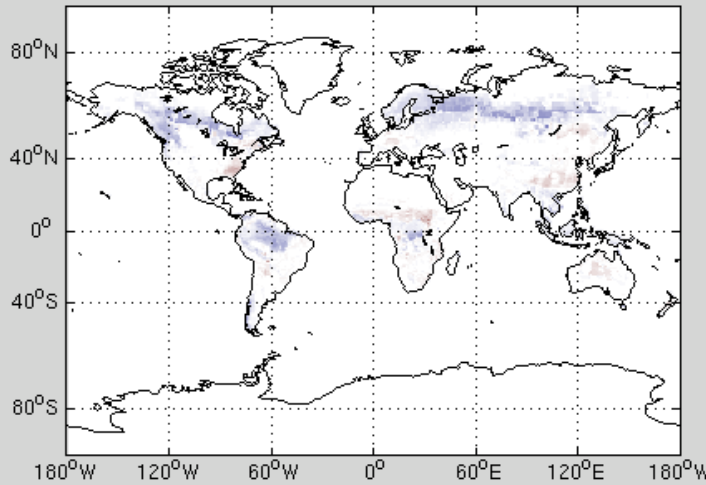
Offline

Coupled

Net
Radiation



Latent
Heat Flux



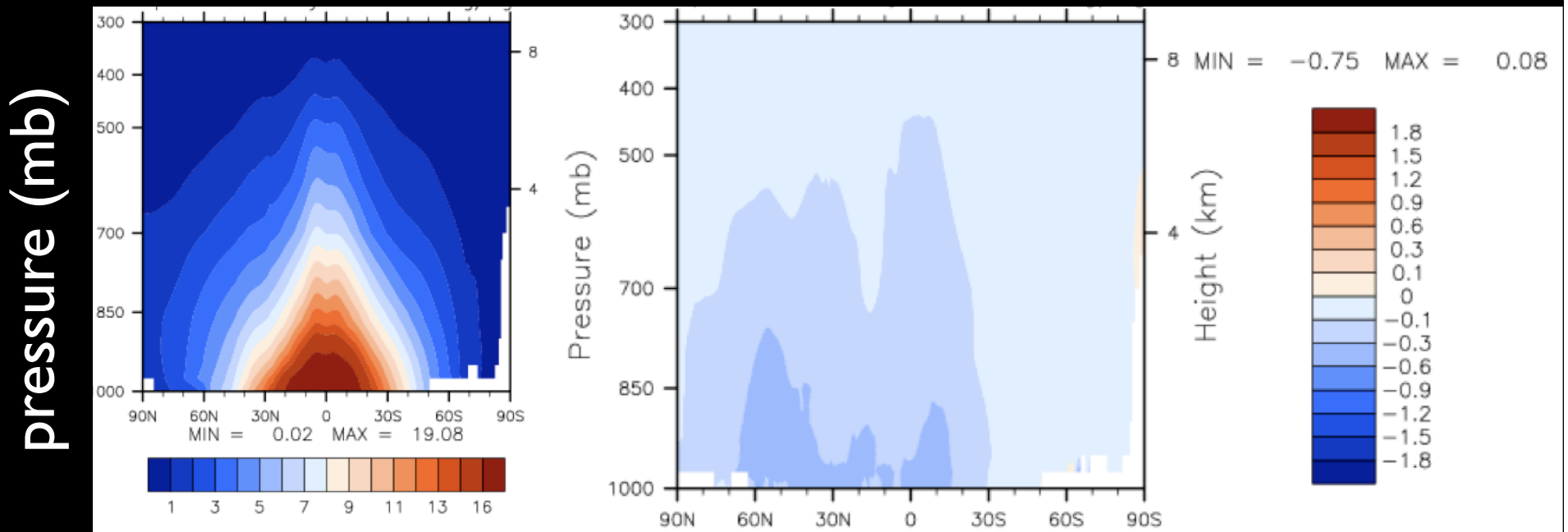
W / m^2

W / m^2

Water Vapor Differences (decadal mean, 2090-2100)

baseline

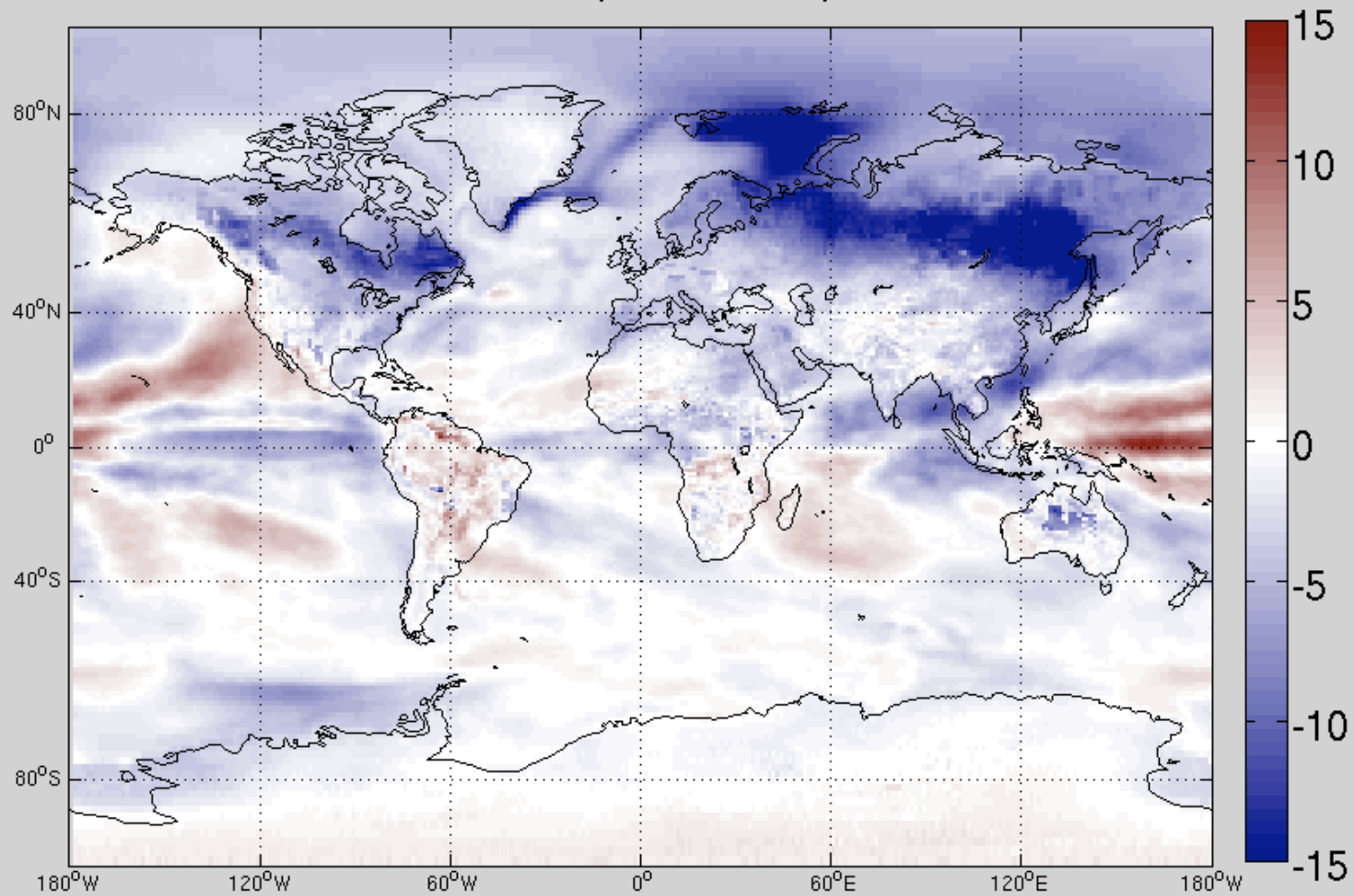
difference



latitude

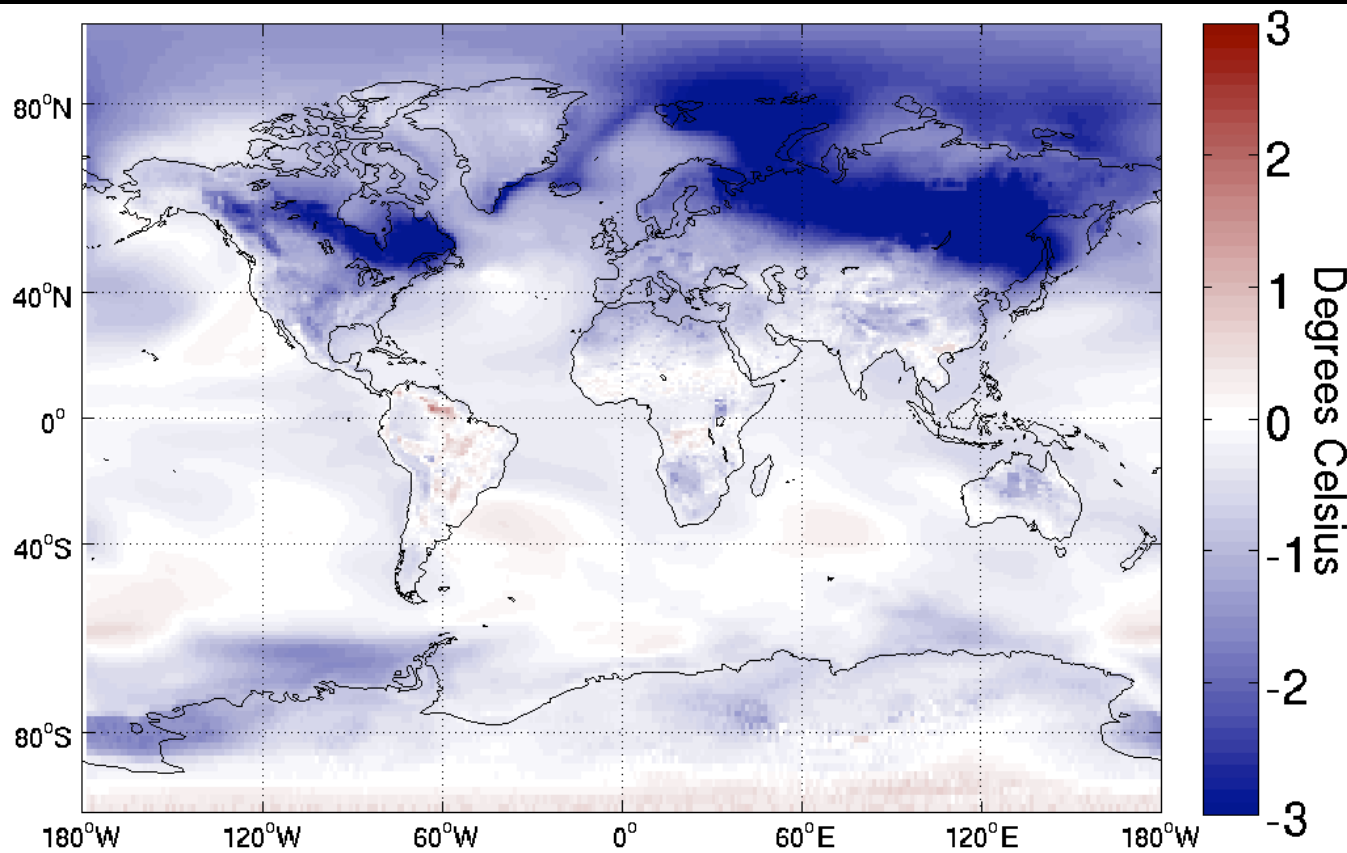
latitude

Greenhouse Effect Difference (FFICT-UCT) for decade 2090-2099

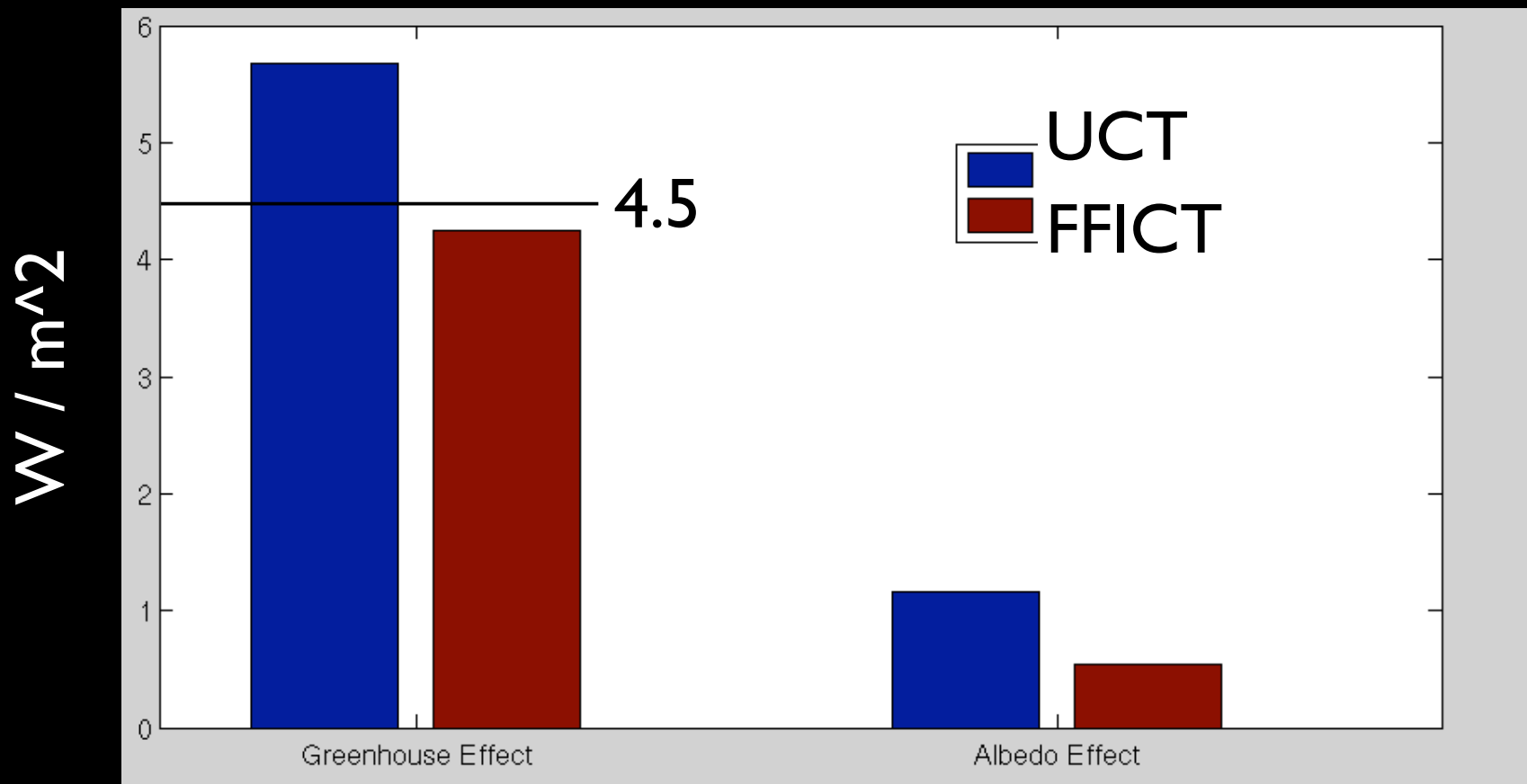


W / m^2

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



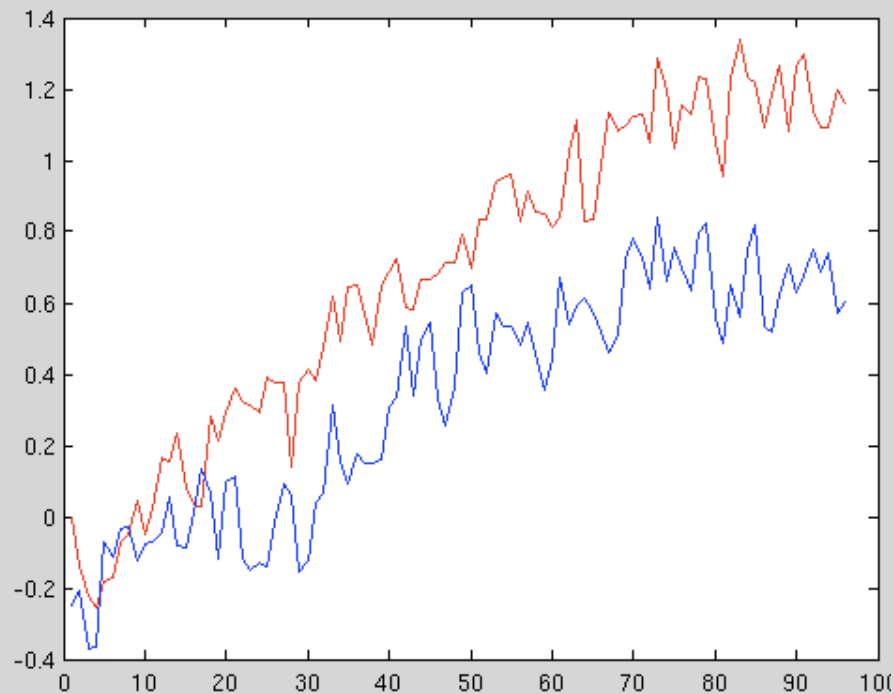
Planetary Energy Budget Changes (last decade minus first)



Conclusions / Discussion

- Neither the magnitude nor spatial pattern of warming is explained by GHG forcing alone
 - Land use is a critical consideration in understanding the outcomes of climate policy
- Different spatial patterns of warming affect feedback processes differently
- Although mean temp change is less drastic in some areas, the RCP4.5 FFICT climate is still quite different
 - We may need new metrics to properly characterize non-CO₂ effects of LUC

Mean Temp



Temp Perturbation

