

# Direct Climate Effects of Managing Terrestrial Carbon



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PNNL - Univ of Maryland - ORNL

16th Annual CESM Workshop - June 21, 2011

# Carbon Management



Re/Afforestation



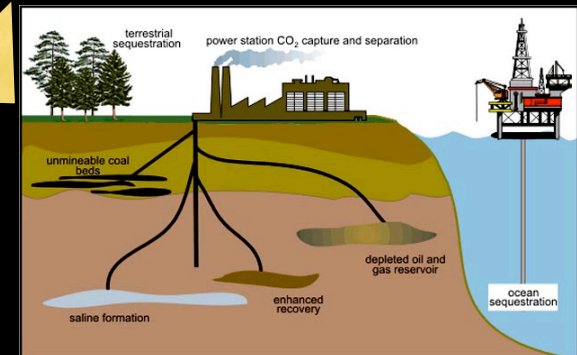
Biomass Harvest



Avoided Deforestation

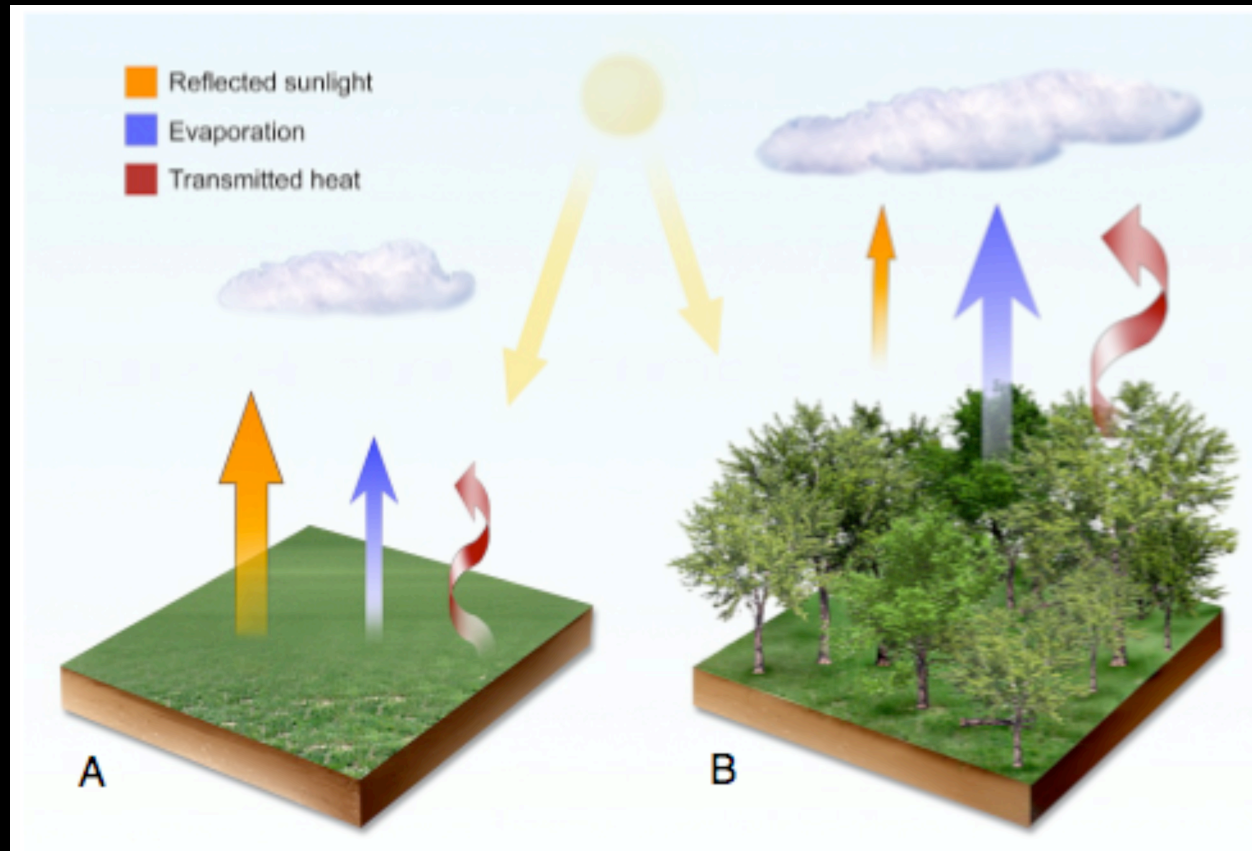


Bioenergy



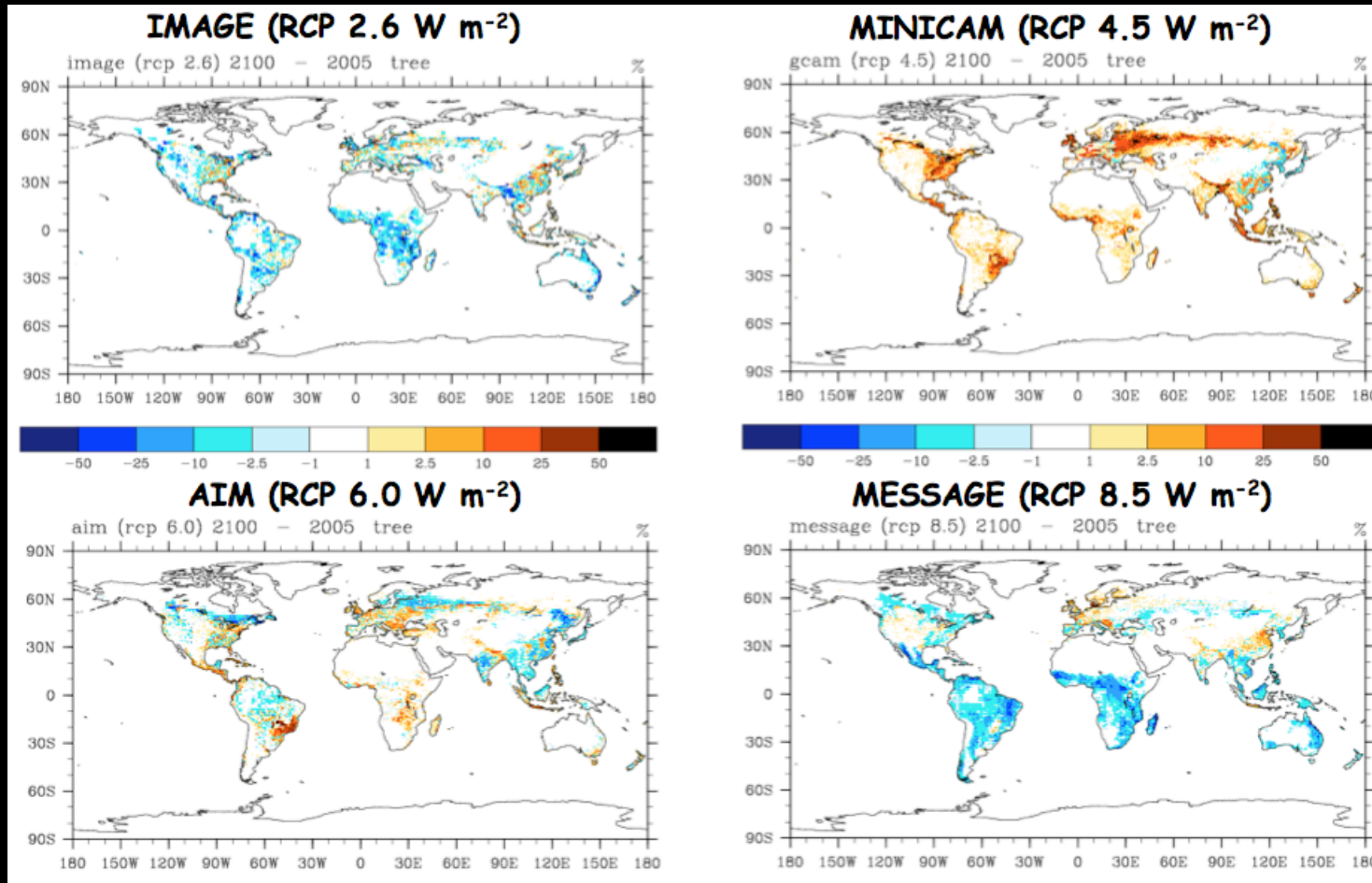
Long Term Sequestration

# Biogeophysical Effects of Land Use Change



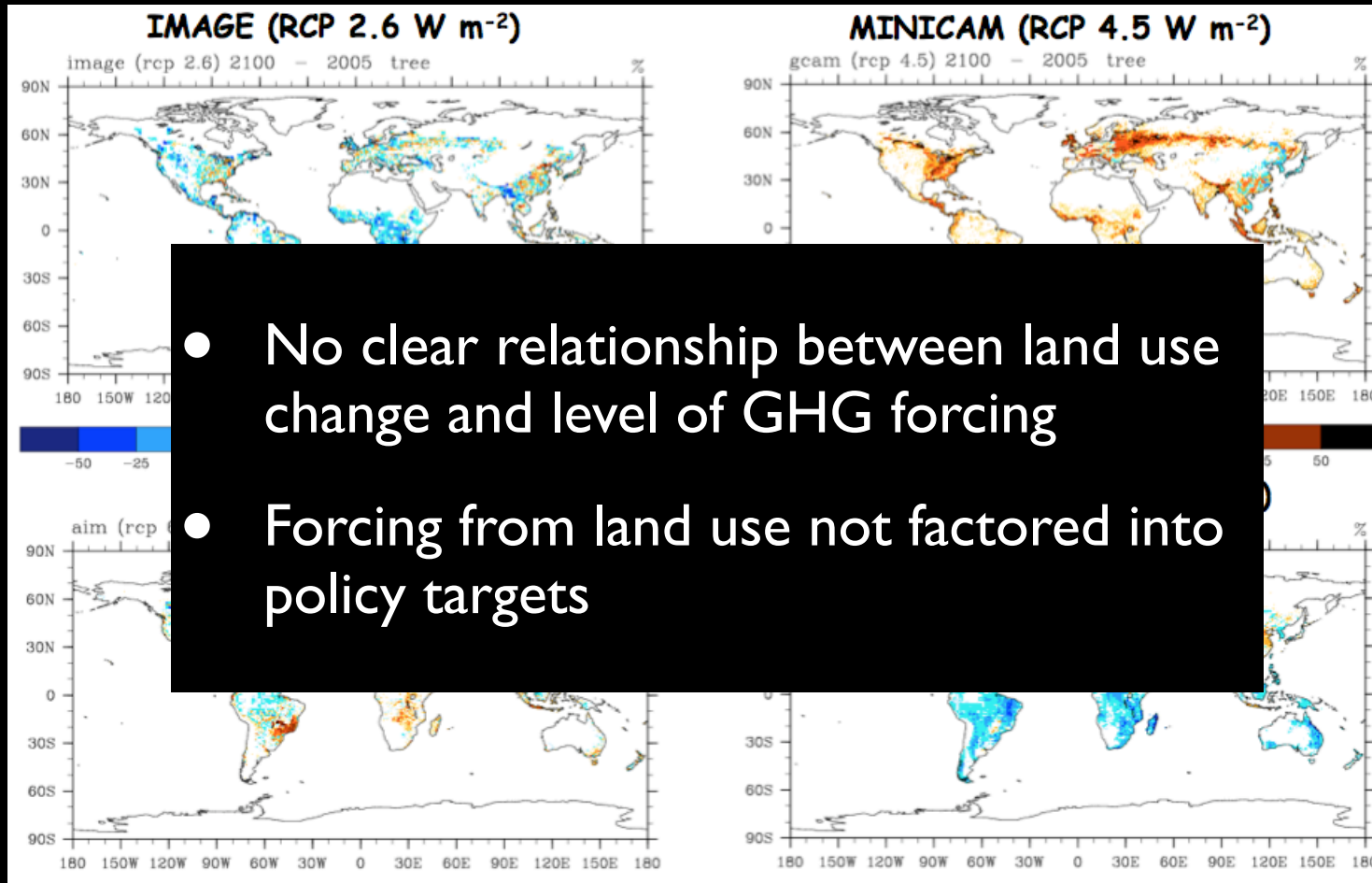
Source - Jackson et al. Environ. Res. Lett.3 (2008) 044006

# 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.

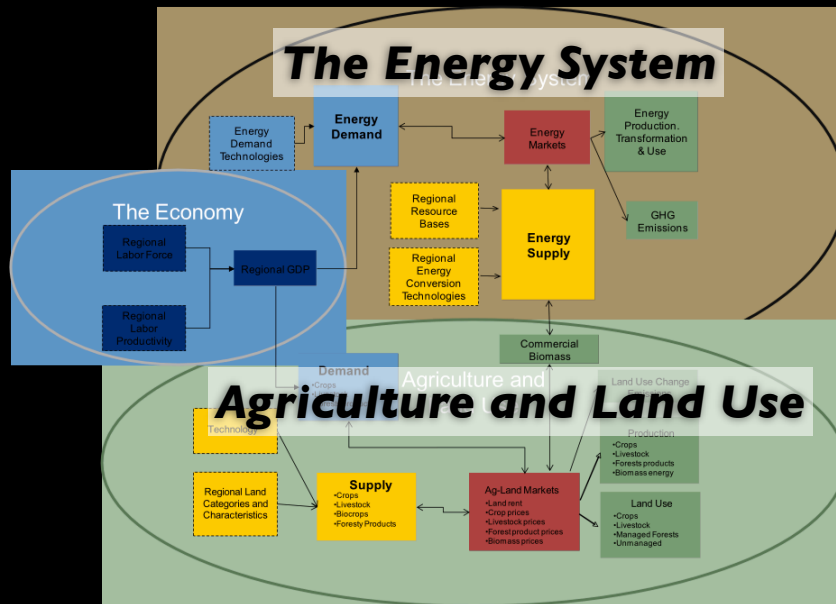
# Future Projections of Land Use Differ Widely



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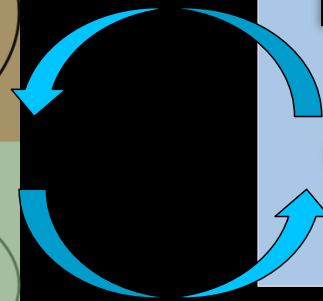
# Do all RCP4.5 policies lead to same climate?

## GCAM and GLM



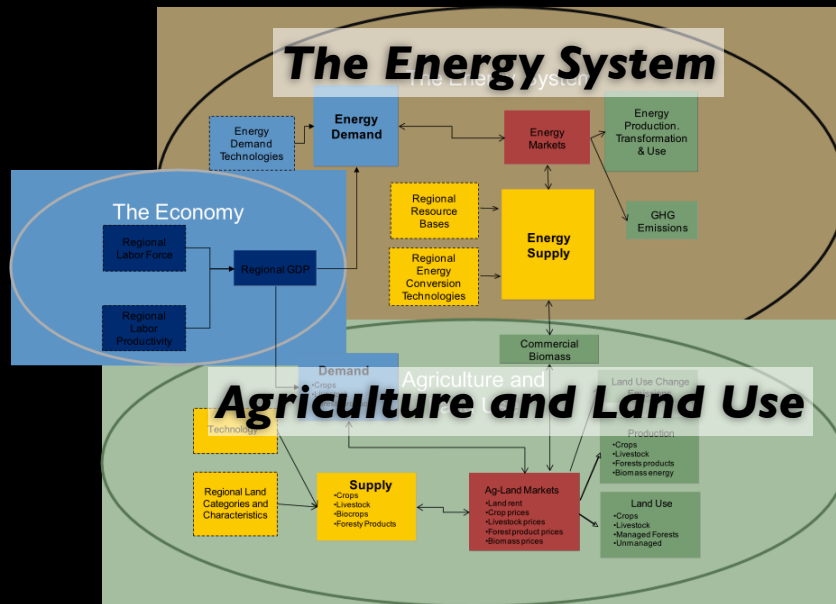
## CESM

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



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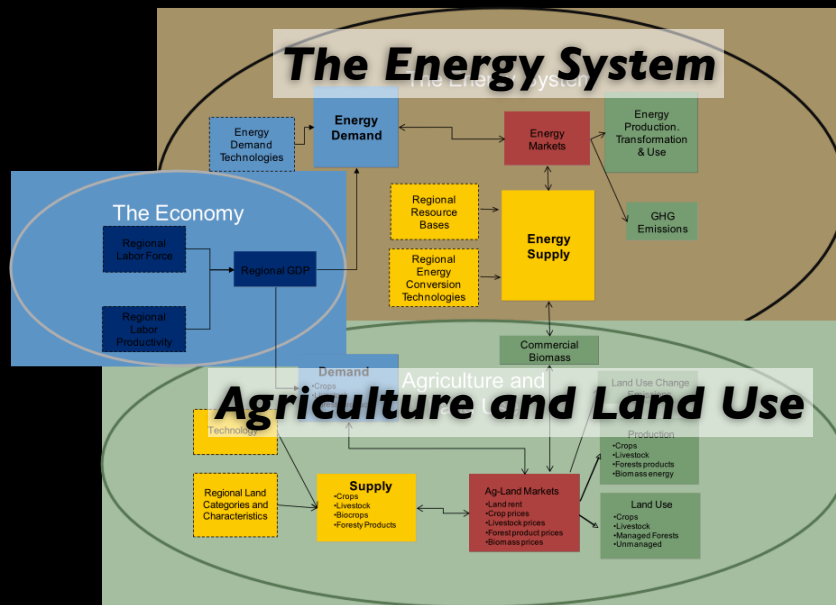


## CESM

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

# Do all RCP4.5 policies lead to same climate?

## GCAM and GLM



## CESM

NCAR Community Earth System Model  
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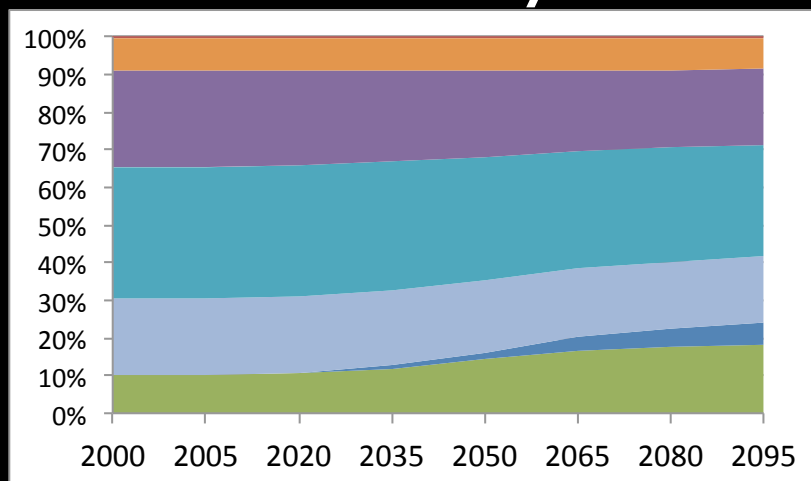
## Two Scenarios: 2005-2100

- RCP4.5 UCT
- RCP4.5 FFICT
- Biofuel and crop expansion
- ~50% forest cover loss

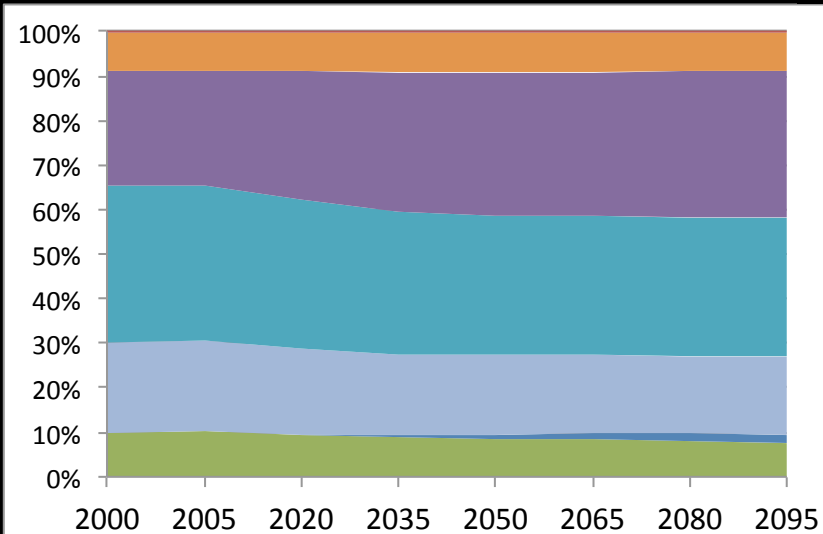
- Fully-Coupled Transient
- 1 degree resolution
- CN model active
- Simple crop model
- Prescribed Atm GHG levels



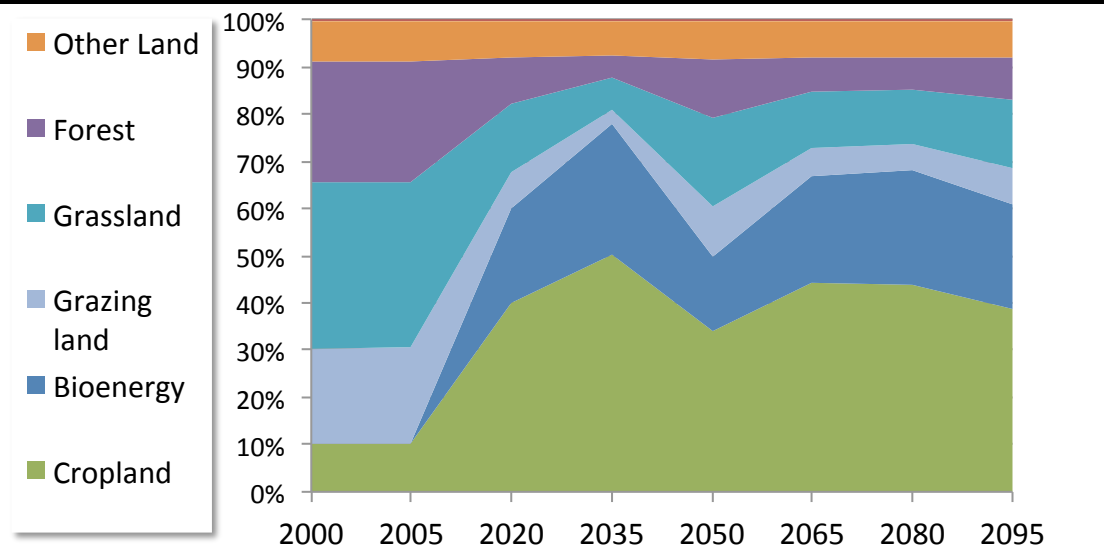
# No Policy



# RCP4.5 UCT



# RCP4.5 FFICT

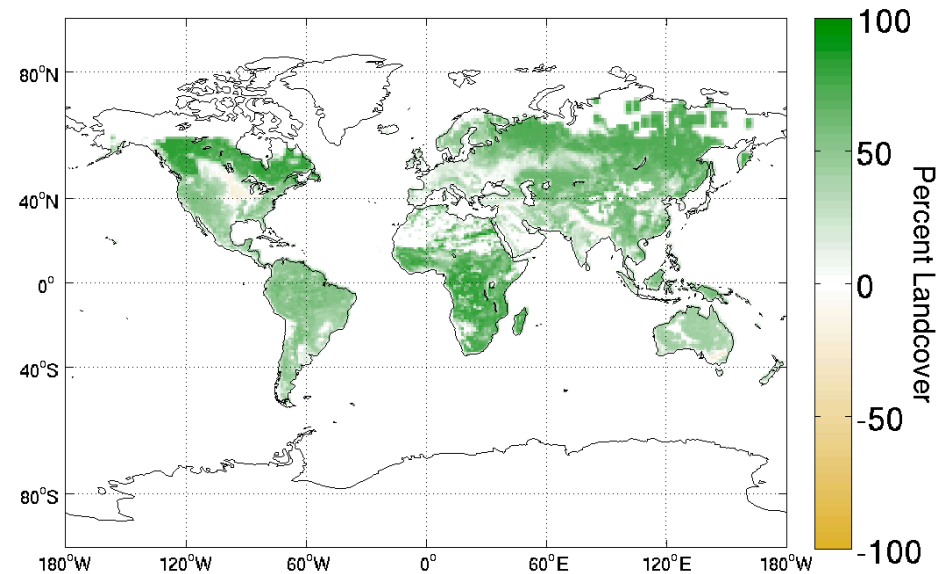
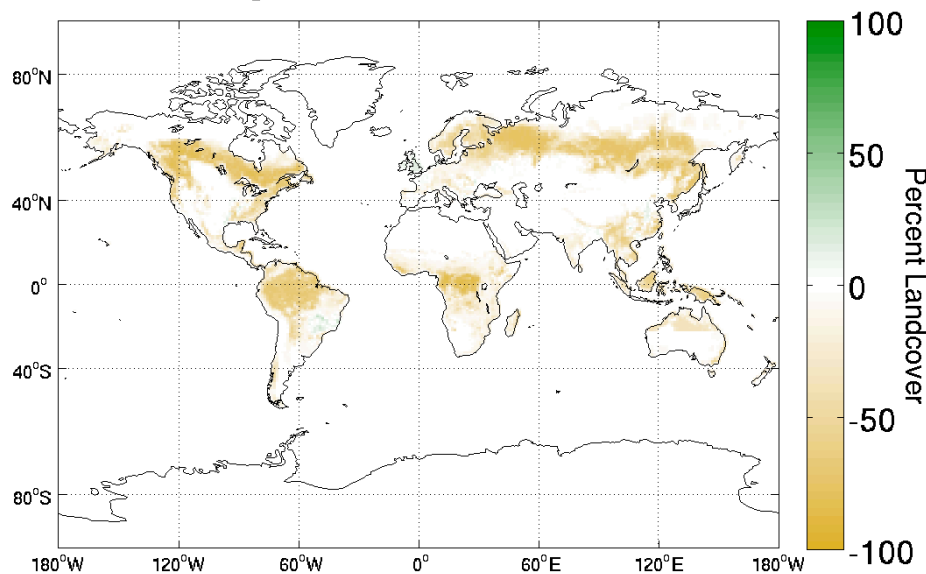


## Fossil Only Tax → Deforestation

# Change in Landcover from 2005 to 2100

FFICT: Change in Forest Cover

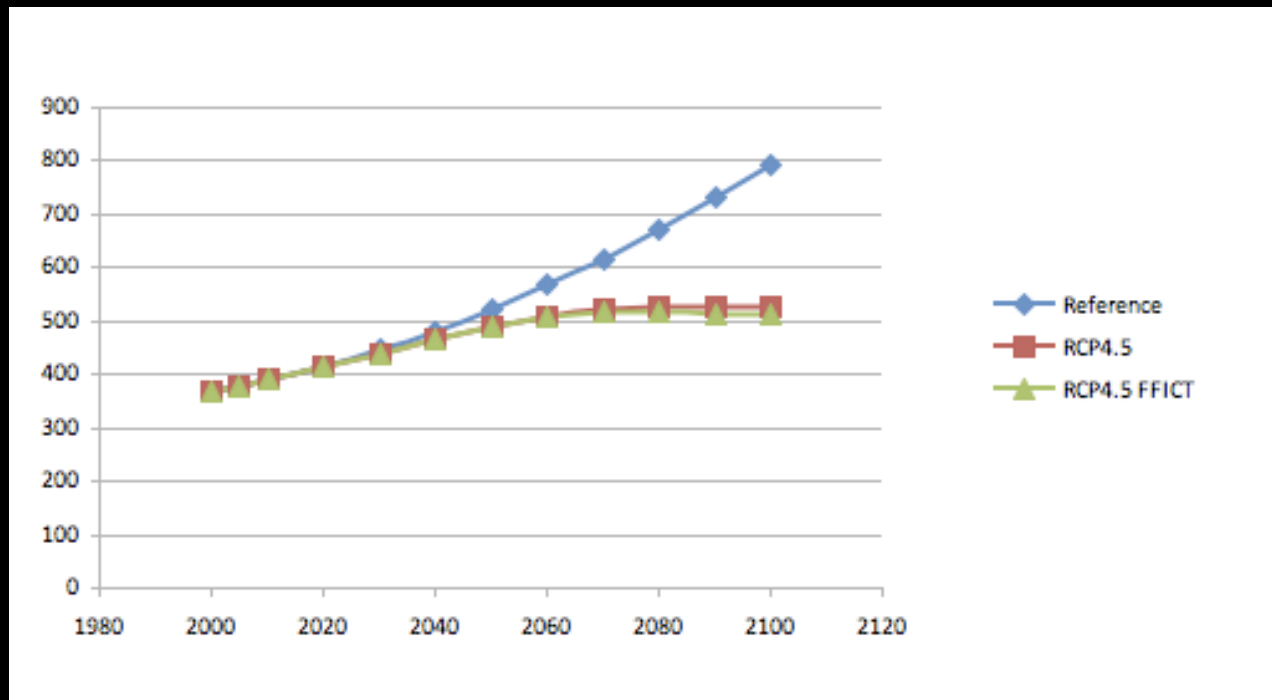
FFICT: Change in Crop Cover



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

# CO2 Concentration

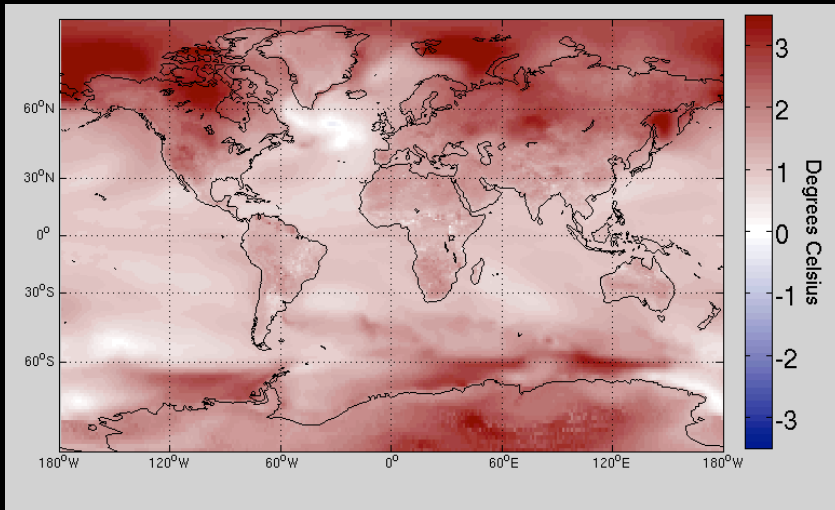
ppm



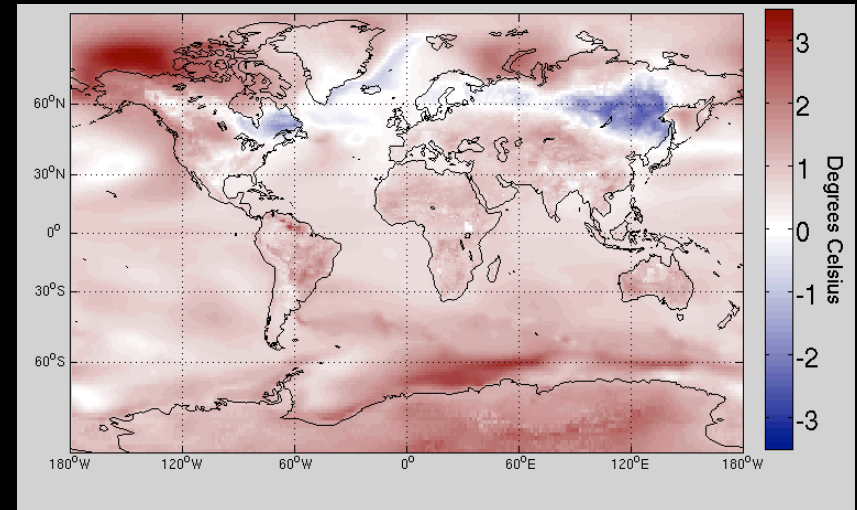
year

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

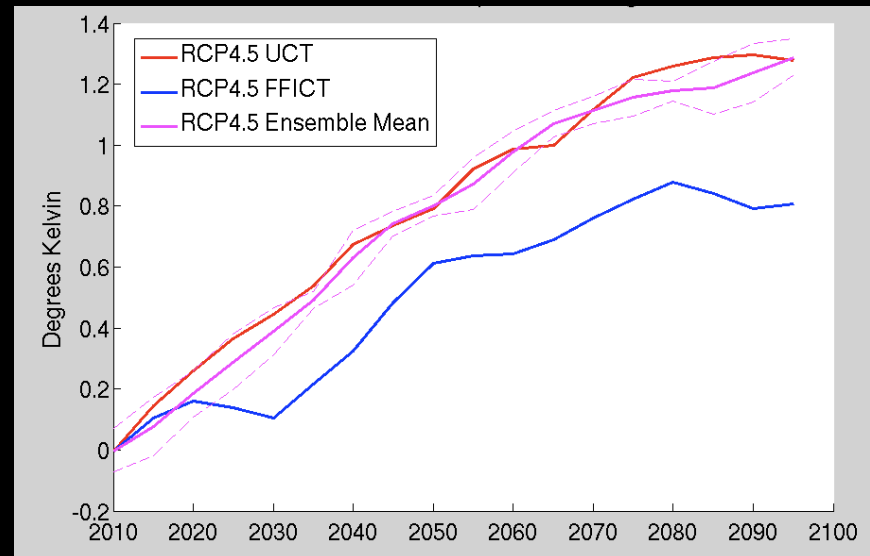
## RCP4.5 UCT



## RCP4.5 FFICT



## Global Mean Temp Change

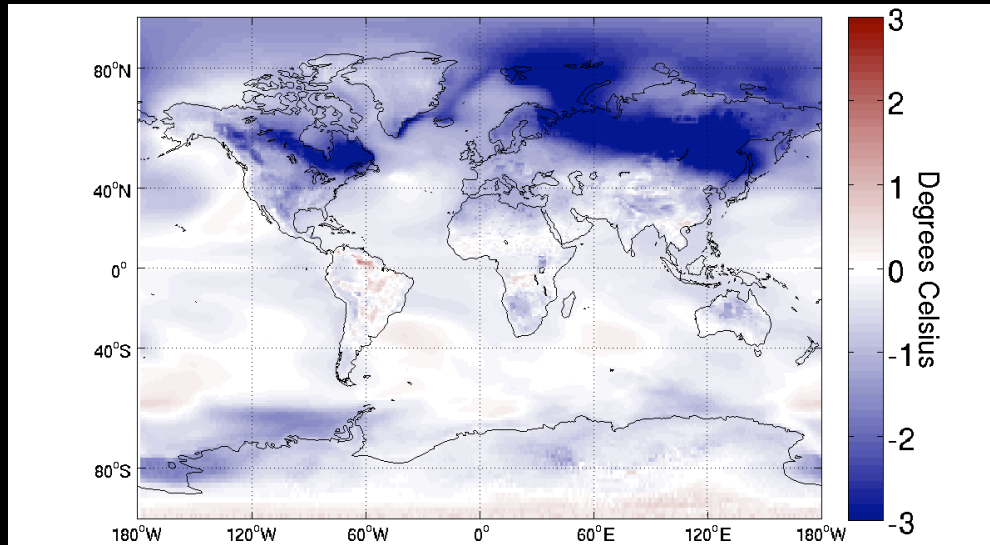


# Temperature difference *FFICT-UCT* (decadal mean, 2090-2100 )

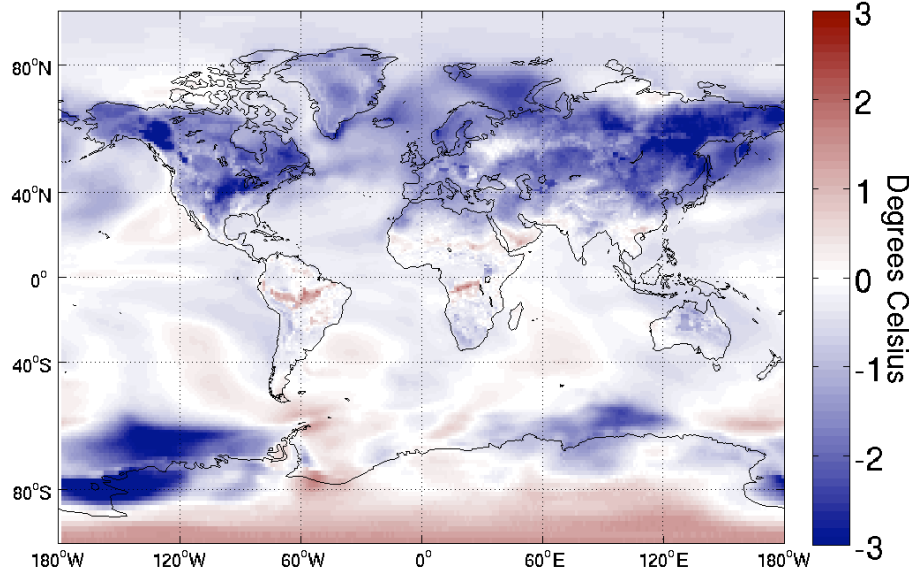
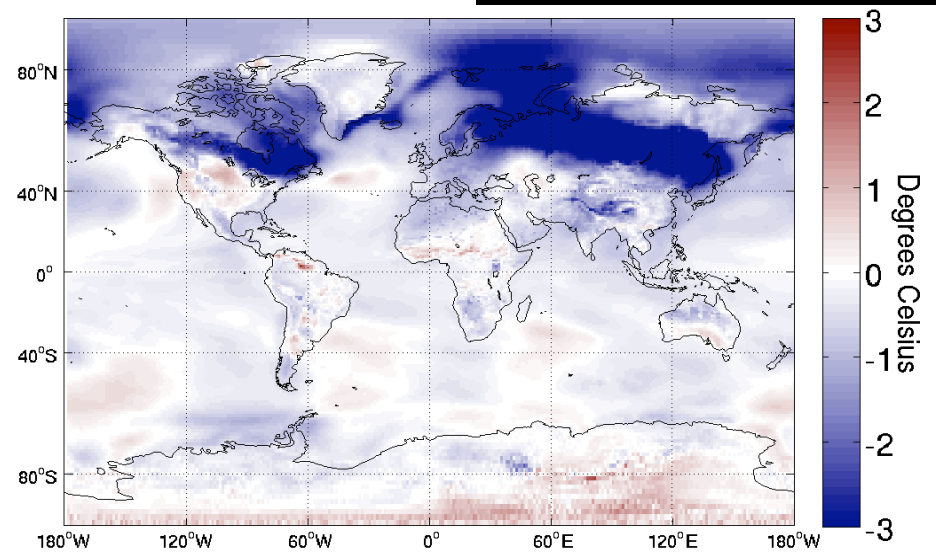
**50% Forest loss**

Annual Mean

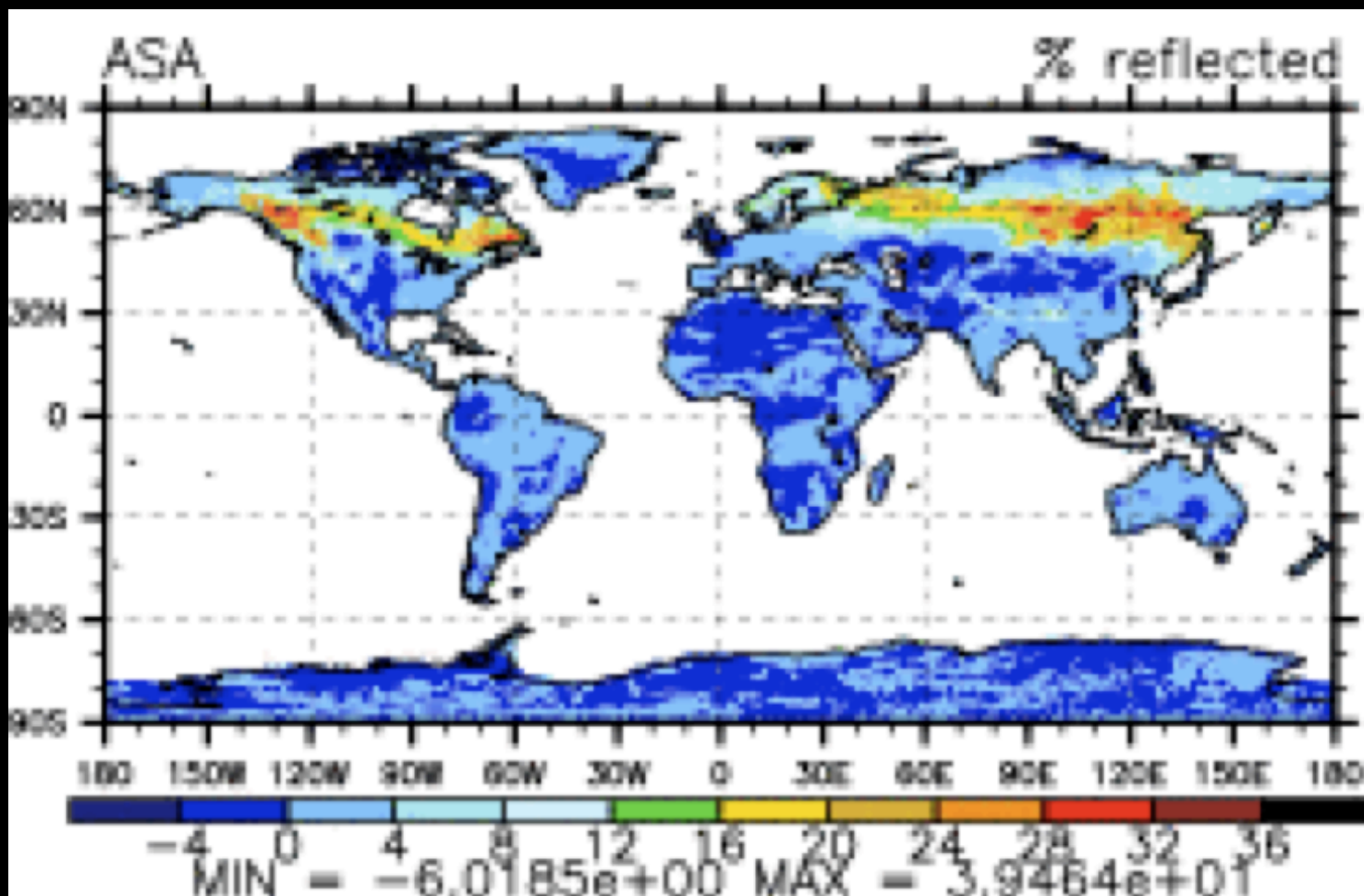
NH Summer



NH Winter

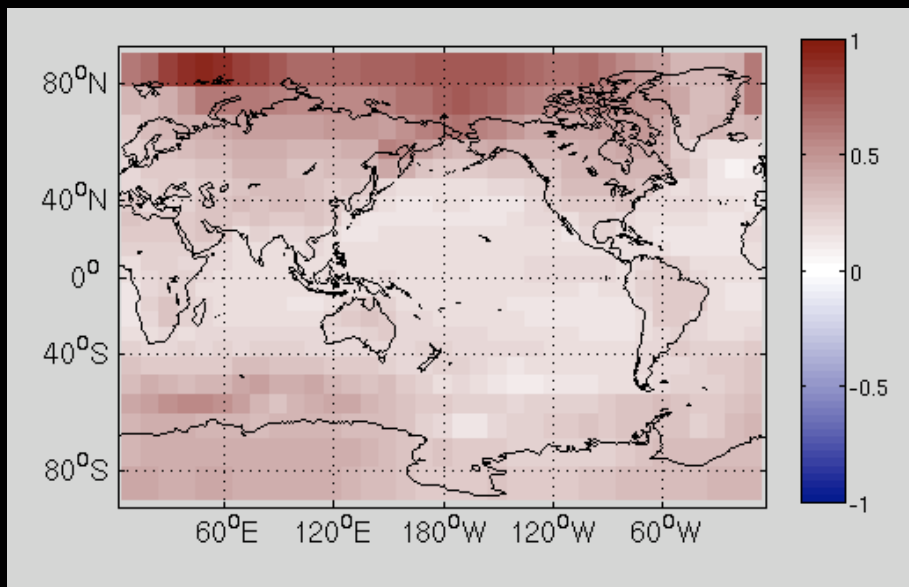


# Albedo difference *FFICT-UCT* (decadal mean, 2090-2100)

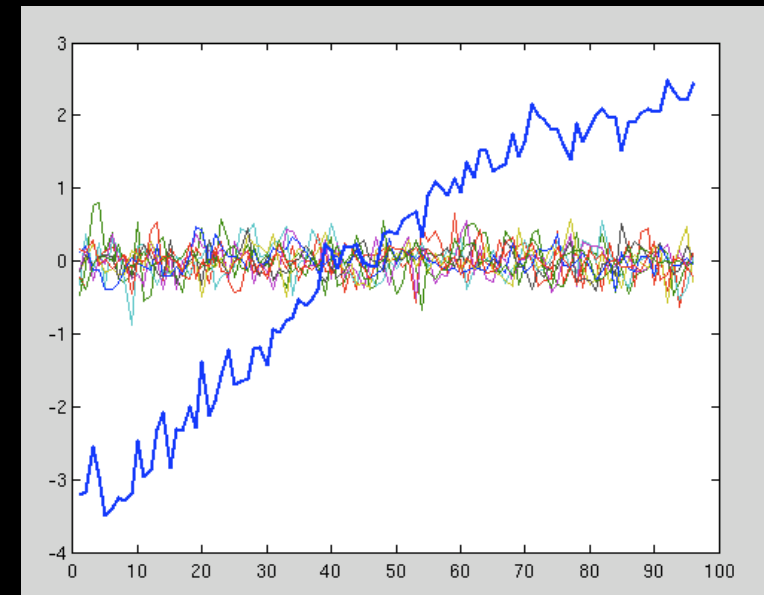


# Spatial Fingerprint Analysis

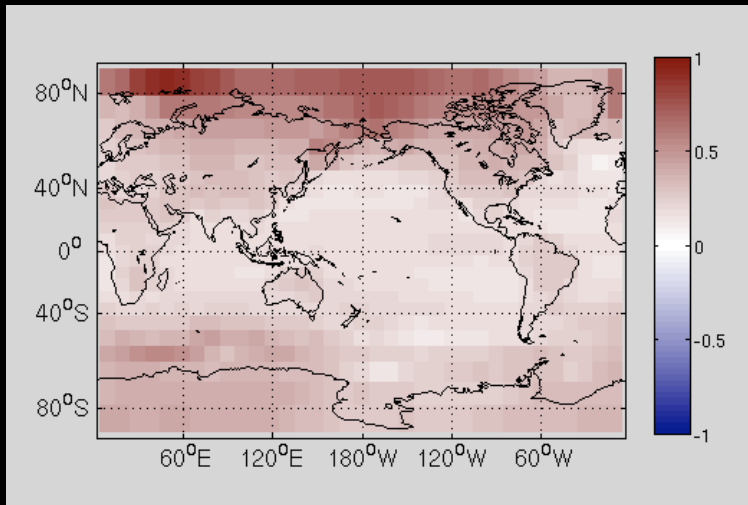
First EOF of Ensemble Mean



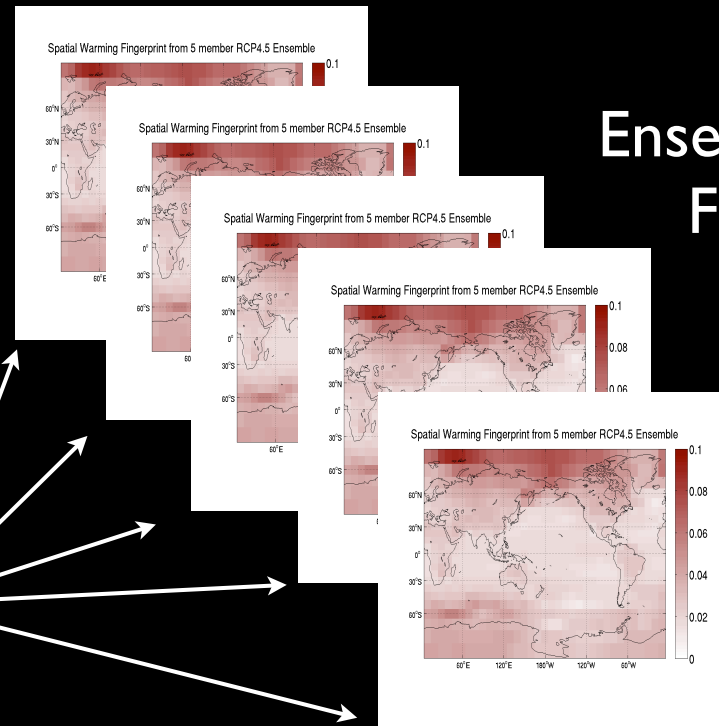
First 10 Principle Components



# Ensemble Mean Fingerprint

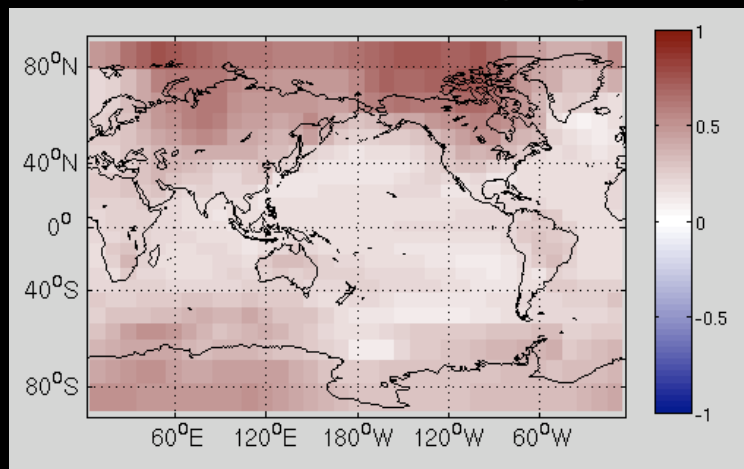


# Ensemble Member Fingerprints

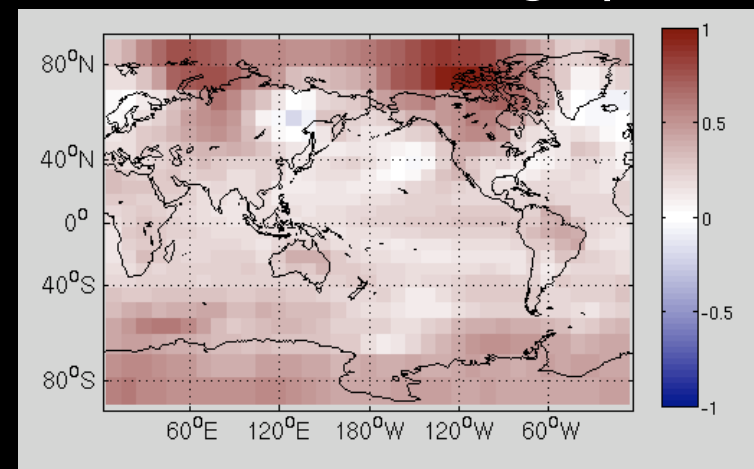


Is FFICT fingerprint distinctive from ensemble members?

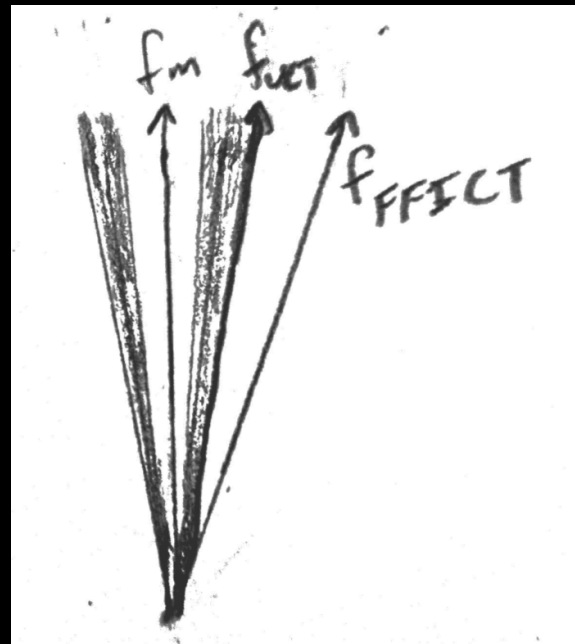
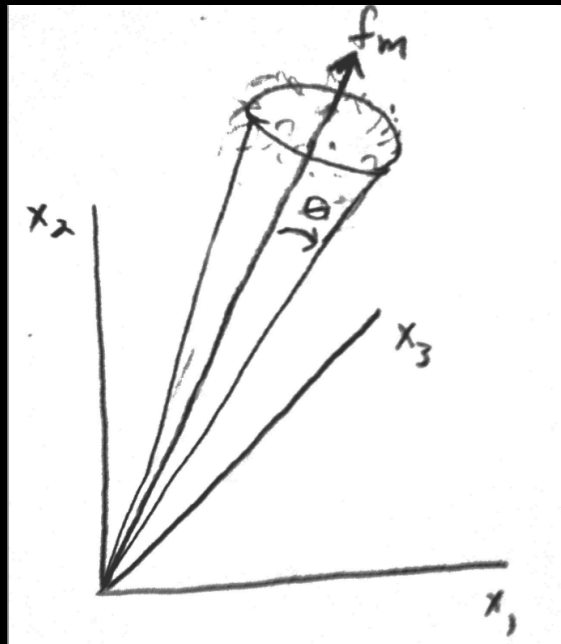
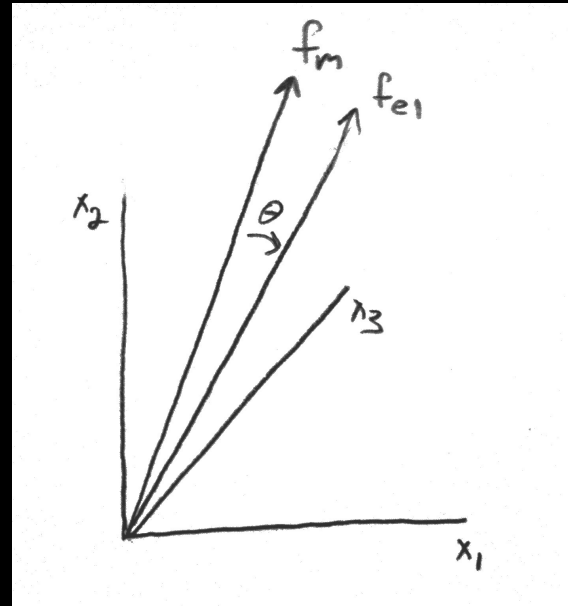
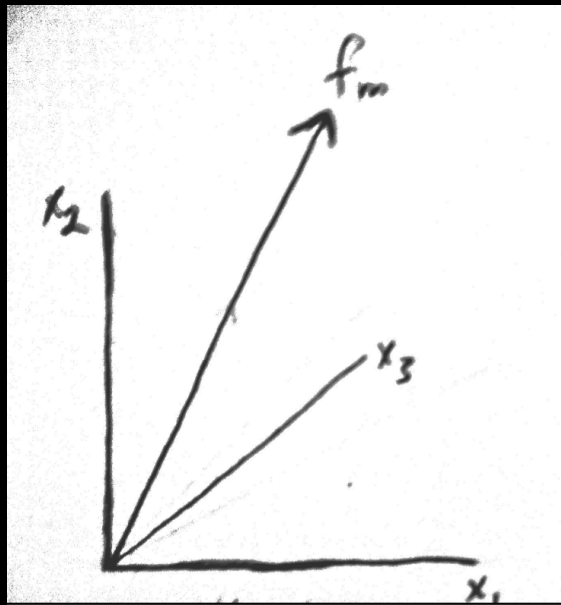
# RCP4.5 UCT Fingerprint



# RCP4.5 FFICT Fingerprint







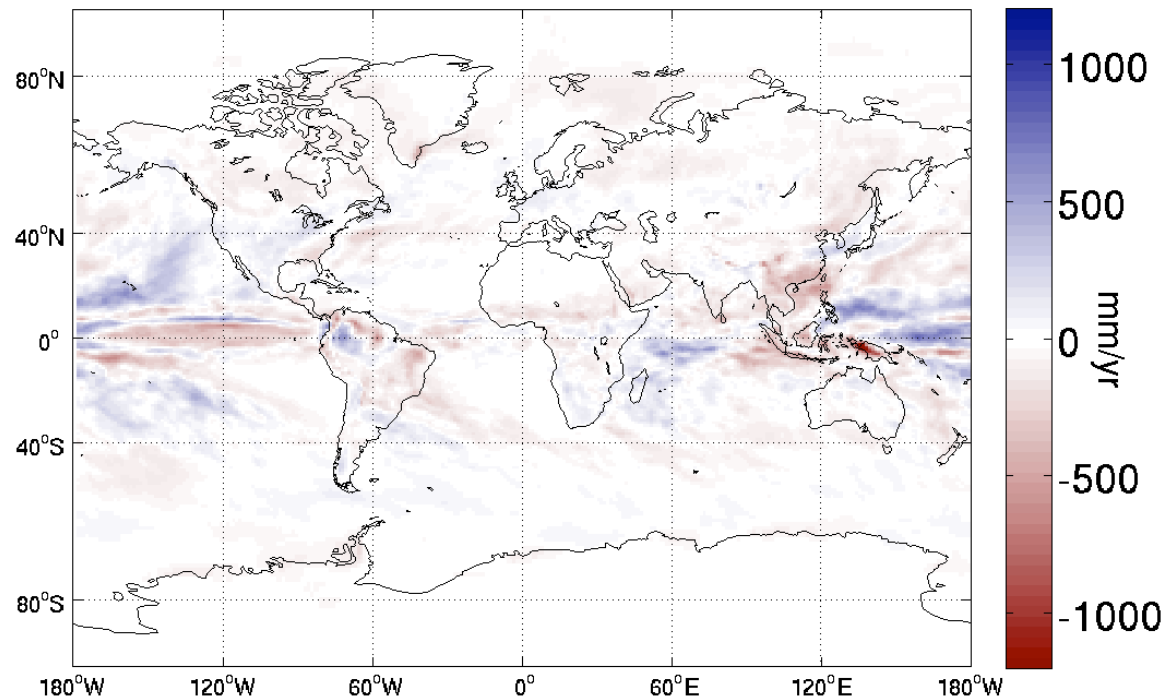
$\theta_{k=}$   
7 +/- 2.5 deg

$\theta_{UCT} = 9.6 \text{ deg}$

$\theta_{FFICT} = 19.5 \text{ deg}$

# RCP4.5 Continental Climate: FFICT is drier than UCT

Final Decade Precipitation Difference: FFICT-UCT



# Conclusions

- Neither the magnitude nor spatial pattern of warming is explained by GHG RF alone
- LUC is critical aspect of future climate
  - especially boreal forests
- Different spatial patterns of warming will affect feedback processes differently
- Although temp change is less drastic in some areas, the RCP4.5 FFICT climate is still quite different