Interpreting anthropogenic land cover/land use information in CLM

Johannes Feddema

Department of Geography

The University of Kansas

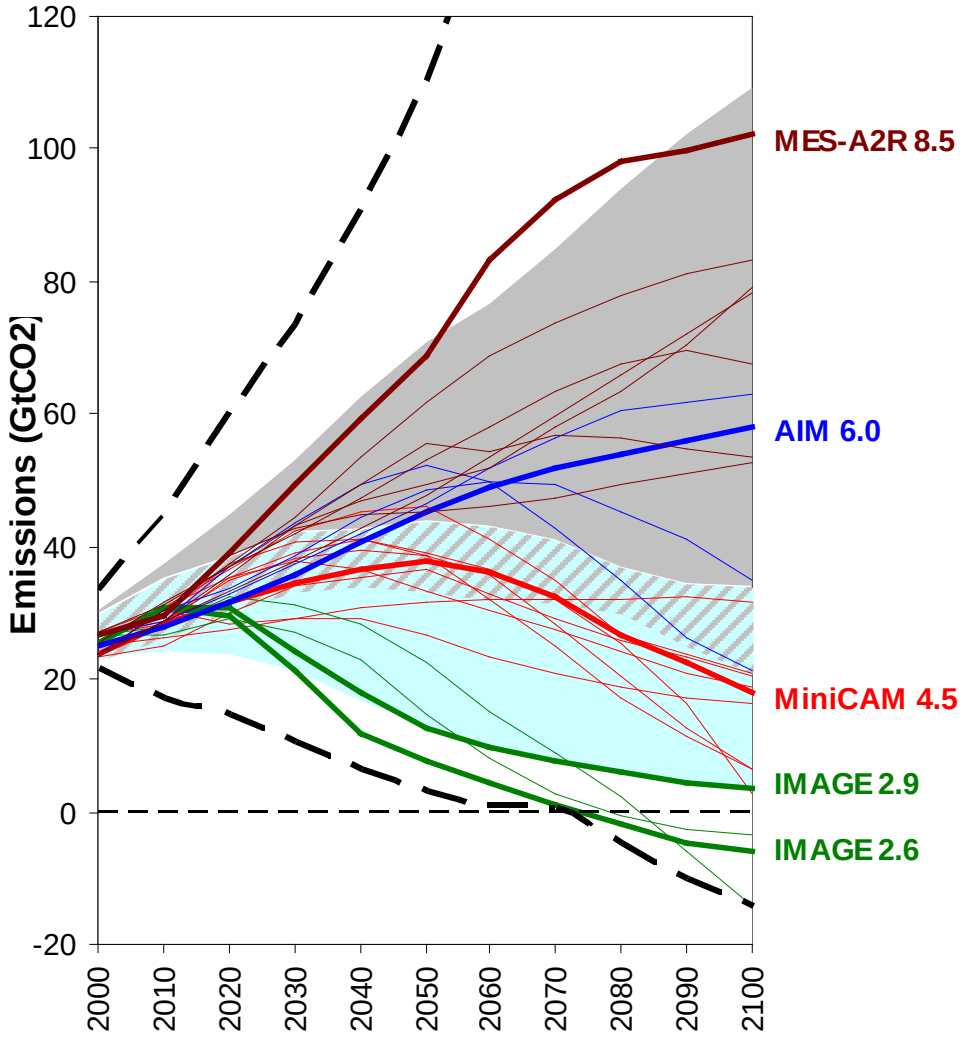
Contributors: Peter Lawrence, Sam Levis, Gordon Bonan, David Lawrence, Keith Oleson, Peter Thornton, Forrest Hoffman, John Bauer, Trish Jackson, Louise Chini-Parsons, Steve Folking, George Hurtt

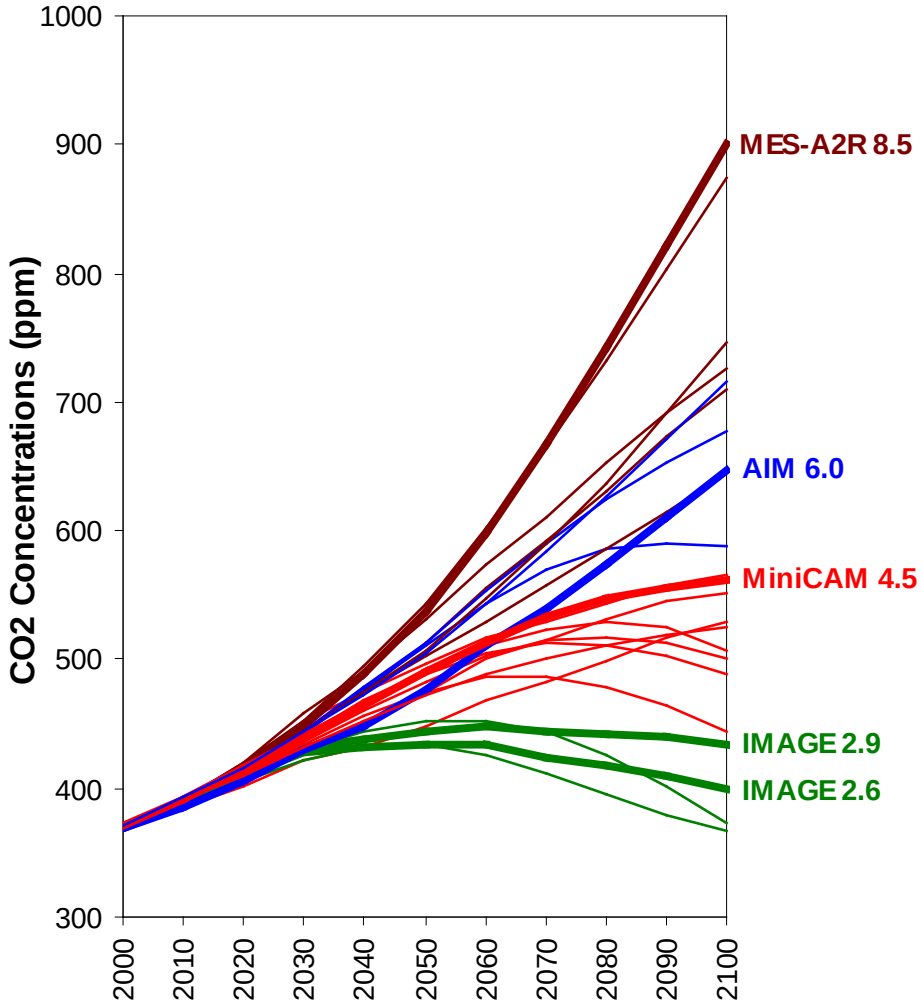
Prescribing Land Cover Change in CLM

IPCC AR5 – RCPs

	Pathway Description	IA Model Group
RCP8.5	Rising radiative forcing pathway leading to 8.5 W/m^2 in 2100.	**MESSAGE**
RCP6	Stabilization without overshoot pathway to 6 W/m^2 at stabilization after 2100	**AIM**
RCP4.5	Stabilization without overshoot pathway to 4.5 W/m^2 at stabilization after 2100	**MiniCAM**
RCP3	Peak in radiative forcing at ~ 3 W/m^2 before 2100 and decline	**IMAGE**

Selected RCP CO_2 Properties



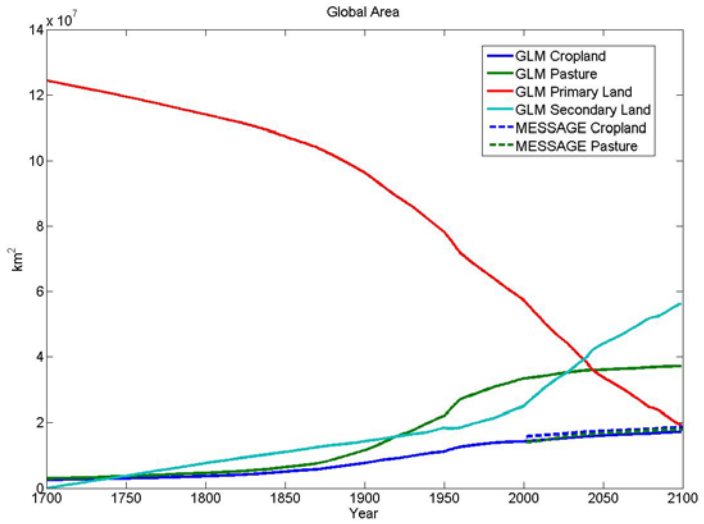


IPCC AR5 – RCP Standardization

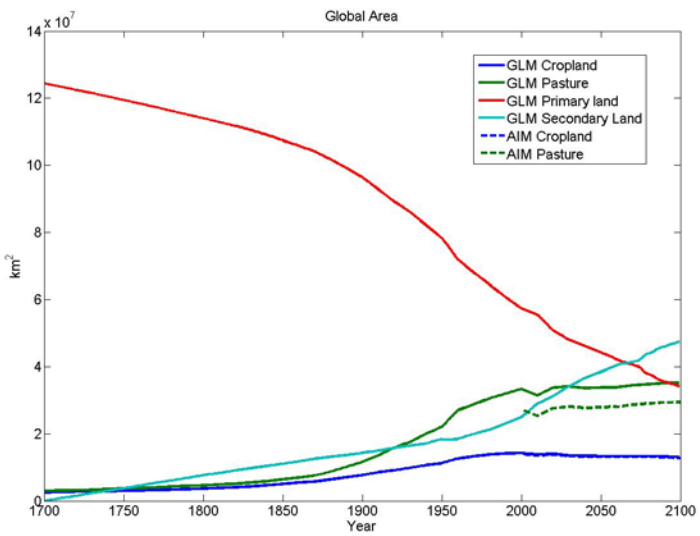
1. All scenarios use an identical 2005 land cover as a starting point
2. All pathways share the same historical trajectory to 2005. After 2005 they diverge following their own representative pathway.
3. For each RCP, minimal information related to land cover change will provide changes in four basic land units:
   - Primary Vegetation (V)
   - Secondary Vegetation (S)
   - Cropping (C)
   - Pasture (P)
4. Historical harvesting of biomass is also prescribed for both primary and secondary vegetation land units (Hurtt, 2006)
5. The University of New Hampshire (UNH) group standardized each scenario and the historical trajectory for harvest and land cover information
6. Each ESM group will have to construct land cover datasets by blending their own natural land cover with the prescribed human activities

RCP Comparisons

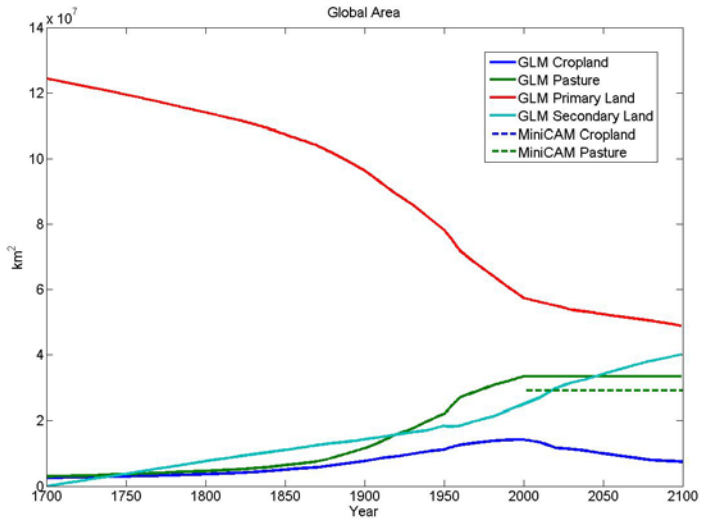
RCP 8.5: Message



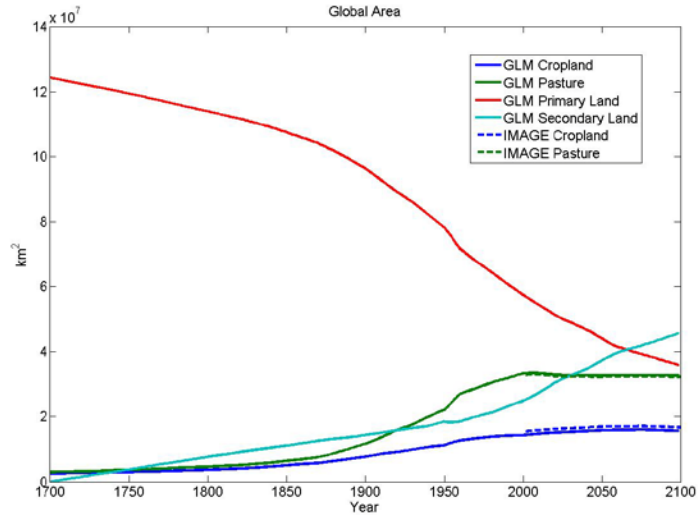
RCP 6.0: AIM



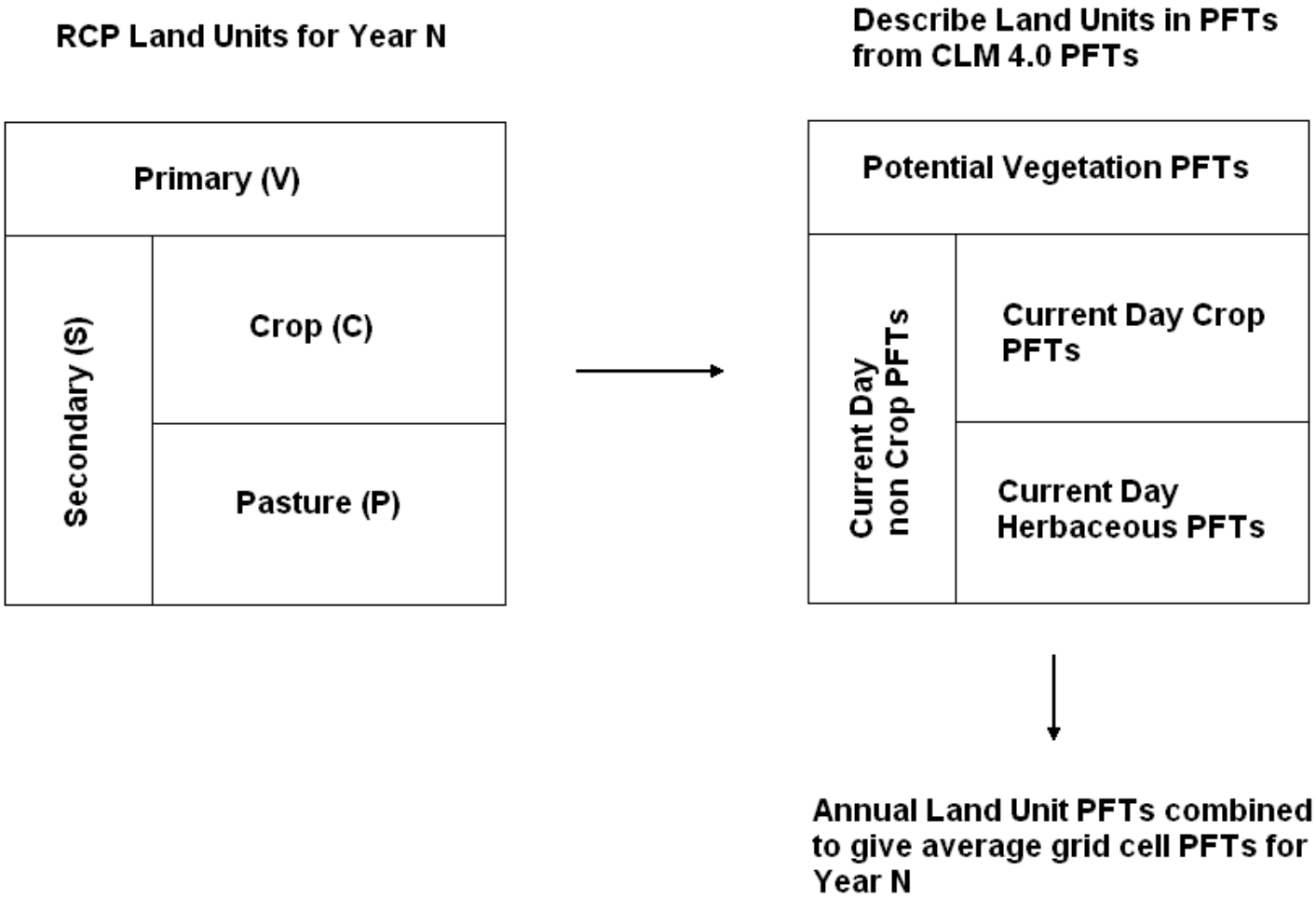
RCP 4.5: Mini-Cam



RCP 2.6: IMAGE



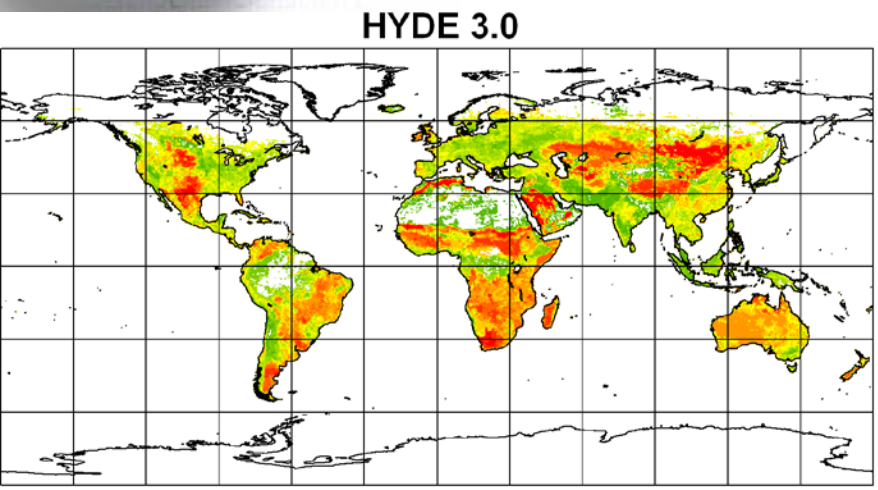
Land Cover Conversion UNH to CLM

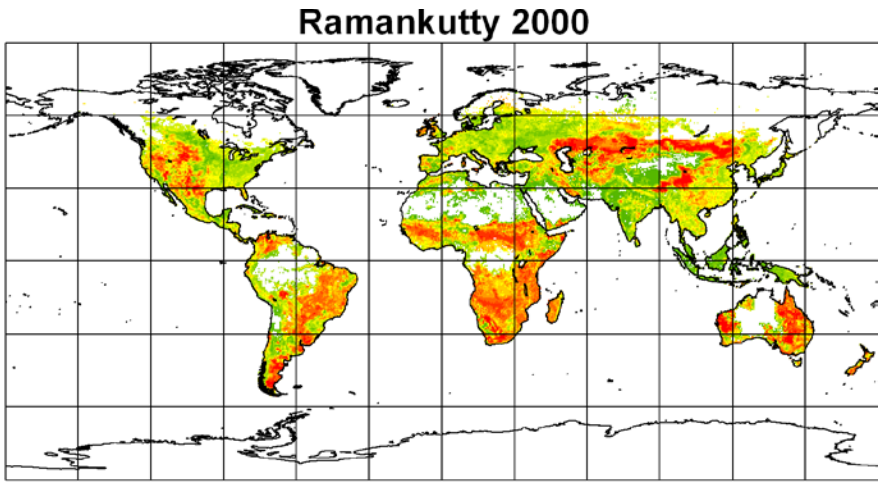


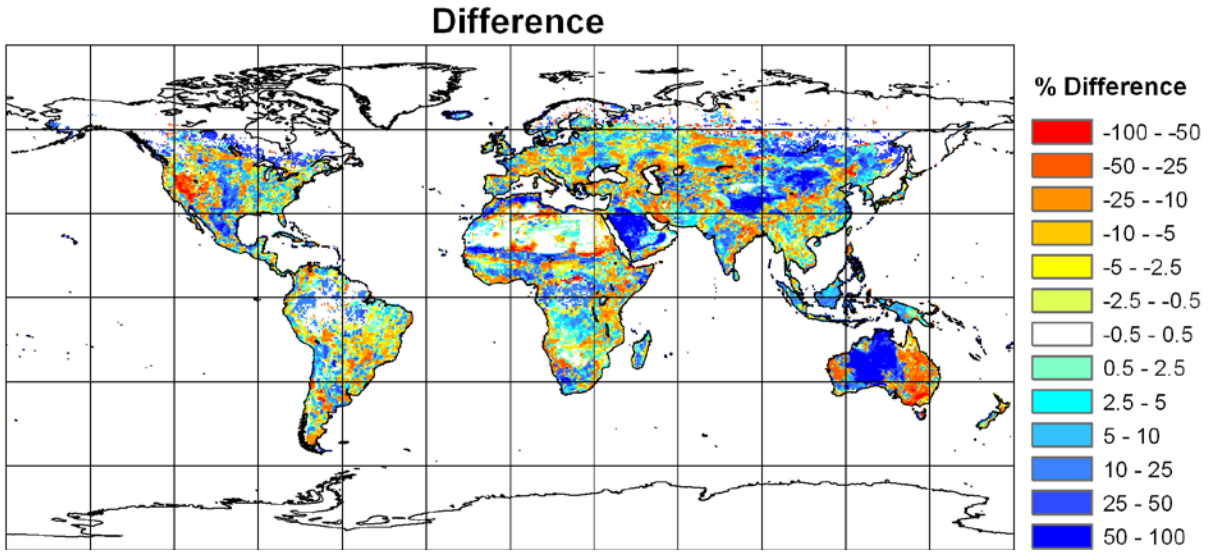
Issues of definitions

What is Pasture/Grazing

Year 2000 Grazing comparison



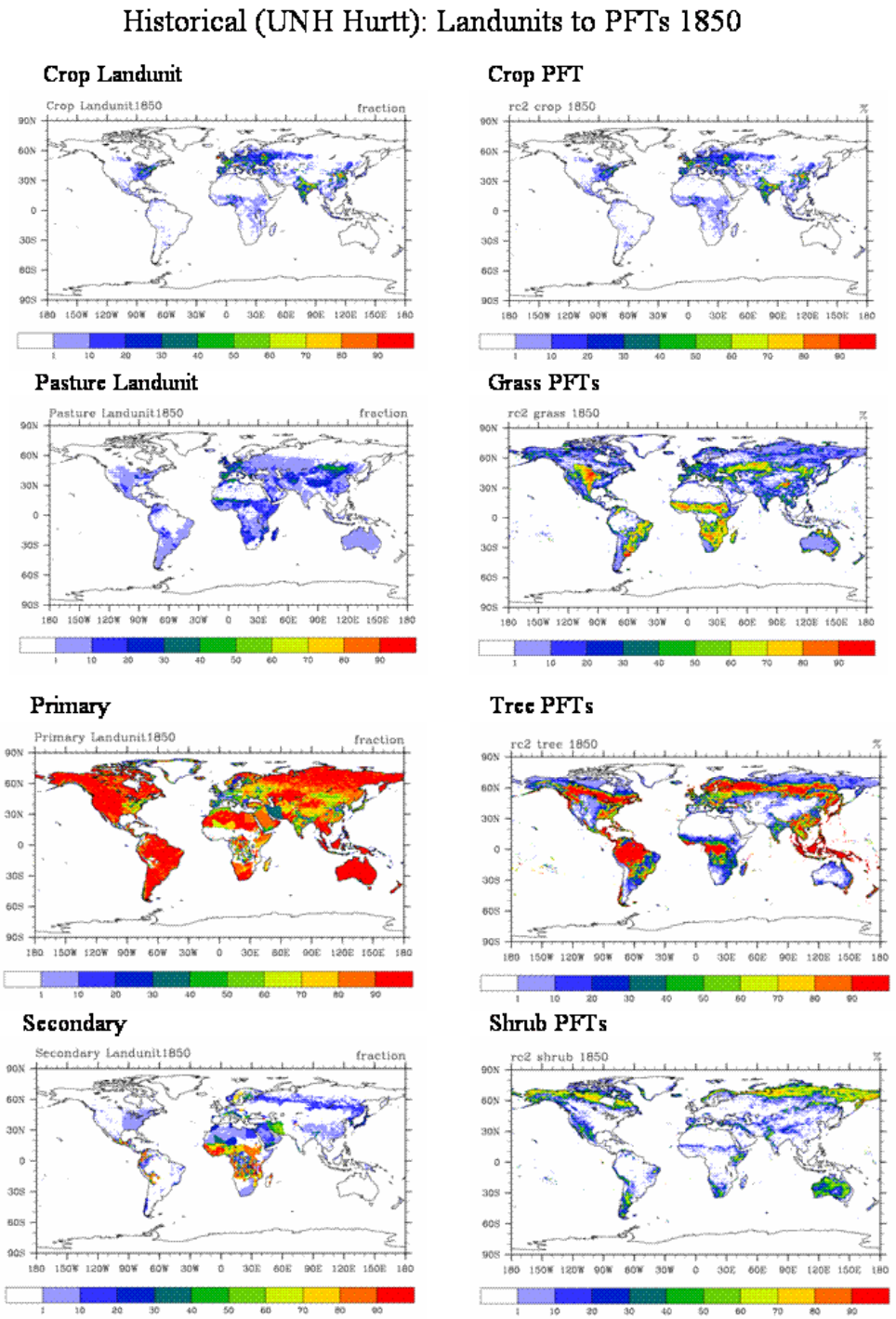




Control: 1850

Translation of UNH landunit to CLM PFTs:

1850



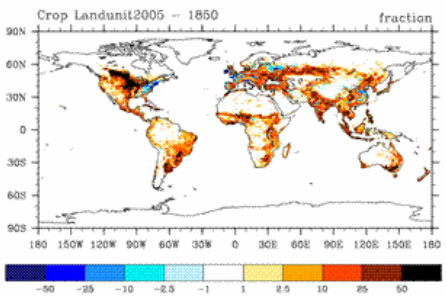
Historical

Change in UNH land units and CLM PFTs from:

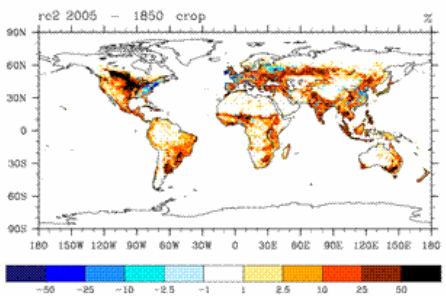
1850 to 2005
Based on HYDE database

Historical (UNH Hurtt): PFT changes 2005-1850

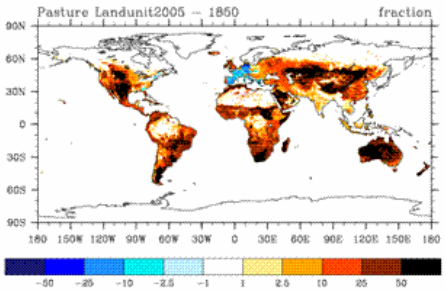
Crop Land Unit



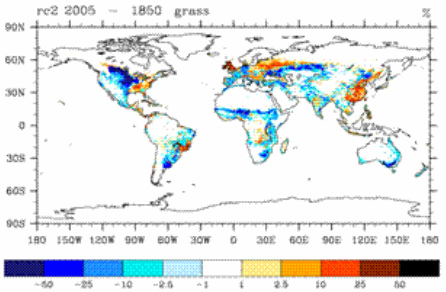
Crop PFT



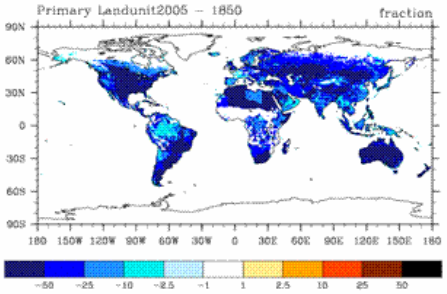
Pasture Land Unit



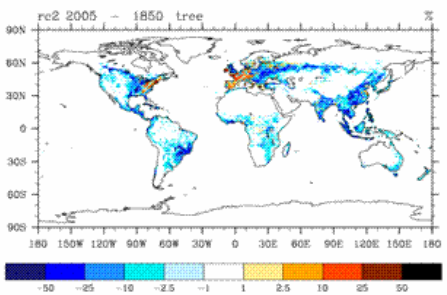
Grass PFTs



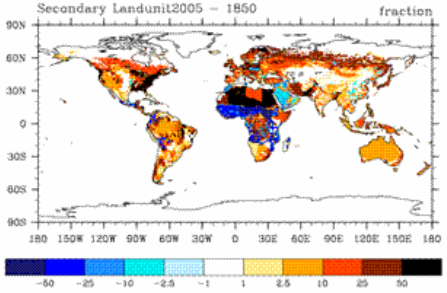
Primary Land Unit



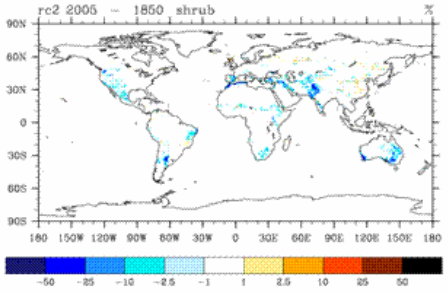
Tree PFTs



Secondary Land Unit



Shrub PFTs



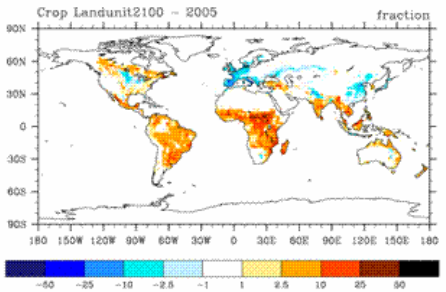
Future

Change in UNH land units and CLM PFTs for:

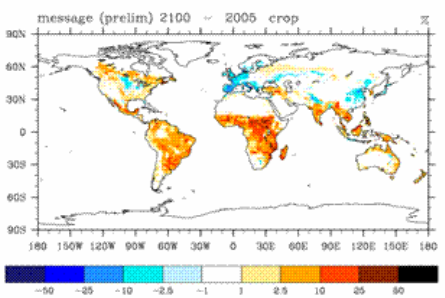
RCP 8.5: 2005 – 2100
Message IAM

Message (RCP 8.5 Wm^{-2}): PFT changes 2100-2005

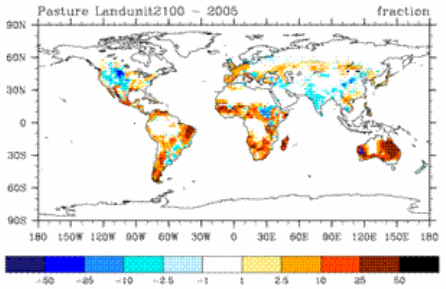
Crop Landunit



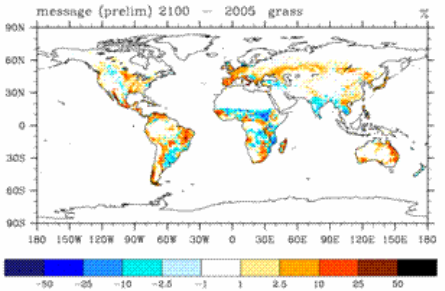
Crop PFT



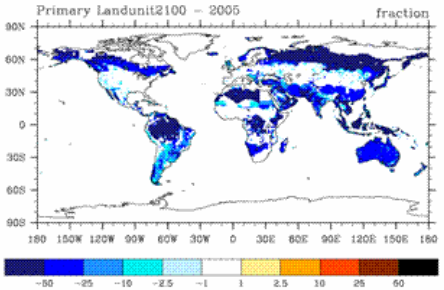
Pasture Landunit



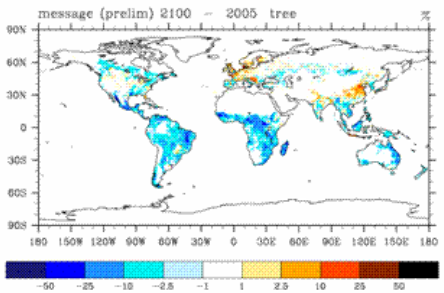
Grass PFTs



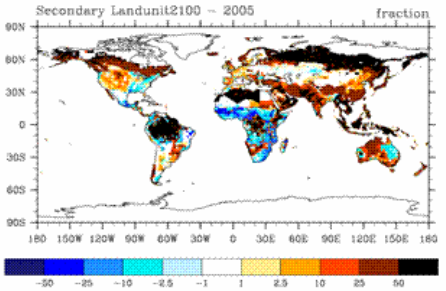
Primary Landunit



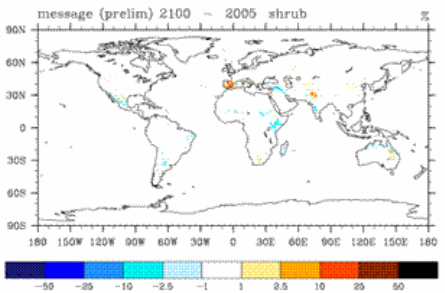
Tree PFTs



Secondary Landunit



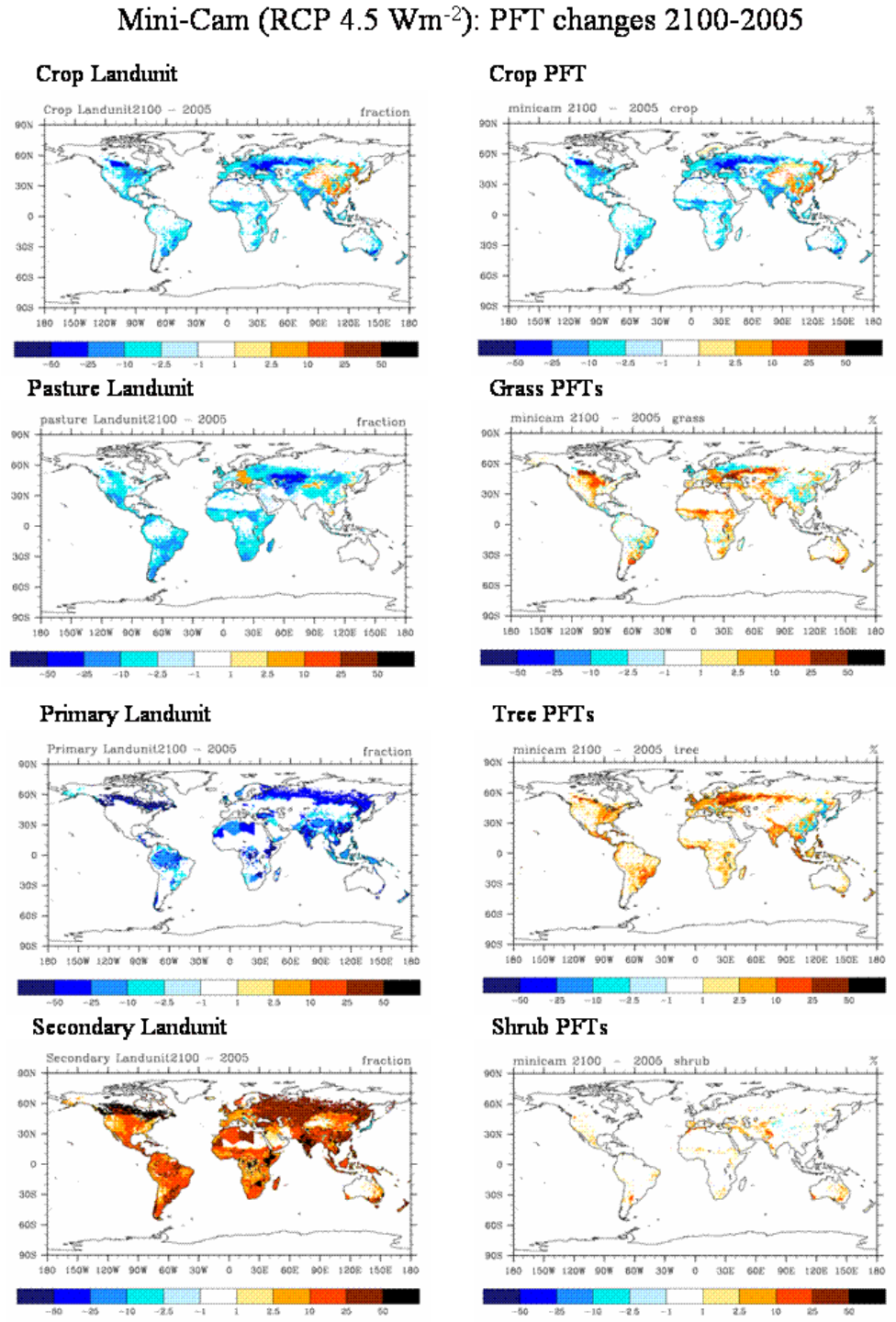
Shrub PFTs



Future

Change in UNH land units and CLM PFTs for:

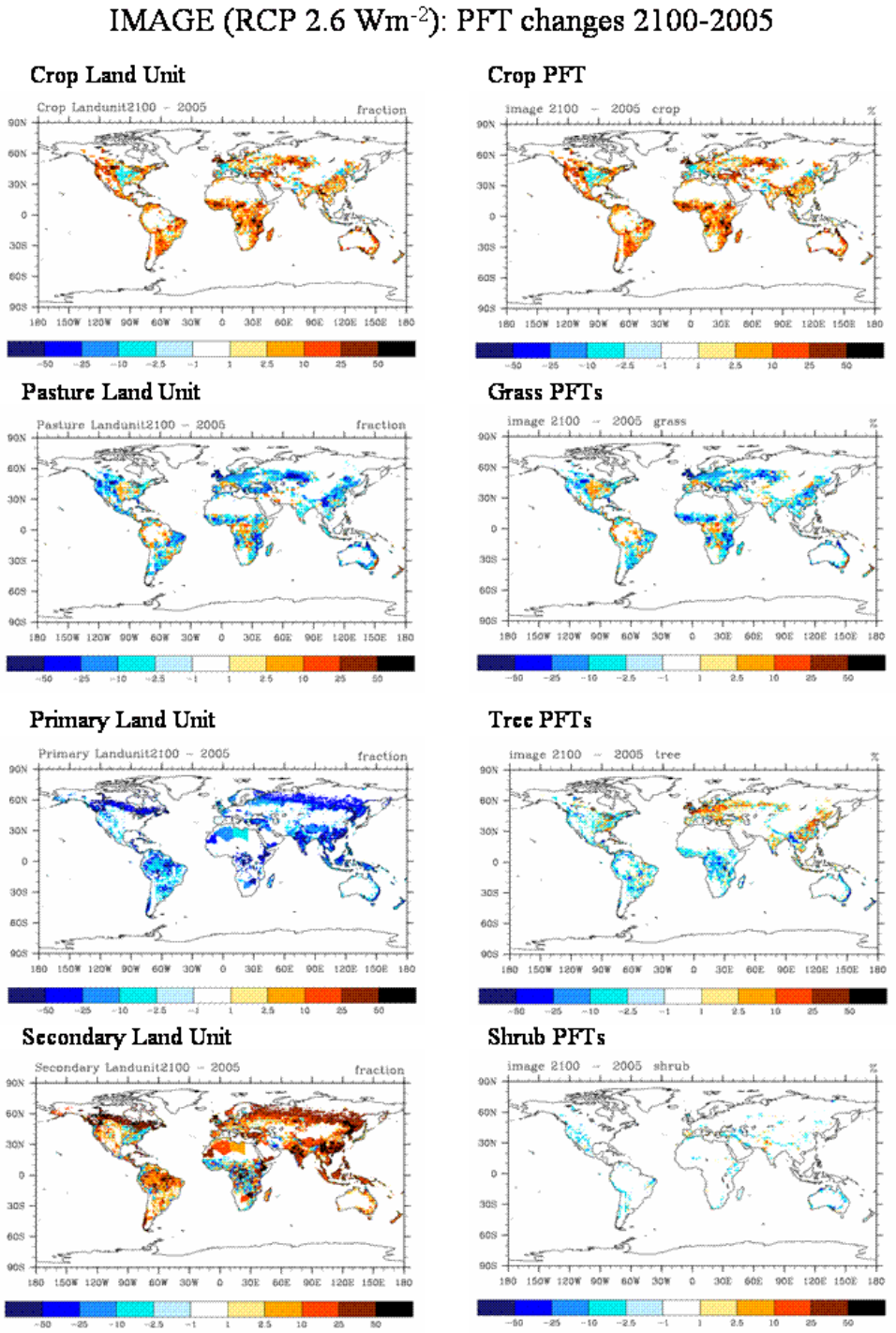
RCP 4.5: 2005 – 2100
Mini-Cam IAM



Future

Change in UNH land units and CLM PFTs for:

RCP 2.6: 2005 – 2100
IMAGE IAM



Prescribing Wood Harvest in CLM

Anthropogenic Deforestation/Wood Harvest

Deforestation classes from Hurtt et al. 2006

Vh1 = harvest of primary (undisturbed) forest (kgC)

Vh2 = harvest from primary non-forested land (kgC)

Sh1 = harvest from mature secondary forest (kgC)

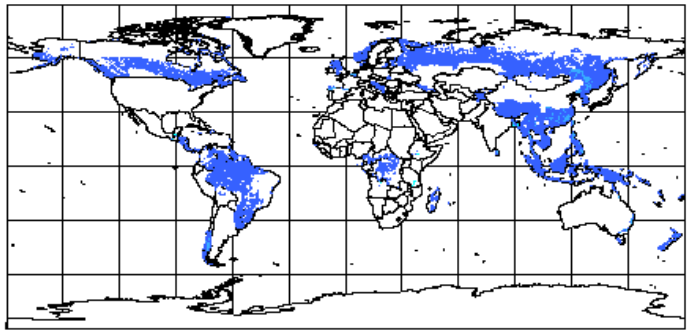
Sh2 = harvest from young secondary forest (kgC)

Sh3 = harvest from primary non-forested land (kgC)

Hurtt GC, Frolking S, Fearon MG, Moore III B, Shevliakova E, Malyshev S, Pacala SW, Houghton RA. (2006) Global Change Biology 12:1208-1229.

Estimating carbon density

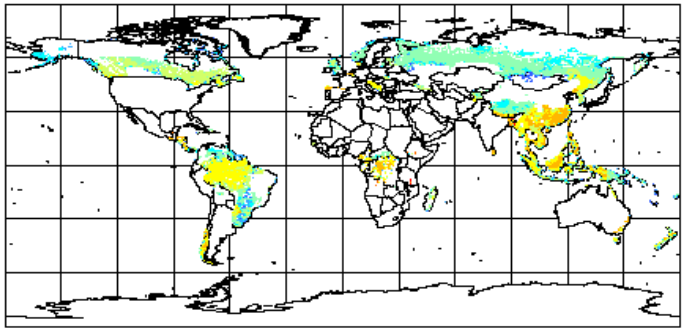
Vh1 deforestation information and density calculation
Year 2000



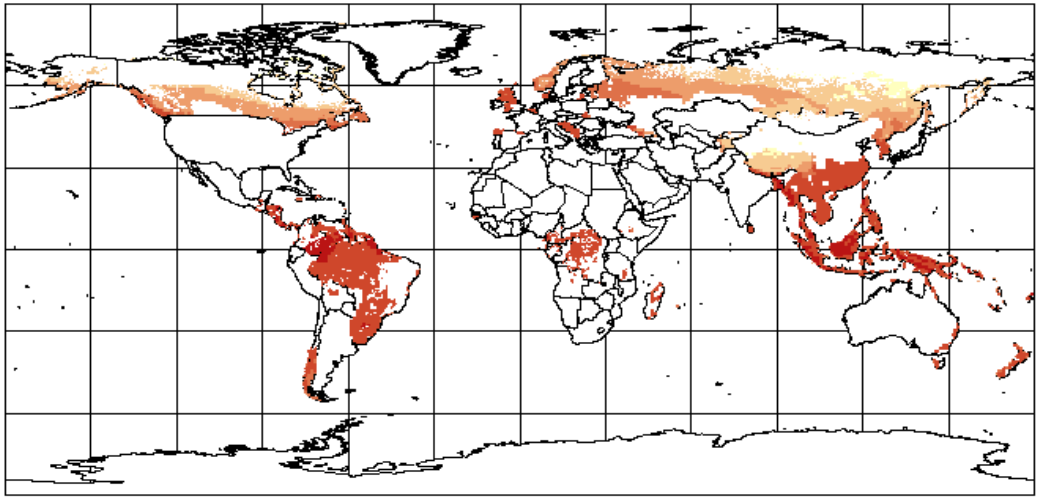
Deforestation
Grid Cell Fraction

- 0 - 0.001
- 0.001 - 1,000,000
- 1,000,000 - 5,000,000
- 5,000,000 - 10,000,000
- 10,000,000 - 25,000,000
- 25,000,000 - 50,000,000
- 50,000,000 - 100,000,000
- 100,000,000 - 250,000,000
- 250,000,000 - 500,000,000
- 500,000,000 - 750,000,000

Grid Cell
Carbon Emissions



- 0 - 0.00001
- 0.00001 - 0.005
- 0.005 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1

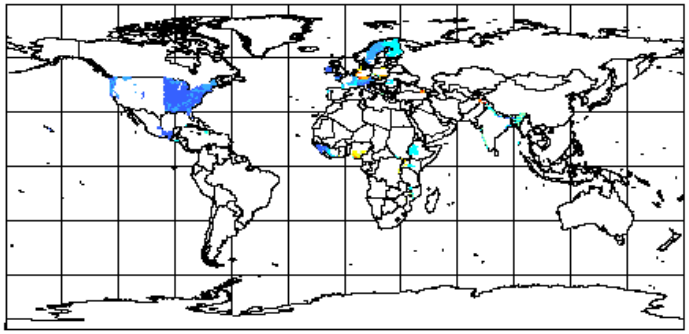


Carbon
Density

- < 0.01
- 0.01 - 0.1
- 0.1 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.50
- 2.50 - 5.00
- 5.00 - 7.50
- 7.50 - 10.00
- 10.00 - 15.00
- 15.00 - 20.00

Estimating carbon density

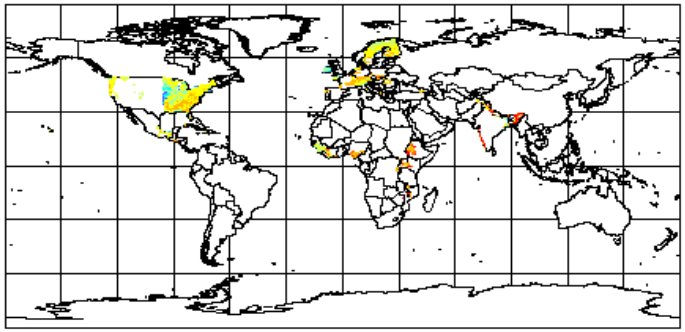
Sh2 deforestation information and density calculation Year 2000



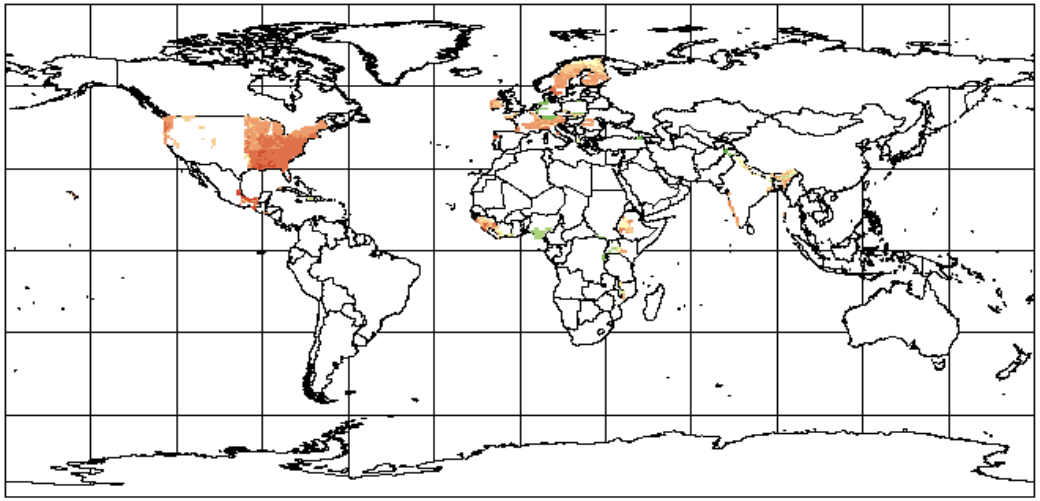
Deforestation
Grid Cell Fraction

- 0 - 0.001
- 0.001 - 1,000,000
- 1,000,000 - 5,000,000
- 5,000,000 - 10,000,000
- 10,000,000 - 25,000,000
- 25,000,000 - 50,000,000
- 50,000,000 - 100,000,000
- 100,000,000 - 250,000,000
- 250,000,000 - 500,000,000
- 500,000,000 - 750,000,000

Grid Cell
Carbon Emissions



- 0 - 0.00001
- 0.00001 - 0.005
- 0.005 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1



Carbon
Density

- < 0.01
- 0.01 - 0.1
- 0.1 - 0.25
- 0.25 - 0.50
- 0.50 - 1.00
- 1.00 - 2.50
- 2.50 - 5.00
- 5.00 - 7.50
- 7.50 - 10.00
- 10.00 - 15.00
- 15.00 - 20.00

Comparative Wood Density by Harvest Class

	Average global carbon density in harvested grid cells kgm^{-2} (**percent of vh1 value**)				
	Vh1	**Vh2**	**Sh1**	**Sh2**	**Sh3**
1851	9.24	0.28 (**0.030**)	4.44 (**0.481**)	7.29 (**0.789**)	1.06 (**0.115**)
2001	8.84	0.30 (**0.034**)	4.67 (**0.528**)	5.83 (**0.660**)	0.42 (**0.048**)
2031 IMAGE	8.69	0.54 (**0.062**)	4.95 (**0.570**)	5.42 (**0.624**)	0.36 (**0.042**)
2031 Mini-CAM	8.74	0.59 (**0.068**)	4.75 (**0.543**)	5.47 (**0.626**)	0.36 (**0.041**)
2100 IMAGE	7.56	0.43 (**0.056**)	5.54 (**0.733**)	4.55 (**0.602**)	0.43 (**0.057**)
2100 Mini-CAM	8.59	0.33 (**0.038**)	5.97 (**0.695**)	4.84 (**0.563**)	0.50 (**0.058**)
Average	*8.61*	*0.412 (**0.048**)*	*5.05 (**0.587**)*	*5.57 (**0.647**)*	*0.52 (**0.061**)*

Outcome:

Wood Harvest area = Vh1 + 0.05*Vh2 + 0.6*Sh1+ 0.6*Sh2 + 0.05*Sh3

Hurtt GC, Frolking S, Fearon MG, Moore III B, Shevliakova E, Malyshev S, Pacala SW, Houghton RA. (2006) Global Change Biology 12:1208-1229.

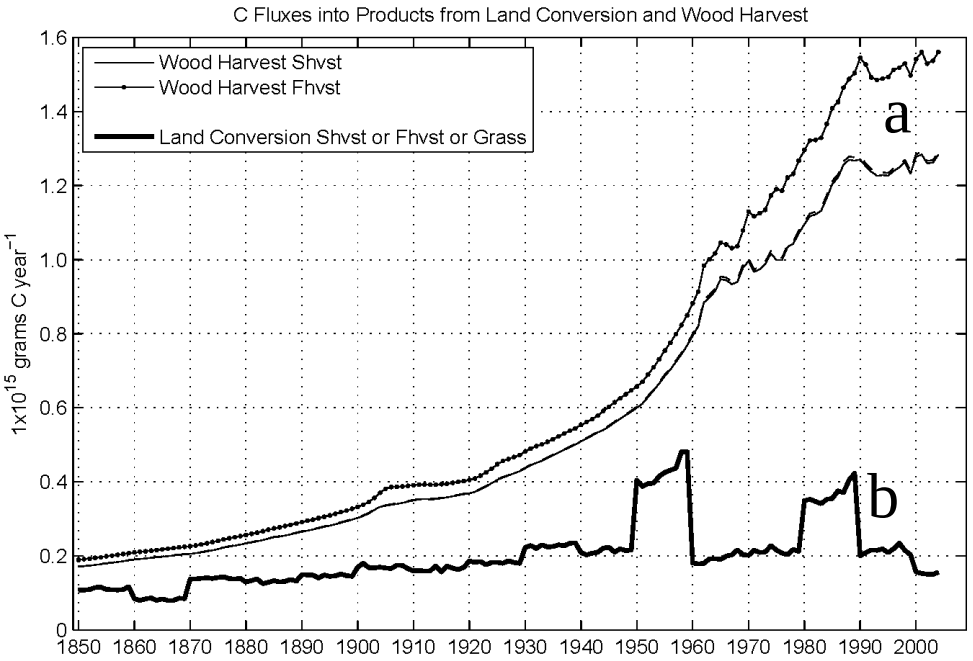
C emissions

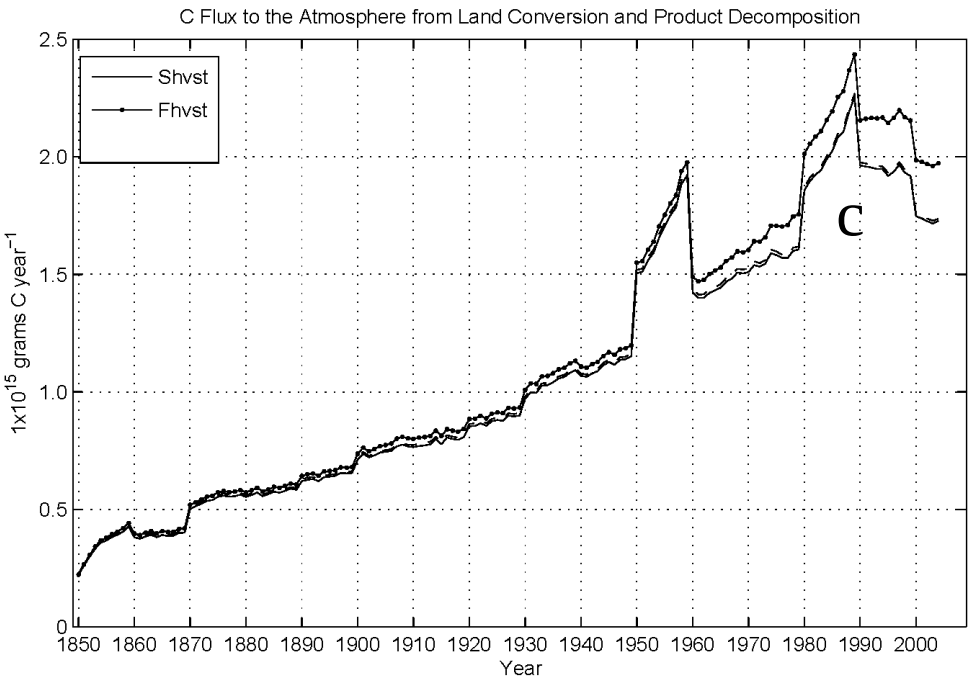
Carbon emissions from

a) Scaled and full wood harvest

b) Land cover conversion

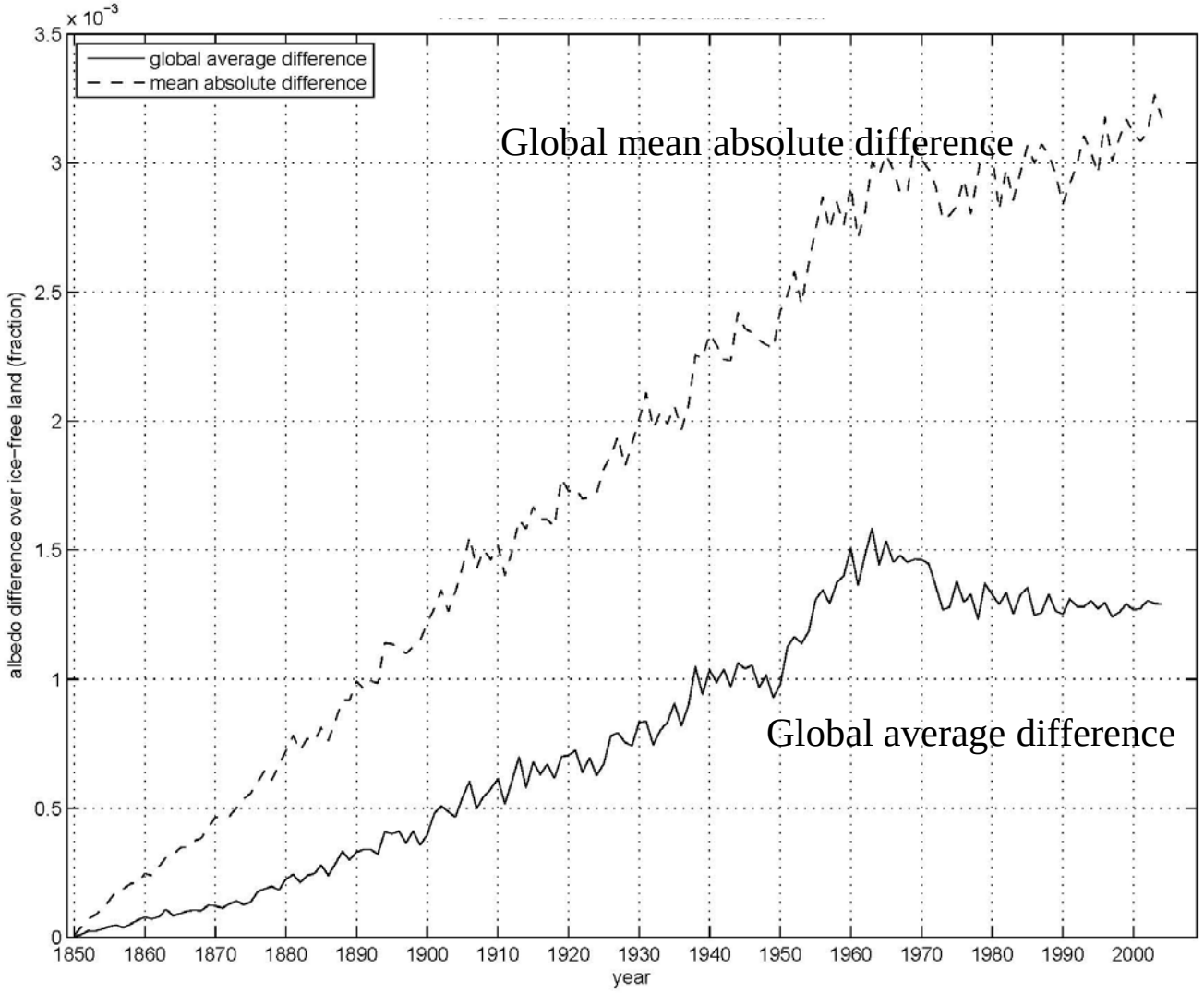
c) Land cover conversion and product decomposition scaled/full





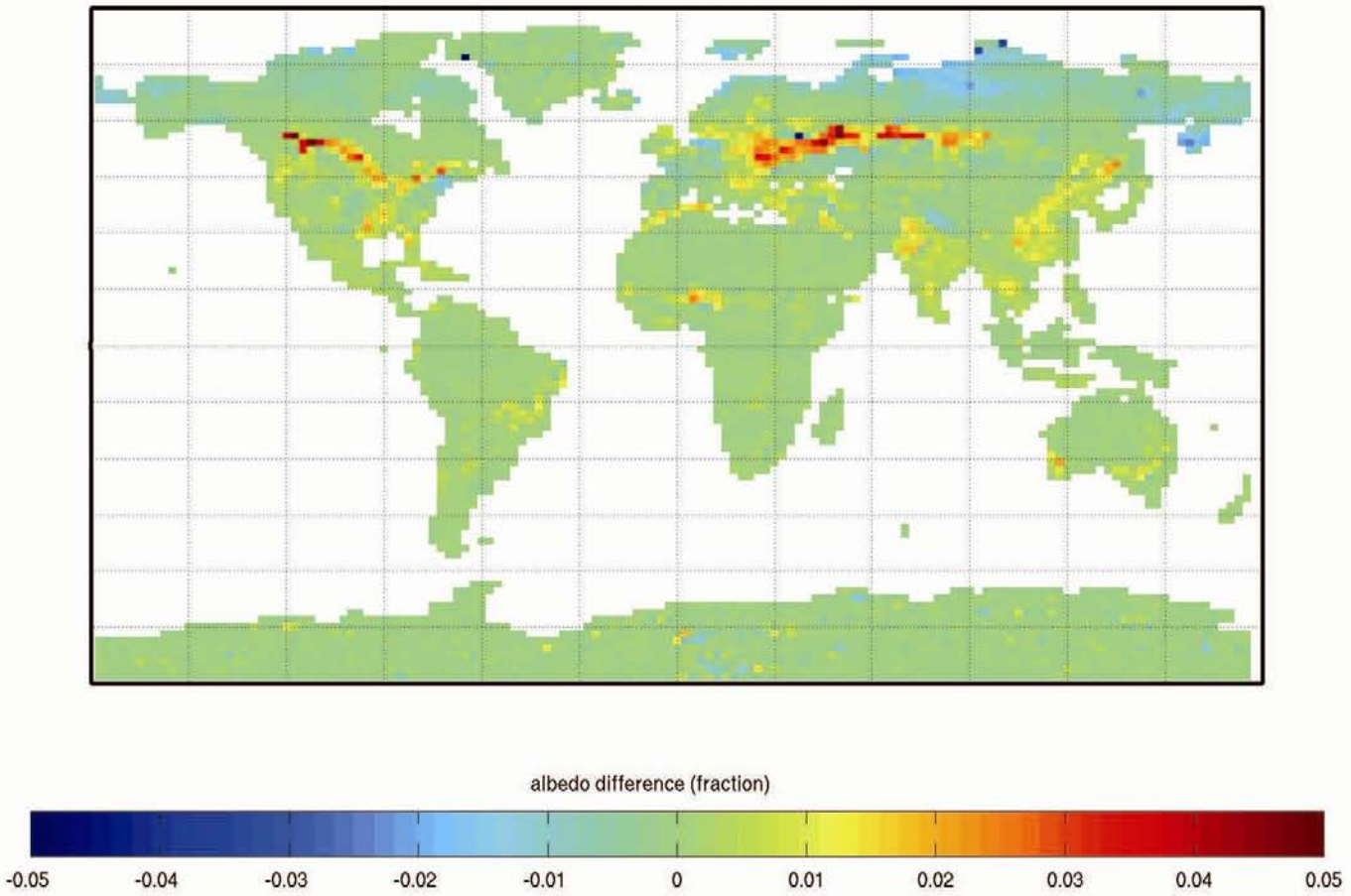
Wood Harvest impact on Global Albedo

1850 – New harvest Coefficients



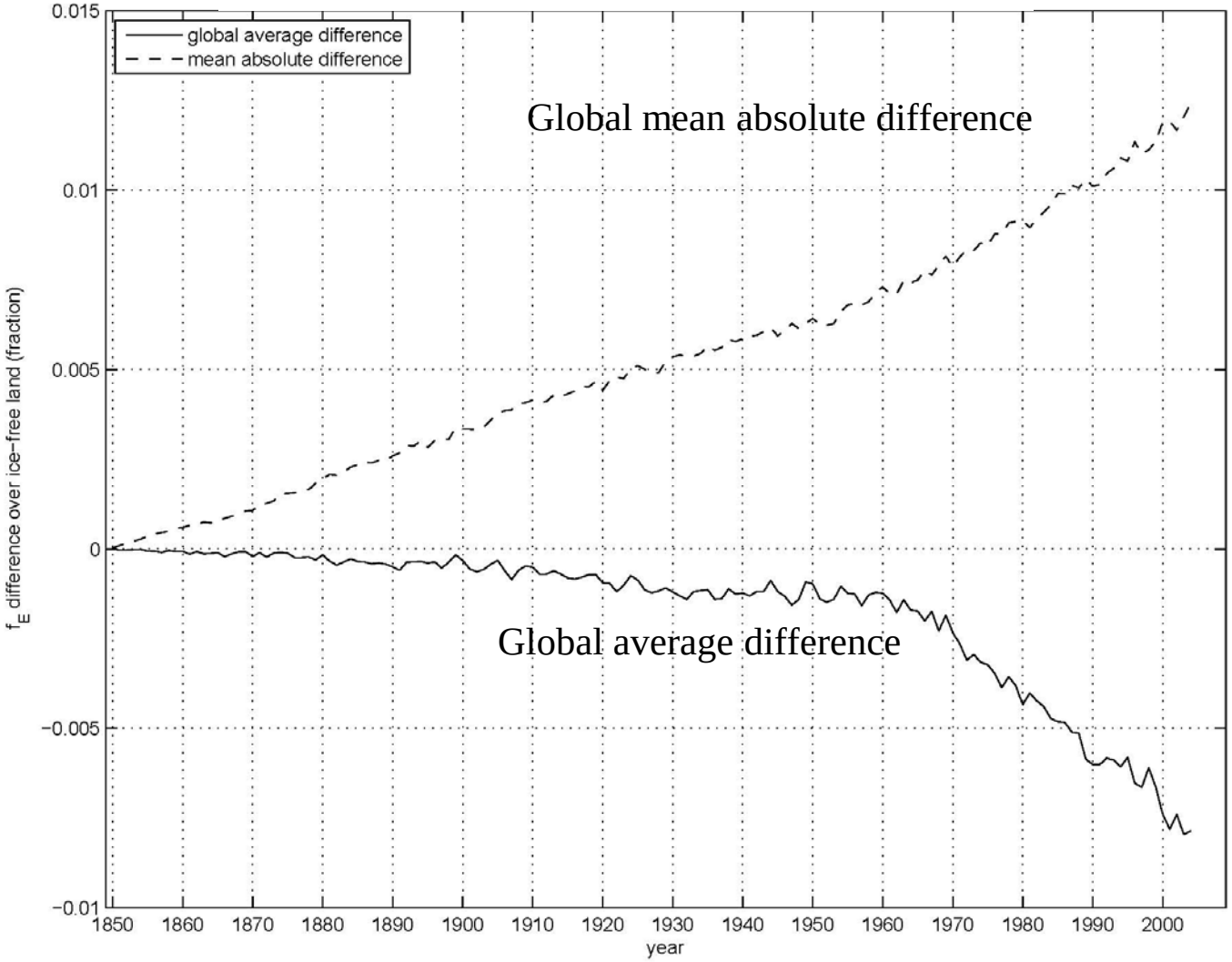
Wood Harvest Albedo Impacts

1850 – New harvest Coefficients



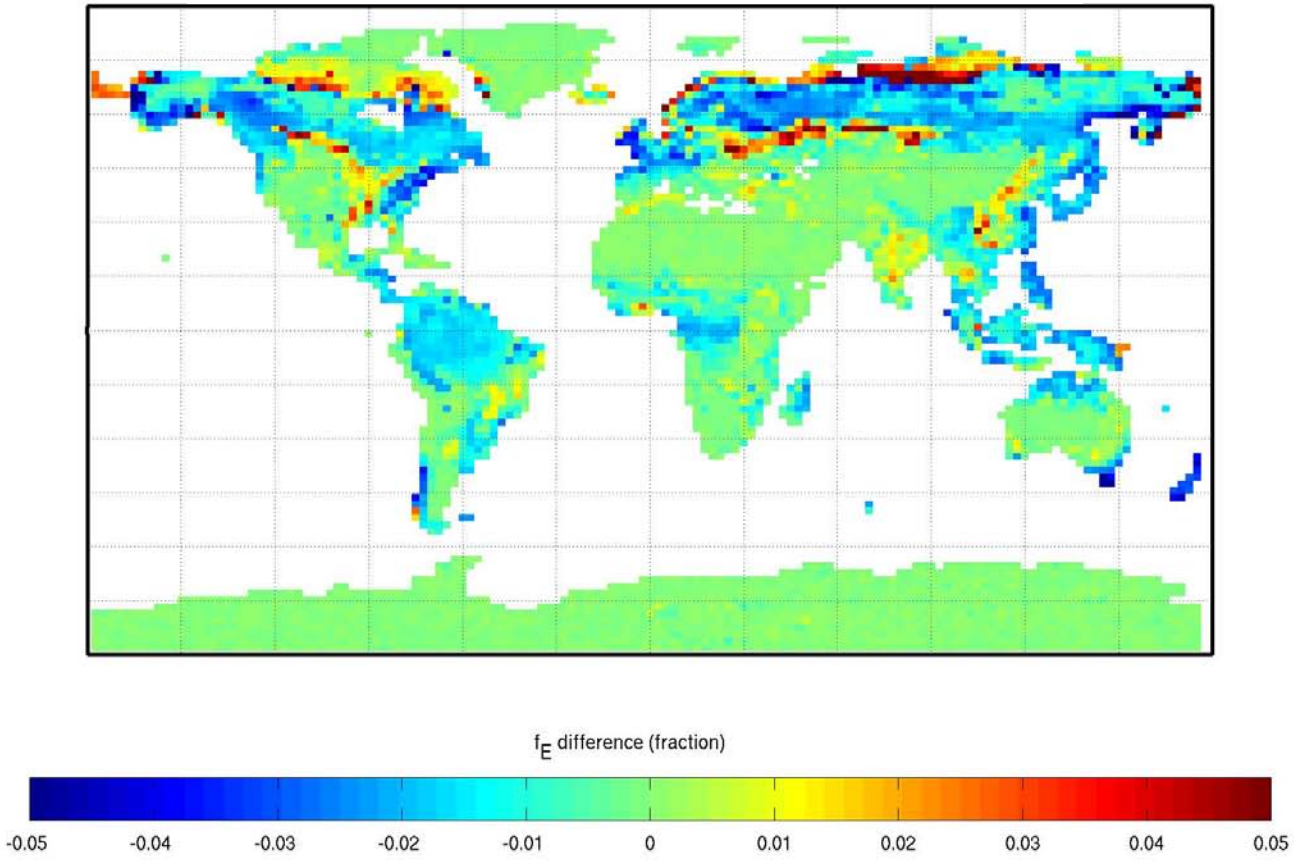
Wood Harvest impact on Global f_E

1850 – New harvest Coefficients

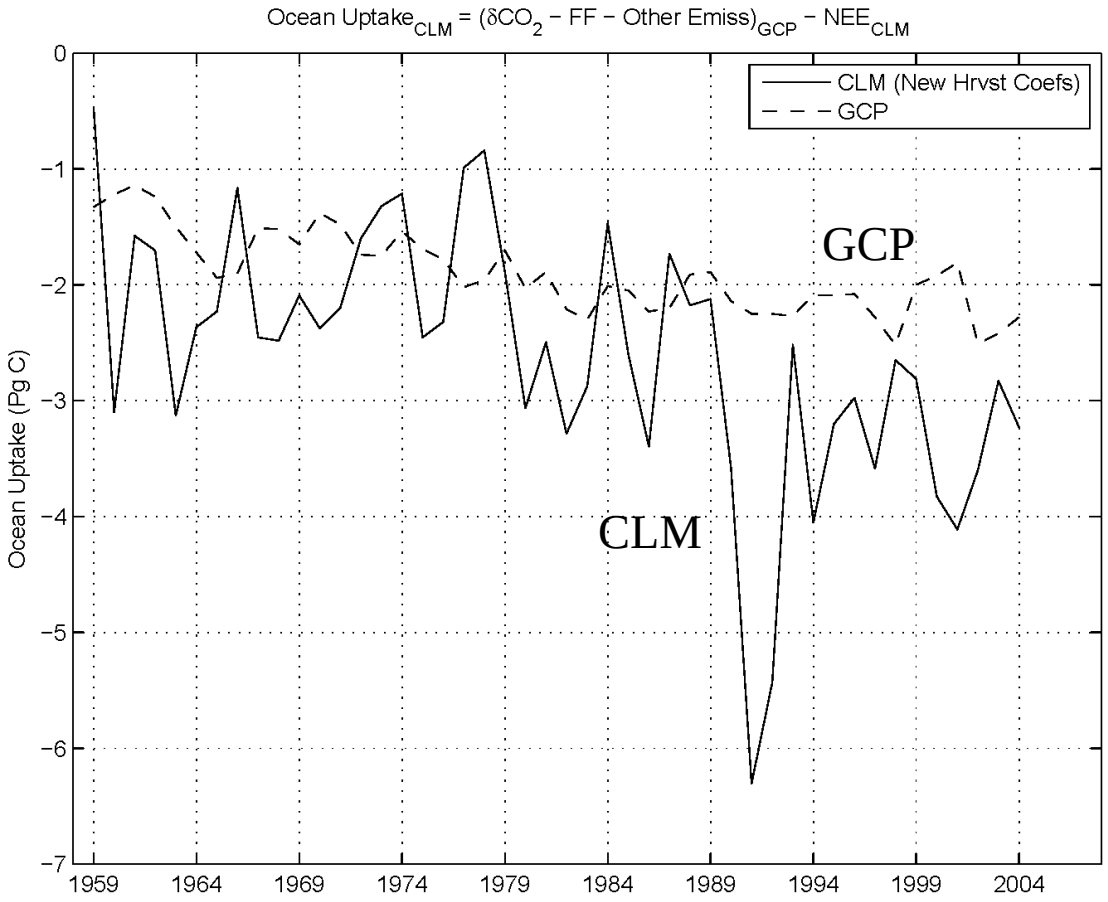


Wood Harvest Evaporative Fraction Impacts

1850 – New harvest Coefficients



Validation – Compare to Ocean Uptake GCP



Source: http://www.globalcarbonproject.org/

Conclusions

Transient land cover datasets for CLM 4.0

- Historical (HYDE) via UNH
  - 1850 – 2005 currently available
  - Potentially can go back to 1500
- Future scenarios
  - 4 RCPs represented
- Conform to IPCC and UNH base datasets, **but**:
  - Interpretation of pasture is unique
  - Wood harvest is uniquely scaled for CLM