NCAR Earth System Laboratory

CCSM4 Last Millennium Run

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Paleoclimate Modeling Intercomparison Project (PMIP) 3: the Last Millennium 850-1850

- As part of the IPCC CMIP5, a series of modeling experiments will be run under the Paleoclimate Modeling Intercomparison Project 3 (PMIP3)
- This talk outlines the PMIP3 Last Millennium experimental design and CCSM4 preparation

PMIP3 Last Millennium Design

Boundary conditions 850-1850:

- Total Solar Irradiance (TSI)
- Volcanic Forcings
- Trace Gases (CO_2, CH_4, N_2O)
- Orbital forcing (internally calculated)
- Vegetation and land-use change
- Initial conditions: we initialize with CCSM4 1850 control run

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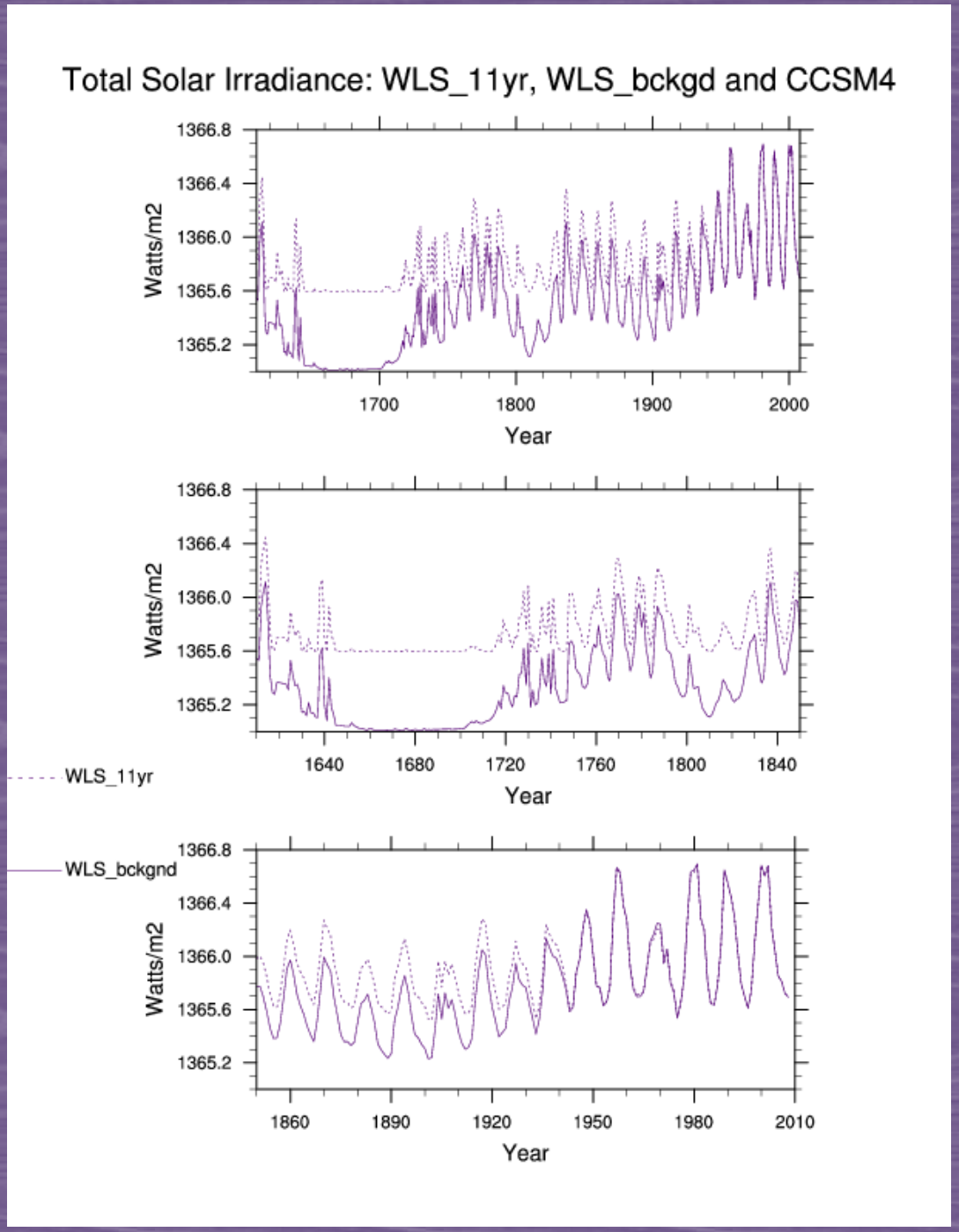
Total Solar Irradiance (TSI)

- Multiple reconstructions to choose from.
- Includes reconstruction used by CCSM4 for the post-1850 CMIP5 simulations (Wang, Lean and Sheely, 2005 – hereafter WLS).
- Each series has an 11 year solar cycle throughout the time series (synthetic for pre-1610, based on a relationship between cycle magnitude and long-term TSI)
- Some series also have a “background” version that includes longer-term trends in the solar minimum
- Each reconstruction is calibrated to the WLS modern values.

WLS TSI Reconstruction, 1610-2000:

1. 11-year cycle alone

2. 11-yr cycle with **background** trends (used in CCSM4 1850 control, and 20th century runs)



TSI reconstructions:

1. **Wang, Lean and Sheely, 2005 (WLS): 1610-2000 CE**
   - "no-background" version that just has TSI variations similar to that seen over a solar cycle today
   - "with background" version with longer term trends in the solar minimum.
2. **Delaygue and Bard, 2009 (DB): 850-1609 CE**
   - Antarctica stack of 10Be records scaled linearly to the modern-to-Maunder Minimum TSI in the two WLS reconstructions.
3. **Muscheler, Joos, Beer, Müller, Vonmoos and Snowball, 2007 (MEA): 850-1609 CE**
   - 14C record scaled based on an inverse regression to the two WLS reconstructions.
4. **Vieira, Krivova and Solanki, 2007 (VK): 850-1849 CE**
   - open and closed magnetic flux model with estimated 11 yr cycle.
5. **Steinhilber, Beer, and Frohlich, 2009 (SBF): 850-1849 CE**
   - Greenland 10Be core, different solar flux model. 11yr cycle is synthetic.

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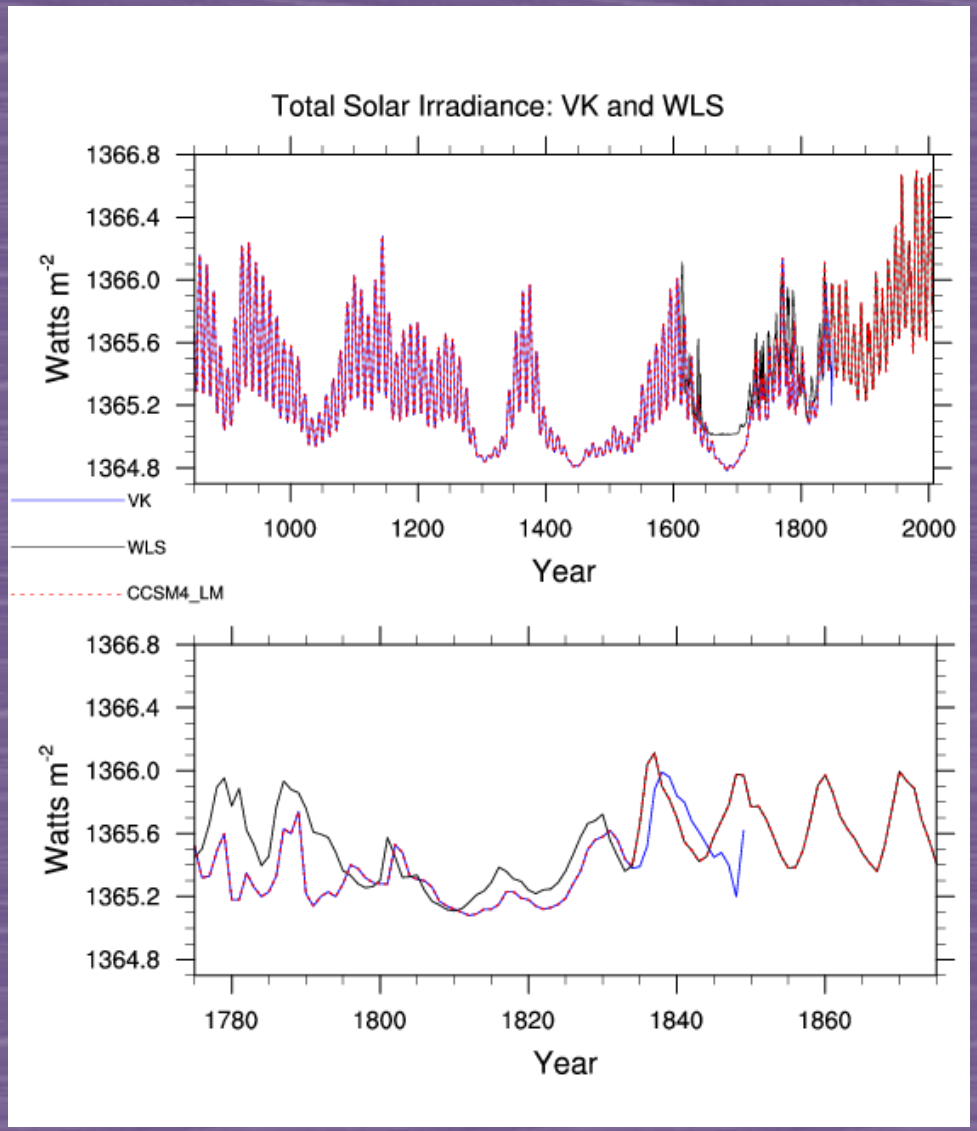
CCSM4 Last Millennium TSI



- VK TSI reconstruction
  - Magnitude, timing of 11 yr cycle and mean values closest to WLS
- Merged VK TSI with WLS TSI in 1834
- WLS and VK TSIs
  - Multiplied by scaling factor 0.9965

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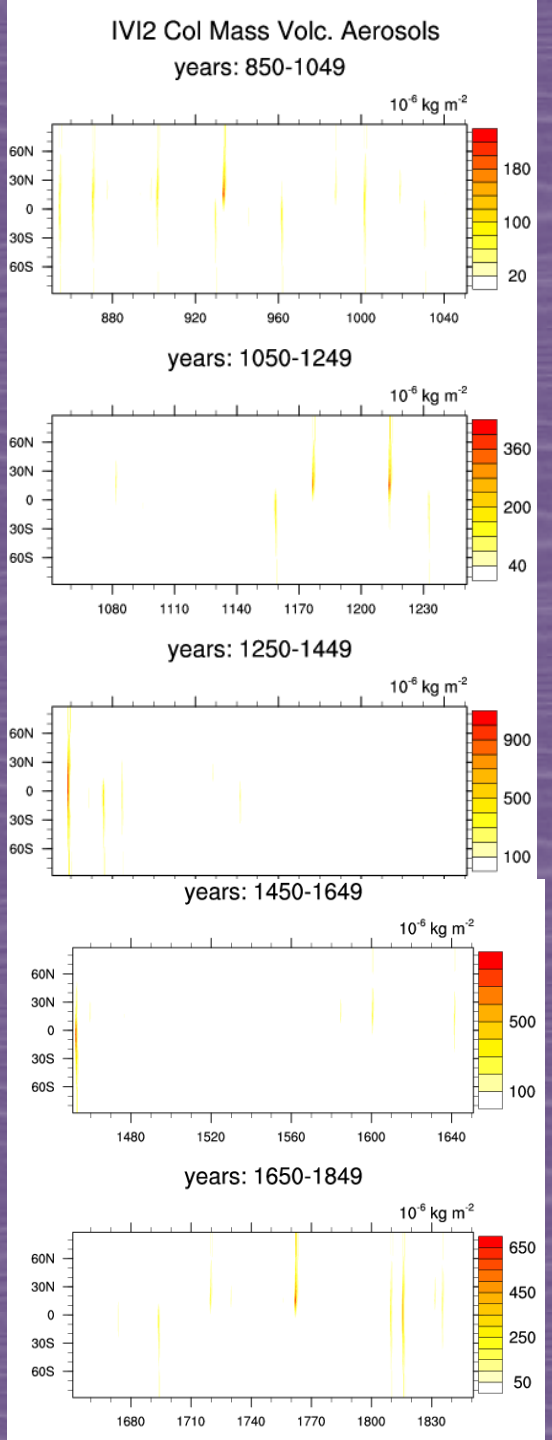
Volcanic Forcings

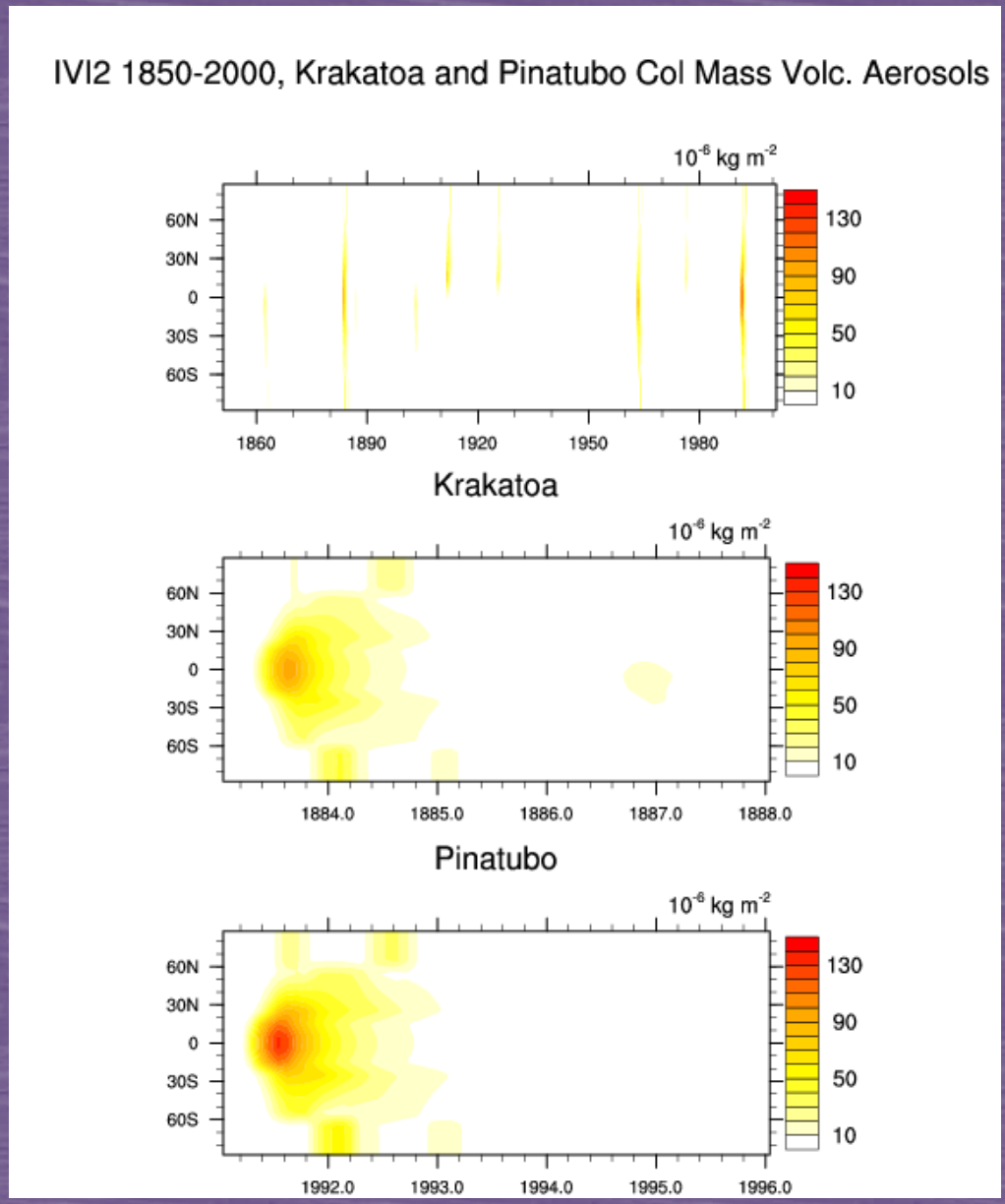
Two alternative data sets from which to choose:

1. **Gao-Robock-Ammann data set** (J. Geophys. Res., 113, D2311, doi:10.1029/2008JD010239, 2008)
   - Derived from 54 ice core records: 32 Arctic and 22 Antarctic.
2. **Crowley data set** (PAGES Newsletter, 16, 22-23, 2008)
   - based on a correlation between sulphate in Antarctic ice cores and satellite data

We use the Gao-Robock-Ammann data (hereafter IVI2) for entire Last Millennium-20th Century (850-2000) run

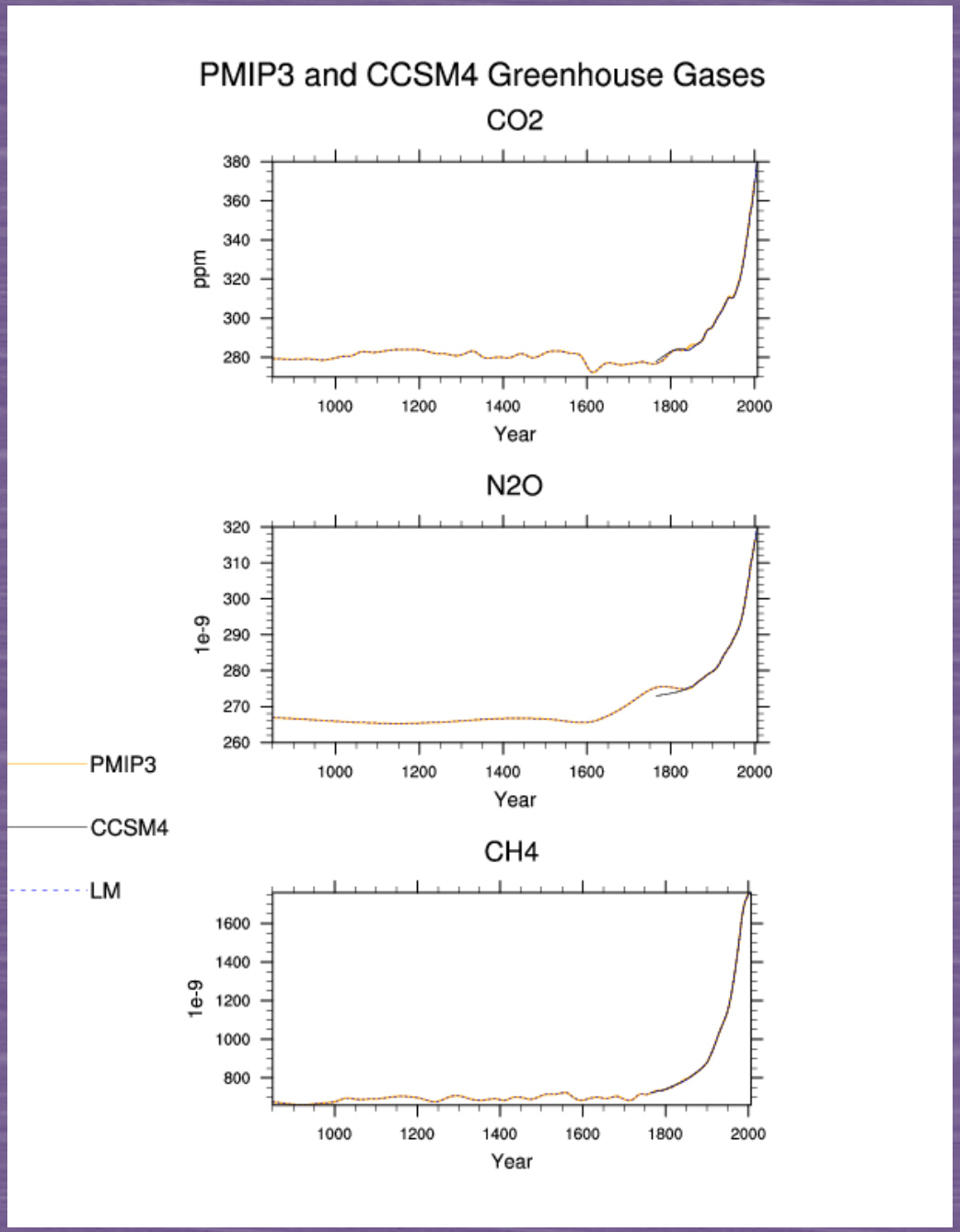
IVI2 Volcanic Aerosols





PMIP3 Trace Gases

- CO_2, CH_4, N_2O evolution, 0-2000, provided by Fortunat Joos:
  - CO_2, CH_2 (1860-2000) and N_2O (1850-2000) from Gavin Schmidt, GISS (http://data.giss.nasa.gov/modelforce/ghgases/GHGs.1850-2000.txt)
  - Industrial period trace gases are linked with splines through ice core results:
    - CO_2, CH_2 0-1859 AD: Law Dome Ice data (filtered w/ 40 yr cut-off period, 16 ppm offset added
    - N_2O 0-1849 AD: spline fit through various ice cores (DomeC, GRIP, EUROCORE, H15)



LM Trace Gases:

PMIP3 merged with CCSM4 in 1834

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IPCC CMIP5 Land Use and Land Cover Change

1. **Land Use and Land Cover Change land surface parameters have been generated for CCSM 4.0 for:**
   - CMIP5 Historical 20th Century (1850-2005) experiments
   - CMIP5 Projected 21st Century (2006-2100) for all four Representative Concentration Pathways (RCP) experiments

2. **Historical parameters generated from Land Use and Land Cover Change data of Hurtt et al (2006) based on the HYDE 3.0 dataset of Klein-Goldewijk (2006).**

3. **RCP parameters generated from Land Use and Land Cover Change data produced by the Integrated Assessment Model groups of RCP 3-PD (IMAGE), RCP 4.5 (MiniCAM), RCP 6.0 (AIM), RCP 8.5 (MESSAGE)**

4. **Historical and future RCP land use and land cover change data described through annual changes in four basic land units:**
   - **Primary Vegetation (V)**
   - **Secondary Vegetation (S)**
   - **Cropping (C)**
   - **Pasture (P)**

5. **Harvesting of biomass was prescribed for both primary and secondary vegetation**

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IPCC PMIP3 Land Use and Land Cover Change

1. To be consistent with the other CMIP5 experiments we would like to use the same methods for 800-1850 as used to generate CCSM 4.0 parameters from 1850-2100.

2. The Historical Land Use and Land Cover Change data of Hurtt et al (2006) describes changes for 1500-2005

3. PMIP3 Protocol suggests using Historical Land Use and Land Cover from Pongratz (2009) for 850-1992.

4. However, Pongratz (2009) data set is in 14 biomes and based on a range of older data than used in Hurtt et al (2006)

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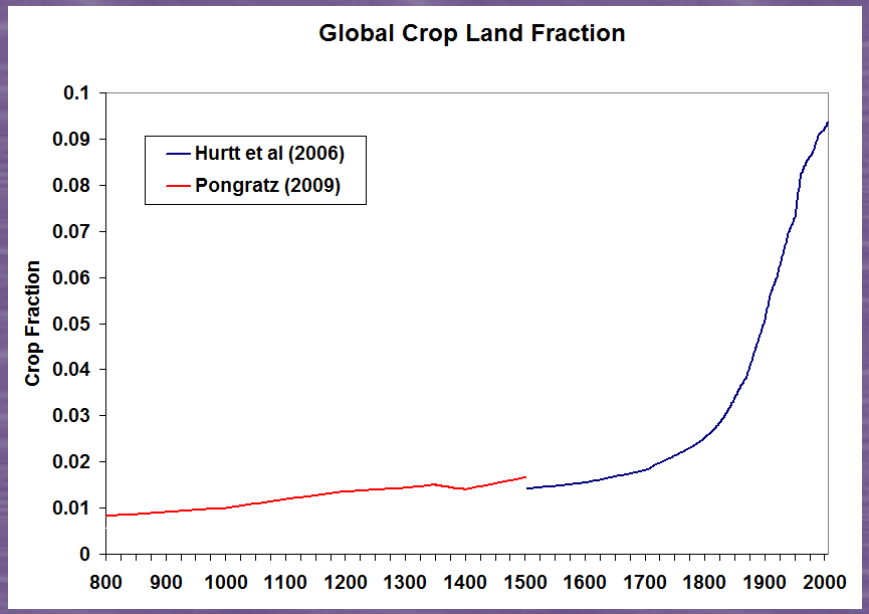
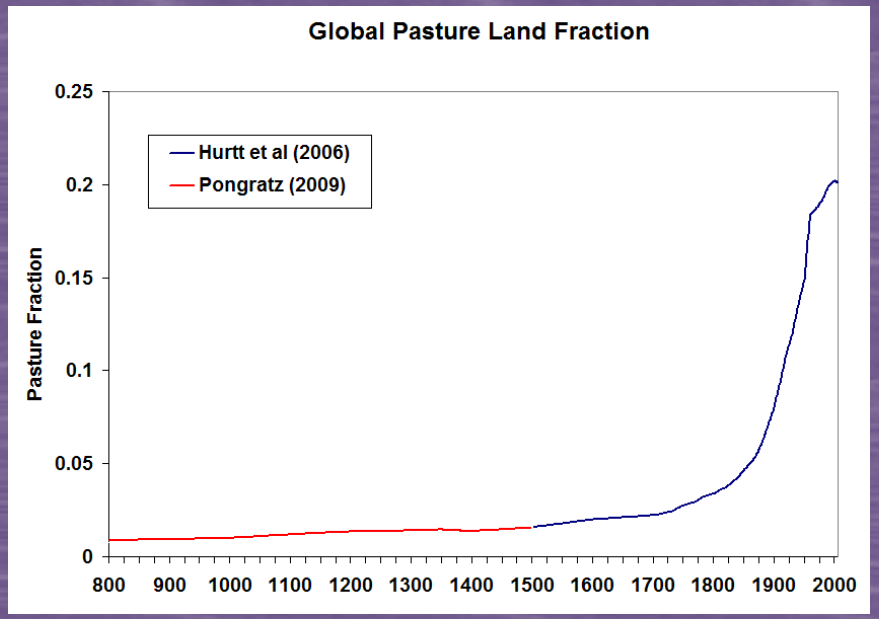
Hurtt et al (2006) vs Pongratz (2009) Global Cropping



Hurtt et al (2006) vs Pongratz (2009) Global Pasture



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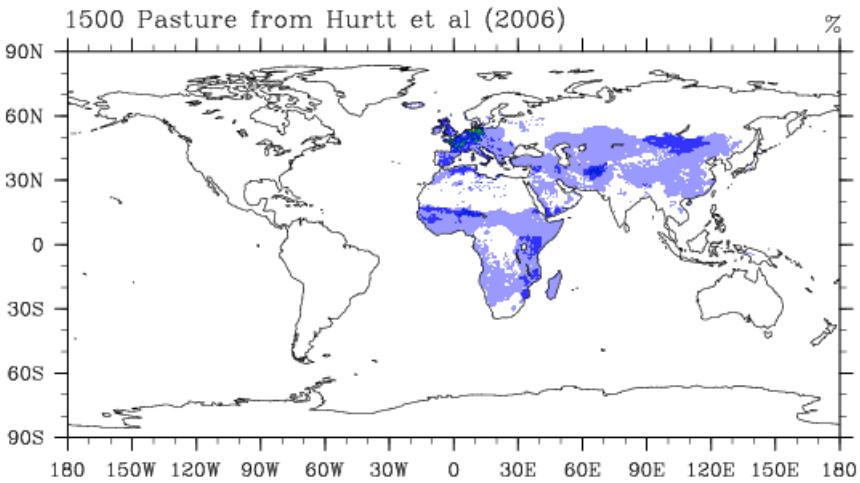
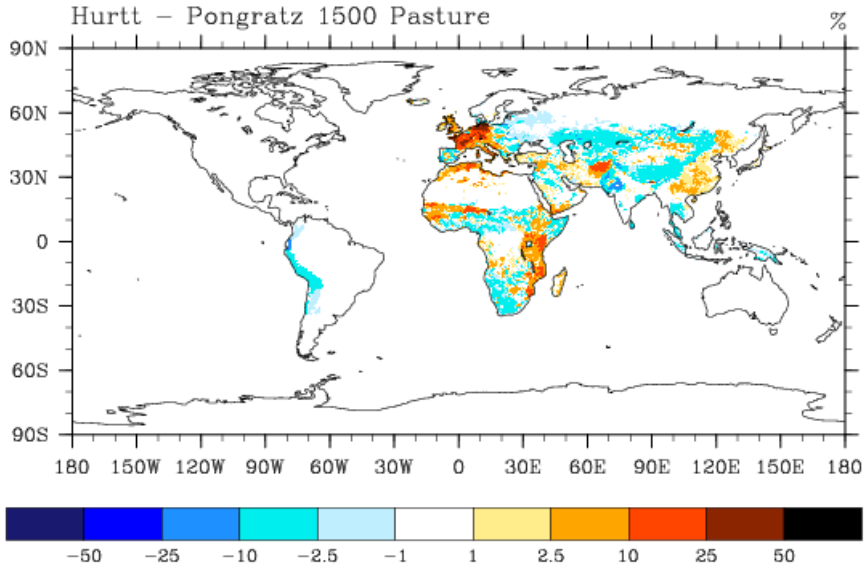
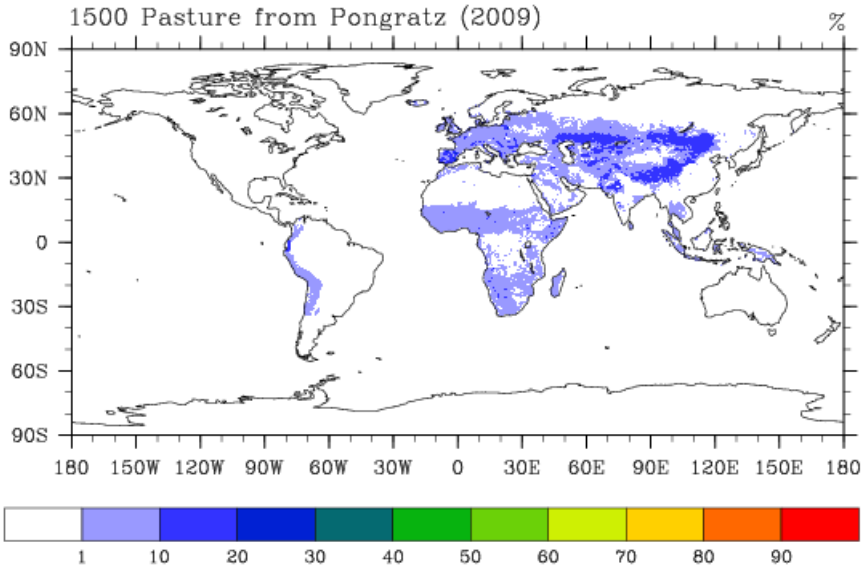
Pasture at 1500 from Hurtt et al (2006) vs Pongratz (2009)







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IPCC PMIP3 Land Use and Land Cover Change

1. To remove the inconsistencies at 1500 the same grid cell harmonization process used between the historical and RCP data in other CMIP5 experiments are applied.

2. If the year >= 1500 then use the data of Hurtt et al (2006) as:

   - Primary Vegetation (V)
   - Secondary Vegetation (S)
   - Cropping (C)
   - Pasture (P)

3. If the year < 1500 then scale the Pongratz (2009) grid cell cropping and pasture values as:

   scaled val(year) = Hurtt(1500) * Pongratz(year) / Pongratz(1500)
   scaled val(year) = 0.0 (if Pongratz(1500) == 0.0)

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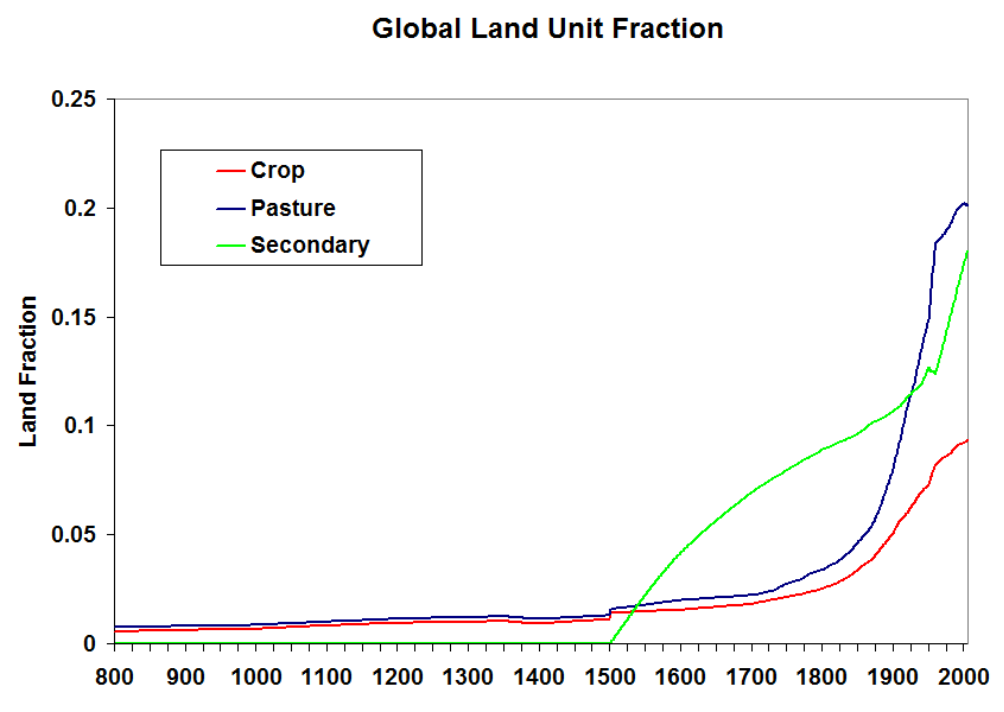
IPCC PMIP3 Land Use and Land Cover Change

1. For the years before 1500 Secondary Vegetation is set to 0.0 as this is the case in the Hurtt et al (2006) data at 1500

2. All Harvest values are set to 0.0 as in the Hurtt data as well

3. Primary Vegetation is calculated as the land fraction that is not assigned to the scaled Cropping and Pasture

Hurtt et al (2006) and Pongratz (2009) Global Land Units



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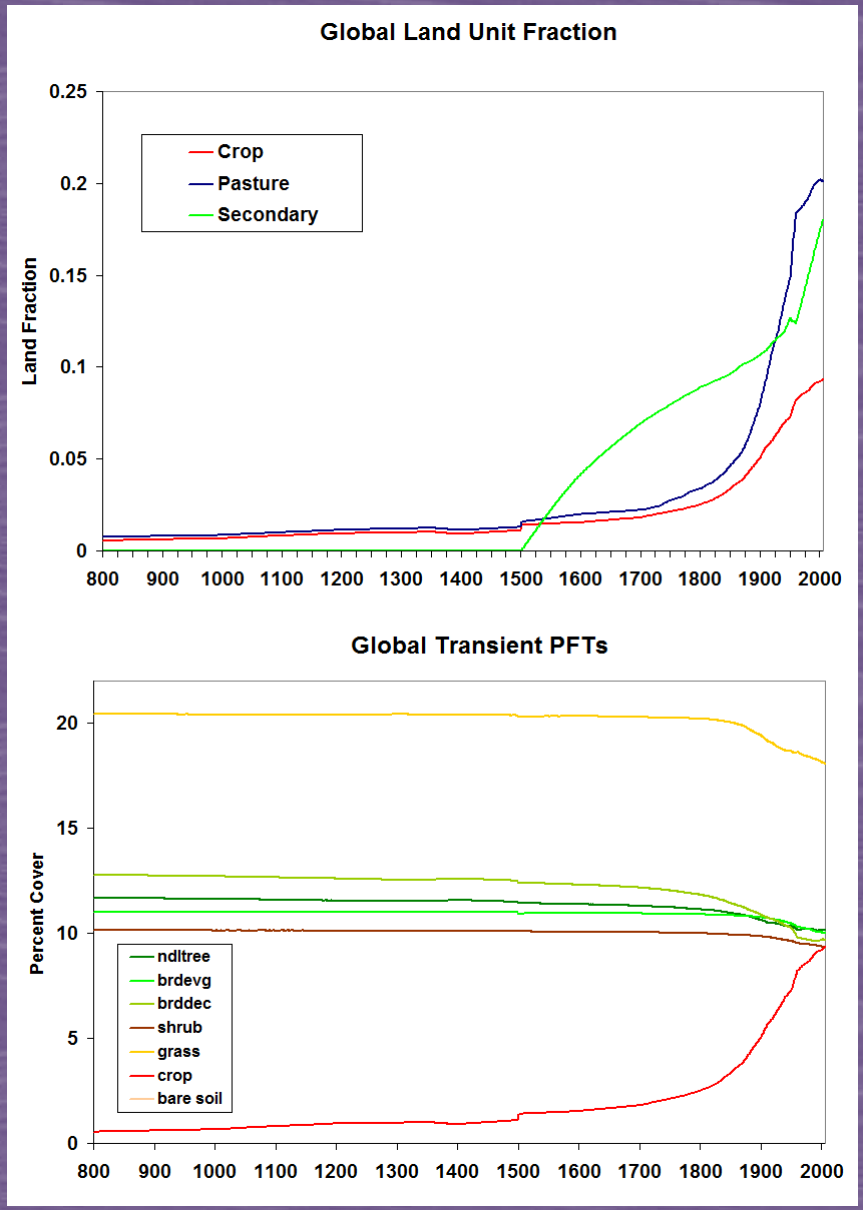
Hurtt et al (2006) and Pongratz (2009) Global PFTs

Global PFTs are:

Percentage Contribution to the vegetated land excluding wetlands, lakes, glaciers and urban



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CCSM4 850 high frequency run

850 high frequency fully-coupled (land, ice, ocean, atmosphere) run:

- Non-transient
- Initialized with 1850 control run
- Boundary forcings (trace gases, volcano, solar) from PMIP3 protocols for 850
- Land cover PFTs from 850 AD Pongratz data modified to merge with Hurtt in 1500 (P. Lawrence – described in previous slides)
- Run for 30 yrs, C, N pools checked to see if we need to run a land-only, off-line version to stabilize pools
- Uncertain whether or not need to run a separate, land-only run
- Continued 850hf run for another 10 yrs
- Output still being processed

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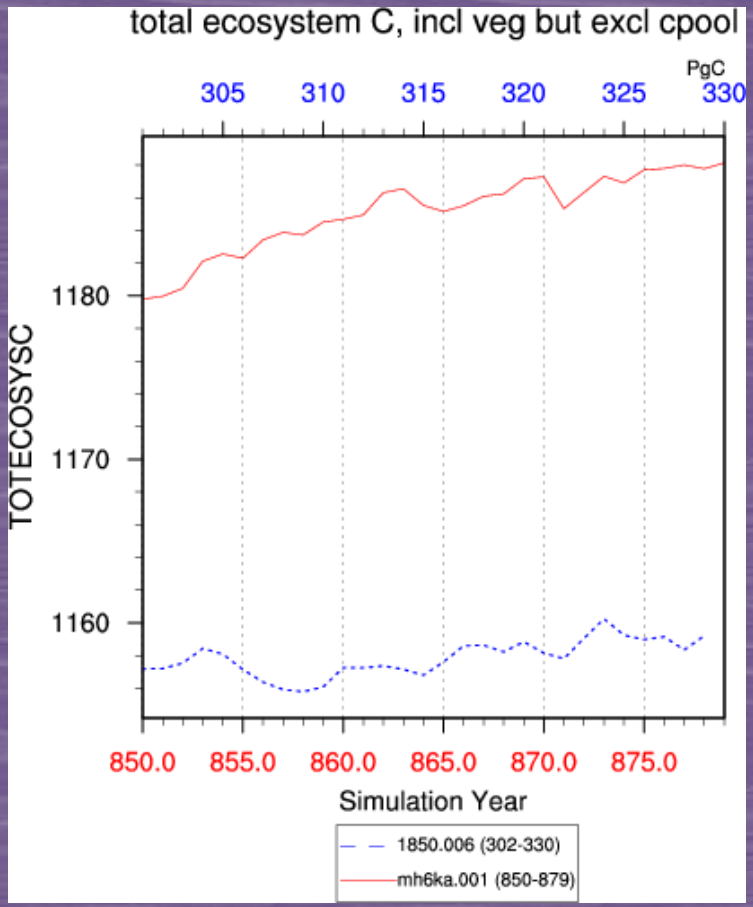
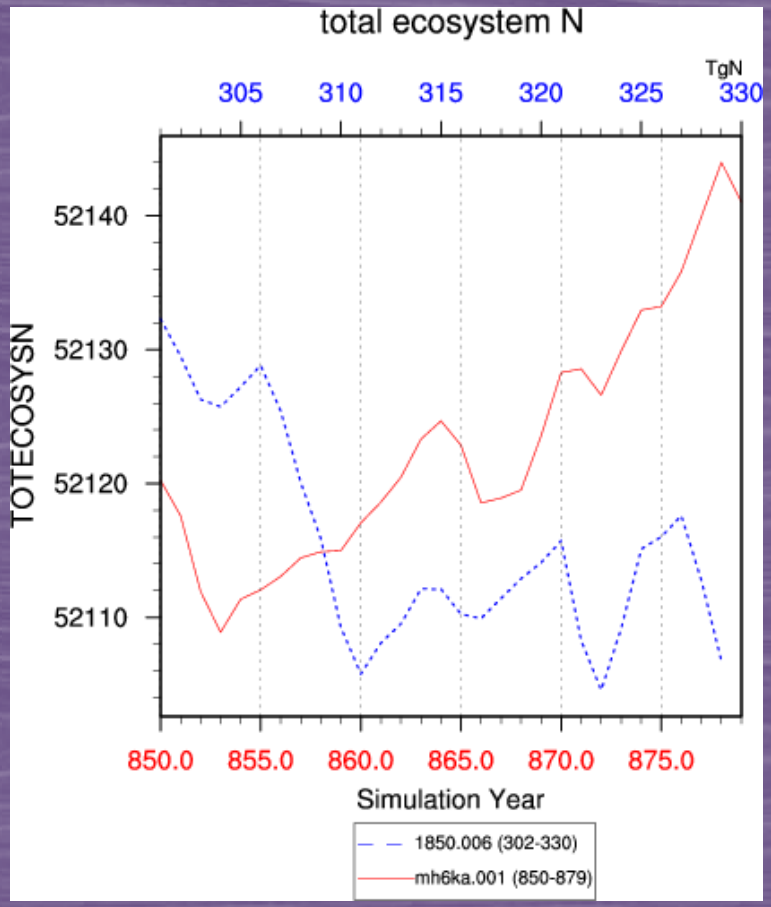
CCSM4 850 high frequency run

Total ecosystem C, N





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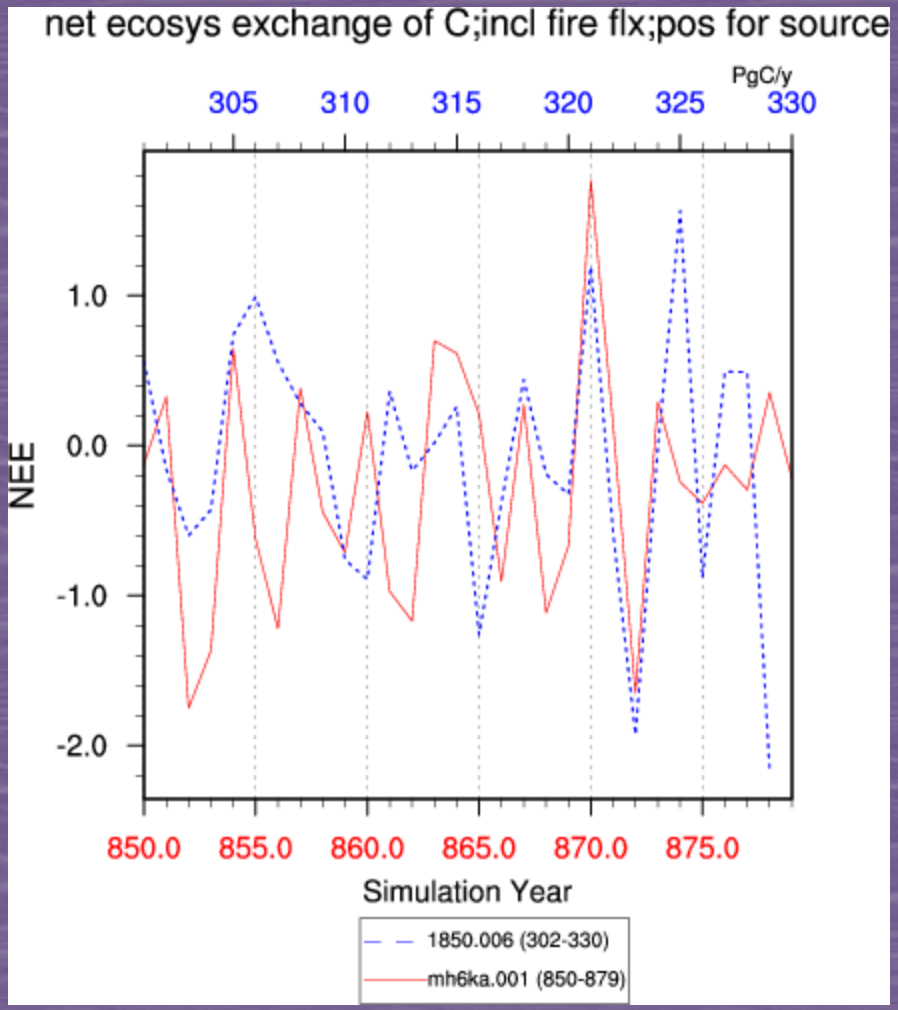
CCSM4 850 high frequency run



Net Ecosystem Exchange of Carbon

Conclusions

- CCSM4 Last Millenium Run forcings are ready
- Initialization run (850 conditions run for 40 yrs) complete:
  - if C-pools stable, we'll run a transient Last Millennium immediately
  - if C-pools not yet stable, we'll run a land-only case to stabilize C pools
- Last Millennium climate experiments will start running after CCSM 4 annual meeting (and C pools stable!)

The NESL Mission is:
To advance understanding of weather, climate, atmospheric composition and processes;
To provide facility support to the wider community; and,
To apply the results to benefit society.

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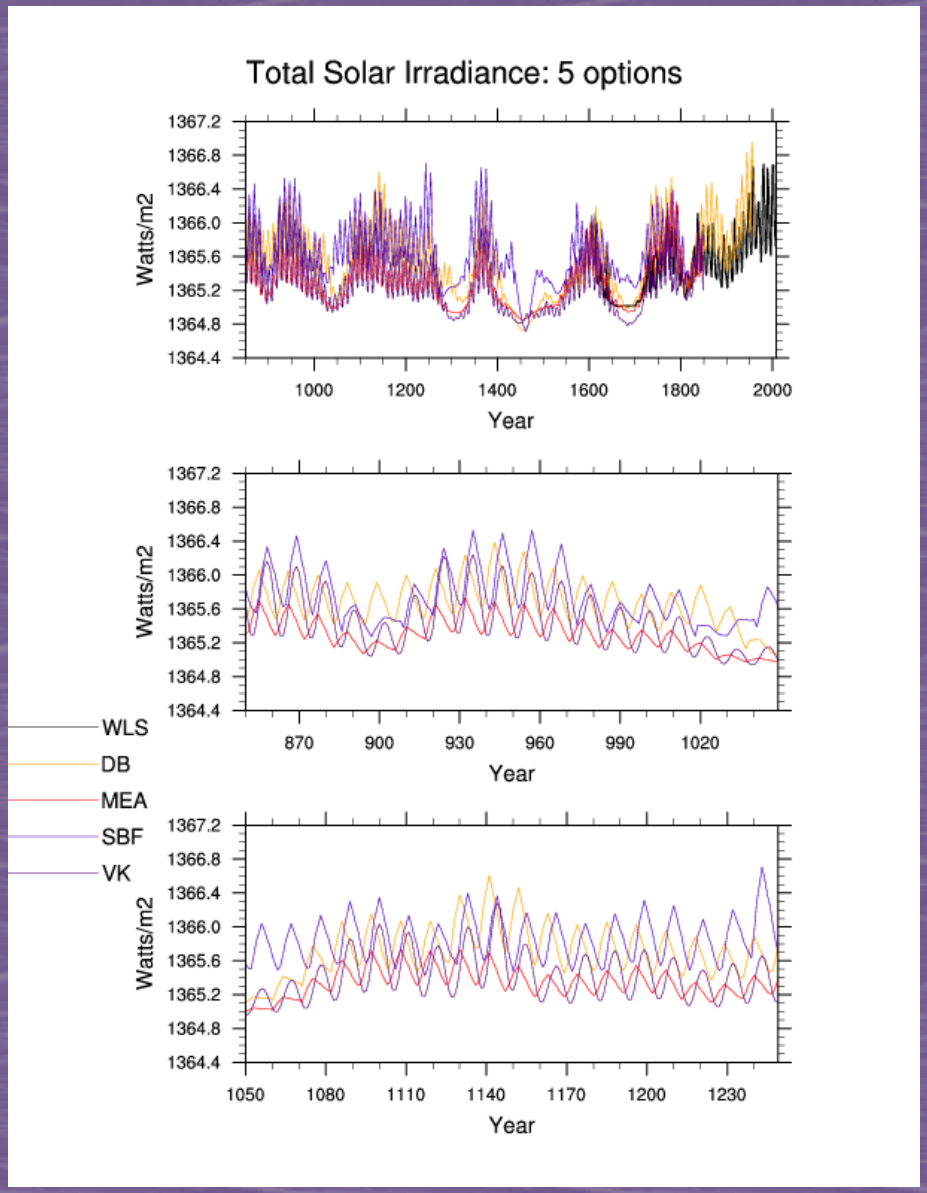
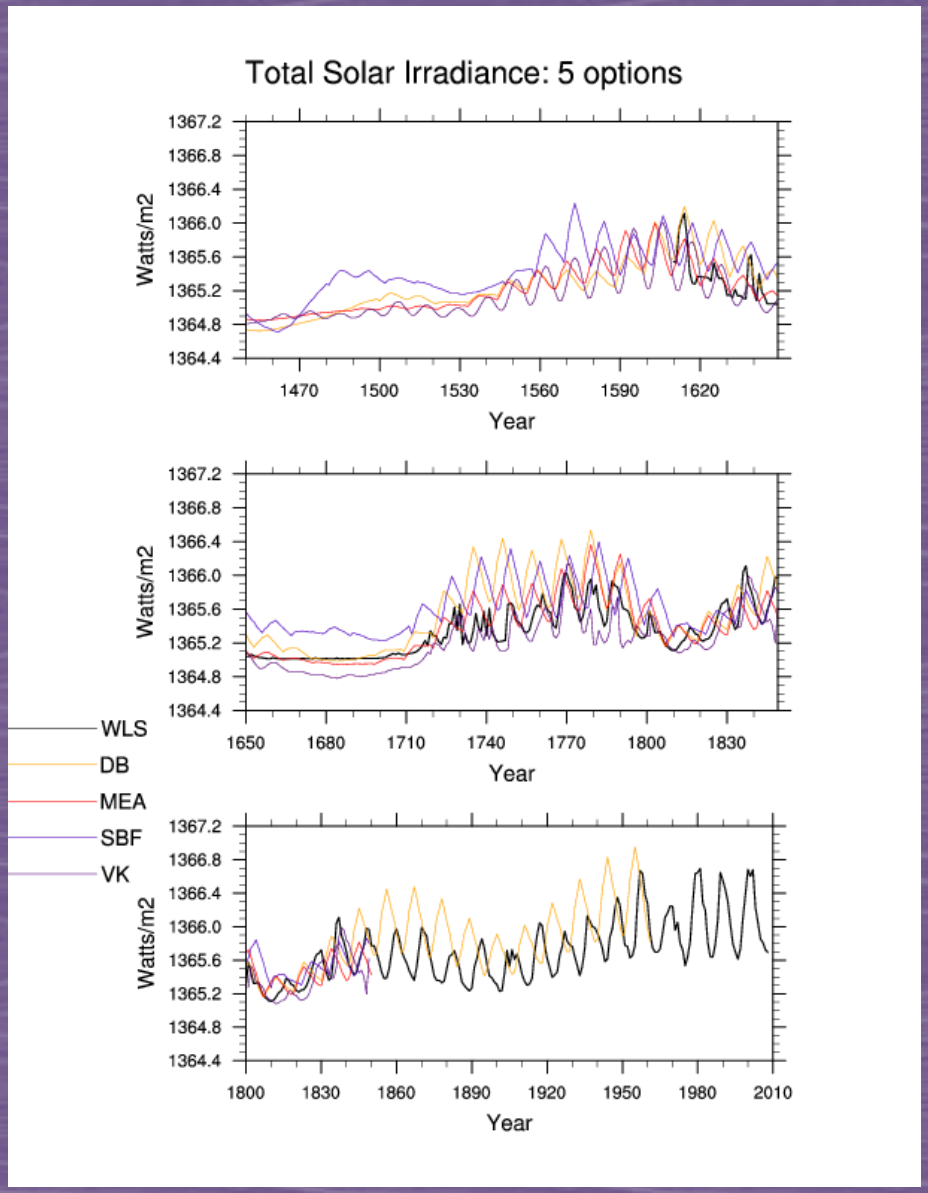
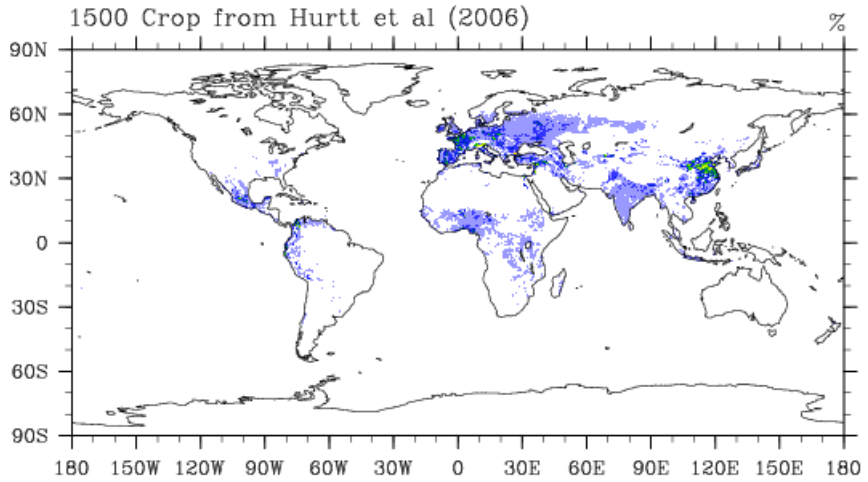
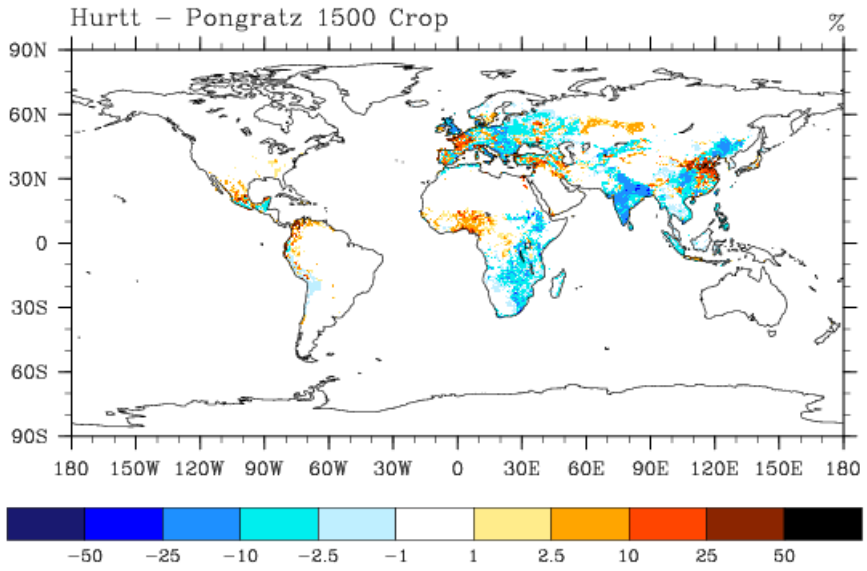
PMIP3 TSI options

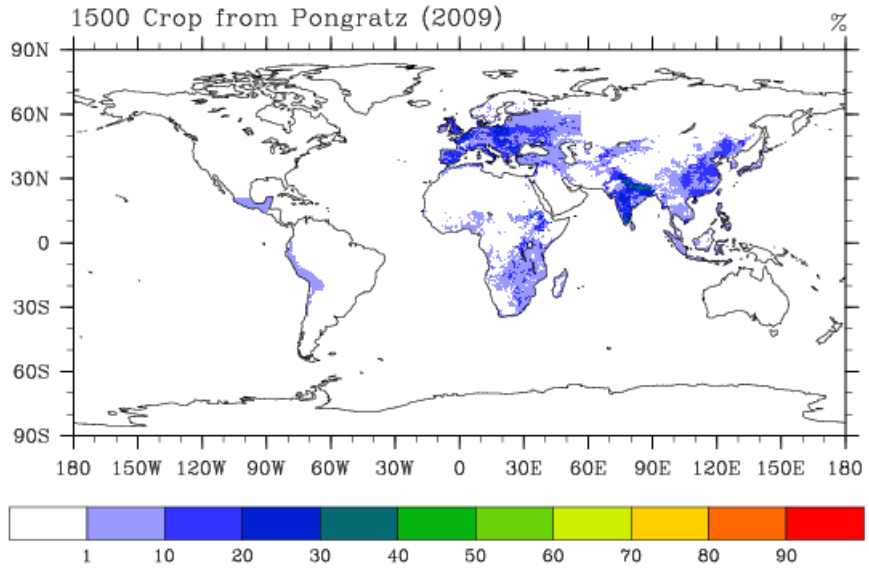




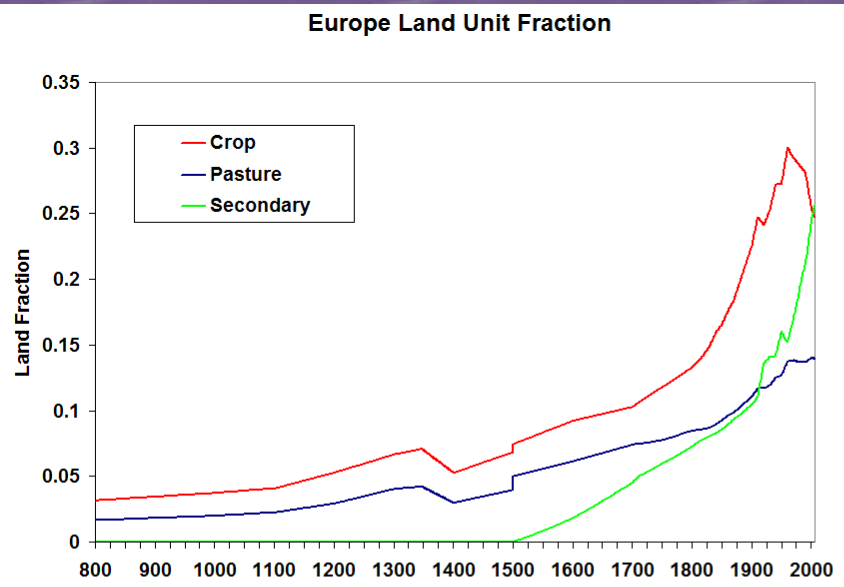
Crop at 1500 from Hurtt et al (2006) vs Pongratz (2009)

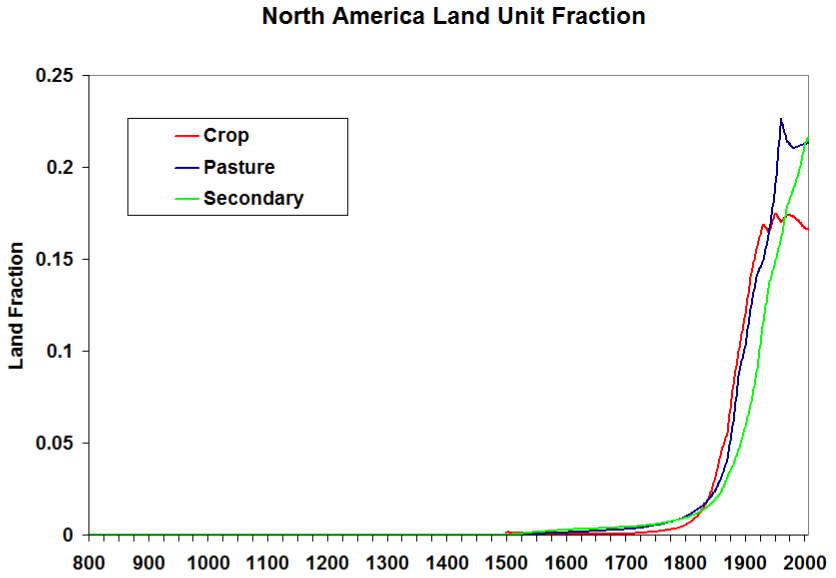


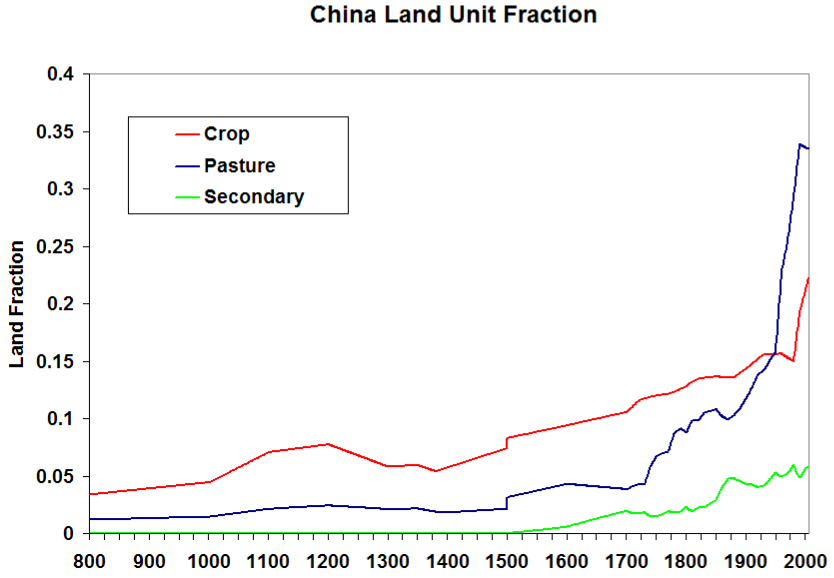


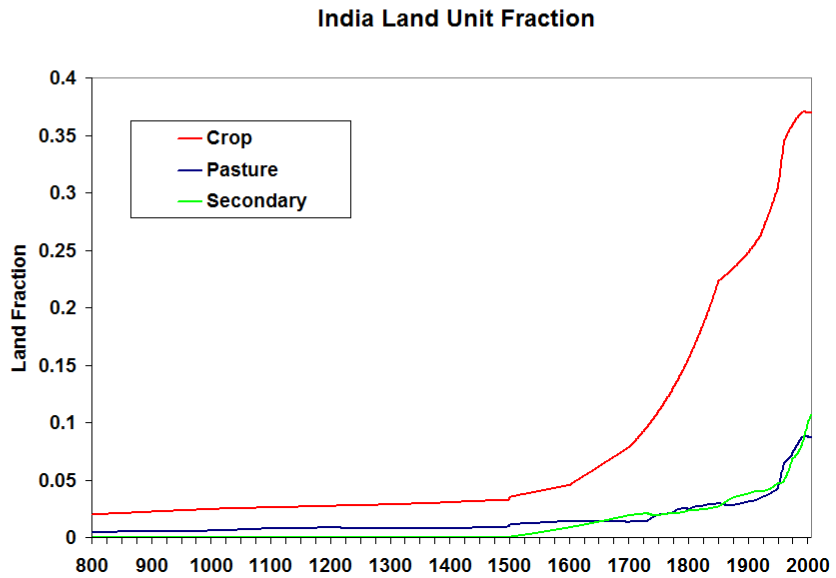


Hurtt et al (2006) and Pongratz (2009) Regional Land Units









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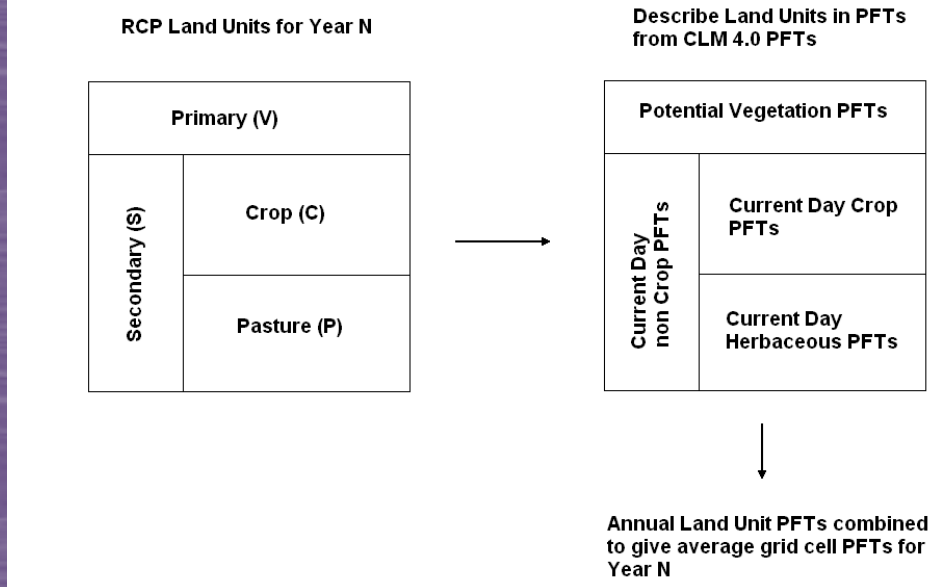
Prescribing Transient Land Cover in CLM 4

1. We need to take the annual land units and make an annual time series of changing Plant Functional Types

2. Current Day (2000) CLM 4 land surface parameters are derived from MODIS satellite data as described in *Lawrence and Chase* 2007 (with forest herbaceous grass bias removed)

3. Potential vegetation CLM 4 parameters are bio-climatically modeled as described in *Lawrence and Chase* 2010



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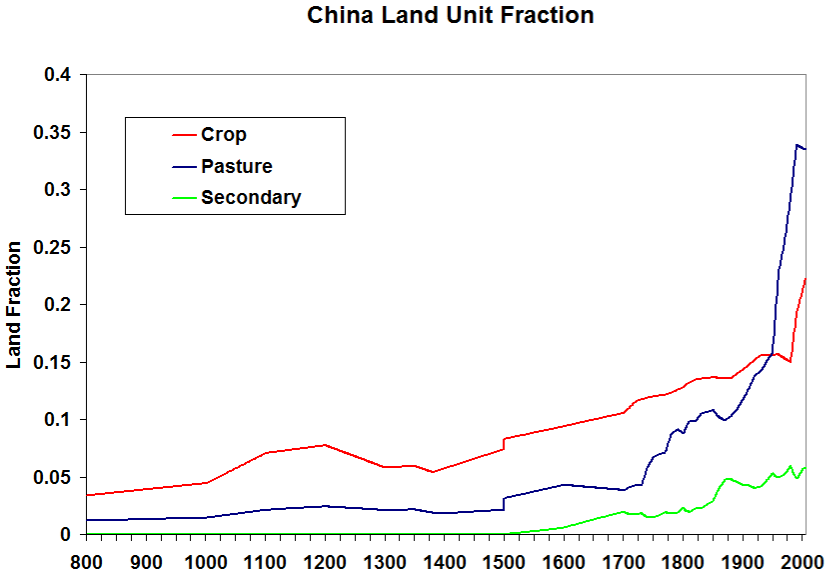
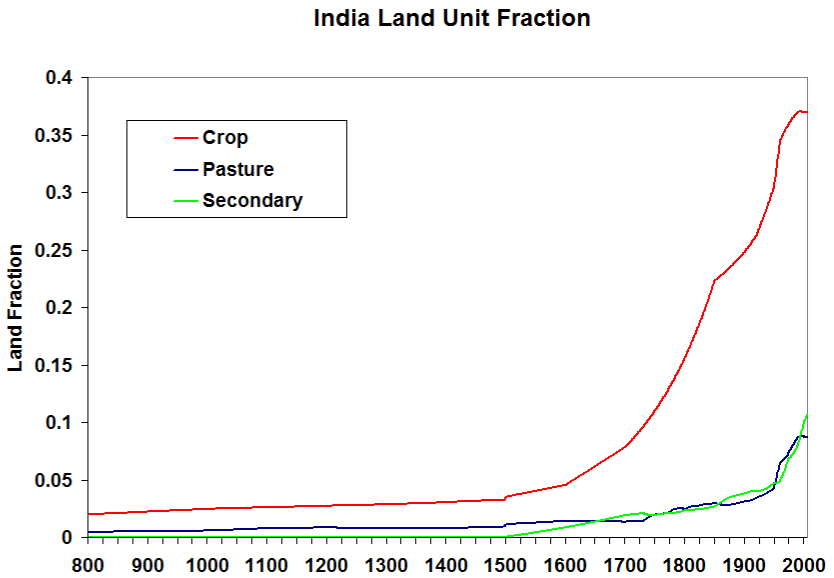
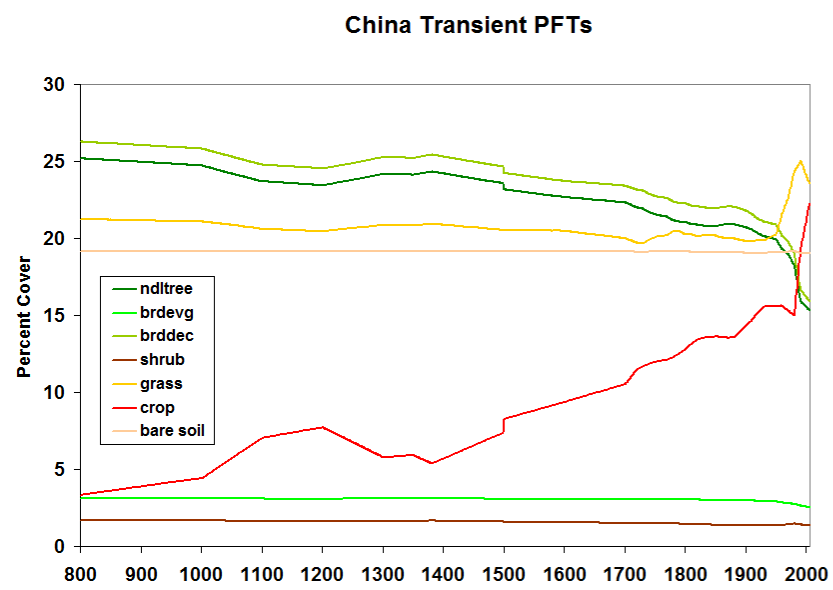
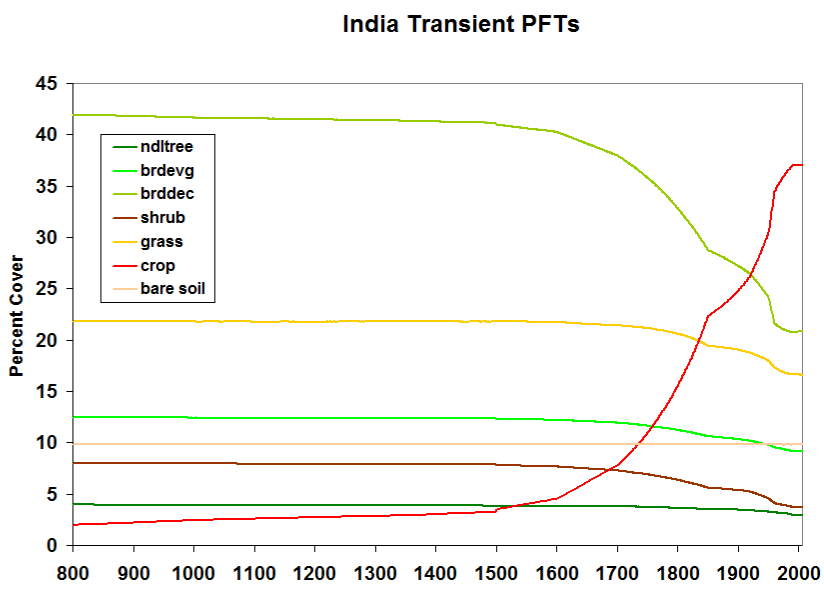
Hurt et al (2006) and Pongratz (2009) Regional PFTs









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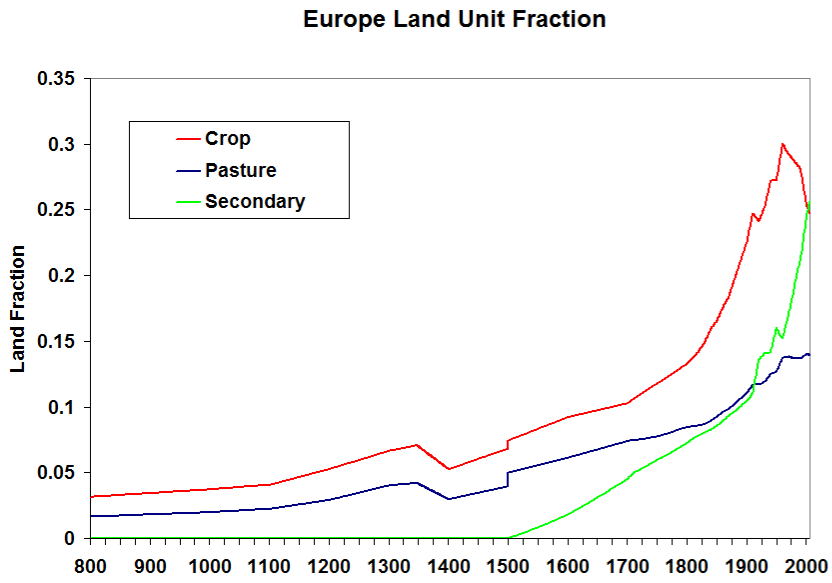
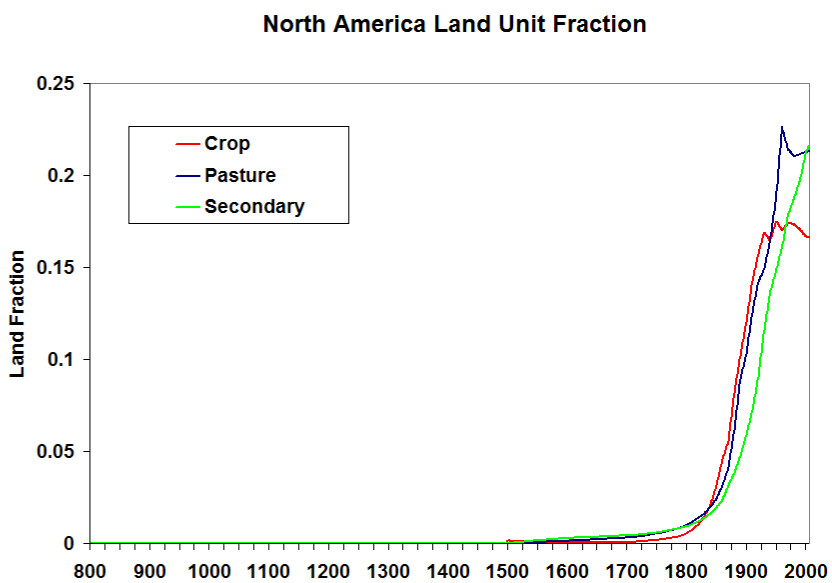
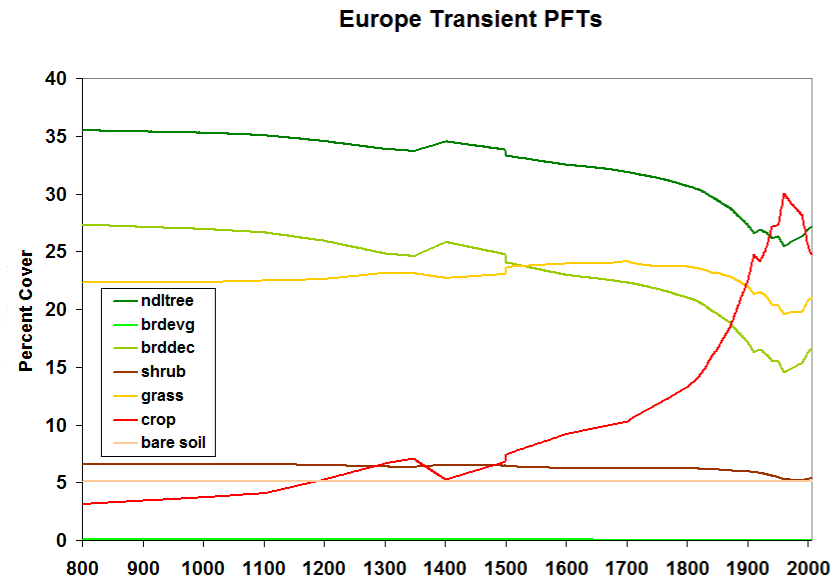
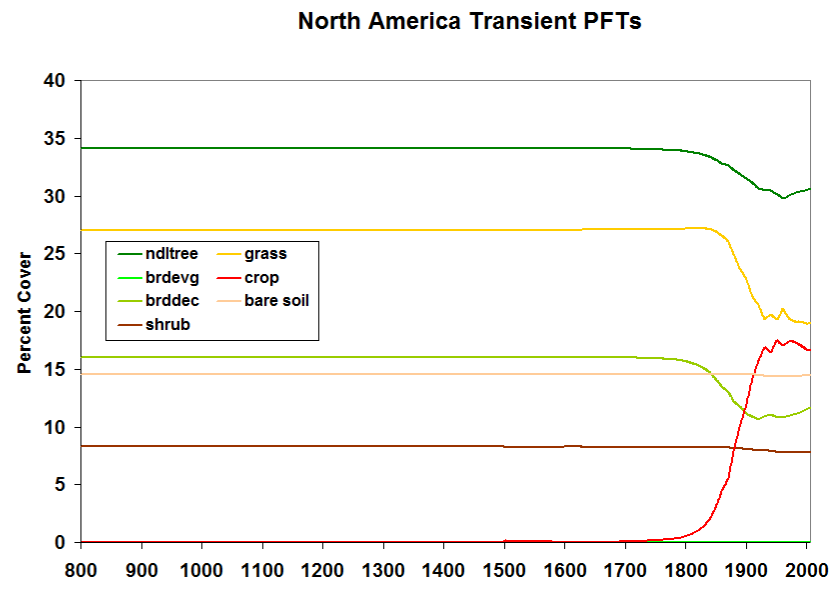
Hurtt et al (2006) and Pongratz (2009) Regional PFTs.









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