

Historical and Future Land Use and Land Cover Change in CLM5 for CMIP6

Peter Lawrence

NCAR – Terrestrial Sciences Section

co authors: Dave Lawrence, Danica Lombardozzi, George Hurtt and Brian O'Neill



CLM5 New Surface Data Time Series: Historical and Future

The new CLM5 capabilities and the LUMIP/CMIP6 scenarios require that annual grid cell data is provided that represents:

- The Forest / non forest information of the LUH2 time series
- Wood Harvest that is prescribed in a carbon amount to be extracted as wood rather than a fraction of trees
- The transient C3/C4 Crops of the time series in the CLM Crop model that are specified for individual crops for each grid cell and each year
- Fertilizer and irrigation management is specified by crop and grid cell every year
- Gross Unrepresented Land Cover Land Use Change that is not captured in the Net Changes resulting from differences in PFTs and CFTs from one year to the next.

CLM5 CMIP6 – New Land Surface Data Sets

1. The new Historical and SSP - RCP land use and land cover change time series are being compiled for through the Land Use and Scenario Model Intercomparison Projects (LUMIP and ScenarioMIP).
2. The Global Land Model (GLM) has been extended to 12 land units to better represent dynamics of agriculture and forests. The new land units include:
 - Primary Forest
 - Secondary Forest
 - Crop C3 Annual
 - Crop C3 Nitrogen Fixing
 - Crop C4 Perennial
 - Grazing Rangeland
 - Primary Non Forest
 - Secondary Non Forest
 - Crop C3 Perennial
 - Crop C4 Annual
 - Grazing Pasture
 - Urban
3. New management information for Crops and Forests is provided with transient N Fertilizer and Irrigation prescription, and new Wood Harvest

CMIP6 LUMIP CLM5 Land Use Harmonization (LUH2)

~ 50x information content of CMIP5!

New Resolution

0.25° grid-cell fraction

New History

Hyde 3.2, FAO based

Landsat F/NF

Multiple crop types (5)

Multiple pasture types (2)

Updated Forest Cover/Biomass

Updated Wood harvest

Updated Shifting Cultivation

Extended time domain (850-2015)

New Management Layers

Agriculture

Fraction of cropland irrigated

Fraction of cropland flooded

Fraction of cropland fertilized

(industrial)

Industrial Fertilizer application rates

Fraction of cropland for biofuels

Fraction of area Crop rotations

Crop Rotations *Wood Harvest*

Fraction used for industrial products

Fraction used for industrial products
Fraction used for commercial biofuels

Fraction used for commerce
Fraction used for fuelwood

New Transition Matrix

A heatmap representing a transition matrix for different states. The y-axis is labeled "FROM" and the x-axis is labeled "TO". The states are listed on both axes: primf, primn, secdf, secdn, c3ann, c4ann, c4per, c3per, c3nfx, pastr, range, and urban. The matrix shows that transitions are primarily limited to adjacent states in the sequence, with darker purple indicating higher transition probabilities.

1. CMIP6 LUMIP CLM5 Land Use Harmonization (LUH2)

~ 50x information content of CMIP5!

New Resolution

0.25° grid-cell fraction

New History

Hyde 3.2, FAO based

Landsat F/NF

Multiple crop types (5)

Multiple pasture types (2)

Updated Forest Cover/Biomass

Updated Wood harvest

Updated Shifting Cultivation

Extended time domain (850-2015)

New Management Layers

Agriculture

Fraction of cropland irrigated

Fraction of cropland flooded

Fraction of cropland fertilized

Industrial Fertilizer application

Fraction of cropland for biofuels

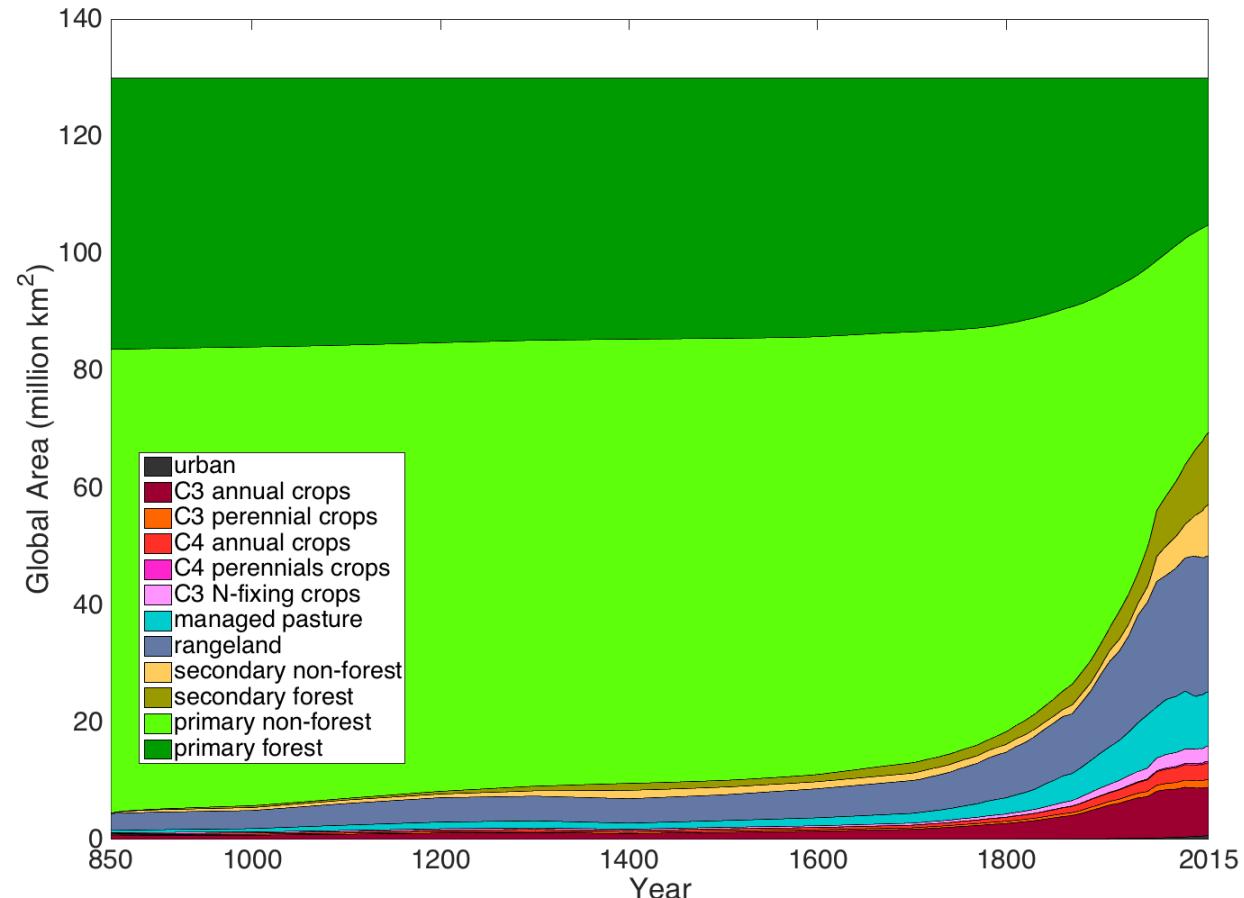
Crop rotations

Wood Harvest

Fraction industrial products

Fraction commercial biofuels

Fraction fuelwood



New Future Scenarios

Six futures, SSP-based

Gridcell



Landunit



Vegetated



Lake



Urban



Glacier



Crop



Unirrig



Irrig



Unirrig



Irrig



Crop1



Crop1



Crop2



Crop2 ...

3. CMIP6 LUMIP CLM5

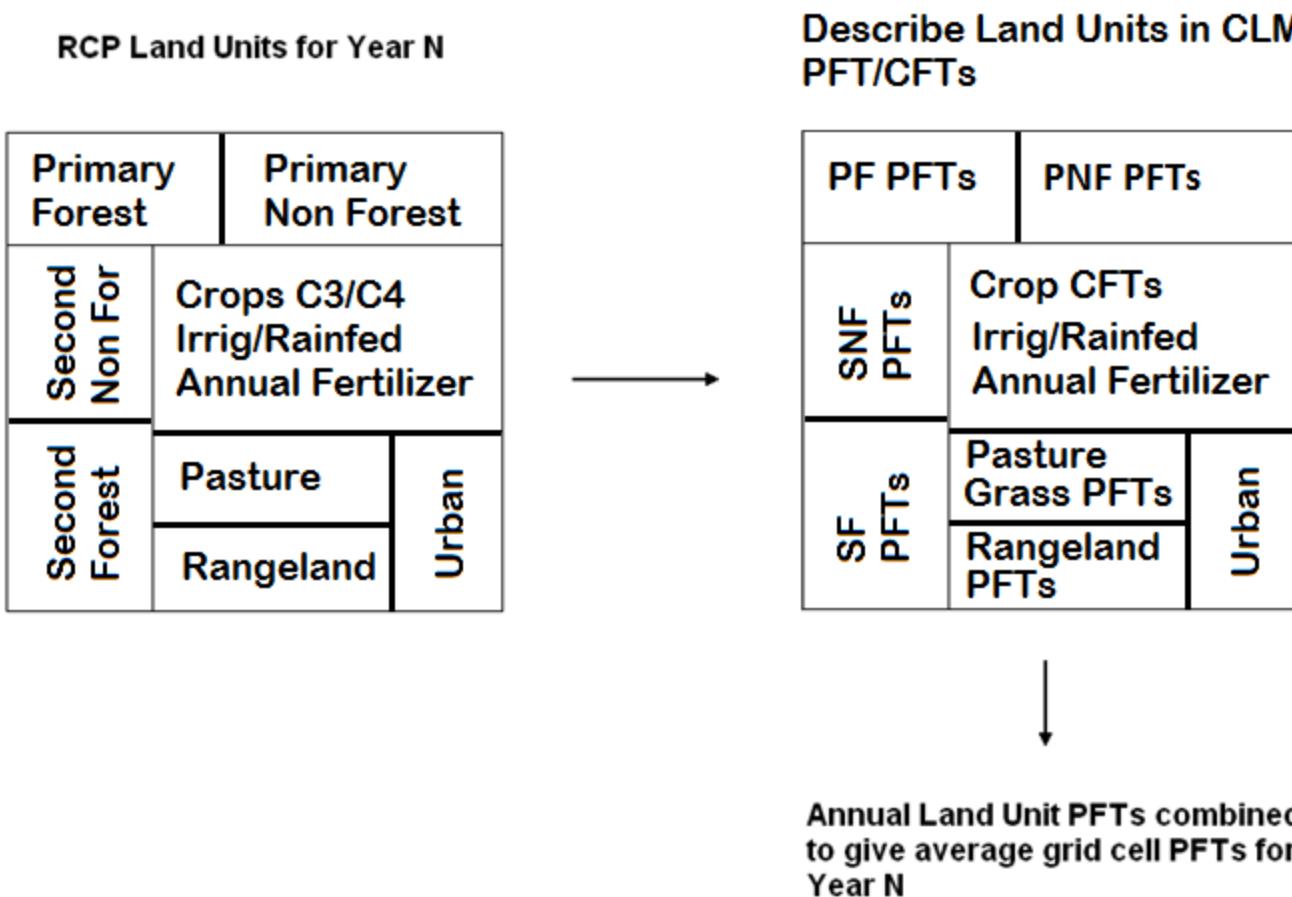
1. The CLM group has developed new LUMIP CMIP6 CLM transient natural vegetation and crop simulation capability with prescribed annual crop N fertilizer and irrigation. New landuse.timeseries files.

For each year of LUMIP/CMIP6 time series specify for each grid cell:

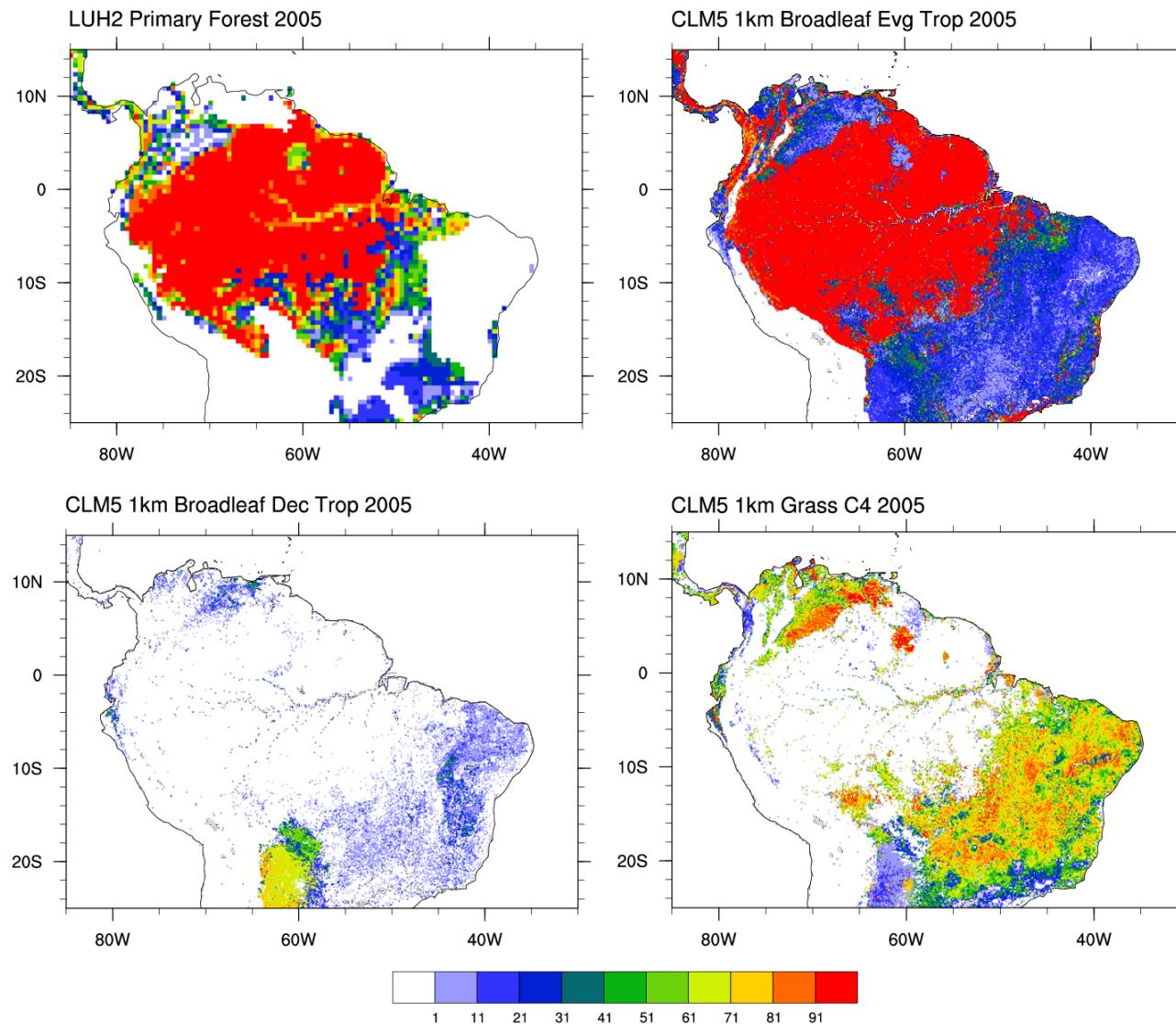
- PCT_NATVEG – percent of gridcell as natural vegetation land unit
- PCT_CROP – percent of gridcell as crop land unit
- PCT_NAT_PFT – percent of natural vegetated land unit for each PFT
- PCT_CFT – percent of crop land unit for each CFT (irrigated/rainfed)
- FERTNITRO_CFT – gN/m²/yr N Fertilizer for each CFT
- HARVEST_PRIMARY_FOR – gC/m²/yr Wood harvest Primary Forest
- HARVEST_PRIMARY_NFOR – gC/m²/yr Wood harvest Primary Non Forest
- HARVEST_SECONDARY_MFOR – gC/m²/yr Wood harvest Second Mature For
- HARVEST_SECONDARY_YFOR – gC/m²/yr Wood harvest Second Young Forest
- HARVEST_SECONDARY_NFOR – gC/m²/yr Wood harvest Second Non Forest
- UNREPRESENTED_PFT_LULCC – percent of PFT unrepresented in Net LULCC
- UNREPRESENTED_CFT_LULCC – percent of CFT unrepresented in Net LULCC

2. Generating CMIP6 Transient Land Cover in CLM 5 PFTs

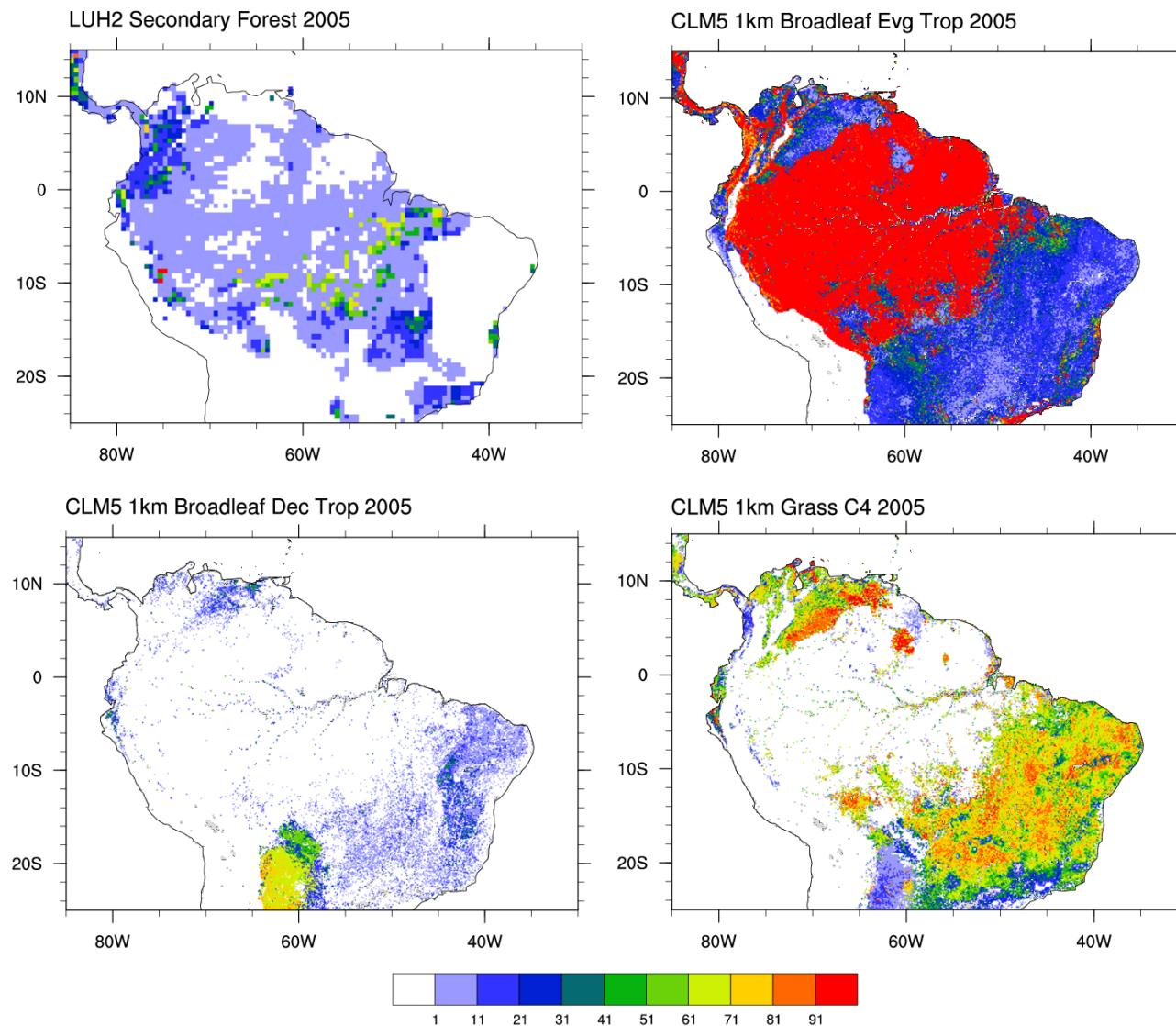
Method GLM 0.25 Degree -> CLM5 PFTs and CFTs



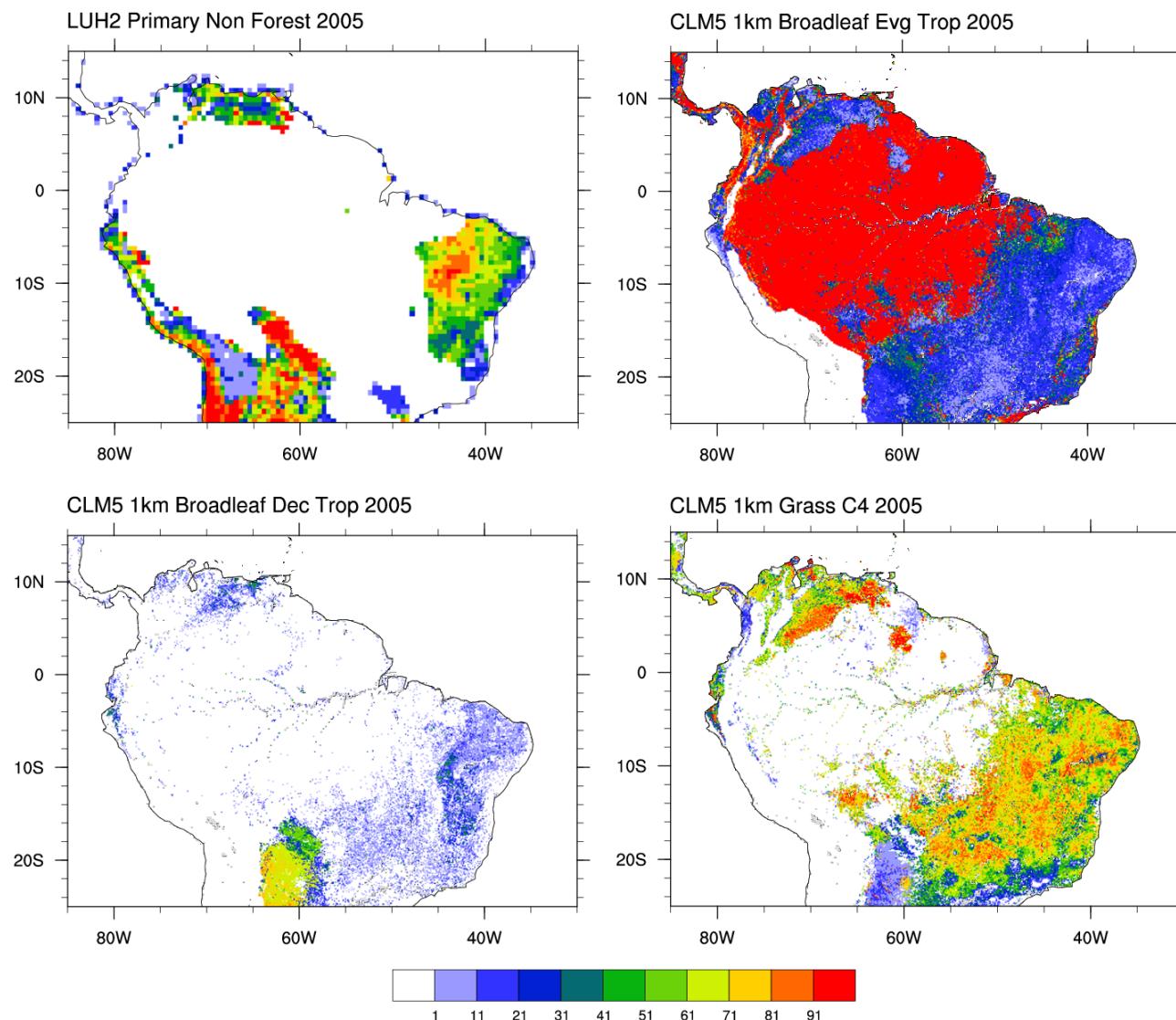
2. CMIP6 Transient Land Cover in CLM 5 PFTs Current Day High Resolution MODIS and LUH2 Time Series



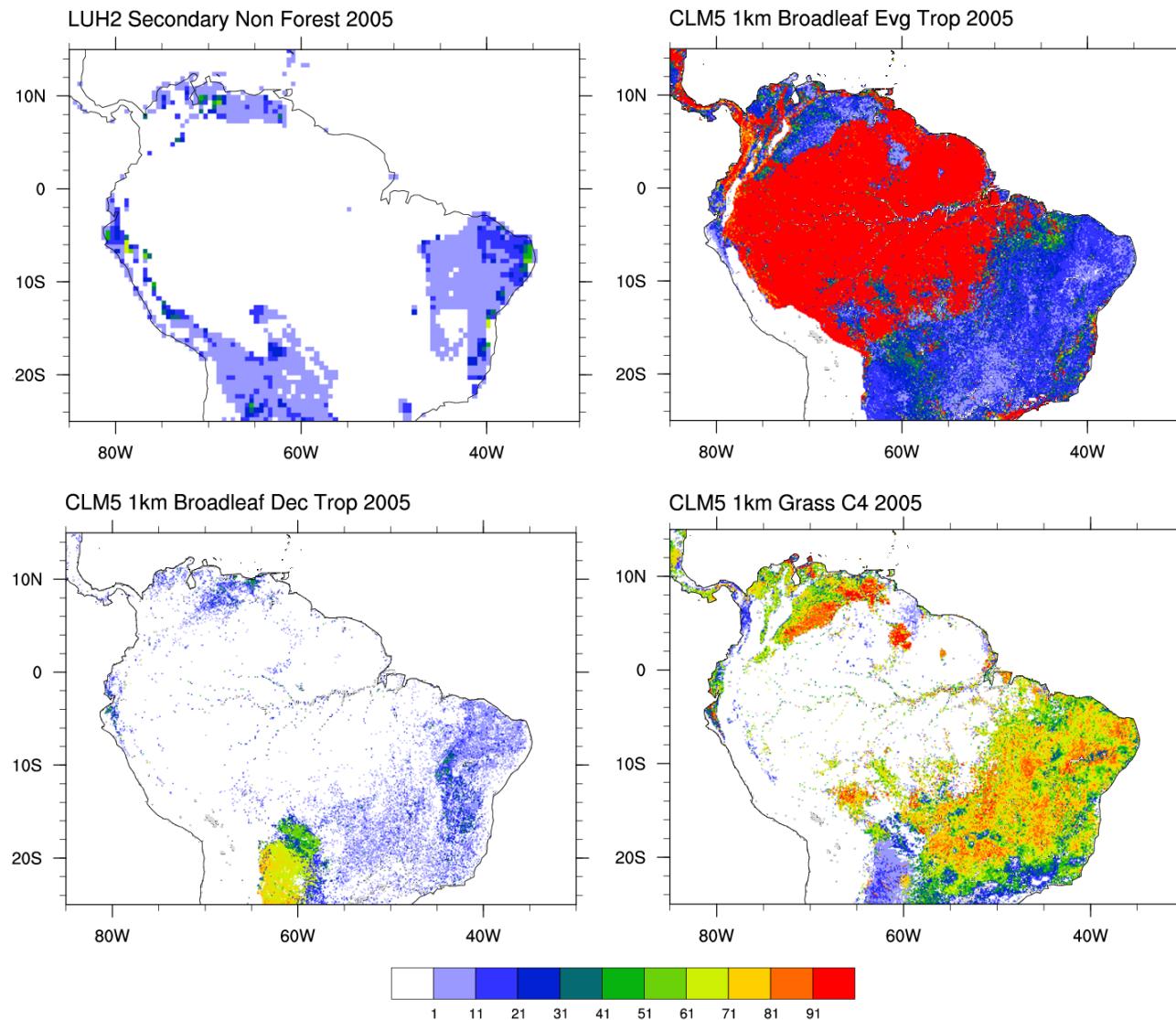
2. CMIP6 Transient Land Cover in CLM 5 PFTs Current Day High Resolution MODIS and LUH2 Time Series



2. CMIP6 Transient Land Cover in CLM 5 PFTs Current Day High Resolution MODIS and LUH2 Time Series

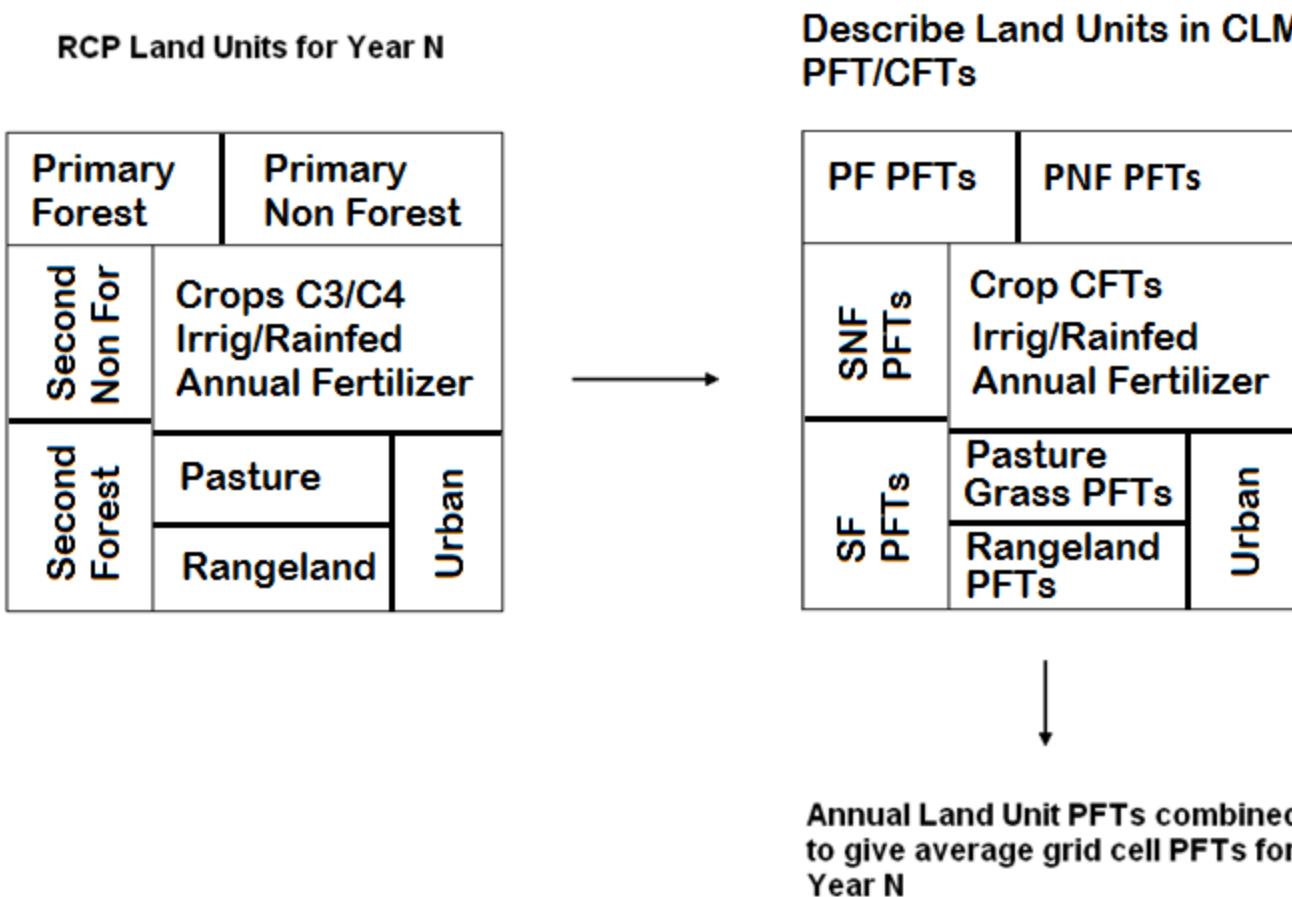


2. CMIP6 Transient Land Cover in CLM 5 PFTs Current Day High Resolution MODIS and LUH2 Time Series

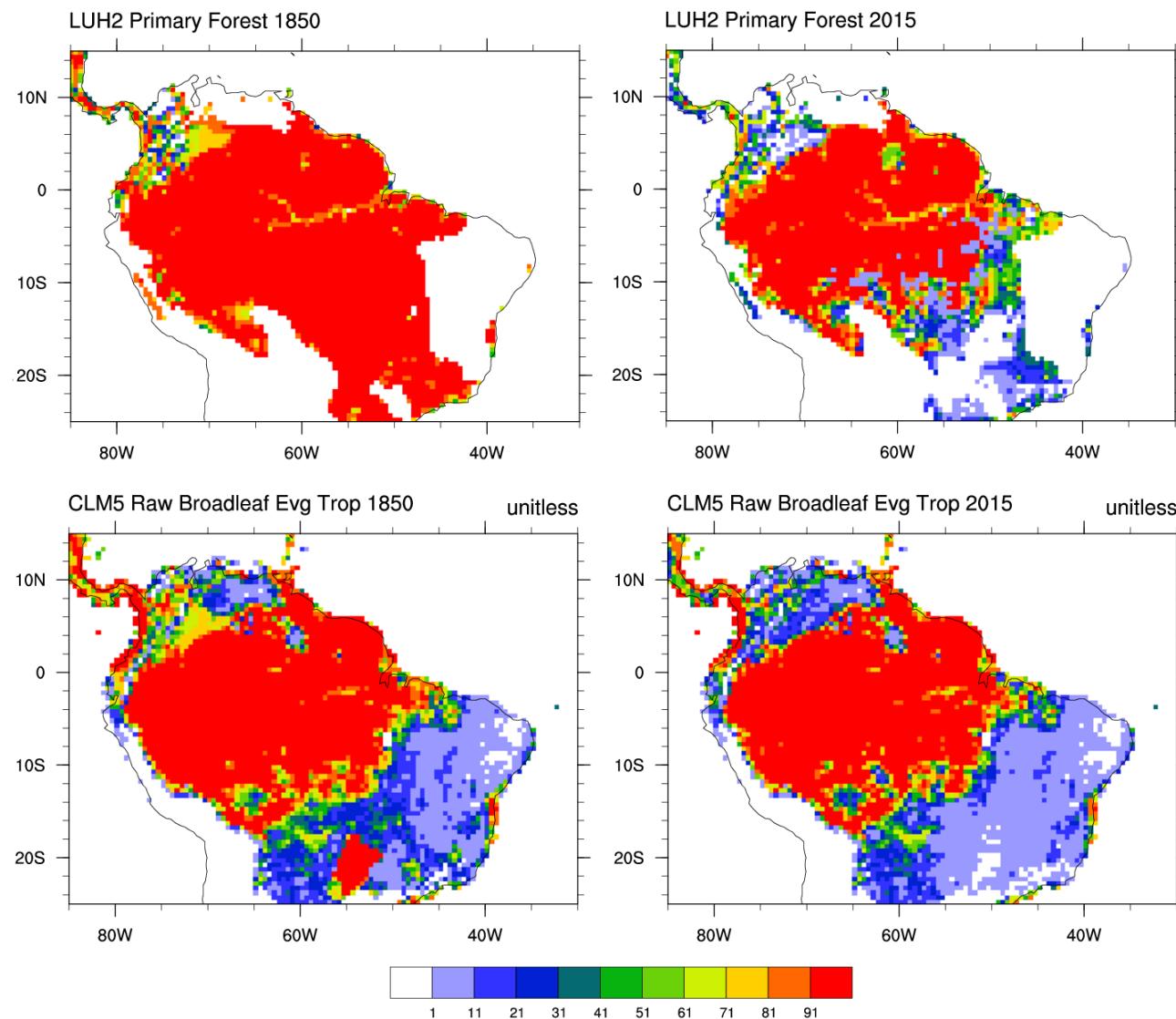


2. Generating CMIP6 Transient Land Cover in CLM 5 PFTs

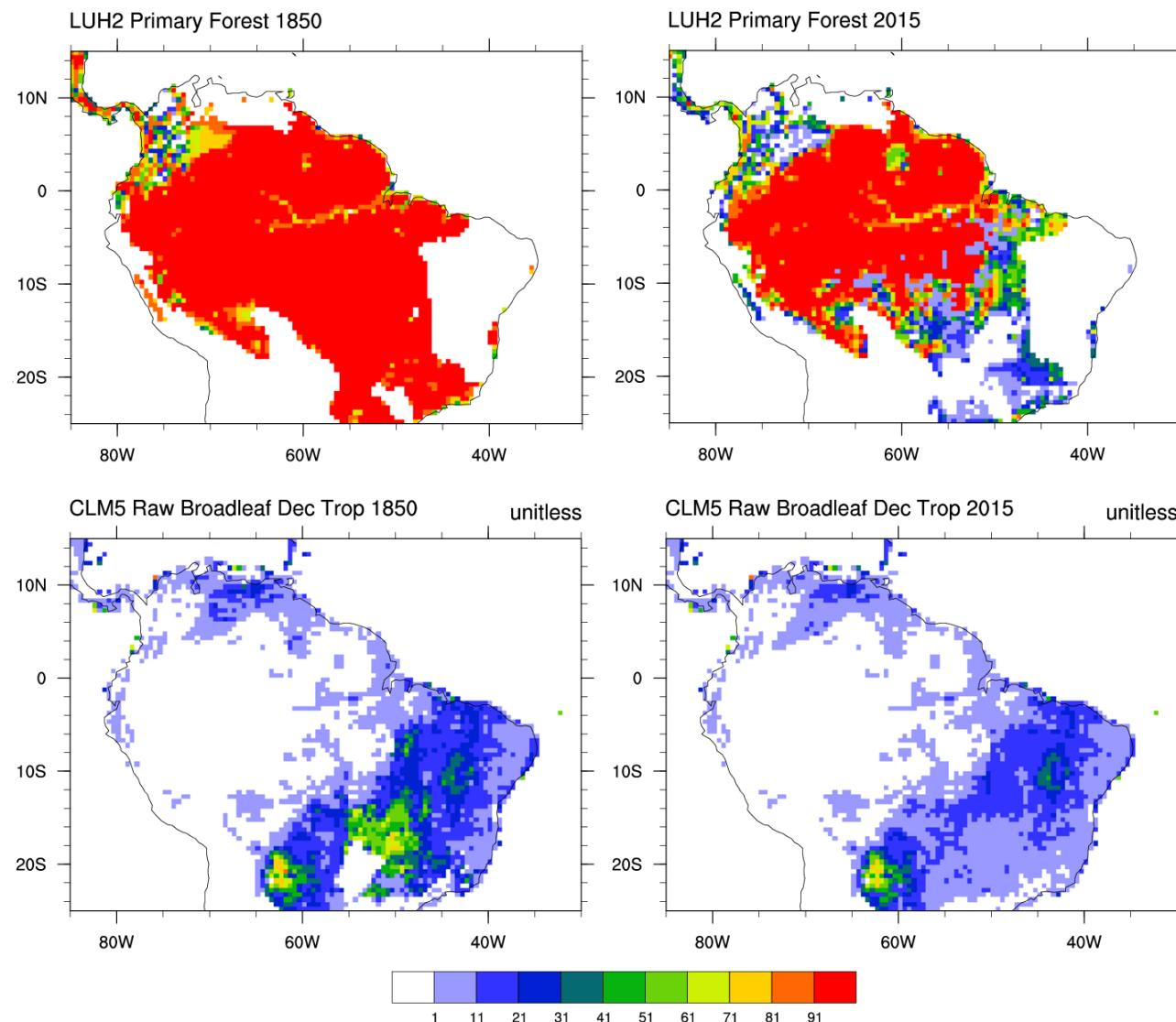
Method GLM 0.25 Degree -> CLM5 PFTs and CFTs



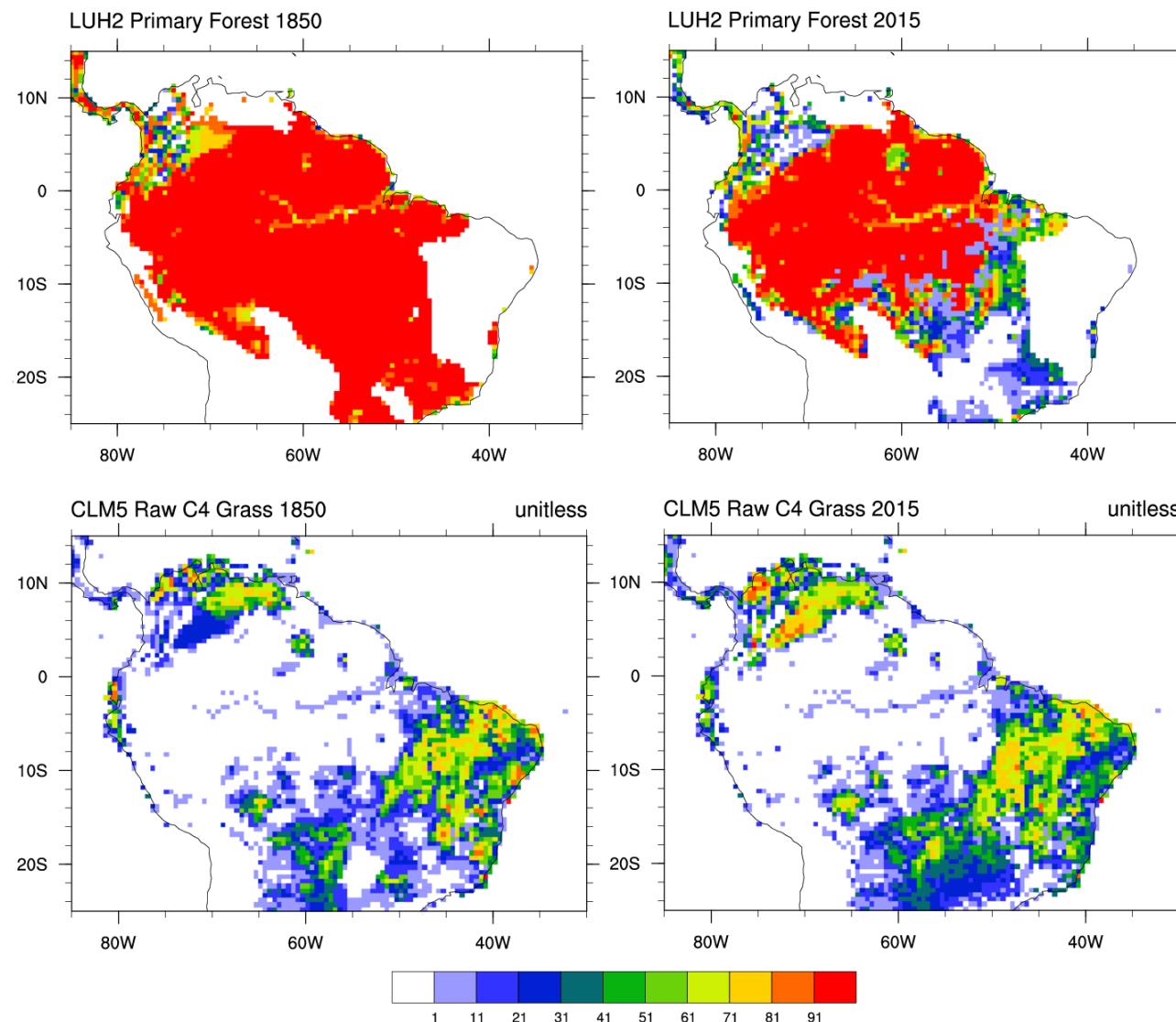
2. CMIP6 Transient Land Cover in CLM 5 PFTs Apply the Current Day Description of Land Units through time



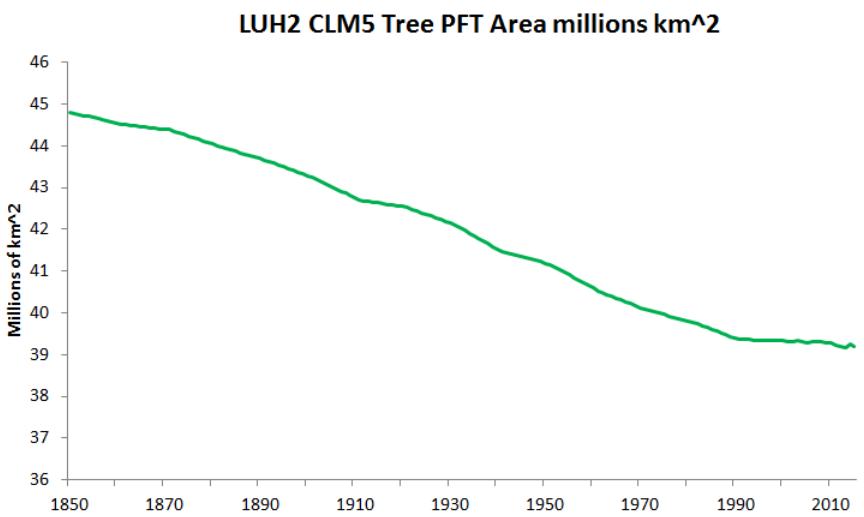
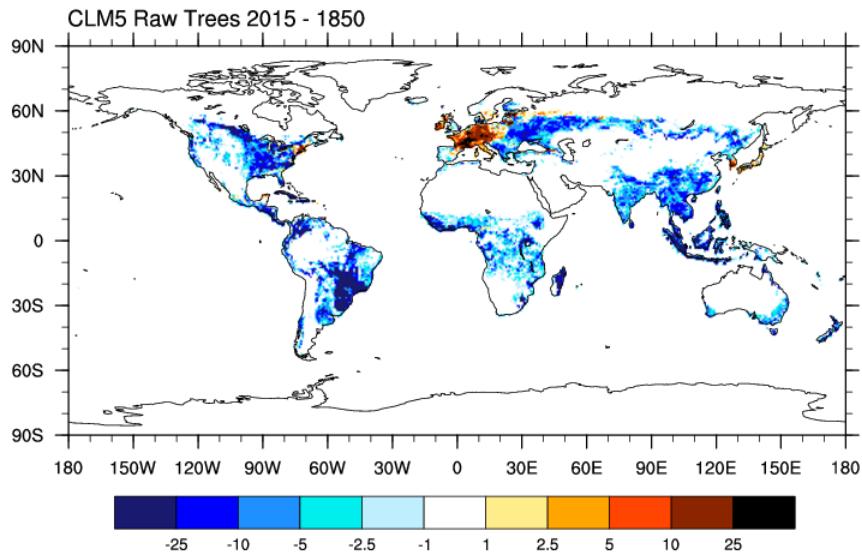
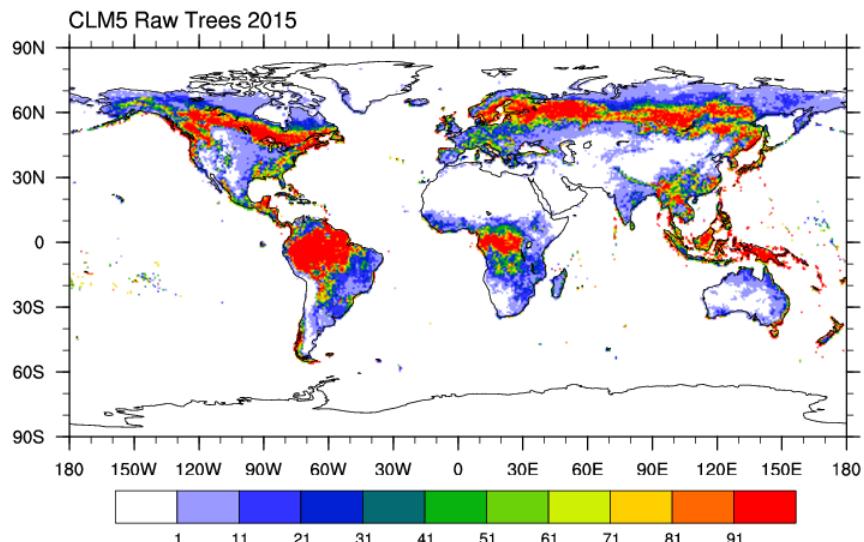
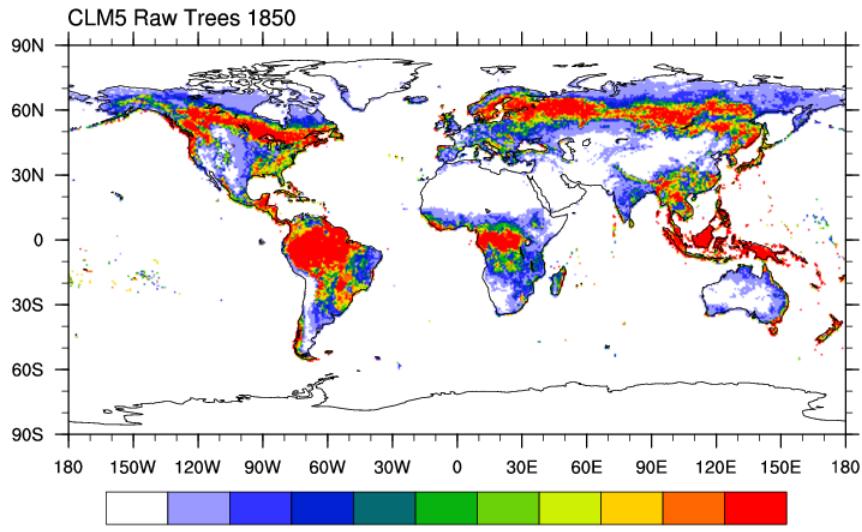
2. CMIP6 Transient Land Cover in CLM 5 PFTs Apply the Current Day Description of Land Units through time



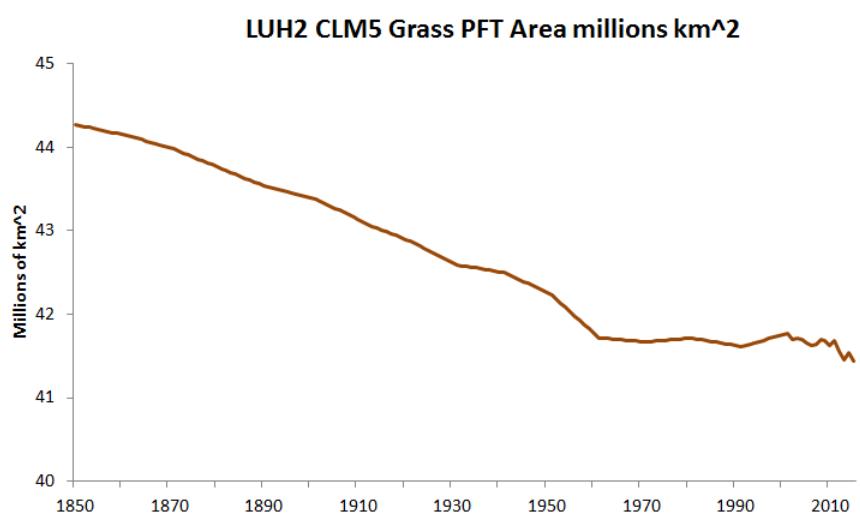
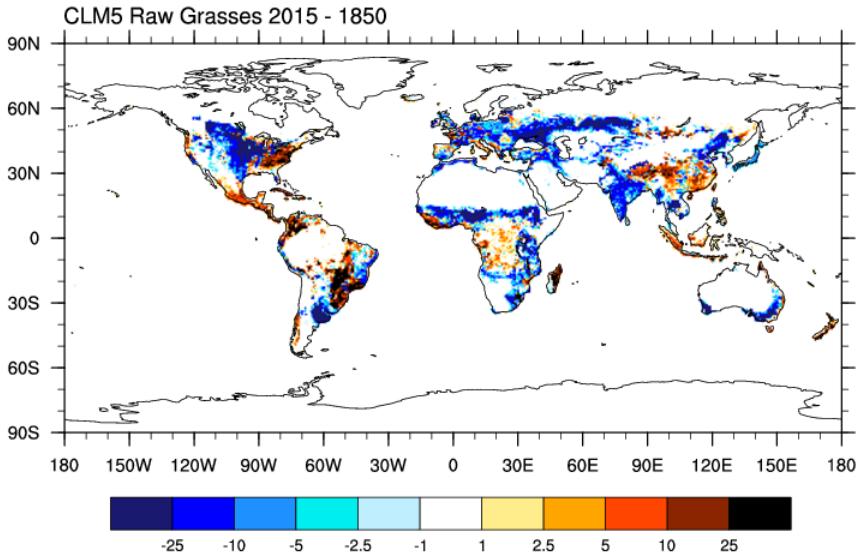
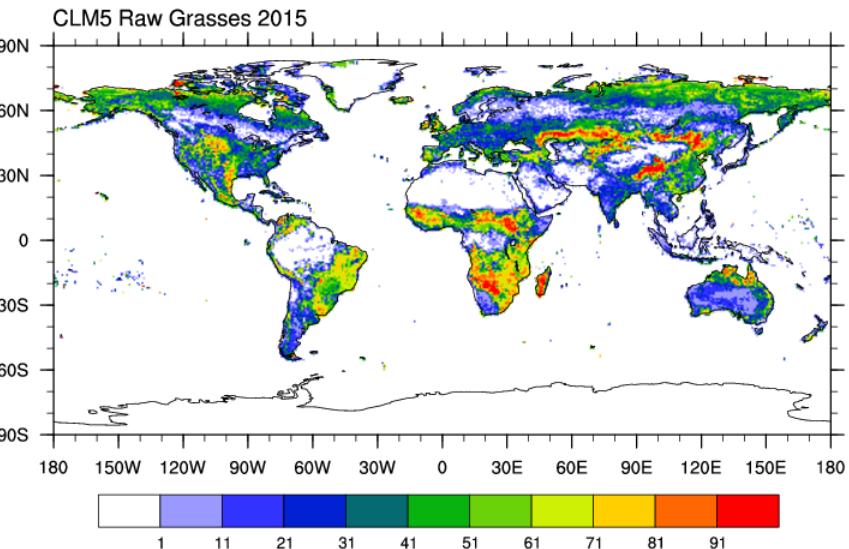
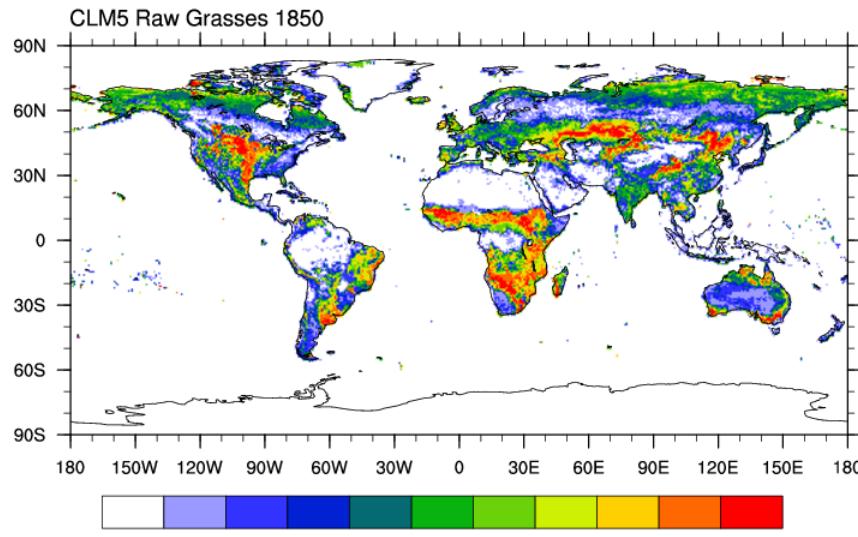
2. CMIP6 Transient Land Cover in CLM 5 PFTs Apply the Current Day Description of Land Units through time



2. CMIP6 Transient Land Cover in CLM 5 PFTs Apply the Current Day Description of Land Units through time



2. CMIP6 Transient Land Cover in CLM 5 PFTs Apply the Current Day Description of Land Units through time

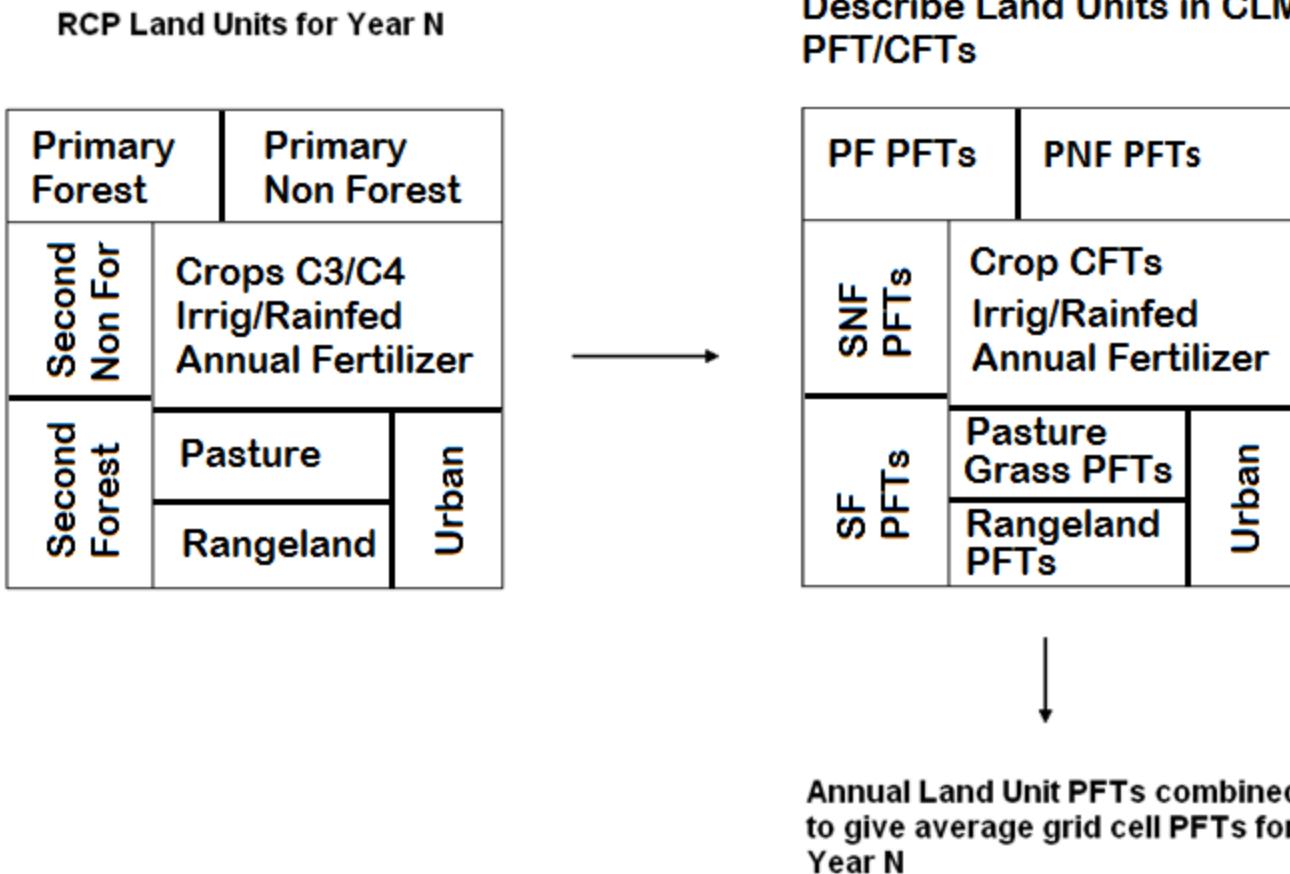


CMIP6 LUMIP CLM5 – CLM Crop Model

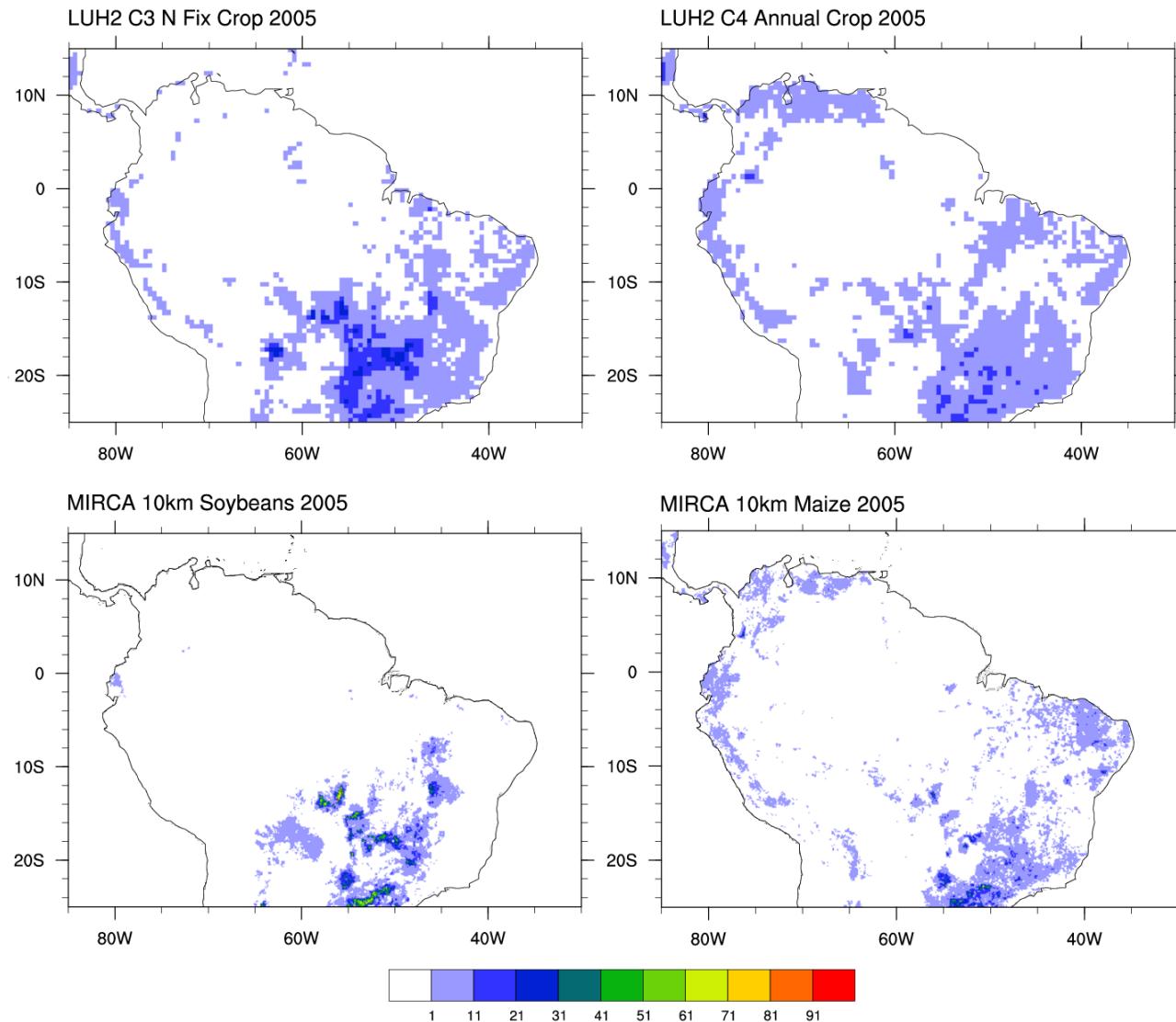
1. CLM5 Crop will be used to simulate the C3/C4 irrigated/rainfed annual/perennial crops specified in GLM time series with fertilizer rates.
2. Crops simulated currently include:
Temperate corn, tropical corn, cotton, rice, sugarcane, temperate soybean, tropical soybean, spring wheat (rainfed and irrigated)
3. Mapping of GLM crop information to CLM5 Crop CFTs based on closest current day crops in CLM Crop of the corresponding type from MIRCA 2000 (Portmann et al 2010)

2. Generating CMIP6 Transient Land Cover in CLM 5 PFTs

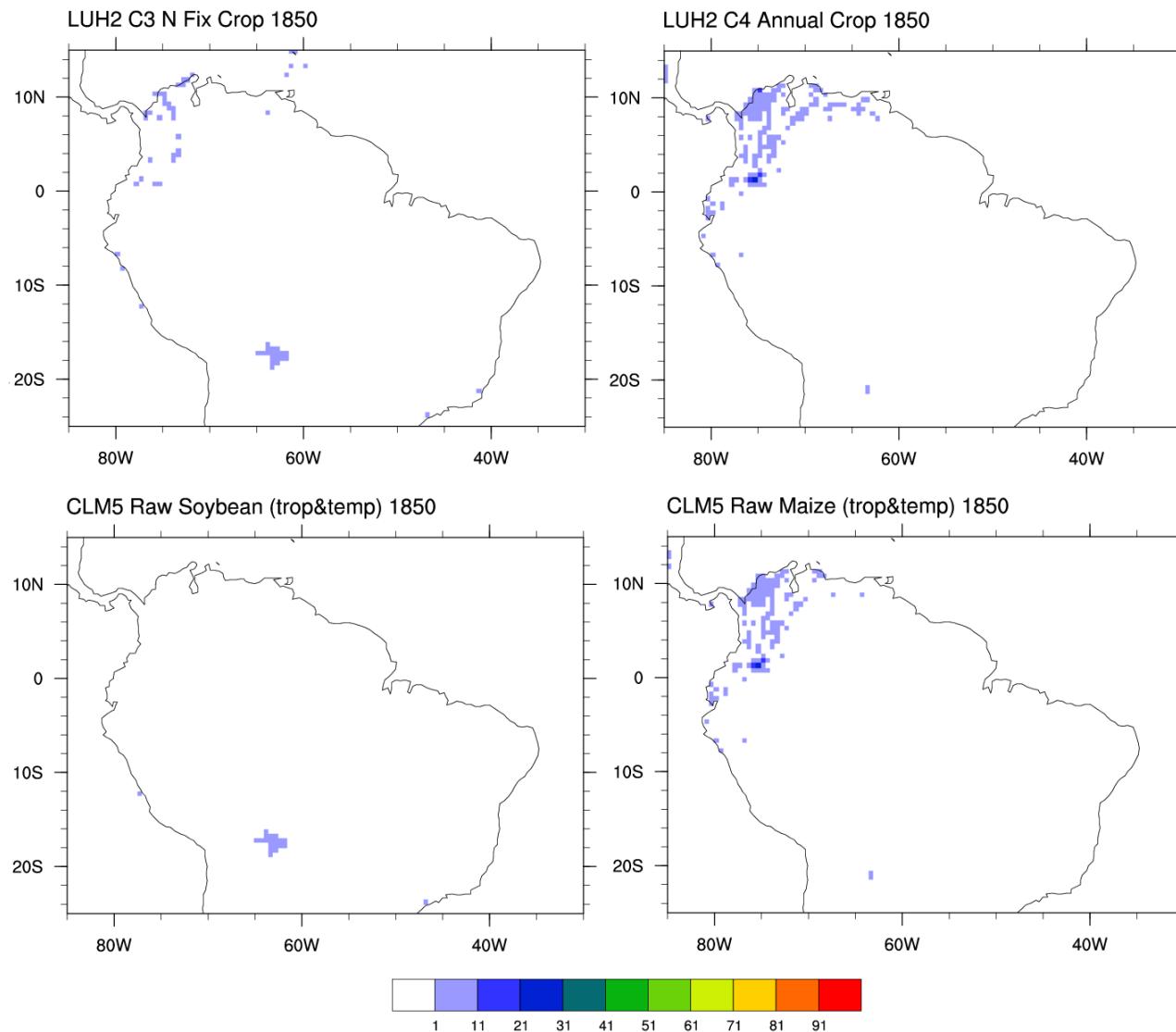
Method GLM 0.25 Degree -> CLM5 PFTs and CFTs



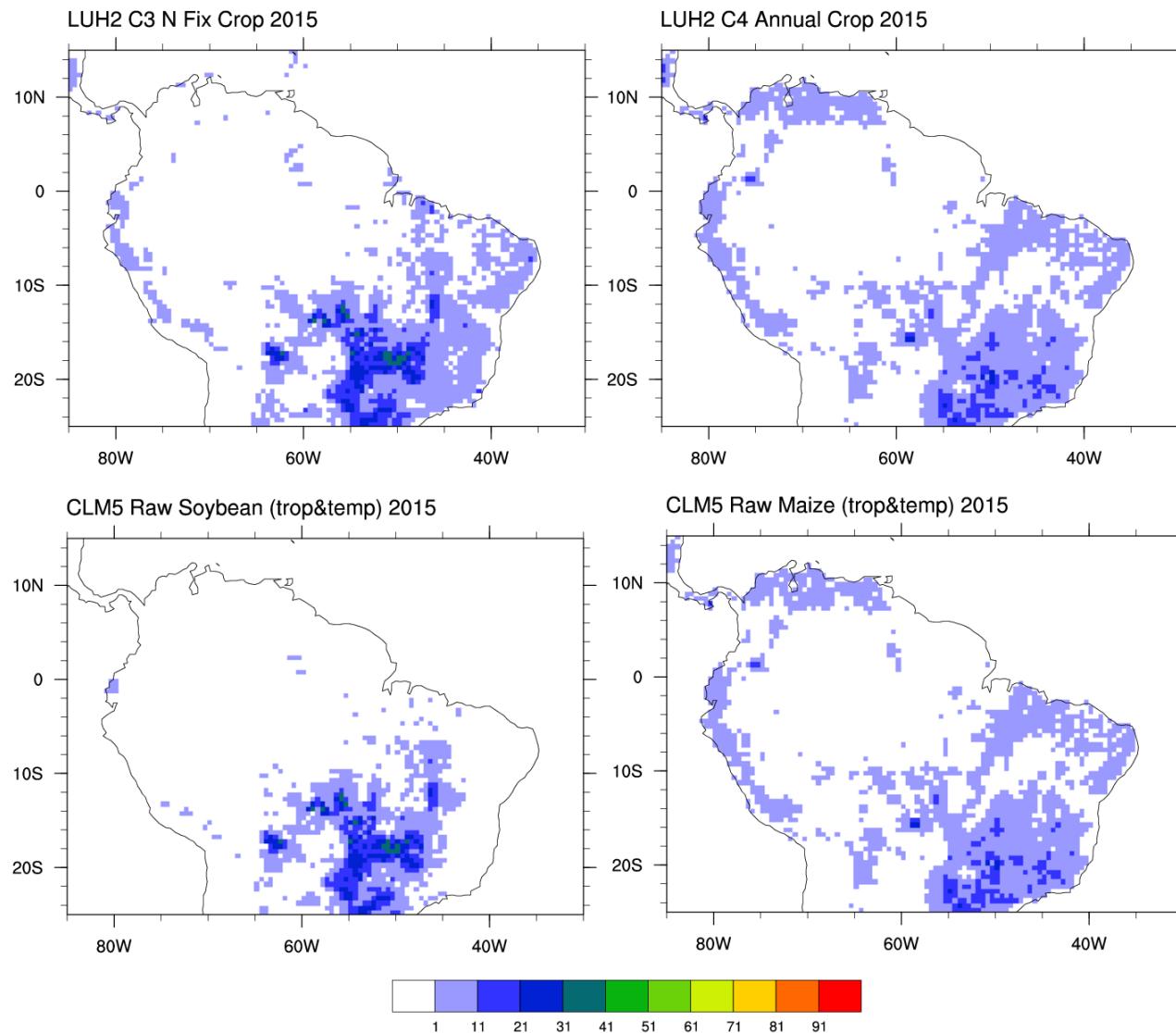
2. CMIP6 Transient Land Cover in CLM 5 CFTs from MIRCA Current Day Crop Distribution



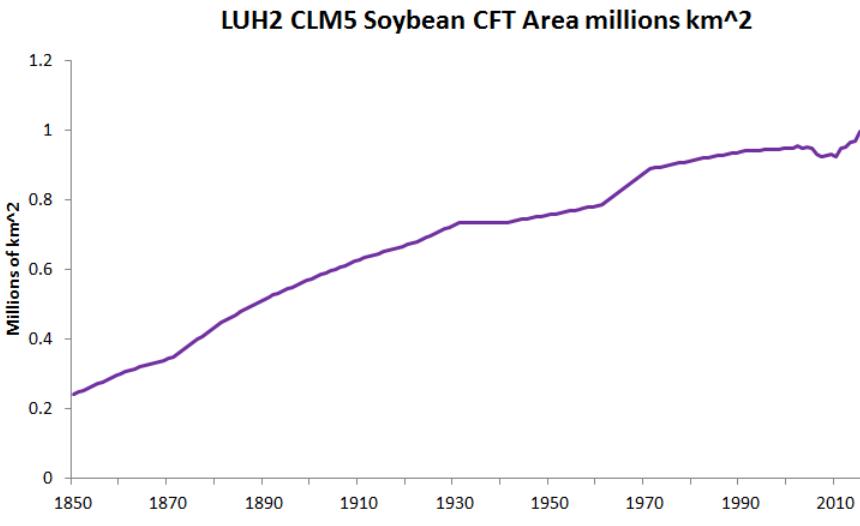
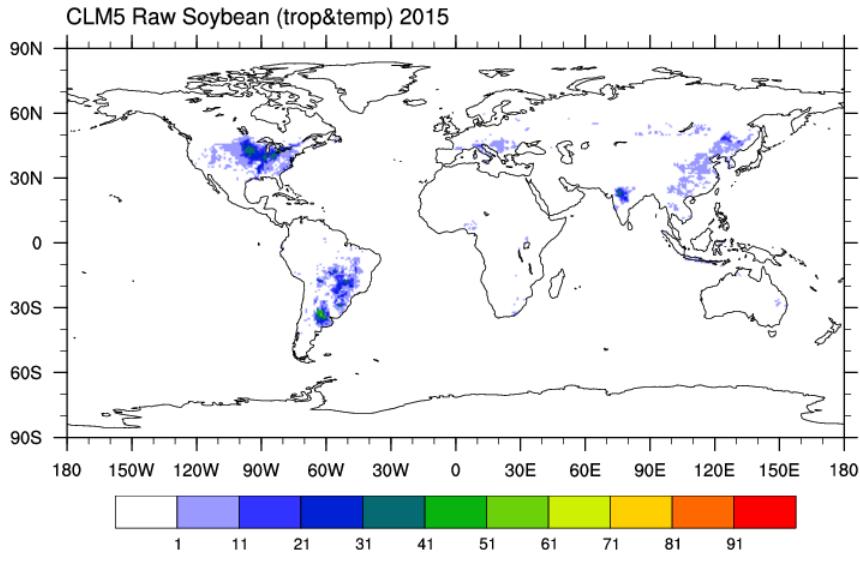
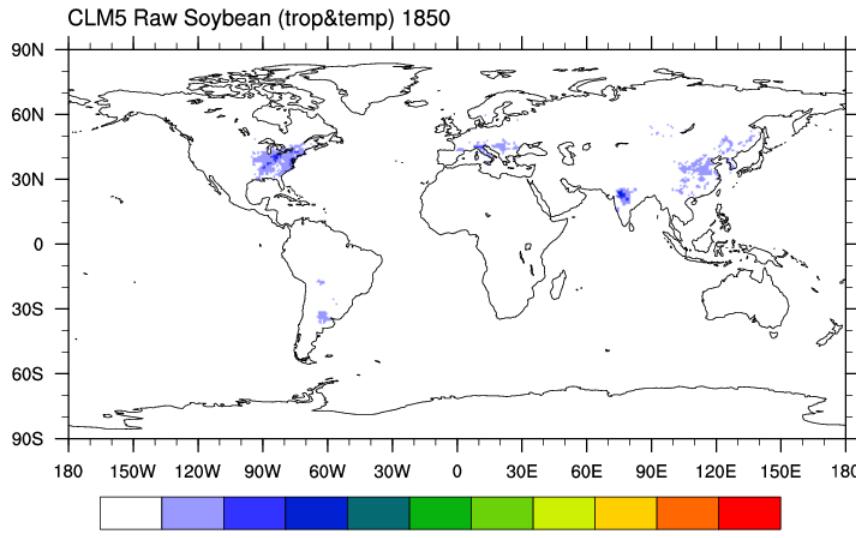
2. CMIP6 Transient Land Cover in CLM 5 CFTs Apply the Current Day Description of Land Units through time



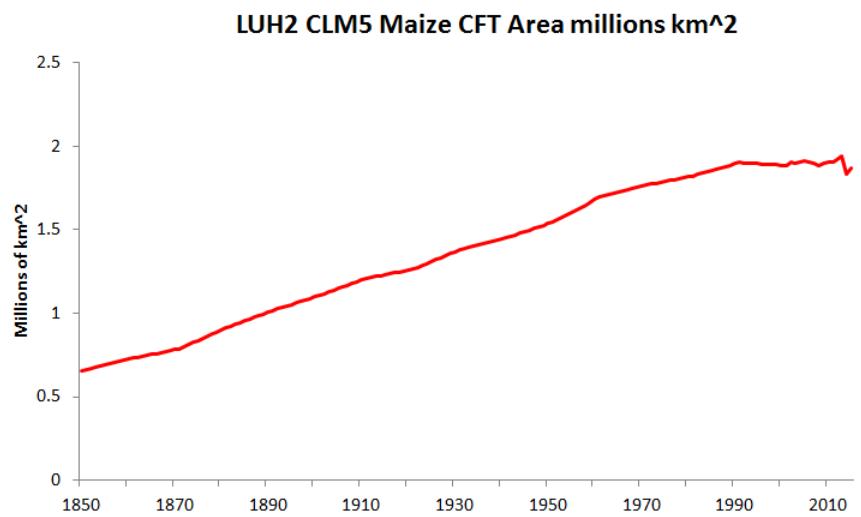
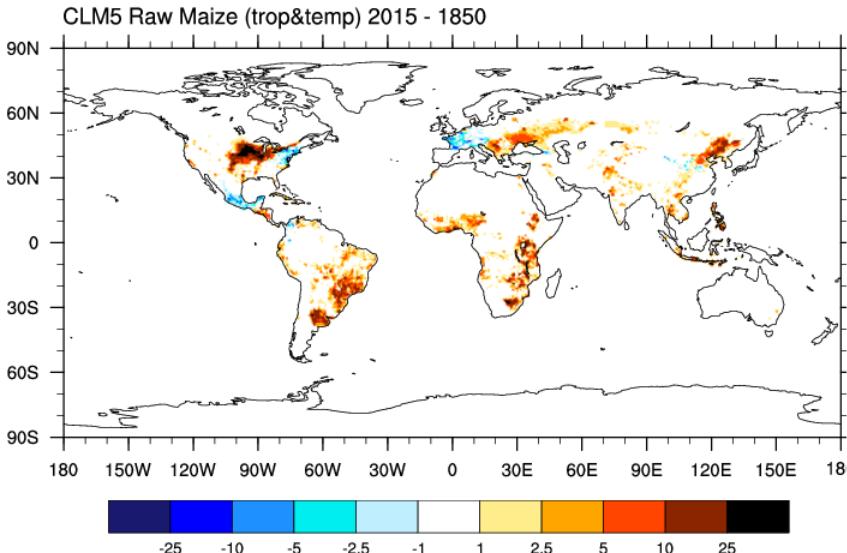
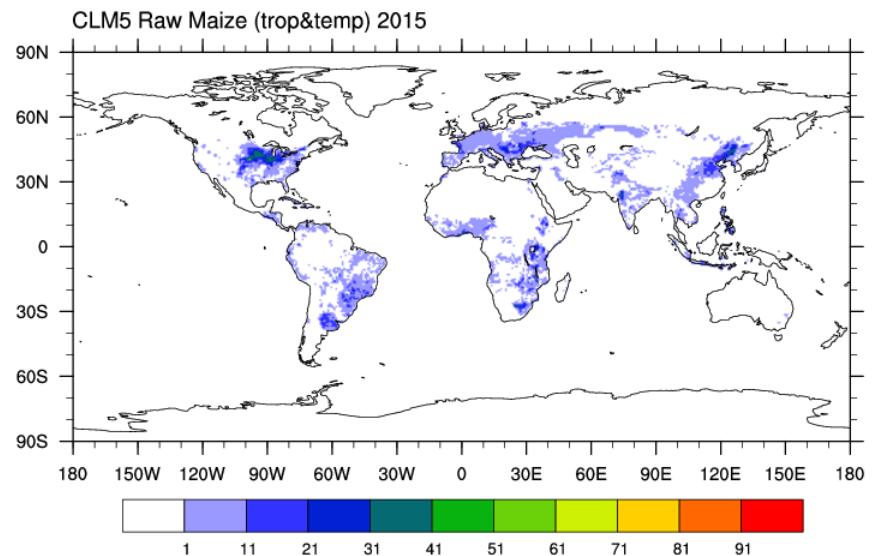
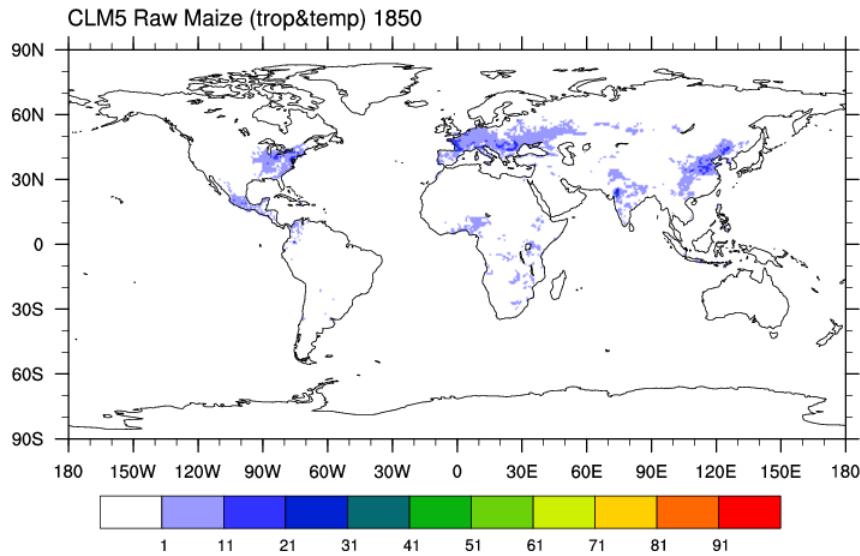
2. CMIP6 Transient Land Cover in CLM 5 CFTs Apply the Current Day Description of Land Units through time



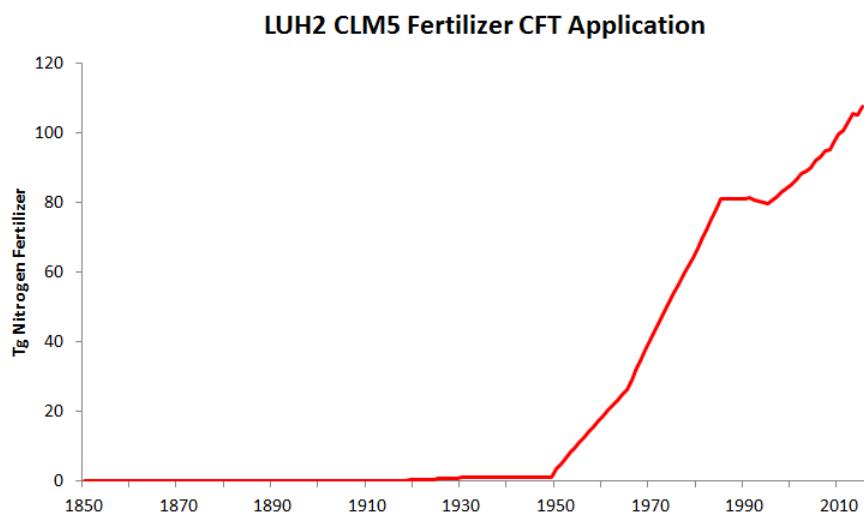
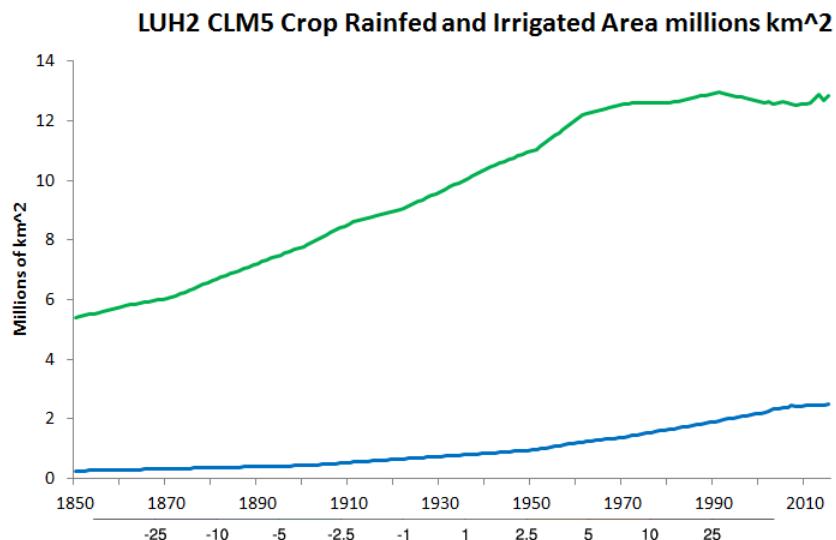
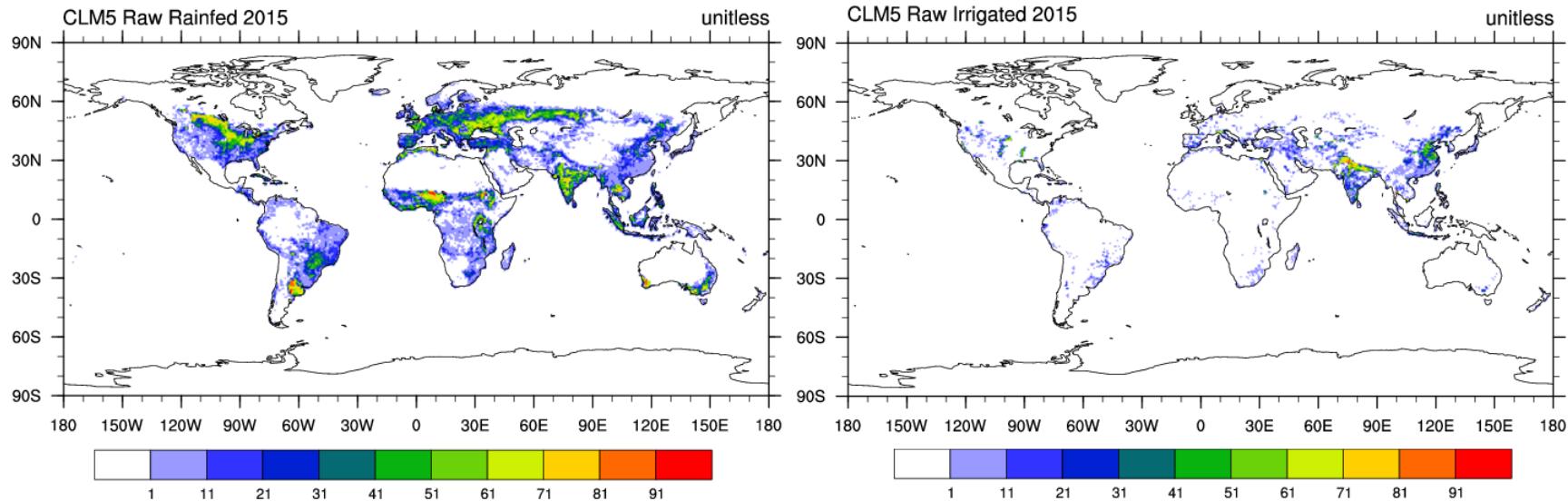
2. CMIP6 Transient Land Cover in CLM 5 CFTs Apply the Current Day Description of Land Units through time



2. CMIP6 Transient Land Cover in CLM 5 CFTs Apply the Current Day Description of Land Units through time



2. CMIP6 Transient Land Cover in CLM 5 CFTs Apply the Current Day Description of Land Units through time



CMIP6 LUMIP CLM5 – CLM Crop Model

1. Crops simulated currently include:
Temperate corn, tropical corn, cotton, rice, sugarcane, temperate soybean, tropical soybean, spring wheat (rainfed and irrigated)
2. Many of the current day CLM5 Crop CFTs need to be remapped to a surrogate crop inside the CLM5 Crop model if that crop is not currently simulated.
3. We are used UNFAO yield data along with MODIS LAI and FLUXNET GPP to build remapping table to find corresponding active CLM Crop CFT
4. Danica Lombardozzi will continue the CLM5 Crop Investigation after the break

CLM5 - MIRCA 2000 Remapping inside CLM5 Crop

CFT	CFT	CFT	CFT	CFT
15. C3 Generic Crop	29. Rye 19. Spring Wheat	43. Datepalm 41. Cotton	57. Pulses 19. Spring Wheat	71. Miscanthus 17. Temperate Corn
16. C3 Generic Crop Irrigated	30. Rye Irrigated 20. Spring Wheat Irrigated	44. Datepalm Irrigated 42. Cotton Irrigated	58. Pulses Irrigated 20. Spring Wheat Irrigated	72. Miscanthus Irrigated 18. Temperate Corn Irrigated
17. Temperate Corn	31. Winter Rye 19. Spring Wheat	45. Foddergrass 19. Spring Wheat	59. Rapeseed 19. Spring Wheat	73. Switchgrass 17. Temperate Corn
18. Temperate Corn Irrigated	32. Winter Rye Irrigated 20. Spring Wheat Irrigated	46. Foddergrass Irrigated 20. Spring Wheat Irrigated	60. Rapeseed Irrigated 20. Spring Wheat Irrigated	74. Switchgrass Irrigated 18. Temperate Corn Irrigated
19. Spring Wheat	33. Cassava 61. Rice	47. Grapes 19. Spring Wheat	61. Rice	75. Tropical Corn
20. Spring Wheat Irrigated	34. Cassava Irrigated 62. Rice Irrigated	48. Grapes Irrigated 20. Spring Wheat Irrigated	62. Rice Irrigated	76. Tropical Corn Irrigated
21. Winter Wheat 19. Spring Wheat	35. Citrus 19. Spring Wheat	49. Groundnuts 61. Rice	63. Sorghum 75. Tropical Corn	77. Tropical Soybean
22. Winter Wheat Irrigated 20. Spring Wheat Irrigated	36. Citrus Irrigated 20. Spring Wheat Irrigated	50. Groundnuts Irrigated 62. Rice Irrigated	64. Sorghum Irrigated 76. Tropical Corn Irrigated	78. Tropical Soybean Irrigated
23. Temperate Soybean	37. Cocoa 61. Rice	51. Millet 75. Tropical Corn	65. Sugarbeet 19. Spring Wheat	
24. Temperate Soybean Irrigated	38. Cocoa Irrigated 62. Rice Irrigated	52. Millet Irrigated 76. Tropical Corn Irrigated	66. Sugarbeet Irrigated 20. Spring Wheat Irrigated	
25. Barley 19. Spring Wheat	39. Coffee 61. Rice	53. Oilpalm 61. Rice	67. Sugarcane	
26. Barley Irrigated 20. Spring Wheat Irrigated	40. Coffee Irrigated 62. Rice Irrigated	54. Oilpalm Irrigated 62. Rice Irrigated	68. Sugarcane Irrigated	
27. Winter Barley 19. Spring Wheat	41. Cotton	55. Potatoes 19. Spring Wheat	69. Sunflower 19. Spring Wheat	
28. Winter Barley Irrigated 20. Spring Wheat Irrigated	42. Cotton Irrigated	56. Potatoes Irrigated 20. Spring Wheat Irrigated	70. Sunflower Irrigated 20. Spring Wheat Irrigated	