

Community Earth System Model (CESM2) Community Land Model (CLM5)

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CLM5 and CESM2 Documentation

Full Technical description and diagnostics including ILAMB assessment

<http://www.cesm.ucar.edu/models/cesm2/land/>

Papers

- Lawrence, D.M. et al, 2019. The Community Land Model version 5: Description of new features, benchmarking, and impact of forcing uncertainty. *Accepted to JAMES*.
- Wieder, W.R., et al., 2019. Beyond static benchmarking: Using experimental manipulations to evaluate land model assumptions. *Glob. Biogeochem. Cyc.*, doi.org/10.1029/2018GB006141.
- Fisher, R., et al., 2019. Parametric controls on vegetation responses to biogeochemical forcing in the CLM5. *JAMES*, doi.org/10.1029/2019MS001609.
- Bonan, G., et al., 2019. Model Structure and Climate Data Uncertainty in Historical Simulations of the Terrestrial Carbon Cycle (1850-2014). *Glob. Biogeochem. Cyc.*,
- Gettelman, A., et al., 2019: High Climate Sensitivity in the Community Earth System Model version 2 (CESM2). *GRL*, doi.org/10.1029/2019GL083978.
- Lombardozzi, D, et al., 2019. Simulating transient crop management in the Community Land Model version 5. *In prep*
- Lawrence, P., et al., 2019. Implementation and impacts of land cover and land-use change in CLM5. *in prep*.
- Danabasoglu, G., et al., 2019. CESM2 overview paper. *In prep*

New or updated land modeling capabilities in the CESM2/CLM5I

Included in default CLM5

- CN (completely updated)
- Vertically-resolved CN (permafrost)
- CH₄ emissions
- C isotopes
- Plant hydraulics
- Spatial explicit soil depth, dry surface layer param for soil evap, snow updates
- *No dynamic biogeography*
- Global crop model with 8 basic crop types; planting, grain fill, harvest
- Irrigation
- Industrial crop fertilization (assumed constant background manure application)
- Wood harvest (by mass)
- Urban environments (3 density classes, heating/cooling wasteheat)
- Anthropogenic fire ignition and suppression

Corn*



Winter wheat



Sugarcane



Soy*



Cotton



Rice



* Temperate and tropical varieties



Heterogeneity in Community Land Model (CLM)

Gridcell



Subgrid landuse data
available at ESGF

n.b. Full subgrid
information available on
request

Landunit



Vegetated



Lake



Urban



Glacier



Crop

Column



Soil



Roof



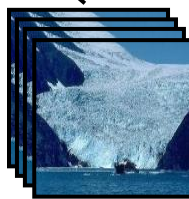
Sun Wall



Shade Wall



Pervious



Elevation
classes

Patch



PFT1



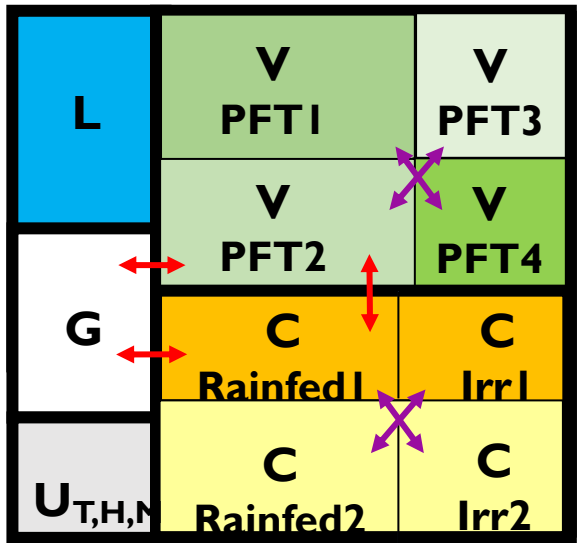
PFT2



PFT3



PFT4 ...



Urban area constant
at present day



Rainfed



Irrig



Rainfed



Irrig



Crop1



Crop1



Crop2



Crop2 ...



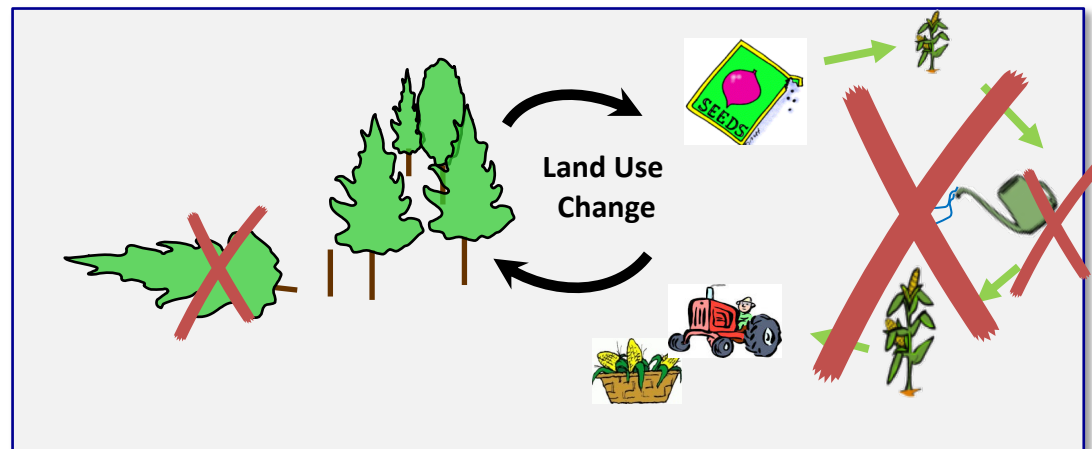
Land Use Model Intercomparison Project (LUMIP) for CMIP6

CLM simulations completed

Set of land-only historic (1850 – 2014) simulations with one-at-a-time modification of particular aspects of land management

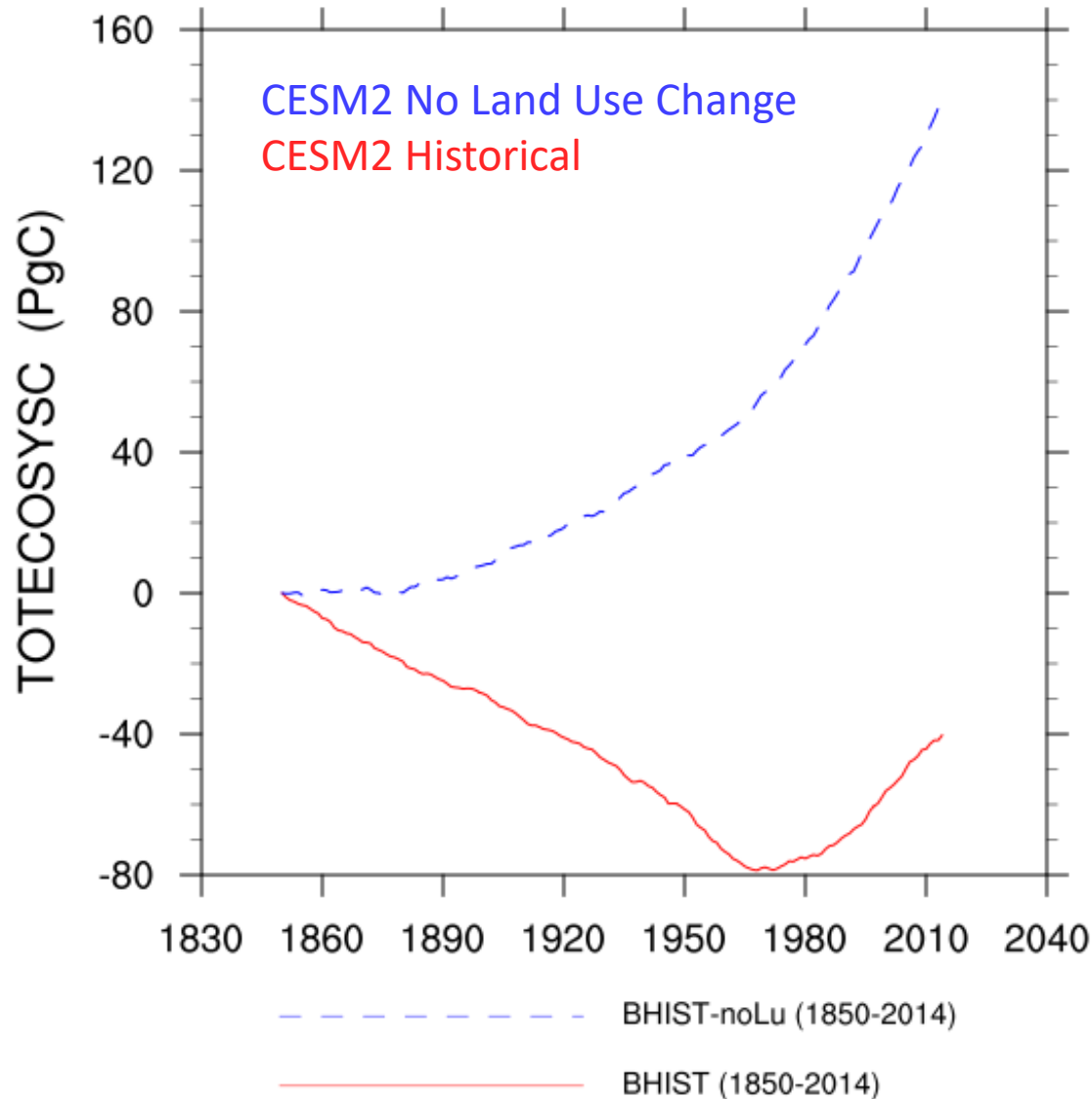
- 1 Land historical all management
- 2 Year 1700 instead of 1850 start
- 3 No LULCC change
- 4 Alternate land use histories
- ~~5 No shifting cultivation~~
- 6 Crop and pasture as unmanaged grassland
- 7 Crops with crop model but no irrigation/fertilization
- 8 No irrigation
- 9 No fertilization
- 10 No wood harvest

- ~~11 No grazing on pastureland~~
- 12 No human fire ignition/suppression
- 13 Constant 1850 CO_2
- 14 Constant 1850 climate





Accumulated Land Use Change Flux



**CESM2 / CLM5
~180 PgC**

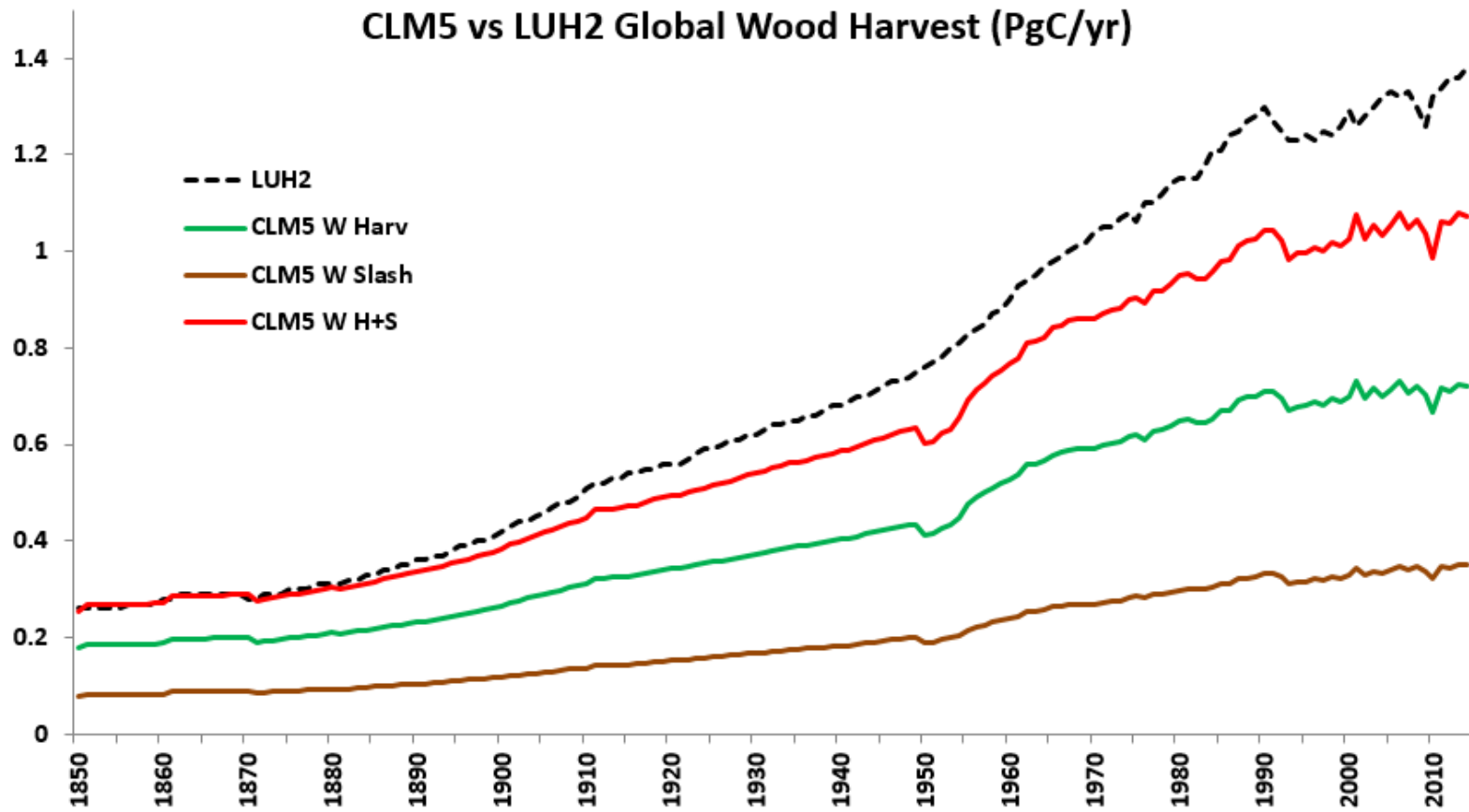
**Houghton estimate
 145 ± 16 PgC**

**Note that with shifting
cultivation, included for
TRENDY 2019, but not
CMIP6, ~200 PgC**

CESM1 ~120 PgC



Wood harvest

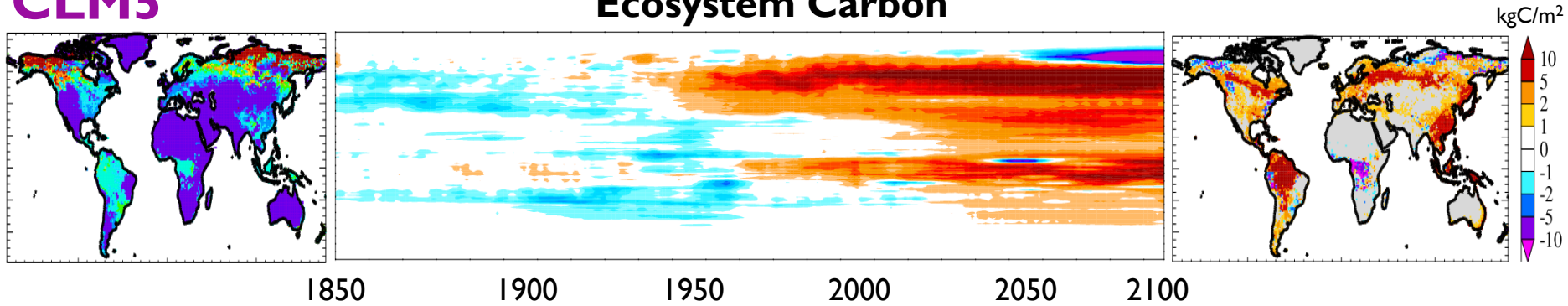




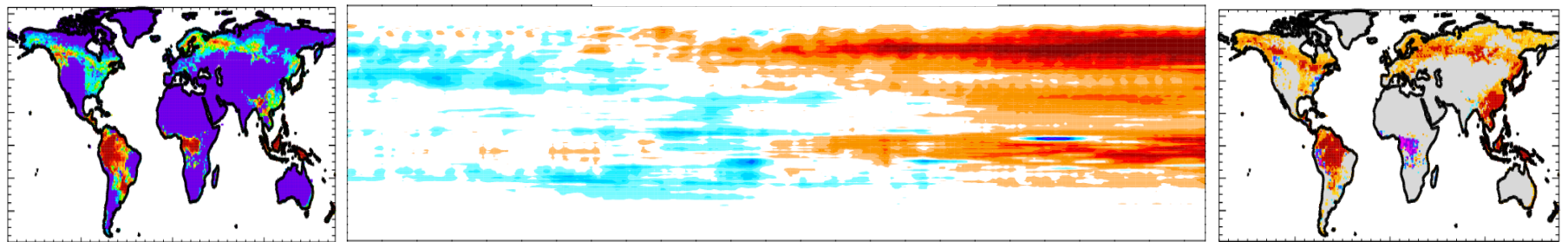
Land carbon stock trends (RCP8.5)

CLM5

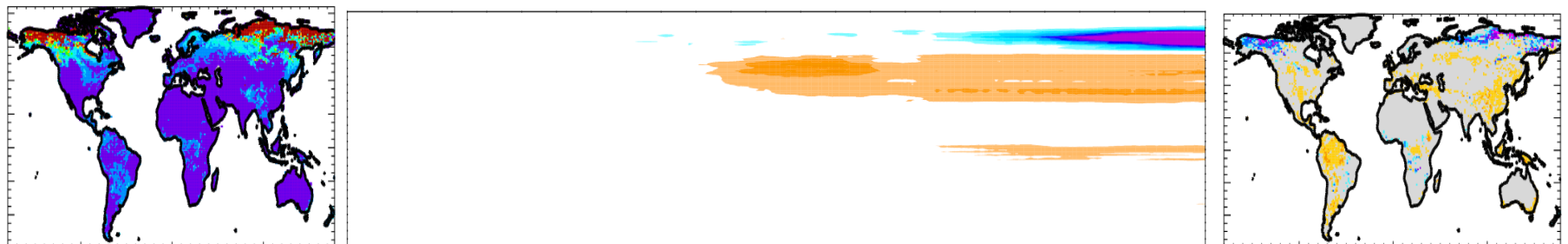
Ecosystem Carbon

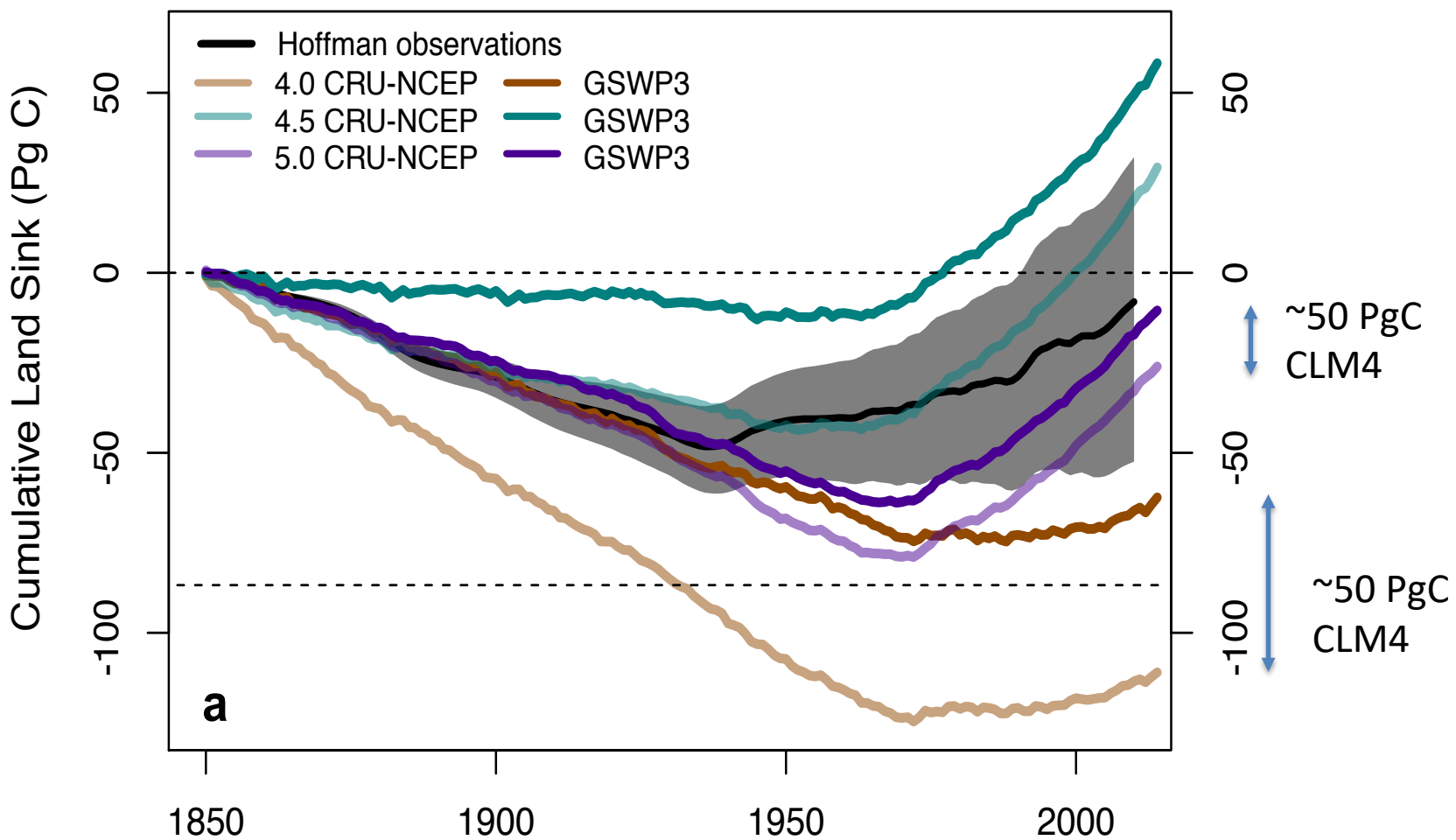


Vegetation Carbon



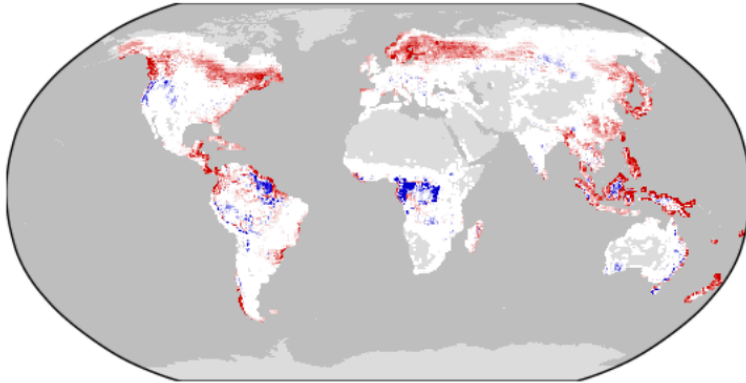
Soil Carbon





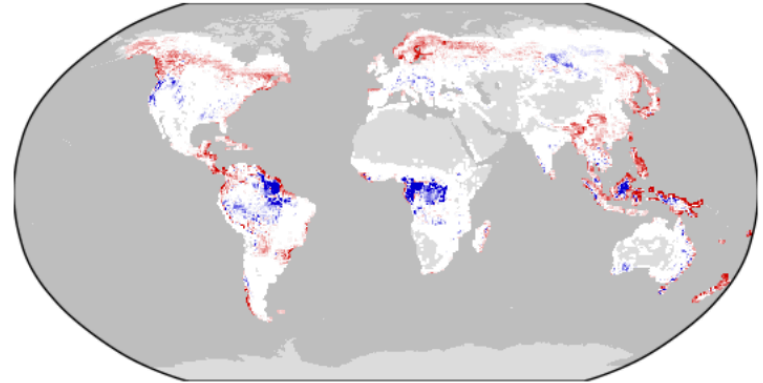
Bias in vegetation biomass (against GEOCARBON dataset)

CLM5_CRUNCEPv7



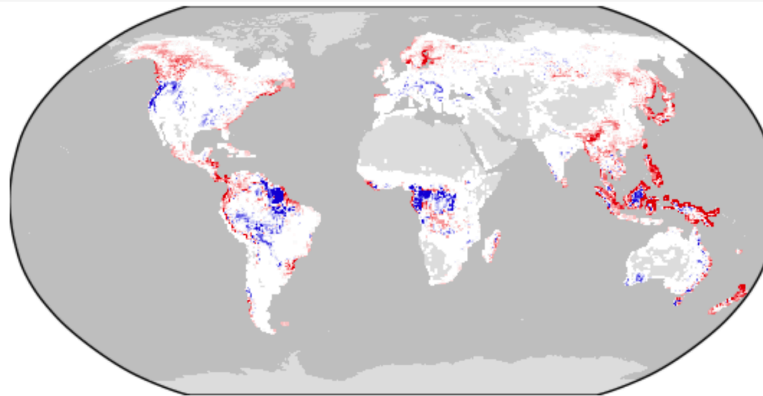
kg m⁻²

CLM5_GSWP3v1



kg m⁻²

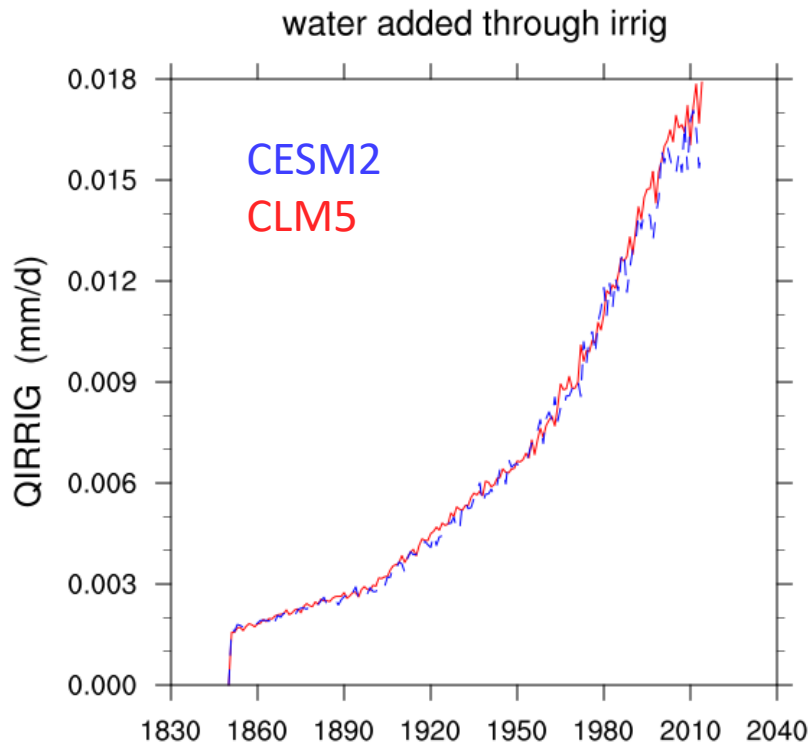
CESM2_1_001



kg m⁻²



Irrigation



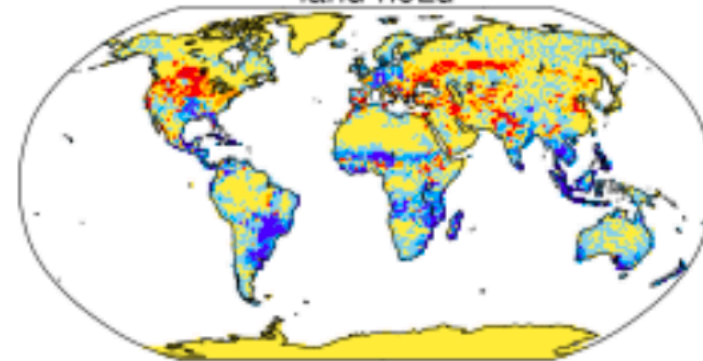
- Irrigation is on for all CMIP6 simulations
- Note that irrigation scheme draws water from surface water (rivers) first and then draws water diffusely from ocean
- Water for irrigation is never limited
- Work ongoing to implement reservoirs and reservoir management, groundwater pumping, and aquifers to permit water-limited irrigation

Preliminary assessment of LULCC climate impacts

Land-hist minus land-noLU

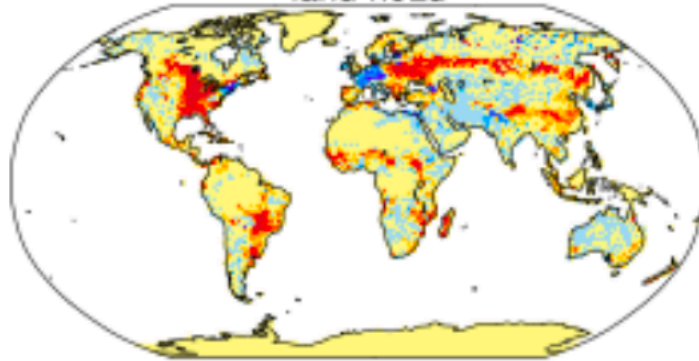
Latent Heat (JJA)

land-hist
- land-noLU

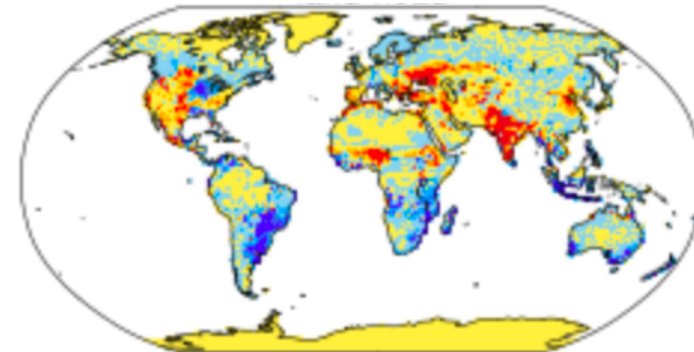


Annual albedo

land-hist
- land-noLU

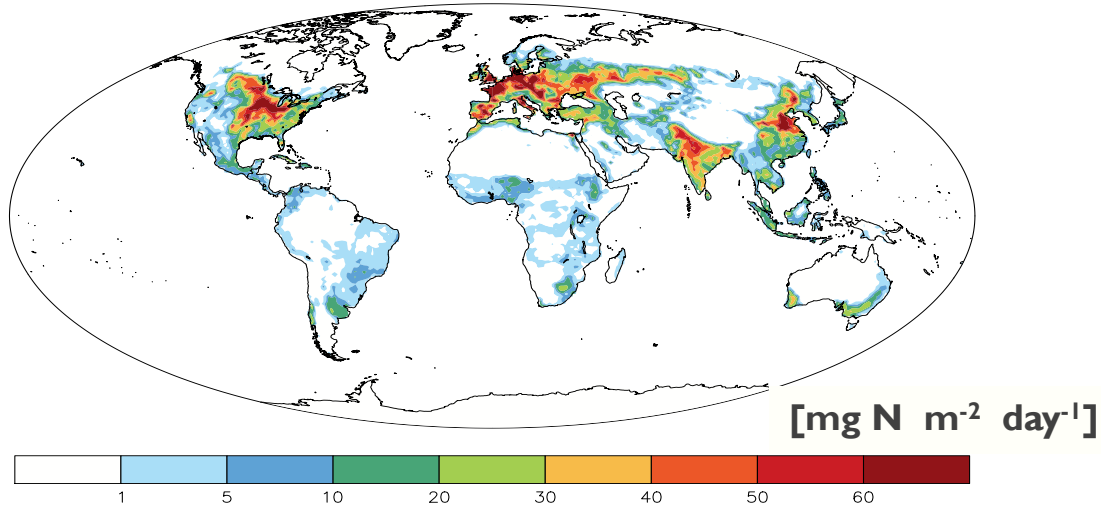


Latent Heat (MAM)



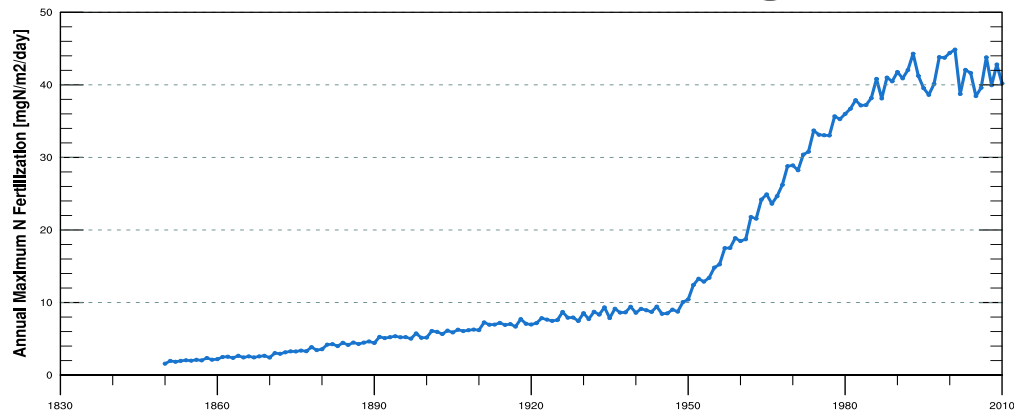
Land management in the Community Land Model

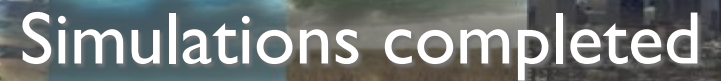
Nitrogen fertilization



Due to limitations in soil biogeochemistry scheme including representation of competition between plants and microbes for N, no confidence in N₂O emissions (not recommended for use)

N Fertilization over the Contiguous US





Add'l ens?

[illegible]