Evaluation of the global carbon cycle in ACCESS-ESM1

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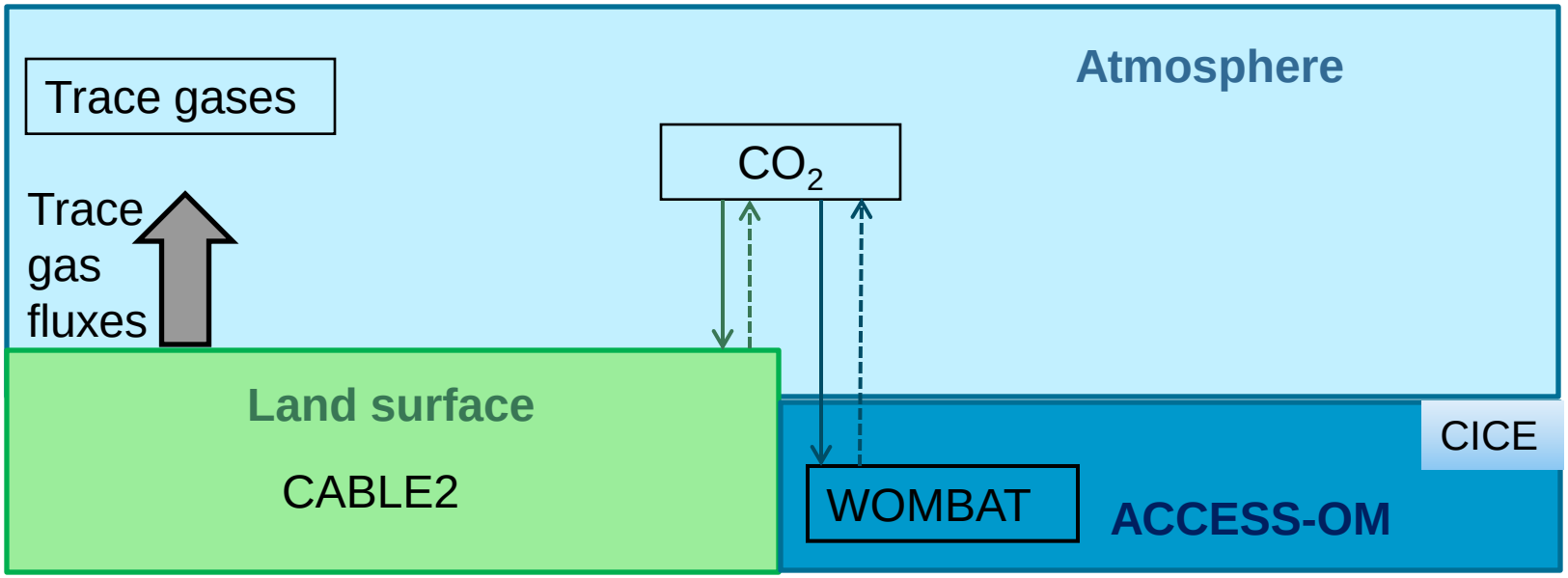
ACCESS1.4 and ACCESS-ESM1



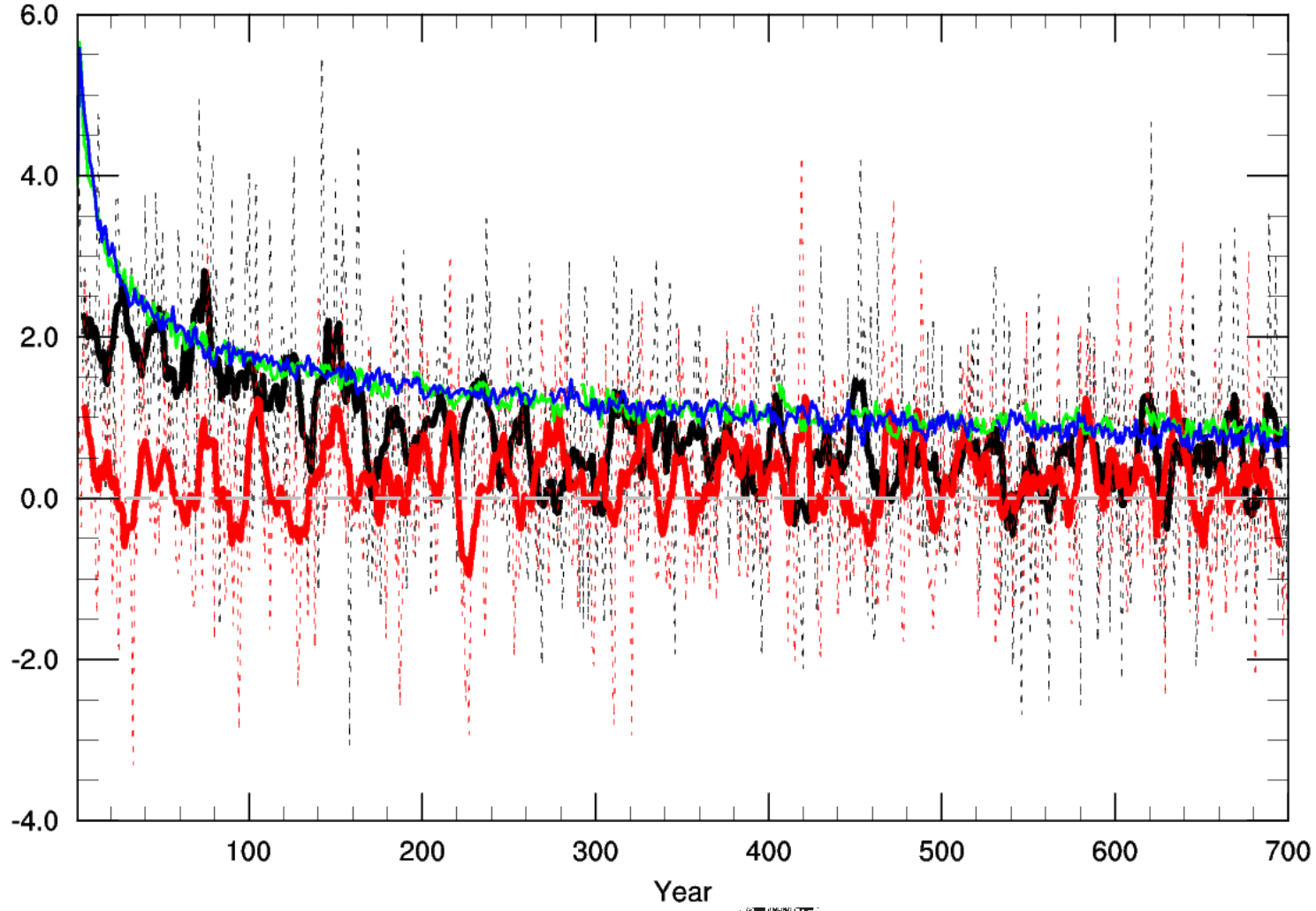
- ACCESS1.4: Similar to ACCESS1.3 but with CABLE2, OASIS-MCT, revised water balance, tuned dust, sea-ice and ocean fixes
- Land carbon fluxes from CABLE2 with biogeochemistry
- Ocean carbon fluxes from WOMBAT (World Ocean Model of Biogeochemistry And Trophic-dynamics), includes a two-component plankton model (phytoplankton and zooplankton)

(slide from Rachel Law)

Control run overview

- All runs with prescribed (non-interactive) CO_2
- Pre-industrial spin-up and control run
  - **Ocean**: warm start for physics from ACCESS 1.4 control run after 155 years, cold start for biogeochemistry (no spin-up of carbon pools)
  - **Land**: all carbon (plus nitrogen, phosphorus) pools from previous coupled PI control test run (land carbon pools should be close to equilibrium)
- 2 scenarios: carbon cycle with prescribed LAI and carbon cycle with prognostic LAI (LAI feedback)

Control run – land and ocean tracer fluxes



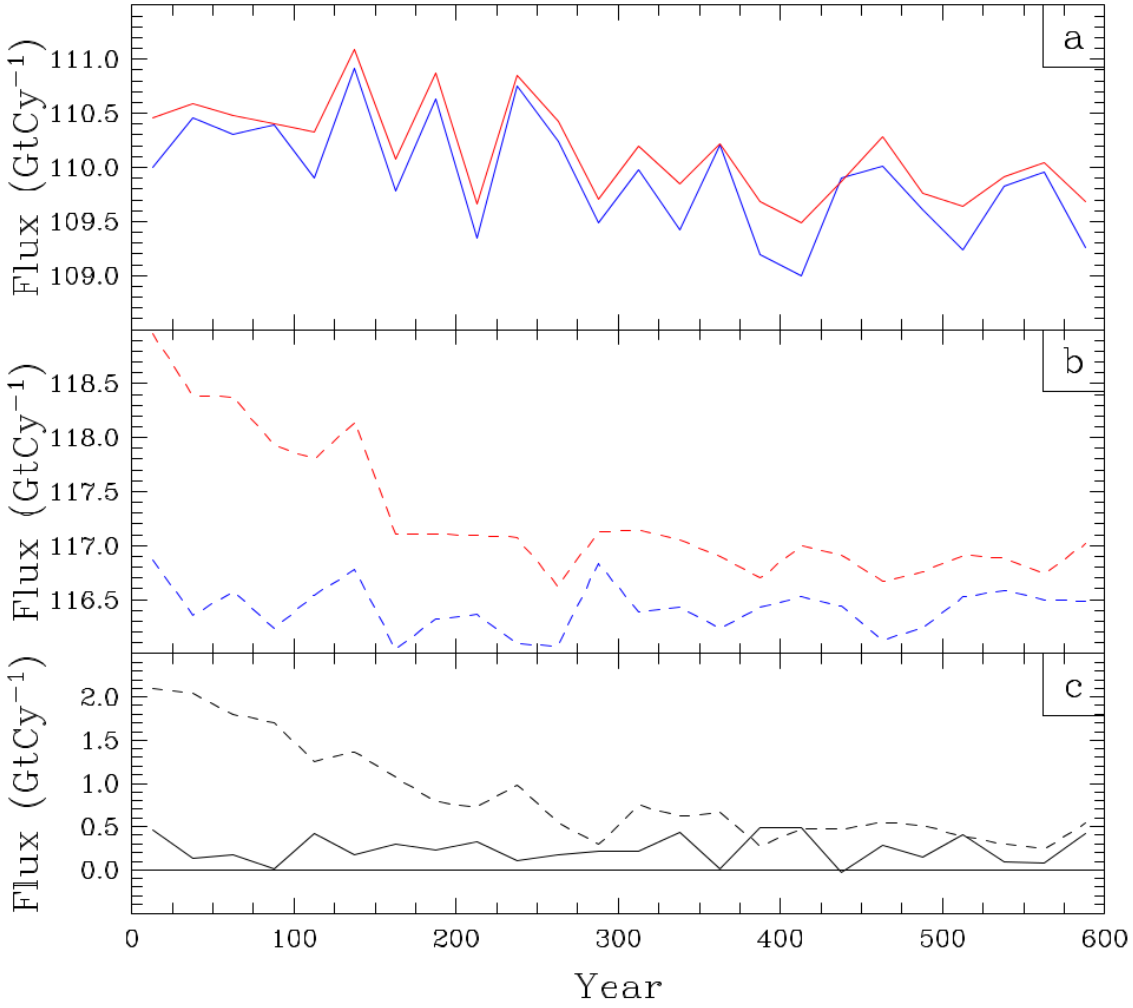
Black: land (pres LAI)

Red: land (prog LAI)

Green: ocean (pres LAI)

Blue: ocean (prog LAI)

Spin up and carbon imbalance



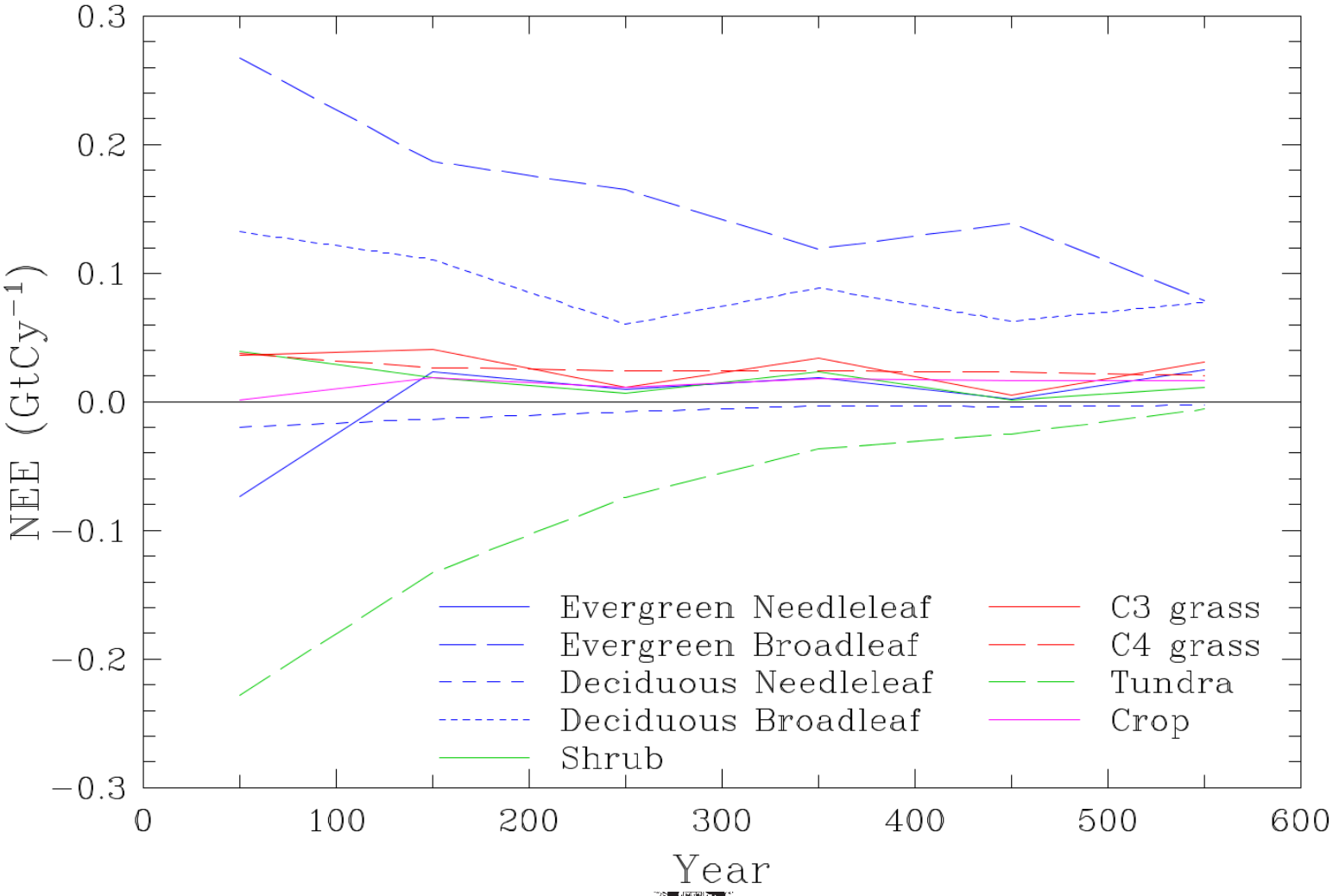
Top: prognostic LAI, GPP 25 yr mean (blue) and R sum 25 yr mean (red)

Middle: prescribed LAI, GPP 25 yr mean (blue) and R sum 25 yr mean (red)

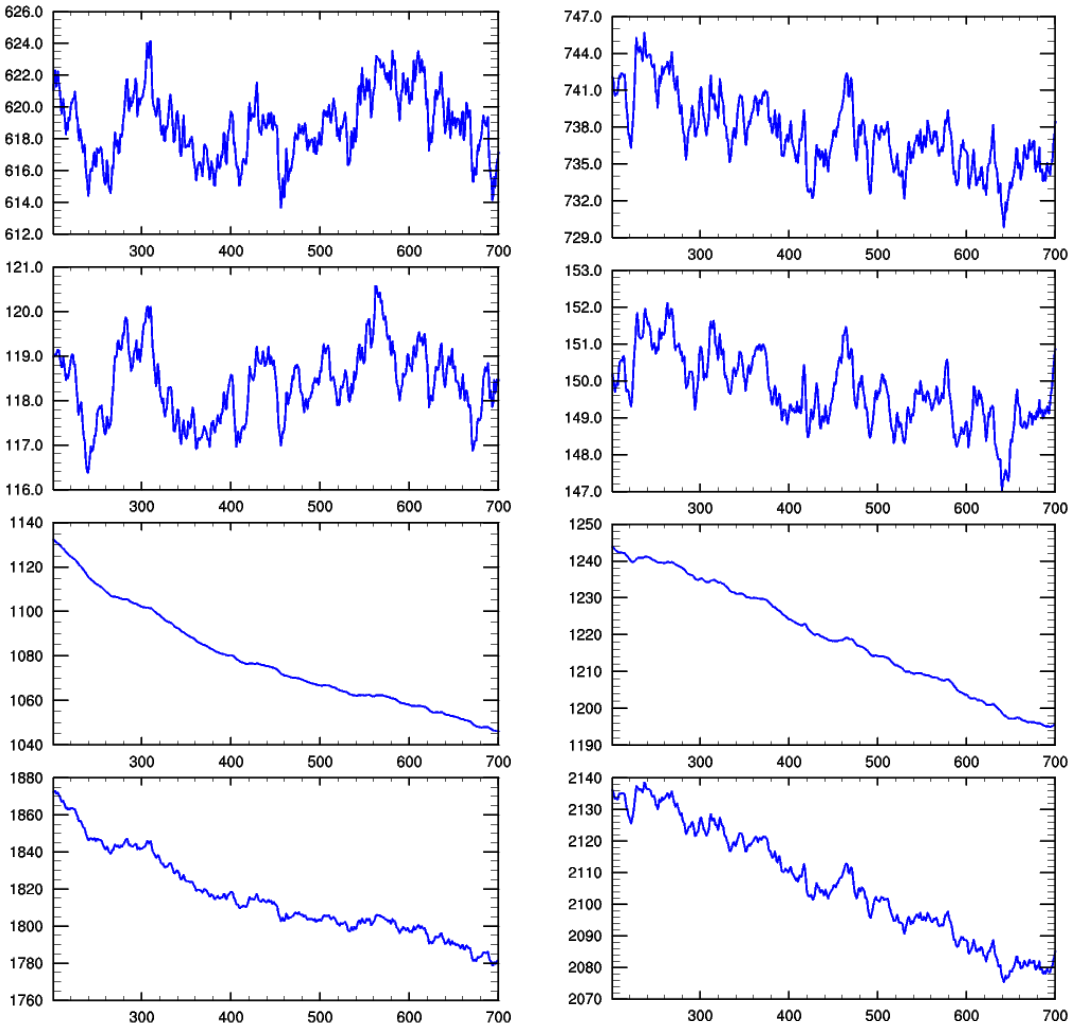
Bottom: NEE 25 yr mean prescribed LAI (dashed) and prognostic LAI (solid)

0.2 PgC/yr imbalance for prognostic LAI case

Spin up and carbon imbalance



Carbon pools [PgC]



Left: prescribed LAI
Right: prognostic LAI

Top to bottom: plant pool, litter pool, soil pool, total

Terrestrial biomass (estimates)

450 – 650 PgC (Prentice et al., 2001)
800 - 1300 PgC (Houghton et al., 2009), includes litter

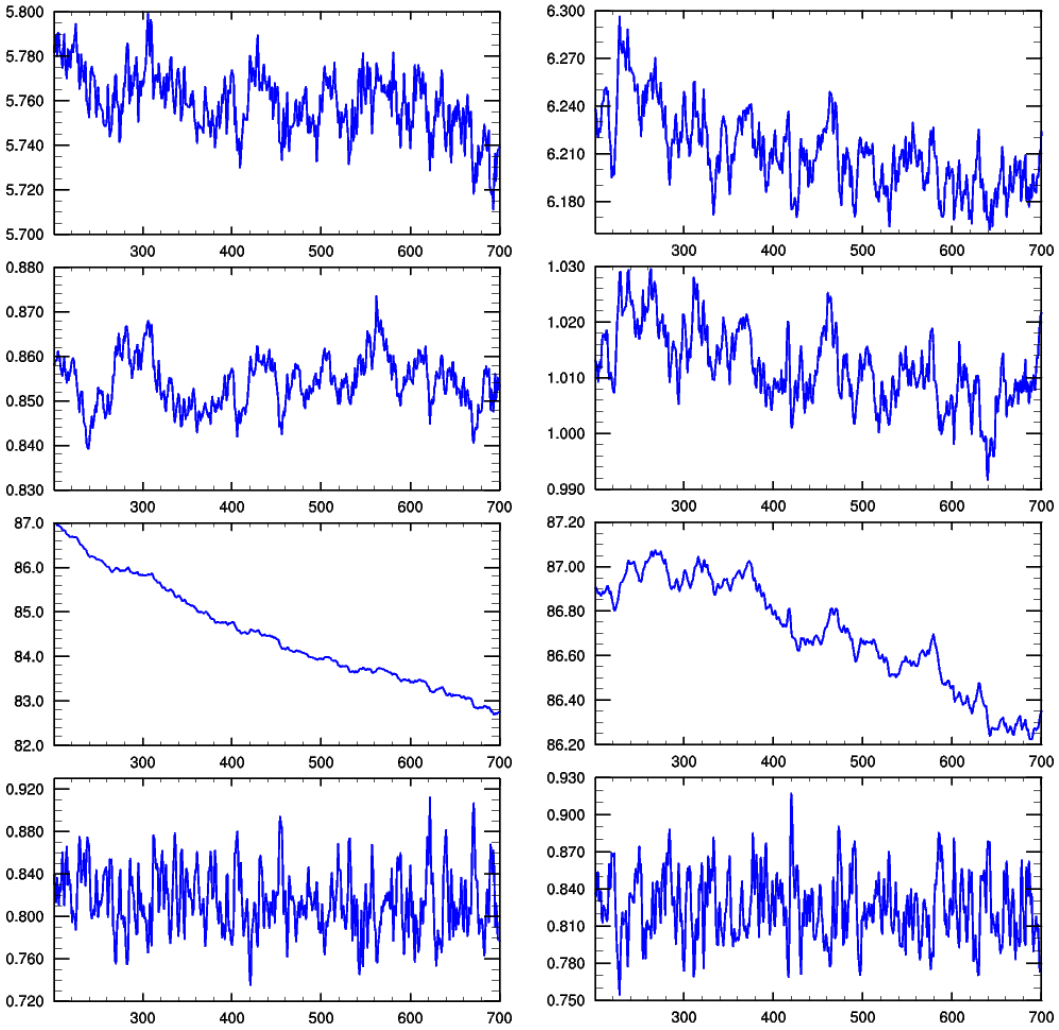
Soil carbon (estimates)

1500 - 2400 PgC (Batjes, 1996)

World soil data base:
1260 PgC (Range: 890-1660 PgC)

Model estimates (11 CMIP5 models):
510 - 3040 PgC (Todd-Brown et al., 2013)

Nitrogen pools [PgN]



Left: prescribed LAI
Right: prognostic LAI

Top to bottom: plant pool, litter pool, organic soil pool, mineral soil pool

Terrestrial biomass (estimates)

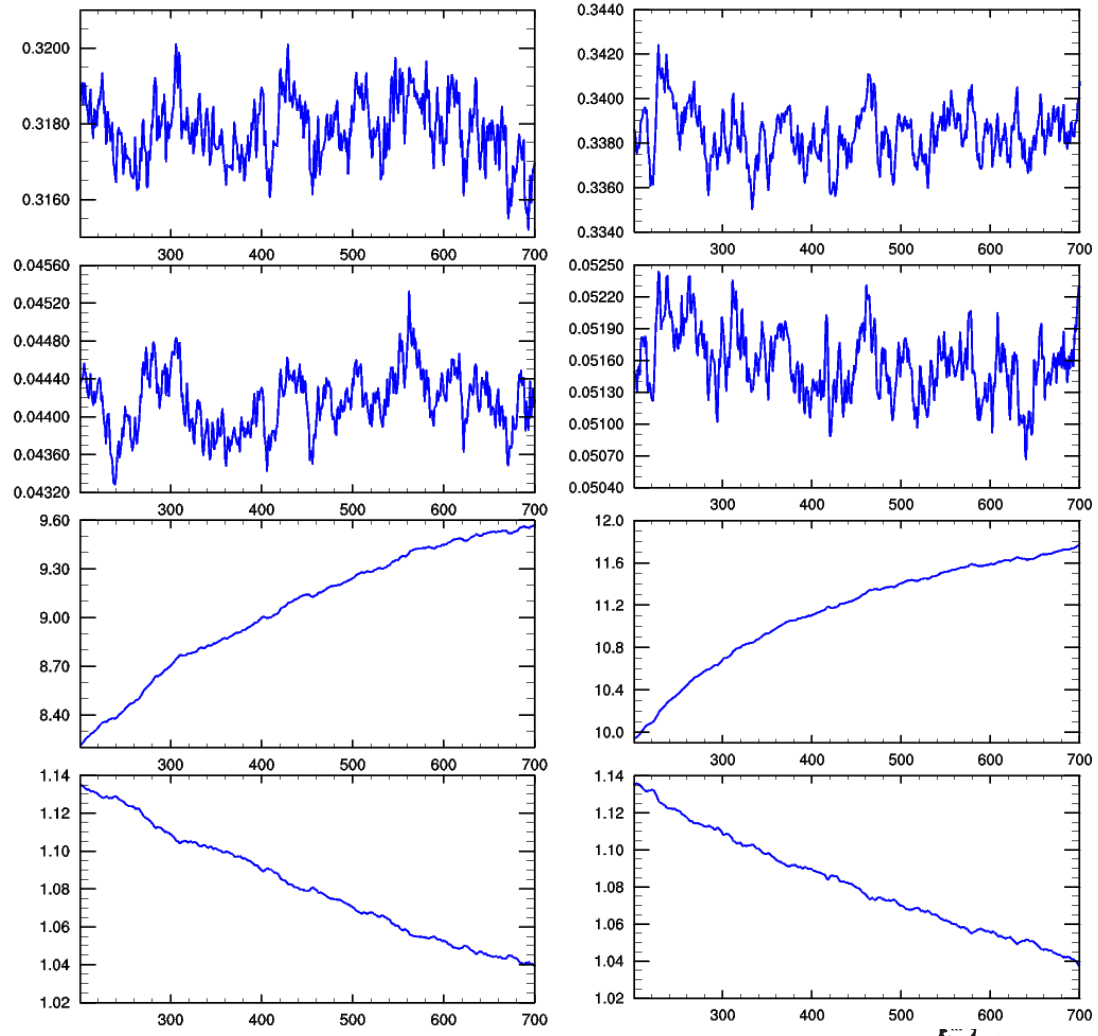
5.6 PgN(Xu-ri and Prentice, 2008) plant
3.1 PgN (Gerber et al., 2010) plant
3.8 PgN (Zaehle et al., 2010) plant

Soil nitrogen (estimates)

100 PgN (Post et al., 1985) organic
156 PgN (Batjes, 1996) organic
67 PgN (Xu-ri and Prentice, 2008) organic

0.9 PgN (Xu-ri and Prentice, 2008) mineral

Phosphorus pools [PgP]



Left: prescribed LAI
Right: prognostic LAI

Top to bottom: plant pool, litter pool, organic soil pool, labile soil pool

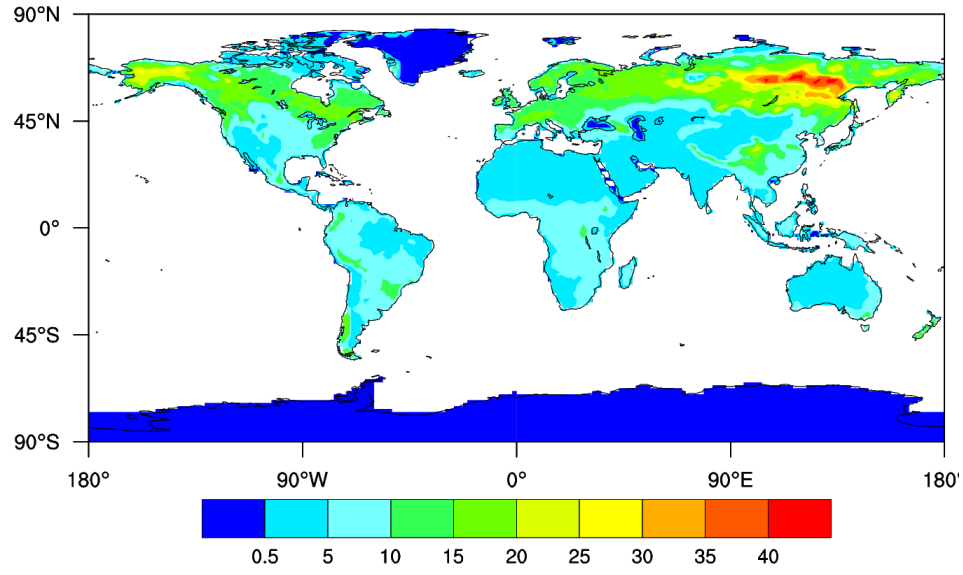
Terrestrial biomass (estimates)

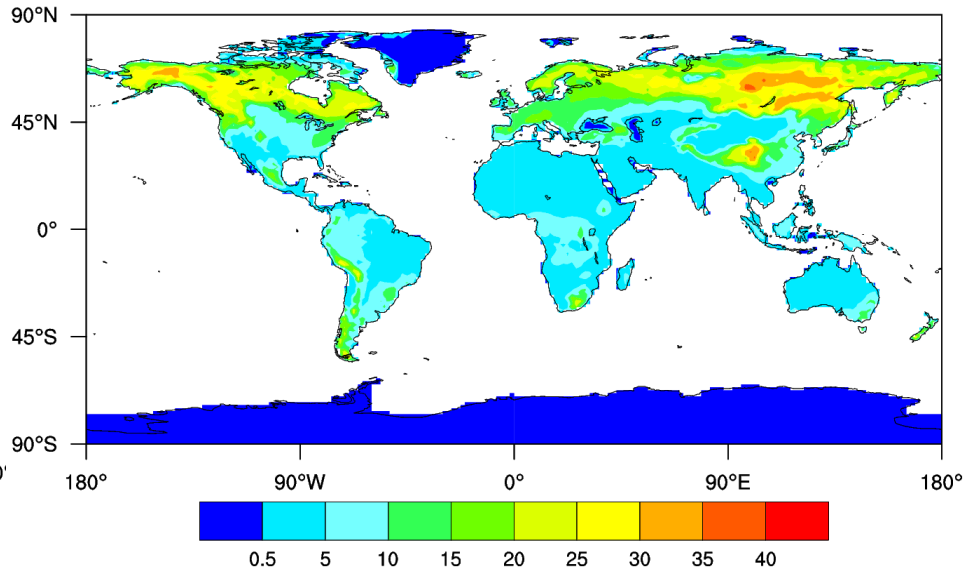
0.5 – 3 PgP (Jahnke, 1992; Smil, 2000) plant

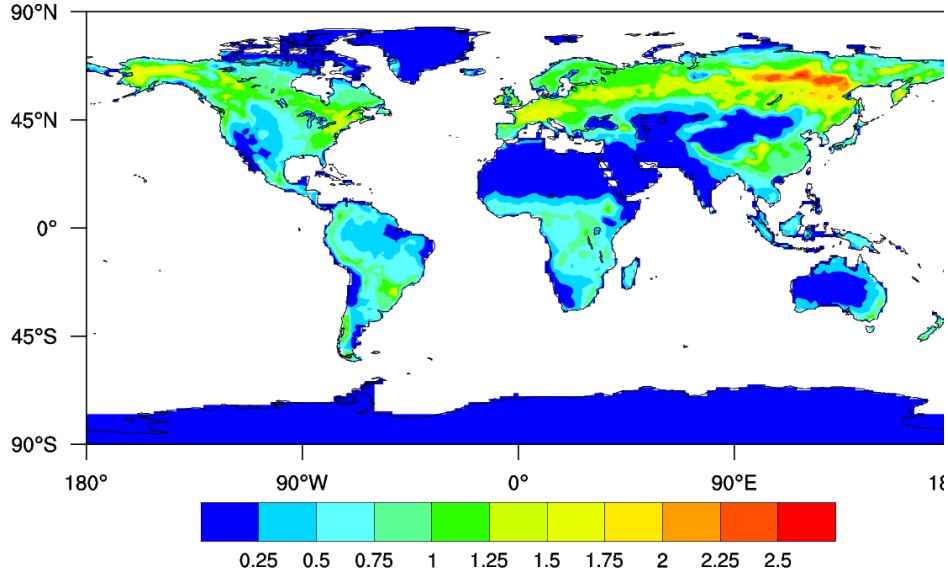
Soil phosphorus (estimates)

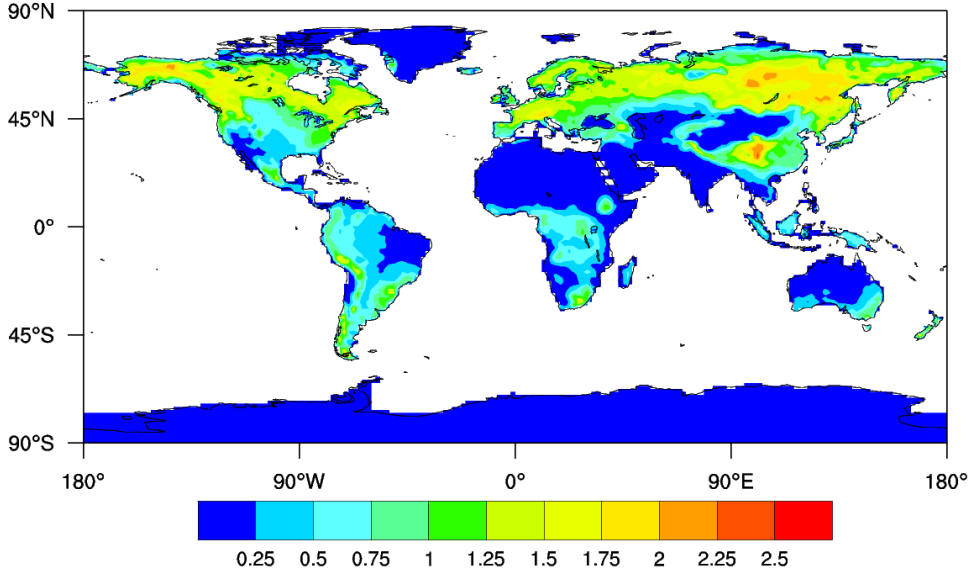
5 – 10 PgP (Smil,2000) organic
5 PgP (Mackenzie et al., 2002) organic

Distribution of soil carbon/nitrogen [kg/m2]







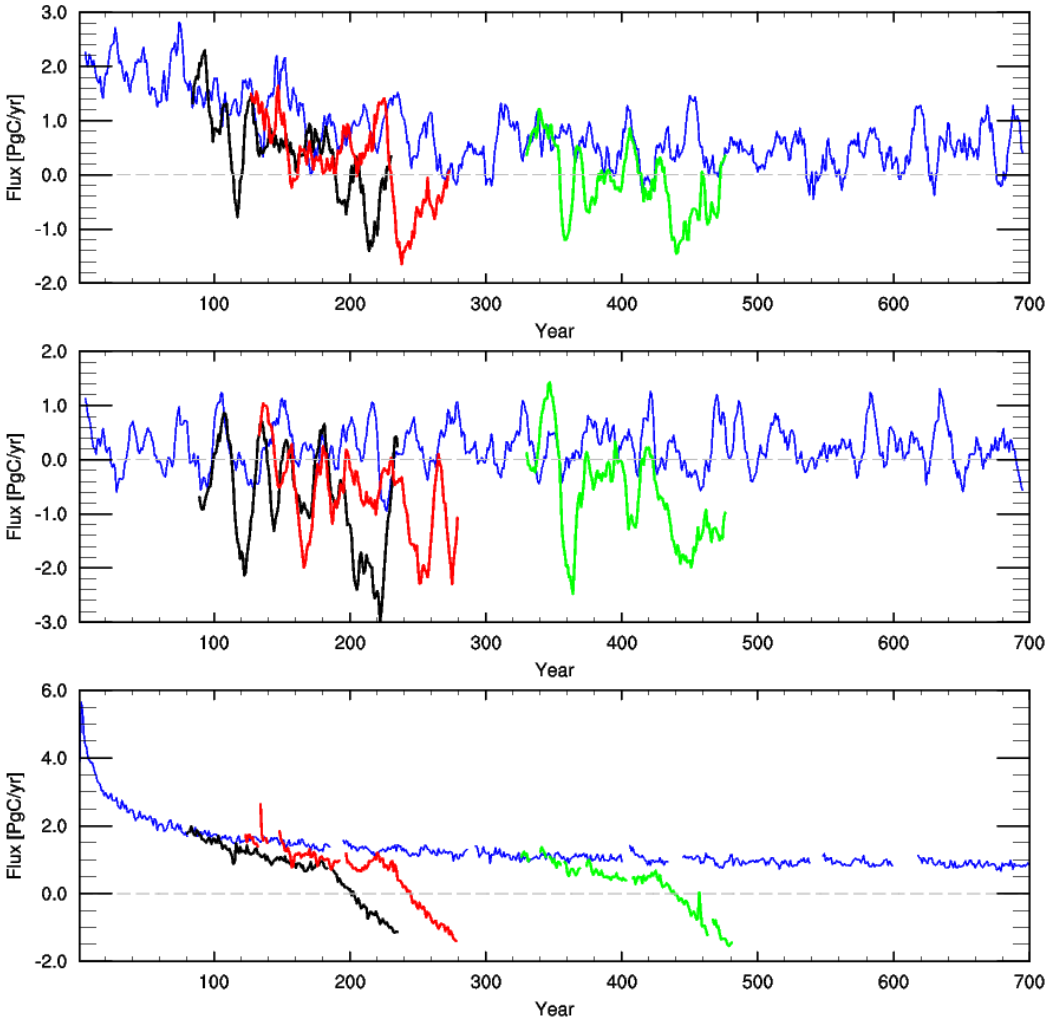


Left: prescribed LAI; **Right:** prognostic LAI

Historical and RCP runs overview

- Historical simulations (1850-2005)
  - Currently 3 realizations, start at 80, 120 and 325 yrs into the control run
- Future projections (2006-2100)
  - RCP4.5 and RCP8.5, continuing the historical run (325 yrs into the control run)
- 2 scenarios: carbon cycle with prescribed LAI and carbon cycle with prognostic LAI (LAI feedback)

Land and ocean tracer flux (1850-2005)



Top: land tracer flux 10yr mean, prescribed LAI (approx. 100 PgC uptake)

Middle: land tracer flux 10yr mean, prognostic LAI (approx. 135 PgC uptake)

Bottom: ocean tracer flux (approx. 130 PgC uptake)

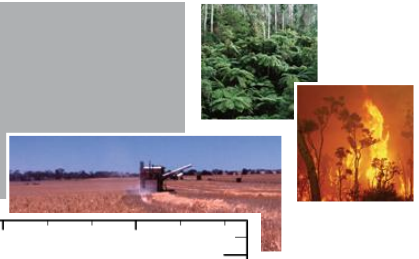
Blue: control run

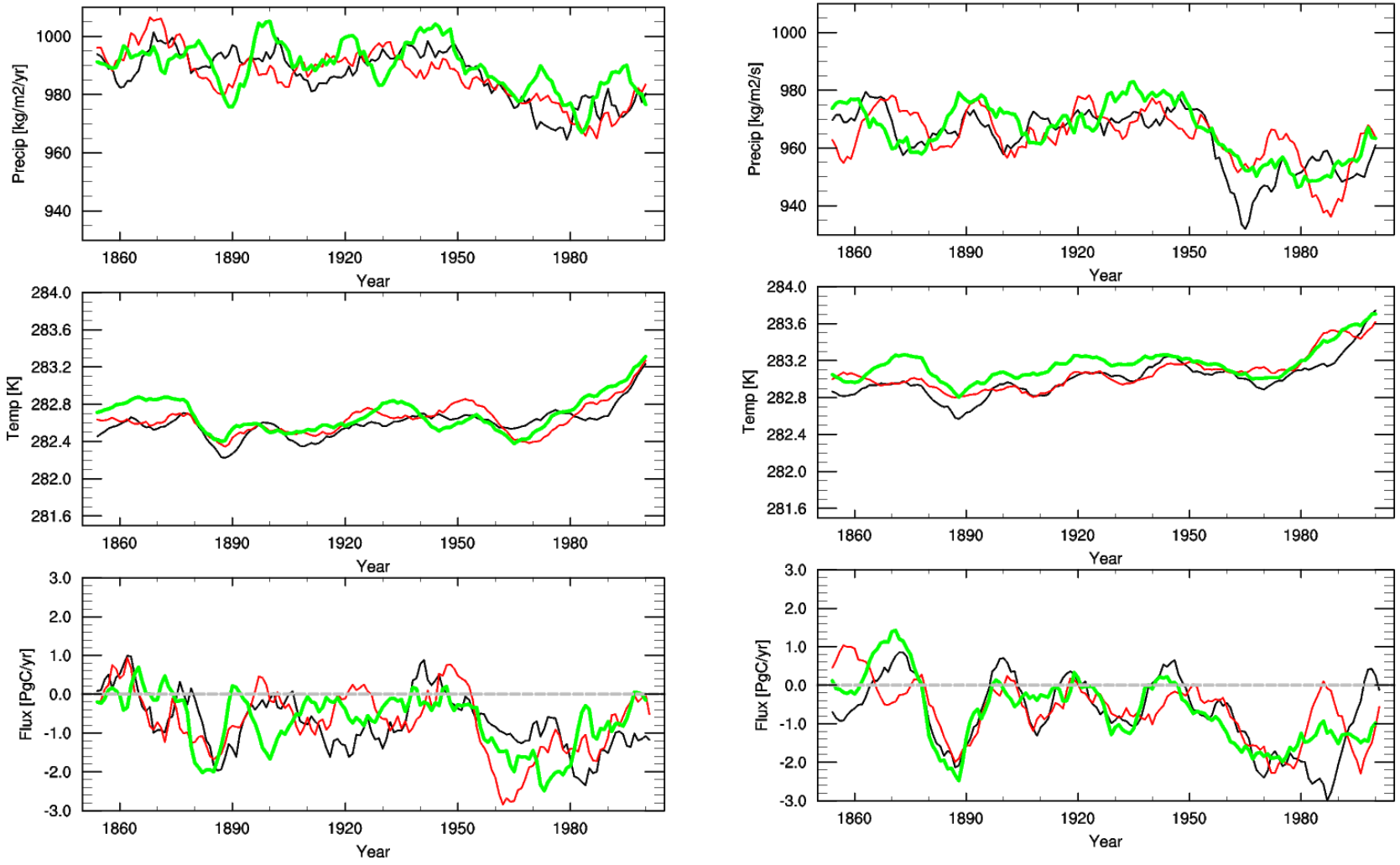
Black: historical at 80yrs

Red: historical at 120yrs

Green: historical at 325yrs

Land net carbon flux (1850-2005)





Left: prescribed LAI; **Right:** prognostic LAI
Start at 80yrs (black), 120yrs (red), 325yrs (red)

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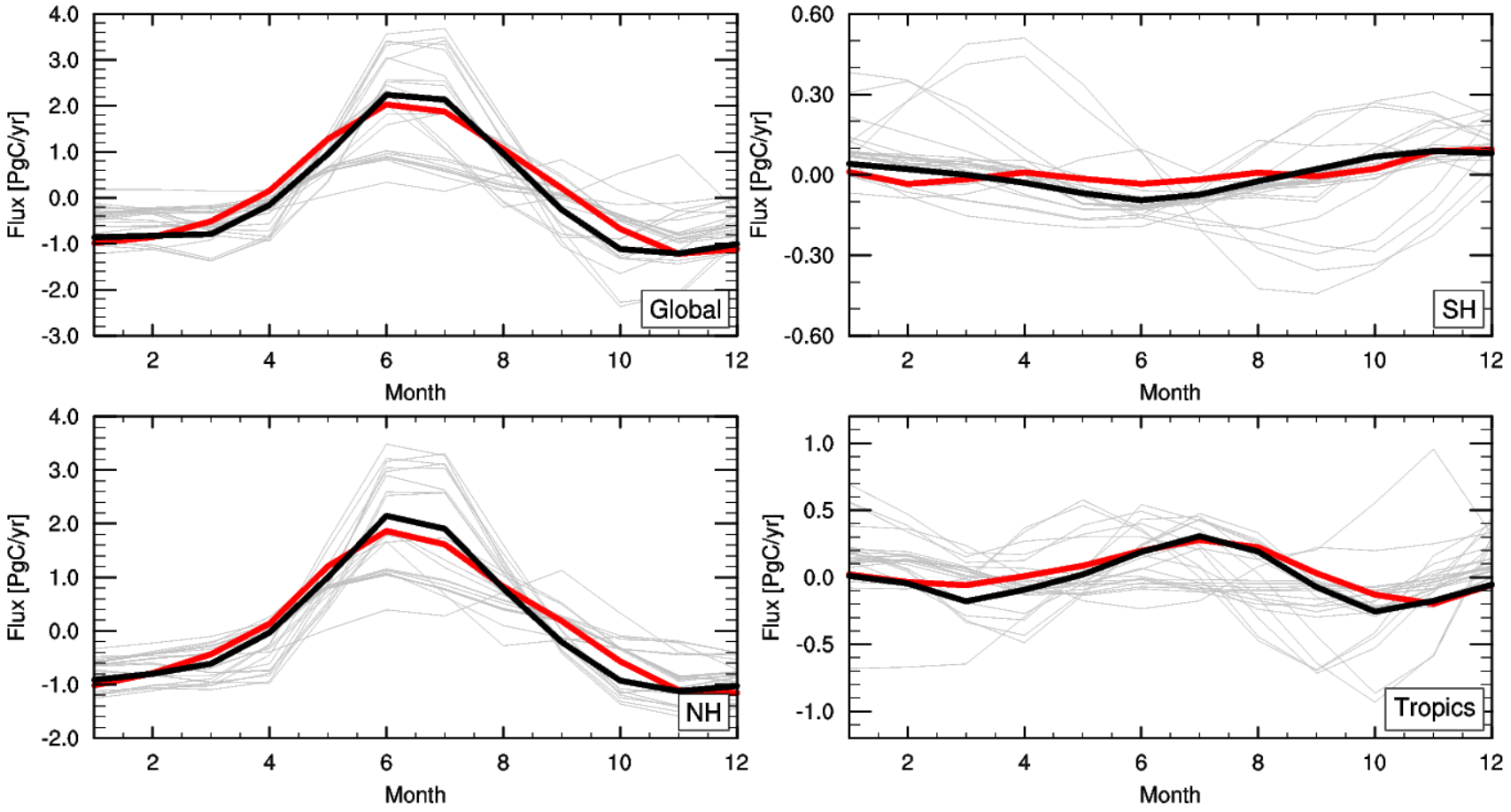
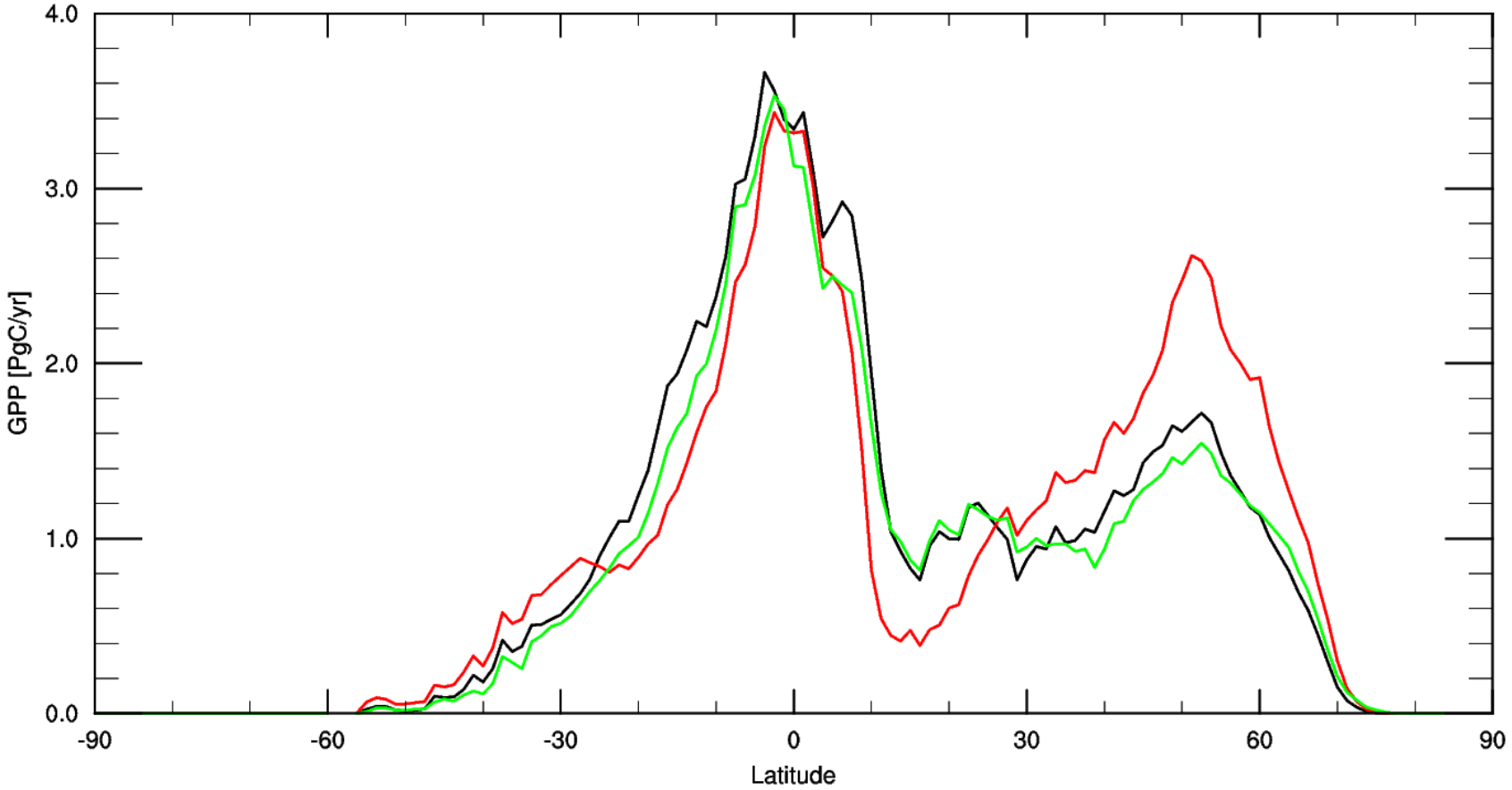
Mean seasonal cycle NEP (1986-2005)



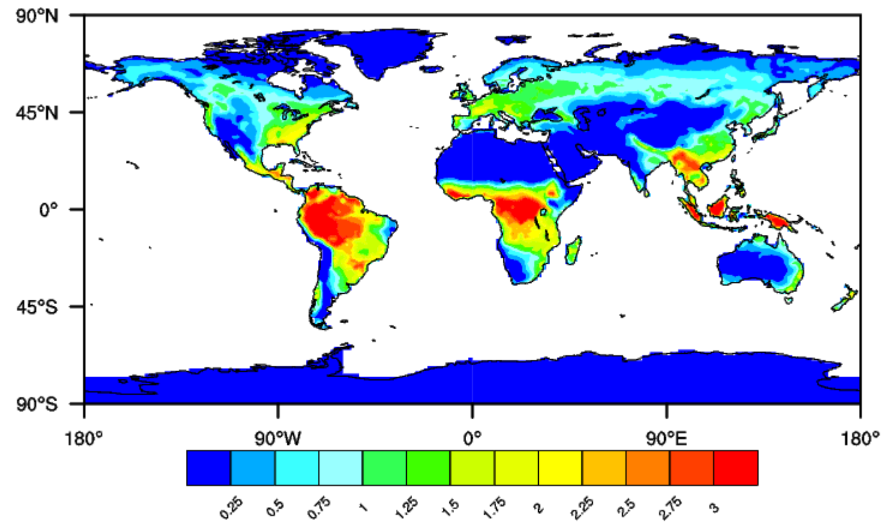
Black: prescribed LAI; **Red:** prognostic LAI; **Gray:** CMIP5 models

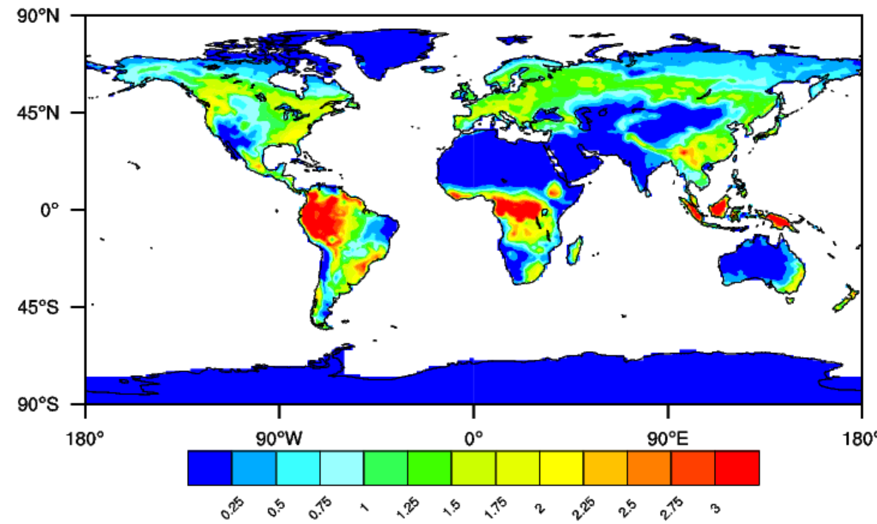
GPP – zonal mean (1986-2005)

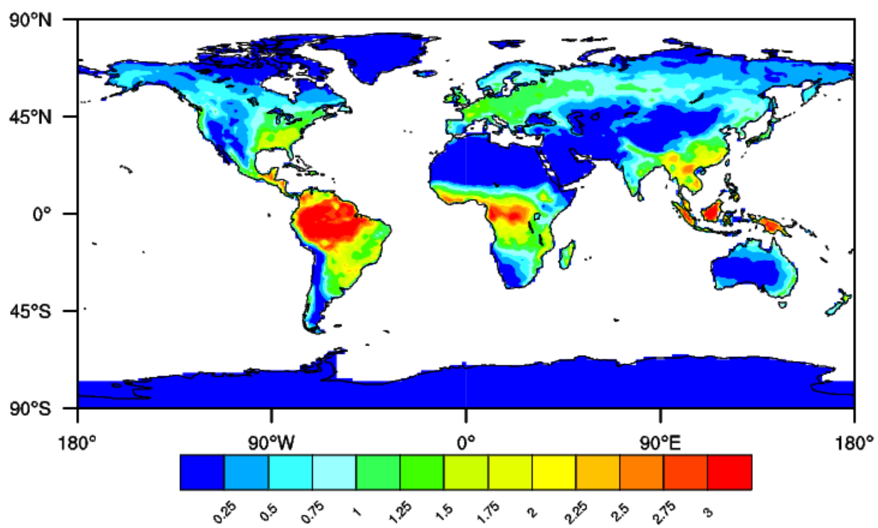


Black: pres LAI (128 PgC/yr); **Red:** prog LAI (130 PgC/yr); **Green:** observations (119 PgC/yr)

GPP – spatial pattern (1986-2005)





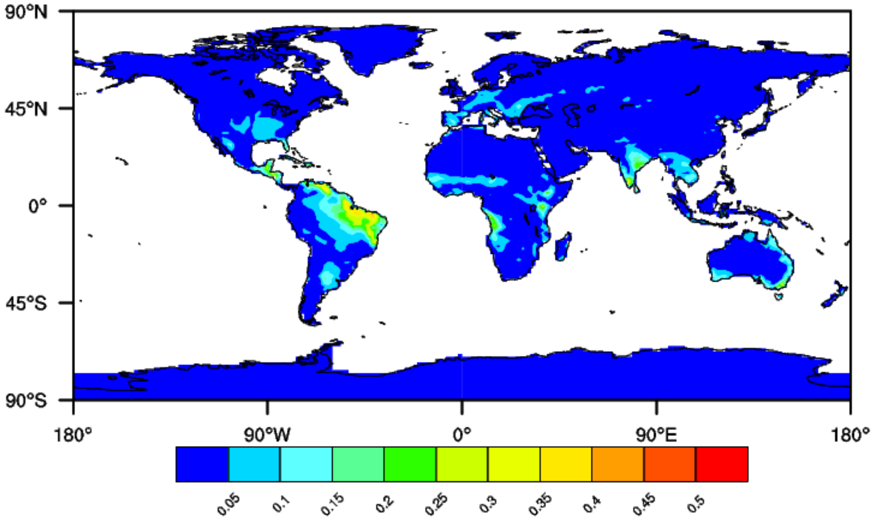


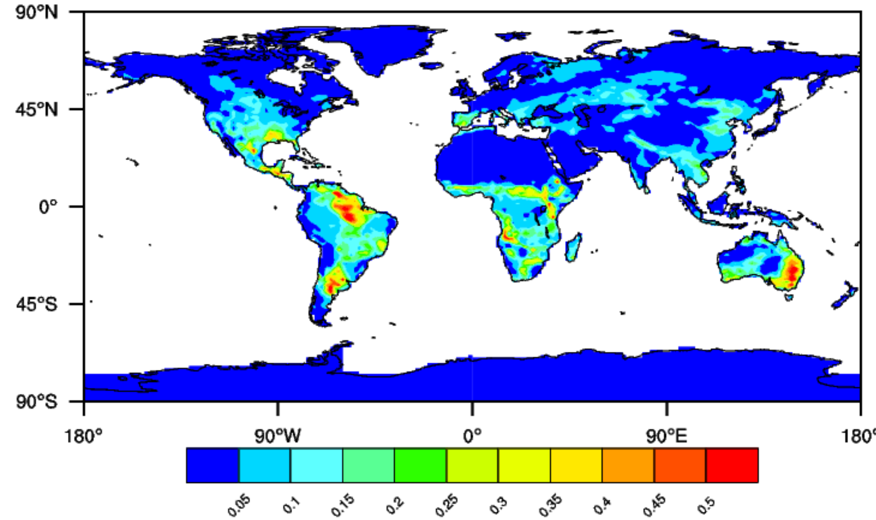
Top left: prescribed LAI

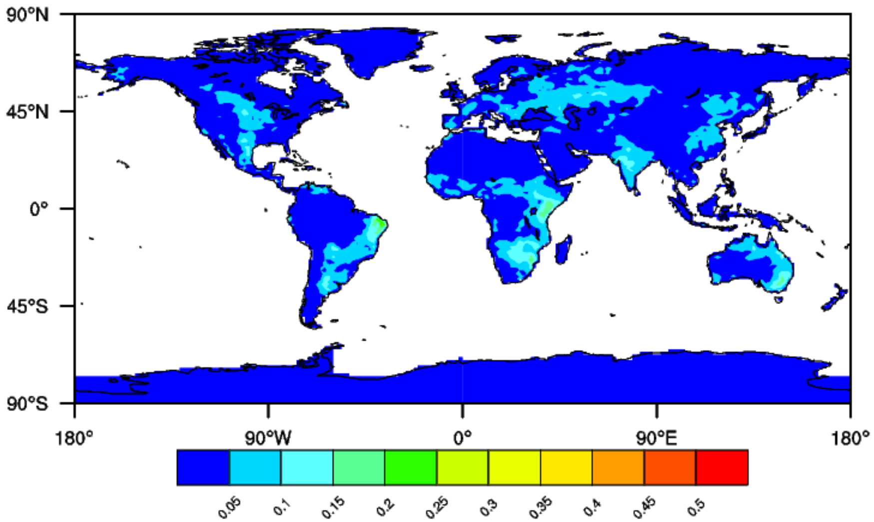
Top right: prognostic LAI

Bottom left: observations (FLUXNET multi tree ensemble Jung et al. 2010)

GPP – inter annual variability (1986-2005)





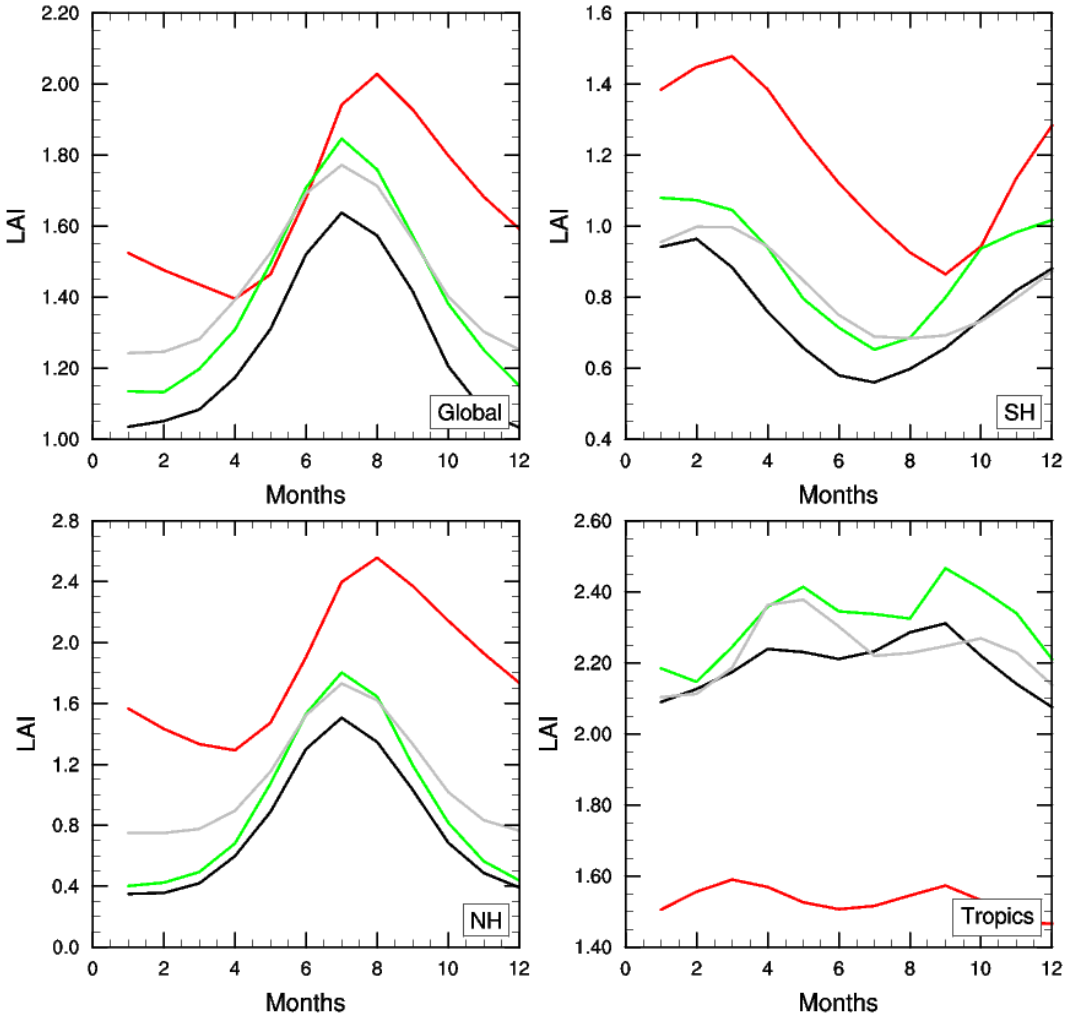


Top left: prescribed LAI

Top right: prognostic LAI

Bottom left: observations

LAI mean seasonal cycle (1986-2005)



Black: prescribed LAI

Red: prognostic LAI

Green: observations (AVHRR)

Gray: observations (MODIS year 2000 only)

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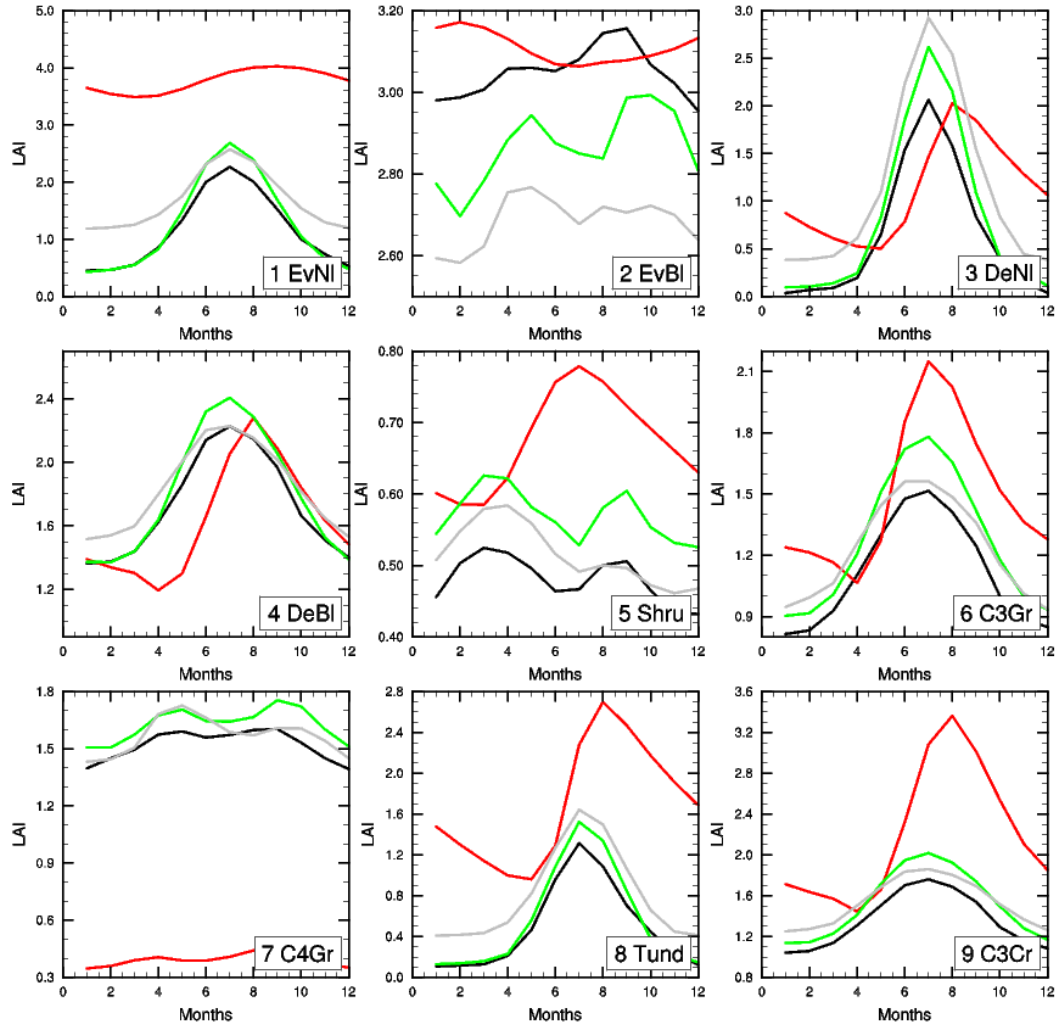
LAI per PFT (1986-2005)



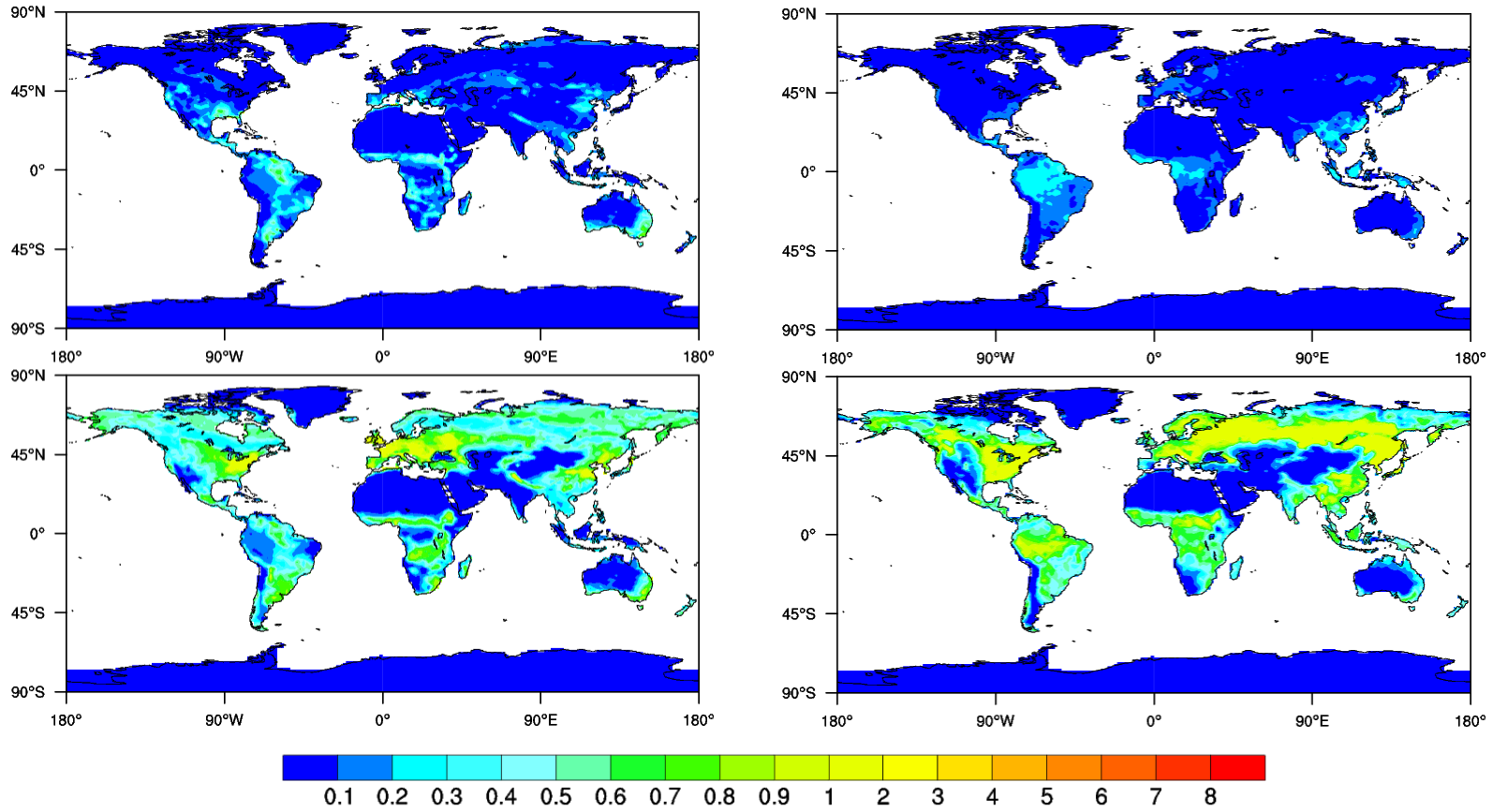
Black: prescribed LAI

Red: prognostic LAI

Green: observations (AVHRR)

Gray: observations (MODIS year 2000 only)

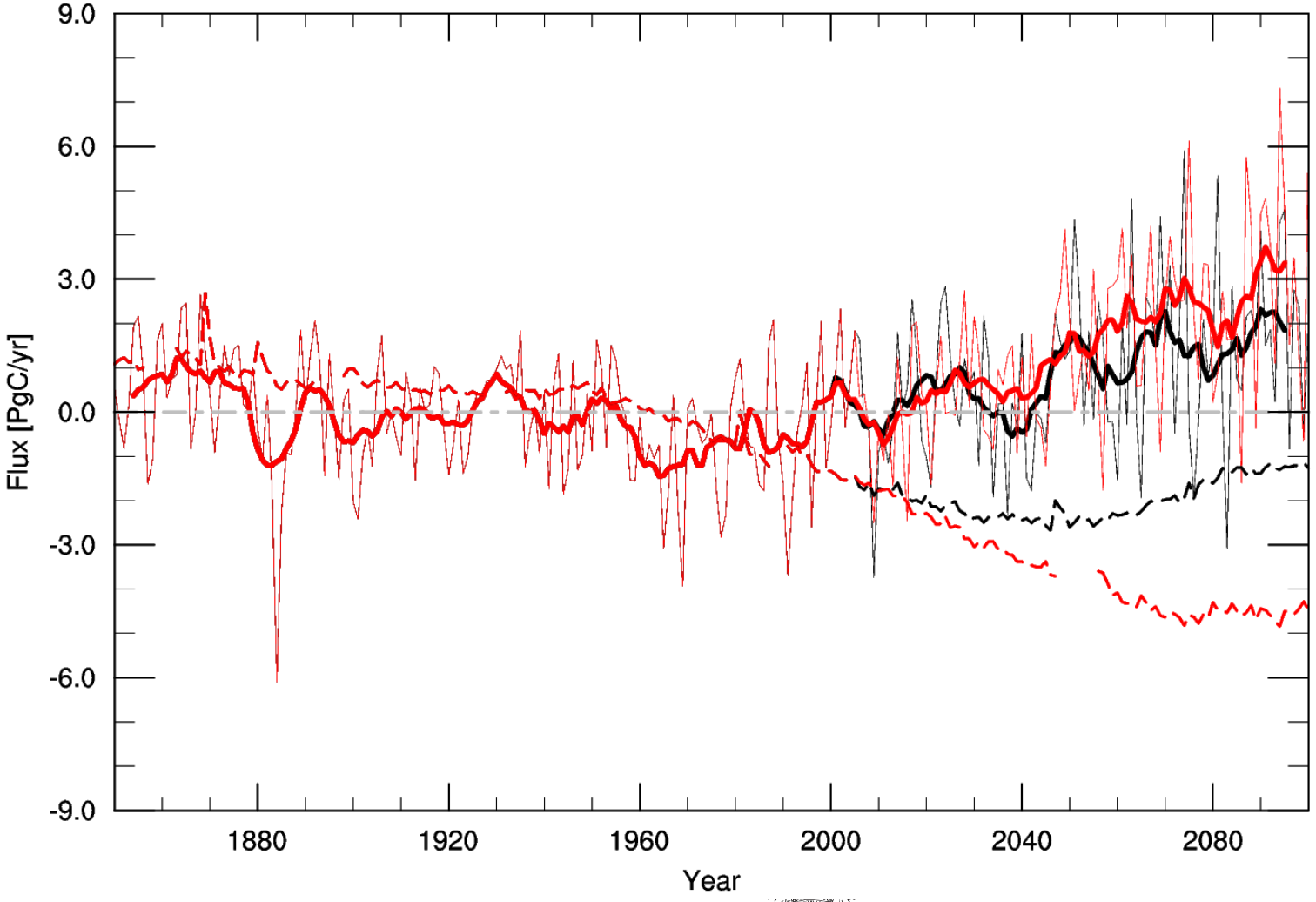
LAI inter annual variability (1986-2005)



Left: prog LAI; **Right:** AVHRR; **Top:** inter annual var; **Bottom:** seasonal + inter annual var

Future scenarios (RCP4.5 and RCP8.5)

Prescribed LAI



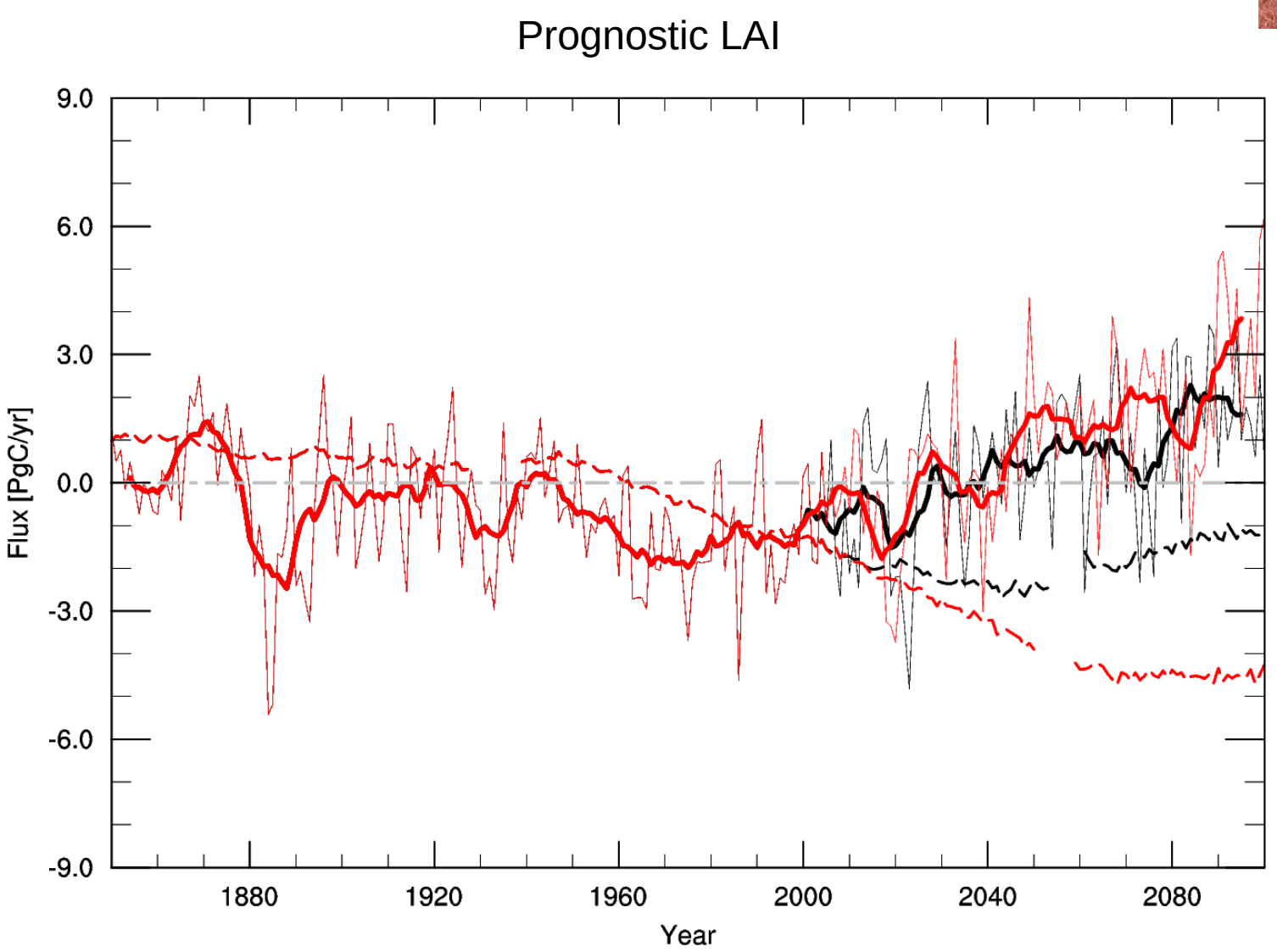
Black: RCP4.5

Red: RCP8.5

Solid: land

Dashed: ocean

Future scenarios (RCP4.5 and RCP8.5)



Black: RCP4.5

Red: RCP8.5

Solid: land

Dashed: ocean

Future work

- Continue pre-industrial control run
- Small ensemble of historical and RCP runs (for prognostic LAI)
- Model description paper
- Paper on historical simulation
- Set-up and run emission driven simulation (interactive CO_2)

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