



Uncertainties associated to the land carbon balance; comparison between ORCHIDEE and CTESSEL

Philippe Peylin, Vladislav Bastrikov, **Nicolas Vuichard**,
Palmira Messina, Devaraju Narayanappa
& the ORCHIDEE project team

Laboratoire des Sciences du Climat et de l'Environnement
CEA/CNRS/UVSQ, IPSL, France

Challenges

- To provide **uncertainty estimates** and bias correction **for the main input drivers** of the carbon re-analysis; eg. the land cover changes
- To provide **uncertainties of carbon fluxes and reservoirs through propagation of errors** associated with the input drivers
- To provide **comparison of gross and net carbon fluxes modelled by ORCHIDEE and CTESSEL models**
- *Associated Deliverables*
 - *D4.13 : Confidence intervals on net and gross carbon fluxes through the surface as well as above and below ground carbon reservoirs for major ecosystems*
 - *D4.14 : Comparison of CTESSEL and ORCHIDEE carbon flux estimates in the satellite period*

Land carbon cycle uncertainties from:

Forcing error

- Land Use Change scenarios
 - Meteo. forcing
 - Soil property uncertainties
- Test different scenarios From LCC & different Meteo forcing

Model parameter error

- Parametric equations with Uncertain parameters (photosynthesis, respiration C allocation,...)
- Test different parameter setting and model versions

Model structure error

- Missing processes
 - Wrong process representation
- Comparison between ORCHIDEE / CTESSEL and other models & approaches

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Land-use harmonization

- LUh2: an harmonized set of land-use scenarios that connects the historical reconstructions of land-use with the future projections
 - land-use transitions
 - annually for the time period 850-2100
 - at 0.25 x 0.25 resolution

Non forested Primary land	Forested Primary Land			
Secondary land forested	Managed Pasture land	Rangeland		
Non forested Secondary land	Urban land	C3 Annual Crop	C4 Annual crop	C3 Nitrogen fixing crop
		C3 Perennial Crop	C4 Perennial crop	

⇒ ***Land-use categories in LUh2***

ESA-CCI land cover product

- Global product
- 19 types of land categories
- At high resolution (~100m)

ESA-CCI Land Cover

↓ *Defines PFT present in each grid cell*

ORCHIDEE PFT's

Tropical Evergreen Forest

Needleleaf Evergreen Forest

....

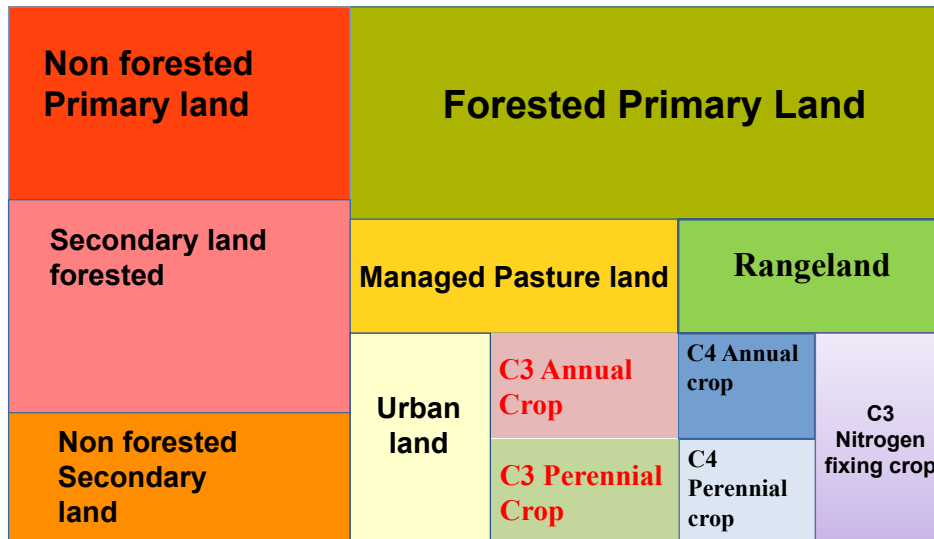
Broadleaf Deciduous Forest

C3 Cropland

C4 Cropland

C3 Grassland

C4 Grassland

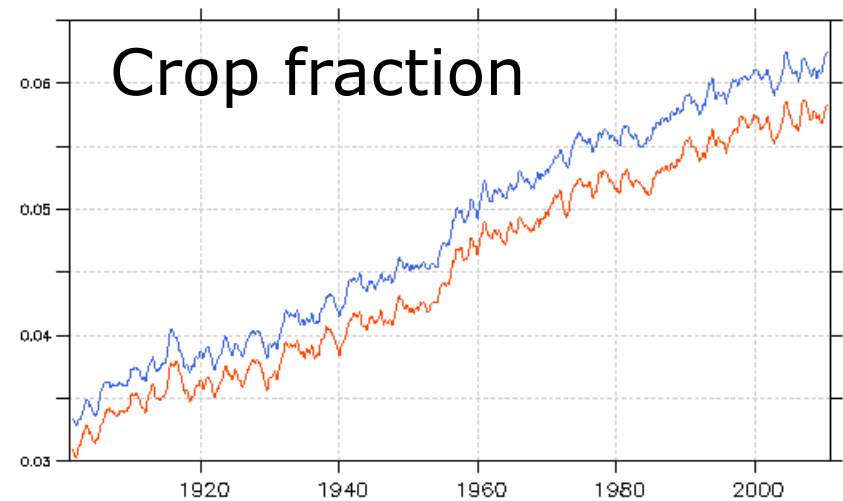
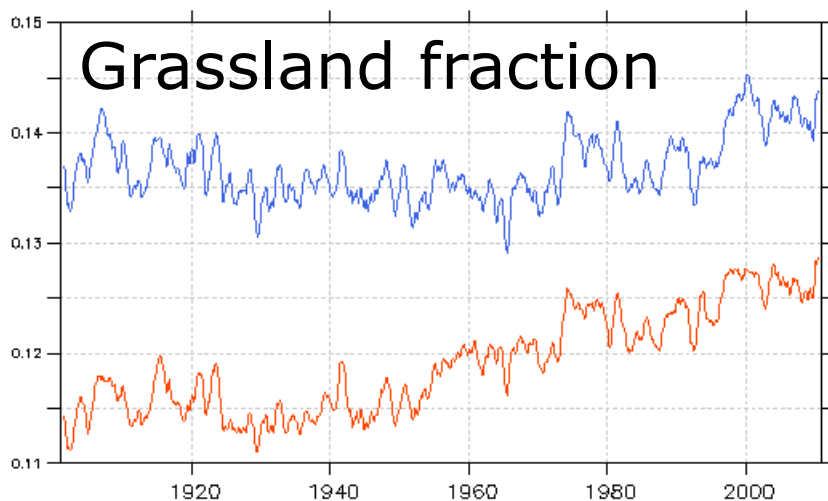
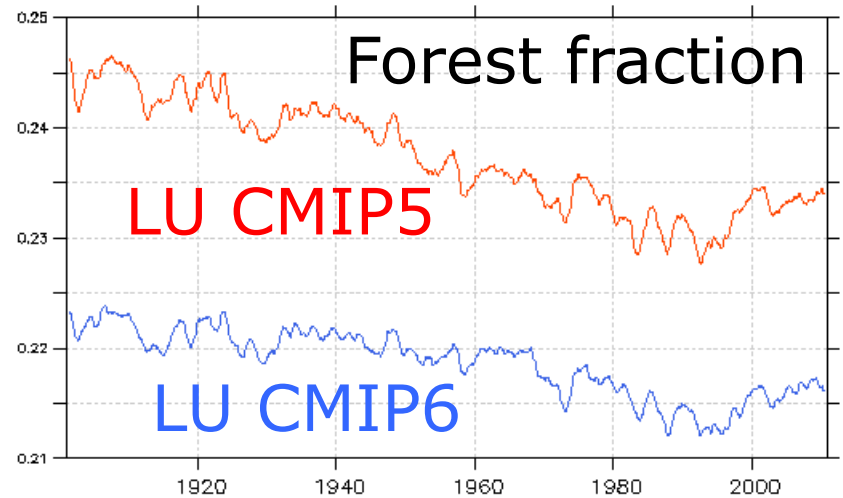


Land-use datasets

		Land-cover datasets	
		Holson	ESA-CCI
Land-use scenarios	LUH1	CMIP5	
	LUH2		CMIP6

LU CMIP6 vs. LU CMIP5

- Similar trends over the 20th century
- Less forest area, more grassland area



Meteorological forcings

- CRUNCEP forcing
 - Covers the 20th century
 - Based on NCEP reanalysis
 - CRU climatology for bias correcting temperature, precipitation,
 - 6-hourly resolution, 0.5 degree
- GSWP3 forcing
 - From the Global Soil Wetness Project
 - Covers the 20th century
 - Based on a dynamical downscaling of 20CR
 - Bias corrected using GPCC data for precipitation and CRU temperature
 - 3-hourly resolution, 0.5 degree

Land carbon cycle uncertainties from:

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Model parameter error

- **Parametric equations with Uncertain parameters (photosynthesis, respiration C allocation,...)**
- Test different parameter setting and model versions

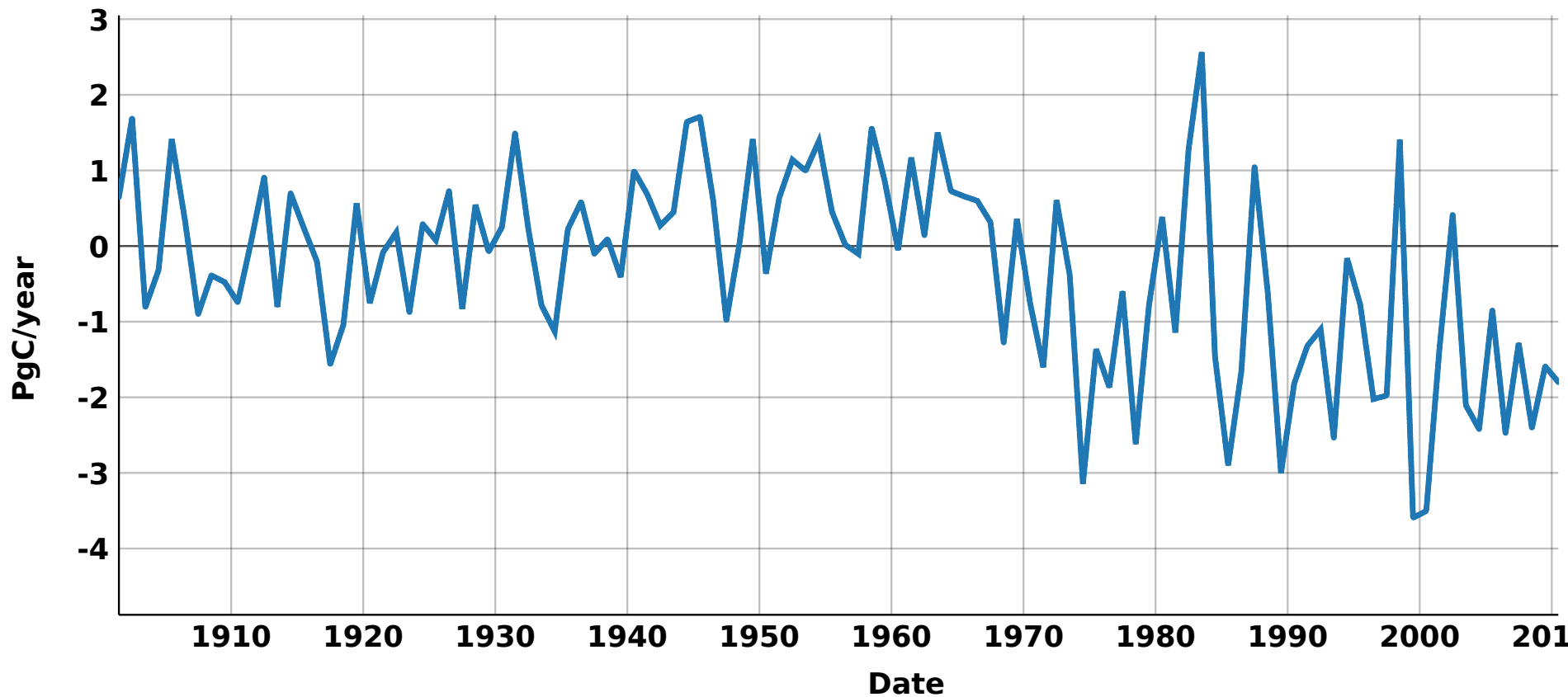
Model structure error

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Model versions

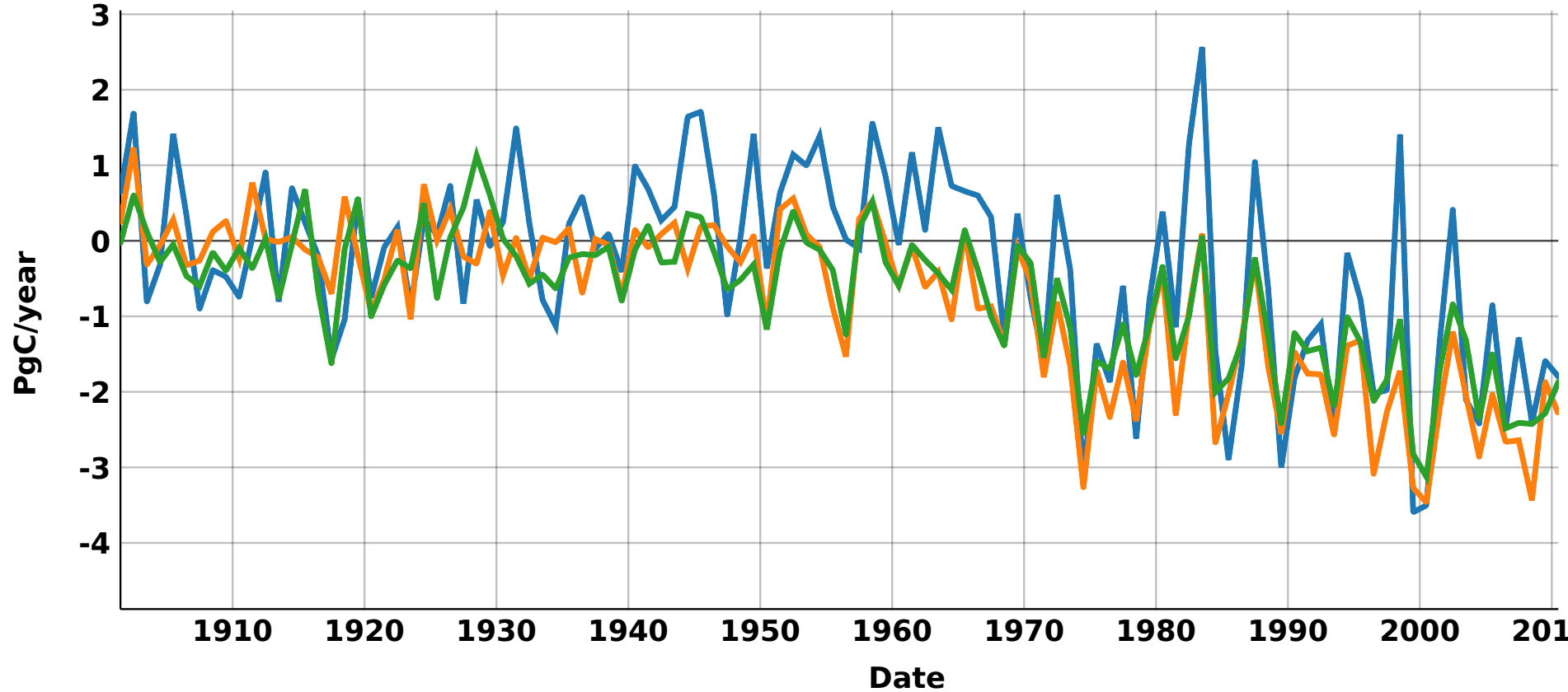
- Revision 3977 – Release Jan 2017 = ORCv1
- Revision 4783 – Release Nov 2017 = ORCv2
 - Optimisation of the parameters driving C assimilation and autotrophic respiration
⇒ Improved seasonal variations and long-term trend of atmospheric CO₂ concentration @ stations
 - Development in order to reduce the model sensitivity to precipitation drop in Amazonia in early 2000's

Net CO₂ flux – Meteorological forcings



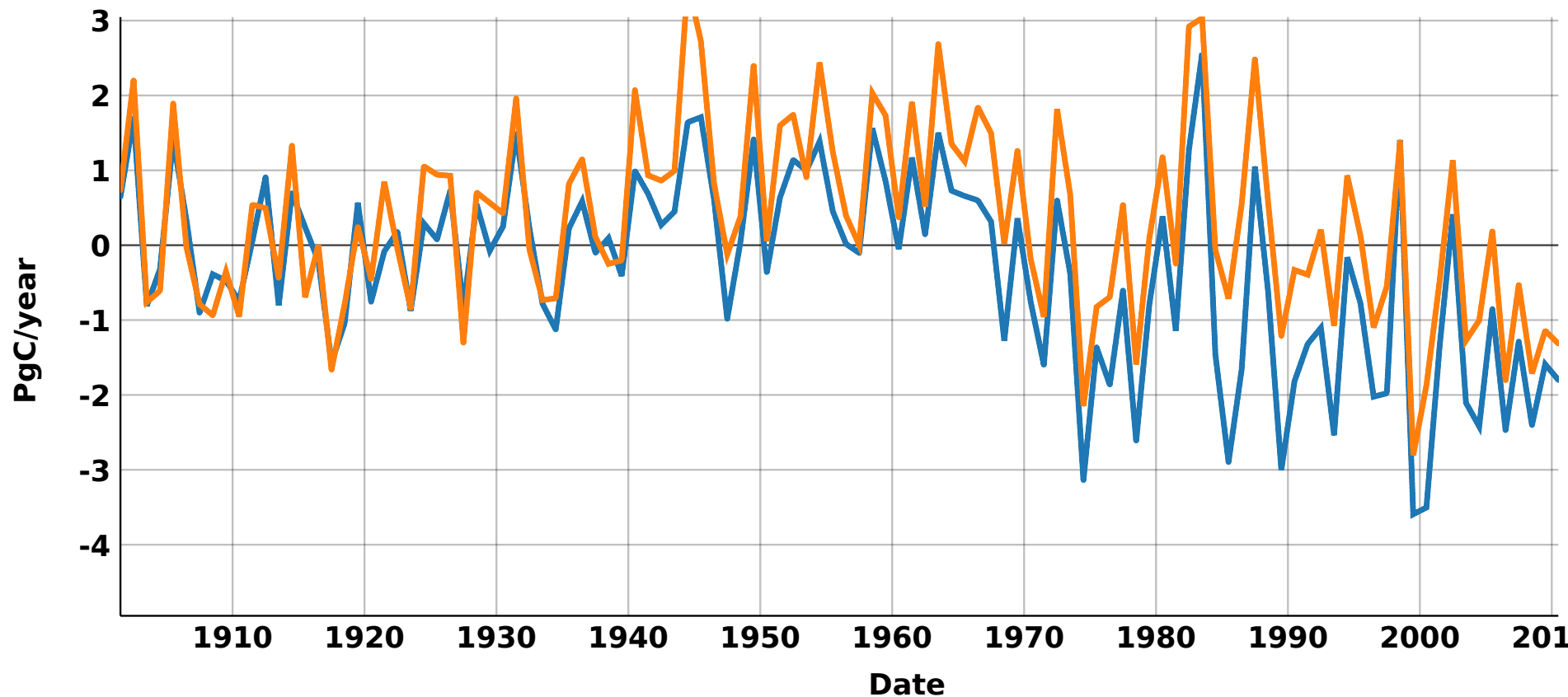
CERA20C

Net CO₂ flux – Meteorological forcings



CERA20C
CRUNCEP
GSWP3

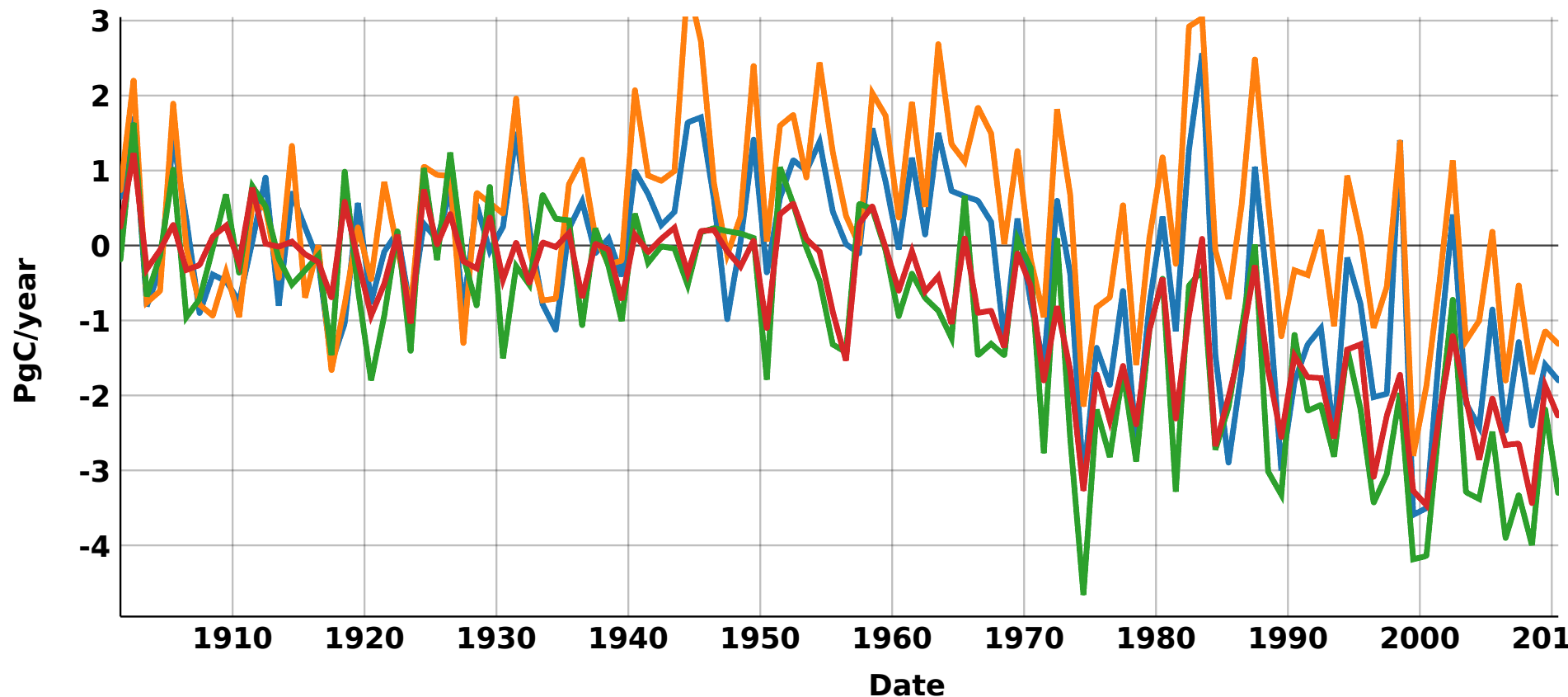
Net CO₂ flux – Different versions



ORCv2-CERA20C

ORCv1-CERA20C

Net CO₂ flux – Different versions



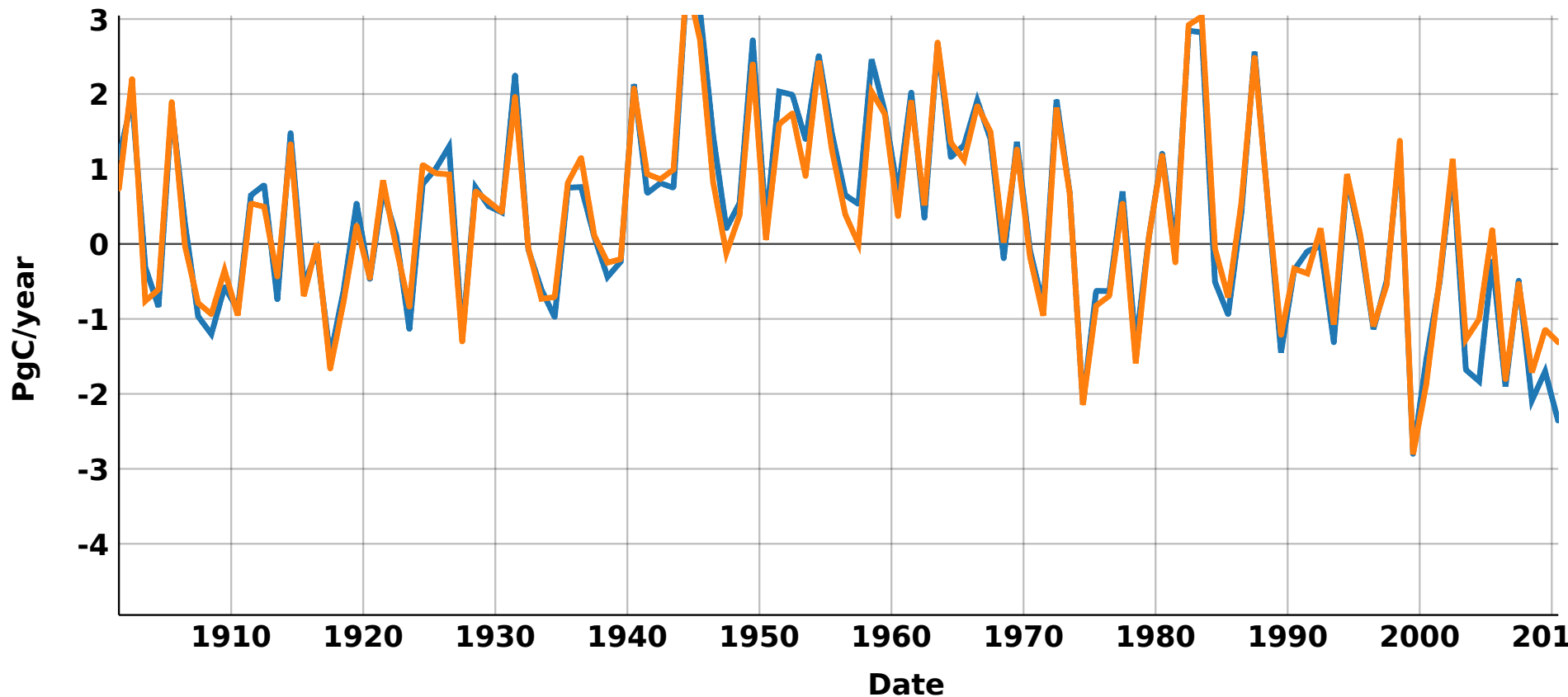
ORCv2-CRUNCEP

ORCv1-CRUNCEP

ORCv2-CERA20C

ORCv1-CERA20C

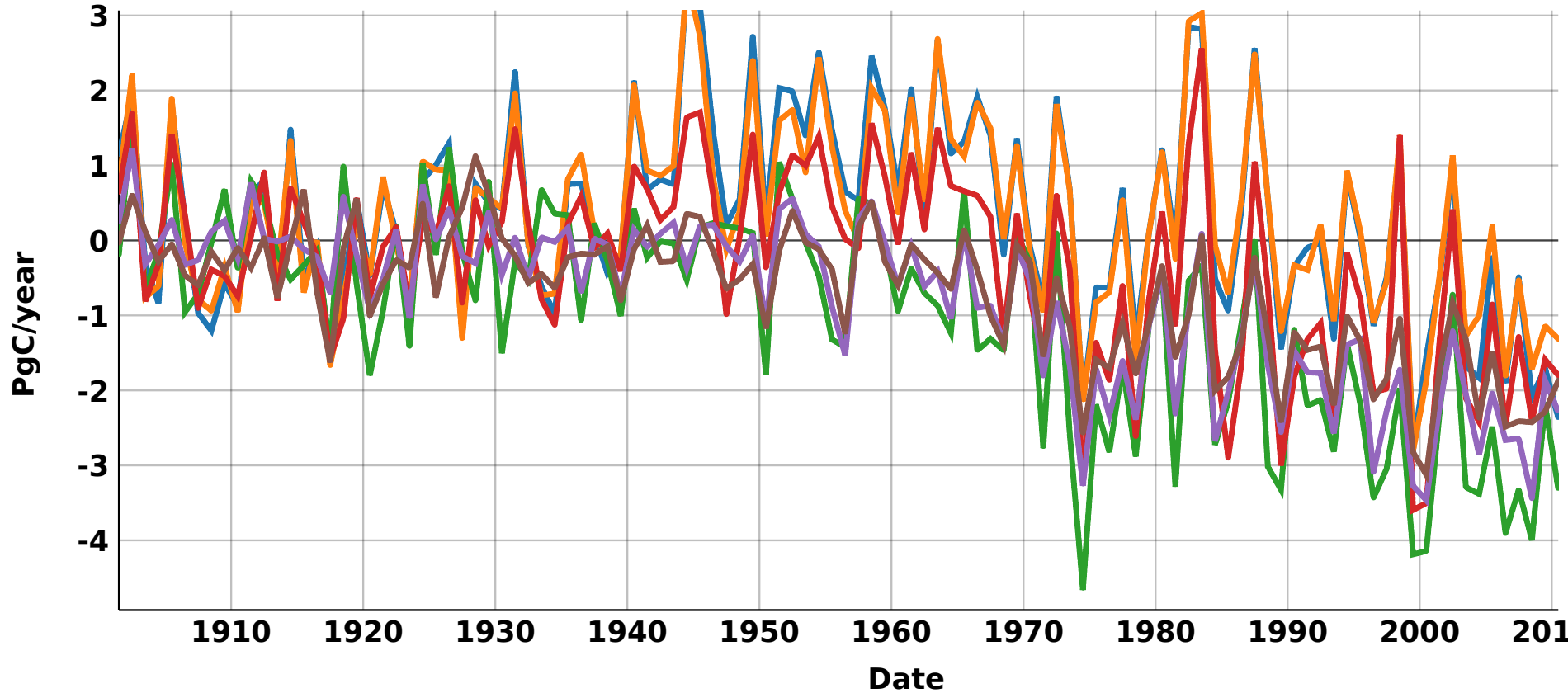
Net CO₂ flux – Different Land-use maps



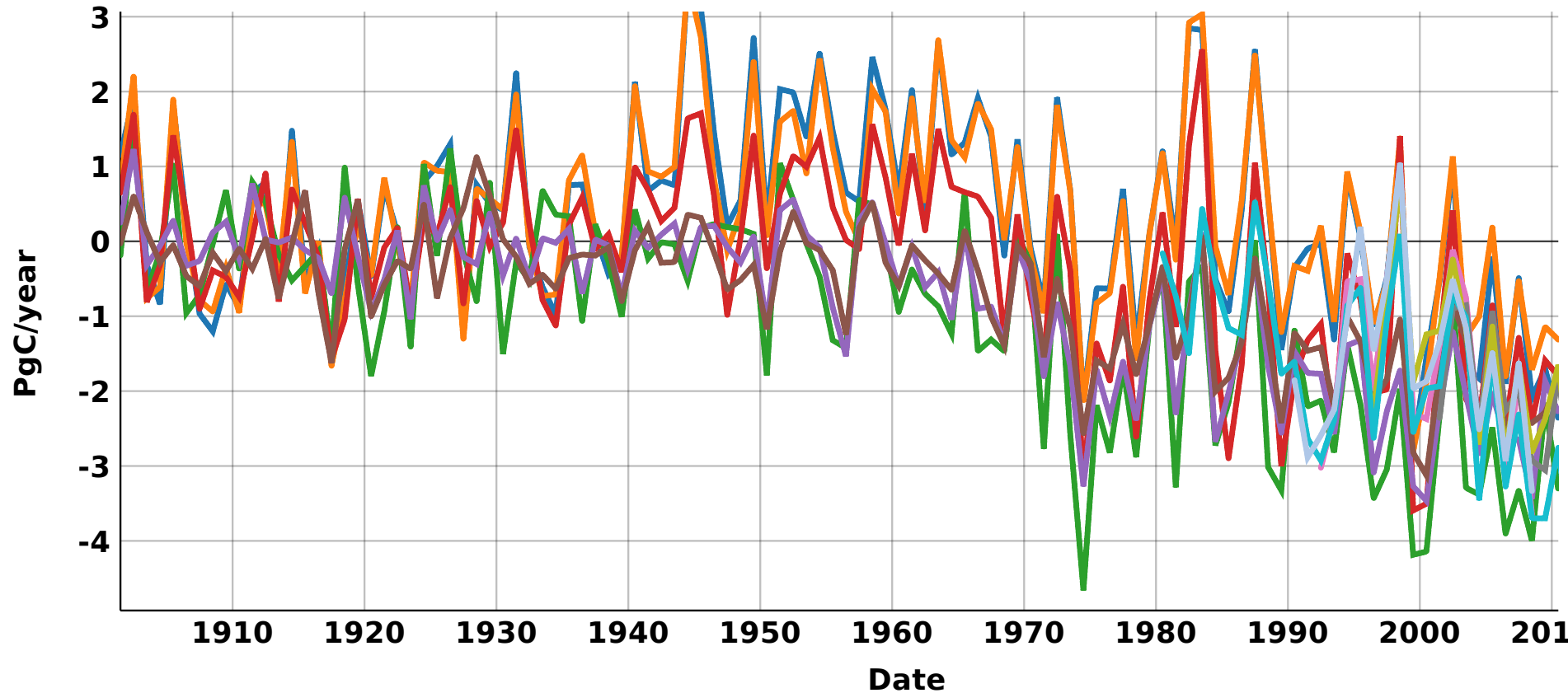
ORCv1-CMIP6

ORCv1-CMIP5

Net CO₂ flux – All uncertainties

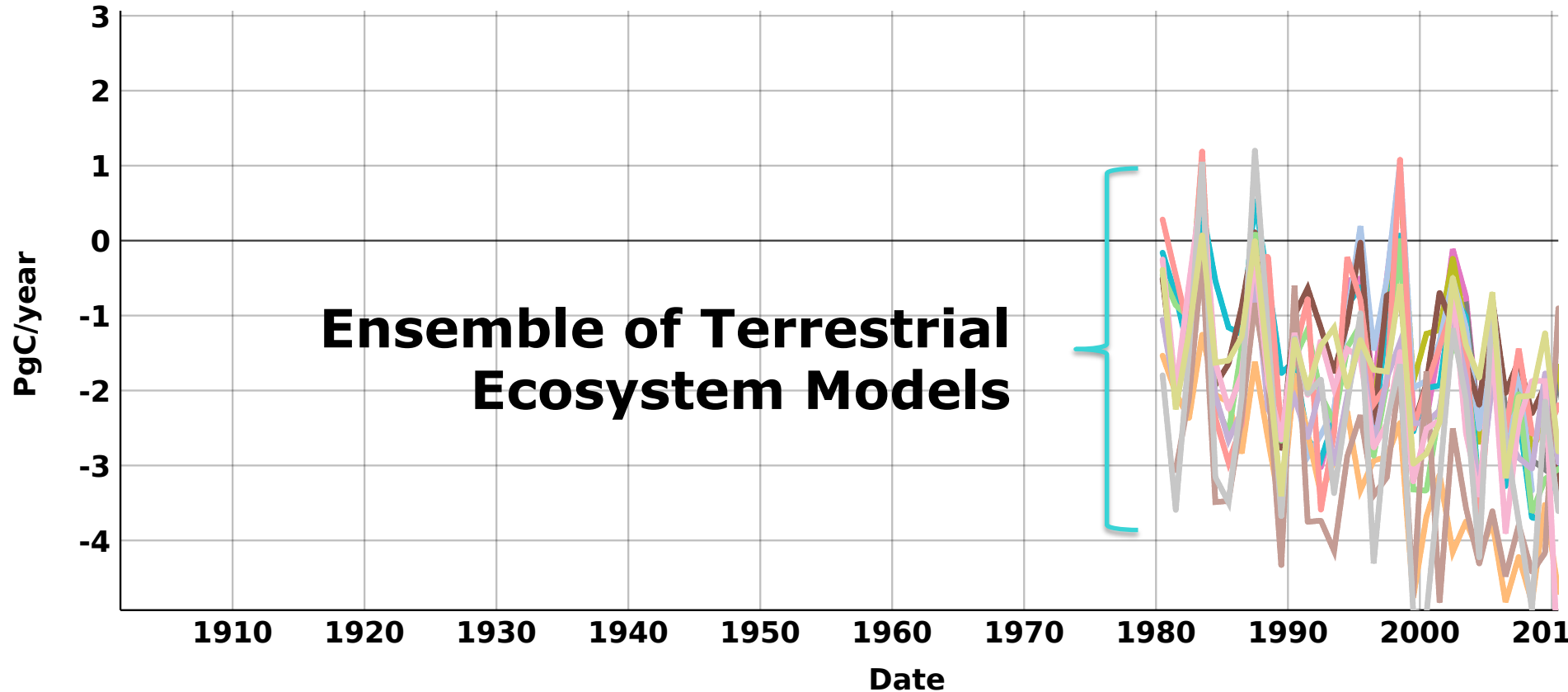


Net CO₂ flux – All uncertainties



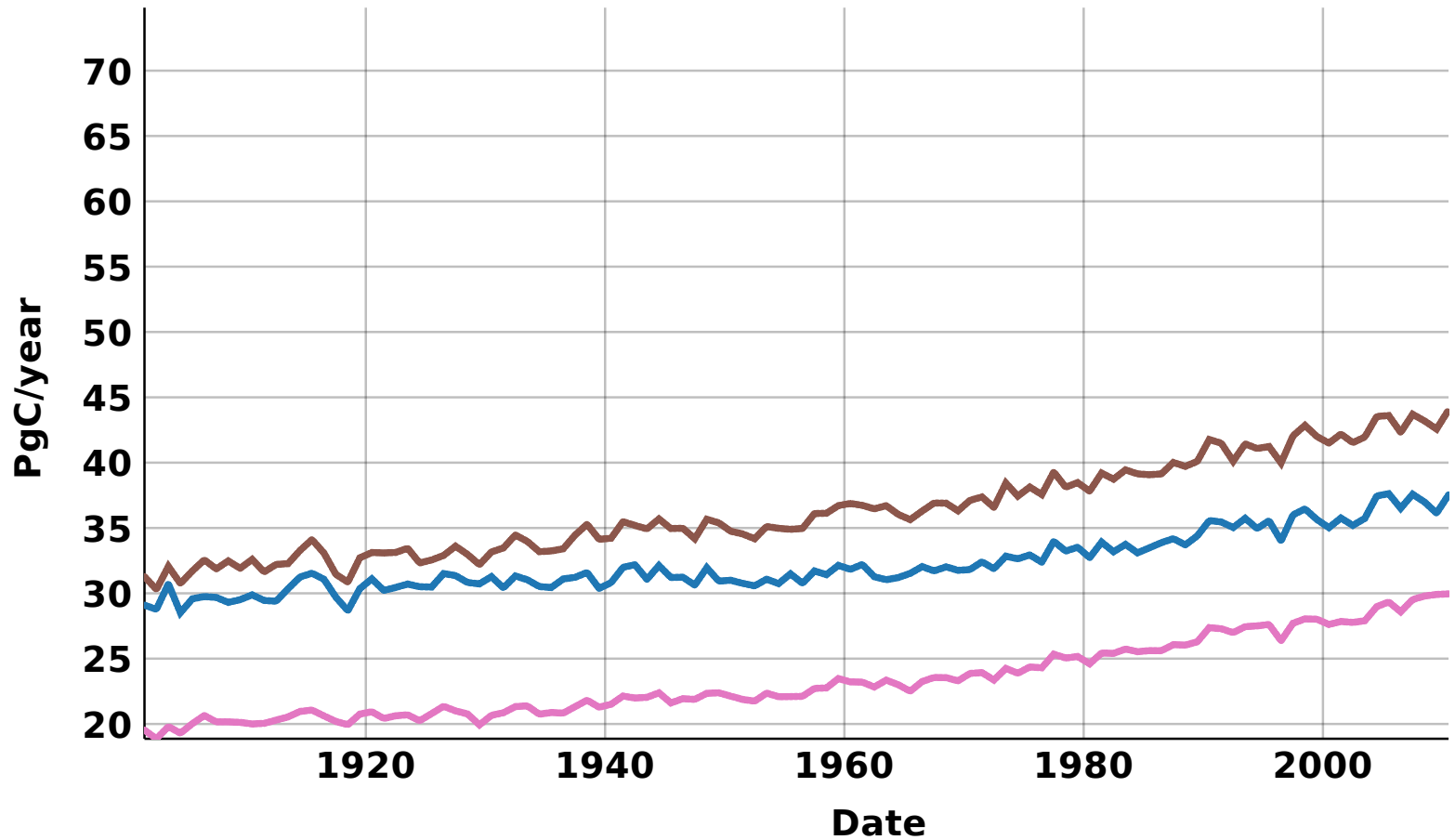
+ Inversions (Top-Down approach)

Net CO₂ flux – All uncertainties



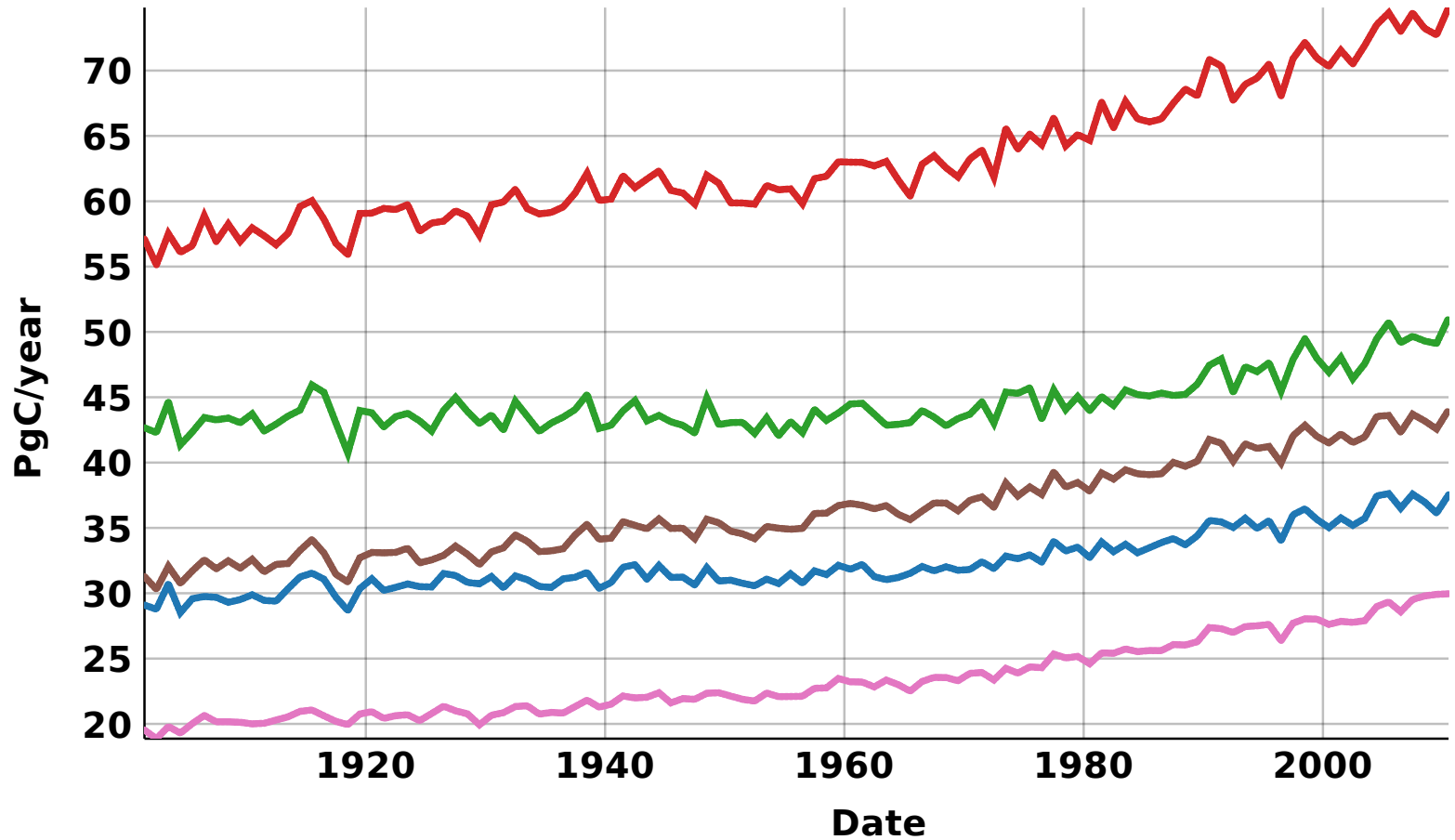
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GPP flux (Photosynthesis) – Northern lands



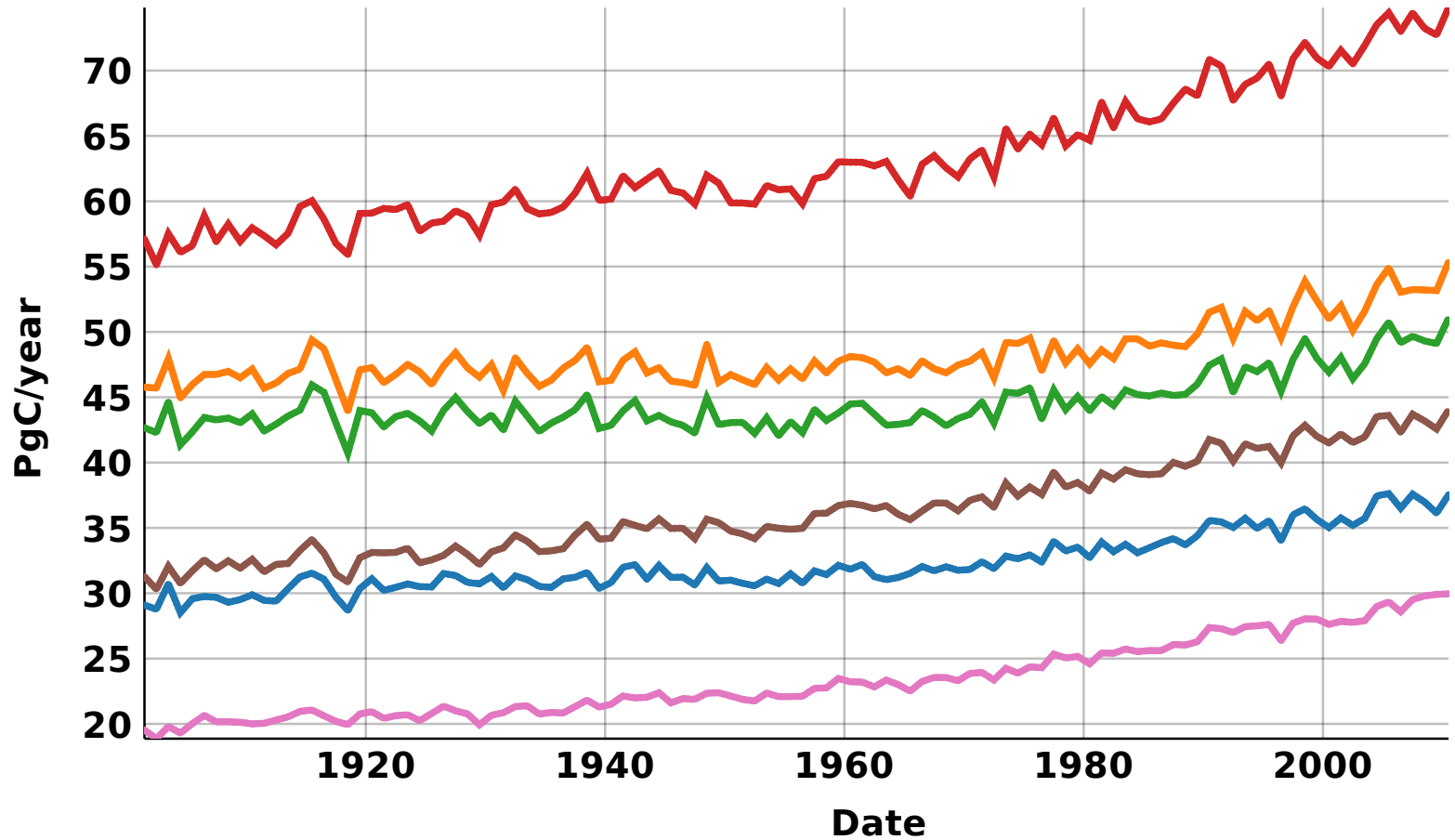
Meteorological forcings

GPP flux – Northern lands



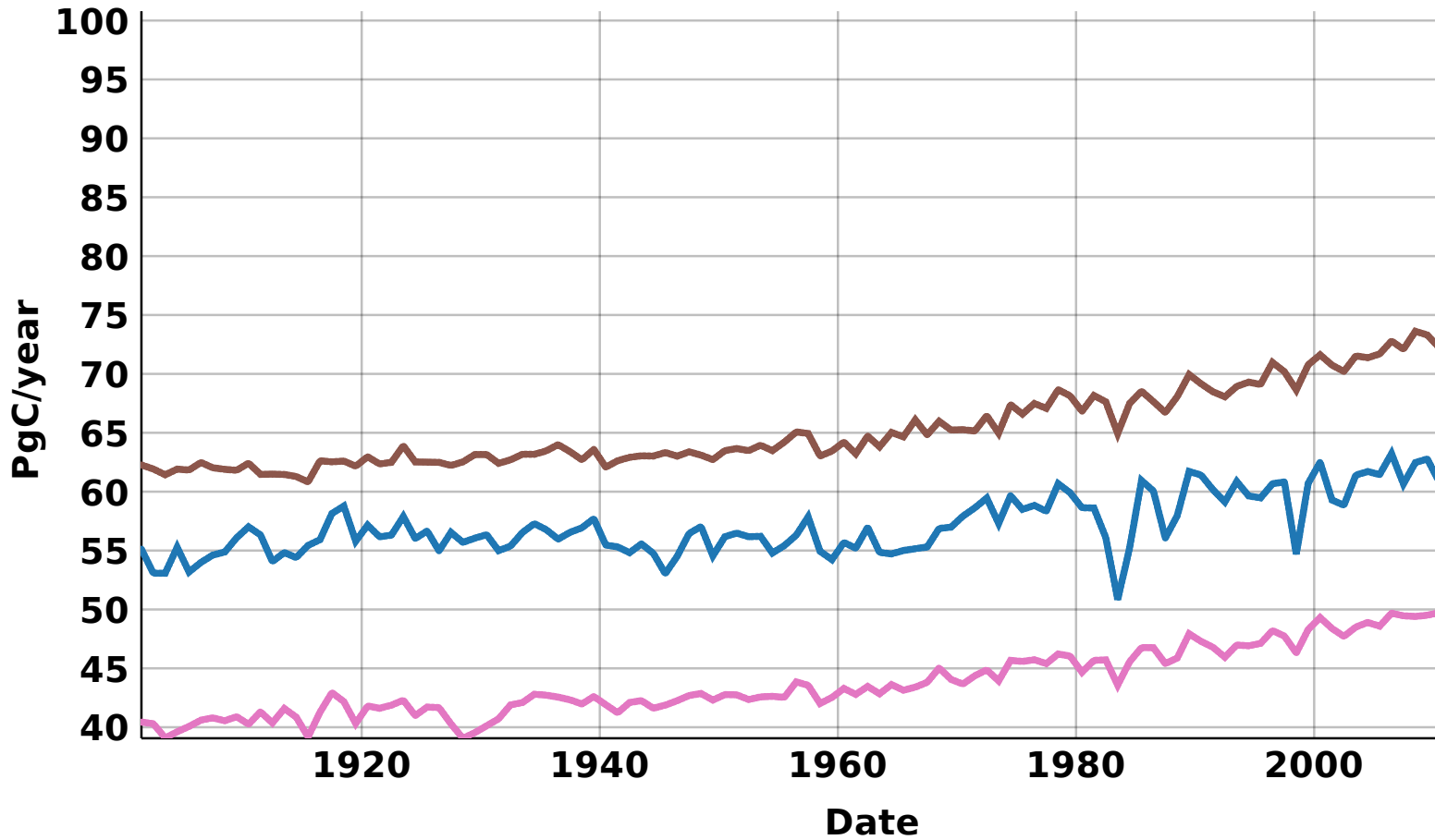
Meteorological forcings + Model version

GPP flux – Northern lands



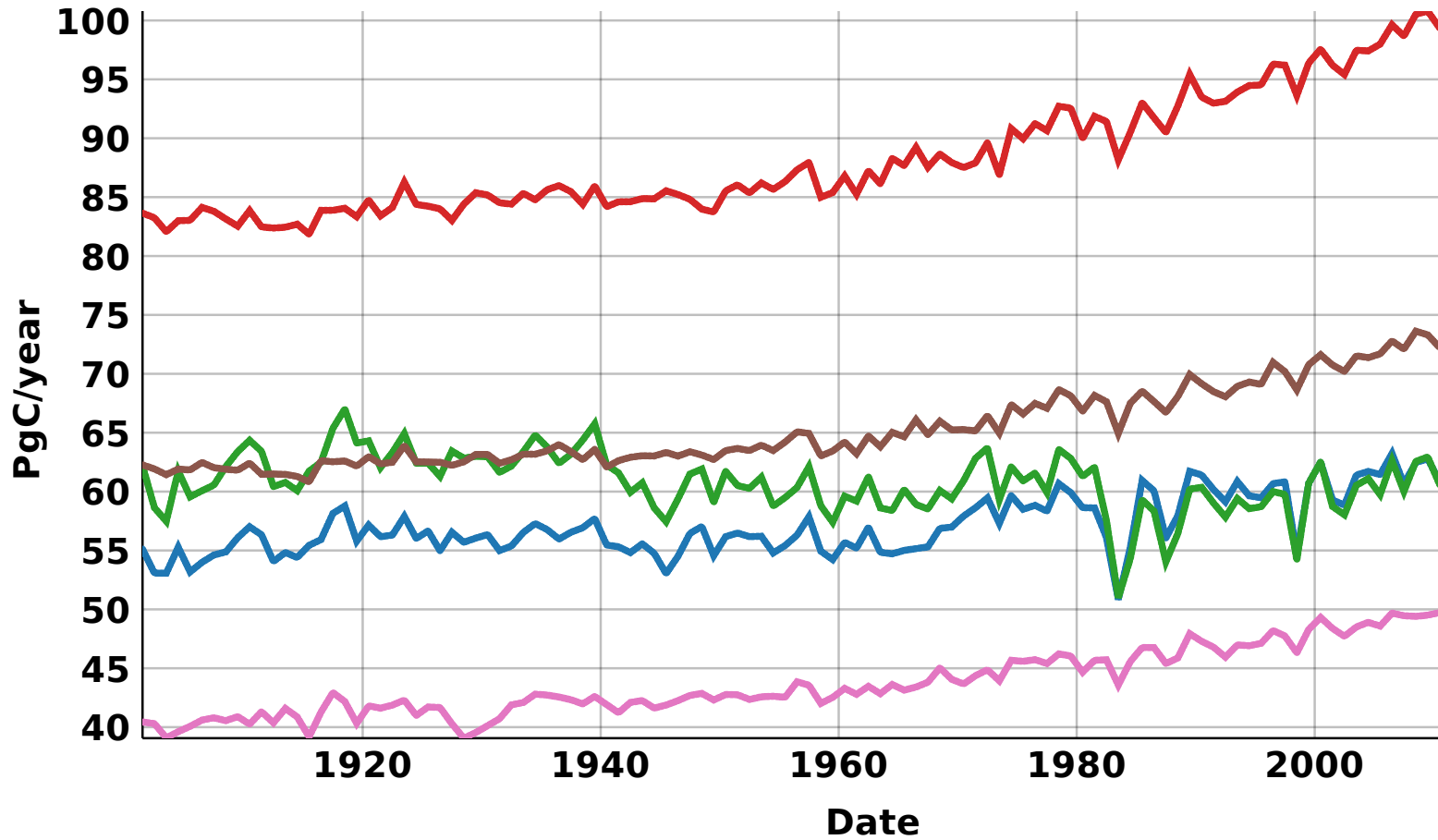
Meteorological forcings + **Model version** + **Land-use**

GPP flux – Tropical lands



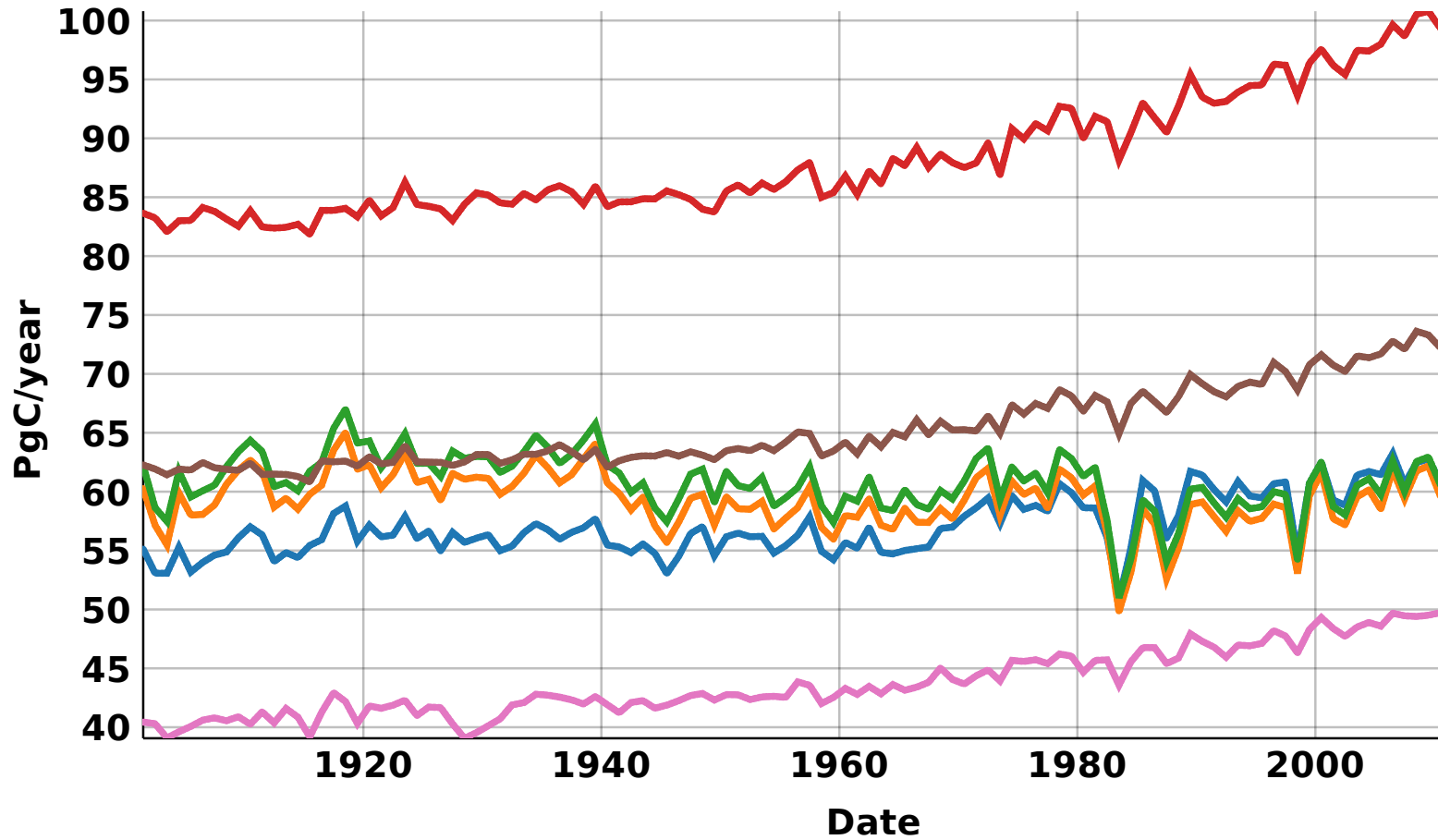
Meteorological forcings

GPP flux – Tropical lands



Meteorological forcings + Model version

GPP flux – Tropical lands



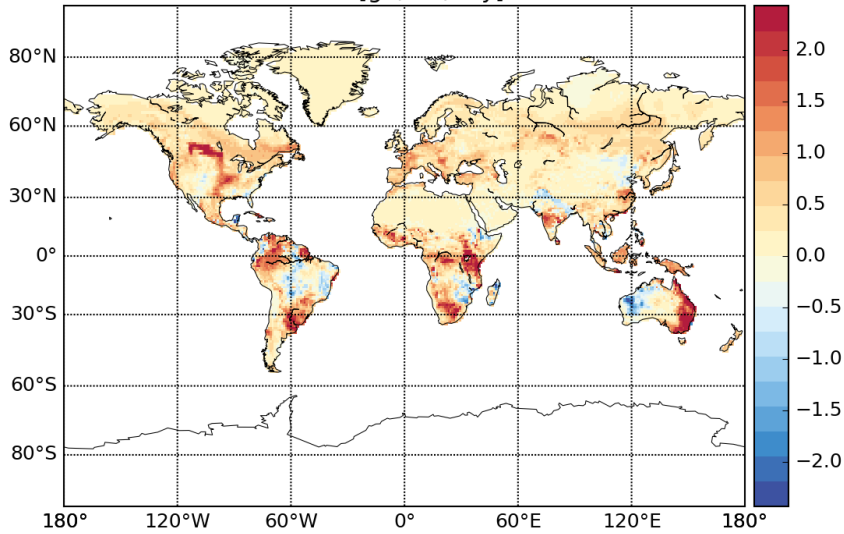
Meteorological forcings + **Model version** + **Land-use**



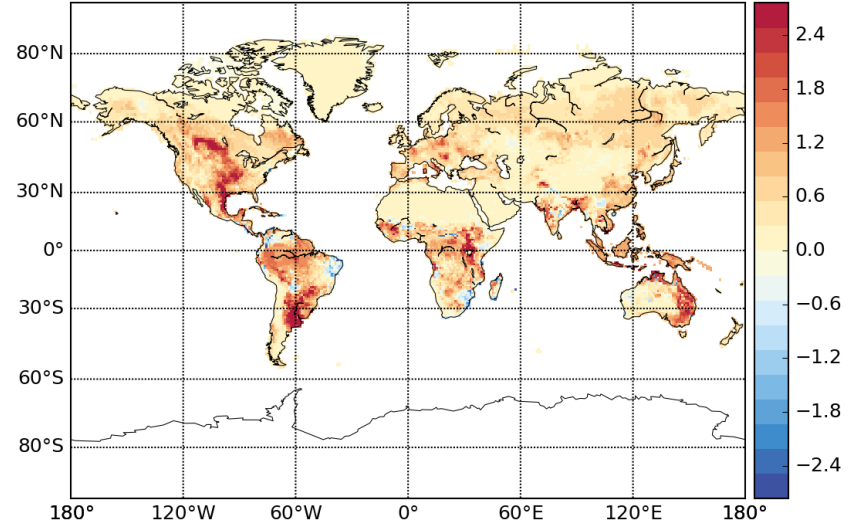
Change in GPP (gC/m²/d): 2010 - 1901

LSCF

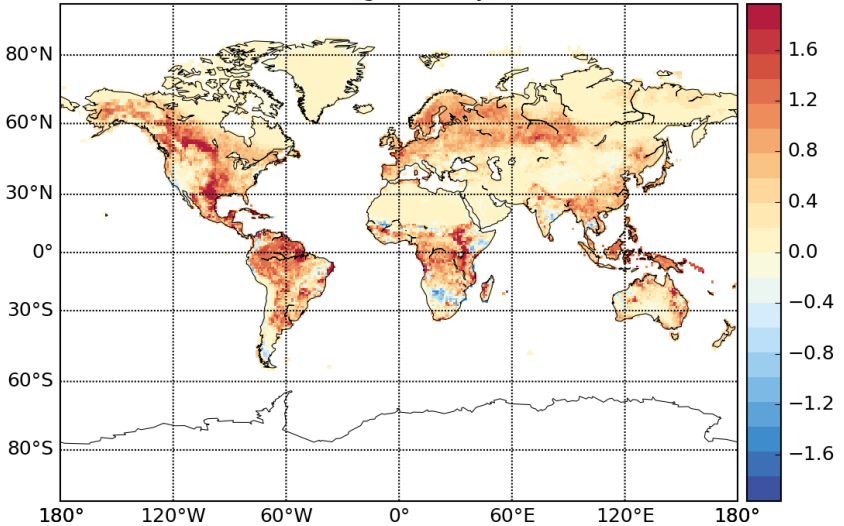
ORCv3-CERA20C-LU6



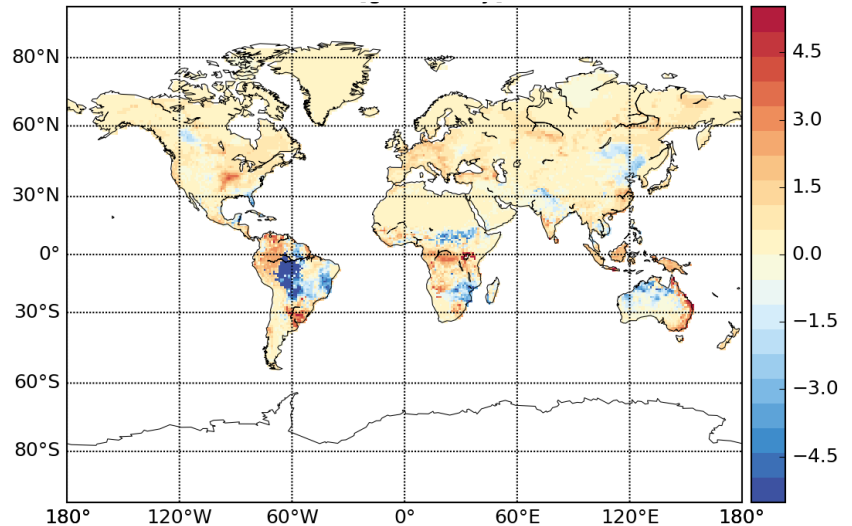
ORCv3-CRUNCEP-LU6



ORCv3-GSWP3-LU6



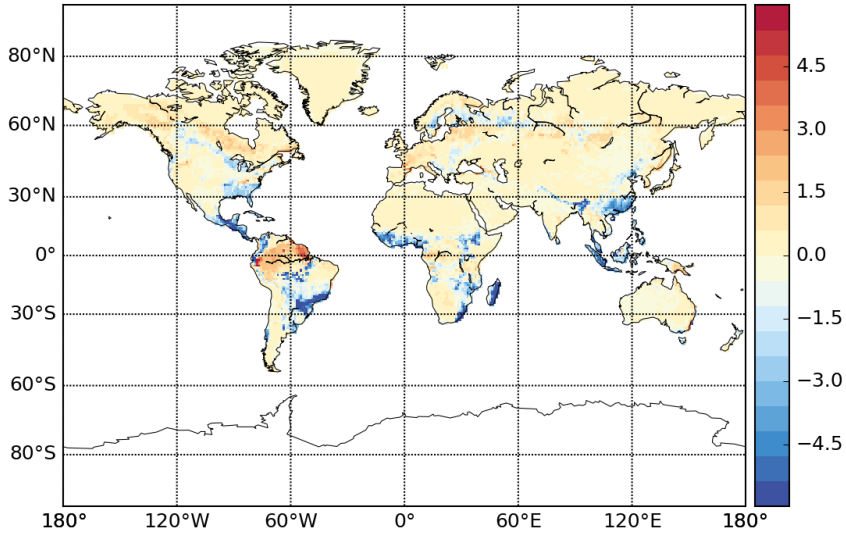
ORCv1-CERA20C-LU6



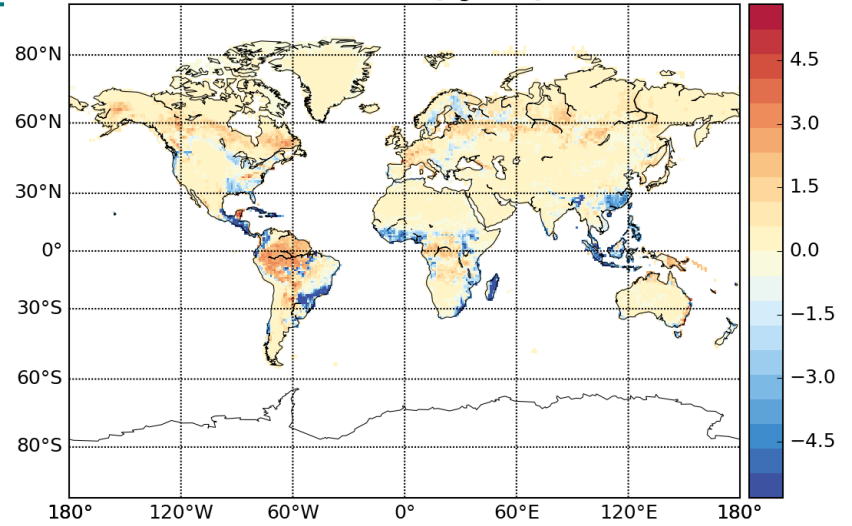
Change in ABG biomass (kgC/m²): 2010 - 1901

LSCF

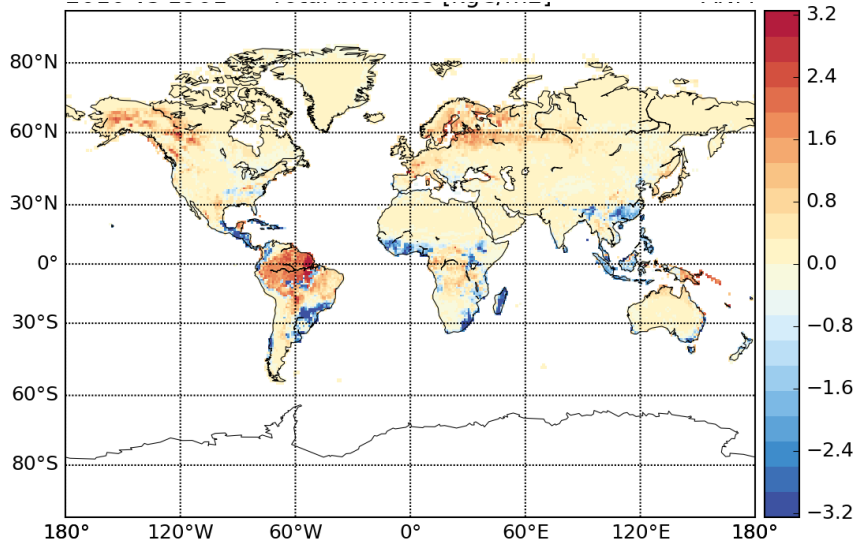
ORCv3-CERA20C-LU6



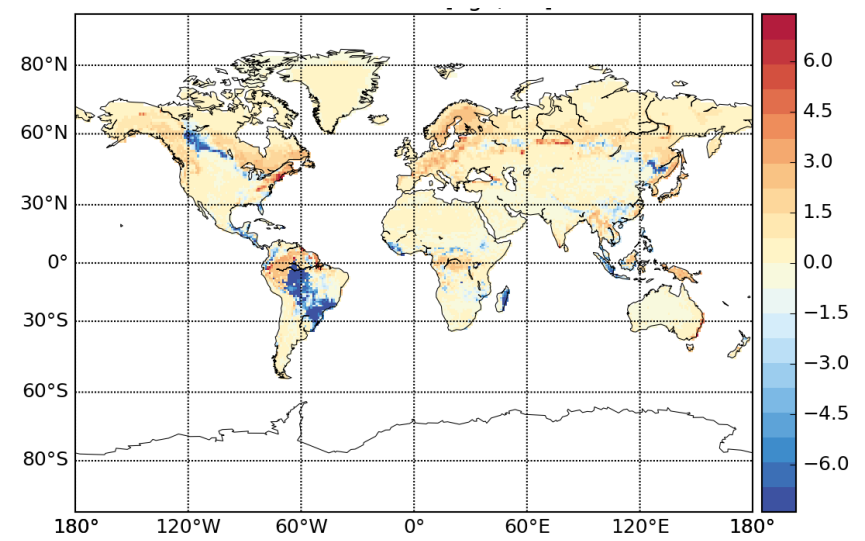
ORCv3-CRUNCEP-LU6



ORCv3-GSWP3-LU6



ORCv1-CERA20C-LU6



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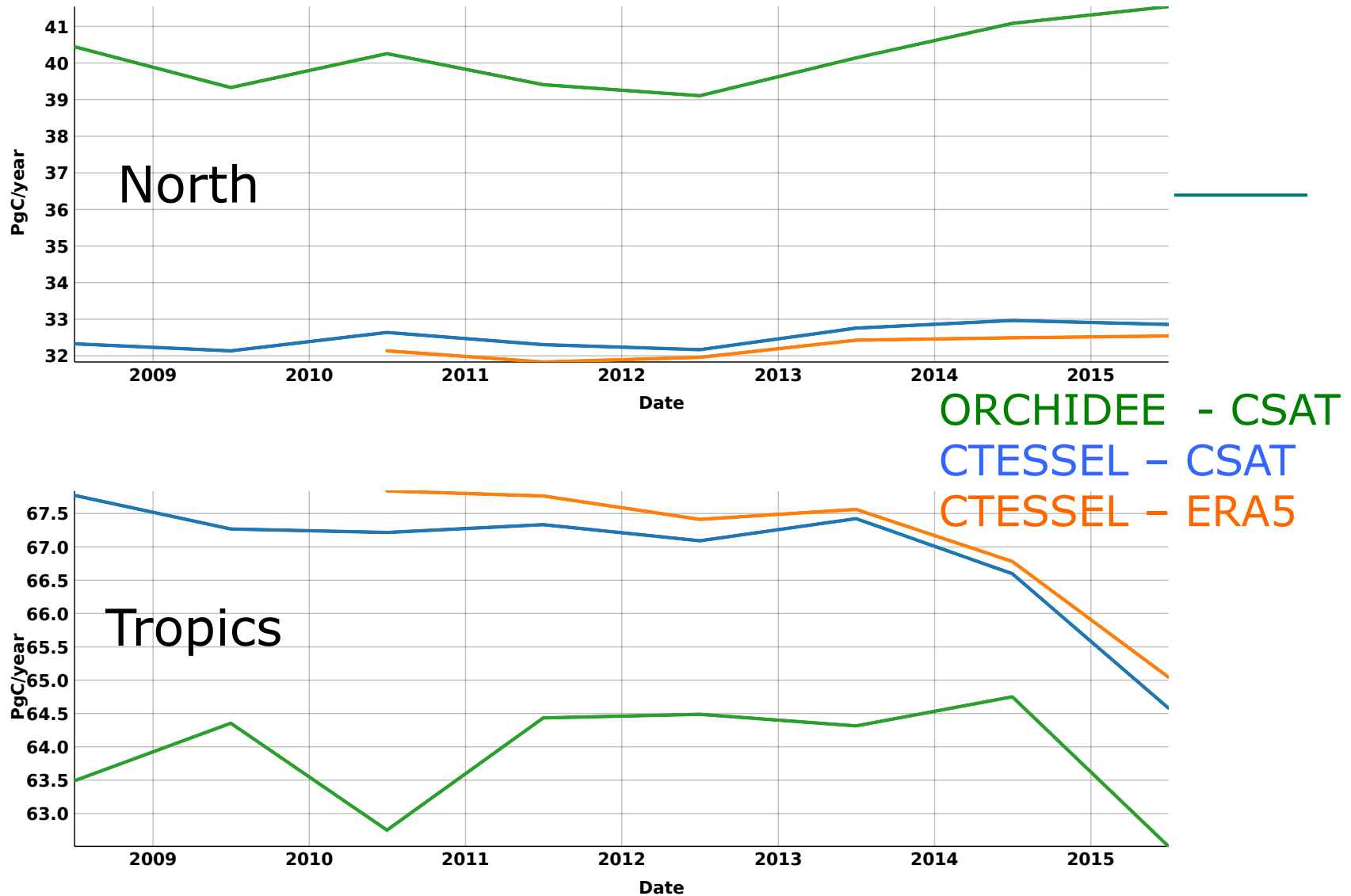
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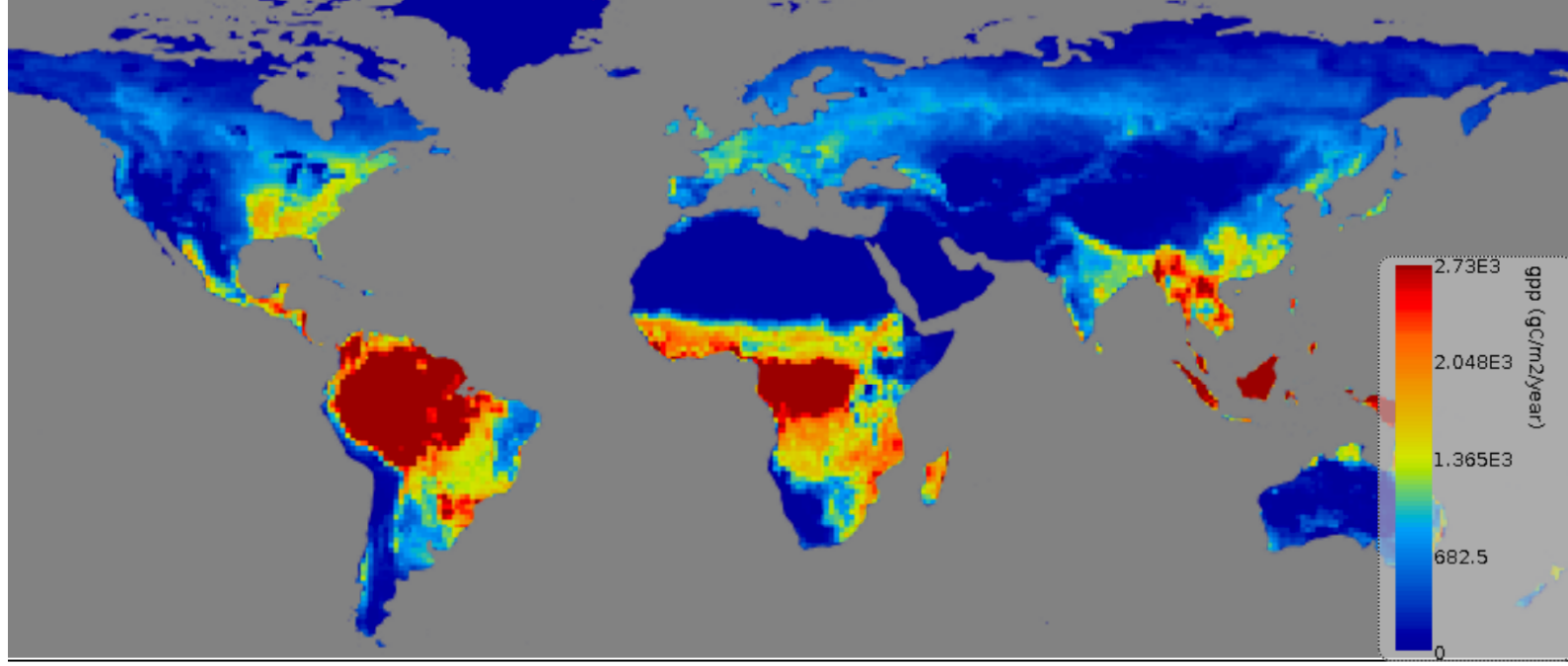
LSCE

CERA-SAT carbon reanalysis

Gross carbon flux (GPP)

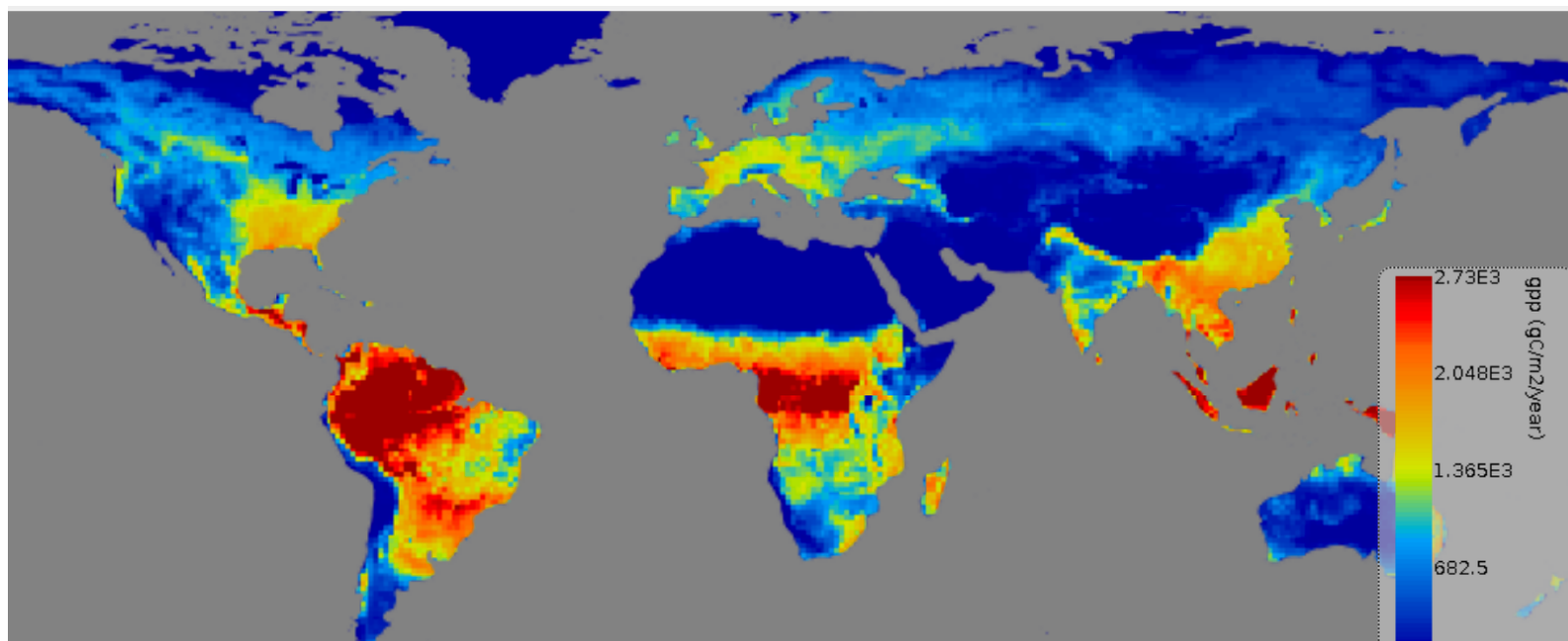


CTESSEL

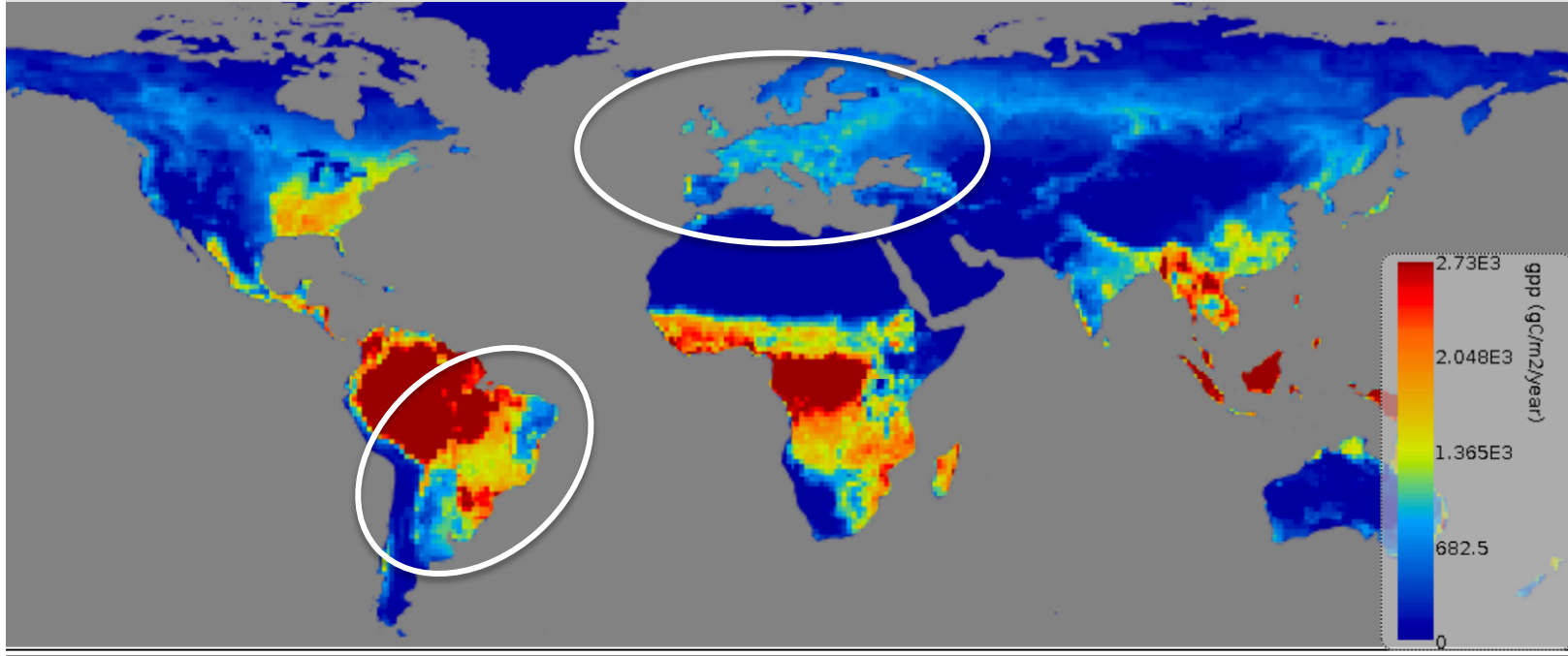


GPP 2008

ORCHIDEE

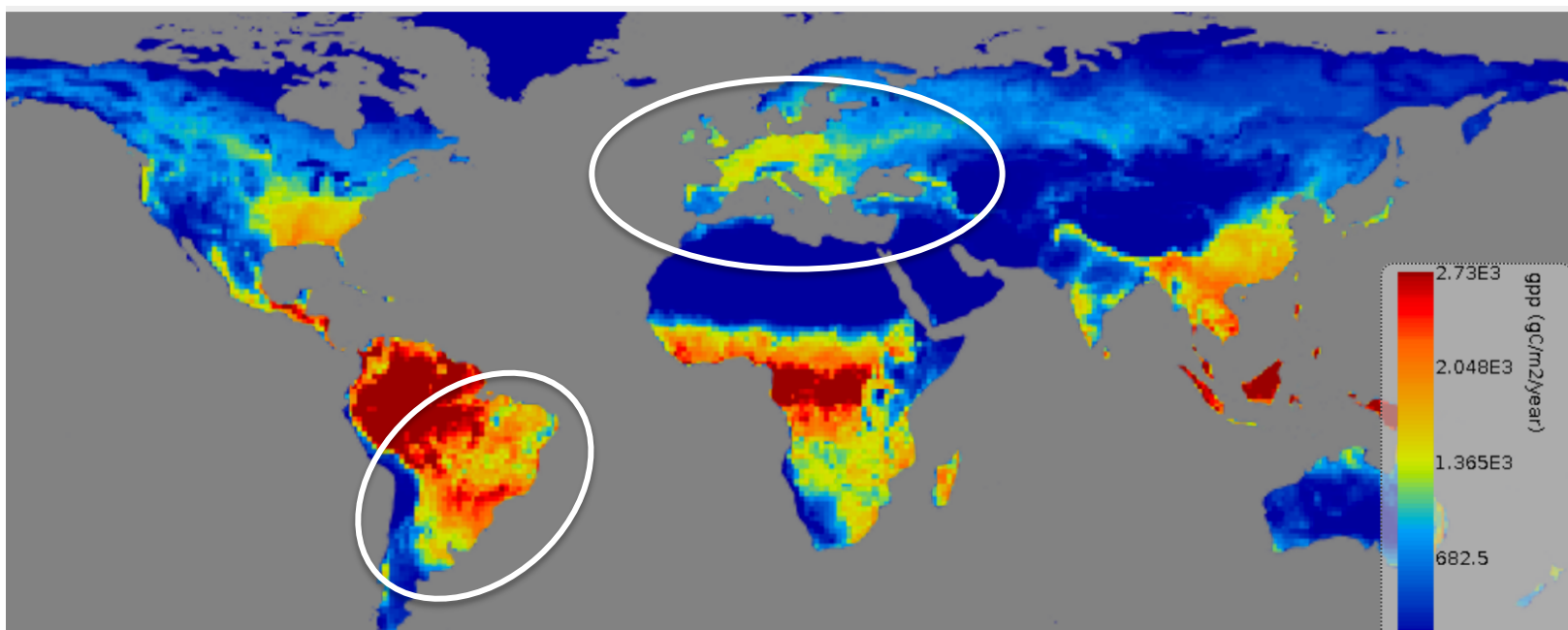


CTESSEL

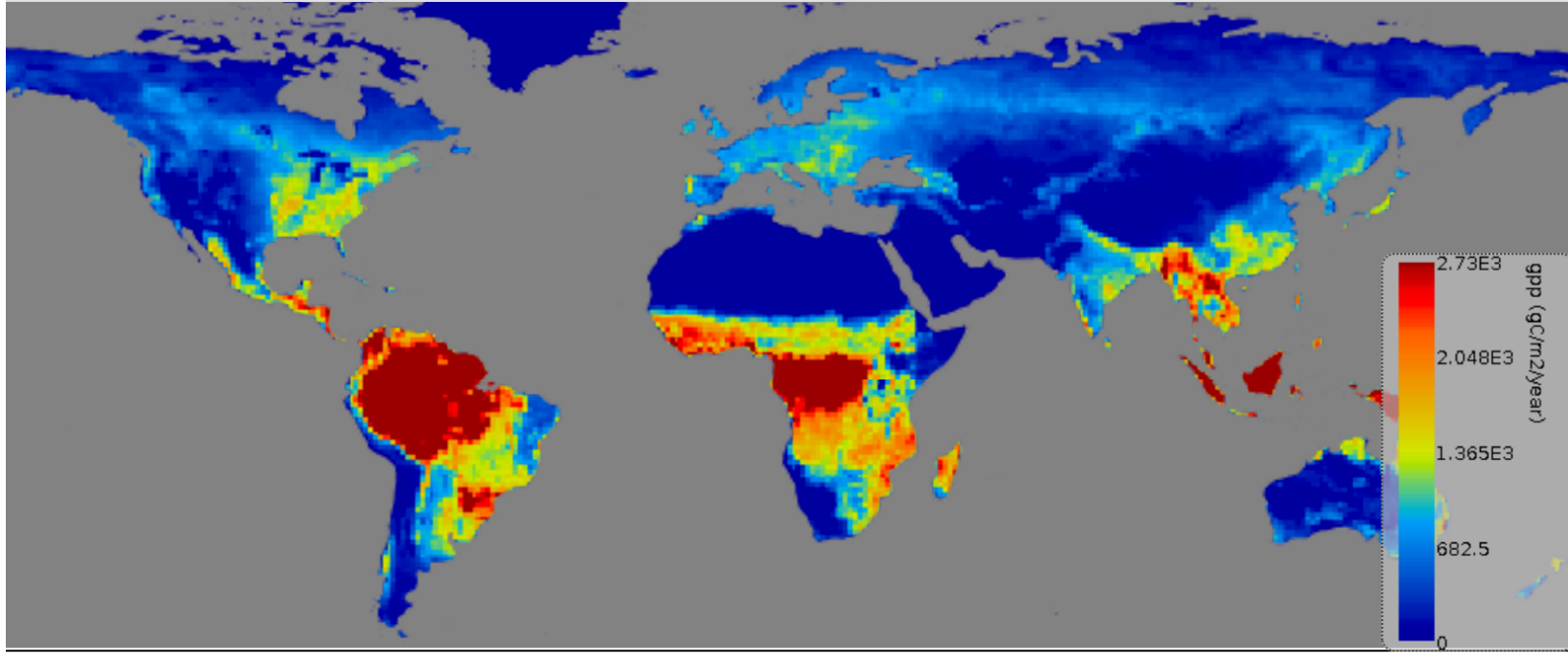


GPP 2009

ORCHIDEE

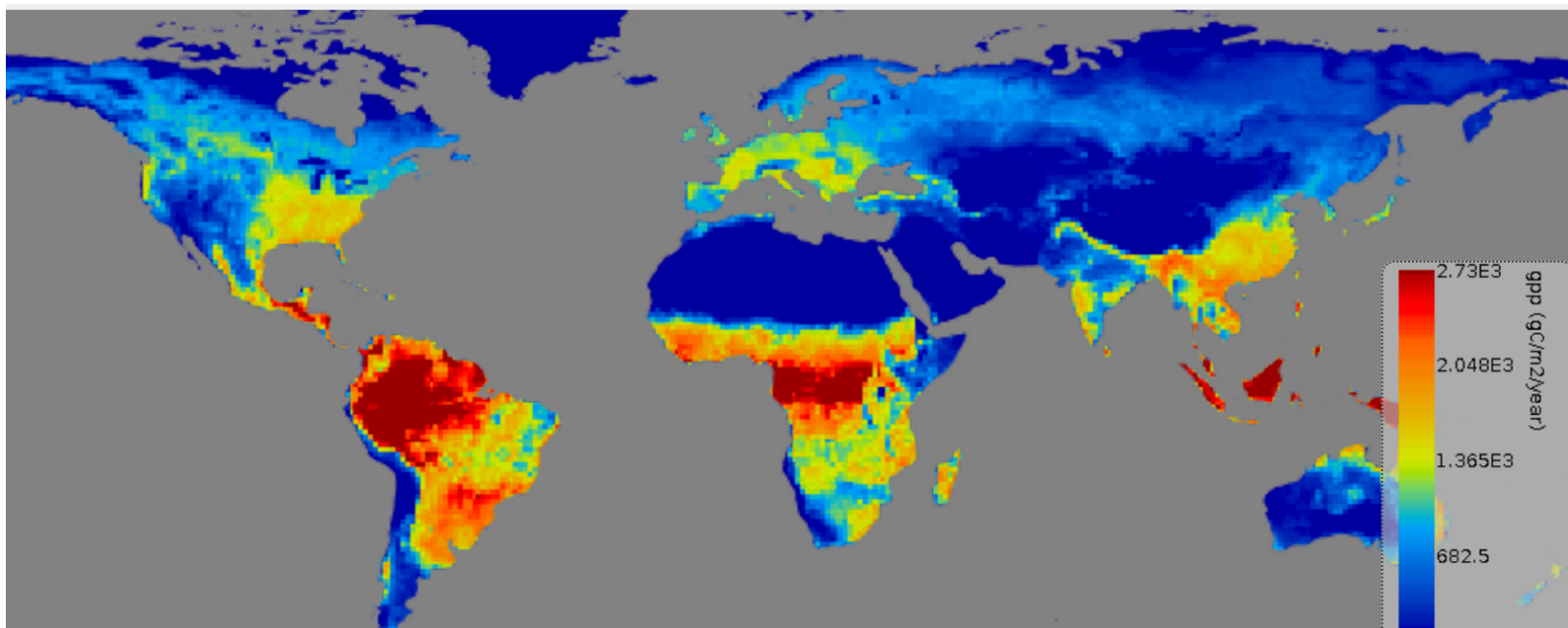


CTESSEL

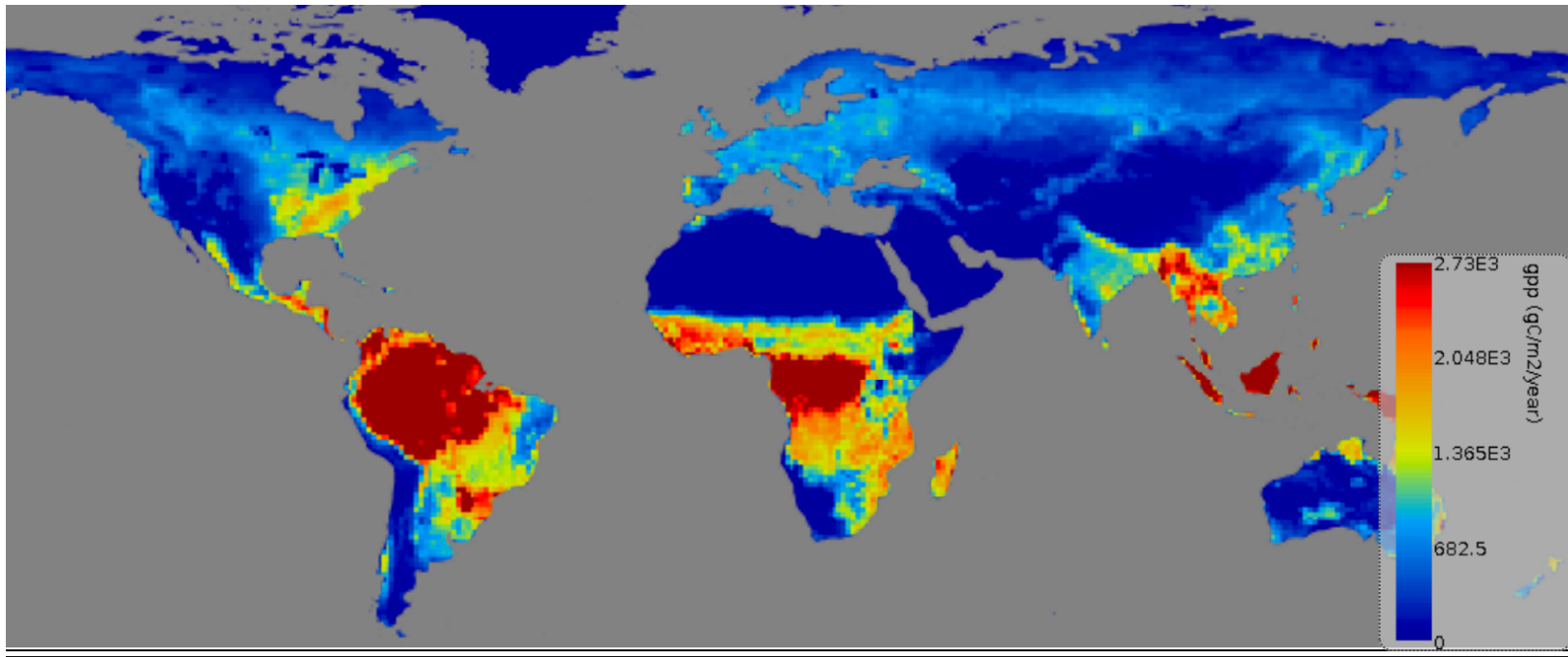


GPP 2010

ORCHIDEE

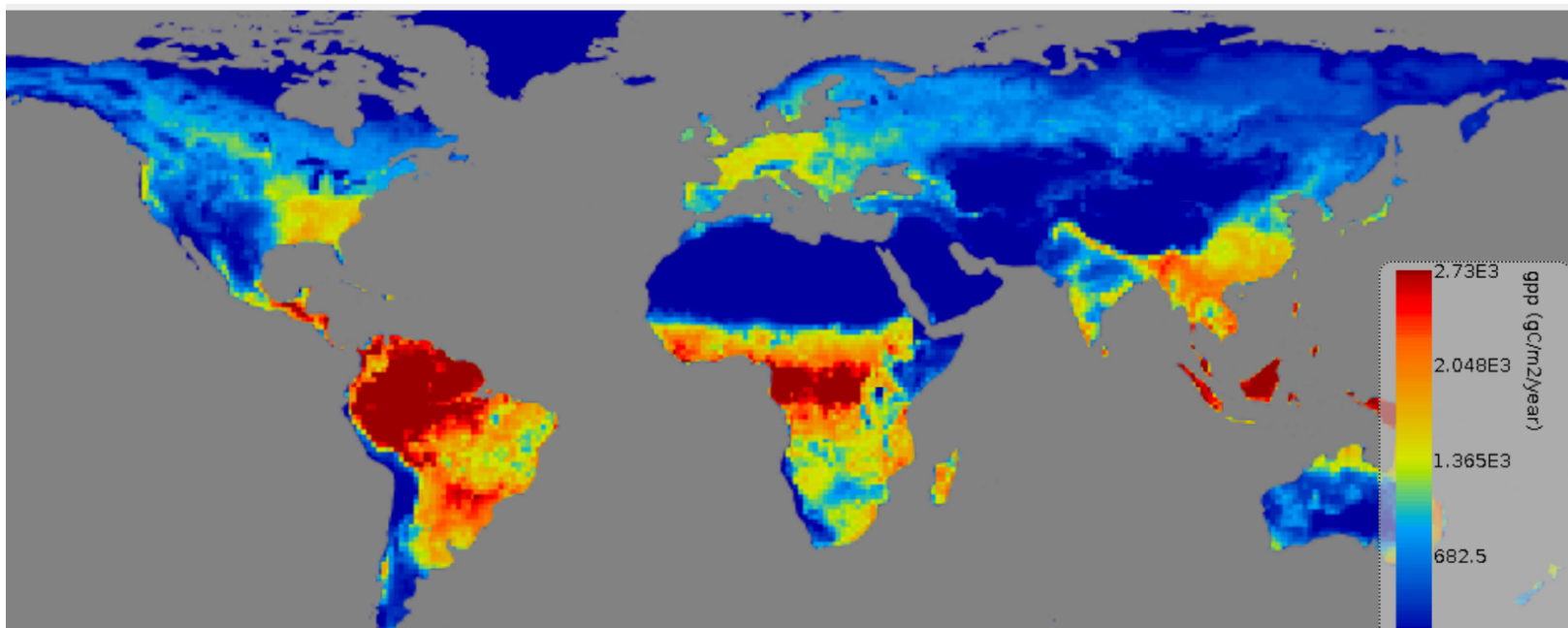


CTESSEL

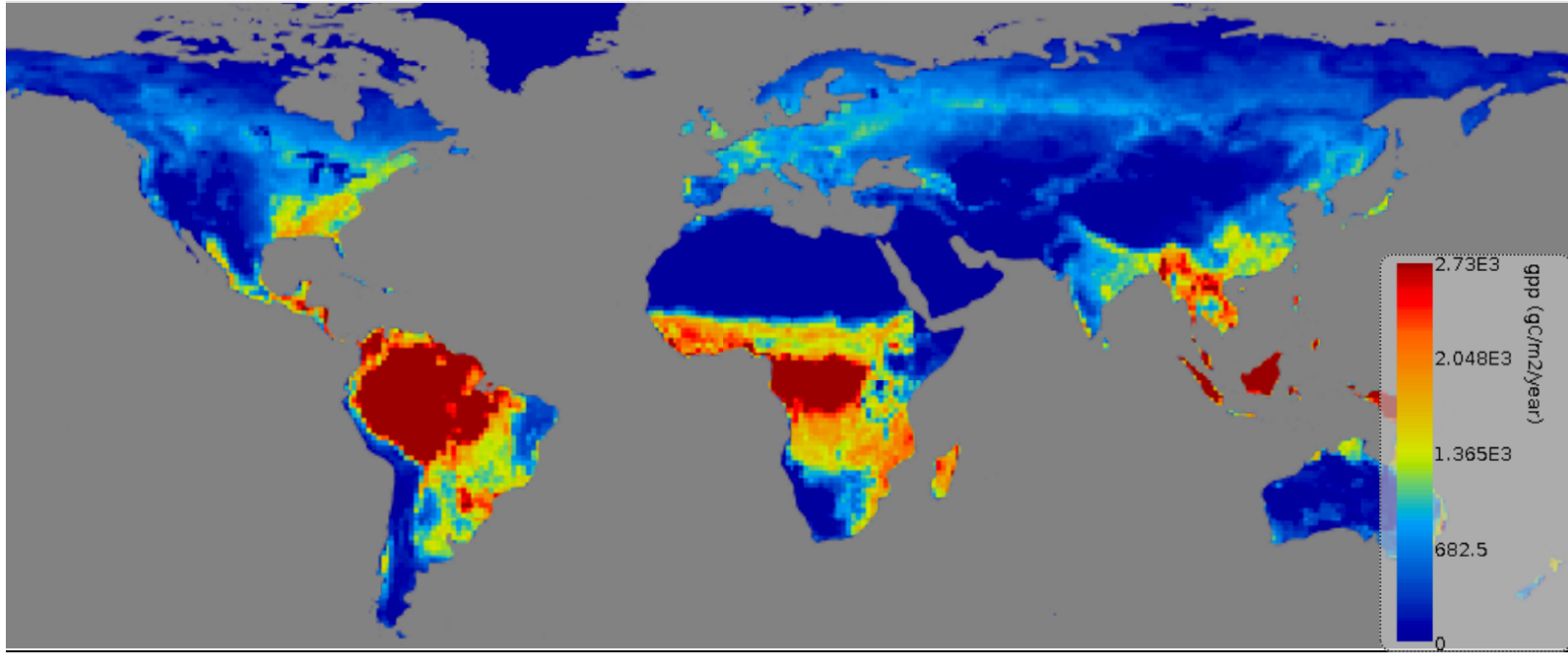


GPP 2011

ORCHIDEE

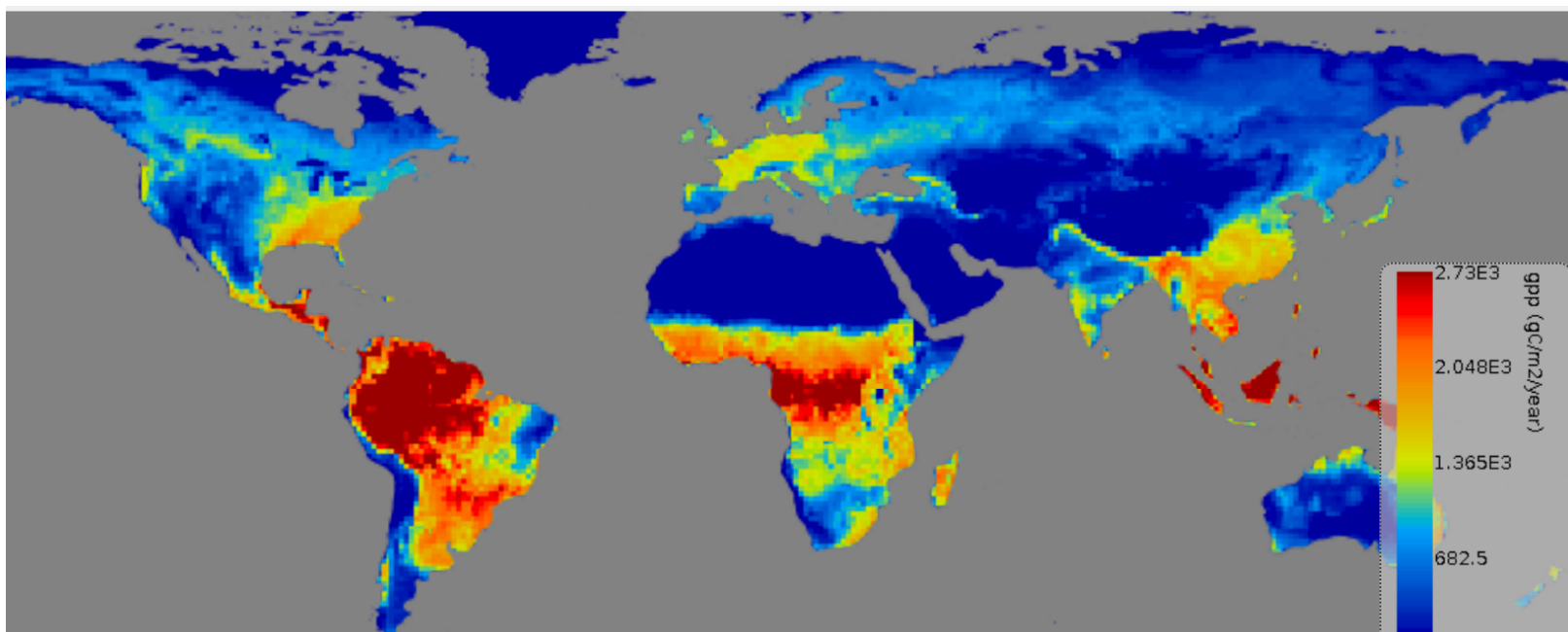


CTESSEL

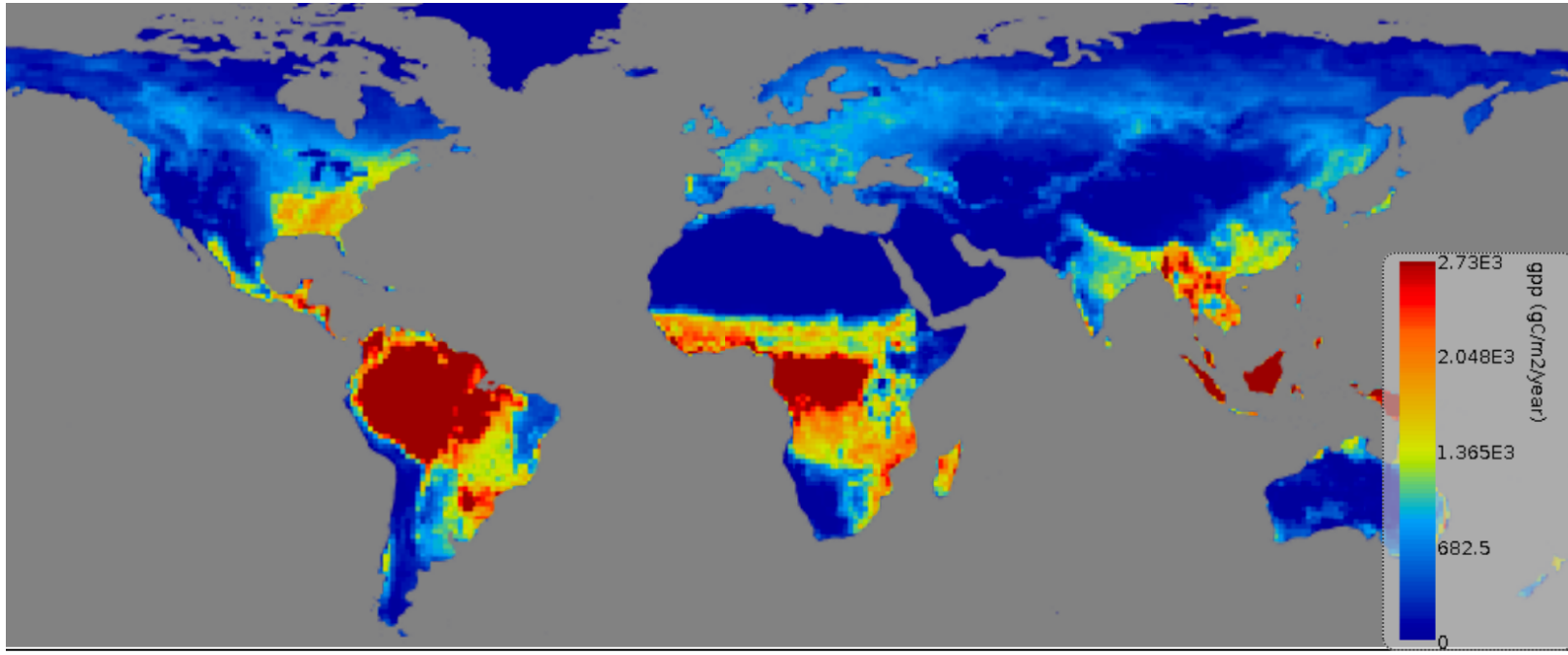


GPP 2012

ORCHIDEE

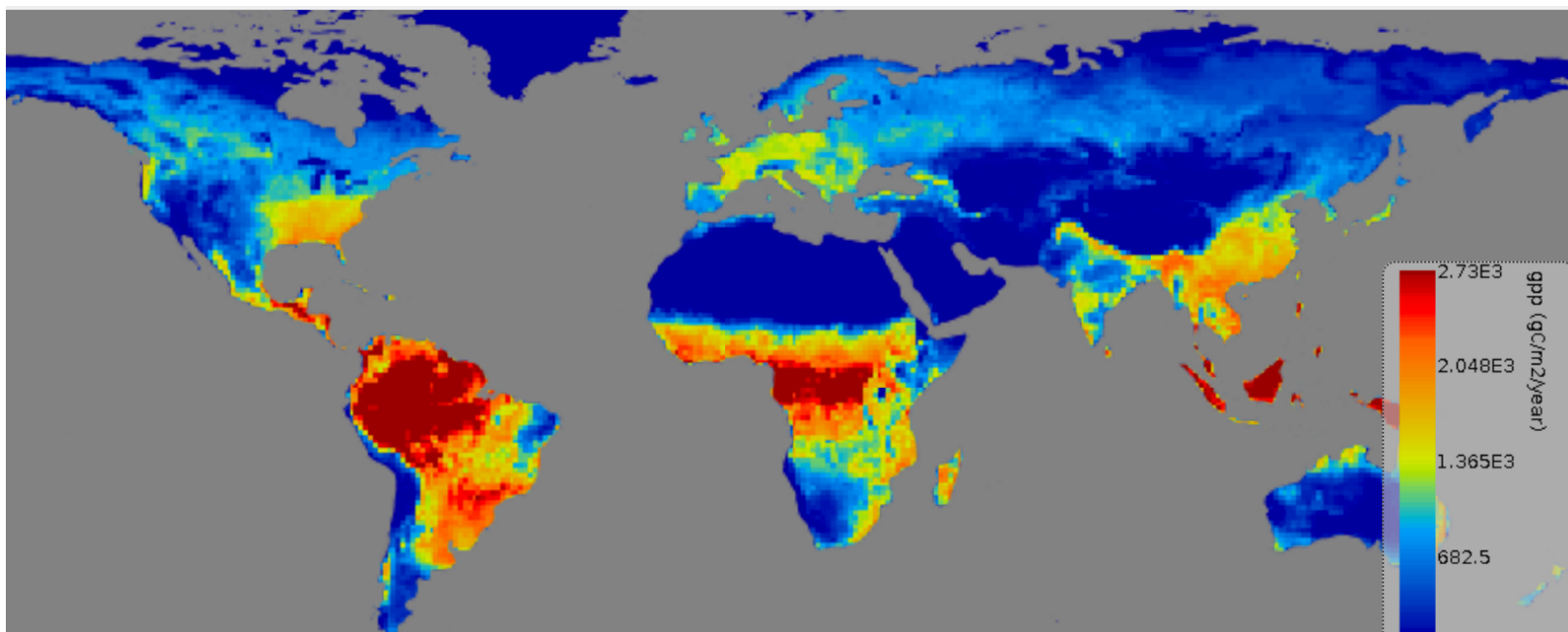


CTESSEL

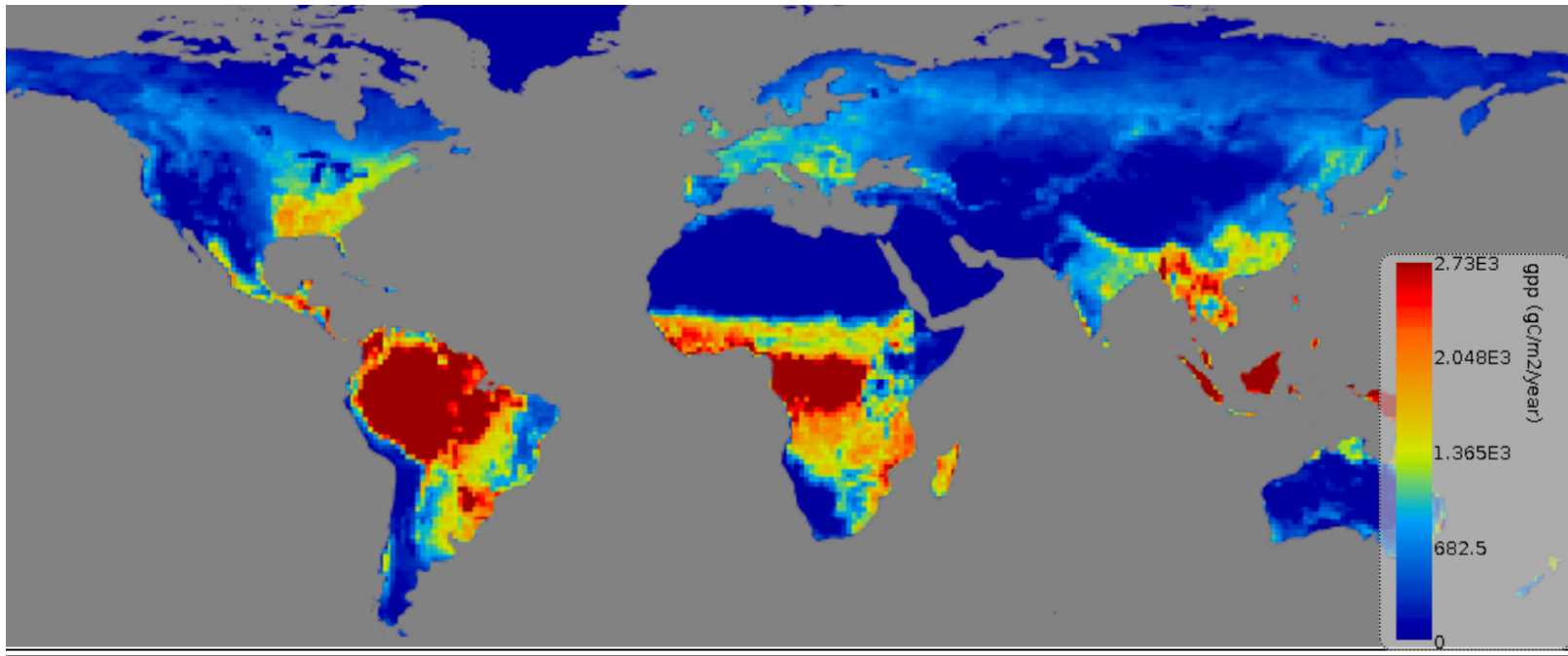


GPP 2013

ORCHIDEE

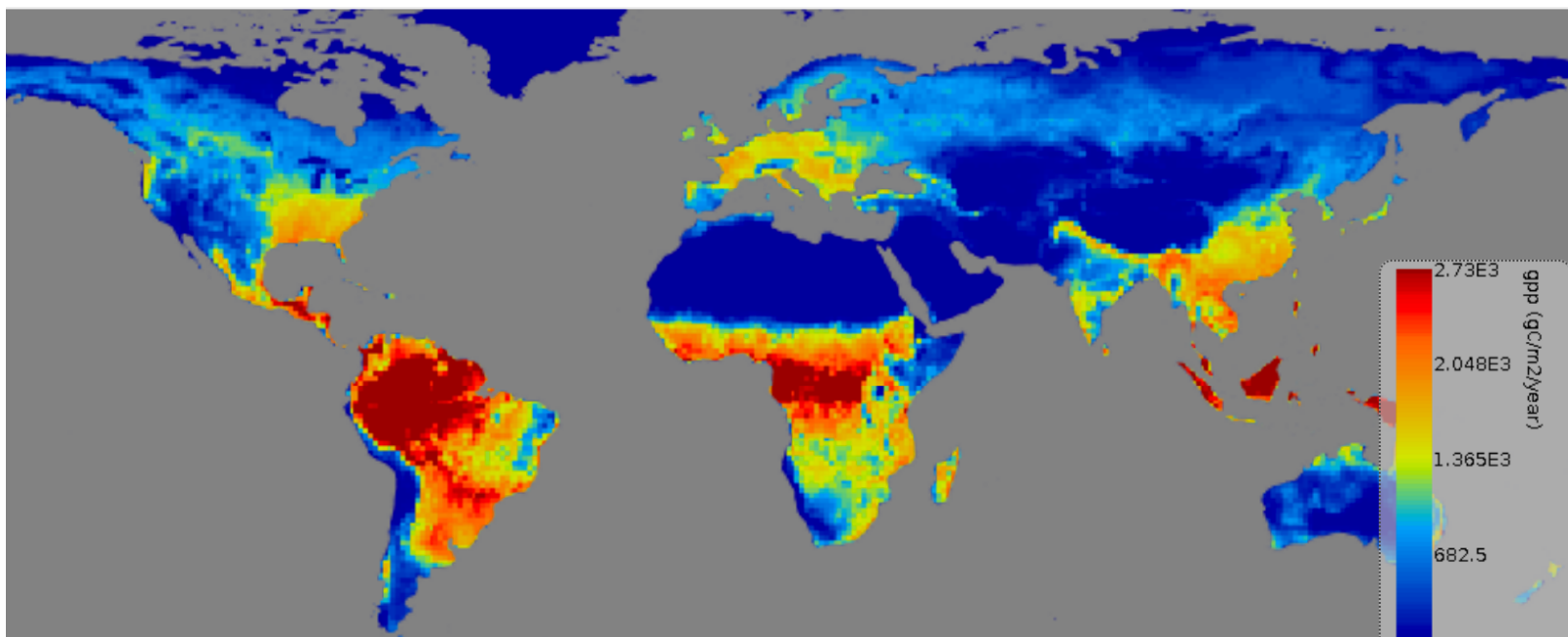


CTESSEL

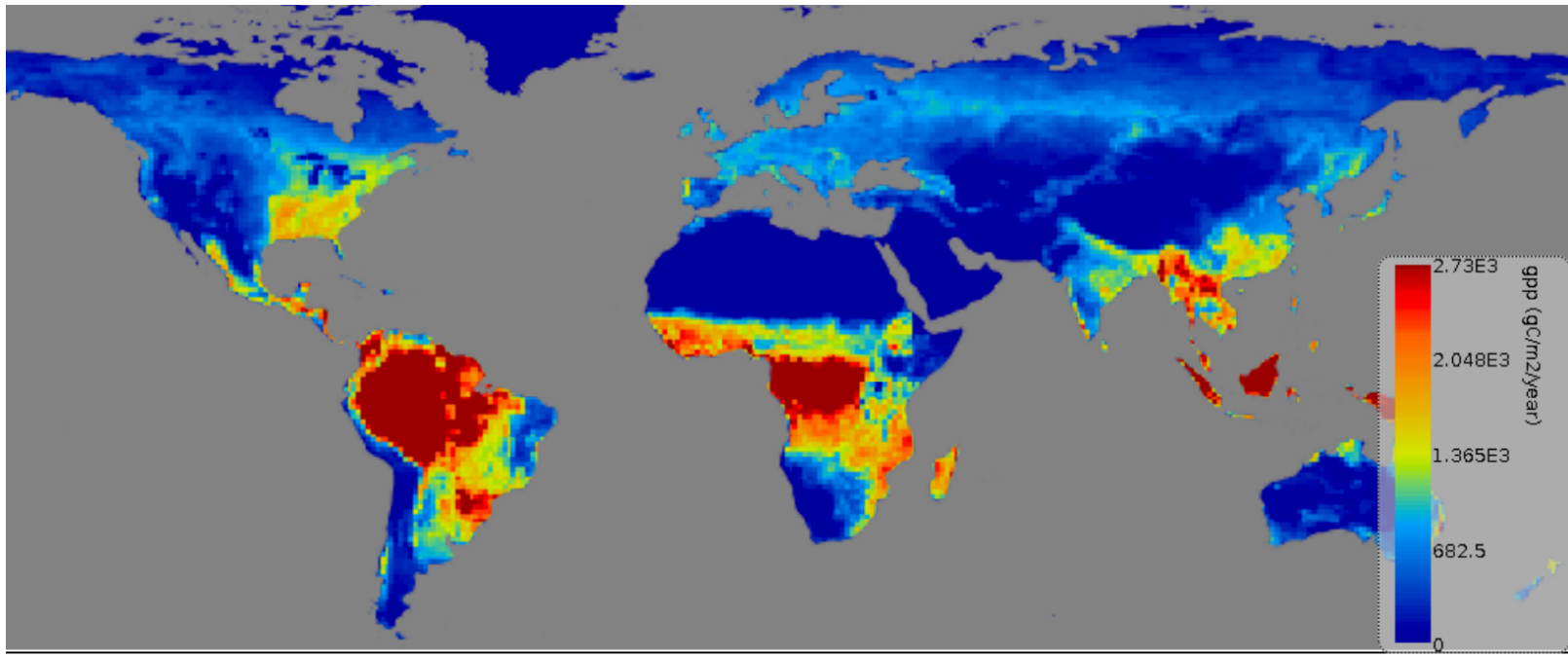


GPP 2014

ORCHIDEE

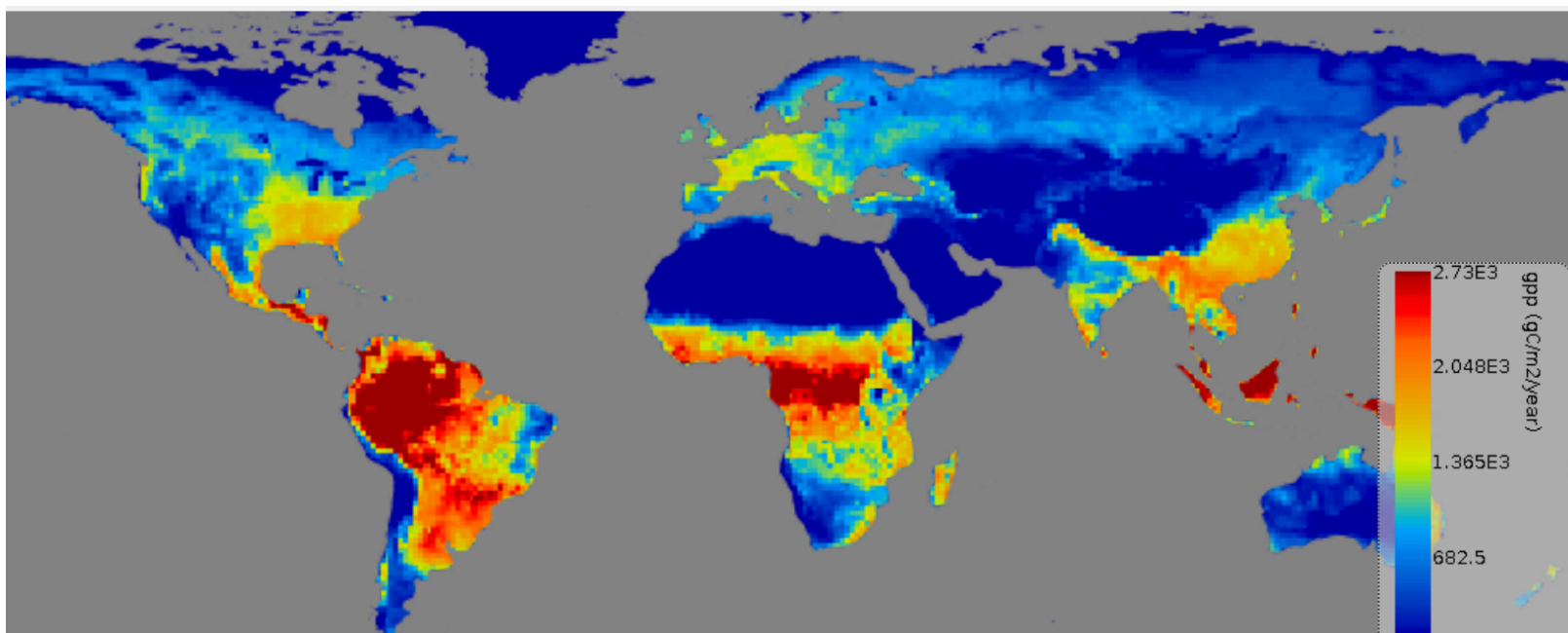


CTESSEL



GPP 2015

ORCHIDEE



Next...

D4.13 : Confidence intervals on net and gross C fluxes

D4.14 : Comparison of CTESSEL and ORCHIDEE

→ To be finalized before 31 dec 2017

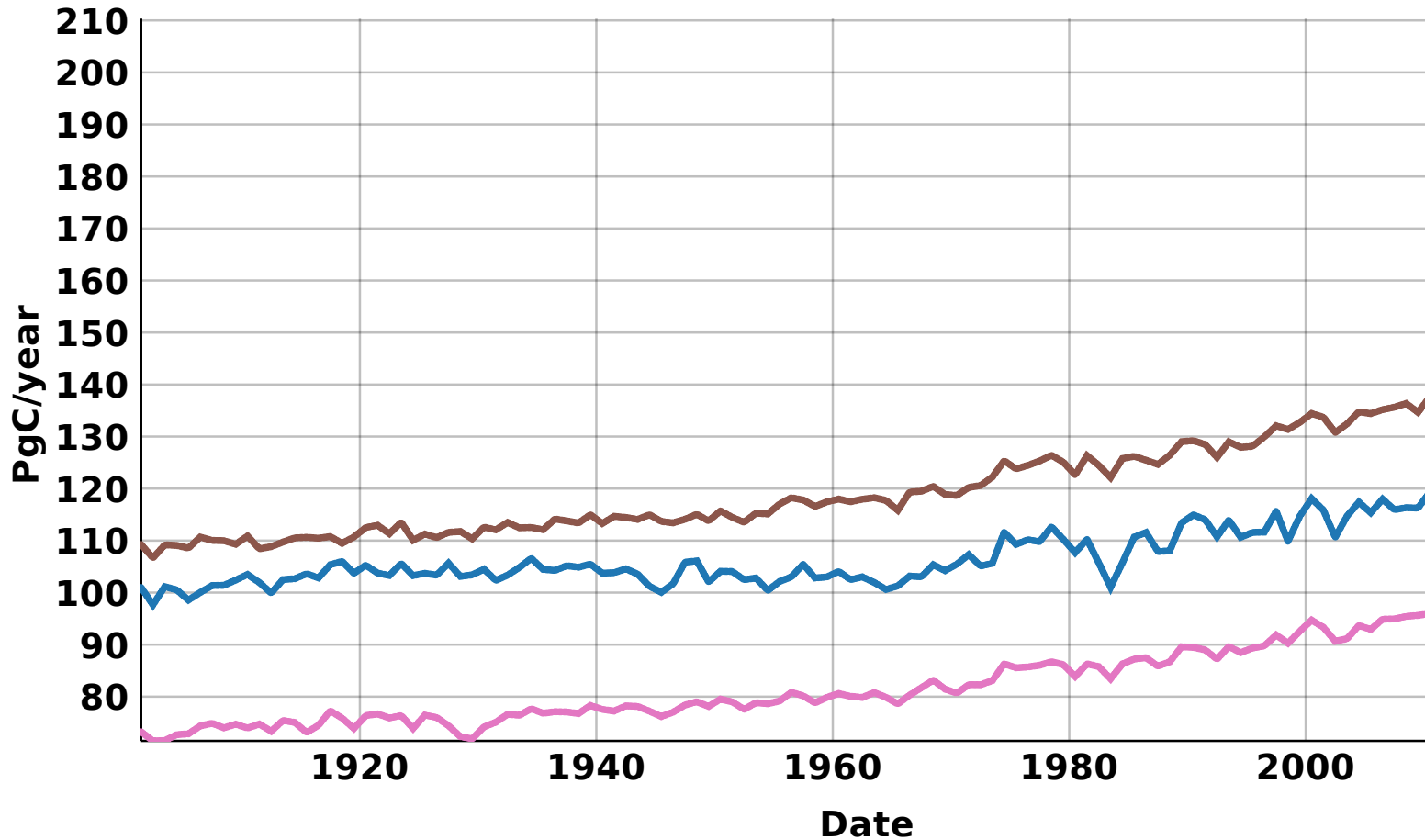
→ Synthesis article (in preparation)

Relative source of uncertainty on carbon fluxes from

- ✓ Model structure
- ✓ Climate forcing (various reanalysis ; members)
- ✓ Land cover reconstruction
- ✓ Parameter uncertainties

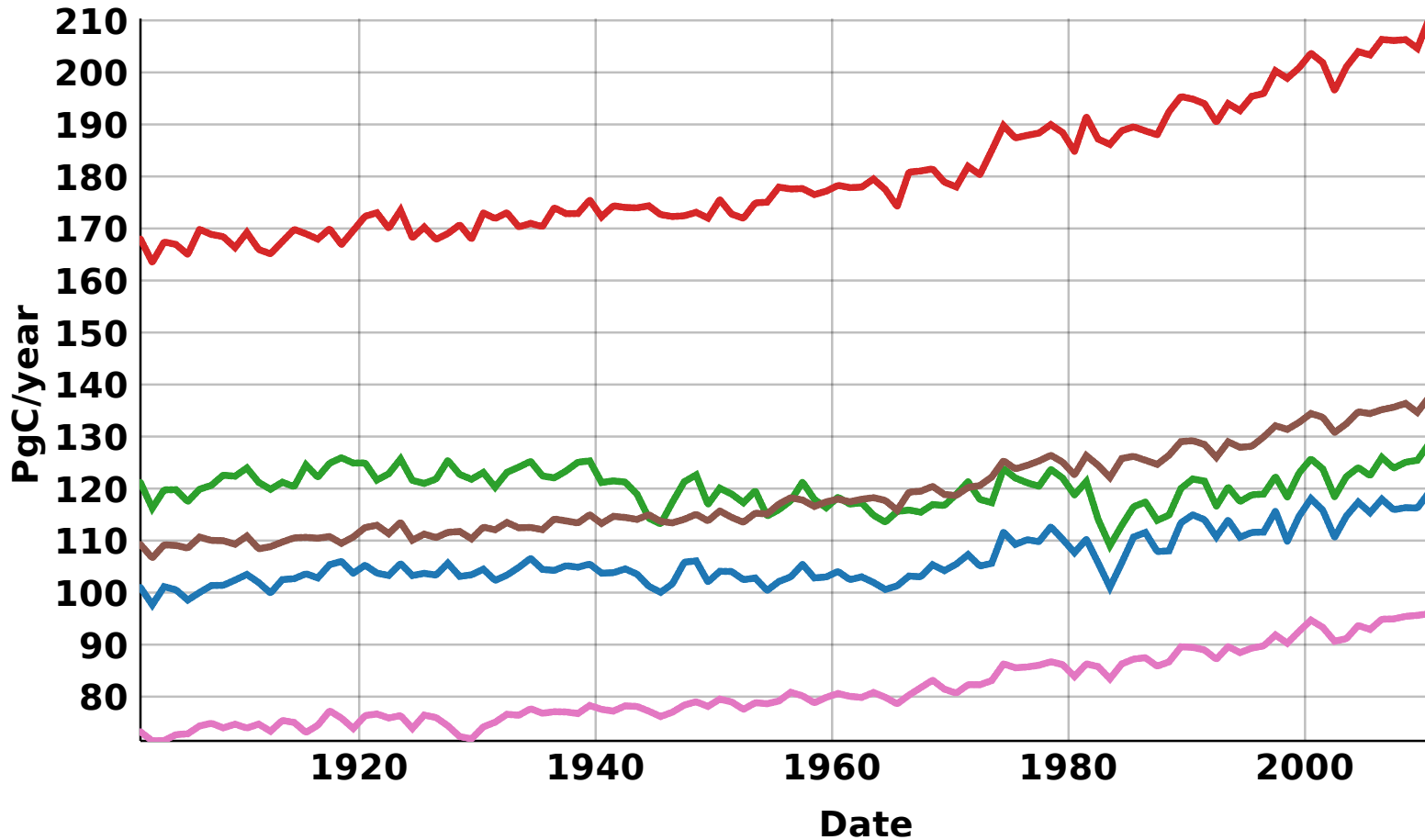
→ Further model improvement (N cycle, Permafrost,...)

GPP flux (photosynthesis) - Global



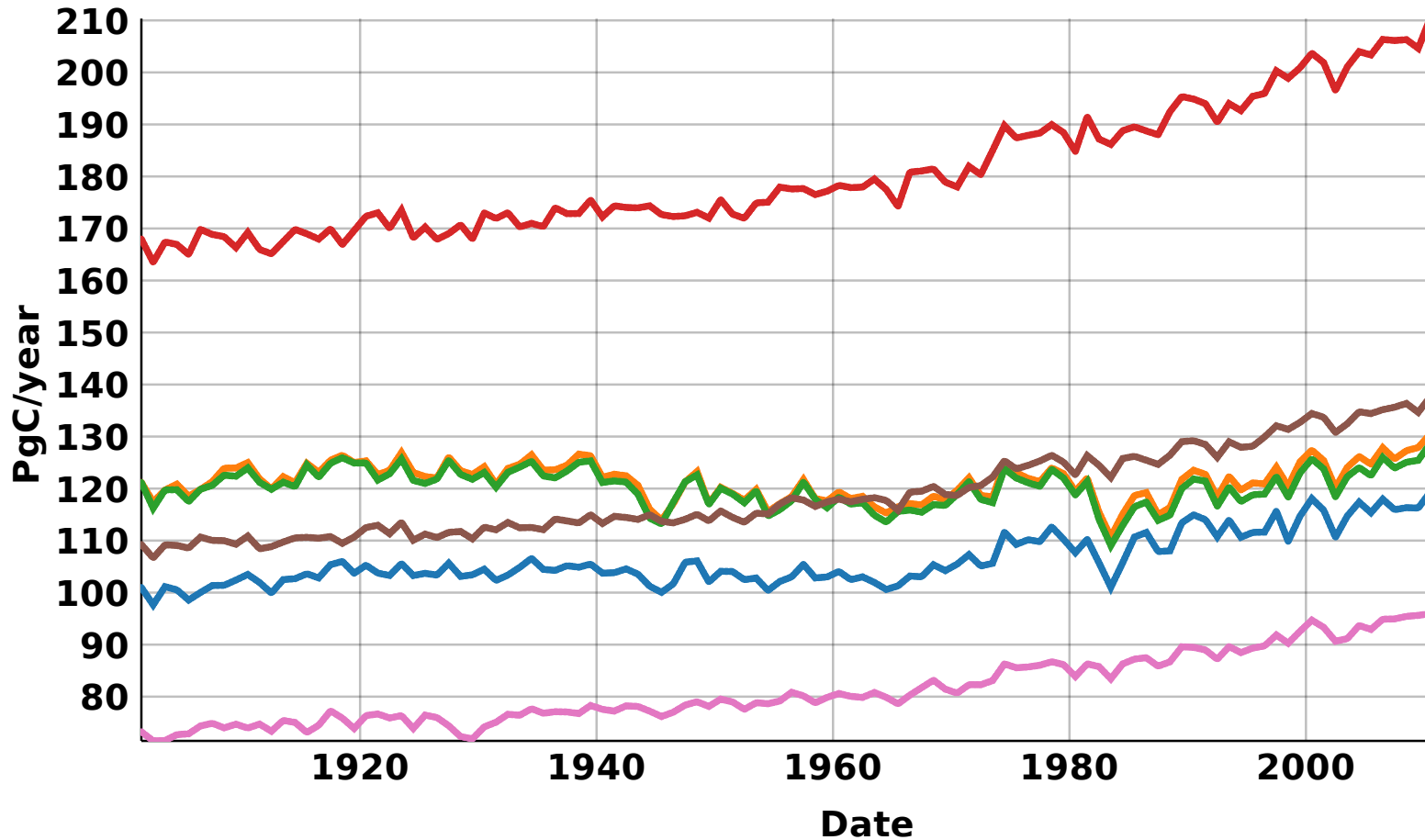
Meteorological forcings

GPP flux (photosynthesis) - Global



Meteorological forcings + Model version

GPP flux (photosynthesis) - Global



Meteorological forcings + **Model version** + **Land-use**