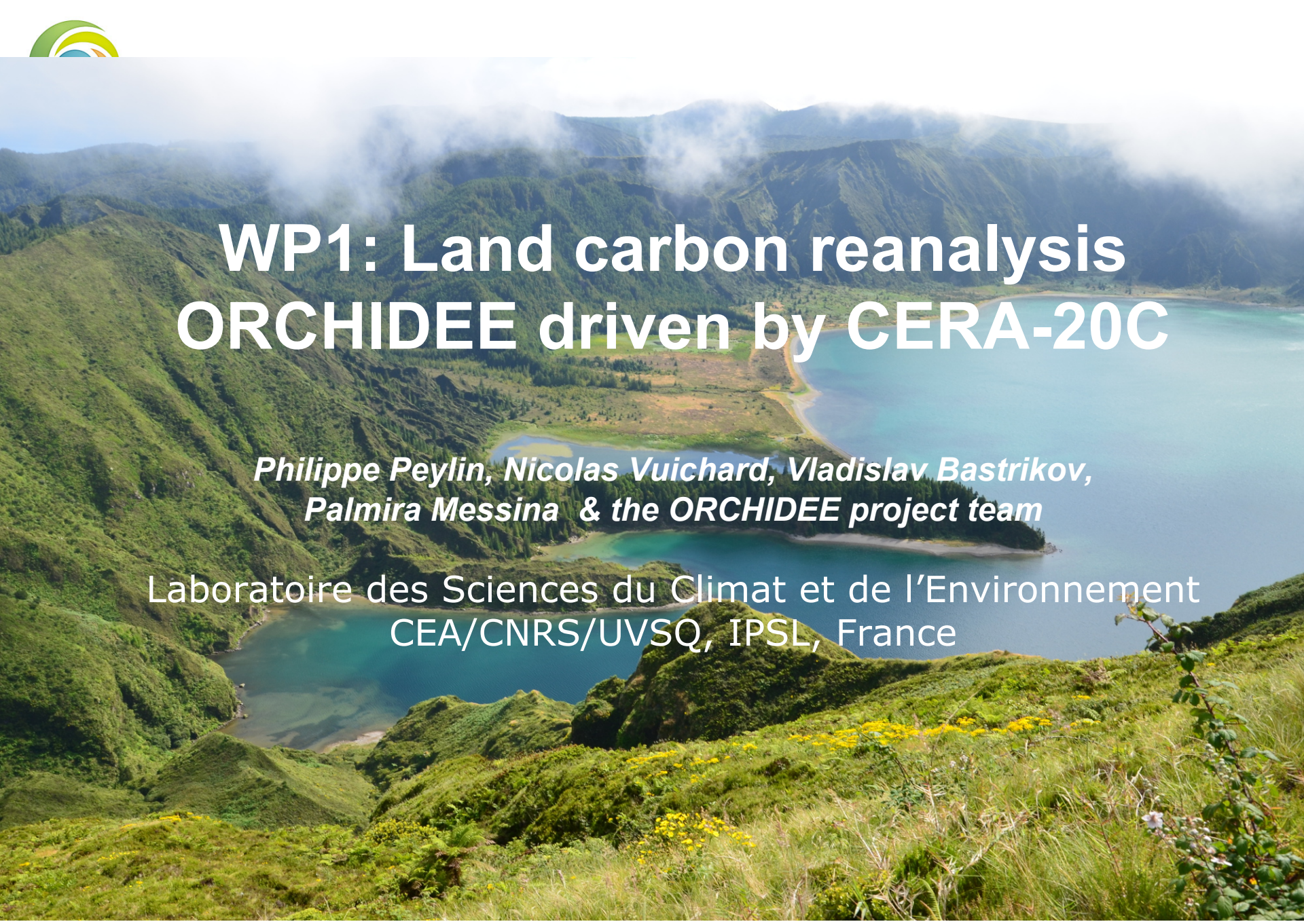


WP1: Land carbon reanalysis ORCHIDEE driven by CERA-20C

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

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

Overall proposed contribution

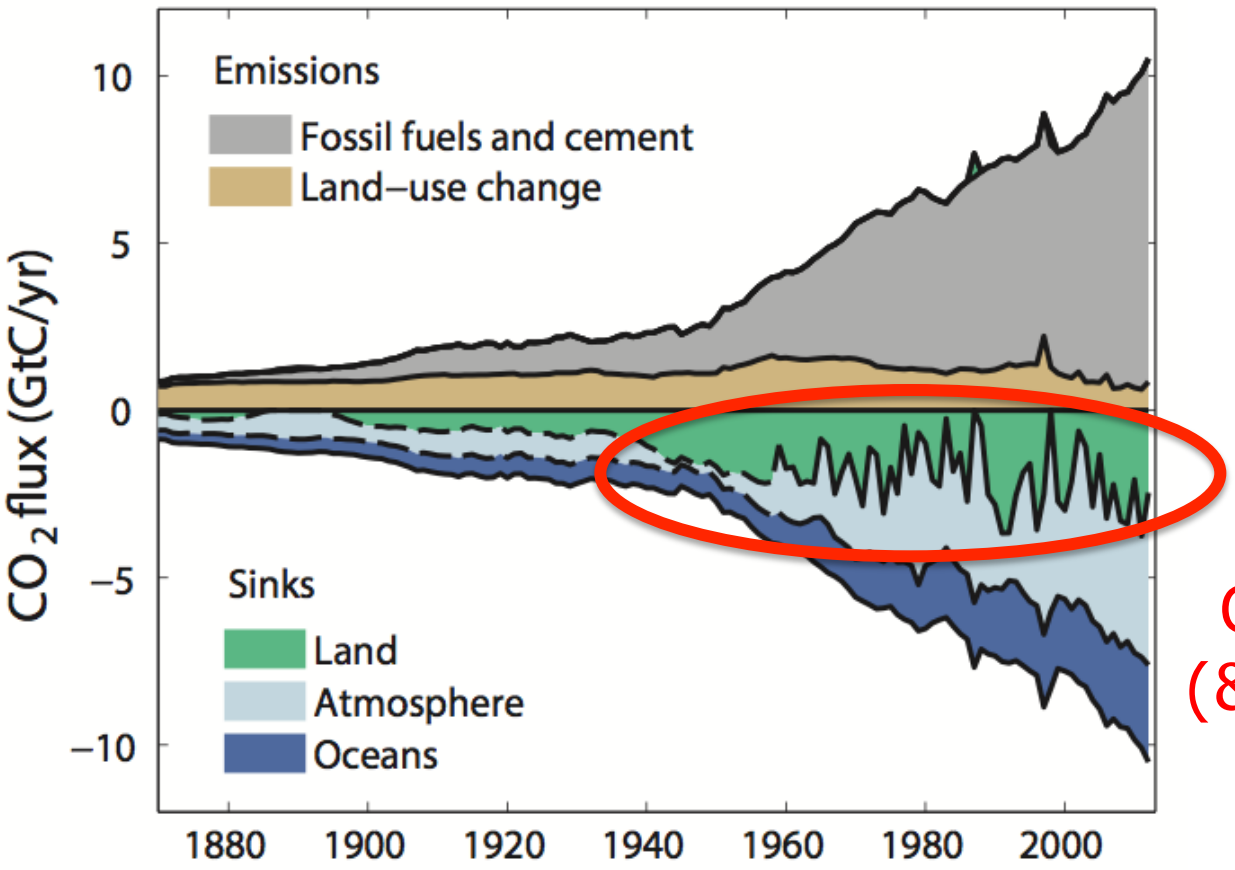
➔Adding the C-cycle to the reanalysis

- 110-year reanalysis with CERA-20C Done
- 9-year reanalysis with CERA-SAT Partly

- Surface C fluxes & uncertainties:
  - land (Net and Gross) fluxes
  - anthropogenic (fossil + LUC)
  - separated for Forests, Grass, Crops

- Land C stocks & uncertainties:
  - Aboveground & Belowground C pools

Global Carbon Budget



LAND focuss with ORCHIDEE (& CTESSEL)

Since 1750, human activities have emitted 555 ± 85 PgC (Fossil fuel + Luse)

Fossil fuel CO_2 emissions are ≈ 10 PgC yr-1 in 2015 (55% > 1990 level)

Over the past 50 years, 44 ± 6 % of emissions remains in the atmosphere

LSCE

Exemple: climate C-cycle links for Europe

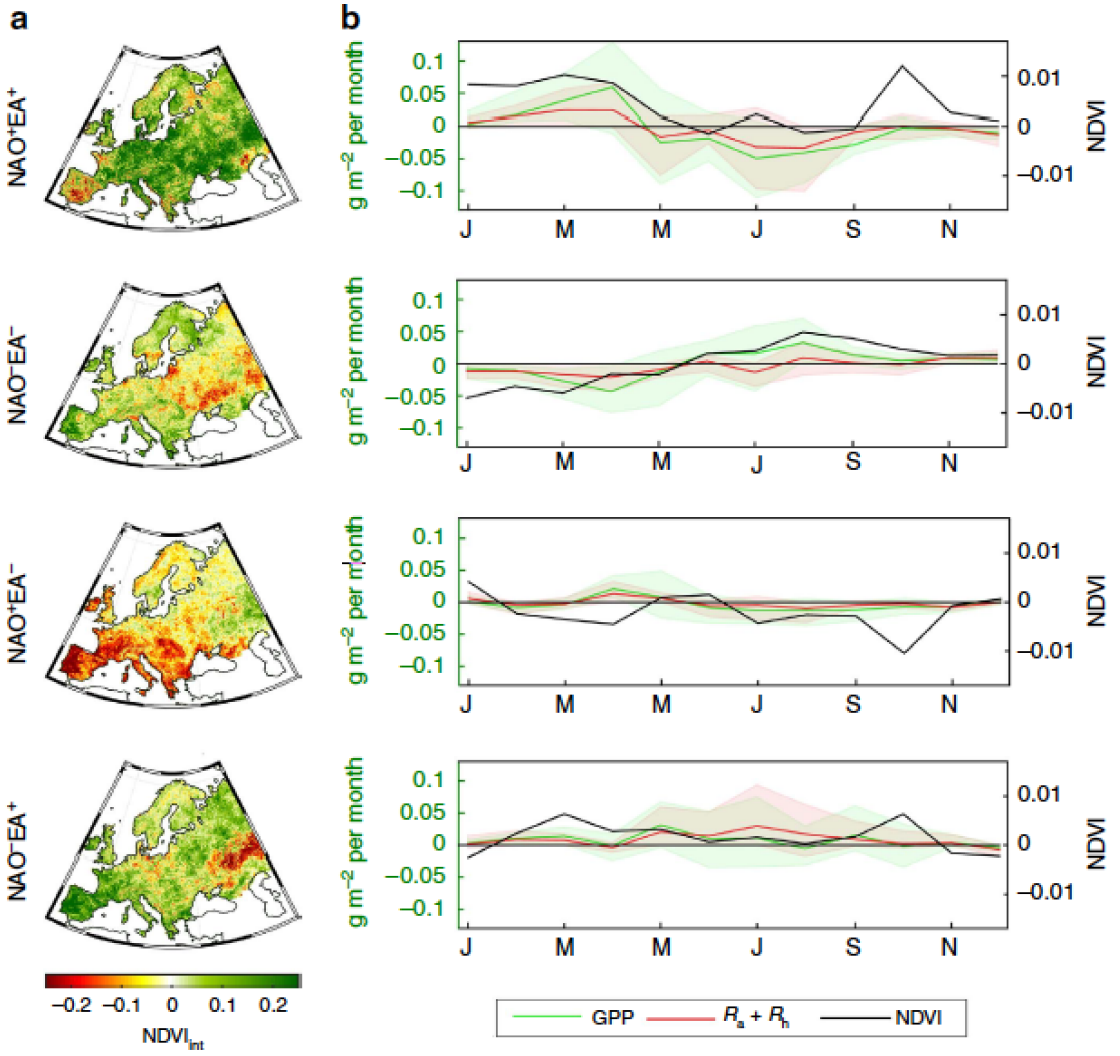
ARTICLE

Received 4 Mar 2015 | Accepted 27 Nov 2015 | Published 18 Jan 2016

DOI: 10.1038/ncomms10315 OPEN

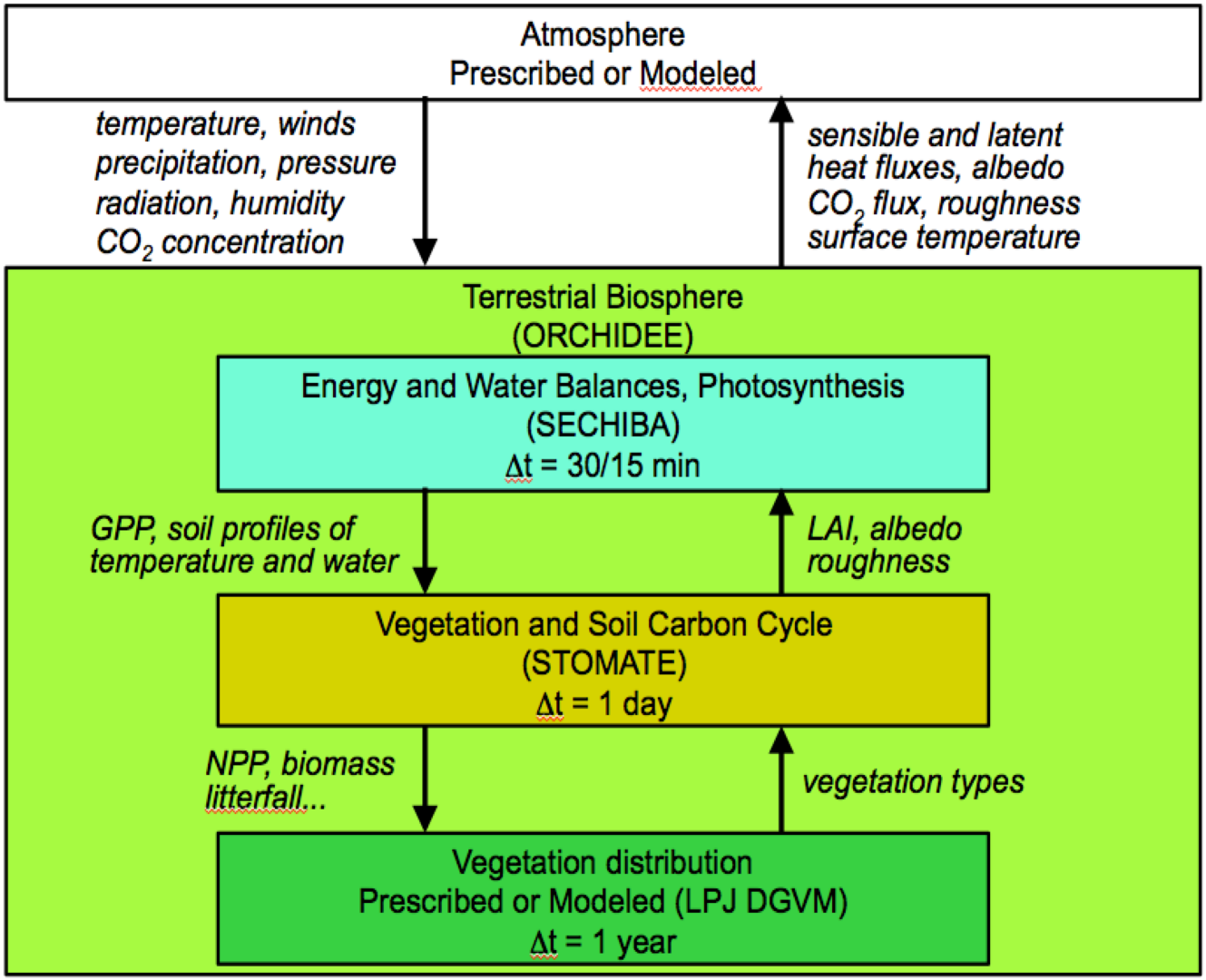
European land CO_2 sink influenced by NAO and East-Atlantic Pattern coupling

Ana Bastos[1,2], Ivan A. Janssens[3], Célia M. Gouveia[2], Ricardo M. Trigo[2], Philippe Ciais[1], Frédéric Chevallier[1], Josep Peñuelas[4,5], Christian Rödenbeck[6], Shilong Piao[7], Pierre Friedlingstein[8] & Steven W. Running[9]



Global Vegetation Model: ORCHIDEE

Simulates the Energy, Water and Carbon balance
Land component of the IPSL Earth System Model



Progresses made in 2017..

1. Update of the ORCHIDEE model; improvement of biophysical and biogeochemical processes
2. Parameter calibration through "data assimilation"
3. Performed several simulation with different
   - Climate forcing (CERA-20C, CERA-SAT, CRUNCEP,…)
   - Land cover scenario
   - Model version
4. Finalize the dedicated web-site to view all results
5. Process the data for easier access by all users

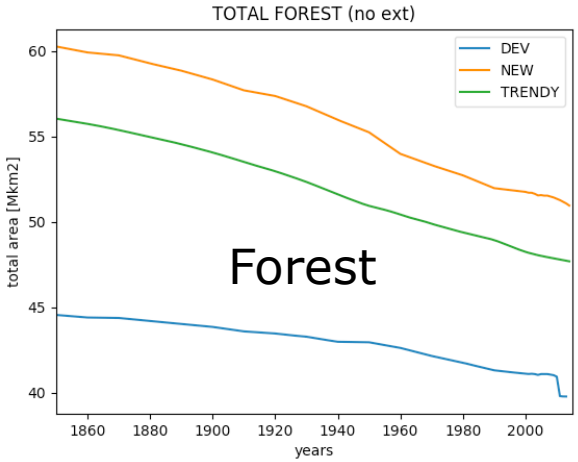
Meteorological forcing – CERA-20C

Climate reanalysis
(several variant)

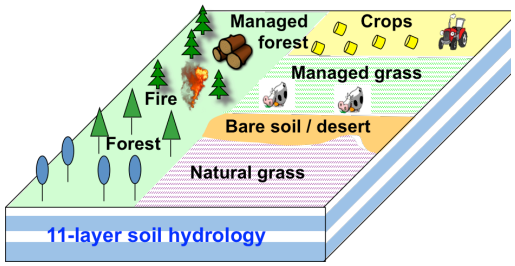
ORCHIDEE forcing

U and V wind at 10 meters
Specific humidity
Temperature at 2 meters
Rainfall
Snowfall
Solar radiation downward
Thermal radiation downwards.

Land cover scenarii
(using ESA-CCI land cover
& LUH historical products)



Model development
New processes
Optimal parameters



ORCHIDEE developments for CMIP6

Implemented: V1

Soon..: V1.5

Merging

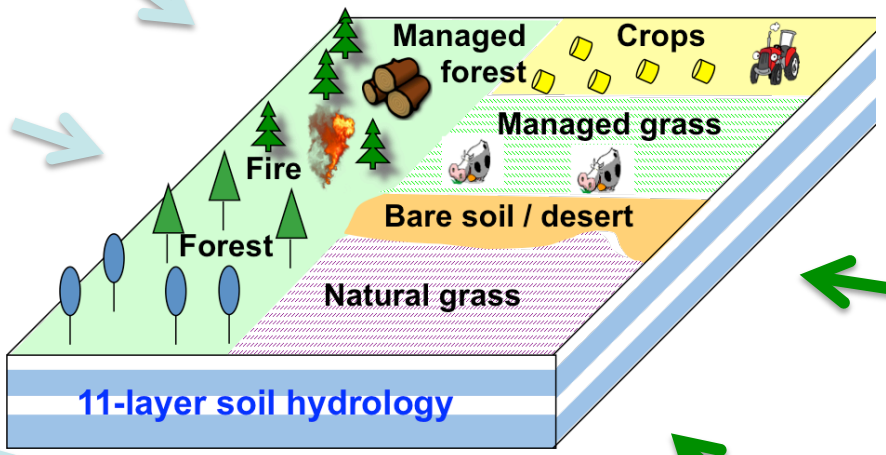
New Aerodynamic resistance

Nitrogen – carbon Coupled cycles

Optimized albedo (using MODIS)

Permafrost carbon

Land cover based on ESA-CCI



Forest management & forest structure

New 3 layers snow model

11-layer soil hydrology With soil freezing

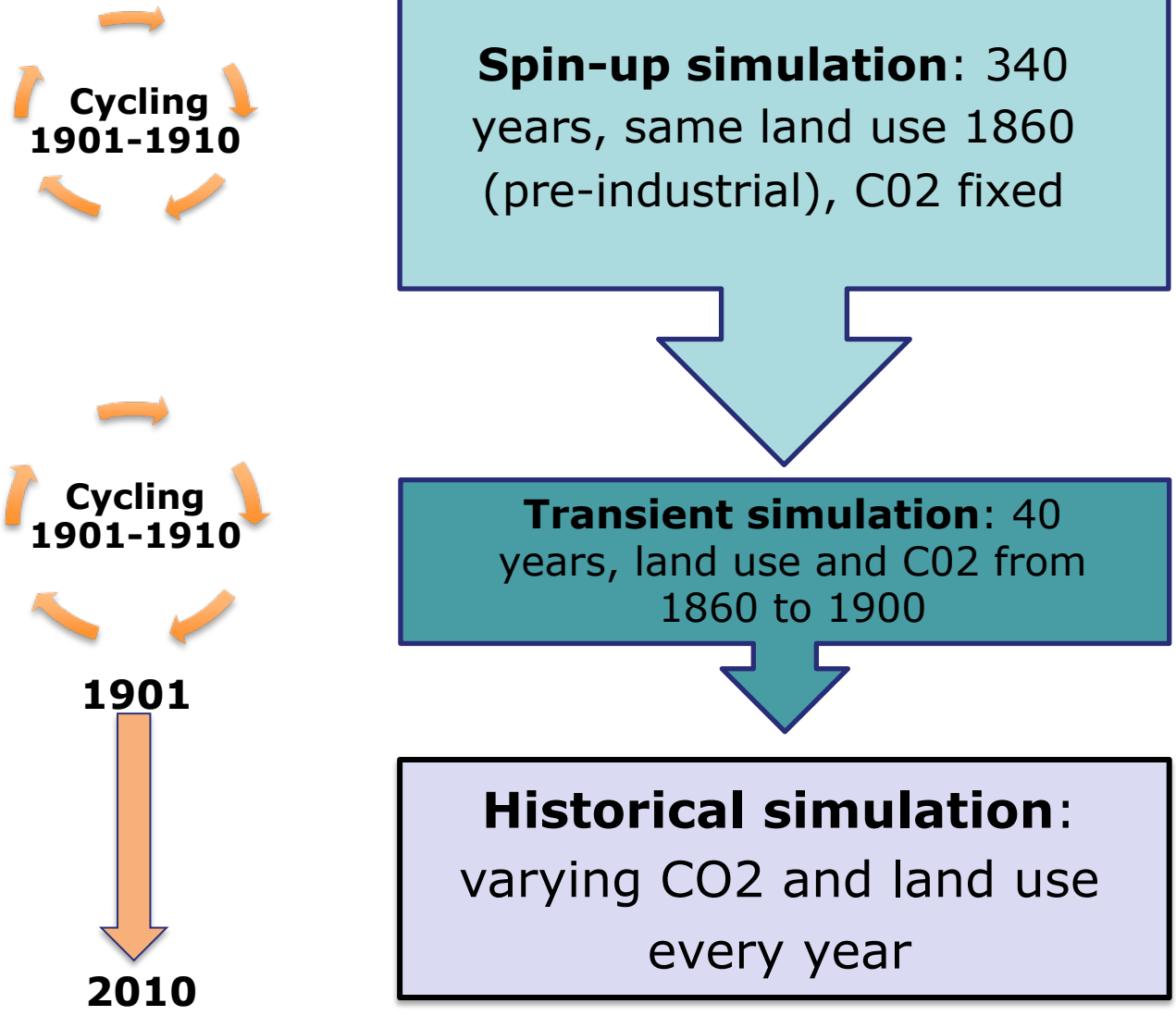
SPITFIRE and Land use gross transitions

Improved Carbon cycle description

COV fluxes

CH4 emissions (wetland and permafrost)

Simulation setup (CERA-20C)



Simulations performed

- 3 model versions : R1, R2, R3
- 5 climate forcing: F1 – F5
- 3 land cover : LC1 – LC3

Nb	Title	Model version	Res.	Meteo forcing	Land cover	Period
1	R1-F1-LC2-1	Rev_3977	1°	CERA-20C	CM6_v1	1901-2010
2	R1-F1-LC1-1	Rev_3977	1°	CERA-20C	CM5	1901-2010
3	R1-F3-LC2-1	Rev_3977	1°	CRU-NCEP	CM6_v1	1901-2010
4	R3-F1-LC3-1	Rev_4783	1°	CERA-20C	CM6_v2	1901-2010
5	R2-F4-LC2-05	Rev_4661	0.5°	WFDEI	CM6_v1	1979-2009
6	R3-F3-LC3-2	Rev_4783	2°	CRU-NCEP	CM6_v2	1901-2010
7	R3-F1-LC1-1	Rev_4783	1°	CERA-20C	CM5	1901-2010
8	R3-F3-LC3-1	Rev_4783	1°	CRU-NCEP	CM6_v2	1901-2010
9	R3-F2-LC3-05	Rev_4783	0.5°	CERA-SAT	CM6_v2	2008-2014
10	R3-F2-LC4-05	Rev_4783	0.5°	CERA-SAT	ESA-CCI	ongoing
11	R3-F5-LC3-1	Rev_4783	1°	GSWP3	CM6_v2	1901-2007
12	R3-F6-LC3-1	Rev_4783	1°	CERA-20C member 2	CM6_v2	ongoing

Issues & ongoing work

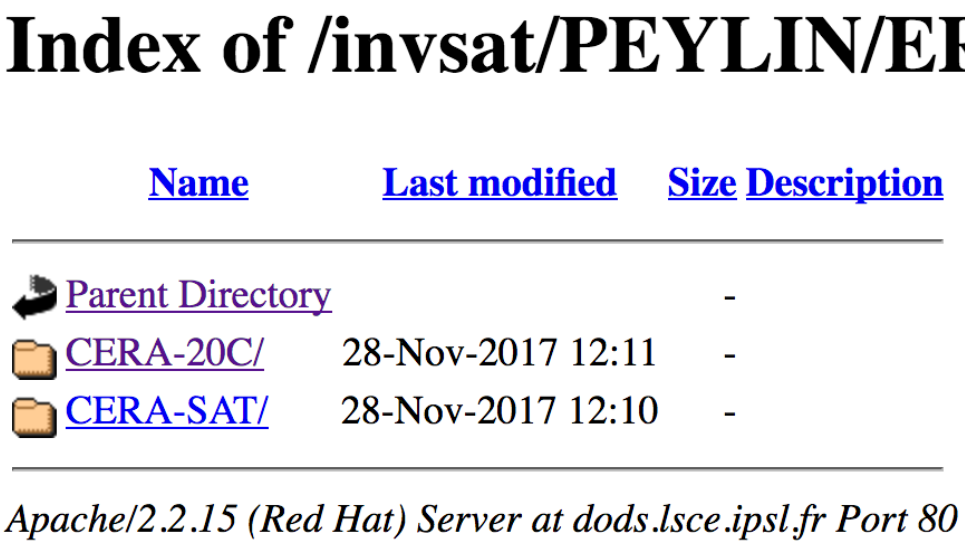
- Late preparation of the CERA-SAT forcing
  - ➔ Simulation without a complete spin-up
  - ➔ Analysis of the gross fluxes only (GPP)
  - ➔ Delays in the deliverables

- Simulation with another climate member (CERA-20C) is still ongoing.
  - ➔ We choose to run in priority other climate forcing

➔ All simulations / data-set will be available at the end of 2017 !

Distribution of the data

- Using a « dods » server:
  http://dods.lsce.ipsl.fr/invsat/PEYLIN/ERACLIM2/



Index of /invsat/PEYLIN/ERACLIM2

Name	Last modified	Size	Description
Parent Directory		-	
CERA-20C/	28-Nov-2017 12:11	-	
CERA-SAT/	28-Nov-2017 12:10	-	

Apache/2.2.15 (Red Hat) Server at dods.lsce.ipsl.fr Port 80

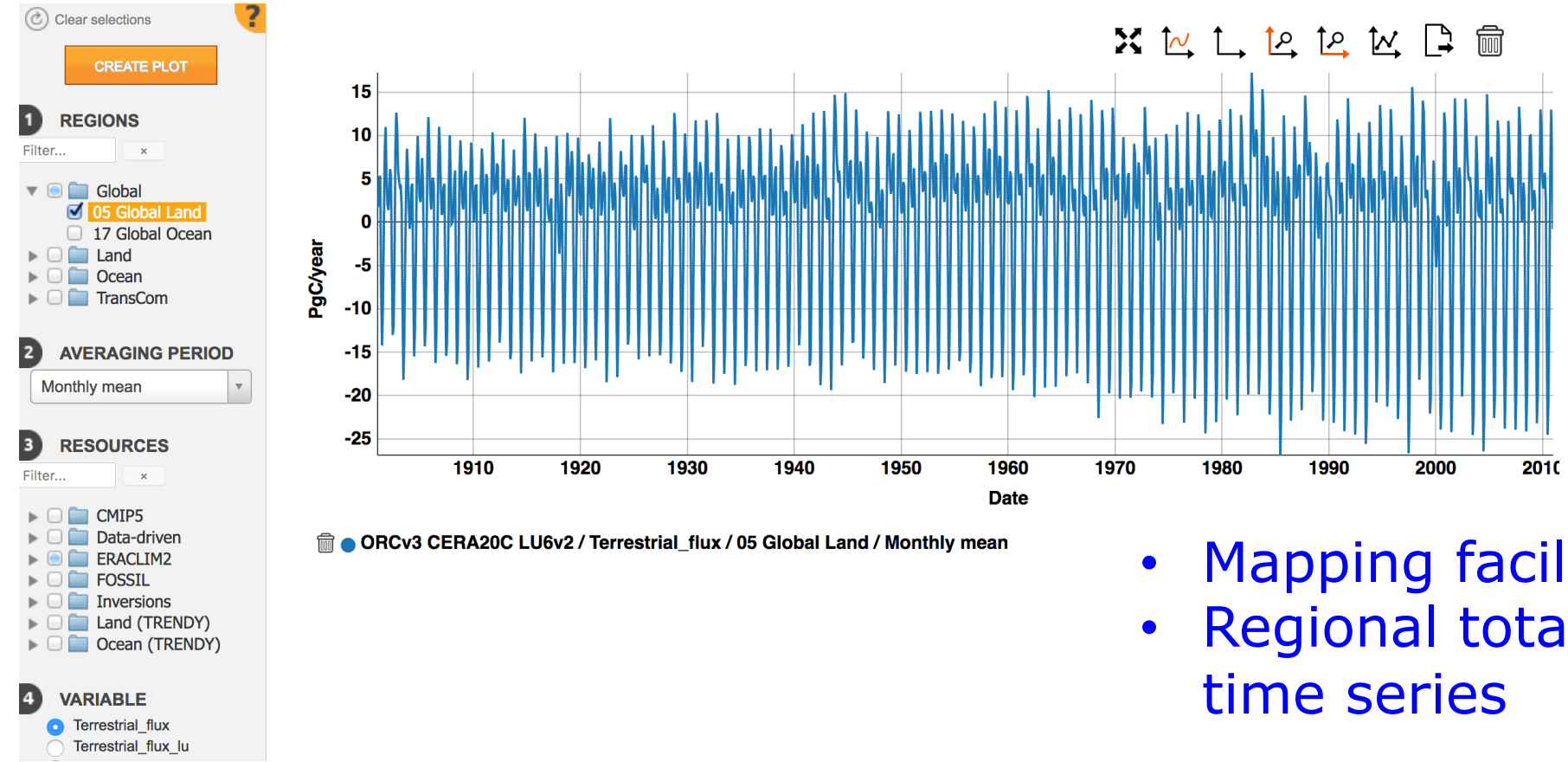
- Update with one file per variable (this week)

Reanalysis with ERA-20C
Analysis & comparison to other products

A dedicated web site to view C results

http://eraclim.globalcarbonatlas.org/

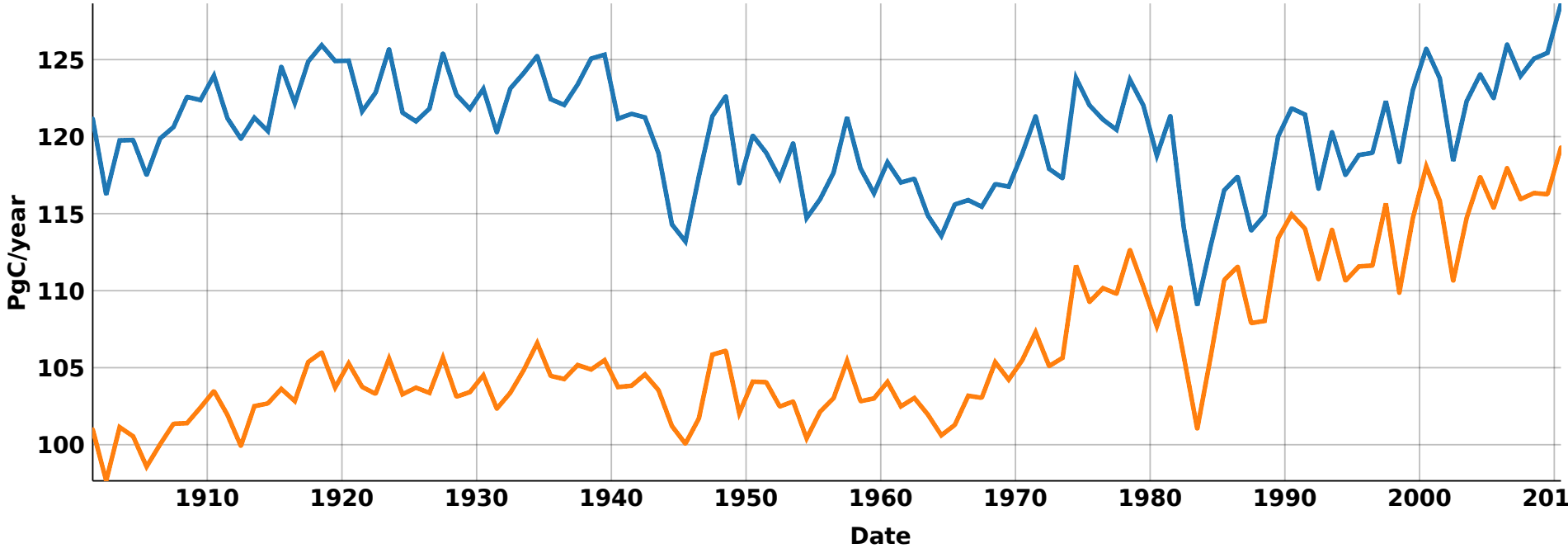
User/Passwd: eraclim / eraclim2017



- Mapping facility
- Regional total time series

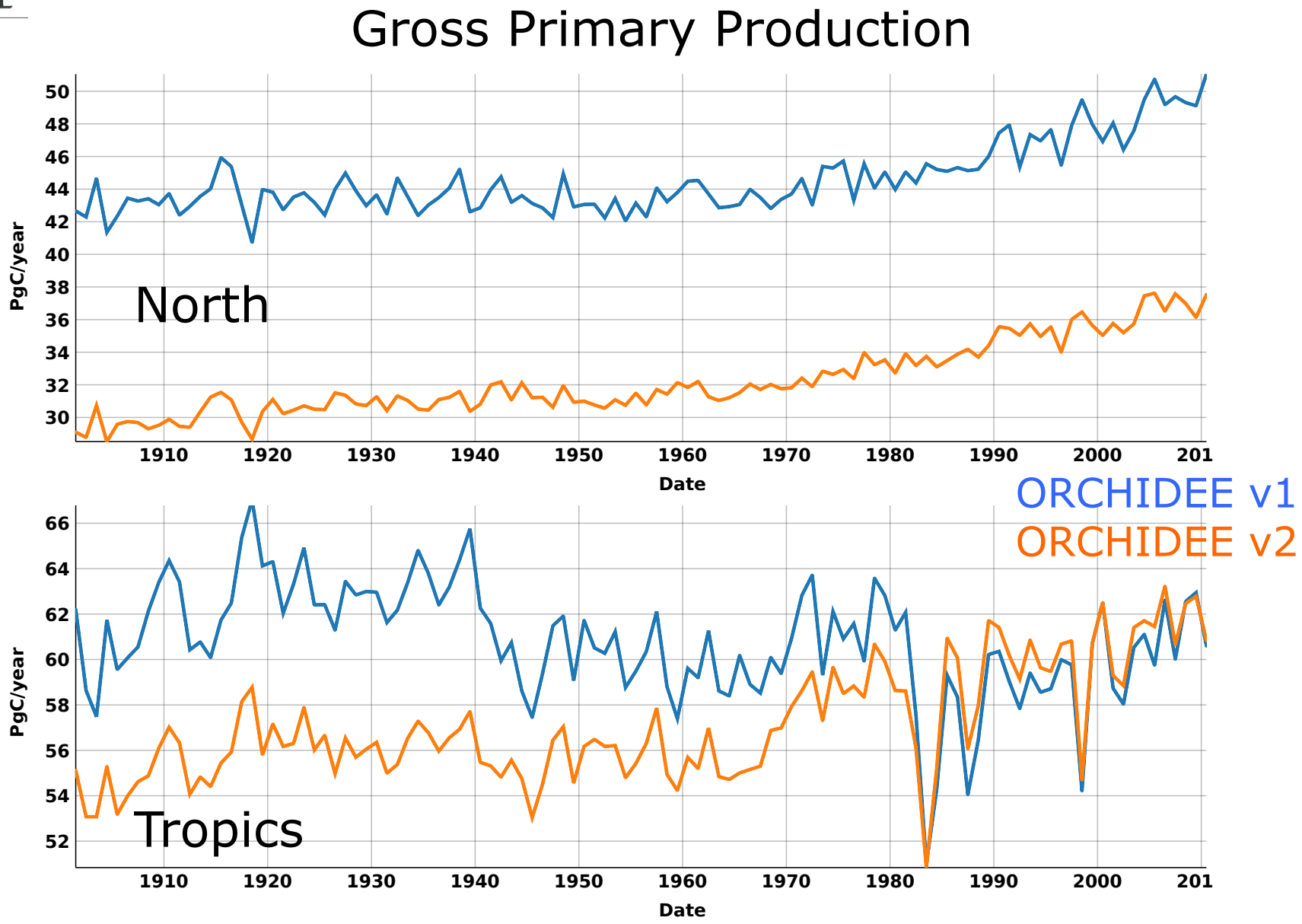
Impact of the new model version

Gross Primary Production (global)



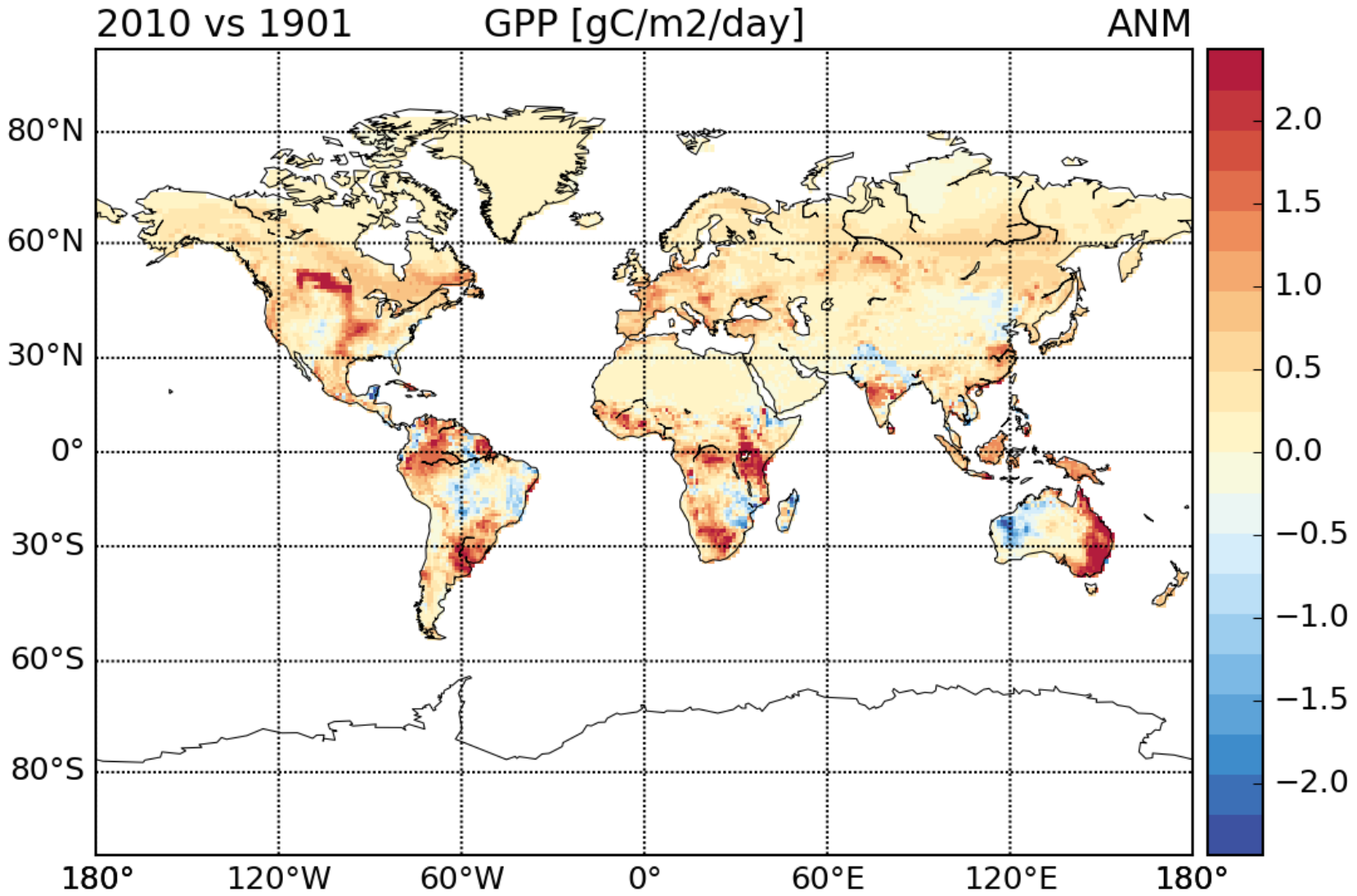
ORCHIDEE v1
ORCHIDEE v2

Impact of the new model version



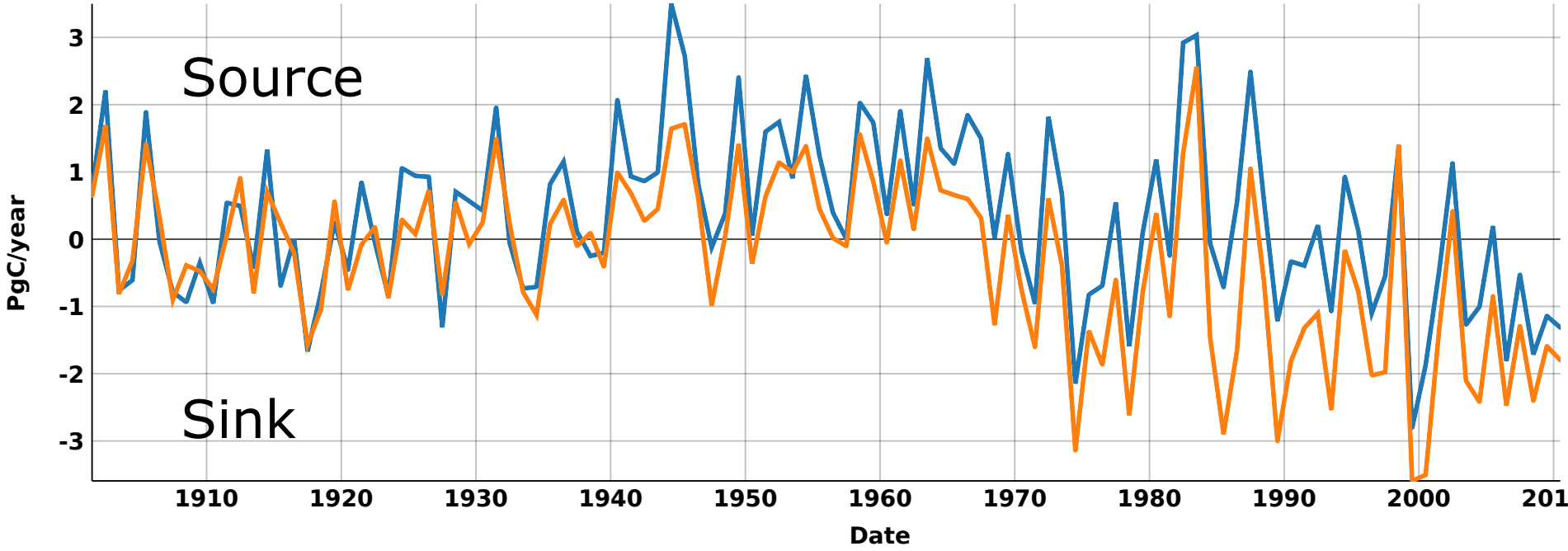
Change of gross primary production

GPP : 2010 - 1901



Impact of the new model version

Net carbon flux (global)

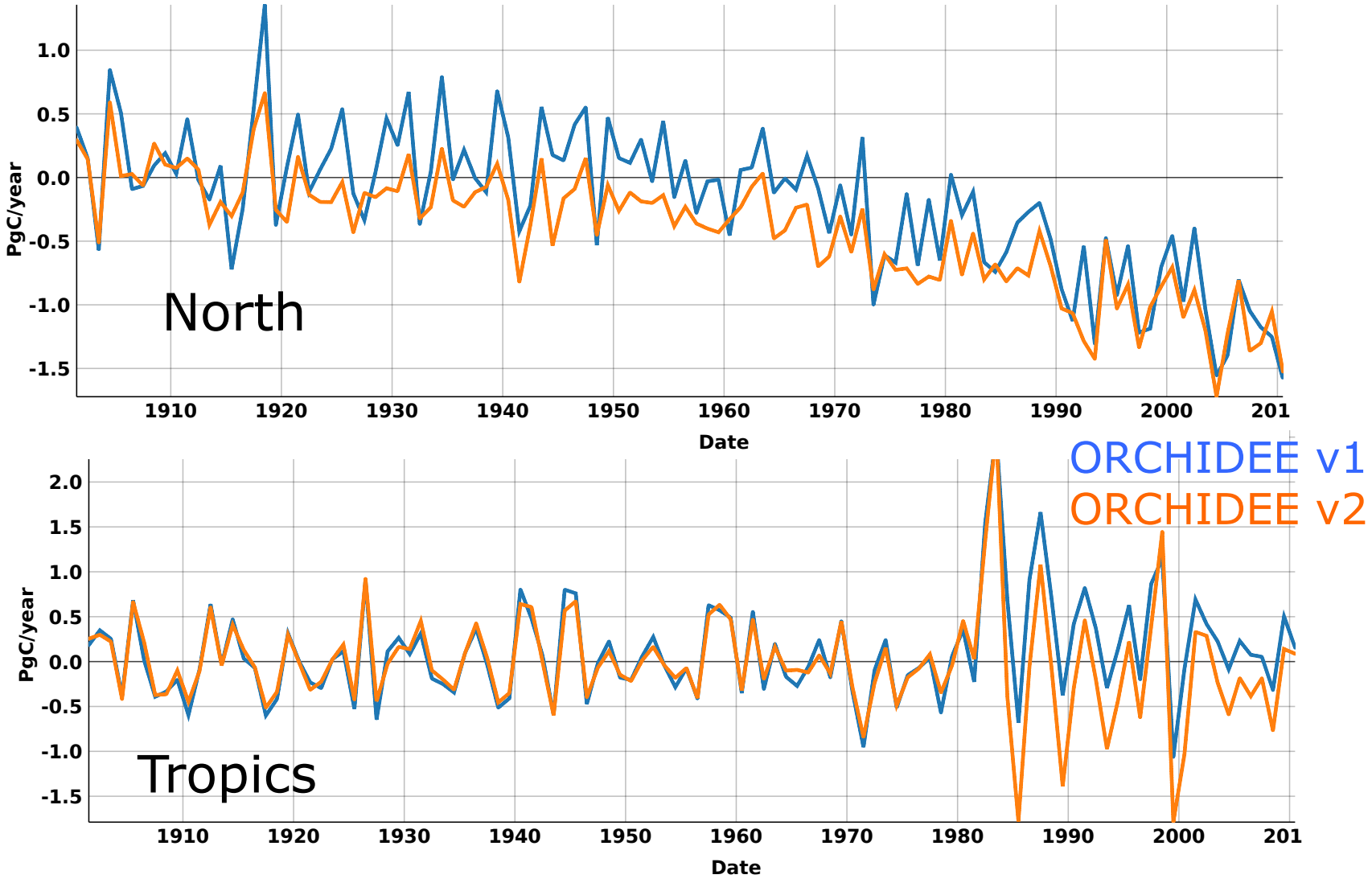


ORCHIDEE v1

ORCHIDEE v2

Impact of the new model version

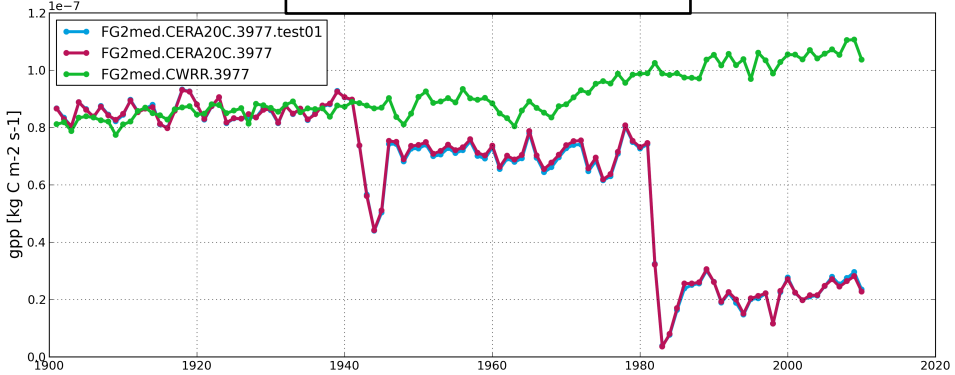
Net carbon flux



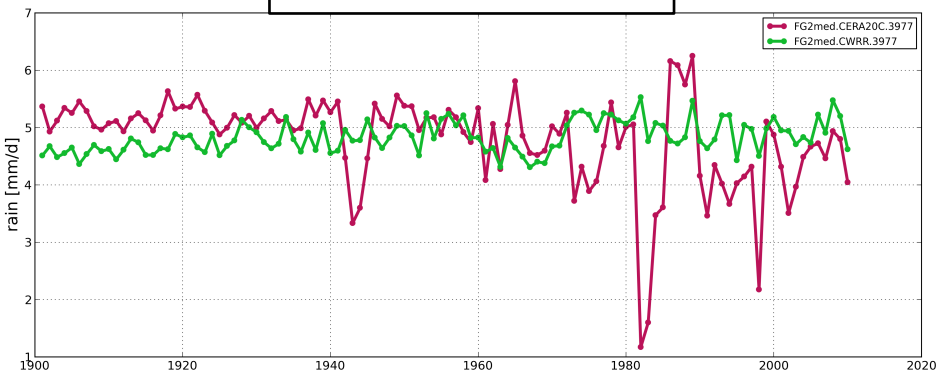
Tropical South America

LSCE

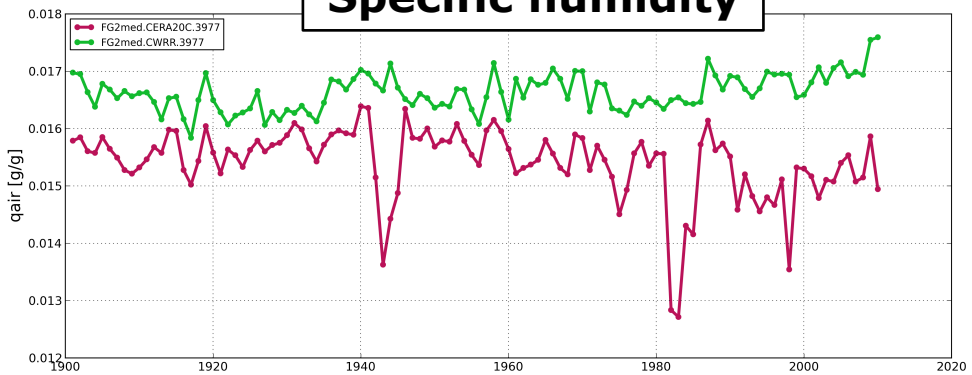
GPP



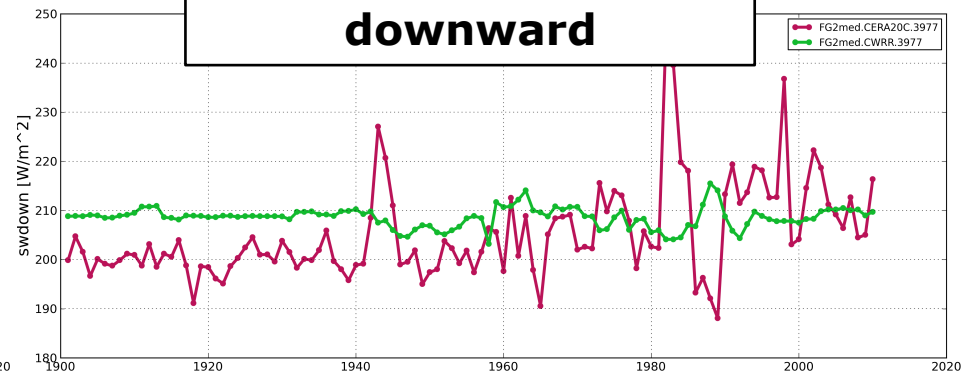
Rain



Specific humidity



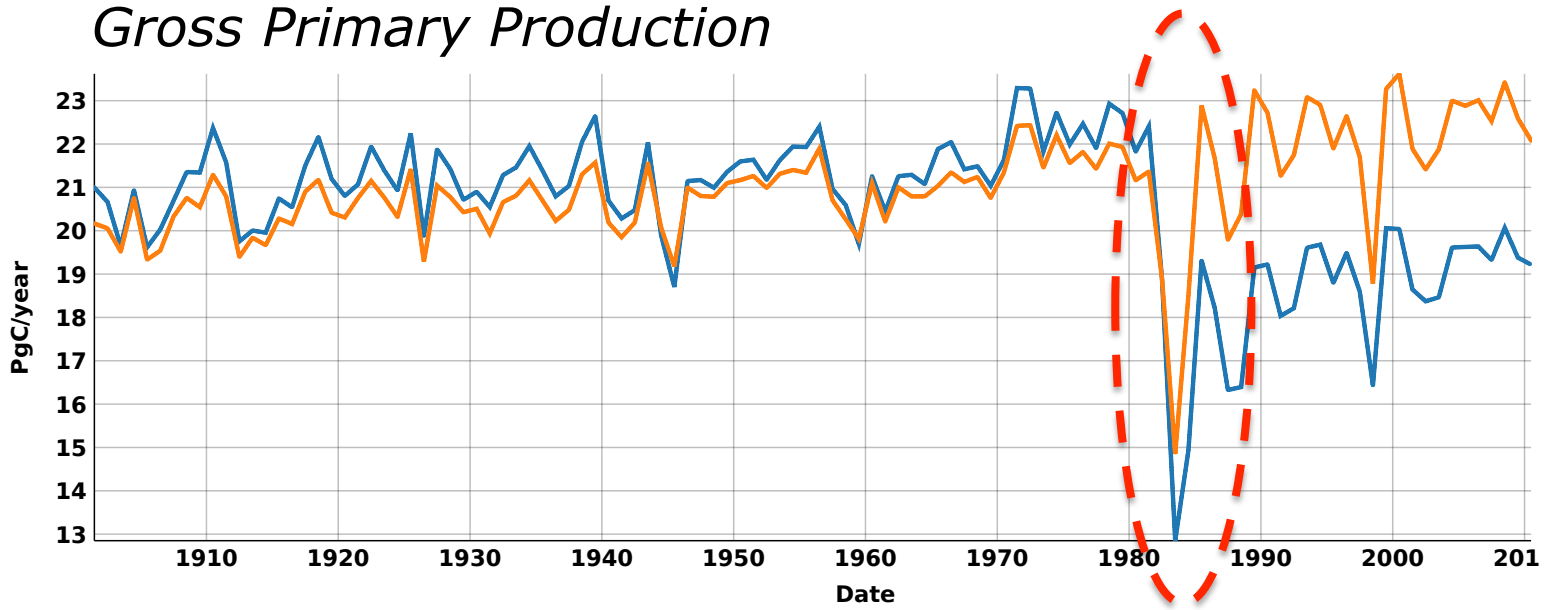
Solar radiation downward

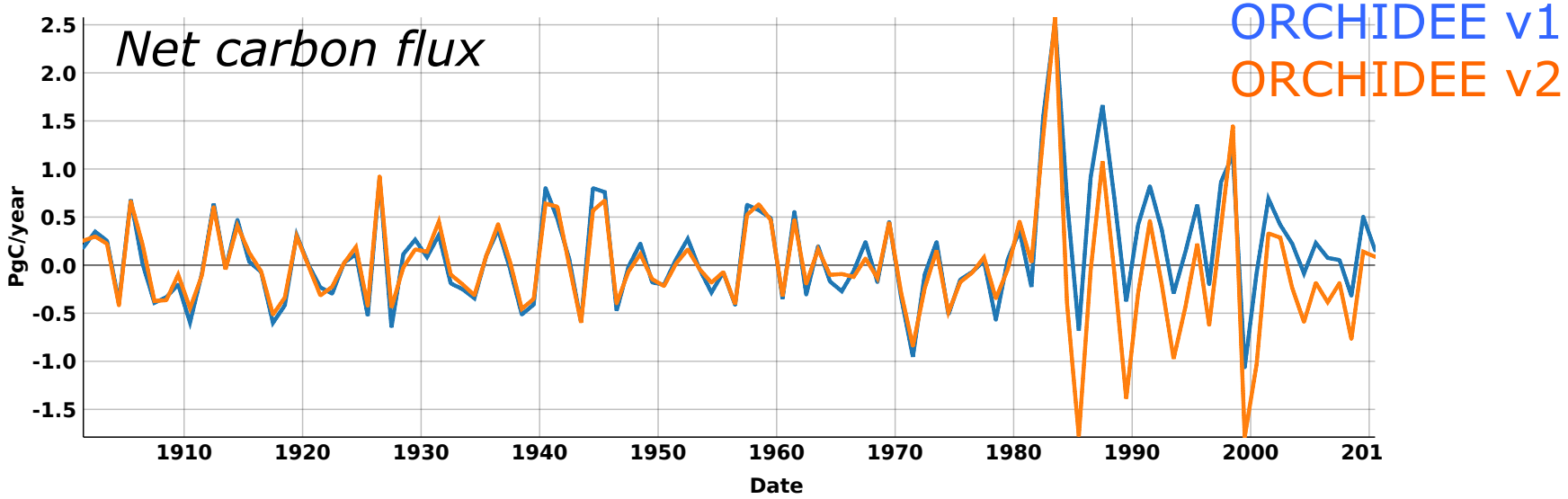


CERA20C **CRUNCEP**

The strong drop of LAI and GPP is linked to a sever decrease of rainfall

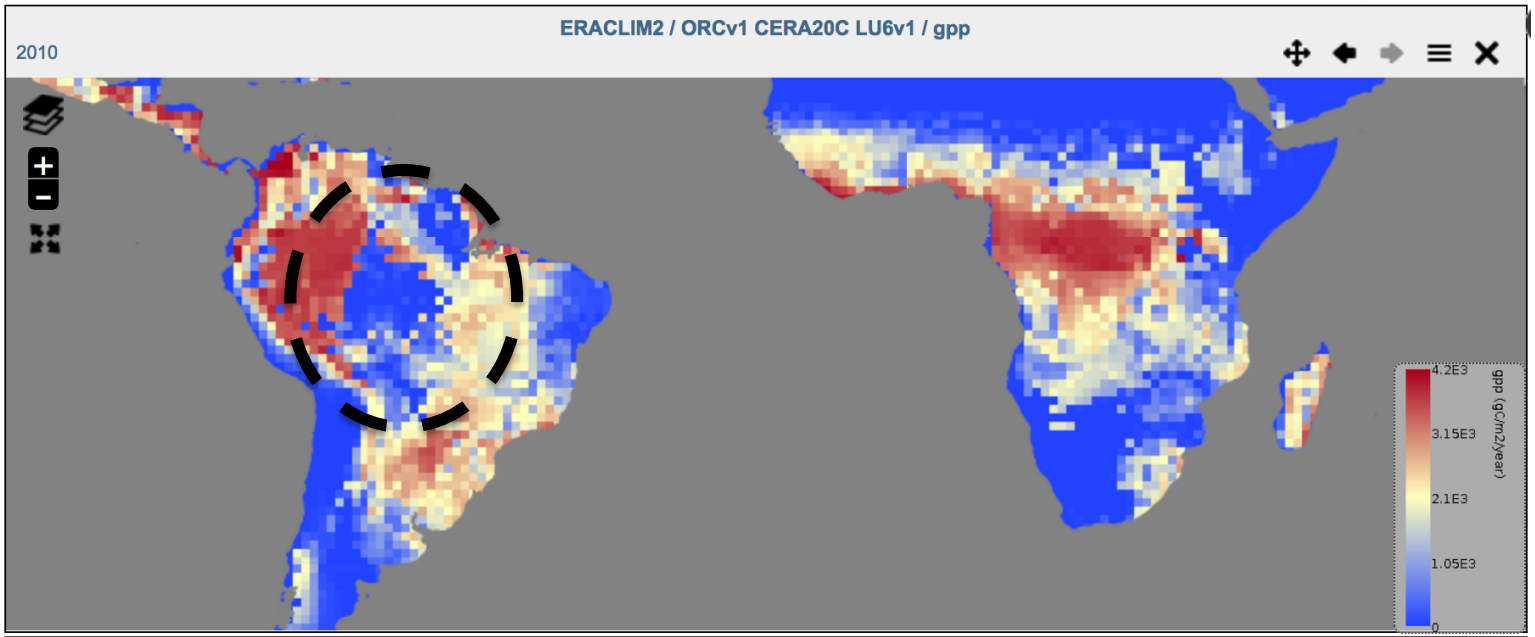
Tropical South America



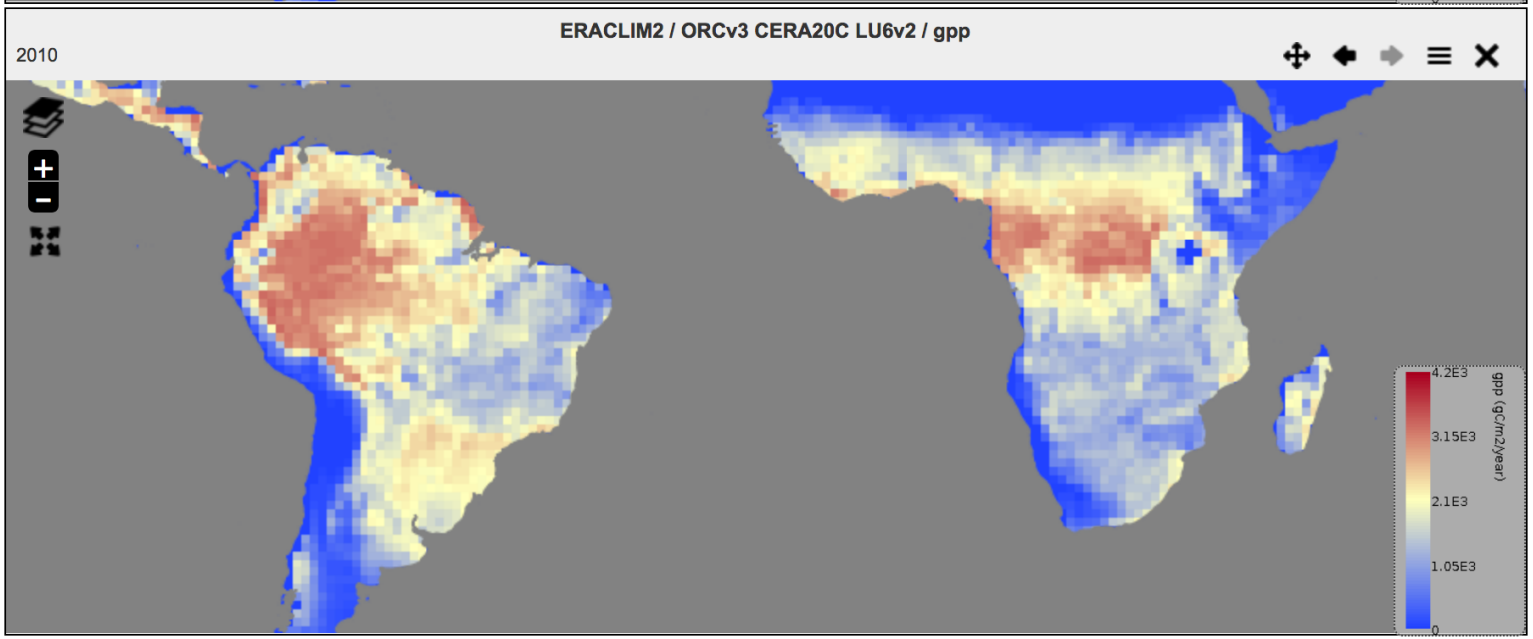


Tropical South America

ORC v1



ORC v2

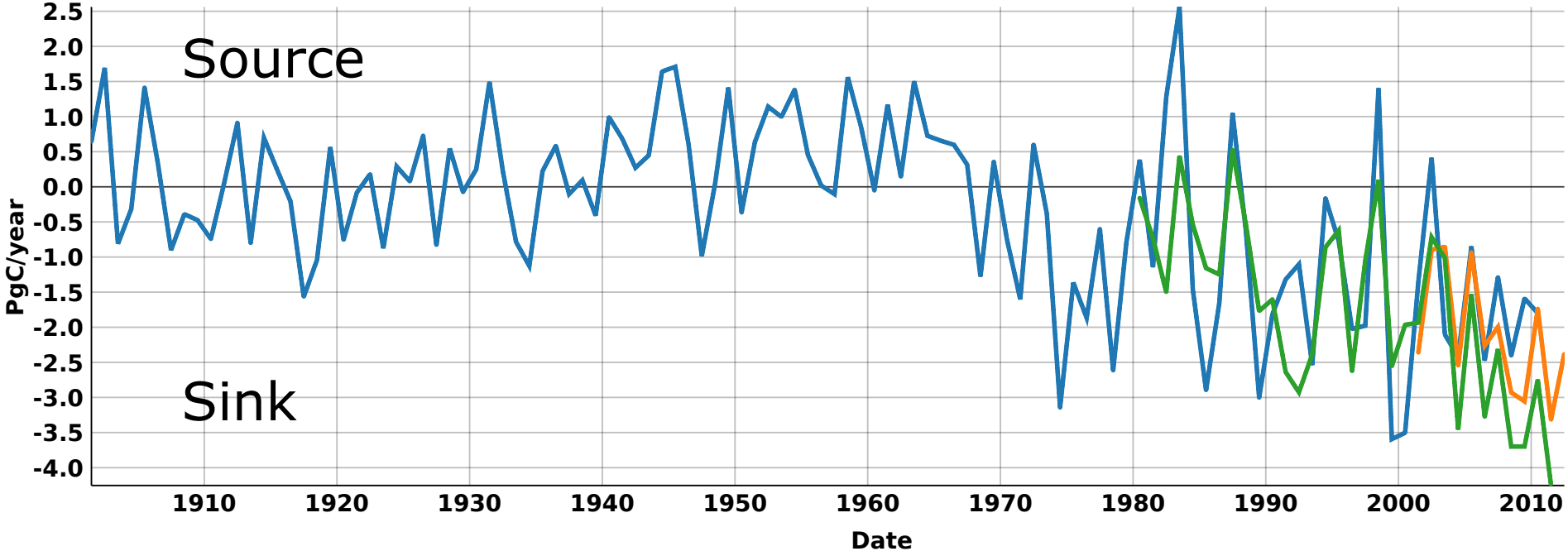


Net Carbon fluxes evaluation

LSCE

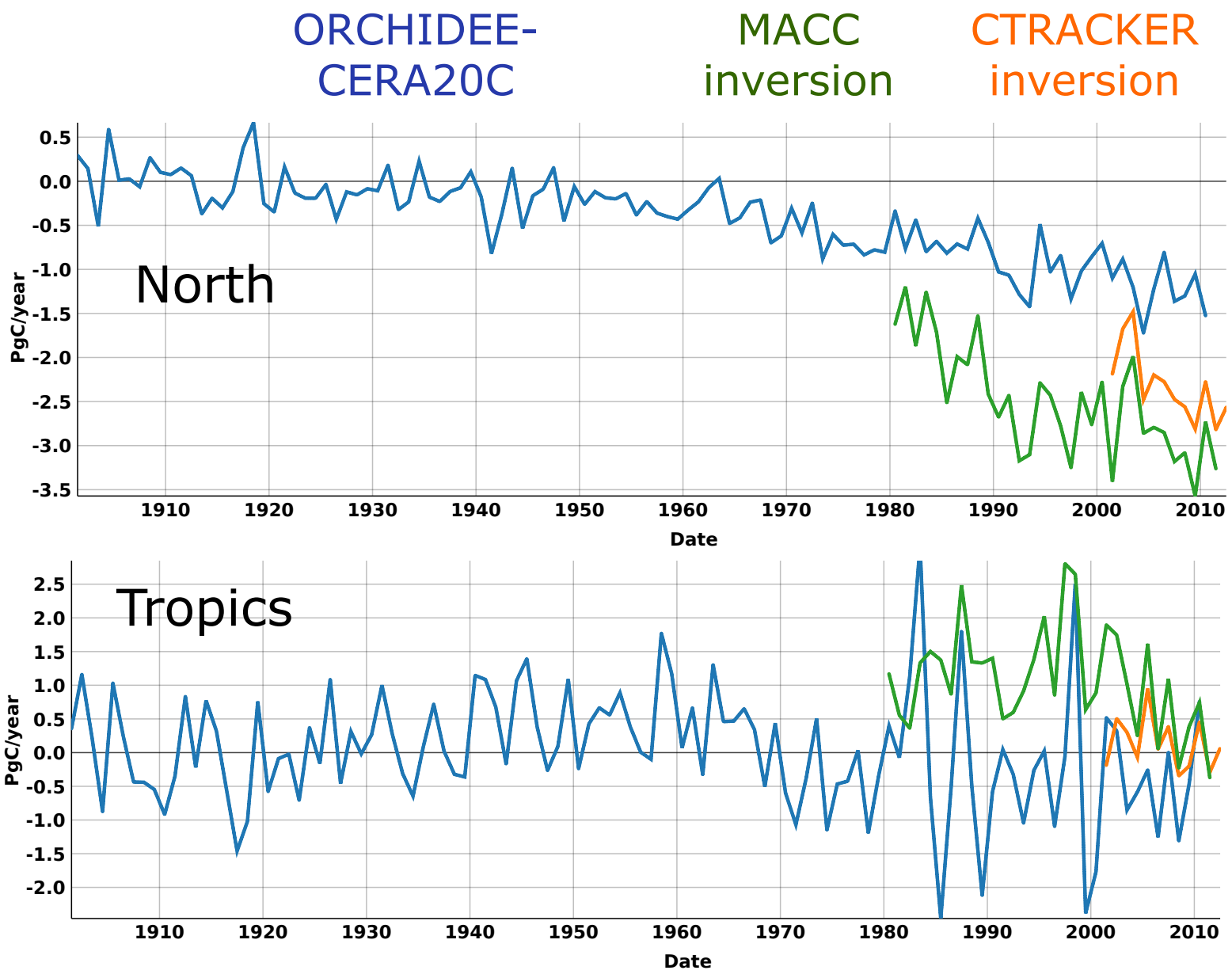
Global land flux (PgC/yr)

ORCHIDEE-CERA20C **MACC inversion** **CTRACKER inversion**



- ORCv3 CERA20C LU6v2 / Terrestrial_flux / 05 Global Land / Yearly mean
- CTRACKER US 2013 / Terrestrial_flux / 05 Global Land / Yearly mean
- LSCE var MACC V12 3 / Terrestrial_flux / 05 Global Land / Yearly mean

Net Carbon fluxes evaluation

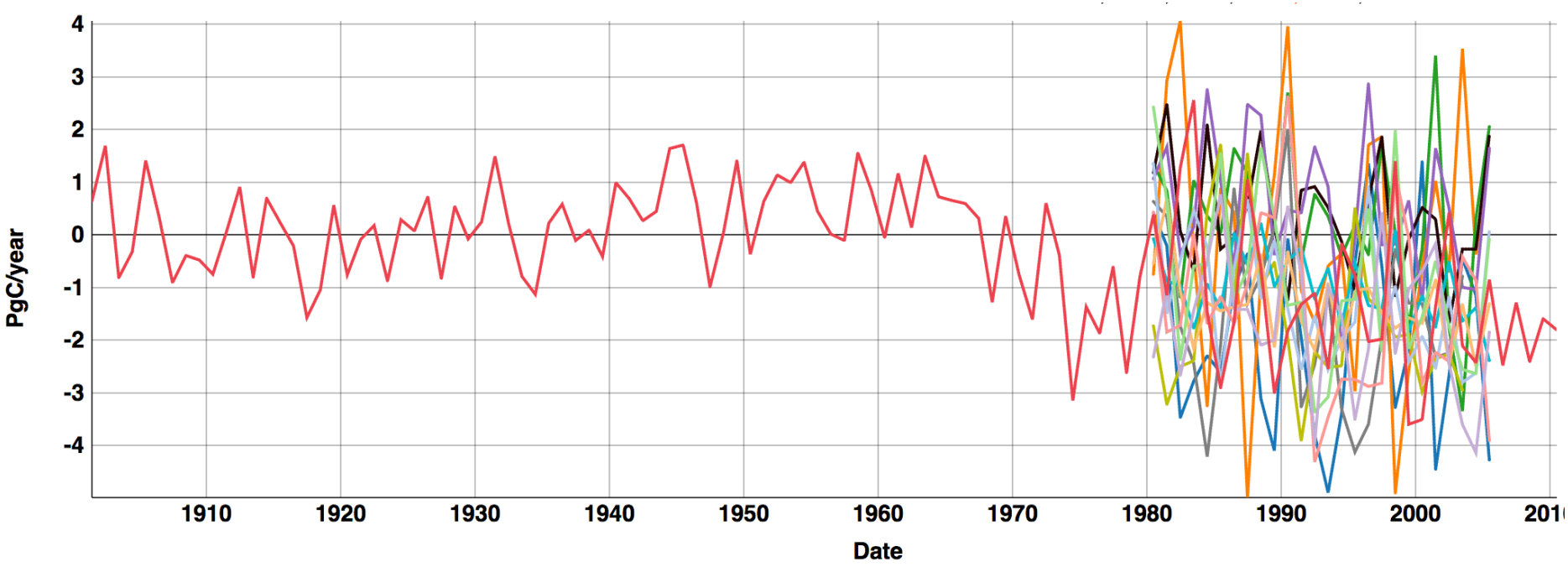


Net Carbon fluxes evaluation

LSCE

ORCHIDEE-CERA20C

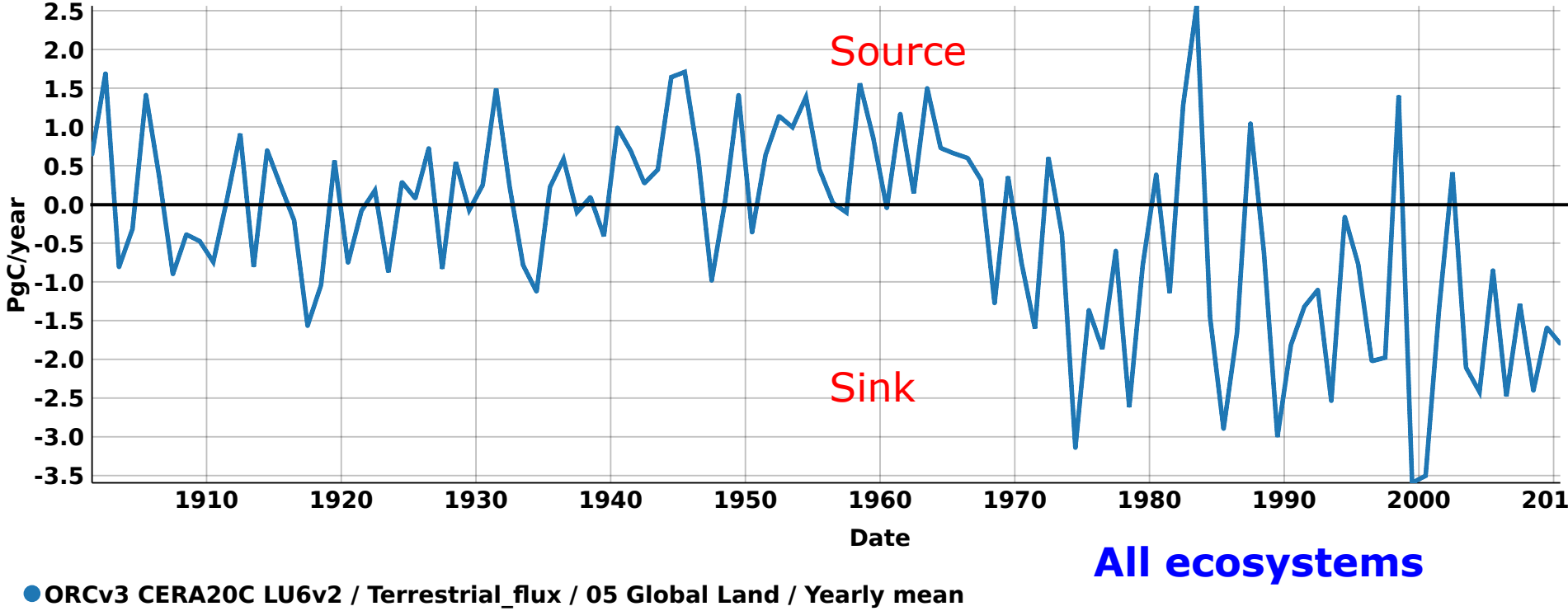
CMIP5 MODELS



- BNU ESM / Terrestrial_flux / 05 Global Land / Yearly mean
- CCSM4 / Terrestrial_flux / 05 Global Land / Yearly mean
- CESM1 CAM5 / Terrestrial_flux / 05 Global Land / Yearly mean
- HadGEM2 ES / Terrestrial_flux / 05 Global Land / Yearly mean
- IPSL CM5A MR / Terrestrial_flux / 05 Global Land / Yearly mean
- MIROC ESM CHEM / Terrestrial_flux / 05 Global Land / Yearly m...
- MPI ESM MR / Terrestrial_flux / 05 Global Land / Yearly mean
- CanESM2 / Terrestrial_flux / 05 Global Land / Yearly mean
- CESM1 BGC / Terrestrial_flux / 05 Global Land / Yearly mean
- HadGEM2 CC / Terrestrial_flux / 05 Global Land / Yearly mean
- IPSL CM5A LR / Terrestrial_flux / 05 Global Land / Yearly mean
- IPSL CM5B LR / Terrestrial_flux / 05 Global Land / Yearly mean
- MPI ESM LR / Terrestrial_flux / 05 Global Land / Yearly mean
- ORCv3 CERA20C LU6v2 / Terrestrial_flux / 05 Global Land / Ye...

Net carbon fluxes per ecosystems

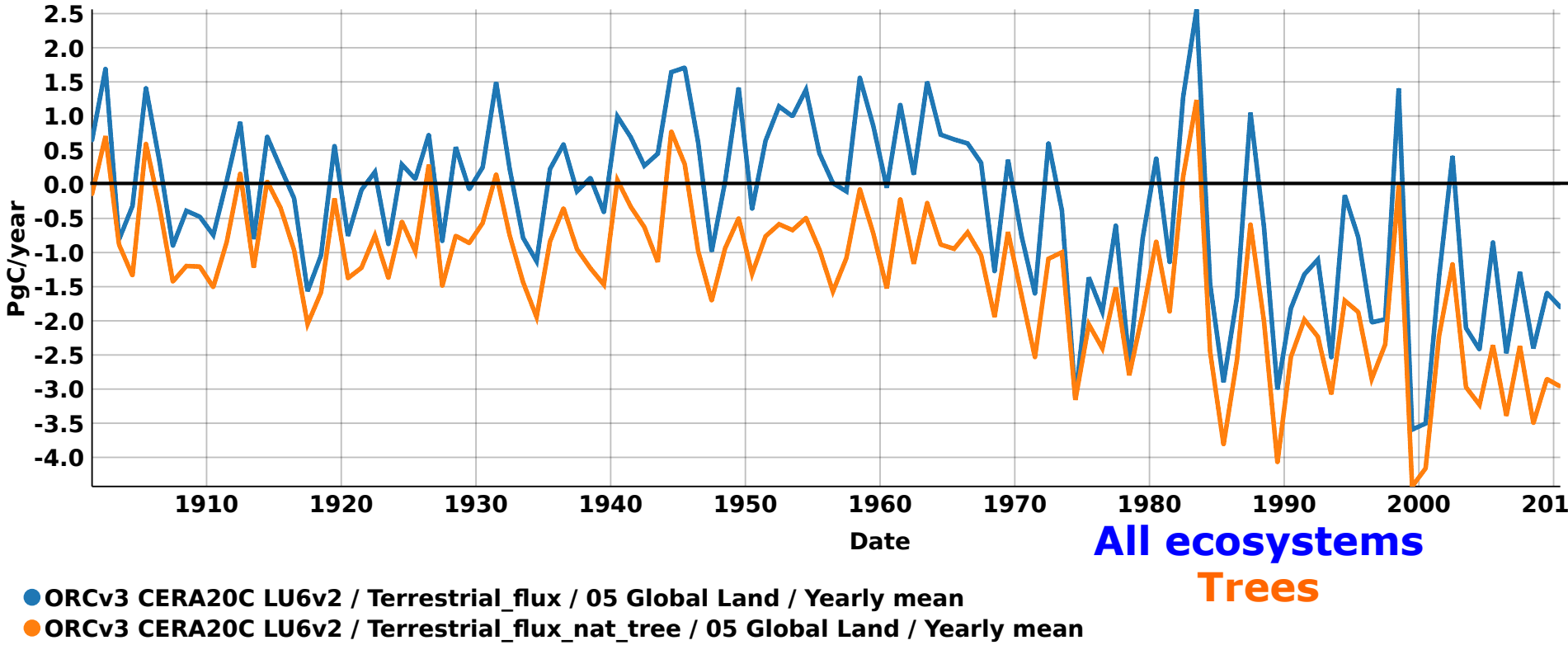
Global net flux



Obtain from:http://eraclim.globalcarbonatlas.org/

Net carbon fluxes per ecosystems

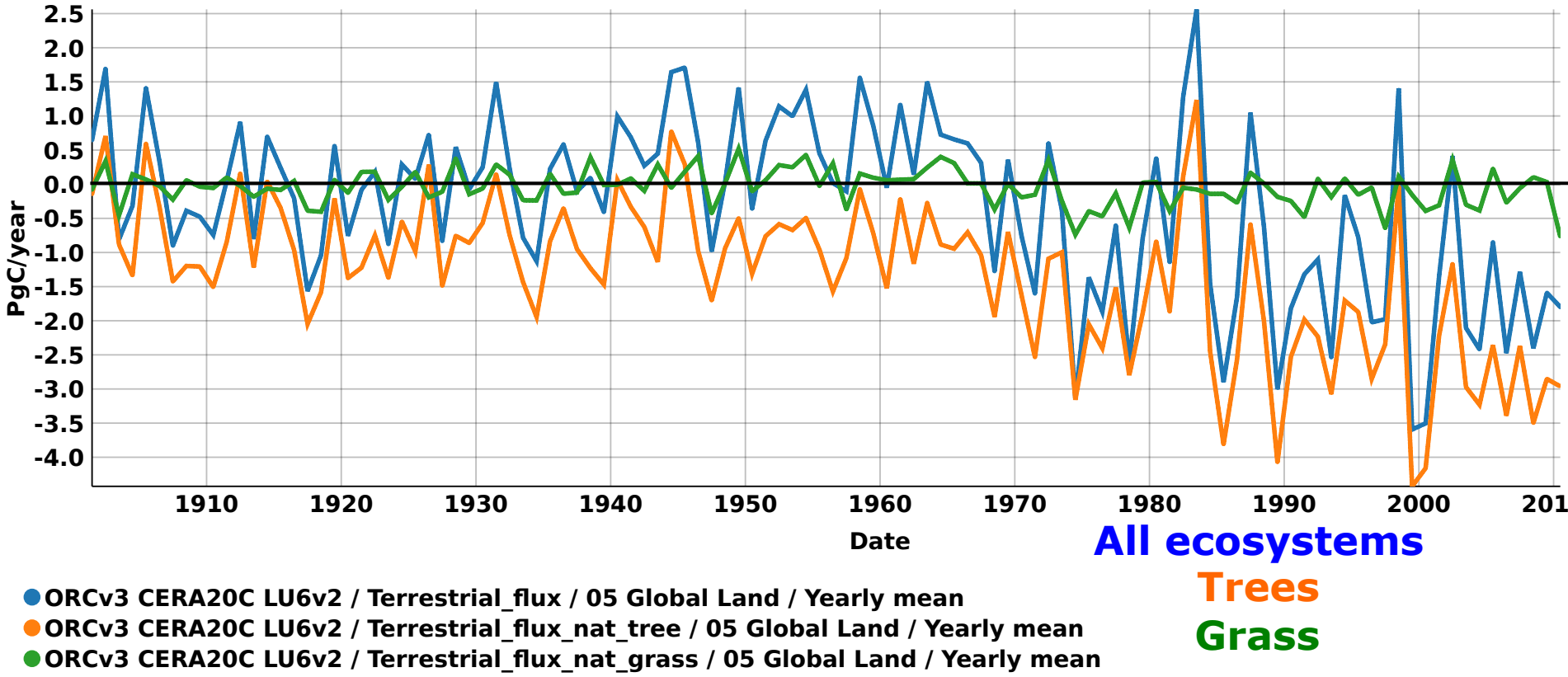
Global net flux



Obtain from:http://eraclim.globalcarbonatlas.org/

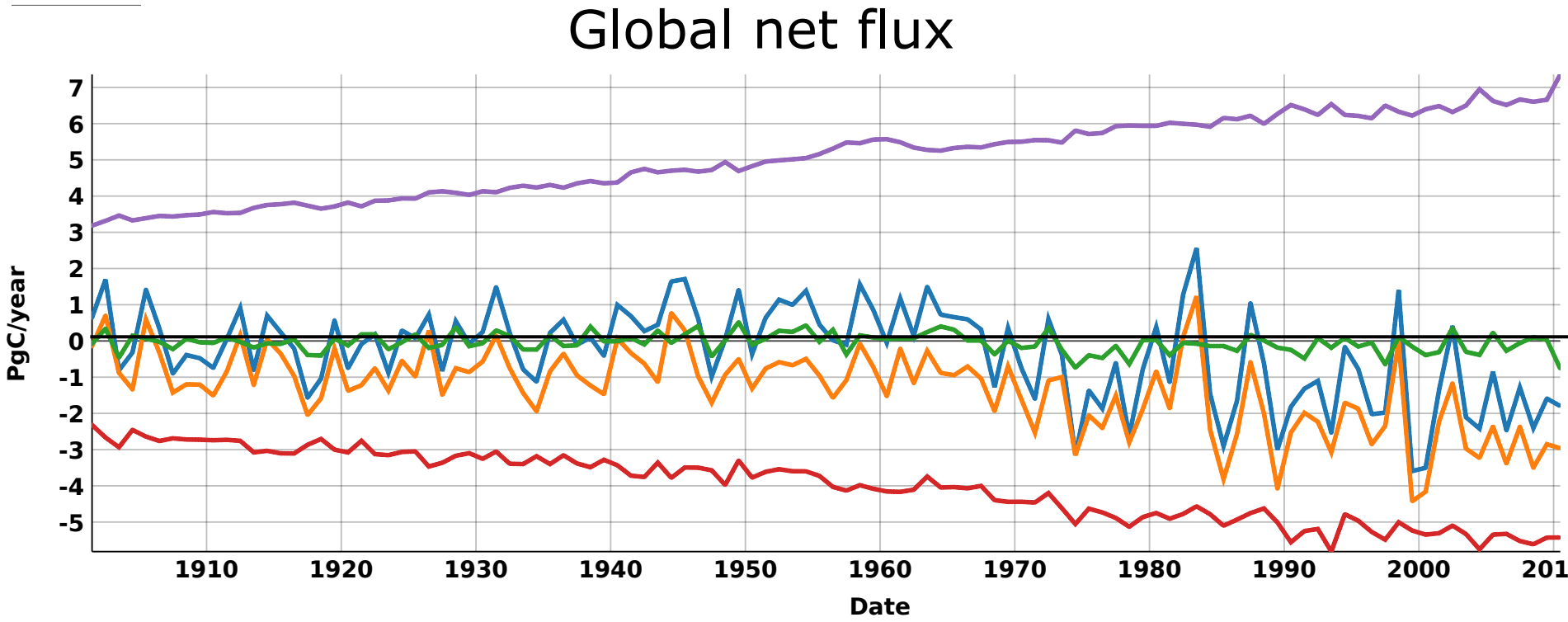
Net carbon fluxes per ecosystems

Global net flux



Obtain from:http://eraclim.globalcarbonatlas.org/

Net carbon fluxes per ecosystems



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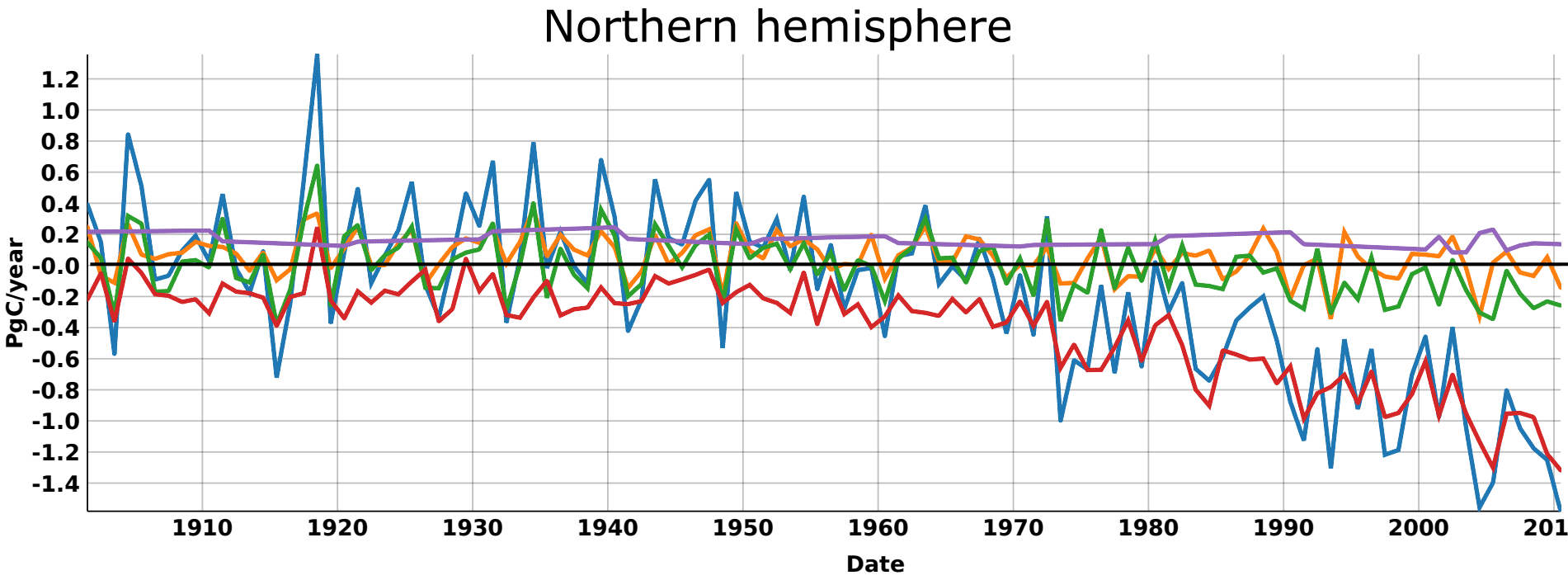
Net Carbon fluxes

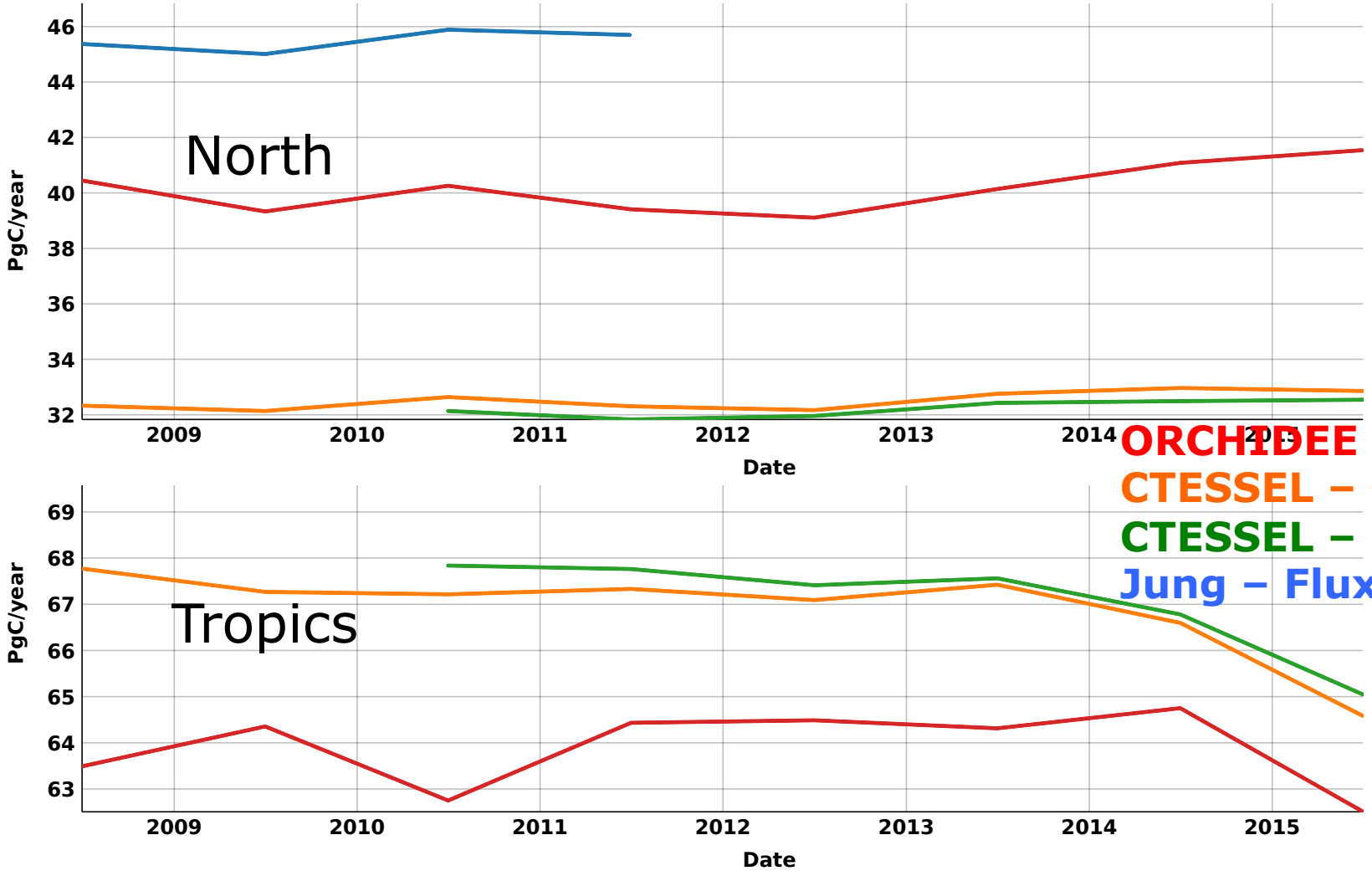


All ecosystems
Trees
Grass
Crop
Land use

Obtain from:http://eraclim.globalcarbonatlas.org/

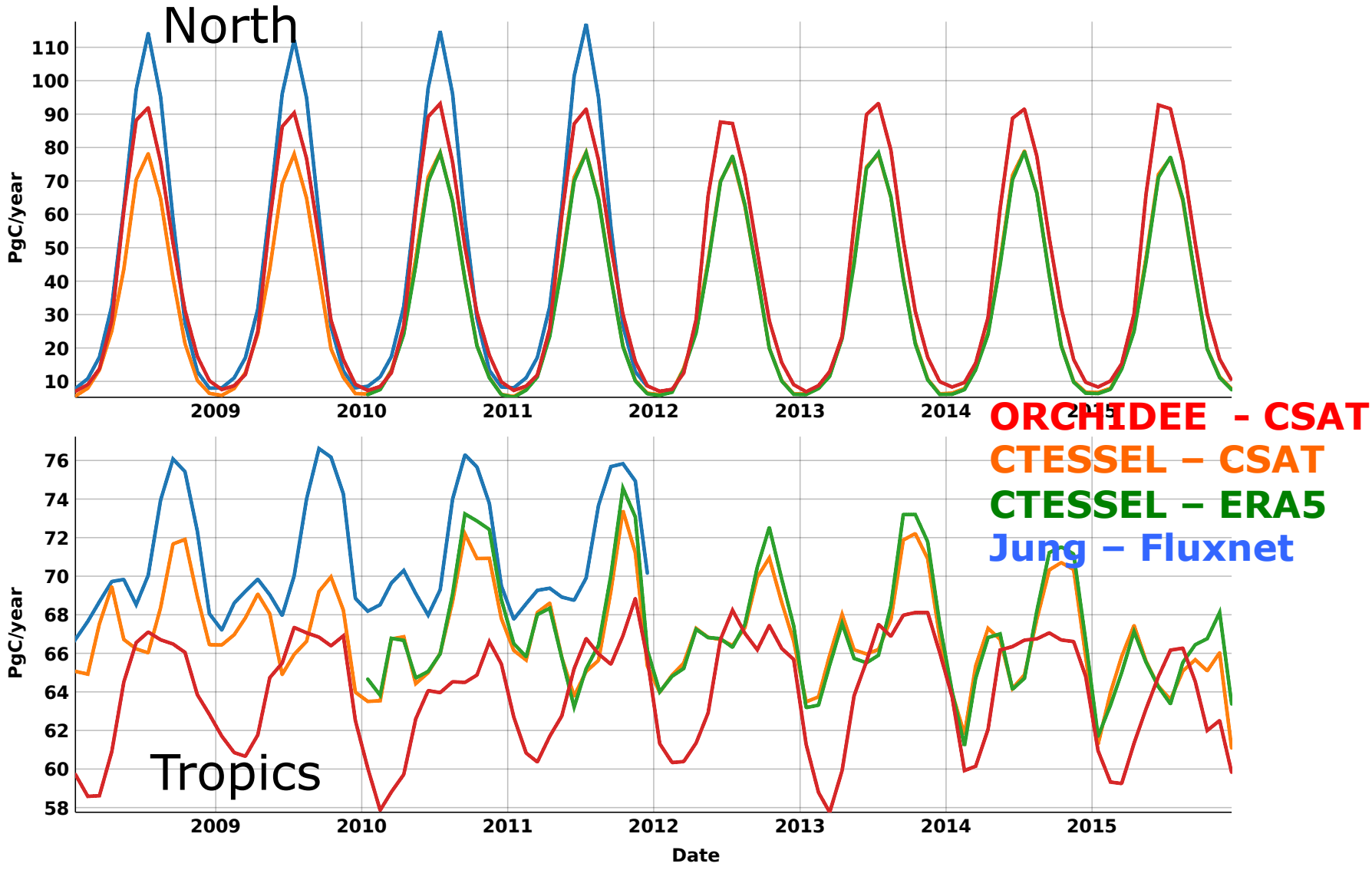
CERA-SAT carbon reanalysis

Gross carbon flux (GPP)

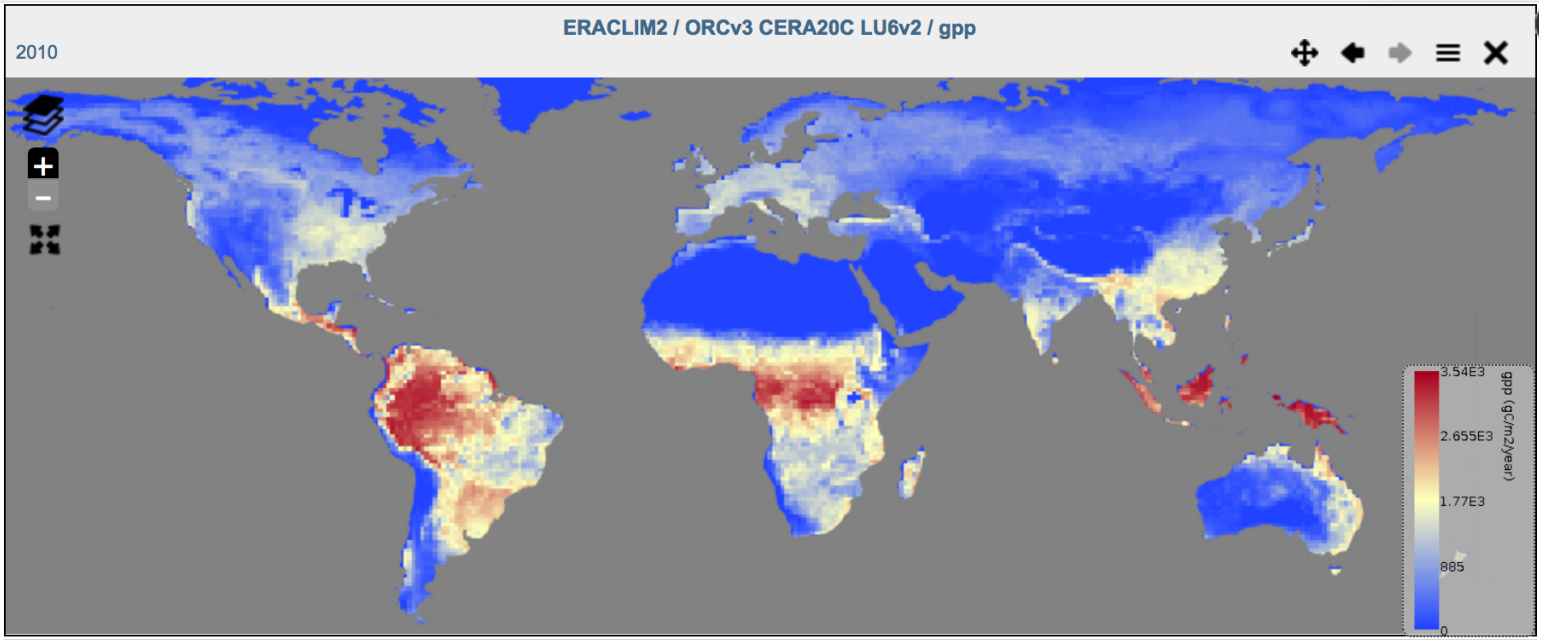


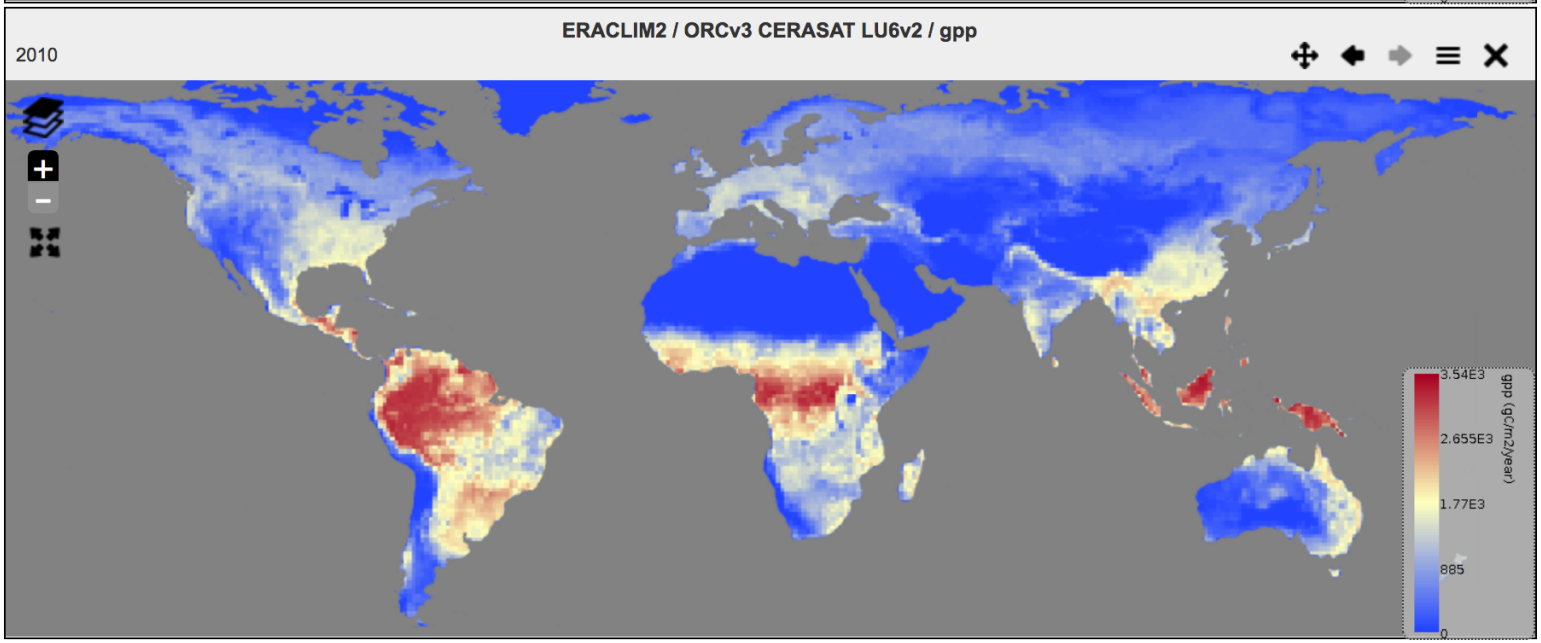
CERA-SAT carbon reanalysis

Gross carbon flux (GPP)

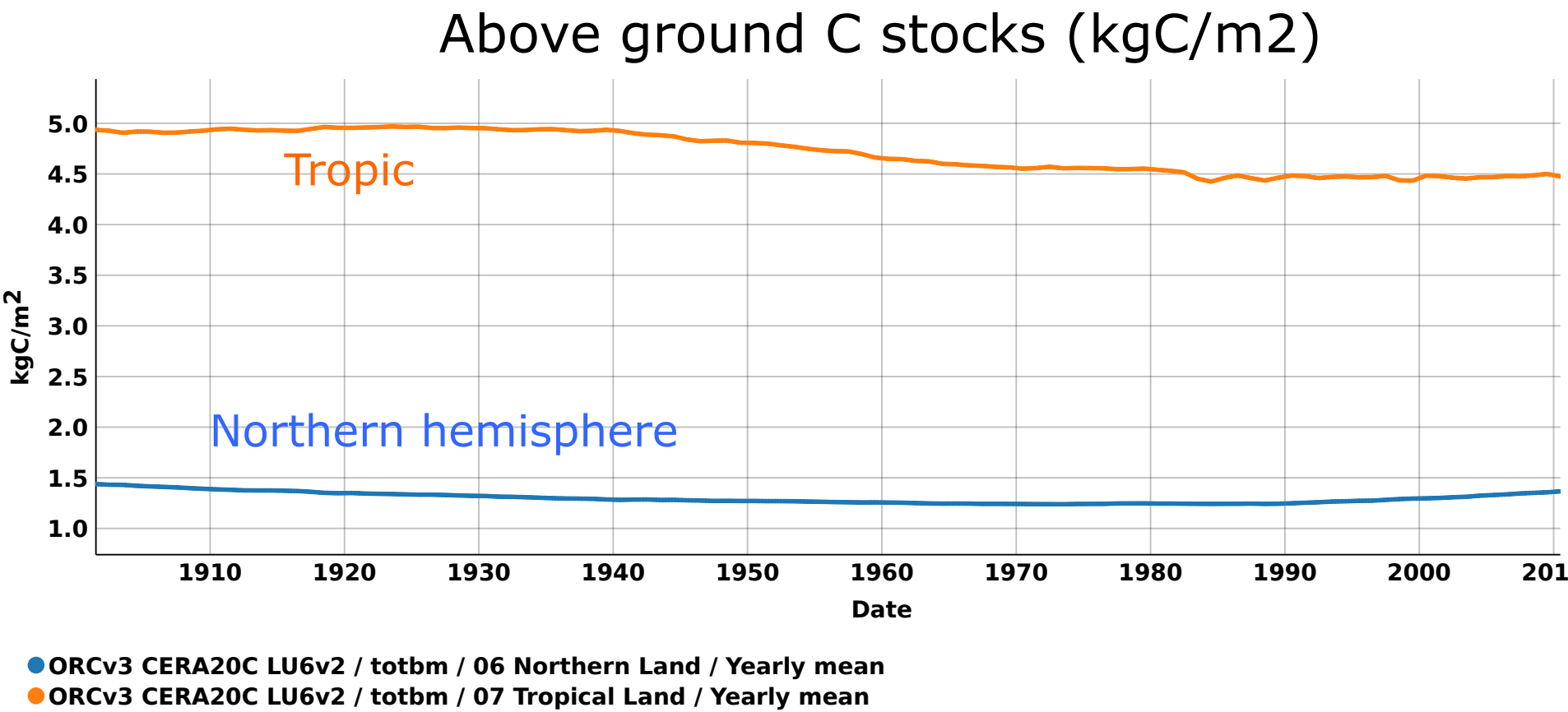


GPP-2010 : CERA-20C vs CERA-SAT

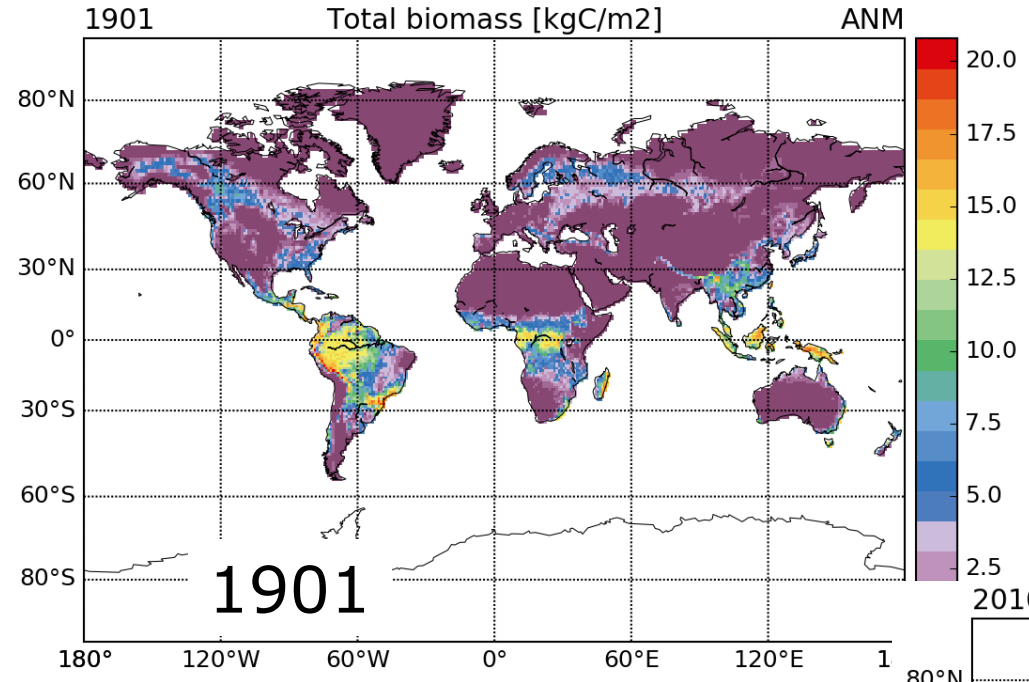




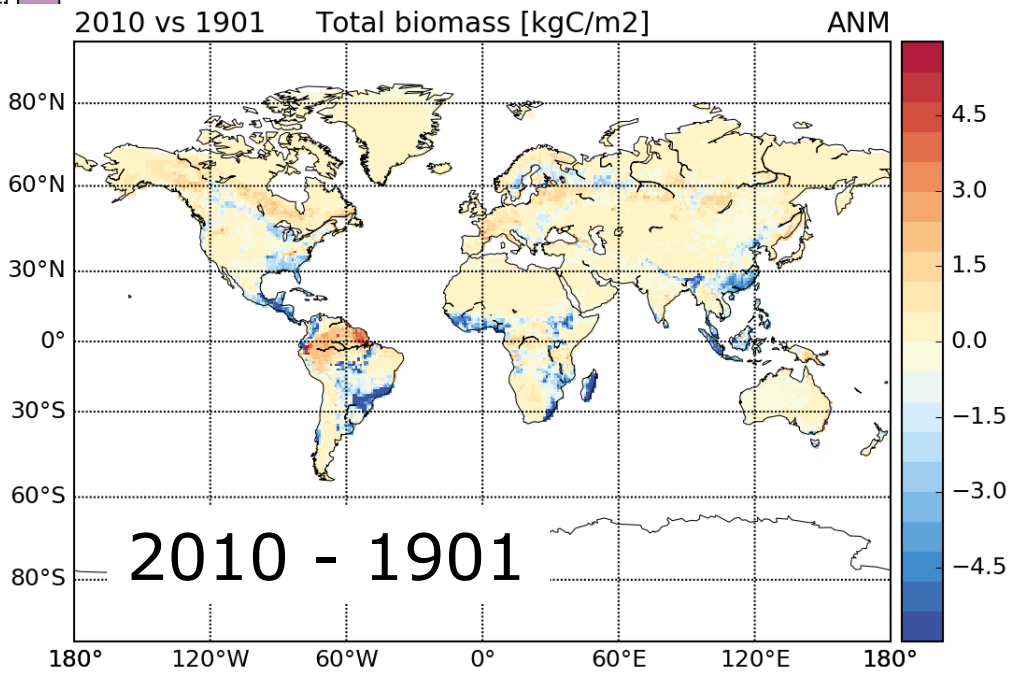
Vegetation carbon stocks



Vegetation carbon stocks



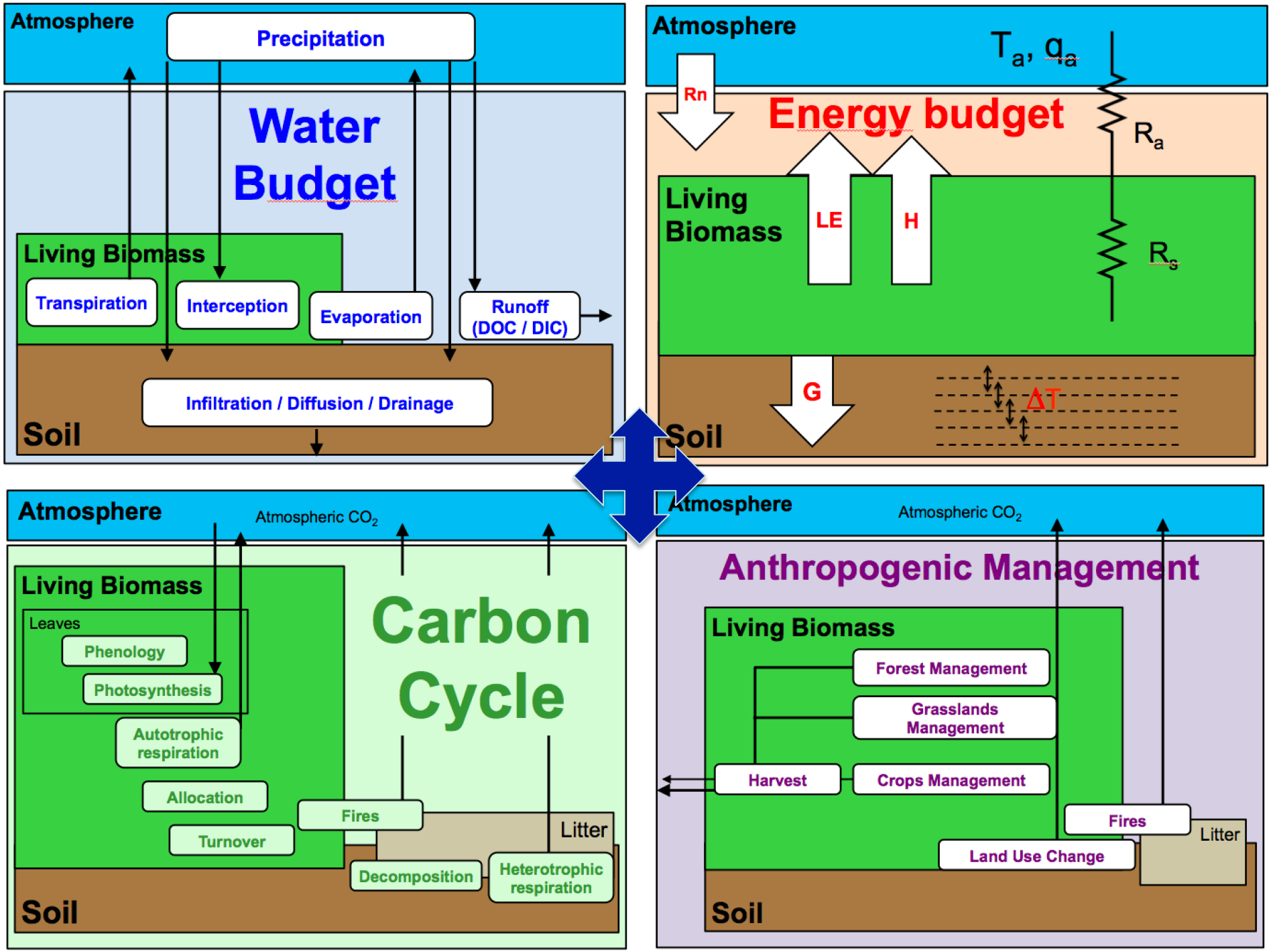
Above ground C stocks (KgC/m2)



Conclusion and Perspectives

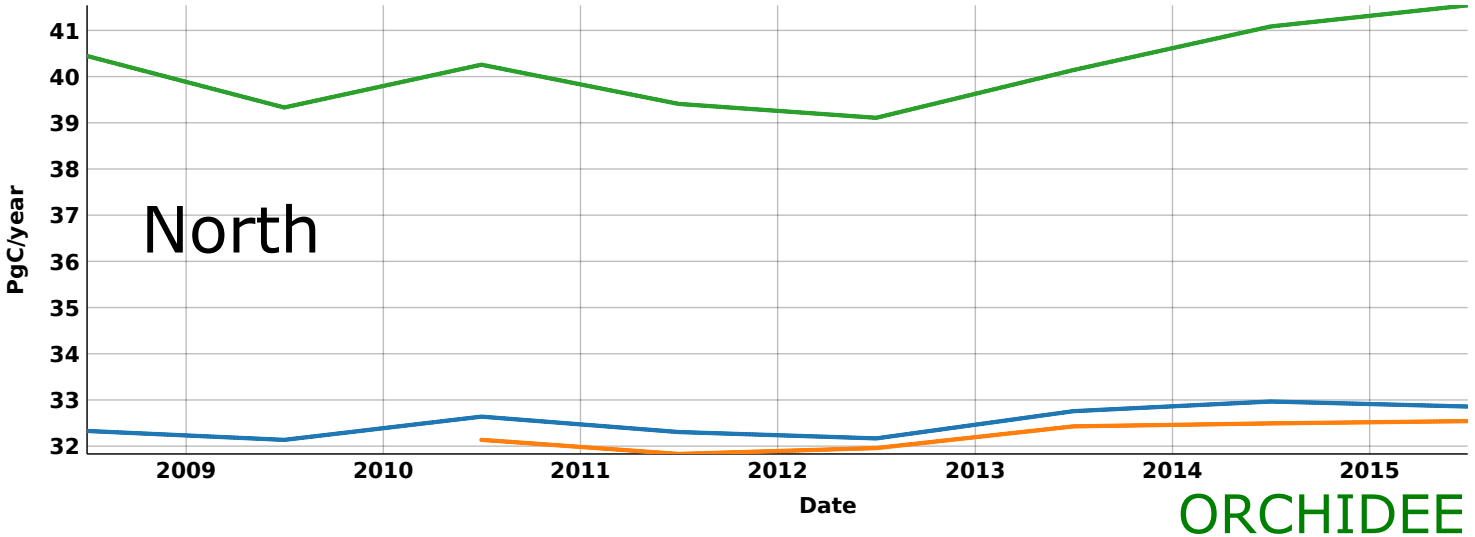
1. All proposed simulations nearly completed
   D1.2 completed ; D1.4 (CERA-SAT) this week.
2. CERA-20C / CERA-SAT ORCHIDEE Carbon reanalysis compare well to other products (CTESSEL, …)
3. CERA-20C lead to lower GPP ; large climate anomalies with significant impact on the C fluxes and strocks
4. Change of ORCHIDEE model parametrization lead to large flux differences
5. Consolidated web-site for “all users” !
6. ➔ Evaluation/synthesis article in preparation

➔Including the C cycle in a global reanalysis may help for future downstream services..
Thank you…
➔http://eraclim.globalcarbonatlas.org/


Atmosphere
Precipitation
Water Budget
Living Biomass
Transpiration
Interception
Evaporation
Runoff (DOC / DIC)
Infiltration / Diffusion / Drainage
Soil
Atmosphere
T_a, q_a
Rn
Energy budget
R_a
Living Biomass
LE
H
R_s
G
ΔT
Soil
Atmosphere
Atmospheric CO_2
Living Biomass
Leaves
Phenology
Photosynthesis
Autotrophic respiration
Allocation
Turnover
Carbon Cycle
Fires
Litter
Decomposition
Heterotrophic respiration
Soil
Atmosphere
Atmospheric CO_2
Anthropogenic Management
Living Biomass
Forest Management
Grasslands Management
Harvest
Crops Management
Fires
Litter
Land Use Change
Soil

CERA-SAT carbon reanalysis

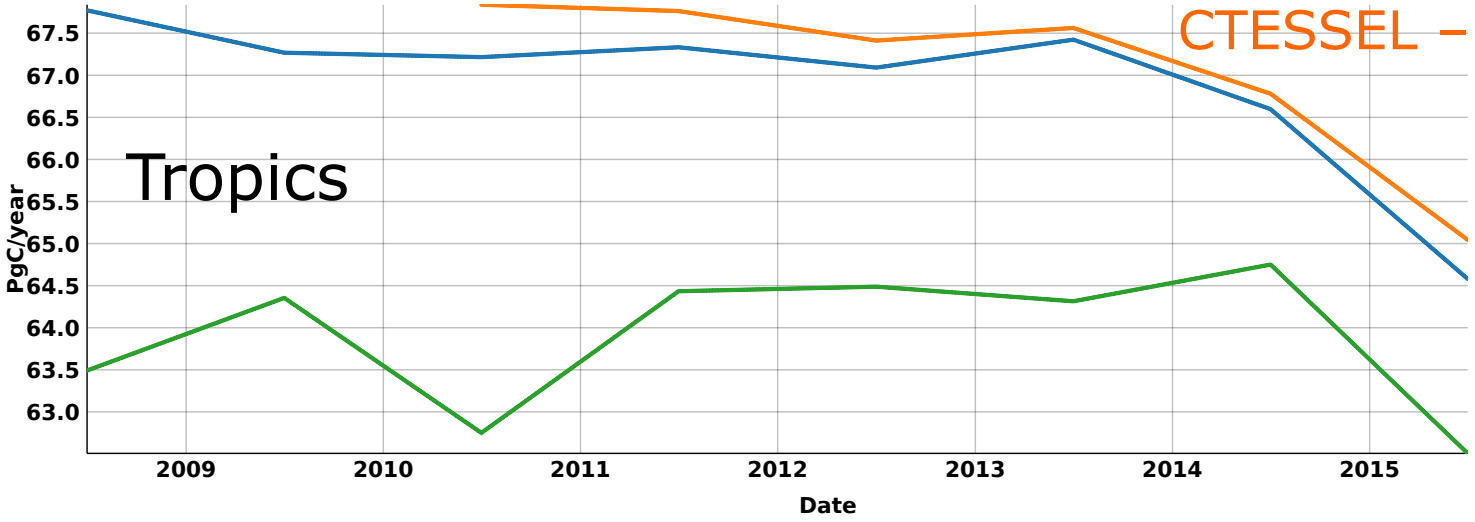
Gross carbon flux (GPP)



ORCHIDEE - CSAT

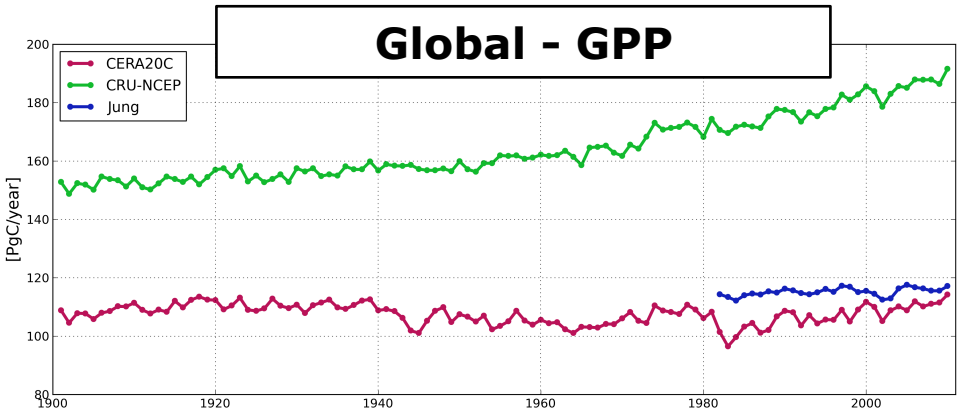
CTESSEL – CSAT

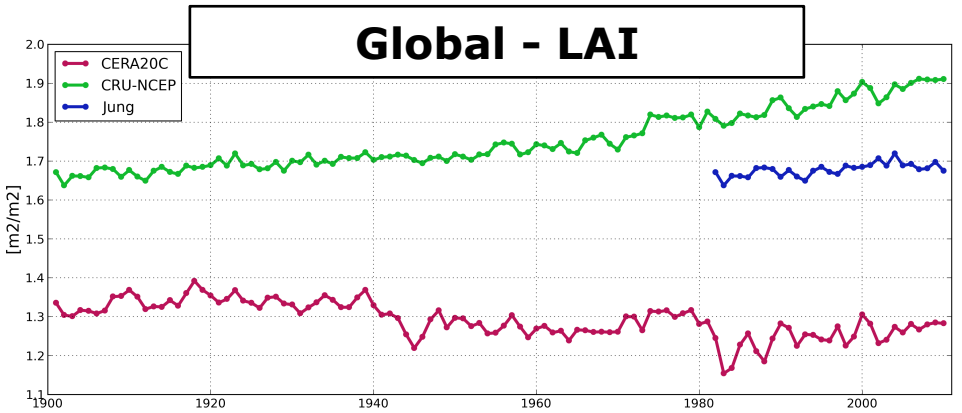
CTESSEL – ERA5

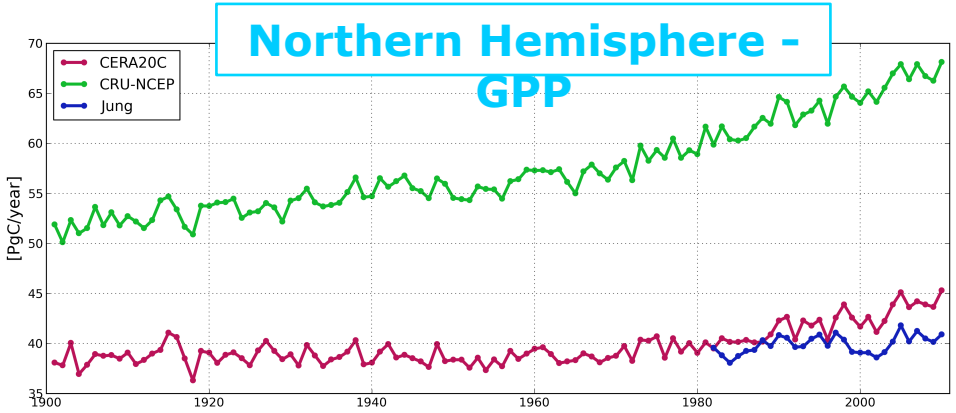


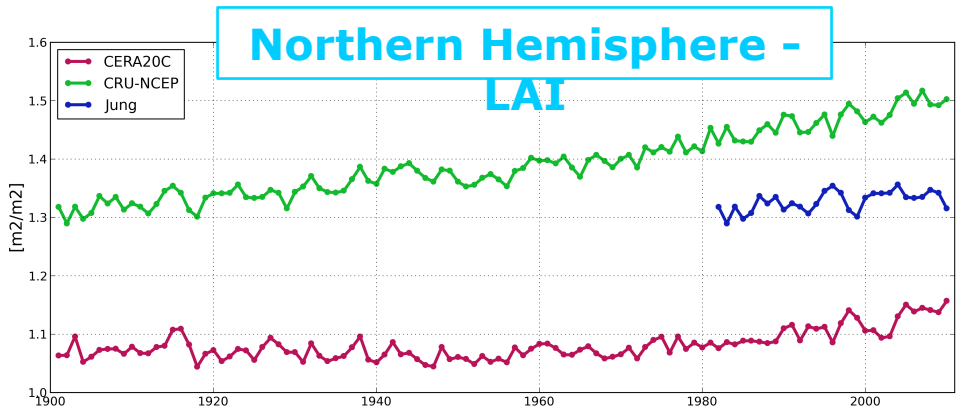
Photosynthesis: Gross Primary Production

CERA20C **CRUNCEP** **Jung MPI product**









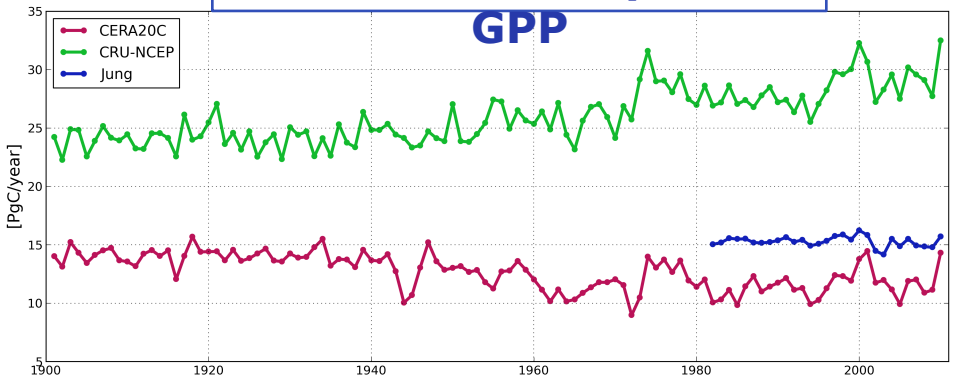
Jung et al. 2011: up-scaled FLUXNET observations to the global scale using the machine learning technique

Leaf area Index and Gross Primary Production

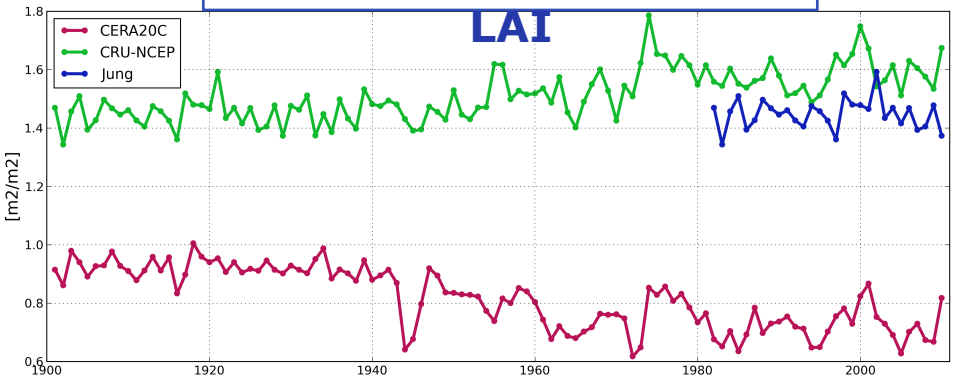
LSCE

CERA20C **CRUNCEP** **Jung MPI product**

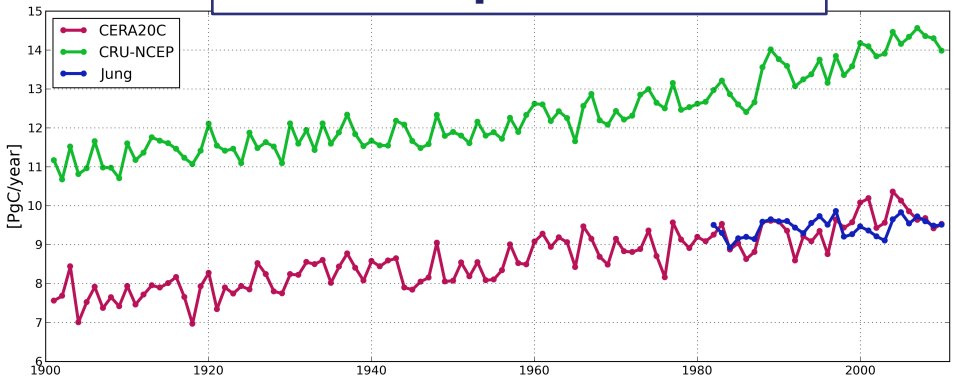
Southern Hemisphere - GPP



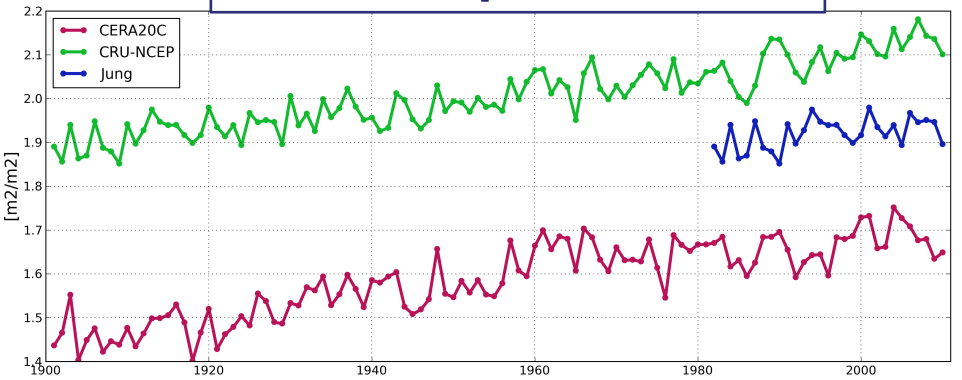
Southern Hemisphere - LAI



Europe - GPP



Europe - LAI

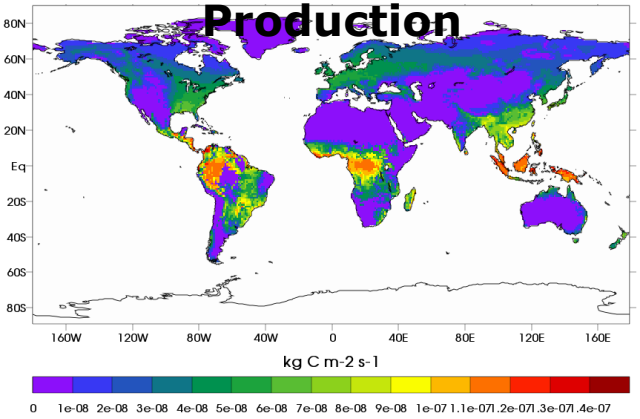


Geographical distribution: 1990-2010

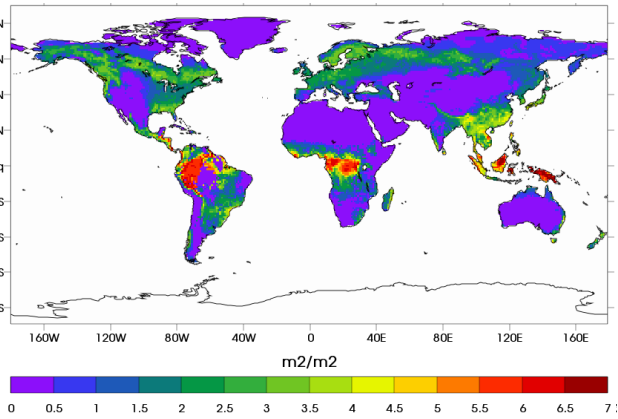
LSCE

CERA20C

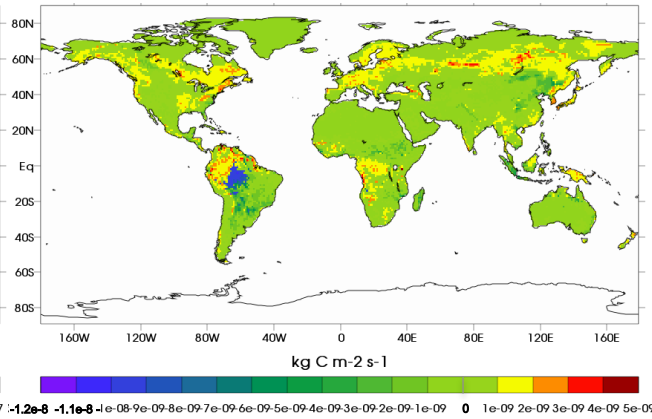
Gross Primary Production



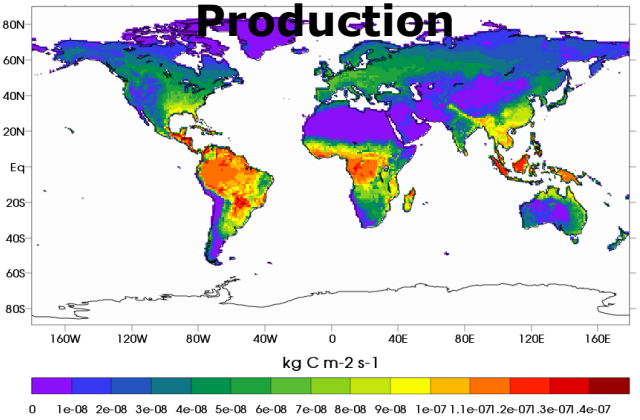
Leaf Area Index



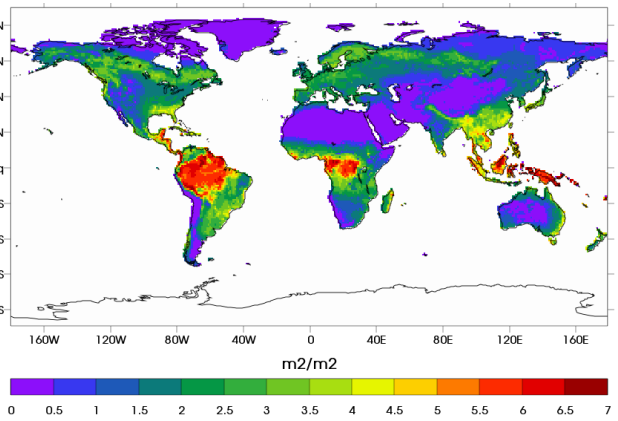
Net Carbon Fluxes



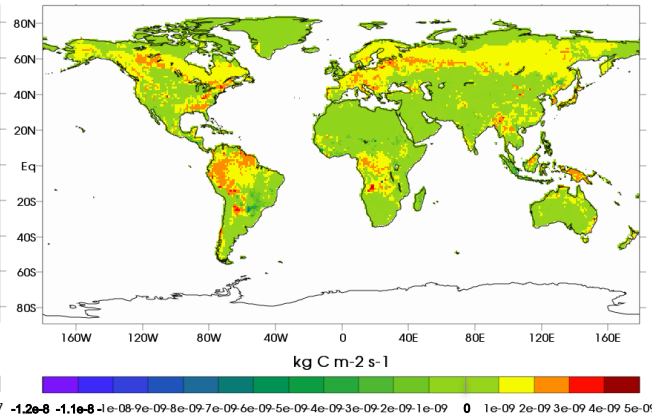
Gross Primary Production



Leaf Area Index



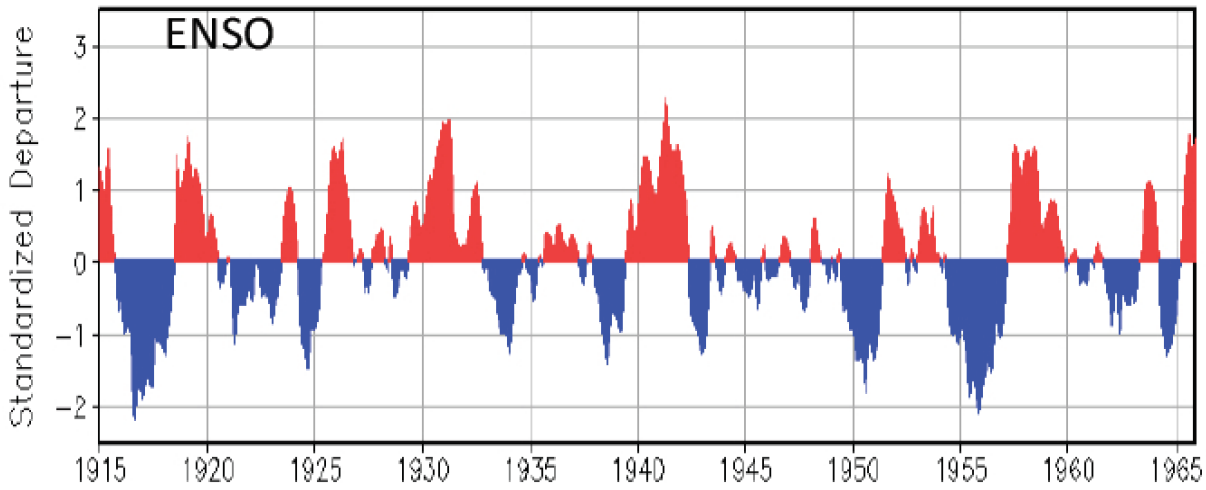
Net Carbon Fluxes



CRUNCEP

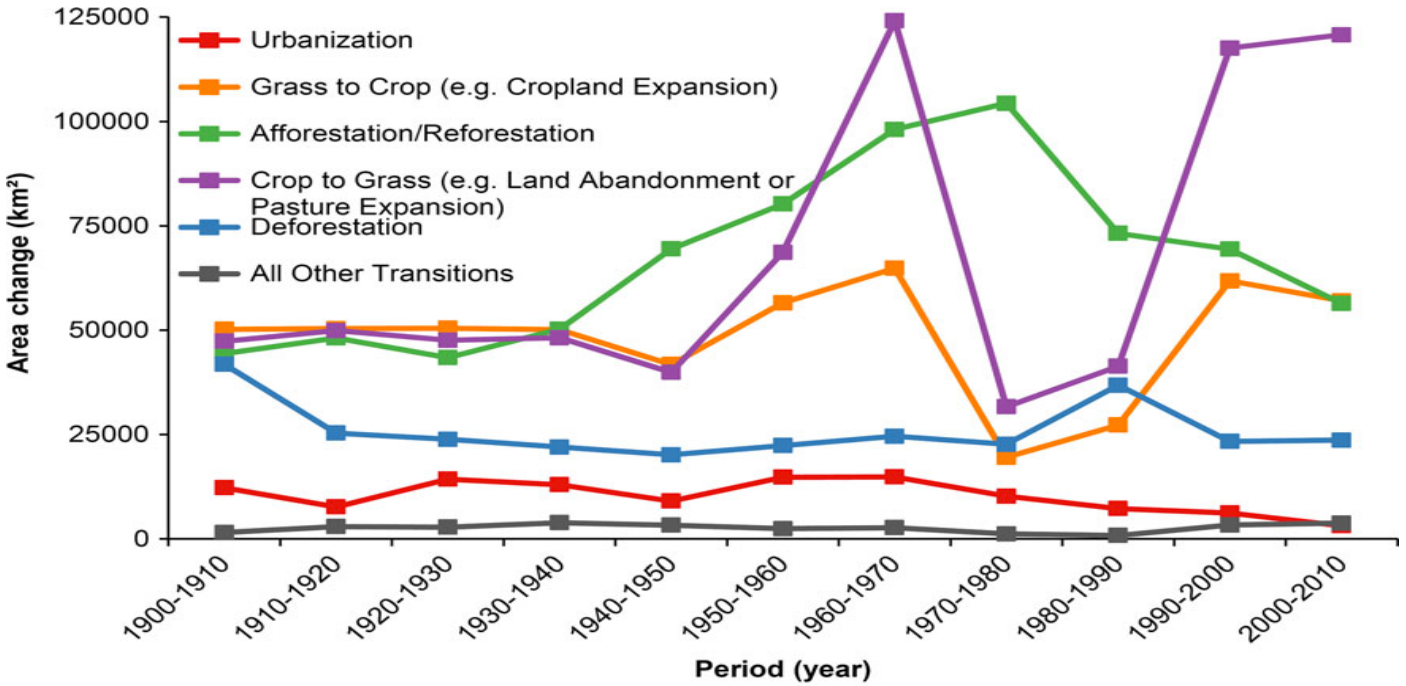
Few major drivers of the C-cycle

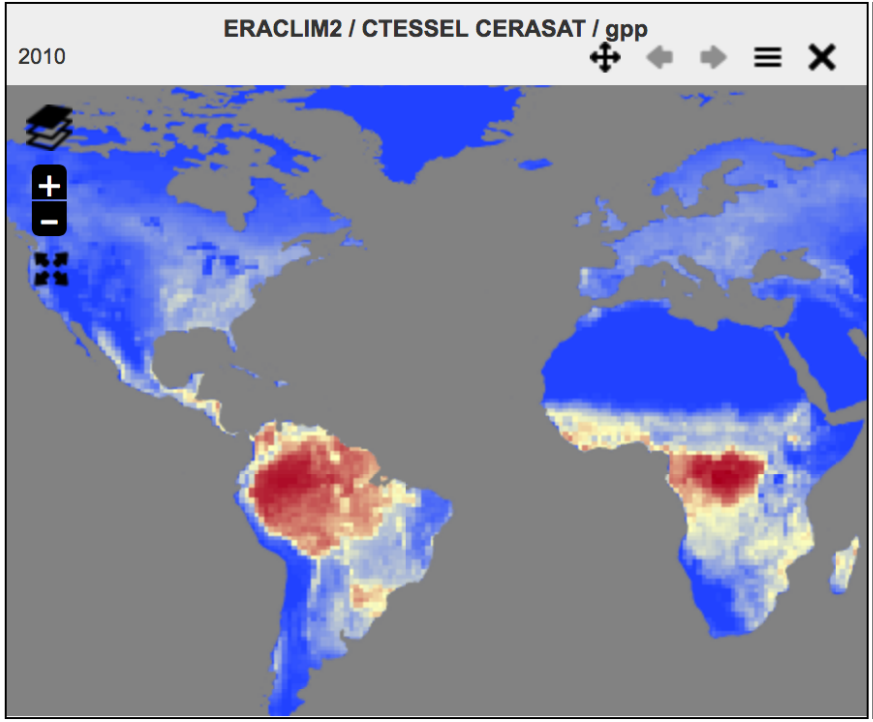
Climate

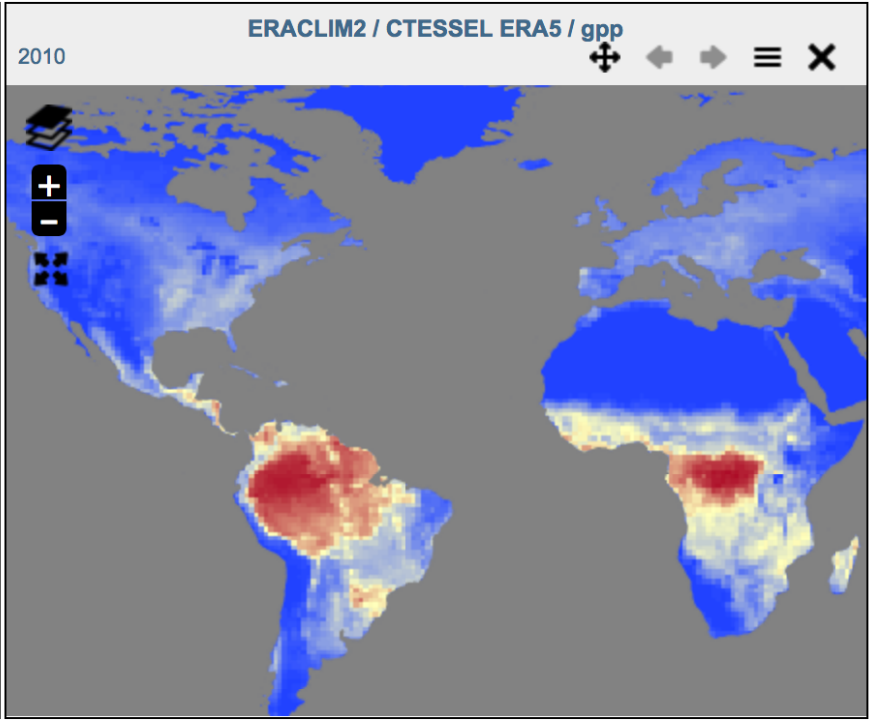


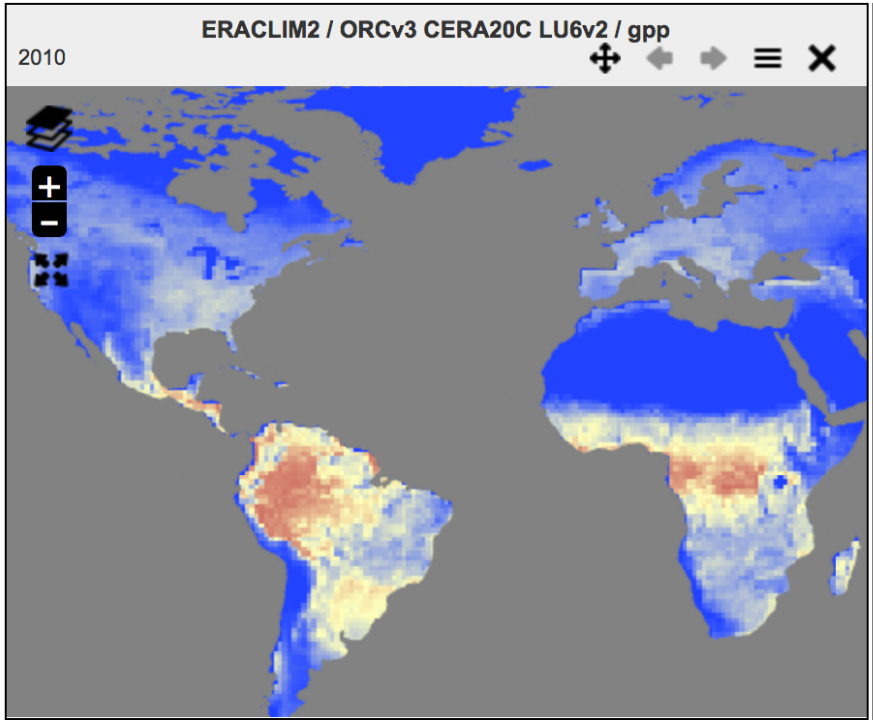
Land use change

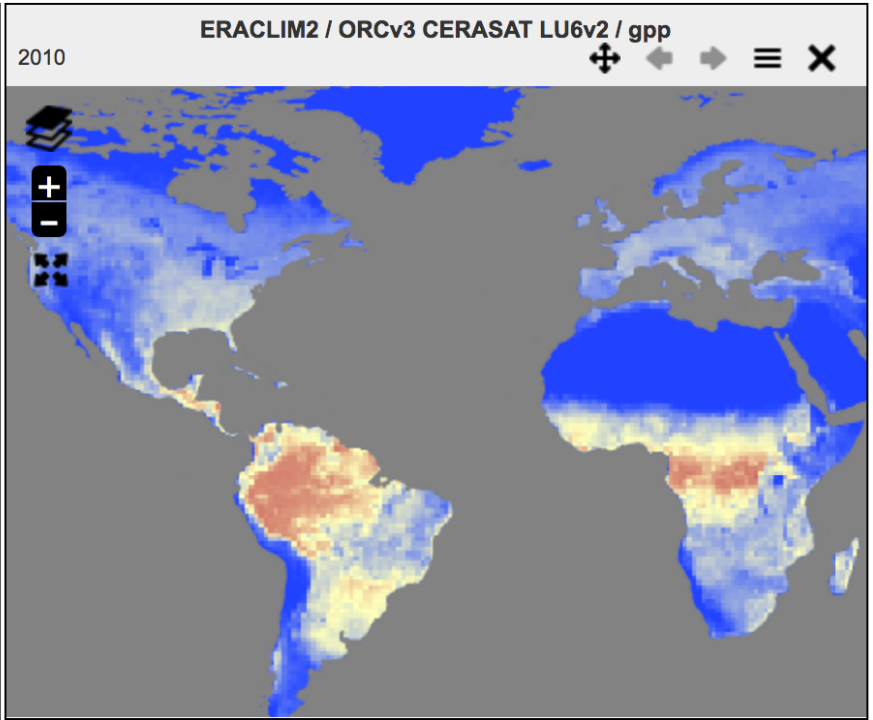
Ex: data from Fuchs et al. 2015 (HILDA)




ERACLIM2 / CTESSEL CERASAT / gpp
2010


ERACLIM2 / CTESSEL ERA5 / gpp
2010

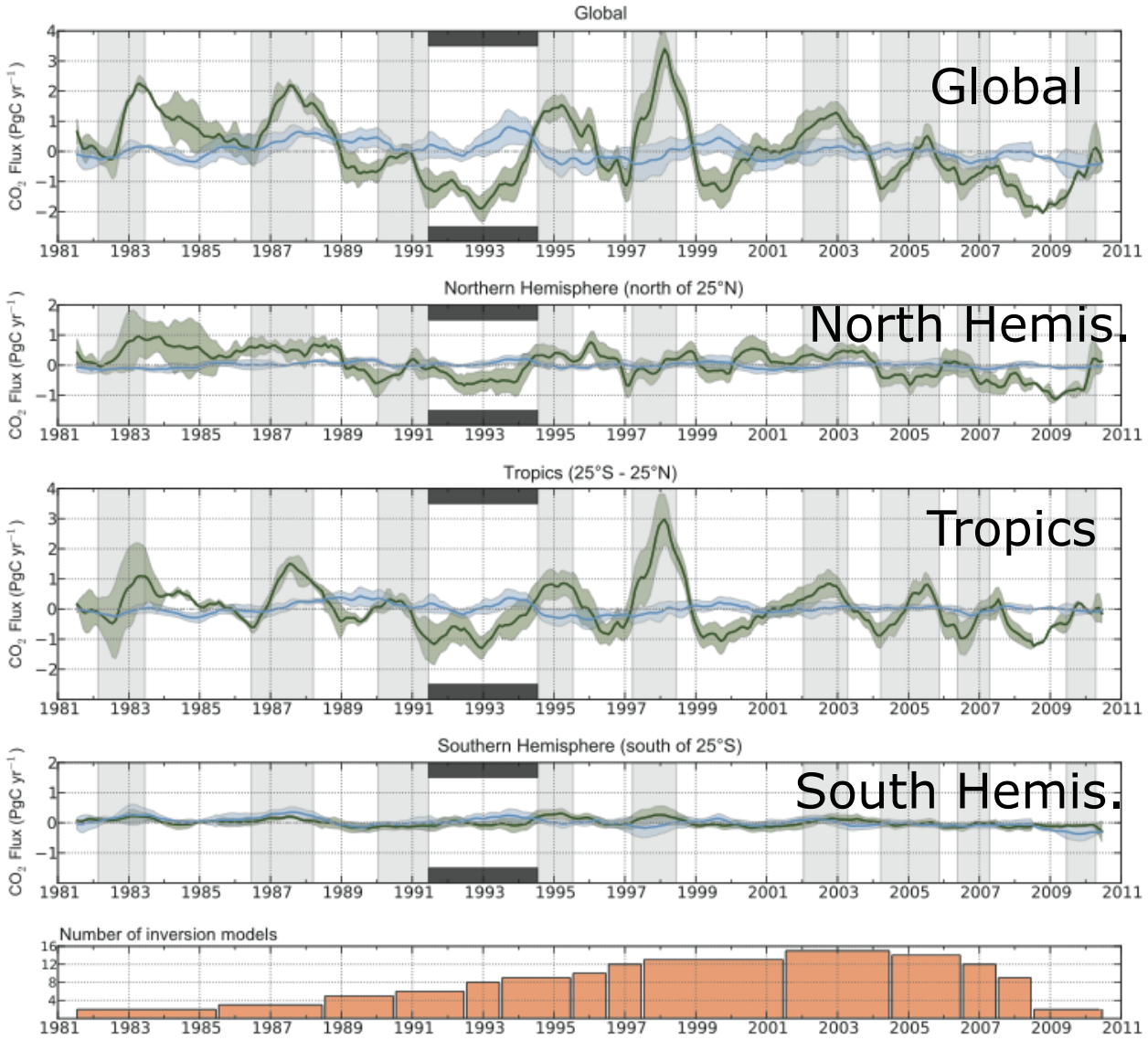

ERACLIM2 / ORCv3 CERA20C LU6v2 / gpp
2010


ERACLIM2 / ORCv3 CERASAT LU6v2 / gpp
2010

Current land / ocean carbon flux anomalies
(from atmospheric CO2 inversion)

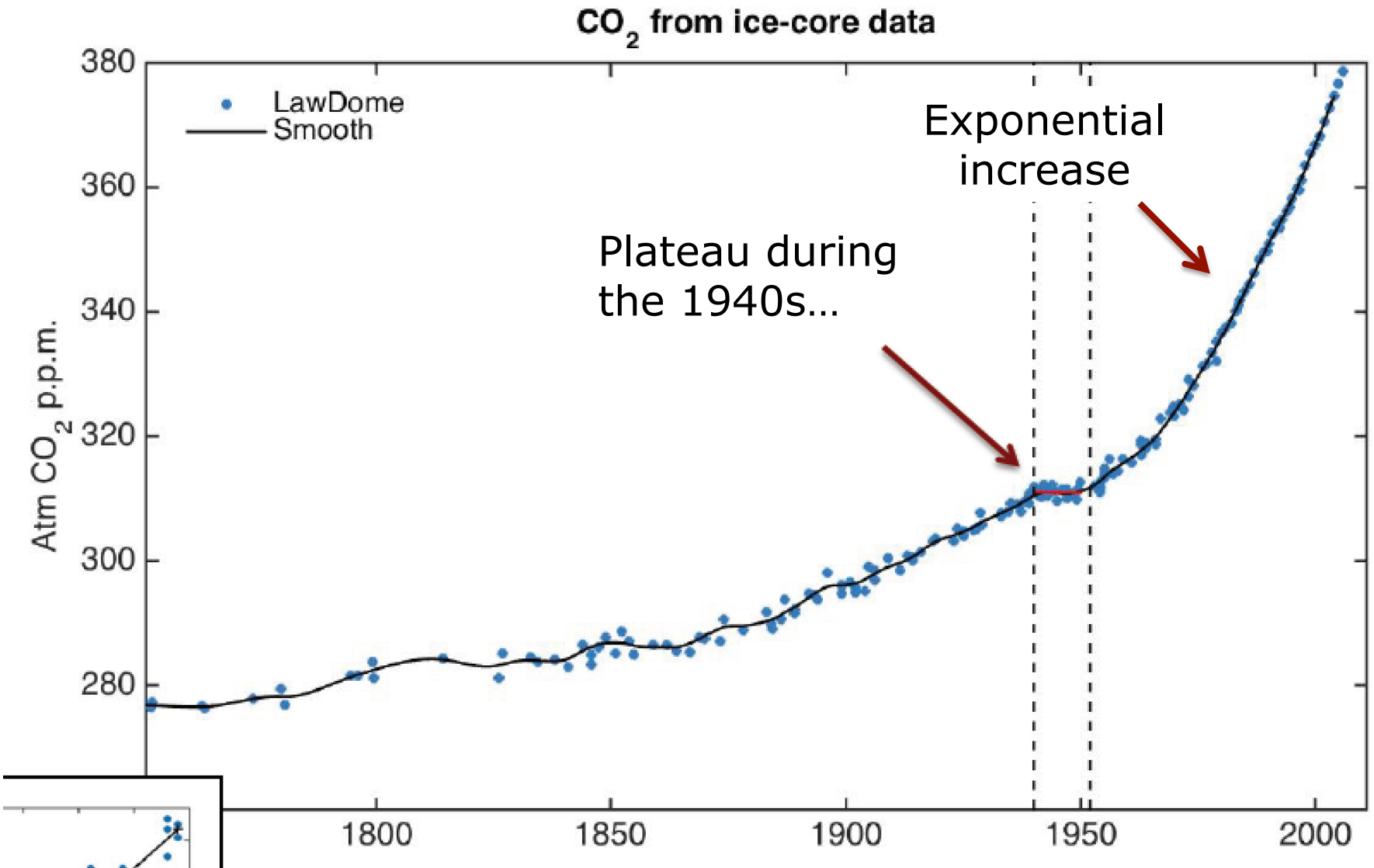
Our obejectives for ERACLIM2

1900

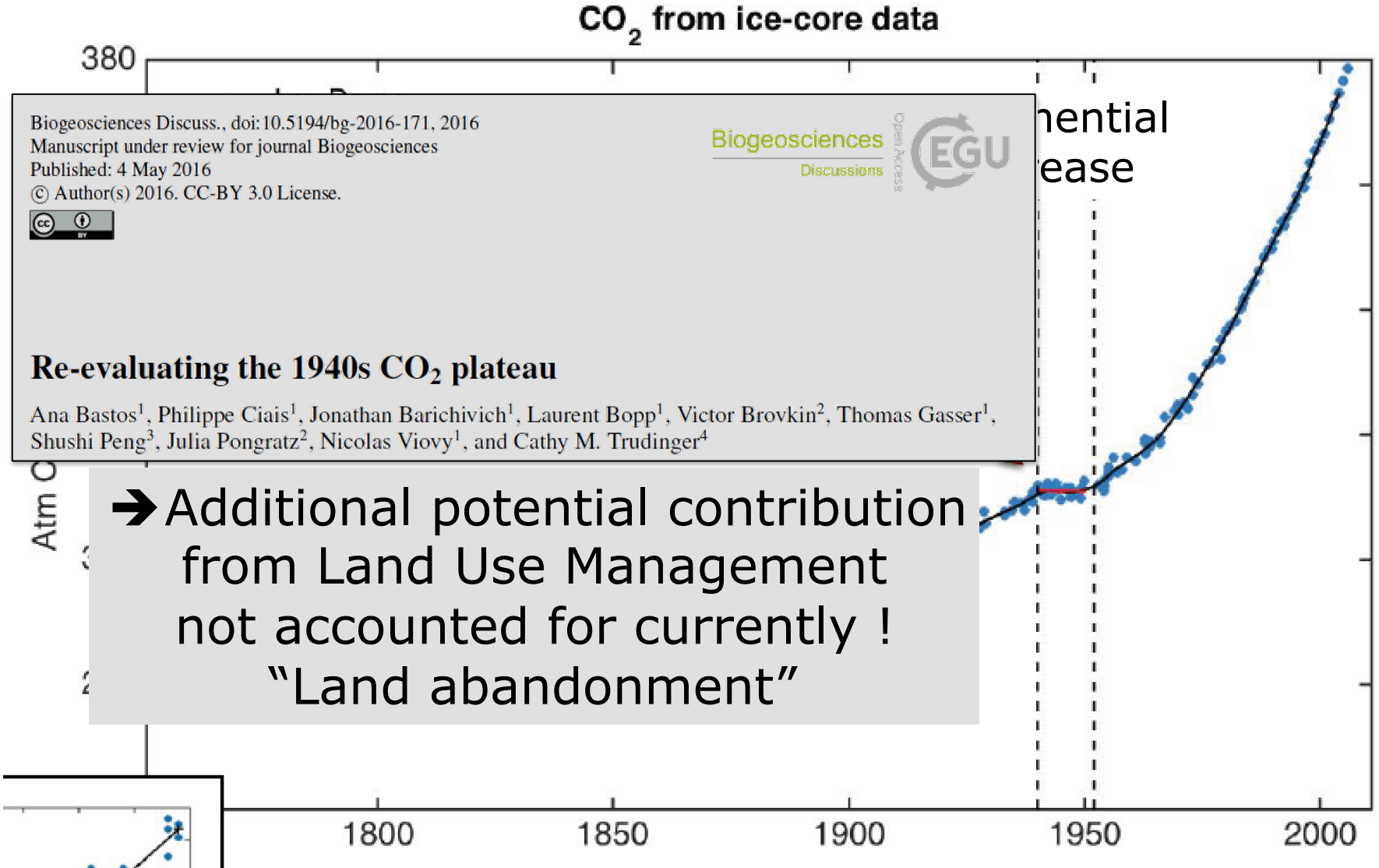


1980 2010

Key features of the global C cycle over the 20th Century



Key features of the global C cycle over the 20th Century



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Manuscript under review for journal Biogeosciences
Published: 4 May 2016
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Biogeosciences Discussions

Re-evaluating the 1940s CO_2 plateau

Ana Bastos[1], Philippe Ciais[1], Jonathan Barichivich[1], Laurent Bopp[1], Victor Brovkin[2], Thomas Gasser[1], Shushi Peng[3], Julia Pongratz[2], Nicolas Viovy[1], and Cathy M. Trudinger[4]

➔ Additional potential contribution from Land Use Management not accounted for currently ! "Land abandonment"