Toward a couple Carbon – Climate reanalysis of the 20th Century

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

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

Challenge….

➔Long term objective: perform a “joint assimilation” including Carbon Cycle feedback on climate !

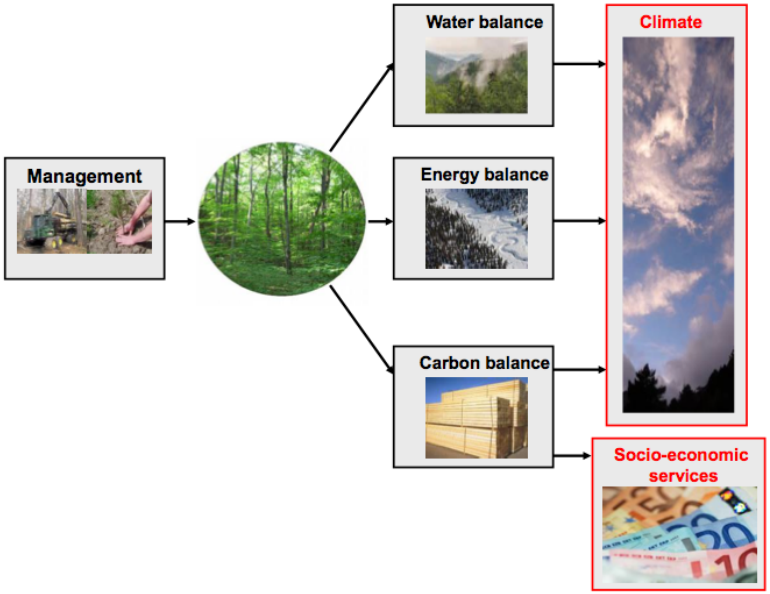
- ERACLIM2 will only establish the needed developments..
  - Join assimilation should be done with CHTESSEL Land surface model of IFS
  - Correction of state variable or model parameters ?

➔On-going work to discuss Discussion ofthe issues & results with ORCHIDEE

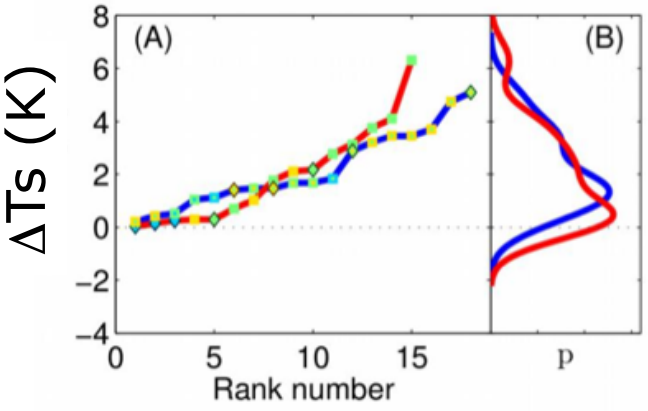
Potential of joint C/W/E assimilation

- Land cover changes

Land cover management



Effect on surface climate (Analysis from nearby FluxNet sites)



Luyssaert et al. 2014

Land cover effect
Land management effect

➔ link betw biogeochemical and biophysical cycles

Parameter vs State variable optimization

State variable optim

- $[CO2]_{atm}$ includes all processes; [LAI] inform phenology
- Less assumption on processes

- Few insight on the processes
- C stocks cannot be assimilated easily
- Only few data cover 20th C
- No predicting capabilities

Parameter optimization

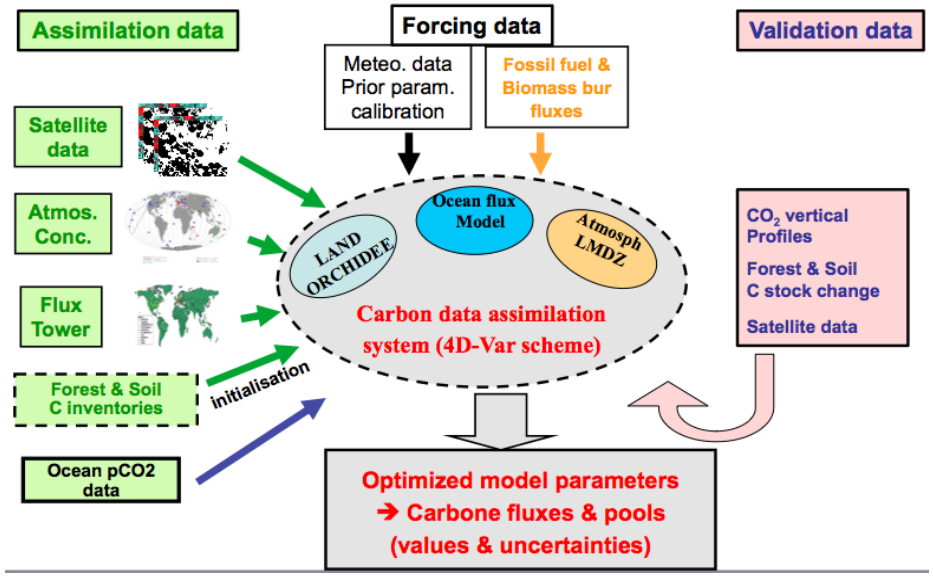
- Easier to use multi-data streams
- Constrain all processes
- Data dont need to cover the full period
- Prediction capabilities

- Rely on LSM structure
- Missing processes ?
- Heavier to handle

Optimizing model parameters

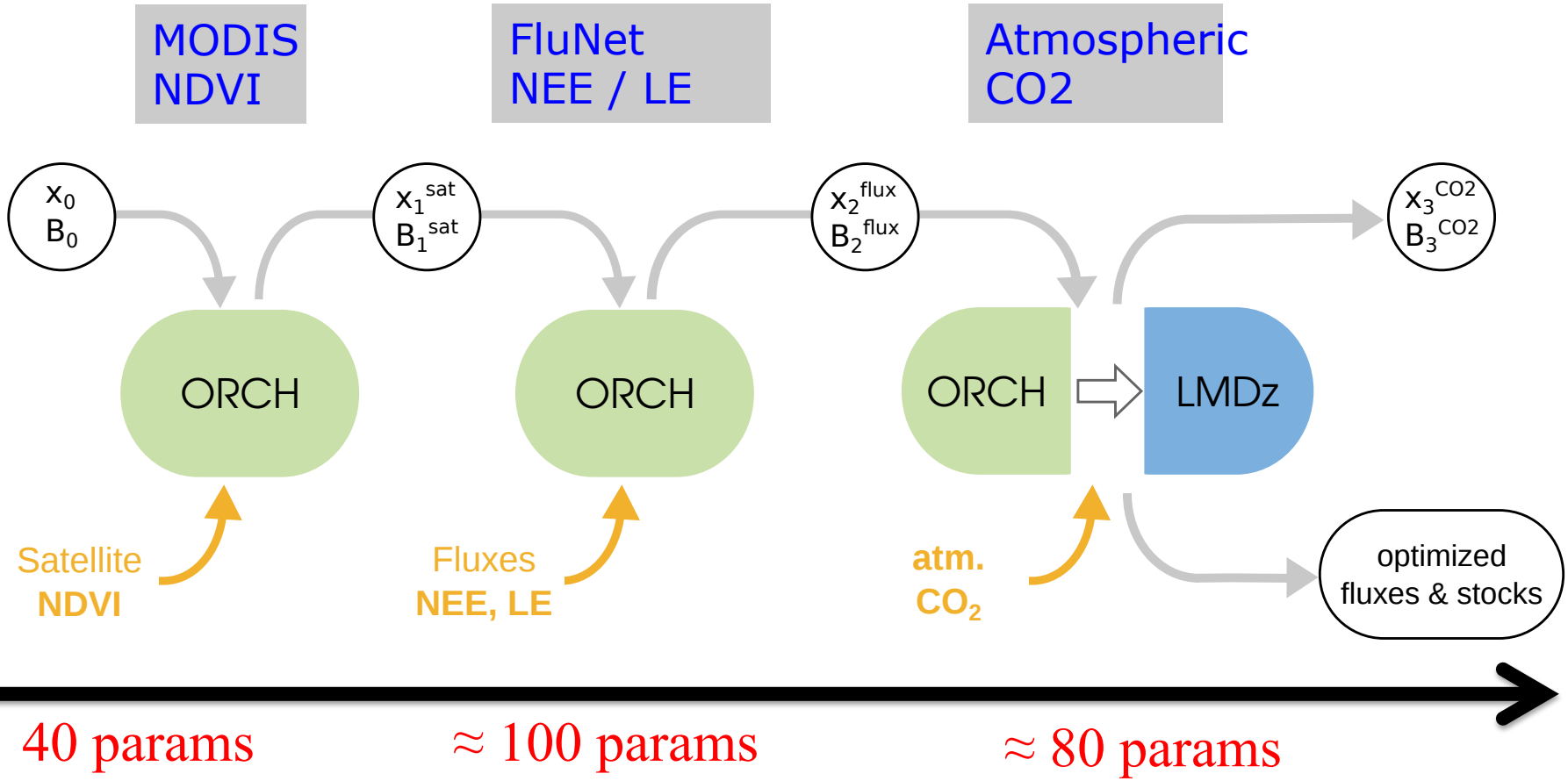
- ORCHIDEE parameters optimized using
  - Atmospheric CO2 data
  - MODIS – NDVI measurements
  - FluxNet (NEE, LE) measurements

Carbon Cycle Data Assimilation System with ORCHIDEE



Step wise data assimilation system

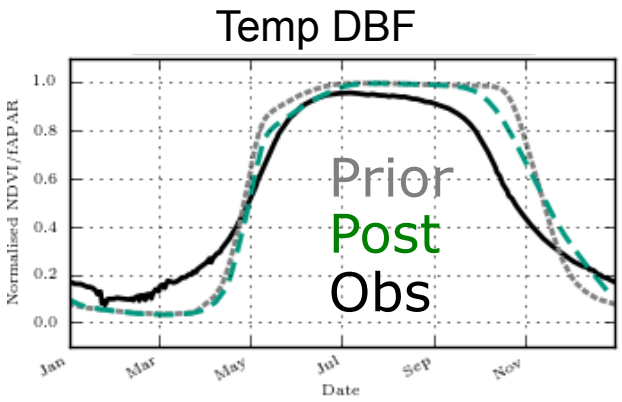
$$J(x) = \underbrace{\tfrac{1}{2}(\mathbf{H}.x-y)^T \mathbf{R}^{-1}(\mathbf{H}.x-y)}_{\text{Observation term}} + \underbrace{\tfrac{1}{2}(x-x_b)^T \mathbf{B}^{-1}(x-x_b)}_{\text{Prior parameter term (from previous step)}}$$

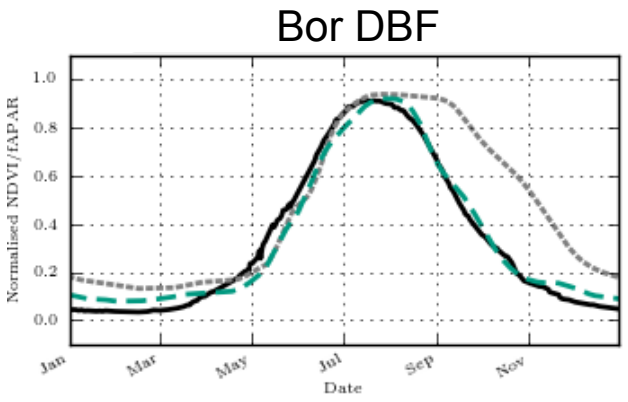


Assimilation of multiple data streams

Step 1:
MODIS-NDVI

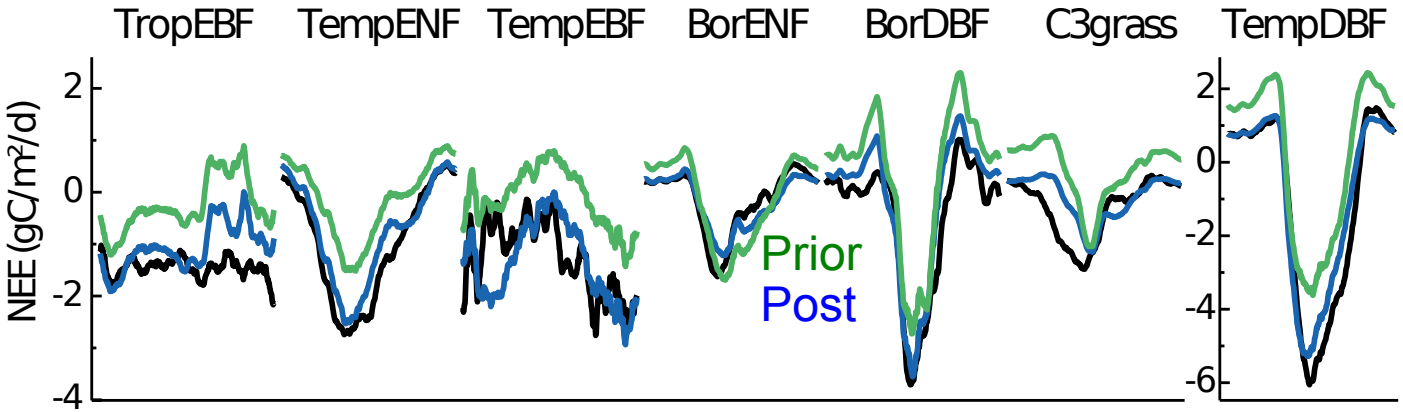
4 params /PFT





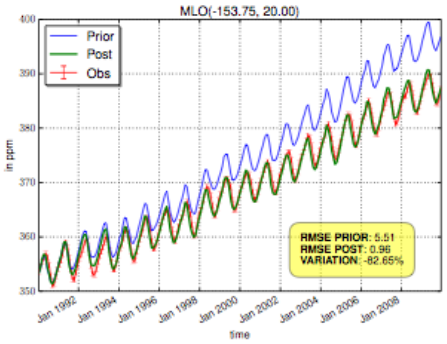
Step 2:
75 fluxnet data

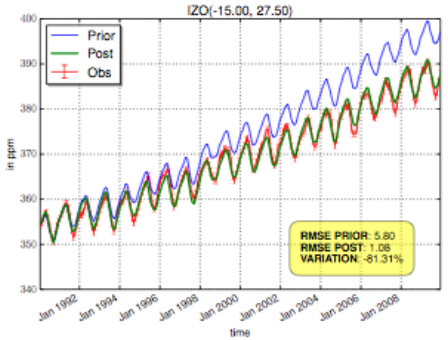
≈ 20 params /PFT



Step 3:
Atmospheric data

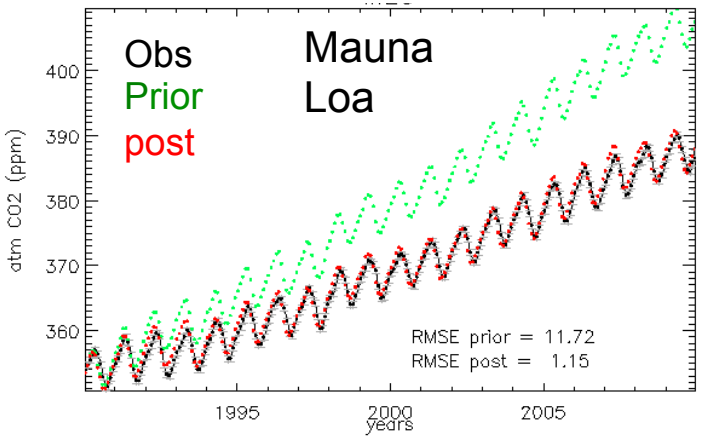
≈ 100 params total





Assimilation of atmospheric [CO_2] data

Optimization of the CO2 trend

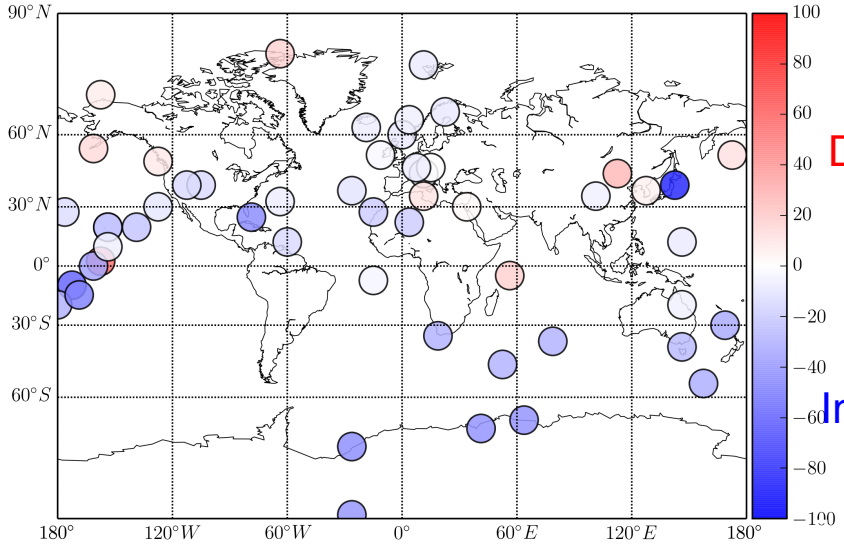


Signal decomposition:

- Amplitude : max – min
- Phase : CPU

(1 – RMSE_poste / RMSE_prior)

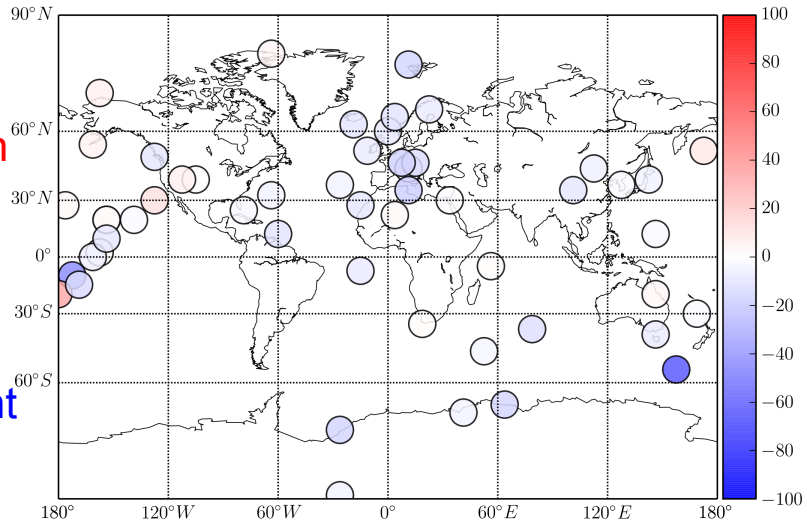
Seasonal amplitude



Degradation

Improvement

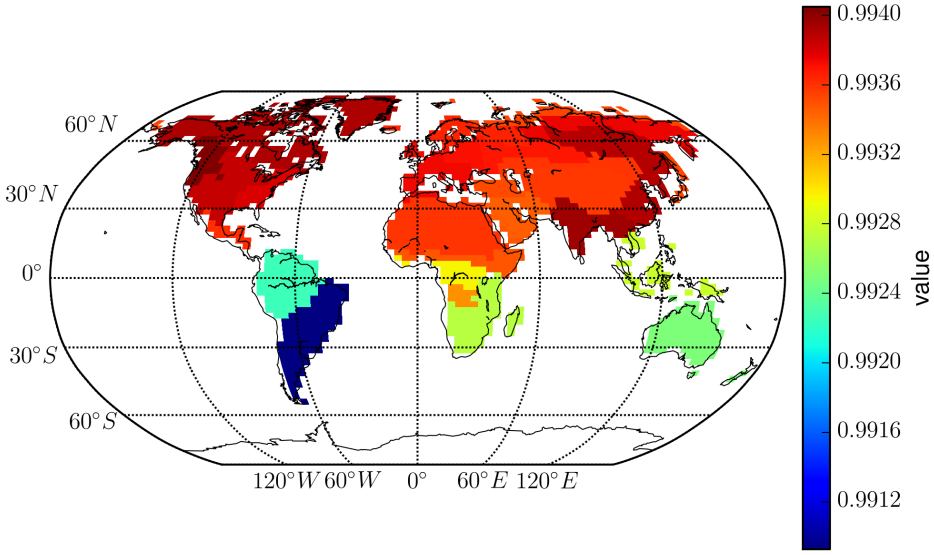
Carbon uptake period length



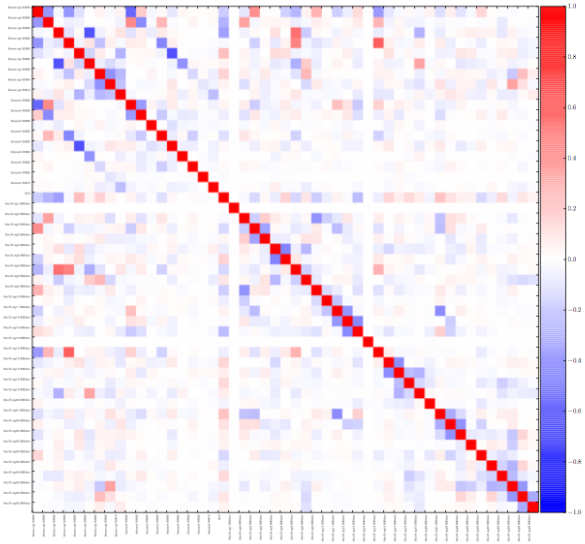
Assimilation of atmospheric [CO_2] data

➔ Primary constraint on:

- Soil initial carbon pools..

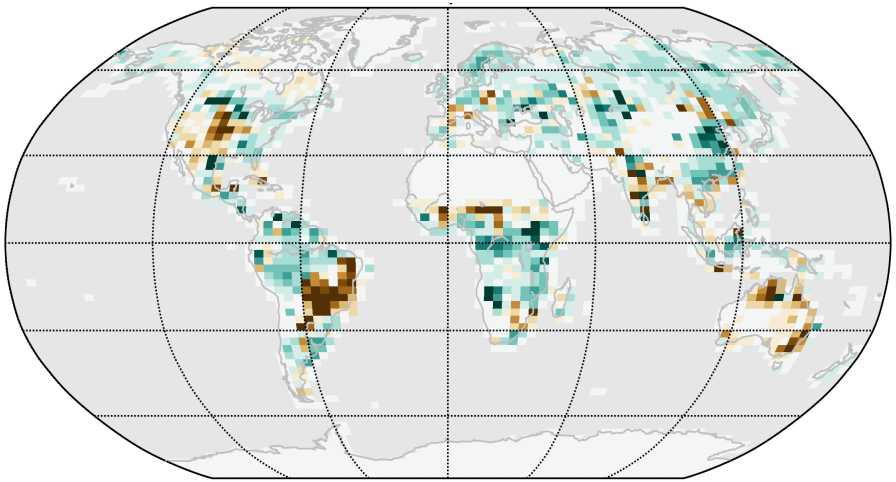


➔ But significant error correlations btw parameters

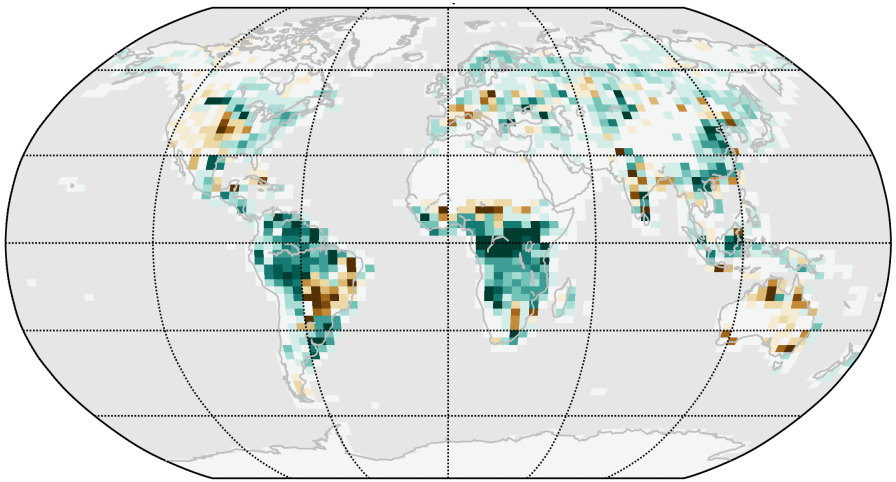


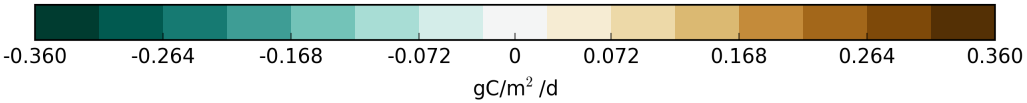
Estimated net carbon fluxes

NEE - Prior



NEE - Posterior

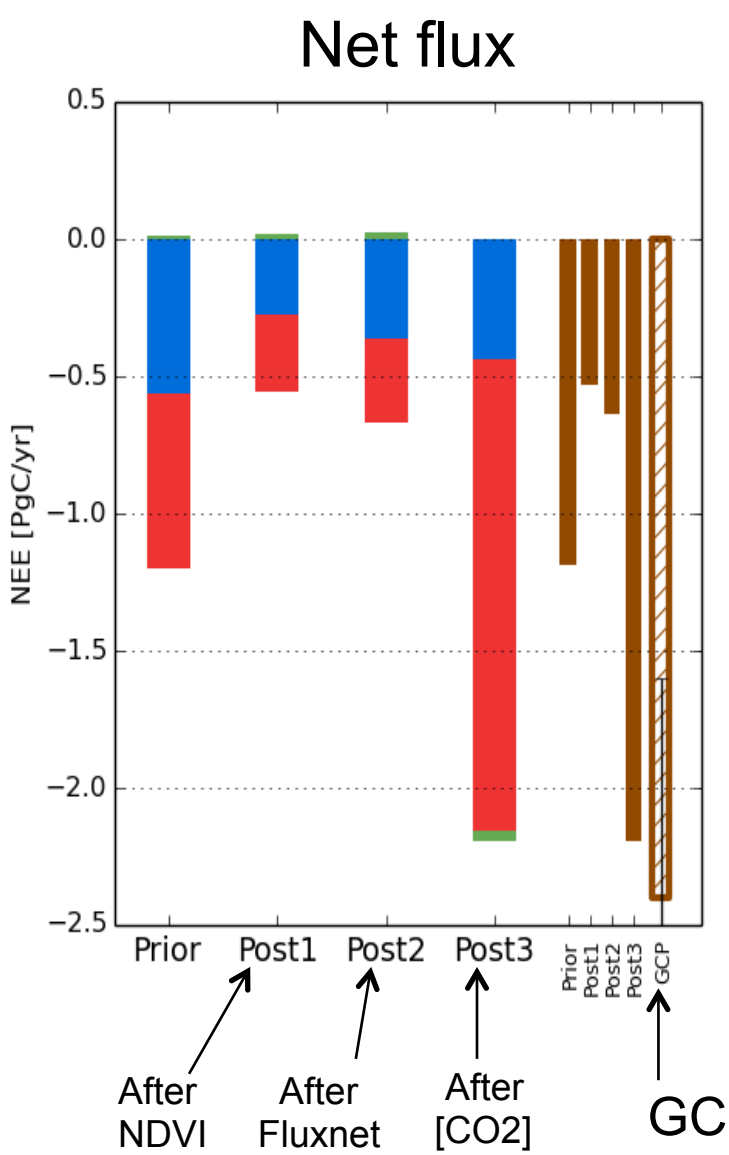


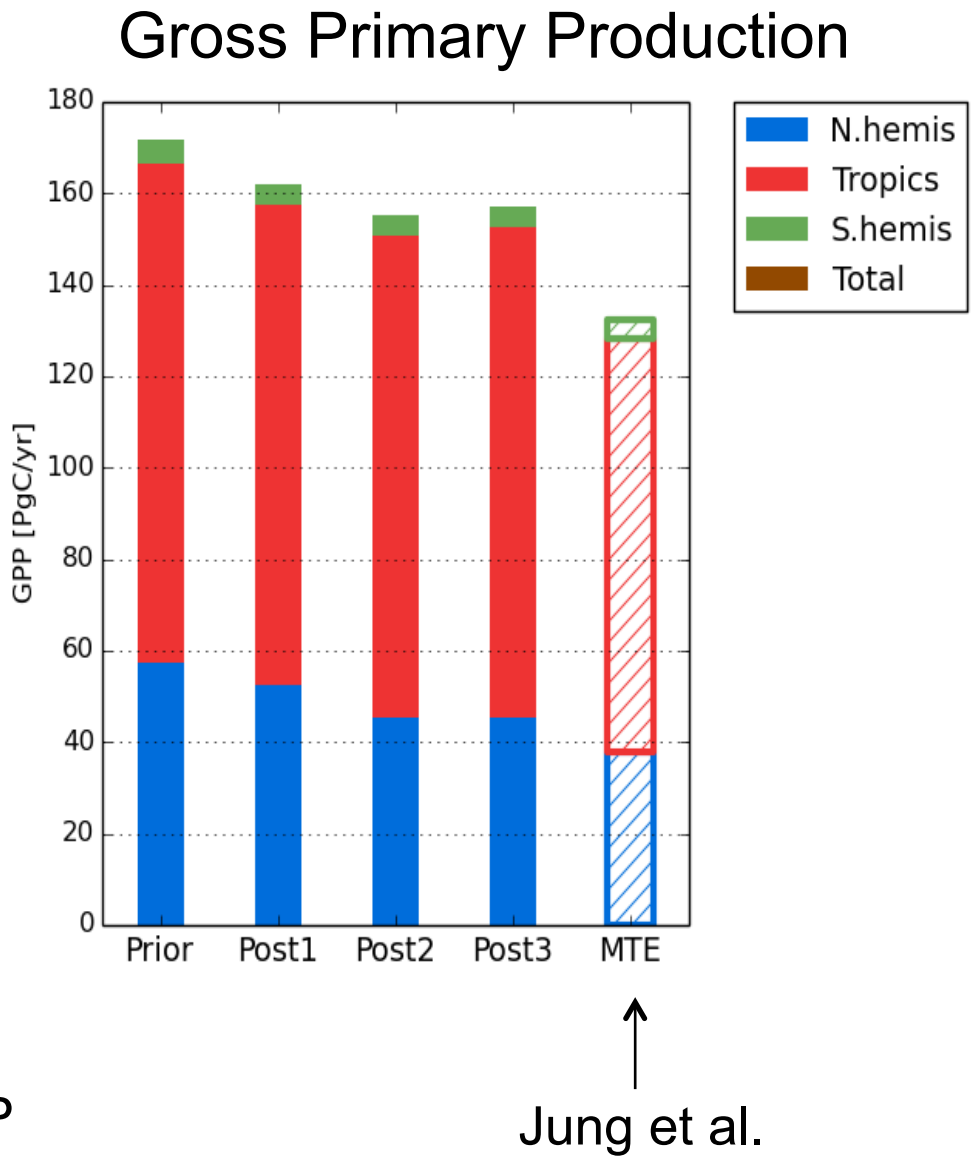


gC/m2/day

➔ Significant changes over the tropics..

Impact of Data Assimilation





Outlook-1…

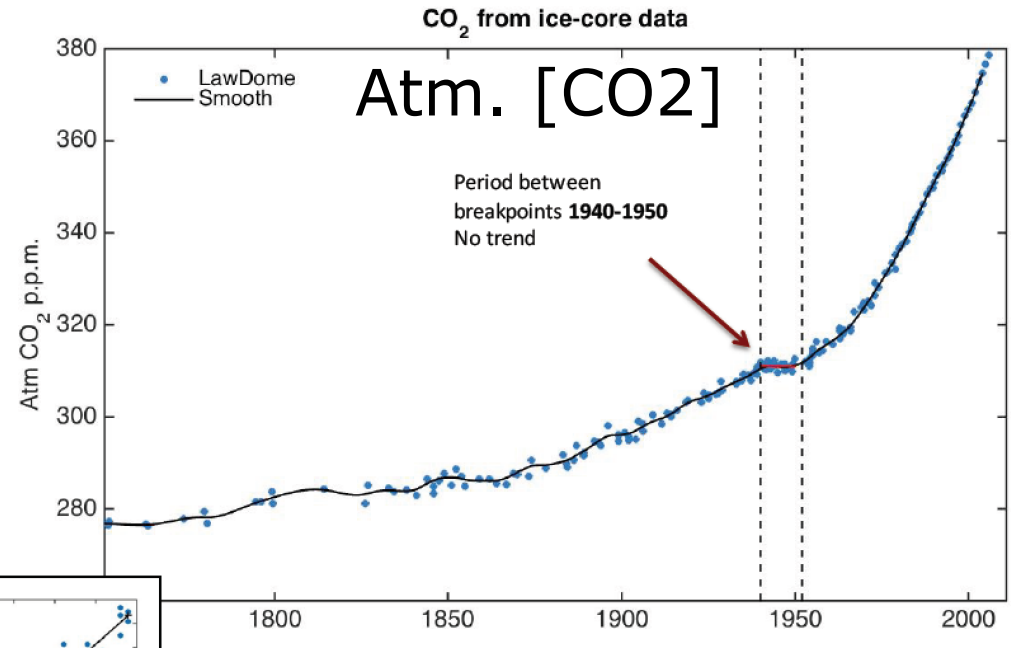
➔ "Investigation" for an homogeneous earth system reanalysis including Carbon-cycle.

- Objective fo the Land:

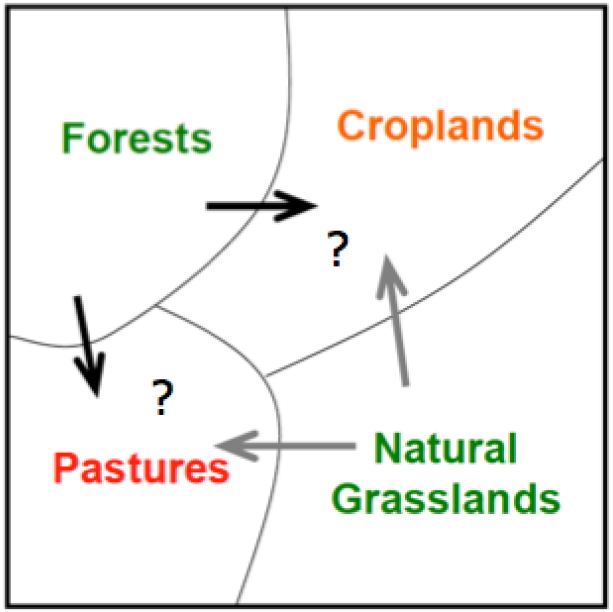
  Apply a "Carbon Cycle Data Assimilation System" over the whole 20th century using:

  - Atm CO2: **in situ recent data + *Ice core data***
  - Satellite NDVI: **GIMS (AVHRR) long record**
  - FluxNet data: **(NEE, LE)**
  - Possibly forest age **: Age reconstruction**

Use the full Atmospheric CO2 record.. to correct for Land Use Change..



Optimization of Land use change scenarios..



Outlook - 2

- Potential iterative approach:

  1. IFS ➔ climate reanalysis
  2. ORCHIDEE + Climate reanalyse + Observations ➔ C – Cycle reanalysis
  3. IFS + C-Cycle forcing ➔ New climate reanalysis

- ➔ “Nearly consistent” comprehensive Carbon fluxes and stocks and climate reanalysis..