ORCHIDEE in CMIP6

(whole ORCHIDEE team…)

- New Developments for CMIP6
- Ongoing « issues »
- Land cover input

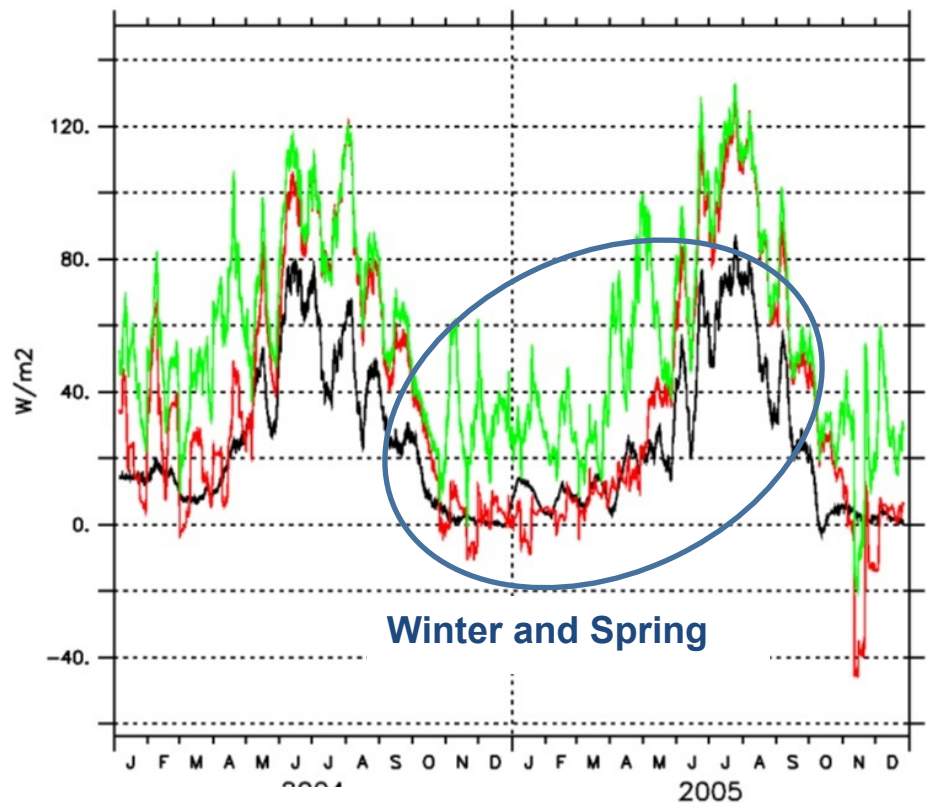
ORCHIDHEE (CM6_v1) : New developments (vs CMIP5)

Biophysic

- 11 layers soil hydrology (done)
- Common soil vertical discretization between Hydrology and Thermics (done)
- New soil thermal properties (USDA texture classes) (done)
- Soil freezing (done, minor correction ongoing)
- New 3 layers snow model (done, minor correction ongoing)
- Improving Aerodynamic resistance (zo) (in progress)
- Adjusted albedos (bare soil mainly) (in progress)

Bias on evaporation

- Shifting from the 2-layer hydrological scheme to the 11-layer one increases latent heat flux for some PFT's
  - That is due to the evaporative component
  - It acts at winter time for deciduous trees when no canopy coverage



US-Bar - Temperate deciduous forest
Servettaz, 2014 (L3 report)

OBS
2-layer
11-layer

How to improve Evap_bare-soil ?

Work on soil resistance

➔Testing 2 formulas for E_{soil} with a soil resistance
rs = f(Θsoil)

=> Best et al. 2011 or Sellers et al. 1992

Work on Evap Potential

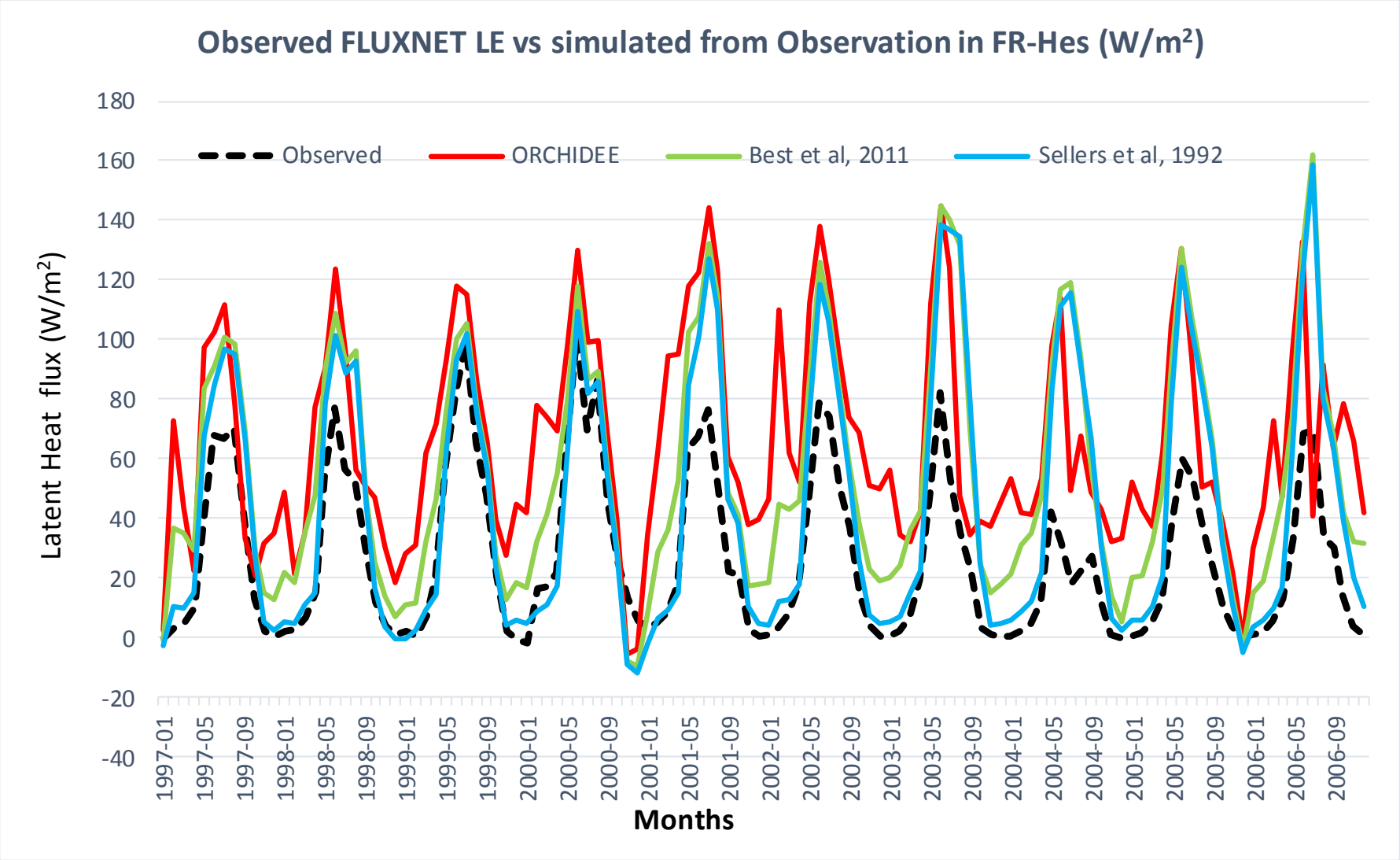
$$E_{pot} = \rho \frac{q_{sat}(T_s) - q_{air}}{r_a}$$

$$r_a = \frac{1}{\kappa^2 u_a}\left[\ln\left(\frac{z-d_0}{z_{0m}}\right)\ln\left(\frac{z-d_0}{z_{0v}}\right)\right]$$

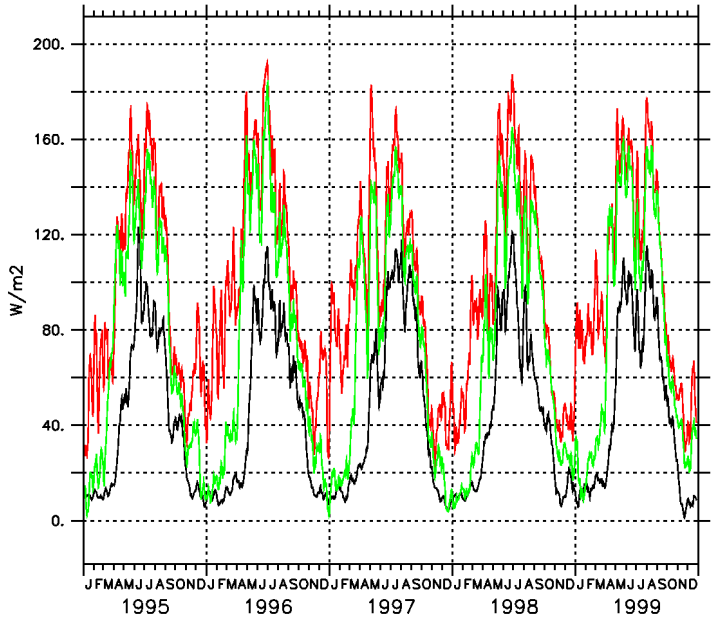
⇒*New* z_0 formulation f (LAI) : Su et al. (2001)

Test of new “rs” (site level)

- Over a deciduous forest

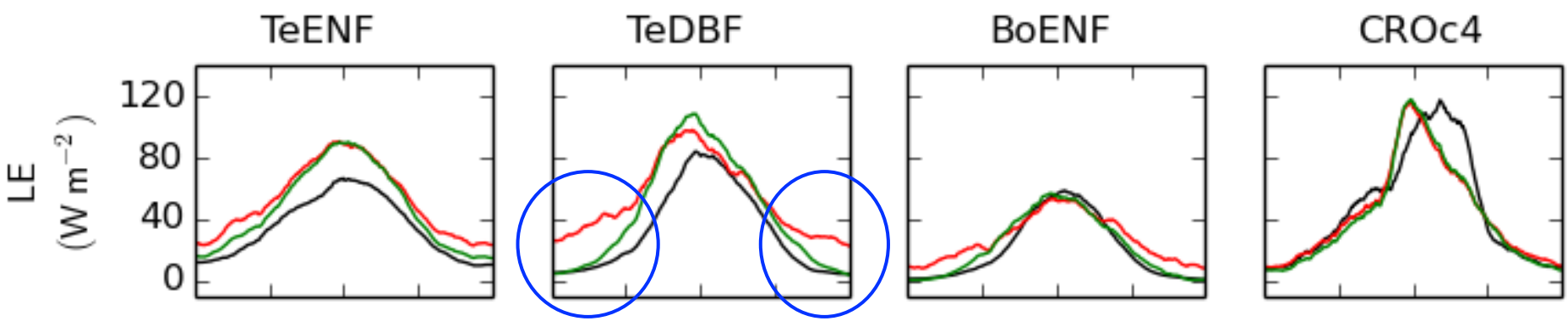


Test of new Z0 (site level)



OBS
11-layer
11-layer with Su

Latent Heat flux @ Walker Branch site (TeDBF)



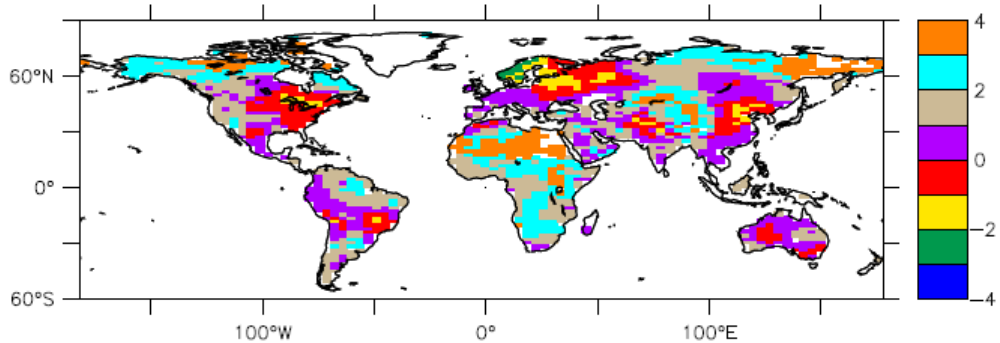
ORCHIDEE Biophysical developments

F. *Cheruy, F. Wang, J.L. Dufresne, S. Ait Mesbah A. Ducharne, N. Vuichard , J. Polcher, P. Peylin*

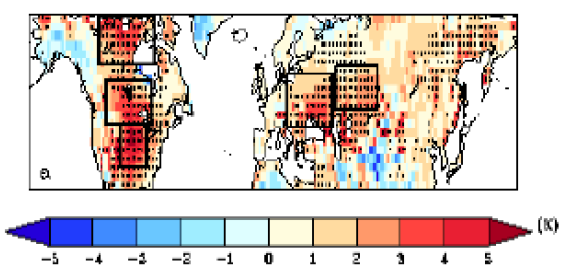
- **A possible source of bias in LMDZ-ORCHIDEE: the roughness lengths for momentum and for heat**

Sensitivity study to z0 formulation
- Su et al. [2001, JAM];
- Revision of z0m bare soil

Mean annual Tsurf diff: (ZO_CTRL) - (Z0_SU)

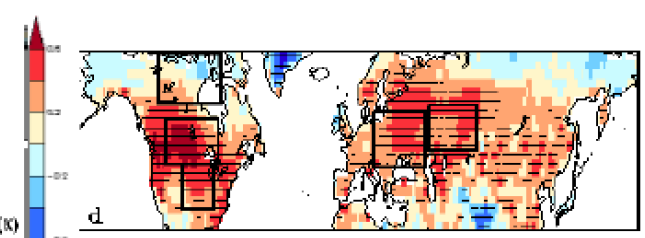


- **The most biased models in the present climate (summer) simulate a larger warming response to the climate change. The deficiencies identified for the bias are involved in the spread of the summer temperature projection amongst models**

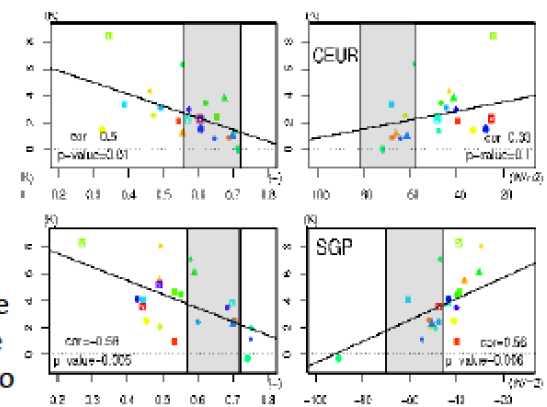


Over land, most state-of-the art climate models contributing to CMIP5 share a strong summer-time warm bias in mid-latitude areas,

Cheruy et al., GRL 2014



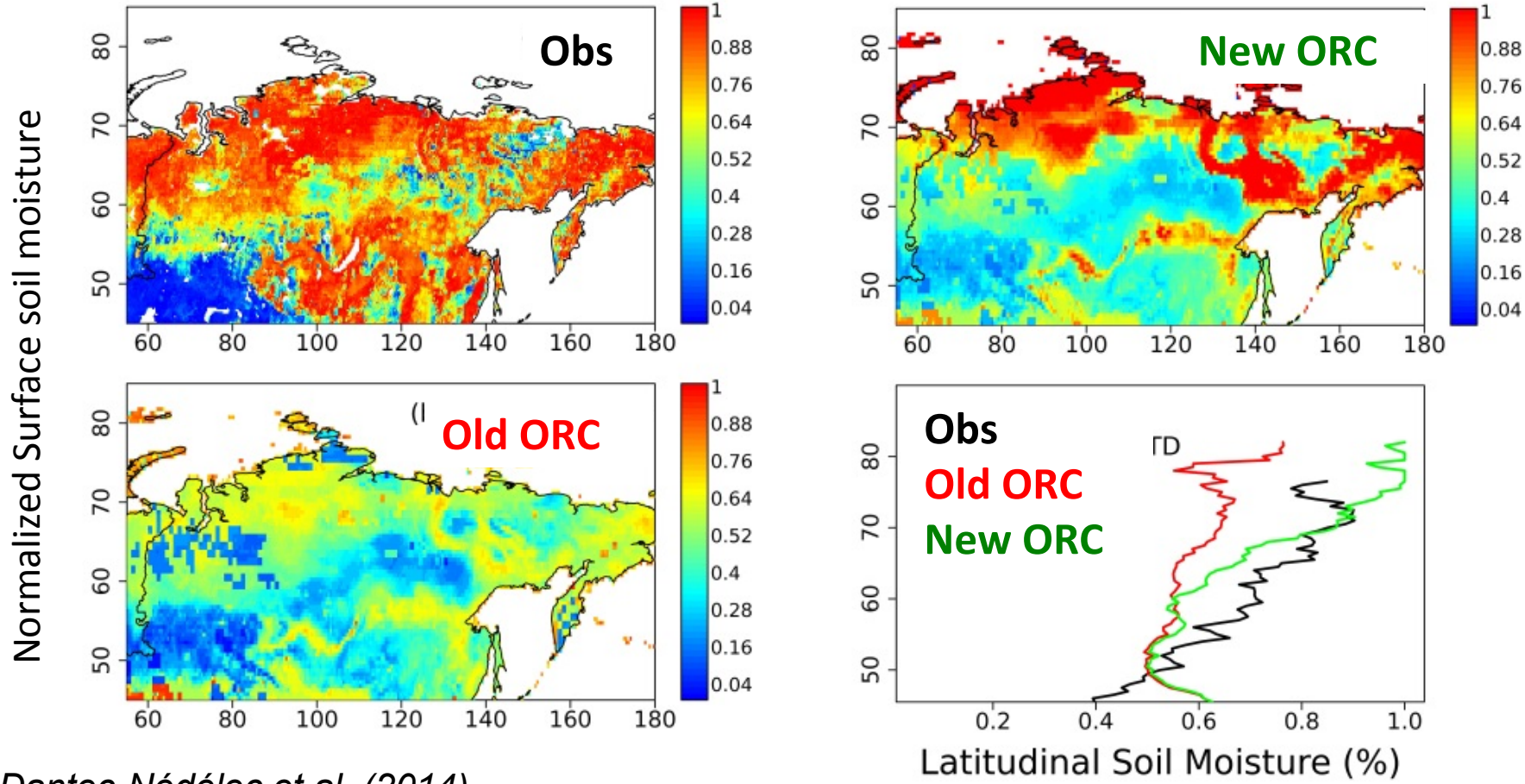
The most biased models in the present climate simulate a larger warming response to climate change thus tend to have a higher sensitivity to climate change amplifying it artificially



The most biased models over-estimate solar incoming radiation, because of cloud deficit and have difficulty to sustain evaporation

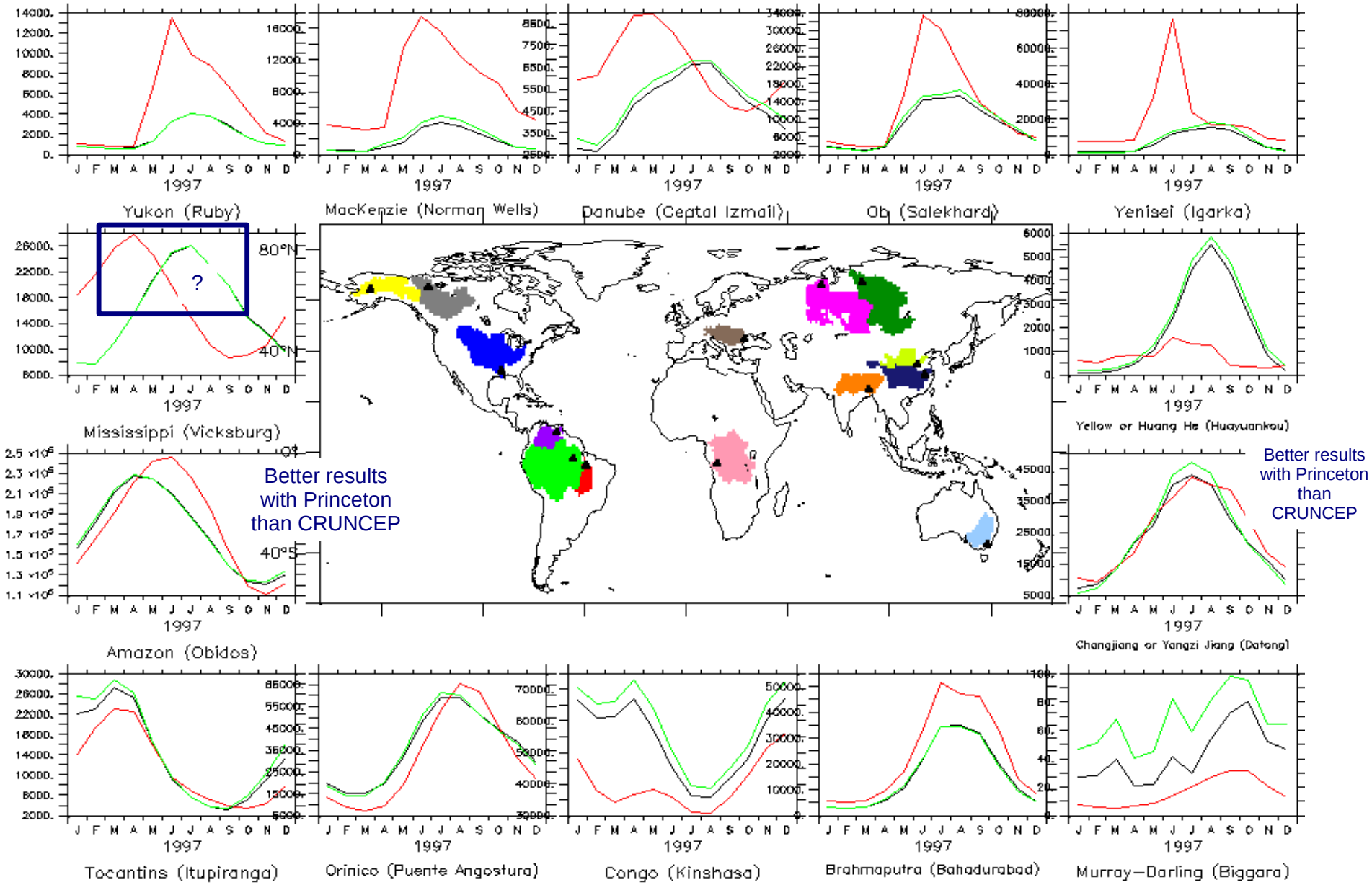
Evaluation at high latitudes: soil moisture

- Obs : ESA – CCI summer soil moisture (1978-2010); 0.25°
- **11-layer hydrology + soil freezing + new snow model**



Dantec-Nédélec et al. (2014)

Runs Agnès
trunk v2686
Princeton_GPCC 1° **3 textures ; 12 textures ; GRDC**
New snow & permafrost: NO

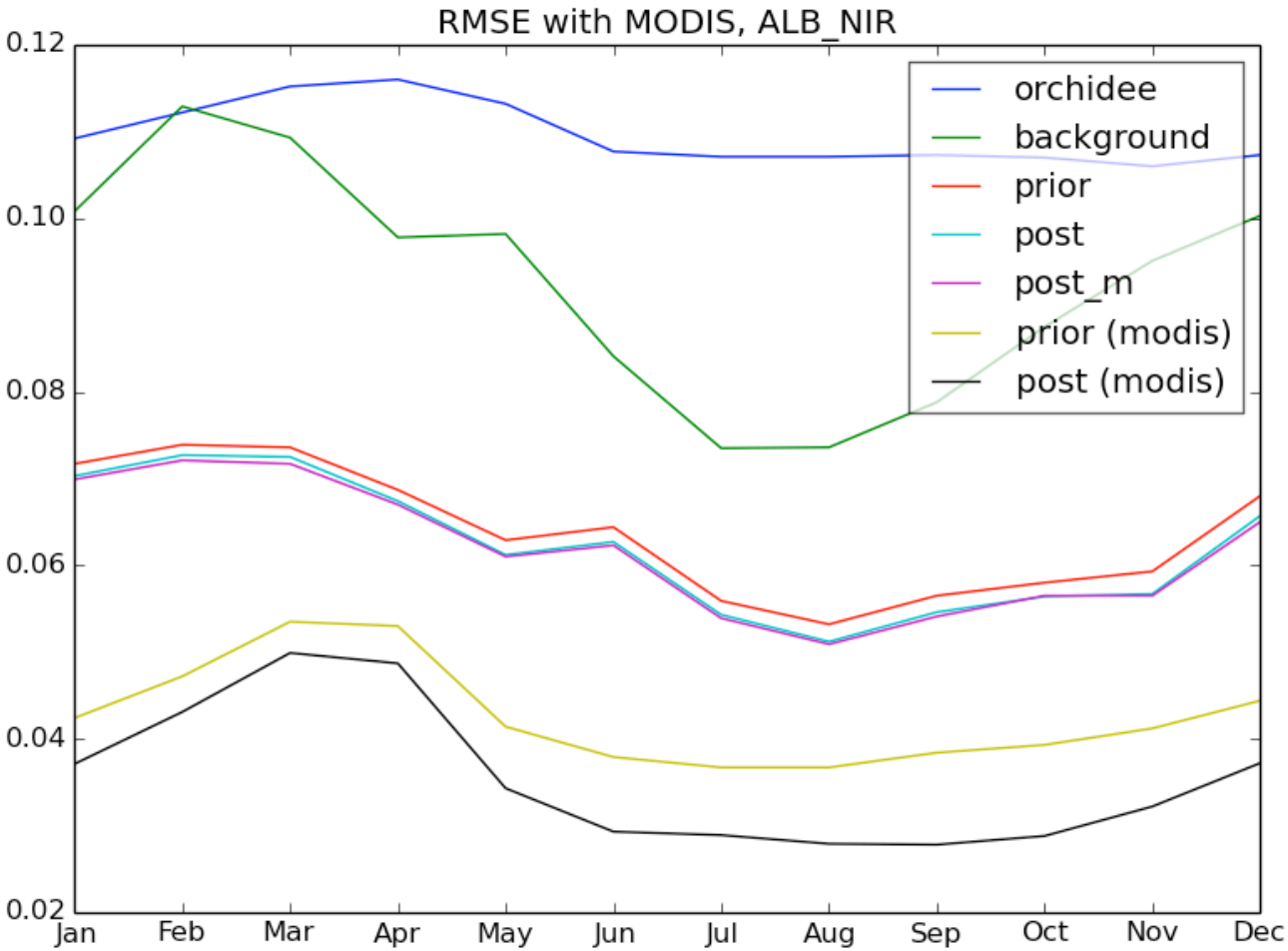


New albedo:

Bare soil: soil color albedo => “background albedo” (JRC -TIP)

- Optimized vegetation albedo coefficients

➔ Evaluation against MODIS albedo



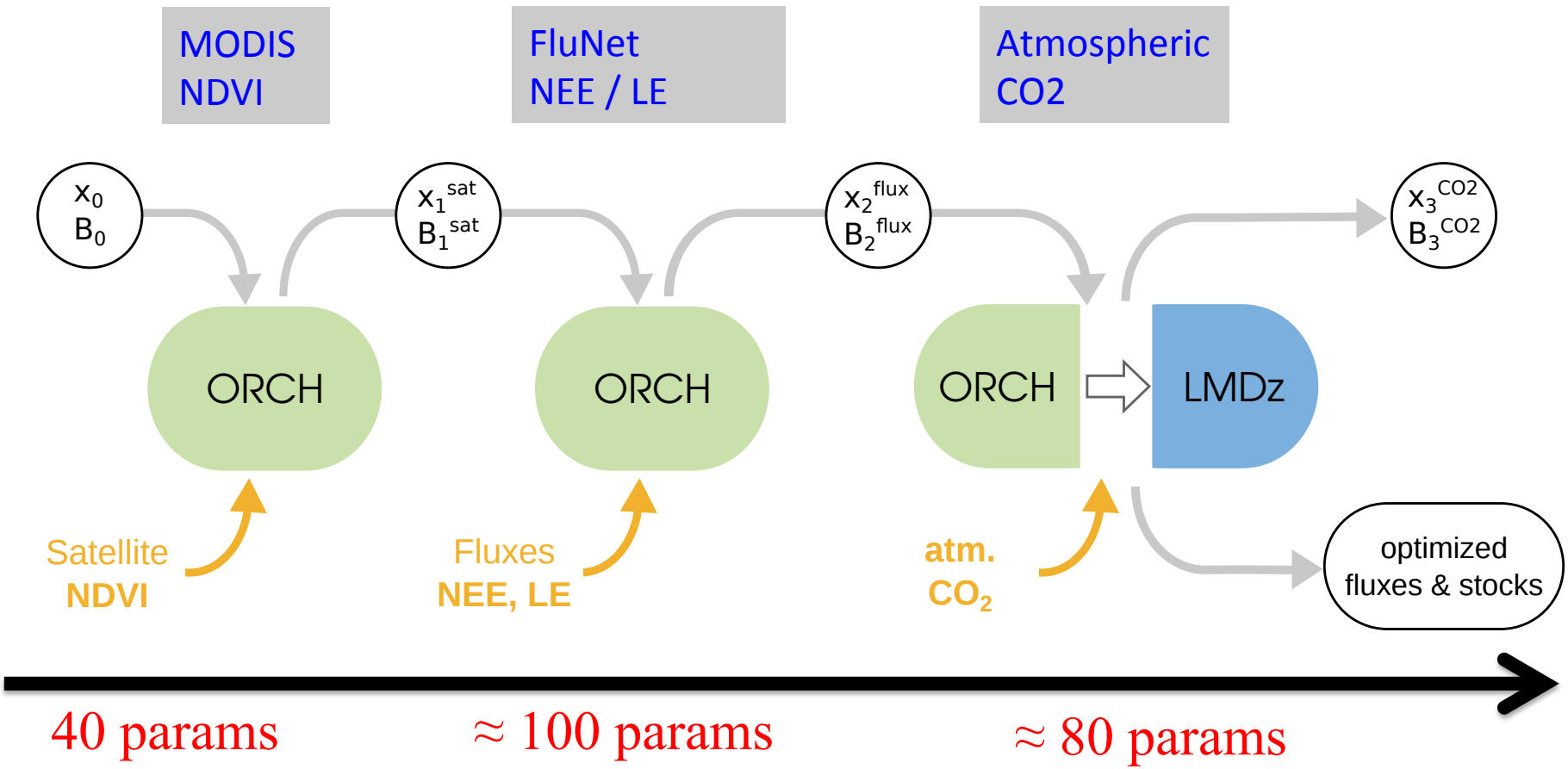
ORCHIDHEE (CM6_v1) : New developments (vs CMIP5)

Biogeochemistry

- Overall “GPP” calibration (done)
- DGVM (done)
- Nitrogen cycle (to be included in Trunk)
- VOC (done)
- FIRE (SPITFIRE) (To be included in Trunk)
- PERMAFROST-Carbone (Developed; to be included in 2016)
- CROPS – GRASS (Possible improvement in 2016) ?

Step wise data assimilation system

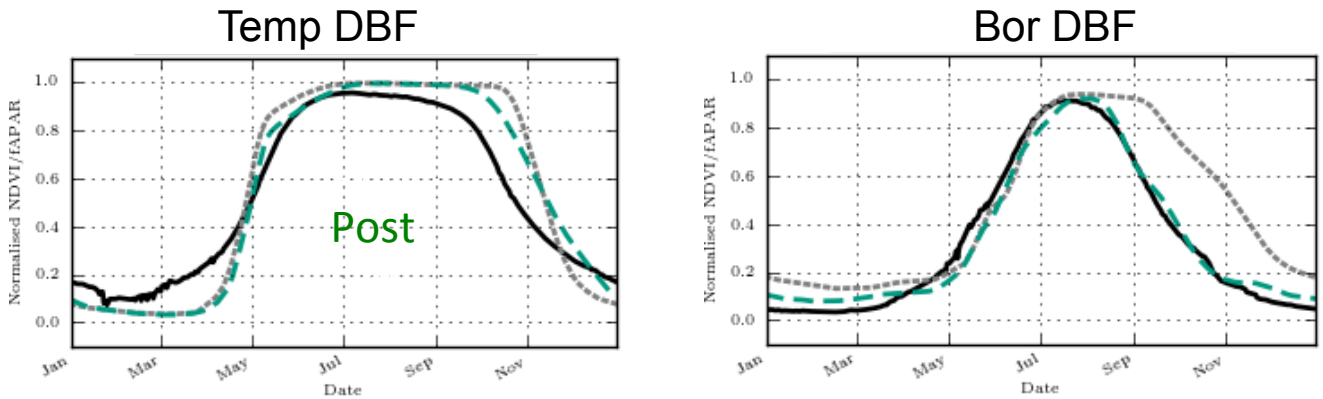
$$J(x) = \underbrace{\tfrac{1}{2}(\mathbf{H}.x-y)^T \mathbf{R}^{-1}(\mathbf{H}.x-y)}_{\text{Observation term}} + \underbrace{\tfrac{1}{2}(x-x_b)^T \mathbf{B}^{-1}(x-x_b)}_{\text{Prior parameter term (from previous step)}}$$



Assimilation of multiple data streams

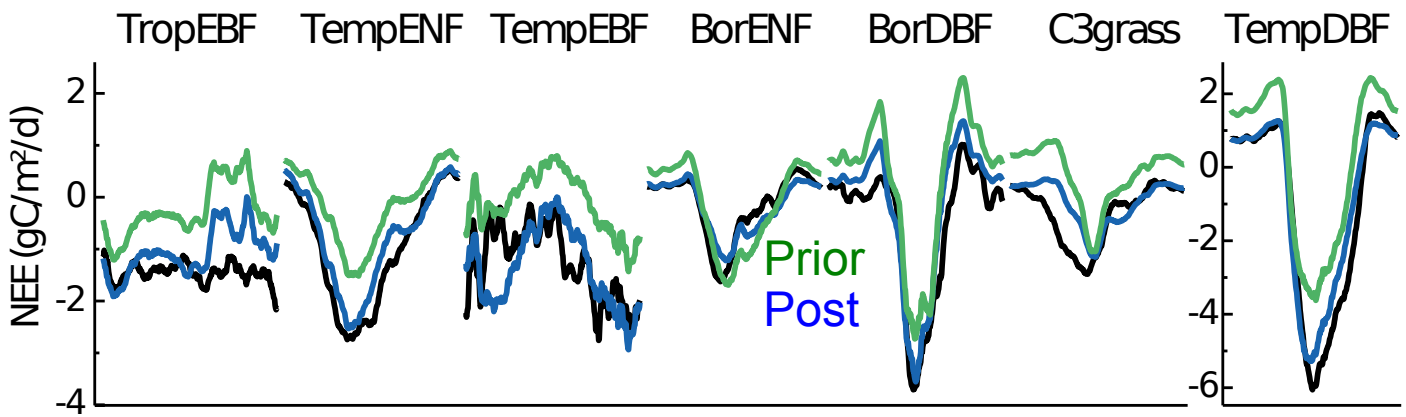
Step 1:
MODIS-NDVI

4 params /PFT



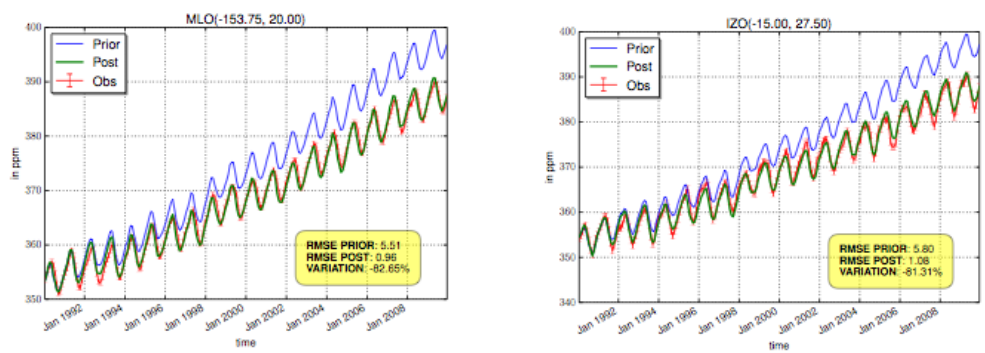
Step 2:
75 fluxnet data

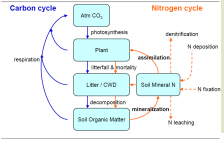
≈ 20 params /PFT



Step 3:
Atmospheric data

≈ 100 params total





Nitrogen cycle in ORCHIDEE

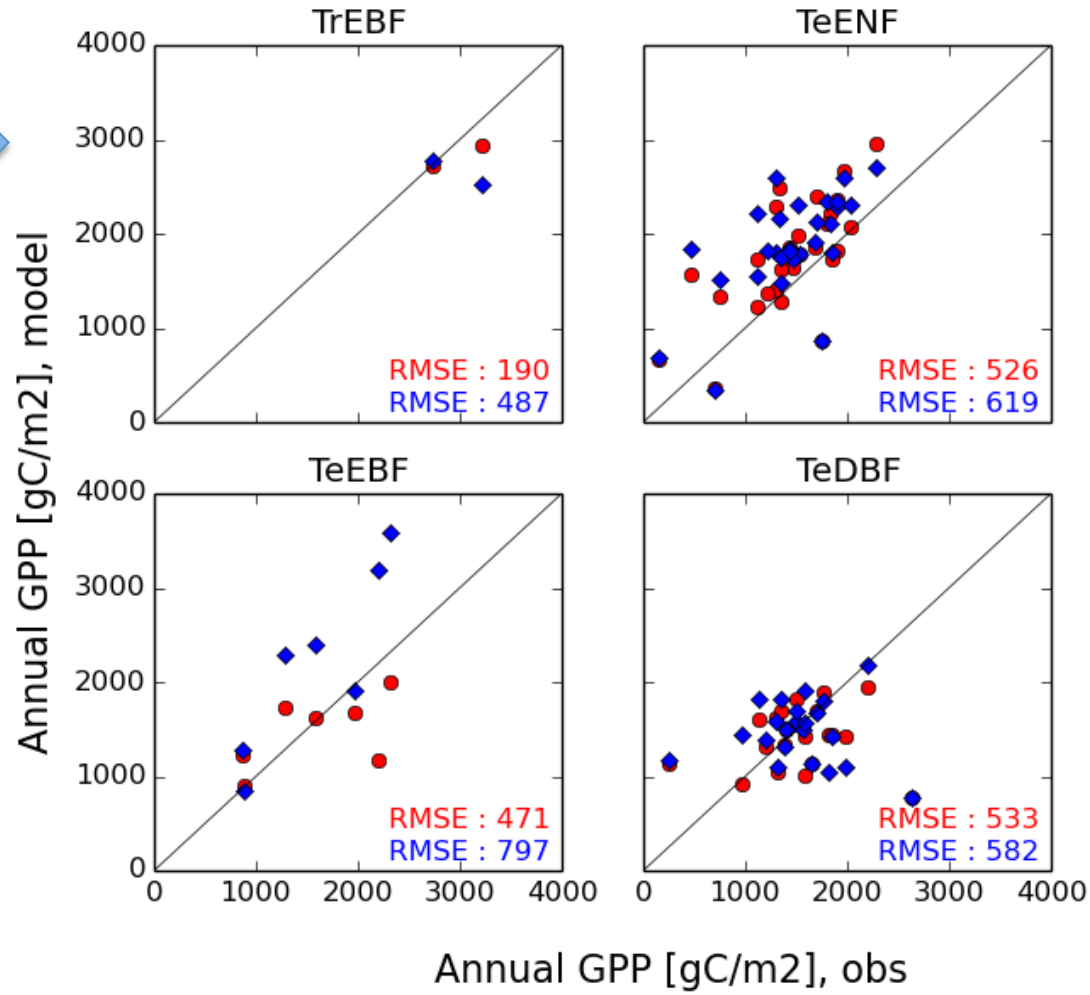
- Implementation of N cycle in ORCHIDEE main version
- Based on OCN model with updated Vcmax = f(N), C-allocation,…

➔ Evaluation at FluxNet sites (improved RMSE)

CN_fixed -> CN_variable

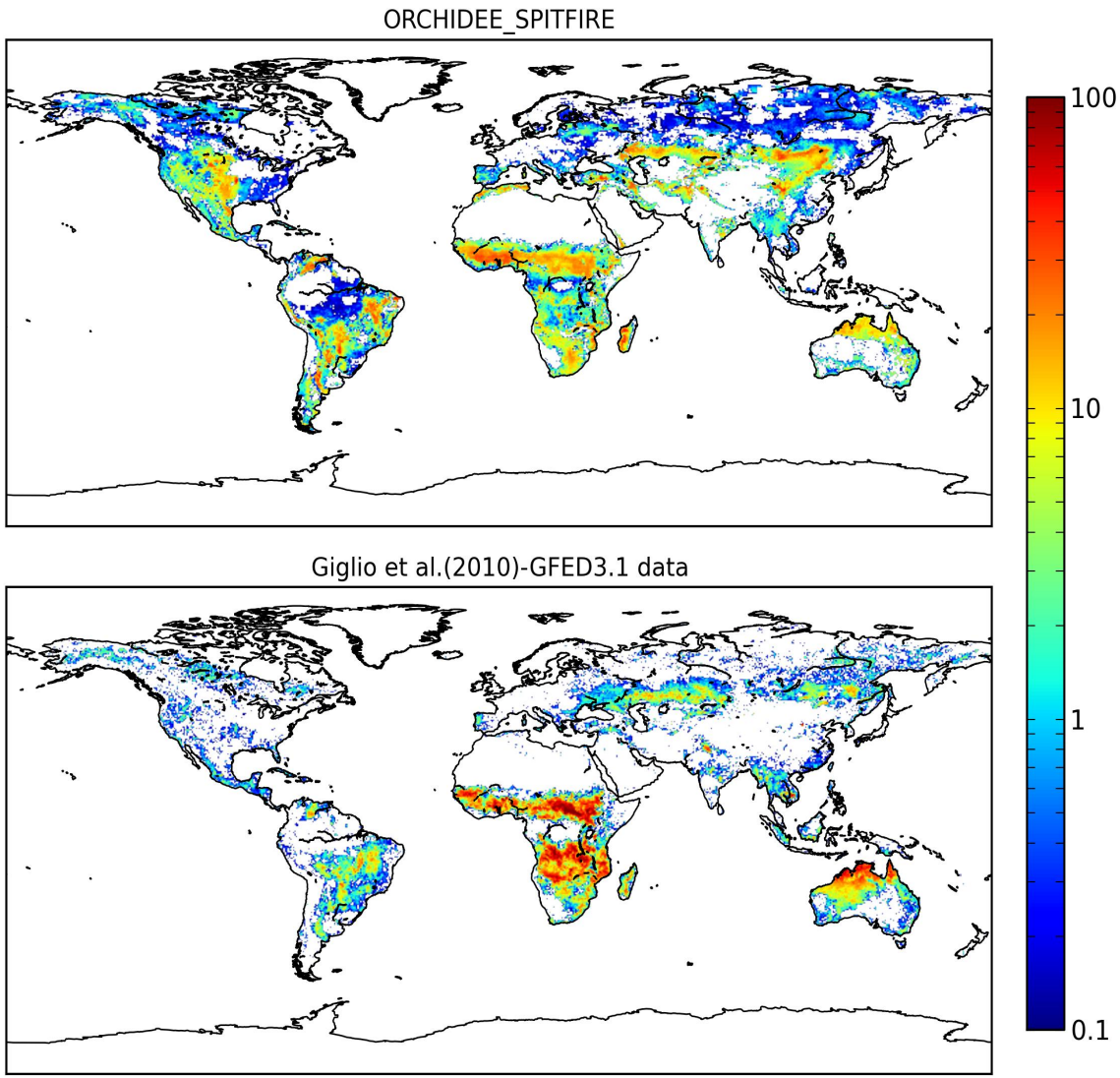
➔ On-going test at global scale (forced & coupled modes)

➔ Will be used in CMIP6



(Vuichard et al., in prep)

Simulated burning fraction in percentage between model (ORCHIDEE-SPITFIRE) and satellite observation (GFED3.1), averaged over 1997-2009

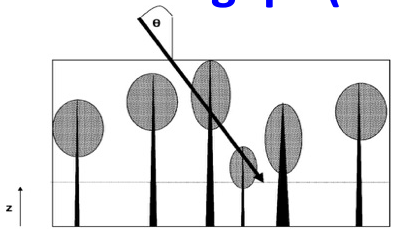


The general spatial pattern is reproduced by the model, however with boreal tundra being overestimated and souther African savanna being underestimated.

CMIP6-V2: new forest structure & management

Include diameter & age classes

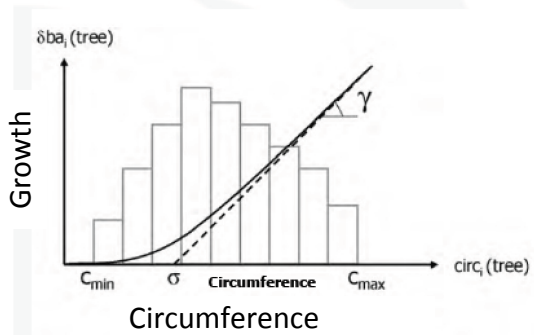
Accounts for gaps (PGAP)



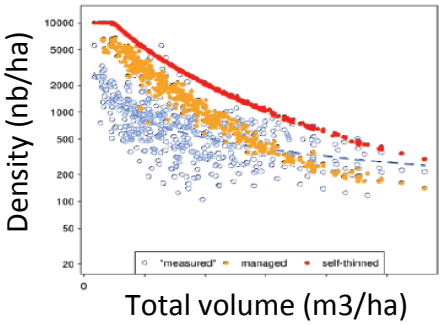
ORCHIDEE
- CAN

(Naudts et al., 2015)

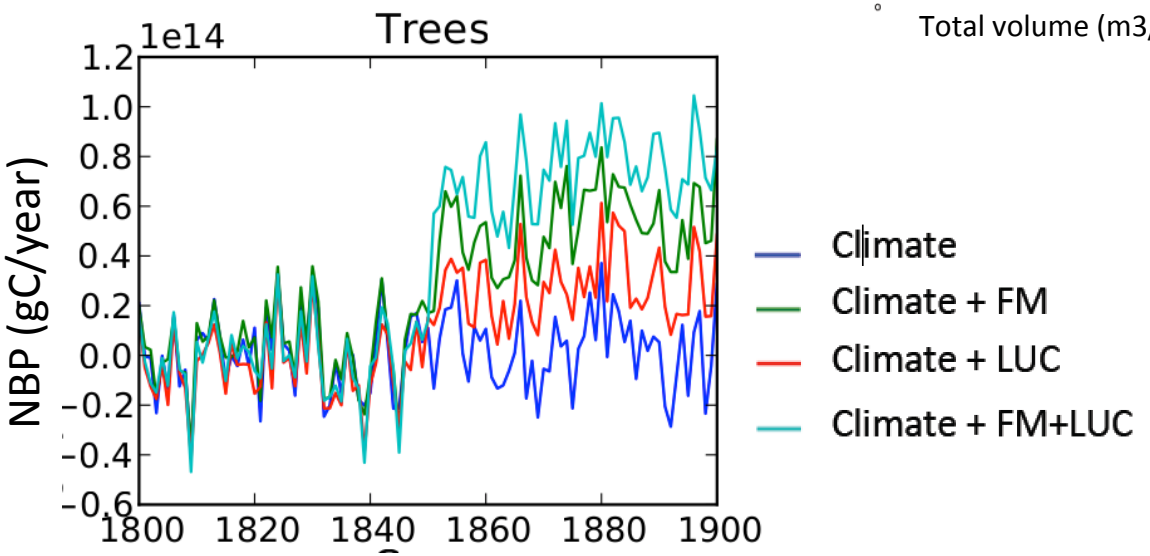
Allocation : "big get bigger"



Mortality from self-thinning



➔ Impact of climate
Forest management
Land Use Change
on European NBP



ORCHIDHEE (CM6_v1) : Other recent/on-going actions

- New Land Cover Classes using ESA - ECVlcover product (In progress)

- Several “BUG” cleaned (done)
  - Water conservation in the soil…
  - Restartability (1 + 1 = 2)
  - Gel du sol et conservation de l’eau
  - …

- Cleaning of the output diagnostics using XIOS (Retreat 19/20 November)

Strategy for new land cover maps..

- Start from the ECVLcover present-day PFT map (**0.25° resolution)**

⇒ Run backward for historical values

⇒ Run Forward for future scenarios

USING the transitions maps proposed by G. Hurtt for CMIP6

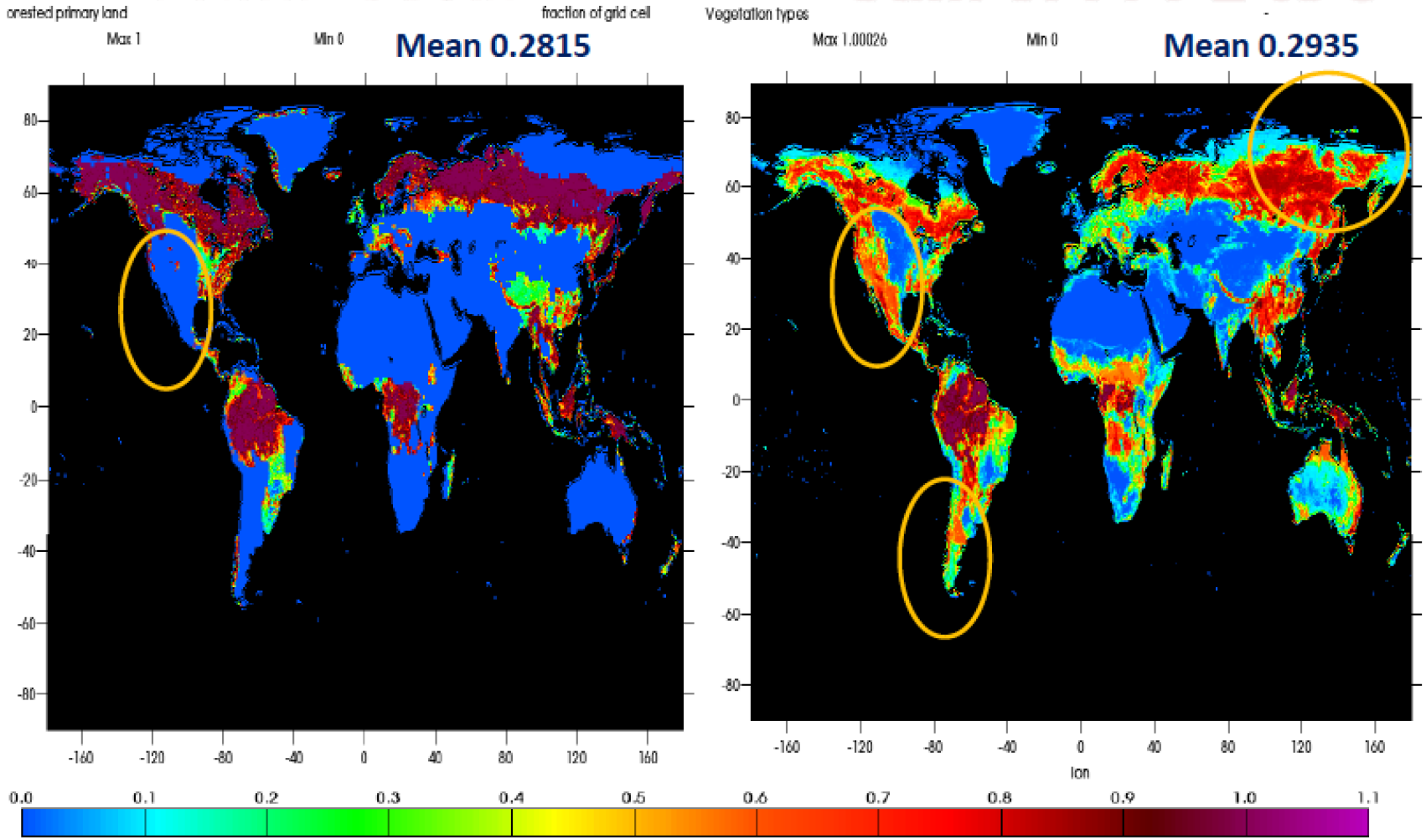
- Need to create an ORCHIDEE PFT map (13 PFT currently) from original LCC classification (22 classes)

=> Issues with Bare soil fraction..

FORESTS

Hurt Primf+SecdF

ORCHIDEE Sum of PFT 2 to 9



Personnes impliquées dans les MIPs

- LUMIP
  - Coordination by Nathalie De Noblet
  - Autres contributeurs (selon avancement des composantes)

- C4MIP
  - Coordination par Laurent B. / Patricia C.
  - Implication d'autres personnes: Philippe P.,…

- LS3MIP
  - Coordination by Gerhard K.
  - Implication directe: Agnes D., Frédérique C.,

➔ **Support d'un ingénieur CRESCENDO pour les simulations AOGCM & Joséfine**

COLLECTED DATASETS

Variable	Scope	Product	Resolution	Period	Frequency	Projected
GPP	global	Jung FLUXNET	0.5°	1982-2012	monthly	✓
Evapotranspiration	global	Jung FLUXNET	0.5°	1982-2012	monthly	✓
	global	Seneviratne LANDFLUX-Eval	1°	1989-2005	monthly	✓
	global	Fisher	0.5°	1986-1995	monthly	
	global	Gleam	1°	1984-2006	monthly	
	global	NTSG	1°	1984-2006	monthly	
	Amazon	MOD16	1°	2000-2008	monthly	
	Amazon	Shuttleworth	1 site	1983-1984	monthly	
CO2	global	Peylin inversions	1°	2001-2010	monthly	✓
		Le Quéré GCP		1959-2013	yearly	
Soil respiration	sites	Raich				
	sites	Bond-Lamberty				
Soil variables	global	ISRIC	1km/5km		average	✓
	global	HWSD	0.5°		average	
	global	IGBP	5’		average	
Soil profiles	sites	ISCN				
Soil carbon	global	HWSD-MPI-BGI	0.5°		average	
Turnover time	global	MPI-BGI	0.5°			
Litter decomposition	sites					
LAI	global	GIMMS3g	0.5°	1982-2010	bi-monthly	✓
	global	GLASS	0.05° AVHRR 1km MODIS	1982-2010	8-day	

COLLECTED DATASETS

Forest ABG biomass	**temperate/boreal northern**	**Thurner**	**1°**		**average**	
	global	Avitabile	0.01°			
	tropics	Saatchi	0.5°		average	
	tropics	Baccini				
Forest basal area		de Rigo/JRC	0.4°x0.6°	2000		
Canopy height	global	GLAS	1km	2005		
Soil moisture	global	ESA CCI ECV	0.25°	1978-2010	daily	
Water height	Amazon/Negro rivers	HYDROWEB/LEGOS		1993-2002		
Soil water profiles	Illinois state	WARM		1997-1999		
	Brazil	ABRACO		1990-1993		
Change in total water storage	global	GRACE	1°	2002-2013	monthly	
River discharge	global/sites	GRDC		1807-today	monthly	
	Amazon/sites	ORE-HYBAM		1967-2011	monthly	
Snow extent	global	Globsnow		2003-2012	daily	✓
Snow water equivalent	global	Globsnow		1979-2013		✓
Freeze/thaw dates		EPIC		2010		
Albedo	global	Globalbedo		1998-2011		✓
	global	MODIS	1°	2000-2010	monthly	
	global	GLASS	0.05° AVHRR 1km MODIS	1981-2010	8-day	
Surface temperature	global					
Radiative fluxes	global	CERES	1°			✓
Precipitation	Amazon	ORE-HYBAM	1°	1980-2009	daily	

ORCHIDEE Tiles planned

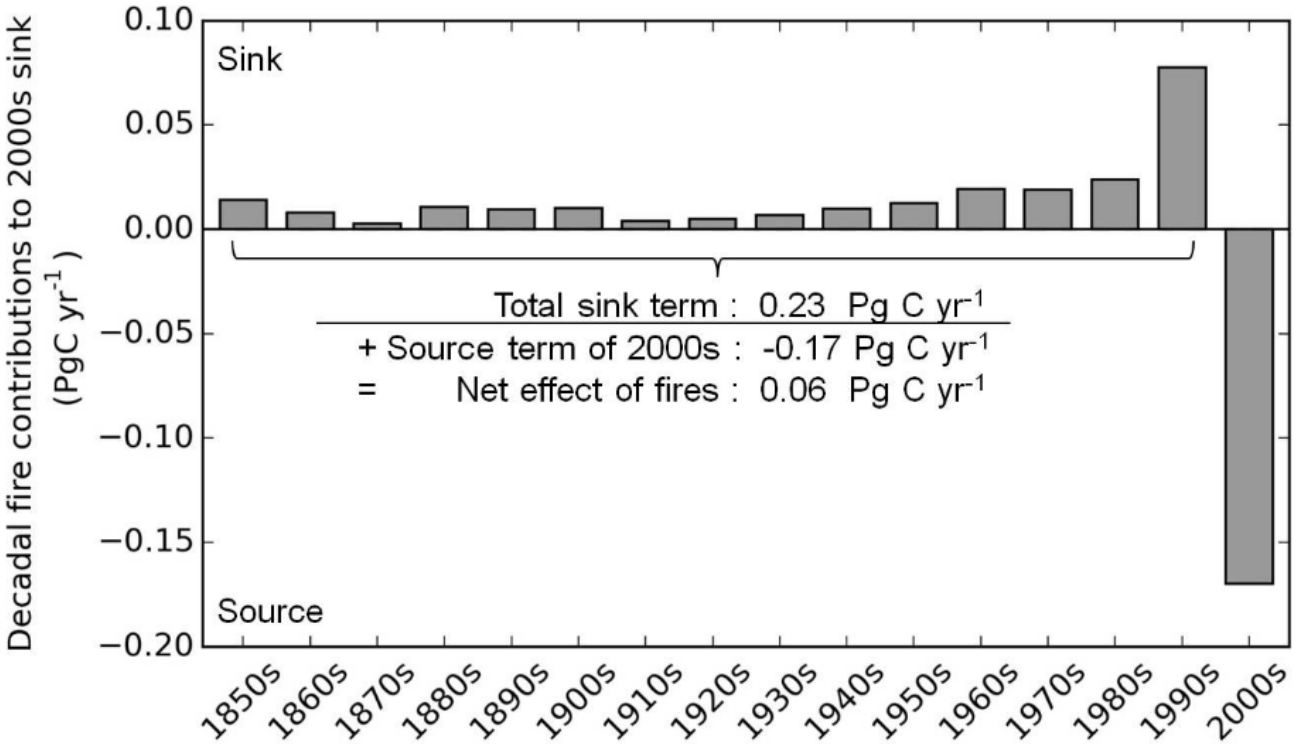
1. Bare ground	12. C3 anthr. grass	13. C4 anthr. grass
2. TropBEf		
3. TropBRf	14. C3 Per crop	15. C4 Per crop
4. TempNEf		
5. TempBEf	16. C3 Ann crop	17. C4 Ann crop
6. TempBSf		
7. BorNEf	18. N-fixing crop	
8. BorBSf		
9. BorNSf	19. Additional crop (if any to be decided)	
10. C3 Natural grass	20. Urban land	
11. C4 Natural grass		

ORCHIDEE – SPITFIRE

➔ SPITFIRE coupled to ORCHIDEE

➔ Ex: impact of past fire disturbance on Boreal ecosystems

Contribution of decadal "fire cohorts" of 1850-2009
to the simulated C sink for 2000-2009



Yue et al., BGD, 2015