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# Assimilation de données: Optimization des paramètres du modèle ORCHIDEE

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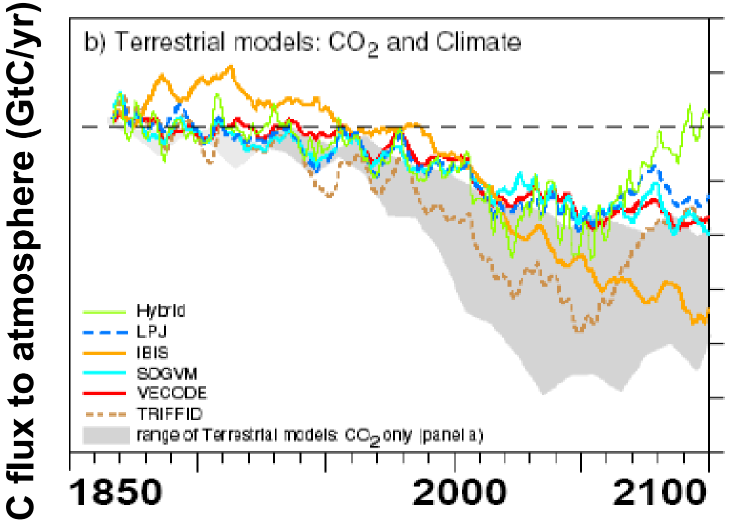
# Optimisation des flux de carbone: Objectifs scientifiques

**Large uncertainty from land to predict global C-balance (C4MIP)**



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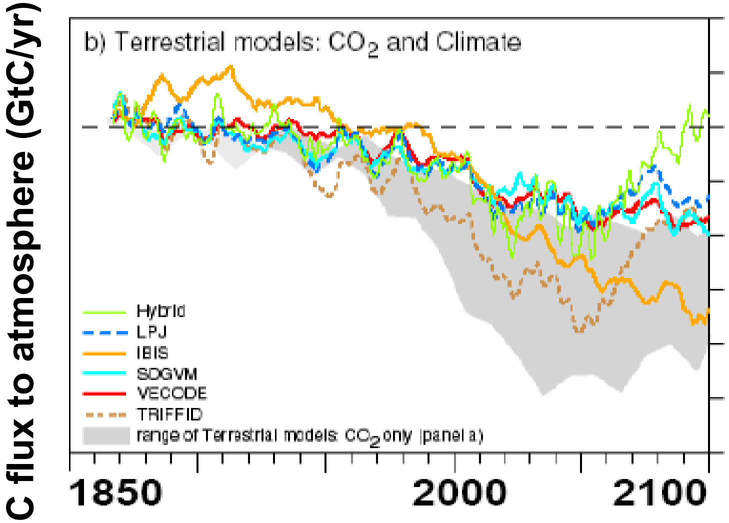
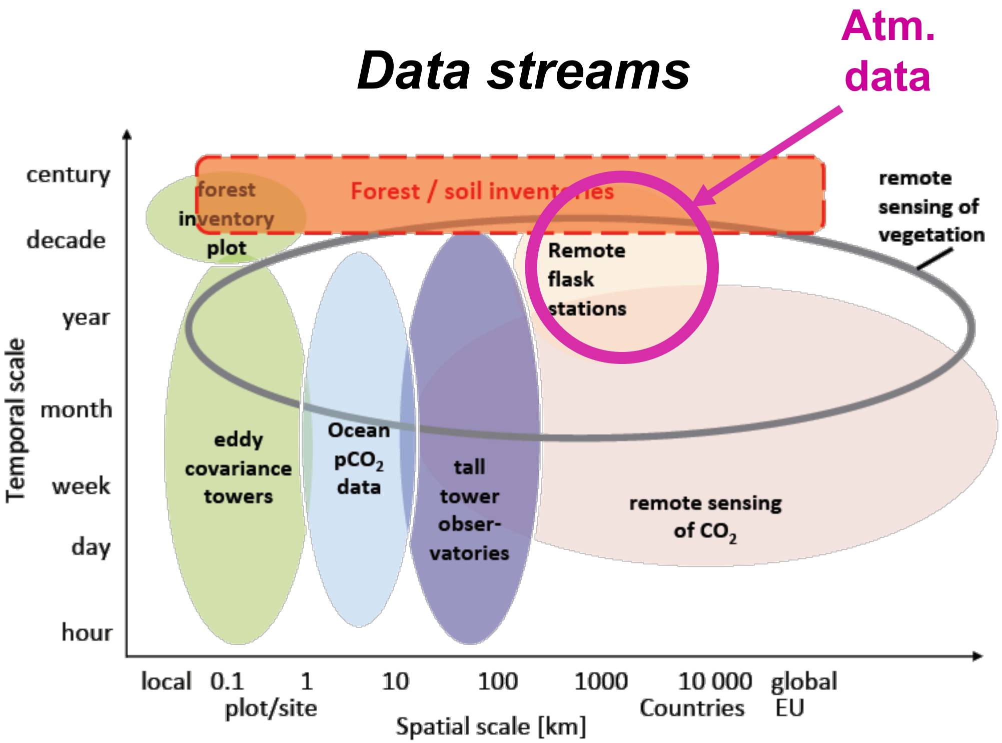



***Data streams***



# Optimisation des flux de carbone: Objectifs scientifiques

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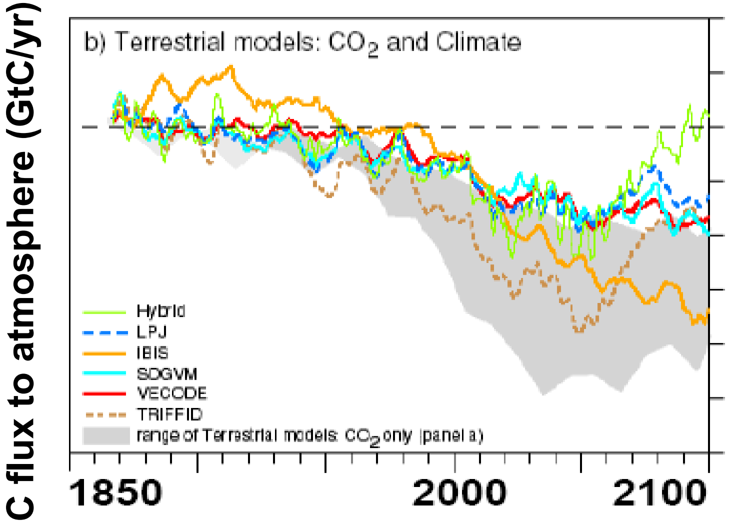
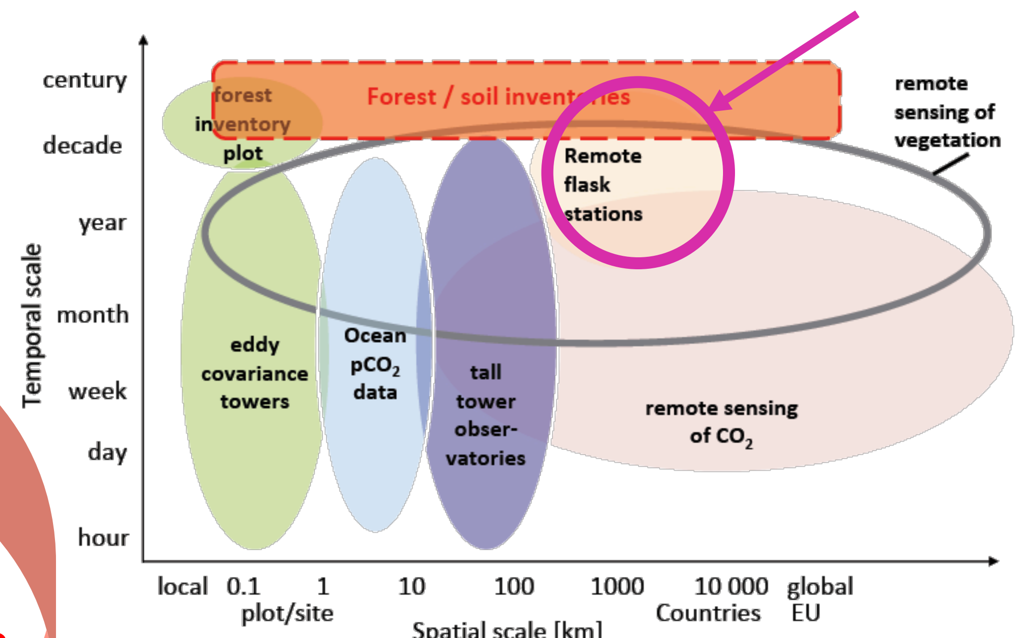



**Data Assimilation**

***Data streams***

**Atm. data**




**Optimized ecosystem models**

**➔ reduce the spread ?**

# Processus et paramètres clés à optimizer…

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**Net SW downwelling Radiation**

$$Rn = (1 - \mathrm{kalbedo})\, R^{i}_{lw} + R^{i}_{sw} - \varepsilon\sigma T^{4}_{surface}$$

**Assimilation**

$$A = Vc.(1 - \Gamma^{*}/C_i) - Rd \qquad Vc = \frac{\mathrm{fstress}.Vc\ max\ .Ci}{Ci + Kc\ .(1 + \frac{O_i}{K_0})}$$

**Evapo transpiration**

$$A = 1/r_a + r_s\ (C_a - C_i)$$

$$ET = \sum_i \frac{K_E}{r_a + r_s}(q_i - q_{air})$$

$$1/r_s = \mathrm{gslope}\ A.RH/C_a + g_0$$

**Sensible heat**

$$H = \frac{\mathrm{kcapa}\ C_{sol}}{r_a}(T_{surf} - T_{air})$$

$$r_a = \frac{1}{\mathrm{kra}.C_d(\mathrm{krugo})}$$

**Maintenance resp.**

$$Rm = \mathrm{krespm} \sum_i \lambda_i B_i f(T_{surface})$$

**Growth resp.**

$$Rg = \mathrm{krespg}\,(A - Rm)$$

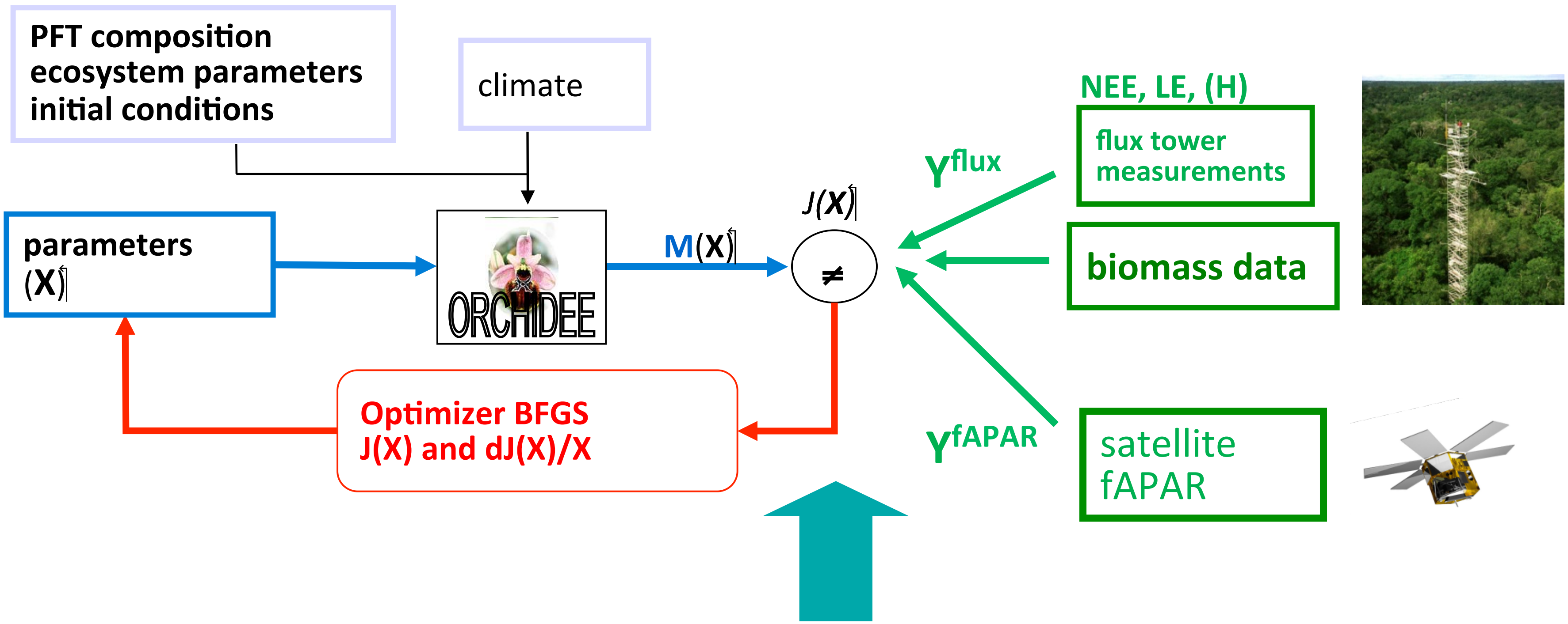
**Heterotrophic resp.**

$$Rh = \mathrm{kresph} \sum_s m_s B_s g(swc)(\mathrm{kQ10})^{\frac{T_{soil}}{10}}$$

**NEE**

$$NEE = Rm + Rg + Rh - A$$

# Optimization implementation..

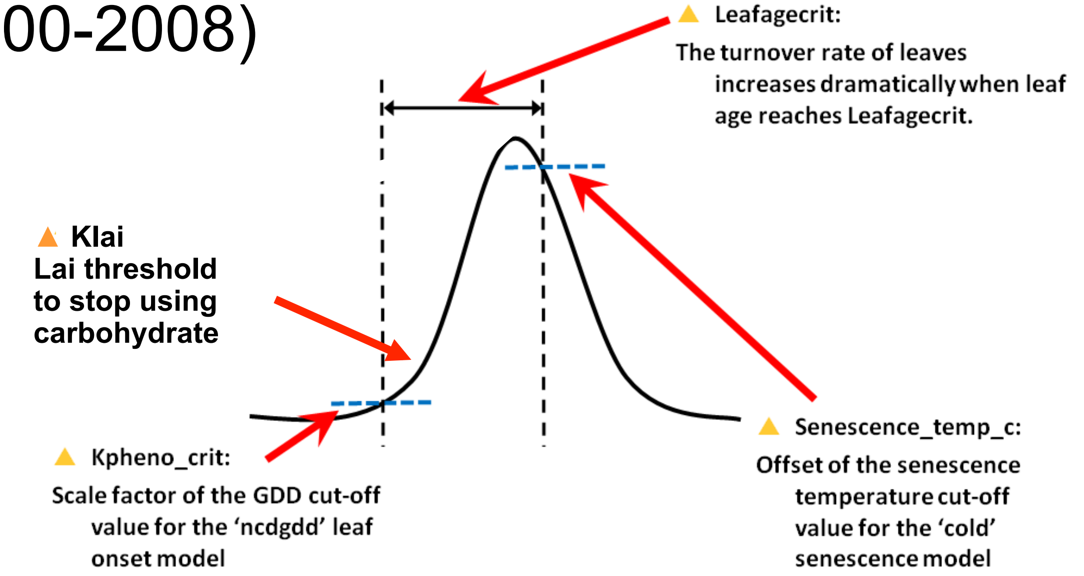



- **Cost function:** $J(x) = \frac{1}{2}\left[\left(y - M(x)\right)^t R^{-1}\left(y - M(x)\right) + (x - x_b)^t P_b^{-1}(x - x_b)\right]$

- **Iterative minimization using either:**
  - **Variational approach (with Tangent Linear model for DJ/dx)**
  - **Monte Carlo approach**

# Assimilation des données MODIS NDVI

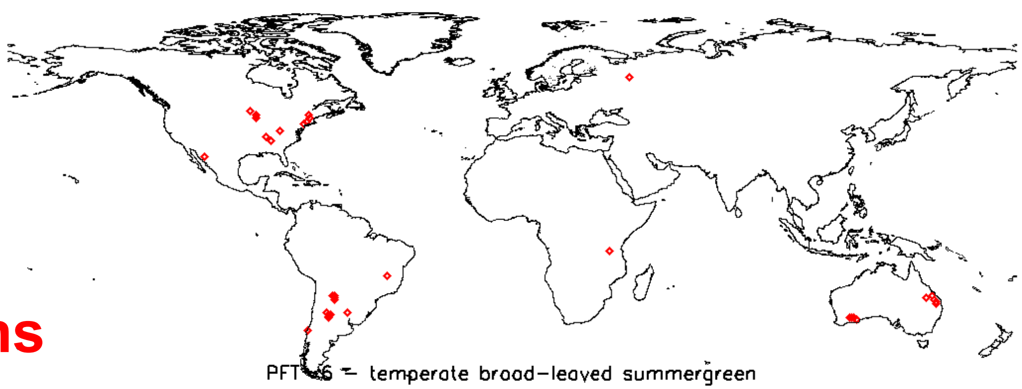
- Optimize 4 phenology parameters using normalised NDVI (2000-2008)




- ORCHIDEE run with IERA Meteo (0.7°)

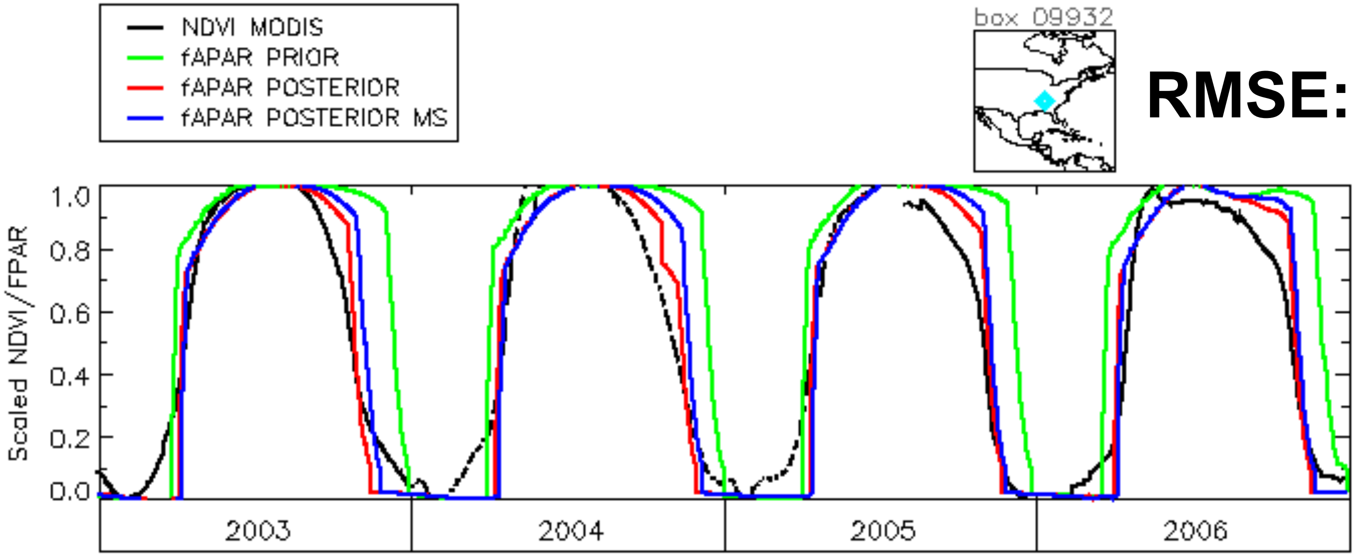
- For each PFT use 30 points with >70% PFT cover

*Ex: Temperate deciduous broadleaf forest*



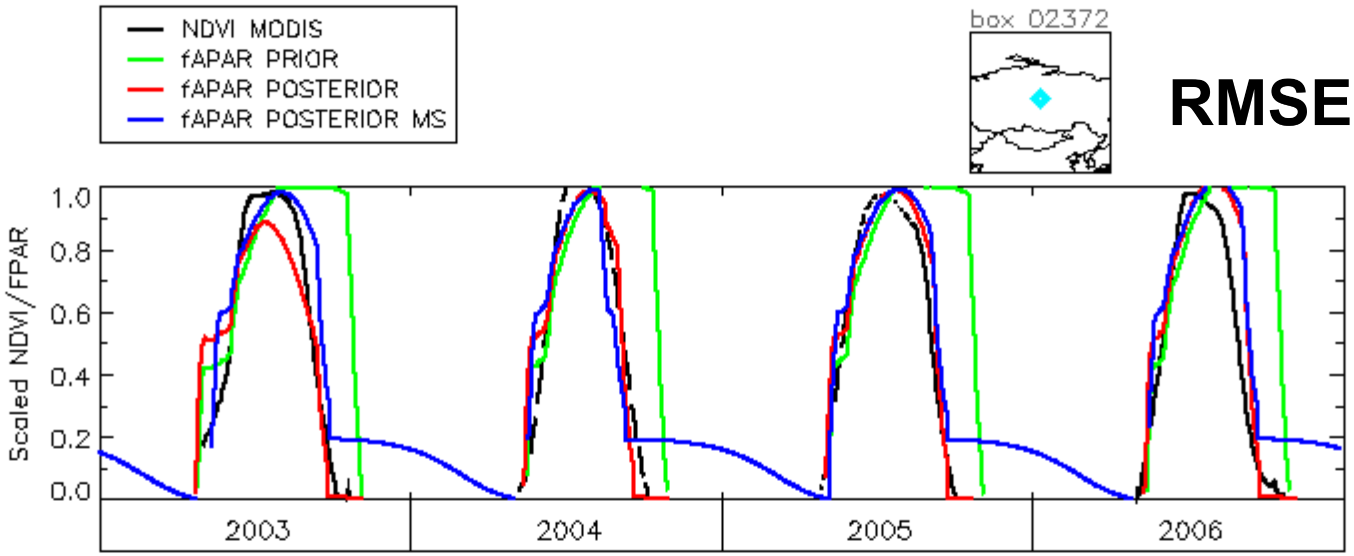

**1 multi-sites optimization**
**& 30 single-site optimizatins**

## PFT : 'temperate broad-leaved summergreen'




RMSE: 0.33 0.13 0.16

## PFT : 'boreal needleleaf summergreen'




RMSE: 0.43 0.13 0.16

Prior

Posterior single-site

Posterior Multi-site

*Maignan et al. 2012*

# Evaluation des nouveaux paramètres

- New **ORCHIDEE global simulation** with optimized parameters for 4 PFTs out of 12

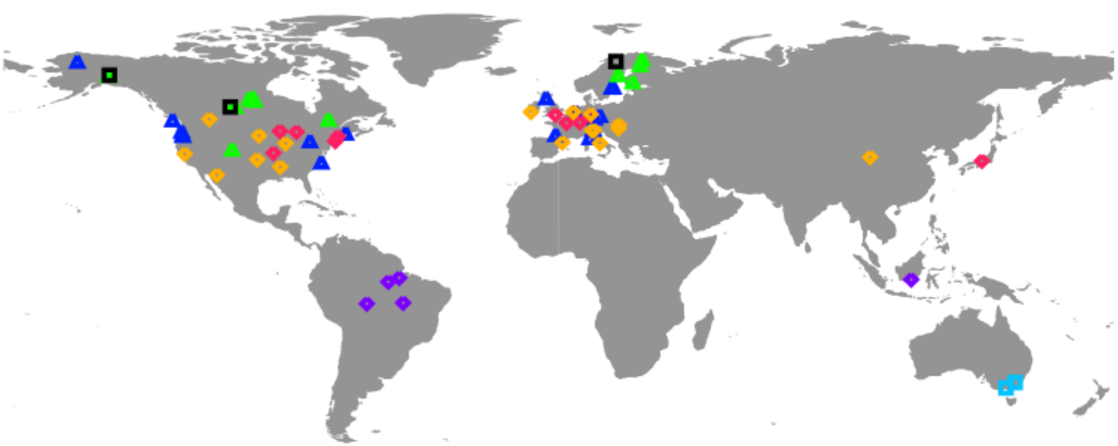
- Global correlations between satellite NDVI and modeled fAPAR time-series:
  ➔ **significant improvement..**

| Mean correlation value | prior | posterior |
|---|---|---|
| **PFT 6: temperate broad-leaved summergreen** | **0.70** | **0.73** |
| **PFT 8: boreal broad-leaved summergreen** | **0.72** | **0.86** |
| **PFT 9: boreal needeleaf summergreen** | **0.39** | **0.89** |
| **PFT 10: C3 grass** | **0.46** | **0.56** |

***Maignan et al. 2012***

# Assimilation des mesures FluxNet

## Localisation of all sites used in the Oprimization




| Parameter | Genericity |
|---|---|
| $V_{cmax,opt}$ | |
| $c_{T,min/opt/max}$ | |
| $L_{age,crit}$, $f_{stressh}$ | PFT |
| $G_{s,slope}$ | PFT |
| $LAI_{MAX}$, SLA | PFT |
| $LAI_{init}$ | **Site** |
| $K_{lai,alloc}$ | PFT |
| $K_{phenocrit}$, $c_{senes}$ | PFT |
| $MR_a$, $MR_b$, $GR_{frac}$ | PFT |
| $Q_{10}$, $HR_b$, $HR_c$ | |
| $Z_{decomp}$ | PFT |
| $K_{soilC}$ | **Site** |
| $K_{albedo,veg}$ | PFT |

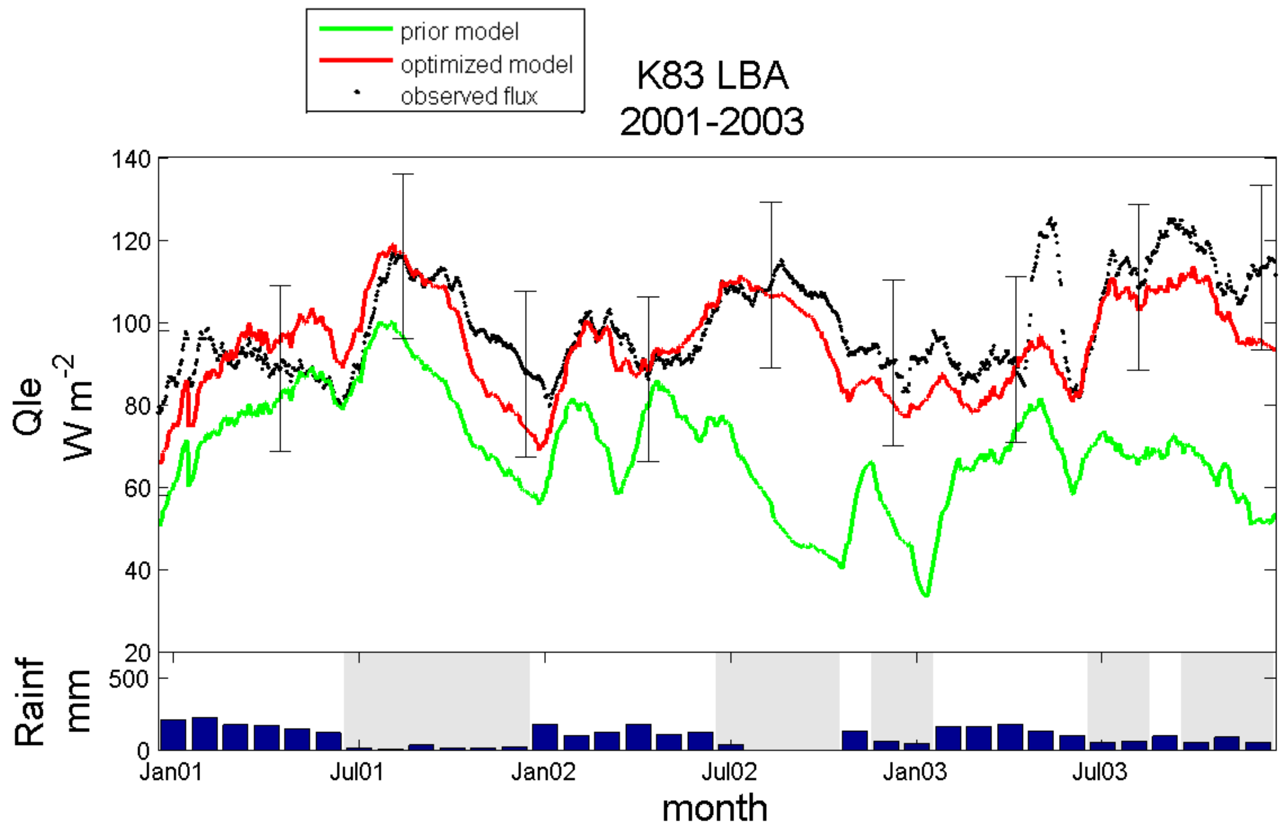
***Kuppel et al. 2012***

➔ Between 60 and 80 sites depending on the tests

➔ Daily NEE & LE : Correction for the Energy budget

# Forêt Tropicale: Flux LE

## Site K83 (bassin Amazonien)



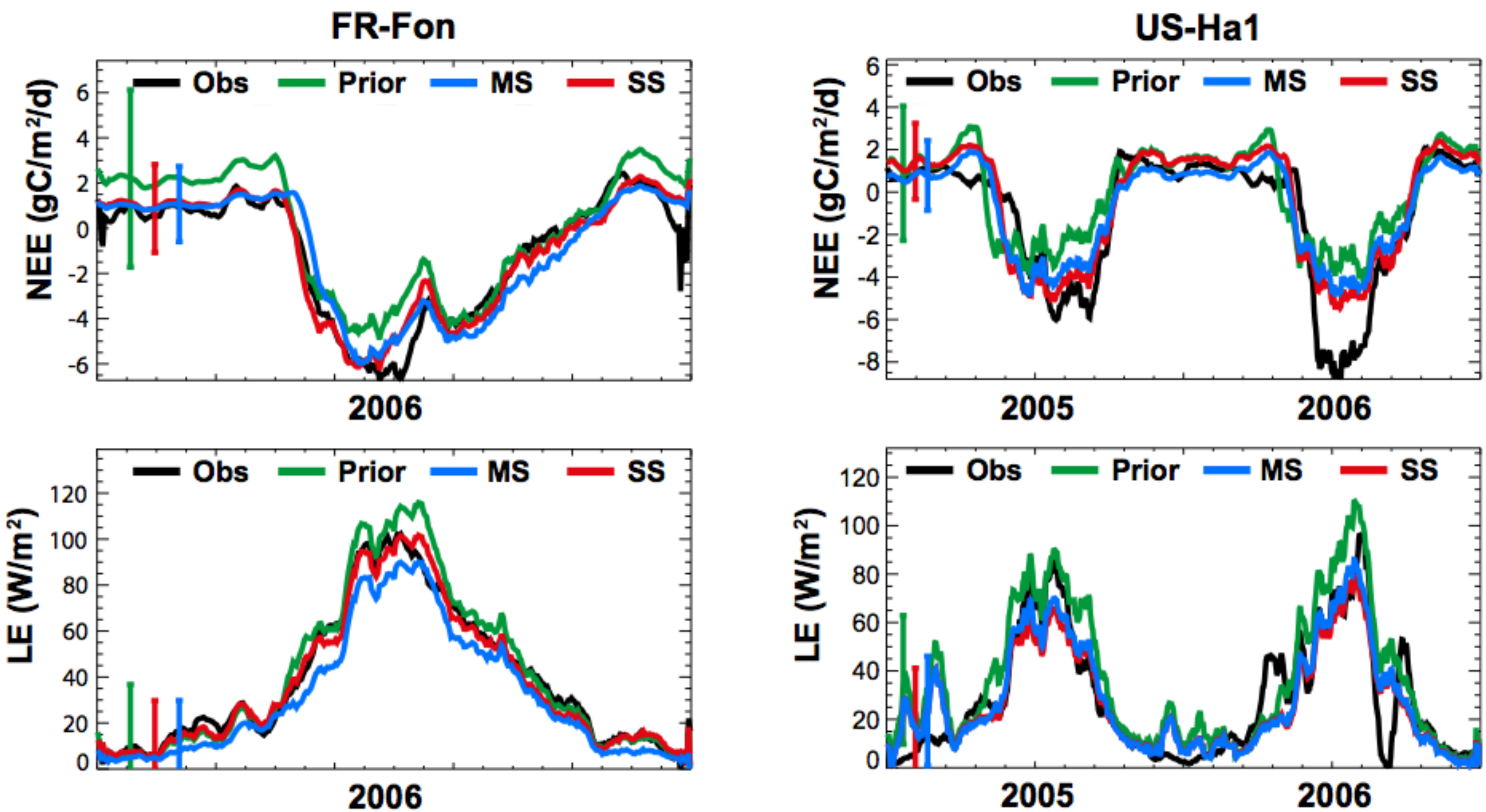

| Soil depth (m) | |
|---|---|
| prior | optim |
| 2.0 | 6.8 |

**=> Small change of the slope of the relation stress = f(soil water)**

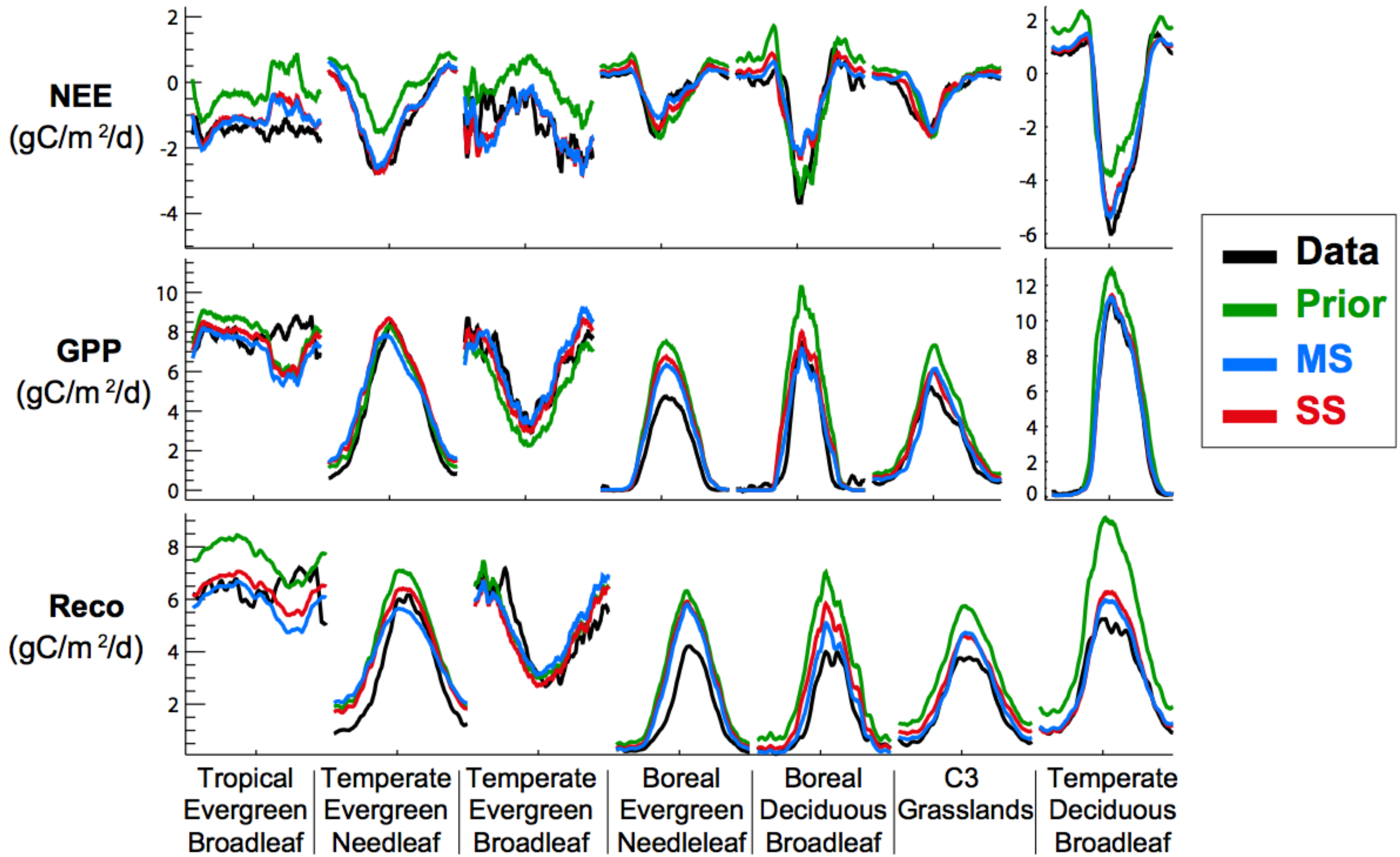
Higher soil depth confirms previous studies: e.g. Kleidon et al. 1999

# Fit modèle – données: forêts décidues

***Broadleaf Deciduous temperate forest***



# Résultats pour tous les types de plante



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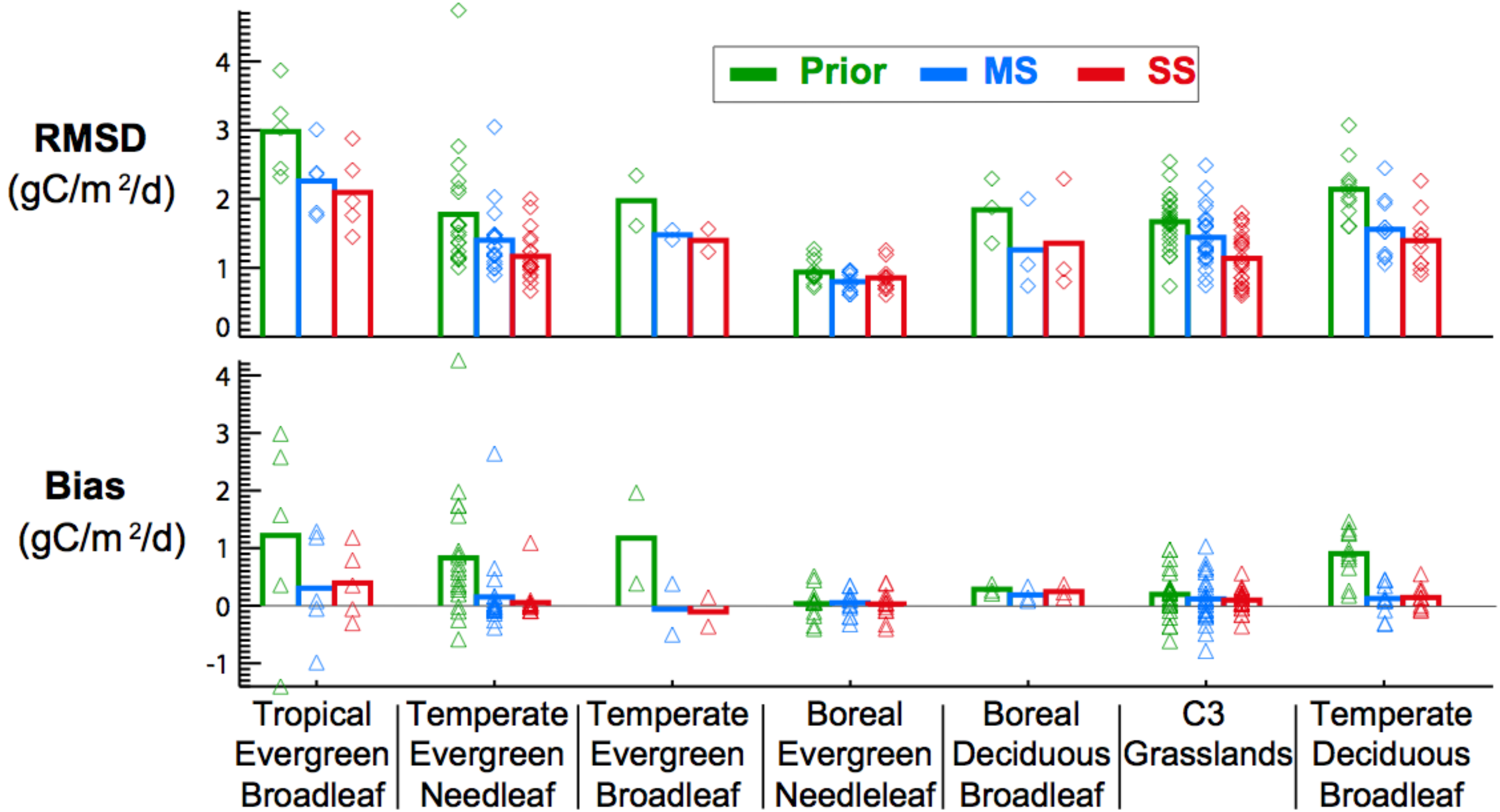
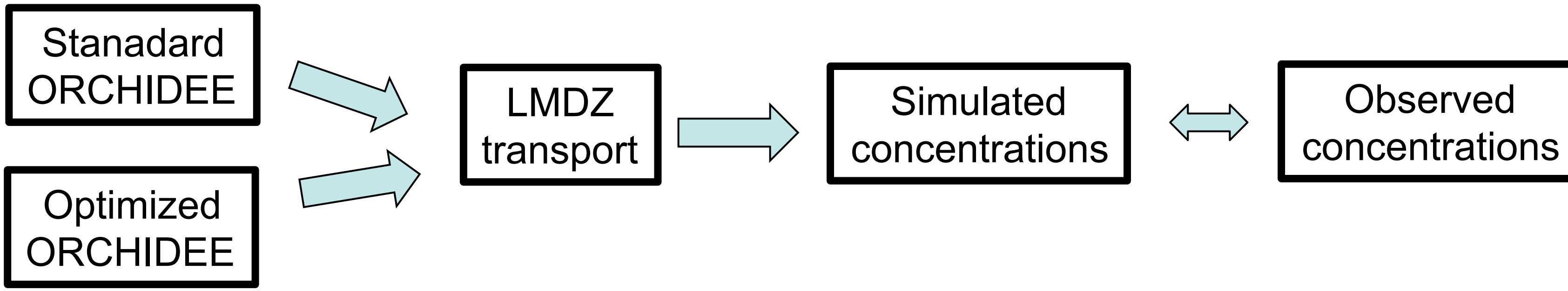
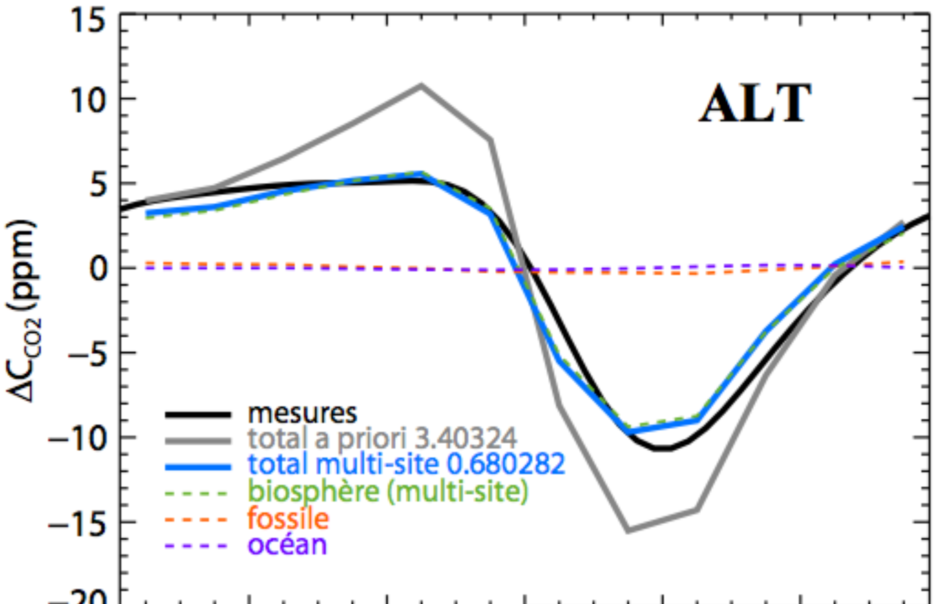



***Kuppel et al. 2012***

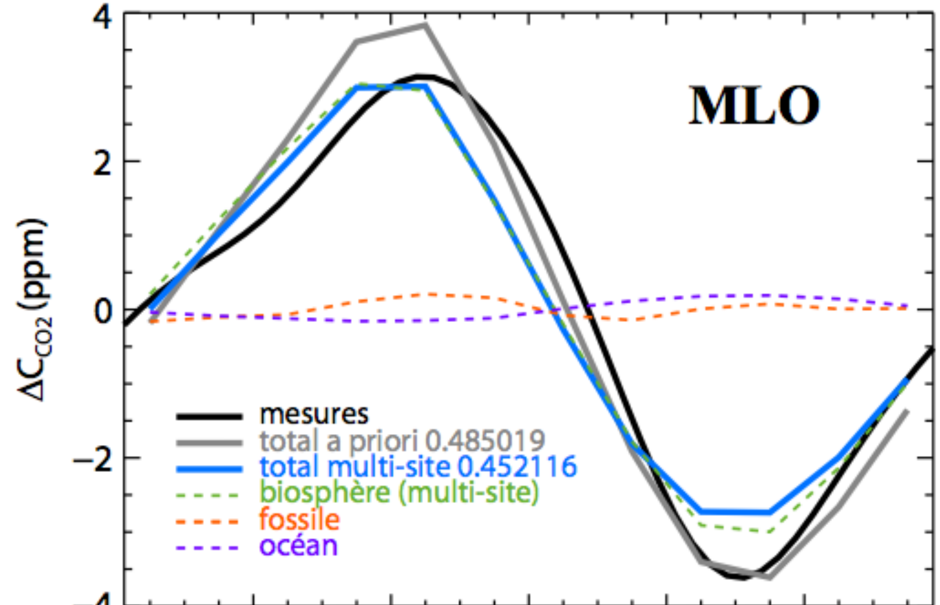
# Evaluation with atmospheric CO2 data




Alaska site




Hawaii site



# Assimilation de données physique de surf.

- Travail en cours pour assimiler Températures de surface (données kilométriques)
  => Instruments MSG et MODIS

- Assimilation des données d'humidité des sols
  => produits CCI (merge ASCAT / SSMI)

- Assimilation des données de cernes d'arbres (largueur, composition isotopique)
  => optimization de la fonction stress hydrique du sol

# Conclusions…

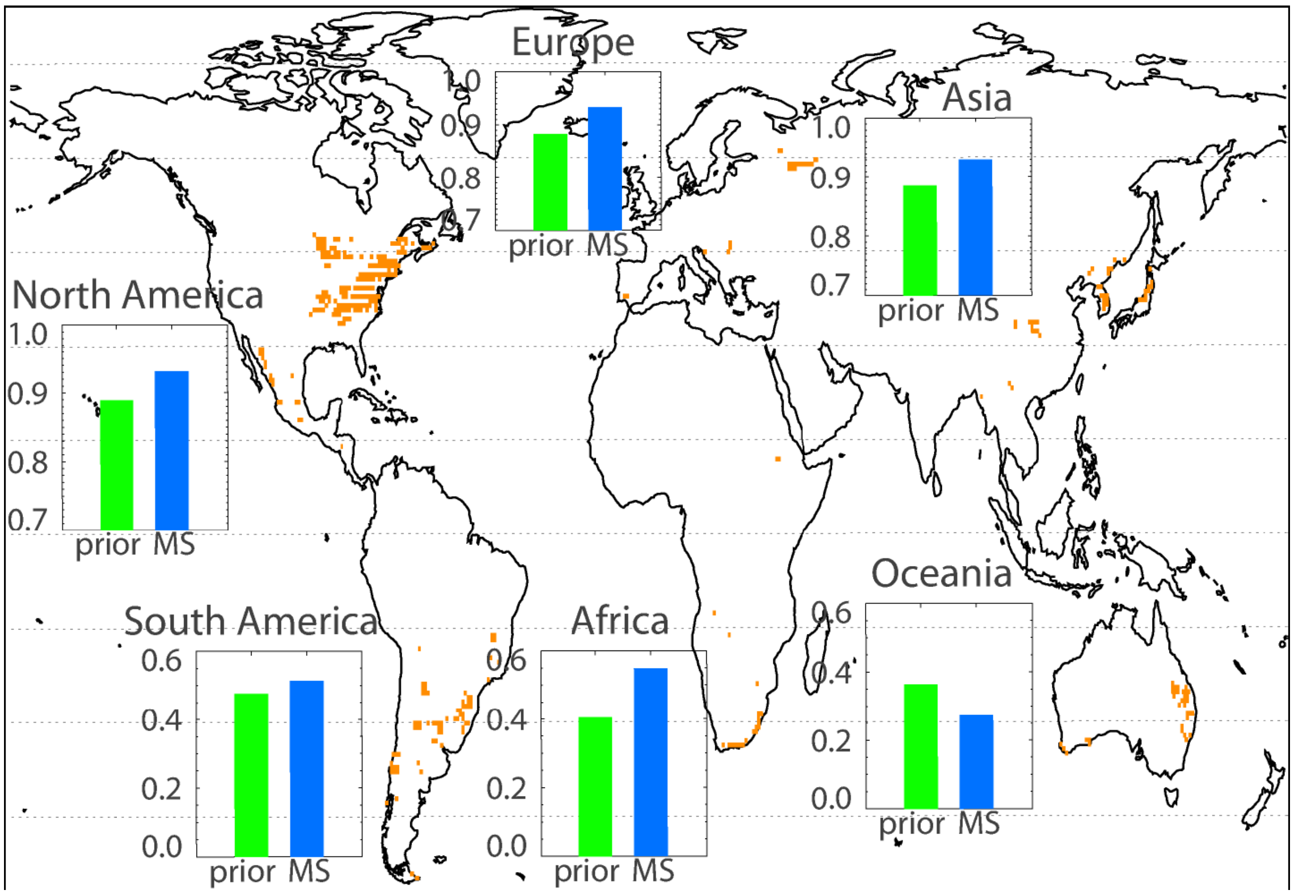
➔ Assimilation de données pour le cycle du carbone très prometteur.

- Tangent Linéaire de ORCHIDEE développé! Modèle Adjoint en cours…
- Optimisation de paramètres a permit:
  - d'améliorer les performances
  - d'identifier des problèmes structurels

- Assimilation multi-données en cours combiner observations biogéochimiques et biophysiques

# Evaluation avec des données indépendantes

➔ Global simulation compared with MODIS NDVI : increase correlation btw model-fAPAR and NDVI for DBF pixels




**Prior model**
**Posterior model**

***Kuppel et al. 2012***