



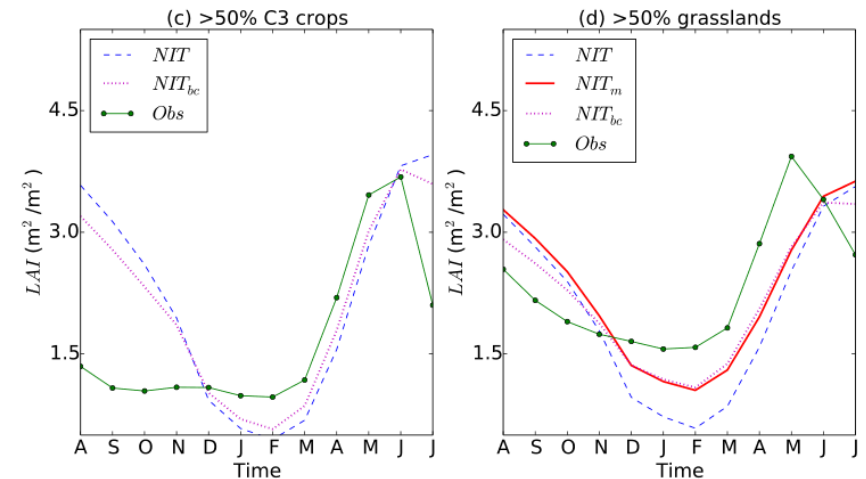
Satellite-derived Leaf Area Index: disaggregation and assimilation

[S. Munier](#), D. Carrer, C. Planque, C. Albergel, D. Leroux, J.-C. Calvet

SURFEX User Workshop – 1st March 2017

Introduction

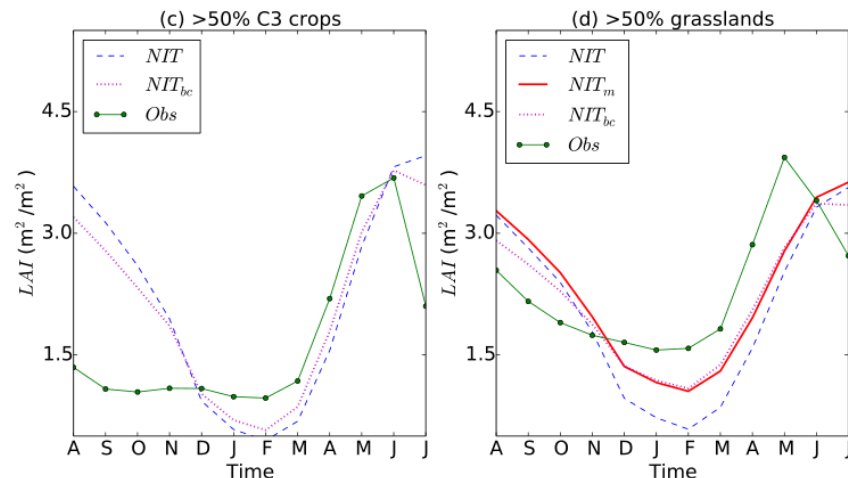
- Minimum LAI in NIT (CO₂ responsive)
 - Prescribed value for each type of vegetation (ECOCLIMAP)
 - But uniform LAI min, and too low for certain types de vegetation



Fairbairn et al. (HESD, 2016)

Introduction

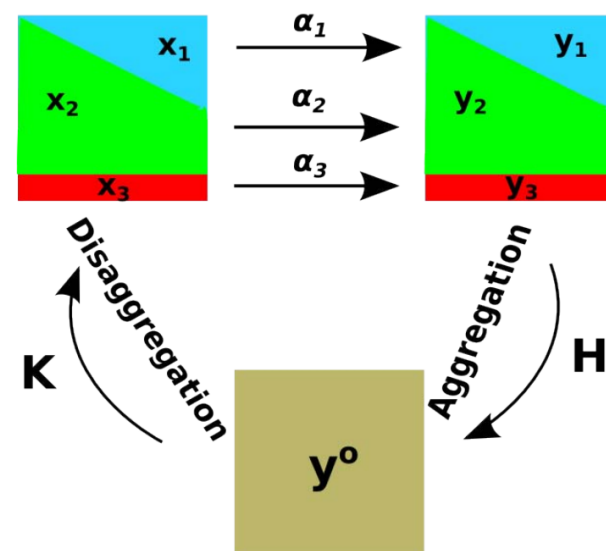
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Fairbairn et al. (HESSD, 2016)

- Assimilation of LAI in SURFEX
 - GEOV1 satellite product (Copernicus GLS)
 - Comparison with aggregated LAI (innovation)
 - Patch fraction to disaggregate the increment

$$\Delta x = \mathbf{K} [y^o - H(x)]$$



Barbu et al. (HESS, 2014)

Objectives

- Pre processing of observations
 - Develop a method to disaggregate the satellite LAI
- New model parametrization
 - Determine the LAI_{min} for each type of vegetation and at the pixel scale
- Land Data Assimilation System
 - Develop the assimilation of disaggregated LAI in SURFEX

Disaggregated LAI

- Disaggregation of the GEOV1 LAI:
 - Satellite global product (1999-2015), every 10 days, resolution 1/20°
 - Kalman Filter

$$X^a = X^b + K(Y - HX)$$

$$\begin{pmatrix} LAI_1^a \\ \vdots \\ LAI_N^a \end{pmatrix} = \begin{pmatrix} LAI_1^b \\ \vdots \\ LAI_N^b \end{pmatrix} + K \left[\begin{pmatrix} LAI_1^{eco} \\ \vdots \\ LAI_N^{eco} \\ LAI^{sat} \end{pmatrix} - \begin{pmatrix} 1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & 1 \\ f_1 & \dots & f_N \end{pmatrix} \begin{pmatrix} LAI_1^b \\ \vdots \\ LAI_N^b \end{pmatrix} \right]$$

$$K = PH^T (HPH^T + R)^{-1}$$

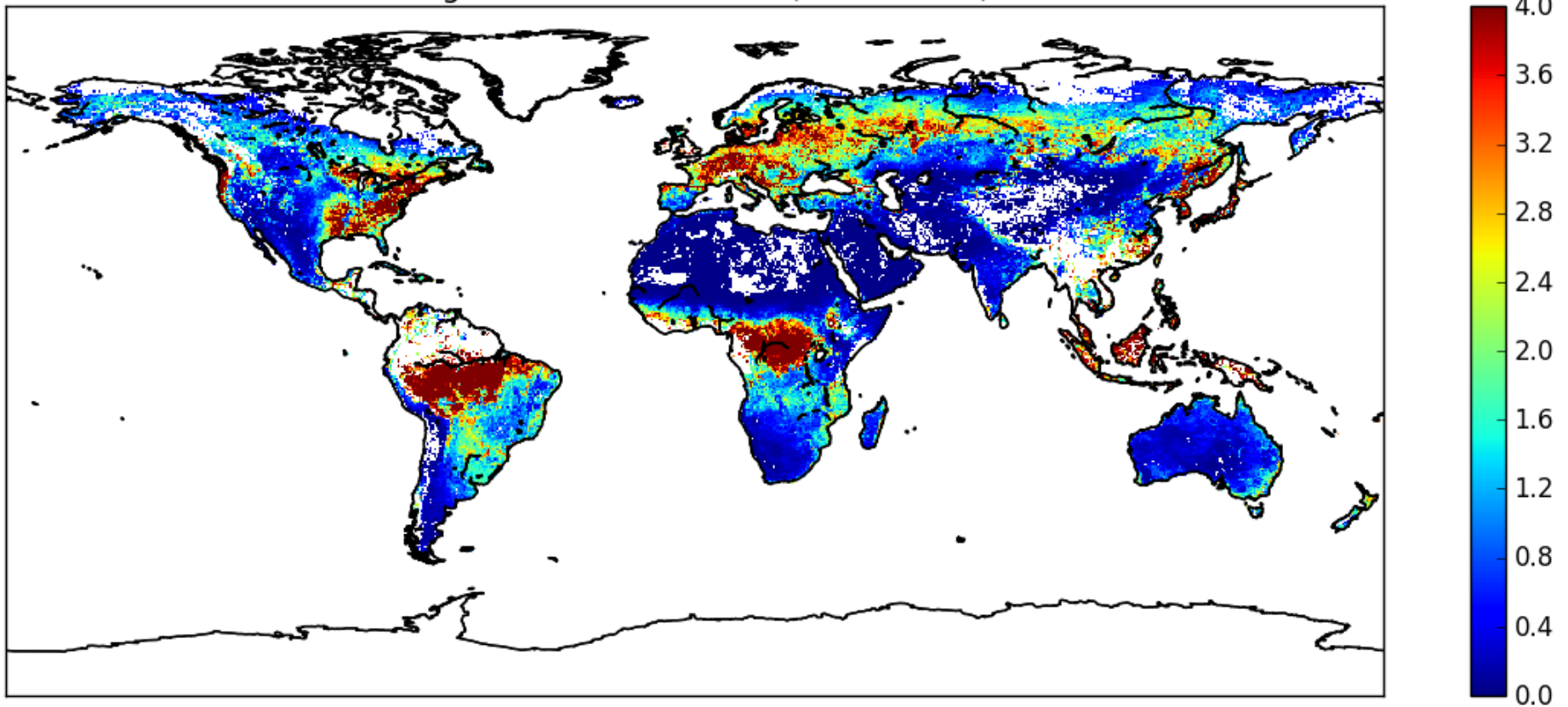
$$P^a = (I_N - KH) P^b$$

$$R = \begin{pmatrix} r^{eco} & \dots & 0 & 0 \\ \vdots & \ddots & \vdots & \vdots \\ 0 & \dots & r^{eco} & 0 \\ 0 & \dots & 0 & r^{sat} \end{pmatrix}, r^{sat} \ll r^{eco}$$

Disaggregated LAI

- Disaggregation of the GEOV1 LAI: example

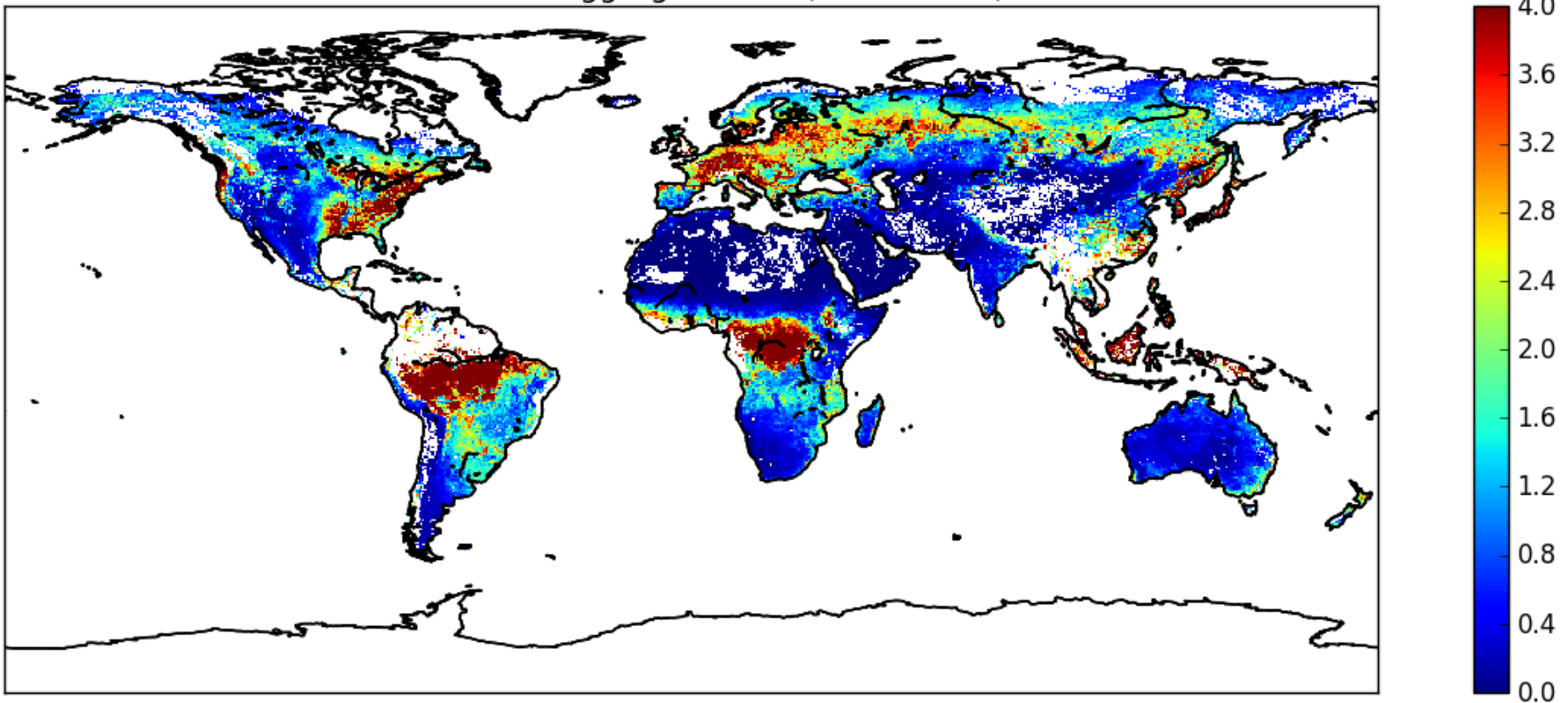
Original LAI from BIOPAR (2000-06-03)



Disaggregated LAI

- Disaggregation of the GEOV1 LAI: example

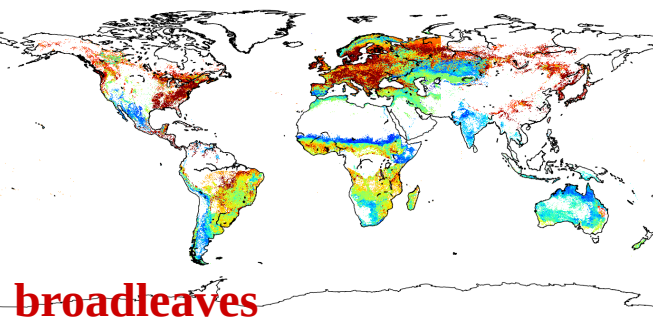
Assimilated aggregated LAI (2000-06-03)



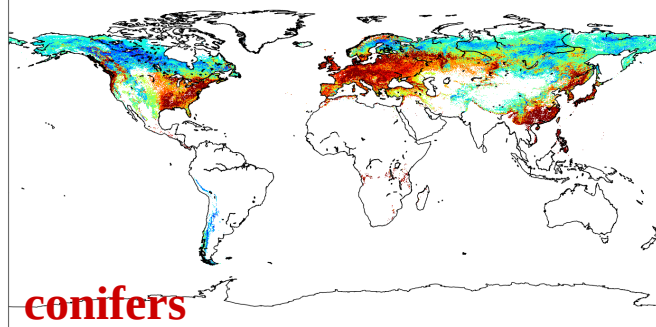
Disaggregated LAI

- Disaggregation of the GEOV1 LAI: example

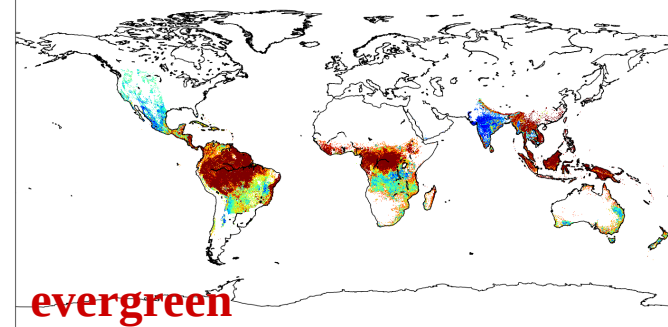
Assimilated LAI for patch 4 (20000603)



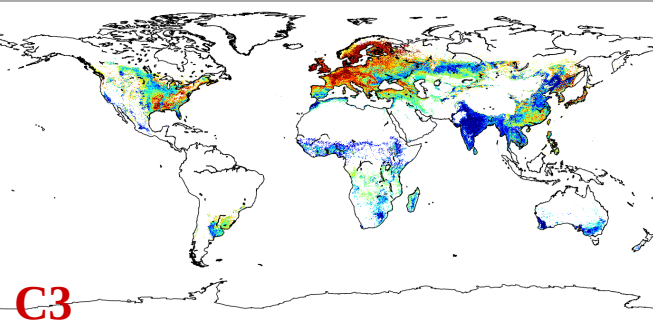
Assimilated LAI for patch 5 (20000603)



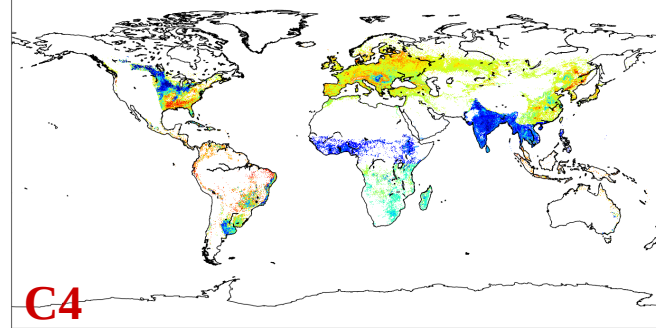
Assimilated LAI for patch 6 (20000603)



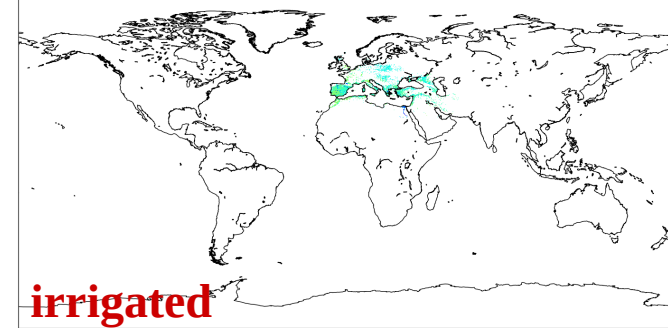
Assimilated LAI for patch 7 (20000603)



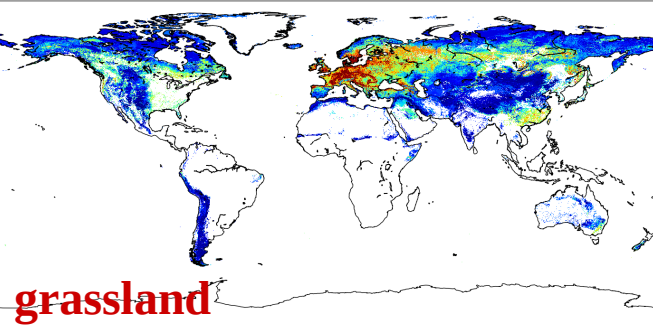
Assimilated LAI for patch 8 (20000603)



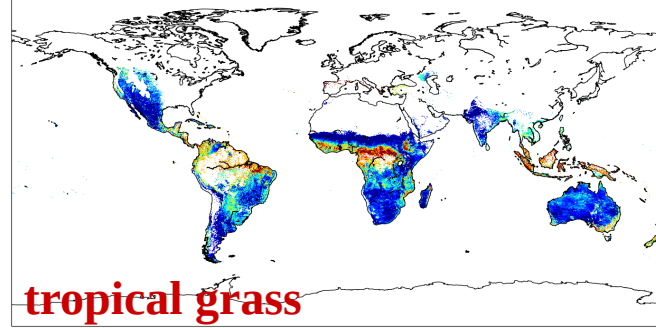
Assimilated LAI for patch 9 (20000603)



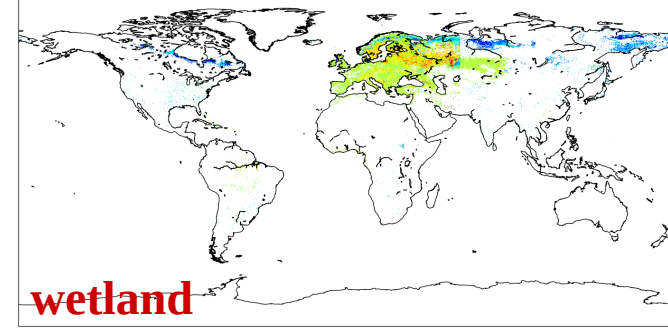
Assimilated LAI for patch 10 (20000603)



Assimilated LAI for patch 11 (20000603)



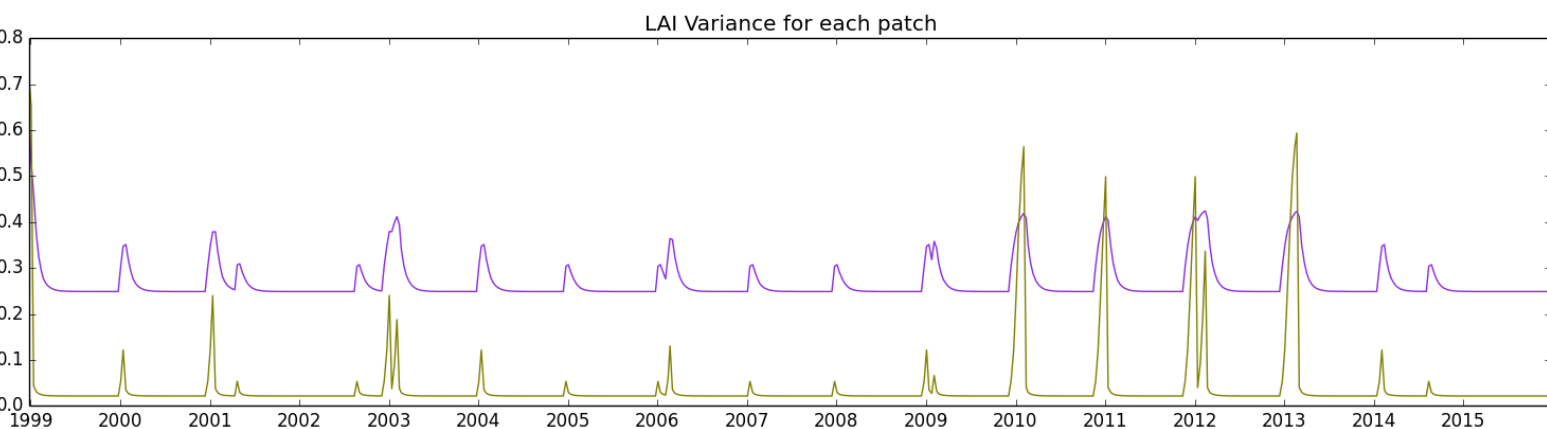
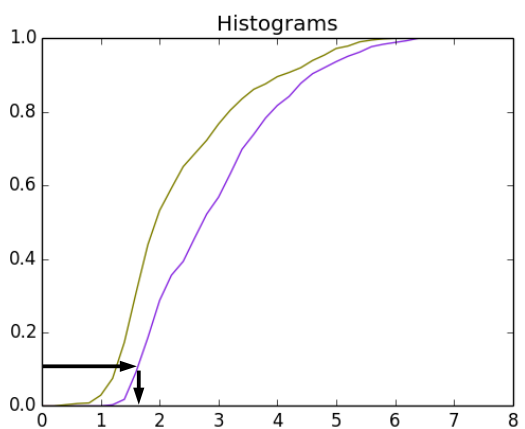
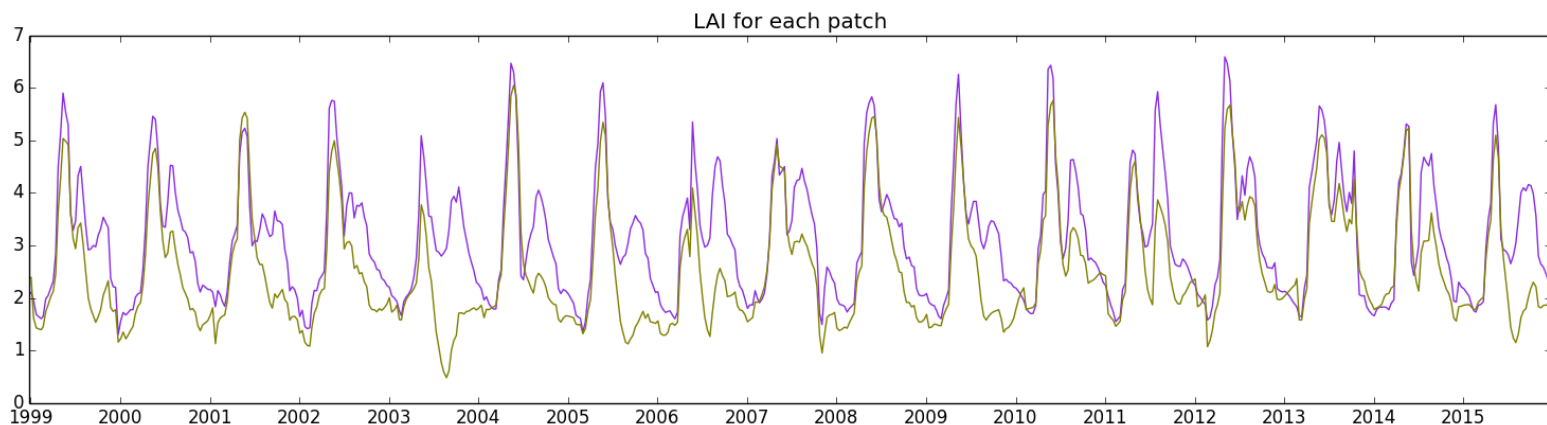
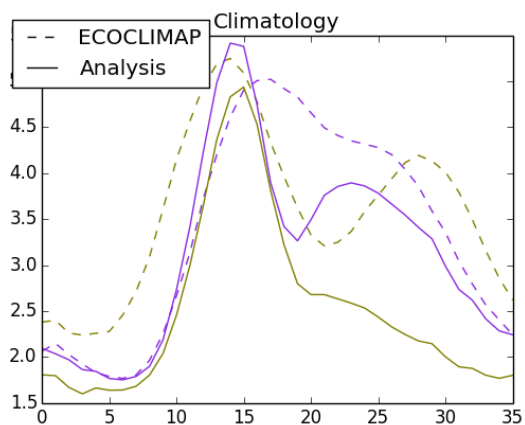
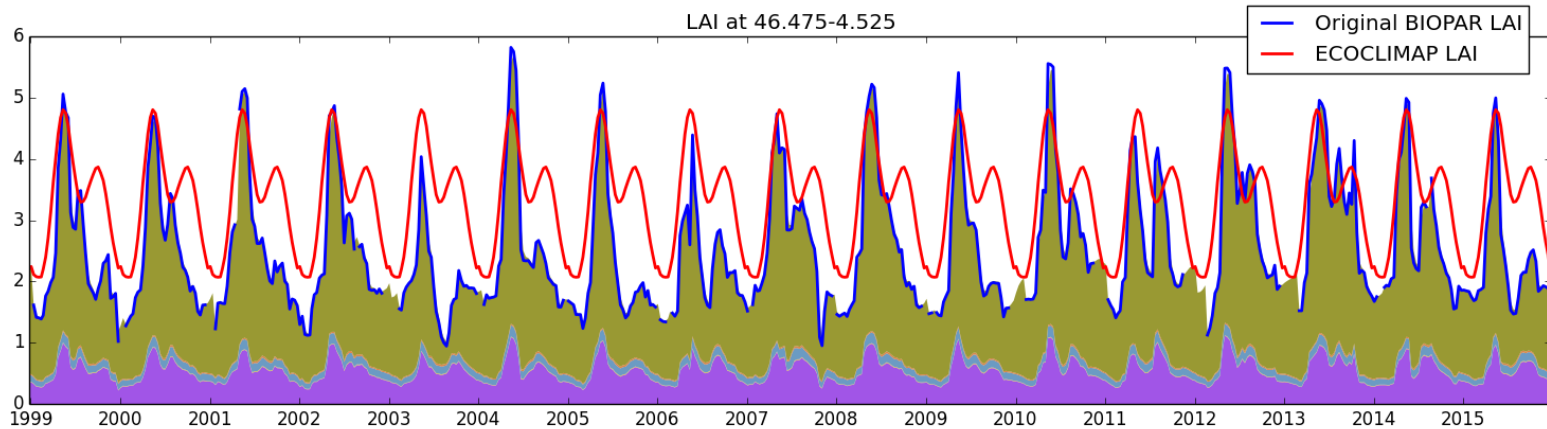
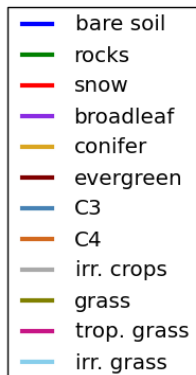
Assimilated LAI for patch 12 (20000603)



Disaggregated LAI

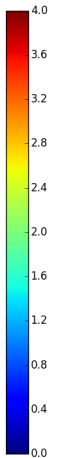
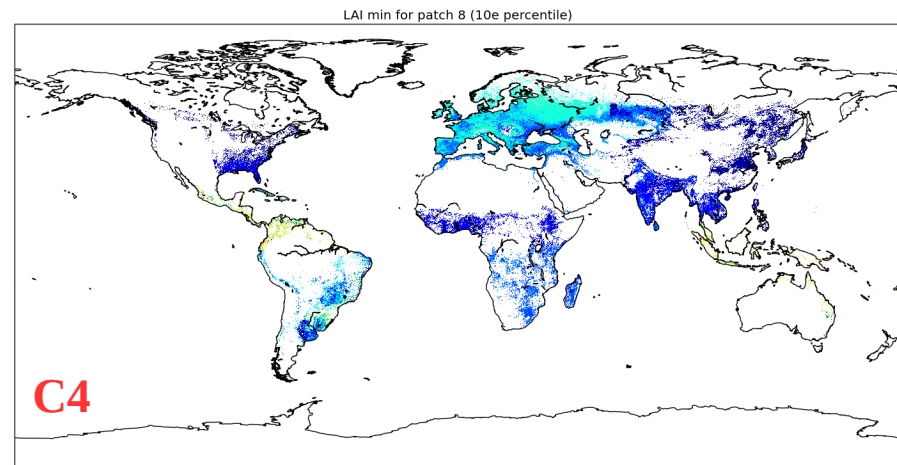
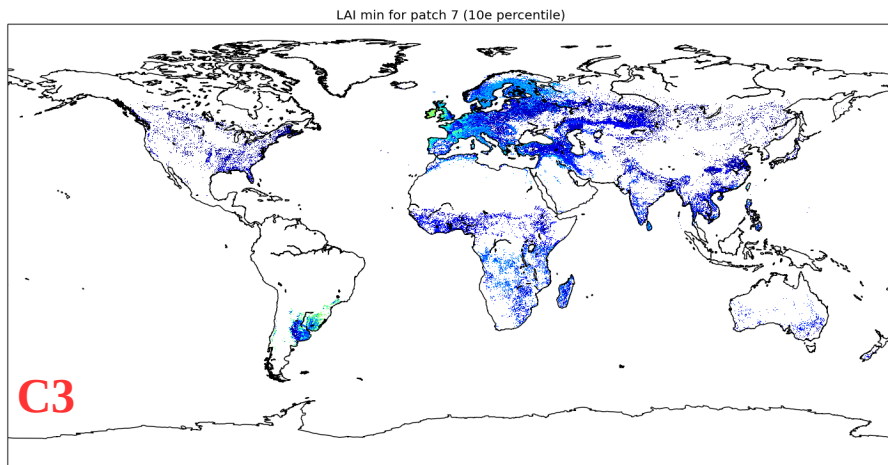
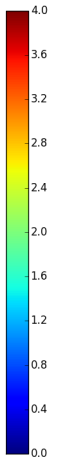
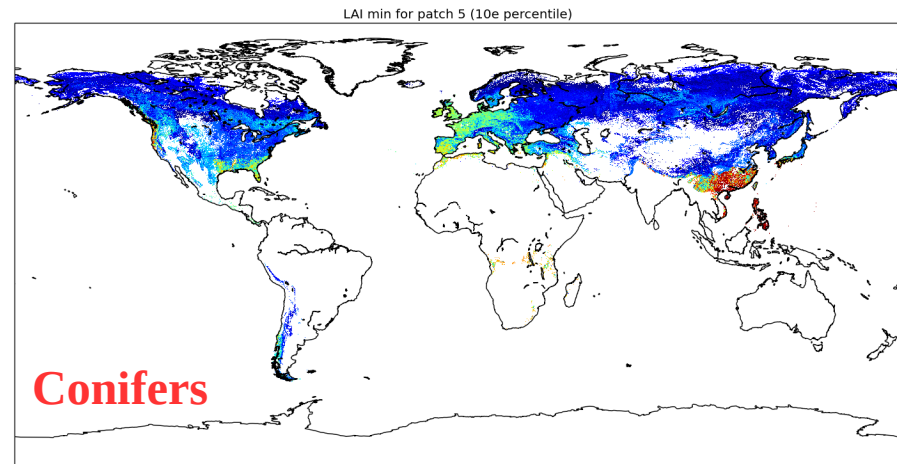
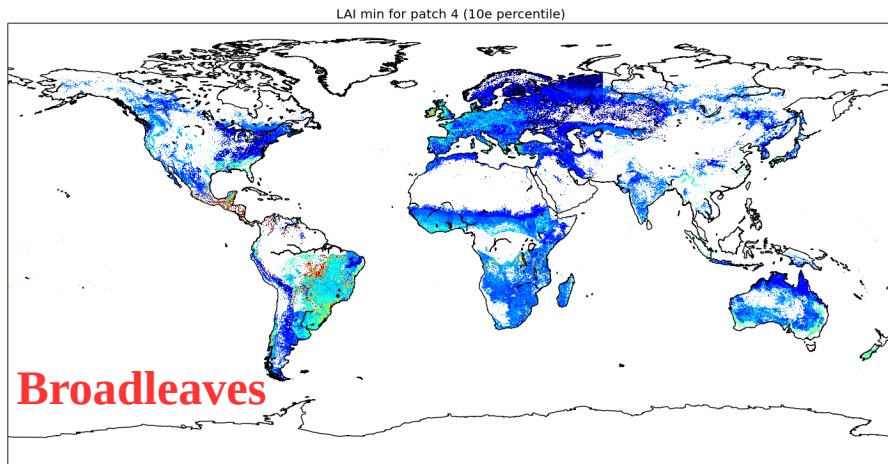


Patch fraction



Minimum LAI for SURFEX

- LAI_{min} per vegetation type (10th percentile)

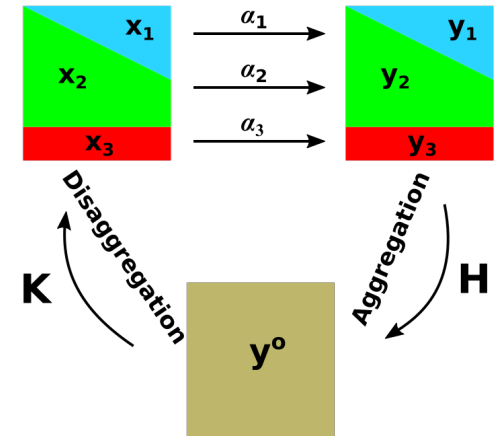


Assimilation of the disaggregated LAI

$$\Delta X = K (Y^o - H X)$$

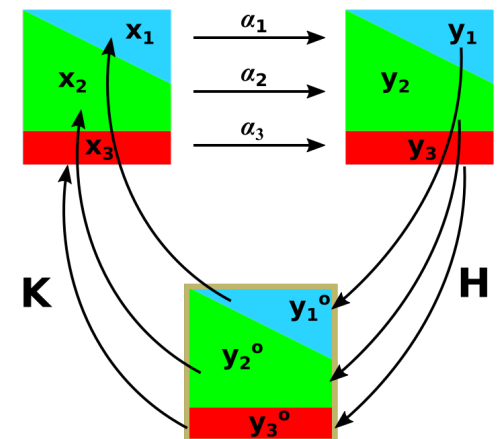
- Aggregated assimilation

$$Y^o = (LAI^o) \quad H = (f_1 \quad \dots \quad f_{12}) \quad X = \begin{pmatrix} LAI_1 \\ \vdots \\ LAI_{12} \end{pmatrix}$$



- Disaggregated assimilation

$$Y^o = \begin{pmatrix} LAI_1^o \\ \vdots \\ LAI_{12}^o \end{pmatrix} \quad H = \begin{pmatrix} 1 & & 0 \\ & \ddots & \\ 0 & & 1 \end{pmatrix} \quad X = \begin{pmatrix} LAI_1 \\ \vdots \\ LAI_{12} \end{pmatrix}$$



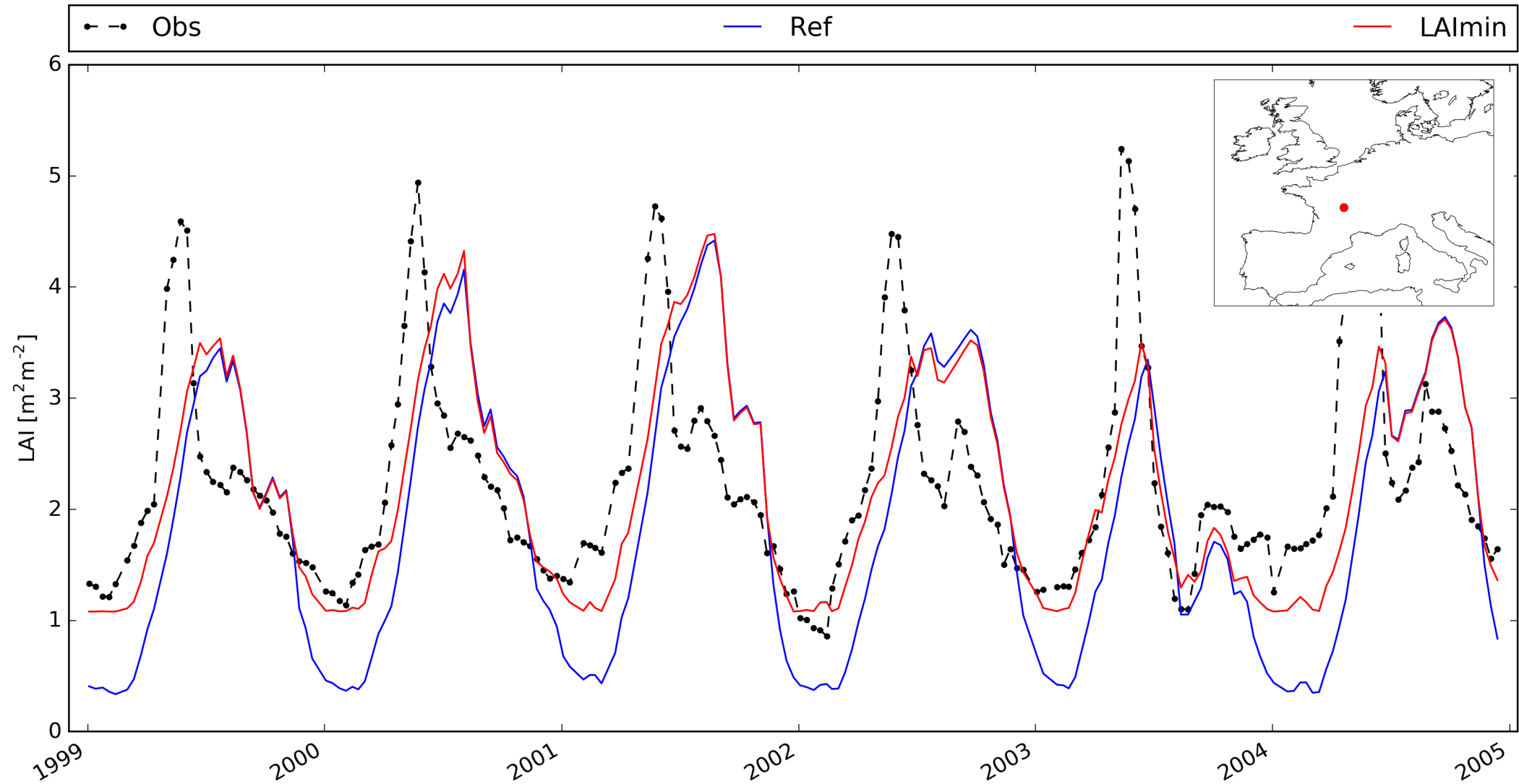
Experimental setup

- Impact of LAImin in SURFEX and assimilation by patch

Experiment	LAI min	Assimilation
REF	ECOCLIMAP	Aggregated
LAImin	BIODis	Aggregated
BIODis	BIODis	Disaggregated

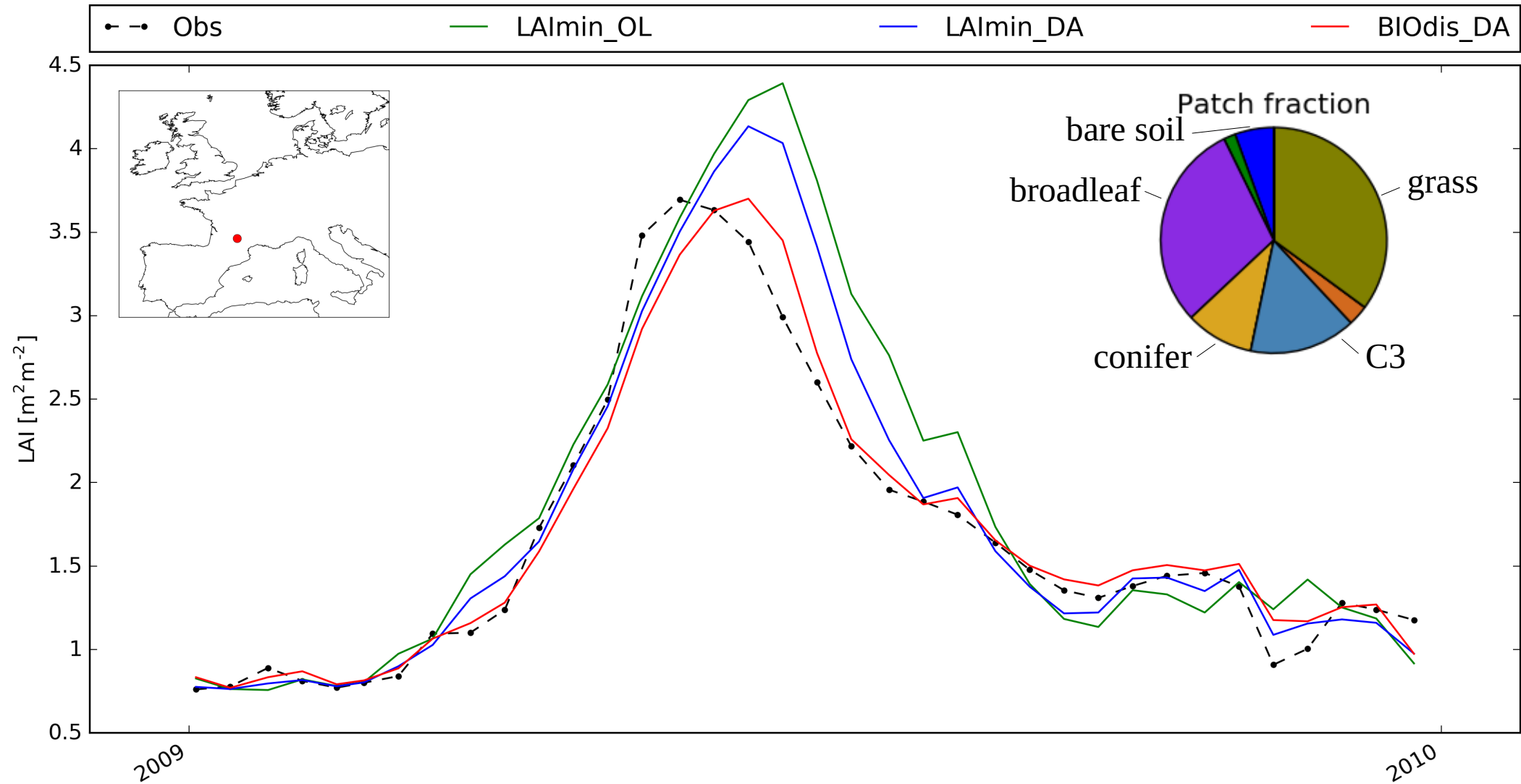
- SURFEX
 - Diffusion scheme (DIF)
 - CO2 responsive (A-gs)
 - interactive vegetation (NIT)
 - 12 patches
 - Europe (0,5°), 1999-2015

Impact of LAImin in SURFEX

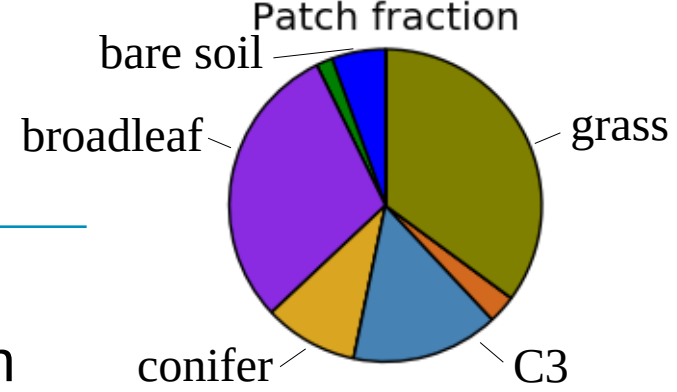


Assimilation of disaggregated LAI

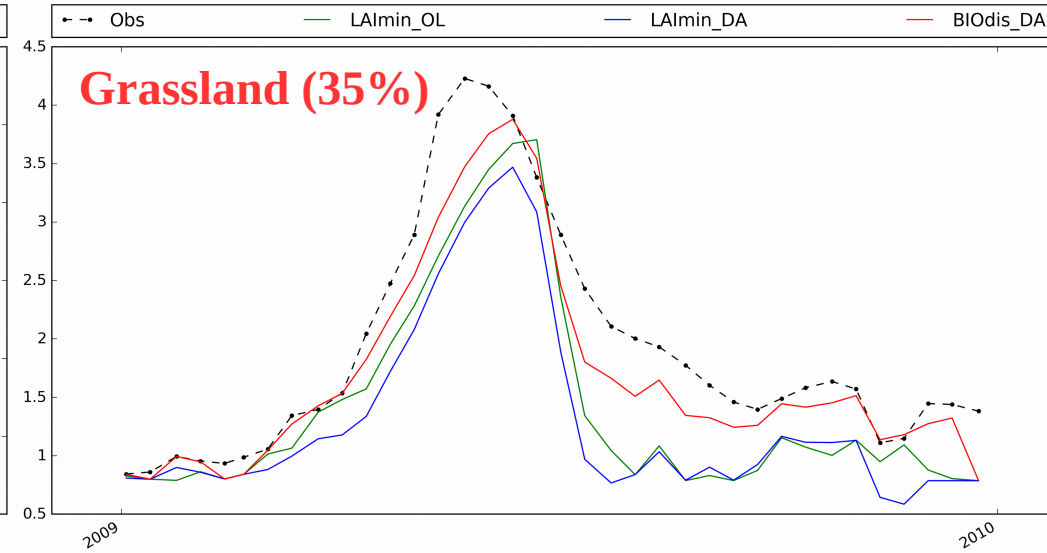
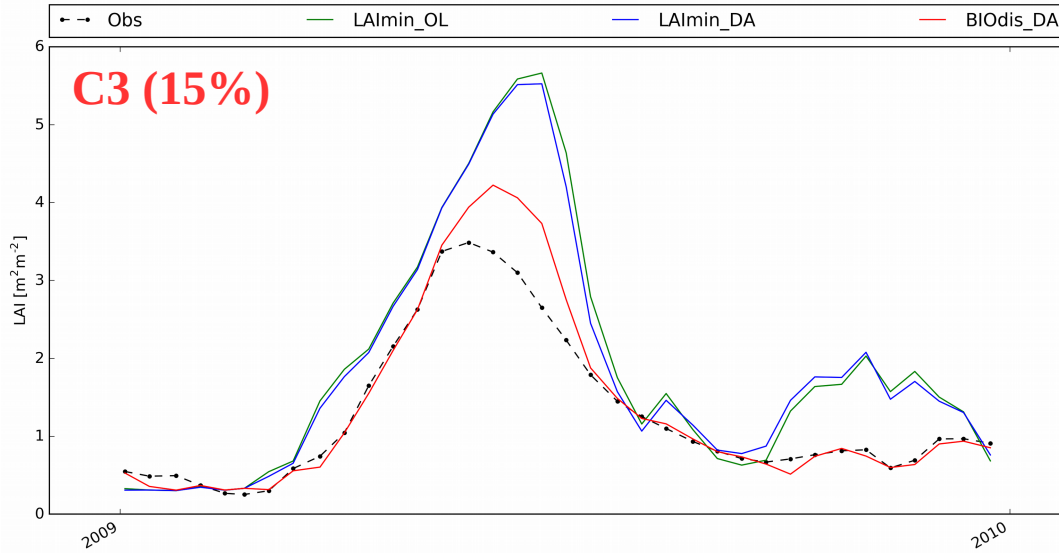
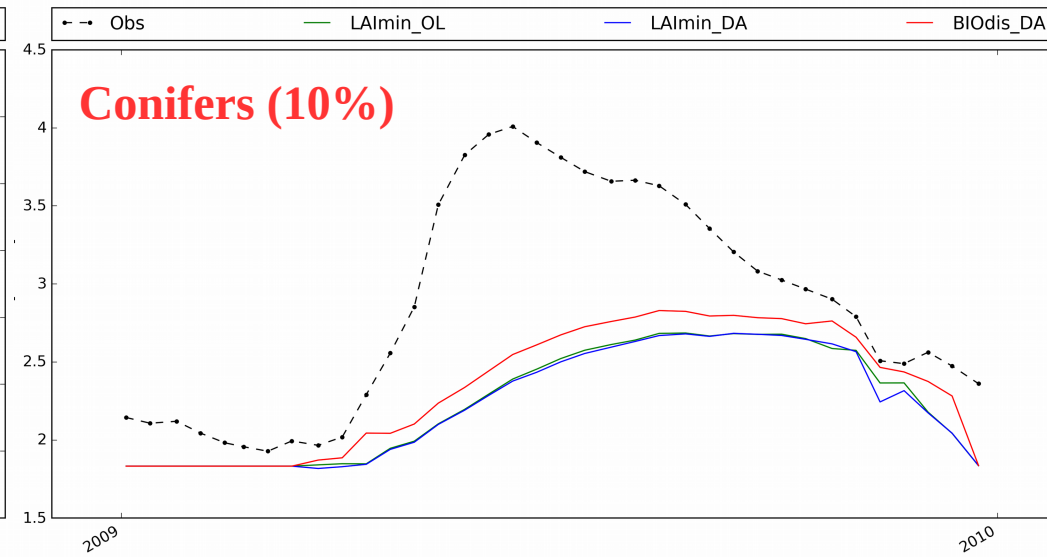
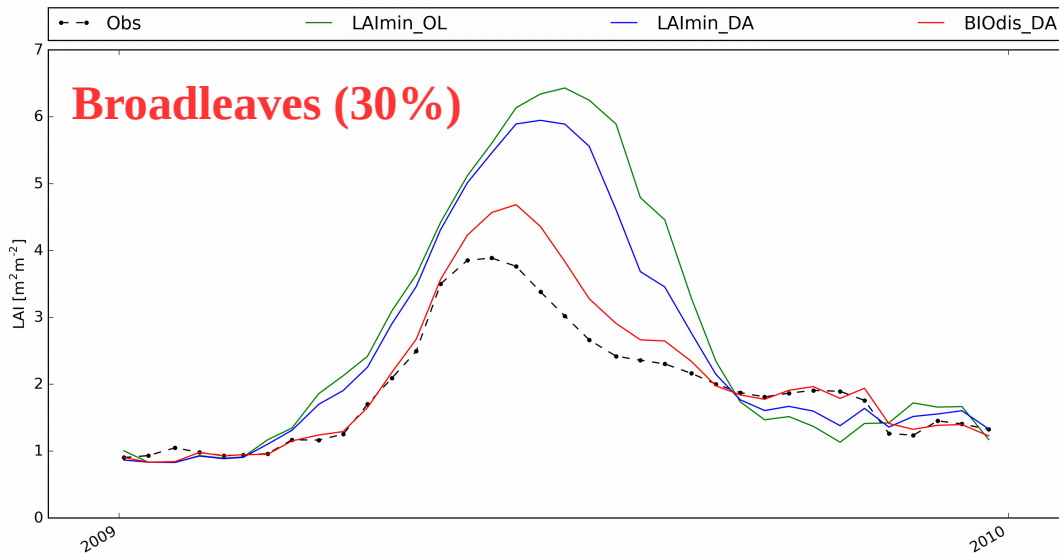
- Impact of LAImin and assimilation by patch: aggregated LAI



Assimilation of disaggregated LAI



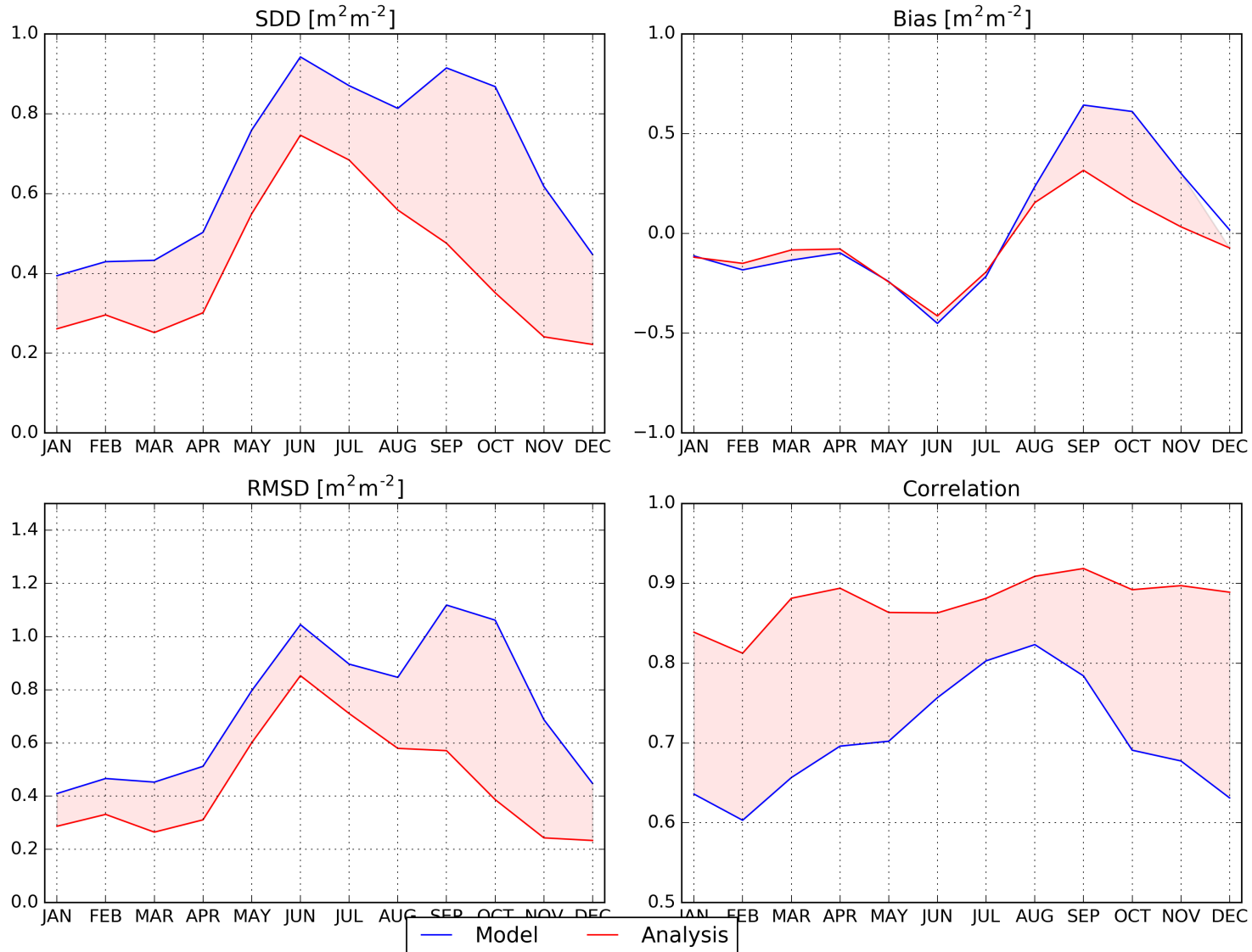
Impact of LAImin and assimilation by patch



Assimilation of disaggregated LAI

- Seasonal performances (1999-2015): average over Europe

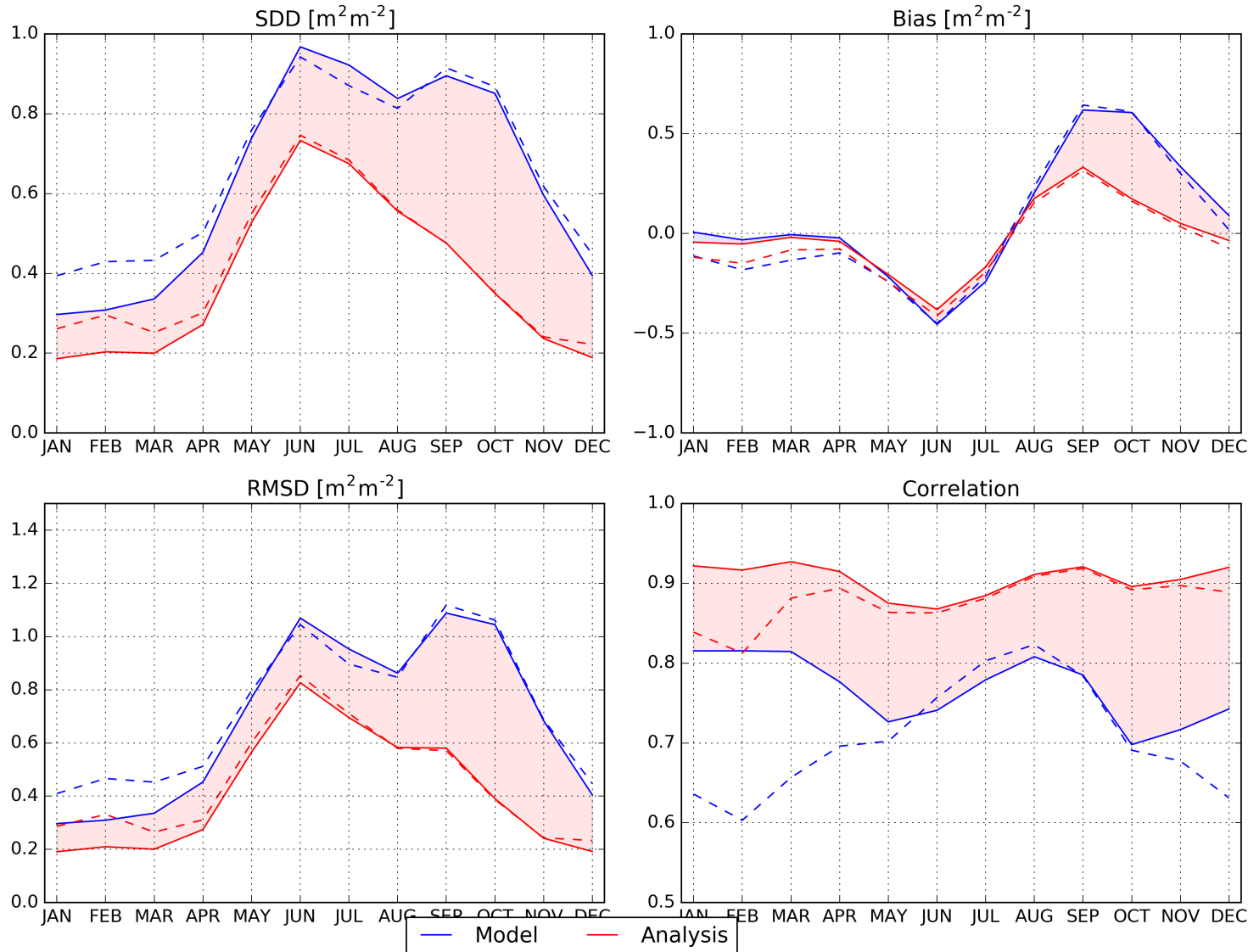
REF



Assimilation of disaggregated LAI

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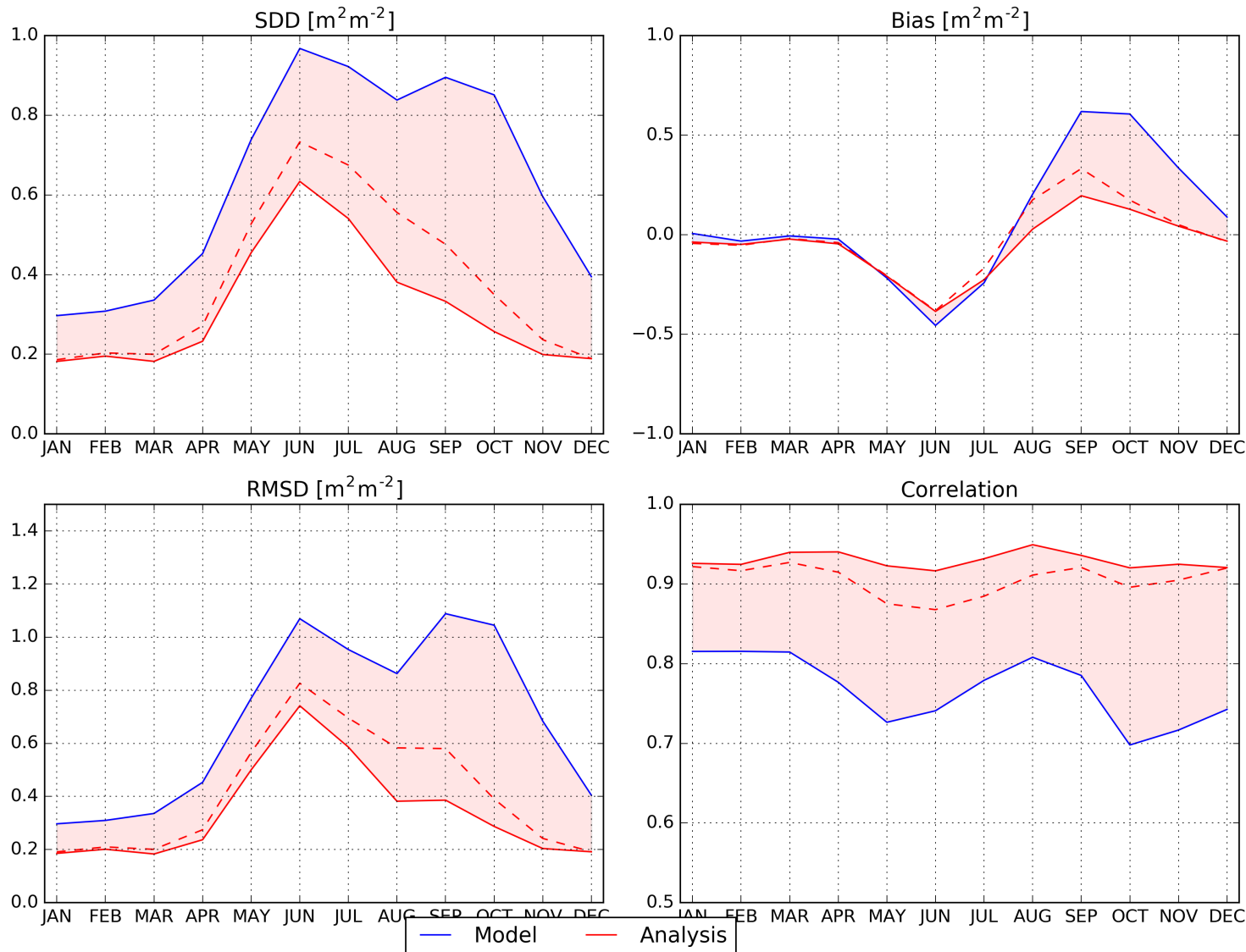
LAImin



Assimilation of disaggregated LAI

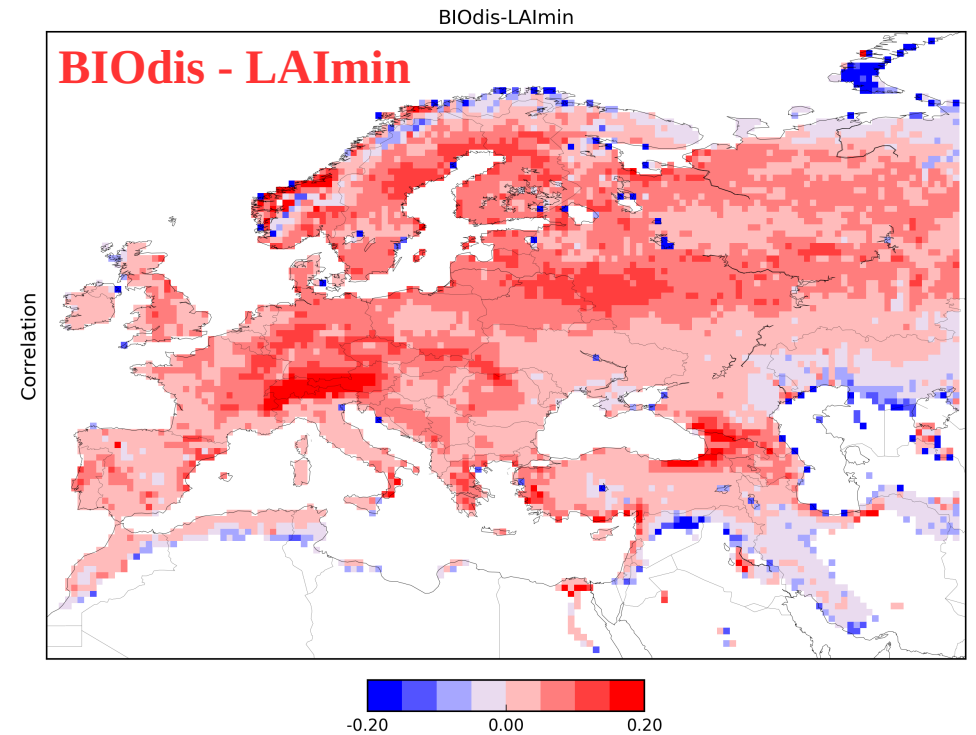
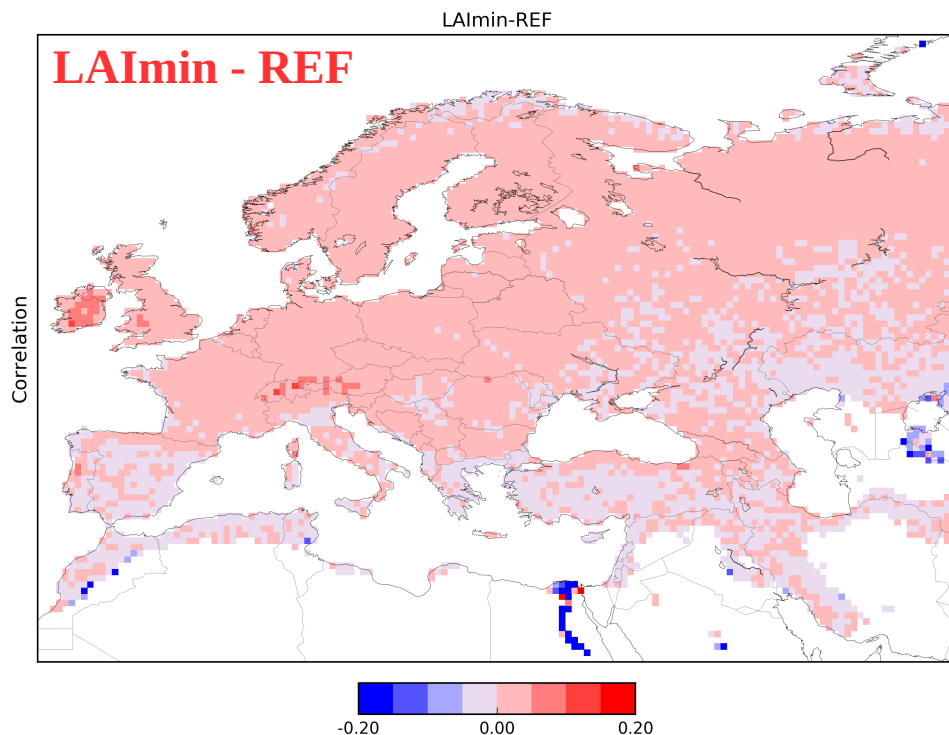
- Seasonal performances (1999-2015): average over Europe

BIOdis



Assimilation of disaggregated LAI

- Assimilation performances: average over 1999-2015
 - Difference of correlations between EKF experiments



Conclusion

- BIODis: disaggregated satellite-derived LAI
 - Global maps (1999-2015, decadal, 5km) for 9 vegetation types
- Used to prescribe minimum LAI in SURFEX
 - For each vegetation type
 - Spatial variability
- Development of assimilation by patch
 - Overall improvement of the assimilation performances
 - Better representation of each vegetation type