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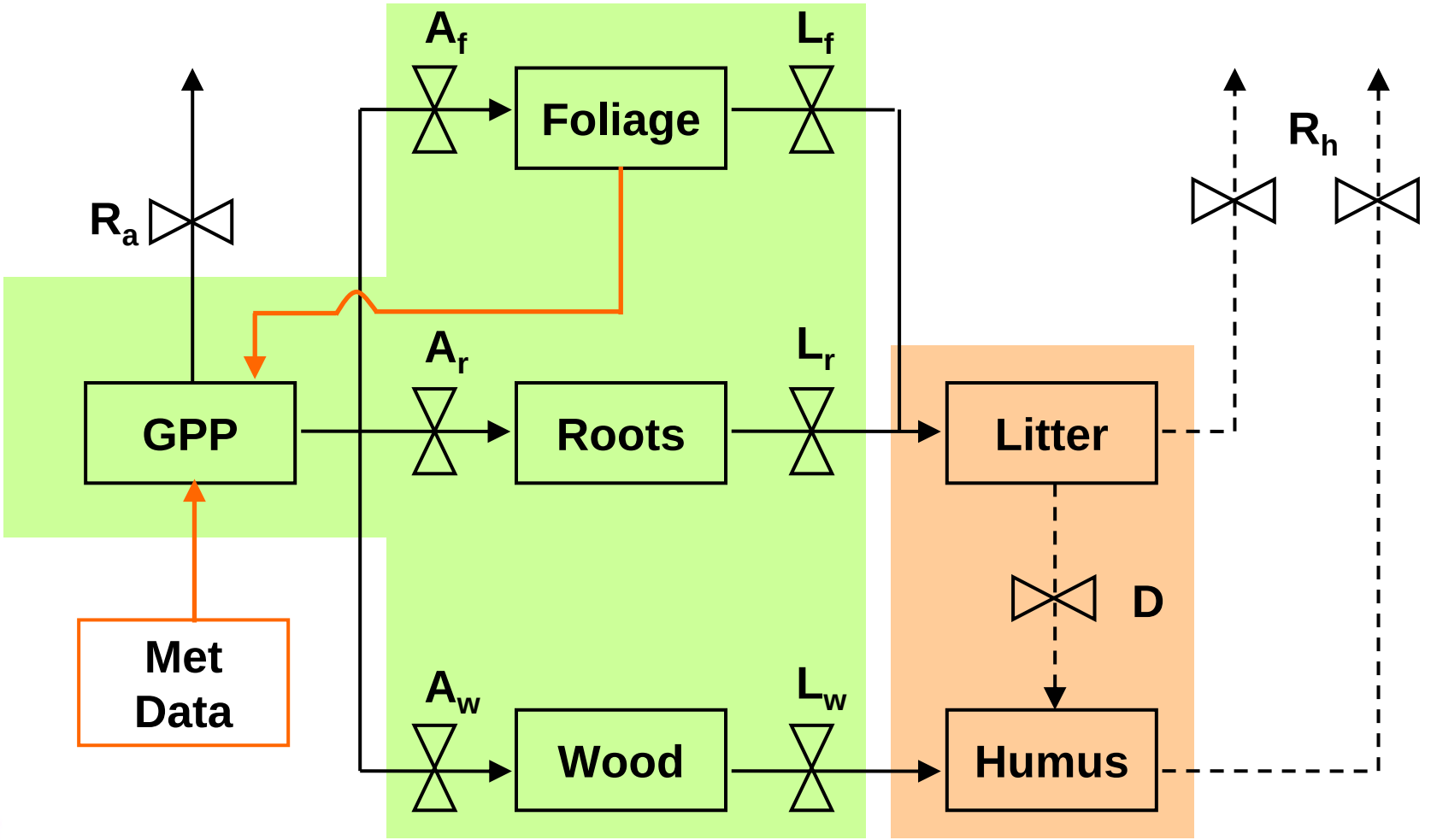
NATURAL ENVIRONMENT RESEARCH COUNCIL

Assimilating canopy reflectance into an ecosystem model

Tristan Quaife




DALEC – ecosystem model



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Ensemble Kalman Filter

$$A^a = A + A'A'^T H^T (HA'A'^T H^T + R_e)^{-1}(D - HA)$$

H = observation operator
A = state vector ensemble
A' = state vector ensemble – mean state vector
D = observation ensemble
R_e = observation error covariance matrix

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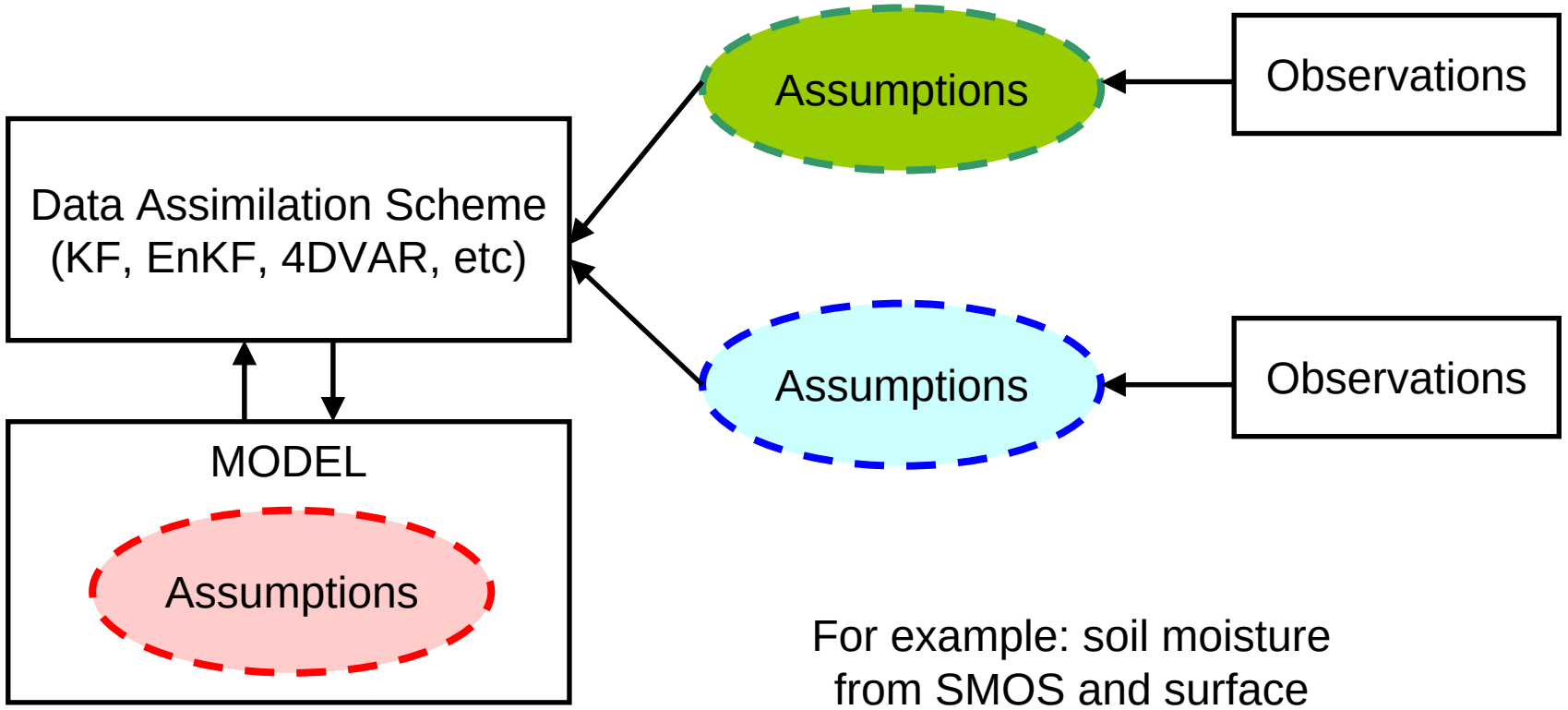
Assimilating products



For example: soil moisture from SMOS and surface temperature from MODIS

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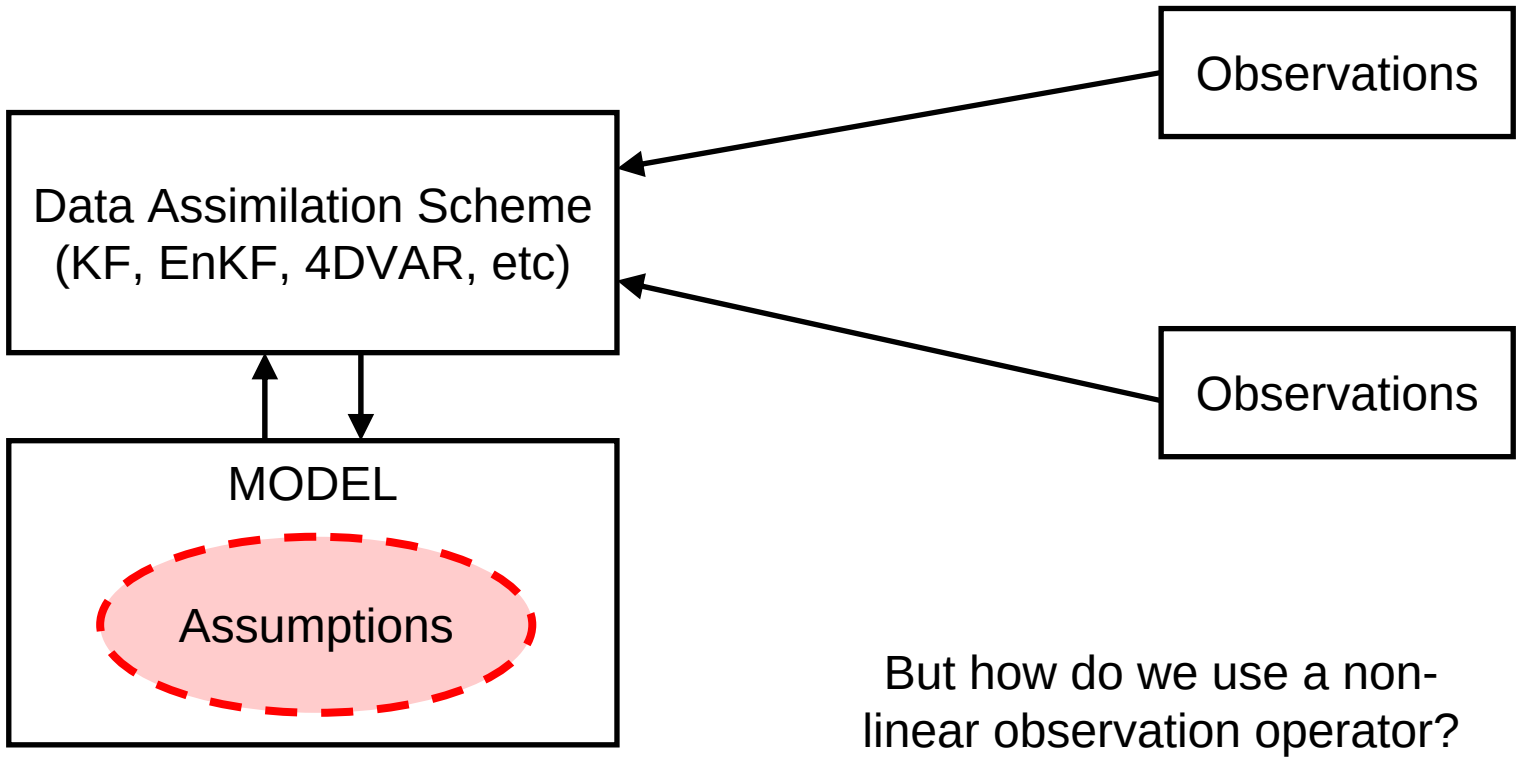
Assimilating reflectance



But how do we use a non-linear observation operator?

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EnKF – augmented analysis

$$A^a = A + A'\hat{A}'^T\hat{H}^T(\hat{H}\hat{A}'\hat{A}'^T\hat{H}^T + R_e)^{-1}(D - \hat{H}\hat{A})$$

$\hat{H}$ = augmented observation operator
$\hat{A}$ = augmented state vector ensemble

$\hat{A} = \mathbf{h}(A)$

h contains a canopy reflectance model

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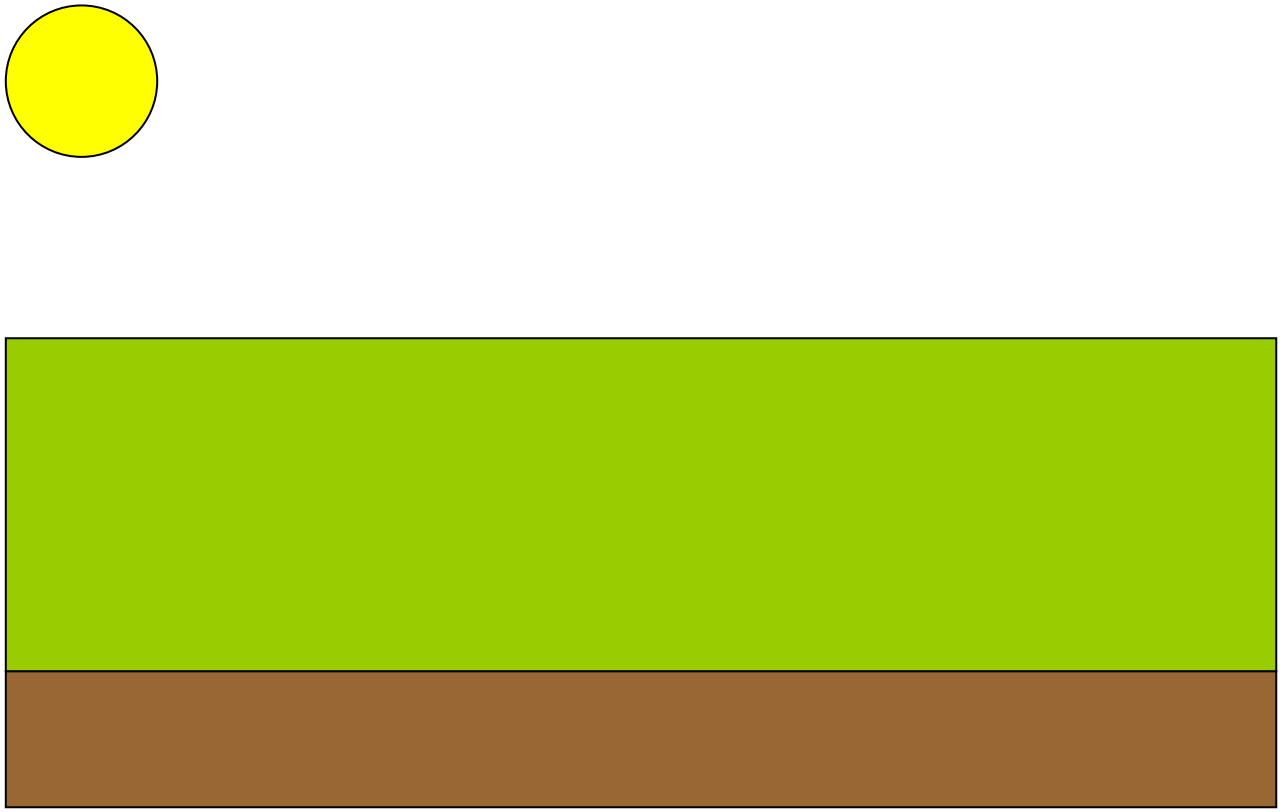
Simple observation operator



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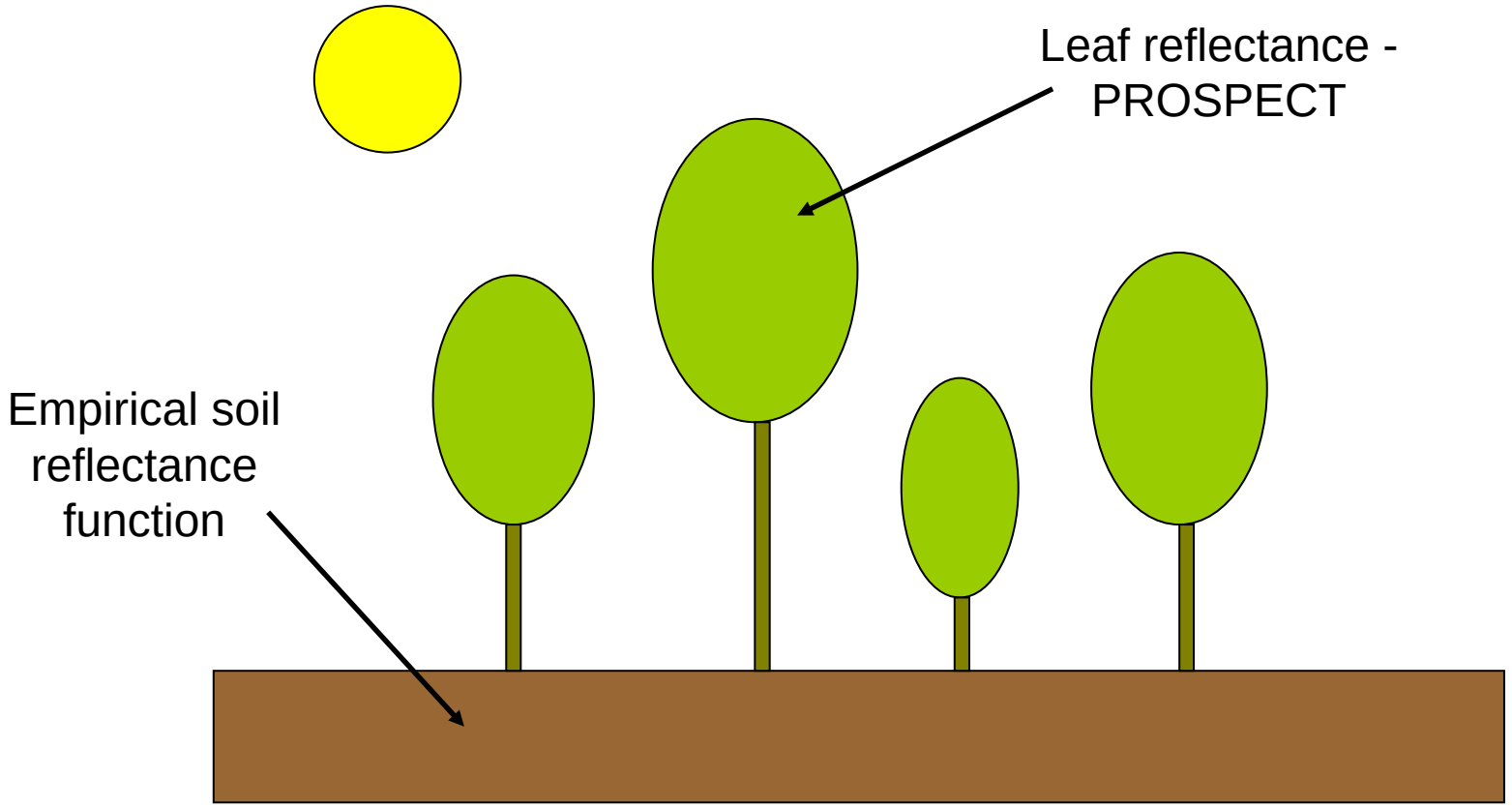
Observation operator - GORT



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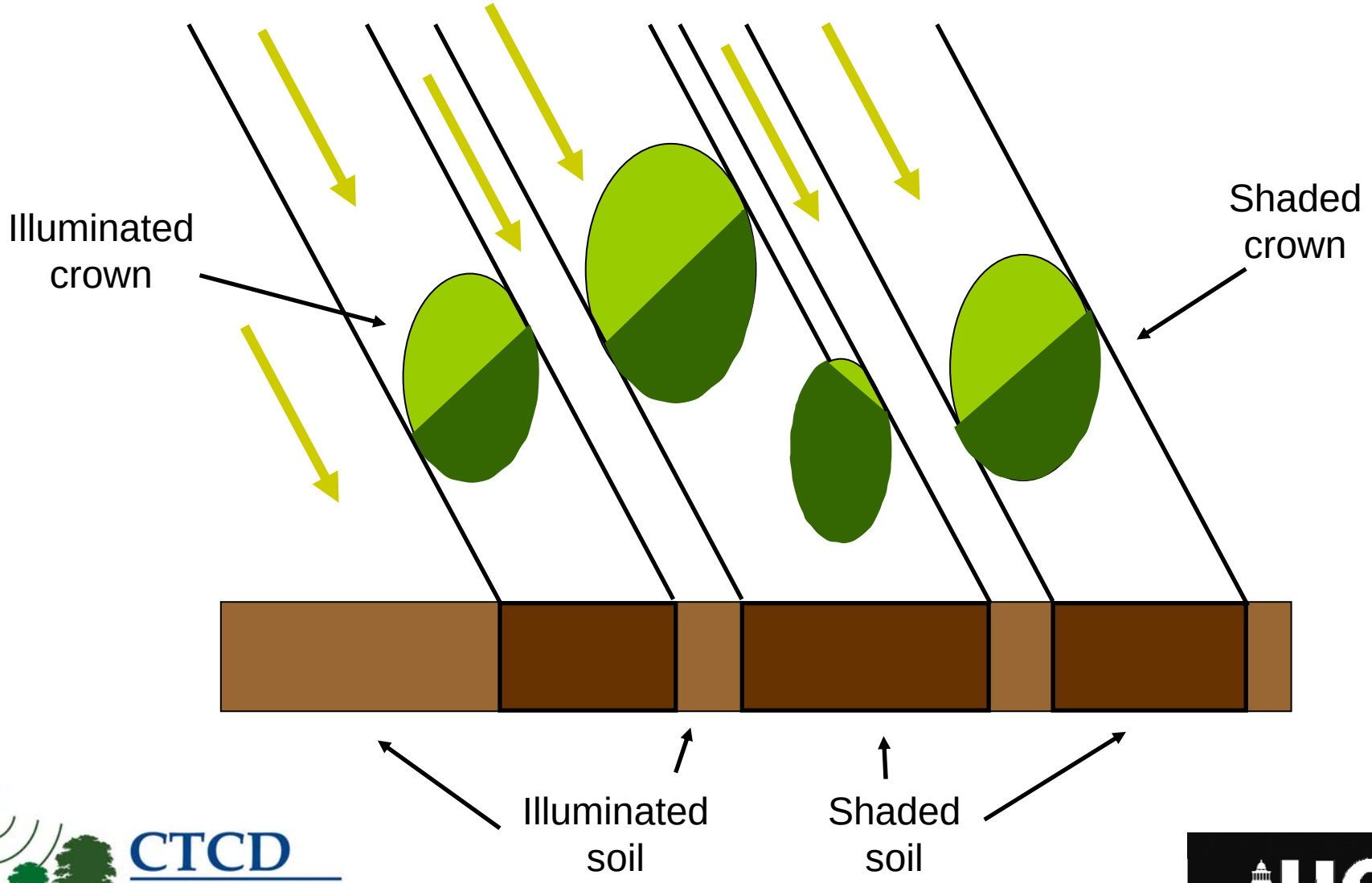
Observation operator - GORT



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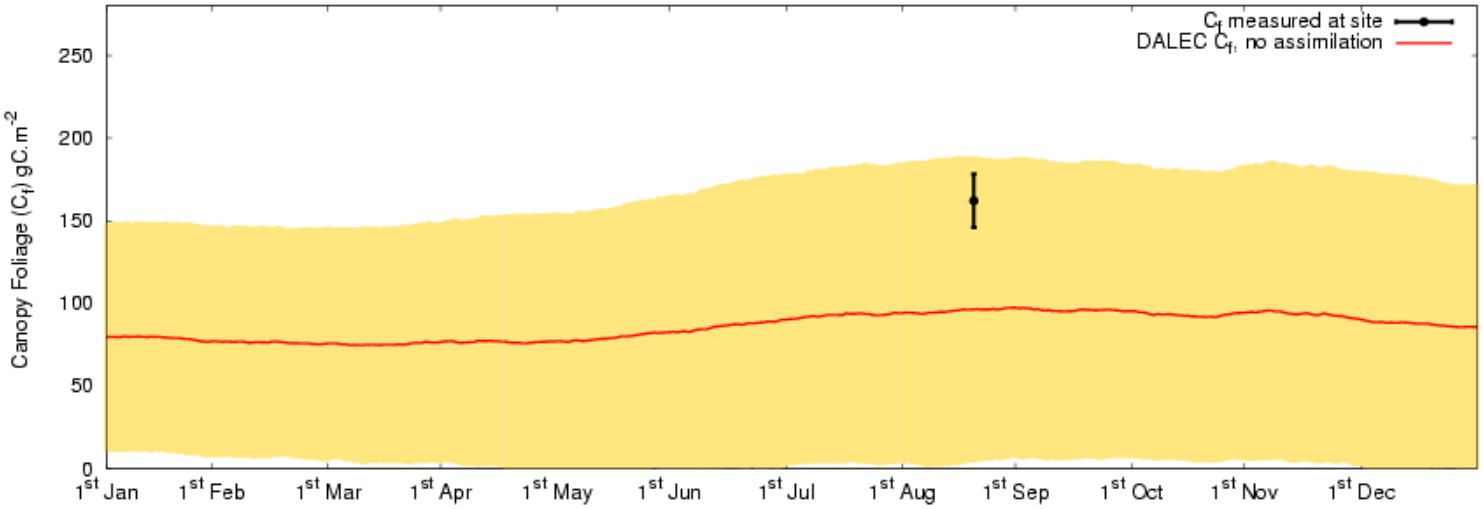
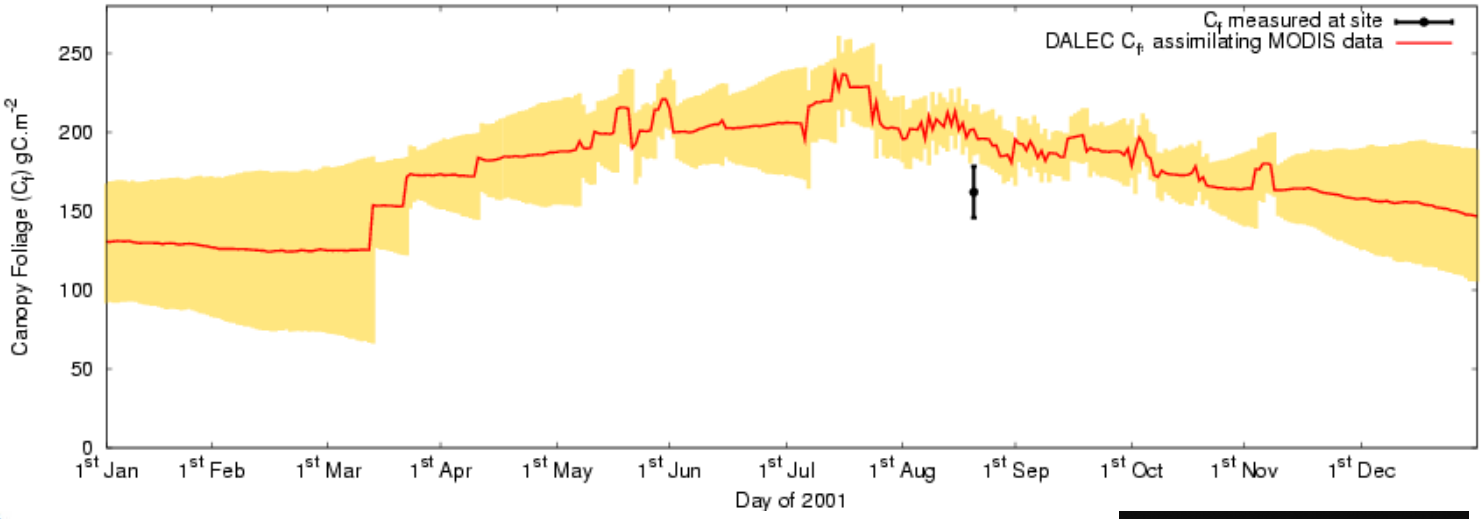
Canopy foliage results

No assimilation



Assimilating MODIS

(bands 1 and 2)



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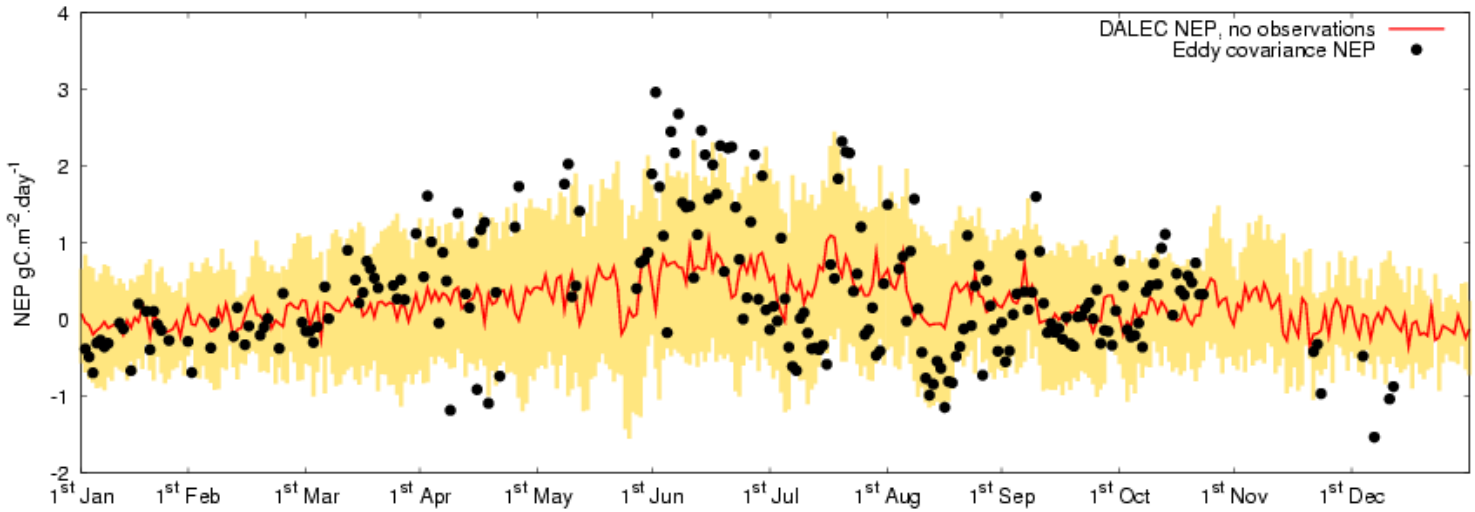
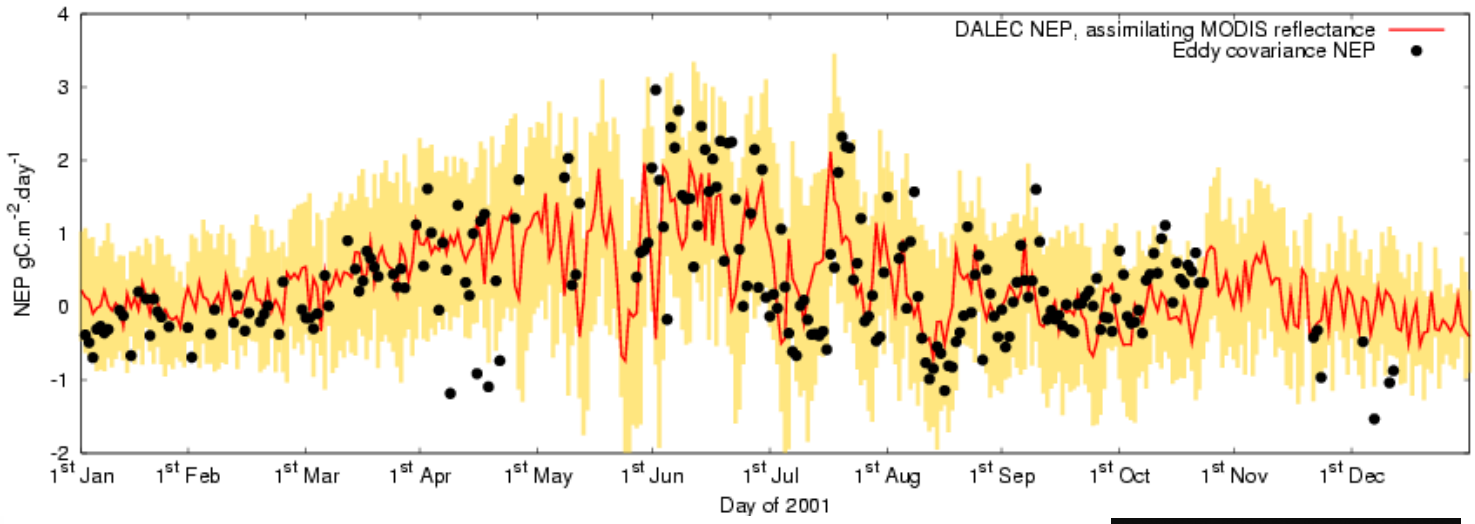
NEP results

No assimilation



Assimilating MODIS

(bands 1 and 2)



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Integrated flux predictions

Flux ($gC.m^{-2}$)	Assimilated data	3yr total	Standard Deviation
NEP	No assimilation	240.2	212.2
	MODIS B1 & B2	373.0	151.3
	Williams et al. (2005)	406.0	27.8
GPP	No assimilation	1646.4	834.5
	MODIS B1 & B2	2620.3	96.8
	Williams et al. (2005)	2170.3	18.1

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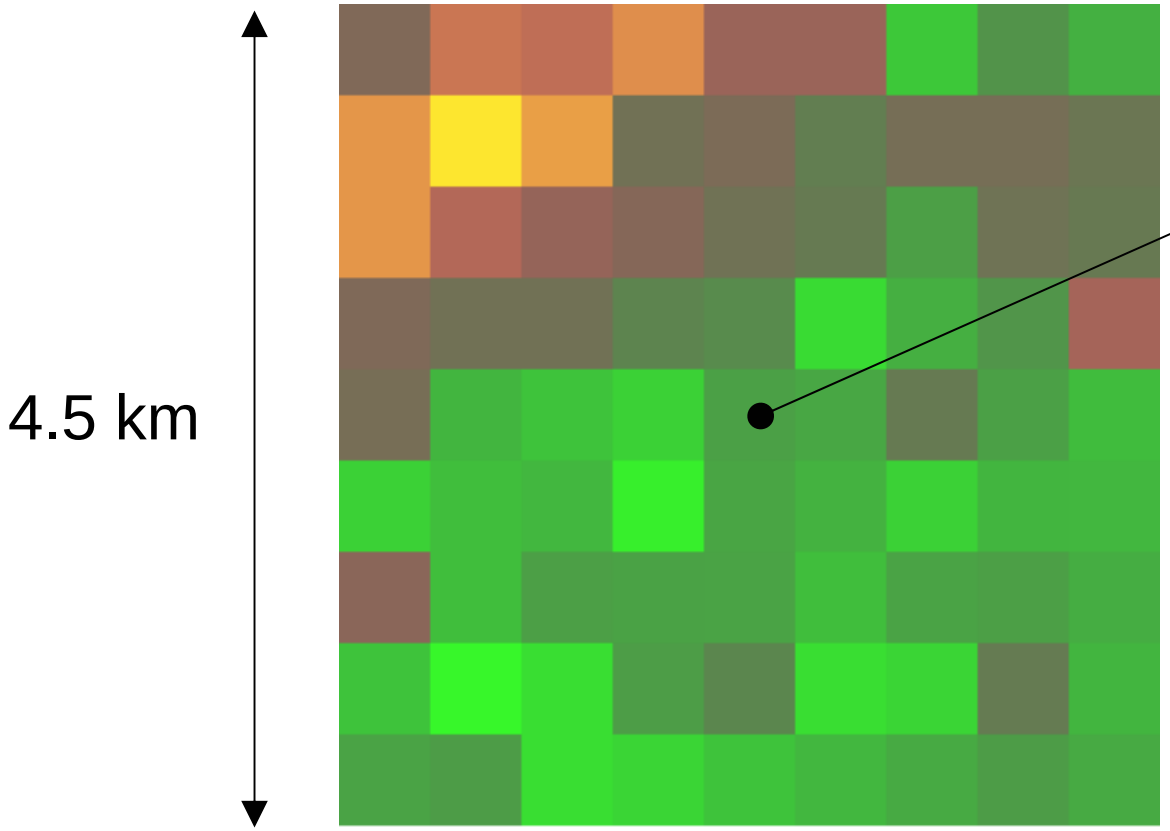
Mean NEP for 2000-2002



Spatial average = 50.9

Std. dev. = 9.7

(gC/m^2/year)

15 65

gC/m^2/year

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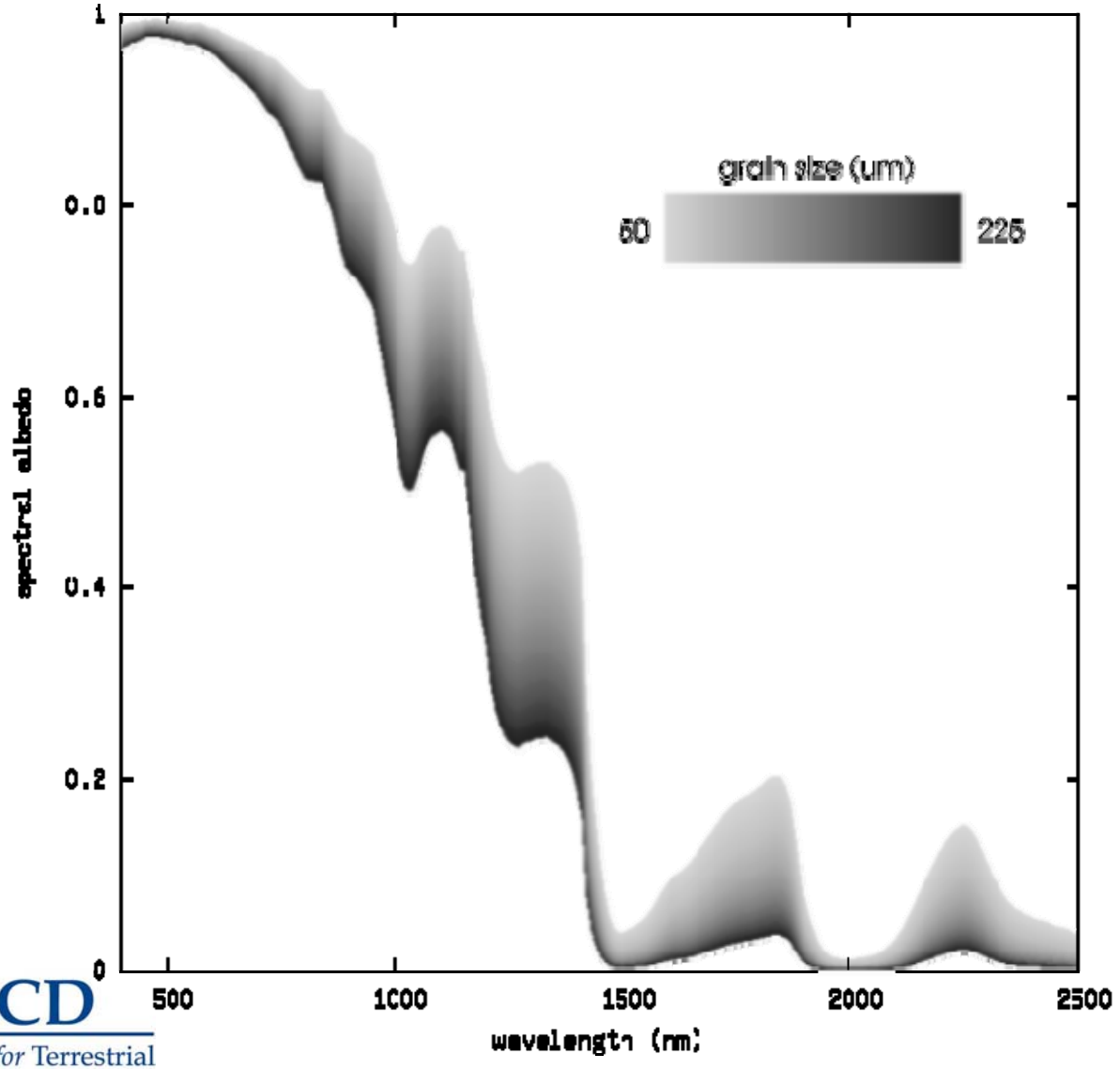
Snow albedo model



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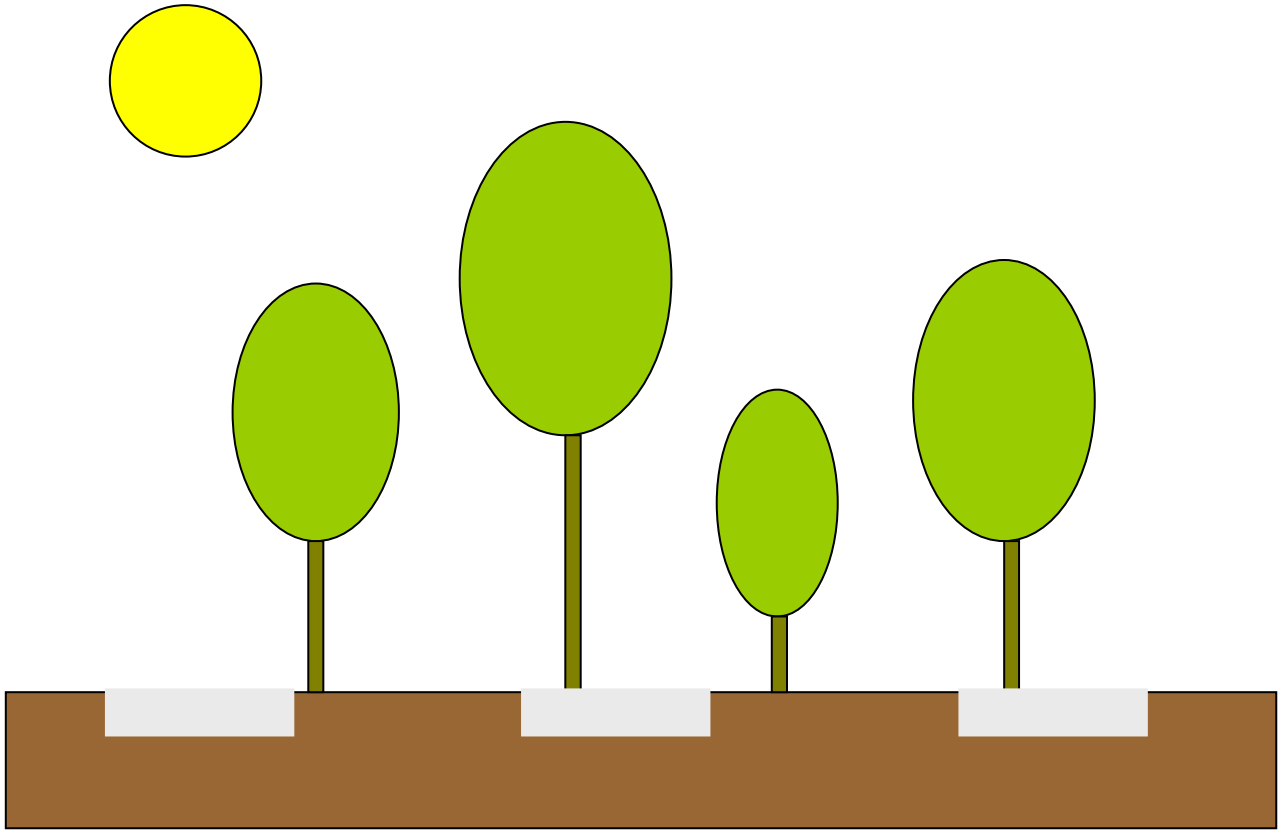
GORT + snow



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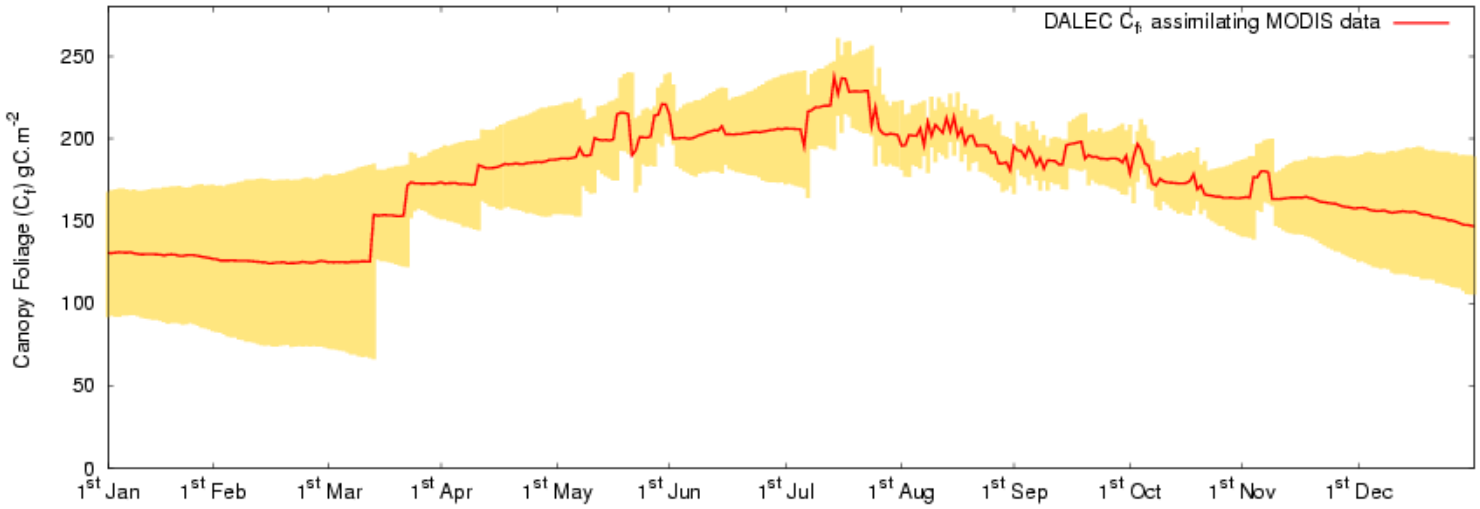
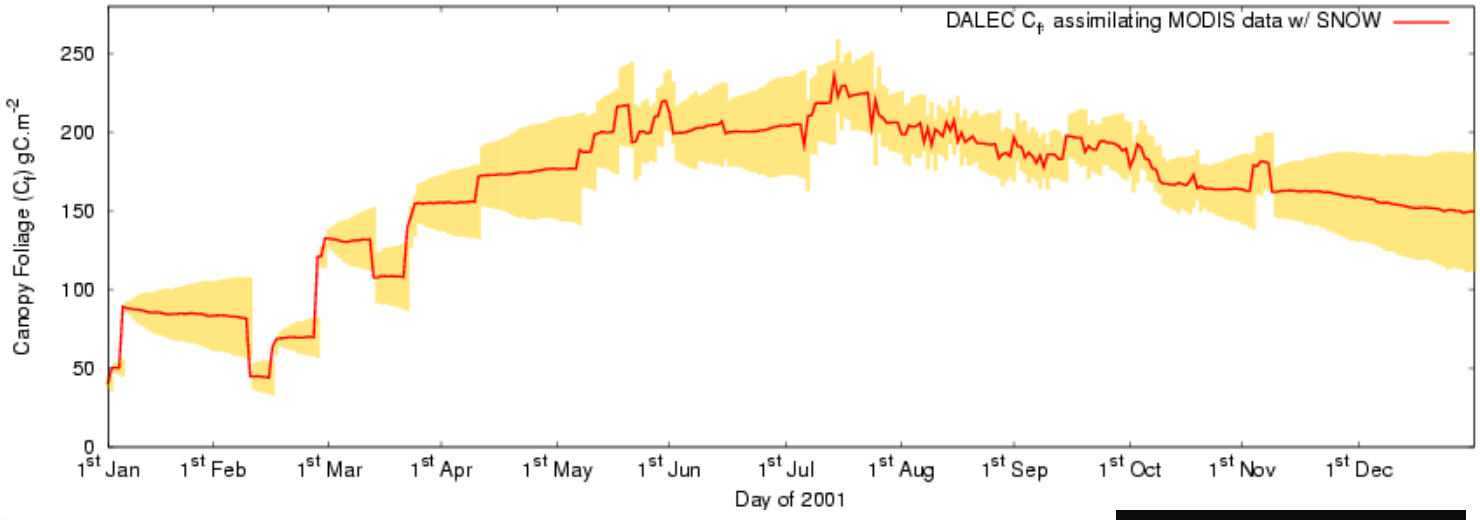
Canopy foliage results

Assimilating MODIS (no snow)



Assimilating MODIS (with snow)



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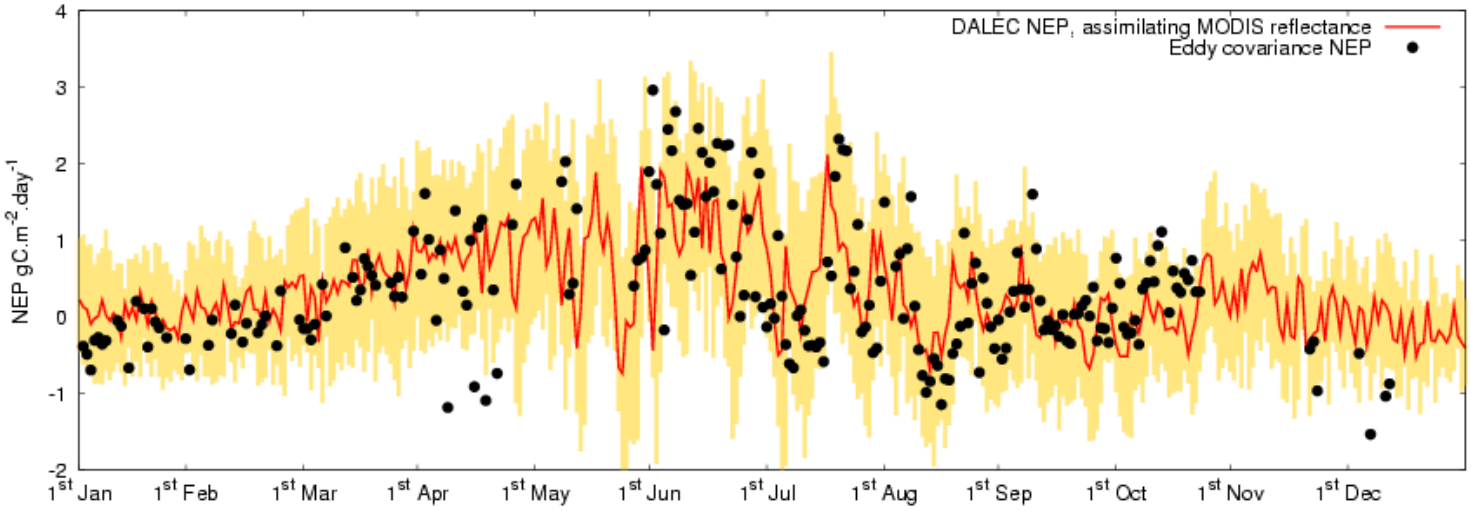
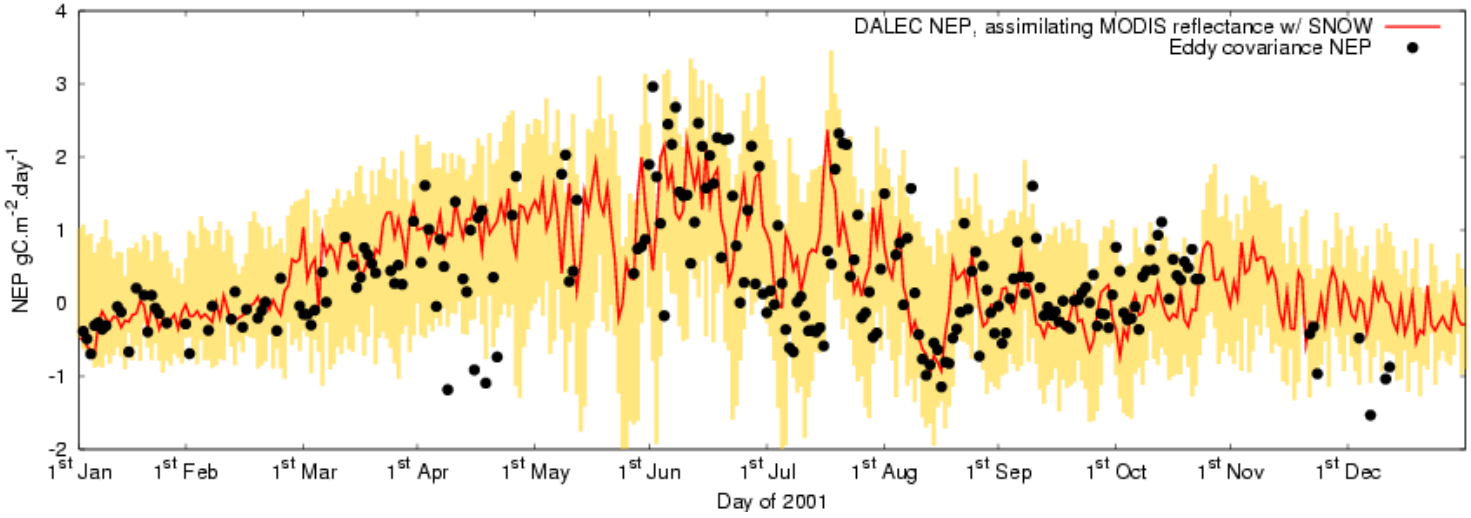
NEP results

Assimilating MODIS (no snow)



Assimilating MODIS (with snow)



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Integrated flux predictions

Flux ($gC.m^{-2}$)	Assimilated data	Total	Standard Deviation
NEP	Assimilation exc. snow	373.0	151.3
	Assimilation inc. snow	404.8	129.6
	Williams et al. (2005)	406.0	27.8
GPP	Assimilation exc. snow	2620.3	96.8
	Assimilation inc. snow	2525.6	42.7
	Williams et al. (2005)	2170.3	18.1

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Current work

- Multi-scale EnKF approach
  - ASTER (15m) & MODIS (500m)
- Improving ecosystem representation
  - Understorey vegetation
- Simplifying observation operator
  - Complexity of GORT >> complexity of DALEC

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DA of EO data into JULES?

- EnKF provides a practical way forward for data assimilation into JULES.
- Technique can be applied to other observations types and other parts of JULES.
- Definition of Observation Operator is key
  - Must be general and *fast*
  - Two stream approach (Pinty et al.)
  - Transform data?

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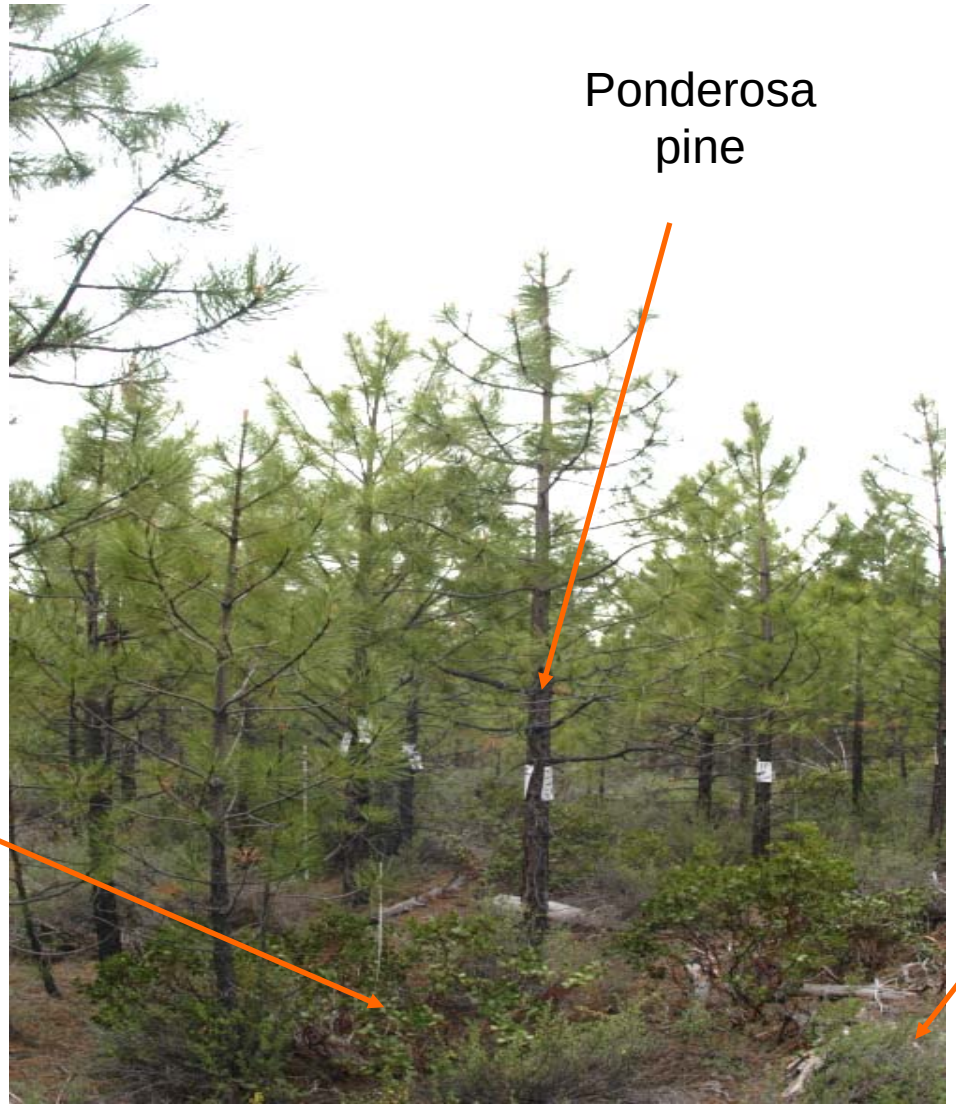
Oregon “young” field site



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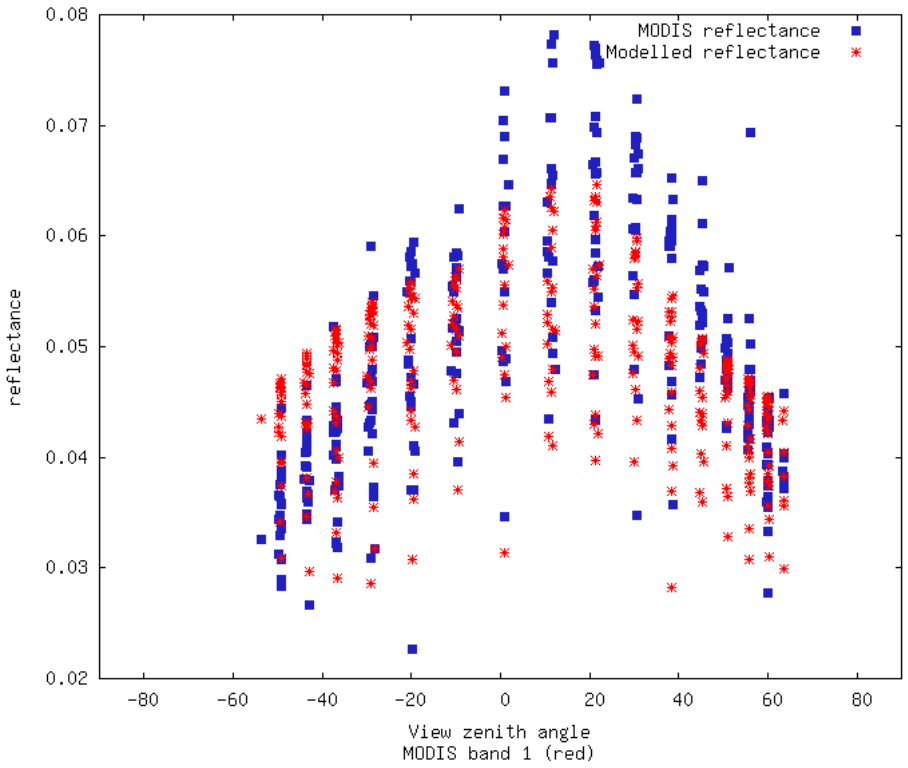
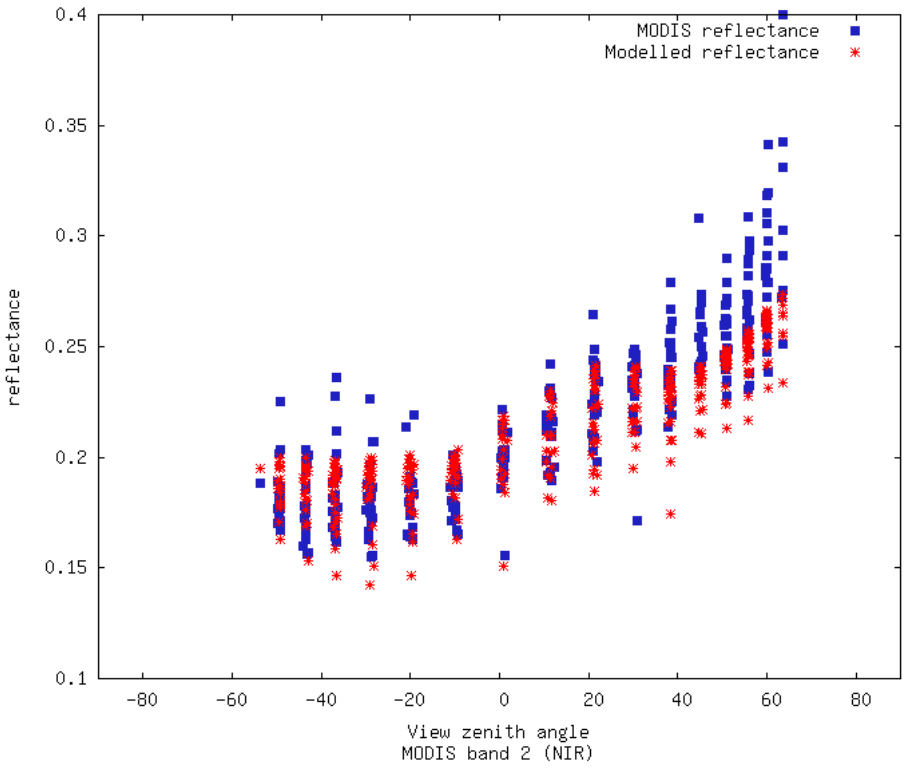
Modelled vs. observed reflectance



Band 1



Band 2

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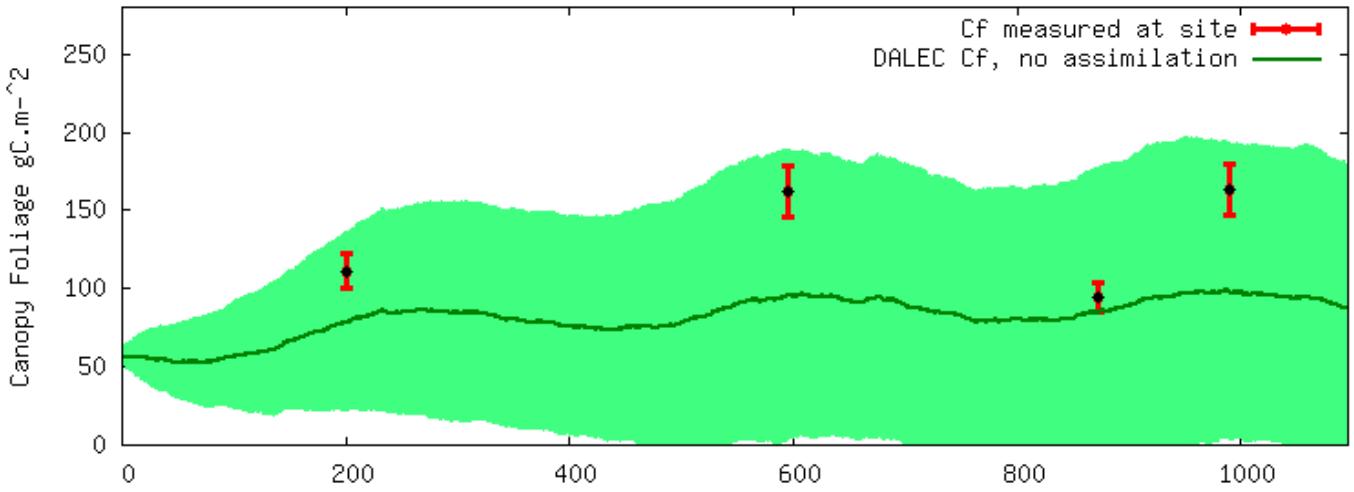
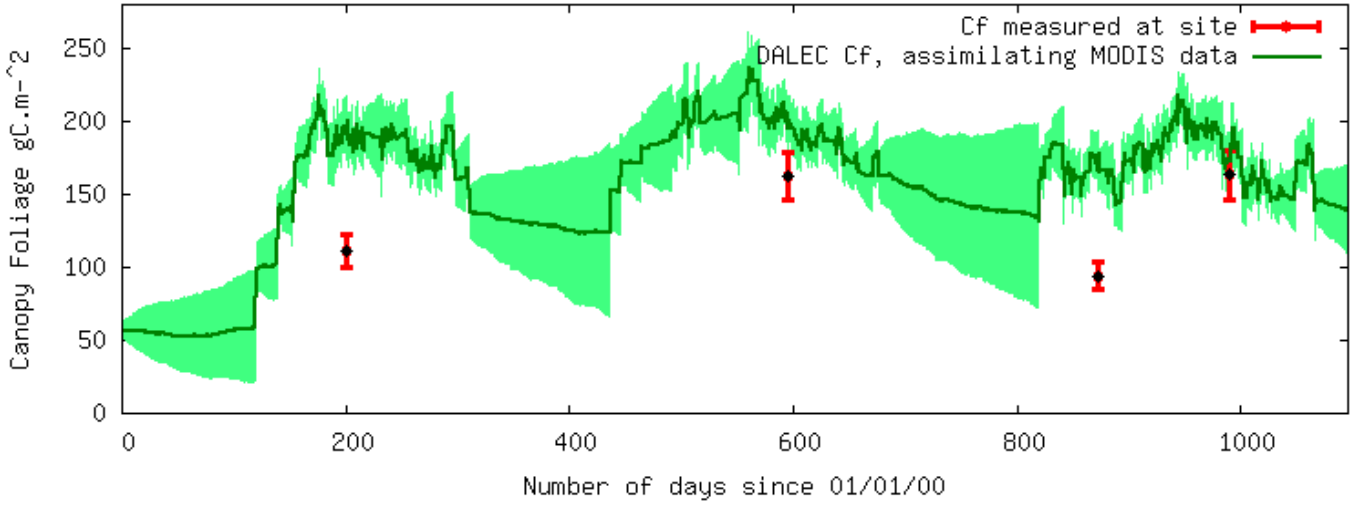
Canopy foliage results

No assimilation



Assimilating MODIS

(bands 1 and 2)



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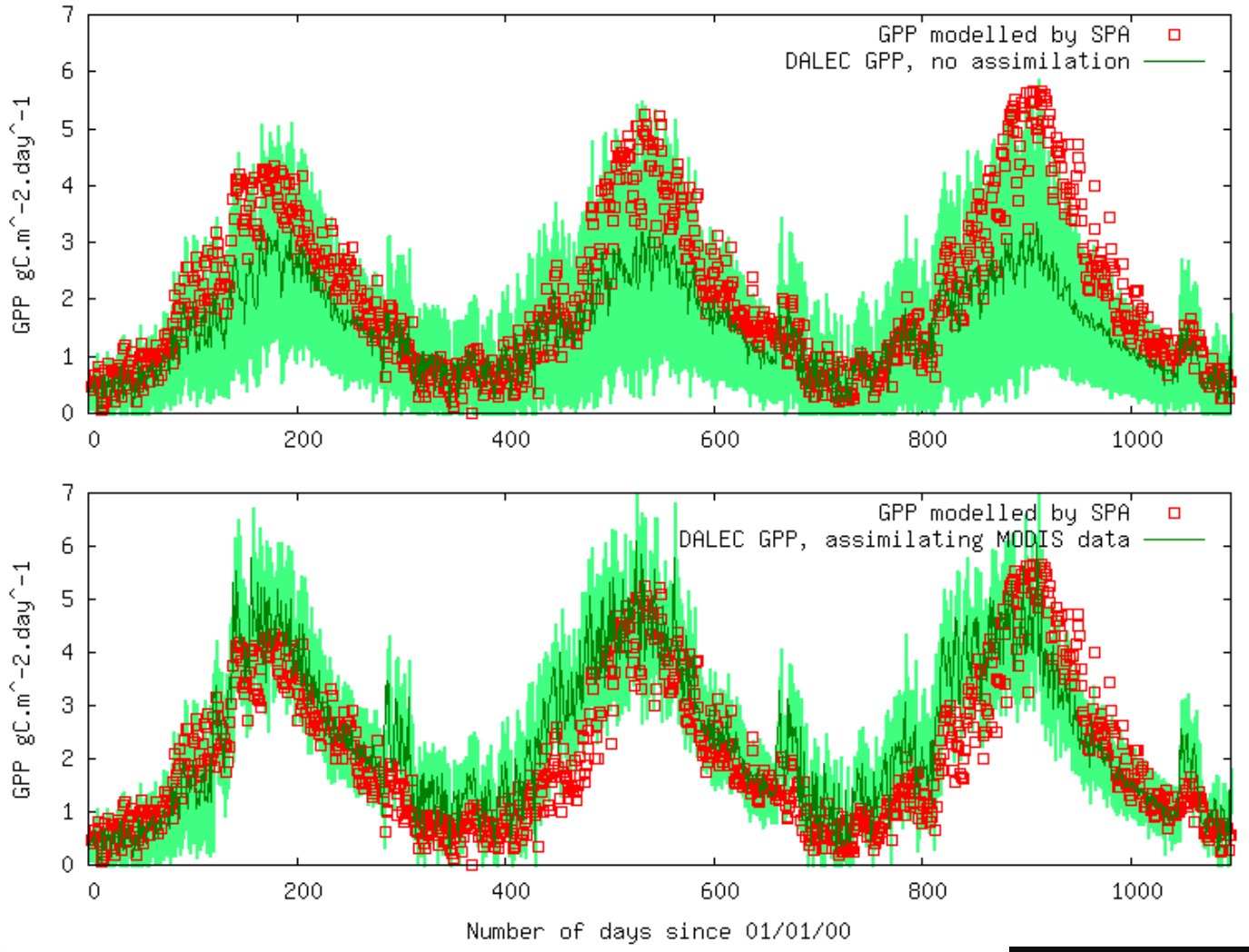
GPP results

No assimilation

Assimilating MODIS

(bands 1 and 2)



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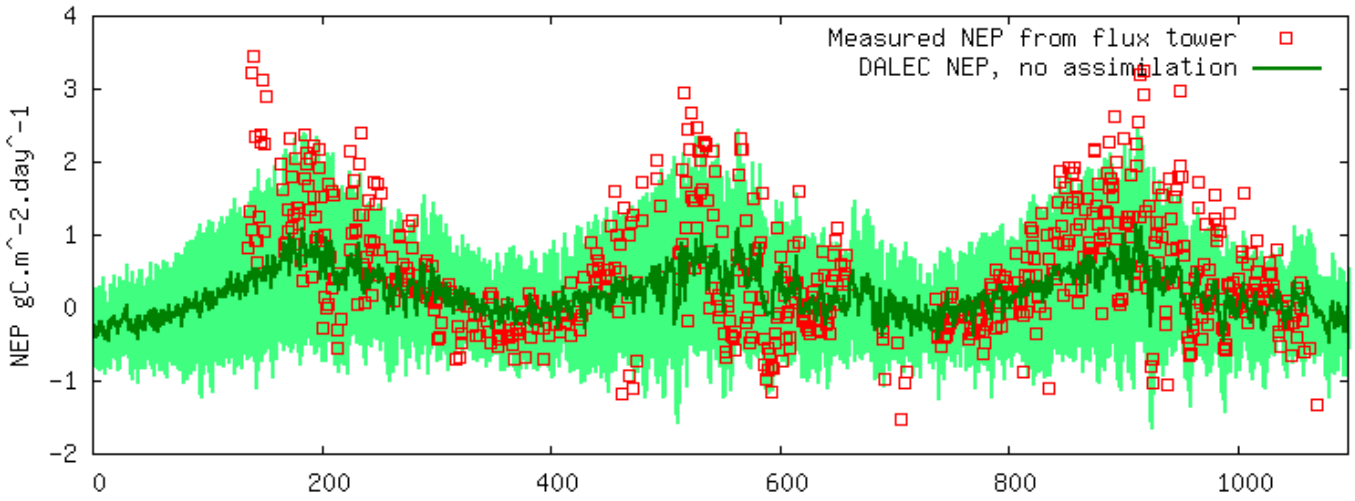
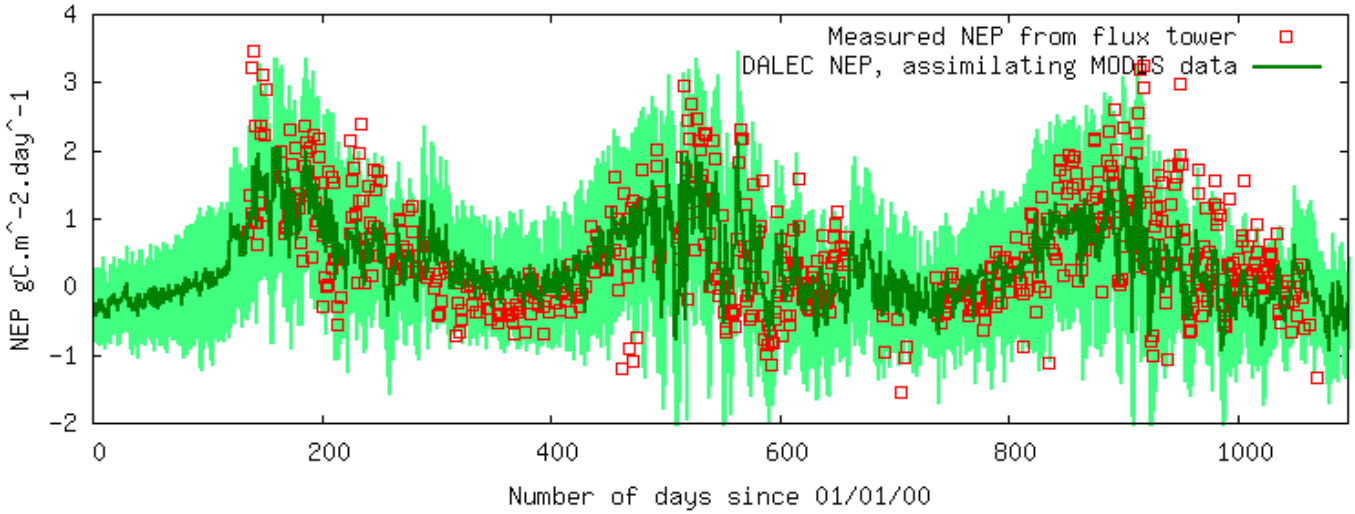
NEP results

No assimilation



Assimilating MODIS

(bands 1 and 2)



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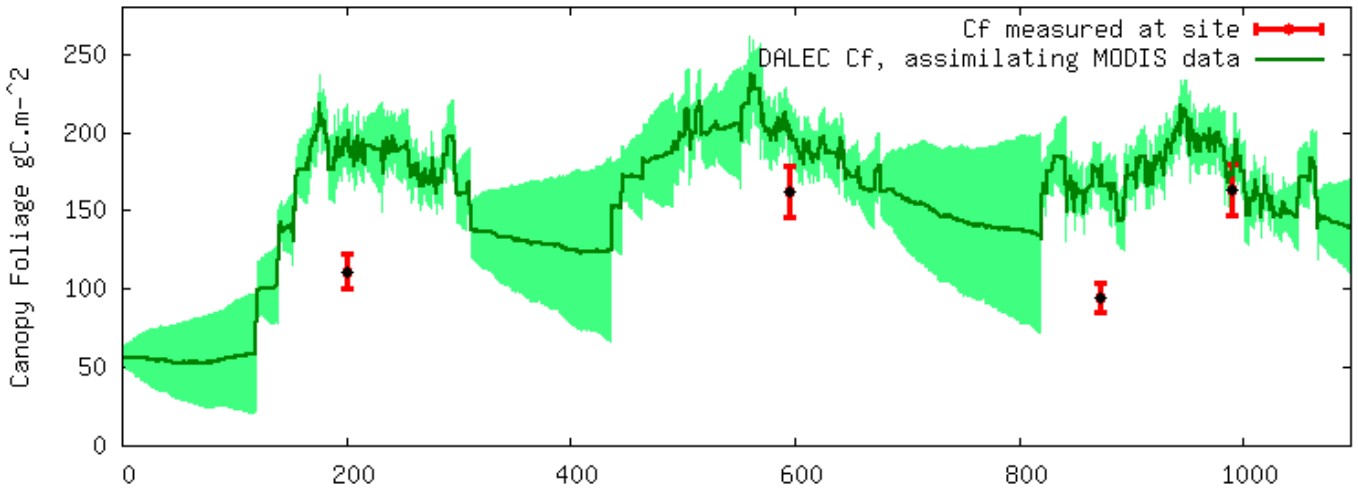
Canopy foliage results

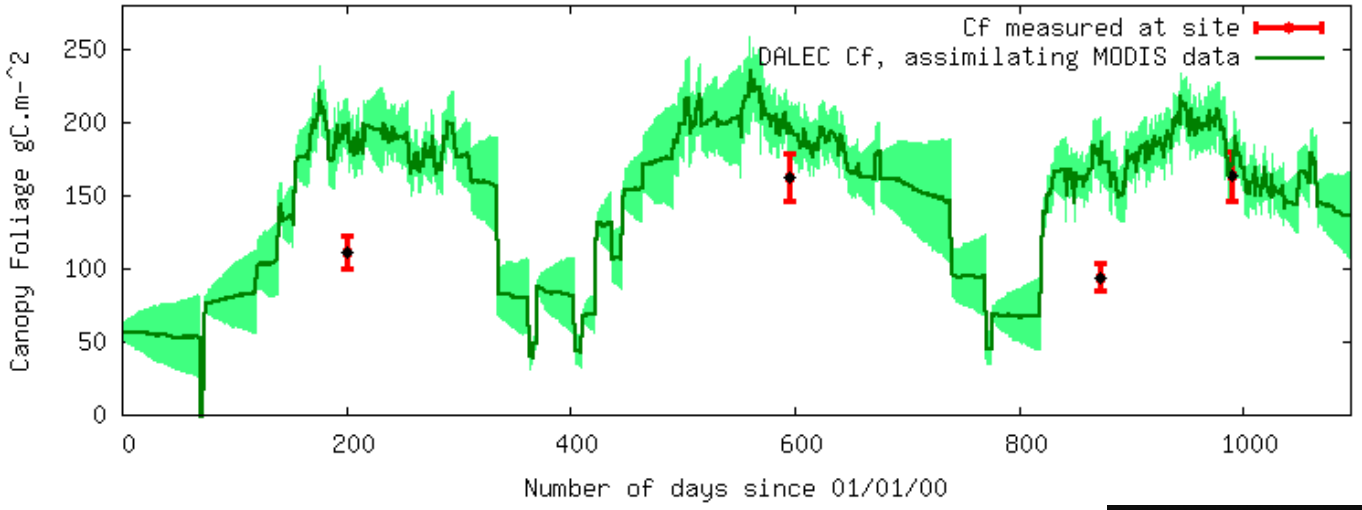
Assimilating MODIS

exc. snow



Assimilating MODIS

inc. snow



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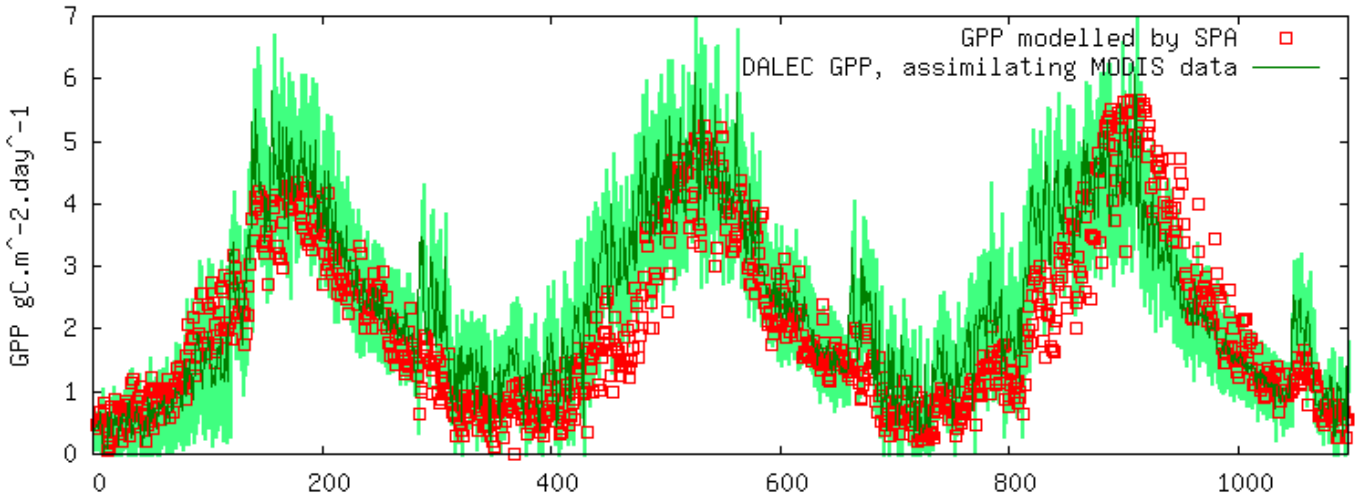
GPP results

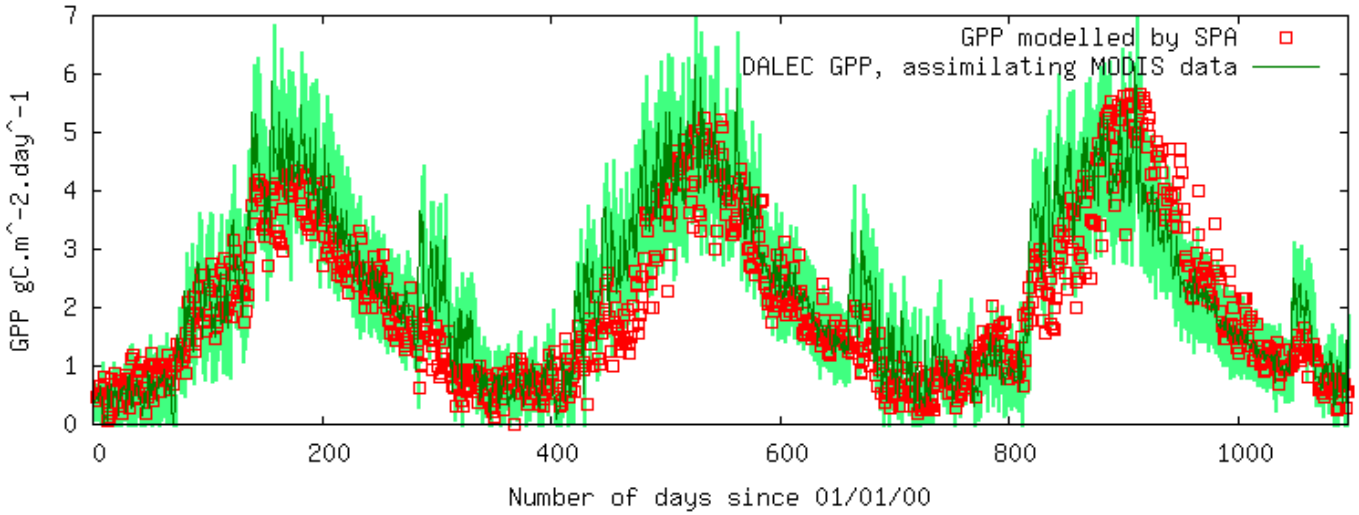
Assimilating MODIS

exc. snow



Assimilating MODIS

inc. snow



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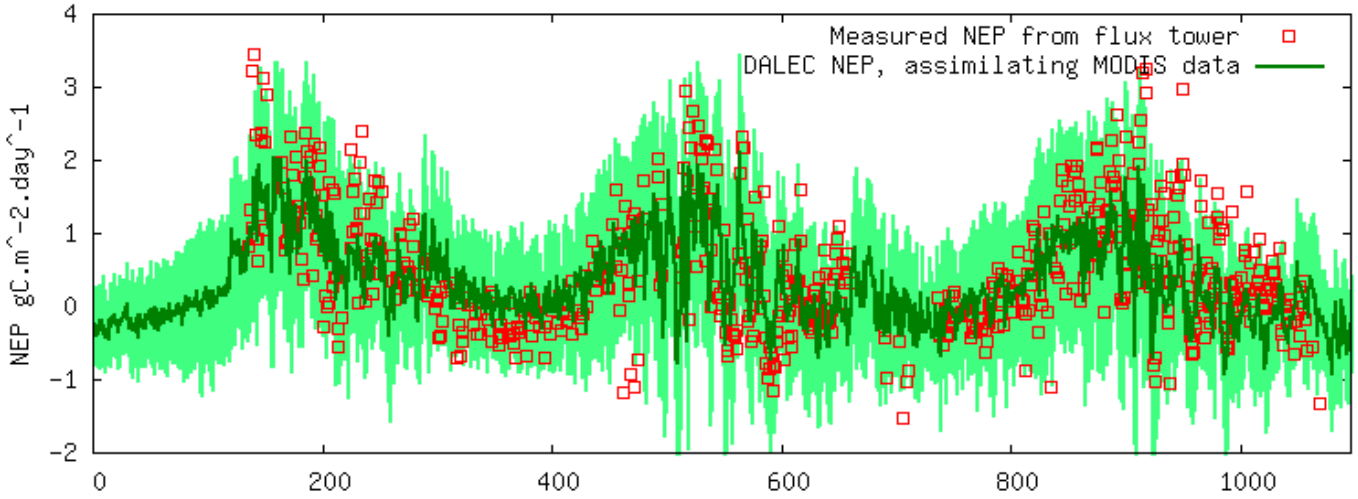
NEP results

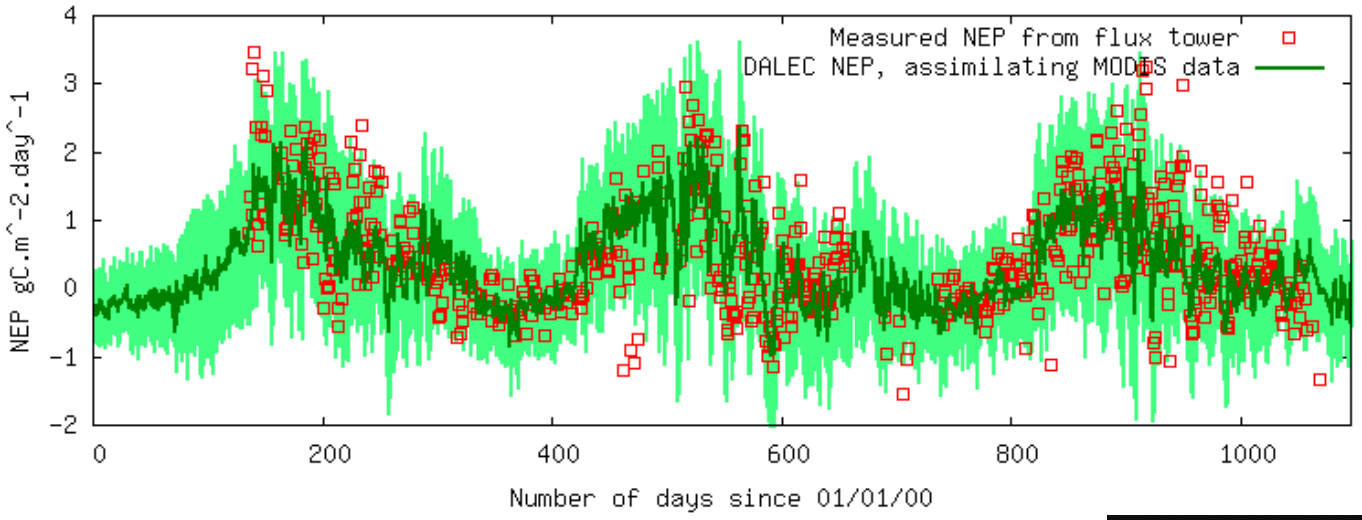
Assimilating MODIS

exc. snow



Assimilating MODIS

inc. snow



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