CMMAP 13th Team Meeting

Meteorological determinants of growing season onset in grassland

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Reto's prognostic phenology:

Simple Biosphere model (SiB3) with Prognostic Phenology to improve our understanding in grasslands (savannas)

- The prognostic phenology model predicts FPAR and LAI and is driven by meteorological predictor data.
- The GSI (Growing Season Index) serves as the foundation for the prognostic phenology model.
- Simulations of the global water and carbon cycle are sensitive to the model representation of vegetation phenology.
- More realistic representation of vegetation phenology in climate models helps predicting the global carbon and water cycle

$$\mathrm{GSI} = f(T) \cdot f(R) \cdot f(M)$$

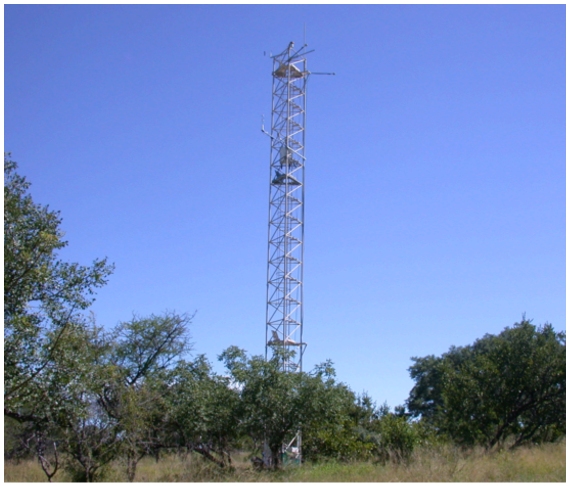
GSI	:	phenological state (0 .. 1)
T	:	temperature, e.g. minimum daily (K)
R	:	light, e.g. global radiation (W/m2)
W	:	moisture, e.g. vapor pressure deficit (Pa)

FPAR (Fraction of Photosynthetically Active Radiation absorbed by vegetation)
LAI (Leaf Area Index) LAI is determined directly by taking a statistically significant sample of foliage from a plant canopy, measuring the leaf area per sample plot and dividing it by the plot land surface area. 0- bare ground and 10- dense conifer forest.

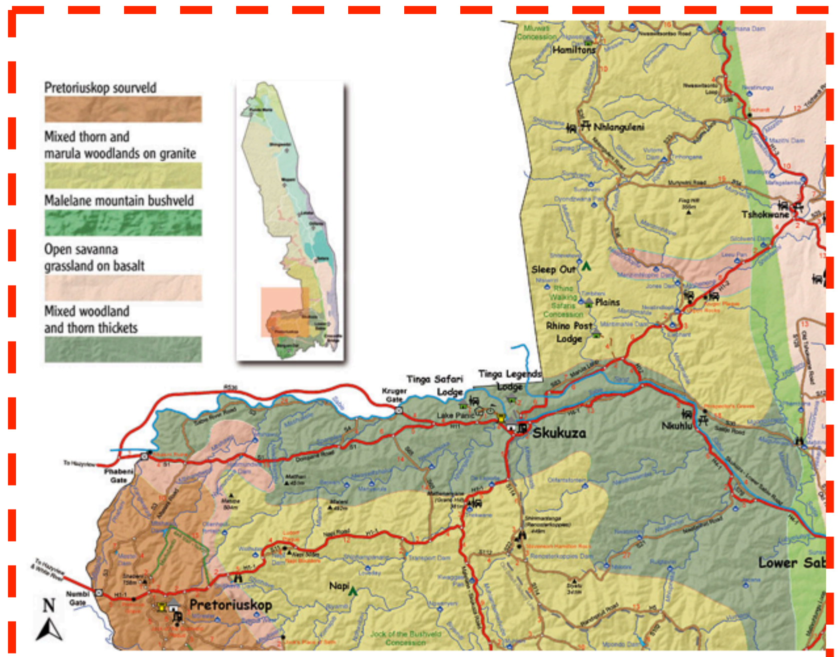
Grasslands

Site: rain green grassland, Skukuza, Kruger Nation Park , South Africa

4 years of flux tower data (Thanks to prof. Niall Hanna)



Site: Skukuza, Kruger National Park
Westernmost Longitude: 31° 29.813' E
Easternmost Longitude: 31° 29.813'E
Northernmost Latitude: 25° 01.184' S
Southernmost Latitude: 25° 01.184' S



Observations from Skukuza:

Hflx ...sensible heat flux [W m-2]
Leflx ...latent heat flux [W m-2]
Fcflx ...turbulent CO2 flux [mg CO2 m-2 s-1]

GSI equation (Reto) :

$$\text{GSI} = f(\overline{T_m}) \cdot f(\overline{R_g}) \cdot f(\overline{vpd})$$

Temperature factor: $$f(\overline{T_m}) = \frac{\overline{T_m} - T_{m_{min}}}{T_{m_{max}} - T_{m_{min}}}$$

Radiation factor: $$f(\overline{R_g}) = \frac{\overline{R_g} - R_{g_{min}}}{R_{g_{max}} - R_{g_{min}}}$$

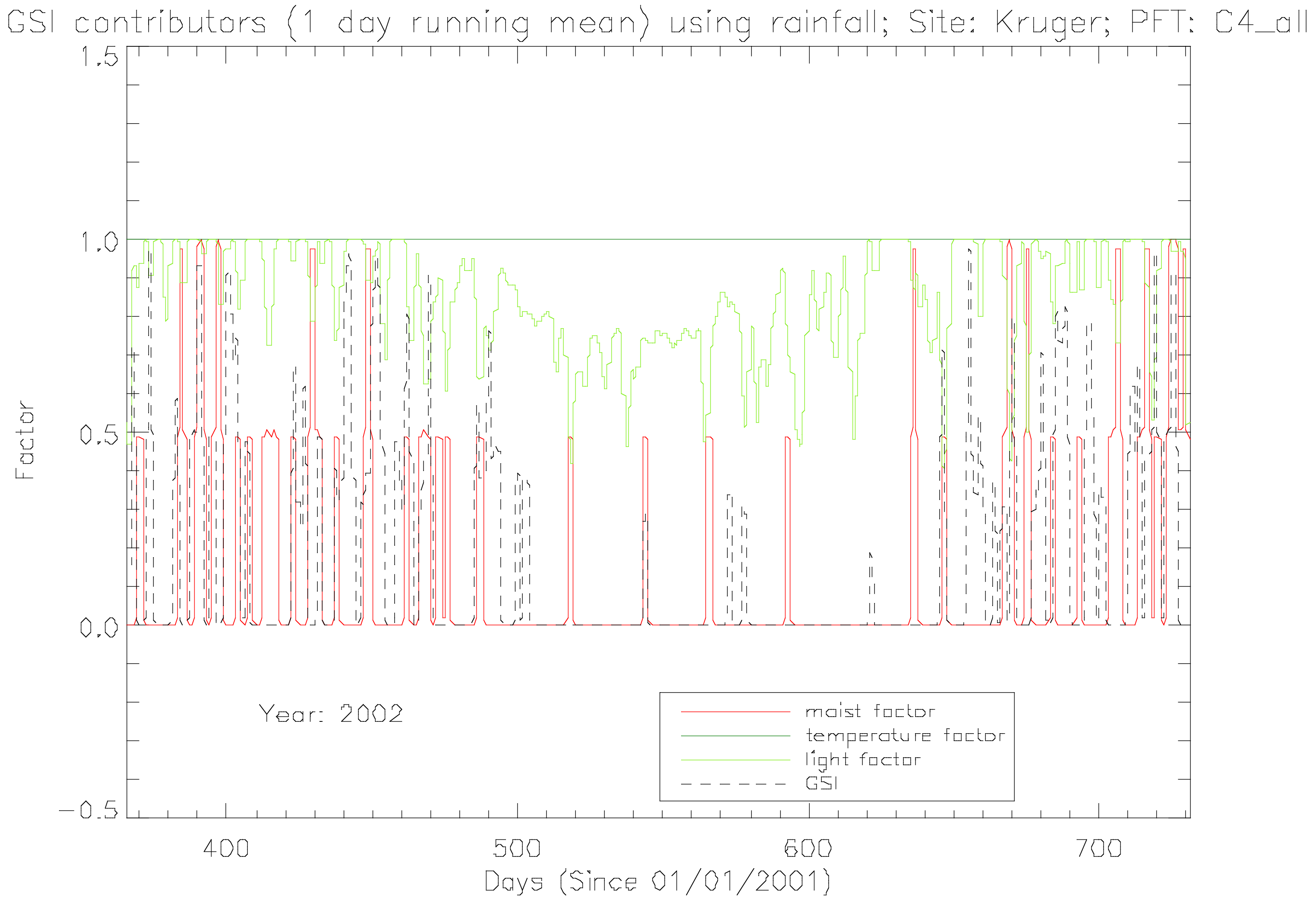
Moist factor: $$f(\overline{vpd}) = 1 - \frac{\overline{vpd} - vpd_{min}}{vpd_{max} - vpd_{min}}$$

vpd_{max} and ***vpd_{min}***: max and min empirical climate parameters ranges

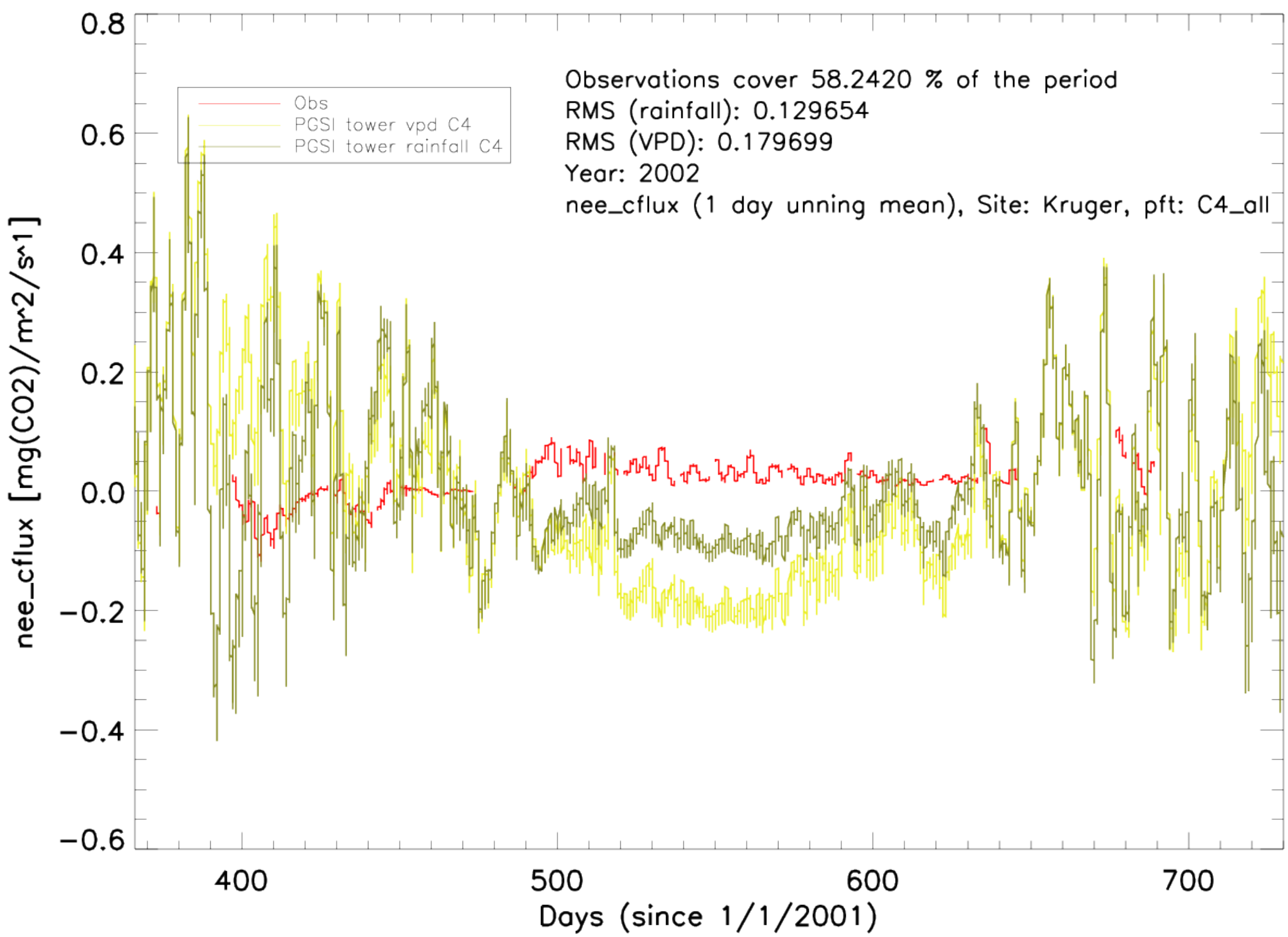
$\overline{vpd}$: multi-day running mean average

Same equation is used with *rainfall* instead of *vpd*

Why moist factor ?



Why rainfall instead of vpd ?



GSI equation (new) :

$$\text{GSI} = f(\overline{T_m}) \cdot f(\overline{R_g}) \cdot f(\overline{vpd})$$

- If **rainfall** less than ***rain***$_{\textbf{min}}$ drying will occur:

$f(\overline{rain}) = f(\overline{rain}) - D_c$

D_c is drying coefficient

$D_c = f(T, W, RH)$

Currently for my 30min time step case Dc is set that no rain scenario will dry the soil form saturated to dry within approximately 4 days

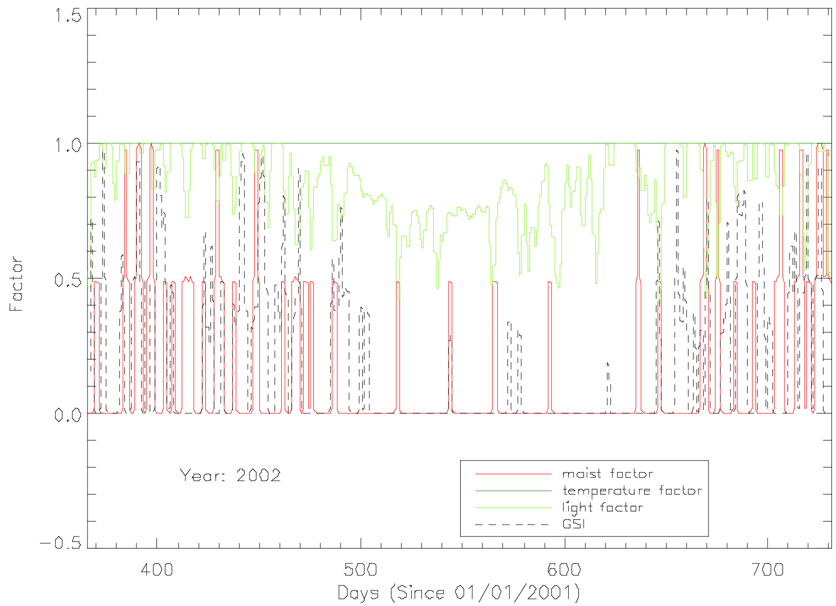
- If **rainfall** grater than ***rain***$_{\textbf{min}}$ moist factor increase:

$f(\overline{rain}) = f(\overline{rain}) + [\overline{rain} - rain_{min}] / [rain_{max} - rain_{min}]$

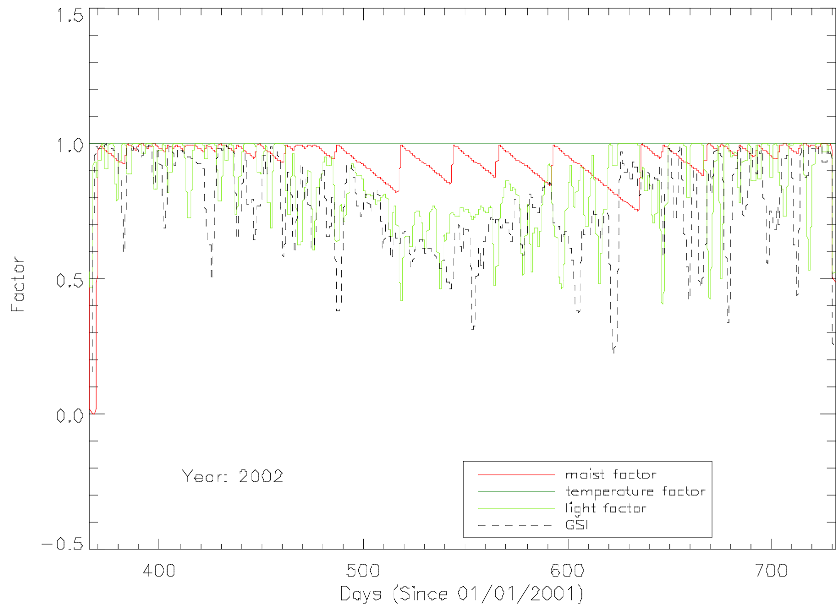
Results

GSI contributors
(1 day running mean)
using rainfall
Kruger site; PFT: C4 all

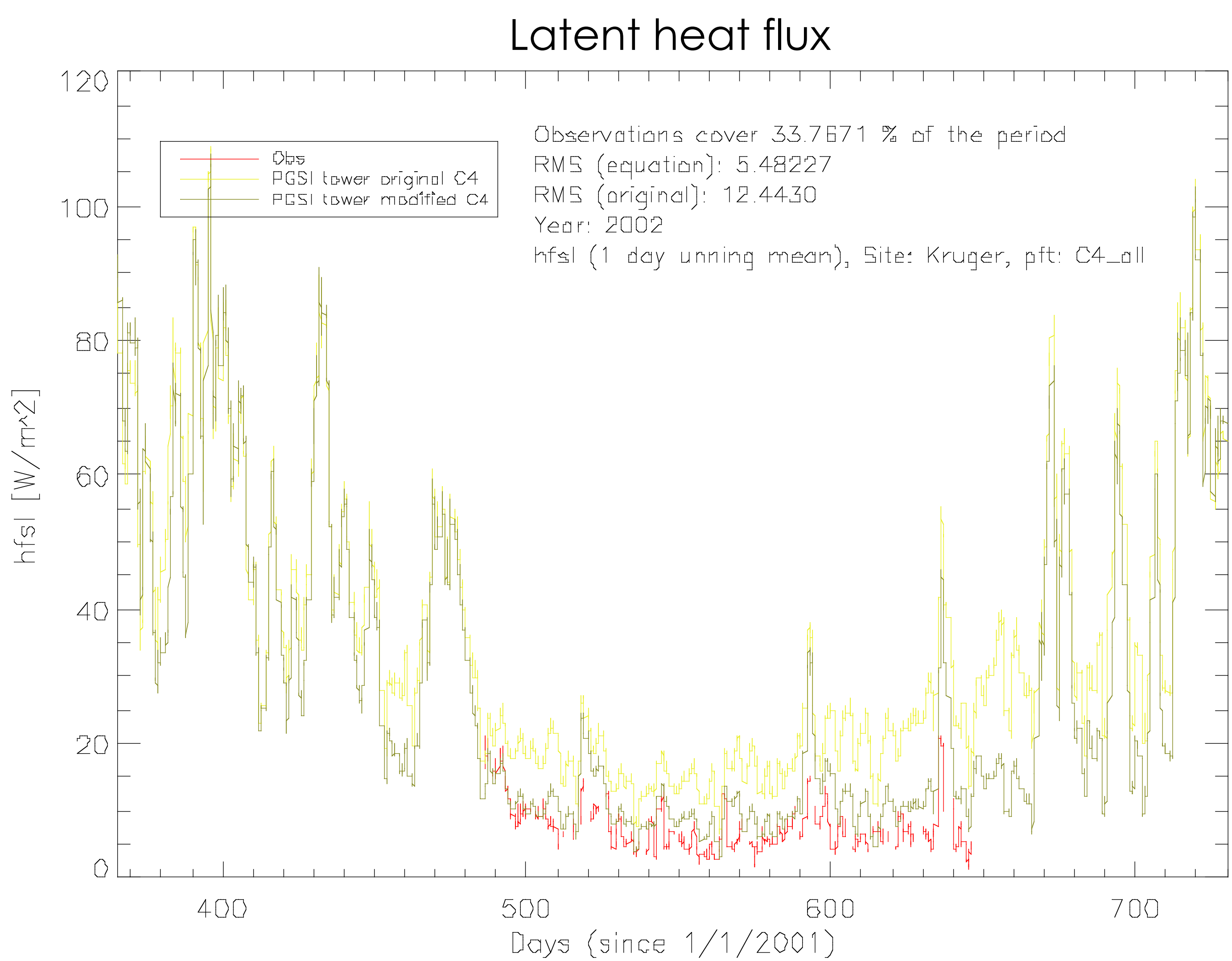
Original Equation



New Equation

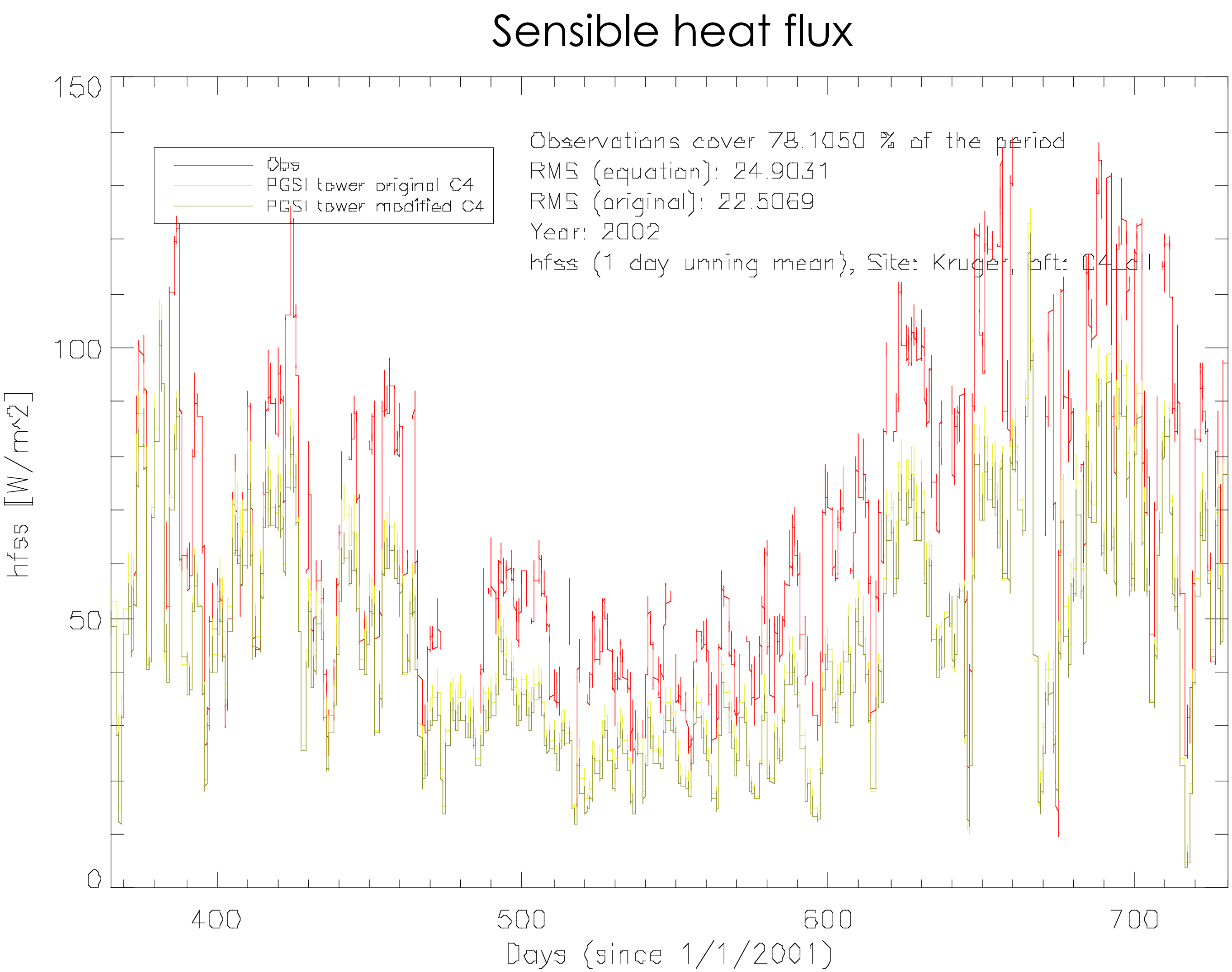


Results



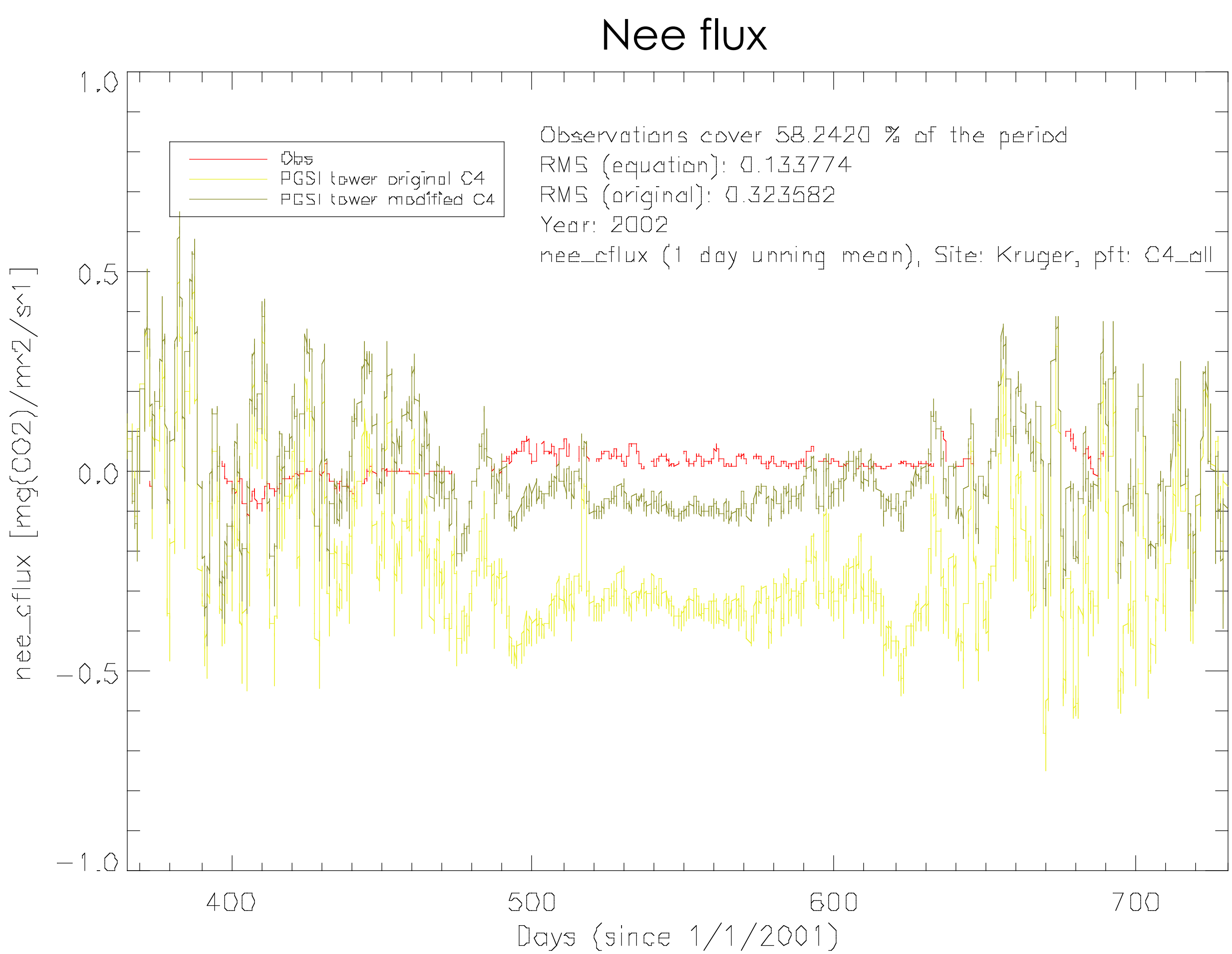
Latent heat flux
Obs
PGSI tower original C4
PGSI tower modified C4
Observations cover 33.7671 % of the period
RMS (equation): 5.48227
RMS (original): 12.4430
Year: 2002
hfsl (1 day unning mean), Site: Kruger, pft: C4_all
hfsl [W/m^2]
Days (since 1/1/2001)
0
20
40
60
80
100
120
400
500
600
700

Results



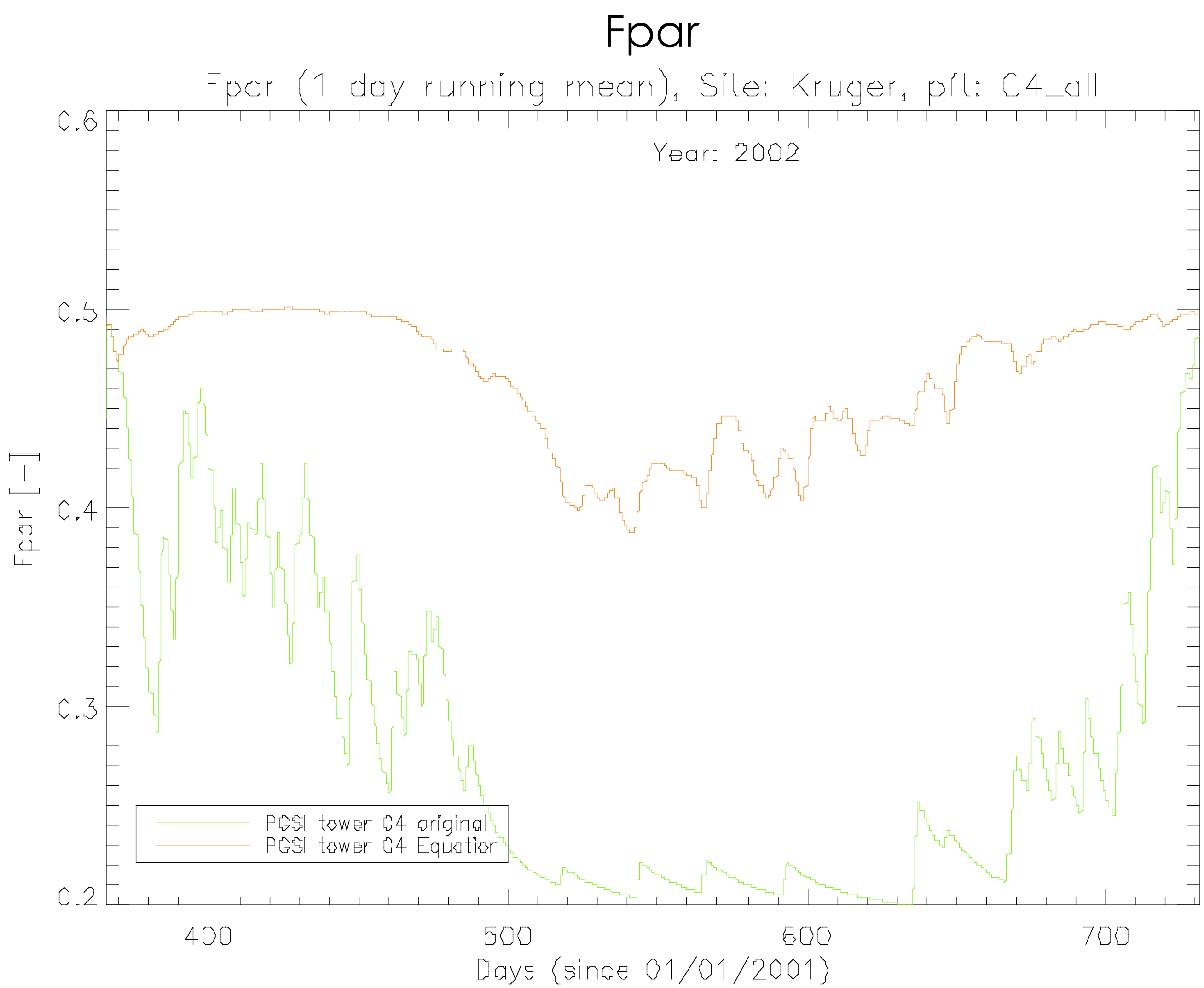
Sensible heat flux
Obs
PGSI tower original C4
PGSI tower modified C4
Observations cover 78.1050 % of the period
RMS (equation): 24.9031
RMS (original): 22.5069
Year: 2002
hfss (1 day unning mean), Site: Kruger, pft: C4_dl
150
100
50
0
hfss [W/m^2]
400
500
600
700
Days (since 1/1/2001)

Results



Nee flux
Obs
PGSI tower original C4
PGSI tower modified C4
Observations cover 58.2420 % of the period
RMS (equation): 0.133774
RMS (original): 0.323582
Year: 2002
nee_cflux (1 day unning mean), Site: Kruger, pft: C4_all
nee_cflux [mg{CO2}/m^2/s^1]
Days (since 1/1/2001)
1.0
0.5
0.0
−0.5
−1.0
400
500
600
700

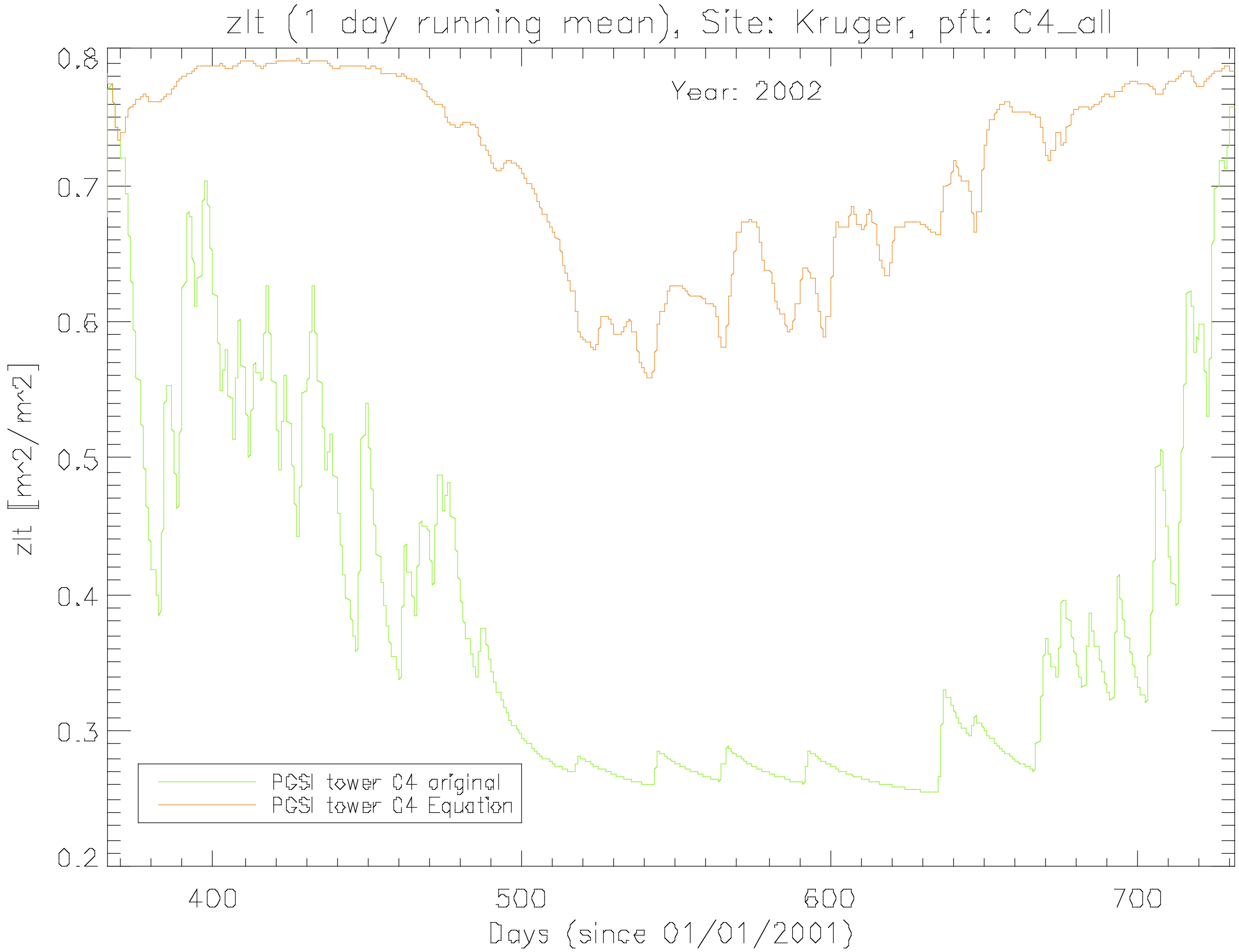
Results



Fpar
Fpar (1 day running mean), Site: Kruger, pft: C4_all
Year: 2002
Fpar [-]
0.6
0.5
0.4
0.3
0.2
400
500
600
700
Days (since 01/01/2001)
PGSI tower C4 original
PGSI tower C4 Equation

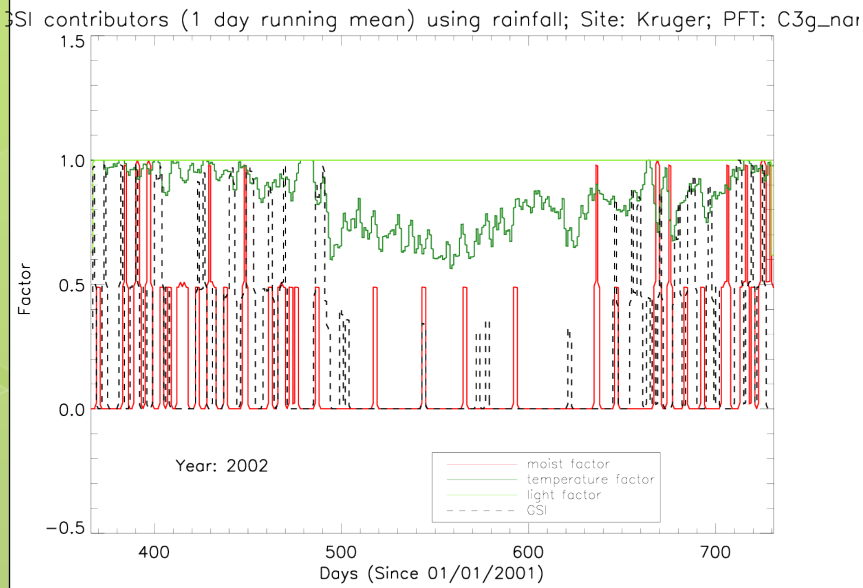
Results

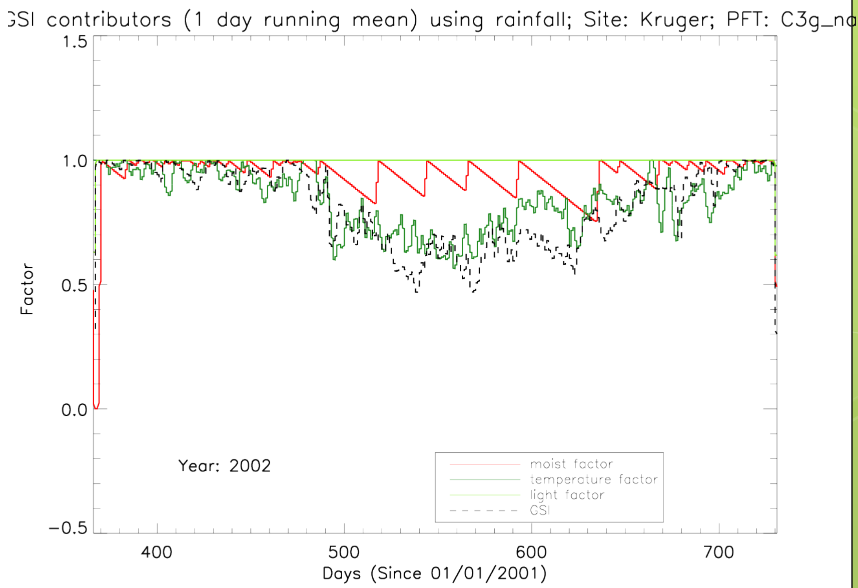
Leaf area index (LAI)



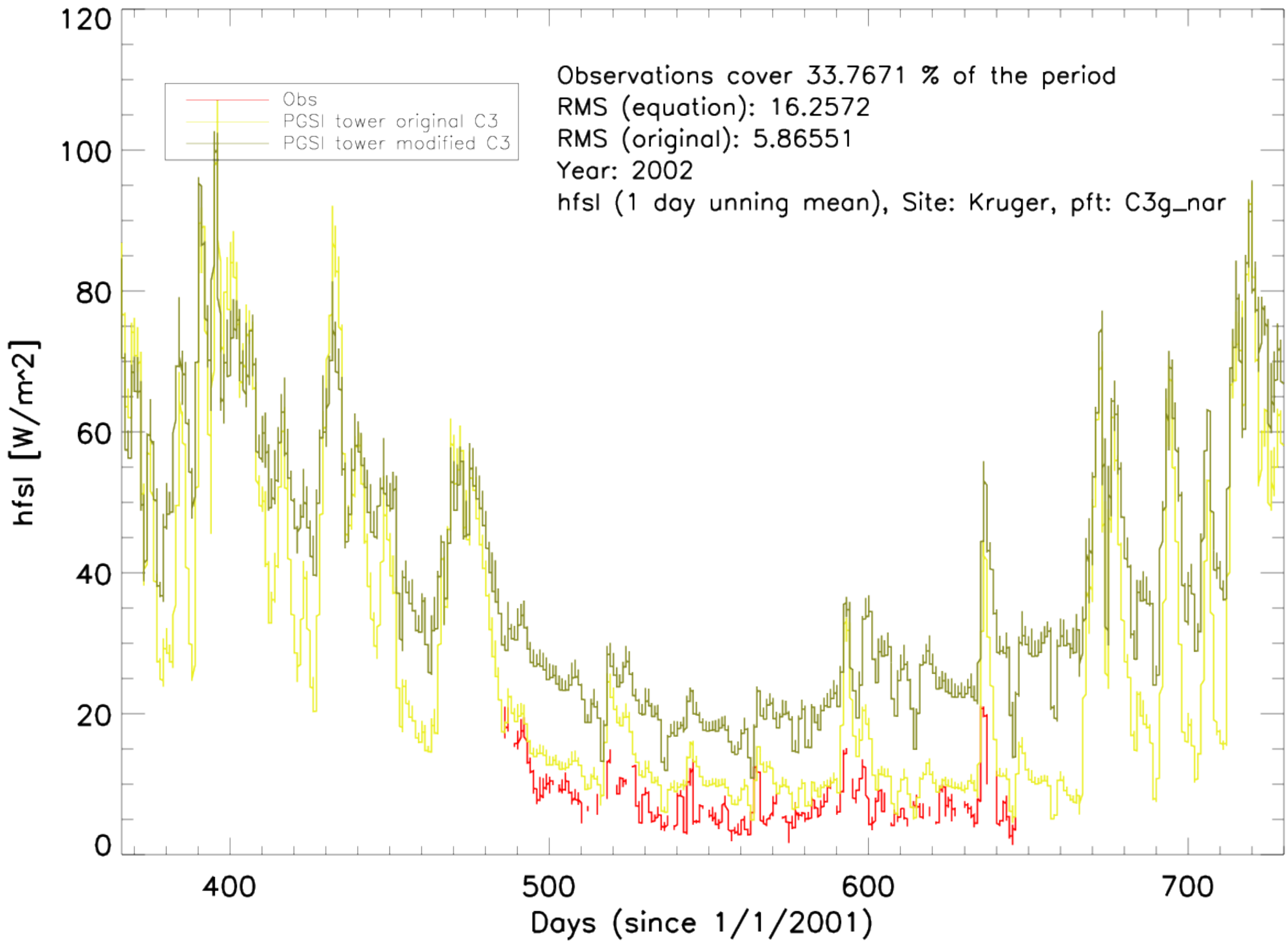
Results

Results


SI contributors (1 day running mean) using rainfall; Site: Kruger; PFT: C3g_nar
1.5
1.0
0.5
0.0
−0.5
Factor
400
500
600
700
Days (Since 01/01/2001)
Year: 2002
moist factor
temperature factor
light factor
GSI

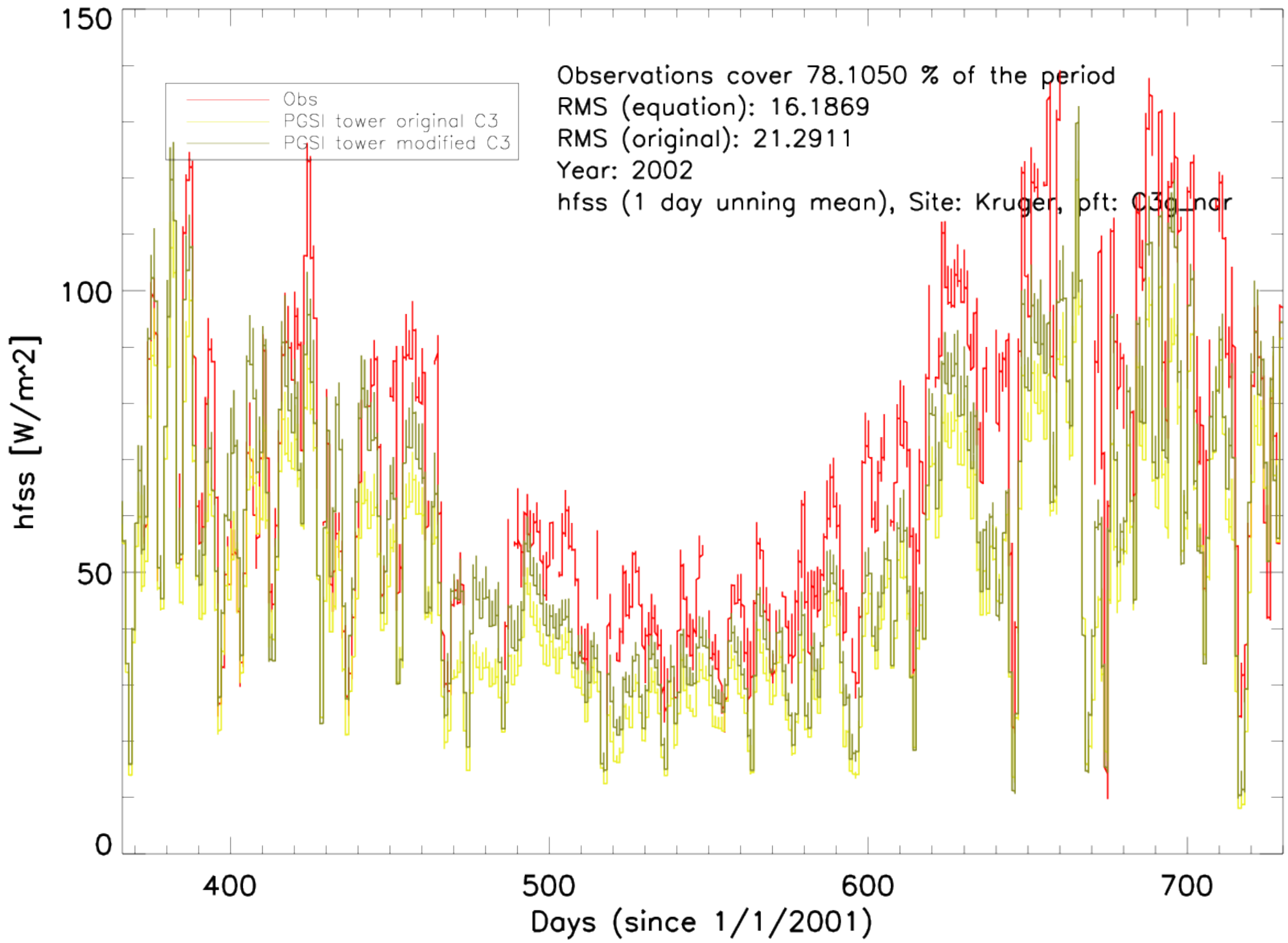

SI contributors (1 day running mean) using rainfall; Site: Kruger; PFT: C3g_nar
1.5
1.0
0.5
0.0
−0.5
Factor
400
500
600
700
Days (Since 01/01/2001)
Year: 2002
moist factor
temperature factor
light factor
GSI

Results



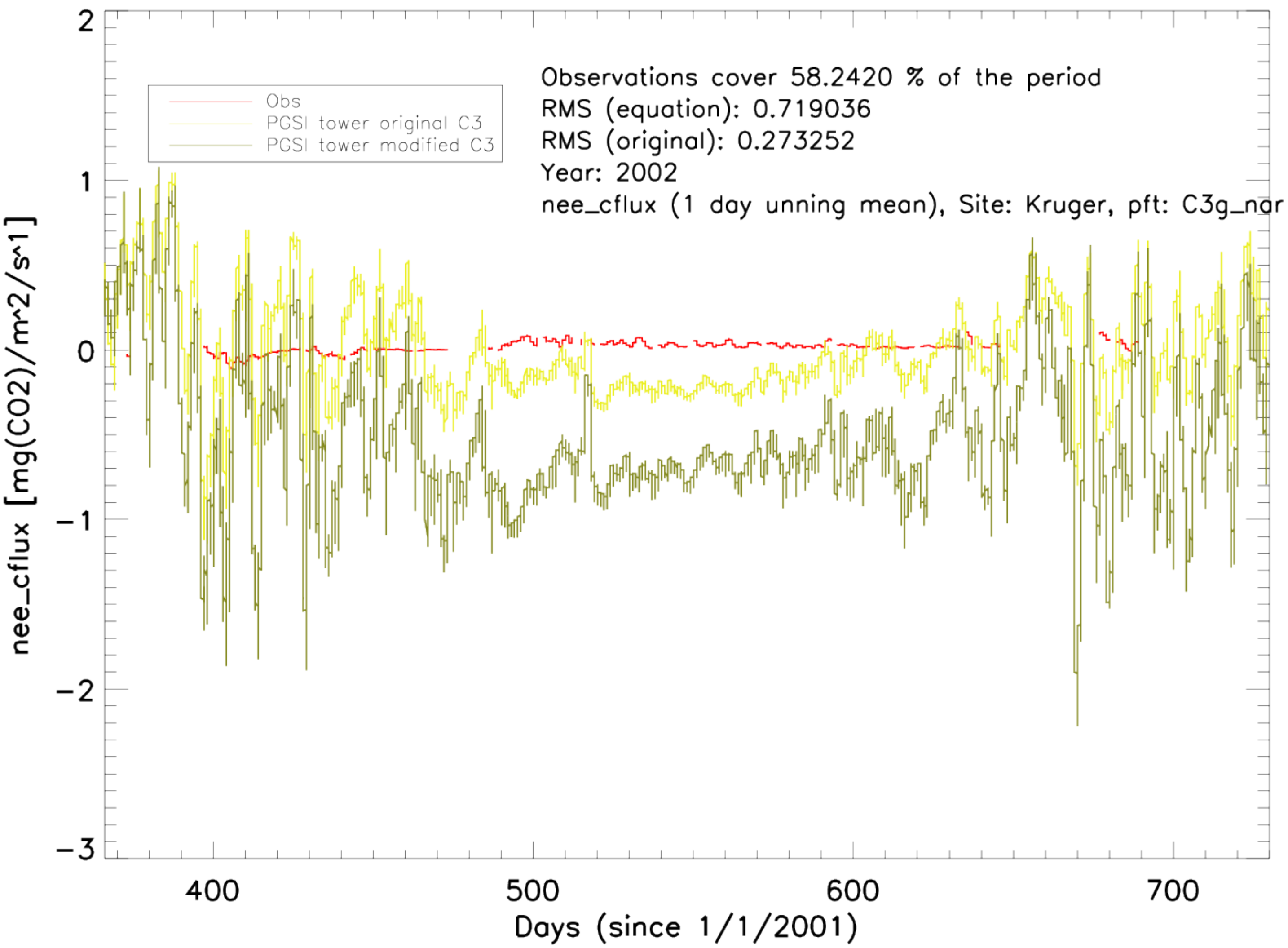
Obs
PGSI tower original C3
PGSI tower modified C3
Observations cover 33.7671 % of the period
RMS (equation): 16.2572
RMS (original): 5.86551
Year: 2002
hfsl (1 day unning mean), Site: Kruger, pft: C3g_nar
hfsl [W/m^2]
Days (since 1/1/2001)
0
20
40
60
80
100
120
400
500
600
700

Results



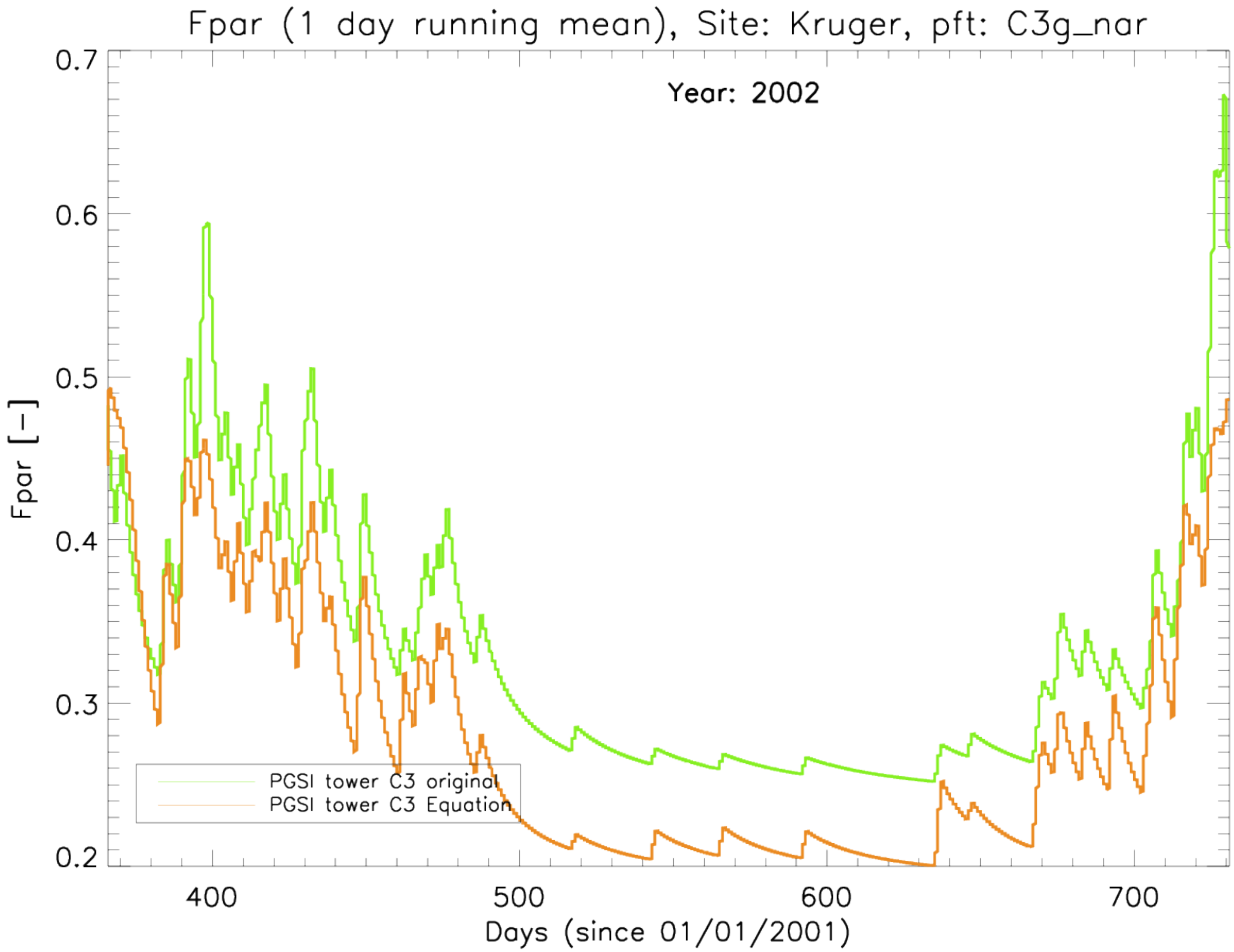
Obs
PGSI tower original C3
PGSI tower modified C3
Observations cover 78.1050 % of the period
RMS (equation): 16.1869
RMS (original): 21.2911
Year: 2002
hfss (1 day unning mean), Site: Kruger, pft: C3g_nar
150
100
50
0
400
500
600
700
hfss [W/m^2]
Days (since 1/1/2001)

Results

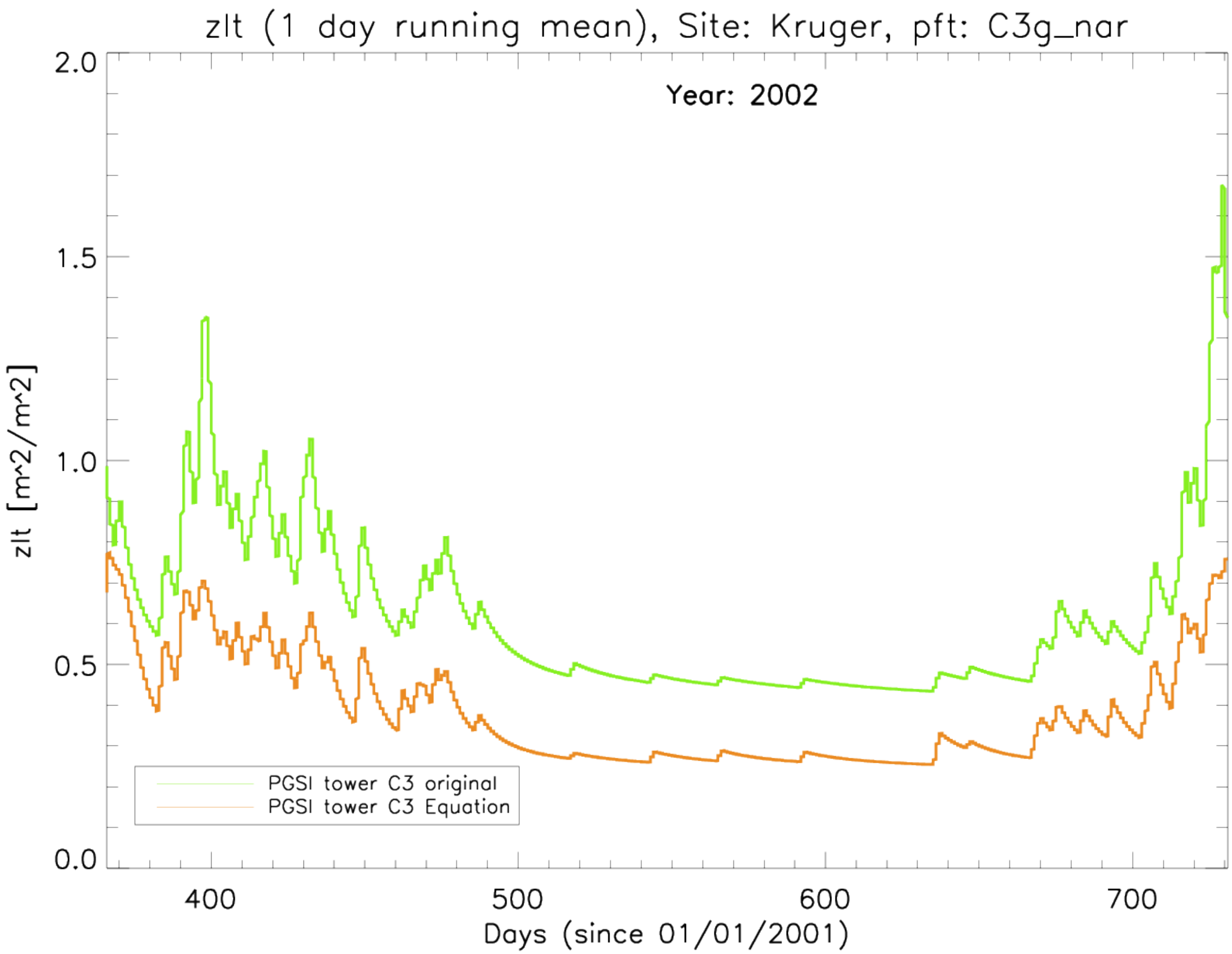


Obs
PGSI tower original C3
PGSI tower modified C3
Observations cover 58.2420 % of the period
RMS (equation): 0.719036
RMS (original): 0.273252
Year: 2002
nee_cflux (1 day unning mean), Site: Kruger, pft: C3g_nar
nee_cflux [mg(CO2)/m^2/s^1]
Days (since 1/1/2001)
2
1
0
−1
−2
−3
400
500
600
700

Results

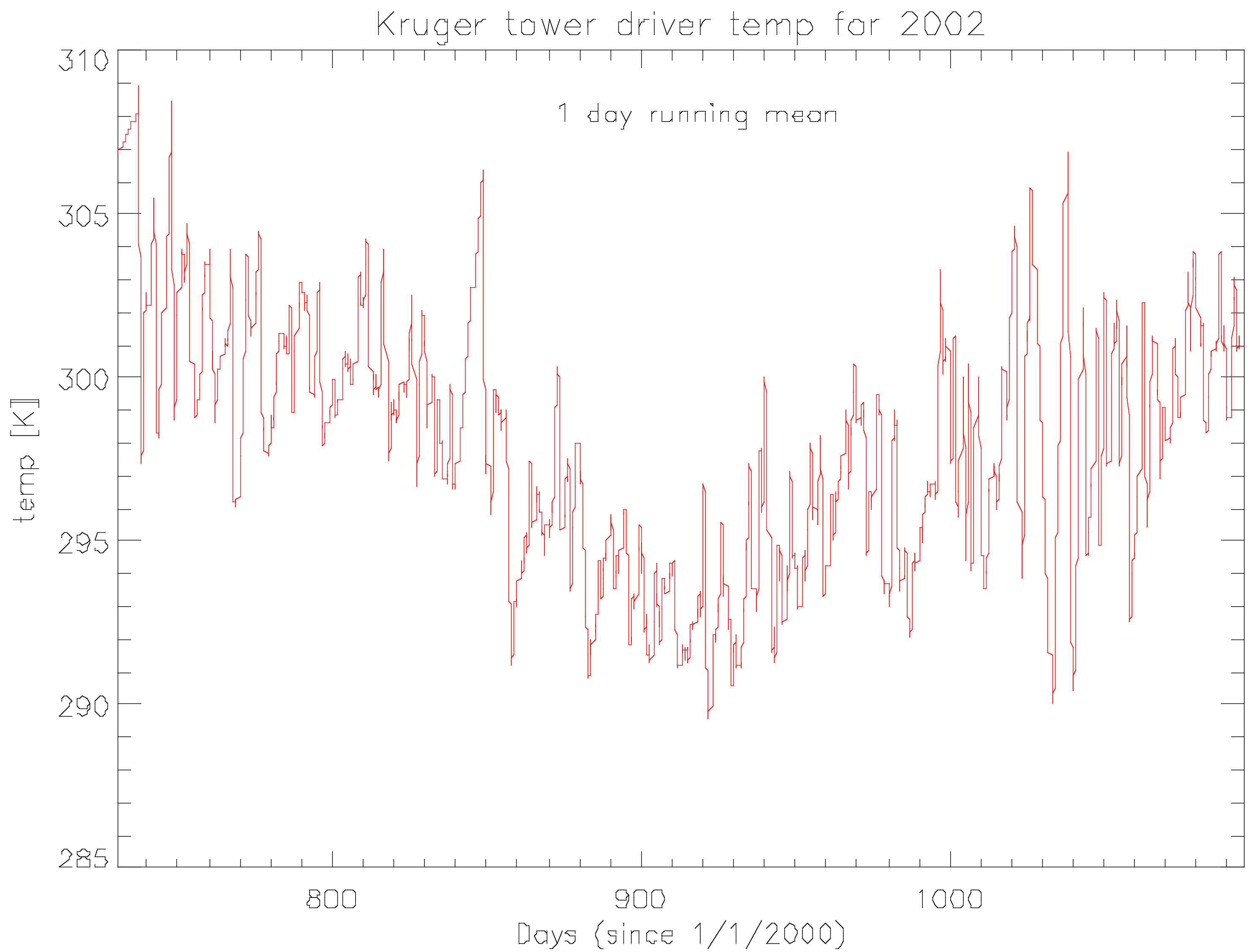

Fpar (1 day running mean), Site: Kruger, pft: C3g_nar
Year: 2002
PGSI tower C3 original
PGSI tower C3 Equation
Fpar [-]
0.7
0.6
0.5
0.4
0.3
0.2
400
500
600
700
Days (since 01/01/2001)

Results

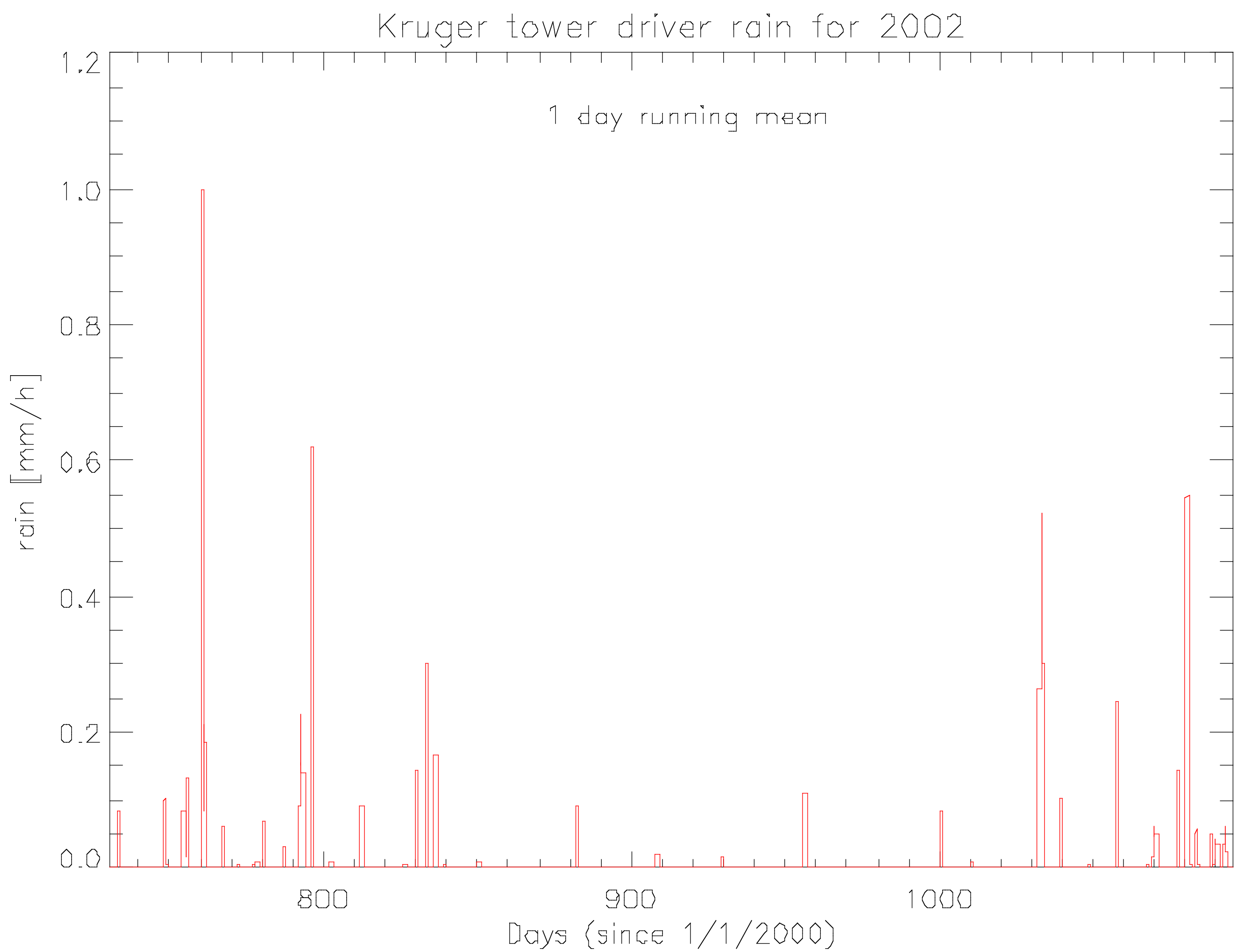


zlt (1 day running mean), Site: Kruger, pft: C3g_nar
Year: 2002
2.0
1.5
1.0
0.5
0.0
zlt [m^2/m^2]
400
500
600
700
Days (since 01/01/2001)
PGSI tower C3 original
PGSI tower C3 Equation

Drivers

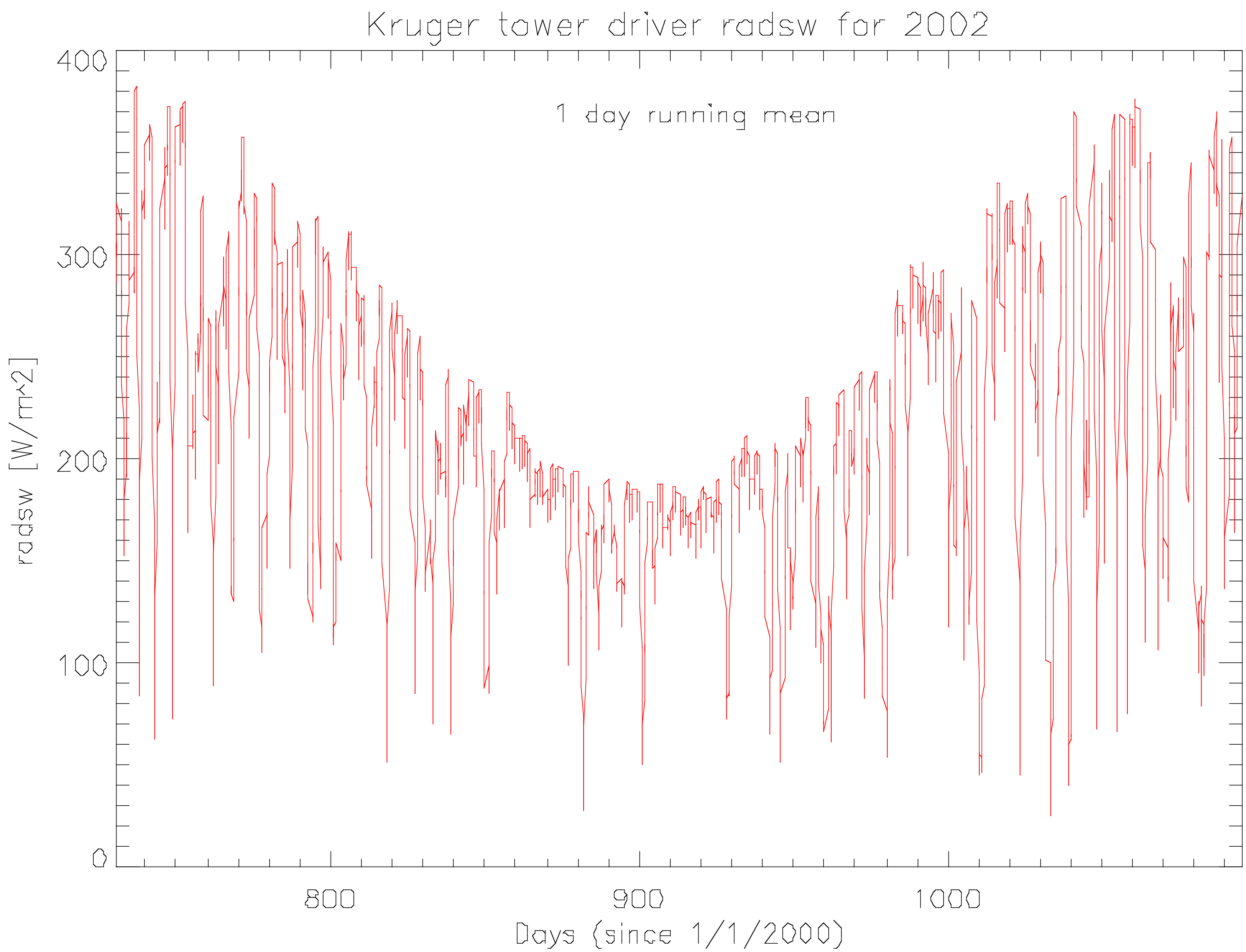

Kruger tower driver temp for 2002
1 day running mean
310
305
300
295
290
285
temp [K]
800
900
1000
Days (since 1/1/2000)

Drivers

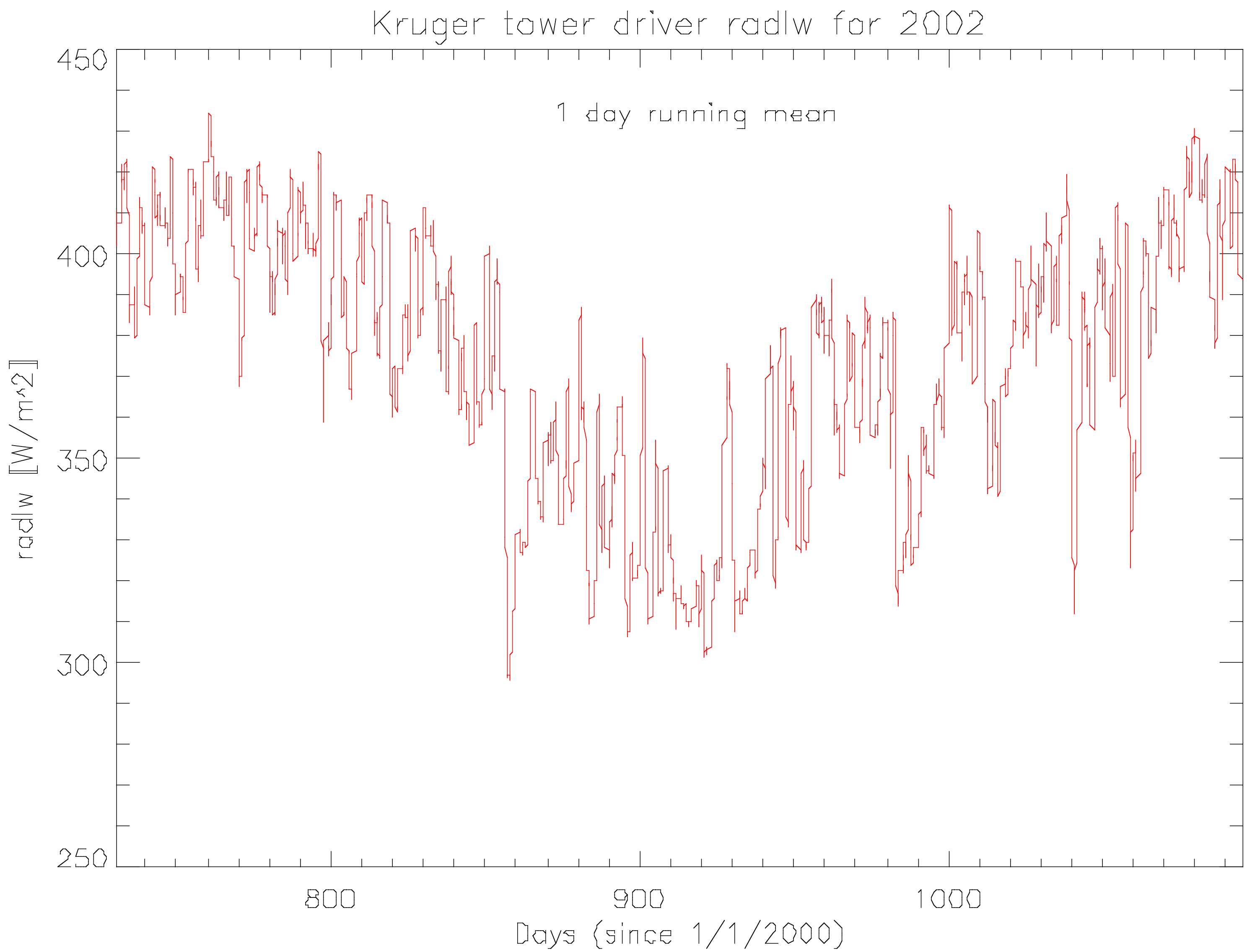


Kruger tower driver rain for 2002
1 day running mean
rain [mm/h]
0.0
0.2
0.4
0.6
0.8
1.0
1.2
800
900
1000
Days (since 1/1/2000)

Drivers


Kruger tower driver radsw for 2002
1 day running mean
radsw [W/m^2]
0
100
200
300
400
800
900
1000
Days (since 1/1/2000)

Drivers



Kruger tower driver radlw for 2002
1 day running mean
450
400
350
300
250
800
900
1000
Days (since 1/1/2000)
radlw [[W/m^2]]

GSI equation:

$$\text{GSI} = f(\overline{T_m}) \cdot f(\overline{R_g}) \cdot f(\overline{vpd})$$

Temperature factor: $$f(\overline{T_m}) = \frac{\overline{T_m} - T_{m_{min}}}{T_{m_{max}} - T_{m_{min}}}$$

Radiation factor: $$f(\overline{R_g}) = \frac{\overline{R_g} - R_{g_{min}}}{R_{g_{max}} - R_{g_{min}}}$$

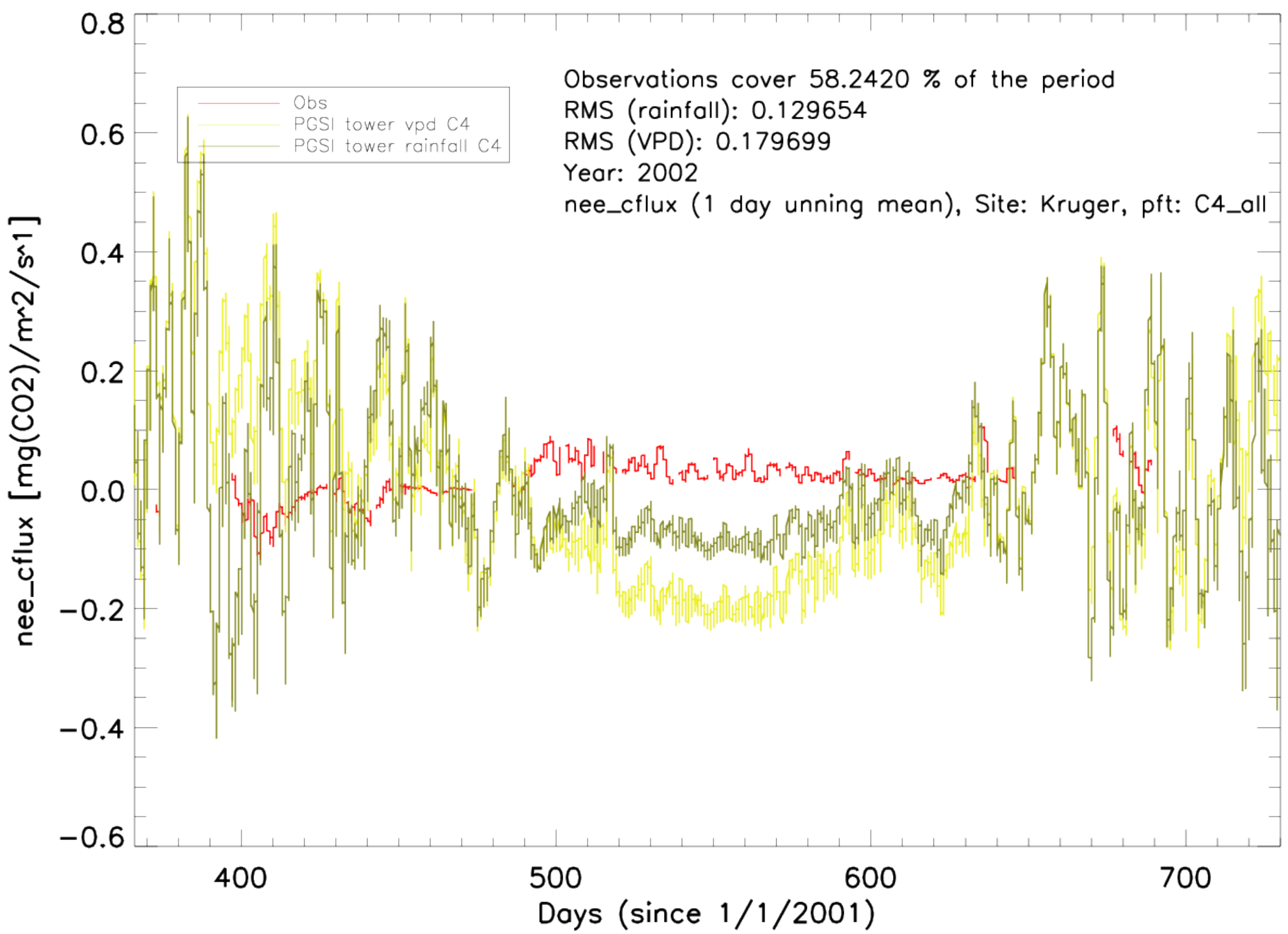
Moist factor: $$f(\overline{vpd}) = 1 - \frac{\overline{vpd} - vpd_{min}}{vpd_{max} - vpd_{min}}$$

***vpd*$_{max}$** and ***vpd*$_{min}$**: max and min empirical climate parameters ranges

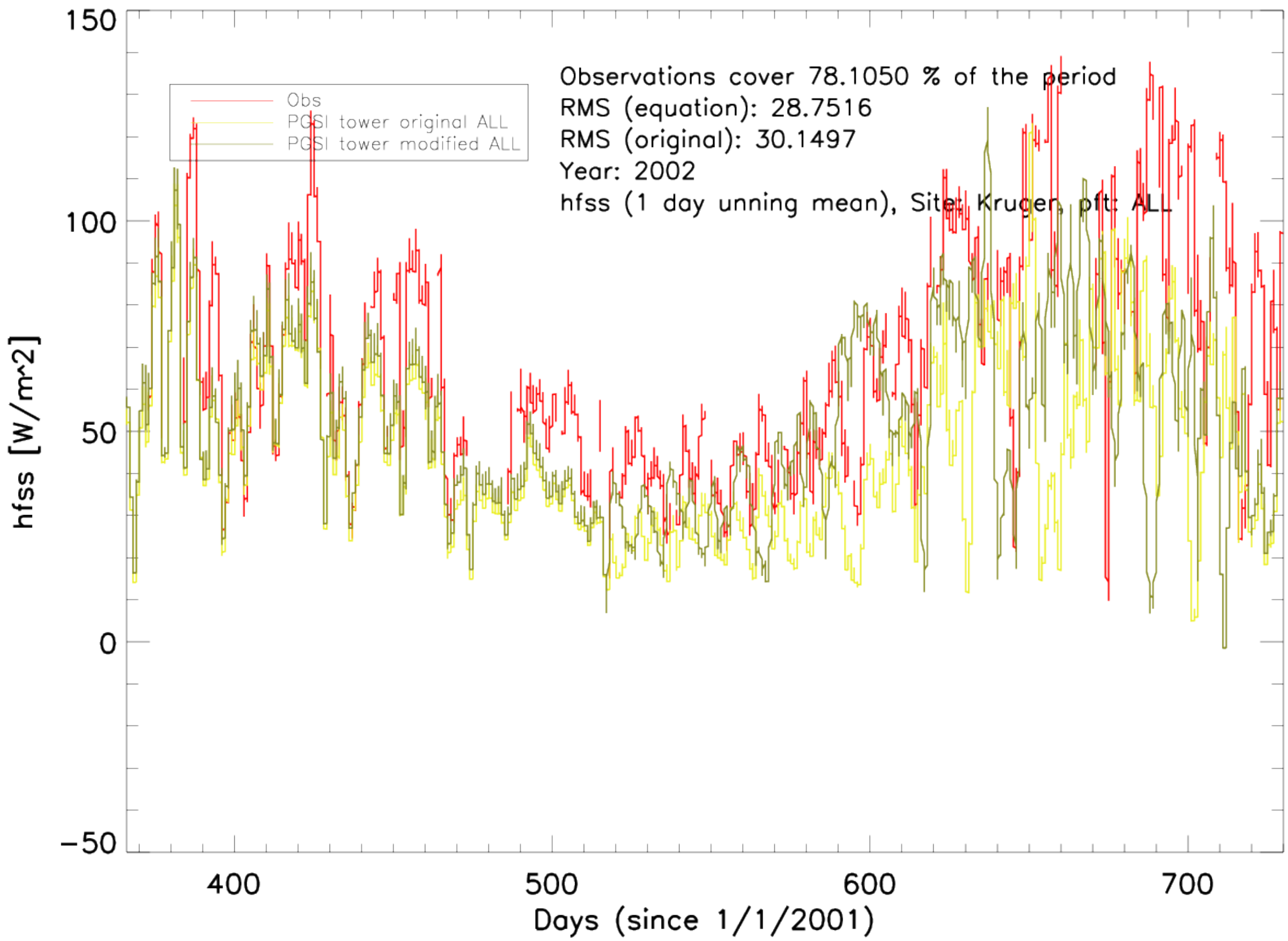
$\overline{\textbf{\textit{vpd}}}$: multi-day running mean average

$$\overline{vpd}^{t+1} = \xi(vpd)\overline{vpd}^{t} + (1 - \xi(vpd))\, vpd^{t+1} \; ; \qquad \xi(vpd) = e^{-1/t_{ave}(vpd)}$$

Results

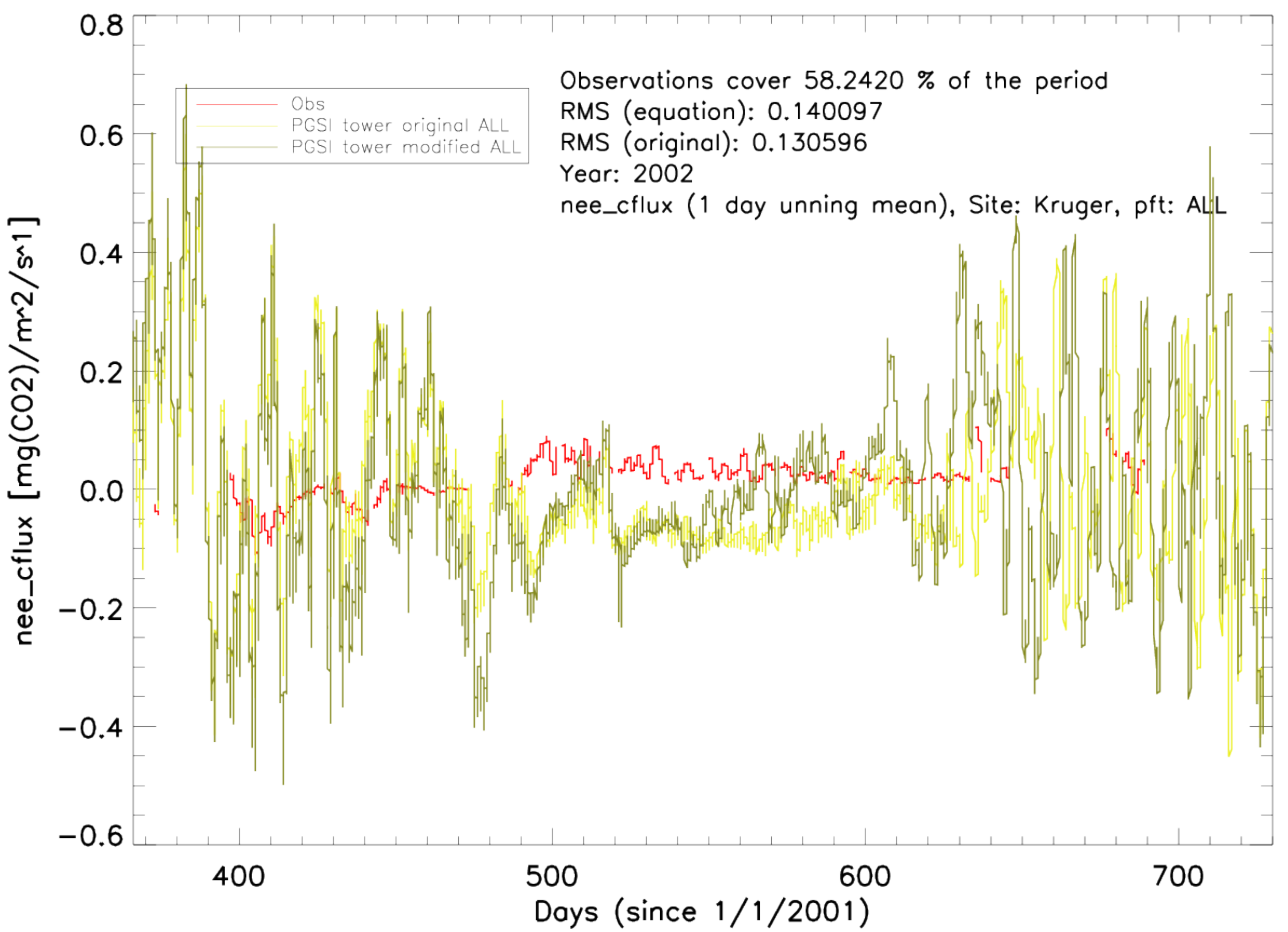

Observations cover 58.2420 % of the period
RMS (rainfall): 0.129654
RMS (VPD): 0.179699
Year: 2002
nee_cflux (1 day unning mean), Site: Kruger, pft: C4_all
Obs
PGSI tower vpd C4
PGSI tower rainfall C4
nee_cflux [mg(CO2)/m^2/s^1]
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
400
500
600
700
Days (since 1/1/2001)

Results



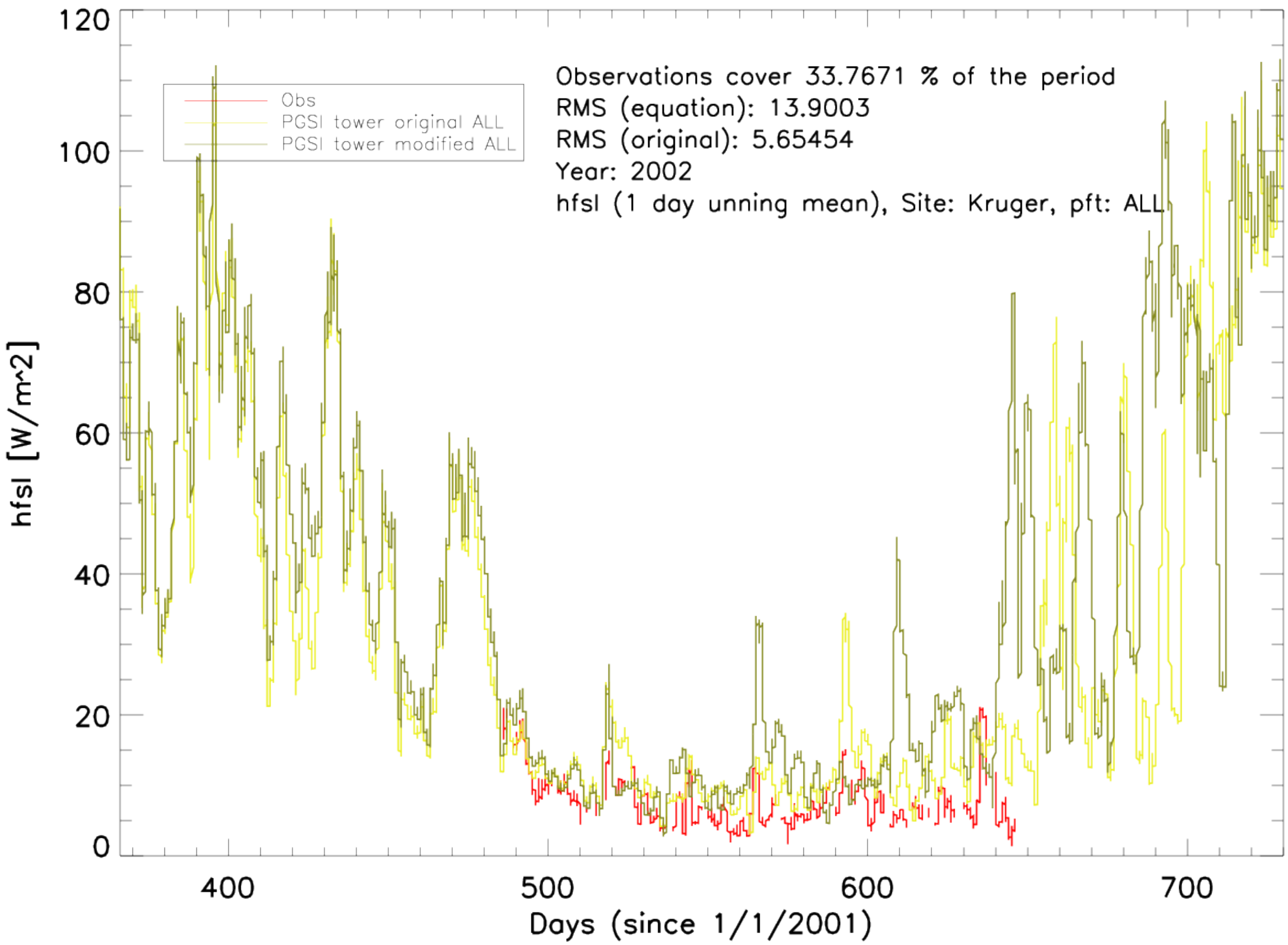
Obs
PGSI tower original ALL
PGSI tower modified ALL
Observations cover 78.1050 % of the period
RMS (equation): 28.7516
RMS (original): 30.1497
Year: 2002
hfss (1 day unning mean), Site: Kruger, pft: ALL
150
100
50
0
−50
hfss [W/m^2]
400
500
600
700
Days (since 1/1/2001)

Results



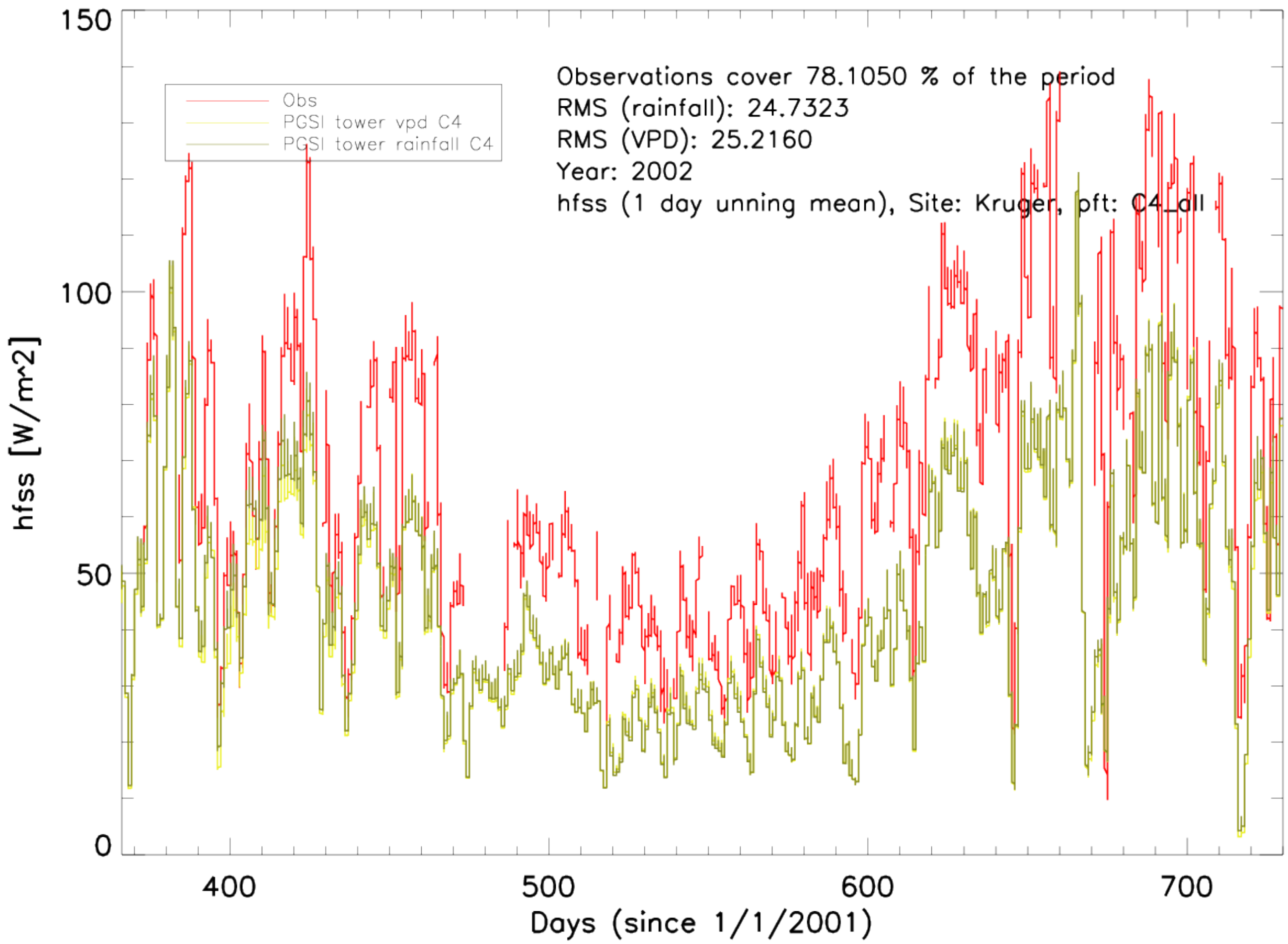
Obs
PGSI tower original ALL
PGSI tower modified ALL
Observations cover 58.2420 % of the period
RMS (equation): 0.140097
RMS (original): 0.130596
Year: 2002
nee_cflux (1 day unning mean), Site: Kruger, pft: ALL
nee_cflux [mg(CO2)/m^2/s^1]
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
400
500
600
700
Days (since 1/1/2001)

Results



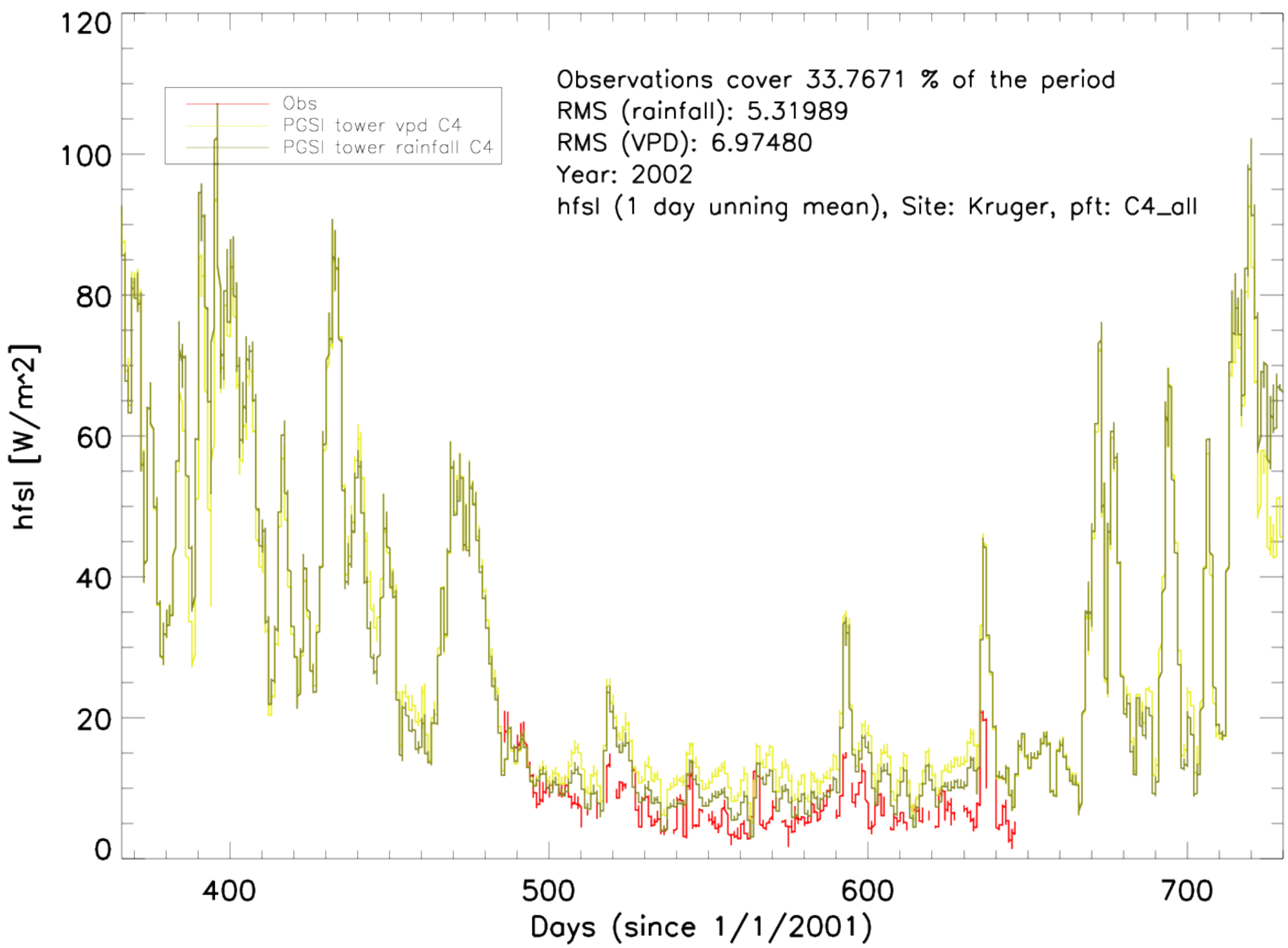
Obs
PGSI tower original ALL
PGSI tower modified ALL
Observations cover 33.7671 % of the period
RMS (equation): 13.9003
RMS (original): 5.65454
Year: 2002
hfsl (1 day unning mean), Site: Kruger, pft: ALL
hfsl [W/m^2]
Days (since 1/1/2001)
0
20
40
60
80
100
120
400
500
600
700

Results



Obs
PGSI tower vpd C4
PGSI tower rainfall C4
Observations cover 78.1050 % of the period
RMS (rainfall): 24.7323
RMS (VPD): 25.2160
Year: 2002
hfss (1 day unning mean), Site: Kruger, pft: C4_all
hfss [W/m^2]
Days (since 1/1/2001)
150
100
50
0
400
500
600
700

Results


120
100
80
60
40
20
0
hfsl [W/m^2]
400
500
600
700
Days (since 1/1/2001)
Obs
PGSI tower vpd C4
PGSI tower rainfall C4
Observations cover 33.7671 % of the period
RMS (rainfall): 5.31989
RMS (VPD): 6.97480
Year: 2002
hfsl (1 day unning mean), Site: Kruger, pft: C4_all