Flux Partitioning

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Background

Motivation

NEE is net flux of two gross fluxes. IThe third post-processing step is partitioning the net flux (NEE) into its gross components GPP and R_{eco}.

$$NEE = R_{eco} - GPP$$

Nighttime-Partitioning
estimate $R_{eco} \sim T$ relationship of nighttime NEE (where $GPP = 0$)
Daytime-Partitioning
fit a model of NEE to global radiation, VPD and temperature.

Sort records to Daytime and Nighttime

The partitioning needs to distinguish carefully between night-time and day-time records.

classified as nighttime, if

1. Threshold of $Rg < 10\,Wm^{-2}$
2. Daytime between compute times of sunrise and sunset

Nighttime flux partitioning

Temperature sensitivity: $\boldsymbol{E_0}$

Respiration is modelled by eq. of Lloyd & Tayler (1994)

$$R_{eco}(T; R_{Ref}, E_0) = R_{Ref} \exp\left[E_0\left(\frac{1}{T_{Ref} - T_0} - \frac{1}{T - T_0}\right)\right]$$

where $T_0 = -46.02°C$ and Reference temperature $T_{Ref} = 15°C$.

Temperature sensitivity, E_0, is fitted to successive 15-day periods on trimmed data.

Annually aggregated, E_0 is then the mean across valid estimates where 1) there were at least six records, 2) temperate ranged across at least 5°C, and 3) estimates were inside range of 30 to 450K.

Respiration at reference temperature: $\boldsymbol{R_{Ref}}$

Respiration at reference temperature, R_{Ref}, is re-estimated from nighttime data

- using the annual E_0 temperature sensitivity estimate
- for 7-day windows shifted consecutively for 4 days.

Then its assigned to the central time-point of the 4-day period and linearly interpolated between periods.

Hence, the obtained respiration-temperature relationship varies across time.

Gross fluxes: R_{eco} and GPP

$$R_{eco} = f(T; R_{Ref}(t), E_0)$$

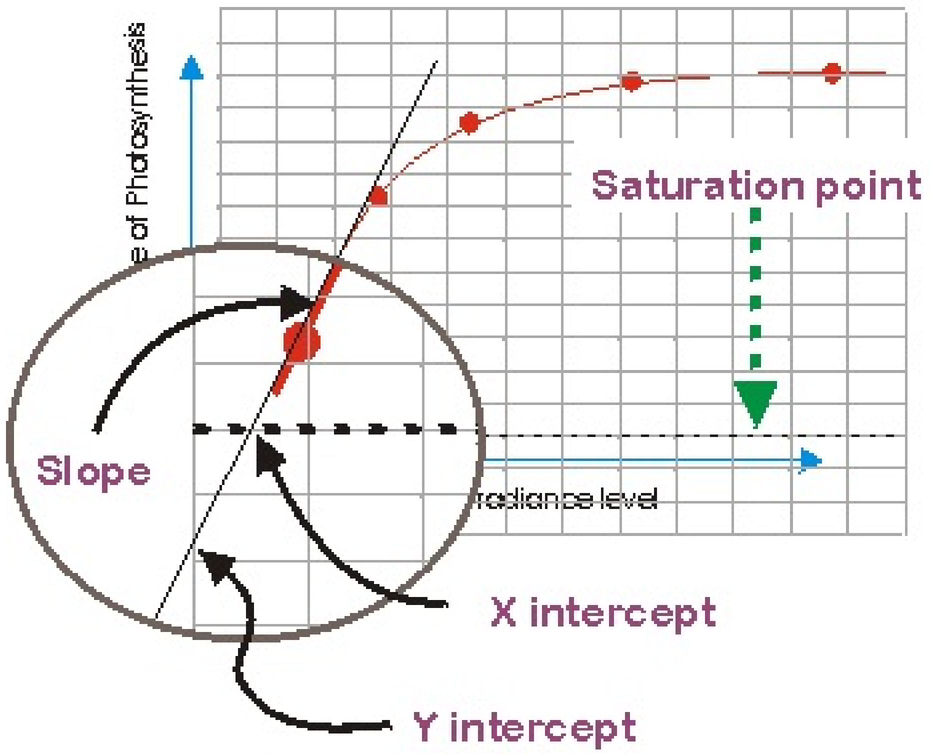
$$GPP = NEE - R_{eco}$$

Note that variation in NEE can lead to negative GPP:

If predicted $R_{eco} > NEE$ then predicted $GPP < 0$.

Daytime flux partitioning

Light response curve (LRC)



Fitting the Light responce curve (LRC)

The method of Lasslop (2010) models NEE:

$$NEE = -GPP(Rg, VPD; \alpha, \beta_0, k) + R_{eco}(T; R_{Ref}, E_0)$$

$$GPP = \frac{\alpha \beta R_g}{\alpha R_g + \beta}$$

$$\beta = \begin{cases} \beta_0 \exp\left[-k(\text{VPD} - \text{VPD}_0)\right] \text{if VPD} > 10 \text{ hPa} \\ \beta_0 \text{ otherwise} \end{cases}$$

α ($\mu mol\, CO_2 J^{-1}$) is the canopy light utilization efficiency and represents the initial slope of the light-response curve,

β ($\mu mol\, CO_2\, m^{-2} s^{-1}$) is the maximum CO2 uptake rate of the canopy at infinite Rg, which is a decreasing function at higher VPD values.

Temperature sensitivty

Temeprature sensitivity, E_0 is estimated from night-time data and provided to the day-time LRC fit to avoid parameter identifyability problems.

Different from the nigh-time partitioning a smoothed time varying estimate is used instead of the annual aggregate. And during E_0 estimation, reference temperature R_{Ref} is set to the median temperature of the time window.

LRC parameters and Reference temperature R_{Ref}

Are are fitted using only daytime data and the previously determined temperature sensitivity (E_0) for each shifting window across records.

Gross fluxes: R_{eco} and GPP

Are predcted by the LRC and Lloyd & Taylor respiration for each central record of the shifting window.

Results are linearly interpolated by the difference to the window centers.

Lasslop 2010
Daytime estimates of reference temperatures are also used for predicting nighttime R_{eco}

Keenan 2019
Nighttime estiamtes of reference temperatures (obtained with the E_0 fits) are used for predicting nighttime R_{eco}

Caution Partitioning is not always applicable

Partitioning only works if there is a good $R_{eco} \sim T$ relationship.

It is not applicable if either there is

- Suppressed respiration at freezing temperatures
- Limited variation of temperature
- Strong controls of other factors such as moisture

Flux Partitioning in REddyProc

Preparations

Specify geographical coordinates and time zone.

Fill mssing values in the used meteorological data.

```
EProc$sSetLocationInfo(LatDeg = 51.0, LongDeg = 13.6, TimeZoneHour = 1)
EProc$sMDSGapFill('Tair', FillAll = FALSE,  minNWarnRunLength = NA)
EProc$sMDSGapFill('VPD', FillAll = FALSE,  minNWarnRunLength = NA)
EProc$sMDSGapFill('Rg', FillAll = FALSE,  minNWarnRunLength = NA)
```

Nighttime partitioning

Repeated for each of the u_* threshold scenario (percentiles of u_{*Th} distribution)

```
EProc$sMRFluxPartitionUStarScens()
grep("GPP|Reco",names(EProc$sExportResults()), value = TRUE)
```

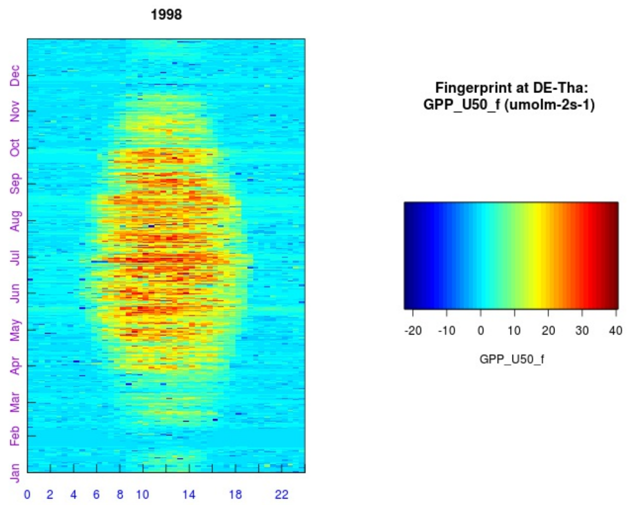
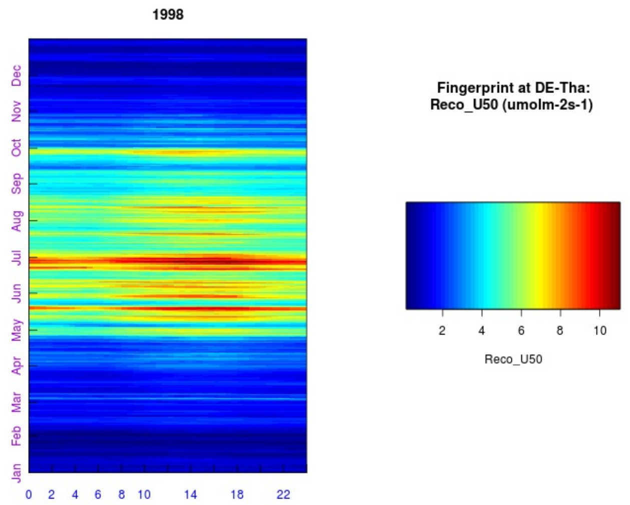
```
##  [1] "Reco_uStar"     "GPP_uStar_f"    "GPP_uStar_fqc" "Reco_U05"
##  [5] "GPP_U05_f"      "GPP_U05_fqc"    "Reco_U50"      "GPP_U50_f"
##  [9] "GPP_U50_fqc"    "Reco_U95"       "GPP_U95_f"     "GPP_U95_fqc"
```

It produces output columns `Reco_<uStar>` and `GPP_<uStar>_f` modified by the respective u_* threshold suffix in the REddyProc class.

`GPP_<uStar>_fqc > 1` denotes bad quality for windows where valid parameter estimates are further away.

Fingerprint plots of Nighttime R_{eco} and GPP

```
EProc$sPlotFingerprint('GPP_U50_f', Dir = "plots", Format = "png")
EProc$sPlotFingerprint('Reco_U50', Dir = "plots", Format = "png")
```

GPP	R_{eco}
	

Daytime partitioning

Repeated for each of the u_* threshold scenario (percentiles of u_{*Th} distribution)

```
invisible(EProc$sGLFluxPartitionUStarScens())
grep("GPP.*_DT|Reco.*_DT",names(EProc$sExportResults()), value = TRUE)
```

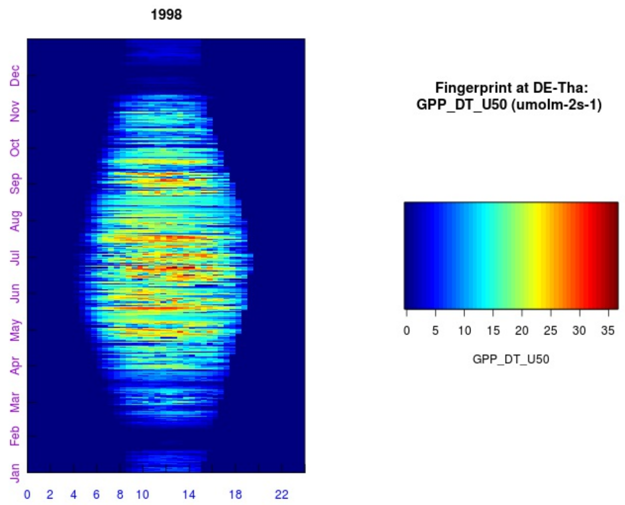
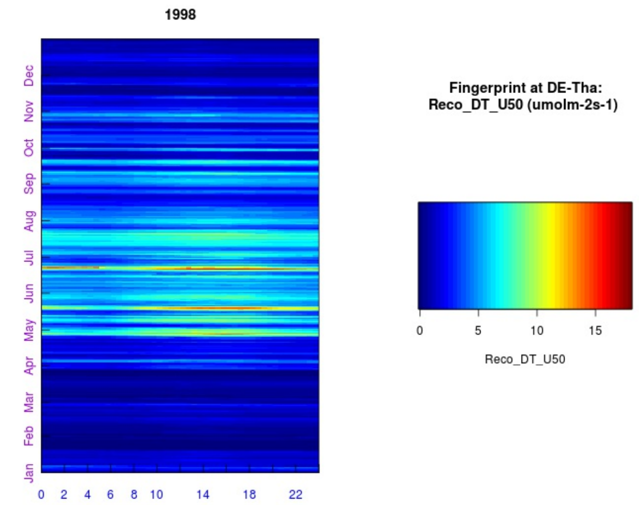
```
##  [1] "Reco_DT_uStar"     "GPP_DT_uStar"      "Reco_DT_uStar_SD"
##  [4] "GPP_DT_uStar_SD"   "Reco_DT_U05"       "GPP_DT_U05"
##  [7] "Reco_DT_U05_SD"    "GPP_DT_U05_SD"     "Reco_DT_U50"
## [10] "GPP_DT_U50"        "Reco_DT_U50_SD"    "GPP_DT_U50_SD"
## [13] "Reco_DT_U95"       "GPP_DT_U95"        "Reco_DT_U95_SD"
## [16] "GPP_DT_U95_SD"
```

It produces output columns `Reco_DT_<uStar>` and `GPP_DT_<uStar>` modified by the respective u_* threshold suffix in the REddyProc class.

`_SD` denotes the standard deviation of the prediction error.

Fingerprint plots of Daytime R_{eco} and GPP

```
EProc$sPlotFingerprint('GPP_DT_U50', Dir = "plots", Format = "png")
EProc$sPlotFingerprint('Reco_DT_U50', Dir = "plots", Format = "png")
```

GPP	R_{eco}
	

Save the results

So far the results are stored internally in the REddyProc class. Get them as a data.frame:

```
results = EProc$sExportResults()
# bind to original original data
appResults = cbind(EddyData, results)
# save to tab-separated file
fWriteDataframeToFile(appResults, "DETha98_proc.txt")
```

```
## Number of NA convertered to '-9999': 615607
```

```
## Wrote tab separated textfile: DETha98_proc.txt
```