Supplement of Geosci. Model Dev., 10, 3379–3390, 2017
https://doi.org/10.5194/gmd-10-3379-2017-supplement
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Geoscientific
Model Development
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Supplement of

FluxnetLSM R package (v1.0): a community tool for processing FLUXNET data for use in land surface modelling

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Supplementary Material

This supplementary material includes Supplementary Tables 1 and 2. A description of synthesis methods for air pressure and incoming longwave radiation is detailed in section S.1. An example script for processing a single site is provided in section S.2.

S.1 Synthesis methods for air pressure and incoming longwave radiation

S.1.1 Air pressure

Air pressure (P_{surf}; Pa) is synthesised from air temperature (T_{air}; K) and elevation (h; m) using the barometric formula:

$$P_{surf} = P_0 * \left(\frac{T_{air}}{T_{air} + l_0 * h} \right)^{g_0/R/l_0} \tag{1}$$

where P_0 is the static pressure at sea level (101325 Pa), l_0 is the standard temperature lapse rate (0.0065 K m^{-1}), g_0 the gravitational acceleration constant (9.80665 m s^{-2}) and R is the specific gas constant (287.04 J kg^{-1} K^{-1}).

S.1.2 Incoming longwave radiation

Incoming longwave radiation (LW_{down}; W m^{-2}) can be synthesised using three alternative methods. This option is controlled by the argument `lwdown_method`, which can be set to one of "Swinbank_1963", "Brutsaert_1975" and "Abramowitz_2012" (default). A full description and a comparison of the methods at FLUXNET sites is available in Abramowitz et al. (2012).

"Swinbank_1963" calculates LW_{down} based on an empirical function of air temperature (T_{air}; K) following Swinbank (1963):

$$LW_{down} = c_1 * T_{air}^6 \tag{2}$$

where c_1 is a constant (5.32 x 10^{-23}).

"Brutsaert_1975" calculates LW_{down} from an empirically derived function of T_{air} and relative humidity (R_h; %) following Brutsaert (1975):

$$LWdown = \varepsilon_{atm} * \sigma * T_{air}^4 \tag{3}$$

where σ is the Stefan-Boltzmann constant (5.67 x 10^{-8} kg s^{-3} K^{-4}). Emissivity for clear sky (ε_{atm}; dimensionless) is calculated from vapour pressure (E_{surf}; Pa) as:

$$\varepsilon_{atm} = b_1 (e_{surf} / T_{air})^{b_2} \tag{4}$$

where b_1 and b_2 are constants (0.642 and 1/7, respectively). E_{surf} is calculated from saturated vapour pressure (e_{sat}; Pa) and R_h as:

$$e_{surf} = \max(5, R_h) / 100 * e_{sat} \tag{5}$$

where

$$e_{sat} = 611.2 * \exp(17.67 * ((T_{air} - 273.15) / (T_{air} - 29.65))) \tag{6}$$

"Abramowitz_2012" (the default option) calculates LW_{down} from R_h and T_{air} using a statistically derived empirical function constructed from FLUXNET data, following Abramowitz et al. (2012):

$$LW_{down} = 2.648 * T_{air} + 0.0346 * e_{surf} - 474 \tag{7}$$

References:

Abramowitz, G., Pouyanné, L. and Ajami, H.: On the information content of surface meteorology for downward atmospheric long-wave radiation synthesis, Geophys. Res. Lett., 39, 1–5, doi:10.1029/2011GL050726, 2012.

Brutsaert, W.: On a derivable formula for long-wave radiation from clear skies, Water Resour. Res., 11, 742–744, doi:10.1029/WR011i005p00742, 1975.

Swinbank, W. C.: Long-wave radiation from clear skies, Q. J. R. Meteorol. Soc., 89, 339–348, doi:10.1002/qj.49708938105, 1963.

S.2 Example usage of FluxnetLSM

```
#' Example data conversion for the Howard Springs site using
#' FLUXNET2015.
#'
#' See LaThuile/example_conversion_single_site.R for the
#' corresponding La Thuile example.
#'
#' Converts useful variables from a FLUXNET2015 "FULLSET" spreatsheet
#' format into two netcdf files, one for fluxes, and one for met
#' forcings. For "SUBSET" data, set flx2015_version="SUBSET" in the
#' main function.
#'
#' The user must provide the input directory path, output directory
#' path and site code. All other settings are optional. This example
#' uses ERAinterim gapfilling for meteorological variables, all other
#' options are set to their default values.
#'

library(FluxnetLSM)

#clear R environment
rm(list=ls(all=TRUE))


#############################
###--- Required inputs ---###
#############################

#--- User must define these ---#

#Fluxnet site ID (see http://fluxnet.fluxdata.org/sites/site-list-
and-pages/)
site_code <- "AU-How"

# This directory should contain appropriate data from
# http://fluxnet.fluxdata.org/data/fluxnet2015-dataset/
in_path <- "./Inputs"

#Outputs will be saved to this directory
out_path <- "./Outputs"
```

```
#--- Automatically retrieve all Fluxnet files in input directory ---#

# Input Fluxnet data file (using FULLSET in this example, see
R/Helpers.R for details)
infile <- get_fluxnet_files(in_path, site_code)

#Retrieve dataset version
datasetversion <- get_fluxnet_version_no(infile)

#Retrieve ERAinterim file
era_file <- get_fluxnet_erai_files(in_path, site_code)


###############################
###--- Optional settings ---###
###############################

#Retrieve default processing options
conv_opts <- get_default_conversion_options()

#Set gapfilling options to ERAinterim
conv_opts$met_gapfill  <- "ERAinterim"


##########################
###--- Run analysis ---###
##########################

convert_fluxnet_to_netcdf(site_code = site_code, infile = infile,
                          era_file=era_file, out_path = out_path,
                          conv_opts = conv_opts)


#Alternatively you can pass the gapfilling option directly to the
main function:
# convert_fluxnet_to_netcdf(site_code = site_code, infile = infile,
#                            era_file = era_file, out_path = out_path,
#                            met_gapfill="ERAinterim")
```

Supplementary Table 1: Default meteorological output variables (shown here for FLUXNET2015 FULLSET). ALMA convention output names are indicated with an asterisk.

Variable	**FLUXNET variable**	**FLUXNET unit**	**Output variable**	**Output unit**	**ERA-Interim variable**	**QC flag**	**Essen-tial**	**Min.**	**Max.**
Near surface air temperature	TA_F_MDS	C	Tair*	K	TA_ERA	Yes	Yes	200	300
Surface incident shortwave radiation	SW_IN_F_MDS	W m^{-2}	SWdown*	W m^{-2}	SW_IN_ERA	Yes	Yes	0	1360
Surface incident longwave radiation	LW_IN_F_MDS	W m^{-2}	LWdown*	W m^{-2}	LW_IN_ERA	Yes	No	0	750
Vapour pressure deficit	VPD_F_MDS	hPa	VPD	hPa	VPD_ERA	Yes	Yes	0	100
Surface air pressure	PA	kPa	Psurf*	Pa	PA_ERA	If gap-filled	No	50000	110000
Precipitation rate	P	mm	Precip*	mm s^{-1}	P_ERA	If gap-filled	Yes	0	0.05
Scalar wind speed	WS	m s^{-1}	Wind*	m s^{-1}	WS_ERA	If gap-filled	Yes	0	75
Near surface relative humidity	RH	%	RH*	%	VPD_ERA	If gap-filled	No	0	100
Near surface specific humidity	RH	%	Qair*	kg/kg	VPD_ERA	If gap-filled	No	0	0.1

Supplementary Table 2: Default evaluation output variables (shown here for FLUXNET2015 FULLSET). ALMA convention output names are indicated with an asterisk.

Variable	FLUXNET variable	FLUXNET unit	Output variable	Output unit	QC flag	Min	Max.
Reflected shortwave radiation	SW_OUT	W m^{-2}	SWup*	W m^{-2}	Yes	-100	1360
Net absorbed radiation	NETRAD	W m^{-2}	Rnet	W m^{-2}	Yes	-1000	1360
Near surface CO_2 concentration	CO2_F_MDS	µmol CO_2 mol^{-1}	CO2air*	ppm	Yes	200	600
Ground heat flux	G_F_MDS	W m^{-2}	Qg*	W m^{-2}	Yes	-1000	1000
Latent heat flux from surface	LE_F_MDS	W m^{-2}	Qle*	W m^{-2}	Yes	-1000	1000
Latent heat flux from surface, corrected for energy balance closure	LE_CORR	W m^{-2}	Qle_cor	W m^{-2}	No	-1000	1200
LE_CORR joint uncertainty	LE_CORR_JOINTUNC	W m^{-2}	Qle_cor_uc	W m^{-2}	No	-1000	1300
Sensible heat flux from surface	H_F_MDS	W m^{-2}	Qh*	W m^{-2}	Yes	-1000	1000
Sensible heat flux from surface, corrected for energy balance closure	H_CORR	W m^{-2}	Qh_cor	W m^{-2}	No	-1000	1000
H_CORR joint uncertainty	H_CORR_JOINTUNC	W m^{-2}	Qh_cor_uc	W m^{-2}	No	-1000	1000
Net ecosystem exchange of CO_2 (variable ustar)	NEE_VUT_REF	µmol m^{-2} s^{-1}	NEE*	µmol m^{-2} s^{-1}	No	-100	100

Supplementary Table 2 continued.

NEE_VUT_REF uncertainty (variable ustar)	NEE_VUT_REF_JOINTUNC	µmol m^{-2} s^{-1}	NEE_uc	µmol m^{-2} s^{-1}	No	-200	200
Gross primary productivity of CO_2 (variable ustar, daytime partitioning)	GPP_DT_VUT_REF	µmol m^{-2} s^{-1}	GPP_DT	µmol m^{-2} s^{-1}	No	-200	200
GPP_DT_VUT_REF standard error	GPP_DT_VUT_SE	µmol m^{-2} s^{-1}	GPP_DT_se	µmol m^{-2} s^{-1}	No	-200	200
Gross primary productivity of CO_2 (variable ustar, nighttime partitioning)	GPP_NT_VUT_REF	µmol m^{-2} s^{-1}	GPP*	µmol m^{-2} s^{-1}	No	-200	200
GPP_NT_VUT_REF standard error	GPP_NT_VUT_SE	µmol m^{-2} s^{-1}	GPP_se	µmol m^{-2} s^{-1}	No	-200	200