Flux Ratio – Active Index Surface Exchange (FRAISE) scheme

User Manual – Version 1.1

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1. Introduction

This manual describes how to set up and run the FRAISE (Flux Ratio - Active Index Surface Exchange) scheme. FRAISE provides an estimate of mean midday (±3 h around solar noon) energy partitioning from information on the surface characteristics and estimates of the mean midday incoming radiative energy and anthropogenic heat release. Please refer to Loridan and Grimmond (2011) for further details.

The main reference for this will hopefully become:
Loridan, T., and C. S. B. Grimmond, 2011: Characterization of energy flux partitioning in urban environments: links with surface seasonal properties. *Journal of Applied Meteorology and Climatology.* (accepted)

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2. Download

Download FRAISE.zip from http://geography.kcl.ac.uk/micromet/ and unzip the directory. The scripts provided are written in R which is freely available at http://www.r-project.org/. Once you have unzipped the file the following subdirectories and scripts should appear:

```
FRAISE/
        README.txt
        main.R
        data/Qdown_LODZ_172.txt
        data/QF_LUCY_LODZ_172
        util/FRAISE_Calculations.R
        util/Functions.R
        outputs/SAMPLE_FRAISE_OUTPUT.txt
```

3. Set up and run

Open the script main.R (via R or any text editor) and edit the "User input section". The supplied (current default) set up is for the site of Łódź, Poland on the 21st of June (DOY 172). First you need to specify the path to the FRAISE directory on your computer (FRAISE_PATH). This is the path to where the main.R script is. Table 1 describes all other needed inputs.

Table 1: Definition of input parameters required for FRAISE

Input	Units	Description	Łódź values
General parameters			
SITE_CODE	-	Code used to name output files	"LODZ"
DOY	-	Day of year for the calculations	172
LATITUDE	deg	Latitude of the study area (positive North)	51.75
LONGITUDE	deg	Longitude of the study area (positive East)	19.46
timezone	hour	Standard time zone (i.e. difference with UTC/GMT, including daylight saving time)	+2
Urban parameters			
URBAN_FRAC	-	Plan area fraction urban	0.7
ROOF_HEIGHT	m	Mean roof height of study area	10.6
ROOF_WIDTH	m	Mean roof width of study area	10.5
ROAD_WIDTH	m	Mean road width of study area	14.1
Vegetation parameters			
GRASS_FRAC	-	Fraction of the vegetation that is grass	0.3
Spring_Start	-	Start (DOY) of leaf-on season	69
Spring_Stop	-	Stop (DOY) of leaf-on season	144
Fall_Start	-	Start (DOY) of leaf-on season	281
Fall_Stop	-	Stop (DOY) of leaf-on season	324
LAI_GRASS	-	Leaf area index to be assumed for grass	1.6
LAI_MIN	-	Minimum LAI of trees/shrub	1.0
LAI_MAX	-	Maximum LAI of trees/shrub	6.0
Input energy fluxes			
QDOWN_MEAN	W m^{-2}	Mean midday estimate of incoming radiative energy	1158
QF_MEAN	W m^{-2}	Mean midday estimate of anthropogenic heat	10.6

In the case of Łódź QDOWN_MEAN is computed from observed incoming solar and longwave radiation (data/Qdown_LODZ_172.txt). If you do not have access to observed fluxes for your study area we suggest you consider using meteorological data from the US National Climatic Data Center (NCDC, http://www.ncdc.noaa.gov/oa/ncdc.html) to model the radiative components (see for instance models by

Offerle et al., 2003 and Loridan et al., 2011[1] for incoming longwave or Liston and Elder, 2006). Alternatively simply provide a reasonable order of magnitude for the site location / day of year but be aware of the implications on the magnitude of predicted fluxes (section 4). For QF_MEAN, we recommend using estimates from the LUCY model (Allen et al., 2010; software available from micromet@kcl)[2] when no other local information is available for the study area. If only interested in the flux ratio and active index values simply set QF_MEAN and QDOWN_MEAN to 0.

To run FRAISE simply source[3] the main.R script in R.

4. Outputs

If FRAISE successfully ran a file called SITE_CODE_DOY_FRAISE_OUTPUT.txt should be created in the output directory. Note that if you try to rerun main.R with the same SITE_CODE/DOY and without deleting or renaming that file you will get the following message:

> "File: C:/Rscripts/FRAISE/outputs/LODZ_172_FRAISE_OUTPUT.txt already exists (delete first if you want to overwrite)"

A sample output file (SAMPLE_FRAISE_OUTPUT.txt) can also be found in the output directory showing what to expect from a successful run. Table 2 lists all FRAISE outputs. Note QH_BOW is probably a better estimate of the daytime turbulent sensible heat flux than QH_RES but it does not ensure closure of the predicted mean daytime surface energy balance. QH_RES does by definition

Table 2: Definition of FRAISE outputs. References relate to Loridan and Grimmond (2011).

Output	Units	Definition	Reference
UZE	-	Urban Zones to characterise Energy partitioning (2=LD; 3=MD; 4=HD)	Fig. 11
CHI_TOT	-	Total active surface index	Eq. 24
CHI_URB	-	Active urban index	Eq. 24
CHI_VEG	-	Active vegetation index	Eq. 24
QUP_RAT	-	Daytime ratio of outgoing radiant energy to that of QDOWN (no QF)	Eq. 25
QS_RAT	-	Daytime ratio of net storage heat to that of QDOWN (no QF)	Eq. 26
QE_RAT	-	Daytime ratio of turbulent latent heat to that of QDOWN (no QF)	Eq. 27
BOWEN	-	Daytime ratio of turbulent sensible heat to that of latent heat (no QF)	Eq. 29
QDOWN	W m^{-2}	Incoming radiant energy (user input)	-
QF	W m^{-2}	Anthropogenic heat (user input)	-
QUP	W m^{-2}	Predicted daytime outgoing radiant flux (with QF)	-
QS	W m^{-2}	Predicted daytime net storage heat flux (with QF)	-
QH_RES	W m^{-2}	Predicted daytime sensible heat flux from residual method (with QF)	Eq. 28
QH_BOW	W m^{-2}	Predicted daytime sensible heat flux from Bowen ratio method (with QF)	-
QE	W m^{-2}	Predicted daytime latent heat flux (with QF)	-
QSTAR	W m^{-2}	Predicted daytime net all-wave radiative flux (with QF)	-

[1] The LUMPS model provides the ability to model Net all wave radiation and can be downloaded from the same location as FRAISE

[2] LUCY model provides the ability to model anthropogenic heat flux. At the simplest, no input data are required beyond the site location and time period of interest. This may be downloaded from the same site as FRAISE

[3] Using R – select File and then Source

5. References

Allen, L., F. Lindberg, and C. S. B. Grimmond, 2010: Global to City Scale Urban Anthropogenic Heat Flux: Model and Variability. *International Journal of Climatology.* DOI: 10.1002/joc.2210

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Offerle, B., C. S. B. Grimmond, and T. R. Oke, 2003: Parameterization of net all-wave radiation for urban areas. *Journal of Applied Meteorology* **42**: 1157–1173.