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Short introduction to EddyUH

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Contents

This is a brief starting guide of EddyUH, the eddy covariance data post-processing software developed at University of Helsinki. All the necessary information needed for using the software are presented. A substantial amount of instruments (sonic anemometers and gas analyzers) are supported, and standardized procedures are fully implemented in EddyUH. In order to advance methodical issues concerning especially CH_4 and N_2O flux, most updated corrections and methods for EC flux estimates for these gases have been also included. The main features of EddyUH are summarized in Table 2.The software is written in Matlab, and distributed as a stand-alone version with graphical user interface (GUI). The user can run EddyUH stand alone version, even if Matlab software is not installed in his computer.

The software can be downloaded from `http://www.atm.helsinki.fi/Eddy_Covariance/` after registration to the webpage. Once the user has registered, he will get an email with username and password. Then he can login and download the EddyUH version suitable for his OS (Win, Linux32, Linux64). If the user has a Macintosh computer, just notify us by email and we can provide a Macintosh version of the software.

Unzip the downloaded software package, and start to install EddyUH, following the instructions given in the file named Install_EddyUH_yourOS.txt.

1 Overview of EddyUH

Data processing is divided into two sections in order to reduce computation time and to make flux calculation more modular and easier process. In the first step raw estimates for covariances and thus fluxes are obtained from running EddyUH_Preprocessor, among other things. It performs flux calculation with minimum corrections and processing methods in order to make the calculation as fast as possible. Software is written in MATLAB and it uses MATLAB's own file format *.mat* to save variables during calculation. This is done simply because saving and loading variables using *.mat*-files is more convenient than using ASCII- or generic binary-files. However final flux files are saved in ASCII-format.

After running the preprocessor the user can use subprograms:
EddyUH_TransferFunctionCalculation
EddyUH_TimeLagOptimizer
EddyUH_SpectralAnalysis
EddyUH_PlanarFitting
prior to calculating the final fluxes with EddyUH_FluxCalculation. The final output will be saved in monthly ASCII-files. All the output files from EddyUH are saved

in one folder which is called project-folder.
High frequency spectral corrections can be applied using theoretical or experimental approach. If the experimental correction method (Aubinet et al., 2000) is used, EddyUH_TransferFunction Calculation can be used in determining corresponding response times. In addition wind direction and relative humidity dependency of high frequency fluctuation dampening is examined. Attenuation of high frequency fluctuation of water vapour signal depends on relative humidity (Mammarella et al., 2009) and parameters describing this dependency can be saved on demand. These parameters can be used when spectral corrections are applied in EddyUH_FluxCalculation. In addition to dampening of high frequency signal, water vapour time lag depends on relative humidity (Ibrom et al., 2007). This dependency can be approximated with EddyUH_TimeLagOptimizer. This approximation can be used in EddyUH_FluxCalculation to make water vapour lag time calculation more reliable and accurate. With EddyUH_SpectralAnalysis, spectral models used in spectral corrections of fluxes can be determined, in addition to plotting different diagnostic spectral figures. The subprogram EddyUH_PlanarFitting can be used to calculate planar fit coefficients and visually check their possible dependence on stability and wind direction.

As a last step EddyUH_FluxCalculation is launched. All the data gathered from other parts of the software can be used in flux calculation, but it is up to the user to choose. EddyUH_FluxCalculation can also be launched immediately after EddyUH_Preprocessor. The user can select how many sets of output files are saved, what variables are included and in what kind of column order. So depending on where the final flux files are needed, the content of the files can be changed accordingly. A flow chart of the software is shown in Figure 1.

2 Getting started with EddyUH

The user can run EddyUH (see Install_EddyUH_yourOS.txt), after the installation is completed. The software is controlled from the main interface EddyUH_main. There the user can create and download projects and run subprograms. Post-processing eddy covariance data with EddyUH is done by processing user-defined projects. A project in this context means a setup-file in which the site specifics, processed time period, selected post-processing methods and measurement system characteristics among other things are listed. This setup-file is later on used in processing data. Therefore all the processed data is always related to one project.

2.1 Create a project

The first thing the user should do is to create a project. This can be done by clicking *Create a project...* button in EddyUH_main. It opens EddyUH_Setup interface, which includes fields for all the necessary information in order to post-process and analyse the data. All the needed information should be given by the user and the procedure should follow these steps:

1. Select a site in the top left corner of EddyUH_Setup. Default setup can be saved by the user, before closing EddyUH_Setup GUI
ALTERNATIVELY
You can start from scratch by selecting "New site" from the same menu in the top left corner of EddyUH_Setup. In this case no default-values are given to any setup-parameter, you have to give everything by yourself.This is the case when the user start to process a new site.

2. Name the project. Name of the project is used in naming the project folder where all the data is saved. Thus select the name wisely.

3. Define processed time period in format YYYYMMDD (see list of reserved letter combinations in Table 3), length of raw data files in minutes (max 60 mins in the current version *EddyUH*_1.0) and the output path (the project folder will be created under this path).

4. Clicking *Raw data setup...* will open a new window where rawdata file format can be described. File name and path can be given by using reserved letter combinations (Table 3). EddyUH can handle raw data in different formats: generic binary, ascii, Edisol(.slt), Campbell TOA and TOB1.

5. Clicking *Meteorological data setup...* will open a new window where files containing auxiliary meteorological data can be described. Three meteo parameters are needed: air temperature, atmospheric pressure and relative humidity. Data can be processed also without meteo data, and in this case virtual meteo data are created. However the usage of real meteo data is recommended. Meteo file name and path can be given by using reserved letter combinations (Table 3).

6. Select if turbulent spectra is calculated and saved. Cospectra is needed in EddyUH_TransferFunctionCalculation and EddyUH_SpectralAnalysis packages.

7. Describe measurement system and select if detection limits and random uncertainties are estimated.

7a. Sonic anemometer related information can be given by clicking *Sonic anemometer setup...* which will open a new window.

7b. Add/Remove gas analysers to your project by clicking *Add gas analyser.../Remove gas analyser...*. In the current version *EddyUH*_1.0, the user can add up to 5 different gas analysers in the same project.

7c. Gas analyser related information can be given by first selecting the gas analyser from *Select gas analyser...* menu and then clicking *Gas analyser setup...* which will open a new window.

8. Give measurement site related information in *Site description* panel.

9. Define used post-processing methods.

10. Describe column order in rawdata files.

11. Save your setup-information.

12. Close EddyUH_Setup.

2.1.1 Sonic anemometer setup

The user can insert sonic anemometer related metadata by using this GUI. Current version of the software supports the following sonic anemometers: Gill-R2, Gill-R3, Gill-HS, Campbell CSAT3, Metek-USA-1.

Nominal conversion factors. By default, the software assumes that u, v, w and sonic temperature are measured by the sonic anemometer. Nominal conversion factors are normally used to scale from voltage units to physical units, but it can be used for any other unit conversion scope. The linear transformation is performed as

$$X_{out} = \text{Gain} \cdot X_{in} + \text{Offset} \tag{1}$$

where Gain and Offset values are given by the user.Note that the conversion factors should be consistent with the units given by the user. For example if the sonic wind velocity components in the rawdata files are already in proper physical units ($\mathrm{m\,s^{-1}}$), the user can simply give Offset = 0 and Gain = 1.

Corrections to the sonic anemometer data. The user can decide to perform the *cross wind correction of sonic temperature* and *angle of attack correction*. Note that these corrections do not apply to all sonic anemometers. See Appendix A for more details.

Inclination angles. If raw data files include also high frequency sampling of inclinometer data, the user must select and load the inclination angles, in order to perform tilt correction for measurements carried out on floating platform (over sea or over lake).

2.1.2 Gas analyser setup

The user can insert gas analyser related metadata by using this interface. Current version of the software supports several gas analysers commercially available (see Table 2).
First of all, the user needs to select the variables measured with the gas analyser and give the related physical units.
Nominal conversion factors. As for the sonic anemometer, nominal conversion factors (Offset and Gain) are given in order to scale the raw data to proper physical units.
Lag times For each gas, the user has to input the *lag window center* (probably close to the expected lag time) and the *lag window width*, both given in sec. For example if the user set *lag window center*=2 and *lag window width*=1, the software will estimated the lag time from a cross-covariance function calculated between 1 and 3 sec. Two methods are used in the Preprocessor to estimate the lag time: 1) standard and 2) alternative method. See Appendix A for more details. Since the lag time for water vapour depends on relative humidity, it is advisable to use a wider window for H_2O.
Sampling setup and gas analyser characteristic. These setup parameters are mainly need in the EddyUH_FluxCalculation package for performing the high frequency spectral correction according to the theoretical approach (Moncrieff et al., 1997).
Instrument calibration.If calibration checking (offset and span) is done regularly for the gas analyser in question, then the user can give the in-situ calibration values in a table. Note that these values should have the same units of the nominal conversion factors.
Correction for air density fluctuations. For a closed path gas analyser, the user can decide to perform this correction point by point (dilution correction) or to the covariance values (WPL correction).

3 Load the project and run the preprocessor

After creating a project and closing EddyUH_Setup, the project should be loaded to EddyUH_main. This can be done by selecting *Load project...*, searching for the project folder and then selecting the setup-file from "setupcommon" subfolder. Name of the setup-file has the format "preproc_YYMMDDHHMIN_id", where id is three first letters from site name and YYMMDDHHMIN is time of saving the file. The file has no file extension. After loading the project the user should start the Preprocessor. It will calculate turbulent spectra, preliminary values for the fluxes, turbulent statistics, and the outputs (in binary matlab format) are saved in subfolders "preproc" and "spectra" under the project folder.

4 Run the subprograms

After running the Preprocessor, the user can use subprograms EddyUH_TransferFunctionCalculation, EddyUH_TimeLagOptimizer, EddyUH_SpectralAnalysis and EddyUH_PlanarFitting. However these subprograms are not mandatory and the user can run also EddyUH_FluxCalculation directly after the preprocessor.

4.1 EddyUH_TimeLagOptimizer

With this subprogram the user can evaluate if the time lags were estimated correctly. Time lag means that wind vertical velocity and gas mixing ratio are not measured simultaneously, but there is a lag between them. This is caused by travel time in the sampling tube (closed-path gas analysers) or spatial sensor separation (open-path gas analysers). The time lag is determined for every averaging period from the point where the covariance function attains its maximum value within the user defined time lag window. The subprogram will plot monthly time series of the time lags, H_2O time lag as a function of RH, among other things.

For instance the user can check if the estimated time lags are constantly on the border of the user defined time lag window. Then it can be said that the window was at a wrong place. In this situation the location of the window should be changed and the preprocessor should be run again.

For water vapour the time lag depends on relative humidity and this dependence can be estimated. In order to have a robust statistics in the fitting procedure, it is recommended to perform this analysis on a period of two months or more. This estimation can be used in EddyUH_FluxCalculation when final values for H_2O fluxes are calculated.

In the EddyUH_TimeLagOptimizer GUI, the user needs to set few options in order to run this subprogram. Information about the site name, processed period and variables are summarized at the top of the interface.

Used time period. The user can select a shorter time period to perform this analysis.

Data screening. The user can decide if only quality screened runs are used to perform the time lag optimization. The data filtering can be done by default quality criteria or by user-defined quality criteria.
Number of classes. Give the number of relative humidity (used for water vapour) and wind direction (used for other gases) classes. For each class ensemble mean and std will be calculated. In order to reduce the statical uncertainty of this analysis, each class should contain a relative large number of 30 min runs. A good compromise is to use between 6 and 8 classes, but of course this depends also on the length of analysed period and on the total number of runs, which passed the quality screening.
Length of subperiods. The time lag optimization can be also performed separately in different subperiods. The length of one subperiod is given as number of months. For example if the processed period is 12 months, then setting the length of subperiod equal to 3, the analysis is done on 4 subperiods of 3 months.
Finally the user can decide to plot several figures related to the time lag and save statistics of this analysis in a file, which can be later used in the EddyUH_Flux Calculation subprogram.

4.2 EddyUH_TransferFunctionCalculation

Covariance related to high frequency fluctuation is almost always underestimated, and this underestimation can be identified experimentally with this subprogram. From this program the user can get the first order response times that describe how much high frequency fluctuations were damped. This information can be used in EddyUH_FluxCalculation when the spectral corrections are done.

For water vapour high frequency dampening (eg.estimated low pass filter time constant) depends on relative humidity. This dependency can be estimated and it can be used in EddyUH_FluxCalculation. In order to have a robust statistics in the fitting procedure, it is recommended to perform this analysis on a period of two months or more.

This interface is very similar to the one for time lag optimization. One small difference is that for each class of relative humidity/wind direction, the low pass filter time constant estimation can be done separately on different ensemble datasets chosen according to wind speed. Typically using two classes of wind speed is a good compromise. If you do not want to use this feature, just give number of wind speed classes equal to 1. Finally the user can decide to plot several figures related to the low pass filter effect and save statistics of this analysis in a file, which can be later used in the EddyUH_Flux Calculation subprogram.

4.3 EddyUH_SpectralAnalysis

With this subprogram the user can plot turbulent spectra. For instance ogive, mean power and cospectra can be plotted from the files that the preprocessor created. In complex terrain the scalar cospectra do not necessarily follow Kaimal-cospectrum. The user can check how well Kaimal-cospectrum fits to the measurements and if it does not fit well, the user can fit a new site specific model cospectrum. This fit can then be used in EddyUH_FluxCalculation when spectral corrections are made, instead of the traditionally used Kaimal-cospectrum. Also location of scalar cospectral peak as a function of atmospheric stability can be estimated.

4.4 EddyUH_PlanarFitting

This subprogram calculates the planar fit coefficients within the full project period or user-defined subperiods. The analysis can be performed also for different wind direction (sector-wise planar fit) or for different stability conditions (unstable and stable stratification). The user can choose to check how the multiple regression analysis performed for his site (by selecting *Plot figures during calculation*) and he can also save the fitting coefficients in a file for further use. This subprogram use the output from the pre-processor, then you can successfully run it after EddyUH_Preprocessor.
For using the planar fit method, you need to select this coordinate rotation option from the project setup GUI. Then when you start the EddyUH_Preprocessor, you will see a pop-up window titled *"Give planar fit coefficient"* on your screen with the following options: a)Calculate new coefficients; b)Load them from a planar fit file; c)Give them manually. At this initial stage, the only possibility is to choose the option (a), then EddyUH will calculate the planar fit coefficients, save them in a file under "setupcommon" subfolder, and it will start automatically the Preprocessor. At this stage only one set of the coefficients (and then the rotation angles) is calculated for the whole time period, and neither sector-wise or stability dependent planar fit is included. After the Preprocessor run is terminated, you can employ the EddyUH_PlanarFitting subprogram to refine your analysis. In case of new planar fit coefficients are saved under setupcommon, then the user needs to run again the Preprocessor, and he can upload the new coefficients by choosing the option (b). The software will ask to the user to give planar fit coefficient also in the EddyUH_Flux Calculation subprogram.

5 EddyUH_FluxCalculation

After running the preprocessor, and possibly also the subprograms, the user can calculate the final fluxes. By clicking *Open flux calculation...* button in EddyUH_main, a new window will open. All the needed information should be given according to the following steps:

1. By default all variables listed in EddyUH_FluxCalculation window will be saved in monthly ascii files in "flux" subfolder. Meaning of all possible variables and their units are listed in Tables 1 and 4. The user can also select some of the variables to be saved in a separate set of files. The user can define the column order and the variables that will be saved by selecting the variables from the listbox in the top left corner of EddyUH_FluxCalculation interface.

2. Time series of the calculated flux data can be plotted. The user should select whether the figures are shown during calculation or after the flux calculation. The user can select which variables will be plotted.

3. The user can select which model cospectrum will be used in spectral corrections. The model cospectrum can be selected from *Select model cospectrum...* menu. If the user selects *Own fit*, then the file containing the output from EddyUH_SpectralAnalysis should be loaded. The file can be found from subfolder "setupcommon" and the name will have format "modco_YYMMDDHHMIN_id.spe", where id is three first letters from site name and YYMMDDHHMIN is time of saving the file.

4. Next the user should select how dependency of cospectral peak on stability is parameterisated. Different selections can be seen in *Select parameterisation...* menu. If the user selects *Own fit*, then the file containing the output from EddyUH_SpectralAnalysis should be loaded. The file can be found from subfolder "setupcommon" and the name will have format "nm_vs_stab_YYMMDDHHMIN_id.spe", where id is three first letters from site name and YYMMDDHHMIN is time of saving the file.

5. Next the user selects the spectral correction methods to use. The sonic anemometer fluxes (sensible heat and momentum fluxes) are always corrected by using theoretical approach. For other fluxes, the user has different options. If the experimental or analytical approaches are used for high frequency loss correction, the user needs to give the experimental estimated response time for each gas.

6. Response times (time constants) which describe dampening of high frequency signal and were calculated with EddyUH_TransferFunctionCalculation can be given in the table on the right hand side of the figure. For water vapour, response time may depend on relative humidity and by selecting "Calculate H_2O transfer function using estimated dependence of time constant on RH" the user can download the file saved by EddyUH_TransferFunctionCalculation, which contains this estimated dependency. The file can be found from subfolder "setupcommon" and the name will have format "resptime_YYMMDDHHMIN_id.Ncl" where id three first letters from site name, N is the amount of RH classes that were used and YYMMDDHH-MIN is time of saving the file.

7. Automatic quality filtering can be done for flux data during data processing. If the user wants to screen the flux data, "Screen the flux data during calculation" should be selected. The user can give the screening criteria in a new window which will open when *Give screening criteria...* button is clicked. Note that, in the current version EddyUH_1.0, the flux quality flags are not used, and the 30 min flux values, which do not pass any of the chosen quality criteria are removed and replaced with missing value (-999). If the user do not select this option, the flux quality flag and/or filtering can be done later by the user, since all the needed quality statistics are always saved in the final output file.

8. After these steps flux calculation can be started by clicking *Save and continue*.

6 Additional software tools

EddyUH_1.0 provides additional tools, which can be found under "Tools" in the EddyUH_main interface.

EddyUH figure viewer. This tool let the user to see all figures previously created by running the subprograms. The figure can be export in several format by choosing "Save As" from the File Menu.

EddyUH rawdata plotter. This tool plots the rawdata and optionally the corresponding auto-covariance and cross-covariance functions.

Appendix A: List of implemented data processing and correction methods

Signal conversion: Raw data is converted into physically meaningful units by using calibration coefficients. If they are not available, data is converted using

nominal conversion factors saved in setup-files.
Despiking: Three different despiking methods are implemented:

- **Limits for difference in subsequent data points**: if difference between consecutive points in raw data exceeds limits given in setup-files, data point is considered as a spike and replaced with previous value.
- **Lower and upper limits for raw data values**: consistency limits for each variable are given in the setup-file, data point exceeding those limits are marked as a spike and replaced with previous value.
- **Despiking method according to Vickers ja Mahrt (1997)**.

Angle of attack correction: This correction is applied according to Nakai et al. (2006). When the wind vector has an angle of attack to the horizontal plane, the measured wind may be affected by the geometry of sonic anemometer. This flow distortion is corrected with this correction. This correction applies only for Gill R3, Gill R2 and Gill Wind Master. However, this is not a standard correction, and his applicability on field conditions is still under debate in the flux community.
Coordinate rotation: The user can select from four different coordinate rotation methods. They are:

- 1D-rotation
- 2D-rotation
- 3D-rotation
- planar fit

In 1D-rotation the coordinates are forced in such direction that u is directed toward mean horizontal wind speed and thus $\overline{v} = 0$. 2D-rotation includes also the previous rotation but after 2D-rotation also $\overline{w} = 0$. 3D-rotation includes both of the previous rotations and also a third rotation that forces lateral momentum flux, $\overline{v'w'}$, equal zero. The planar fit method is an alternative rotation procedure, proposed by citetWiczaketal2001,in which it is assumed that the mean vertical velocity is equal zero only on averaging periods longer than 30 min. In this method a mean streamline plane is retrieved, and the estimated planar fit coefficients are then used for calculating the pitch and roll angles. In EddyUH the planar fit is performed by the EddyUH_PlanarFitting subprogram.

Detrending: Three different detrending methods are implemented:

- Block-averaging
- Linear detrending
- Running mean filtering (RMF)

In block-averaging mean is subtracted from the time series, in linear detrending a linear trend is fitted to the timeseries and it is subtracted and in running mean filtering method a running mean is subtracted in order to achieve the fluctuating part of the signal. If RMF is used, the user can select time constant used in filtering.

Lag time correction: Sampling tube induced lag time between sonic anemometer measurements and gas analyser measurements are corrected by maximizing the covariances. In the EddyUH_Preprocessor this is done in two different ways: 1) *standard method*. In this method the covariance is maximized by searching maximum of cross-covariance function inside the lag time window given by the user. 2)*alternative method*. In this method a linear trend is first subtracted from the cross-covariance function before the maximum value is searched.

Cross-wind correction to sonic temperature: This correction takes into account the influence of crosswind in sonic anemometer's temperature measurements. Implemented according to Liu et al. (2001).

High frequency spectral corrections: These corrections can be performed with theoretical transfer function for all fluxes and with experimental transfer function for all gas analyser related fluxes. Theoretical transfer functions related to high frequency signal loss are implemented according to Moncrieff et al. (1997) and experimental transfer function is calculated following procedure introduced in Aubinet et al. (2000).

Low frequency spectral corrections: Low frequency spectral corrections can be applied only with theoretical transfer functions. They are implemented according to Rannik ja Vesala (1999).

Correction for humidity effect on sonic heat flux: This correction is implemented according to Schotanus et al. (1983). This is needed because humidity affects speed of sound in air and thus it has also an effect on sonic anemometer's temperature measurements.

Webb, Pearman and Leuning (WPL) Density Correction: WPL-correction (Webb et al., 1980) is applied after spectral corrections. For closed-path systems only a correction due to humidity fluctuations is applied and for open-path analysers also temperature fluctuation term is included.

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Name	**Meaning**	**Unit**
Year	year	-
DOY	day of year	-
Hour	hour	-
Minutes	minutes (middle of averaging period)	-
U	mean wind speed	m/s
WD	mean wind direction	degrees
Eta	first coordinate rotation angle	degrees
Theta	second coordinate rotation angle	degrees
Beta	third coordinate rotation angle	degrees
SH	sensible heat flux	W/m^2
Tau	momentum flux	m^2/s^2
UST	friction velocity	m/s
Lmo	Obukhov-length	m
errpacket	max. amount of spikes	#
Fluxes.var	final flux of variable var	see Table 4
Covs.var	covariance of variable var and vertical wind speed	see Table 4
Mx.var	mean value of variable var	see Table 4
Sx.var	standard deviation of variable var	same as Mx.var
Lags.var	lag time of variable var	indeces in rawdata
Nspikes.var	amount of spikes in variable var data	#
FI.var	flux intermittency of variable var	-

Name	**Meaning**	**Unit**
FST.var	flux stationarity (FST) of variable var	-
RFE.var	relative flux error of variable var	-
FA.var	flux attenuation of variable var	-
covsvar.var	change in covariance of variable var	%
	between two last iteration loops	
rho	air density	kg/m^3
metdata.Press	air pressure	hPa
metdata.Tair	air temperature	°C
metdata.RH	relative humidity of air	%
SKx.var	skewness of variable var	-
KUx.var	kurtosis of variable var	-
overall_qflag.var	overall quality flag of Fluxes.var	-
ITC_qflag.var	quality flag of Fluxes.var based on ITC test	-
FST_qflag.var	quality flag of Fluxes.var based on FST test	-
Hm.var	Haar mean of variable var	same as Mx.var
Hv.var	Haar variance of variable var	$(Mx.var)^2$
covs_noWPL.var	covariance of variable var without WPL correction	same as Covs.var
wpl_q.var	H_2O-term in WPL correction (variable var)	same as Covs.var
wpl_T.var	T-term in WPL correction (variable var)	same as Covs.var
covs_WPLq.var	H_2O covariance calculated with var lag time	same as Covs.H_2O
crosstalk_coeffA.var	Coefficient A used spectroscopic correction	-
crosstalk_coeffB.var	Coefficient B used spectroscopic correction	-
crosstalk_coeffC.var	Coefficient C used spectroscopic correction	-
unc1.var	Instrumental noise (random shuffle method)	same as Covs.var
unc2.var	standard deviation of the covariance (variable var)	same as Covs.var
unc3.var	Instrumental noise (variable var) (Lenschow method)	same as Covs.var
detlim.var	detection limit of the flux (variable var)	same as Covs.var
fpr.x_peak	distance to the footprint peak	m
fpr.x_80	distance to the 80th percentile of the footprint	m

Table 1: List of output variable names.

Supported instruments	
Sonic anemometers	Gill-R2, Gill-R3, Gill-HS, Campbell CSAT3, Metek-USA-1
Gas analyzers	Licor-6262 (CO_2, H_2O), Licor-7000 (CO_2, H_2O), Licor-7500 (CO_2, H_2O), Licor-7200 (CO_2, H_2O), Licor-7700 (CH_4), Campbell TDL (CH_4, N_2O), Los Gatos (CH_4, N_2O, H_2O), Picarro (CH_4, CO_2, H_2O), TSI CPC (Particle number conc), Unisearch Associates LOZ-3 (O_3), Aerodyne QCL (N_2O, CH_4, CO_2, H_2O),
Implemented methods/corrections	
Raw data level	Units conversion and Calibration; Spike detection; Cross-wind correction (Liu et al., 2001); Dilution correction point by point; Angle of attack correction (Nakai et al., 2006); Block averaging, linear detrending and autoregressive running mean filter; Time lag estimation
Coordinate rotation	Planar fit (Wilczak et al., 2001); Streamwise rotation (1D, 2D or 3D) according to Kaimal ja Finnigan (1994)
Quality statistics	Skewness, kurtosis, flux non-stationarity, random flux error, flux intermittency
High frequency loss	Theoretical (Moncrieff et al., 1997); Empirical estimation of the transfer function (Aubinet et al. (2000); Mammarella et al. (2009)
Low frequency loss	According to Rannik ja Vesala (1999)
Humidity corr to sensible heat flux	According to Schotanus et al. (1983)
WPL correction	Based on Webb et al. (1980), (Ibrom et al., 2007) for closed-path GA
Spectroscopic correction	for Licor-7700, Los Gatos and Aerodyne QCL

Table 2: Main features of EddyUH.

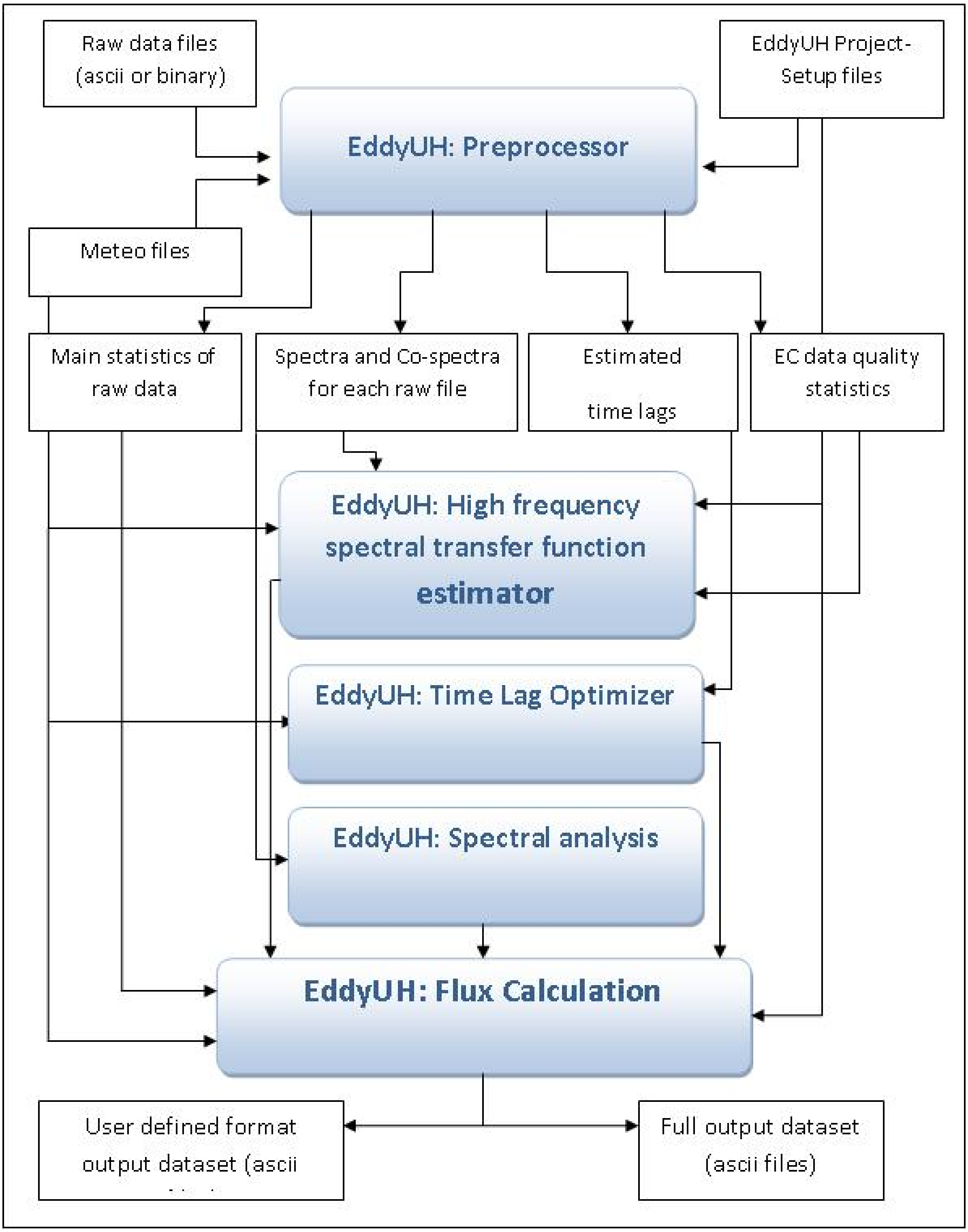

Figure 1: Flow chart of EddyUH.

letter combination	meaning
YYYY	year with four digits
YY	year with two digits
MM	month with two digits
DD	day of month with two digits
DOY	day of year with three digits
HH	hour with two digits
MIN	minutes with two digits

Table 3: List of reserved letter combinations in EddyUH. Letter combinations are case sensitive.

	Variable var	unit
Covs.var	u, v, w	m^2/s^2
	Ts	(°C) *m/s
	H_2O	$(mmol_{H_2O}/mol_{air})$ *m/s
	CO_2, CH_4, CO	ppm*m/s
	N_2O, O_3, COS	ppb*m/s
	Part	#*m/s
Mx.var	u, v, w	m/s
	Ts	°C
	H_2O	$mmol_{H_2O}/mol_{air}$
	CO_2, CH_4, CO	ppm
	N_2O, O_3, COS	ppb
	Part	#
Fluxes.var	H_2O	$mmol/(m^2s)$
	LE	W/m^2
	CO_2, CH_4, CO	$\mu mol/(m^2s)$
	N_2O, O_3, COS	$nmol/(m^2s)$
	Part	#*m/s

Table 4: Units of different variables.