



EASY FLUX-DL

Overview

EasyFlux™-DL (DL for datalogger) is a free CRBasic program that enables a CR3000 datalogger to report fully-corrected fluxes of CO₂, latent heat (H₂O), sensible heat, and momentum from a Campbell Scientific open-path eddy-covariance (EC) system. Final fluxes are processed from raw time-series (10 Hz) data by applying commonly used corrections found in scientific literature.

In the past, Campbell's datalogger EC programs roughly estimated fluxes, and PC post-processing software was used to fully correct the

flux measurements. Now with the EasyFlux-DL program, Fully-corrected fluxes are processed by the datalogger and reported at the end of each EC averaging interval.

EasyFlux-DL has been tested at several stations in various environments, including irrigated alfalfa, grassland, maize, open water, forest, and desert. The results have shown good agreement with fluxes processed using traditional PC-based software applications.

Benefits and Features

- › Accesses final fluxes quickly without the burden of post-processing unwieldy time series data sets.
- › Produces flux output tables that are smaller than time series tables, which allows flux data to be frequently collected using cellular, radio, or other lower-bandwidth telemetry options.
- › Available, at no charge, from www.campbellsci.com/easyflux-dl.
- › Matches the fluxes provided by PC post-processing software packages (assuming same filtering of raw data and same selection of correction procedures).
- › Saves time-series data on the datalogger's CompactFlash card in case reprocessing is later needed.
- › Includes data quality and footprint characteristics.
- › Reports uncorrected and intermediate values in an auxiliary output table for more detailed data inspection.

Supported Sensors

Required

- › EC150 Open-Path CO₂/H₂O Gas Analyzer with CSAT3A 3D Sonic Anemometer

OR

- › IRGASON Open-Path CO₂/H₂O Gas Analyzer and 3D Sonic Anemometer



IRGASON

Optional*

- › FW05, FW1, or FW3 Fine-Wire Thermocouple
- › HC2S3 or HMP155A Temperature and Relative Humidity Probe
- › CNR4, NR01, or NR-LITE2 Radiometer
- › CS300 or LI200X Pyranometer
- › LI190SB Quantum Sensor
- › SI-111 Infrared Radiometer
- › TE525MM Tipping Bucket Rain Gage
- › TCAV Soil Temperature Probe (quantity up to two)
- › CS616 or CS650 Soil Water Content Probe (quantity up to two)
- › HFP01 or HFP01SC Soil Heat Flux Plate (quantity up to four)

*It may be possible to add non-standard sensors to the program upon request and for a fee.

Main Correction and Processing Procedures

- › Despiking and filter 10 Hz data using sonic anemometer and gas analyzer diagnostic codes, signal strengths, and measurement output range thresholds.
- › Apply coordinate rotations with an option to use the double rotation method (Tanner and Thurtell, 1969) or planar fit method (Wilczak, 2001).
- › Lag CO₂ and H₂O measurements against sonic wind measurements for maximization of CO₂ and H₂O fluxes (Horst and Lenschow, 2009; Foken et al, 2012), with additional constraints to ensure lags are physically possible.
- › Apply frequency corrections using commonly used cospectra (Moore, 1986; Dijk, 2002; Moncrieff et al., 1997) and transfer functions for block averaging (Kaimal et al, 1989), line/volume averaging (Moore, 1986; Moncrieff et al, 1997; Foken et al, 2012; Dijk, 2002), time constants (Montgomery, 1947; Shapland et al, 2014; Geankoplis, 1993), and sensor separation (Horst and Lenschow, 2009; Foken et al, 2012).
- › Apply a modified SND correction (Schoanus et al., 1983) to derive sensible heat flux from sonic sensible heat flux following the implementation as outlined in Van Dijk (2002). Additionally, fully corrected sensible heat flux computed from a fine-wire thermocouple is provided if our FW05, FW1, or FW3 is used.
- › Apply correction for air density fluctuations using WPL equations (Webb et al., 1980).

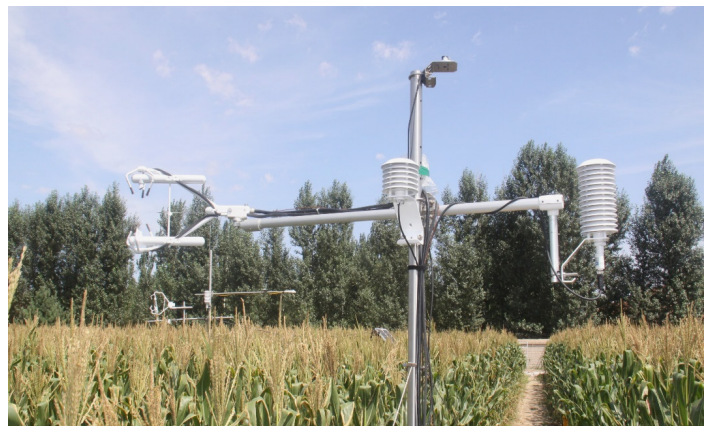


Figure 1. Fully-corrected fluxes are calculated using EasyFlux-DL over a field of maize.

- › Assign data quality classifications based on steady state conditions, surface layer turbulence characteristics, and wind direction following Foken et al. (2012).
- › Calculate footprint characteristics using Kljun et al. (2004) or Kormann and Meixner (2001).
- › If energy balance sensors are used, calculate energy closure based on energy balance measurements and corrected sensible and latent heat fluxes.

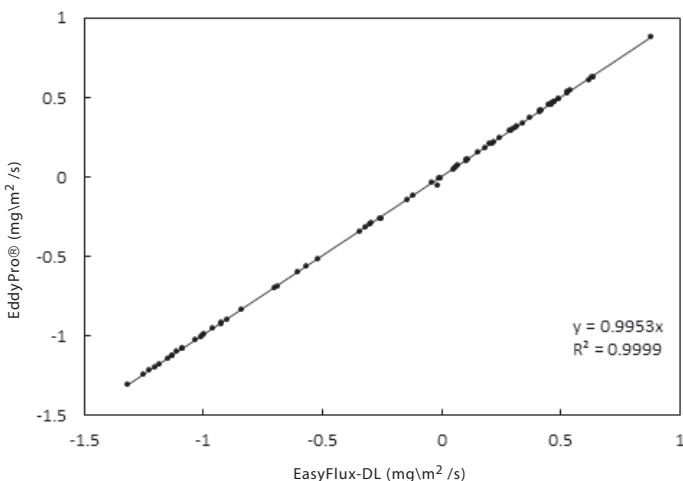


Figure 2. CO₂ fluxes over maize are calculated and compared using EasyFlux-DL and EddyPro® (LI-COR, Inc., Lincoln, NE) after applying similar diagnostic and despiking filters to raw data. Data shown represent half-hour fluxes taken over a four-day period in August.

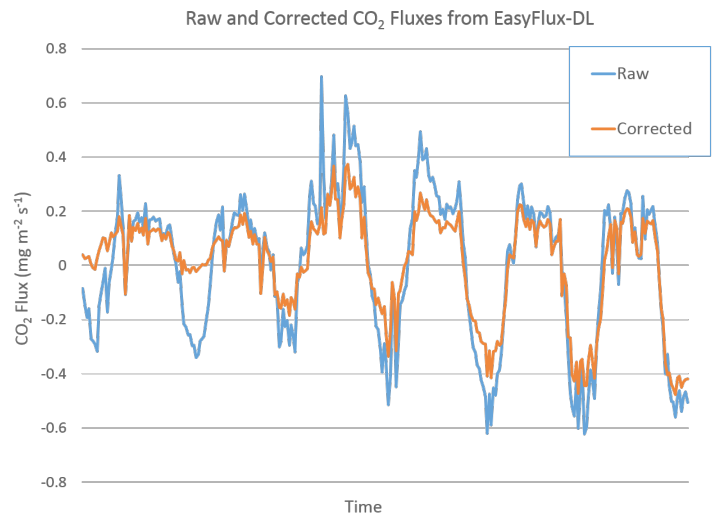


Figure 3. Corrected CO₂ fluxes from EasyFlux™-DL are compared to uncorrected CO₂ fluxes over a week period from an irrigated alfalfa field soon after the alfalfa was harvested.