Cross-site evaluation of methods for the estimation of aerodynamic roughness parameters from flux-tower data

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The networks of eddy covariance tower sites across continents and ecoregions provide valuable datasets of direct and continuous measurements of fluxes (e.g., momentum, CO_2, H_2O, energy) that have been used across disciplines and application. Aerodynamic roughness parameters (i.e., roughness length (z_0), zero plane displacement height (d), or aerodynamic canopy height) are one of the potential data products that are crucial for the applications of land surface and ecosystem modelling but have not yet been routinely generated in AmeriFlux or FLUXNET dataset. This study aims to test and compare several available methods for the estimation of aerodynamic roughness parameters from single-level eddy covariance measurements and evaluate their feasibility and robustness for the application for future AmeriFlux or FLUXNET datasets.

We plan to test estimation across sites with different canopy structures ranging from tall-, short-canopy, to bare soil/open water, from closed/homogeneous to open/ heterogeneous canopy, and from evergreen to those with evident seasonal dynamics (e.g., deciduous, harvested). Two groups of approaches based on the surface-layer theory (i.e., logarithmic wind profile) (Graf et al., 2014; Martano, 2000; Maurer et al., 2013) and flux variance similarity (i.e., turbulent characteristics) (De Bruin and Verhoef, 1997; Panofsky, 1984) are adopted to estimate z_0 and d simultaneously at a daily time step by using single-level eddy covariance measurements (Figure 1). Each approach is implemented by using a series of estimation techniques (Figure 1), such as running-window least-square regression, numerical iteration, and Markov chain Monte Carlo methods. In addition, a semi-empirical approach based on the assumptions of presumably known relationships among aerodynamic roughness parameters is also applied and tested (Pennypacker and Baldocchi, 2015). Last, we especially look for sites with multilevel wind measurements, such that we could adopt the conventional wind-profile approach to estimate z_0 and d and use estimates to validate those from single-level methods.

Mandatory variables include half-hourly or hourly wind speed (WS), friction velocity (USTAR), wind direction (WD), Monin-Obukhov length (MO_LENGTH), and Standard deviation of vertical wind velocity (W_SIGMA) at the eddy covariance level above the canopy (details in Table 1). Optional but important variables are wind speed (WS_#) measured at additional level(s) above the canopy (i.e., at least 1 additional level). Additional-level wind speed measured by high-precision anemometers (e.g., sonic anemometer) is preferred, but data from other types of wind monitors is also accepted. We prefer the length of dataset to be one or multiple years, or at least covering the growing season, such that we are able to test the estimates of seasonal dynamics. Basic QA/QC is preferred, and please let us know briefly what filters/criteria have been applied to screen out the data. Gap-filling is not needed.

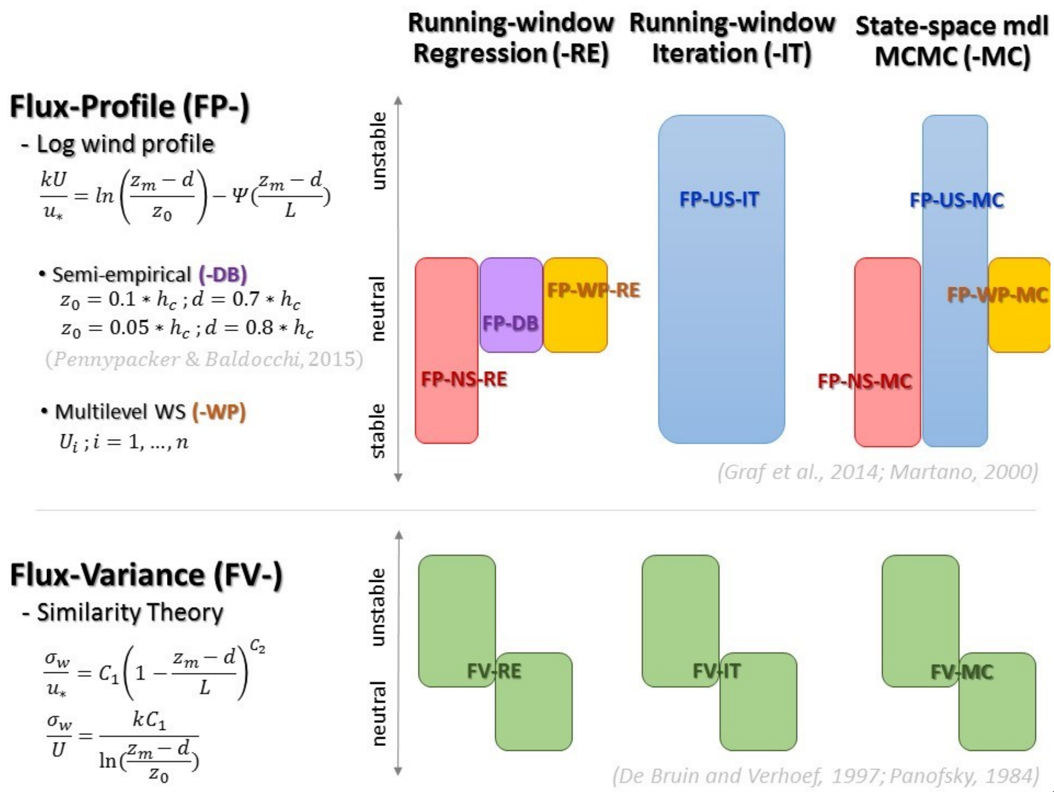

Figure 1. Summary of the methods for estimation of aerodynamic roughness parameters.

Table 1 List of required variables.

Variable	Description and Unit
Single-level (half-)hourly ***(Mandatory, preferably measured at the same location)***	
TIMESTAMP_START	ISO timestamp start of averaging period (YYYYMMDDHHMM) [I]
TIMESTAMP_END	ISO timestamp end of averaging period (YYYYMMDDHHMM) [I]
WS	Horizontal wind speed (m/s) at eddy covariance level
USTAR	Friction velocity (m/s) at eddy covariance level
WD	Wind direction (degree) at eddy covariance level
MO_LENGTH	Monin–Obukhov length (m) at eddy covariance level [II]
W_SIGMA	Standard deviation of vertical wind velocity (m/s) at eddy covariance level (after coordinate rotation)
Additional-level(s) (half-)hourly ***(Optional)***	
WS_#	Additional level(s) horizontal wind speed (m/s) [III]
Ancillary information ***(Mandatory)***	
z_m	Measurement heights of eddy covariance (m)
z_{mi}	Measurement heights of additional wind profiles (m)
h_c	Canopy height (m) [IV]
LAI	Leaf area index (m2/m2) [IV]

[I] We also accept other time stamp formats. See http://ameriflux.lbl.gov/data/aboutdata/data-variables/ for a list of examples.

[II] If MO_LENGTH is not calculated, please provide TA (air temperature, °C) or T_SONIC (sonic temperature, °C), RH (relative humidity, %) or VPD (vapor pressure deficit, kPa), PA (atmosphere pressure), and H (sensible heat flux, W/m2).
[III] We prefer additional wind speed measured by high-precision anemometers (e.g., sonic anemometer), but we still receive data from other types of wind monitors (Please specify the anemometer types).
[IV] Please provide at least the maximum canopy height and LAI.

Other ancillary information

1. Information about any dynamics/seasonality of canopy heights, structure, or LAI
2. Information about local topography (flat, rolling, sloping…), or any obstacle (tower, solar panels, building)
3. Independent estimates of aerodynamic roughness parameters (z_0 and d), e.g., from ground inventory, LIDAR, etc.

Upload or Send file

For AmeriFlux registered sites, you could upload files through the AmeriFlux data upload portal (http://ameriflux.lbl.gov/data/upload-data/). While uploading, please specify 'Data for roughness syntheses' in the file description. Alternatively, you could send files directly to Housen Chu (hchu@berkeley.edu) or share via Dropbox.

Deadline

Preferable submission date is due September 15, 2016.

Co-authorship and Data policy

This study will follow the AmeriFlux data policy unless directed otherwise by PIs. All data would be properly acknowledged, and that data contributors will have the opportunity to make an intellectual contribution and as a result have the opportunity to be a co-author.

Reference

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