Algorithmic uncertainties in GPP/RE Partitioning and Gapfilling of NEE, at annual and half-hourly time scales

Andrew Richardson
University of New Hampshire
(andrewr@solo.sr.unh.edu)

Analysis of GPP/RE partitioning uncertainty

1. *Annual time scale*
    a. Using data from Desai et al (2008), I calculated the standard deviation (sd, across all 23 partitioning methods) of the annual sums of NEE, GPP and RE for 10 site-years of data.
        i. For NEE, 1 sd = ±15 g C m-2 y-1 (mean across all 10 sites), and there was no correlation between NEE and sd. Across all 10 sites, the mean range in NEE from the different algorithms was 75 g C m-2 y-1. These might be viewed as estimates of uncertainty due to gap-filling algorithm at the annual time step.
        ii. For GPP and RE, there is a strong correlation between sd and the integrated annual flux. For GPP, 1 sd ≈ ± 5% of annual GPP; for RE, 1 sd ≈ ±7.5% of annual RE.
        iii. For GPP and RE, there is a strong correlation between the max-min range (across methods) and the integrated annual flux. For GPP, range ≈ 21% of annual GPP; for RE, range ≈ 34% of annual RE.
        iv. Note that if we take a 95% confidence interval as 2 times the sd, then these estimates are all more or less consistent: e.g., for GPP, 1 sd = ± 5%, so a 95% CI is ± 10%, implying a 95% range of 20%, which is just slightly smaller than the observed (100%) range of 21%. Similarly for NEE and also RE.

    b. I also conducted the above analysis using only the FLUXNET standard partitioning algorithm and the FCRN standard algorithm. The FLUXNET algorithm consistently predicts more GPP and more RE than the FCRN algorithm. There is no longer a strong correlation between range (i.e., the FCRN-FLUXNET difference) and annual flux magnitude. The mean range (across 10 sites) is 10 g C m-2 y-1 for NEE, 60 g C m-2 y-1 for RE and 6 g C m-2 y-1 for GPP. The maximum range is as large as 25 g C m-2 y-1 for NEE, and 95 g C m-2 y-1 for RE and GPP.

2. *Half hourly time scale*
    a. Using data from Desai et al (2008), I calculated the standard deviation (sd) GPP and RE for 10 site-years of data, across the range of partitioning methods, for each half-hourly measurement period. I then calculated the average sd for fluxes binned by magnitude.
        i. The sd of GPP across algorithms increases approximately with GPP squared, as i.e. sd = 0.94 + 0.0024 * GPP^2. At GPP = 20 μmol m^{-2} s^{-1}, one sd of the algorithmic uncertainty is thus ± 1.9 μmol m^{-2} s^{-1}.

ii. For RE, the pattern is similar; sd = 0.50 + 0.021 * RE^2, and one sd of the algorithmic uncertainty is thus ± 2.6 μmol m^{-2} s^{-1} at RE = 10 μmol m^{-2} s^{-1}.

b. I also calculated the FCRN-FLUXNET difference, and evaluated whether the sd of this difference varied according to flux magnitude. For GPP, it did not; thus the algorithmic uncertainty of GPP due to FCRN vs. FLUXNET is approximately constant at 1.2 μmol m^{-2} s^{-1} regardless of the magnitude of GPP; for RE, the difference scales with flux magnitude, and sd = 0.75 + 0.024 * RE^2

Analysis of gap filling uncertainty due to algorithmic differences

1. *Annual time scale*

a. Based on a survey of 18 different gap filling methods, Moffat et al (2007) concluded that *many* methods produced estimates of annual integrated NEE that were within 25 g C m-2 y-1 of the mean of the other methods.

b. Furthermore, Moffat et al (2007) concluded that all gap filling methods rated to have “good” reliability fell within a range of ± 25 C m-2 y-1; it is difficult to attach a level of statistical significance to this estimate

c. Using data from the six gap-filling methods used in section 2 (below), I estimate the standard deviation across these methods to be ± 15 g C m-2 y-1, with a range of 40 g C m-2 y-1, for the 10 site-years of data used. The standard deviation across methods did not appear to be strongly correlated with annual NEE.

2. *Half hourly time scale*

a. Using a selection of data from Moffat et al (2007), which were subsequently used in the uncertainty analysis of Richardson et al (2008), I calculated the sd and range of half-hourly fluxes predicted by six gap-filling methods. I then evaluated these statistics in relation to the flux magnitude (as predicted by the ANN model).

b. Both sd and range across methods increased with increasing flux magnitude, and patterns were robust across site. At the half-hourly time step, uncertainty in gap-filled NEE (NEEgf) due to algorithmic differences can be approximated as:

i. 1 sd = 0.70 + 0.08 * abs(NEEgf) g C m-2 y-1

ii. range = 1.10 + 0.21 * abs(NEEgf) g C m-2 y-1

c. Note that these regressions have a non-zero intercept, meaning that even when gap-filled NEE is near-zero, there is still a base level of uncertainty that cannot be eliminated