**NACP Uncertainty Analysis 11 Aug 2009**
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## 1. Summary

We evaluated the uncertainties in eddy-covariance NEE, RE and GPP associated with (a) random noise and (b) uncertainties in the $u_*$ (friction velocity) threshold $u_*^{Th}$ for all site-years in the NACP site-level synthesis. The sign convention adopted here is: positive for net ecosystem exchange NEE when the ecosystem is a C source, negative for NEE when the ecosystem is a C sink, and positive for both total ecosystem respiration RE and gross primary production GPP:

$$\mathrm{NEE} = -(\mathrm{GPP} - \mathrm{RE}) \qquad (1)$$

Data summaries by site are given in Appendix A. The following data products have been submitted to the NACP site-level synthesis archive:

Table 1: Reprocessed NACP data products, submitted Aug 2009.

| | **Product** | **Description** |
|---|---|---|
| **1** | Filled NEE, RE and GPP time series | Modified Fluxnet-Canada gap-filling (Appendix B), with separate products for (a) median annual $u_*^{Th}$ and (b) seasonally-varying $u_*^{Th}$ |
| **2** | Random uncertainty | 95% confidence intervals in NEE, RE and GPP, at daily, weekly, monthly and annual time scales, and for the mean monthly and annual diel (diurnal) cycles |
| **3** | Uncertainty associated with the annual $u_*^{Th}$ | 95% confidence intervals in NEE, RE and GPP, at daily, weekly, monthly and annual time scales, and for the mean monthly and annual diel (diurnal) cycles |

Site-level data summaries are being sent to each flux-tower PI for their feedback. The gap-filing algorithm produced robust results for most but not all site years (Section 2 and Table A1). As required, a reanalysis and second data submission will be completed this fall, based in PI feedback.

We recommend: (a) that the gap-filled NEE, RE and GPP time series, estimated using the modified Fluxnet-Canada method, be compared with values from other accepted gap-filling methods but using the $u_*^{Th}$ detection method from this study; and (b) that the uncertainty analyses be repeated using another gap-filling method, to confirm that the uncertainty estimates are not sensitive to the gap-filling method.

## 2. Filling Gaps in NEE and Partitioning NEE into RE and GPP

The uncertainty analyses required the repeated use of a gap-filling / partitioning method. We chose the Fluxnet-Canada method (Barr et al. 2004), with slight modifications (Appendix B), because we were familiar with its use and because it produced robust results at most sites in this study. Annual sums of gap-filled NEE, RE and GPP are given in Tables A3 and A4, Appendix A. At a few sites, the modified Fluxnet-Canada method performed poorly, including sites where temperature was not the primary control on the seasonal cycle of RE (e.g. USSO2, USTon, and USVar, see Table A1), or where part of the year included no night (e.g. UAAtq and USBrw). We are exploring simple methodological improvements to correct these shortcomings.

## 3. Evaluating the $u_*^{Th}$

The analyses required automated evaluation of the low-$u_*$ threshold ($u_*^{Th}$) filter that is used to identify and reject bad NEE measurements during low-turbulence periods at night (Appendix C). The $u_*^{Th}$ detection algorithm was patterned after Papale et al. (2006) as implemented in the La Thuile FLUXNET synthesis but with modifications as described in Appendix C. Results for the $u_*^{Th}$ are given in Table A2, Appendix A.

Following Papale et al. (2005), we evaluated the $u_*^{Th}$ for each site-year of data, stratified into four quarters per year and up to seven temperature classes per quarter. For each of the four by seven strata, the $u_*^{Th}$ was determined from a plot of binned mean nighttime NEE (or $F_c$, the $CO_2$ eddy flux without storage, when the storage flux was not available) versus $u_*$. We modified the $u_*^{Th}$ algorithm with respect to the details used to stratify and bin the data, the method used to assign the $u_*^{Th}$ within each stratum, and the computation of the annual $u_*^{Th}$ from the stratified values (Appendix C). The new $u_*^{Th}$ algorithm included robust detection of cases where no distinct $u_*^{Th}$ was found. The failure rate was high at some sites (Tables A1 and A2).

At some sites with sparse NEE data, where an annual analysis was not possible, a single (multi-year) analysis was done on all years combined. The multi-year analysis often produced smaller uncertainties than the annual analysis, depending on the combined sample size.

Uncertainty in the $u_*^{Th}$ was estimated by bootstrapping, conducted annually with 1,000 draws per site-year, then pooling of all years and calculation of the lower and upper 95% confidence intervals from the median and the 2.5 and 97.5 percentiles of the pooled $u_*^{Th}$ values. Individual annual bootstrap estimates were rejected when any quarter has less than two strata with significant $u_*^{Th}$, as determined by an F test (Appendix C). The uncertainty analysis was limited to sites where the data were dense enough to support an annual analysis. The site-specific $u_*^{Th}$ was set to the median of the pooled bootstrap annual estimates.

## 4. Evaluating Uncertainty in NEE, RE and GPP Associated with the $u_*^{Th}$

The uncertainties in NEE, RE and GPP associated with uncertainties in the $u_*^{Th}$ were evaluated by running the modified Fluxnet-Canada gap-filling routine (Appendix B) at 1,000 $u_*^{Th}$ values, drawn randomly from the pooled annual bootstrapping estimates. This produced 1,000 realizations of the gap-filled NEE, RE and GPP time series. The uncertainties in NEE, RE and GPP, estimated as the upper and lower 95% confidence intervals, were estimated from median and the 2.5 and 97.5 percentiles of the gap-filled data, aggregated over several time scales.

## 5. Random Uncertainty

Random uncertainty in NEE, RE and GPP, reported as symmetric 95% confidence intervals, were estimated following Richardson et al. (2007). The NEE random uncertainty characteristic curve, which characterizes random uncertainty in NEE as a function of NEE, was estimated for each site-year based on the differences between the measured data and the output of the gap-filling model (Appendix B). The estimation procedure begins with synthetic NEE data generated by the gap-filling model, introduces gaps (the same gaps as in the measured data after $u_*^{Th}$ filtering), adds synthetic noise (defined by the NEE random uncertainty characteristic curve using a Monte-Carlo approach), then fills gaps in the noisy, gappy synthetic data. The process was repeated 1,000 times for each site-year, and the random uncertainty was estimated from median and the 2.5 and 97.5 percentiles of the gap-filled data, aggregated over several time scales.

## 6. Ongoing Analyses

### *6.1. Seasonality of $u_*^{Th}$*

We assessed seasonality in the $u_*^{Th}$ in two ways:

6.1.1. Four-season
by comparing estimates from the four quarterly strata in 2, and

6.1.2. Seasonal
by estimating seasonal variation in $u_*^{Th}$ using a moving window, applied once (without bootstrapping) to the entire multi-year time series. The window size was flexible, with two constraints: it could not exceed 122 days, and it must contain between 4 and 8 temperature strata with 250 (or 150) points per stratum (i.e. 50 $u_*$ bins with 5 (30-min data) or 3 (60-min data) points per bin). The window was moved to provide 50% overlap between adjacent windows. The mean Julian day $t$ was computed for each stratum and the entire ($t$, $u_*^{Th}$) data set was fit to an annual sine curve:

$$u_*^{Th} = a_0 + a_1 \sin(\omega(t - a_2)) \qquad (2)$$

where $\omega$ is $2\pi/365.25$. Equation 2 was then used to estimate a seasonally-varying $u_*^{Th}$, identical for all years.

Table A2 (Appendix A) gives a summary of the $u_*^{Th}$ by site.

### *6.2. Impacts of NEE outlier rejection*

We tested the sensitivities of (a) annual NEE, RE and GEP, and (b) random uncertainty in NEE, RE and GEP, to four levels of NEE outlier rejection for all site-years (Table 2).

Table 2: Values of limits $n_s$ and $n_c$ (5.2.1 and 5.2.2) used to exclude NEE outliers.

| | **Level** | $n_s$ | $n_c$ |
|---|---|---|---|
| **0** | Off | n/a | n/a |
| **1** | Mild | 7 | 2*7 |
| **2** | Moderate | 5 | 2*5 |
| **3** | High | 3 | 2*3 |

Outliers in NEE were found in three passes:

6.2.1. NEE, spike detection
following Papale et al. (2009) but extended to include periods with missing adjacent values. Spikes were detected as:

$$abs(d_i) > n_s s_d \quad \text{where} \quad d_i = x_i - (x_{i-1} + x_{i+1})/2,$$

and

$$abs(\hat{d}_i) > n_s s_d \quad \text{where} \quad \hat{d}_i = x_i - (\hat{x}_{i-1} + \hat{x}_{i+1})/2,$$

where the subscript $i$ denotes the period, $n_s$ defines the limits (Table 2), $s_d$ is the annual standard deviation of $d$, $x$ is NEE, and $\hat{x}$ is the NEE estimate from the gap-filling model.

6.2.2. NEE bias, asymmetric confidence intervals
applied to the bias $b$ between measured NEE and the NEE estimate from the gap-filling model. Outliers were detected as:

$$(q_b^1 - b_i) > n_c (q_b^2 - q_b^1)$$

and

$$(b_i - q_b^3) > n_c (q_b^3 - q_b^2)$$

where $b$ is the NEE bias $(x - \hat{x})$ (measured - modeled), $n_c$ defines limits (Table 2), and $q_b^1$, $q_b^2$ and $q_b^3$ are the lower, middle and upper $b$ quartiles. For each point, the quartiles were estimated using a window of 28 days centered on the point.

6.2.3. NEE bias, spike detection
repeats 5.2.1 but based on NEE bias rather than NEE.

## References


Barr AG, Black TA, Hogg EH et al. 2004. Inter-annual variability in the leaf area index of a boreal aspen-hazelnut forest in relation to net ecosystem production. *Agricultural Forest Meteorology*, 126: 237-255.

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processing of Net Ecosystem Exchange measured with eddy covariance technique: algorithms and uncertainty estimation. *Biogeosciences*, 3: 571-583
Richardson AD and Hollinger DY. 2007. A method to estimate the additional uncertainty in gap-filled NEE resulting from long gaps in the CO2 flux record. *Agricultural and Forest Meteorology*, 147, 199-208.

## Appendix A: Analysis Summaries

Table A1: Analysis notes. Except where stated otherwise, the analysis produced stable results.

| Site | Analysis Notes and Issues |
|---|---|
| CACa1 | • The CACa1, CACa2 and CACa3 sites are the only Canadian sites where the PI-preferred gap-filling departs from the standard Fluxnet-Canada gap-filling method. The modified method is identical to the Fluxnet-Canada method except for the RE = $f(T_s)$ relationship; the CACa* sites model RE as log(RE) = $a_0 + a_1 T_s$. At these sites and especially at CACa1, this modification reduces RE more than GPP, thus making NEE considerably more negative. |
| CACa2 | • See note for CACa1. |
| CACa3 | • See note for CACa1. |
| CAGro | • The NEE, RE and GPP data in the NACP database do not sum to zero for 2005. |
| CALet | • The large random uncertainties 2007 probably result from a weakness of the gap-filling method for site-years where soil temperature explains only a limited fraction of the variance in RE. |
| CAMer | • The NEE versus $u_*$ relationship used to identify the $u_*^{Th}$ was atypical in that NEE was enhanced not suppressed at low $u_*$. Because the response was subtle, the $u_*^{Th}$ analysis often failed to find a distinct change point. |
| CANS1 | • Because NEE was often missing, missing NEE values were replaced with $F_c$ (i.e., the eddy flux without storage) in all analyses. |
| CAOas | |
| CAObs | |
| CAOjp | |
| CAQfo | • The $u_*^{Th}$ had strong seasonality (Table A2) which may weaken the results obtained using a fixed $u_*^{Th}$ at this site. |
| CASJ1 | • The $u_*^{Th}$ analysis often failed to find a distinct change point. |
| CASJ2 | • The $u_*^{Th}$ analysis often failed to find a distinct change point. |
| CASJ3 | |
| CATP4 | • The $u_*^{Th}$ had strong seasonality (Table A2) which may weaken the results obtained using a fixed $u_*^{Th}$ at this site. |
| CAWP1 | |
| USARM | • The large random uncertainties in 2006 and esp. 2007 probably reflect a weakness of the gap-filling method or a problem in the input data.<br>• The $u_*^{Th}$ analysis often failed to find a distinct change point. |
| USAtq | • The processing algorithms failed at this site and will require modification. |
| USBrw | • The processing algorithms failed at this site and will require modification. |
| USDk2 | • The processing algorithms failed at this site and will require modification. |
| USDk3 | • Many outputs seem questionable, with unusual interannual variability and very high uncertainty estimates. The cause may be a weakness in the processing methods. |

| | |
|---|---|
| | • Years 1998-2002 have too few good RE values to characterize the annual RE cycle.<br>• The $u_*^{Th}$ analysis often failed to find a distinct change point.<br>• The NEE versus $u_*$ relationship used to identify the $u_*^{Th}$ was atypical in that NEE was enhanced not suppressed at low $u_*$. |
| USHa1 | • The $u_*^{Th}$ analysis often failed to find a distinct change point.<br>• The $u_*^{Th}$ had strong seasonality (Table A2) which may weaken the results obtained using a fixed $u_*^{Th}$ at this site. |
| USHo1 | |
| USIB1 | |
| USIB2 | |
| USLos | • Missing NEE values were replaced with $F_c$ (i.e., the eddy flux without storage) in all analyses. |
| USMMS | |
| USMe2 | • The $u_*^{Th}$ analysis often failed to find a distinct change point. |
| USMe3 | |
| USMe4 | • Unidentified processing problems. |
| USMe5 | • The $u_*^{Th}$ analysis often failed to find a distinct change point. |
| USMoz | • The $u_*^{Th}$ had strong seasonality (Table A2) which may weaken the results obtained using a fixed $u_*^{Th}$ at this site. |
| USNR1 | • The $u_*^{Th}$ had strong seasonality (Table A2) which may weaken the results obtained using a fixed $u_*^{Th}$ at this site. |
| USNe1 | • The $u_*^{Th}$ analysis often failed to find a distinct change point. |
| USNe2 | • The $u_*^{Th}$ analysis often failed to find a distinct change point.<br>• We have not allowed for interannual differences in the $u_*^{Th}$ associated with crop rotation. |
| USNe3 | • The $u_*^{Th}$ analysis often failed to find a distinct change point.<br>• We have not allowed for interannual differences in the $u_*^{Th}$ associated with crop rotation. |
| USPFa | |
| USSO2 | • The gap-filling and partitioning analysis produced questionable outputs in most years, esp. 2002. |
| USShd | |
| USSyv | • The $u_*^{Th}$ analysis often failed to find a distinct change point. |
| USTon | • The $u_*^{Th}$ analysis often failed to find a distinct change point. |
| USUMB | • The $u_*^{Th}$ analysis often failed to find a distinct change point. |
| USVar | • Many outputs seem questionable, with unusual interannual variability and high uncertainty estimates. The cause may be a weakness in the gap-filling method at sites where soil temperature explains only a limited fraction of the variance in RE.<br>• The $u_*^{Th}$ analysis often failed to find a distinct change point. |
| USWCr | • The standard processing seems to have failed for 2001.<br>• The $u_*^{Th}$ had strong seasonality (Table A2) which may weaken the results obtained using a fixed $u_*^{Th}$ at this site. |

**Table A2** Analysis of the $u_*$ threshold $u_*^{Th}$ (m s$^{-1}$) used to exclude eddy-covariance NEE measurements during low wind speed periods at night, including annual mean, quarterly medians, and moving window analysis fit to Equation 2.

| | | | | | **Annual (Bootstrap)** | | | | **Quarterly Medians** | | | | **Moving Window (Equation 2)** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Site** | **Analysis Period** [1] | **Flux** | **% Sig**[2] | **% Ex**[3] | **n**[4] | **Prc 2.5** | **Mdn** | **Prc 97.5** | **DJF** | **MA M** | **JJA** | **SON** | **n** | **Mdn** | $a_0$ | $a_1$ | $a_2$ | $r^2$ |
| | | | | | | | | | | | | | | | | | | |
| CACa1 | Ann | NEE | 63 | 74 | 5640 | 0.28 | 0.34 | 0.44 | 0.34 | 0.35 | 0.39 | 0.29 | 669 | 0.34 | 0.35 | 0.05 | 70 | 0.08 |
| CACa2 | Ann | NEE | 45 | 77 | 2623 | 0.09 | 0.12 | 0.14 | 0.10 | 0.13 | 0.12 | 0.11 | 303 | 0.12 | 0.12 | 0.01 | 64 | 0.08 |
| CACa3 | Ann | NEE | 52 | 73 | 2099 | 0.15 | 0.17 | 0.22 | 0.15 | 0.18 | 0.18 | 0.18 | 279 | 0.19 | 0.19 | 0.01 | 245 | 0.00 |
| CAGro | Ann | $F_c$ | 55 | 66 | 1006 | 0.33 | 0.44 | 0.55 | 0.55 | 0.44 | 0.43 | 0.33 | 201 | 0.39 | 0.40 | 0.06 | 11 | 0.05 |
| CALet | Ann | NEE | 62 | 54 | 4758 | 0.15 | 0.20 | 0.32 | 0.23 | 0.20 | 0.18 | 0.19 | 748 | 0.21 | 0.21 | 0.01 | 303 | 0.00 |
| CAMer | Ann | NEE | 51 | 44 | 3015 | 0.07 | 0.12 | 0.19 | 0.17 | 0.11 | 0.06 | 0.10 | 327 | 0.14 | 0.14 | 0.04 | 293 | 0.09 |
| CANS1 | Ann | $F_c$ | 60 | 61 | 3067 | 0.25 | 0.33 | 0.42 | 0.48 | 0.29 | 0.28 | 0.23 | 545 | 0.29 | 0.31 | 0.08 | 328 | 0.14 |
| CAOas | Ann | NEE | 61 | 44 | 7162 | 0.24 | 0.31 | 0.45 | 0.29 | 0.35 | 0.25 | 0.30 | 759 | 0.34 | 0.34 | 0.05 | 298 | 0.04 |
| CAObs | Ann | NEE | 83 | 55 | 5870 | 0.22 | 0.28 | 0.34 | 0.27 | 0.25 | 0.28 | 0.28 | 584 | 0.28 | 0.28 | 0.03 | 229 | 0.02 |
| CAOjp | Ann | NEE | 56 | 50 | 3881 | 0.18 | 0.25 | 0.39 | 0.34 | 0.24 | 0.21 | 0.21 | 437 | 0.27 | 0.27 | 0.06 | 294 | 0.07 |
| CAQfo | Ann | $F_c$ | 52 | 60 | 1705 | 0.28 | 0.39 | 0.49 | 0.51 | 0.42 | 0.26 | 0.36 | 219 | 0.37 | 0.40 | 0.17 | 290 | 0.27 |
| CASJ1 | MYr | NEE | 33 | 69 | 65 | 0.34 | 0.44 | 0.52 | 0.57 | 0.50 | 0.19 | 0.52 | 43 | 0.37 | | | | |
| CASJ2 | Ann | NEE | 27 | 53 | 268 | 0.10 | 0.14 | 0.17 | 0.29 | 0.08 | 0.11 | 0.08 | 111 | 0.14 | | | | |
| CASJ3 | Ann | $F_c$ | 61 | 66 | 1234 | 0.25 | 0.31 | 0.37 | 0.43 | 0.27 | 0.29 | 0.25 | 150 | 0.31 | 0.32 | 0.07 | 321 | 0.11 |
| CATP4 | Ann | $F_c$ | 53 | 57 | 2914 | 0.36 | 0.45 | 0.61 | 0.83 | 0.42 | 0.31 | 0.29 | 372 | 0.46 | 0.50 | 0.23 | 308 | 0.34 |
| CAWP1 | Ann | NEE | 54 | 50 | 2478 | 0.07 | 0.12 | 0.21 | 0.14 | 0.11 | 0.14 | 0.09 | 323 | 0.13 | 0.13 | 0.03 | 261 | 0.04 |
| USARM | Ann | NEE | 23 | 64 | 247 | 0.24 | 0.29 | 0.36 | 0.45 | 0.19 | 0.17 | 0.31 | 69 | 0.29 | | | | |
| USAtq | MYr | NEE | | | | | | | | | | | 31 | 0.31 | | | | |
| USBrw | MYr | NEE | | | | | | | | | | | | | | | | |
| USDk2 | MYr | NEE | | | | | | | | | | | 39 | 0.37 | | | | |
| USDk3 | MYr | NEE | 19 | 63 | 170 | 0.23 | 0.31 | 0.39 | 0.35 | 0.37 | 0.23 | 0.28 | 84 | 0.28 | | | | |
| USHa1 | Ann | NEE | 36 | 66 | 543 | 0.35 | 0.49 | 0.67 | 0.75 | 0.60 | 0.19 | 0.45 | 225 | 0.46 | 0.49 | 0.33 | 302 | 0.61 |
| USHo1 | Ann | NEE | 49 | 53 | 3098 | 0.20 | 0.27 | 0.36 | 0.30 | 0.27 | 0.21 | 0.26 | 434 | 0.27 | 0.28 | 0.05 | 306 | 0.06 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USIB1 | Ann | $F_c$ | 67 | 54 | 944 | 0.12 | 0.17 | 0.23 | 0.27 | 0.21 | 0.12 | 0.07 | 165 | 0.17 | 0.18 | 0.11 | 318 | 0.45 |
| USIB2 | Ann | $F_c$ | 54 | 51 | 779 | 0.11 | 0.19 | 0.24 | 0.43 | 0.12 | 0.13 | 0.08 | 161 | 0.17 | 0.18 | 0.08 | 293 | 0.17 |
| USLos | Ann | $F_c$ | 84 | 46 | 5999 | 0.12 | 0.15 | 0.21 | 0.16 | 0.13 | 0.14 | 0.14 | 610 | 0.17 | 0.16 | 0.03 | 300 | 0.04 |
| USMMS | Ann | $F_c$ | 43 | 64 | 980 | 0.33 | 0.45 | 0.57 | 0.61 | 0.42 | 0.34 | 0.40 | 218 | 0.43 | 0.43 | 0.14 | 311 | 0.21 |
| USMe2 | Ann | NEE | 80 | 54 | 252 | 0.51 | 0.65 | 0.73 | 0.76 | 0.69 | 0.64 | 0.53 | 39 | 0.62 | | | | |
| USMe3 | Ann | $F_c$ | 67 | 72 | 1143 | 0.18 | 0.23 | 0.30 | 0.25 | 0.24 | 0.23 | 0.20 | 112 | 0.22 | 0.22 | 0.03 | 354 | 0.10 |
| USMe4 | | NEE | | | | | | | | | | | 31 | 0.16 | | | | |
| USMe5 | MYr | $F_c$ | 44 | 52 | 176 | 0.13 | 0.24 | 0.40 | 0.38 | 0.29 | 0.13 | 0.15 | 146 | 0.17 | | | | |
| USMoz | Ann | $F_c$ | 51 | 67 | 1585 | 0.27 | 0.34 | 0.44 | 0.56 | 0.30 | 0.26 | 0.25 | 232 | 0.36 | 0.38 | 0.16 | 297 | 0.32 |
| USNR1 | Ann | NEE | 46 | 56 | 3953 | 0.28 | 0.54 | 0.85 | 0.81 | 0.40 | 0.37 | 0.43 | 611 | 0.59 | 0.62 | 0.35 | 288 | 0.29 |
| USNe1 | MYr | NEE | 25 | 58 | 120 | 0.12 | 0.22 | 0.29 | 0.32 | 0.24 | 0.15 | 0.14 | 126 | 0.17 | 0.17 | 0.03 | 339 | 0.03 |
| USNe2 | Ann | NEE | 40 | 49 | 541 | 0.09 | 0.14 | 0.23 | 0.21 | 0.10 | 0.12 | 0.10 | 147 | 0.16 | 0.16 | 0.05 | 339 | 0.08 |
| USNe3 | Ann | NEE | 34 | 45 | 376 | 0.09 | 0.15 | 0.25 | 0.14 | 0.15 | 0.11 | 0.13 | 148 | 0.16 | 0.16 | 0.04 | 311 | 0.04 |
| USPFa | MYr | $F_c$ | 54 | 70 | | | | | | | | | 60 | 0.33 | | | | |
| USSO2 | Ann | $F_c$ | 54 | 70 | 2636 | 0.17 | 0.23 | 0.31 | 0.23 | 0.29 | 0.15 | 0.23 | 378 | 0.24 | 0.24 | 0.10 | 293 | 0.20 |
| USShd | Ann | $F_c$ | 57 | 51 | 1460 | 0.16 | 0.22 | 0.28 | 0.24 | 0.25 | 0.23 | 0.14 | 271 | 0.25 | 0.24 | 0.04 | 331 | 0.05 |
| USSyv | MYr | NEE | 47 | 49 | 122 | 0.39 | 0.49 | 0.60 | 0.57 | 0.42 | 0.58 | 0.38 | 59 | 0.45 | | | | |
| USTon | Ann | NEE | 31 | 75 | 381 | 0.18 | 0.23 | 0.28 | 0.24 | 0.23 | 0.20 | 0.23 | 209 | 0.24 | 0.24 | 0.03 | 321 | 0.09 |
| USUMB | Ann | NEE | 57 | 61 | 686 | 0.32 | 0.40 | 0.53 | 0.43 | 0.39 | 0.38 | 0.37 | 149 | 0.39 | 0.39 | 0.01 | 302 | 0.00 |
| USVar | Ann | NEE | 35 | 78 | 284 | 0.10 | 0.14 | 0.16 | 0.16 | 0.13 | 0.12 | 0.14 | 178 | 0.13 | 0.13 | 0.01 | 239 | 0.01 |
| USWCr | Ann | $F_c$ | 57 | 45 | 2574 | 0.33 | 0.40 | 0.51 | 0.59 | 0.44 | 0.25 | 0.28 | 258 | 0.45 | 0.41 | 0.18 | 302 | 0.32 |

[1] Ann (annual) -- the $u_*^{Th}$ and its uncertainty were analyzed separately for each year; MYr (multi-year) -- the $u_*^{Th}$ and its uncertainty were analyzed for all years combined because the data were too sparse to support an annual analysis.

[2] Percentage of cases (strata) when the change-point detection algorithm found a significant $u_*^{Th}$.

[3] Percentage of nighttime NEE data excluded by median annual $u_*^{Th}$.

[4] Number of bootstraps, summed over all years, that successfully produced annual estimates of $u_*^{Th}$, i.e., that had at least two strata with significant $u_*^{Th}$ values in each of the four quarters.

**Table A3** Annual NEE, RE and GPP (g C $m^{-2}$ $y^{-1}$) and its uncertainty. The annual fluxes are from the NACP database (PI-preferred values for Canadian sites and La Thuile MDS estimates for US sites) and from a reprocessing using the modified Fluxnet-Canada gap-filling method (Appendix B) with fixed annual and seasonally varying $u_*^{Th}$ (Table A2). The uncertainties are symmetric 95% confidence intervals for (a) random uncertainty and (b) the uncertainty associated with uncertainty in the $u_*^{Th}$.

Notes:

- *Values are missing where the site-year had a data gap of 31 days or longer, or where the algorithm failed to identify the* $u_*^{Th}$.
- *A few values (included but not flagged) are questionable and may show a failure of the processing methods for these site-years.*
- *The uncertainties associated with uncertainty in the* $u_*^{Th}$ *are based on an annual bootstrapping analysis at most sites. At a few sites where the NEE data were to sparse to support an annual analysis (Table A1), a single (multi-year) analysis was done on all years combined.*

| | | **NACP Database (PI values for CA, LaThuile for US)** | | | **Reprocessed Moving $u_*^{Th}$** | | | **Reprocessed Fixed $u_*^{Th}$** | | | **Random Uncertainty (95% CI)** | | | **Uncertainty from $u_*^{Th}$ (95% CI)** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **NEE** | **RE** | **GPP** | **NEE** | **RE** | **GPP** | **NEE** | **RE** | **GPP** | **NEE** | **RE** | **GPP** | **NEE** | **RE** | **GPP** |
| | | | | | | | | | | | | | | | | |
| CACa1 | 1998 | -379 | 1752 | 2131 | -312 | 2010 | 2322 | -300 | 2030 | 2330 | 56 | 150 | 103 | 19 | 46 | 30 |
| CACa1 | 1999 | -382 | 1642 | 2024 | -262 | 1981 | 2243 | -273 | 1944 | 2217 | 59 | 122 | 76 | 28 | 63 | 36 |
| CACa1 | 2000 | -400 | 1693 | 2093 | -282 | 1999 | 2281 | -287 | 1990 | 2276 | 57 | 121 | 70 | 23 | 56 | 33 |
| CACa1 | 2001 | -410 | 1667 | 2077 | -285 | 2053 | 2338 | -297 | 2023 | 2320 | 56 | 128 | 78 | 22 | 61 | 38 |
| CACa1 | 2002 | -277 | 1676 | 1953 | -124 | 2033 | 2157 | -118 | 2027 | 2146 | 55 | 112 | 66 | 42 | 94 | 53 |
| CACa1 | 2003 | -353 | 1725 | 2078 | -253 | 2009 | 2261 | -257 | 1986 | 2243 | 46 | 98 | 61 | 33 | 76 | 43 |
| CACa1 | 2004 | -267 | 2071 | 2338 | -149 | 2349 | 2498 | -151 | 2338 | 2489 | 63 | 138 | 82 | 28 | 71 | 43 |
| CACa1 | 2005 | -355 | 1955 | 2310 | -228 | 2272 | 2500 | -241 | 2232 | 2473 | 57 | 113 | 69 | 17 | 52 | 35 |
| CACa1 | 2006 | -386 | 1726 | 2112 | -273 | 2028 | 2301 | -275 | 2017 | 2291 | 49 | 99 | 62 | 22 | 49 | 28 |
| | | | | | | | | | | | | | | | | |
| CACa2 | 2001 | 535 | 698 | 163 | 606 | 919 | 313 | 602 | 907 | 306 | 28 | 54 | 31 | 26 | 63 | 38 |
| CACa2 | 2002 | 570 | 1099 | 530 | 625 | 1161 | 536 | 613 | 1127 | 514 | 26 | 54 | 31 | 19 | 41 | 24 |
| CACa2 | 2003 | 580 | 1202 | 622 | 624 | 1269 | 644 | 622 | 1258 | 635 | 23 | 49 | 30 | 7 | 15 | 10 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CACa2 | 2004 | 593 | 1453 | 859 | 655 | 1515 | 860 | 647 | 1494 | 847 | 30 | 65 | 38 | 9 | 25 | 17 |
| CACa2 | 2005 | 422 | 1533 | 1111 | 456 | 1517 | 1061 | 456 | 1519 | 1063 | 30 | 67 | 41 | 13 | 33 | 20 |
| CACa2 | 2006 | 420 | 1204 | 784 | 492 | 1372 | 879 | 490 | 1358 | 868 | 29 | 75 | 50 | 16 | 54 | 38 |
| | | | | | | | | | | | | | | | | |
| CACa3 | 2002 | 121 | 1393 | 1272 | 161 | 1513 | 1352 | 152 | 1486 | 1334 | 39 | 92 | 72 | 17 | 45 | 28 |
| CACa3 | 2003 | 99 | 1306 | 1207 | 120 | 1430 | 1310 | 115 | 1416 | 1301 | 35 | 66 | 44 | 20 | 50 | 32 |
| CACa3 | 2004 | 133 | 1589 | 1457 | 167 | 1702 | 1535 | 167 | 1702 | 1534 | 28 | 56 | 38 | 22 | 61 | 39 |
| CACa3 | 2005 | -20 | 1674 | 1694 | 9 | 1825 | 1816 | 7 | 1815 | 1807 | 30 | 74 | 54 | 17 | 47 | 30 |
| CACa3 | 2006 | -15 | 1475 | 1490 | 23 | 1654 | 1632 | 15 | 1633 | 1619 | 27 | 63 | 47 | 27 | 76 | 49 |
| | | | | | | | | | | | | | | | | |
| CAGro | 2004 | -111 | 851 | 962 | | | | | | | | | | | | |
| CAGro | 2005 | -71 | 958 | 1031 | -51 | 1059 | 1109 | -46 | 1064 | 1110 | 32 | 59 | 43 | 14 | 39 | 26 |
| CAGro | 2006 | -93 | 1027 | 1086 | -32 | 1133 | 1165 | -27 | 1145 | 1172 | 28 | 56 | 43 | 16 | 37 | 21 |
| | | | | | | | | | | | | | | | | |
| CALet | 1999 | | | | | | | | | | | | | | | |
| CALet | 2000 | | | | 12 | 269 | 257 | 12 | 269 | 257 | 7 | 11 | 8 | 3 | 10 | 7 |
| CALet | 2001 | | | | -17 | 240 | 258 | -18 | 240 | 258 | 8 | 9 | 9 | 6 | 16 | 10 |
| CALet | 2002 | | | | -295 | 527 | 822 | -295 | 527 | 822 | 13 | 21 | 19 | 6 | 22 | 16 |
| CALet | 2003 | | | | -230 | 439 | 669 | -230 | 438 | 668 | 14 | 16 | 17 | 6 | 21 | 15 |
| CALet | 2004 | | | | -117 | 500 | 618 | -117 | 502 | 619 | 13 | 24 | 20 | 4 | 16 | 12 |
| CALet | 2005 | | | | -260 | 588 | 849 | -261 | 587 | 848 | 14 | 24 | 21 | 10 | 36 | 26 |
| CALet | 2006 | | | | -124 | 377 | 501 | -124 | 378 | 502 | 11 | 16 | 14 | 7 | 21 | 15 |
| CALet | 2007 | | | | -30 | 148 | 178 | -30 | 148 | 178 | 18 | 59 | 90 | 17 | 66 | 95 |
| | | | | | | | | | | | | | | | | |
| CAMer | 1999 | -65 | 582 | 646 | -61 | 555 | 617 | -65 | 560 | 626 | 15 | 54 | 51 | 10 | 4 | 13 |
| CAMer | 2000 | -32 | 431 | 463 | -38 | 463 | 501 | -39 | 468 | 507 | 12 | 28 | 24 | 22 | 28 | 9 |
| CAMer | 2001 | -2 | 541 | 543 | 2 | 540 | 539 | -12 | 520 | 532 | 12 | 30 | 27 | 34 | 61 | 27 |
| CAMer | 2002 | -13 | 498 | 511 | -21 | 492 | 513 | -26 | 479 | 504 | 11 | 21 | 16 | 24 | 41 | 20 |
| CAMer | 2003 | -15 | 480 | 495 | -17 | 511 | 528 | -23 | 498 | 521 | 13 | 39 | 33 | 27 | 50 | 24 |
| CAMer | 2004 | -115 | 568 | 683 | -129 | 587 | 716 | -134 | 581 | 715 | 11 | 22 | 18 | 13 | 20 | 7 |

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| CAMer | 2005 | -90 | 597 | 687 | -100 | 617 | 717 | -102 | 614 | 716 | 10 | 20 | 15 | 7 | 14 | 7 |
| CAMer | 2006 | -148 | 624 | 772 | -149 | 655 | 804 | -147 | 664 | 811 | 11 | 20 | 14 | 7 | 19 | 13 |
| | | | | | | | | | | | | | | | | |
| CANS1 | 1994 | 168 | 796 | 614 | | | | | | | | | | | | |
| CANS1 | 1995 | 40 | 828 | 783 | 36 | 705 | 668 | 47 | 757 | 709 | 26 | 51 | 43 | 6 | 27 | 23 |
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| CANS1 | 1997 | 39 | 745 | 700 | | | | | | | | | | | | |
| CANS1 | 1998 | -6 | 764 | 768 | | | | | | | | | | | | |
| CANS1 | 1999 | -6 | 746 | 744 | | | | | | | | | | | | |
| CANS1 | 2000 | -10 | 690 | 691 | -12 | 607 | 619 | -8 | 628 | 636 | 32 | 36 | 51 | 11 | 86 | 11 |
| CANS1 | 2001 | -22 | 710 | 729 | -13 | 615 | 628 | -4 | 653 | 656 | 17 | 36 | 29 | 8 | 24 | 17 |
| CANS1 | 2002 | -24 | 585 | 607 | 42 | 537 | 495 | 53 | 572 | 520 | 17 | 37 | 30 | 13 | 34 | 21 |
| CANS1 | 2003 | -57 | 637 | 692 | 65 | 618 | 553 | 80 | 656 | 576 | 20 | 48 | 39 | 25 | 74 | 49 |
| CANS1 | 2004 | -19 | 614 | 623 | -29 | 465 | 494 | -32 | 471 | 503 | 13 | 33 | 29 | 3 | 13 | 11 |
| CANS1 | 2005 | -5 | 697 | 697 | -22 | 547 | 568 | -23 | 550 | 573 | 15 | 25 | 20 | 2 | 6 | 4 |
| CANS1 | 2006 | -73 | 710 | 781 | -73 | 642 | 715 | -84 | 645 | 729 | 21 | 58 | 57 | 9 | 16 | 8 |
| | | | | | | | | | | | | | | | | |
| CAOas | 1997 | -123 | 1015 | 1139 | -100 | 1035 | 1134 | -103 | 1031 | 1134 | 22 | 35 | 27 | 22 | 45 | 23 |
| CAOas | 1998 | -263 | 951 | 1214 | -249 | 979 | 1228 | -249 | 978 | 1228 | 21 | 35 | 29 | 28 | 89 | 61 |
| CAOas | 1999 | -116 | 965 | 1081 | -116 | 983 | 1099 | -113 | 996 | 1108 | 19 | 32 | 25 | 22 | 65 | 43 |
| CAOas | 2000 | -144 | 945 | 1088 | -138 | 961 | 1099 | -138 | 964 | 1102 | 18 | 30 | 24 | 11 | 27 | 17 |
| CAOas | 2001 | -325 | 892 | 1217 | -332 | 902 | 1235 | -332 | 903 | 1235 | 22 | 33 | 28 | 28 | 79 | 51 |
| CAOas | 2002 | -125 | 766 | 891 | -124 | 773 | 896 | -120 | 783 | 903 | 18 | 23 | 21 | 21 | 54 | 33 |
| CAOas | 2003 | -94 | 823 | 917 | -100 | 817 | 916 | -100 | 816 | 916 | 15 | 23 | 20 | 13 | 36 | 22 |
| CAOas | 2004 | -16 | 842 | 858 | -15 | 862 | 877 | -13 | 867 | 880 | 15 | 26 | 22 | 23 | 68 | 45 |
| CAOas | 2005 | -122 | 924 | 1046 | -119 | 968 | 1087 | -120 | 963 | 1083 | 17 | 26 | 22 | 16 | 48 | 32 |
| CAOas | 2006 | -281 | 1024 | 1305 | -293 | 1014 | 1308 | -292 | 1023 | 1315 | 19 | 32 | 26 | 32 | 93 | 60 |
| | | | | | | | | | | | | | | | | |
| CAObs | 2000 | -56 | 765 | 821 | -58 | 776 | 834 | -57 | 781 | 838 | 13 | 26 | 20 | 10 | 27 | 17 |
| CAObs | 2001 | -77 | 743 | 820 | -76 | 758 | 834 | -75 | 763 | 838 | 14 | 34 | 26 | 7 | 20 | 12 |

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| CAObs | 2002 | -30 | 684 | 714 | -28 | 685 | 713 | -29 | 683 | 712 | 14 | 26 | 20 | 7 | 20 | 13 |
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| | | | | | | | | | | | | | | | | |
| CAOjp | 2000 | -65 | 522 | 586 | -70 | 548 | 618 | -64 | 566 | 629 | 13 | 23 | 17 | 9 | 38 | 29 |
| CAOjp | 2001 | -37 | 578 | 614 | -53 | 558 | 611 | -45 | 586 | 631 | 13 | 29 | 20 | 7 | 30 | 23 |
| CAOjp | 2002 | 21 | 531 | 510 | 9 | 526 | 517 | 15 | 544 | 530 | 12 | 24 | 17 | 5 | 19 | 14 |
| CAOjp | 2003 | -24 | 529 | 553 | -22 | 556 | 579 | -19 | 563 | 582 | 12 | 23 | 17 | 5 | 17 | 13 |
| CAOjp | 2004 | -4 | 556 | 560 | -15 | 575 | 590 | -15 | 581 | 597 | 17 | 32 | 25 | 6 | 22 | 16 |
| CAOjp | 2005 | -36 | 558 | 594 | -36 | 606 | 642 | -39 | 594 | 634 | 13 | 26 | 20 | 6 | 13 | 7 |
| CAOjp | 2006 | -33 | 606 | 639 | -59 | 582 | 641 | -42 | 640 | 681 | 21 | 54 | 41 | 20 | 60 | 36 |
| | | | | | | | | | | | | | | | | |
| CAQfo | 2004 | -8 | 582 | 590 | -41 | 559 | 600 | -22 | 619 | 641 | 17 | 28 | 19 | 24 | 58 | 35 |
| CAQfo | 2005 | -4 | 687 | 691 | -3 | 697 | 699 | 3 | 722 | 719 | 16 | 27 | 18 | 11 | 27 | 16 |
| CAQfo | 2006 | -25 | 632 | 657 | -19 | 685 | 704 | -22 | 680 | 703 | 13 | 23 | 16 | 8 | 18 | 10 |
| | | | | | | | | | | | | | | | | |
| CASJ1 | 2002 | | | | | | | | | | | | | 1 | 5 | 4 |
| CASJ1 | 2003 | | | | | | | 0 | 263 | 263 | 9 | 18 | 14 | 1 | 2 | 1 |
| CASJ1 | 2004 | -66 | 494 | 560 | | | | 59 | 452 | 392 | 11 | 32 | 23 | 6 | 14 | 9 |
| CASJ1 | 2005 | -79 | 513 | 592 | | | | 25 | 534 | 508 | 25 | 41 | 31 | 4 | 7 | 4 |
| | | | | | | | | | | | | | | | | |
| CASJ2 | 2003 | 152 | 225 | 72 | | | | | | | | | | | | |
| CASJ2 | 2004 | 155 | 245 | 89 | 150 | 223 | 74 | 154 | 243 | 88 | 5 | 14 | 12 | 2 | 5 | 4 |
| CASJ2 | 2005 | 123 | 222 | 99 | 104 | 215 | 111 | 105 | 222 | 117 | 6 | 17 | 14 | 2 | 5 | 4 |
| CASJ2 | 2006 | 173 | 453 | 280 | 98 | 277 | 179 | 92 | 267 | 175 | 6 | 19 | 15 | 3 | 8 | 6 |
| | | | | | | | | | | | | | | | | |
| CASJ3 | 2005 | 31 | 542 | 512 | -72 | 552 | 624 | -74 | 549 | 623 | 13 | 32 | 24 | 2 | 10 | 8 |
| CASJ3 | 2006 | | | | -98 | 528 | 626 | -90 | 556 | 646 | 21 | 57 | 45 | 8 | 31 | 23 |

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| CATP4 | 2003 | -219 | 1096 | 1330 | -220 | 1165 | 1385 | -223 | 1172 | 1394 | 20 | 30 | 24 | 10 | 21 | 12 |
| CATP4 | 2004 | -155 | 1180 | 1357 | -167 | 1220 | 1387 | -170 | 1223 | 1393 | 22 | 35 | 26 | 9 | 25 | 15 |
| CATP4 | 2005 | -36 | 1176 | 1237 | -38 | 1209 | 1247 | -34 | 1221 | 1256 | 30 | 55 | 38 | 10 | 26 | 16 |
| CATP4 | 2006 | -148 | 1292 | 1468 | -113 | 1387 | 1499 | -145 | 1338 | 1482 | 28 | 47 | 34 | 10 | 18 | 9 |
| CATP4 | 2007 | -120 | 1203 | 1354 | -92 | 1317 | 1409 | -94 | 1334 | 1429 | 34 | 66 | 44 | 23 | 53 | 30 |
| | | | | | | | | | | | | | | | | |
| CAWP1 | 2004 | 147 | 568 | 715 | -168 | 541 | 710 | -158 | 581 | 740 | 14 | 39 | 32 | 8 | 40 | 32 |
| CAWP1 | 2005 | 270 | 530 | 800 | -279 | 566 | 845 | -278 | 578 | 855 | 13 | 28 | 22 | 4 | 27 | 23 |
| CAWP1 | 2006 | | | | -187 | 690 | 877 | -183 | 703 | 886 | 15 | 69 | 66 | 7 | 24 | 19 |
| CAWP1 | 2007 | | | | -170 | 797 | 967 | -164 | 832 | 996 | 18 | 78 | 73 | 8 | 71 | 64 |
| | | | | | | | | | | | | | | | | |
| USARM | 2003 | -236 | 375 | 611 | -145 | 486 | 630 | -129 | 525 | 654 | 26 | 43 | 26 | 24 | 53 | 30 |
| USARM | 2004 | -269 | 357 | 626 | -203 | 489 | 692 | -198 | 510 | 707 | 31 | 54 | 36 | 24 | 68 | 44 |
| USARM | 2005 | -278 | 228 | 506 | -233 | 347 | 580 | -225 | 368 | 593 | 31 | 64 | 49 | 11 | 79 | 68 |
| USARM | 2006 | | | | 81 | 510 | 429 | 79 | 506 | 427 | 60 | 92 | 66 | 4 | 9 | 5 |
| USARM | 2007 | | | | -176 | 758 | 935 | -169 | 778 | 944 | 216 | 319 | 108 | 14 | 24 | 11 |
| | | | | | | | | | | | | | | | | |
| USAtq | 2003 | 12 | 10 | -2 | | | | | | | | | | | | |
| USAtq | 2004 | -25 | 31 | 55 | | | | | | | | | | | | |
| USAtq | 2005 | 10 | 64 | 55 | | | | | | | | | | | | |
| USAtq | 2006 | -87 | 94 | 181 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| USDk3 | 1998 | | | | | | | | | | | | | | | |
| USDk3 | 1999 | | | | | | | -114 | 1301 | 1415 | 214 | 412 | 207 | 76 | 158 | 82 |
| USDk3 | 2000 | | | | | | | -483 | 1044 | 1527 | 132 | 265 | 132 | 65 | 147 | 82 |
| USDk3 | 2001 | | | | | | | | | | | | | | | |
| USDk3 | 2002 | | | | | | | 248 | 2594 | 2346 | 242 | 468 | 245 | 72 | 269 | 39 |
| USDk3 | 2003 | | | | | | | -273 | 1499 | 1771 | 66 | 115 | 71 | 23 | 52 | 29 |
| USDk3 | 2004 | | | | | | | -592 | 1537 | 2129 | 64 | 115 | 68 | 27 | 56 | 30 |

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| USDk3 | 2005 | | | | | | | -886 | 1644 | 2530 | 62 | 99 | 61 | 32 | 81 | 49 |
| | | | | | | | | | | | | | | | | |
| USHa1 | 1992 | -138 | 970 | 1108 | -172 | 963 | 1135 | -190 | 954 | 1145 | 54 | 99 | 70 | 49 | 94 | 44 |
| USHa1 | 1993 | 418 | 2003 | 1586 | -127 | 1175 | 1301 | -164 | 1139 | 1302 | 63 | 119 | 85 | 50 | 90 | 43 |
| USHa1 | 1994 | -166 | 1008 | 1174 | -121 | 1098 | 1220 | -117 | 1142 | 1259 | 41 | 71 | 50 | 49 | 95 | 46 |
| USHa1 | 1995 | -252 | 999 | 1251 | -225 | 1021 | 1247 | -238 | 1018 | 1256 | 39 | 67 | 48 | 31 | 125 | 255 |
| USHa1 | 1996 | -101 | 1192 | 1294 | -158 | 1175 | 1334 | -148 | 1250 | 1399 | 45 | 89 | 58 | 48 | 168 | 255 |
| USHa1 | 1997 | -65 | 1295 | 1361 | -96 | 1295 | 1391 | -89 | 1360 | 1449 | 53 | 115 | 85 | 58 | 131 | 79 |
| USHa1 | 1998 | -108 | 1137 | 1245 | -85 | 1085 | 1170 | -89 | 1129 | 1218 | 45 | 80 | 56 | 34 | 174 | 269 |
| USHa1 | 1999 | -193 | 1166 | 1359 | -191 | 1178 | 1369 | -175 | 1245 | 1420 | 45 | 87 | 60 | 32 | 65 | 48 |
| USHa1 | 2000 | -269 | 1188 | 1457 | -216 | 1234 | 1450 | -262 | 1143 | 1405 | 42 | 64 | 45 | 44 | 84 | 41 |
| USHa1 | 2001 | -386 | 1172 | 1558 | -355 | 1233 | 1587 | -382 | 1157 | 1538 | 46 | 82 | 60 | 59 | 79 | 262 |
| USHa1 | 2002 | | | | -177 | 1371 | 1548 | -225 | 1309 | 1534 | 58 | 111 | 81 | 60 | 115 | 64 |
| USHa1 | 2003 | -123 | 1288 | 1412 | -151 | 1327 | 1478 | -116 | 1427 | 1543 | 59 | 124 | 83 | 76 | 353 | 587 |
| USHa1 | 2004 | -418 | 1271 | 1689 | -405 | 1267 | 1673 | -432 | 1227 | 1659 | 48 | 72 | 57 | 18 | 32 | 15 |
| USHa1 | 2005 | -312 | 977 | 1289 | | | | | | | | | | | | |
| USHa1 | 2006 | -471 | 1082 | 1553 | -405 | 1214 | 1619 | -416 | 1186 | 1601 | 43 | 70 | 51 | 15 | 33 | 23 |
| | | | | | | | | | | | | | | | | |
| USHo1 | 1996 | -218 | 1143 | 1361 | -171 | 1254 | 1424 | -172 | 1252 | 1424 | 36 | 66 | 44 | 16 | 39 | 23 |
| USHo1 | 1997 | -242 | 1075 | 1317 | -184 | 1213 | 1397 | -180 | 1228 | 1408 | 31 | 57 | 42 | 16 | 41 | 26 |
| USHo1 | 1998 | -214 | 1303 | 1518 | -172 | 1380 | 1552 | -176 | 1367 | 1543 | 32 | 55 | 39 | 11 | 27 | 17 |
| USHo1 | 1999 | -220 | 1337 | 1557 | -238 | 1340 | 1578 | -243 | 1307 | 1550 | 40 | 68 | 49 | 7 | 32 | 27 |
| USHo1 | 2000 | -316 | 1272 | 1587 | -305 | 1326 | 1631 | -296 | 1342 | 1638 | 32 | 55 | 41 | 9 | 29 | 21 |
| USHo1 | 2001 | -263 | 1360 | 1623 | -234 | 1417 | 1652 | -234 | 1431 | 1665 | 30 | 50 | 34 | 13 | 37 | 25 |
| USHo1 | 2002 | -194 | 1238 | 1432 | -162 | 1322 | 1484 | -158 | 1338 | 1496 | 29 | 45 | 34 | 6 | 13 | 8 |
| USHo1 | 2003 | -305 | 1065 | 1370 | -258 | 1196 | 1453 | -254 | 1202 | 1456 | 28 | 46 | 31 | 10 | 19 | 10 |
| USHo1 | 2004 | -326 | 1113 | 1439 | -293 | 1193 | 1486 | -294 | 1188 | 1482 | 27 | 43 | 32 | 8 | 19 | 12 |
| | | | | | | | | | | | | | | | | |
| USIB1 | 2006 | | | | -269 | 1187 | 1456 | -269 | 1214 | 1483 | 30 | 55 | 41 | 9 | 18 | 10 |
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| USIB2 | 2006 | | | | -100 | 1187 | 1287 | -86 | 1233 | 1319 | 41 | 64 | 50 | 9 | 31 | 22 |
| | | | | | | | | | | | | | | | | |
| USLos | 2001 | | | | -75 | 758 | 834 | -77 | 759 | 836 | 22 | 33 | 32 | 16 | 36 | 21 |
| USLos | 2002 | | | | -83 | 679 | 762 | -84 | 679 | 762 | 15 | 38 | 32 | 8 | 21 | 13 |
| USLos | 2003 | | | | -53 | 731 | 784 | -47 | 747 | 794 | 17 | 64 | 58 | 9 | 24 | 15 |
| USLos | 2004 | | | | -53 | 650 | 702 | -51 | 665 | 716 | 21 | 47 | 39 | 3 | 18 | 18 |
| USLos | 2005 | | | | -115 | 863 | 978 | -115 | 882 | 997 | 15 | 79 | 75 | 3 | 21 | 20 |
| USLos | 2006 | | | | -94 | 903 | 997 | -94 | 896 | 989 | 17 | 69 | 67 | 4 | 10 | 9 |
| | | | | | | | | | | | | | | | | |
| USMMS | 1999 | -359 | 810 | 1169 | -347 | 900 | 1247 | -348 | 899 | 1248 | 31 | 33 | 34 | 4 | 12 | 8 |
| USMMS | 2000 | -288 | 923 | 1211 | -298 | 1021 | 1319 | -301 | 1010 | 1311 | 34 | 37 | 36 | 7 | 11 | 8 |
| USMMS | 2001 | -330 | 1059 | 1389 | -312 | 1100 | 1412 | -314 | 1098 | 1412 | 37 | 49 | 41 | 5 | 19 | 15 |
| USMMS | 2002 | -402 | 1052 | 1455 | -372 | 970 | 1342 | -364 | 983 | 1347 | 40 | 53 | 43 | 12 | 22 | 12 |
| USMMS | 2003 | -336 | 891 | 1227 | -293 | 971 | 1264 | | | | 56 | 71 | 60 | 38 | 95 | 174 |
| USMMS | 2004 | -460 | 922 | 1382 | -415 | 926 | 1341 | -406 | 953 | 1358 | 65 | 76 | 66 | 15 | 44 | 30 |
| USMMS | 2005 | -420 | 892 | 1312 | -367 | 924 | 1291 | -356 | 953 | 1309 | 53 | 75 | 61 | 13 | 29 | 17 |
| USMMS | 2006 | -618 | 628 | 1246 | -500 | 571 | 1071 | -334 | 895 | 1228 | 152 | 274 | 143 | 155 | 299 | 179 |
| | | | | | | | | | | | | | | | | |
| USMe2 | 2002 | -339 | 1081 | 1419 | | | | | | | | | | | | |
| USMe2 | 2004 | -570 | 991 | 1561 | | | | | | | | | | | | |
| USMe2 | 2005 | -480 | 997 | 1477 | | | | -475 | 987 | 1461 | 34 | 67 | 49 | 16 | 49 | 33 |
| USMe2 | 2006 | -468 | 754 | 1223 | | | | | | | | | | | | |
| USMe2 | 2007 | -578 | 800 | 1378 | | | | -597 | 858 | 1455 | 82 | 122 | 71 | 46 | 85 | 39 |
| | | | | | | | | | | | | | | | | |
| USMe3 | 2004 | -188 | 718 | 906 | -238 | 617 | 855 | -239 | 619 | 857 | 30 | 61 | 43 | 20 | 50 | 31 |
| USMe3 | 2005 | -96 | 702 | 797 | -155 | 597 | 751 | -157 | 599 | 757 | | | | 6 | 113 | 112 |
| | | | | | | | | | | | | | | | | |
| USMe4 | 1999 | -863 | 383 | 1246 | | | | | | | | | | | | |
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| USMe5 | 2000 | | | | -276 | 538 | 814 | -276 | 537 | 813 | 10 | 11 | 11 | 1 | 5 | 4 |

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| USMe5 | 2001 | -116 | 620 | 737 | -131 | 561 | 692 | -131 | 560 | 691 | 10 | 15 | 14 | 4 | 10 | 5 |
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| | | | | | | | | | | | | | | | | |
| USMoz | 2005 | -455 | 1086 | 1541 | -398 | 1135 | 1533 | -376 | 1218 | 1594 | 53 | 110 | 70 | 25 | 69 | 44 |
| USMoz | 2006 | -264 | 1022 | 1285 | -178 | 1166 | 1344 | -182 | 1180 | 1362 | 37 | 65 | 40 | 18 | 34 | 17 |
| USMoz | 2007 | -432 | 805 | 1236 | -382 | 892 | 1274 | -359 | 947 | 1306 | 42 | 75 | 50 | 21 | 47 | 26 |
| | | | | | | | | | | | | | | | | |
| USNR1 | 1999 | -19 | 832 | 851 | -84 | 764 | 848 | -78 | 796 | 874 | 19 | 35 | 27 | 18 | 38 | 20 |
| USNR1 | 2000 | -26 | 742 | 768 | -50 | 701 | 752 | -36 | 758 | 794 | 16 | 29 | 22 | 19 | 47 | 29 |
| USNR1 | 2001 | -51 | 734 | 786 | -69 | 712 | 782 | -52 | 769 | 821 | 16 | 26 | 20 | 26 | 58 | 33 |
| USNR1 | 2002 | -24 | 601 | 625 | -60 | 589 | 649 | -41 | 659 | 699 | 18 | 37 | 27 | 14 | 42 | 29 |
| USNR1 | 2003 | -18 | 660 | 679 | -28 | 678 | 707 | -13 | 742 | 755 | 24 | 53 | 35 | 22 | 56 | 35 |
| USNR1 | 2004 | -42 | 460 | 502 | -16 | 782 | 798 | -6 | 850 | 855 | 20 | 50 | 42 | 20 | 68 | 49 |
| USNR1 | 2005 | 4 | 714 | 710 | -21 | 722 | 744 | -7 | 778 | 785 | 18 | 40 | 32 | 19 | 53 | 34 |
| USNR1 | 2006 | -28 | 685 | 713 | -68 | 689 | 757 | -54 | 755 | 809 | 19 | 37 | 28 | 19 | 56 | 39 |
| USNR1 | 2007 | -52 | 698 | 749 | -69 | 709 | 778 | -48 | 796 | 843 | 19 | 56 | 45 | 17 | 53 | 35 |
| | | | | | | | | | | | | | | | | |
| USNe1 | 2002 | -511 | 1152 | 1663 | -535 | 1215 | 1750 | -502 | 1291 | 1793 | 37 | 56 | 46 | 26 | 69 | 45 |
| USNe1 | 2003 | -421 | 1052 | 1473 | -445 | 1200 | 1645 | -434 | 1224 | 1659 | 40 | 94 | 77 | 17 | 53 | 39 |
| USNe1 | 2004 | -376 | 1141 | 1517 | -403 | 1278 | 1681 | -391 | 1300 | 1691 | | | | 26 | 91 | 67 |
| USNe1 | 2005 | -380 | 1122 | 1502 | -387 | 1302 | 1689 | -369 | 1352 | 1722 | 33 | 64 | 54 | 11 | 38 | 27 |
| | | | | | | | | | | | | | | | | |
| USNe2 | 2003 | -671 | 918 | 1590 | -612 | 1327 | 1939 | -620 | 1306 | 1927 | | | | 40 | 108 | 71 |
| USNe2 | 2004 | 95 | 954 | 859 | 88 | 1076 | 988 | 64 | 1079 | 1016 | 34 | 74 | 65 | 10 | 60 | 56 |
| USNe2 | 2005 | -577 | 1016 | 1593 | -584 | 1289 | 1873 | -590 | 1330 | 1920 | 33 | 127 | 121 | 25 | 71 | 53 |
| | | | | | | | | | | | | | | | | |
| USNe3 | 2002 | -28 | 772 | 800 | -45 | 780 | 825 | -23 | 836 | 860 | 33 | 52 | 41 | 38 | 97 | 59 |
| USNe3 | 2003 | -418 | 866 | 1284 | -417 | 1055 | 1472 | -411 | 1095 | 1505 | 40 | 80 | 69 | 31 | 66 | 43 |
| USNe3 | 2004 | -17 | 832 | 849 | -35 | 857 | 892 | -39 | 885 | 923 | 32 | 62 | 52 | 18 | 82 | 64 |
| USNe3 | 2005 | -534 | 926 | 1460 | -558 | 1044 | 1603 | -559 | 1048 | 1607 | 32 | 57 | 53 | 19 | 60 | 43 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USPFa | 1997 | | | | | | | 8 | 1086 | 1078 | 34 | 97 | 83 | 3 | 16 | 14 |
| USPFa | 1998 | | | | | | | 63 | 1061 | 998 | 53 | 110 | 87 | 8 | 25 | 17 |
| USPFa | 1999 | | | | | | | 50 | 1075 | 1025 | 48 | 107 | 79 | 8 | 18 | 11 |
| USPFa | 2000 | | | | | | | 30 | 1004 | 975 | 31 | 55 | 39 | 6 | 15 | 9 |
| USPFa | 2001 | | | | | | | 74 | 1024 | 950 | 37 | 61 | 48 | 11 | 29 | 18 |
| USPFa | 2004 | | | | | | | | | | | | | 4 | 17 | 14 |
| | | | | | | | | | | | | | | | | |
| USSO2 | 1999 | | | | | | | | | | | | | | | |
| USSO2 | 2000 | | | | -62 | 459 | 521 | -76 | 439 | 515 | 35 | 45 | 18 | 13 | 19 | 6 |
| USSO2 | 2001 | | | | | | | | | | | | | | | |
| USSO2 | 2002 | | | | 86 | 82 | -4 | 107 | 81 | -27 | | | | | | |
| USSO2 | 2004 | | | | 164 | 408 | 243 | 164 | 417 | 253 | 15 | 37 | 23 | 11 | 24 | 17 |
| USSO2 | 2005 | | | | -76 | 435 | 511 | -65 | 466 | 532 | 19 | 38 | 26 | 28 | 58 | 30 |
| USSO2 | 2006 | -75 | 183 | 259 | -14 | 311 | 325 | -18 | 304 | 322 | 14 | 29 | 20 | 8 | 9 | 9 |
| | | | | | | | | | | | | | | | | |
| USShd | 1998 | | | | -30 | 1209 | 1239 | -32 | 1207 | 1239 | 20 | 21 | 21 | 4 | 12 | 9 |
| USShd | 1999 | | | | -118 | 1279 | 1397 | -119 | 1280 | 1398 | 23 | 26 | 24 | 5 | 17 | 12 |
| | | | | | | | | | | | | | | | | |
| USSyv | 2002 | -85 | 995 | 1079 | | | | -62 | 1117 | 1179 | 36 | 71 | 48 | 6 | 32 | 29 |
| USSyv | 2003 | | | | | | | | | | | | | | | |
| USSyv | 2004 | | | | | | | | | | | | | | | |
| USSyv | 2005 | -85 | 1088 | 1173 | | | | | | | | | | | | |
| USSyv | 2006 | 107 | 1168 | 1060 | | | | 159 | 1296 | 1136 | 31 | 70 | 45 | 12 | 36 | 25 |
| | | | | | | | | | | | | | | | | |
| USTon | 2002 | -216 | 612 | 829 | -65 | 738 | 803 | -82 | 798 | 880 | 40 | 73 | 42 | 25 | 43 | 19 |
| USTon | 2003 | -169 | 732 | 902 | -26 | 924 | 949 | -36 | 904 | 940 | 46 | 84 | 56 | 32 | 60 | 29 |
| USTon | 2004 | -189 | 606 | 794 | -105 | 725 | 830 | -130 | 687 | 818 | 43 | 69 | 41 | 25 | 42 | 18 |
| USTon | 2005 | -219 | 823 | 1042 | -109 | 1064 | 1173 | -142 | 1021 | 1163 | 57 | 94 | 55 | 58 | 100 | 47 |
| USTon | 2006 | -63 | 776 | 840 | -37 | 796 | 833 | -30 | 808 | 839 | 35 | 64 | 38 | 13 | 24 | 13 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| USTon | 2007 | -69 | 739 | 808 | 32 | 864 | 832 | 13 | 832 | 819 | 37 | 62 | 34 | 22 | 39 | 17 |
| | | | | | | | | | | | | | | | | |
| USUMB | 1999 | -156 | 1093 | 1247 | -101 | 1200 | 1301 | -104 | 1181 | 1285 | 45 | 84 | 58 | 24 | 48 | 24 |
| USUMB | 2000 | -160 | 1030 | 1190 | -123 | 1065 | 1189 | -121 | 1080 | 1202 | 33 | 55 | 44 | 20 | 45 | 25 |
| USUMB | 2001 | -92 | 1084 | 1176 | -39 | 1119 | 1158 | -32 | 1134 | 1167 | 37 | 66 | 49 | 23 | 54 | 30 |
| USUMB | 2002 | -171 | 1018 | 1189 | -123 | 1084 | 1207 | -124 | 1076 | 1200 | 36 | 69 | 50 | 15 | 37 | 21 |
| USUMB | 2003 | -179 | 965 | 1144 | -125 | 1038 | 1162 | -117 | 1051 | 1169 | 39 | 71 | 48 | 24 | 52 | 29 |
| USUMB | 2004 | -179 | 1111 | 1290 | -109 | 1043 | 1153 | -104 | 1064 | 1167 | 39 | 64 | 42 | 19 | 41 | 22 |
| USUMB | 2005 | -179 | 1072 | 1251 | -219 | 966 | 1184 | -219 | 965 | 1184 | 41 | 76 | 53 | 11 | 23 | 13 |
| USUMB | 2006 | -226 | 1025 | 1251 | -234 | 908 | 1142 | -235 | 907 | 1142 | 37 | 65 | 47 | 8 | 17 | 10 |
| | | | | | | | | | | | | | | | | |
| USVar | 2001 | -58 | 610 | 668 | -72 | 572 | 645 | -78 | 562 | 640 | 29 | 62 | 56 | 7 | 12 | 5 |
| USVar | 2002 | -37 | 605 | 641 | -23 | 606 | 629 | -2 | 548 | 549 | 28 | 64 | 61 | 18 | 49 | 46 |
| USVar | 2003 | -68 | 724 | 792 | 18 | 830 | 812 | 16 | 824 | 808 | | | | 25 | 55 | 26 |
| USVar | 2004 | -6 | 512 | 518 | 88 | 483 | 395 | 68 | 491 | 423 | 52 | 73 | 74 | 23 | 64 | 52 |
| USVar | 2005 | -148 | 898 | 1046 | -21 | 843 | 864 | -18 | 852 | 870 | 86 | 96 | 62 | 408 | 532 | 136 |
| USVar | 2006 | 19 | 665 | 647 | 48 | 685 | 637 | 59 | 708 | 649 | 46 | 60 | 72 | 8 | 15 | 7 |
| USVar | 2007 | -8 | 656 | 665 | -2 | 681 | 683 | 6 | 697 | 690 | 131 | 329 | 354 | 152 | 362 | 363 |
| | | | | | | | | | | | | | | | | |
| USWCr | 1999 | -222 | 628 | 850 | | | | | | | | | | 13 | 41 | 52 |
| USWCr | 2000 | -395 | 747 | 1142 | -325 | 851 | 1177 | -357 | 758 | 1115 | 25 | 43 | 34 | 3 | 10 | 8 |
| USWCr | 2001 | -32 | 986 | 1017 | 249 | 879 | 630 | 237 | 849 | 612 | 102 | 171 | 68 | 21 | 41 | 22 |
| USWCr | 2002 | -444 | 687 | 1131 | -165 | 714 | 879 | -192 | 653 | 845 | 51 | 78 | 42 | 36 | 71 | 36 |
| USWCr | 2003 | -481 | 853 | 1334 | -335 | 874 | 1209 | -373 | 744 | 1117 | 38 | 62 | 44 | 19 | 62 | 45 |
| USWCr | 2004 | | | | | | | | | | | | | | | |
| USWCr | 2005 | -470 | 967 | 1437 | -382 | 989 | 1371 | -428 | 864 | 1292 | 41 | 60 | 42 | 6 | 16 | 10 |
| USWCr | 2006 | -472 | 702 | 1173 | | | | | | | | | | 20 | 50 | 31 |

## Appendix B: Modified Fluxnet-Canada Gap-Filling Method

Six modifications were made to the Fluxnet-Canada standard gap-filling method (Barr et al. 2004).

1. NEE outliers were identified and excluded using the methods described in 6.2 above, level 1.
2. Because the soil temperature $T_s$ depths in the NACP database were not always shallow enough to meet our requirements (2 or 5 cm), we used a weighted temperature $T$ as the dependent variable in the RE = $f(T,t)$ relationship, estimated as $(2*T_s + T_a)/3$ where $T_a$ is air temperature. This ensured a significant diurnal cycle.
3. The time-varying parameters $r_w(t)$ and $p_w(t)$ (Equations B2 and B4 below) were estimated, not by forced-origin linear regression, but as the ratio of means (see below). They were also not allowed to be negative.
4. Night was delineated, not from solar position, but from global shortwave radiation of less than 5 W $m^{-2}$.
5. Gaps of 31 days and longer were not filled.
6. At a few sites where NEE was routinely unavailable, we substituted $F_c$ for missing NEE.

The Fluxnet-Canada gap-filling procedure: (a) derives measured RE and GPP from measured NEE, (b) fills gaps in RE and GPP using simple empirical models that are highly constrained by the measured data, and (c) fills gaps in NEE from the gap-filled RE - GPP. The data are processed one year at a time. Two simple annual empirical relationships are determined from measured data, one between RE and temperature $T$ and the other is between GPP and downwelling PAR radiation $Q_{\downarrow}$ above the stand. For each relationship, annual parameters are first obtained for the annual analysis, then one additional parameter per relationship is allowed to vary over time with the other parameters held constant. The temporal variation in the time-varying parameter accounts in part for changes in vegetation and environmental variables, such as, e.g., LAI, soil water content, air temperature, air saturation deficit and freeze-thaw events.

The time-varying parameters are determined using a flexible moving window. Within each window, the time-varying parameter is calculated as the ratio of the mean RE (or GPP) obtained from the measurements and the corresponding mean from the annual regression relationships (equations B1 and B3). The implementation of the moving window uses a fixed number (100) of measured (non-missing) data points rather than a fixed period of time. The window is moved in increments of 20 (non-missing) points at a time. For each window, the corresponding time is assigned as the mean time of the 100 data points (i.e. usually near the centre of the window). The values of the time-varying parameters for each individual half-hour period are then estimated by linear interpolation. These adjusted relationships are then used to fill data gaps. The sensitivity of RE to $T$ and GPP to $Q_{\downarrow}$, respectively, is largely determined by the annual relationships, but is modified to some extent by the time-varying parameters within each window period.

The post-processing steps are as follows. First, nighttime NEE data are excluded at low $u_*$ (below the $u_*^{Th}$). Small gaps in NEE (four periods or less) are filled by linear interpolation before larger gaps are filled using the procedure outlined below.

Measured RE is estimated as RE = NEE during periods when GPP is known to be zero, i.e., at night and during both night and day in the cold season (periods when both $T_a$ and $T_s$ are less than 0 ˚C). An empirical, logistic relationship is fit to the measured $R$ values from the entire year:

$$\text{RE} = r_1/(1 + \exp\,[r_2(r_3 - T)]) \quad \text{(B1)}$$

where $r_1$, $r_2$ and $r_3$ are empirical constants. An additional empirical parameter, $r_w(t)$, is introduced into (B1), resulting in

$$\text{RE} = f(T_s,t) = r_w(t) r_1/(1 + \exp\,[r_2(r_3 - T)]) \quad \text{(B2)}$$

where $r_w(t)$ is allowed to vary in time ($t$). Its value is estimated within a 100-point moving window as the ratio of mean measured RE to mean modeled RE from (B1). The RE = $f(T,t)$ model (B2) is used to estimate RE during the day and to fill gaps in RE at night.

"Measured" GPP is estimated as –NEE (measured) + RE (modeled daytime) or zero (nighttime and during periods when both $T_a$ and $T_s$ are less than 0˚ C). An empirical model is fit to the daytime, warm-season GPP data for the entire year:

$$\text{GPP} = \alpha Q_{\downarrow} P_x/(\alpha Q_{\downarrow} + P_x) \quad \text{(B3)}$$

where $\alpha$ is the quantum yield and $P_x$ is the photosynthetic capacity ($P$ at light saturation). Both parameters are treated as constants. An additional empirical parameter, $p_w(t)$, is introduced into (B3), resulting in

$$\text{GPP} = f(Q_{\downarrow},t) = p_w(t) \alpha Q_{\downarrow} P_x/(\alpha Q_{\downarrow} + P_x) \quad \text{(B4)}$$

$p_w(t)$ is allowed to vary in time and is estimated within a 100-point moving window as the ratio of mean measured GPP to mean modeled GPP from (B3). The GPP = $f(Q_{\downarrow},t)$ model (B4) is used to fill gaps in GPP.

Gaps in NEE are filled using modeled GPP – modeled RE from (B2) and (B4).

## Appendix C: Modifications to the Papale $u_*^{Th}$ Detection Algorithm

We adopted the $u_*^{Th}$ detection approach of Papale et al. (2005) as implemented in the La Thuile FLUXNET synthesis, but with important modifications to the stratification, binning, threshold detection and averaging details, as outlined in Table C.

Table C: Modifications to the Papale et al. (2005) $u_*^{Th}$ detection algorithm.

| | **Detail** | **Papale et al. (2005)** | **NACP** |
|---|---|---|---|
| **1** | **Stratification and binning** | | |
| | Quarter delineation | JFM, AMJ, JAS, OND | DJF, MAM, JJA, SON |
| | Temperature used to stratify | Air temperature | Shallow soil temperature |
| | Number of NEE data per $u_*$ bin | ? | • Minimum of 5 (30-min data)<br>• Minimum of 3 (60-min data) |
| | Number of $u_*$ bins per strata | 20 | 50+ |
| | Number of temperature strata per quarter | 3 to 7 | 3 to 7 |
| **2** | **Threshold detection** | | |
| | Method | Stabilization of 5-point moving mean | Change-point detection (Lund and Reeves 2002 but modified to two connected line segments) |
| | Failure detection | Unclear | F test (Wang et al. 2007) |
| **3** | **Uncertainty analysis** | Bootstrapping, 100 replications | Bootstrapping, 1000 replications |
| **4** | **Averaging** | | |
| | Within year | Median within each quarter, then maximum of four quarterly medians, then annual distribution from bootstraps | Median within each quarter, then mean of four quarterly medians, then annual distribution from bootstraps. Individual bootstraps excluded if any quarter had less than two strata with a significant $u_*^{Th}$. |
| | Among years | Different $u_*^{Th}$ for each site-year | Site-specific $u_*^{Th}$, all years pooled |