



CO₂ Flux Measurement Uncertainty Estimates for the NACP Site-Level Interim Synthesis

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Outline

- Background
- NEP (= -∫NEE) uncertainty associated with uTh uncertainty
- NEP random uncertainty
- Summary



Purpose of this Talk

- Update community on progress (work in progress)
- Solicit feedback



Eddy-Covariance (EC) Measurement Uncertainties

Random uncertainty

- associated with random measurement noise
- can be characterized using:
 - similar periods on consecutive days
 - proximate paired towers
 - highly-tuned (gap-filling) model output
- NOT negligible at the annual time scale

Systematic uncertainty

- Iess well understood, less easily characterized
- caused by inadequate EC system design or violation of EC assumptions (as seen in, e.g., under-measurement at low windspeeds (*u*_{*} or σ_w filtering); energy balance non-closure; cold-air drainage or other 3D flow regimes)

Quantifying NEP Uncertainty Related to the Low-*u*^{*} NEE Exclusion Threshold *u*^{*}

(adapted from Papale et al. 2006 with modifications)

 Estimate uTh and its uncertainty using change-point detection

NEP (=-NEE)

- stratify each year into 4 seasons and each season into 3-7 temperature classes
- plot binned NEE vs. u and evaluate the change-point for each stratum
- aggregate all stra
- Bootstrap 1,000 t
- Pool estimates fr
- Fill gaps in NEE all values of uTh
- Estimate NEP un intervals from 2.

 u_{+} (m s⁻¹)

95% Confidence Intervals in the u_*^{Th} in Relation to u_*^{Th}



List of Sites

NACP Site-Level Interim Synthesis

Land Cover	Canada	USA
Permanent Wetland (2)	CAMer CAWP1	
Cropland (5)		USARM USIB1 USNe1,2,3
Shrubland/Savanna (3)		USLos USSO2 USTon
Grassland (4)	CALet	USIB2 USShd USVar
Juvenile Forest (6)	CACa2,3 CASJ1,2	USMe3,5
Mature Evergreen Needleleaf Forest (12)	CACa1 CANS1 CAObs CAOjp CAQfo CASJ3 CATP4	USDk3 USHo1 USMe2,4 USNR1
Mature Deciduous Broadleaf Forest (6)	CAOas	USHa1 USMMS USMoz USUMB USWCr
Mature Mixedwood Forest (4)	CAGro	USDk2 USPFa USSyv

Median *u*^{*} Grouped by Land Cover

Land Cover	Mean ± S.D. (n)
Permanent Wetland	0.12 ± 0.00 (2)
Cropland	0.19 ± 0.06 (5)
Shrubland & Savanna	0.20 ± 0.05 (3)
Grassland	0.21 ± 0.05 (5)
Juvenile Forest	0.20 ± 0.07 (6)
Mature Evergreen Needleleaf Forest	0.38 ± 0.13 (11)
Mature Deciduous Broadleaf Forest	0.40 ± 0.07 (6)
Mature Mixedwood Forest	0.41 ± 0.07 (3)

Percentage of Nighttime Net Ecosystem Exchange NEE Data Excluded by the Median *u**Th



u^{*}Th-Related Uncertainty in Annual NEP (95% Confidence Interval, g C m⁻²) in Relation to Annual NEP



Quantifying Random Uncertainty

(annual analysis following Richardson et al. 2006, 2007)

- Quantify NEE random uncertainty curve
- Apply Monte-Carlo process
 - Begin with gap-free synthetic data from Fluxnet-Canada gapfilling model
 - Add random noise
 - Fill gaps
 - Repeat 1,000 times
 - Calculate uncertainty at different time scales as 95% confidence intervals from 2.5 and 97.5 percentiles



Random Uncertainty in NEE

(showing μ (μ mol m⁻² s⁻¹) from a double exponential distribution in relation to gap-filling NEEHat)



Random Uncertainty in Annual NEP (95% Confidence Interval, g C m⁻²) in Relation to Annual NEP



Ameriflux 2009

Random Uncertainty in Annual NEP (95% Confidence Interval, g C m⁻²) in Relation to Ecosystem Respiration RE



Random Uncertainty in Annual NEP (95% Confidence Interval, g C m⁻²) in Relation to Annual RE: Forest Sites



Random Uncertainty in Annual NEP (95% Confidence Interval, g C m⁻²) in Relation to Annual RE: Non-Forest Sites



Why Inter-Site Differences? Two possibilities to explore:

- 1. It's in the data.
 - Differences in system design or data processing?
 - Differences in site characteristics?
- 2. It's in the processing.
 - Poor performance of Fluxnet-Canada gap-filling method at some sites causing overestimation of random errors.

Summary

- *u*Th is well defined at most sites.
- Mean nighttime NEE exclusion of 59%.
- Overall NEP uncertainties (g C m⁻² yr⁻¹, mean ± s.d.):
 - random: 30 ± 16
 - u_{*}^{Th} related: 18 ± 16
- Both uncertainties scale with RE but some sites have higher uncertainties than others.



Next Steps ...

- Explore differences among sites.
- Repeat random uncertainty analysis with other gapfilling methods.
- Get feedback from site PIs, identify problems and weaknesses, complete a second analysis at some sites.
- Extend uTh. analysis to entire FLUXNET database.

