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Biogeosciences Discussions

Interactive comment on "Drivers of interannual variability in Net Ecosystem Exchange in a semi-arid savanna ecosystem, South Africa" *by* S. Archibald et al.

Anonymous Referee #1

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This study aimed to quantify the ecological mechanisms that explain year-to-year variation NEE and its integral, net ecosystem production (NEP), in a semi-arid savanna in South Africa. In the process, the authors developed/employed novel ways (advanced neural network algorithms) to fill “missing” half-hourly NEE gaps that occurred over the sampling period as a result of eddy covariance data not meeting the minimal requirements of the method. They also attempted to construct new algorithms for estimating/calculating ecosystem respiration and applying calculated values to estimate daytime ecosystem respiration and then calculate GPP. These components of NEP, the authors seem to contend, may be more ecologically relevant in helping to explain temporal variations in NEE, especially at the interannual time scale. The premise

of the study, and indeed many of the results presented, will be/are very valuable to anyone involved in analyzing eddy covariance data and desiring to evaluate the effects of current interannual variability in precipitation amount on ecosystem carbon storage, as well as climate-change induced variations in precipitation. A main driver of the research, the authors state, is the failure of traditional, temperate-site gap-filling models (that use solar radiation and temperature as environmental independent variables) to accurately fill in gaps in CO2 flux data in semi-arid ecosystems. I feel that this paper makes a strong contribution toward solving some of the problems researchers have in calculating NEE using eddy covariance in arid and semi-arid ecosystems. The value of this study is further amplified by the fact that 40% of Earth’s land surface is covered by these dry ecosystems!

The authors point to the role that the size, frequency and duration of precipitation pulses can play in defining temporal responses in NEE from earlier studies (Huxman et al. 2004, Williams et al. 2008, and Veenendaal 2004) and the need for gapfilling algorithms to include these immediate and lagged responses to water availability. Wohlfahrt et al. (2008) looks at effects of rains on NEE and seems to show some less pronounced responses of Reco to pulses of various sizes (although initial responses generally tend to generate net ecosystem CO2 efflux).

Methods: 1. A single EC tower place at the ecotone of two savanna vegetation types generated NEE values for almost five years—but with 41 to 49% missing values. It was not clear whether any attempts were made to distinguish CO2 fluxes of the two ecosystem types. However, that was not the central objective of this study, it seems. Thus, NEE values appear to derive from a mixed contribution of the two systems. 2. Were soil moisture readings from each of the respective ecosystems matched to the area being sampled for NEE by the EC tower in the new gap-filling calculations? 3. The multiple methods used to calculate/estimate daytime ecosystem respiration values seem to be carefully thought through and argued. However, I still have an uncertain feeling about the true robustness/consistency of the Reco on tem-

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5, S2037–S2039, 2008

Interactive Comment

perature relationships. I would be curious to know how the elimination of NEE values that showed nighttime net CO2 uptake (negative NEE values) from the regressions might have affected the (a) nighttime analyses, and (b) the extrapolation to daytime Reco values. What percentage of valid nighttime values were negative? 4. I do not have a good feeling for whether 372 daily values for Reco and 529 days of valid GPP out of ca. 1760 days (ca. 4 years x 365 days/year + ca. 300 days) would permit confident estimates of interannual variation in these measures, or not. I do admire very much, though, the stringency that the researchers applied to their data sets! So I feel relatively confident that a lot of care was taken in the analyses. 5. I know too little about the intricacies of ANN to evaluate the results produced using these methods, but they seem to produce “reasonable” values in this study.

Results and discussion: 6. I am wondering about the level of confidence that the authors seem to have in the annual NEE (NEP) values, although they do acknowledge that there were times where data were limiting (e.g. Fig. 1). What would the error terms in Table 5 look like for 42, 155, 150, -138 and -83 g C m-2 year-1? Reflecting back on one of the rationales that helped motivate this study (outlined in the Introduction), the need to understand ecological and environmental mechanisms that co-determine ecosystem C sink/source strength, it would seem quite relevant to express confidence estimates around these calculated annual NEE values. A recent paper by Wohlfahrt et al. (2008) demonstrates one way that this may be attempted. Indeed, the authors did this (Table A1) for a number of other flux-tower derived variables. 7. Fig. 4 is a nice illustration of how inclusion of soil moisture variables can improve gap-filling accuracy. 8. Fig. 6 is a stretch for me, especially given the uncertainties that are inherent in the relationships depicted in Figs. B1 and B3. Is there a way to show the estimated error/variance around the means presented in these bars?

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