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Interactive comment on "Investigation of scale interaction between rainfall and ecosystem carbon exchange ofWestern Himalayan Pine dominated vegetation" *by* Sandipan Mukherjee et al.

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Final Response: Title: Investigation of scale interaction between rainfall and ecosystem carbon exchange of Western Himalayan Pine dominated vegetation Author(s): Sandipan Mukherjee et al. MS No.: bg-2018-299 MS Type: Research article

Reply to the comments of Reviewer - 1: Thank you very much for reviewing the article. However, due to the lack of detailed comments and suggestions we are unable to make major revisions to the manuscript, although a number of significant modifications are proposed to be made to account for the comments and suggestions from Reviewer#2. Some of these proposed modifications might be useful to clarify some of your con-

cerns. With respect to the comment made on 'winter rainfall' this is to emphasize that the rainfall time series used in this study was for the period of 16 Jan, 2014 to 30 Dec, 2016 which include winter seasonal rainfall observation over the site. Furthermore, this is to elaborate that this manuscript is not primarily focused on assessing climatology or dynamics of winter rainfall and/or orographic effect on rainfall over Himalaya, as substantial research publications are available for winter rainfall and/ orographic impact on winter and summer monsoon rainfall (Dimri, 2009, Yadav et al., 2010, Dimri, 2013a, Dimri, 2013b, Yadav et al., 2013, Mukherjee et al., 2016) rather, impact of rainfall seasonality along with changes in the vapour pressure deficit and air temperature, referred in this draft as 'associated meteorology', were assessed on NEE using wavelet. Moreover, in spite of using wavelet to justify objectives, the article is developed around multi-dimensional application of various wavelet methods; and similar application of wavelet methods can be found in Kwon et al, 2010. The rationale for using the ERA forced CASA-GFED3 model was to test efficiency of a carbon cycle model to simulate comparable scale interactions between ecosystem flux and rainfall variability, and that is explicitly mentioned in line number 5, pp-3 of the draft. Similarly, 'scale interaction' terminology is also categorically explained in line no 34-35, pp-2 and subsequently, bands and periods representing various scales are sufficiently elaborated in the results section. However, we do agree that instead of CASA-GFED3 model, a site-specific model could be used to improve understanding of the interactions between rainfall and ecosystem fluxes. Unfortunately, we do not have access to any finer spatial resolution global/regional ecosystem models that could produce carbon exchanges at sub-daily time intervals. Further, as noted by the reviewer, the lacuna in introduction and in result with respect to rationale and use of CASA-GFED3 model could be elaborated if a revised manuscript is considered.

Reply to the comments of Reviewer - 2: We appreciate the helpful comments and suggestions by anonymous reviewer on the article. With respect to the comment made on 'Goal of the article with underlying hypothesis' this is to emphasize that the overarching aim of this article was to assess interaction between rainfall (both monsoon and winter seasons) and ecosystem exchange of a Pine dominated forest of Western Himalaya. Subsequently, cause and effect relationship between two important meteorological parameters (i.e. air temp, VPD) and rainfall were also assessed. The study was initiated with the rationale that the western Indian Himalayan Pine dominated mixed forest patches, which encompasses almost 60% land use of the Uttarakhand state of India, are expected to respond disparately to different spells of rainfall during summer and winter which is not yet quantified. Therefore, the particular aim of this study was to quantify this cause and effect relationships between NEE and rainfall using observed data. Moreover, the sub-daily scale global model product was used to assess similar rainfall and ecosystem exchange interactions which can be generalized for the entire Pine dominated forests of Western Indian Himalayan region such as the one reported in Hong and Kim (Global Change Biology,17, 2011). With respect to the comments on 'Over use of wavelet analysis', we have included only those wavelet diagrams (i.e continuous wavelength and cross wavelength) of parameters which were providing significant signatures. Therefore, according to the authors, wavelet analyses included in the draft were optimum and necessary. However, the figure for cross wavelet interaction and wavelet coherence between rainfall-VPD and rainfall-air temperature (Figure 7) could be removed and only the results could be highlighted in a revised draft. The 'use of CASA-GFED3 model and goal of using such global model' is primarily inspired by convenience as we are aware of the coarse resolution of the model to represent the observational site but that is the data we had at our disposal and not many ecosystem model results are available at sub-daily time resolution. Moreover, as indicated by the reviewer, site specific verification of global model products implies a better up-scaling of carbon source-sink distribution, which could be elaborated in the revised draft emphasizing role of validation of global model products with observations for enhancing model accuracy and acceptance of model products for better carbon budget estimation. With respect to the comments made on the 'Fetch area of the mast with role of topography', this is to elaborate that a detailed footprint analysis was not included in the draft, rather variation in the wind shear was represented as a function of wind

speed. However, the theoretical cumulative footprint function (FPc), as estimated using the footprint model of Hsieh et al. (2000) for each 30 minute observations, indicated 80% of the fluxes were originating within 1.06 km of the measurement tower irrespective of the wind direction and atmospheric surface layer stability (ζ = z-d/L, where z is measurement height, d is displacement height and L is Obukhov length). When the footprint fluxes were partitioned with respect to dominant wind direction, 80% of the fluxes were found to be originating within a radius of 1.06 km for NE wind (0-90o), 0.94 km for SE wind (90-150o) and 1.18 km for NW wind (270-355o) regimes (Figure A1). For convective/unstable periods (ζ< 0), the footprint fetch was found to vary between 40-300 m signifying most of the fluxes were contributed by the surrounding forest patches, whereas, for stable atmosphere (ζ > 0) maximum footprint fetch was as much as 2400 m, irrespective of wind direction. Further, this is to be noted that the footprint fetch estimation was made under the assumption of horizontally homogeneity of surface sources which was not entirely satisfied by the underlying conditions of the current terrain, hence a separate error estimation for source area identification will be needed which is out of the scope of this draft. Further, we acknowledge that the current manuscript lacks 'discussion on radiance and PPFD' due to non inclusion on these parameters for wavelet analysis, as we have tried to particularly focus on rainfall variability. Comments related to 'Figure captions', 'Change in figure spacing', 'Occasional typos' and 'More detailed discussion of results' could be incorporated in a revised draft.

Reply to the comments of Short Comment - 1: Pramit Deb Burman, IITM , India With respect to comments on the '3-hourly CASA-GFED3 model product' this is to emphasize that the 3 hourly data was converted to daily average values, afterwards, wavelet analysis was carried out. As indicated above, not many ecosystem model results are available at sub-daily time resolution, hence, the CASA-GFED3 data was used. The scale difference in Figs – 4, 6 and 7 are due to inclusion of all statistically significant signatures of different parameters. Hence, a forced equal wavelet scale would either include statistically insignificant information (i.e. inclusion of 1/64 in case of 1/32) or removal of significant information (i.e. restriction of scale up to 1/32 where valid signatures are present in 1/64). The color scale of Fig-5 can be explained in a revised draft. For the detail LAI information Singh et al. (2014a) is referred. The comment on 'relationships between NEE-VPD and NEE-air temperature' is not appropriate as no direct wavelet based relationships between these parameters were derived, rather VPD-rain and air temperature-rain relationships were highlighted to physically correlate meteorological parameters during different seasons and scales. Similarly, as indicated in the draft, power spectra of NEE were evenly distributed for all the three monsoon periods. Since, carbon budget estimation was not the objective of the study, no detail uncertainty and error estimation was carried out. The generic understanding of continental scale temperature gradient and subsequent monsoon rainfall is a regional scale phenomenon within the central and peninsular India. The same monsoonal trough does not propagate much beyond the foothills of Himalaya. Therefore, localized convection and moist adiabatic lifting of air parcel play significant role for precipitation within Himalaya even during monsoon. The temperature enhancement following rainfall, particularly during premonsoon periods, can be corroborated to sufficient latent heat release after rainfall events. This information could be incorporated in the revised draft. The phase-lock conditions in cross wavelet analysis represent periods when two events are having similar oscillation. The details mathematical explanations of wavelet methods are not provided in the draft as the same could be found in Grinsted et al. (2004) and Weib et al. (2011). Similarly, comments related to 'Figure captions', 'Change in figure spacing', 'Occasional typos' could be incorporated in a revised draft.

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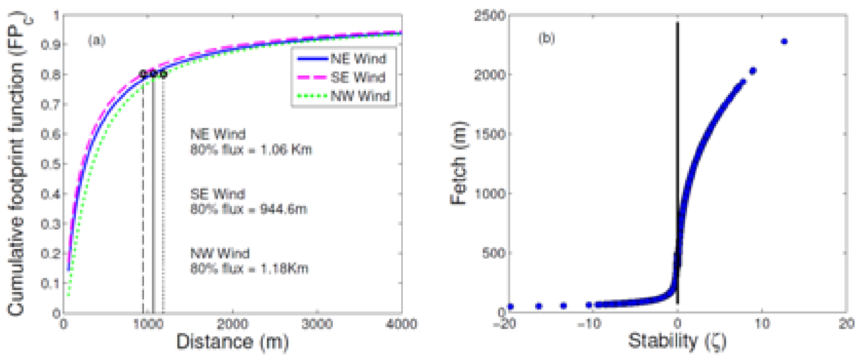

Fig. 1. Subplot (a) indicates Cumulative footprint function (FPc) with respect to three dominant wind regimes; and subplot (b) indicates variation of footprint fetch (m) with respect to atmospheric stability