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Interactive comment on "Does predictability of fluxes vary between FLUXNET sites?" *by* Ned Haughton et al.

Anonymous Referee #2

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This manuscript presents a methodology for quantifying the "predictability" of land atmosphere fluxes of water, energy and carbon across 155 eddy covariance sites, with the goal of helping to better interpret comparisons between these observations and output from land surface models. This idea has considerable merit, and could be of interest to a large number of land surface model developers, and other synthesizers of eddy covariance data sets. Unfortunately, in its current form it is difficult to extract the most important information, as there is insufficient emphasis on what might be valuable, and much material is included which is not relevant. Overall, it needs to be much more focused, and the authors need to concentrate on: (i) predictability and their predictability metric; (ii) the models used, whilst greatly streamlining the hypotheses, given the inconclusiveness of the majority of the analysis.

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General Comments

1. As the authors acknowledge, “there is no single definition of predictability” – and this is a key challenge to this paper. The introduction needs to address this much earlier than the bottom of page 3, so there aren’t several pages of text discussing something that has not been defined, or at least how it is being treated in the context of this manuscript.

2. It seems that the authors are treating predictability as the inverse of “uniqueness”, which is characterized as the deviation between a globally optimized model, versus a locally optimized model. This needs additional clarification and justification. With this definition, the predictability is inherently model dependent, rather than some intrinsic property of the site alone. This is always the case possibly, but needs to be spelt out. It also highlights the importance of the models.

3. A reliance on this uniqueness as a proxy for predictability seems like it might have drawbacks. Consider the NEE plots in Figure 1. There are a group of sites with relatively high “uniqueness”, and thus low predictability, but with a global RMSE less than 7, which is lower than for a large fraction of sites indicating a better mean performance. Are these sites more or less predictable? It seems that this can only be quantified through combing the uniqueness metric with the mean performance into a single metric, but uniqueness is discussed in isolation throughout the results section.

4. This can be addressed by combining the metrics with appropriate weights. The authors say this is not done due to the difficulty in combining the different metrics, but given the lack of information in the metrics other than RMSE, and the apparent requirement to combine uniqueness and mean performance, this should be reconsidered, with at least these two components of each metric combined.

5. What is the additional information gained from switching from Cartesian to polar coordinates? Would not a simple mean of the global and local models, and the normalized difference between then suffice?

6. This manuscript relies heavily on previous work (Best et al, 2015, Haughton et al., 2018). Indeed, it is not possible to understand much about the models with out consulting this closely. Given how dependent the predictability metrics are on these models, some further description of them is required here.

7. Indeed, it's very unclear why multiple models are being used at all? What is the benefit of doing this rather than using the single "best" model?

8. Although the authors suggest they want to leave this for future work as it is "substantially more complex", it seems at least some examples are required to explain how the predictability metrics are sensitive to the models, and how this can be interpreted when discussing specific sites. For example, it seems that many semi-arid sites are characterized by these models to have high uniqueness, but what would happen if soil moisture was included in the model?

9. Whilst uniqueness as defined here is certainly a useful metric to assess flux sites by, and to help interpret comparisons between observations and land surface model output, it is unclear it represents something like the inverse of "predictability". In fact, a contrary argument could be made that the sites that exhibit large reductions in model error when optimized with local data are the most predictable. Whilst for those sites that don't see model improvement when just local data are used this lack of sensitivity might also be interpreted as a lack of predictability, particularly for sites with low mean performance. In this context, a predictable site is one where given more information, model skill increases, and whilst at an unpredictable site specific information does not increase skill.

10. Both sections 2.2 and 3.2 read as an overly long laundry list of "everything we tried". It will be easy to greatly increase the overall focus of the manuscript by addressing this. Given the lack of conclusiveness regarding the majority of the hypotheses about determinants of predictability, a brief note that they were considered and findings were inconclusive is all that is required.

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Specific Comments

P1 L1-8. Rather like the manuscript as a whole, the abstract needs much more focus. Emphasis specific detail, not background information and motivation.

P4 L13-21. Not methods.

P8 Fig 1. Don't understand the need for colored dots?

P12 L29. Yes, you might want to [QUANTIFY] that

P15 Fig 4. Presumably it is the mean values that are being plotted here?

P15 Fig 4. Seems like NEE needs a different scale?

P16 Fig 5. The two sites with an aridity index higher than 3 haven't been excluded.

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