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Interactive comment on "Calculating the turbulent fluxes in the atmospheric surface layer with neural networks" *by* Lukas Hubert Leufen and Gerd Schädler

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Reply to referee #2: Our reply is structured like this: we quote the essential part of the referee's comment in inverted commas, followed by our reply

"... BC is entirely empirically specified ...": the BC (or rather u* and T*) is derived on the basis of MOST, and as we state in sec 2.1, on this basis our goal is to determine u* and T* from known quantities, which are in our case modelled or observed wind and temperature gradients in the surface layer. So it's not "entirely empirical".

"Little insight into the data ...": data have been described and checked carefully for

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compatibility with MOST (sec. 2.3). Underlying physics is MOST, described in sec. 2.1. Performance of the algorithms is discussed in secs. 3 and 4.

"... and the authors' own results suggest a much simpler model would fit their data equally well. A path they do not investigate.": that was not our aim. Our aim in this paper was to see specifically if and how well the stability functions could be approximated by an ANN.

"... is that of more-or-less uncritically applying ANNs to the data-set, without examining their suitability, and to what extent the data can be explained by simpler models": we gave the reasons why we tried ANNs: see remarks above and secs. 1 and 2.1 of the paper. What would a critical application look like in the opinion of the referee?

"In fact you show a 1-layer, 1-neuron "network" performs basically the same as 1-layer, 12-neurons, or a deep network with 2-layers with 7-7 neurons (7 inputs).": this is not the case.Especially in fig. 3 one can see a substantial trend that a network with one single hidden neuron is outperformed by networks with several hidden neurons. Also fig. 4 shows this trend in an attenuated pattern.

"This result strongly suggests that almost all the predictive power of ANN for this data is contained in a linear fit.": a linear fit would certainly not work. Stability functions are highly nonlinear, see formulas in sec. 2 and e.g. Arya's book.

"Given this, it seems redundant and unnecessarily complicated to use the heavymachinery of ANNs, with its associated costs": we don't think ANNs can be considered heavy machinery nowadays; the difficult parts of the work are a) obtaining and filtering data, and b) validation and testing - this has to be done for all kinds of regression methods.

"... an extremely simple main relationship between features and output:" the task is indeed simple: approximate a single valued nondimensional function of one variable (which is a nondimensional combination of other variables). The essential physics is captured in the Monin-Obukhov length and the dimensionless gradients (i.e. stability functions).

"Indeed the difference between these figures indicates that the more complex networks are overfitting the data from the available towers.": we discuss our use of the (less complex) 6-3-2 ANN in secs. 3 and 4.

"... comparison with simpler models ...": as explained above, this was not our aim; a comparison is done in secs. 3 and 4 with the regression (not physics!) based functions in the literature.

"Only if ANNs do significantly better than linear models is the current work worth publishing.": why?

"I'm not convinced by the assertion that there is a significant computational speed advantage to be gained by replacing MOST with an ANN ...": we are not sure here either - but we would like to try. This was the first step - next step will be implementation in a regional climate model (RCM).

"3d LES simulation": we do not intend to do LES simulations.

"Please explain what is special about your models that causes this situation to be reversed. Please quantify the time spend by your code in various parts of the calculation": The situation is not reversed. Climate models, especially RCMs, are very expensive to run (climatologically relevant multidecadal simulations at high resolution can take several tens of weeks on a high performance system), so every saving is valuable, especially in view of the other advantages. We hope to save around five percent (i.e. about one week), taking into account parallelisation.

"I would appreciate in Section 2 an enumeration of all assumptions made, perhaps with some comment on their validity and their role in simplifying the MOST model.": this is done in the data section: ... Reasons for this could be a violation of the assumptions of the Monin-Obukhov theory like inhomogeneous terrain around the site or wind direction

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dependence of the roughness length.

"Are these fluxes measured directly": at all sites used, fluxes are measured by the eddy covariance method, from which u*and T* are derived with the formulas from sec. 2.

"What modelling assumptions are inherent to your ANN approach?": this is explained in sec. 2.1. "Title should be "turbulence fluxes" not "turbulent fluxes".": we would like to stick to the terminology used in the boundary layer meteorology community, which is "turbulent fluxes" (see e.g. Arya's book).

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