Atmospheric Measurement Techniques Discussions

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Comment on amt-2021-279

Anonymous Referee #1

Referee comment on "Wind speed and direction estimation from wave spectra using deep learning" by Haoyu Jiang, Atmos. Meas. Tech. Discuss.,
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Indeed, as described in the preprint that the sea surface wind and waves are important parameters for the marine environment and ocean dynamics. This also implies that the interactions between them involve complex dynamic procedures resulting in the intricacies of coupling between them that make their individual characteristics difficult to resolve. Buoys on one hand though with limited amounts and distributions have been long providing good measurements of both wind and wave parameters respectively and simultaneously, on the other hand making complementary to remotely sensed wind and waves from satellites. The wind-wave interaction can then be modelled from buoy observations, while deep learning provides powerful tools in non-linear modelling and regression. The author thereby applies a deep neural network (DNN) for extracting wind information from wave spectrums provided by buoys for further applications to buoys without wind measuring ability benefitting such buoys with lower costs. The motivation and origin of this research are reasonable and good.

Unfortunately, the research in this preprint falls into the trap set by that the DNN theory that can fit all models provided wide enough (though which is true mathematically). This may be due to ignoring that the meaning of the DNN model expressed is data and inputs-outputs dependent or self-consistent within such boundary. The model is only physically meaningful than mathematical results when not only the data or inputs are of good quality but also considering underlying physical principles to an extent a DNN can resolve. This can also be expressed with the state for one of the challenges for the application of artificial intelligence in ocean science: moving from purely statistical prediction to process-based models that embody causal relationships (Catalán, I., A. Solana, et al, 2021).

More specifically for this research, it applies the spectrum parameters all at once as inputs for wind speed and direction ignoring the underlying multi-scale heterogeneity in time and space due to the complex relation of the interface interaction that can be embodied by a spectrum interpreting them in different approximations of the governing equation for energy distributed for different k values. Such approximation cannot only be expressed in another way round by expanding the observed energy distributed for different k values

(spectrums are fitting of the observations) for another fitting from DNN. In other words, here DNN makes little extra contribution than the observed spectrum from this research. What is captured by DNN cannot be clarified makes things worse. Around Line 115, from the results, “the wave spectrum might also better reflect wind information a short period before” is contradictory to the fact that wind-wave spectrum ranges from lower frequencies to higher frequencies due to momentum transformation between waves of different lengths. For wind estimation, short wave measurement is relevant while the modulations from longer waves are non-negligible, from tilting effects to the short waves or modification of amplitudes of the short waves by exchange of energy altering atmosphere conditions close to the sea surface.

Moreover, though the training procedure is mathematically accomplishable, as in the preprint, where the results can be validated in error analysis from the testing set. Let alone the comparison of results to remotely sensed winds are not validated ignoring representative features of remote sensing results and buoy observations. Buoys generally provide the spot-based measurement of winds while remote sensing results are averages of a large region. The distributions of samples for each wind (and direction) bin are not discussed, the sample number may be skewed due to distributions of nature winds, while such effects are ignored in this research.

Although some sensitive analysis for inputs as the selection of frequency discussed in part 4, this was unfortunately misinterpreted as well, due to the little effort taken for understanding the relation between observed inputs and outputs. This is similar to the results part around line 115, longer waves are with wind information that cannot be resolved by the mapping to winds from the DNN established directly fitting the observations.

The discussions following such content are not proper as well. When the model boundary is not clear due to the aspects listed above, there is little chance for these DNN models to apply in QC procedures or other applications. The results are also not likely to be improved including compact wave drifters, as the air-sea interaction in different scales is not likely to be well described in the reasons above.

To wrap up, for such a model without awareness of the causalities between the inputs and outputs, especially under the circumstances such causalities are complex and wraps between even inputs and outputs, the deductions made based on them can easily go wrong. This is exactly the case for wind-wave interactions, such that improper analysis generally appears here and there for this preprint.

There are also other defects in descriptions:

1) around line 25, the description of the lack of meteorological buoys may be inherited from the reference (Voermans et al, 2020), while this is only partly true. There are such buoys available in India (NIOT, National Institute of Ocean Technology) and China (NOTC,

National Ocean Technology Center). There are also publications applications applying such buoys though NOTC is currently not openly accessible.

2) Around line 30, as mentioned before, short gravity-capillary waves are modulated by longer waves, though in the case of scatterometry, the orbital velocity of longer waves cannot be observed, and the tilting effect may not be obvious for them modulated to gather on the crests, by modulating the surface wind stress that changes the amplitudes of the short waves, which cannot be ignored, the long wave information does exist in scatterometer observations.

3) Around line 30, the measuring in the nadir of altimeters does not result in low spatial resolution cross-track, maybe the coverage cross-track is low was meant to express.

4) Around line 35, low temporal resolutions do not cause low performance near shore. There are near-shore products from scatterometers for example. Besides, inter-constellation will solve the coverage problems to an extent.

5) Around line 45, again, direct comparisons of buoy results are remote sensing products are not validated.

6) After all listed above, It is difficult to believe this research is included in the projects listed around line 255.

In all, I suggest a rejection of this manuscript for publishing.

Catalán, I., A. Solana, et al. "OCEANS OF BIG DATA AND ARTIFICIAL INTELLIGENCE." OCEAN SCIENCE CHALLENGES FOR 2030. 2021