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Bias Correction of Operational Storm Surge Forecasts Using Neural Networks

Paulina Tedesco[1,2], Jean Rabault[2], Martin Lilleeng Sætra[3,4], Nils Melsom Kristensen[3], Ole Johan Aarnes[3], Øyvind Breivik[3,5], and Cecilie Mauritzen[3]

[1]University of Oslo, Faculty of Mathematics and Natural Sciences, Department of Physics, Norway (paulinte@student.matnat.uio.no)

[2]Norwegian Meteorological Institute, Information Technology Department, Norway

[3]Norwegian Meteorological Institute, Research and Development Department, Norway

[4]Oslo Metropolitan University, Department of Computer Science, Norway

[5]University of Bergen, Geophysical Institute, Norway

Storm surges can give rise to extreme floods in coastal areas. The Norwegian Meteorological Institute (MET Norway) produces 120-hour regional operational storm surge forecasts along the coast of Norway based on the Regional Ocean Modeling System (ROMS). Despite advances in the development of models and computational capability, forecast errors remain large enough to impact response measures and issued alerts, in particular, during the strongest storm events. Reducing these errors will positively impact the efficiency of the warning systems while minimizing efforts and resources spent on mitigation.

Here, we investigate how forecasts can be improved with residual learning, i.e., training data-driven models to predict, and correct, the error in the ROMS output. For this purpose, sea surface height data from stations around Norway were collected and compared with the ROMS output.

We develop two different residual learning frameworks that can be applied on top of the ROMS output. In the first one, we perform binning of the model error, conditionalized by pressure, wind, and waves. Clear error patterns are visible when the error conditioned by the wind is plotted in a polar plot for each station. These error maps can be stored as correction lookup tables to be applied on the ROMS output. However, since wind, pressure, and waves are correlated, we cannot simultaneously correct the error associated with each variable using this method. To overcome this limitation, we develop a second method, which resorts to Neural Networks (NNs) to perform nonlinear modeling of the error pattern obtained at each station.

The residual NN method strongly outperforms the error map method, and is a promising direction for correcting storm surge models operationally. Indeed, i) this method is applied on top of the existing model and requires no changes to it, ii) all predictors used for NN inference are available operationally, iii) prediction by the NN is very fast, typically a few seconds per station, and iv) the NN correction can be provided to a human expert who gets to inspect it, compare it with the ROMS output, and see how much correction is brought by the NN. Using this NN residual error

correction method, the RMS error in the Oslofjord is reduced by typically 7% for lead times of 24 hours, 17% for 48 hours, and 35% for 96 hours.