

Ensemble simulations of future North Sea storm surges

Dear referee,

Thank you very much for reviewing our paper. Please find below the answers to your questions and a description of the changes we make in the manuscript.

1. *My first comment is about the title of this paper. The major analysis of this manuscript is focused on the water level (or sea level) instead of storm surge. The author only discussed the storm surge and tide in section 5 as a by-product. A more appropriate title should be chosen.*

You are right. We therefore changed the title to “An ensemble study of extreme storm surge related water levels in the North Sea in a changing climate”.

2. *The storm surge model description is not very clear. In Section 2.1, the model description is very brief, and it leaves important details out. e.g. For the tidal forcing in the lateral boundary, which dataset is used for this model? TPXO6.2 or FES2004, or some else? Which harmonics constituents are used? Is river outflow accounted for in any way? All the above factors are very important for the storm surge study.*

Details of the forcing can be found in the reference Gerritsen et al., 1995. We explicitly name the ten tidal constituents in the revised paper and mention the river inflow.

3. *My main concern is about directly using the GCM outputs to drive the high resolution storm surge model. The author evaluated the extreme wind speed. However, how about the mean sea level pressure? The inverted barometer effect is another important factor for storm surge. If the coarse GCM cannot produce the reliable low pressure system, how can the author convince the reader to believe that the WAQUA is capable of simulating storm surge using coarse resolution GCM forcing?*

We try to convince the reader with sections 3.1 and 3.2. In section 3.1 we show that ESSENCE can generate SLPs as low as, or even lower than, observed values (Figure 2a). In section 3.2 we use ERA-40 data, downgraded to ESSENCE resolution, to drive WAQUA/DCSM-98, and obtain good agreement with observed water levels (Figure 3a) if we correct for the fact that ERA-40 winds are too low (Figure 1). See also answer to your next concern.

4. *In Section 2.3, the author said they interpolate ERA40 data to ESSENCE resolution, then use it to drive WAQUA model. If my understanding is right, all the forcing data should be interpolated to WAQUA resolution (8km) to drive the WAQUA model. Therefore, why the author firstly interpolate ERA40 data (125km) to ESSENCE resolution (220km), then interpolate to WAQUA resolution (8km)? Why not directly interpolate from ERA40 resolution to WAQUA resolution (8km)? Some bias can be induced by the authors interpolation sequence and some detail information maybe lost during the interpolation from high ERA40 resolution to coarse ESSENCE resolution. I may miss an important point here, but the author need clarify this.*

Of course you are right, the forcing has to be interpolated onto the WAQUA grid. However, we use the runs driven by ERA-40 data to investigate whether a forcing derived from the coarse-resolution ESSENCE is adequate to drive WAQUA. Therefore, we first interpolate ERA-40 data to the even coarser ESSENCE grid. We then have data with the spatial resolution of ESSENCE that follow the “real” development of the weather, so that results from WAQUA runs driven by these data can be directly compared with water level observations. This is explained in section 2.3 of the paper, and in section 3.2 it is

shown that the coarse-resolution forcing constructed by downgrading ERA-40 data is able to produce results that compare well with observations.

5. *Page 1038, Line 9: Suggest European Centre for Median-Range Weather Forecasts (ECMWF)*
OK.

6. *Define models and systems like WASA, ESSENCE etc. when they first appear in the text for sufficient any reader not familiar with these systems.*

In principle you are right, all abbreviations should be defined when they first appear. However, most abbreviations are just well-memorizable names for something which can be described only by clumsy expressions. For instance, ESSENCE is the acronym for “Ensemble SimulationS of Extreme weather events under Nonlinear Climate changE”. Important in the context of the present paper is only that within ESSENCE a 17-member ensemble of climate integrations has been performed, and this is the information given at the beginning of section 2.2. Defining all abbreviations and acronyms without adding any real information yields clumsy texts. So we prefer not to explain all abbreviations and acronyms and leave it to the discretion of the editor to decide.