The effect of the Wadden Sea for very high resolution atmospheric regional climate models

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1. INTRODUCTION

Non-hydrostatic climate models such as the COSMO model, which is a limited-area atmospheric prediction model of the German weather service (DWD), are used for simulations with high resolutions (<10 km). There are numerous studies, which show added value (especially for precipitation) for these high-resolution convection-permitting simulations (Prein et al. 2013). But such simulations pose new challenges since they have to take into account mesoscale features and processes in contrast to lower resolution simulations. The Wadden Sea is an intertidal zone in the southeastern part of the North Sea which falls dry and is flooded twice daily, respectively. This study deals with the question if it is necessary to consider the tidal cycle of the Wadden Sea in order to achieve realistic weather states at this high resolution.

2. MODEL SET-UP

For this reason two test simulations with the model COSMO-CLM (CCLM), which is the climate version of the COSMO model, was used (Rockel et al. 2008). The tide cycle and the related change of sea-/land area are not implemented in CCLM. Two simulations were computed with a horizontal grid distance of 1 km, 86 x 82 grid points, and forced by the CoastDat II data set (Geyer 2014) with double nesting. Simulated is the year 1962 which is the year of the big storm surge in Hamburg. One simulation was done in the state “low tide” and one in the state “high tide” which were created by using new land-sea masks. The domain includes the Wadden Sea around the North Frisian Islands of Northern Germany (Figure 1).

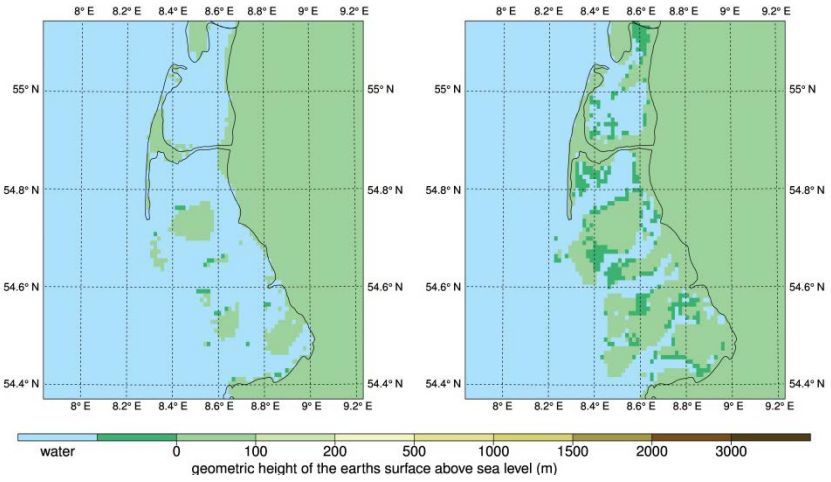

Figure 1: Model domain of the simulations and according topography of the a) “high tide” state and b) “low tide” state.

3. RESULTS

10 m wind speed and 2 m temperature were analyzed. In the low-tide state the mean autumn and winter temperatures are decreased by more than 3 K in the Wadden area. In the winter time the North Sea is warmer than the air temperature and heats the near surface air. This heating does not apply if the sea area falls dry in the low tide state, which results in lower 2 m temperatures (Figure 2). This effect is most pronounced in the Wadden area, but also in the close surroundings a temperature decrease (especially in winter time) is visible, which also extends to the lee side a few kilometers further inland.

On the other hand, the roughness length increases for low tide. Therefore the 10 m wind speed is reduced in this area (up to 1.7 m/s for seasonal mean), especially in seasons with high wind speeds (winter and autumn). In contrast to the 2 m temperature the effect is limited to the areas where the surface type changes from water to land (Figure 3).

Precipitation does not show any significant differences between low and high tide. In this study only the two extreme conditions low and high tide are examined and realistic conditions of continuous change from low to high tide for six hours and back.

Nevertheless, 20% of the grid points fall dry and become flooded in this model domain and should thus be taken into account for grid distances of 1 km and less, although the effect shown in this study is certainly overestimated. The temperature difference is quite large, because the sea level temperature (SST) is taken from NCEP I reanalysis with a resolution of 1.875° (about 200 km). This means, that the whole model domain comprises only parts of a single NCEP grid point. Therefore not only the changes between land and sea should be considered, but also the resolution of the SST should be improved when simulating the Wadden Sea area with this high resolution.

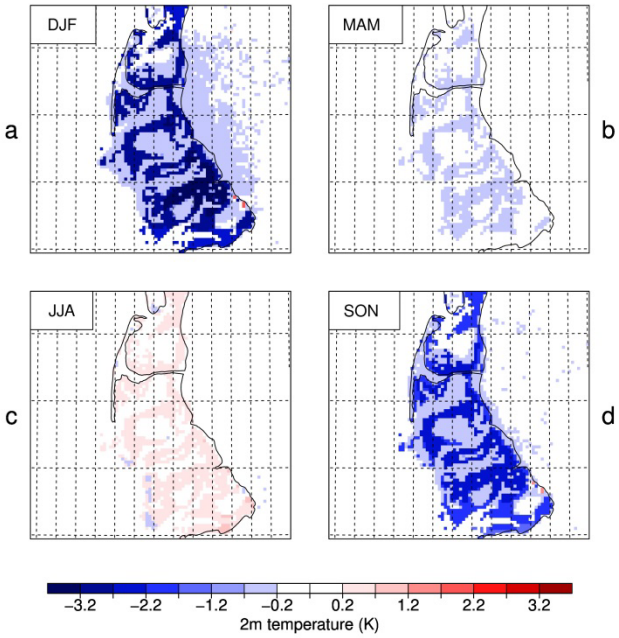

Figure 2: Difference of the seasonal mean 2 m temperature between low and high tide state for a) winter, b) spring, c) summer, and d) autumn.

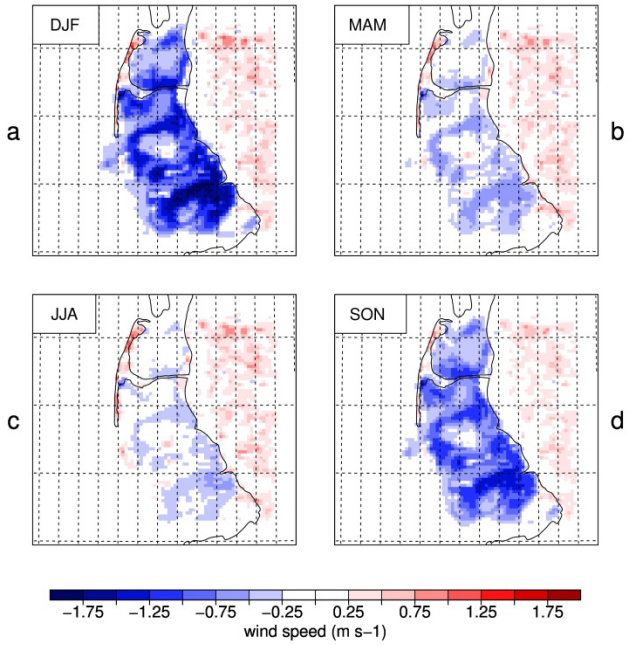

Figure 3: Difference of the seasonal mean 10 m wind speed between low and high tide state for a) winter, b) spring, c) summer, and d) autumn.

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