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Modelling the effects of sheltering, depth-induced wave breaking and refraction on the wave field in coastal archipelagos

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The coastal areas of Finland are covered with islands and shoals of variable sizes. The total amount of islands is over 73 000. Ca. 40 000 of the islands are located in the south-western extremity of Finland in the Archipelago Sea. The size of the islands varies from a few meters to several kilometres in diameter. The bathymetry is complex; there are many shoals which cause depth-induced wave refraction and wave breaking. Some of these areas have potential to generate high concentration of wave energy and even caustics. The accurate modelling of the wave field in the archipelago areas is essential for the safety of the marine traffic, the marine spatial planning and the modelling of the coupled physical-biogeochemical processes in the coastal waters. The wave field in the Archipelago Sea was modelled with the wave model WAM using ten different realisations of high-resolution grids. Two different resolutions were used, 0.5 nmi and 0.1 nmi, with different ways to define the land mask and grid obstructions in the archipelago areas. The modelled wave field inside the Archipelago Sea was compared against measurements made during a research cruise of R/V Aranda in September 2010. The depth-induced wave breaking and wave refraction were shown to have significant effect on the modelled wave field at the southern edge of the Archipelago Sea when the 0.1 nmi resolution grids were used. Inside the Archipelago Sea the 0.1 nmi grids predicted the local wind waves with good accuracy when the forcing wind field was in agreement with the measurements. However, due to the coarse temporal and spatial resolution of the forcing wind field, WAM was unable to represent the temporal variability of the wave parameters in full detail. The attenuation of the open sea waves propagating into the Archipelago Sea was slightly overestimated by the 0.1 nmi grids. The computational demands of the 0.1 nmi resolution grids restrict their use e.g. in operational forecasting. Therefore, coarser resolution grids that are able to model the wave field with sufficient accuracy are needed. The 0.5 nmi resolution grids were unable to describe the depth-induced wave breaking and refraction in as much detail as the 0.1 nmi grids. Furthermore, the 0.5 nmi grids overestimated the energy of the local wind waves and underestimated the attenuation of the open sea waves. However, when grid obstructions were used in the 0.5 nmi grids, the attenuation of wave energy was predicted with good accuracy, but the energy of the local wind waves was slightly overestimated. Development of additional methods that take into account the wave refraction and wave breaking in sub-grid scale might further improve the accuracy of the coarser resolution grids in modelling of the wave field in archipelago areas.