Mesoscale Numerical Modelling of Met-Ocean Interactions

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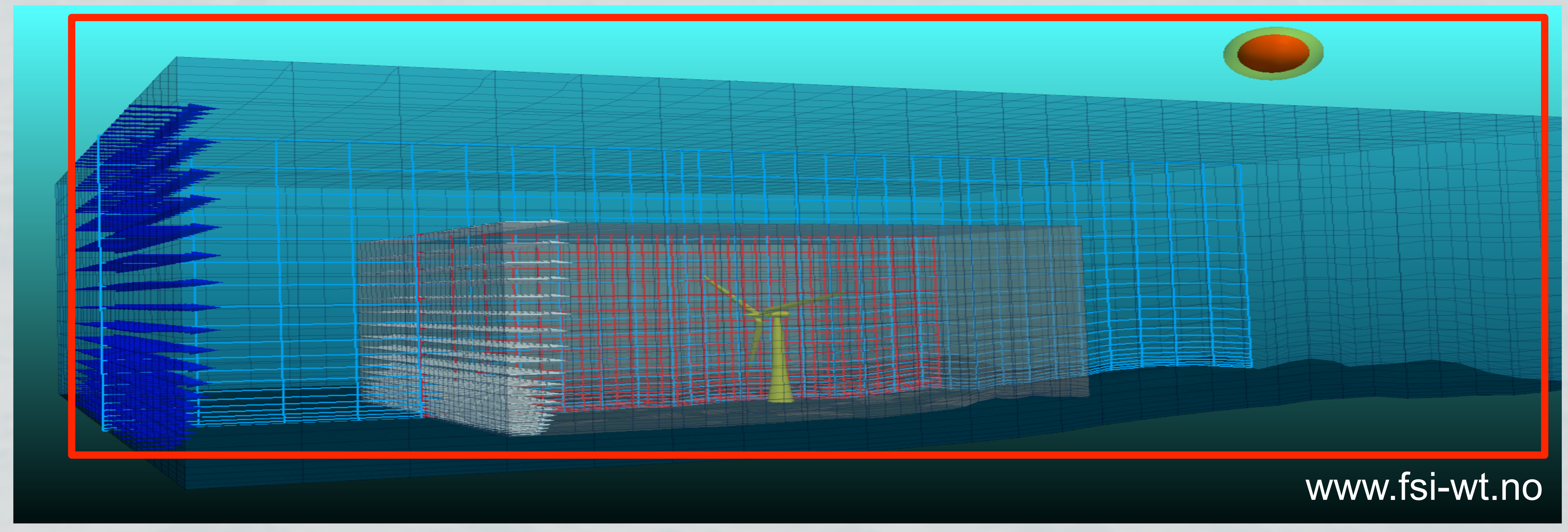
INTRODUCTION

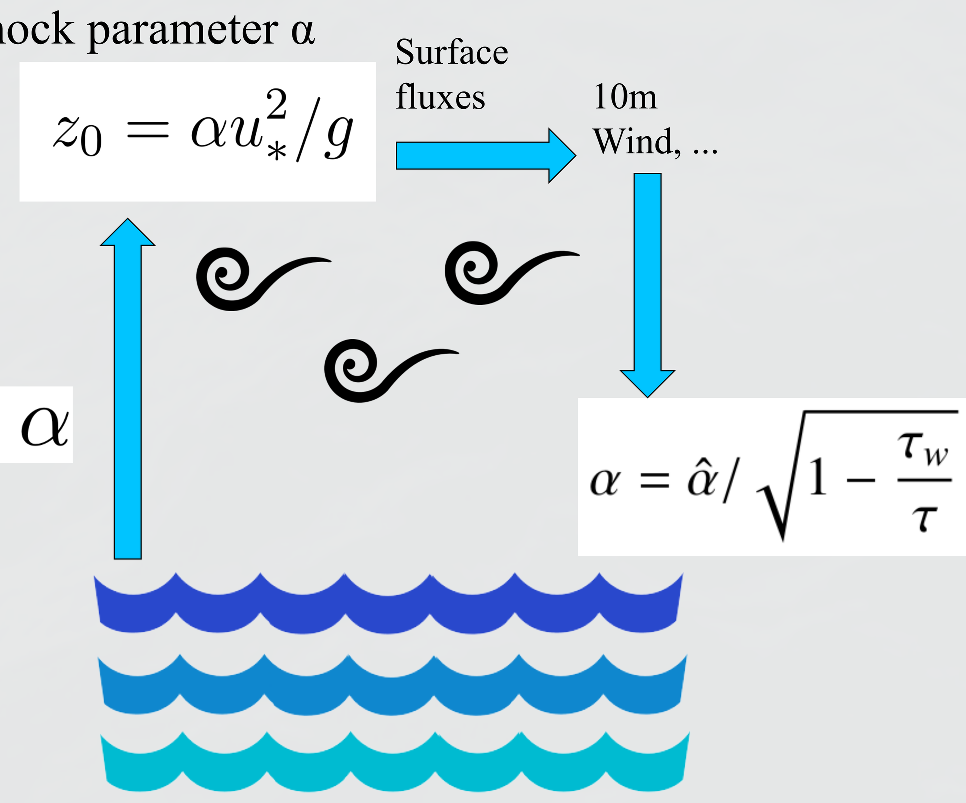
Offshore wind turbines have to operate in conditions affected by phenomena characteristic of marine boundary layer. Complete inversion of wind profiles close to coasts, strong high waves and their interaction with the structures supporting the turbines can have a profound influence on the performance of wind turbines and their life time. In order to understanding the behavior of turbines in operational condition, a good understanding of the marine boundary layer and ocean waves is an obvious prerequisite. Here we present the coupling of an atmospheric model HARMONIE using AROME physics with the ocean wave model WAM. Some preliminary results related to the effects of coupling on wind speed and significant wave height is presented for a site close to the Norwegian coast.



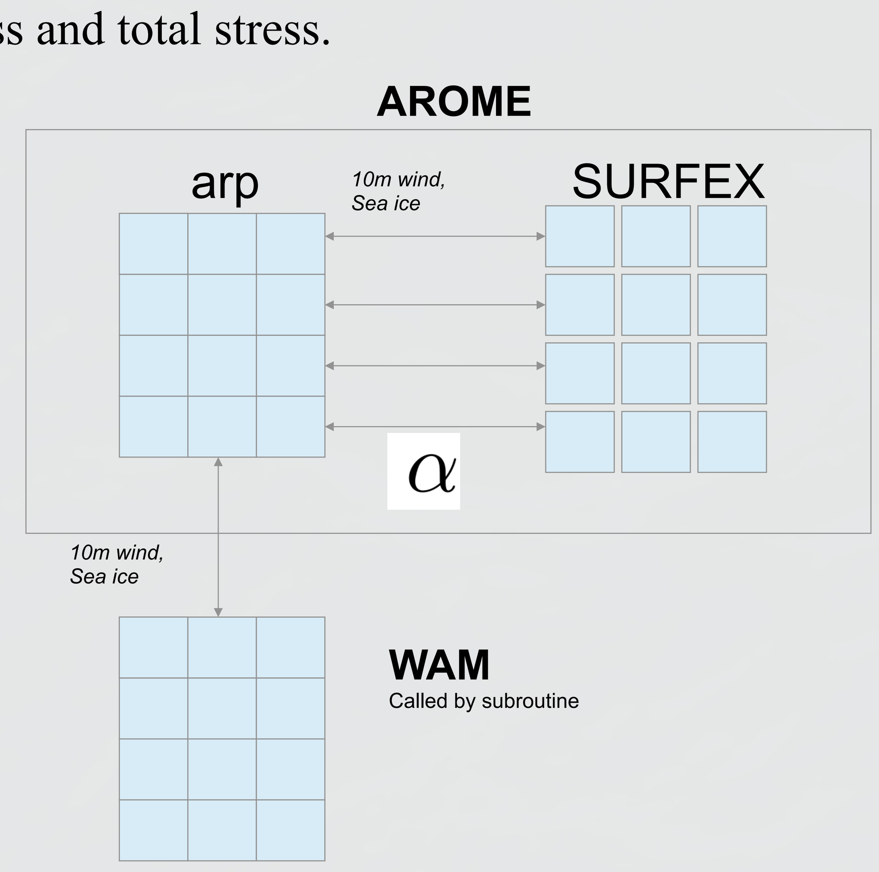
COUPLING

The surface fluxes (momentum and heat) over an ocean surface depend on the state of the surface. For example, young ocean waves typically have a larger roughness than older waves. To get a realistic representation of the ocean, the ocean wave model WAM is coupled with the atmospheric model AROME.

In AROME, the surface fluxes depends on the surface roughness length, Z0, which depends on the friction velocity, u*, acceleration of gravity, g, and the Charnock parameter α



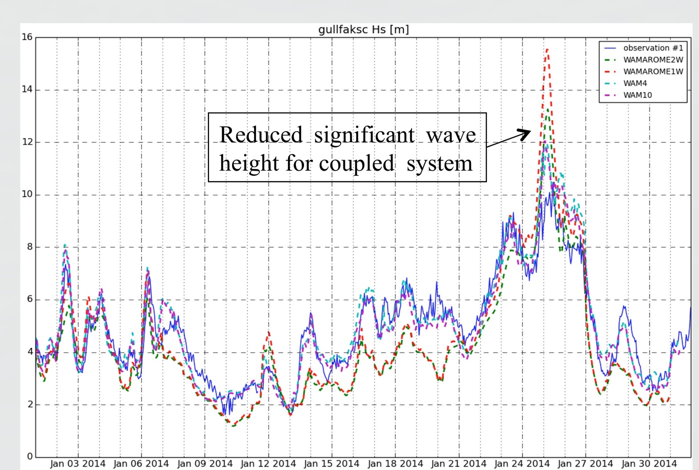
The Charnock parameter is a constant when running without a wave model. In WAM, the Charnock parameter depends on ratio between wave induced stress and total stress.



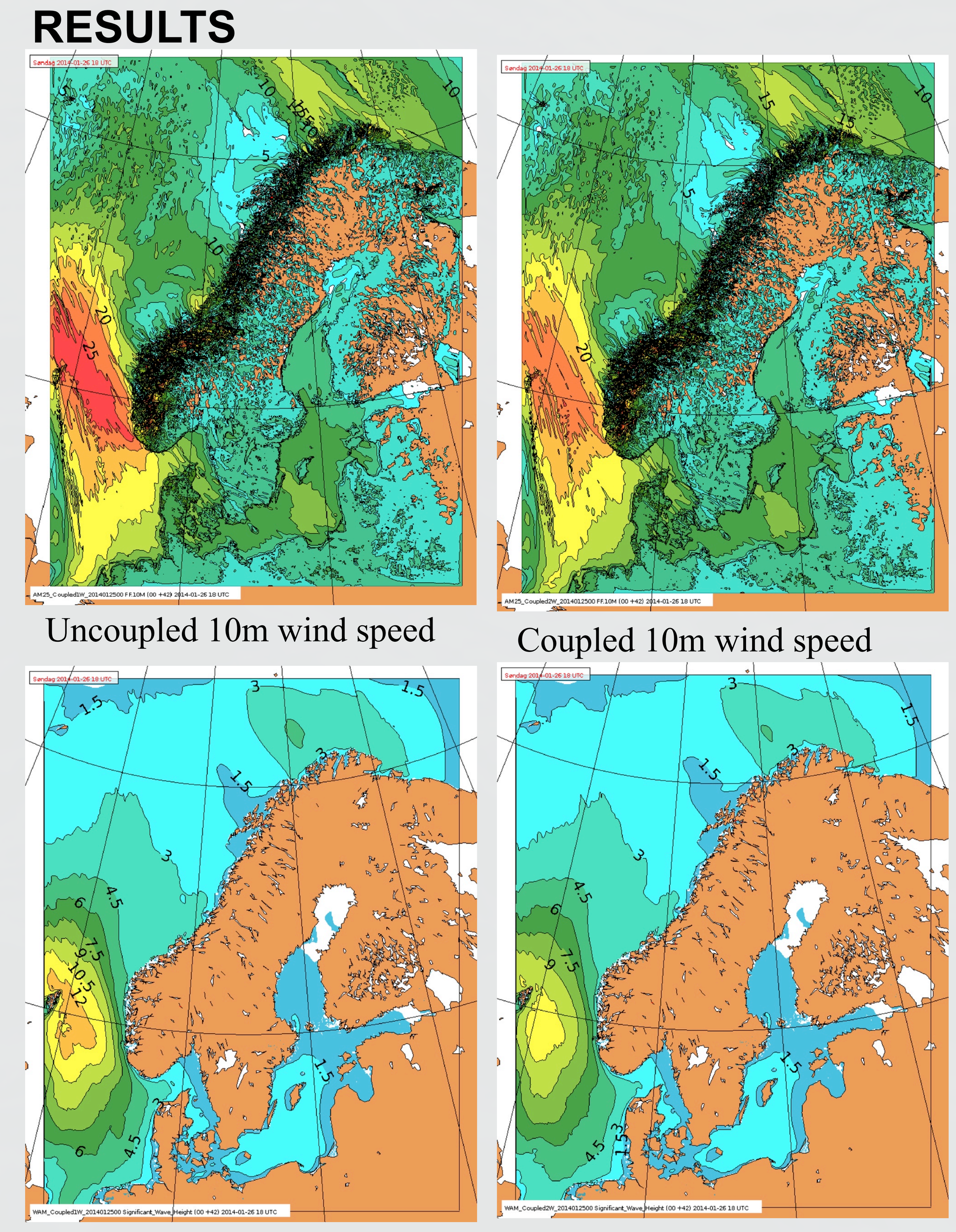
AROME and WAM runs on same grid with the same time step. WAM is called from subroutine each 60s timestep. The model resolutions are 2.5 km^2. AROME uses SURFEX for calculations in the surface layer. AROME provides 10m wind and sea ice each timestep. The Charnock parameter is calculated in WAM and is used for calculations in the next timestep.

RESULTS

10m wind speed and significant wave height is reduced in regions with high wind speed when two way coupling is enabled.



Time series of significant wave height. The 2-way coupled model (WAMAROME2W) show a reduced height compared to the 1-way coupled (WAMAROME1W) in situation with high waves. The large errors are due to problems with the rotation of boundary spectrum for the wave model.

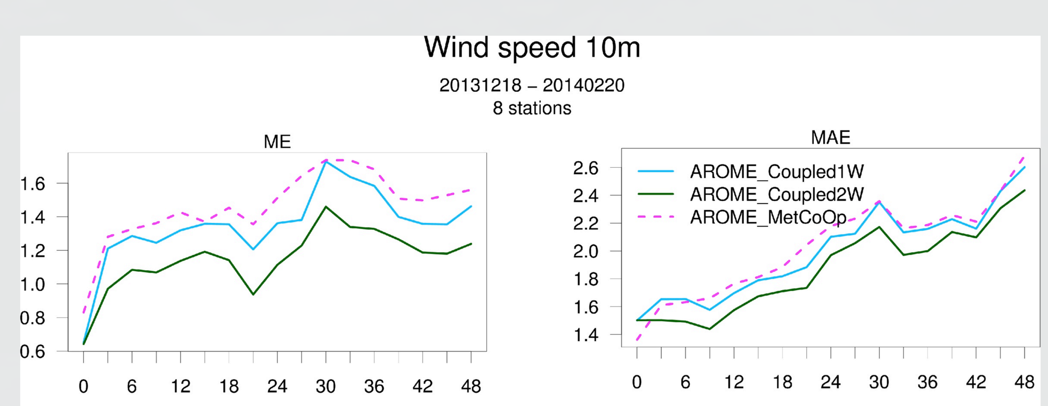


Uncoupled 10m wind speed

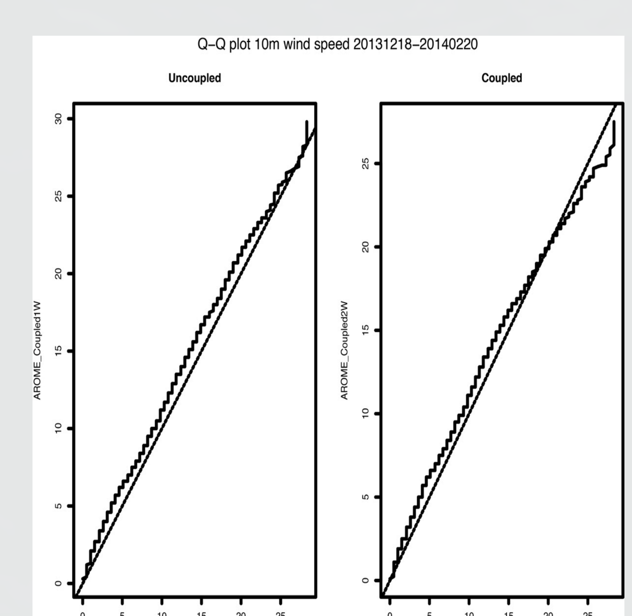
Coupled 10m wind speed

Uncoupled significant wave height

Coupled significant wave height



Mean Error (ME) and Mean Absolute Error (MAE) averaged over one lead time (48h) and 8 ocean stations. The coupled system shows a reduced bias and error of the 10m wind speed. The overestimation of wind speeds over ocean is consistent with results from verification against scatterometer measurements.



Quantile-quantile plot shows a reduction of high wind speeds.

CONCLUSIONS

- Reduced significant wave height in situations with high waves is a step in the right direction.
- Reduced wind speed over ocean is desirable. The Q-Q plot shows that the reduction might be too big for high wind speeds. A solution to this will be to include the destructive effects of wind speeds (above ~25m/s) on the waves, making the surface smoother.

PLANNED WORK

More extensive validation of the model using 2D wave spectrum and verification of the coupling parameterization using Large Eddy Simulation

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