Demonstrating the improved performance of an Ocean-Met model using bi-directional coupling

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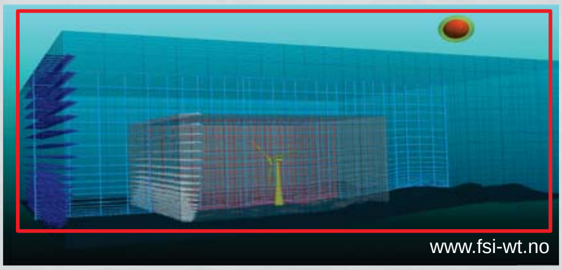
INTRODUCTION

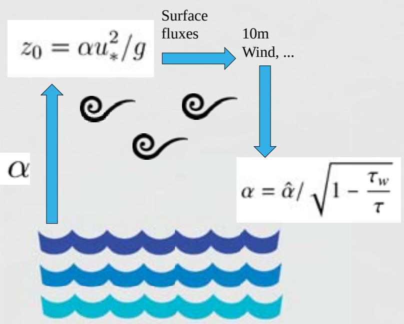
The mass, momentum and energy fluxes between the atmosphere and ocean surface depend on the state of the ocean surface. The fluxes in turn can significantly alter the nature of the marine boundary layer and the state of the ocean surface. These interactions can be modelled deterministically using a multiphase modelling approach or using a semi-stochastic approach. While the multiphase approach can give better insights (e.g. wave generation), it is computationally too expensive and not suited for modelling ocean waves which are inherently random in nature. It is for this reason that in a forecasting context, semi-stochastic approach is still the workhorse. Furthermore, even in a semi-stochastic approach ocean and atmospheric models can be coupled in either unidirectional way (ocean affecting the atmosphere) or bidirectional way (both ocean and atmosphere affecting each other). Current work compares the performance of these two coupling approaches and validates them using Significant wave heights and 10m wind magnitude.



COUPLING

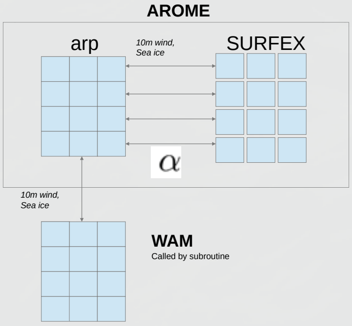
The surface fluxes (momentum and heat) over an ocean surface depend on the state of the surface. For example, young ocean waves typically have a larger roughness than older waves. To get a realistic representation of the ocean, the ocean wave model WAM is coupled with the atmospheric model AROME.

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.

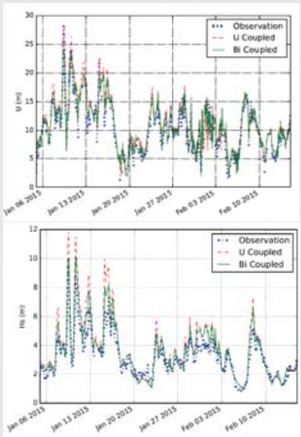
AROME



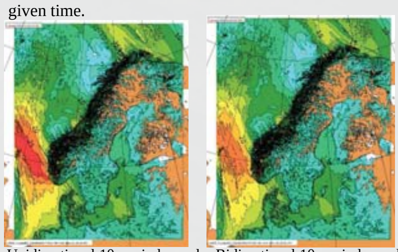
AROME and WAM runs on same grid with the same time step. WAM is called from subroutine each 60s time step. The model resolutions are 2.5 km^2. AROME uses SURFEX for calculations in the surface layer. AROME provides 10m wind and sea ice in each time step. The Charnock parameter is calculated in WAM and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

RESULTS

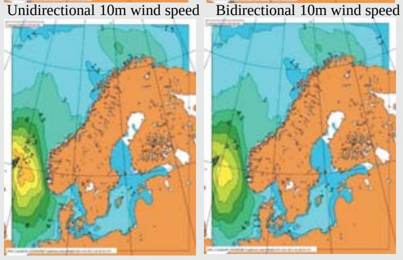
Validation below - Comparison of wind speed (U) and wave height (Hs) as predicted by Uni and Bi coupled approaches over a month with observations measured on Sleipner platform.



Snapshots below - Comparison of wind speed (U) and wave height (Hs) as predicted by Uni and Bi coupled at a given time.



Unidirectional 10m wind speed | Bidirectional 10m wind speed



Unidirectional significant wave height | Bidirectional significant wave height

QQ plots below.

Below - **Left side figure** of the 10m wind speed recorded vs modelled comparison for coastal stations and offshore stations. For coastal stations performance of the Uni-directional coupled model is better than the Bi-directional coupled model. **Right side figure** - QQ plot of wind speed comparing Unidirectional and Bidirectional coupled methods. The Bidirectional coupled system shows a reduced bias and error of the 10m wind speed. The overestimation of Unidirectional coupled wind speeds over ocean is consistent with results from verification against scatterometer measurements.

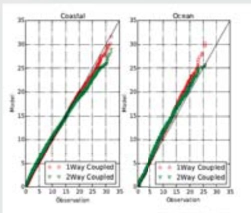


FIGURE 3. QQ PLOT FOR COASTAL AND OFFSHORE STATIONS

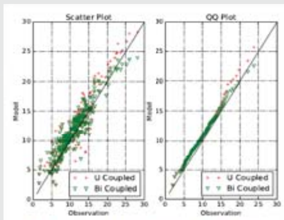


FIGURE SCATTER AND QQ PLOTS FOR WIND SPEED

CONCLUSIONS

Atmospheric code HARMONIE was uni and bi-directionally coupled to the stochastic wave model WAM. Significant wave heights and 10m wind magnitude were used for a quantitative validation. Based on the validation results, it can be concluded that bidirectional coupling, as expected is more accurate than the unidirectional coupled approach specially when the wind and significant heights have bigger values. Uni-directionally coupled model tends to over estimate both wind as well as wave height. Further, the bidirectional approach might not be valuable for coastal regions due to the inherent limitations and coarse resolution of wave model.

PLANNED WORK

A continuation of this work will be to validate the vertical profiles of wind and temperature profile using radiosonde data. These profiles can then be used for MBL characterization. The characterized profiles of wind, temperature and turbulence can then be used to simulate flow in an offshore wind farm.

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