NEMO-WAVE WG meeting

Liverpool: 10th + 12th September 2017

DAY 1: 10th September 2017

PLACE: NOC lab. Brownlow Street n.6, postcode: L3 5DA, Doodson Room (http://noc.ac.uk/about-us/contact-us)

AGENDA:

14:30 – 14:45	Introduction to the meeting + actual wave coupling implemented in NEMO	Emanuela Clementi (INGV)
14:45 – 15:00	Role of Ocean Waves in ECMWF Earth System model	Jean Bidlot (ECMWF)
15:00 – 15:15	Wave-current interactions at NOC	Lucy Bricheno (NOC)
15:15 – 15:30	UK Environmental Prediction: new developments in the UKC3 system	Juan Castillo (UK-MetOffice)
15:30 – 15:45	The role of wave-induced forcing on the regional scales (North Sea and the Baltic Sea)	Joanna Staneva (HZG)
15:45 – 16:00	Wave-ice interactions at NOC	Yevgeny Aksenov (NOC)
16:00 – 16:15	Coupling of WAVEWATCH III with LIM3 and NEMO using OASIS3-MCT: applications to upper ocean mixing and wave-ice interactions in the marginal ice zone, from academic to real cases	Fabrice Ardhuin (IFREMER)
16:15 – 17:00	Open discussion on wave-ice interaction processes to be included in NEMO	All
17:00 – 17:30	Initial discussion on wave enhanced mixing	All

DAY 2: 12th September 2017

PLACE: Hilton Hotel

AGENDA:

18:00 – 18:10	IBI and/or global ocean/wave coupling	Lofti Aouf (Meteo FR)
18:15 – 18:30	Summary of the 1st day meeting	Emanuela Clementi
18:30 – 20:00	Continue open discussion on wave enhanced mixing + Interactions with different wave models + possible other issues	All
20:15	Dinner together at GUSTO restaurant	

LIST OF PARTICPANTS:

NEMO-WAVE Meeting Participants	10-Sep	12-Sep
Emanuela Clementi (INGV)	yes	yes
Joanna Staneva (HZG)	Yes	yes
Fabrice Arduin (IFREMER)	Yes	yes
Oyvind Breivik (MetNO)	No	yes
Yevgeny Aksenov (NOC)	Yes	no
Judith Wolf (NOC)	Yes	yes
Lofti Aouf (Meteo FR)	No	yes
Juan Castillo (UK MetOffice)	Yes	yes
Lucy Bricheno (NOC)	Yes	yes
Jean Bidlot (ECMWF)	yes	yes
Stefanie Rynders (NOC)	yes	no
Stephan Law Chune (Mercator)	no	yes

MINUTES

- Outcomes from the previous NEMO Dev Com Meeting have been communicated to the working group:

  1) Coastal wave processes are not a priority, should be included after the finalization of large-scale processes: in particular the group should focus on enhanced wave mixing and wave-ice interactions

  2) The NEMO WGs should correspond to the chapters of the NEMO Strategic Plan, so since the wave coupling section is included in the "air-sea interaction" chapter, the Wave WG should be included in a new WG working on the air-sea interactions (to be further discussed during next Dev. Com and established by the end of 2017) → Emanuela will keep the group informed

- The actual status of NEMO-WAVE coupling processes included in the trunk have been presented and discussed.

- The wave-coupling processes available on the trunk have been tested at UK-MetOffice (Juan), HZG (Joanna), Meteo-France (Lofti) and Mercator (Stephan).
  Feedbacks are provided and possible modifications to the actual implementations are suggested:
  1. Drag coefficient: Consistency of WW3 (and WAM?) vs ocean drag:
     drag(WW3) = ρ_air * drag(NEMO)
  2. Check the consistency when using the relative vs absolute wind speeds in wave and ocean models (in forced mode only)
  3. $\overrightarrow{\tau_{oc}}$ should be directly communicated to the ocean instead of tauoc rate

     $$\overrightarrow{\tau_{oc}} = \overrightarrow{\tau_a} - \rho_w g \int_0^{2\pi} \int_0^{\propto} d\omega d\Theta \frac{\vec{k}}{\omega} (S_{in} + S_{diss})$$

     Further studies on the effects of wave-induced stress are needed: instead of going into the NEMO model with a scalar of the normalized tau_oc better to use the tau_oc_x and tau_oc_y. More options to be included on how to use this?
  4. Because the input and dissipation source functions are not specified above the cut-off frequency ω_c, an implicit balance between input, dissipation and nonlinear interaction can be assumed above the cut-off frequency. As a consequence, the contribution from the nonlinear source term should be considered in the wave model when evaluating the wave stress (note that it is now only up to ω_c):

     $$\overrightarrow{\tau_{oc}} = \overrightarrow{\tau_a} - \rho_w g \int_0^{2\pi} \int_0^{\omega_c} d\omega d\theta \frac{\vec{k}}{\omega} (S_{in} + S_{diss} + S_{NL})$$

  5. The surface roughness can be modified in vertical mixing:
     roughness_length = significant_wave _height

Vertical Mixing:

If effects of advection are ignored, the turbulent kinetic energy (TKE) equation describes the rate of change of turbulent kinetic energy e due to processes such as shear production (including the shear in the Stokes drift), damping by buoyancy, vertical transport of TKE, and turbulent dissipation ε. It reads

$$\frac{\partial e}{\partial t} = \frac{\partial}{\partial z}\left(\nu_q \frac{\partial e}{\partial z}\right) + \nu_m S^2 + \nu_m S \frac{\partial U_S}{\partial z} - \nu_h N^2 - \varepsilon,$$

where $e = q^2/2$, with q the turbulent velocity, $S = \partial U/\partial z$ and $N^2 = g\rho_0^{-1}\partial\rho/\partial z$, with N the Brunt-Väisälä frequency. The eddy viscosities for momentum, heat, and TKE are denoted by ν_m, ν_h and ν_q. E.g $\nu_m = l(z)q(z)S_M$ where $l(z)$ is the mixing length and S_M depends on stratification.

Wave-induced turbulence is introduced by the boundary condition:

$$\rho_w \nu_q \frac{\partial e}{\partial z} = \Phi_{oc}, \quad z = 0.$$

while effects of Langmuir turbulence are introduced by the term involving the shear in the Stokes-drift profile.

1) The modified vertical mixing due to breaking waves in NEMO should be accounted by modifying the surface kinetic energy including energy flux from wave model (PHIOC)
2) When the previous point is implemented, the Qiao parameterization should be removed from the code.
3) Concerning the Langmuir parameterization, further studies are needed before implementing. To check with George Nurser and Alan Grant on progress.

Seaice-wave interactions

1) Developments on the ice-waves interaction is done at NOC, including sea ice break up & Ocean Mixing due to wave roughness; this is focussed on the Marginal Ice Zone but also is developed for the pack ice as well

- The mixing in the GLC scheme uses significant wave height (Hs) modified by the ice cover
- It sets background (minimum) surface roughness to 6 cm rather than to 2 cm
- The scheme currently ignores the roughness length of the sea ice cover itself (to be included the next year)
- Ice break-up by waves and floe size distribution due to break-up, thermal and dynamical evolution, including collisional MIZ rheology is developed in NEMO with CICE and will be transferred to LIM3 (timescale TBD but around next year), this is a complimentary development to the Ifremer development of the wave-ice models interaction (below)

2) At IFREMER a coupling of WW3 with LIM3 and NEMO using OASIS3-MCT has been implemented. Applications to upper ocean mixing and wave-ice interactions in the marginal ice zone have been shown:

Ice in WW3: 3 attenuation processes: friction (1), scattering (2), anelastic attenuation (3)

•NEMO-LIM3 send ice properties to WW3

•WW3 determines the sea state → ice break-up or not → Floe Size Distribution (FSD)

+ computation of radiative stress (RS).

3) It is pointed out that there is the need to have a NEMO reference configuration coupled with wave model allowing a 2way coupling

4) A SeaIce NEMO WG (SIWG) has been established and Yevgeny and Fabrice are part of the group. The SIWG has recommended to merge the different sea ice components into a European community model for sea ice modelling in NEMO in 2 phases:

- Phase 1 contains all the key physics from existing LIM3 and adding the necessary physics and functionality from the CICE and GELATO models. Phase 1 is planned to last until mid-2019
- Phase 2 contains a wish list for the longer-term development of a communal sea ice model, on which there is no consensus, only open questions. This includes also sea ice-wave coupling: representation of floe size and floe breaking must be introduced to introduce the key dependence of wave attenuation on floe size.

5) Since some developments have been started at NOC and IFREMER, it is proposed to evaluate the possibility to start working on a development branch next year. In order to check the feasibility, it is proposed to contact the SIWG to set up a VC for a joint meeting.

A continuous communication among the 2 working groups is needed → Yevgeny volunteered to be the link between the 2 groups

FINAL DISCUSSIONS:

- According to the highlighted feedbacks and discussions, some improvements could be included by the end of 2017 in the trunk:
    - Breivik et al 2016 Stokes Drift vertical profile should be included (already done by Gurvan? Joanna and Juan have already implemented in their codes)
    - $\overrightarrow{\tau_{oc}}$ should be directly communicated to the ocean instead of tauoc rate (Juan will work on this issue)

- Next year plan should include the modification of the surface kinetic energy by including energy flux from wave model (PHIOC) (Joanna, Juan and Stephan have already worked on it and some developments are already shared)