Note on the ECMWF branch

(Branch 2014/dev_r4642_WavesWG #1323)

Import of surface wave components from the 2013/dev_ECMWF_waves branch
+
a few compatibility changes and some mislaid documentation

Modified Paths: ----------
DOC/TexFiles/Biblio/Biblio.bib
DOC/TexFiles/Chapters/Chap_DYN.tex
DOC/TexFiles/Chapters/Chap_SBC.tex
DOC/TexFiles/Chapters/Chap_ZDF.tex
DOC/TexFiles/Namelist/namsbc

NEMOGCM/CONFIG/ORCA2_LIM/EXP00/namelist_cfg
NEMOGCM/CONFIG/SHARED/namelist_ref
NEMOGCM/NEMO/OPA_SRC/SBC/sbc_oce.F90
NEMOGCM/NEMO/OPA_SRC/SBC/sbcblk_core.F90
NEMOGCM/NEMO/OPA_SRC/SBC/sbcmod.F90
NEMOGCM/NEMO/OPA_SRC/SBC/sbcwave.F90
NEMOGCM/NEMO/OPA_SRC/ZDF/zdftke.F90
NEMOGCM/NEMO/OPA_SRC/step.F90
NEMOGCM/NEMO/OPA_SRC/step_oce.F90

Added Paths: ----------
NEMOGCM/NEMO/OPA_SRC/DYN/dynstcor.F90
NEMOGCM/NEMO/OPA_SRC/SBC/sbcwave_ecmwf.F90

Processes accounted in the wave current interaction:

1- surface boundary condition for the momentum

2- surface boundary condition for the kinetic energy

3- Stokes Coriolis force

surface boundary condition for the momentum

- NEMO/OPA_SRC/SBC/sbc_oce.F90: introduces additional parameters and Boolean for the wave coupling
- NEMOGCM/NEMO/OPA_SRC/SBC/sbcblk_core.F90: computes Drag over Ice with empirical formula to avoid mismatch between land sea mask (Ice, Ocean , Wave) and modifies the wind stress to account for the amount of energy stored into the wave field.
- NEMOGCM/NEMO/OPA_SRC/SBC/sbcmod.F90: adapted to account for the wave interaction;
- NEMOGCM/NEMO/OPA_SRC/SBC/sbcwave_ecmwf.F90: reads the ECMWF wave parameters (similar to sbcwave.F90)

Rationale:

The momentum transfer from atmosphere to the ocean is reduced because part of it is stored into the wave field and released not locally.

Comment on Code Structure:

The process has been implemented in the ***CORE*** bulk formulation. It should be coded independently from the kind of bulks used and probably placed in ***sbc*** (***sbcmod.F90***). The bulks already implemented in NEMO should be used to obtain a first guess of τ and then the τ should be modified accounting for the wave effect. In this way also the "flux" option (the fluxes as external data) could be included.

Stokes-Coriolis force

NEMOGCM/NEMO/OPA_SRC/DYN/dynstcor.F90 New routine, computes the 3D Stokes Drift (from Surface Stokes Drift values, significant wave height, mean wave period provided as external data) and computes the Stokes-Coriolis force.

Comment on Code Structure:

The Stokes is computed in *dyn_stcor* and simultaneously the Stokes-Coriolis force computed and included in the general momentum trend. The Stokes Drift computation should be replaced and the Stokes Drift current becomes a state **public variable** in the *sbc_wave* module, so it can be used also in other terms (tracers and momentum advection). The algorithm proposed to compute the 3D Stokes Drift current is a better approximation than the

approximation currently used. The usd3d, vsd3d and wsd3d variables should be computed following the **Breivik** code in sbc_wave.

Technical Question:

rn_deptmaxstcor: Is a limiting factor (in the ECMWF report is stated that below this depth, 150, the Stoke Drift is sufficiently small). This has been implemented to avoid loop over the whole z dimension, however it is not clear if an ***IF*** statement within the ***DO*** loops can improve the performances.

Numerical Issues:

1. Independently of the choice done for the momentum equation horizontal component (flux or vector form), there are 4 different options to compute the advection+Coriolis terms. Namely they are Energy, Enstrophy, Energy Enstrophy, Mixed Conserving Schemes. In *dyn_stcor* none of them is considered. At least one scheme should be used (EEN?). In addition the code does not account for the staggered grid, Coriolis and velocities (zonal and meridional) are not in the same positions. This is a bug and should be corrected.
2. Should we also consider the curvature metric term for the Stoke Drift when the FLUX form is used?

Yes, we have to compute:

- vector invariant form

rotn × u + f × u + f × u_stokes

- flux form

(f + metric + metric_stokes) × u + (f + metric) × u_stokes (see equation 26-27 of Uchiyama OM 2010 for instance, or 14-15 of Kumar OM 2012)

One way to do it may be to call vorticity routines twice with input arguments :

- vorticity
- velocity for metrics
- velocity for vorticity

For instance

CALL vor_een (kt, ntot, rotn, un+ust, vn+vst, un, vn, ua, va) ! usual trend + eventually advection metric including wave

CALL vor_een (kt, ntot, 0 , un , vn, , ust, vst, ua, va) ! stokes coriolis

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Another way may be to add all the different cases and play with kvor inside the routines.

Remark:

Even correcting the code following the above mentioned issues, the time-splitting case is not implemented. Two parts are missing. First the Stokes-Coriolis contribution should be removed from the general trend during the "coupling" phase. Second the barotropic Stokes-Coriolis term should be introduced in the barotropic loop.

I didn't realize at the meeting but yes … I suppose it also relies on the simplification. It's kind of blocking if filtered free surface is removed.

Anyway I confirm I can code the above modifications in dynvor and send it to ECMWF for test.

surface boundary condition for the kinetic energy

NEMO/OPA_SRC/ZDF/zdftke.F90: includes the new surface boundary condition for the KE.

In ***sbcwave_ecmwf.F90*** *phioc_wavepar* is defined as:

INTEGER,PARAMETER::jp_phioc=5!index of normalized energy flux into the ocean (non-dim) Bug to be corrected (it should be in physical units)

In ***zdftke.F90*** is used as:

```
! The energy flux from the wave model in physical units
 zphio_flux = MAX(phioc_wavepar(ji,jj), 0.0_wp)
! TKE at surface (Mellor and Blumberg, 2004)
e0(ji,jj) = 0.5_wp*( 15.8_wp*zphio_flux/rau0 )**0.67_wp
```

as already divided by alpha

Question:

Being ***phioc_wavepar*** already in physical units implies it is already divided by *alpha*. On one hand the ***phioc_wavepar*** in physical units is available from ECMWF database, on the other hand *alpha* could be an important tuning parameter.