Action report

Action VALID-09_Lovato Test Wave coupling in Mediterranean Sea
PI(S) Tomas Lovato, Emanuela Clementi
Digest
Test the wave-current interaction processes in the Mediterranean Sea forced by WW3. Evaluate single process impact on the hydrodynamic fields. Propose possible modifications and enhancements. This action doesn't require a development branch to be created; it is an activity supporting WAVE coupling development.

Ticket http://forge.ipsl.jussieu.fr/nemo/ticket/2013
Wiki http://forge.ipsl.jussieu.fr/nemo/wiki/2018WP/VALID-09_Lovato_TestWave_MedSea

Technical notes

NEMO code r9966 (trunk after V4 release)
Configuration Mediterranean Sea 1/24 deg horizontal resolution, 141 vertical levels

The following summarize the namsbc namelist fields to handle the wave coupling:

```
!-----------------------------------------------------------------------
&namsbc        !   Surface Boundary Condition manager                  (default: NO selection)
!-----------------------------------------------------------------------
   nn_fsbc     = 1         !  frequency of SBC module call

...

   ln_wave     = .true.    !  Activate coupling with wave  (T => fill namsbc_wave)
   ln_cdgw     = .true.    !  Neutral drag coefficient read from wave model (T => ln_wave=.true. & fill namsbc_wave)
   ln_sdw      = .true.    !  Read 2D Surf Stokes Drift & Computation of 3D stokes drift (T => ln_wave=.true. & fill namsbc_wave)
   nn_sdrift   =  0        !  Parameterization for the calculation of 3D-Stokes drift from the surface Stokes drift
      !                    !   = 0 Breivik 2015 parameterization: v_z=v_0*[exp(2*k*z)/(1-8*k*z)]
      !                    !   = 1 Phillips:                      v_z=v_o*[exp(2*k*z)-beta*sqrt(-2*k*pi*z)*erfc(sqrt(-2*k*z))]
      !                    !   = 2 Phillips as (1) but using the wave frequency from a wave model
   ln_tauwoc   = .false.   !  Activate ocean stress modified by external wave induced stress (T => ln_wave=.true. & fill
namsbc_wave)
   ln_tauw     = .false.   !  Activate ocean stress components from wave model
   ln_stcor    = .true.    !  Activate Stokes Coriolis term (T => ln_wave=.true. & ln_sdw=.true. & fill namsbc_wave)

...

/
```

In next paragraph about simulation description is shown the content of namsbc_wave to provide NEMO with wave model data.

Note that we started from a previous version and bugfixes were reported in the code, wrt to the implementation of this validation configuration (see revisions: 9807, 9812, 9821, r9966)
In particular, when selection option nn_sdrift = 2 the formulation to compute the peak wave number (k) was erroneously assuming to deal with angular velocity, while the code ingest the input fields from the wave model as frequencies.

At r9966, the computation of peak wave number (k) was corrected as follow:

$k = \omega^2 / g = (2*\pi*fp)^2 / g$, being $\omega = 2*\pi*fp$

where fp is the wave frequency provided by the coupled wave model, g is the gravitational acceleration, and ω the angular velocity.

Simulations

All the tests listed in the table below were carried out on a short-term horizon (1 mo) using initial climatological conditions (year 2017) and boundary forcing for January 2017.

Wave fields were produced with WaveWatch3 model for January 2017 and provided to NEMO with a hourly frequency, as show in namsbc_wave here below.

```
!-----------------------------------------------------------------------
&namsbc_wave   ! External fields from wave model                        (ln_wave=T)
!-----------------------------------------------------------------------
   cn_dir      = './'      !  root directory for the waves data location

!___________!_____________________________!____________________!___________!_____________!________!___________!____________________!_______
___!_____________!
   !           !  file name              ! frequency (hours) ! variable  ! time interp.!  clim  ! 'yearly'/ ! weights filename !
rotation ! land/sea mask !
   !           !                         !  (if <0  months)  !   name    !   (logical) !  (T/F) ! 'monthly' !                 !
pairing  !    filename   !
   sn_cdg      =  'ww3.out'              ,        1          , 'Cdg'     ,  .true.  , .false., 'daily'   ,  ''             , ''
, ''
   sn_usd      =  'ww3.out'              ,        1          , 'SDx'     ,  .true.  , .false., 'daily'   ,  ''             , ''
, ''
   sn_vsd      =  'ww3.out'              ,        1          , 'SDy'     ,  .true.  , .false., 'daily'   ,  ''             , ''
, ''
   sn_hsw      =  'ww3.out'              ,        1          , 'hs'      ,  .true.  , .false., 'daily'   ,  ''             , ''
, ''
   sn_wmp      =  'ww3.out'              ,        1          , 't'       ,  .true.  , .false., 'daily'   ,  ''             , ''
, ''
   sn_wfr      =  'ww3.out'              ,        1          , 'fp'      ,  .true.  , .false., 'daily'   ,  ''             , ''
, ''
   sn_wnum     =  'ww3.out'              ,        1          , 'nws'     ,  .true.  , .false., 'daily'   ,  ''             , ''
, ''
/
```

Here are referenced the simulation performed for this validation activity (with the specific 3D-Stokes drift) :

EXP01	Reference: NO wave coupling (ln_wave=F)
EXP04	Wave forcing with 3D-Stokes drift option nn_sdrift = 0 (Breivik 2015 parameterization: v_z=v_0*[exp(2*k*z)/(1-8*k*z)])
EXP05	Wave forcing with 3D-Stokes drift option nn_sdrift = 0 (Phillips: v_z=v_o*[exp(2*k*z)-beta*sqrt(-2*k*pi*z)*erfc(sqrt(-2*k*z))])
EXP06	Wave forcing with 3D-Stokes drift option nn_sdrift = 2 (Phillips, but using the wave frequency from the wave model)

Outcomes summary

The different variants of the wave coupling were compared on a short-term simulation by analyzing daily fields (at day 31) of sea surface temperature (F1) and zonal and meridional components of both sea surface current velocity and stokes drift velocity (F2 to F5).
Note that anomalous patterns at the Atlantic boundaries are mainly due to adjustments from climatological initial conditions.

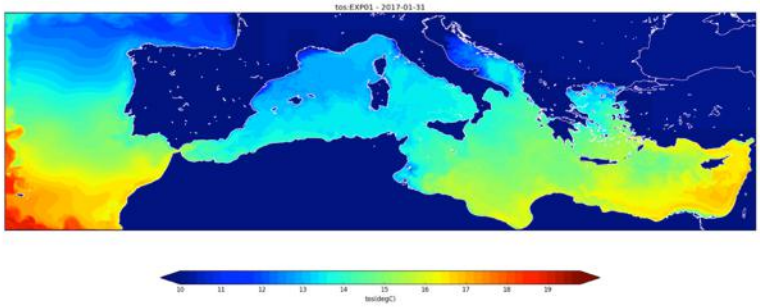
In figure F1 to F3 are illustrated the outcomes from the reference case without waves (EXP01) and the differences between this reference simulation and those obtained with 3D-Stokes drift computed using the available parameterizations (see table above for details).

Overall, deviations from the reference case of the available parameterizations are rather small, with both temperature and current velocities having similar ranges among the three cases.

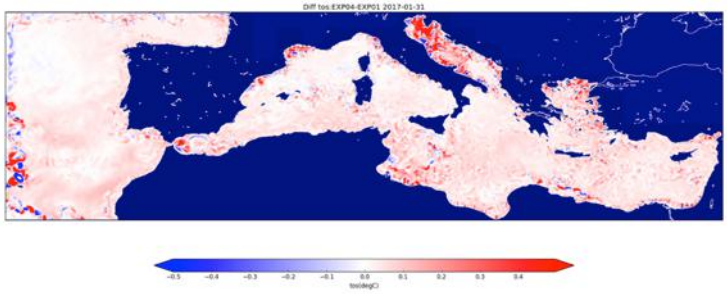
The simulated zonal (F4) and meridional (F5) Stoke's drift velocities appear to be very close between the three parameterizations, whereas the fields obtained in EXP06 appear to have slightly higher maximum values within the Mediterranean Basin.

F1. Sea Surface Temperature

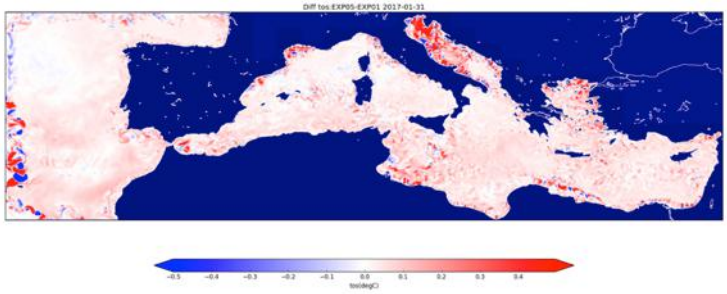
EXP01 (no WAVE)



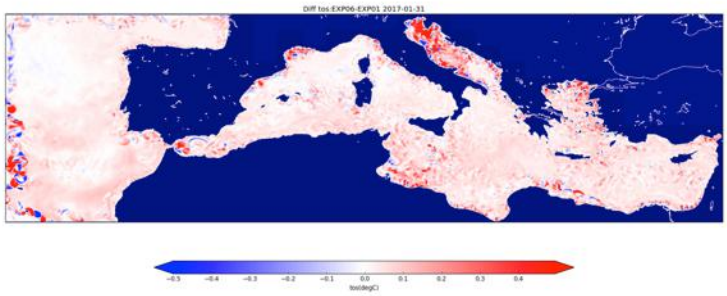
EXP04-EXP01



EXP05-EXP01

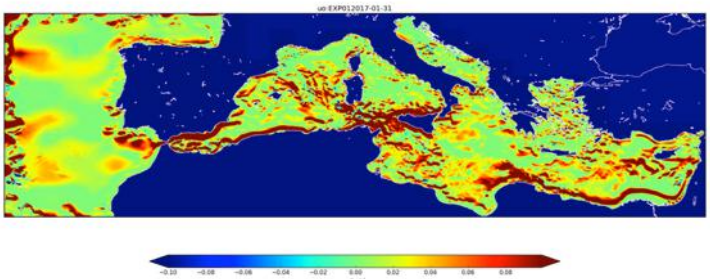


EXP06 -EXP01

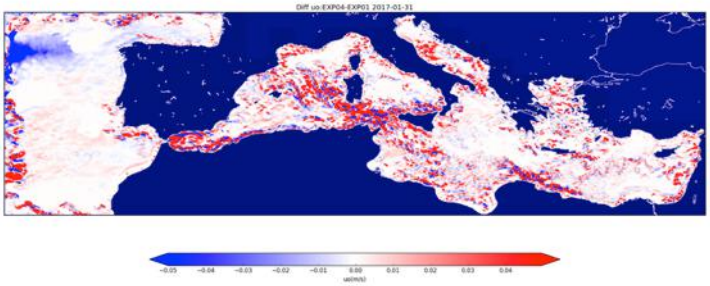


F2. Sea Surface Zonal Velocity

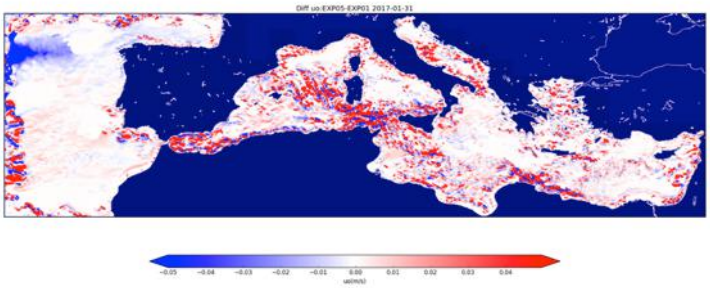
EXP01 (no WAVE)



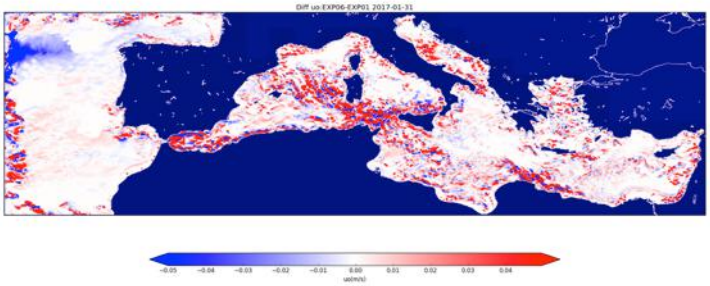
EXP04-EXP01



EXP05-EXP01

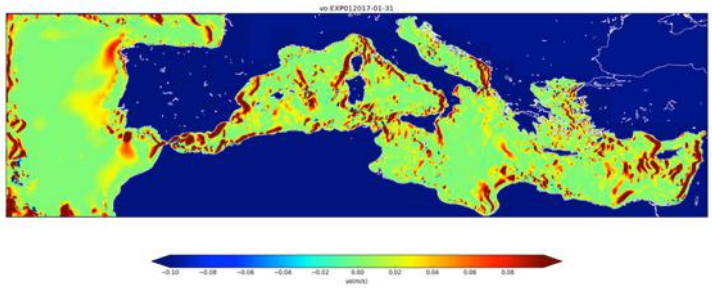


EXP06 -EXP01

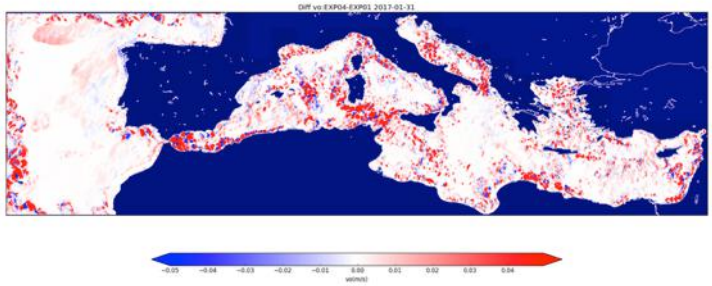


F3. Sea Surface Meridional Velocity

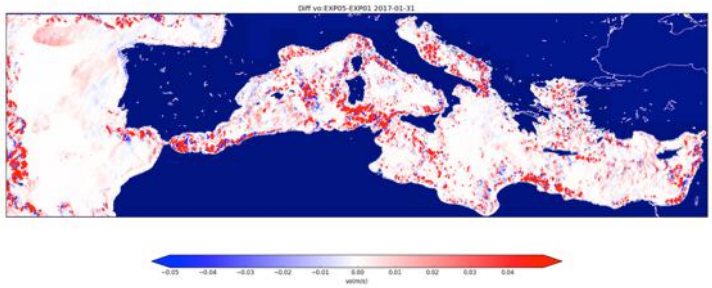
EXP01 (no WAVE)



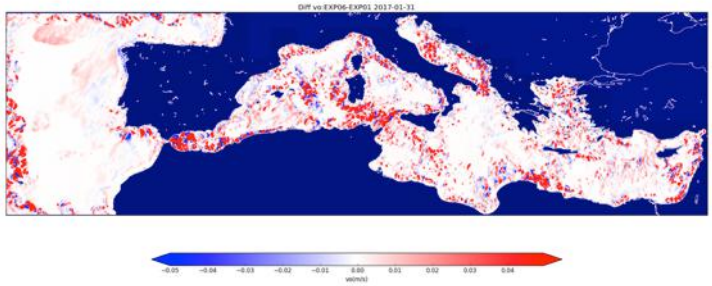
EXP04-EXP01



EXP05-EXP01

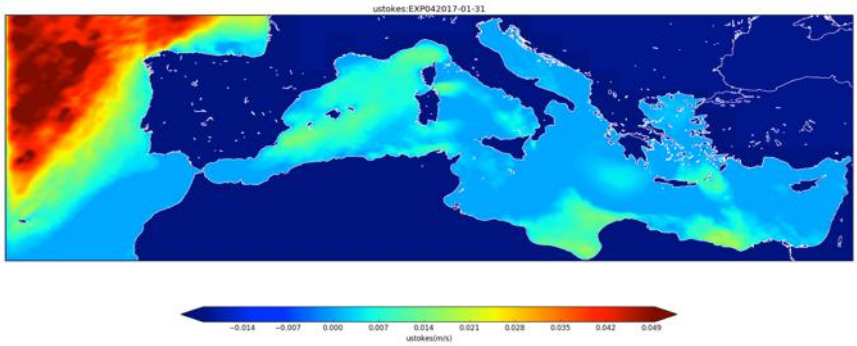


EXP06-EXP01

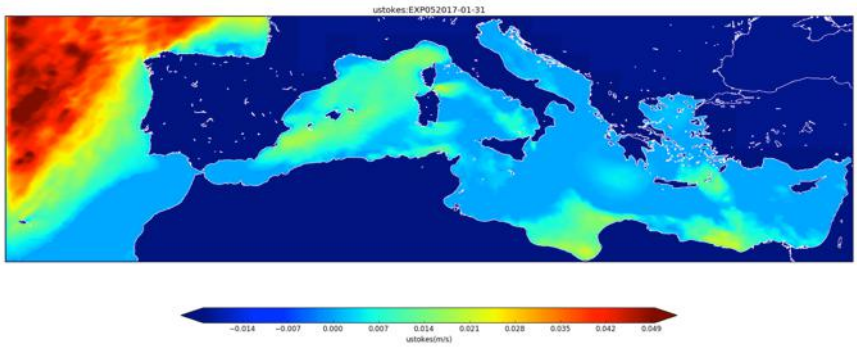


F4. Sea Surface Zonal Stokes Drift Velocity

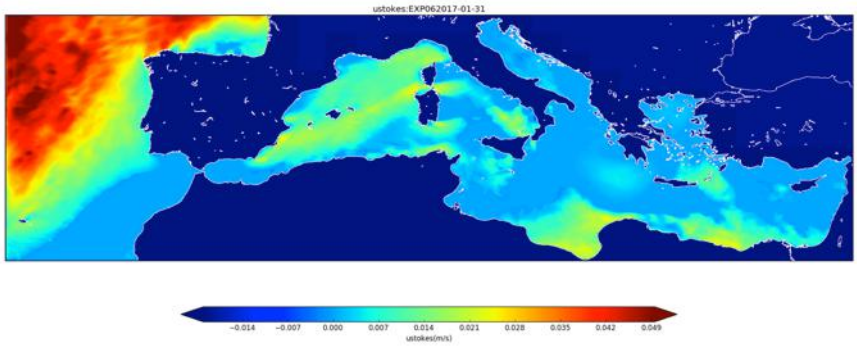
EXP04



EXP05

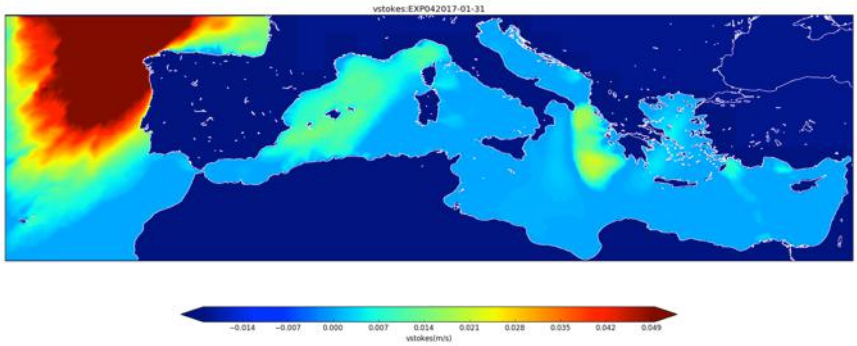


EXP06

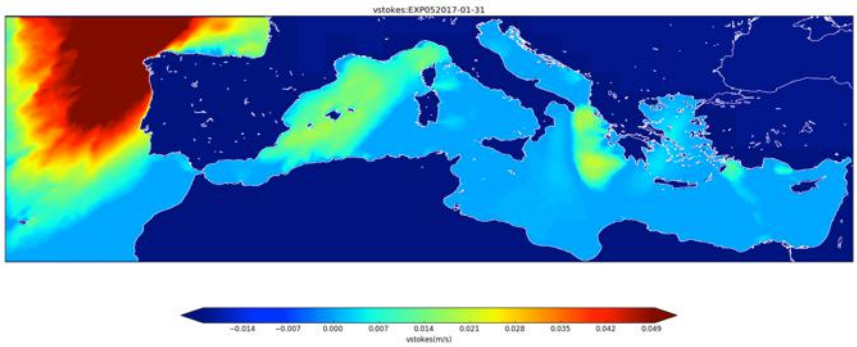


F5. Sea Surface Meridional Stokes Drift Velocity

EXP04



EXP05



EXP06