Tides-related innovations in NEMO v4.2

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New tidal-forcing options (collaboration with Nicolas Bruneau)

- **Tunable tidal tilt factor** $1 + k - h$

```
$ grep rn_tide_gamma cfgs/SHARED/namelist_ref
rn_tide_gamma = 0.7                  ! Tidal tilt factor
```

- **Revised and extended default tidal parameter set**

```
$ grep nn_tide_var cfgs/SHARED/namelist_ref -A 1
nn_tide_var    = 1           !  Variant of tidal parameter set and tide-potential computation
!                            !     (1: default; 0: compatibility with previous versions)
```

+ **11 additional constituents in tidal potential**
+ **8 constituents newly available for forcing at open boundaries**
+ **Matches FES2014** constituent set (https://www.aviso.altimetry.fr/en/data/products/auxiliary-products/global-tide-fes.html)

NEMO v4.2	legacy option
Long-period tidal constituents	
Mf	(Mf)
Mm	(Mm)
Ssa	-
Mtm	(Mtm)
Msf	-
Msqm	(Msqm)
(Sa)	-
Diurnal tidal constituents	
K1	K1
O1	O1
P1	P1
Q1	Q1
J1	-
(S1)	(S1)
Semidiurnal tidal constituents	
M2	M2
S2	S2
N2	NS
K2	K2
$\nu 2$	$\nu 2$

Constituents in parantheses are not included in tidal potential

NEMO v4.2	legacy option
Semidiurnal tidal constituents (cont.)	
$\mu 2$	$\mu 2$
2N2	2N2
L2	L2
T2	T2
$\epsilon 2$	-
$\lambda 2$	-
R2	-
Terdiurnal tidal constituents	
M3	-
Compound tides	
(MKS2)	-
(MN4)	-
(MS4)	-
Overtides	
(M4)	(M4)
(N4)	-
(S4)	-
(M6)	-
(M8)	-

Flexible multiple linear regression analysis for NEMO

- **Multiple linear least-squares regression** in terms of **scalar products** between dependent time-stepped model diagnostics $|y\rangle$ and regressors $|x_m\rangle$, $\langle y\,|x_m\rangle$ and $\langle x_n\,|x_m\rangle$

$$\begin{pmatrix} r_1 \\ \vdots \\ r_{n_r} \end{pmatrix} = \mathrm{M}^{-1} \begin{pmatrix} \langle y\,|x_1\rangle \\ \vdots \\ \langle y\,|x_{n_r}\rangle \end{pmatrix}, \text{where } \mathrm{M} = \begin{pmatrix} \langle x_1\,|x_1\rangle & \dots & \langle x_1\,|x_{n_r}\rangle \\ \vdots & \ddots & \vdots \\ \langle x_{n_r}\,|x_1\rangle & \dots & \langle x_{n_r}\,|x_{n_r}\rangle \end{pmatrix}.$$

- **XIOS** I/O server receives the dependent variables $|y\rangle$ as 2D and 3D fields from NEMO, **can compute regressors** $|x_m\rangle$ from a clock signal sent by NEMO, **can be configured to compute the scalar products**, and can **periodically output accumulated scalar products**
- **Parameter substitution** in XIOS regressor configurations such as

```
<field [...] expr="__TDE_M2_amp__ * sin( __TDE_M2_omega__ * dmlr_time + __TDE_M2_phase__ )" [...] />
```

  and configuration of scalar-product diagnostics **at runtime** by NEMO

+ **Wide range of applications** (e.g., tidal harmonic analysis, seasonal detrending, etc.)
+ **Flexibility during post-processing** (e.g., restriction of anaylsis to regressor subset, choice of analysis interval within granularity of scalar-product output)

Tidal harmonic analysis innovations (w.r.t. current/previous NEMO release versions)

+ Tidal harmonic analyses **across model restarts**
+ Analysis **interval selection** during post processing
+ Tidal harmonic analyses of **any 2D and 3D diagnostic field**
+ Computational **efficiency**
+ **External analysis tool** to faciliate analyses (rudimentary `tools/DIAMLR/diamlr.py`, to be developed further)