HYCOM developments and tests in the MOUTON project

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Objective of the project:

*Develop and validate a model able to represent the ocean dynamics (=currents, temperature and salinity fields) in both deep and shallow regions at high resolution (1 km)*

**Operational needs:**
- Underwater warfare (navig., acoustics in coastal areas)
- Mine warfare (mine drift + burial)
- Special operations (commandos, amphibious ops)
- Police operations at sea
  (rescue at sea, drift of objects, pollutions, …).

Launched 2001, finish 2008/9

**Numerical Modeling:**
- Include tide in OGCMs
- «Clean» river run-off
- Deal with the cont. shelf
- …
=> based on HYCOM

**Data Assimilation:**
- Observations (Altimetry, RHF, …)
- «Filters» dev.
- …

**Validation:**
- Campaigns at sea
  CONGAS/MOUTON campaigns 2004->2009
CHOICE OF THE AREA: Process studies

- Wetting/drying tide
- O/A intercations (HF)
- Tide + internal tide
- Current + drift
- Seasonal stratification (formation of thermocline)
- Vortices/Eddies
- Coastal/deep ocean exchanges
- Upwelling internal waves (solitons)
- Med waters
Characteristics of the demonstration models

V 1 : basin model – Resolution 1/12°
assimilation of altimetry (RSMAS+COAPS)

V 2.1 : local model – Resolution 1,7 km
33 levels
Initial state and boundary conditions forced by
• MERCATOR
• MOG2D (tide – Le Provost and Lyard)
Atmospheric forcings:
ARPEGE
(METEO-France)

V 2.2 : local model – Resolution 1,7 km
150 m (only tide)
Numerical developments and results

- Wetting drying version of HYCOM (modified barotp)
  ⇒ tides

- New time stepping for the slow part of barotropic fields (slight modif main and momtum)
  ⇒ to deal with strong currents in shallow areas (tides)

- Time varying stratification characteristics (new subroutine)
  ⇒ manage seasonal thermocline

- New boundary conditions for BT mode (new subroutine)
  ⇒ clean forcing of the tide and rivers

- Original data assimilation method
  ⇒ Adaptive filter (adjoint)

- 4th order advection scheme for momentum (new momtum)
  ⇒ more efficient than 2nd order scheme at high resolution
Wetting/Drying

Non-linear terms included in barotropic Mode (no approximations)

Drastic modification Of the numerical Schemes (but based On the schemes used In HYCOM for Baroclinic mode)

⇒ Has a cost ! (but only for barotropic mode)

20-25 september 1997
New time stepping for BT mode

Slow evolution of Btropic mode: original code is unstable (CFL)!

Integration of baroclinic part

Integration of barotropic part

Baclin = 12 s batrop = 1.5s

Baclin = 12 s batrop = 0.5s

Baclin = 6 s batrop = 1.5s

Baclin = 12 s batrop = 1.5s

LSBM
Time evolution of stratification characteristics

AXBT MOUTON – MAY 2004

Position of geop. levels is evolved Monthly according to the averaged stratification in the area from climatology.
Time evolution of stratification characteristics

HYCOM ATL 1/12°

Mercator

Temperature (°C), section méridienne 8.00W

AXBT

HYCOM GASC-M

Temperature (°C), meridian section 8.00W

AXBT MOUTON – JULY 2004
AXBT MOUTON JULY 2004 (zoom 0-200m)

HYCOM
GASC-M

OBS

MOUTON
Boundary conditions: rivers

Temperature: comparison between observations (- -) and model (-) (data source: SOMLIT + EPOC)
Boundary conditions: rivers

Salinity: comparison observations (- -) model (-)
(data source: SOMLIT + EPOC)
TIDES IN THE MANCHE (CHANEL)

model includes all modifications (all are important)
TIDE M4

Observations (Le Provost/Chabert d’Hières)

M4 Phase – old barotp (degree) Model
TIDE M2

Observations (Le Provost/Chabert d’Hières)

Model
SST – May 2004
DATA ASSIMILATION

OI:
applied to bassin and regional
demonstration
models

Adaptive filter:
applied to bassin demonstrator (Indian ocean)
⇒Adjoint of HYCOM

Used to deal with high frequency
(tides) using HF radars

SST error (after 5 months) : free run and with assimilation (SSH, SST + in-situ)
Conclusion: ongoing and future developments

Locally adaptive stratification (modification of « hybgen ») ⇒ improve evolution of thermocline and prepare coupling with atmospheric models (Cécile Renaudie – SHOM/MF)

Simulation over 20 days, wind=20 m/s, air temperature=1°C, radiative flux=0W/m² with 40 hybrid layers, in May (dp00=1.01m, dp00x=1.41m, dp00f=1.04) compared with an all z-levels solution (4476 layers of 1m each).

Alternative:
dp00f from the previous time step geometrical series to calculate dp00:

\[ S = dp00 \frac{1 - dp00f^{nbz}}{1 - dp00f} \]
Conclusion: ongoing and future developments

most important processes (coastal) are reproduced at least qualitatively but need some modification of the code
⇒ confidence in model for coastal modeling

Data assimilation:
Deal with high/low frequency processes (tides)
Adapt « adaptive filter » to regional model

Pursue validation (test upwellings, gravity currents, internal tides)

AGRIF package (modification of « entire » code: look out for syntax in future release)
⇒ automatic 1-2 way nesting