2D modelisation of non-hydrostatic internal waves on idealised embankment

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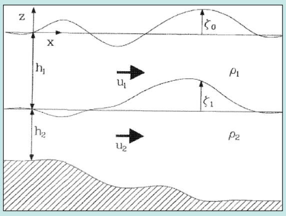
Study aim : In this study, we test the possibility of integrated non-hydrostatics terms under weakly nonlinear and nonhydrostatic approximation in the isopycnic coordinate ocean model HYCOM in order to model the desintegration of internal waves into solitons on idealised embankment. Non-hydrostatic (NH) terms derived with this assumption are directly added to the hydrostatic equations.

Theoretical model

From Diebels *& al.* (1994)



Hypothesis :
- 2 isopycnal layers
- weakly NL and NH
- bottom topography
- expressed in terms of currents

To N layers : recurrence method

$$\bar u_{1t} + \epsilon \bar u_1 \bar u_{1x} + \zeta_{0x} - \epsilon^2\left(\tfrac{1}{3}h_1^2 \bar u_1 + \tfrac{1}{2}h_1 h_2 \bar u_2\right)_{xxt} = 0$$

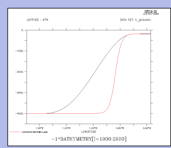
$$\bar u_{2t} + \epsilon \bar u_2 \bar u_{2x} + \frac{\rho_1}{\rho_2}\zeta_{0x} + \left(1 - \frac{\rho_1}{\rho_2}\right)\zeta_{1x}$$

$$-\epsilon^2\left(\tfrac{1}{2}\tfrac{\rho_1}{\rho_2} h_1^2 \bar u_{1xxt} + \tfrac{\rho_1}{\rho_2} h_1 (h_2 \bar u_2)_{xxt} + \tfrac{1}{2} h_2 (h_2 \bar u_2)_{xxt} - \tfrac{1}{6} h_2^2 \bar u_{2xxt}\right) = 0$$

Numerical implementation

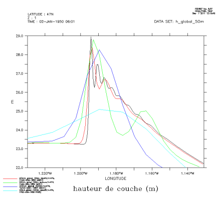
HYCOM :
- **M2 tide**
- Latitude 48° N
- 2 isopycynical layers
- strongly NL
- hydrostatic approximation
- idealised bottom topography
- expressed in terms of currents
- only 2DV

Resolution :
- Separation of barotropic and baroclinic mode
- **Leap-Frog** scheme with Asselin filter



Implementation in the momentum equation of time derivative terms
⟹ Choice of the numerical scheme?

Numerical dispersion



Hydrostatic simu. : $\Delta x = 1000$ m

To observe NH effects, Δx must be reduced. But truncature error contains a term $\propto \bar u_{xxt}$.

Numerical dispersion looks like weak NH effects.

Numerical stability

Since explicit scheme failed, NH terms are introduces implicitly.

$$\frac{u_i^{n+1} - u_i^*}{2\Delta t} + [\text{NH terms}]_{n-1}^{n+1} = 0$$

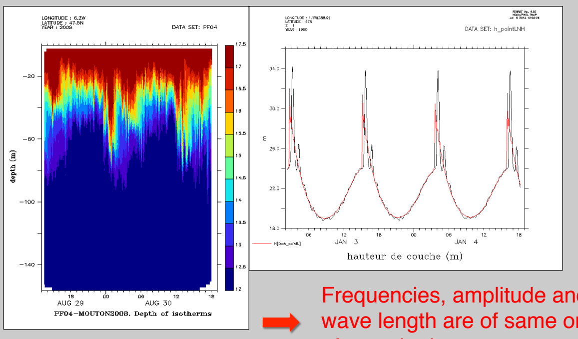
$$\text{avec } u_i^* = u_i'^* + \bar u_i^{n+1}$$

Initial conditions

Since we implement high-order derivatives of current and bathymetry, the initial high-order derivatives must be smoothed properly.

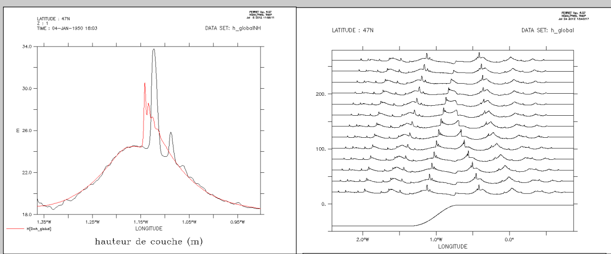
RESULTS

(1)

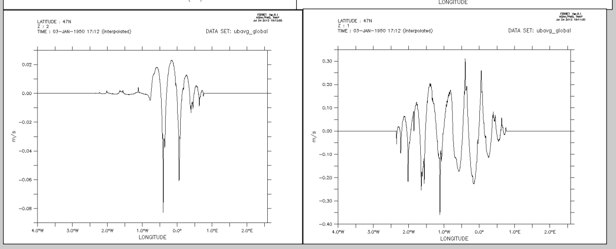


Frequencies, amplitude and wave length are of same order of magnitude

(2)



(3)



Simulation of the desintegration of internal waves into soliton

(1) Variation of the thermocline position in time (in-situ and numerical simulation)
(2) Variation of the thermocline position in space (zoom on one tidal wave length and each-tidal-time representation
(3) Variation of the baroclinic current in each layer

Perspectives

(1) Implement the NH terms : for N vertical layers and in the y- direction
(1) Use a realistic bathymetry
(2) Compare with the in-situ 3D measurements from MOUTON compaign

Converging Oceaniac Internal Waves, Somalia, Africa (Nasa Image eXchange)