A new 3D fully wave-current model MARS-WWATCH III: Application to the Biscarosse beach

A-C. Bennis[3,2], F. Ardhuin[1,2], F. Dumas[2]

1 - IFREMER, L.O.S, 29280 Plouzané, France
2 - IFREMER, DYNECO/PHYSED, 29280 Plouzané, France
3 - LPO, 6 avenue Le Gorgeu, 29200 Brest, France

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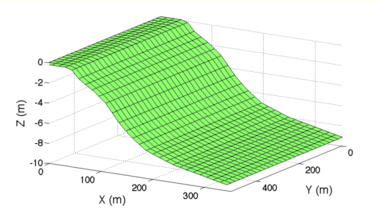
Outline

Anne-Claire BENNIS (bennis@univ-brest.fr)

NSTS → Configuration and goal



Bathymetry - Leadbetter Beach, CA (4/02/1980)

- NSTS Experiment, 4/02/1980 (cf. Thornton et Guza,1986 et Wu et al, 1985)
- **Simulation of the longshore current.**
- dx=4m, dy=20m, 100 sigma levels (mesh refinement near bottom and surface), dt=1s.
- One-way coupling.

Goal

- Validation of the 3D version of the coupled model based on the theoretical model of Ardhuin et al (2008) in surf zone.
  - Breaking waves: addition of the $F_{d,x}$ and $F_{d,y}$ terms.
  - Bottom stress+resolution of the WBBL: addition of the $F_{b,x}$ et $F_{b,y}$ terms.
  - Turbulent mixing: addition of the $F_{m,x}$ et $F_{m,y}$ terms.

NSTS → The equations: part 1

$$(1):\ \frac{\partial \widehat{u}}{\partial t} + \widehat{u}\frac{\partial \widehat{u}}{\partial x} + \widehat{v}\frac{\partial \widehat{u}}{\partial y} + \widehat{w}\frac{\partial \widehat{u}}{\partial z} - f\widehat{v} + \frac{1}{\rho}\frac{\partial p^H}{\partial x} = \left[f + \left(\frac{\partial \widehat{v}}{\partial x} - \frac{\partial \widehat{u}}{\partial y}\right)\right] V_s - W_s\frac{\partial \widehat{u}}{\partial z} - \frac{\partial J}{\partial x} + \widehat{F}_{d,x} + \widehat{F}_{m,x} + \widehat{F}_{b,x},$$

$$(2):\ \frac{\partial \widehat{v}}{\partial t} + \widehat{u}\frac{\partial \widehat{v}}{\partial x} + \widehat{v}\frac{\partial \widehat{v}}{\partial y} + \widehat{w}\frac{\partial \widehat{v}}{\partial z} + f\widehat{u} + \frac{1}{\rho}\frac{\partial p^H}{\partial y} = -\left[f + \left(\frac{\partial \widehat{v}}{\partial x} - \frac{\partial \widehat{u}}{\partial y}\right)\right] U_s - W_s\frac{\partial \widehat{v}}{\partial z} - \frac{\partial J}{\partial y} + \widehat{F}_{d,y} + \widehat{F}_{m,y} + \widehat{F}_{b,y}.$$

$$(3):\ \frac{\partial e}{\partial t^\star} = \frac{1}{D^2}\cdot\frac{\partial}{\partial \varsigma}\left(\frac{\nu_V}{s_e}\cdot\frac{\partial e}{\partial \varsigma}\right) - \frac{\partial e}{\partial \varsigma}\cdot\frac{\partial \varsigma}{\partial t} + \text{Prod} + \text{Buoy} - \epsilon + P_e,$$

$$(1)$$

$$(4):\ \frac{\partial \epsilon}{\partial t^\star} = \frac{1}{D^2}\cdot\frac{\partial}{\partial \varsigma}\left(\frac{\nu_V}{s_\epsilon}\cdot\frac{\partial \epsilon}{\partial \varsigma}\right) - \frac{\partial \epsilon}{\partial \varsigma}\cdot\frac{\partial \varsigma}{\partial t} + \frac{\epsilon}{e}\left(c_1\text{Prod} + c_3\text{Buoy} - c_2\epsilon F_{wall}\right) + P_\epsilon.$$

NSTS → The equations: part 2

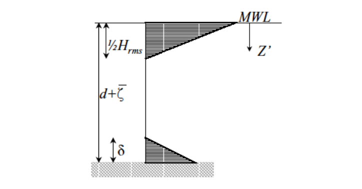
P_e and P_ϵ are respectively the TKE and dissipation source terms due to breaking waves and bottom stress.

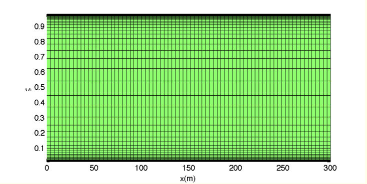
Their expressions are given by : (cf. Walstra et al 2000)

$$P_e = \frac{4D_w}{H_{rms}}\left(1-\frac{2z'}{H_{rms}}\right)_{z'\leq H_{rms}/2} + \frac{2D_f}{\delta}\left(1-\frac{D-z'}{\delta}\right)_{D-\delta\leq z'\leq D}, \quad (2)$$

$$P_\epsilon = c_{1\epsilon}\frac{\epsilon}{e}P_e(z') \text{ avec } c_{1\epsilon} = 1.44, \quad (3)$$

where D_w and D_f are respectively the energy dissipation generated by the breaking wave and bottom stress and δ is the WBBL thickness.

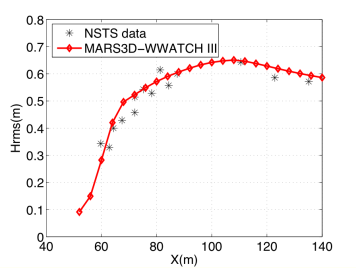




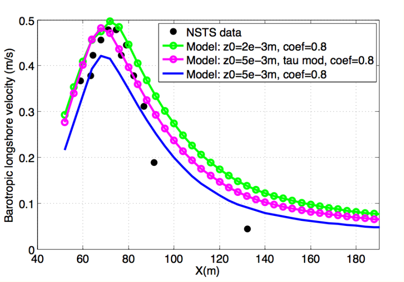
MARS-WW3

Anne-Claire BENNIS (bennis@univ-brest.fr)

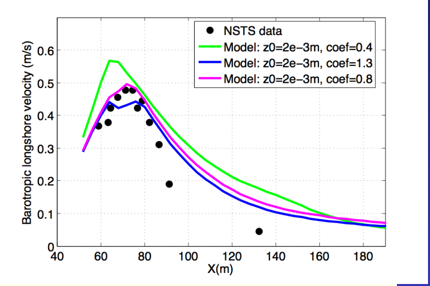
NSTS → Sensitivity tests



Sensitivity to the rugosity length

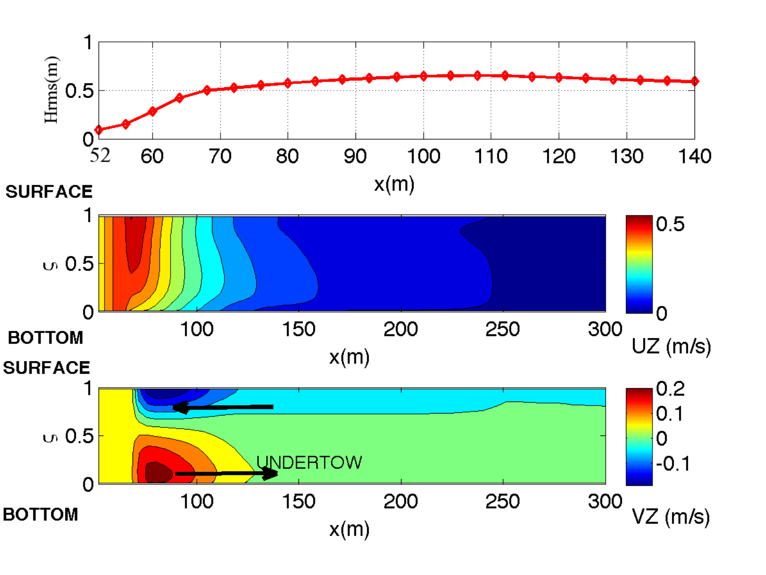


Sensitivity to the WBBL thickness



Anne-Claire BENNIS (bennis@univ-brest.fr)

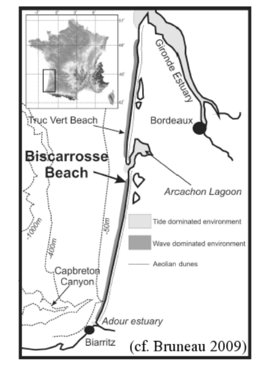
NSTS → Vertical profiles

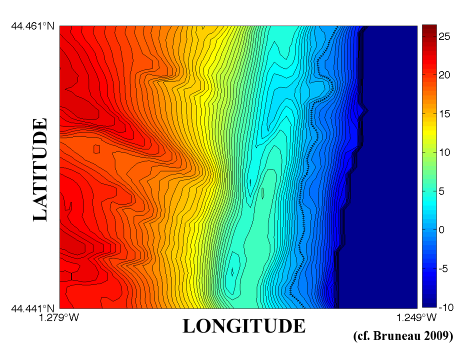


Outline

Anne-Claire BENNIS (bennis@univ-brest.fr)

BISCA → Configuration and Goals

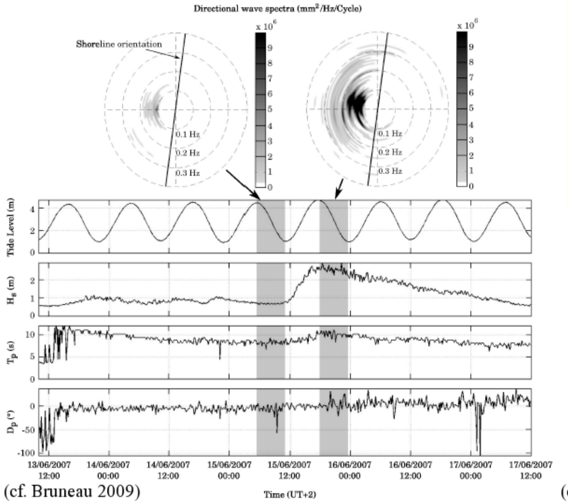




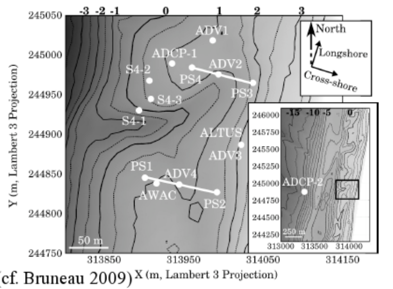
Goals

- Validation of the 3D version of the coupled model based on the theoretical model of Ardhuin et al (2008) in surf zone.
- Impact of the feedback on the rip current.
- Vertical structure of the rip current.

BISCA → The field experiment description



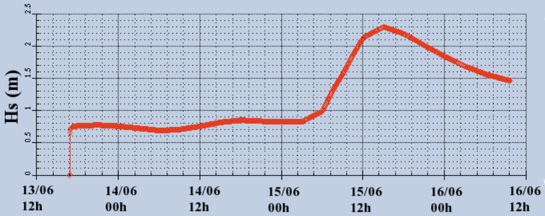
(cf. Bruneau 2009)

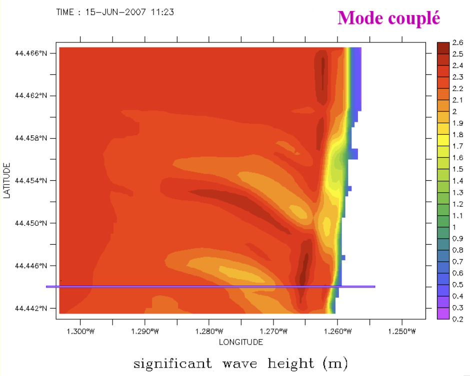


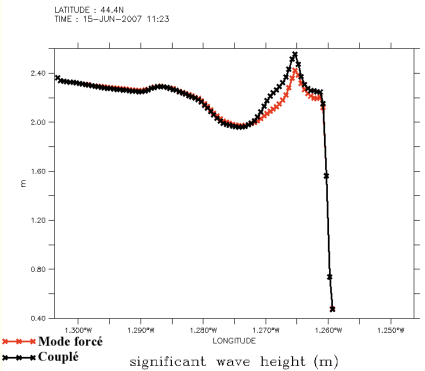
(cf. Bruneau 2009)

Anne-Claire BENNIS (bennis@univ-brest.fr)

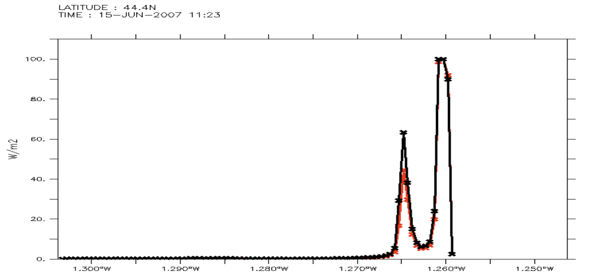
BISCA → Significant wave height

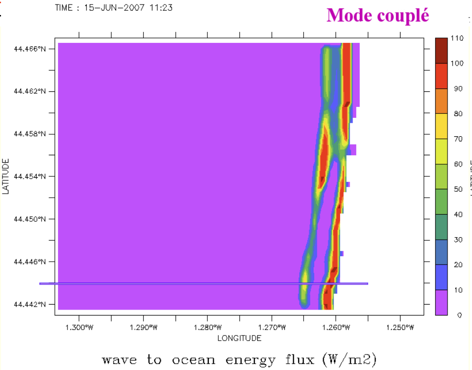


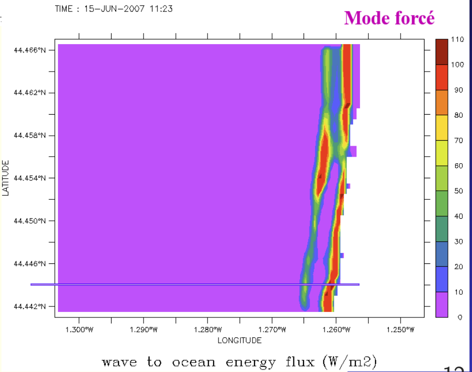




BISCA → Dissipation due to the wave breaking

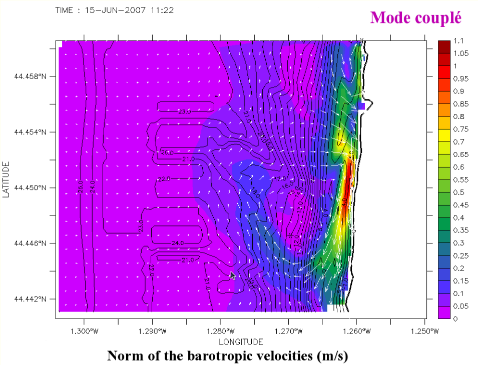


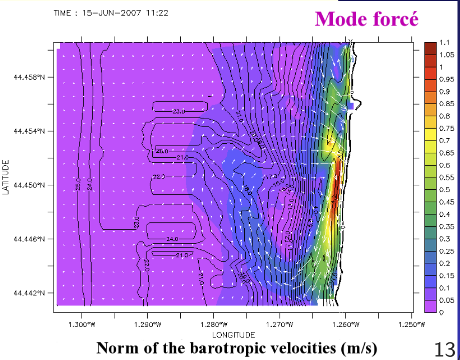




BISCA → Map of current

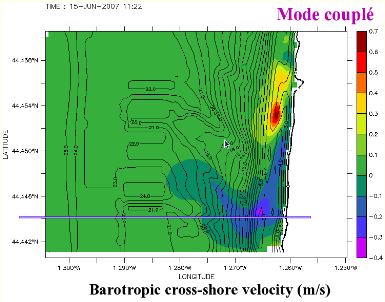
- Comparison between the coupled (left panel) and forced (right panel) modes.
- Vector velocity is drawn over the mean depth and the norm of the barotropic velocities (the reference vector is equal to $0.5 \ \mathrm{m.s^{-1}}$).

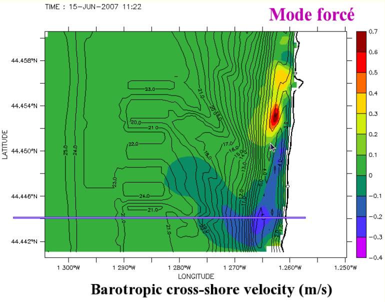




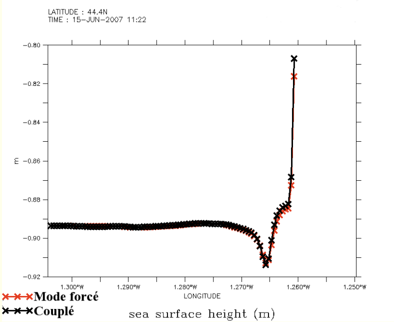
BISCA → Map of barotropic cross-shore velocity

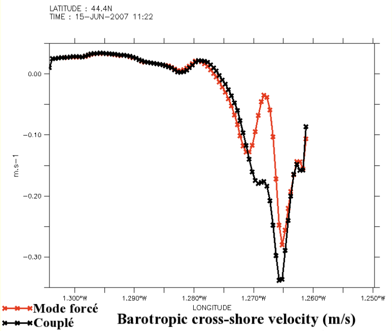
- Comparison between the coupled (left panel) and forced (right panel) modes.
- The barotropic cross-shore velocity is drawn over the mean depth.
- The barotropic cross-shore velocity is higher with the coupled mode and the rip current is spatially shifted.

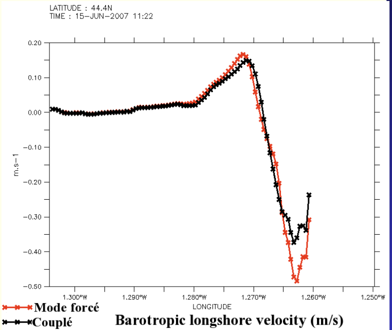




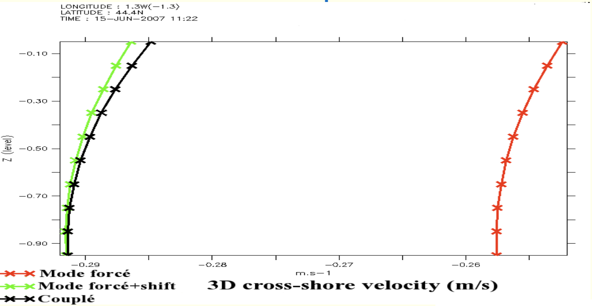
BISCA → Cross-shore profiles

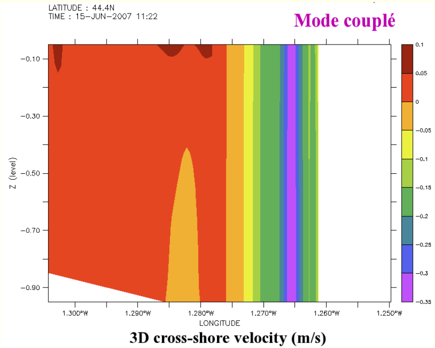


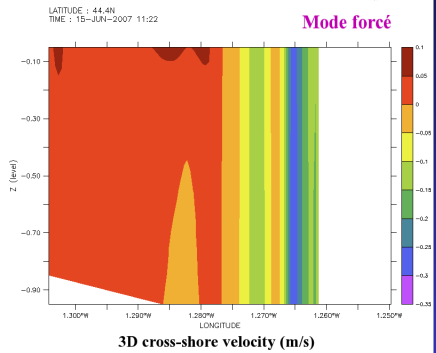




BISCA → Vertical profiles of zonal velocity







Anne-Claire BENNIS (bennis@univ-brest.fr)

Outline

NSTS experiment

BISCAROSSE experiment

Summary

Summary

- **IN THE FUTURE**

- Improve the vertical and horizontal resolutions.

- Investigate the vertical structure of the rip current.

- Comparison with MARS-SWAN results and observations.

Anne-Claire BENNIS (bennis@univ-brest.fr)

The End.
Thank you.

Questions?

Anne-Claire BENNIS (bennis@univ-brest.fr)