Development of eddies in an idealized shelf slope area due to an along slope barotropic jet

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Motivation

ENVISAT ASAR
Widswatch images
SAR Eddy mapping
NERSC
Overview

- Model/model setup
- Model result
  - Horizontal surface velocities
  - 2D Fourier figures
  - Vertical section figures
- Stability analysis
- Conclusion

Jonsmod 04
Model

- Bergen Ocean Model (BOM)
- $\sigma$-coordinate model
- Mode splitting
- Assumptions
  - Hydrostatic approximation
  - Boussinesq approximation
Model

Vertical view of the shelf topography.
Model

- 2.5 km grid resolution in horizontal
- 61 $\sigma$-layers in vertical
- FRS zones (15 grid cells wide)
- Gaussian jet along the shelf (0.4 m/s)
- Viscosity 0.2 m$^2$/s
- No bottom friction
Overview over the model area (km)
Simulations

- Barotropic simulation
- 2-layer simulation
  - Interface at approximately 550 m depth
  - Density surface layer $\rho_{surf} = 1027.5$
  - Density bottom layer $\rho_{bott} = 1028.05$
- Jet in both layers
Barotropic simulation

Horizontal surface velocities after 240 hours.
Barotropic simulation

2D Fourier components after 240 hours.
Barotropic simulation

Vertical profile after 240 hours.
Barotropic simulation

Solid line: \( \approx 40 \text{ km} \)
Growth rate \( 0.53 \text{ day}^{-1} \)

Dashed line: \( \approx 80 \text{ km} \)

Sum of Fourier components.
Summary barotropic simulation

- Generation of eddies
  - Cyclonic (weak) at deeper part
  - Anti cyclonic (strong) at shallow part
    - 40-80 km along shelf
    - 40-$\infty$ km cross shelf
- Spatial fluctuations of the jet
Stability analysis

Unstable modes: 35 - 75 km
Max growth rate: 0.43 day$^{-1}$
Wavelength $\approx$ 40 km
Stability analysis

Unstable mode with wave length $\lambda = 43$ km.

Horizontal current field.
Stability analysis

Unstable mode with wave length \( \lambda = 58 \) km.

Horizontal current field.
Visual comparison

Unstable mode with wave length $\lambda = 43$ km is recognized in the model result after 120 hours.
Two layer simulation

Horizontal surface velocities after 240 hours.
Two layer simulation

2D Fourier components after 240 hours.
Two layer simulation

Vertical profile after 240 hours.
Two layer simulation

Velocity arrows from the surface (upper) and the interface (lower) show barotropic behavior.
Barotropic vs two layer

Sum of Fourier components.

Bold line: barotropic
Narrow line: 2 layer
Solid line: $\approx 40$ km
Dashed line: $\approx 80$ km
Summary two layer simulation

- Generation of weak eddies
  - Cyclonic (weak) at deeper part
  - Anti cyclonic (stronger) at shallow part
    - 40 km along shelf
    - 50-80 km cross shelf
- High activity in the interface
  - Relatively directional stable
- Barotropic behavior of the eddies
Conclusions

- Eddies developed due to an along shelf jet
- Barotropic simulation
- Length scale and growth rate in accordance with Gjeviks stability analysis
Conclusions

- Two layer
- Weaker eddies than in the barotropic simulation
- High activity in the core of the jet
- Eddies have barotropic behavior