Resolution sensitivity of isolated eddy evolution with/without steep topography

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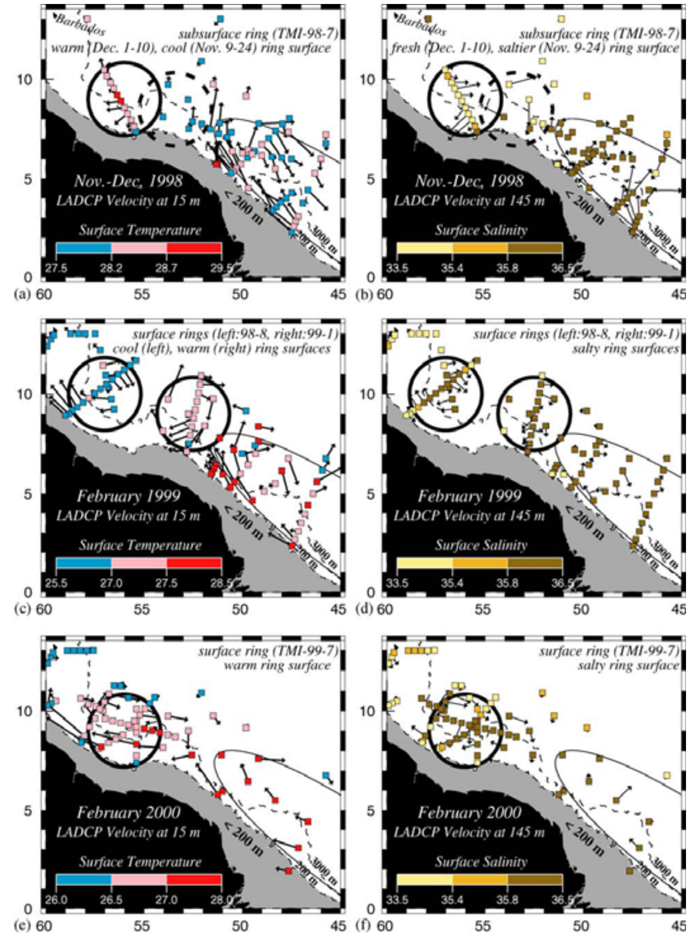
Overview

- Motivation
- Model configuration
- Resolution sensitivity on the **flat bottom**
  - Propagation (trajectory, speed), dissipation
  - Resolution convergence
- Resolution sensitivity to **eddy-topography interaction**
  - Eddy driven surface/deep currents
  - Collision trajectory over steep topography
  - Cross-shelf currents, shelf break jets
  - Shelf-slope, slope-abyssal exchange
- Conclusions
- Future works

Motivation

Hurlburt & Hogan (2000, DAO)

Ffield (2005, DSR)



NBC rings-slope interaction

What is the effect of resolution on eddy propagation, eddy-topography interaction?

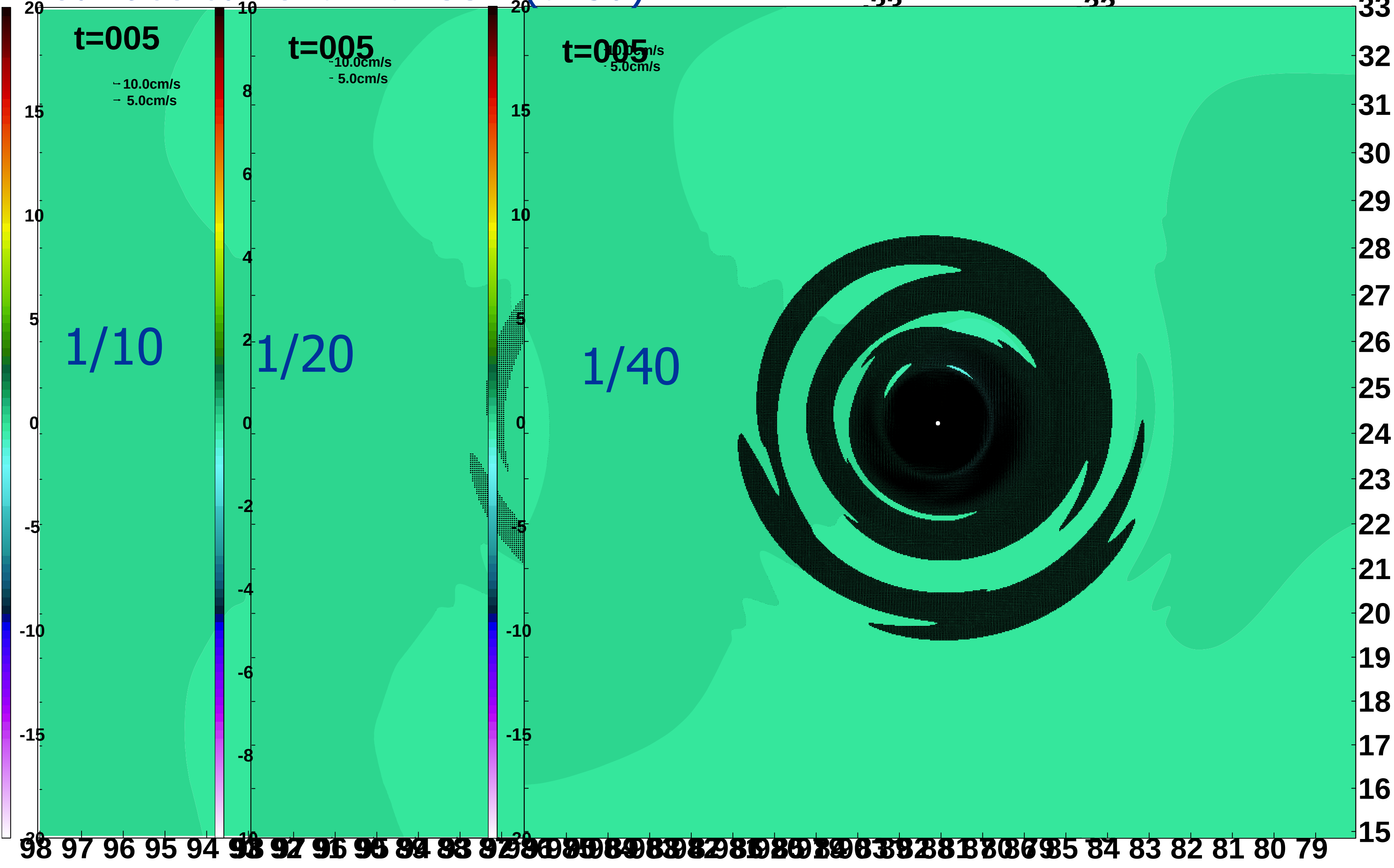
Model Details

- HYCOM
  - Version 2.1, vertical 10 layers
  - Closed boundary with idealized domain
  - No forcing, horizontally uniform density from GDEM (Teague 1990)
  - Biharmonic viscosity factor visco4= 0.2
  - Biharmonic diffusion velocity veldf4= 0.01 m/s (momentum), thkdf4=0.005 m/s (thickness)
  - Laplacian diffusion velocity temdf2= 0.005 m/s (T,S)
  - Linear bottom friction cbar=0.05 m/s
  - quadratic bottom friction cb=$2x10^{-3}$
- Domain
  - Horizontal resolution: 1/3, 1/5, 1/10, 1/20, 1/40 degrees resolution
  - 2000x2000km (800x800 nodes for 1/40 resolution)
  - depth: 50m-3500m
- Initialization of Eddy (Herbette et al. 2003 JPO)
  - R=80km
  - PVA (t=0)= 3.0f (f=7.0 x 10^{-5} s^{-1})
  - Max. Speed ~50 cm/s

1. flat bottom

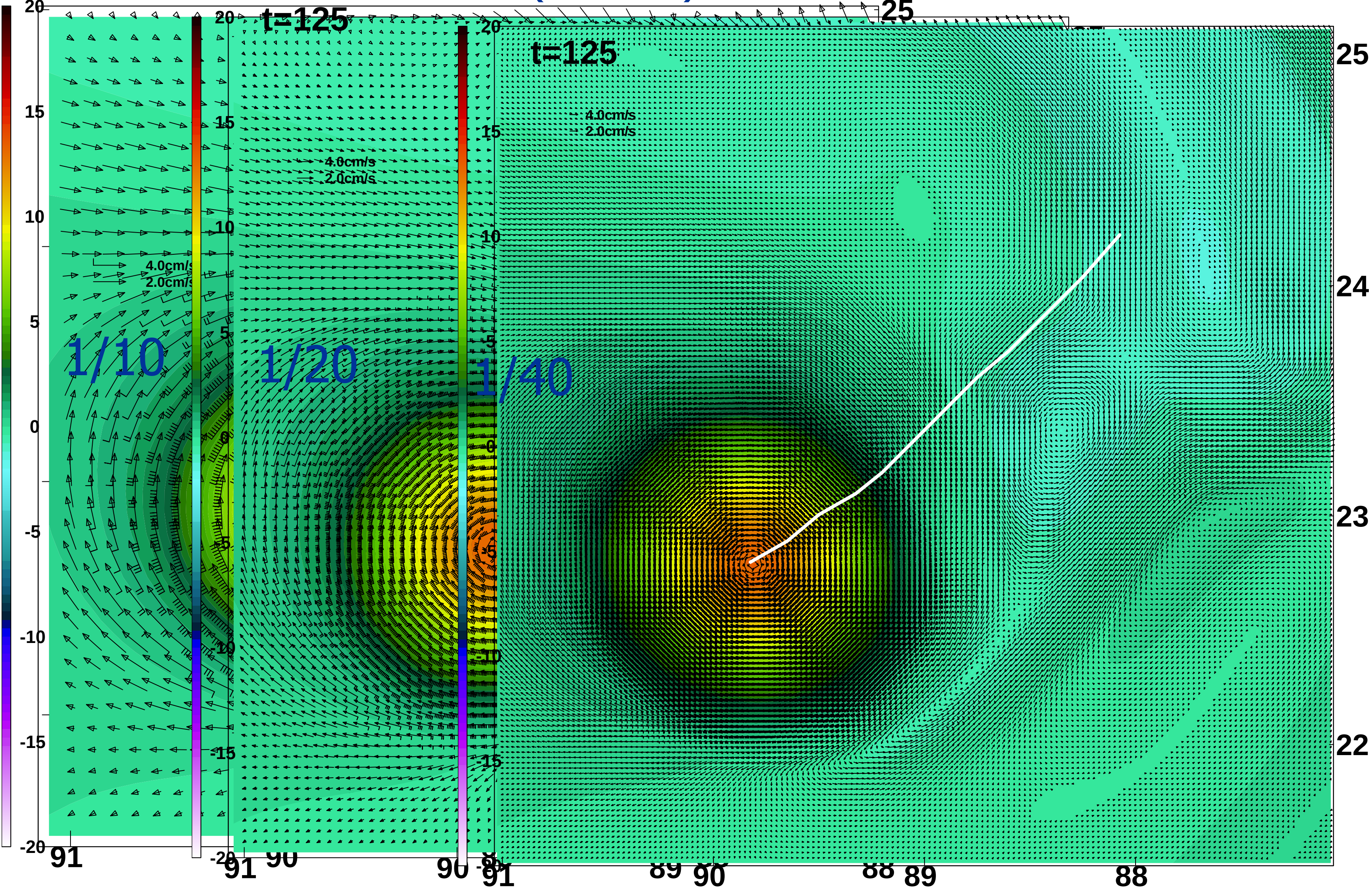
sensitivity to initial adjustment

surface current with SSH (t=5d)



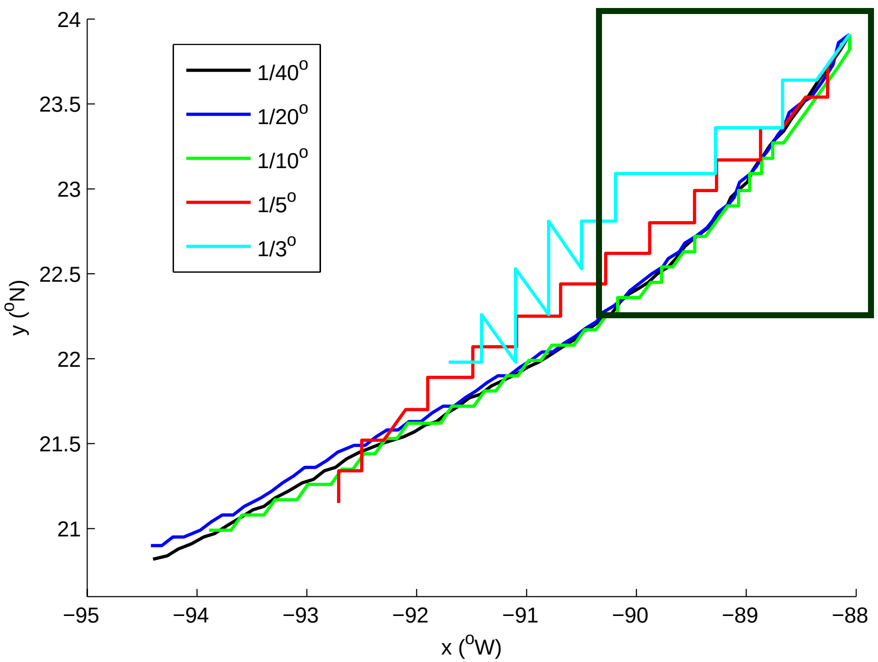
sensitivity to propagation

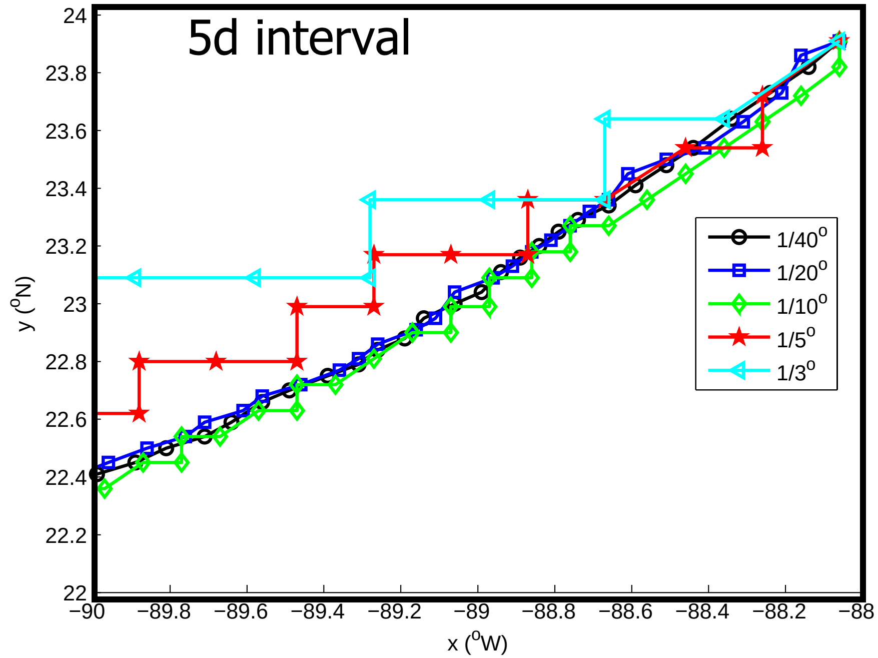
surface current with SSH (t=125d)



sensitivity to trajectory

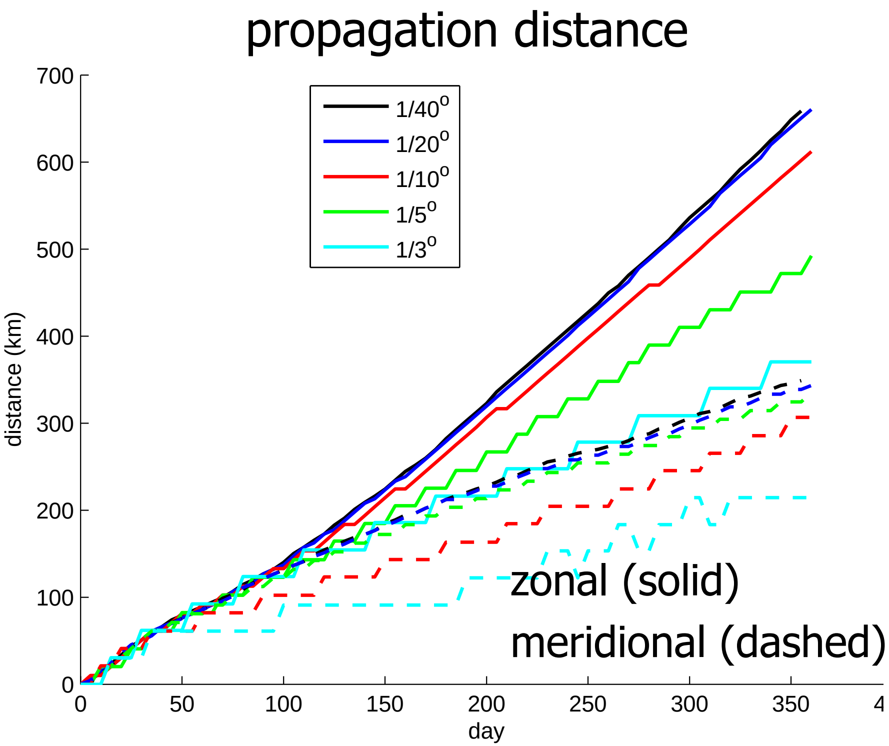
trajectory for 1 yr

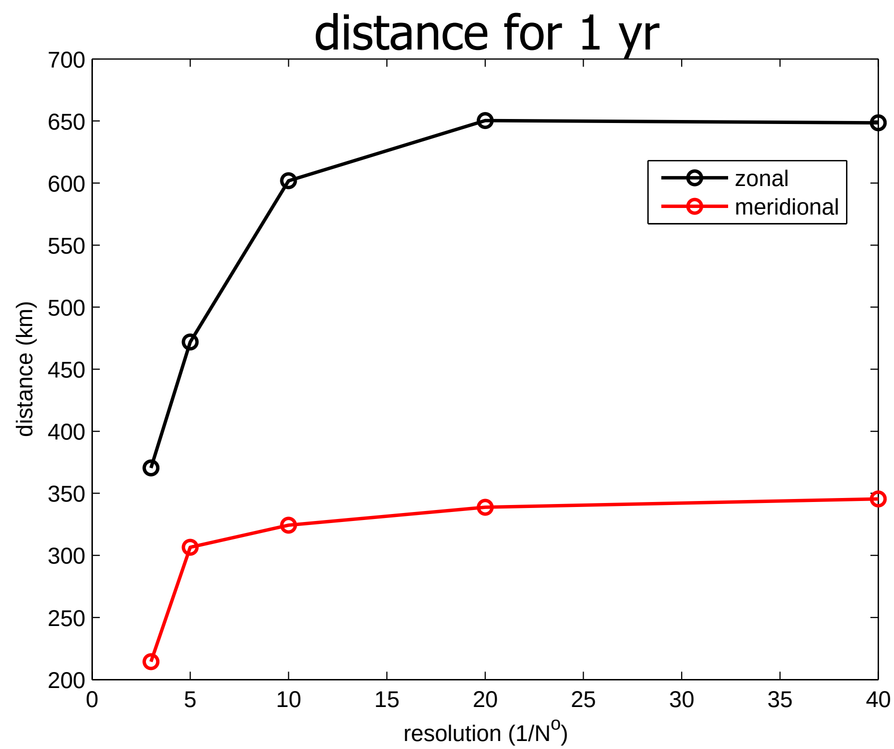




- Stepwise/continuous trajectory with low/high resolution
- Resolution convergence: 1/20

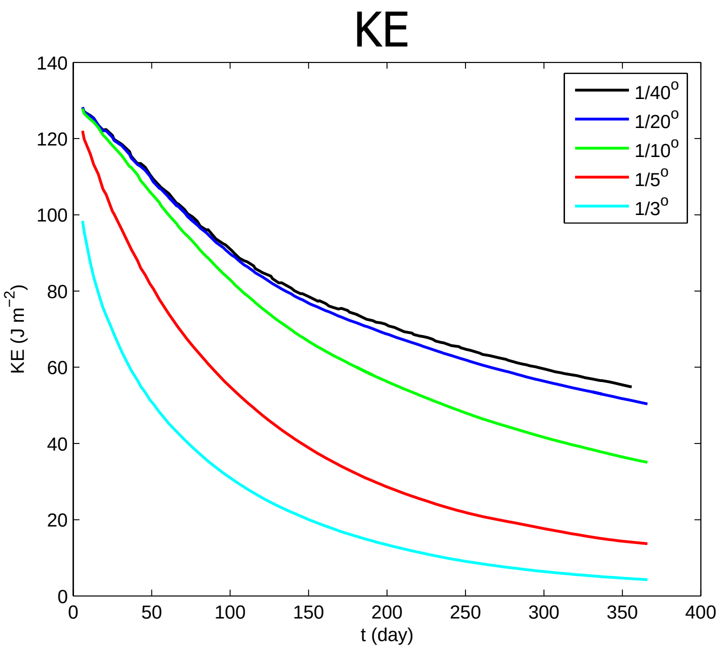
sensitivity to propagation speed

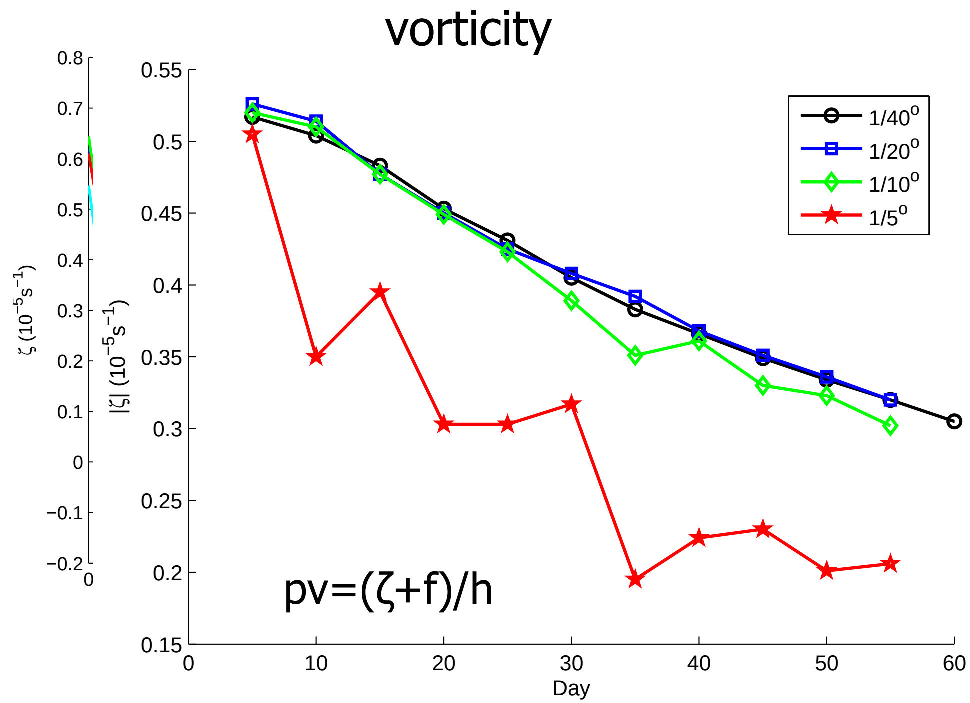


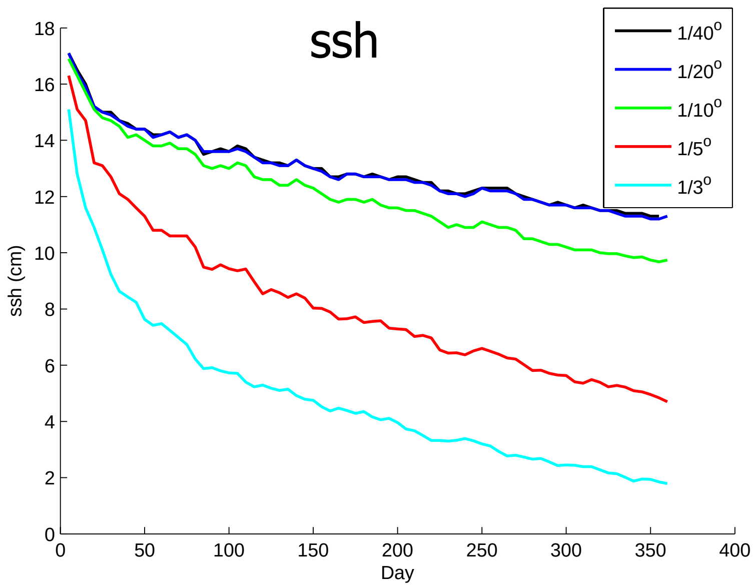


- Faster propagation with high resolution (1/20 is 2 times faster than 1/3)
- Resolution convergence at 1/20

sensitivity to dissipation





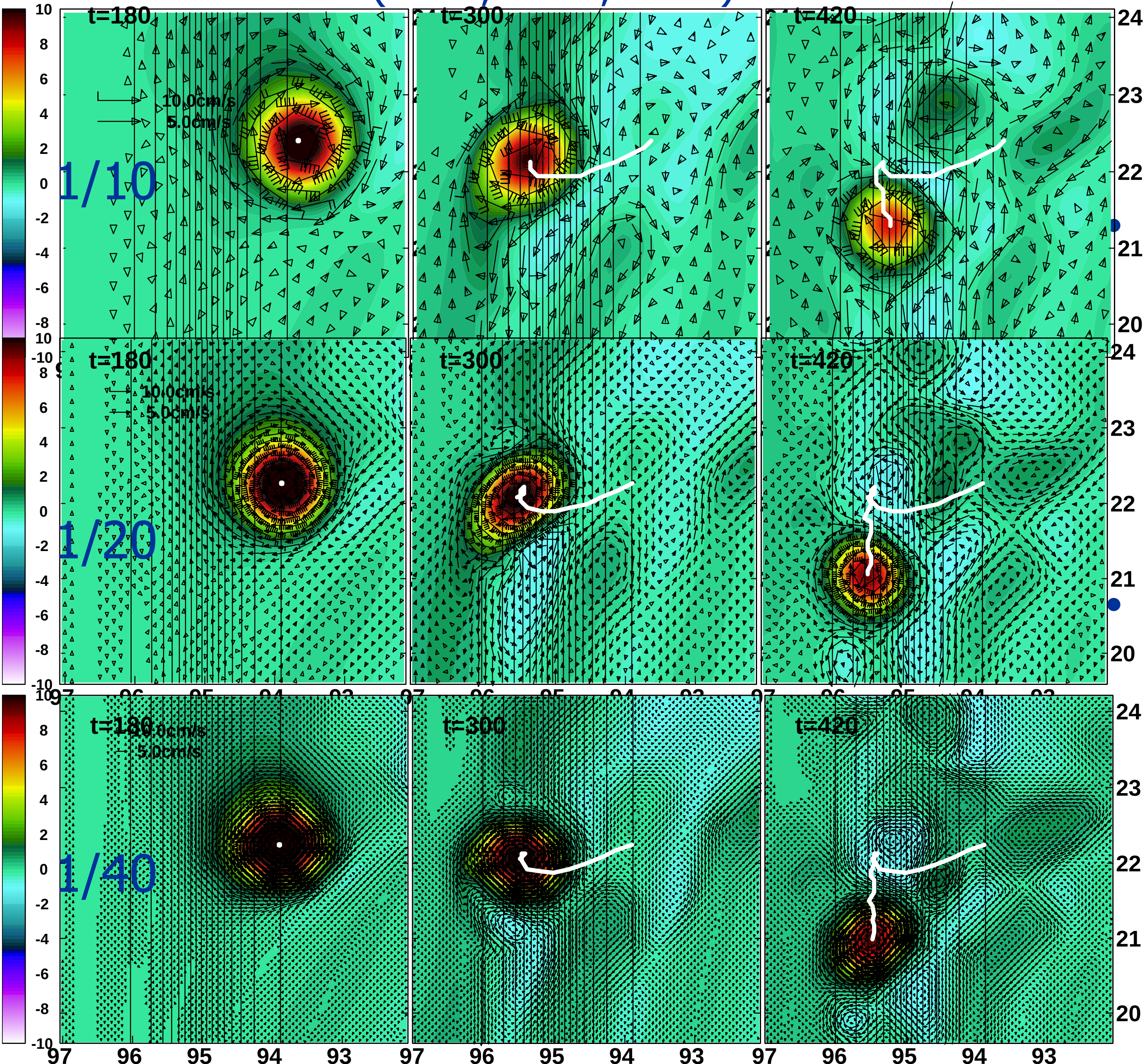


- Slow dissipation with high resolution (1/20 dissipates ~20% slower than 1/10)
- Resolution convergence 1/20
- Vorticity: oscillatory/continuous dissipation with low/high resolution

2. Eddy-topography interaction

sensitivity to surface current

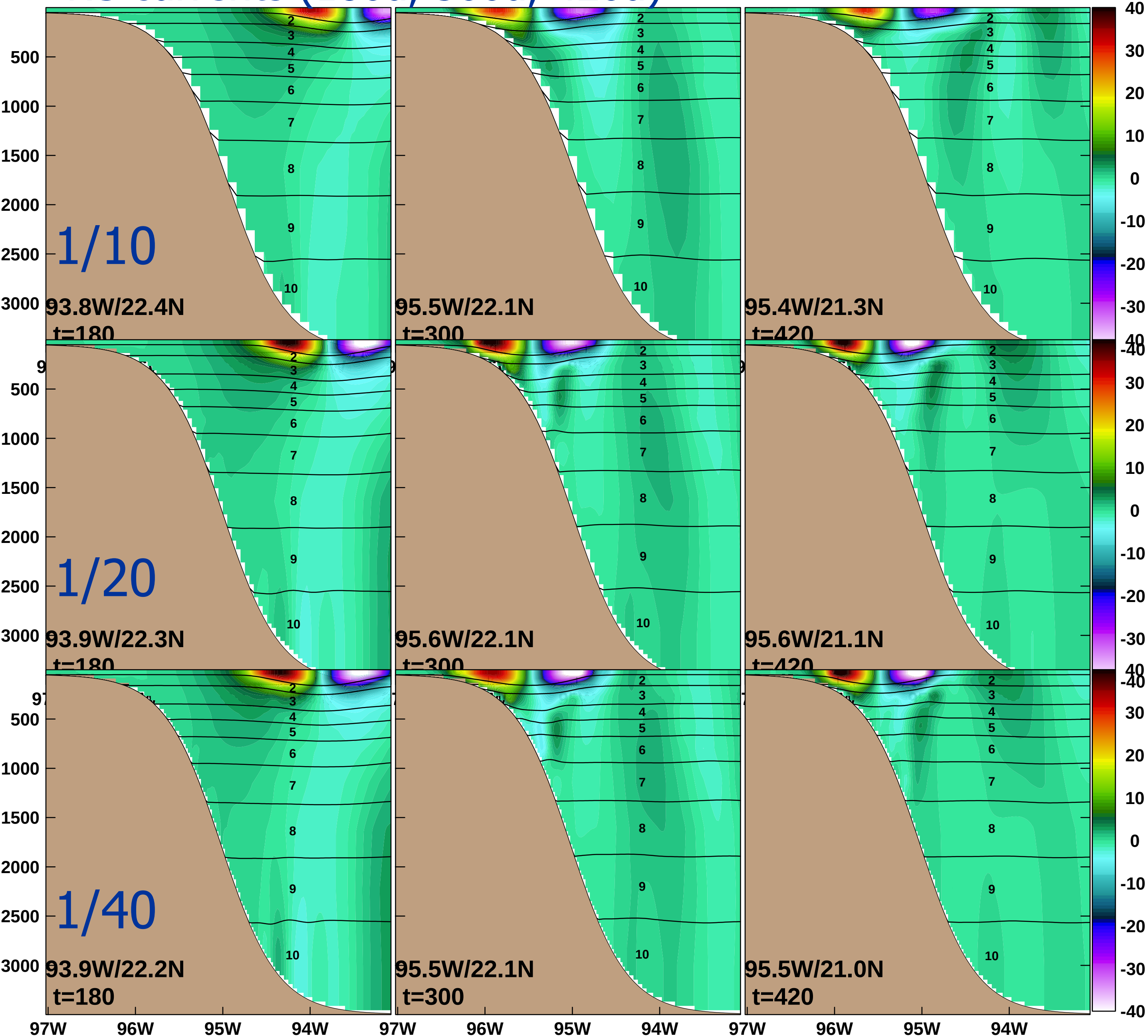
surface currents (180d, 300d, 420d)



- Cross-slope /alongslope translation before/after collision, slope jet (qualitatively consistent for >1/10)
- 1/40 well- resolved for filament/frontal eddies

sensitivity to subsurface current

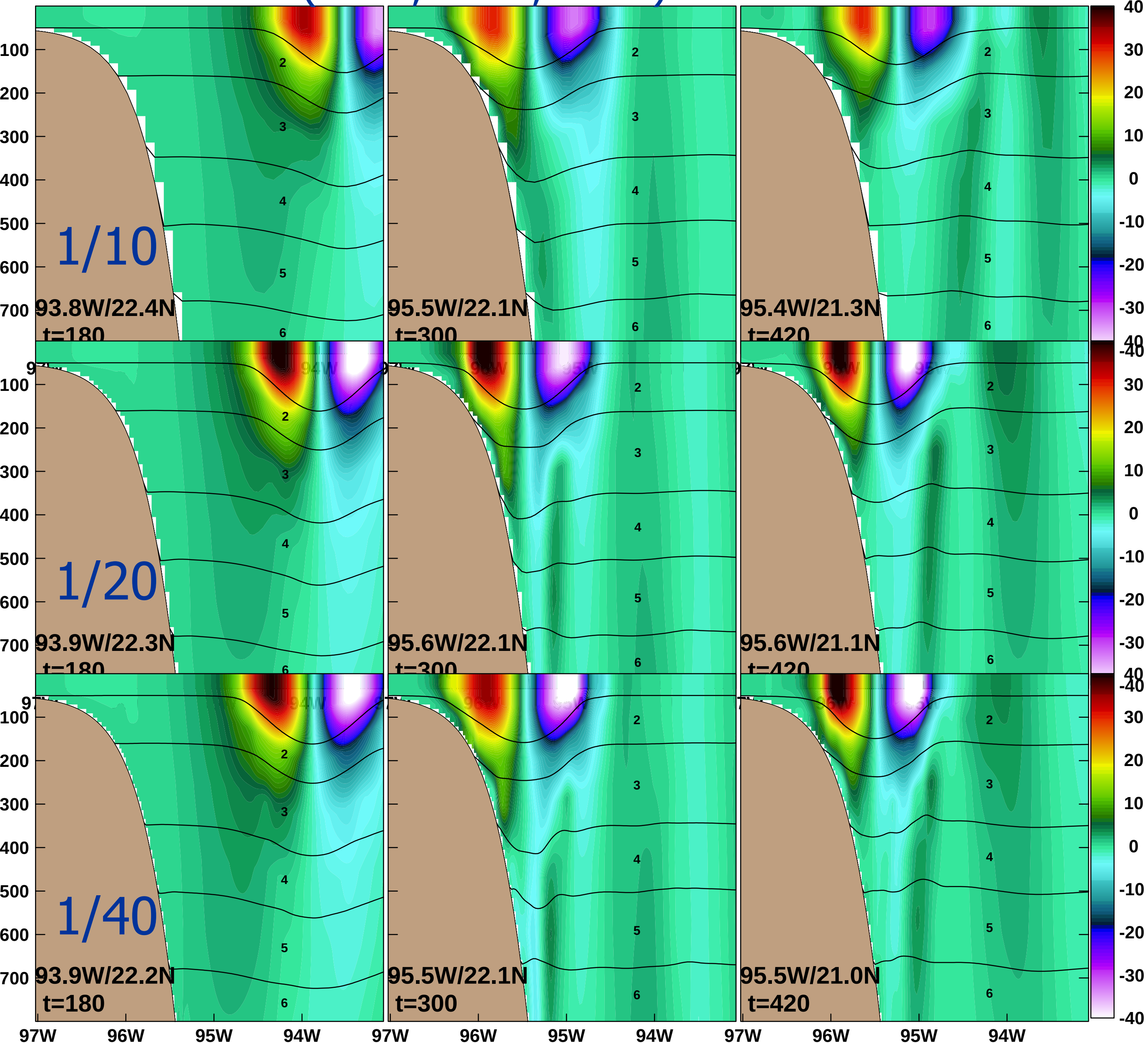
NS currents (180d, 300d, 420d)



- Stronger subsurface cyclone for > 1/20

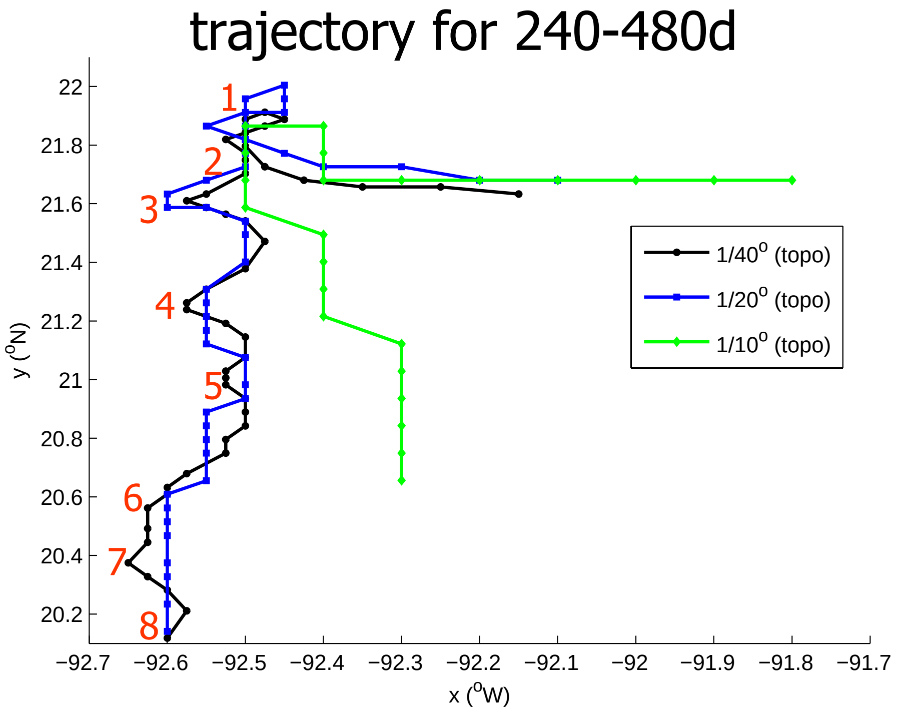
sensitivity to subsurface current

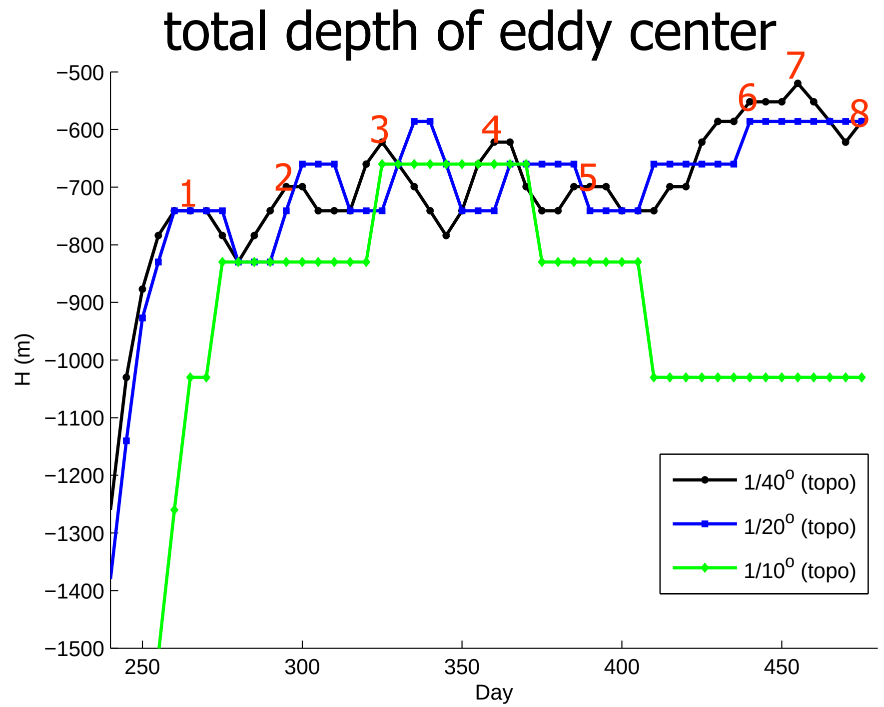
NS currents (180d, 300d, 420d)



- Strong deep cyclonic current (1/20, 1/40)
- 1/40 resolved better than 1/20 for deep cyclone

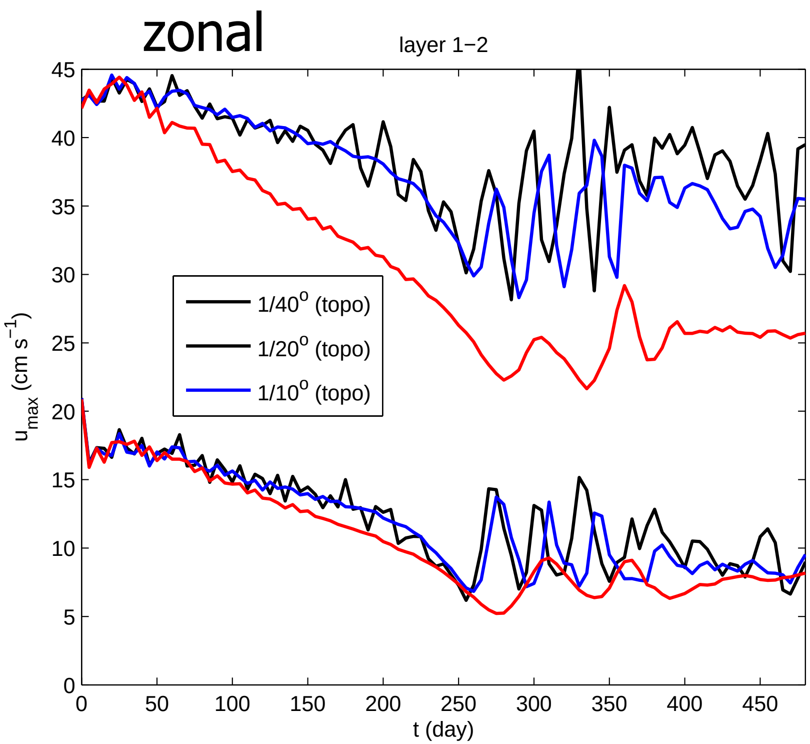
sensitivity to collision/reflection

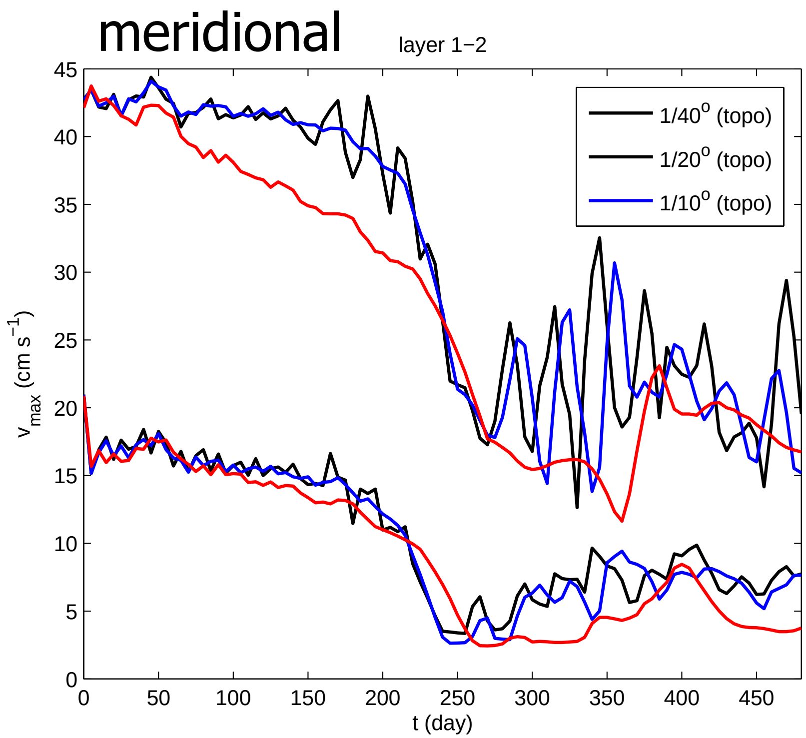




- 1st impinging depth is shallow with high resolution: 740m (1/20, 1/40), 820m (1/10)
- Shallowest point: topographic β effect max
- Offshore turning point: topographic β effect balances planetary β effect
- Smooth collision trajectory with high resolution
- Low resolution suppresses cross-isobaths oscillation
- Frequent collision with high resolution

sensitivity to eddy swirl currents

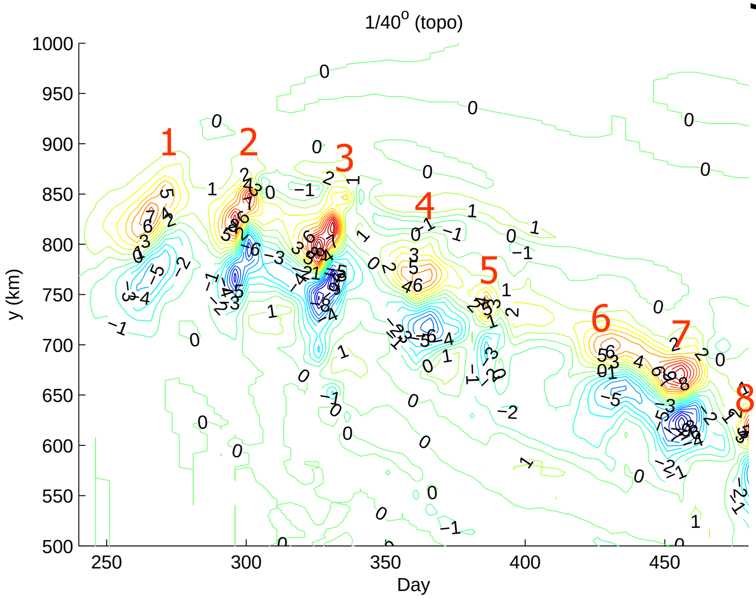


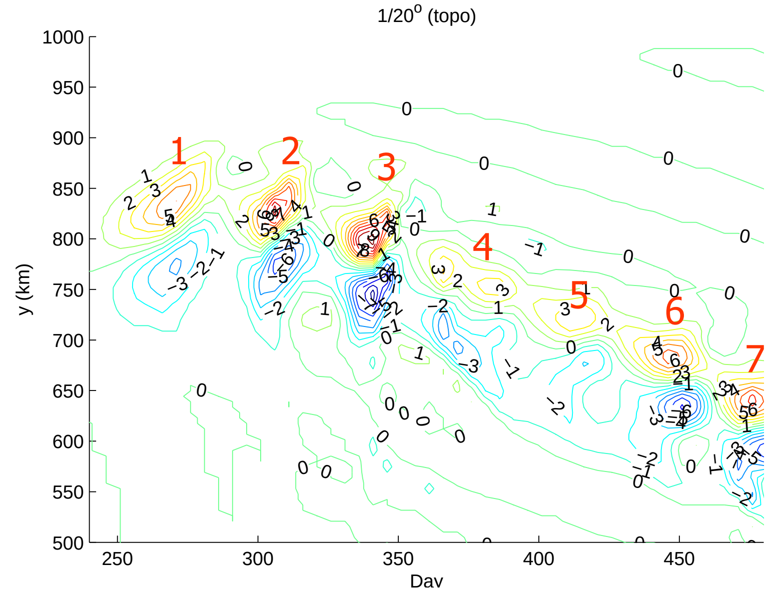


- strong dissipation/oscillation over topography; zonal/meridional oscillation
- faster dissipation with lower resolution
- 1/20 resolution convergence but smoothed pattern (following the mean of 1/40)
- 1/40 stronger oscillation amplitude (more realistic)

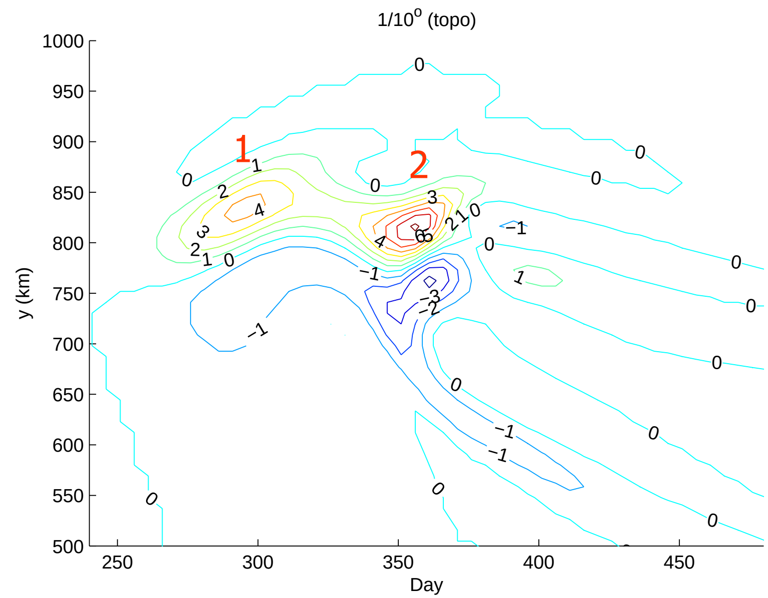
sensitivity to cross-shelf current

ubaro along the shelf break



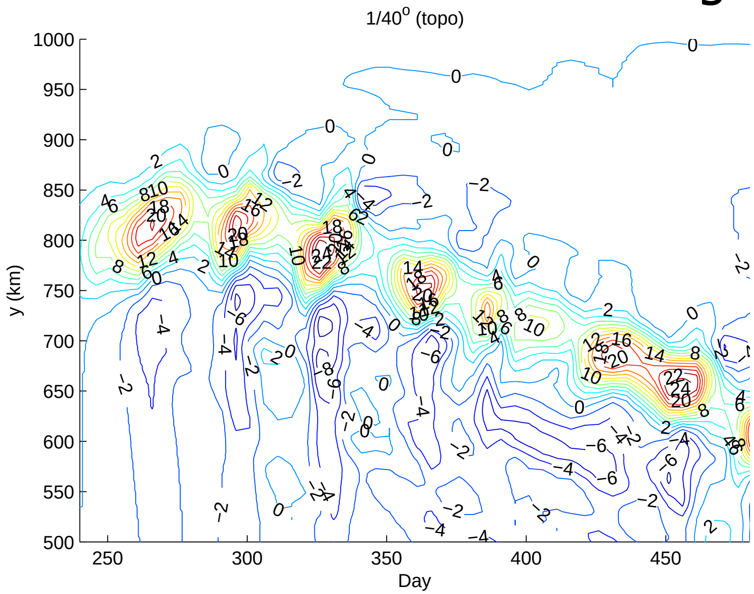


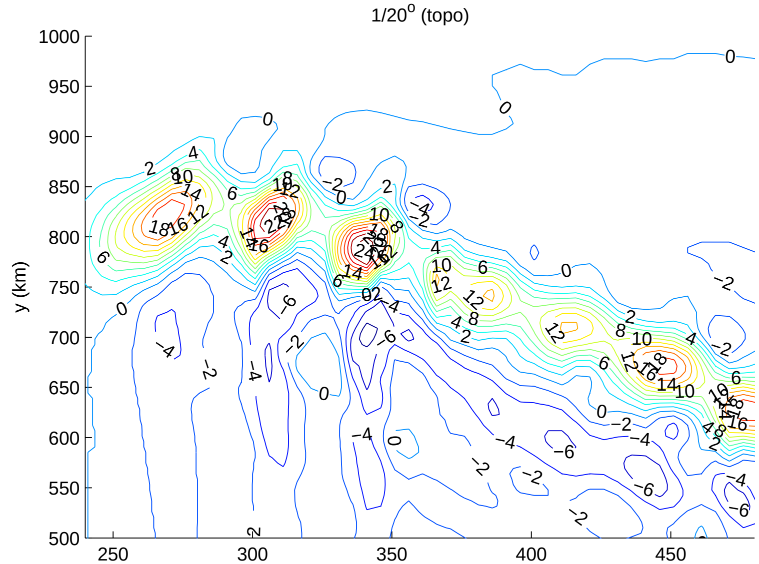
- shelf break depth = 163m
- stronger cross-shelf current core speed, frequent collision with high resolution



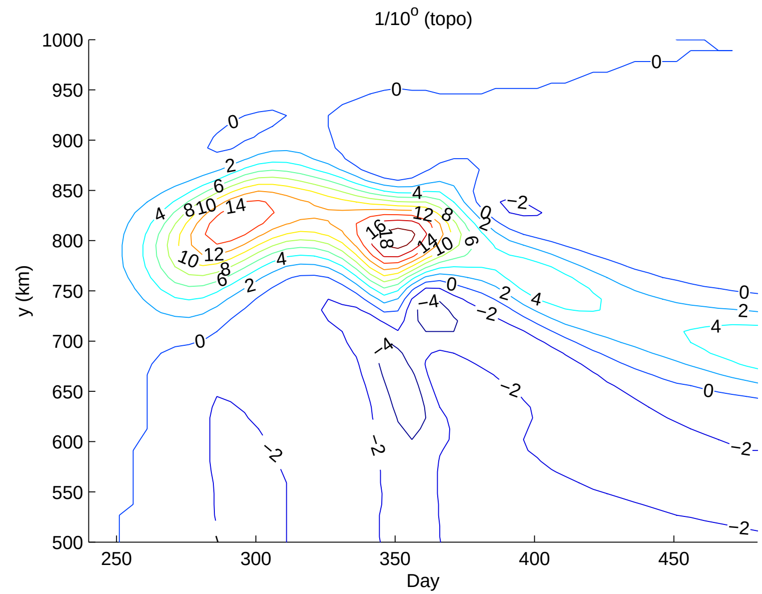
sensitivity to shelf break jet

vbaro along the shelf break



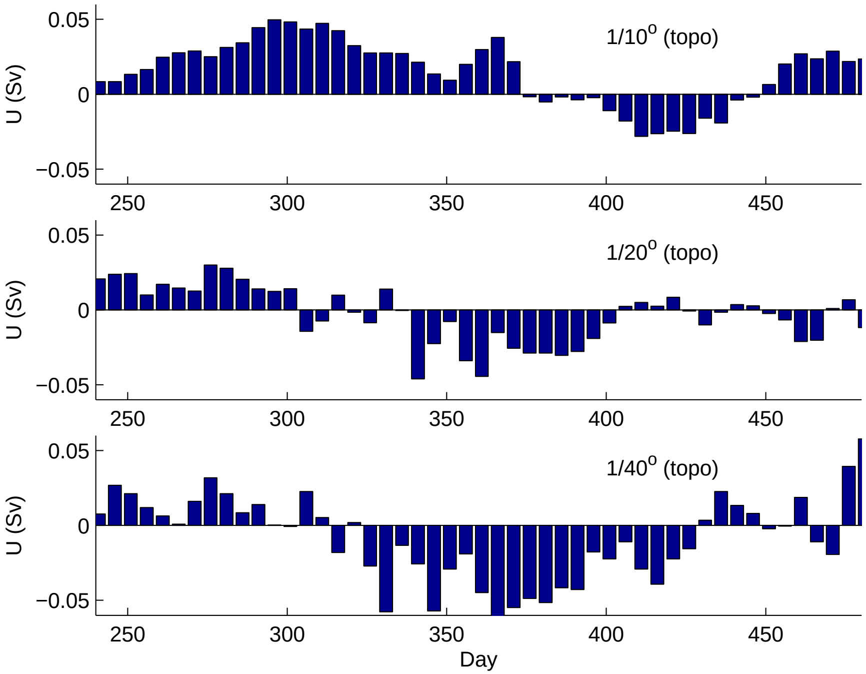


- Stronger/frequent shelf break jet with high resolution

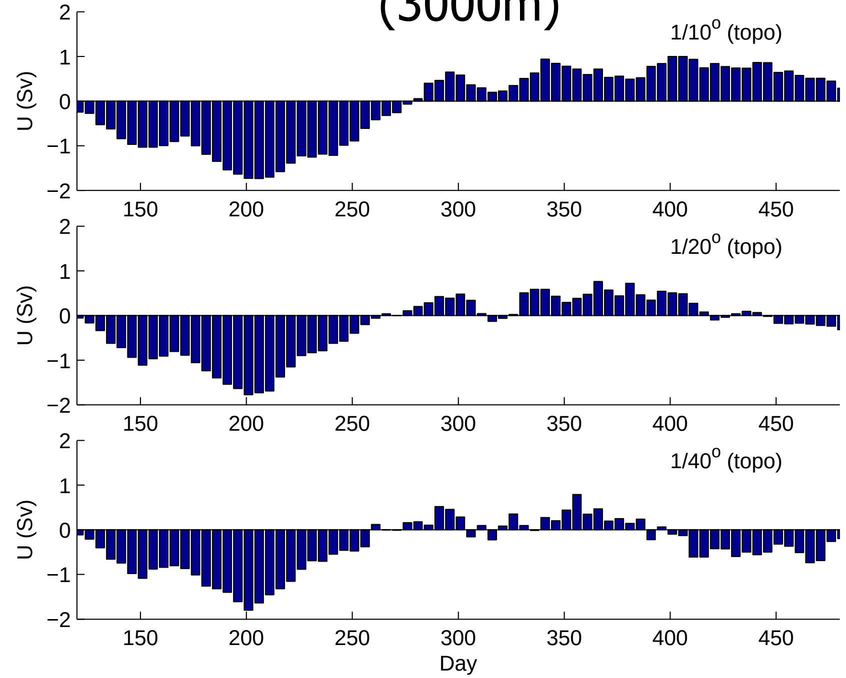


net shelf-slope-abyssal exchange

integrated ubaro along the shelf break



integrated ubaro along the slope bottom (3000m)



- Larger on-shelf transport with higher resolution
- Smaller off-slope transport with higher resolution

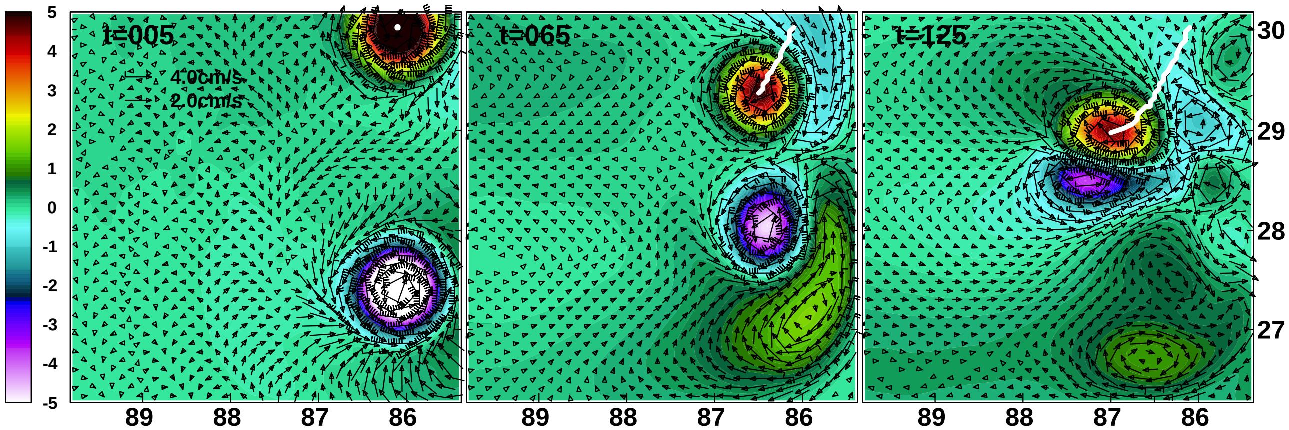
Conclusions

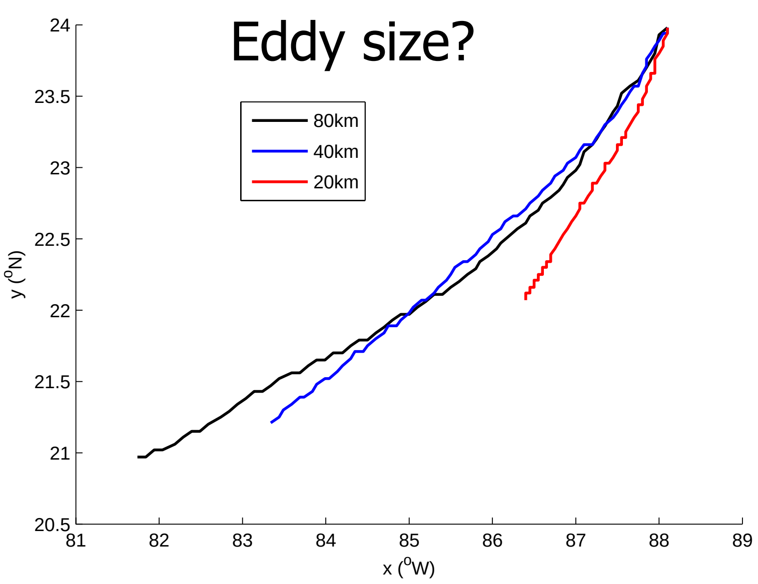
- On flat bottom, stepwise propagation, oscillatory dissipation with low resolution
  - Qualitative agreement in propagation for >1/10
  - Resolution convergence at 1/20 according to propagation and dissipation

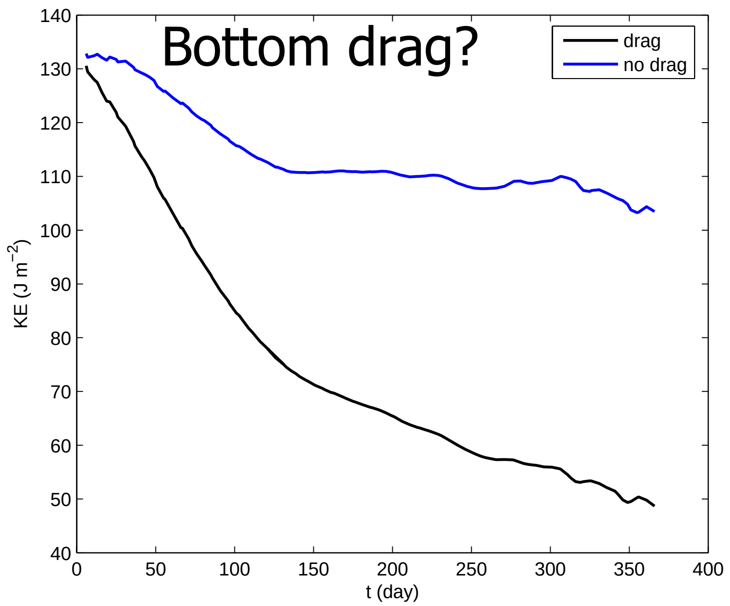
- Eddy-topography interaction requires high resolution (>1/20)
  - Frequent/stronger collision, smoothed trajectory with high resolution
  - Low resolution suppresses cross-isobaths translation
  - Enhanced on-shelf, reduced off-slope transport with high resolution

Future works

Inter-eddy interaction







Acknowledgments

- HYCOM consortium group : HYCOM model
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- SEED (Shelf to slope Energetics and Exchange Dynamics)