

Resolution sensitivity of isolated eddy evolution with/without steep topography

Kyung Hoon Hyun* and Patrick J. Hogan**
hyun@nrlssc.navy.mil hogan@nrlssc.navy.mil

* University of Southern Mississippi
** Naval Research Laboratory

24-26 April 2007 HYCOM meeting, NRL, Stennis Space Center, MS, USA

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE APR 2007		2. REPORT TYPE		3. DATES COVERED 00-00-2007 to 00-00-2007	
4. TITLE AND SUBTITLE Resolution sensitivity of isolated eddy evolution with/without steep topography				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Research Laboratory,Stennis Space Center,MS,39529				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

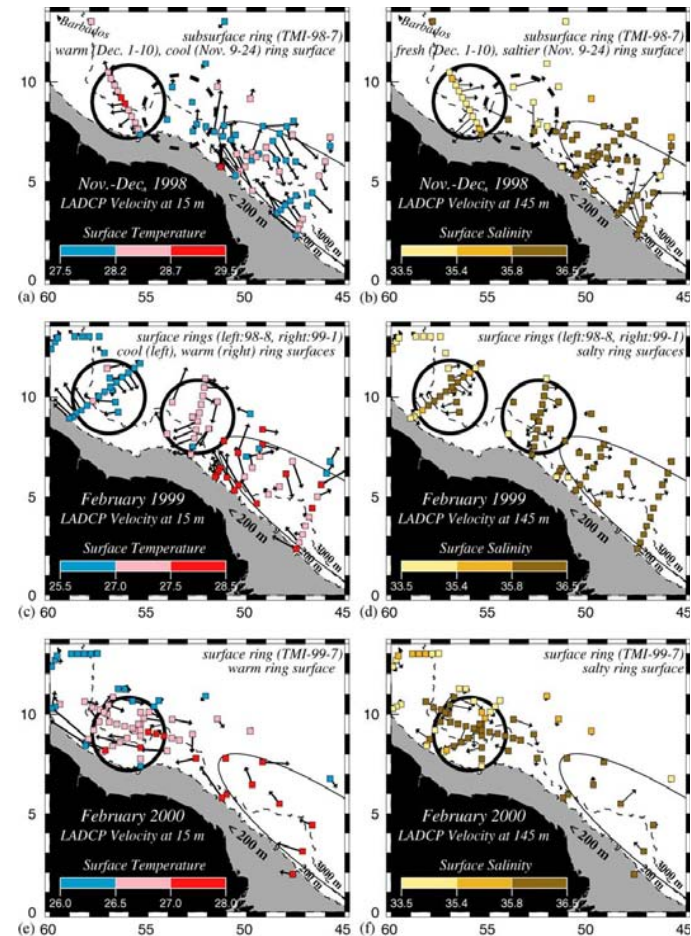
Overview

- 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?

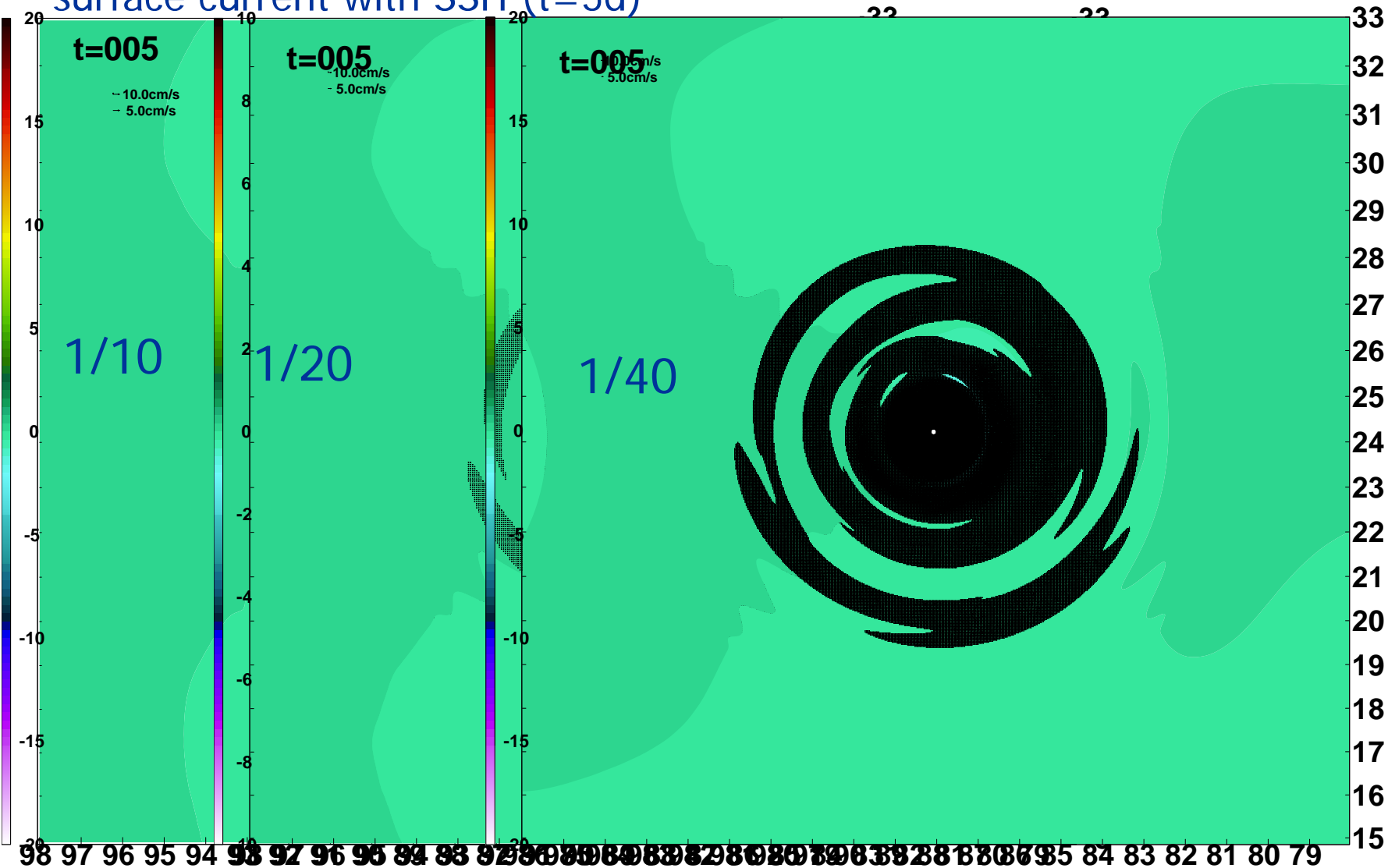
Model Details

- HYCOM
 - Version 2.1, vertical 10 layers
 - Closed boundary with idealized domain
 - No forcing, horizontally uniform density from GDEM (Teague 1990)
 - Biharmonic viscosity factor $\text{visco4} = 0.2$
 - Biharmonic diffusion velocity $\text{velf4} = 0.01$ m/s (momentum), $\text{thkdf4} = 0.005$ m/s (thickness)
 - Laplacian diffusion velocity $\text{temdf2} = 0.005$ m/s (T,S)
 - Linear bottom friction $\text{cbar} = 0.05$ m/s
 - quadratic bottom friction $\text{cb} = 2 \times 10^{-3}$
- 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)
 - $R = 80$ km
 - $\text{PVA}(t=0) = 3.0f$ ($f = 7.0 \times 10^{-5} \text{ s}^{-1}$)
 - Max. Speed ~ 50 cm/s

1. flat bottom

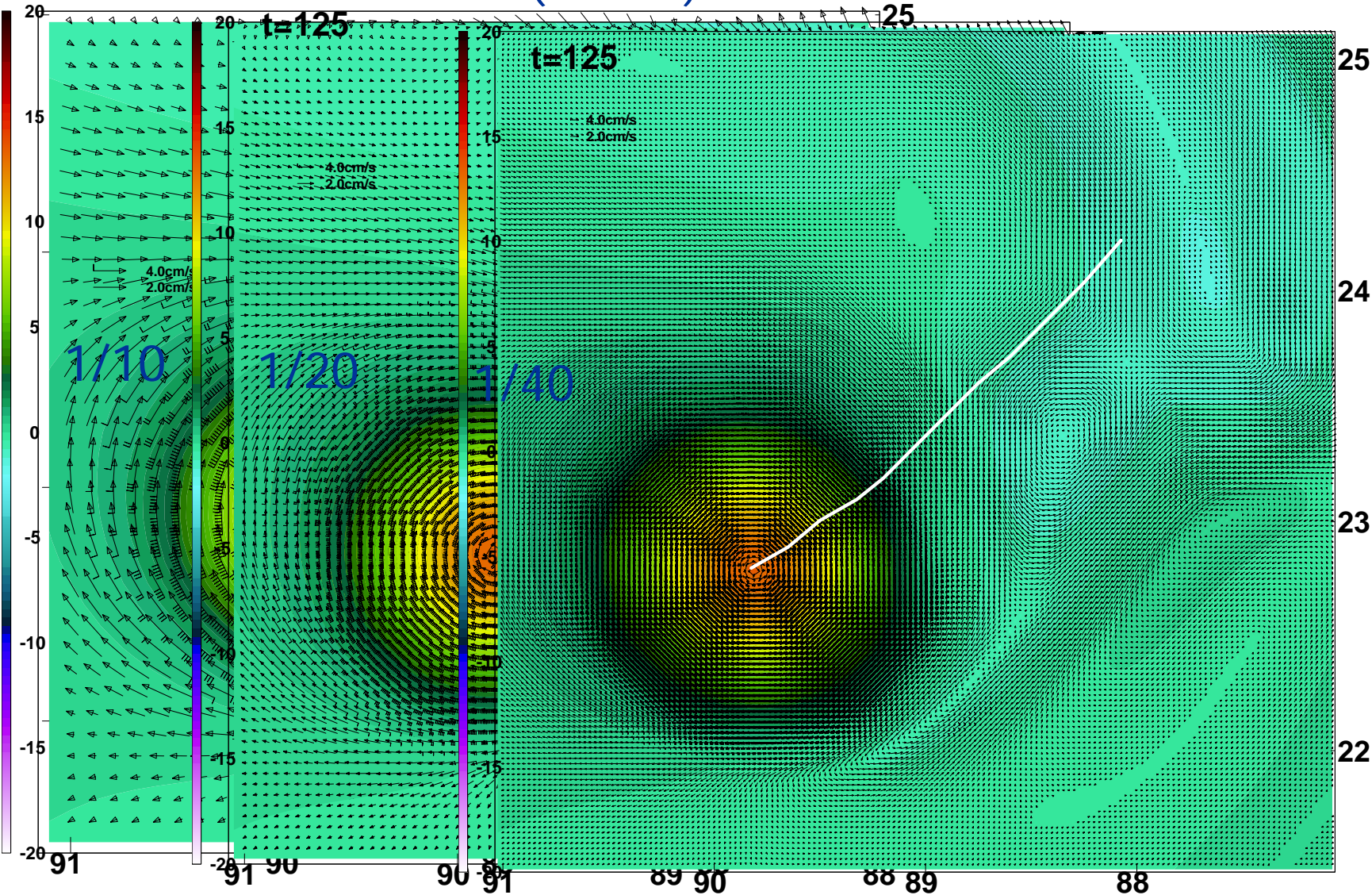
sensitivity to initial adjustment

surface current with SSH (t=5d)



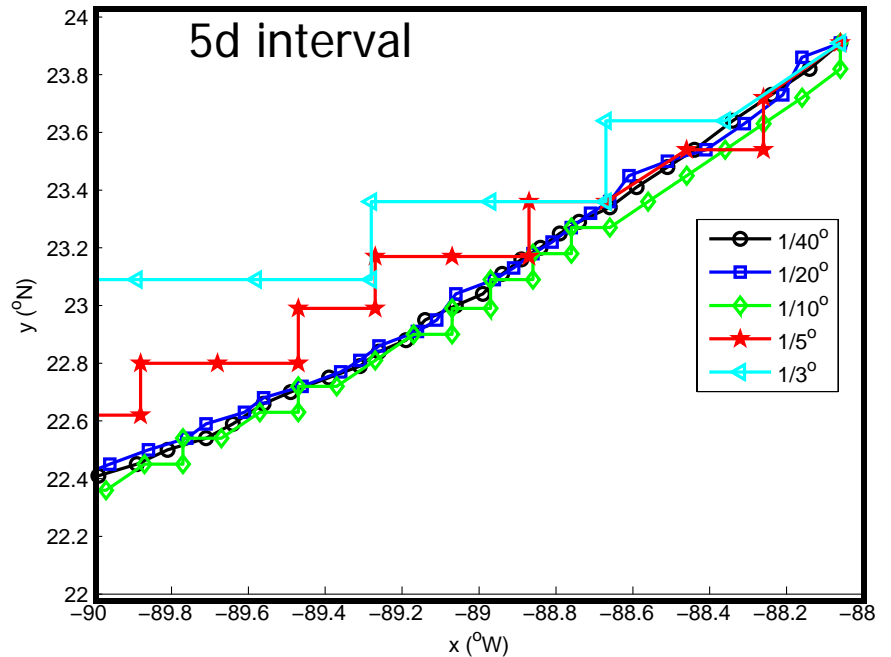
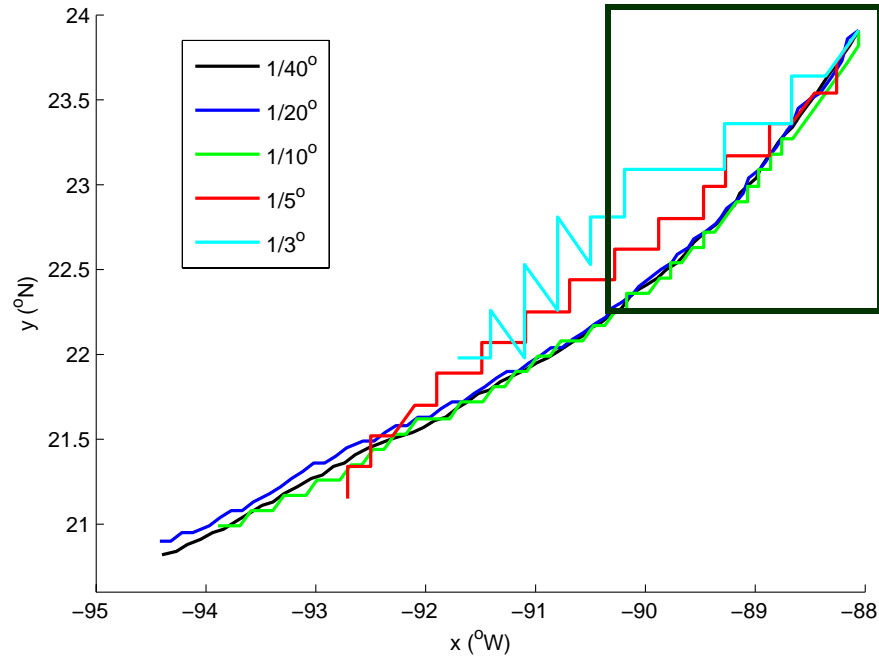
sensitivity to propagation

surface current with SSH (t=125d)



sensitivity to trajectory

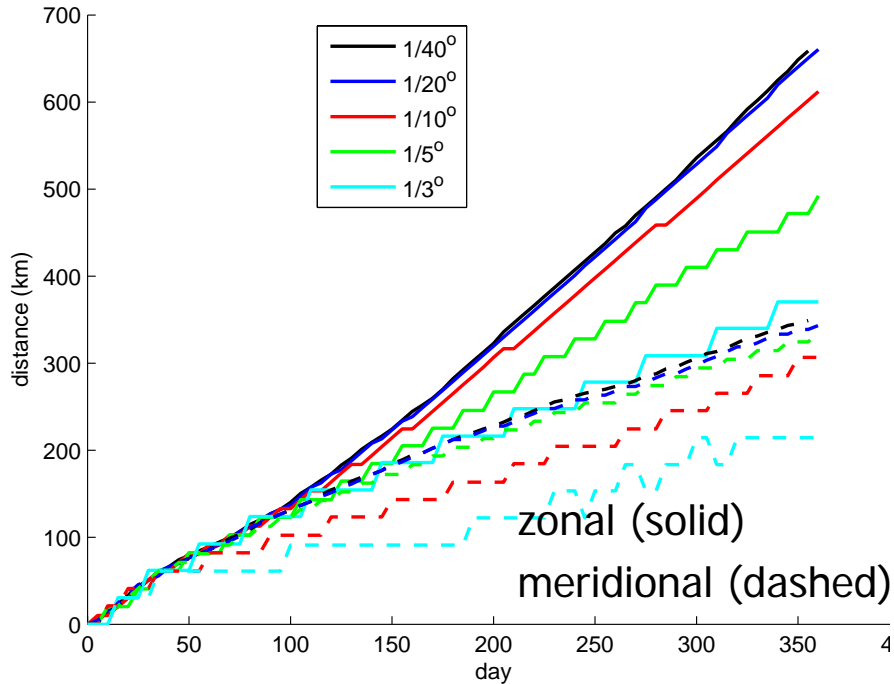
trajectory for 1 yr



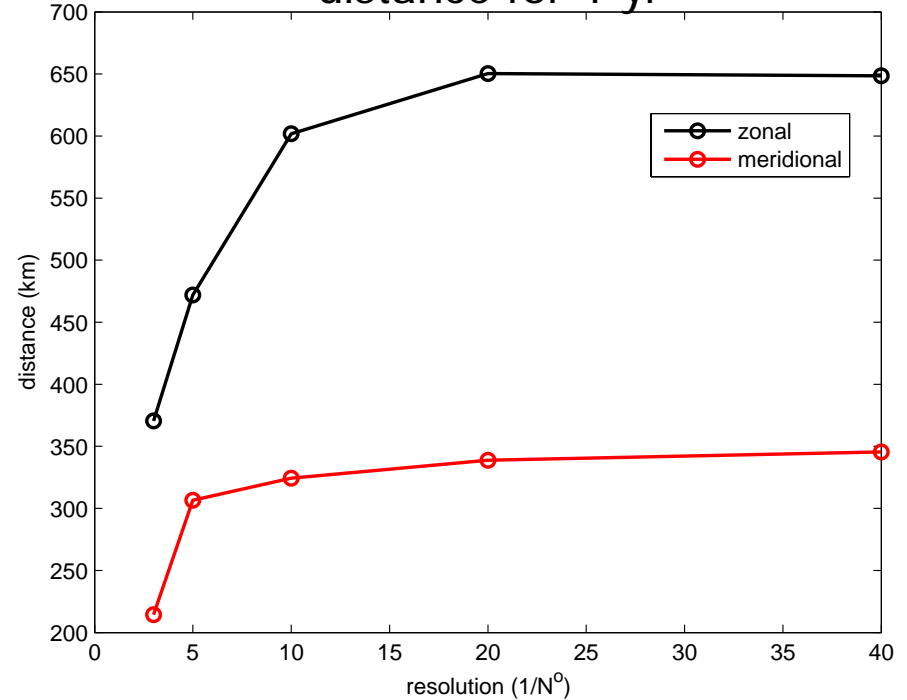
- Stepwise/continuous trajectory with low/high resolution
- Resolution convergence: $1/20$

sensitivity to propagation speed

propagation distance

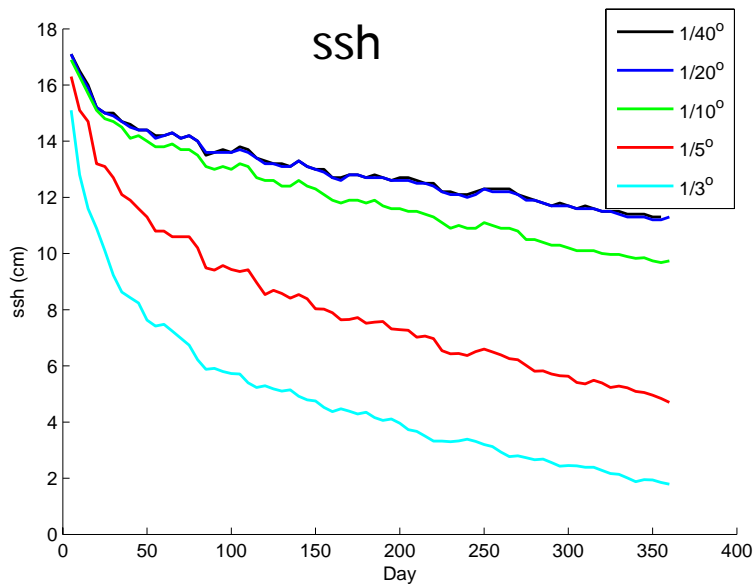
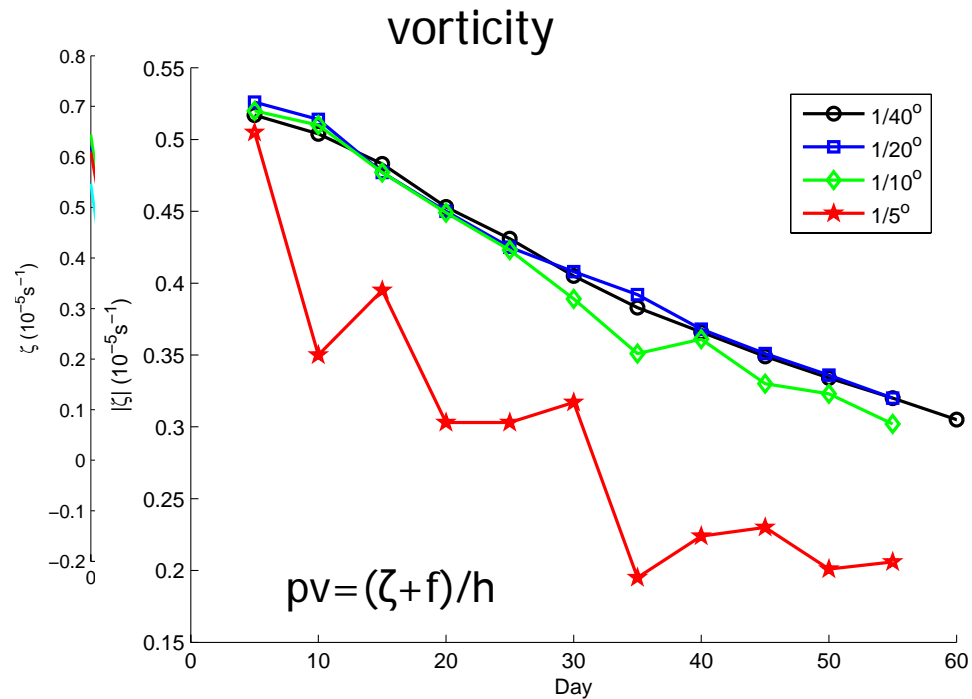
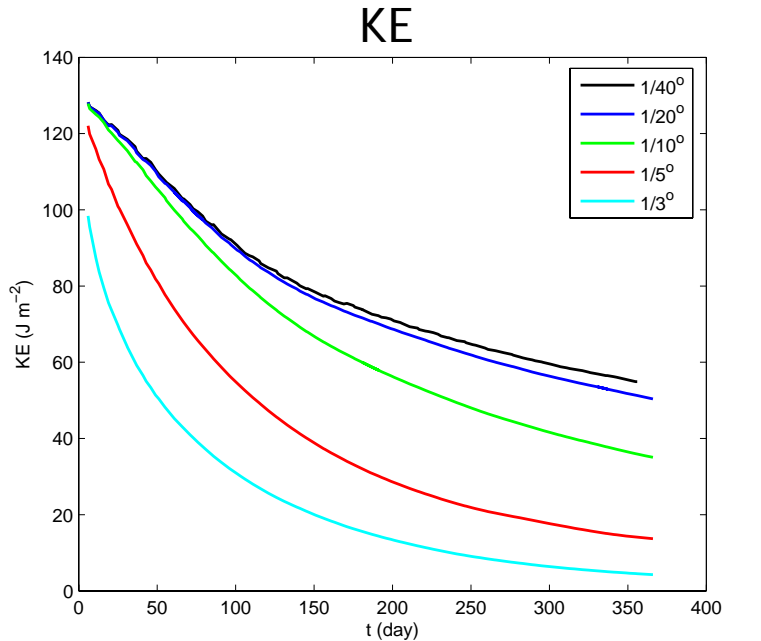


distance for 1 yr



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

sensitivity to dissipation

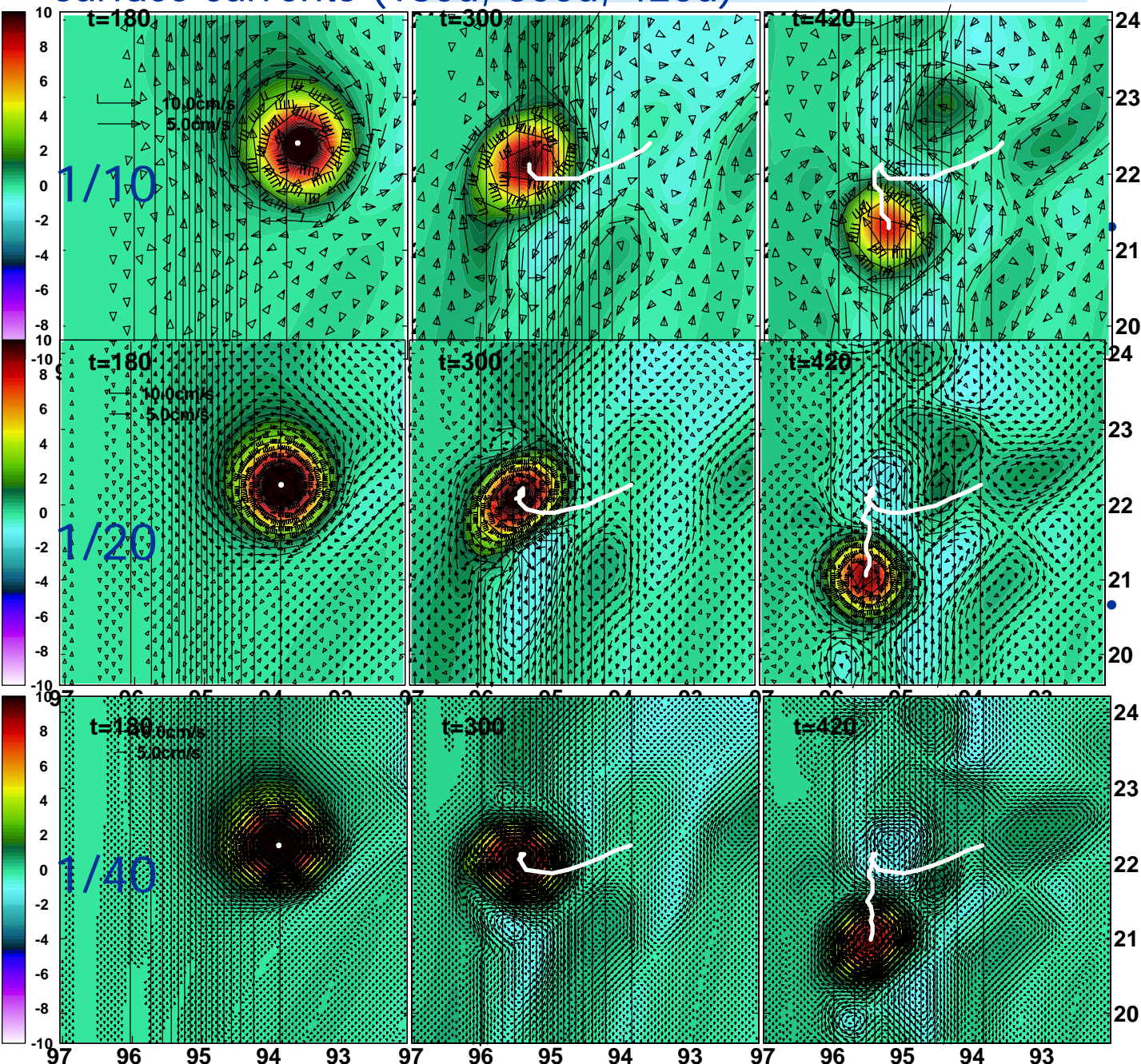


- Slow dissipation with high resolution (1/20 dissipates ~20% slower than 1/10)
- Resolution convergence 1/20
- Vorticity: oscillatory/continuous dissipation with low/high resolution

2. Eddy-topography interaction

sensitivity to surface current

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

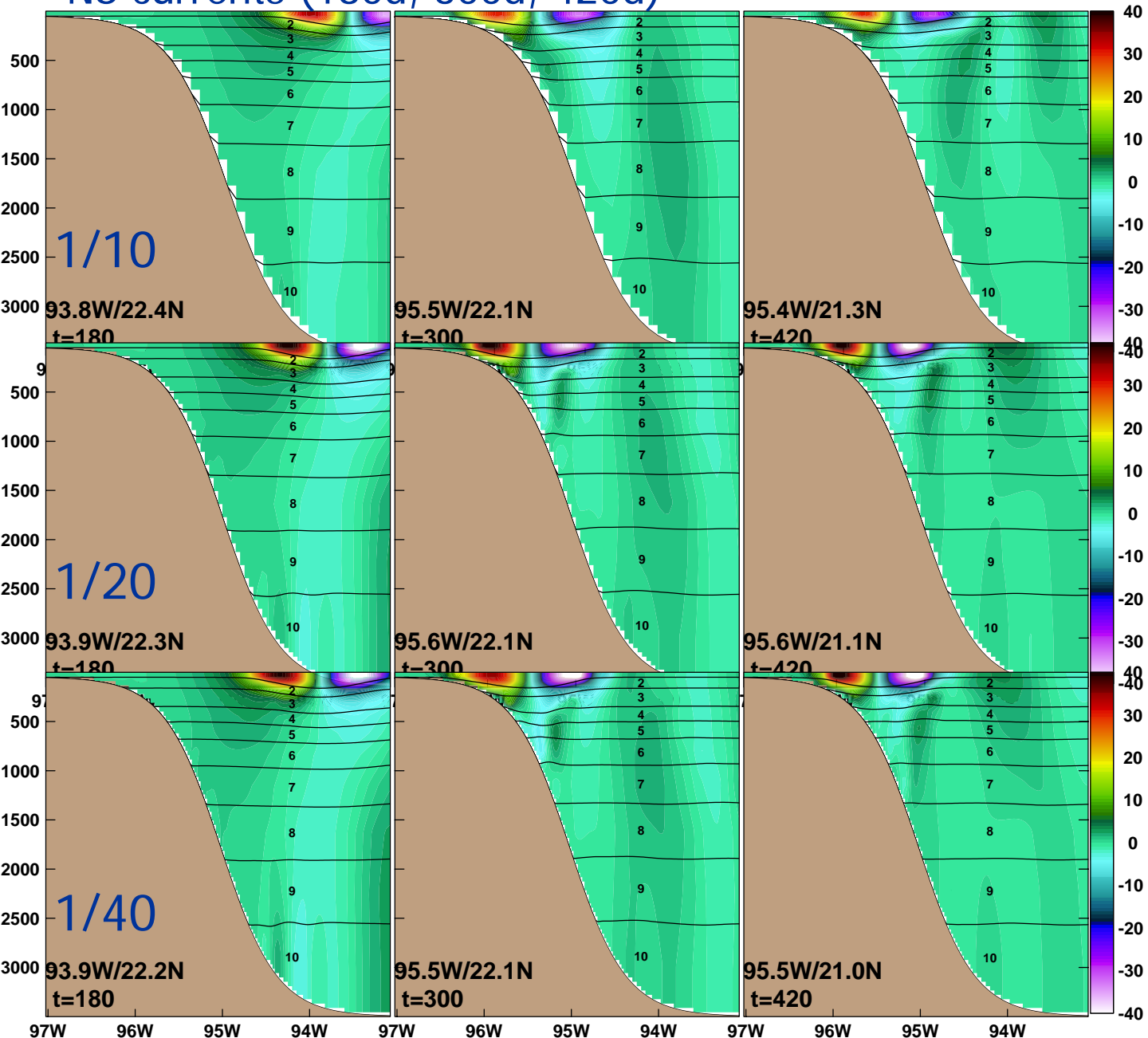


Cross-slope / alongslope translation before/after collision, slope jet (qualitatively consistent for $>1/10$)

1/40 well-resolved for filament/frontal eddies

sensitivity to subsurface current

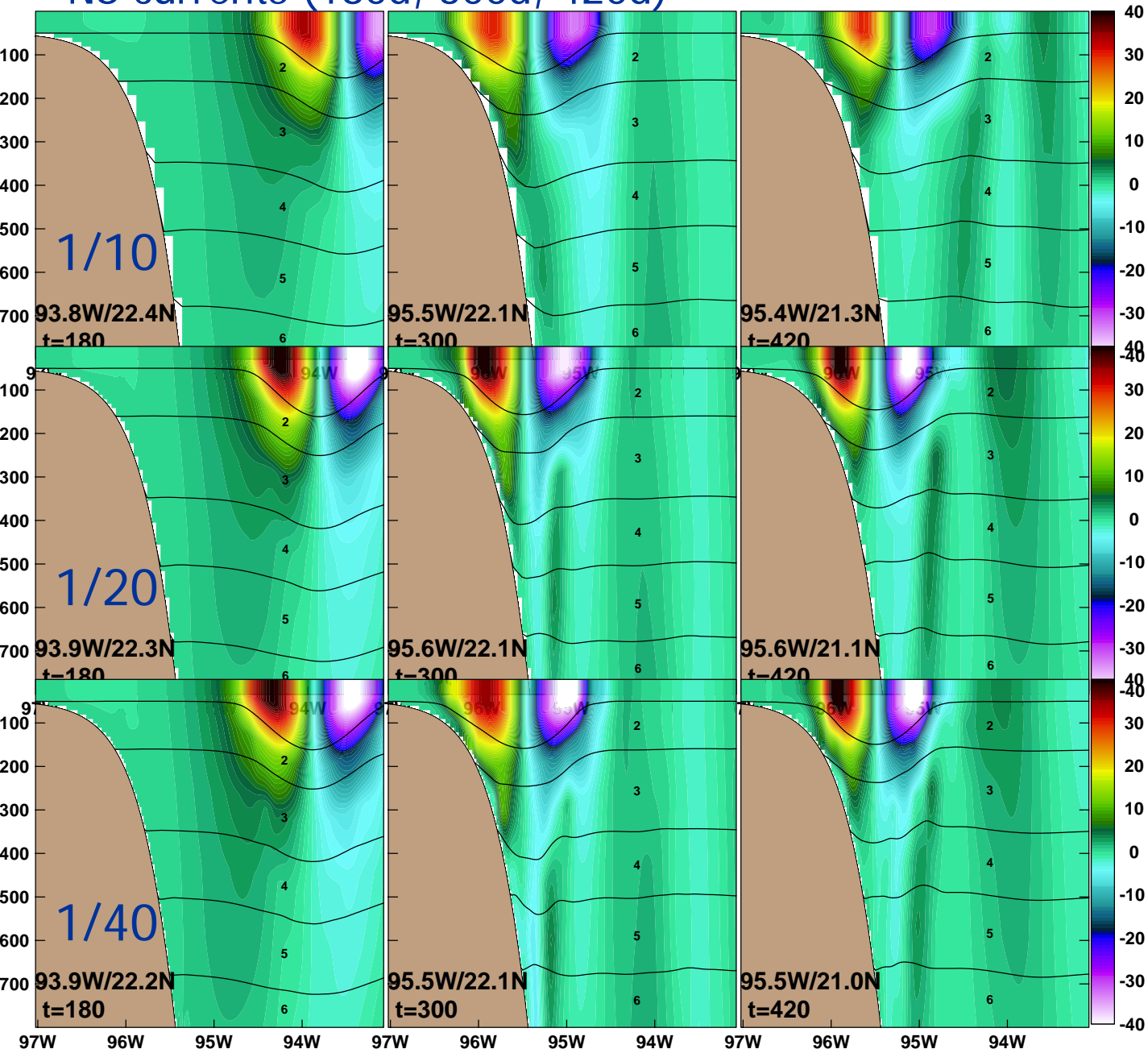
NS currents (180d, 300d, 420d)



- Stronger subsurface cyclone for $> 1/20$

sensitivity to subsurface current

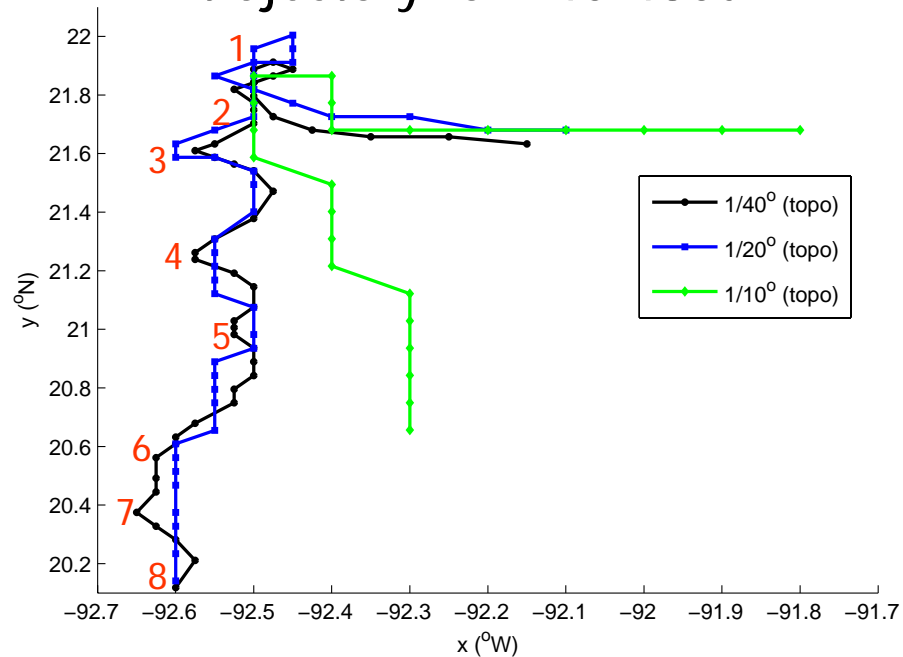
NS currents (180d, 300d, 420d)



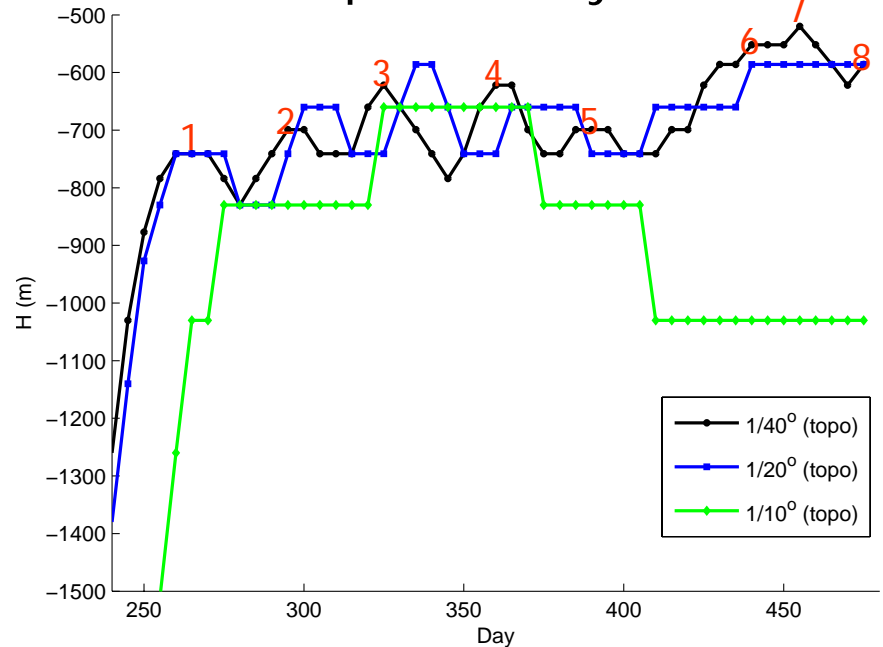
- Strong deep cyclonic current (1/20, 1/40)
- 1/40 resolved better than 1/20 for deep cyclone

sensitivity to collision/reflection

trajectory for 240-480d

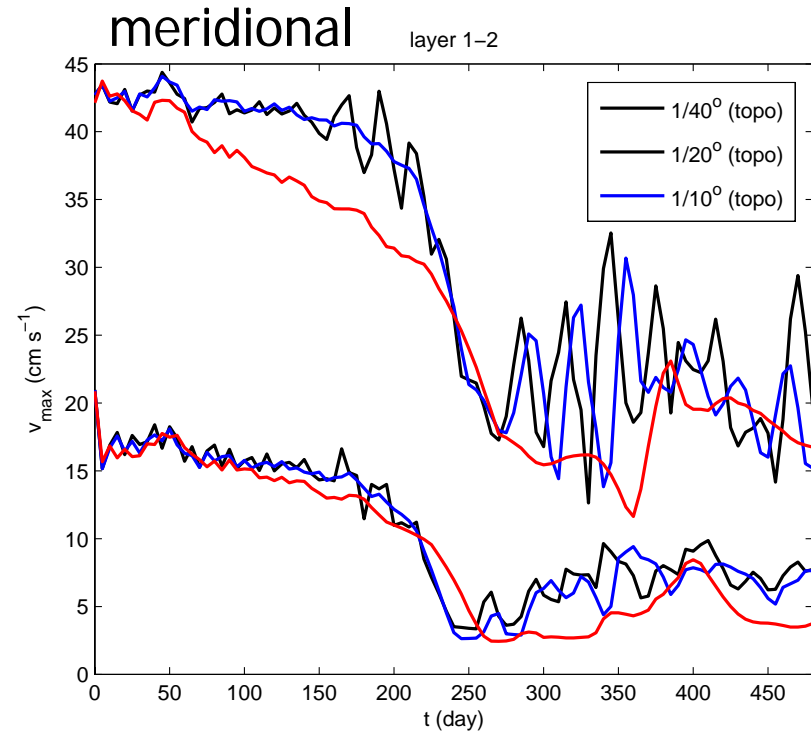
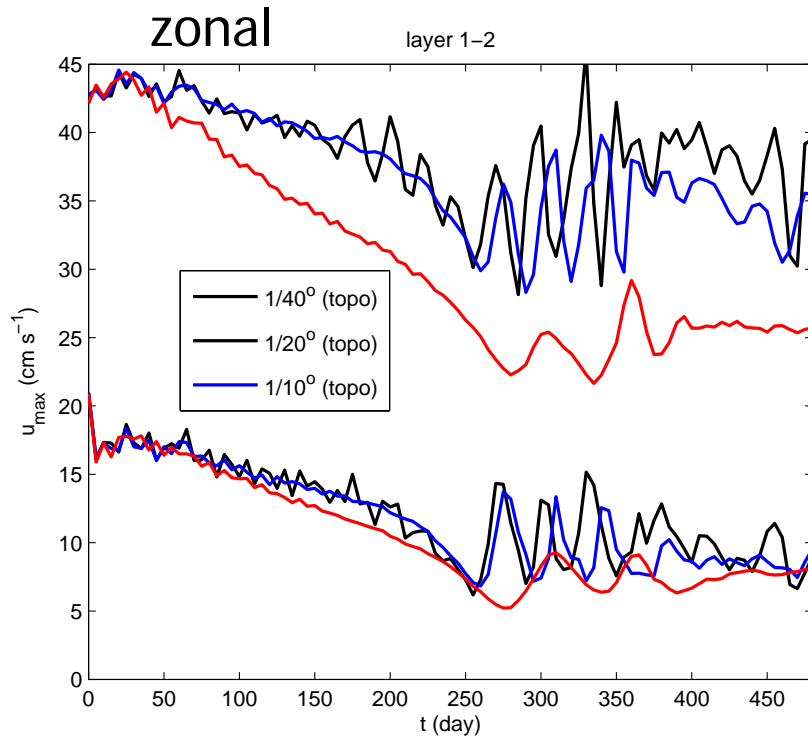


total depth of eddy center



- 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

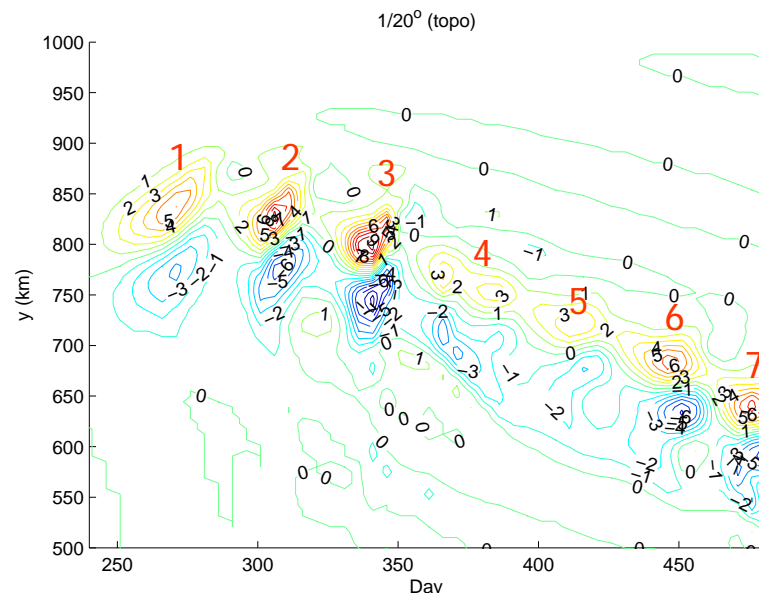
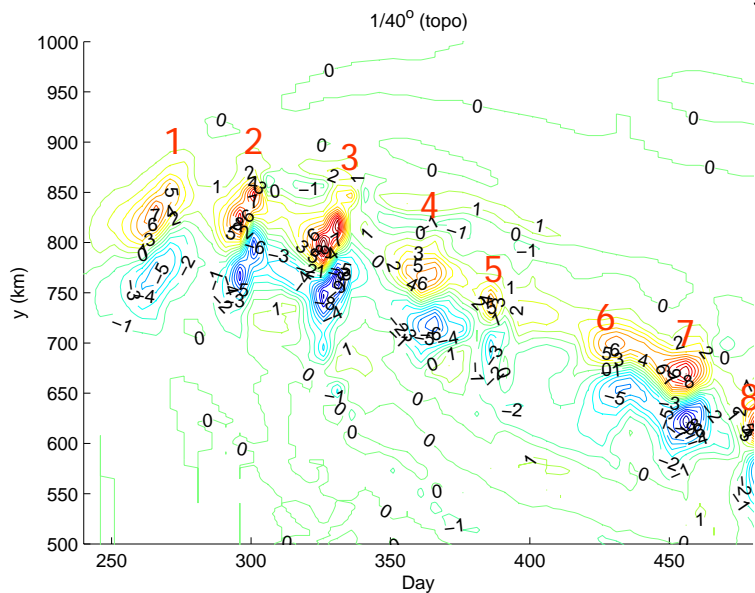
sensitivity to eddy swirl currents



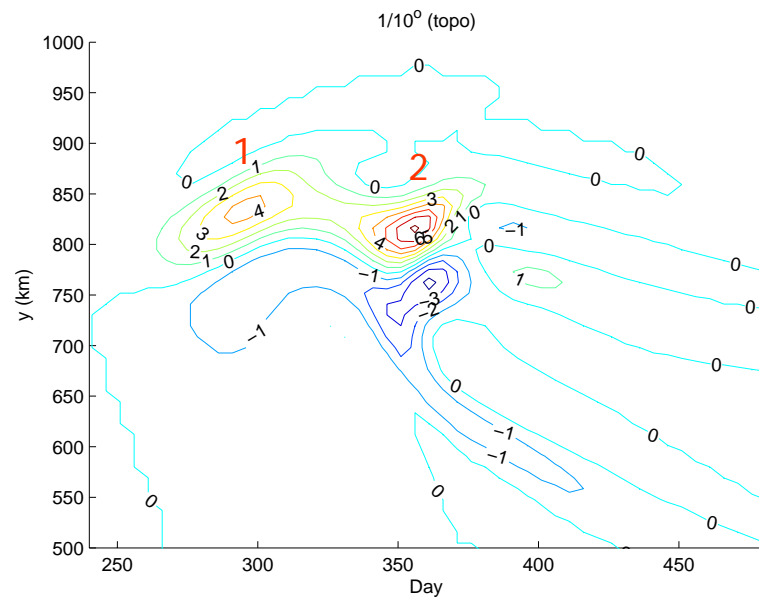
- strong dissipation/oscillation over topography; zonal/meridional oscillation
- faster dissipation with lower resolution
- 1/20 resolution convergence but smoothed pattern (following the mean of 1/40)
- 1/40 stronger oscillation amplitude (more realistic)

sensitivity to cross-shelf current

ubaro along the shelf break

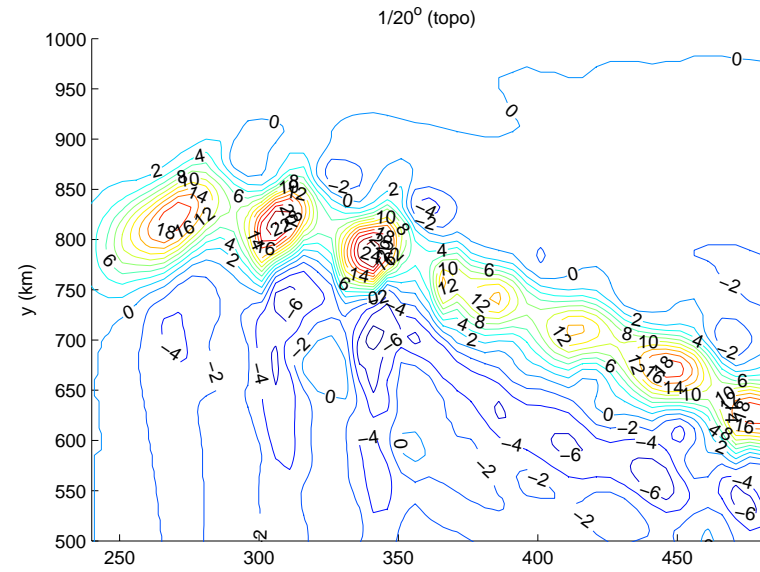
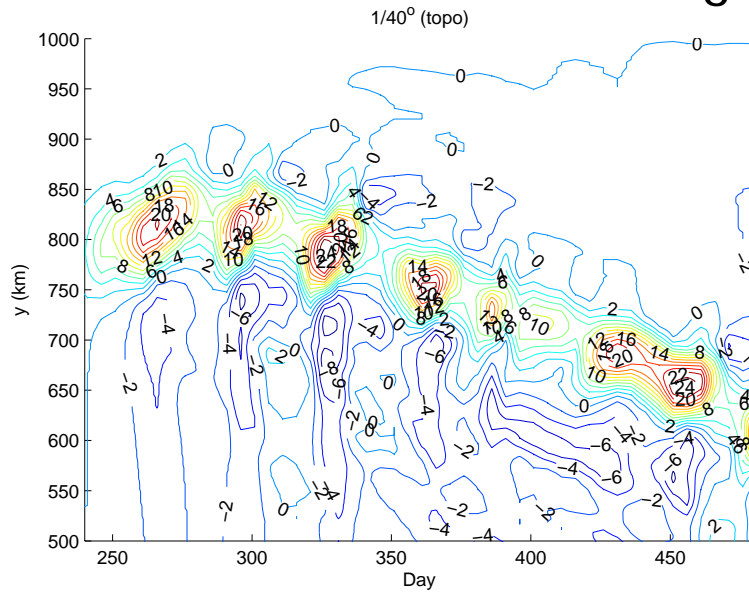


- shelf break depth = 163m
- stronger cross-shelf current core speed, frequent collision with high resolution

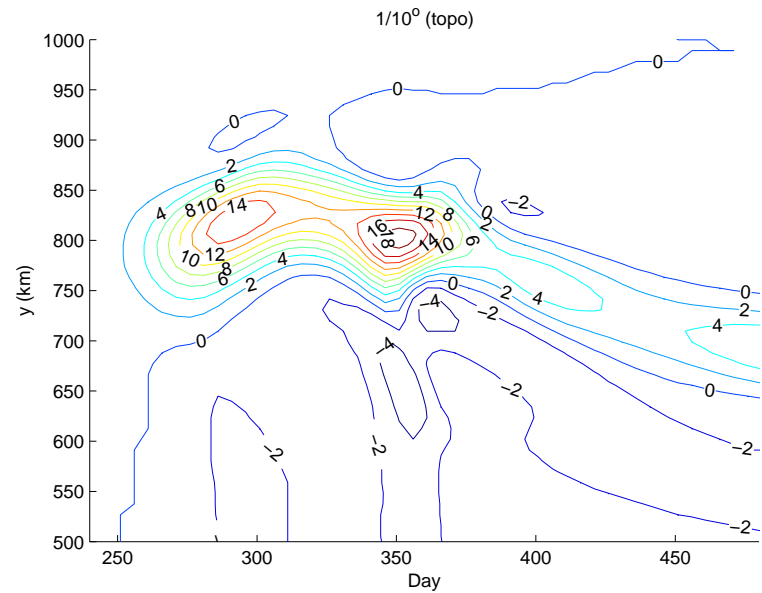


sensitivity to shelf break jet

vbaro along the shelf break

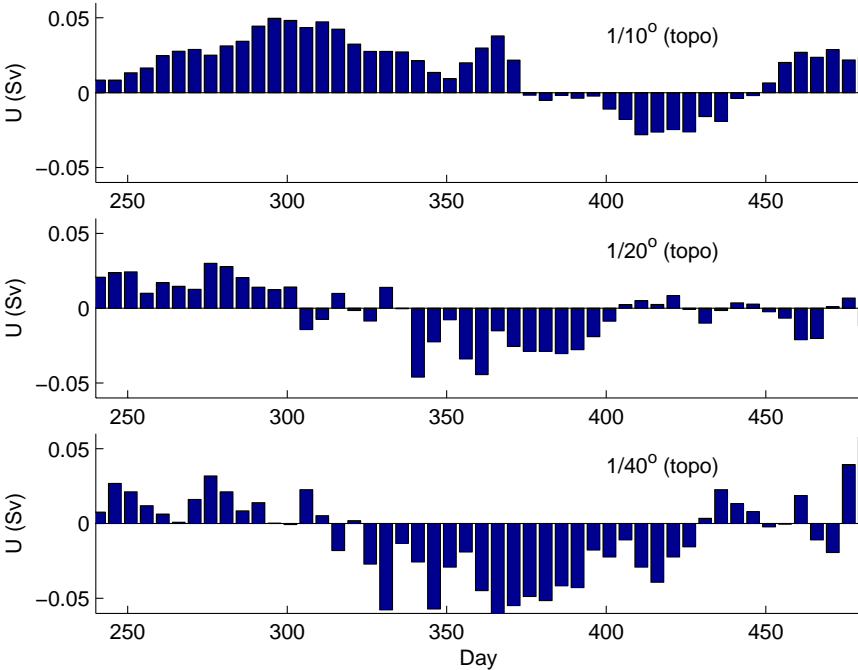


- Stronger/frequent shelf break jet with high resolution

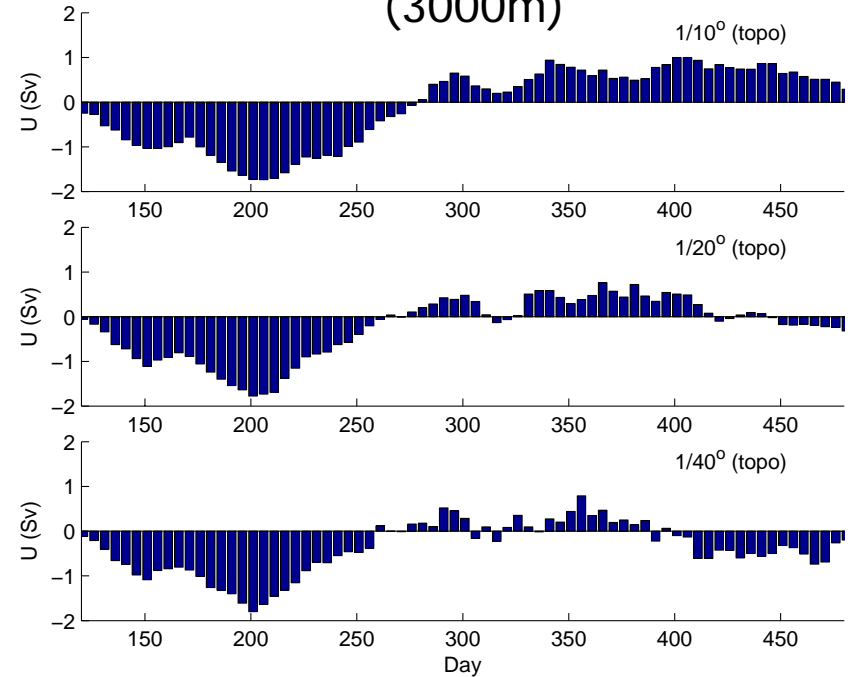


net shelf-slope-abyssal exchange

integrated ubaro along the shelf break



integrated ubaro along the slope bottom (3000m)



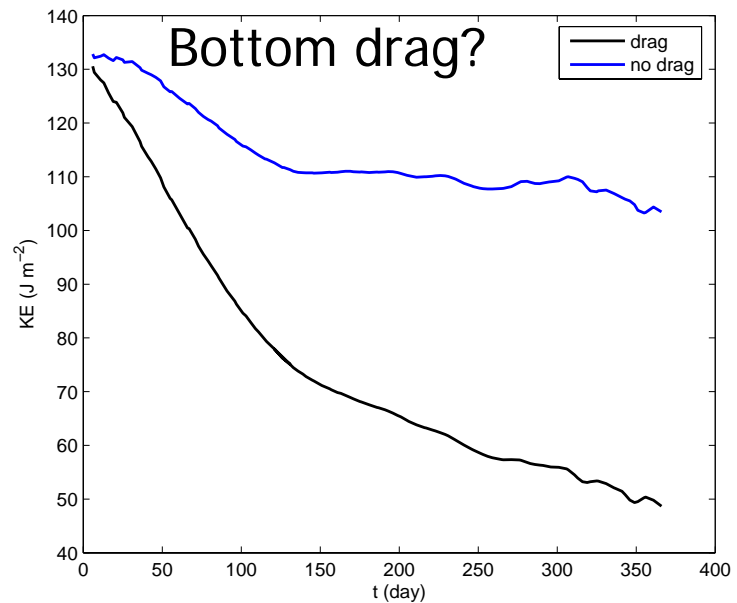
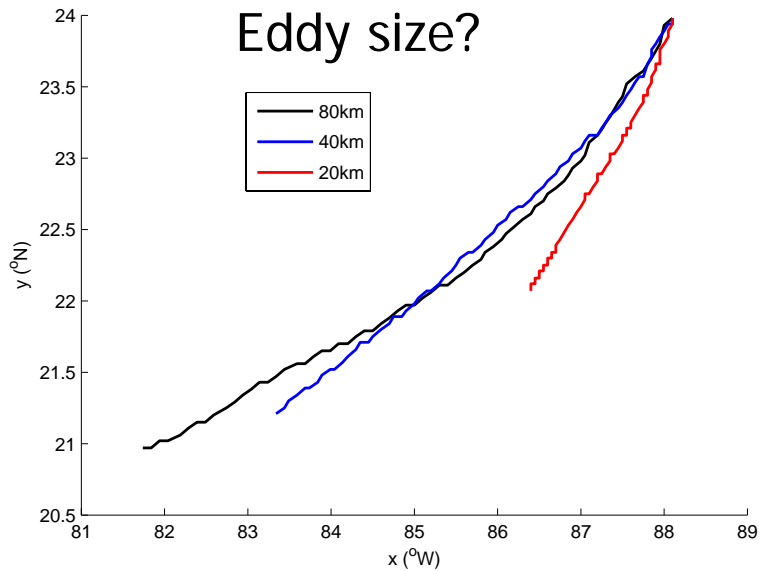
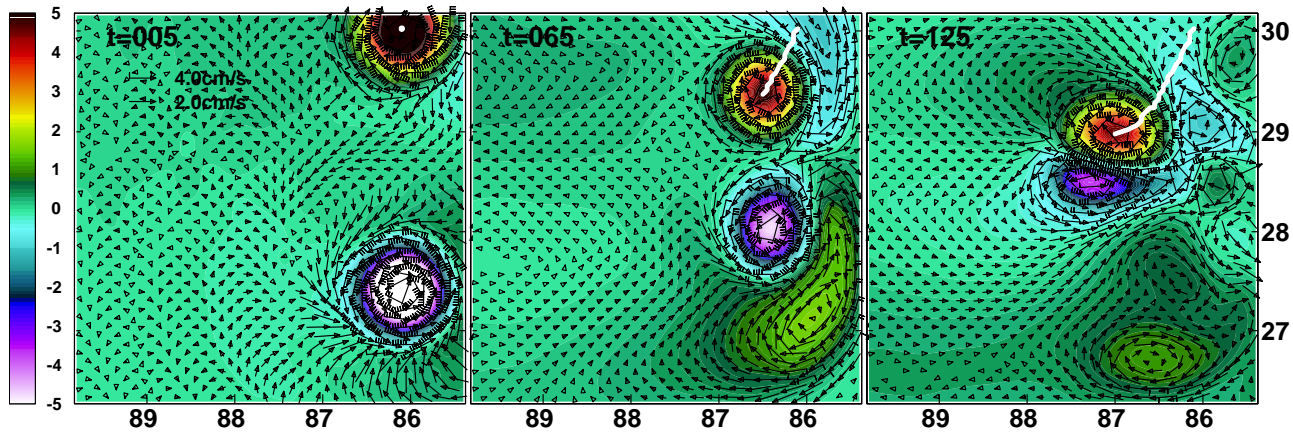
- Larger on-shelf transport with higher resolution
- Smaller off-slope transport with higher resolution

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
- Dr. Wallcraft : HYCOM Utility, ARSC HPC
- SEED (Shelf to slope Energetics and Exchange Dynamics)