Submesoscale processes at Depth in Gulf of Mexico

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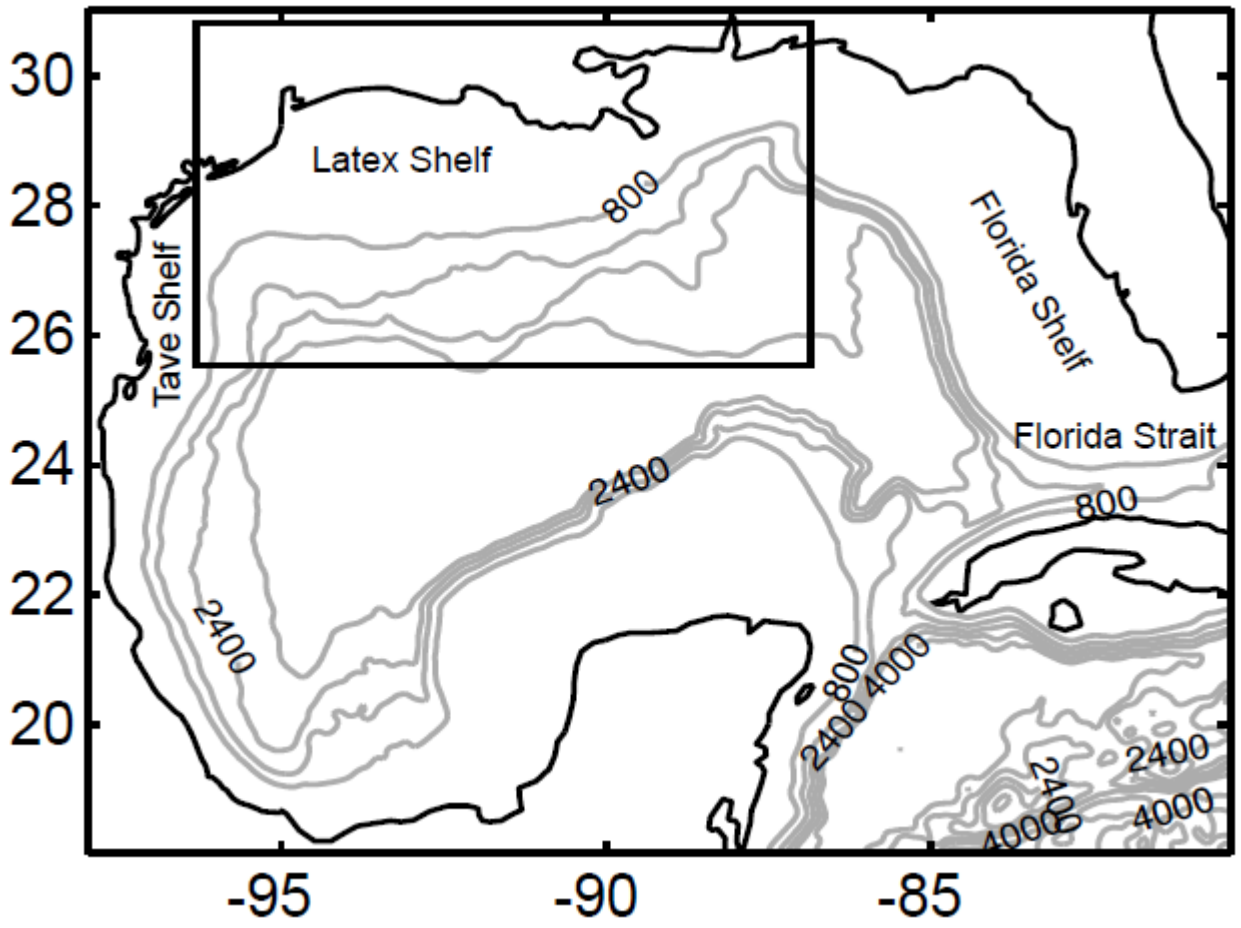
Hao Luo, Jim McWilliams

ECOGIG contribution # 309
GRIIDC #: R1.x132.141:0005

Model Setup: ROMS-AGRIF 2.1

- Domain:
  - **LR** -> 5km (98.0W~80.4W) & (18.0N~31.0N)
  - **HR** -> 1.6km (96.3W~86.9W) & (25.4N~30.7N)
- 70 vertical terrain-following layers
- HYCOM GoM 31.0: Boundary and Initial Condition
- ECMWF ERA-interim reanalysis (6-hour wind stress and daily heat fluxes)
- Run dates

  Jan 2010 – Dec 2012



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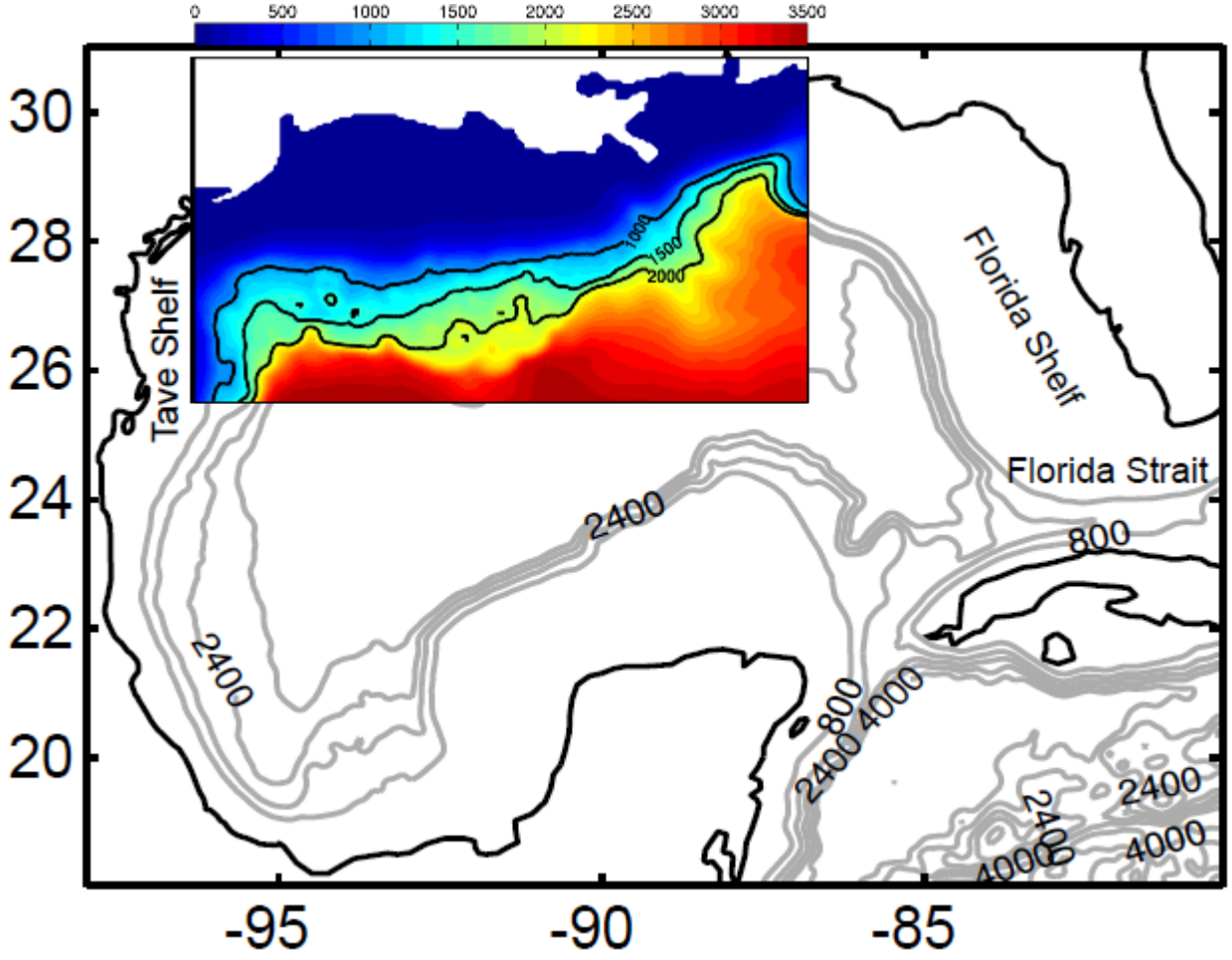

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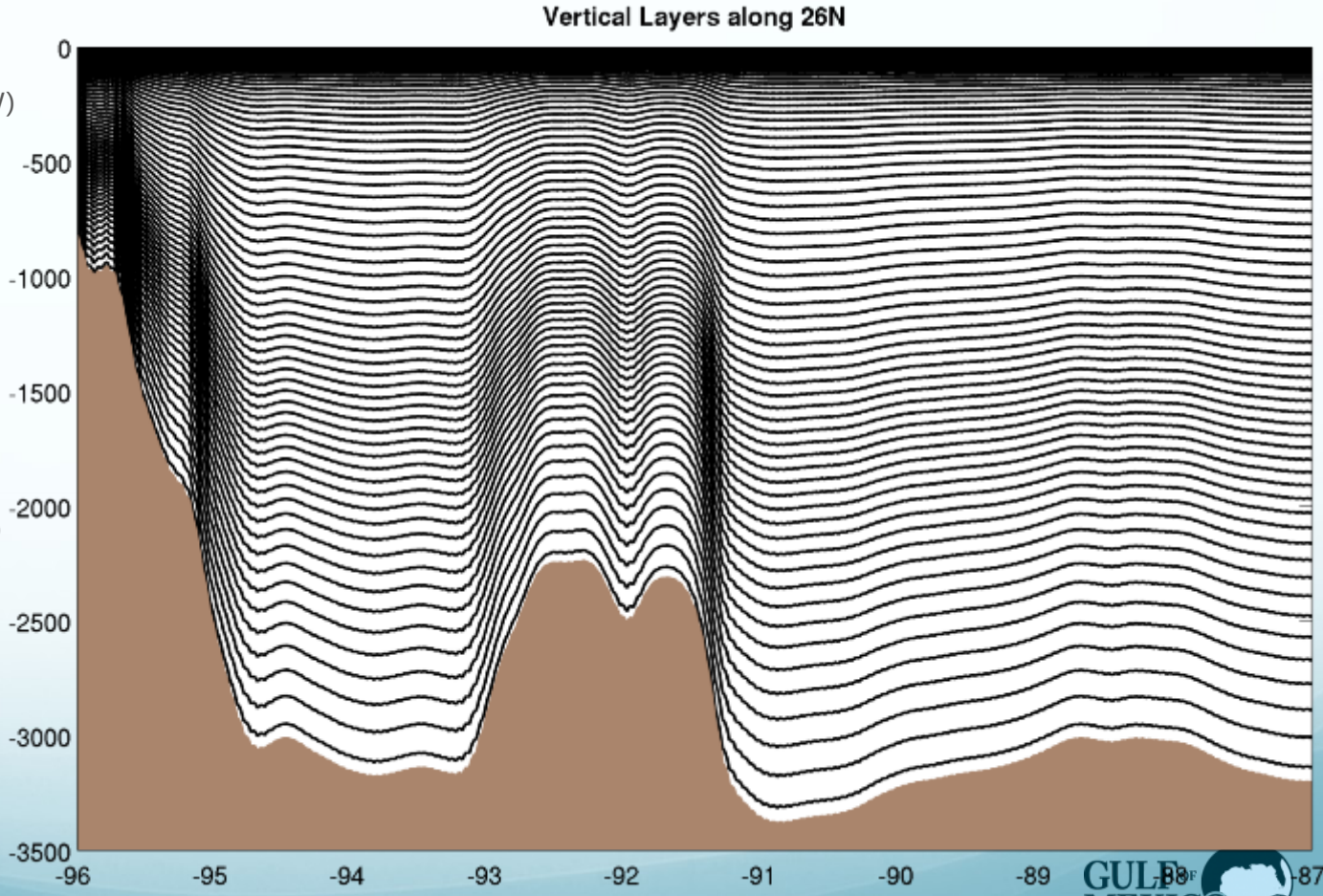

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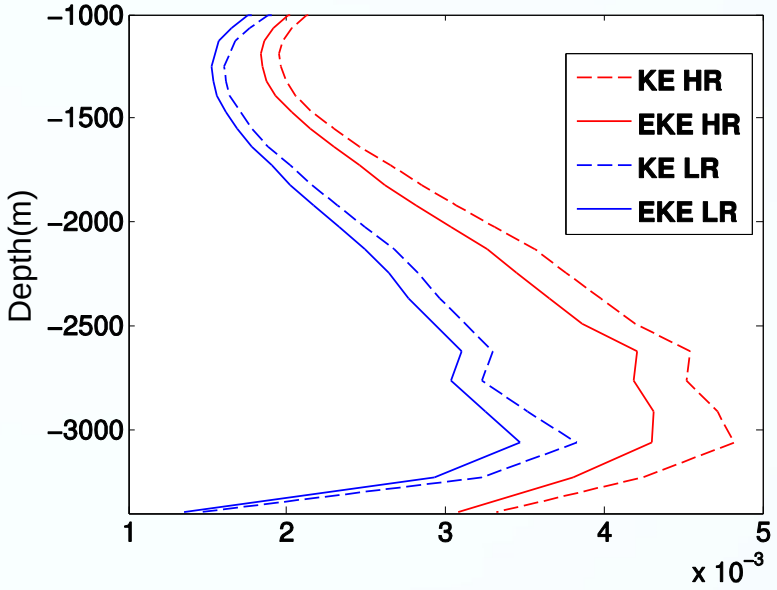
Mean Flow

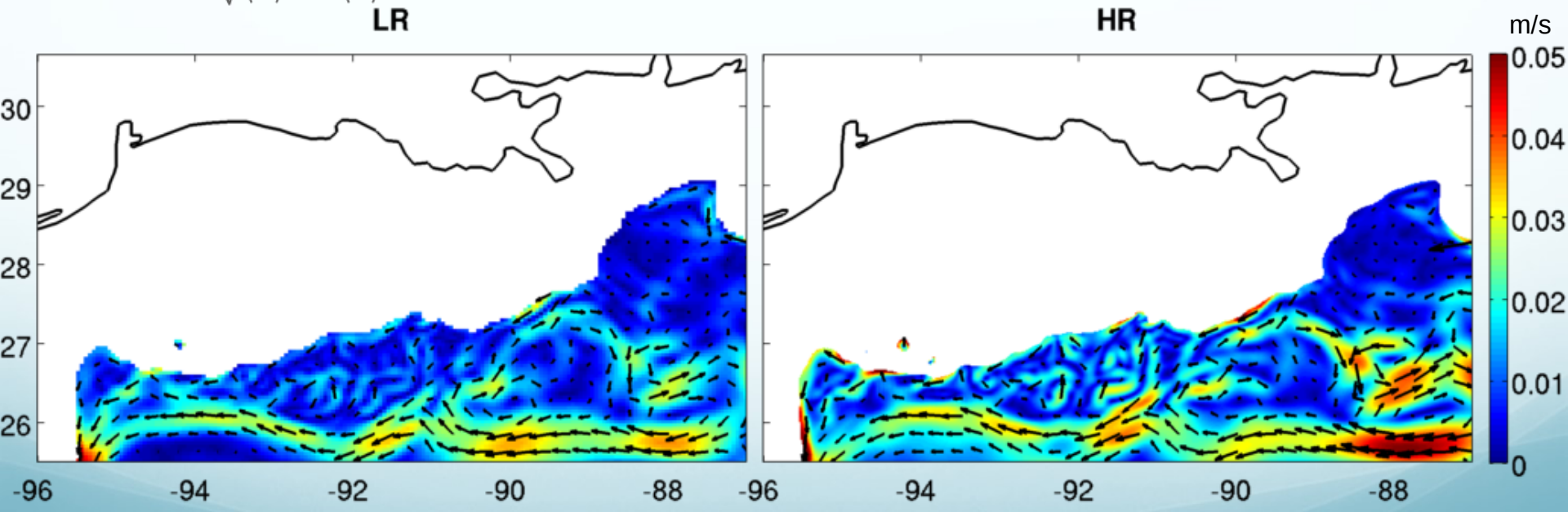
Mean velocity field vectors over 3 year run

contours from mean speed

$$= \sqrt{\langle u \rangle^2 + \langle v \rangle^2}$$

Energy Profile below 1000m (right)





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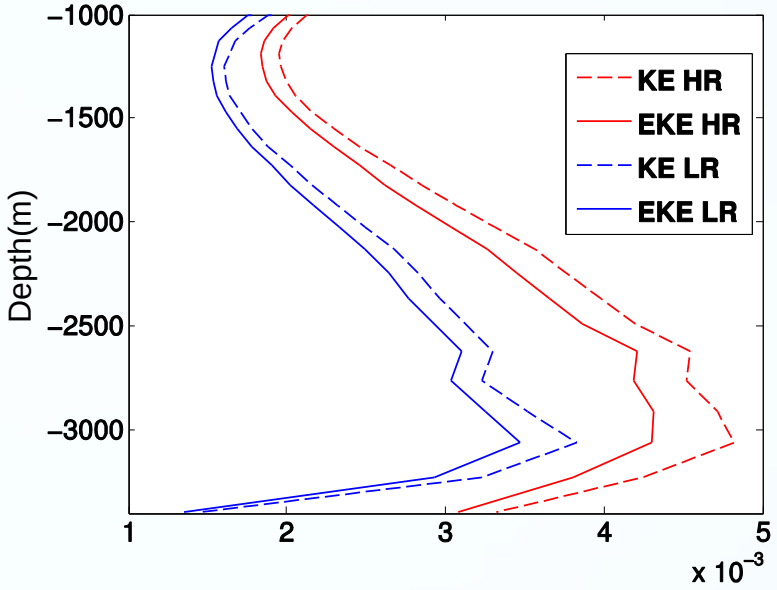
EKE variability

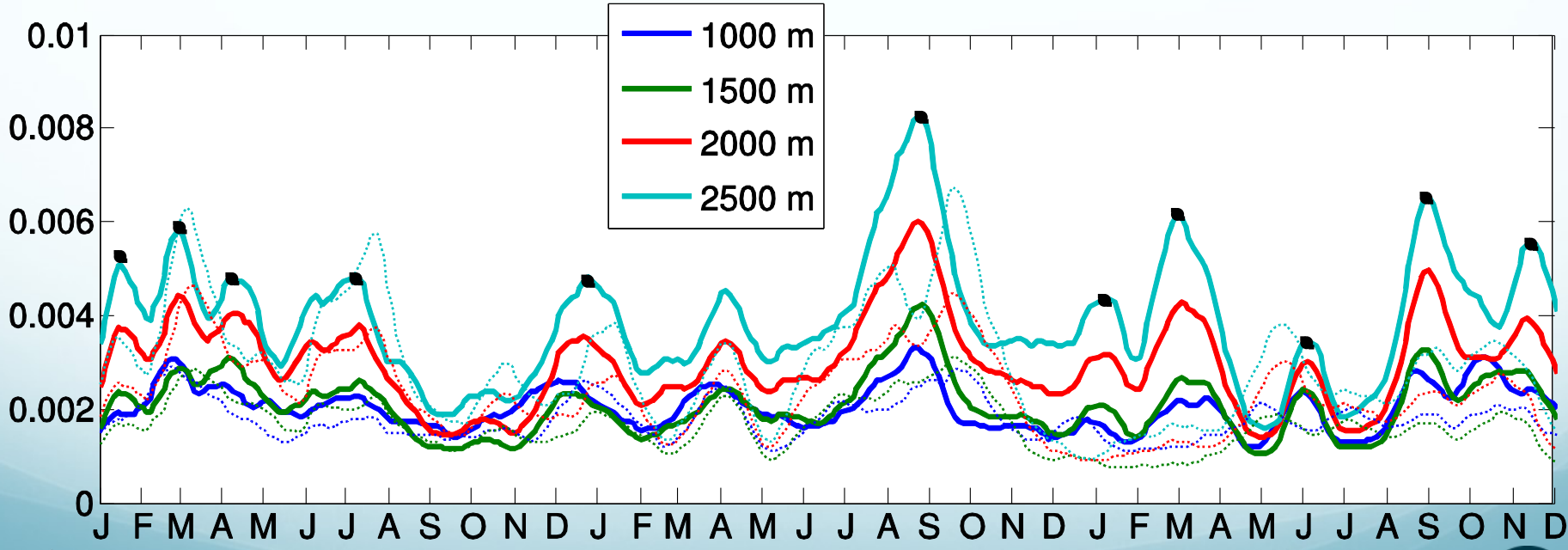
- greater EKE variability in HR
- black dots: consistent separation cyclone off Mississippi Fan

$$KE = \frac{1}{2}(u^2 + v^2)$$

$$u' = u - \langle u \rangle;\ v' = v - \langle v \rangle$$

$$EKE = \frac{1}{2}(u'^2 + v'^2)$$





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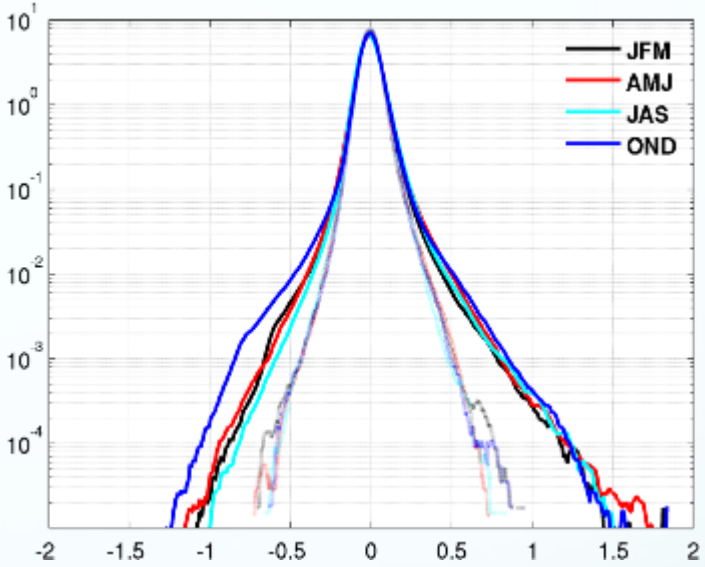
Vorticity generation

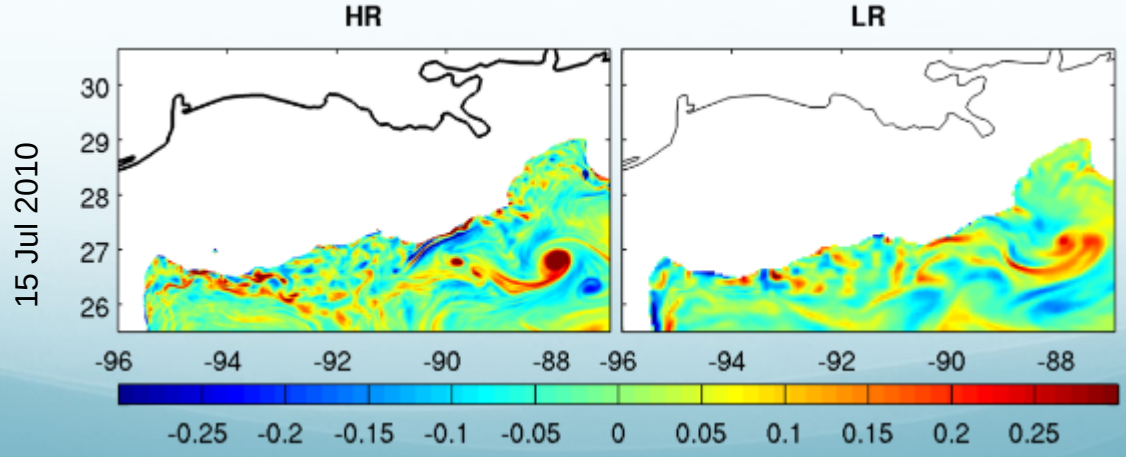
Seasonal Vorticity PDF @1000m
LR – lighter dashed line
HR – darker line



Vorticity: $\frac{\zeta}{f} = \left(\frac{dv}{dx} - \frac{du}{dy}\right)/f$

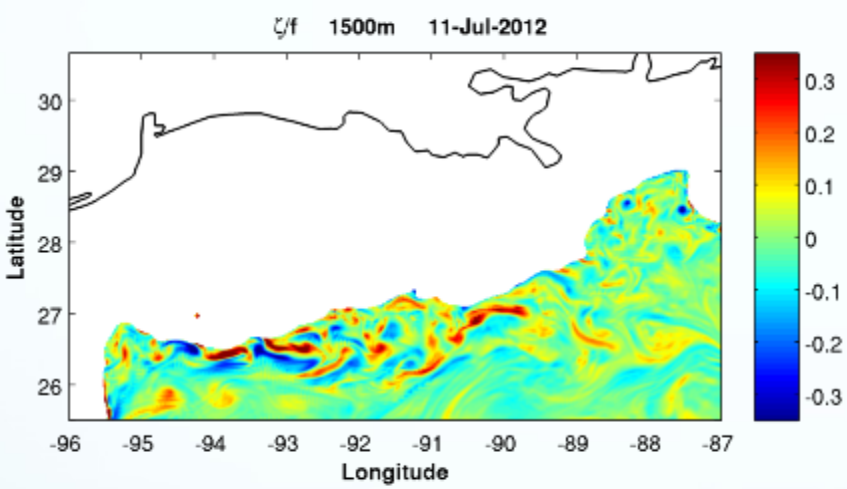
HR: $\zeta/f \sim 1$ generated in
- Separation cyclone
- Boundary layer instability
- Sigsbee escarpment

Skewness
@1000m
HR – 0.95; LR – 0.55
@2000m
HR – 1.58; LR – 1.10

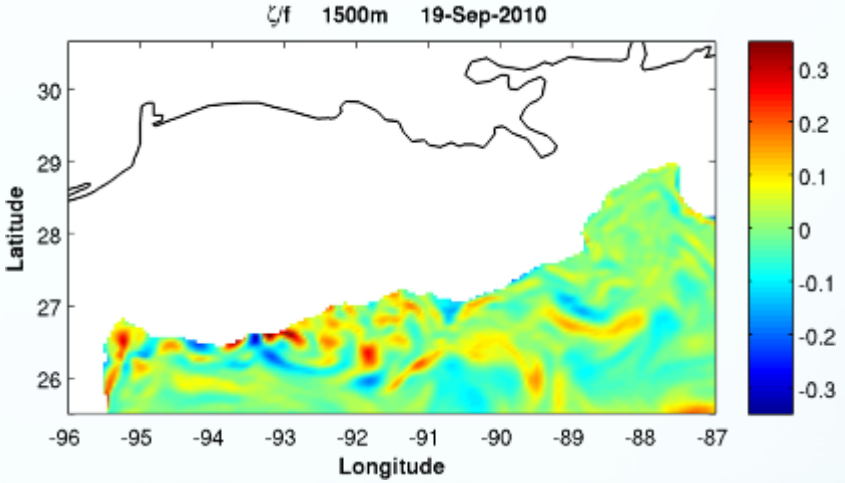


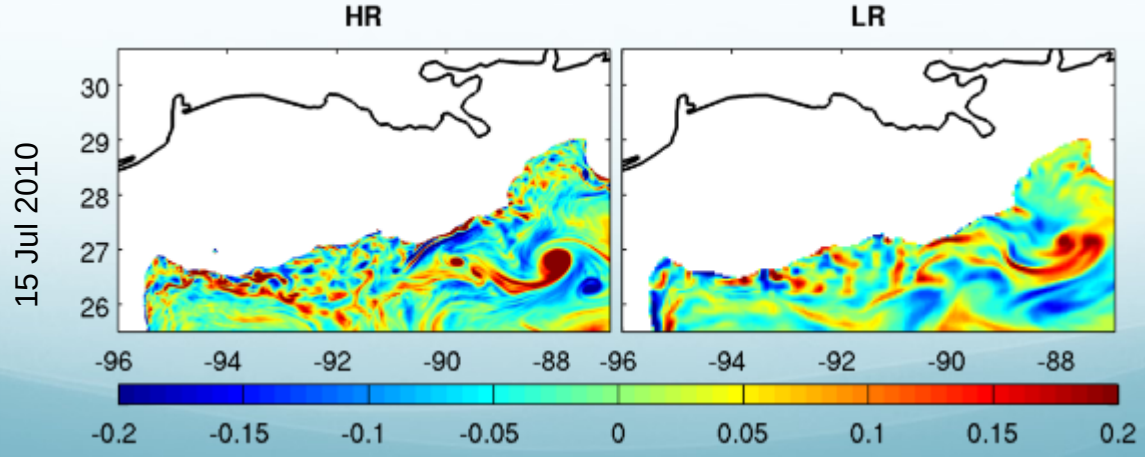
Vorticity generation

HR



LR





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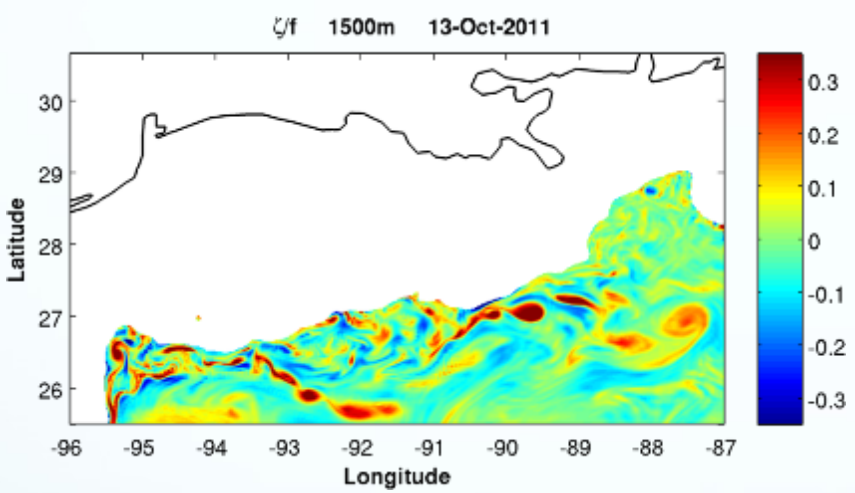
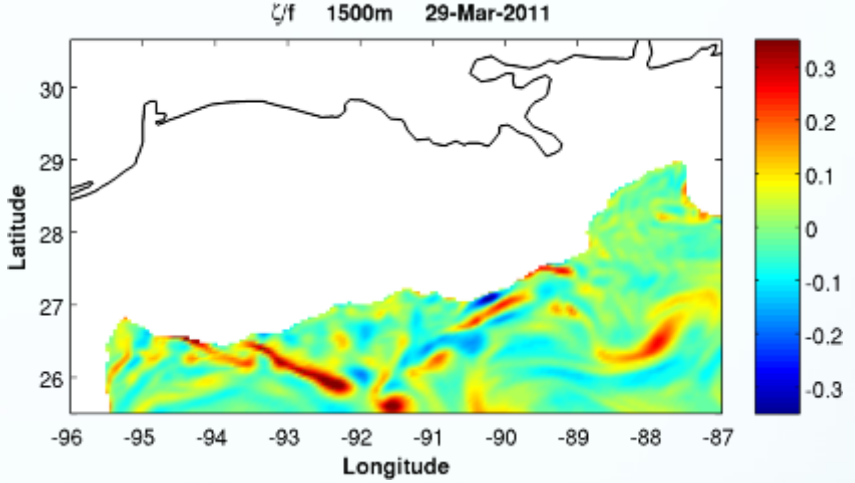
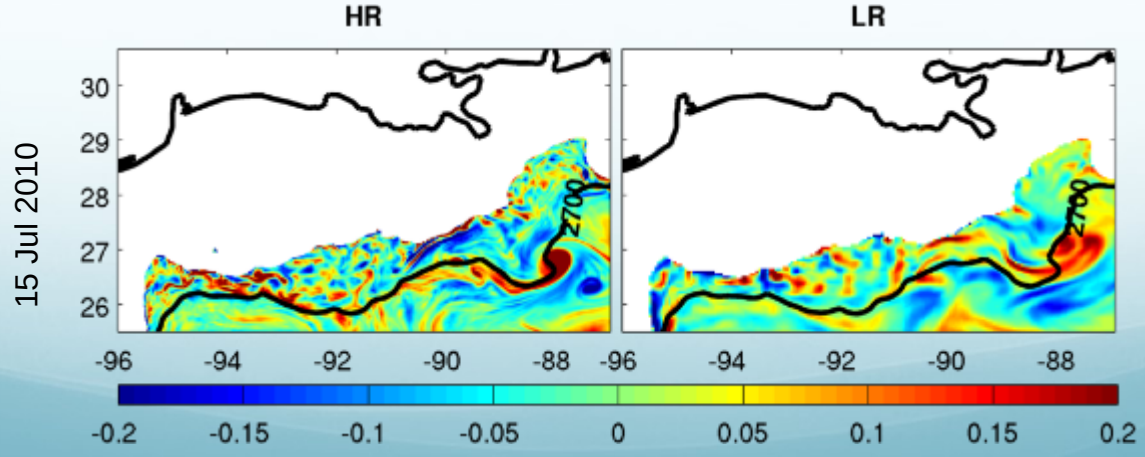
Vorticity generation

HR



LR





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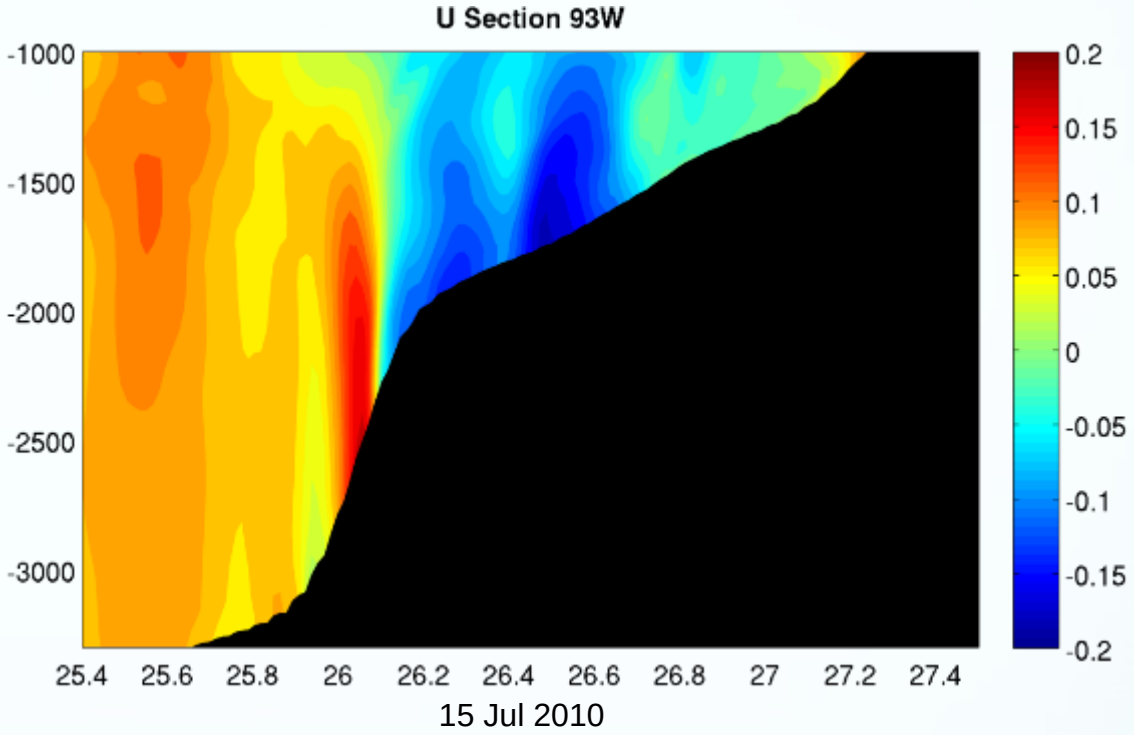
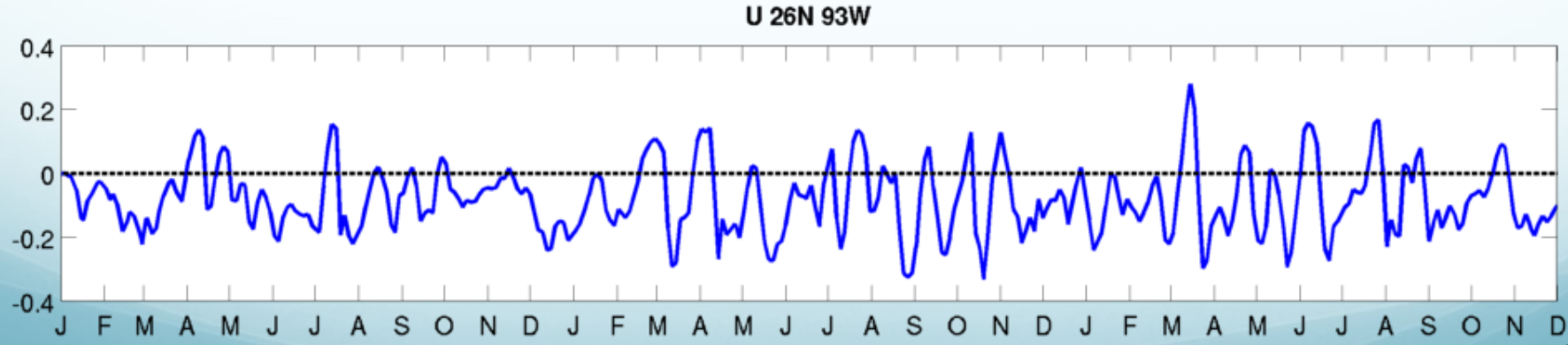
Boundary Layer

- generates cyclonic vorticity filament consistently
- better resolved boundary layer at 1.6km, higher population of eddies

$$\zeta = \frac{dv}{dx} - \frac{du}{dy} \sim -du/dy$$



15 Jul 2010



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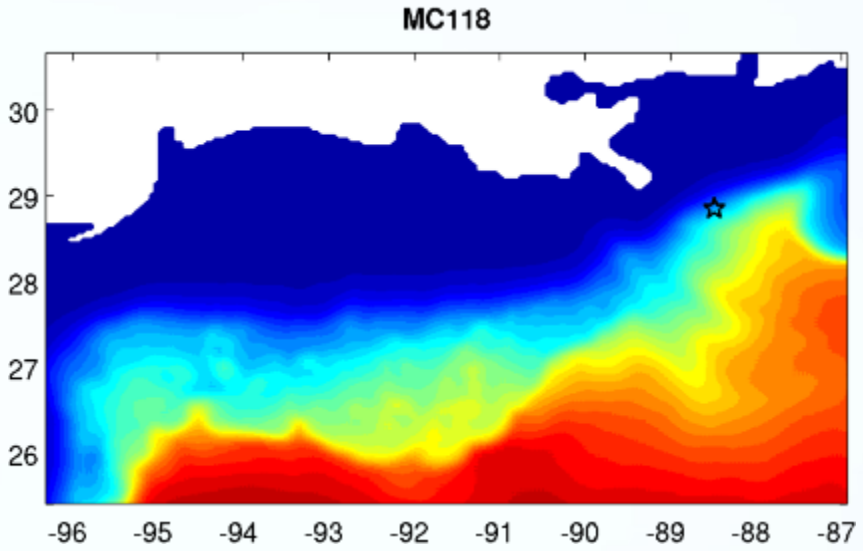
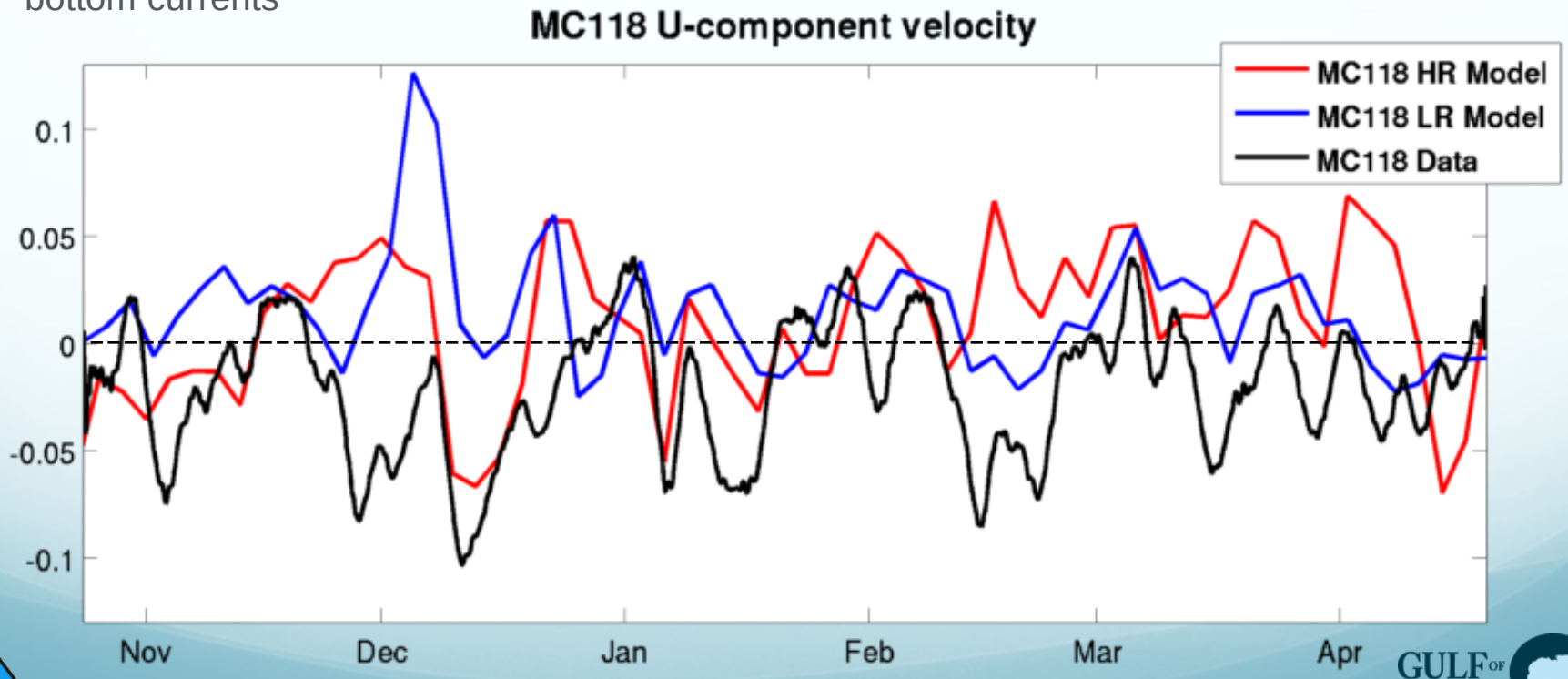
U-variability: data

Data gathered every 2 minutes by lander at MC118 location, natural seep site
3-day lowpass applied to all data
More data needed for validation of bottom currents





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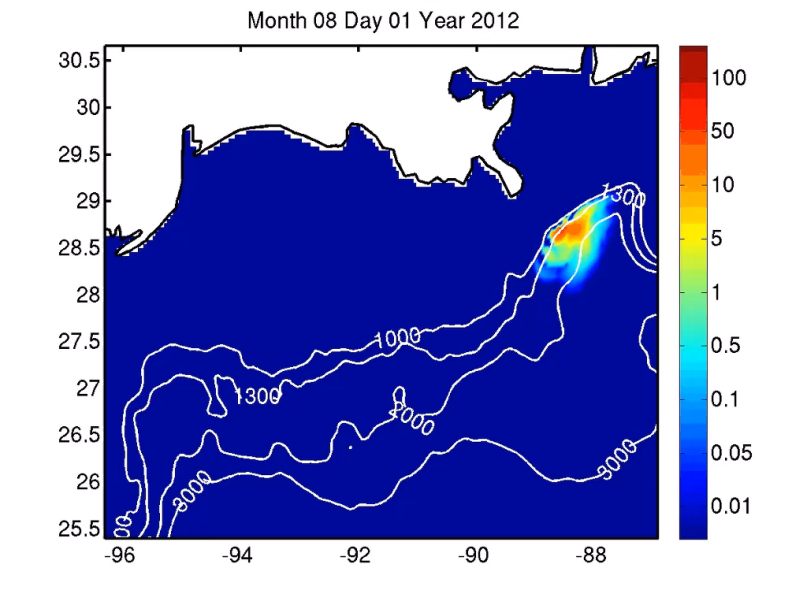
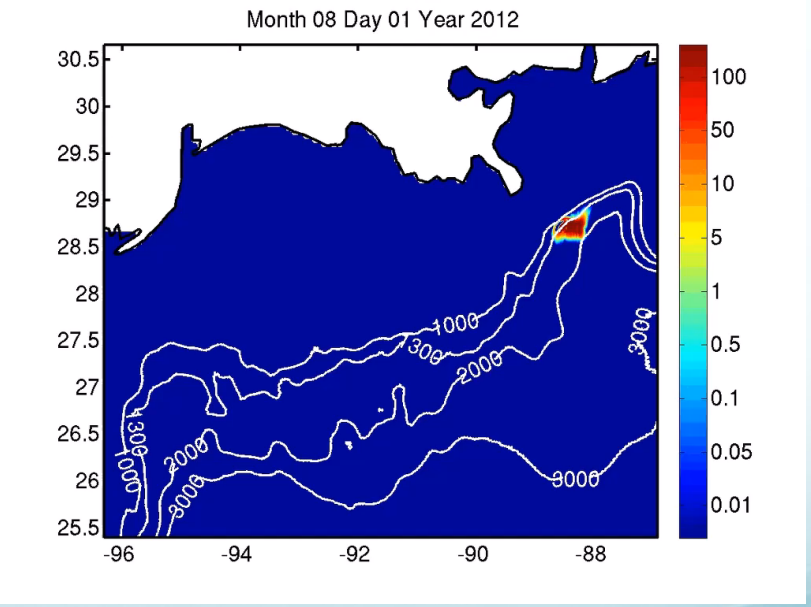
Tracer Evolution

Tracers released on Jul. 28 2012, close to Macondo Blowout site, advected for 4 months

LR



HR



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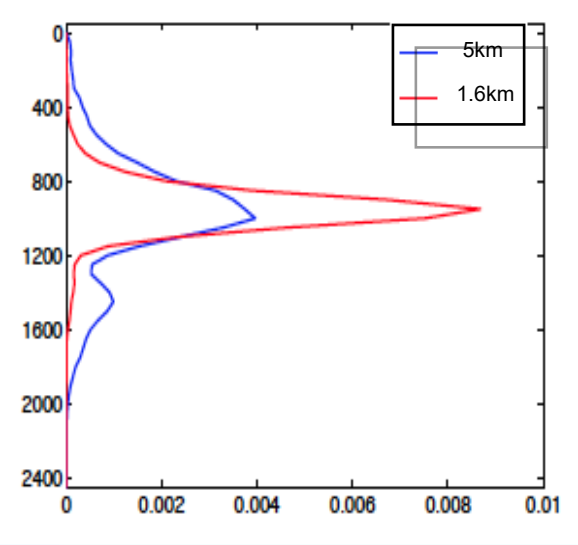
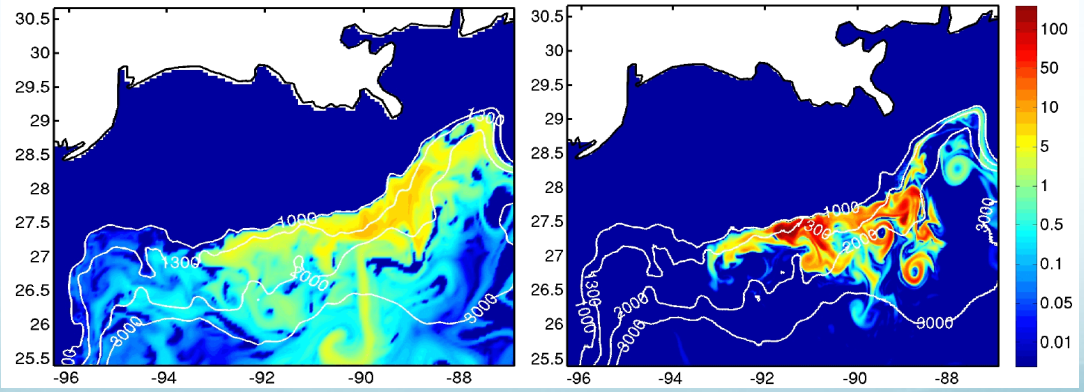
Tracer vertical distribution



LR tracer diffuses more both horizontally and vertically

HR traps tracer in submesoscale structures along the continental slope

LR HR



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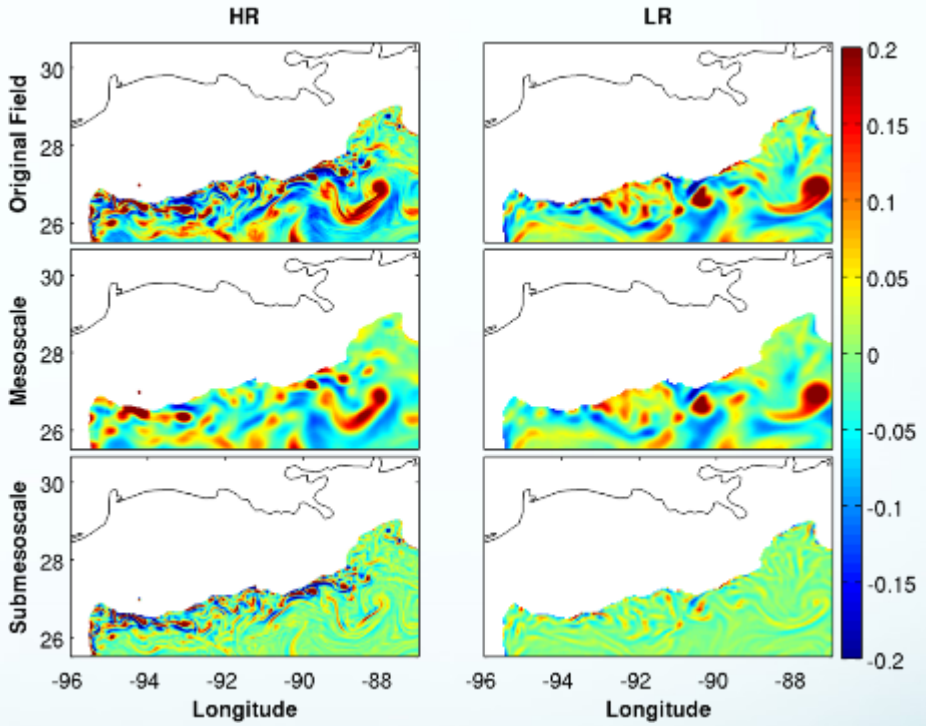
Summary

- 1.6 km run
  - better resolves boundary layer and consequent instabilities
  - produces high vorticity populations: $\zeta/f \sim 1$, at depth as a result
- Submesoscale resolving models important for predicting transport and mixing of tracer or particles suspended in the ocean, even at depth



15-Sep-2011

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