



Synoptic Study of Warm Rings in the North Brazil Current Retroflexion Region using Altimetry Data

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Objective

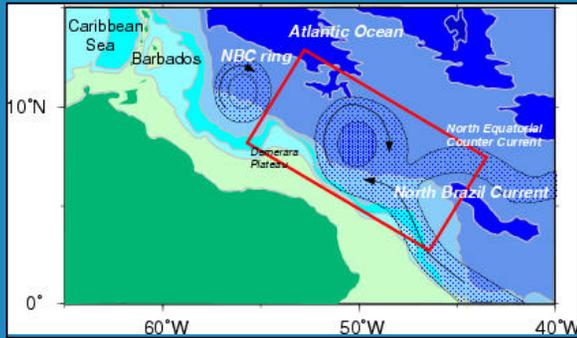
Estimate the contribution of NBC rings in the transport of SA waters into the north Atlantic ocean using TOPEX/Poseidon altimeter data.

Study of NBC rings:

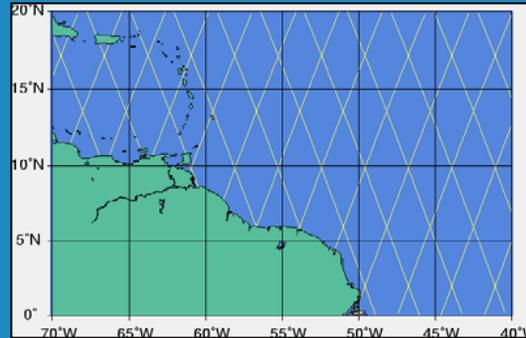
- 1. Formation**
- 2. Trajectories**
- 3. Dimensions**
- 4. Translation speeds**
- 5. Volume transports**
- 6. Energy**

About this Work

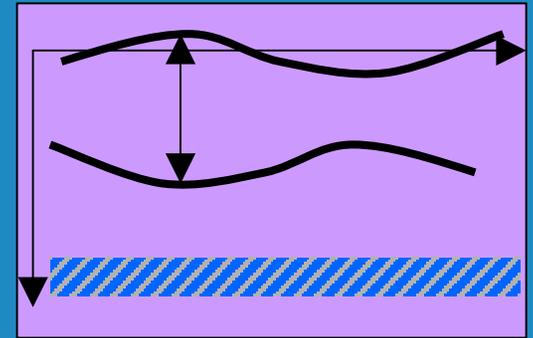
Motivation



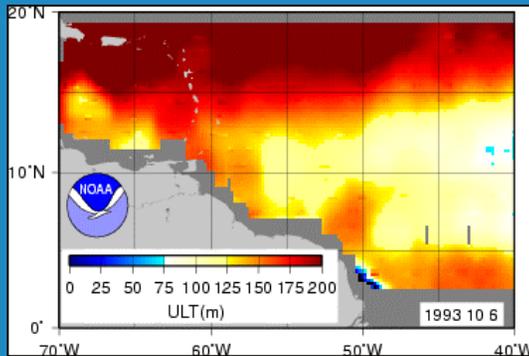
Altimetry



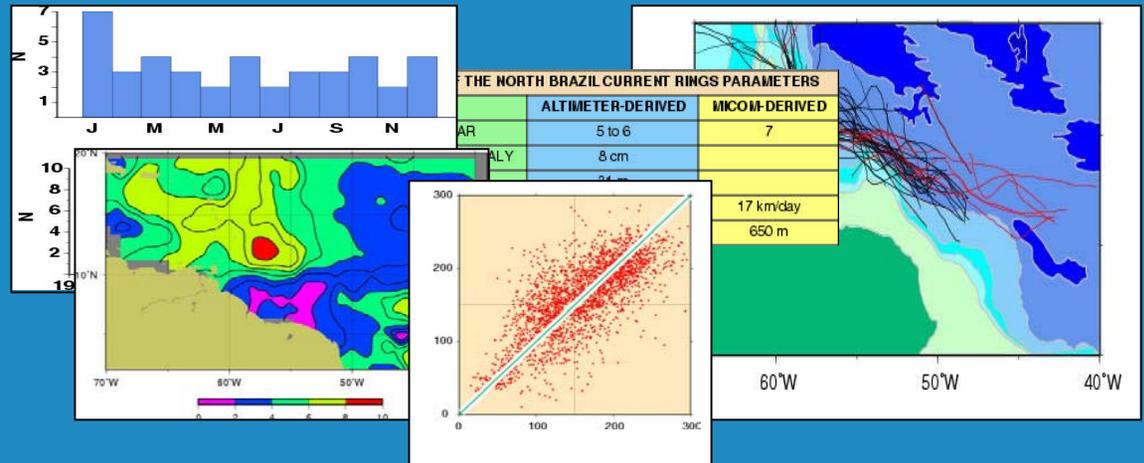
2L scheme



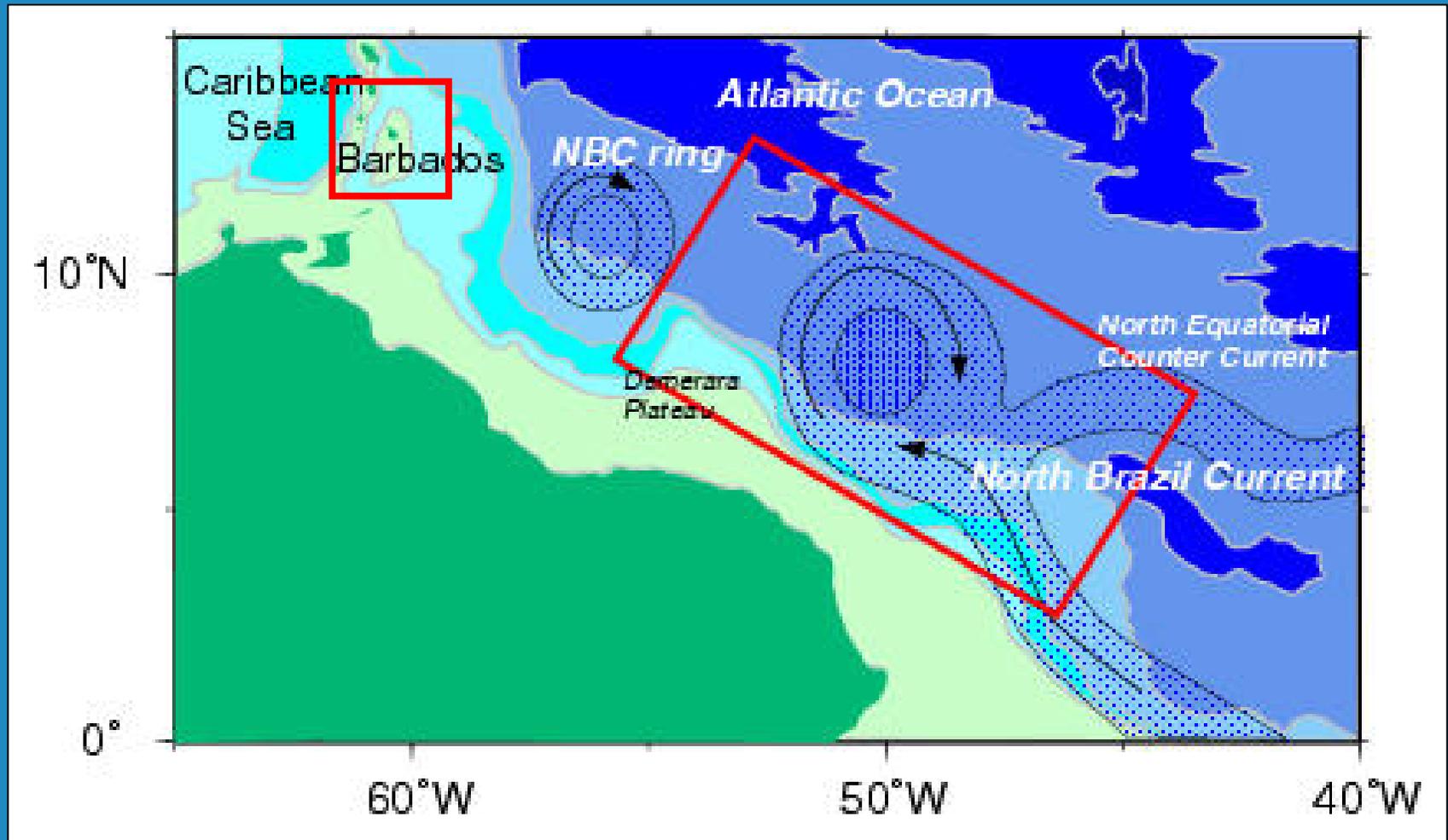
ULT Maps



Results



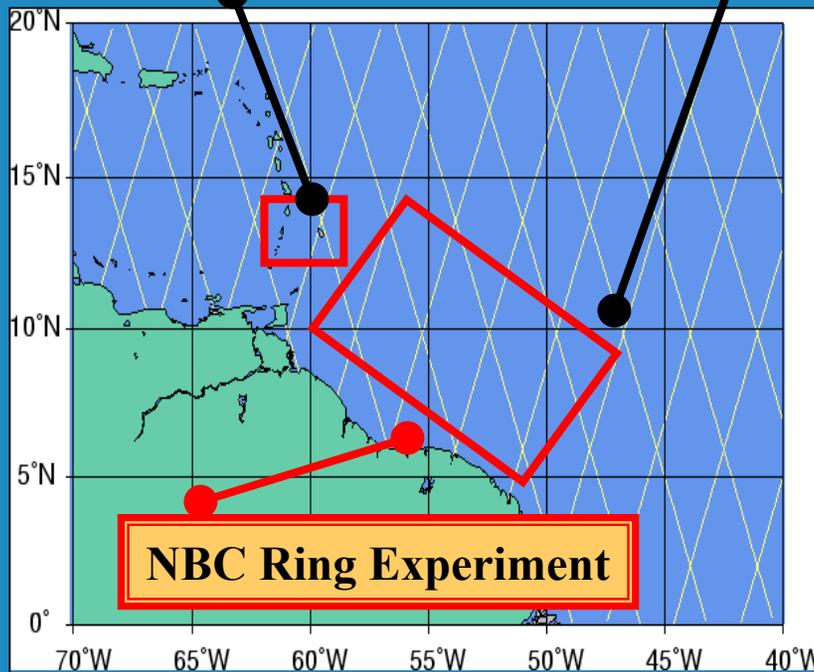
Motivation



Previous Altimetry Work

Kelly et al, *JGR*, 98, 1993;
and Cowen et al, 2003:

* Identification of low
salinity lenses off Barbados



Didden and Schott, *JGR*, 98, 1993.

* Shedding from Nov – Jan
* Account for 3 Sv of IH water mass
transfer

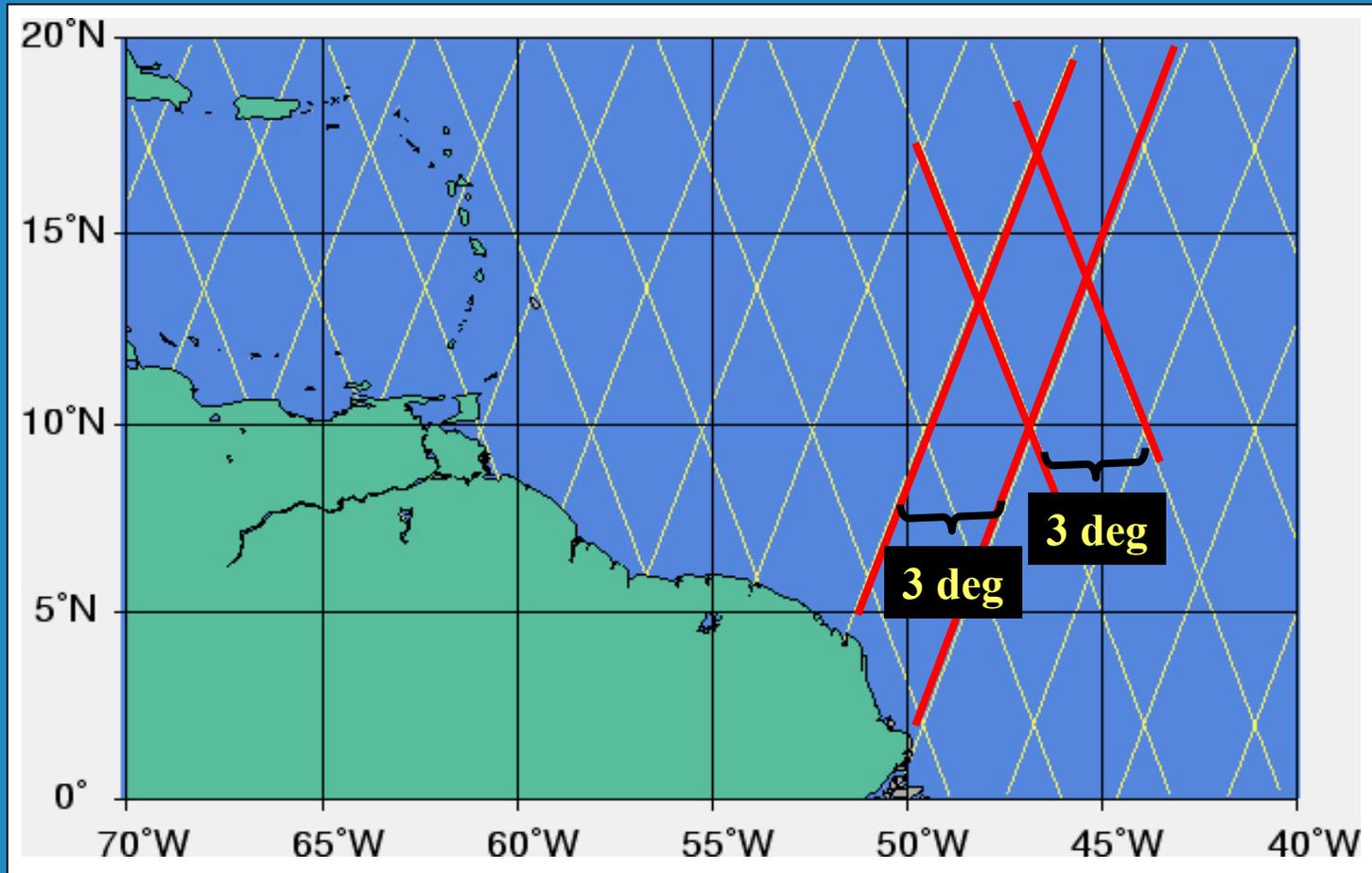
Fratantoni, Johns and Townsend,
JGR, 100, 1995.

* 2 to 3 rings shed per year
* 1 Sv transported per ring
* 20% total meridional heat transport

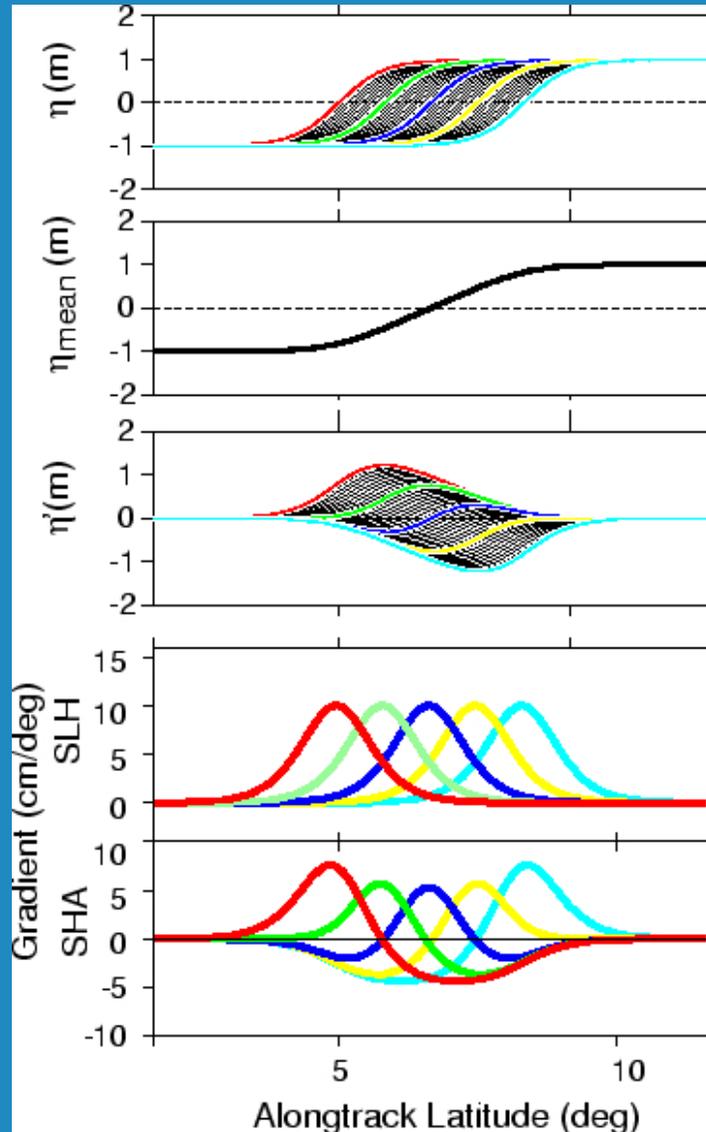
Goni and Johns, *GRL*, 28, 2001.

* NBC rings, NBC eddies, eddies
* 5 rings shed per year
* weak seasonality
* (may) transport more SA water
than previously thought.

TOPEX/Poseidon Altimeter Groundtracks



Altimetry and sea height anomalies



Sea height

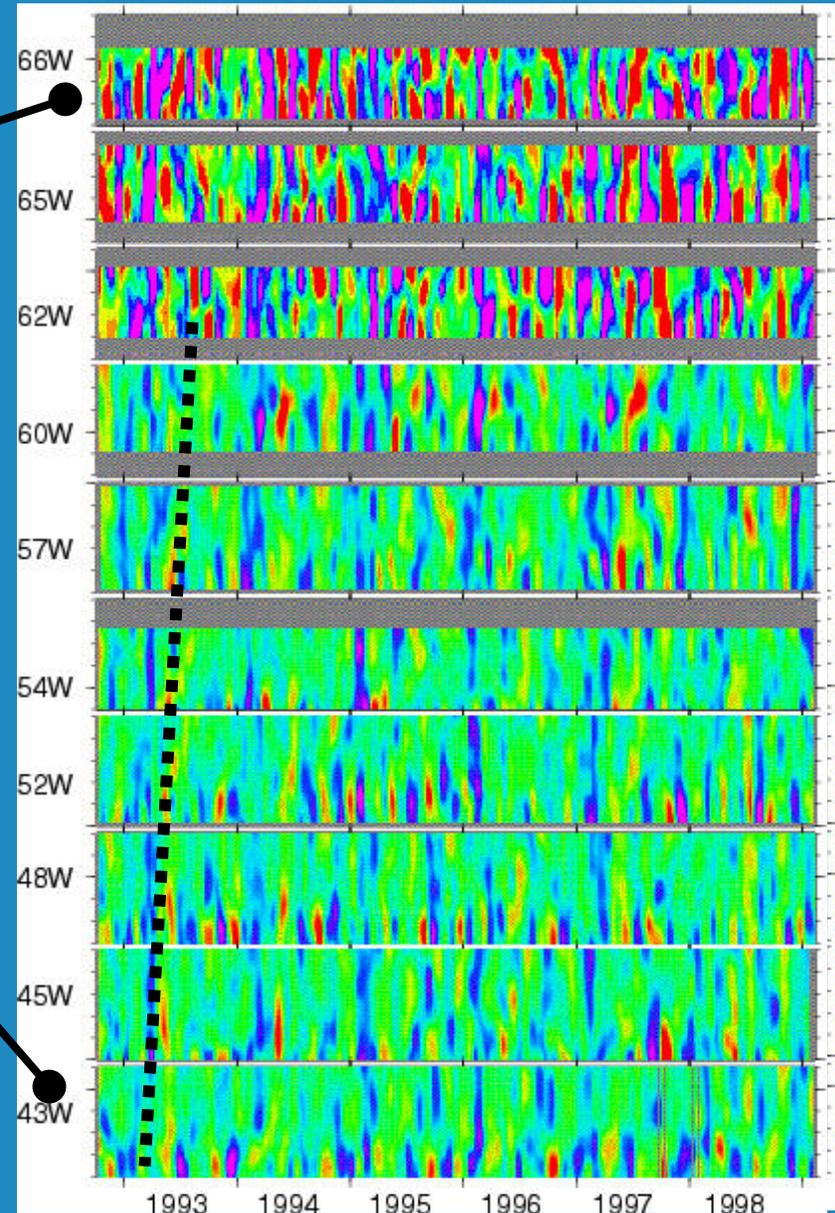
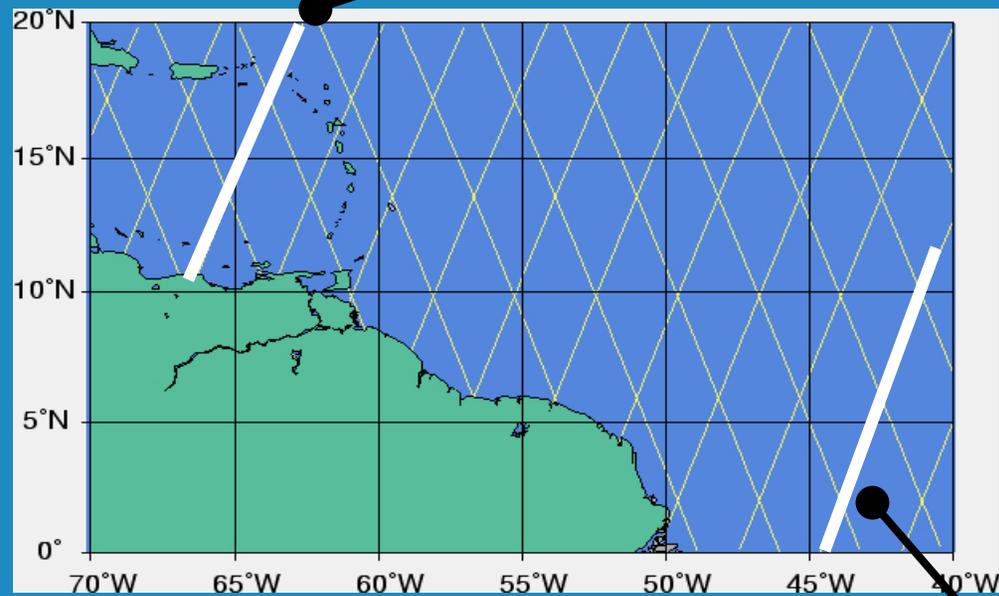
Mean sea height

Sea height anomalies

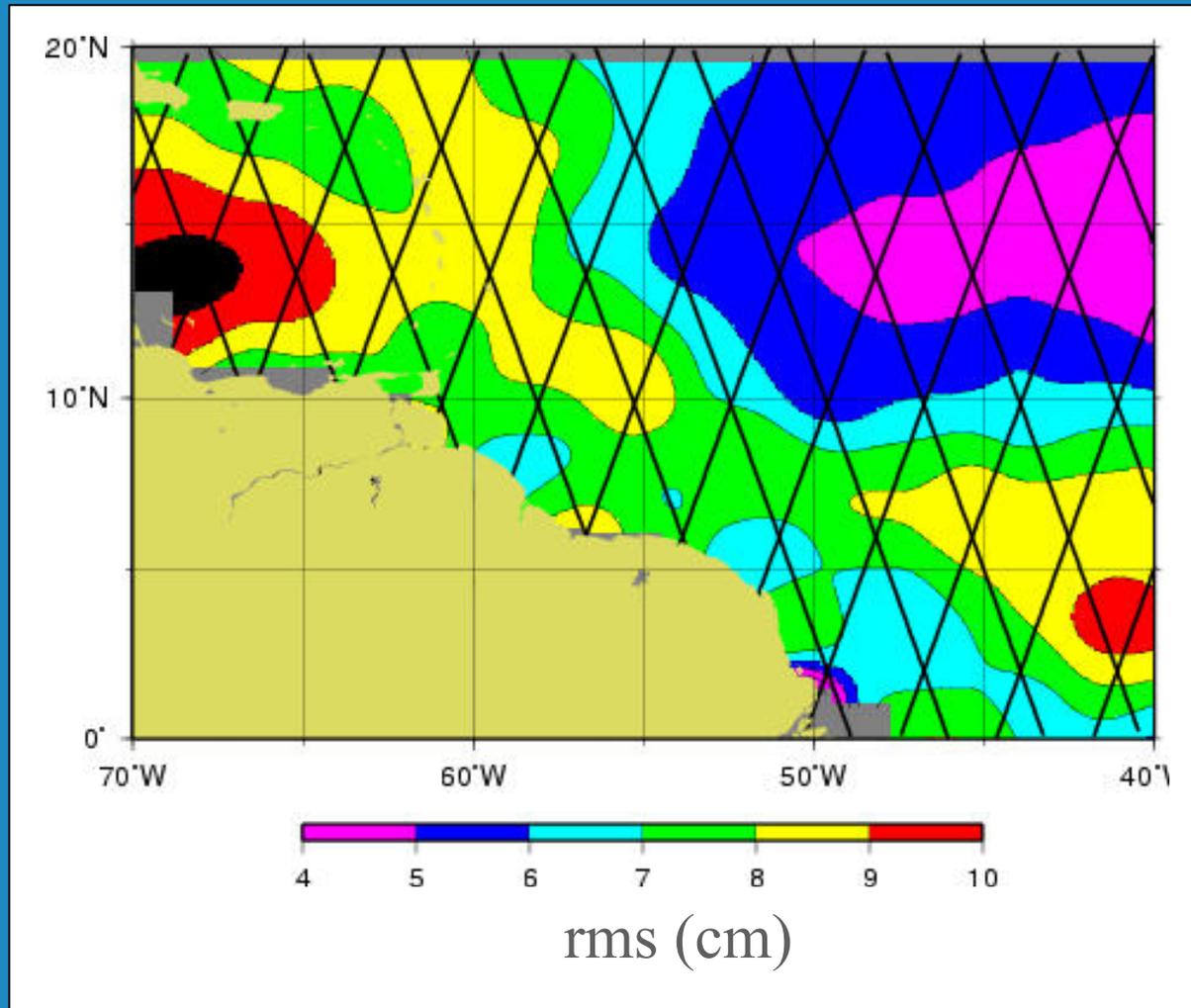
Gradient Sea height

Gradient SHA

Sea Height Anomalies and Sea Height Residues

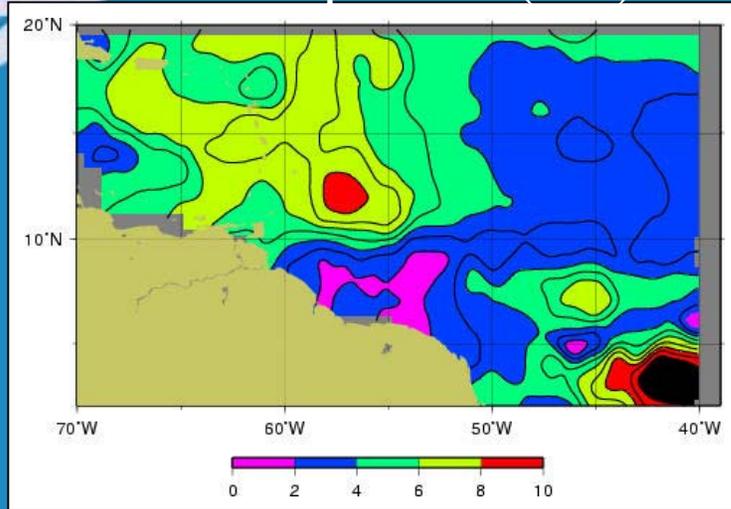


Sea height variability

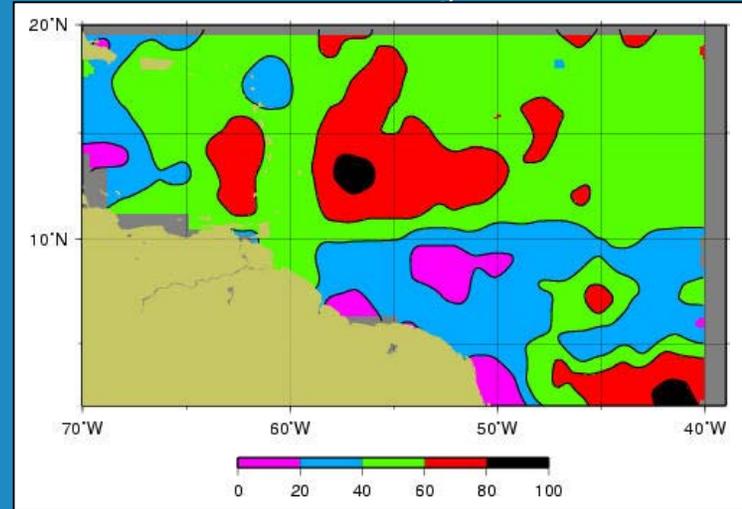


Annual and semiannual components

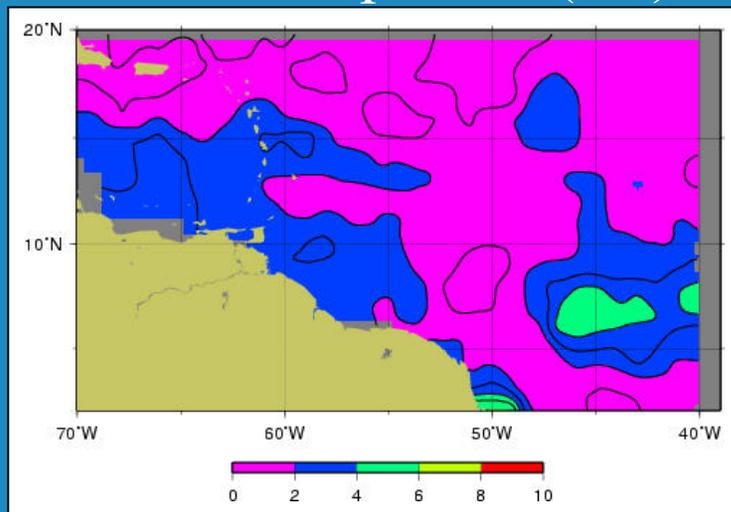
AC Amplitude (cm)



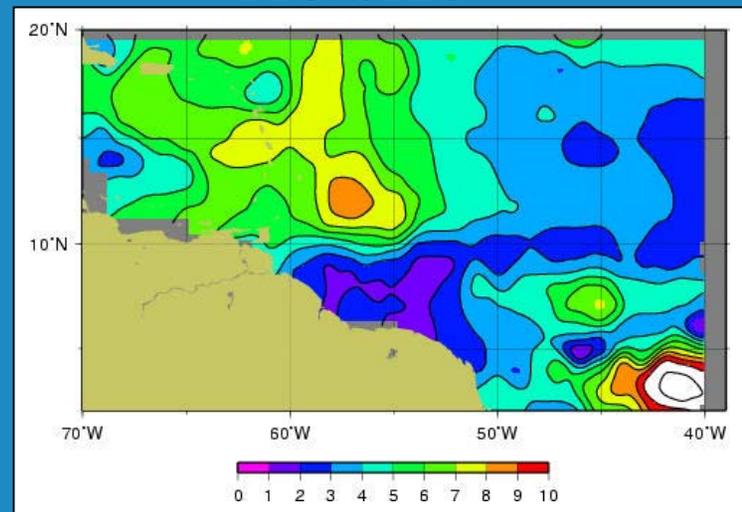
% Variability AC



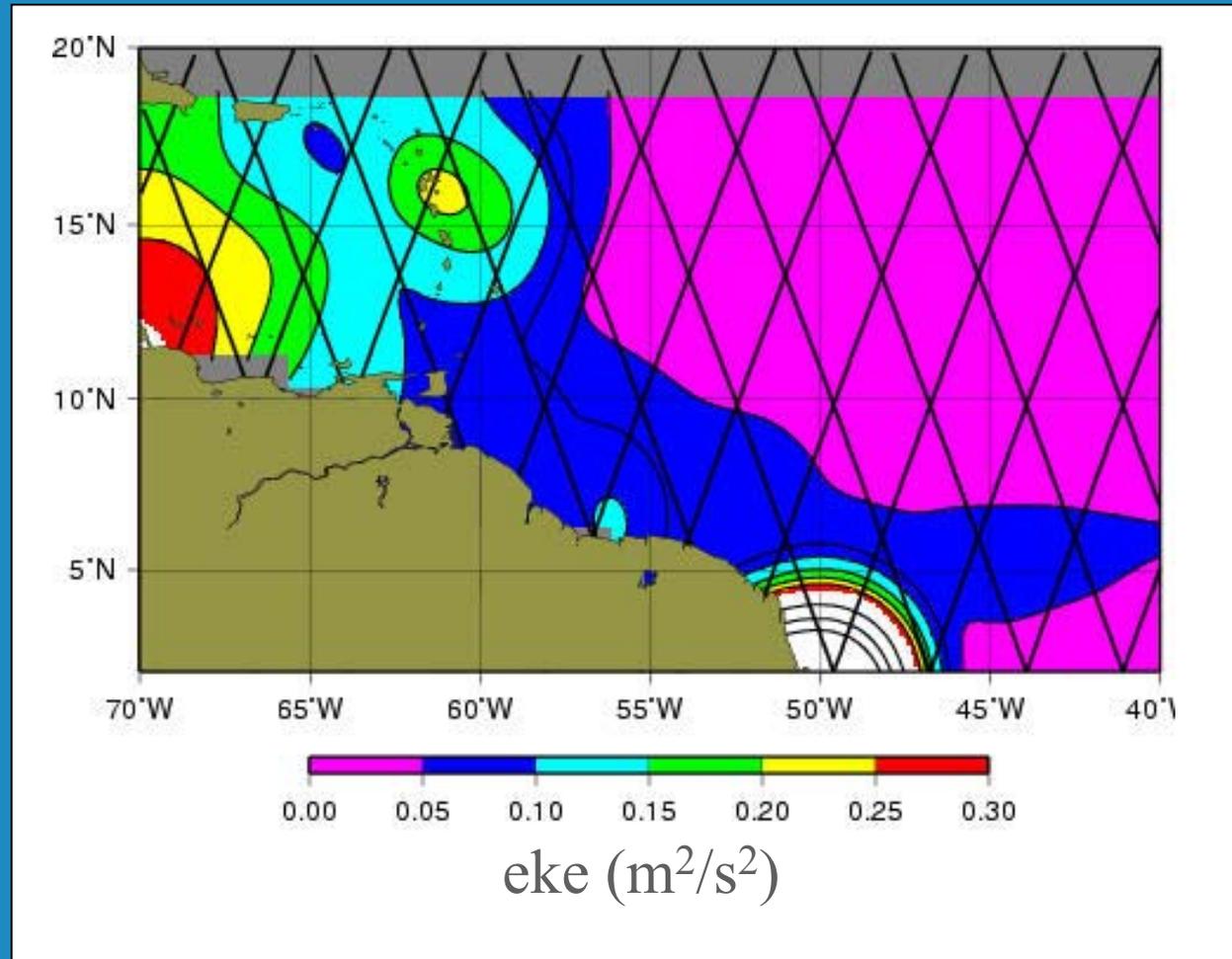
SAC Amplitude (cm)



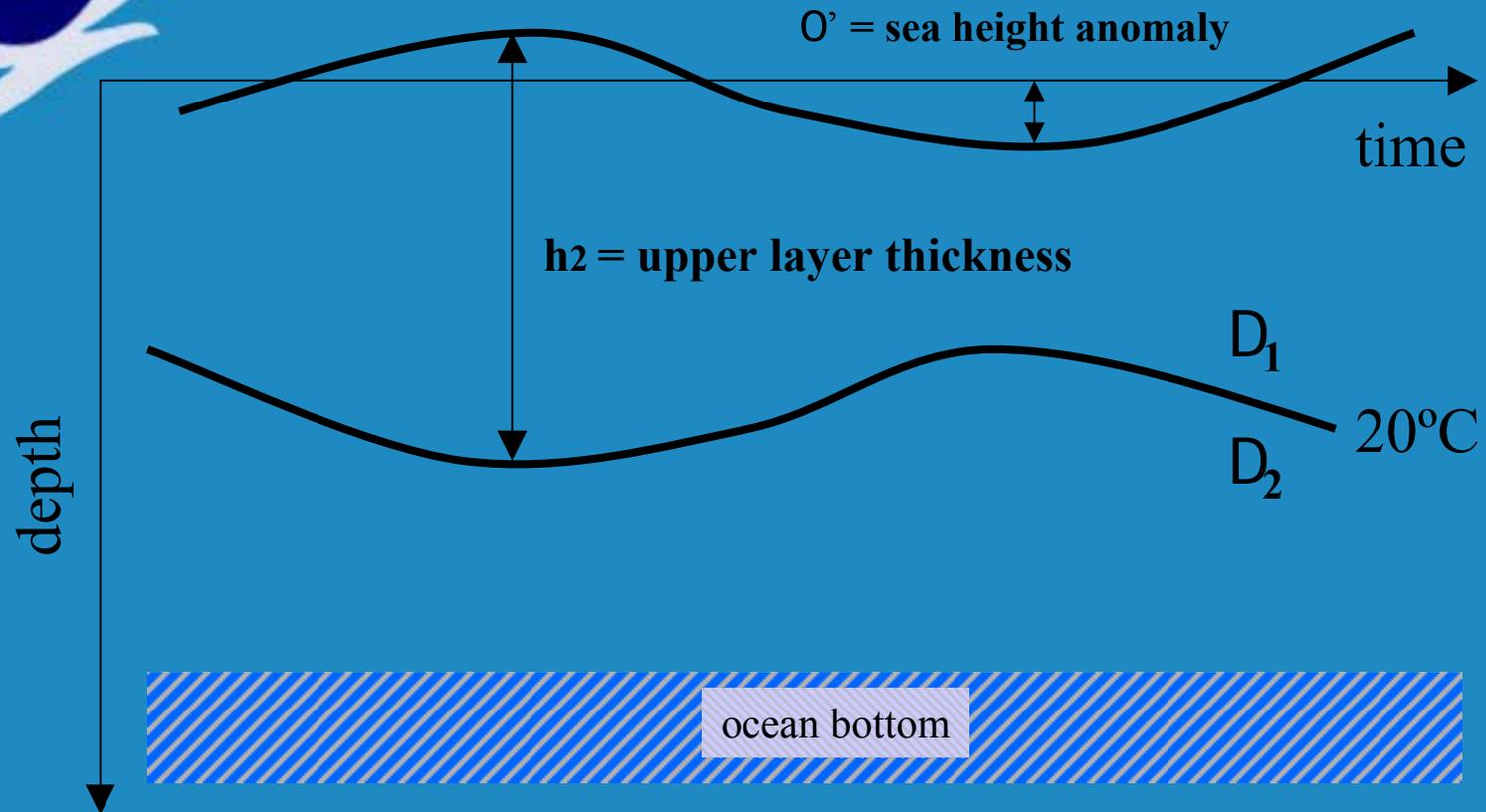
AC/SAC



Eddy kinetic energy



Two-Layer Reduced Gravity Approximation



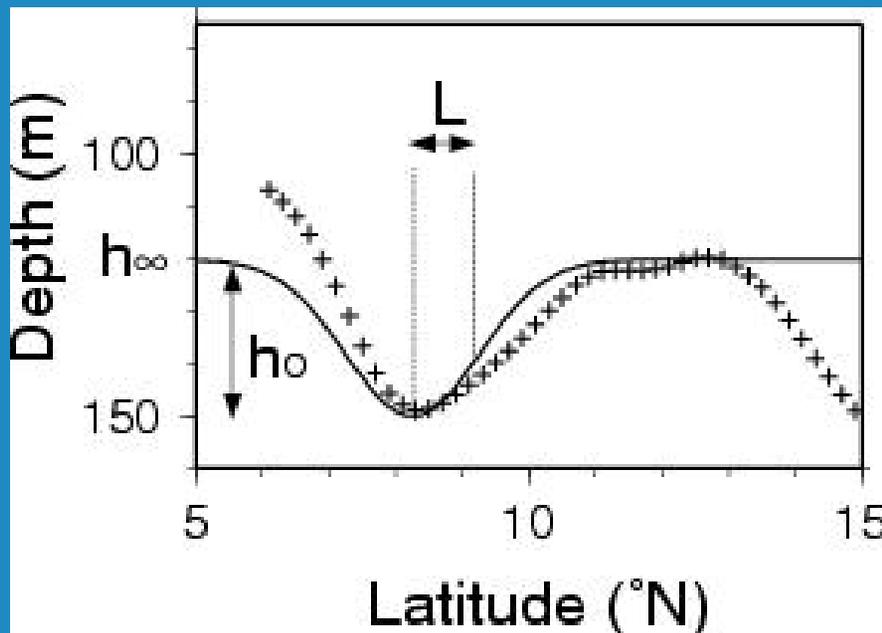
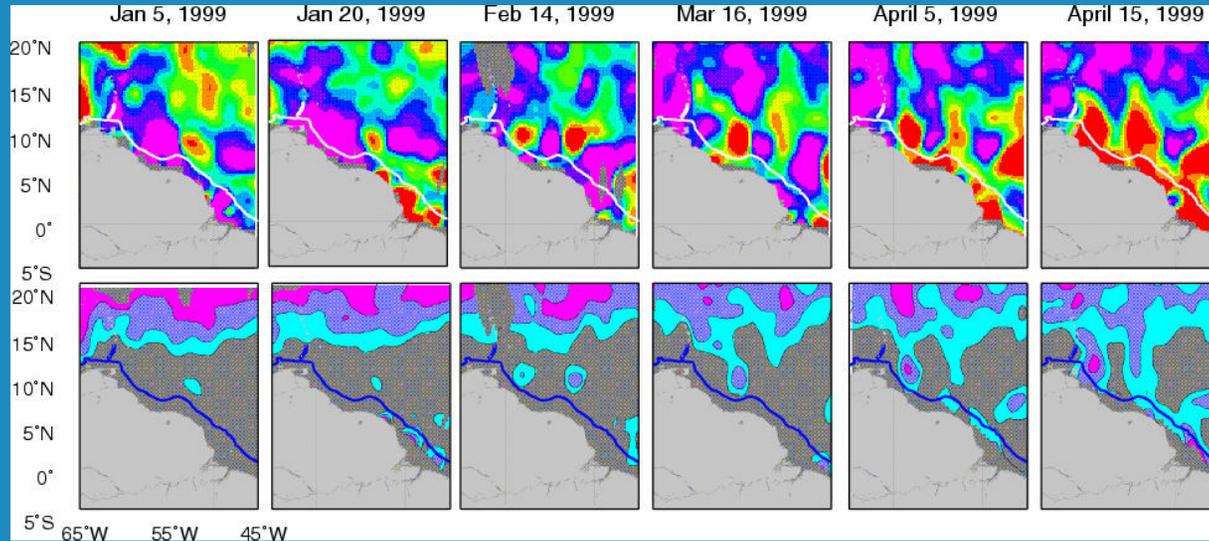
$$h_2(x,y,t) = \bar{h}_2(x,y) + [1/\bar{\rho}(x,y)] O'(x,y,t) + B'(x,y)$$

$$\bar{\rho}(x,y) = [D_2(x,y) - D_1(x,y)] / D_2(x,y)$$

$$\text{Baroclinic Transport} = [g'(x,y)/2f(y)] * \Delta h^2_2(x,y,t)$$

$$g'(x,y) = \varepsilon(x,y) * g(x,y)$$

Ring parameters

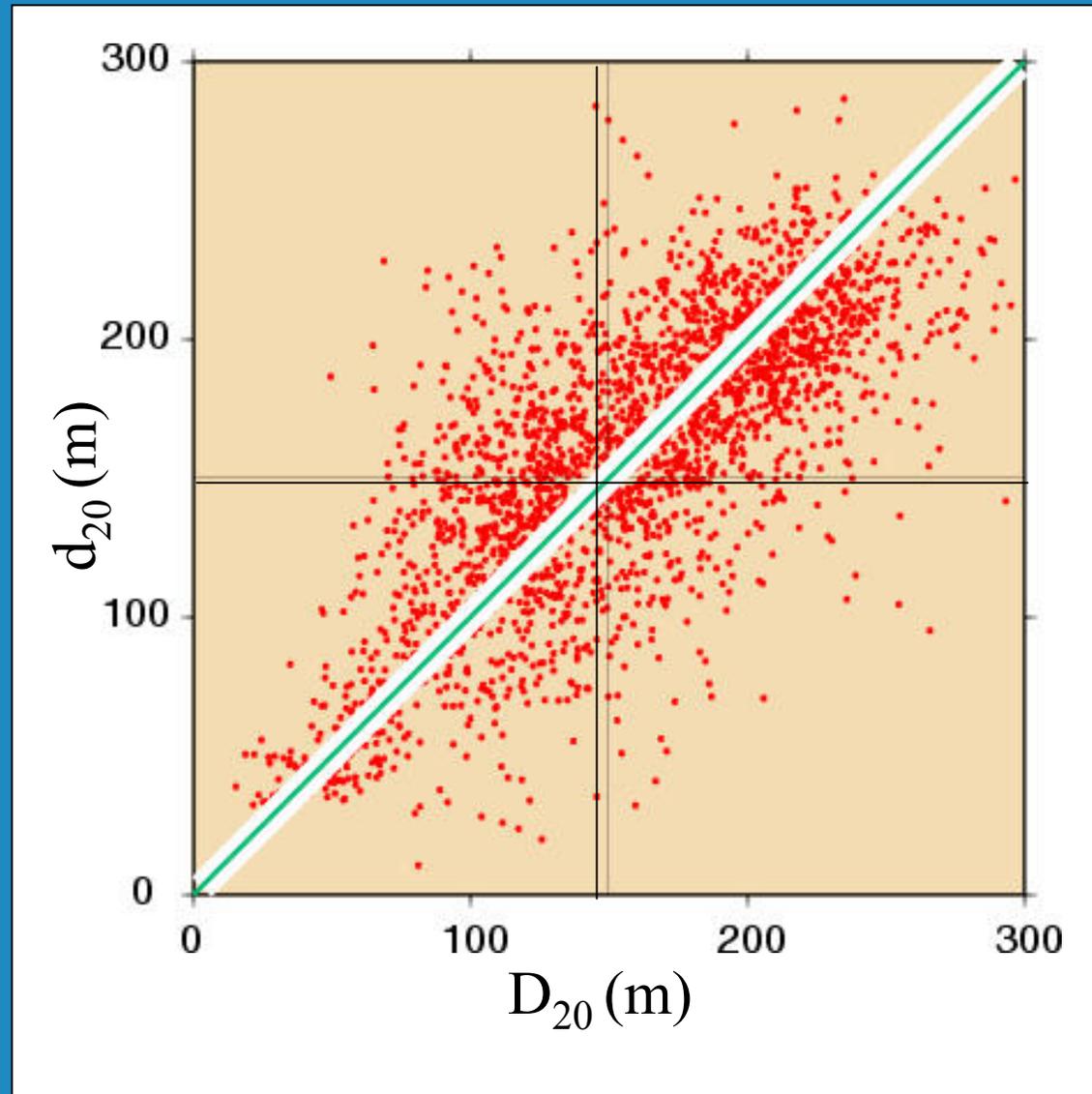


$$h_1(r) - h_\infty = h_0 e^{-r^2/2L^2}$$

$$L=110 \text{ km}$$

$$V=4.5 \times 10^{12} \text{ m}^3$$

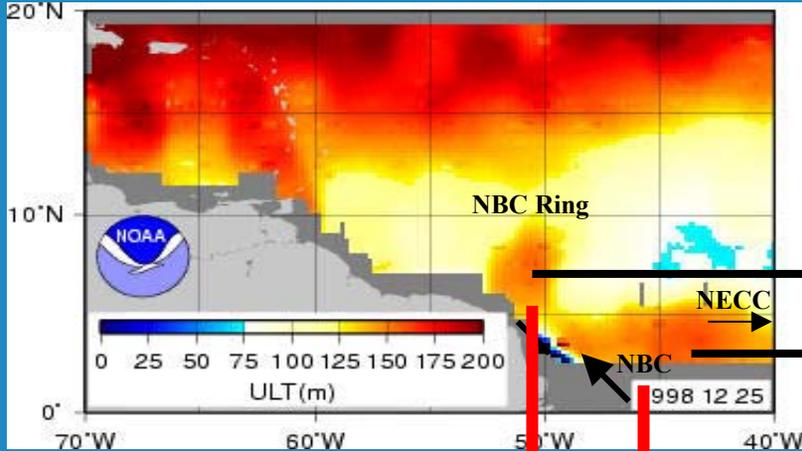
Comparison with XBT data



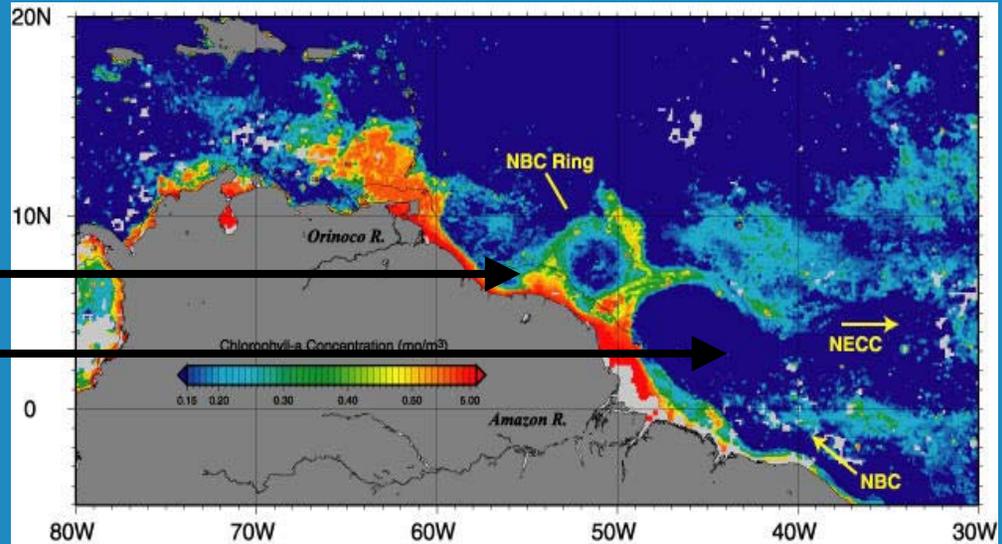
$n=121,989$
 $r=0.71$
 $\sigma_{D_{20}}=150\text{m}$
 $\sigma_{d_{20}}=140\text{m}$

Validation

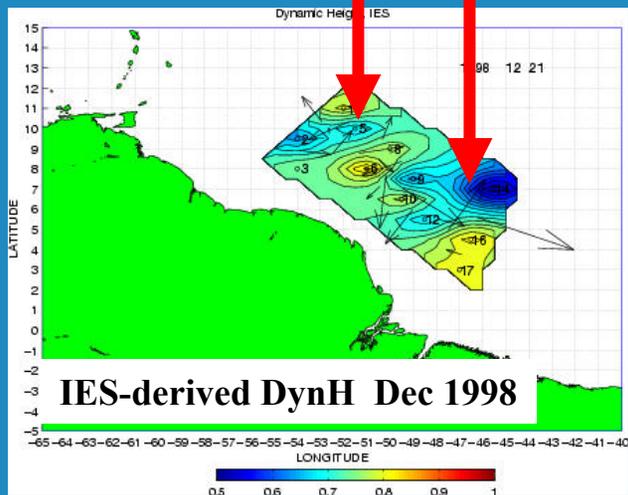
Altimeter-derived ULT December 1998



SeaWiFS chlorophyll-a composite December 1998

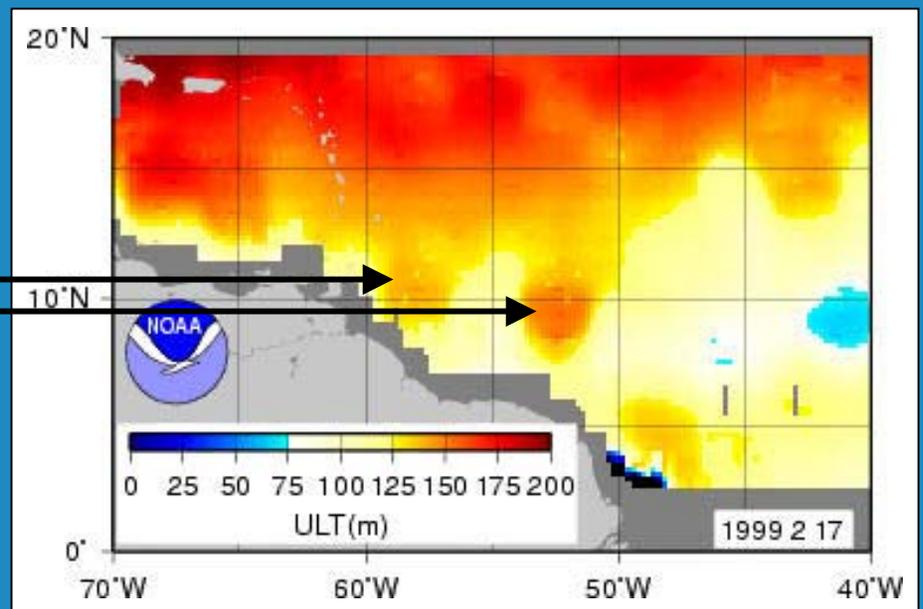
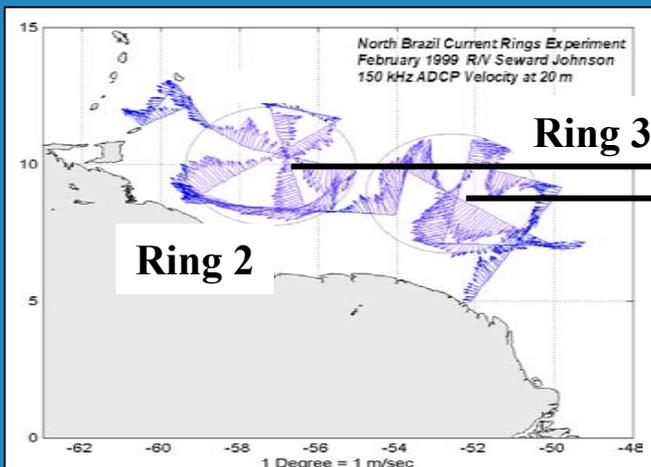
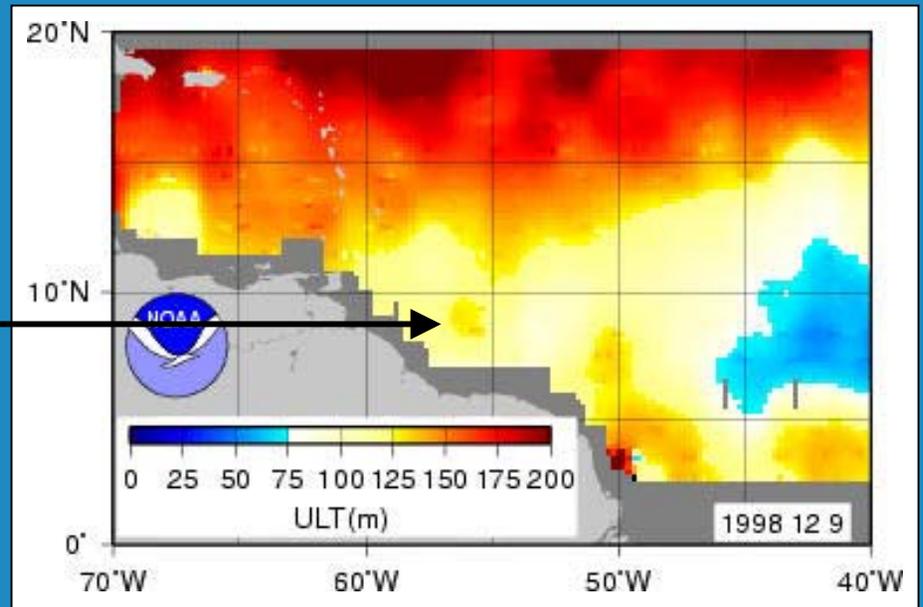
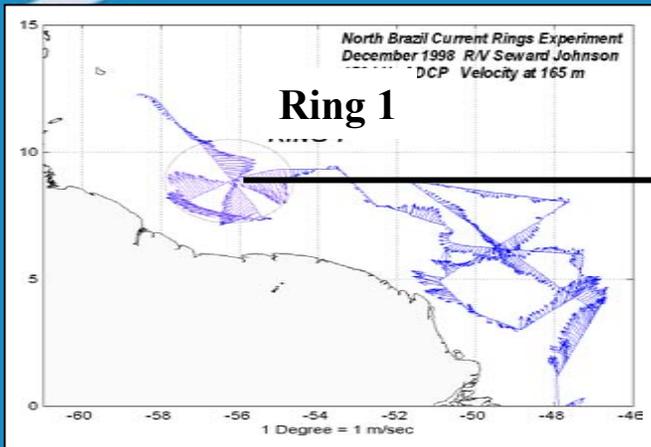


Courtesy of David Fratantoni

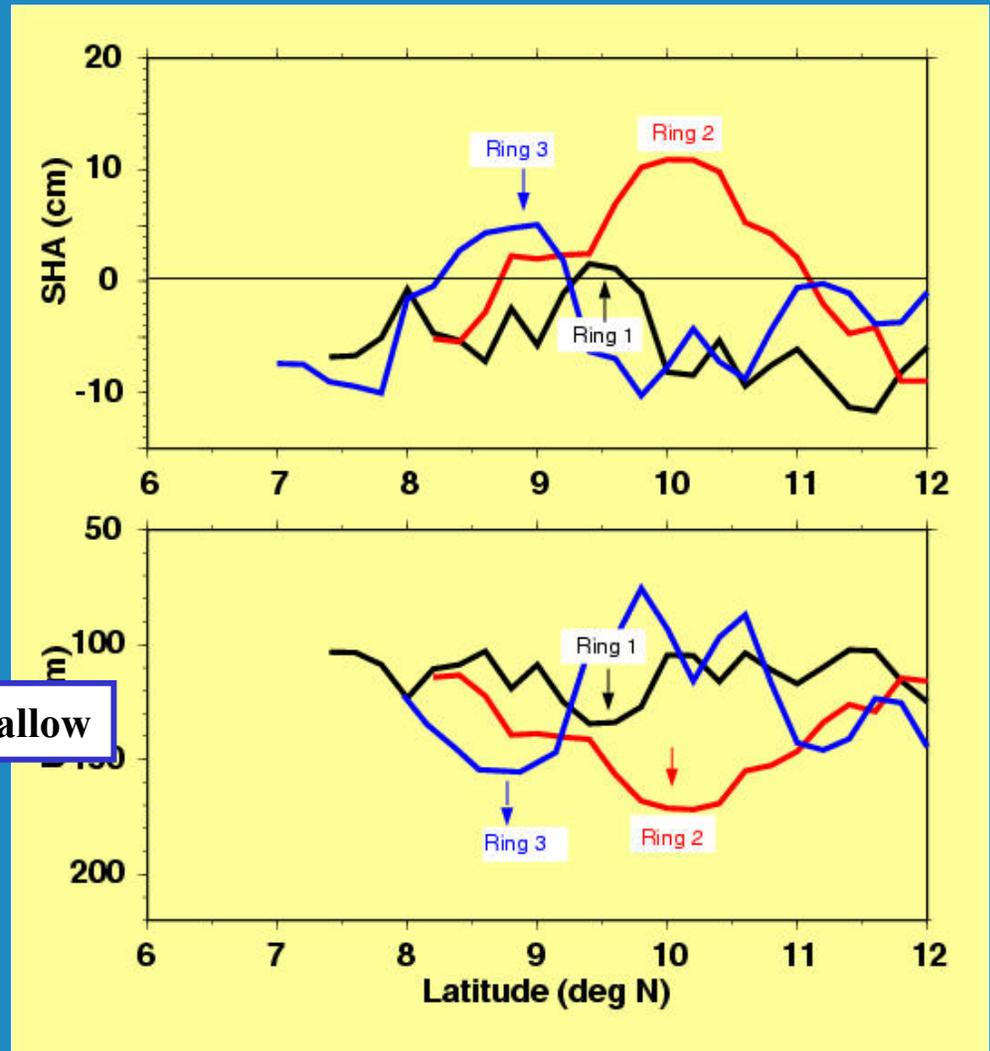
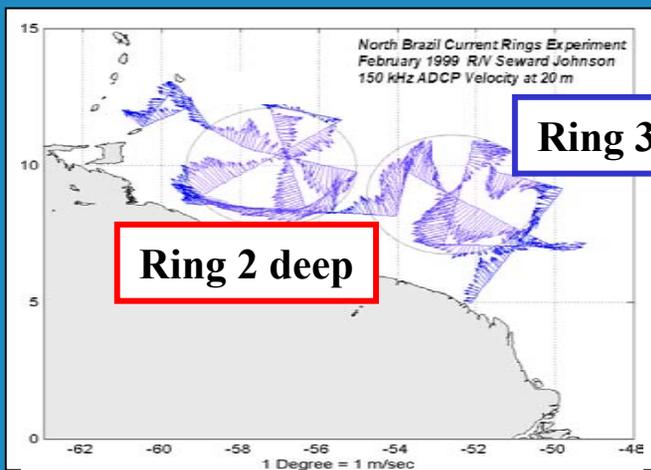
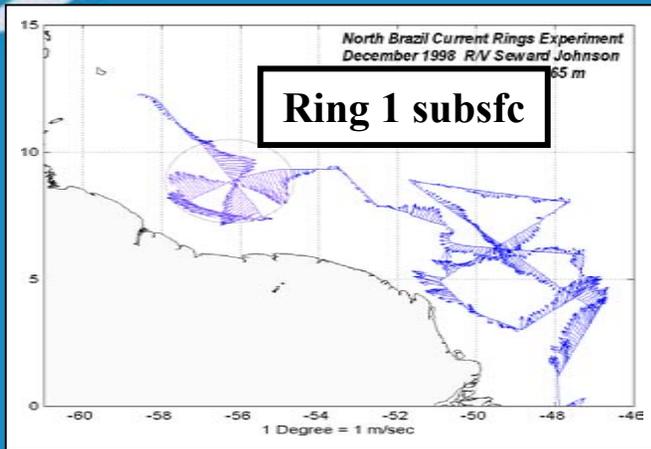


Courtesy of S. Garzoli and Q. Yao

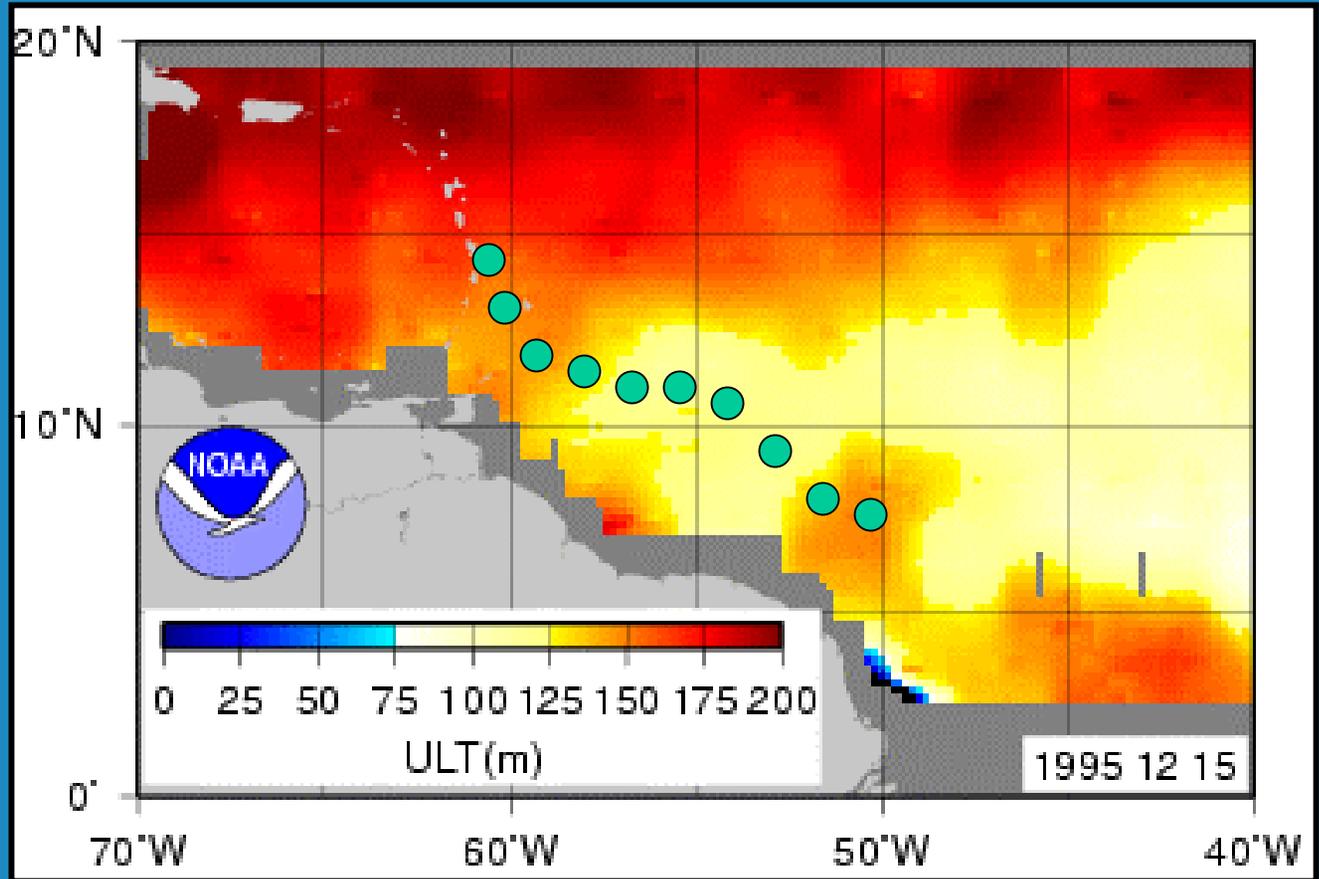
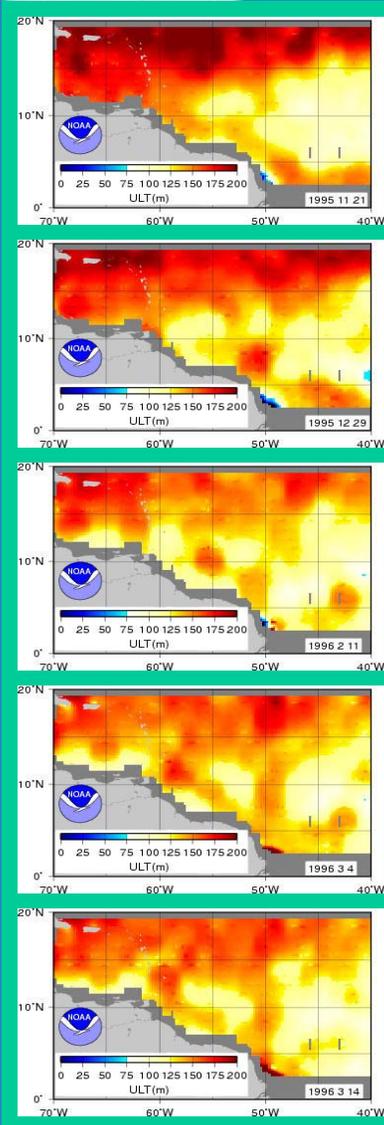
Validation



Validation

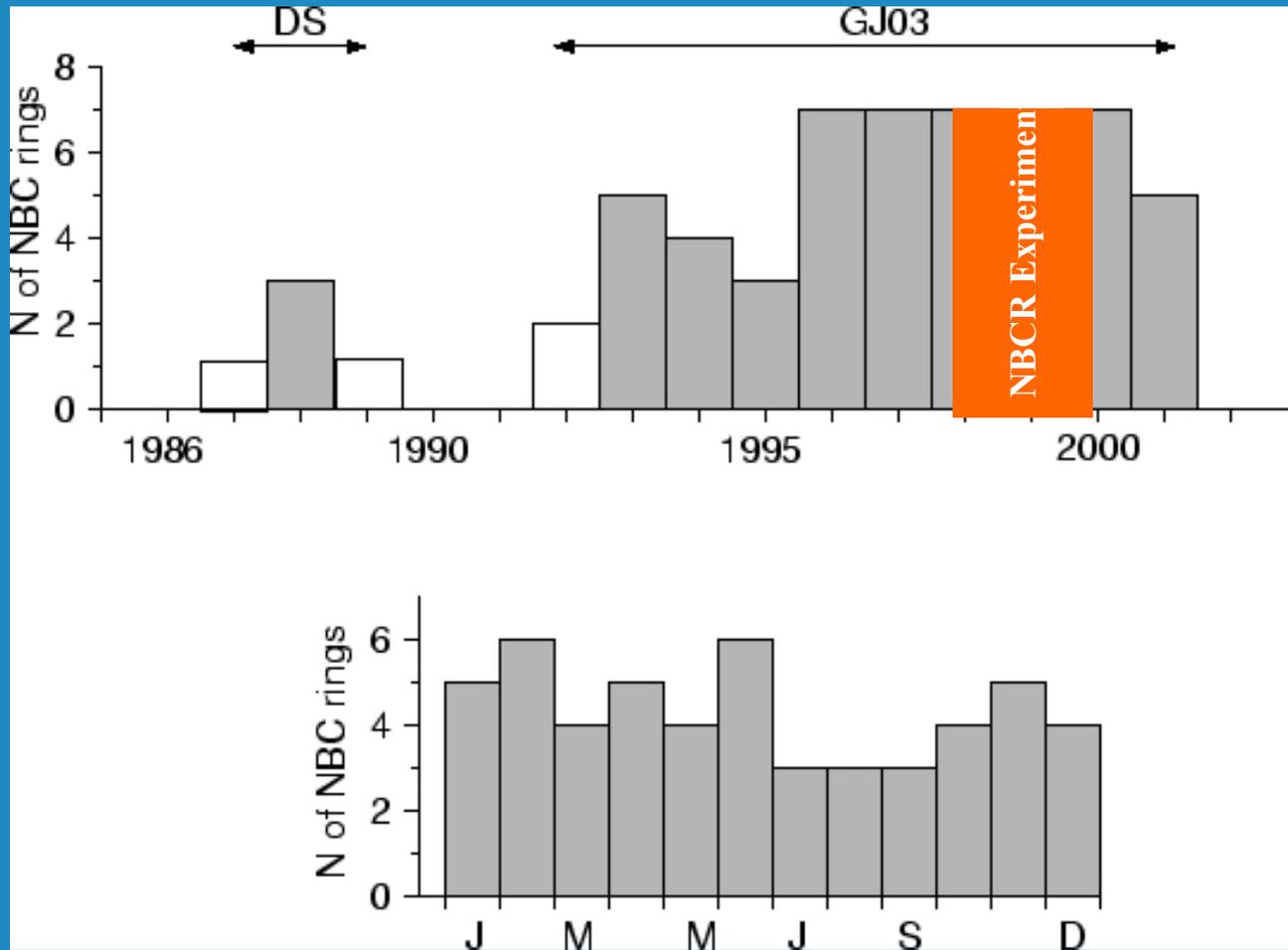


Tracking NBC Rings with ULT maps

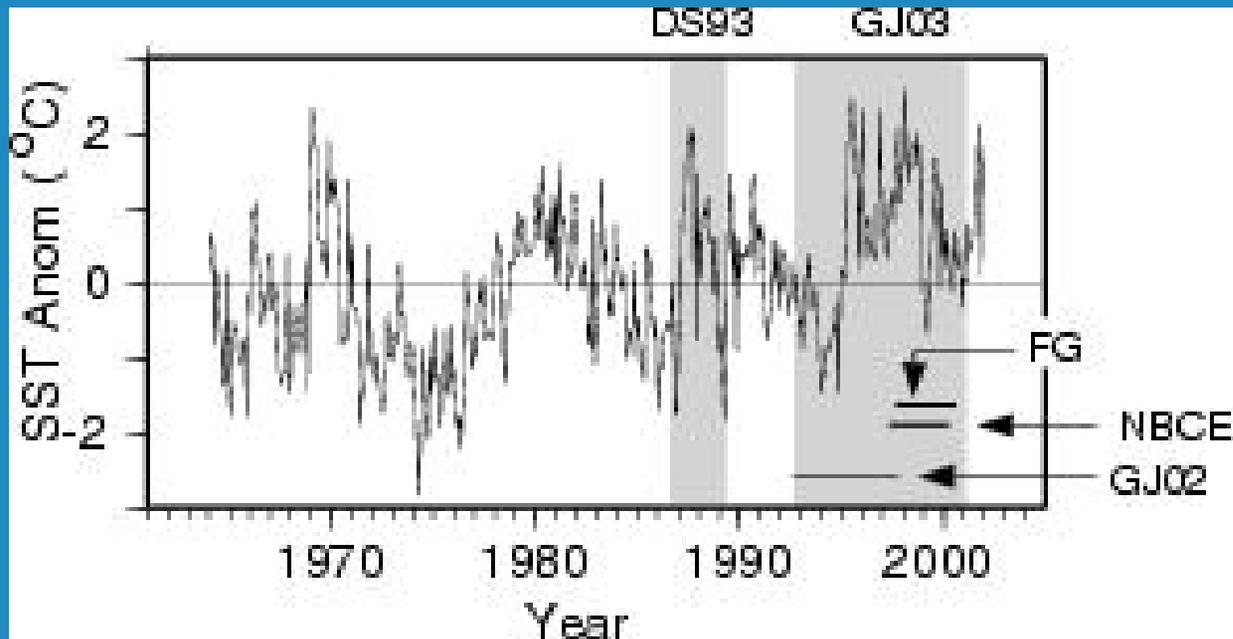


Shedding: Dec 1995/Jan 1996
Velocity: 14 km/day
Length scale: 107 km

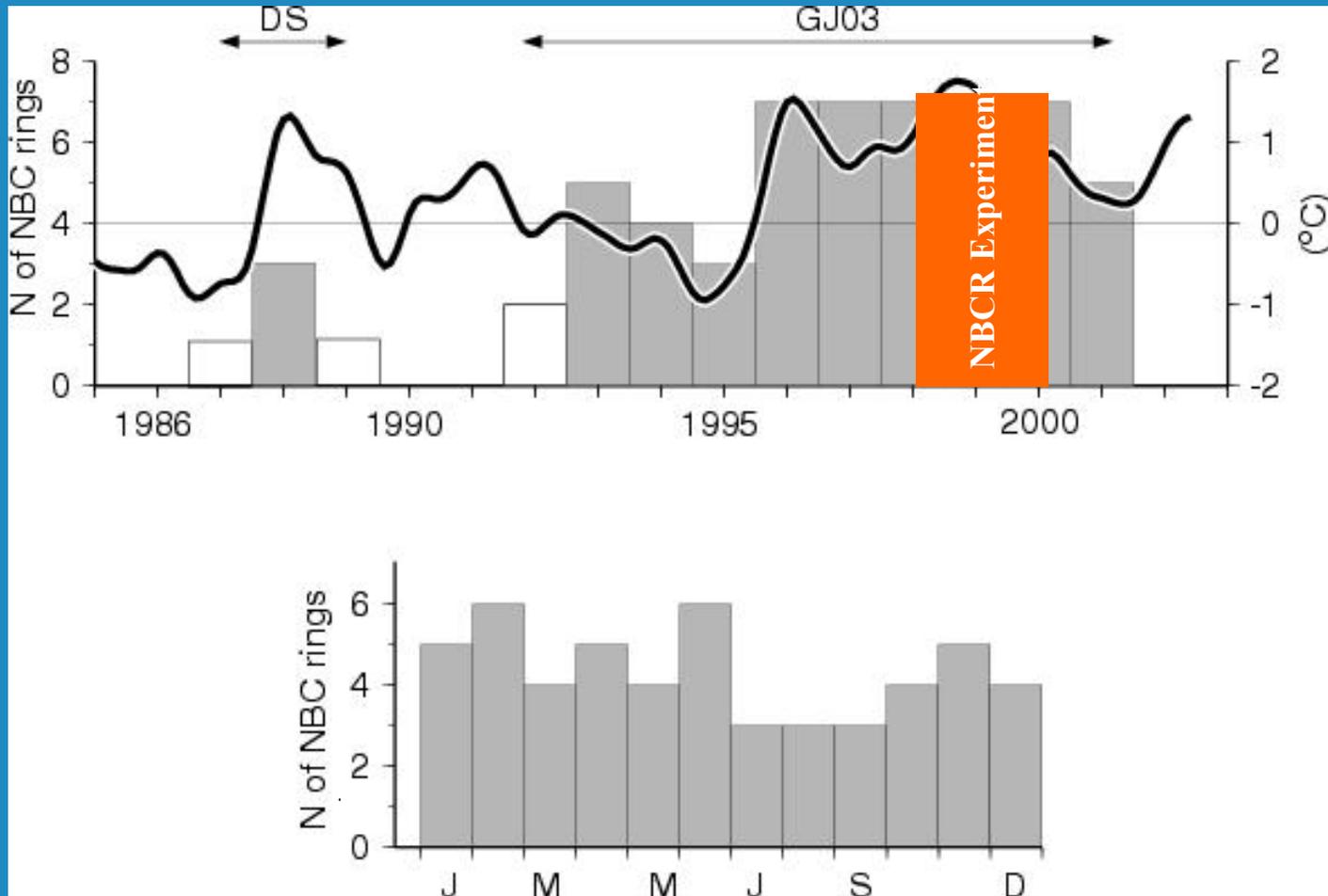
Ring Shedding



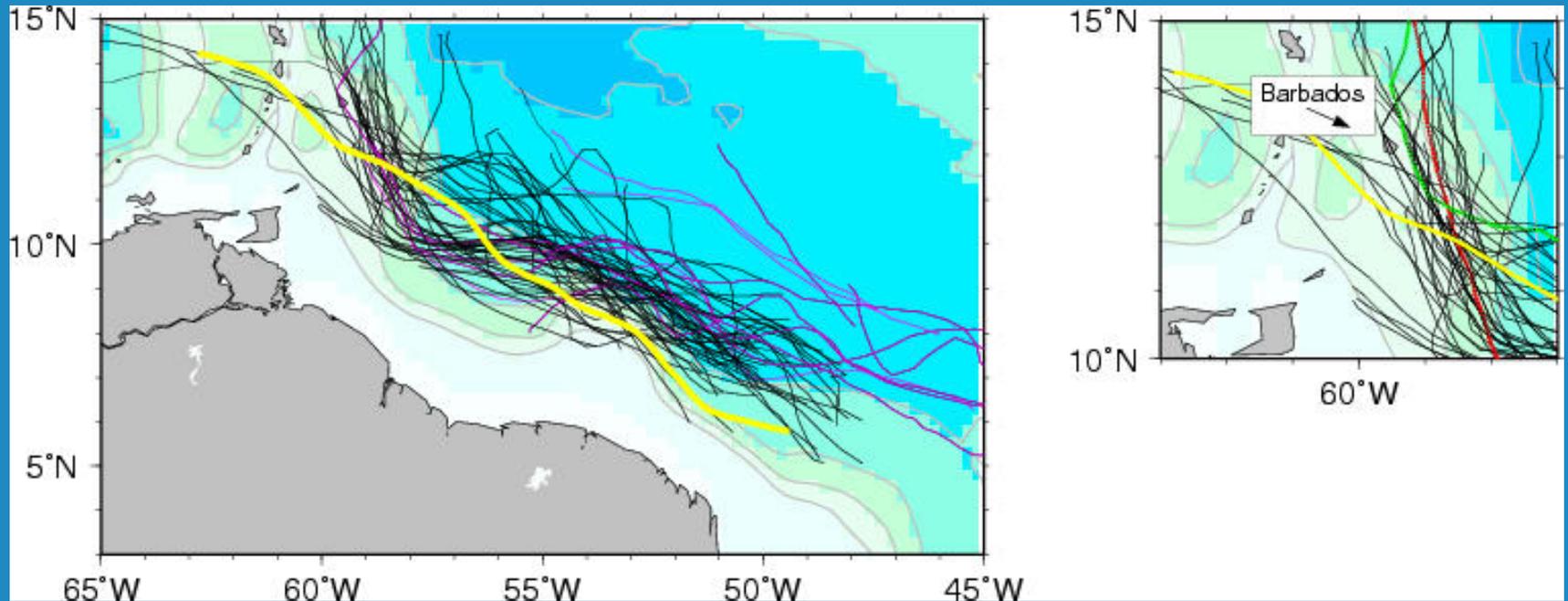
Tropical North Atlantic Index



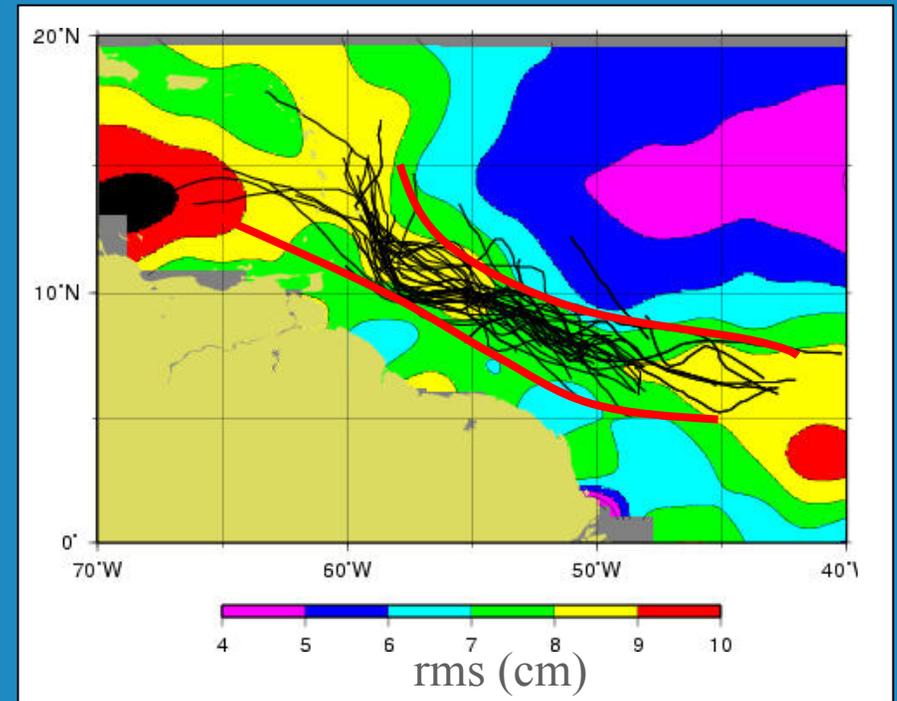
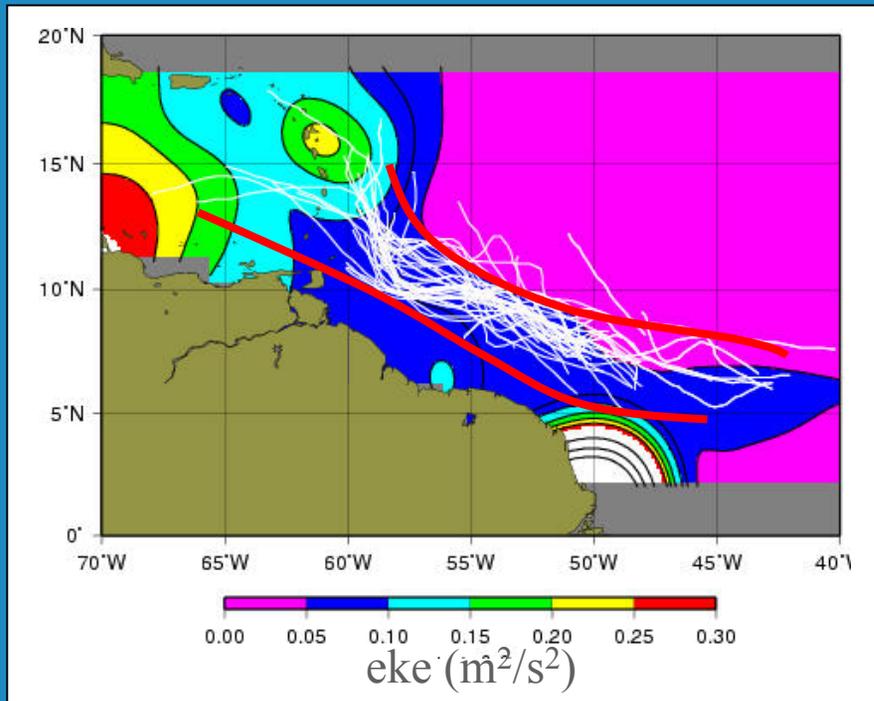
Ring Shedding



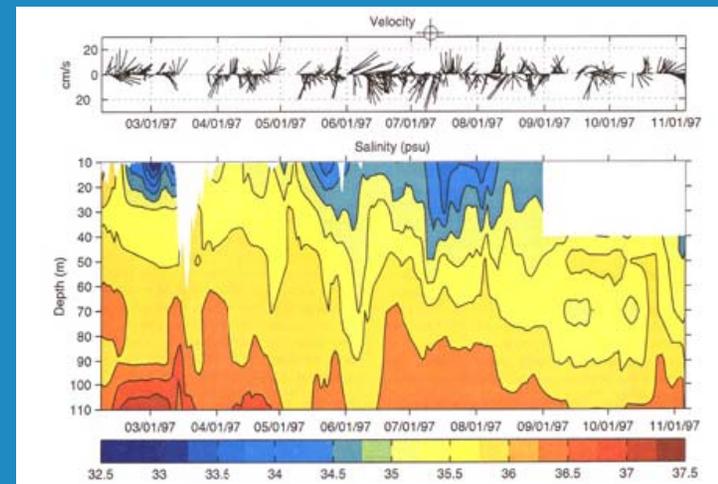
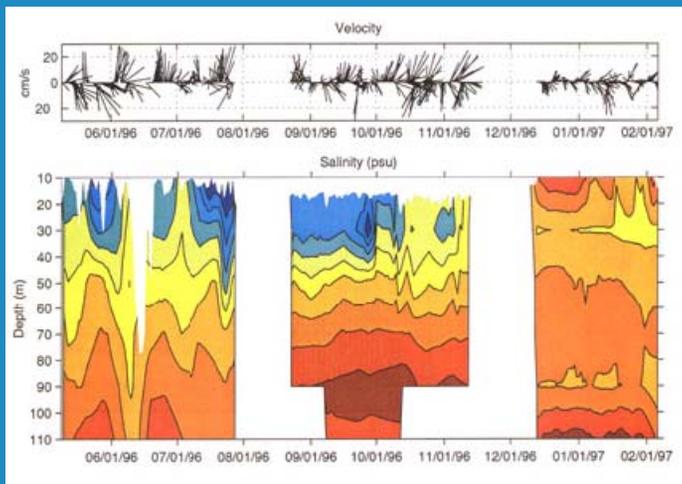
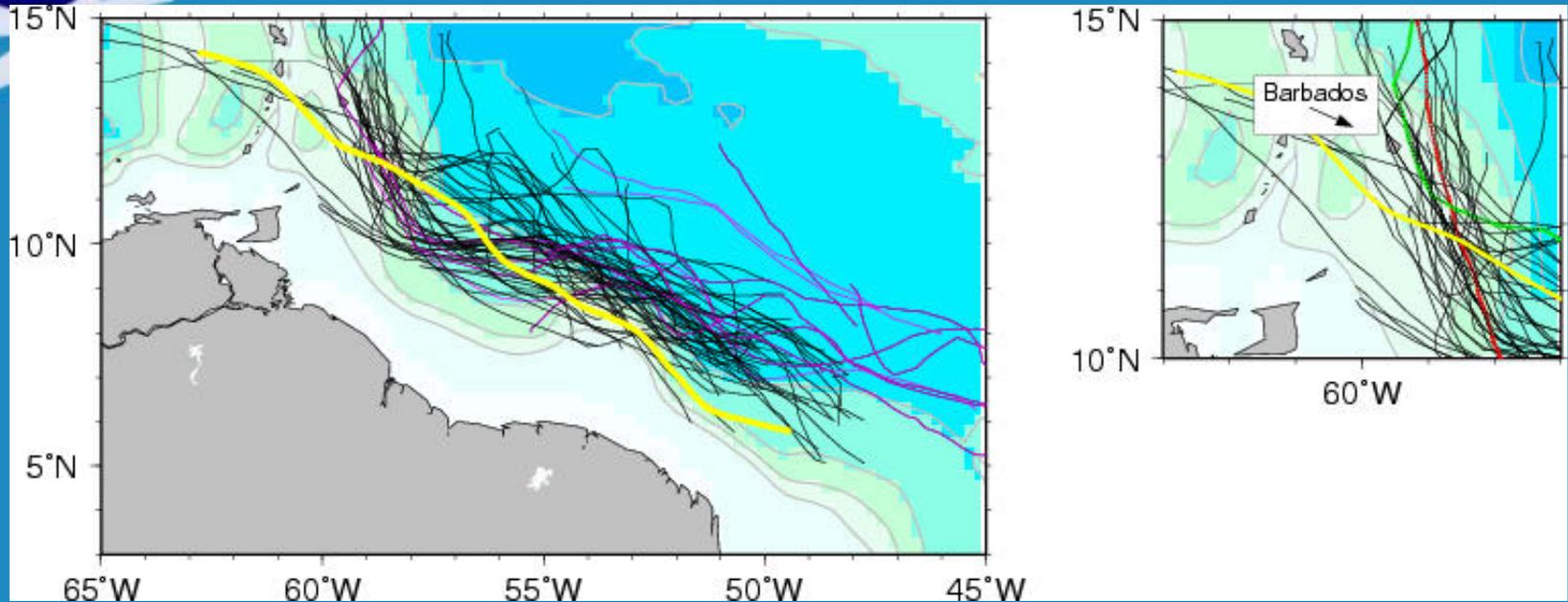
Altimetry-derived NBC Ring and eddy trajectories



Altimetry-derived NBC trajectories



Altimetry-derived NBC Ring and eddy trajectories



From Kelly et al, 2000

NBC Rings

ESTIMATES OF NORTH BRAZIL CURRENT RINGS PARAMETERS		
PARAMETER	ALTIM-DERIVED	MICOM-DERIVED
RINGS PER YEAR	5	7
SEA HEIGHT ANOMALY	8 cm	
ULT ANOMALY	40 m	
TRANSLATION SPEED	15 km/day	17 km/day
DEPTH MAX VELOC		650

MICOM results provided by Z. Garraffo

MAJOR WARM CORE RINGS IN THE OCEANS					
LOCATION	g' (m/s ² s)	L (km)	APE (x10E15 J)	H1 (m)	Reference
Brazil	0.014	55	2.3	260	Lentini (per. com)
Brazil	0.012	60	5.6	400	Gordon (1989)
Gulf Stream	0.011	50	4.2	500	Olson et al (1985)
Gulf Stream		79	9.1		Joyce (1984)
Agulhas	0.018	123	41	500	Olson and Evans (1986)
Agulhas	0.013	80	11.3	690	Dumcombe Rae et al (1996)
Agulhas	0.011	26	24	600	Goni et al (1997)
Kuroshio		90	22	500	Tomosada (1978)
NBC	0.012	125	9.2	500	Fratantoni et al (1995)
NBC	0.010	95		175	THIS STUDY
EA		85	14		Nilson and Cresswell (1981)
G of M		149	10		Elliot (1982)
EP			4		Hansen and Maul (1991)

Adapted from Lentini et al, 2002

Summary

- Use of SHA within a two-layer reduced gravity scheme
- More rings shed per year than previously reported
- Large interannual variability, linked to TNA index
- No strong seasonal shedding as previously thought
- Translation speed averages 15 km/day
- One in four/five rings enters the Caribbean Sea
- Results supported by other methodologies
- These results help understand observations done during NBC Ring Experiment

Future Work: Combination of altimetry with hydrographic Data (GEMS?), estimate of ring volume, comparison with different models, eddies, splitting of rings, Caribbean Sea.