Development of a physical-ecosystem (ROMS) model for the

Mesoamerican Barrier Reef System (preliminary results)

ROMS EM, GRENOBLE OCTOBER 6-8

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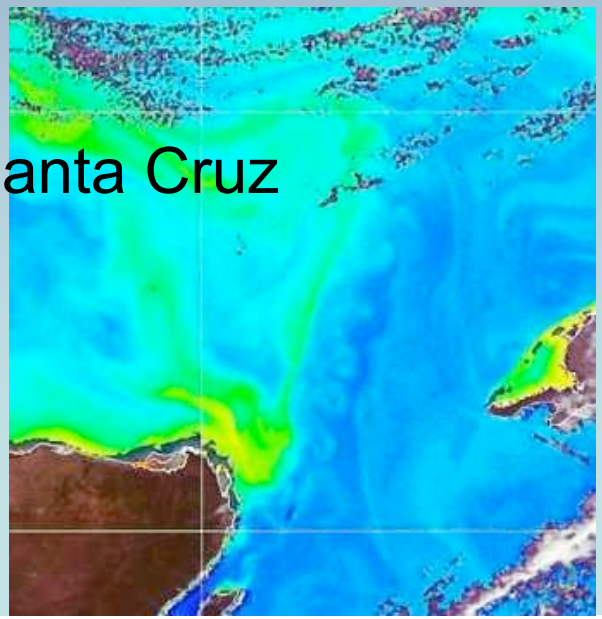
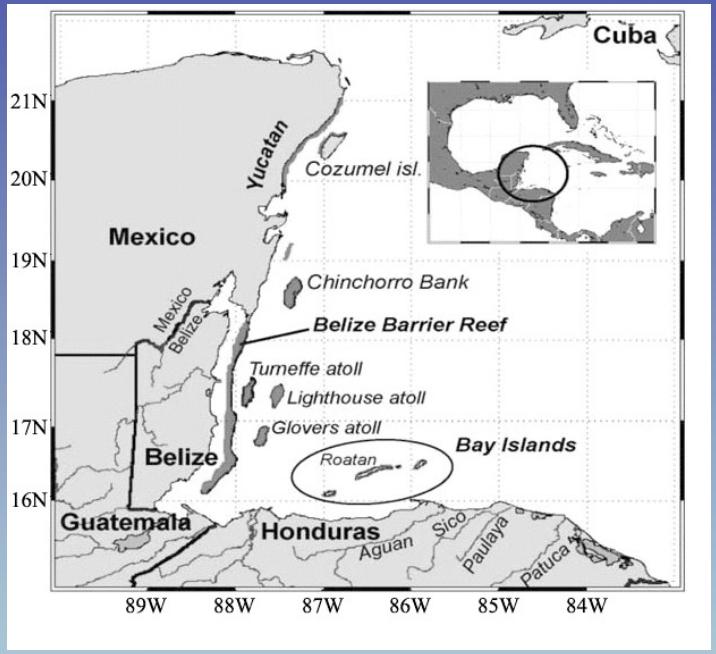
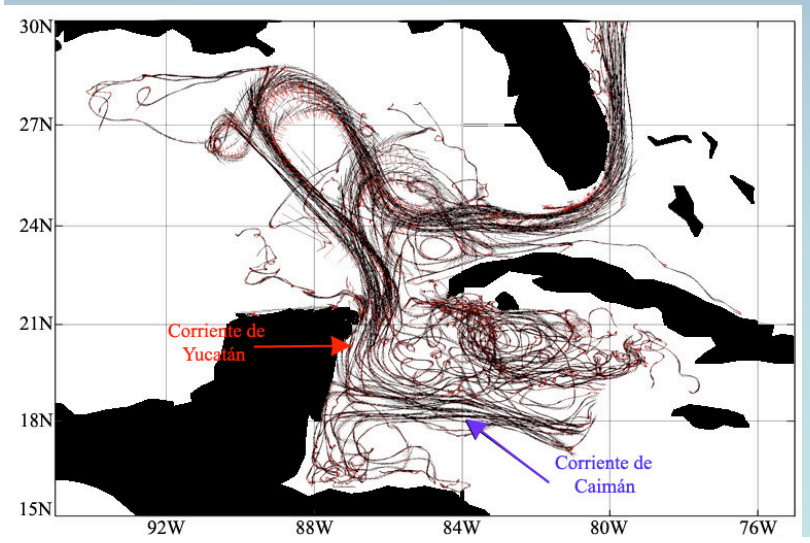
UCMEXUS Project



THE MBRS IS THE SECOND LARGEST BARRIER REEF SYSTEM IN THE WORLD





- 1000 X 1000 km^2

Strong Currents and Eddies

- Biodiversity

THE OBSERVATIONS:

MORE THAN 10 YEARS OF MOORING OBS ALONG THE MEXICAN CARIBBEAN

REEF LAGOON (PUERTO MORELOS)

CHINCHORRO BANK (OPEN OCEAN ATOLL)

QUESTIONS:

WHAT ARE THE BASIC PROCESSES THAT SUSTAIN THIS LARGE ECOSYSTEM?

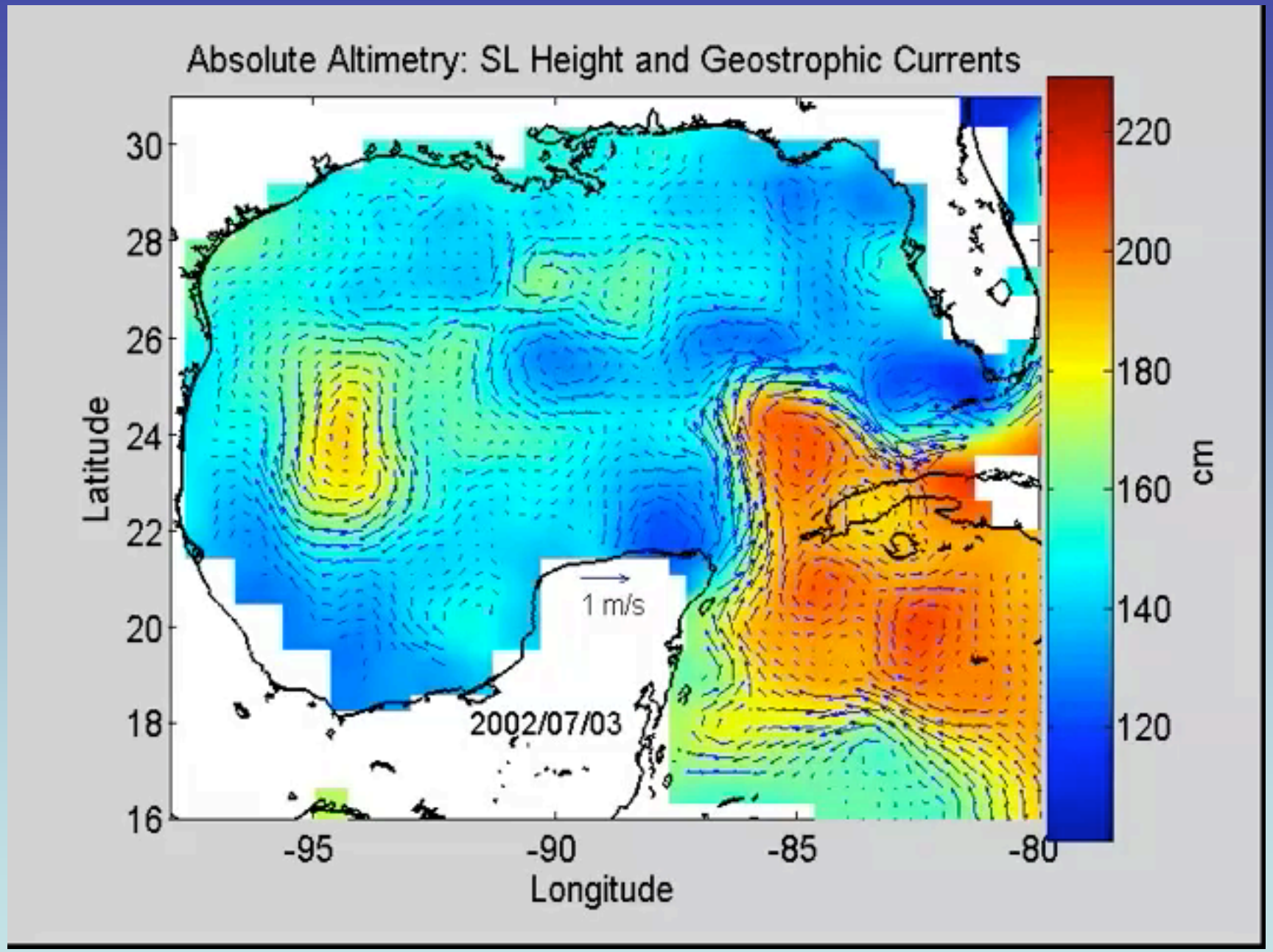
ROLE OF EDDIES AND GENERAL CRCULATION

INTERACTION BETWEEN THE DEEP CIRCULATION AND REEF LAGOON PROCESSES

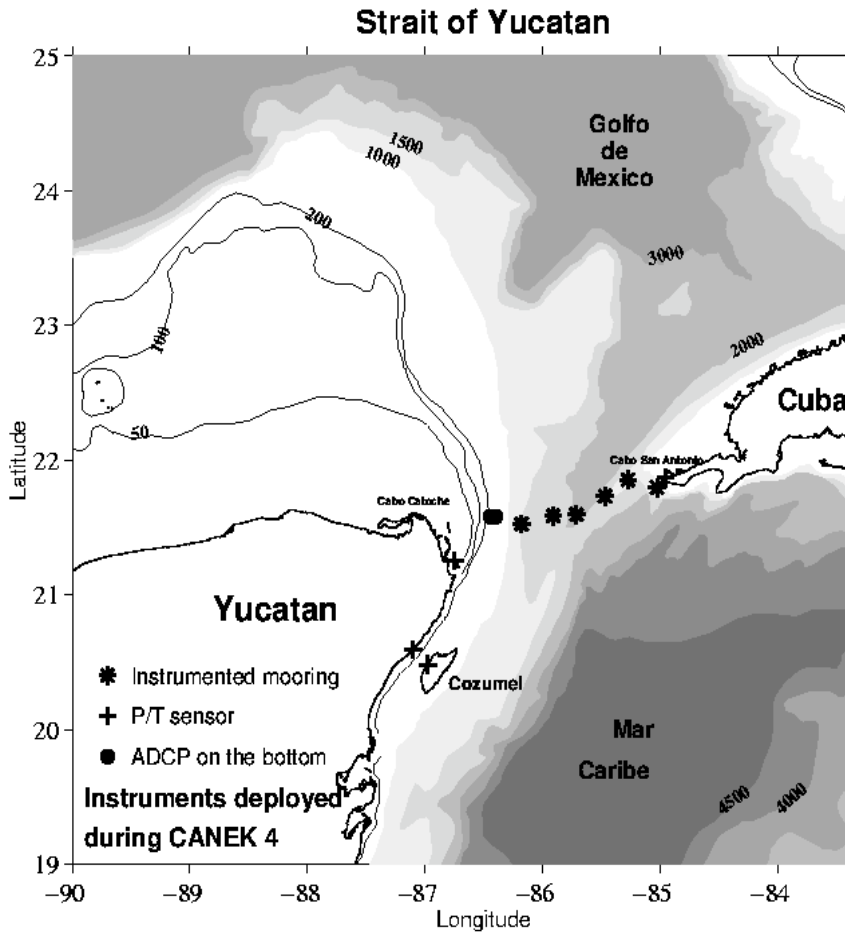
ROLE OF HURRICANES AND WIND RELATED PROCESSES

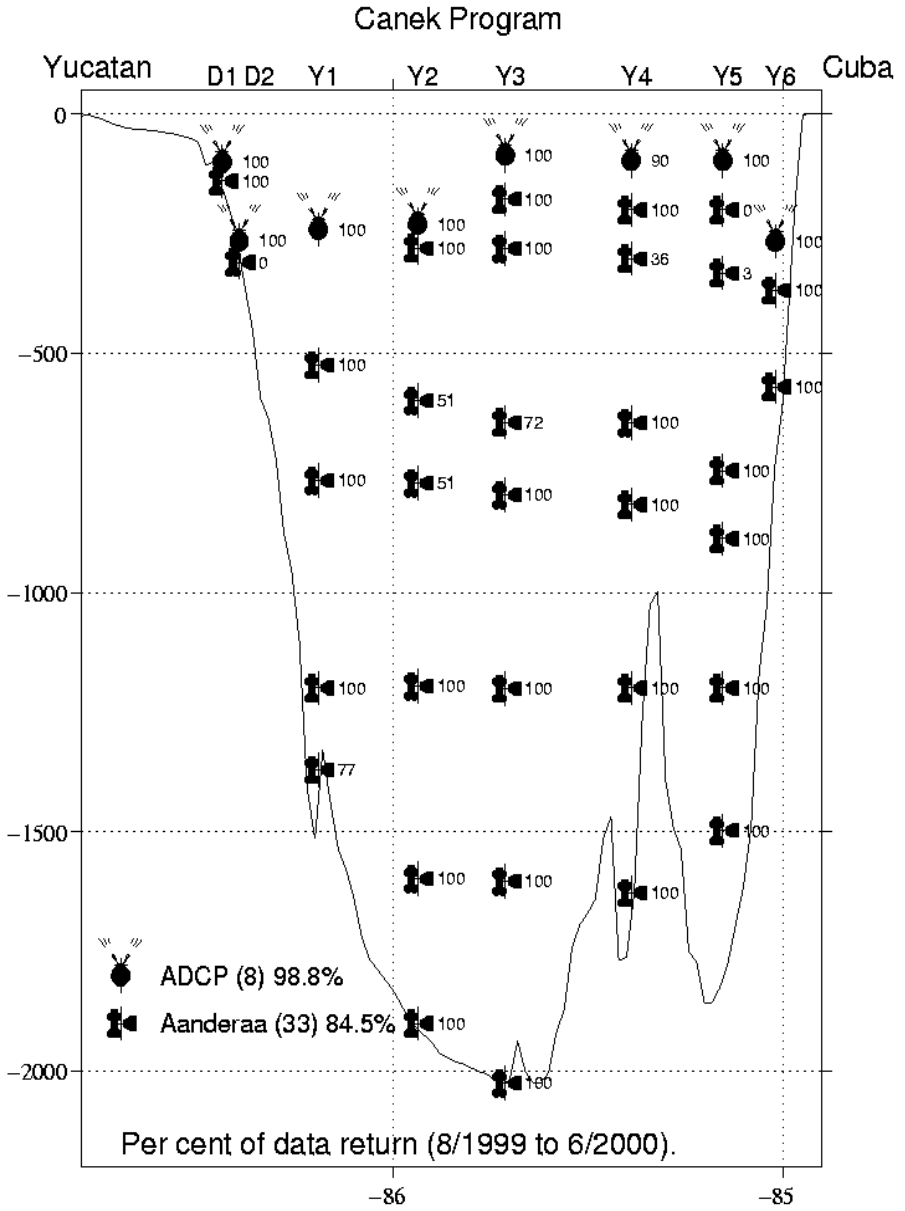
INTERNAL TIDES, COASTAL WAVES

CONECTIVITY

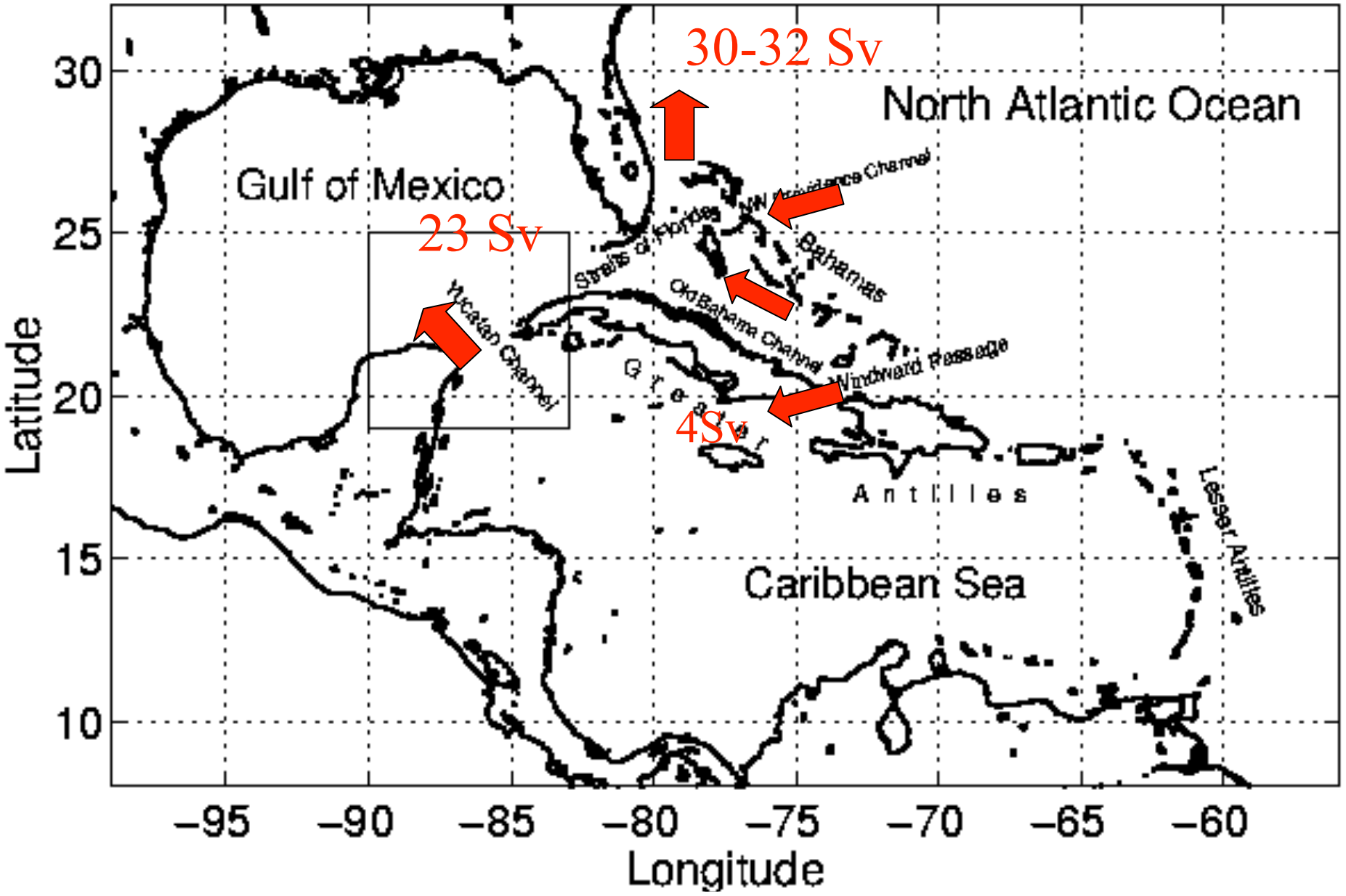

Absolute Altimetry: SL Height and Geostrophic Currents
Latitude
Longitude
30
28
26
24
22
20
18
16
-95
-90
-85
-80
220
200
180
160
140
120
cm
1 m/s
2002/07/03

CANEK 4, agosto de 1999, instalación en el Canal de Yucatán

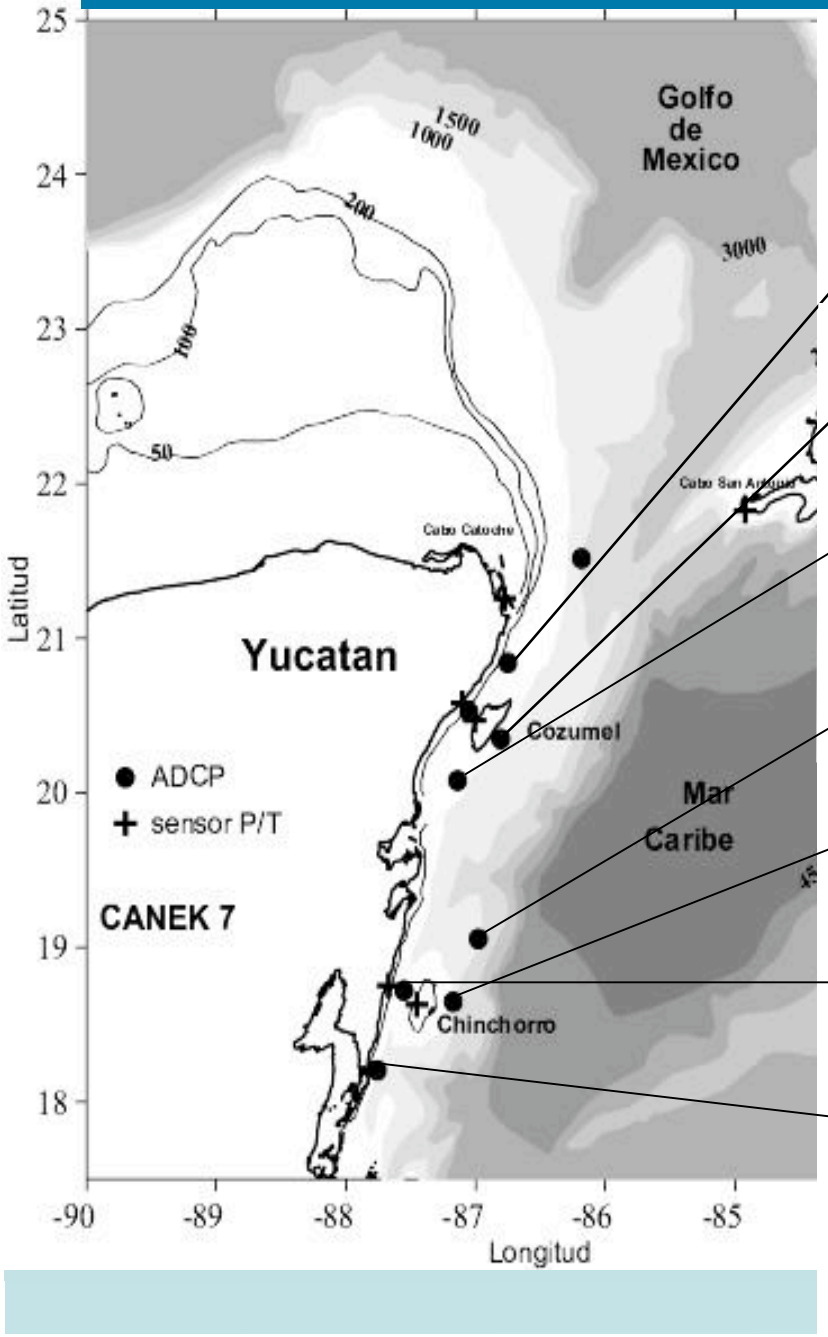


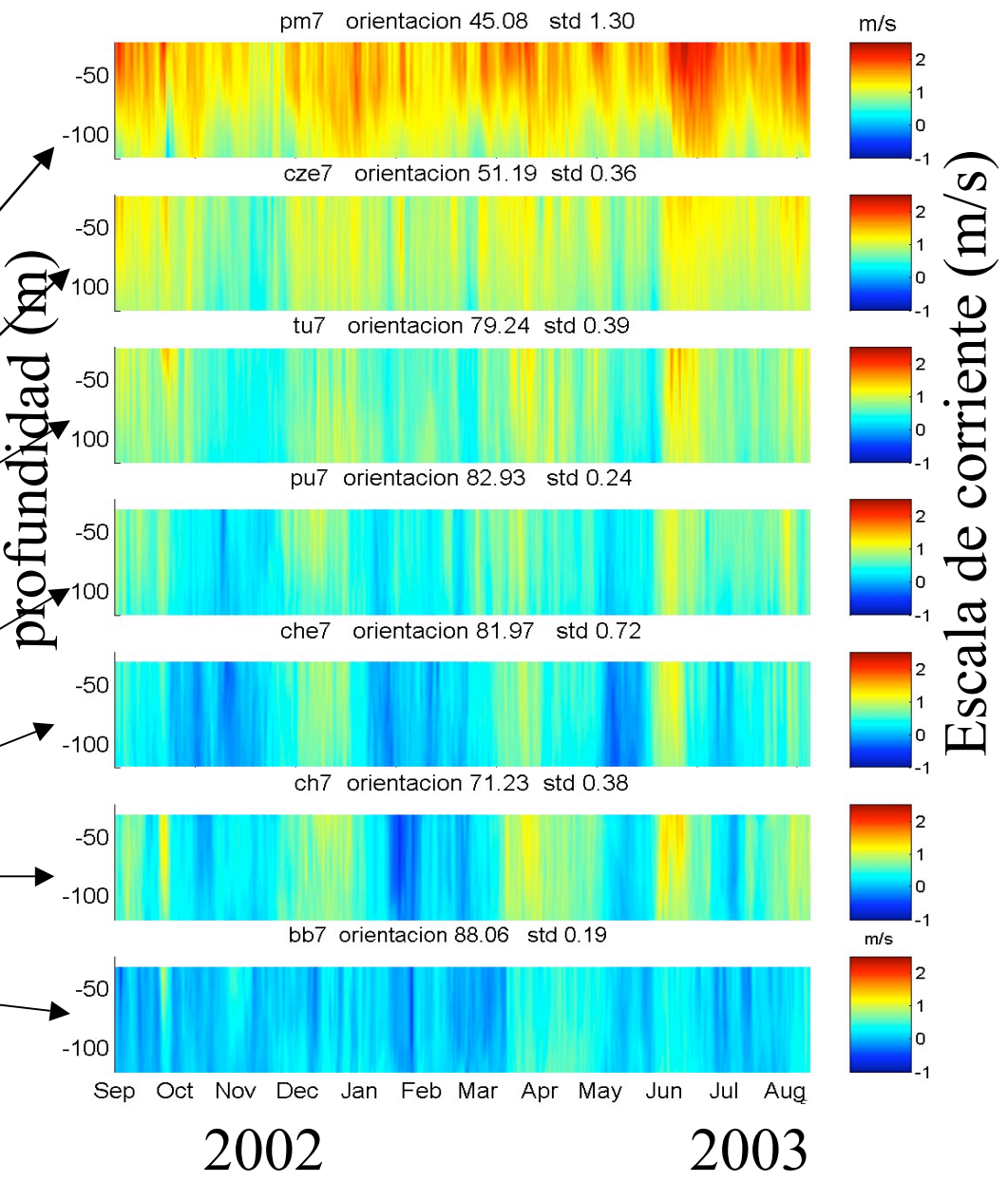


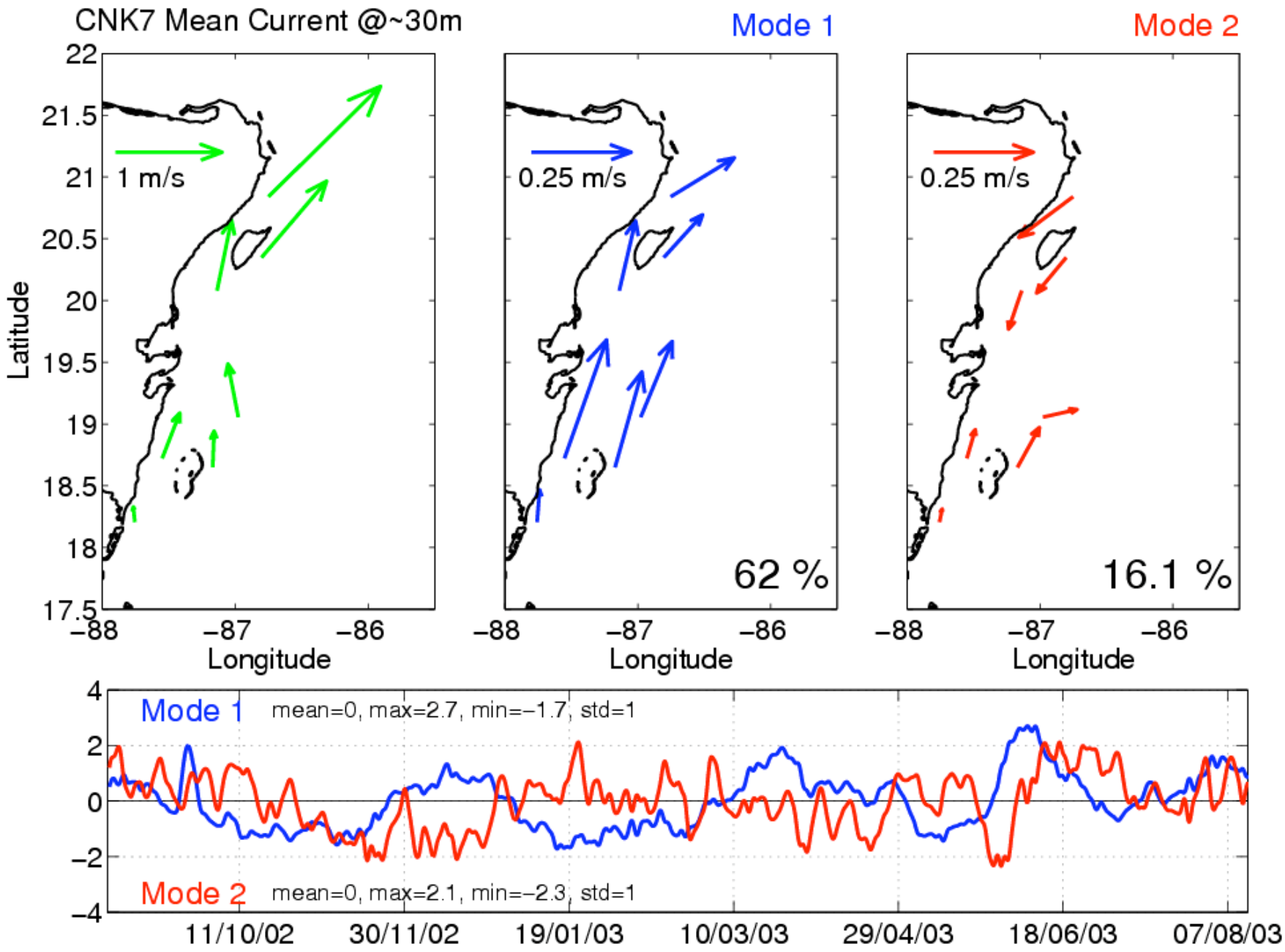
Mediciones de 8/1999 a 7/2001


30-32 Sv
North Atlantic Ocean
Gulf of Mexico
23 Sv
Yucatan Channel
Straits of Florida
NW Providence Channel
Bahamas
Old Bahama Channel
Windward Passage
4Sv
Antilles
Lesser Antilles
Caribbean Sea
Latitude
Longitude
30
25
20
15
10
−95
−90
−85
−80
−75
−70
−65
−60

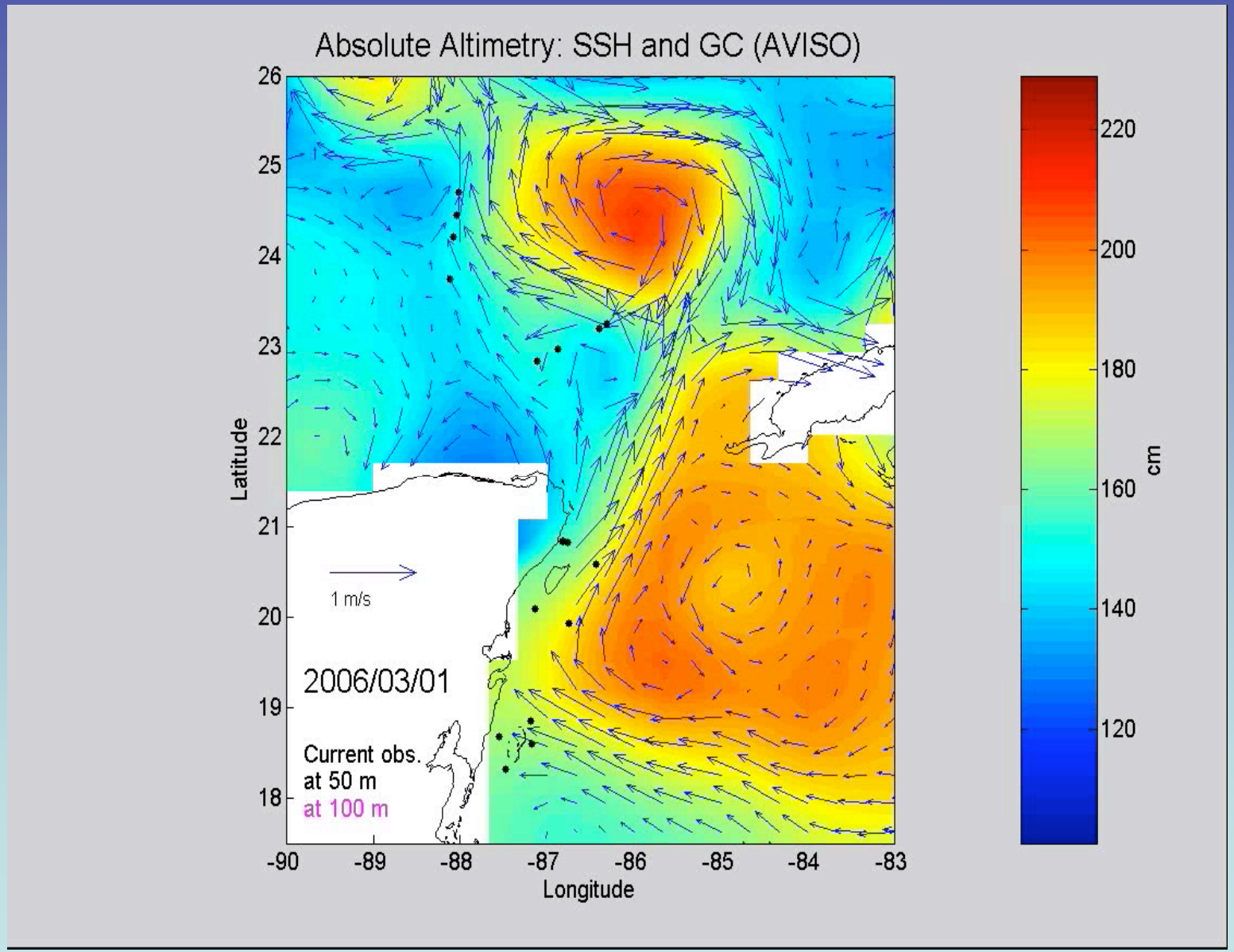
Observed Currents along their principal axis.



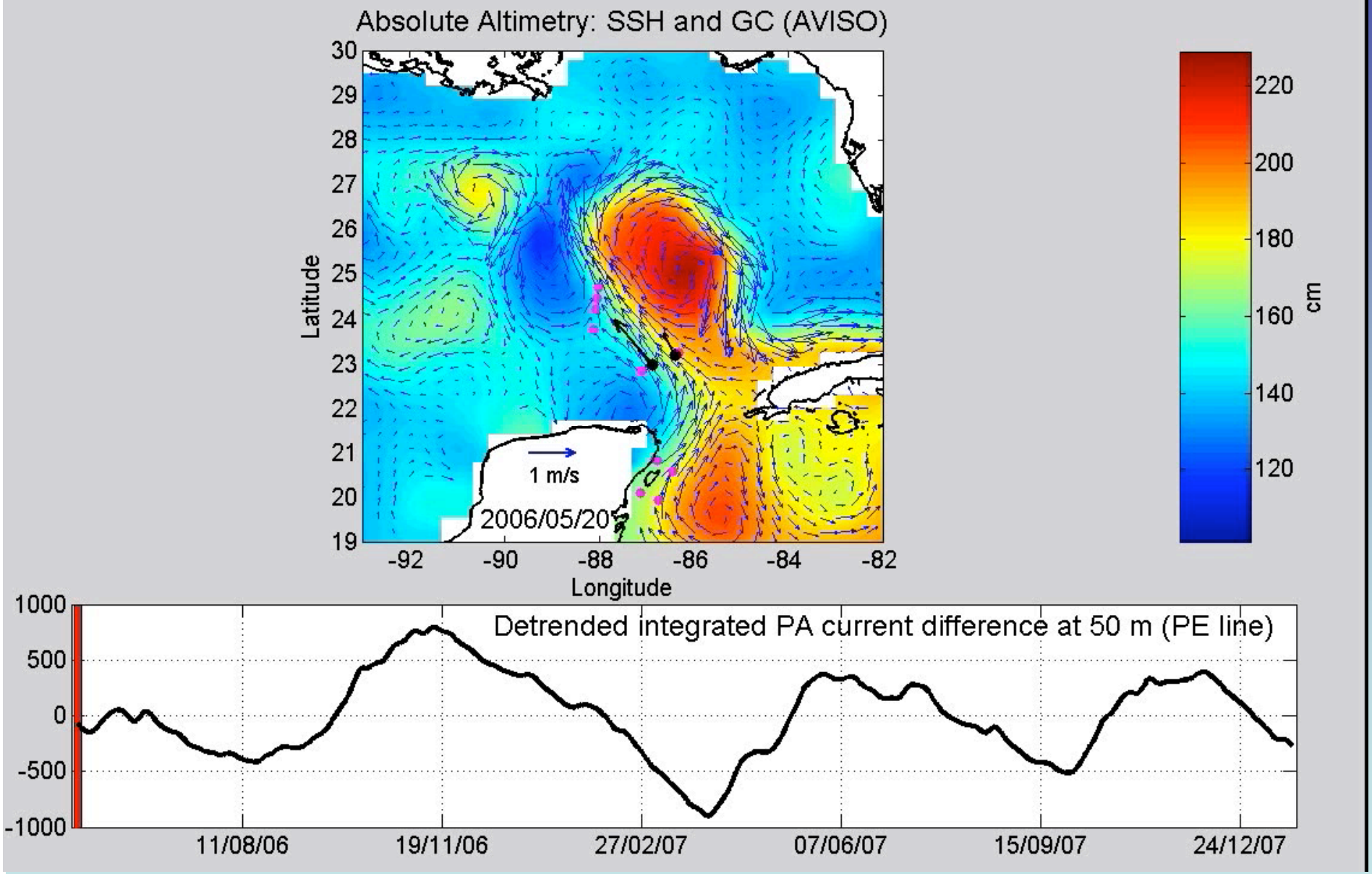


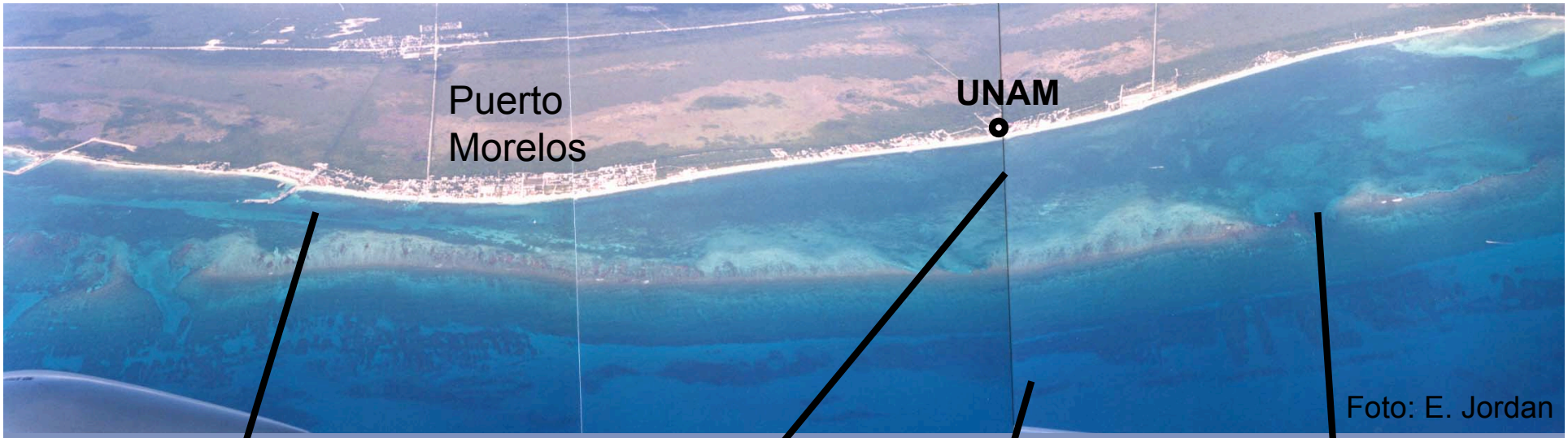

CNK7 Mean Current @~30m
Mode 1
Mode 2
1 m/s
0.25 m/s
0.25 m/s
62 %
16.1 %
Latitude
Longitude
Mode 1 mean=0, max=2.7, min=−1.7, std=1
Mode 2 mean=0, max=2.1, min=−2.3, std=1
11/10/02
30/11/02
19/01/03
10/03/03
29/04/03
18/06/03
07/08/03

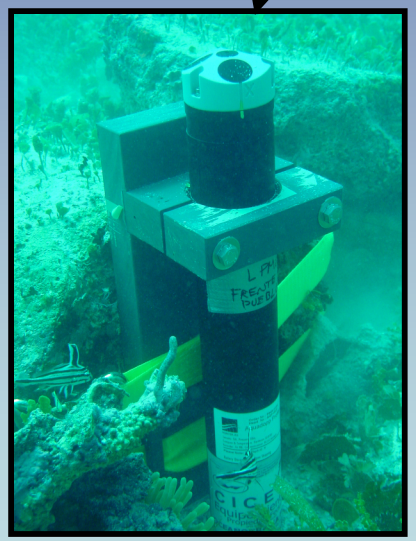
Moorings vs. altimetry (AVISO)



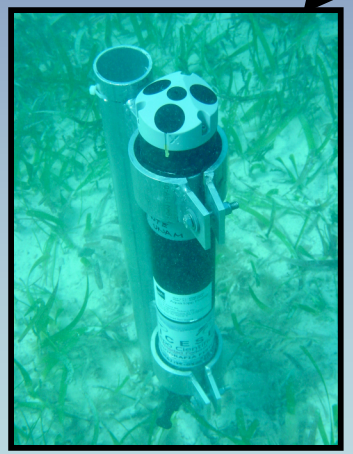
Flux of vorticity and LC ring separation



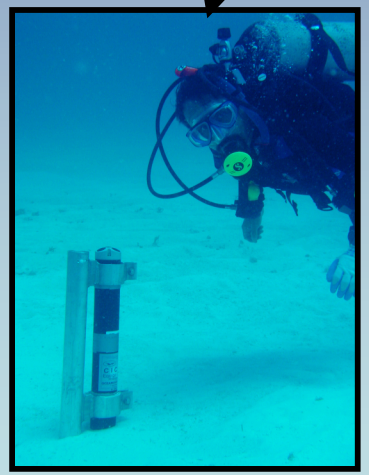




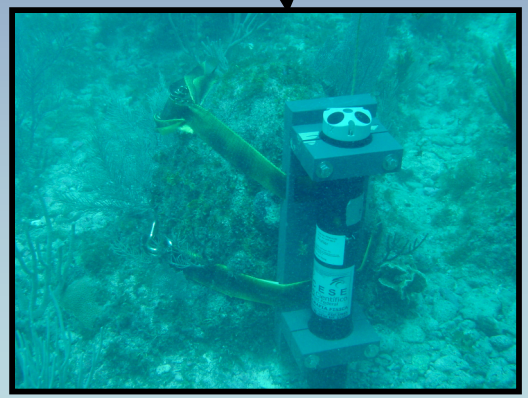
LPM0 (8 m)
Boca sur



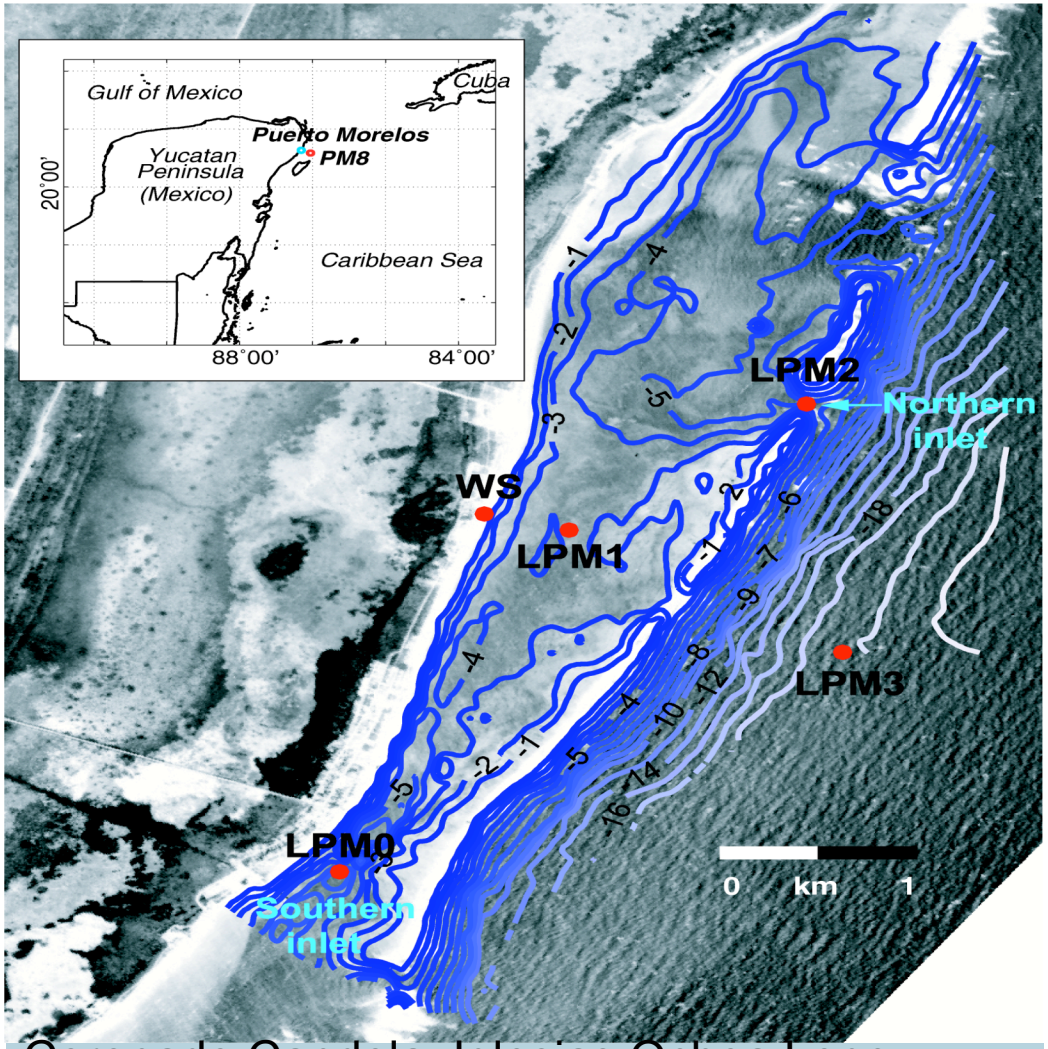
LPM1 (4 m)
Laguna Interior

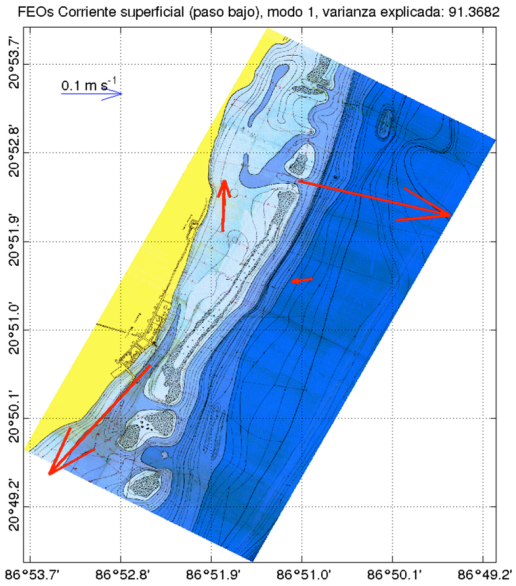


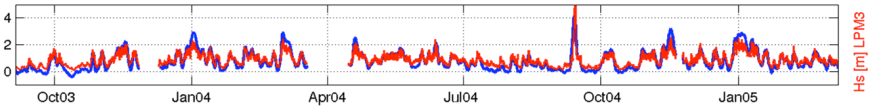
LPM3 (25 m)
Exterior

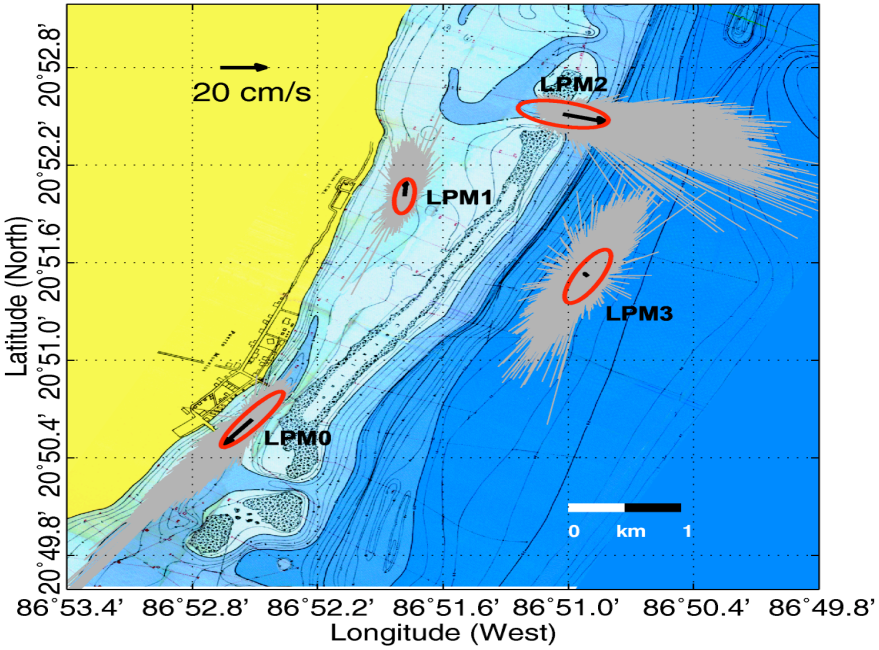


LPM2 (6 m)
Bocana



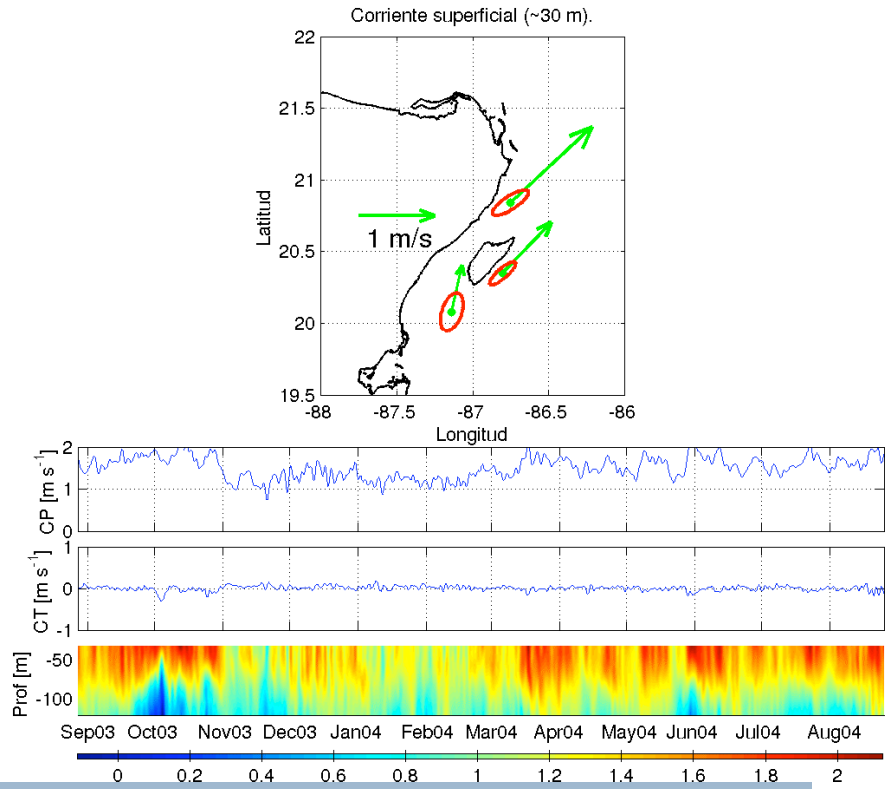




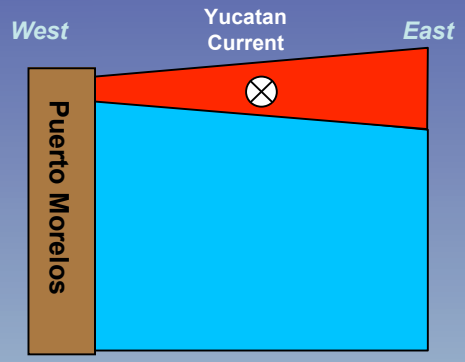


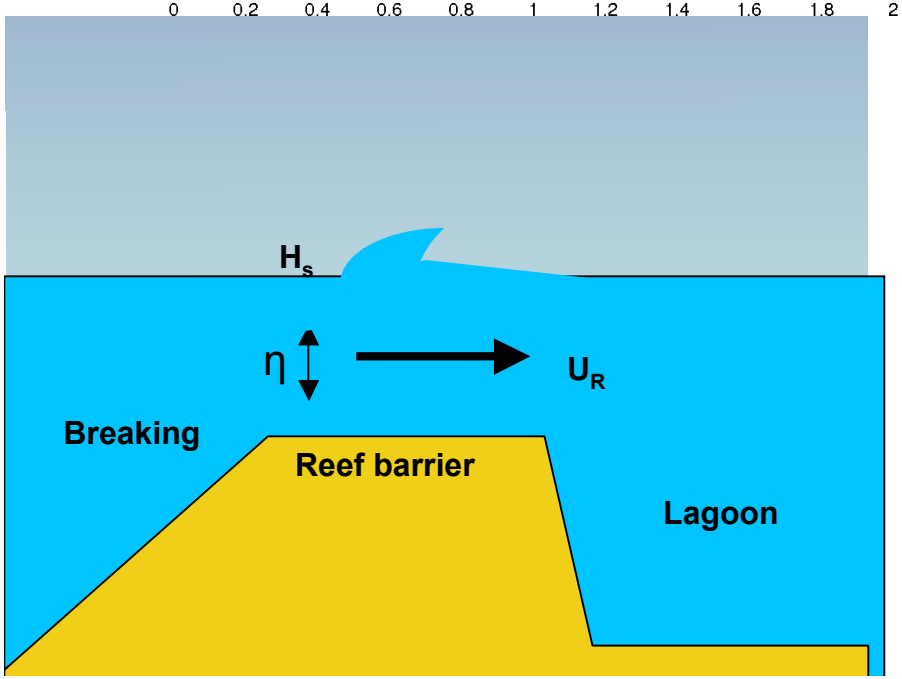
Coronado,Candela, Iglesias,Ochoa,Lopez Sheinbaum.

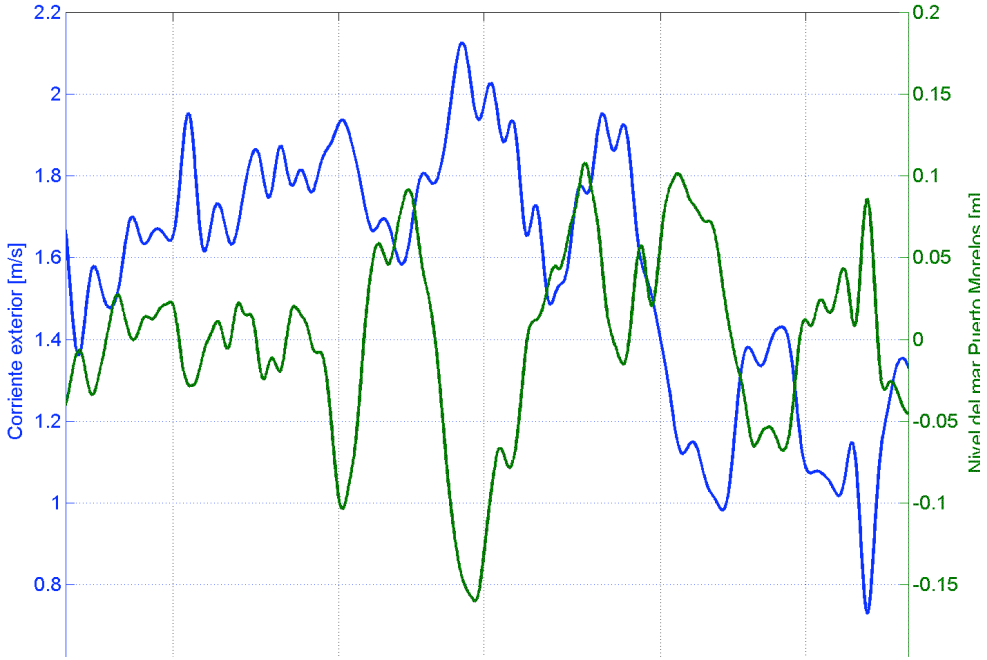
WHAT CONTROLS THE CIRCULATION WITHIN THE REEF LAGOON, WHAT IS ITS CONNECTION WITH THE LARGE SCALE CIRCULATION?



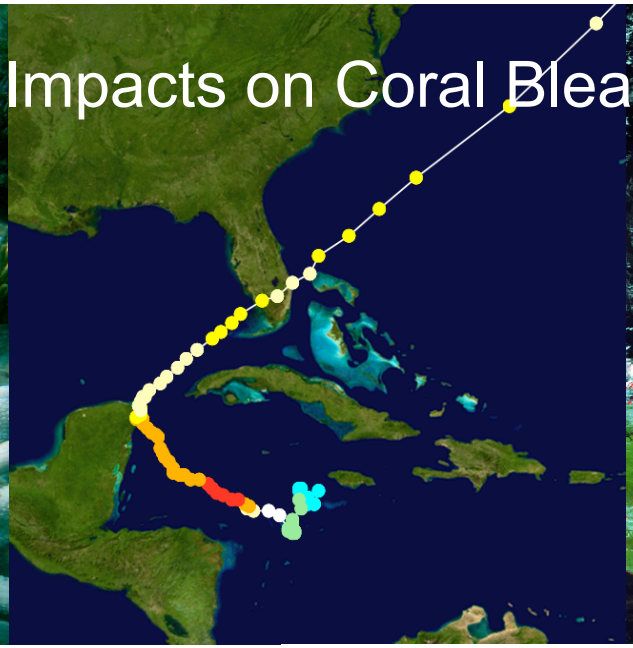
The strong connection Between the Yucatan Current and the flow in the reef lagoon

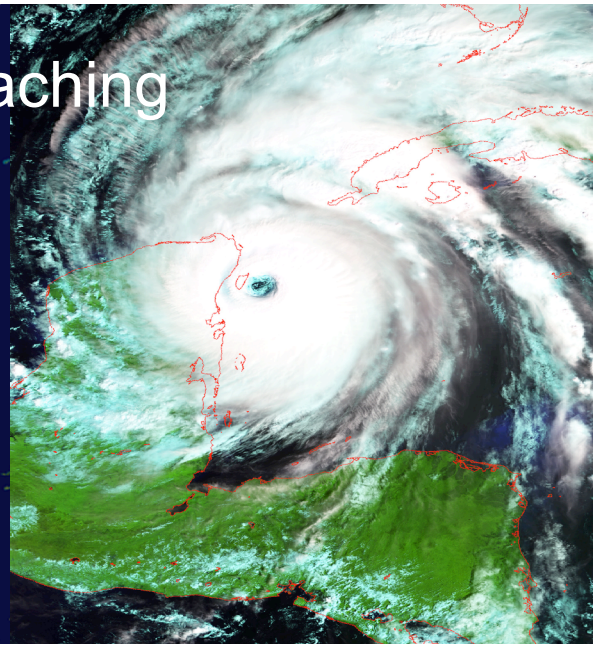


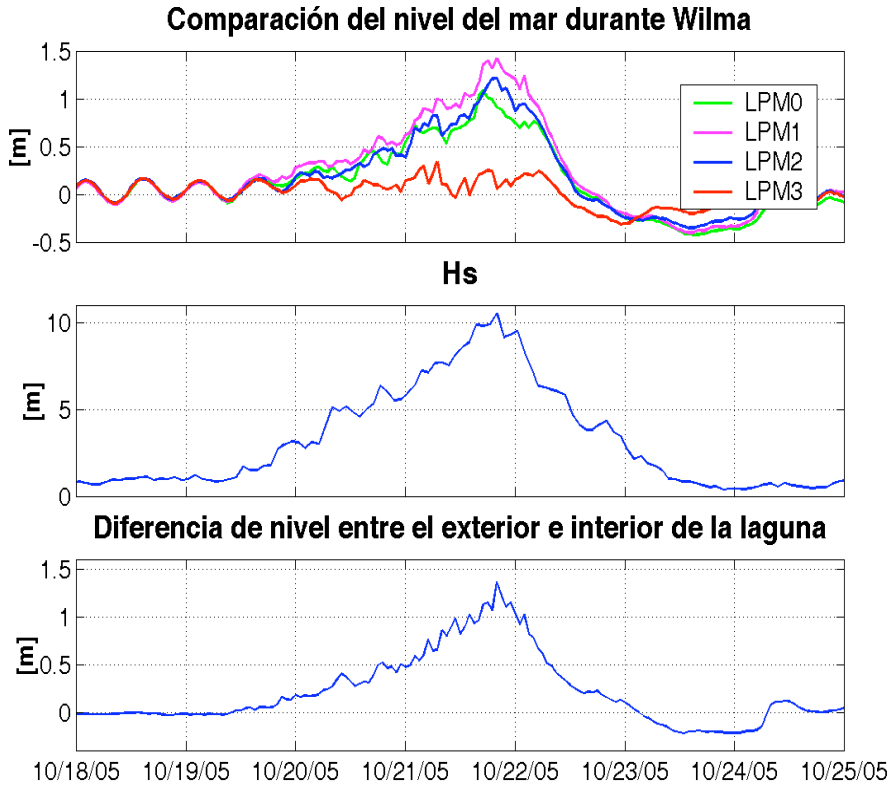


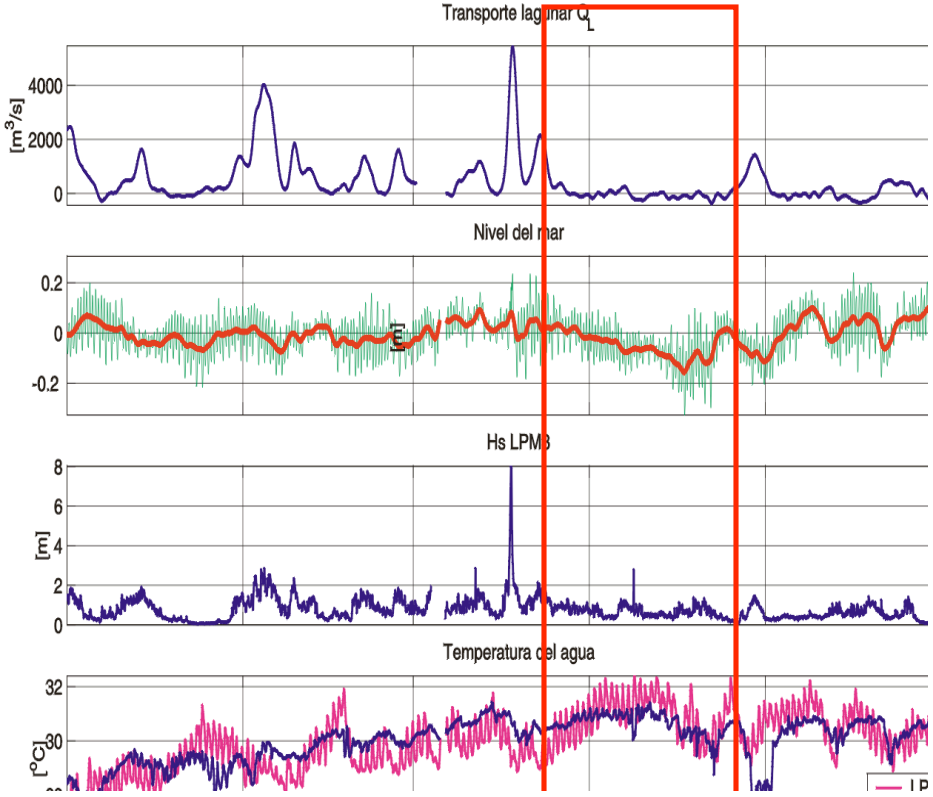


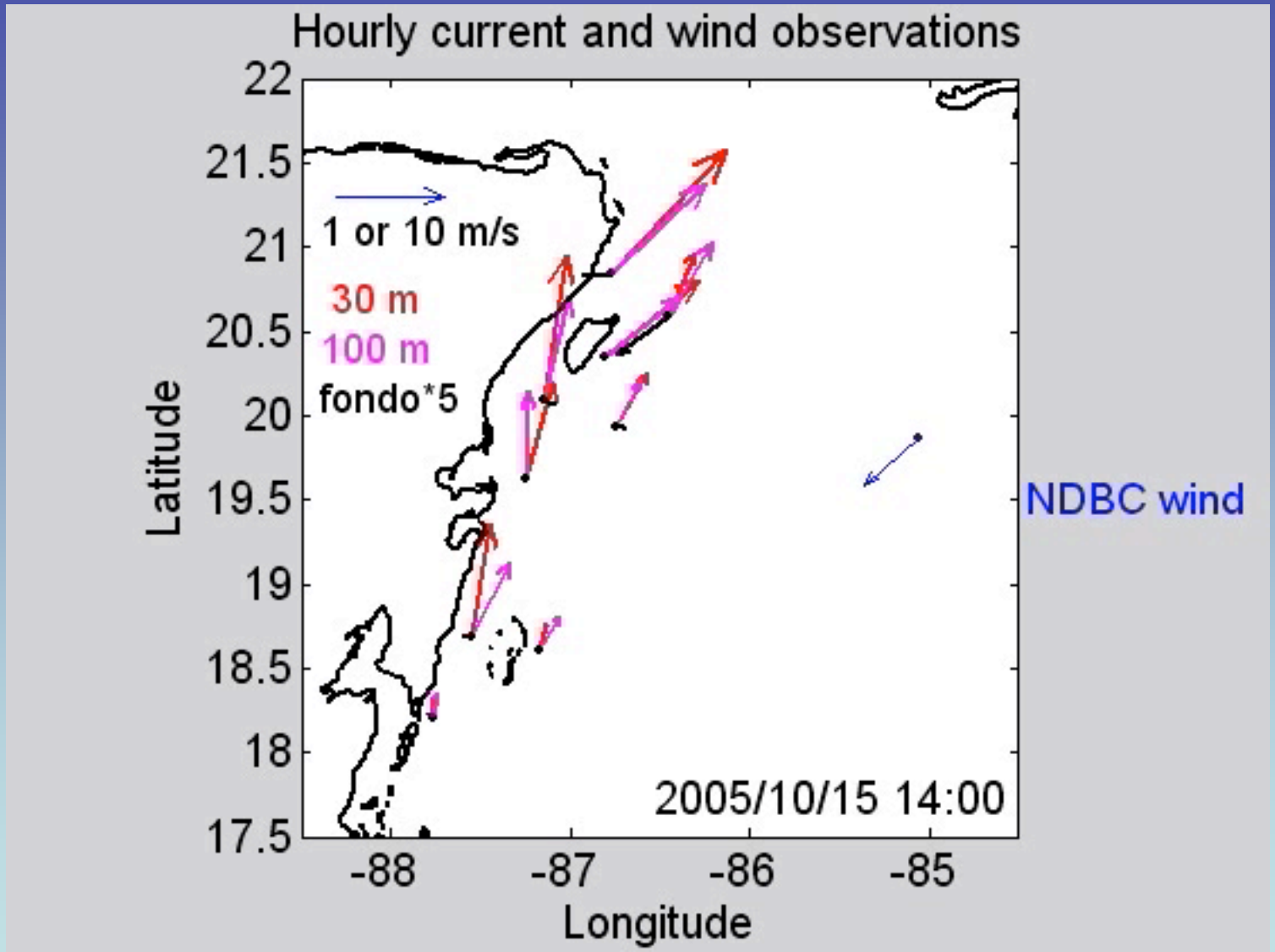
Hurricane Impacts on Coral Bleaching





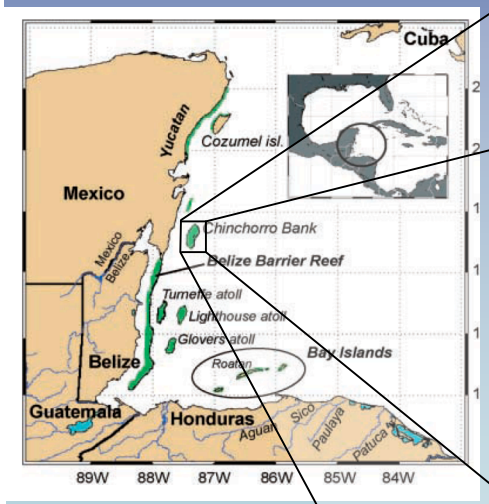


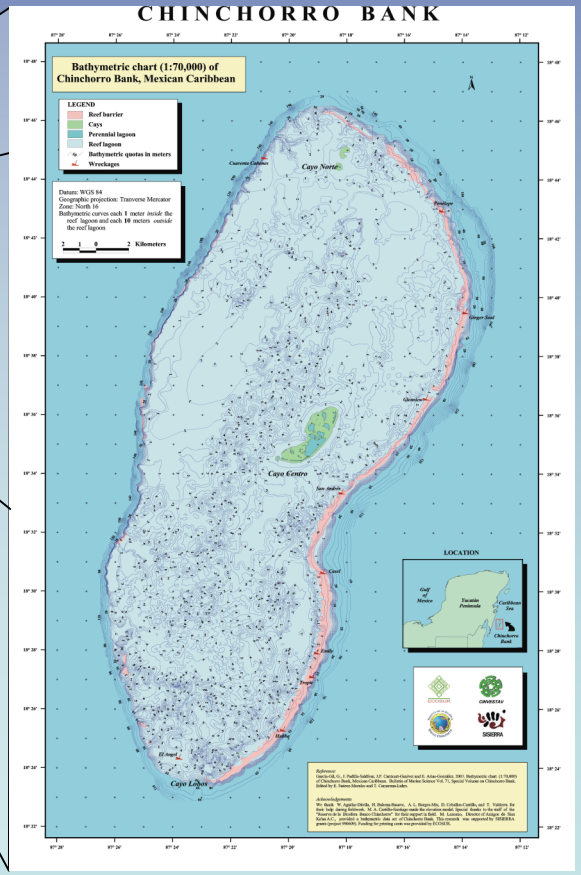



Hourly current and wind observations
22
21.5
21
20.5
20
19.5
19
18.5
18
17.5
Latitude
1 or 10 m/s
30 m
100 m
fondo*5
2005/10/15 14:00
-88
-87
-86
-85
Longitude
NDBC wind

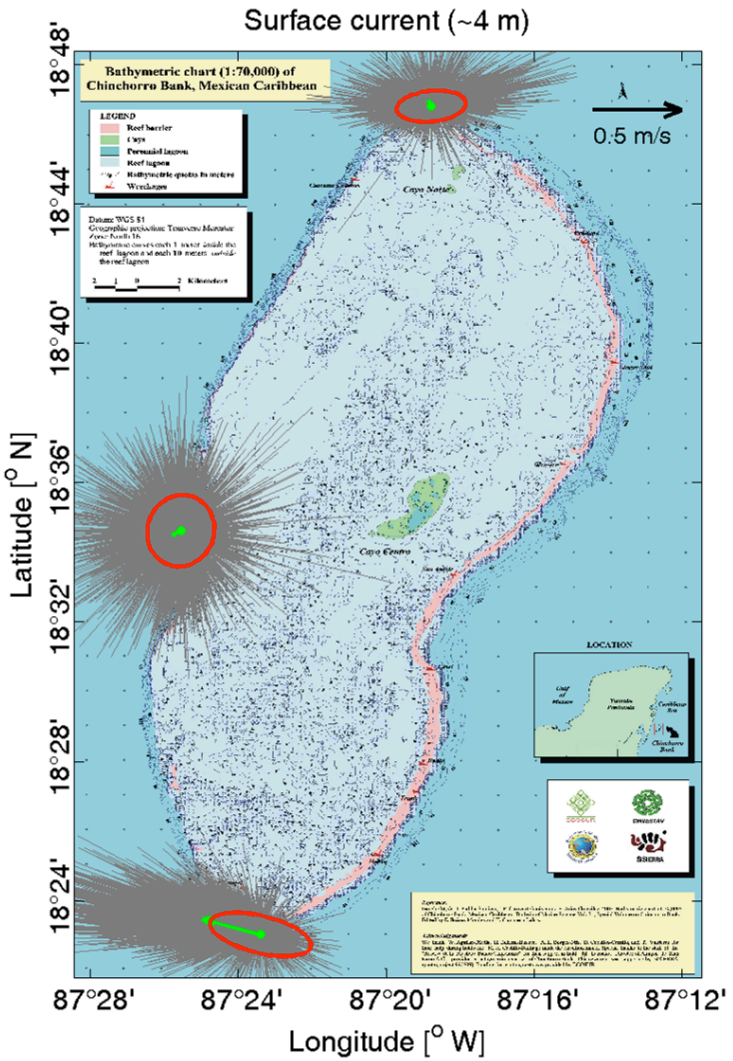
Chinchorro Bank:

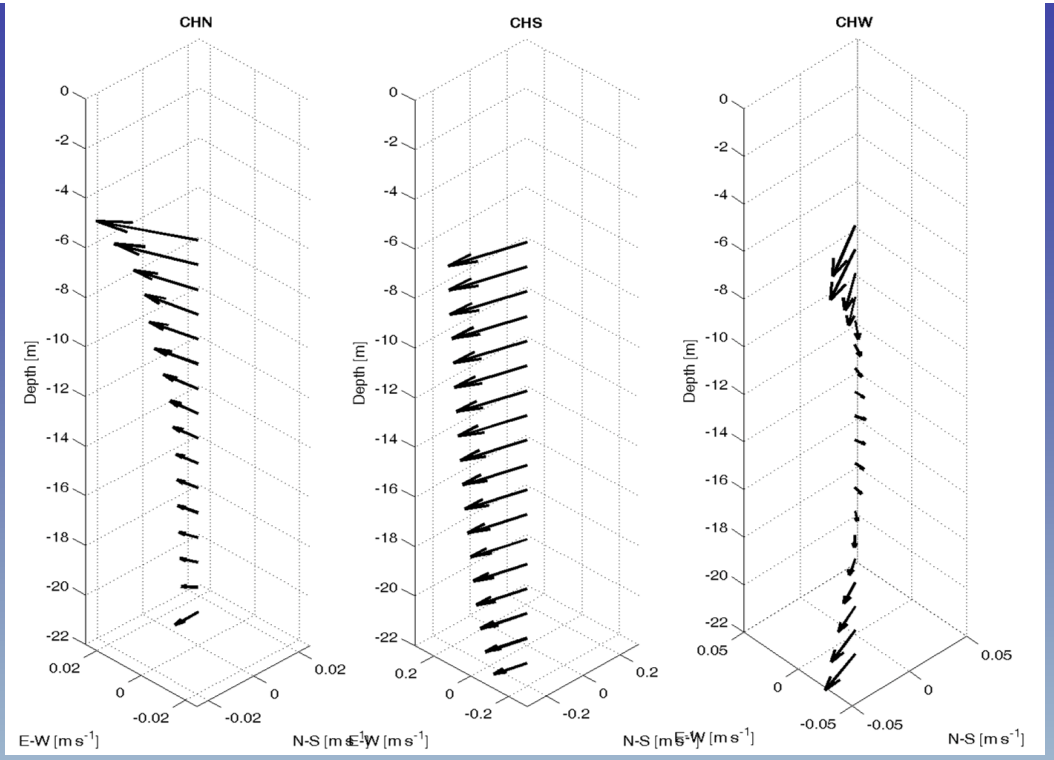
Chinchorro Bank (CB) is the largest atoll-like reef in the Caribbean Sea, centered at 87° 21' W, 18° 35' N. It has an oval shape and approximately 44 km length and 20 km width (Figure 1). A channel separating its western rim from the Yucatan Peninsula has a width of 30 km and a sill depth of 700 m. On recent years, there has been a growing scientific interest on the ecological importance of this pristine environment. Due to its isolated location, it has been a strong attractive to divers, although there is no defined strategy to develop tourism there yet. Since 1966 CB has been an important zone for exploitation of spiny lobster *Panulirus argus* and queen conch *Strombus gigas.* Numerous studies have identified CB as the most important source for spiny lobster larvae, settling large lobster populations downstream of the Yucatan Current.



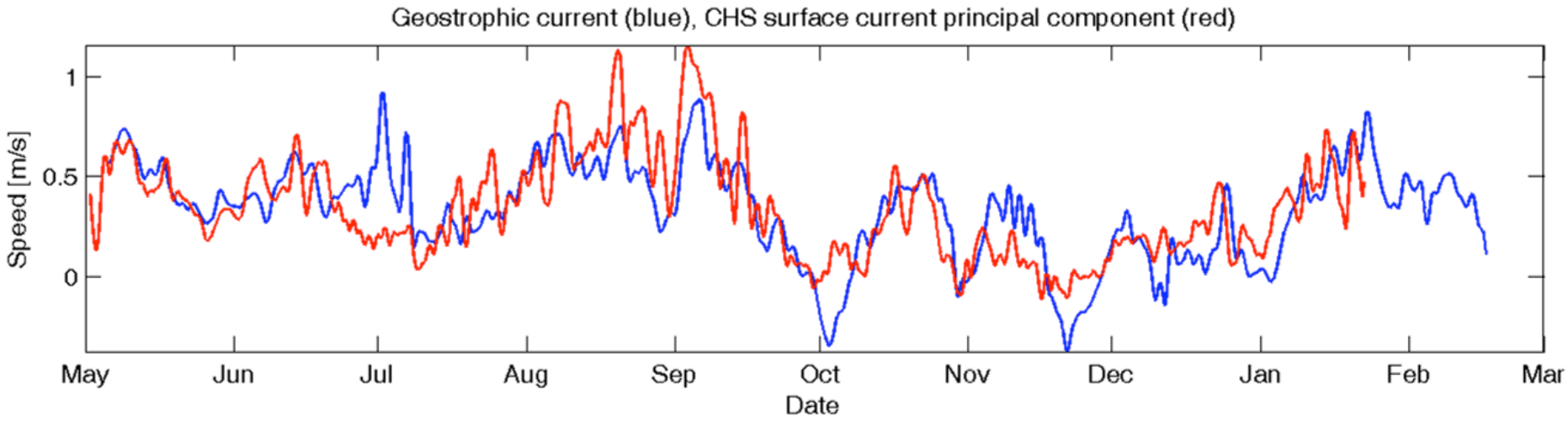


CHINCHORRO BANK



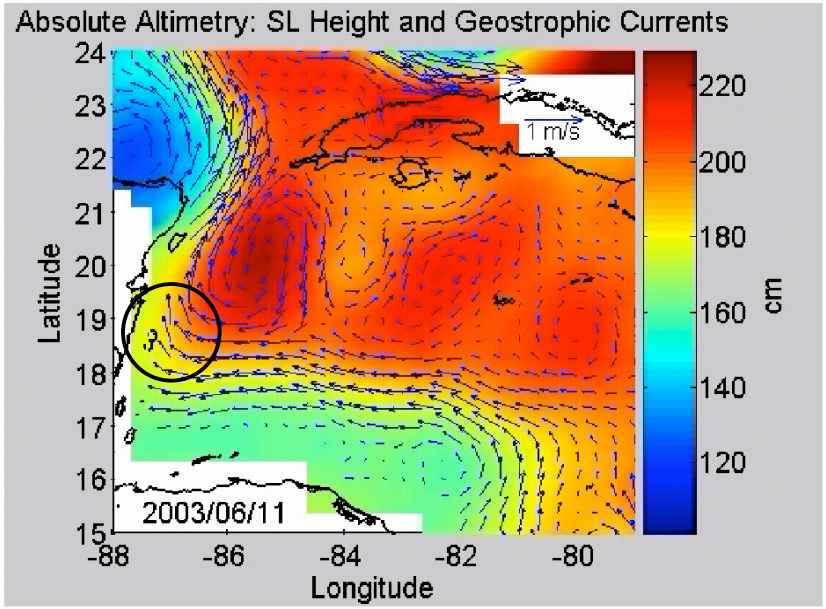


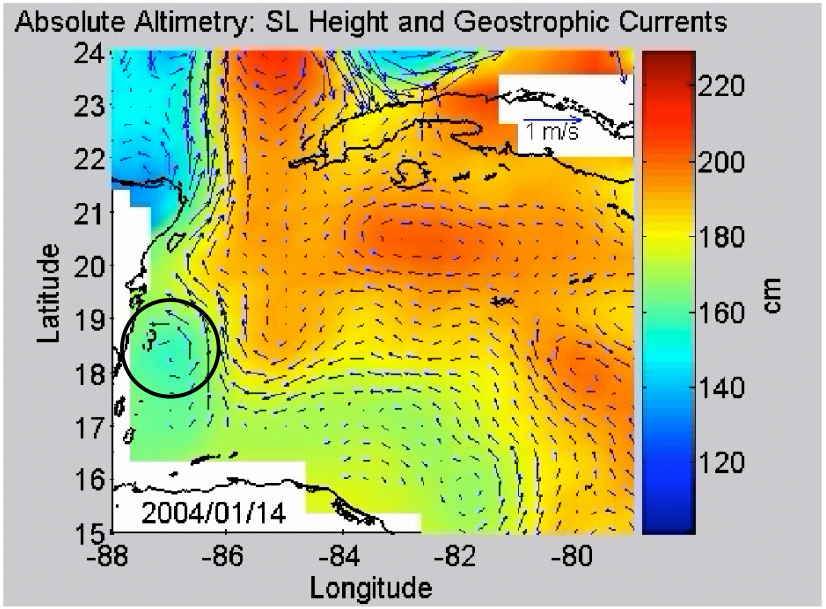
Location	CHN	CHS	CHW
Dominant tidal constituent	O_1	O_1	*
Mayor [m/s]	0.109	0.055	*
Minor [m/s]	0.008	0.003	*
Inc [deg]	9.12	355.43	*
Phase	283.99	333.58	*
% Explained variance	14.7	23.2	*

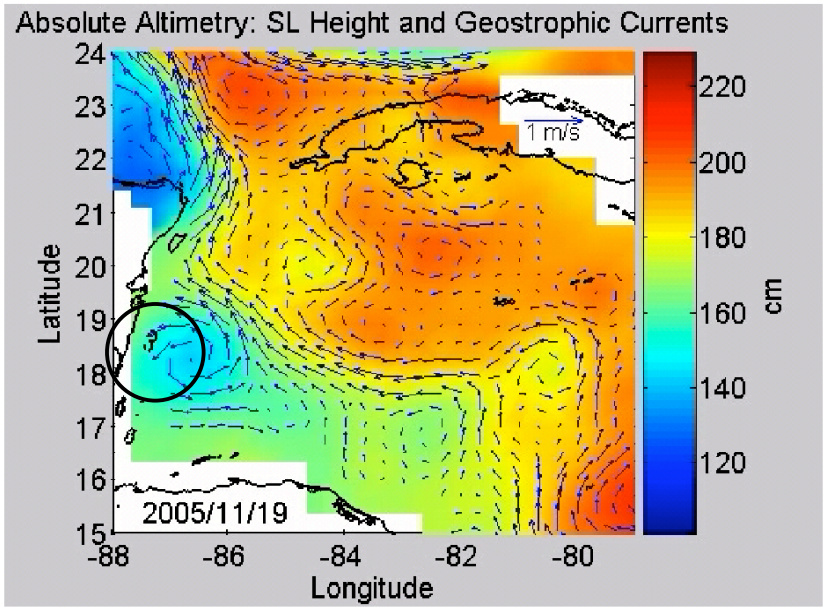


Data

This study is based on measurements collected between May 2006 and February 2007 using an array of three Nortek 1 MHz ADCPs, mounted on the bottom just outside the reef rim, at ~20 m depth. These instruments recorded the current profile each 30 min, along with water temperature and pressure at the instrument head. Surface waves were sampled every two hours, collecting bursts of 1,024 samples at 1 Hz. Two SBE26 pressure sensors, averaging subsurface pressure every 10 minutes, were used to monitor the pressure gradient across the channel.



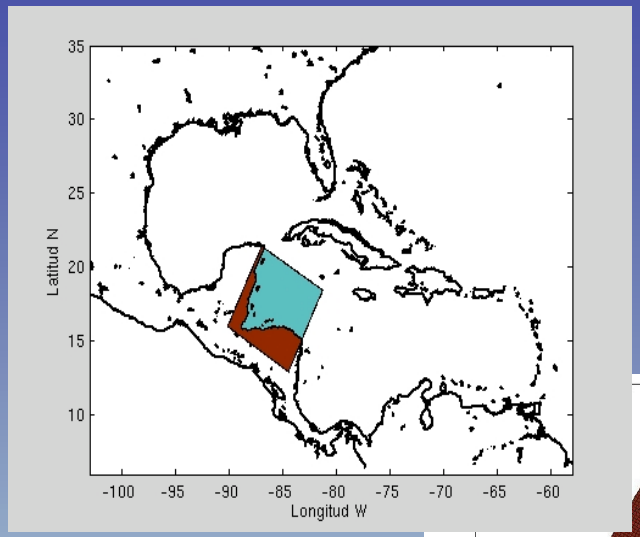


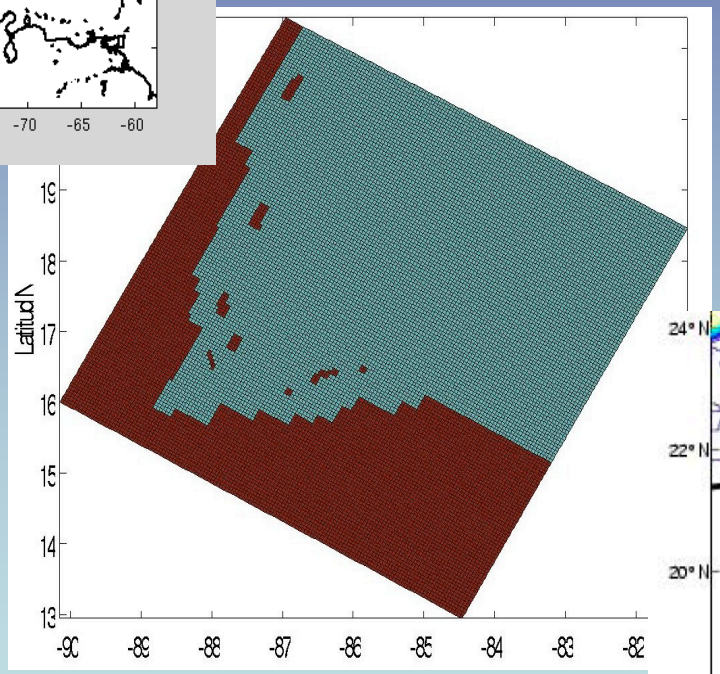


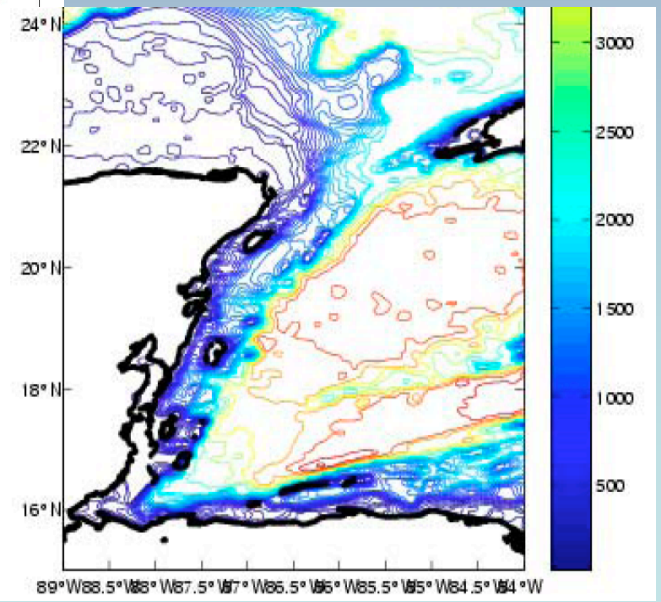
Satellite altimetry from AVISO and derived geostrophic velocities on the Western Caribbean. Chinchorro Bank is indicated with a circle. Note on A) the Cayman Current flowing westward through BC, part of it forming the northbound Yucatan Current. On B) a cyclonic eddy is forming near BC due to the meandering of the Cayman current. C) a fully developed cyclonic eddy originates southbound flows in the channel between BC and the Yucatan Peninsula.

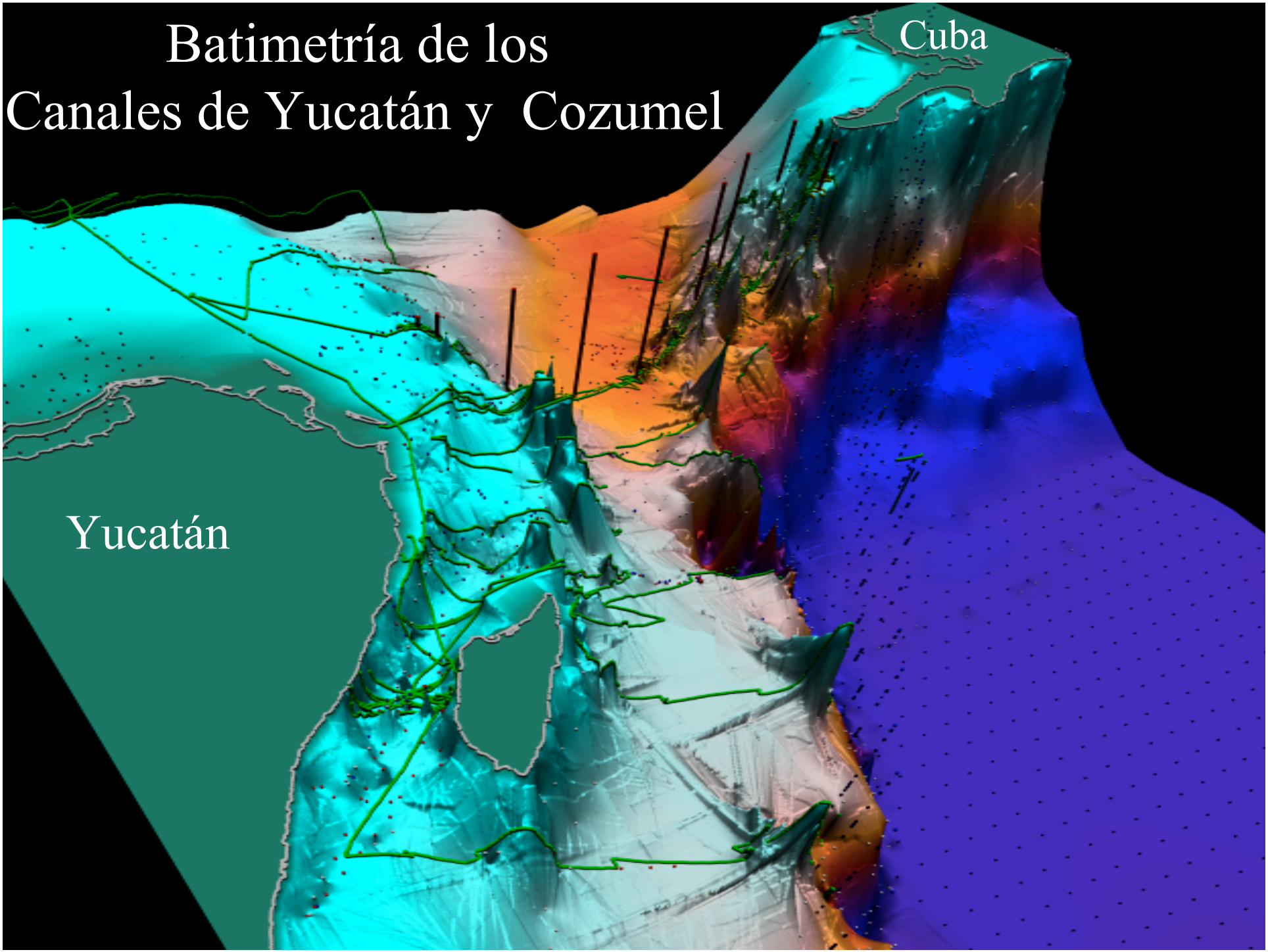
THE MBRS ROMS SET UP

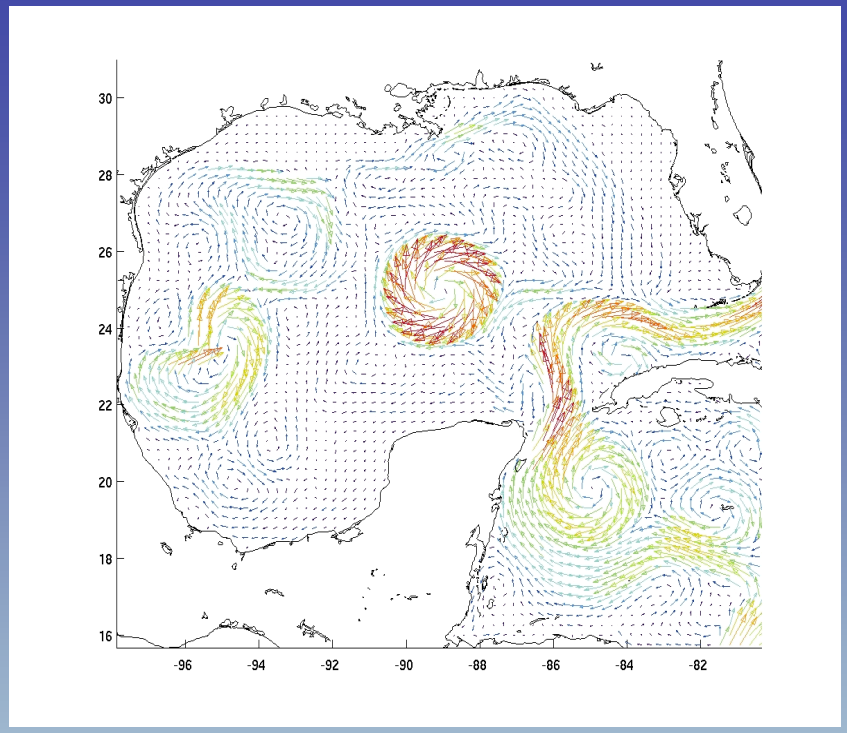
5 Km horizontal resolution
30 s levels
Rotated grid as IAS grid
WORKING now also with a 2 km grid








Batimetría de los
Canales de Yucatán y Cozumel
Cuba
Yucatán



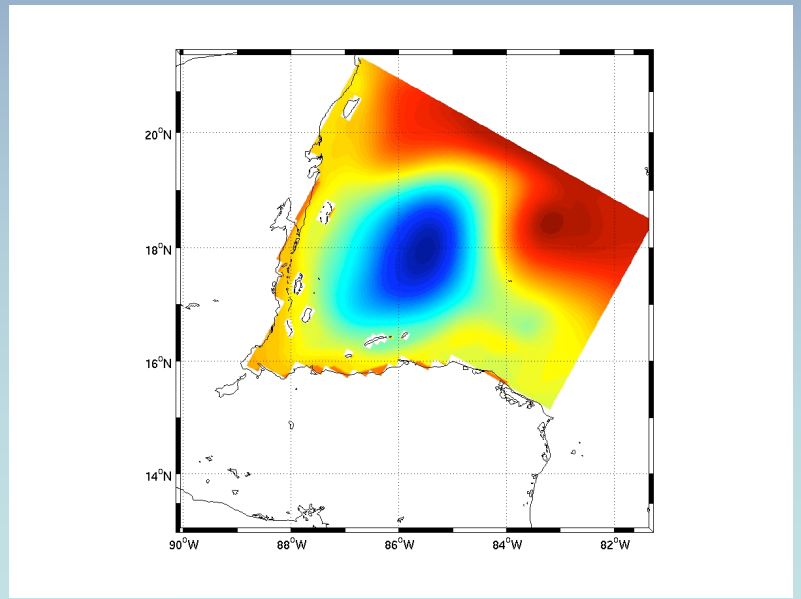
ROMS-GoM

EMBEDDING:

MBRS: L. Guerrero

Moore-Sheinbaum UC-MEXUS

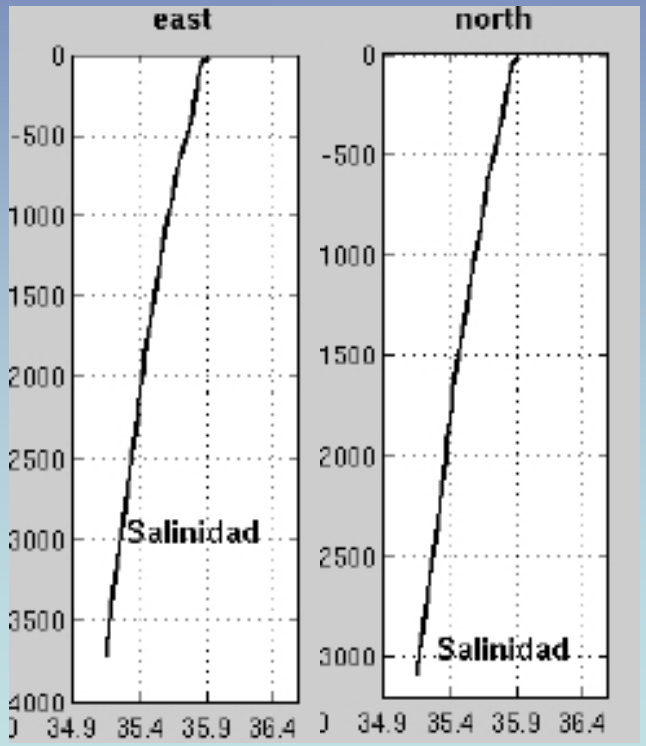
Physical-Biological modeling

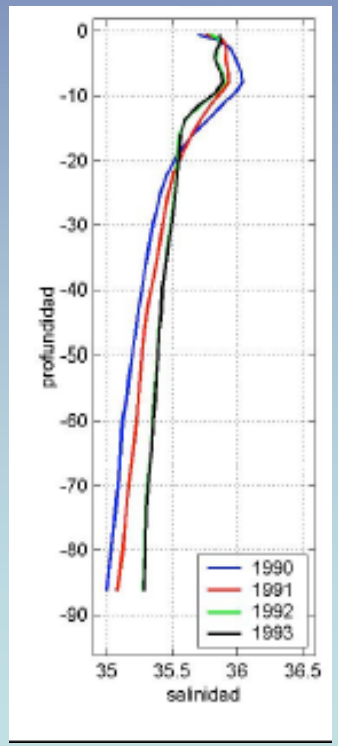


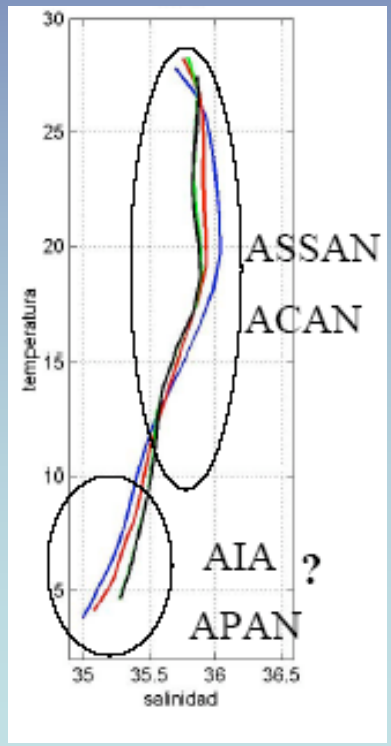
FIRST RUNS

* 5 years simulation
* OBCS IAS-40km.
* FORCING NCEP+QS (c/6hr de1990-2006)

EXCESIVE MIXING! TRACED BACK TO OBCS…







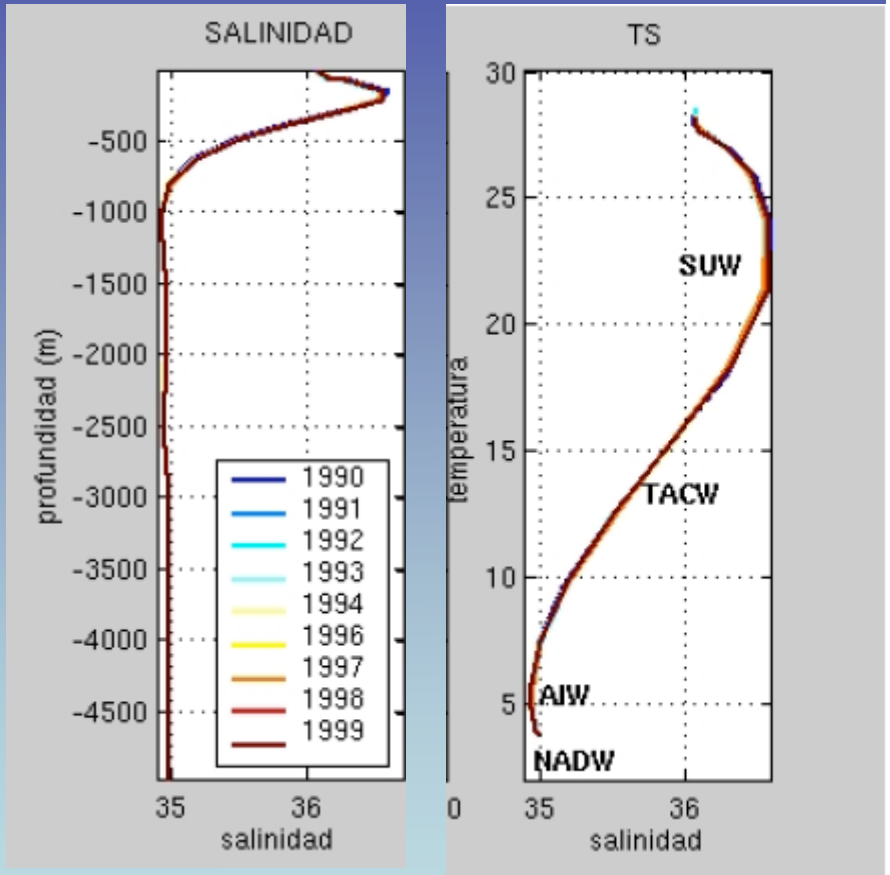
OBCS IAS 40 km interp. to mbrs 5 km

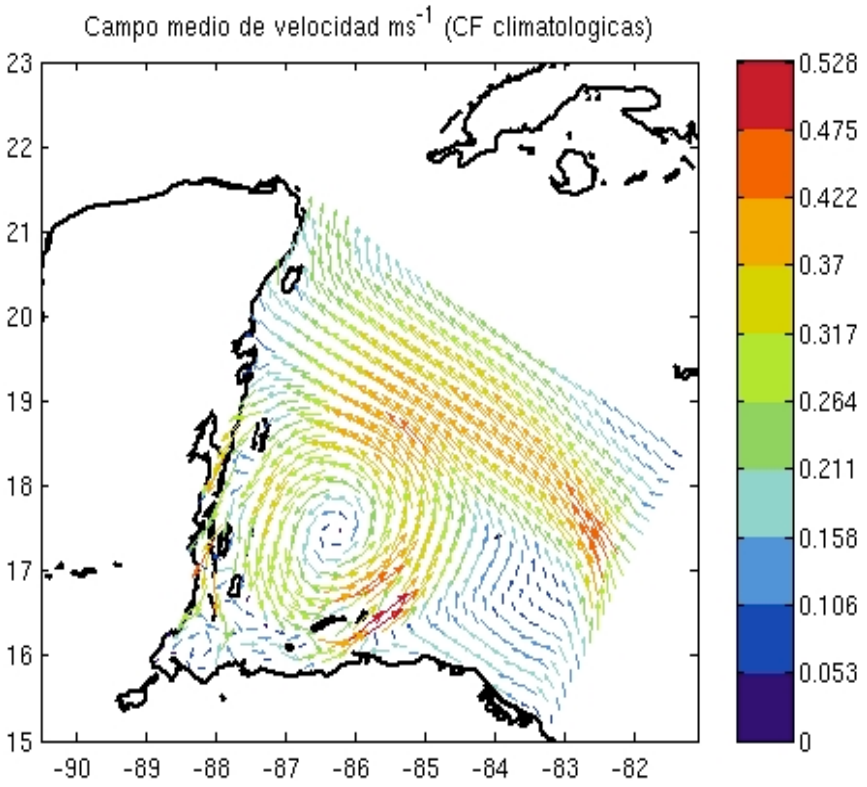
TEST RUN

* 20 years run with climatology

* Climatological OBCS
* ICS TS Climatology (u,v)=0

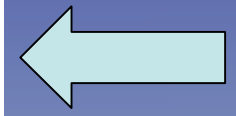
* NCEP FORCING c/6hr
2º x 2º (wind, shwr, lwr, P-E, T air)

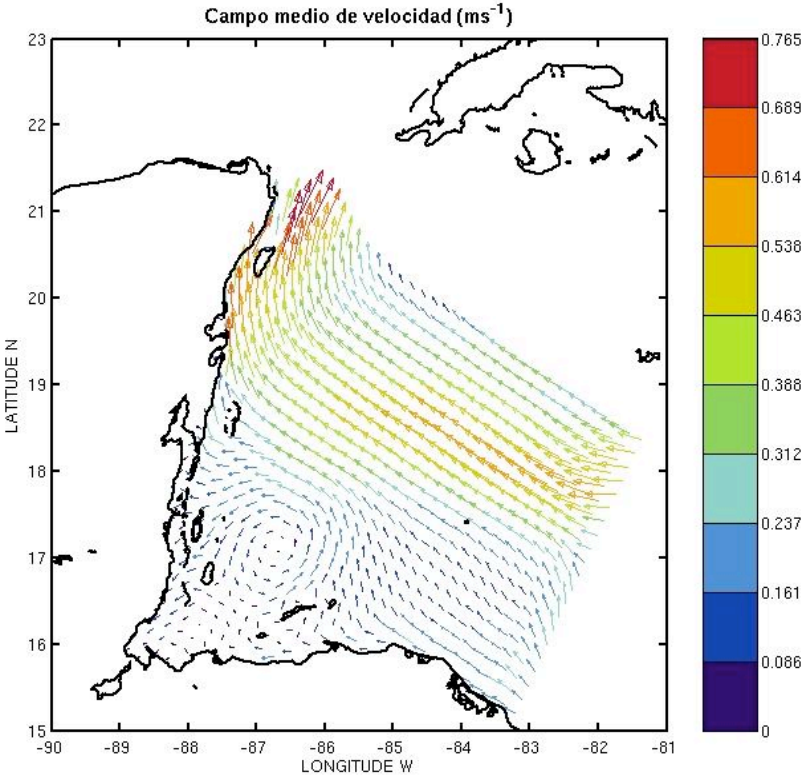




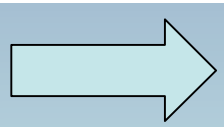
MEAN SURFACE VEL

Climatology





SODA MEAN



OBCS FROM SODA
(Simple Ocean Data Assimilation)
(monthly, 2º x 2º, 6 years)

-Initial Conditions 20 years.

-Forcing NCEP+ QS (R. Milliff)

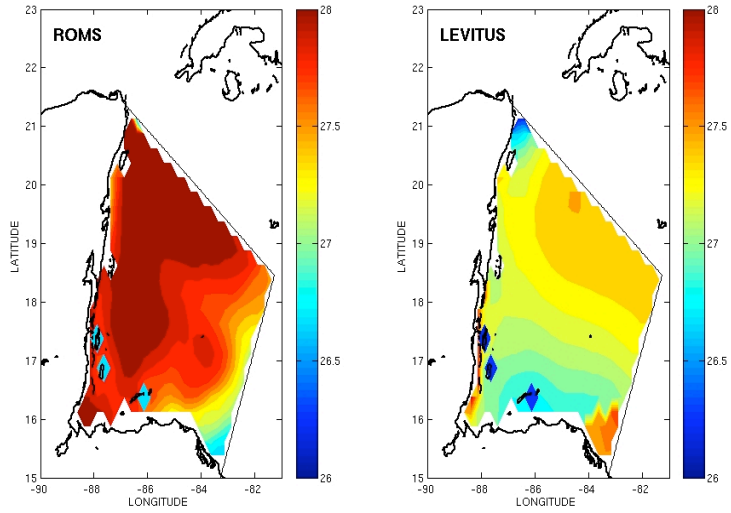
-Comparison vs Climatology

-Temperature averages

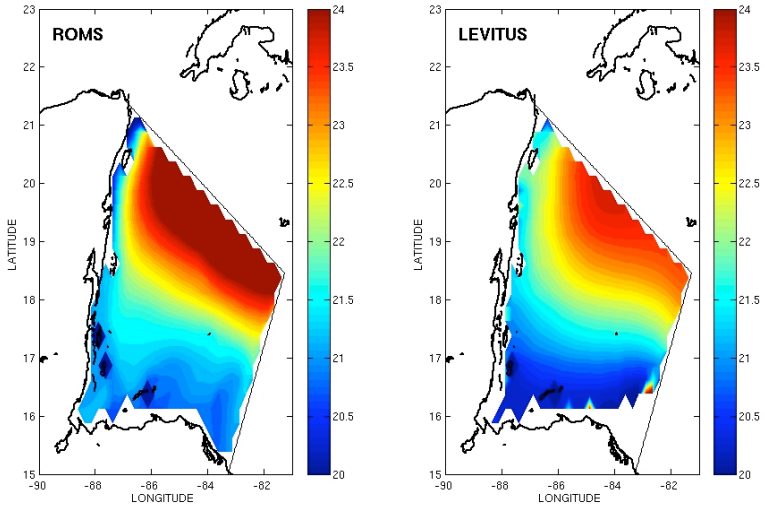
level 1 (0-100 m)
level 2 (125-250 m)
level 3 (300-1000 m)
level 4 (1100-1750 m)
level 5 (2000-3500 m)

-Levitus Climatology (1/4º res)

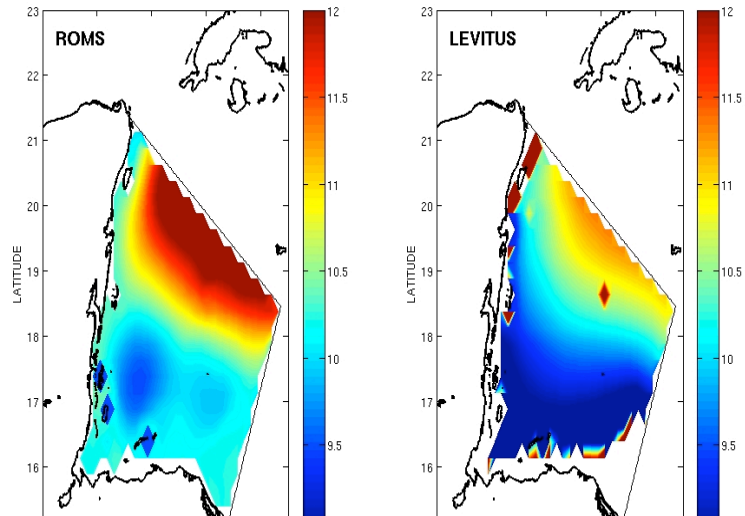
TEMPERATURE - promedio de: 0 - 100 m de prof



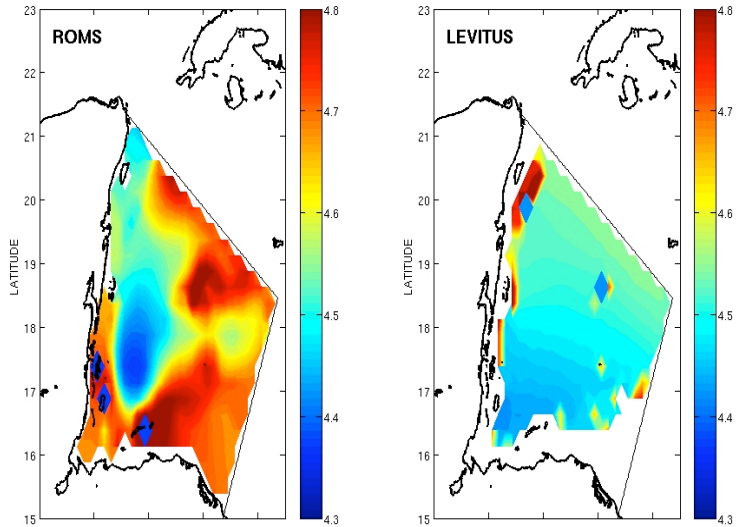
TEMPERATURE - promedio de: 100 - 250 m de prof



TEMPERATURE - promedio de: 250 - 1000 m de prof



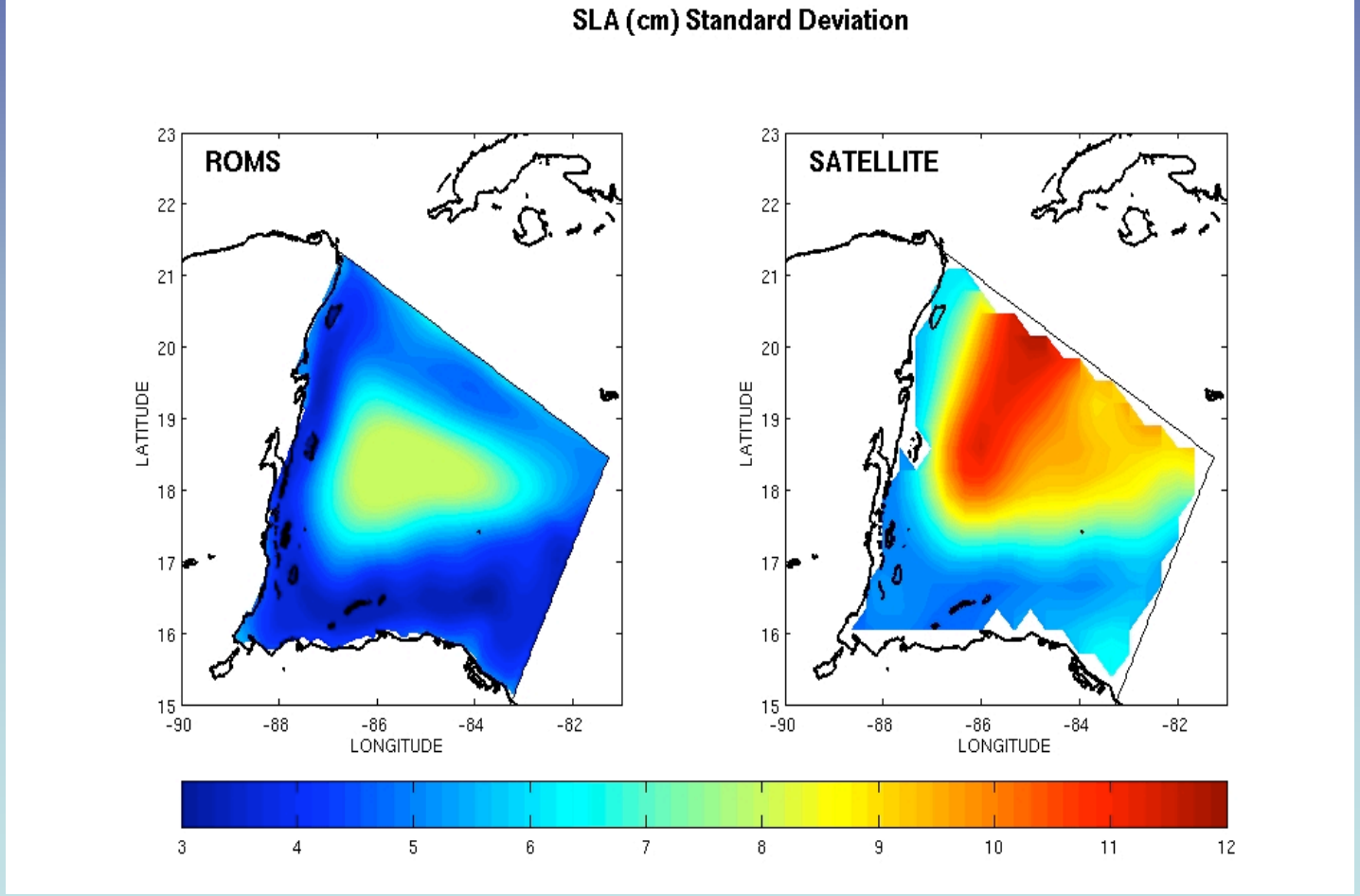
TEMPERATURE - promedio de: 1000 - 1750 m de prof

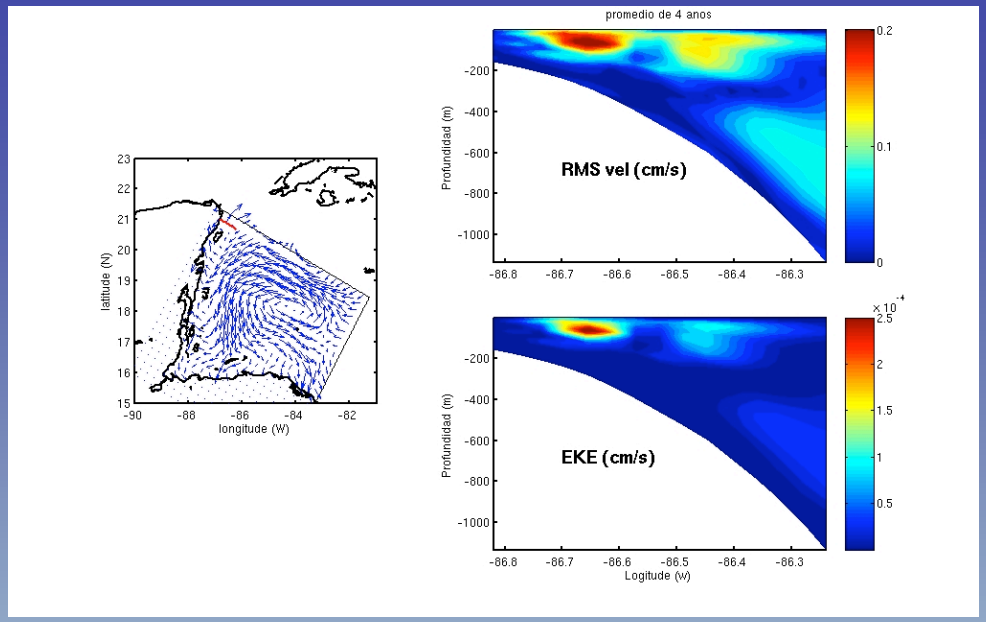


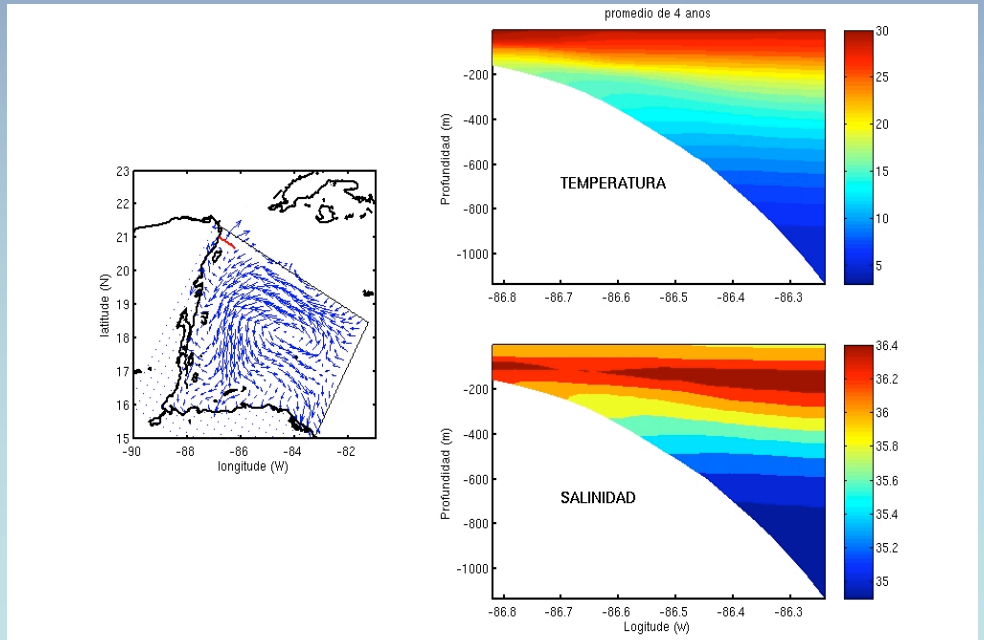
SLA ⇨ ROMS Vs. SATELITE

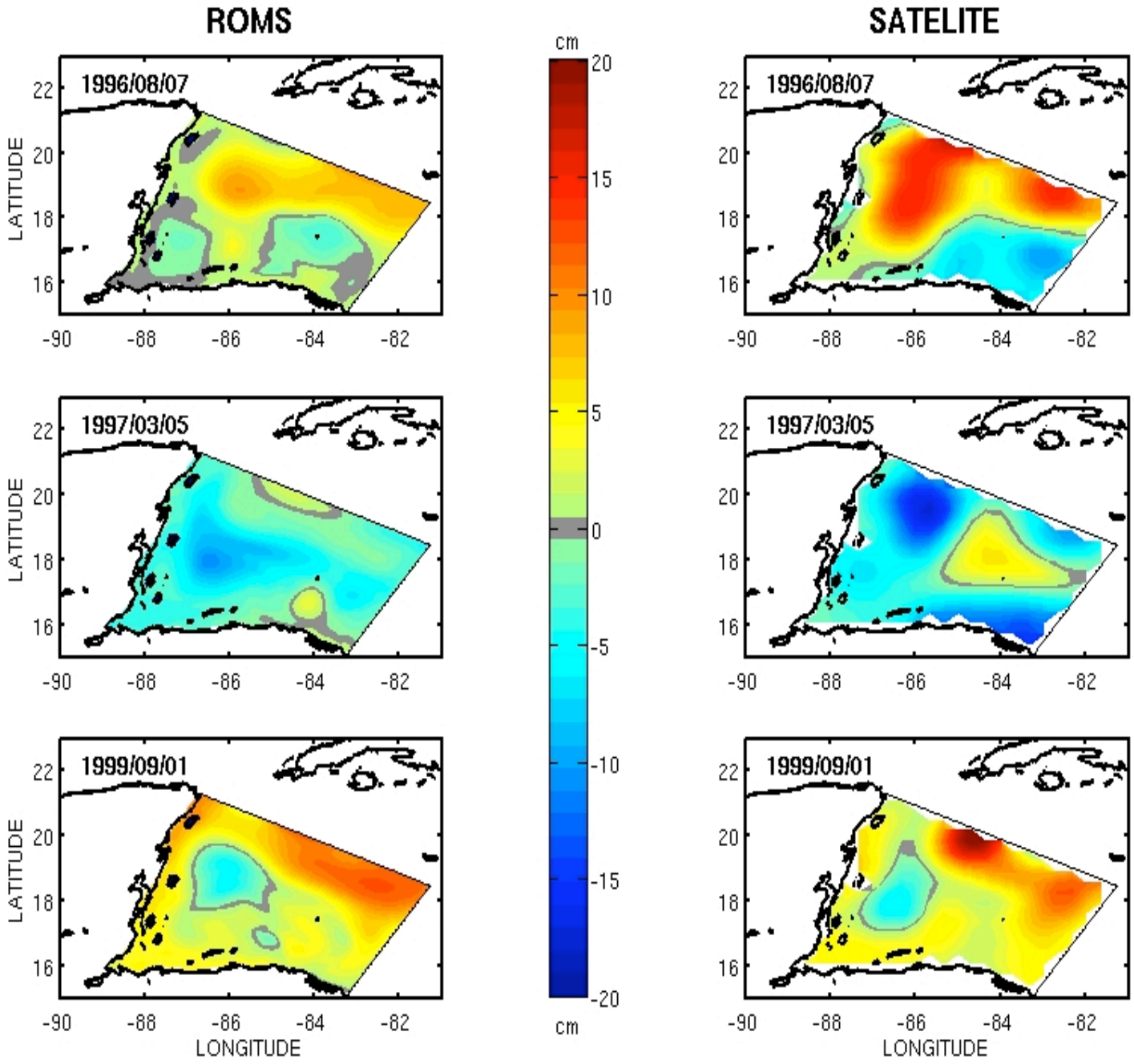
STD – ROMS

STD – SATELITE

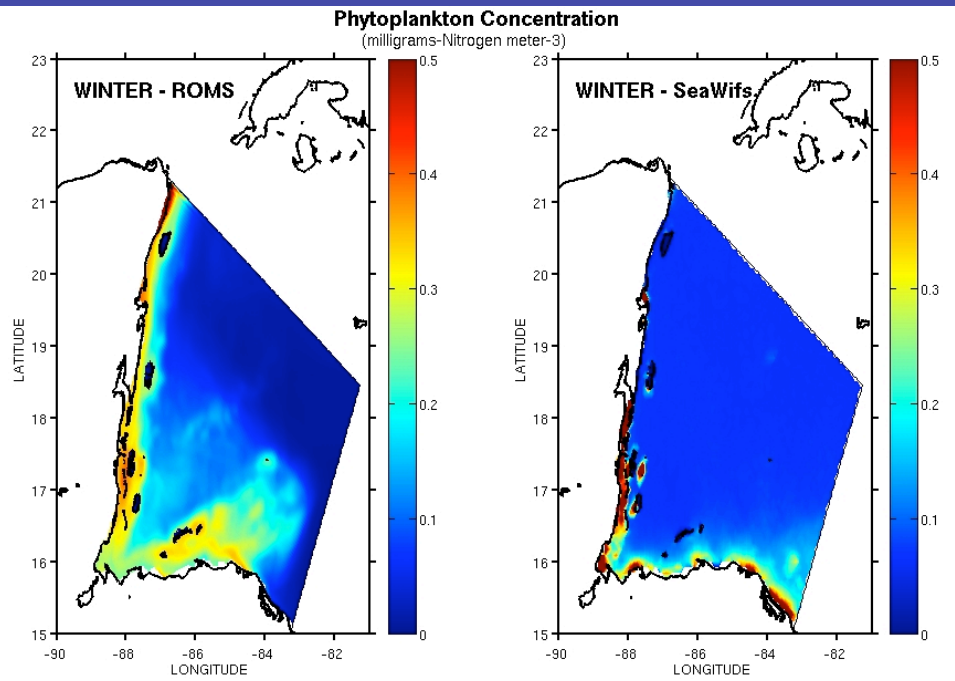



promedio de 4 anos
RMS vel (cm/s)
EKE (cm/s)
Profundidad (m)
latitude (N)
longitude (W)
Logitude (w)


promedio de 4 anos
TEMPERATURA
SALINIDAD
Profundidad (m)
latitude (N)
longitude (W)
Logitude (w)

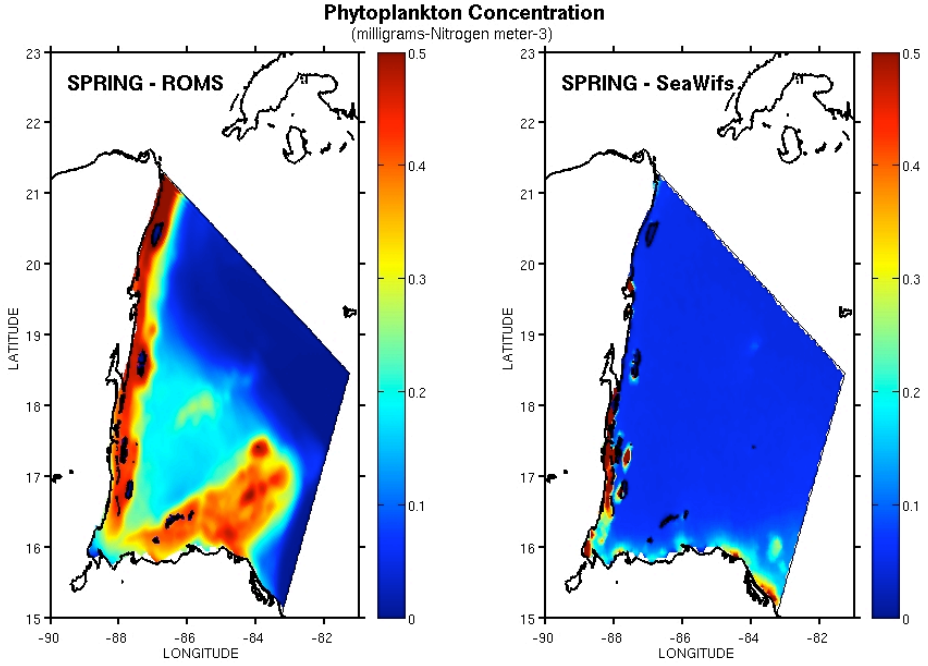

ROMS
SATELITE
1996/08/07
1997/03/05
1999/09/01
LATITUDE
LONGITUDE
22
20
18
16
-90
-88
-86
-84
-82
cm
20
15
10
5
0
-5
-10
-15
-20

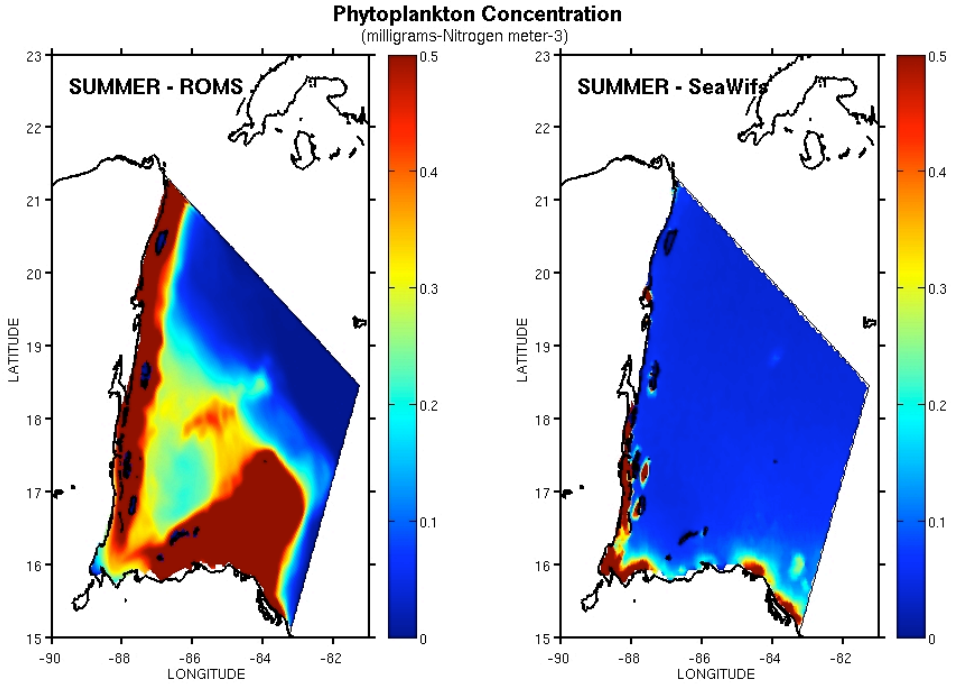
NEMURO:
ROMS VS SeaWifs
Seasonal variability



WINTER

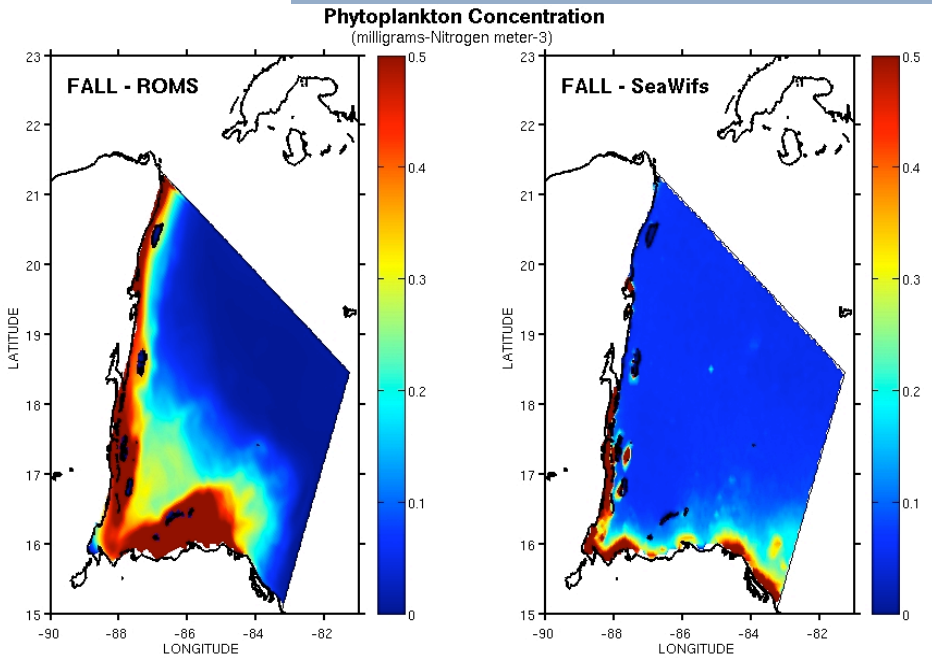
SPRING



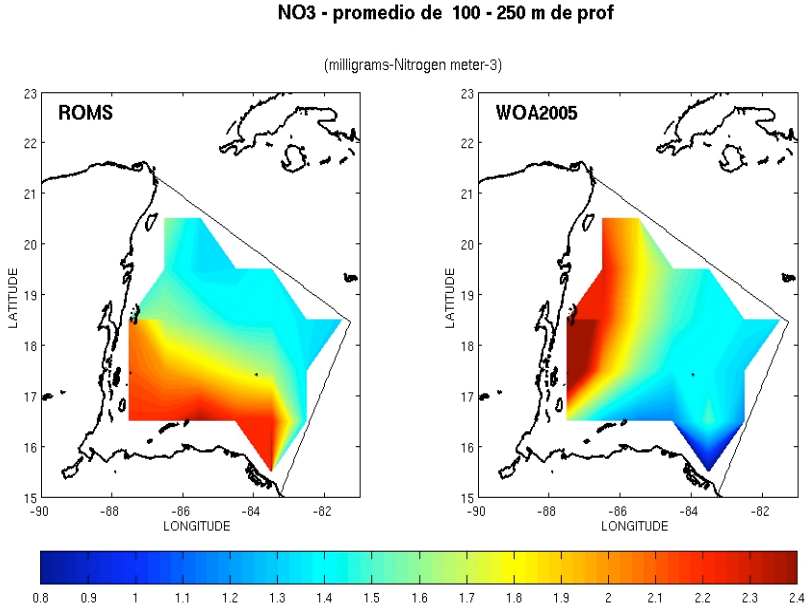

Phytoplankton Concentration
(milligrams-Nitrogen meter-3)
SUMMER - ROMS
SUMMER - SeaWifs
LATITUDE
LONGITUDE
23
22
21
20
19
18
17
16
15
-90
-88
-86
-84
-82
0.5
0.4
0.3
0.2
0.1
0

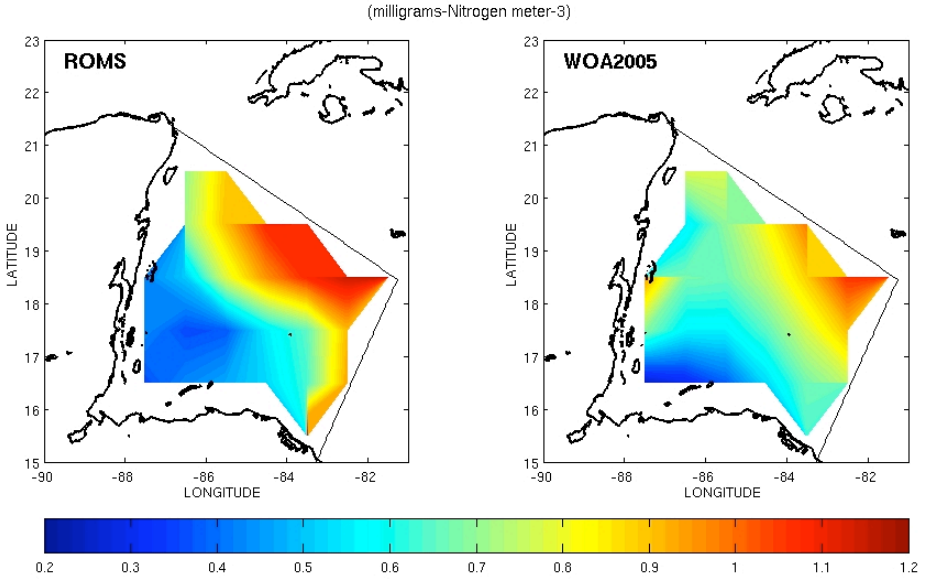
FALL

SUMMER


Phytoplankton Concentration
(milligrams-Nitrogen meter-3)
FALL - ROMS
FALL - SeaWifs
LATITUDE
LONGITUDE
23
22
21
20
19
18
17
16
15
-90
-88
-86
-84
-82
0.5
0.4
0.3
0.2
0.1
0

NO3


NO3 - promedio de 100 - 250 m de prof
(milligrams-Nitrogen meter-3)
ROMS
WOA2005
LATITUDE
LONGITUDE
23
22
21
20
19
18
17
16
15
-90
-88
-86
-84
-82
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
2.1
2.2
2.3
2.4


NO3 - promedio de 250 - 500 m de prof
(milligrams-Nitrogen meter-3)
ROMS
WOA2005
LATITUDE
LONGITUDE
23
22
21
20
19
18
17
16
15
-90
-88
-86
-84
-82
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2

FINAL THOUGHTS…

Goal is to model coastal and open ocean circulation and biological interactions

Steep topography

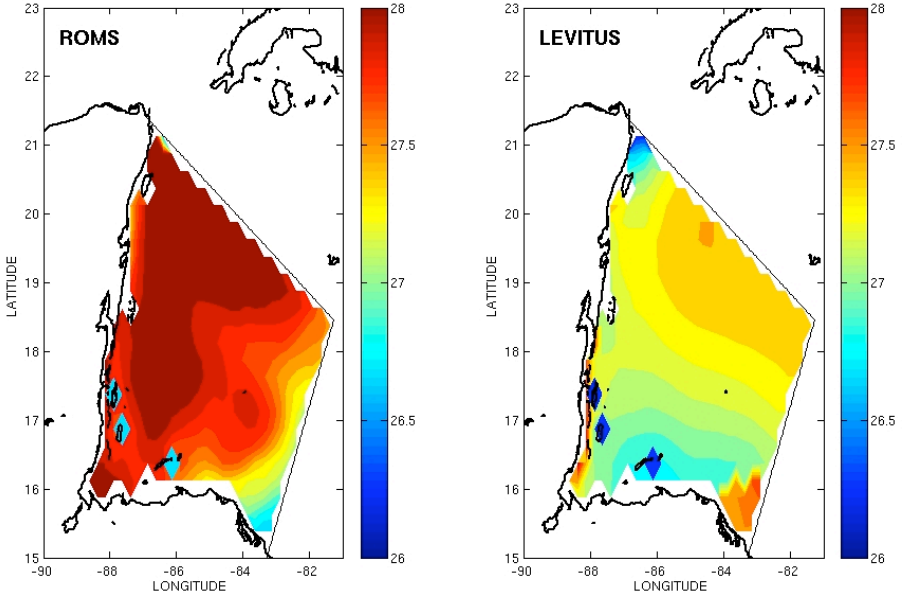
How to model the wind wave breaking on the reef

Horizontal resolution necessary to include vertical Transport associated with eddies

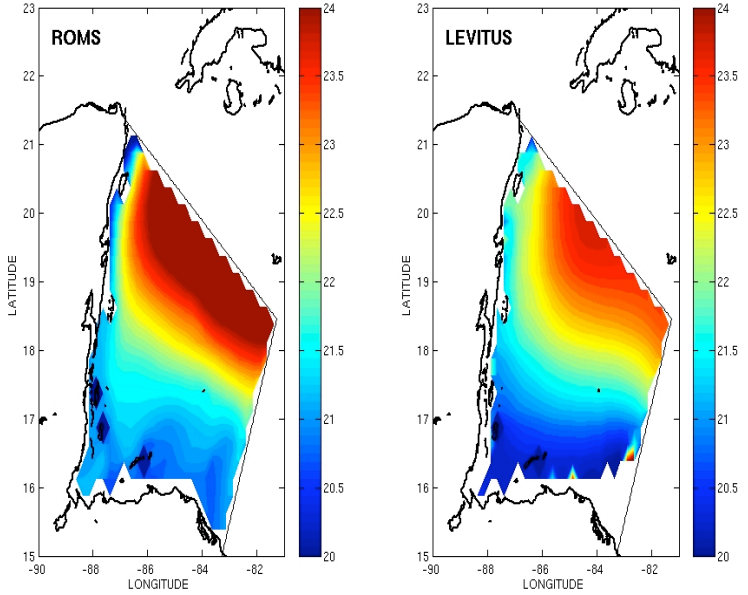
Role of internal tides (?)

STILL A LONG WAY TO GO….

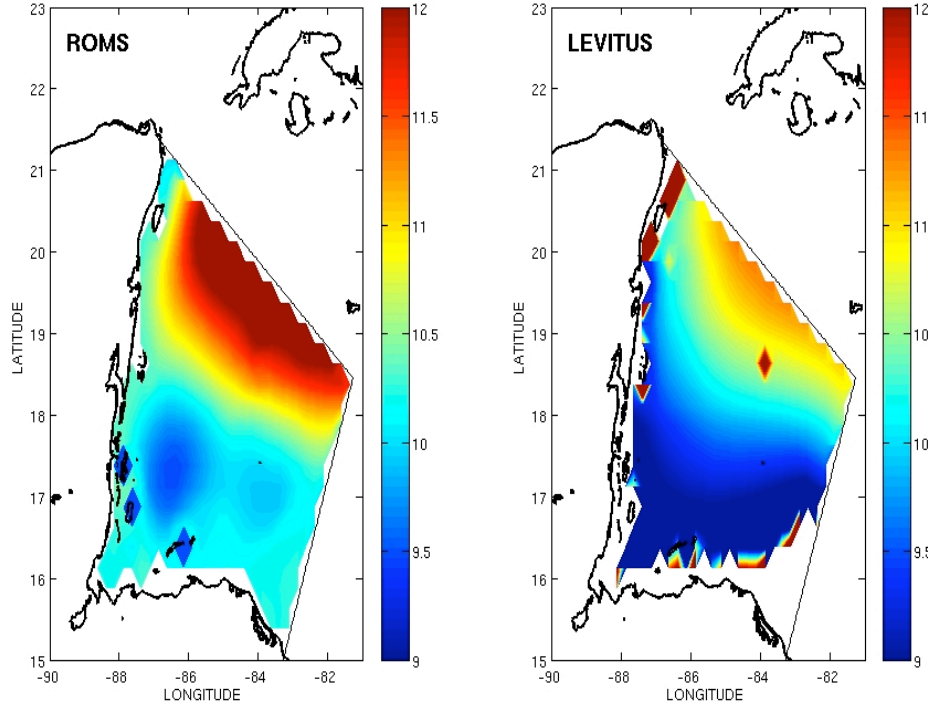
TEMPERATURE - promedio de: 0 - 100 m de prof



TEMPERATURE - promedio de: 100 - 250 m de prof



TEMPERATURE - promedio de: 250 - 1000 m de prof



TEMPERATURE - promedio de: 1000 - 1750 m de prof