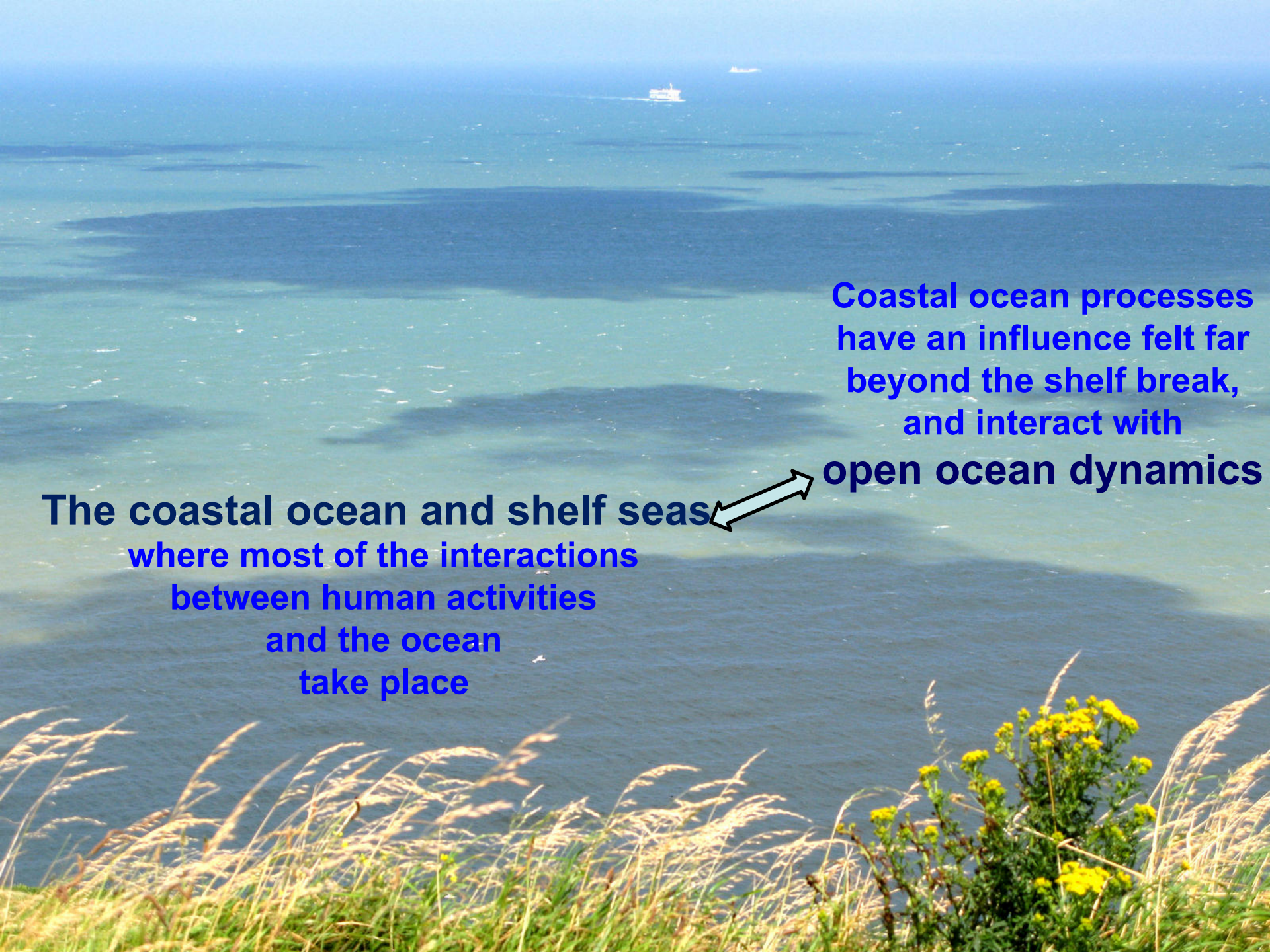
Contributions of Coastal Altimetry to the GODAE/OceanView Coastal and Shelf Seas activities

Villy Kourafalou
University of Miami/RSMAS - USA
Pierre De Mey
LEGOS - France

GODAE OceanView ***COSS-TT co-chairs***


Coastal ocean processes
have an influence felt far
beyond the shelf break,
and interact with
open ocean dynamics
The coastal ocean and shelf seas
where most of the interactions
between human activities
and the ocean
take place

COSS-TT **GODAE OceanView:** long lasting legacy of the Global Ocean Data Assimilation Experiment

- The development and improvement of Ocean Forecasting Systems demands an **international approach**
- GODAE OceanView (GOV) provides a **forum for global/regional/coastal forecasting centers** to communicate and exchange knowledge and expertise
- The COSS-TT is one of the 5 GOV TTs:
  - **Coastal Ocean and Shelf Seas**
  - Intercomparisons and Validation
  - Marine Ecosystem & Prediction
  - Observing System Evaluation
  - Short- to Medium-Range Coupled Prediction

www.godae-oceanview.org

➢2013: GODAE OceanView & WGNE Joint Workshop on Short-to Medium-range coupled prediction for the atmosphere-wave-sea-ice-ocean: Status, needs and challenges, NOAA-NCEP, Washington DC, 19-22/3/13

COSS-TT GODAE/OceanView Coastal Ocean and Shelf Seas Task Team

No	Name	Institutions/projects	Country
1	Barth, Alexander	University og Liège / GHER	EU-Belgium
2	Chao, Yi	UCLA	USA
3	Chassé, Joël	DFO / St Lawrence-Newfoundland	Canada
4	Cirano, Mauro	REMO	Brazil
5	De Mey, Pierre (Co-chair)	CNRS / LEGOS / SAF-COSS	EU-France
6	Dumas, Franck	IFREMER / Previmer	EU-France
7	He, Ruoying	NCSU	USA
8	Herzfeld, Mike	CSIRO /ROAM / CLAM-TC	Australia
9	Hirose, Naoki	Kuyushu University	Japan
10	Jianping, Gan	Hong Kong University of S&T	China
11	Kourafalou, Villy (Co-chair)	University of Miami / RSMS / NOPP GODAE-HYCOM	USA
12	Kurapov, Alexander	Oregon State University / COAS	USA
13	Lui, Guimei	NMEFC	China
14	O'Dea, Enda	Met Office	EU-UK
15	Oddo, Paolo	INGV / ADRICOSM	EU-Italy
16	Oey, Leo	University of Princeton / POM	USA
17	Patchen, Richard	NOAA / NOS	USA
18	Pinardi, Nadia	University of Bologna / INGV	EU-Italy
19	Richman, Jim	NRL / SSC	USA
20	Stanev, Emil	HZG / German Bight	EU-Germany
21	Zhu, Jiang	IAP/CAS	China

- The Coastal Ocean and Shelf Seas Task Team (COSS-TT) continues the action of the GODAE Coastal and Shelf Seas Working Group (2006-2009):
  - De Mey, P., and R. Proctor, 2009 : Assessing the value of GODAE products in coastal and shelf seas. Editorial, Special Issue of Ocean Dynamics, 2007 GODAE Coastal and Shelf Seas Workshop, Liverpool, UK. *Ocean Dynamics,* **59,** 1–2, DOI 10.1007/s10236-008-0175-0.
  - De Mey, P., P. Craig, F. Davidson, C. A. Edwards, Y. Ishikawa, J. C. Kindle, R. Proctor, K. R. Thompson, Jiang Zhu, and the GODAE Coastal and Shelf Seas Working Group (CSSWG) community, 2009 : Applications in coastal modelling and forecasting. *Oceanography Magazine,* **22,** 3, 198-205.
- The 1st international COSS-TT workshop took place in Jan 2012 (Miami, USA).
- The 2nd international COSS-TT workshop is scheduled for February 2013 (Lecce, Italy).

GODAE OceanView

COSS-TT

Coastal Ocean and Shelf Seas-TT: Strategy and priorities

- Strategic goal: help achieve a seamless framework from the global to the coastal/littoral scale.

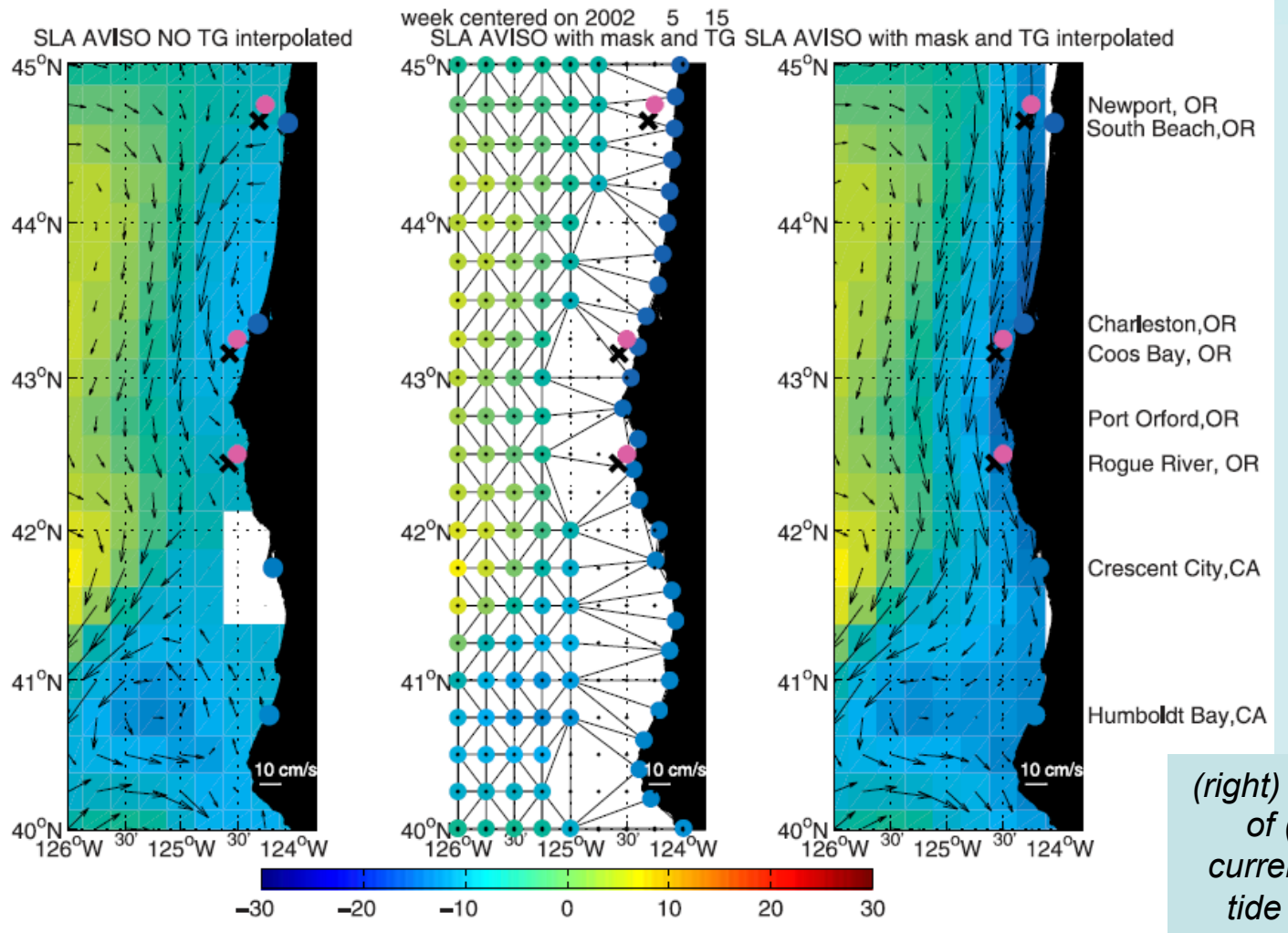
- Primary objectives: the scientific coordination of (ongoing) Coastal Ocean Forecasting Systems and the advancement of the related scientific methodologies in modeling, monitoring and data assimilation.

- Framework: working in coordination with GODAE OceanView and other international initiatives related to ocean observing systems, data assimilation and prediction, toward the provision of a sound scientific basis for sustainable multidisciplinary downscaling and forecasting activities in the world coastal oceans.

➢ Under this framework, a
close synergy with the Coastal Altimetry community
is essential.

Coastal Altimetry: recent developments important for COSS systems

- **Improving 2D maps:** examples (1)
  - by using tide gauges along the coast *(Saraceno et al., 2008, Wang et al., 2011)*



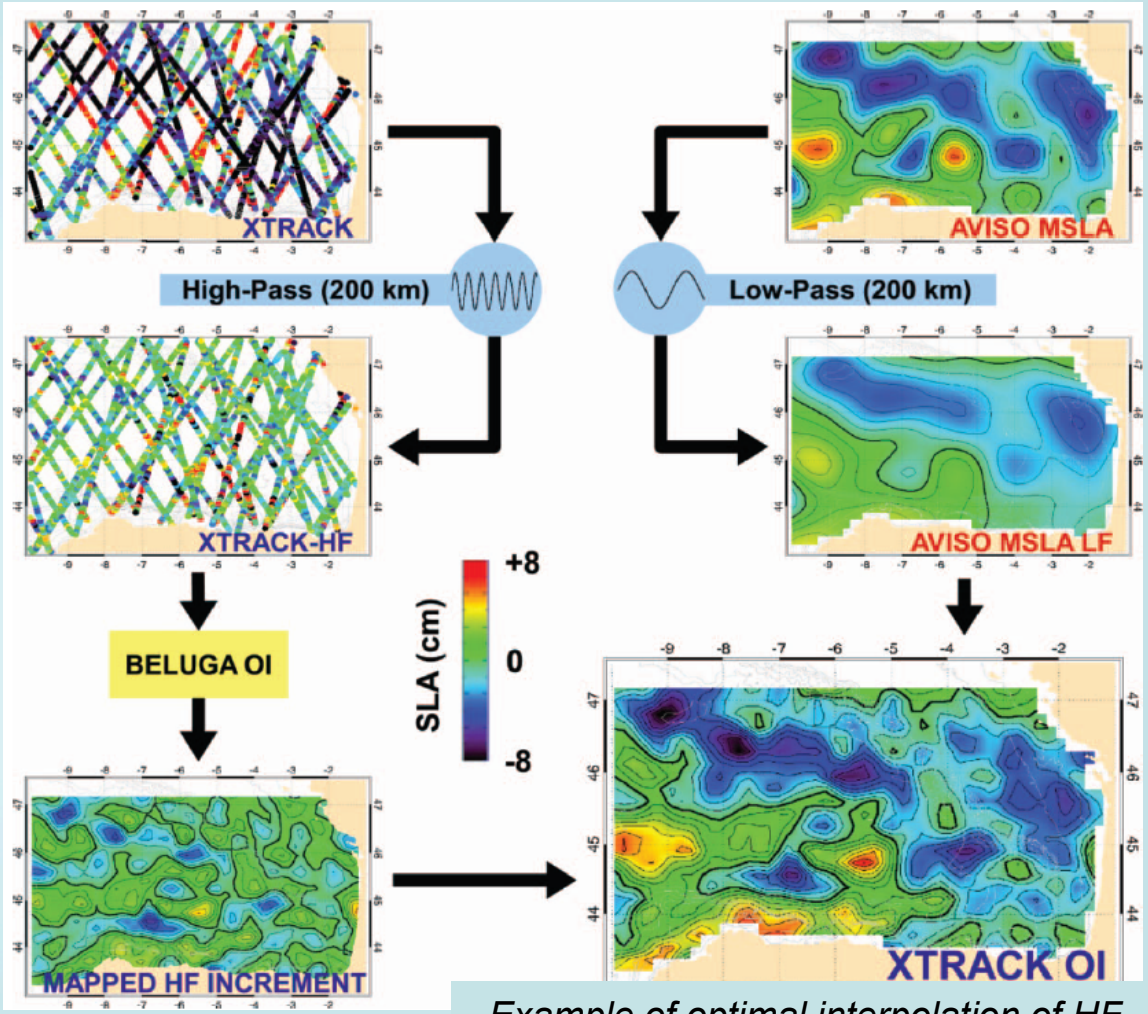
(right) Example of interpolation of (left) AVISO SLA and currents based on the use of tide gauges data (middle). From Saraceno et al., 2008.

⇒ Improved along-shore currents

Coastal Altimetry: recent developments important for COSS

➢**Improving 2D maps:** examples (2)

• by using **shorter correlation scales**, in combination with **multi-mission** dataset



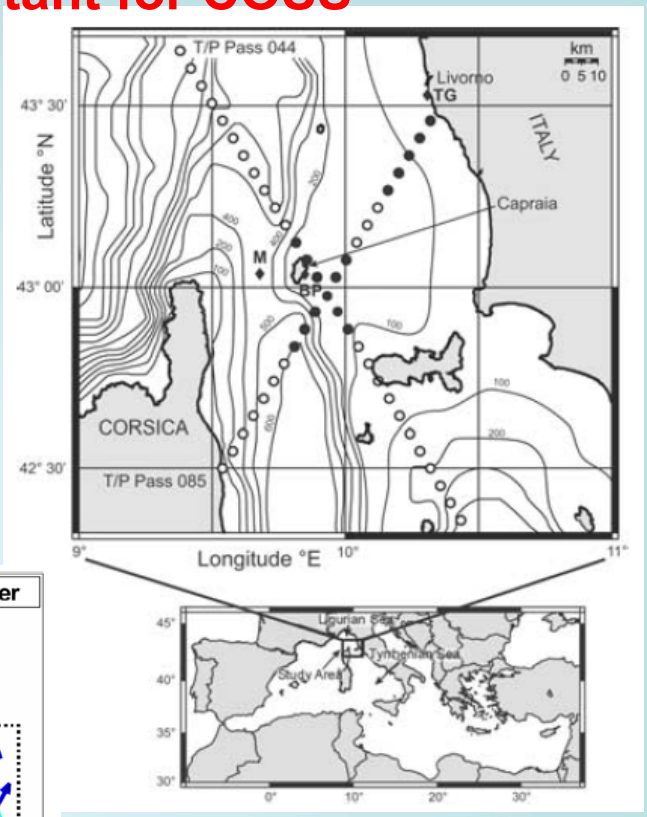
Example of optimal interpolation of HF along-track data to access mesoscale dynamics. (Dussurget et al., 2011).;

➢ *3 or more altimeters required*

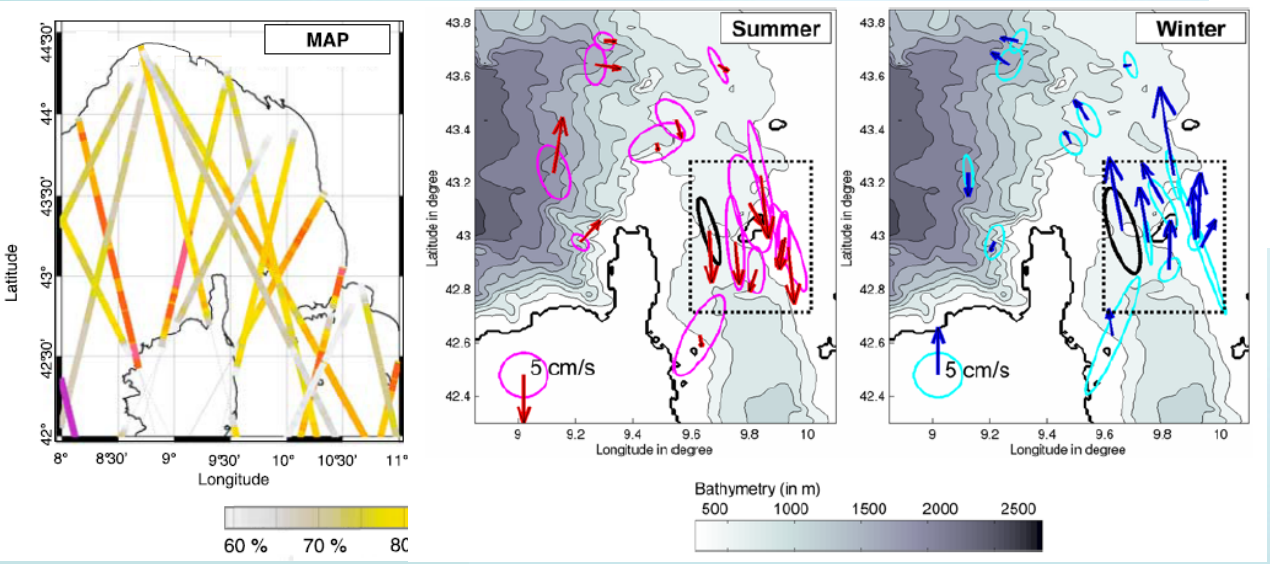
Coastal Altimetry: recent developments important for COSS

➢ **Improving along-track data:** examples (1)

- use of raw data with **improved data flagging**: retrieve steric signal in SLA
- improved **tidal** and **atmospheric** corrections: currents at seasonal scale
- use of **high resolution** data (10, 20 Hz)



Methodologies developed around the Capraia Island. (Vignudelli et al., 2005).



Improvement of data coverage in the Capraia Island area. (Bouffard et al., 2008)

Estimation of the geostrophic velocity anomalies. (Bouffard et al., 2008)

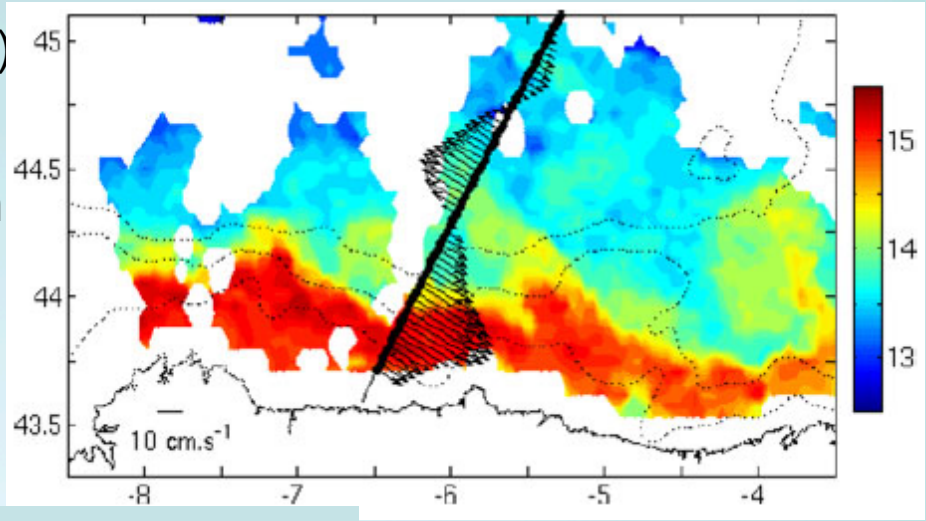
Coastal Altimetry: recent developments important for COSS systems

➢ **Improving along-track data:** examples (2)

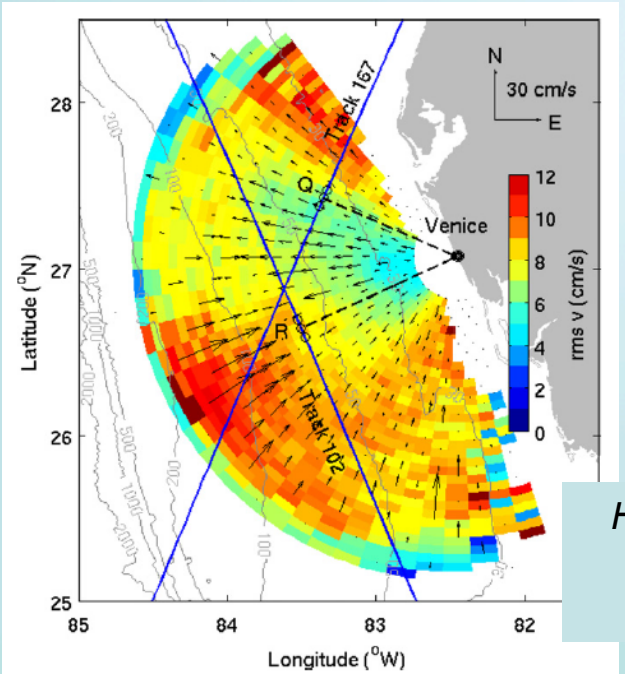
• Bay of Biscay (NE Atlantic): characterization of the **Navidad Current** (North of Spain)

• India: study of the **East India Coastal Current** (EICC)

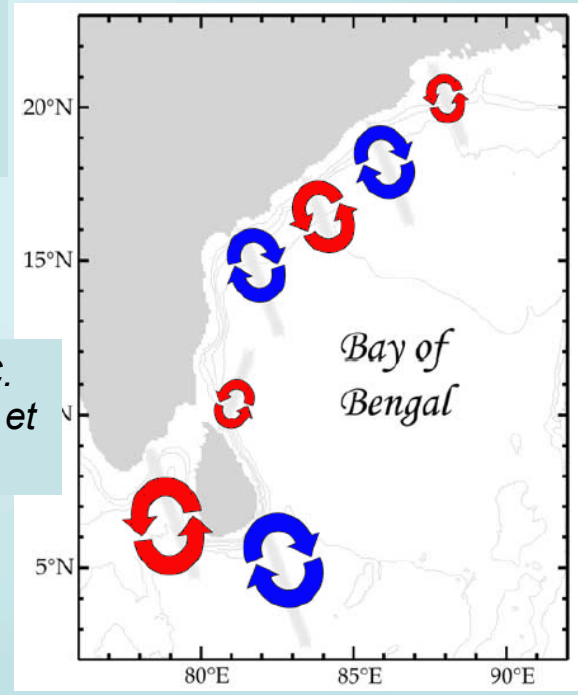
• West Florida Shelf: **performance assessment** over a wide shelf



Signature of the Navidad Current in along-track geostrophic current anomaly and SST. (Le Hénaff et al., 2011).



HF radar radial velocity with satellite tracks (Liu et al., 2011)

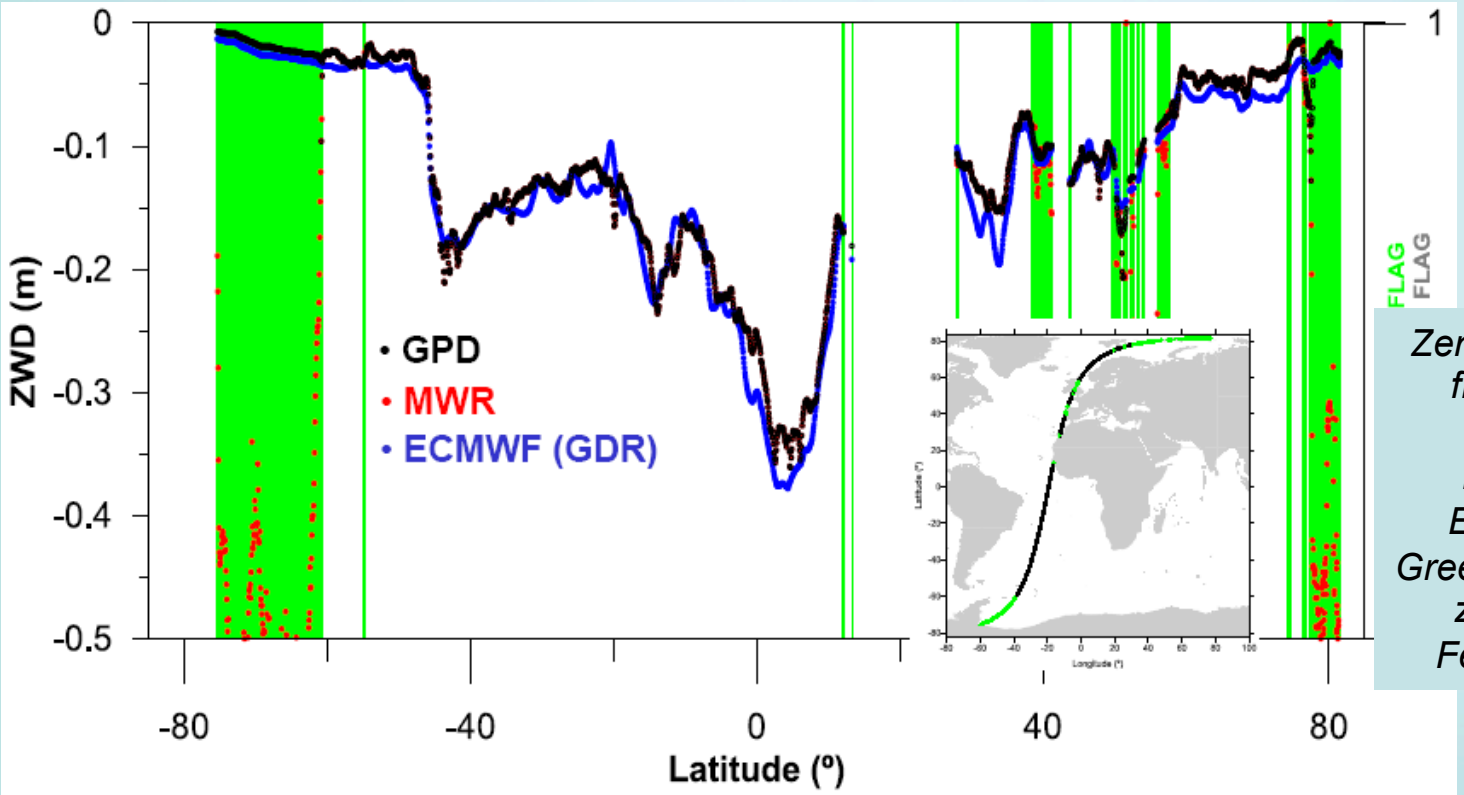


Structure of the EICC. (Adapted from Durand et al., 2009).

Coastal Altimetry: recent developments important for COSS systems

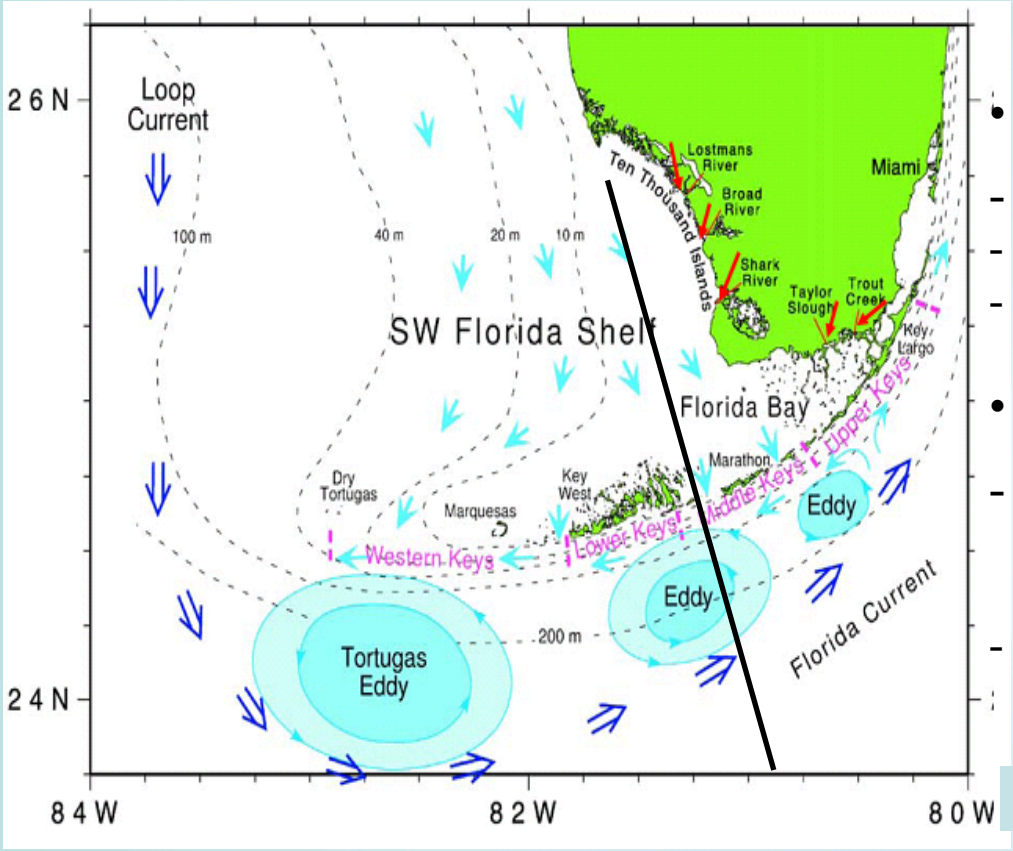
➢ **improving along-track data:** examples (3)

- **waveform** analysis (PISTACH, COASTALT)
- **wet tropospheric** correction (PISTACH, COASTALT):
  - better account for **land in the altimeter footprint** *(Desportes et al., 2007)*
  - combine altimeter **radiometer** measurements, **local measurements** and improved **atmospheric models** *(GPD product, Fernandes et al., 2010)*



Zenith wet delay (ZWD, m) from the GPD method (black), the inboard radiometer (red) and ECMWF model (blue). Green area are polar/coastal zones. (Adapted from Fernandes et al., 2011).

Example of CA and COSS synergy : prediction around the South Florida Coastal and Shelf Seas



- **Complex topography**

- **broad** SW Florida **shelf** and Florida Bay
- **narrow** Atlantic Florida Keys **shelf**
- **deep** Straits of Florida

- **Complex dynamics**

- **shelf flows & coastal currents:**
  wind-driven & buoyancy-driven
  (river runoffs, **Earth System framework**)
- intense **coastal to offshore** interactions:
  Florida Current front and **eddies**

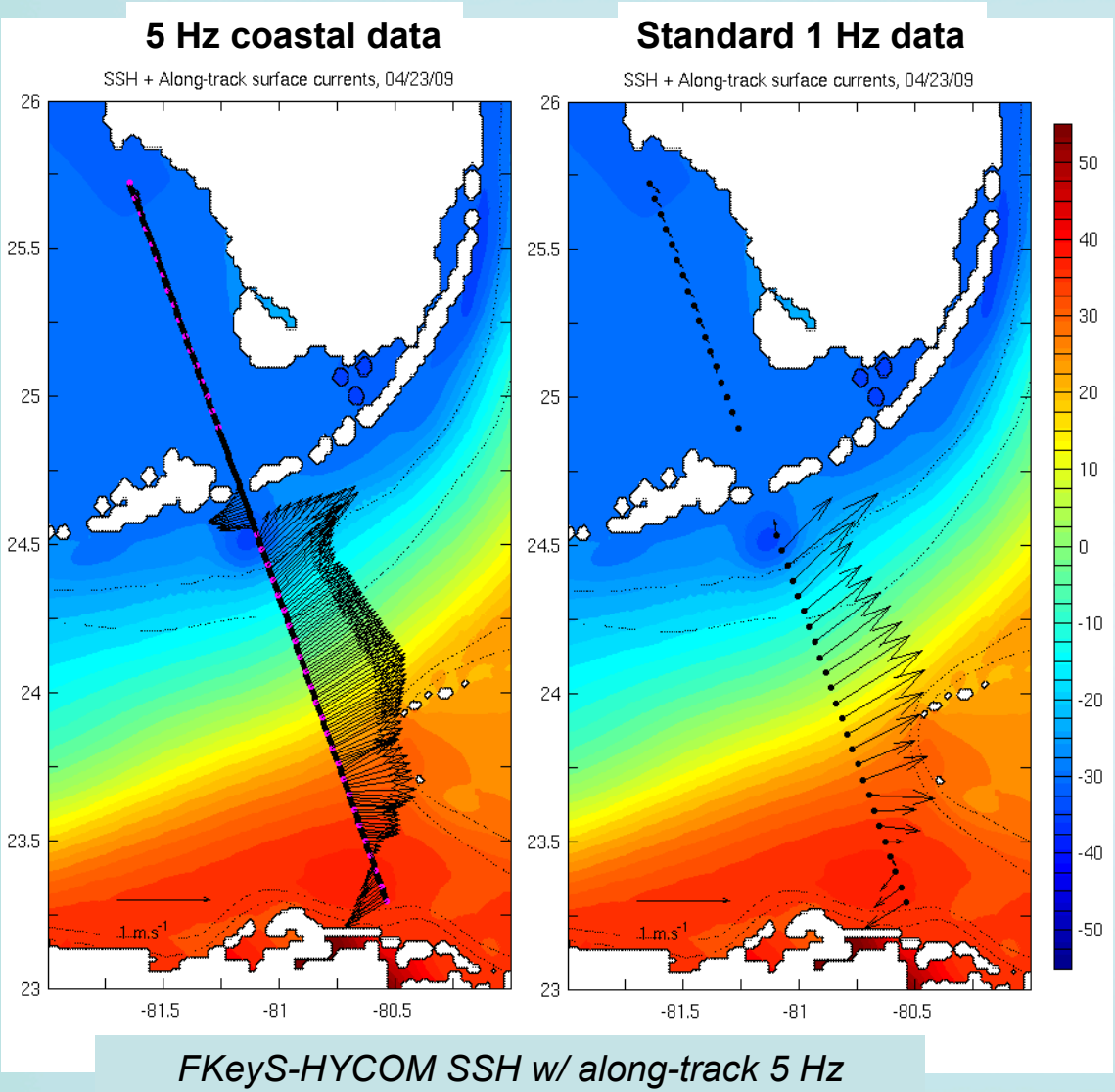
Adapted from Lee et al., 2002.

- ***Jason*** *track 102 is perfectly oriented:* ***perpendicular*** *to bathymetry and main current*
- ***Data available*** *from PISTACH, CTOH, COASTALT*

COSS Prediction system: high resolution (900 m) FKeyS-HYCOM model nested in regional (3.5 km) GoM-HYCOM model

http://coastalmodeling.rsmas.miami.edu

Example of CA and COSS synergy: resolve features crucial in forecasting



FKeyS-HYCOM SSH w/ along-track 5 Hz surface currents (left) and 1 Hz currents (right)

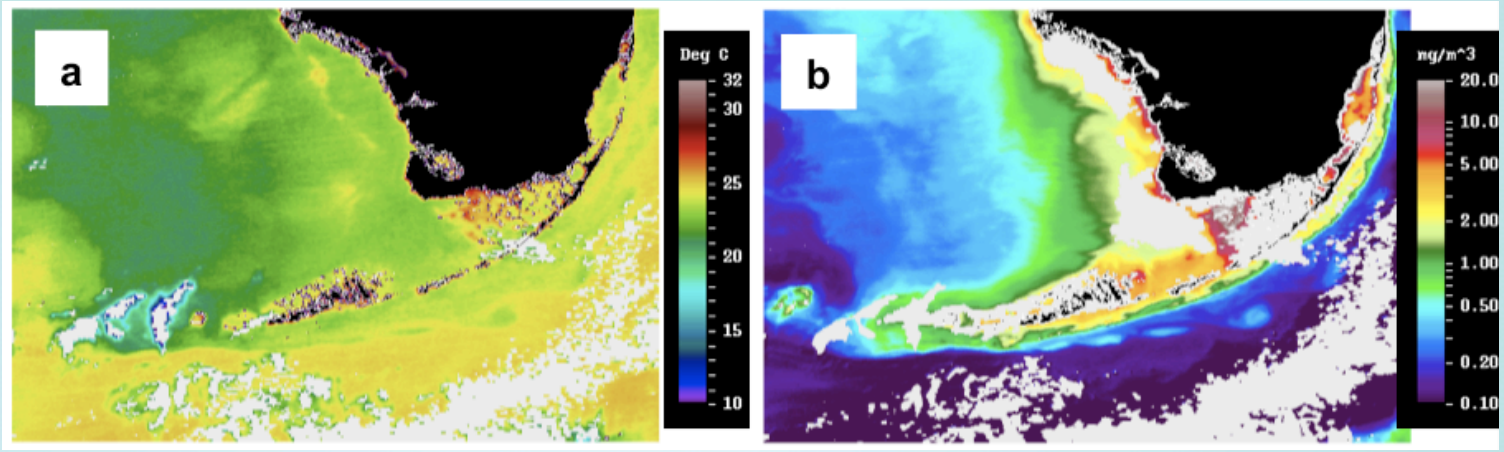
- Coastal altimetry is able to observe **meso-scale eddies** along the Keys island chain
(crucial for circulation and transport, physical and biological connectivity)

- Standard altimetry **misses** such eddy features
(significant value added from CA)

=> The detection of small frontal eddies in CA is possible thanks to:
- **data availability** closer to the coast
- **high rate** data

Kourafalou et al., 5th CAW

Example of CA and COSS synergy: observing strategies

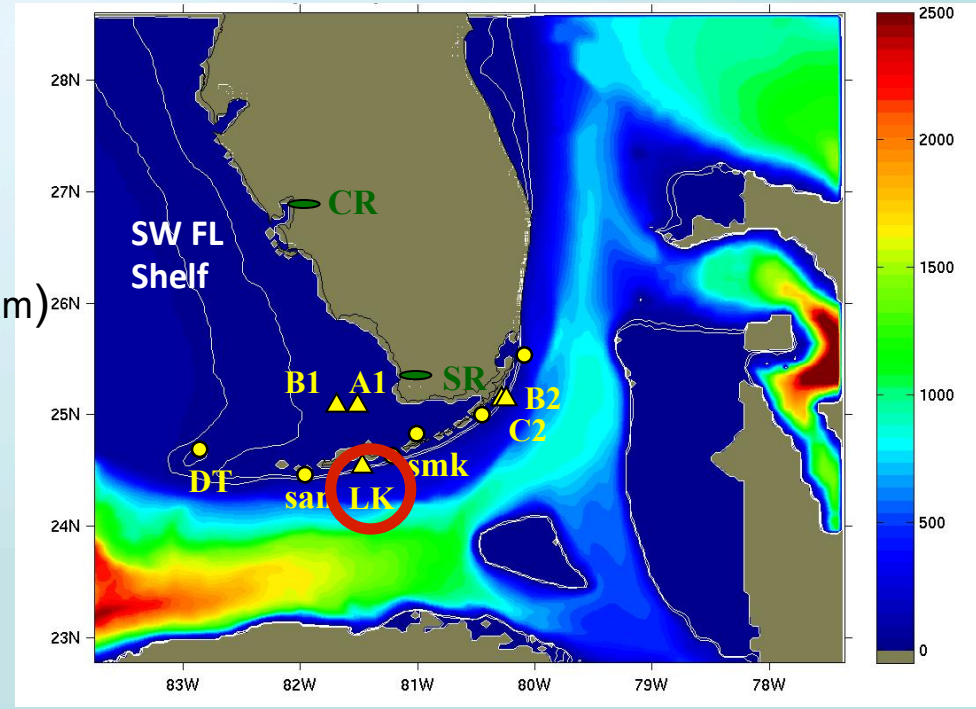


MODIS-A SST and chl-a (C. Hu, USF/IMARS)

➢ **Validation** using ancillary data sets:

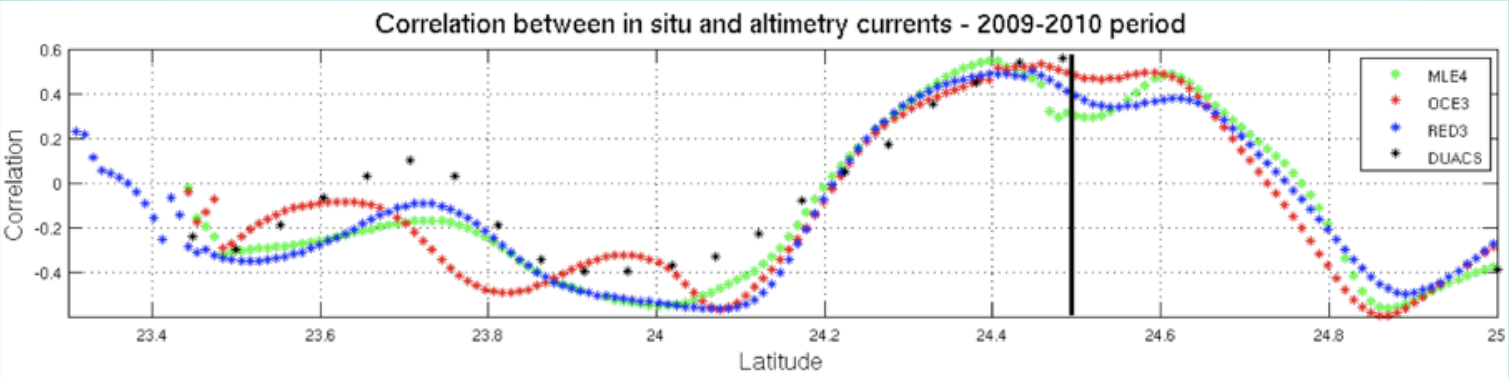
▪ **high resolution** ocean color and/or SST **maps** (GHRSST)

▪ **in-situ ADCP data** (Looe Key, 30km upstream)



Location of S. Florida in-situ moorings (UM/RSMAS and NOAA/AOML)

Example of CA and COSS synergy: CA product evaluation and applications



Correlation between *in situ* current (Looe Key, marked by vertical black line) and Jason-2 GCA along the reference track:

a) PISTACH data from 3 waveform analyses (standard MLE, green; coastal dedicated OCE3, red; RED3, blue) and

b) standard along-track altimetry data (DUACS, black).

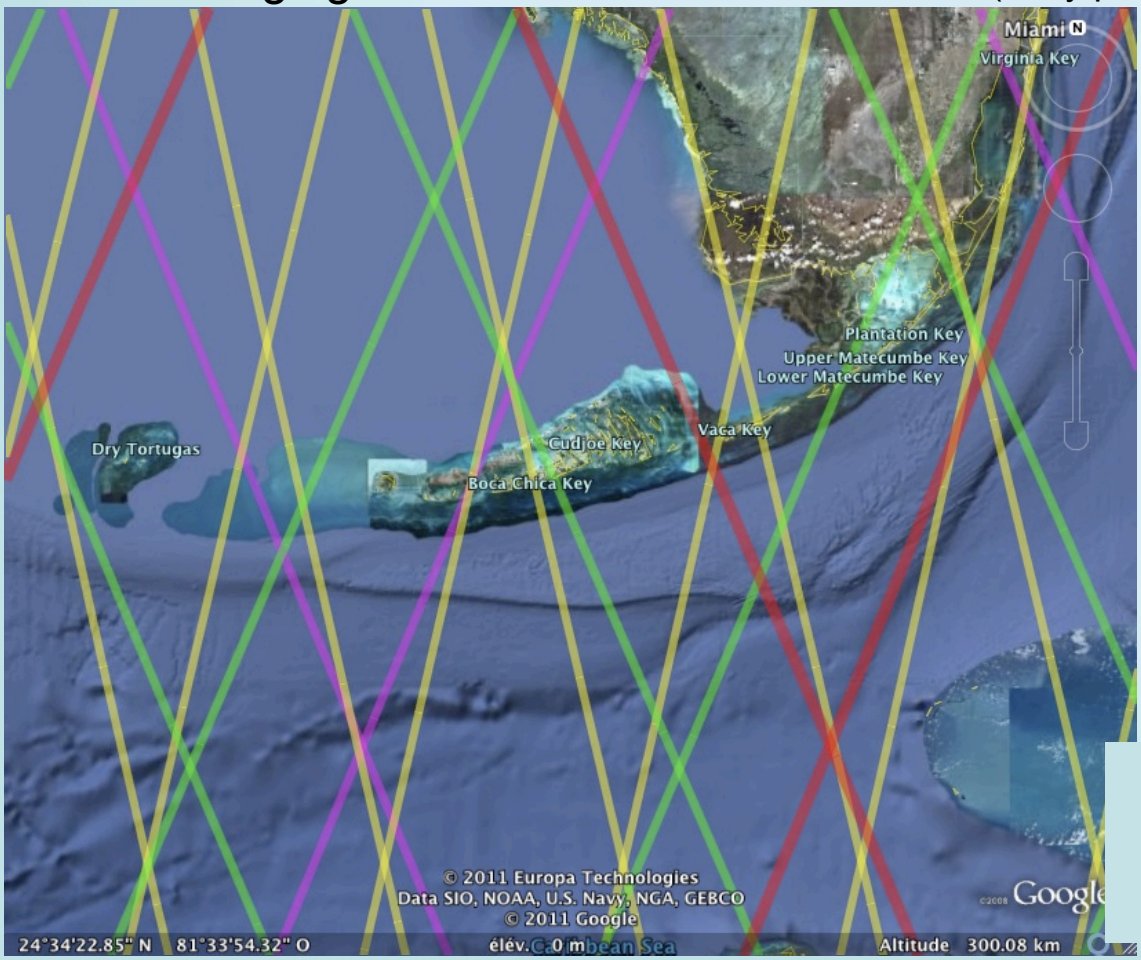
Cancet et al., 5th CAW

CA : PISTACH group
In situ: NOAA-AOML and UM/RSMAS

Example of CA and COSS synergy: monitoring requirements

- What are the desired outcomes from CA datasets?
- medium to long-term **trends** (long time series)
- isolated **events** (when simultaneously detected with other data sources)
- **limitation**: one track every 10 days (Topex-Jason orbit)

  -> challenging to observe short-term events (eddy passage, wind burst current)



Location of Jason 2 (red), Jason 1 (magenta), Envisat (yellow) and GFO (green) tracks.

… but with **multi-satellite**: more opportunities for detection

Potential for feedback from COSS to CA

➢ Relevant data developments

• **mean sea surface** (several datasets)

• **dynamic atmospheric** correction (DAC):

- signal due to **wind** and **pressure** removed with **barotopic model** *(Carrère and Lyard, 2003)*

- global model **real-time products**(delayed-time?;regional real time model developments?)

• **tidal** correction:

-global tidal model in many zones; nested high-resolution DA **regional model** *(G. Egbert, 5th CAW)*

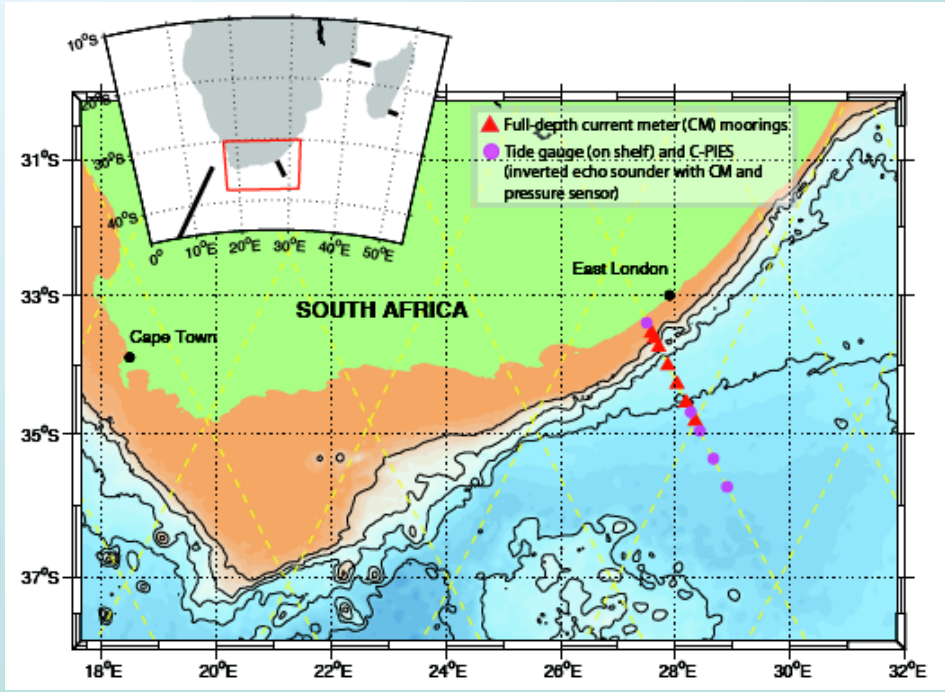
- along-track **harmonic analysis**

➢ Model contributions needed

• CA corrections/upgrades must be **evaluated**

• COSS systems offer an excellent **testbed**!

• best way forward: **common planning**



Configuration of in-situ moorings array under a Jason track. (Beal et al., 2009)

CA and COSS synergy: challenges to address

➢ **Evaluate the CA contribution to COSS hindcasts and forecasts**

- short-term: compare the **physical content** of models and observations *(need complementary data)*

- long-term: **assimilate** the data and quantify their impact on model simulations

➢ Existing **issues** with Data Assimilation in COSS areas:

- **Coastal and Shelf Seas**: superposition of **multiple scales**

⇒ **adapt the DA strategy**: observation data treatment and covariance scales *(Yi Chao, 5th CAW)*
⇒ use **multivariate DA** to constrain the model *(A. Kurapov; 5th CAW)*

- **Coastal and Shelf Seas**: assimilate SLA in the presence of **tides**

(large signal on shelf areas; **largest** tidal model **errors)**

√1st idea: **remove** tidal signal from the model before assimilating de-tided SLA *(Xie et al., 2011).*
How can we optimize such filtering? Do we lose some information?
Can we use that information directly? *(the tidal signal is included in the altimetric data)*

√ 2nd idea: **correct the tidal boundary forcing** *(Barth et al., 2011, HF radar);*
Do we need to correct bathymetry? *(Mourre et al., 2006)*

- **Coastal and Shelf Seas**: assimilate CA products in coupled **circulation-waves** models

address the consistency between altimetry estimates of roughness and model estimates of waves, wave action and vertical turbulence.

Going forward: Synergy between the CA and COSS communities

Main point: **COSS systems and applications offer an excellent testbed for the evaluation of ongoing CA product updates**

➢ **Specific CA achievements that can benefit COSS:**

- **2D:** extend SLA to the coast, improve the resolution
- **along-track:** validation, derive geostrophic current in poorly sampled areas (still a big effort for the assessment; need collaboration between users and data providers)

➢ **New modeling strategies:**

- The COSS community needs to become familiar with CA products, give feedback to data providers *(short term*); develop suitable assimilation techniques and quantify value added in coastal forecasts *(long term)*
- The COSS community must demonstrate this capacity to the global modeling community, so that operational model products used for boundary conditions of COSS systems also invest in the new CA products and eventually include them in their assimilation data stream

➢ **Benefits to the CA community:**

- Better access to *in situ* data (used/maintained by COSS groups)
- Observing system requirements can be derived in synergy (benefit for SWOT)