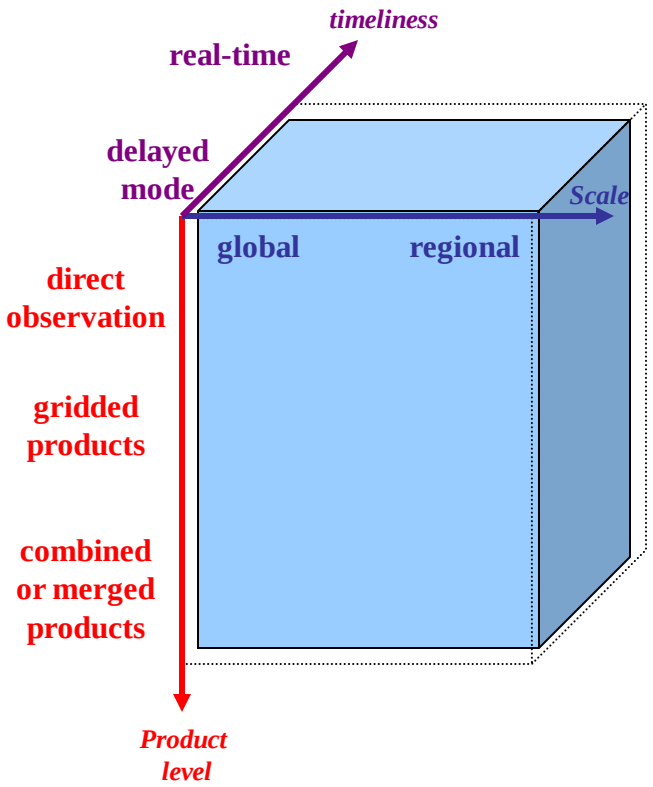
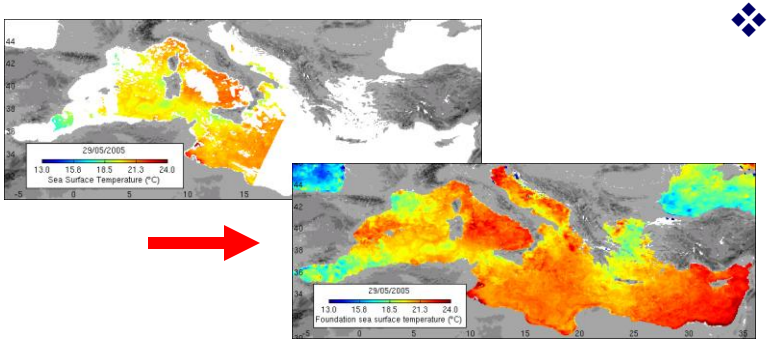
Data Integration and Products

- A. Bingham, F. Collard, C. Donlon, J. Johannessen, J.-F. Piollé
- CWPs Bourassa et al., Cippolini et al., Dohan et al., Donlon et al., Goni et al., Lagerloef et al., Scott et al.

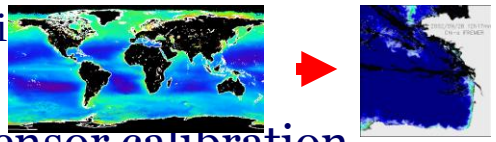
- Realizing the (full) potential …

Level 1 to Level 4





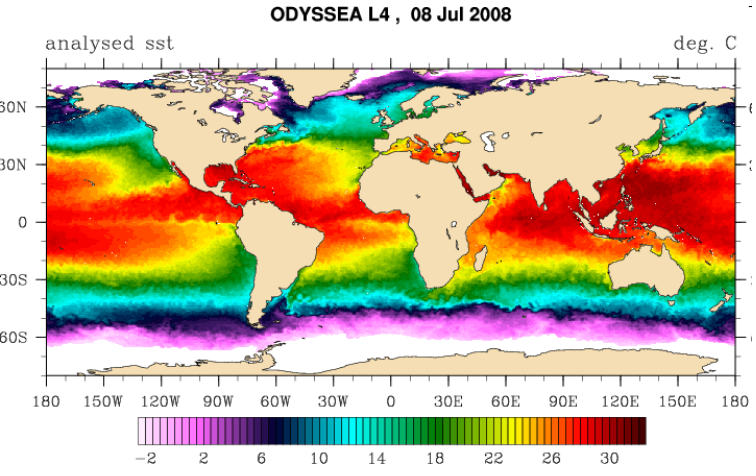
- Start with level 1 and 2 swath data
  - ✓ Sensor physics, retrieval algo, cal/val activities,…
  - ✓ Can serve a wide range of needs but not always convenient (data volume, sensor patterns,…)
- Developping synoptic products Level 3
  - ✓ Gap free, fix grid, small volume, long-time series
  - ✓ Wider range of users, forcing fields
  - ✓ Sensor merging
  - ✓ Improved temporal resoluti
  - ✓ New products: fluxes, …

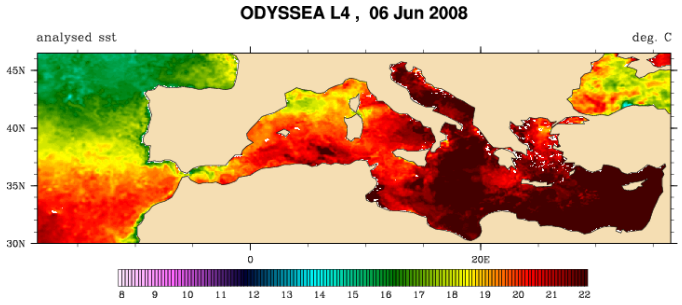


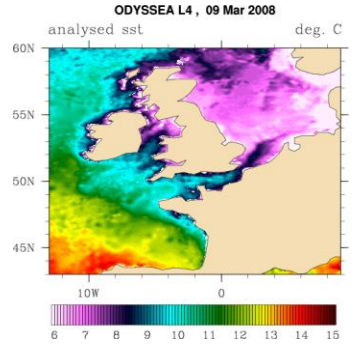
- Higher resolution, local sensor calibration
  - ✓ Specific regional products
  - ✓ New derived quantities
  - ✓ New communities : biogeochemical studies
- Toward real-time
  - ✓ Serving more specific demands
  - ✓ Model assimilation and forcing products
  - ✓ Monitoring of regional areas
  - ✓ Rapid assessment

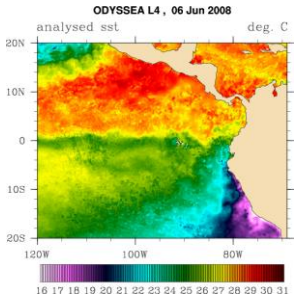
L4 SST products (GHRSST-PP project, Medspiration (ESA))

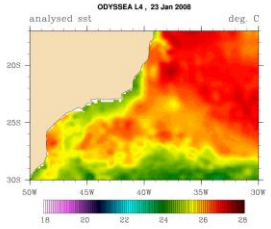
- Objective : high resolution gap free maps of SST fundation
  - Optimal interpolation
  - Merging all sensors available (high resolution IR [AVHRR NOAA&METOP, MSG, AATSR, GOES] and low resolution MW [AMSRE,TMI])
  - Intercalibration of all sensors against AATSR
- High (10km) to very high resolution (2km): ~90 Gb L2P data received

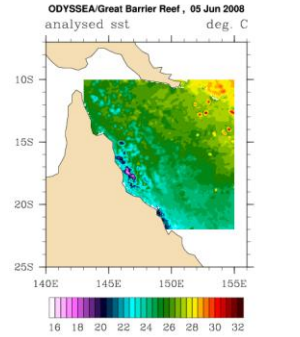












Level 2 : PODAAC & CERSAT

ID	Product Name	Mission or Project
179	NAVOCEANO MCSST Level 2 HRPT/LAC Data	AVHRR
143	AVHRR Orbital 9km MCSST Level 2 (NAVOCEANO)	AVHRR
69	AVHRR Oceans Pathfinder SST and buoy match-up data (Podesta et al.)	AVHRR
231	GHRSST Level 2P AATSR (EUR ATS_NR_2P)	GHRSST
240	GHRSST Level 2P SEVIRI (EUR SEVIRI_SST)	GHRSST
246	GHRSST Level 2P AMSR-E (REMSS AMSRE)	GHRSST
241	GHRSST Level 2P AMSR-E (EUR AMSRE)	GHRSST
232	GHRSST Level 2P AVHRR-16 Global Area Coverage (EUR AVHRR16_G)	GHRSST
233	GHRSST Level 2P AVHRR-16 Local Area Coverage (EUR AVHRR16_L)	GHRSST
234	GHRSST Level 2P AVHRR-17 Local Area Coverage (EUR AVHRR17_G)	GHRSST
235	GHRSST Level 2P AVHRR-17 Local Area Coverage (EUR AVHRR17_L)	GHRSST
260	GHRSST Level 2P AVHRR-17 Global Area Coverage (NAVO AVHRR17_G)	GHRSST
259	GHRSST Level 2P AVHRR-17 Local Area Coverage (NAVO AVHRR17_L)	GHRSST
261	GHRSST Level 2P AVHRR-18 Global Area Coverage (NAVO AVHRR18_G)	GHRSST
252	GHRSST Level 2P AVHRR-18 Local Area Coverage (NAVO AVHRR18_L)	GHRSST
271	GHRSST Level 2P MetOp-A AVHRR Global Area Coverage (NAVO AVHRRMT	GHRSST
238	GHRSST Level 2P North Atlantic Region AVHRR 16 (EUR NAR16_SST)	GHRSST
239	GHRSST Level 2P North Atlantic Region AVHRR 17 (EUR NAR17_SST)	GHRSST
244	GHRSST Level 2P North Atlantic Region AVHRR 18 (EUR NAR18_SST) GHRS	GHRSST
248	GHRSST Level 2P MODIS Aqua (JPL MODIS_A)	GHRSST
257	GHRSST Level 2P GOES 11 (OSDPD GOES11)	GHRSST
258	GHRSST Level 2P GOES 12 (OSDPD GOES12)	GHRSST
242	GHRSST Level 2P TMI (EUR TMI)	GHRSST
270	GHRSST Level 2P TMI (REMSS TMI)	GHRSST
152	GRACE L1B (Level 1B)	GRACE
153	GRACE L2 (GFZ)	GRACE
154	GRACE L2 (UTSCR)	GRACE
155	GRACE L2 (JPL)	GRACE
131	Jason-1 Geophysical Data Record	Jason-1
132	Jason-1 Sea Surface Height Anomaly	Jason-1
168	Jason-1 Interim Geophysical Data Record	Jason-1
167	Jason-1 Operational Sensor Data	Jason-1
133	Jason-1 Along Track Gridded Sea Surface Height Anomaly	Jason-1
36	T/P Geophysical Data Record (B)	TOPEX/Poseido..
68	T/P Merged Geophysical Data Record (B)	TOPEX/Poseidon
189	T/P Sea Surface Height Anomaly	TOPEX/Poseidon
157	T/P Along Track Gridded Sea Surface Height Anomaly	TOPEX/Poseidon
2	Global Dealiased Surface Wind Vectors (Atlas)	SEASAT
29	Global Dealiased Wind Vectors 1978 (Wentz et al.)	SEASAT
31	Global 50km Sigma-0 data 1978 (Wentz)	SEASAT
30	SMMR Global Gridded Wind Speed, Water Vapor, and Liquid Water (Wentz)	Nimbus-7
63	Level 1.7 Swath Binned Ocean Sigma-0 Cells (JPL)	NSCAT
64	Level 2 Swath Binned Ocean Sigma-0 and Wind Vector Cells (JPL)	NSCAT
84	High Resolution Merged Ocean Sigma-0 and Wind Vector Cells (JPL, Dunba	NSCAT
108	SeaWinds Level 2B 25 km Ocean Surface Wind Vectors (JPL)	QuikSCAT
158	Near-Real-Time Reduced MGDR Ocean Surface Wind Vectors	QuikSCAT
286	SeaWinds Level 2B 12.5 km Ocean Surface Wind Vectors (JPL)	QuikSCAT
141	SeaWinds Level 2B 25 km Ocean Surface Wind Vectors (JPL)	ADEOS-II
174	SeaWinds Level 2B 12.5 km Ocean Surface Wind Vectors (JPL)	ADEOS-II
287	SeaWinds Level 2B 25 km Ocean Surface Wind Vectors with AMSR Correct	ADEOS-II
	ERS-1 Altimeter Ocean Product (OPR)	ERS-1
	ERS-2 Altimeter Ocean Product (OPR)	ERS-2
	ERS-1 Scatterometer Wind Product (WNF)	ERS-1
	ERS-2 Scatterometer Wind Product (WNF)	ERS-2
	ERS-1 SAR Wave Mode (IWA)	ERS-1
	ERS-2 SAR Wave Mode (IWA)	ERS-2
	ERS-1 Vapour Liquid Content (VLC)	ERS-1
	ERS-2 Vapour Liquid Content (VLC)	ERS-2
	Envisat ASAR Wave Mode (WVW)	Envisat
	ENVISAT RA2 Geophysical Data Record	Envisat
	ENVISAT RA2 Interim Geophysical Data Record	Envisat
	GFO Altimeter Geophysical Data Record (MOE)	GFOSAT
	METOP ASCAT Ocean Wind Vectors (KNMI)	METOP
	GHRSST Level 2P METOP (AVHRR_METOP_A)	METOP
	SEVIRI hourly SST	MSG
	GHRSST Level 2P North Atlantic Region AVHRR METOP (EUR NAR_METOP_A	METOP

Level 3&4 : PODAAC & CERSAT

185	MODIS Aqua Global Level 3 Mapped Mid-IR SST	MODIS	2002-Jul-04	Current
184	MODIS Aqua Global Level 3 Mapped Thermal IR SST	MODIS	2002-Jul-04	Current
163	MODIS Terra Global Level 3 Mapped Mid-IR SST	MODIS	2000-Feb-24	Current
162	MODIS Terra Global Level 3 Mapped Thermal IR SST	MODIS	2000-Feb-24	Current
216	AVHRR Pathfinder SST v.5	AVHRR	1985	2009 May
190	GOES L3 6km Near Real-Time SST (NOAA/NESDIS)	AVHRR	2003-May	Current
16	AVHRR Weekly Global 18km Gridded MCSST (Miami)	AVHRR	1981-Nov-11	2001-Feb-0
269	GHRSST Level 3 Global AMSR-E (REMSS)	GHRSST	2002-Jun	Current
270	GHRSST Level 3 Tropical Global TMI (REMSS)	GHRSST	1998-Jan	Current
	Atmospheric and Ocean De-Aliasing	GRACE	2002-Jan	Current
	Barotropic Ocean Model Output	GRACE	2002-Mar	Current
	Dynamic Ocean Topography	TELLUS	2008-Jul	2008-Aug
	Post Glacial Rebound	TELLUS		
	GRACE Monthly Mass Grids	TELLUS	2003-Jan	Current
	Monthly Steric Sea Level Grids	TELLUS	2003-Jan	2005
8	Global Gridded Monthly Surface Wind Stress (Chelton)	SEASAT	1978-Jul-7	1978-Oct-1
13	Global Gridded Dealiased Wind Vectors (JPL-UCLA-AES)	SEASAT	1978-Sep-6	1978-Sep-2
175	Enhanced Resolution Sigma-0 Maps (D. Long)	SEASAT	1978-Jul-7	1978-Oct-1
65	Level 3 Global Ocean Surface Wind Vectors (JPL)	NSCAT	1996-Sep-15	1997-Jun-2
176	Enhanced Resolution Sigma-0 Maps (D. Long)	NSCAT	1996-Sep-15	1997-Jun-2
79	SSM/I Derived Global Ocean Surface Wind Components (A	CCMP	1987-Jul-1	2004-Dec-3
109	SeaWinds Gridded Ocean Surface Wind Vectors (JPL)	QuikSCAT	1999-Jul-19	Current
121	Daily Sigma-0 Browse Images (D. Long)	QuikSCAT	1999-Jul-19	Current
122	Enhanced Resolution Sigma-0 Maps (D. Long)	QuikSCAT	1999-Jul-19	Current
123	Daily Sigma-0 Browse Images (D. Long)	ADEOS-II	2003-Apr-10	2003-Oct-2
124	Enhanced Resolution Sigma-0 Maps (D. Long)	ADEOS-II	2003-Apr-10	2003-Oct-2
142	SeaWinds Gridded Ocean Surface Wind Vectors (JPL)	ADEOS-II	2003-Apr-10	2003-Oct-2
288	SeaWinds Gridded Ocean Surface Wind Vectors with AMSI	ADEOS-II	2003-Apr-10	2003-Oct-2
289	Cross-Calibrated Multi-Platform Ocean Surface Wind Velo	CCMP	1987-Jul-01	2008-Jun-3

GHRSST Level 3 Global ODYSSEA (EUR)	GHRSST	2008	Current
SeaWifs Ocean color Chlorophyll,SPM and Turbidity	MARCOAS	1998	
Meris Ocean color Chlorophyll,SPM and Turbidity	MARCOAS	2002	Current
Modis Ocean color Chlorophyll,SPM and Turbidity	MARCOAS	2002	Current
SeaWinds on QuikSCAT Level 3 Sea-Ice Maps on 25km Po	CERSAT	1999	Current
SSM/I Sea-Ice concentration Maps on 12.5 km Polar Grid	CERSAT	1991	Current
NSCAT on ADEOS-1 Level 3 Sea-Ice Maps on 25km Polar (	CERSAT	1996	1997
AMI-Wind on ERS Level 3 Sea-Ice Maps on 25km Polar Gri	CERSAT	1991	2000

NCEP Reynolds Historical Reconstructed Sea Surface Temperature Data Set	AVHRR
NCEP Reynolds Optimally Interpolated Sea Surface Temperature Data Sets	AVHRR
AVHRR Pathfinder Global 9 km SST Climatology	AVHRR
NSIPP AVHRR Pathfinder and Erosion Global 9km SST Climatology (Casey, Cornill	AVHRR
Ocean Circulation and Currents Product: global 0.5 and 1.0 deg grids (JPL, WOCE	AVHRR
GHRSST Level 4 Global OSTIA (UKMO)	GHRSST
GHRSST Level 4 Global ODYSSEA (EUR)	GHRSST
GHRSST Level 4 Global AVHRR_OI (NCDC)	GHRSST
GHRSST Level 4 Global AVHRR_AMSR_OI (NCDC)	GHRSST
GHRSST Level 4 Global mw_ir_OI (REMSS)	GHRSST
GHRSST Level 4 Mediterranean Sea ODYSSEA (EUR)	GHRSST
GHRSST Level 4 Galapagos Islands ODYSSEA (EUR)	GHRSST
GHRSST Level 4 Northwest Europe ODYSSEA (EUR)	GHRSST
GHRSST Level 4 Mediterranean Sea (EUR) (superseded by ODYSSEA)	GHRSST
GHRSST Level 4 North Sea Baltic DMI_OI (DMI)	GHRSST
GHRSST Level 4 Global GAMSSA (ABOM)	GHRSST
GHRSST Level 4 Australia RAMSSA (ABOM)	GHRSST
GHRSST Level 4 Global K10_SST (NAVO)	GHRSST
SSM/I Derived Global Ocean Surface Wind Components (Atlas et al.)	CCMP
Cross-Calibrated Multi-Platform Ocean Surface Wind Velocity (Atlas et al.)	CCMP
AMSR-E Sea-Ice Drift Vectors	CERSAT
Merged Sea-Ice Drift Vectors	CERSAT
AMI-Wind on ERS Level 4 Gridded Mean Wind Fields in 1° Geographical Grid	CERSAT
NSCAT on ADEOS-1 Level 4 Gridded Mean WInd Fields in 1° Geographical Grid	CERSAT
SeaWinds on QuikSCAT Level 4 Gridded Mean Wind Fields in 0.5° Geographical (	CERSAT
Blended Level 4 Gridded Mean Wind Fields in 0.25° Geographical Grid, 6-hourly	MyOcean
Precipitations products from the available dual-frequency altimeters	CERSAT
SeaWinds on QuikSCAT Level 4 Gridded Mean CO2 Exchange Coefficients (K) in (	CARBOOC
AMI-Wind on ERS Level 4 Gridded Mean CO2 Exchange Coefficients (K) in 1° Gec	CARBOOC
Analysed Multi-sensor Ocean Color Chlorophyll,SPM and Turbidity	CERSAT
Multi-sensor turbulent fluxes (sensible and latent heat)	CERSAT

Opening the Pandora's box ?

- **Archiving data leads to very large heterogeneous and multimodal databases**

  Data assimilation is growing in response to the growth of data collected, but (personal opinion) tremendous amounts of information still remain hidden in data archives.

- **Knowledge trees and complex algorithms are essential to avoid the Google's principle, i.e. pertinence = popularity**

  Research efforts to be concerned with the definition of adequate exploratory processes to detect relevant patterns in large, heterogeneous, multidimensional observation data sets with different resolutions to better approach complex spatial and/or temporal dynamics of the ocean system.

Improved Synthesis and Analysis

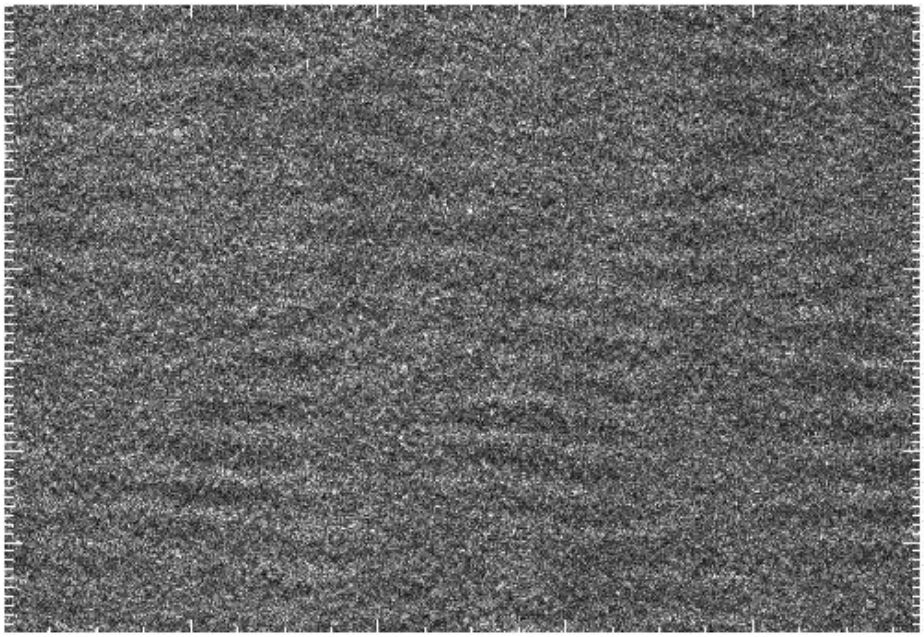
- Forcing fields and fluxes
- Global ocean surface circulation estimates combining satellite (altimetry, scatterometer winds) and in situ, e.g. OSCAR, SURCOUF, …
- Tools and Applications: Eddy tracking, StormWatch, Stormtracks, …, SSTFronts, Optical-Flow or correlation methods, … Image analysis, …
- Dynamical frameworks:
  - use of Earth Simulator numerical experiments to build transfer functions, e.g. effective Surface Quasi-Geostrophy,
  - Geometrical-Optics Wave propagation

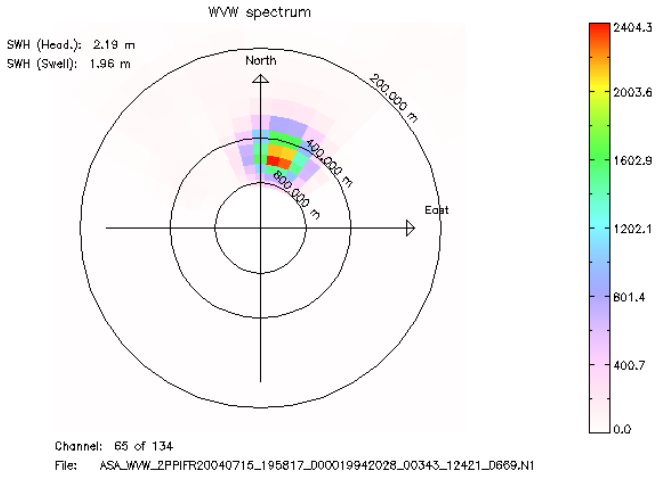
Waves across the Pacific revisited

« A comparison with meteorological events in the Southern Ocean would be far more meaningful if such Observations could be made at a time when a weather satellite is in suitable orbit » (Munk et al. 1963)

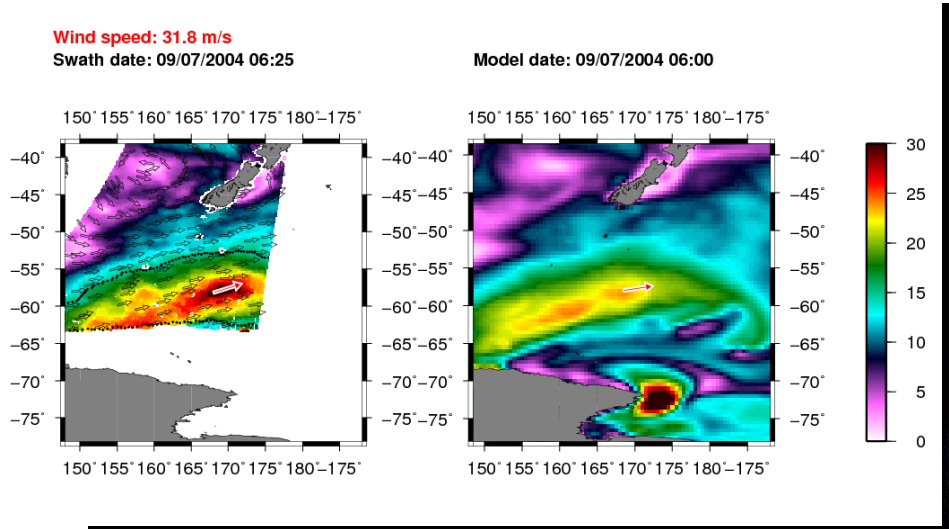
Data sources:
NDBC buoys
ENVISAT ASAR
Altimeters
(+propagation models)

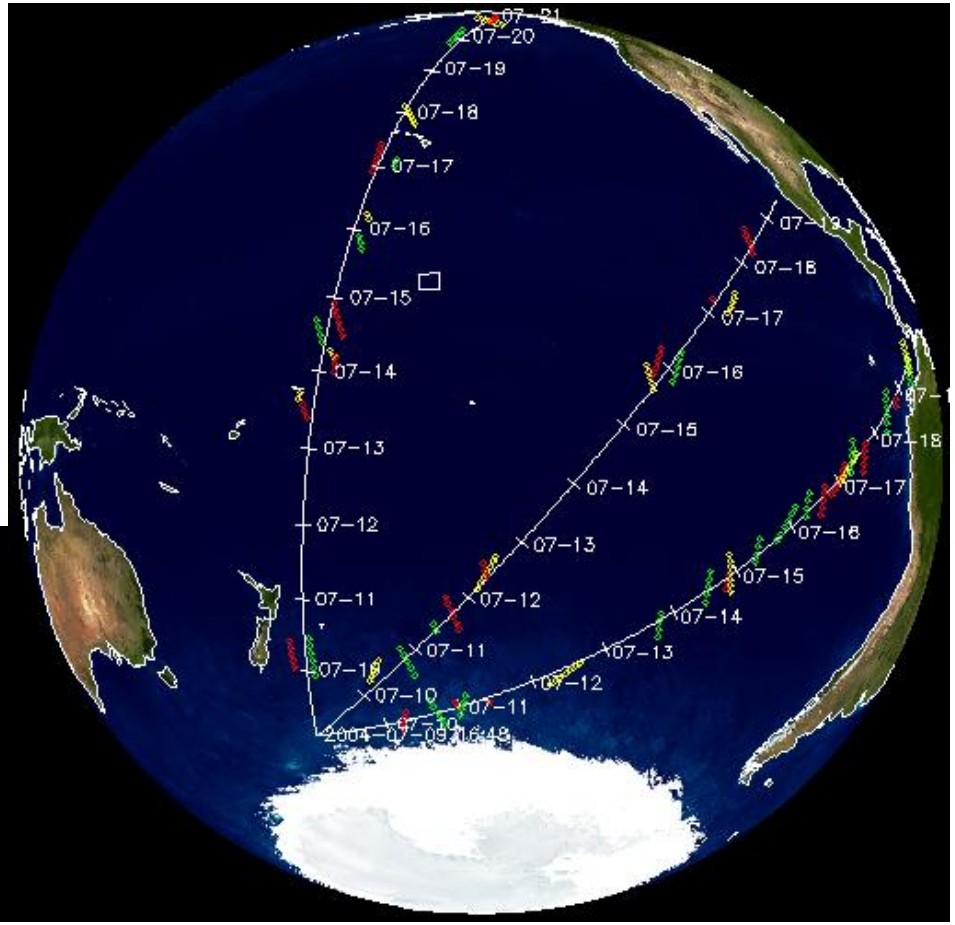
SAR is *the* swell instrument
-ERS and ENVISAT wave mode products





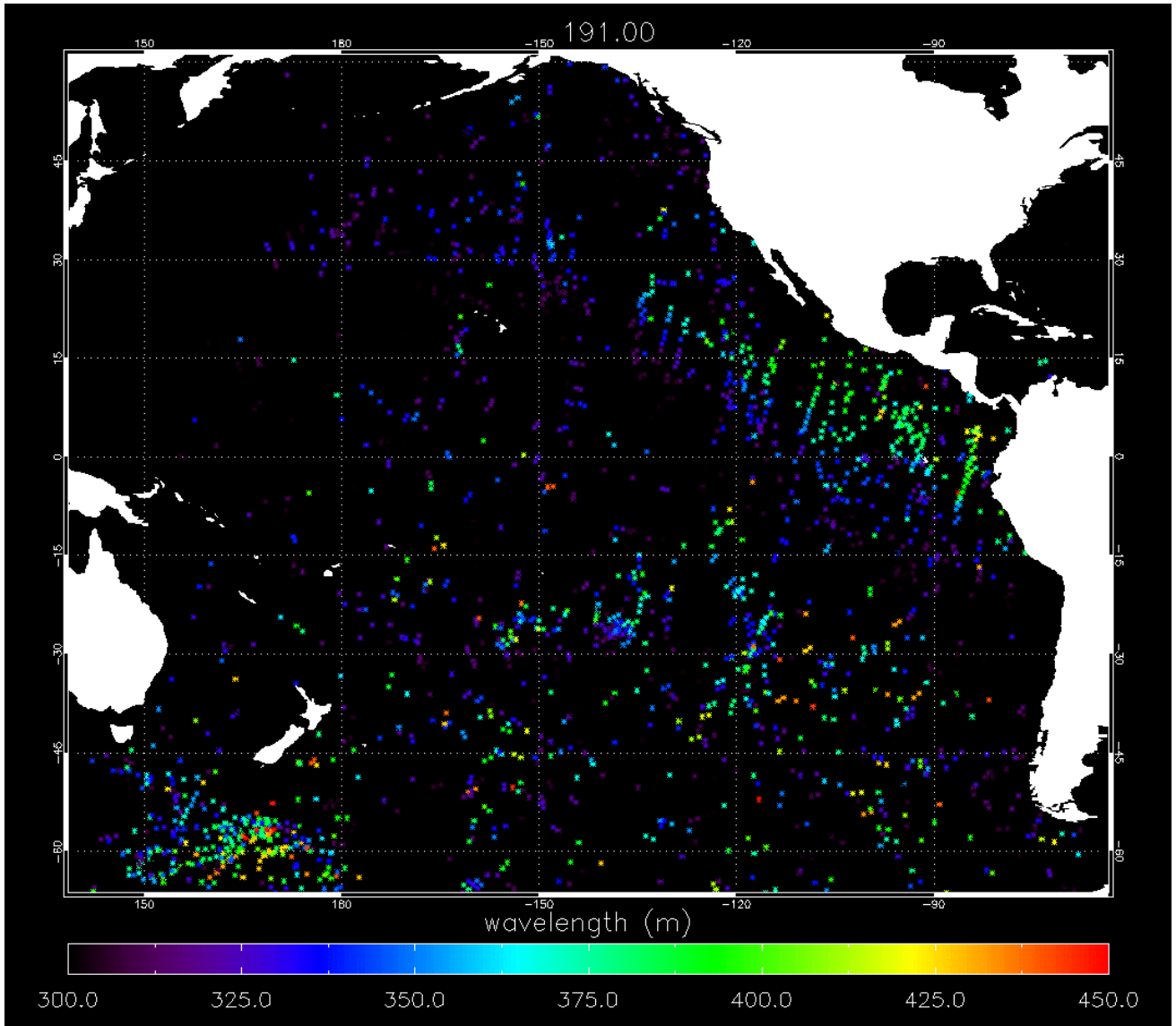
Stormwatch + wavetracker





RED : ENVISAT ASAR
GREEN : ENVISAT RA2
YELLOW : JASON ALTIMETER

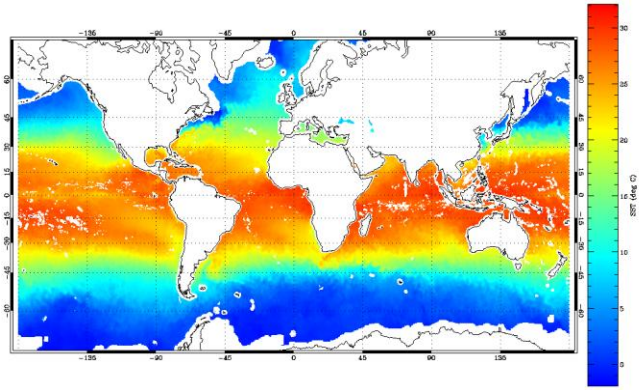
Observed propagation of 13s to 17s swell from July 8 to July 20, 2004

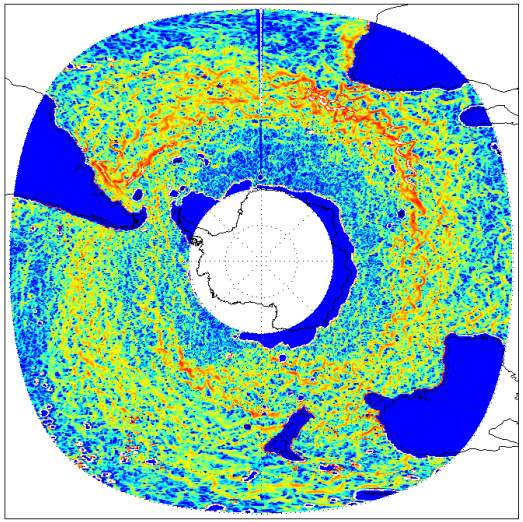


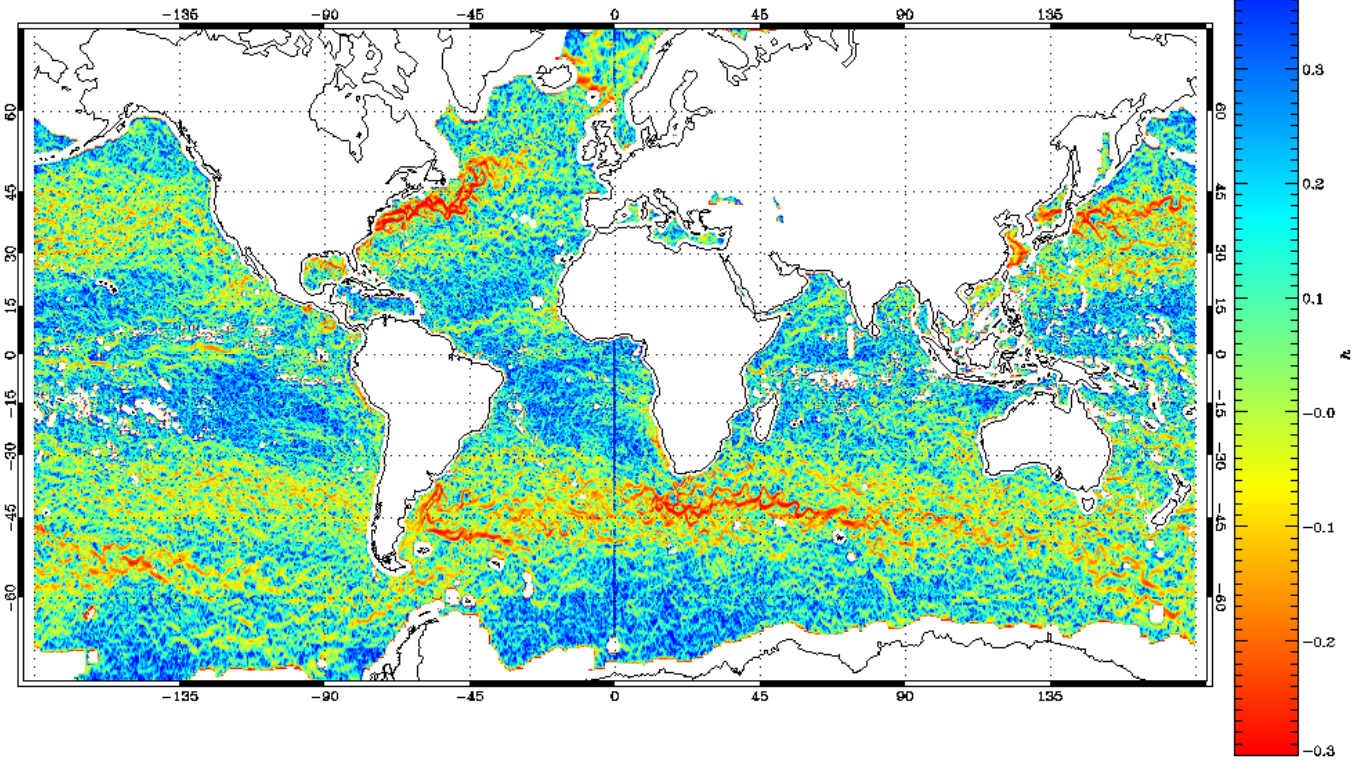
- 6 hour time step
- Wavelength from 300 to 450m
- Wave period from 13 to 17 seconds

Singularity exponents

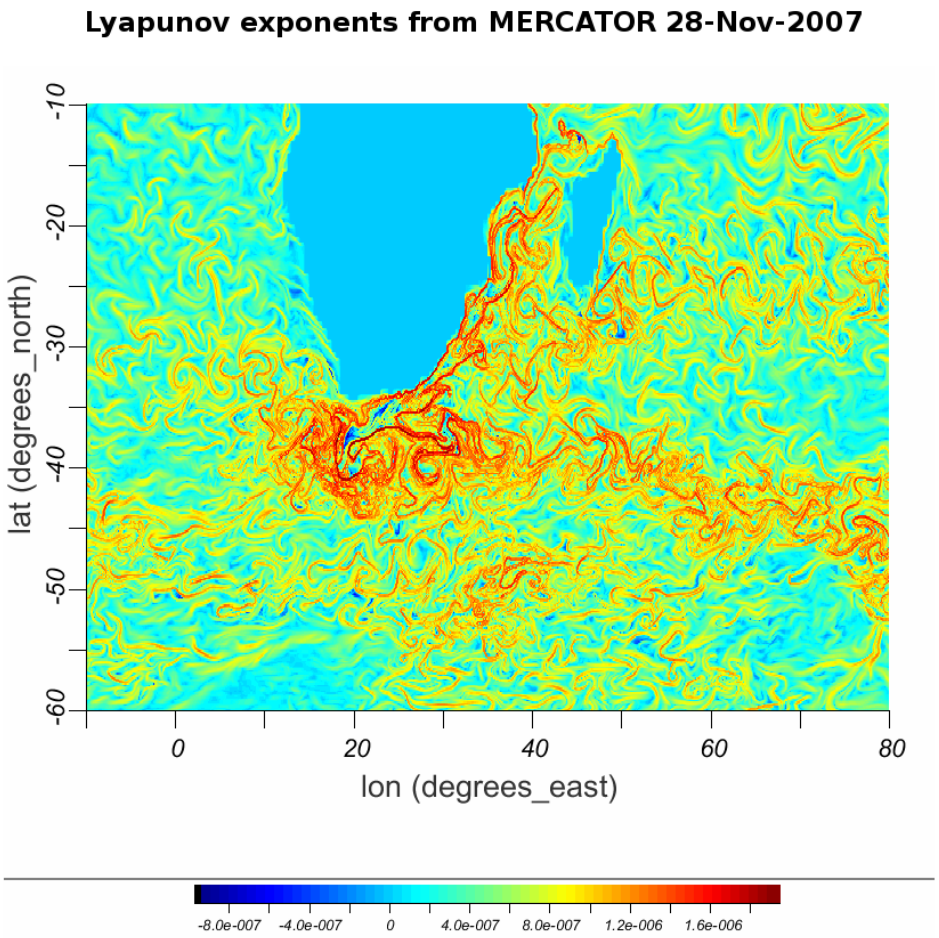
- AMSR-E SST 3 day mean
- March 1, 2008
- More examples in Turiel et al, RSE 2008





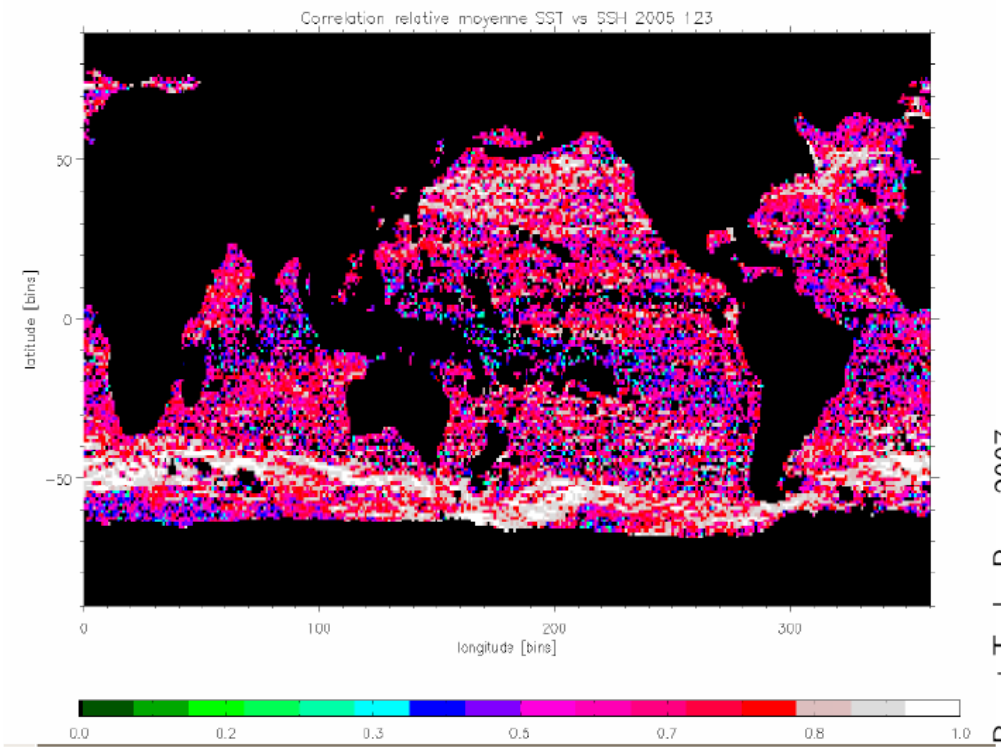


Model Analysis: Lagrangian diagnostic



Correlation between SST and Altimeter Level-3

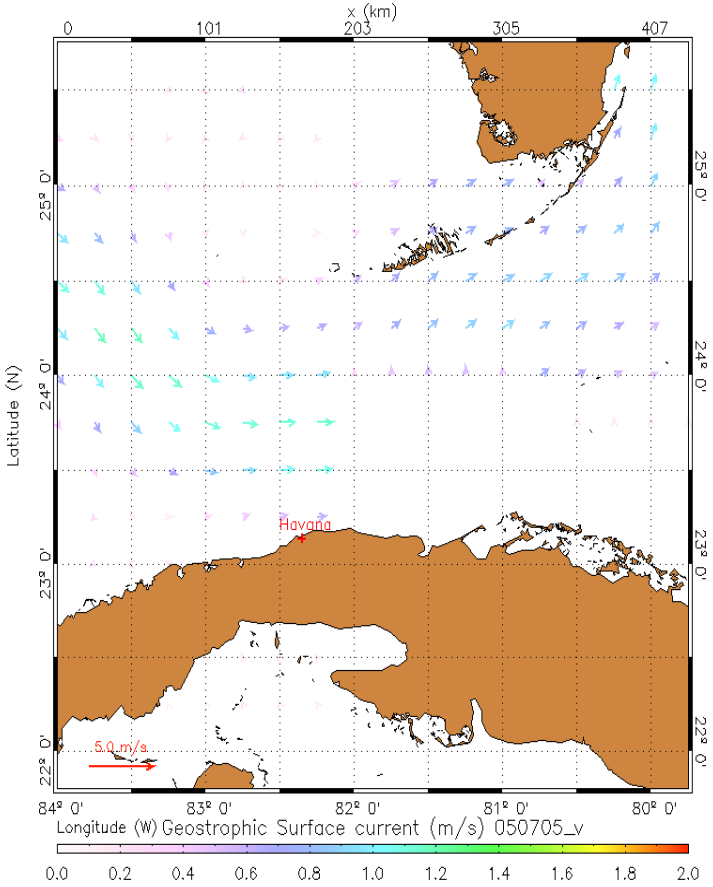
- To identify the regions where the eSQG approximation could be applied, the correlation between microwave SST and SSH have been computed in the world ocean (Boost Technologies Tech. Rep. 2007)

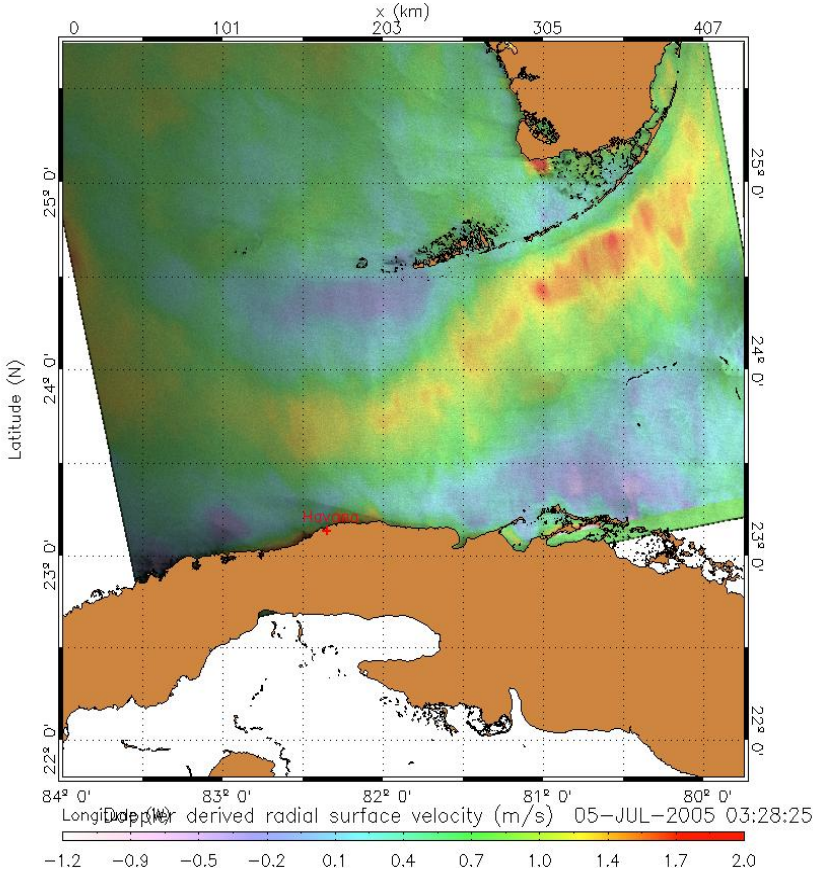


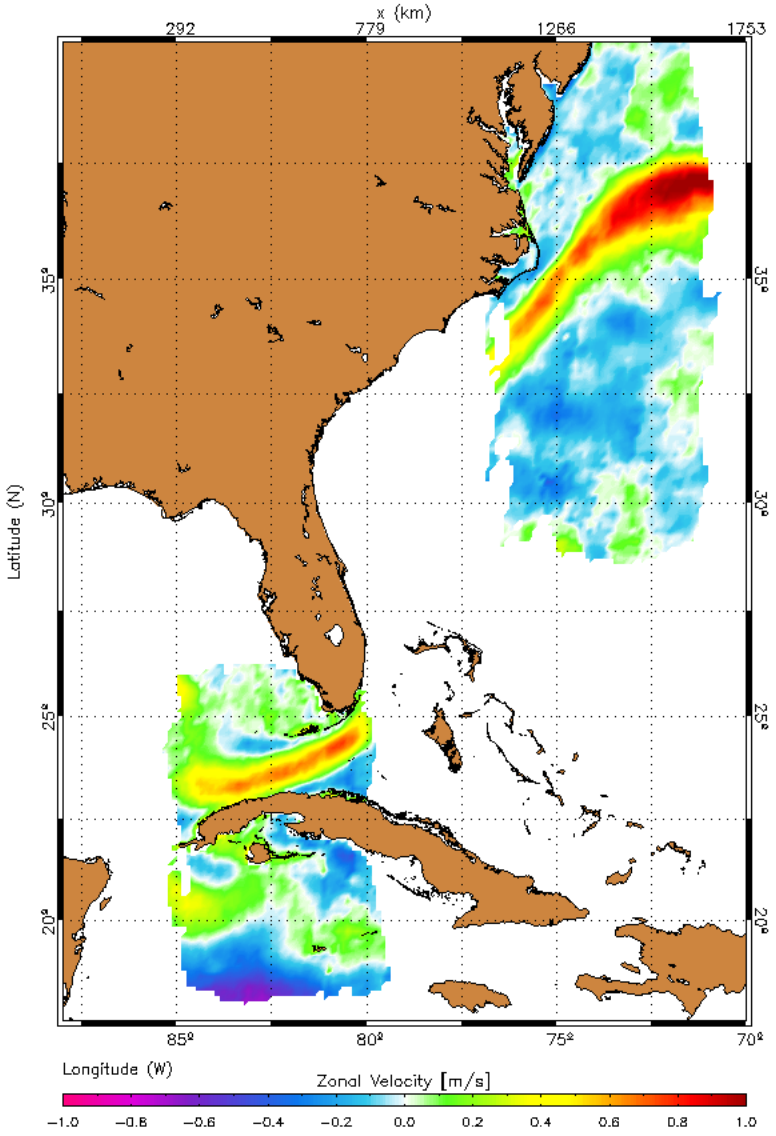
- Best results are obtained in regions with **high mesoscale activity and large SST gradients**.

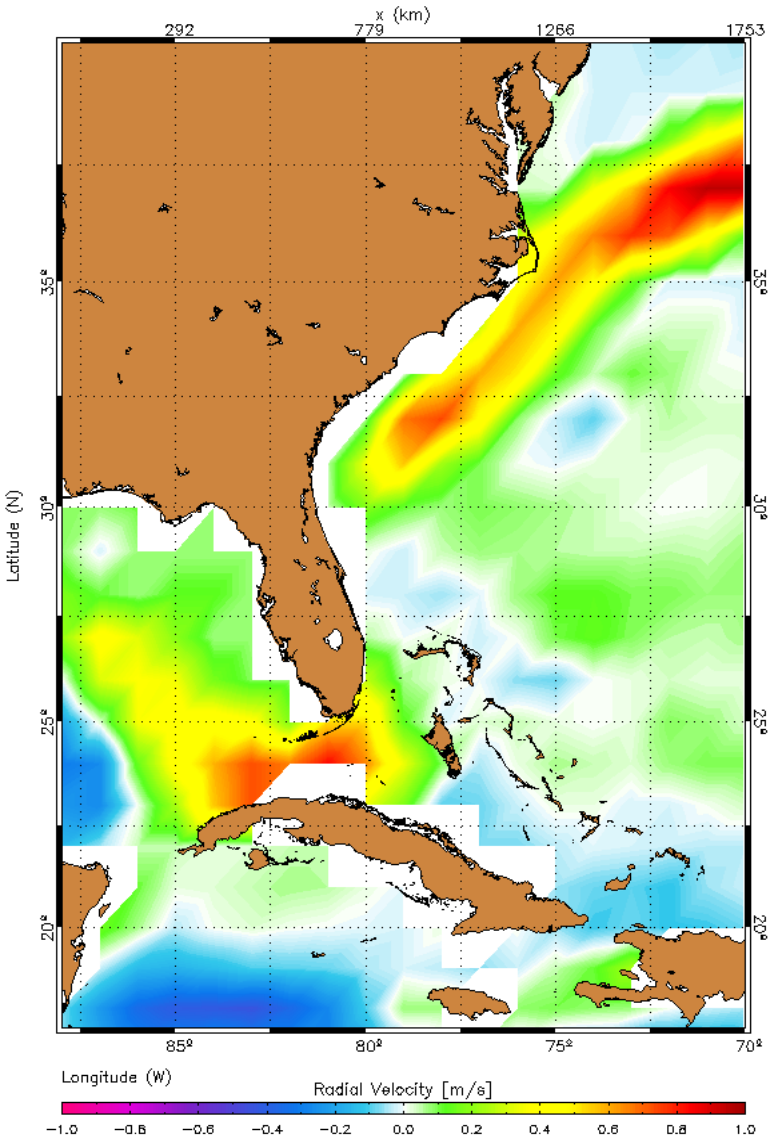
- Correlations depend on seasons, **better results are found in winter**.

Single antenna SAR Doppler anomaly analysis (a poor-man surrogate for interferometry)

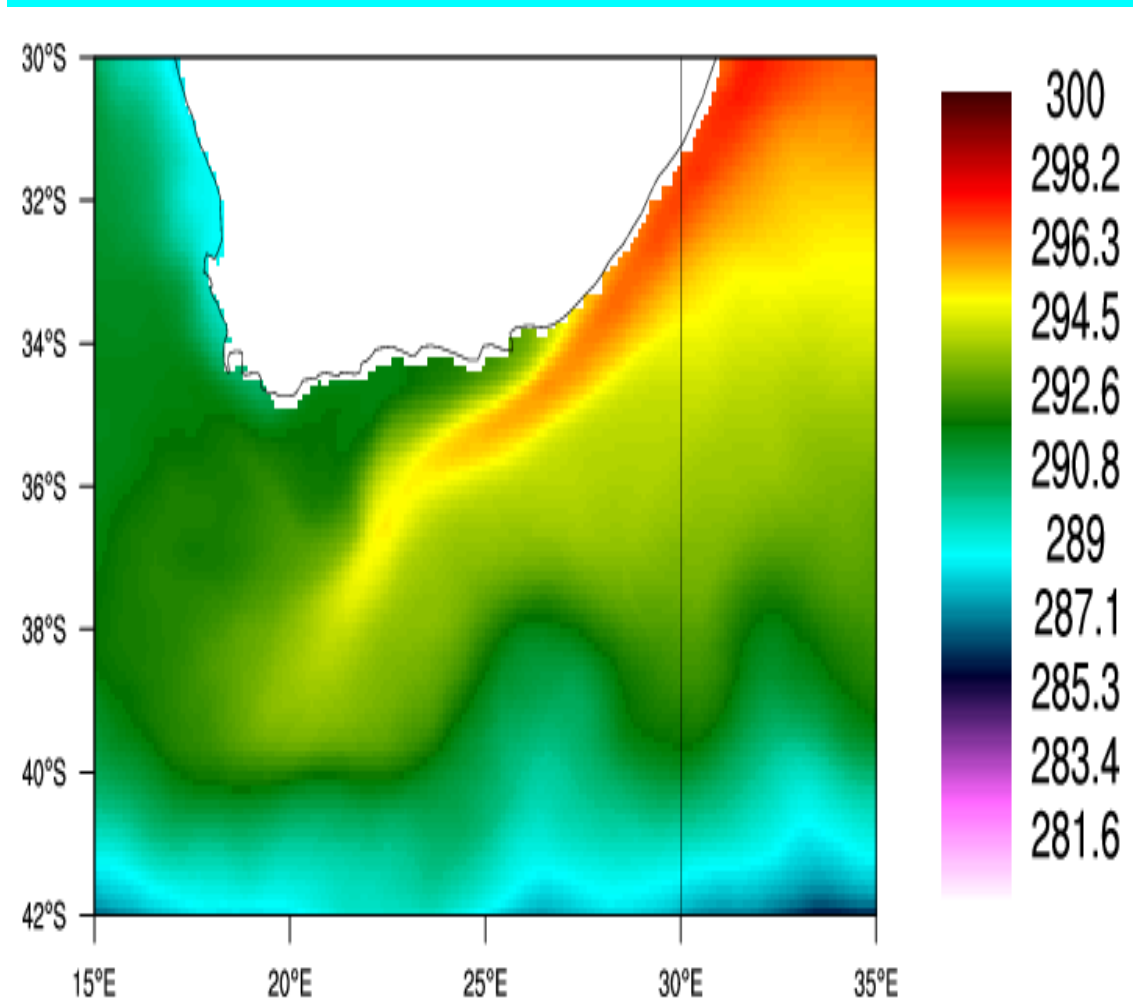


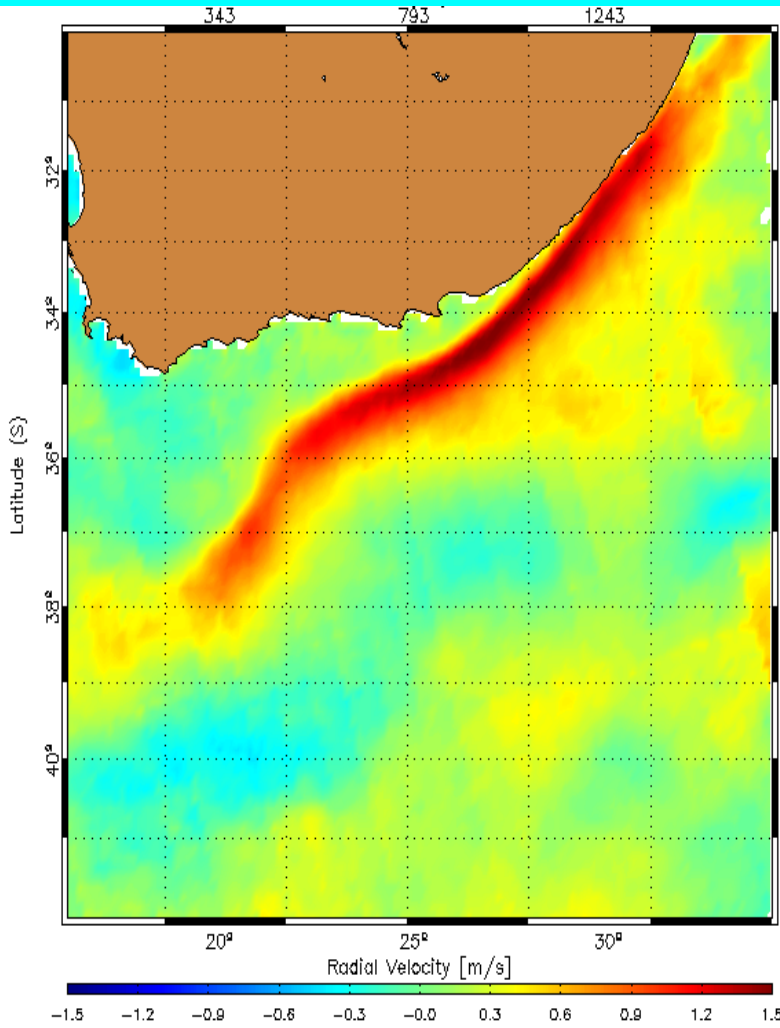



x (km)
292
779
1266
1753
35º
30º
25º
20º
Latitude (N)
85º
80º
75º
70º
Longitude (W)
Zonal Velocity [m/s]
−1.0
−0.8
−0.6
−0.4
−0.2
0.0
0.2
0.4
0.6
0.8
1.0

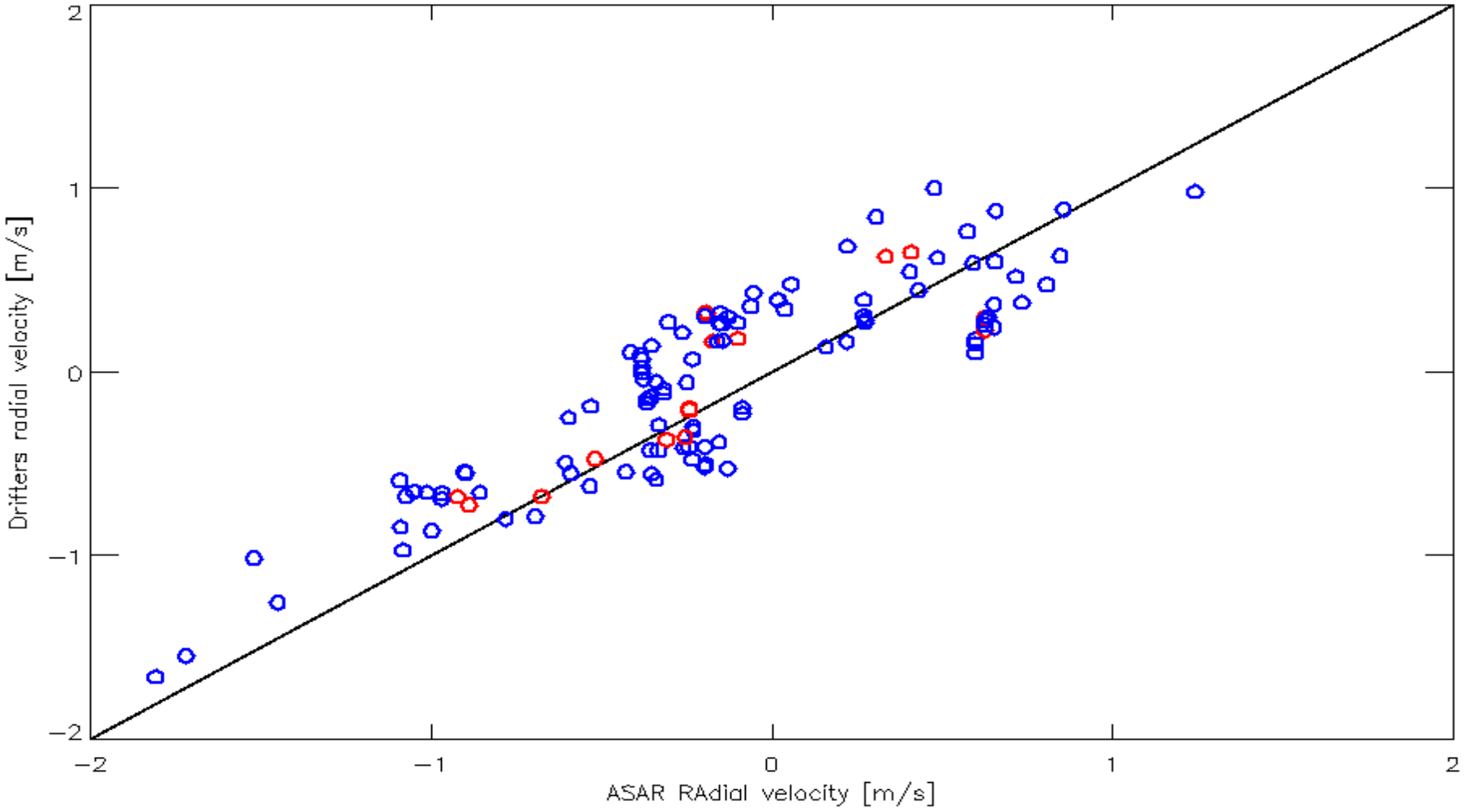

x (km)
292
779
1266
1753
35º
30º
25º
20º
Latitude (N)
85º
80º
75º
70º
Longitude (W)
Radial Velocity [m/s]
−1.0
−0.8
−0.6
−0.4
−0.2
0.0
0.2
0.4
0.6
0.8
1.0

Mean SST and mean range Doppler velocity

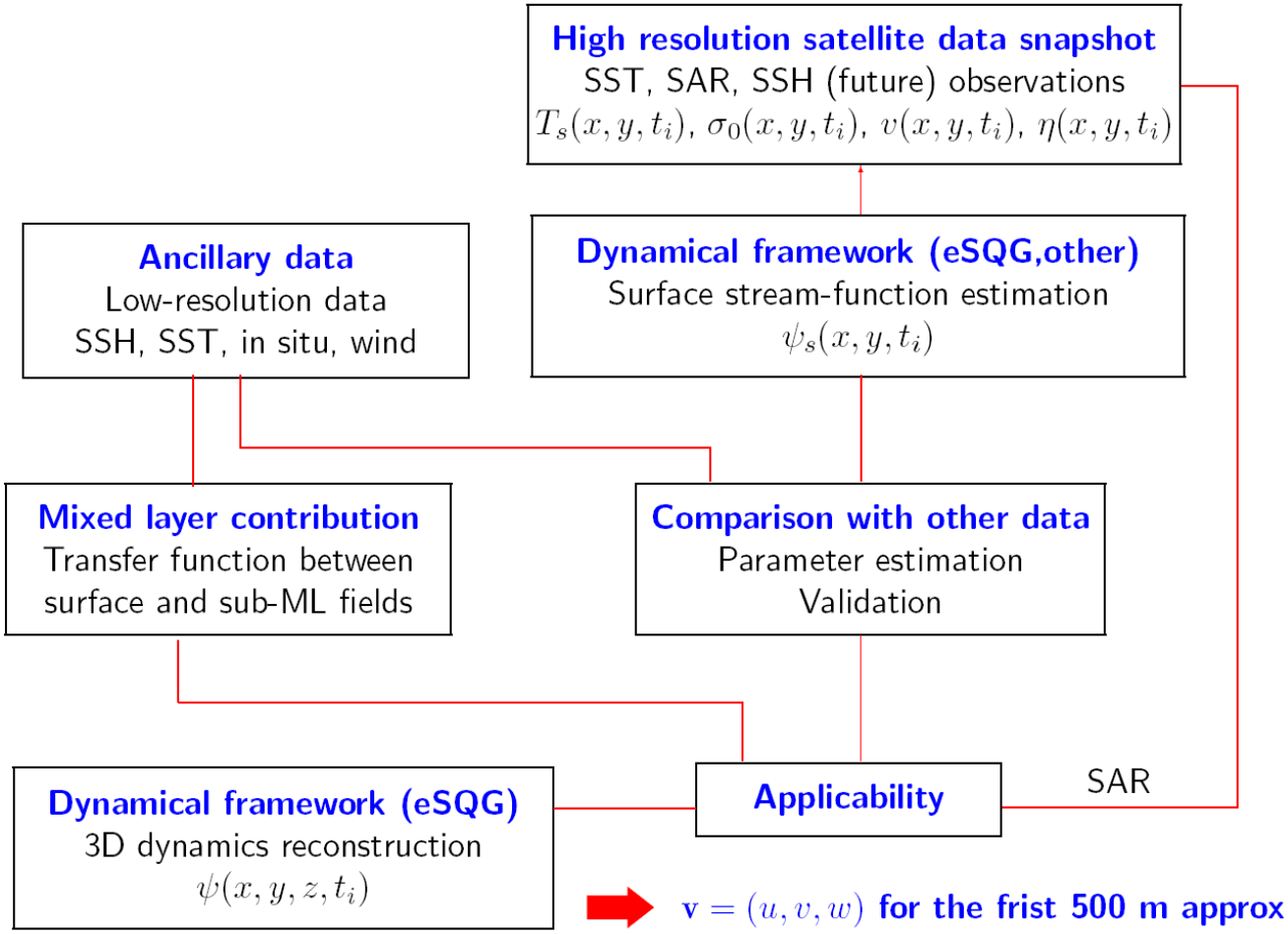




Range surface drifter and range Doppler velocities



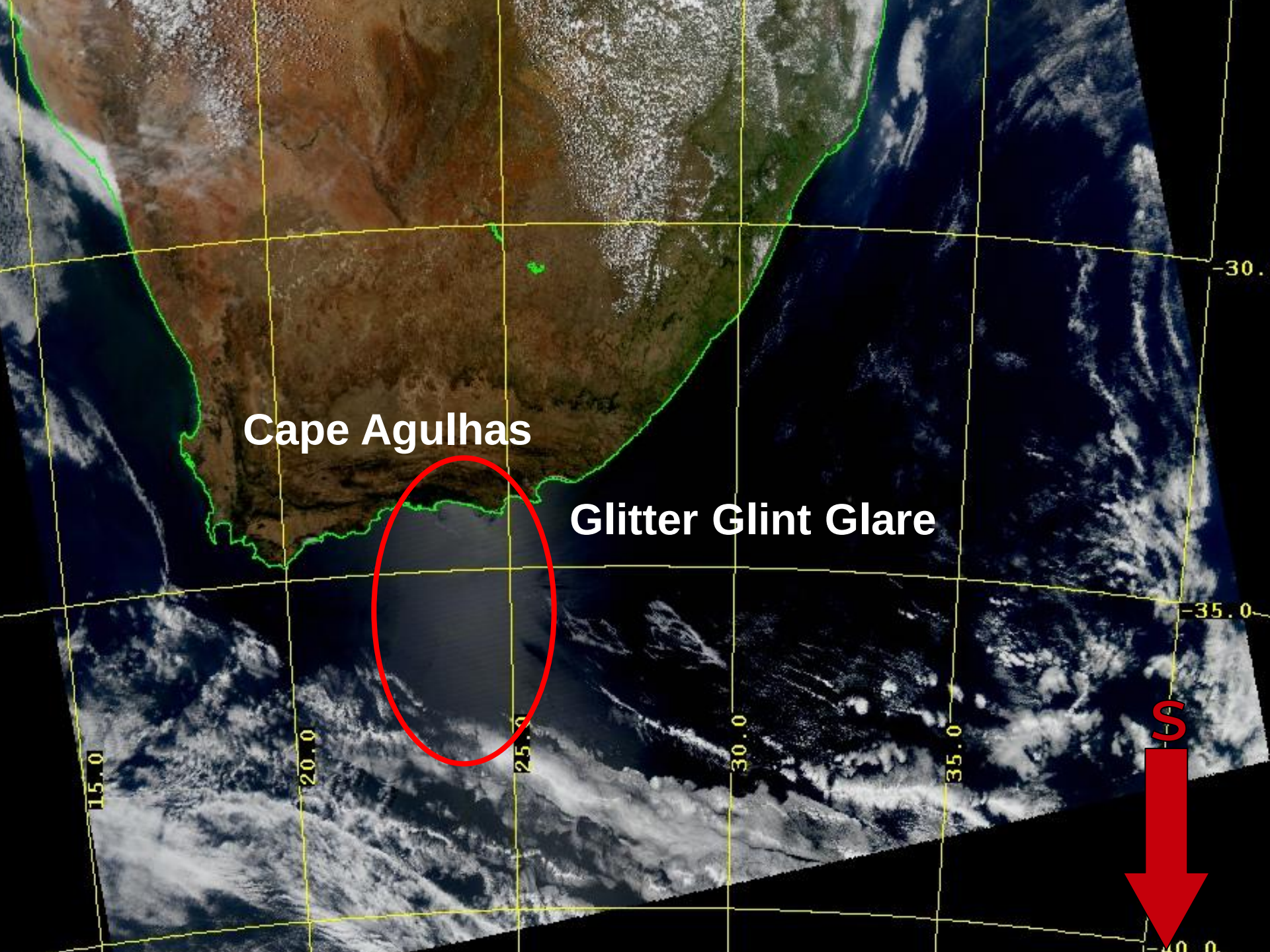
High resolution 3D upper ocean dynamics reconstruction from surface data

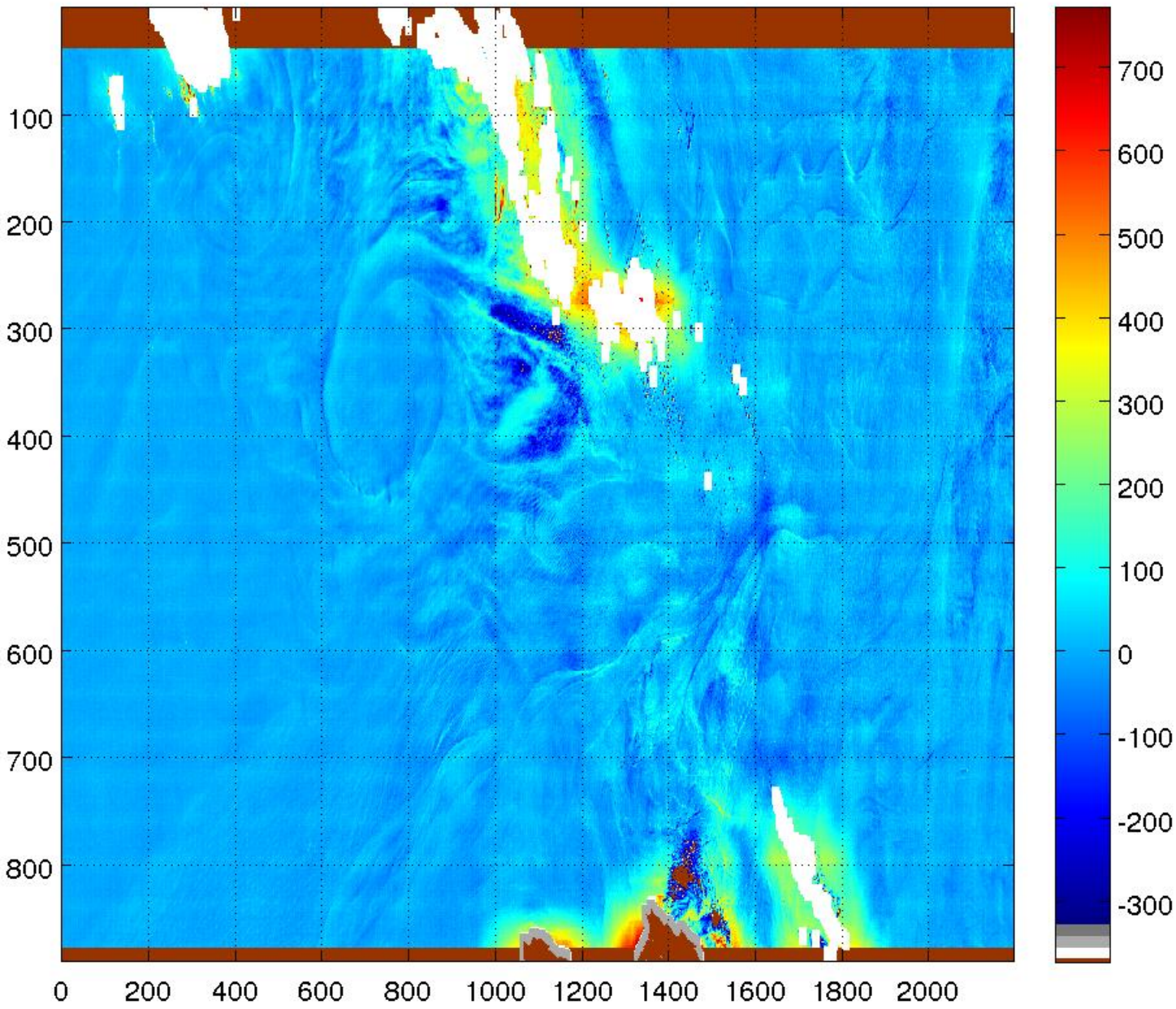


Hidden information

- … most observations are not yet sufficiently explored and used

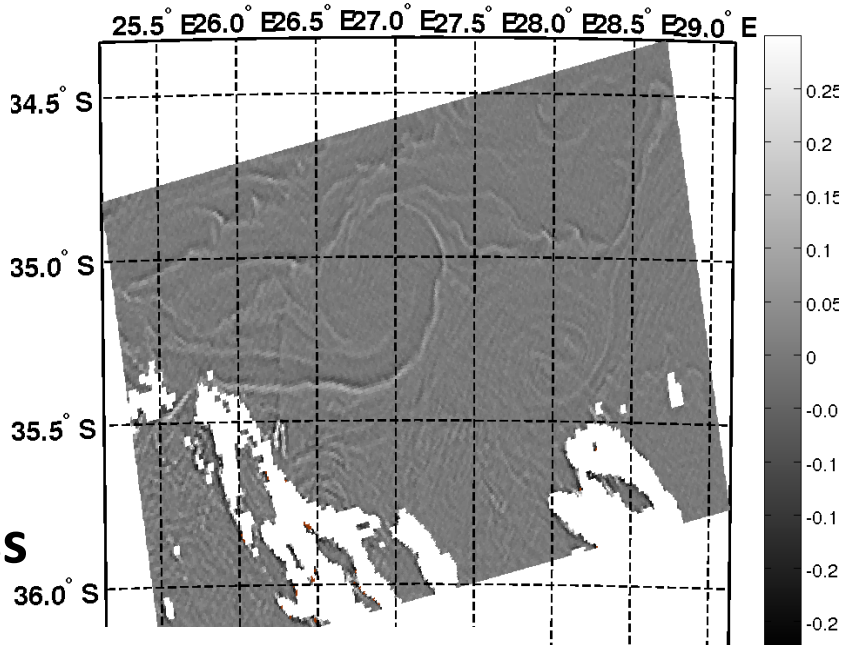
  Synergy between Very-high resolution observations to reveal near-surface dynamics, convergence/divergence fronts and roughness contrasts


Cape Agulhas
Glitter Glint Glare
-30.
-35.0
15.0
20.0
25.0
30.0
35.0
S

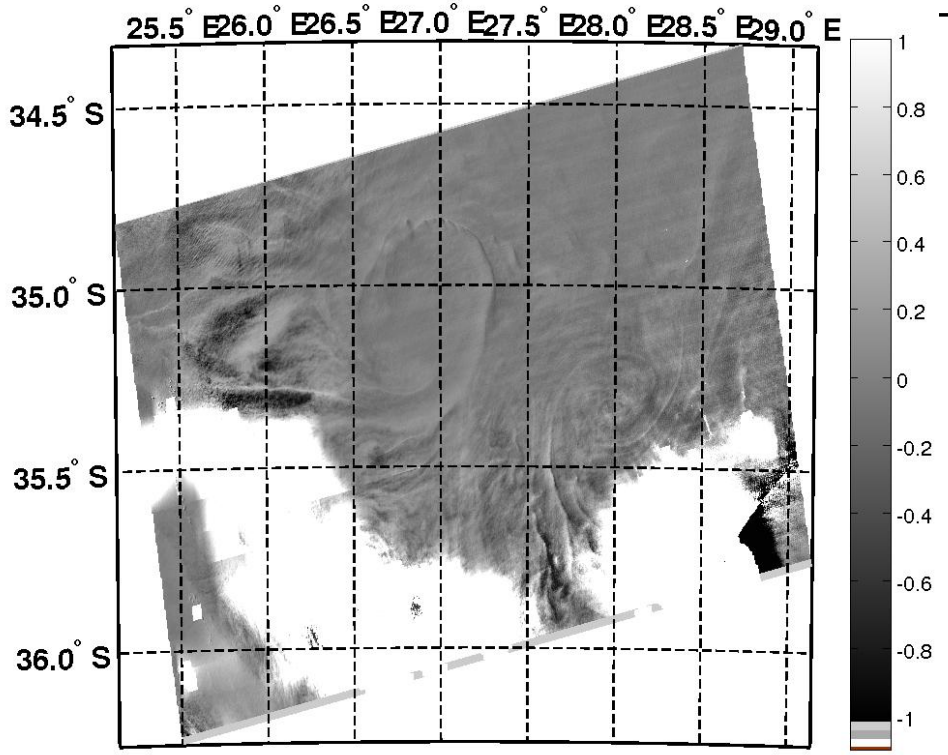


Brightness Variations

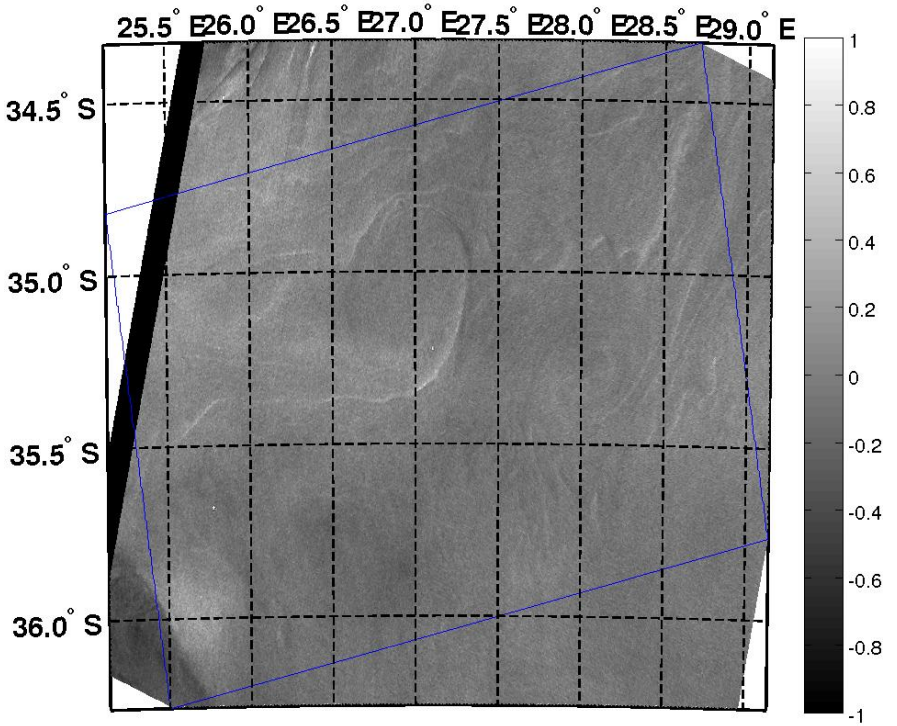
SST Laplacian



Optical roughness



Radar roughness

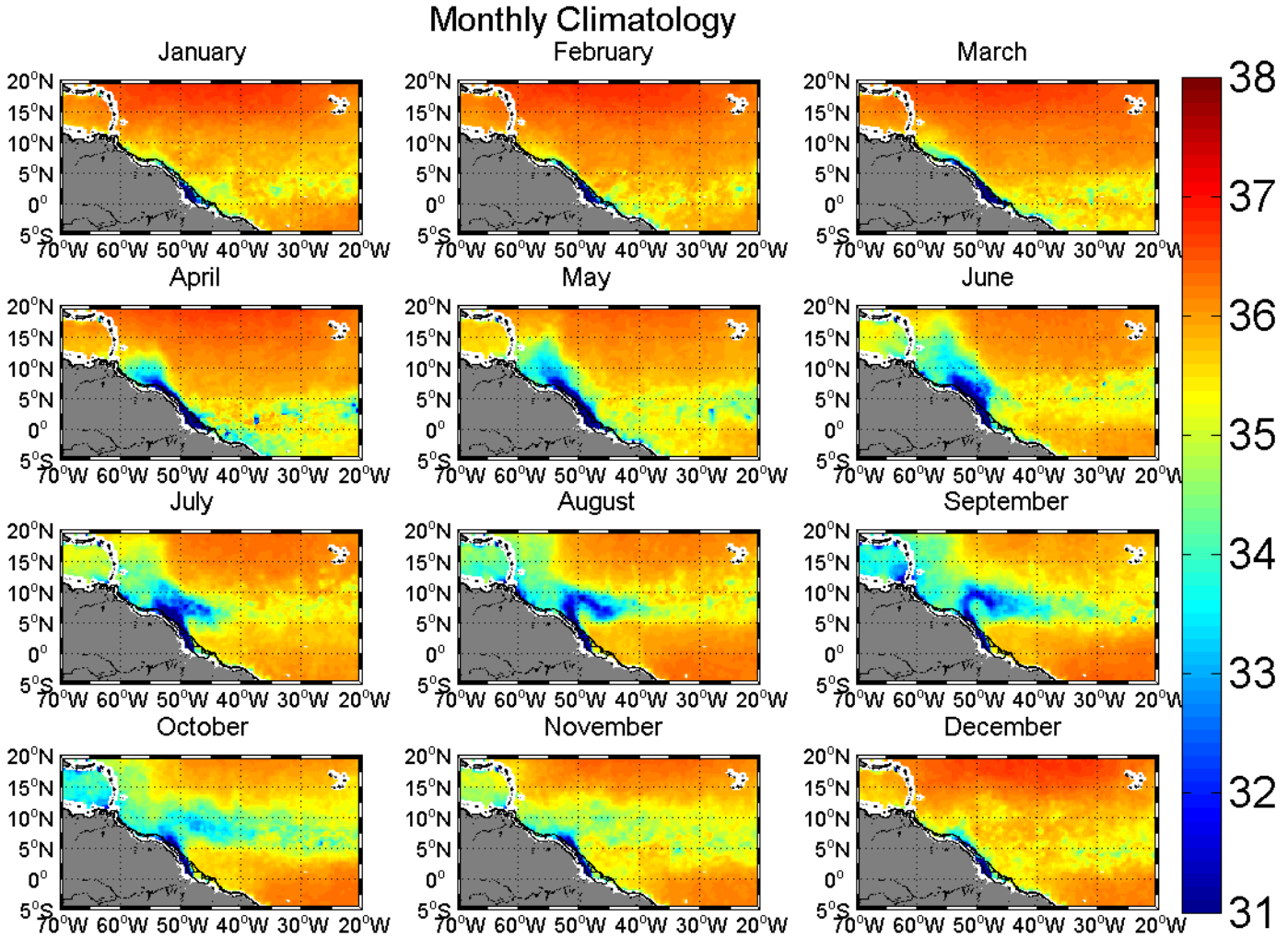


New Challenges: to estimate Sea Surface Salinity from space

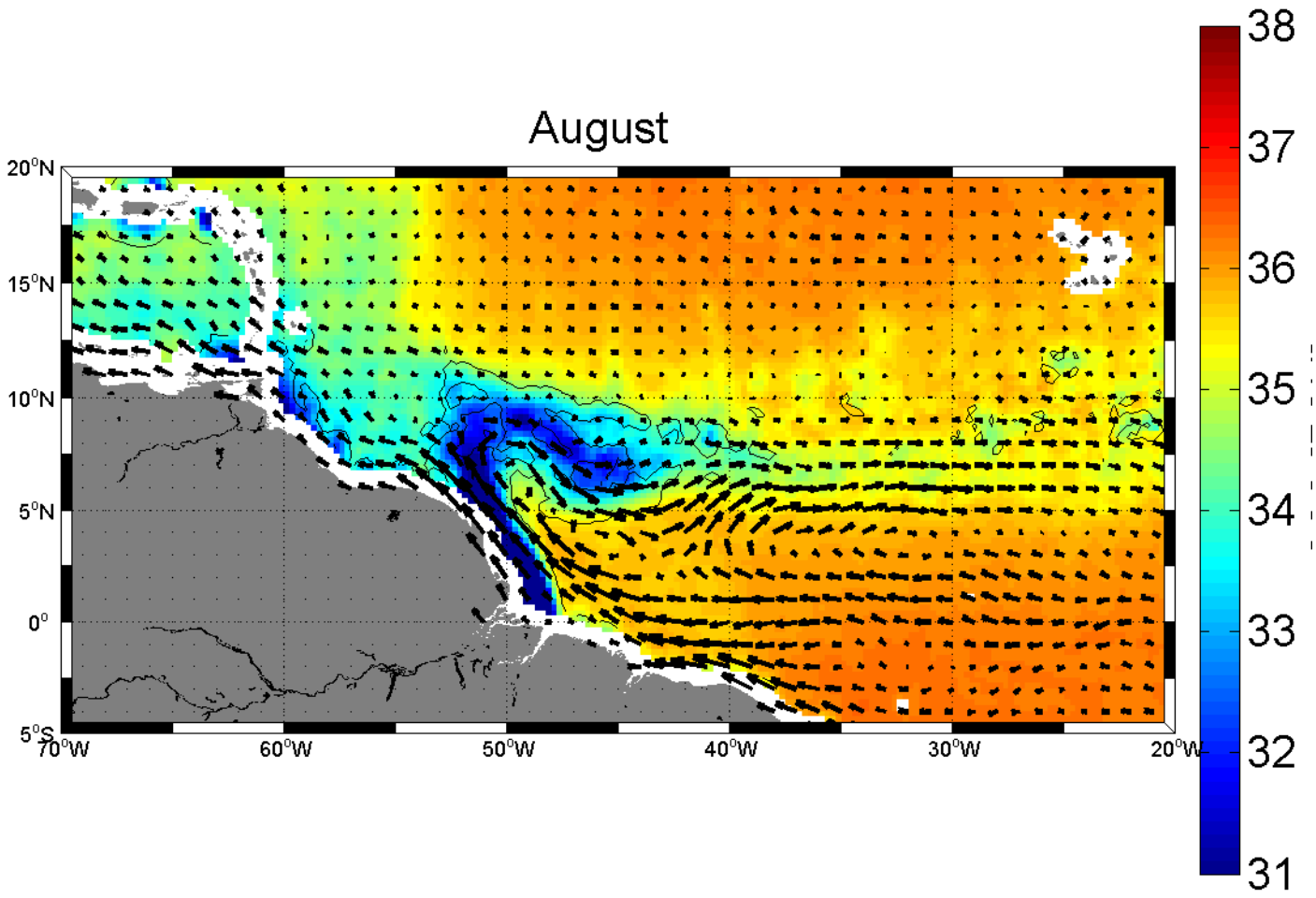
SMOS and AQUARIUS coming soon: crucial ancillary information needed

First analysis using existing AMSR-E (C and X-band) brightness temperature measurements: sensitivity 10 times lower than L-band dedicated measurements

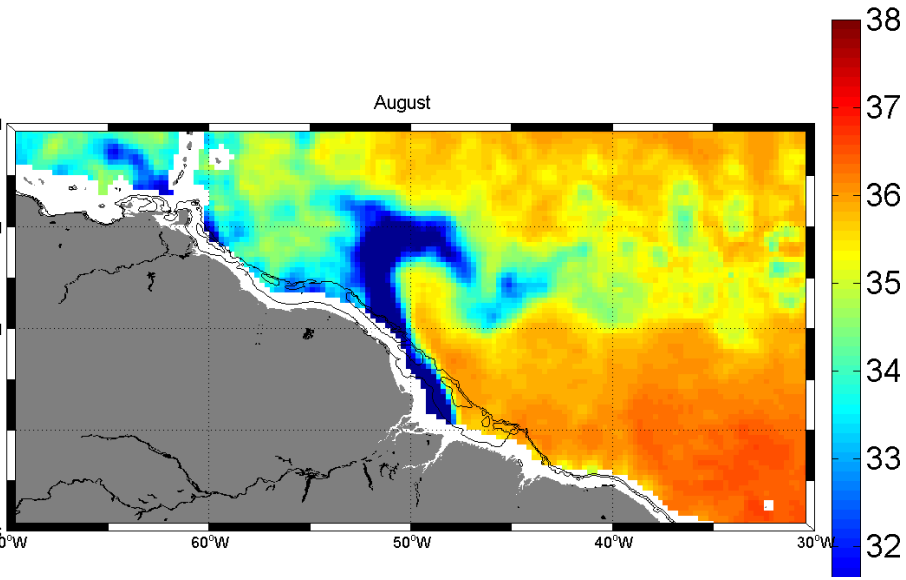
Monthly AMSR-E climatological SSS products over period 2003-2008



Monthly Climatology of AMSR-E SSS & drifter-derived near-surface currents

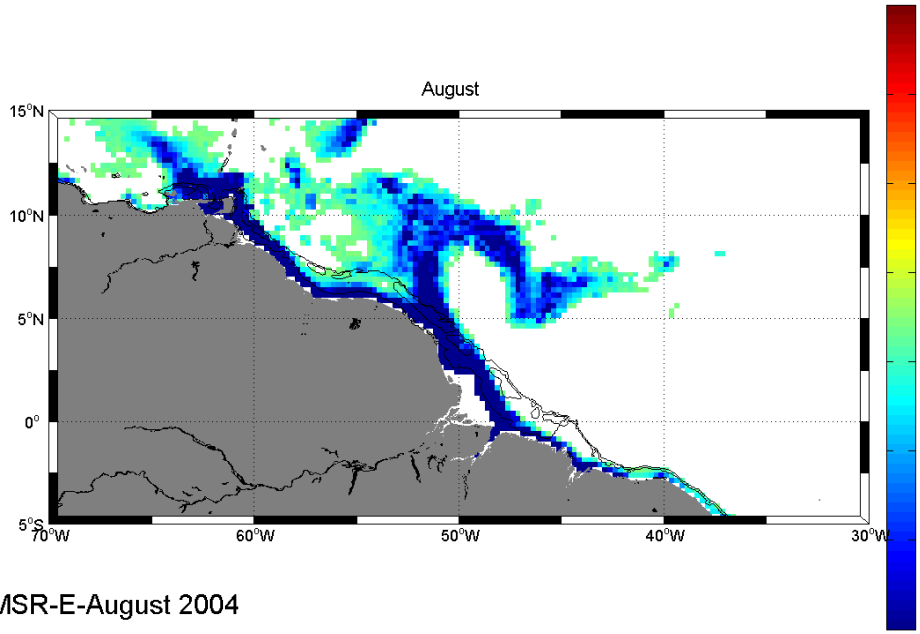


SSS from AMSR-E August 2004

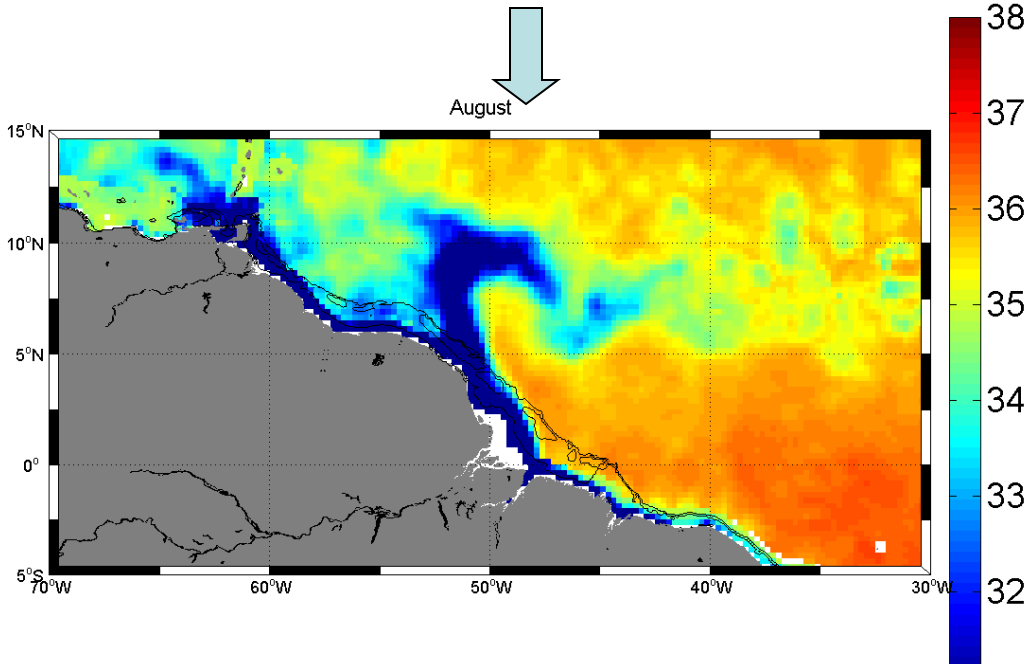


+

SSS from CDOM August 2004



Merged SSS from CDOM & AMSR-E-August 2004



Thoughts …

- An ideal instrument … (cloud-free, wide-swath, high-resolution, topography, roughness, Doppler, emissivity, reflectance, …) = the combined use of observations
- Improved technologies (instruments, resolution, computer capabilities, storage, dissemination) all contribute to improved combined analysis
- Theoretical and dynamical frameworks must be used to assess the quiddity, causes, contexts and essences of the different observations (including sensor physics, observability conditions and instrument capabilities)
- Development of future observing systems (including in situ) to capitalize on such a wealth: new analyzing tools and improved dynamical frameworks shall complement the definitions of new sensors.

And more …

- Thematically-driven Mining applications shall rapidly emerge to avoid the data deluge, and to emphasize the synergy between observations (in situ and satellite), numerical simulations and theoretical developments
- 'collaborative' efforts to promote future developments to avoid (limit) computation burden and/or (redundant) archive volume growth.
- Data on an EO-'cloud' and software utilities/applications more efficiently developed to search, process, visualize, analyze the data in a common approach.
- Usual discussions – the need for standard data formats, metadata conventions, open access etc.