

→ 4th ESA ADVANCED TRAINING  
ON OCEAN REMOTE SENSING

Synergy between Optical, Infrared and  
Microwave Sensors for Ocean Remote  
Sensing Applications

7–11 September 2015 | IFREMER | Brest, France

What do different satellite sensors have in common?

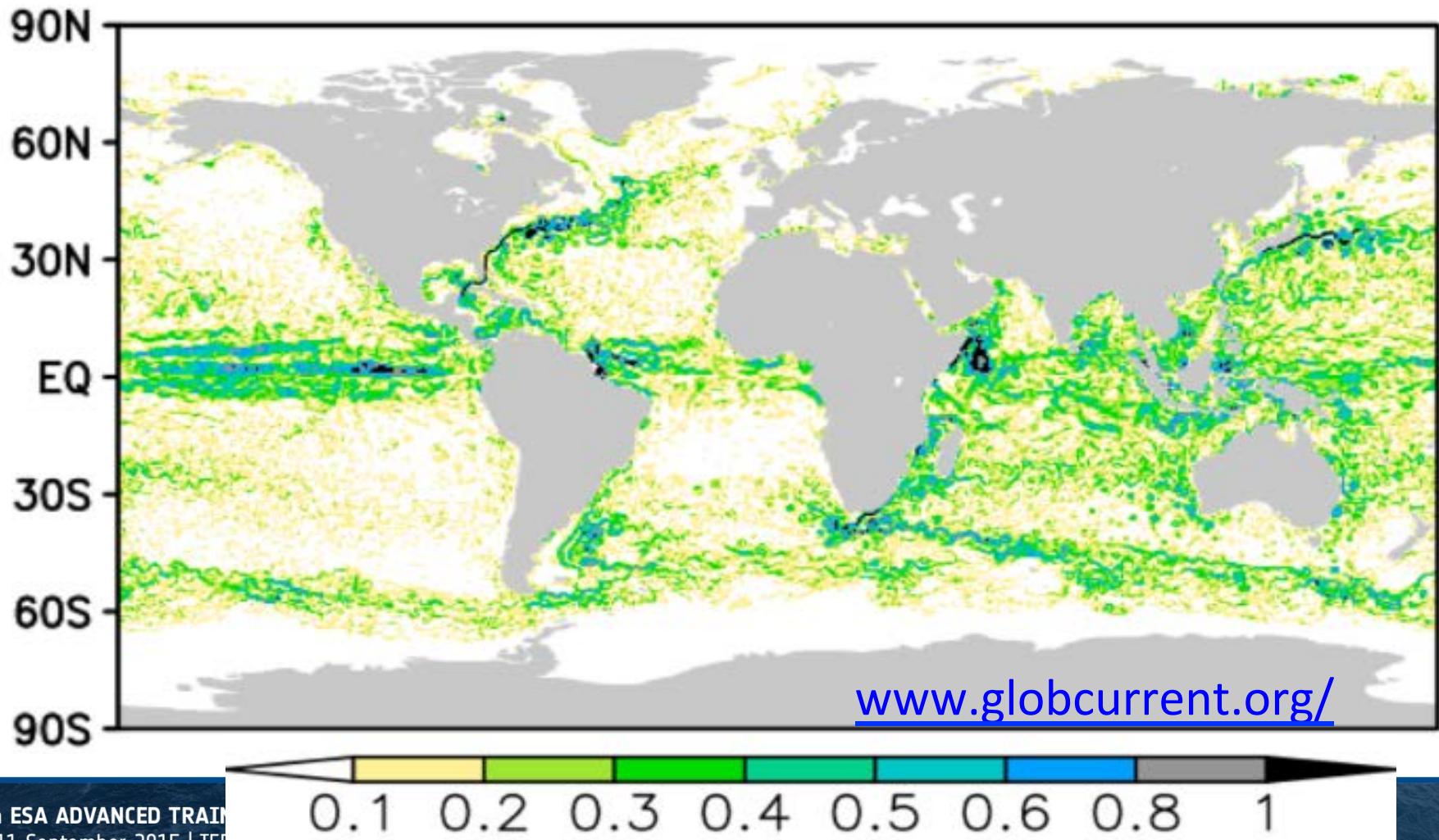
They have

- fronts
- eddies
- meandering currents

IR, Spectrometers, Altimeters, SAR, Scatterometers, PM  
detect and manifests these features through the gradients  
and anomalies in the SST, OC, sunglint anomalies, SSH, NRCS  
and range Doppler, near surface wind and SSS



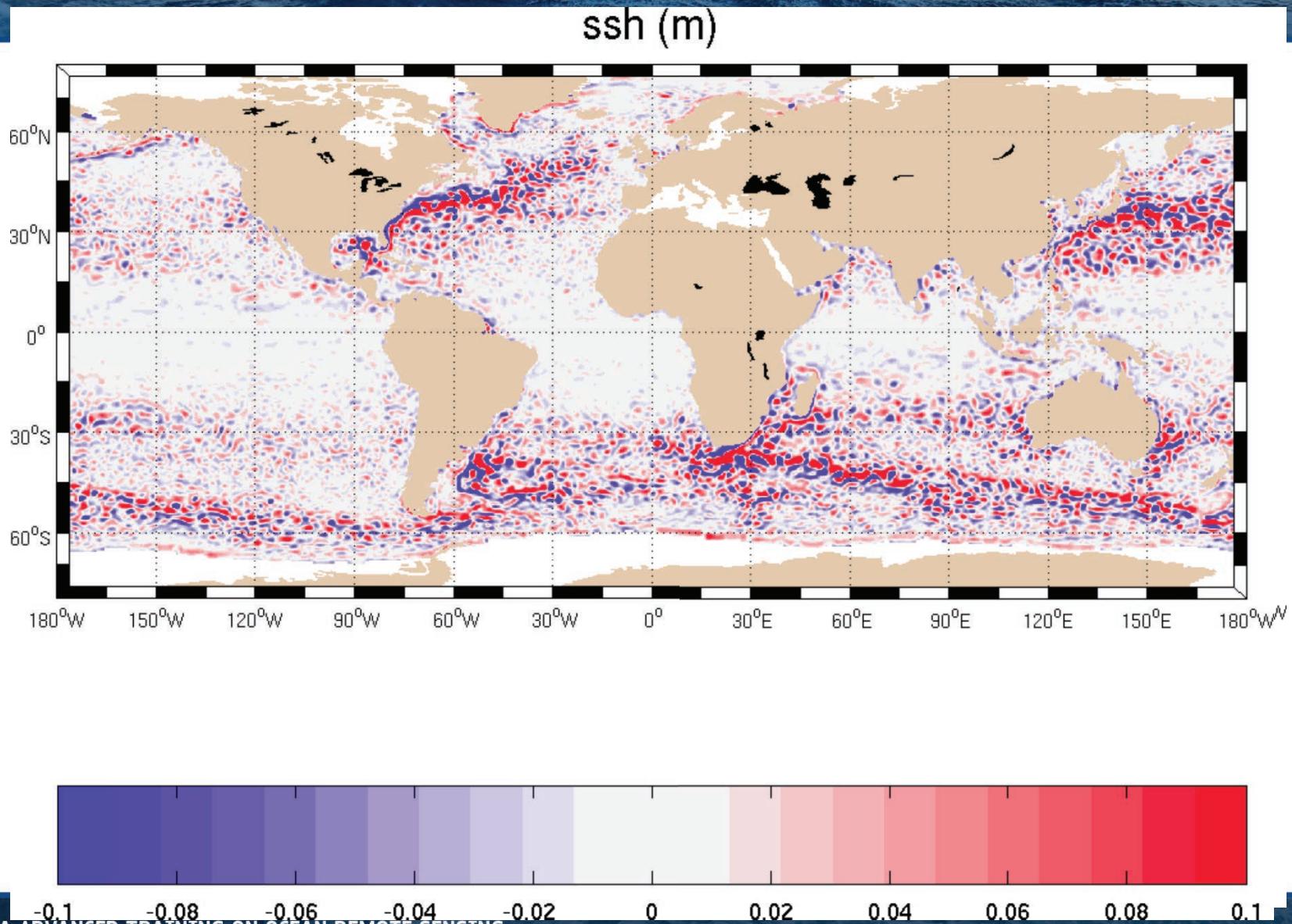
## Global Surface Geostrophic Current Product



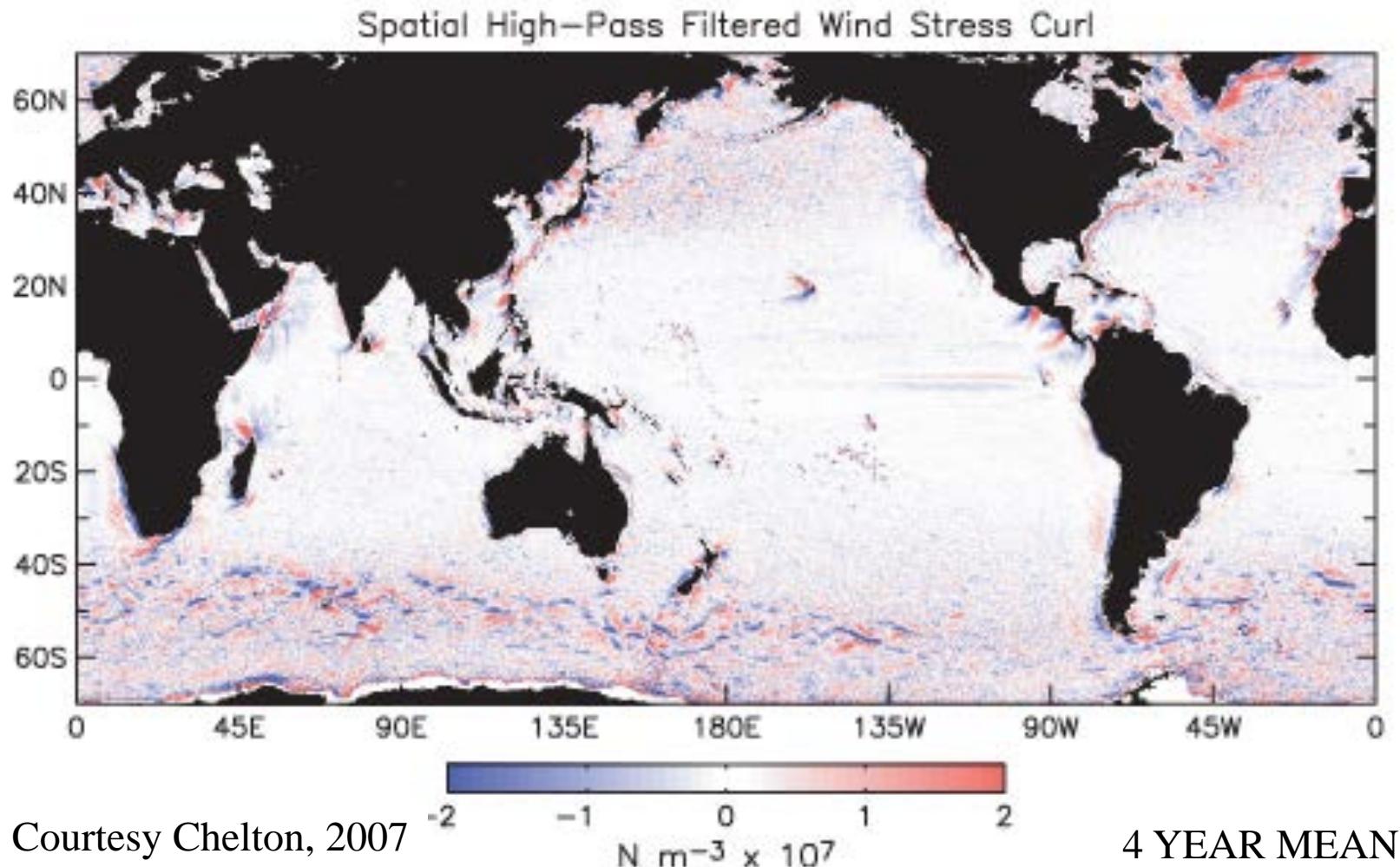
# Example SST and SSH gradients DISPLAY CURRENT FRONTS (global scale)

Ifremer

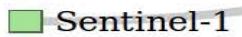
esa



## LINKS BETWEEN WIND STRESS CURL AND BIG CURRENT FRONT (SCALE > 100 KM)



# Platform



## Sensor Type

- █ IR
- █ RA
- █ Spectrometer
- █ Sun Glint
- █ SAR
- █ Argo
- █ Gravity
- █ HF Radar
- █ PMW
- █ SCAT
- █ Surface Drifters

## Ocean Variable

- Roughness Anomalies
- Ocean Colour
- SSH
- Waves
- Wind
- SST
- Surface Velocity
- SSS
- Mixed Layer Depth
- Geoid

## Derived Quantity

- Surface Current Boundaries
- Surface Tracer Velocity
- Ekman Current
- Inertial Current
- Surface Vorticity
- Surface Geo Current
- Stokes Drift
- Range Doppler Velocity
- Tidal Current

## Platform

## Sensor Type

## Ocean Variable

## Derived Quantity

Sentinel-3

- [Blue square] IR
- [Orange square] RA
- [Yellow square] Spectrometer
- [Green square] Sun Glint

Roughness Anomalies

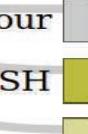
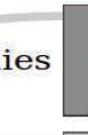
Ocean Colour

SSH

Waves

Wind

SST



Surface Current Boundaries

Surface Tracer Velocity

Ekman Current

Inertial Current

Surface Vorticity

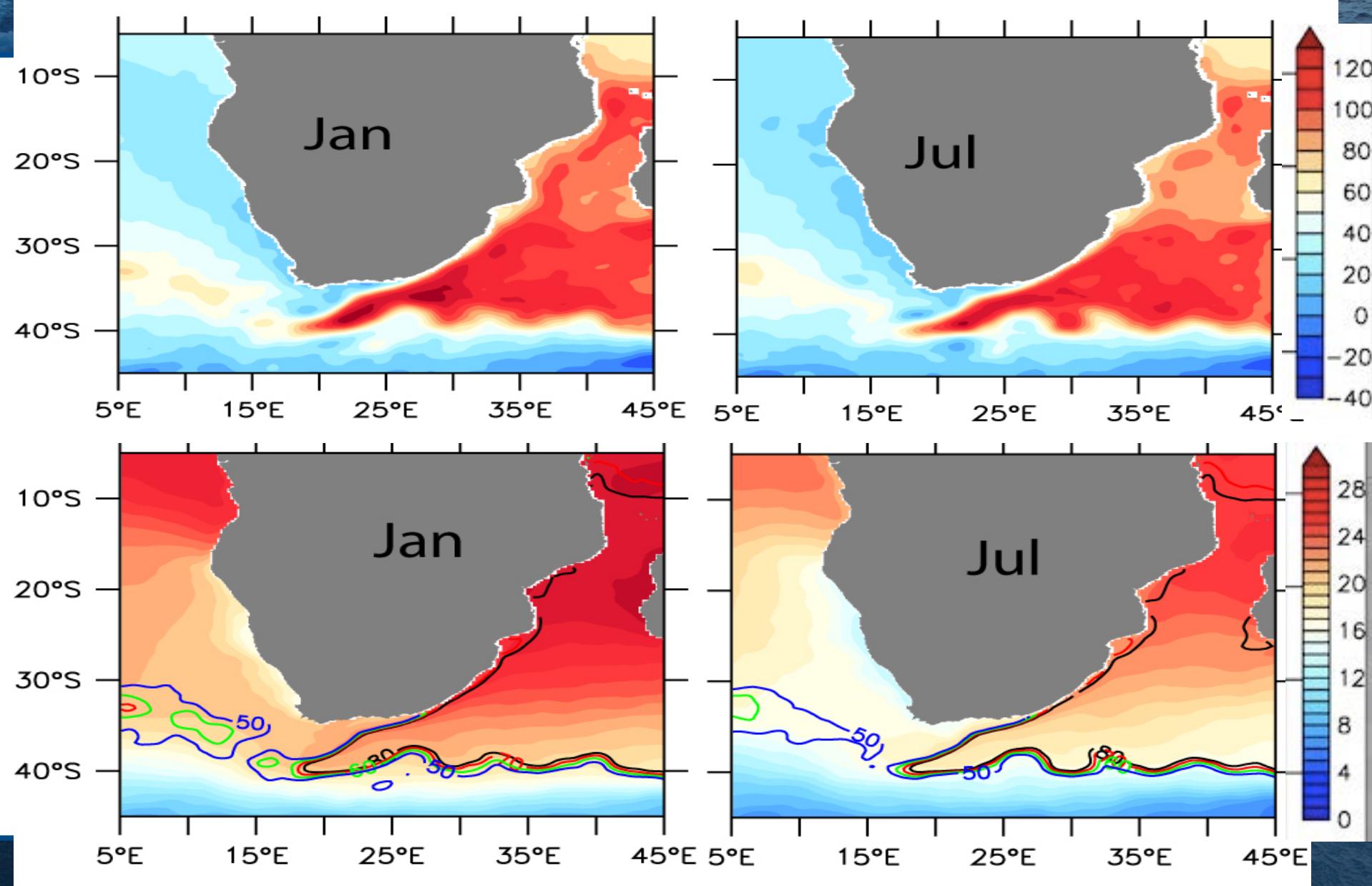
Surface Geo Current

Stokes Drift

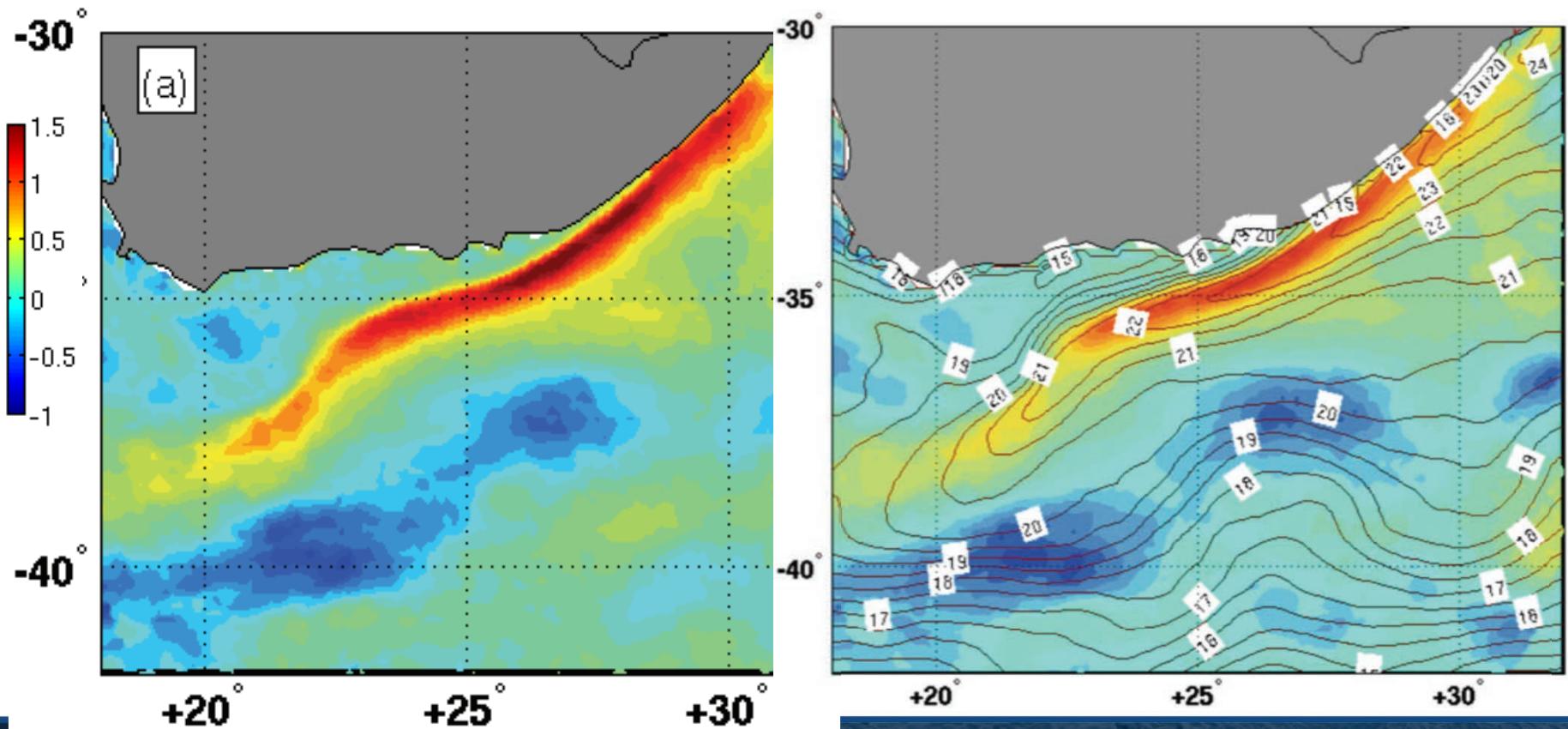
What spatial scales are valid when we look for these common features?

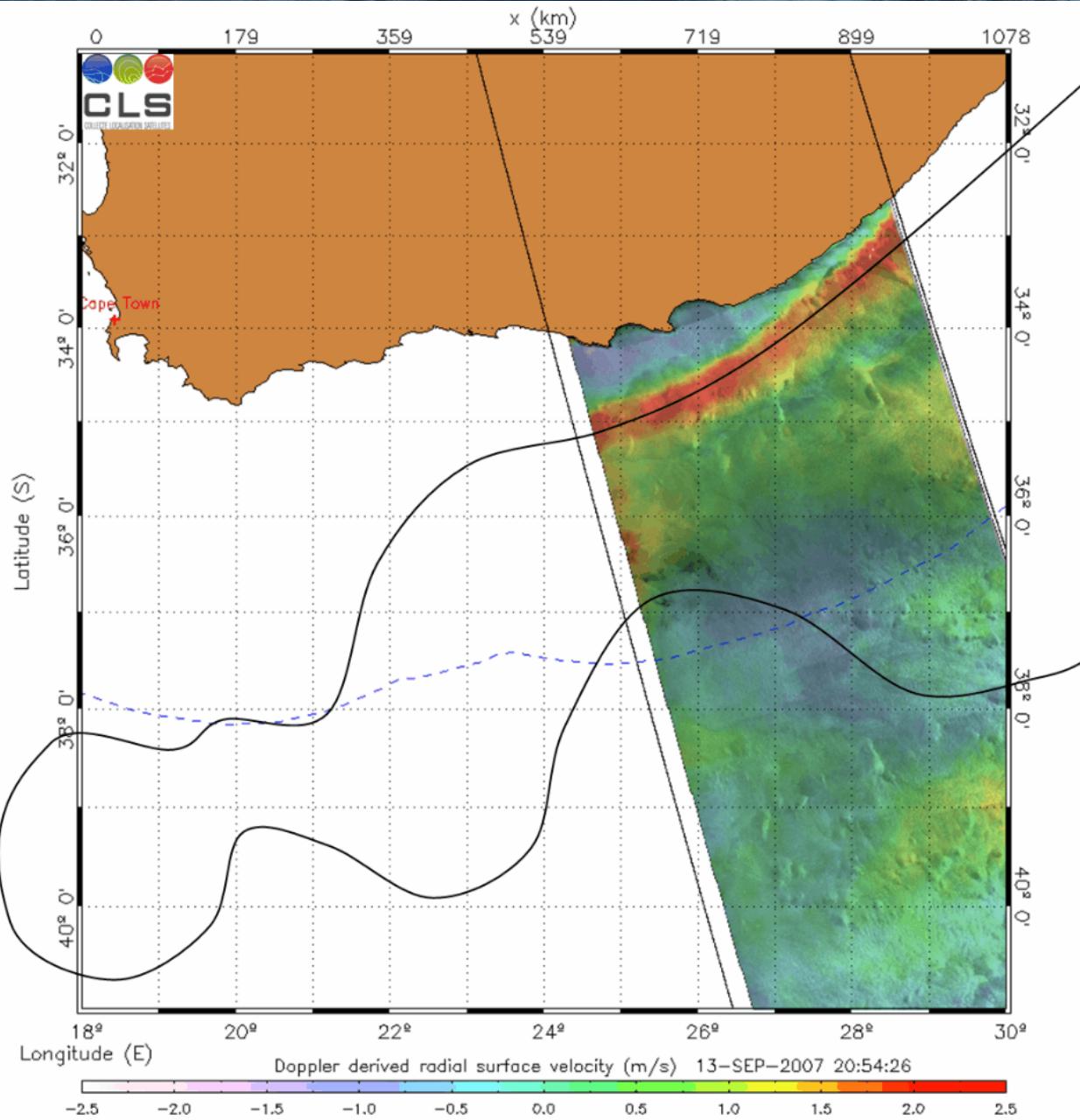
- Global, large scale at >100-200 km  
(SST, SSH, SSS, wind stress curl)
- Regional mesoscale at 30-100 km (low latitude)  
(SAR, range Doppler, SST, SSS, OC, sunglint, SSH)
- Regional mesoscale at 10-30 km (high latitude)  
(SAR, range Doppler, SST, OC, sunglint)
- Regional to local submesoscale at 1-10 km  
(SAR, range Doppler, SST, OC, sunglint)

# CLIMATOLOGY OF SSH AND SST (regional scale, 1993-2012)



## Mean Range Doppler velocity and SST for 2007-2012

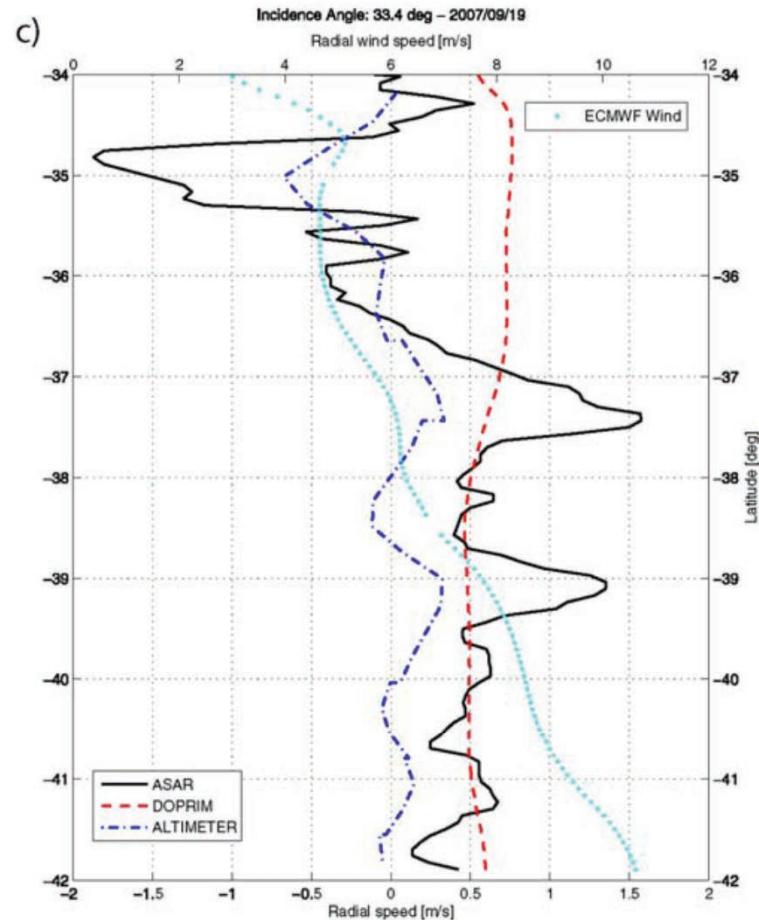
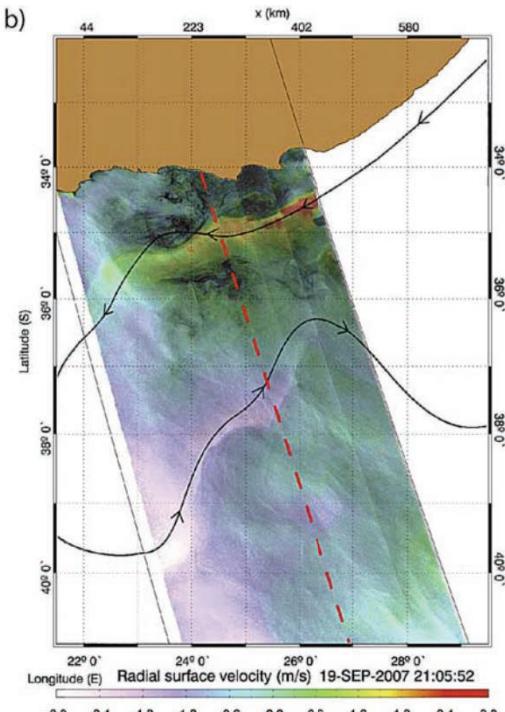
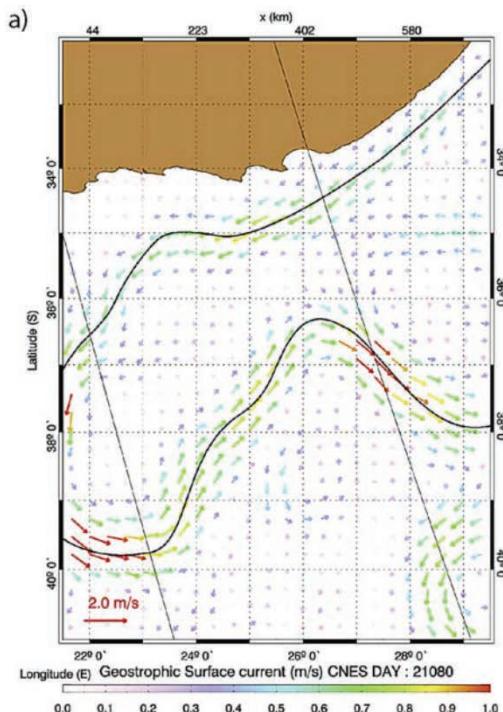




SAR Radial  
Surface velocity  
products from  
13, 16, 18, 19  
and 22  
September 2007

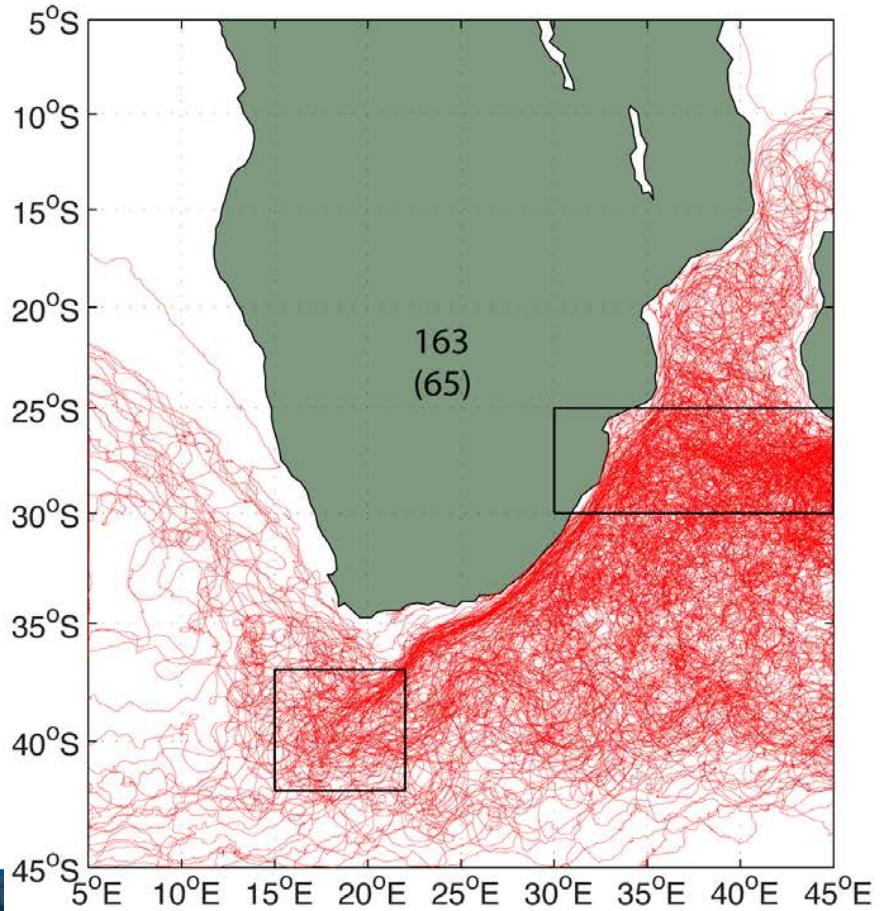
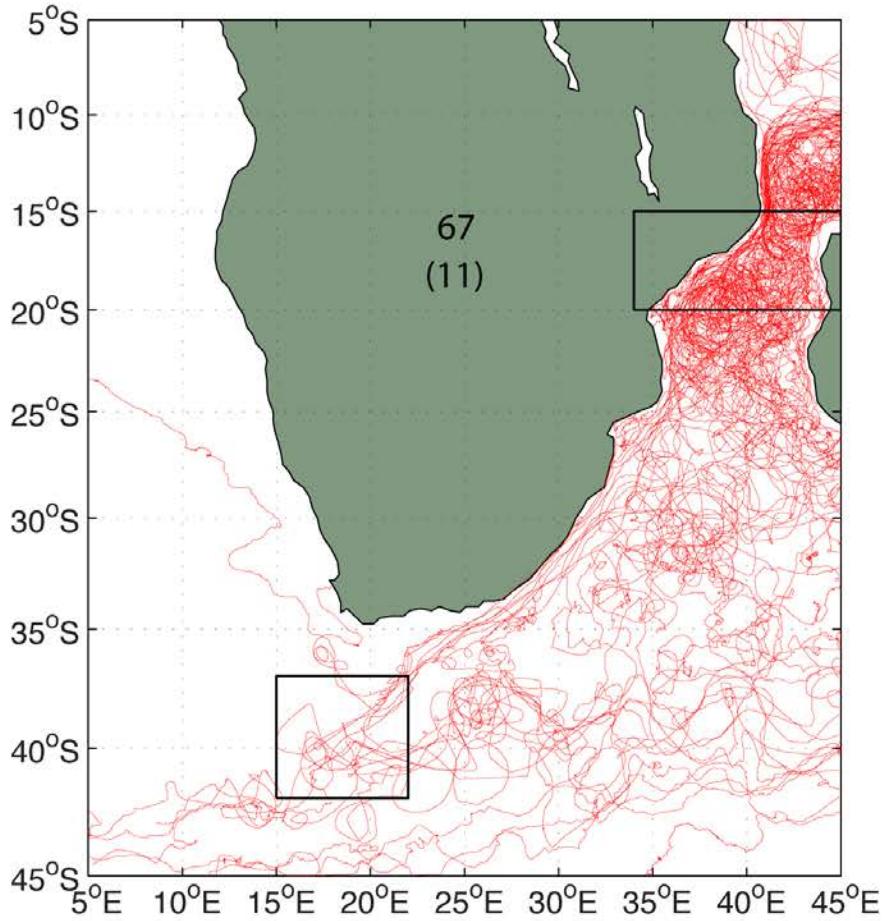
Accuracy around  
5 Hz or  $\sim$ 25 cm/s  
at 30 degree  
incidence angle

Johannessen et al., 2008

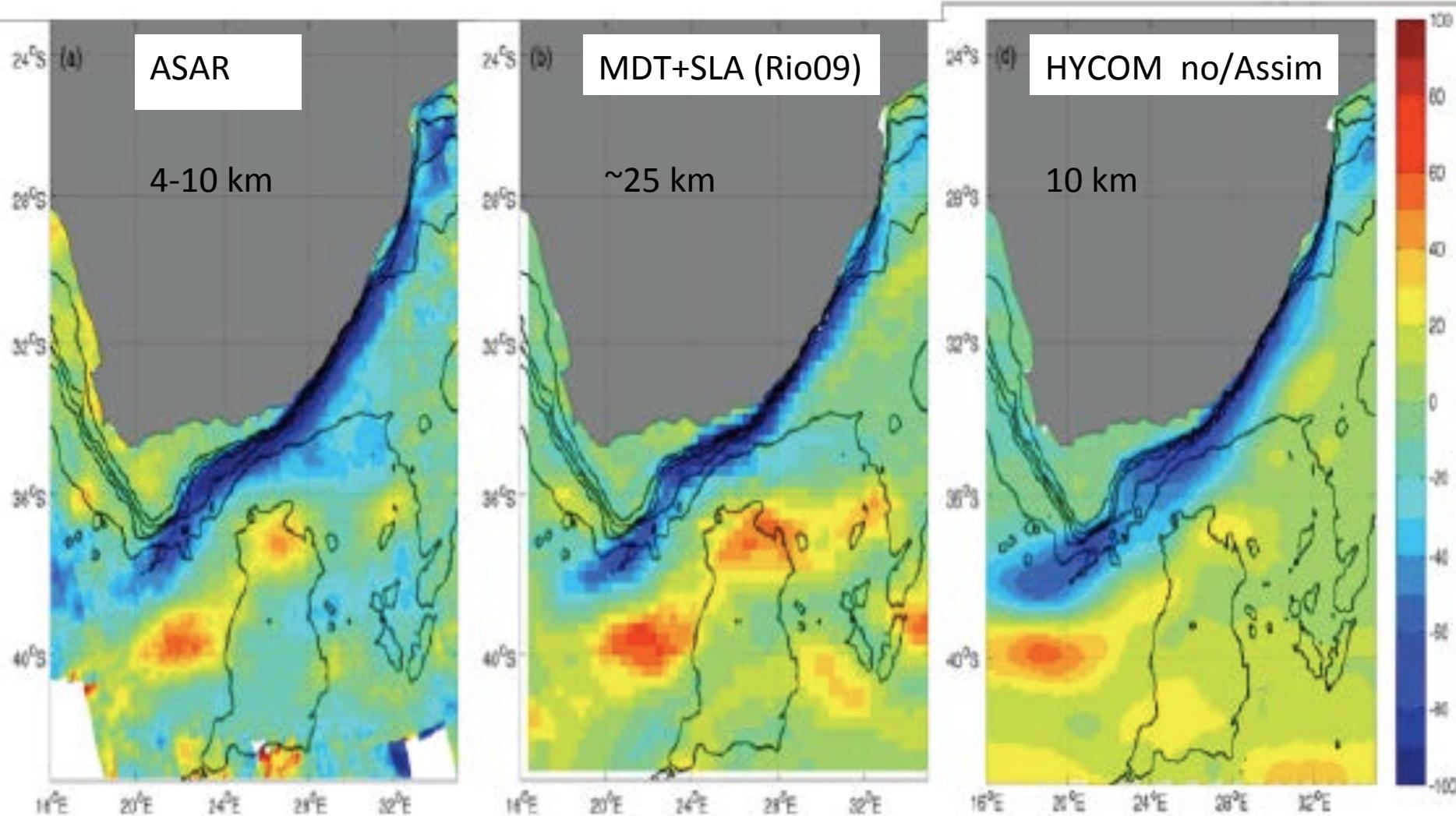


Johannessen et al., 2008

## Validation: Surface drifter velocity 1992-2014



# Agulhas Surface Current Climatology 2007-2009



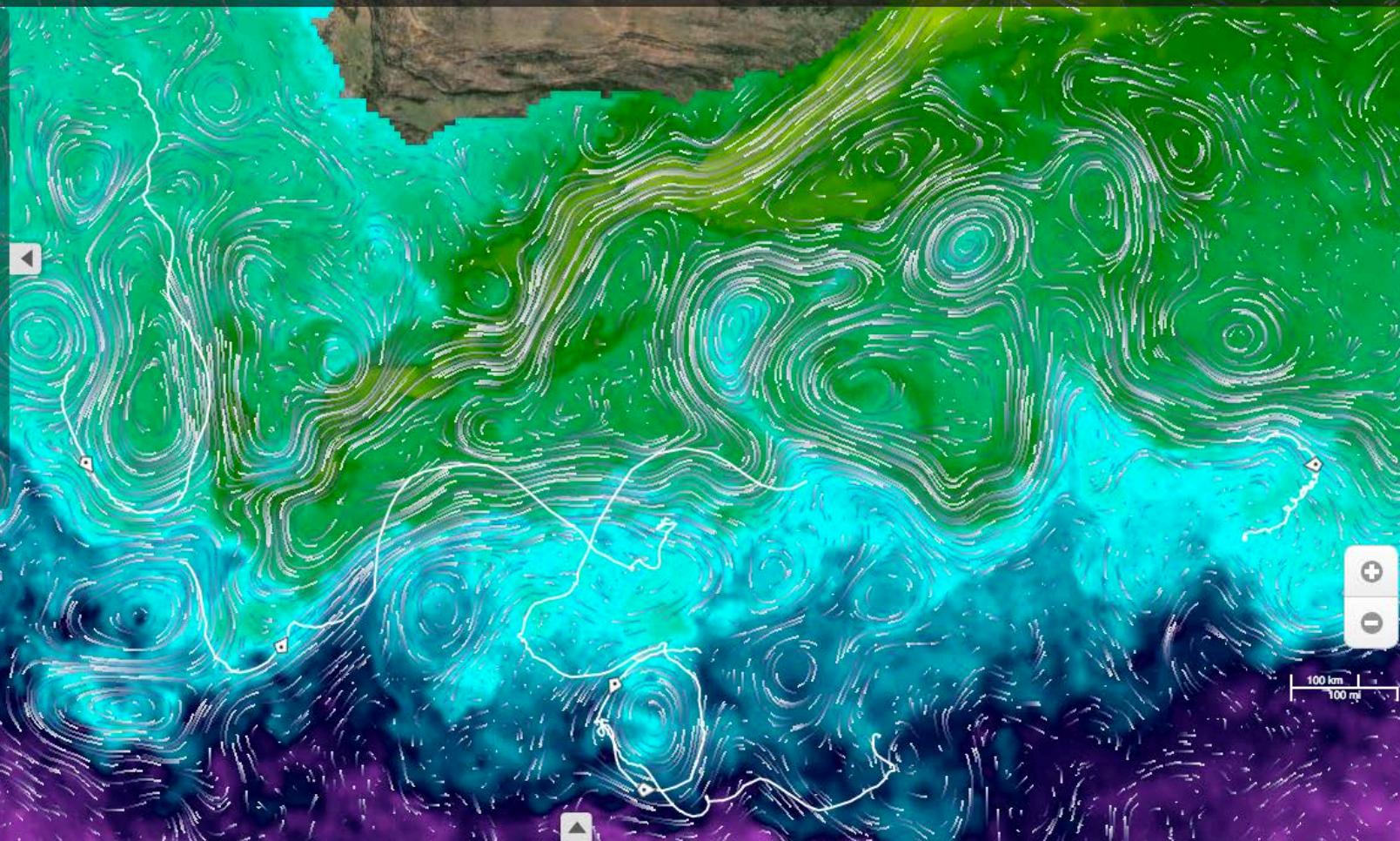
→ 4th ESA ADVANCED TRAINING ON OCEAN REMOTE SENSING  
Johannessen et al 2014

MarSAR 2015 Workshop  
7-11 September 2015 | IFREMER | Brest, France

UCT, Cape Town, 14-16 January 2015

**Products**

- Geostrophic surface current streamlines (Globcurrent)
- HF radar velocity (NOAA)
- HF radar streamline (NOAA)
- SST Odyssea Regional South Africa (IFREMER)
- SST Odyssea Global (IFREMER)
- OSCAR surface current streamline (NOAA)
- User Shapes
- SAR roughness (ESA,OceanDataLab)
- SST SMOS L4 (ECMWF, IFREMER)
- OSCAR current SMOS L4 streamline (NOAA, IFREMER)
- SSS SMOS L4 (ESA, IFREMER)
- Drifters 15m drogue (Globcurrent)
- SST MODIS denoised (NASA, OceanDataLab)



1x

Daily

3-Day

Weekly



221 dataset(s)

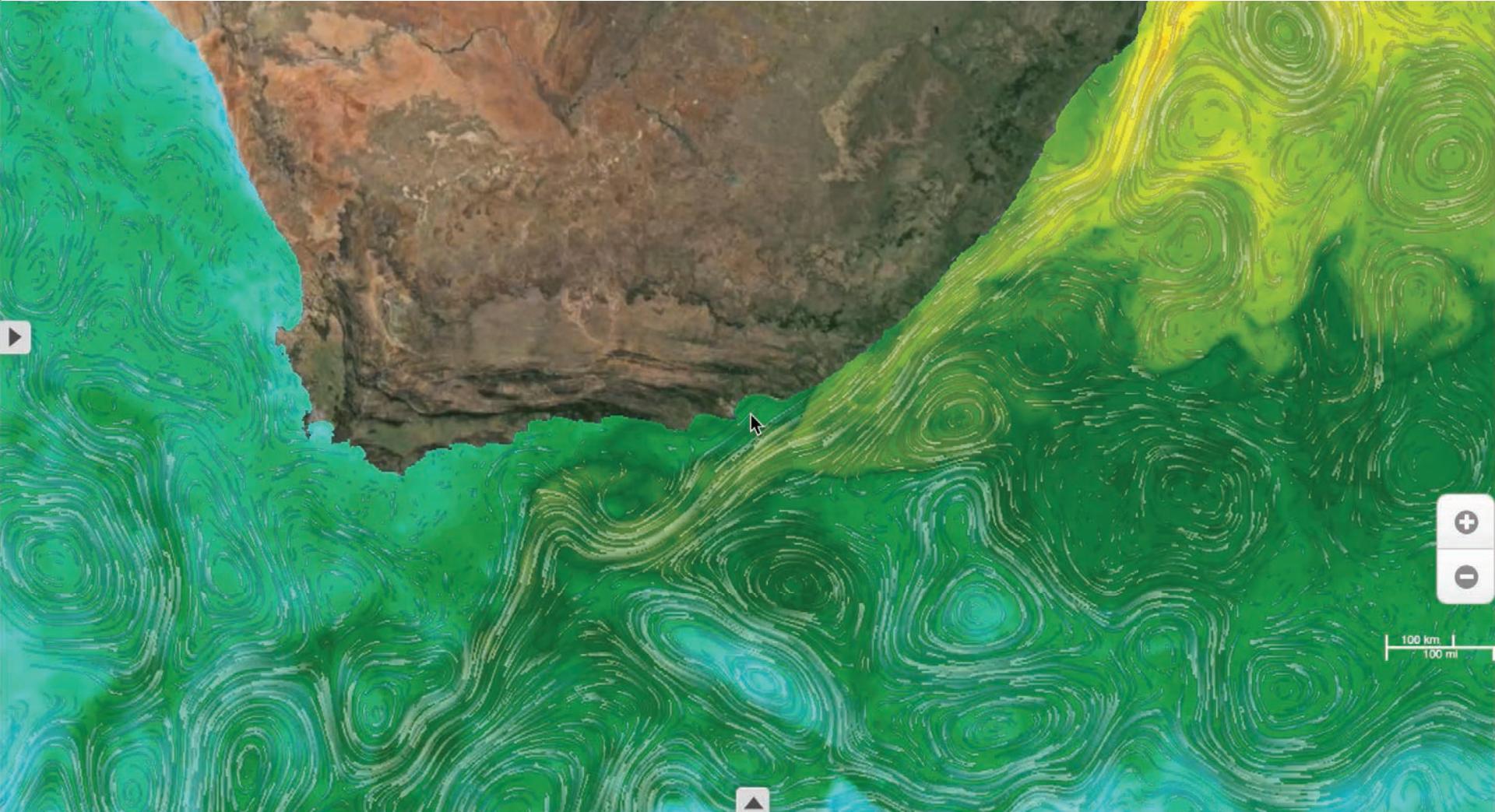
10.82°, -40.60°



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SNAPSHOT 6 SEPTEMBER 2012

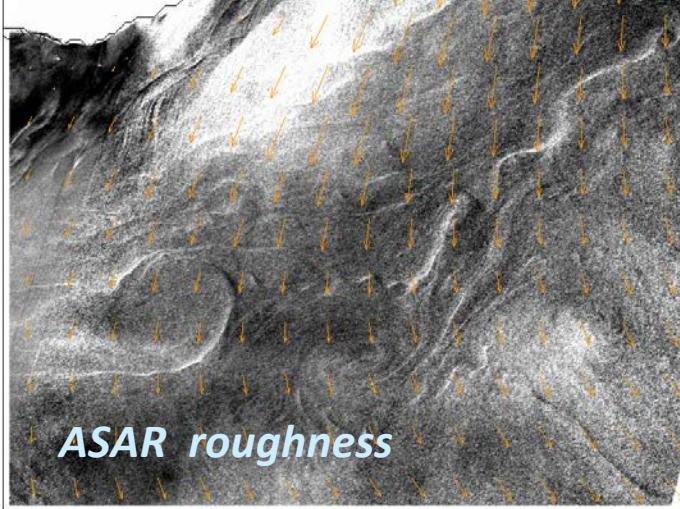
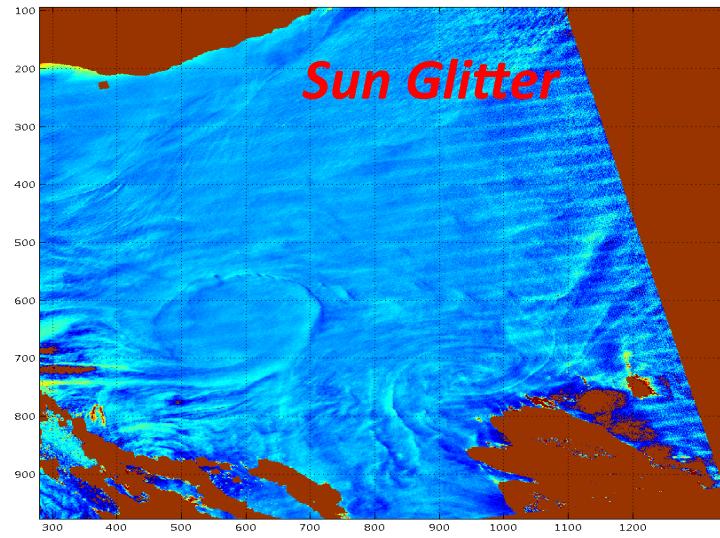
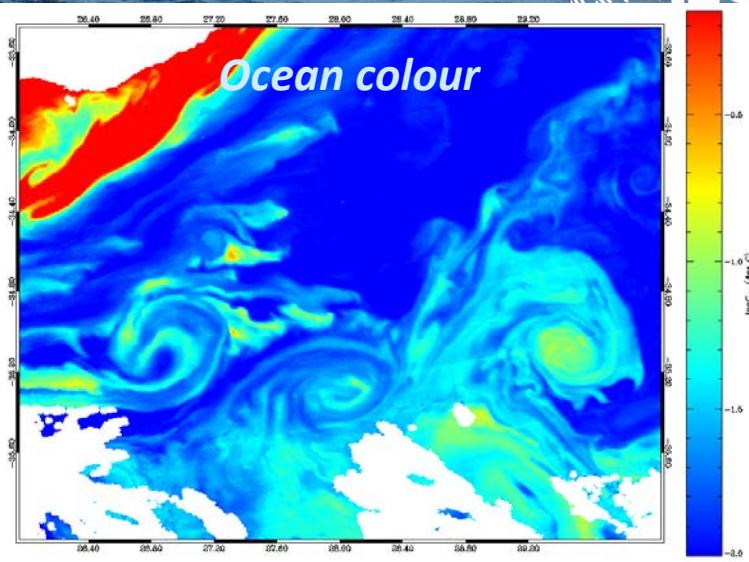
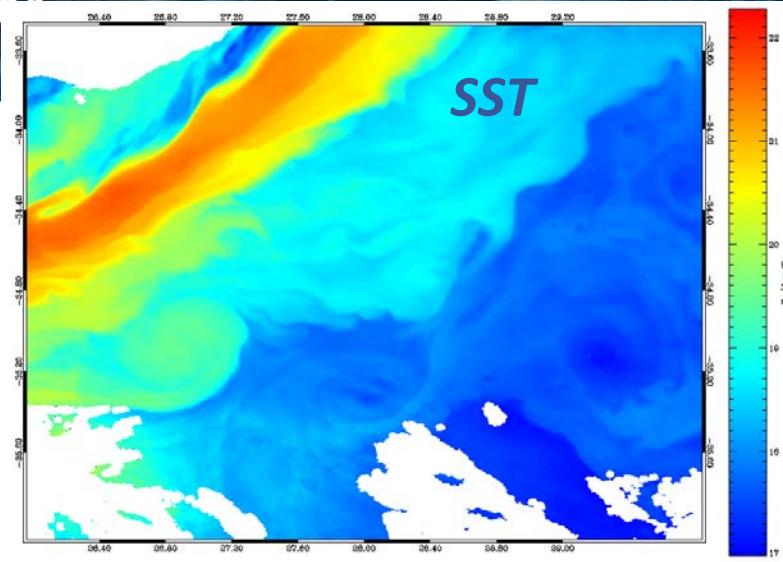
Lido, Venice, Italy, 2-6 June 2015



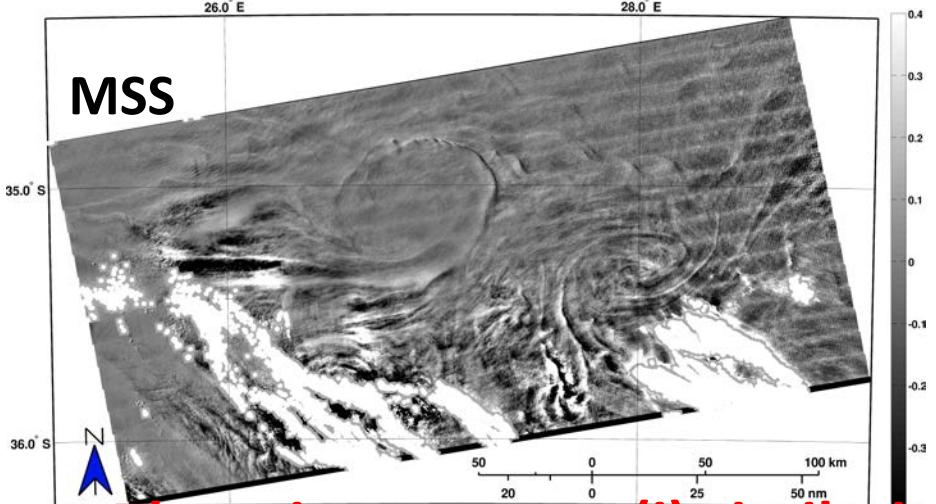
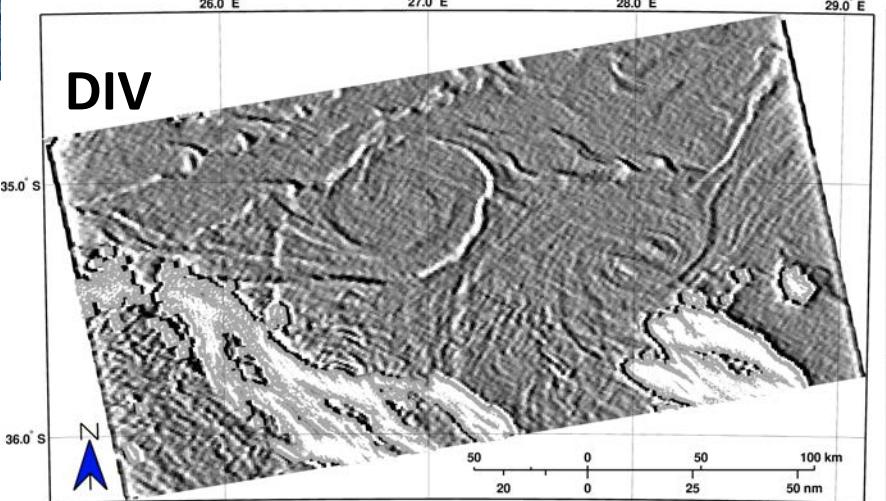
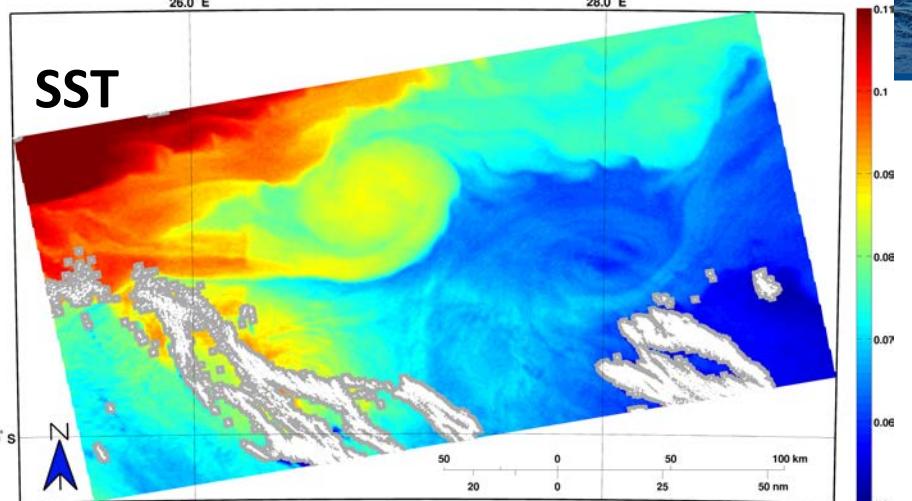
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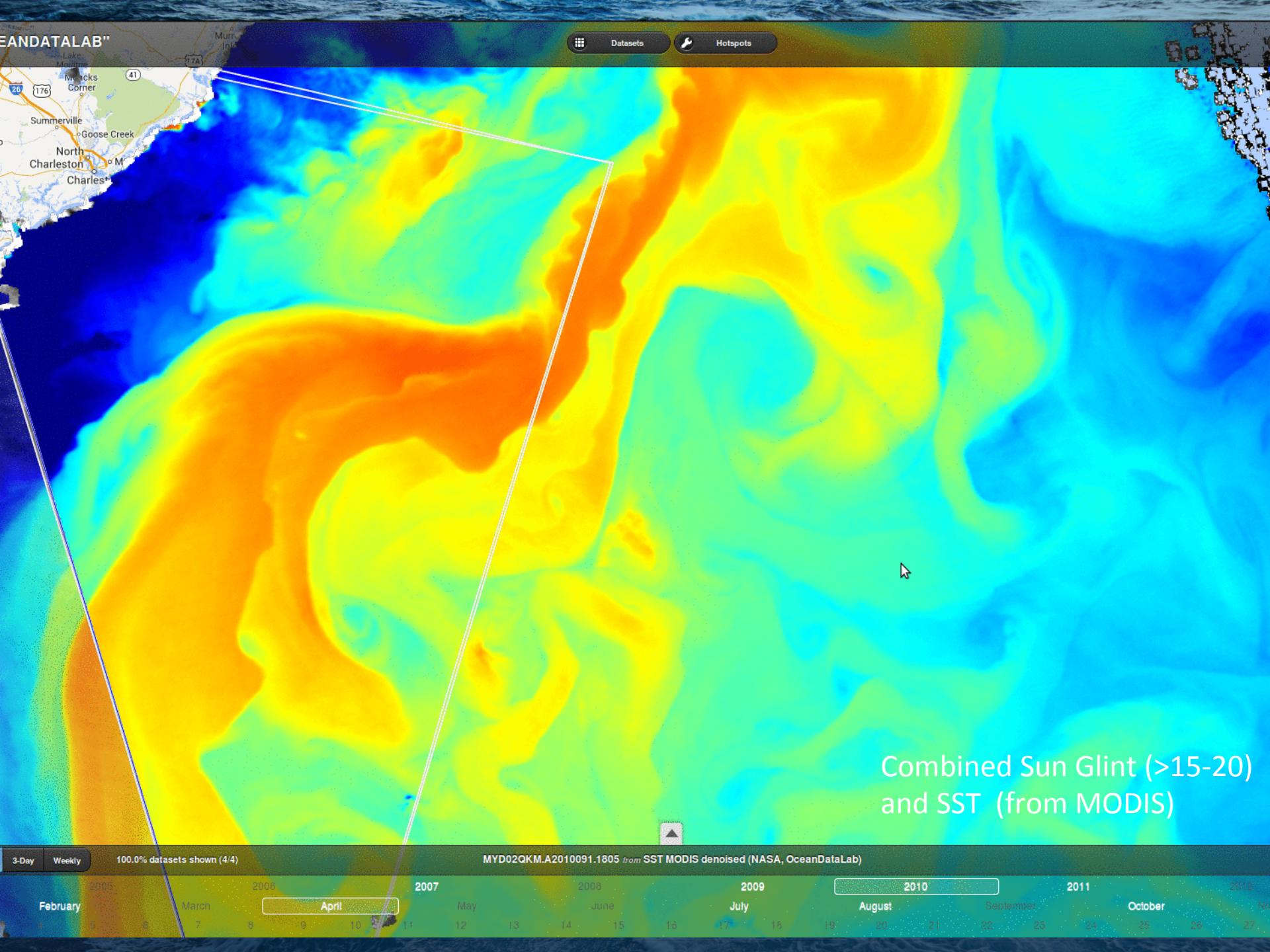
## Challenges at the mesoscale (Synergy)



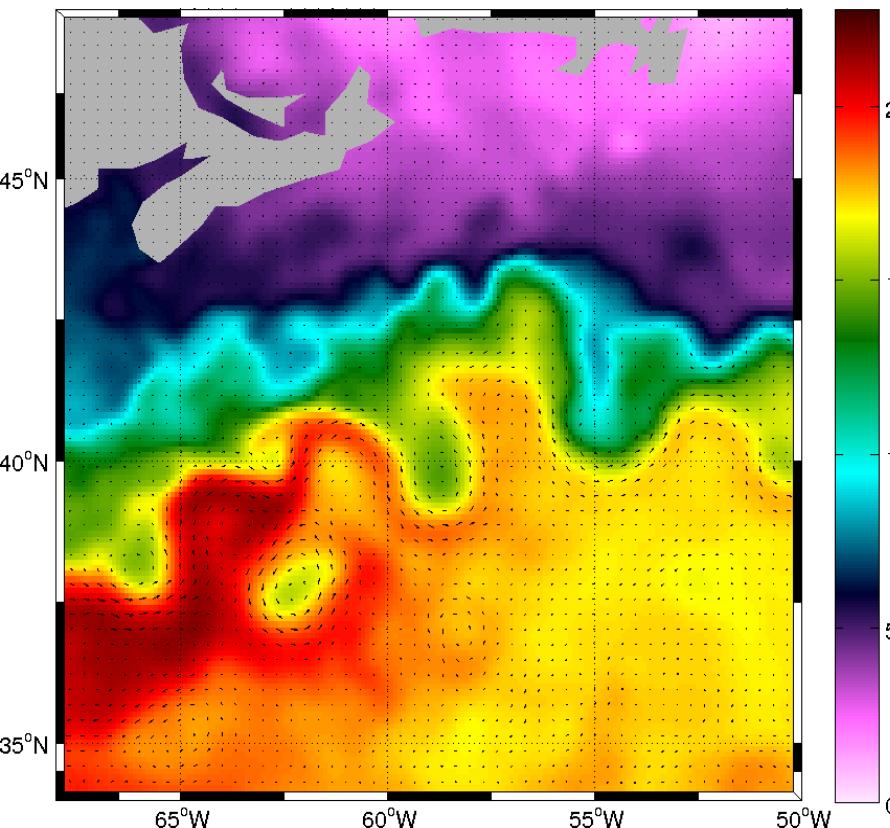
Kudryavtsev, A. Myasoedov, B. Chapron, J.A. Johannessen, F. Collard, JGR; 2012



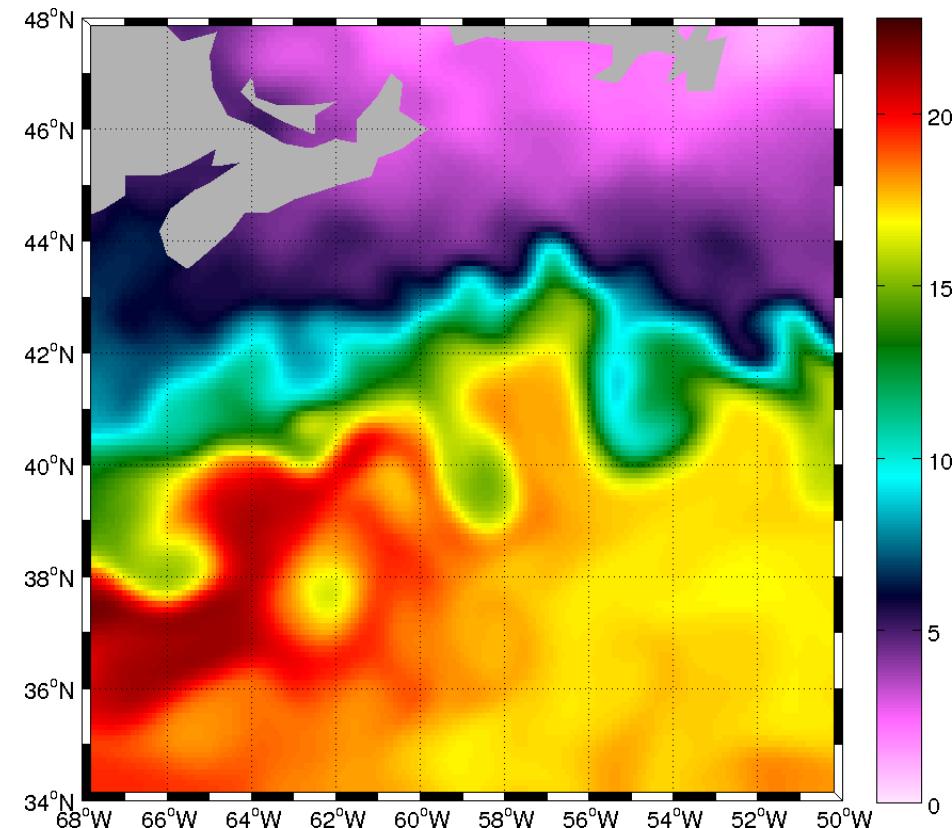
**There is apparent (i) similarity between MSS and SAR NRCS signatures, and (ii) correlation with surface current convergence**



# Forward Lagrangian Advection from 02/05 to 06/05 2010

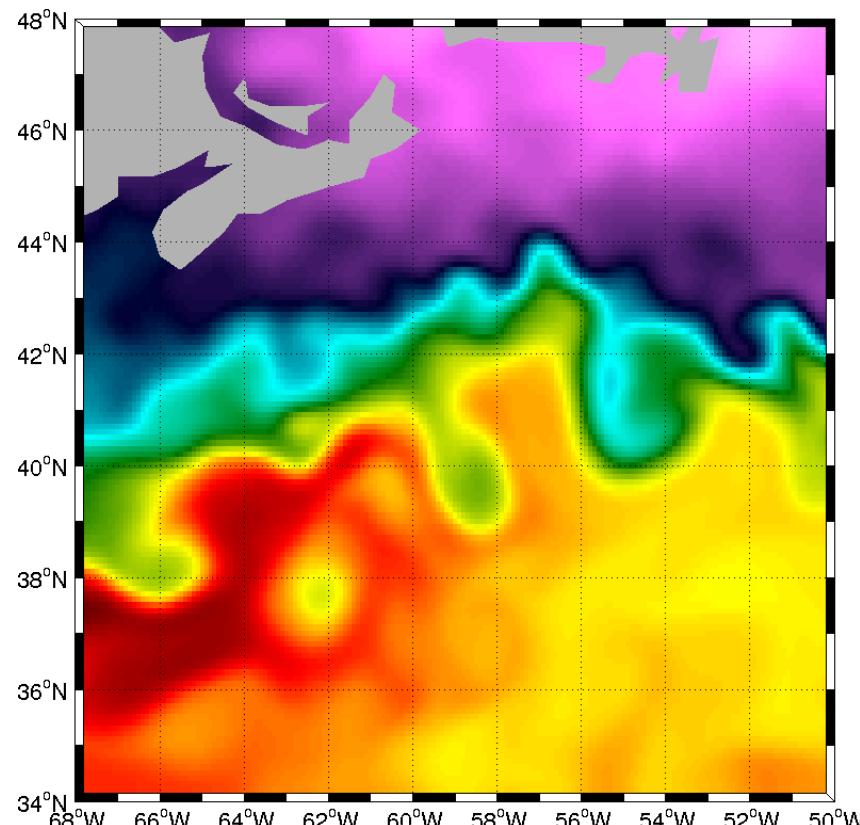


SST and AVISO Current Vectors at 25 km  
resolution (02/05/2010)

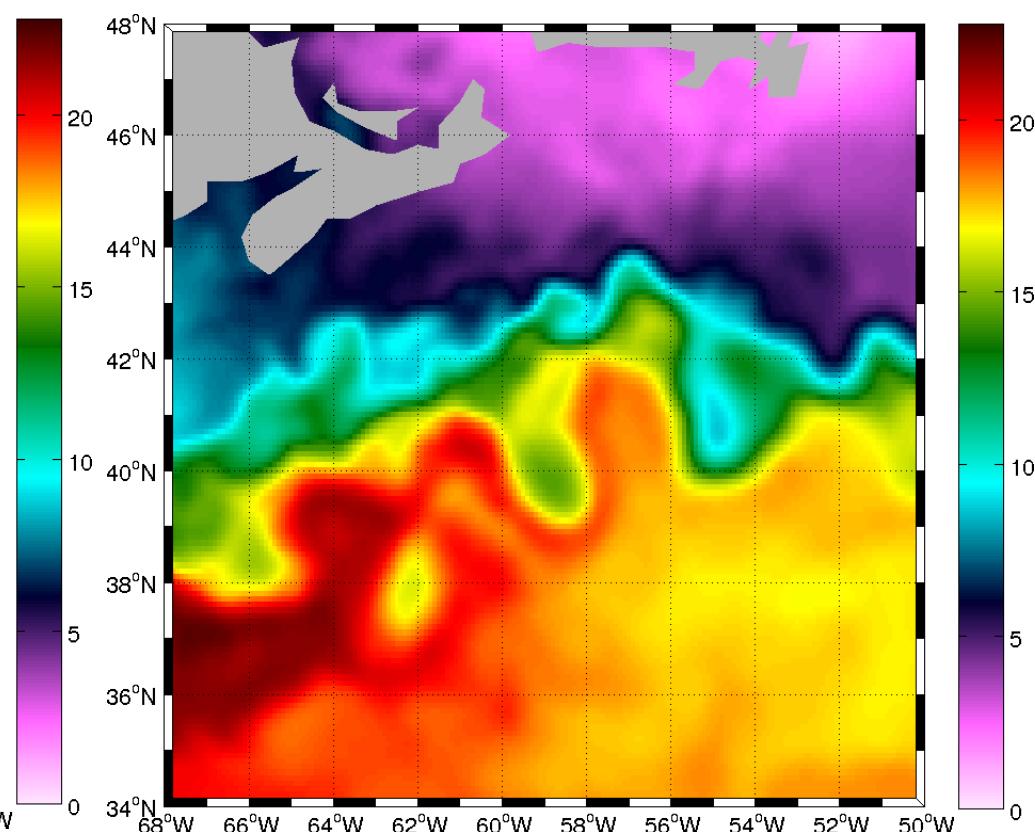


06/05/2010 - « smoothed »  
adverted SST (4 days)

# Forward Lagrangian Advection from 02/05 to 06/05 2010



06/05/2010 - « smoothed »  
advection SST (4 days)

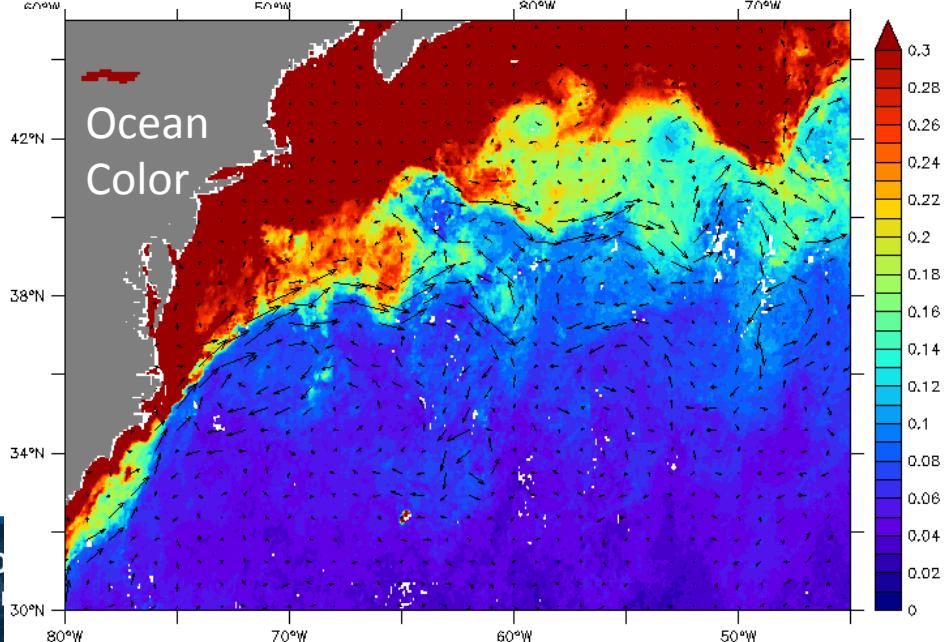
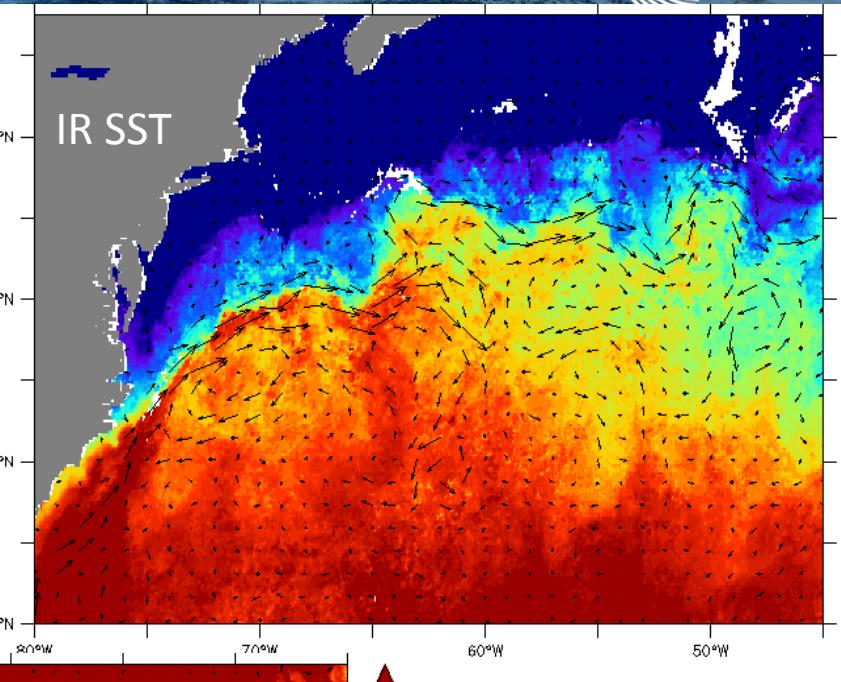
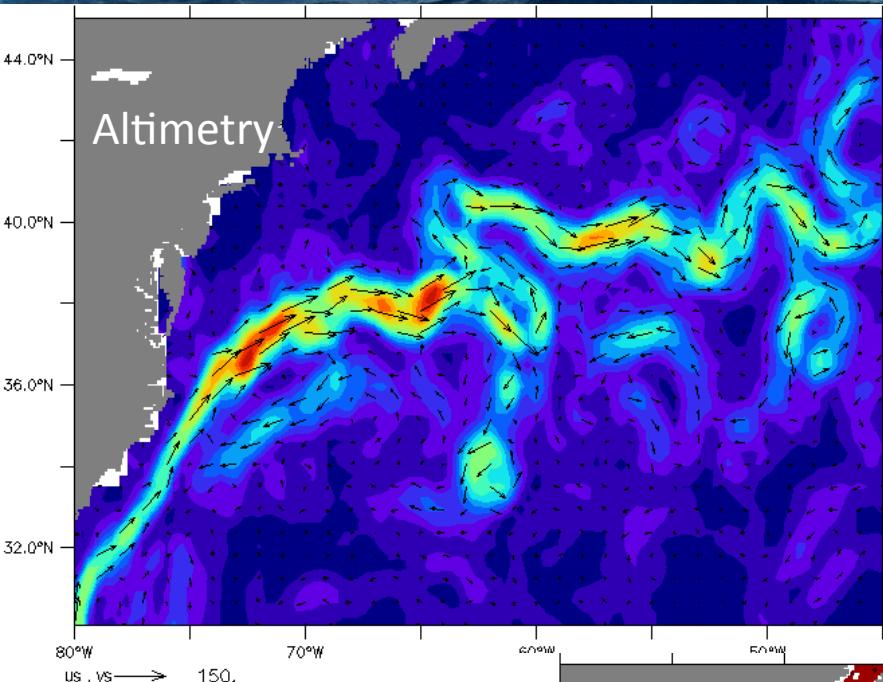


06/05/2010 – Observed SST



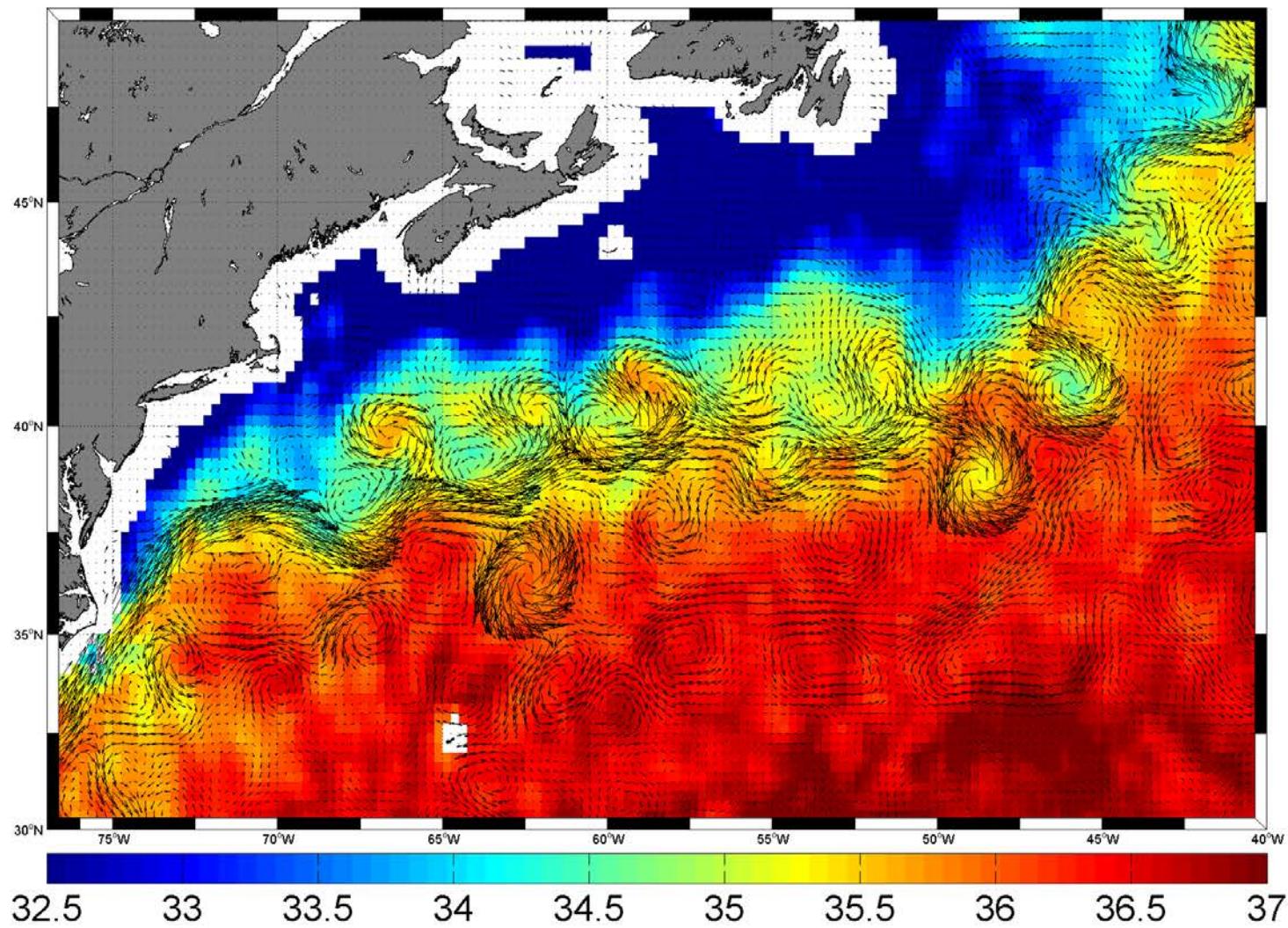
Ifremer

# SSH , SST, OC

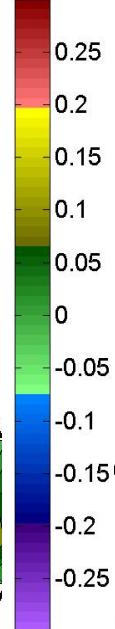
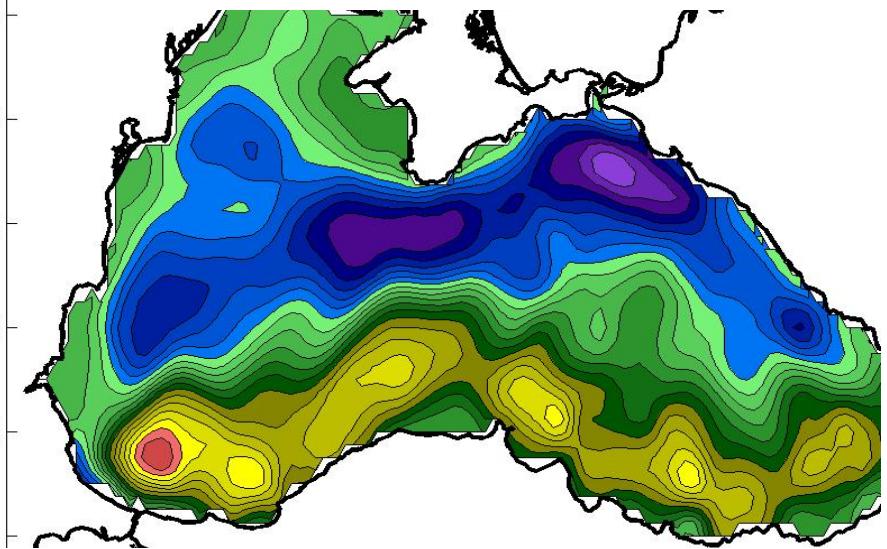


September mean 2009

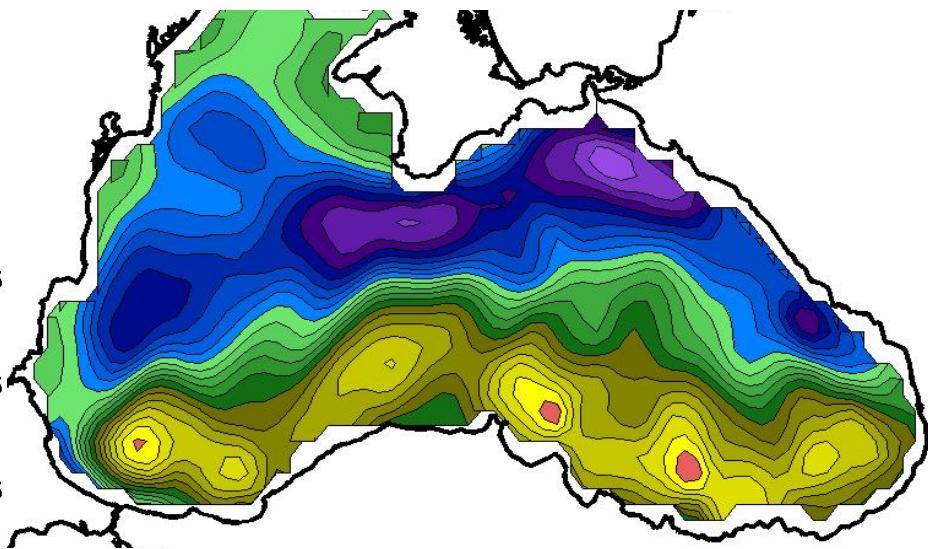
SMOS SSS (color)+ currents (vector) from 01/07 to 15/07 2012



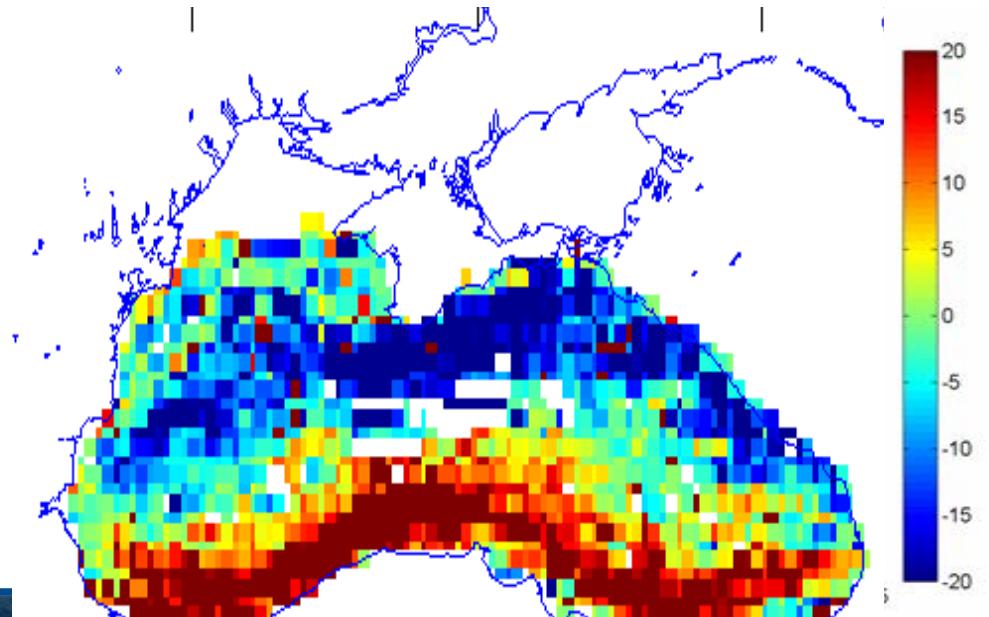
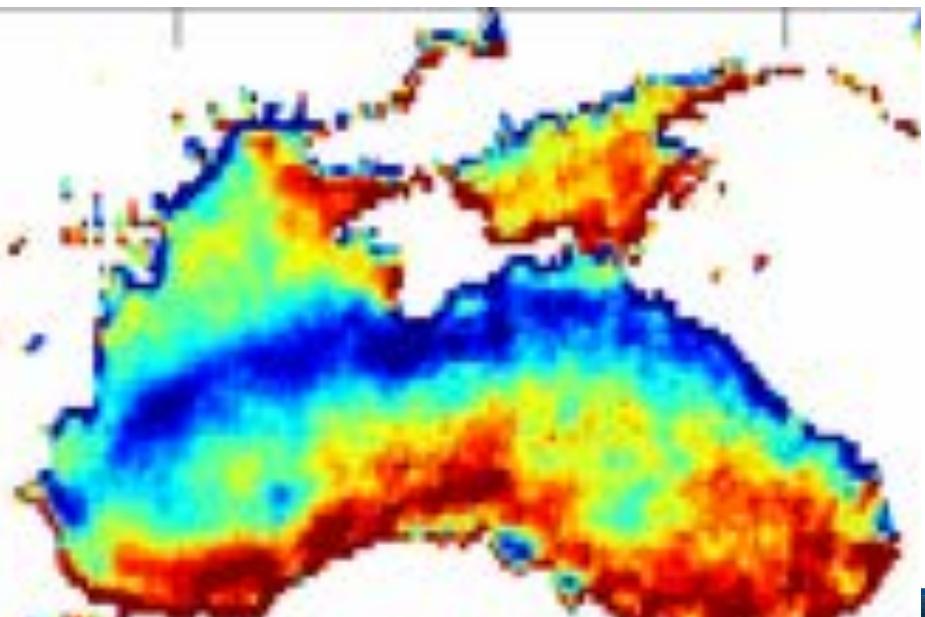
Mean Zonal Velocity from alt



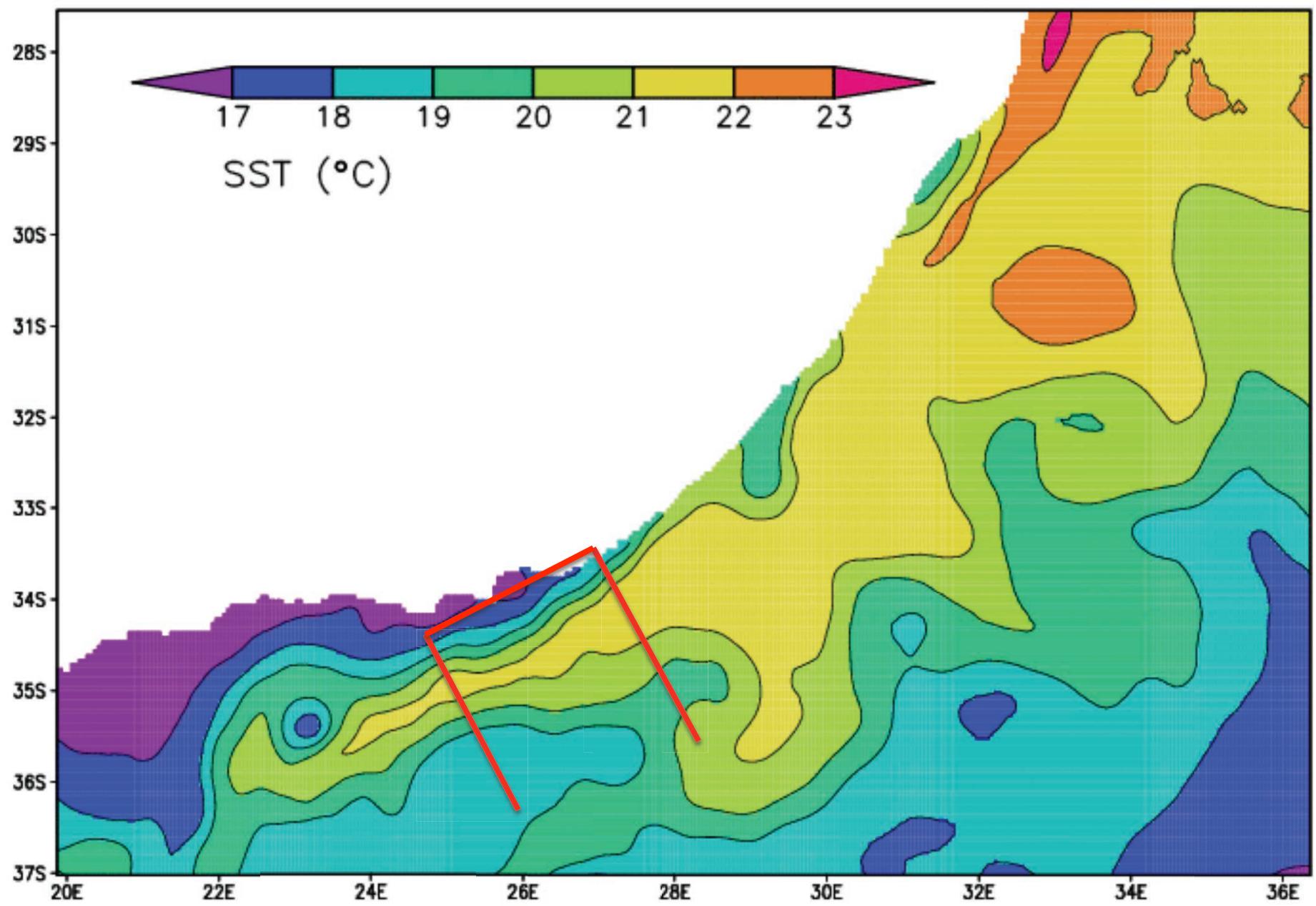
Mean Zonal Velocity from MM5

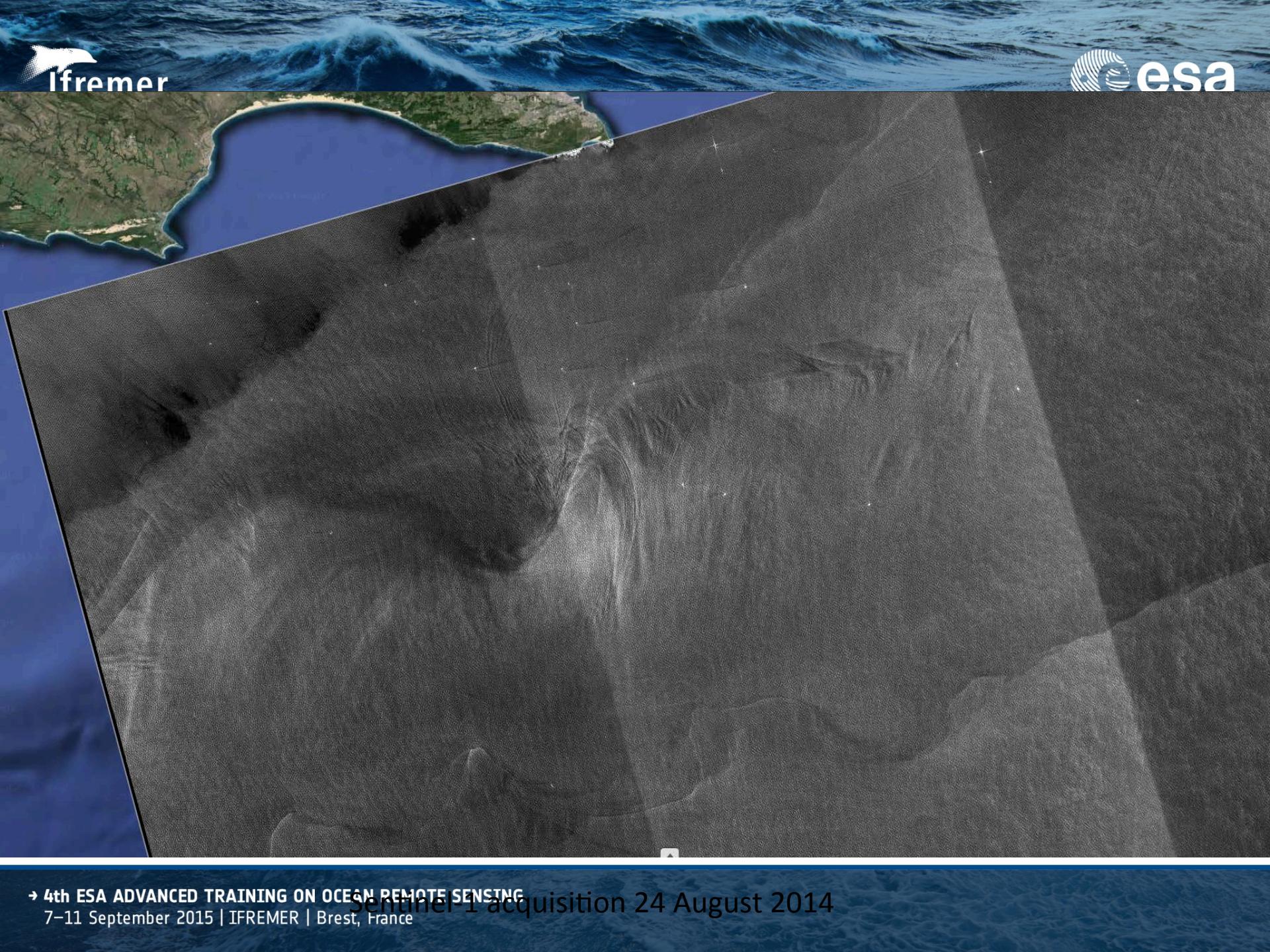


Drifter Mean Zonal Velocity

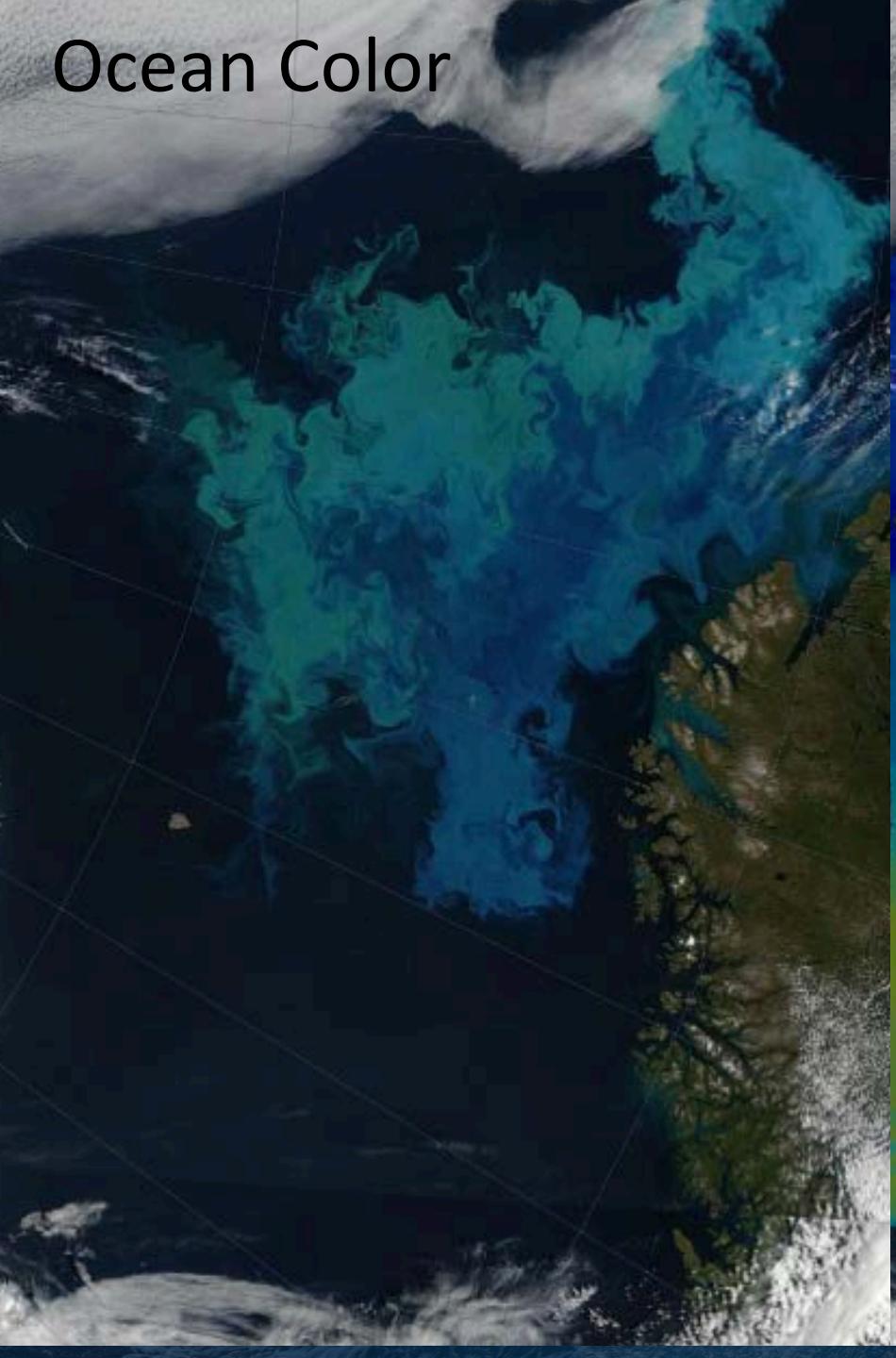


OSTIA 2014-08-24-12

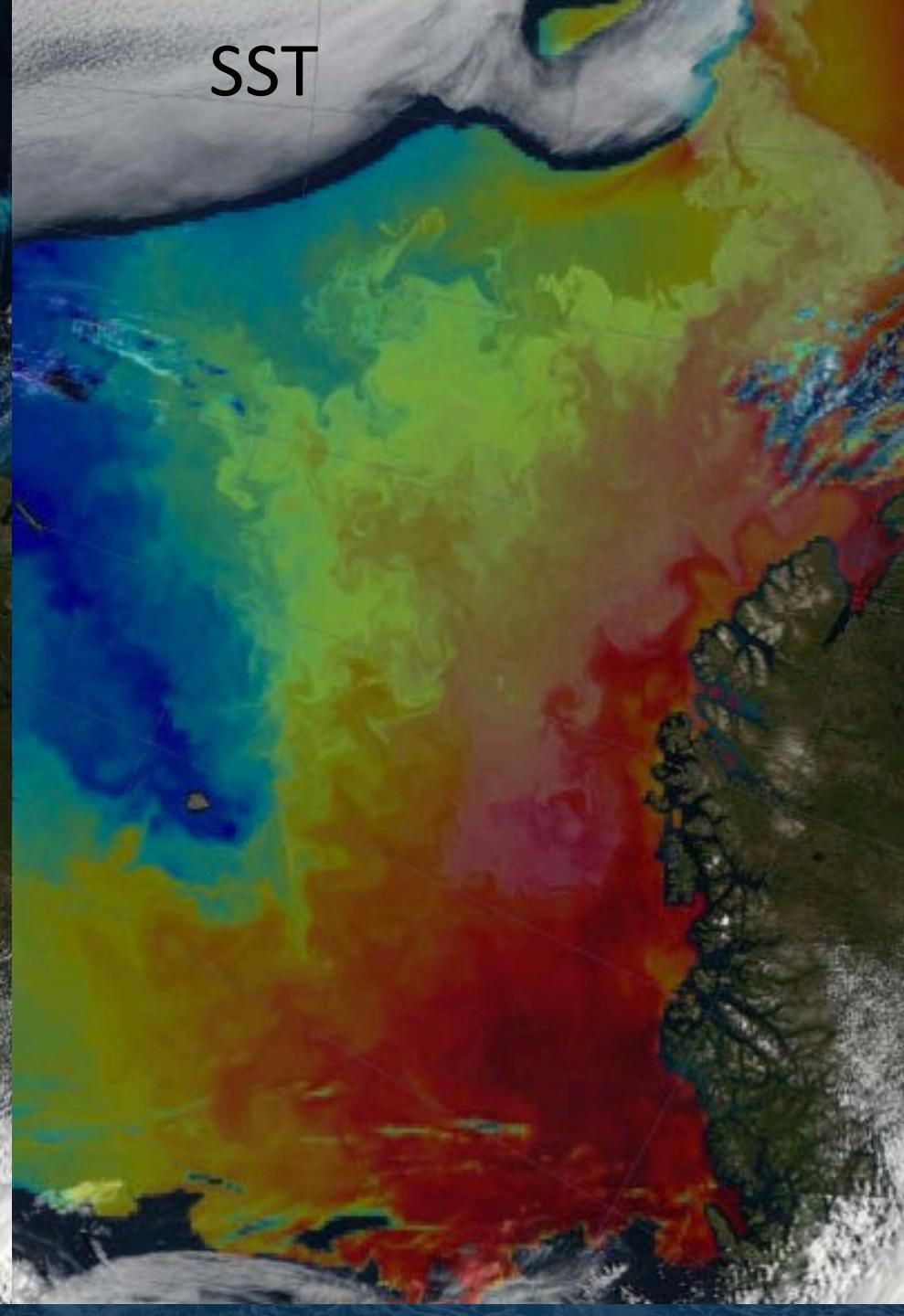




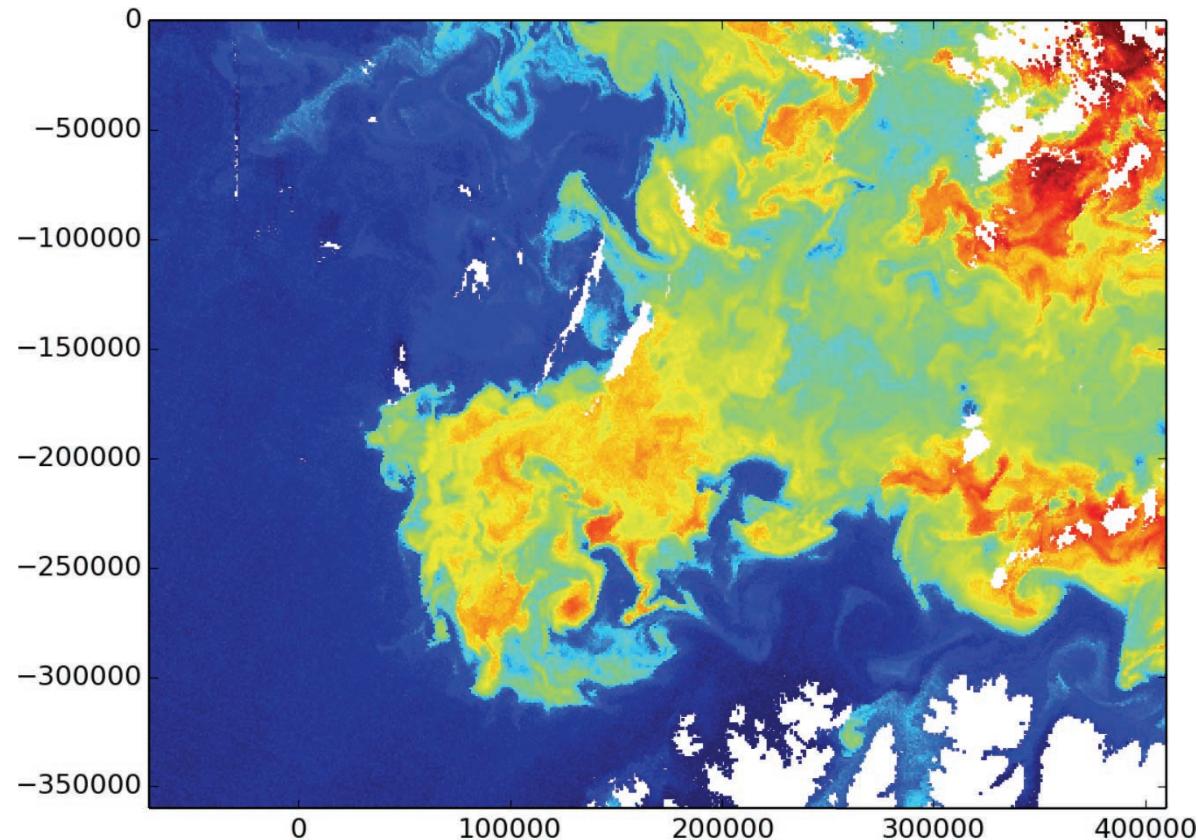
Ocean Color



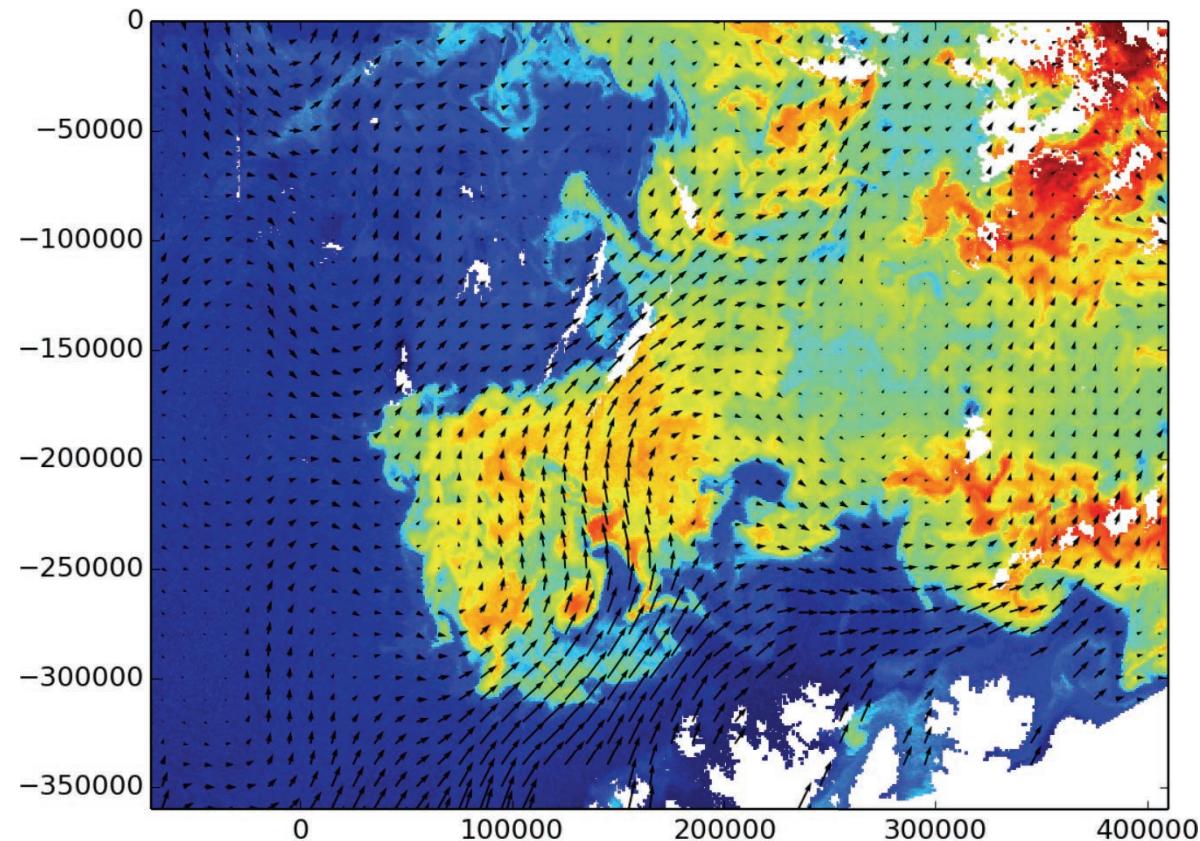
SST



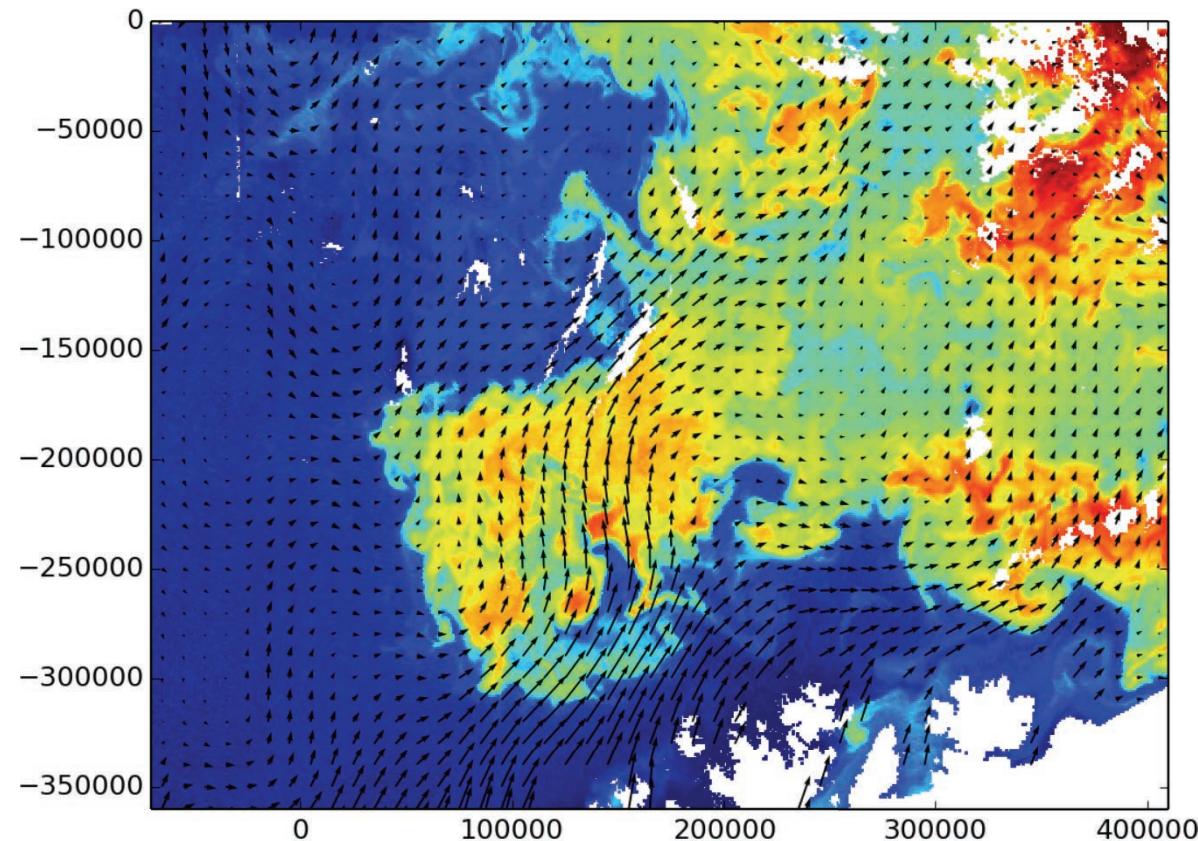
2012-08-17 12:00



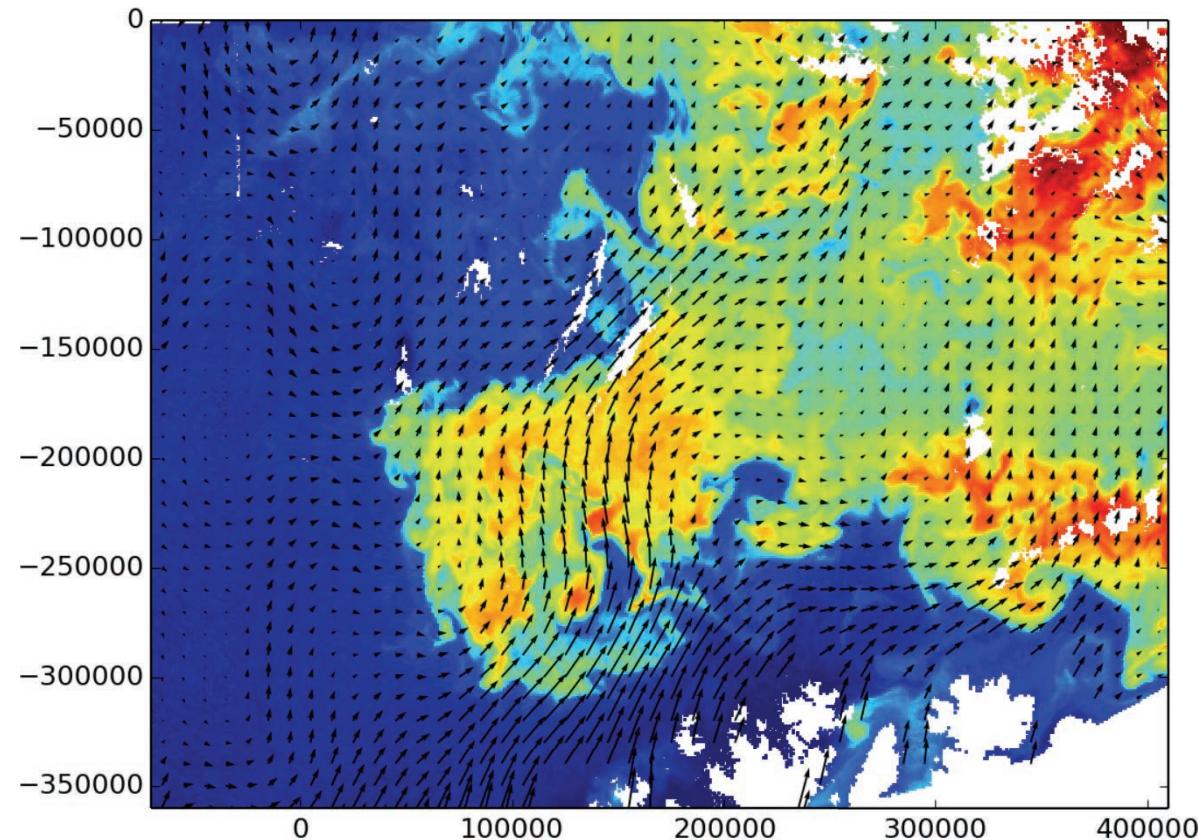
2012-08-17 15:00



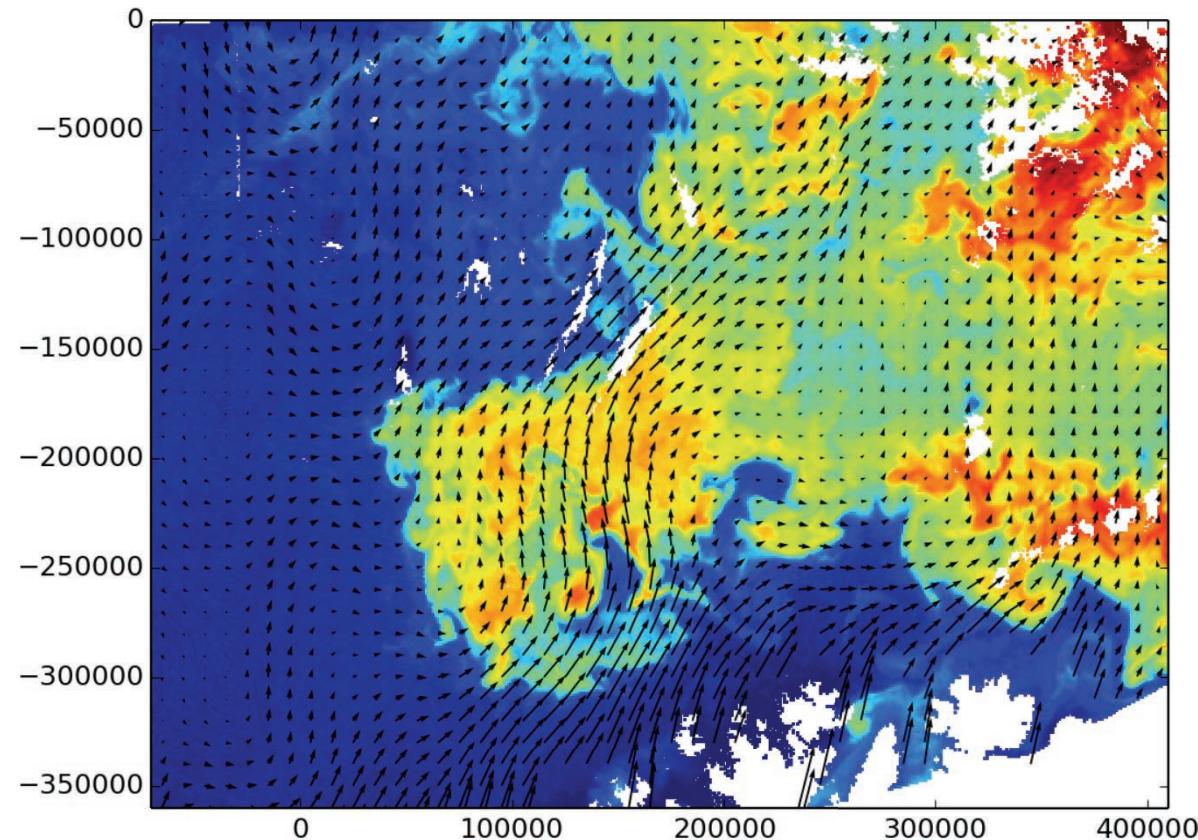
2012-08-17 18:00



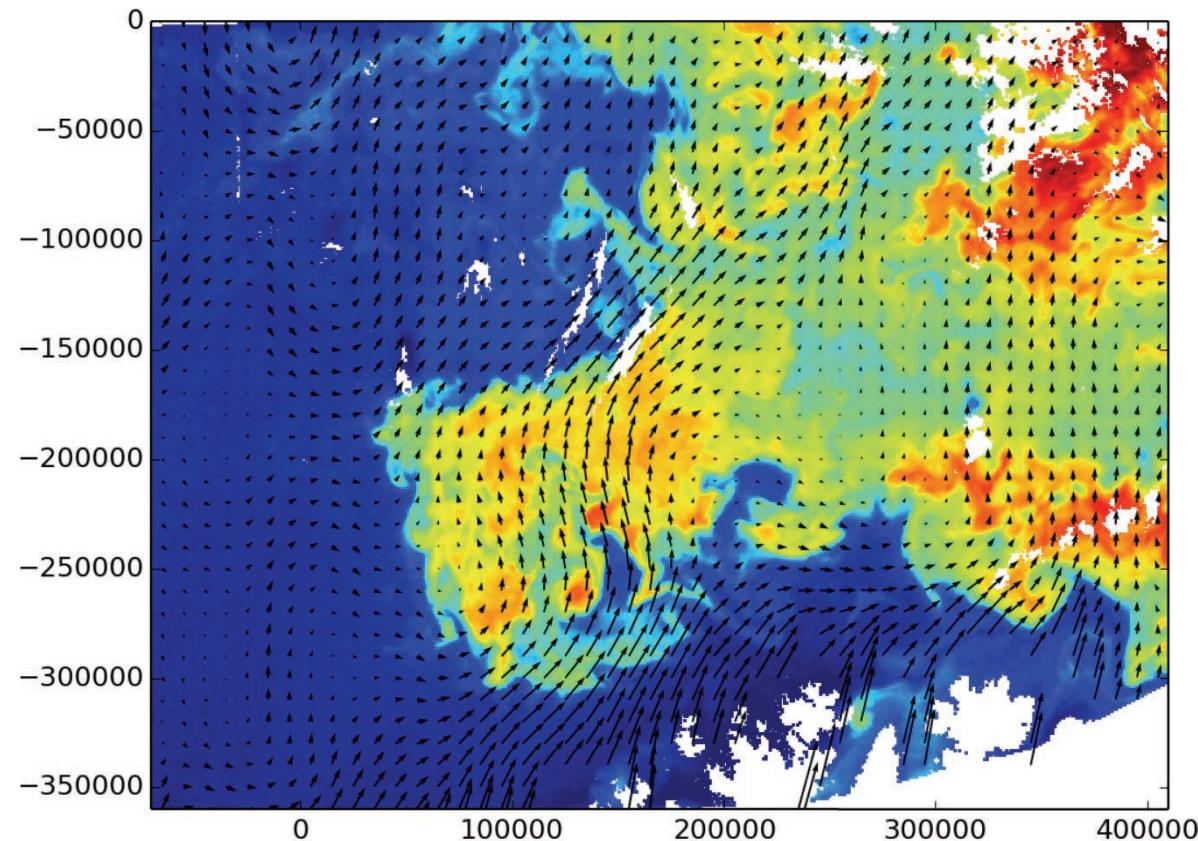
2012-08-17 21:00



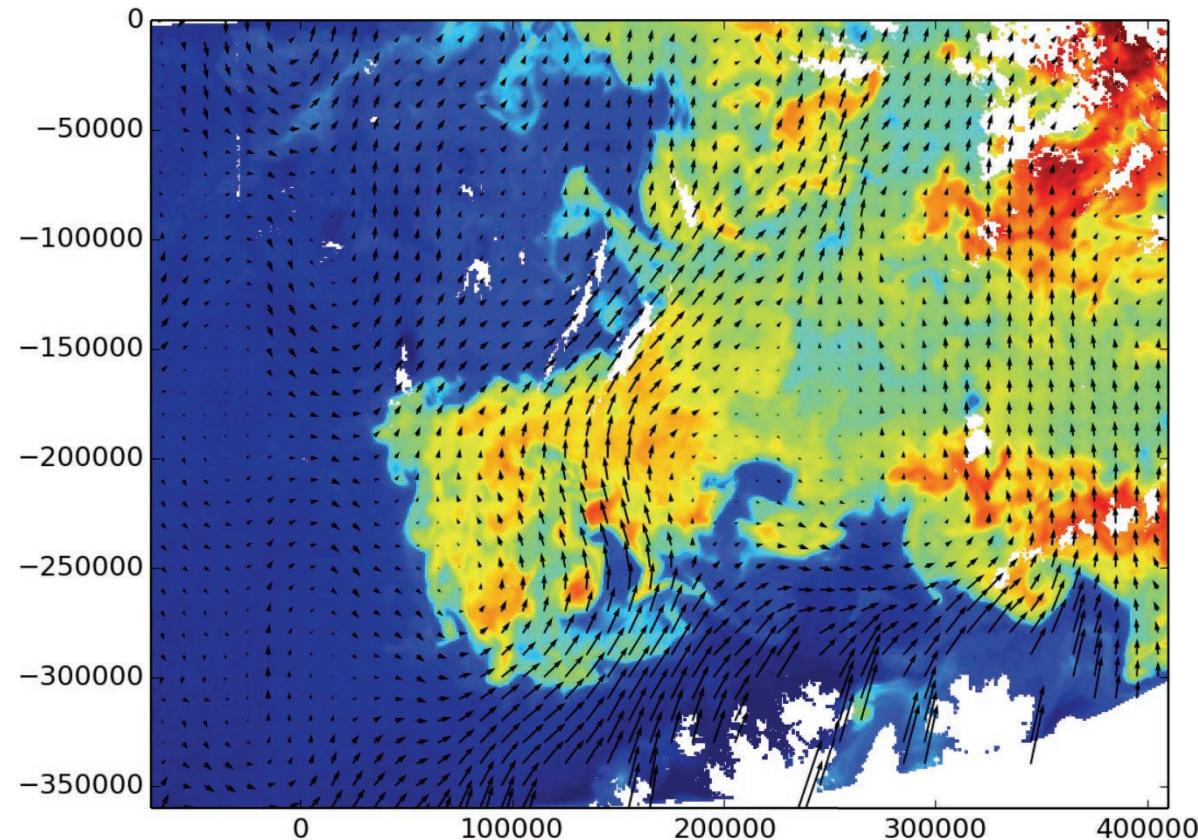
2012-08-18 00:00



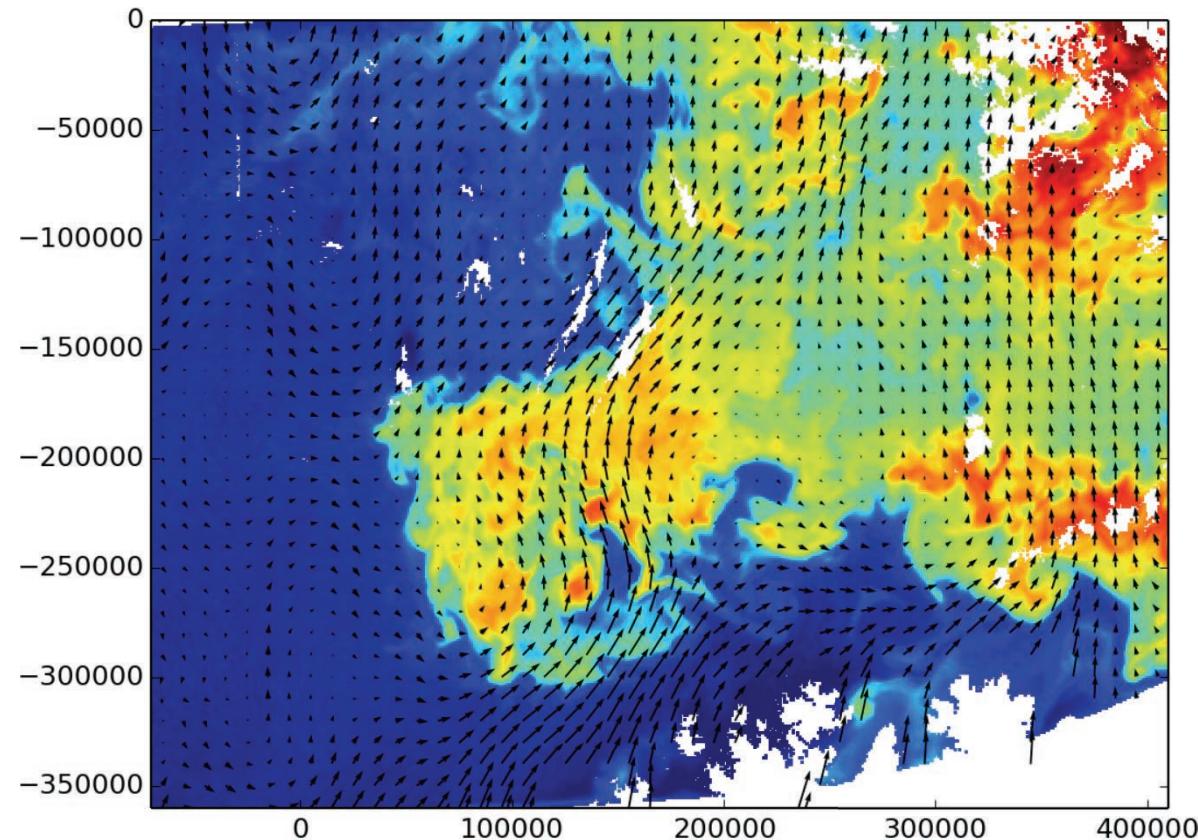
2012-08-18 03:00



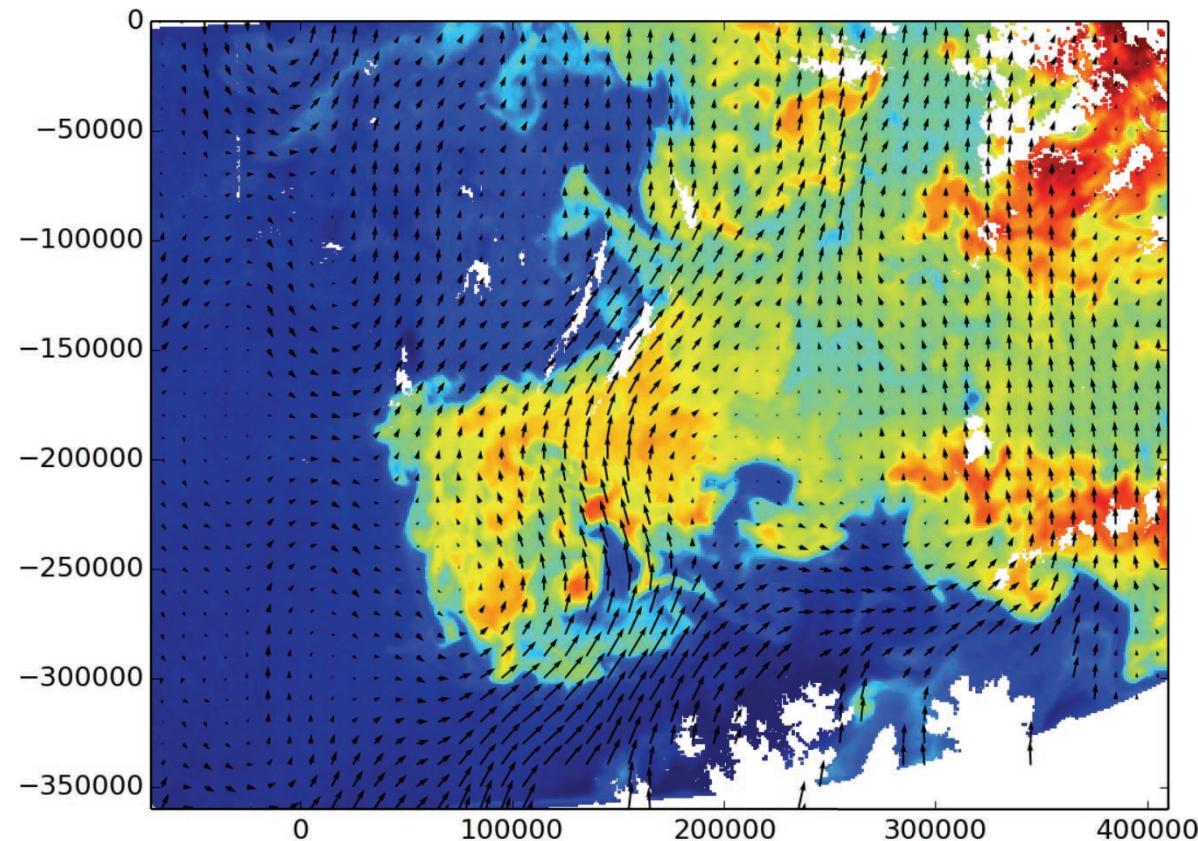
2012-08-18 06:00



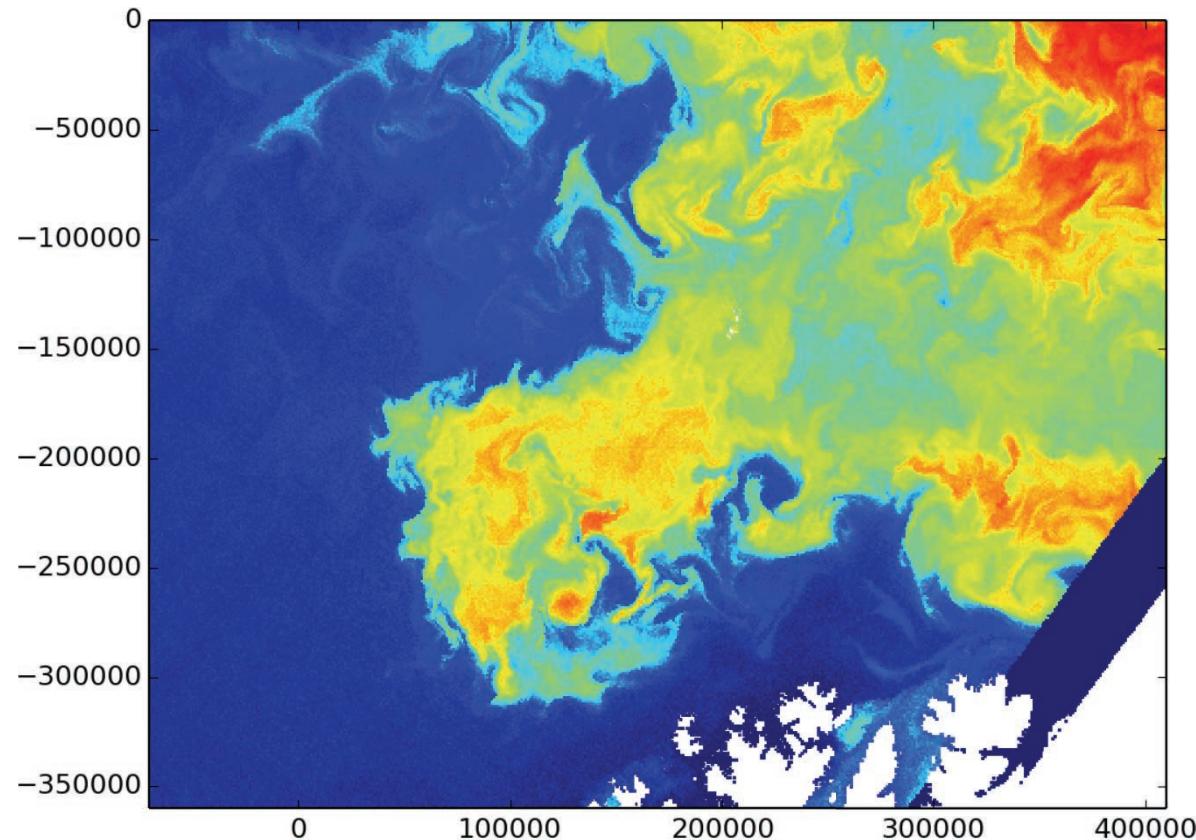
2012-08-18 09:00



2012-08-18 12:00



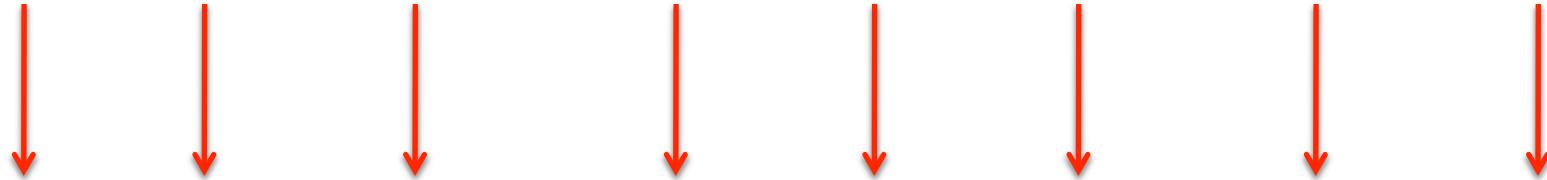
2012-08-18 12:00



# Satellite Sensor Synergy

Infrared, Visible, Microwaves (passive, radars), Accelerometers

IR   OC   Sun Glint   Alt   SAR   Scatt   PMW   Gravity



RANGE OF TWO DIMENSIONAL SURFACE EXPRESSIONS WHICH OFTEN HAVE ONE THING IN COMMON – NOTABLY RELATED TO THE OCEAN SURFACE DYNAMICS



## Outlook

- A new framework for satellite sensor synergy is now emerging that can advance studies of the upper ocean ( $\sim 100$  m) dynamics. Towards the end of the year the global data base will be extended to cover 2002-2015. Will be available at [www.globcurrent.org/](http://www.globcurrent.org/)
- The goal is to ensure simple and easy access and use of the framework
- A User Consultation Meeting will take place at IFREMER, Brest 4-6 November following an ESA science conference on future current

