Fartsmåling fra satellitt

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Direct ocean surface velocity measurements from space: Improved quantitative interpretation of Envisat ASAR observations

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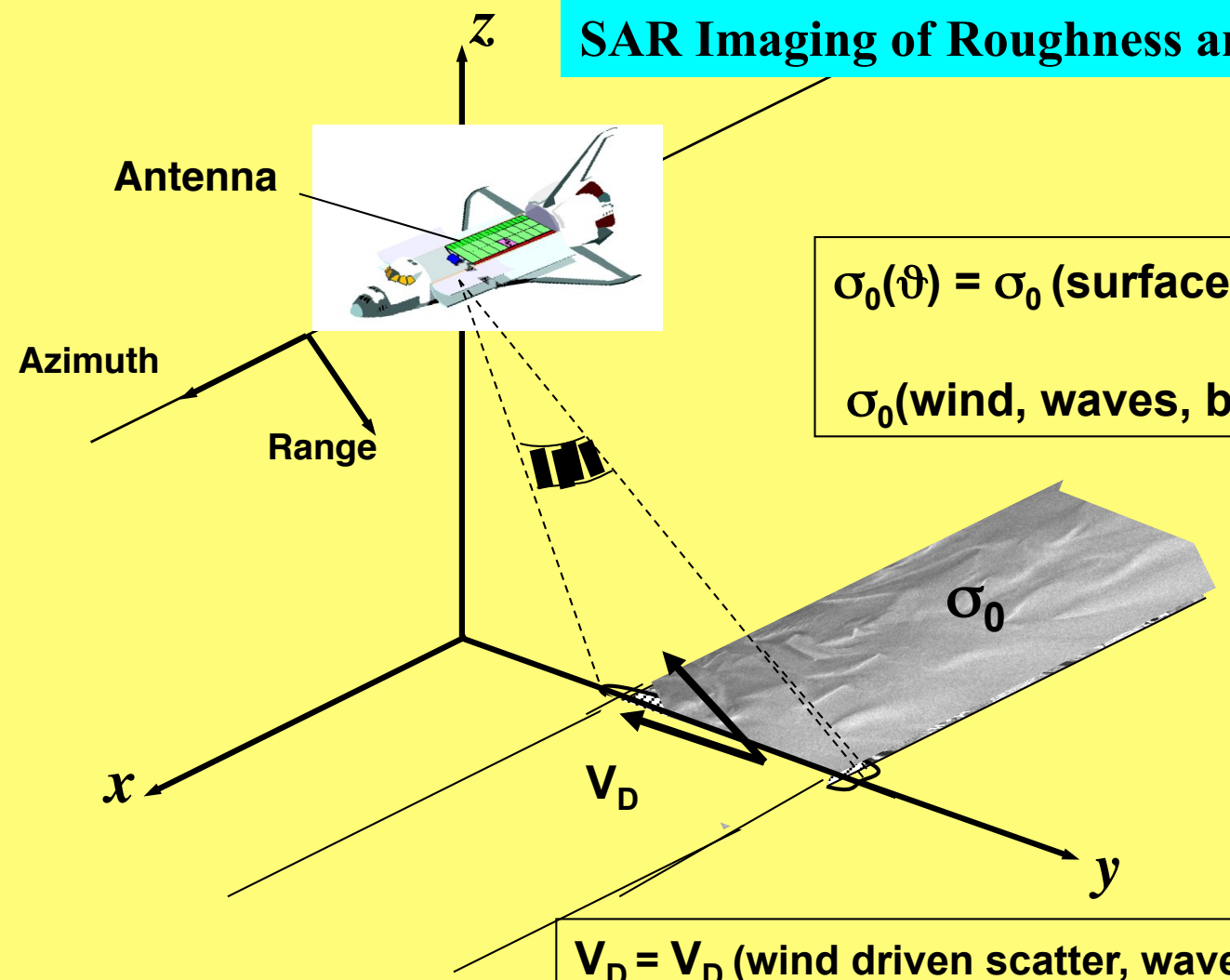
SAR Imaging of Roughness and Doppler Shift



$\sigma_0(\vartheta) = \sigma_0$ (surface roughness) =

σ_0(wind, waves, breaking, current

$V_D = V_D$ (wind driven scatter, waves, breaking, current

Estimation of Doppler anomaly

- Anomaly = measured – predicted
- Compensated non-geophysical sources of anomaly :
  - Antenna misspointing
  - Instrumental bias
  - Doppler estimator bias caused by azimuthal variation of backscatter (artificial correlation between doppler and sigma0).
- **Retrieval accuracy about 5 Hz which is about 0.2 m/s**

Estimation of Doppler anomaly

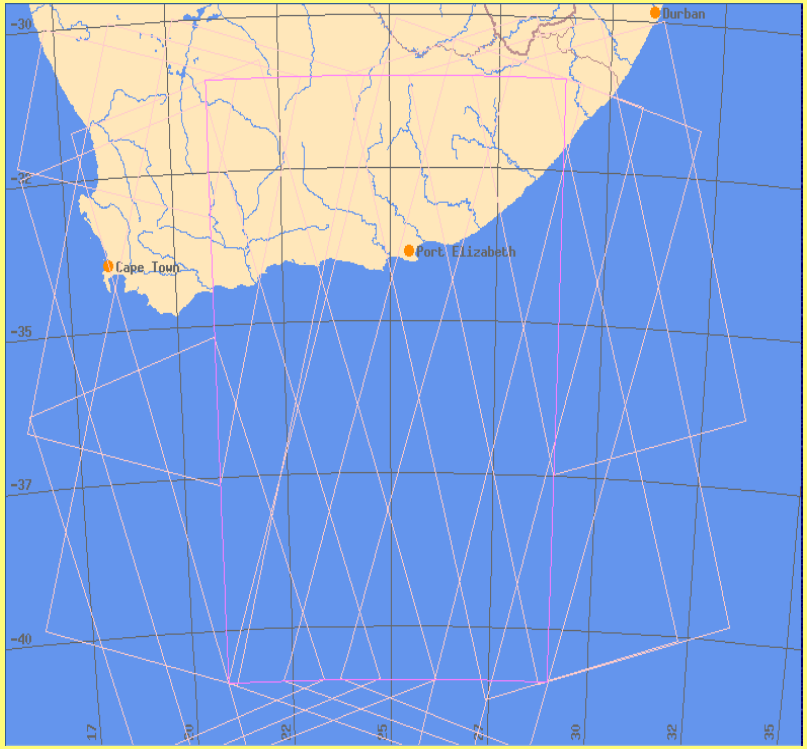
Anomaly (shift) = measured – predicted

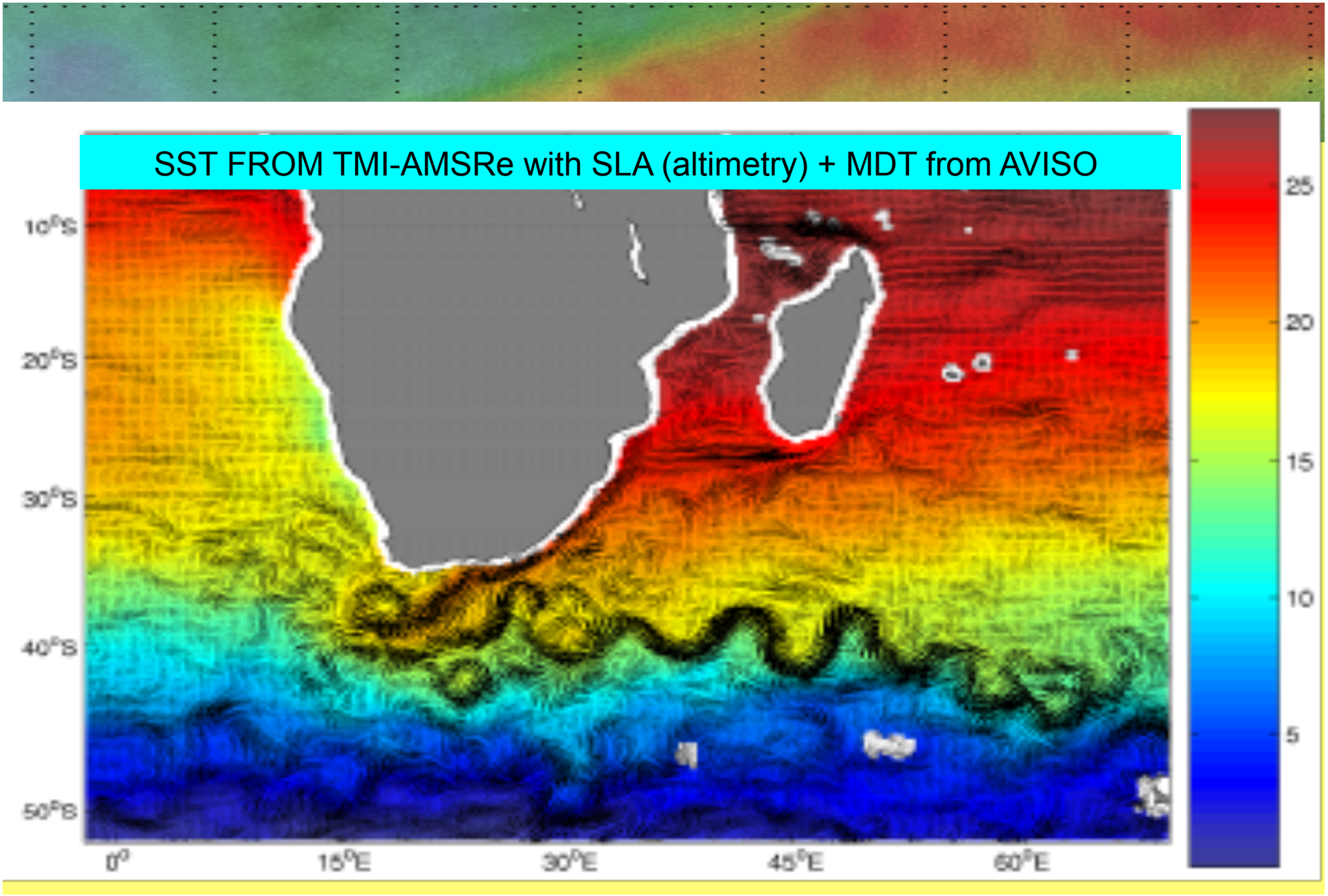
$$\frac{\pi f_D}{k_R} = -\frac{(u\sin\theta - w\cos\theta)\overline{\sigma_0(\theta+\Delta\theta)}}{\overline{\sigma_0(\theta+\Delta\theta)}}$$

f_D: Doppler shift
K_R: Radar Wave number
θ : Incidence angle
U: horizontal velocity
W: vertical velocity
σ_0: radar cross section

Study Area

Agulhas Current is excellent strong and intense current to be used as natural laboratories to explore satellite synergy (SAR, IR and OC) and develop new methods for quantitative estimates of current information and surface dynamics.




SST FROM TMI-AMSRe with SLA (altimetry) + MDT from AVISO
10°S
20°S
30°S
40°S
50°S
0°
15°E
30°E
45°E
60°E
25
20
15
10
5

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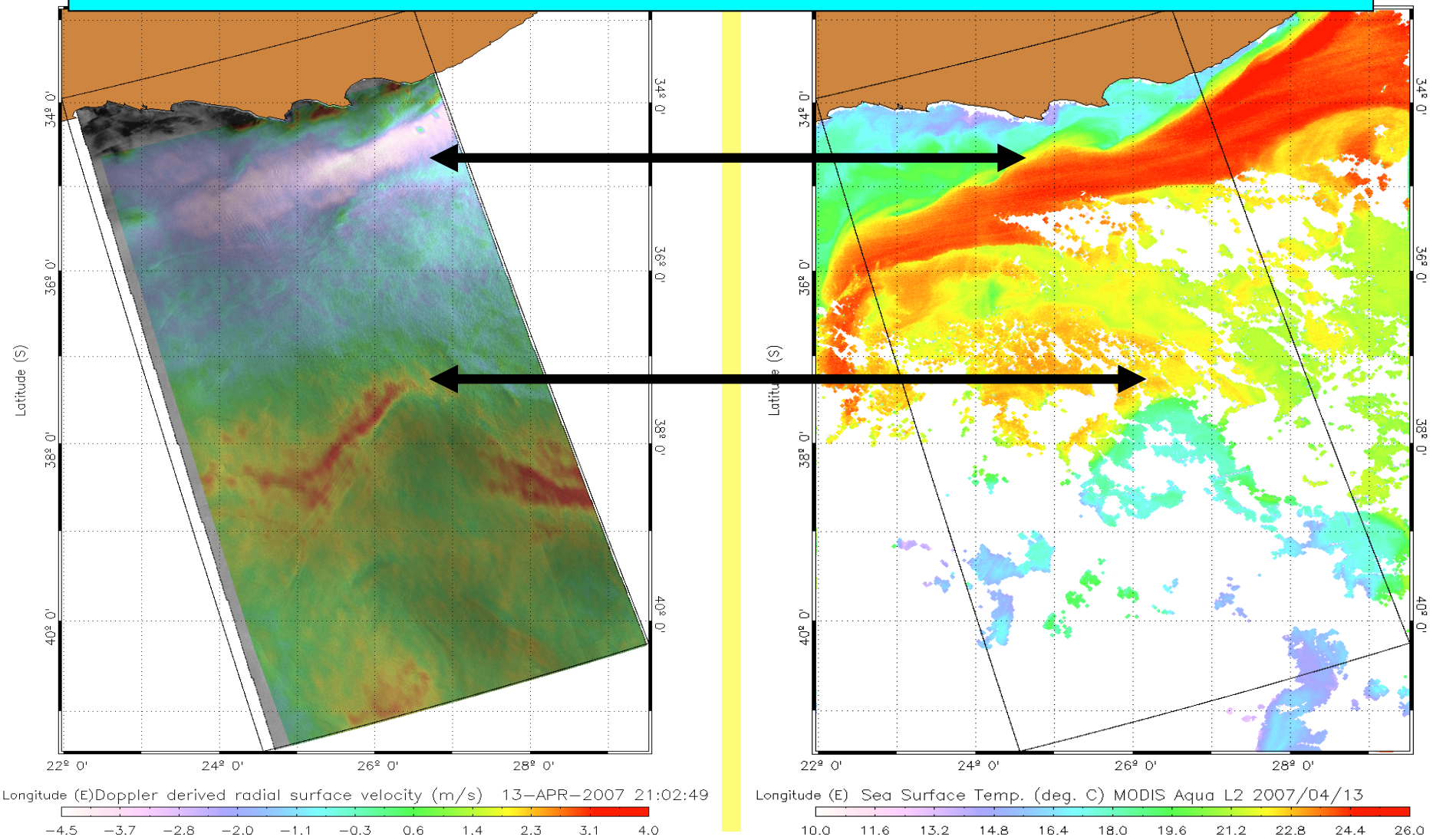
DOPPLER VELOCITY FROM ASAR COMPARED TO NOAA SST



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How is the wind effecting the results

- the wind speed dependency of the Doppler signal for each month is evaluated using the global collocated (ASAR and ECMWF winds) data set,

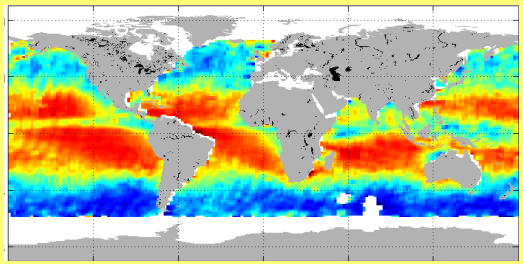
- this allows the establishment of an empirical CDOP model relating observed Doppler anomalies to wind speed at different incidence angles, polarization, azimuth directions,

- in turn the removal of the wind contribution to the Doppler anomalies is possible

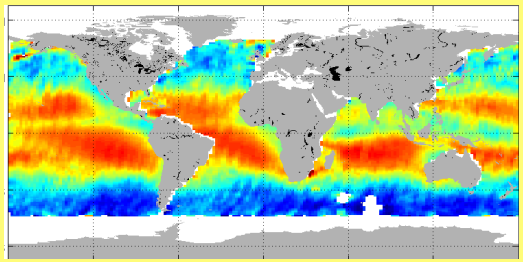
Following this the simulations of NRCS and Doppler anomalies is then consistently assessed and compared to the observations and empirical retrievals.

RESULTS

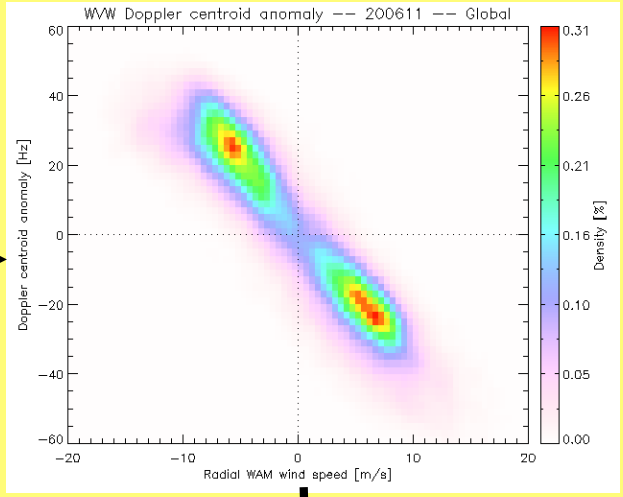
Simple methodology to remove wind effects



Doppler Anomaly/Velocity (ASAR WM)



Radial Wind Speed (ECMWF)

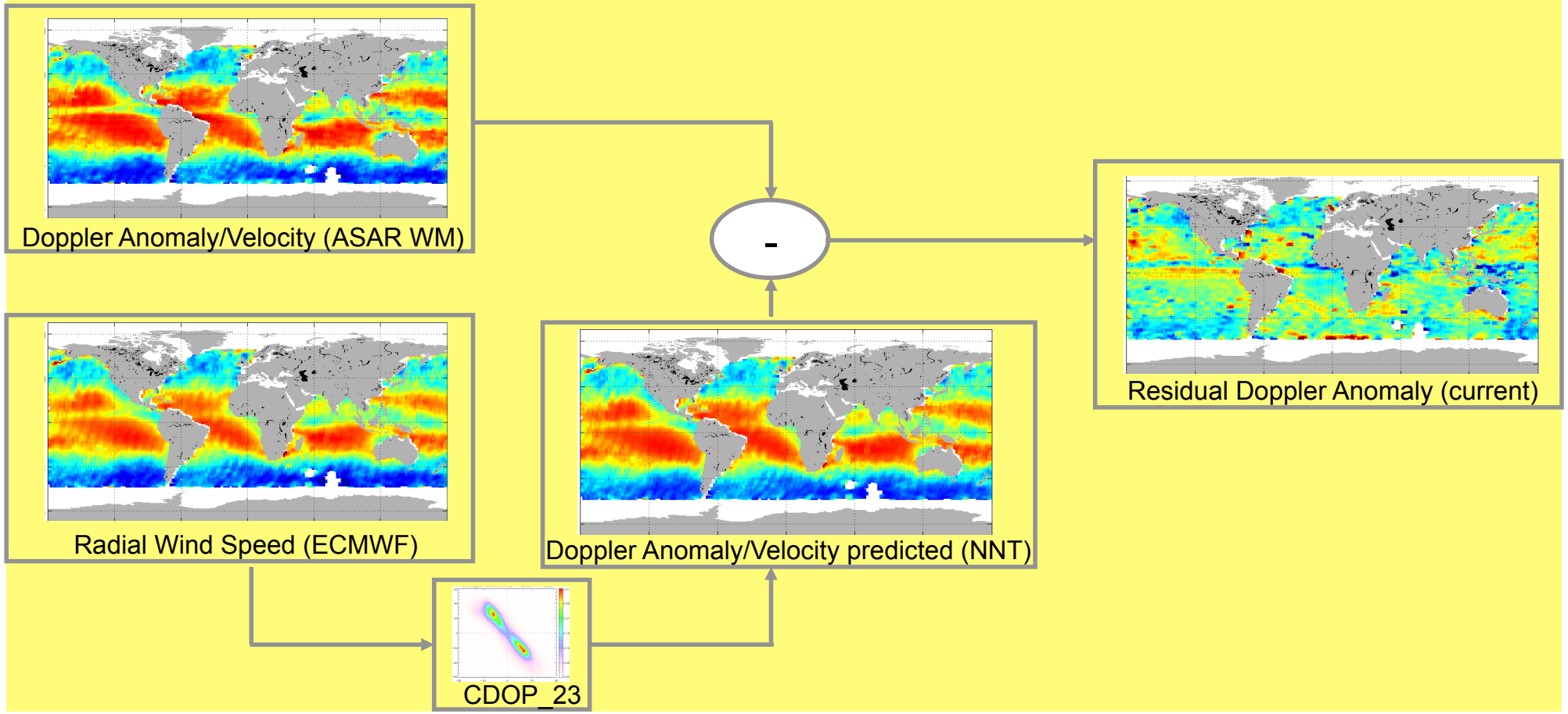


Neural Network training

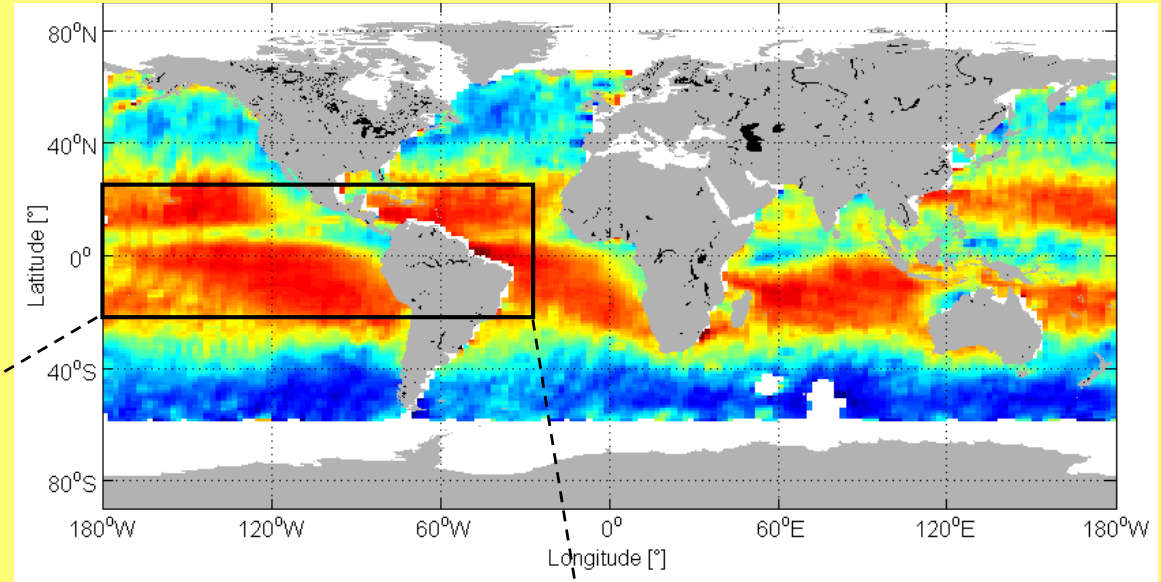
CDOP_23 = f(wind speed/direction)

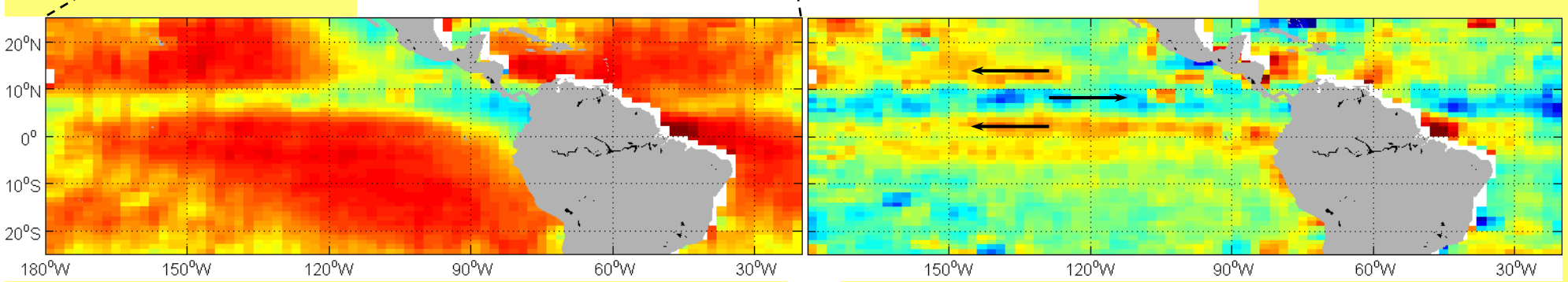
PART 3: THE NEW RESULTS

Simple methodology to remove wind effects



Equatorial Pacific monitoring





Radial Velocity (wind effect no removed))

Radial Current Velocity (wind effect removed)

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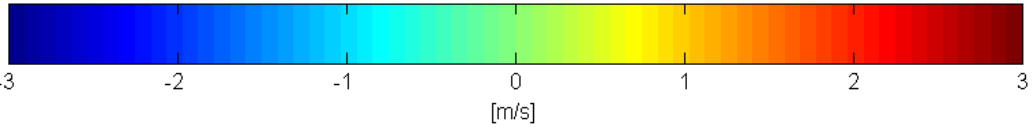
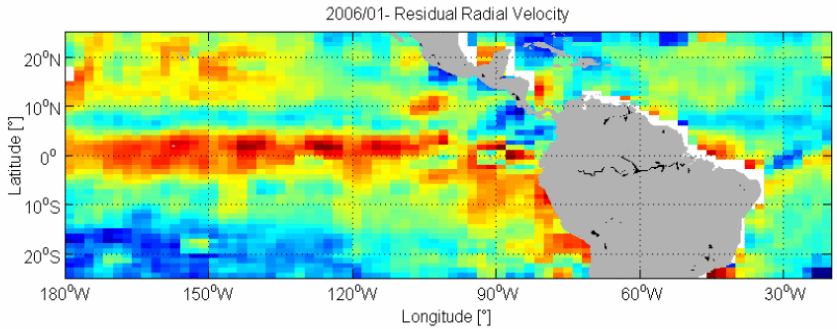
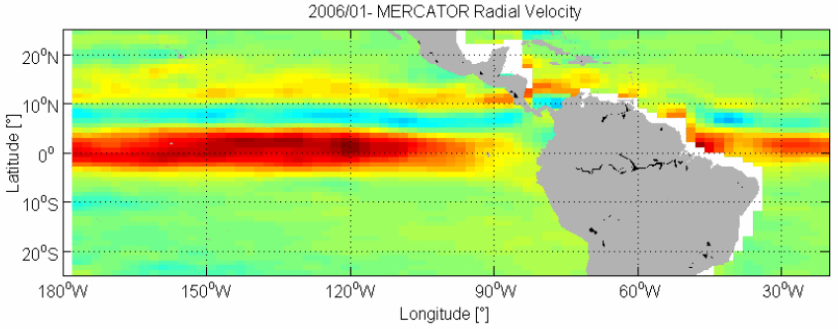
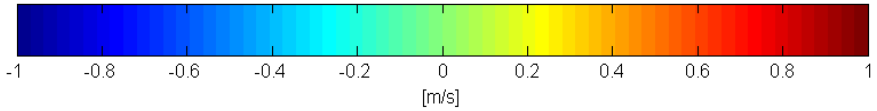


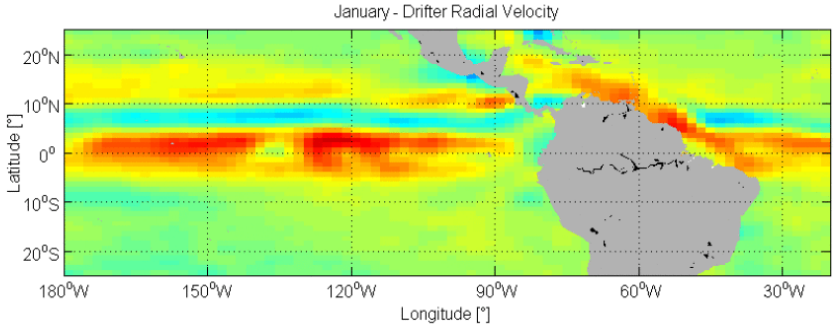
6-7 november 2008

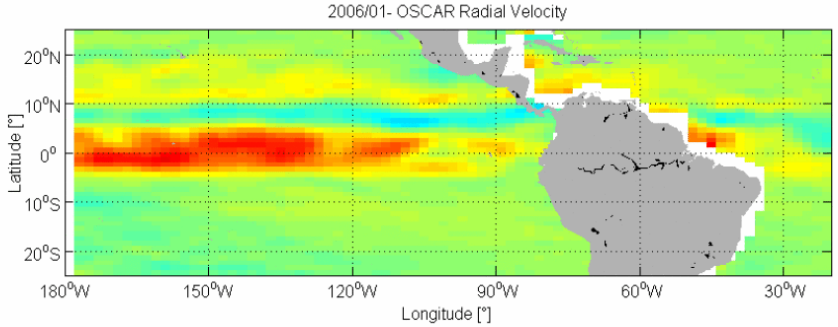
Equatorial Pacific monitoring: The seasonal cycle





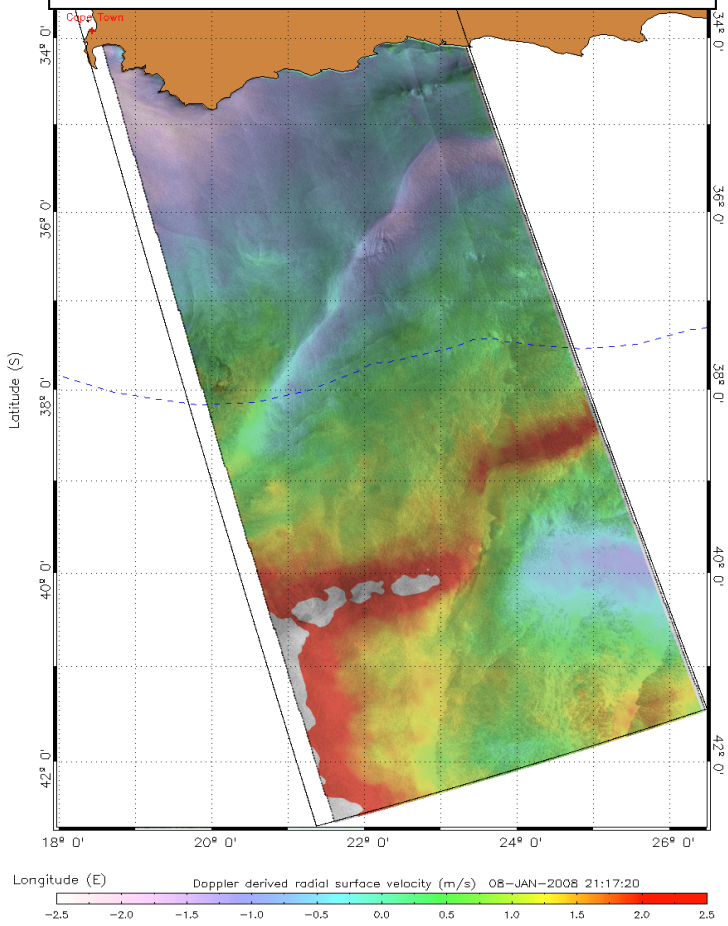




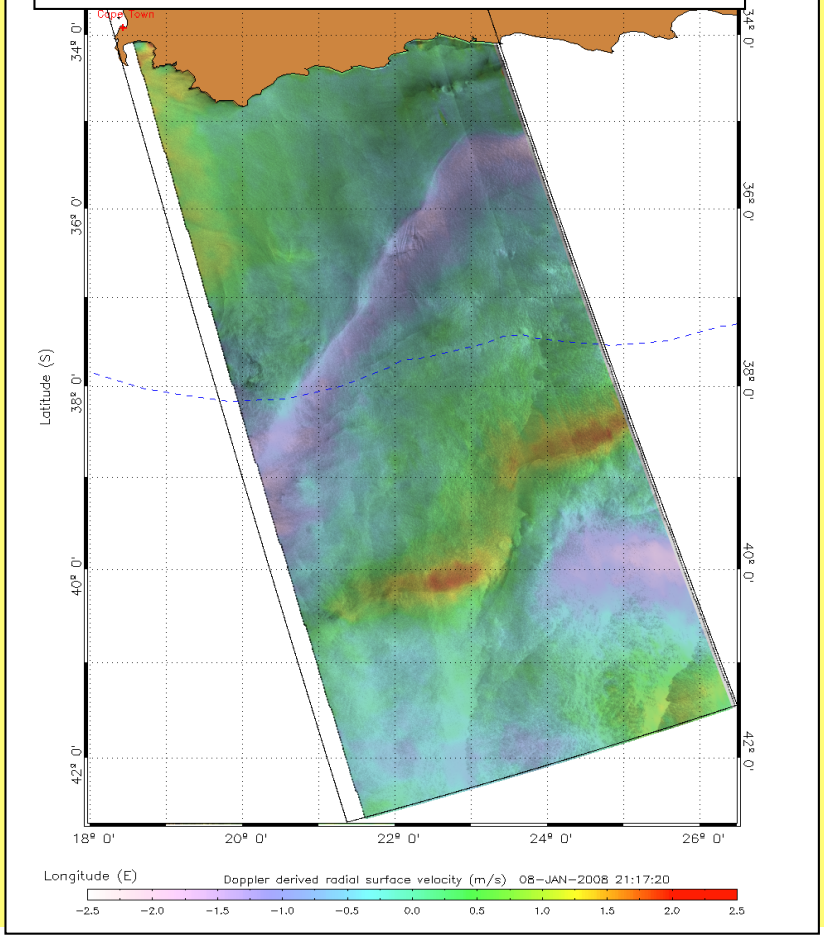


CDOP correction in Wide Swath

Total velocities



Residual velocities



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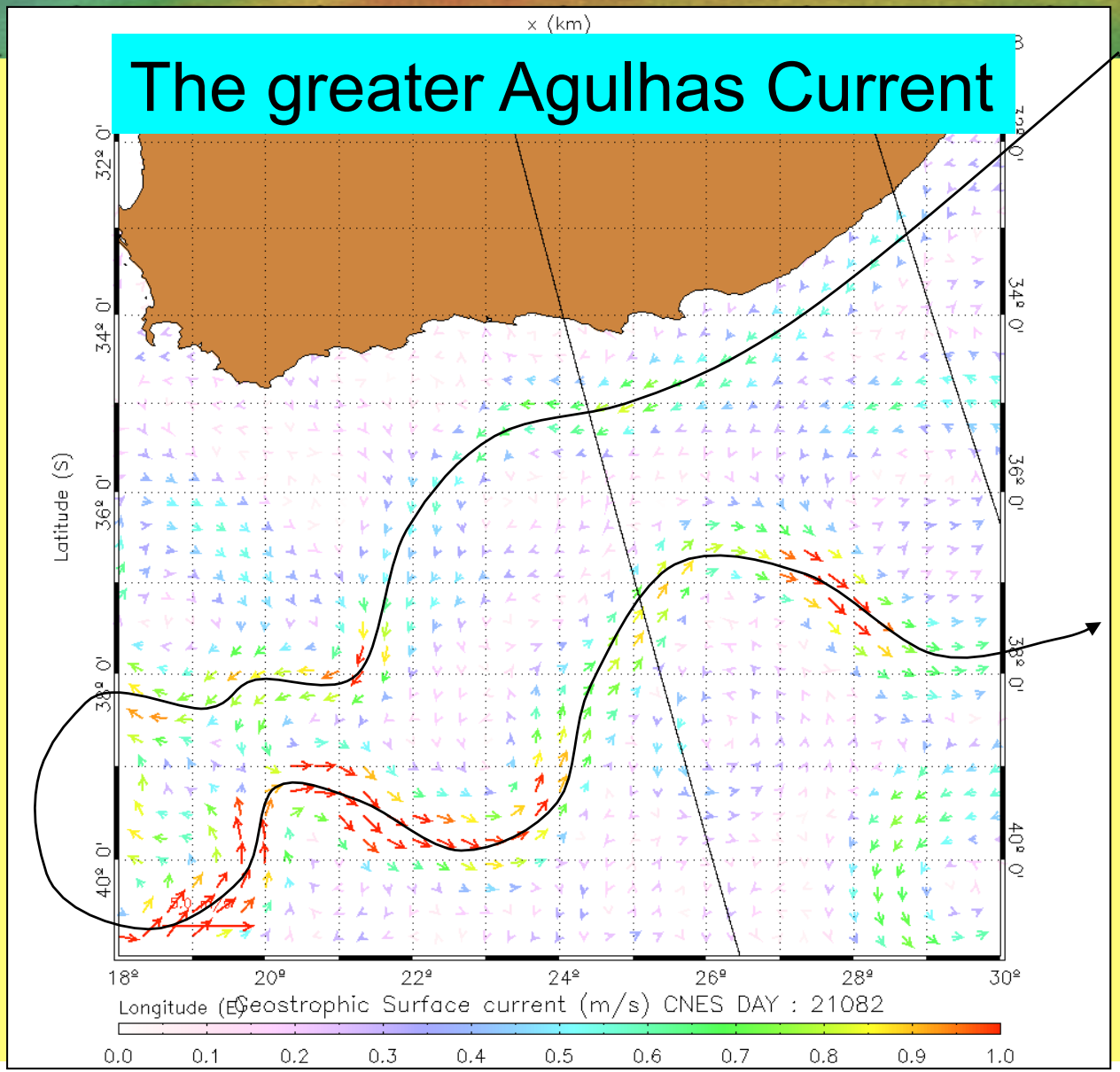
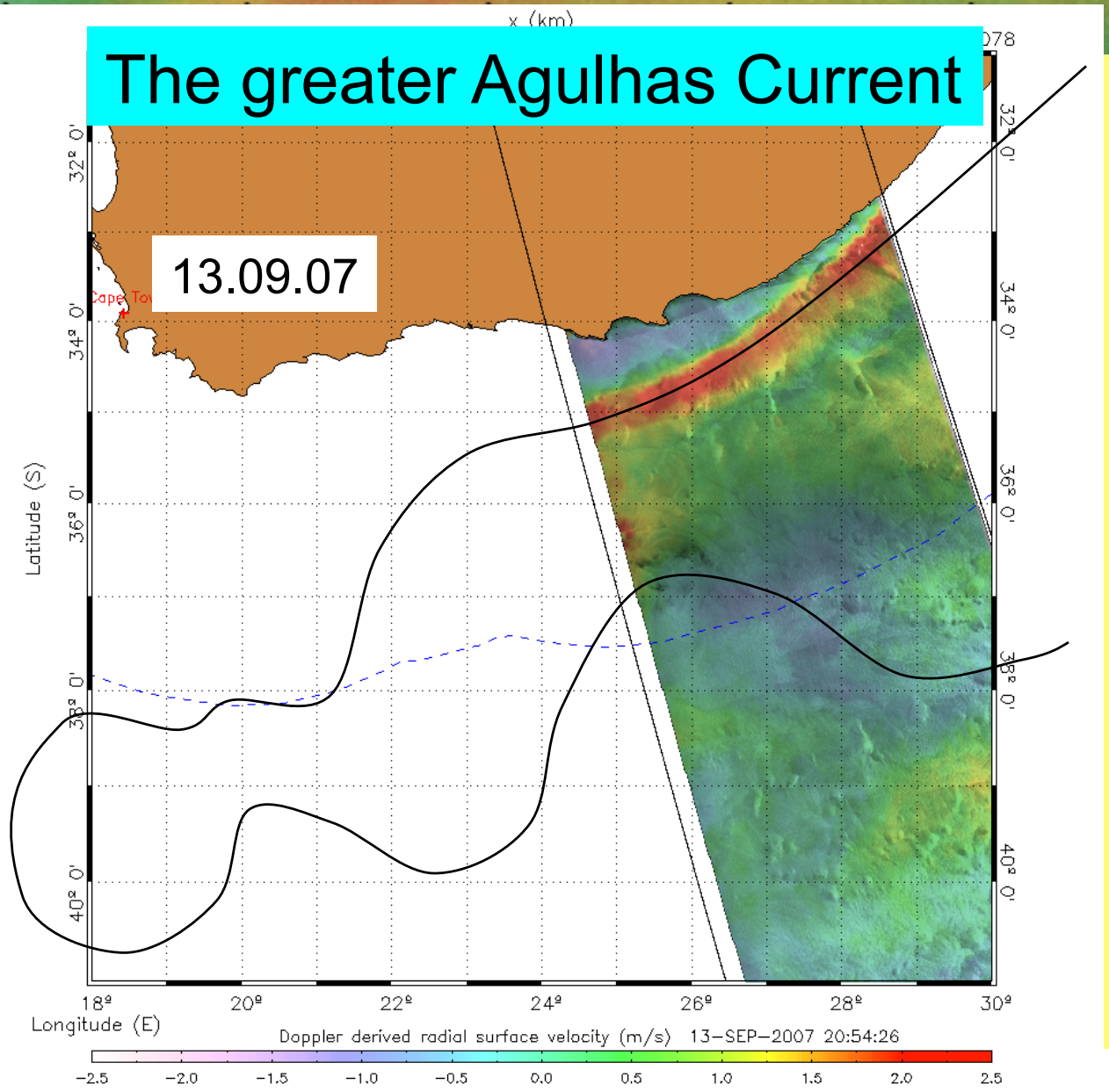
The greater Agulhas Current

Altimetry derived surface current : 7 days mean (13-20 September)



The greater Agulhas Current

Range directed surface Doppler velocity after removal of wind contribution



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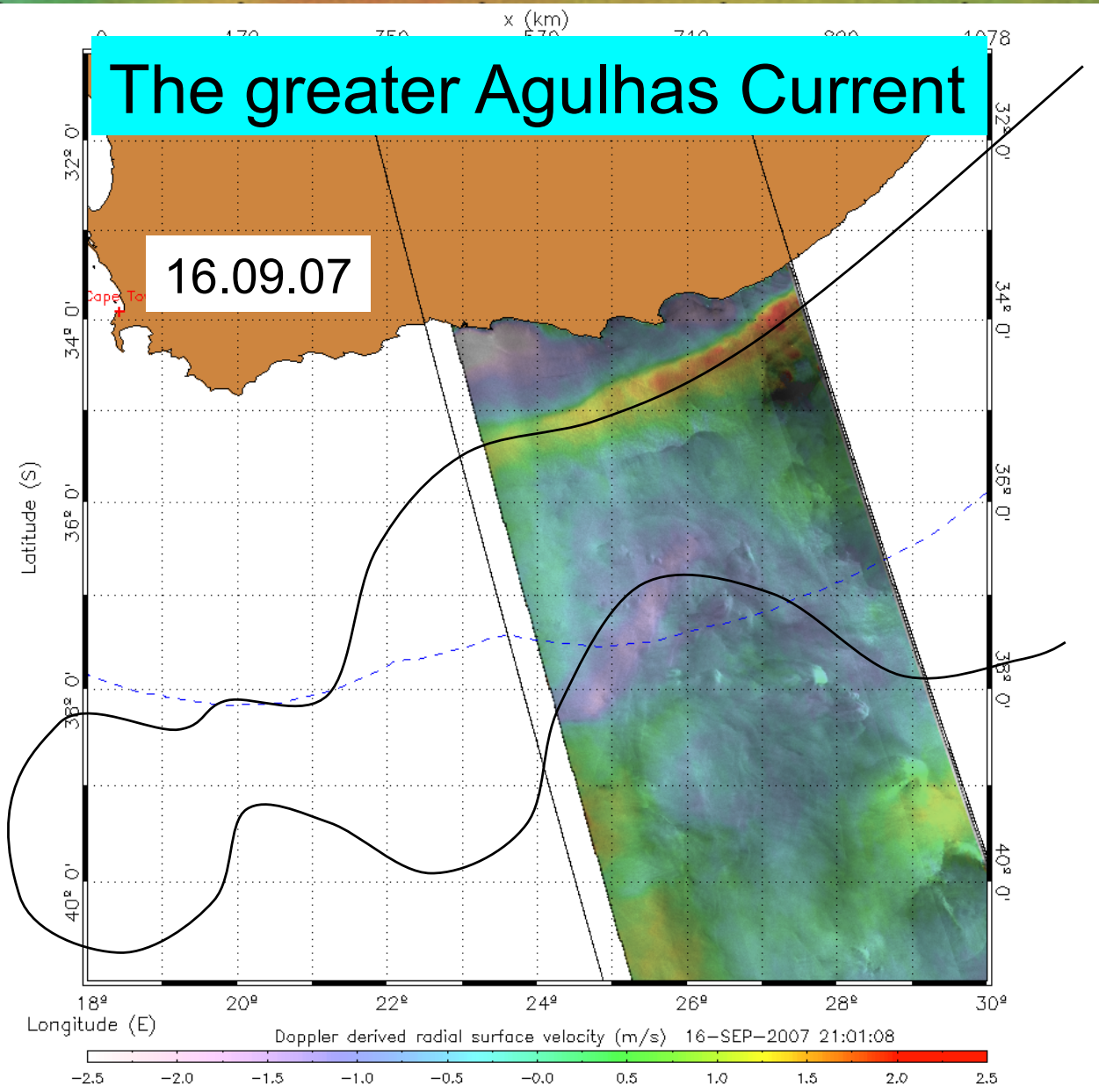
The greater Agulhas Current

Range directed surface Doppler velocity after removal of wind contribution



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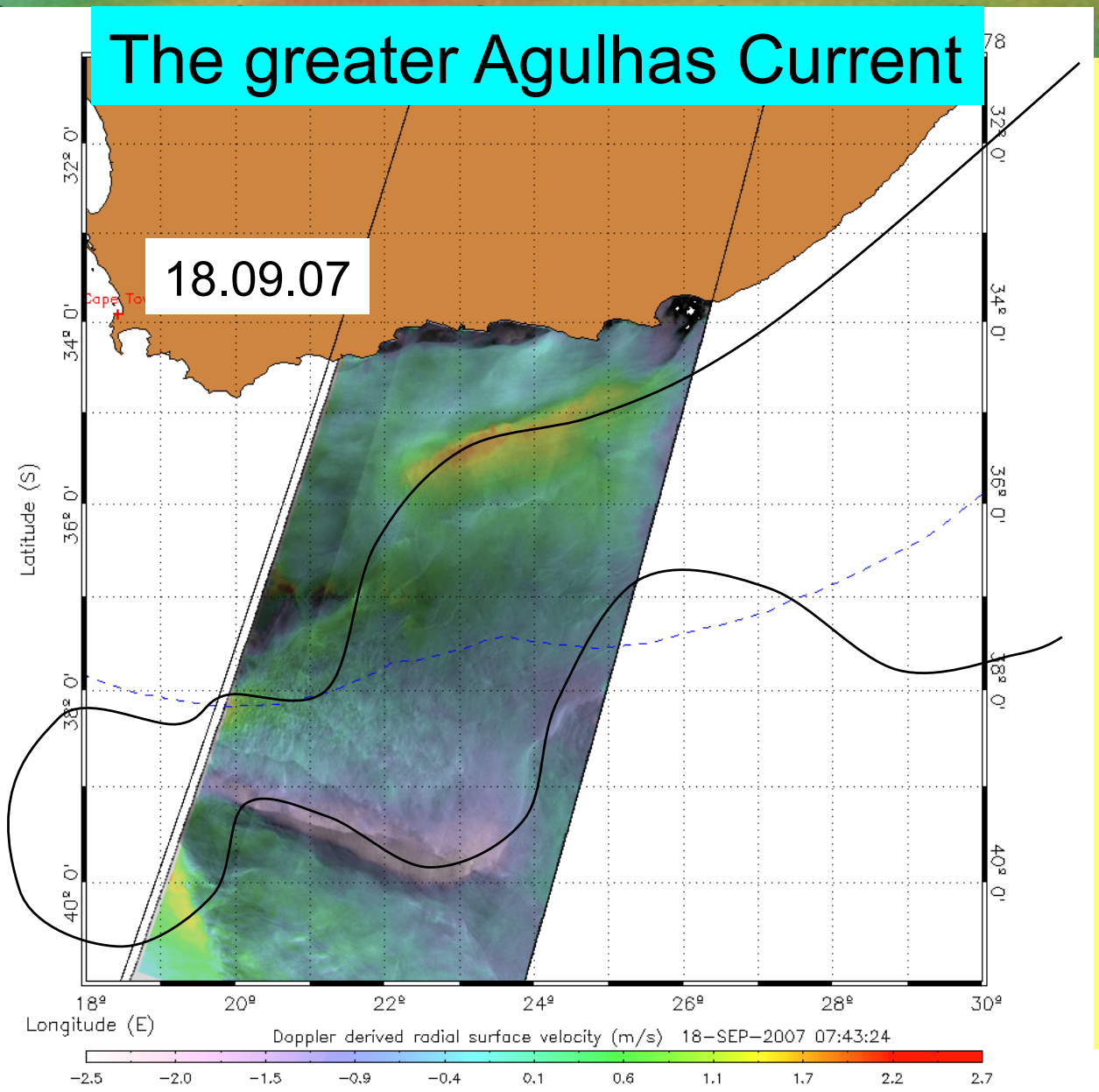
The greater Agulhas Current

Range directed surface Doppler velocity after removal of wind contribution



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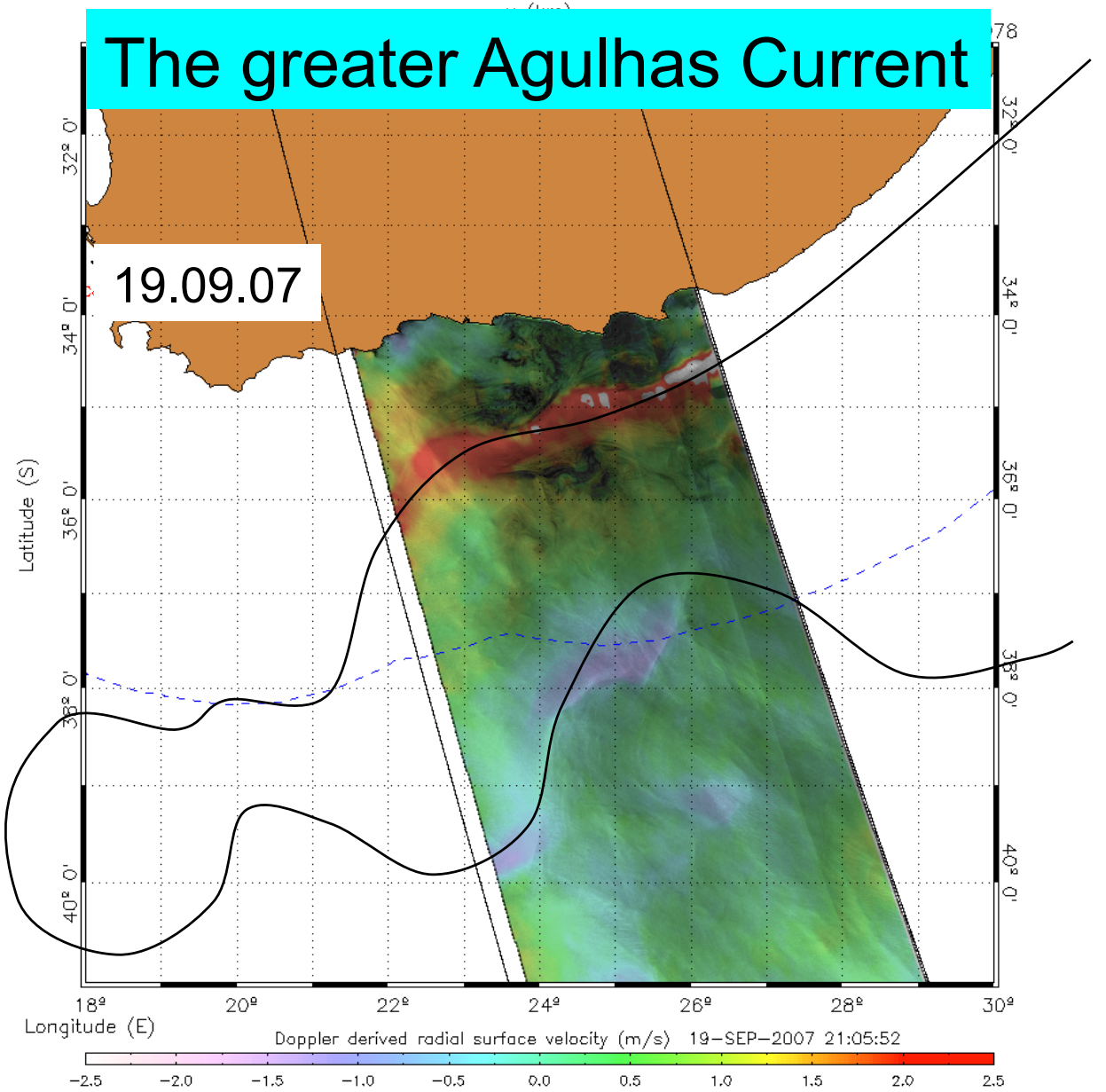
The greater Agulhas Current

Range directed surface Doppler velocity after removal of wind contribution



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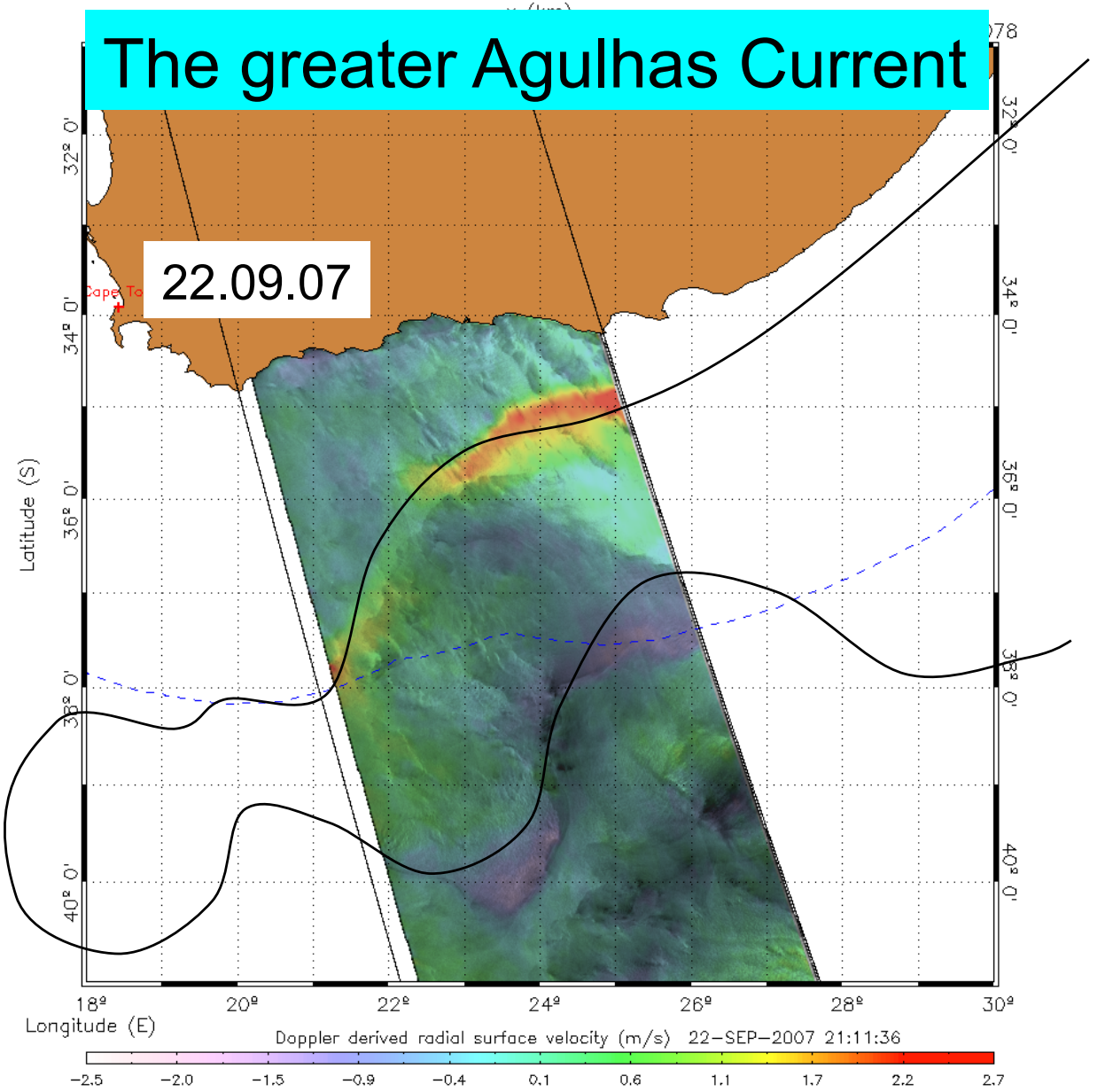
The greater Agulhas Current

Range directed surface Doppler velocity after removal of wind contribution



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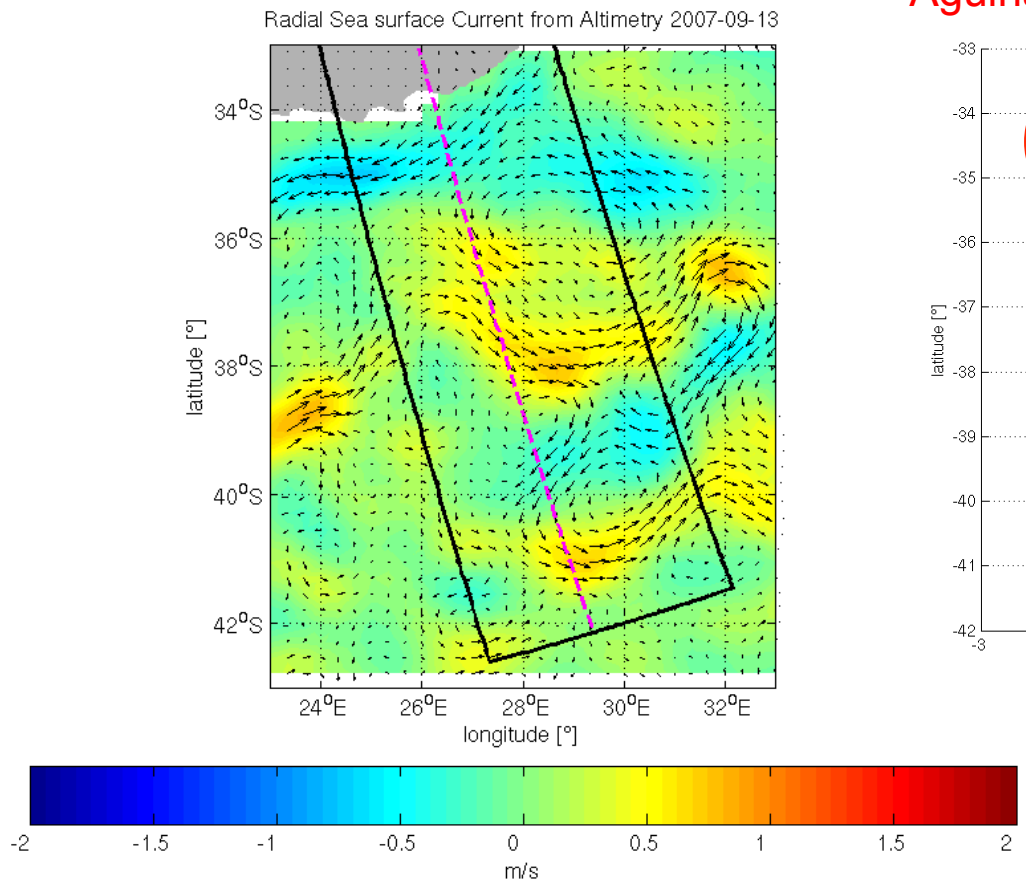
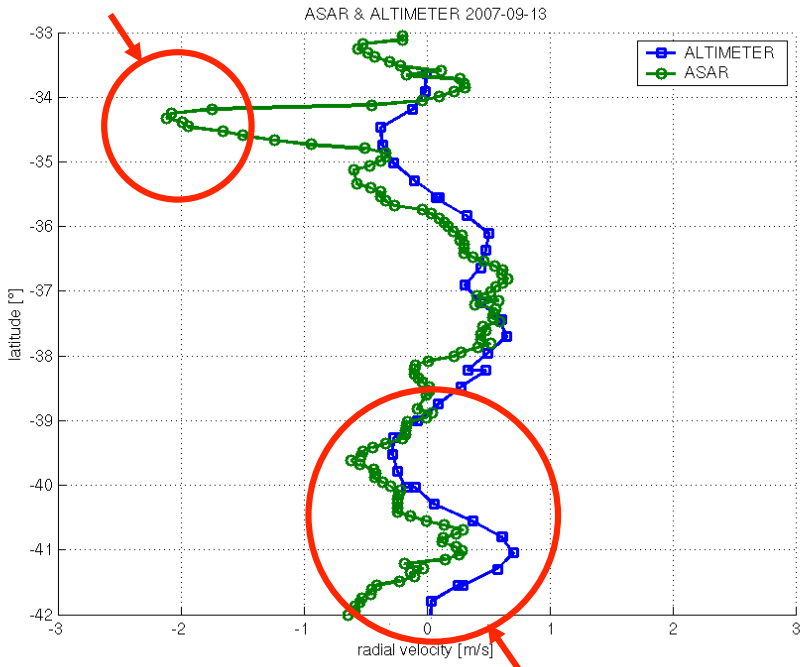
Validation exercise using altimetry

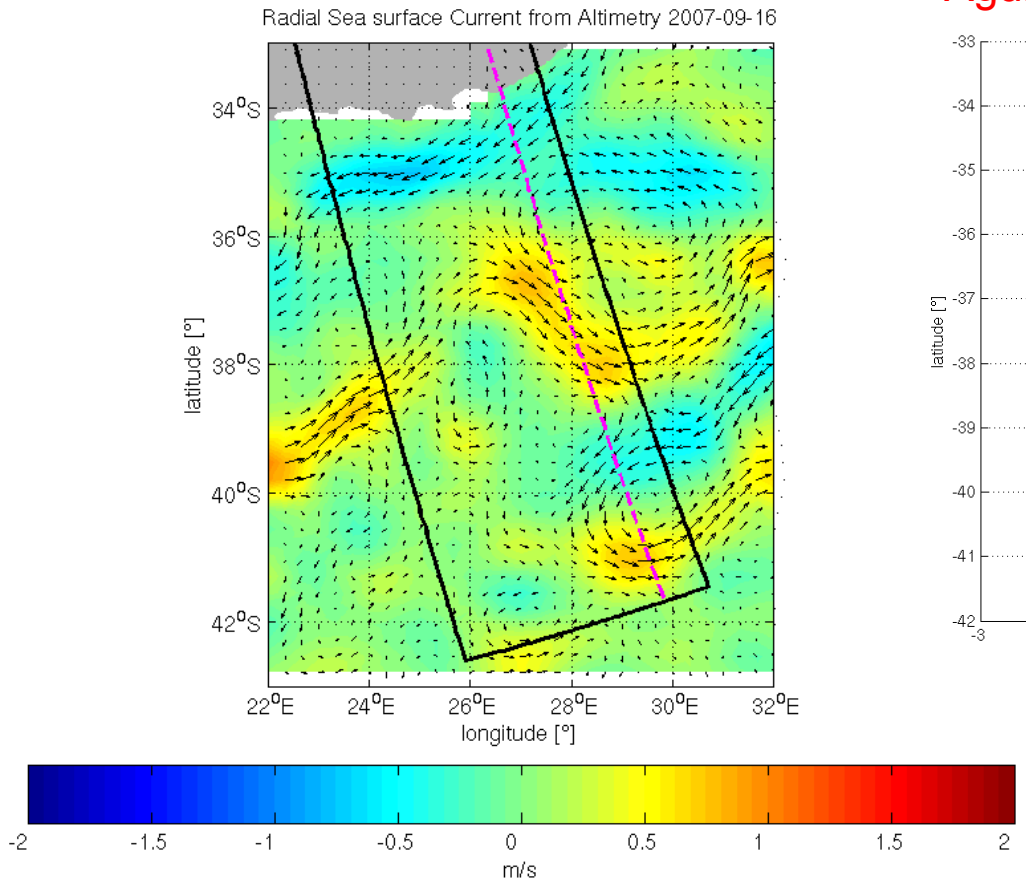


Agulhas main stream

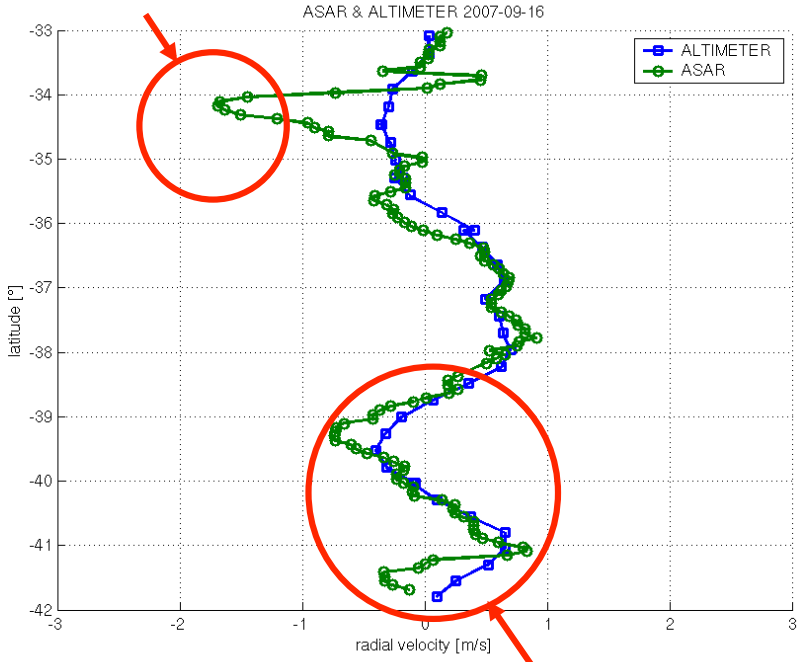


Mesoscale eddie

Validation exercise using altimetry

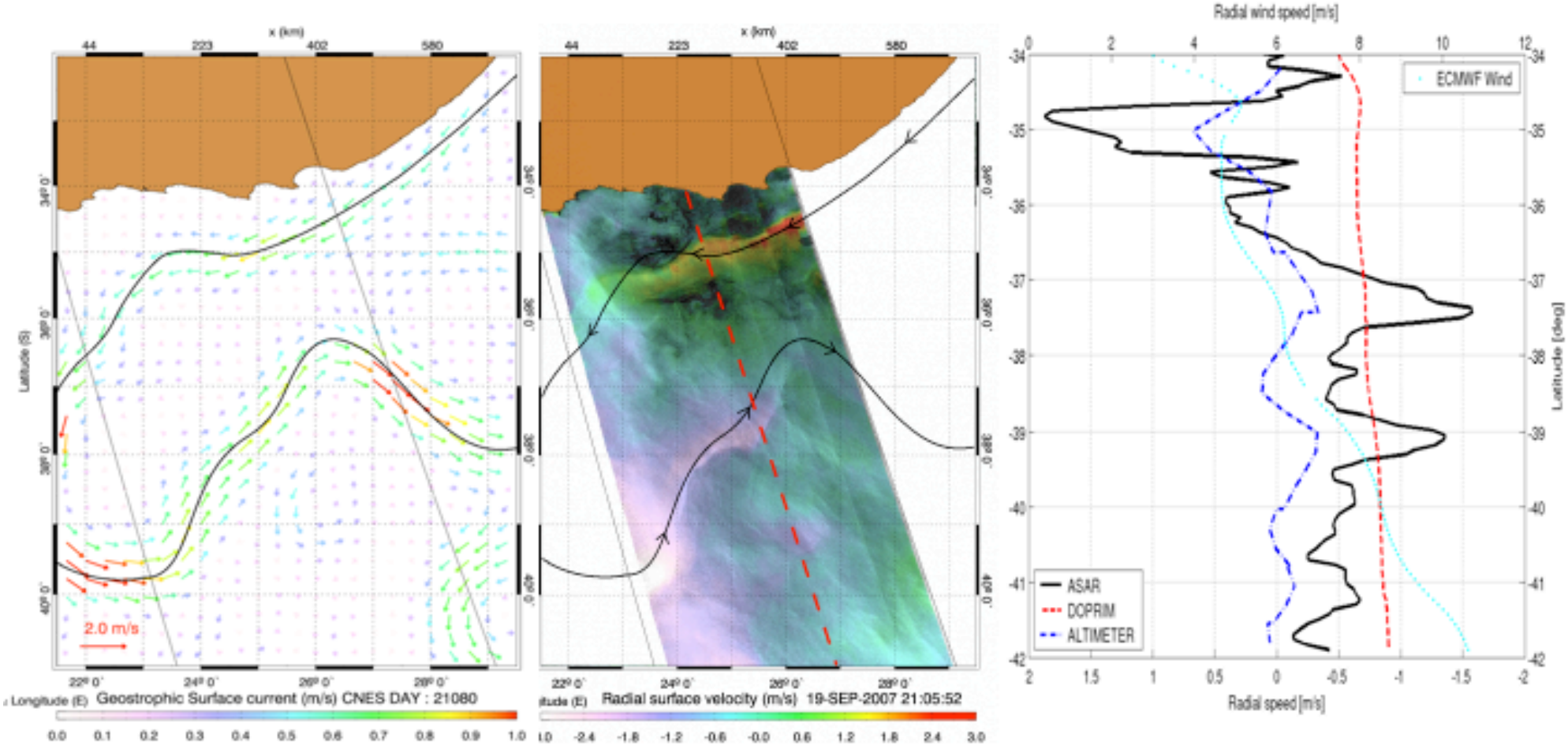


Agulhas main stream



Mesoscale eddie

The greater Agulhas Current



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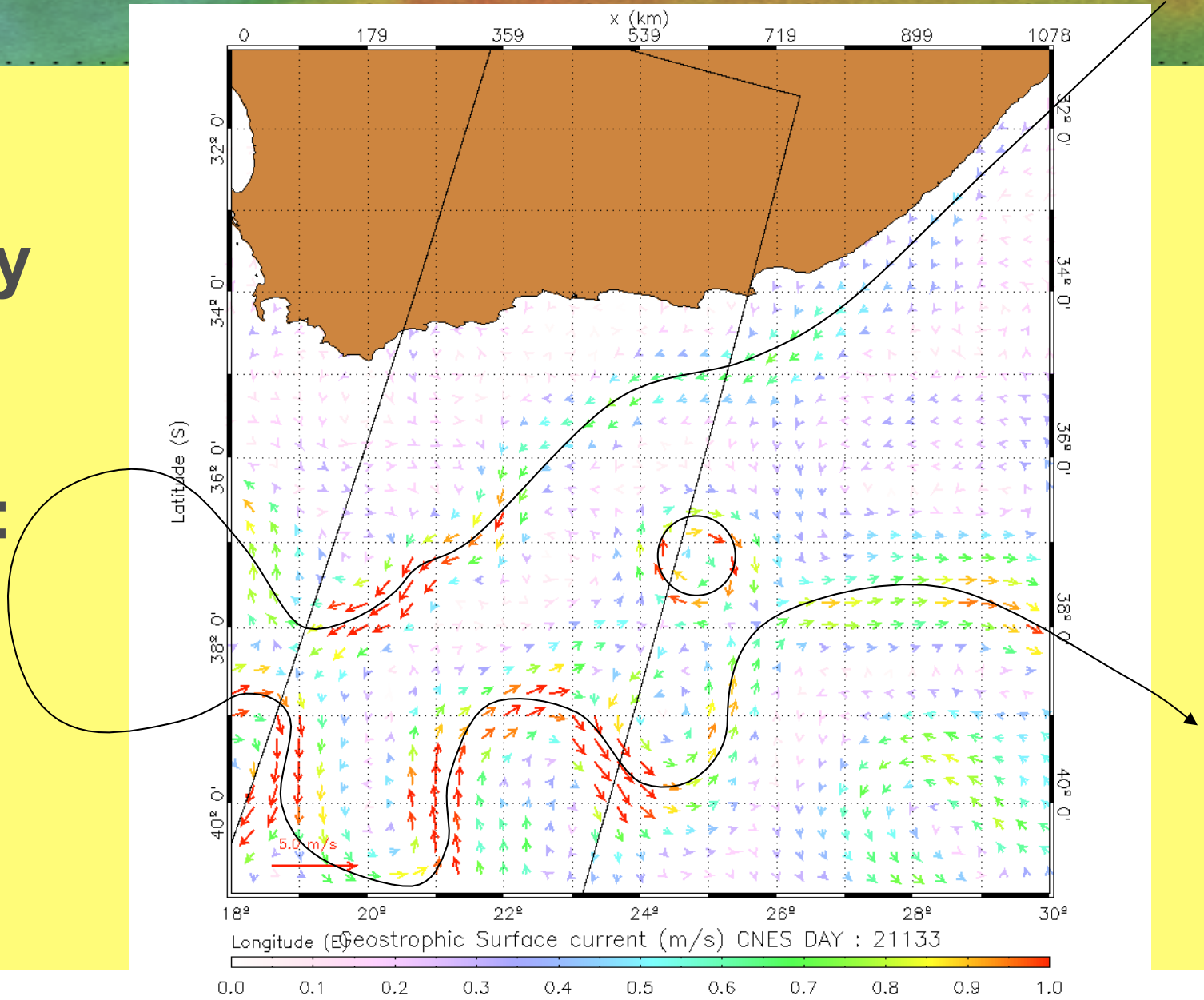
Altimetry derived surface current : 3 days mean



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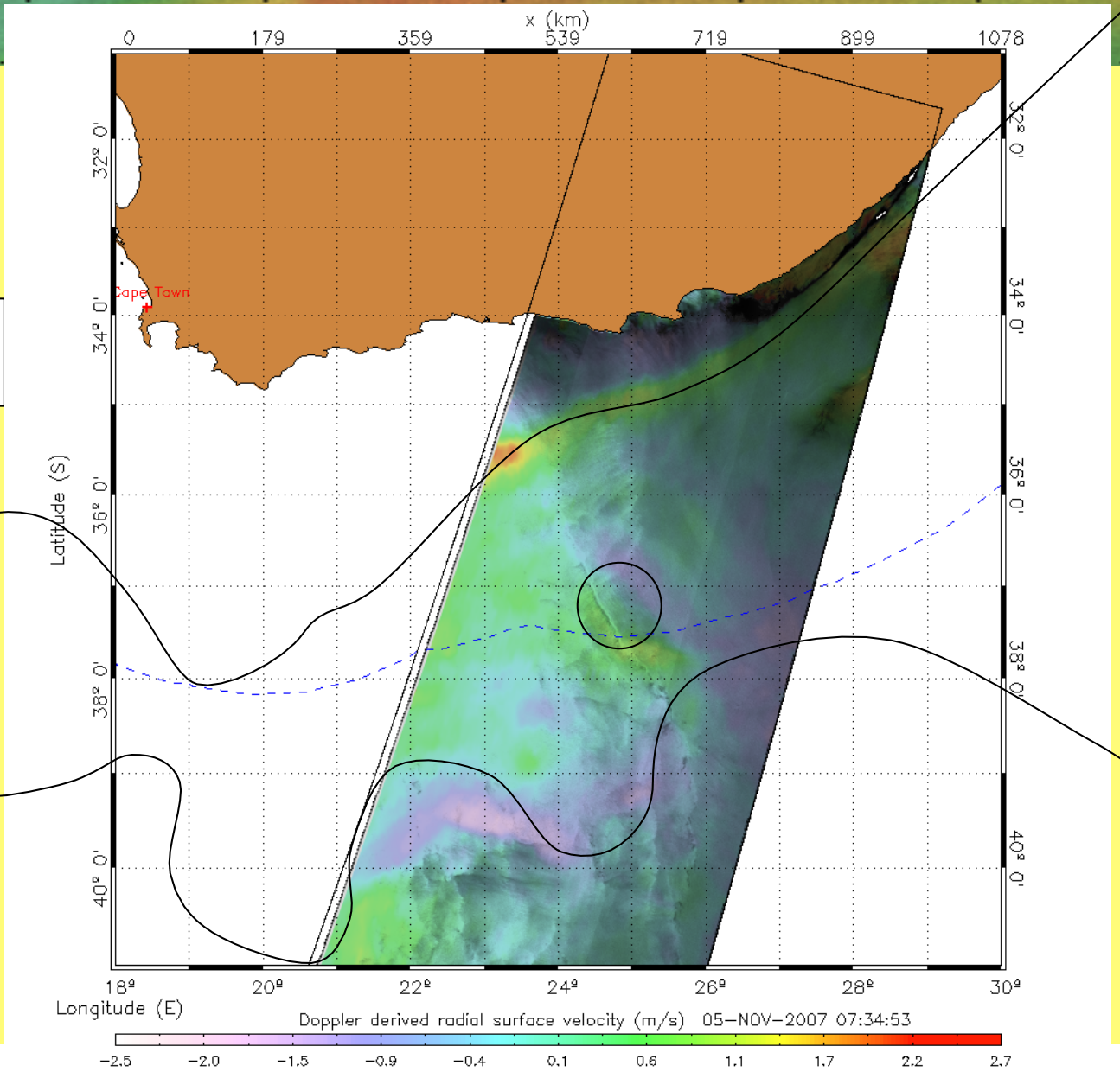
- Nov 5, 2007



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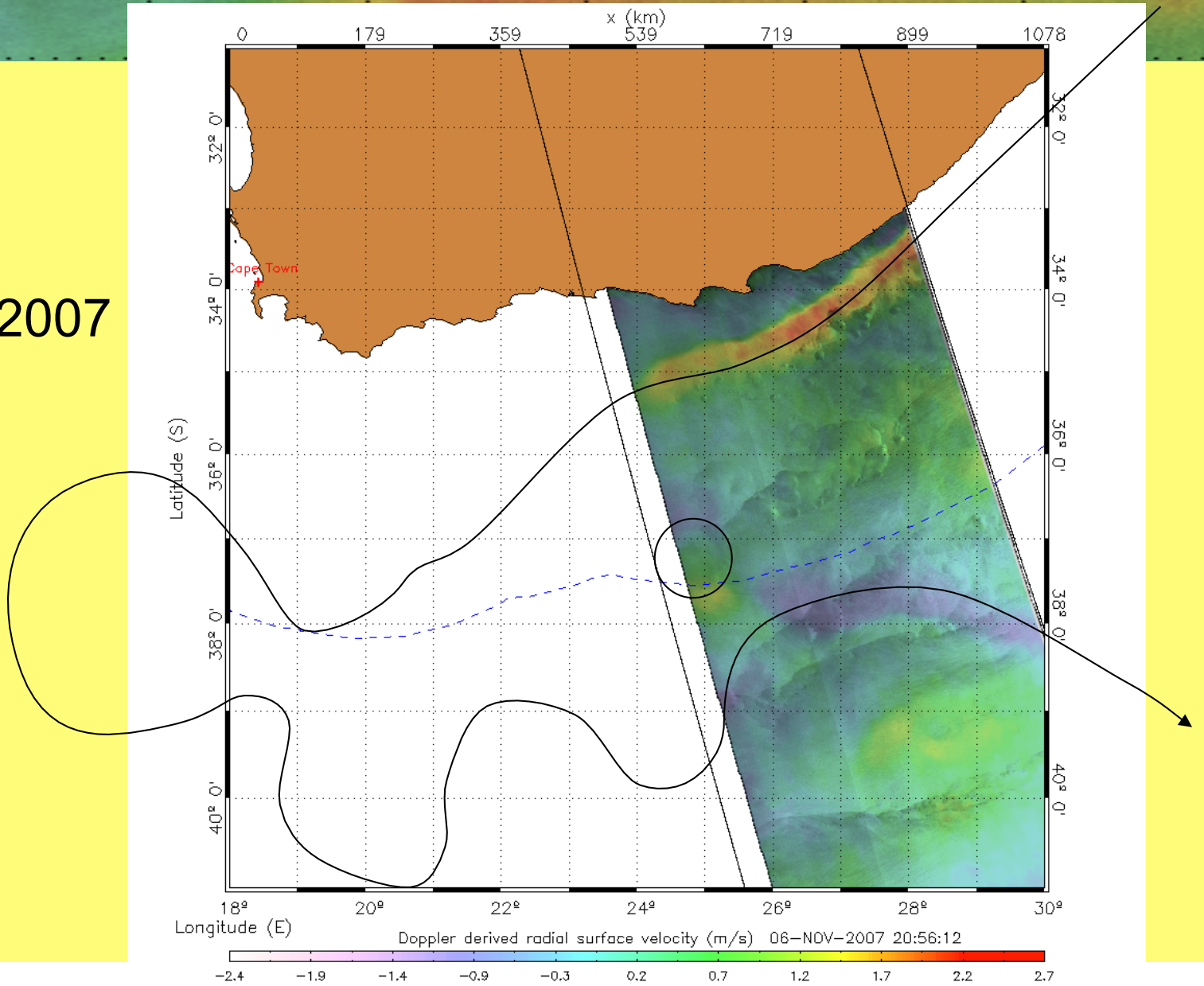

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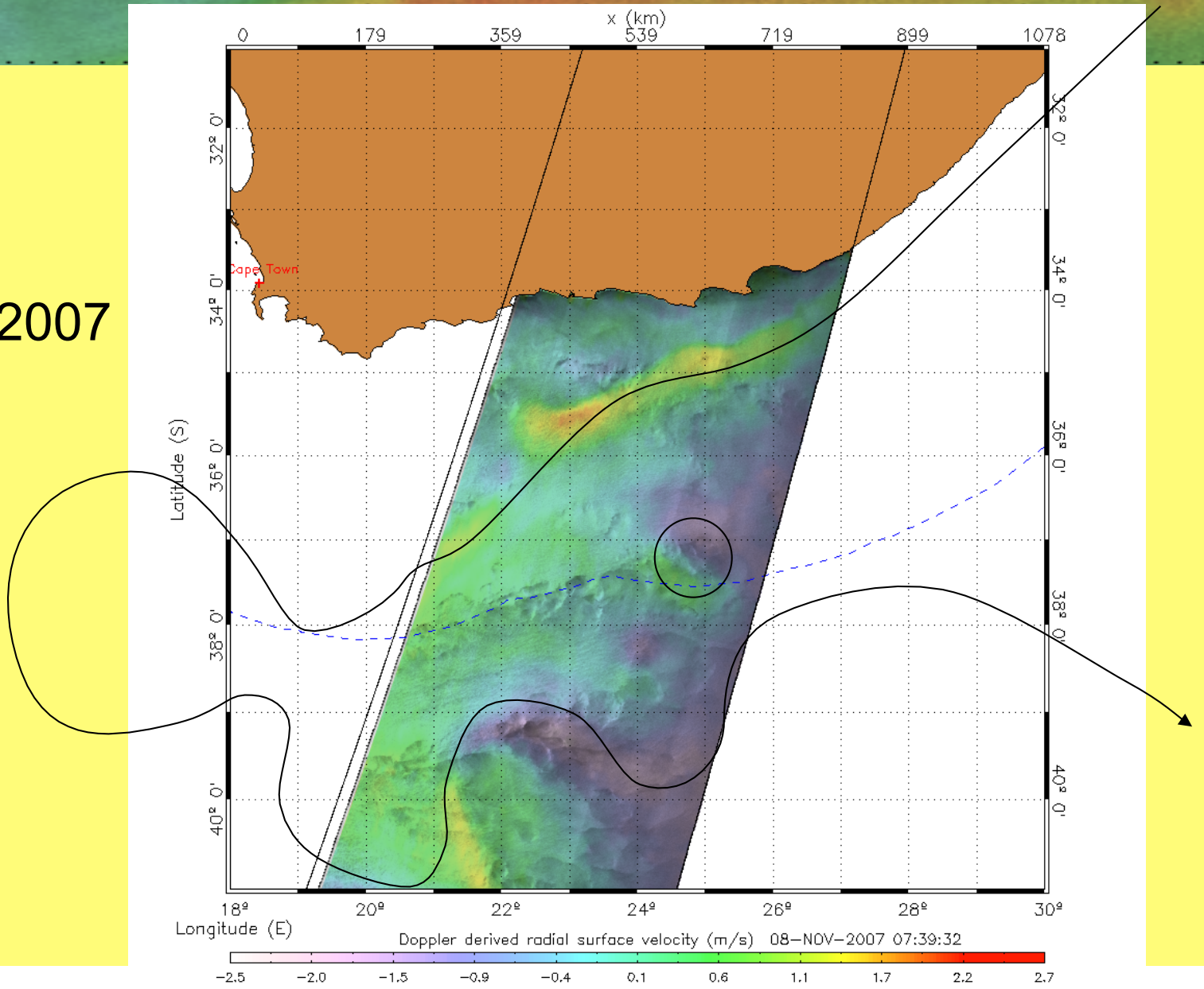

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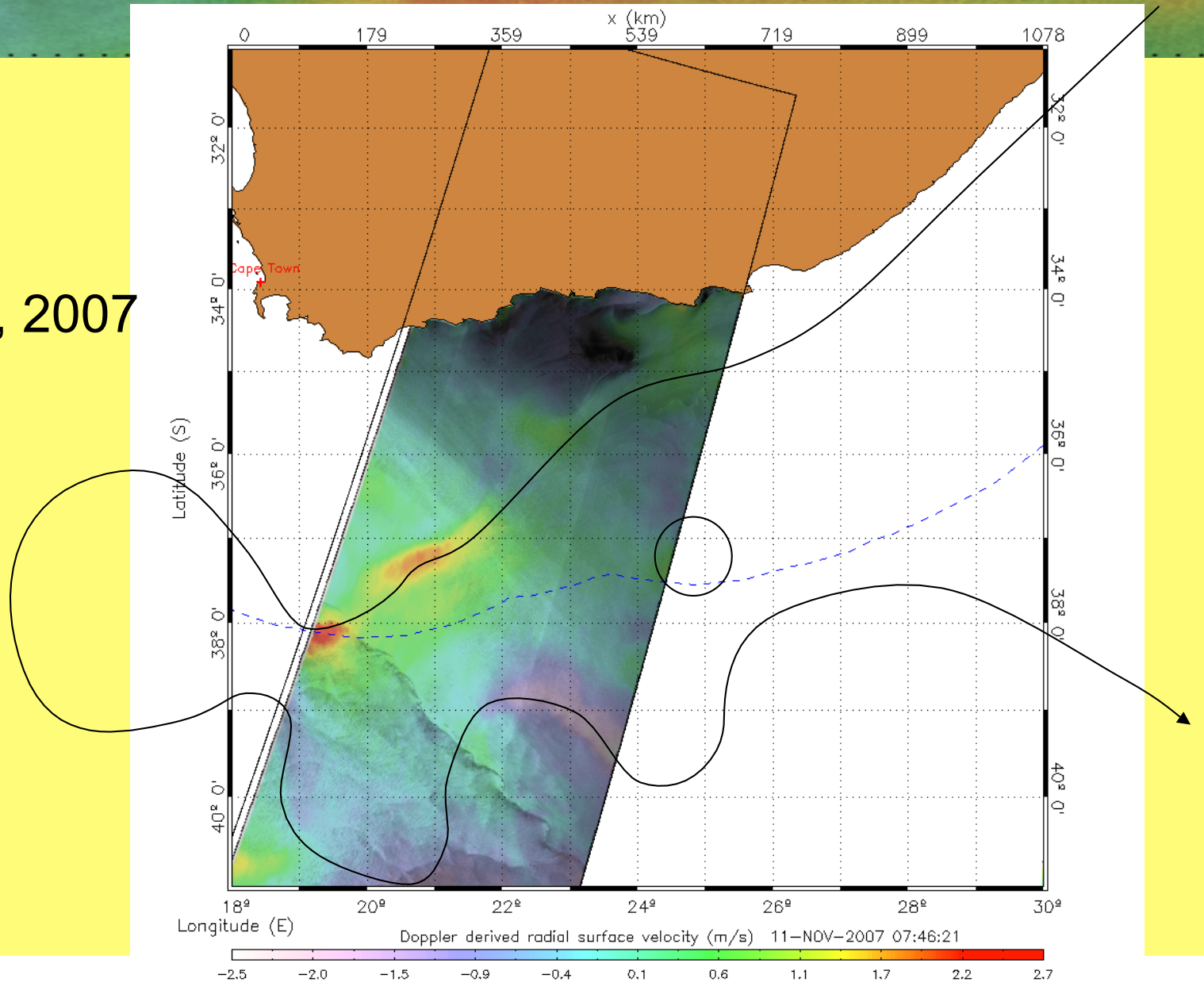

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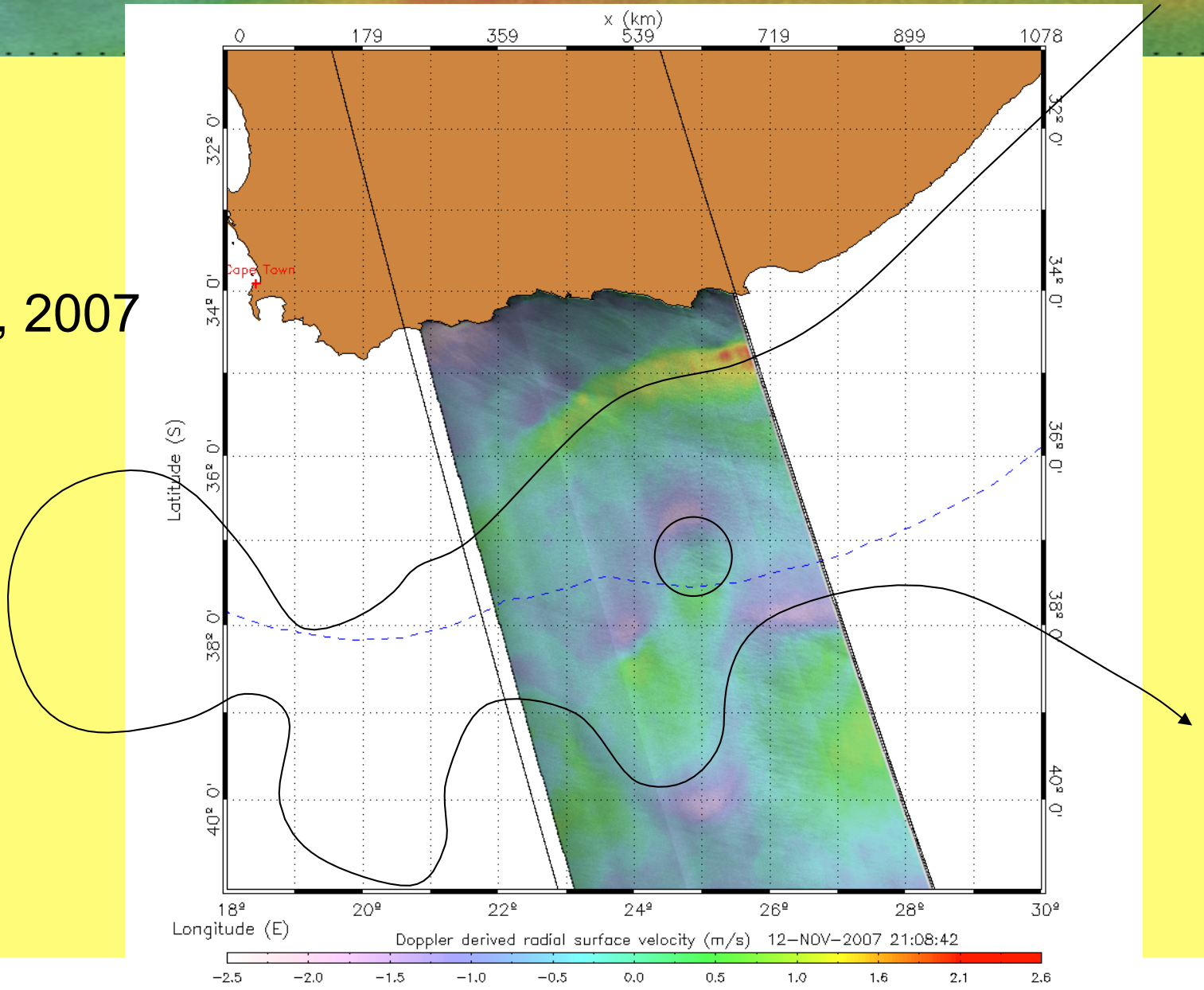

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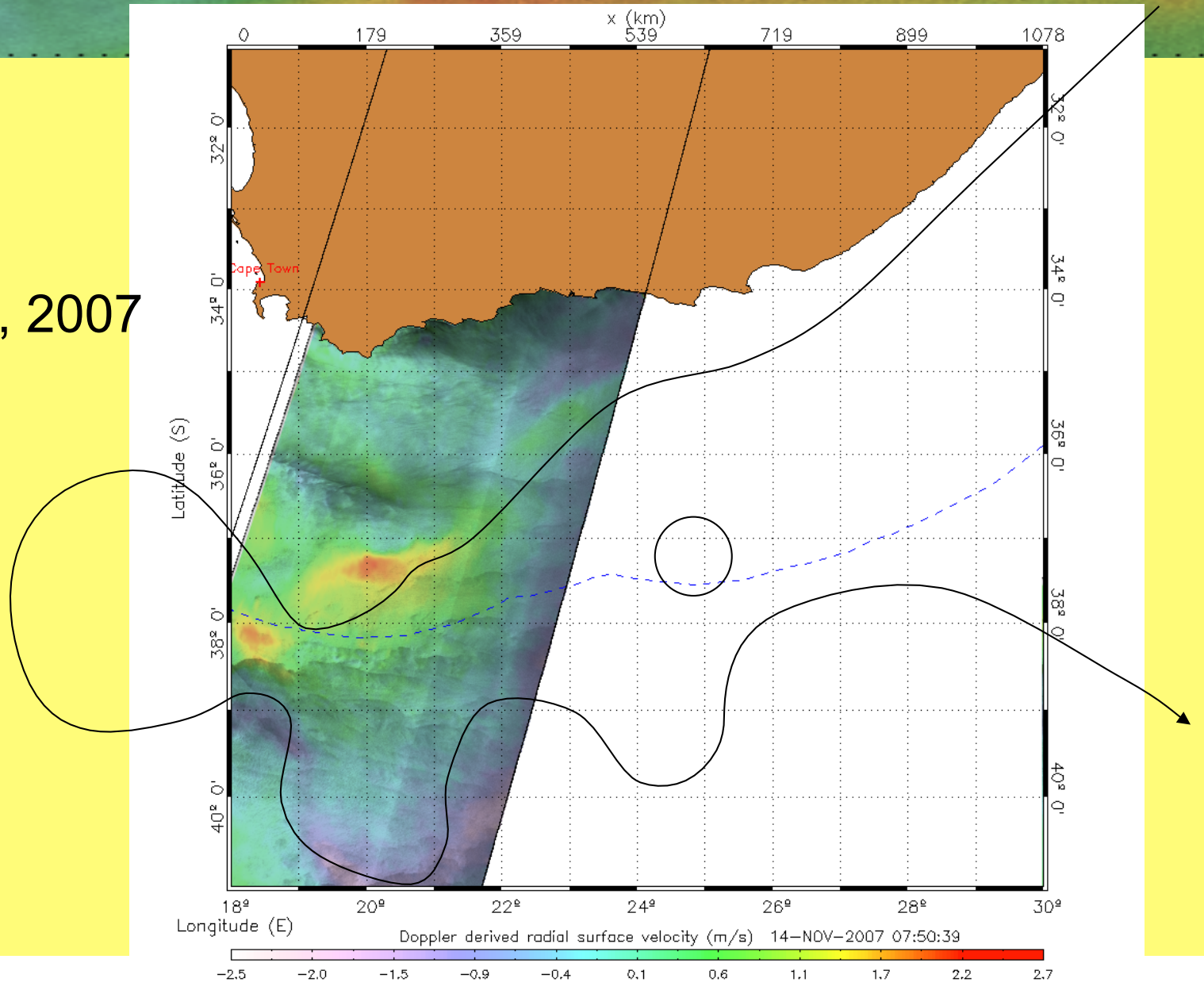

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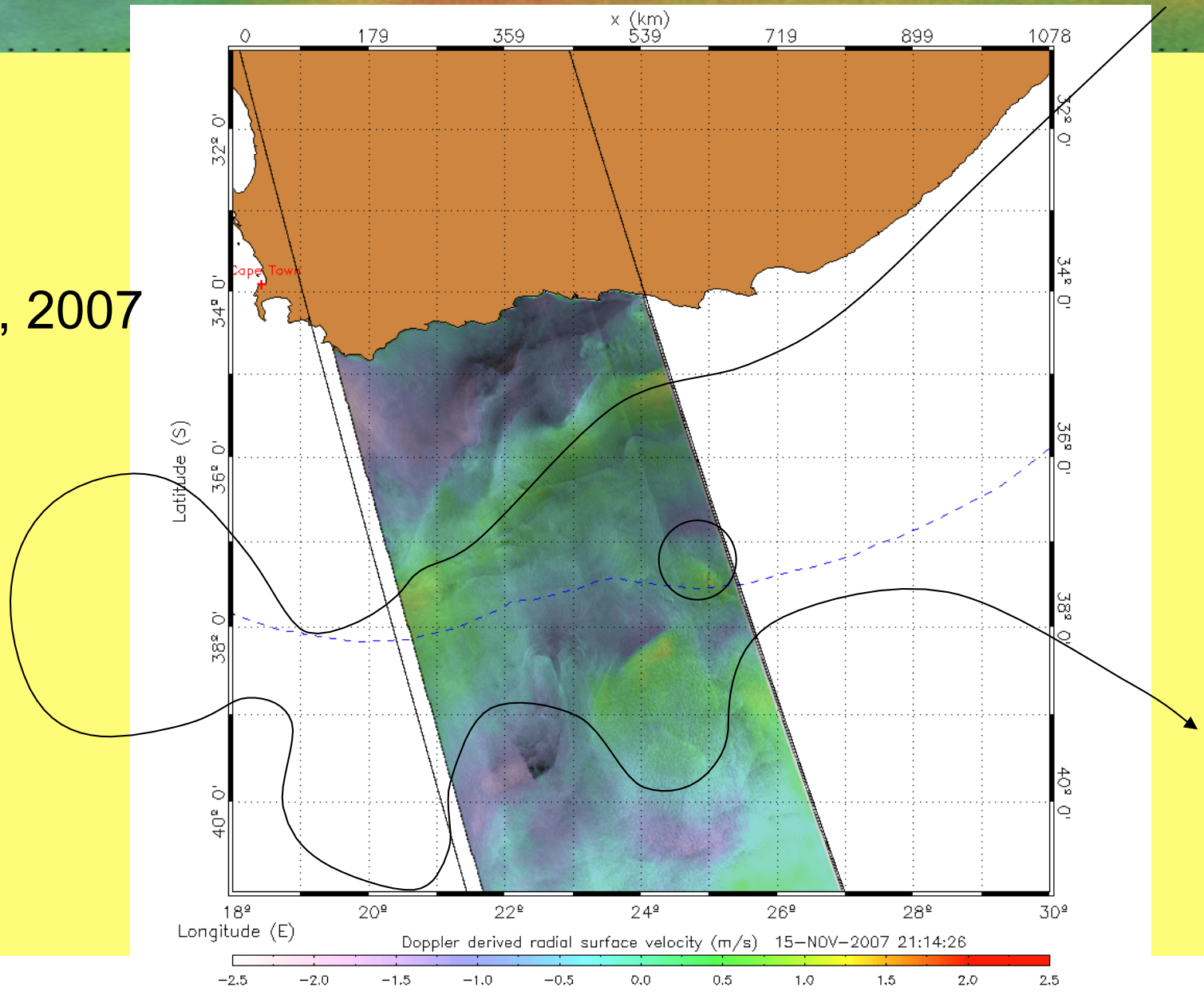

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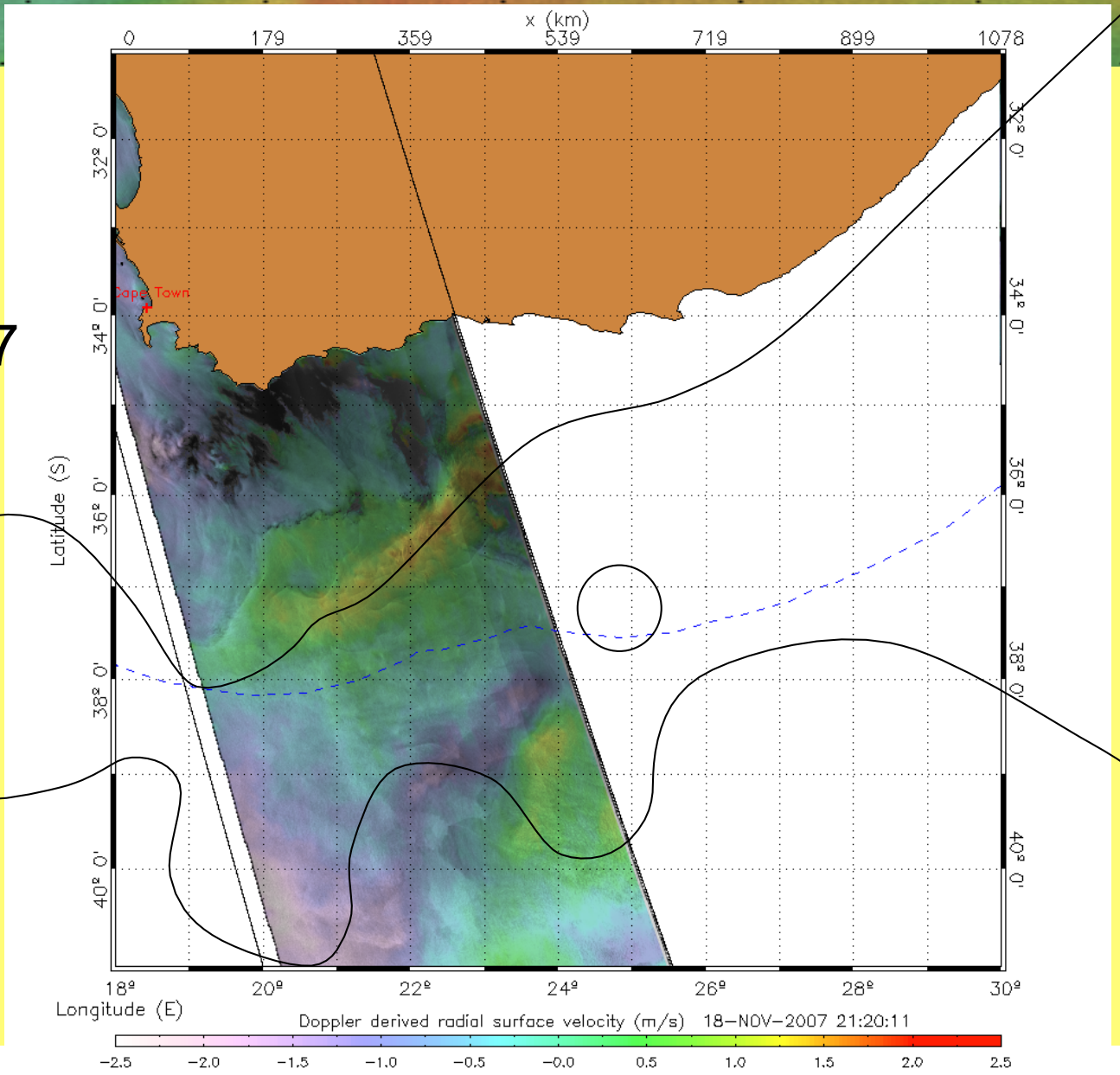
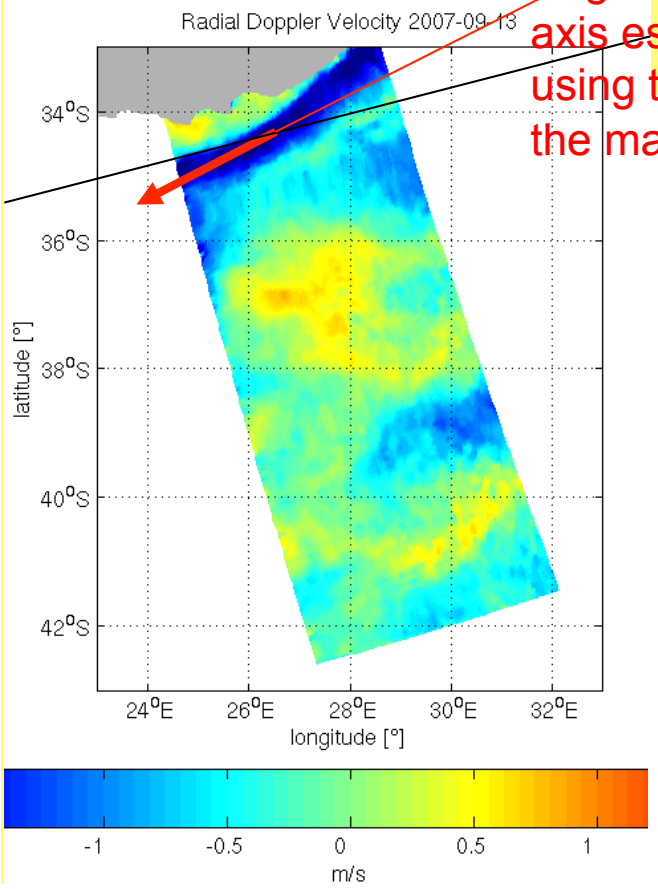
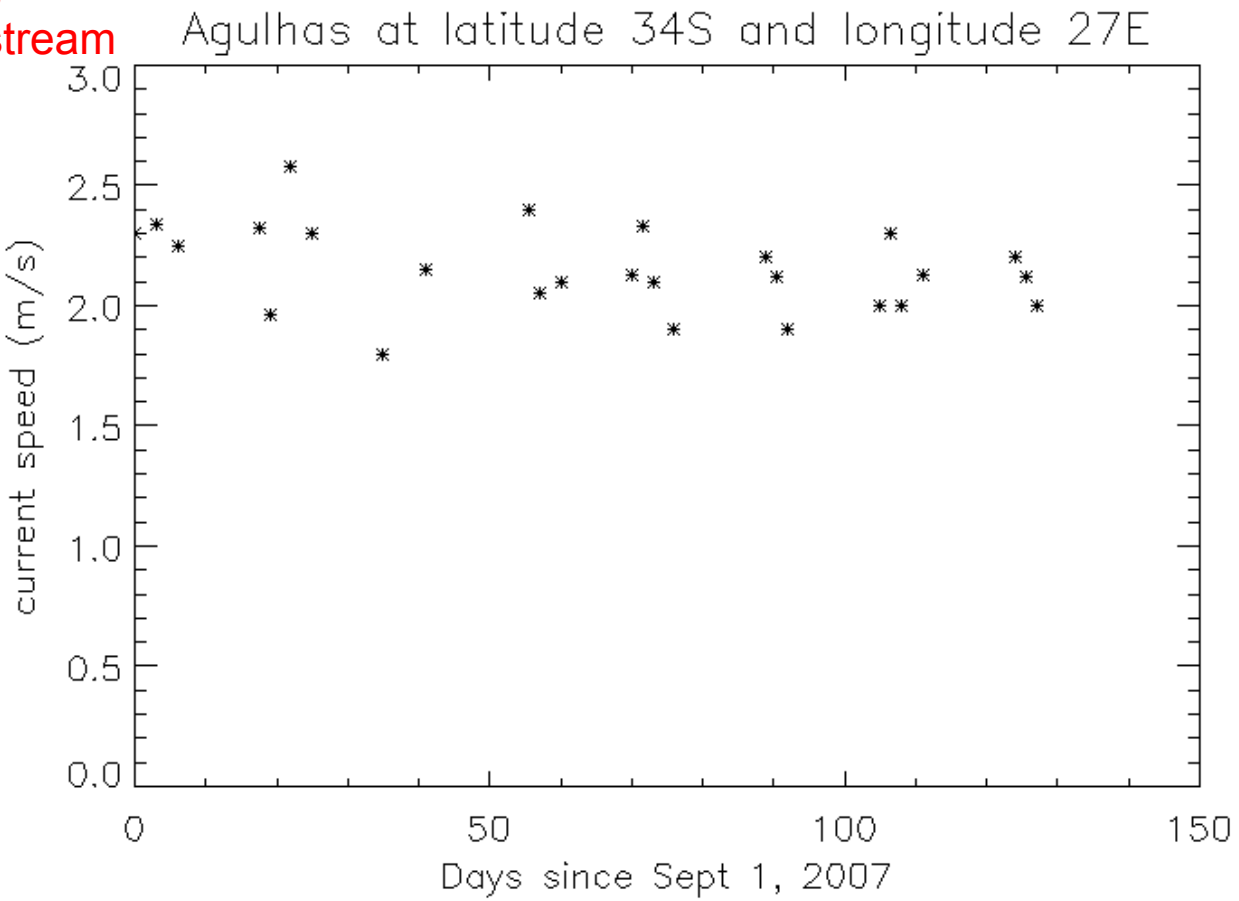

x (km)
0
179
359
539
719
899
1078
32º 0'
34º 0'
36º 0'
38º 0'
40º 0'
Cape Town
Latitude (S)
18º
20º
22º
24º
26º
28º
30º
Longitude (E)
Doppler derived radial surface velocity (m/s) 18-NOV-2007 21:20:11
-2.5
-2.0
-1.5
-1.0
-0.5
-0.0
0.5
1.0
1.5
2.0
2.5

Agulhas main stream velocity

- From Sept 1 2007 to Jan 17 2008
- Angle to radial axis estimated using tangent to the main stream

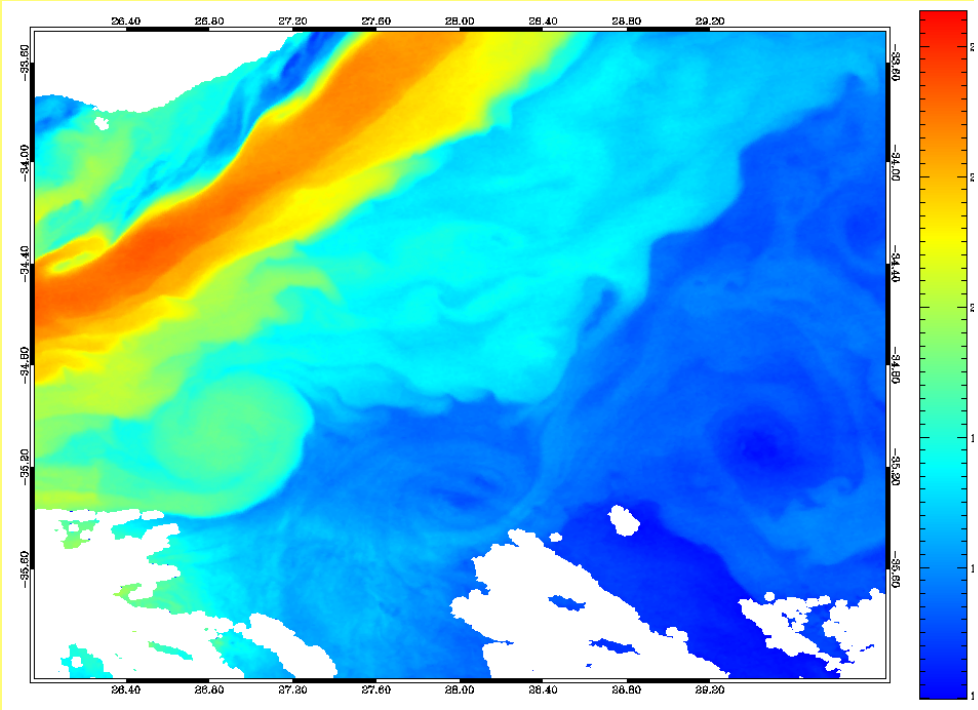


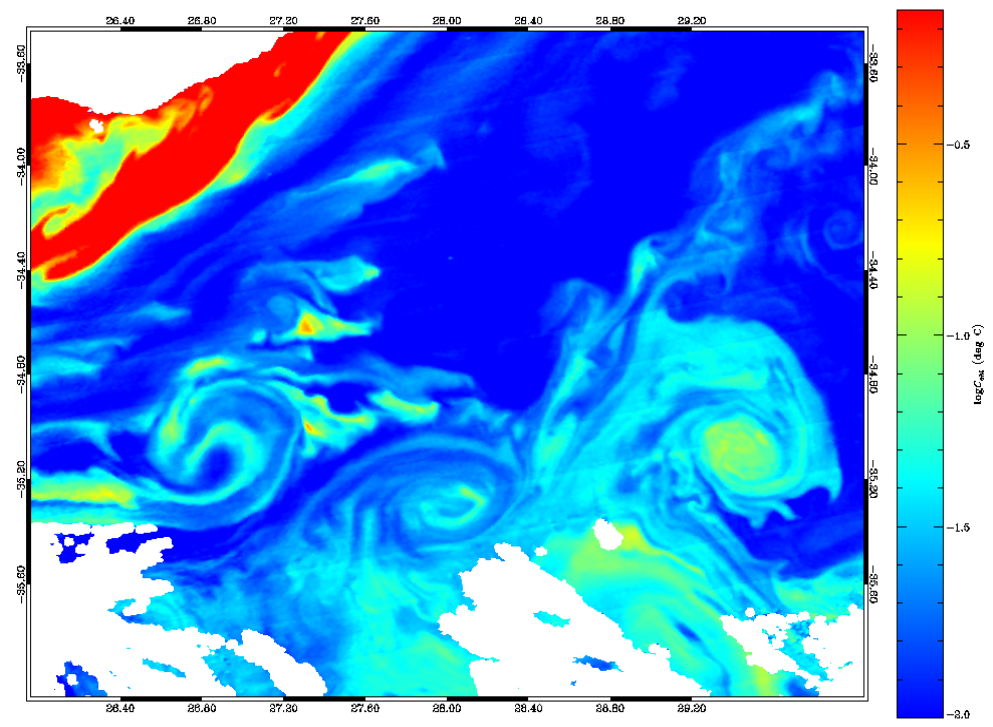


Summary

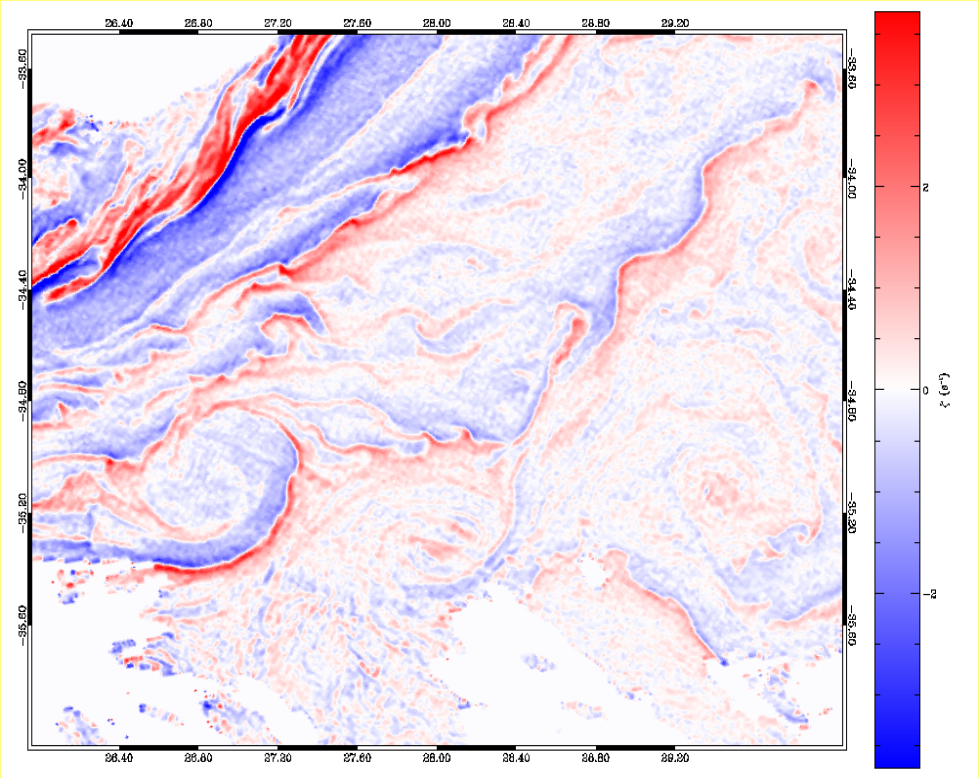
- Large scale surface velocity observed by SAR with possibility to obtain estimations of surface current in the radar look direction.
- CDOP applicable to the C band for removal of wind contribution to the Doppler velocity
- Combined with surface drifters and altimeter-derived surface geostrophic current, monitoring of the dynamics of intense current regimes may be advanced.
- Need for high resolution validation dataset. Routine acquisitions over HF radar is an option, but dedicated field campaign is needed.
- Accuracy and resolution of Doppler centroid estimation need more investigation.

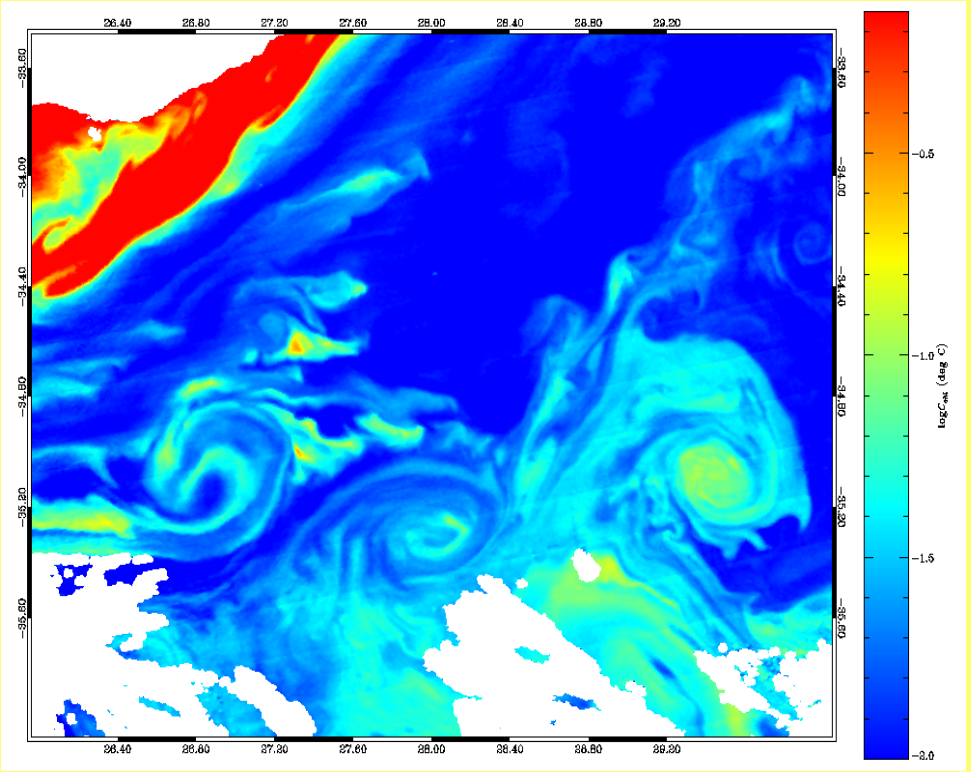
MODIS Brightness temperature and colour





MODIS Brightness temperature SQG-derived vorticity $|\nabla\zeta|_{\zeta=0}$ and colour





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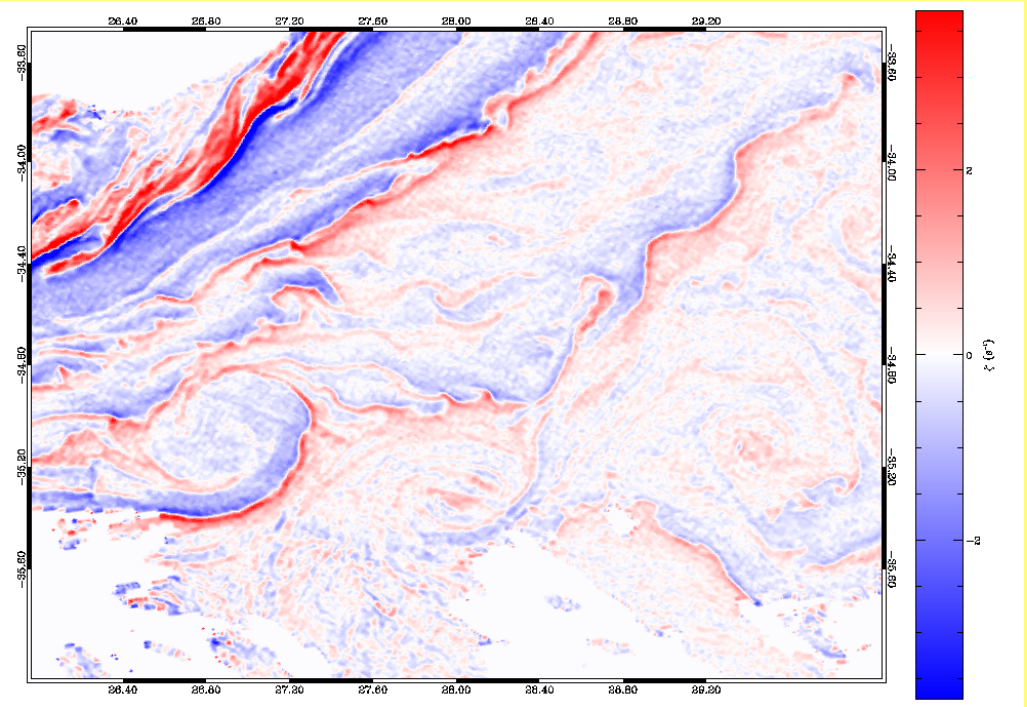
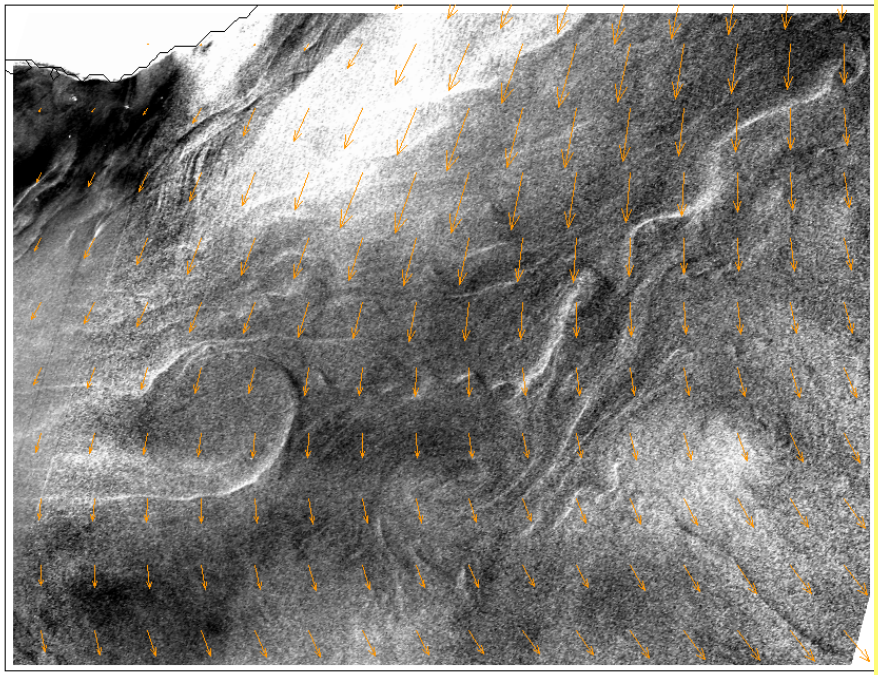
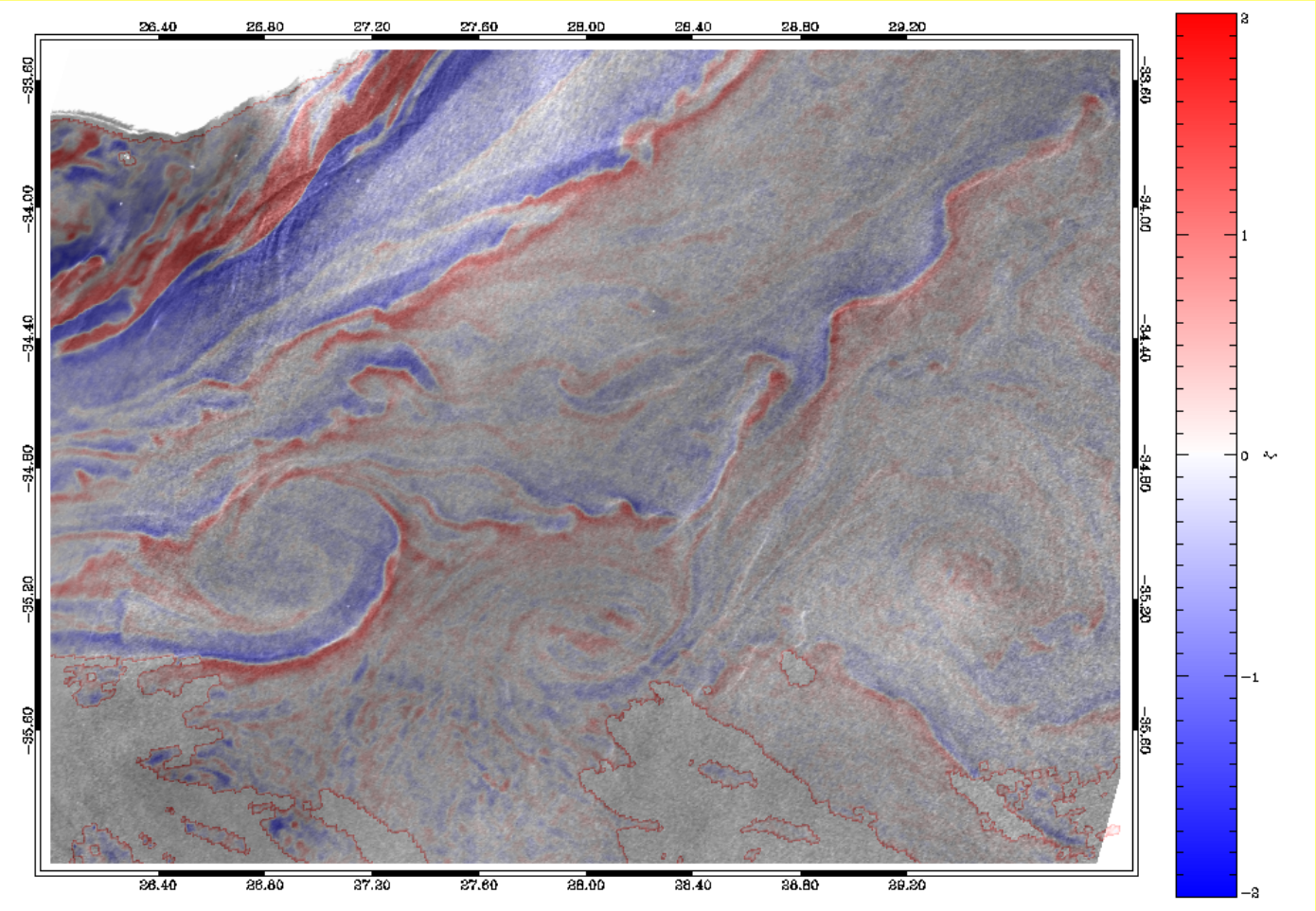
MODIS Brightness temperature SQG-derived vorticity $|\nabla\zeta|_{\zeta=0}$ and ENVISAT radar roughness variations



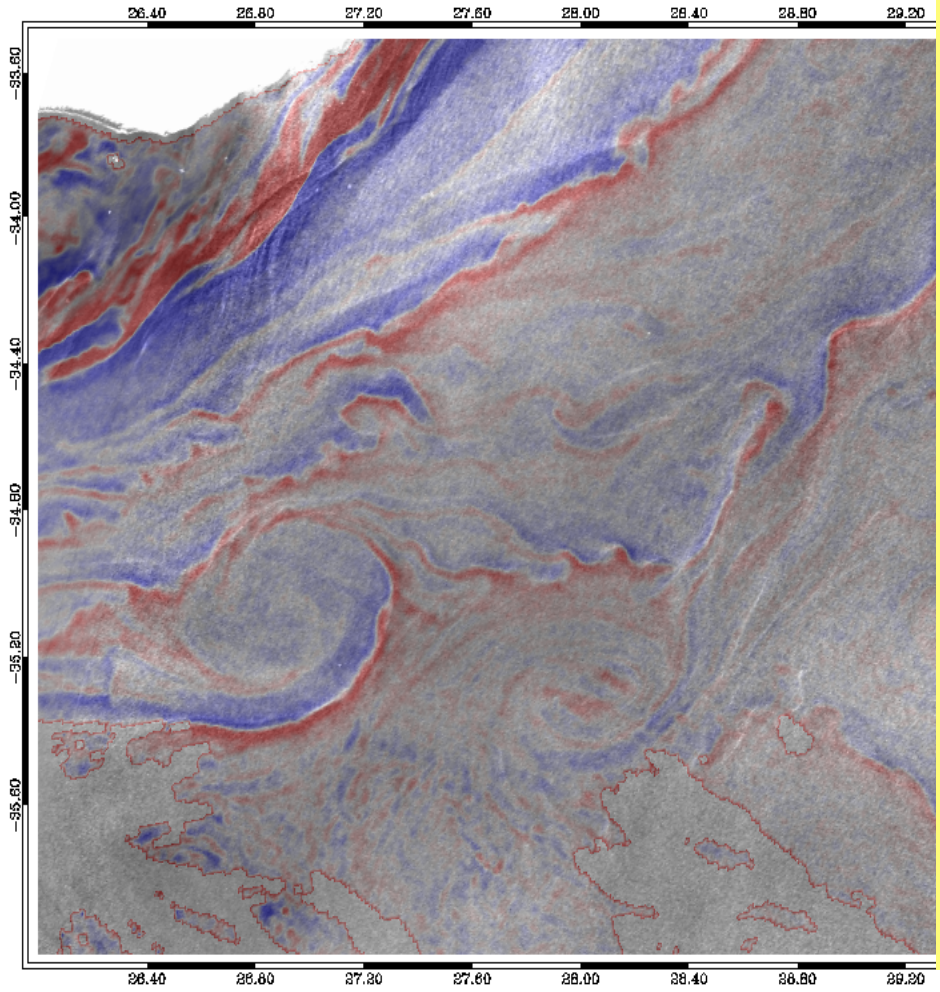


Overlaid MODIS SQG-derived vorticity and ENVISAT radar roughness variations

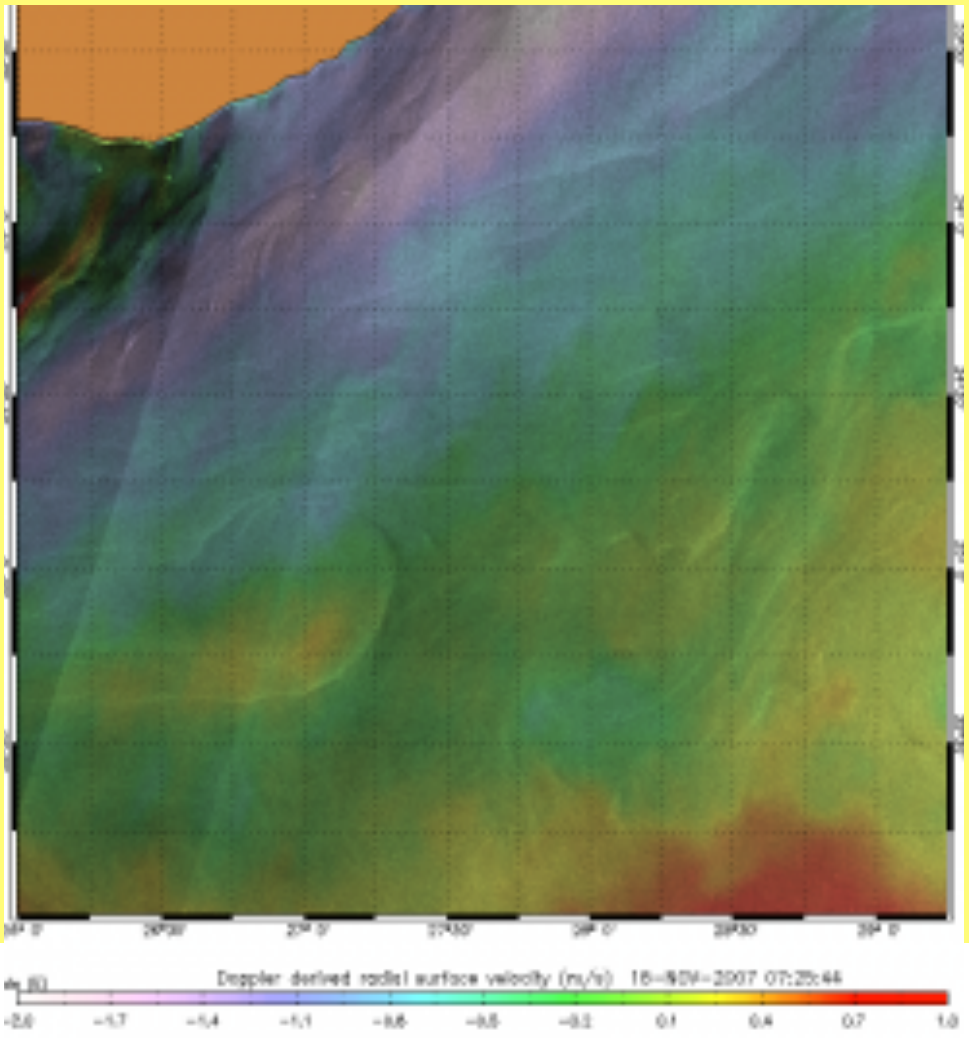
$$\left|\nabla\varsigma\right|_{\varsigma=0}$$



Overlaid MODIS SQG-derived vorticity and ENVISAT radar roughness variations

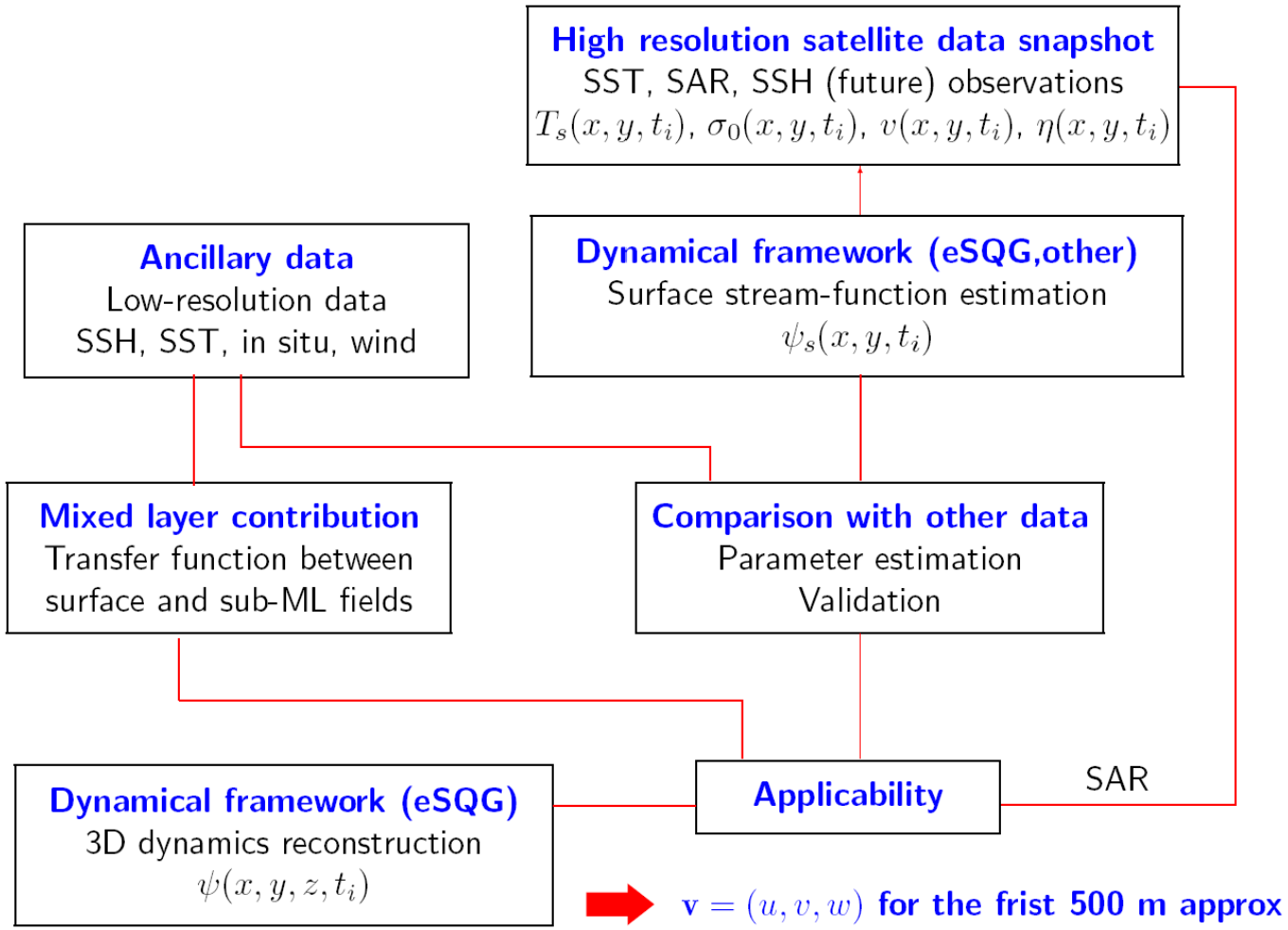


ASAR Doppler velocity



$|\varsigma| \propto |w_z|$

High resolution 3D ocean dynamics reconstruction from surface satellite data



The Doppler shift simulation in DopRIM

$$\frac{\pi f_D}{k_R} = -\frac{\overline{(u\sin\theta - w\cos\theta)\sigma_0(\theta+\Delta\theta)}}{\overline{\sigma_0(\theta+\Delta\theta)}}$$

f_D: Doppler shift
K_R: Radar Wave number
θ : Incidence angle
U: horizontal velocity of scatterers
W: vertical velocity of surf scatterers
σ_0: radar cross section

$$V_D = -\frac{\pi f_D}{k_R \sin\theta} = u_S + \bar{c}_f - \frac{1}{\tan\theta}\cdot\frac{\overline{\tilde{w}\tilde{\sigma}_0}}{\bar{\sigma}_0} + \frac{\overline{\tilde{u}\tilde{\sigma}_0}}{\bar{\sigma}_0}$$

V_D: Doppler velocity
C_f: Mean scatterer velocity
Us: surface current in range
σ_0 : NRCS

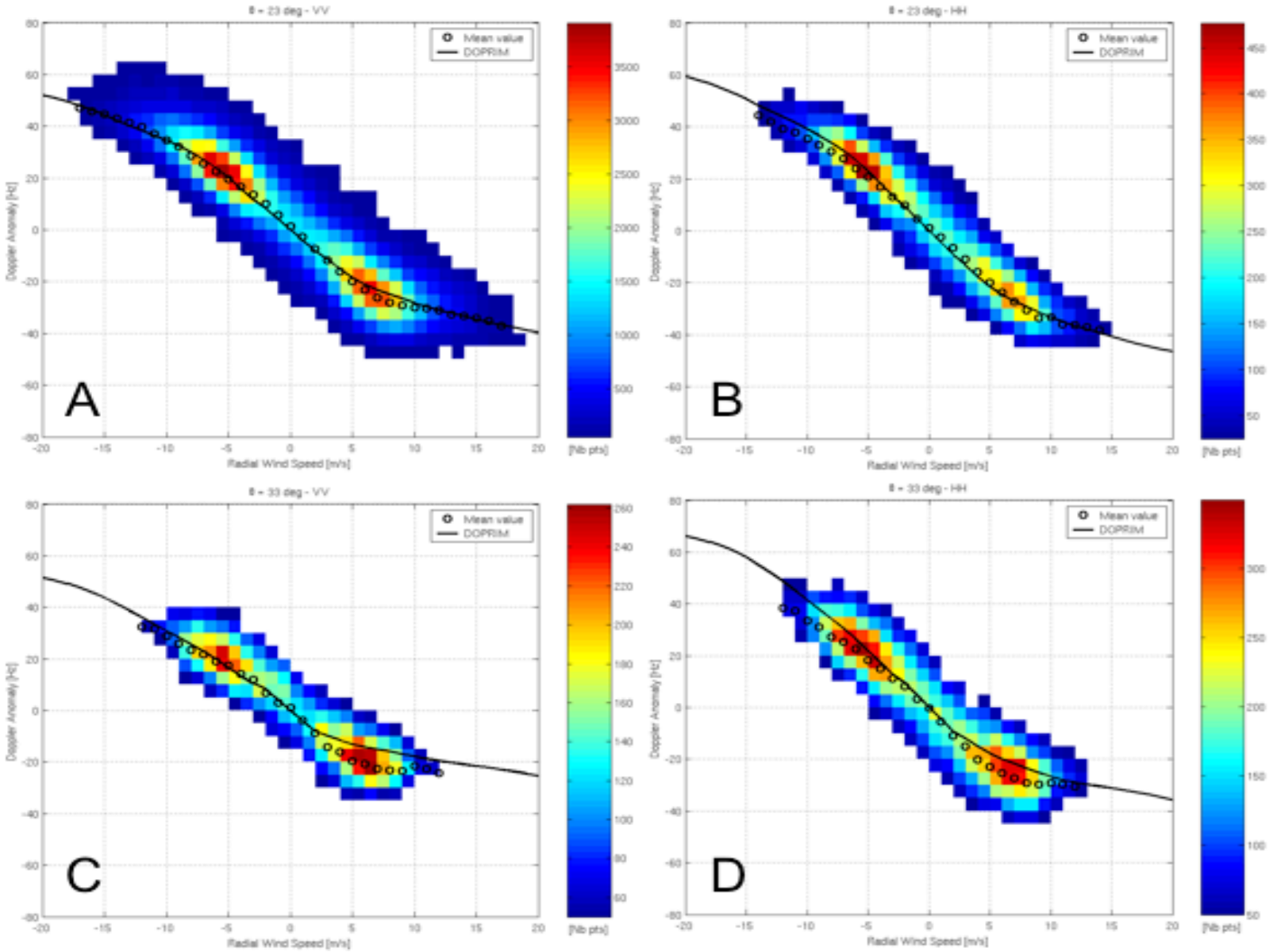
$$V_D = u_S + \bar{c}_f + \bar{c}_f^{\,TH}$$

$$V_D = u_S + \sum P_f^p(\bar{c}_f + \bar{c}_f^{\,TH})$$

p: pol

f: br, sp, wb

THIS IS THE BEAUTY OF DopRIM


θ = 23 deg - VV
Mean value
DOPRIM
A
Doppler Anomaly [Hz]
Radial Wind Speed [m/s]
[Nb pts]
θ = 23 deg - HH
Mean value
DOPRIM
B
Doppler Anomaly [Hz]
Radial Wind Speed [m/s]
[Nb pts]
θ = 33 deg - VV
Mean value
DOPRIM
C
Doppler Anomaly [Hz]
Radial Wind Speed [m/s]
[Nb pts]
θ = 33 deg - HH
Mean value
DOPRIM
D
Doppler Anomaly [Hz]
Radial Wind Speed [m/s]
[Nb pts]

NERSC