Ray swell propagation in the Agulhas current through the use of different oceanic current estimates

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CFOSAT 3rd International Science Team Meeting

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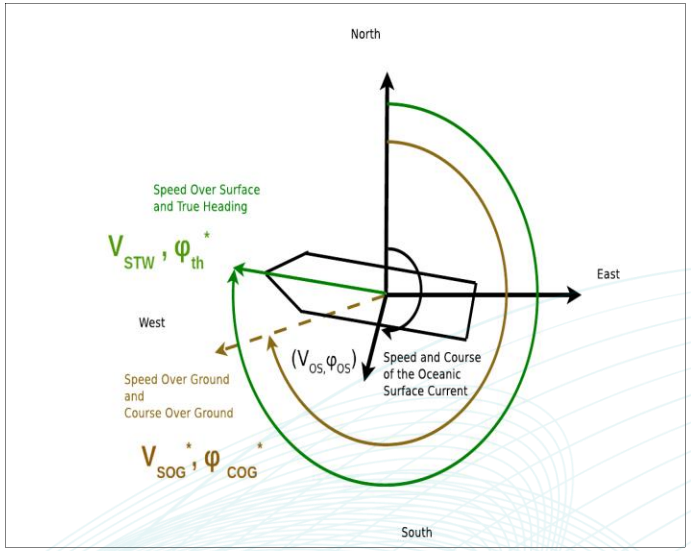
eOdyn

AIS current estimates



$$\overrightarrow{V_{Boat/Ground}} = \overrightarrow{V_{Boat/Sea}} + \overrightarrow{V_{Sea/Ground}}$$

$$\begin{cases} V^*_{sog} sin(\varphi^*_{cog}) = V_{stw} sin(\varphi^*_{th}) + u_{drift} & (\text{zonal}) \\ V^*_{sog} cos(\varphi^*_{cog}) = V_{stw} cos(\varphi^*_{th}) + v_{drift} & (\text{meridional}) \end{cases}$$

Space-time homogeneity
of the oceanic surface current

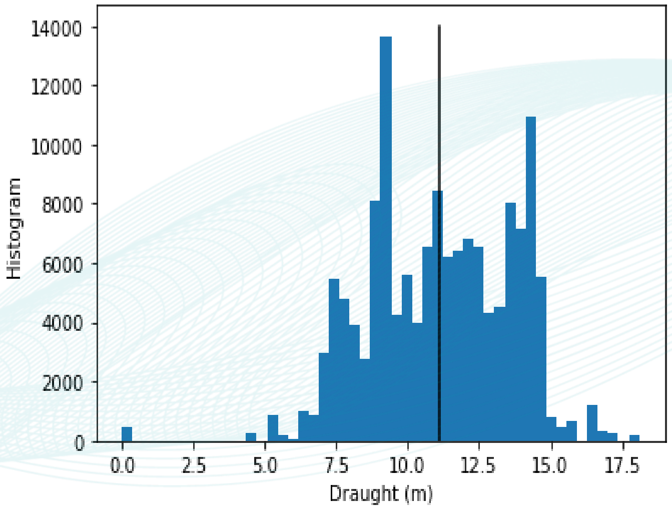
$$\begin{cases} V^*_{sog_1} sin(\varphi^*_{cog_1}) = V_{stw_1} sin(\varphi^*_{th_1}) & + u_{os} \\ V^*_{sog_1} cos(\varphi^*_{cog_1}) = V_{stw_1} cos(\varphi^*_{th_1}) & + v_{os} \\ \vdots \quad\quad \vdots & \vdots \\ V^*_{sog_n} sin(\varphi^*_{cog_n}) = V_{stw_n} sin(\varphi^*_{th_n}) & + u_{os} \\ V^*_{sog_n} cos(\varphi^*_{cog_n}) = V_{stw_n} cos(\varphi^*_{th_n}) & + v_{os} \end{cases}$$

$$Ax = b$$

with A being the matrix to invert in order to calculate the oceanic surface current such as:

$$A = \begin{pmatrix} 1 & 0 & sin(\varphi^*_{th_1}) & 0 & \dots & 0 \\ 0 & 1 & cos(\varphi^*_{th_1}) & 0 & \dots & 0 \\ \vdots & \vdots & & \ddots & & \\ 1 & 0 & 0 & \dots & 0 & sin(\varphi^*_{th_n}) \\ 0 & 1 & 0 & \dots & 0 & cos(\varphi^*_{th_n}) \end{pmatrix}, x = \begin{pmatrix} u_{os} \\ v_{os} \\ V_{stw_1} \\ \vdots \\ V_{stw_n} \end{pmatrix}, b = \begin{pmatrix} V^*_{sog_1} sin(\varphi^*_{cog_1}) \\ V^*_{sog_1} cos(\varphi^*_{cog_1}) \\ \vdots \\ V^*_{sog_n} sin(\varphi^*_{cog_n}) \\ V^*_{sog_n} cos(\varphi^*_{cog_n}) \end{pmatrix}$$

Which Depth ??



<u>Limiting the lee-way drift due to the wind</u>

Only cargo type vessels are kept = the ratio between the Air draught and the Water draught must be weak

(Richardson et al 1997)

AIS derived Current

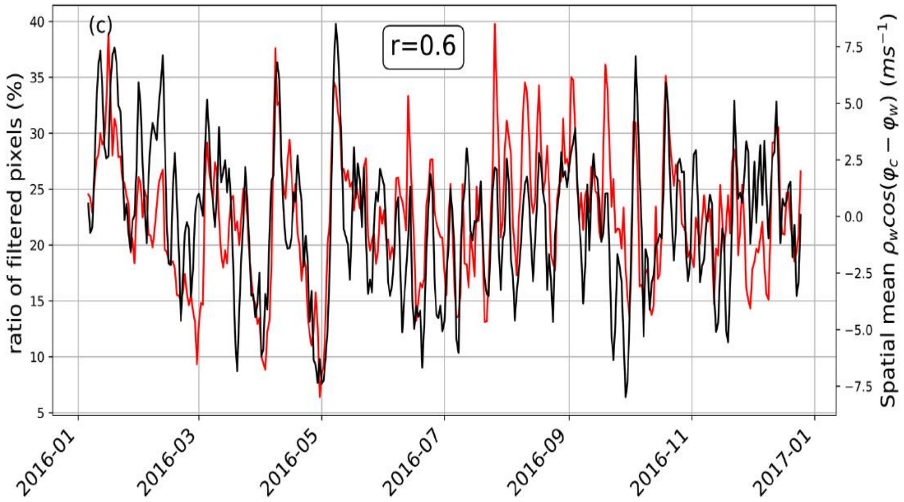
All the solutions do not correspond to realistic current.

Reasons :

-Vessels are going into the same direction : over-determined system

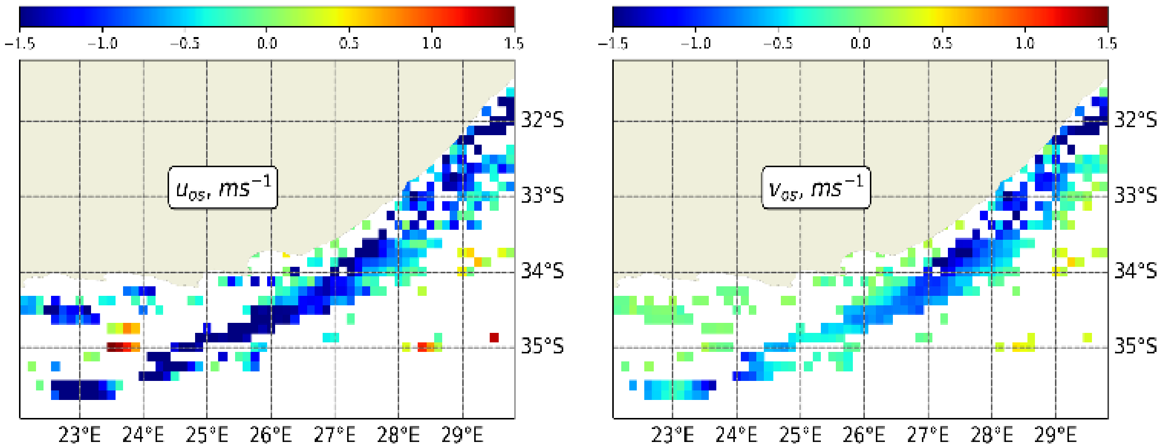
-Stormy weather conditions

Solutions : Filtering the data by comparing the speed through water and the speed over ground



Red= ratio of the pixels we keep after filtering

Black =wind blowing with (+) or against the current (-)



Monitoring the Greater Agulhas Current With AIS Data Information

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Merging AIS and altimetry - Multiscale Inversion for Ocean Surface Topography (MIOST) tool

Based on
Optimal Interpolation

$$\mathbf{x_a} = \mathbf{BH}^T(\mathbf{HBH}^T + \mathbf{R})^{-1}\mathbf{y}$$

- $\mathbf{x_a}$: Estimate
- $\mathbf{BH}^T$: (grid,obs) signal cov.
- $\mathbf{HBH}^T$: (obs,obs) signal cov.
- $\mathbf{R}$: (obs,obs) error cov
- $\mathbf{y}$: SLA obs

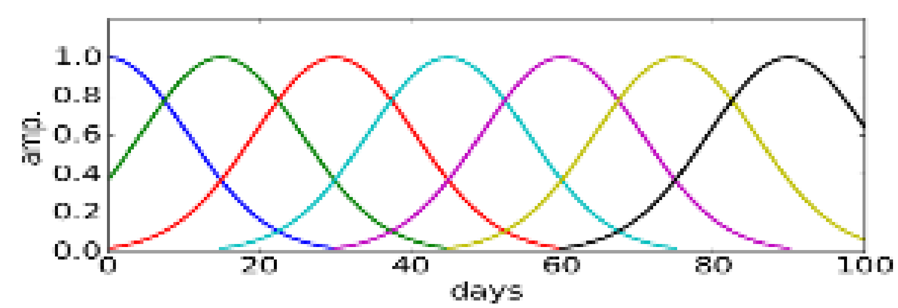
(Ubelmann et al., 2021)

- Decomposition of the signal in different components:

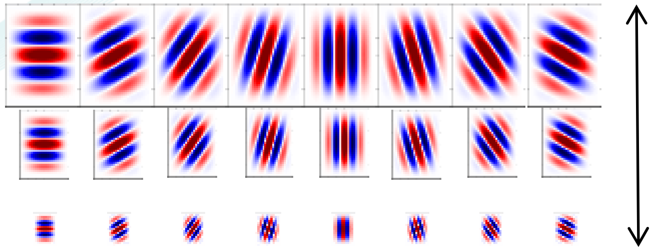
$$x = x_{geo} + x_{ek} + x_{inertie} \ \ldots$$

- Projection of each component on a wavelet basis

Example for the geostrophic component

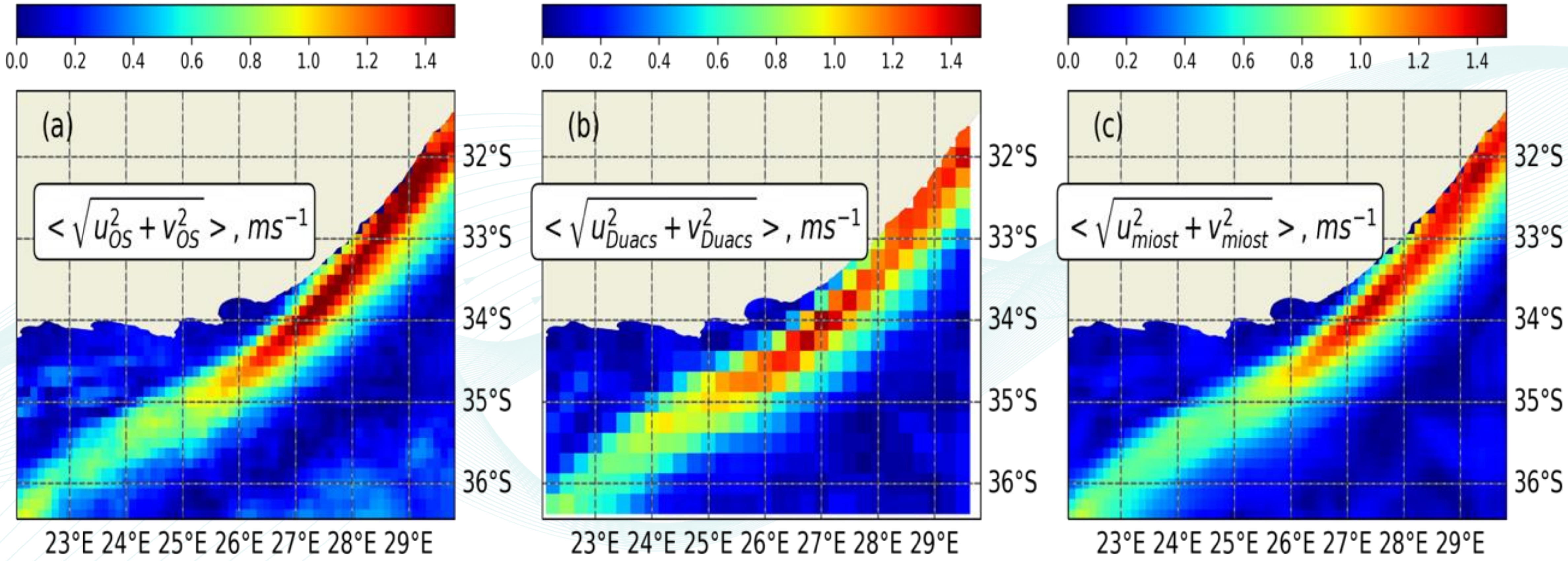


Temporal decorrelation scale:
~10 days (depend on the area as in DUACS)

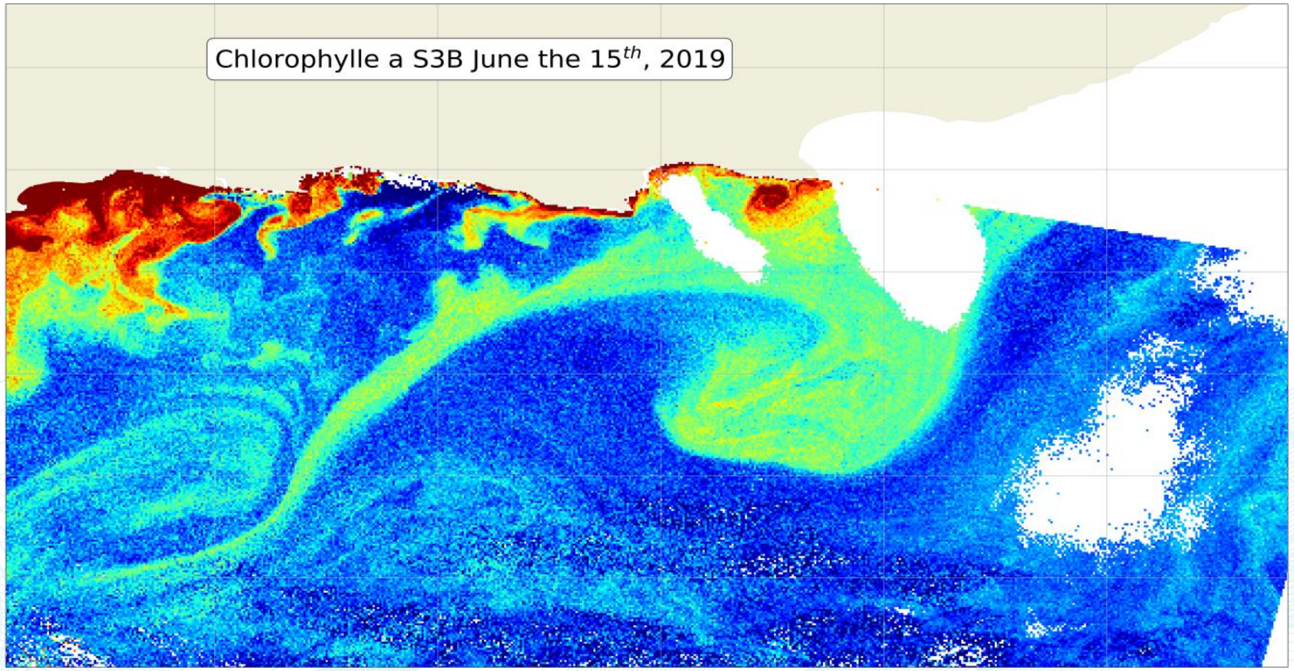


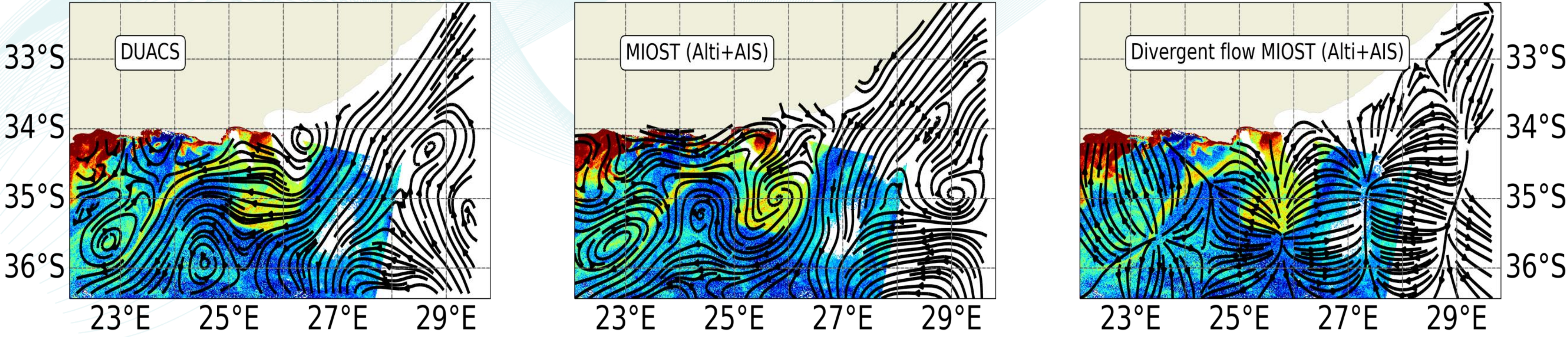
Spatial extension : 80 to 800 km

Time mean (2019-2020) of Agulhas Current



Results : Chlorophyll a Sentinel 3





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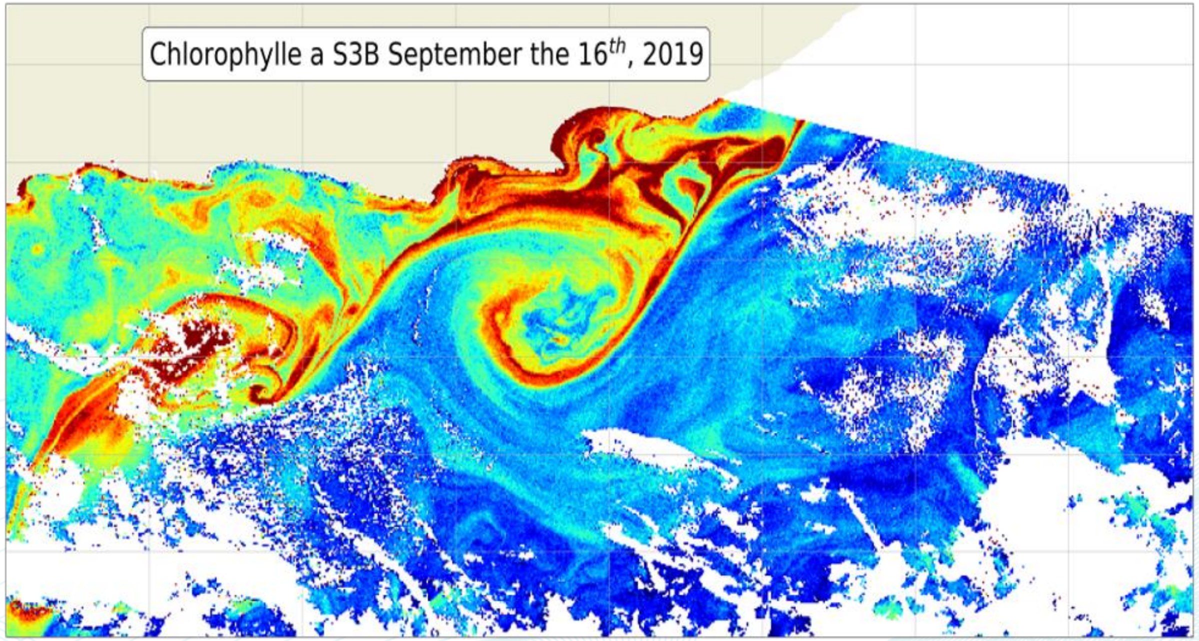
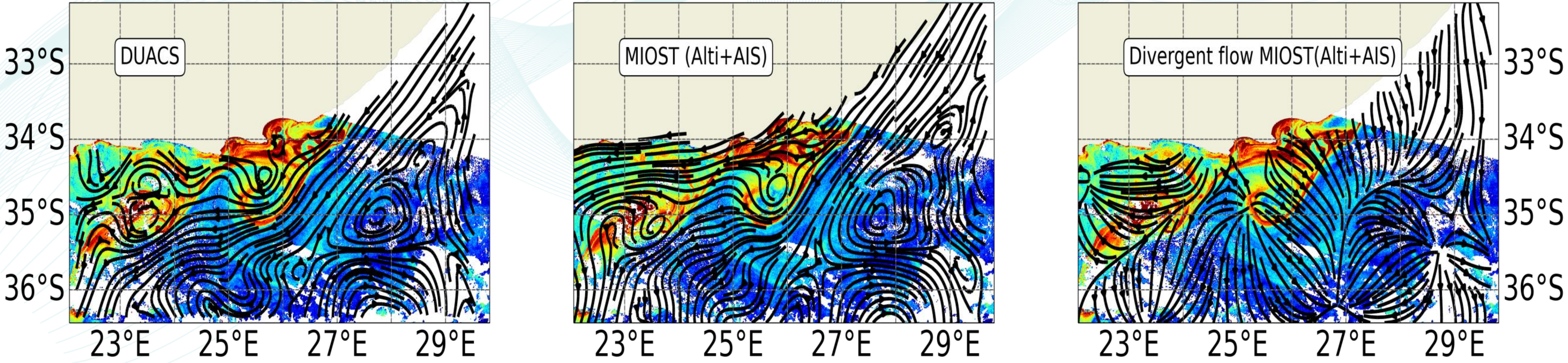
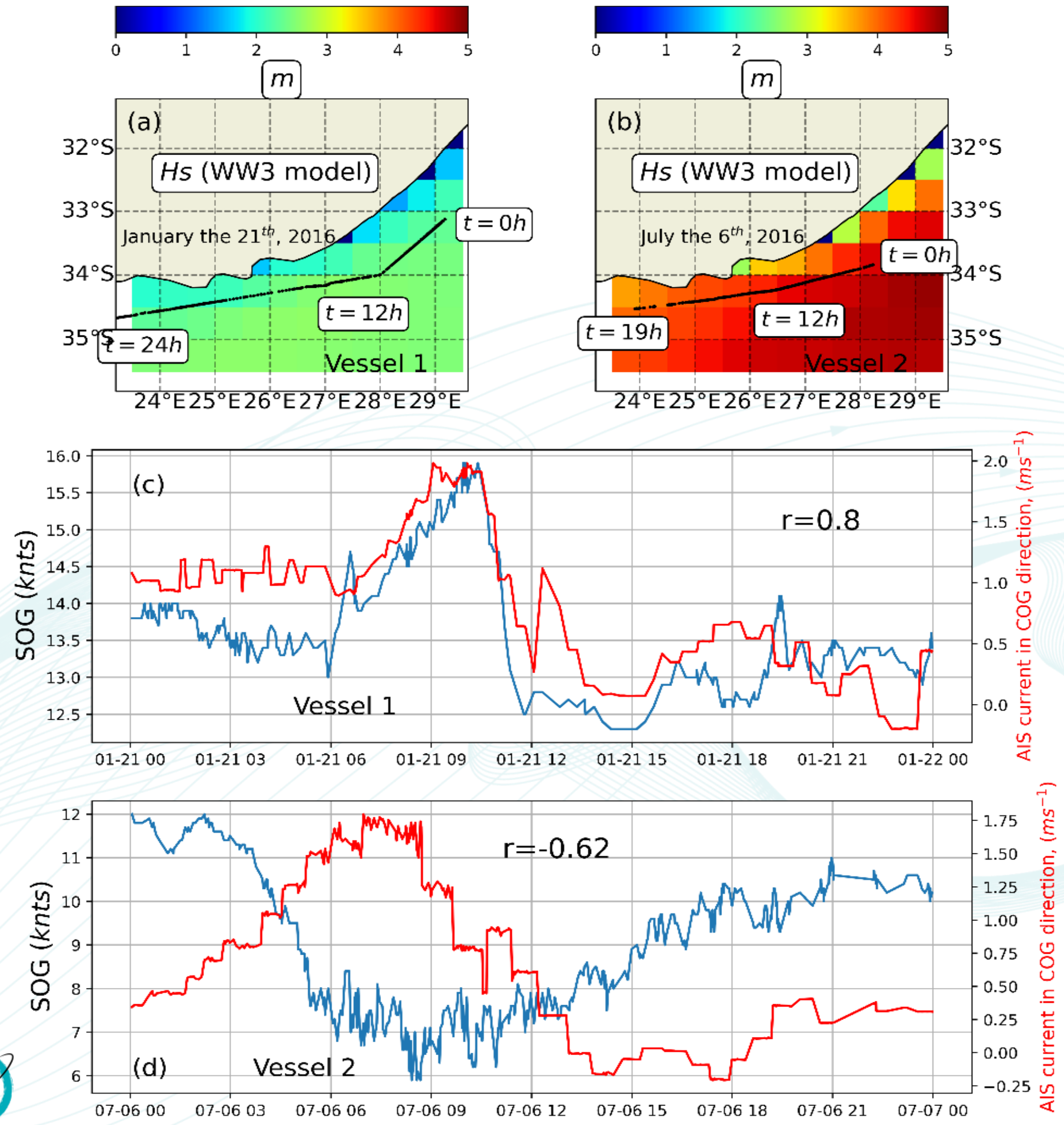
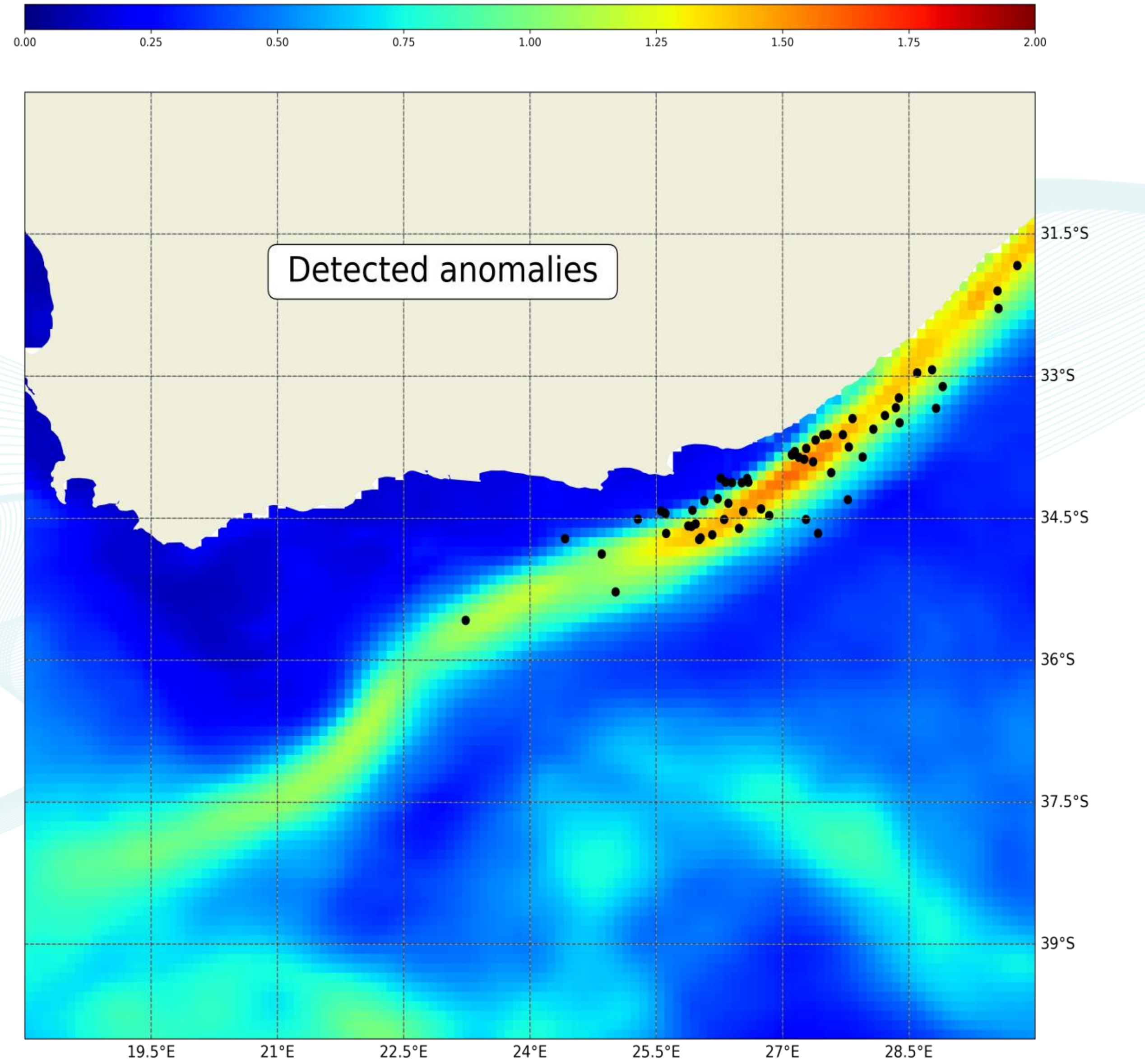


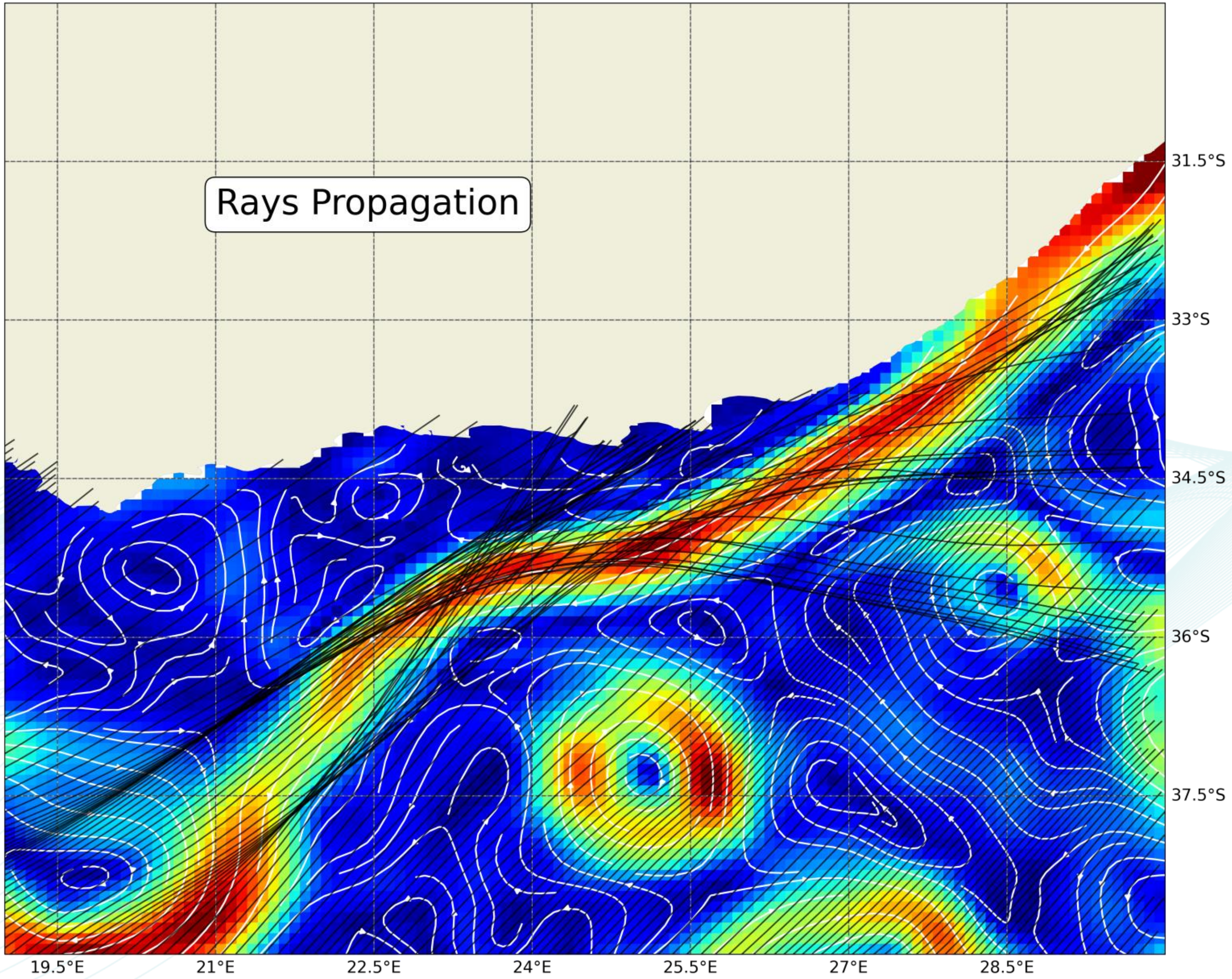


Anormal behaviors of vessels





Ray swell propagation



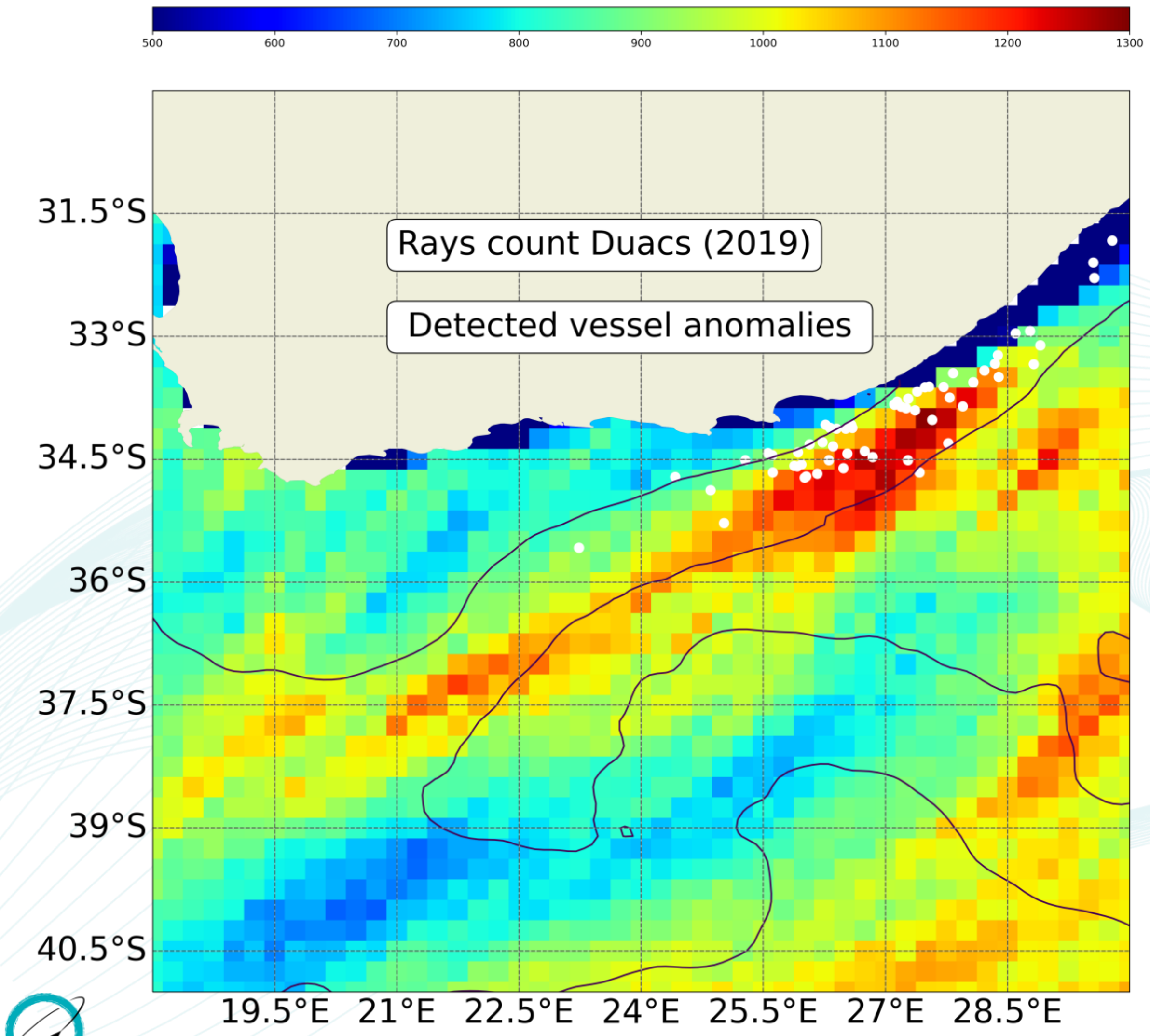
$$\frac{dx}{dt} = \frac{\partial \Omega}{\partial k}$$

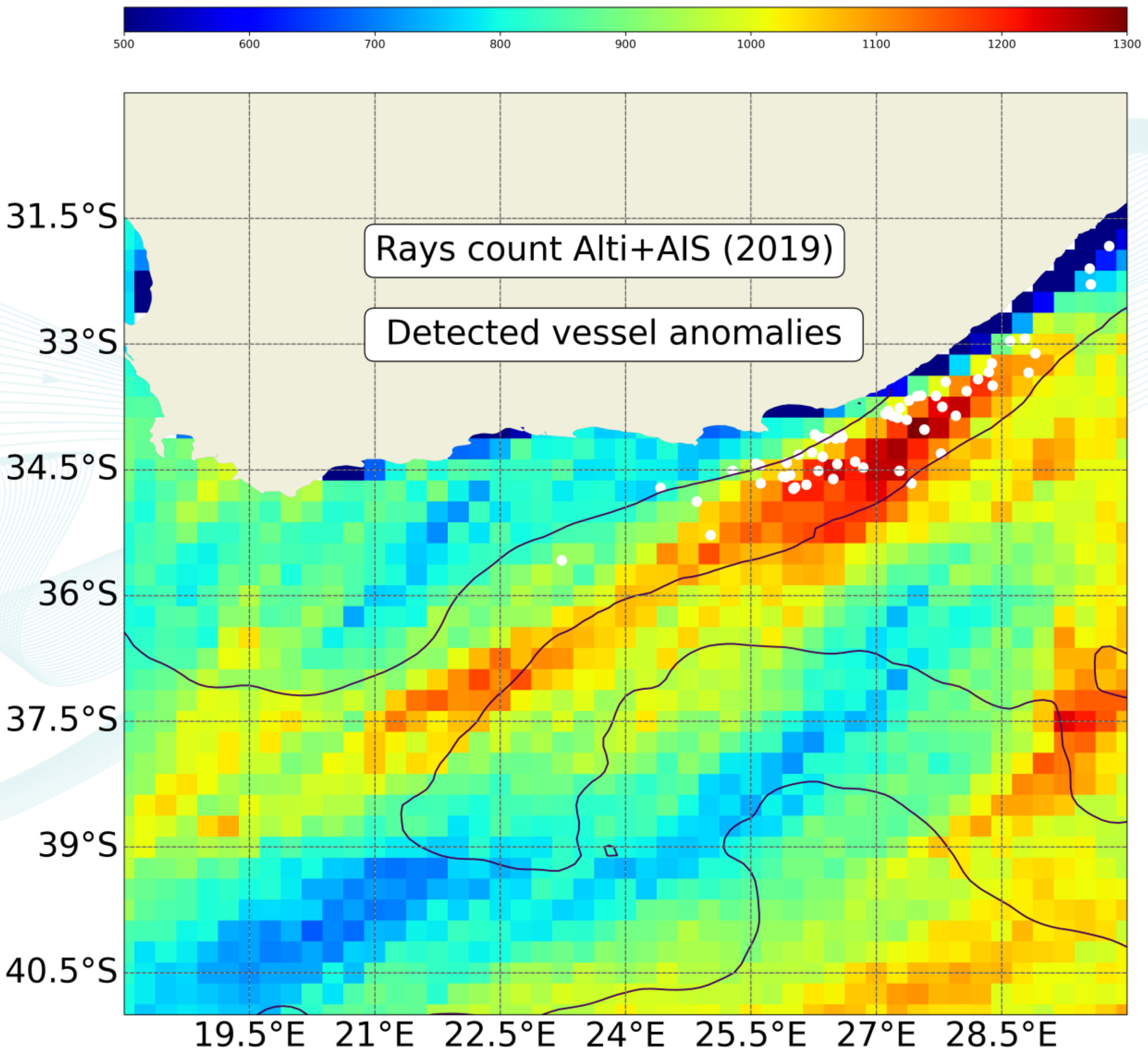
$$\frac{dk}{dt} = -\frac{\partial \Omega}{\partial x}$$

$$\Omega(k, x) = \sqrt{gk} + k.u$$

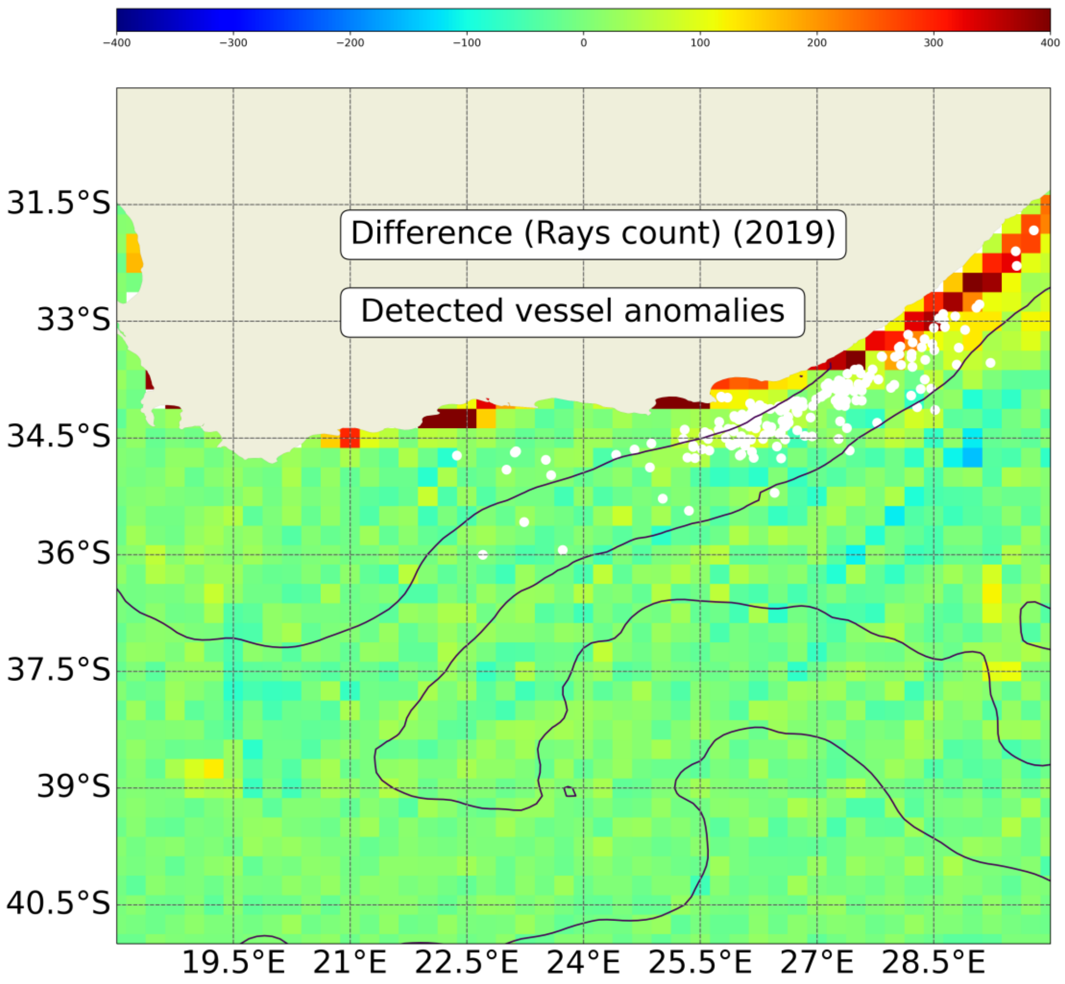
(Quilfen et al., 2018)
(Quilfen and Chapron, 2019)

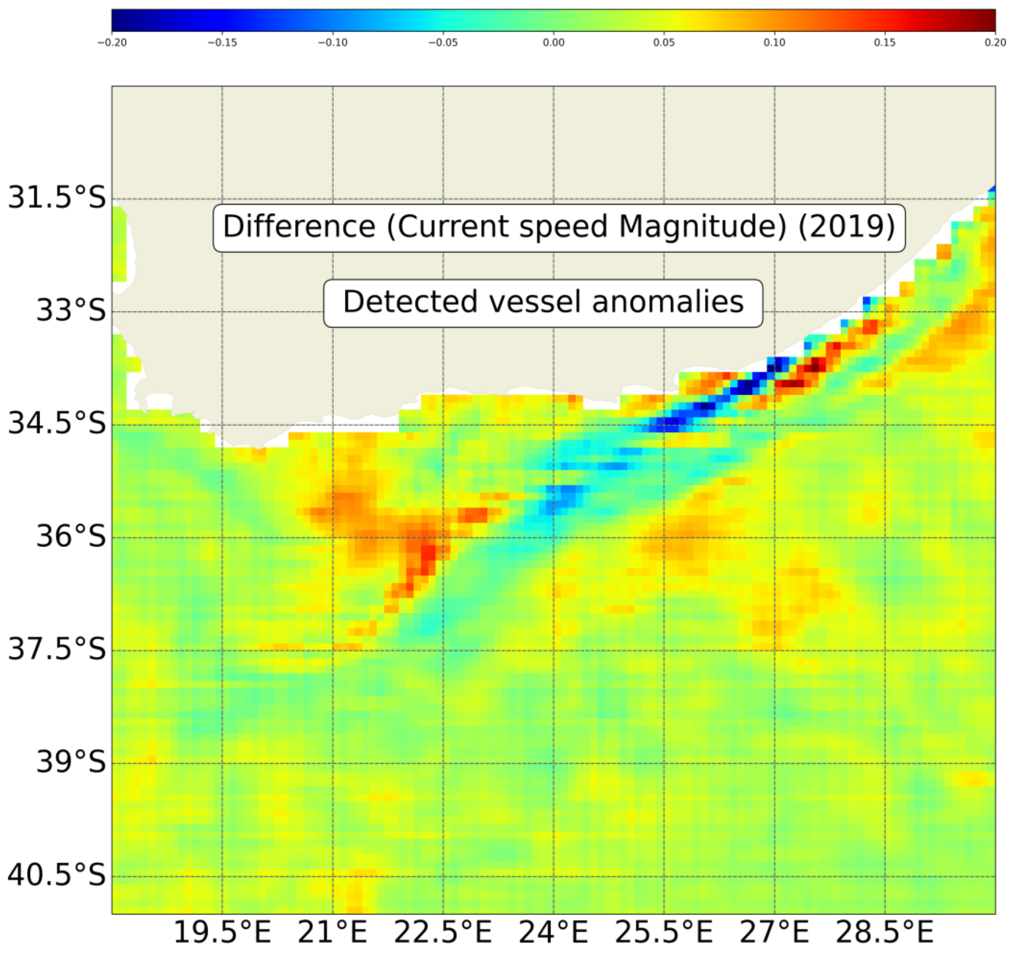
Annual Mean (2019)



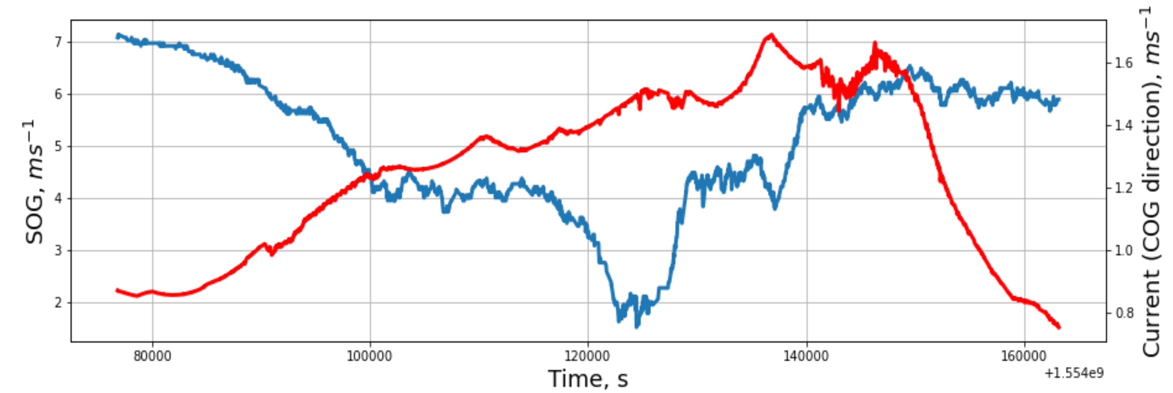


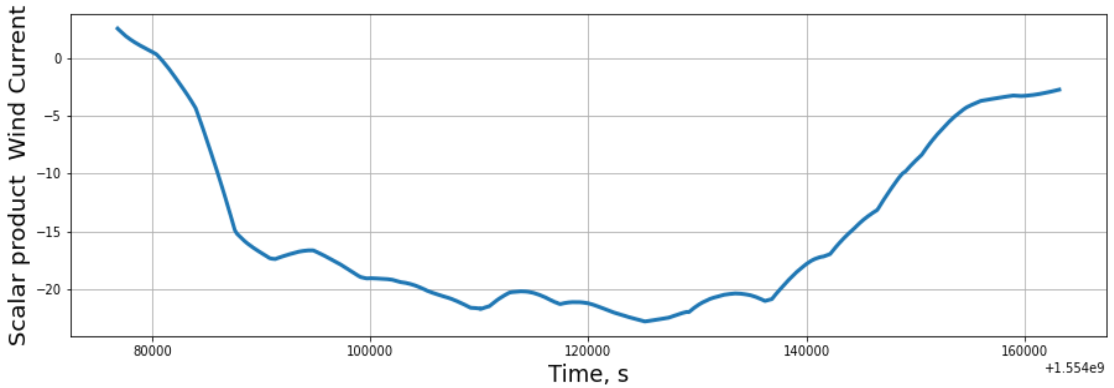
Differences (2019)

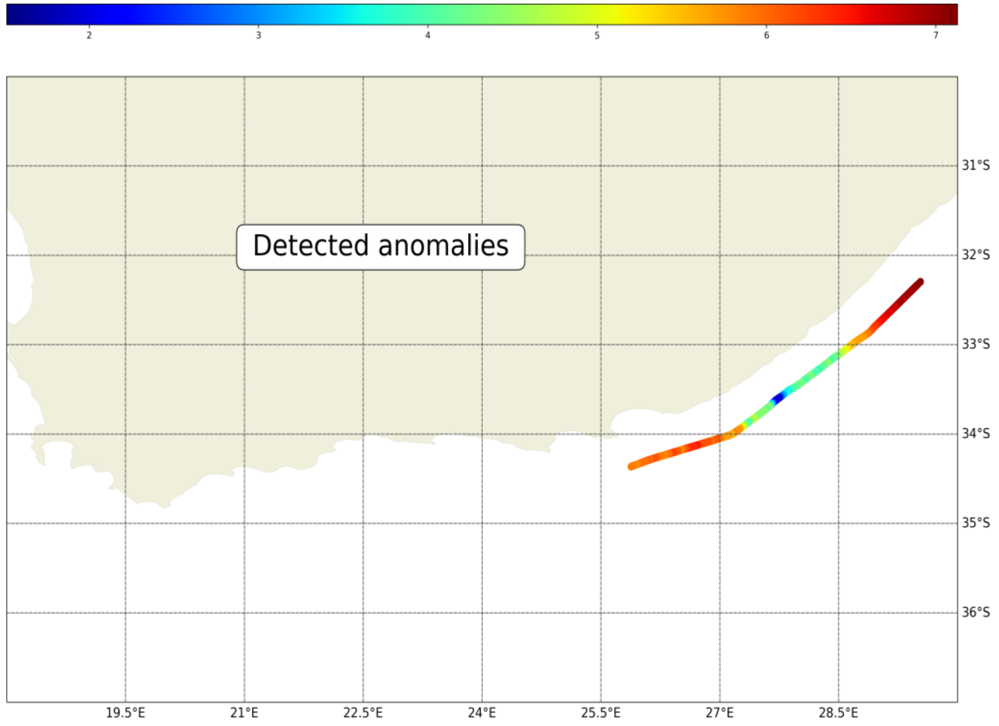




Example: April the 1st (2019)

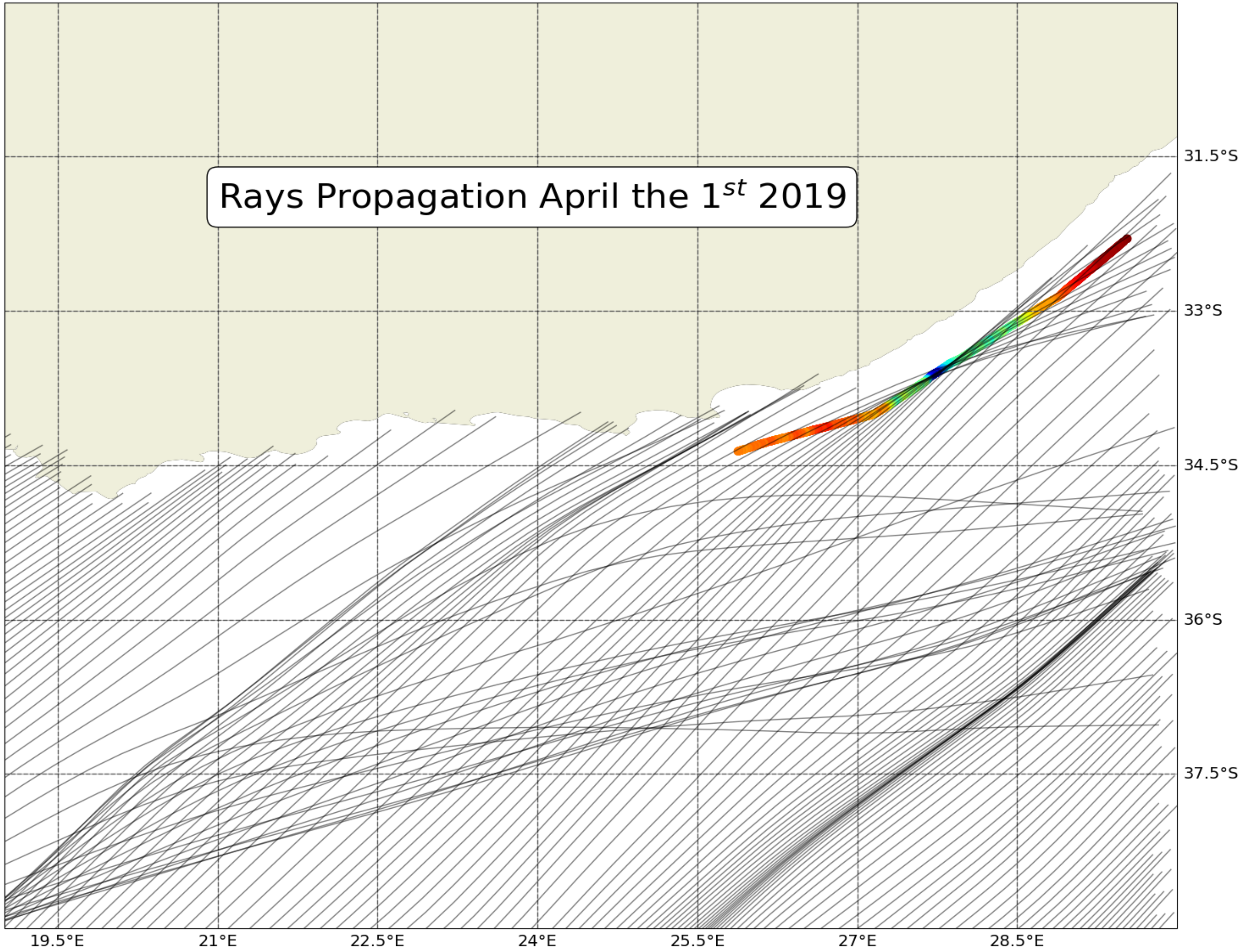






300 meters

300000 tons



Rays Propagation April the 1st 2019
31.5°S
33°S
34.5°S
36°S
37.5°S
19.5°E
21°E
22.5°E
24°E
25.5°E
27°E
28.5°E

- On going Work
- Difficulties of the commercial vessels are due to the effect of the wind blowing against the current and/or Focusing of the Ray swell
- Classifying the vessels following their behaviors/difficulties
- Validation with SWIM and Altimeter