Detection of open ocean fronts and eddies with Sentinel-3 data

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The Sentinel-3 study

- In preparation for the future SWOT mission's 2D swath observations, we analyzed **Sentinel-3 1D alongtrack altimeter data** at fine scales **across ocean eddies and fronts**, detected with today's 2D gridded DUACS altimeter maps, in the SW Pacific near New Caledonia.

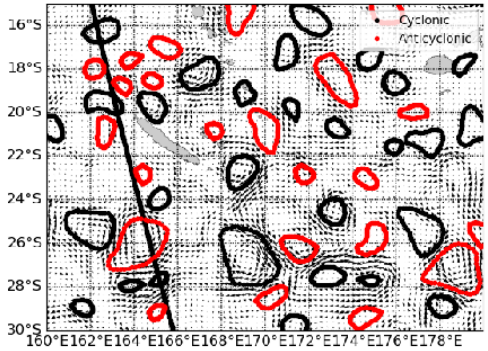
- Sentinel-3 alongtrack altimeter data is in SAR-mode globally, with improved signal to noise compared to conventional altimetry, and potentially a better 1-D resolution of small-scale SSH structures across fronts and eddies.

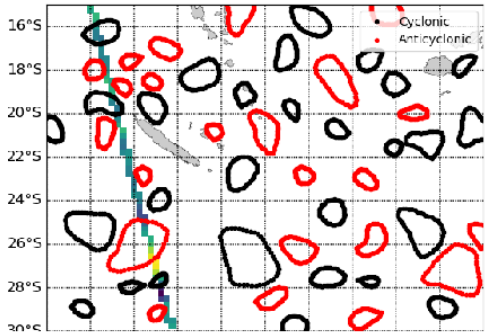
Objectives :

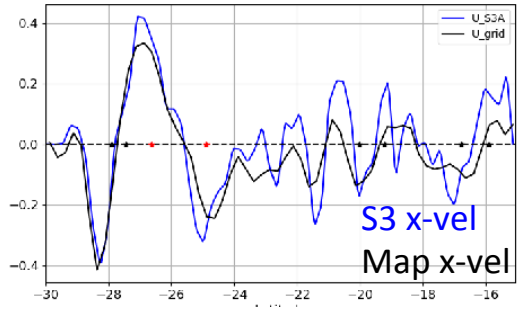
- We **colocated S3 SAR altimeter data with the AVISO+ mapped eddy tracking product and FSLE front product**, in order to quantify whether 1) the alongtrack S3 gradients are well colocated with the mapped gradients, 2) they have similar or increased amplitudes, and 3) to identify the strongest fronts.

- We will use **S3 surface SST and OC tracer fields**, combined with the dynamic velocity parameters derived from 1D and 2D altimetry, in order to study fine-scale changes across the fronts and eddies.

S3 colocated with tracked eddies







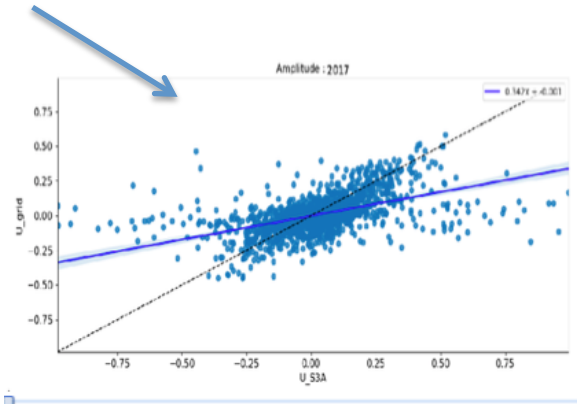
Eddy positions were located in daily maps using the *pyeddy* algorithms developped by CLS/AVISO

We identify the contour having the maximum eddy speed from the gridded multi-mission data, and then search for the positions/values of maximum cross-track S3 currents

We found :

- **No offset in position** : maximum currents from alongtrack S3 data were well centred at the position of maximum eddy speed in the gridded 2D maps (expected : S3 data are included in the multi-mission maps)
- **Max eddy speed in gridded maps is reduced by 20%** in current amplitude compared to alongtrack S3 data crossing S. Pacific eddies

(30% reduction from alongtrack to gridded maps when crossing E Mediterranean Sea eddies with a smaller Rossby radius)

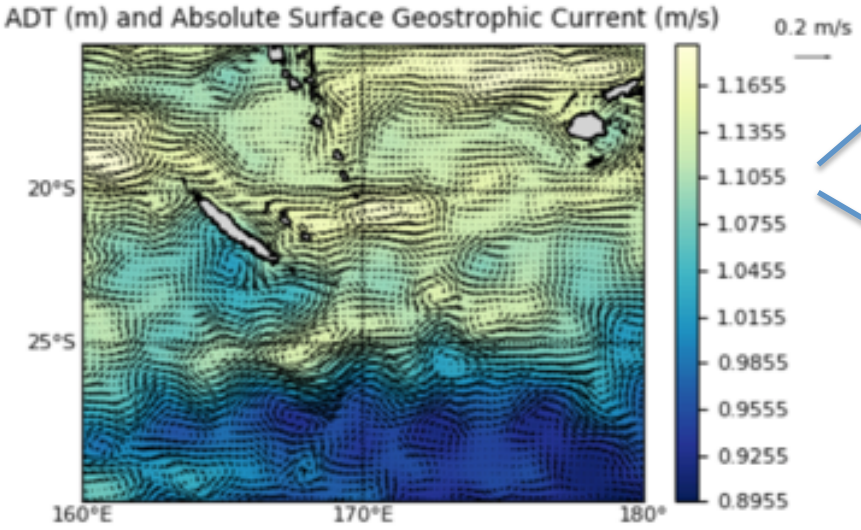


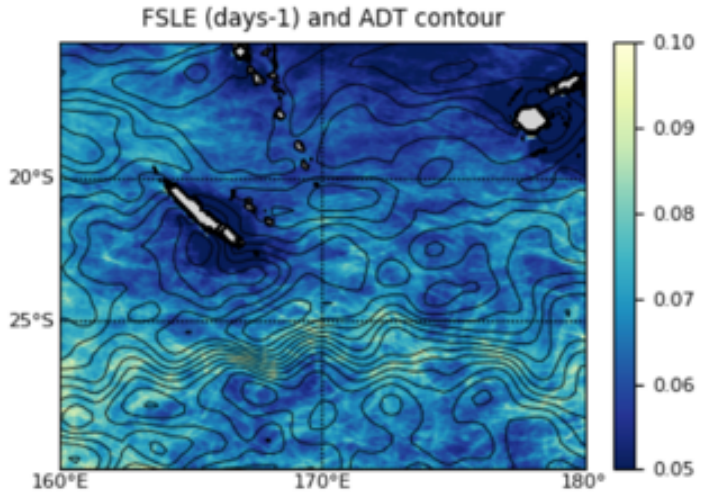
2D mapped altimetric front indices

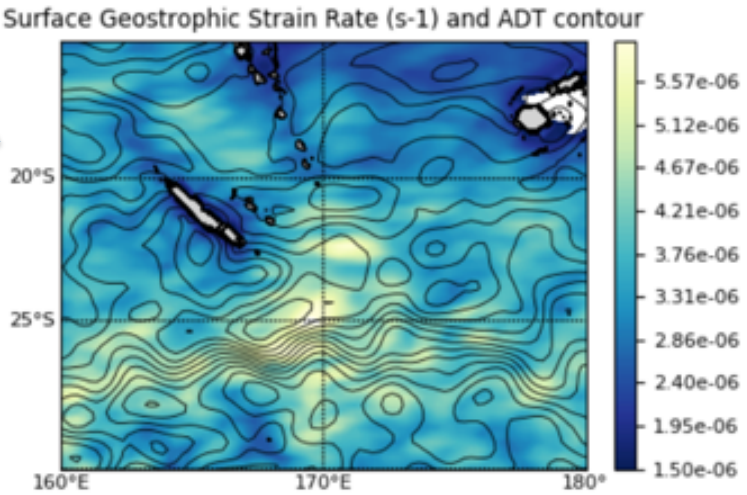
We considered two different **indicators of open ocean fronts**, derived from daily 2D mapped altimeter data :

1) Finite-Size Lyapunov exponents (**FSLEs**) identify transport barriers linked to ocean fronts.

2) **Geostrophic strain rate** calculated from the absolute surface geostrophic current maps





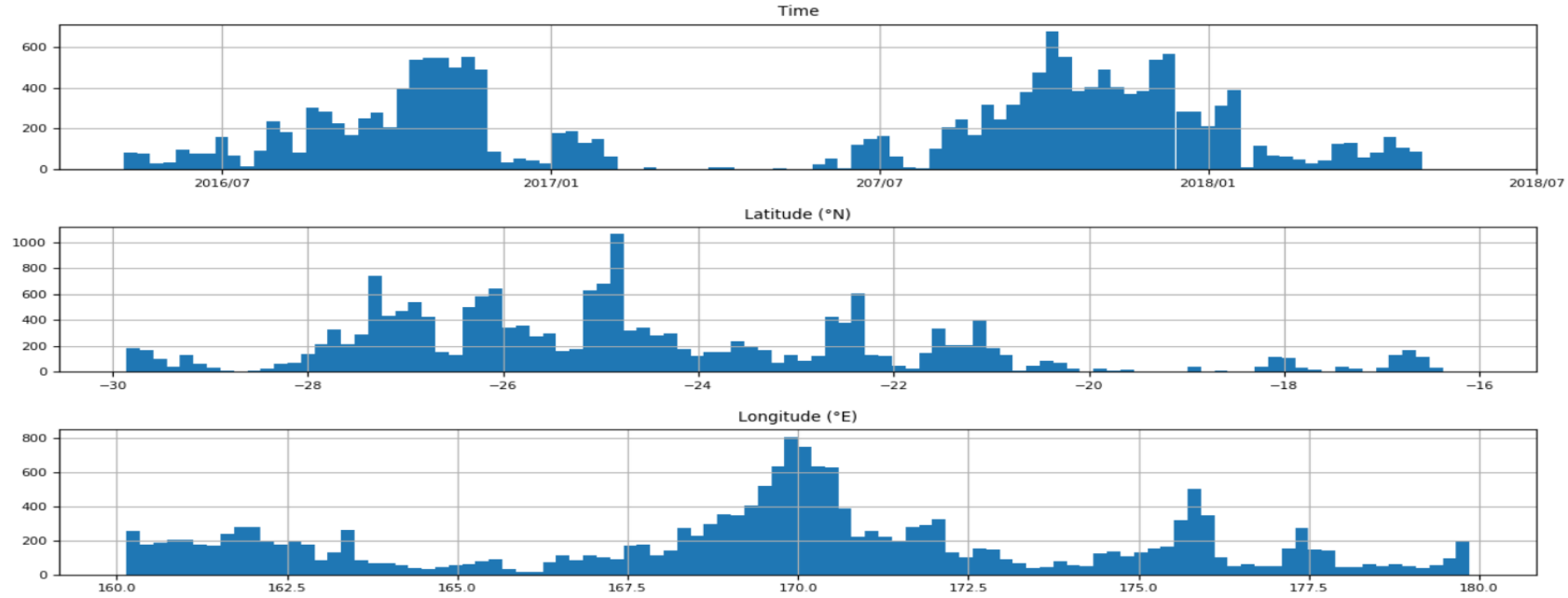


Maps show 3-year mean values : 05/2016 to 05/2018 in the New Caledonia region

Identifying the stronger front indices

We identified the occurrences of frontal events where the FSLE values AND the geostrophic strain rate are strong. We chose strongest values that occur 0.5% of the time over the entire region, but these strong fronts are identified somewhere in the region 2/3 of the time.

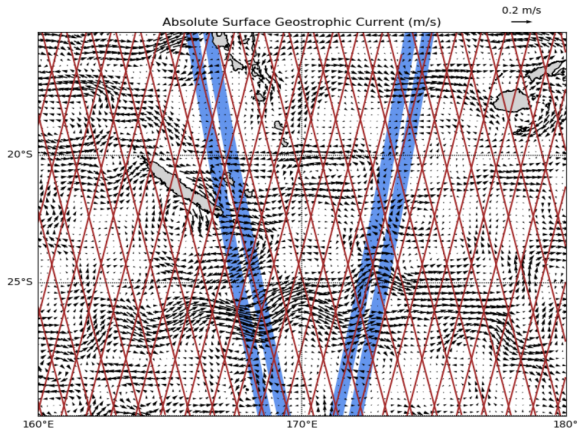
Strongest fronts in the New caledonia region (15-30°S; 160-180°E) are detected from altimetry from **Sept to Dec**, and centred around **170°E**

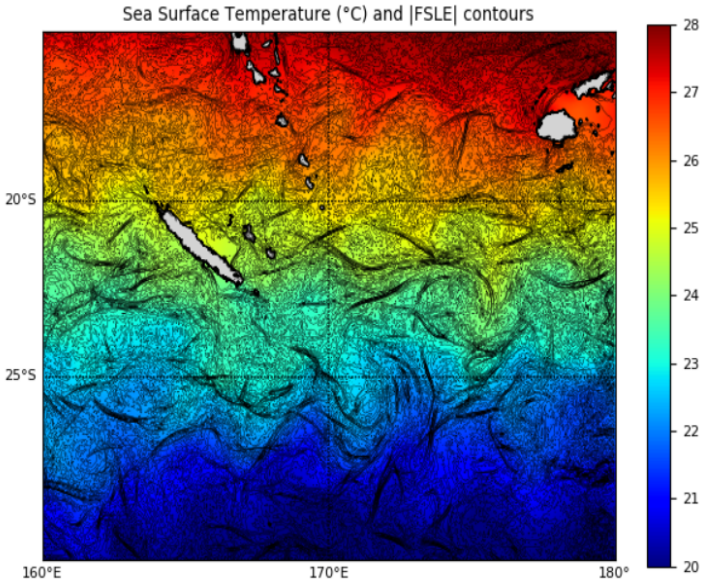


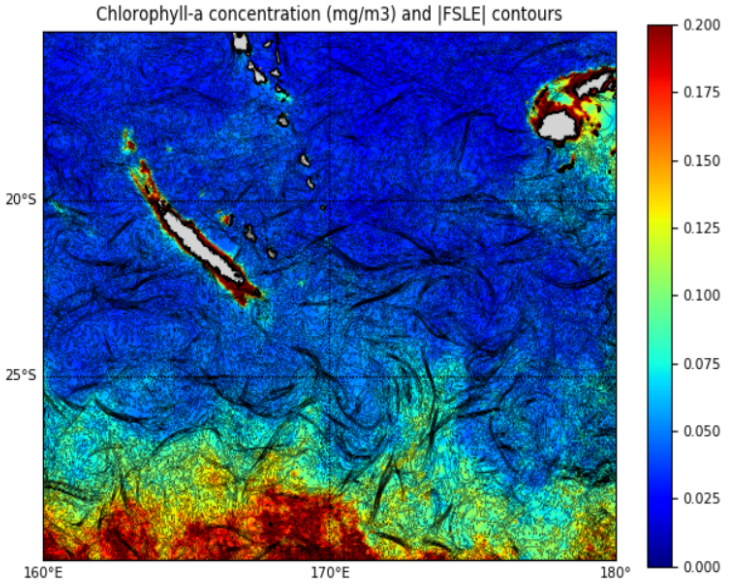
Distribution in time, latitude and longitude of the strong ocean front events (|FSLE| > 0.338 days-1 and surface geostrophic strain rate > 1.108e-05 s-1) in the New Caledonia region (15-30°S; 160-180°E) for the period 2016/05/01 to 2018/05/01.

Strong front locations and SST & OC data

So the strongest fronts occur in the Sept – Dec period.
October Monthly mean SST and OC Chl-A concentrations over the 3-years are shown below (in colour) with the monthly mean FSLE positions (in black).
Mean gradients of SST and OC are clearly aligned with the mean FSLEs, even with a 3-year Oct monthly average.
We then investigated how the colocated tracer gradients vary along the S3 tracks (in red), and in preparation for SWOT (blue tracks)



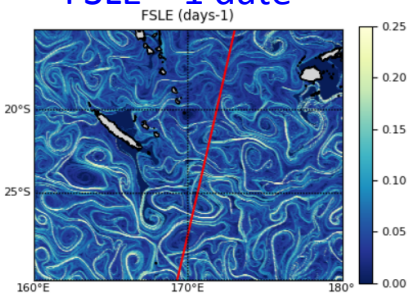




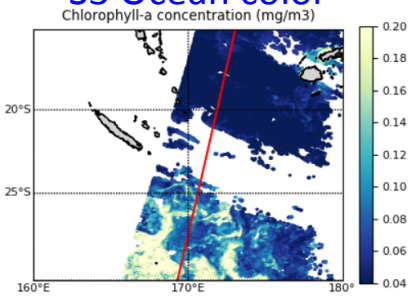
Example : How S3 alongtrack parameters vary crossing strong fronts

- Strong frontal events identified from mapped FSLE & strain products are extracted along S3 tracks (gray bars)
  - These are clearer indicators than S3 alongtrack geostrophic current

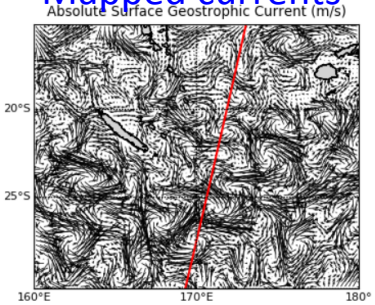
FSLE – 1 date



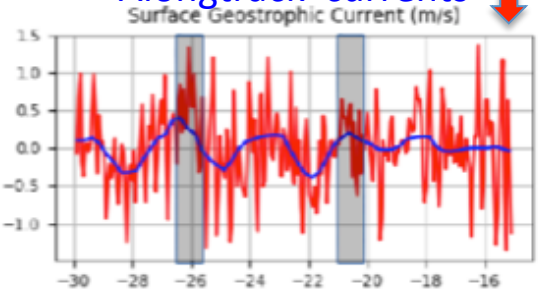
S3 Ocean color



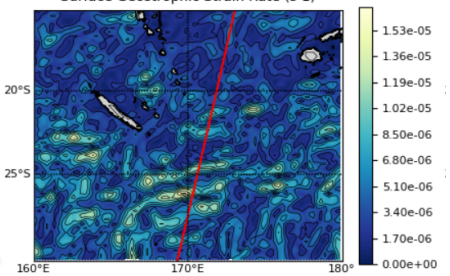
Mapped currents



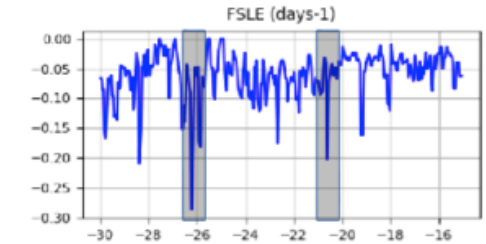
Alongtrack currents

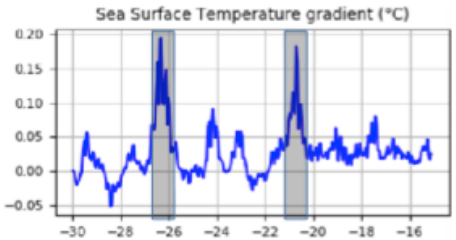


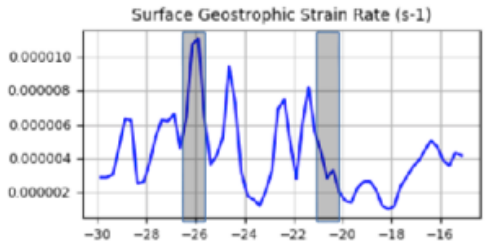
Geostrophic strain

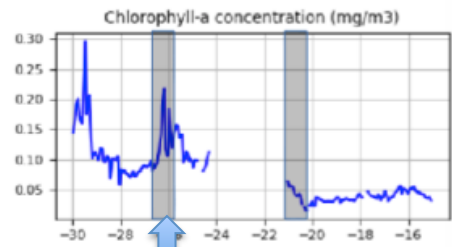


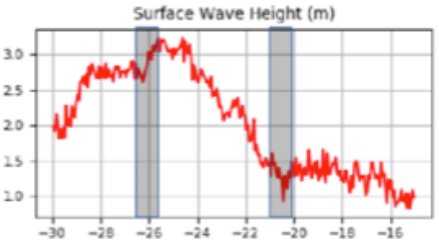
Derived from gridded DUACS fields











Strong FSLE & strain events have strong gradients in SST and OC Chl-A

And detected anomalies in S3 surface wave and roughness (sigma-0)

Work in progress…

These examples show the potential of using gridded mesoscale field products (tracked eddies, FSLEs and geostrophic strain) to help **identify the stronger ocean fronts and eddies**.

Max eddy speed in gridded maps is reduced by 20% in current amplitude compared to alongtrack S3 data crossing S. Pacific eddies, with a 30% reduction crossing E Mediterranean eddies. A more systematic global study should be perfomed with S3 data crossing eddies and fronts.

Strong geostrophic strain is not always exactly colocated with strong FSLEs, strain can be spatially offset or spanning the FSLEs. Their joint relation is still being studied.

Sentinel-3 in SAR mode has good signal-to-noise in alongtrack SSH, SWH and sigma-0, with temporally colocated SST and OC to study smaller-scale, rapidly evolving fronts

We are continuing with a more systematic study of the finer-scale 1-D S3 alongtrack parameters crossing the identified strong fronts, in preparation of the 2D structure we expect to observe with SWOT.