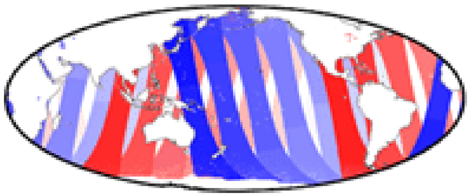
International Ocean Vector Wind Science Team Meeting
2 - 4 June 2014



IOVWST Meeting
June 3, 2014, Brest

Upwelling events at the western African coast related to atmospheric structures: An analysis with satellite observations
[focus on the Benguela system].

Fabien Desbiolles[1,2], Bruno Blanke[1] & Abderrahim Bentamy[2]

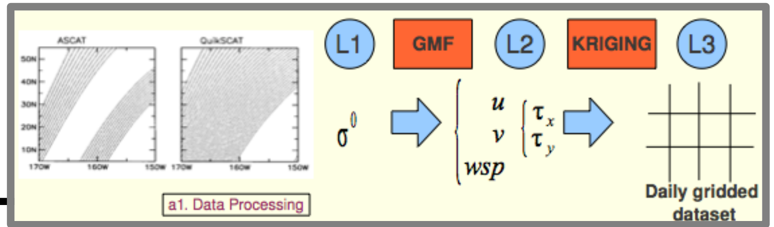
(1) Laboratoire de Physique des Océans – UMR 6523 CNRS-Ifremer-IRD-UBO, Brest, France
(2) Laboratoire d'Océanographie Spatiale – Ifremer – Plouzané, France

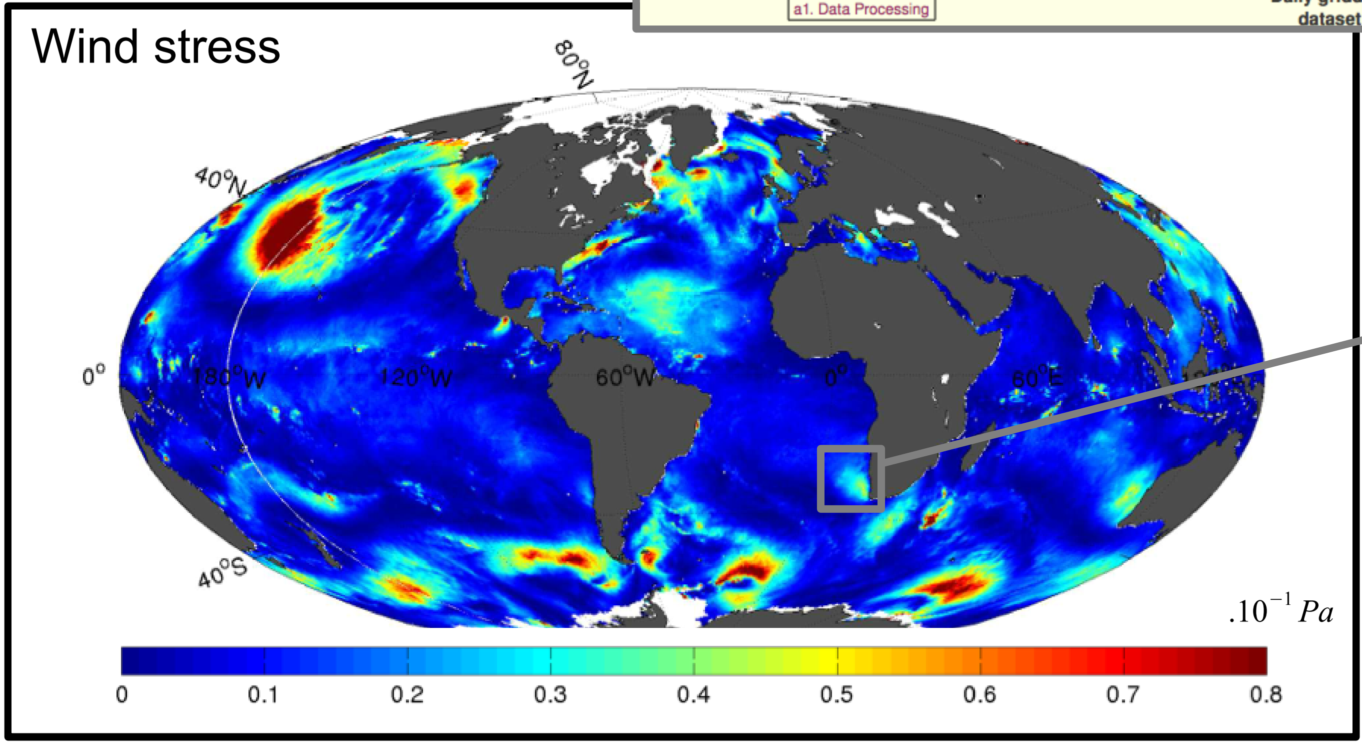
Introduction : Motivations

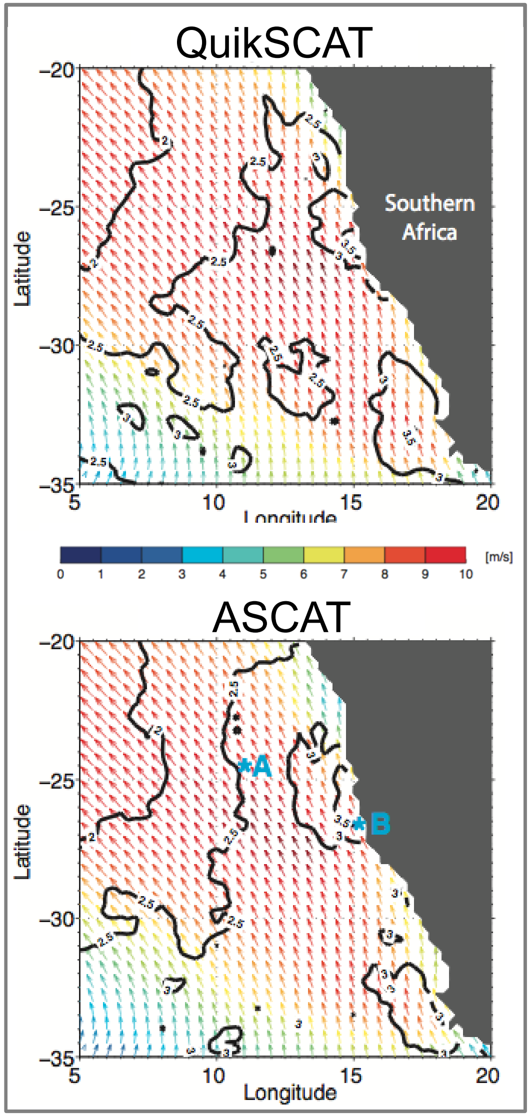
Ifremer/LOS-CERSAT, Brest, France

What about regional scales, especially in upwelling regions ?

1. Retrieval wind algorithm







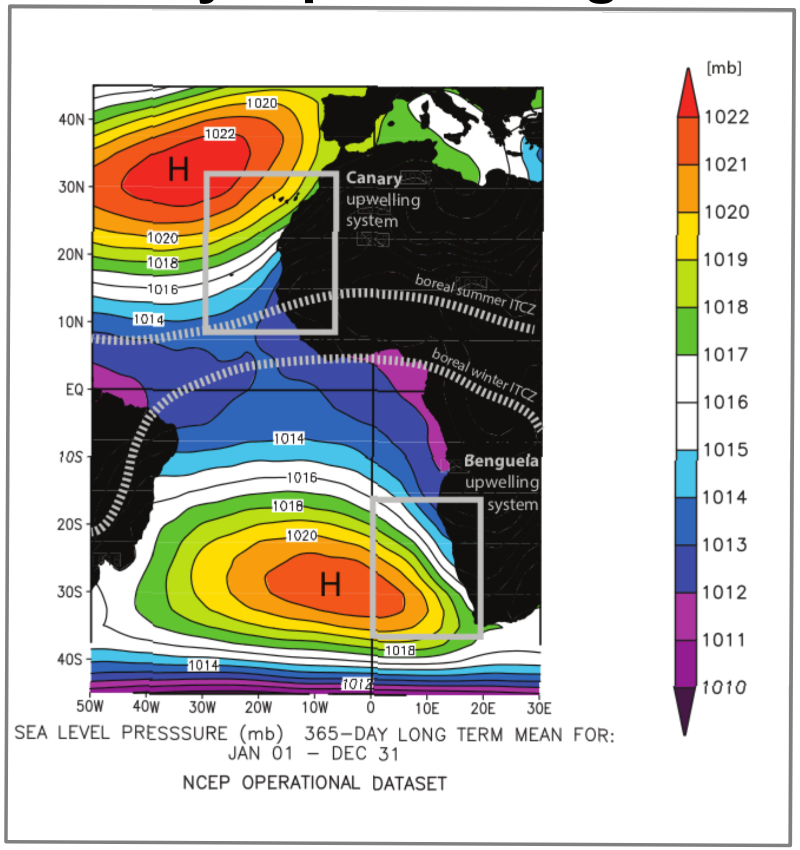
2. Improvements in air-sea turbulent fluxes (i.e., latent and sensible fluxes).

[Bentamy et al., IJRS 2013]

Presentration – Abderrahim Bentamy, Analysis of Turbulent Flux Quality – CR 16:15

Atmosphere-driven cooling processes

Synoptic forcing



The trade winds variability controlled by two atmospheric high-pressure systems drives the upwelling seasonality in both Atlantic systems.

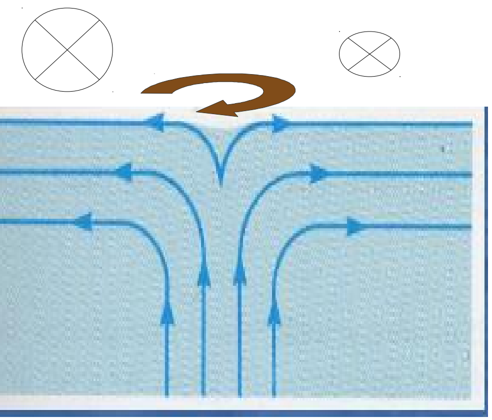
Mechanism: Offshore Ekman Transport

Seaward advection in the upper ocean
==> compensating upward movement at the coast.

Local forcing

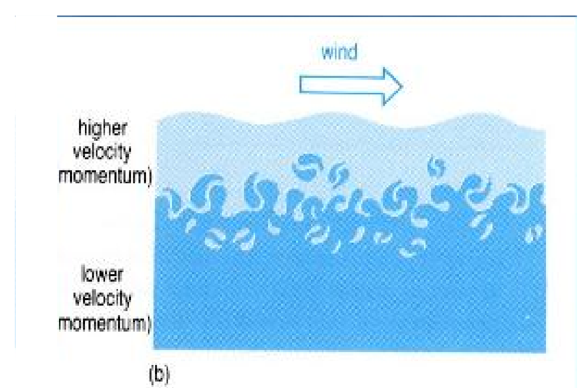
Local horizontal wind shear

Mechanism: Ekman pumping



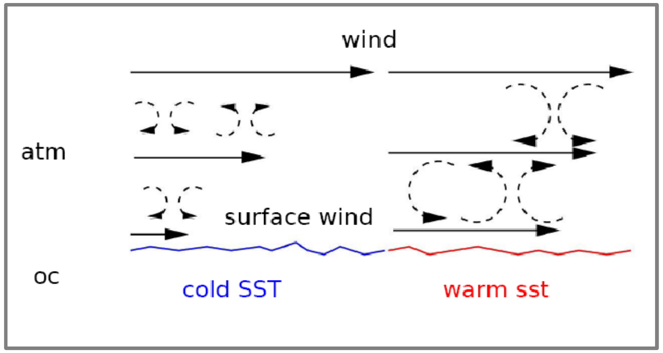
Increase in the momentum fluxes
==> Deepening of the surface mixed layer.

Mechanism: Vertical mixing

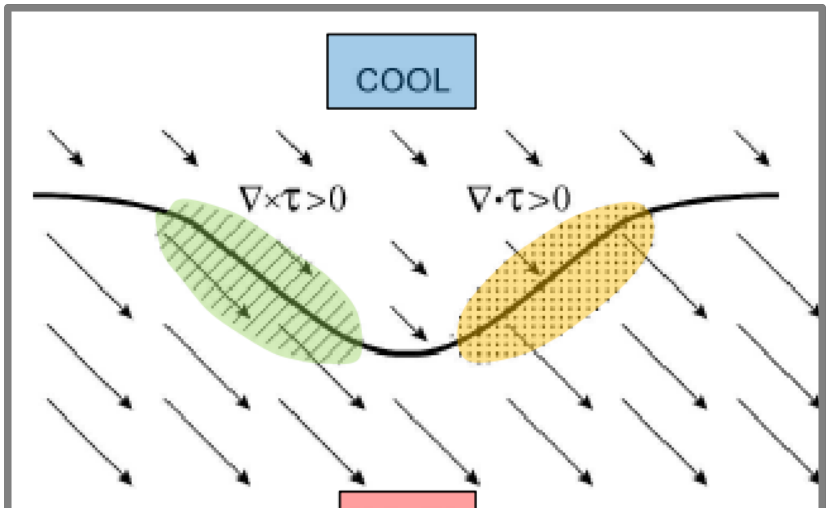


Introduction : Upwelling systems

When the ocean feeds back on the atmospheric flow



Modulation of the stability of the Marine Atmospheric Boundary Layer (MABL) by the Sea Surface Temperature (SST). Deceleration (acceleration) of the wind over cold (warm) waters.



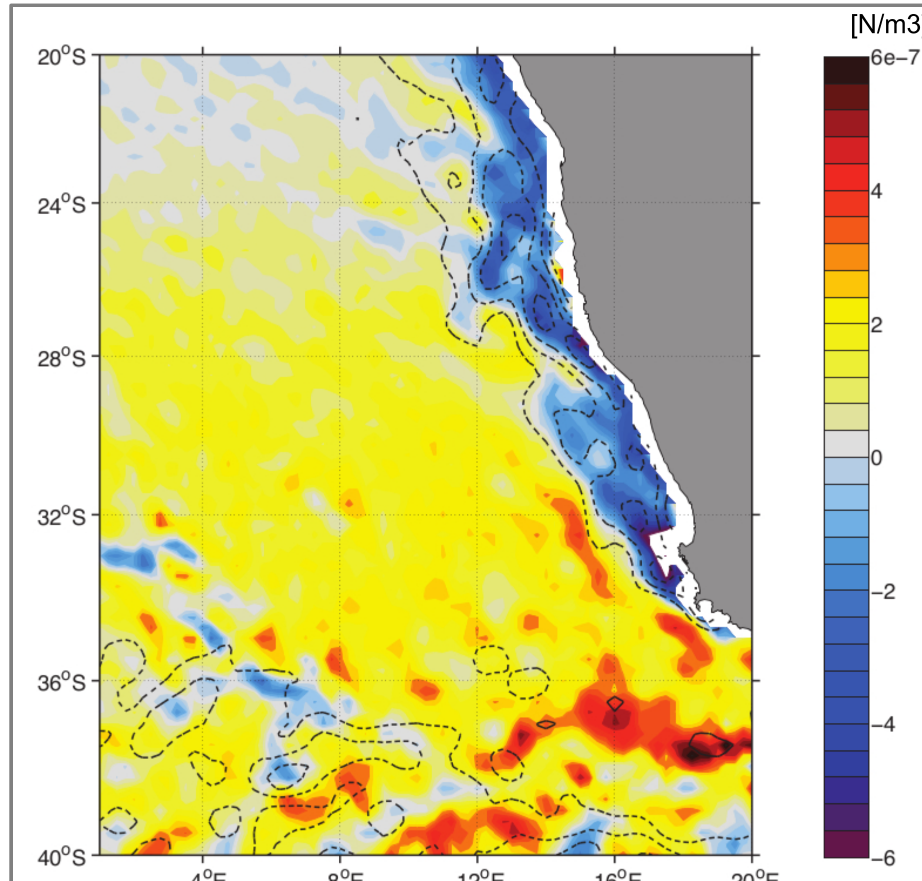
[Chelton et al., 2007]

Wind stress curl ~ Crosswind SST gradient

Wind stress divergence ~ Downwind SST gradient

Approximate linear relationships between the fields

Benguela system



Summertime 2005, mean conditions

Wind stress curl (colors) and crosswind SST gradient (contours, CI=0.3° per 100 km)

Outlines

Can new satellite observations describe better the different physical processes at play during coastal upwelling events ?

1. Comparison of different wind products

Actual space resolution of global wind products.

2. Origin of the differences: Oceanic feedbacks

SST/wind coupling process
Evidence of SST feedback and orographic signature.

3. Short-lived upwelling events

Description of upwelling dynamics with satellite observations:
Short-term cold SST events -- Remote and local forcing

4. Conclusions

1. Comparison of different wind products

<u>List of products:</u>

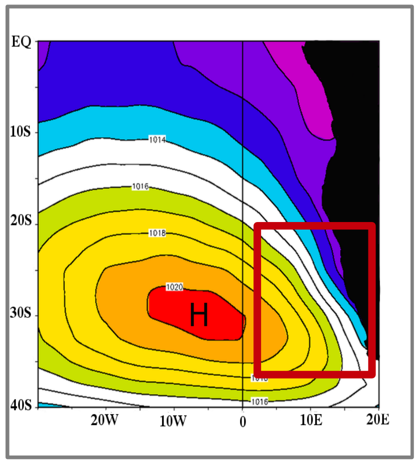
QuikSCAT– Grid sampling 25km, **QS25**
QuikSCAT– Grid sampling 50km, **QS50**
ASCAT– Grid sampling 25km, **AS25**
ECMWF– Grid sampling 50km

European Center for Medium-Range Weather Forecast

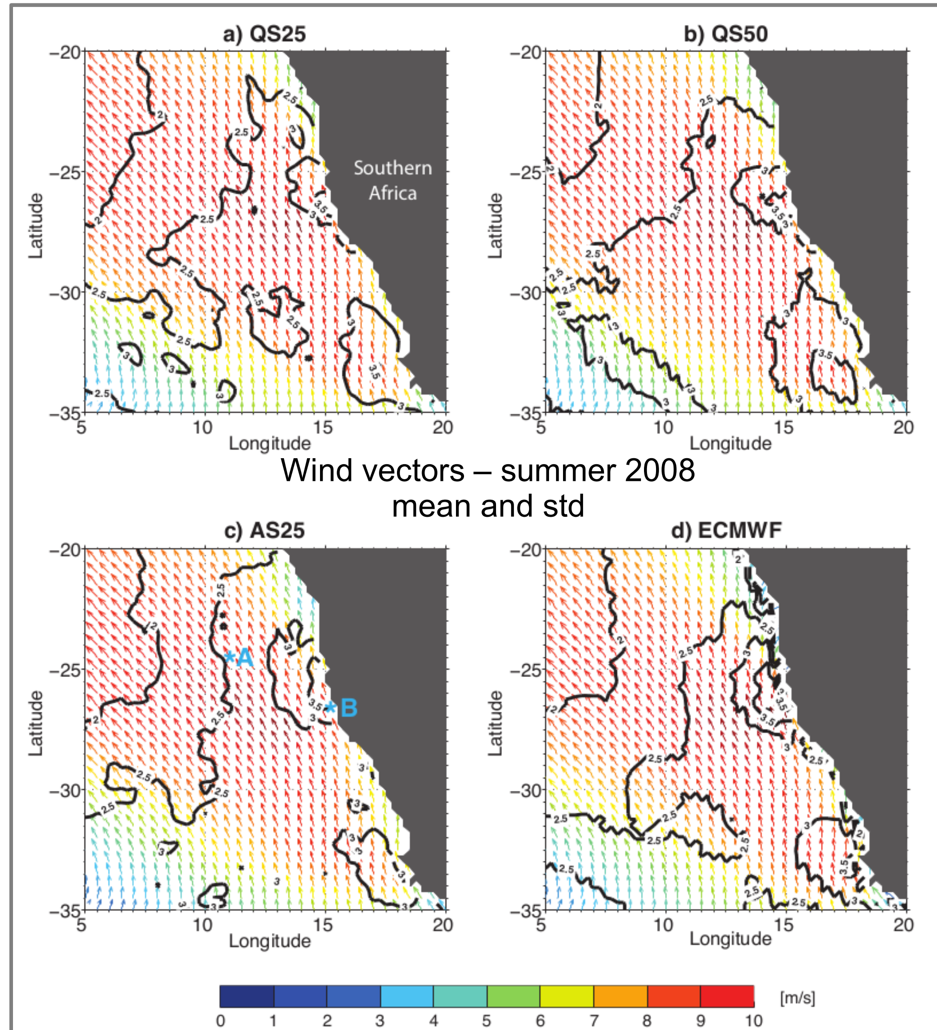
Data processed and provided by LOS/CERSAT

Products	QS50	QS25	AS25	ECMWF
Sources	QuikSCAT	QuikSCAT	MeTop-A	Model
Revisit time (days)	4	4	4	n/a
Orbital period (min)	101	101	101	n/a
Intrinsic resolution (°)	1/2	1/4	1/4	1/2

k-NN algorithm to derive zonal and meridional wind components on the same grid stencil (i.e., QS25 grid)



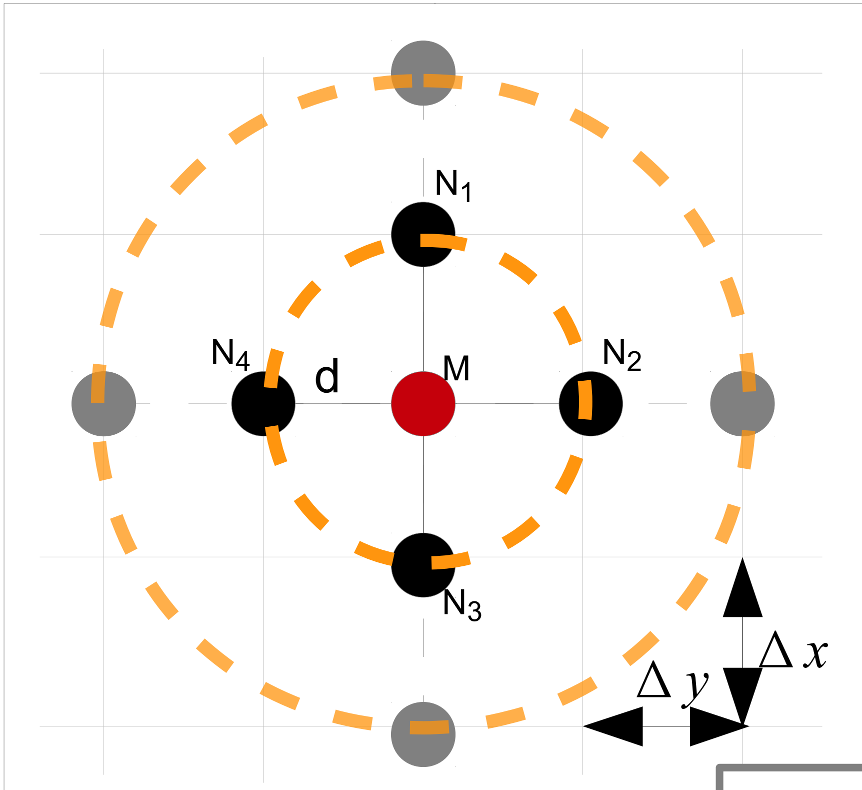
SLP – summer 2008 mean



Wind vectors – summer 2008 mean and std

All products show consistent similarity during austral summer : the wind vector is mostly favorable to upwelling, i.e., northward or northwestward over the whole domain.

Intrinsic (given grid) **vs. <u>actual</u> spatial resolution**



<u>Cross-correlation calculations :</u>

$$M_{i,j}(t), \quad N^{p}{}_{i,j}(t) = \frac{1}{p}\sum N_{p}(t)$$

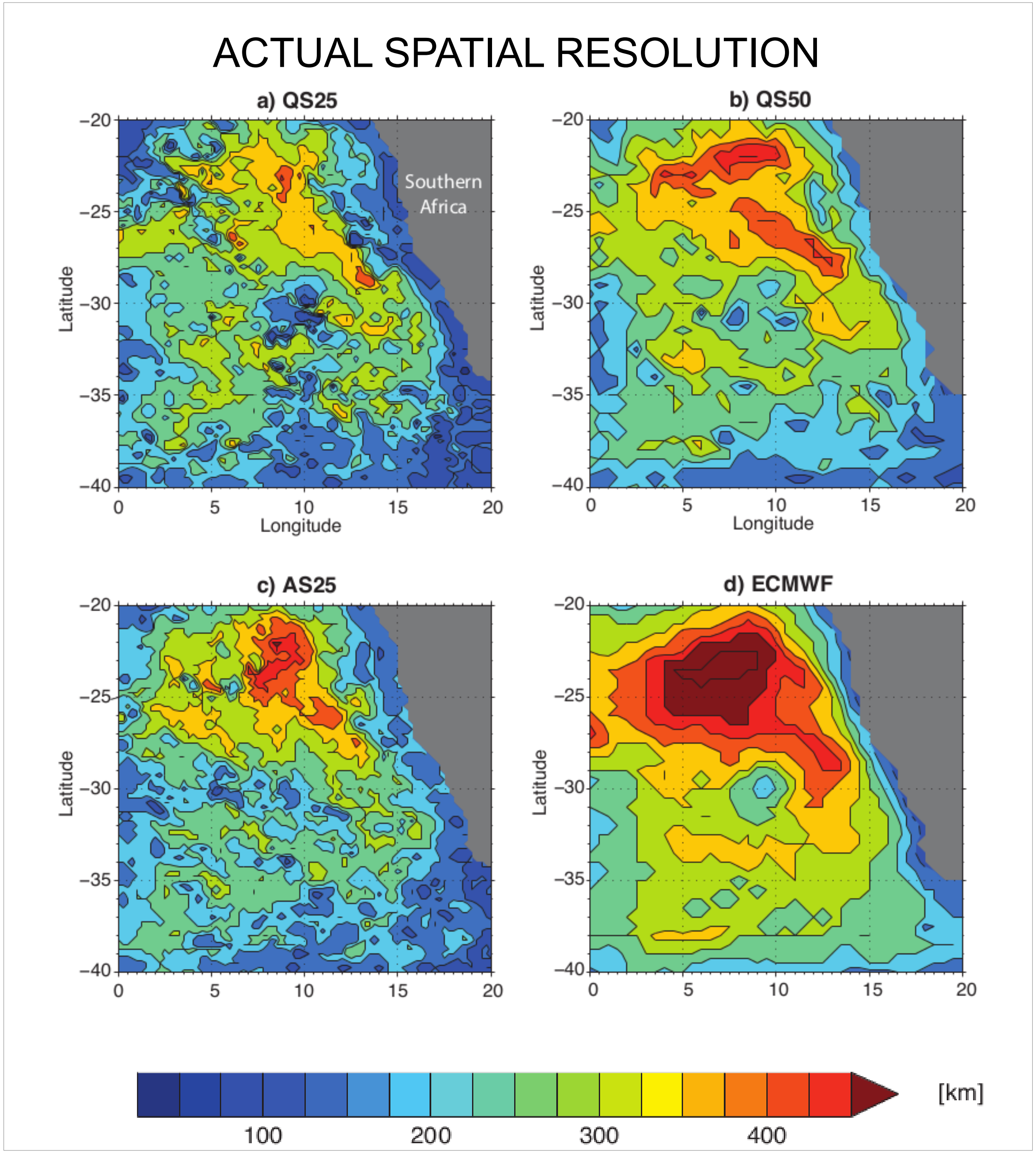
$$\rho_{i,j} = \frac{\sigma_{M_{i,j} N^{p}{}_{i,j}}}{\sigma_{M_{i,j}} \cdot \sigma_{N^{p}{}_{i,j}}}$$

The computation is repeated with an increasing distance and we keep the distance *d* for which

$$\rho_{i,j} < 0.95$$

d: Local and horizontal coherence of the wind, assumed to be the actual spatial resolution of each product.

1. Comparison of different wind products



Distance *d* varies according to zones and products:

Large decorrelation distance (>300km) → coherent winds, large-scale patterns.

Finer scales found in new satellite products (QS25, AS25).

Coastal band characterized by strong spatial inhomogeneities

→ areas where strong air-sea-continent interactions are expected.

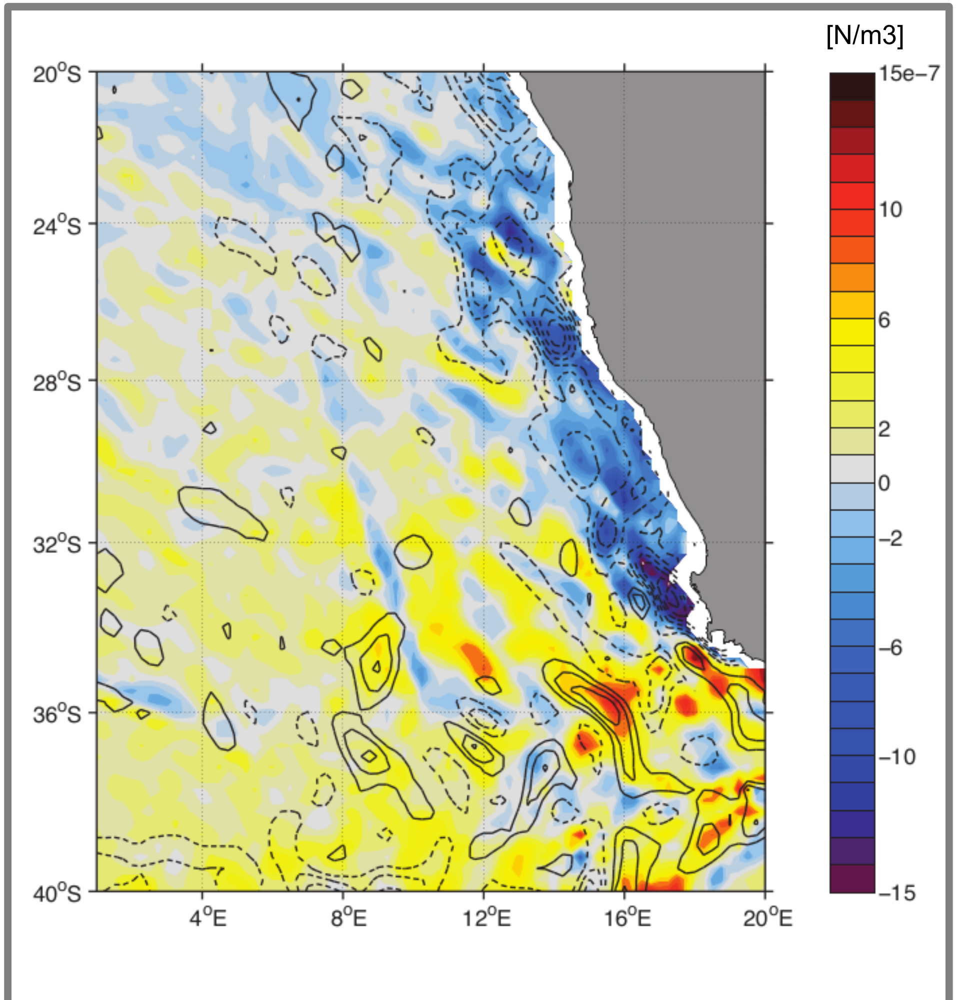
Improvement in actual resolution of the new satellite products at regional scale

Consistent with results obtained at global scale [Bentamy et al., JGR 2012]

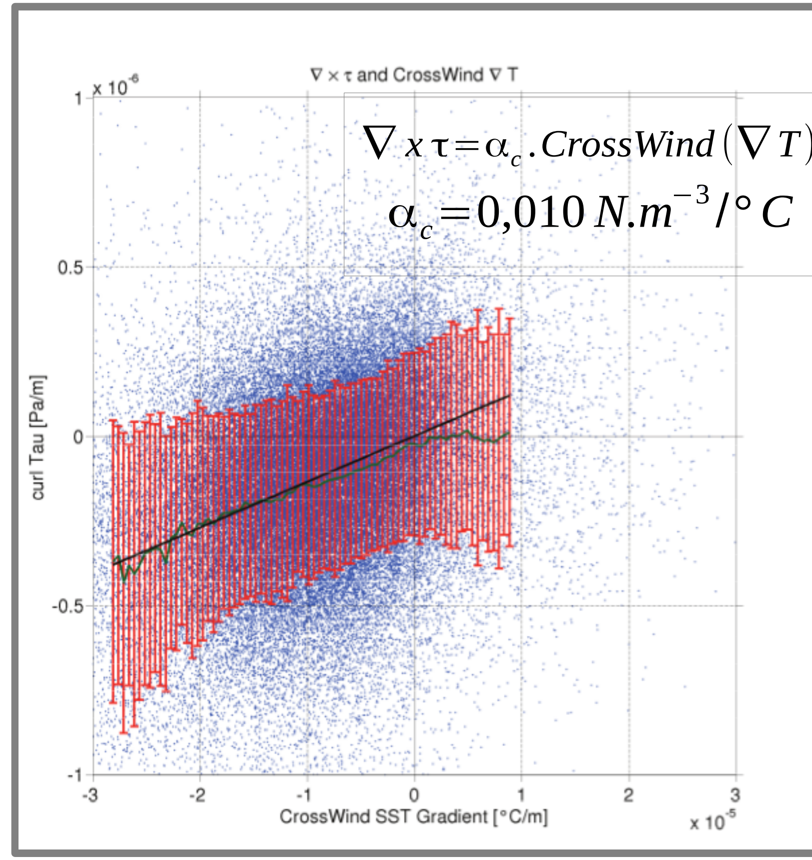
2. Origin of the differences

Evidence of SST feedback in the QS25 wind product.

Hypothesis : **Linear relationship** between the wind stress curl and the crosswind SST gradient [Chelton et al., Science 2004] from weekly to seasonal time scales.



Wind stress curl (colors) and crosswind SST gradient (contours, CI=0.3°C per 100 km)

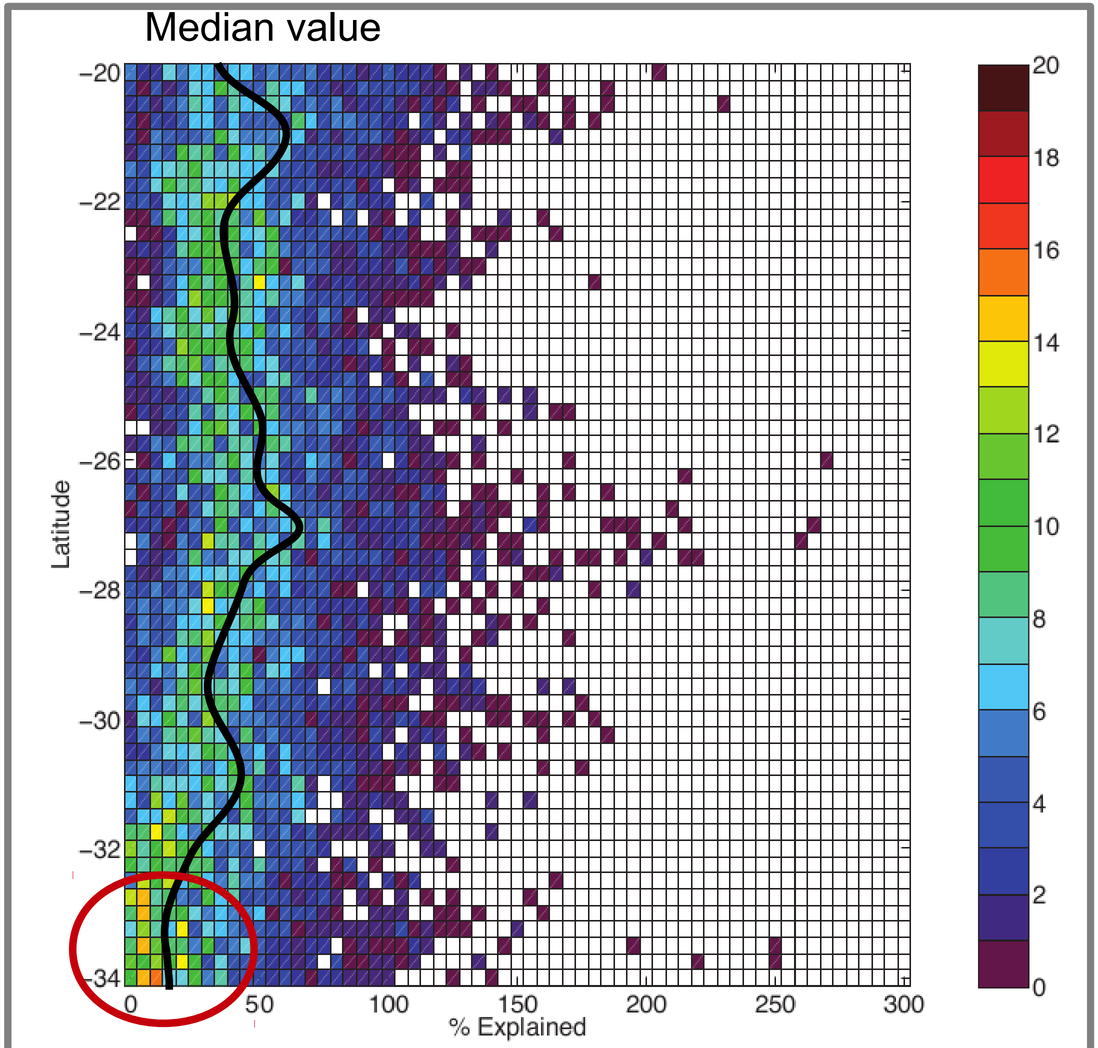


Statistical response studied by bin-averaging weekly averages of QS25 wind stress curl as a function of weekly-averaged crosswind SST gradients over 261 weeks.

2. Origin of the differences

Evidence of SST feedback in the QS25 wind product.

Part of the wind stress curl is plausibly explained by SST spatial variability.



$$\% \ \ explained = 100.\frac{\alpha_c.Crosswind(\nabla T)}{\nabla x \tau}$$

$$\alpha_c = 0{,}010 \, N.m^{-3} / {}^\circ C$$

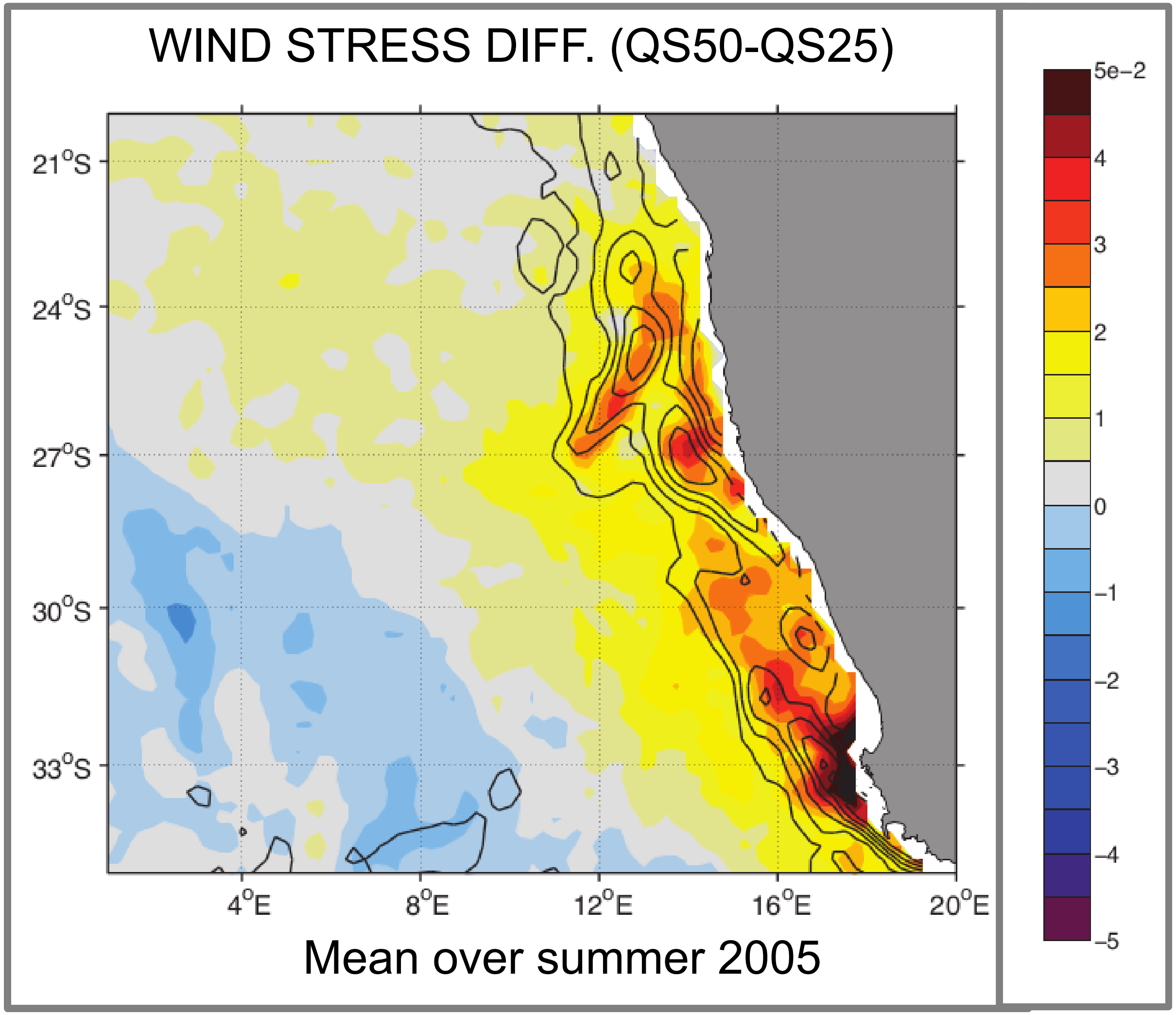
% explained → 0 : Presence of capes

Elsewhere: somewhat Gaussian-shaped distribution with median value up to 70% locally during the upwelling season.

The SST-driven curl can be a primary contributor to local curl variability and magnitude

2. Origin of the differences

QS25/QS50 comparison



Wind stress difference (colors) and SST gradient (contours, CI: 5e-5 °C/m)

QS50/QS25 difference :

Large differences in wind stress magnitude match patterns in SST gradient.

The QS50 product poorly accounts for SST-wind interaction in the coastal band.

Factors that could explain differences in actual spatial resolution between QS25 and QS50 :

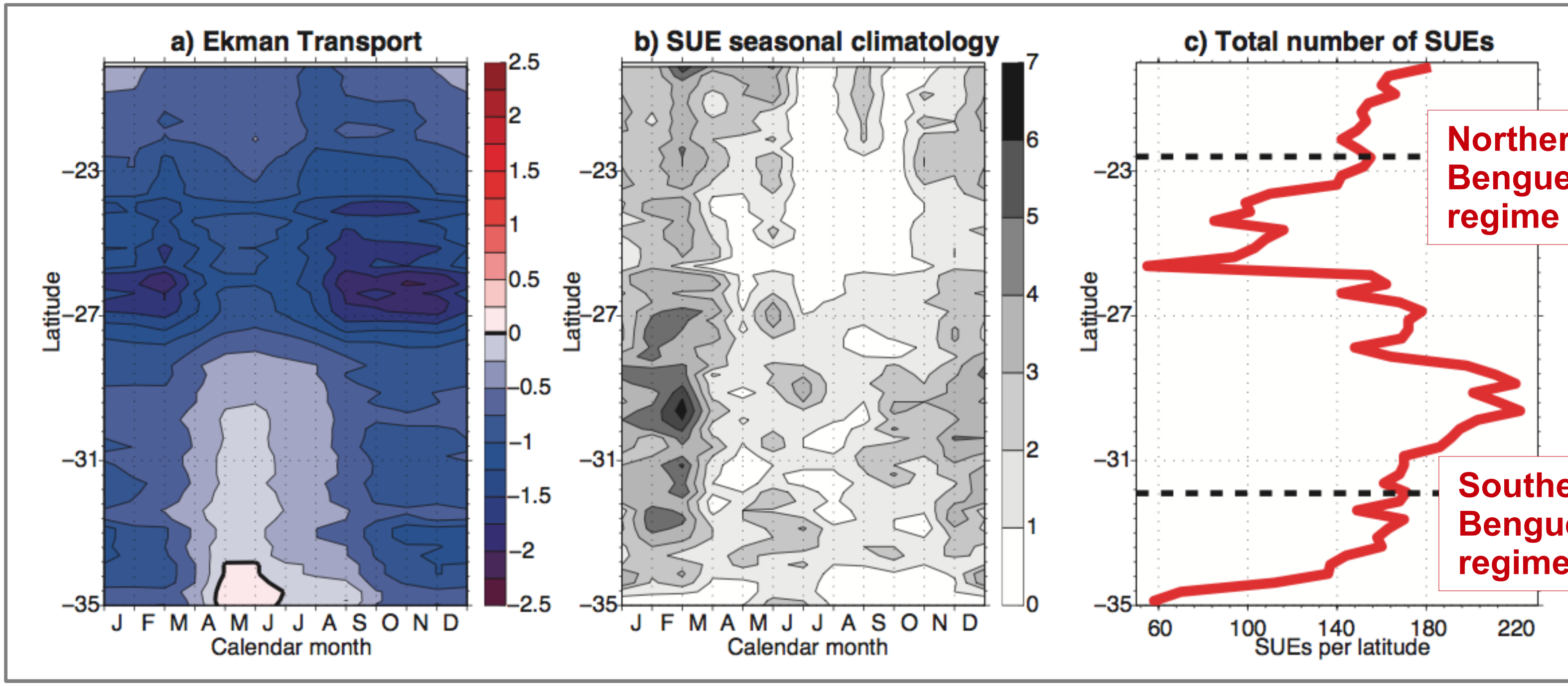
1. QS25 winds are more sensitive to SST than QS50 winds.

2. An orographic signal seems to be capture by the QS25 wind stress curl.

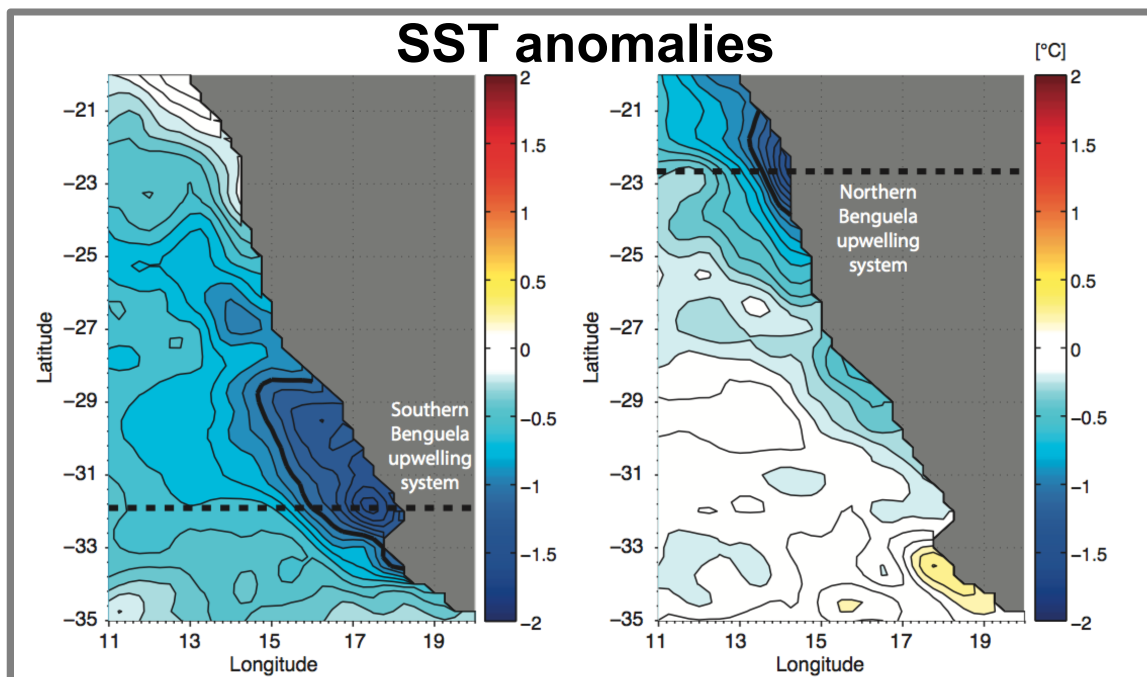
3. Short-lived upwelling events

Short-term Upwelling Events (SUEs):

Local, short-lived cold perturbations that add to seasonal upwelling variability.



Characterization of **concomitant atmospheric synoptic conditions** for SUEs identified at chosen latitudes.



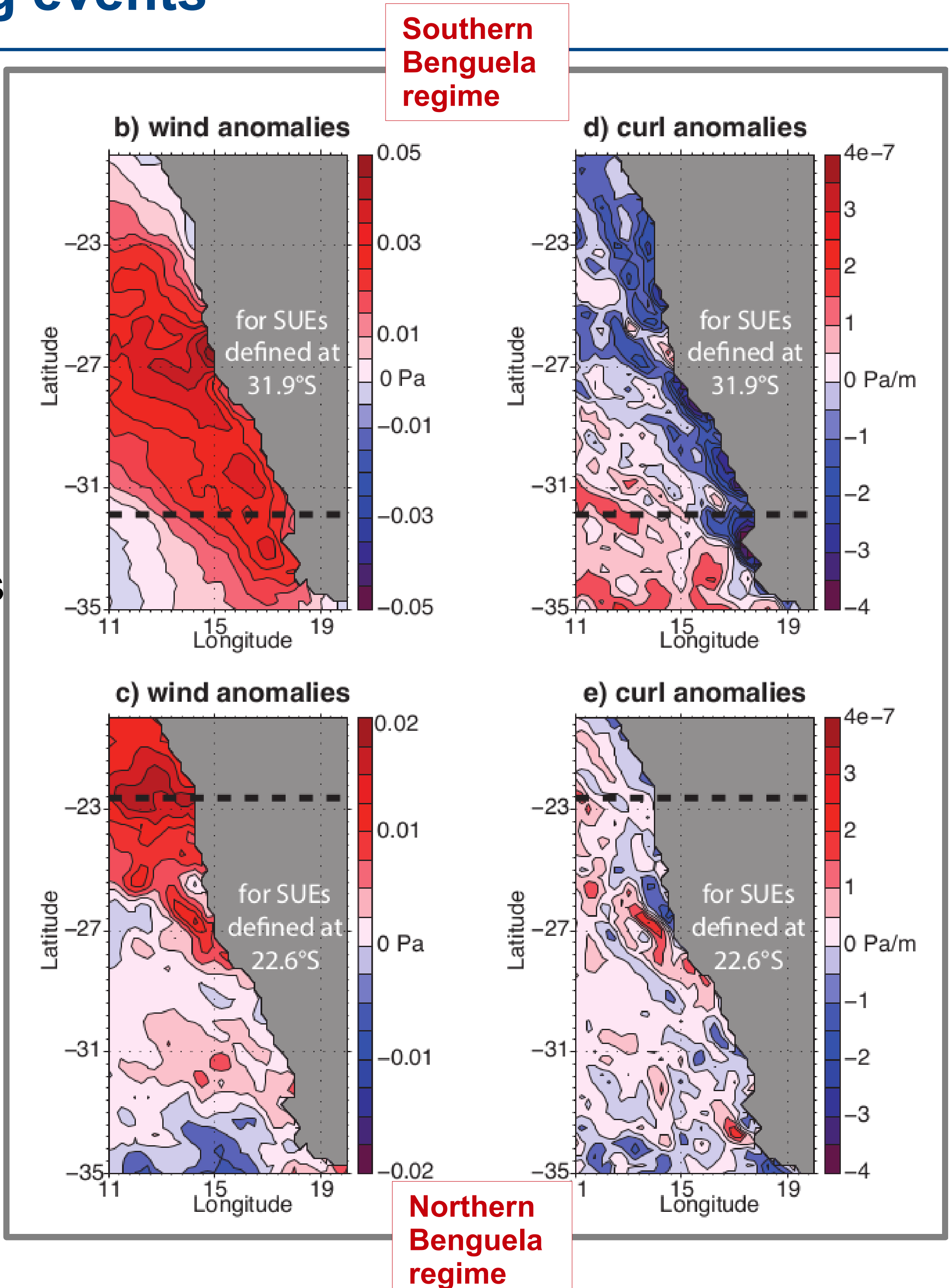
3. Short-lived upwelling events

→ **Two subregions** are characterized with contrasted patterns for the alongshore wind speed component and curl.

→ **Asynchronous cold SST events** in both subregions agree with published literature and are related to north/south migration of the core of atmospheric highs (i.e., Saint-Helena anticyclones).

→ Both **coastal upwelling** and **Ekman pumping** contribute to cold SST anomalies.

→ **Vertical turbulent mixing** induced by intensified local winds may cool the SST in a comparable way.

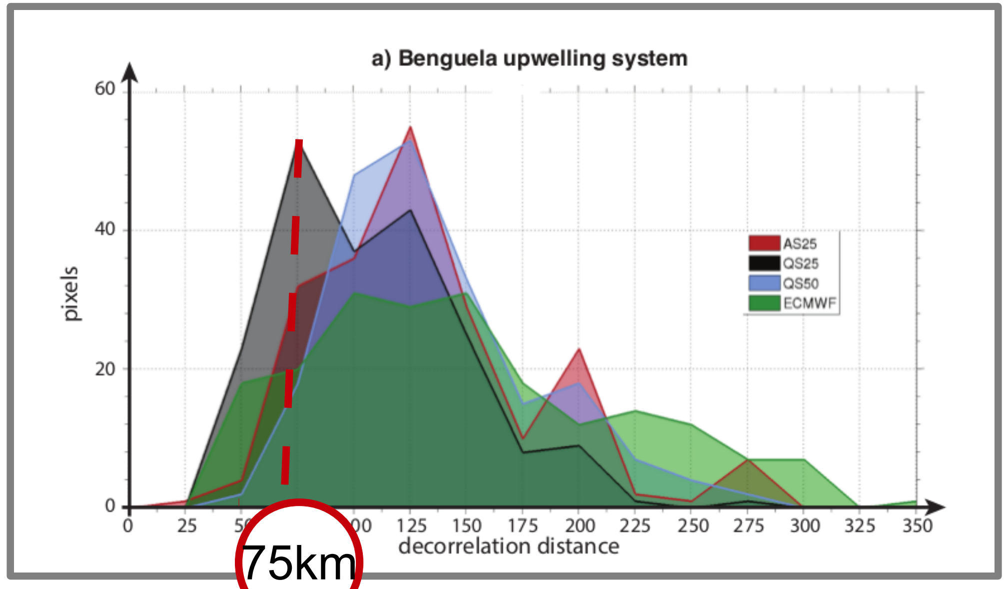


More details in **Desbiolles et al. [JGR, 2014]**

4. Conclusions

Improvement in actual resolution of the new satellite products, especially in the coastal band.

QS25 : Actual spatial resolution O(75 km)



Number of pixels over the continental shelf binned as a function of the decorrelation distance (with 25 km bins) for the four wind products.

The QS25 product is a relevant dataset to capture wind variability in the nearshore region.

Good representation of SST/wind interactions in the upwelling extension zone

Orographic signature in the wind stress curl, especially off coastal promontories.

Relevant description of wind-driven upwelling dynamics with satellite observations

Thanks for your attention