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Omani upwelling dynamics: when eddies get involved

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Plan

- ❖ Introduction
- ❖ Methods and data
- ❖ Results of the Observation
- ❖ Results of the HYCOM data
- ❖ Idealized simulation (CROCO) result
- ❖ Conclusion

Introduction

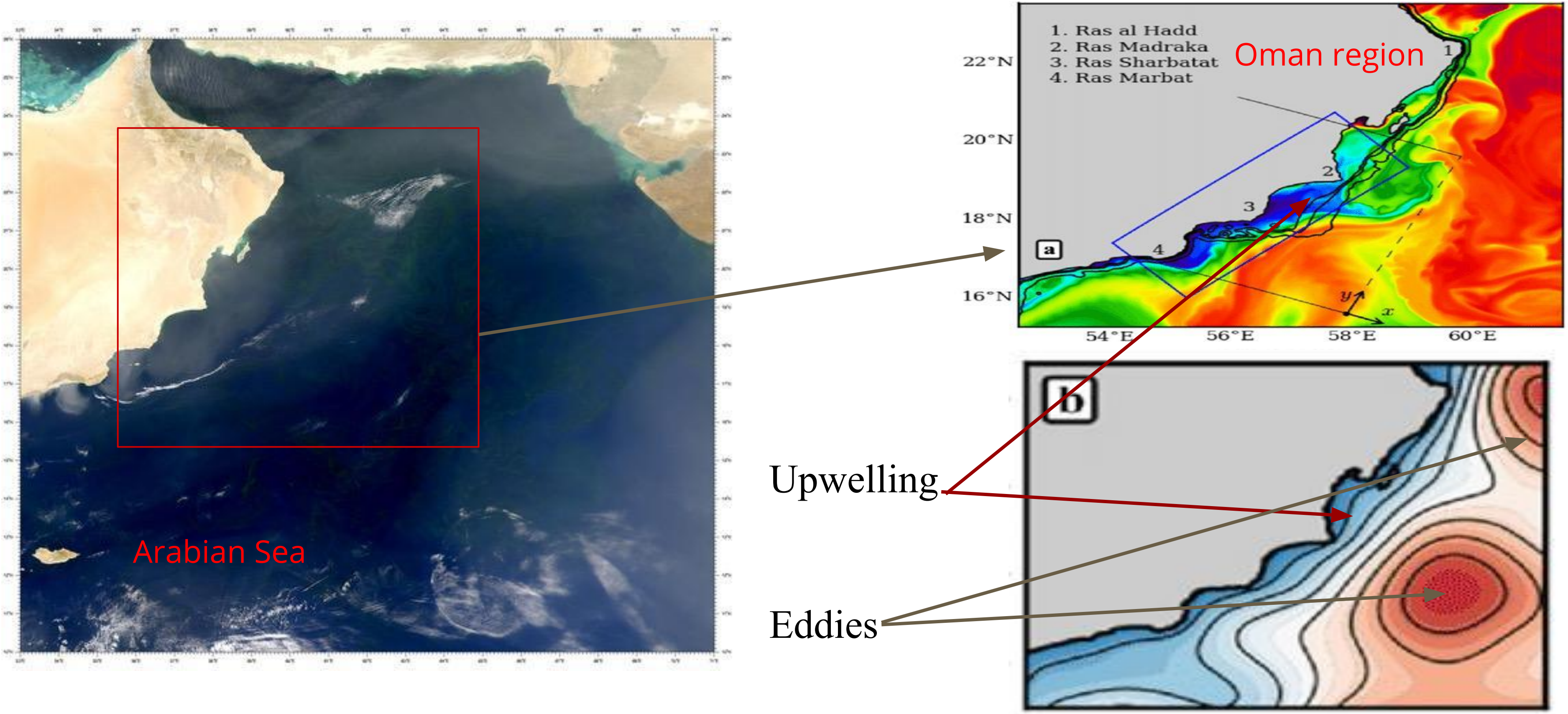
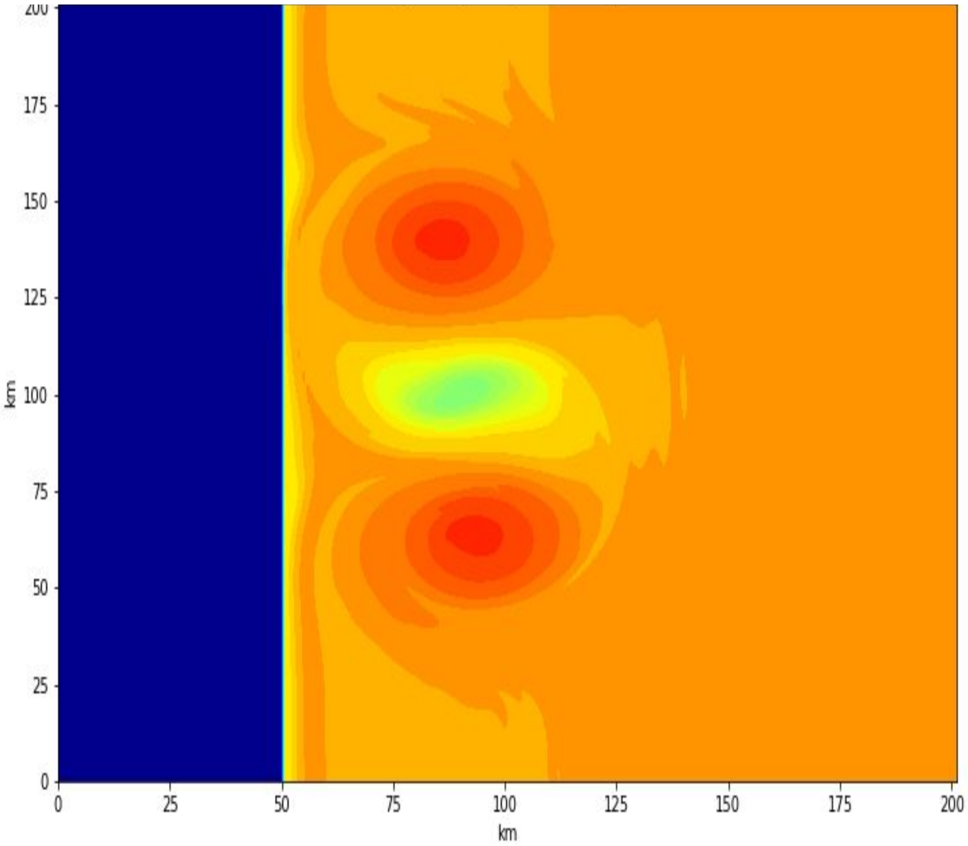


Figure 1: Satellite image showing the general context and the study domain. Presence of upwelling and eddies

Aims



- The goal of this work is to study the dynamic of the Omani upwelling in the presence of these vortices

- Does the presence of a tripole or a vortex weaken or strengthen the upwelling?

Methods and data

❖ Data from observations

- ❑ SSH → AVISO altimetric data (provided by CLS)
- ❑ SST → Provided by NOAA (National Oceanographic Data Center)
- ❑ Wind → Reanalyses of CMEMS (my.cmems-du.eu) (Mercator - Ocean)

→ *Resolution: 1/4°*

❖ Models output

- ❑ HYCOM (Hybrid Coordinate Ocean Model)

→ hybrid coordinates (isopycnal and z)

→ horizontal resolution 5 km

→ 40 vertical levels

- ❑ CROCO model

Methods and data

- Wind

- Wind stress

$$\mathcal{T} = \rho_a C_d |V_a| V_a$$

Cd ≈ 1.210-3

- Wind stress curl

$$\vec{\nabla} \wedge \vec{\mathcal{T}}\, |_z = \frac{\partial \mathcal{T}_y}{\partial x} - \frac{\partial \mathcal{T}_x}{\partial y}$$

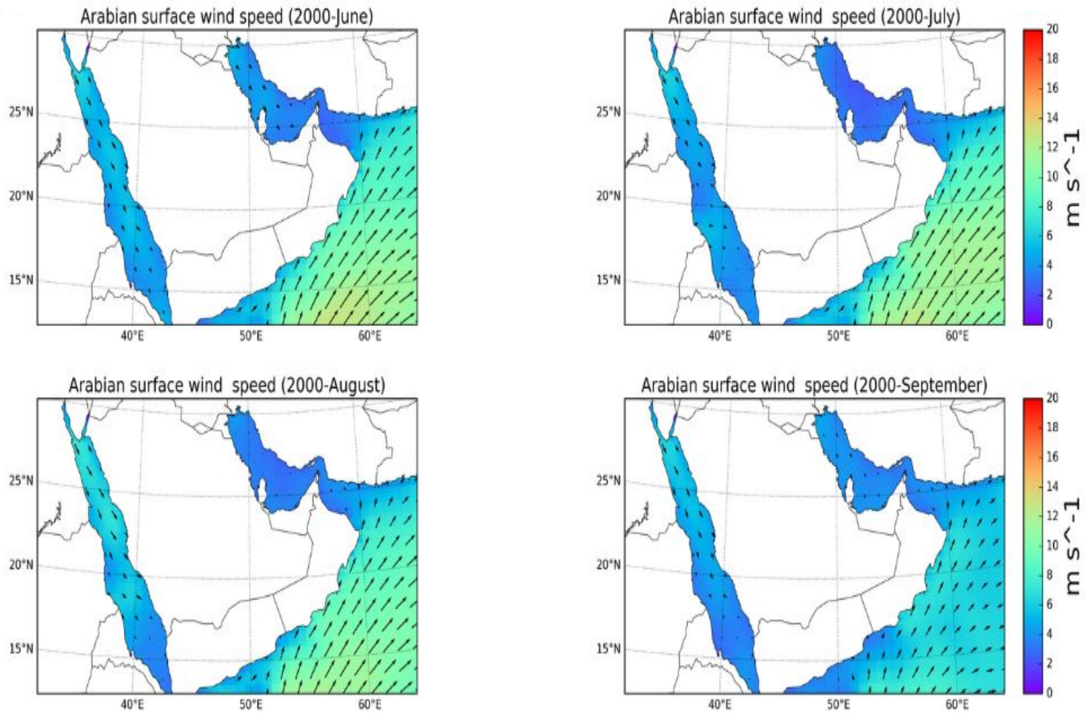
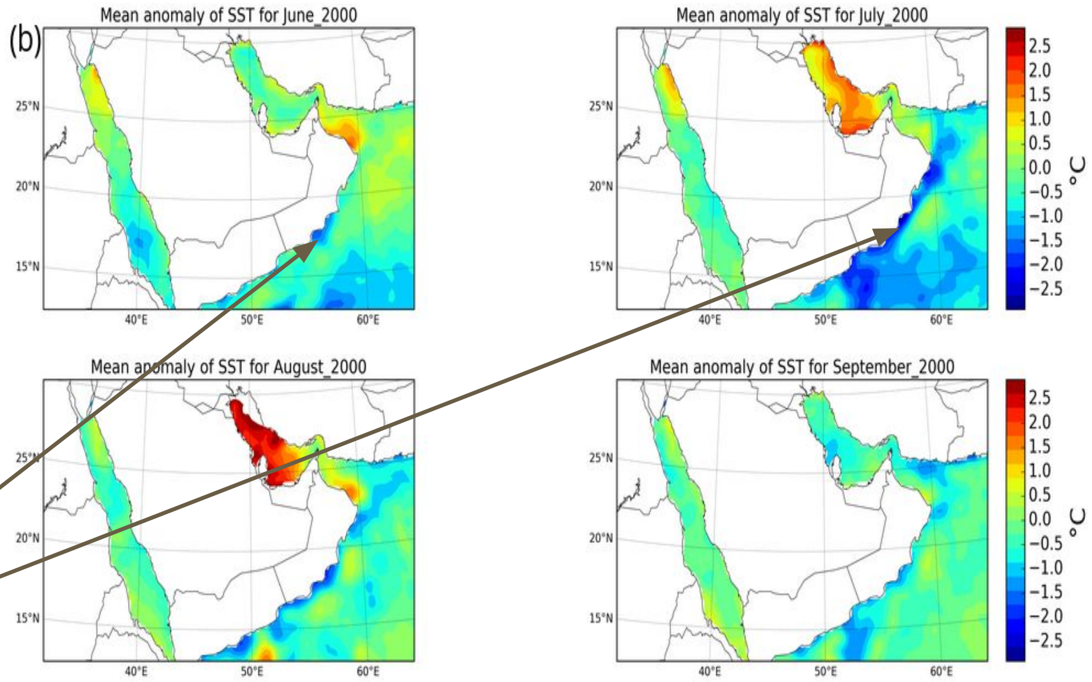


Figure 2: Monthly mean of the wind speed (summer 2000).

Methods and data

- ❖ SST

Figure 3: Monthly Mean Anomaly of the SST (Summer 2000) .

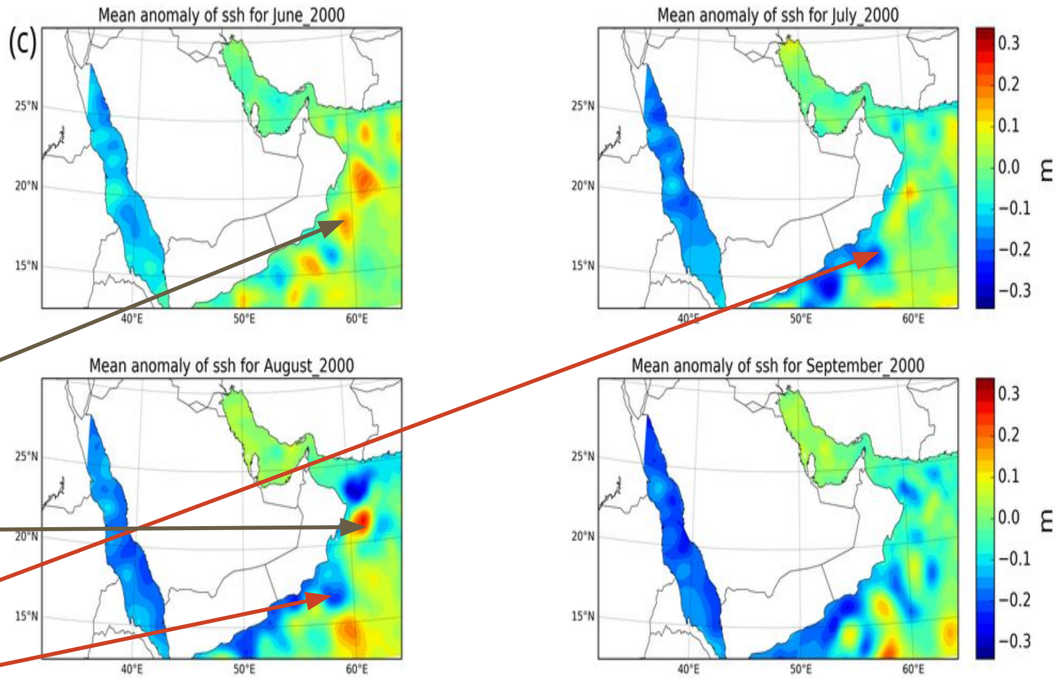


→ Signature of the upwelling

Methods and data

- ❖ SSH

Figure 4: Monthly Mean Anomaly of the SSH (Summer 2000) .



→ Anticyclone

→ Cyclone

Results of the Observation

- ➢ period of occurrence
- ➢ Annual and inter-annual variation

Inter-annual variation of SST, WSC and the appearance of upwelling

Low WSC Value:

→ Upwelling

→ Negative SST Anomaly

❖ A drop in temperature ranging from 0.5 to 1.2°C

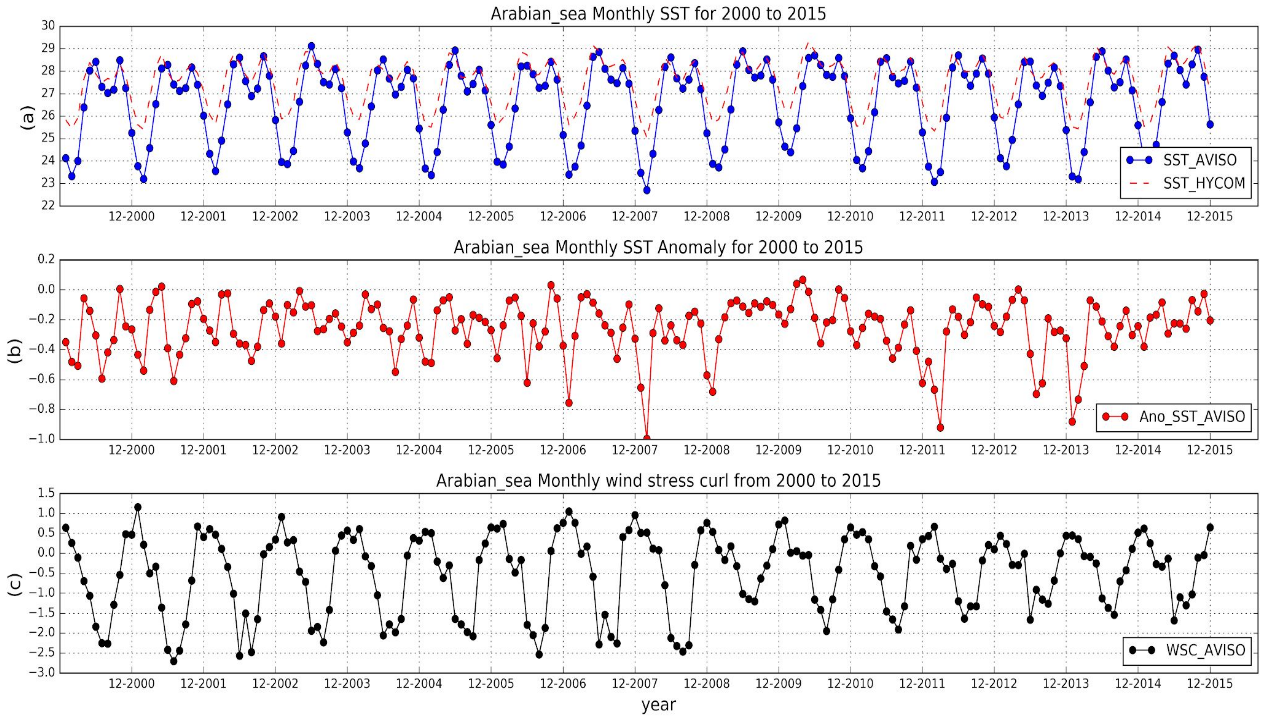


Figure 5: Inter-annual variations in OHS, OHS anomaly and WSC in the Arabian Sea and its Gulfs from 2000 to 2015; the solid blue curve and the dashed red curve in (a) represent the SST for the AVISO and HYCOM data, respectively; the red curve (b) represents the SST anomaly and the black curve (c) the rotational wind pressure WSC.

Inter-annual variation of SST, WSC and the appearance of upwelling

Peaks:

- ➢ Beginning
- ➢ End
- ❖ Upwelling presence

- ❖ A drop in temperature ranging from 0.5 to 1.4°C

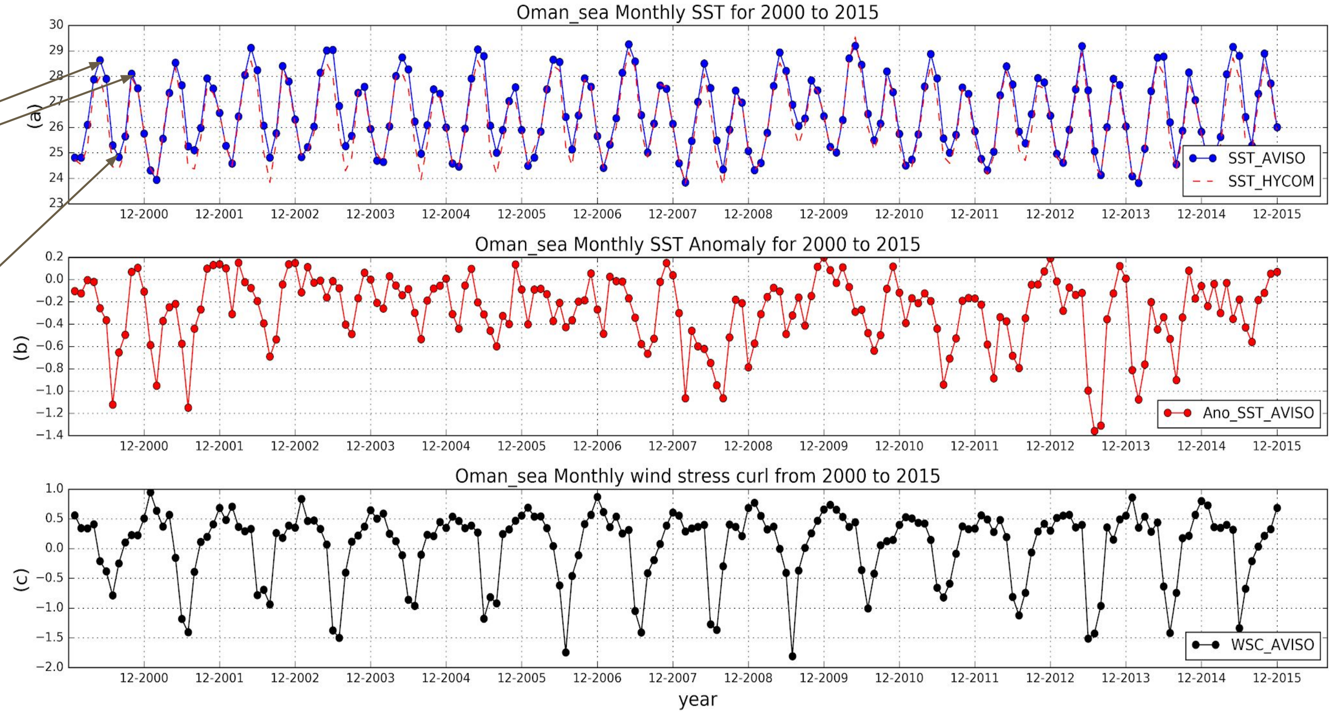
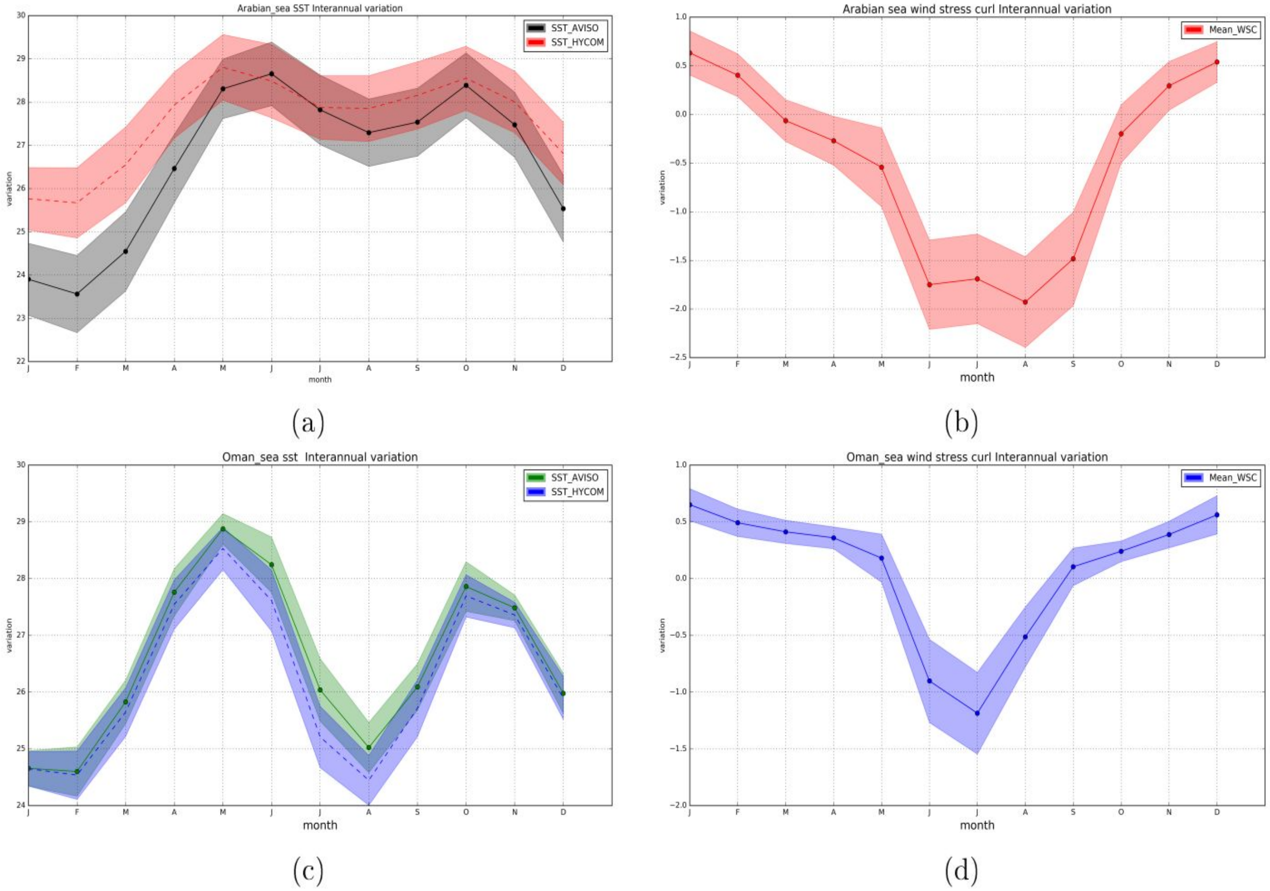


Figure 5: Inter-annual variations in OHS, OHS anomaly and WSC on the Omani coast from 2000 to 2015; the solid blue curve and the dashed red curve in (a) represent the SST for the AVISO and HYCOM data, respectively; the red curve (b) represents the SST anomaly and the black curve (c) the rotational wind pressure WSC.

Annual cycle and interannual variability of upwelling

Figure 6: Annual variation of SST (a, c) and WSC (b, d) throughout the Arabian Sea (a, b) and in the upwelling region (c, d); on average over the period 2000-2015.



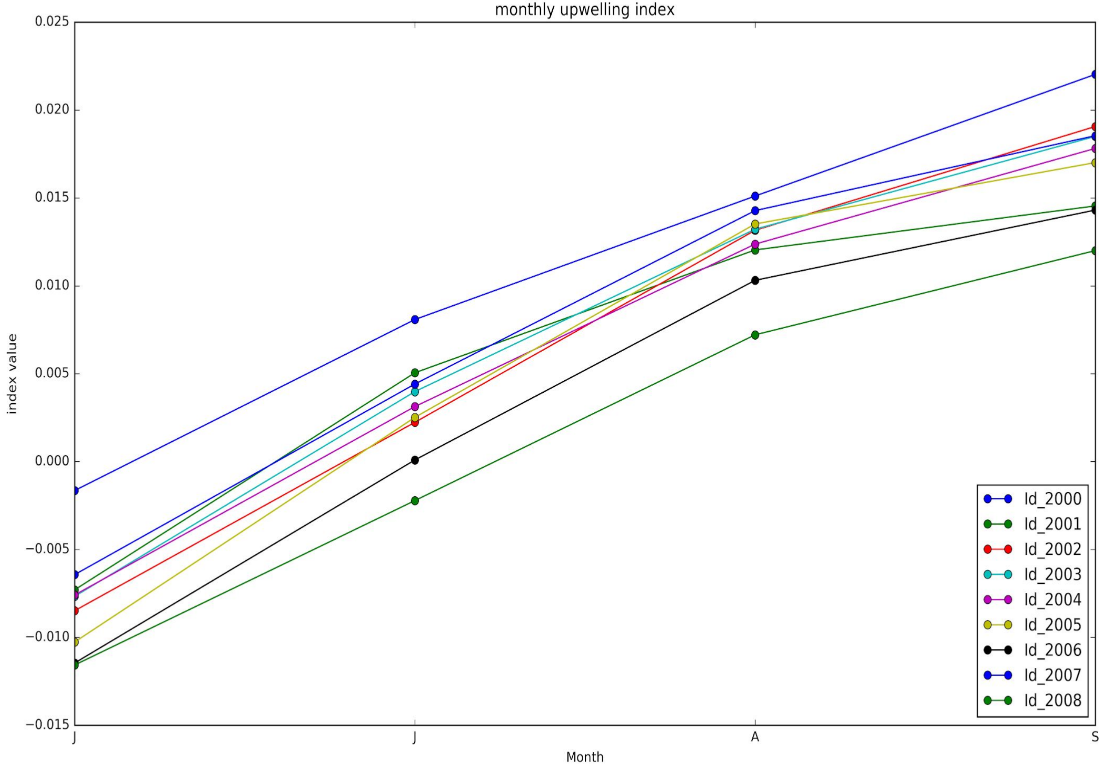
- ➢ ***Its appearance corresponds to the low values of SSH and SST near the coast***
- ➢ The HYCOM data are well correlated with the observation data

Results of the HYCOM data

- Vertical profile of upwelling
- Vertical velocity

Oman Upwelling index

Figure 7: Monthly variation of upwelling index between 2000 and 2008 on the coast of Oman.



- ❖ Index

Index = (rho_winter - rho_summer)/rho_winter

Description of the upwelling from the HYCOM model

❑ Temperature profile and density

❖ A drop in temperature ranging from 2 to 5.5°C between July and August

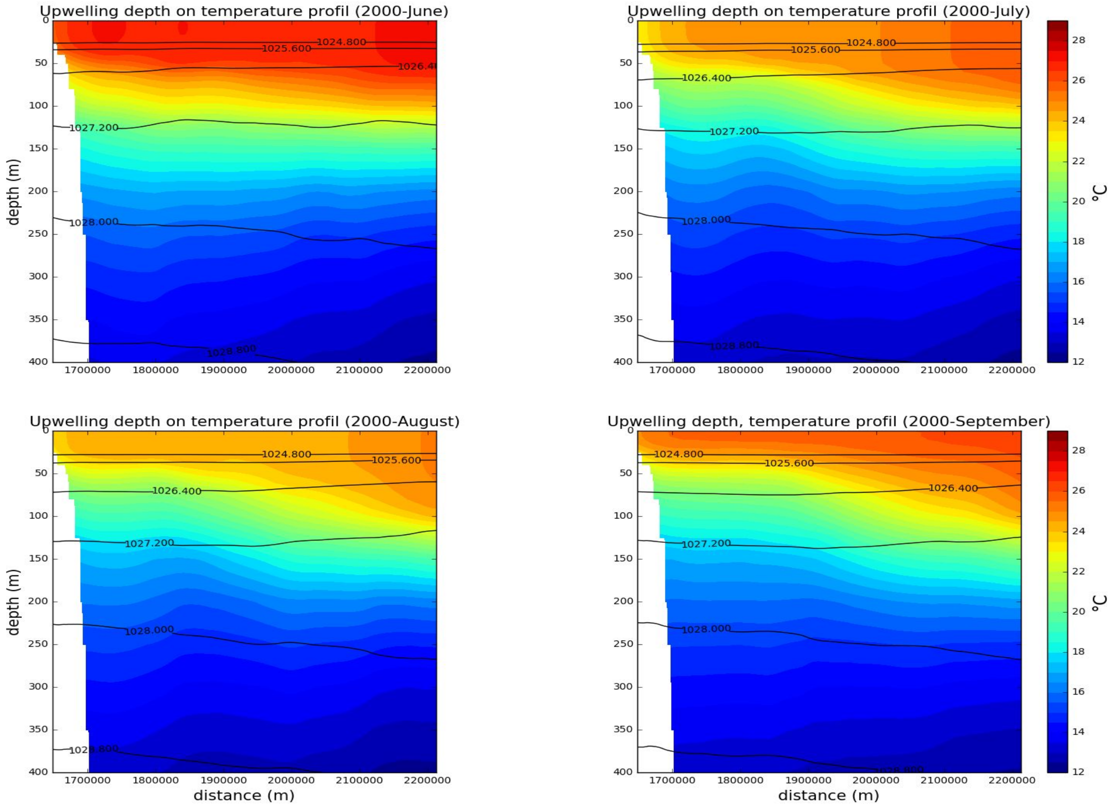
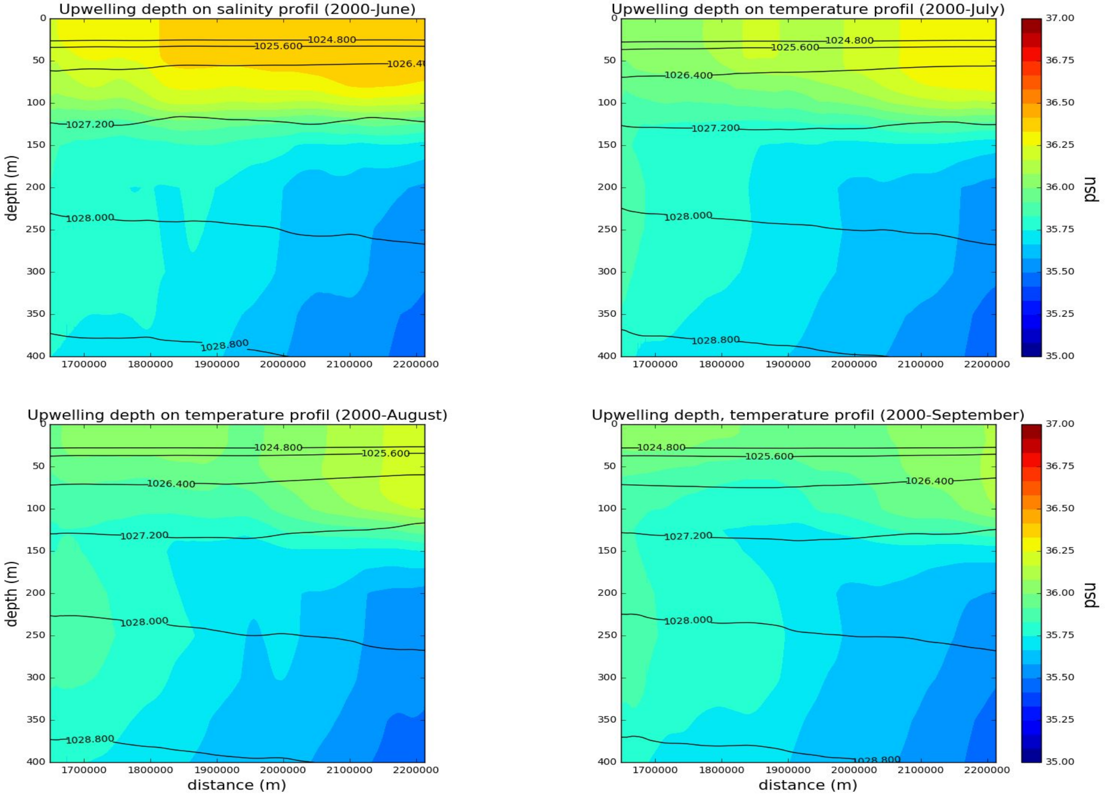


Figure 8: Vertical profile of the temperature perpendicular to the Omani coast; the black contours represent the isopycnals during the upwelling season (June, July, August and September).

Description of the upwelling from the HYCOM model

❑ Salinity profile and density

Figure 9: Vertical profile of the temperature perpendicular to the Omani coast; the black contours represent the isopycnals during the upwelling season (June, July, August and September).

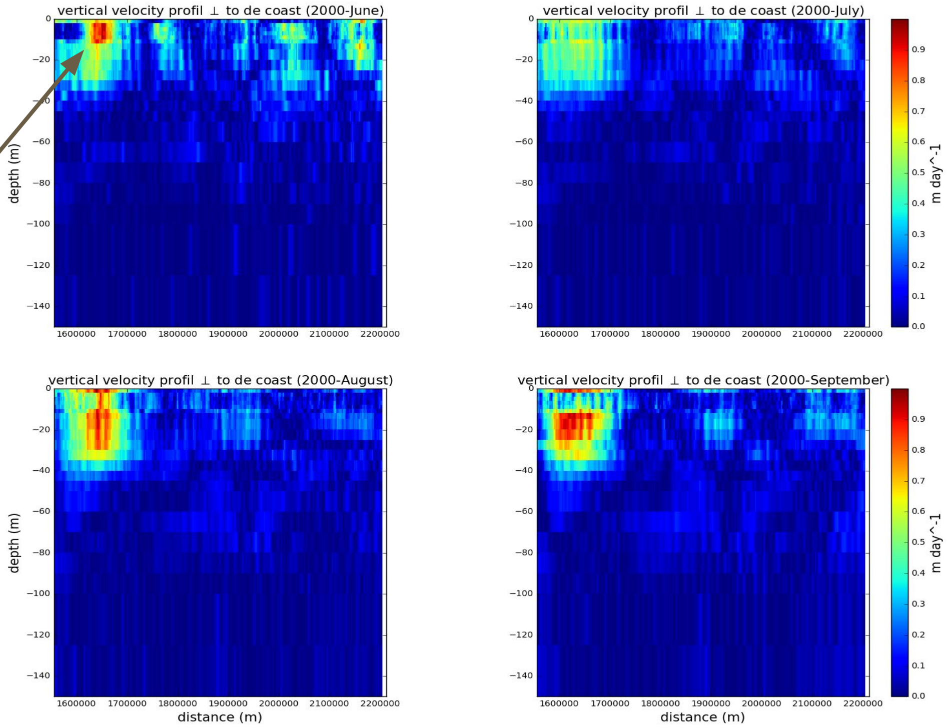


- *A 1 psu drop in salinity*
- ***the vertical signature of the upwelling is observed to a depth of 400m***

Description of the upwelling from the HYCOM model

❑ Vertical velocity

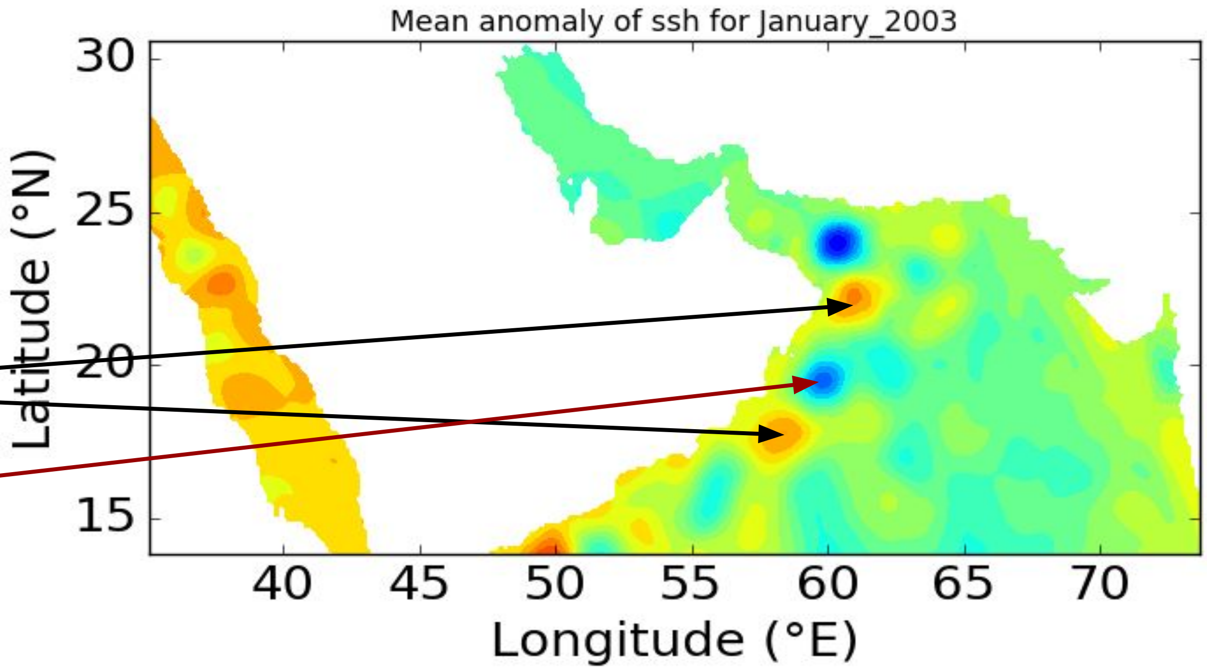
Figure 10: Vertical velocity profile perpendicular to the Omani coast during the upwelling season.



❖ *High values of w near the coast*

Idealized simulation (CROCO) result

- ❖ Presence of tripole:
- ➢ Anticyclone
- ➢ Cyclone



Idealized simulation : (CROCO)

→ Horizontal resolution: 10 km

→ The wind stress is set at 0.075N m- 2

→ Vertical levels: 30

→ Vortices radius: 100 km

Étude de la dynamique de l'upwelling: impact des tourbillons

❖ Presence of tripole:

➢ Anticyclone

➢ Cyclone

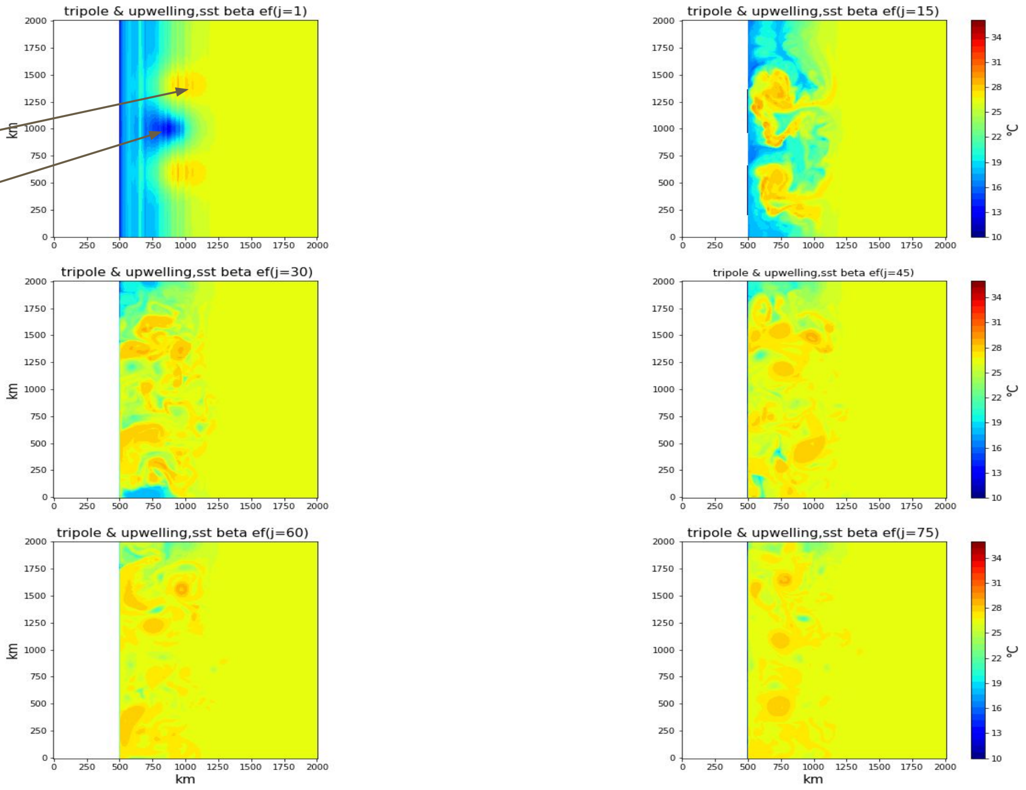


Figure 11: Variation of the SST; temporal evolution of a tripole in the presence of the upwelling front and their effects with beta effect. The vortices have a radius of 100 km

Étude de la dynamique de l'upwelling: impact des tourbillons

- ❖ Presence of tripole:
- ➢ Anticyclone
- ➢ Cyclone

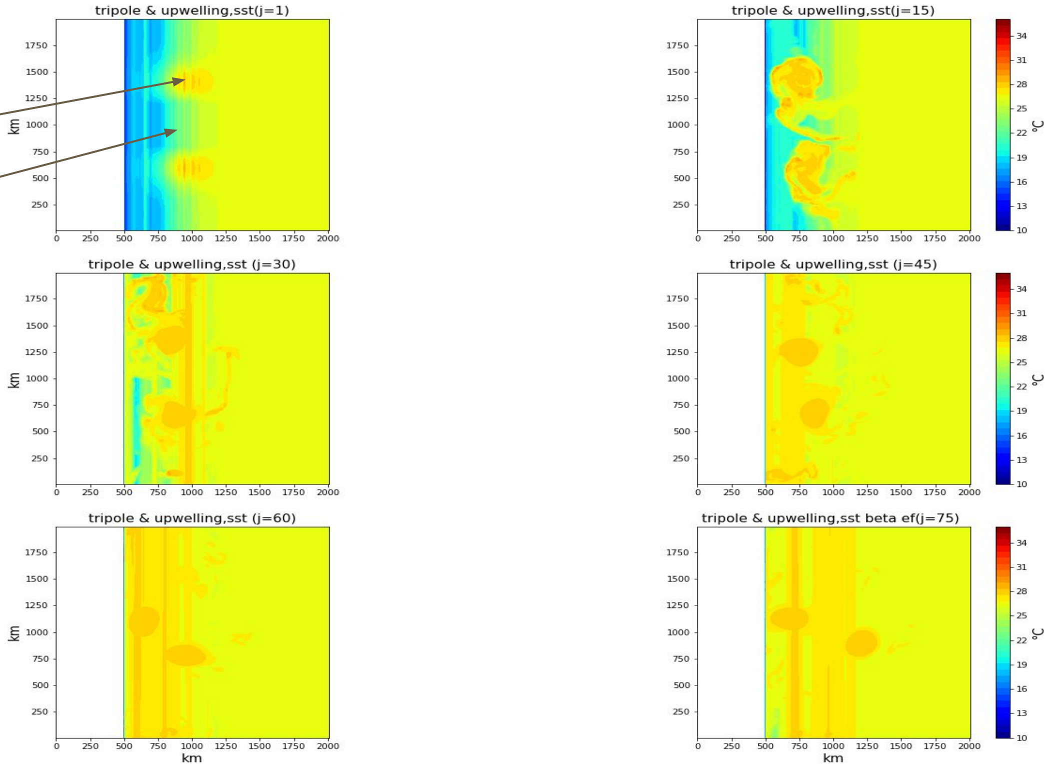
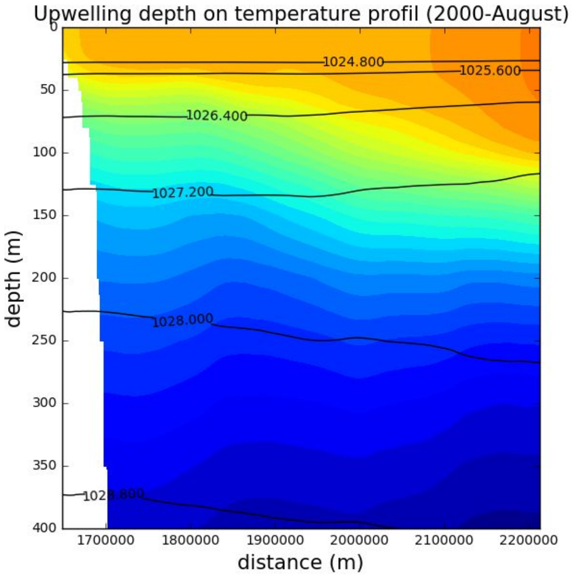
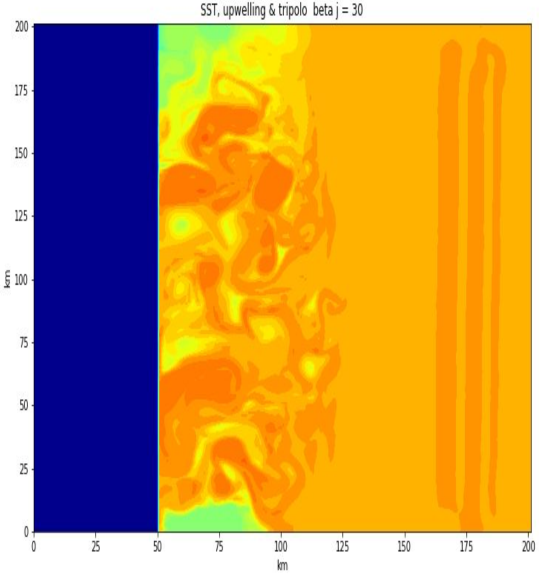


Figure 12: Variation of the SST; temporal evolution of a tripole in the presence of the upwelling front and their effects without beta effect. The vortices have a radius of 100 km

Conclusion

- The Omani upwelling starts in June with an inversion of wind direction (N-E to S-W) and an increase in force
- It can extend down to a depth of 400m with vertical speeds in the order of 0.2 to 0.9 m/day
- The tripole which formed during the upwelling period has a large effect on the upwelling signature in presence of Rossby waves
- The cyclone influenced the upwelling less than the anticyclone with or without the beta effect





❖ vertical profile of upwelling and tripole effect

Thank you for your attention

Appendix

Étude de la dynamique de l'upwelling: impact des tourbillons

Interaction between an upwelling and an anticyclone

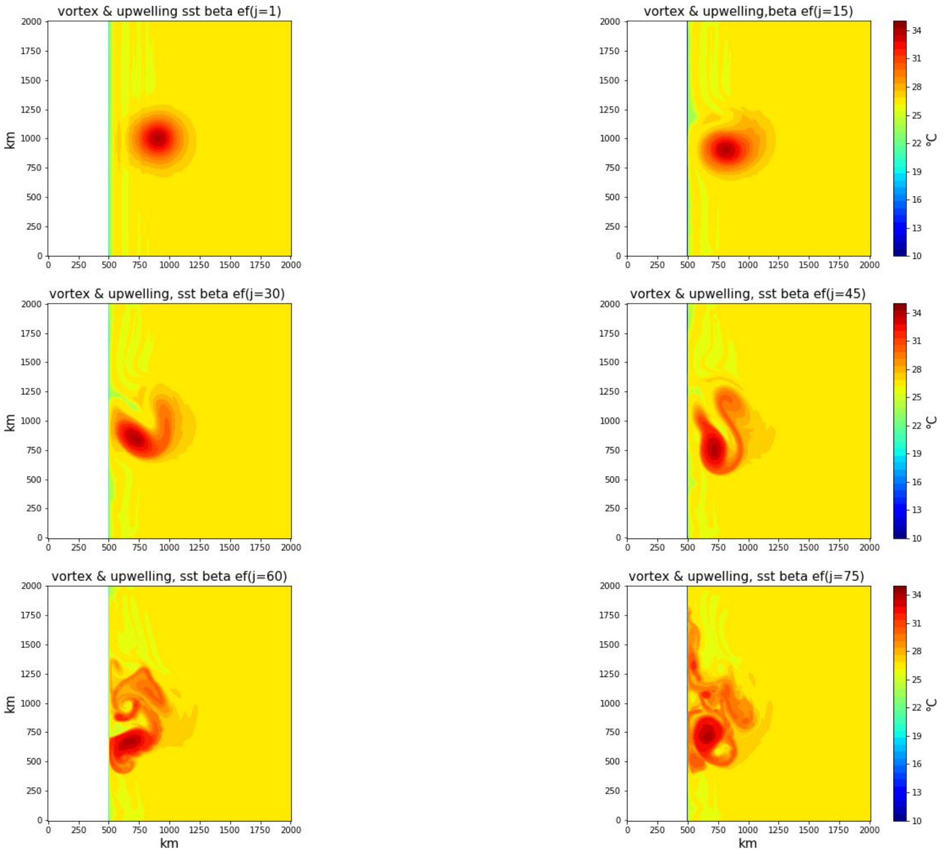


Figure 13: Variation of the SST; temporal evolution of an anticyclone in the presence of the upwelling front with beta effect. The vortices have a radius of 100 km.

Étude de la dynamique de l'upwelling: impact des tourbillons

Interaction between an upwelling and a cyclone

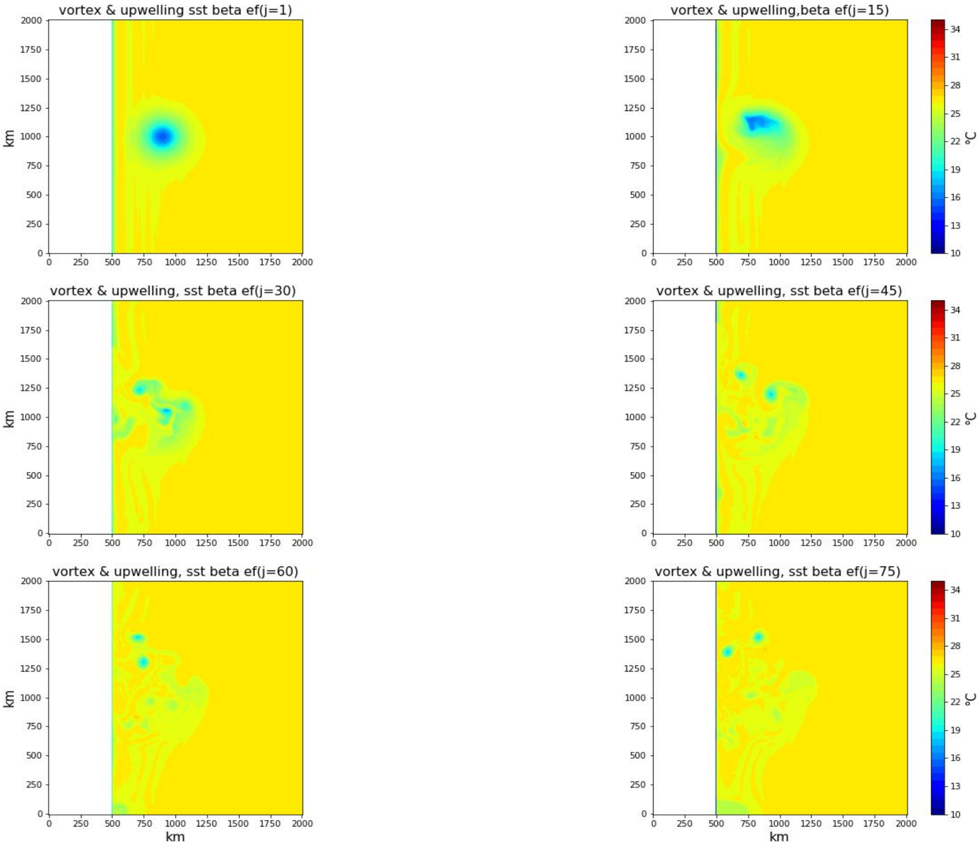


Figure 14: Variation of the SST; temporal evolution of an cyclone in the presence of the upwelling front with beta effect. The vortices have a radius of 100 km.