Vertical velocities in the Northwestern Mediterranean Sea: combining in situ and modeling approach

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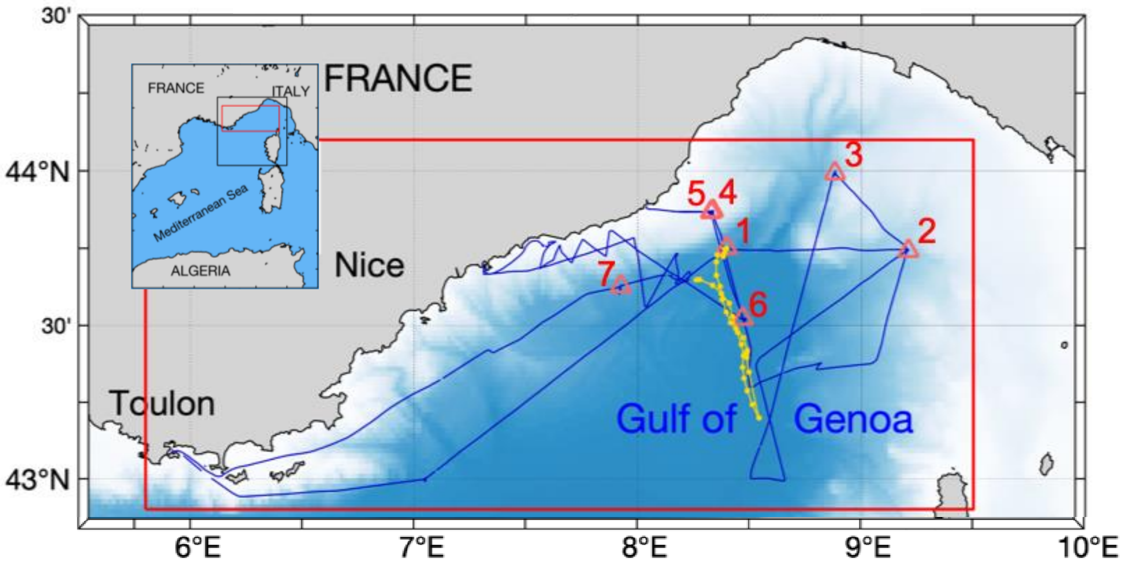
May 26th, 2022

Vertical velocities – methodology



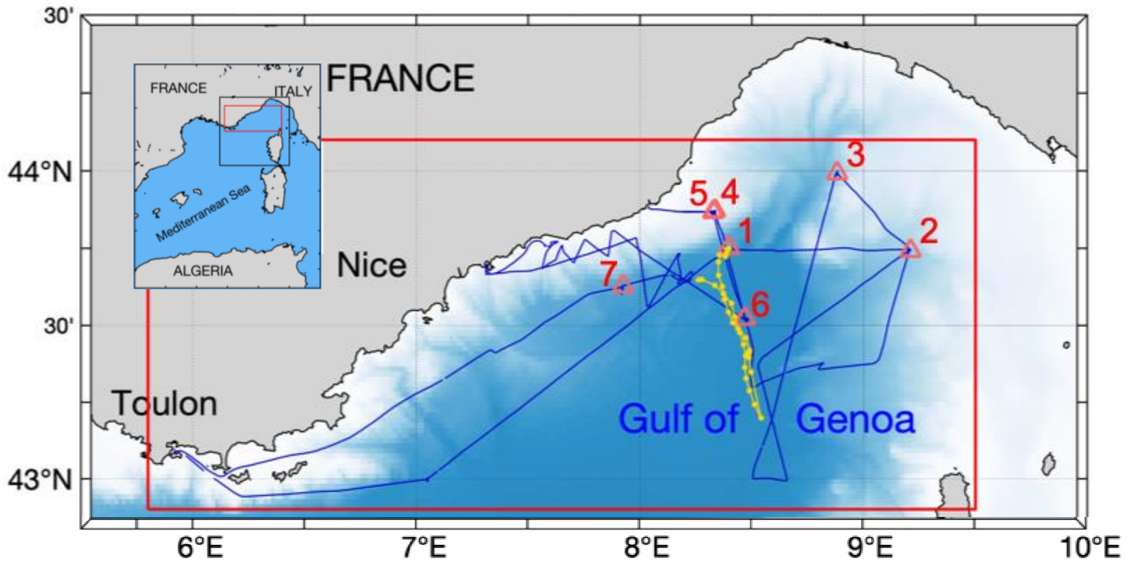
Sampling conditions: FUMSECK 2019 cruise

6 “vertical velocities” stations

4 sampling days 01/05/2019 – 04/05/2019

Measuring instruments ADCPs and CTD probes

Vertical velocities – methodology



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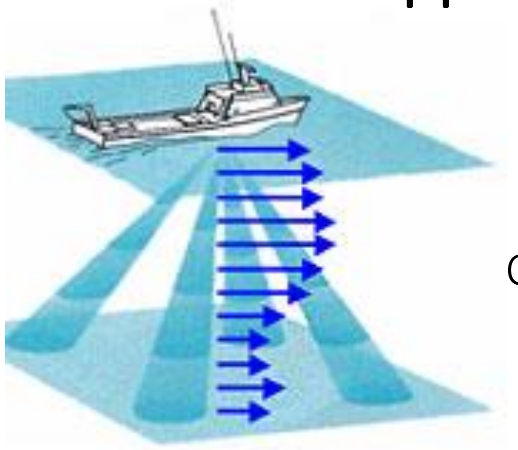
ADCP – Acoustic Doppler Current Profiler

General uses: vessel mounted, lowered, moored

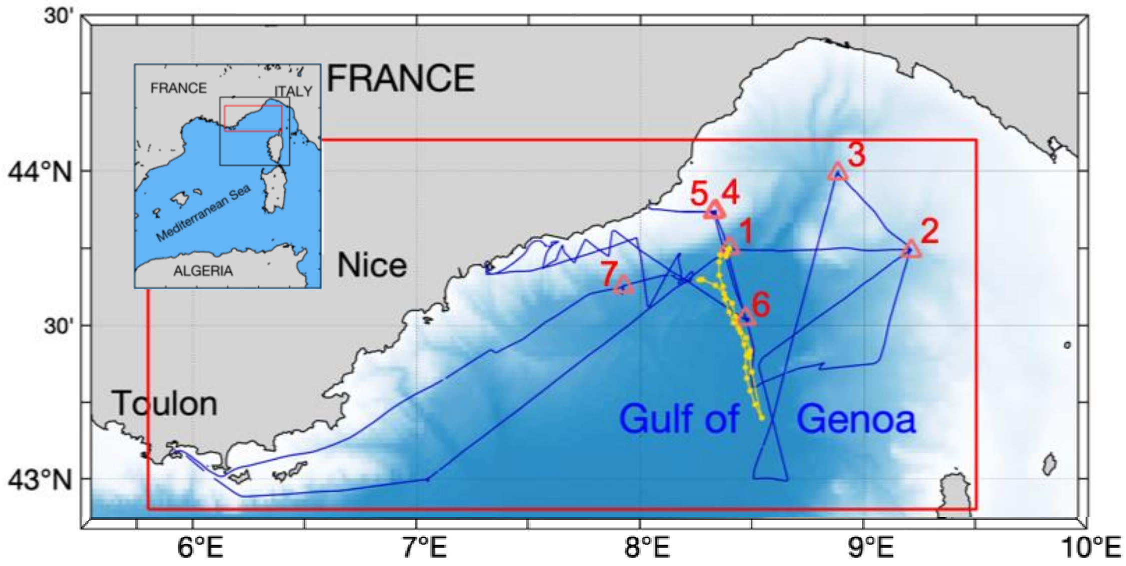


Conventional 4-beams

↓

Classical derivation of u, v, and **estimation** of **w**

Vertical velocities – methodology



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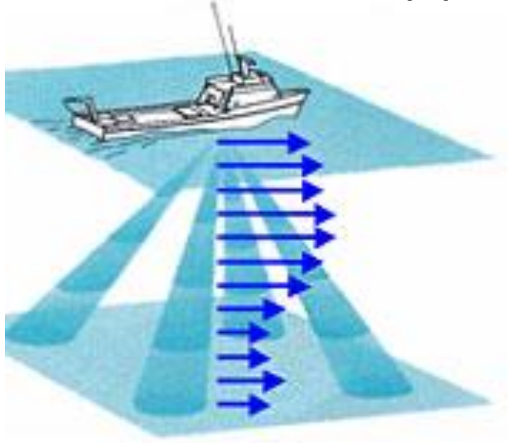
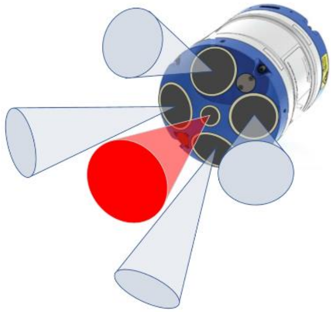


Conventional 4-beams

⬇

Classical derivation of u, v, and **estimation** of **w**

New generation: Sentinel V50 (*Teledyne RDI*)



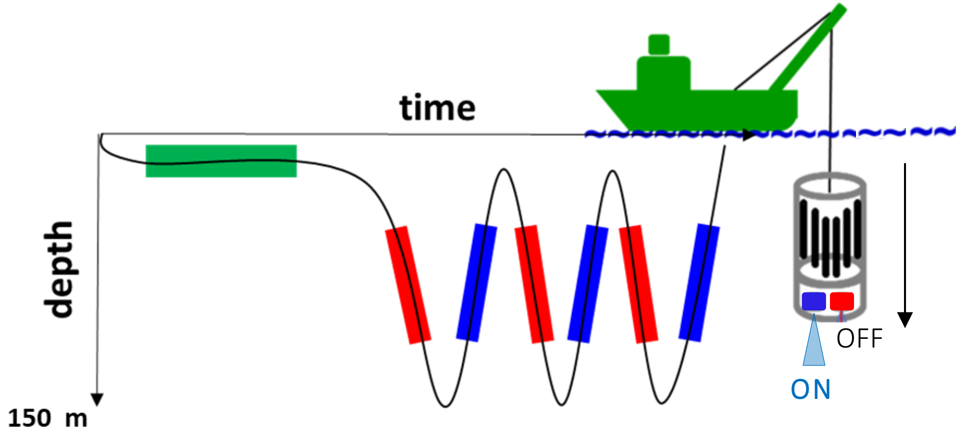
Presence of a 5th beam
➡ **Direct estimation of w**

L-ADCP

L-Sentinel

FF-ADCP

Classical **4-beams** ADCP
lowered



Winch connected
→ Under the influence of vessel movements

* All ADCPs are associated with CTD probes

Vertical velocities – Sampling protocols

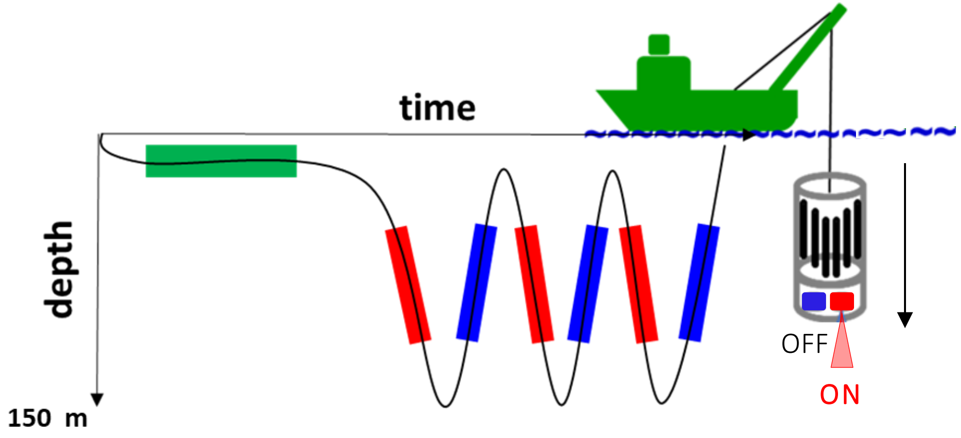
L-ADCP

Classical **4-beams** ADCP
lowered

L-Sentinel

New **5-beams** ADCP
lowered

FF-ADCP



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Vertical velocities – Sampling protocols

L-ADCP

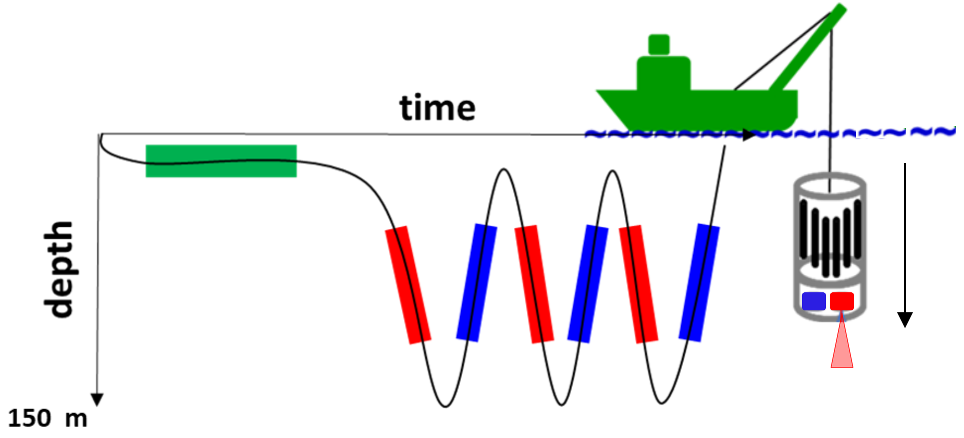
Classical **4-beams** ADCP **lowered**

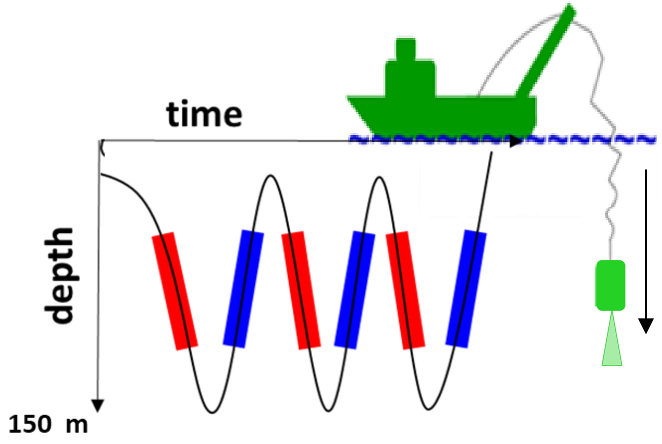
L-Sentinel

New **5-beams** ADCP **lowered**

FF-ADCP

Classical **4-beams** ADCP used in **free-fall**





Winch connected
→ Under the influence of vessel movements

Free falling
→ Independent of vessel movements

* All ADCPs are associated with CTD probes

Vertical velocities – results 1/2

Direct *in situ* measurements of vertical velocities

3 instruments used → 4 measures of *w*

L-ADCP, Sentinel *4 beams*, Sentinel *5th beam*, FF-ADCP

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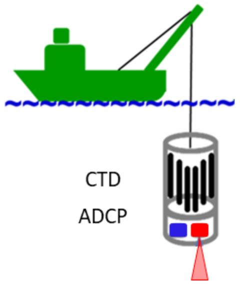

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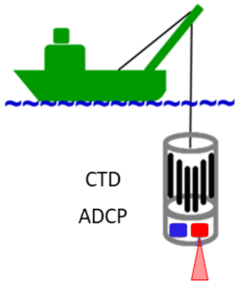

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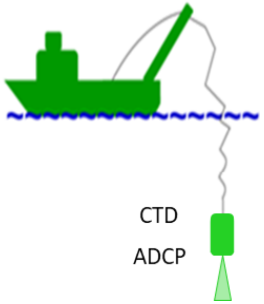

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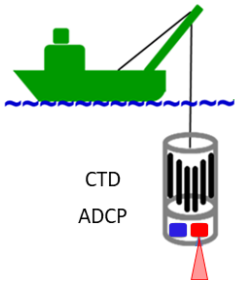

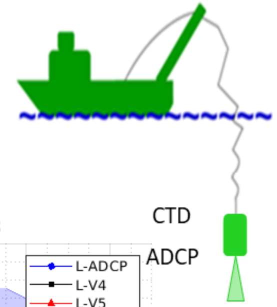

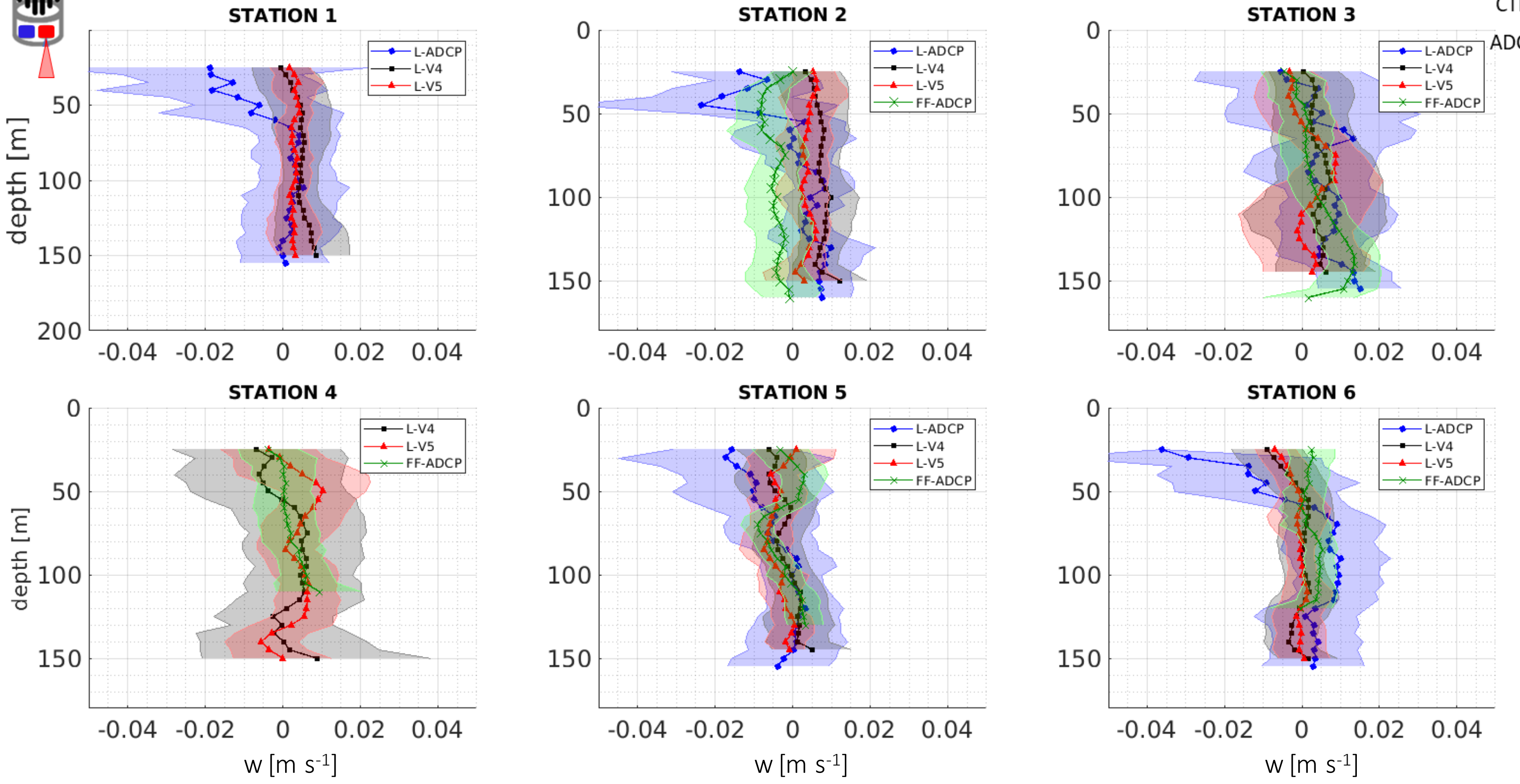

Comby *et al.* in revision for JAOT

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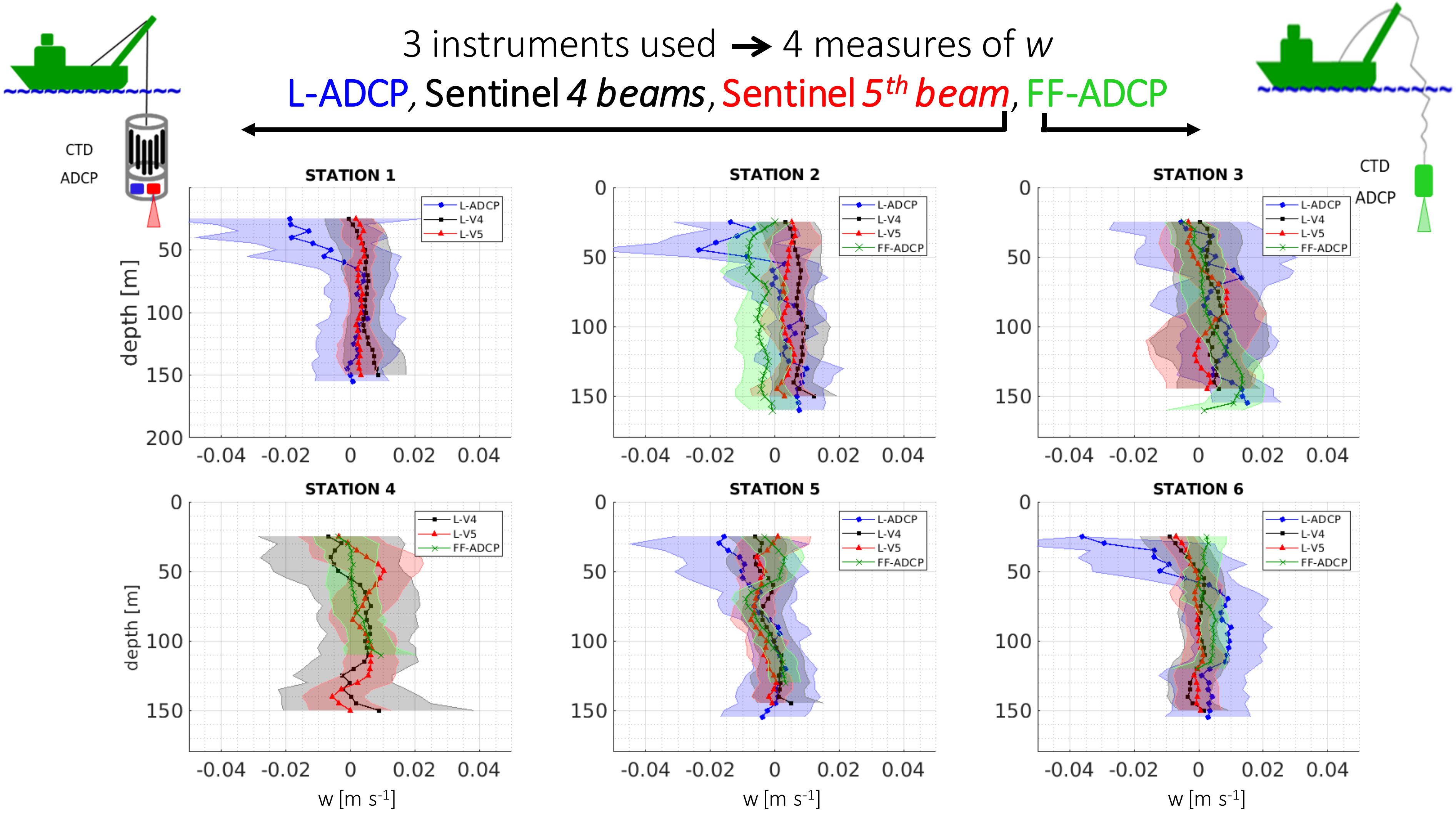

→ Good agreement between the different measurement methods

Comby *et al.* in revision for JAOT

Vertical velocities – results 2/2

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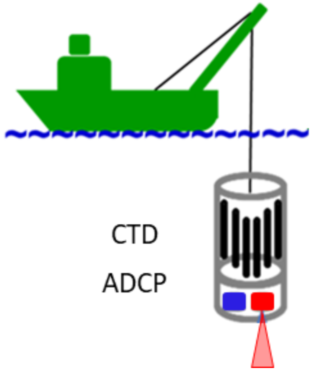
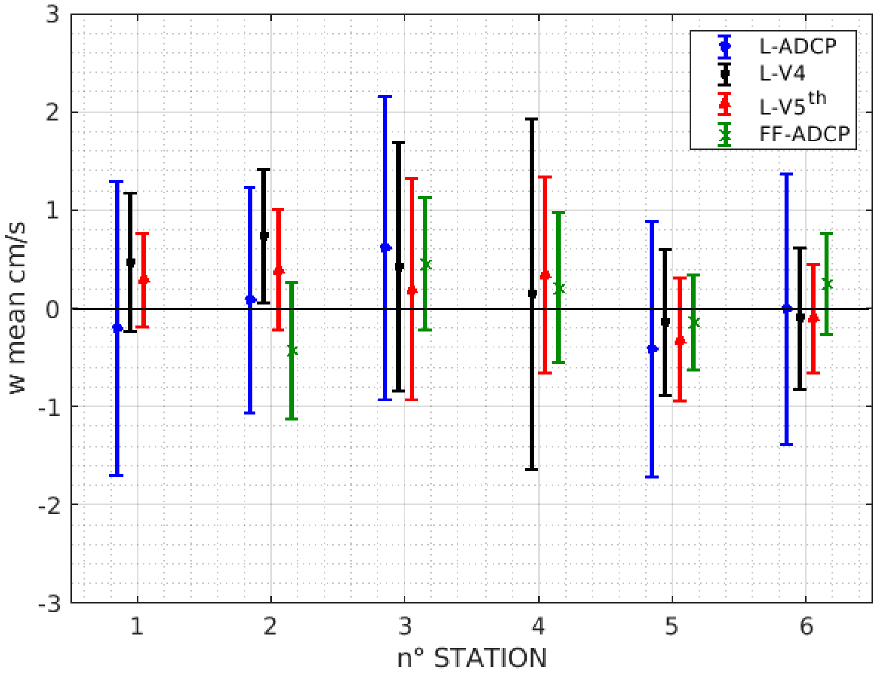
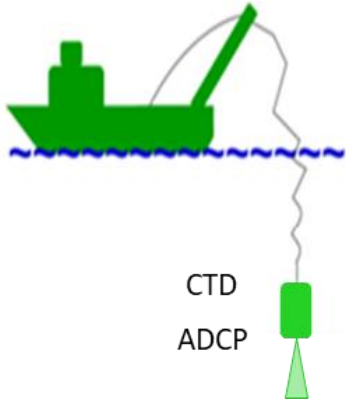




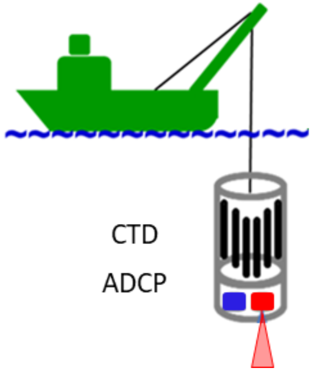


Downcasts data 0 – 150 m

μ ~ mm/s

0.02	**0.26**	**0.14**	**0.06**	cm/s

Vertical velocities – results 2/2



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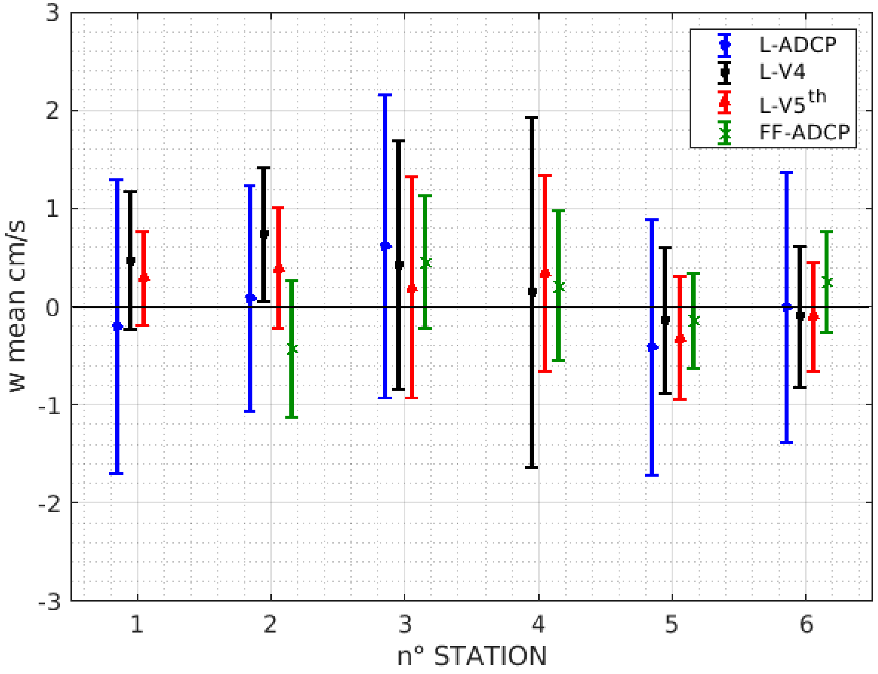

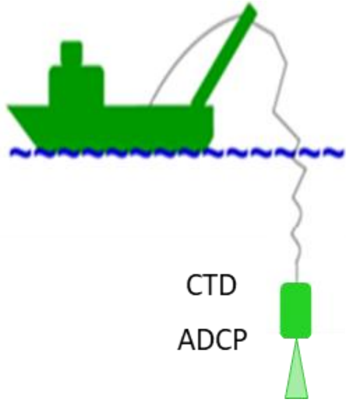

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0.02 **0.26** **0.14** **0.06** cm/s

σ ~ cm/s

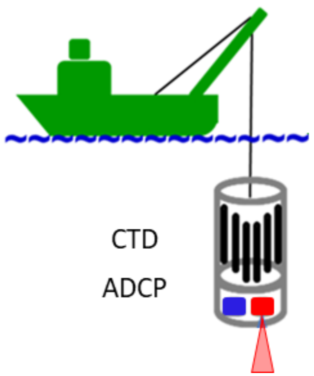
1.3 **1.0** **0.7** **0.6** cm/s

L-ADCP > L-V4 > L-V5 > FF-ADCP

Best accuracies:

Sentinel *5th beam* & FF-ADCP

Vertical velocities – results 2/2



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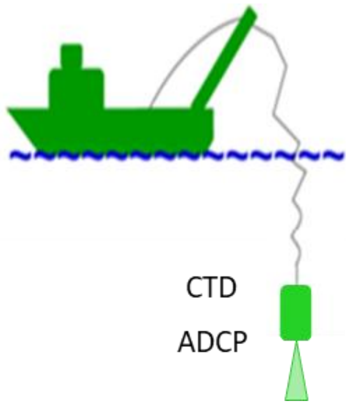

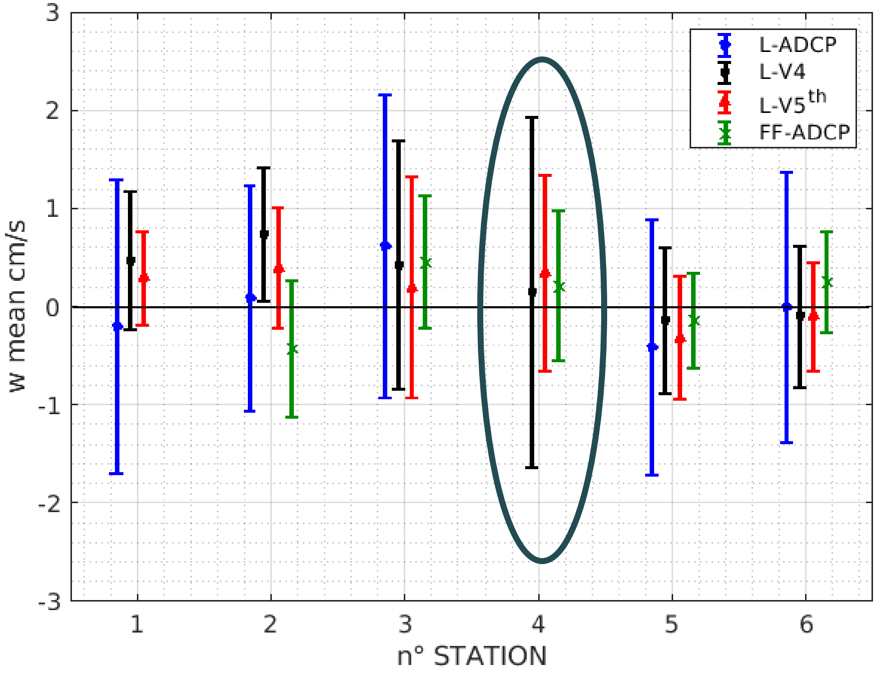

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L-ADCP > L-V4 > L-V5 > FF-ADCP

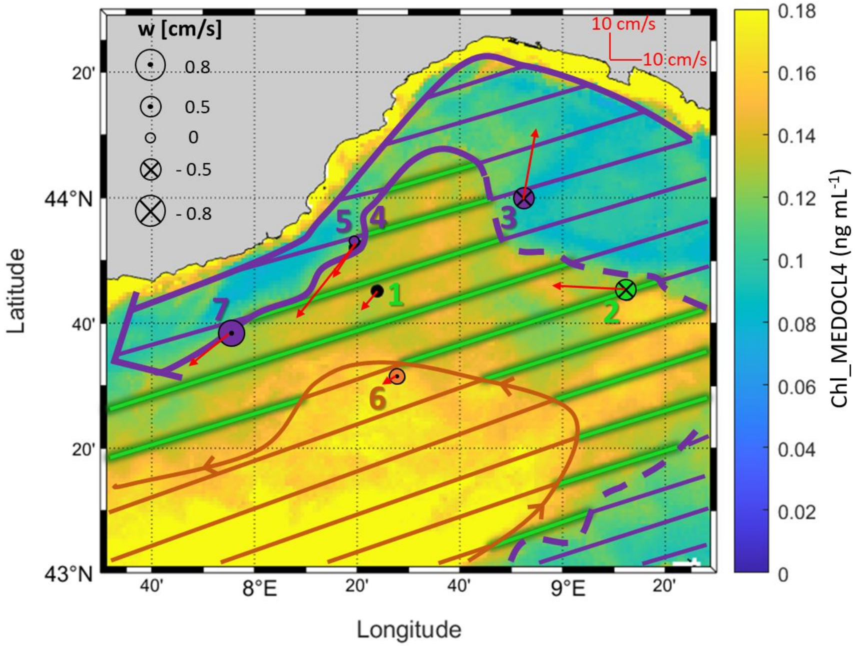
Best accuracies:

Sentinel *5th beam* & FF-ADCP

1) **Free-fall** technique not sensitive to sea state conditions

2) ***Sentinel 5th beam*** **more accurate** than a classical ADCP

in situ and modelling coupling



- Association with **remote sensing** data and **horizontal currents**

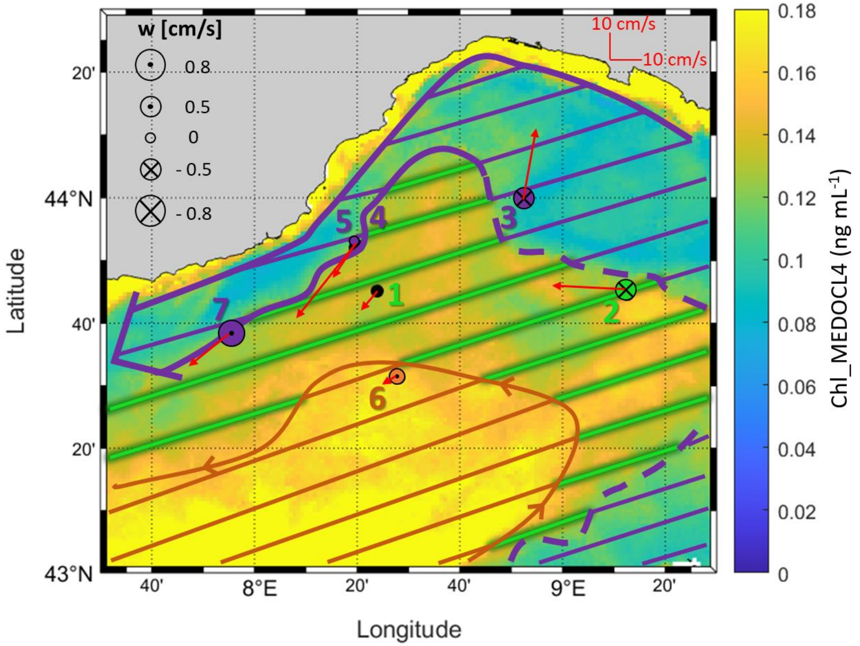
Distinction of several zones:

Northern Current (*Liguro-provençal*)
Cyclonic recirculation
Intermediate zone

Influence on vertical velocities:

Intensification of the velocities at the edges of the Northern current, of a meander or AC eddy

in situ and modelling coupling



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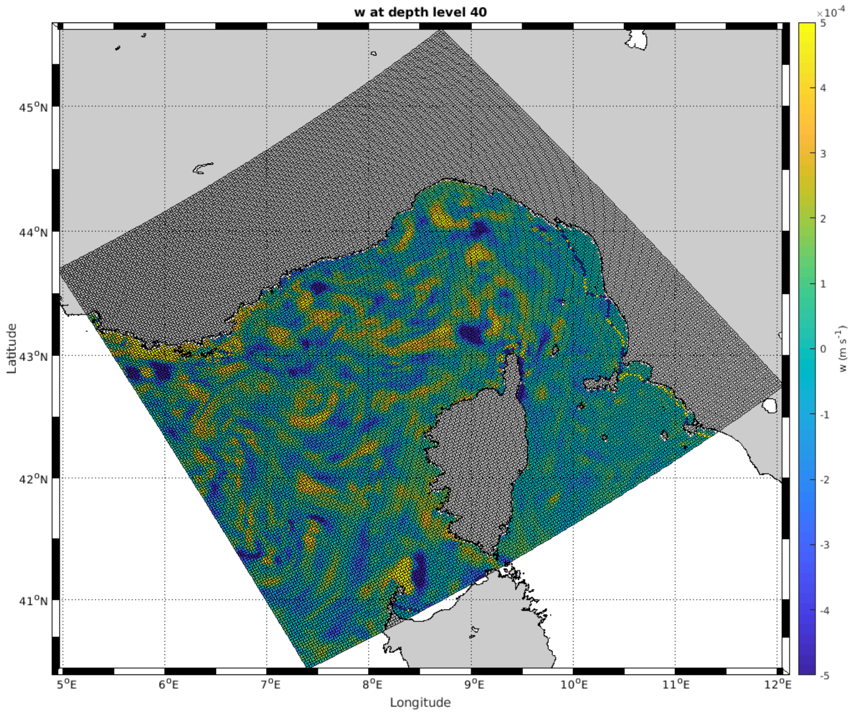

- Numerical model **characteristics**

Distinction of several zones:

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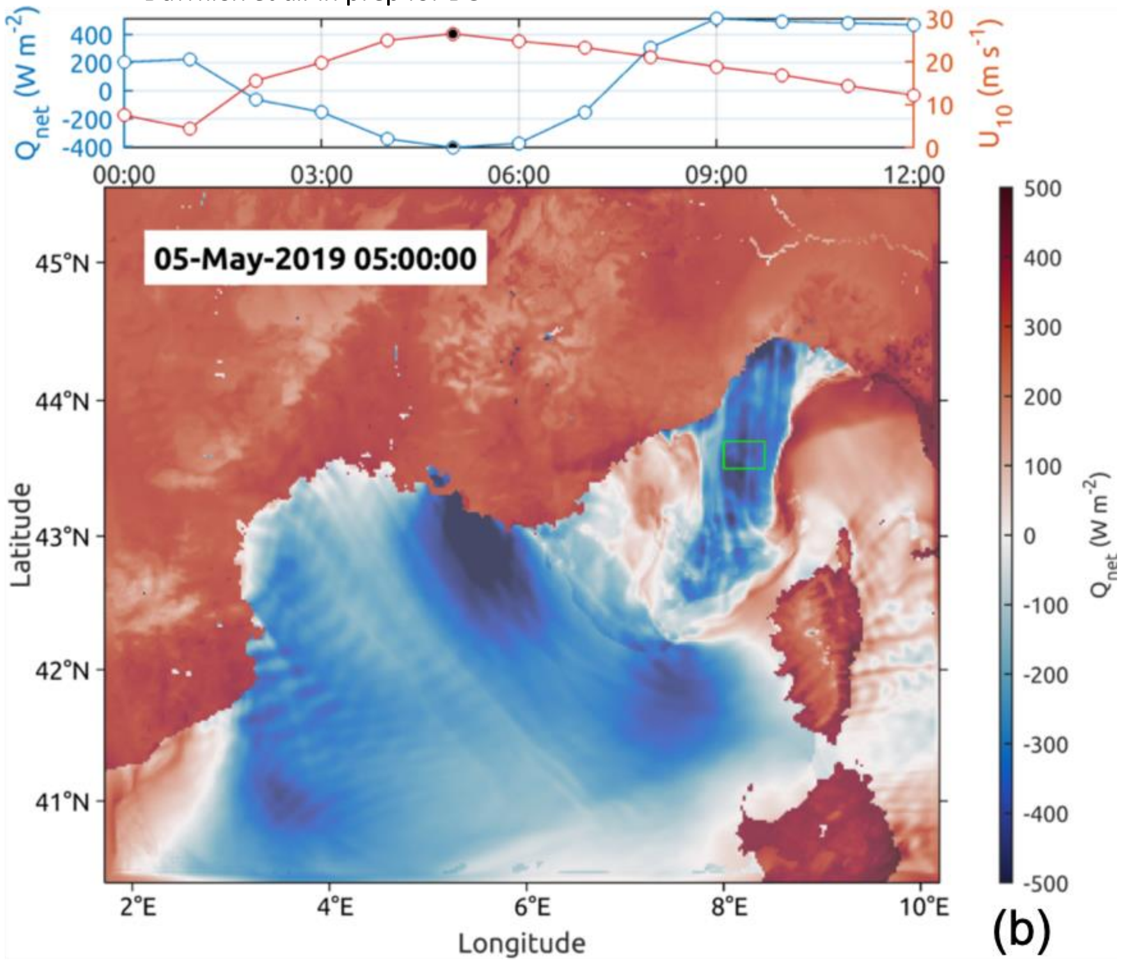
Hydrostatic model
Arakawa C grid
60 vertical sigma-hybrid levels
Model resolution: 2-3 km horizontal
2085 s (35 minutes)

FUMSECK *SYMPHONIE model*

Barrillon *et al.* in prep for BG



Meteorological event considered as exceptional

→ annual to semi-decadal storm

FUMSECK *SYMPHONIE model*

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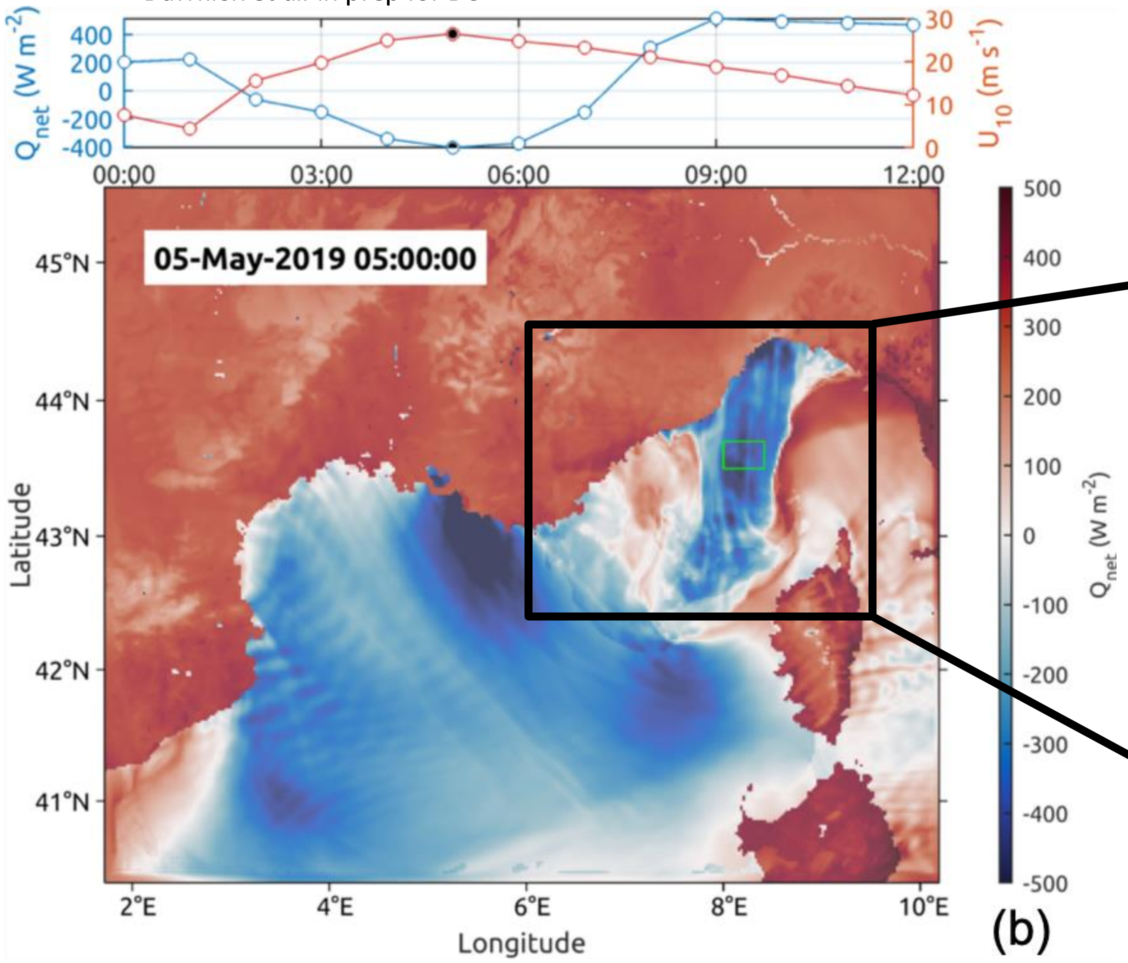
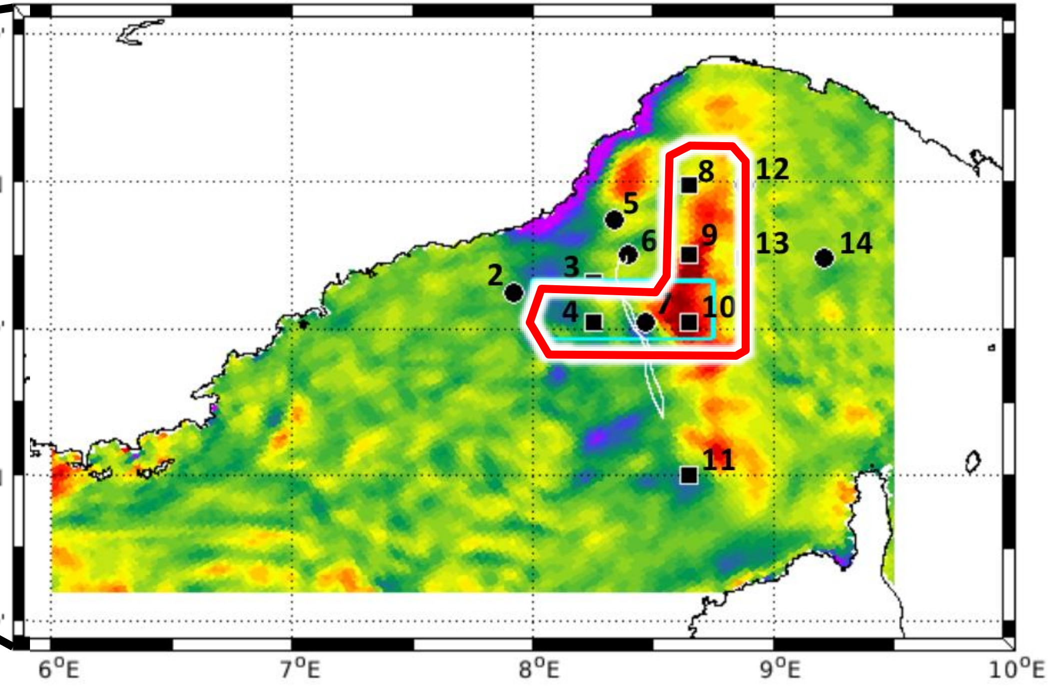


Lack of *in situ* measurements

→ numerical outputs

focus from May 1st to 8th, 2019



Meteorological event considered as exceptional

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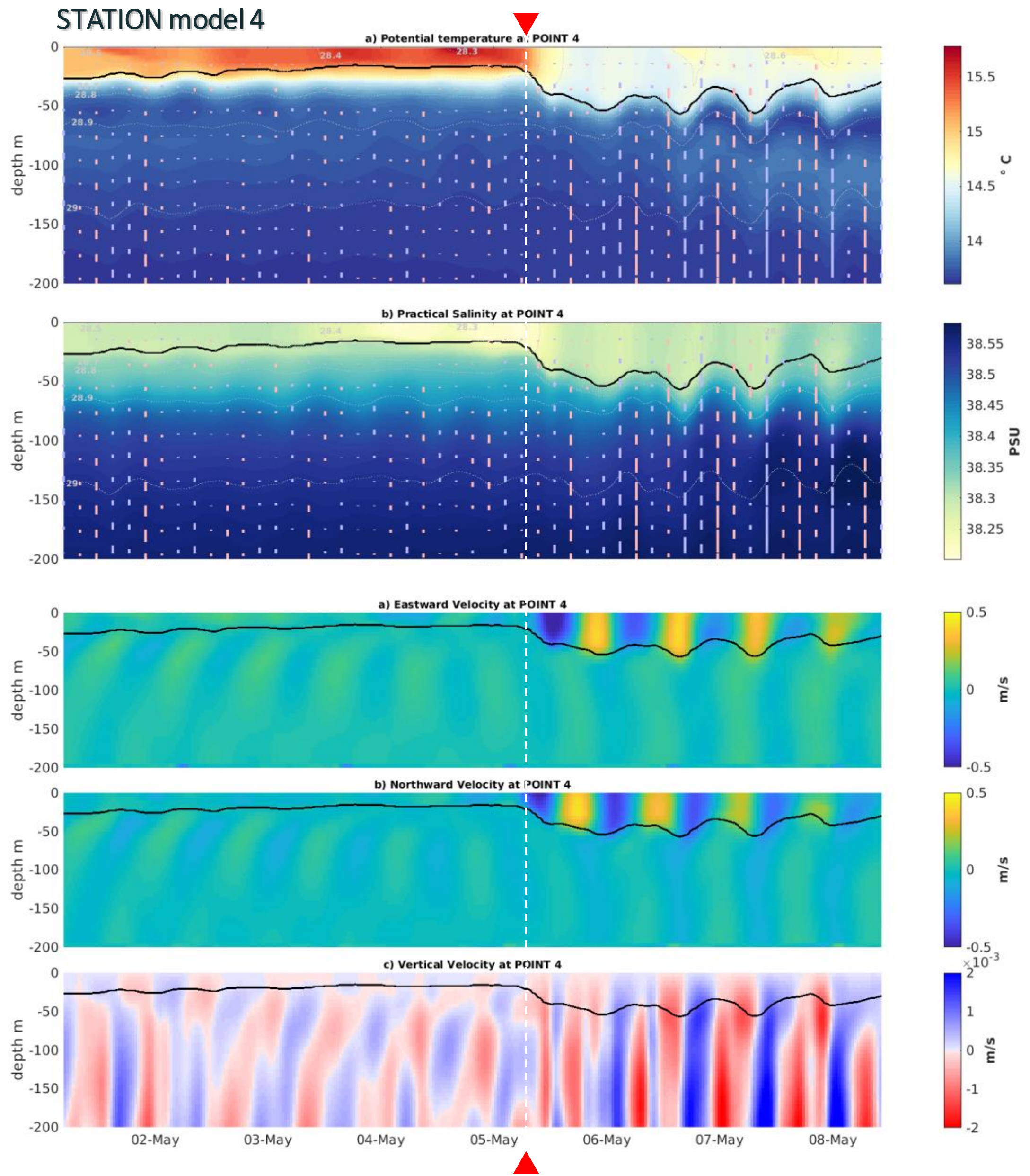
Analysis of hydrodynamics

for the **area** most affected by the storm

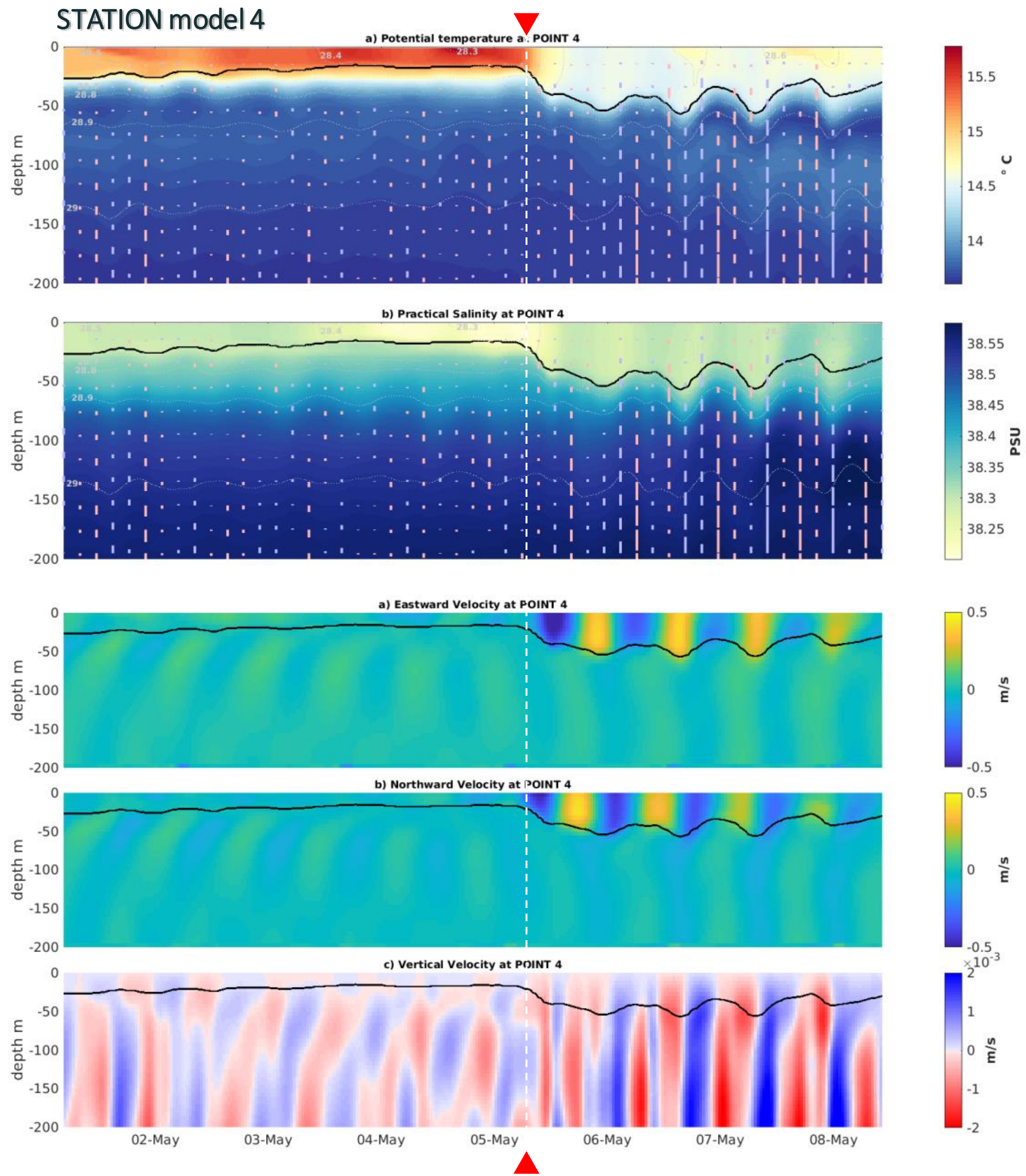
Impulse event: annual to mid-decadal storm



Impact of the storm on water column dynamics:

1) **Deepening** of the Mixed Layer Depth
2) **Triggering of oscillations** for all **3** current components
3) Currents **velocity intensification** :
   u, v → contained in the mixed layer
   w → > 200 meters

Impulse event: annual to mid-decadal storm



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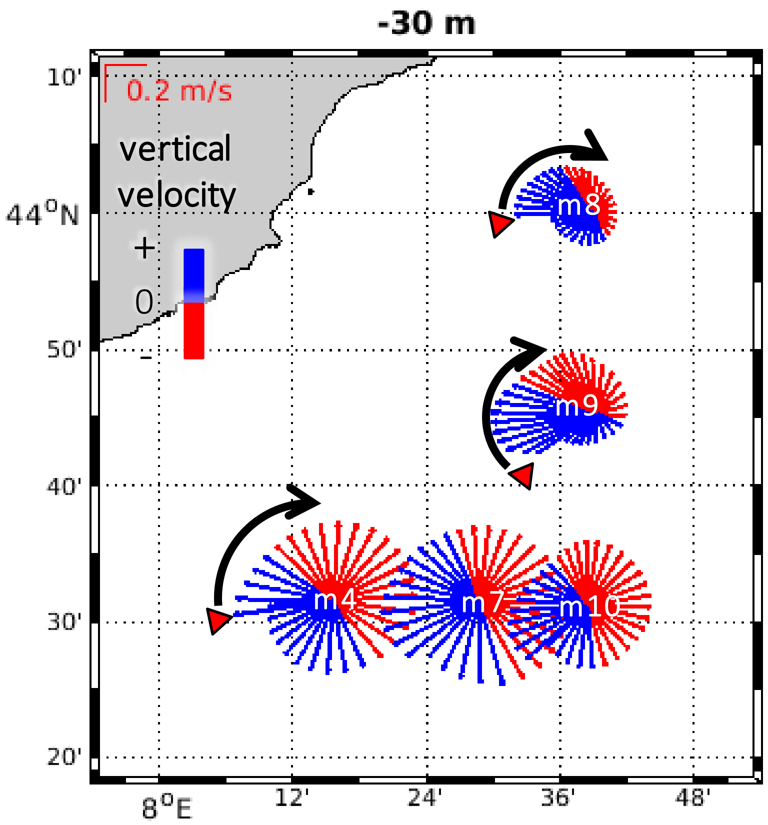
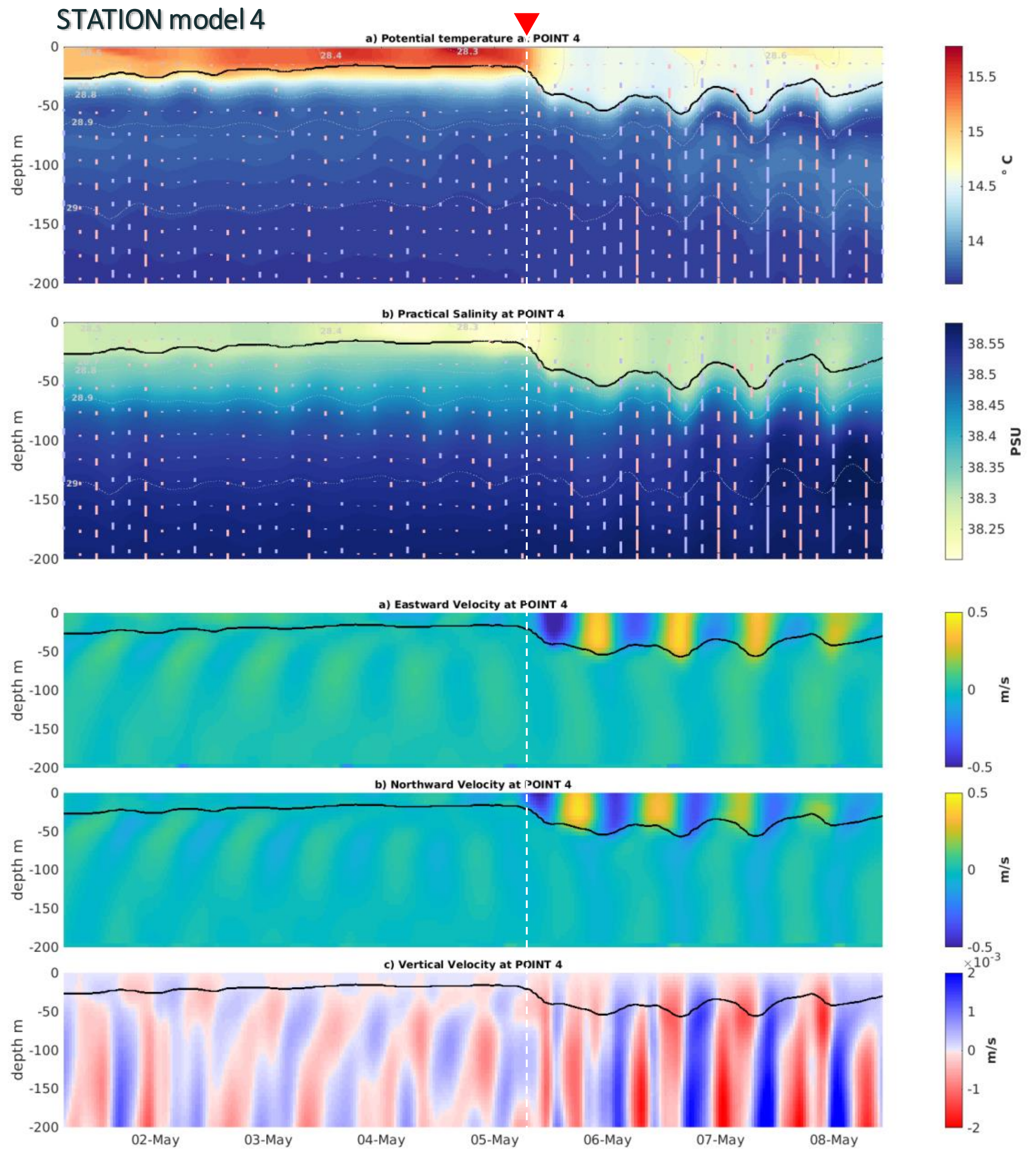


Ellipse 1st period
Clockwise rotation
1 cycle u,v
1 oscillation w
Period = 17h20' – 18h30'

Impulse event: annual to mid-decadal storm



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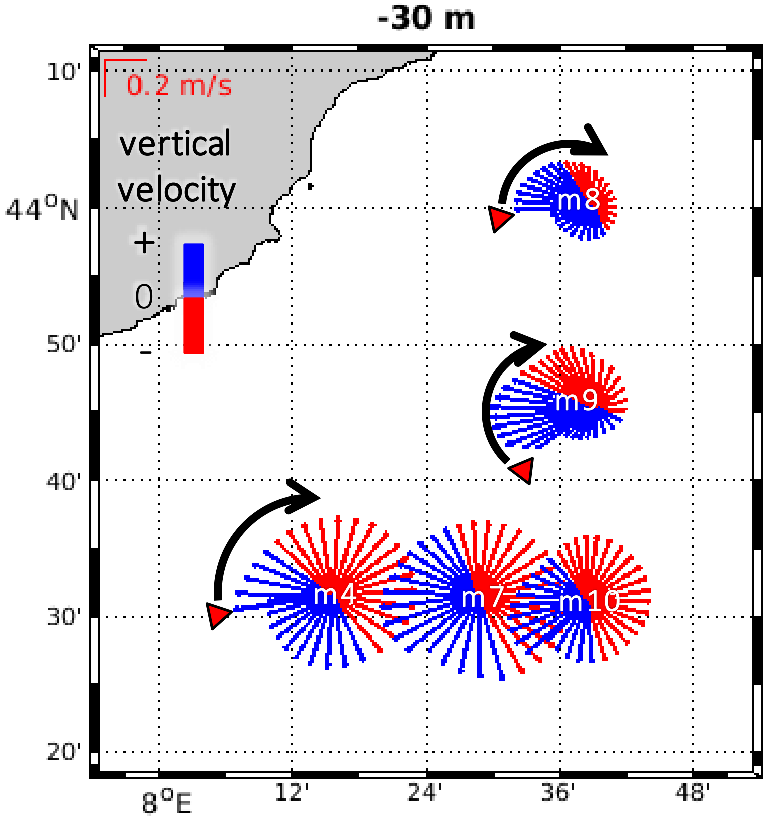


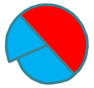
Ellipse 1st period
Clockwise rotation
1 cycle u,v
1 oscillation w
Period = 17h20' – 18h30'

Close to the inertial period in the Northwerstern Mediterranean Sea

Impulse of quasi-inertial oscillations

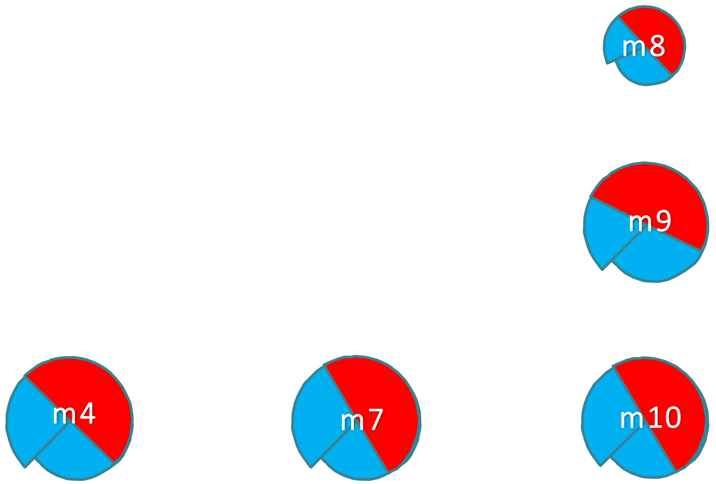
Impulse event: space-time impact

w < 0



mX : station n°X from the **model**

w > 0



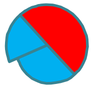
<u>Time impact</u>

May 6th, 2019

30 m depth

Impulse event: space-time impact

w < 0



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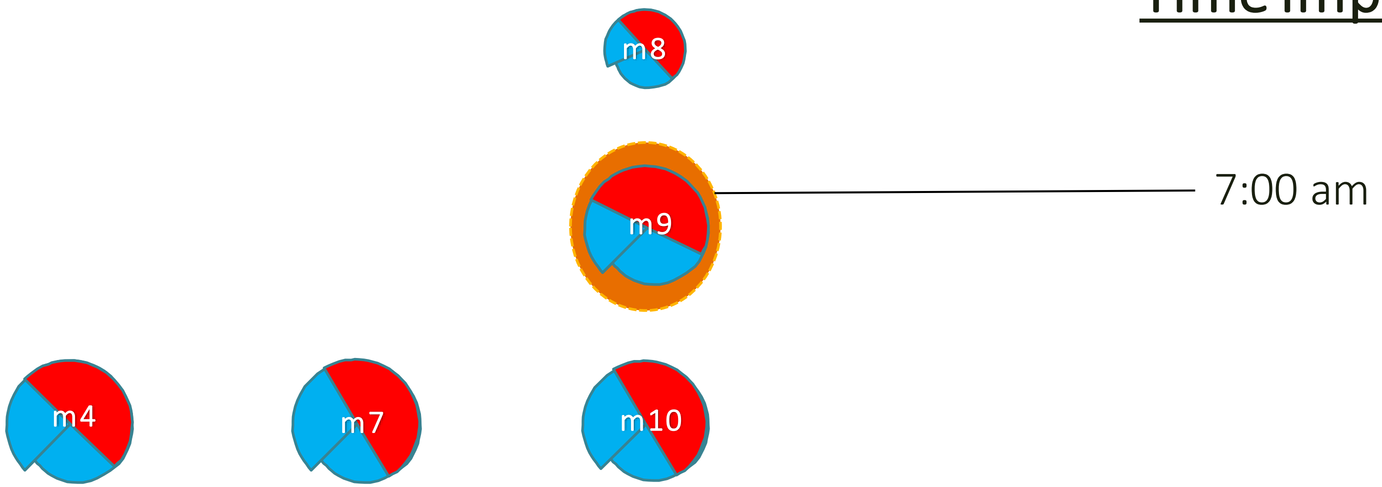

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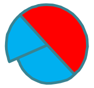

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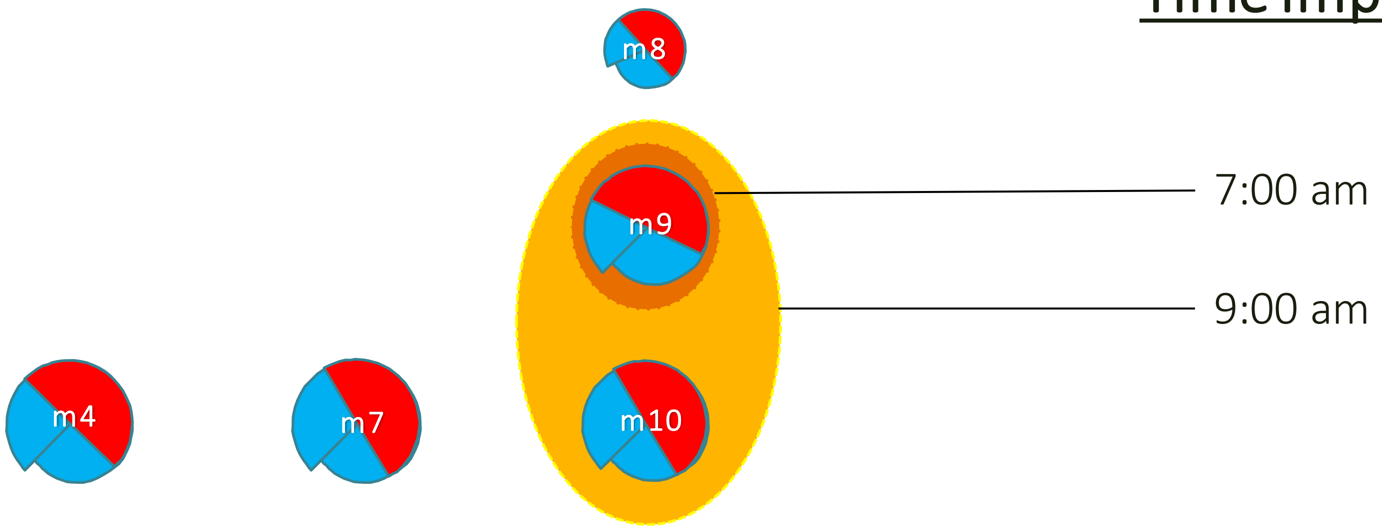

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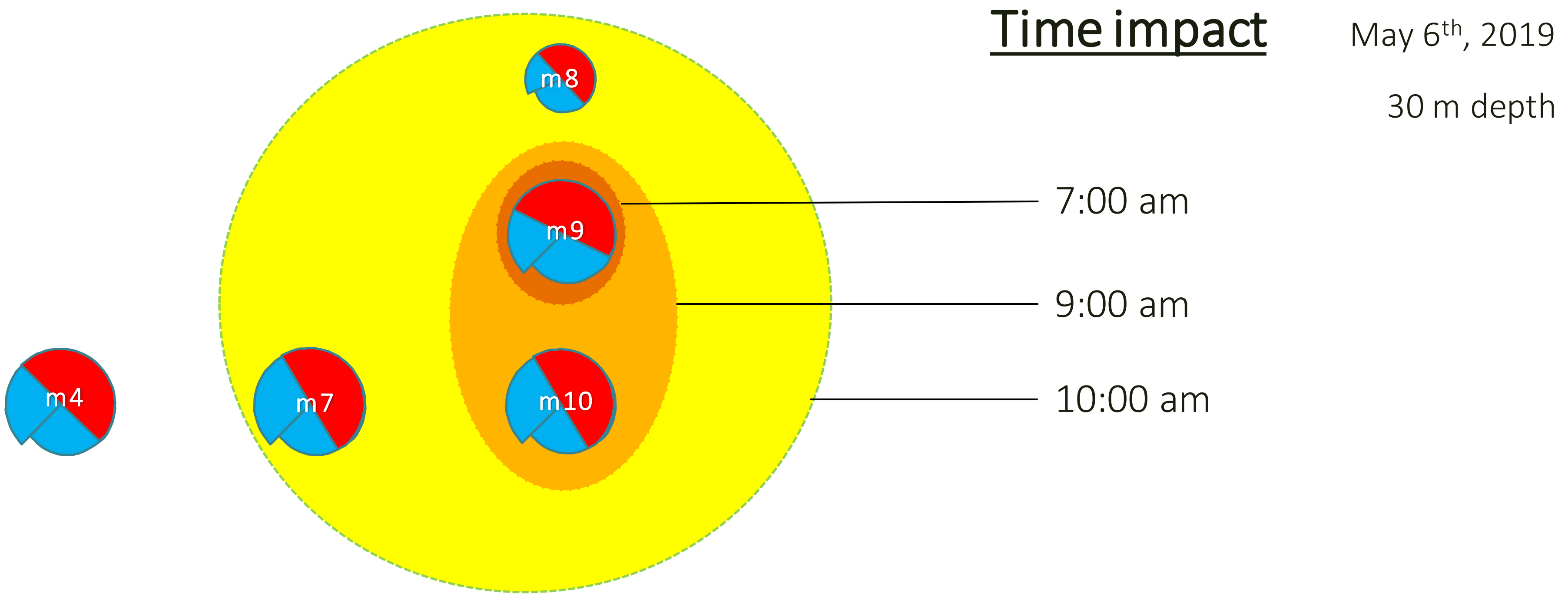

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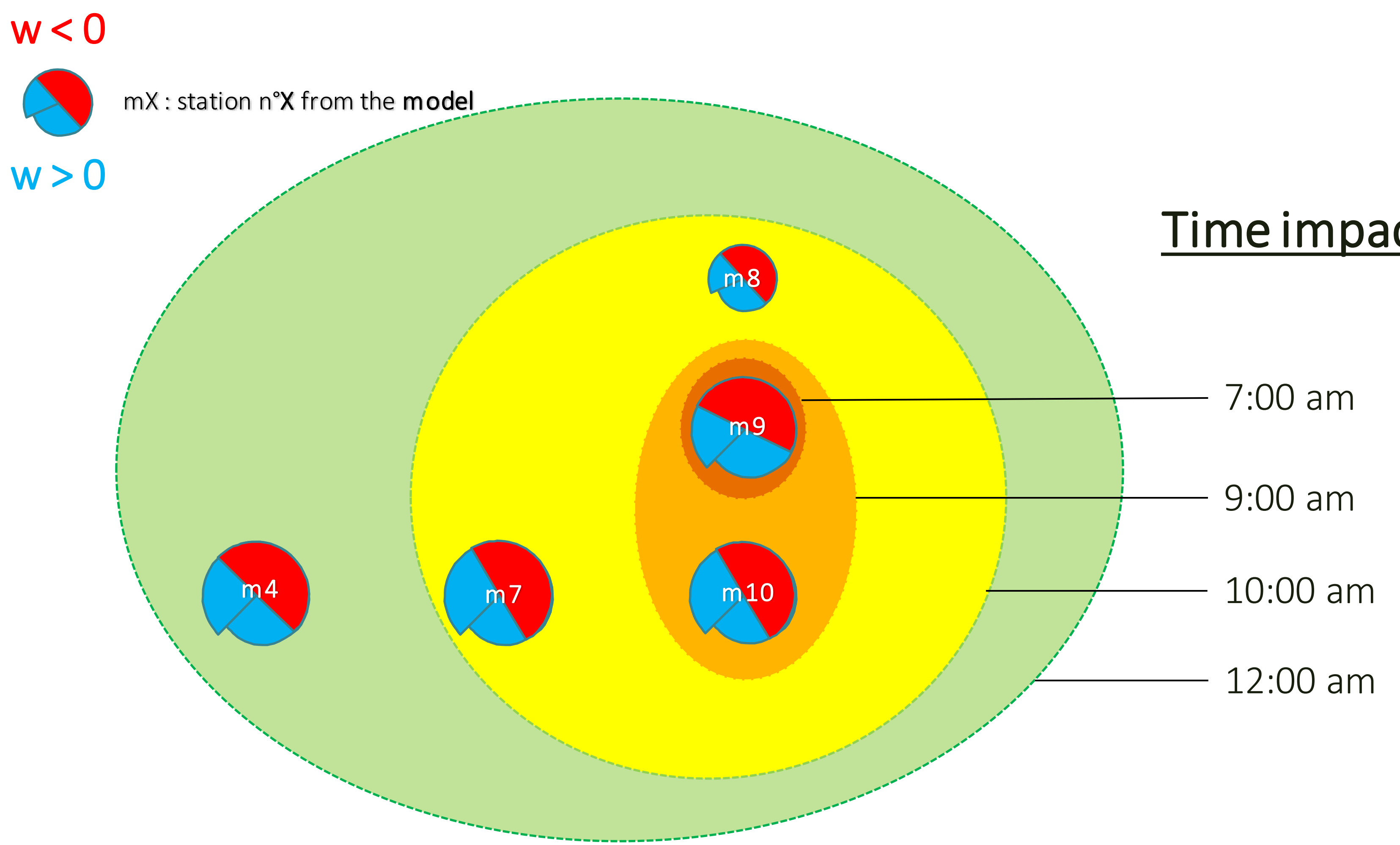

Time impact

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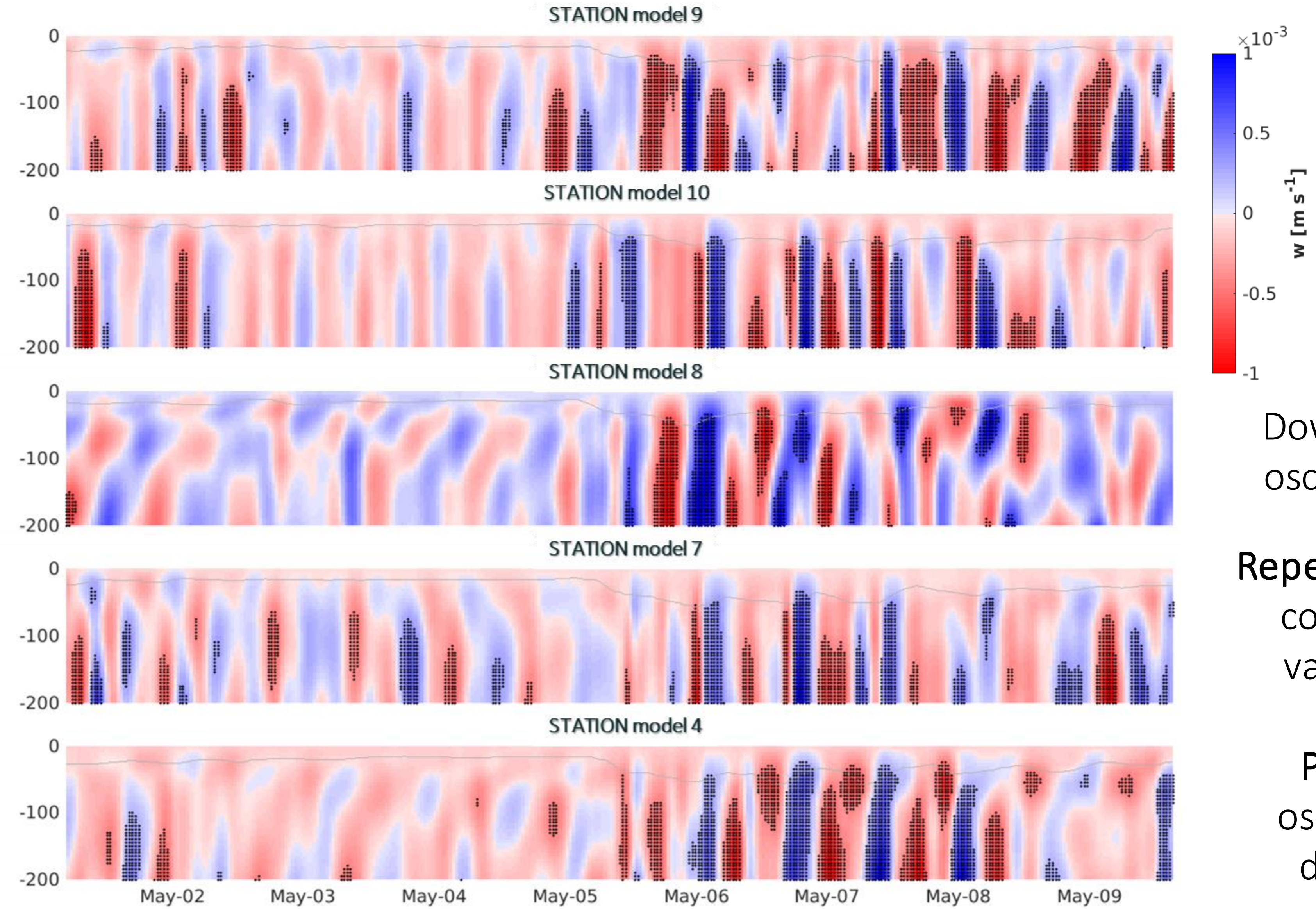
30 m depth

Impulse event: effect on vertical velocities



- Threshold
  $|w| > 0.7\ 10^{-3}$ m s^{-1}

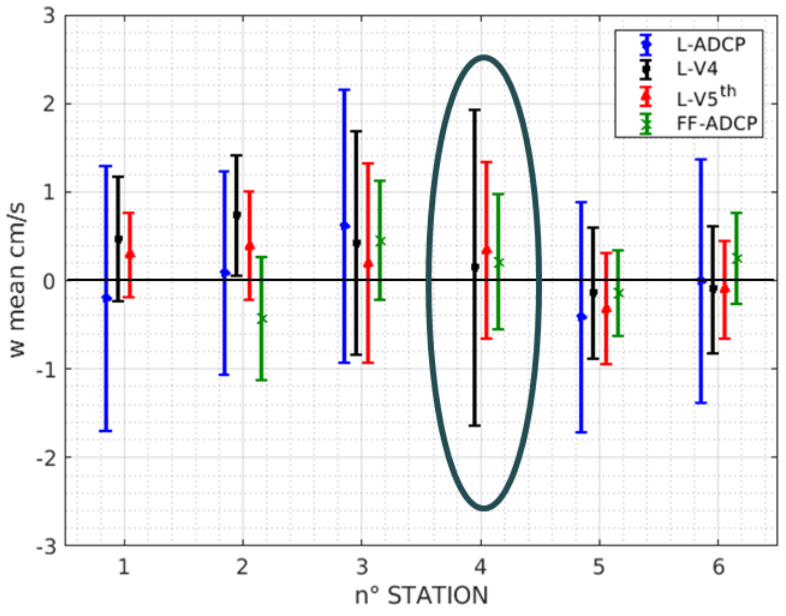
Downward/upward vertical velocity oscillations of **intensity > 0.7 mm/s**

Repercussion overall the water column, contrary to the horizontal velocity variations constrained in the MLD

Persistence of the quasi-inertial oscillation of the vertical velocities during 4 to 6 periods (**few days**)
> Horizontal oscillations

Conclusions

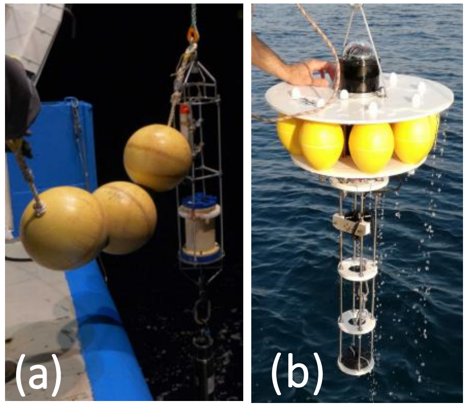
- **Generalized method to measure** vertical velocity with different instruments $O(10^{-3} - 10^{-2})$ **m/s**
  → FF-Sentinel: under development (expectation of an optimal accuracy)



- **Coupling with numerical modelling** is essential when physical sampling is no longer possible
  → for Northwestern Mediterranean Sea, regional numerical models as Symphonie appear to be the solution

- **Other options to estimate w**:
  Omega-equation, glider flight models,
  Vessel mounted ADCPs,
  New prototypes under development

- **Instrumental development at MIO**:
  FF-ADCP / FF-Sentinel (**a**)
  Vertical Velocity Profiler (**b**)



Acknowledgements

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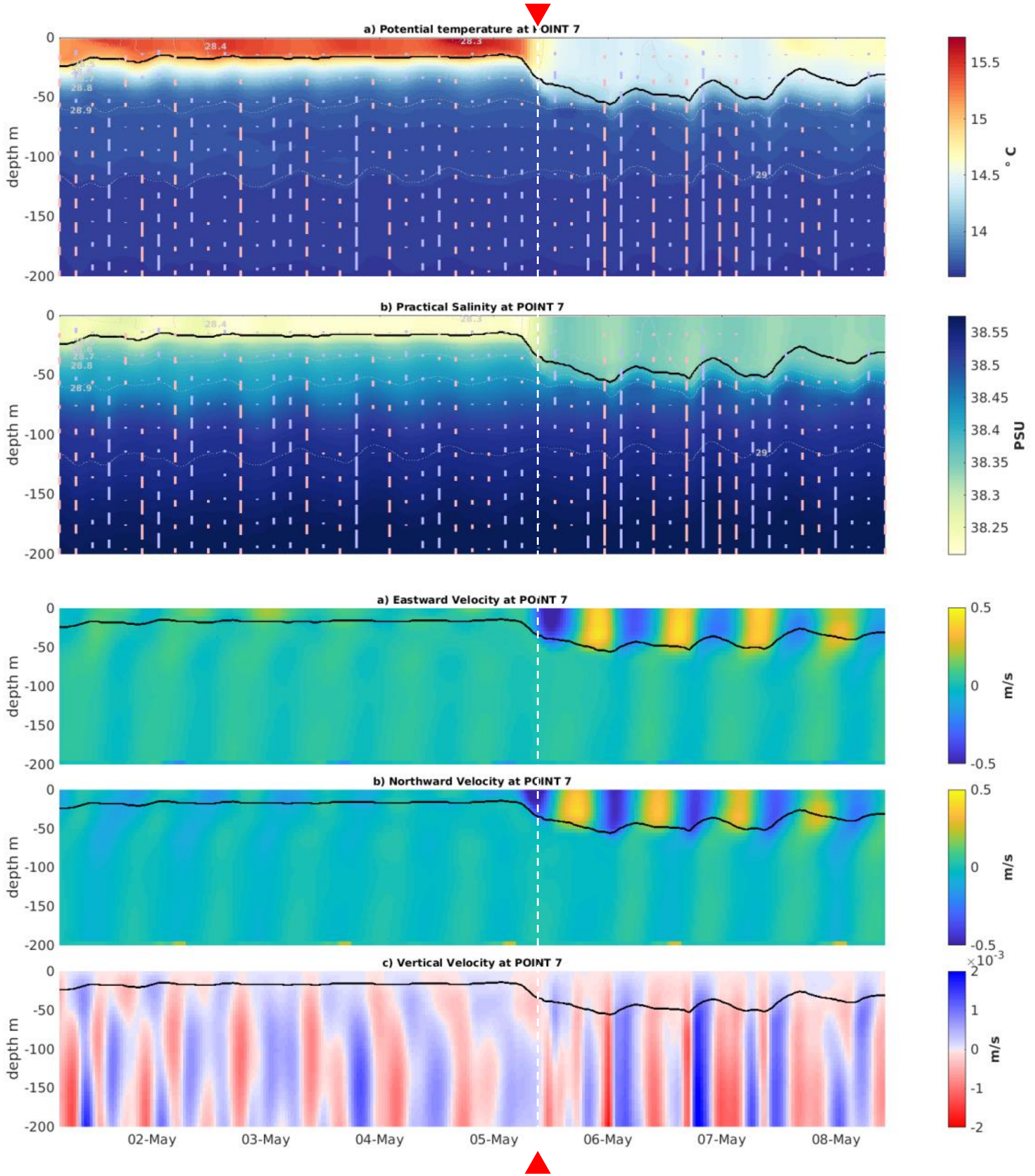
Collaborators: CNES, Teledyne RD Instrument

Funders: MENRT French national PhD grant, BIOSWOT project, FUMSECK-vv LEFE project

TITLE

STATION 7

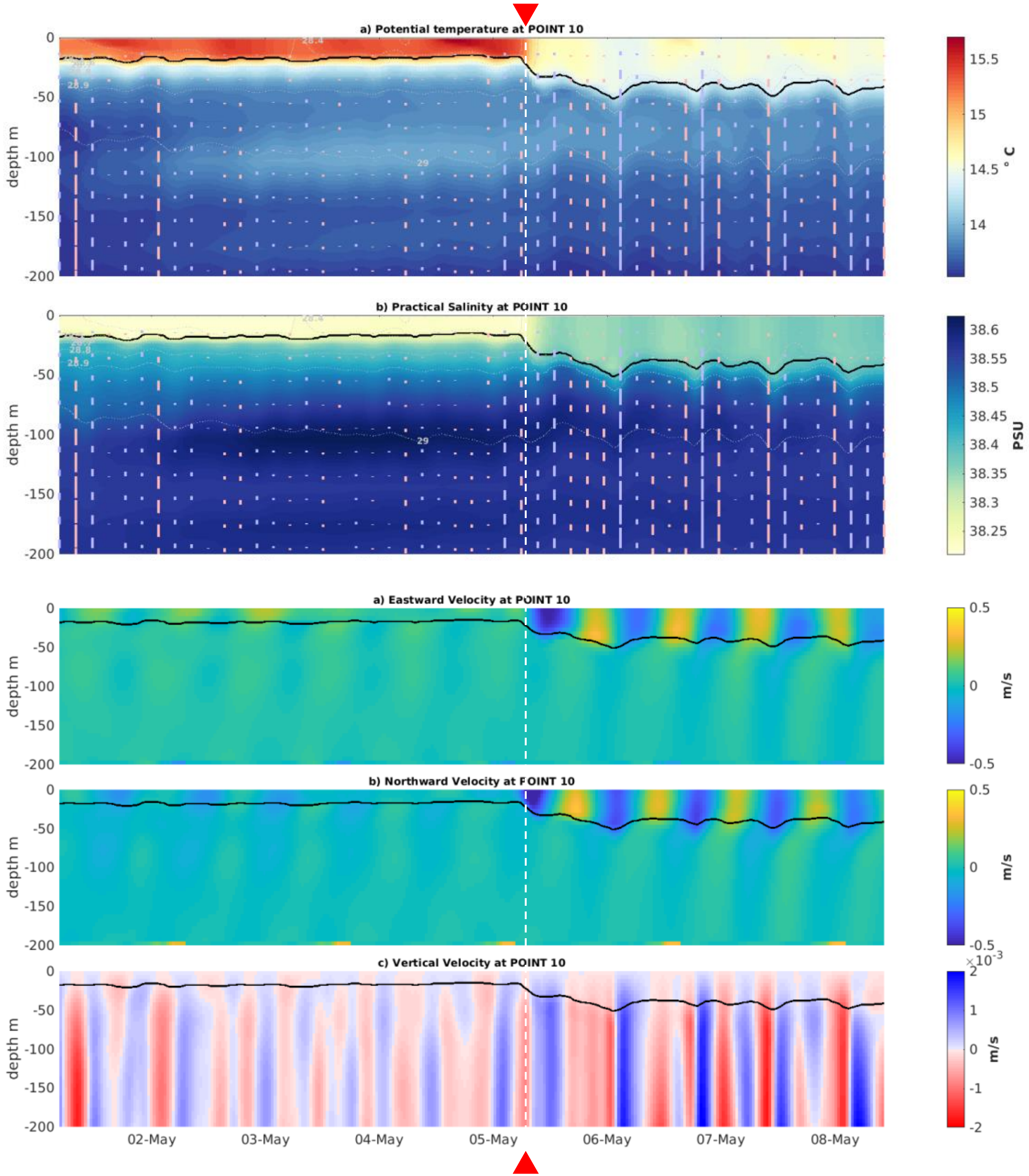


Approfondissement de la couche de mélange

Déclenchement d’oscillations quasi-inertielles

Intensification des vitesses verticales

TITLE



STATION 10

Approfondissement de la couche de mélange

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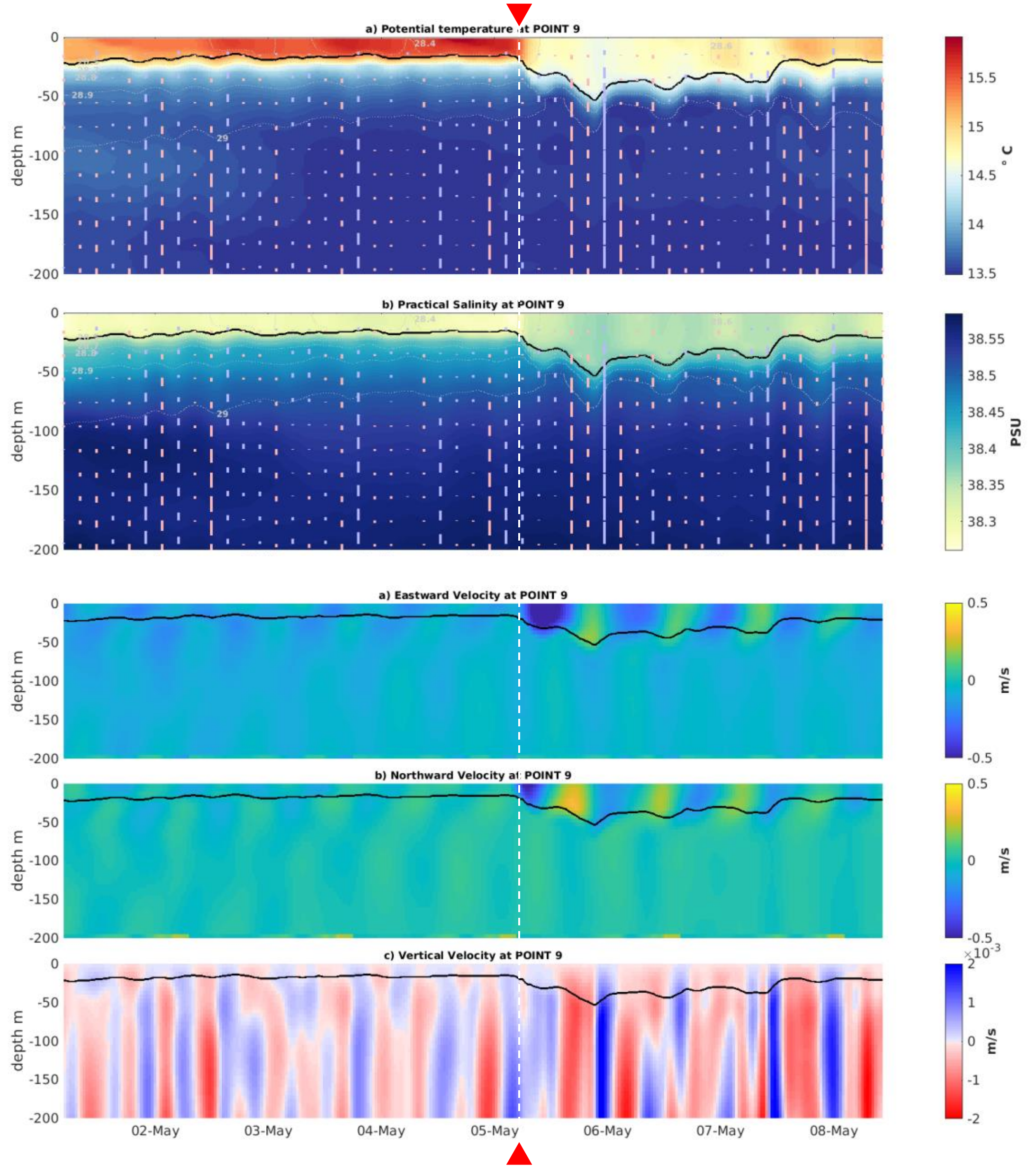
Intensification des vitesses verticales

TITLE



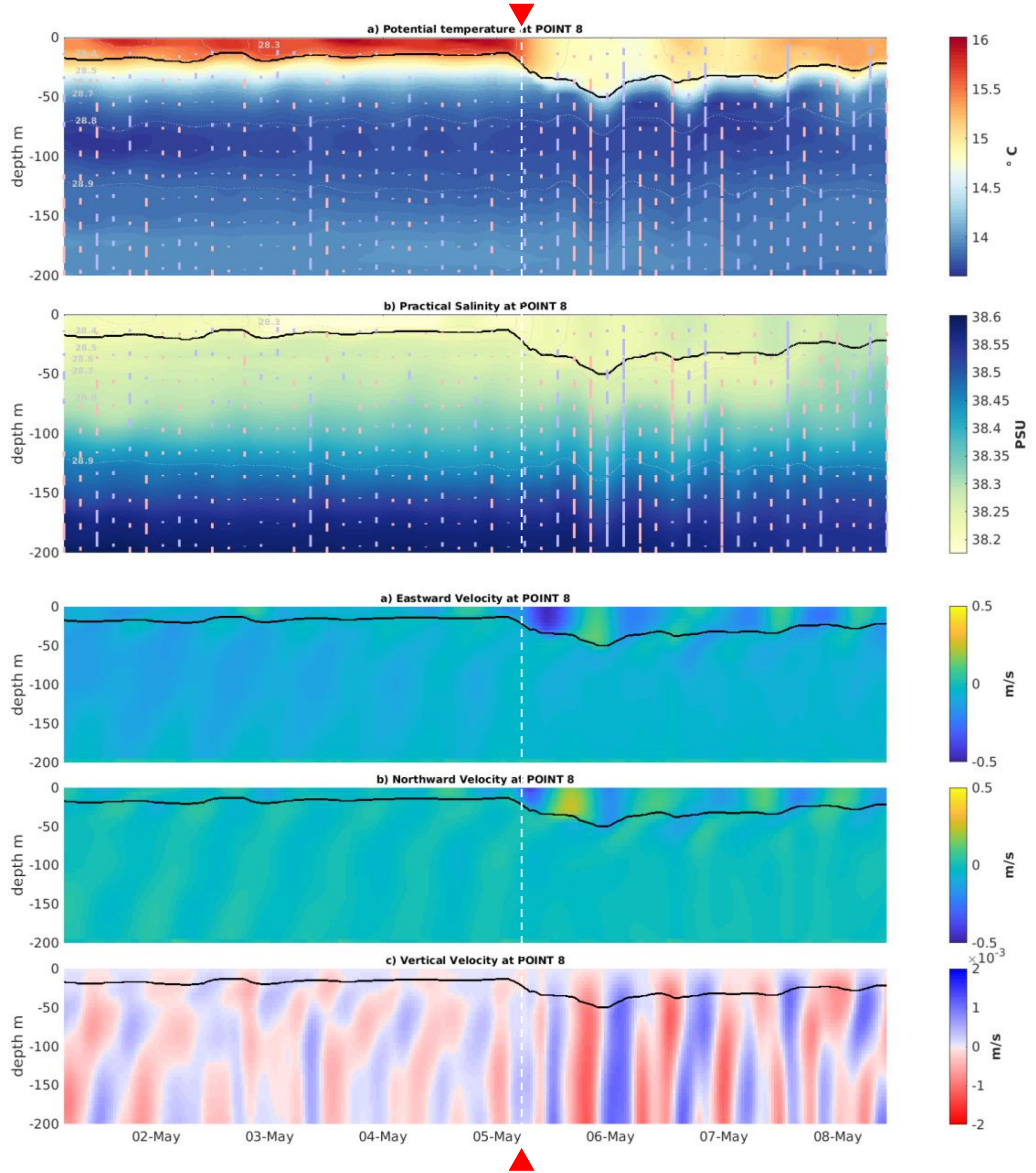
STATION 9

Approfondissement de la couche de mélange

Déclenchement d’oscillations quasi-inertielles

Intensification des vitesses verticales

TITLE



STATION 8

Approfondissement de la couche de mélange

Déclenchement d’oscillations quasi-inertielles

Intensification des vitesses verticales