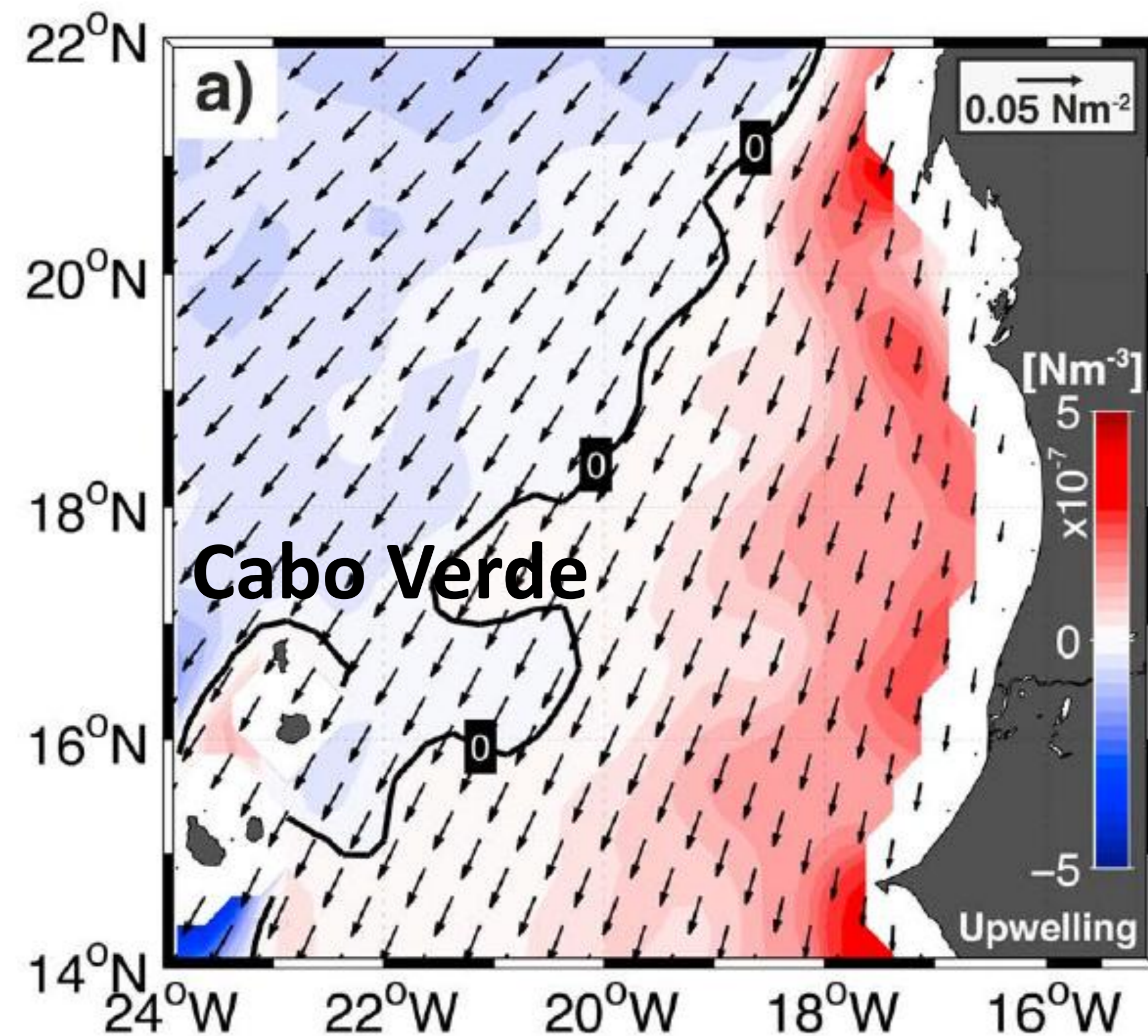# Eddies in the Canary eastern boundary upwelling system
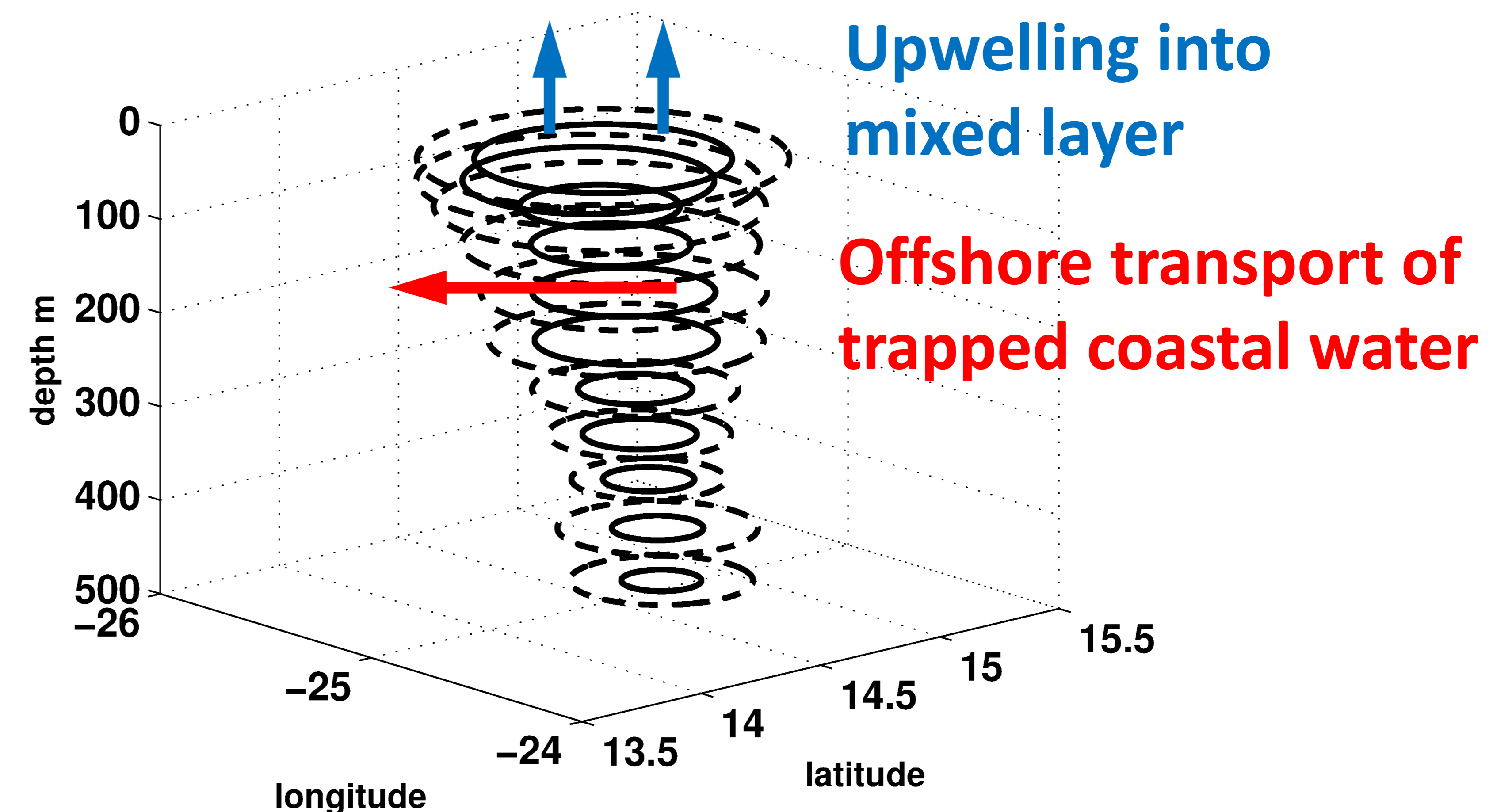
Tim Fischer,[1] Johannes Karstensen,[1] Ahmad Fehmi Dilmahamod,[1] Marcus Dengler,[1] Florian Schütte [2]

[1] GEOMAR Helmholtz Centre for Ocean Research Kiel, [2] Max Planck Institute for Meteorology Hamburg,   contact: tfischer@geomar.de

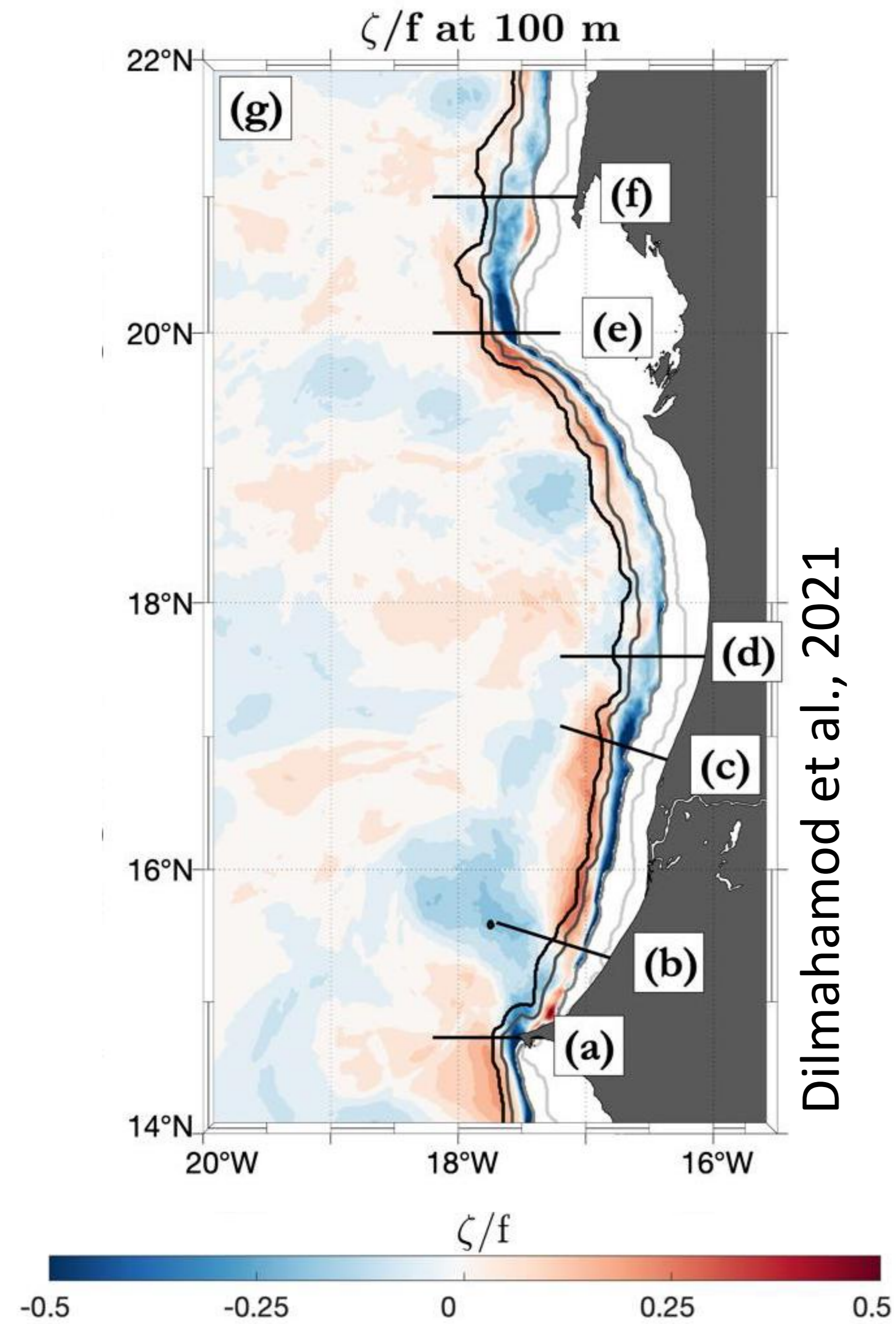## Coastal upwelling and wind stress curl driven upwelling
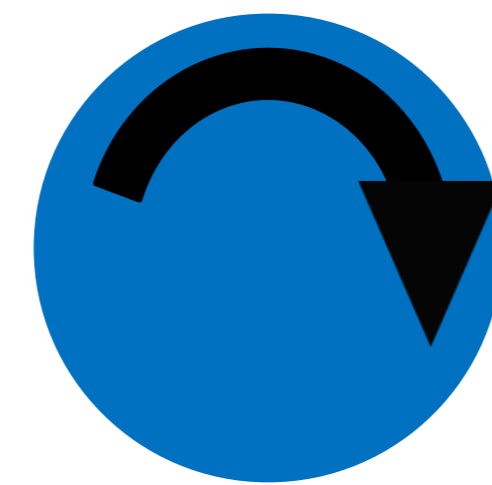
Additional effects by eddies ('Extended upwelling')

Upwelling into mixed layer

Offshore transport of trapped coastal water

Role of Eddies in the carbon pump of Eastern Boundary Upwelling Systems

Coastal eddy genesis and statistics

Coastal eddy genesis
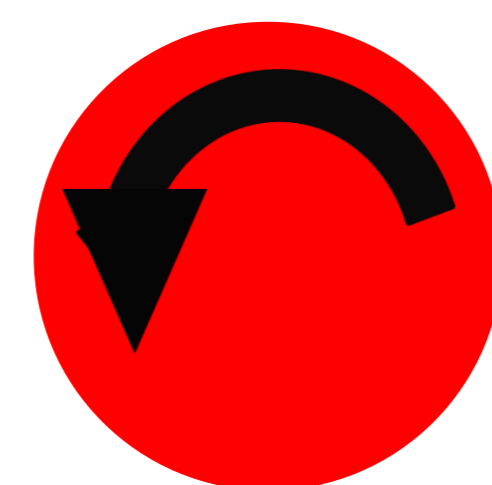

Dilmahamod et al., 2021

Dilmahamod et al., 2021
In a high-res. model study
(1.5 km MOM)

Anticyclones and
Anticyclonic modewater eddies
(ACME)
Generated by negative vorticity
of poleward coastal flow and
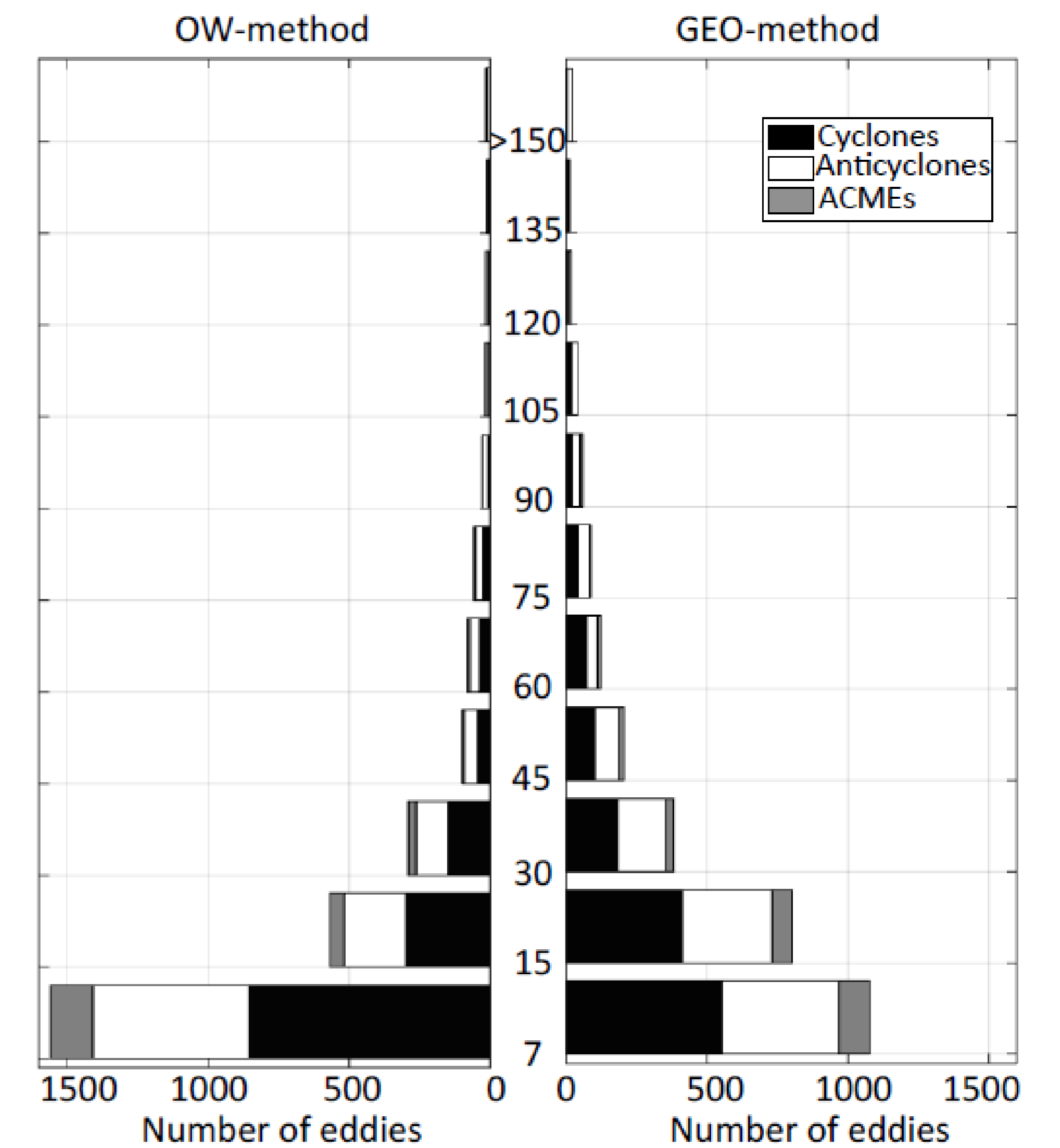**flow separation**

Cyclones
Generated as a secondary effect
between anticyclones and
coastal flow
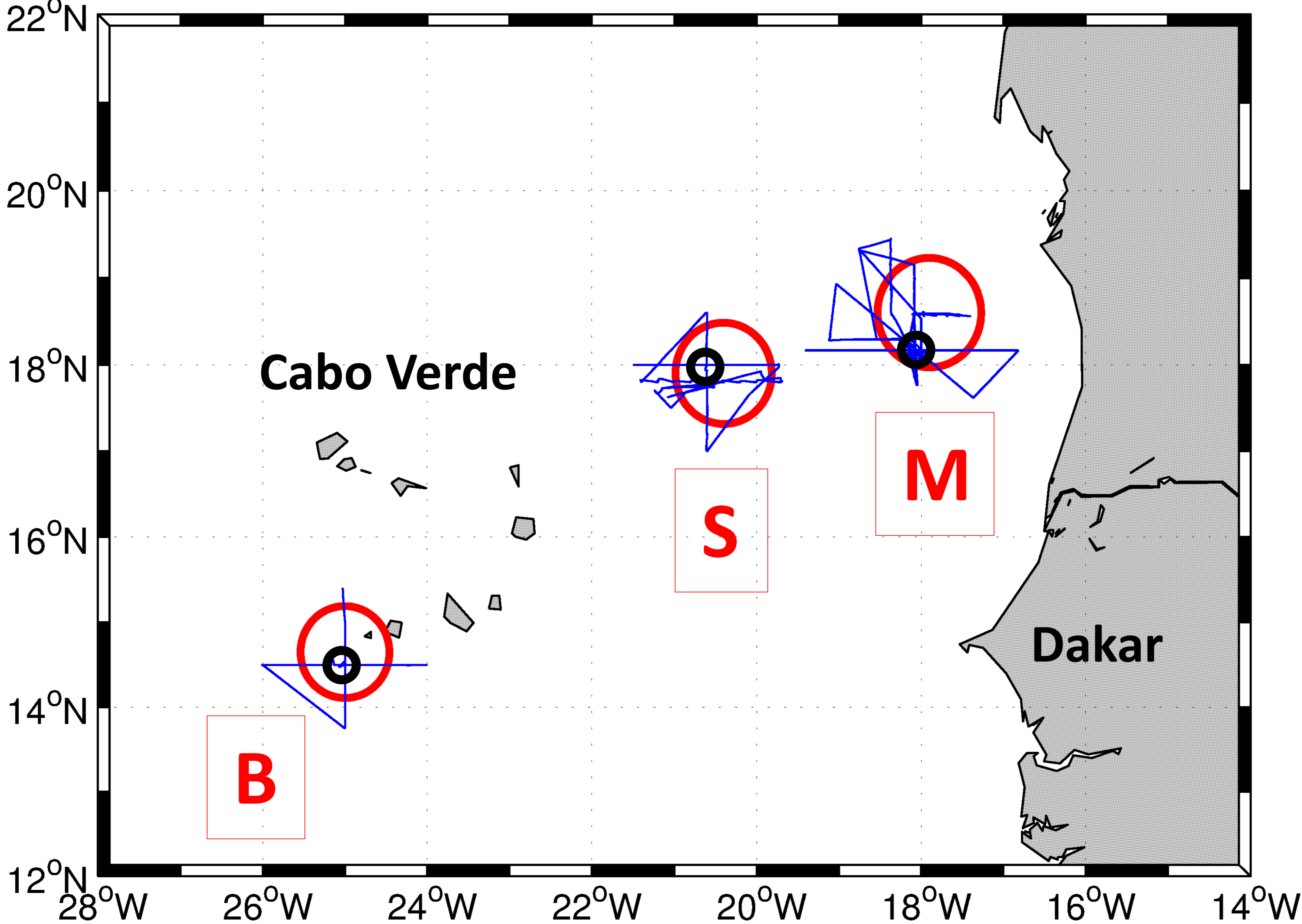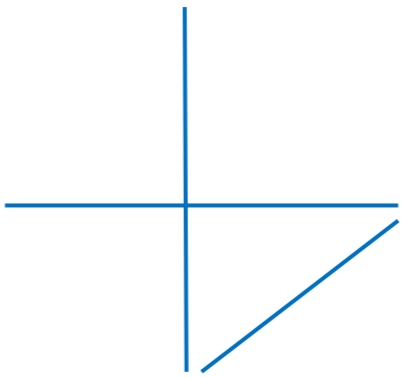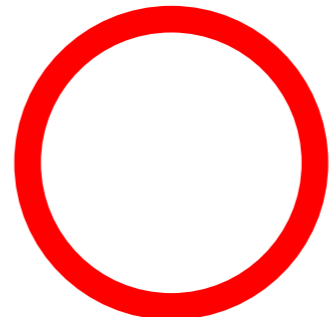
Eddy statistics
(19 years)

Schütte et al., 2016

Average lifetime 30 d
Average westward drift 3 km/d

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Observation of three individual cyclonic eddies

2019:

Interdisciplinary multiplatform survey of three cyclonic eddies (REEBUS/MOSES eddy study)

Ship tracks with in-situ current velocity profiles

A posteriori best estimates of eddy centre and radius

Satellite based estimates of eddy centre

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From current observations: extract mesoscale eddies as a circular symmetric structure

For each depth layer:

observed velocity

circular symmetric fit

residual velocity

=

+
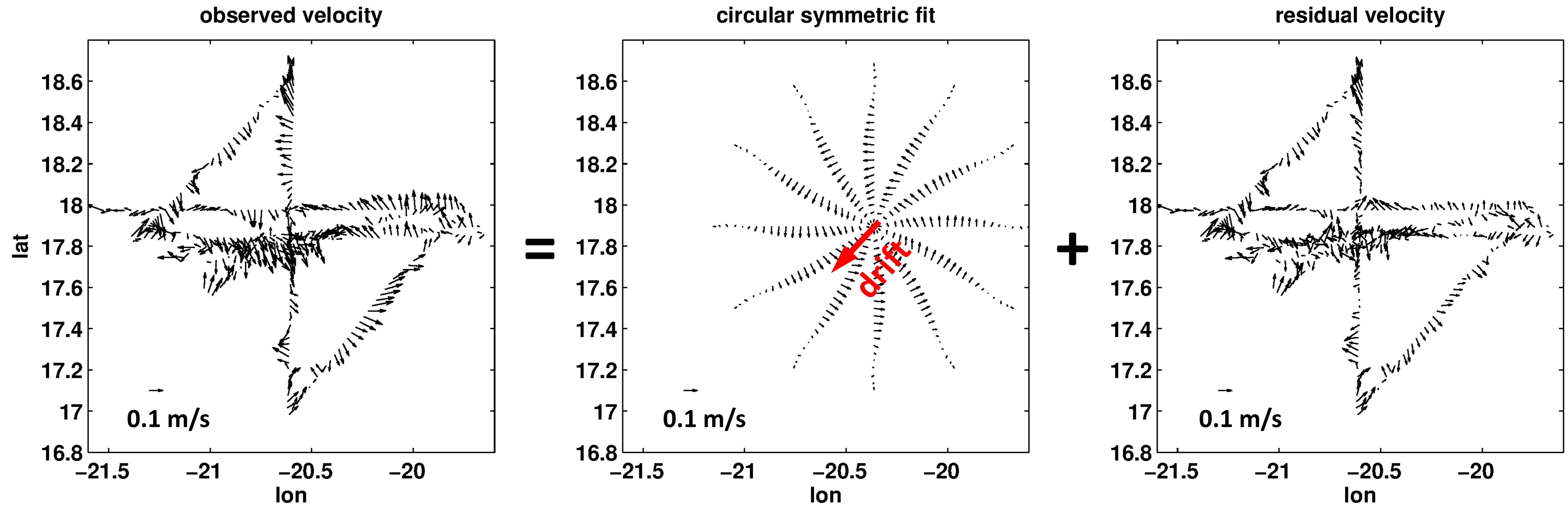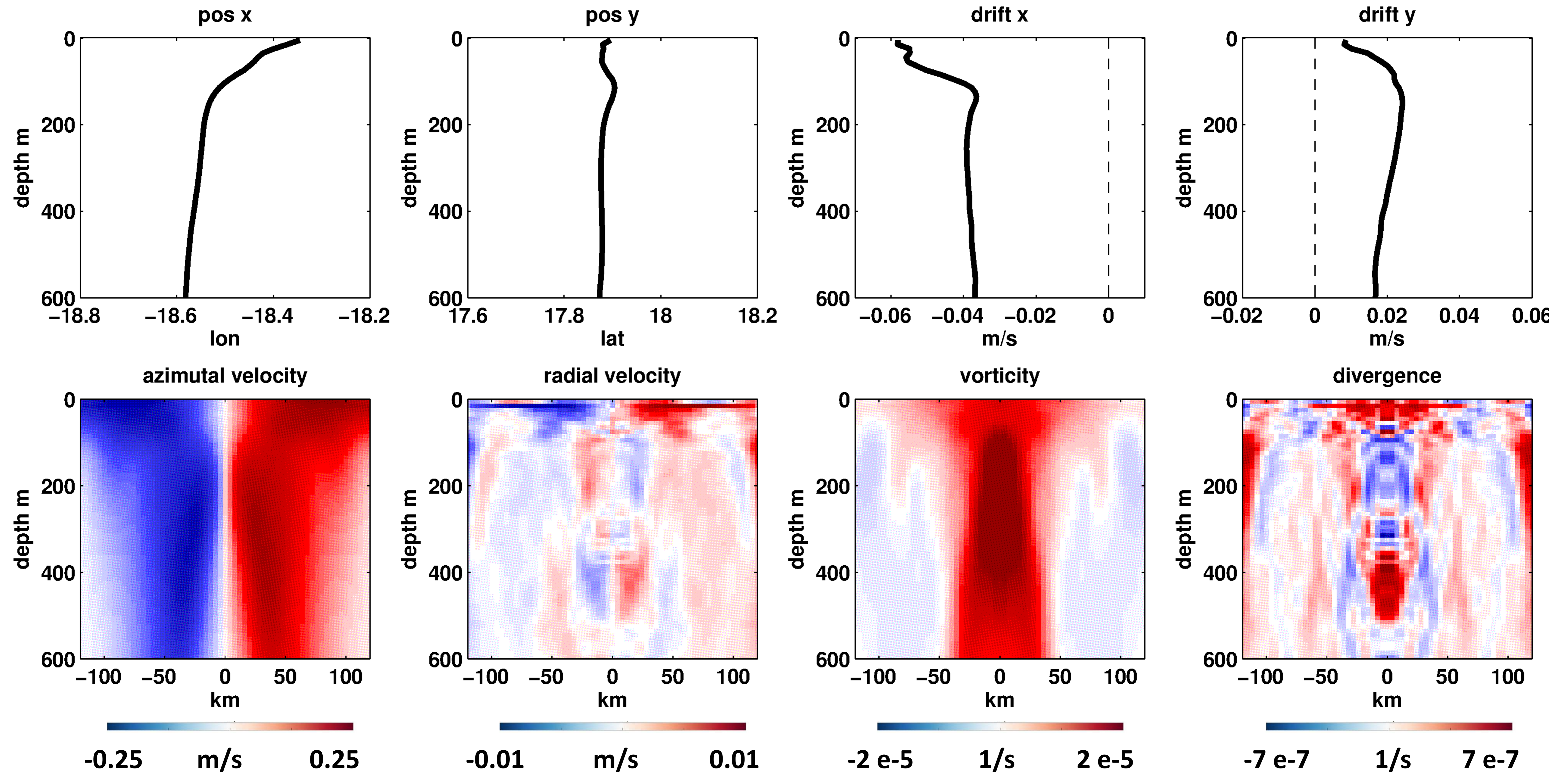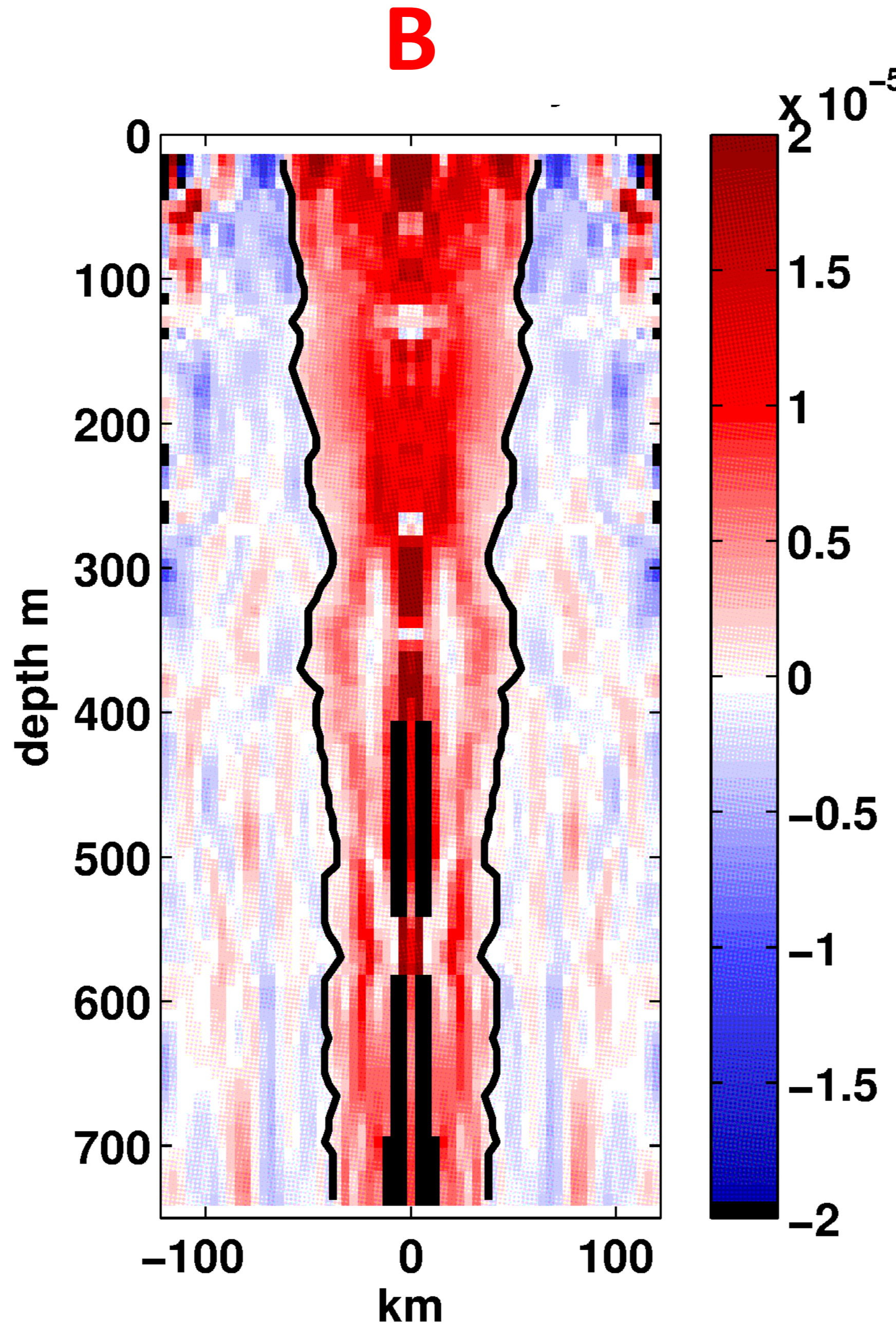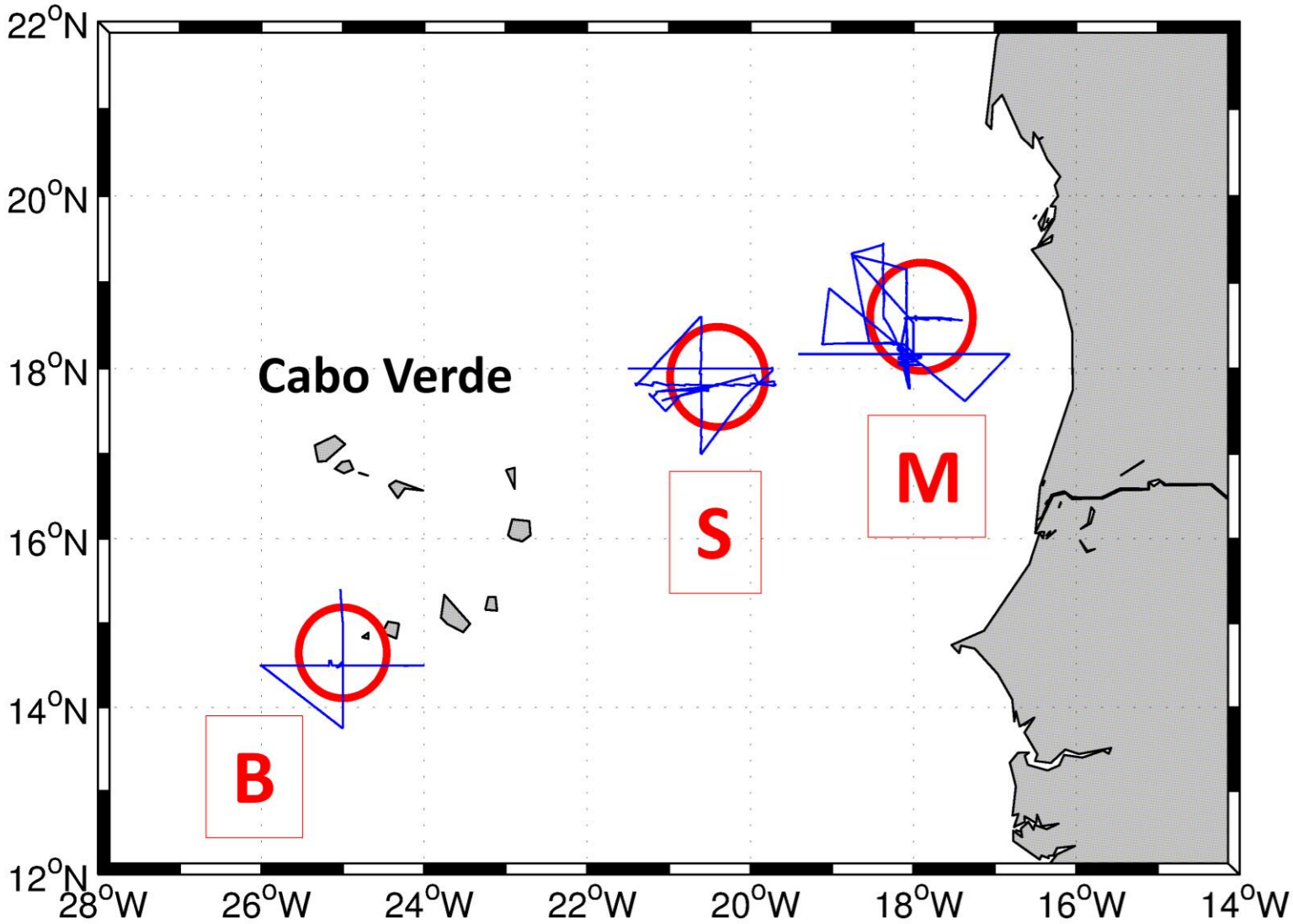
Enables localization
(position and drift) and
3-D reconstruction of dynamics

N.B.: important parts of the
dynamics might hide in the
residual (e.g. small scales)

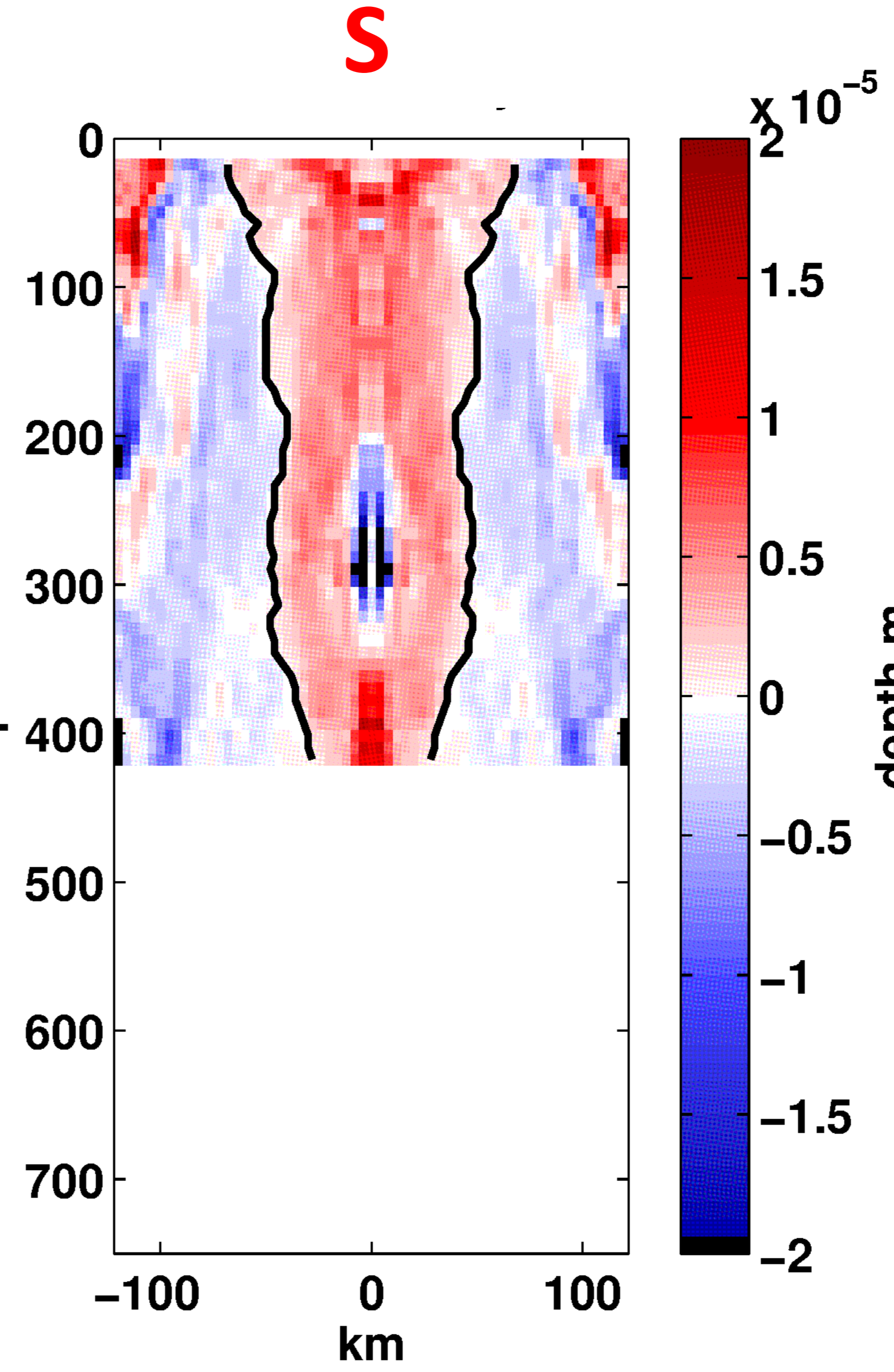tfischer@geomar.de   Lima22 session 10   21.9.22

Example: localization and 3-D reconstruction of a modelled cyclone
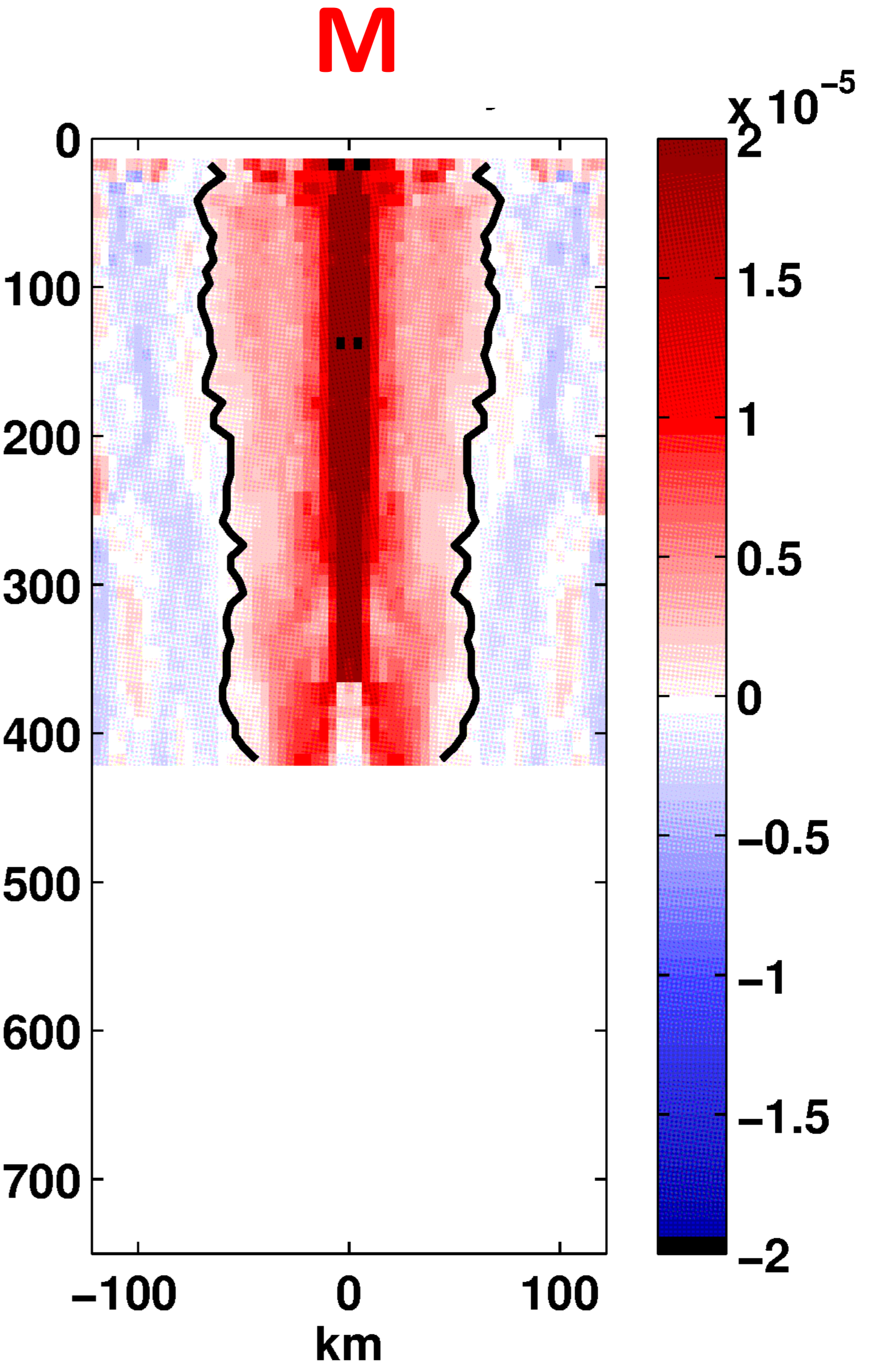
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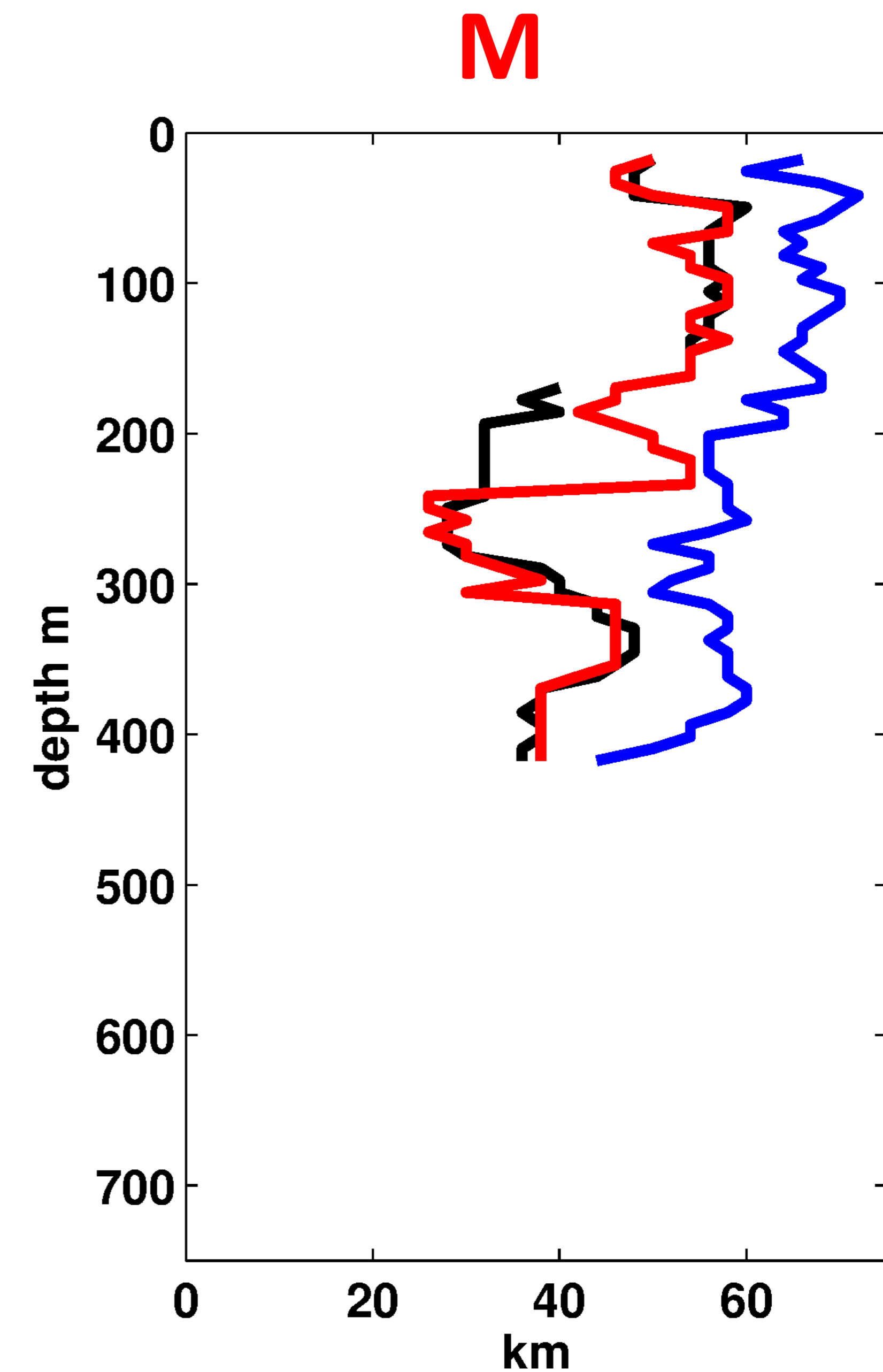# Vorticity structure of the three observed cyclones

$\zeta/f = 0.4$ $\zeta/f = 0.1$ $\zeta/f = 0.5 \ldots 0.1$

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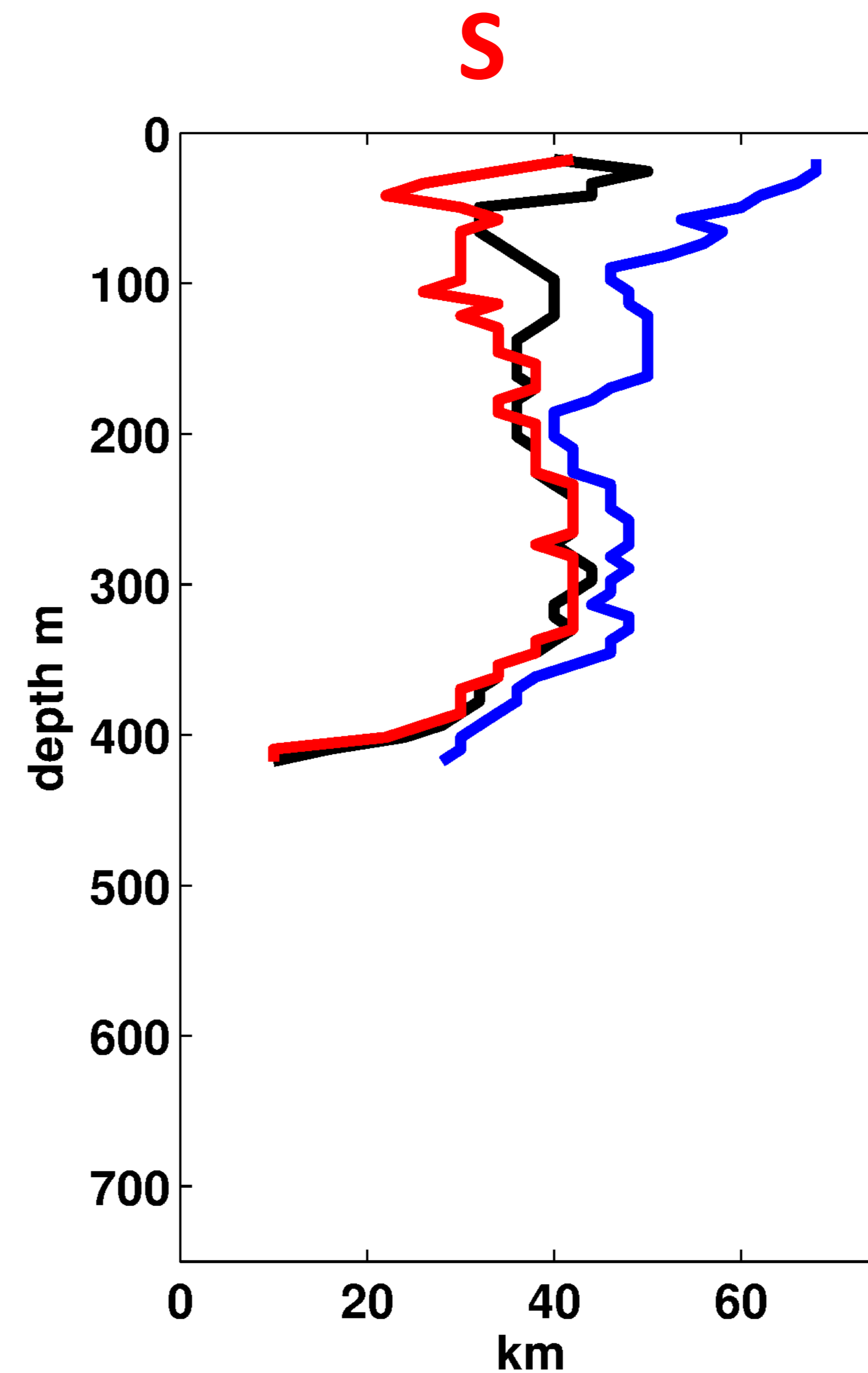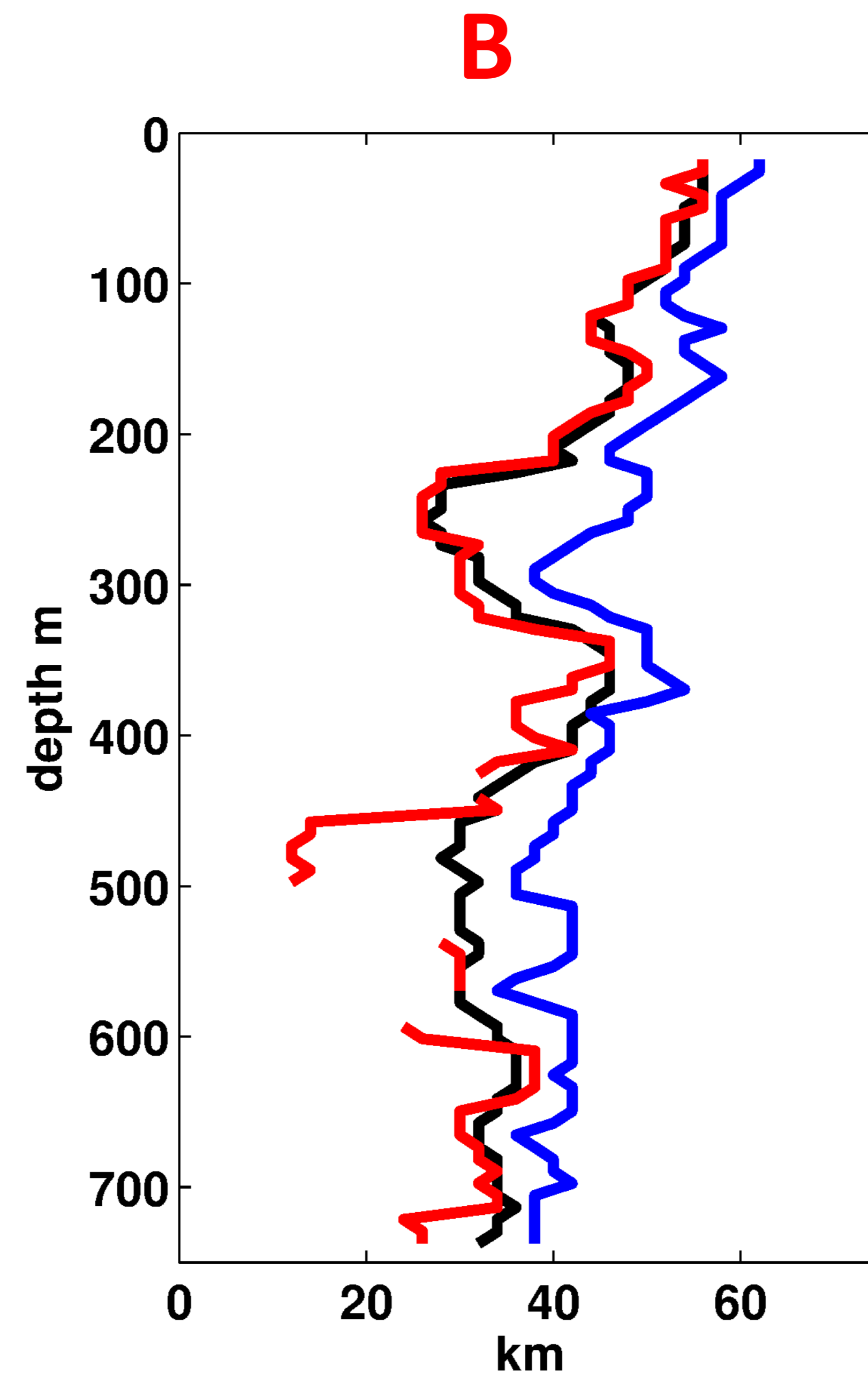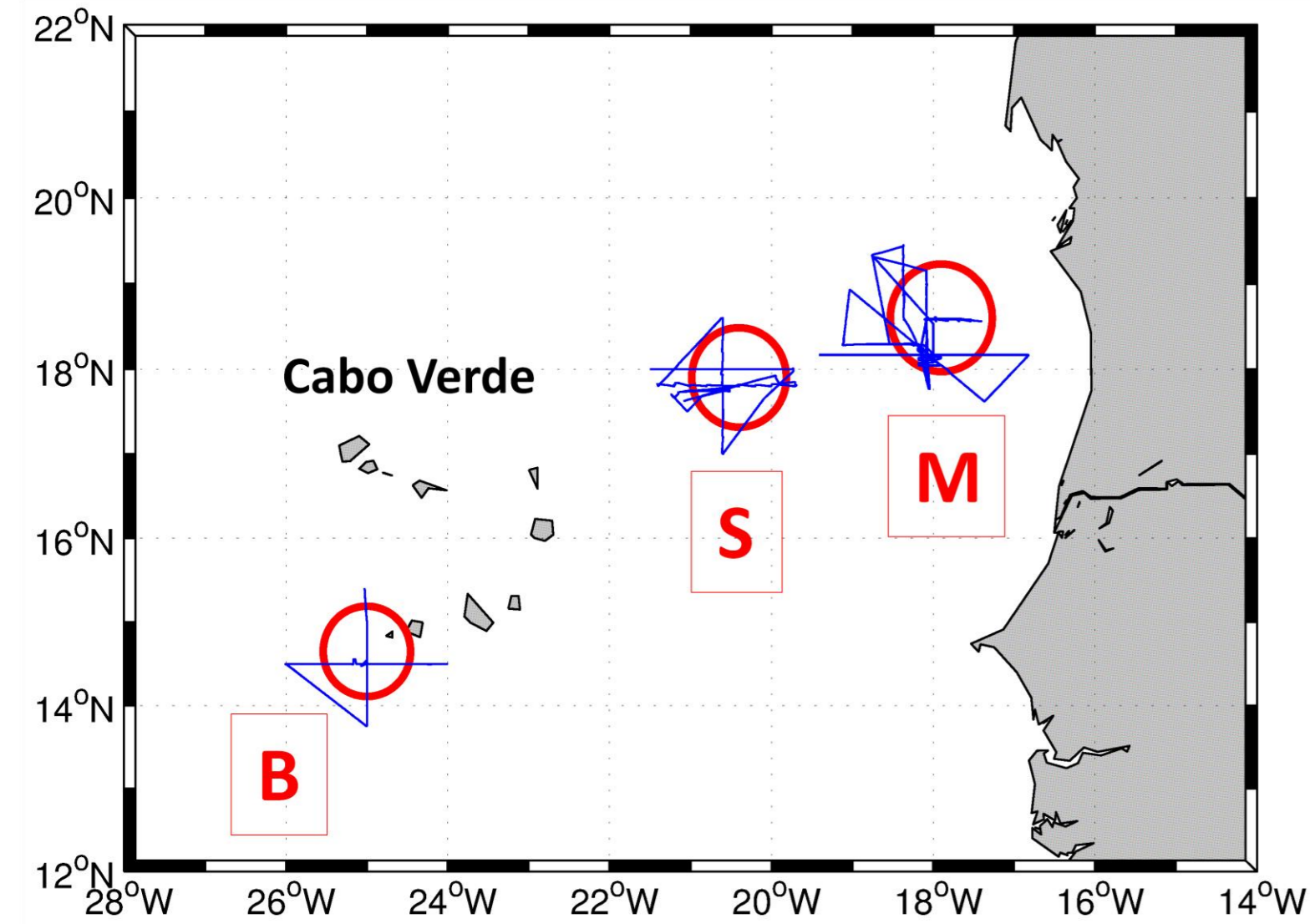
Trapping of water: there exist different criteria for the trapping radius

Azimutal/swirl velocity is maximum (Provenzale 1999)
Okubo-Weiss parameter is zero (Provenzale 1999)
Vorticity is zero (Early et al., 2011)

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Trapping of water: there exist different criteria for the trapping radius

B

S

M

radii candidates volumes (50m to 400m)

B   S   M

The criteria make a difference for the trapped volume

Azimutal/swirl velocity is maximum (Provenzale 1999)
Okubo-Weiss parameter is zero (Provenzale 1999)
Vorticity is zero (Early et al., 2011)

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Trapping of water: there exist different criteria for the trapping radius

B **S** **M**
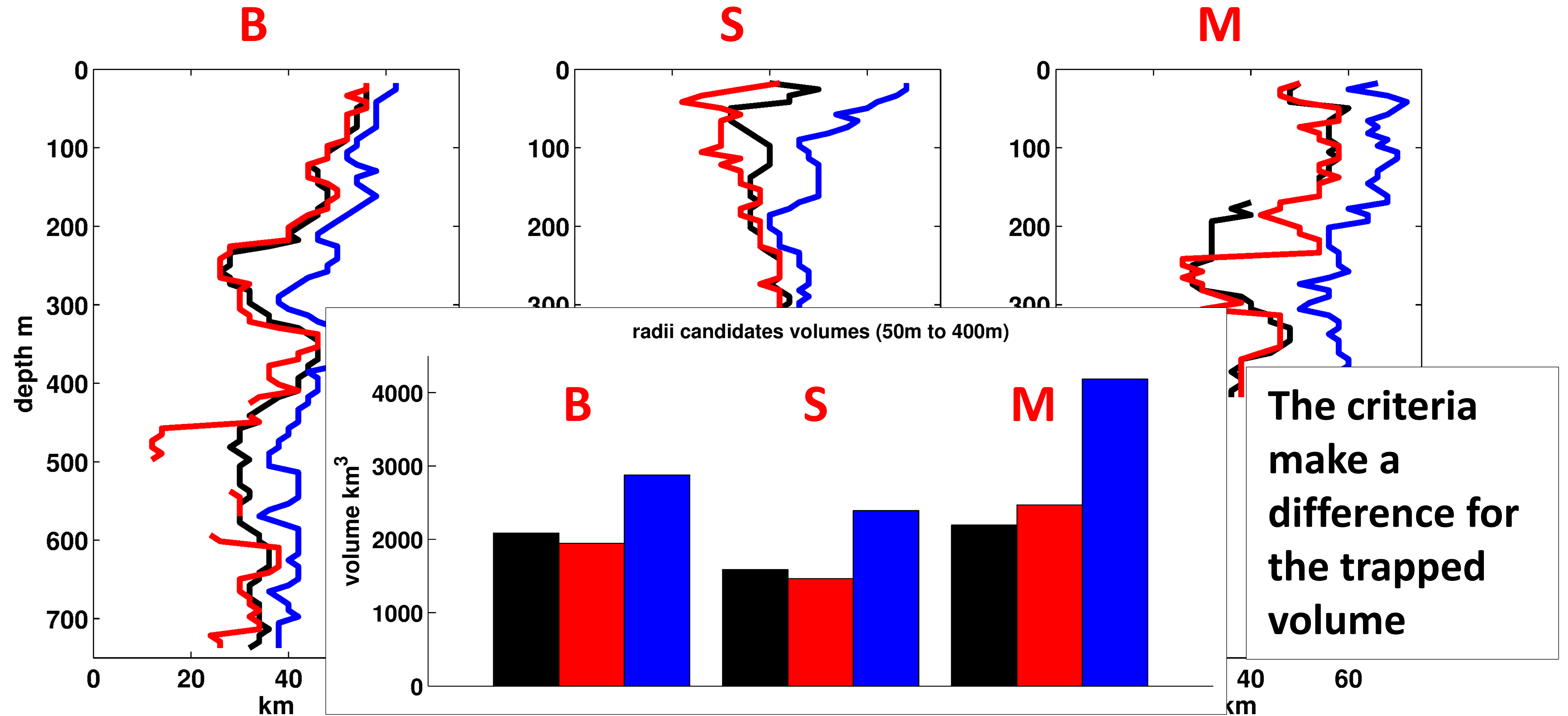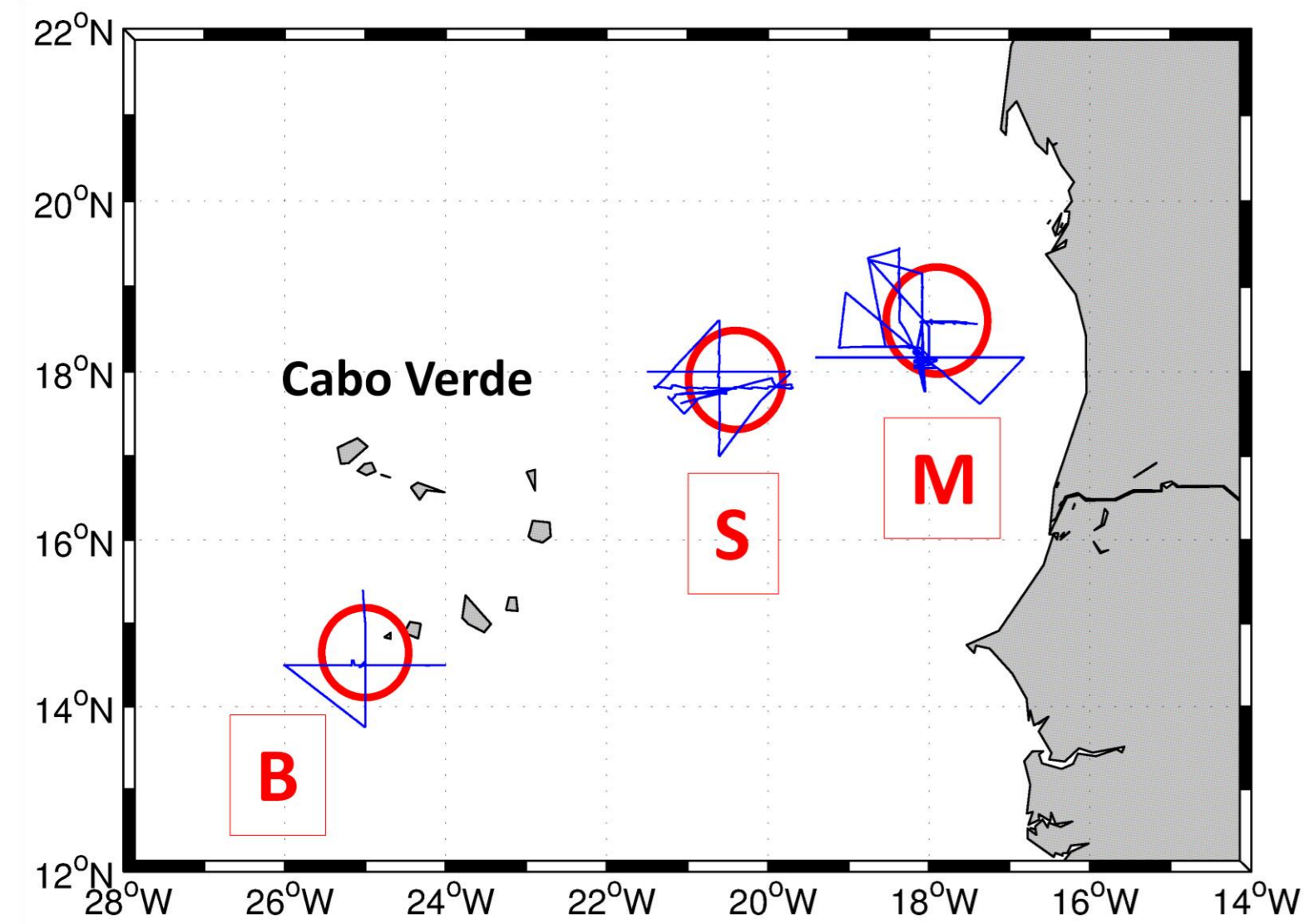
Examine trapping
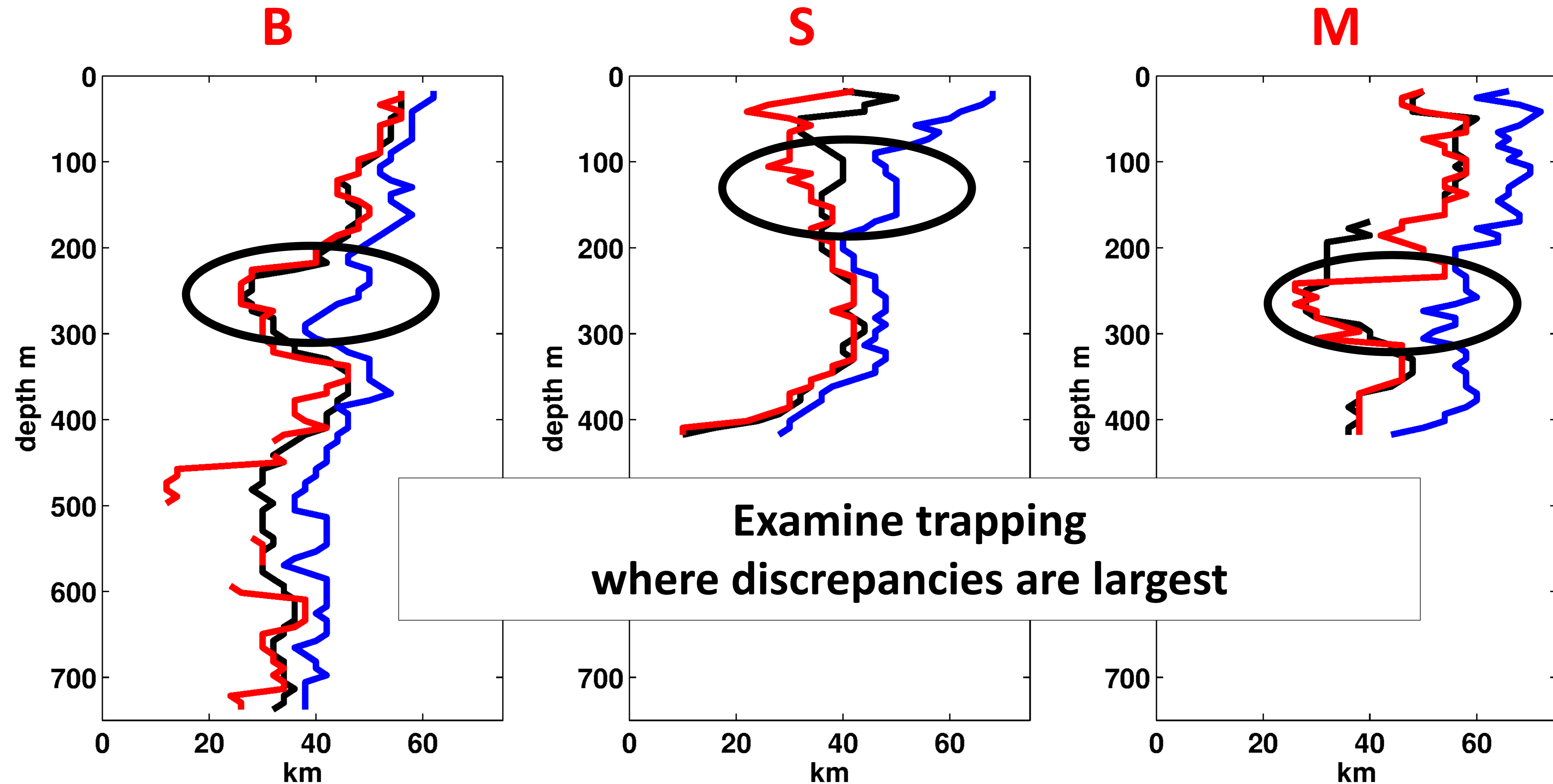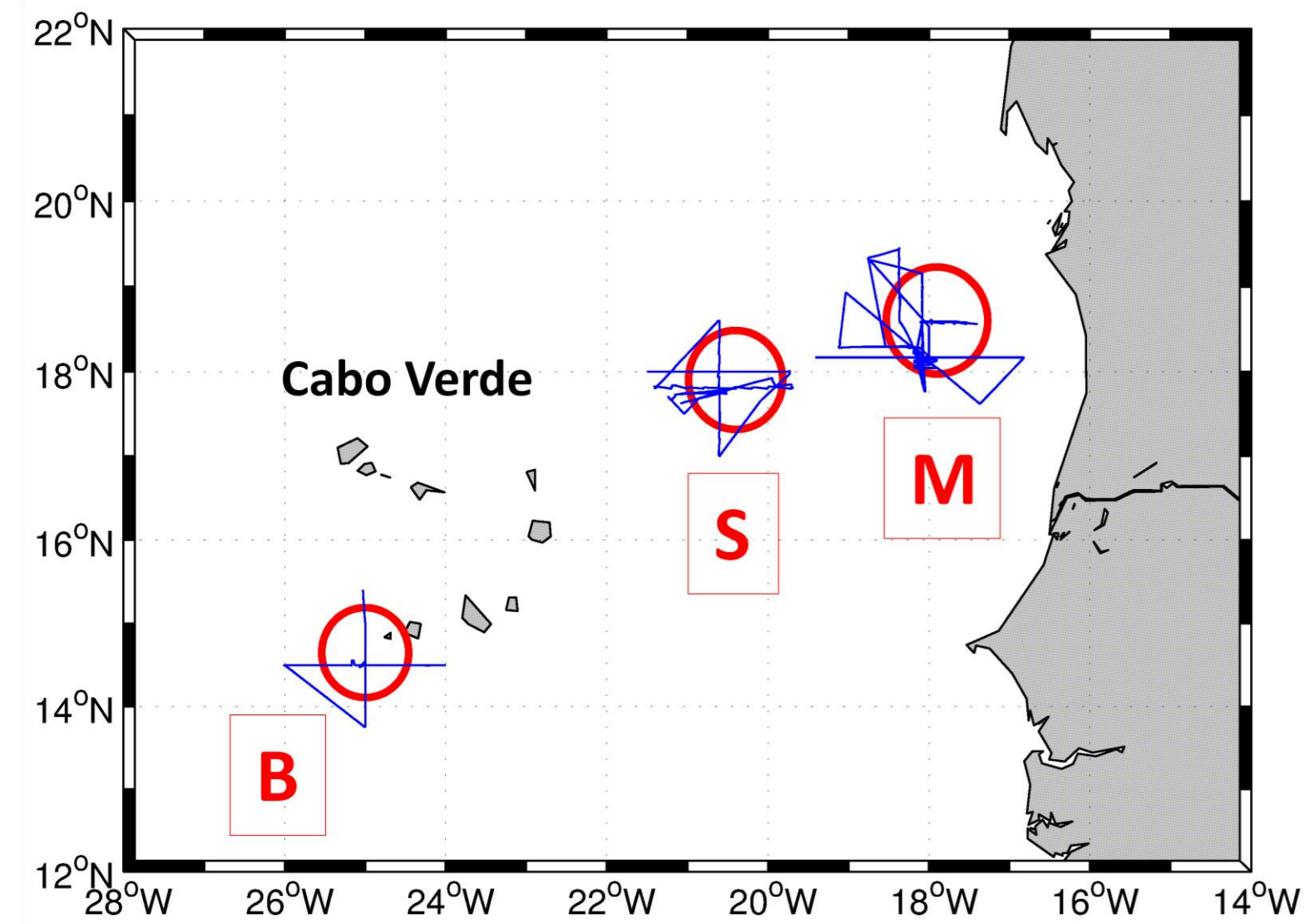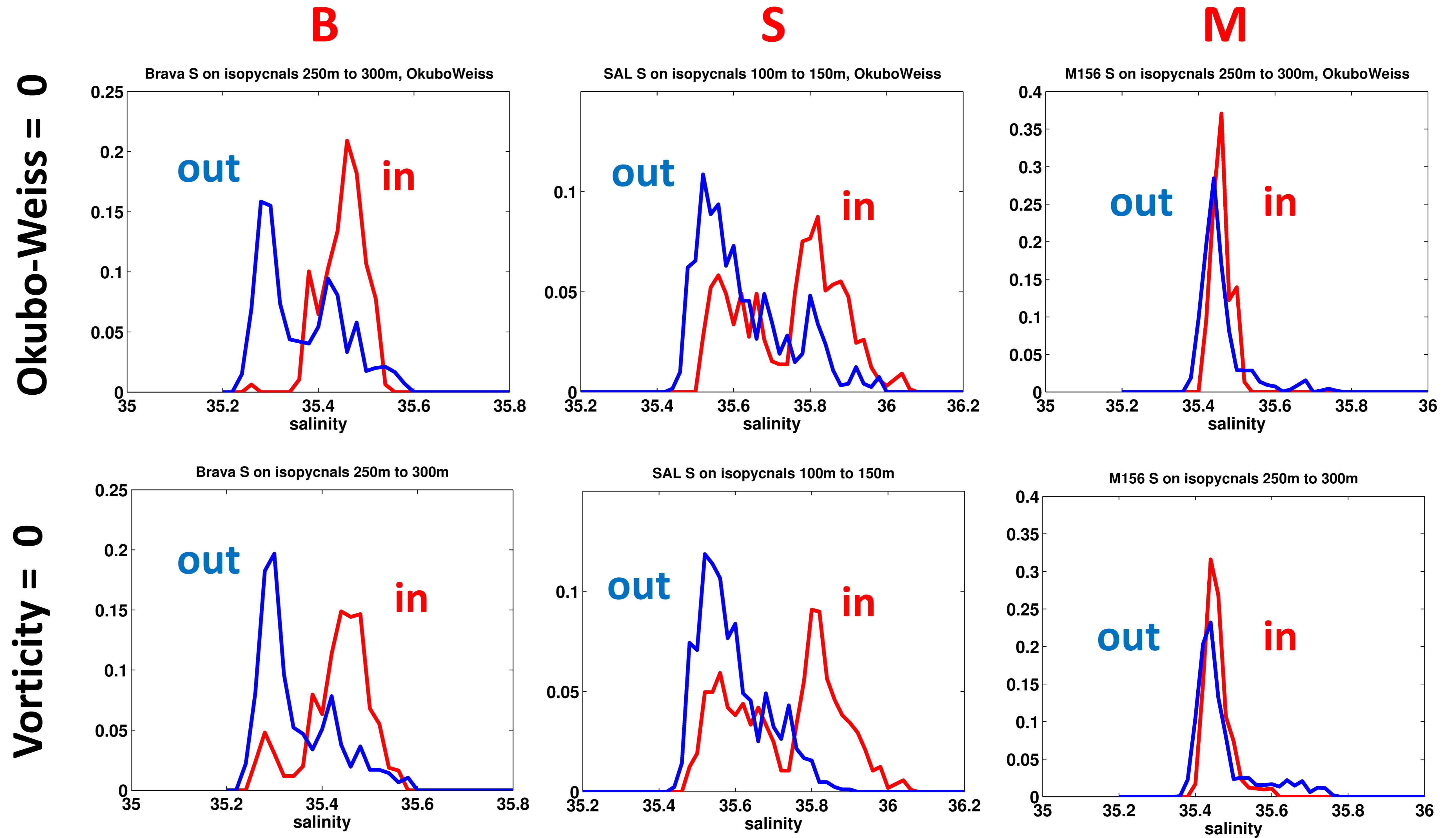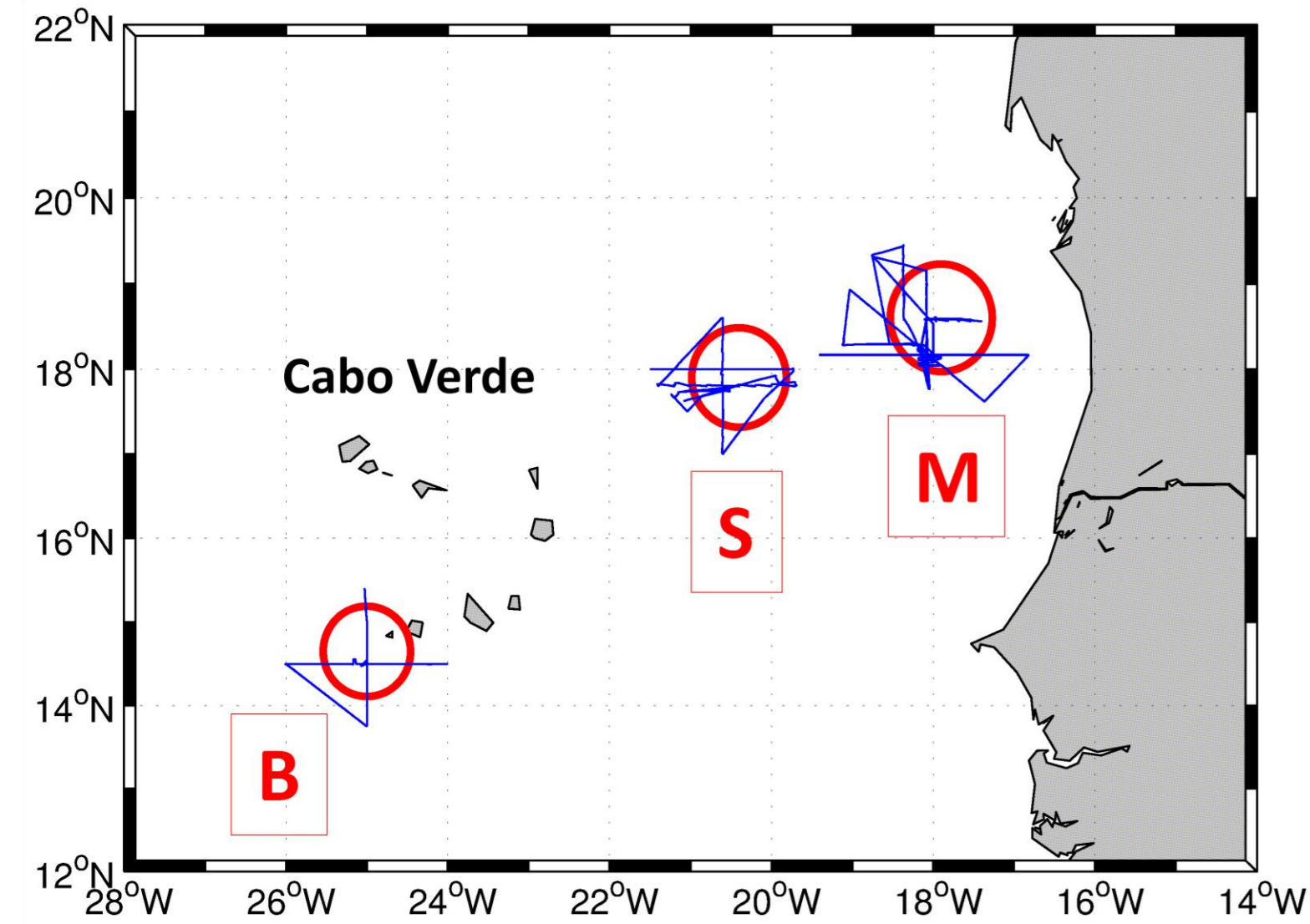where discrepancies are largest
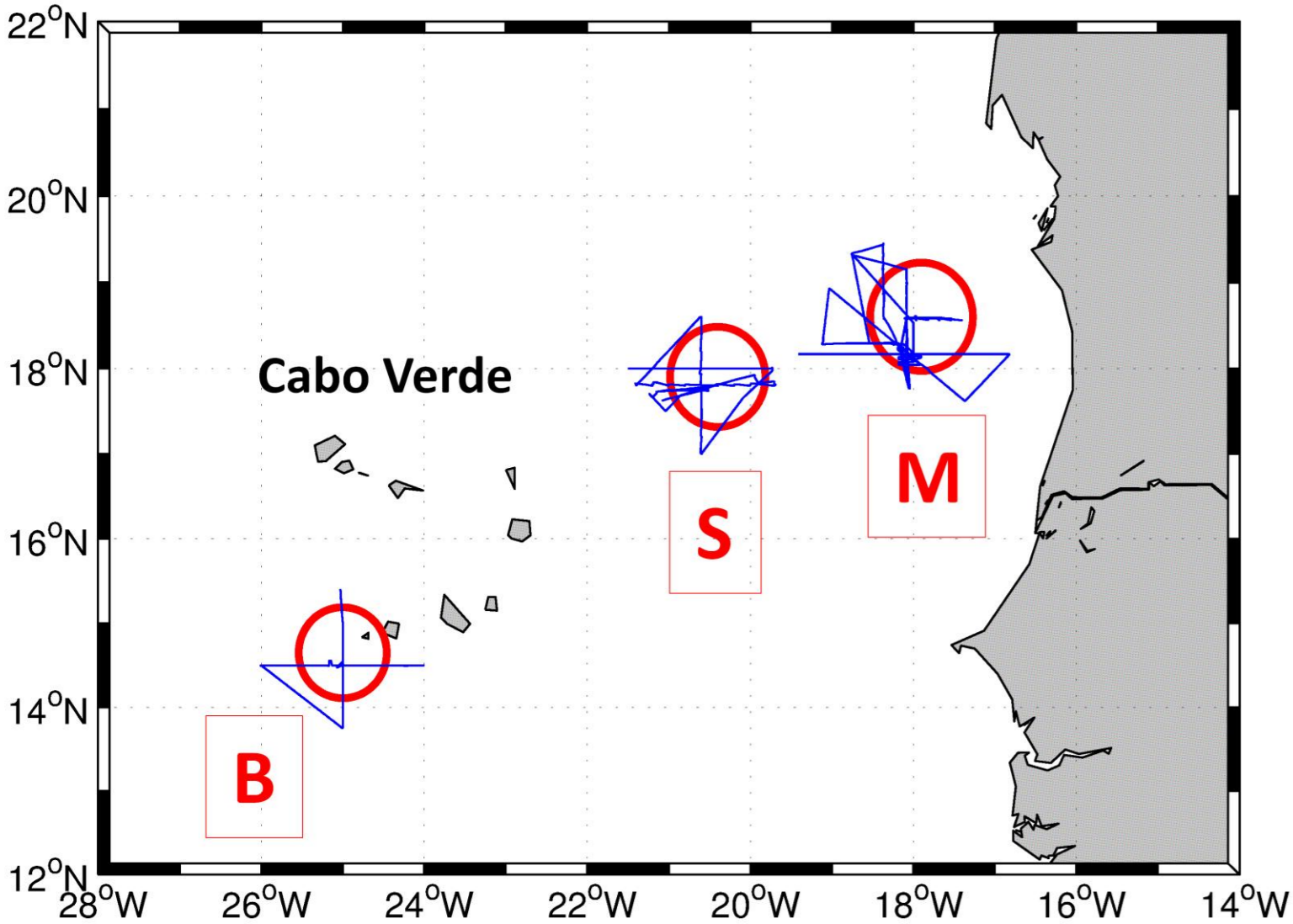
Azimutal/swirl velocity is maximum (Provenzale 1999)
Okubo-Weiss parameter is zero (Provenzale 1999)
Vorticity is zero (Early et al., 2011)

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Compare salinity on isopycnals   (inside vs. Outside)

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Compare salinity on isopycnals   (inside vs. Outside)

Okubo-Weiss = 0

B   Brava S on isopycnals 250m to 300m, OkuboWeiss — out / in

S   SAL S on isopycnals 100m to 150m, OkuboWeiss — out / in

M   M156 S on isopycnals 250m to 300m, OkuboWeiss — out / in

Two distinct water masses – not much mixing

Out plus streaks of **in** — **in** — Clear distinction

in plus streaks of **Out** — Trapping ceased ?

in = **Out**   **in** = **Out** — No information

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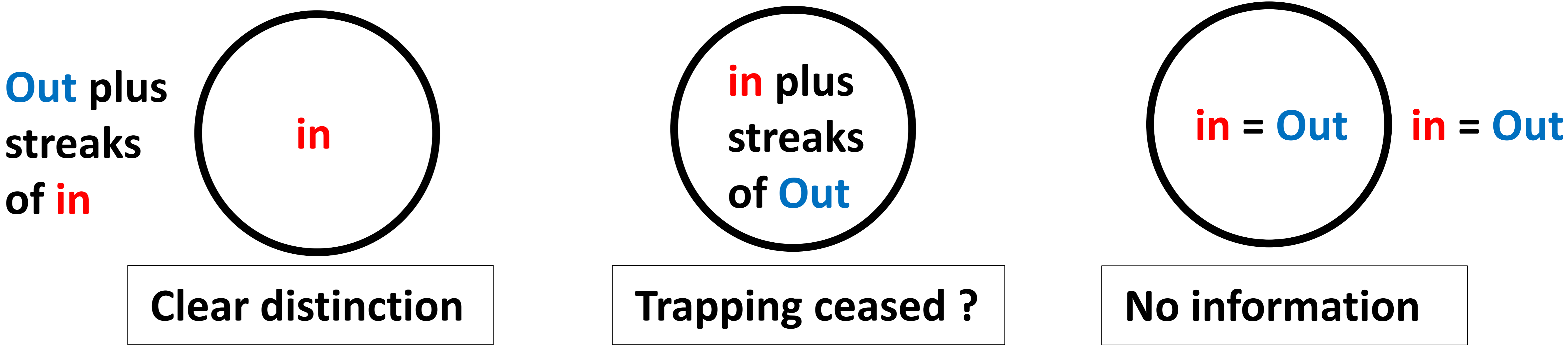
Conclusions

- Comprehensive statements on trapping radius need more data.

- Even so:

    - The observed eddies confirm Rossby radius as eddy limit.

    - Trapped volumes are between 1500 km3 and 4000 km3.
      Using the eddy frequency and lifetime statistics of Schütte et al. (2016),
      this adds up to an average offshore transport of order 1 Sv.
      Comparable to boundary current and to upwelling.

    - The weak eddy ($\zeta/f = 0.1$) ($U/c = 2$) seems to have lost trapping ability.

- In-situ velocity data are useful to investigate individual eddies:
  Localization in position and drift, 3-D dynamical characterization, water samples can be allocated.

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21.9.22