Can we estimate mesoscale frontal variability from repeated glider sections? The Ligurian front example (NorthWestern Mediterranean Sea)

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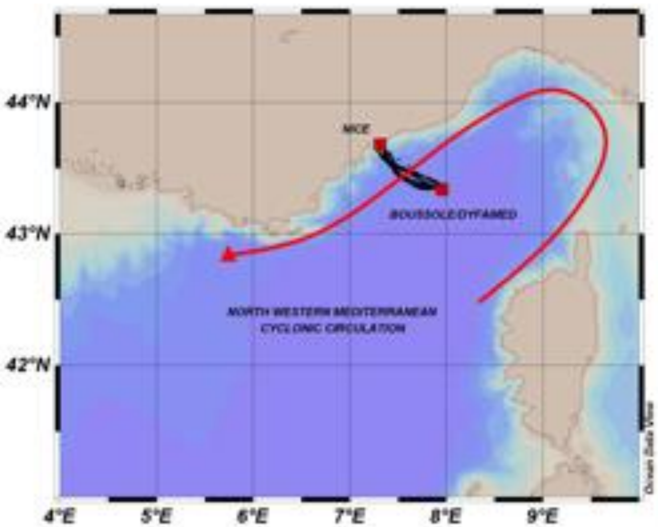

Region of interest, Ligurian current (red line) and glider path (black lines).

- Gliders are expected to play an important role in 3D monitoring of the ocean
- To use them in an optimal way, it is crucial to take into account their characteristics.
- Gliders move at ~ 20-30 km/day, i.e. close to the propagation speed of several ocean phenomena.
- Glider transects ("screenings") are often not synoptic, and time and space variability can appear as convoluted (Doppler smearing)

Glider distance versus time along the cross shore section (black lines) and stations from a ship cruise (red dots)

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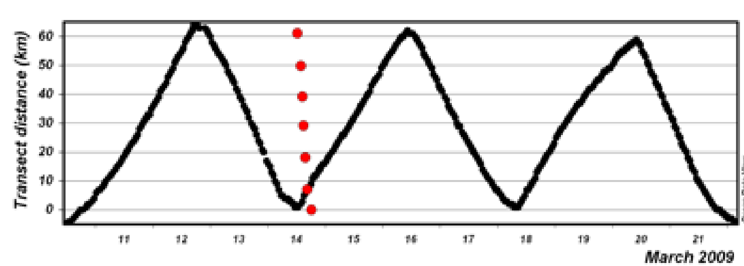
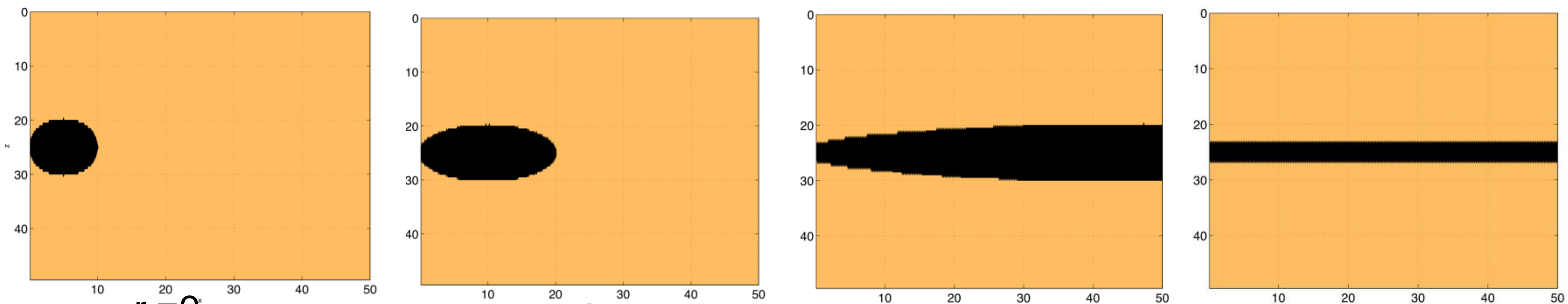
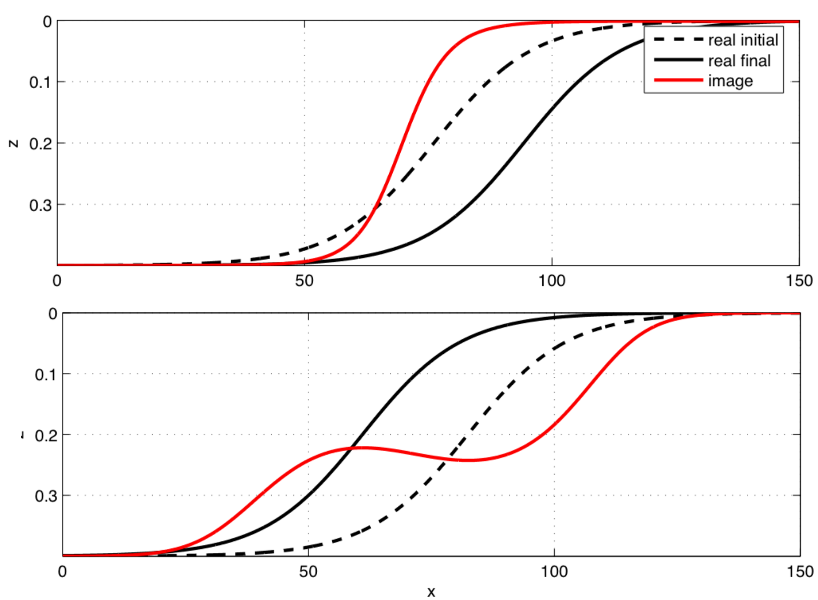


Idealized examples of Doppler smearing

1) Examples of glider screenings (in x,z) depicting a circular tracer intrusion (black) for different values of the ratio *r*=V/v, where V and v are the velocities of the intrusion and glider respectively. Both glider and intrusion move to the right.

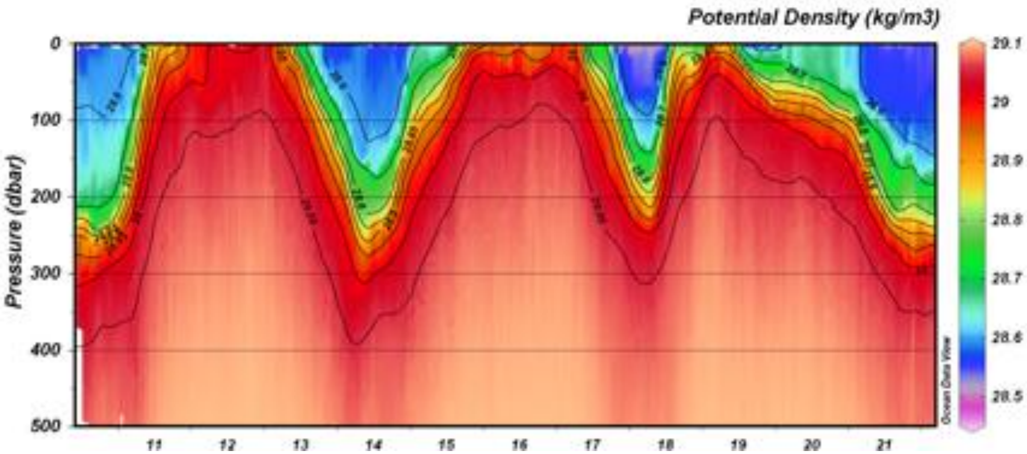


r =0 *r* = 0.25 *r* =0.5 *r* =1



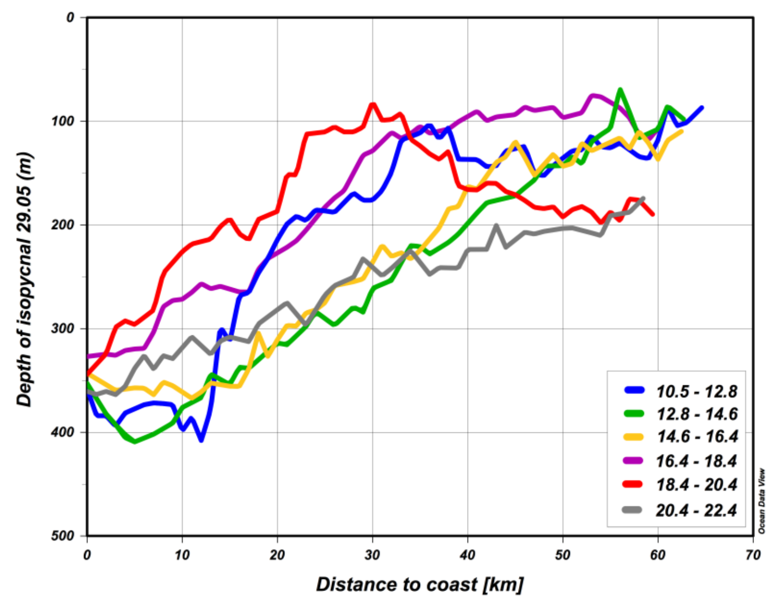
2) Glider screenings (red lines) of a frontal isopycnal (black lines) moving back and forth along a transect with sinusoidal velocity (*r*= 1.15). The glider moves four times along a cross frontal transect. Upper (lower) panel shows first (fourth) section. Glider and front start moving together toward the right, but they quickly become out of phase

Glider screenings of the Ligurian front (March 2009)



Glider screenings of potential density versus time

- Glider Milou covered 6 consecutive cross-frontal transects (three back and forth between the coast and 70 km offshore) during March 10-22.
- The vertical density sections show high variability.



Depth of 29.05 isopycnal versus cross shore distance

- Deep frontal isopycnals (28.9-29.05 kg/m3) have been chosen to characterize deep (~diabatic) frontal processes, like instabilities and meander propagation.
- Typical Ligurian meanders have periods 3-10 days and phase speed 10-20 km/day. Glider covers a section in approx 2 days with speed ~ 30km/day. Doppler smearing can occur
- How can we deconvolute the isopycnals?

A simple method for deconvoluting isopycnal data given repeated glider transects

- The method capitalizes on the fact that the glider repeatedly covers the cross-frontal section, therefore repeatedly sampling the various locations along the axis

- Time series of (spatially averaged) isopycnal depth are created at fixed points along the section axis, interpolating the glider data through nonlinear regression

- From the time series, the isopycal space pattern is estimated at various times.

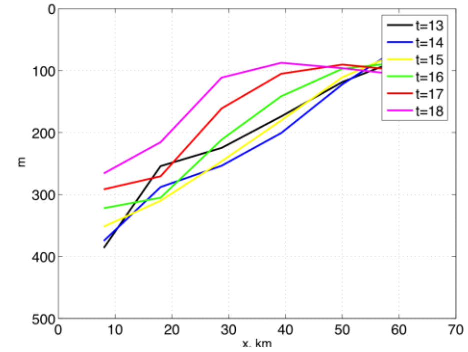
- When appropriate, a function fitting to a simple frontal model is used, to describe time variability in terms of few parameters such as frontal position x_0 and steepness R

- **NOTICE**: the goodness and time resolution of the estimates depend on repeated data coverage along the transect . For the Ligurian data, the coverage varies between 1-3 day depending on the transect location.

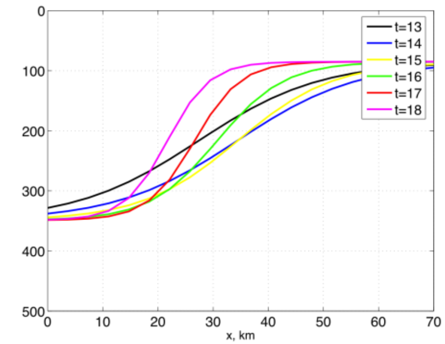
- Scales T of the order or shorter than 1 day are not resolved.

First four transects, March 10.5-18.4: Smooth meandering front

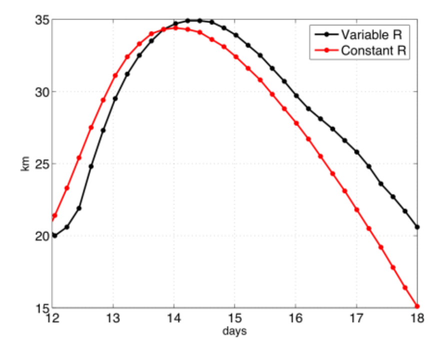
- Deconvoluted (a) and function fitted (b) isopycnals show that the front moves first off-shore while flattening, and then inshore while steepening
- Maximum front velocity is ~ 8km/day (c), significantly less than glider velocity
- Isopycnal deconvolution is robust to changes in function fitting (c) and compatible with synoptic cruise transect
- Results indicate a propagating meander (see also SST image), and local wind appears to play a role in reinforcing frontal motion



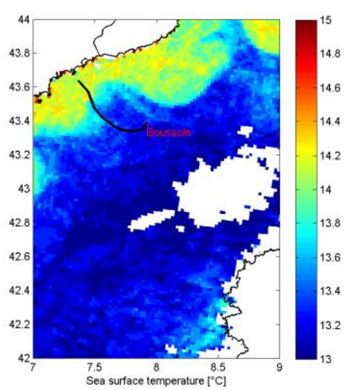
a)



b)



c)



a) deconvoluted isopycnals;
b) example of function fitting;
c) estimated front position x_0 *versus time for two different function fitting*

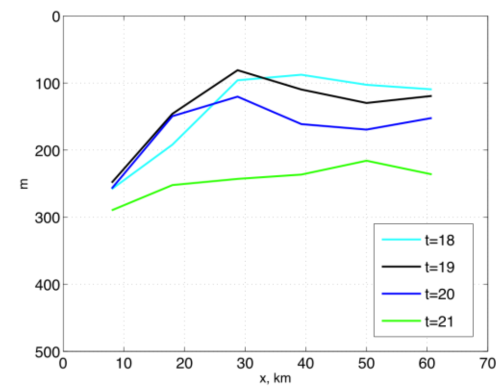
Last two transects, March 18.4-22.4: Sharp transition

- Deconvoluted isopycnals (a) show the presence a local maximum (dome) at days 19-20, and a flattening and strong deepening at day 21.

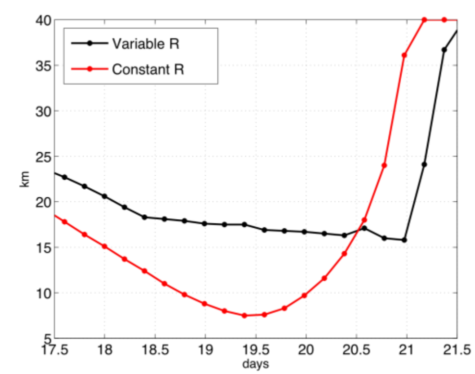
- Maximum front velocity (b) is ~ 20-30 km/day, i.e. of the same order as the glider velocity

- Robusteness of the results is questionable, as shown also by the dependence on function fitting (b).

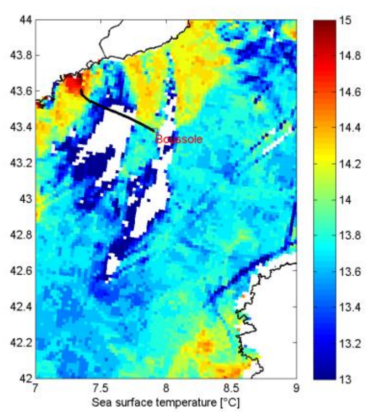
- The dome can be due to either: 1) Doppler smearing due to a meander moving faster than the glider and passing it, or 2) an intrusion of offshore water sampled by the glider. SST image suggests 2)



a)



b)



a) deconvoluted isopycnals; b) estimated front position x_0 versus time for two different function fitting

Summary

- A general formalism has been introduced to describe how time variability can be folded into space variability in glider screenings due to Doppler smearing (Rudnick and Cole, 2011)

- A simple method has been introduced to deconvolute space and time variability of isopycnal depth across a front repeatedly sampled by a glider

- The method resolves scales T greater than the typical sampling interval of the glider along the transect. For the Ligurian front case, T>1 day.

- The method is applied to eight glider sections across the Ligurian front. A general meandering signal is recovered, with period ~ 4-6 days and amplitude ~ 30 km, in agreement with previous works. The role of local wind is analyzed.

- More in details, during the first four transects (8 days) the front oscillation is smooth, with speed lower than the glider, and the deconvolution method is robust. During the last two transects (4 days), the front is disrupted by intrusions and filaments at scales of the order of 1 day, and the method is not completely robust.

- Future works include: a) sampling strategy targeted to scales of interest; b) fusion with other data and models to help deconvoluting the info and provide 3d pictures of frontal evolution