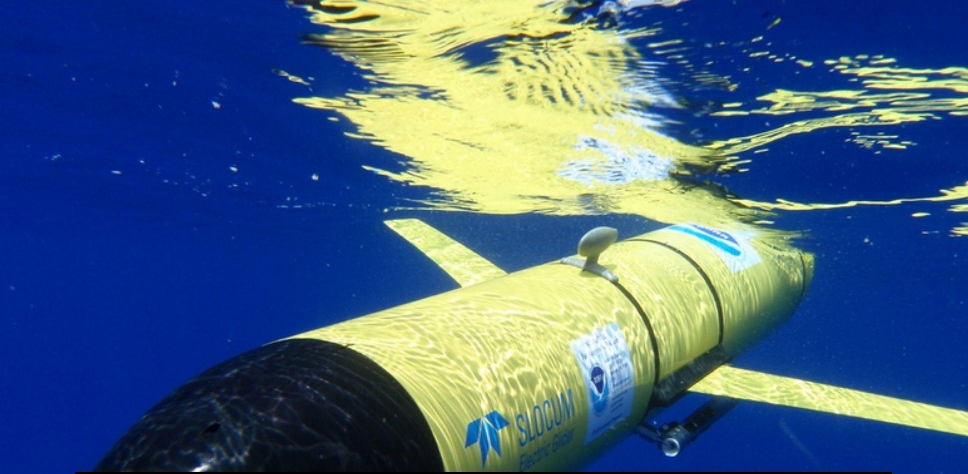


Characterization of convective plumes associated with oceanic deep convection from autonomous gliders

F. Margirier[1], P. Testor[1], A. Bosse[1] and L. Mortier[2]
[1]CNRS, LOCEAN-IPSL [2]ENSTA, LOCEAN-IPSL

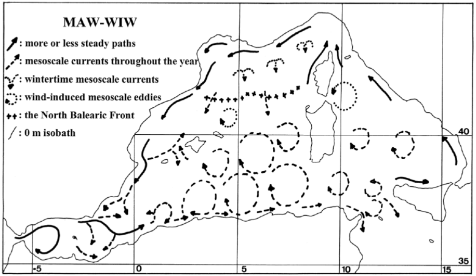
Overview

Circulation in the Western Mediterranean Sea and deep convection

Glider flight model and detection of deep convection episodes

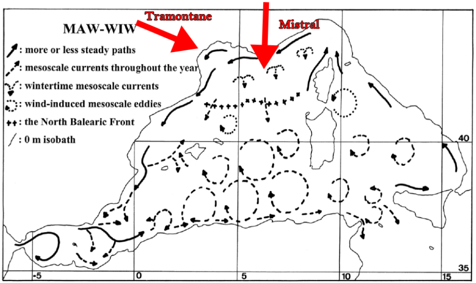
Properties of convective plumes

Circulation and the Gulf of Lions



Circulation in the Western Mediterranean Sea,
Millot 1999, JMS

Circulation and the Gulf of Lions



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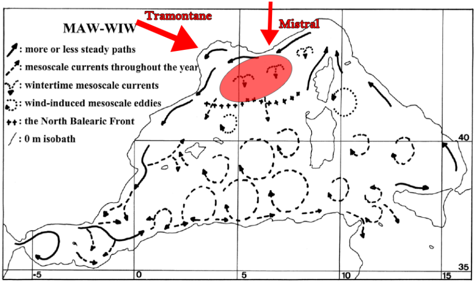

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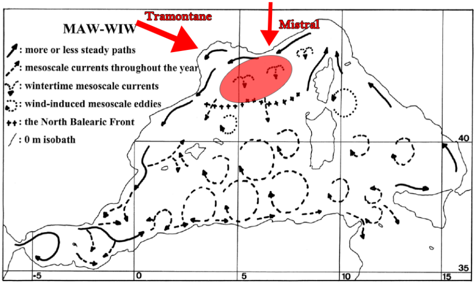
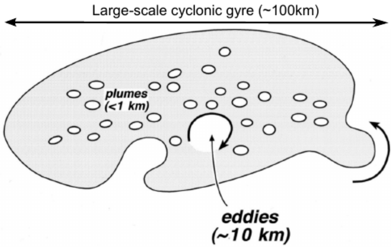


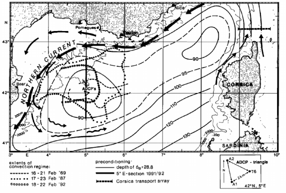
Circulation in the Western Mediterranean Sea, Millot 1999, JMS

Deep convection

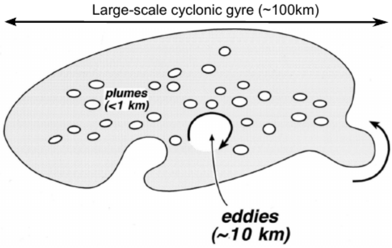
- thermohaline circulation
- ventilation
- projects (HyMeX)
- hard to observe
- local, not fully understood

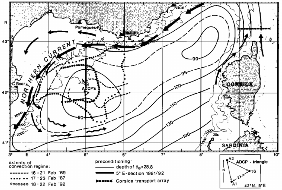
Deep convection





Deep convection

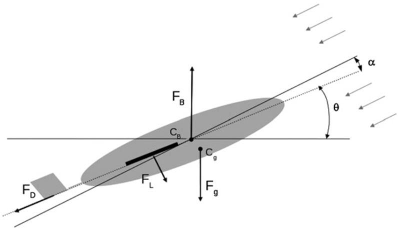




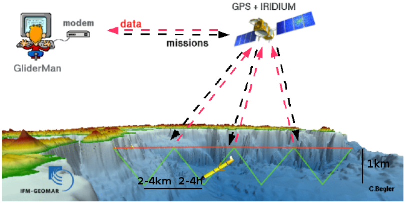
- Preconditioning
- Violent mixing
- Lateral exchange and spreading

Open-Ocean convection : Observations, theory, and models, Marshall and Schott 1999

Glider flight model and vertical velocities



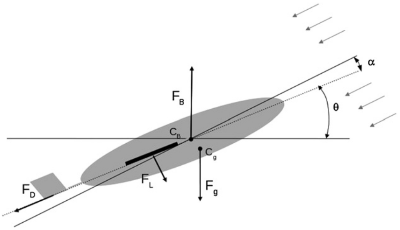
Forces applied on the glider (A Glider Network Design Study for a Synoptic View of the Oceanic Mesoscale Variability, L'Hévéder et al. 2013)



2-4km, 2-4h between surfacings, 1km depth

26° with the horizontal plane

Glider flight model and vertical velocities



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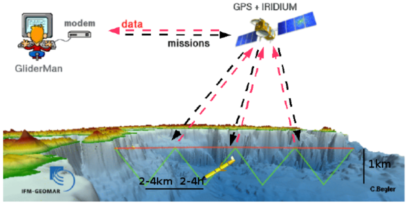
$$F_B = g\rho(V_g(1 - \epsilon P + \alpha_T(T - T_0)) + \triangle V_g)$$
$$F_g = m_g g$$
$$F_L = \frac{1}{2}\rho S U^2 a\alpha$$
$$F_d = \frac{1}{2}\rho S U^2 (C_{D_0} + C_{D_1}\alpha^2)$$
$$\alpha = \frac{C_{D_0} + C_{D_1}\alpha^2}{atan(\theta+\alpha)}$$

$$W_{water} = W_{pressure} - W_{glider}$$

Merckelbach et al. [2010], Frajka-Williams et al. [2011].



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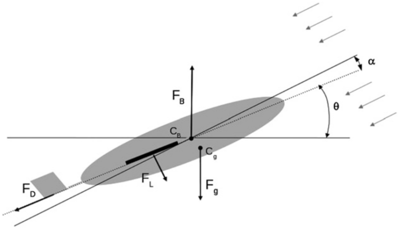

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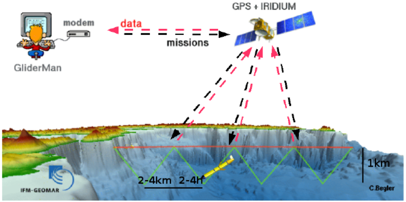

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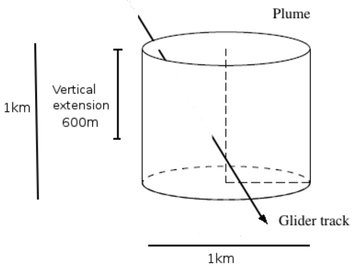

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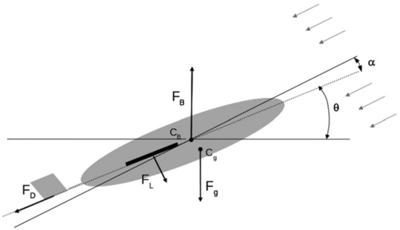

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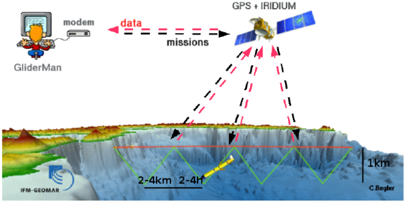

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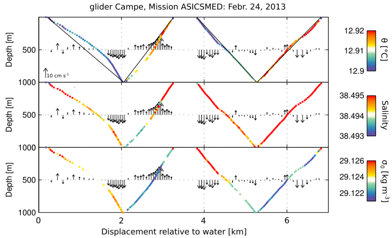
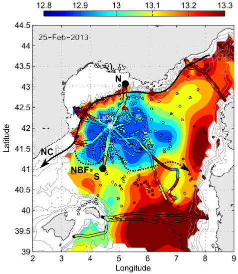
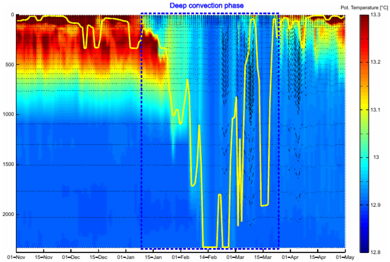


Lion mooring and the detection of deep convection





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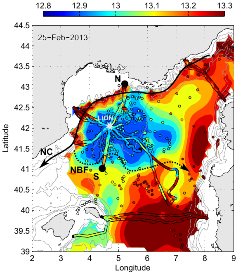

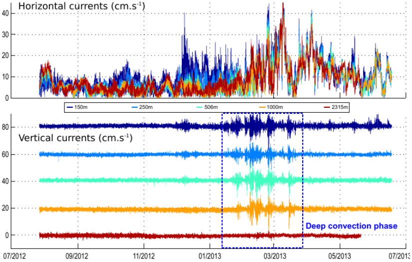

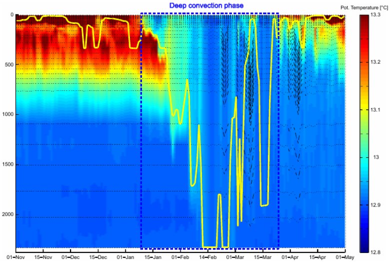

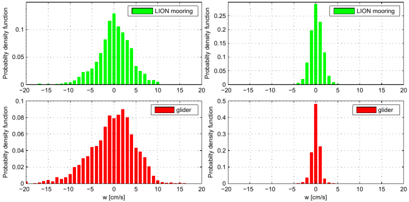

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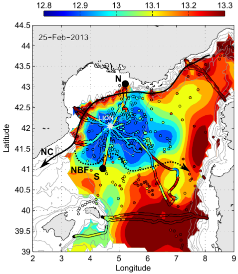
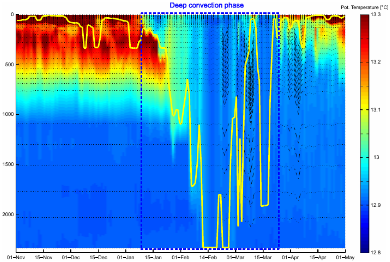
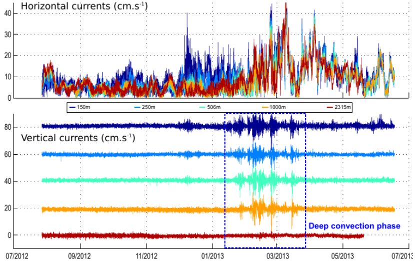
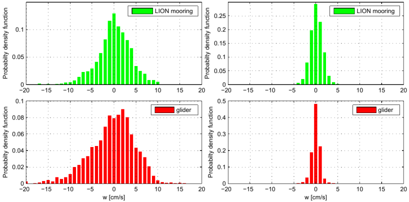




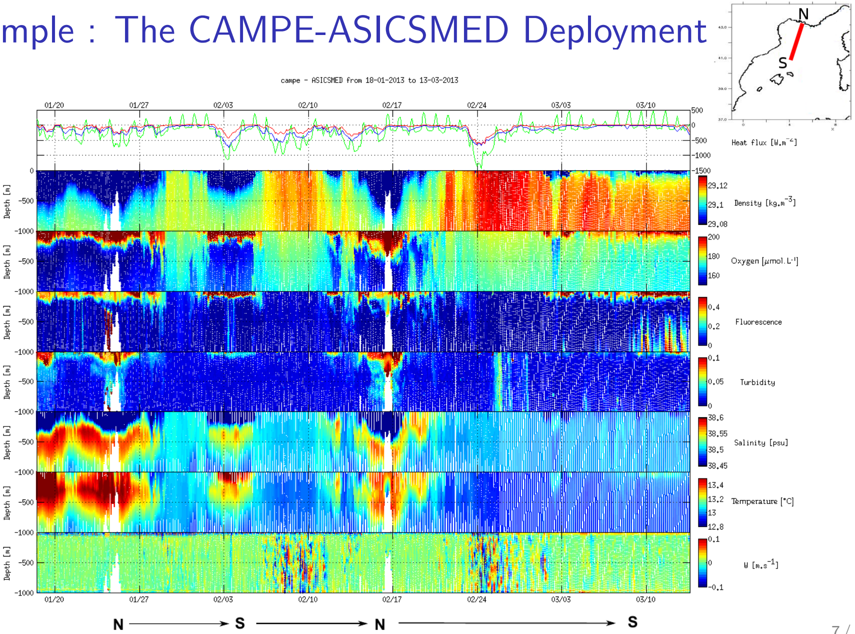




Vertical velocities > $4 cm.s^{-1}$

Horizontal extension > 300m

Example : The CAMPE-ASICSMED Deployment



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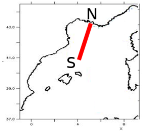

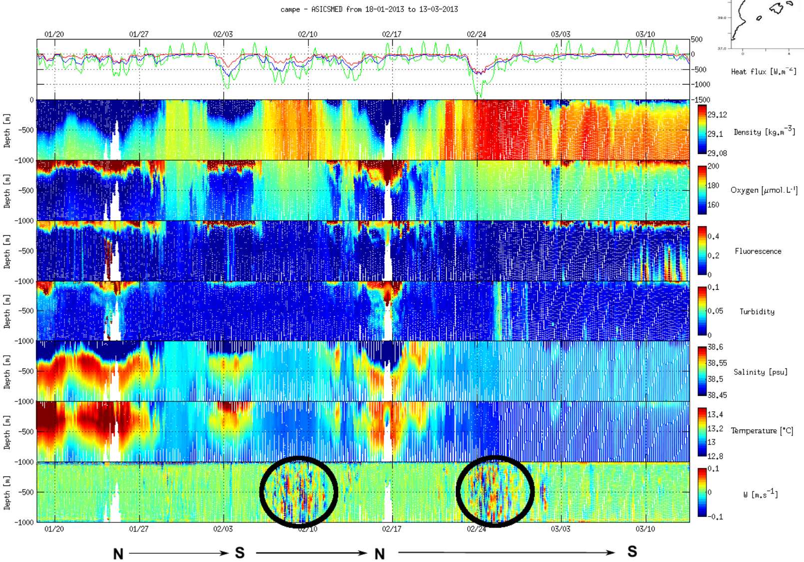

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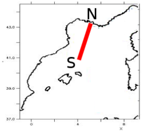
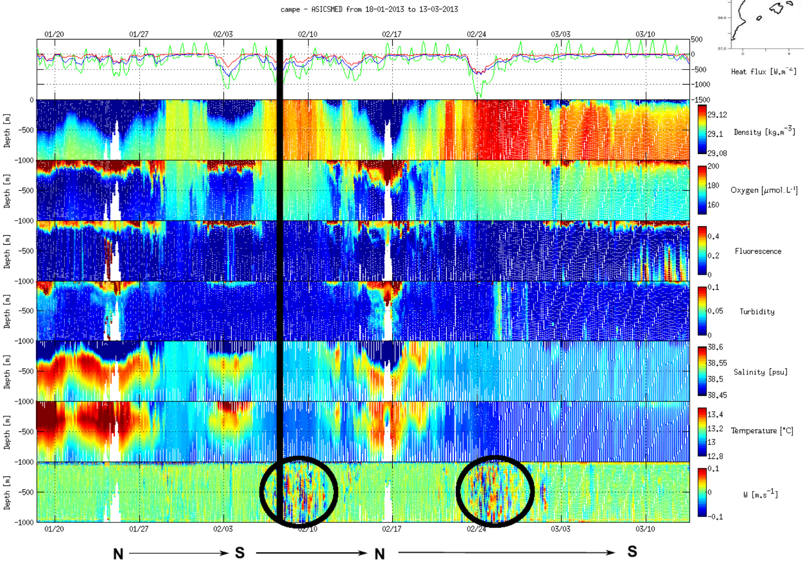
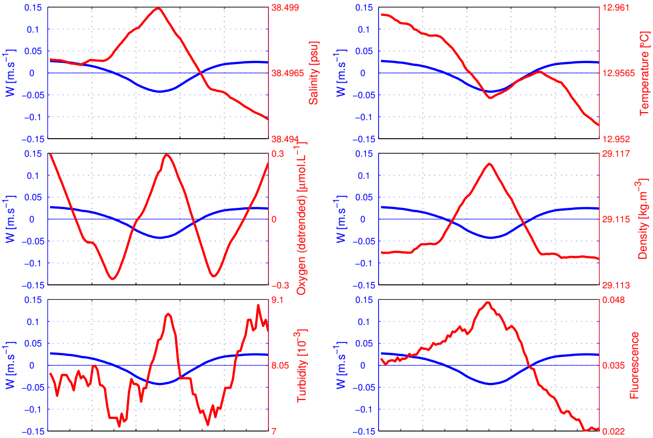




A convective plume



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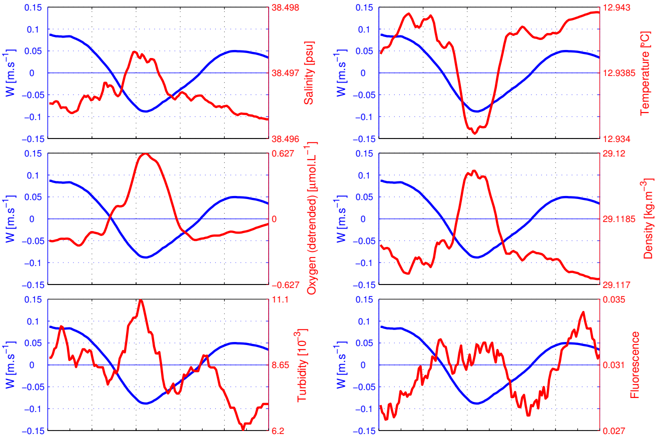
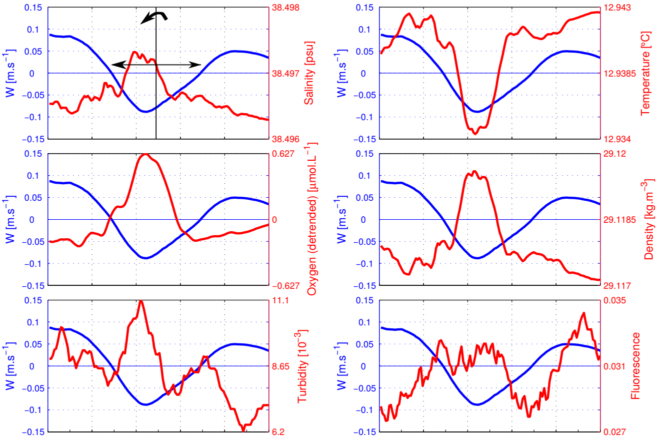


Downwelling waters twice as fast as upwelling ones,
Saltier, colder, denser, more oxygen, more turbid, more fluorescent

A convective plume



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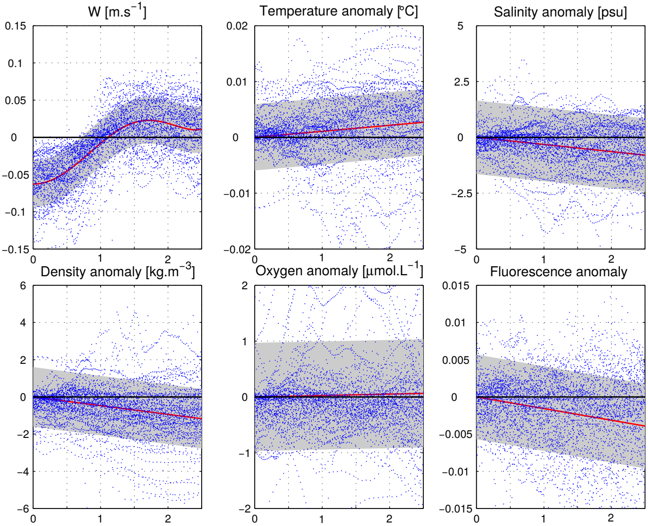
Saltier, colder, denser, more oxygen, more turbid, more fluorescent

- Radius normalisation

Winter 2013/2014 : 3 deployments, 120 plumes



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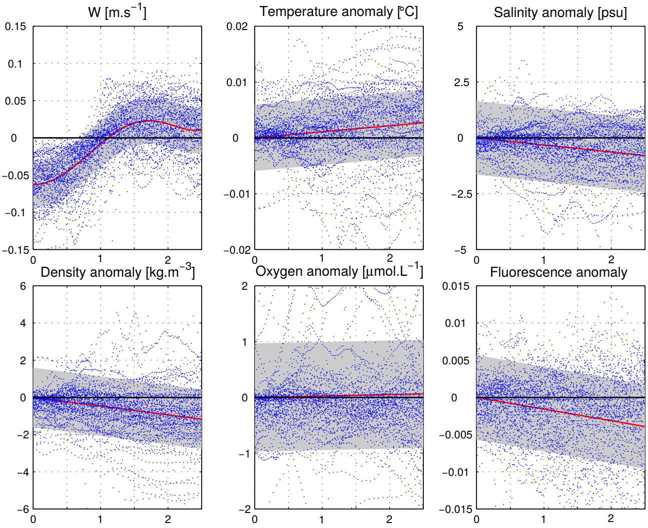
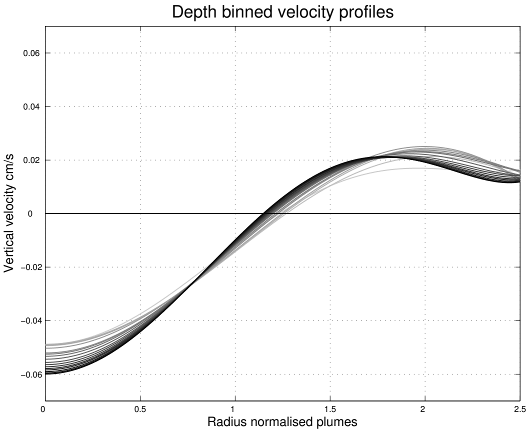


Downwelling waters :

- w -6cm.s^{-1}
- denser +0.0015kg.m^{-3}
- saltier +0.001psu
- colder -0.005°C

Vertical properties of the plumes



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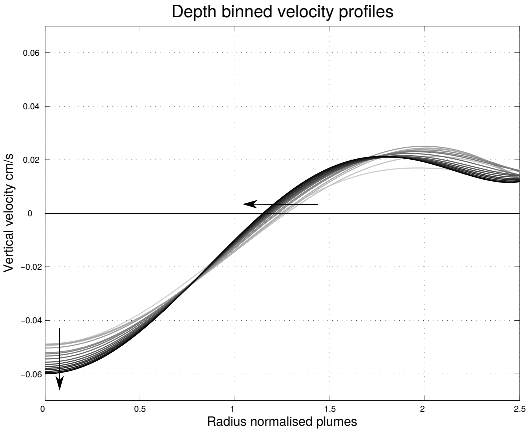
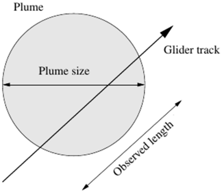


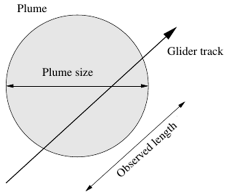
Narrowing and intensifying with depth.

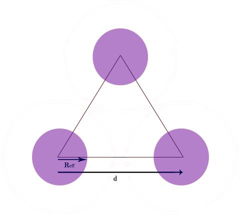
Plume coverage of the convective zone



Mean radius 350m (LES model Paluszkiewicz [1994], 300-500m)
Mean distance in between plumes 1.8km (Smeed [2007], 2km)

Plume coverage of the convective zone





Mean radius 350m (LES model Paluszkiewicz [1994], 300-500m)
Mean distance in between plumes 1.8km (Smeed [2007], 2km)

Convective plumes are dense

Negative velocities cover 40% of a glider track and 20% of the area in the convective zone.

Conclusions

- Glider : only tool capable of capturing the spatial and temporal characteristics of plumes
- Automatic detection of plumes
- Patterns
- Plumes densely cover the convective area
- Influence of rotation (Marshall and Schott [1999], Maxworthy and Narimousa [1994])

Perspectives

- Huge dataset
- MLD depth
- Physical/Biogeochemical coupling
- Experimental/numerical scalings
- Towards a parameterisation of deep convection for numerical models