

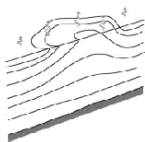


Sustained intense monitoring of the deep convective area in the Northwestern Mediterranean: Stratification versus Fluxes

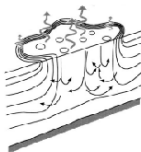
Félix Margirier, Pierre Testor, Anthony Bosse, Loic Houpert, Laurent Mortier, Emma Heslop, Katia Mallil & Laurent Coppola

Deep convection in the Northwestern Mediterranean Sea

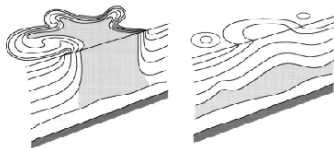
Preconditioning



Violent Mixing



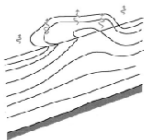
Restratisation and spreading



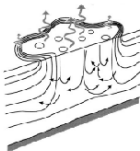
[Open-Ocean convection : Observations, theory, and models, Marshall and Schott 1999]

Deep convection in the Northwestern Mediterranean Sea

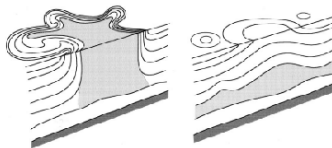
Preconditioning



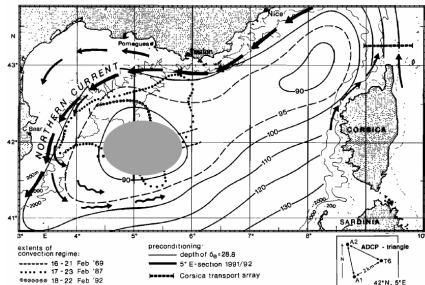
Violent Mixing



Restratification and spreading

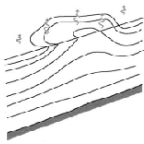


[Open-Ocean convection : Observations, theory, and models, Marshall and Schott 1999]

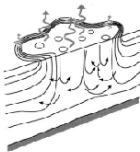


Deep convection in the Northwestern Mediterranean Sea

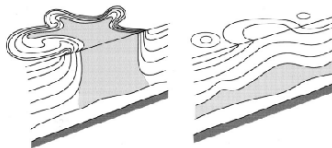
Preconditioning



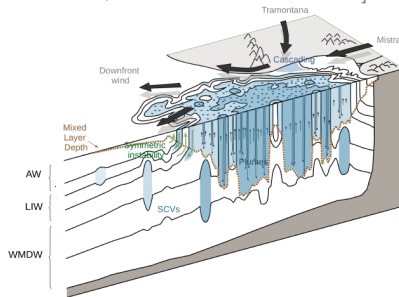
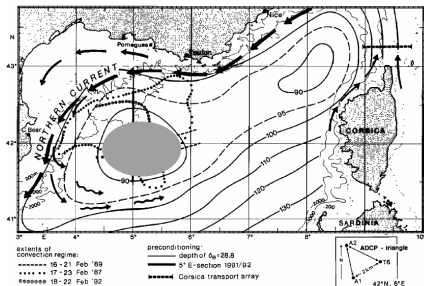
Violent Mixing



Restratification and spreading



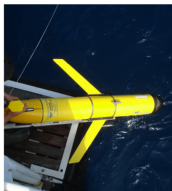
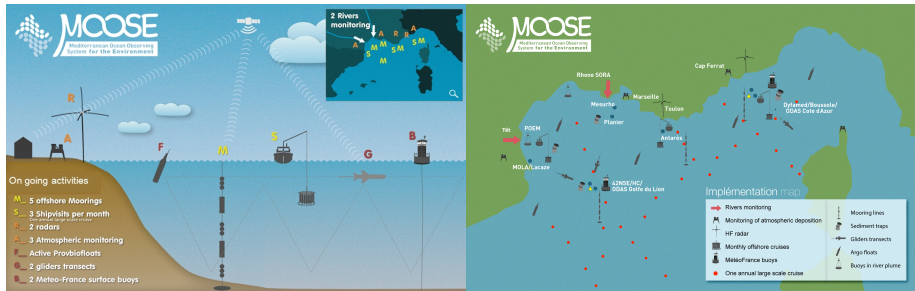
[Open-Ocean convection : Observations, theory, and models, Marshall and Schott 1999]



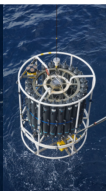
[Testor et al. 2017]

Northwestern Mediterranean observational context

Sustained observations since 2007



Glider deployment



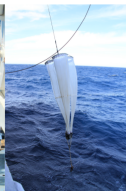
Ship CTD



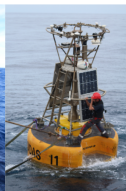
ARGO float



Mooring operation



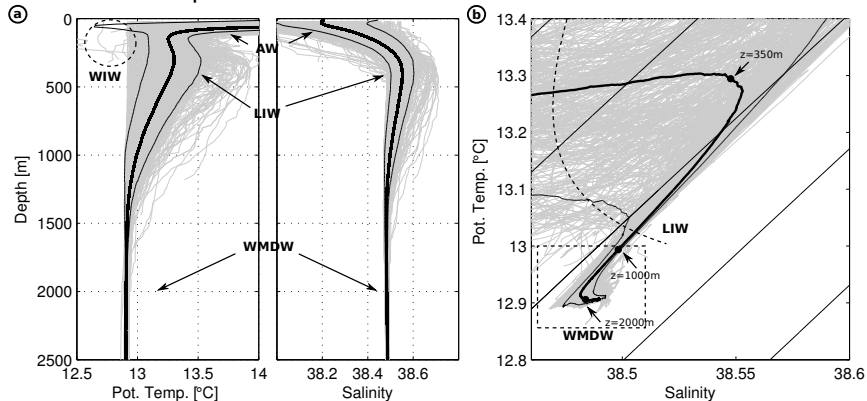
Phytoplankton nets



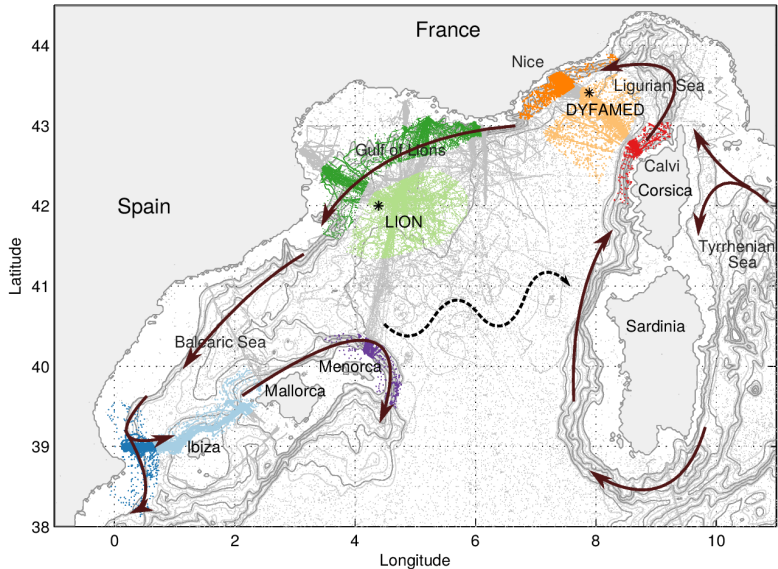
Surface Buoy

Mediterranean water properties

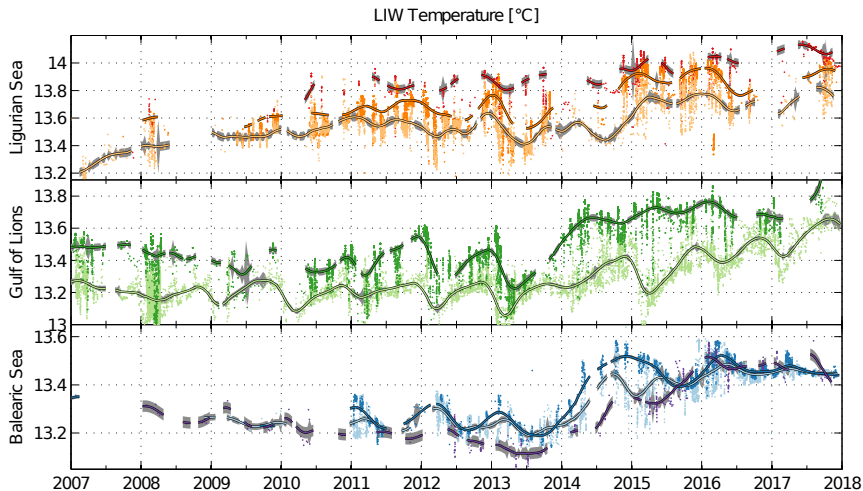
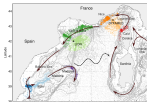
Mean profiles in the Northwestern Mediterranean Sea



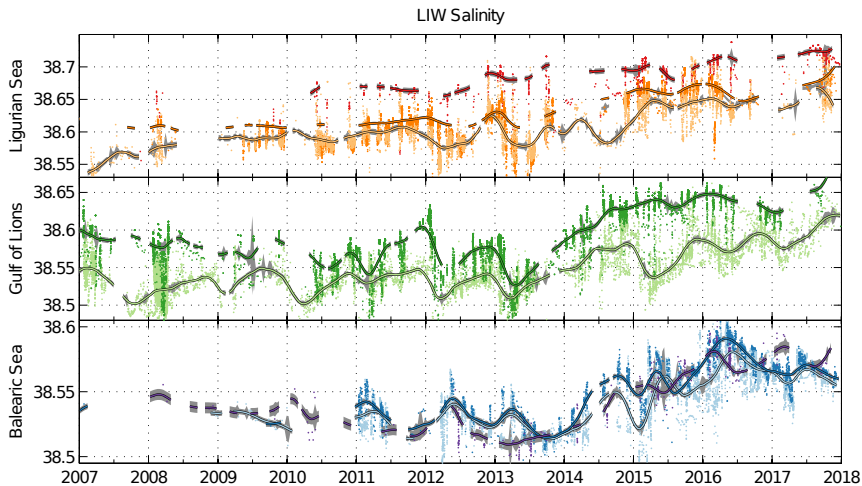
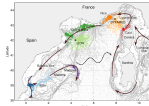
LIW circulation pattern and chosen regional boxes



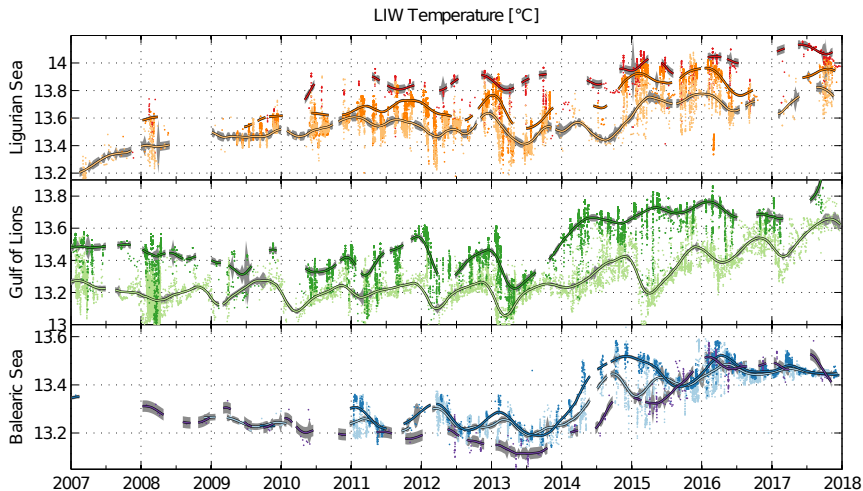
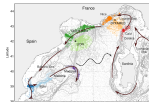
LIW core time series



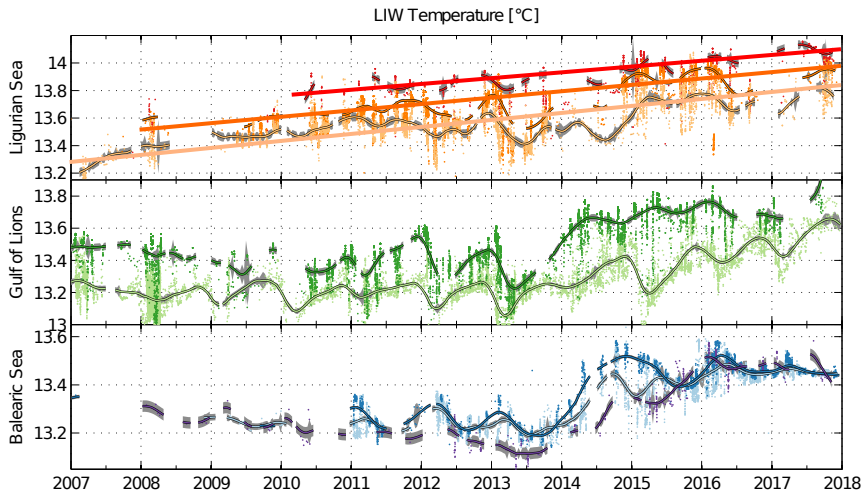
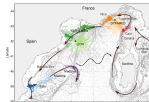
LIW core time series



LIW core time series

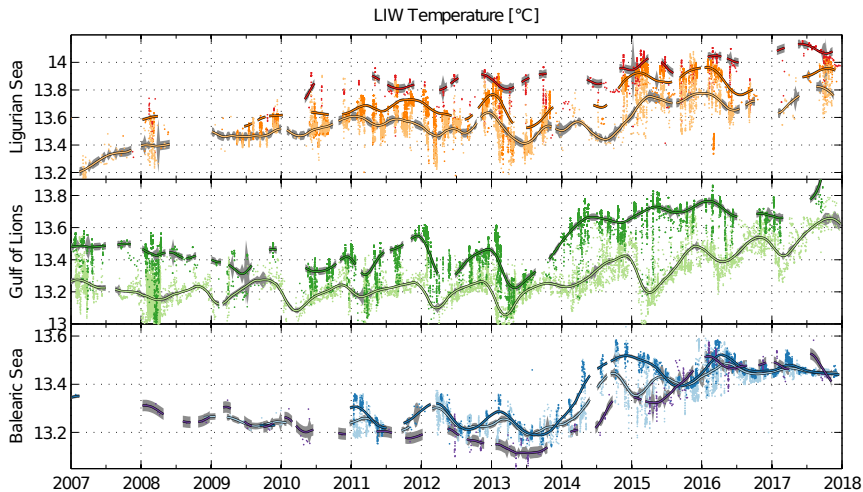
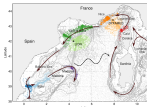


LIW core time series

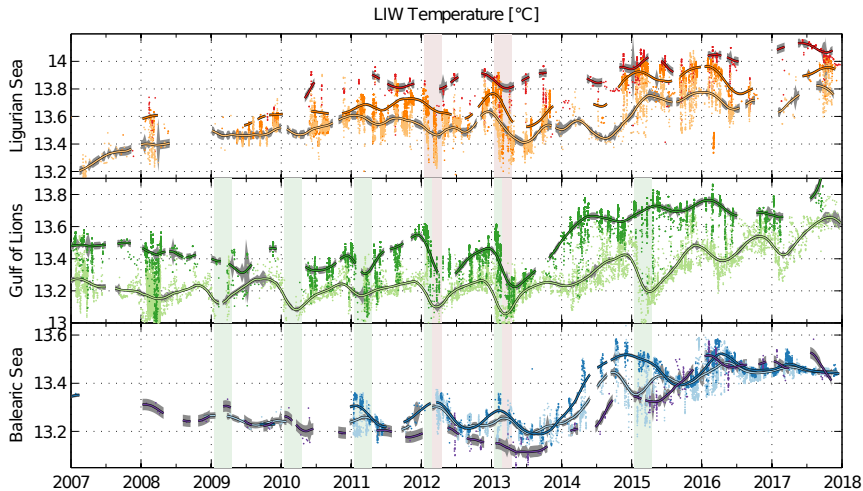
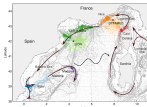


Input in the Northwestern Mediterranean Basin : $+0.06\text{ }^{\circ}\text{C}.\text{year}^{-1}$,
 $+0.012\text{ psu}.\text{year}^{-1}$

LIW regulated by deep convection

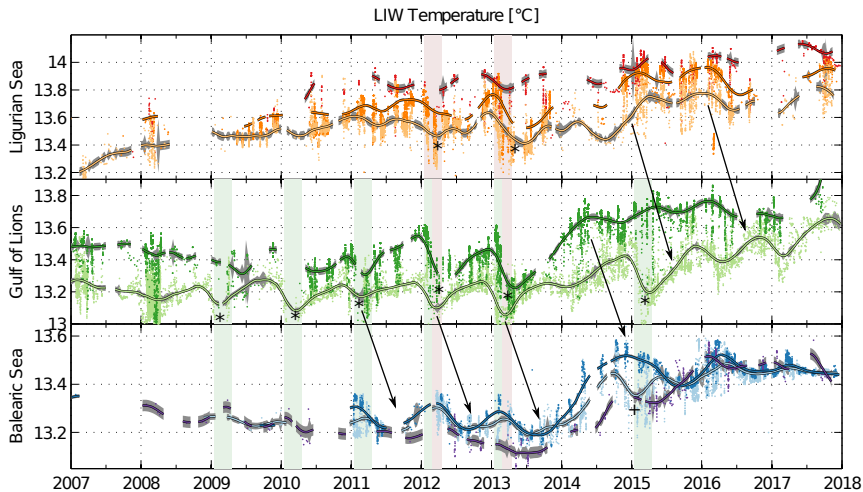
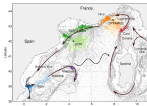


LIW regulated by deep convection

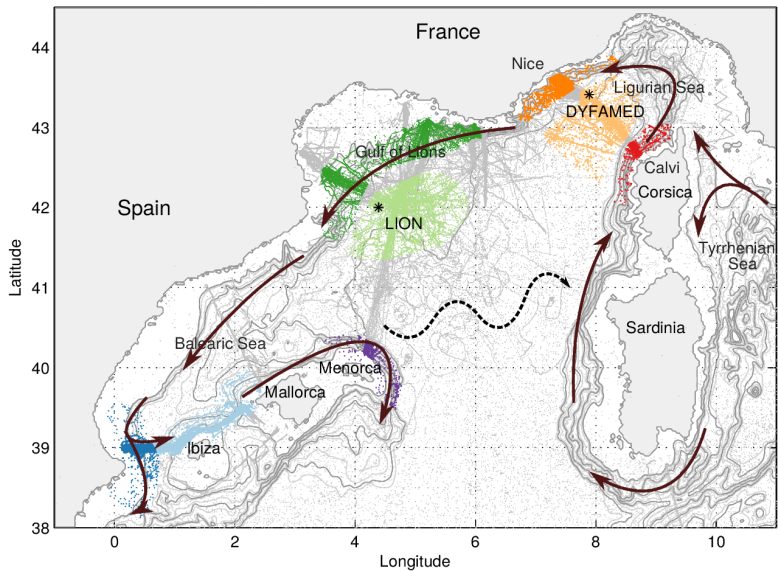


2014 'jump' : $+0.3\text{ }^{\circ}\text{C}$, $+0.08\text{ psu}$

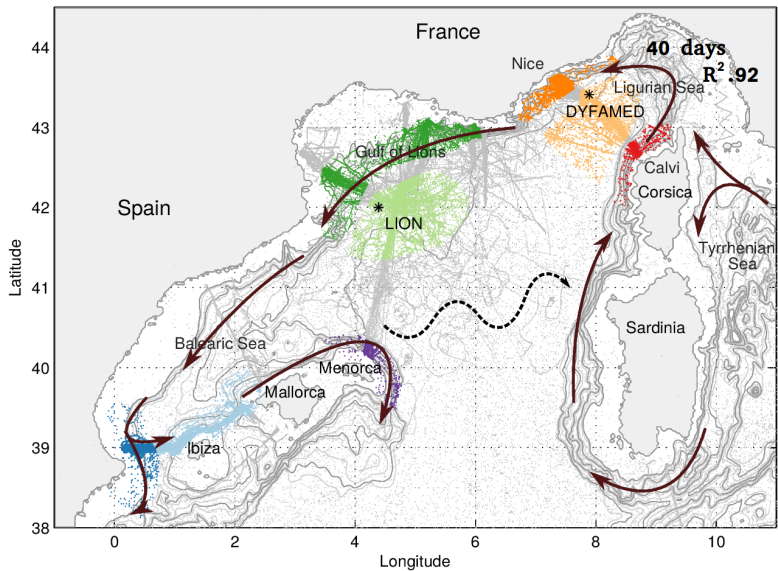
LIW regulated by deep convection



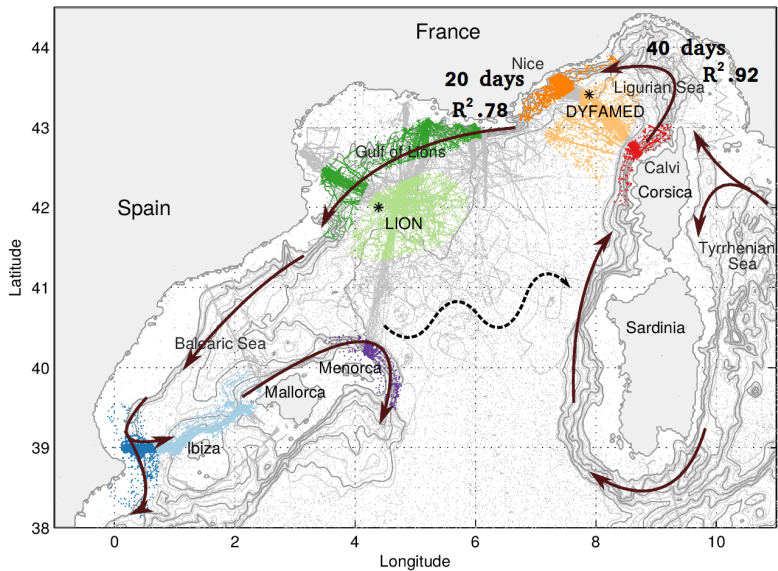
Estimated LIW circulation times



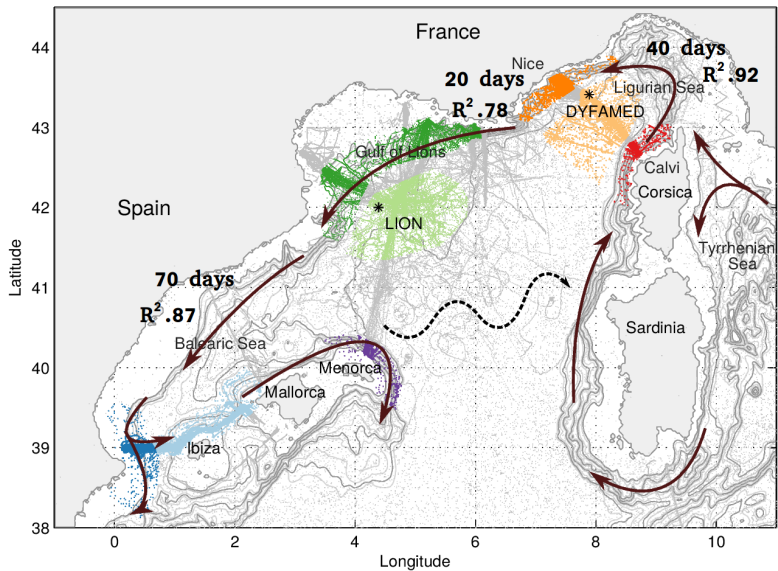
Estimated LIW circulation times



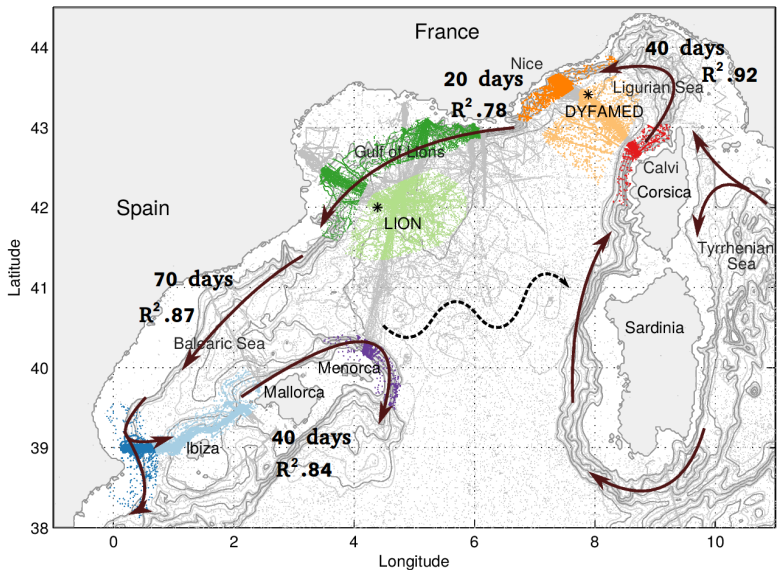
Estimated LIW circulation times



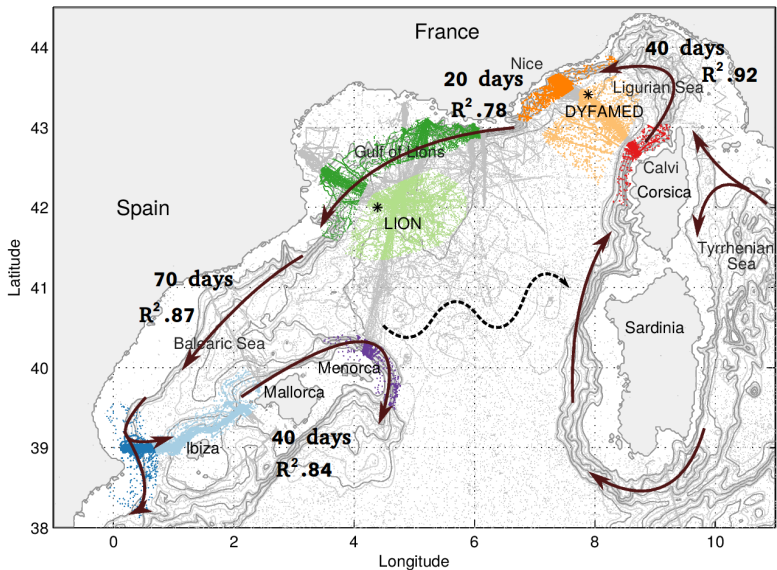
Estimated LIW circulation times



Estimated LIW circulation times

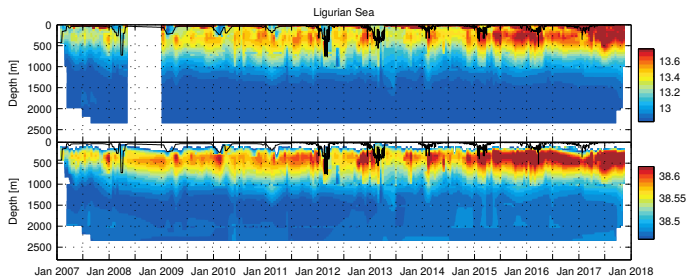


Estimated LIW circulation times

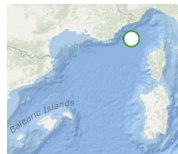


equivalent to $5-10 \text{ cm.s}^{-1}$: boundary currents

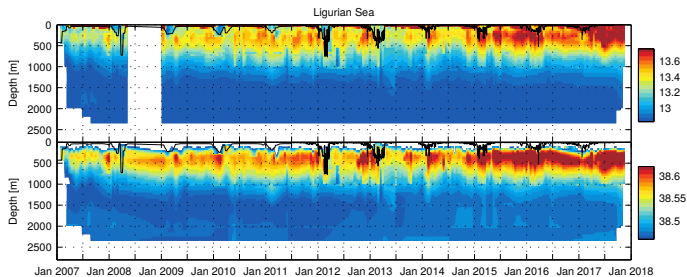
LION and DYFAMED mooring locations : heat and salt



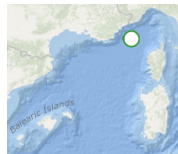
DYFAMED



LION and DYFAMED mooring locations : heat and salt



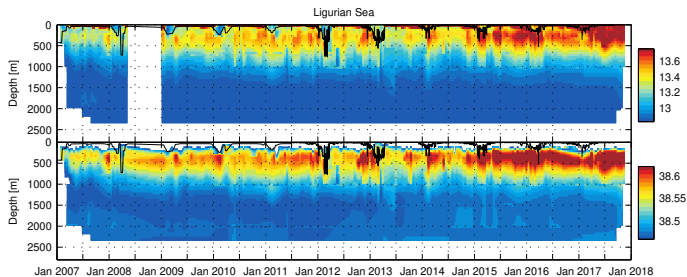
DYFAMED



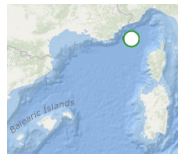
LIW:

$+0.06 \text{ }^{\circ}\text{C}.\text{year}^{-1}$,
 $+0.012 \text{ psu}.\text{year}^{-1}$

LION and DYFAMED mooring locations : heat and salt

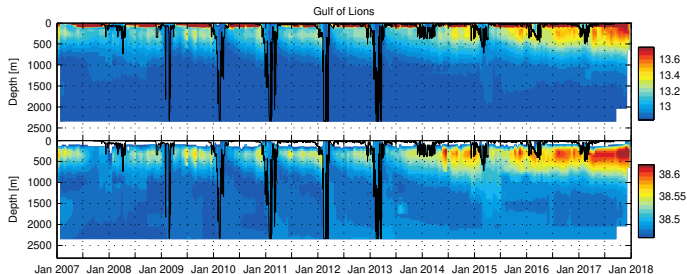


DYFAMED



LIW:

$+0.06 \text{ }^{\circ}\text{C}.\text{year}^{-1}$,
 $+0.012 \text{ psu}.\text{year}^{-1}$



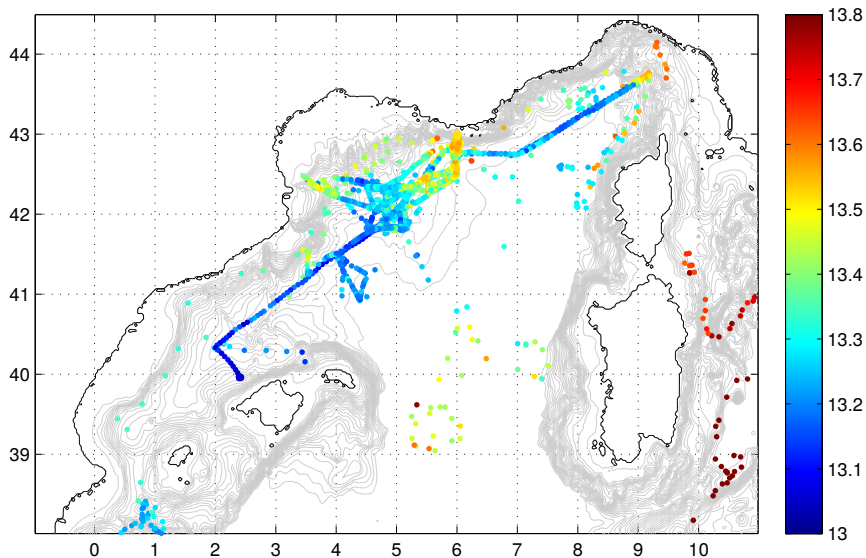
LION



Deep convective
year :
 $\text{MLD} > 1000 \text{ m}$

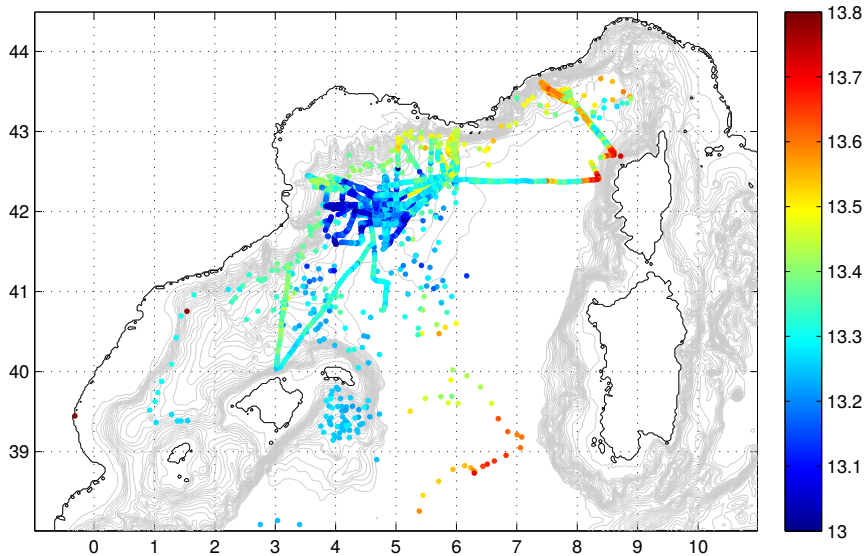
LIW invasion

2007 LIW core Temperature [$^{\circ}\text{C}$]



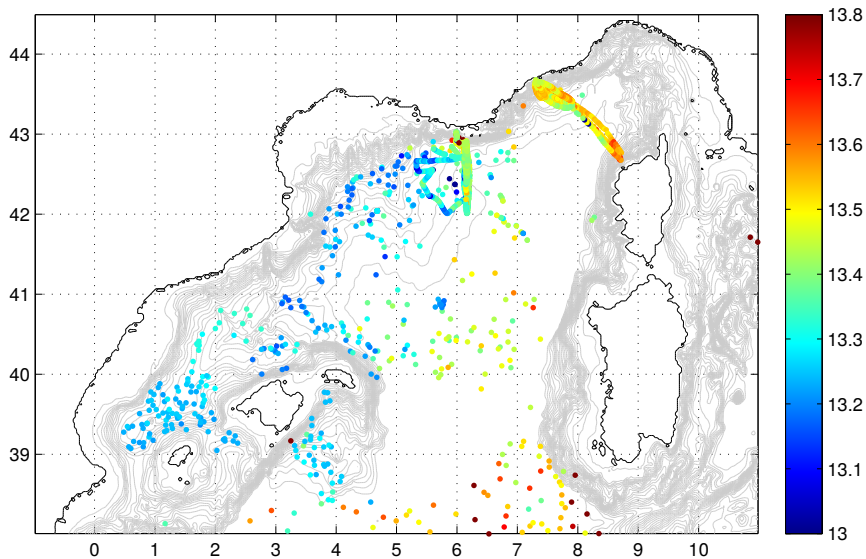
LIW invasion

2008 LIW core Temperature [$^{\circ}\text{C}$]



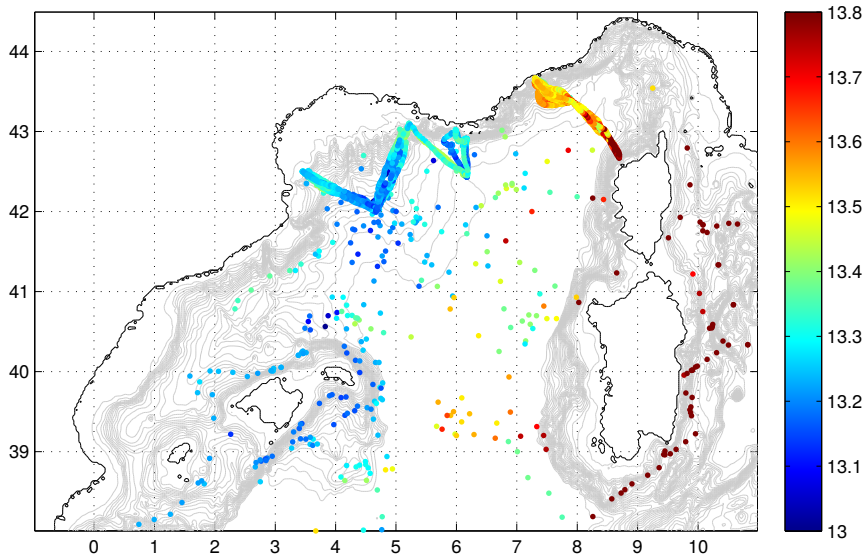
LIW invasion

2009 LIW core Temperature [$^{\circ}\text{C}$]



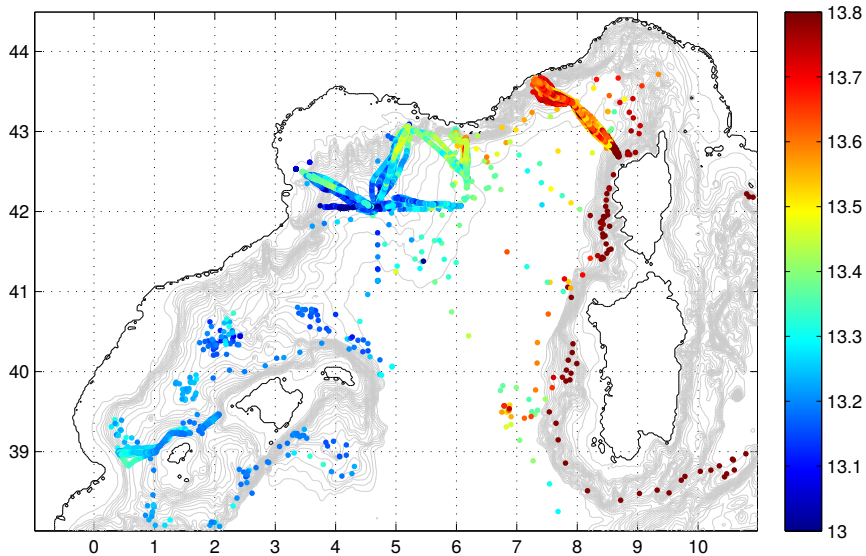
LIW invasion

2010 LIW core Temperature [$^{\circ}\text{C}$]



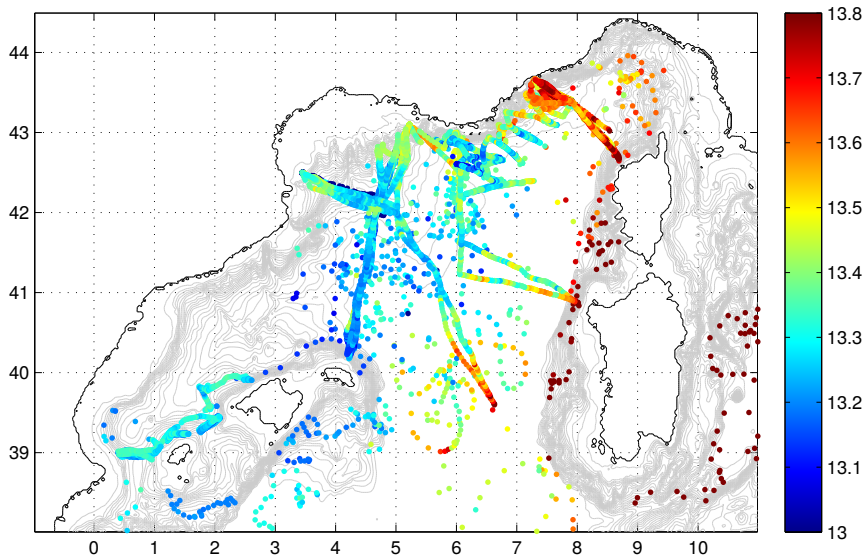
LIW invasion

2011 LIW core Temperature [$^{\circ}\text{C}$]



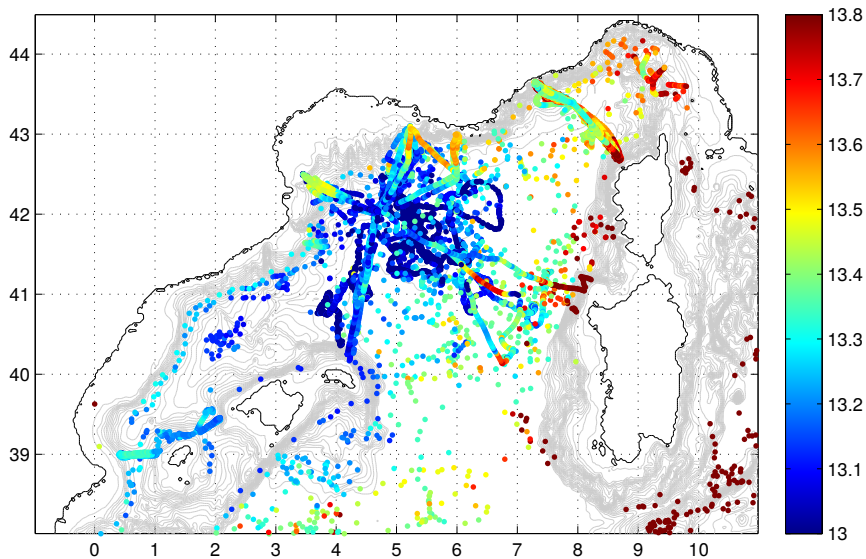
LIW invasion

2012 LIW core Temperature [$^{\circ}\text{C}$]



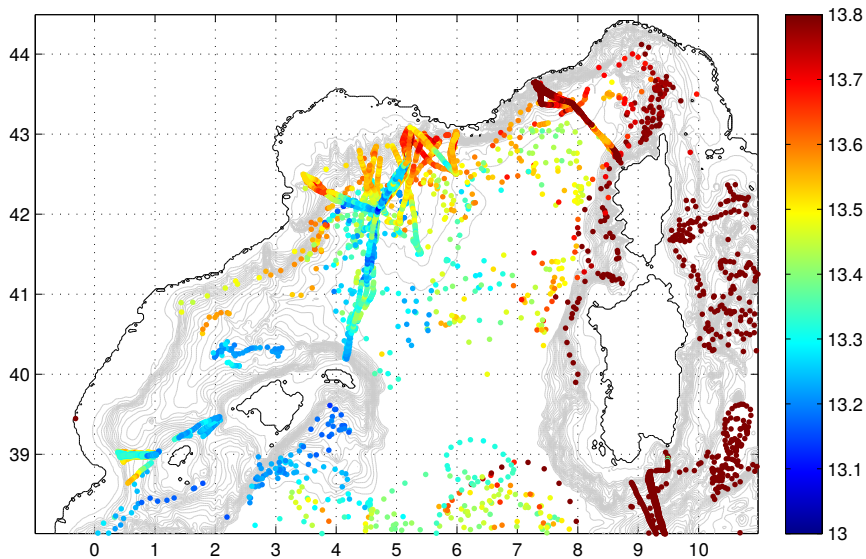
LIW invasion

2013 LIW core Temperature [$^{\circ}\text{C}$]



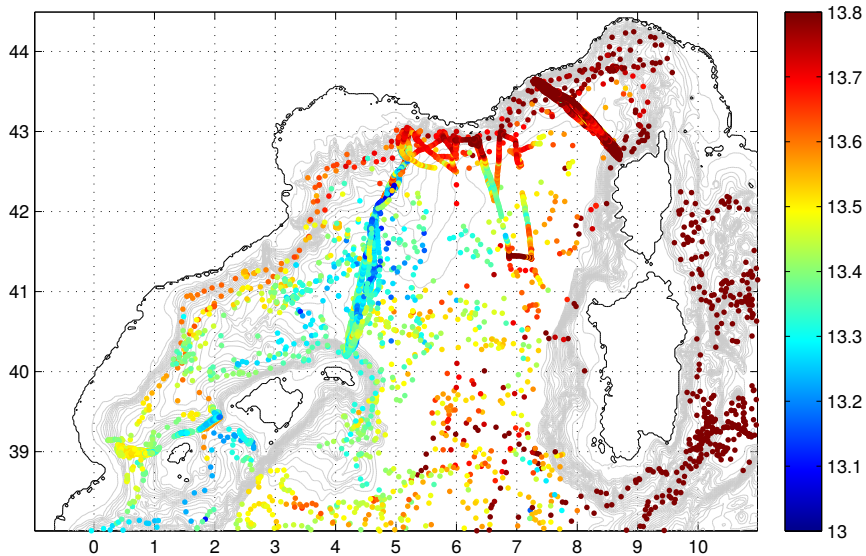
LIW invasion

2014 LIW core Temperature [$^{\circ}\text{C}$]



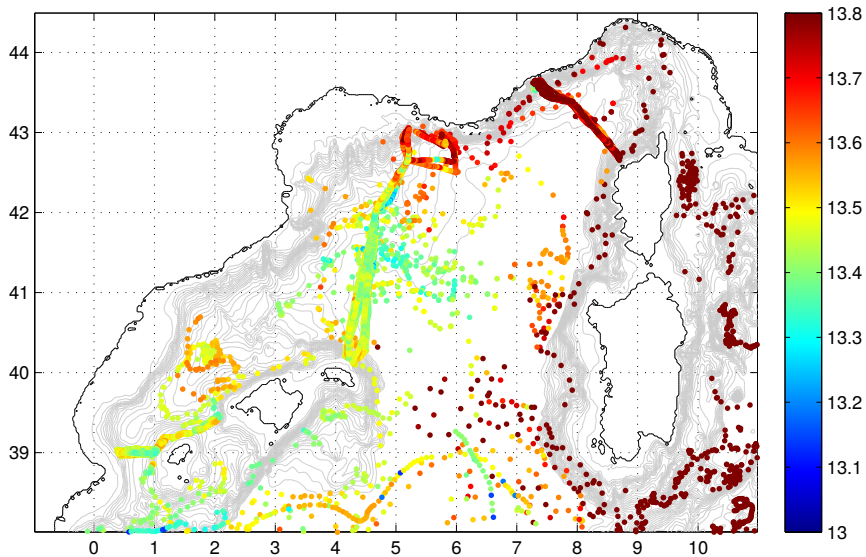
LIW invasion

2015 LIW core Temperature [$^{\circ}\text{C}$]



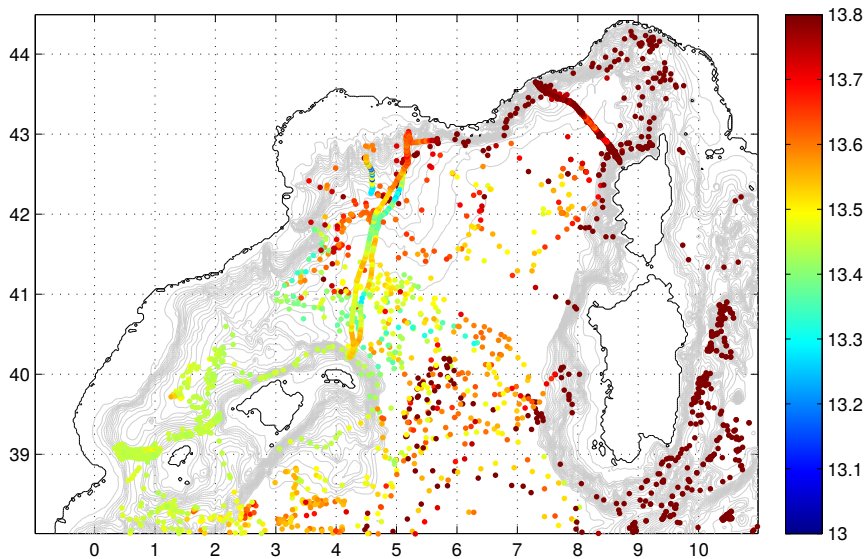
LIW invasion

2016 LIW core Temperature [$^{\circ}\text{C}$]



LIW invasion

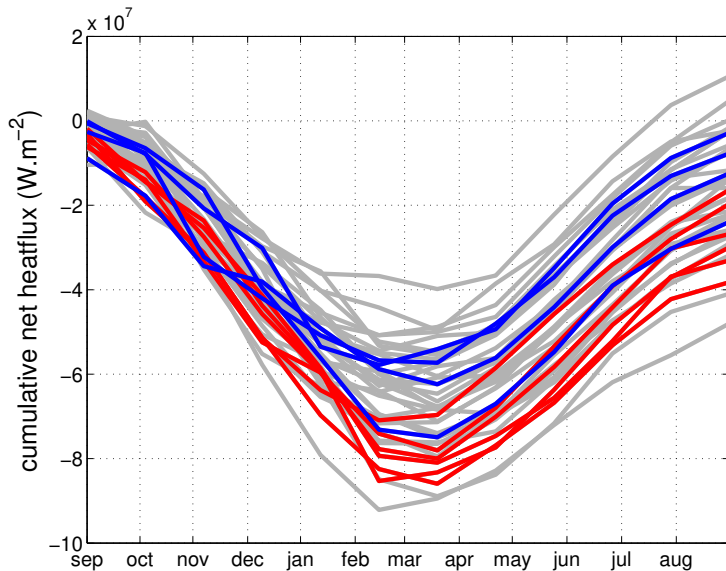
2017 LIW core Temperature [$^{\circ}\text{C}$]



Fluxes and Stratification :
Is deep convection still possible ?

Heatfluxes dominating ?

2007/2017 LION period



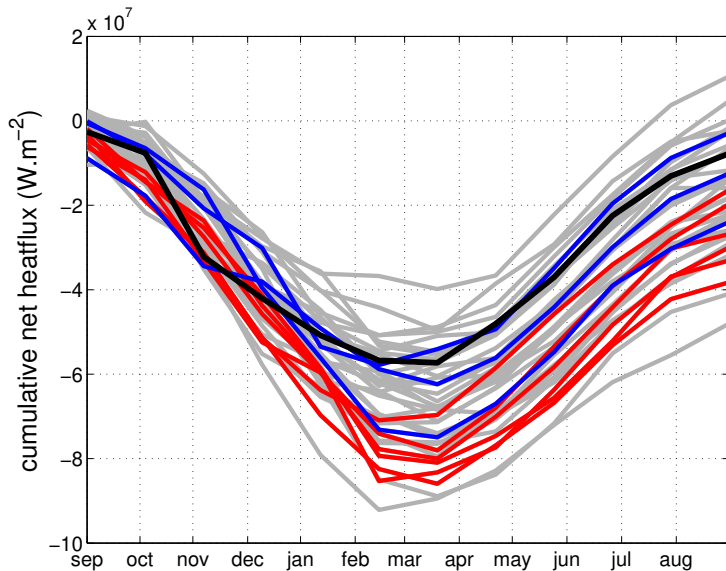
Non deep
convective
year

Deep
convective
year
(MLD > 1000m)

ERA-Interim
historical
fluxes
(starting in
1979)

Heatfluxes dominating ?

2013/2014 transition winter



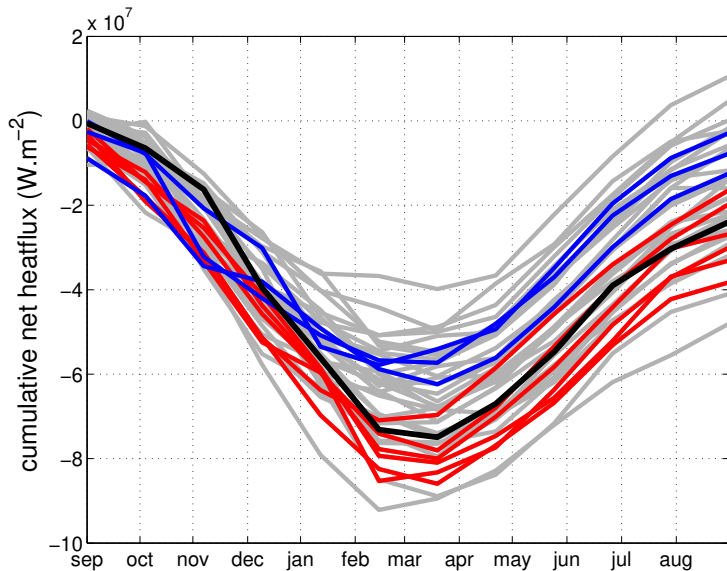
Non deep
convective
year

Deep
convective
year
(MLD > 1000m)

ERA-Interim
historical
fluxes
(starting in
1979)

Heatfluxes dominating ?

2014/2015 paradoxical year



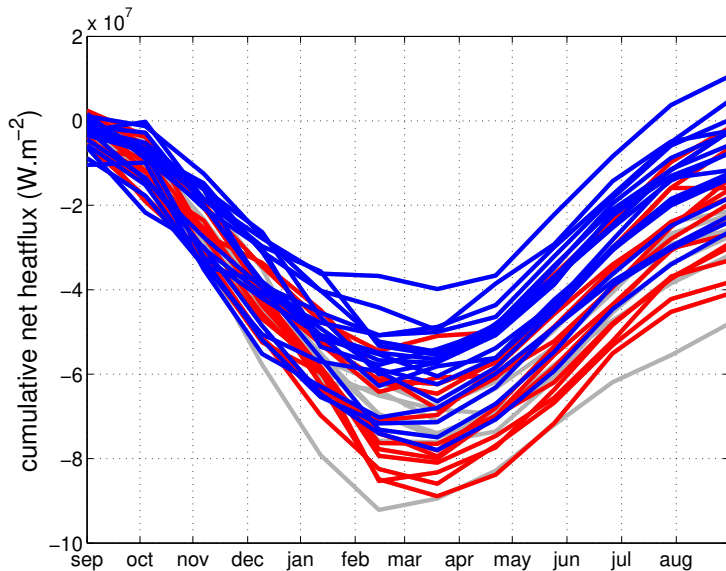
Non deep
convective
year

Deep
convective
year
(MLD > 1000m)

ERA-Interim
historical
fluxes
(starting in
1979)

Heatfluxes dominating ?

1981/2013 Dense Water Formation records



Non deep
convective
year

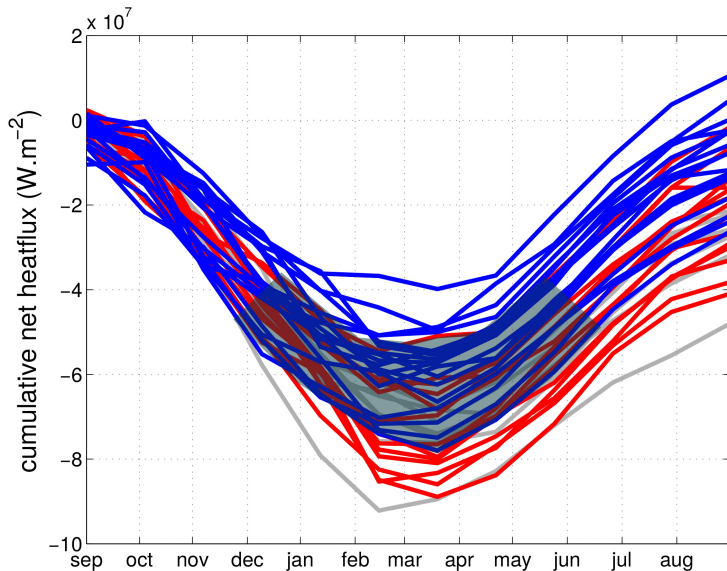
Deep
convective
year
($\text{MLD} > 1000\text{m}$)

ERA-Interim
historical
fluxes
(starting in
1979)

[Somot et al.
2016]

Heatfluxes dominating ?

1981/2013 Dense Water Formation records



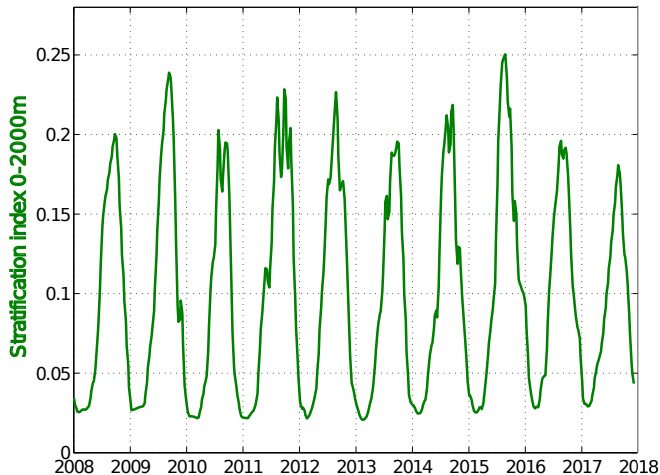
Non deep
convective
year

Deep
convective
year
(MLD > 1000m)

ERA-Interim
historical
fluxes
(starting in
1979)

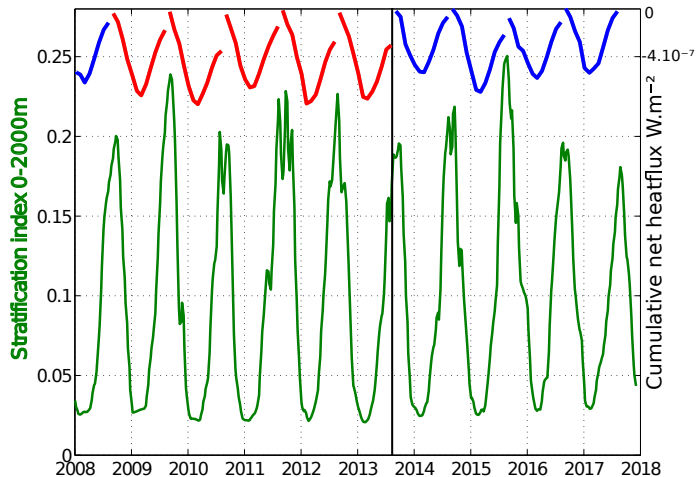
[Somot et al.
2016]

Stratification index 0-2000m : time series



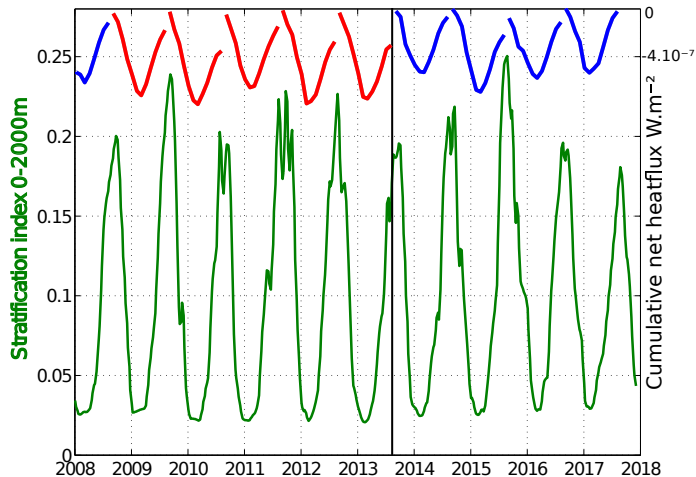
$$S = \int_0^Z \frac{g}{\rho_0} \frac{\partial \rho}{\partial z} z dz$$

Stratification index 0-2000m : time series



$$S = \int_0^Z \frac{g}{\rho_0} \frac{\partial \rho}{\partial z} z dz$$

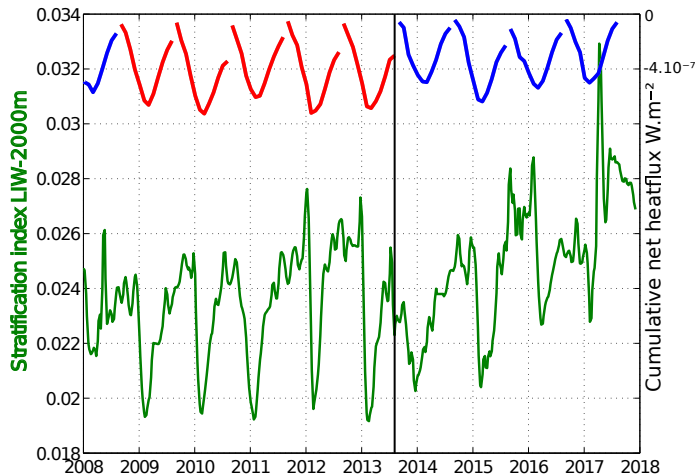
Stratification index 0-2000m : time series



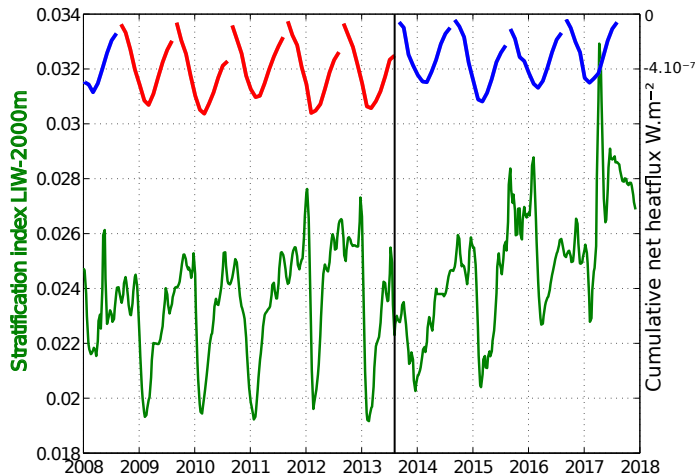
$$S = \int_0^Z \frac{g}{\rho_0} \frac{\partial \rho}{\partial z} z dz$$

seasonal cycle

Stratification index LIW-2000m : time series

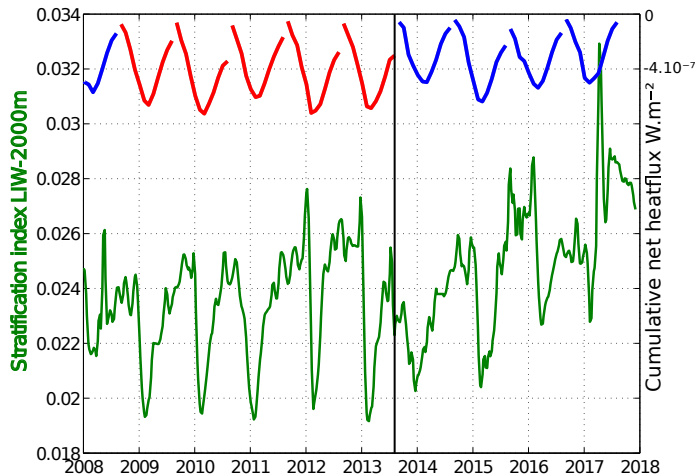


Stratification index LIW-2000m : time series



LIW-bottom
stratification
index

Stratification index LIW-2000m : time series

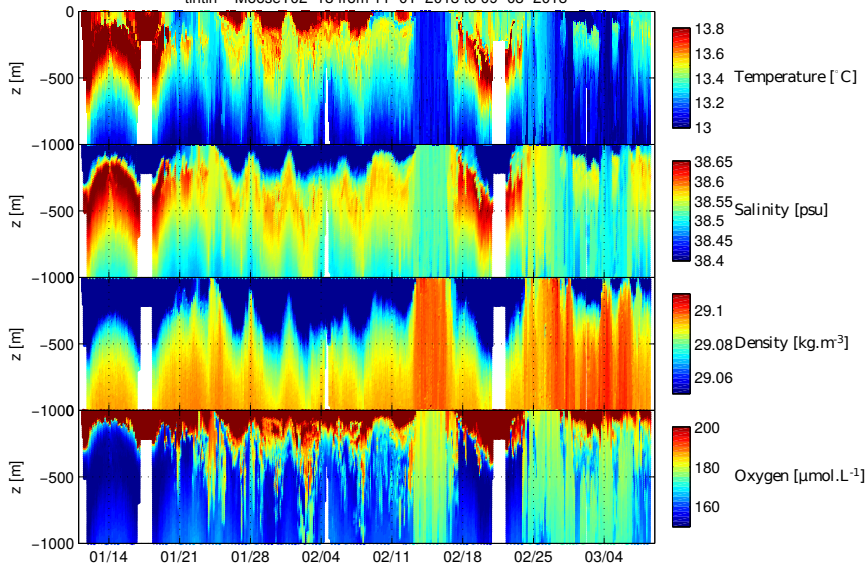


LIW-bottom
stratification
index

key buoyancy
loss timing

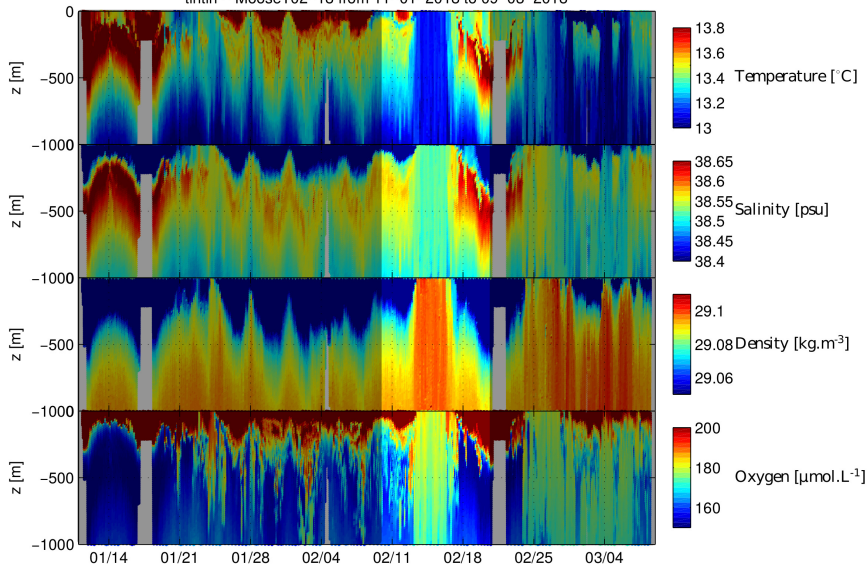
2018, a deep convective year !

tintin - MooseT02-18 from 11-01-2018 to 09-03-2018

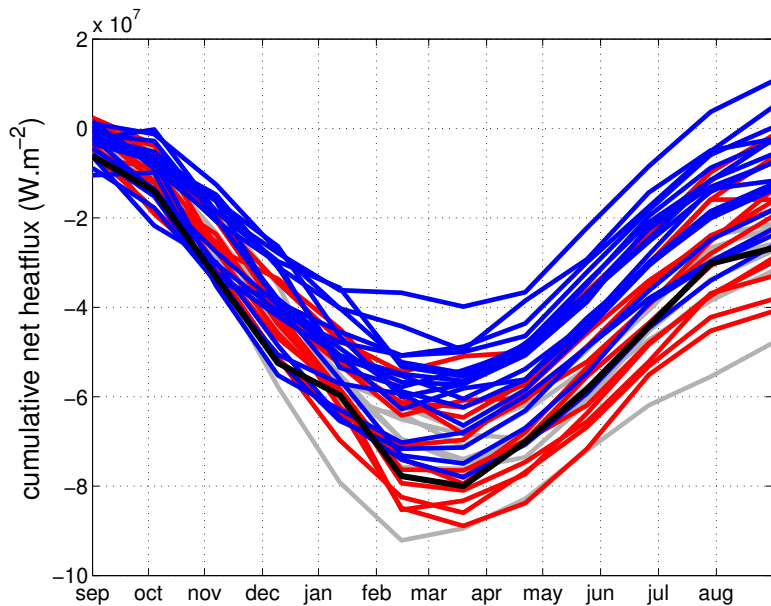


2018, a deep convective year !

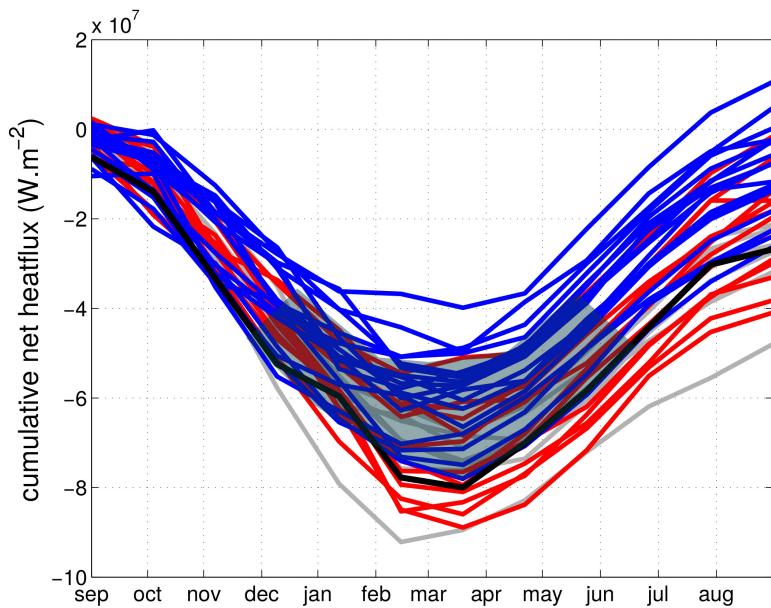
tintin - MooseT02-18 from 11-01-2018 to 09-03-2018



2018 heatfluxes



2018 heatfluxes



Conclusions

Numerous observations :

- ▶ Quantification of the basin-scale and interannual impact of Deep Convection (Invasion of heat and salt at intermediate layer)
- ▶ Stratification below the LIW is key
- ▶ Deep convection depending on the previous year being convective or not

