Contribution to the Mediterranean Sea water and heat budget definition: links between the Tyrrhenian and the Liguro-Provençal subbasins

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Introduction

One of the Target Areas (TA) that have been defined in the HyMeX framework is the north-western Mediterranean, where all the intense hydrometeorological phenomena of interest for HyMeX occur (heavy precipitation, flash-flooding, cyclogenesis, dense water formation and deep ocean convection).

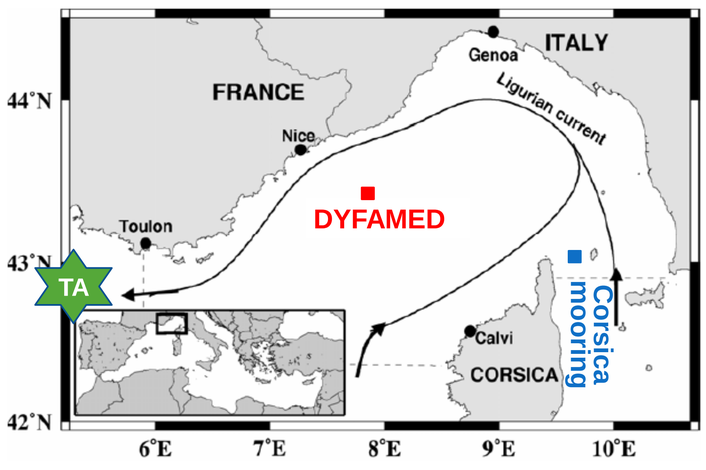

Figure 1: Location of the mooring in the Corsica Channel (blue) and the DYFAMED station (red) in the Ligurian Sea, upstream from the TA in the North-western Mediterranean (green star). [From Marty & Chiaverini, 2010].

The monitoring of the exchanges through the Corsica Channel is a fundamental task for the quantification of the heat and salt import from the Tyrrhenian Sea towards this TA and thus to the dense water formation site. The transport in the Corsica Channel has been monitored since July 1985 with a sub-surface mooring, which measures currents and temperature at different depths (Fig. 3), in order to permit the detection of the exchanges both in the surface and the deep layers. In the deep layer, the mooring is also equipped with a high quality CTD probe, to detect the hydrographic variability in correspondence to the LIW layer. Furthermore, hydrographic campaigns are planned every six months. In the central Liguro-Provençal basin the DYFAMED data are collected on a monthly basis since 1995. Both data sets constitutes a main tool for the assessment of the heat and water budgets determination of the TA.

The Target Area in the NW-MED

During the 3rd HyMeX Workshop in June 2009, three Target Areas (TA) have been proposed as candidates for the first EOP/SOP series (Enhanced/Special Observing Periods): the north-western Mediterranean, the Aegean and the Adriatic. The objective of the EOP is to assess the convection variability and the volume of dense water formed, which cannot be captured by one mooring, thus the convection area should be regularly covered by gliders transects. The SOPs are dedicated to the formation and dispersion of dense water and the expected result is to evaluate uncertainties on the different terms of the budget. Several scientific cruises should help to monitor this basin-scale process at different time steps: enhanced monitoring of water masses and mixed layer depth evolution before and after convection; documenting the effect of intense events on the early destratification of upper layer. The TA in the NW-MED will be included also in the LOP (Long Observing Period) strategy, whose backbone will be permanent deep offshore moorings.

A major contribution to Mediterranean sea water and heat budgets definition would be to link the observations made in the TA to observations made upstream: in the Corsica Channel (CNR-ISMAR) and in the Ligurian Sea (CNRS-INSU).

The Corsica Channel

The Corsica Channel is representative of the exchanges between the Tyrrhenian and the Liguro-Provençal basins and is particularly sensitive to the winter cooling occurring in the latter and the unbalance of the winter air-sea exchanges, significantly different in the two subbasins. While the Liguro-Provençal basin is characterized by intense air-sea fluxes, which may induce deep water formation processes, the Tyrrhenian Sea, less concerned by the Mistral events, experiences significantly lower air-sea interactions. The mean transport through the channel and its variability have the same order of magnitude (0.49±0.42 Sv). The current, flowing almost permanently northward, has a clear seasonal cycle, with high values in winter and almost negligible values in summer. The seasonal cycle is quite regular and explains a large percentage of the observed variability. The interannual variability related to the winter periods (the colder the winter, the higher the transport) is remarkable: the higher transports observed during the '80s were significantly reduced during the '90s.

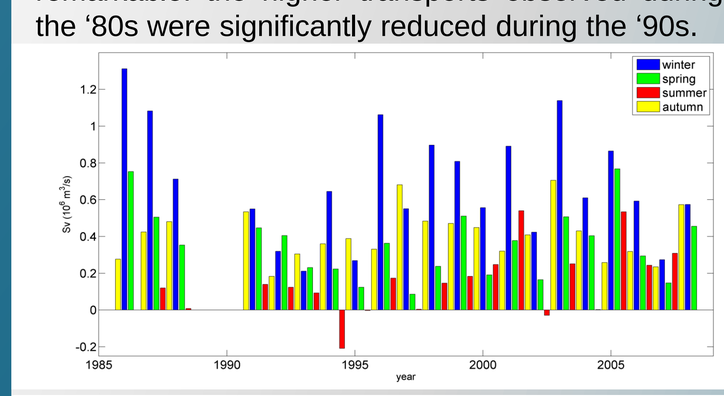

Figure 2: Seasonal evolution of the transport in the Corsica Channel. Blue bars indicate the winter transport [updated from Gasparini et al., 2008]

The Ligurian Sea

Systematic deep CTD casts down to 2000m are realized monthly at the DYFAMED (DYnamique des Flux Atmospheriques en MEDiterranee) since 1995. The site is located 50 km off Cape Ferrat, at 43° 25.0 N, 7° 52.50 E in the Ligurian Sea (Fig. 1).

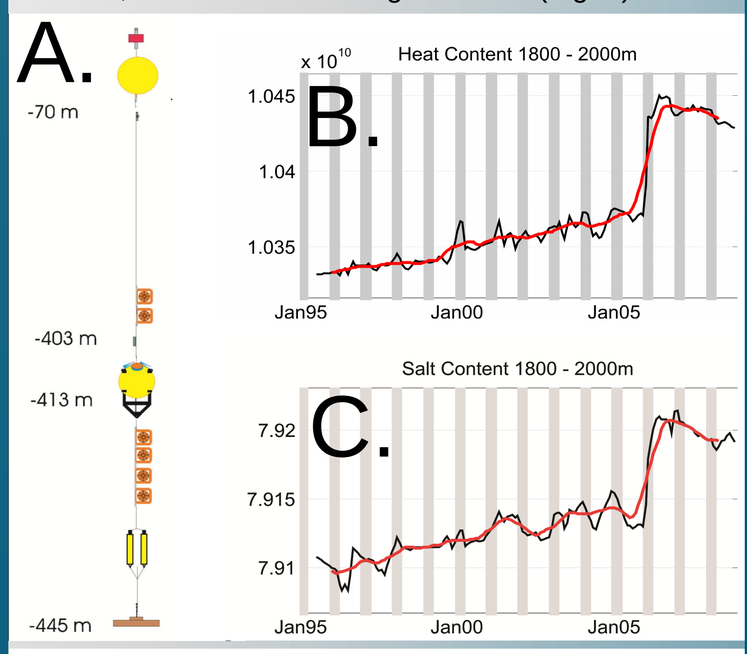

Figure 3: (A) Corsican mooring scheme, with 2 T-S probes (at 70 m and 403 m) and an upwardlooking ADCP at 413 m; (B) heat and (C) salt content time-series in the 1800-2000 m layer at DYFAMED of (B) heat content and (C) salt content [Schroeder et al., 2010].

Data were used to examine hydrological changes (Fig. 3B and 3C): a regular increase of T and S (0.005 °Cy^{-1}, 0.0022 psu y^{-1}) was recorded in deep waters during 1995–2005 [Marty & Chiaverini, 2010]. In February 2006 an abrupt increase in T (+0.1 °C) and S (+0.03 psu) was measured as the result of successive intense winter mixing events during the 3 previous years [Marty & Chiaverini, 2010; Schroeder et al., 2010].

Links and contribution to HyMeX

Comparing the time series at 400 m (along the path of the LIW) in the Corsica Channel and in the Liguro-Provençal basin (DYFAMED) we may observe lower temperature (and salinity) values in the latter, due to the mixing of the LIW along its path. The most striking feature is that there is a similar long-term oscillation in both time series (Fig. 4), with increasing temperature until 2004, followed by a sharp decrease until spring 2006. Finally, the return of a warming period in the intermediate layer started in May 2006 in the Corsica Channel and one month later at the DYFAMED station (June 2006). Interestingly, both records at 400 m (Corsica Channel and DYFAMED) reached their absolute maximum and their absolute minimum in a time period of two years (from 2004 to 2006), suggesting dramatic changes occurring in recent years [Schroeder et al., 2008; Marty & Chiaverini, 2010].

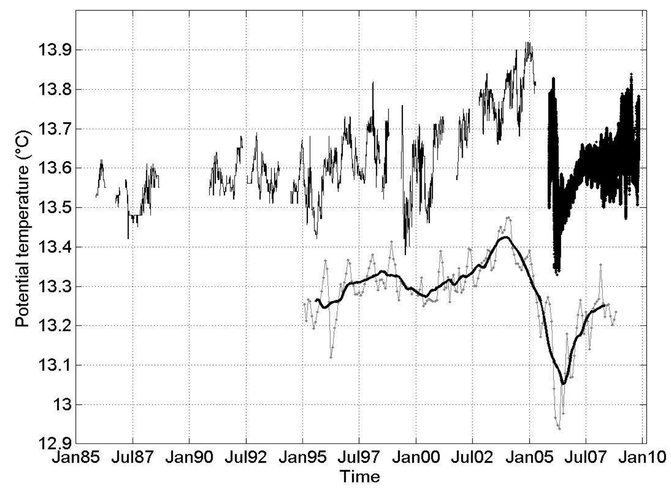

Figure 4: Comparison between potential temperature time series at 400 m depth in the Corsica Channel (above), and at the DYFAMED station (below).

In the framework of HyMeX, the assessment of the variability of the mass, heat and salt fluxes through this channel towards the Liguro-Provençal basin, and its effects on the DYFAMED observations will be able to:

- ❑ give insights to teleconnection patterns that may be important for the north-western Mediterranean Sea (WG4): there are evidences of a possible influence of the NAO on winter atmospheric conditions in the Liguro-Provençal basin and thus on the air-sea exchanges, which are very active in this region. A comparison between the winter transport in the Corsica Channel (Fig. 2) and the NAO winter index showed that negative NAOI values correspond to higher values of the transport from the Tyrrhenian to the Liguro-Provençal basin. Conversely, if the NAOI is very positive, the transport through the channel records the lowest values [Gasparini et al., 2008];
- ❑ contribute to the definition of the Mediterranean sea water and heat budgets, in particular for the Target Area of the north-western Mediterranean (WG1);
- ❑ give insights to the interannual variability of the deep water formation in this region (WG4);
- ❑ contribute to the LOP (WG1).

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