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Modern view of Western Mediterranean hydrography (Arne Richter Award Lecture for OYS)

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The Mediterranean Sea is in many ways a miniature ocean. It has deep water formation varying on interannual time scales and a well-defined overturning circulation, and there are distinct surface, intermediate and deep water masses circulating between the western and the eastern basin. What makes the Mediterranean particularly useful for climate change studies is that its time scale is much shorter than for the global ocean, with a turnover time of roughly 60 years compared with more than 500 years for the global ocean. Changes can happen faster, on the time scale of a human lifetime. Thus the Mediterranean is useful as a laboratory for documenting changes within it (and hence anticipating similar changes in the global ocean) and for understanding the role of key processes involved in climate change (thus to make inferences on those processes on the global scale).
It is a semi-enclosed basin for which a rewarding monitoring strategy should rely on regular ship-based surveys (Med-SHIP, as a component of GO-SHIP, to provide data over the entire water column, especially for the deep ocean below 2 km, i.e. more than 20% of Mediterranean volume), physical process studies (e.g. mixing, strait flows) and using it as a laboratory for climate change (e.g. deep water formation, slow changes in salinity and temperature).
In the western deep layers, an almost constant trend towards higher salinity and temperature has been observed since the ‘50s. More recent observations evidenced an acceleration of this tendency. An alteration of the stratification, associated with an abrupt temperature and salinity increase has been observed. In particular, since March 2005 large volumes of new bottom water have formed in the northwestern Mediterranean Sea. Remarkably this new bottom water is warmer and saltier than the old deep waters so it has become an easily recognized water mass when temperature and salinity profiles are made through the water column. Since its formation, this new bottom water has spread out into the western Mediterranean so that now it forms a bottom layer of warm salty water up to 1000 m thick throughout the western Mediterranean basin. The new bottom water has provided a natural tracer release experiment for understanding how bottom water fills the basin.
The processes of deep water formation, the filling of the western Mediterranean with the new deep waters formed in the north, and the mixing between old and new deep waters are keys to understand how the Mediterranean is changing under changing climate conditions. An important open issue is how the old and new deep waters mix, on what time scale and by what processes, and in particular to quantify the role of turbulent mixing in the overall diffuse upwelling, the returning branch of the vertical thermohaline circulation.