OceanGliders Water Formation Observing Network

Many aspects of our environment, such as the characteristics and changes of the global/regional climate, the weather, ecosystems, the living resources and the biodiversity are strongly linked to the ocean. The ocean also plays a major role in many human activities like coastal protection, tourism, search and rescue, defense and security, shipping, aquaculture, offshore industry and marine renewable energy. These activities are all major drivers for studies aiming to better understand the ocean (physical, chemical and biological) functions and a constant monitoring of its state. Physical, chemical, and biological properties are imported, redistributed and exported in huge amounts by the oceanic circulation and any attempt to understand, model, predict the evolution of, the global and regional climates and marine ecosystems must include its variability and sensitivity to external changes. Indeed, fluctuations in the one are expected to lead to changes in the others, with the potential for feedback loops between those.

Much of what is known about the oceanic circulation derives from the fundamental concept of water mass. The global/regional ocean is composed of a limited number of water masses that are formed during strong air-sea interactions in winter, in particular regions due to favorable local conditions (atmospheric regimes, stratification, topography,...). The water formation processes lead to large mixed patches (100s km) presenting quasi-homogeneous (physical, chemical and biological) properties and intermediate (100s of m, shelf/slope bottom) or sometimes deep (1-2 km, bottom), mixed layer depths. Later on, in spring, when the air-sea fluxes diminish, the water masses formation areas restratify, while these new water masses subduct and mix with their surroundings. These processes can “buffer” or “memorize” climatic (physical, biogeochemical and biological) signals for long periods of time, until these water masses have again a contact with the atmosphere in the following years/decades/centuries, and possibly far away (1000s of km) from their formation areas, via general vertical mixing/diffusion or again by winter vertical mixing reaching the depths of these subducted waters and leading to newly-formed water masses in the same or in remote areas.

While average conditions of the oceanic circulation and processes have been studied and assessed during the past years, little is known about the evolution of the system because it is challenging to observe these water formation phenomena each year and estimate the source (physical, chemical, biological) properties and volumes of these newly-formed water masses. These are critical elements to conveniently assess the evolution of the global/regional oceans, and in particular their deep reservoirs of heat, salt, nutrients, etc. that are mostly impacted by these ventilation processes. Water formations occur on an “intermittent” basis, sometimes in very local patches (~100km) that are not well resolved by the present GOOS, during relatively short episodes of strong air-sea fluxes and result from different oceanic and atmospheric factors that must considered at least on a period starting the previous summer/fall due to preconditionning effects. This implies sustained in-situ observing efforts must be carried out on relatively large areas, though with high horizontal resolution because of the small scale circulation features involved, almost throughout the year, and moreover in winter/spring, when it is very difficult to carry out in-situ measurements due to severe conditions at sea. The observation of such phenomena remained a challenge until the use of autonomous underwater gliders in combination with more classical ocean observing techniques.

The OceanGliders Water Formation network aims to complement existing ocean observing systems that are not able to monitor these major energy and matter fluxes. The horizontal speed of a glider being order of 30km/day allows to capture most of the oceanic (physical/biogeochemical) variability of the upper ocean layer (~1km), strongly driven by oceanic waves having slower propagation speeds even during severe conditions at sea. Being able to repeat observations along a 300km section at a 10 days repeat-rate, gliders deployed along a repeat-section can actually scan a particular area at the regional scale and provide a synoptic view of the different water masses circulating there. Only the glider capacities and versatility allow, but in combination with other observing techniques, to monitor a water formation area with sufficient accuracy and to finally estimate the source characteristics of a water mass and its ventilation rates on an interannual basis. This is of critical importance for the ocean state estimates by global and regional models not only locally but also at large scale since the water masses spread over great distances (1000s km) and periods of time (years/decades/centuries/...).

Today, there are already some sustained regional glider lines and networks in water formation areas:

- In the Western Mediterranean repeat glider transects have been undertaken to monitor the variability of the Western Mediterranean Deep Water formation in the north of the basin by CNRS and partners (France) since 10 years.
- In the Adriatic Sea,...
- In the Labrador Sea, ...
- In the Southern Ocean, ...
- In the Greenland Sea,...

In addition, there are several proposed and planned efforts:

- ...

The intention of the OceanGliders Water Formation Task Team (WFTT) is to provide coordination and linkage for a global observing program on water masses formation and assist, with guidance and best practice, other teams in engaging in the glider technology in order to address these ventilation rates issues on an interannual basis at the global scale. The OceanGliders WFTT will promote methodologies to estimate water formation rates and best practice in glider mission design, glider operations, data management, data public dissemination and data analysis. Expected benefits concern a better and sustained quality control. The overaching goal of this WFTT is to provide a comprehensive information on the water mass variability, as a key constraint for atmosphere/ocean modeling. Because the water formation processes occur at the regional level, the WFTT will rely on a network of regional networks monitoring water formation rates in a consistent way.

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