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Air-sea fluxes and satellite-based estimation of water masses formation

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Recent work linking satellite-based measurements of sea surface salinity (SSS) and sea surface temperature (SST) with traditional physical oceanography has demonstrated the capability of generating routinely satellite-derived surface T-S diagrams [1] and analyze the distribution/dynamics of SSS and its relative surface density with respect to in-situ measurements. Even more recently [2,3], this framework has been extended by exploiting these T-S diagrams as a diagnostic tool to derive water masses formation rates and areas.

A water mass describes a water body with physical properties distinct from the surrounding water, formed at the ocean surface under specific conditions which determine its temperature and salinity. The SST and SSS (and thus also density) at the ocean surface are largely determined by fluxes of heat and freshwater. The surface density flux is a function of the latter two and describes the change of the density of seawater at the surface. To obtain observations of water mass formation is of great interest, since they serve as indirect observations of the thermo-haline circulation. The SSS data which has become available through the SMOS [4] and Aquarius [5] satellite missions will provide the possibility of studying also the effect of temporally-varying SSS fields on water mass formation.

In the present study, the formation of water masses as a function of SST and SSS is derived from the surface density flux by integrating the latter over a specific area and time period in bins of SST and SSS and then taking the derivative of the total density flux with respect to density. This study presents a test case using SMOS SSS, OSTIA SST, as well as Argo ISAS SST and SSS for comparison, heat fluxes from the NOCS Surface Flux Data Set v2.0, OAFlux evaporation and CMORPH precipitation.

The study area, initially referred to the North Atlantic, is extended over two additional ocean basins and the study period covers the 2011-2012 timeframe. Yearly, seasonal and monthly water mass formation rates for different SST and SSS ranges are presented. The formation peaks are remapped geographically, to analyze the extent of the formation area. Water mass formation derived from SMOS and OSTIA compares well with the results obtained from in-situ data, although slight differences in magnitude and peak location occur. Known water masses can then be identified.

Ongoing/future work aims at extending this study along different avenues by: 1) expand systematically the spatial and temporal domain of the study to additional ocean basins and to the entire time period of available SSS observations from SMOS/Aquarius; 2) perform a thorough error propagation to assess how errors in satellite SSS and SST translate into errors in water masses formation rates and geographical areas extent; and 3) explore the different options to connect the surface information to the vertical buoyancy structure to assess potential density instability (e.g., Turner angle).

References

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