{rokbox title=|RADMED project stations :: Image: Authors| thumb=|images/stories/ieo/imagenespublicaciones/centro-oceanografico-baleares-ieo-csic-observations-mediterranean-waters-30-year-monitoring-radmed-vargas-et-al-2023-thumb.jpg|}images/stories/ieo/imagenespublicaciones/centro-oceanografico-baleares-ieo-csic-observations-mediterranean-waters-30-year-monitoring-radmed-vargas-et-al-2023.jpg{/rokbox}

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Observations in the Spanish Mediterranean Waters: A Review and Update of Results of 30-Year Monitoring
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Abstract: The Instituto Español de Oceanografía (IEO, Spanish Institute of Oceanography) has maintained different monitoring programs in the Spanish Mediterranean waters (Western Mediterranean) since 1992. All these monitoring programs were unified in 2007 under the current program RADMED (series temporales de datos oceanográficos en el Mediterráneo), which is devoted to the in situ multidisciplinary sampling of the water column of coastal and open-sea waters by means of periodic oceanographic campaigns. These campaigns, together with a network of tide-gauges, are part of the IEO Observing system (IEOOS). In some cases, the temperature and salinity time series collected in the frame of these monitoring programs are now more than 30 years long, whereas sea level time series date to the beginning of the 1940s. This information has been complemented with international databases and has been analyzed in numerous works by the Grupo mediterráneo de Cambio Climático (GCC; Mediterranean Climate Change Group) for more than 20 years. These works have been devoted to the detection and quantification of the changes that climate change is producing on the physical, chemical, and biological properties of the Spanish Mediterranean waters. In this work, we review the results obtained by the GCC since 2005 in relation to the changes in the physical properties of the sea: water column temperature, salinity, and density, heat content, mixed layer depth, and sea level. Time series and results are updated from the last works, and the reliability of the existing time series for the detection of climatologies and long-term trends are analyzed. Furthermore, the different sources of uncertainty in the estimation of linear trends are

considered in the present work. Besides this review and update of the results obtained from the data collected in the frame of the IEOOS, we conduct a review of the existing monitoring capabilities from other institutions in the Spanish Mediterranean waters and a review of results dealing with climate change in the Spanish Mediterranean obtained by such institutions. In particular, we include a review of the results obtained by SOCIB (Servicio de Observación y Predicción Costero de las Islas Baleares; Balearic Islands costal observing and forecasting system) in relation to the study of marine heat waves and the warming of the sea surface, and the results corresponding to the intense warming of the Catalan continental shelf at L'Estartit oceanographic station. All these results evidence that the surface Spanish Mediterranean waters are warming up at a rate higher than that affecting the global ocean (>2 °C/100 years). This warming and a salinity increase are also observed along the whole water column. Marine heat waves are increasing their intensity, frequency, and duration since 1982, and coastal sea level is increasing at a rate of 2.5 mm/yr. The salinity increase seems to have compensated for the warming, at least at surface and intermediate waters where no significant trends have been detected for the density. This could also be the reason for the lack of significant trends in the evolution of the mixed layer depth. All these results highlight the importance of monitoring the water column and the necessity of maintaining in situ sampling programs, which are essential for the study of changes that are occurring throughout the Spanish Mediterranean waters.

Keywords: climate change, Spanish Mediterranean waters, Western Mediterranean, ocean observing systems