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A global view of the 2007-2015 oceanic variability in the Copernicus Marine Service global ocean monitoring and forecasting system

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The global high resolution monitoring and forecasting system PSY4 at Mercator-Ocean has achieved 11 years of global ocean state estimation, initialized in October 2006. Based on the NEMO global 1/12° configuration driven at the surface by the IFS ECMWF atmospheric analyses and forecasts, PSY4 includes data assimilation of satellites and multi-instrument in situ observations by means of a reduced-order Kalman filter with a 3D multivariate modal decomposition of the forecast error. This operational system benefits from significant updates compared to the previous version (e.g., new Mean Dynamic Topography, assimilation of satellite sea-ice concentration, week constraint imposed on temperature and salinity into the deep ocean). In parallel to this monitoring system, a twin free simulation (without any assimilation) has been performed for the period 2007-2015. First, improvements of PSY4 compared to the previous version are presented by focusing on both hindcast and forecast performances. Then, monthly-averaged fields are compared with observation products for the period 2007-2015, to examine the consistency of PSY4 fields with related observations for large-scale variability and to provide a baseline mainly focused on in situ comparisons for validation/qualification of on-going system developments. Results demonstrate that observations play a critical role for correctly positioning the major energetic structures, both in space and time. In addition, data assimilation appears to overcome others model deficiencies by reducing SST bias in upwelling regions and by increasing the thermocline gradient in the tropics. Globally, the amplitude of the large-scale variability in both PSY4 estimates is consistent with observations datasets, suggesting that almost no large-scale energy is incorporated in the system through data assimilation. Annual cycles in temperature, salinity and sea surface height of both PSY4 estimates are regionally and globally consistent with observations. At longer-term variability, changes in ocean heat and freshwater contents are significantly improved regionally thanks to data assimilation, but some progress is still needed for better representing the amplitude of changes of such integrated quantities.