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Joint altimetric and in-situ data assimilation using the GRACE mean dynamic topography: a 1993–1998 hindcast experiment in the Tropical Pacific Ocean

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Abstract The altimetric satellite signal is the sum of the geoid and the dynamic topography, but only the latter is relevant to oceanographic applications. Poor knowledge of the geoid has prevented oceanographers from fully exploiting altimetric measurements through its absolute component, and applications have concentrated on ocean variability through analyses of sea level anomalies. Recent geodetic missions like CHAMP, GRACE and the forthcoming GOCE are changing this perspective. In this study, data assimilation is used to reconstruct the Tropical Pacific Ocean circulation during the 1993–1996 period. Multivariate observations are assimilated into a primitive equation ocean model (OPA) using a reduced order Kalman filter (the Singular Evolutive Extended Kalman filter). A 6-year (1993–1998) hindcast experiment is analyzed and validated by comparison with observations. In this experiment, the new capability offered by an observed absolute dynamic topography (built using the GRACE geoid to reference the altimetric data) is used to assimilate, in an efficient way, the in-situ temperature profiles from the TAO/TRITON moorings together with the T/P and ERS1&2 altimetric signal. GRACE data improves compatibility between both observation data sets. The difficulties encountered in this regard in previous studies such as Parent et al. (J Mar Syst 40–41: 381–401, 2003) are now circumvented. This improvement helps provide more efficient data assimilation, as evidenced, by assessing the results against independent data. This leads in particular to significantly more realistic currents and vertical thermal structures.

Keywords Altimetric data · Gravimetric data · Ocean modeling · Data assimilation · Tropical Pacific · Kalman filter

1 Introduction

For the past 15 years, altimetric satellites have provided high-precision, high-resolution, and quasisynoptic observations of sea surface height (SSH), representing the height of the sea level above a reference ellipsoid (Fig. 1). This SSH has two components: (1) the dynamic topography (DT), which represents the signature of the ocean circulation, and (2) the geoid, which reflects the earth's field of gravity. Poor knowledge of the geoid has prevented, and still prevents, oceanographers from fully exploiting the altimetric signal (Nerem et al. 1994). Only the temporal mean of the SSH, the mean sea surface (MSSH), is known with precision (Hernandez et al. 2001). It corresponds to the sum of the geoid and of the mean dynamic topography (MDT), which reflects the mean circulation of the oceans. It is this MSSH that is taken from the SSH, thereby providing access to the variable part of the ocean signal, that is the sea level anomaly (SLA), which is known with a centimetric precision.

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