Decadal Variability of Net Water Flux at the Mediterranean Sea Gibraltar Strait

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Introduction

Long-term variability of the net water flux into the Mediterranean Sea at the Gibraltar Strait over the period 1960-2011 is explored on an approach combining multiple observational datasets and results from a regional climate model simulation. The goal of this work is to study the decadal variations in net water flux at the Strait of Gibraltar and to indirectly explore the correctness of the equilibrium condition assumption made in state-of-art models.

Direct mass estimation from GRACE

Direct estimates of water mass variation in the Mediterranean Sea over the last decade have been derived from GRACE measurements finding a good agreement with steric-corrected sea level from altimetry [2]. Two composite time-series representing the basin averaged mass change signal have been constructed by:

1. correcting the GRACE signal for the continental hydrology contaminating the GRACE basin averages,
2. removing the steric component from total sea level.

In the Mediterranean Sea the GRACE-derived seawater mass signal has an annual amplitude of 23.5±3 mm peaking in December and a positive linear trend of 6.3±1.3 mm/yr. It is consistent with the steric-corrected altimeter derived seawater mass signal with agreement in amplitude, phase and trend within 1 mm, 40 days and 3 mm/yr. Correlation and RMS errors of the de-seasoned composite time-series are 0.62 and 71 mm (Fig. 1b).

The Bosphorus (B) and the Gibraltar (G) net fluxes are derived from closure of the total water budget (Eq. 1, 2, Fig. 2). The resulting net inflows in Mediterranean Sea from Black Sea and from Atlantic Ocean have annual amplitudes of 0.01 Sv and 0.06 Sv peaking in March-April and October respectively.

Long-term water budget variability

Before 2002 direct water mass measurements are not available. The mass change can be estimated from steric-corrected altimeter data in 1993-2002 and from a steric-corrected sea level reconstruction before 1993.

Sea level:

To determine the sea level trend patterns variability over the last decades (1970-2006) we use the sea level reconstruction by [7]. Original in this reconstruction is the use of long-term sea level patterns (EOP5) deduced from a 33-year long run of the JERPE-extended NEMOMED8 ocean model [1] instead of the short sea level record (13 years in [1]). Its agreement with the altimeter measurements in 1993-2006 is shown by a comparison of the basin averages (Figure 5).

Conclusions

1. the changes in the Mediterranean mass-induced sea level are relatively small compared to water fluxes at the sea surface with a sea-level trend over 1970-2009.
2. The mass change derived from steric-corrected altimetry and from GRACE in 2002-2010 are in good agreement, the mass change obtained from the steric-corrected reconstruction and steric-corrected altimetry in 1992-2006 (Figure 4).

References

[8] M. V. Struglia, A. Mariotti, G. Sannino, B. Meyssignac, and A. Carillo. The Mediterranean Sea as a coupled system in 1970-2001 with atmospheric model forced laterally by ERA40 and ocean model forced by the MedAtlas monthly climatological data (Figure 8).

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