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sea level budget closure cci

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Global Sea Level Budget and Ocean Mass Budget Assessment

Preliminary Results From ESA's CCI Sea Level Budget Closure (SLBC) Project

Introduction

Studies of the sea-level (SL) budget are a means of assessing and understanding how sea level is changing and what are the causes.

Closure of the total sea-level budget implies that the observed changes of global mean sea level as determined from satellite altimetry equal the sum of observed (or otherwise assessed) contributions, namely changes in **ocean mass** and **ocean thermal expansion** and **haline contraction**.

Here, **ocean mass changes** can be either derived from GRACE satellite gravimetry (since 2002) or from assessments of the individual contributions from glaciers, ice sheets, land water storage, snow pack and atmospheric water content. Estimates of thermosteric sea level are obtained from ocean in situ measurements with additional plans for the inclusion of satellite derived Sea Surface Temperature information.

Misclosure of the sea level budget indicates errors in some of the components or contributions from missing or unassessed elements in the budget.

SLBC_cci

ESA's Climate Change Initiative (CCI) has conducted a number of projects related to sea level. Among those projects, the Sea Level CCI project, the Greenland and Antarctic Ice Sheet CCI projects and the Glaciers CCI project directly benefit from satellite altimetry data. The Glaciers CCI project and the Sea Surface Temperature CCI project provide additional insights into phenomena related to sea level change.

The aim of the ongoing **CCI Sea Level Budget Closure project** is to use the CCI data products, together with further data products provided by the project partners to re-assess the sea-level budget.

Specifically, the project further develops and analyzes products based on the CCI projects mentioned above in conjunction with in situ data for ocean thermal expansion (e.g., Argo), GRACE-based ocean mass change assessments, and model-based data for glaciers and land hydrology. The work benefits from directly involving the expertise on the product generation for all the involved sea-level contributions.

Global Ocean Mass Budget

$$\Delta M_{ocean} = -\Delta M_{glaciers} - \Delta M_{ice\ sheets} - \Delta M_{landwater}$$

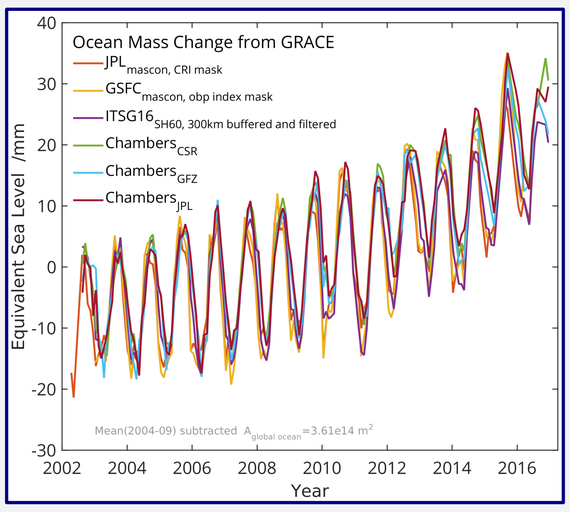

Fig. 1: Global ocean mass change from several GRACE solutions. Here, the seasonal signal is still included.

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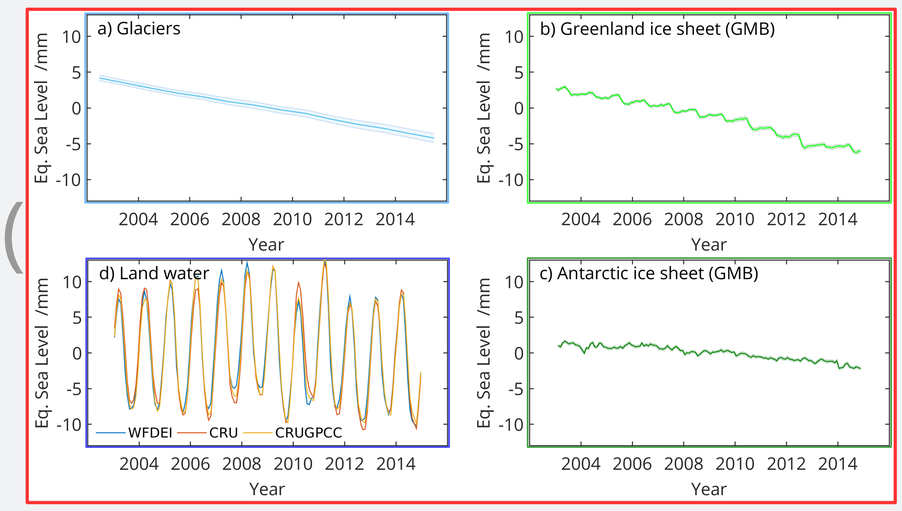

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Fig. 2: Individually assessed contributions of components. Note the strong seasonal signal of the land water component. In this figure, mass loss means mass gain for the ocean.

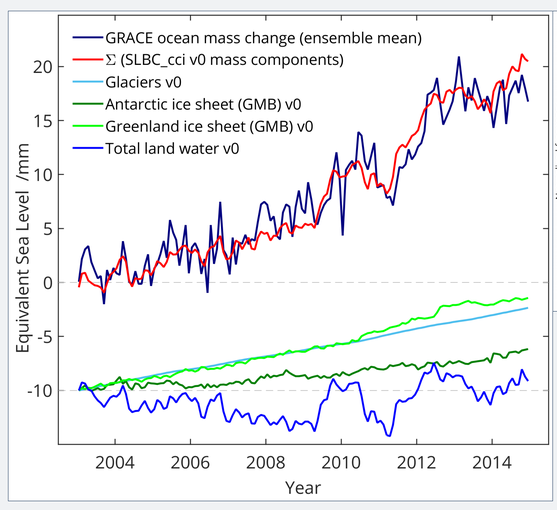


Fig. 3: Global ocean mass change from GRACE (ensemble mean, dark blue, upper panel) and the sum of the individual components (red). For this figure, the seasonal signal has been removed.

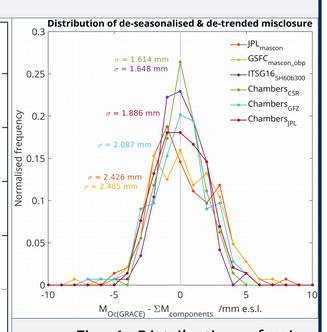


Fig. 4: Distribution of misclosure between measured ocean mass change and sum of components. Linear and seasonal signal has been subtracted.

Global Sea-Level Budget

$$\Delta SL_{observed} = \Delta SL_{ocean\ mass} + \Delta SL_{steric}$$

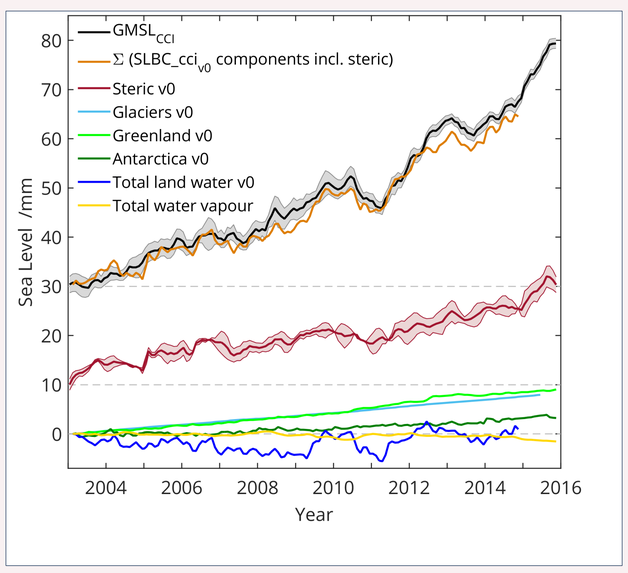


Fig. 5: The contributing mass components (lower set of curves) together with the steric expansion (dark red) add up to the orange curve. This is compared with observed sea-level change (black).

Table 1: Trends 2003–14/15 of components that contribute to the sea-level budget; with standard uncertainties.

SLBC_cci_v0 components	2003–2014 Trend mm/yr	2003–2015 Trend mm/yr
Glaciers	0.63 ±0.04	0.63 ±0.04
Greenland	0.77 ±0.03	0.76 ±0.03
Antarctica	0.27 ±0.10	0.29 ±0.10
Total Water Storage	0.17	0.17 (until 2014)
Water Vapour	-0.045	-0.07
∑ components	**1.80 ±0.11**	**1.78 ±0.11**
Steric	0.96 ±0.09	1.14 ±0.09
∑ compon. incl. steric	**2.75 ±0.14**	**2.92 ±0.14**

Table 2: GMSL trend budget 2003–14/15; with standard uncertainties. Cf. Figure 6a.

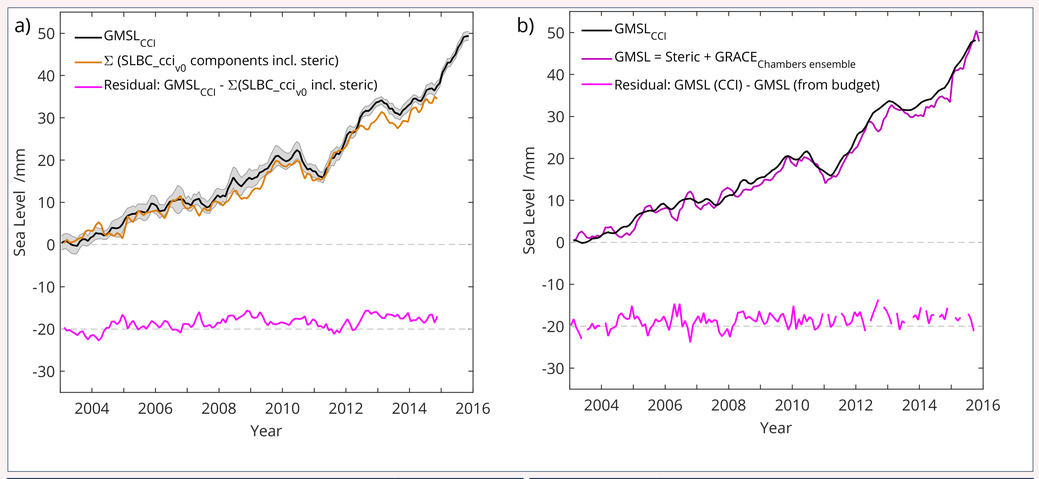
SLBC_cci_v0 GMSL budget closure	2003–2014 Trend mm/yr	2003–2015 Trend mm/yr
Observed GMSL	**2.99 ±0.40**	**3.36 ±0.40**
∑ compon. incl. steric	**2.75 ±0.14**	**2.92 ±0.14**
Residual	**0.24 ±0.42**	**0.44 ±0.42**

Fig.6: Global mean sea-level (black curves) versus:

a) sum of components (orange) and

b) sum of observed mass change and steric change (purple).

The misclosure is plotted below, respectively (pink). In (b) only the Chambers ensemble mean is displayed.



Tables 3 & 4: Global ocean mass change trends from different GRACE solutions (left) and their misclosure with the observed GMSL (right). Cf. Figure 6b.

Ocean mass change component from GRACE solutions		2003–2015 Trend mm/yr
SLBC_cci (initial, v0.3)	JPL mascon	1.70
	GSFC mascon	1.84
	ITSG16 SH60 300 km b&f, GADrest.	1.51 ±0.35 +?
Chambers	CSR Spherical Harmonics	2.05
	JPL Spherical Harmonics	1.95
	GFZ Spherical Harmonics	2.10
	Ensemble Mean	2.03

2003–2015 Trend Misclosure: GMSL(observed) - GMSL(steric+GRACE)		mm/yr
SLBC_cci (initial, v0.3)	JPL mascon	0.50
	GSFC mascon	0.39
	ITSG16 SH60 (300 km buffered & filtered, GAD restored)	0.67 ±0.54 +?
Chambers	Ensemble mean	0.15

Results Summary

Our initial assessment uses data products that were available by the beginning of the project. We focus on the 2003–2015 (GRACE / ARGO) period. We consider the budget of **(a)** the long-term trends and **(b)** the overlaid interannual variations.

Our account for uncertainties of the individual contributions builds on the expertise of all project partners. **We find that the budgets are closed within uncertainties**. Systematic uncertainties in the ocean mass change estimates appear to dominate the uncertainty budget.

References

A collection of survey papers is freely available in the Surveys of Geophysics 2017, 38(1), special issue "ISSI Workshop on Integrative Study of the Mean Sea Level and its Components". https://link.springer.com/journal/10712/38/1

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