Small scale sea level budgets in the North-Atlantic

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Introduction

Using satellite altimetry it is possible to determine the total sea level. The two components, mass and steric sea level, are respectively measured using satellite gravimetry and Argo. If these measurements are consistent, the budget described by

$$SL_{total} = SL_{mass} + SL_{steric} \quad (1)$$

is closed.

Until recently, sea level budget research is mostly focussed on global scales. A few studies have been investigating basin scale budgets, or pattern differences in budgets. We aim to find a method to close the budget on multiple scales: basin scale and at scales an order smaller than the ocean basins, like the North-Atlantic.

Methodology

Altimetry

- Jason-1 and Jason-2 for consistent sampling (from RADS).
- Latitude dependent intermission bias correction (Ablain et al., 2015).
- Variance-covariance matrices using correlation functions of Le Traon et al. (2001).
- 10 day temporal resolution.

Argo

- Statistical interpolation with correlation functions of Gaillard et al. (2009).
- Variance-covariance matrices for the whole North-Atlantic grid.
- Monthly grids.

Gravimetry

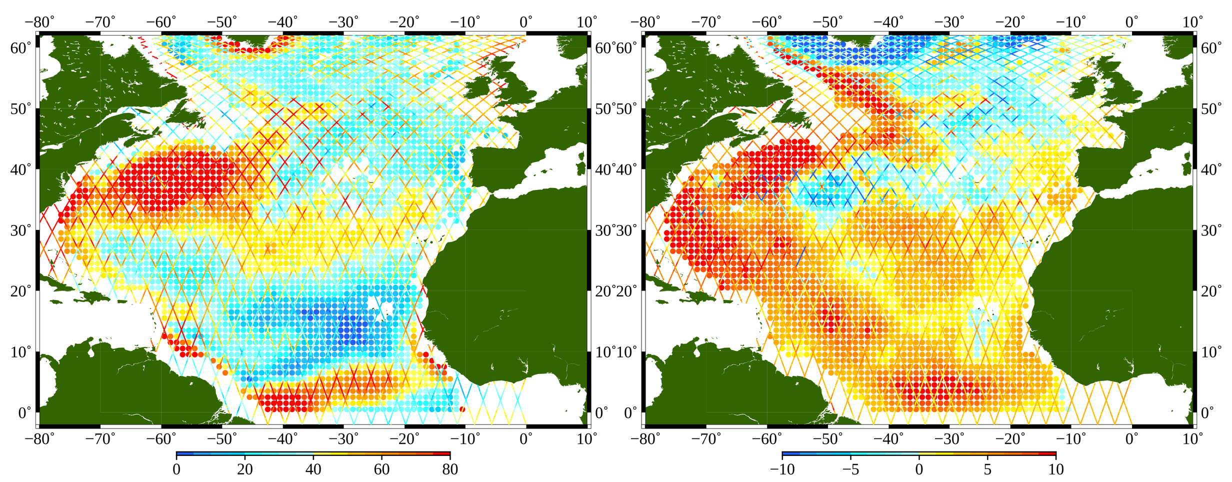
- CSR GRACE gravity fields with full covariance matrices.
- Wiener filter to reduce striping, while minimizing leakage (Klees et al., 2008).
- Fan filter to remove ringing (Zhang et al., 2009).
- Variance-covariance matrices for the whole North-Atlantic grid.
- Monthly grids.

Glacial Isostatic Adjustment (GIA) correction

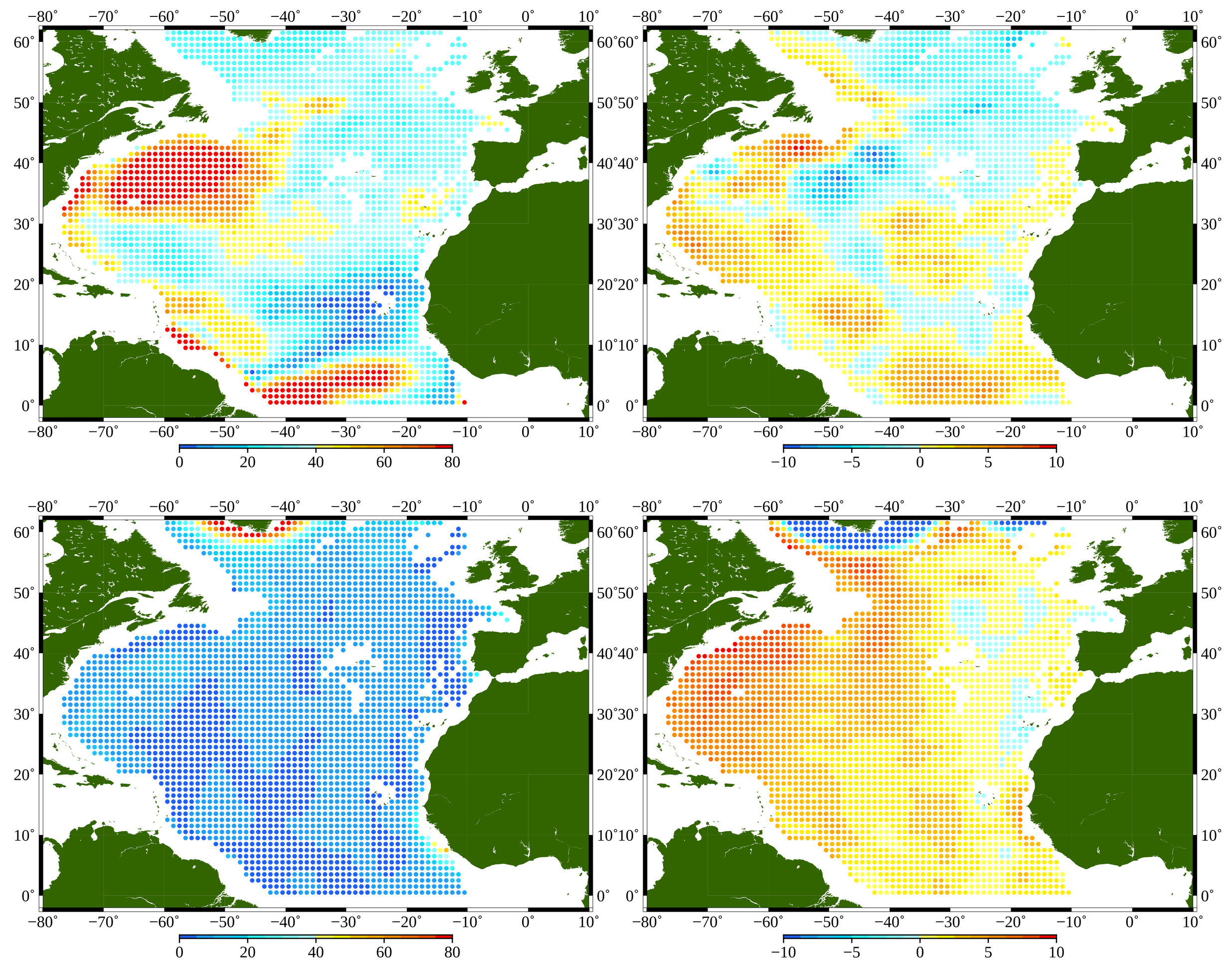
The GIA effect is corrected for using the ICE6G-model (Peltier et al., 2015). Therefore, the relative sea level component is subtracted from altimetry measurements, while the mass component is subtracted from the GRACE gravity fields.

Averaging

The monthly grids are averaged over the regions in the figure on the right to increase the signal to noise ratio. While the steric and mass grid cells are weighted as a function of latitude, the altimetry measurements are weighted based on the number of measurements in a particular latitude band. Full variance-covariance matrices are used to compute the errors of the monthly mean sea levels. The resulting trends have a standard error of around 1 mm/yr.

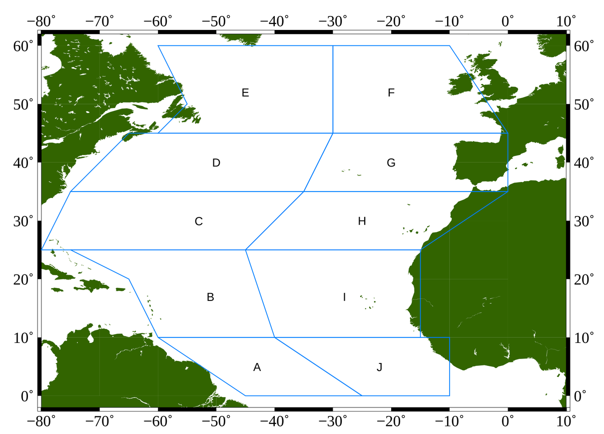


Annual amplitudes in mm (left) and trends in mm/yr (right) of the sum of the components and from total sea level from altimetry.



Annual amplitudes of the steric (top) and mass (bottom) components in mm on the left. The right graphs show the corresponding trends between 2004 and 2014 in mm/yr.

Results



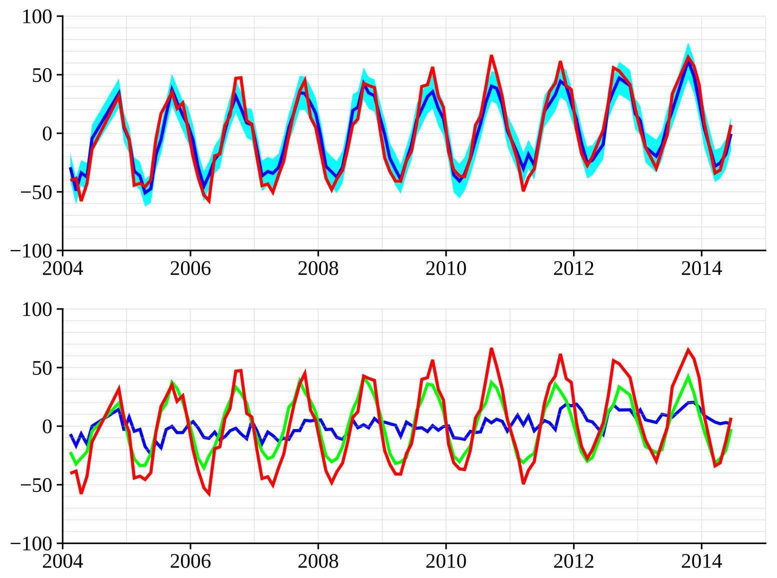
The large scale patterns of sea level amplitudes and trends are comparable. The datasets are however not spectrally consistent, altimetry especially recovers smaller features in the trends and amplitudes.

Trends are dominated by the mass signal, while the annual amplitudes are dominated by the steric signal. Argo appears to underestimate amplitudes around the Azores and South-East of the Gulf Stream.

The time series from altimetry and the sum of the components resemble each other well. For eight of the ten polygons, the estimated trends from both time series resemble to within the error bars. However, for only five polygons the annual amplitudes are comparable.

polygon	crit. value: 1.2 goodness-of-fit	altimetry trend [mm/y]	steric+mass trend [mm/y]	altimetry amplitude [mm]	steric+mass amplitude [mm
A	**0.3**	**2.9±0.5**	**4.7±1.6**	**42.4±1.2**	**34.3±6.5**
B	**0.6**	**3.5±0.4**	**5.4±0.9**	34.7±0.8	20.8±3.9
C	**0.3**	**4.2±0.4**	**5.4±0.9**	**54.5±0.6**	**49.9±3.6**
D	**0.5**	**2.7±0.4**	**4.2±0.8**	81.4±0.5	63.9±5.0
E	**0.7**	2.4±0.4	-0.8±0.9	48.3±0.4	33.0±3.6
F	**0.5**	**-1.3±0.4**	**-1.3±0.8**	45.6±0.5	34.6±3.3
G	**0.4**	**1.1±0.4**	**0.2±0.8**	44.6±0.6	33.6±3.2
H	**0.3**	5.2±0.4	2.5±0.8	**49.5±0.6**	**46.3±3.5**
I	**0.3**	**2.9±0.4**	**2.4±0.8**	**21.4±0.6**	**18.1±3.4**
J	**0.3**	**2.8±0.5**	**3.4±1.1**	**38.7±1.1**	**45.4±4.5**
Total	**0.5**	**2.8±0.4**	**2.2±0.4**	44.4±0.2	35.8±1.8

Trends and amplitudes computed from mean sea levels of the polygons. The goodness-of-fit column shows if the time series statistically resemble.

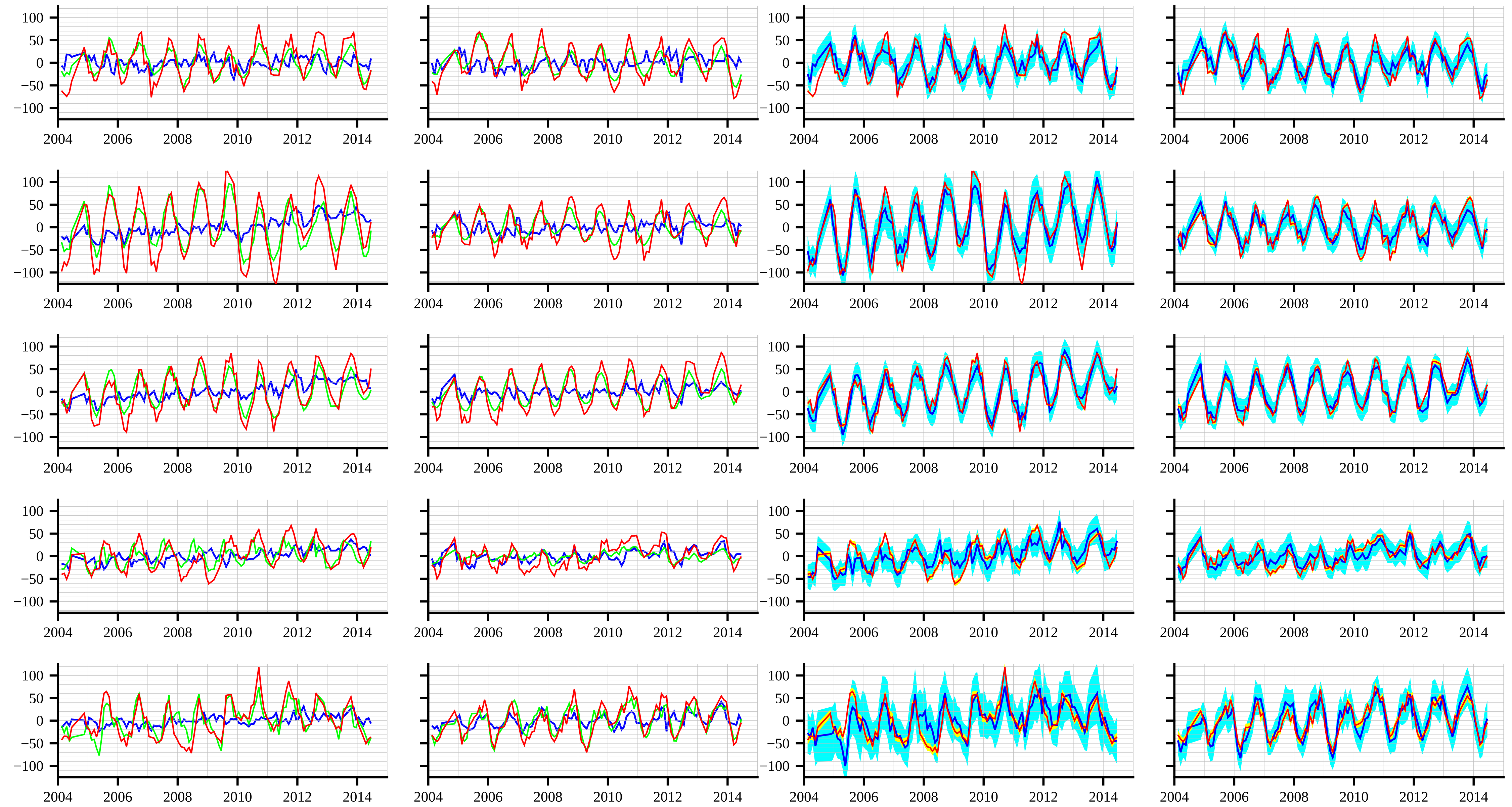


Conclusions

- First time budgets are investigated at sub-basin scales.
- Time series are statistically equal on basin and sub-basin scale.
- Trends are comparable, but the amplitudes of steric+mass are smaller.
- Basin and sub-basin scale redundancy of systems.

[Left] Time series of North-Atlantic mean sea level in mm. In the top graph the sum of steric and mass components in blue and total sea level from altimetry in red. In the bottom graph the individual components: steric (green), mass (blue) and total from altimetry (red).

[Below] On the left the individual components of sea level averaged over the polygons. On the right the sum of the components against total sea level from altimetry. The graphs are shown in the same configuration as the polygons such that the bottom left corresponds to polygon A and the bottom right to polygon J.



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