INHERENT UNCERTAINTIES WITHIN ALTIMETRIC GLOBAL MEAN SEA LEVEL TIME SERIES

clisap

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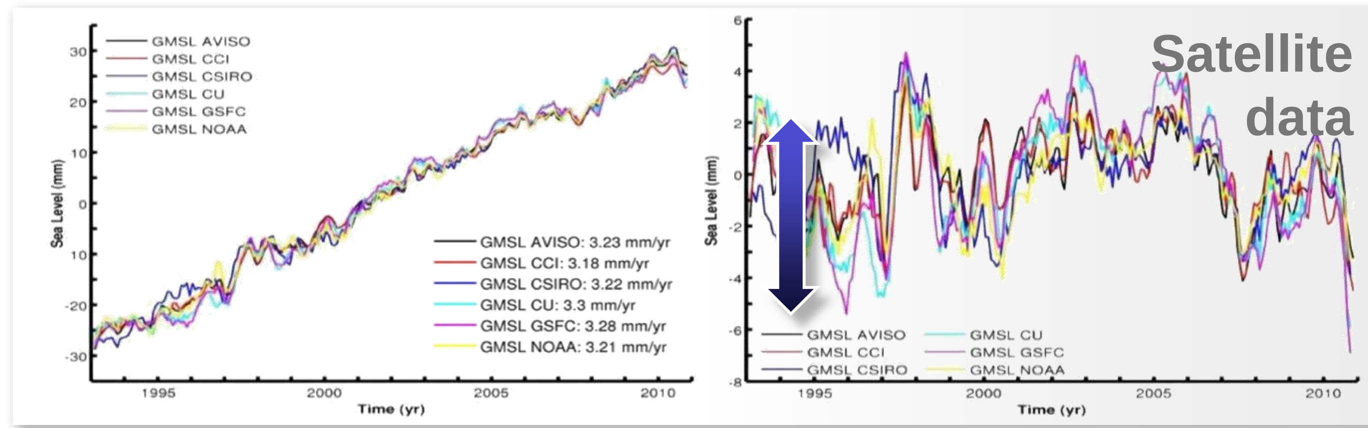
Introduction

Individual Global Mean Sea Level (GMSL) estimates differ substantially in their high-frequency variations around the linear trend, leading to a spread of the order of 2 to 10mm that exist at each time step between all products. This short term variability can be interpreted as uncertainty existing in individual estimates [MASTERS et al., 2012; HENRY et al., 2014, ABLAIN et al., 2015; LEGEAIS et al., 2018]. However, any systematic uncertainty resulting from an under-sampling of the global ocean, from the aliasing of the ocean variability, or from any systematic biases in the altimeter data would not be presented through this spread. It therefore remains an open issue to quantify the uncertainties intrinsic to each GMSL estimate resulting from the sampling characteristics of altimetric satellites and the subsequent data processing details.

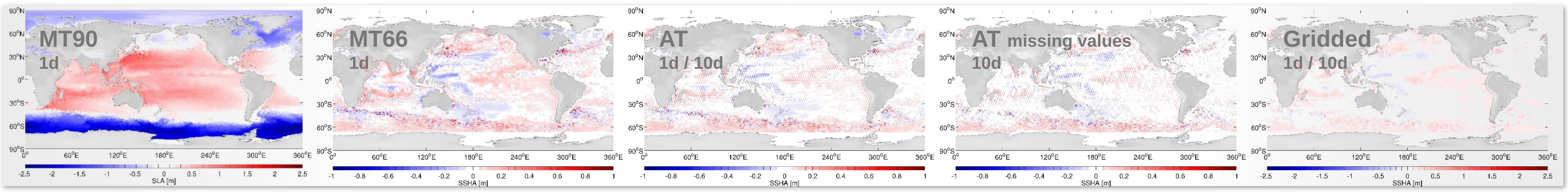
Building on previous results, the objective of this study is to systematically quantify uncertainties in existing GMSL estimates resulting from different data processing approaches and from the incomplete space-time sampling schemes of the global sea level field by satellite missions.



(left) GMSL trend [ABLAIN, 2015] for the different working group. (right) Short term variability of the different GMSL estimates after subtracting the respective GMSL trend for each working group.

Synthetic SSH

For this purpose, daily Sea Surface Height (SSH) fields for the period 1993 – 2010, simulated by the high resolution **STORM/NCEP** model [VON STORCH et al., 2012] were used as **Synthetic Model Truth (MT)** to estimate GMSL, to test the effects of the latitudinal coverage and temporal sampling, of applying different averaging methods of inclination weighting (for along-track) versus area weighting (for gridded products, as optimal interpolation and box-gridding), as well as of missing values due to flagged data, coastal criteria.



Truly global synthetic model truth of absolute SSH. The Global Mean (GM) is zero for each time step.

MT SSH anomalies omitting regions poleward of 66°, reflecting the area the reference SSH missions cover.

Subsampled MT66 for all TP/J1/J2 satellite along-track points, at artificial 1d and true 10d coverage.

Additionally omitting values at flagged satellite measurement positions. Omitting values for coastal regions.

Interpolated from the AT products to 1/4x1/4, 1x1, 2x1 and 3x1° grids using Optimal Interpolation and Box-Gridding.

Inherent Uncertainty estimates of GMSL

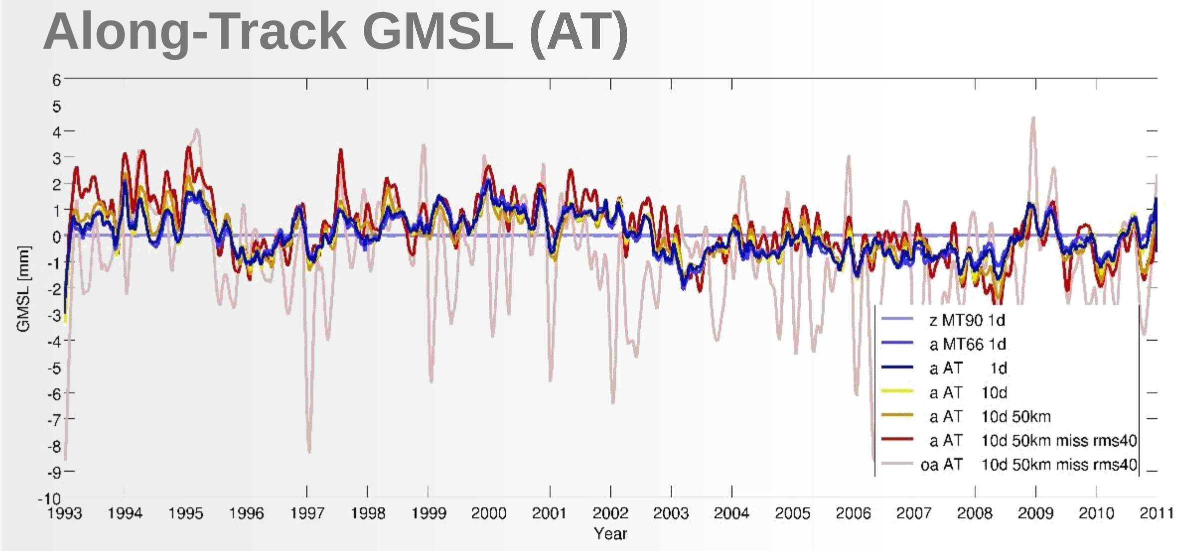
z MT90 1d The GMSL is calculated using area weighting and is referenced to the actual ocean surface of the STORM model. The GMSL is zero for each time step. For all shown GMSL estimates, the annual and semi-annual signals are removed from the GMSL time series and only SSH anomalies are considered. [SCHARFFENBERG and STAMMER, to be submitted].

Limited Meridional Coverage

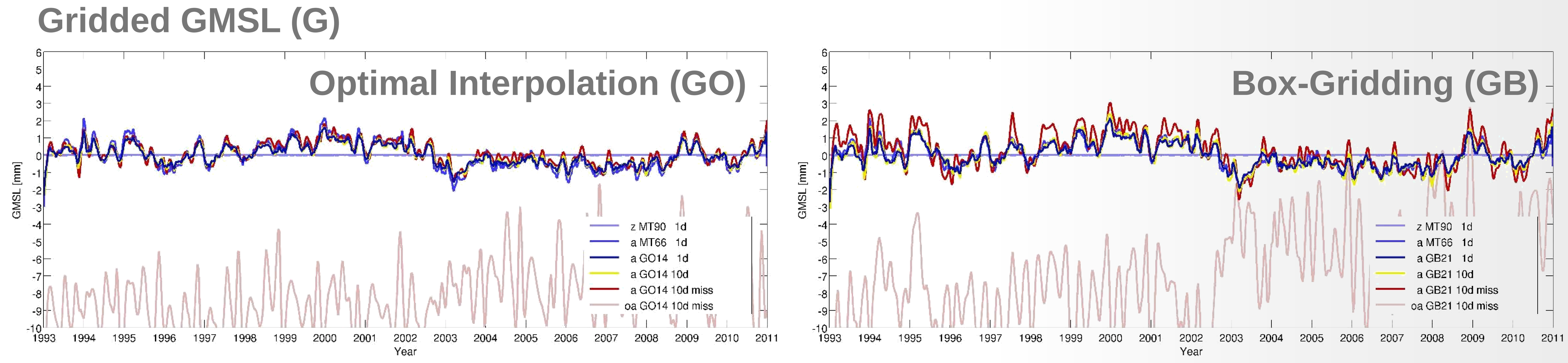
z MT66 1d TOPEX/POSEIDON und Jason reference series cover the ocean between 66° N and S. Omitting all latitudes poleward of 66° creates an artificial offset for absolute SSH (z) of *71.1mm* to the GMSL estimate. The offset originates from the negative SSHs that are omitted in the southern latitudes around Antarctica. Further, an artificial uncertainty of *1.2mm* and an annual signal of *1mm* are generated (not shown).

In the following only SSH anomalies are considered (*SSHA = absolute SSH - MSS*). The MSS is either directly based on the temporal mean SSH of the model, resulting in SSH anomalies (a), or by additionally omitting all actually missing along-track SSH values from the reference mission, resulting in original SSH anomalies (oa). All following correlations are given with respect to the GMSL zMT661d.

Along-Track GMSL (AT)



Gridded GMSL (G)



Temporal Sampling

a AT 1d Subsampling aMT661d along the reference satellite tracks, gives the artificial AT daily product. The missing data in-between the satellite tracks do not change the statistics significantly.
Correlation (***0.98***) STD (***1.2mm***) Annual Signal (***1.1mm***)

a AT 10d Subsampling aMT661d at the actual satellite over-flights for the corresponding 10 day repeat cycles has significant influence on the correlation, while, reducing the uncertainty only marginally.
Correlation (*0.75*) STD (*1.1mm*) Annual Signal (*1.2mm*)

a GO14 1d Optimally interpolating aAT1d onto 1/4x1/4° improves GMSL estimates due to the optimal interpolated sea surface.
Correlation (***0.99***) STD (***0.9mm***) Annual Signal (***0.6mm***)

a GO14 10d Optimally interpolating the subsampled aAT10d onto 1/4x1/4° leads to improved statistics. Compared to aGO14 1d, the loss of information for the slower temporal sampling gets evident.
Correlation (*0.76*) STD (*0.8mm*) Annual Signal (*0.6mm*)

a GB21 1d Box-gridding aAT1d onto 2x1° hardly changes the GMSL estimate, while reducing the annual signal significantly.
Correlation (***0.96***) STD (***1.1mm***) Annual Signal (***0.5mm***)

a GB21 10d Box-gridding the subsampling aAT10d onto 2x1°, has, as for aGO1410d, a significant influence on the correlation while the artificial annual signal is improved, as compared to aAT10d .
Correlation (*0.74*) STD (*1.1mm*) Annual Signal (*0.6mm*)

Missing SSH Values

a AT 10d 50km miss rms40 Subsampling aMT661d as before at the original 10d repeat cycles, while additionally omitting missing SSH values as in the real TP/J1/J2 data, and coastal values, leads to a further degradation of the resulting GMSL estimates.
Correlation (***0.66***) STD (***1.5mm***) Annual Signal (***1.6mm***)

a GO14 10d miss Optimally interpolating aAT10dmiss onto 1/4x1/4 leads to better GMSL estimates (compared to AT) in terms of correlation and uncertainty, due to the optimal interpolated SSH field.
Correlation (***0.73***) STD (***0.8mm***) Annual Signal (***0.5mm***)

a GB21 10d miss Box-gridding aAT10dmiss onto 2x1° does not improve the uncertainties and correlation as much as for the optimal interpolation.
Correlation (***0.72***) STD (***1.3mm***) Annual Signal (***0.9mm***)

Influence of used Mean Sea Surface

oa AT 10d 50km miss rms40 Changing additionally only the MSS, to be calculated using the original anomalies (oa), has a substantial impact on the GMSL estimates.
Correlation (*0.32*) STD (*2.6mm*) Annual Signal (*19.0mm*)

oa GO14 10d miss By only changing to the MSS(oa) derived from original SSH anomalies, thus, optimally interpolating oaAT10dmiss onto 1/4x1/4, leads to a de-correlated GMSL estimate.
Correlation (*0.05*) STD (*2.4mm*) Annual Signal (*11.8mm*)

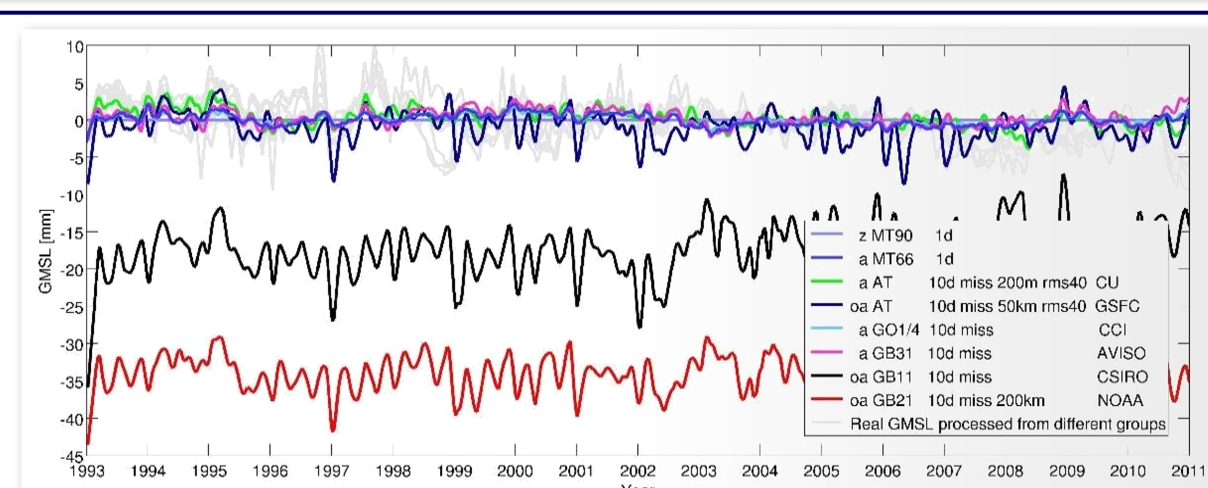
oa GB21 10d miss Box-gridding oaAT10dmiss onto 2x1° results, as for oaGO1410dmiss in a de-correlated time series with artificial uncertainties of more than 3mm.
Correlation (*-0.05*) STD (*3.5mm*) Annual Signal (*20.9mm*)

Working Groups

The best GMSL estimate results from the optimal interpolation method by using a combined MSS(a), **CCI** - COR (*0.73*) STD (*0.8mm*) AS (*0.5mm*). The fine grid resolution (1/4 x 1/4) yield better GMSL estimates for the optimal interpolation method. According to the used interpolation method, the applied grid resolutions of the different working groups are well chosen, as for coarser resolutions of 2 x 1 and 3 x 1, box-gridding leads to better GMSL estimates, compared to the optimal interpolation method at the same resolution. **AVISO** - COR (*0.71*) STD (*1.3mm*) AS (*0.8mm*) and **CU** - COR (*0.59*) STD (*1.6mm*) AS (*2.3mm*).

The least restrictive handling of coastal values, as using a distance to coast criteria instead of a depth criteria has a smaller influence on the GMSL estimates and their artificial uncertainty.

The largest impact on the GMSL estimates, however, has the used MSS. The use of a combined MSS might improve the GMSL estimates, for **GSFC** -COR (***0.32***) STD (***2.6mm***) AS (***19mm***), **NOAA** -COR (***0.13***) STD (***3mm***) AS (***18mm***), **CSIRO** -COR (***-0.01)*** STD (**4.2mm**) AS (***27mm***).



Conclusions

- The satellite space-time sampling and missing SSH values have a substantial impact on the GMSL estimate. Only omitting SSH values poleward of 66° introduces an inevitable uncertainty of ~1.2mm to any GMSL estimate.

- The findings suggest that based on the current realistic possibilities and procedures to estimate GMSL along-track and from gridded fields, all effects together lead to inevitable artificial uncertainties of GMSL estimates from actual altimetry missions, that are on the level of 0.8 to 3.5mm (rms).

- This uncertainty range is of the same order as the rms differences between the GMSL estimates available from the different working groups of about 2mm.

25 Years of Progress in Radar Altimetry and Ocean Surface Topography Science Team Meeting, September 24th – 28th, 2017
Poster #ERR_001, September 27th, 18:00-20:00 and 28th, 14:00-15:00,
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