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THE CAUSES OF THE SEA LEVEL TREND IN THE SOUTHWESTERN ATLANTIC CONTINENTAL SHELF

OSTST MEETING 2022

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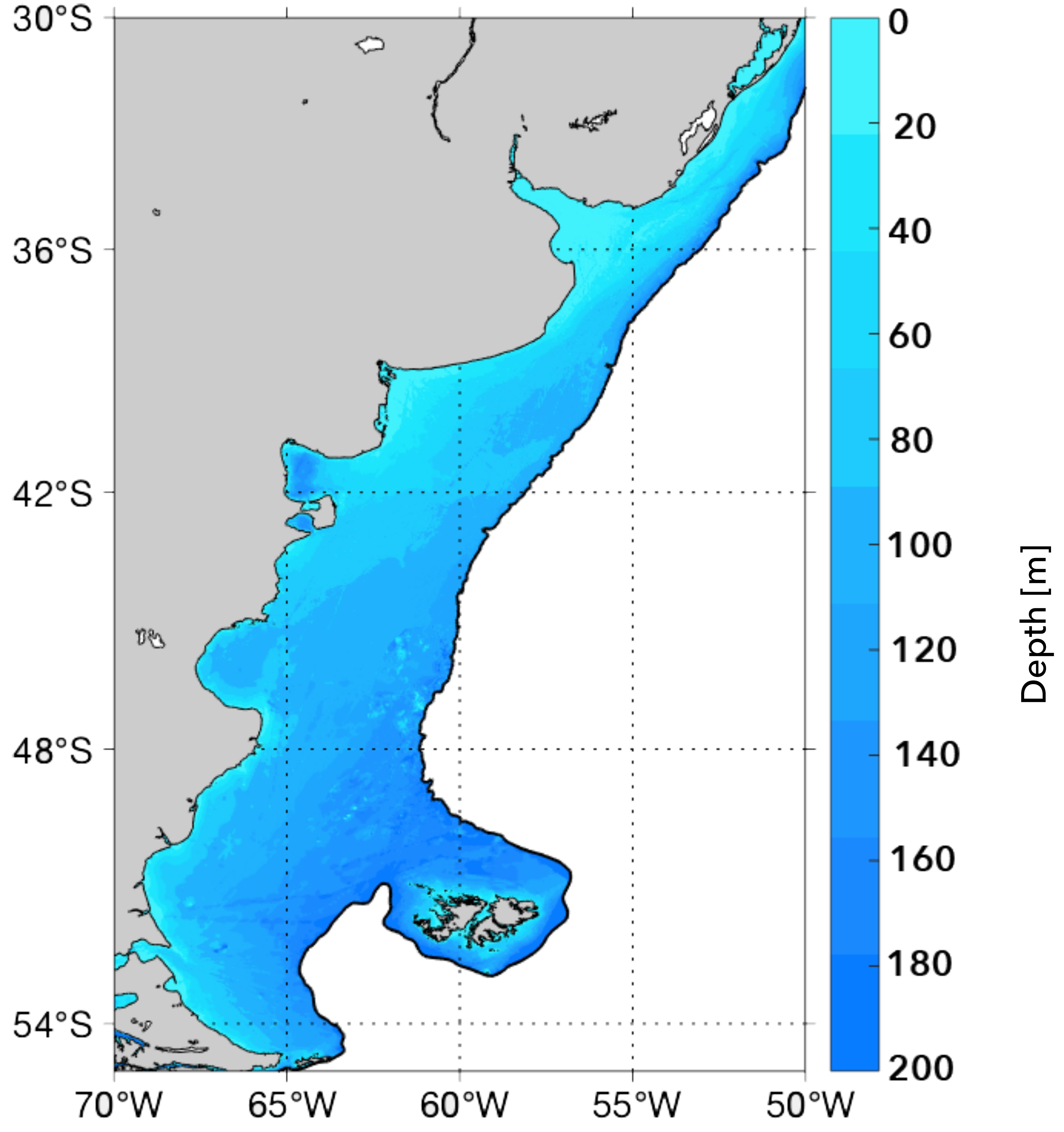
INTRODUCTION AND OBJECTIVE

In the last decades, several studies have detected a global sea level rise, and it was associated mainly to two factors related to global warming:

- Mass changes due to the transfer of water between continental ice and oceans,
- Sea-water density changes due to the increasing temperature.

However, little is known about these effects in the Southwestern Atlantic Continental Shelf (SWACS). Thus, the objective of this work is to **study the role of mass change and density change in the SWACS** using 23-year of satellite data and model data.



Study area. The black curve represents the 200 m isobath.

DATA AND METHOD

DATA

- Reanalysis models: ORAS5, successor to the ORAP5 model, which was validated in the study region (Bodnariuk et al., 2020); and GLORYS.
- Satellite data: gridded altimetry SLA maps of CMEMS and ESA-CCI, and GRACE gridded sea height maps.

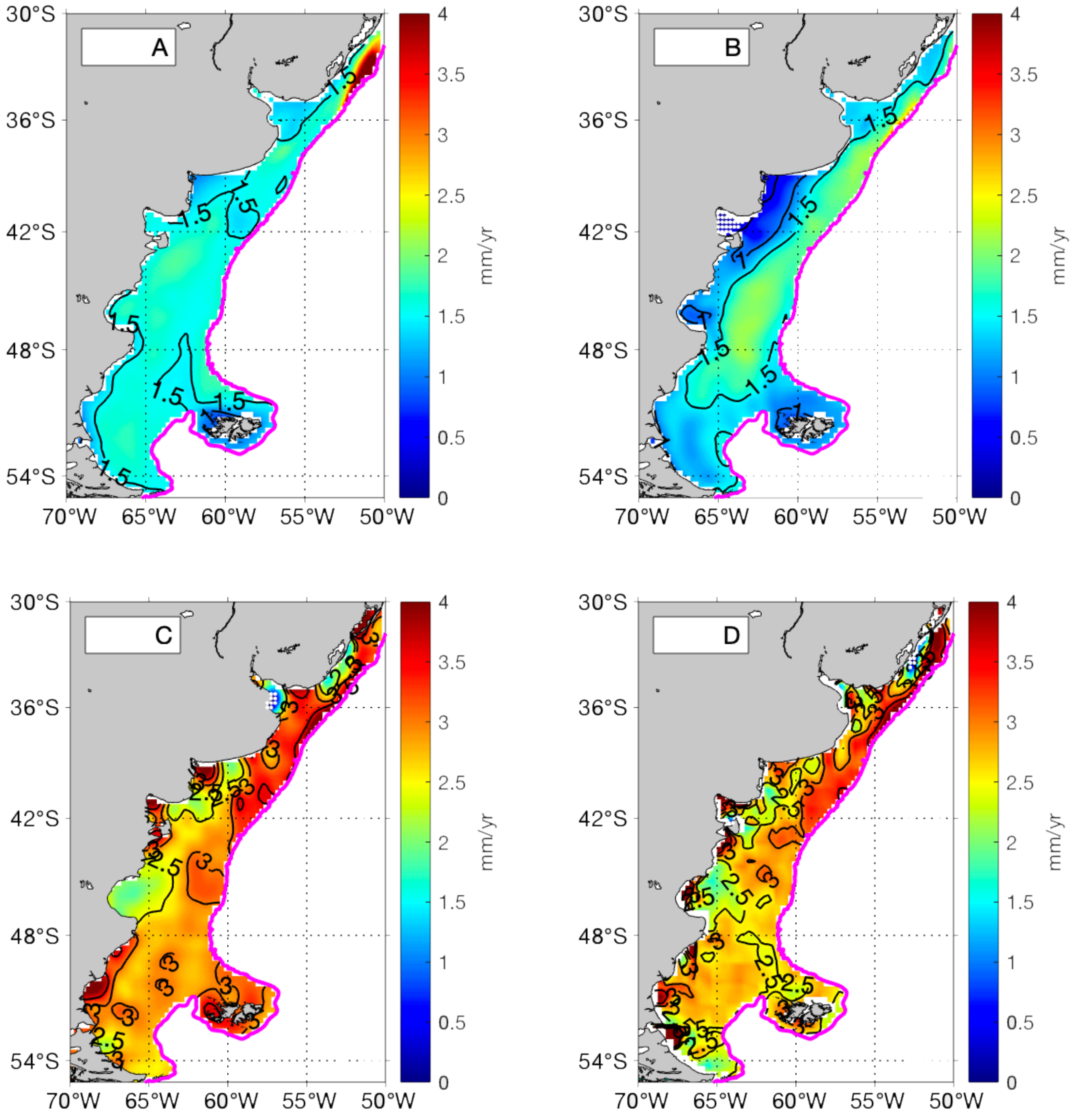
METHOD

- The regional sea level budget equation was used as a starting point:
  Sea Level Anomaly (SLA) = Mass Change (CM) + Steric Height (SH)
- Altimeter data was corrected by Glacial Isostatic Adjustment (GIA) since, unlike the model and GRACE, satellite data does contain the GIA variability as: $SLA_s - GIA$
- Models SH was calculated as: $SH_m = SH_{thermic} + SH_{haline}$

  and that of the satellites as: $SH_s = SLA - CM_{GRACE}$
- MC was computed as: $MC = SLA - SH$
- The trend of inter-annual sea surface height and its components were calculated by applying linear regression and Student's test for significance at 95%.

RESULTS

Fig. 1: Significant trend map (CL 95 %) of sea level (mm/year) derived from ORAS5.0 (A), GLORYS (B) and satellite altimetry from CMEMS (C) and ESA-CCI at inter-annual scale for the period 01/01/1993 - 01/12/2015. The magenta line represents the 200 m isobath.



Maps of SLAm trend show a homogeneous increase in SLA of approximately 1.5 mm/year for the models data while the maps of SLAs trend show heterogeneities with an average increase of ~3 mm/year. Even though both data sets indicate that the inter-annual SLA is increasing in the entire SWACS, the models do not correctly represent the spatial variations of the SLA trends and underestimate the rate of increment.

Underestimation of the rate of increment by the models

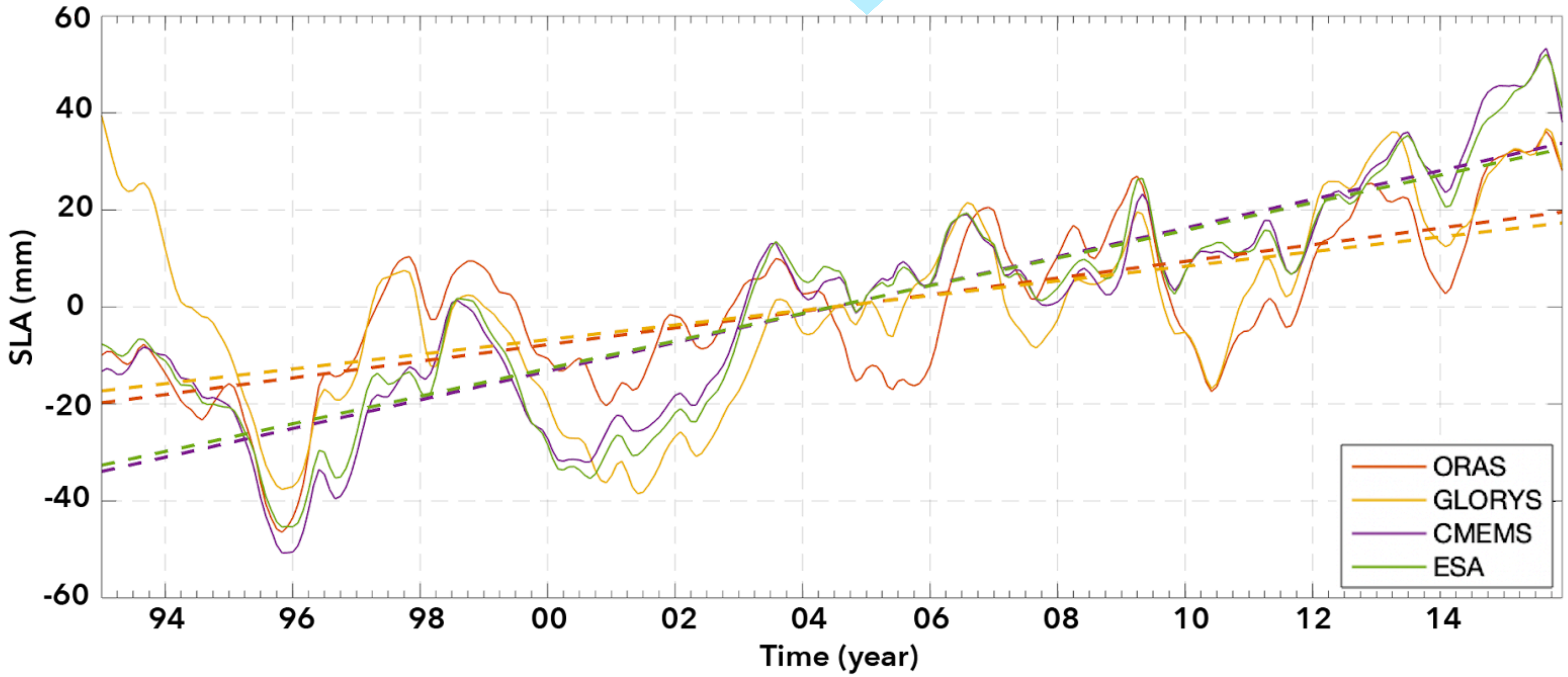
RESULTS

Similar temporal variabilities of the databases

Underestimation of sea level rise by the models

Fig. 2: Time series of the pixel area-weighted spatial average of SLA. The dashed lines represent the linear regression for the period 01/01/1993 - 01/12/2015.

Data	Trend
SLA [mm/yr]	
ORAS5	1.72 ± 0.21
GLORYS	1.51 ± 0.30
CMEMS	2.95 ± 0.20
ESA-CCI	2.85 ± 0.21



Trends were also calculated for the weighted spatial average of the satellite and model SLA and their components (see table above). The results show that both models underestimate sea level rise by about 15 mm over the 23 years studied. Nonetheless, temporal variabilities of the four databases are similar, except for the first two years where GLORYS shows high SLA values.

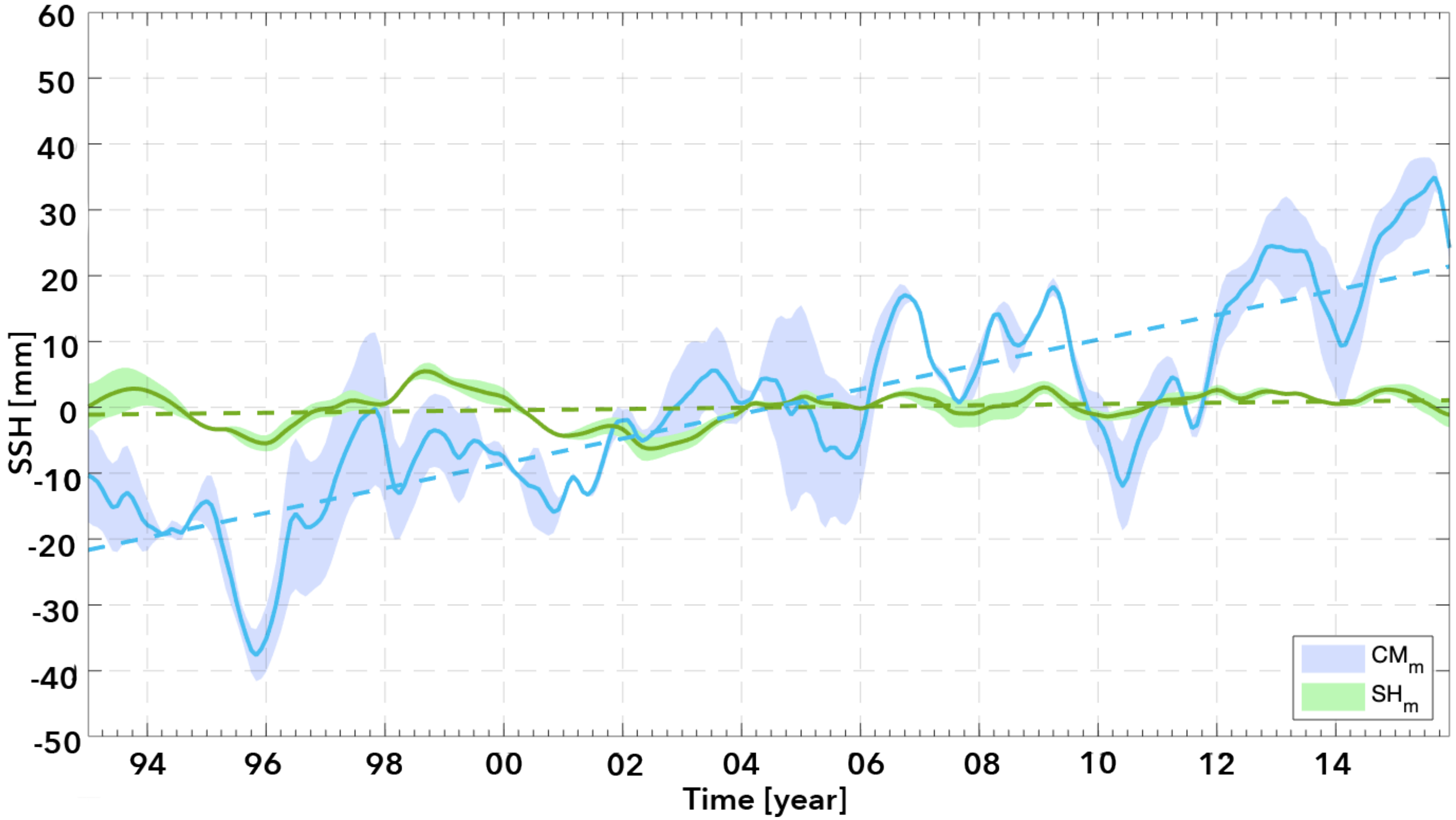
RESULTS

MC presents a significant variability and a higher trend than SH. The dominance of MC in the SLA trend could be due to wind variability, the variation of the discharge of the Rio de la Plata and other rivers and the melting of ice and glaciers.

Fig. 3: Time series of the pixel area-weighted spatial ensemble mean of ORAS5 and GLORYS models of CM (blue) and SH (green). The dashed lines represent the linear regression for the period 01/01/1993 - 01/12/2015.

Data	Trend
SSH [mm/yr]	
CM	1.88 ± 0.14
SH	0.09 ± 0.04

MC dominates in the SLA trend



RESULTS

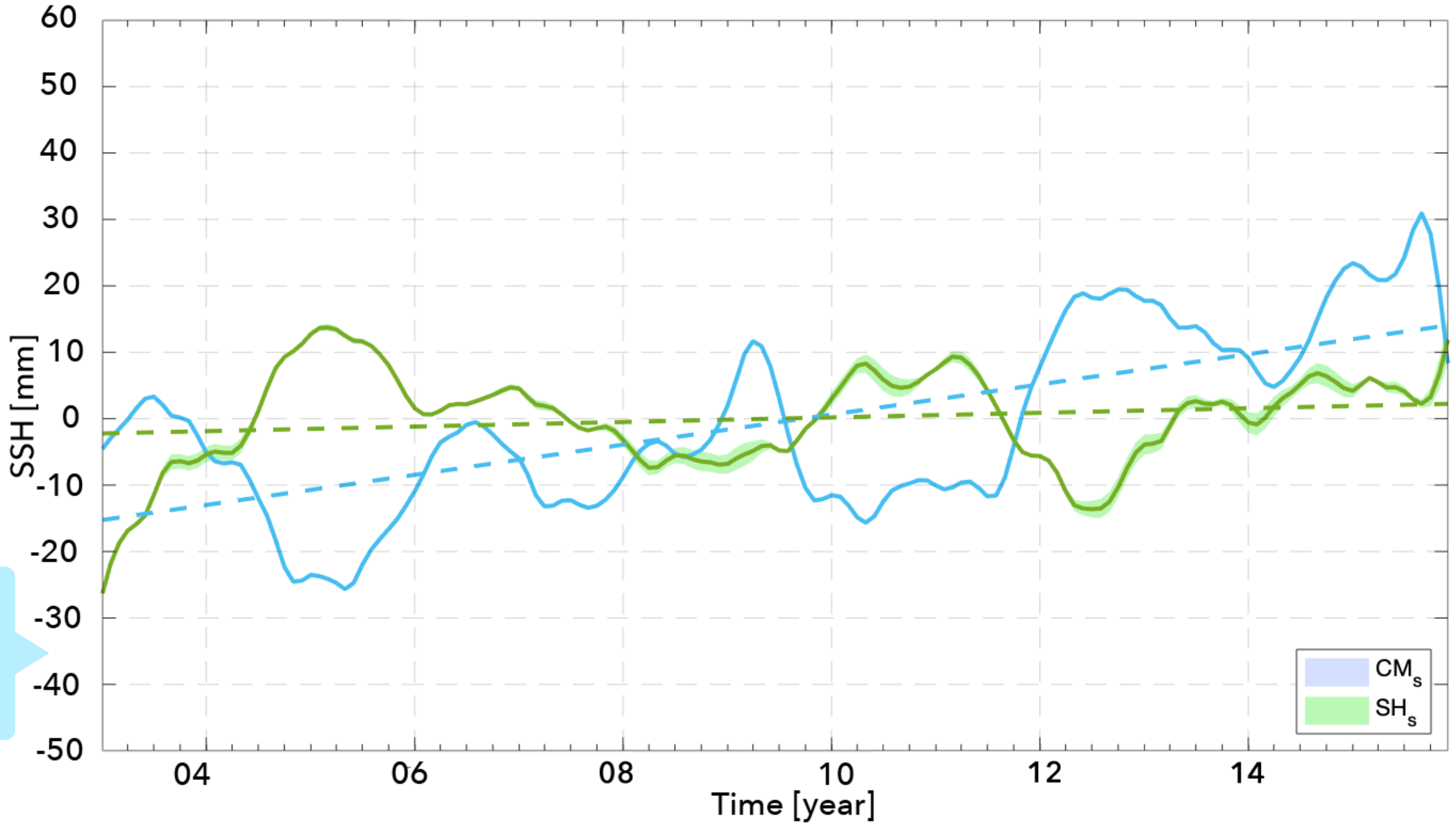
As with the model data, the figure shows that the trend for MC is considerably higher than that for SH. It is also observed that SHs has a higher variability but a similar trend compared with SHm.

Fig. 4: Time series of the pixel area-weighted spatial ensemble mean of ESA and CMEMS of CM (blue) and SH (green). The dashed lines represent the linear regression for the period 01/01/2003 - 01/12/2015.

Data	Trend
SSH [mm/yr]	
CM	2.51 ± 0.41
SH	0.34 ± 0.31

Similarity between the SH trends

Underestimation of SH variability by the models

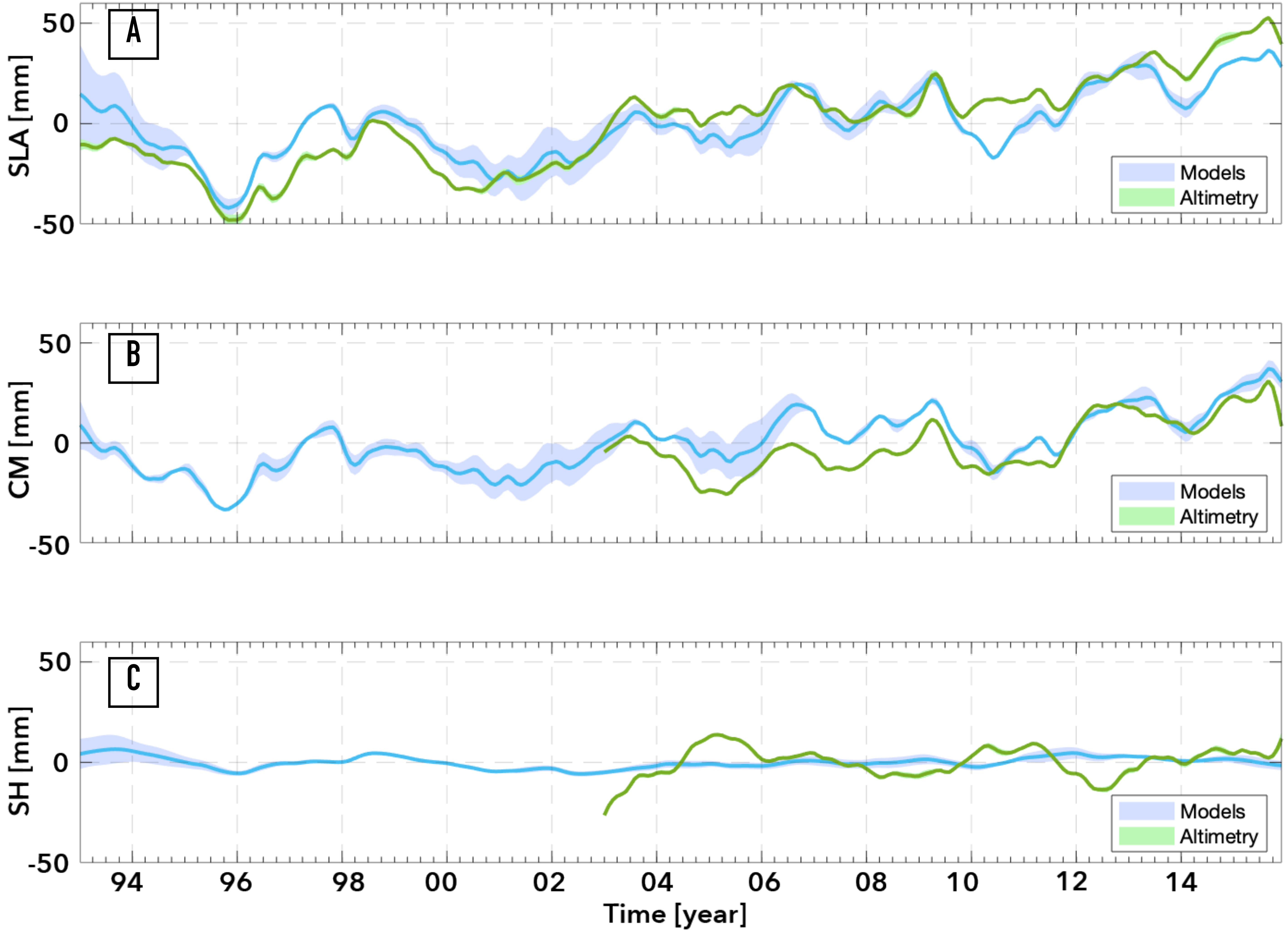


RESULTS

Models data are more dispersed than satellite data

Minor importance of SH in SLA

Fig. 5: Southwestern Atlantic Continental Shelf mean sea level time series (A) and its components, MC (B) and SH (C) derived from model (ensemble mean of GLORYS and ORAS5, blue) and satellite (ensemble mean of CMEMS and ESA, and GRACE, green). The blue and green shaded areas represent the standard error.



Trend values [mm/yr]

		1993-2015	2003-2015
SLA	Model	1.64±0.23	2.36±0.42
	Satellite	2.18±0.20	2.88±0.33
CM	Model	1.88±0.14	1.91±0.36
	Satellite	-----	2.51±0.41
SH	Model	0.09±0.04	0.19±0.06
	Satellite	0.06±0.10	0.34±0.30

CONCLUSIONS

- Models data are more dispersed than satellite data.
- The trend analysis shows an increase in sea level across the entire shelf with both satellite and model data.
- The rate of increase calculated with the models is lower than that observed by satellite altimetry.
- MC is the major contributor to the SLA trend in SWACS.
- SSH is not rising linearly, but is accelerating.
- The results of this study allow understanding the main causes of sea level rise in the SWACS, contributing to the comprehension of the regional effects of global warming.

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The satellite altimetry product "SEALEVEL_GLO_PHY_L4_REP_OBSERVATIONS_008_047" is produced and distributed by Copernicus Marine and Environment Monitoring Service (CMEMS, https://www.marine.copernicus.eu). The GRACE product "TELLUS_GRAC-GRFO_MASCON_CRI_GRID_RL06_V2" is produced and distributed by NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC, https://podaac.jpl.nasa.gov/).