# SeaLevel Newsletter

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## Welcome to the SPP–1889 SeaLevel Newsletter!

We are pleased to present the latest news and research outcomes of the SPP SeaLevel program and its community,
In this newsletter, find out a brief summary of the World Climate Research Programme (WCRP) Sea Level Conference 2022 which took place in Singapore on 12-16 July 2022 and some of research results of the SPP SeaLevel program that were presented there, more specifically from the DECVAR-2 research project i.e. about projected sea level change and variability in the Southeast Asia region and about several aspects of the sea level research based on the MPI-ESM model such as about sea level changes mechanisms in the MPI-ESM under FAFMIP forcing conditions, ocean model resolution dependence of sea level change, as well as future shifts in sea level statistics and implications for the MPI-GE model.

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Moreover, find out about the latest fieldwork of the BlueUrban project on coastal adaptation practices and paradigms in Jakarta and Samarang, about the final conference of the SALTSA project on ground water salinization with a focus at the North Sea coast, and many more in this edition.

*Fig. 1: Impression from the WCRP Sea Level Conference in Singapore on 12-16 July 2022.*

# A brief summary of the WCRP Sea Level Conference 2022 in Singapore, July 2022

Yi Jin, Center for Earth System Research and Sustainability, University of Hamburg

The WCRP Sea Level Conference 2022 had been successfully held in Singapore during 12-16 July 2022 with the theme of “Advancing Science, Connecting Society”. As the chair of the WCRP Joint Scientific Committee, Prof. Dr. Detlef Stemmer gave the first speech of WCRP’s commitment to sea-level research. This hybrid conference attracts global researchers concerning climate-related sea-level science and provides a great platform to share the up-to-date studies.

Surrounding the topic of sea level, there are several sessions about paleo sea level and glacial isostatic adjustment, coastal sea level variability, sea level budget, and sea level projection, presenting the recent explorations of the sea level during the past, at present and in the future. However, the key focus of the conference lies on the application of sea level science for adaptation and stakeholder needs.

Under the background of climate change, many islands and cities (like Ho Chi Minh City, Tokyo, Philadelphia and Copacabana discussed in the conference) are currently threatened by sea level rise. How to provide scientific insight for adaption planning and policy decision is an urgent question to figure out at this critical moment. To bridge the science and practice, sea-level researchers and adaptation practitioners should strengthen exchanges and cooperation. During the conference, extensive discussions are conducted concentrating on transforming academic results to risk assessment, adaptation planning and efficient actions, including the consideration of the effect of WCRP. This sea level conference will definitely benefit the critical need for climate adaptation practice in the near future.




*Fig. 2-4: Impressions from the WCRP sea level conference in Singapore in July 2022.*

# **DECVAR:** Sea Level Changes Mechanisms in the MPI-ESM under FAFMIP forcing conditions

Xiaolin Zhang, Sayantani Ojha, Armin Köhl, Helmuth Haak, Johann H. Jungclaus[2], Detlef Stammer
UNIHH, MPI`

The Flux-Anomaly-Forced Model Intercomparison Project (FAFMIP) Experiment was implemented to rationalize differences occurring between the projections of individual models under the idealized FAFMIP forcing. The imposed anomaly patterns for wind stress, heat, and freshwater fluxes were derived from CMIP5 "1pctCO2" runs at the time when doubled $CO_2$ concentration has been reached. The objective here is to quantify the response of dynamic sea level due to these individual forcing changes.

The study is based on the output of the Max-Planck-Institute Earth System Model (MPI-ESM) coupled AOGCM run in a high-resolution setting using FAFMIP forcing anomalies. The goal is to understand mechanism how individual forcing component dynamically and kinematically affect sea level change. The kinematic effects is quantified by passive tracers that for temperature accumulates and advects the absorbed heat (□A in Fig.1) while the effects from the change in dynamics are quantified by redistribution tracers (for temperature □r in Fig.5).

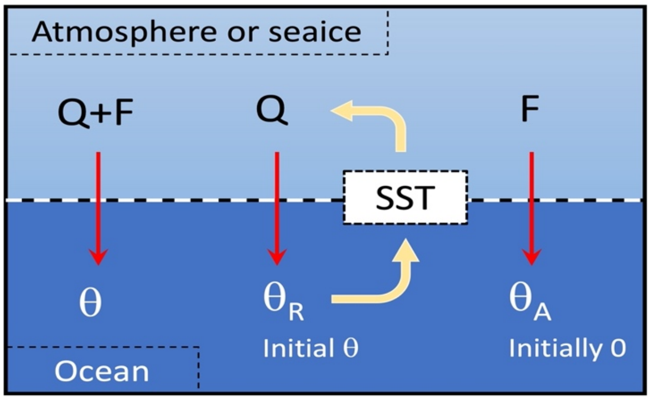


*Fig. 5: Description how the flux perturbation F affects various tracers. Q is the net surface heat from the atmosphere and sea ice into the ocean and F is the flux perturbation. The SST based on the redistri-buted temperature tracer □r (independent of F) is used to calculate the surface heat flux to atmosphere and sea ice.*

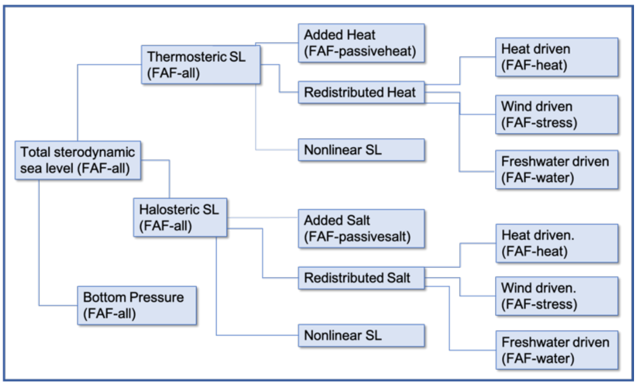


*Fig. 6: Schematic of the decomposition of the sea level response. For the decomposition into contributions from different FAFMIP experiments it is assumed that the total SL from FAF-all can be represented by the sum of the individual forcing experiment.*

The total sealevel response can then be decomposed into the components form salinity and temperature changes and a small redistribution of mass (Fig.6). With the help of the responses due to individual forcing components and the contributions from the additional traces, a complete decomposition into the dynamic and kinematic effect of the forcing changes is achieved

We found that thermosteric dominates the total SL and halosteric component mainly contributes north of 60°N. The estimation of the added and redistributed components further suggest that the added component dominates the thermosteric SL and the redistributed component dominates the halosteric SL. The strong impact of heat flux in causing the SL change outside of the Southern Ocean and north of 60ºN is evident whereas the freshwater flux is mostly counter acting poleward of 40˚N/S except some parts of the Arctic Ocean

**Reference**

Zhang, X., Ojha, S., Köhl, A., Haak, H., Jungclaus, J. H., & Stammer, D. (2022). Sea level changes mechanisms in the MPI-ESM under FAFMIP forcing conditions. *Climate Dynamics*, 1-23.

# **BlueUrban**: Fieldwork in Jakarta and Semarang, June 2022

Johannes Herbeck (Uni-Bremen) and Rapti Siriwardane (Leibniz-ZMT Bremen)

As part of the empirical program within the BlueUrban-project, Rapti Siriwardane and Johannes Herbeck were on fieldwork in Jakarta and Semarang, Indonesia between late May until the end of June 2022. After a training phase on ethnographically-inspired methods for an interdisciplinary team of researchers of Universitas Indonesia, all involved researchers spent several days visiting older field sites in North Jakarta (Kamal Muara, Kampung Akuarium) to understand the afterlives of seawall construction and artificial island reclamation, and their implications on low-income post-pandemic spaces of informality.
Following these brief revisits of earlier work, the team went on to exploring two case studies identified in Semarang. The focus here was on following and tracing knowledge networks that experiment with two distinct yet interrelated coastal adaptation practices/paradigms: 'multifunctionality' in terms of dyking and 'floating' design with respect to housing and public space. Interviews were led with teams of civil engineers who overlook the construction of a multifunctional dike/toll road connecting Semarang and Demak, with university groups and planning teams in Jakarta and Semarang that experiment with different forms of hybrid traditional-modernist methods of building on water, with local authorities involved in coastal planning and infrastructure development, with NGOs and advocacy groups, etc.
Our field explorations were embedded in broader questions relating to speculative futuristic visions of coastal city-making, and the im/possibilities that contemporary real estate legislature, land tenure and property ownership together with socio-cultural value systems place upon experiments that seek alternative ways of living with tidal flux. Furthermore, in order to understand the complexities governing community-based adaptation practices and the potential impacts that larger-scale technological interventions have had, the team visited littoral communities both in Semarang and Jakarta that are not only fast subsiding due to relative sea level rise but are also left contending with the negative coastal impacts of overbuilt protective infrastructure.
Other activities during the stay also entailed two hybrid talks, a Studium Generale at the Department of Civil Engineering at Universitas Islam Sultan Agung (Unissula) in Semarang, and a research seminar at the National Research and Innovation Agency (Badan Riset dan Inovasi Nasional, BRIN formerly LIPI) in Jakarta.
This empirical work will continue into the coming months, with regular cross-disciplinary training and co-learning sessions spanning diverse research methods and exchange formats between researchers at Universitas Indonesia, Leibniz-ZMT, and the Sustainability Research Center (artec), University of Bremen.

New publication:
Herbeck, J., Siriwardane-de Zoysa, R. (2022). Transformations of Urban Coastal Nature(s): Meanings and Paradoxes of Nature-Based Solutions for Climate Adaptation in Southeast Asia. In: Misiune, I., Depellegrin, D., Egarter Vigl, L. (eds) Human-Nature Interactions. Springer, Cham. [https://doi.org/10.1007/978-3-031-01980-7_6](https://doi.org/10.1007/978-3-031-01980-7_6)

*Fig. 7: Impression from the fieldwork of the BlueUrban project at Semarang.*

# **DECVAR-2:** Ocean model resolution dependence of sea level change in SSP5-8.5 climate projections in MPI-ESM

Chathurika Wickramage[1], Armin Köhl[1], Johann Jungclaus[2], and Detlef Stammer[1]
[1] Universität Hamburg, [2] MPI.

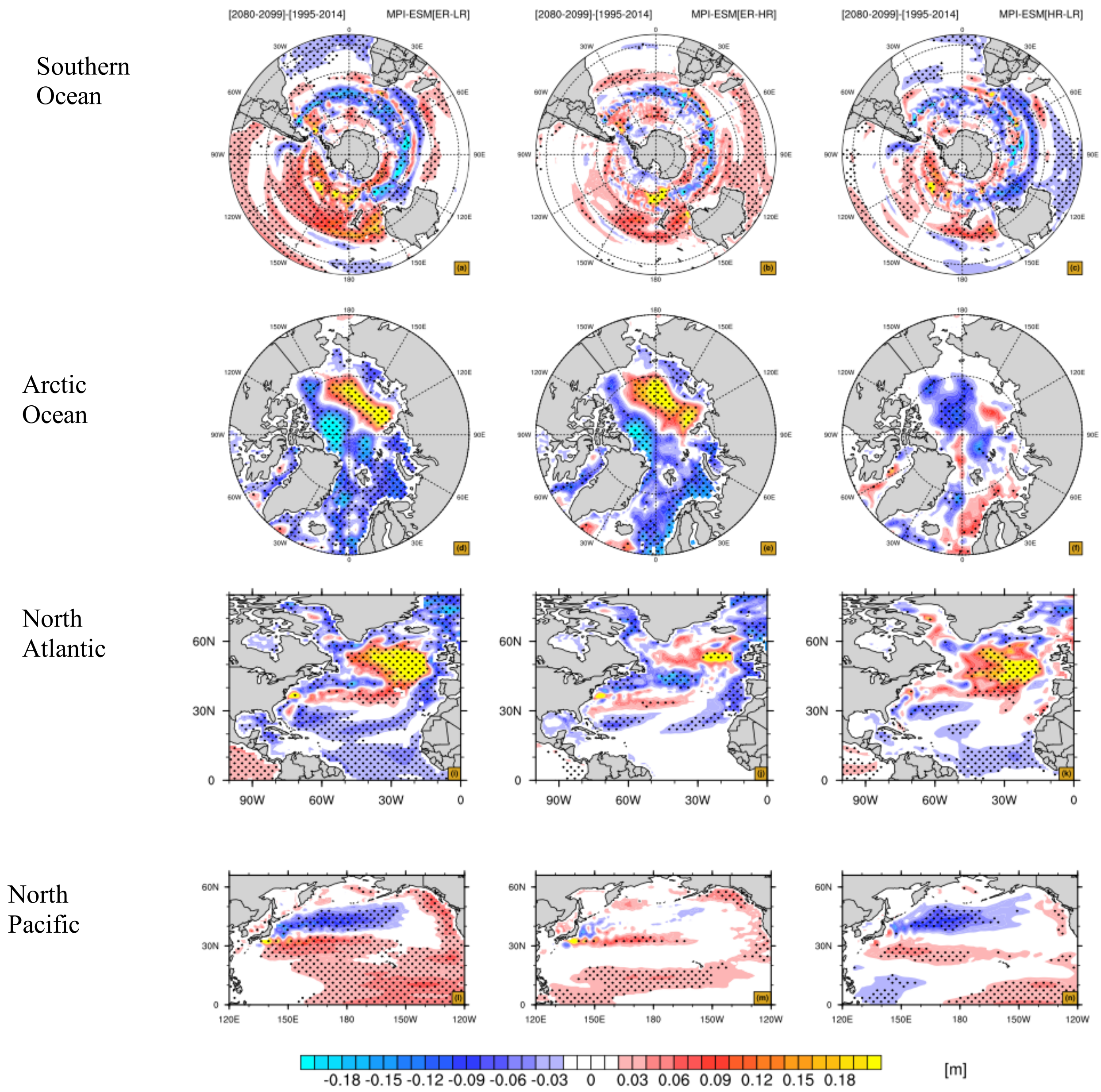


*Fig. 8: Dynamic Sea Level change between various resolutions for the ER, HR and LR between the time mean over the years 2080-2099 and time mean over years 1994-2014*

Improving reliable sea-level projections is essential for successful adaptation and mitigation investments for policymakers and coastal communities over the following decades.

Sea level change is expected to be more realistic when mesoscale processes are explicitly resolved in the climate models. However, the development of eddy resolving models is computationally expensive. Therefore, current sea level projections are based on climate models in which ocean-eddies are parameterized. The recent representation of sea-level by these models considerably differs from actual observations, particularly in the eddy-rich regions such as the Southern Ocean and the western boundary currents, implying erroneous ocean circulation that affects the sea level projections. Taking this into account, we review the sea-level change pattern in a climate model with featuring an eddy rich ocean model and compare the results to state of the art coarser resolution versions of the same model.

We compare Max Planck Institute Earth System Model (MPI-ESM) simulations with spatial resolution, ranging from Low Resolution (LR), High-Resolution (HR), to Eddy Rich (ER) resolution. For each run the Dynamic Sea Level (DSL) changes are evaluated by comparing the time mean of the SSP5-8.5 climate change scenario for the years 2080–2099 to the time mean of the historical simulation for the years 1995–2014. The differences between each pair of results from the ER, HR, and LR have been examined as the spatial pattern of differences for the DSL change. The analyses are separated geographically, focusing on the North Atlantic, the North Pacific, the Southern and the Arctic Oceans in individual subsections.

Our main conclusions are that the North Atlantic subtropical region, the Kuroshio region, and the Arctic Ocean all show larger sea level changes in the model version that captures mesoscale processes than do models with parameterized eddies. Smaller but still significant changes in sea level have occurred in the Southern Ocean and the North Atlantic subpolar region.

Our results indicate that the magnitude of regional sea-level change differs in eddy rich to the low-resolution climate models. However, the basic DSL change patterns and dynamics are similar in each ocean basin, suggesting that the low-resolution models will remain valid in understanding the sea-level change patterns. On the other hand, the detailed, qualitative responses essential for adequate adaptation strategies on a regional scale depend on horizontal resolution. Thus, the climate models that represent relatively small-scale ocean eddies can hence have profound large-scale effects on our understanding of future sea-level change as well as on planning future investments to adapt to climate change around the world. The sea-level projections based on low-resolution climate models should be interpreted with great care, predominantly in eddy active regions. Therefore, one should be aware of climate model horizontal resolution when planning future adaptation and mitigation investments.

**Reference:**

Chathurika Wickramage, Armin Köhl, Johann Jungclaus, and Detlef Stammer (2022). Sensitivity of MPI-ESM sea level projections to its ocean spatial resolution. Submitted to Journal of Climate.

## **SALTSA:** Successful final conference of the SALTSA project

Karrasch, L., Seibert, S. L., Greskowiak, J., Siebenhüner, B., Massmann, G., Department of Business Administration, Economics and Law & Institute for Biology and Environmental Sciences, Carl von Ossietzky University of Oldenburg.

On September 17th, 2021 the final conference of the project "SALTSA: Groundwater salinization by rising sea levels as a social challenge - the example of Northwest Germany" took place. SALTSA is an inter- and transdisciplinary project in which a synthesis of social perceptions and challenges with hydrogeological modeling was carried out. In addition, 15 experts from 14 institutions and authorities involved in water management were involved in the project.

The focus of the event was the presentation of the project results. For example, it was shown that the perception and awareness of the problem of groundwater salinization and the processes that caused it has increased among most of the participating actors during the course of the project. The results of the hydrogeological modeling suggest that the rise in sea level and the change in drainage levels in particular will have a strong impact on the future situation of salinization. Future issues mainly relate to modern, dynamic and holistic water management.

The conference was rounded off by two further program items. Gualbert Oude Essink, Dutch expert on groundwater systems (Deltares), gave a keynote on the topic “Supporting decisions on strategic water management issues of stakeholders using modeling tools: on some dutch cases”. In addition to vivid examples from the work of Deltares, a national Dutch institute with the aim of effective and timely climate change adaptation and direct integration into the national political system, he presented models and possible adaptation strategies for the Dutch region of Zeeland with regard to groundwater salinization. The conference ended with a lively panel discussion. Uwe Sütering (OOWV), Jörg Elbracht (LBEG) and Godehard Hennies (Wasserverbandstag) gave keynote speeches on the subject of “Groundwater salinization at the North Sea coast - what is the current status? What are the needs regarding knowledge and action?".

The SALTSA final conference took place in a corona-compliant hybrid format. The actors who worked closely with the project team over the course of the project were invited to be present. At the same time, the conference was broadcast digitally and 38 interested listeners from science and practice took part online.

*Fig. 9: Impression of the final conference of the SALTSA project, which took place as hybrid format.*

# **DECVAR-2:** Projected sea level change and variability in the Southeast Asia region based on MPI-ESM-ER

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2.The Ocean in the Earth System, Max Planck Institute for Meteorology, Hamburg, Germany

Southeast Asia (SEA) seas include the largest archipelago globally and provide an oceanic pathway connecting the Pacific and Indian Oceans. However, because of the complex coastline and numerous straits of this island region, the projected sea level change and variability have not been detailly discussed in previous coarse resolution simulations. In this study, based on a high-resolution (~0.1° for ocean model) coupled global climate model MPI-ESM-ER (Gutjahr et al. 2019), the projected change and variability of sea level are investigated based on the historical period 1950-2014 and under SSP5-8.5 scenario for 2015-2100.

For the projected sea level changes, thermosteric sea level change is dominant in deep regions, while manometric sea level change is significant in shallow regions. Compared with the other two components, the halosteric sea level change is weak (Fig.10). For the sea level variability, every sea level component is highly correlated with ENSO, showing a close bond between SEA sea level and large-scale natural variability.

Owe to high-resolution simulation, we enclose the SEA seas by 14 straits (or channels) to investigate the contributions from individual straits compared with regional atmospheric. The most obvious changes are the heat and freshwater fluxes through No.2 and 4 straits (in Fig.10a), which show opposite trends and significant negative correlation (-0.93 and -0.66, respectively). Further flux decomposition indicates that these fluxes are mainly induced by changing volume transport, which is caused by the northward maximum current velocity in northwest Pacific region (Fig.11).
The following work will focus on the changes of the outflow side (to Indian Ocean), and its connection with inflow (from Pacific Ocean), which could be related with projected slowdown Indonesian throughflow (e.g., Shilimkar et al. 2022) and corresponding changes of South China Sea throughflow (Gordon et al. 2012).

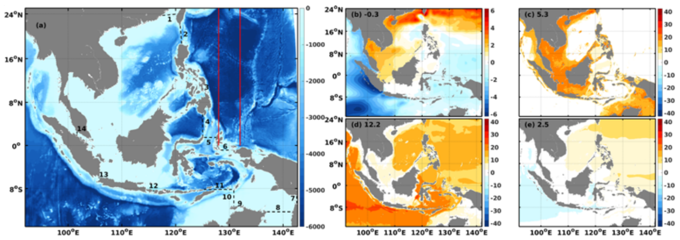

*Fig. 10. (a) Study region with bathymetry (m). The SEA region is enclosed by 14 straits/channels indicated by dash lines and numbers. Projected changes of (b) Dynamic Sea Level change (DSL; cm; relative to global mean), (c) manometric sea level (cm), (d) thermosteric sea level (cm), and (e) halosteric sea level (cm) between 2080-2099 and 1995-2014. The numbers at the top-left corners are the regional mean values (cm).*

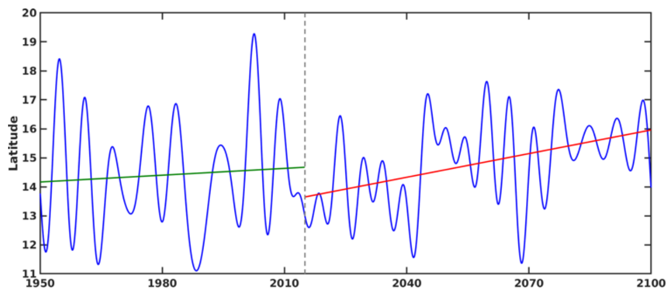

*Fig. 11. The time series (blue) of the latitude of the maximum westward current velocity averaged between the two red lines in Fig. 1a within top 4000 m.*

References:
- Gordon A L, Huber B A, Metzger E J, et al. South China Sea throughflow impact on the Indonesian throughflow. *Geophysical Research Letters*, 2012, 39(11).
- Gutjahr, O. et al., Max Planck Institute Earth System Model (MPI-ESM1.2) for the High-Resolution Model Intercomparison Project (HighResMIP). *Geoscientific Model Development* , 2019, 12, 3241-3281.
- Shilimkar V, Abe H, Roxy M K, et al. Projected future changes in the contribution of Indo-Pacific sea surface height variability to the Indonesian throughflow. *Journal of Oceanograp*hy, 2022, 1-16.

# Future shifts in Sea level Statistics- Implications with the MPI-GE

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Information about impacts of future climate change on global and regional sea level variability, and the potential impact of extreme sea level on coastal risk management are scarce and a growing matter of concern. Future impacts can be investigated by analyzing sea level statistics. The main aims of our research is to use the Max Planck Institute Grand Ensemble (MPI-GE) simulations to estimate regional sea level variability by the end of the 21st century under two emission scenarios (RCP4.5 & 8.5) & shifts in the probability distribution statistics of skewness and kurtosis; both of which are indicative of the Gaussian nature or deviations thereof of sea level PDFs. Among the benefits of using a large ensemble created from a single climate model is that we can better capture the total variability from the ensemble spread and the variability in time.

The model's tropical SSH variability shows a most pronounced deviation from Gaussian statistics, notably in the western and eastern tropical Pacific. By the end of 2100, SSH variability of the western tropical Pacific shows the tendency toward a more Gaussian variability linked with weaker zonal easterly wind stress pulses and thus reduced ENSO activity in the warm pool region. Globally, SSH variability changes in a complex pattern with some regions becoming less variable, e.g., off the eastern coast of the north American continent, while other regions become more variable in SSH, notably the Southern Ocean, and the North Pacific. In the North Atlantic, the enhanced west (decrease)-east (increase) gradient in the RCP8.5 SSH variability is related with changes in basin gyre circulation and the declining AMOC, with the effect of external forcing is dominating.

Our results suggest that sea level variability increases for the high-end scenario in some regions, e.g., Northwest Atlantic, North Pacific and the Southern Ocean, but declines for Northeast Atlantic. Most importantly, our study shows that the overall future global and regional projected sea level shifts in the mean and 99th percentiles toward higher values (in all scenarios); indicating increase in sea level extremes; which is vital for coastal adaptations under climate change. Key Points: Changes In future sea level variability in the North Atlantic and Southern Ocean can be linked to changes in regional wind stress and wind stress curl. Regionally, they result in a widening of the PDF, i.e., an increase in high-end numbers.

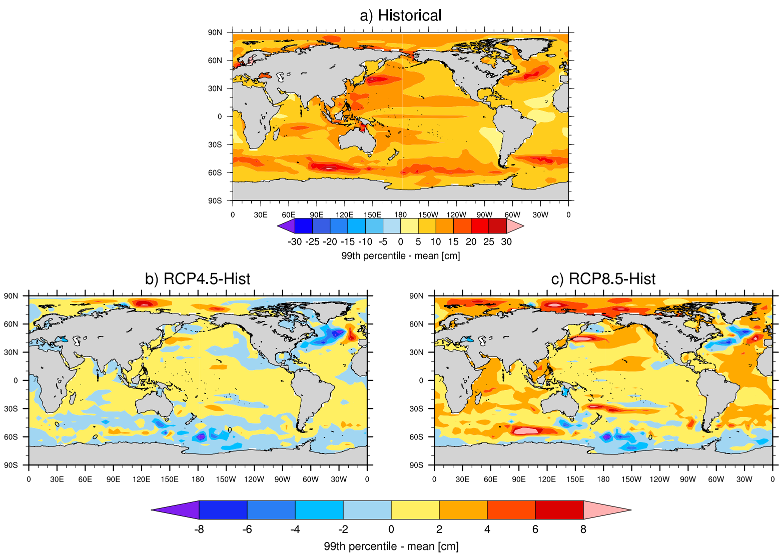
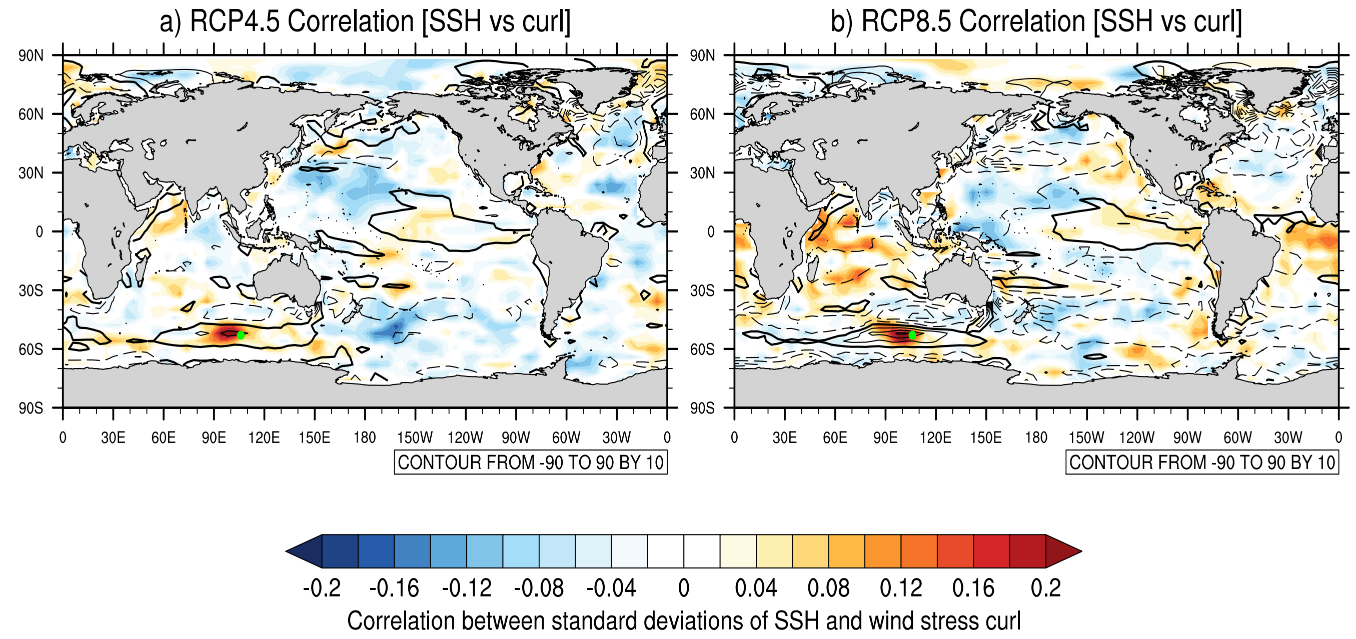



Fig. 12: (a)SSH variations in the SSH 99th percentiles relative to the ensemble mean for the last 20 years of historical run, (b) and (c) show similar fields for RCP4.5 and 8.5 from which the field shown in (a) was subtracted.



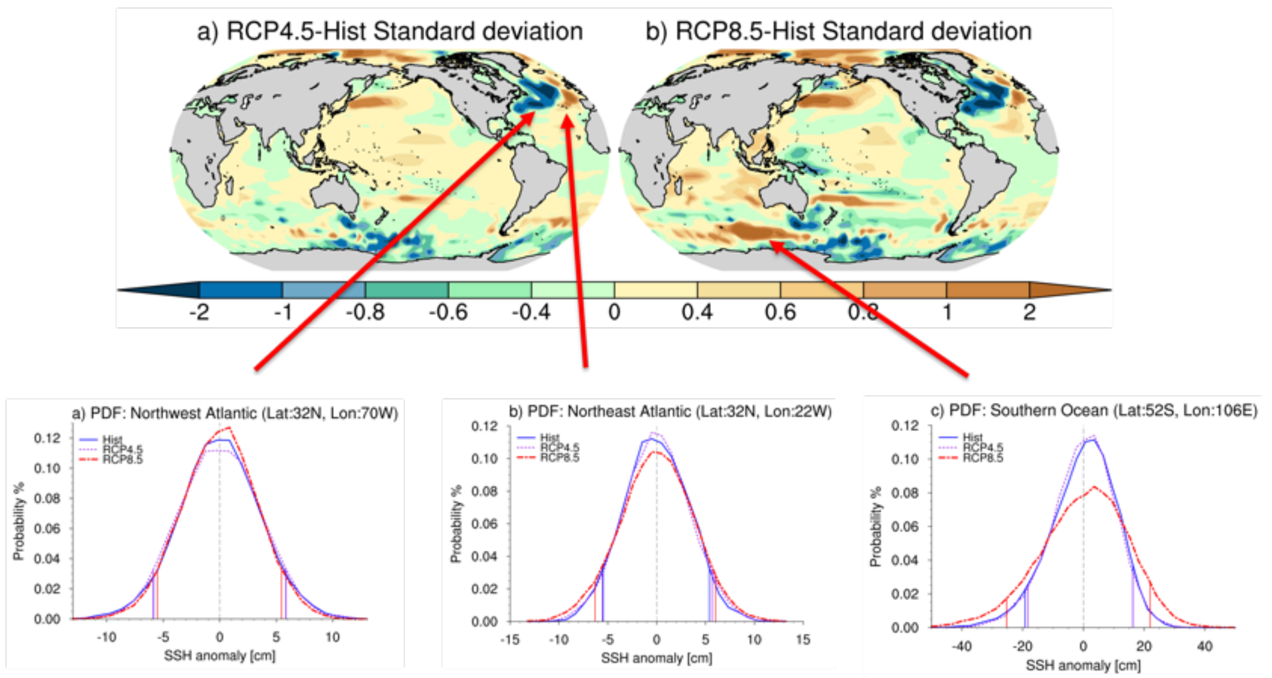




*Fig. 13: Regional changes in variability shown by red arrows, pointing to the shifts in regional PDFs.*

## Recent SPP SeaLevel Publications:

**BlueUrban:** Herbeck J., and R. Siriwardane (2022), Transformations of Urban Coastal Nature(s): Meanings and Paradoxes of Nature-Based Solutions for Climate Adaptation in Southeast Asia, in Misiune, I., Depellegrin, D., Egarter Vigl L. (eds), Human-Nature Interactions, Springer, Cham., doi: 20.1007/978-3-031-01980-7_6.

**SALTSA:** Karrasch, L., T. Grothmann, T.A. Michel, M. Wesselow, H. Wolter, ..., and B. Siebenhüner (2022), Intergrating knowledge within and between knowledge types in transdisciplinary sustainability research: Seven case studies and an indicator framework, Environmental Science and Policy, 131, 14-25.

**DECVAR:** Zhang, X., S. Ojha, A. Köhl, H. Haak, J.H. Jungclaus, and D. Stammer (2022), Sea level changes mechanisms in the MPI-ESM under FAFMIP forcing conditions, Climate Dynamics, doi: 10.1007/s00382-022-06231-2.

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## Future Events related to sea-level research:

*Sea Level Rise Conference* 2022, 17-18 October 2022, Venice, Italy.

Summer School on “Sea level change: evidence, challenges and policy”, 29.8.2022-2.9.2022, Delft, the Netherlands.

World Conference on Climate Change & Sustainability (Climate Week 2022), 1-3 September 2022, Frankfurt, Germany.

Economist Impact’s ESG and Climate Risk Week, 13-15 September 2022, London, UK.

European Urban Resilience Forum (EURESFO), 14-15 September 2022, Athens, Greece.
Daring Cities, 3-7 October 2022, ONLINE.