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 Community,
In this newsletter, read about the new findings of the SLOSH project on the rapid warming of the subtropical ocean that serves as the primary culprit for expanding the tropics; and a new technique from the RespOnse project for glacier-specific calibration for modelled glacier reconstructions.
Also in this newsletter issue, find out more about the latest research of the SEASTORM project on the reconstruction and projection of past and future storm signals at the southeastern North Sea; the method proposed by the ROCSTAR project for model correlations to find coherent Argo profiles and thus, contribute to mapping of Argo data into sparsely sampled areas, and many more in this edition.

INSIDE THIS ISSUE

Fig. 1-3: Moments from the latest fieldwork of the BlueUrban project and PI Dr. Rapti Siriwardane together with their Jakarta team members in Jakarta province, Indonesia. The fieldwork was exclusively in the sinking informal settlements of northern Jakarta and focused on 1. community perspectives and knowledge gaps on land subsidence and 2. a local practice featuring small-scale land reclamation called *nimbun* as an answer to living with subsidence. All images copy rights reserved.

SLOSH: Rapid warming subtropical ocean is expanding the tropics

Hu Yang, Gerrit Lohmann. Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung (AWI). SLOSH

In the past decades, increasing amount of evidence indicates that the climate zones are moving towards higher latitudes under climate change, affecting the pattern of precipitation, ocean circulation, storm tracks and regional sea level rise. This phenomenon is commonly referred to as tropical expansion. The underlying dynamical mechanism driving this phenomenon has puzzled the scientific community for more than a decade, however, is still not entirely clear.

A number of investigations argue that the atmospheric processes, in the absence of the ocean dynamics, lead to the tropical expansion. For example, increasing greenhouse gases, decreasing ozone and increasing aerosols are suggested to be the dominant factors contributing to expanding the tropics. However, these investigations are mostly based on model simulations. Observations show strong discrepancies in respective to the variability, magnitude and regional characteristic of tropical expansion.

In a recent study (Yang and Lohmann et al. 2020a) supported by SPP-SLOSH project, we find that the tropical expansion is primarily driven by the fundamental changes in the ocean surface temperature. More specifically, a rapid warming subtropical ocean is the primary culprit for expanding the tropics.

Under a warming climate, the ocean does not warm up at the same rate. The radiative surface heating is easier to accumulate in the subtropical ocean (Fig. 4), because the subtropical ocean is a region of surface convergence zone. These convergence zones are also well-known as region where the floating plastic pollution accumulate (Fig. 5), mostly due to the same reason. The rapid warming subtropical ocean shifts the mid-latitude meridional temperature gradients and associated pattern of wind, precipitation, storm track and edges of tropics towards higher latitudes.

Our new hypothesis (Fig. 6), supported by both observations and climate model simulations, suggest that global warming has already significantly contributes to the expanding tropics.

The expanding tropics have broad social and environmental implications. For example, on a climatological perspective, centre of tropics is wet and lush, due to the intensive upward airflow of the Inter Tropical Convergence Zone (ITCZ). In contrast, the boundaries of the tropics are hot and dry, causing the driest land, such as the Sahara Desert (Fig. 7). Wider tropics moves the subtropical dry climate zone further towards higher latitudes, causing severe drought over the Mediterranean countries, California, Australia, Brazil and South Africa (Fig. 7). Wildfire has been frequently reported over these regions in recent years. Part of the reason is because that the precipitation pattern has changed by the expanding tropics.

Wider tropics also reshape the pattern of atmospheric wind and drive a poleward shift of the major ocean gyres. The change of ocean circulation pattern produces a relative stronger regional sea level rise over the mid-latitude bands (Yang and Lohmann et al. 2020b).

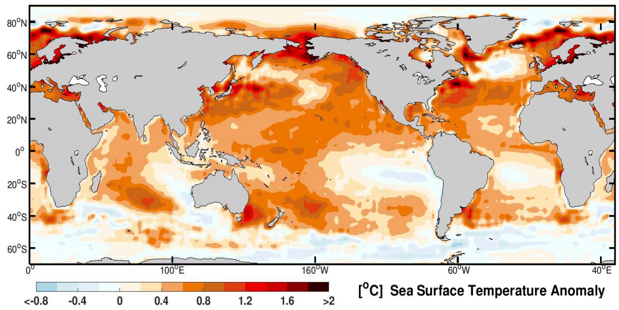

Fig. 4. Satellite observational sea surface temperature anomaly during the last five years (2015-2019), reference to the first five years of satellite observation (1982-1986). A rapid subtropical ocean warming emerges over the latitude band around 20-40 degrees.

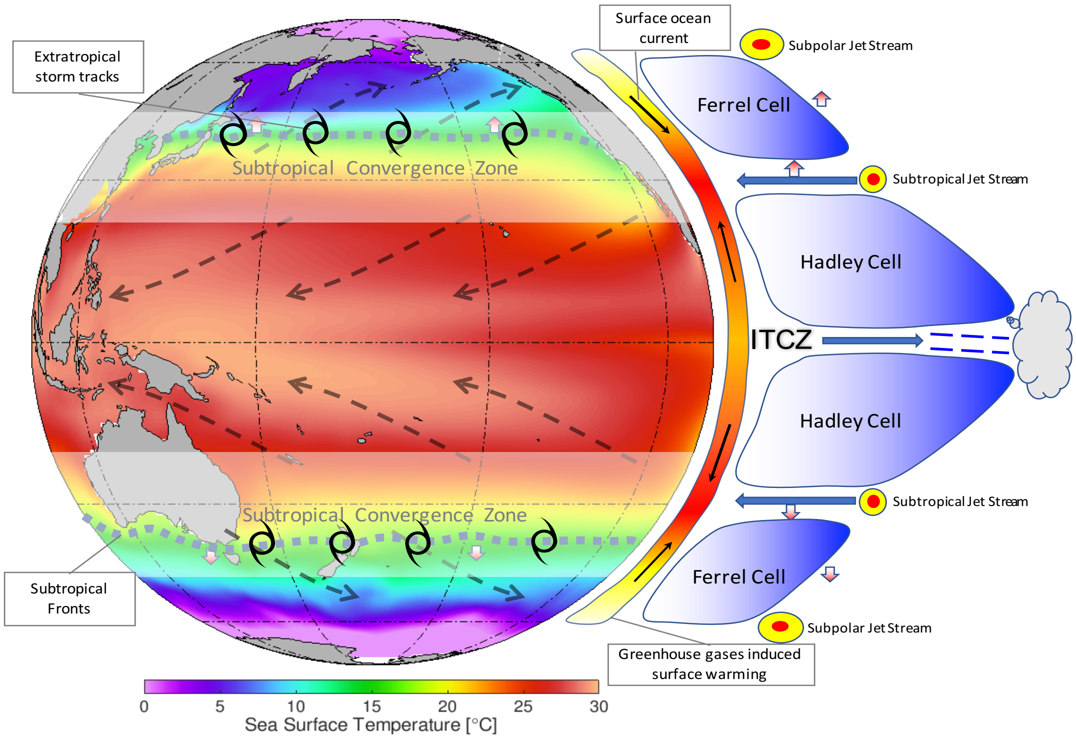

Fig. 5. Schematic diagram explaining the mechanism of tropical expansion. The shading indicates the sea surface temperature, the black dashed arrows illustrate the near surface winds, the white patches are the subtropical convergence zones, and the thick grey dashed lines represent the subtropical fronts. The deep tropical heating maintains the rising branch of the Hadley circulation, namely, the ITCZ. The upper airflow losses buoyancy when it is cooled by radiative cooling, generating the sinking branch of the Hadley circulation near the subtropics. Under the forcing of trade and westerly winds, the subtropical ocean is a zone of convergence of the surface water. Therefore, greenhouse gas-induced radiative forcing produces more warming over the subtropical convergence zone. Such warming expands the tropical warm water zones, and pushes the mid-latitude meridional temperature gradient and associated storm tracks, jet streams, and descending branch of Hadley circulation toward higher latitudes.

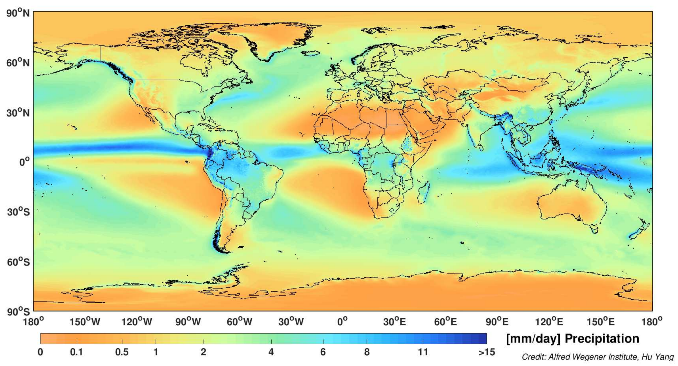

Fig. 6. Climatology pattern of global precipitation. Central of the tropics is wet and lush, while boundaries of the tropics are dry and arid.

Yang, H., G. Lohmann, J. Lu, E.J. Gowan, X. Shi, J. Liu, and Q. Wang (2020), Tropical Expansion Driven by Poleward Advancing Midlatitude Meridional Temperature Gradients: JGR Atmospheres.
Yang, H., Lohmann, G., Krebs-Kanzow, U., Ionita, M., Shi, X., Sidorenko, D., & Gowan, E. J. (2020). Poleward shift of the major ocean gyres detected in a warming climate. Geophysical Research Letters, 47, e2019GL085868.
IPRC (International Pacific Research Center), 2008. Tracking Ocean Debris. IPRC Climate, 8, 2.

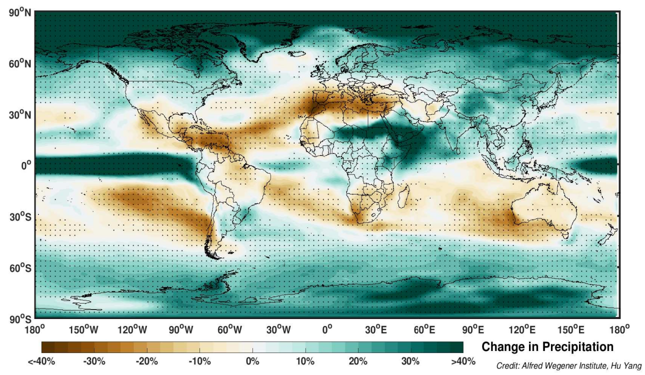

Fig. 7. Projected changes in precipitation by the end of this century under the course of RCP8.5 scenario. Increasing drought over the Mediterranean, California, Australia, Southern Africa and Brazil are linked to the tropical expansion. Over these regions, wildfire has been frequently reported in recent years, very likely due to expanding tropics under global warming.

RespOnSe: The validation of modelled glacier reconstructions

Julia Eis, Ben Marzeion, Universität Bremen, RespOnSe

Estimations of global glacier mass changes over the course of the entire 20th century require knowledge about the state of all glaciers of the world at the beginning of this time period. However, glacier information about the past is strongly limited. Long-term observations exist only for a few hundreds of glaciers worldwide, calling for the use of numerical reconstruction methods. To this end, Eis et al. (2019) developed a method to reconstruct past glacier geometries, e.g. in 1850, from past climate information and present-day geometry alone. The method is developed using the Open Global Glacier Model (OGGM, Maussion et al., 2019) and can be applied globally. Tested in an idealized framework, the study aimed to quantify how much information present-day glacier geometry carries about their past. Multiple possible past glacier geometries are tested and evaluated based on their difference to the present-day geometry. The method was not applied to real world cases and therefore the results could not be compared with observations.

A new study (submitted to Frontiers in Earth Sciences) closes the gap to real world applications by introducing a glacier-specific calibration. This procedure ensures that the modelled glacier area matches the observed area at present-day. We apply the method to glaciers for which either mass balance observations or length records are available, anywhere in the world. The modelled reconstructed glacier changes are then compared to the observations. Figure 1 shows three example glaciers. In Figure 1A the reconstruction matches the observation perfectly; Figure 1B and 1C show two cases with exceptionally bad performance. As OGGM is supposed to deliver good results on a global scale and not for individual cases, statistical analysis about the mean performance become more important.

Thus, we validated the reconstruction method based on different statistical values (e.g. mean bias error, root-mean-square error, correlation). Both the reconstructed mass balances and glacier lengths are in good agreement with the observations, especially for glaciers with many observation years. These results open the door to a future global application.

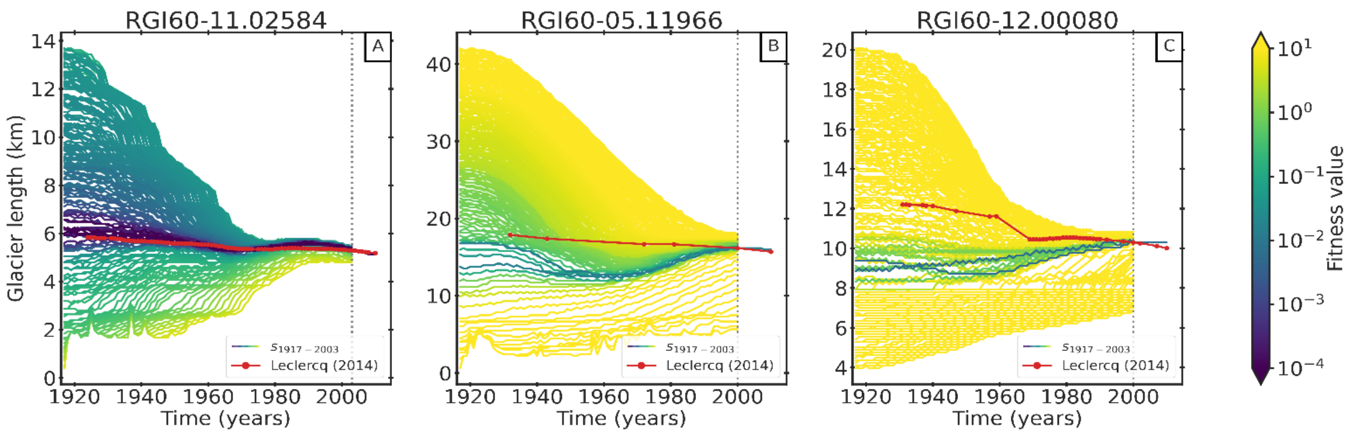

Fig 8: Reconstructed glacier length of three example glaciers. Red line indicates the length observation. The remaining lines are colored by their difference to the present-day geometry. Glacier states that matches the present-day geometry perfectly are colored in violet, states with a large difference are marked in yellow.

References:

Eis, J., Maussion, F., and **Marzeion, B**.: Initialization of a global glacier model based on present-day glacier geometry and past climate information: an ensemble approach, The Cryosphere, 13, 3317–3335, https://doi.org/10.5194/tc-13-3317-2019, 2019

Maussion, F., Butenko, A., Champollion, N., Dusch, M**., Eis, J**., Fourteau, K., Gregor, P., Jarosch, A. H., Landmann, J., Oesterle, F., Recinos, B., Rothenpieler, T., Vlug, A., Wild, C. T., and **Marzeion, B.**: The Open Global Glacier Model (OGGM) v1.1, Geosci. Model Dev., 12, 909–931, https://doi.org/10.5194/gmd-12-909-2019, 2019

SEASTORM: Reconstruction and projection of past and future storm-climate signals at the south-eastern North Sea

D. Bunzel[a], A. Lang[b], K. Müller-Navarra[a], G. Schmiedl[a], U. Mikolajewicz[b], S. Lindhorst[a], Y. Milker[a], C. Betzler[a]; [a] Institute for Geology, University of Hamburg; [b] MPI Meteorology Hamburg

Well-stratified sedimentary sequences from coastal salt marshes prove to be exceptional archives to unravel the climate variability of the past century. However, for the evaluation of different impacts from human activities, regional storm surges, and super-regional atmosphere-ocean variability, an accurate chronostratigraphic control is of critical importance. Obtaining robust age information from salt-marsh sediments is challenging due to frequent sediment reworking by storm surges. To solve this problem, we have combined radionuclides (^{210}Pb, ^{137}Cs, ^{241}Am, ^{14}C) with trends of the industrial mercury (Hg) pollution history, and XRF-based sedimentological inter-correlation (ln(Zr/Rb) ratio), to reconstruct the accretion rates for the past century[1]. For this purpose, we investigated sediment sequences from different salt-marsh regions that are located along the south-eastern North Sea coast (Fig. 9). Local changes in the sedimentary organic matter quality were traced by using ln(Br/Cl) ratios, in which prominent drops occurred concomitant with relatively coarser sand layers (Fig. 10), likely indicating impacts of regional winter storm surges. During these times, the suspended material of the water columns commonly contains less marine organic carbon, i.e., less Bromine is available. In addition, the pore volume of the quartz-rich layers favours an accumulation of the Chloride at the same time. The ln(Zr/Rb) ratios were further used as a grain-size proxy, revealing variability at inter-decadal to multi-decadal time scales. Hence, the results suggest a close linkage of sediment deposition to the large-scale atmospheric-ocean oscillation patterns over the North Atlantic and Europe[2].

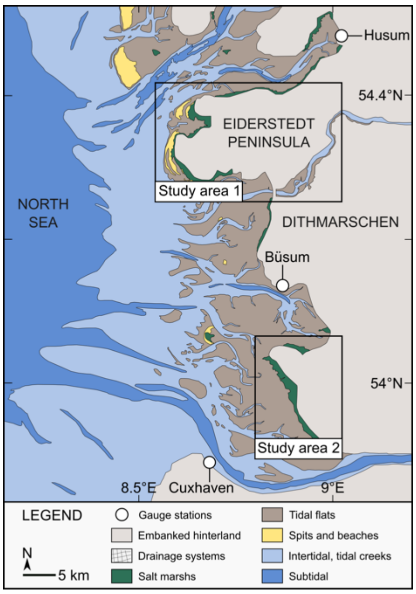

Fig. 9: North Sea coast with location of the study areas.

Model simulations of extreme high sea levels (ESL) in the German Bight exhibited a large variability of the more extreme events[3]. The results have shown that a large ensemble approach (32 ensemble members) is required for the robust analysis and quantification of future sea level extreme statistics under increasing atmospheric CO_2 concentrations scenarios (*1pctCO₂*). The results indicated an increase of the highest extreme values (up to 0.5 m of the ESL change for 50-year return periods), without taking the mean sea level rise into account[4].

Read more in:

Bunzel, D. *et al. (2020), Integrated stratigraphy of foreland salt-marsh sediments of the south-eastern North Sea region, Newsletters on Stratigraphy, doi:10.1127/nos/2020/0540.*

Bunzel, D. *et al. (2020), North Sea salt-marsh archives trace past storminess and climate variability, Global and Planetary Change, in review.*

Lang, A., & Mikolajewicz, U. *(2019), The long-term variability of extreme sea levels in the German Bight, Ocean Science, doi: 10.5194/os-15-651-2019.*

Lang, A., & Mikolajewicz, U. *(2020), Rising extreme sea levels in the German Bight under enhanced CO_2 levels: a regionalized large ensemble approach for the North Sea, Climate Dynamics, doi:10.1007/s00382-020-05357-5.*

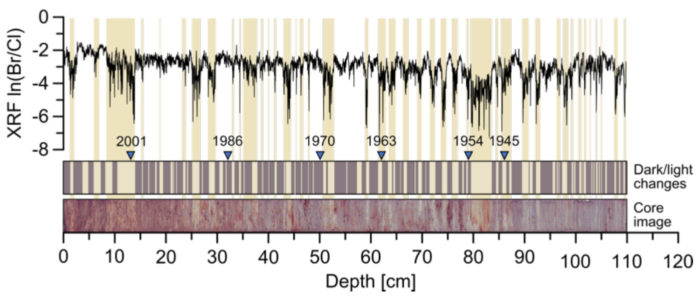

Fig. 10: Considered age markers and variability of the Bromine vs. Chloride ratio (ln(Br/Cl)) within a salt-marsh sequence at the Bay of Tümlau, Eiderstedt Peninsula.

ROCSTAR: Using model correlations to find coherent Argo profiles

Alisa Yakhontova, University of Bonn, Germany and Roelof Rietbroek, ITC Faculty of Geo-Information Science and Earth Observation/The Netherlands

The excess energy from the Earth system trapped in form of heat in the ocean leads to the thermosteric expansion of sea water. One of the ways to study steric sea level rise and the associated Ocean Heat Content (OHC) changes is by using 4-D temperature and salinity (T/S) data. Growing steadily since in 2000, almost 4000 profiling floats of the Array for Real-time Geostrophic Oceanography (Argo) program currently provide T/S data in the upper 2000m of the ocean every 10 days at the expected global resolution of 3˚x3˚. However, Argo suffers from spatio-temporal sampling problems, and some signals are not well captured e.g. in the deeper ocean below 2000m, around the boundary currents, in the Arctic or in the shelf/coastal regions which are not frequently visited by floats.

Mapping of Argo data into sparsely sampled areas would greatly benefit from additional physical information of coherent temperature and salinity behavior in the form of covariance functions.. A standard Argo profile only contains the uncorrelated errors of the measurement instruments and estimating a meaningful covariance function based solely on available observations is difficult, since Argo observations are quite sparse and the spatial variability of the T/S fields strongly depends on latitude and depth. Instead, we use climatology from the general ocean circulation model FESOM to provide information on the variability of T/S fields per depth level. This information is then used to screen whether an Argo measurement has a strong enough correlation ($\rho \geq 0.7$) with the point of interest, and the modeled covariance will be used to quantify this relationship. Using this approach, we construct search areas which are physically motivated rather than just based on a naive distance- or binning approach (typically 3˚x3˚ bins).

To illustrate this, we highlight in Fig 9 an example point in the South Atlantic showing a distinct anisotropic pattern due to the Atlantic Circumpolar Current and the underlying bathymetric features in this region.

The above technique is a quick preview of our current work, where we map temperature and salinity in the South Atlantic. We hope to submit a paper on this topic in the near future.

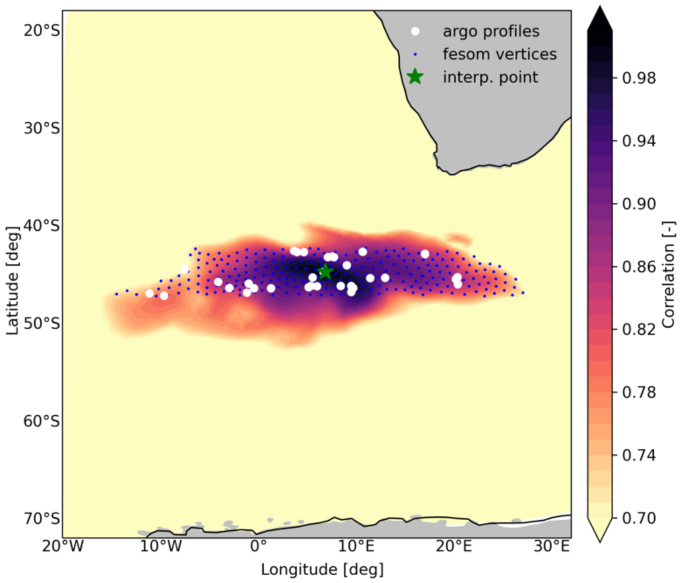

Fig. 11: The search area around the point of interest (green) where we use relevant Argo measurements is elongated due to the Antarctic circumpolar current. A simple distance or binning approach would ingest unrelated measurements.

Recent SPP SeaLevel Publications:

TRANSOCAP I: Bott, L.M., B. Pritchard, and B. Braun (2020),Translocal social capital as a resource for community-based responses to coastal flooding -Evidence from urban and rural areas on Java, Indonesia: Geoforum, doi:10.1016/j.geoforum.2020.08.012.

SEASchange: Bender, M., T. Mann, P. Stocchi, D. Kneer, T. Schöne, J. Illinger, J. Jompa, and A. Rovere (2020), Late Holocene (0-6 ka) sea-level changes in the Makassar Strait, Indonesia, Clim. Past, 16(4).

SEASTORM: Bunzel, D. Y. Milker, K. Müller-Navarra, H.W. Arz, . Friedrich, N. Lahajnar, and G. Schmiedl (2020), Integrated stratigraphy of foreland salt-marsh sediments of the south-eastern North Sea region, Newsletter on Stratigraphy, 53, 415-442.

Lang., A., and U. Mikolajewicz (2020), Rising extreme sea levels in the German Bight under enhanced CO_2 levels: a regionalized large ensemple approach for the North Sea., Clim. Dyn.

DICES: David, G., and T. Schlurmann, Hydrodynamic drivers and morphological responses on small coral islands – The Thondu spit on Fuvahmulah, the Malvides, Front. Mar. Sci.

EMERSA: Siriwardane-de Zoysa, R., T. Schöne, J. Herbeck, J. Illigner, M. Haghighi, H. Simarmata, E. Porio, A. Rovere, A.-K. Hornidge (submitted), The Wickedness of Governing Land Subsidence: Policy Perspectives from Urban Southeast Asia, submitted to PLOS One.

Siriwardane-de Zoysa, R. (2020), Beyond the Wall: Dying as an object of everyday governance in the Bay of Manila, Marine Policy, 112.

SLOSH: Yang, H.G., Lohmann, J. Lu, E.J. Gowan, X. Shi, J. Liu, and Q. Wang (2020), Tropical Expansion Driven by Poleward Advancing Midlatitude Meridional Temperature Gradients: JGR. Atmospheres.

Find the full list of the SPP SeaLevel published papers at *www.spp-sealevel.de* → *“Resources”* → *“Publications”*

Future Events related to sea-level research:

Regional climate change projections: climate change analysis using CORDEX regional climate models over South Asia, 12-14 October and 19-21 October 2020, ONLINE.

Humanities and Social Sciences for Sustainability, 21-22 October 2020, ONLINE.

Virtual Conference of Ocean Governance for Sustainability, 19-20 November 2020, ONLINE.

AGU Fall Meeting, 1-17 December 2020, ONLINE.

Cryosat 10th Anniversary Conference, 14-17 June 2021, Taormina (Sicily),Italy.

Climate Change in Coastal Cities: Centring the Voices of Urban Residents in Asia and Africa, 24-27 August 2021, Kyoto, Japan.

MISCELLANEOUS ANNOUNCEMENTS:

New Principal Investigator at the SPP HAnsea research project

Prof. Dr. Hildegard Westphal, Workgroup leader Geoecology & Carbonate Sedimentology, ZMT, Bremen as the new PI of the SPP HAnsea project as Dr. Thomas Mann starts new postdoc position at BGR Hannover in October 2020.

We all wish to Thomas Mann and Hildegard Westphal every success to their new job research positions.

Documentary "Climate Risk: Sea -When the flood comes" at ZDF channel.

"Climate Researchers have been warning of the potentially devastating consequences of rising sea levels caused by climate change, what if the worst-case scenarios occur?"

The documentary "Climate Risk: Sea -When the flood comes" can be watched online at the ZDF channel.

SPP social science meeting held in Bremen

A SPP meeting held by our SPP colleagues in Bremen took place in September 2020 in Bremen, where the projects BlueUrban, TRANSOCAP II and SEATRAC together with G. Gussman (Global Climate Forum) and Dr. J. Koerth (Uni-Kiel) gathered to discuss their research work + cooperation potential.

SeaLevel Coordination Office news/announcements

The SPP SeaLevel website is being renewed in collaboration with Lfda web design company, All research projects are invited to send the SPP SeaLevel Coordination Office any material for the construction of their individual project webpage as soon as possible please.

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