SeaLevel Newsletter

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Welcome to the 2nd SPP–1889 SeaLevel Newsletter!

The diverse community of natural and social scientists from various disciplines embraced within the ***SPP-1889 "Regional Sea Level Change and Society" (SeaLevel) program*** means that interaction and exchange of knowledge and information are essential elements of its interdisciplinary nature.

This issue, aiming to offer an insight into the SeaLevel activities and achievements of the different research projects, overviews the outcomes of the recent meetings of the SeaLevel members, namely the 2nd Annual SPP SeaLevel Meeting, a workshop dedicated exclusively to the Early Career Scientists of the program, as well as one focusing the scientific interest on Indonesia, one of the SPP SeaLevel study regions.

Other highlights in this issue include a report from fieldwork in Indonesia megacities; an example of the effective collaboration of SPP SeaLevel natural and social researchers and their published work on sea level rise, flooding and social adaptation in Central Java, Indonesia; as well as a new paper in Nature Climate Change from one of our SPP PIs!

We hope you will enjoy reading our Newsletter and find it useful. We encourage you to get in touch with any comments/questions you may have about the SeaLevel, or if you wish to subscribe to our Newsletter.

Thanks for your interest in the SeaLevel program!

INSIDE THIS ISSUE

Boosting integration & interaction: 2nd Annual SPP SeaLevel Gathering

The SeaLevel program had an exciting and productive 2nd annual status seminar in March at the Institute of Oceanography, CEN, University of Hamburg. About 60 scientists from 19 projects gathered together for 3 days to present and discuss their new results and progress, but also future steps.

The gathering of social and natural scientists working within the SPP-1889 SeaLevel overviewed the complex, multi-dimensional sea level research issue and the state-of-art knowledge on the field, demonstrating the comprehensive, multi- and interdisciplinary character of the SeaLevel program.

Science presentations from the SPP community covered new findings on global and regional level changes and extremes in the two study regions of

Fig.1: The participants of the 2nd SPP-1889 SeaLevel Annual Meeting (March 2018, CEN/ Institute of Oceanography, University of Hamburg).

Fig 2: The 2nd annual gathering of the SPP SeaLevel at CEN/Institute of Oceanography, University of Hamburg on 19-21 March 2018.

the SPP SeaLevel, namely the Northeast Atlantic with the North and Baltic Seas, and the Southeast Asia and Indonesia region, impacts in these regions, as well as developments on adaptation options and different pathways, decision analysis and governance.

Among the meetings' highlights included examples of collaboration between natural and social disciplines and the exchange of complementary information among projects, further pointing out the benefits gained from the cross-disciplinary approach of the SeaLevel program and the great advantage of working within such a wide-ranging scientific community. Moreover, the SPP research scientist Ben Marzeion from the SPP PARSL-Glac project, expert on glaciers, presented results from a new research paper on glacier mass loss, which was first published in Nature Climate Change during the days of the 2nd SPP annual meeting. Find out more about the paper in page 5.

Guest speaker Jason Lowe from Met Office UK, discussed the different aspects and forms that sea level information is needed by a variety of different users for decision making, as well as he talked about sea level rise under 1.5 degree warming, high-end sea level scenarios and associated uncertainties.

A main focus of the SPP SeaLevel meeting was the identification and implementation of new ways to strengthen more and expand this ongoing exchange of information and interactions among the different disciplines and projects, while discussions further covered the future steps of the SPP program and its continuation.

Fig 3: Images from the 2nd annual SPP SeaLevel meeting in Hamburg: (from top left to right bottom) Johannes Herbeck (Uni-Bremen), Monika Rhein (IUP/MARUM), Gerhard Schmiedl (Uni-Hamburg), Gabriel David (Uni-Hannover) and Susann Adloff (Uni-Kiel), Rapti Siriwardane (ZMT-Bremen), Jochen Kinkel (GCF, Potsdam).

"A meeting from us for us!"
1st SPP-1889 SeaLevel Early Career Scientists (ECS) Meeting

Following the 2nd annual meeting of the SeaLevel on 19th-21st March, another successful and highly stimulating meeting dedicated exclusively to the Early Career Researchers (ECS) of the program took also place at CEN/Institute of Oceanography, University of Hamburg.

The 2-day meeting, initiated, organized and ran by the SPP SeaLevel ECS community itself with the motto "a meeting from us for us", brought together PhD students and postdocs from the social and natural sciences to present their individual research work inside each SPP project, reinforcing interactions with each other and integration within the SPP SeaLevel community.

The meeting served as a great opportunity to understand each other's research to a more fundamental level, providing "down to the basics" information and thus building on background knowledge, which is essential for obtaining both a wider overview and a deeper understanding into the diverse natural, socio-politico-economic and cultural aspects of the sea level research field, but also of the interdisciplinary character of the SPP SeaLevel itself. In turn, this enabled the ECS to better perceive the involvement of their own work within the whole SPP SeaLevel program.

Benefiting from the expertise of SPP Principal Investigators (PIs), the ECS meeting further included lectures on key sea level topics. Jochen Hinkel (Global Climate Forum, Potsdam) discussed to what extent the coastal societies are able to adapt to sea level rise, and what kind of sea level information are required for coastal adaptation and risk management, and Tilo Schöne (German Research Centre for Geosciences-Helmholtz Centre Potsdam (GFZ)), gave a lecture on measuring sea level with different tools and getting a consistent reference frame.

Fig 4: Snapshots from the 1st Early Career Scientists Meeting of the SPP SeaLevel and their excursion in Hamburg waterfront to visit the storm surge and flood protection cites of the city.

Fig 5: Images from the excursion of the SPP ECS members to the flood protection cites of Hamburg, guided by Mr Jan-Moritz Müller from the Department for Roads Bridges and Waterways (LSBG).

In addition, guest speakers from the Department for Roads, Bridges and Waterways (LSBG) talked about storm surges and flood protection strategies and accompanied the ECS participants for an excursion to the flood protection cites in Hamburg, offering a more thorough insight into the range of storm surge needs, designs and approaches. Moreover, Patrick Wagner, PhD student in the SPP IndoArcipel project, demonstrated a practical exercise on GIT version control software, while the comprehensive agenda of the meeting also included a lecture on writing and presentation skills for interdisciplinary topics and audience from a corpus linguist guest speaker from the University of Birmingham, UK.

We are building a sea level-related literature database!
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You can also forward us your papers!

Recent SPP SeaLevel Publications:

MOREWACC project: Bacherer, J., J. Hofstede, U. Gräwe, K. Purkiani, **E. Schulz and H. Buchard** (2018), The Wadden Sea in transition- consequences of sea level rise:: Ocean Dyn., 68, 131-151.

TRANSOCAP project: **Bott, L.M., J. Illigner,** M.A. Marfai, **T. Schöne, and B. Braun** (2018), Meeresspiegelastieg und Überschwemmungen an der Nordküste Zentraljavas- Physische Ursachen und soziale Anpassungsmaßnahmen, Geographische Rundschau, 70(4), S. 4-8.

CoRSEA project: Esselborn, S., S. Rudenko, and **T. Schöne** (2018), Orbit-related sea level errors for TOPEX altimetry at seasonal to decadal timescales, Ocean Sci., 14, 205-223.

PARSL-Glac project: **Marzeion, B.,** G. Kaser, F. Maussion, and N. Champollion (2018), Limited influence of climate change mitigation on short-term glacier mass loss: Nature Climate Change, 8, 305-308.

CoRSEA project: Rudenko, S., K.-H. Neumayer, D. Dettmering, S. Esselborn, **T. Schöne,** and J.C. Raimondo (2017), Improvements on precise orbits of altimetry satellites and their impact on mean seal level monitoring, IEEE Transactions of Geoscience and Remote Sensing, 55(6).

Glacier mass loss: past the point of no return

Climate researchers from the Universities of Bremen and Innsbruck, including Ben Marzeion (Uni Bremen), Principal Investigator of the SPP PARSL-Glac project, show in a recent study that the further melting of glaciers cannot be prevented in the current century - even if all emissions were stopped now. However, due to the slow reaction of glaciers to climate change, our behaviour has a massive impact beyond the 21st century: In the long run, five hundred meters by car with a mid-range vehicle will cost one kilogram of glacier ice. The study has now been published in Nature Climate Change.

In the "Paris Agreement", 195 member states of the United Nations Framework Convention on Climate Change have agreed to limit the rise in global average temperature to significantly below 2°C, if possible to 1.5°C above pre-industrial levels. This should significantly reduce the risks of climate change. What does this plan - if successful - mean for the evolution of glaciers? Climate researchers Ben Marzeion and Nicolas Champollion from the Institute of Geography at the University of Bremen and Georg Kaser and Fabien Maussion from the Institute of Atmospheric and Cryospheric Sciences at the University of Innsbruck have investigated this question by calculating the effects of compliance with these climate goals on the progressive melting of glaciers. "Melting glaciers have a huge influence on the development of sea level rise. In our calculations, we took into account all glaciers worldwide - without the Antarctic and Greenland ice sheets and peripheral glaciers - and modelled them in various climate scenarios," explains Georg Kaser.
One kilogram of CO_2 emitted costs 15 kilograms of glacier ice.

Whether the average temperature rises by 2 or only 1.5°C makes no significant difference for the development of glacier mass loss over the next 100 years. "Around 36 percent of the ice

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Limited influence of climate change mitigation on short-term glacier mass loss

Ben Marzeion[1]*, Georg Kaser[2], Fabien Maussion[2] and Nicolas Champollion[1]

Glacier mass loss is a key contributor to sea-level change[1,2], slope instability in high-mountain regions[3,4] and the changing seasonality and volume of river flow[5,6]. Understanding the causes, mechanisms and time scales of glacier change is therefore paramount to identifying successful strategies for mitigation and adaptation. Here, we use temperature and precipitation fields from the Coupled Model Intercomparison Project Phase 5 output to force a glacier evolution model, quantifying mass responses to future climatic change. We find that contemporary glacier mass is in disequilibrium with the current climate, and 36 ± 8% mass loss is already committed in response to past greenhouse gas emissions. Consequently, mitigating future emissions will have only very limited influence on glacier mass change in the twenty-first century. No significant differences between 1.5 and 2 K warming scenarios are detectable in the sea-level contribution of glaciers accumulated within the twenty-first century. In the long-term, however, mitigation will exert strong control, suggesting that ambitious measures are necessary for the long-term preservation of glaciers.

On time scales of many millennia and longer, glaciers are shaped through interactions with their bedrock[7–11]. On millennial and shorter time scales, their geometry is an expression of the atmospheric conditions surrounding them[12,13]: positive mass balances lead to an expansion of the glacier to lower terminus elevations, while negative mass balances lead to a retreat of the glacier to higher terminus elevations. This mechanism provides a negative feedback[13] through which glaciers adjust their elevation–area distribution to the atmospheric forcing. However, the signal of a perturbed mass balance is distributed over the glacier at a finite velocity, which results in a lagged response of the glacier length to changes in mass balance forcing[14,15]. During periods when climate change is happening rapidly relative to glaciers' response times, glaciers may therefore experience a strong disequilibrium with climate conditions[16]. The amount of ice stored in glaciers[17,18] at any given time may therefore contain a substantial fraction that is not sustainable under concurrent climate conditions.

To quantify this disequilibrium, we first estimate the glacier mass that is sustainable under different global mean temperatures. Note that the spatial distribution of glaciers relative to the spatial pattern of atmospheric temperature change implies that glaciers on average experience higher atmospheric temperature changes than the global mean[19]. We consider all glaciers globally, but exclude peripheral glaciers in Greenland and Antarctica, as well as the ice sheets. Using anomaly fields of temperature and precipitation obtained from the Coupled Model Intercomparison Project Phase 5 (CMIP5) model ensemble and gridded climate observations from the period 1961 to 1990 (refs [20,21]), we force a global glacier evolution model to quantify the long-term response of each glacier contained in the Randolph Glacier Inventory (RGI) version 5 (ref. [22]), which provides initial surface area and elevation distribution values, to these anomaly fields. This is achieved by repeatedly applying identical climate forcing, corresponding to a given global mean temperature change, to each glacier, until the volume change of the glacier becomes negligible (see Methods for details of the setup of the experiment). The results shown in Fig. 1 indicate a strong disequilibrium between the present-day global glacier mass and present-day climate conditions (when referring to present-day glacier mass, we refer to the year 2015; for present-day climate conditions, we refer to the mean over the years 2006 to 2015), consistent with current in situ observations of glacier mass change[23]. While our estimate of present-day glacier mass is 307 ± 18 mm sea-level equivalent (SLE; the uncertainty indicates the 90% confidence interval), the sustainable ice mass is estimated to 195 (173–222) mm SLE (the numbers in brackets indicate the fifth and ninety-fifth percentiles of the glacier model ensemble), indicating that 36 (28–44)% of the present-day ice mass is unsustainable and would melt if the current climate were to remain stable for the coming centuries. This number is close to previous estimates of 27 ± 5%[23] (for the reference year 2006) and 38 ± 16%[24] (for the reference period 2000–2010) of already committed but not yet realized glacier mass loss obtained from observed accumulation area ratios. To sustain present-day ice mass, the global mean temperature would have to drop to pre-industrial conditions (when referring to pre-industrial, we refer to the mean over the years 1850–1879). This finding is consistent with previous results that indicate glaciers were strongly responding to the end of the preceding, cooler period of the Little Ice Age before anthropogenic warming became the dominant cause of their mass loss in the second half of the twentieth century[25]. Further global warming increases the present-day commitment to future ice mass loss to 159 (115–179) and 191 (139–205) mm SLE for 1.5 and 2 K warming relative to pre-industrial temperatures, respectively. The equilibrium response of glaciers to warming is nonlinear, with decreased sensitivity at higher temperatures, which is explained by the decreasing surface area and mass of glaciers available for melt.

Using an approximated linear relationship between global anthropogenic CO_2 emissions and global mean temperature change of 1,700 Gt CO_2 emissions per 1 K of warming[26], we calculate the global glacier mass change commitment of CO_2 emissions as a function of the global mean temperature (Fig. 2). Since this mass change commitment is calculated from the equilibrium glacier mass, it is independent of, and in addition to, any potential mass changes committed in the past, but not yet realized. We find that under present-day climate conditions, every emitted kg of CO_2 will eventually be responsible for a glacier mass loss of 15.8 (5.9–20.5) kg. Again, since the global glacier mass is decreasing with increasing temperatures,

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still stored in glaciers today would melt even without further emissions of greenhouse gases. That means: more than a third of the glacier ice that still exists today in mountain glaciers can no longer be saved even with the most ambitious measures," says Ben Marzeion.

However, looking beyond the current century, it does make a difference whether the 2 or 1.5°C goal is achieved. "Glaciers react slowly to climatic changes. If, for example, we wanted to preserve the current volume of glacial ice, we would have to reach a temperature level from pre-industrial times, which is obviously not possible. In the past, greenhouse gas emissions have already triggered changes that can no longer be stopped. This also means that our current behaviour has an impact on the long-term evolution of the glaciers - we should be aware of this," adds glaciologist Kaser. In order to make these effects tangible, the scientists have calculated that every kilogram of CO_2 that we emit today will cause 15 kilograms of glacier melt in the long term. Calculated on the basis of

an average car newly registered in Germany in 2016, this means that one kilogram of glacier ice is lost every five hundred meters by car," clarifies Ben Marzeion.

This work was funded by the German Federal Ministry of Education and Research (grant 01LS1602A) and German Research Foundation (grant MA 6966/1-1), and supported by the former Austrian Federal Ministry of Science and Research as part of the UniInfrastrukturprogramm of the research platform Scientific Computing at the University of Innsbruck.

Ben Marzeion is also Lead Author of Chapter 4: Sea Level Rise and Implications for Low Lying Islands, Coasts and Communities, of the IPCC Special Report on the Ocean and Cryoshere in a Changing Climate (SROCC) which will be finalized in September 2019.

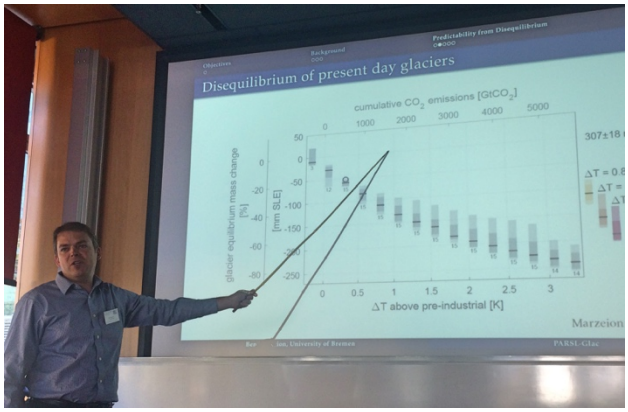

Fig 6: Ben Marzeion, PI at the SPP PARSL-Glac project, presented his new research work at the 2nd Annual SPP Meeting the day when it was also first published in Nature Climate Change.

A Day focusing on Indonesia & Networking

SPP-1889 SeaLevel projects with a main research focus on sea level changes and the impact on society in the Southeast Asia and Indonesia Overflow region gathered in Bremen earlier this year to exchange information and foster their interaction and collaboration.
The Indonesian Networking Day, organized by SPP colleagues working in the EMERSA project, took place at the Leibniz Center for Tropical Marine Research (ZMT), bringing together representatives from the projects Asia-Floods, CoRSEA, EMERSA, IndoArchipel, SEASchange, and TRANSOCAP. The SPP SeaLevel Coordination Office also joined this interesting meeting.

The participating projects comprising both natural and social scientists presented an overview of their objectives and new results from their research and fieldwork in Indonesia, as well as they had the opportunity to reflect on and discuss each other's research outcomes, as well as to inform each other about future activities and fieldwork, upcoming workshops and other plans.

Among others, the discussion emphasized both the impacts of sea level on the society but also those caused by human action itself, particularly land subsidence, which in cities such as Semarang, Surabaya and Jakarta can reach 10 cm per year, leading to frequent tidal and river floods. Thus, it constitutes a serious issue for the local communities and poses the question of how and for how long affected societies will be able to deal with it in socio-economically feasible manners.

The participating projects further focused on mapping common grounds of interest and possible ways for further interaction, communication and cooperation among the projects.

A focal point of the discussion was what kind of information is needed from the natural sciences to feed into the research of social sciences involved in the SPP SeaLevel program, and vice versa, as well as further pathways to carry out and reinforce this exchange of knowledge. Examples of such a joint effort and collaboration have been already demonstrated, such as between the social scientists from the TRANSOCAP project and the natural scientists from the CoRSEA project, inspiring further courses of actions in this direction among the projects. Read more about this collaboration and the resulting publication in page 8.

CoRSEA: Field trip to Jakarta, Surabaya and Semarang

Julia Illigner[1], Tilo Schöne[1], [1]Helmholtz Centre Potsdam, German Research Centre for Geosciences (GFZ)

The aim of the CoRSEA project is to use state-of-the-art geodetic sensors (Tide gauges, GNSS, Radar Altimetry, InSAR) to identify and examine sea level patterns and changes, find extreme sea level events from tide gauge records, and study coastal flooding under the view of local subsidence. This knowledge is then used as background information for socio-economic assessments.

The GFZ installed 3 tide gauges in northern Java, i.e. in Jakarta (2013), Semarang (2012) and Surabaya (2014), to study the local sea level, particularly under the influence of subsidence.

"In February 2018, we carried out a field trip to these tide gauges. For the purpose of vertical land motion monitoring, regular levelling measurements between sensors, GNSS antenna and the surrounding are crucial. To exclude a possible drifting of sensors, it is advisable to carry out regular dipping measurements additionally", explains Julia Illigner, researcher in the CoRSEA project.

In Semarang, subsidence rates of up to 10cm/year cause severe problems for the local community. The population numbers have been growing recently, and accordingly the amount of groundwater withdrawal. Due to land reclamation, some parts of the city have a great potential of soil compaction, which gets even worse by the growing number of massive buildings to accommodate the newcomers.

The surrounding mountains of Semarang intensify the problem. During heavy rain, the water runs down into the city and is dammed by the sea, which is almost on an even level with the city elevation. Especially during high tide, the rainwater cannot drain back to the sea. To avoid the frequent flooding, new building projects, such as the new highway, are built on embankments. These massive constructions add megatons of weight to the compacting soil.

The consequences of the resulting subsidence to the landscape of the city is clearly visible. Even our tide gauge itself, which has been well above the surrounding area in 2012 (Fig 7), is now to be found about 1 m below the new street level (Fig 8).

A site survey in the highly effected areas of Semarang reveals to what extent the population is affected by this development. Some streets were uplifted frequently every 2 years by 20 cm. The houses appear to be 'sinking', while the street level appears to be 'rising'. Fig 9 shows an inhabited house with an eaves height of ~1,20 m. The uplift of the street level clearly deteriorates the situation, since the water has nowhere else to go except into the low-lying houses.

Fig 7: Tide gauge in Semarang 2012 (©Julia Illigner).

Fig 8: Tide gauge in Semarang 2018 (©Julia Illigner).

Fig 9: 'Sinking' houses Semarang 2018
The roof of the house in the foreground is just 1,20m above street level. The 1th floor balcony of the next house now serves as entrance, while the ground floor serves as basement. (©Julia Illigner).

TRANSOCAP and CORSEA:

Sea level rise and flooding on the northeast coast of Central Java. Physical causes and social adaptation

Lisa-Michéle Bott[1], Julia Illigner[2], Muh Aris Marfai[3], Tilo Schöne[2], and Boris Braun[1] [1]University of Cologne, [2]Helmholtz Centre Potsdam, German Research Centre for Geosciences (GFZ), [3]Gadjah Mada University, Indonesia

Sea level rise and flooding on the north coast of Central Java. Physical causes and social adaptation Coastal floods and their causes and consequences can be understood as coupled socio-ecological systems. The pattern of regional sea level rise in Indonesia is highly divergent, showing rates from -5 to more than +10 cm per annum. In Semarang, the capital of Central Java, GNSS-corrected tide gauge data show a strong rise of the local sea level of 10 cm per annum. This rise of the local sea level is mainly caused by land subsidence, which is due to tectonic instabilities, excessive groundwater withdrawal and increased surface load. As a consequence of the subsiding land surface, low-lying urban districts are faced with frequent tidal and river floods. So far, local people in Semarang have been able to cope with these harsh environmental conditions, largely through mutual help, collective action and social capital. Outmigration from affected areas is very limited. But questions remain of whether people will be able to keep up with a possible future increase in the absolute sea level and how long staying in the affected areas will continue to be economically and socially feasible.

Fig 10: Central Java, Indonesia (Source: pixabay).

The full article is published at the German journal for Geography Geigraphische Rundscau: Bott, L.M., J. Illigner, M.A. Marfai, T. Schöne, B. Braun (2018), Meeresspiegelastieg und Überschwemmungen an der Nordküste Zentraljavas- Physische Ursachen und soziale Anpassungsmaßnahmen, Geographische Rundschau, 70(4), 4-8.

*It will be presented to the public during the **public lectures of Geography Society of Cologne on 21st June** in Cologne by Lisa-Michéle Bott, PhD student in the TRANSOCAP project.*

Future Events related to sea-level research:

8th GEWEX Science Conference on Extremes and Water on the Edge, 6-11 May 2018, Canmore, Canada
ESA Cryosphere Remote Sensing Training Course, Svalbard, Norway
SCAR & IASC POLAR2018 Conference: Where the Poles come together, Davos, Switzerland
CLIVAR-FIO Joint Summer School on "Past, Present and Future Sea Level Changes", 25-30 June 2018, Qingdao, China
Sea Level Futures Conference, 2-4 July 2018, Liverpool, UK
INQUA-PAGES Early Career Researchers Workshop: "Impacts on sea-level rise from past to future", 26-29 August 2018, Utrecht, The Netherlands
Symposium on "Translating Sea-Level Change in Urban Life: Policies, Practices,and their Intersections in Island Southeast Asia", 5-6 September, Jakarta, Indonesia
IV International Conference on El Niño Southern Oscillation: ENSO in a warmer Climate, 16-18 October, Guayaquil, Ecuador

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