

# WCRP REPORT

World Climate Research Programme



ICSU

International Council for Science



## Project report

Report of the 2<sup>nd</sup> WCRP GC Sea Level Science Steering Team Meeting

**8 – 9 February, 2016 New York, USA**

February 2016

WCRP Informal/Series Report No. 16/2016  
*ICPO Informal Report 211/2016*

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# 1. Welcome and charge to the meeting

The local organizer from the New York University, USA, David Holland and Denise Holland welcomed all participants to the meeting and made introductory remarks about the local logistic.

There were 19 participants at the meeting. Catia Domingues from University of Tasmania, Australia, and Tony Payne from University of Bristol, UK, were unable to participate in person but attended some sessions via Gotomeeting. One steering team member, Ayako Abe-Ouchi from University of Tokyo, Japan asked to resign from the team due to personal reasons and was absent in the meeting.

Detlef Stammer, thanked the New York University host and local organizers, Mr and Mrs Holland. Before starting the agenda, Detlef asked Kathleen McInnes from CSIRO, Australia to introduce the recent problem on climate research scientists in CSIRO.

According to Kathleen, funding to the CSIRO was cut in the 2014 federal government budget leading to CSIRO losing about 20% of its workforce. As well as that, funding for climate science in CSIRO had also reduced dramatically since 2014 as several other government-funded climate science programs coming to an end. Following a review of external revenue prospects across all CSIRO divisions, CSIRO's CEO, Larry Marshall, recommended cuts in a number of areas including the climate science research programs. The justification given by Marshall was that climate change is now settled science, and basic research is no longer needed, "the new question is what do we do about it, and how can we find solutions for the climate we will be living with". The participants questioned the behavior of the new CEO, and suggested writing to high level to explain the problem in Australia. Detlef said the Director of WCRP, David Carlson was working on it. He suggested watching out and seeing evolvement of this problem. Almost at the same time as the SL meeting (8<sup>th</sup> Feb), WCRP put out a strongly worded statement against these cuts, which can be accessed via the link:

<http://www.wcrp-climate.org/images/documents/news/CSIRO-Climate.pdf>.

Detlef went through the agenda, gave a brief introduction of the WCRP "Grand Challenge" (GC): the "Regional Sea Level Change and Coastal Impacts" (SL), whose overarching goal is to establish a quantitative understanding of the natural and anthropogenic mechanisms of regional to local sea level variability; to promote advances in observing systems required for an integrated SL monitoring; and to foster the development of SL predictions and projections that are of increasing benefit for coastal zone management. He also reiterated on the structure of the SL team, with five Working Packages (WP) working within their own scope and interacting with other WPs:

- WP 1) An integrated approach to historic sea level estimates (paleo time scale)
- WP 2) Quantifying the contribution of land ice to near-future sea level rise
- WP 3) Contemporary regional sea level variability and change
- WP 4) Predictability of regional sea level
- WP 5) Sea level science for coastal zone management

Participants of the meeting were reminded that besides many new science results, the expected outcomes of the GC will include:

- Coastal Community Requirements Report

- Document outlining a multidisciplinary long-term program of SL research in support of coastal community.
- Bi-annual Assessment Report: Update on state-of-understanding (SREX style) and future SL estimates.
- Database of climate quality observational data set including uncertainties (paleo to present) and Data requirement document
- A model requirement document.
- Model intercomparison analyses on sea level variability and change and participation in CMIP6 design.
- Recommended metrics for CMIP outputs
- Observing System requirements for monitoring, model development, model evaluation/validation, initialization – both satellite and in-situ.

The goals of the 2 day meeting was then introduced as:

- Discuss progress of individual WPs
- Reports on CMIP6 and FAFMIP
- Plan workshops and new activities
- Review and revise WP teams
- Finalize Science and Implementation Plan
- Planning for the Sealevel Conference 2017
- White paper and any other writing assignments
- National programs and proposal opportunities
- Summer Schools
- Any other activity

## 2. Action items from the 1<sup>st</sup> SL meeting

Action items from the 1<sup>st</sup> SL meeting and other important issues were discussed first.

### 1) WCRP letter of appointment:

At the last meeting Kathleen asked for a letter to the host institution that states the involvement of the each member in this WCRP GC team. Detlef then wrote to David Carlson, Director WCRP, who supported the idea and was willing to produce such letters to all the members. Lei has collected the necessary personal information to appear on those letters. But the text of the letter is still to be drafted.

*Action: Draft the text of the WCRP letter of appointment and send to WCRP to produce them for each GC member.*

### 2) SL Summer school:

A goal of the GC Sea level continues to be the organization of bi-annual summer schools. Roderik suggested the topics of such a first summer school should come from WP1-WP4, and the scale being 50 students for around 10 days. David Holland pointed out that a summer school would be quite demanding for both organizer and lecturers. Detlef reiterated the importance of summer school is not only to learn, but to network people. Kate White mentioned there was a funding opportunity for such activities from NATO.

*Action: Look into the details of requesting fund of NATO program. (Kate White)*

### **3) New member to replace Ayako:**

One of the SL members, Ayako Abe-Ouchi requested to resign due to family reasons. The new member to replace Ayako was discussed. David Holland suggested proposing names associated with PAGES. Detlef agreed it would be good to have someone from PAGES to join the WP2.

*New Action: Propose names of new membership of WP2. (Tony Payne, David Holland, Roderik van de Wal). After the meeting Pascal Braconnot was suggested by PAGES members at the JSC annual meeting in Geneva.*

## **3. Review of the WP's progresses and plans**

Members from all the five WPs presented their progresses on polishing the science plan and discussed the interactions with other WPs.

**WP 1: An integrated approach to paleo time scale sea level estimates** (Lead: Natalya Gomez, Roderik van de Wal, and Mark Tamisiea)

Natalya Gomez presented the status of WP 1 “An integrated approach to paleo time scale sea level estimates”. She reviewed the elements of the science plan of WP1, which includes:

- How past sea-level changes and GIA influence our understanding of present day observed changes;
- How GIA effects influence every observation we make of sea-level changes, including relative sea level (tide gauges, ocean bottom pressure recorders), altimetry, gravity measurements (GRACE), crustal motion (GPS);
- How GIA corrections vary spatially and temporally leading to scientific challenges to be addressed by the model development:
- Generating a consistent sea level budget for different time periods, such as the Last Glacial Maximum, the last interglacial and other warm periods in the past, and the recent 20<sup>th</sup> century and recent budgets considered in WP 3;
- Understanding ice and sea level histories over the Holocene.

She then explained the part of the science plan to be developed, which includes:

- Implications of global versus regional Earth and sea level models,
- Assessing the effects of lateral variations in Earth structure and non-Maxwell rheologies,
- Understanding the impacts of model resolution on predictions and how they compare with observations,
- Assessing the optimal time scales for coupling models given the modelling assumptions, e.g. mantle rheology and conditions at the ice-bed interface.

New science highlights that emerged after the last GC meeting in March, 2015, were also briefly introduced, such as:

- Public availability of the new Global GIA models ICE-6G\_C (VM5a) (Peltier et al., 2015);
- Coupled ice sheet–sea level modeling and its application to a study of future Antarctic retreat;

- Large-ensemble simulations for different RCP scenarios with varying hydro-fracturing and cliff parameters;
- Lakes as loading terms and the effect on ice-sheet evolution;
- 3D thermodynamical ice sheet–ice shelf model “IMAU-ICE” and its simulation of the Greenland ice sheet from 238 kyr BP to present day;

The plans for 2016 and beyond of WP1 include:

- To attend the meetings in 2016, such as PAGES’s PlioVAR Modeling Workshop on 29th February, SCAR’s Annual Meeting in August, PALSEA2 2016 meeting in September which conflicts with CLIVAR OSC ([www.clivar2016.org](http://www.clivar2016.org));
- To submit an AGU 2016 session on “sea level, ice sheet, solid Earth interactions on a range of timescales and length scales”;
- To plan a meeting on Coupled Modeling in 2017 coincident with EGU’s topical meeting;
- To build connection with WP2 via the cross linkage in both ISMIP6 and MISOMIP.

Discussion afterwards focused on two main issues: how to increase the participation and ownership of the work package by the community and how to increase coordination with related efforts by other organizations. An important effort identified would be establishing a formal relationship with PALSEA2. This joined effort could be particularly focused on the modeling of ice sheet and sea level interactions. WP1 will begin contacting individuals and groups who may want to be involved in the effort, including those who WP1 members used to work with, to bring information from this other community in.

In terms of wider community engagement, it was suggested that WP1 develop an introductory email to distribute to the community to solicit participation, bringing attention to upcoming meetings.

Given the level of these other meetings occurring during 2016, it appeared that a separate session at the Fall AGU meeting would not be beneficial. Thus, the focus would be on highlighting overlap with other ongoing meetings and preparing community input and discussion for the larger meeting in New York.

*Action: Contact individuals and groups that may want to be involved in the group. (Mark, Gomez)*

*Action: Suggest to CMIP6 to couple ice to run online. AOI-GCM. (Detlef)*

**WP 2: *Quantifying the contribution of land ice to near-future sea level rise*** (Lead: Tony Payne, David Holland, Roderik van de Wal)

WP2 is focused on quantifying the contribution of land ice to near-future sea level rise. The uncertainty surrounding the possible large, future contributions arises in large part from the relatively underdeveloped state of glacier models as compared to other components of global climate models. In addition, the coupling of glacier models into global climate models requires an extensive re-engineering of the global model, to allow the ice sheets and ocean to exchange volume and space. A number of international activities, mostly modeling but also some observational, have sprung up over the last year or so, and are now well underway aimed at addressing the current shortcomings of land ice models. WP2 is working to support these activities by informally reviewing the science activities, and at the same time making the various projects aware of one another so as to optimize international coordination and collaboration.

Detailed reports were received on land ice activities and are summarized here. David Holland reported on the Marine Ice Sheet and Ocean Modeling Intercomparison (MISOMIP) project. The goal of MISOMIP is to have a number of international groups compare simulations of coupled land-ice and ocean models. That activity also brings together groups who are intercomparing just land ice and ice shelf models (i.e. Marine Ice Sheet Intercomparison Project, MISOMIP+) and just ocean models beneath ice shelves (i.e. Ice Shelf and Ocean Model Intercomparison Project, ISOMIP+). A second MISOMIP workshop is being organized at New York University in Abu Dhabi during May 16-18, 2016.

In addition to the coupling of land ice with ocean, some discussion was given to the idea of also coupling in the bedrock, and its viscous and elastic responses to ice sheet and ocean load changes. Such an activity could provide a strong linkage between WP1 and WP2. It was decided, however, that while a potentially fruitful avenue, it is premature at this juncture while MISOMIP+ is still in its early stages of operation.

Sophie Nowicki provided an update in the ISMIP6 (Ice Sheet Model Intercomparison Project for CMIP6). The project brings together for the first time a consortium of international ice sheet models and coupled ice sheet-climate models to more fully explore the sea level rise contribution from the Greenland and Antarctic ice sheets. ISMIP6 is a collaboration between ice sheet and climate modelers, along with observationalists and remote sensing experts over the polar regions. The primary goal of ISMIP6 is to estimate past and future sea-level contributions from the Greenland and Antarctic ice sheets, along with associated uncertainty. The MISOMIP activity, focused on regional outlet glaciers, may eventually feed input to the ISMIP6 activity. It was noted the Helene Seroussi serves in on the steering committee for both MISOMIP and ISMIP6 and will be able to assist in keeping these two projects coordinated. ISMIP6 is currently planning coupled climate ice sheet CMIP experiments for Greenland. This is planned to commence in summer 2016 after initMIP (see below) is completed. It will be based on CMIP5 results and provide a dry run for the later CMIP6 exercise. Furthermore, the design of standalone Greenland and Antarctic ice sheet inter-comparisons with emphasis on initial states (initMIP) is underway and initial results were discussed at the AGU workshop (December 2015). Final results are due to be discussed at the EGU 2016 with the intention of submitting papers on model description and results in 2016. It is considered to be tempting to include the Sea Level change prediction in CMIP6, which is missing in CMIP5.

The discussion then moved to glaciers. Tony Payne, joining the meeting over video link, brought GlacierMIP into the conversation and mentioned that initial work has been done on the design of CMIP experiments for the global glacier inventory. GlacierMIP is planning on submitting a paper on experiment design and results.

On the observational side, the state of GrIOOS (Greenland Ice Sheet and Ocean Observing System) was discussed. This project, among other objectives, seeks to improve the development of iceberg calving models through observations that can feed into the MISOMIP and ISMIP6 activities. David Holland, Sophie Nowicki, and Tony Payne attended the pre-AGU Fall 2015 GrIOOS workshop and have established a liaison between these observational and modeling activities going forward with GrIOOS organizers, Fiamma Straneo and Patrick Heimbach.

Turning to observations around Antarctica, Tony Payne discussed the need for WP2 to liaise with CliC on creation of activity aimed at process understanding of continental shelf ocean (including ice shelf cavities)

dynamics (e.g., SOOS). It was mentioned that a discussion of this was held at the CliC Scientific Steering Group in Copenhagen during early February 2016. Potential links could be made to CLIVAR/CliC/SCAR Southern Ocean Region Panel (SORP) who are planning Southern Ocean MIPs (outside of CMIP). A follow-up action here could be to contact Kenny Matsuoka for the SORP and also Lynne Talley for the Southern Ocean Model Intercomparison Project (SOMIP). Current plans for these projects seem unlikely to include ice shelf cavities and so a discussion is needed here to clarify any potential for collaboration.

On the atmospheric side of things, Tony Payne suggested WP2 should liaise with CORDEX and CLIVAR on regional simulations of atmospheric and oceanic climate above and around the ice sheets of Greenland and Antarctica. Discussions of this nature were held at the CliC Scientific Steering meeting with Polar CORDEX coordinator Annette Rinke. Arctic CORDEX plans are well advanced but may use too coarse a resolution (50 km) to be useful for Greenland. Some of these models are coupled ocean-atmosphere while most are just atmosphere. Discussions about a more focused CORDEX activity on Greenland only were inconclusive. Modest progress to date on Antarctic CORDEX although CliC have an action to encourage activity in this area.

WP2 is interested in encouraging the creation of suitable international funding opportunities to help support the grass roots observational and modeling activities surrounding land ice contribution to sea level. It was reported that inconclusive discussions were held at the CliC Scientific Steering meeting. The possibility of a proposal to the Belmont group to cover support for CMIP6 organization was raised.

Regarding the funding issue, David Holland showed the annual investment of the NSF in its Antarctic and Southern Ocean Research report reached \$300K, with projects being mission targeted and curiosity driven. It is worth thinking a way to influence the NSF funding.

Mission of WP2 is very relevant to CliC, to avoid competition, co-design with CliC and CliC's contributions to this GC were intended.

*Action: Setup a cross link on SL page with CliC MISOMIP and other links. (Lei Han)*

**WP 3: Contemporary regional sea level variability, change and extremes** (Lead: Catia Domingues, Kevin Horsburgh, Benoit Meyssignac, Rui Ponte, and Detlef Stammer)

Rui Ponte made a presentation introducing the efforts made for WP3's goals in the past one year. The challenges to be addressed in the terms of reference of WP3 include:

- Understanding and reducing the uncertainties in mass and steric contributions to contemporary SL budget at global, regional and local spatial scales,
- Determining the role of climate modes (e.g., ENSO, IOD, PDO, SAM, NAO, AMO) and internal variability in general on sea level,
- Understanding the role of coastal and ocean interior processes (e.g., shelf sea dynamics, ocean mixing, freshwater input, etc.) on local sea level,
- Attribution of regional sea level change to natural (e.g., solar, volcanic) and anthropogenic (e.g., tropospheric aerosols, greenhouse gases) radiative forcing agents,
- Requirements for an optimal and integrated (satellite and ground-based) sea level observing system,

- Understanding contemporary subsidence and extremes.

Some recent results on sea level budgets, sea level variability, and coastal sea level were briefly introduced such as

- New model and data updated the slope of the global mean sea level from 3.2mm/year to 2.6mm/year. (Watson et al, Nature CC, 2015)
  - Sea level budget: Residual from data errors and missing contributions (Dieng et al. 2015a, b)
- Importance of the budget closure to estimate and monitor; Earth energy imbalance (von Shuckmann et al. 2016)
- Sea level variability: Exploring model-data synthesis and state estimates (Forget and Ponte 2015)
- Assessing 20th century sea level rise from climate models at global and regional scale (Melet and Meyssignac 2015, Meyssignac et al. in prep., Slangen et al. in prep)
- Missing physics of geothermal flux (Piecuch et al. 2015)
- Understanding contributions of barotropic and baroclinic processes to bottom pressure (Piecuch et al. 2015)
- ‘Coastal sea level:
- Cautionary tales on the role of the inverted barometer (Piecuch and Ponte 2015)
- How good are current models in simulating coastal sea level? (Piecuch et al. in prep)
- Reanalysis data is not good enough to resolve the coastal SL variation

Role of waves (set up and run up) on the interannual to decadal variability of coastal sea level (Melet et al. in revision)

- D&A studies:

Evidence of anthropogenic origin in global thermosteric and total sea level (Slangen et al. 2015, in revision)

Cautionary note on regional D&A

Evidence of underestimation of the internal variability in dynamic sea level in climate models (Serazin et al. 2015, Serazin et al. in prep.)

Uncertainty in regional sea level observations higher than expected (Palanisamy et al. 2015, Prandi et al. in prep).

WP3 has been involved in some activities with other groups such as engaging the NASA Sea Level Change program (presentation on the SL GC efforts at last N-SLC team meeting) and the CCI sea level program (presentation of the SL GC effort at the last CCI sea level meeting). Future plans of WP3 are to finalize WP3 science plan in a couple of weeks, to define and contact possible WP3 additional members and establish wider team, to create a group under International Space Science Institute (ISSI) in Bern, Switzerland to deal with WP3 topics particularly having to do with satellite observations, and to pursue the intercomparison project on sea level altimetry.

A main point of following discussion was the need to refocus the WP3 science plan. In particular, the inclusion of a separate topic on “understanding contemporary subsidence and extremes” was revisited. The general consensus was that most relevant issues related to subsidence and extremes would be best treated under WP5, and this would help sharpen the focus of WP3. At the same time, it was recognized that some aspects of extremes (.e.g., climatologies of extremes, effects of wave set up/run up to coastal

sea level on long time scales) are importantly linked to other topics in WP3. Such aspects can still be addressed under WP3 as needed, and composition of the wider WP3 team should take this into account. More generally, the need to finish up the WP3 science plan text, sharpening its focus and highlighting its “flagship” products, was also discussed.

*Action: Move the 6<sup>th</sup> challenge topic of WP3 on “understanding contemporary subsidence and extremes” to WP5.*

**WP 4: Predictability of regional sea level (Lead: Jonathan Gregory, Jianjun Yin, and Tony Payne)**

Jonathan Gregory reviewed the objectives, scientific challenges and next steps of WP4, starting with showing the IPCC AR5 projections of 21st-century GMSLR under four emission scenarios and the global distribution of SL change induced by ocean density and circulation, glacier mass loss, ice sheet mass loss, and glacial isostatic adjustment, respectively, under RCP 4.5.

The outcome of WP4 is the establishment of peer-reviewed methods for the global and regional sea level projections, for particular emissions scenarios, including all contribution and uncertainties. These scientific results should be achieved in time to provide a basis for future IPCC assessments, so that the lead authors can rely more directly on the literature and have less need to devise their own methods.

The scientific challenges to be addressed by WP4 include:

- Determine limits of predictability of sea level as function of space and time scale and the role of changing climate modes for sea level predictions.
- Understand and reduce regional inter-model spread in predicted sea level change due to change in ocean properties (temperature, salinity, circulation).
- Incorporate ice-sheets in ESMs used for projections, because of their interaction with atmosphere and ocean climate change and the solid Earth.
- Increase the confidence in estimates of the sea level contribution from anthropogenic intervention in terrestrial hydrology.
- Provide reliable uncertainties for sea level predictions and projections, including those for the contributions from ice sheets and glaciers, with particular attention to the upper ends of the distribution of predictions.
- Reduce the uncertainty in the thresholds of climate change beyond which the Greenland and Antarctic ice-sheets would be partially or largely eliminated, and on whether the ice-sheet mass loss would be irreversible on the long term.

The ways to tackle the above challenges for WP4 were identified as,

- Promote research on the decadal predictability of regional sea level change.
- FAFMIP (Flux-Anomaly-Forced Model Intercomparison) to address the uncertainties in the ocean contribution to sea level change (ocean heat uptake efficiency, ocean dynamic topography change).
- ISMIP6 to address the uncertainties in the ice-sheet contribution to sea level change (surface mass balance with evolving topography, ice dynamic response to ice-shelf basal and surface mass balance with evolving ice-shelf thickness, grounding line and bathymetry).
- Begin a discussion on working towards sea-level projections for IPCC AR6. How would we revise

the methods given today's state of knowledge? What is the role of expert elicitation and semi-empirical approaches?

- Initiate discussions with WP5 and the wider community on the limitations and uncertainties of sea level projections, and how to interpret these in a policy-relevant way.

The FAFMIP was proposed with the goal to account for the spread in simulated ocean response to changes in surface fluxes resulting from CO<sub>2</sub> forcing. This is an aspect of the CMIP6 science question on the Earth system response to forcing. In all FAFMIP experiments, the parallel portion of piControl, and abrupt4xCO2 and 1pctCO2, the process-based diagnostics of ocean temperature and salinity change proposed by the CLIVAR OMDP was particularly requested. Regarding the participants, ten modelling groups have said they will participate, and five have carried out experiments with existing models (not CMIP6) and some results from these will be included in the GMD paper on FAFMIP. The FAFMIP steering committee would like to hold a workshop in around 2018.

A thorough discussion followed about how to best interpret SL projections in a policy-relevant way and what kind of SL projection is most useful to the coastal planners under the state of the art. In some circumstances, planners are interested only in possibility, not probability, because they aren't going to do a cost-benefit calculation, and accept they will protect at all costs. Adding a safety margin to projections when making planning and policy decisions is a rational and sensible thing to do. But the safety margin cannot come directly from IPCC WG1, since it involves arbitrary decisions that aren't precisely constrained by science. It is believed useful that WP4 could join WP5 to produce a joint statement of common understanding about the SL projection for the policy makers.

**WP 5: *Sea level science for coastal zone management*** (Lead: Robert J. Nicholls, Goneri Le Cozannet, and Kathy McInnes)

Several presentations were made from WP5 by Robert J. Nicholls, Jochen Hinkel, Pietro Teatini, Kathy McInnes and Kate White. Robert reviewed the current status of WP5. The scope of WP5 is intentionally limited to the development of advanced sea-level information for coastal users.

There are five deliverables which are:

- Requirements Report (Workshops, literature and users surveys)
- Scientific information needed to facilitate the development of future coastal climate services, covering regional to local scales and watershed to the coast
- Roadmap to enhance synergies with coastal community (after first delivery of validated sea-level rise scenarios)
- Impact of future subsidence and extremes.
- Uncertainty estimates and communication of coastal sea level change

Robert recognized that the aspects of WP5 involve a very diverse and dispersed community, including the coastal impact specialists, adaptation specialists, coastal managers, coastal engineers, coastal environmentalists, coastal city planners, and so on. Thus one great outcome of both WP5 and the GC would be to create a more joined up perspective. WP5 is now involved in RISES-AM (<http://www.risesam.eu/>) (EU FP7 Project: 2013 to 2016). The relevant outputs from WP5 were

suggested such as the SLR value in future centuries with a certain probability range, and the coastal adaptation to the SLR. Several journal review articles as contributions to the community were being planned within 2016-2017, including a review of information needs for sea-level science to support coastal management (Goneri leads), a review of coastal subsidence to inform coastal management (Pietro leads), a review of extremes and coastal science to inform coastal management (Kathy leads), and so on. Relevant funding opportunities were also addressed, such as the JPI Climate Call on Climate Services (<http://www.jpi-climate.eu/news-events/news/10867203/Pre-announcement-for-ERA4CS-Joint-Call>) and H2020 call on climate services (SC5-01-2016-2017 and SC5-08-2017).

Pietro Teatini reported on the impact of land subsidence on the Relative SLR (RSLR). RSLR takes into account the vertical elevation of the land with respect to the sea mainly due to over-pumping of the underground water, thus has more crucial significance to the coastal cities than SLR only. Actually, the contribution of land subsidence to the RSLR is much more than SLR itself. The importance of RSLR has to be recognized and included in the guidance on coastal adaptation.

Kathleen McInnes presented the research on coastal extremes related with SLR. As stated in IPCC AR5, “It is very likely that there will be a significant increase in the occurrence of future sea level extremes by 2050 and 2100. This increase will primarily be the result of an increase in mean sea level (high confidence)”. Available datasets and projects useful to this research theme were cited: WCRP Expert Team on Climate Change Detection and Indices (ET-CCDI), Global Extreme Sea Level Analyses (GESLA) phase 1 and 2, DINAS-COAST, Atmospheric Circulation Reconstructions of Earth (ACRE), and so on. A number of tide gauge records back to early nineties are still to be digitized in Australia. Inspired by the Coordinated Ocean Wave Climate Project (COWCLiP), Kathleen proposed establishment of a Coordinated Ocean Storm Surge Climate Project (COSSCLiP), with the help of fine-resolution global storm surge models, to provide a consistent set of coastal data for extremes with COWCLiP.

#### ***Contributions from invited guests:***

Jochen Hinkel gave a talk on how to address the sea-level rise information for climate adaptation from a risk management perspective. Problems within IPCC AR5 methodology on SLR projections were pointed out. More approaches such as semi-empirical models, paleo record, and physical constraints should be combined with the process-based climate models for projecting SLR. He suggested that the deliverables of WP5 should include the scientific information needed for coastal climate services and communication of coastal SLR with plurality of expert studies instead of a single set of scenarios. The objective of WP5 or the GC can only be addressed as a co-operation between SL science and decision science.

Triggered by Hinkel’s presentation and the earlier Nature Climate Change commentary (Hinkel et al., 2015), the GC members had a constructive debate on how to improve the alignment of sea-level rise information to coastal risk management needs. It was identified that there are significant differences in language between sea-level and decision science with respect to the uncertainty language that is used. While the production of process-model based probabilities is interesting from a sea-level science perspective of trying to understand the geophysics of the earth system and the models built to capture this, decision science needs probabilities that are not conditional on a given emission scenario or a

particular set of earth system models. Furthermore, given that unconditional probabilities are difficult/impossible to obtain, sea-level rise science efforts also need to be directed at exploring the geophysical conditions that could lead to high-end and upper-bound sea-level rise information. Coastal decision makers' focus strongly on this type of estimate to bound their decision space, and it is important that sea-level scientists understand this. From the side of decision sciences, effort is needed to introduce decision making frameworks to sea-level scientists that deal with situations for which it is difficult to establish probabilities and possibilities (e.g. robust decision making, dissensus methods, etc.). It is important that this dialogue continues within the Grand Challenge.

Kate White gave a talk on Applying Global Sea Level Rise Scenarios to Adaptation Engineering, introducing the concept of USACE on water infrastructure planning. It is important to consider a full range of potential future conditions, especially extremes, instead of relying heavily on model results in the planning process. She also demonstrated with an example of anomalous high SL along the eastern US in 2009 that it is not always the extreme event that can cause flooding, in some circumstances, the combination of a variety of environmental factors may also produce significant anomalies.

Felix Landerer introduced the NASA SL team (N-SLCT) and their recent research activities on closing global SL budget, Alaska glaciers mass balance, IS mass balance and bed topography database, SLR slowdown in the decade, predicted nuisance flooding at Boston, and so on. A portal website would be coming online: [sealevel.nasa.gov](http://sealevel.nasa.gov). He also informed the successful launch of Jason-3 few weeks ago. During the discussion, the suggestions to bring N-SLCT or NOAA people into the GC was proposed by some members. USCLIVAR can be incorporated if interested. Though it is not desired, duplicated database among different research teams seems unavoidable.

A.S. Unnikrishnan reported the Indian Ocean Sea Level Science Workshop and GLOSS-GE meeting during 19-23 October 2015 and the SL research efforts in India.

## **4. Planning of the SL science conference in 2017**

Detlef introduced the planning progress of the SL conference in July, 2017 in NYU. A large community including coastal people will attend. The expected number of participants is 400. This conference is organized by the GC SL team to commemorate the ten years anniversary since the first WCRP sea level conference that took place in Paris in 2006, and to facilitate the preparation of IPCC AR 6. This conference will address:

- new insights into regional and coastal sea level changes
- predictions and projections of sea level changes, regionally and in coastal areas
- Remaining challenges in describing regional sea level changes and in quantifying intrinsic uncertainties.

The objectives of the conference are:

- Establish a consensus on the state of our quantitative understanding of the natural and anthropogenic mechanisms of regional to coastal sea level variability
- Quantify remaining uncertainties and foster the development of SL predictions and projections that are of increasing benefit for coastal zone management.

- The conference will promote advances in observing systems required for integrated SL monitoring and climate modeling to improve sea level projections and predictions.

The expected outcomes include:

- Assessment of the current state of the sea level science.
- Outline of future research requirements for improving our understanding of sea-level rise and variability.
- Description of the observational requirements (both experimental and sustained systematic observations).
- Report specifying the information on coastal sea level change required by coastal communities for adaptation and decision making purposes.

The main components of the conference include mainly plenary session, one poster session every day, possibility for 1 splinter meeting at a time  $\pm 20$  p, public event Wednesday night, group dinner Thursday.

The draft conference program contains five days, whose daily themes are:

- Day 1: Contemporary regional sea level variability and change
- Day 2: Quantifying the contribution of land ice to future sea level rise
- Day 3: Sea level science for coastal zone management
- Day 4: An integrated approach to paleo time scale sea level research
- Day 5: Predictability of regional sea level

The daily themes of the conference program were devised as per the five WPs of the GC. But during the open discussion on the program, David suggested shortening the names of daily themes. Jochen suggested rearranging sequences of the themes to: projection, coastal, contemporary, paleo. In order to draw more attention within USA, Robert thought it may be a good idea to include such sentences in the flyer as: coastal flooding is made worse by SLR. The largest rises due to glacier melting occur in this region (North America).

Lei will be in charge of the website. ESA is going to support the meeting system. The necessity to add NOAA and USCLIVAR persons into the steering committee was mentioned. A maximum of 10 people will make up the Exec-SOC committee. The members of the local organizing committee (LOC) was discussed. Mike Patterson, ESA representative, Denise Holland, NYU representative should be in the LOC. David mentioned some names to involve into the conference like Judith Robin of Rockefeller foundation, CM2 company, Ruffolo of Blomberg, and Schmidt foundation.

Timeline of key dates was determined as:

- 1) Science committee: February
- 2) Flyer: 1<sup>st</sup> Apr
- 3) Program Draft: 1<sup>st</sup> May
- 4) 2nd announcement: Sep

*Action: Send a flyer of the SL conference to announce people to block the dates. (?)*

*Action: Have a face-to-face meeting for the Exec-SOC in April to nail down the program. (Detlef)*

*Action: Revise conference program: change days to topics, and move coastal to Day 4. (?)*

## 5. Other business

### **SL Terminology:**

The GC team reviewed the SL terms Jonathan drafted. As Detlef pointed out, a same term may have different concept to modeller and observation community, therefore it is necessary to unify the terms in SLR research. Some recommendations were given during the discussion: “Mean sea level” needs definition; Reconciling the local separation of the SL effects of density and mass change (or bottom pressure) advocated by Rui with the ocean-dynamic separation of GMSLR from ocean dynamic topography change outlined by me (consistent with most literature about SL projections in AOGCMs); Rename GDR because of the confusion with geophysical data record. Participants agree that it would be better to publish some form of it. For example, put onto the webpage of GC SL and ask people to cite and use, or publish in Wikipedia for more widely spread and influence.

*Action: Revise the SL terminology and circulate it among GC team and a few more people. (Jonathan Gregory)*

### **White paper:**

Jochen thought an attainable way was to publish three scientific papers on SL, decision science, and coastal management, respectively. Detlef and Robert supported the idea that it should be dialogue instead of one way with sociologists and coastal engineers. In the message to communicate will include what parameter/quantity they want from us, and the observational instruments need to be installed, and so on.

Regarding the GC paper in Earth’s Future, the consensus is that the white paper could work as that GC paper, but it is not possible to finish by the deadline of end March. So there is no way to finish that paper.

### **Summary of action Items:**

**Here we should list again all action items from above and merge them with the planned activities from within WPs.**

### **Summary of what need to do for WPs:**

WP1:

WP2:

Tony and Sophie work on ISOMIP6, Denise and David work on MISOMIP;

Find a new team member for WP2 to replace Ayako Abe-Ouchi;

Help with planning for the 2017 SL conference;

Liaise WP5 on DEM.

WP3:

Finalize science plan, form a group for updating and improving the science plan;  
Convene a WP3 topic session in AGU Fall meeting;

WP4:

Work on ISMIP6;  
Coastal projection;  
Investigate how projection can be presented in future;  
SL terminology;

WP5:

Four activities.

Decisioncentric work, subsidence in the future, both aspects fit in the idea of the white paper.  
The dialogue triggered by Jochen's talk is important and opened up the group.  
Be more comprehensive about the whitepaper by embracing SL science, extremes and so on.

# Appendix A: Agenda

New York University, February 8./9. 2016

## Febr. 8:

8:30am Opening:

Logistics, Status, Goal of Meeting

Action Items from last meeting

9:00am WP 1 Leads: Status WP 1:

Update on Science Plan

Work performed in 2015

New Science Highlights

Plans for 2016

Planed workshops

10:30am WP 2 Leads: Status WP 2:

Update on Science Plan

Work performed in 2015

New Science Highlights

Plans for 2016

Planed workshops

Sophi Nomicki (20 min.): Ice Sheet Model Intercomparison Project for CMIP6

11:00pm WP 3 Leads: Status WP 3:

Update on Science Plan

Work performed in 2015

New Science Highlights

Plans for 2016

Planed workshops

Felix Landerer (20 min): An Overview of the Activities of the NASA Sea Level Change Team (N-SLCT)

1 – 2pm lunch

2pm WP 4 Leads: Status WP 4

Update on Science Plan

Work performed in 2015

Plans for 2016

Planed workshops

Jonathan Gregory: Status FAFMIP

3:30 – 4pm coffee

4pm WP 5 Leads: Status of WP 5

Update on Science Plan

Work performed in 2015

Plans for 2016

Planned workshops

Pietro Teatini: Including subsidence in the Grand Challenge

Kate White: USACE SLR scenarios and related work and plans.

Kate White: Sandy and help us think about a field visit during the 2017 conference.

Jochen Hinkel: Sea-level rise information for climate adaptation

Meeting Dinner (no host)

**Febr. 9:**

8:30am Summary of first day

Summary Planned Meetings

Summary Resources

9am US CLIVAR and NASA activities reg. sea level

9:30 Model Improvements wrst to sea level

10am 2017 Sea Level Conference

2pm White Paper

3:30 pm Other planned activities and meeting summary

4pm End of meeting

## Appendix B: List of participants:

Name	Affiliation, Country	
Detlef Stammer	CEN, Germany	GC Lead, Co-chair
Roderik van de Wal	U. Utrecht, The Netherlands	Co-chair
Robert Nicholls	U. Southampton, UK	Co-chair
Kevin Horsburgh	NOC, UK	member
Natalya Gomez	Harvard, USA	member
Mark Tamisiea	NOC, UK	member
David Holland	Courant, USA	member
Rui Ponte	AER, USA	member
Benoit Meyssignac	LEGOS, France	member
Jonathan Gregory	U. Reading, UK	member
A.S. Unnikrishnan	NIO, India	member
Kathy McInnes	CSIRO, AU	member
Pietro Teatini	U. Padova, Italy	member
Lei Han	FIO, China	ICPO
Jochen Hinkel	Global Climate Forum, Germany	Invited
Kathleen White	US Army Corps of Engineers, USA	Invited
Sophie Nowicki	NASA, USA	Invited
Felix Landerer	JPL, NASA, USA	Invited