Sea Level 2017 CONFERENCE STATEMENT

More than 350 Participants from 42 nations attending the five-day WCRP/IOC Sea Level 2017 Conference at Columbia University in New York recognize that sea-level rise has accelerated over the past 100 years due to global warming. Conference participants, representing natural scientists, social scientists, coastal engineers, managers and planners, discussed evidence indicating that sea-level rise represents a major challenge for coastal societies. Scientists need to work more closely with a broad stakeholder community to enhance understanding of sea-level change, and to project its regional mean and extreme states. This is essential for assessing sea-level rise impacts, as well as for enhancing climate mitigation and adaptation measures over the short-, medium- and long-term.

Coasts are vulnerable places due to the combination of extreme events such as storm surges and waves. Many coasts have dense and growing populations and economies, and important ecosystems. Major human and economic losses have occurred due to storm surges: e.g., nearly 2,000 deaths and over $100 billion losses during Hurricane Katrina (US, 2005) and over 100,000 deaths during Cyclone Nargis (Myanmar, 2008).

While global sea levels have varied by over 100 m over geological scales, sea level has been relatively stable through recorded history. Global sea levels started to rise in the mid 19th century and increased by about 14 to 17 cm during the 20th century. The two largest contributions to this rise are the expansion of the oceans as they warm and the addition of mass from melting glaciers. Due to ongoing climate change, sea-level rise is accelerating and currently occurs at a rate of about 30 cm per century.

If greenhouse gas emissions continue without mitigation, global sea levels could rise one meter or more throughout the 21st century, several meters by 2300, and many meters over longer timescales. With substantial and sustained reductions in greenhouse gas emissions, these changes could be greatly reduced, but even then sea level would continue to rise for many centuries. The largest uncertainty and concern in this respect is the stability of the ice sheets in Greenland and Antarctica. Substantial mass loss from these ice sheets, would have significant consequences for global sea level rise.

Highlights of the conference

Paleo sea-level change analyses provide important data and show that (1) the paleo sea-level budgets need further analysis and refinement, (2) dynamic mantle topography is more important than previously thought over timescales of thousands of years or more, requiring further investigation, particularly around past sea level high stands.

Physical understanding of the ice sheets has improved, but ice-ocean interaction remains poorly constrained. While understanding of the role of grounding lines has improved substantially, questions related to buttressing and the processes that control it have moved to the forefront.

There is improved closure of the 20th Century sea-level budget indicating a better understanding of its different components. Despite this progress, we still lack information on sea-level change at regional scales and in coastal zones. In addition, the contributions from the deep ocean and regions covered by sea ice remain open.

Our understanding of extreme sea levels is improving. Trends in extremes largely follow mean sea-level changes. Elevated local sea level can often be related to climate modes (e.g., North Atlantic Oscillation, El Nino). Encouraging pilot forecasts of monthly sea levels across the Pacific can predict extremes linked to coastal flooding. Global scale modelling of storm surges has progressed greatly, although representing the effects of tropical storms remain challenging. Progress is more limited for waves: first ensembles of wave projections exist, but uncertainties remain large and require further development.

The availability of high-resolution regional sea-level projections is important for science and decision makers alike. Probabilistic descriptions of sea-level rise incorporating regional details combined with information about flood recurrence frequencies are useful tools to communicate projected changes to stakeholders. Nonetheless, the future behaviour of ice sheets remains an area of uncertainty, and there is considerable disagreement within the community on the shape of the tails of the sea-level rise probability distribution for the second half of this century and beyond.

Impact and adaptation assessments and planning require consideration of a range of different drivers - mean changes (including uplift/subsidence), extremes and waves. Evolving data and model systems have the potential to provide these if ongoing research efforts are sustained. There are encouraging signs that these can be provided. In particular, human-induced land subsidence is a major problem in some coastal areas, especially in coastal cities located in deltas. Historic changes in subsidence have in some local regions greatly exceeded climatically-driven mean sea-level rise, and this may continue through the 21st Century. Observations of human response to past subsidence provide a useful analogue for human response to climate-induced sea-level rise, which should be better exploited in the future. Impacts of sea-level rise will disproportionality impact the poor and vulnerable.

Consequences and Future Requirements

Major immediate climate-related impacts of sea-level rise occur due to the increased likelihood of extreme sea-level events arising from the combination of high tides, storm surges and waves on top of higher sea levels. This increased frequency of extreme sea-level events, and increased impact of storm surges and waves, is already being observed, including routine flooding on spring tides at some locations. Hence it is important to understand present and future occurrence of extreme conditions, in addition to mean sea-level rise.

Coastal impacts will not only depend on sea-level rise but will also be heavily influenced by the strong socio-economic trends in coastal areas (expanding populations, urbanization, etc.), which will almost certainly continue in the coming decades.

If the world does not respond to the challenges of sea-level rise, impacts are likely to be severe. Both climate mitigation to reduce emissions and adaptation to deal with rising sea levels that cannot be avoided will be needed. Adaptation offers many possible measures, which, when planned appropriately, are highly effective in managing coastal risks and impacts.

The conference recognizes the need for an enhanced and internationally coordinated new sea-level change program, including the provision of appropriate sea-level change climate services as part of a wider sea-level rise impact and adaptation effort. This program should be designed in consultation with users to serve the needs of local to national stakeholders, as well as the global community to cope with present and future sea-level change risks.

Hence, the conference calls for:

- A commitment to sustained and systematic global and regional sea-level observations, including the different components of sea-level change (cryosphere, ocean heat content and other relevant ocean parameters, land hydrology).
- The implementation of new observations where necessary, making use of both remotely-sensed and *in-situ* observations. Special emphasis should be given to the monitoring of coastal regions worldwide where a variety of climate- and non-climate-related processes interact. These observations can provide early warnings of sea-level rise acceleration.
- Additional paleo data, particularly local evidence in the polar regions, in conjunction with better earth, ice sheet and sea-level models, are needed both to characterize better the natural variability and non-anthropogenic contributors to ongoing sea-level rise, and to develop a better understanding of sea-level high stands, rates of change, and ice-sheet behavior in past states of the world warmer than at present.
- A broad-scale assessment of uplift/subsidence, especially human-induced subsidence, to guide analysis of regional sea-level change.
- The development of improved sea-level forecasts and projections for planning, early warning, adaptation and mitigation. The time frame should extend beyond 2100 to highlight the evolution of sea level and address the sea-level commitment.
- Improvements of our understanding of the physics of ice sheets for better projections of their contributions to future sea-level change.
- An open climate model development effort based on a range of models with advanced process parametrizations and enhanced calibration by observations to produce improved regional coastal sea level information including storm surges, waves, subsidence and land water storage at high resolution in support of the needs of coastal stakeholders.
- Development of a stakeholder forum that enables timely and effective exchange of vital information for mitigation of and adaptation to sea-level change including present states of and projected changes in mean and extreme sea levels, wave conditions, and potential impacts such as changes in coastal flooding events, coastal erosion, and saltwater intrusion.
- Development of policies and regulatory frameworks for impact and adaptation assessments for all vulnerable coastal areas, such as major cities, deltas and islands.

In summary, the present state of sea-level science provides unambiguous evidence that sea level is rising and that the increase will continue to accelerate with unmitigated emissions. This requires that scientists closely collaborate with the stakeholder community to develop plans for responding to sea-level change affecting their coasts and to implement adequate adaptation measures. Without urgent and significant mitigating action to combat climate change continued greenhouse gas emissions will almost certainly commit the world to several meters of sea-level rise in the next few centuries.

July 19, 2017,
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