

National Sea Level Programme (NEA-NSLP)

Grant call ID: NEANSLP02

Full proposal closing date: 4pm, 28 April 2020 (Singapore Standard time)

Summary

The Centre for Climate Research Singapore (CCRS) is inviting proposals under the National Sea Level Programme (NSLP). The NSLP aims to bring together the climate research community in Singapore and address key knowledge gaps in understanding and modelling of the physical mechanisms of sea level rise and variability, with specific focus on Singapore and South East Asia. The NSLP, managed by CCRS, will be jointly delivered by the Singapore universities and research institutes.

1. Background

Singapore is a low-lying island state and is particularly vulnerable to the impact of sea level rise in a warming climate. Singapore coastlines are densely populated by homes, business districts, and crucial national infrastructure. Developing successful strategies to cope with sea level changes largely depends on advancing our scientific understanding of processes driving sea level rise and variability, available scientific information on sea level changes at the coast and their uncertainties. To meet urgent societal and economic needs for useful information on future sea level changes in Singapore, the NSLP has been announced.

A number of sea level rise studies for Singapore were conducted previously, including the sea level rise assessments provided under the Second National Climate Change Study¹. The NSLP is intended to fill in the scientific gaps from past studies and to help bridge the science with decision-making in coastal adaptation planning. Outcomes of the NSLP will thus inform future sea level rise projections and coastal protection measures under the national framework² involving government agencies in the Inter-Ministerial Committee on Climate Change's Resilience Working Group (RWG).

2. Scope

The **main objective** of the NSLP is to develop scientific capability in sea level research in Singapore, providing advanced scientific evidence about the past and future sea level rise in Singapore in support for the development of the adaptation policies by government agencies.

To achieve the NSLP main objective requires an improved understanding of many aspects of regional sea level changes, ranging from processes influencing sea level on global and basin scale, to geophysical processes acting on regional to local scales.

¹ See full report (Chapters 8, 9 and 10): <http://ccrs.weather.gov.sg/Publications-Second-National-Climate-Change-Study-Science-Reports>

² <https://www.nccs.gov.sg/climate-change-and-singapore/adapting-to-climate-change/coastal-protection>

Specific objectives:

- i. **Quantify** at the coastlines the contributions to sea level rise from climate-related factors due to changing atmospheric forcing, changes in ocean circulation, and associated non-uniform thermo- and halo-steric expansion of sea water, in addition to mass redistribution;
- ii. **Enhance** current understanding of the contribution of changes of the large polar ice sheets (e.g. Greenland and Antarctica) to Singapore and wider regional sea level rise, especially estimates of contribution to extreme sea level projections;
- iii. **Improve** current understanding of the rate of vertical land movement in Singapore and South East Asia and to provide estimates of future changes in the rate of vertical land movement for future coastal sea level projections;
- iv. **Advance** scientific understanding on regional interactions between the open ocean dynamics and adjustment mechanisms in coastal areas;
- v. **Investigate** regional sea level change predictability for our coastal study areas;
- vi. **Derive** respective uncertainty information for future sea level projections and formulate probabilistic information from the uncertainty to assist decision-making for coastal adaptation planning;
- vii. **Merge** dynamical sea level information with responses expected from the solid earth and shoreline.

To address these objectives of NSLP, we invite proposals in four main research areas:

Item	Research area
A	Advanced understanding of past and present day sea level changes along coastal areas of Singapore and South East Asia, including changes to the cryosphere
B	Physical mechanisms of regional sea level variability, with focus on variability in seasonal- decadal timescale
C	Extreme events in a warming climate (e.g. high frequency variability, waves, storm surges, combined coastal and urban flooding)
D	Future sea level rise projections by 2100 and beyond, taking into consideration the uncertainty and probabilistic risk information

A. Advanced understanding of past and present day sea level changes along coastal areas of Singapore and South East Asia, including changes to the cryosphere

We expect proposals with the central objectives:

- i. Quantify the role of the main mechanisms for spatial/temporal characteristics of sea level rise in Singapore and on the coast of the South East Asia using available observations (e.g. tide gauge records, coastal altimetry, paleo indicators and other available sources of information) over the past 25, 100 years and longer time period (relevant to assessment of the future sea level changes). New methodology/approaches with innovative use of information from the satellite gravity and altimetry observations are highly encouraged.
- ii. Investigate Solid Earth deformation and gravity changes due to surface loading in tropical areas (including Singapore).
- iii. Study the impact of changes of ice mass loss in the polar regions, e.g. the Antarctica and Greenland, on sea level rise in Singapore and the Southeast Asian region.

B. Physical mechanisms of coastal sea level variability, with focus on variability on seasonal- decadal timescales

We invite proposals to address the gap in understanding of drivers of coastal sea level variability and its predictability over seasonal-to-decadal timescales. The primary focus on the **mechanisms of sea level variability** in Singapore and coastal areas of South East Asia, largely on the processes leading to spatially highly inhomogeneous patterns of coastal sea level change on seasonal – decadal time scales.

Current climate (AOGSMs) and Earth System models, used for sea level projections, lack both the horizontal and vertical resolution and the basic shelf sea dynamics process representations to adequately simulate these processes at the coast, leading to the large uncertainties in future sea level projections in the coastal areas.

We expect proposals to address:

- i. Comprehensive understanding of the key **physical mechanisms** driving regional sea level variability and its patterns in South East Asia, by integrating observations and model outputs in order to determine the origin of regional sea level changes from seasonal to decadal time scales;
- ii. The role and the relative contribution of different processes and drivers to the **variability** in coastal sea levels (observations and model outputs), including unresolved processes, sampling biases in measurements- to assess the magnitude of uncertainties. We encourage novel techniques and approaches (e.g. use of Machine Learning/Artificial intelligence) to improve simulations of coastal sea level variability;

- iii. It is well known that there is link between seasonal variability in coastal sea level observations (e.g. tide gauge records) and changes in heat content of the ocean, wind and air pressure, waves (wave setup and runup), land and sea ice melt which may be contributed by the changes of large polar ice sheets, circulation change, river runoff etc. In addition, ENSO and other climate modes modulate variability on longer timescales through distant ocean dynamics (e.g. ENSO signal propagation from the Pacific along the shelf slope). However, there is a lack of understanding in **attributing the coastal variability to specific physical mechanisms** and how these mechanisms might change in a warming climate.

C. Extreme events in a warming climate (e.g. high frequency variability, waves, storm surges, combined coastal and urban flooding)

Local sea level rise and extreme sea levels are the main concerns for coastal communities due to their damaging impacts on coastal infrastructure and population. However, there is a lack of understanding about the future changes in extreme sea levels and their link to climate change, given the potential contribution in the aspect of ice mass loss in the polar regions e.g. the Antarctica and Greenland. Future changes in extreme sea levels are poorly understood, as changing mean and extreme coastal water levels depend on a combination of near shore and offshore processes, related to climatic and anthropogenic factors, such as natural land movement arising from tectonics, volcanism or compaction and changes in coastal morphology resulting from sediment transport induced by natural and/or anthropogenic factors.

We invite proposals with a focus on identifying, characterising and predicting the variables that influence the occurrence, severity and duration of extreme sea levels in Singapore and in South East Asia.

The central objectives are:

- i. Identify the mechanisms for the extreme sea levels in South East Asia (including Singapore) and investigate the changes in extreme sea levels in a warming climate by 2100, including impact of changes of the large polar ice sheets to Singapore and regional sea level rise;
- ii. From model simulations determine probability density function for changes in wave climate, tide and storm surges for selected time slices (e.g., 2040, 2070 and 2100) for RCP8.5, RCP4.5 and warming of 1.5°C and 2 °C scenarios.

D. Future sea level rise projections by 2100 and beyond

For Singapore, in particular, future sea level rise is one of the most damaging aspects of climate change. Coastal areas in South East Asia are the most vulnerable coastlines in the world due to the impact of future sea level rise. Despite significant progress in the scientific understanding of the physical mechanisms contributing to sea level change, projections beyond 2050 remain highly uncertain, especially with the impact of changes in polar regions, e.g. the Antarctica and Greenland, on Singapore and the coastal regions still not sufficiently understood.

Proposals with novel approaches, e.g. Bayesian methods, Artificial Intelligence) to analyse the uncertainties and their propagation, are encouraged.

Objective:

- i. Develop the framework for probabilistic global, regional and local (e.g. Singapore) sea level projections with new available outputs from CMIP6 simulations, including the breakdown of the contribution from each source of uncertainty in the projections, covering the aspect of ice mass loss in the polar regions.

3. Application process and requirements

- 3.1 Project funding follows the Guidelines for the Management of Research Grants and NRF Terms and Conditions issued by the National Research Foundation (attached).
- 3.2 Applicants can propose projects covering one or more areas (A-D) above and address the stated objectives in part or in full.
- 3.3 Applicants can apply as a Principal Investigator (PI) for one proposal only (however, could be involved as Co-Investigator (Co-I) in several proposals).
- 3.4 Proposals are up to SGD 1.5 million; duration of the project is up to 48 months.
- 3.5 Involvement of PhD student(s), if any, should be highlighted in the proposal. Large proposals (above SGD 1 million) are required to include PhD students, capped at a maximum of 2 PhD students per proposal.
- 3.6 Applicants shall highlight partnerships with other local and/or international collaborators (if any) and articulate the value such partnerships will bring to the project. This includes connecting with other researchers while developing their proposal and indicating the likely synergies between their respective submissions.
- 3.7 Awarded projects may be expected to collaborate with researchers from the Centre for Climate Research Singapore.
- 3.8 The template for project application is attached. The contents of the Research proposal must not exceed 12 pages (excluding the Annexes), using Arial font, size 12 pt., with single-line spacing. All figures, charts and tables must be clearly labelled.
- 3.9 The individual CVs of all team members (Lead PI, Co-Is and Collaborators) must be attached and not exceed 2 pages each.

4. Key Performance Indicators/Deliverables for the NSLP proposals

KPIs/Deliverables	Target
Number of PhD students trained (KPI applicable for proposals above SGD1 million)	1
Number of publications (in top 10% journals in the respective fields)	Minimum 2
Dissemination of published results through participation in international conferences	Minimum 2