

National Sea Level Programme (NEA-NSLP) 2nd Grant Call

Grant call ID: N.A

Full proposal closing date: 4pm, 10 December 2020 (Singapore Standard time)

Summary

The Climate Science Research Programme Office (CSRPO), under the Centre for Climate Research Singapore (CCRS) is inviting proposals under the National Sea Level Programme (NSLP). The CCRS, through the CSRPO and NSLP, will coordinate and drive research in sea level rise science supporting key research areas identified as crucial for adaptation in Singapore. The NSLP aims to coordinate relevant climate research 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 CSRPO, will be jointly delivered by local research institutes and Institutes of Higher Learning.

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 have been conducted previously, including the sea level rise assessments provided under the Second National Climate Change Study (V2)¹. 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).

Following the conclusion of the first NSLP grant call (April 2020) and subsequent identification of important knowledge gaps, CSRPO aims to continue this mission-driven approach to ensure that all key research areas under NSLP are adequately covered. Potential research gaps identified include, but are not limited to:

- i. Monitoring of both vertical land movement (VLM), a highly localised phenomenon, as well as a more continuous observation of sea level height in Singapore and the region using new technologies such as Global Navigation

¹See 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>

Satellite Systems (GNSS) which is a direct measure of absolute sea level height at the coast as compared to relative sea level changes measured by tide gauges;

- ii. Analysis of low frequency variability and extremes of storm surges in the surrounding ocean near Singapore using high resolution ocean model data (based on Coupled Model Inter-comparison Project (CMIP6) models) to understand both historical and future changes of variability in the time scales from seasons to decades, hence providing more updated insights on the modelling uncertainties associated with sea level changes; and
- iii. Establish a probabilistic framework for understanding uncertainties of the various sea level components for use in Singapore sea level projections.

2. Scope

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

To achieve the 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. Specific objectives include:

- 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 of 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 NSLP objectives, we invite proposals in four main research areas:

Item	Research area
A	Advanced understanding of past and present-day sea-level changes, including monitoring of VLM to understand spatial characteristics of sea level changes along coastal areas of Singapore and South East Asia.
B	Analysis of physical mechanisms of regional sea level variability, using high resolution ocean modelling data, with a focus on low frequency variability on seasonal-decadal timescales.
C	Extreme events in a warming climate (e.g. high frequency variability, waves, storm surges, combined coastal and urban flooding), using high resolution ocean modelling data.
D	Future sea level rise projections to 2100 and beyond, taking into consideration uncertainty and probabilistic risk information through employment of statistical frameworks to understand the range of sea level projections, including high tail-end (extreme sea levels).

A. Advanced understanding of past and present-day sea-level changes, including monitoring of VLM to understand spatial characteristics of sea level rise along coastal areas of Singapore and South East Asia

We expect proposals with the following 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, including the monitoring of VLM 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 GNSS and altimetry observations are highly encouraged.
- ii. Investigate Solid Earth deformation and gravity changes due to surface loading in tropical areas (including Singapore).

B. Analysis of physical mechanisms of coastal sea level variability, using high resolution ocean modelling data, with a focus on low frequency variability on seasonal- decadal timescales

The proposals should 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 low-frequency 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 Atmosphere-Ocean General Circulation Models (AOGCMs) (AOGCMs) 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 the following:

- 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. New methodology/approaches with innovative use of information from high resolution ocean modelling data are highly encouraged.
- ii. 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, the El Nino-Southern Oscillation (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), using high resolution ocean modelling data

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. Previously, V2 findings indicated only small future changes to the storm surge and wave components based on ocean model data from CMIP5 coarse-resolution models.

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. New methodology/approaches with innovative use of information from high resolution ocean modelling data, taking into consideration atmospheric forces from downscaled global models/data sets are highly encouraged;
- 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 different future emission pathways (RCP8.5 and RCP4.5) and different future warming levels (1.5°C and 2°C scenarios).

D. Future sea level rise projections by 2100 and beyond, through employment of statistical frameworks such as copulas to understand the range of sea level projections, including high tail-end (extreme sea levels).

For Singapore, future sea level rise is one of the most potentially 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. Previously, V2 findings on sea level rise projections did not take into account the contribution of the collapse of ice sheets. Novel approaches, (e.g. combining Probability Density Functions (PDFs), Bayesian methods, and others) to analyse and quantify the uncertainties and their propagation, are encouraged. The proposals should address the central objective:

Objective:

- i. Develop the framework for probabilistic global, regional and local (e.g. Singapore) sea level projections, including the high tail-end or extreme sea levels, with new available outputs from CMIP6 simulations. Include the breakdown of the contribution from each source of uncertainty in the projections, (covering the aspect of ice mass loss in the polar regions) in the creation of joint probability functions.

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).



Guidelines for the Research Grant TnCs
Management of Rese.(as of 1 Jan 2020).pdf

- 3.2 Applicants can propose projects covering one or more areas (A-D) above and address the stated objectives in part or in full. Proposals that are meant to collaborate in delivering the research should be submitted as a single proposal.
- 3.3 Principal Investigator (PI) is allowed to submit one proposal only.
- 3.4 Proposal is 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 Each proposal submitted under the USS Integration Fund will be evaluated based on the impact of the proposed solutions in addressing our national needs, the scientific/technical merits and the robustness of management/governance. The detailed evaluation criteria for proposal applications is as follows:
 - a) Impact: The proposal should address our national strategic needs, with clear alignment with the USS mission and other national priorities. There should be justification on build vs buy to ensure that the research funds are supporting niche R&D areas where technologies/capabilities are unavailable, and to sharpen Singapore's competitive advantages, where possible. The proposal should also articulate the pathway for deployment and/or commercialisation upon successful completion of the research;
 - b) Scientific/Technical Merits: The proposal should involve innovative and cutting-edge research or technology, and encourage collaboration within Singapore's research ecosystem to strengthen research capabilities and core competencies. The quality and experience of the R&D team would also be considered. The lead PI should have a track record of leadership ability in coordinating research programmes and providing mentorship to research teams, as well as having productive research outcomes; and
 - c) Robust management/governance: The proposal should have defined objectives, quantifiable stretched targets with reasonable milestones and deliverables, and a clear structure of accountability. The proposal should also address the funding gap and not duplicate existing/past initiatives.
- 3.8 Awarded projects may be expected to collaborate with researchers from the Centre for Climate Research Singapore.

3.9 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.



Proposal
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3.10 The template for CV is attached. Individual CVs of all team members (Lead PI, Co-Is and Collaborators) must be attached and not exceed 2 pages each.



CV
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3.11 **By submitting your proposal for the grant call, you acknowledge and declare that you meet the evaluation criteria, guidelines and T&C highlighted in this document.**



Acknowledgement
form for NSLP Call 2.

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