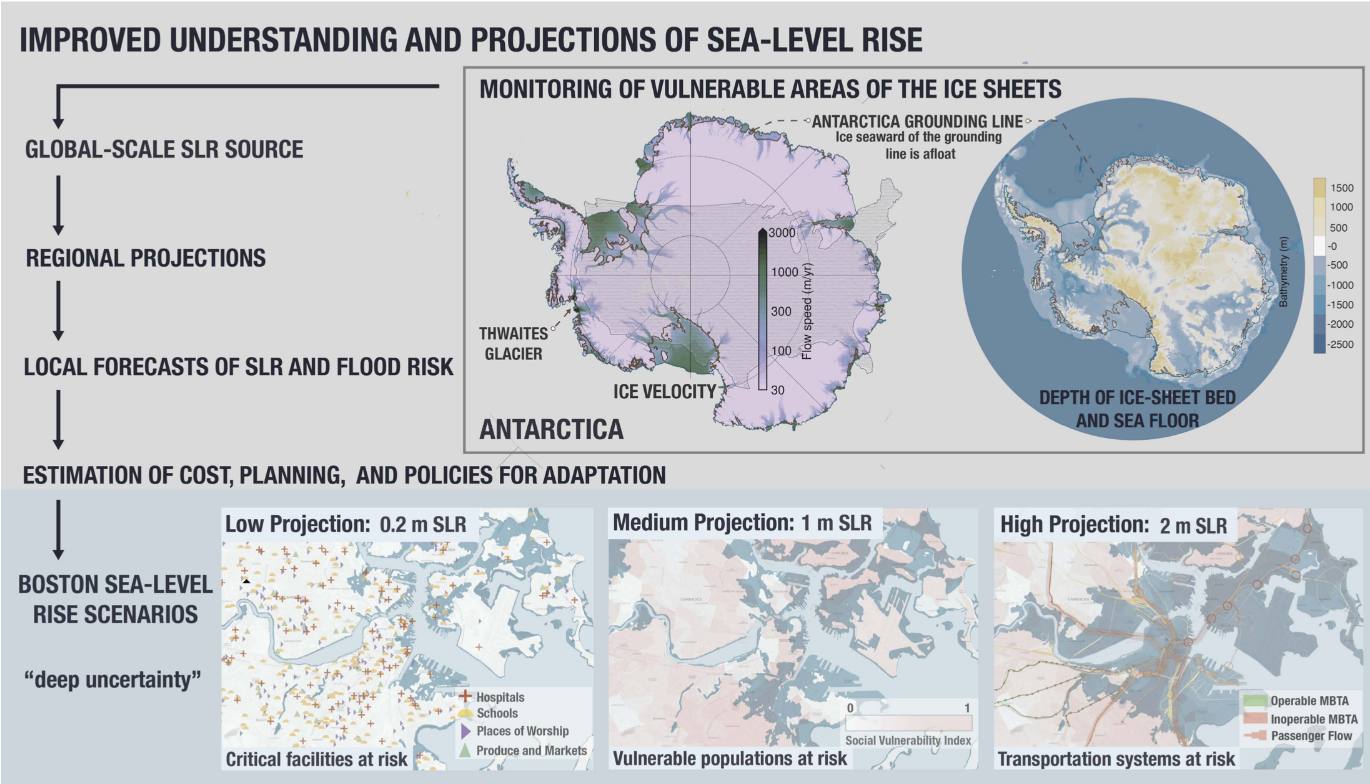
Quantifying and Managing the Risks of Sea-level Rise

We propose a multidisciplinary project that brings together climate scientists, economists, city planners, engineers, and ecologists from across MIT to develop a broader and deeper understanding of the risks of sea level rise (SLR). The potential impacts of SLR are profound and include inundation and flooding of coastal areas, worsening of storm surges, loss of habitat and infrastructure, and displacement of large numbers of people. Global sea levels are projected to rise by 0.2–2 meters or more by the year 2100, a meter-scale uncertainty that creates formidable challenges to adaptation planning and policy. Reductions in CO_2 emissions are unlikely to prevent disruptive levels of SLR in this century, so the challenge for society is to adapt to rising seas.

This is a multi-faceted project whose outputs will help improve SLR risk quantification and management. To better quantify risk, we aim to advance global-scale projections of SLR through novel observational technologies and computational models of ice sheet change and to link those projections to regional- to neighborhood-scale estimates of costs and options for adaptation. To manage risk, we will develop tools that help communities, planners, decision-makers, and other stakeholders evaluate the costs and benefits of their various response options. Education is a pivotal aspect, and we will use our project as a basis to train undergraduate and graduate students in real-world, interdisciplinary problem-solving.



STRATEGIES

We expect to make several important and novel contributions to the quantification and management of SLR risk over the next 5–10 years.

1. Probability of SLR

Our contributions in improving projections of SLR will come from a combination of new observational technologies and computational methods and models:

- The development of new observational technologies is divided into two complementary efforts.
    - One is the **development of an autonomous aircraft (drone)** that can fly for months at a time over vulnerable areas of the ice sheets continuously collecting high spatial and temporal resolution data from a lightweight, low-power imaging radar system that we propose to develop for this purpose. The resulting data will allow us to constrain for the first time the stresses that cause icebergs to calve and glaciers to accelerate, both features of the natural ice sheets that govern rates of SLR but are not well represented in models used to project SLR.
    - The other technology we propose to develop will allow for a more detailed view of these same processes by proving the ability to **air-drop geophysics-grade seismometers and GPS receivers in areas where ice is breaking up**. Making observations in these areas while the ice is fracturing is essential to advance the science of SLR projections but is not possible at the moment because it is too dangerous to send people to deploy instruments. Our air-dropped sensors will solve this accessibility issue and provide data that complement those collected from the drone and existing satellites.

- Our modeling efforts are similarly divided into two complementary tracks.
  - One effort is devoted to **learning physics from the data collected from satellites, our drones, and our air-dropped sensors**. This work will leverage advances in machine learning to help us develop and test new model parameterizations for processes like iceberg calving, which are among the primary sources of uncertainty in SLR projections.
  - The complementary modeling component will focus on **improving the representation of ice sheets in climate models**. This work involves coupling an ice-flow with CliMA, a new climate model being developed by MIT in collaboration with Caltech and coded in Julia.

2. Costs of SLR

We will fill gaps in current cost estimates related to the impact of SLR on private-sector capitol and environmental impacts in coastal lands and oceans. Estimates of economic costs involve the development of cost-estimation methods that take into account increased flooding to due SLR and its impact on property values and critical infrastructure. These methods will be applicable to coastal cities worldwide. For ecological damage, we propose to assess the ecological impact of SLR on coastal lands and oceans, with a focus on degradation of water quality and loss of habitats.

3. Risk Management and Adaptation Strategies

We will contribute to adaptation efforts from engineering, policy, and planning angles. We will develop more reliable methods of engineering design and investment strategies that consider both “grey” (e.g., walls and levees) and “green” (e.g., marshes and mangroves). We will work with communities in the Boston area and elsewhere to develop an inclusive policy toolkit that considers adaptable, multi-functional infrastructure and emphasizes planning across a range of timescales, from the next 5–10 years to the next century. Finally, we will develop new methods to help plan migration of people from areas vulnerable to SLR to areas of higher elevation.

PROJECT SCOPE

This broad project is intended to last for five years. The various components of the project will be led by the team member with relevant expertise. **Brent Minchew** (Earth, Atmospheric, and Planetary Sciences) is the lead PI and is responsible for the overall management of the project.

While we are committed to the success and integration of all parts of the project, we designed the project to be modular to help mitigate the overall risk by ensuring that each component can be successful even if another portion of the project encounters unforeseen difficulties. We believe this project is well positioned to be part of a broader vision for MIT to help address climate issues—from science to technology to society. In essence, our goals are to harness the collaborative and innovative spirit of the institute to develop new technologies that enable essential scientific insight to directly address one of the grandest climate challenges. The expertise of the team members has the breadth and depth to make valuable, lasting contributions to the quantification and management of SLR risk while contributing useful collaborative effort and input to other projects proposed as part of MIT’s Climate Grand Challenge.