# Preparing for a New World of Weather and Climate Extremes

Global warming is changing the frequency and intensity of extreme weather and climate events such as heat waves, heavy rainfall, and droughts. These extreme events can have devastating impacts, and most of the risk to society from climate change involves changes in extreme events rather than changes in the mean climate. We will address three major challenges:

1. We already know that extremes are intensifying on global and continental scales, but new scientific knowledge is urgently needed to characterize changes in extremes at specific locations to account for the rarest events that have the biggest impacts (e.g., 100-year events) and to assess the risk of tipping points to a more extreme climate.
2. Processes of adaptation to new weather and climate extremes are progressing slowly, and those currently underway primarily serve communities with extensive existing resources. More accessible climate-change adaptation tools, based on the best-available science and modeling of extremes, are needed to inform adaptation in less resourced communities.
3. Transitioning to low-carbon energy resources will help reduce greenhouse gas emissions, but both our existing energy system and promising renewable energy sources—wind, solar, and hydroelectric—are vulnerable to weather and climate extremes. To enable this transition, we require an improved understanding of the impacts of extreme weather on renewable resources, as well as practical tools to adapt to the effects of changing extremes on energy supply, demand, and transmission.

## OBJECTIVES AND PROPOSED SOLUTIONS

**Objective 1.** Reduce key scientific uncertainties in how weather and climate extremes respond to warming.

We will build physical understanding of weather and climate extremes, which is necessary to interpret future climate projections and to ensure their credibility. We will focus on extremes of heat, precipitation, and wind, and extremes with long return periods (100 years or more). We will address the risk of climate tipping points using rescaling of past extreme climate events. We will also use emergent constraints and physical storylines to address uncertainty in the large-scale circulation response, which has large effects on the local response of extremes.

**Objective 2.** Assess the risk of current and changing extremes in specific locations.

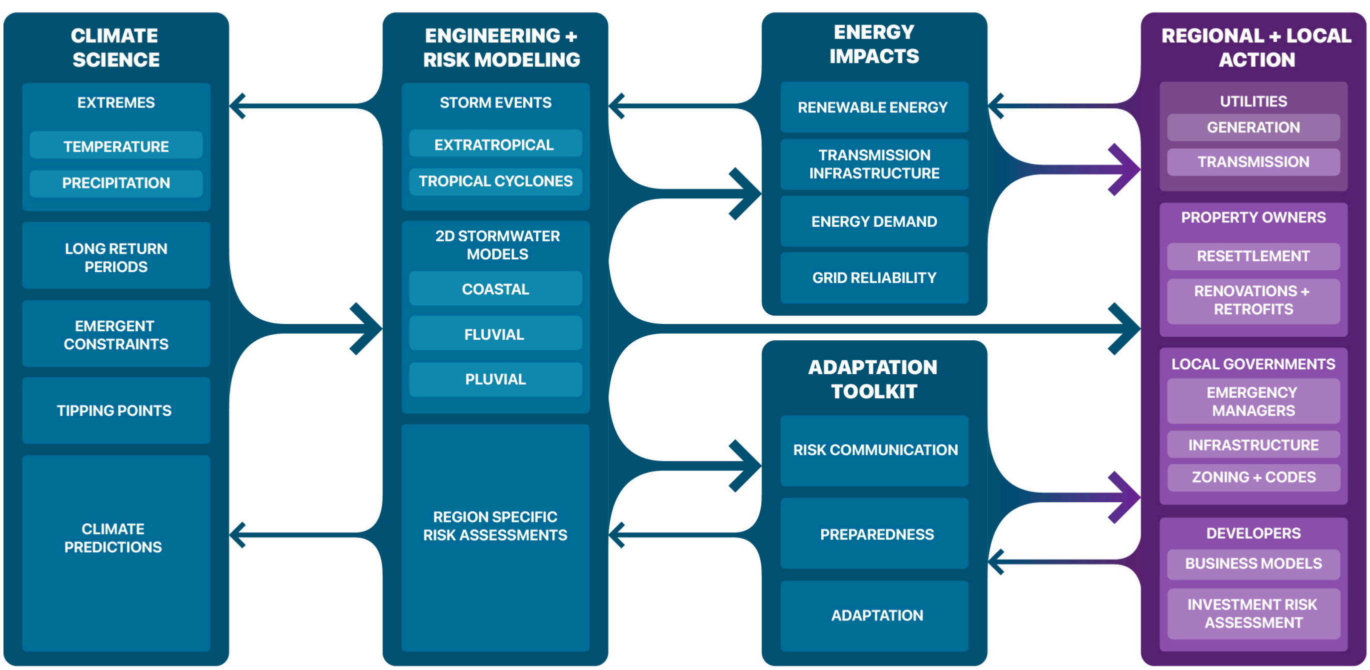
Risk assessment of weather extremes in a changing climate requires downscaling of global climate simulations and local flood modeling. We will develop new downscaling approaches that combine physics with statistical methods (e.g., to downscale cyclones) and through machine learning. We will also use dynamical downscaling with regional high-resolution simulations that have good representations of extreme precipitation.

**Objective 3.** Develop and apply a Climate Adaptation and Preparedness Toolkit for cities.

This Climate Adaptation and Preparedness Toolkit will enable climate scientists and local stakeholders to work together to develop new understandings of changing weather and climate extremes considering local needs. This work will help integrate robust, location-based urban flooding models with a series of risk communication, planning, development, and design modules. The toolkit modules will include online platforms and will guide semi-structured interviews, participatory mapping, and workshops. The toolkit will be developed in partnership with stakeholders in a broad range of locations in the U.S. and Southern Africa.

**Objective 4.** Quantify and prepare for the risk to renewable energy and grid resilience from changing weather and climate extremes

We will investigate how extreme weather events can cause shortages of renewable energy resources and damage to energy generation and transmission infrastructure. We will also study how these threats to renewable energy supply intersect with events that dramatically increase energy demand, and we will develop accessible tools for decision-makers that account for the probabilistic nature of climate risks and convey how these risks impact various stakeholders and communities.



## TEAM EXPERTISE, LEADERSHIP, AND KEY EXTERNAL PARTNERS

The team includes 17 professors and research scientists at MIT with broad expertise covering modeling and science of weather extremes, downscaling approaches and machine learning, climate tipping points and paleoclimate, flood modeling, climate adaptation and preparedness for cities, the real estate market, urban policy and equity, renewable energy systems, and energy grid resilience.

The three team leaders are:

- Professor **Paul O'Gorman** (Earth, Atmospheric, and Planetary Sciences): expertise in extreme precipitation, extratropical cyclones and atmospheric dynamics, and use of machine learning in climate science
- Associate Professor **Miho Mazereeuw** (Architecture): expertise in adaptation and preparedness for cities and working with local communities and federal agencies
- Professor **Kerry Emanuel** (Earth, Atmospheric, and Planetary Sciences): expertise in tropical cyclones, downscaling and risk assessment, atmospheric convection, and severe weather

The team also includes two external team members: **Dr. Andreas Prein**, a project scientist at the National Center for Atmospheric Research (NCAR), and **Dr. Talia Tamarin-Brodsky**, who will join MIT as a faculty member during the period of the project.

Other key external partners include municipalities in the U.S. and Southern Africa, renewable energy companies, and the Zambezi Watercourse Commission.