Large ensemble modeling of Earth system on long time scales
PI: Alexander Robinson

The Greenland and Antarctic ice sheets (GrIS and AIS, respectively) and the Atlantic Meridional Overturning Circulation (AMOC) are prominent examples of tipping elements in the Earth system that have the potential to respond nonlinearly to small changes in forcing. Tipping elements can thus give rise to climate surprises, i.e., low-probability, high-impact events that may be triggered earlier than expected. Simulating such climate surprises and their impacts, on the relevant multi-centennial timescales and beyond, is particularly challenging. Today, the right methods are not available, resulting in deep uncertainty in future projections. Here I aim to develop a novel, probabilistic methodology to robustly forecast climate surprises such as ice-sheet and AMOC collapse on long timescales. This requires simultaneous advances beyond the state of the art on two fronts. First, a new generation Fast Earth System Model (FESM) will leverage the latest advances in our understanding of key processes to represent the GrIS, AIS and AMOC realistically, in a coupled framework and on long timescales. Critically, this will be the first comprehensive model fast enough to run the large ensembles of simulations needed to quantify the uncertainty associated with deeply uncertain processes. Second, a highly novel and generalized probabilistic approach will be developed, to constrain the FESM to be consistent with output from the latest generation of Earth System Models. FORCLIMA will generate probabilistic estimates of climate surprises for the medium-term future (centuries to millennia) with much higher confidence than we have today, and inform about interactions between key tipping elements in the climate system. This project will therefore greatly advance the state of the art in coupled climate – ice-sheet modeling, and lead to an unparalleled understanding of the long-term impacts of climate change on the Earth system.