CryoTipping – Detecting Marine Ice Sheet Instability

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CryoTipping Overview

- Part of CLIMATE-SPACE **Tipping Elements Activity**
- **Goal of project:** Assessing the proximity and timing of tipping points at Thwaites glacier
  - Is the current pace of grounding line retreat indicative of the onset of marine ice sheet instability?
  - Can we detect tipping points in Thwaites' future evolution?
- **Timeframe:** Feb 2025 – Feb 2028
- **Bringing together experts from the ice sheet EO and modelling communities:**
  - ESA AIS CCI+
  - EU Horizon 2020: TiPACCs (Tipping Points in Antarctic Climate Components) & PROTECT (Projecting Sea-Level Rise: from Ice Sheets to Local Implications)
  - International community initiatives: ESA-NASA IMBIE (Ice Sheet Mass Balance Intercomparison Exercise) & ISMIP7 (Ice Sheet Model Intercomparison Project for ISMIP7)

Northumbria University NEWCASTLE

Centre for Polar Observation and Modelling
Natural Environment Research Council

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

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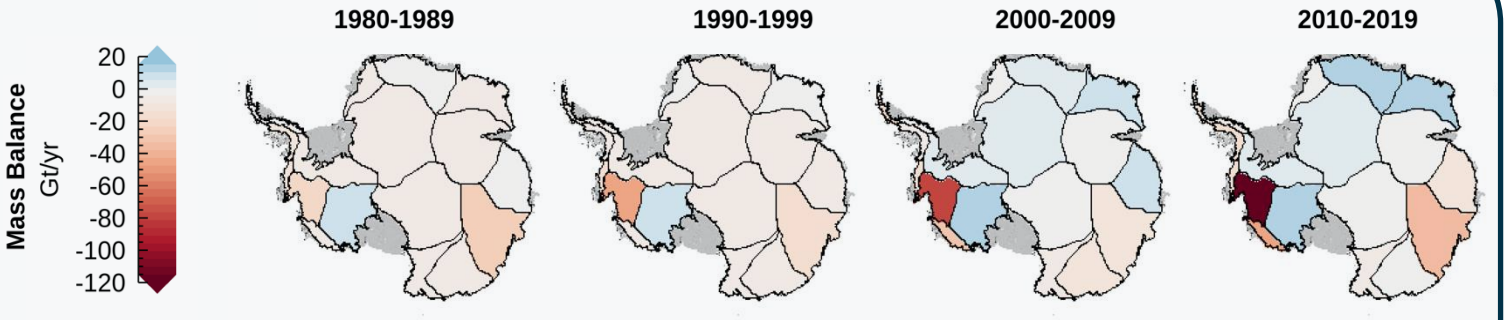
CryoTipping Motivation and Objectives

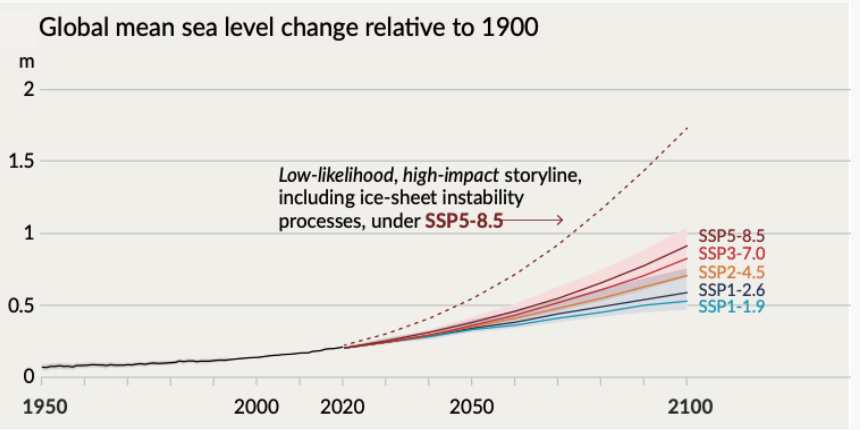
The Amundsen Sea Sector is the most rapidly changing regions of Antarctica

- Pine Island and Thwaites Glaciers account for 76% of Antarctica's total ice losses
- There has been a 3-fold increase in mass loss between the 1990s and 2010s



"Considering high impact-low probability events (such as **marine ice sheet instability**), sea level rise greater than 15m cannot be ruled out (low confidence)"

(IPCC, AR6)



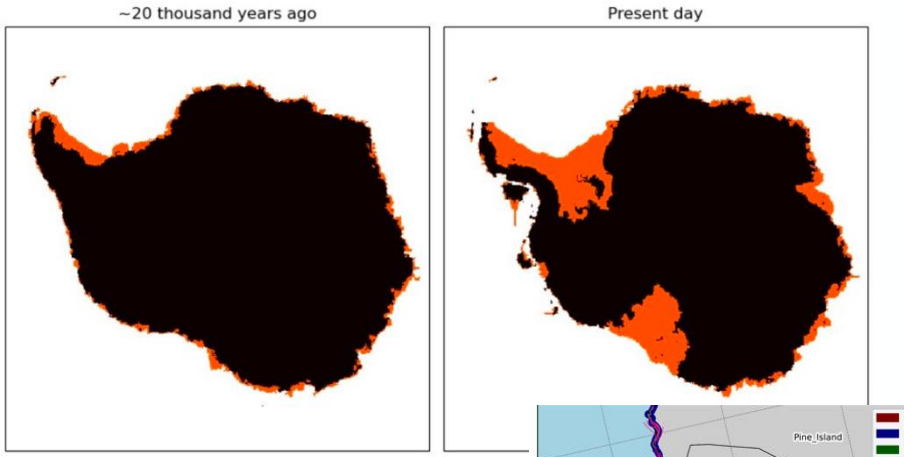
Is MISI already underway in West Antarctica? How close is Thwaites Glacier to a tipping point?

Contrasting past and present grounding line migration rates

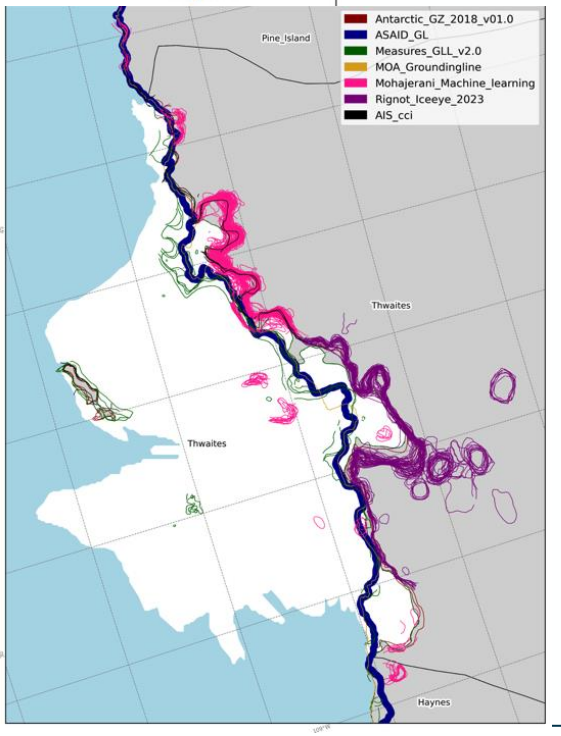
Objective: Contrast Holocene rates of grounding line retreat from ice sheet model simulations with current and past rates of grounding line retreat of Thwaites glacier from satellite observations.

Tasks:

- Estimate rates of Holocene and deglaciation grounding line retreat of Thwaites glacier from PISM-VILMA ice sheet model simulations
- Estimate rates of grounding line retreat of Thwaites glacier during the satellite record (1990s - present)
- Contrast modelled rates with observed ones



PISM
PARALLEL ICE SHEET MODEL

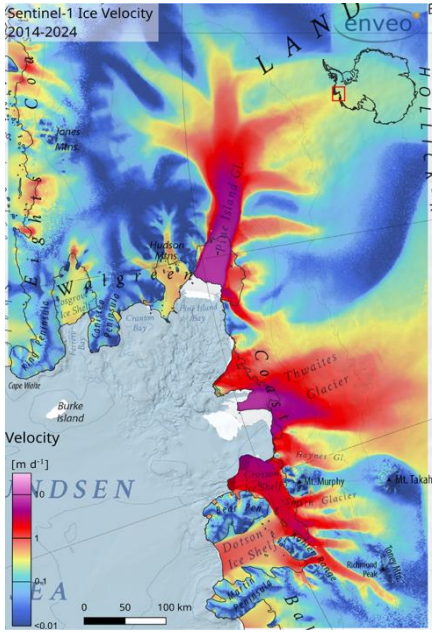


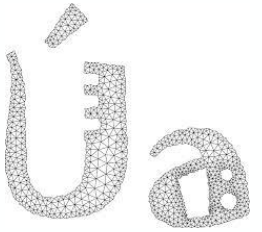
Detecting tipping points in Thwaites' future evolution

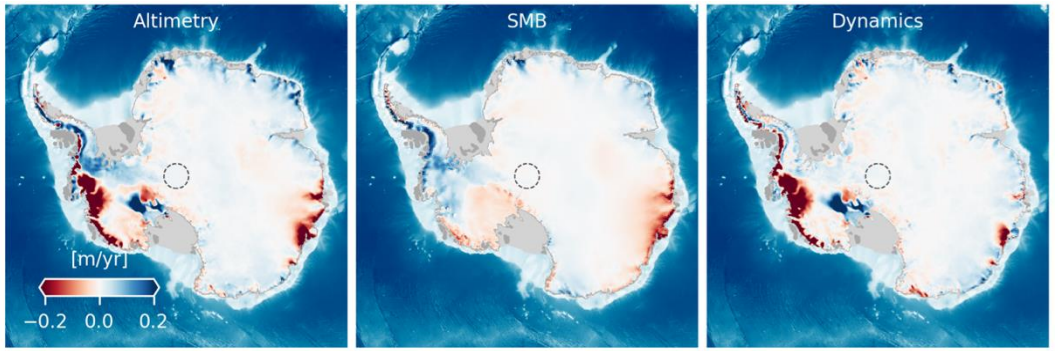
Objective: Calculate early warning indicators for future model simulations of Thwaites Glacier to identify if one or several tipping points are crossed as the glacier retreats as a result of future climate perturbations

Tasks:

- Initialise ice sheet models with satellite observations of present-day ice velocity, grounding line location, and surface elevation changes
- Conduct forward model experiments of Thwaites glacier driven by ocean thermal forcing using Úa
- Calculate early warning indicators



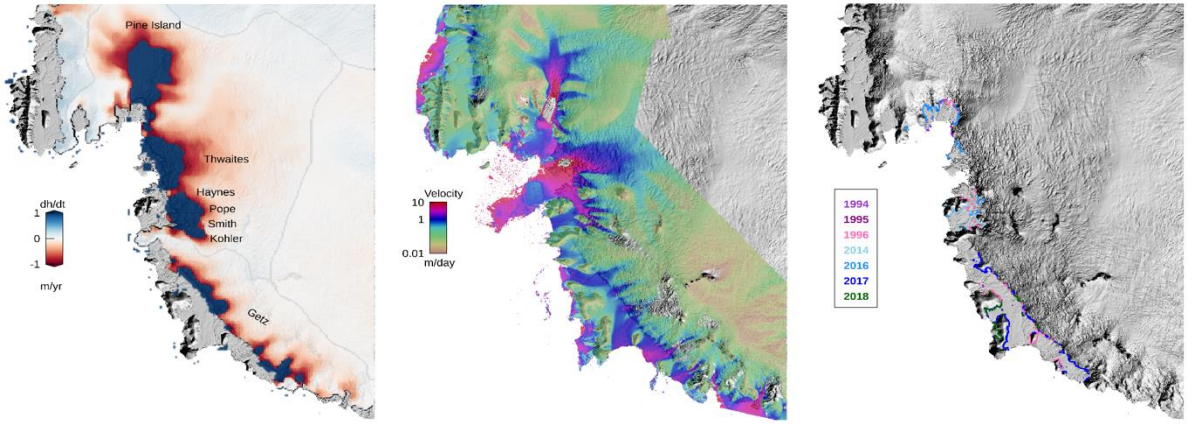




ECVs being used

Antarctica CCI provides key parameters for describing the current state of the ice sheets & initialise ice sheet models to look into the future:

- surface elevation change
- ice velocity
- grounding line position



Strengths and weaknesses:

+ More than three decades of observations

+ Data products include some measure of uncertainties

- Spatial/temporal gaps need to be filled for comparison/integration in models

Important to exchange between EO and modelling experts:

- Models do not include all processes (e.g. grounding line VS grounding zone)

Results & relevance to the CCI community

- Antarctica is the largest source of uncertainties in future projections of SLR
- By combining EO and modelling, we will better understand the timing of tipping points at Thwaites Glacier and help reduce these uncertainties
- This is relevant for quantifying future ice sheet changes, freshwater fluxes to the ocean, sea level budget studies, and tipping point cascading mechanisms