ONE Planet Doctoral Training Partnership

Natural Environment Research Council

Project title: GTIP: Quantifying tipping points in Greenland outlet glacier dynamics

Ref: OP2422

Keywords: Glaciers, Greenland, Arctic, climate change

One Planet Research Theme:

Climate & Climate Change ☒ | Earth System Processes ☒ | Anthropocene ☐ | Environmental Informatics ☐

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Key Research Gaps and Questions:

1. Will Helheim Glacier cross a tipping point and what does this mean for sea level rise?
2. Which Greenland outlet glaciers have tipping points and when do these occur?
3. What is the impact of these tipping points on Greenland's sea level rise contribution?

Project Description: The Greenland Ice Sheet (GrIS) contributed 10.6 mm to global SLR between 1992 and 2018 (Shepherd et al., 2019). About half of recent ice loss is due to accelerated discharge from marine-terminating outlet glaciers (Mouginot et al., 2019), but their behaviour is a major source of uncertainty in Greenland's future SLR contribution (IPCC AR6, 2021). Many of Greenland's major outlet glaciers lie on bedrock that slopes downwards inland (Morlighem et al., 2017), which could theoretically encourage rapid, irreversible retreat (e.g. Schoof et al., 2007) and cause the glacier to cross a tipping point. However, the impact of the reverse slope can be offset by the stabilising influence of lateral drag (Gudmundsson et al., 2012), meaning that numerical modelling is the only way to confirm whether Greenland's glacier may cross tipping points in the near future.

Initially, the project will focus on Helheim Glacier (HG), south-east Greenland, which is one of the GrIS's three largest glaciers and was the largest single contributor to GrIS ice discharge in 2020. HG has repeatedly undergone periods of accelerated ice discharge and dynamic change: the latest phase began in 2014 and has potentially brought HG to a tipping point, whereby further retreat could move the terminus onto a retrograde bed slope and trigger rapid, irreversible retreat (Khan et al., 2020, Williams et al., 2021). Given its potentially large contribution to sea level rise, it is an urgent priority to determine: i) whether HG will cross a tipping point and ii) the envelope of its potential 21st Century SLR contribution for a range of forcings. After development at HG, the PhD project will expand to identify potential tipping points at other major Greenland outlet glaciers and will quantify the potential sea level rise envelope of those glaciers up to 2100.

The project will use the open-source model Úa (e.g. Gudmundsson 2020), which uses a finite element approach, allowing for flexible glacier geometry descriptions, and is coupled to the ocean model MITgcm (De Rydt et al., 2016). To assess whether HG will cross a tipping point, the model will be set up using remotely-sensed data from 2014/15 and then we apply: i) present day rates of retreat and thinning; ii) rates observed during the historical record; and iii) a range of future SMB and ocean warming scenarios. From this, HG's potential envelope of 21st Century sea level rise contribution will be calculated. The approach will then be expanded to other major Greenland outlet glaciers.

Prerequisites: We seek a candidate with experience in Matlab, numerical modelling and handling remotely sensed data. Training will be provided in the numerical model Úa by the model originator and support will be provided by the supervisory team, who are regular Úa users, and the broader Úa user community at Newcastle and Northumbria Universities.

For more information, please contact Rachel Carr (Rachel.carr@newcastle.ac.uk).

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