

STAGE DE RECHERCHE de MASTER 2^{ème} ANNEE

Master SOAC / WAPE

Année Universitaire 2025-2026

Subject: Future Evolution of Surface Ablation Processes over the Antarctic Ice Sheet

Short description: This internship aims to analyze regional climate projections for the Antarctic Ice Sheet in order to assess how the relative importance of blowing snow and meltwater runoff as surface ablation processes changes under future warming.

Supervisor and host laboratory: Charles Amory – Institut des Géosciences de l'Environnement (Grenoble)

Level and prerequisite: Master 2 in climate science, oceanography, hydrology, or a related field

Key words: regional modelling – blowing snow – surface mass balance – Antarctic ice sheet

Duration: approx. 5 months (February–June 2026)

Context: With an equivalent sea-level potential of about 58 meters, Antarctica represents the largest source of uncertainty in global sea-level rise projections (Fox-Kemper et al., 2021). The ice sheet mass balance is defined as the difference between the surface mass balance (SMB) and ice discharge, the latter corresponding to the flow of grounded ice into the ocean. The SMB is the resultant of accumulation (precipitation, wind deposition, condensation) and ablation (sublimation, wind erosion, meltwater runoff) processes at the ice-sheet surface. Because of the vast extent and harsh environmental conditions of the Antarctic continent, numerical modeling remains the primary tool for estimating its SMB.

Across Antarctica, large amounts of airborne snow originating from both clouds and the surface are continuously transported by near-surface winds — a process known as blowing snow (Fig. 1). This process has been estimated to currently dominates surface ablation over much of the ice sheet (e. g., Agosta et al., 2019; Gerber et al., 2023; Gadde et al., 2024). Mass loss occurs when snow particles eroded from the surface sublime during transport and return to the atmosphere as water vapor, or, to a lesser extent, are exported to the ocean off the continental margins. In contrast, meltwater runoff remains limited to peripheral regions (Fig. 2) and is presently negligible, as most meltwater refreezes within the snowpack (Mottram et al., 2021). However, under a warming climate, this balance between ablation processes can be expected to shift. Rising air temperatures will favor meltwater production and drive the inland expansion of runoff areas (The Firn Symposium Team 2024), while the increasing presence of liquid water at the surface may inhibit blowing snow.

Despite its climatic and hydrological significance, most Earth System Models (ESMs) participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6) omit blowing snow entirely, which may introduce biases in projections of Antarctic SMB. Understanding the interactions between blowing snow and meltwater runoff is therefore essential to assess how surface ablation will evolve in a warming climate.

Objectives: This internship will analyze an ensemble of 21st-century regional climate projections over Antarctica produced with the regional climate model MAR, which explicitly represents blowing-snow processes (Amory et al., 2021). For each of the four CMIP6 ESMs dynamically downscaled by MAR, a pair of simulations, respectively with and without blowing snow, is available under the high-emission scenario SSP5-8.5.

The objectives are to:

- Examine the evolution of individual surface ablation components (sublimation, erosion, runoff) up to the end of the century.
- Quantify the impact of blowing snow on melt, runoff, and the extent of the ablation zone.
- Identify the climatic thresholds under which meltwater runoff overtakes blowing snow as the dominant surface ablation process.
- Discuss the implications of these results for Antarctic SMB projections and the representation of ice-sheet surface ablation in ESMs.



Fig. 1 | Blowing snow cloud seen from the French research station Dumont d'Urville, about 5 km from the edge of the ice margins. Credit: Julien Guilhermet.

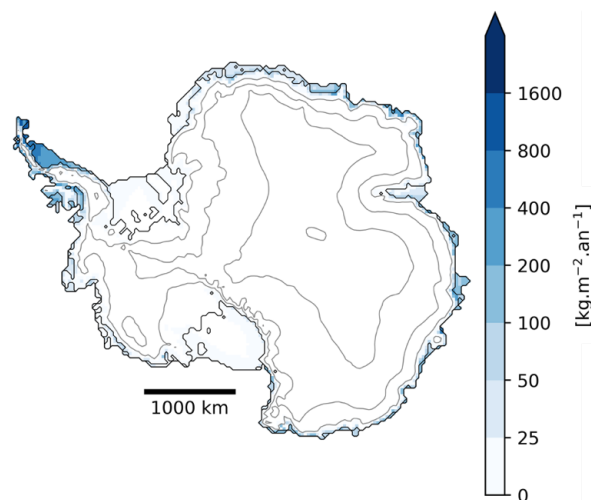


Fig. 2 | Mean annual (1980–2014) surface melt over Antarctica, including liquid water within the snowpack and on bare ice, as simulated by the regional climate model MAR. Adapted from Amory et al. (2024).

Required skills: Background in climate science and/or numerical modeling; experience with NetCDF data handling; proficiency in Python for data analysis and visualization.

Nature of the internship: The internship focuses on the analysis of numerical simulations, with a strong emphasis on data processing, and interpretation of climate-related variables. It involves a moderate level of theoretical understanding, but no experimental or instrumental work.

Possibility of continuation: This internship may possibly lead to a PhD project, subject to discussion.

How to apply : Interested candidates should send a CV and a short motivation letter (maximum one page) to charles.amory@univ-grenoble-alpes.fr

References :

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The Firn Symposium team: Amory, C., Buizert, Buzzard, S., et al.: Firn on ice sheets, *Nat. Rev. Earth. Environ.*, <https://doi.org/10.1038/s43017-023-00507-9>, 2024.