Climatology and Evolution of the Antarctic Peninsula Föhn Wind-induced Melt Regime from 1979-2018

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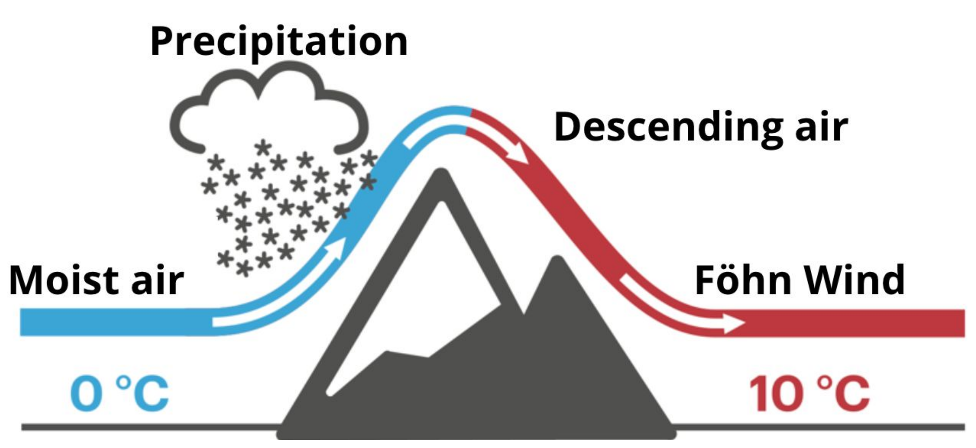
Introduction

Warm and dry föhn winds cause surface melt on the Antarctic Peninsula in all seasons.



We use AWS observations to train a machine learning (ML) model to identify the föhn signature in ERA5 reanalysis and RACMO2 output. We quantify the spatial and temporal extent, drivers, evolution of föhn-induced surface melt from 1979-2018.

Approach

Data

- **12 Automatic Weather Stations** (Figure 1)
- **ERA5**: Satellite derived reanalysis data, 30 km x 30 km resolution
- **RACMO2.3p2**: Regional Climate model data, 5.5 km x 5.5 km resolution

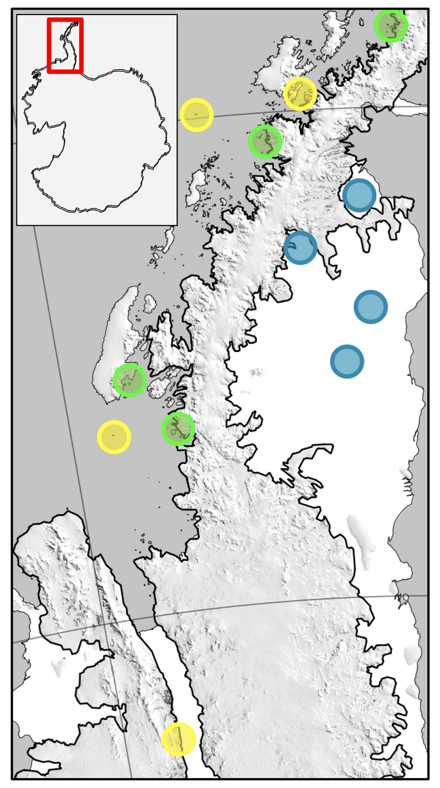


Figure 1: Study Domain and AWS locations. White shading indicates ice shelves, Grey shading indicates the ocean.

Föhn Detection and Machine Learning

- Created a **Föhn Detection Algorithm (FonDA)** to identify föhn wind events in AWS data.
- We use **XGBoost Gradient Boosting** decision tree Machine Learning.
- We use AWS identified föhn events to train two Machine Learning models to identify föhn in ERA5 and RACMO2 output.

Table 1: ML Model performance showing each models ability to identify föhn-induced melt compared to AWS identified events and concurrent melt. Event classification is dependant on temperature; Strong (>7 °C), Moderate (>3.5 °C, <7 °C), Weak (<3.5 °C).

ERA5 föhn classification				
AWS classification	Model classified correct	Föhn melt	Occurrence	Melt captured
Strong	100.0%	7.1%	3.6%	7.1%
Moderate	98.9%	20.5%	23.1%	20.3%
Weak	87.8%	72.4%	73.3%	63.5%
		Total föhn-induced melt captured		**90.9%**
RACMO2 föhn classification				
AWS classification	Model classified correct	Föhn melt	Occurrence	Melt captured
Strong	100.0%	6.8%	3.0%	6.8%
Moderate	95.9%	19.5%	19.0%	18.7%
Weak	93.5%	73.7%	78.0%	68.9%
		Total föhn-induced melt captured		**94.4%**

Surface Energy Budget and Melt

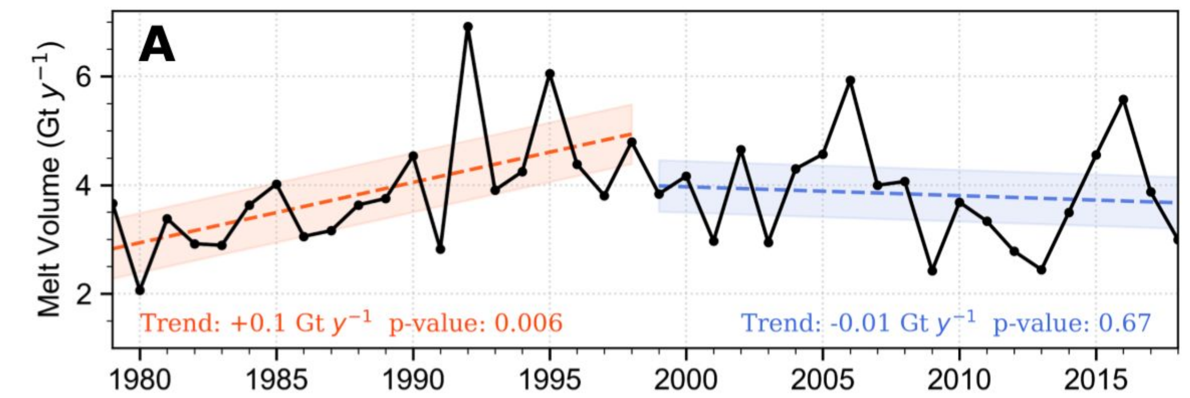
- Combine föhn events identified with Machine Learning models and the surface energy budget to create a climatology of surface melt and the surface energy budget.

$$Energy = SW_{net} + LW_{net} + H_S + H_L \quad (W\ m^{-2})$$

Results

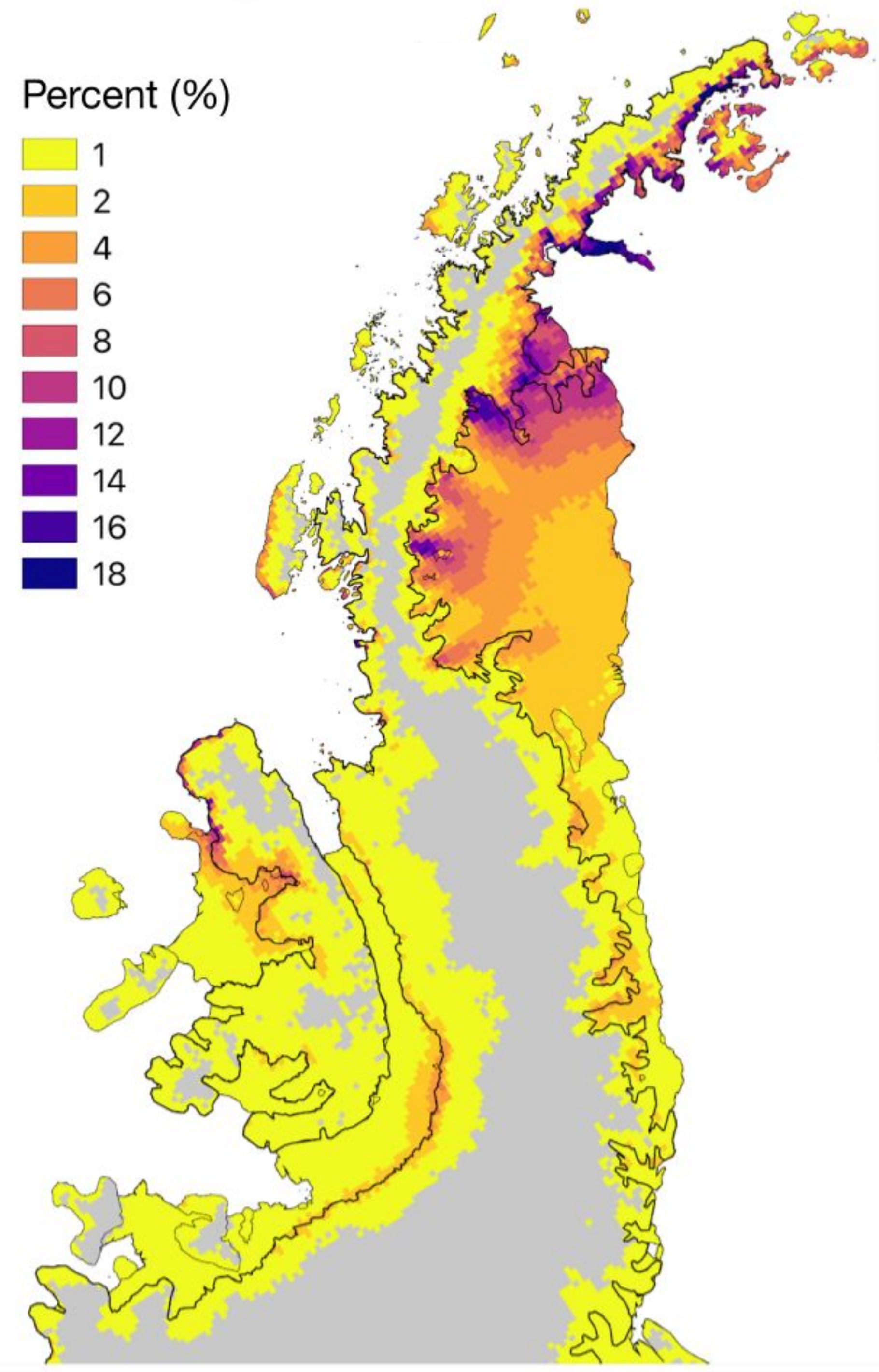
What fraction of the total AP melt is caused by föhn winds?

- Föhn wind-induced melt accounts for **3.1%** of the total melt.
- Can be as high at **18%** east of the AP mountains.



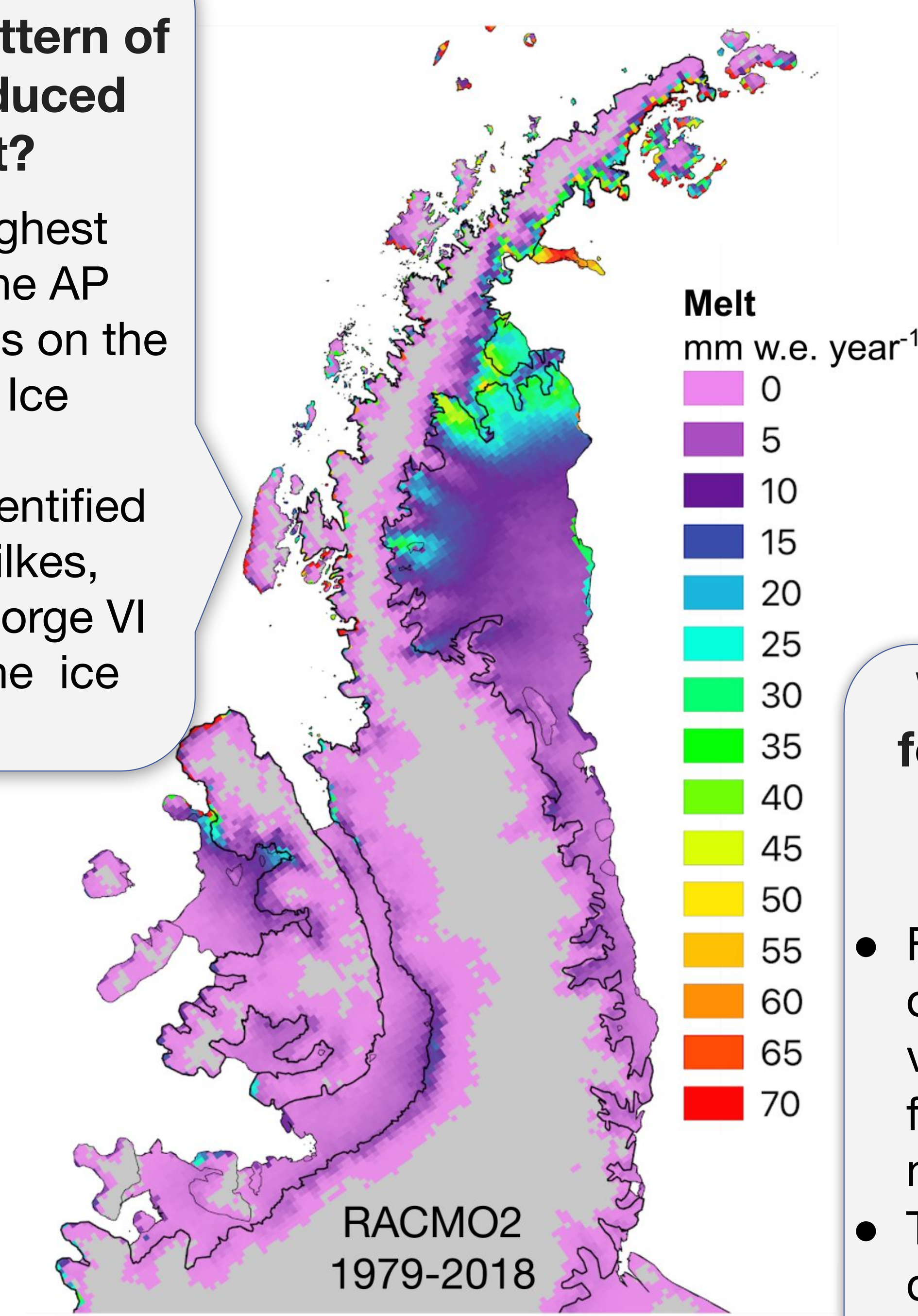
How does föhn-induced melt vary?

- Melt does not significantly increase from 1979-2018.
- A significant increase (+0.1Gt y-1) and subsequent decrease/stabilization occurred in 1979-1998 and 1999-2018, consistent with the AP warming and cooling trends.



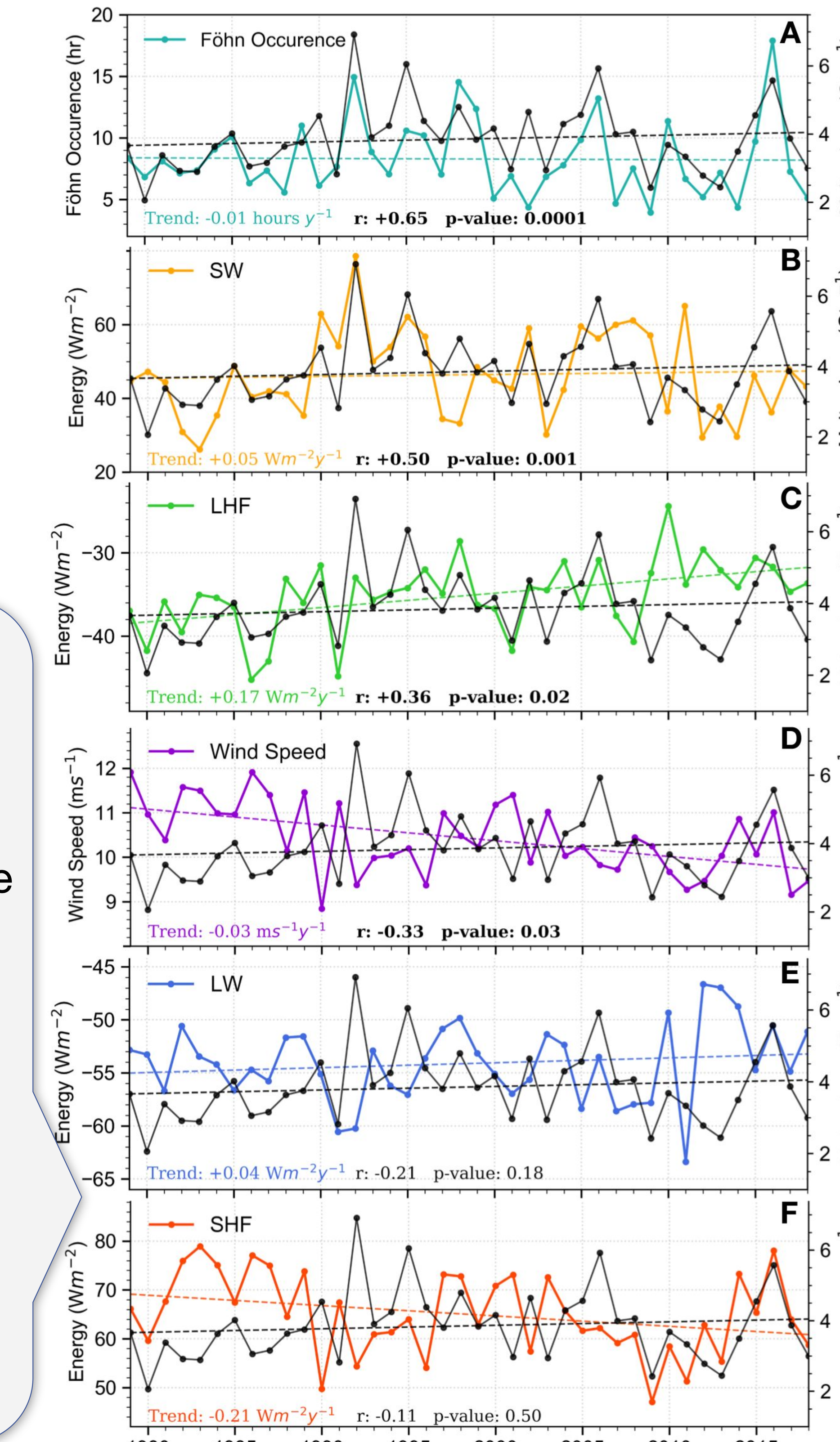
What is the spatial pattern of föhn-induced melt?

- Melt is highest west of the AP mountains on the Larsen C Ice Shelf.
- Melt is identified on the Wilkes, Bach, George VI and Ronne ice shelves.



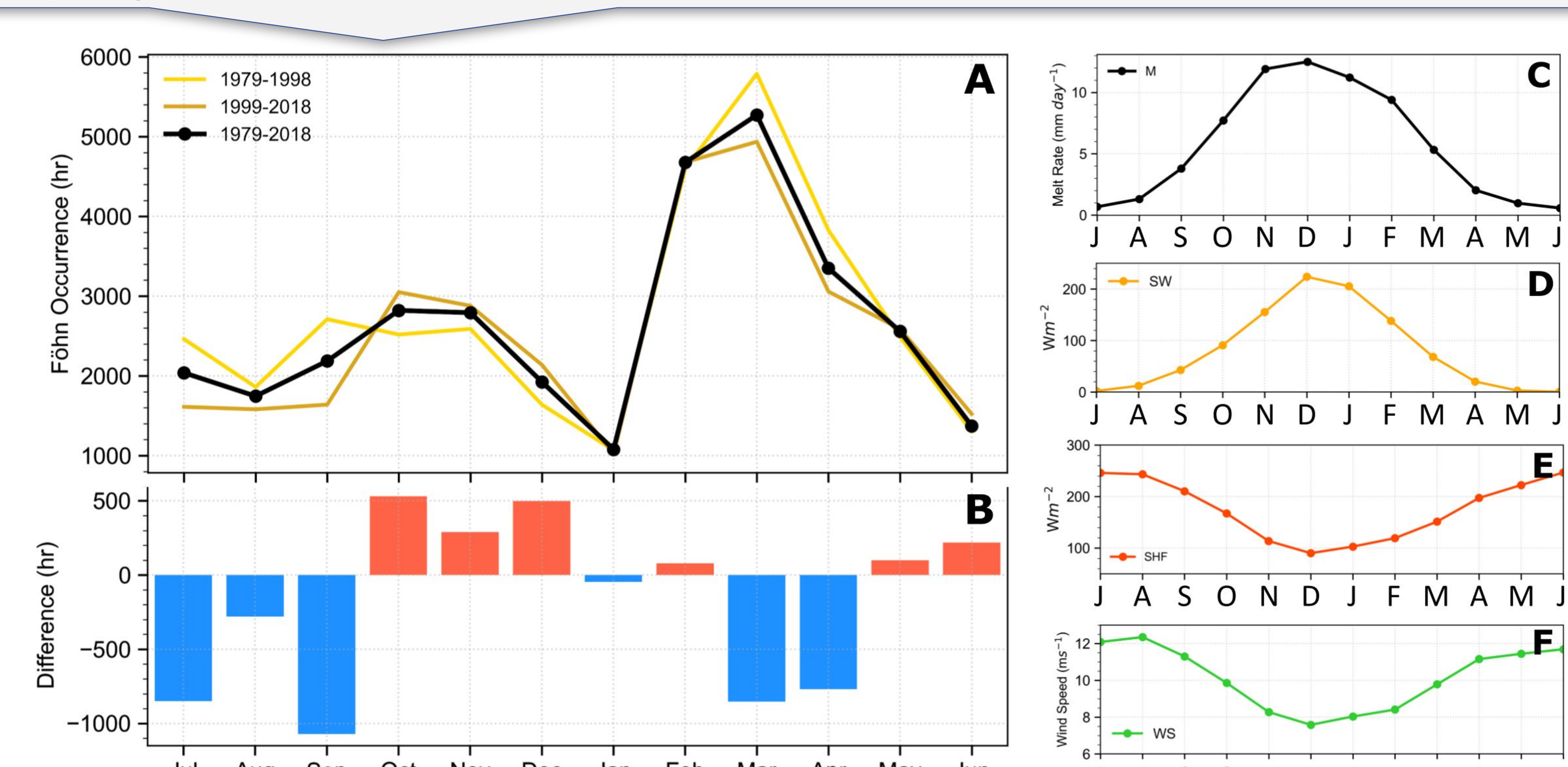
What drives föhn-induced melt annual variability?

- Föhn occurence drives annual variability in föhn-induced melt.
- Trends in föhn drivers suggest föhn-induced melt has changed through time.



How and why does föhn-induced melt evolve through time?

- Föhn-induced melt evolution is attributed to seasonal changes in föhn occurrence.
- More föhn melt events occur in summer and less events occur in fall, winter, and early spring.



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