Modelling perennial firn aquifers in the Antarctic Peninsula (1979-2016).

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Perennial Firn Aquifer (PFA)

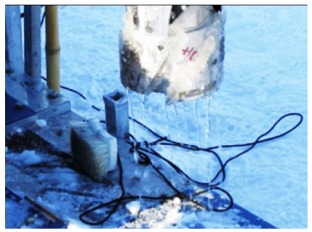
Definition:

The perennial firn aquifer (PFA) stores liquid water produced in the melt season within the subsurface firn year-round, including throughout the winter.

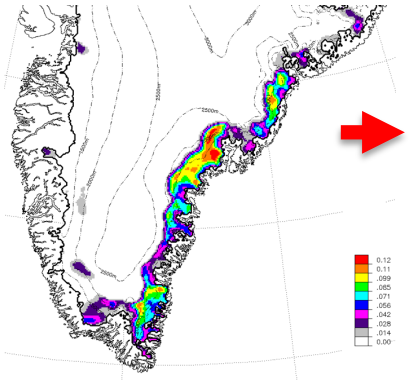
Motivation

Before:
Accidental **Perennial Firn Aquifer (PFA)** discovery in **Greenland**

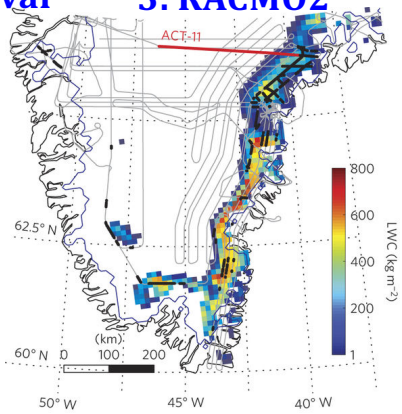
1. Ice core drilling



2. ASCAT Firn Aquifer retrieval

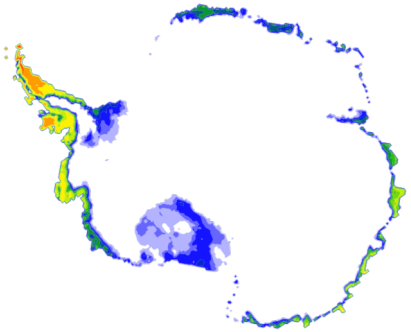


3. RACMO2

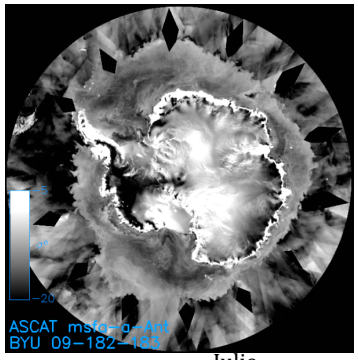


Now:
Using **RACMO2** and two **firn models** in identifying **PFAs** in **Antarctica,**
as a pointer for observations

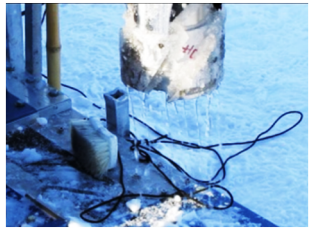
1. RACMO2



2. ASCAT retrieval



3. Finding PFAs in-situ



Julie Miller ©

The Antarctic Peninsula

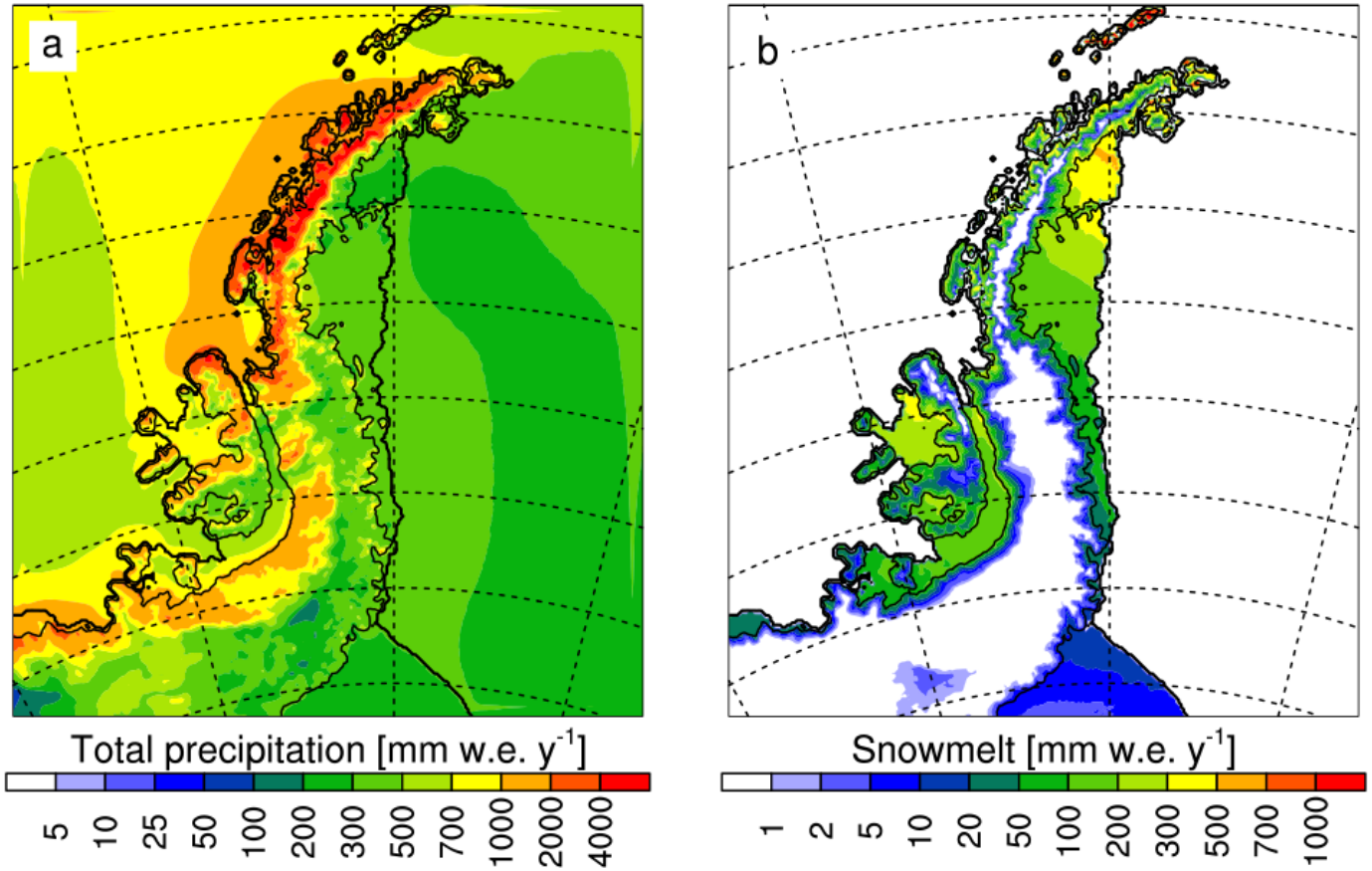
RACMO2.3p2 output, Van Wessem et al, *The Cryosphere, 2018*

Requirements for PFAs:

1. High **accumulation**
2. High **surface melt**

Kuipers Munneke et al., *GRL,* 2014

Where? The Antarctic Peninsula!

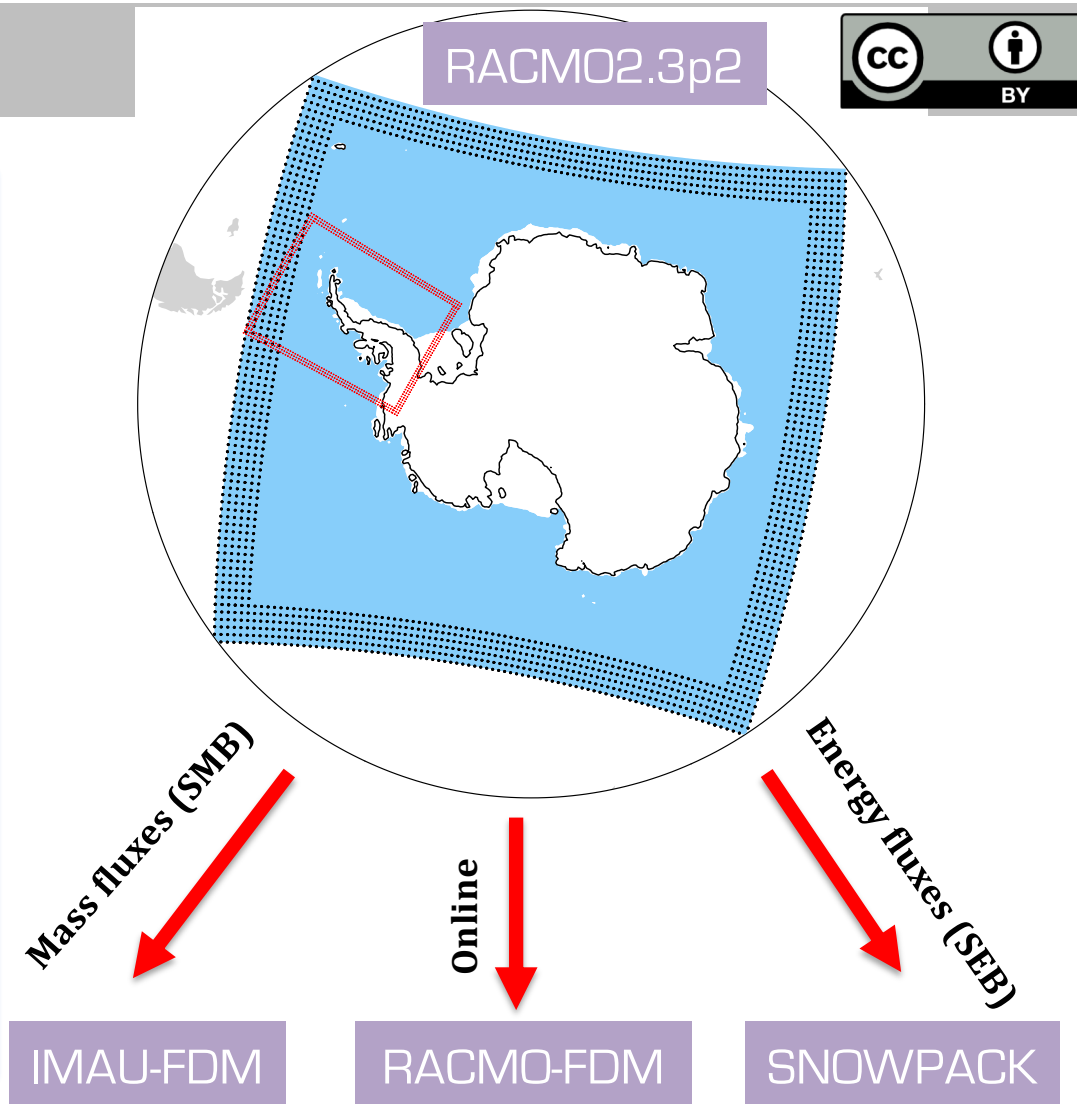


Methods

1. **Atmospheric/surface forcing** (SMB or SEB) from **RACMO2.3p2**

2. Two offline **1D Firn/snow** models

- **IMAU-FDM** (Ligtenberg et al., *The Cryosphere*, 2011)
- **SNOWPACK (SP)** (Lehning et al., *Cold Regions Science and Technology,* 2002; Steger et al., *The Cryosphere,* 2017)



Evaluation

Main differences snowmodels (FDM vs SP)

1. Irreducible water content (2% vs ~4%)
2. SMB vs SEB -> different melt
   - slightly different turbulent (and sublimation) fluxes
3. SP dry snow densification is weaker

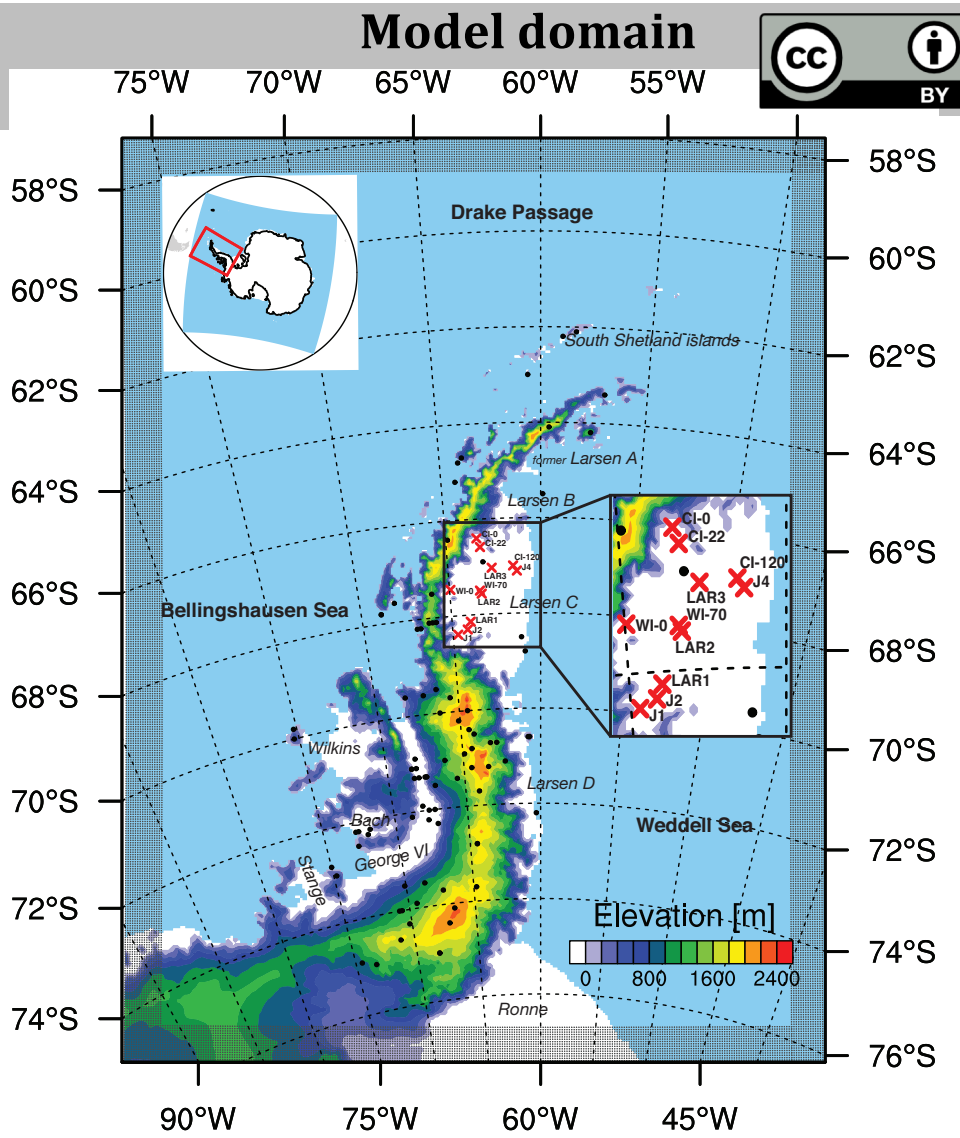


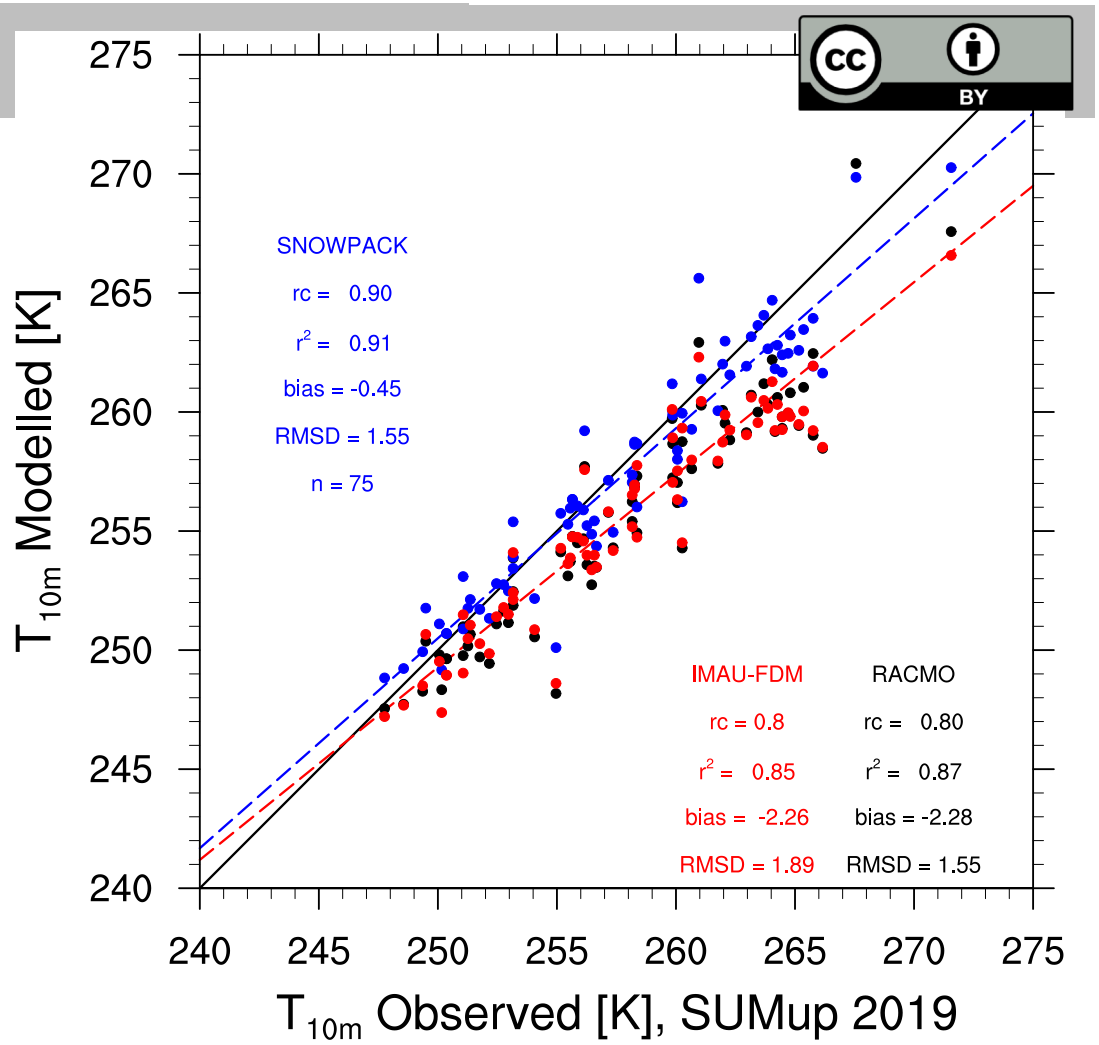
Figure: Dots represent 10 m snow temperature observations, crosses density profiles

Evaluation

10 m snow temperature important PFA parameter, as it represents meltwater (refreezing) effects

Results:

1. SNOWPACK in SEB mode **better** in **warmer** conditions
2. Increasing **bias** towards higher **melt-rates**

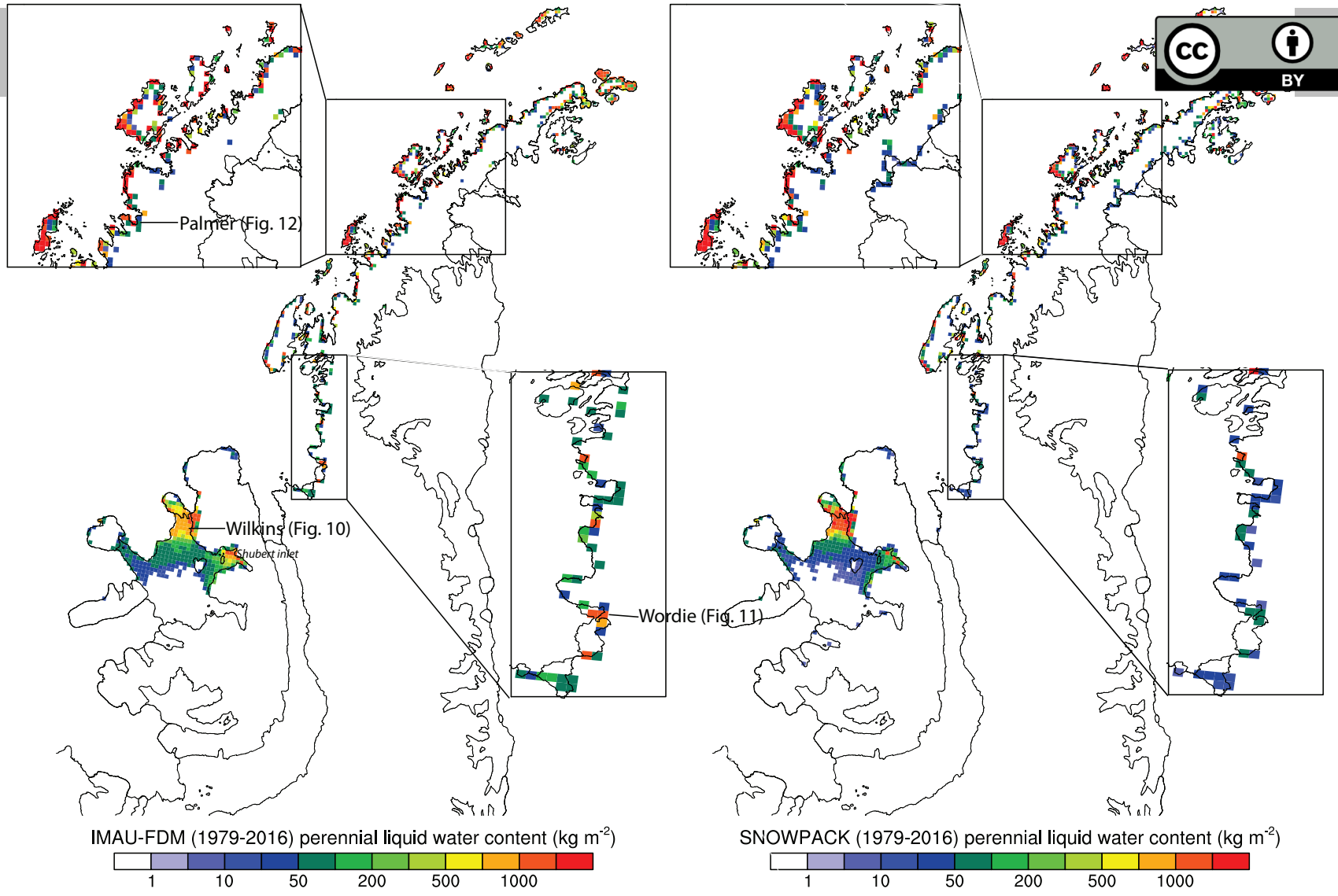


RESULTS

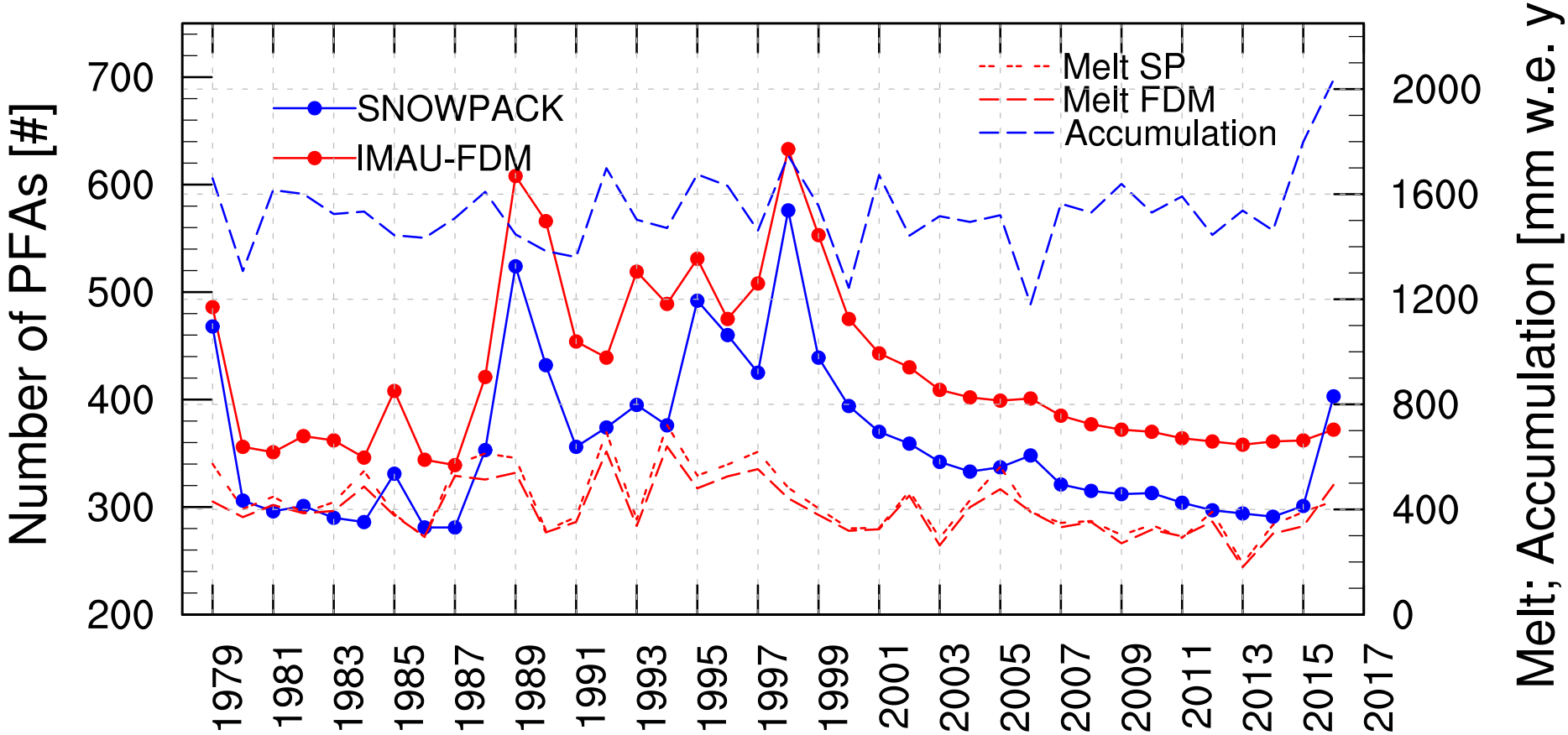
A small subset of results:

1. Modelled PFA locations in the Antarctic Peninsula
2. PFA sensitivity to accumulation/melt
3. Example: Wilkins ice shelf

MODELLED PERENNIAL LIQUID WATER LOCATIONS



Interannual PFA variability



Example: Wilkins ice shelf

Features:

- Large interannual variability
- Merging PFAs
- Refreezing in 00's

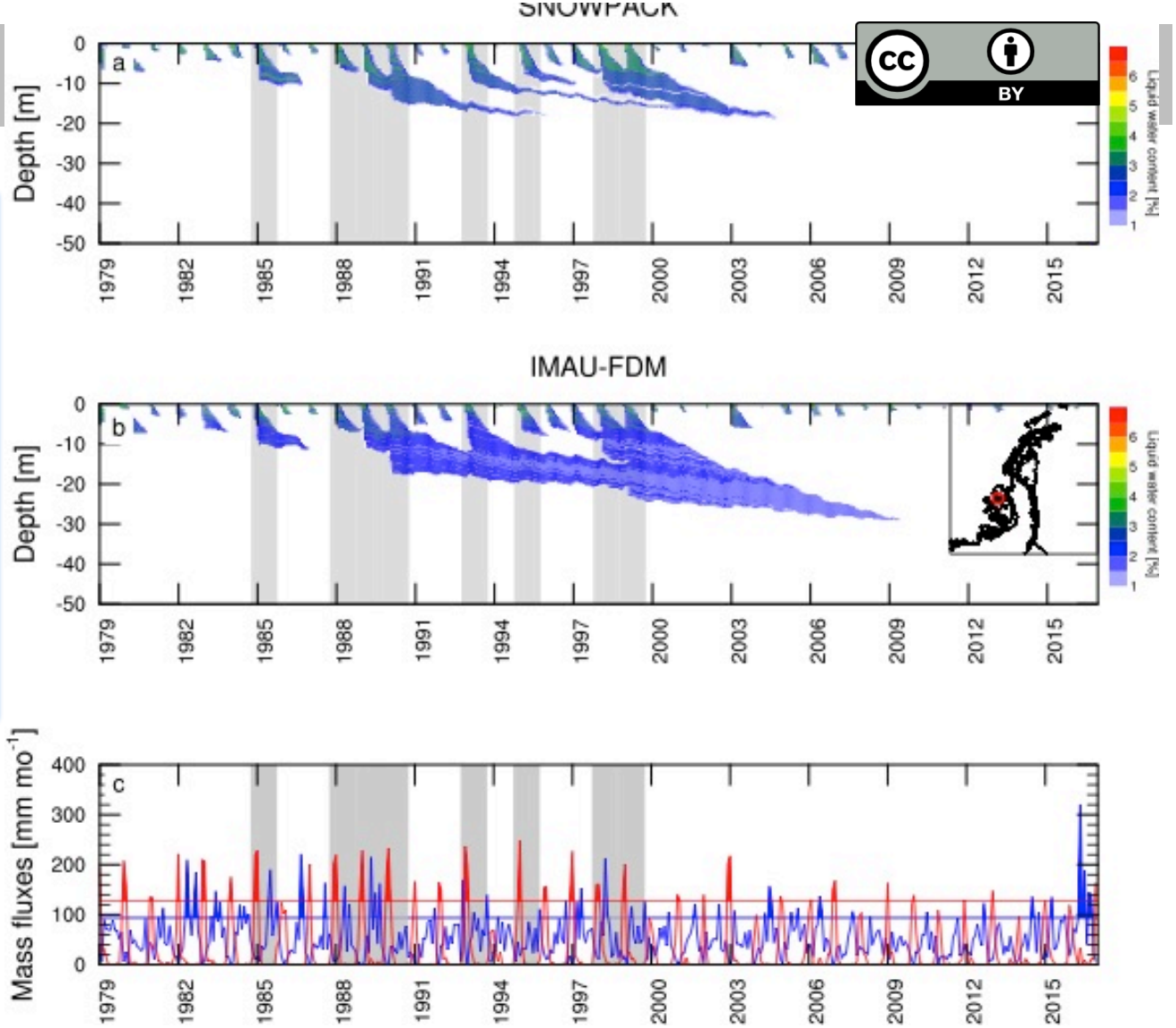


Figure: a,b) Volumetric water content (%), c) Monthly melt (red) and accumulation (blue).
Grey highlights represent significant PFA formation years

Discussion

Model limitations:

Due to computational limitations no meltwater ponding and superimposed ice; therefore PFAs only mimicked by irreducible water content. Also no lateral water movement. Results are first order estimate of firn processes and serves as first PFA identification.

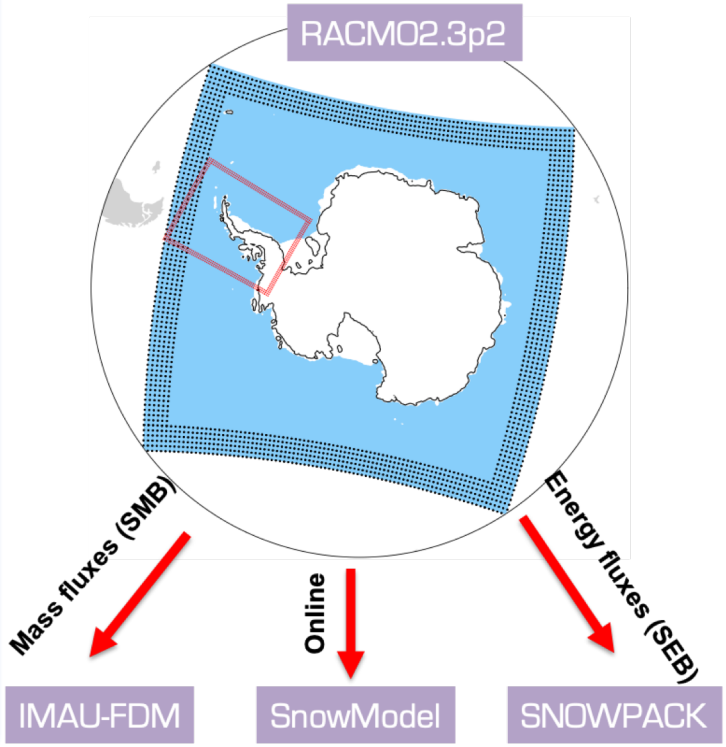
Outlook:

Do PFA locations coincide with viable or disintegrated ice shelves? (See Prince Gustav, Larsen A, B, Wordie and Wilkins ice shelves)

Conclusions

We want to identify PFAs in the Antarctic Peninsula using a sophisticated Firn/Snow Model:

- Results from **IMAU-FDM / SNOWPACK** are consistent, but with local differences; SNOWPACK performs slightly better for relevant locations
- Several locations in the western AP that have PFAs: **Wilkins, Wordie, Palmer Land**
- Links to **ice shelf stability** are possible



Thank you!

IMAU Ice & Climate group:
http://www.projects.science.uu.nl/iceclimate

Ask your questions in the chat, or email me through **j.m.vanwessem@uu.nl**;
Or tweet me through: @jmvanwessem

Obviously more results are available than in this brief presentation.