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Added value of the regional climate model MAR for simulating the surface mass balance of the Antarctic ice sheet compared to a global climate model (ACCESS1.3)

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I. Introduction

Global climate models (**GCMs**) are used to perform climate projections and their results **will be used as inputs for ice sheets models for the next IPCC report**

BUT: GCMs
- Poor representation of polar climates specificities (snowpack evolution in terms of melting, refreezing, or albedo change, katabatic winds, drifting snow,…)
- Spatial resolution too coarse for correctly representing the ice sheet margins or areas with a high Surface Mass Balance (SMB) variability

} Base of a polar-oriented **Regional Climate Model (RCM)**

Question: Is using a RCM required to represent the (current) SMB of the Antarctic Ice Sheet?

II. Methods

Comparison of the SMB computed with ACCESS1.3 outputs and the SMB modelled by the RCM MAR

- **SMB =** mass gain (**Snowfall, rainfall, deposition)** - mass loss (**sublimation, runoff)** at the surface
- **ACCESS1.3**
  - Best GCM for simulating precipitation over the Antarctic ice sheet (Palerme *et al*., 2017)
  - Best GCM for forcing a RCM (Agosta *et al*.,2015)
  - **1.25°x1.25° resolution**
- **MAR**
  - Polar-adapted physics (interactive snowpack module, polar clouds, ice-snow-atmosphere interactions)
  - RCM that correctly represents the Antarctic SMB
  - Two set of simulations at a **35 km resolution**

MAR forced by the reanalysis ERA-Interim over 1980-2005 (**MAR-ERI**)

MAR forced by ACCESS1.3 over 1980-2005 (**MAR-AC3**)

III. Results

a. Evaluation against SMB observations

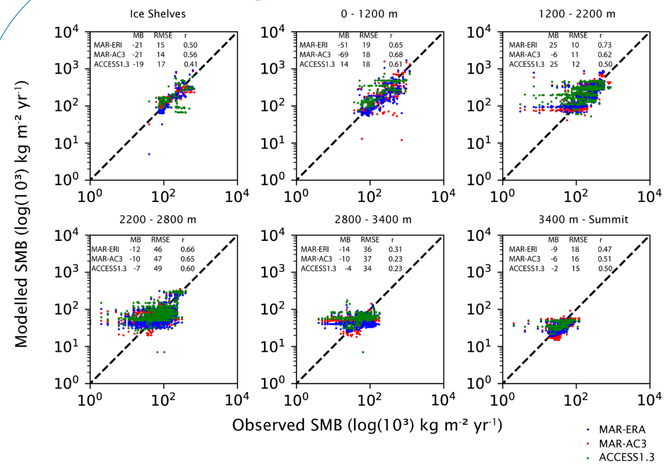

Fig 1. Comparison of the SMB modelled by MAR-ERI*, MAR-AC3 and computed with ACCESS1.3 against SMB observations at different altitude bins. Locations of SMB observations are shown in Fig 2.(a). *Mean values over 1980-2005 are used to remove the advantage of using a reanalysis as forcing.

b. Spatial comparison

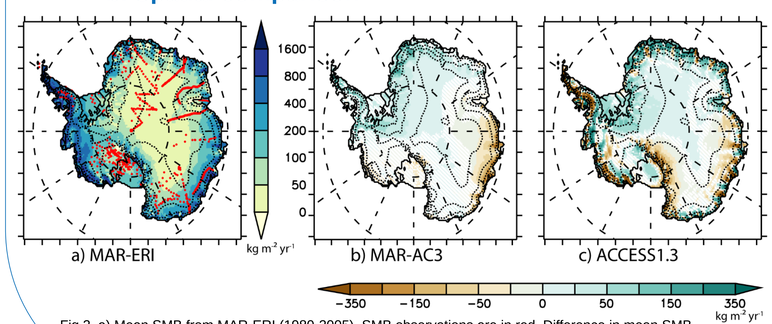

Fig 2. a) Mean SMB from MAR-ERI (1980-2005). SMB observations are in red. Difference in mean SMB for a) MAR-AC3 b) ACCESS1.3 compared to MAR-ERI. Non-significant differences are hatched.

c. Integrated values

	SMB	SF	RF	SU	ME
MAR-ERI	2557	2664	33	140	35
MAR-AC3	2635	2717	41	123	41
ACCESS1.3	2507	2714	21	228	-

Tab 1. Integrated mean Surface Mass Balance, Snowfall, Rainfall, Sublimation and Melting over the whole Antarctic Ice Sheet* over 1980-2005 in Gt yr^{-1} (*as defined by the MAR ice mask).

- **No significant difference in the comparison with the observations between ACCESS1.3 and MAR**
  - **Observations too sparse** (notably where there are large differences between ACCESS1.3 and MAR)
- No significant difference in the integrated mean SMB and components (except for the sublimation)
- **Few significant differences between MAR-ERI and MAR-AC3 while Significant differences between ACCESS1.3 and MAR-ERI** (notably over margins and glacier valleys or regions with a high topographic variability)
- ACCESS1.3 correctly represents the mean current SMB of the Antarctic ice sheet (compared to available observations) since **current melting** and runoff **are negligible**

IV. Discussion

Representation of summer temperatures

	Mean Bias	RMSE	r
MAR-ERI	-1.6	2.2	0.99
MAR-AC3	-1.2	2.6	0.99
ACCESS1.3	-2.6	4.1	0.97

Tab 2. Comparisons (Mean Bias, Root Mean Squared error in °C and correlation), with temperature observations at 51 locations.

- **MAR better represents summer temperatures**
- Importance in the context of global warming
  - Representation of snow melting and associated feedbacks

V. Conclusion

- **Using a RCM seems to be not required to represent the current mean SMB of the Antarctic Ice Sheet since the SMB mainly depends on snowfall**
  - But biased evaluation due to the lack of observations
- Better representation of the summer climate by MAR that can also simulate snow melting and associated feedbacks
  - It suggests an **added-value of a RCM in a warmer climate**
- Next steps = performing projections with MAR forced by ACCESS1.3 and comparing SMB changes at the end of the 21st century

References

Agosta, C., Fettweis, X., and Datta, R.(2015) Evaluation of the CMIP5 models in the aim of regional modelling of the Antarctic surface mass balance, *The Cryosphere*, 9, 2311-2321, https://doi.org/10.5194/tc-9-2311-2015.
Palerme, C., Genthon, C., Claud, C., Kay, J. E., Wood, N. B., and L'Ecuyer, T. (2017). Evaluation of current and projected Antarctic precipitation in CMIP5 models. *Climate dynamics*, *48*(1-2), 225-239.