DE LA RECHERCHE À L'INDUSTRIE

Insights from the first analysis of Antarctic water stable isotope simulations for the historical period

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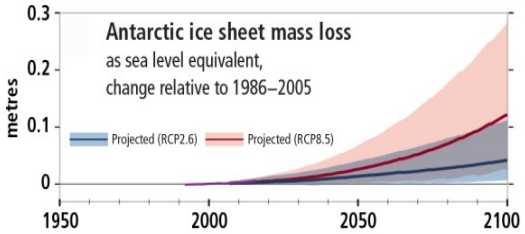
Context

1. The Antarctic continent, a high potential of sea level rise with many uncertainties



Adapted from IPCC, SROCC, 2019

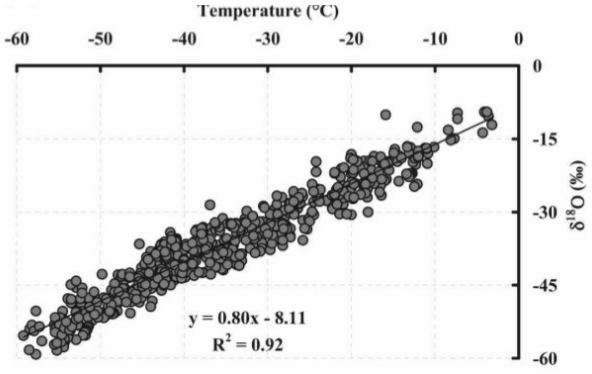
The problem

2. A drilling in the past for a better comprehension of present climates

EGU blogs, Credit: Brice Van Liefferinge

The field

3. Analyses of climate proxy from archives for the reconstruction of past climates



Masson-Delmotte et al., AMS, 2008

Results based on theory

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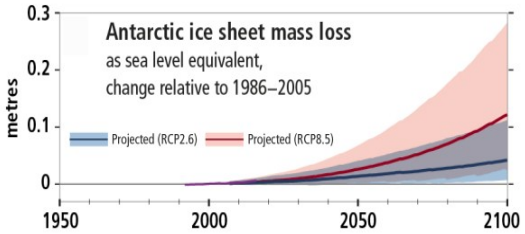

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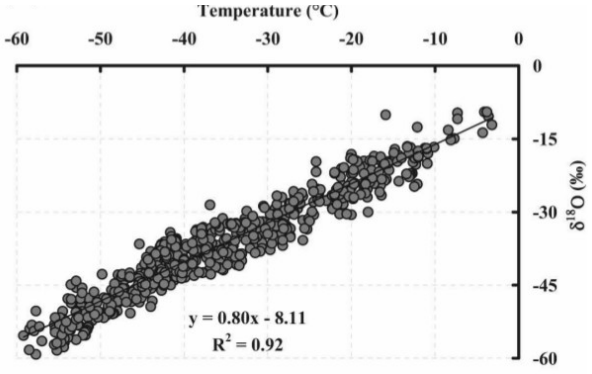

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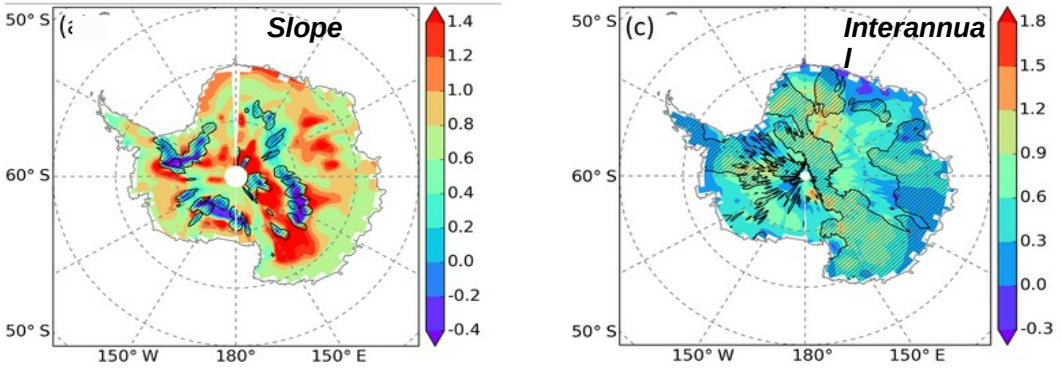
Results based on theory

BUT…
… the theory does not hold in time and space !

The Surface Air Temperature (SAT) – $\delta^{18}O$ slope



Adapted from Goursaud et al., CP, 2019

Results from an ECHAM5-wiso simulation over 1979-2013

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The contribution of individual drivers of the SAT – $\delta^{18}O$ relationship

Definition of the proxy

$$\delta^{18}O = 1,000 \times \frac{\frac{H_2^{18}O}{H_2^{16}O}}{R_{VSMOW} - 1}$$

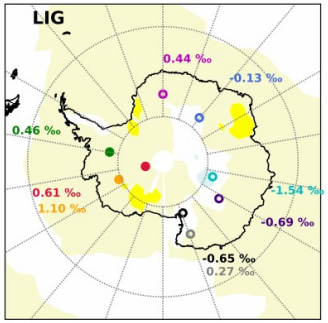
+ precipitation weighted means

Toolbox

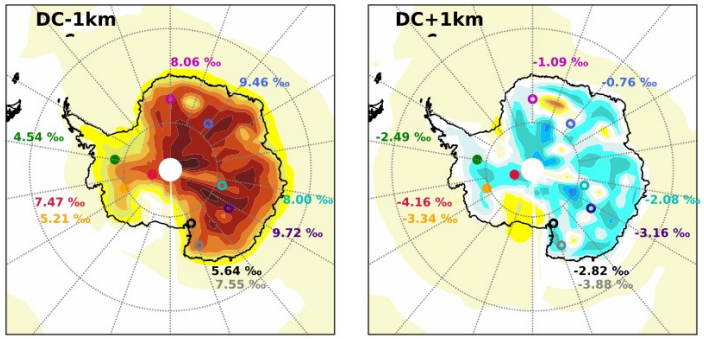
The atmospheric climate model **HadCM3** equipped with water stable isotopes (Tindall et al., JGR, 2009) with a grid resolution of 2.5° x 3.75°

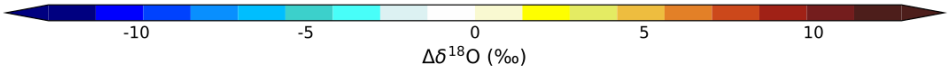
State of the art: for the Last Interglacial (LIG; 130,000 – 115,000 y ago with a peak at 127,000 y)

→ ***Pre-Industrial***



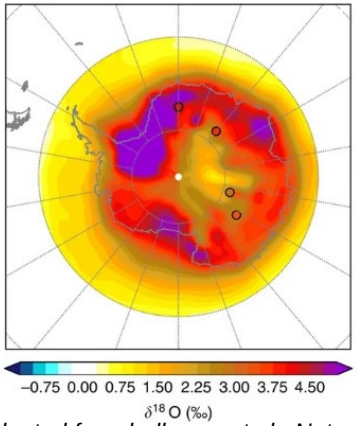
→ ***Effect of the elevation***





Adapted from Goursaud et al., GRL, 2021

→ ***Effect of the sea-ice***

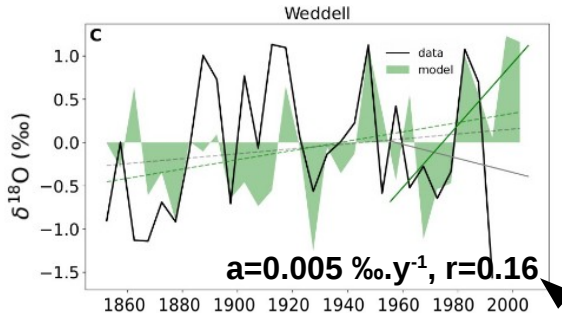


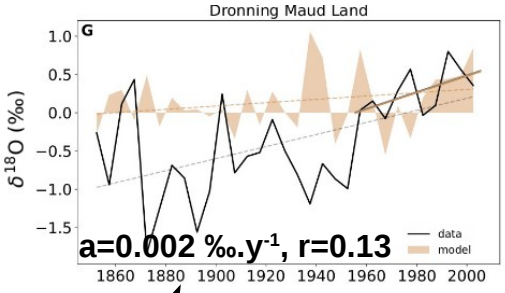
Adapted from holloway et al., Nature, 2016

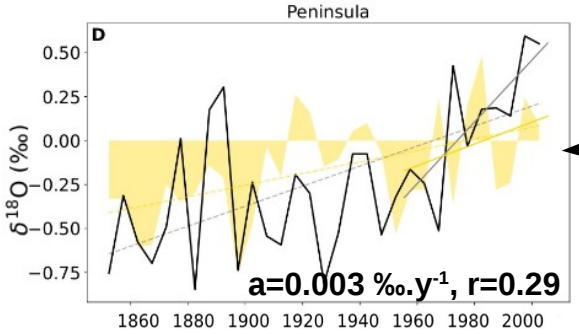
This study

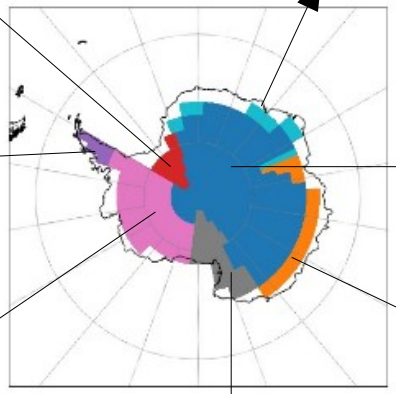
- A set of 6 simulations over the period 1850-2004
- Analyses of detrended SAT, precipitation and $\delta^{18}O$
- Regional scale: 5 years binned outputs for a comparison with data

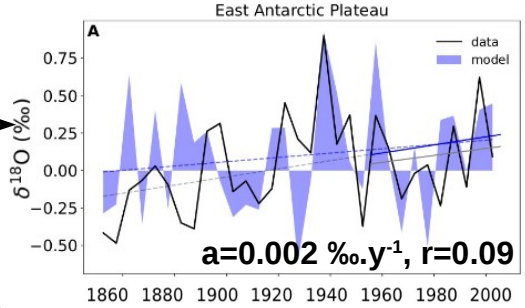
Very weak $\delta^{18}O$ relationships at the regional scale over the period 1850-2004

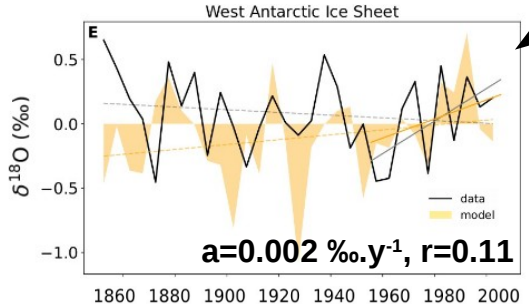


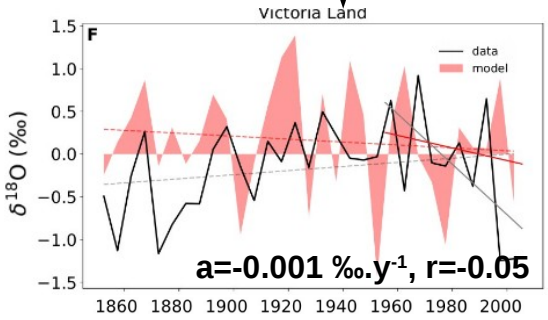


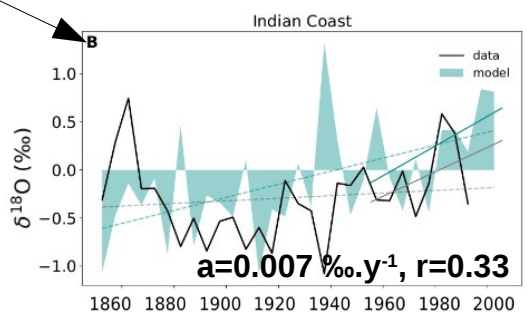






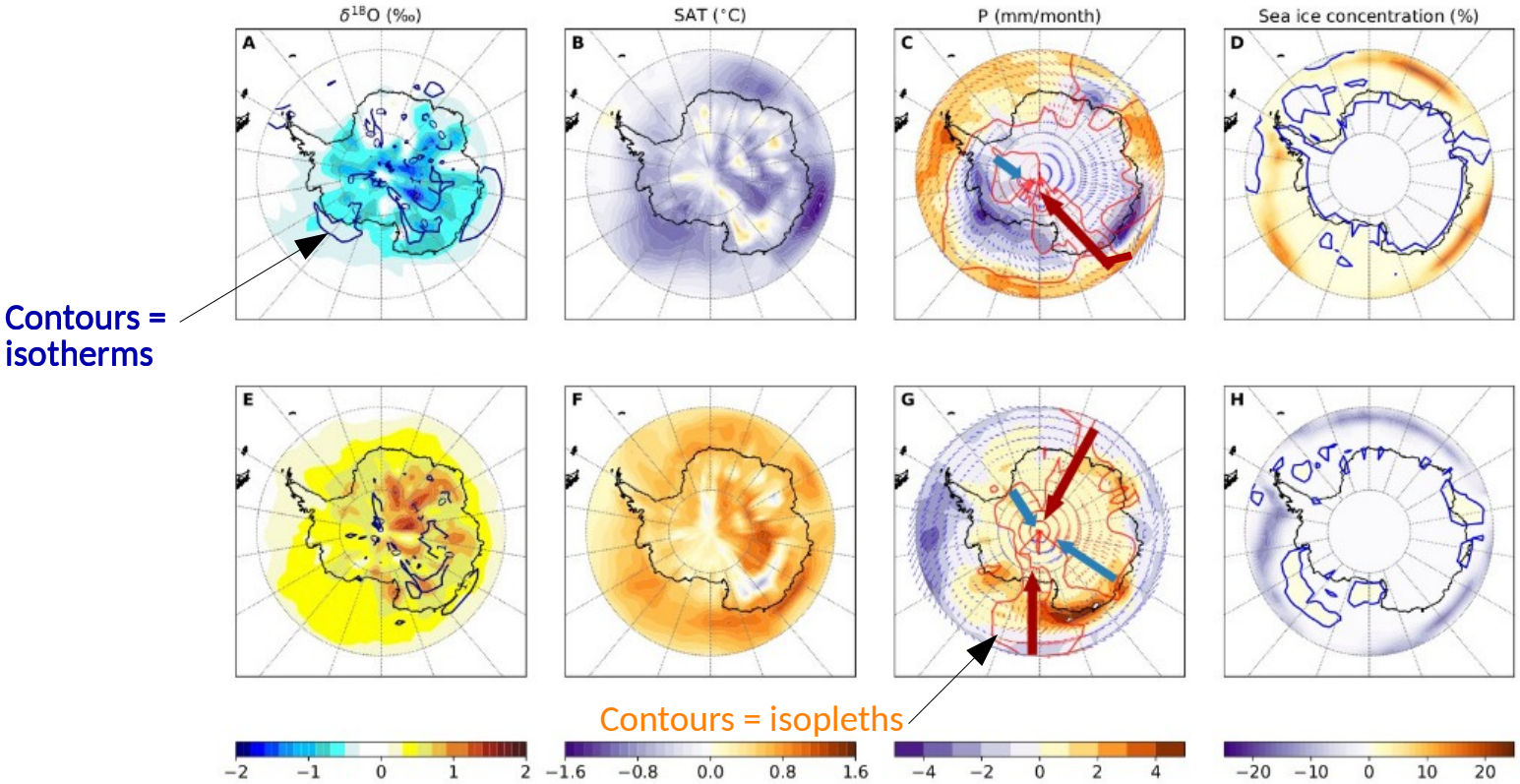






Investigation of cold and warm ensembles (~20 years), a dynamic response

[Ensembles defined as: SAT out of the mean ± 2 standard deviation range]



1. Cold and warm ensembles are not symmetric for $\delta^{18}O$, P and winds contrary to SAT
2. *In the cold ensemble* : (1) Cold and wet air masses entering through Victoria Land > depleted $\delta^{18}O$ over VL ; (2) coastal wet and cold air masses entering from Weddel > depleted $\delta^{18}O$ over a ~280° longitudinal ridge
3. In the warm ensemble : Warm and dry air masses entering from the Ross sea and at ~30° resulting in enriched $\delta^{18}O$ in these areas

Conclusions and perspectives

Take-home points:

- Historical outputs from the HadCM3 model show that $\delta^{18}O$ changes are linked to the mesoscale atmopheric dynamic.

- This is not taken into account when weighting by the precipitation (precipitation of the grid where $\delta^{18}O$ is computed).

- This might be a reason for weaker temporal SAT – $\delta^{18}O$ linear relationships.

Perspectives:

- A quantification of these processes is required for each key past period at the regional scale for better reconstructions from ice core records.

- An inter-comparison between models equipped with water stable isotopes woud help deciphering what result from model drifts from atmospheric dynamic, and thus build a benchmark for the ice core community.

Thanks for your attention