Reconstructing the distribution of surface mass balance over East Antarctica (DML) from 1850 to present day

N. Ghilain, S. Vannitsem (RMI), Q. Dalaiden, H. Goosse (UCLouvain)

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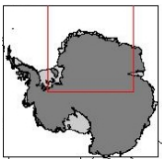
- **SMB total AIS** increase since 1800 AD

  → 75% due to Antarctic Peninsula (Thomas et al, 2017)

- **SMB over DML** decreases at many places (Schlosser et al, 2014; Altnau et al, 2015), but increases in others (Philippe et al, 2016, Shepherd et al, 2012).



However, climate models over DML are not always in agreement with ice cores.

Our objective:

Reconciliation ice core & models ? ⇨ **High resolution maps needed !**

	Point	5 km	50 – 100 km
Past 40 yrs	Ice cores	RCM	Reanalyses
Past 150 yrs	Ice cores	**This study**	GCM

This study - reconstruction in 3 questions:

How ? | **Past 40 years ?** | **Past 150 years ?**

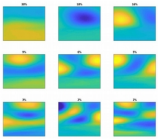
How

How do we reconstruct snowfall (& SMB) @5 km over DML coast ?

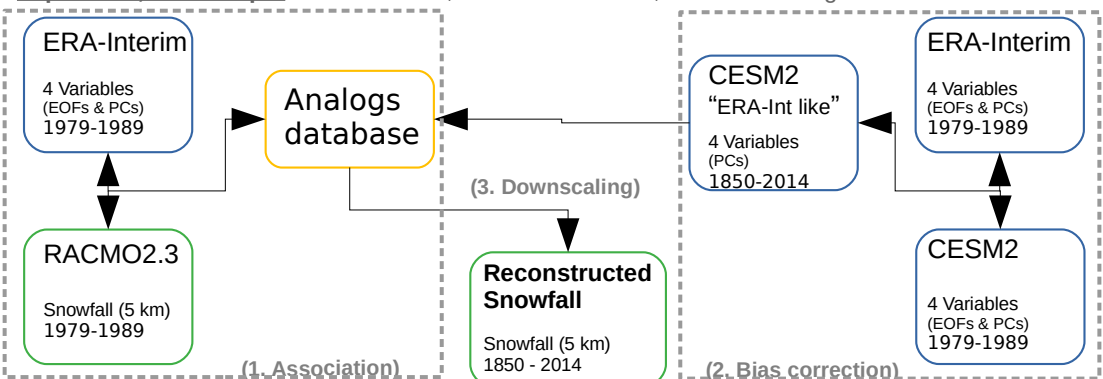
Analogs of Principal Components
from daily large-scale meteorological fields (GCM)
and their association to daily snowfall from RCM.

Analogs
Similar conditions result to similar estimations

Principal Components Analysis
A field can be expressed as a linear combination (PCs) of orthogonal states (EOFs).



In practice, the 3 steps: 1. Association, 2. Bias correction, 3. Downscaling



How

(1. association) Scoring the different "options" of the method helps determining the best choice

Options to test (Examples)

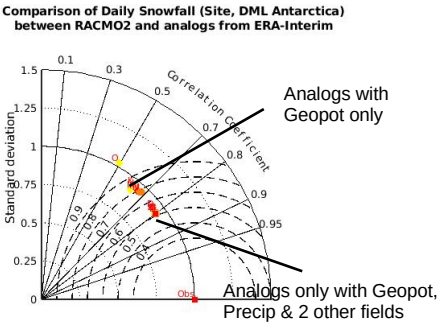
How many years necessary for constructing database ?

Which variables to use ?

Choice based on best statistical scores

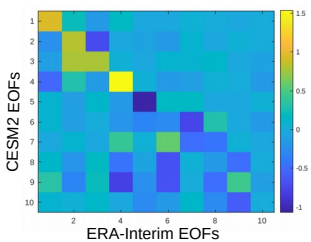
3 minimum (10 yrs used in practice)

Precip, Z_{500hPa}, RH_{700hPa}, Ta_{700hPa} (40 PC)



(2. Bias correction) CESM2 "ERA-Int like" is obtained by linear regression of EOFs

Linear combination



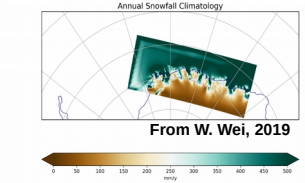
Verification

- Occurence PCs for 1979-1989 similar to ERA-Interim
- Magnitude PCs for 1979-1989 similar to ERA-Interim

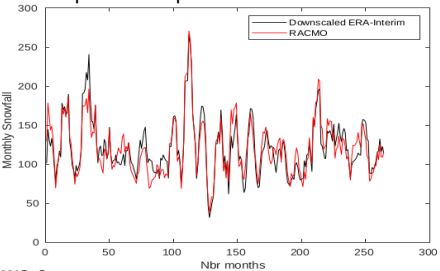
Past 40 years

Comparison of downscaled ERA-Interim reanalysis with RACMO2.3

Region of DML covered by RACMO2.3

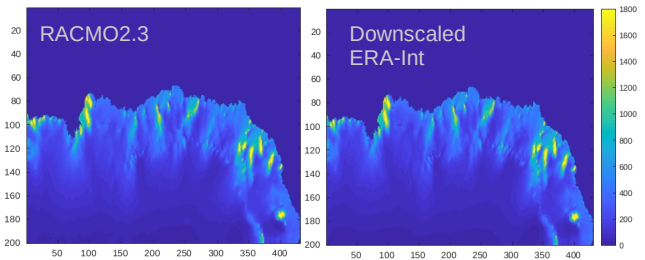


Example near a point of maximum accumulation

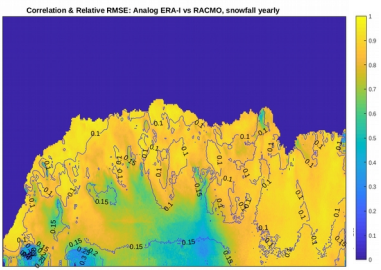


The comparison on the period from 1979 to 2000 **shows a good performance** of the downscaling approach

Comparison for 1996 (Yearly accumulation)

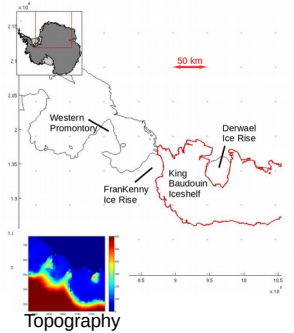


Statistical scores (yearly): total period

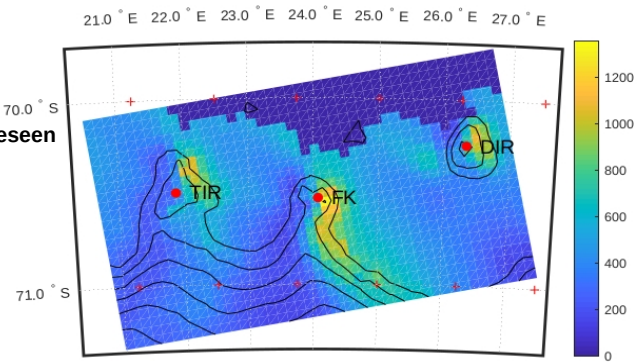


Past 40 years

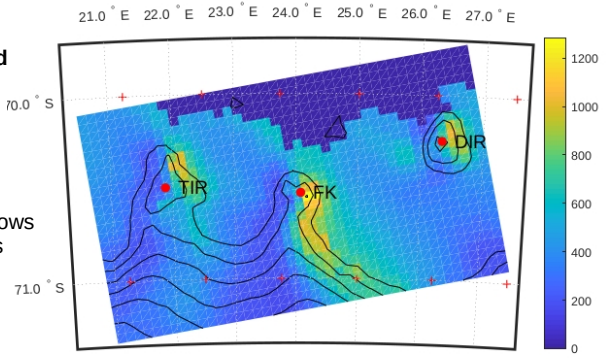
Comparison for 1996 (Yearly accumulation)
Focus on the area of the 3 ice cores sites foreseen



RACMO2.3



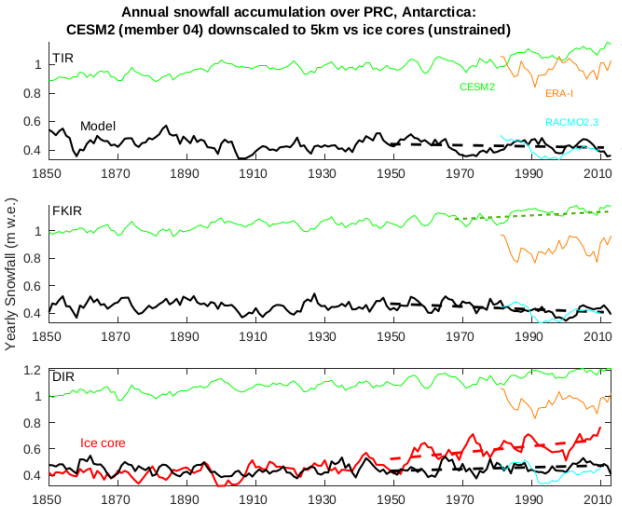
ERA-I downscaled with Analogs



The comparison of yearly accumulation shows a **consistent distribution** over the Princess Ragnhild Coast.

Past 150 years

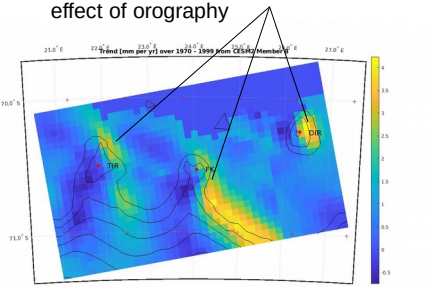
Downscaling of CESM2 runs (10 members)



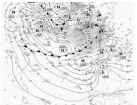
Downscaling with our approach allows a more direct comparison with local measurements:

- bias reduction
- potentially different tendency

Takes into account the effect of orography



From the 10 members, only one is reproducing an increasing tendency at Derwael Ice Rise ice core.



When available, TIR & FKIR ice cores will tell if this scenario is plausible, and changes in weather patterns would be analyzed thanks to the PCs recorded.

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Conclusion

- A downscaling approach based on Analogs of Principal Components to obtain daily snowfall has been set up.
- It uses synoptic scale meteorological fields (only 4 variables).
- The method is applied to reanalysis (past 40 yrs) and to climate simulations (past 165 yrs).
- It yields satisfactory performance when compared to the reference used for training (RACMO).
- Realistic tendencies are found over the past 165 years.
- It is more suitable to comparison with local measurement than coarse scale climate runs.

Next steps

- Comparison with SMB time series from the 3 ice cores and possible interpretation
- Analysis of the characteristic weather patterns, their change through time
- A dataset to be used for further analyses is being constructed. (10 members, 1850-2014, 5 km)