Institut Pierre Simon Laplace
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combine

NEEM

Climat et bilan de masse du Groenland avec un nouveau modèle de neige: Validation et application en paléo-climat

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Réunion des utilisateurs LMDZ, 2 Avril 2012

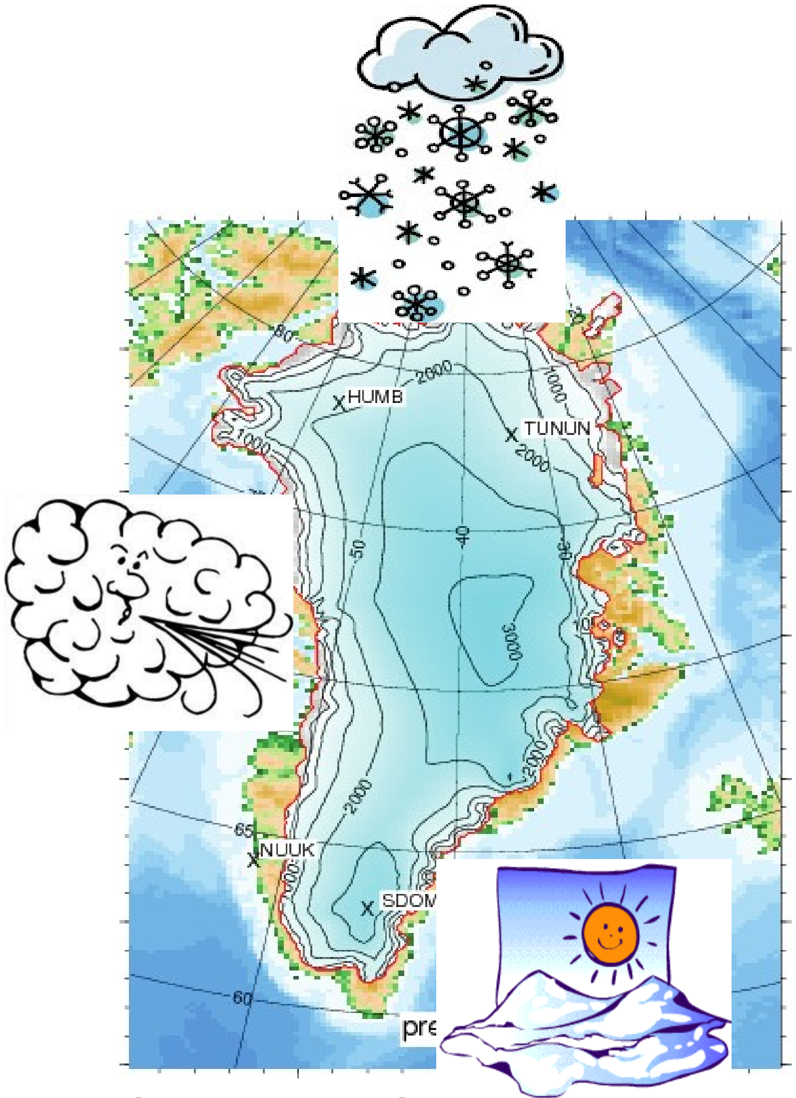
LGGE

Objectives

Improve Greenland surface mass balance (SMB) modelling in LMDZ GCM

Compare SMB to degree-day method

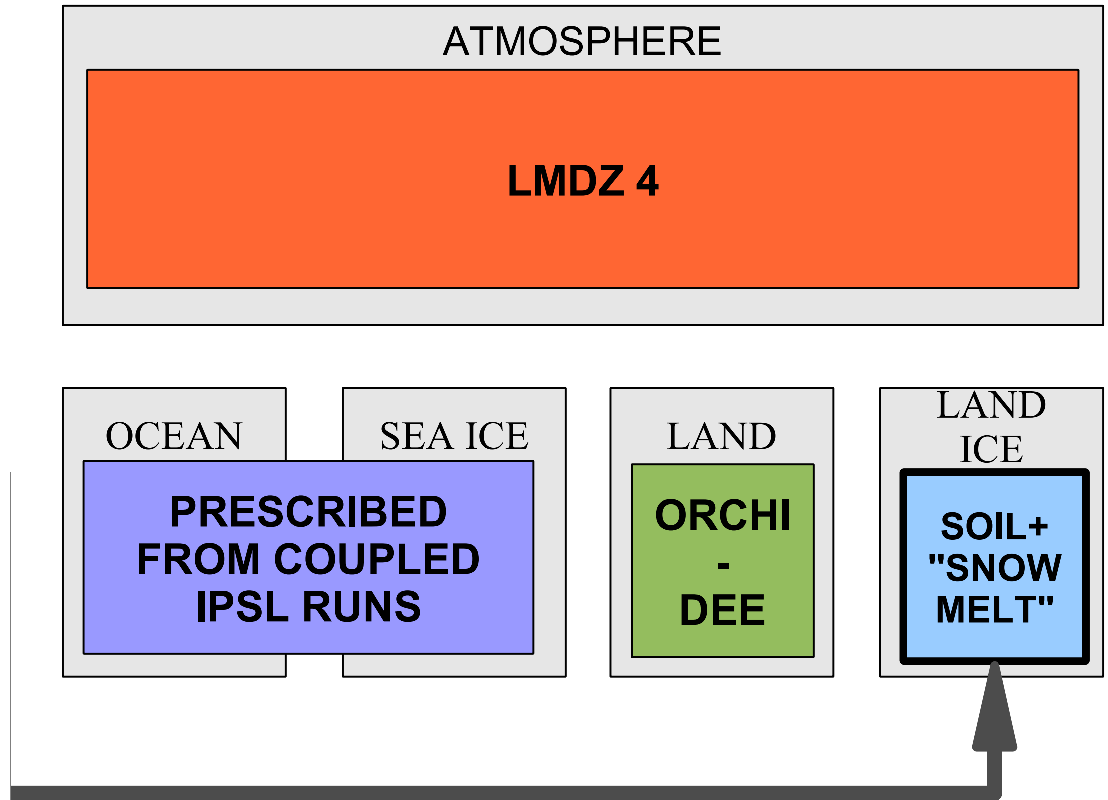
Test sensitivity in paleo-climates



Quiquet et al TCD 2012

Starting Point

Atmospheric GCM
LMDZOR_v2 (2009)

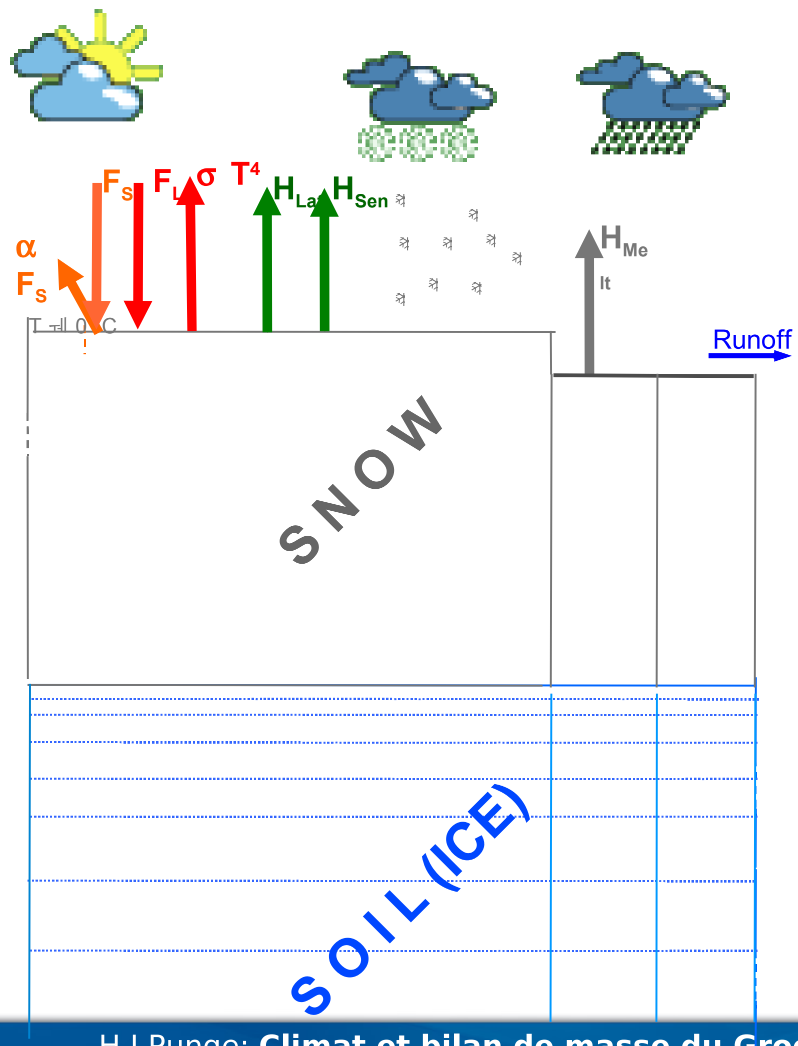


- constant snow albedo, aging not activated
- simple melt routine
- no refreezing
- no percolation
- no snow physics
- fixed accumulation limit

=> SMB representation judged insufficient for ice sheet coupling

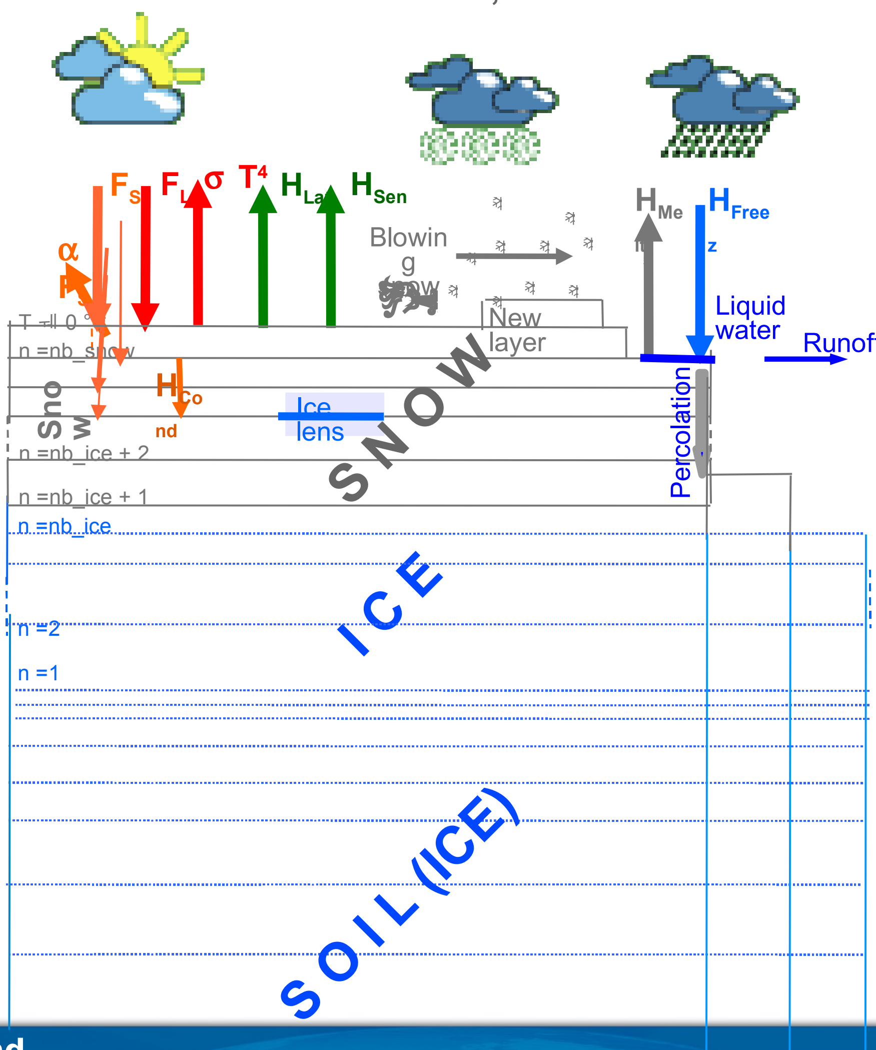
Snow schemes

Standard LMDZ



LMDZ-SISVAT (MAR)

Lefebre JGR 2003, Fettweis TC 2009



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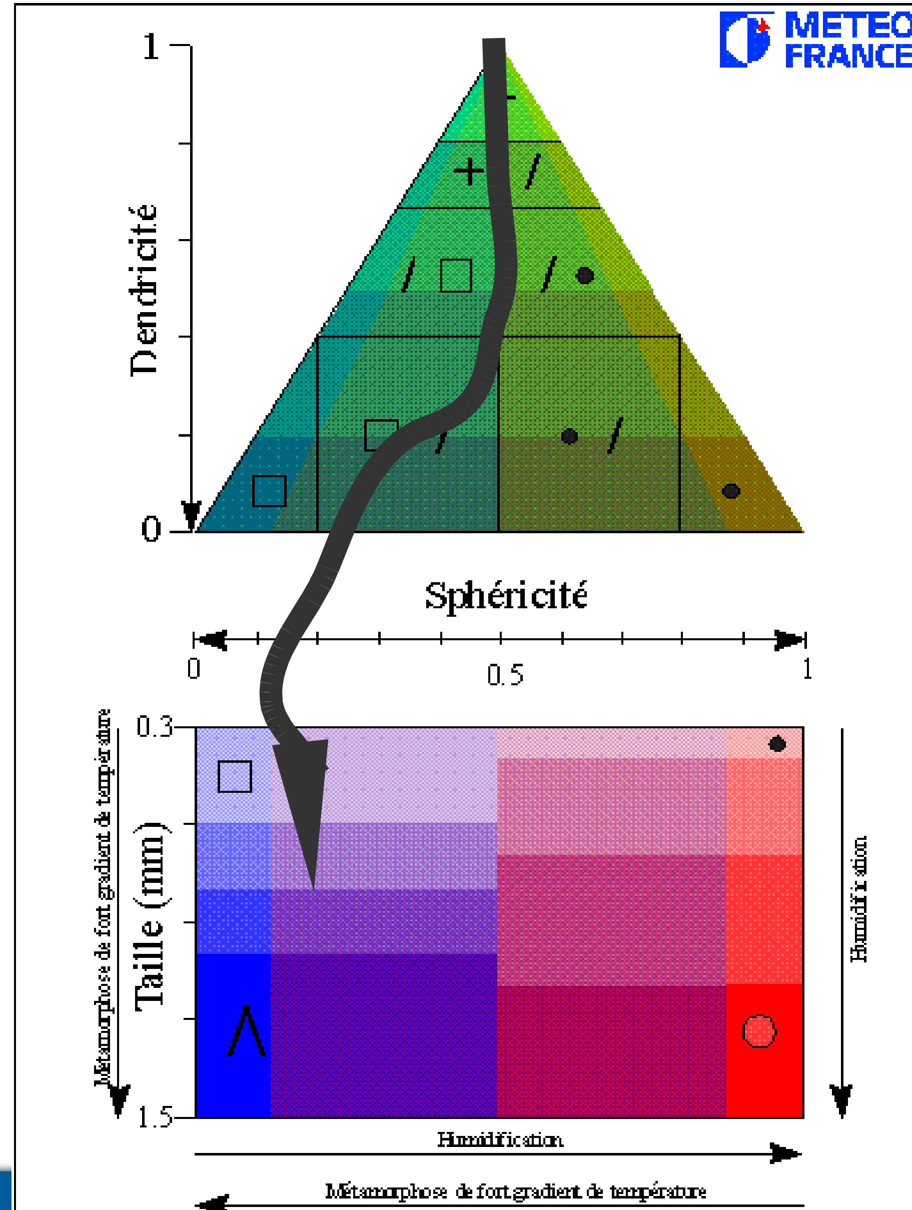
Snow properties

Semi-Empiric Snow description

CROCUS (Brun et al 1989, 1992)**:**

- Fresh snow characterized by dendricity, sphericity

- Aged snow characterized by sphericity, grain size



Principal features

Discrete snow pack (1-35 layers)

Model density and structural properties of snow (from CROCUS model)

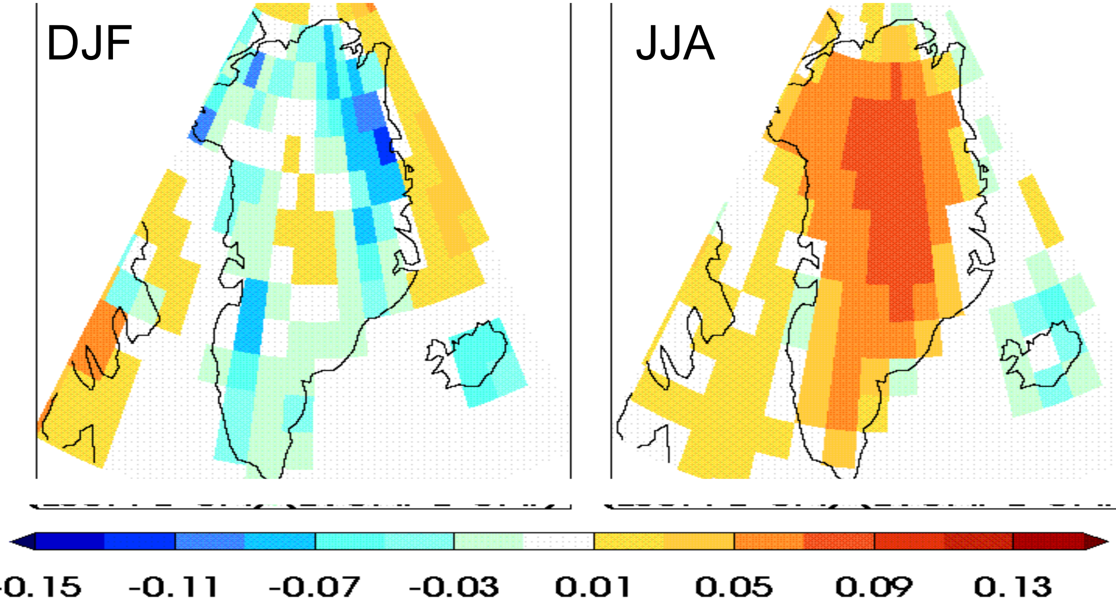
Allow for ice layers and water at surface

Refreezing

Percolation

Variable albedo, 3 wavelength bands

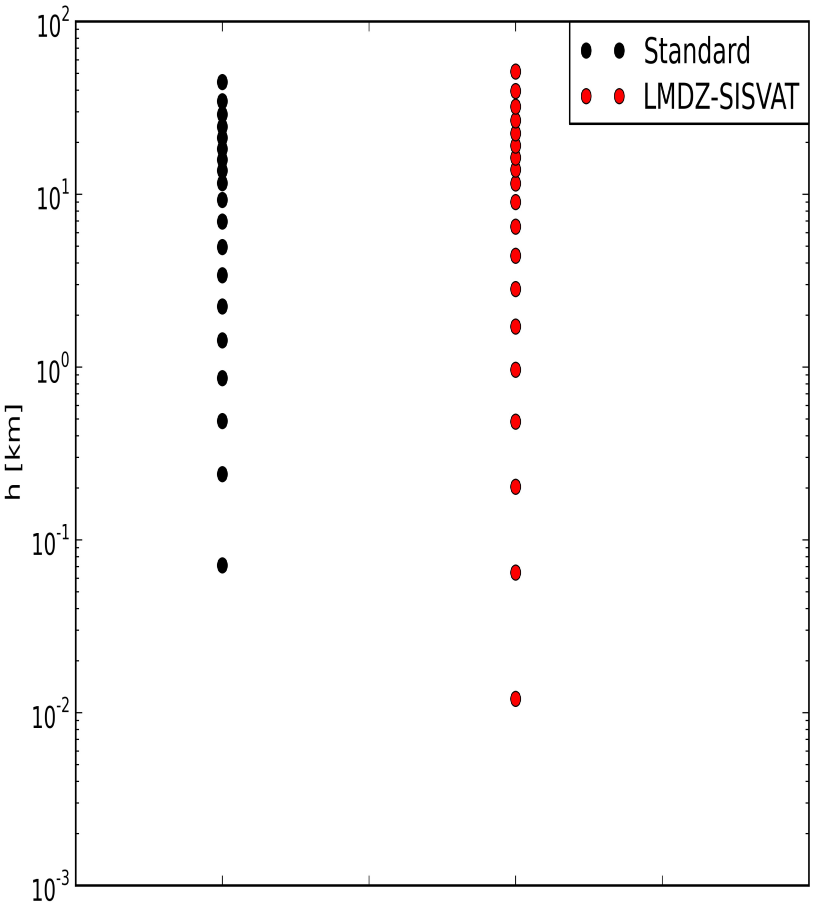
Example:
Climatological albedo, LMDZ-SISVAT
- LMDZ standard



Vertical Levels

Need to have lower first level for better stability

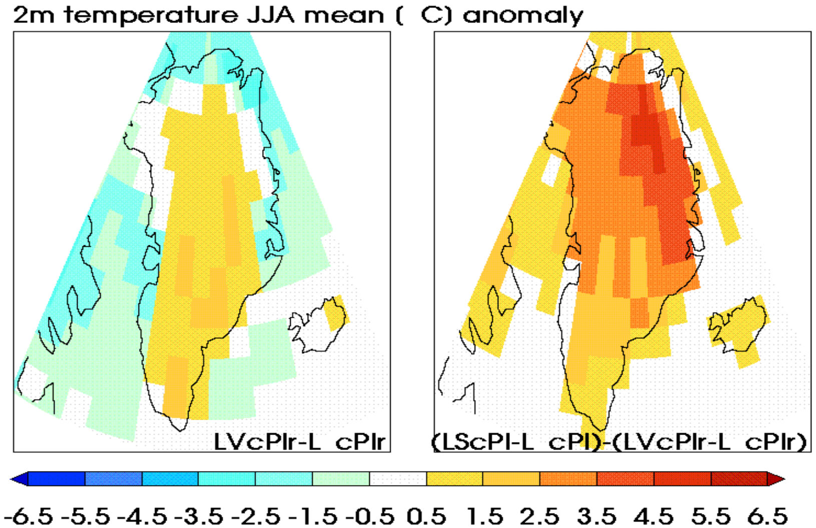
(12m instead of 70m for L19)



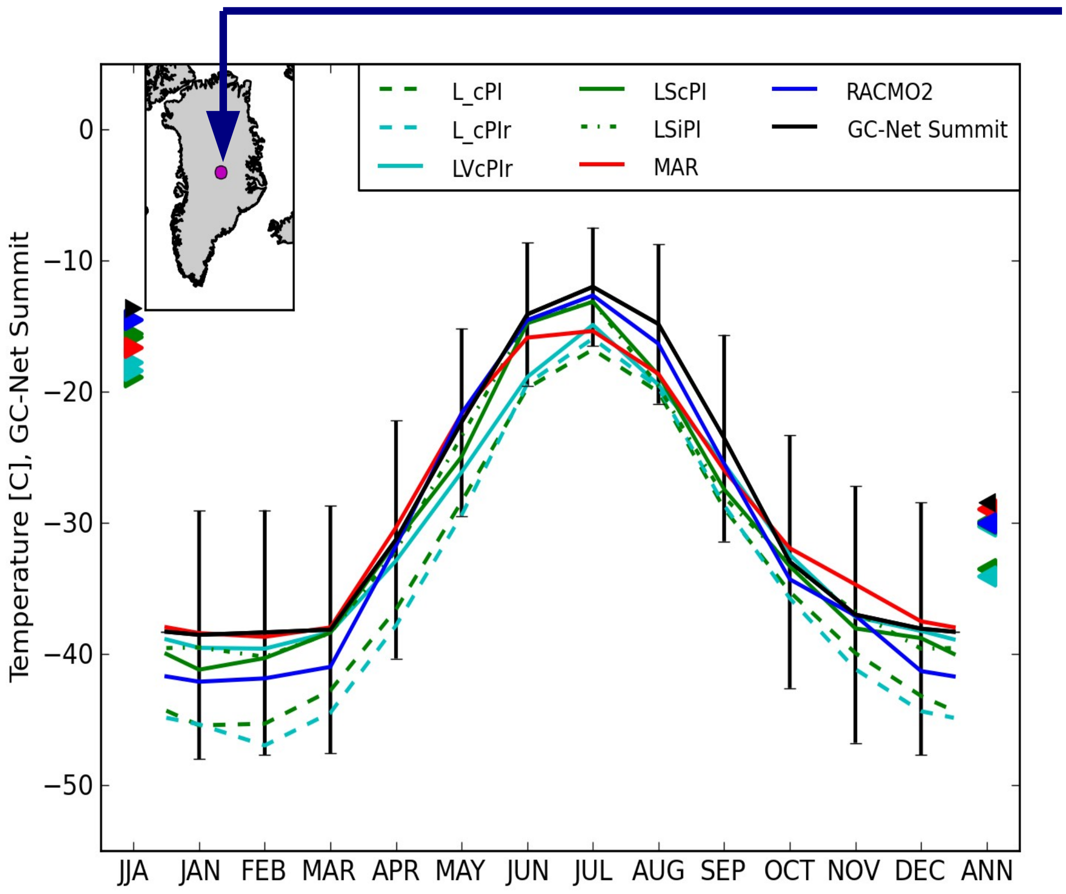
Effect on climate (clouds, heat & moisture transport, ...)

Summer 2m temperature:

Effect of level Change | **Effect of snow model**



Validation



Greenland Summit (3216m asl)

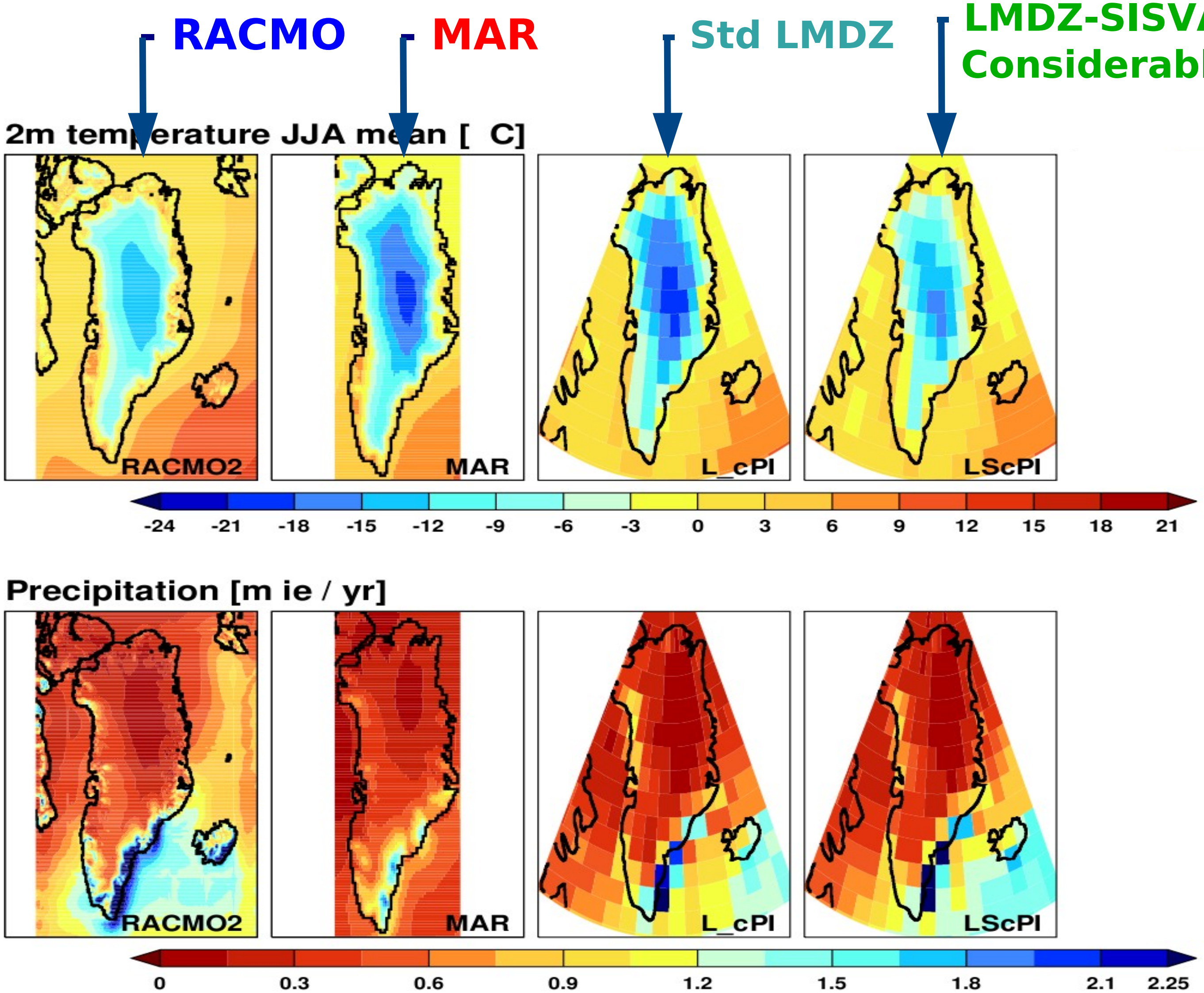
Comparison of LMDZ (LMDZ- SISVAT) simulations to Greenland station data GC-Net (K. Steffen), regional models MAR and RACMO

Level changes: remove cold bias in winter (- - vs —)

LMDZ- SISVAT: removes cold bias in summer (~snow albedo)

Done for 16 stations on and around the ice sheet

JJA temperature, Precipitation

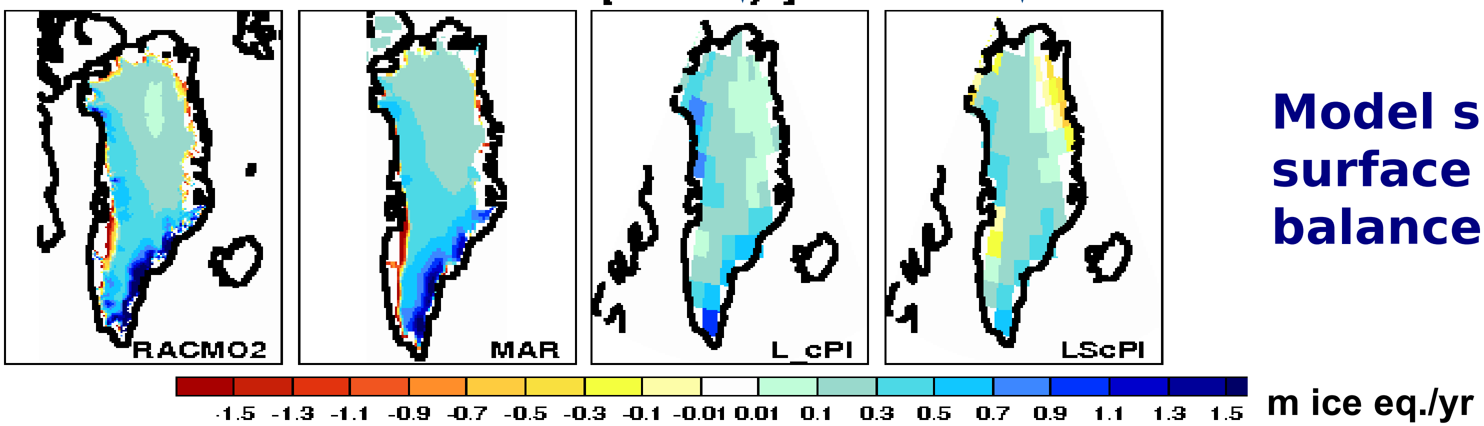


SMB: Better than PDD estimation?

Std LMDZ without threshold

- Melt zones in SW and NE
- Low bias in the NE, SE

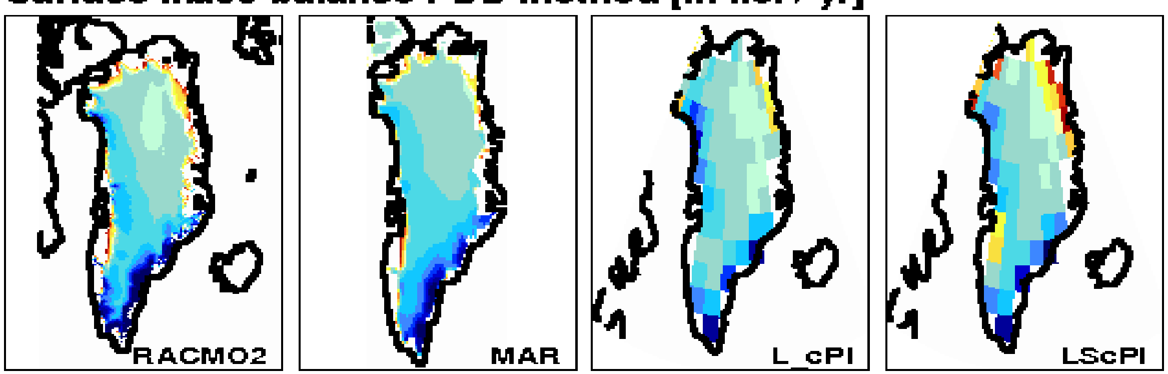
Modelled surface mass balance [m i.e. / yr]



Model simulated surface mass balance

Totals: +464 +371 +415 +238 km3/yr

Surface mass balance PDD method [m i.e. / yr]

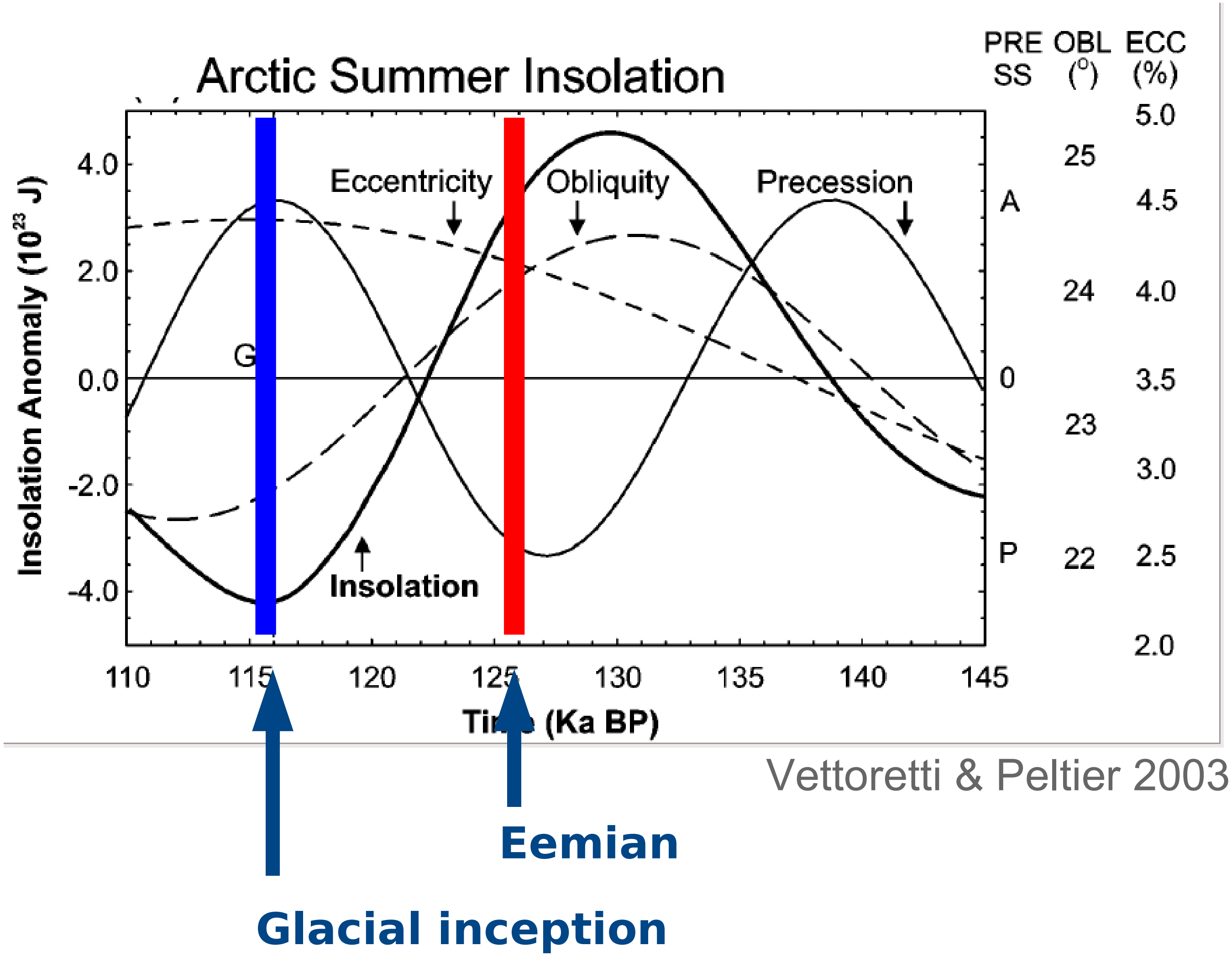


Positive degree days (PDD):

- Empirical method
- estimate SMB from monthly mean temperature and precipitation

Totals: +570 +476 +315 +74 km3/yr

Test sensitivity in Paleo climates



Vettoretti & Peltier 2003

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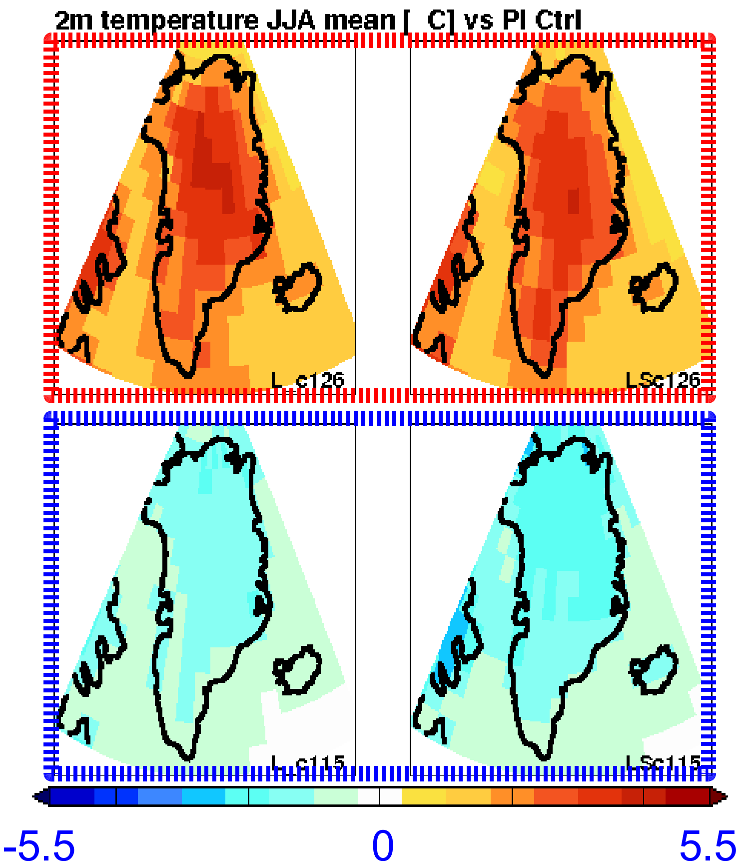
Difference: Past vs PI climate

T2m [°C] JJA

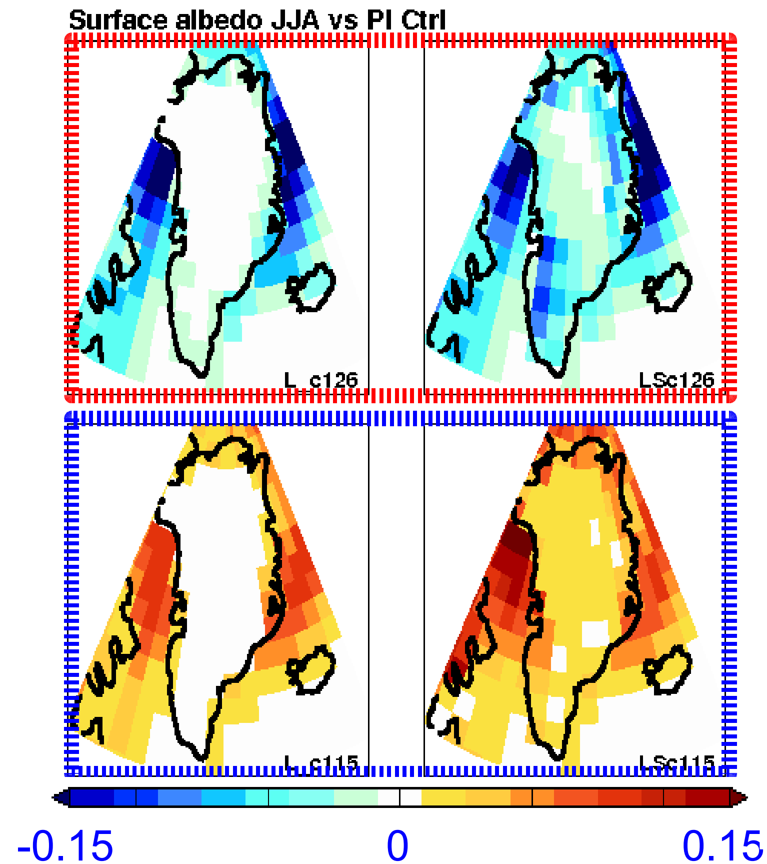


STD LMDZ **LMDZ-SV**

126k - PI

115k - PI

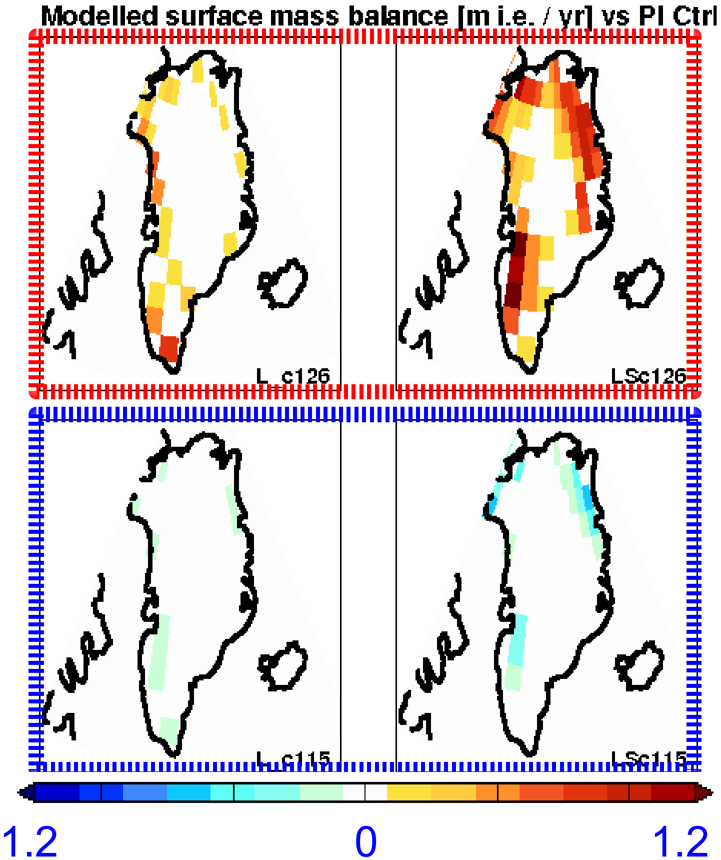
SURFACE ALBEDO JJA



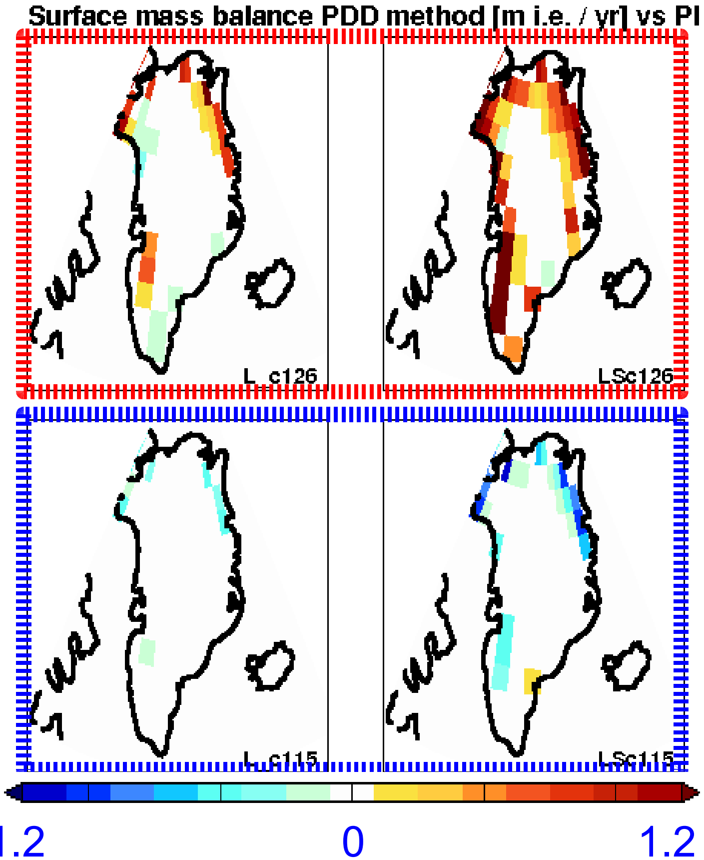
STD LMDZ **LMDZ-SV**

Difference: Past vs PI climate

SMB model [m i.e./yr]



SMB PDD [m i.e./yr]



126k – PI

115k - PI

STD LMDZ **LMDZ-SV**

STD LMDZ **LMDZ-SV**

Conclusions

- New snow model implemented in LMDZ

- Modelled mass balance realistic on central Greenland

- Low bias in coastal zone, related to low resolution, warm bias in NE

- Eemian/inception: Higher alteration of SMB in the new version due to
  - albedo feedback
  - warmer temperatures

- Higher resolution study encouraged

Perspectives

For LMDZ:

- Integrate snow model on ice sheets (as an option?) in LMDZ development tree

- Test it with the new physics/PBL scheme

Ice sheet modelling:

- Calculate snow scheme on ice sheet model grid with downscaled input

- Use snow scheme SMB to force ice sheet model

References

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Summary SMB

Table 2. Summary of simulations, with GIS surface area $[10^6 km^2]$ and total GIS SMB components $[km^3/yr]$

Simulation	Lower boundary	Period	Ice area	Total precip	Evaporation	Months with melt	Runoff	SMB model	SMB PDD
MAR	observed	1979-2005	1701	629	5	—	304	371	476
RACMO	observed	1980–1999	1711	744	26	—	248	466	570
L_cPI	climatol.	PI (ctrl)	1864	652	55	4.2	173	415	315
LScPI	climatol.	PI (ctrl)	1864	697	76	8.2	294	238	74
LSiPI	interann.	PI (ctrl)	1864	709	76	5.6	368	262	78
L_c126	climatol.	126 ka	1864	745	62	10.2	404	285	-55
LSc126	climatol.	126 ka	1864	770	81	14.5	512	-331	-857
LSi126	interann.	126 ka	1864	799	81	11.0	566	-272	-764
L_c115	climatol.	115 ka	1864	646	51	3.7	143	453	440
LSc115	climatol.	115 ka	1864	693	82	6.4	249	367	377
LSi115	interann.	115 ka	1864	673	82	4.6	348	345	330