



CESM winter meeting

Boulder, February 9, 2016

Ice sheet climate in CESM

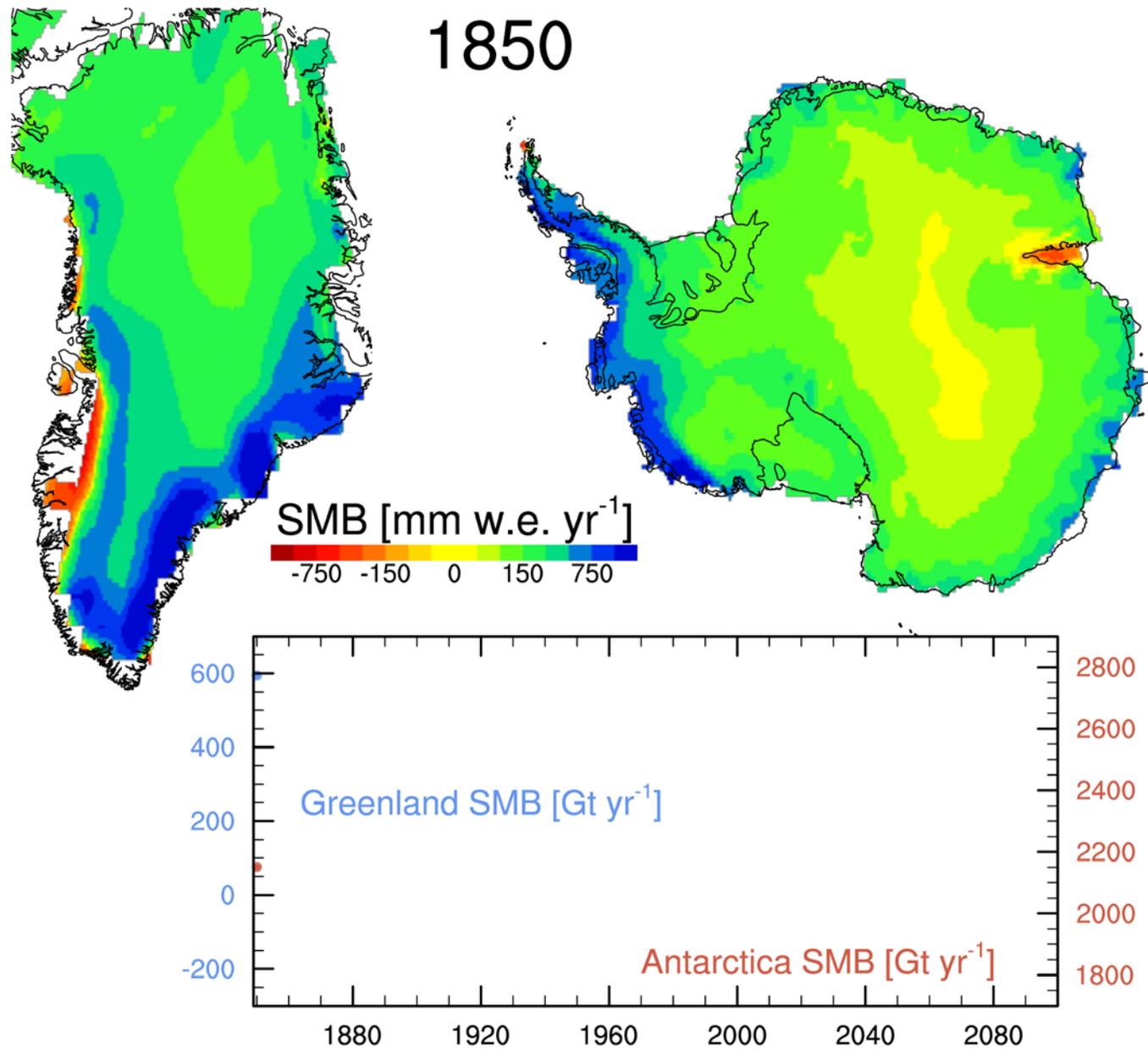
Jan Lenaerts

& many CESM community members!



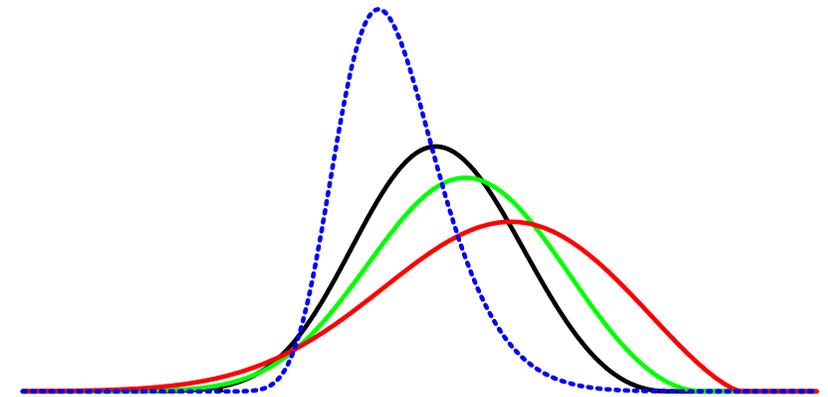
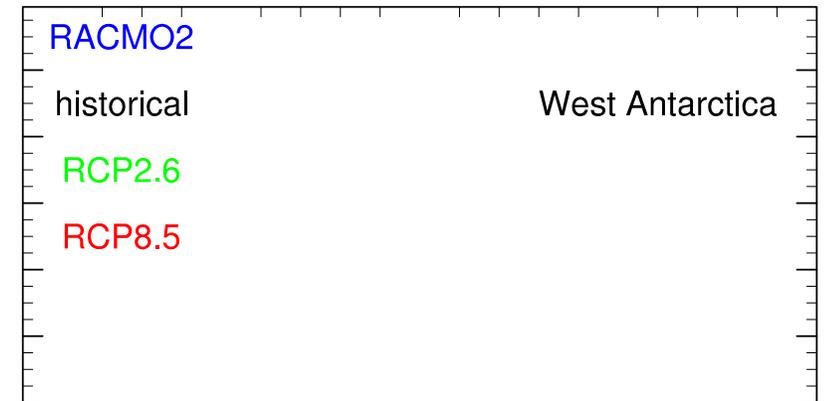
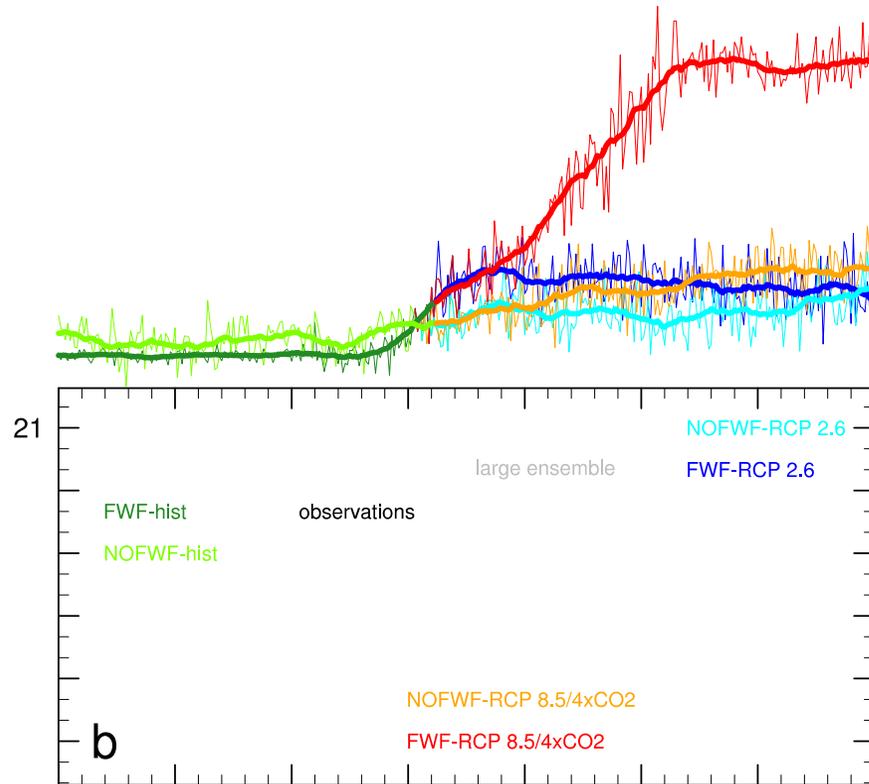
Universiteit Utrecht





Exciting CESM land ice science in 2015

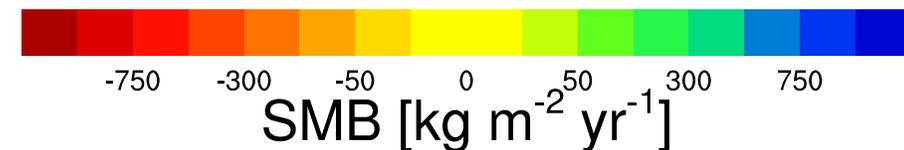
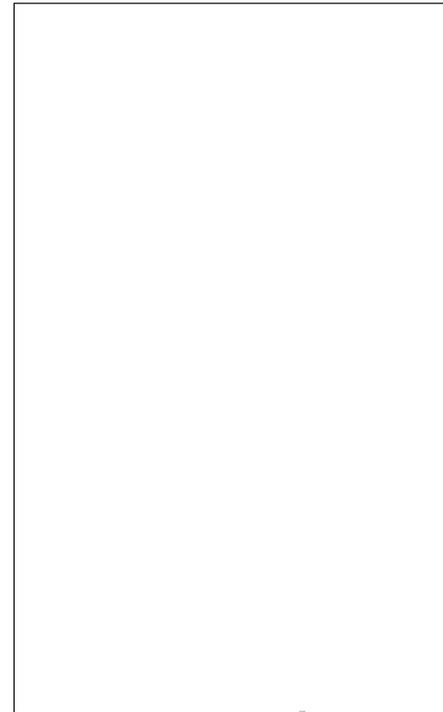
Impact of 'realistic' GrIS mass loss on AMOC (Lenaerts et al., 2015 (GRL))



Historical and future Antarctic SMB (Lenaerts et al., 2016 (Clim. Dyn.))

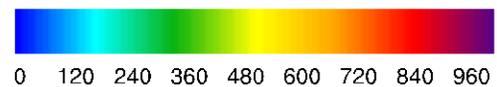
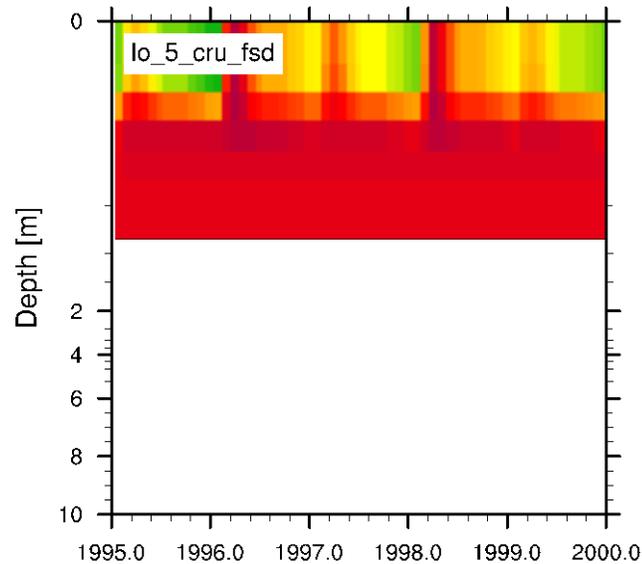
CESM1 ice sheet biases

- I. Meltwater refreezing
- II. Snow density
- III. Clouds
- IV. Winds



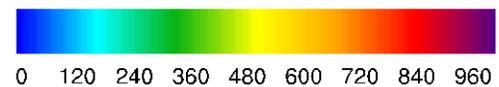
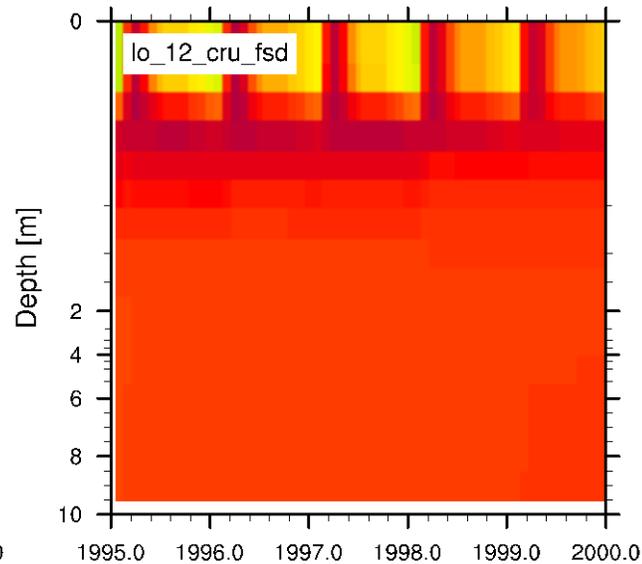
I. Improved snow model resolution

(and repaired a major bug)



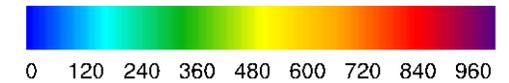
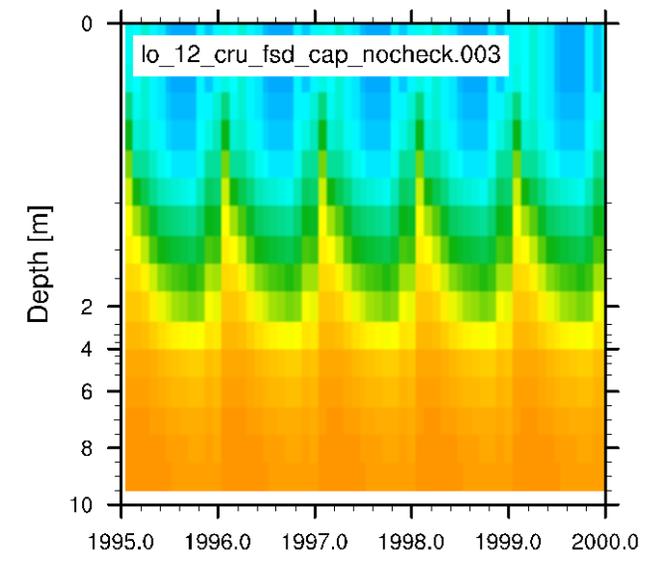
Time [years]

5 layers



Time [years]

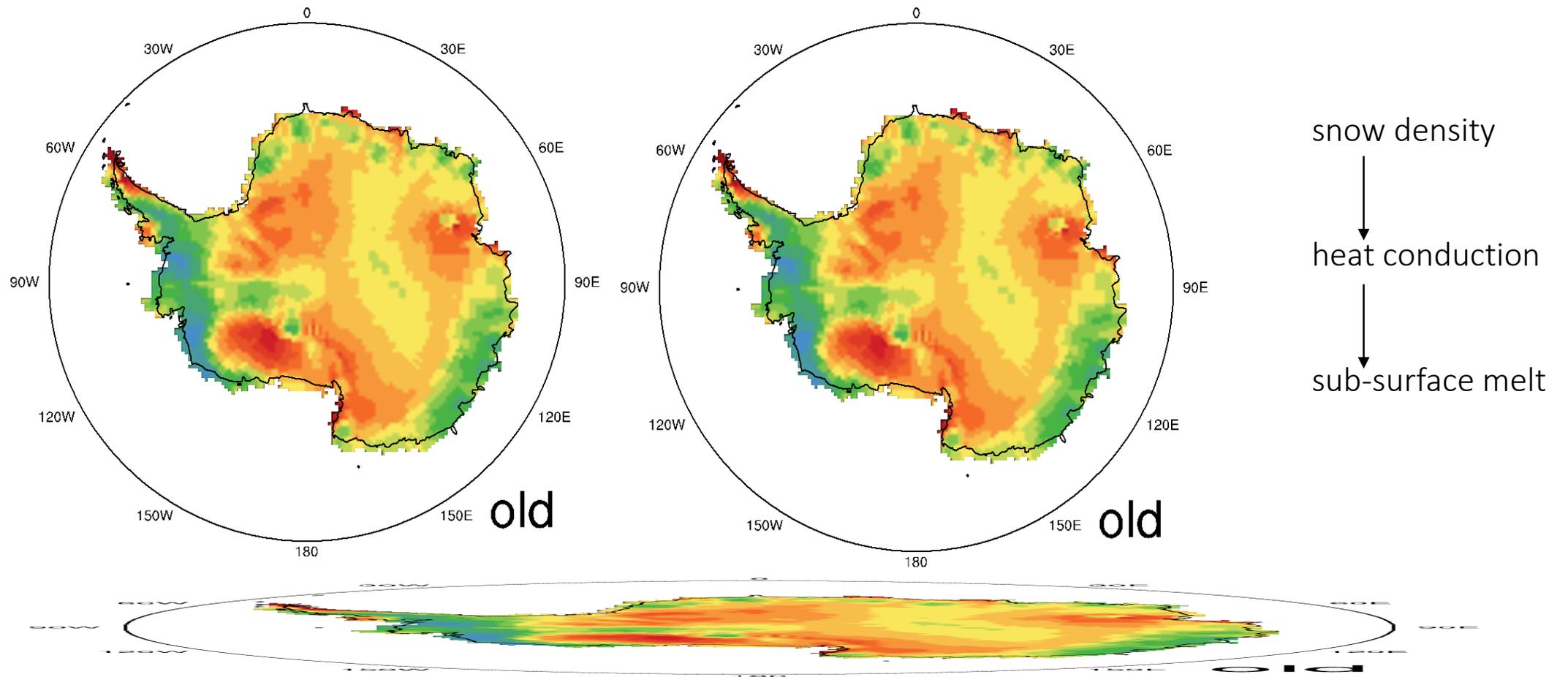
12 layers



Larsen C [lon: 298 lat: -67]
Time [years]

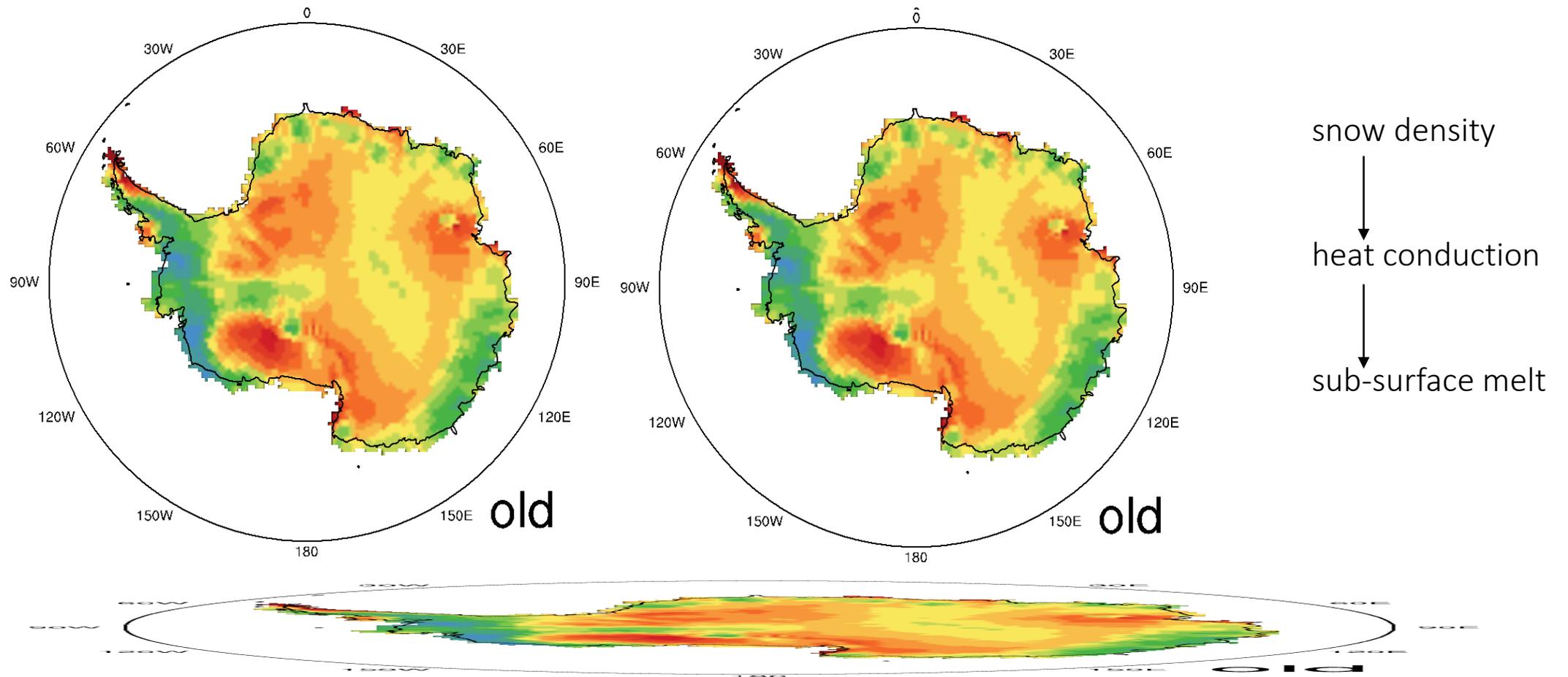
12 layers+ cap

II. Wind-enhanced snow compaction



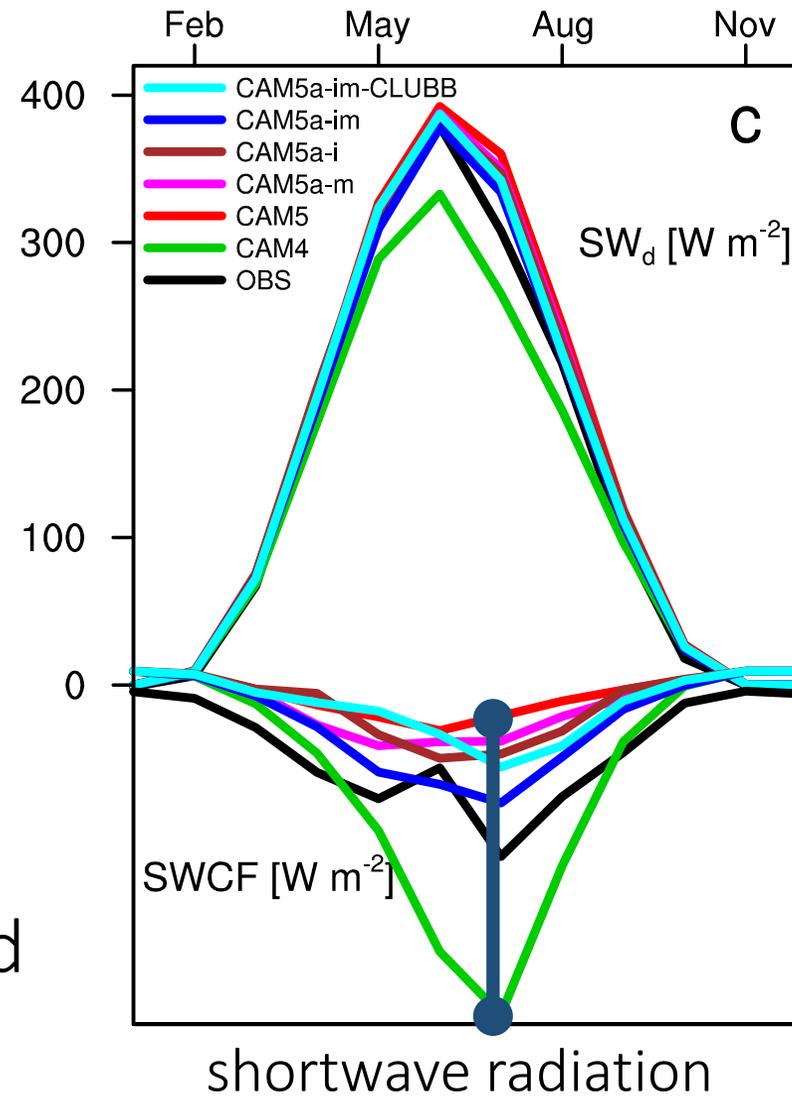
Van Kampenhout et al., in prep.

II. Wind-enhanced snow compaction

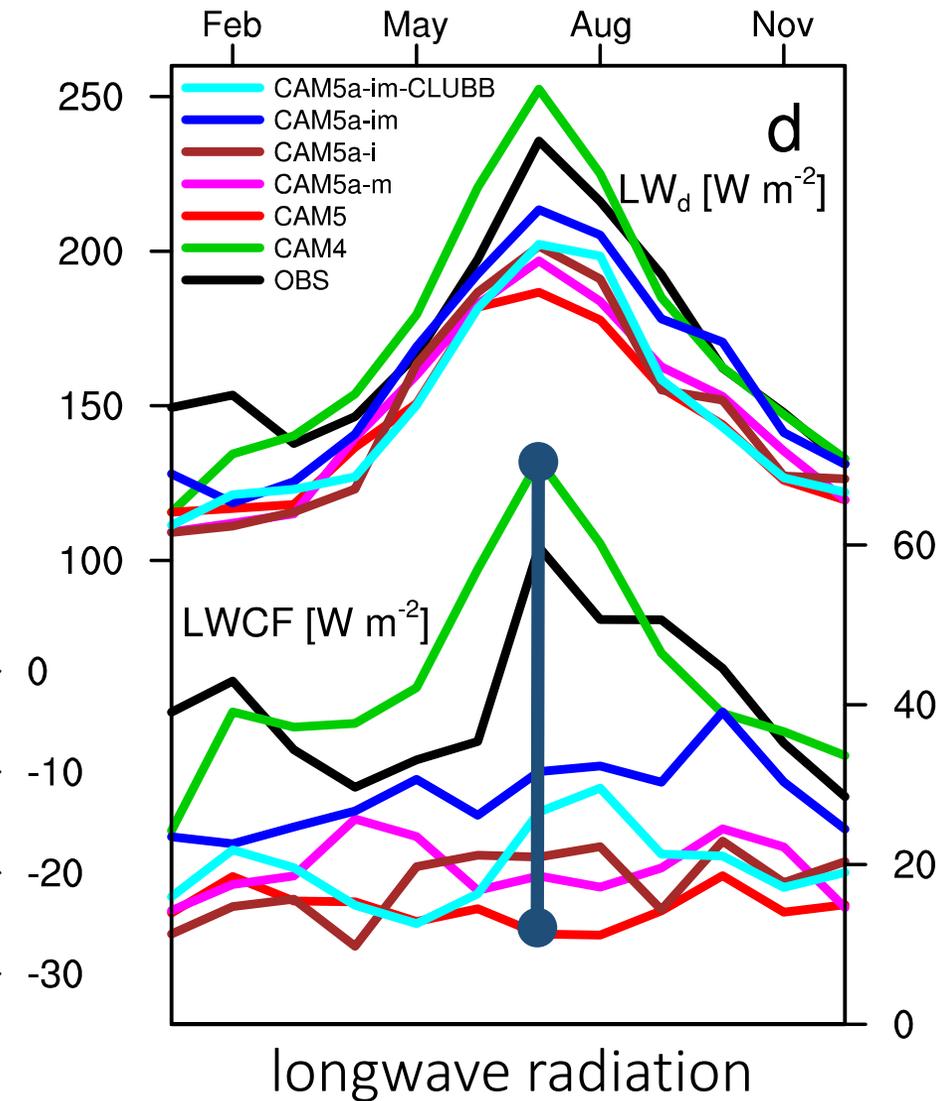


Van Kampenhout et al., in prep.

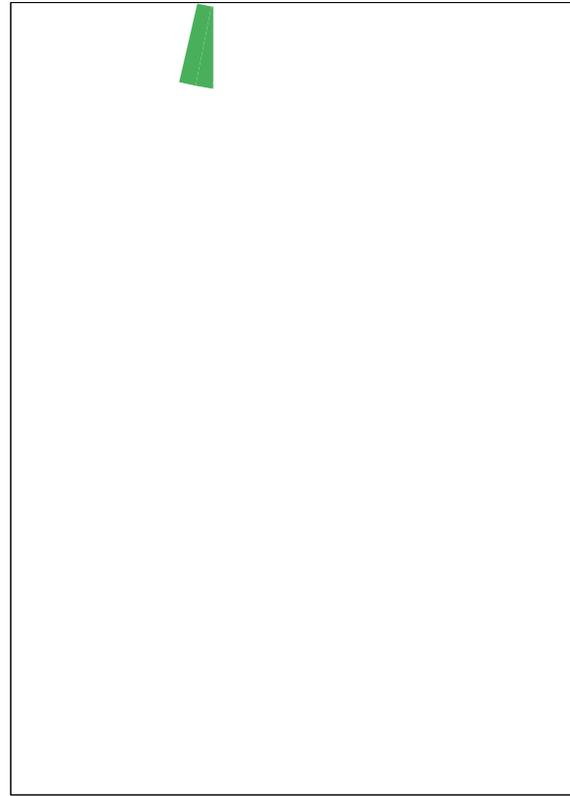
III. Clouds



Summit, Greenland



III. Clouds

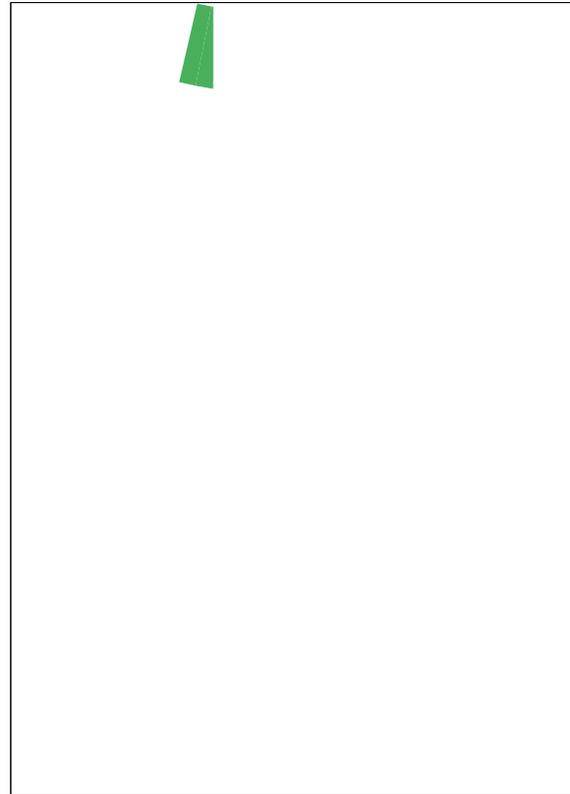


Van Tricht et al., Nat. Comm., 2016.

0 150 224

LWP [g m^{-2}]

III. Clouds

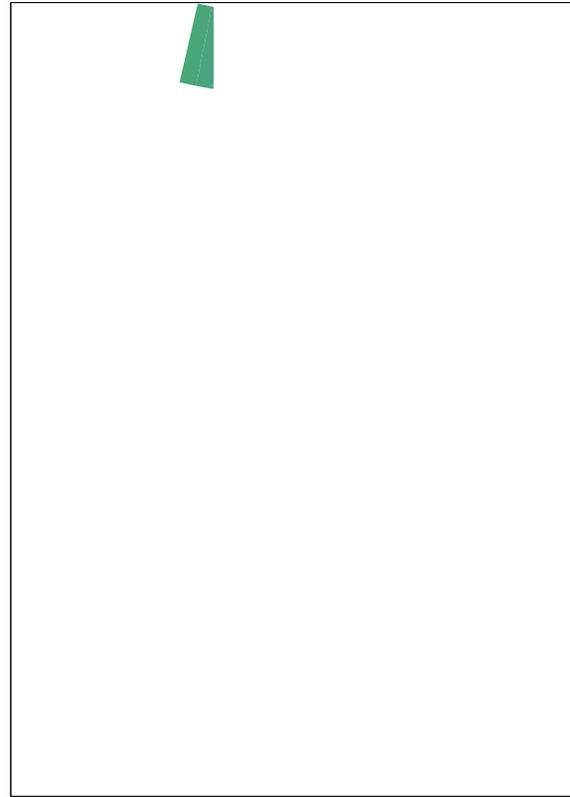


Van Tricht et al., Nat. Comm., 2016.

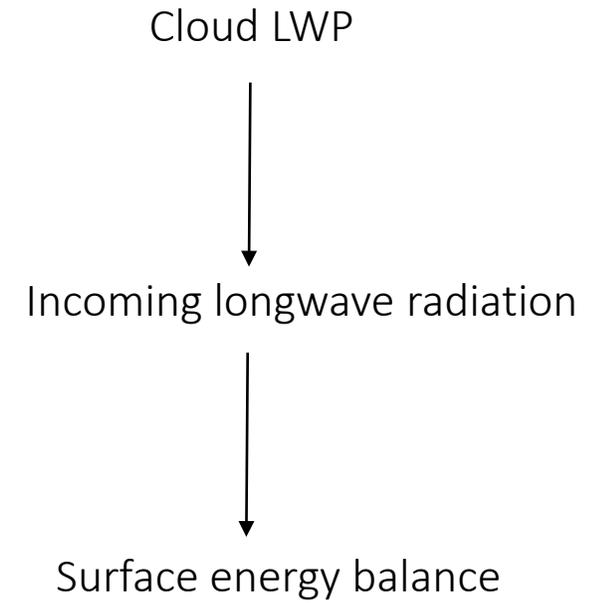
0 150 224

LWP [g m^{-2}]

III. Clouds



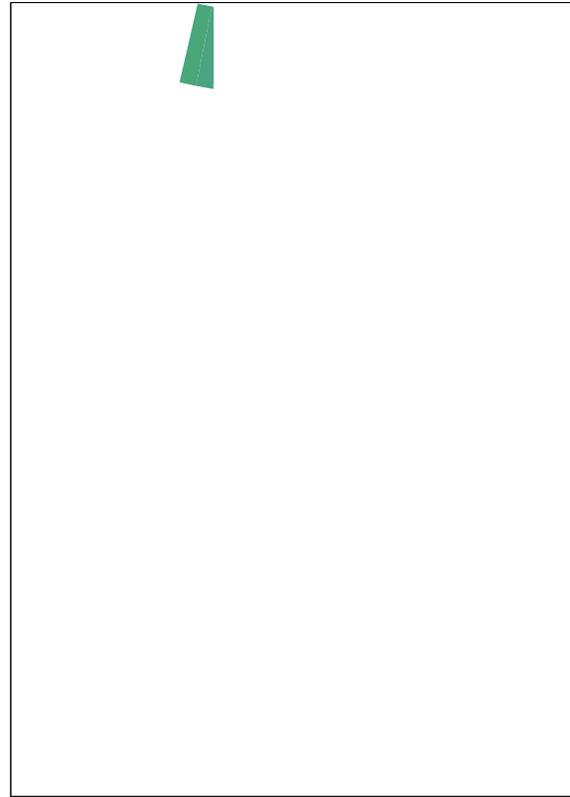
Van Tricht et al., Nat. Comm., 2016.



0 184 198 212 226 240 254 268 282 296

Incoming LW [W m^{-2}]

III. Clouds

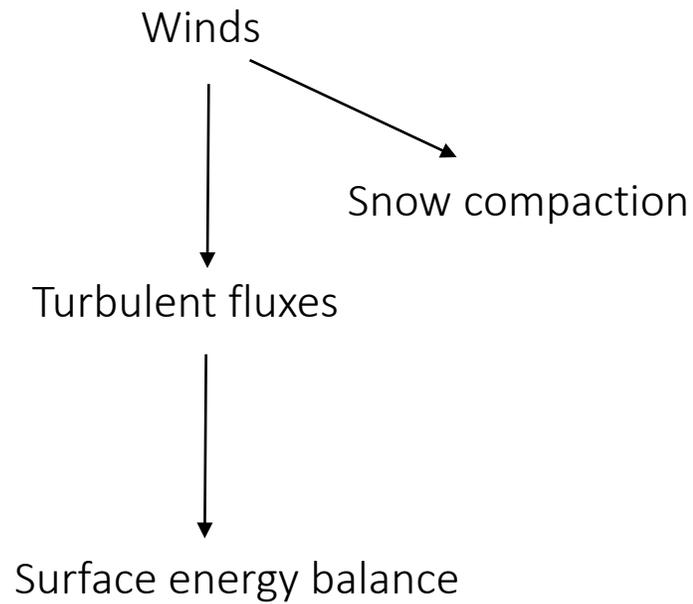


Van Tricht et al., Nat. Comm., 2016.

0 184 198 212 226 240 254 268 282 296

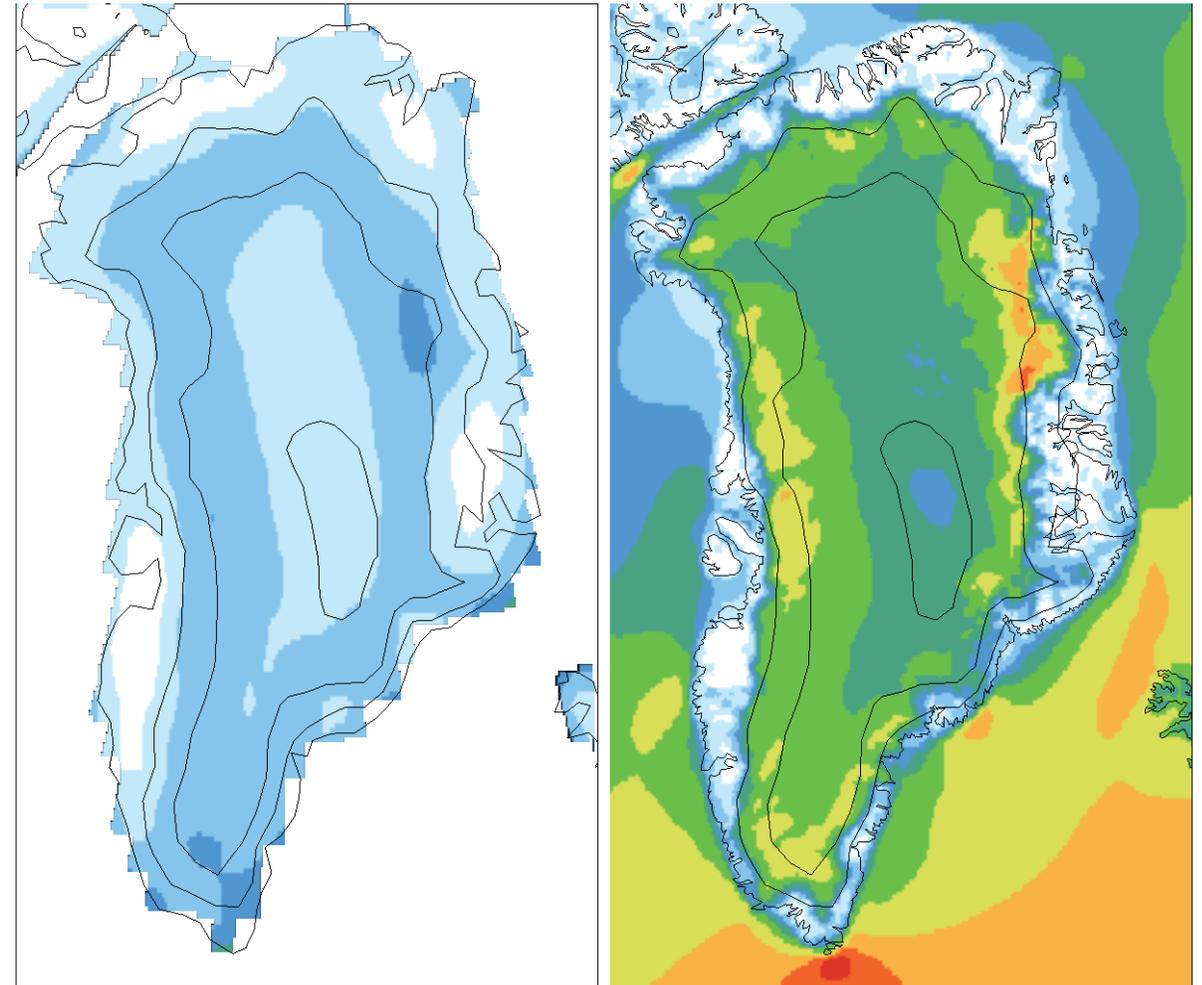
Incoming LW [W m^{-2}]

IV. Surface winds

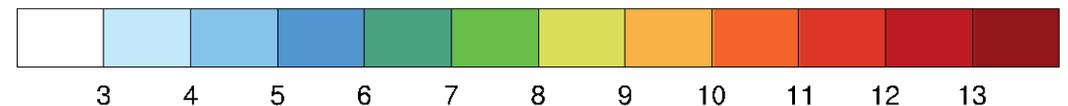


CESM2control sim #28

RACMO2.3

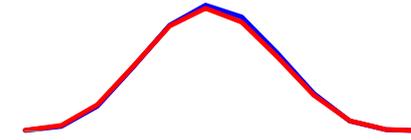


10 m wind speed [m s^{-1}]



TMS

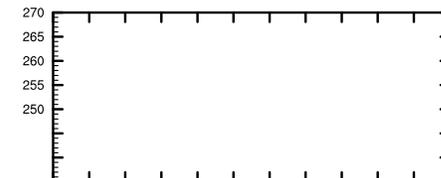
- Turbulent mountain stress
- Added to improve general circulation
- Enhances surface drag of subgrid terrain by increasing roughness length



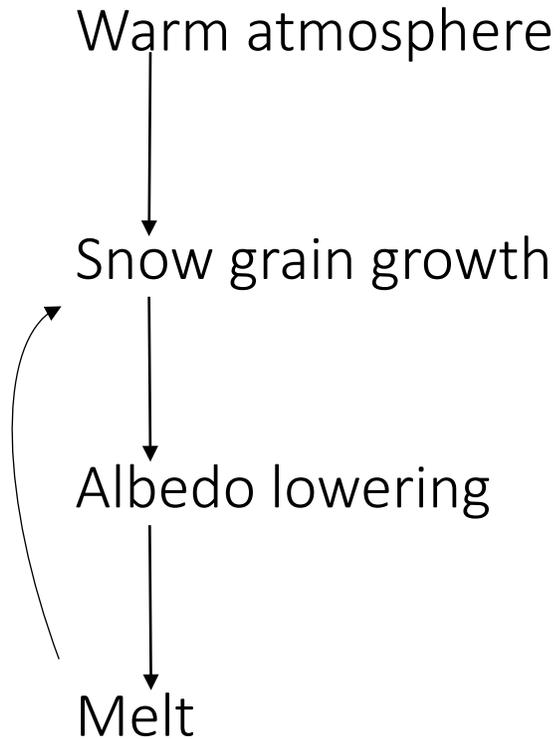
New wave drag scheme

- Julio Bacmeister (NCAR)
- In latest stages of development
- Can 'replace' TMS, only if general circulation is not degraded

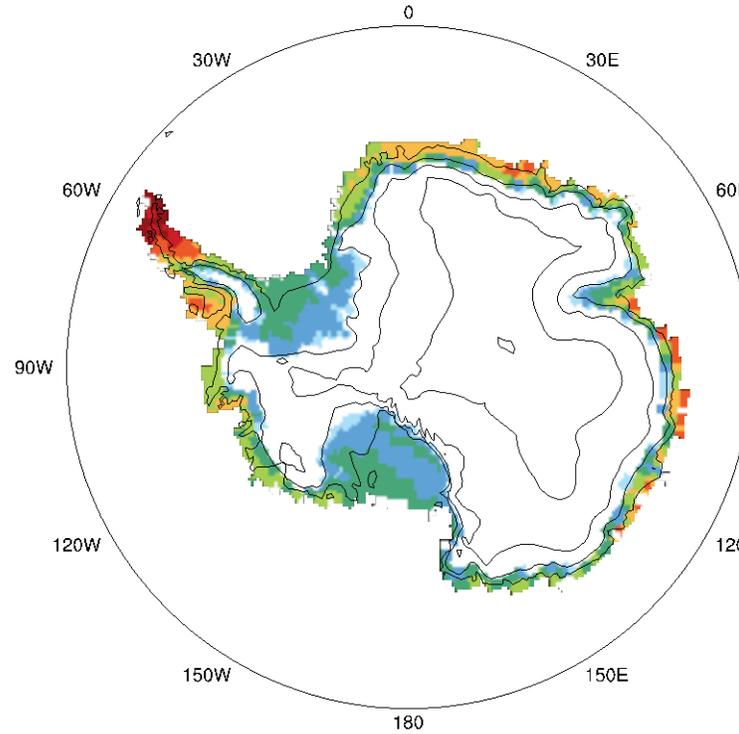
**Improves ice sheet wind climate
& eliminates winter temperature bias**



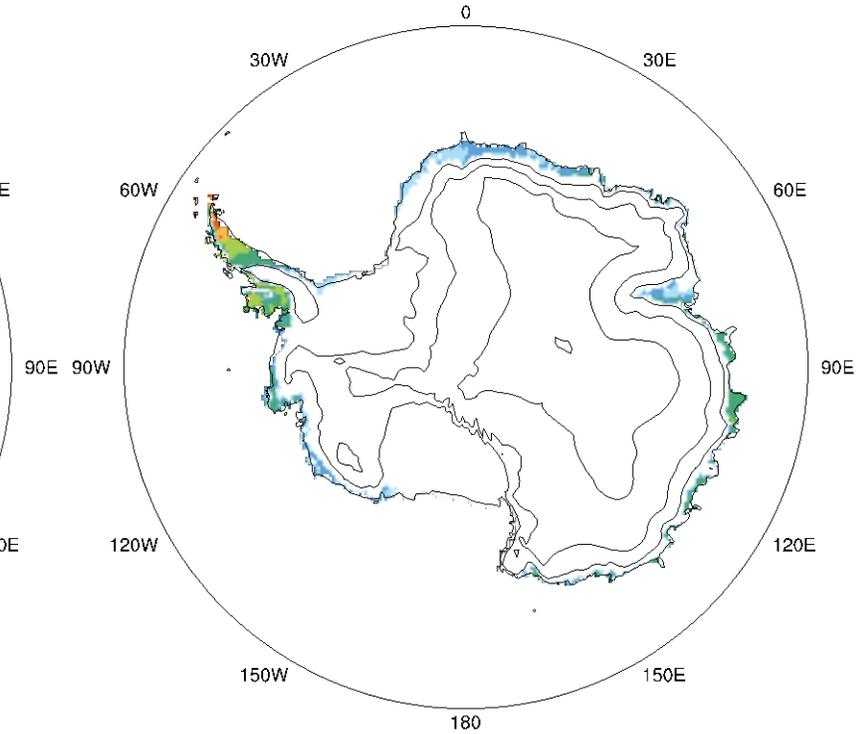
Antarctic melt



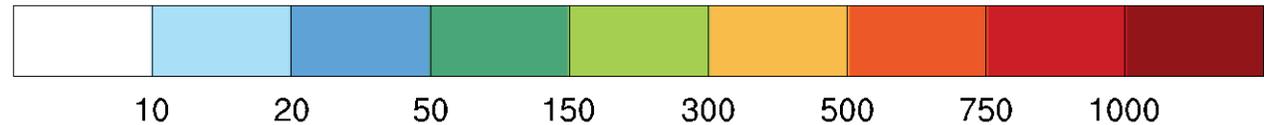
1980-2005
CESM2control sim #28



RACMO2.3



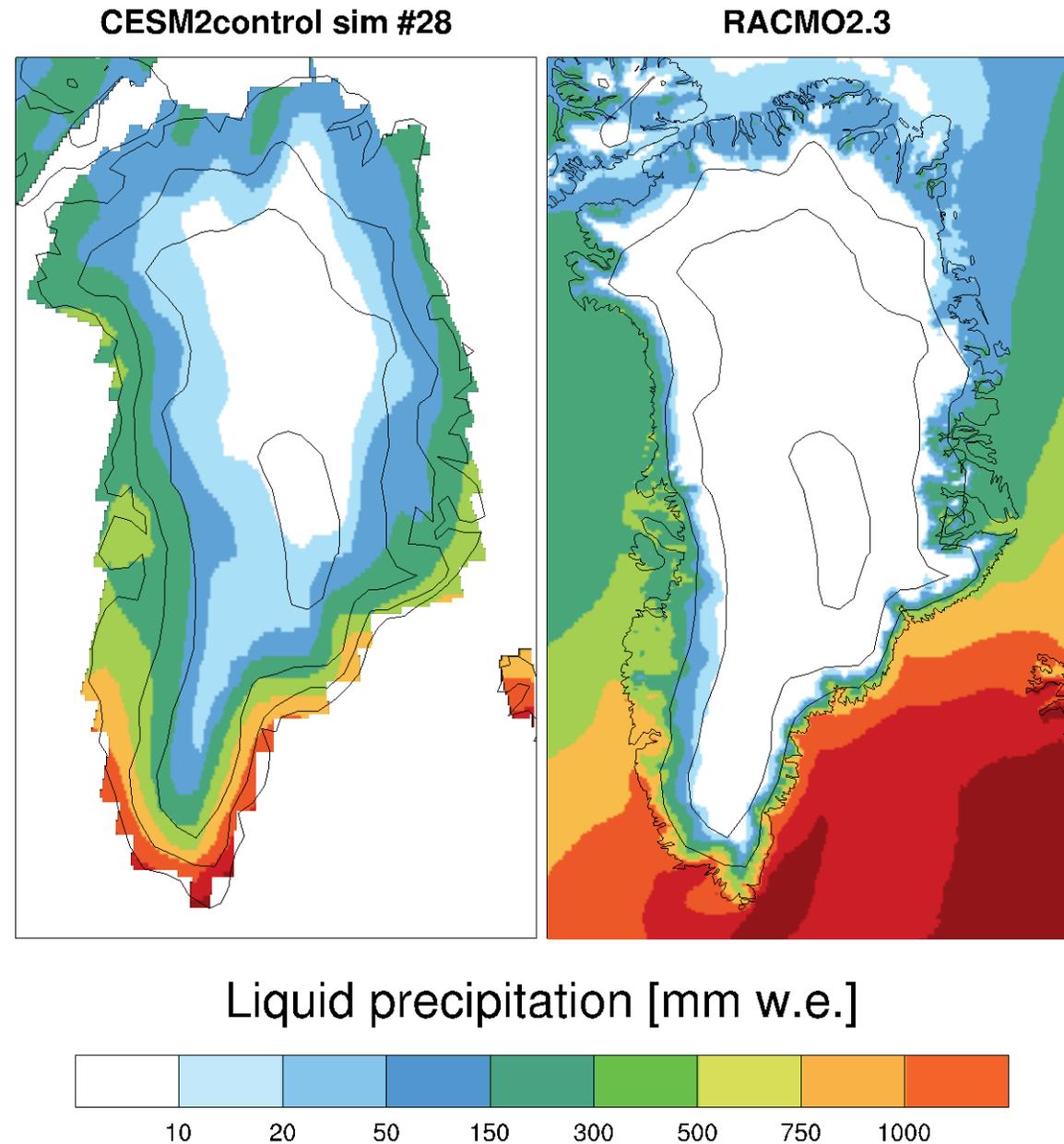
Surface melt [mm w.e.]



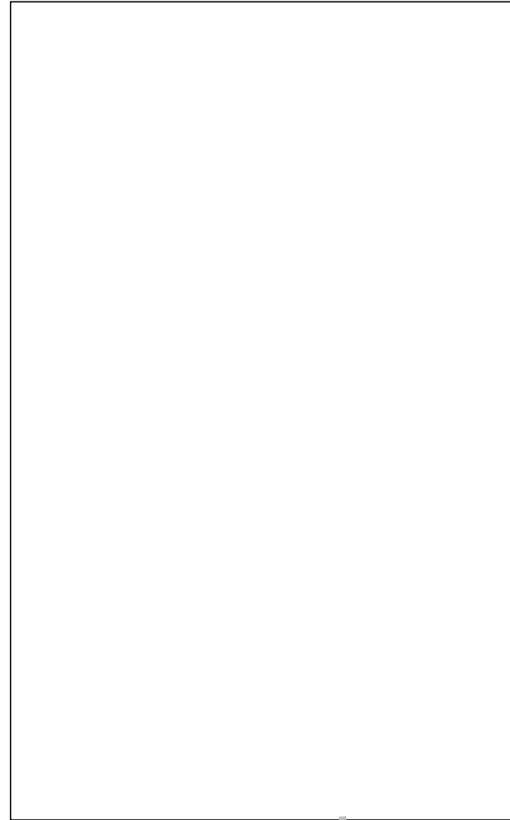
New bias: precipitation

High-elevation liquid precipitation is back!

Hands-on solution: liquid converted to solid in CLM with surface flux correction.



Greenland SMB

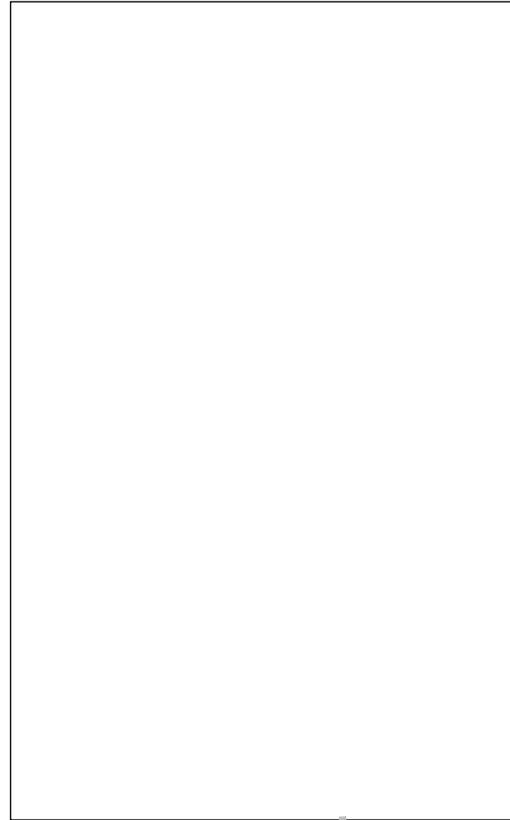


-750 -300 -50 0 50 300 750

SMB [$\text{kg m}^{-2} \text{yr}^{-1}$]

Averages for 1980-2005

Greenland SMB

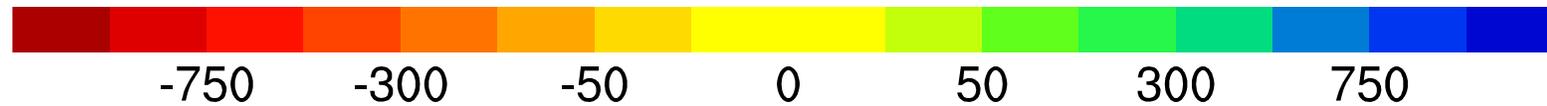
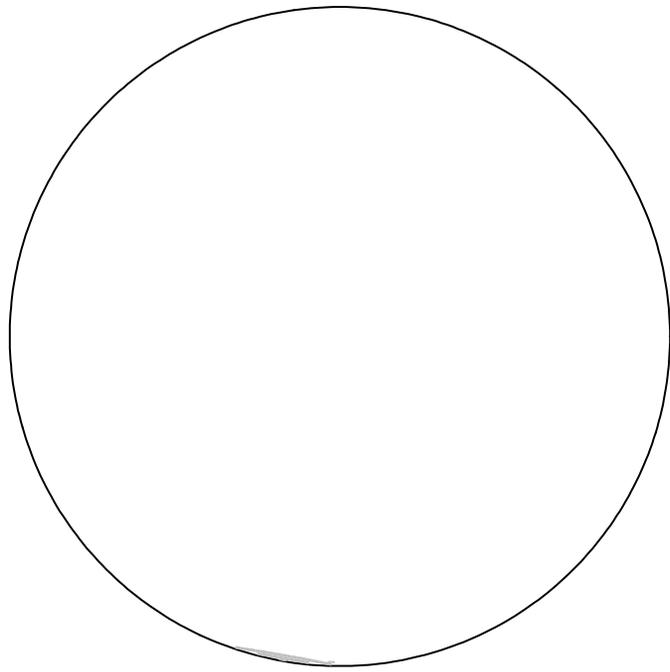


-750 -300 -50 0 50 300 750

SMB [$\text{kg m}^{-2} \text{yr}^{-1}$]

Averages for 1980-2005

Antarctic SMB



-750

-300

-50

0

50

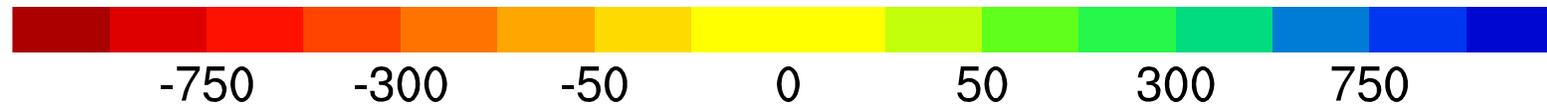
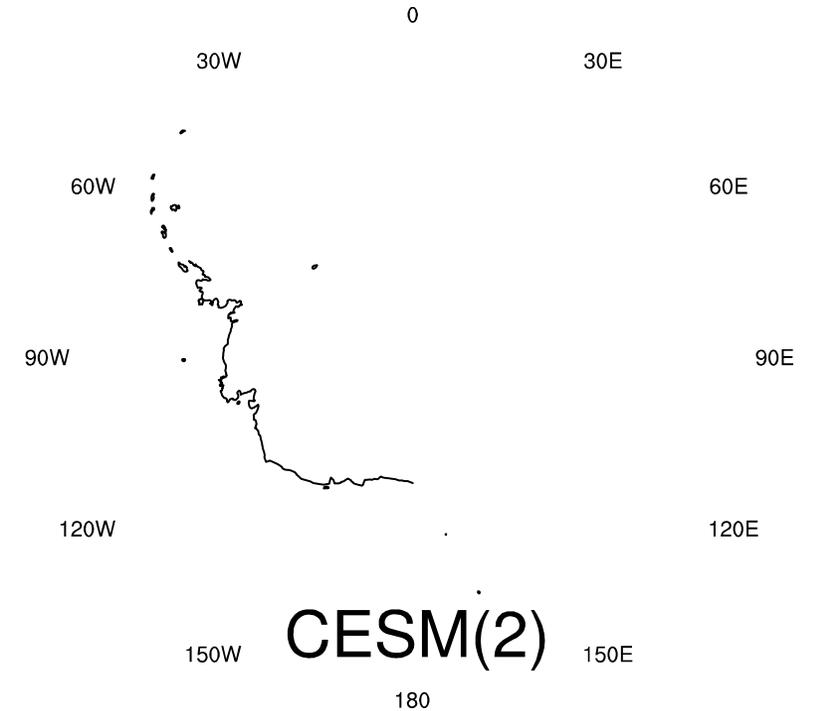
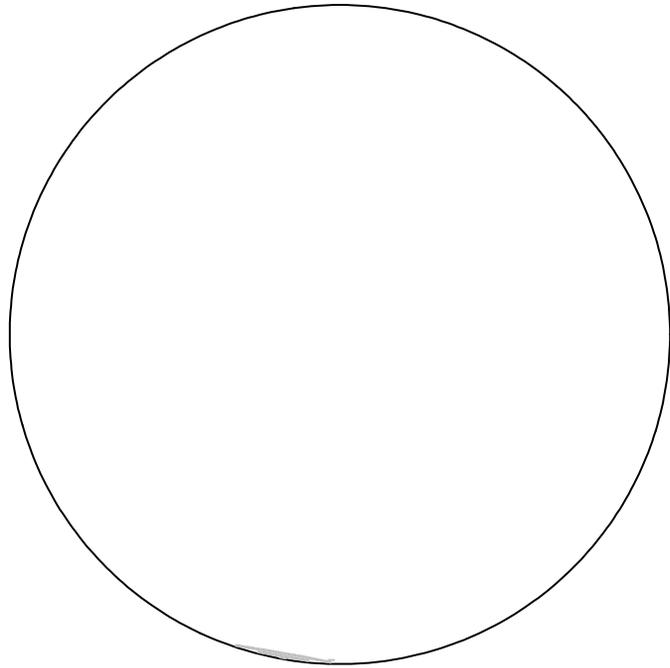
300

750

SMB [kg m⁻² yr⁻¹]

Averages for 1980-2005

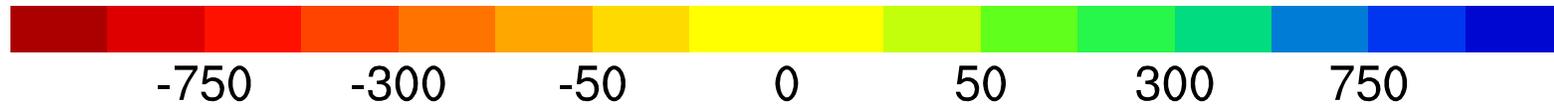
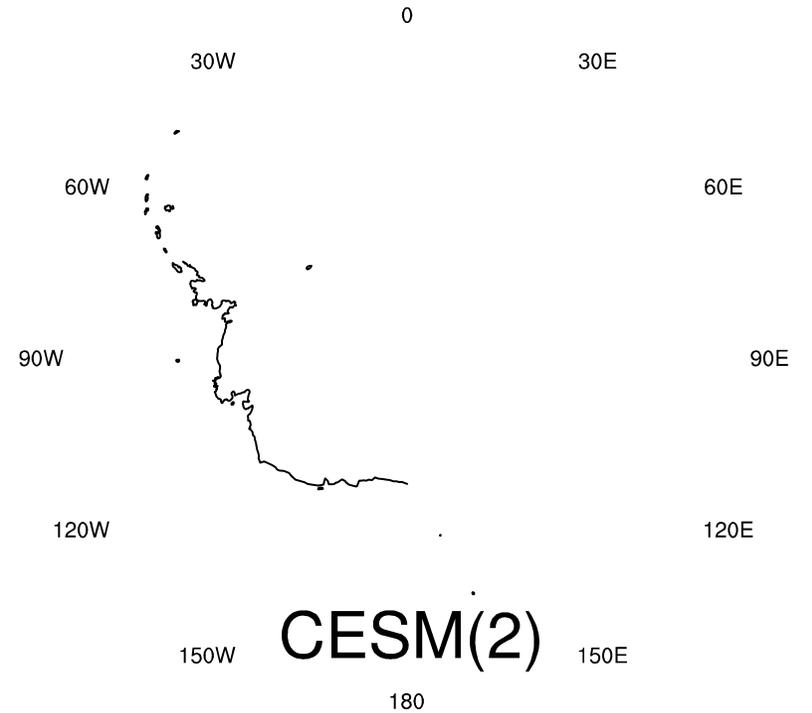
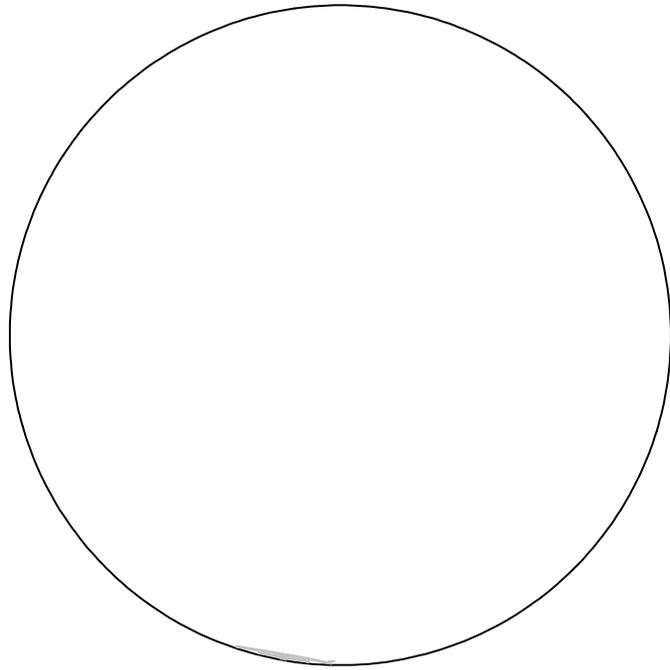
Antarctic SMB



SMB [kg m⁻² yr⁻¹]

Averages for 1980-2005

Antarctic SMB



SMB [kg m⁻² yr⁻¹]

Averages for 1980-2005

Some numbers

Greenland

	CESM2 #28	CESM2 #31	<i>best estimate</i>
Snowfall	760	740	660
Rain	160	130	40
Melt (snow)	560	440	500
Melt (ice)	170	120	
Refreezing	380	310	250
Sublimation	<10	<10	40
SMB	540	590	400

	CESM2 #28	CESM2 #31	<i>best estimate</i>
Snowfall	2840	2760	2600
Rain	180	160	<10
Melt (snow)	730	720	100
Melt (ice)	20	20	
Refreezing	690	670	100
Sublimation	60	60	200
SMB	3000	2900	2400

Antarctica

Averages for 1980-2005

Ongoing/Future work of 'Dutch CESM group'

Drifting snow (Jan + Leo)

Snow compaction (Leo + Jan)

SMB downscaling (Vincent + Miren + Jan + Leo)

Offline CISM – Greenland 'threshold' (IMAU PhD)

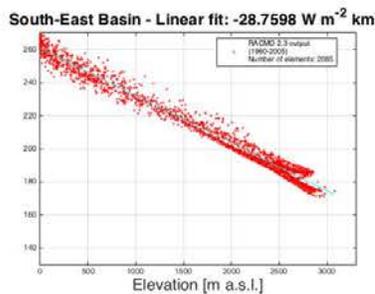
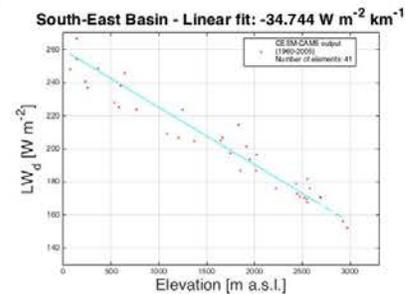
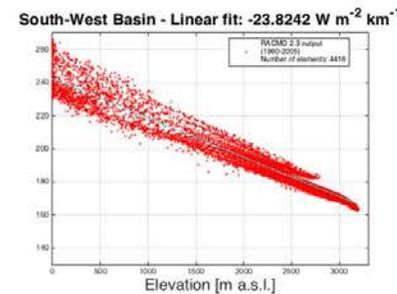
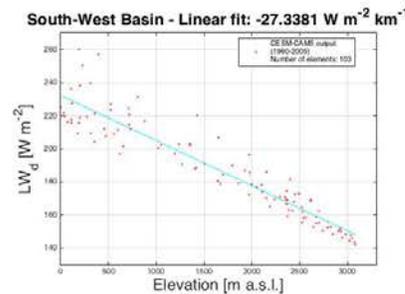
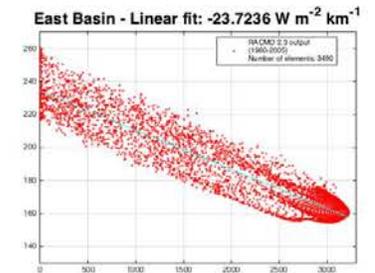
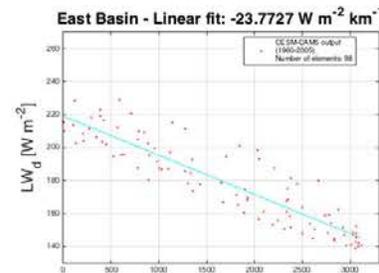
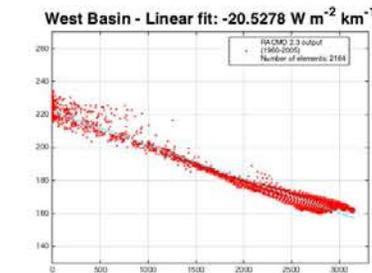
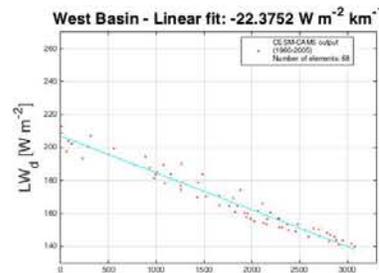
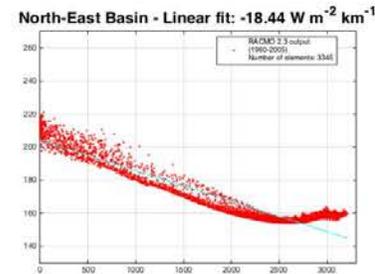
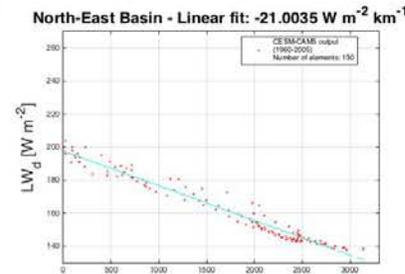
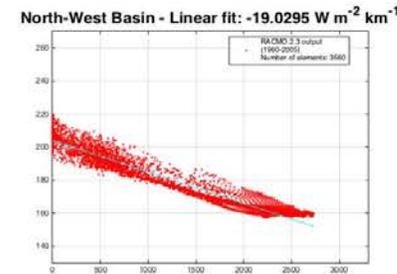
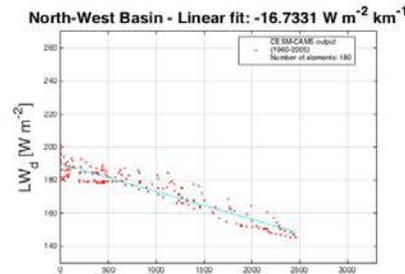
Coupled CESM-CISM (Miren ERC + IMAU)



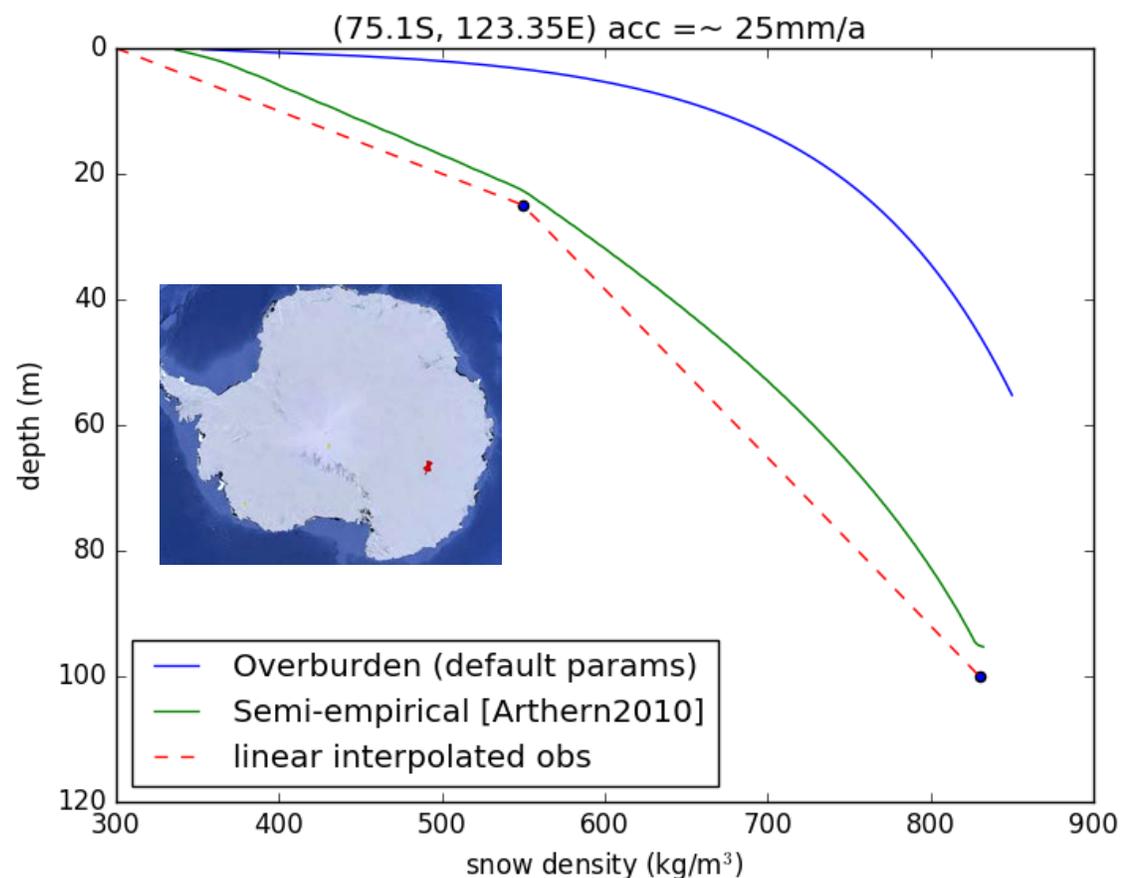
SMB downscaling

elevation

Incoming longwave



Firn compaction



Goal:
improve meltwater refreezing properties of polar firn

Firn air content	
Semi-empirical model (Arthern 2010)	27.8 m ³
Overburden (Anderson 1976)	10.3 m ³

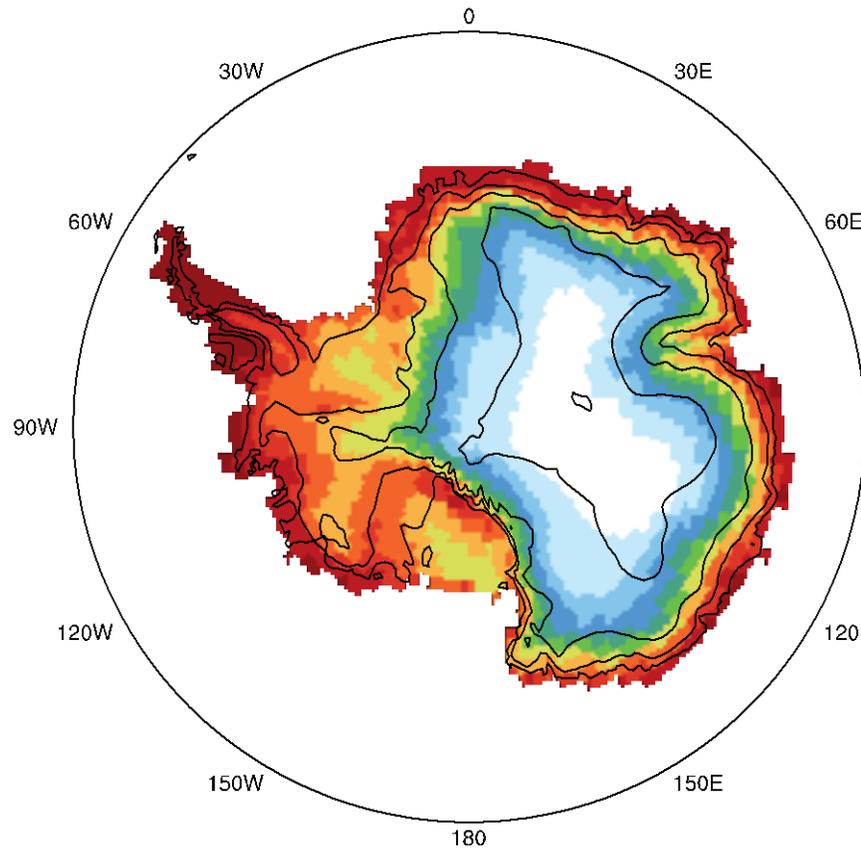
- **underestimation** of firn air content in large parts of Antarctica (low acc. areas)
- can we tune overburden parameters to work in **low temperature**, **low accumulation** regimes?
- non-linear optimization problem with 58 firn core measurements

Conclusions

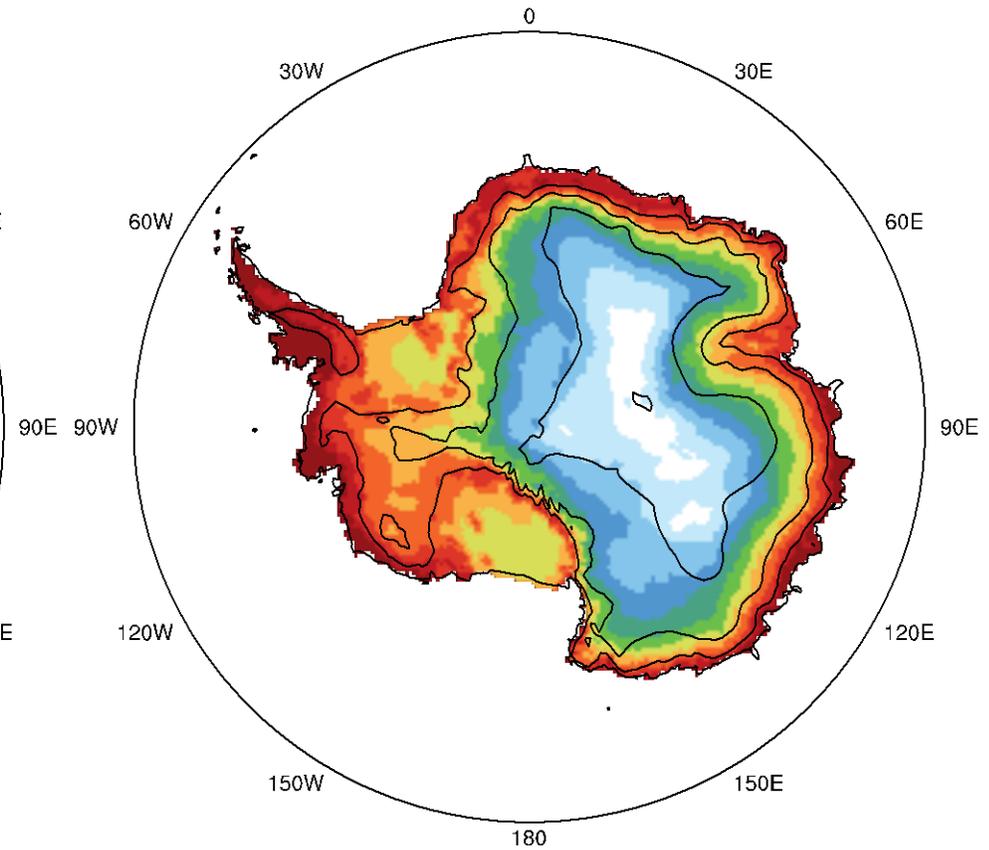
- CESM2 (control) improves certain aspects of CESM1 over ice sheets
 - Clouds and longwave radiation
 - Firn processes
 - Snow density
 - Winds (hopefully...)
- CESM2 has more realistic ice sheet SMB than CESM1
 - Subject of concern: too much precipitation & high Antarctic melt
- CESM2 will be run with SMB downscaling on by default
 - Natural SMB variability
 - Ensemble solutions for ice sheet contribution to SLR
 - Detection/attribution

Additional slides

CESM2control sim #28



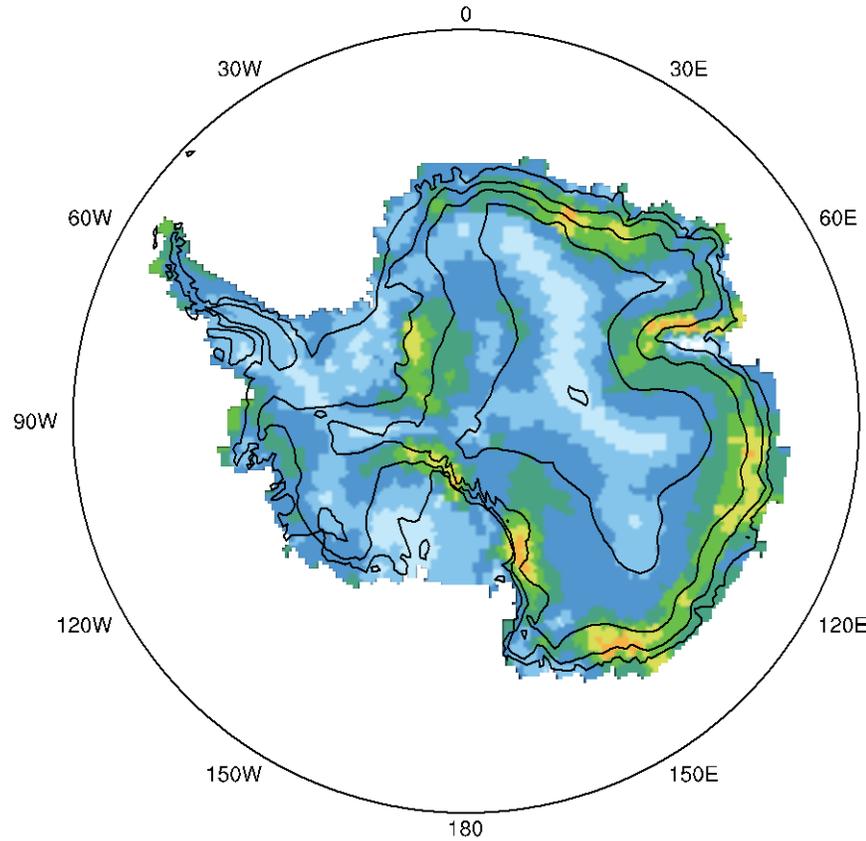
RACMO2.3



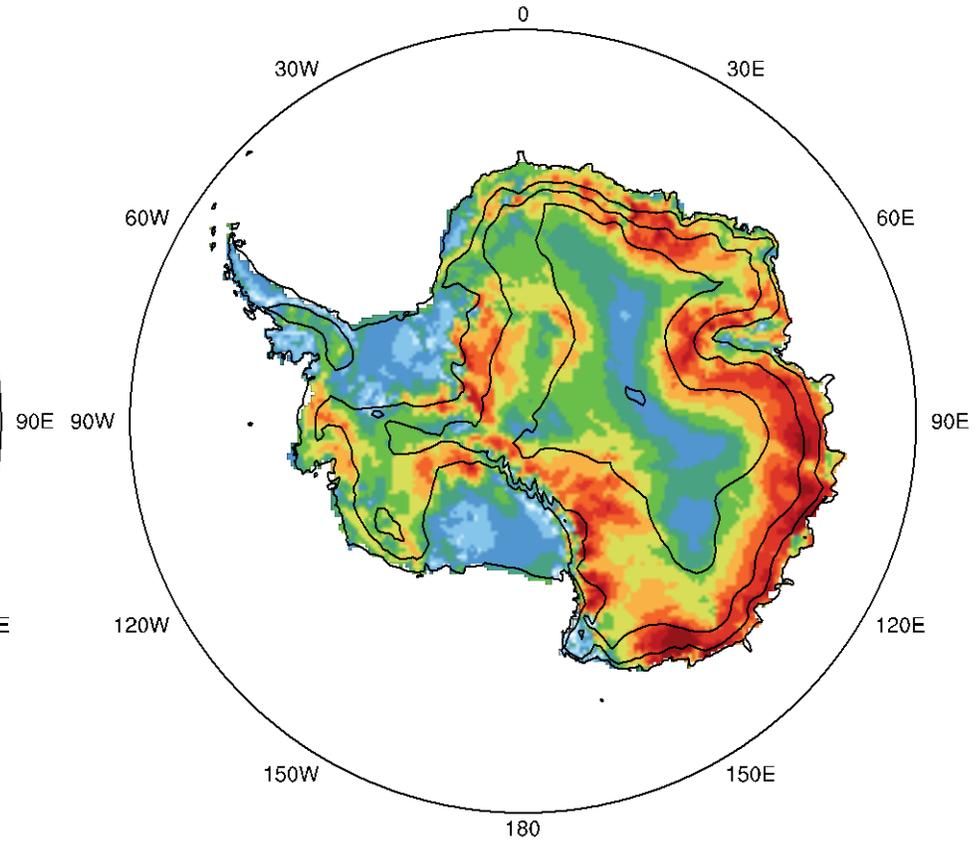
2 meter air temperature [K]



CESM2control sim #28



RACMO2.3



10 m wind speed [m s^{-1}]

