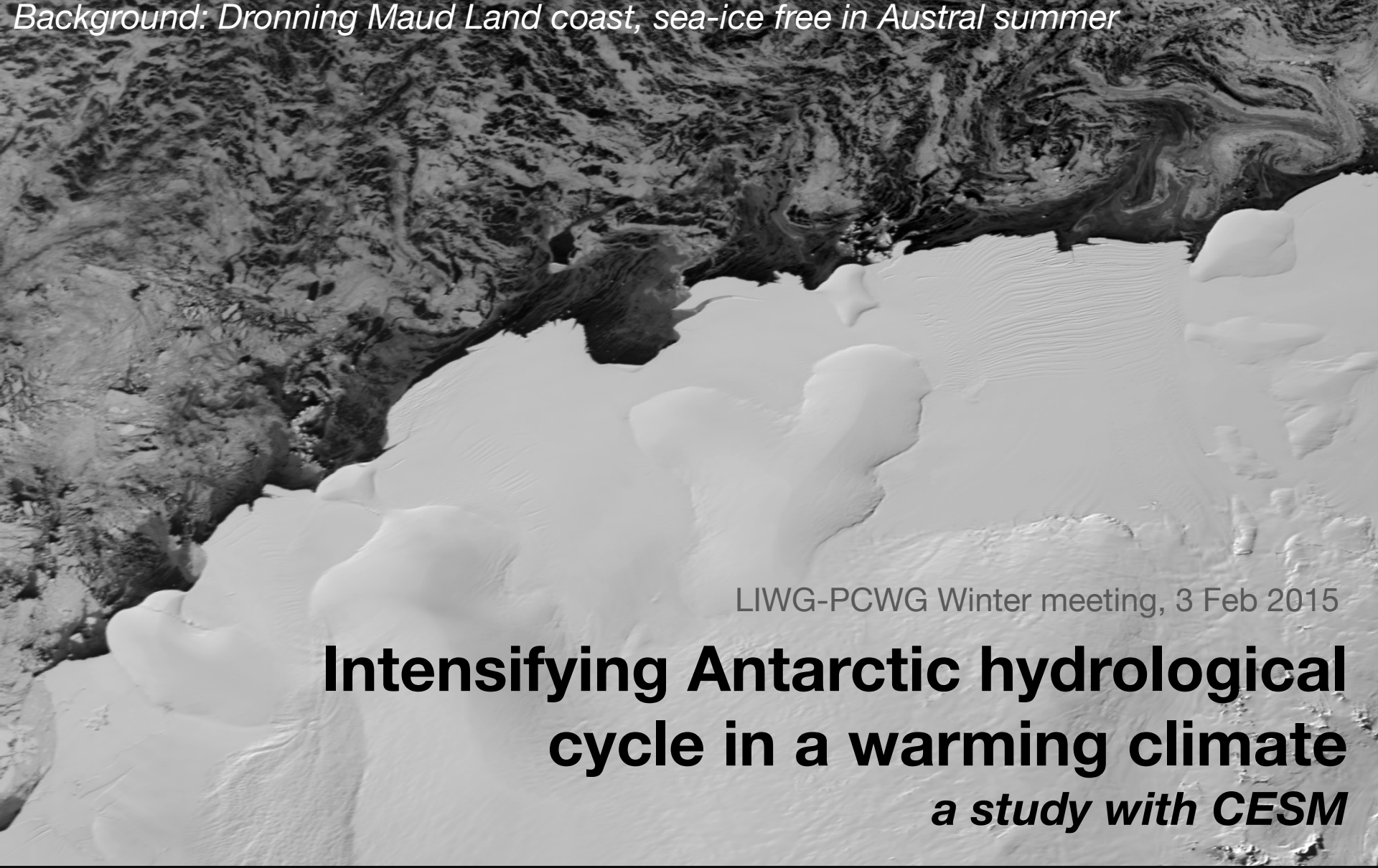


LIWG-PCWG Winter meeting, 3 Feb 2015

Intensifying Antarctic hydrological cycle in a warming climate

a study with CESM

Jan Lenaerts, Miren Vizcaino,
Jer Fyke, Leo van Kampenhout

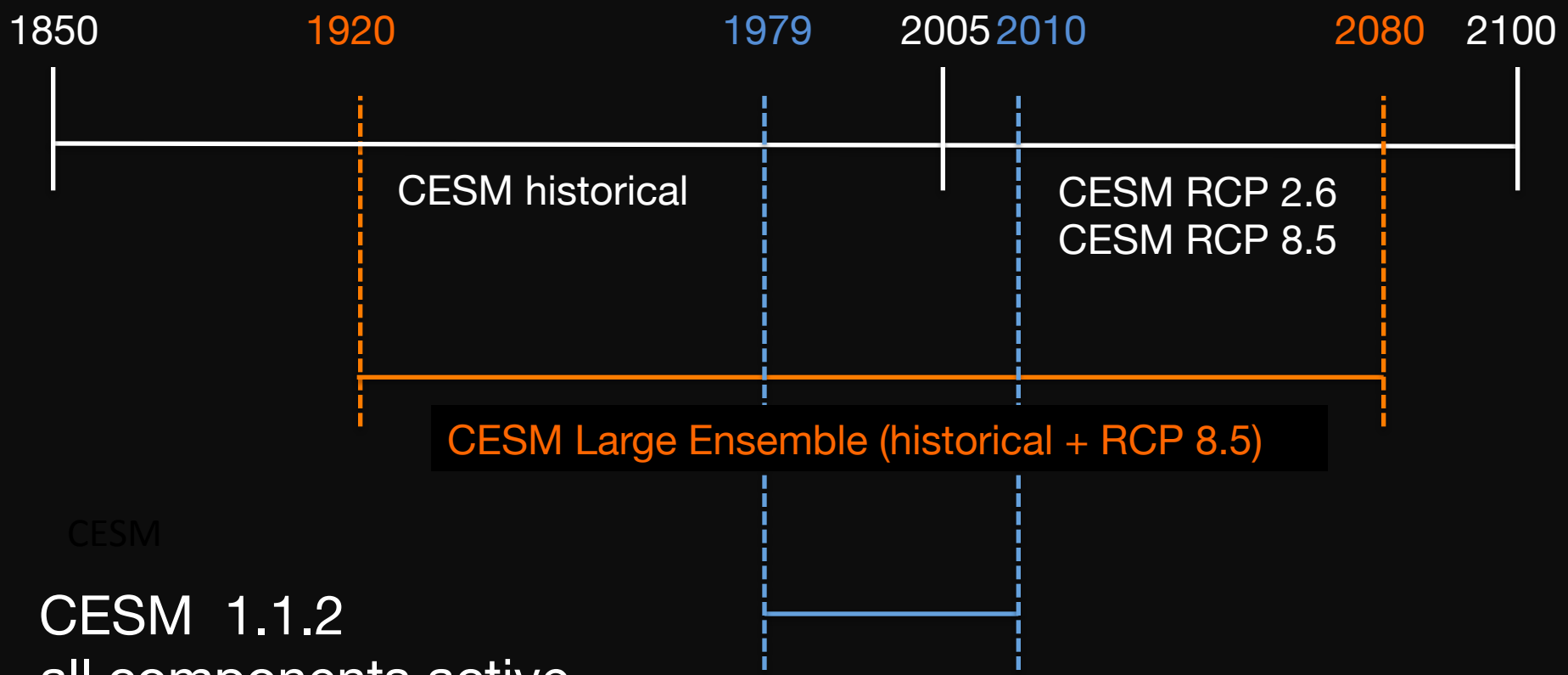
Universiteit Utrecht

IMAU
Institute for Marine and Atmospheric research Utrecht

Introduction

- CESM is ESM with multi-layered snow model, vital for ice sheet SMB studies (Vizcaino 2013, Leo's talk)
- Enable studies of interaction of ice sheets with other components of climate system
- Antarctica is relatively poorly studied compared to Arctic/Greenland
- Challenging for models: ice shelves (ice – ocean), recent sea-ice trends, very few observations

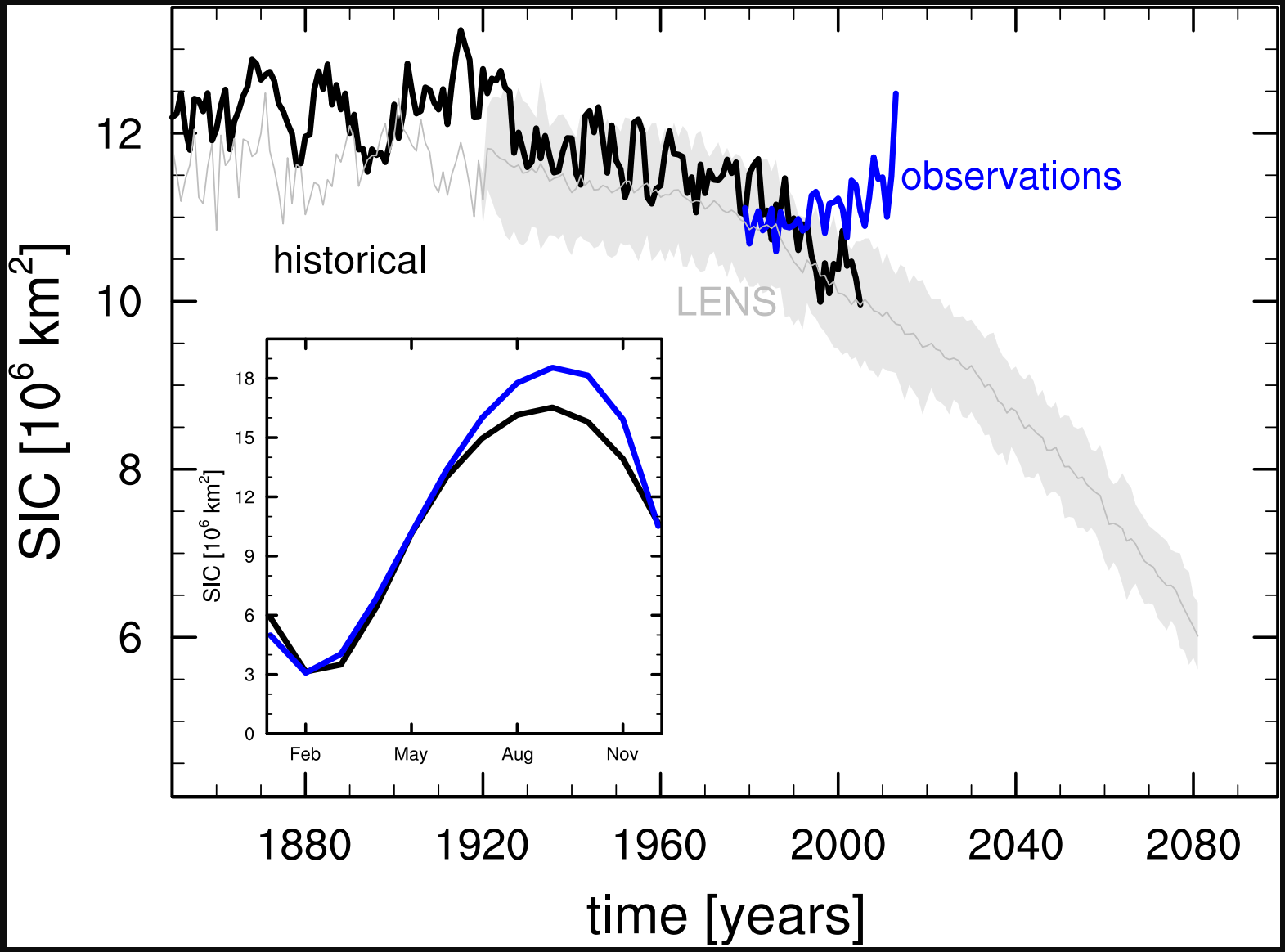
Tools



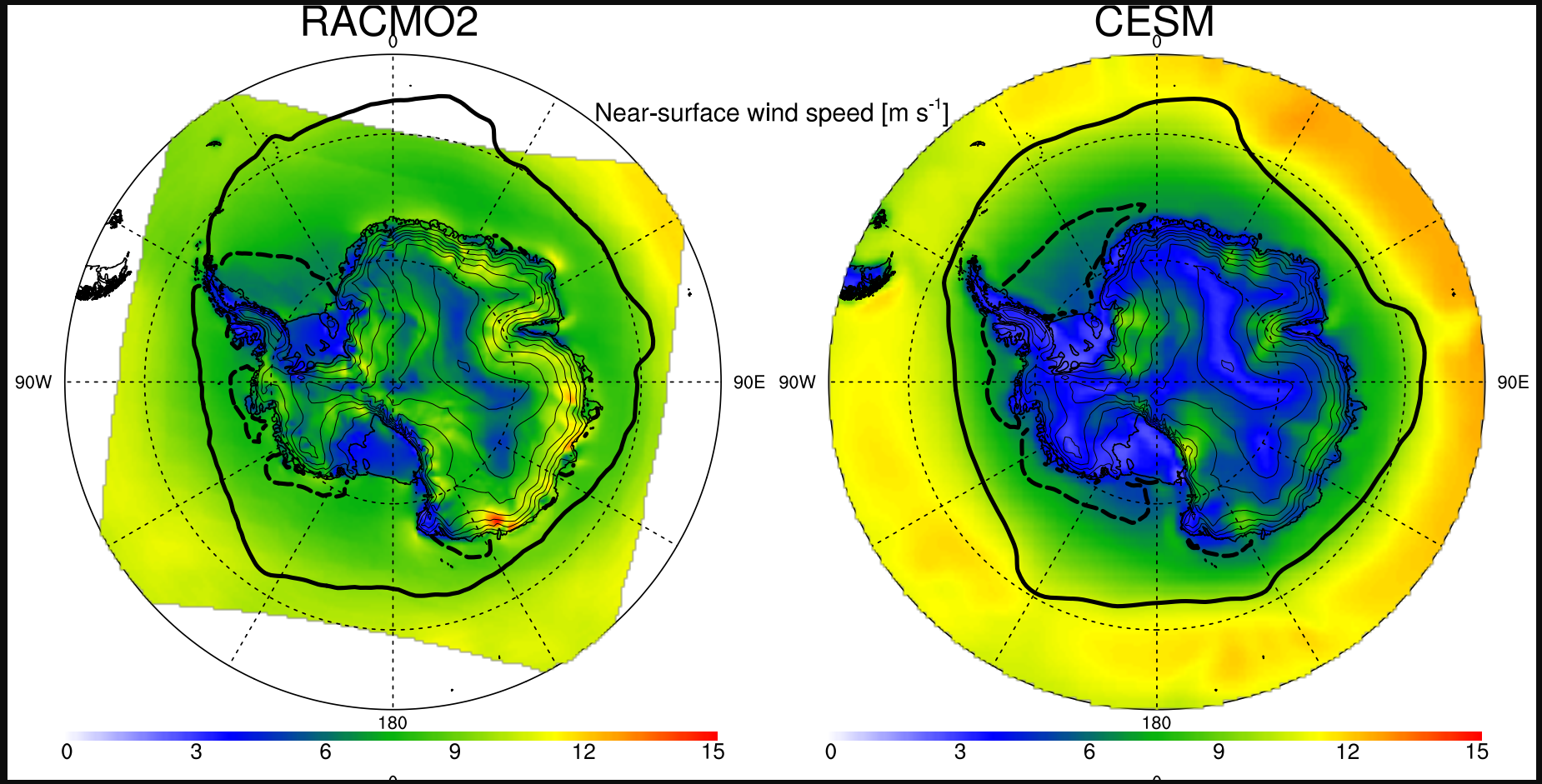
CESM

CESM 1.1.2
all components active
SMB enabled
0.9 x 1.25 degrees

Sea ice

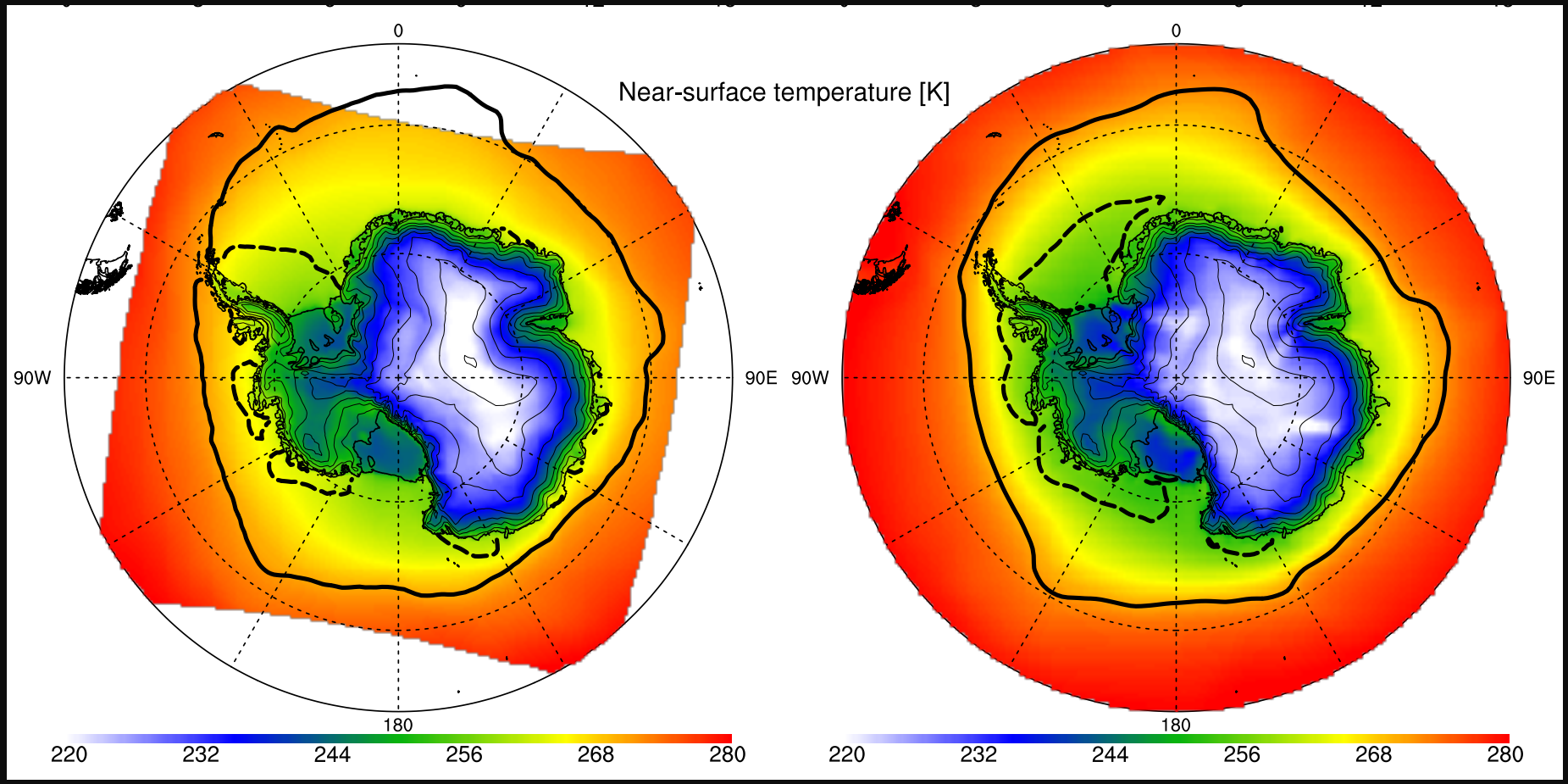

SIC [10^6 km^2]
12
10
8
6
historical
LENS
observations
SIC [10^6 km^2]
18
15
12
9
6
3
0
Feb
May
Aug
Nov
1880
1920
1960
2000
2040
2080
time [years]

Near-surface climate (I)



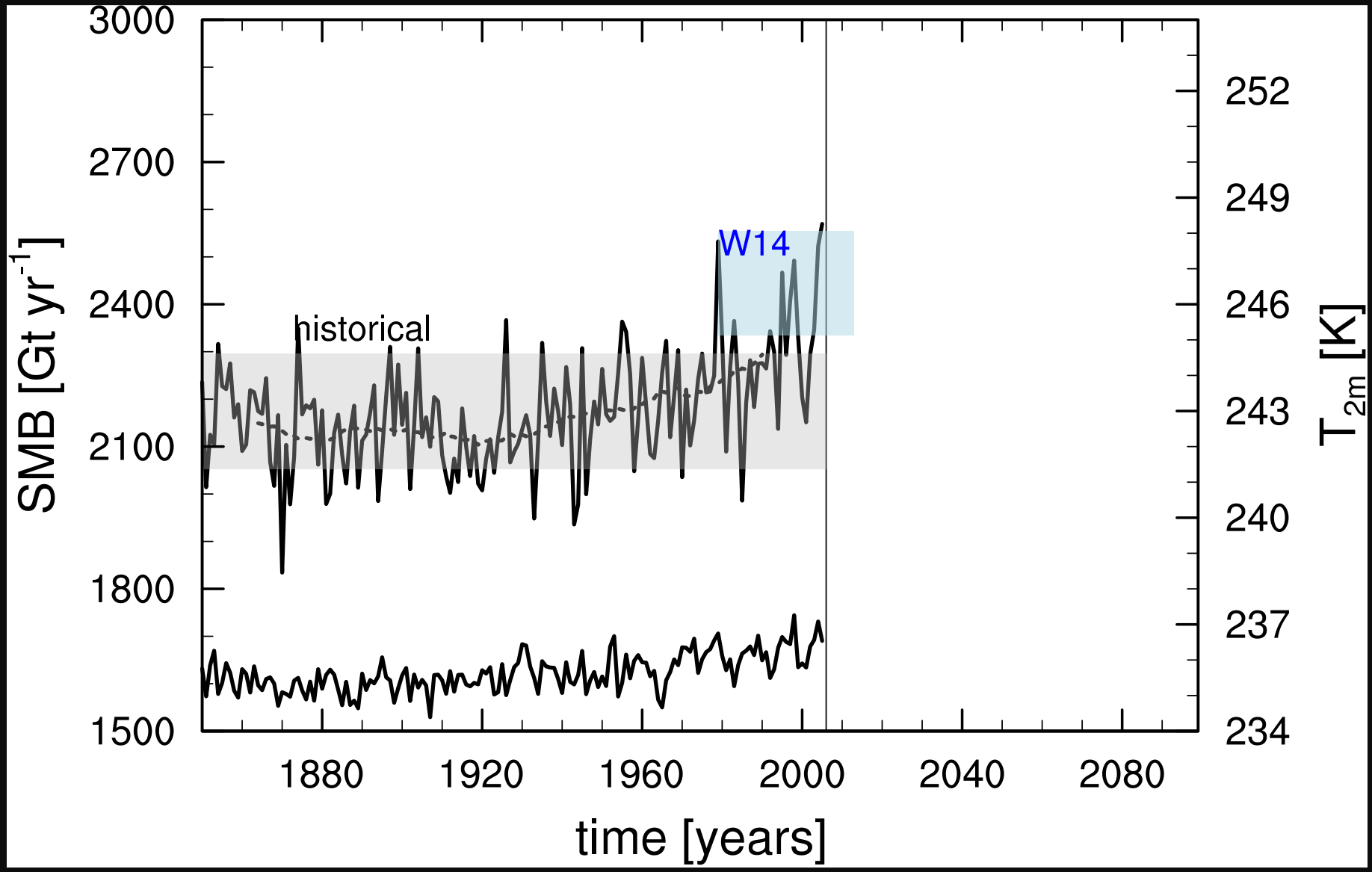
Wind patterns OK, values underestimated. Sea ice pattern realistic.

Near-surface climate (II)

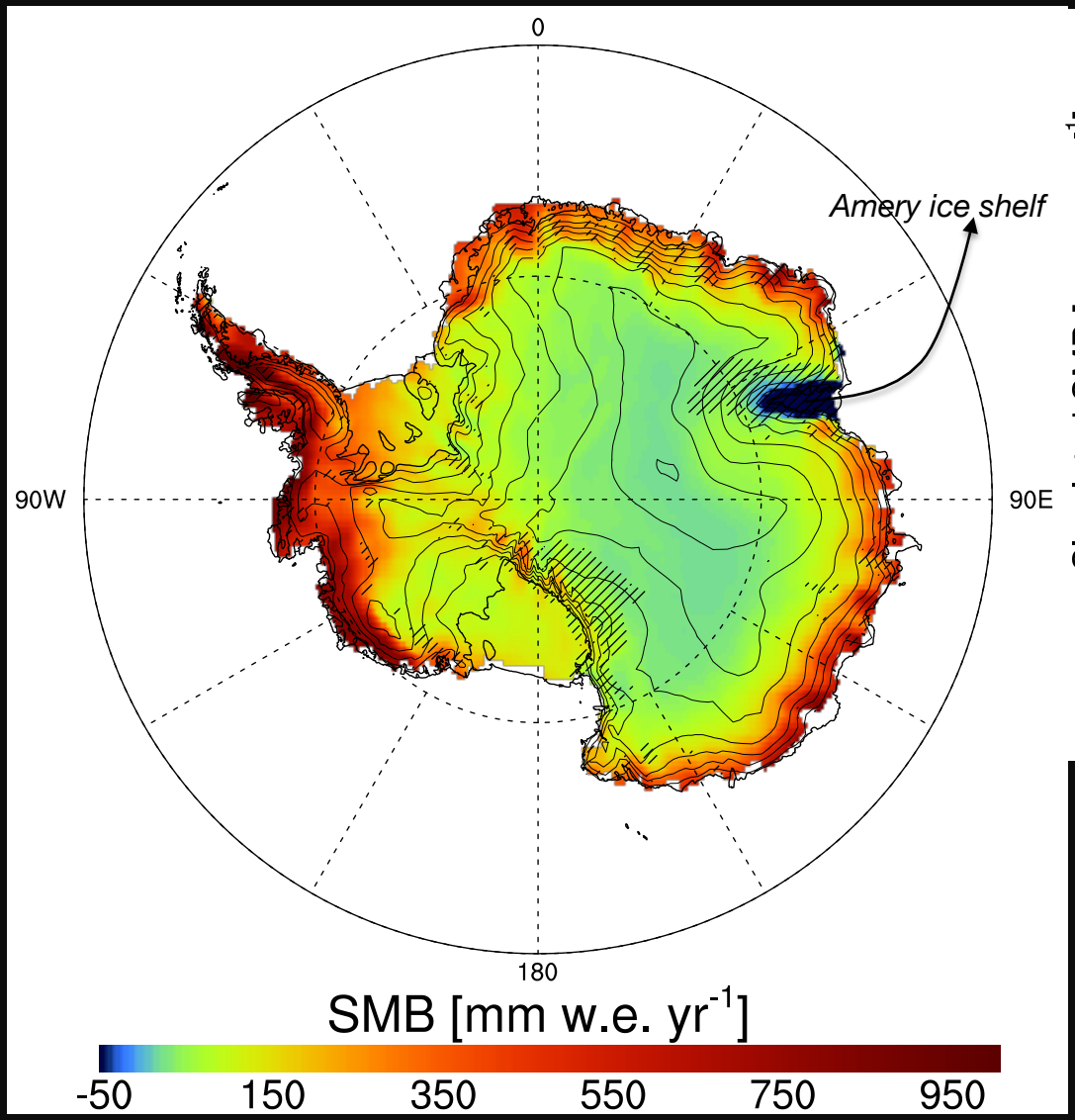


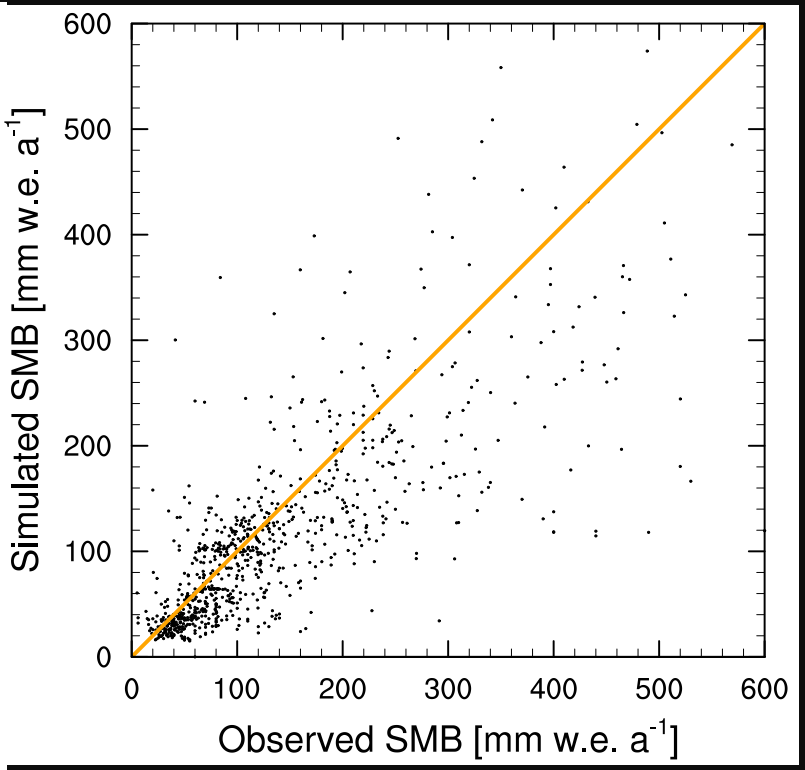
Interior T overestimated, mean T underestimated (similarly to GrIS)

SMB – time evolution



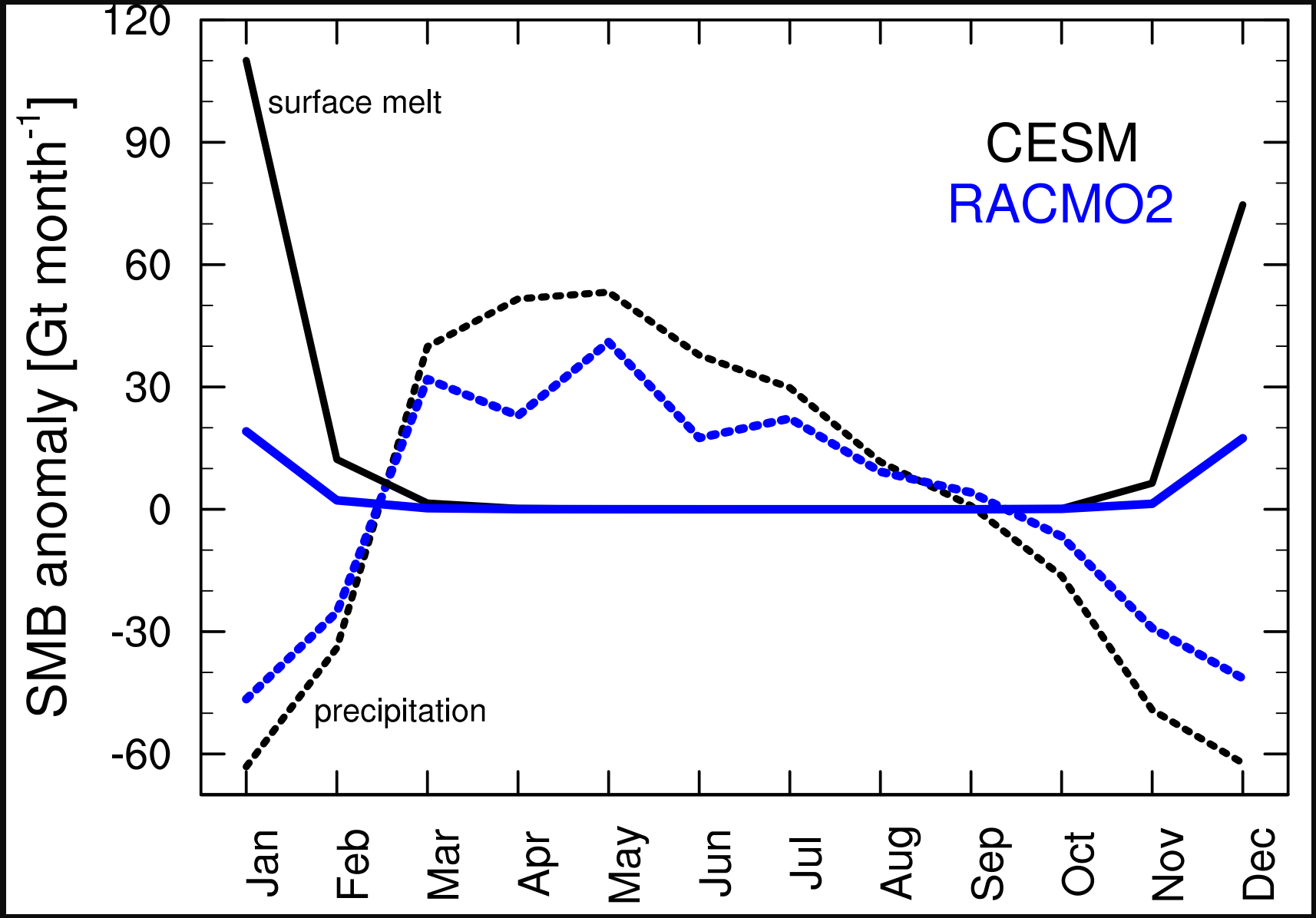
SMB – spatial field



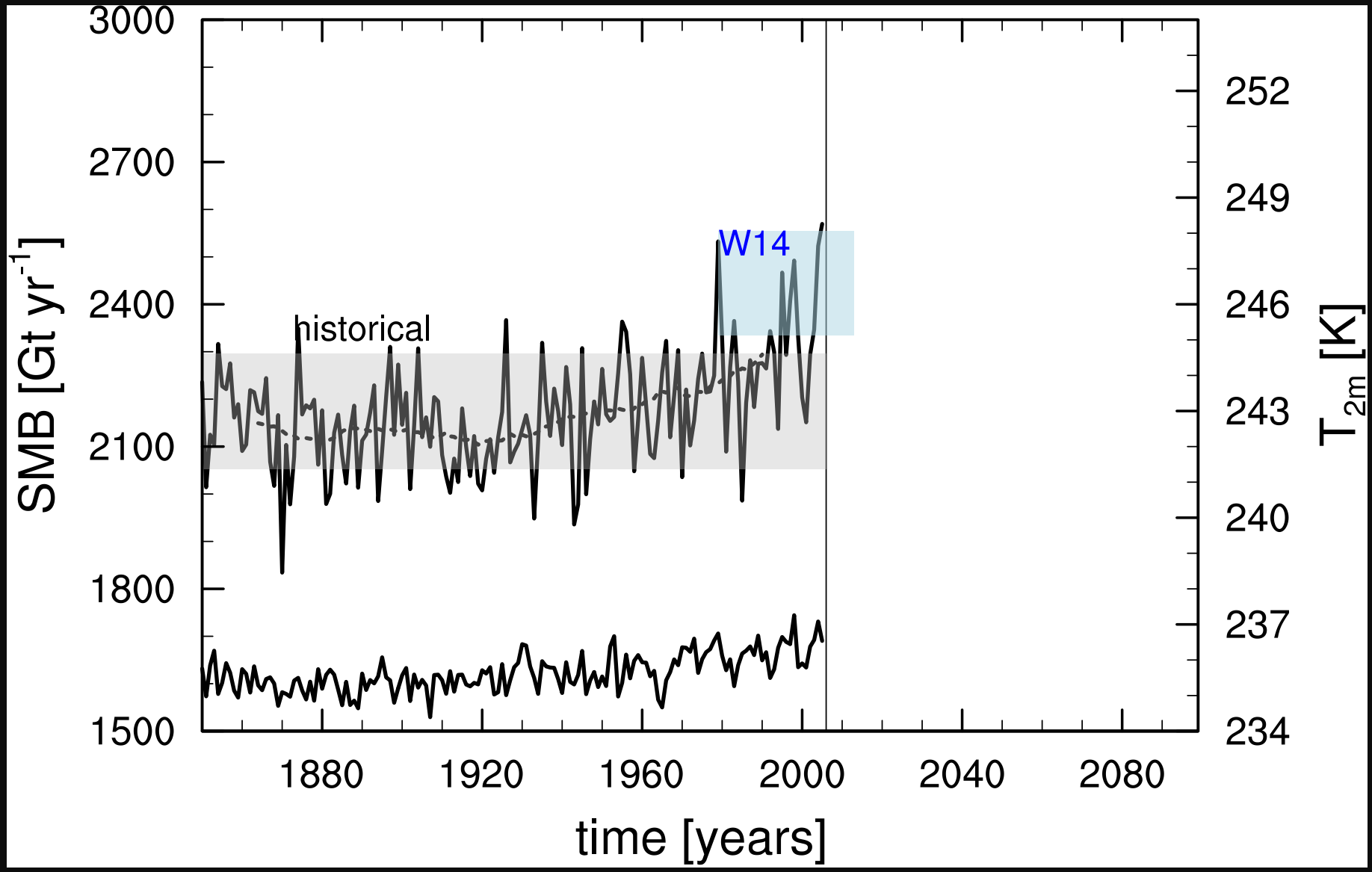


Observations: Favier et al. (2013, updated)

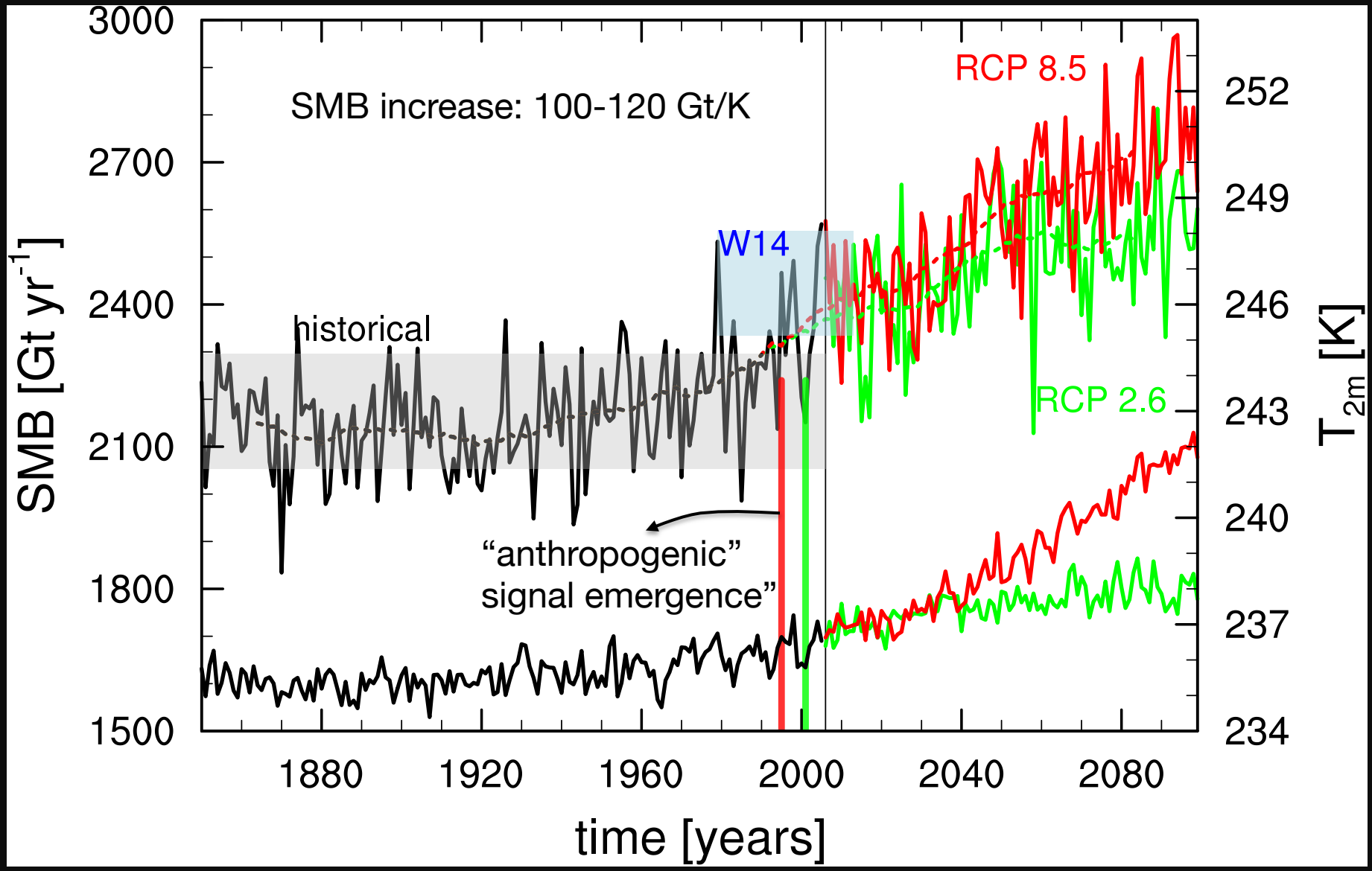
SMB – seasonal cycle



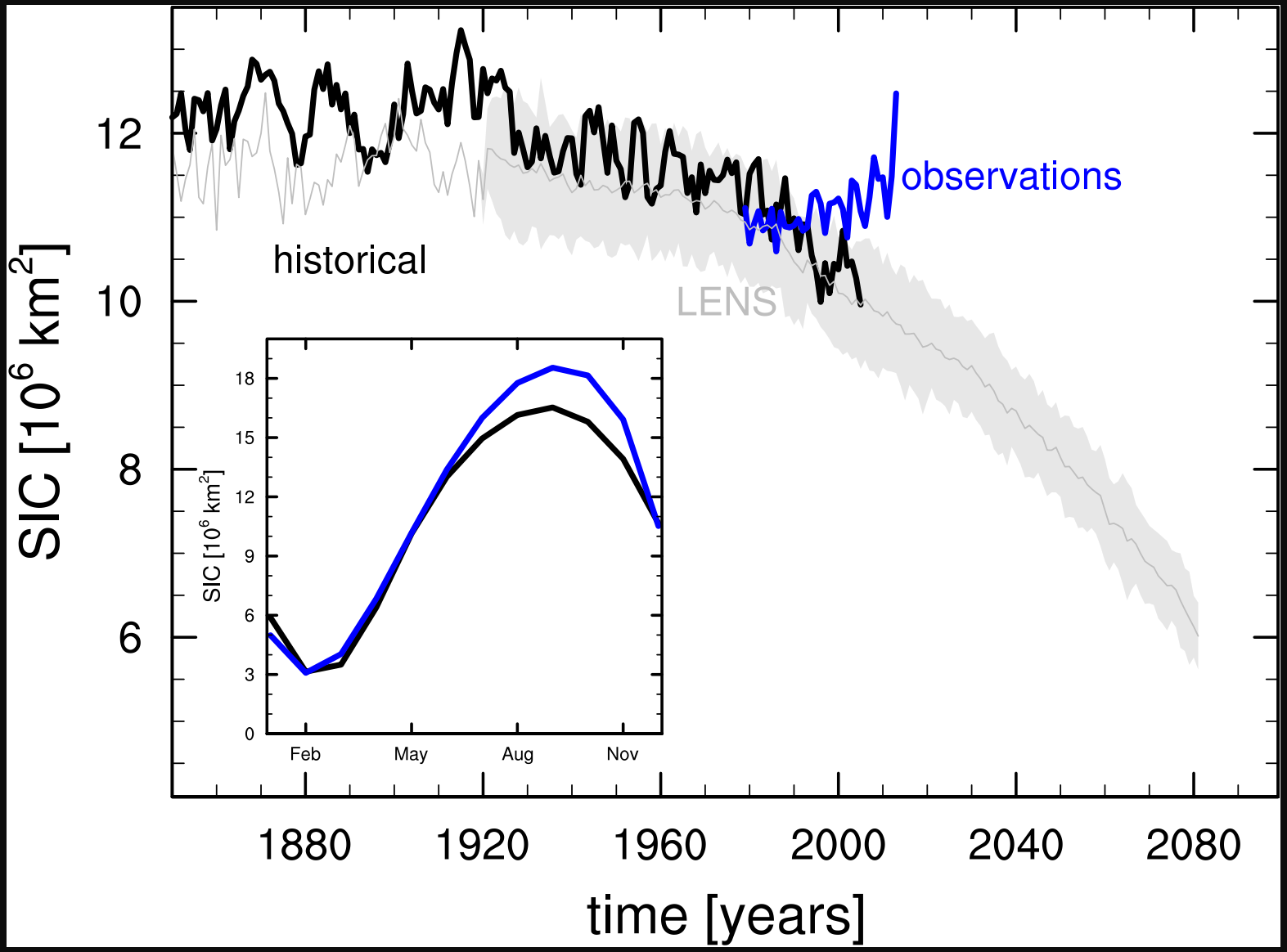
Future SMB (I)


3000
2700
2400
2100
1800
1500
SMB [Gt yr^{-1}]
historical
W14
252
249
246
243
240
237
234
T_{2m} [K]
1880
1920
1960
2000
2040
2080
time [years]

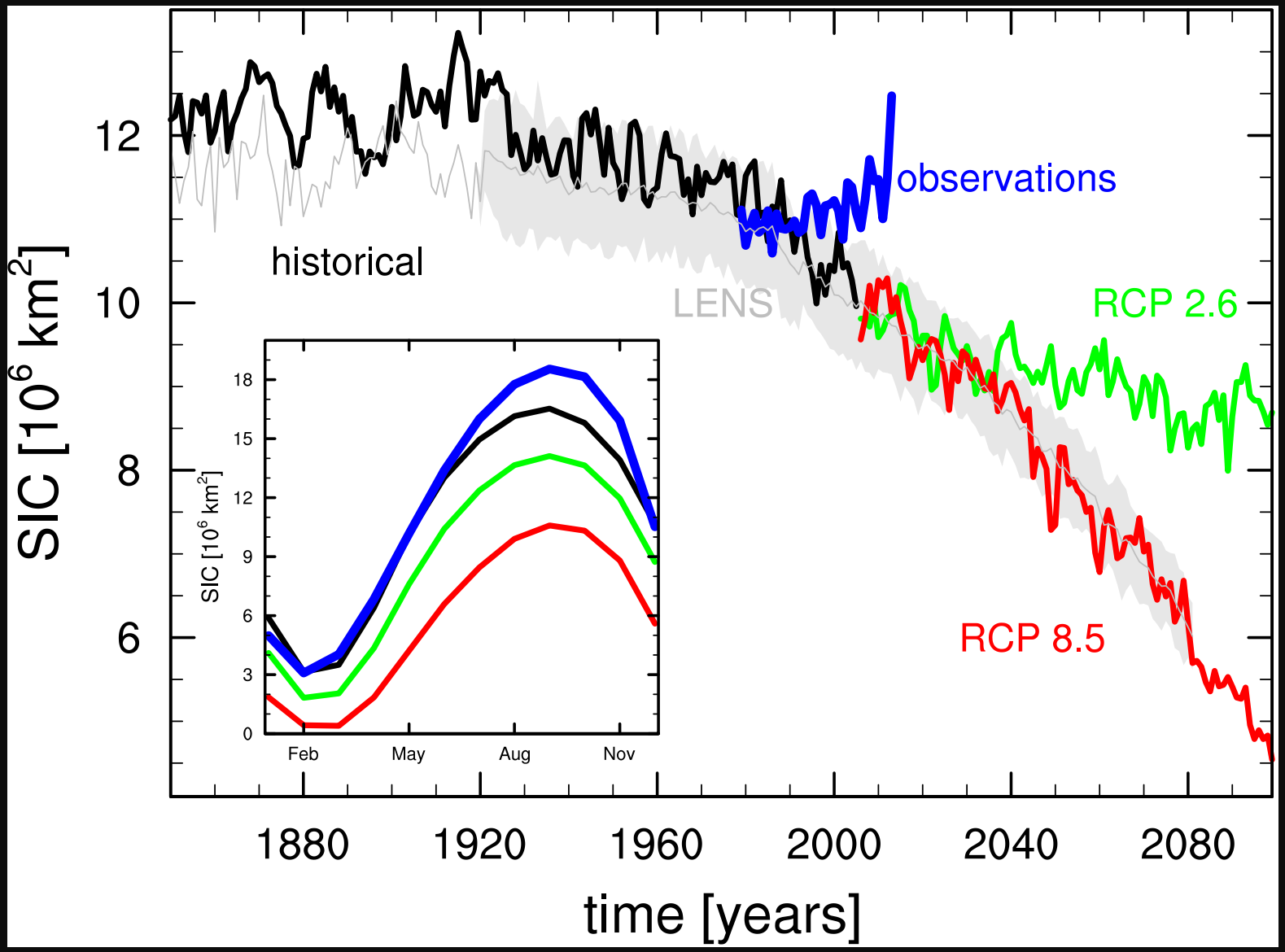
Future SMB (II)



Future sea ice (I)

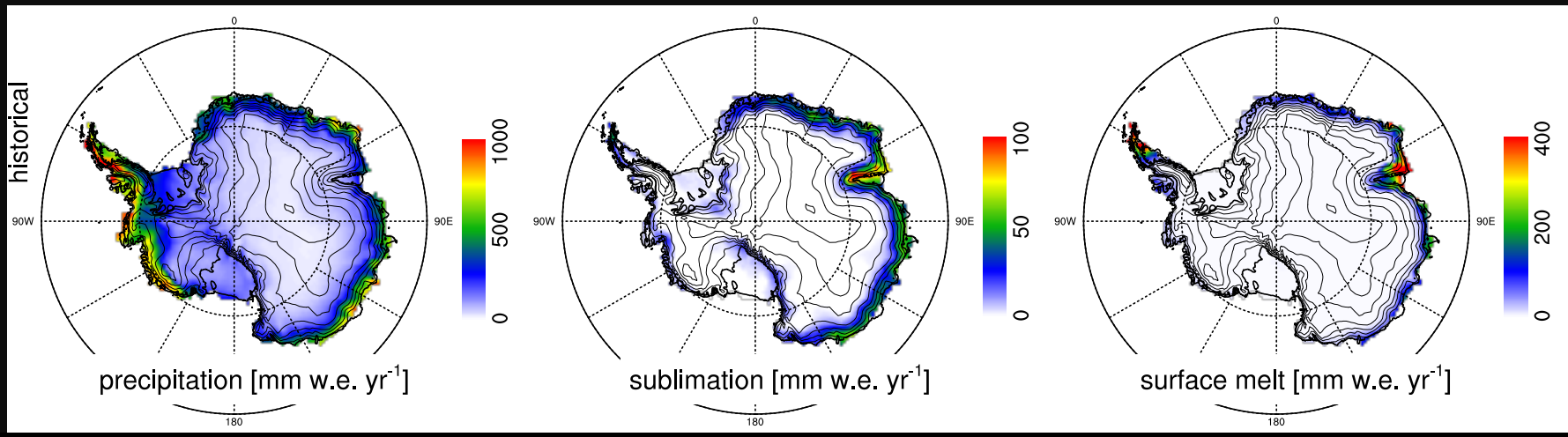


Future sea ice (II)



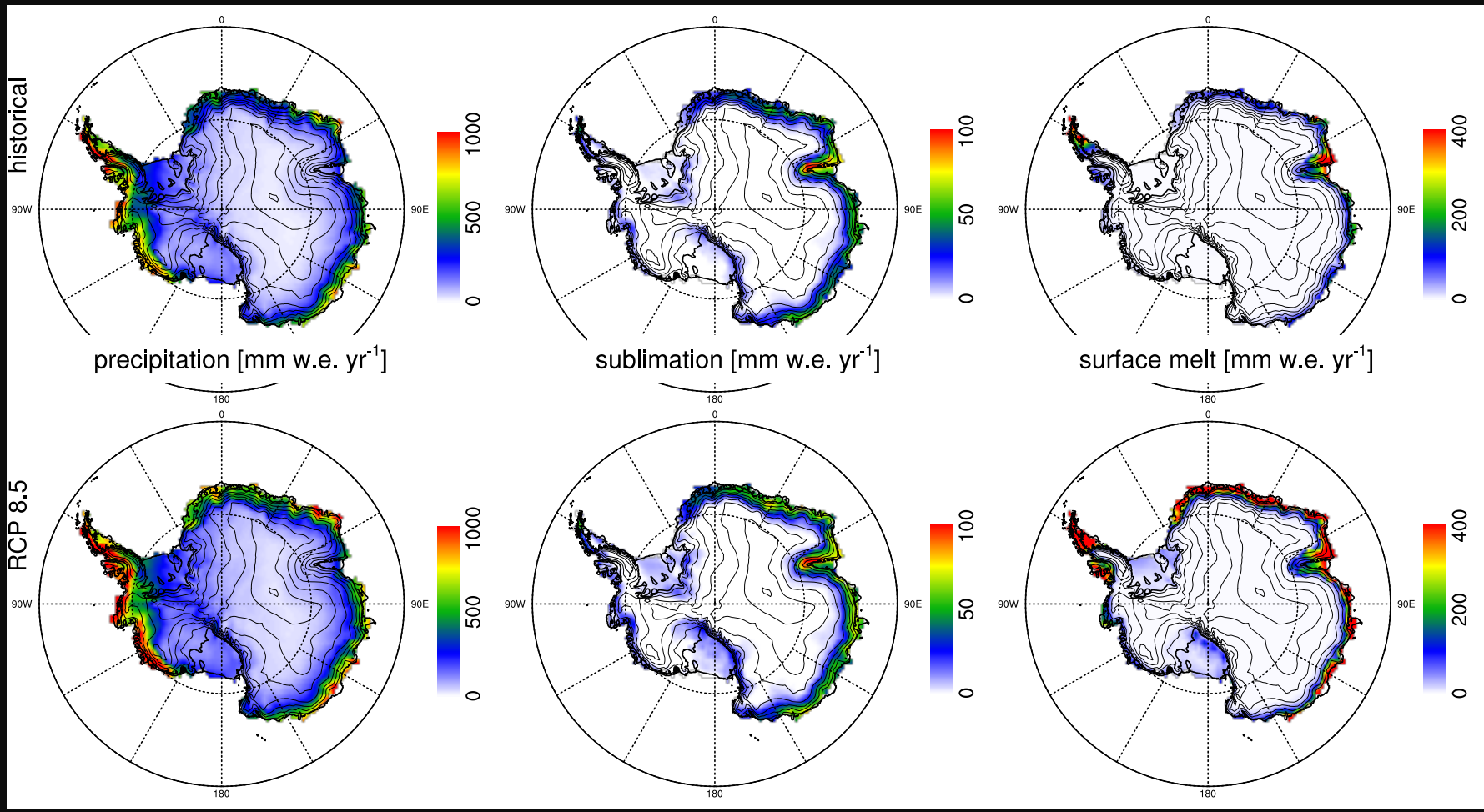
SMB components (I)

historical

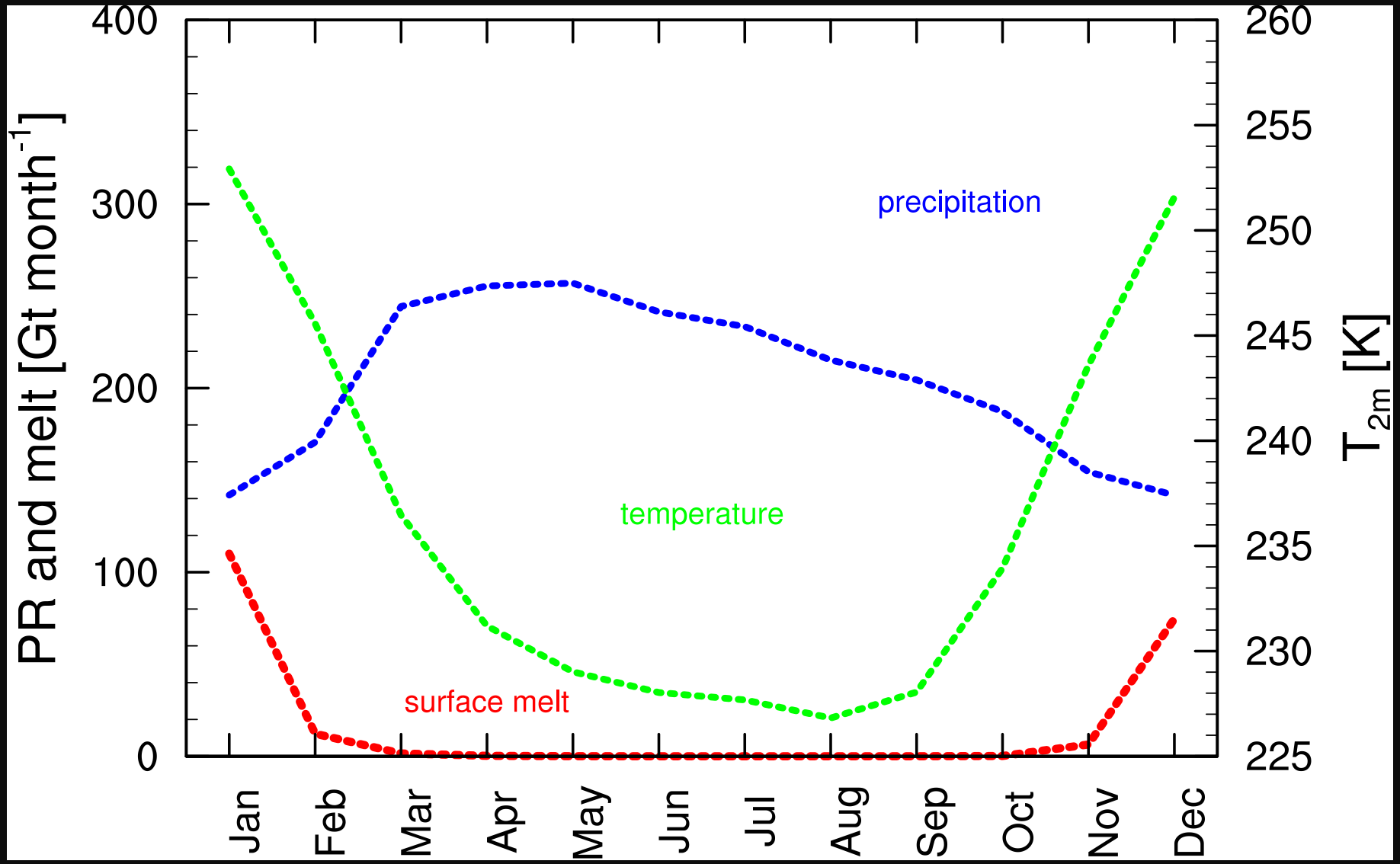


RCP 8.5

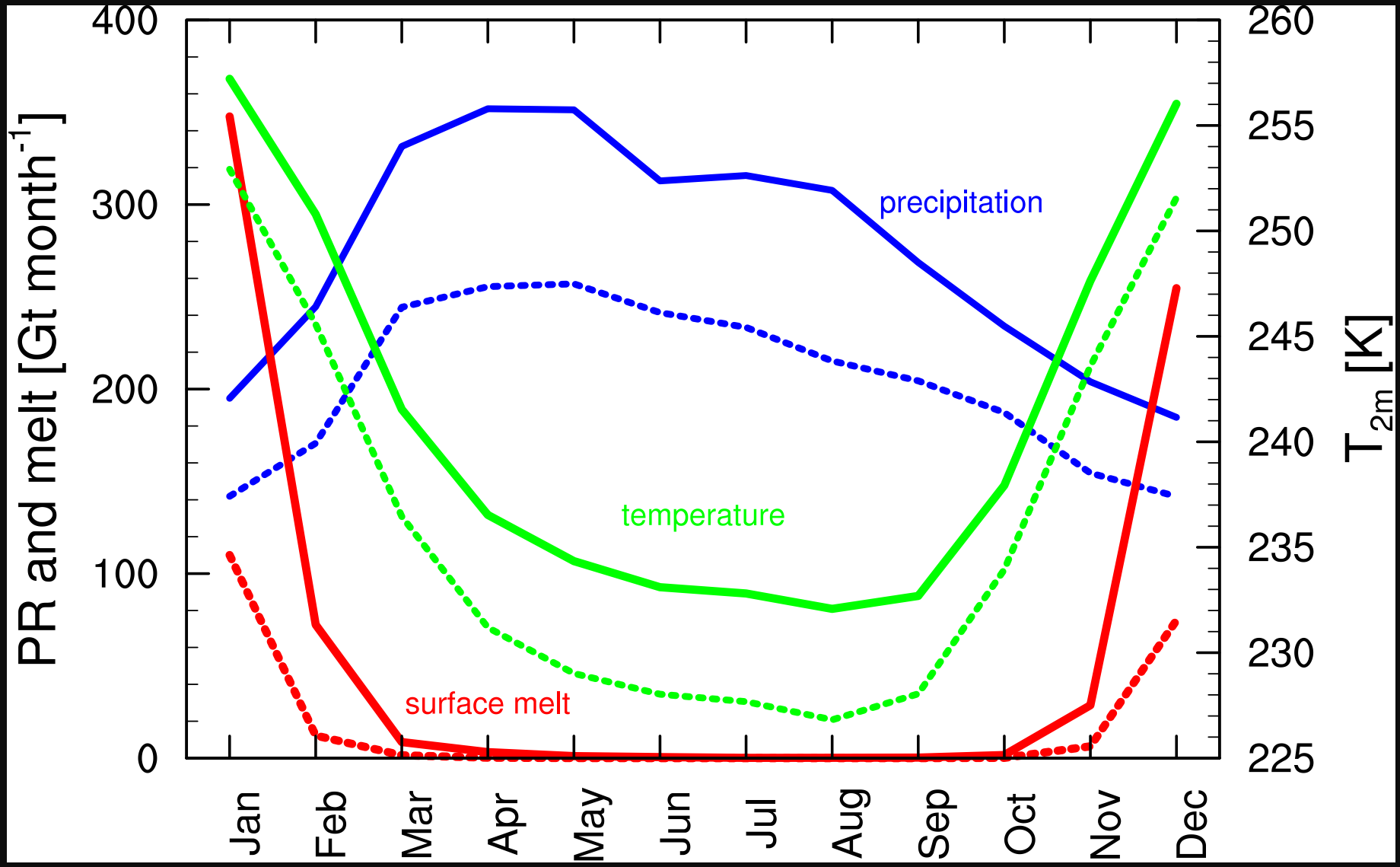
SMB components (II)



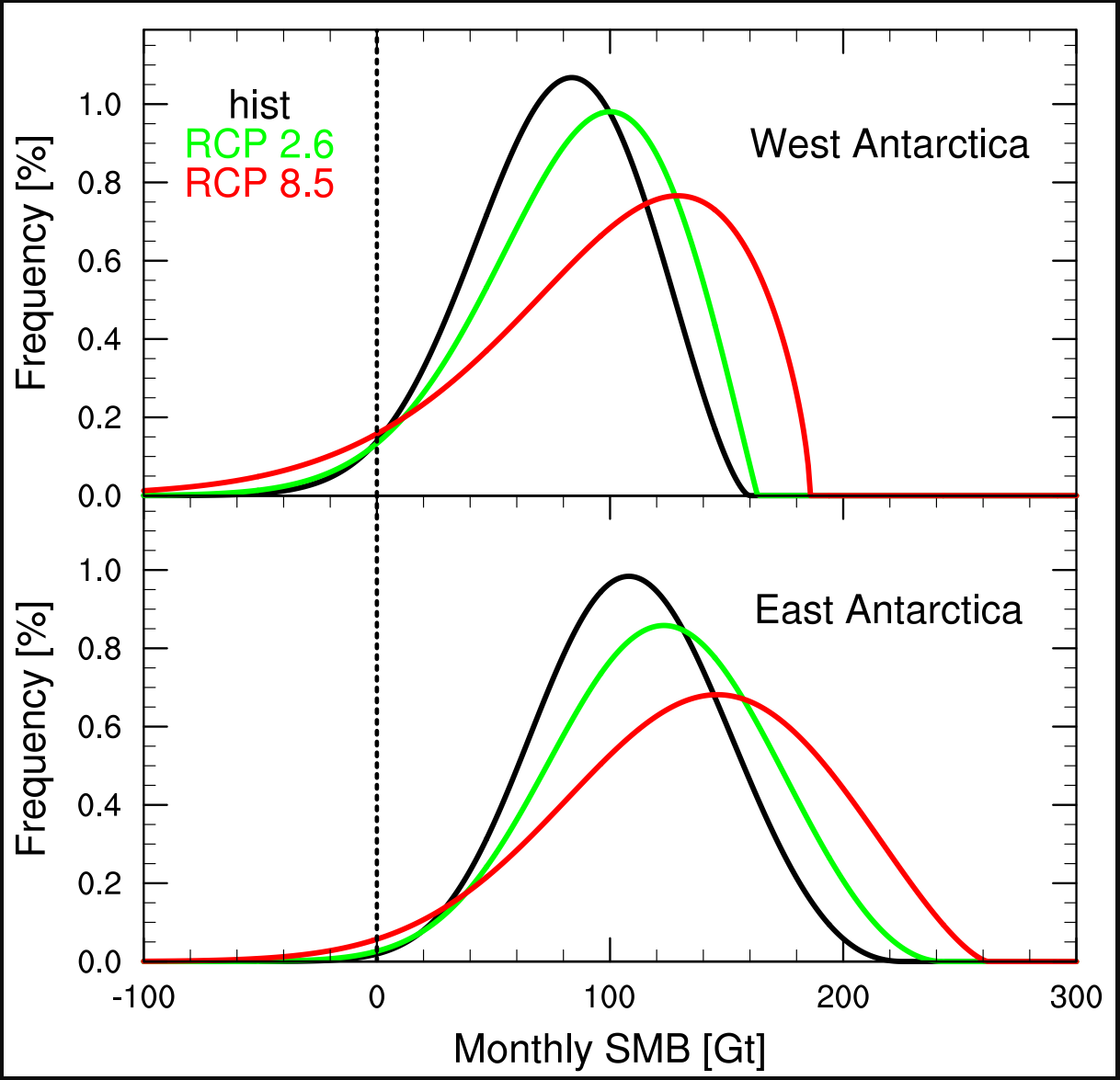
Hydrological cycle (I)



Hydrological cycle (II)



Extreme value analysis



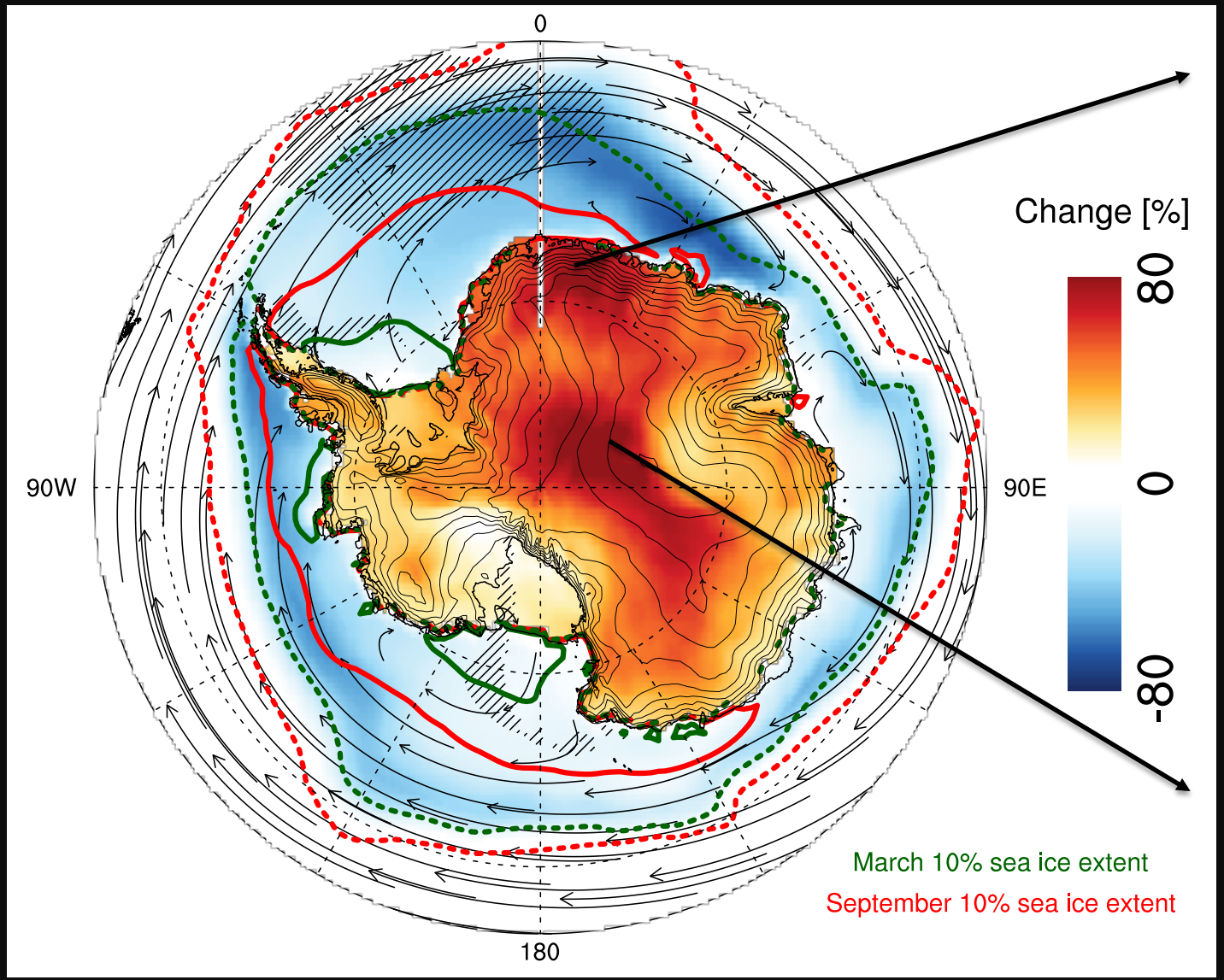
Heavy left tail

Warming -> melt & runoff

Heavy right tail

Warming -> snowfall

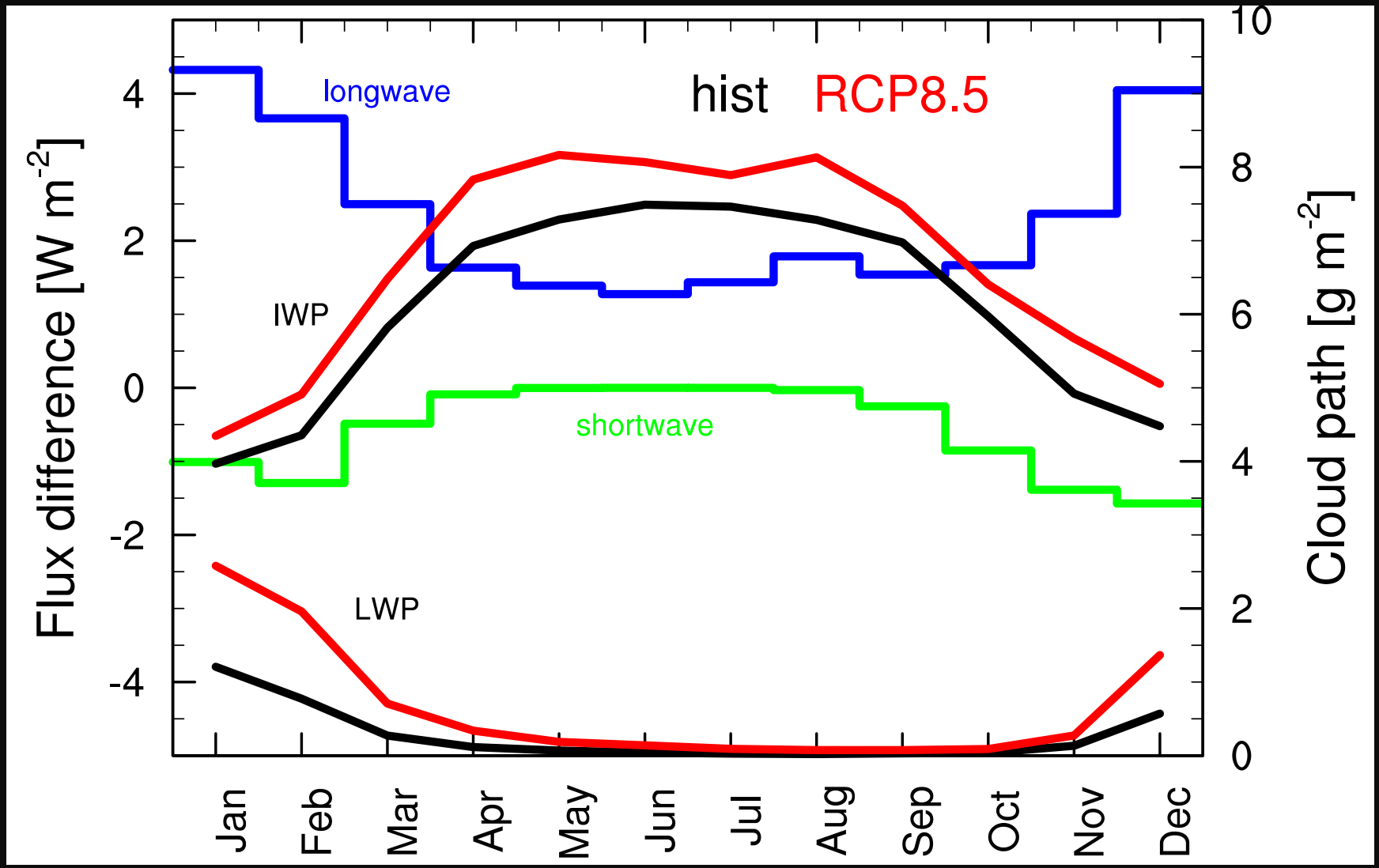
Sea ice – SMB coupling



Ocean warming
Sea ice retreat

Clausius-Clapeyron

Impact of clouds



Longwave (clouds) dominates shortwave (albedo) effect

Conclusions

- CESM is well able to represent large-scale atmospheric circulation, near-surface climate and SMB of Antarctica
- Sea-ice trends problematic, especially because sea ice and SMB are tightly coupled
- Higher SMB in future (~100 Gt/K), and enhanced seasonal variability – more runoff & snowfall (deficiency: snow model)
- Warming impacts SMB through enhanced WV, less sea ice and changing clouds