The Antarctic surface mass balance using MAR (1979-2015), dominant and missing processes
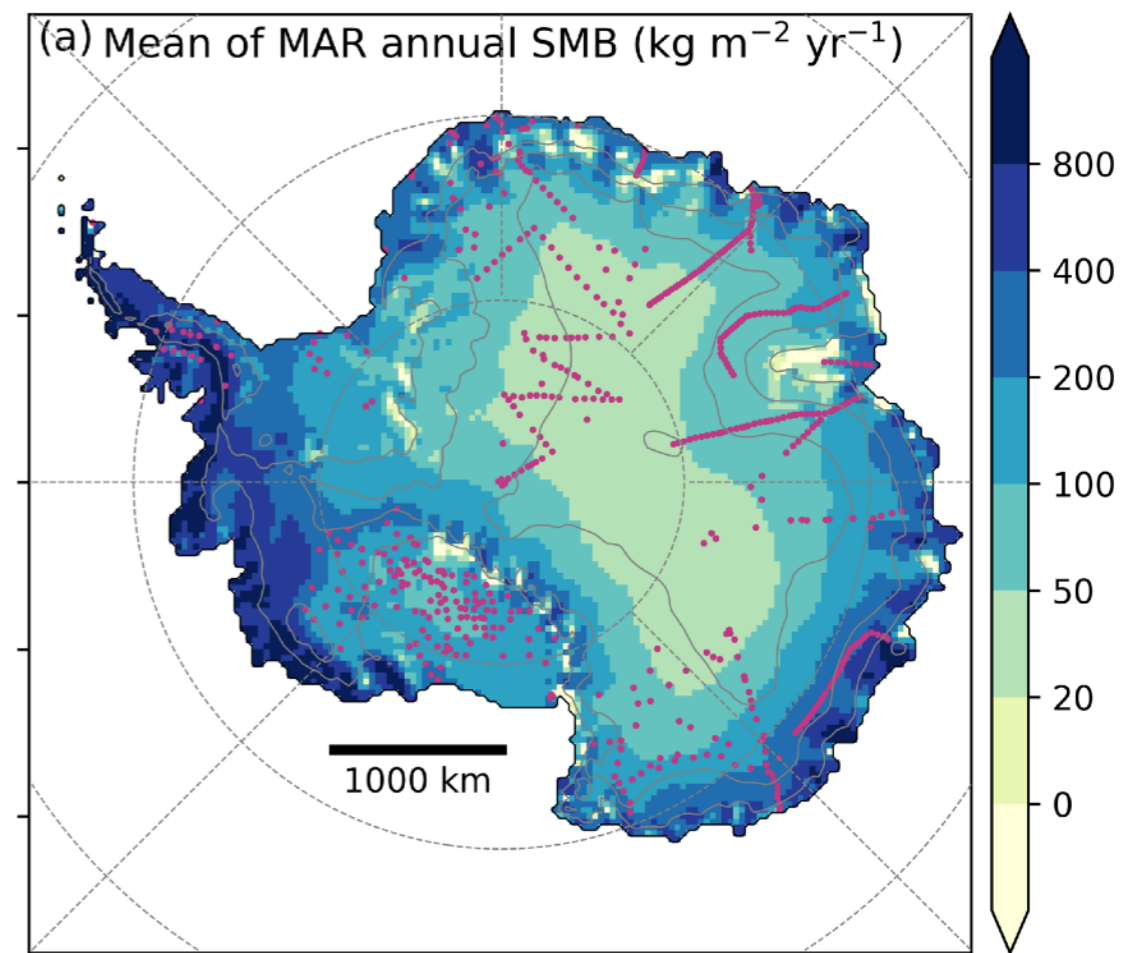
MAR with 3 reanalyses forcing:
ERA-Interim, JRA-55, MERRA2

Resolution: **35 km**

What's new ?
‣ Fresh snow density from obs.
‣ Roughness length = f(temperature)
‣ Topography from Bedmap2
‣ Projection polar stereo south
‣ Nudging at the top of the troposphere
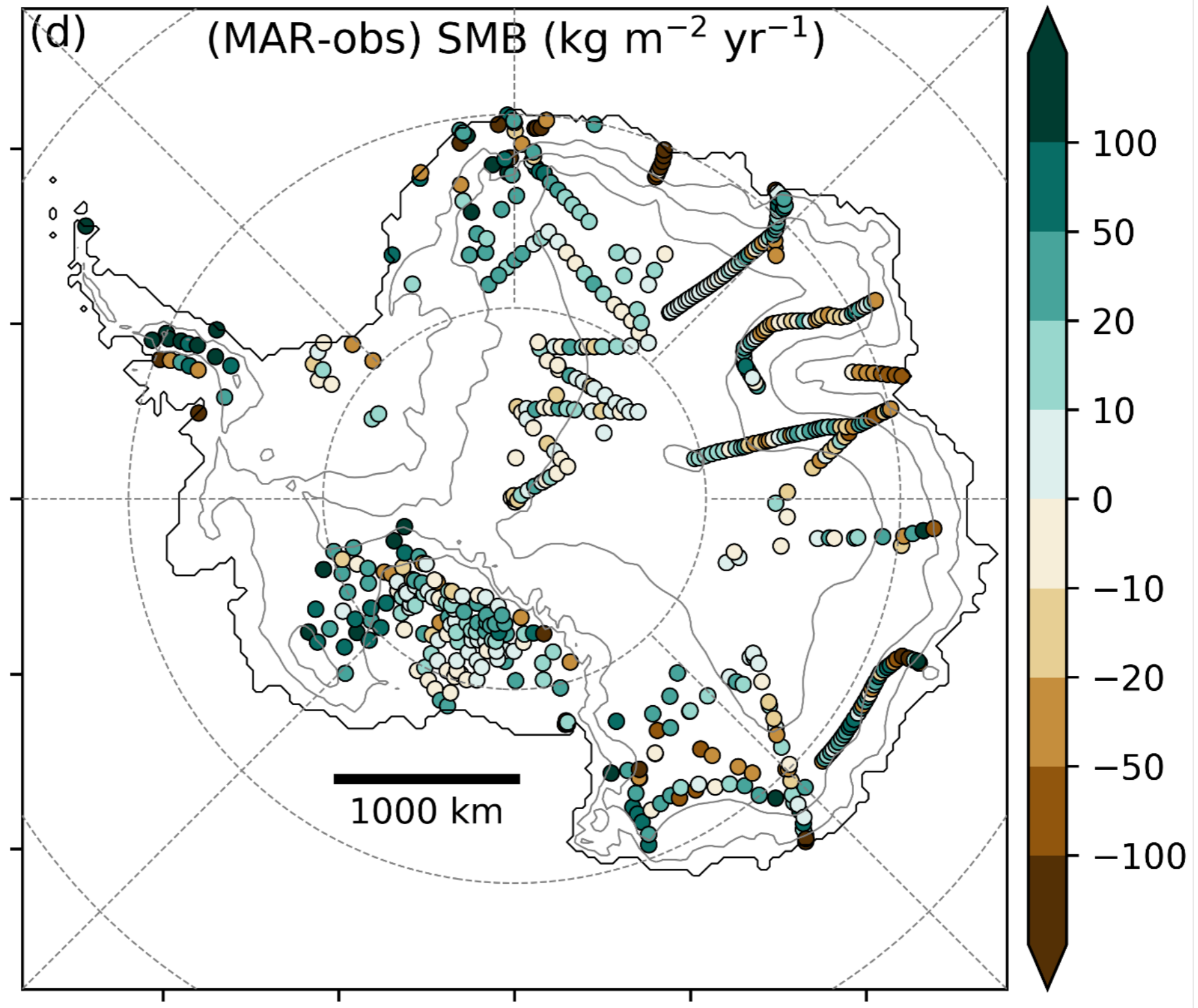
Not new: drifting snow **not** activated

(a) Mean of MAR annual SMB (kg m^{-2} yr^{-1})

MAR(ERA-Interim) SMB climatology (1979-2015)

SMB MAR(ERA-Interim) vs. observations

(d) (MAR-obs) SMB (kg m^{-2} yr^{-1})

1000 km

SMB observations: GLACIOCLIM SAMBA dataset
(**Favier et al., 2013**) updated by **Wang et al. (2016).**

Syowa–Dome F

Mawson–Lambert Glacier

Law Dome–Wilkes Land

Zhongshan–Dome A

Obs.
RACMO2(ERA-Interim)
MAR(ERA-Interim)
MAR(JRA-55)
MAR(MERRA2)

Missing erosion deposition ?

3
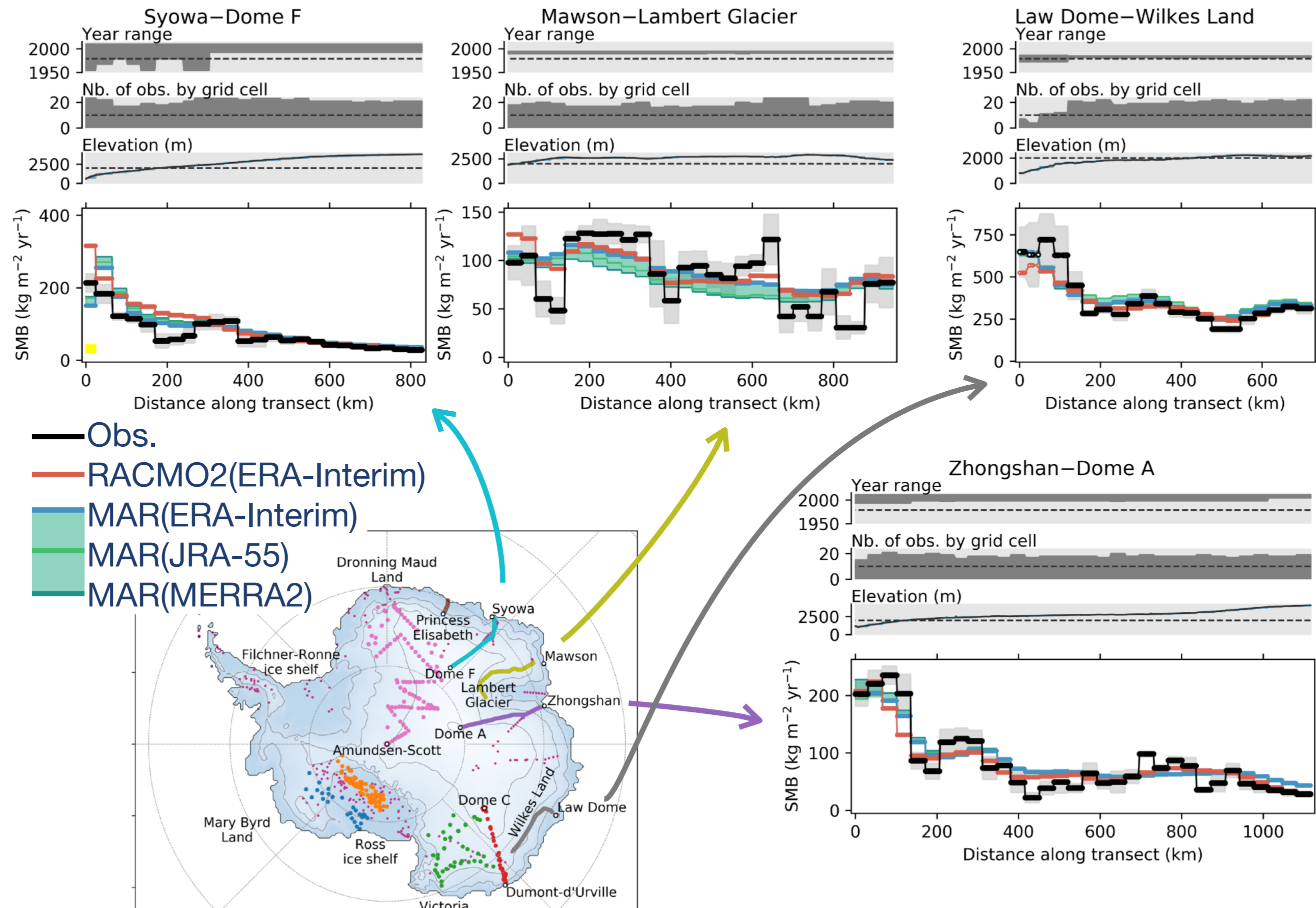
Missing erosion deposition ?

Curvature (m-1) ≈ derivative of the slope

Curvature >> 0: **crests**
⟹ wind divergence
⟹ **mass export (« erosion »)**
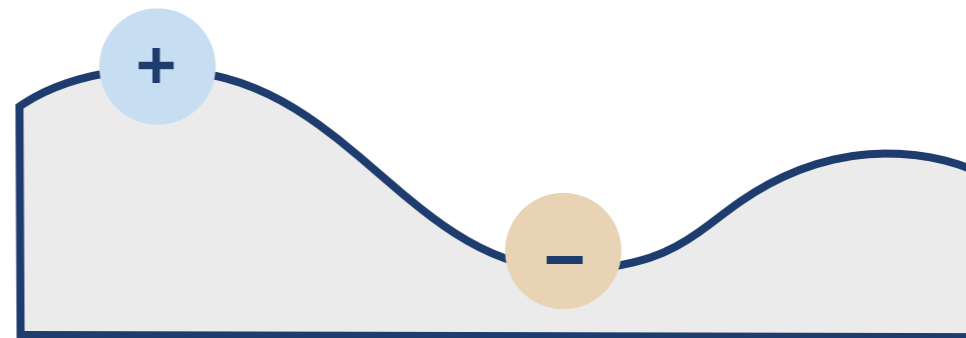
Curvature << 0: **valleys**
⟹ wind convergence
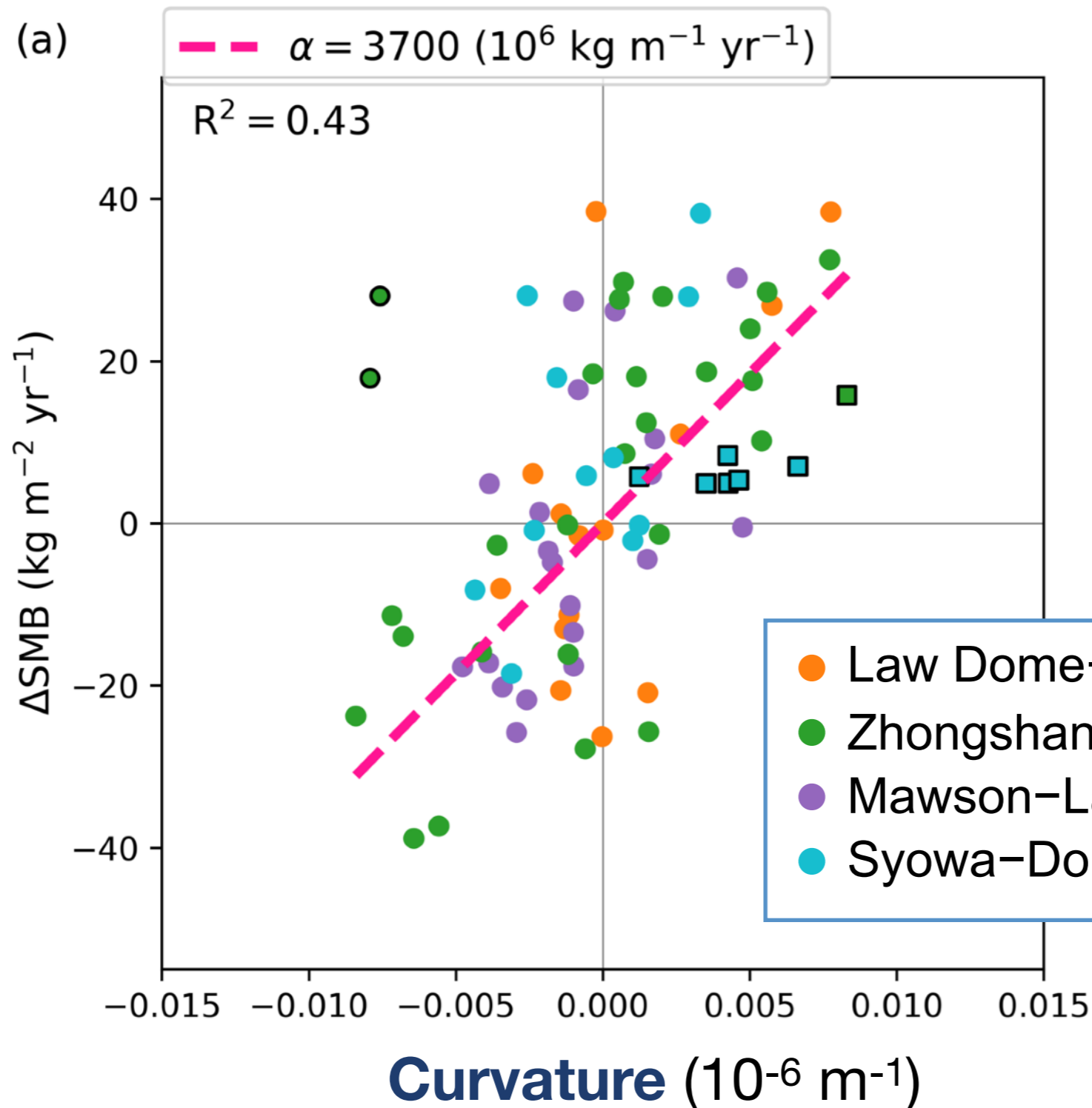⟹ **mass import (« deposition »)**

We compute the **curvature on the 35 km grid**.
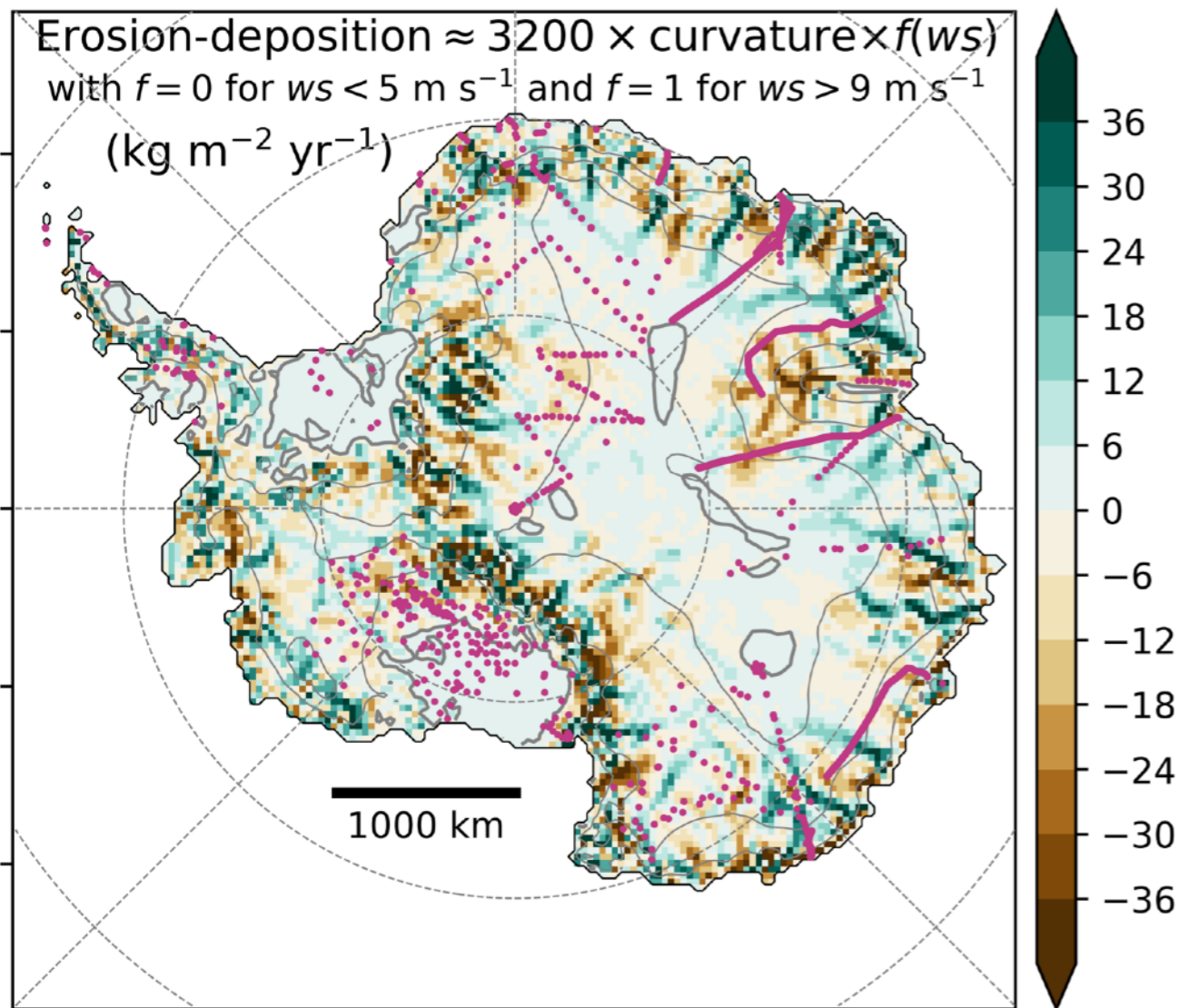At this scale, the surface wind flow is strictly downslope.

MAR bias in SMB explained by missing erosion-deposition

(a)

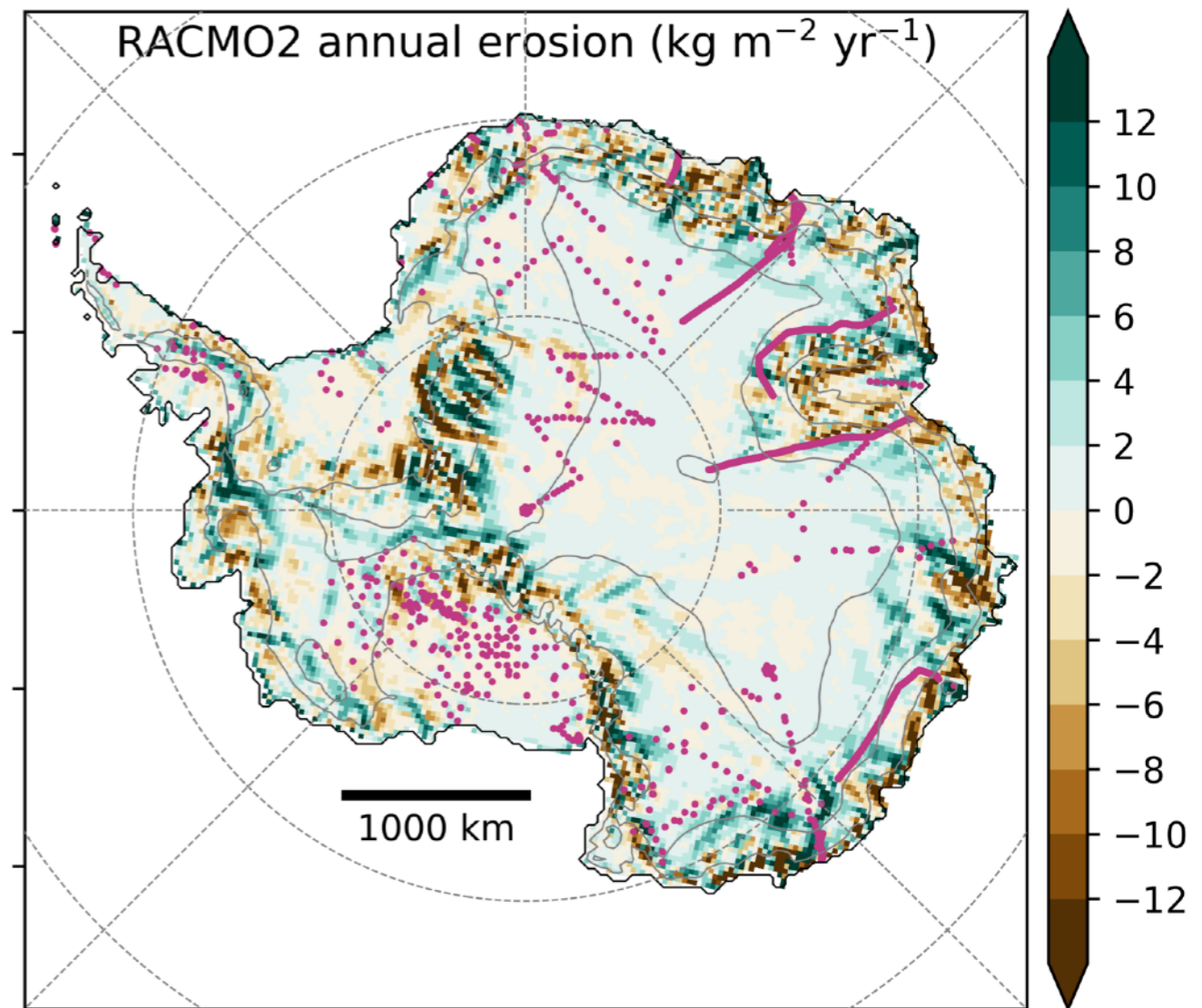Legend: $\alpha = 3700$ (10^6 kg m^{-1} yr^{-1})

$R^2 = 0.43$

Y-axis: SMB bias (MAR − observed), ΔSMB (kg m^{-2} yr^{-1})

X-axis: Curvature (10^{-6} m^{-1})

Shifts might be related to the Coriolis deflection

- Law Dome−Wilkes Land (shift: -1)
- Zhongshan−Dome A (shift: +1)
- Mawson−Lambert Glacier (shift: -1)
- Syowa−Dome F (shift: +2)

MAR bias in SMB explained by missing erosion-deposition

factor 3

Erosion-deposition based on curvature

Erosion-deposition from RACMO2.3p2

Erosion-deposition $\approx 3200 \times$ curvature$\times f(ws)$
with $f = 0$ for $ws < 5$ m s^{-1} and $f = 1$ for $ws > 9$ m s^{-1}
(kg m^{-2} yr^{-1})

1000 km

RACMO2 annual erosion (kg m^{-2} yr^{-1})

1000 km
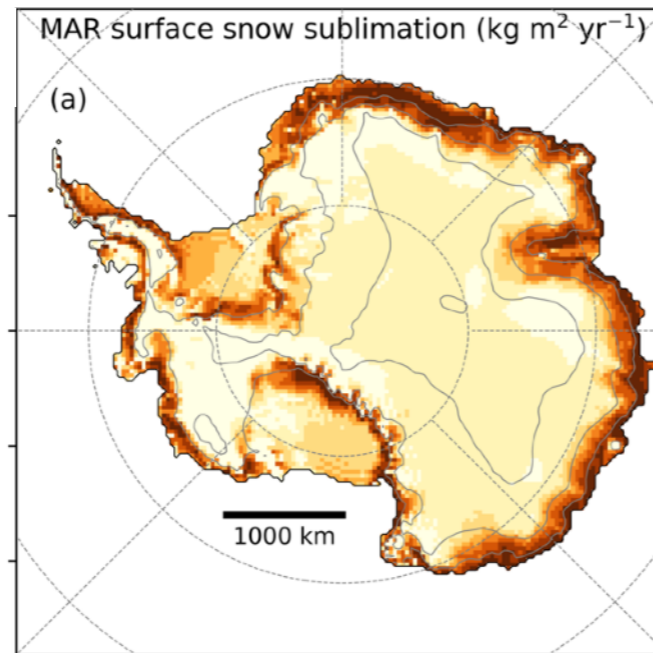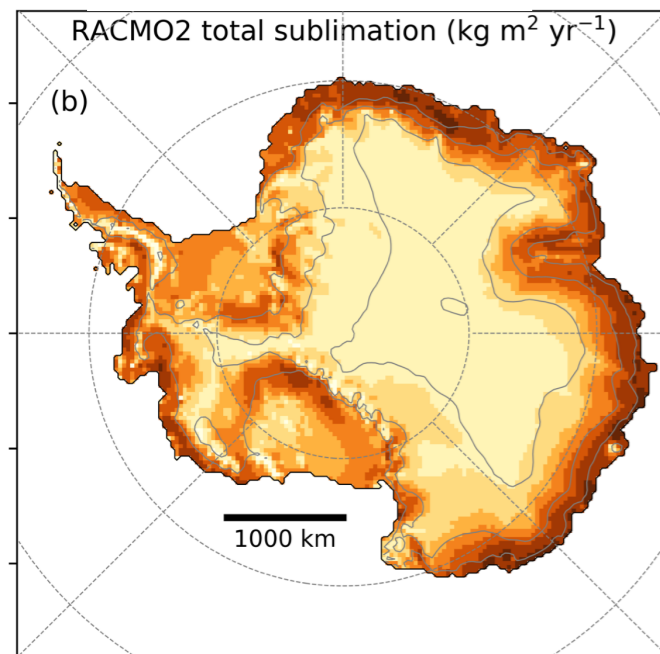
Grounded ice-sheet: erosion 75 Gt/yr, deposition 66 Gt/yr, net 9 Gt/yr

Higher surface snow sublimation partly compensate for missing drifting snow sublimation
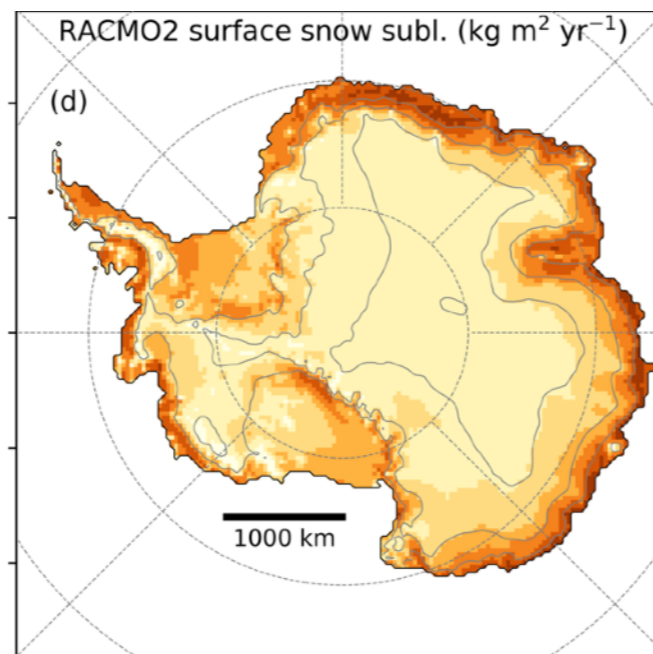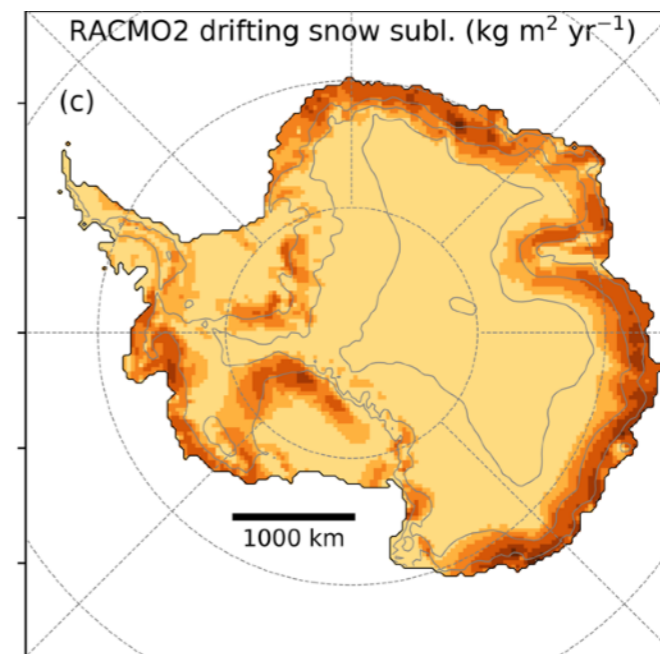
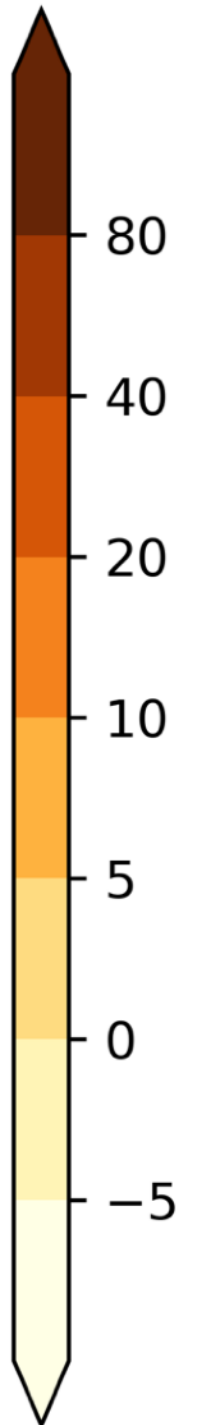**MAR surface snow sublimation**

RACMO2 total sublimation

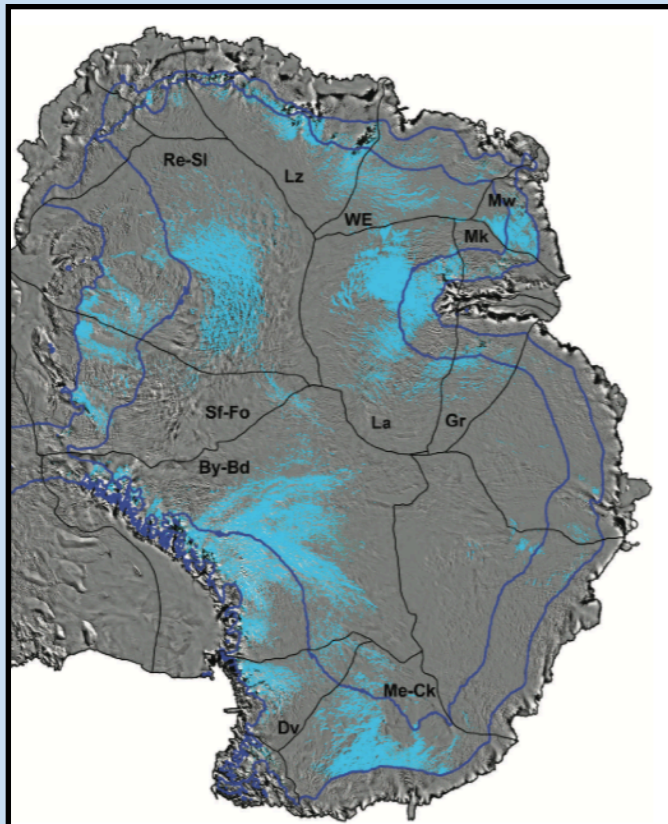**RACMO2 surface snow sublimation**

RACMO2 drifting snow sublimation

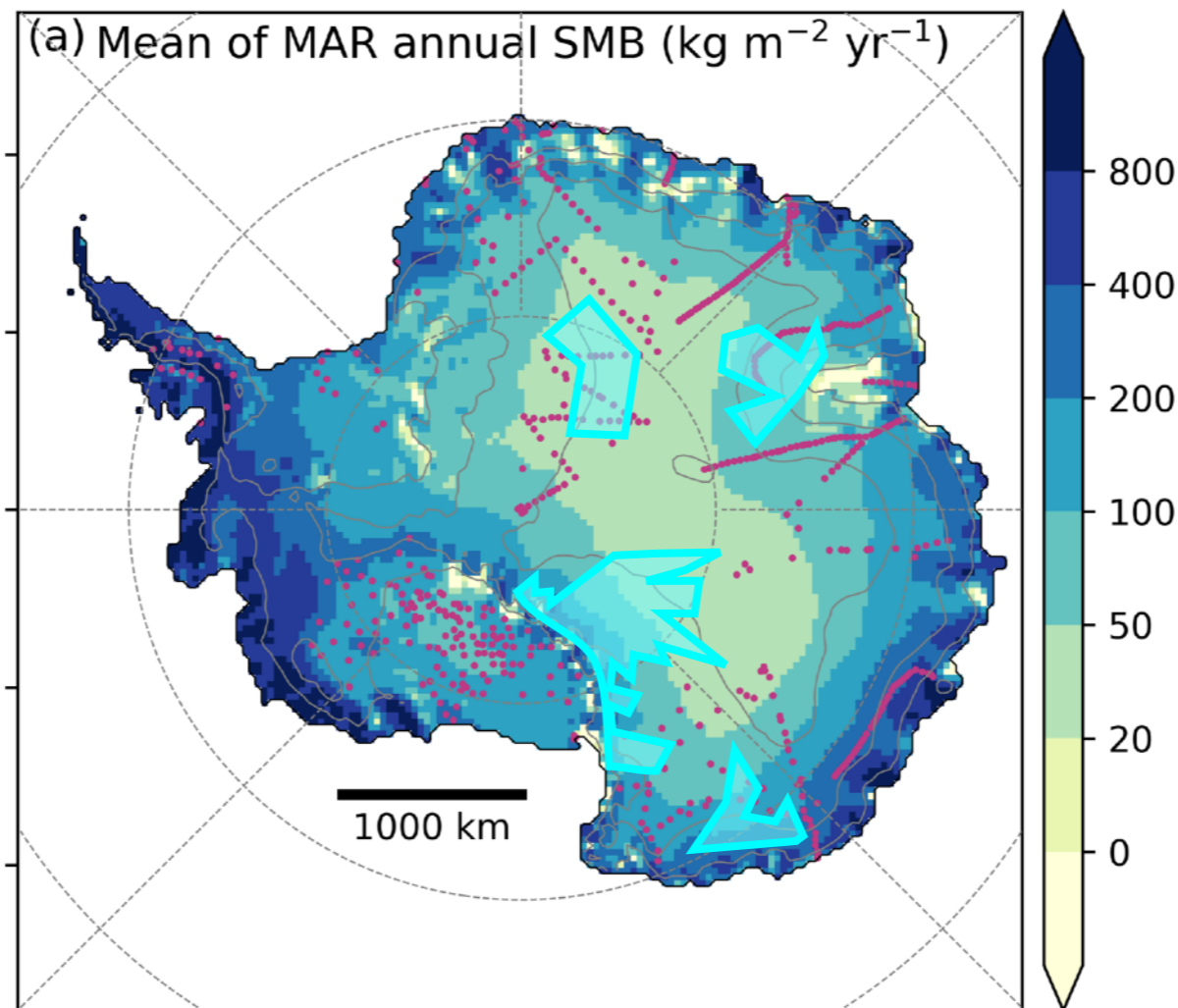# Can drifting snow sublimation explain unresolved wind glaze areas in MAR ?

Wind glaze areas: SMB≈0.

Scambos et al. (2012), J. Glaciol.
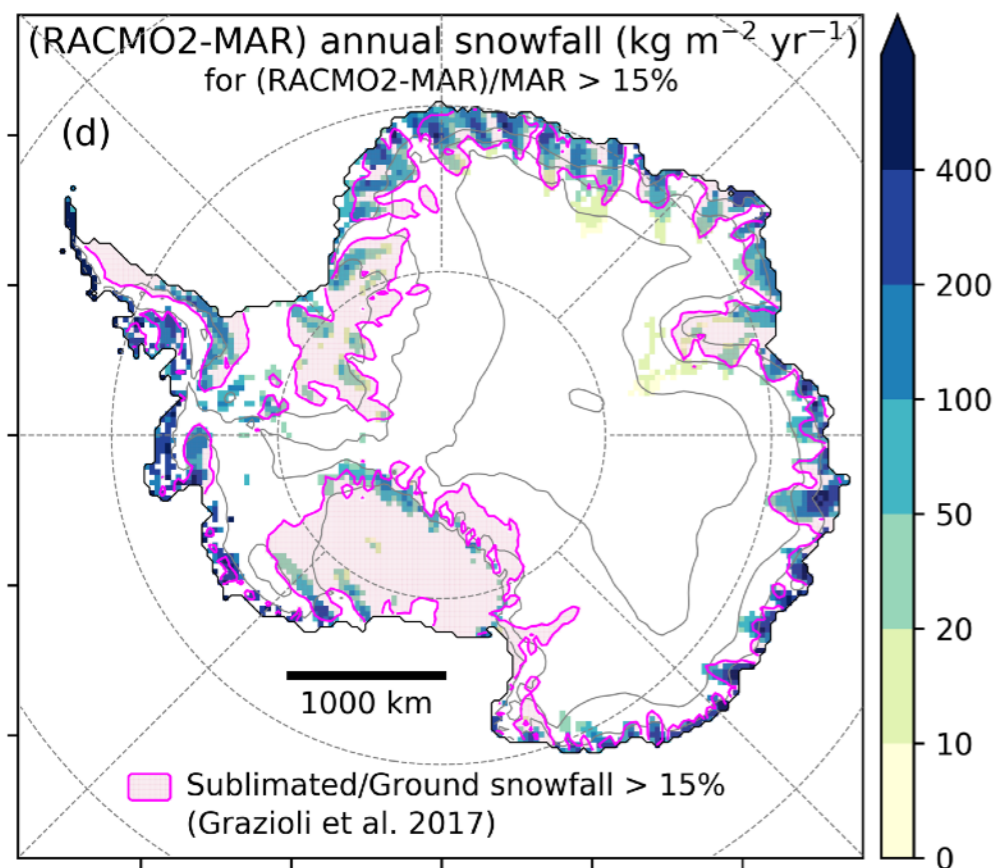
Wind glaze areas from remote-sensing observations

MAR SMB climatology


(a) Mean of MAR annual SMB (kg m^{-2} yr^{-1})

1000 km

Snowfall sublimation in the katabatic layer: a large mass sink (we confirm)

(RACMO2-MAR) snowfall where MAR < RACMO2

(RACMO2-MAR) annual snowfall (kg m^{-2} yr^{-1})
for (RACMO2-MAR)/MAR > 15%

(d)

1000 km

Sublimated/Ground snowfall > 15%
(Grazioli et al. 2017)

Katabatic winds diminish precipitation contribution to the Antarctic ice mass balance

Jacopo Grazioli[a,1], Jean-Baptiste Madeleine[b], Hubert Gallée[c], Richard M. Forbes[d], Christophe Genthon[c], Gerhard Krinner[c], and Alexis Berne[a,2]

B Total sublimated snowfall

[mm]

Dumont d'Urville (DdU)
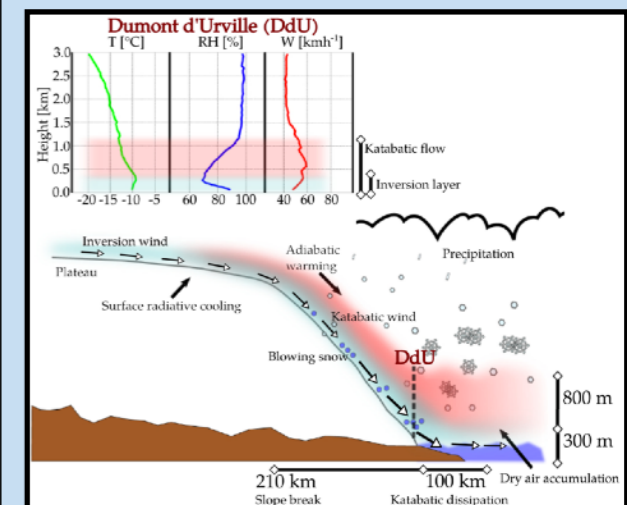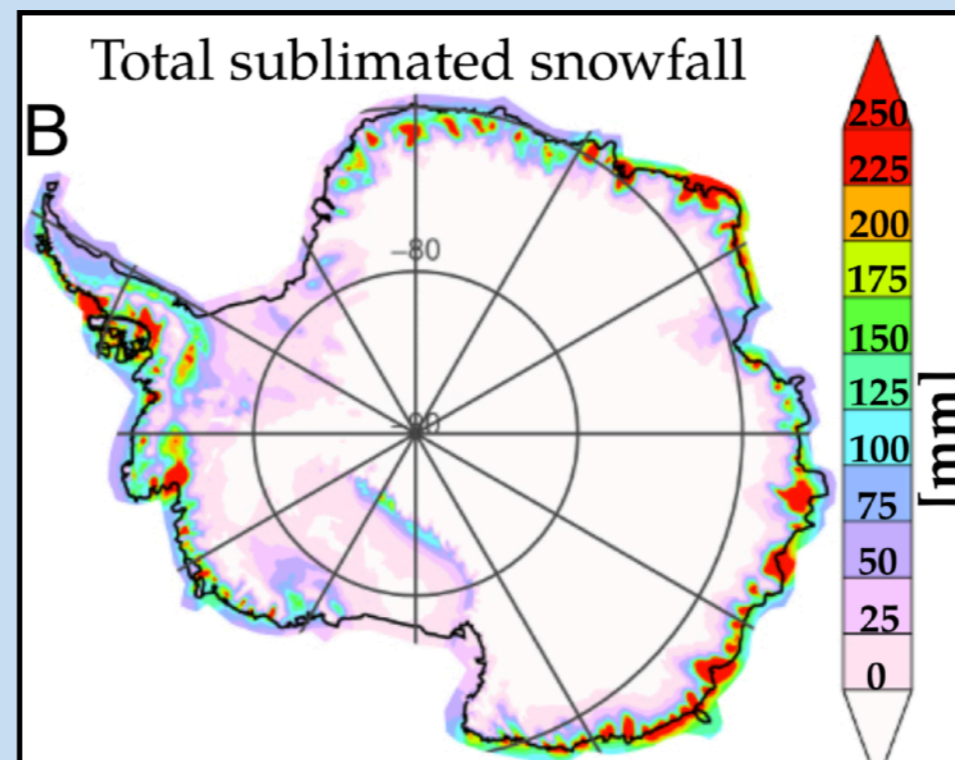
Grazioli et al. (2017), PNAS

Snowfall sublimation in the atmospheric layers, included in MAR and not in RACMO2, may represent **250 Gt yr^{-1}** of difference in SMB at the ground.

9

Conclusions of MAR-Antarctica runs

Modeling the Antarctic surface mass balance:

– **drifting snow does matter, and need to be better constrained**
(factor 3 in erosion-deposition $\implies$ factor ? in drifting snow sublimation)

– **sublimation of precipitation in the atmospheric layers** is significant
(major difference between MAR and RACMO2)

– **new standard output: precipitation rate in the atmospheric layers**,
for comparison with satellite products at several levels

Observations, we will use your input:

– stake lines, precipitation radars, accumulation radars, drifting snow
fluxes, remote sensing of precipitation and blowing snow…

Snowfall sublimation in the katabatic layer: a large mass sink (we confirm)

Katabatic winds diminish precipitation contribution to the Antarctic ice mass balance

Grazioli et al. (2017), PNAS

Jacopo Grazioli[a,1], Jean-Baptiste Madeleine[b], Hubert Gallée[c], Richard M. Forbes[d], Christophe Genthon[c], Gerhard Krinner[c], and Alexis Berne[a,2]