Blowing snow in Antarctica and its contribution to the surface mass balance

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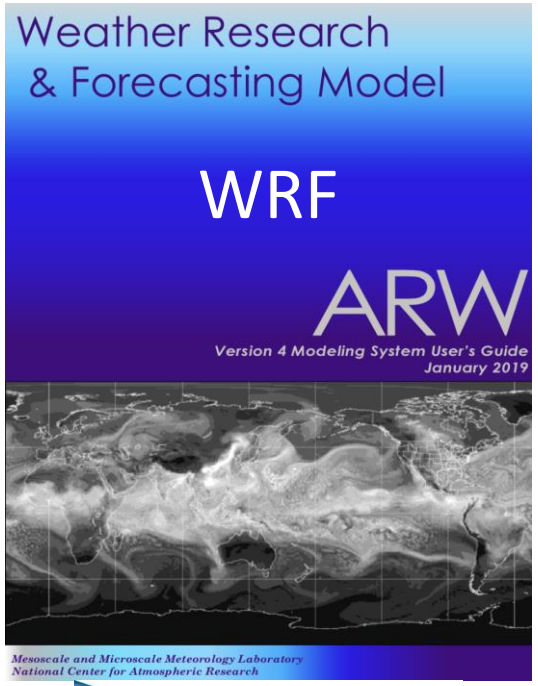
CRYOWRF: a new coupled atmosphere-snow model



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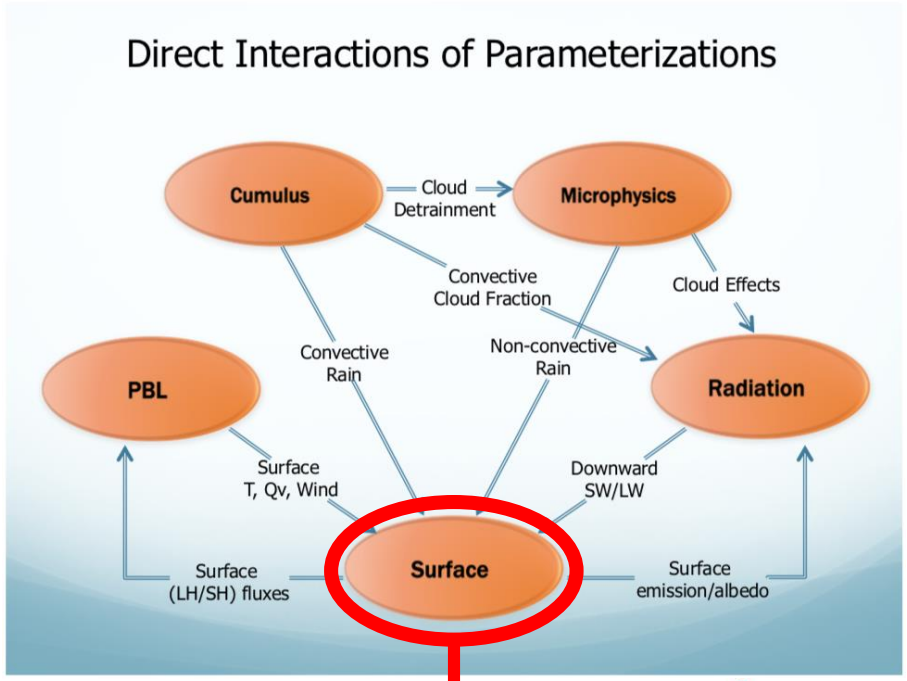
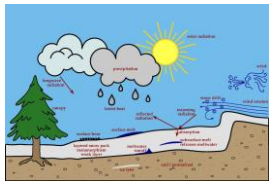




SNOWPACK

SLF

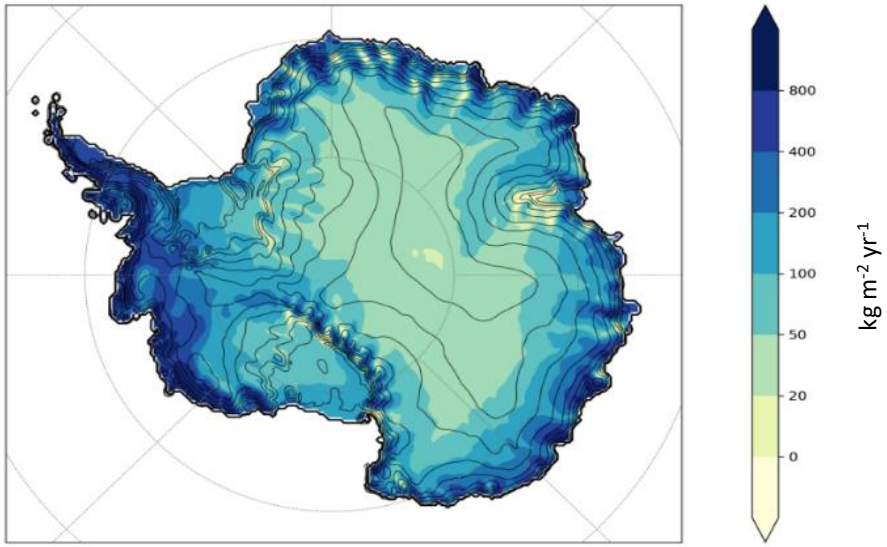
CRYOWRF

- CRYOWRF couples the atmospheric Weather Research and Forecasting model (WRF) with the snow model SNOWPACK
- Includes grain information of multiple snow layers
- Additional near-surface atmospheric layers for blowing snow
- Interaction of blowing snow and precipitation

Fully coupled non-hydrostatic model including blowing snow interaction with the atmosphere

Surface mass balance (SMB) in Antarctica

CRYOWRF without blowing snow (annual mean)



SMB = Precipitation - Sublimation

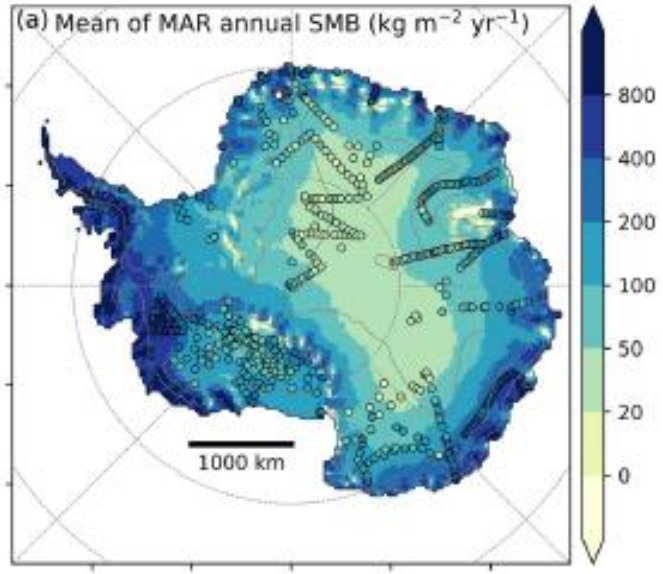
CRYOWRF period: 2011-07-01 – 2017-07-01

SMB in CRYOWRF
– without blowing snow

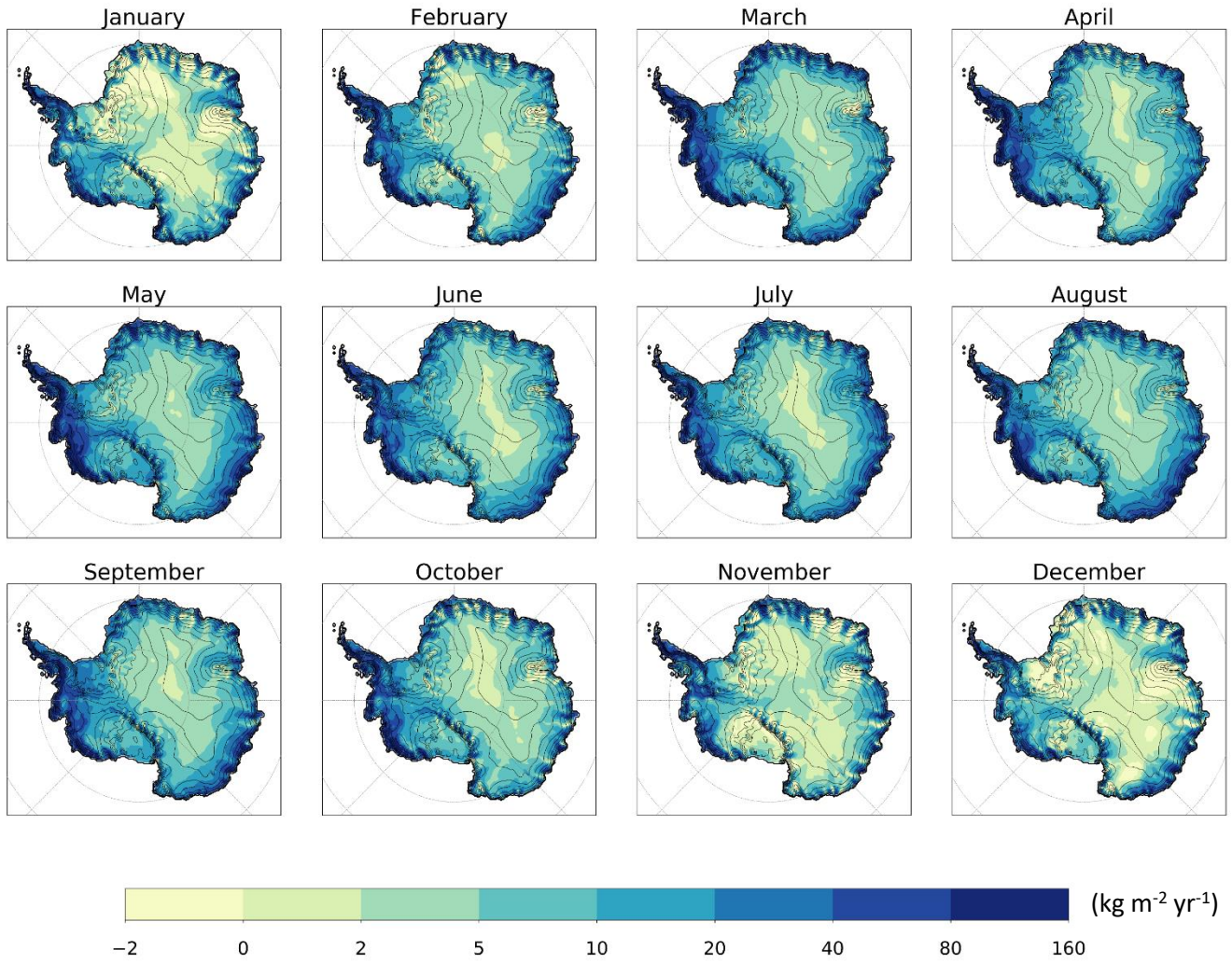
- 7-years simulation (1 year spin-up)
- Annual mean surface mass balance for the period 2011-07-01 – 2017-07-01
- High SMB in coastal regions, low SMB over continent

SMB in CRYOWRF without blowing snow in good agreement with SMB in Agosta et al., 2019

SMB in Agosta et al., 2019



Surface mass balance (SMB) in Antarctica

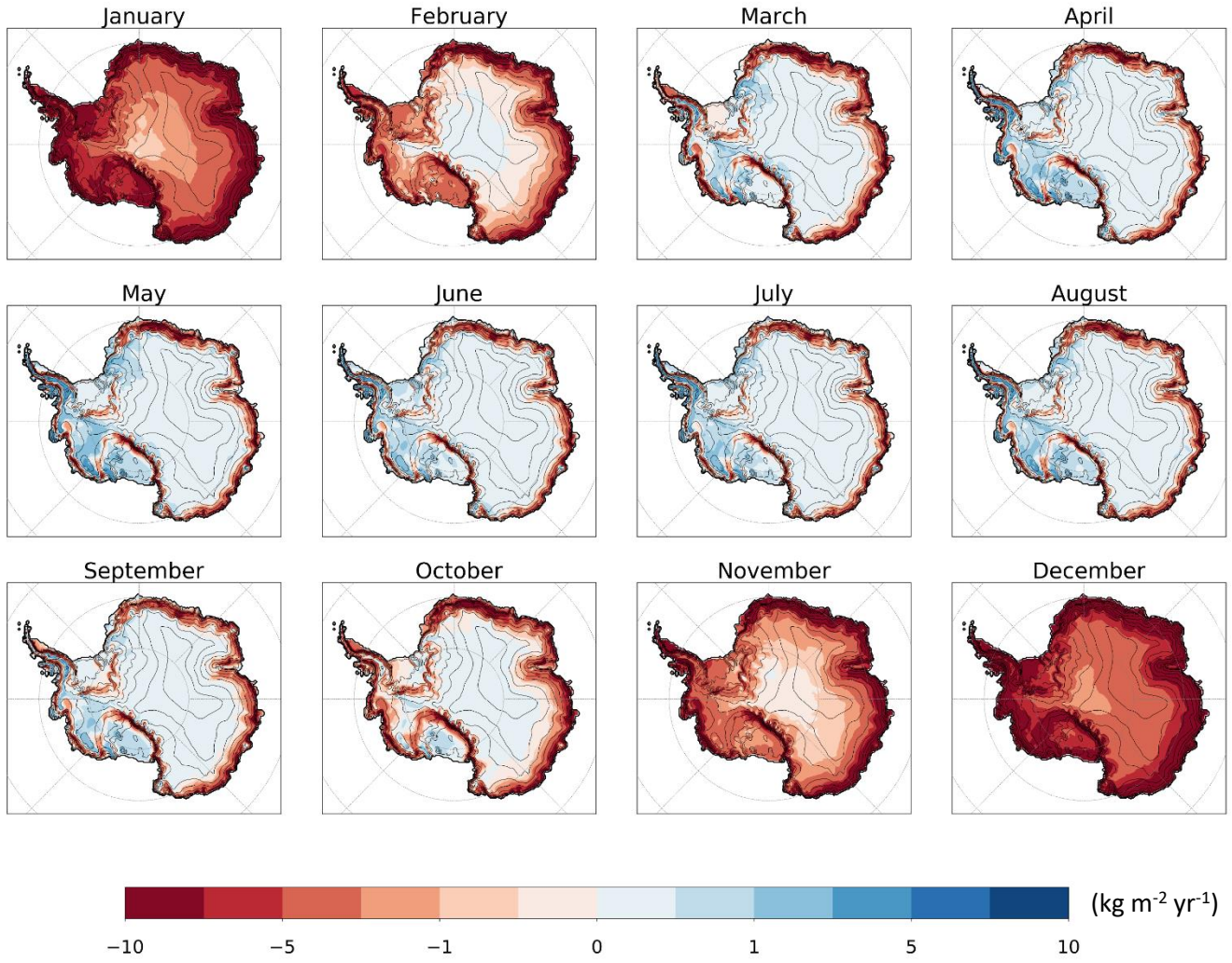


Monthly SMB in CRYOWRF – without blowing snow

- 7-years simulation (1 year spin-up)
- Monthly mean surface mass balance for the period 2011-07-01 – 2017-07-01
- Seasonal differences

More negative SMB in summer months in agreement with warmer temperatures and higher sublimation rates (see next slide).

Surface mass balance (SMB) in Antarctica

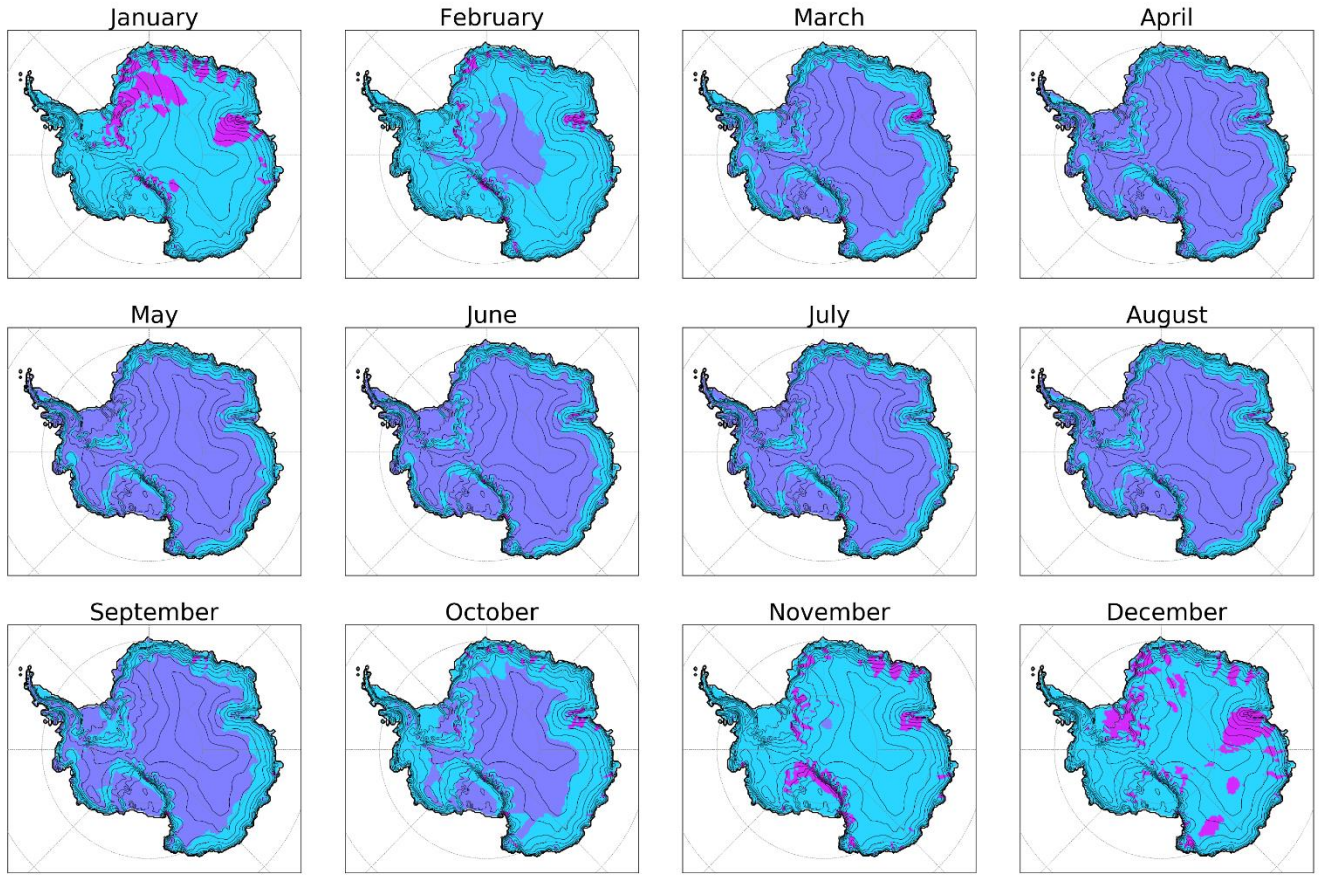


Monthly sublimation in CRYOWRF – without blowing snow

- 7-years simulation (1 year spin-up)
- Monthly mean surface mass balance for the period 2011-07-01 – 2017-07-01
- Strong regional and seasonal differences

Sublimation strongest over the coastal regions and in summer. Deposition over the continental regions in winter.

Surface mass balance (SMB) in Antarctica



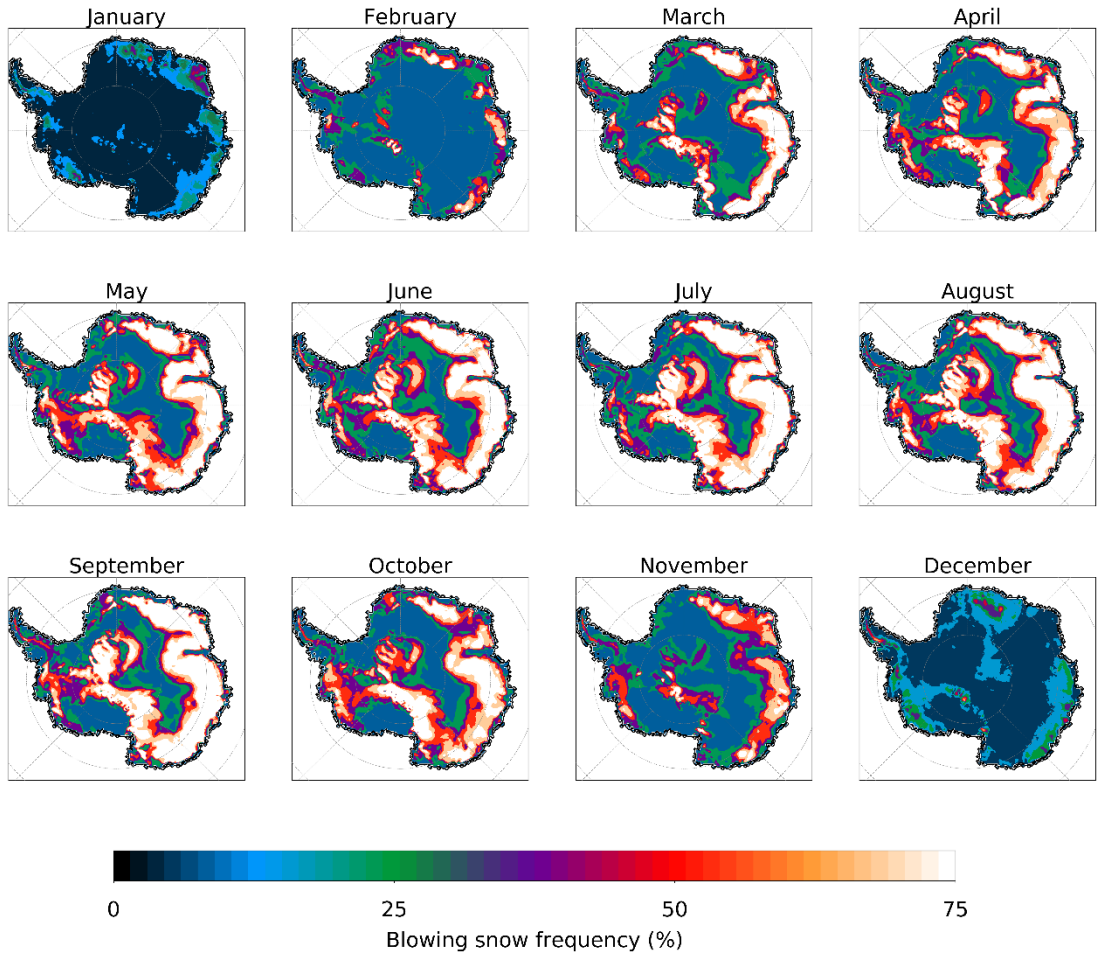
Monthly dominant regimes in CRYOWRF – without blowing snow

- 7-years simulation (1 year spin-up)
- Monthly mean surface mass balance for the period 2011-07-01 – 2017-07-01
- 3 regimes:
  - Less sublimation than precipitation
  - Deposition adds to precipitation
  - More sublimation than precipitation

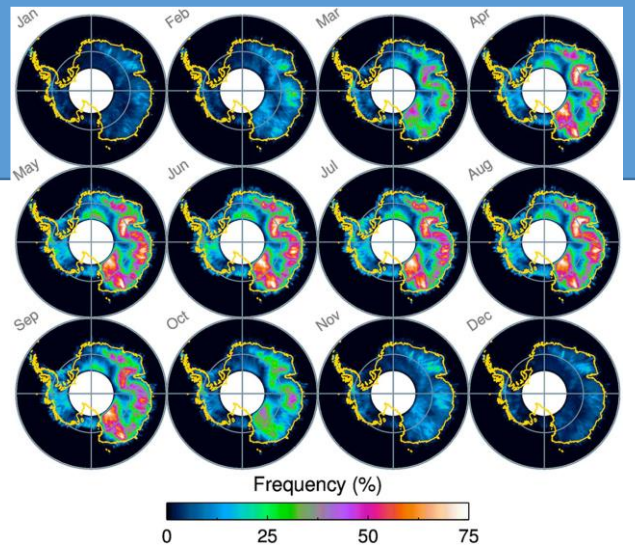
Regions where sublimation exceeds precipiation, even in the annual mean (e.g. Amery region).

Blowing snow in Antarctica

CRYOWRF monthly blowing snow frequencies



Palm et al., 2018*



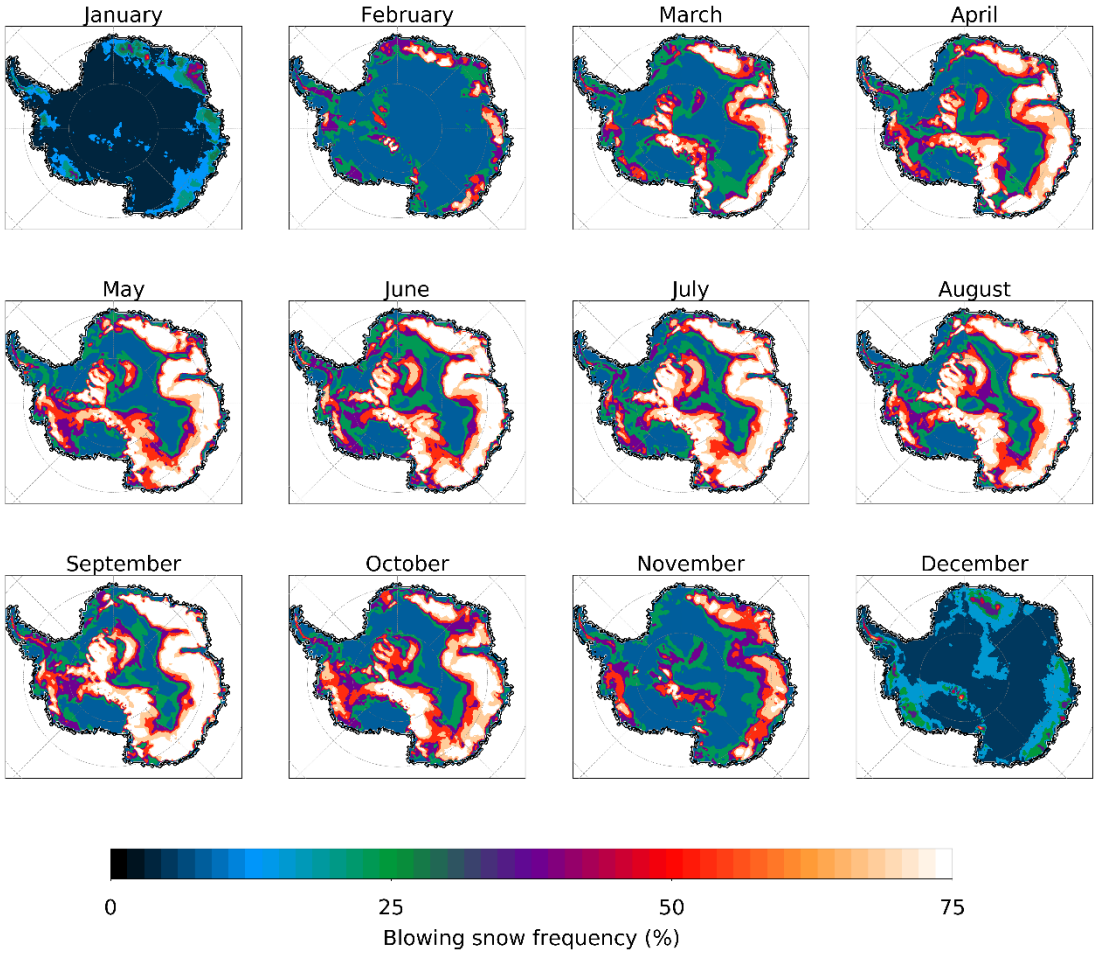
Monthly blowing snow frequncies in CRYOWRF

- 21 month simulation
- Monthly frequencies
  for the period 2011-03-01 – 2012-12-31
- Highest blowing snow frequencies in coastal regions with katabatic wind and the transantarctic mountains

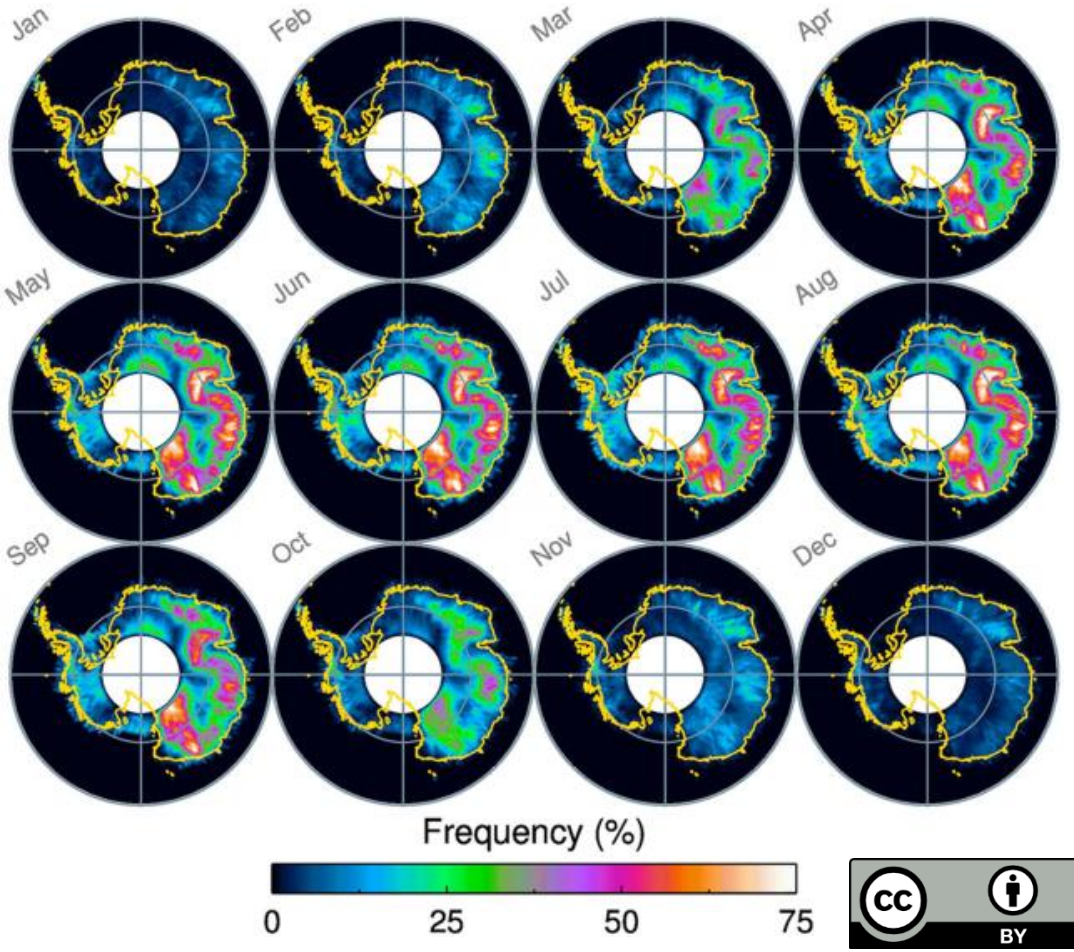
Patterns of blowing snow frequency in good agreement with patterns from the satellite product by Palm et al., 2018 (see next slide for zoom-in)

Blowing snow in Antarctica

CRYOWRF monthly blowing snow frequencies



Satellite product of monthly blowing snow frequencies by Palm et al., 2018*



Conclusion

- Good agreement of CRYOWRF (without blowing snow) to the study by Agosta et al., 2019
- Strong regional differences of surface sublimation
- Blowing snow frequency patterns well represented compared to the satellite product by Palm et al., 2018

References

- Agosta, C., Amory, C., Kittel, C., Orsi, A., Favier, V., Gallée, H., van den Broeke, M. R., Lenaerts, J. T. M., van Wessem, J. M., van de Berg, W. J., Fettweis, X., 2019: Estimation of the Antarctic surface mass balance using the regional climate model MAR (1979-2015) and identification of dominant processes, The Cryosphere, 13, 281 – 296, https://doi.org/10.5194/tc-13-281-2019
- Palm, S. P., Kayetha, V. and Yang, Y., 2018: Toward a satellite-derived climatology of blowing snow over Antarctica, Journal of Geophysical Research – Atmospheres, 123, 10301 – 10313, https://doi.org/10.1029/2018JD028632

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