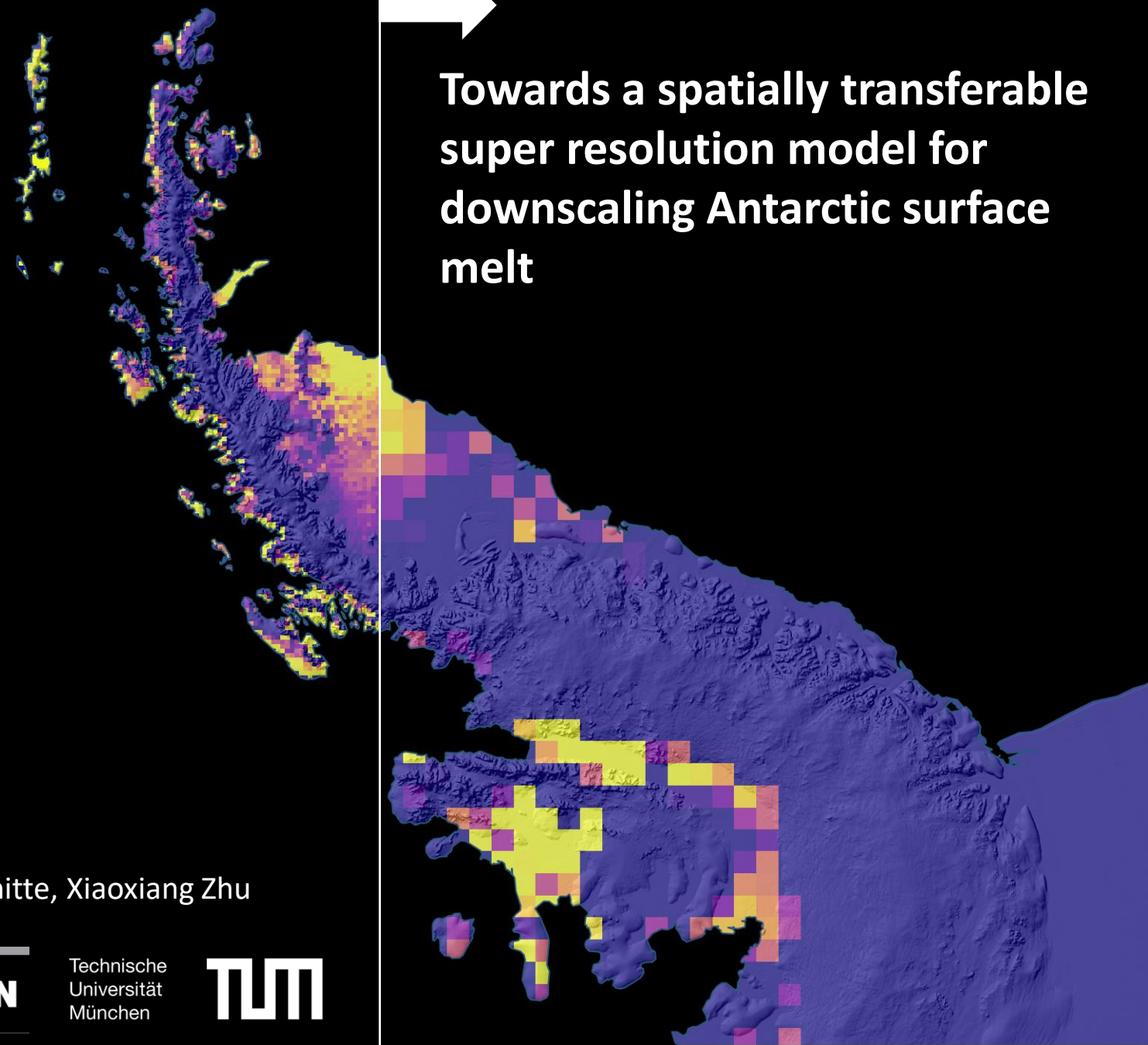
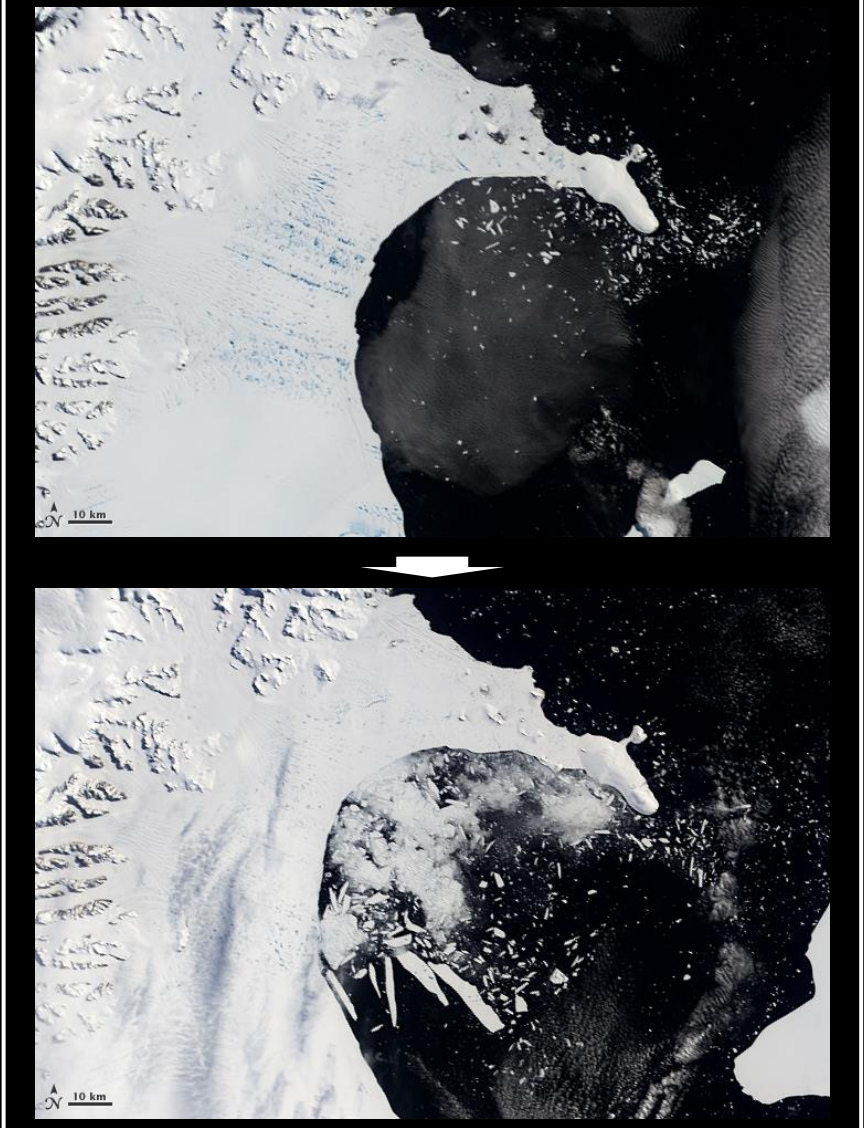
Towards a spatially transferable super resolution model for downscaling Antarctic surface melt



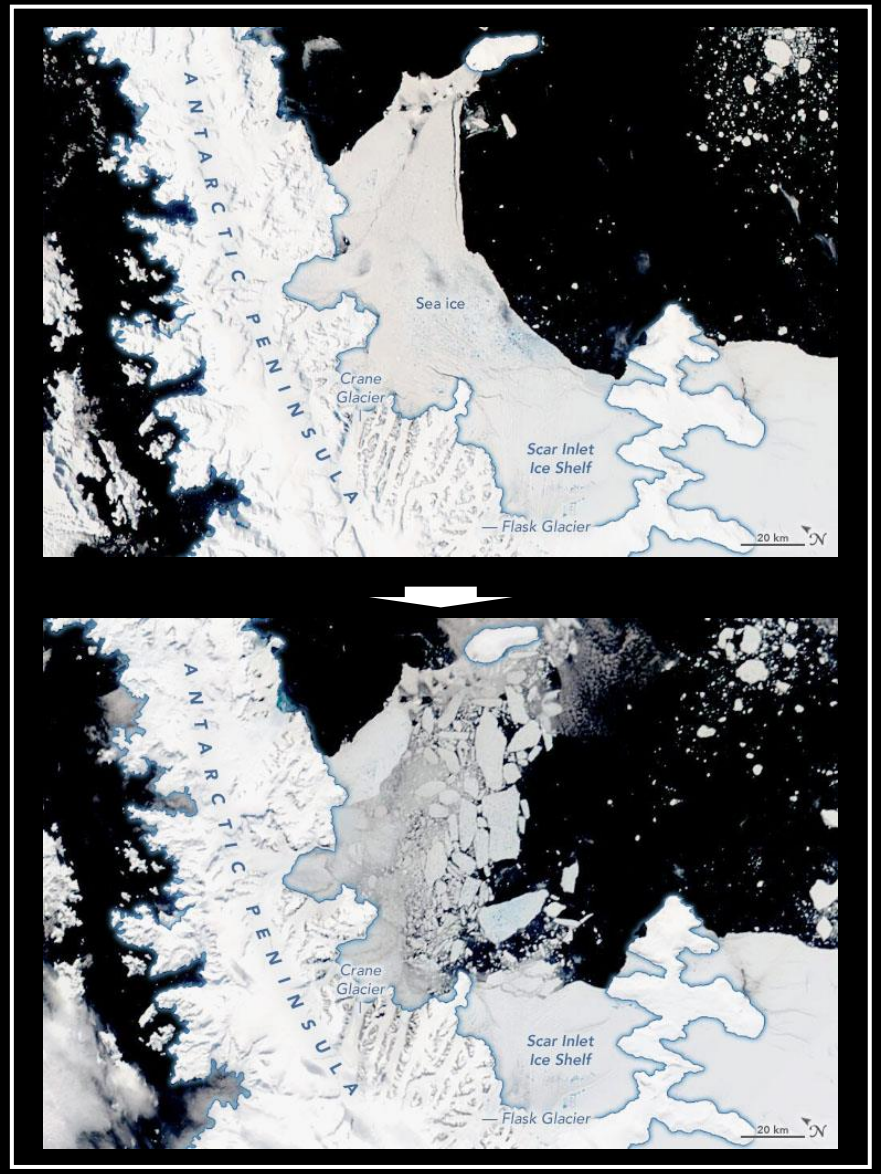
Zhongyang Hu, Yao Sun, Peter Kuipers Munneke, Stef Lhermitte, Xiaoxiang Zhu

Universiteit Utrecht
TU Delft
KU LEUVEN
Technische Universität München

World of Change: Collapse of the Larsen-B Ice Shelf (NASA 2002)

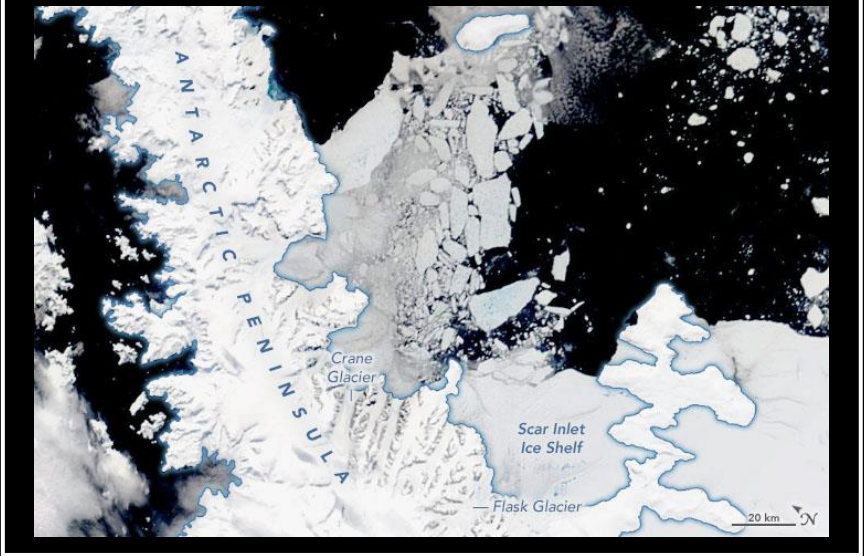


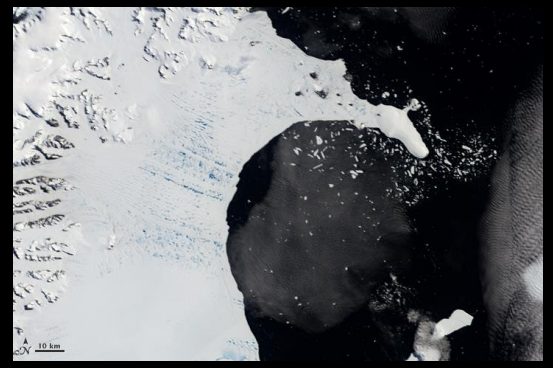
Larsen B Embayment Breaks Up (NASA, 2022)



World of Change: Collapse of the Larsen-B Ice Shelf (NASA 2002)

Larsen B Embayment Breaks Up (NASA, 2022)



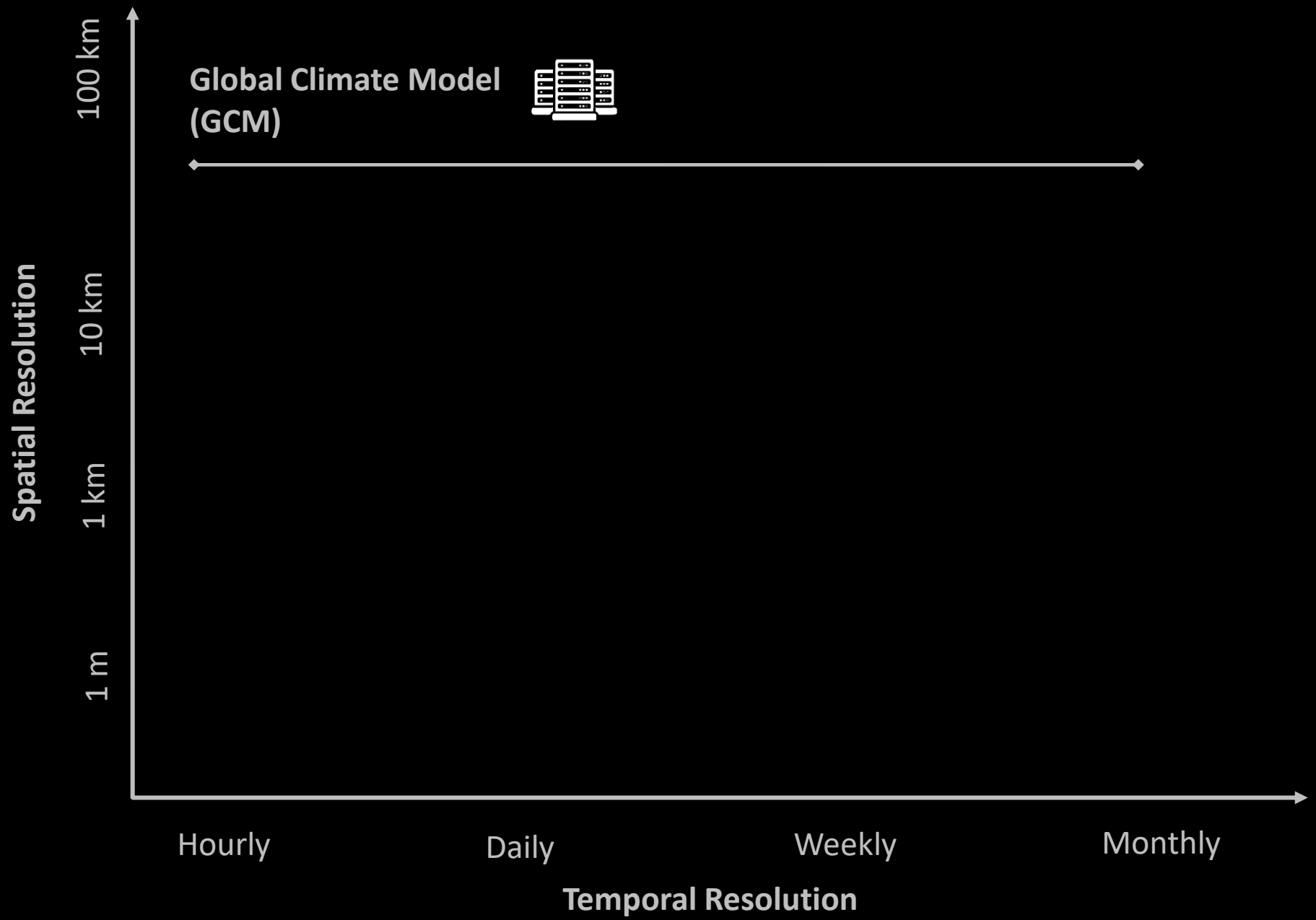


January 31, 2002

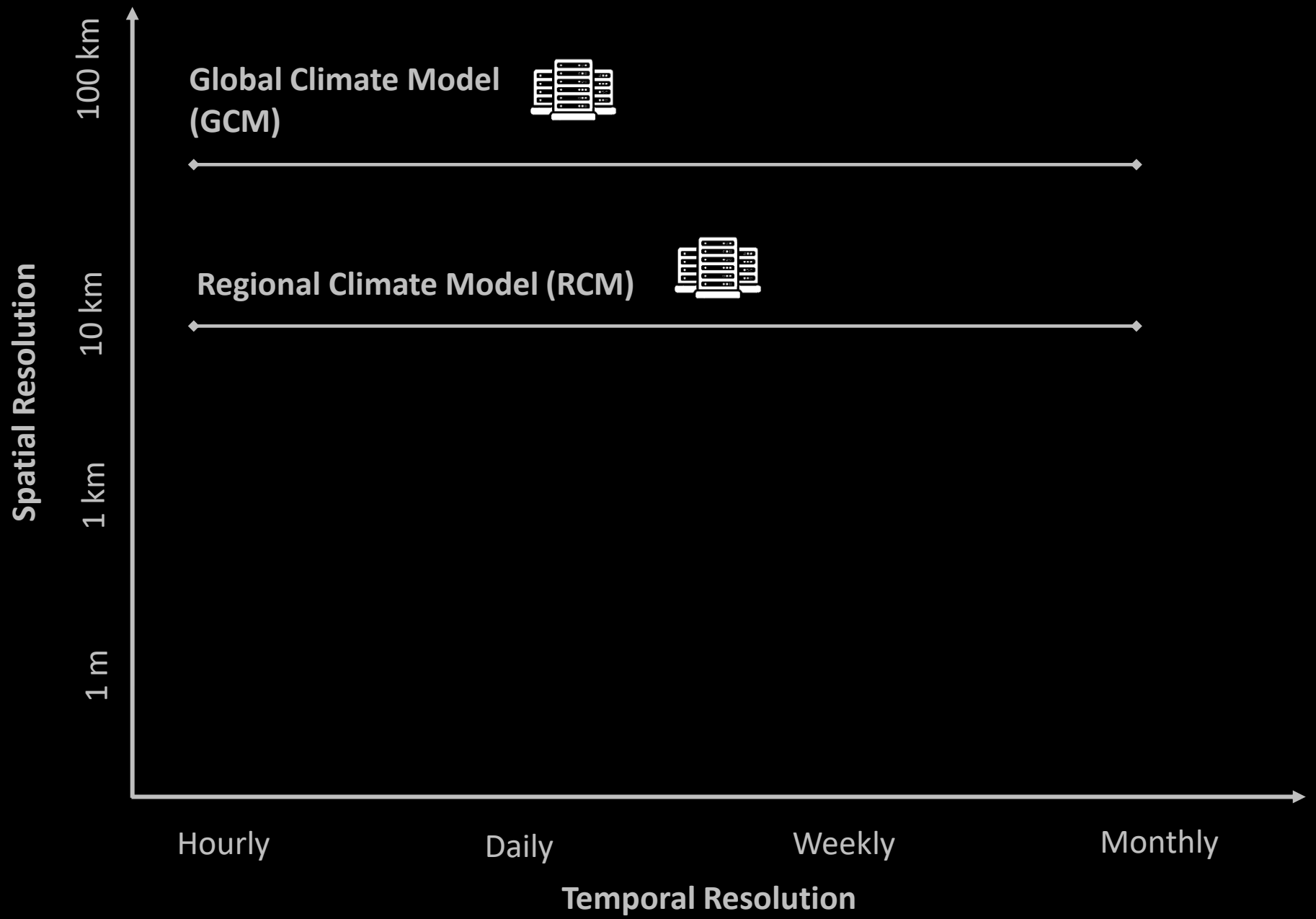
February 17, 2002

February 23, 2002

Why do we need super resolution for downscaling surface melt over Antarctica?



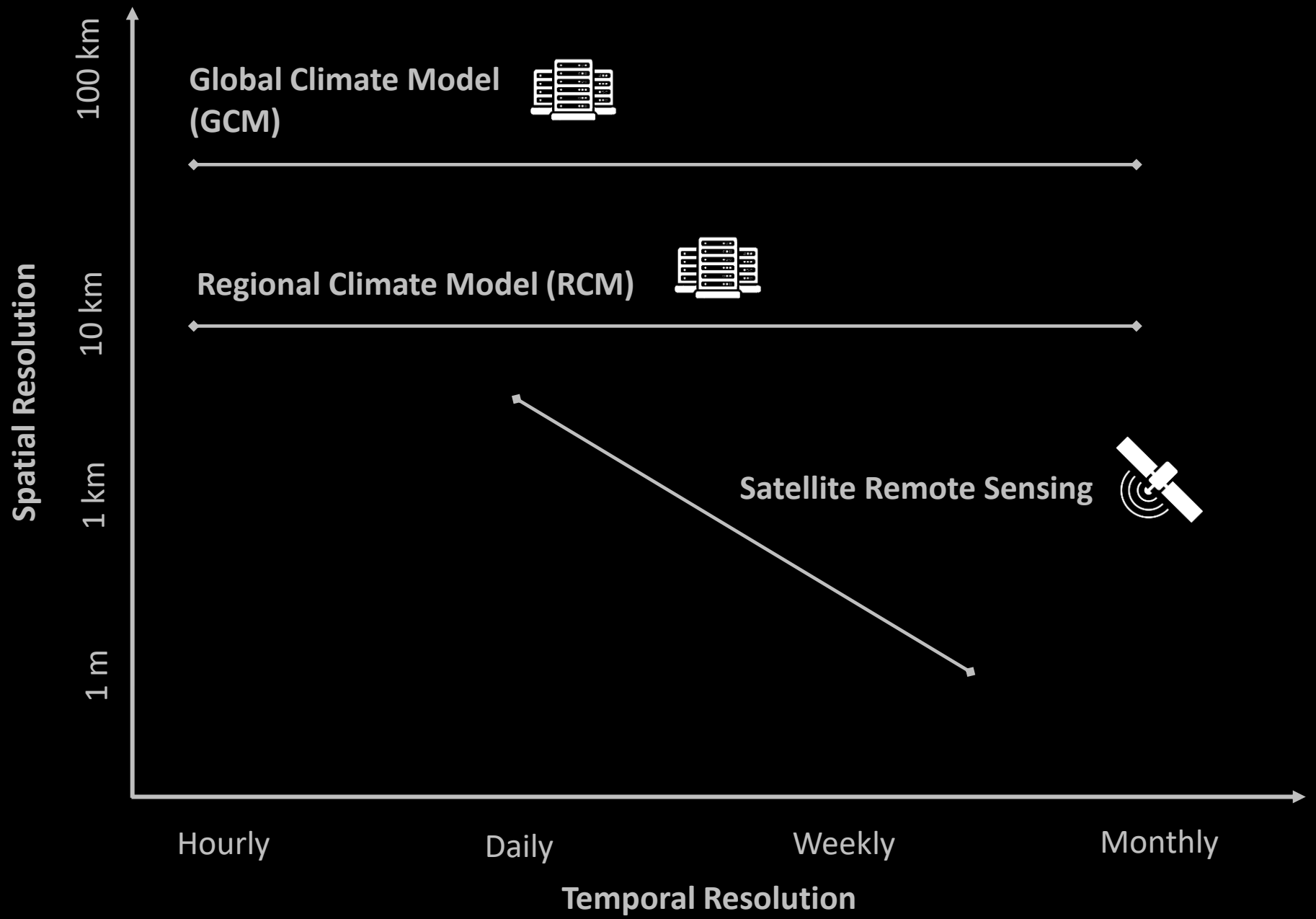
Why do we need super resolution for downscaling surface melt over Antarctica?



RACMO2 27 km
Antarctica
From 1970s

RACMO2 5.5 km
Peninsula
From 1970s

Why do we need super resolution for downscaling surface melt over Antarctica?

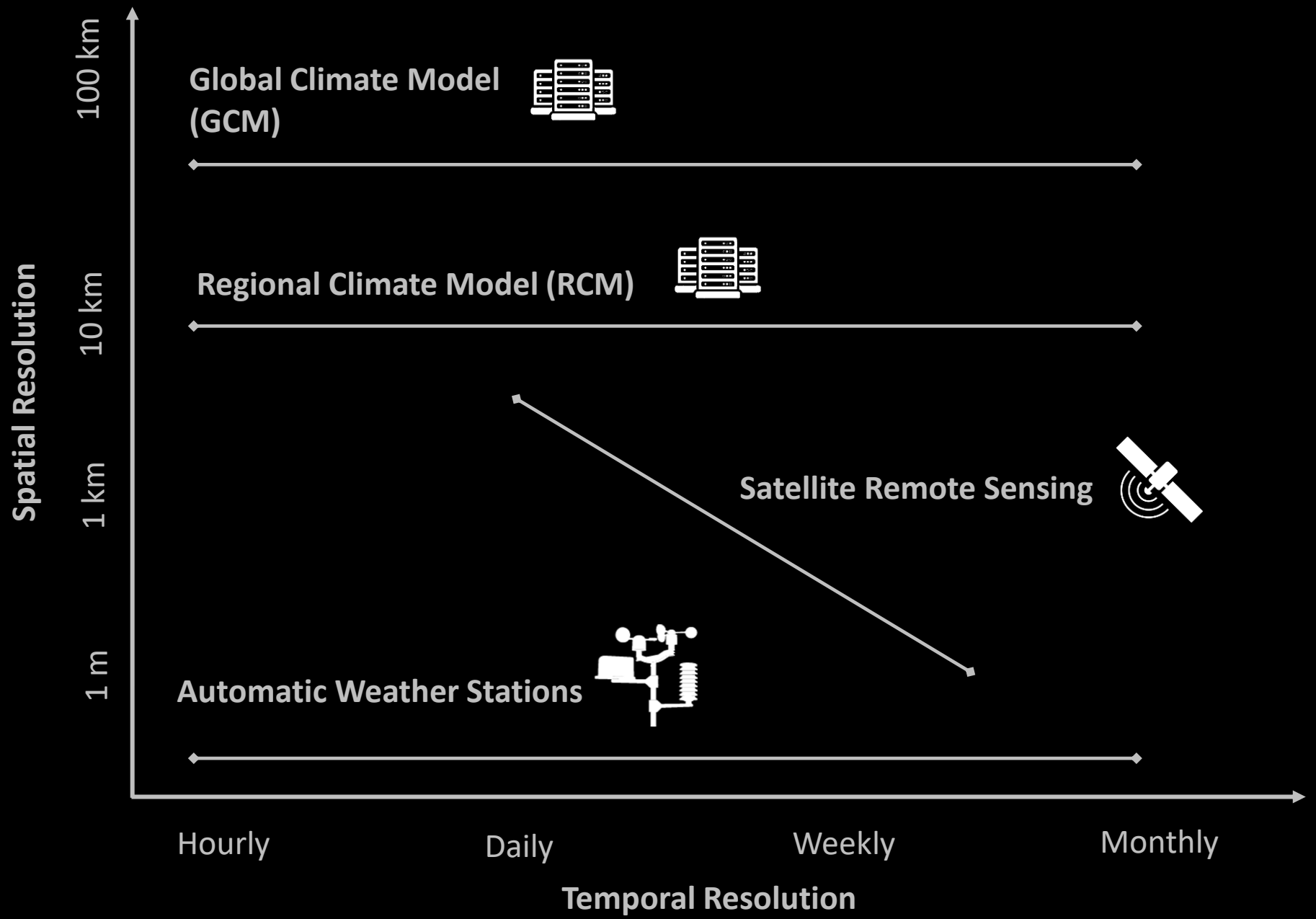


RACMO2 27 km
Antarctica
From 1970s

RACMO2 5.5 km
Peninsula
From 1970s

MODIS
Antarctica
Since 1999/2000

Why do we need super resolution for downscaling surface melt over Antarctica?



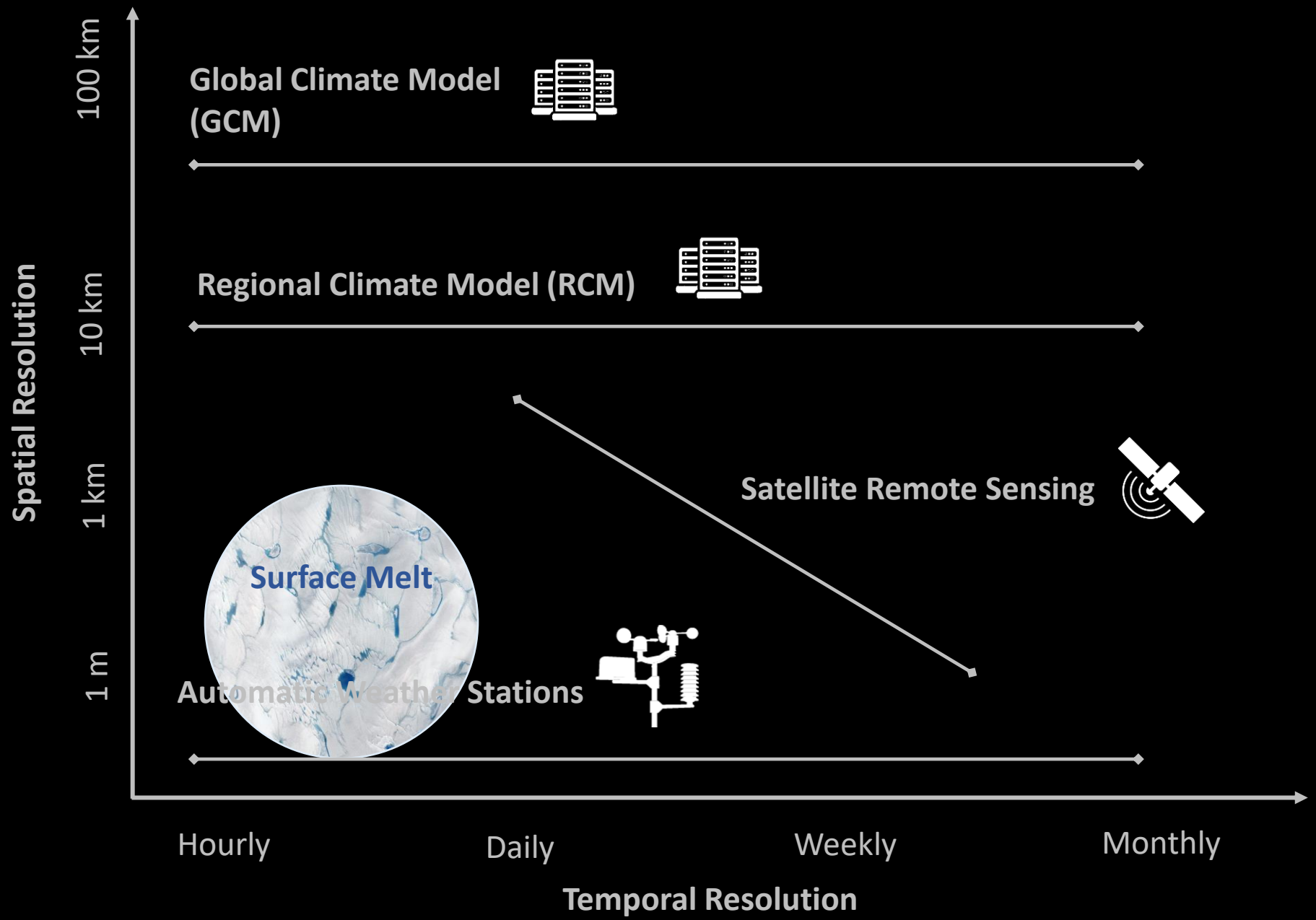
RACMO2 27 km
Antarctica
From 1970s

RACMO2 5.5 km
Peninsula
From 1970s

MODIS
Antarctica
Since 1999/2000

AWS 14
Point-based Measurements
From 2009

Why do we need super resolution for downscaling surface melt over Antarctica?



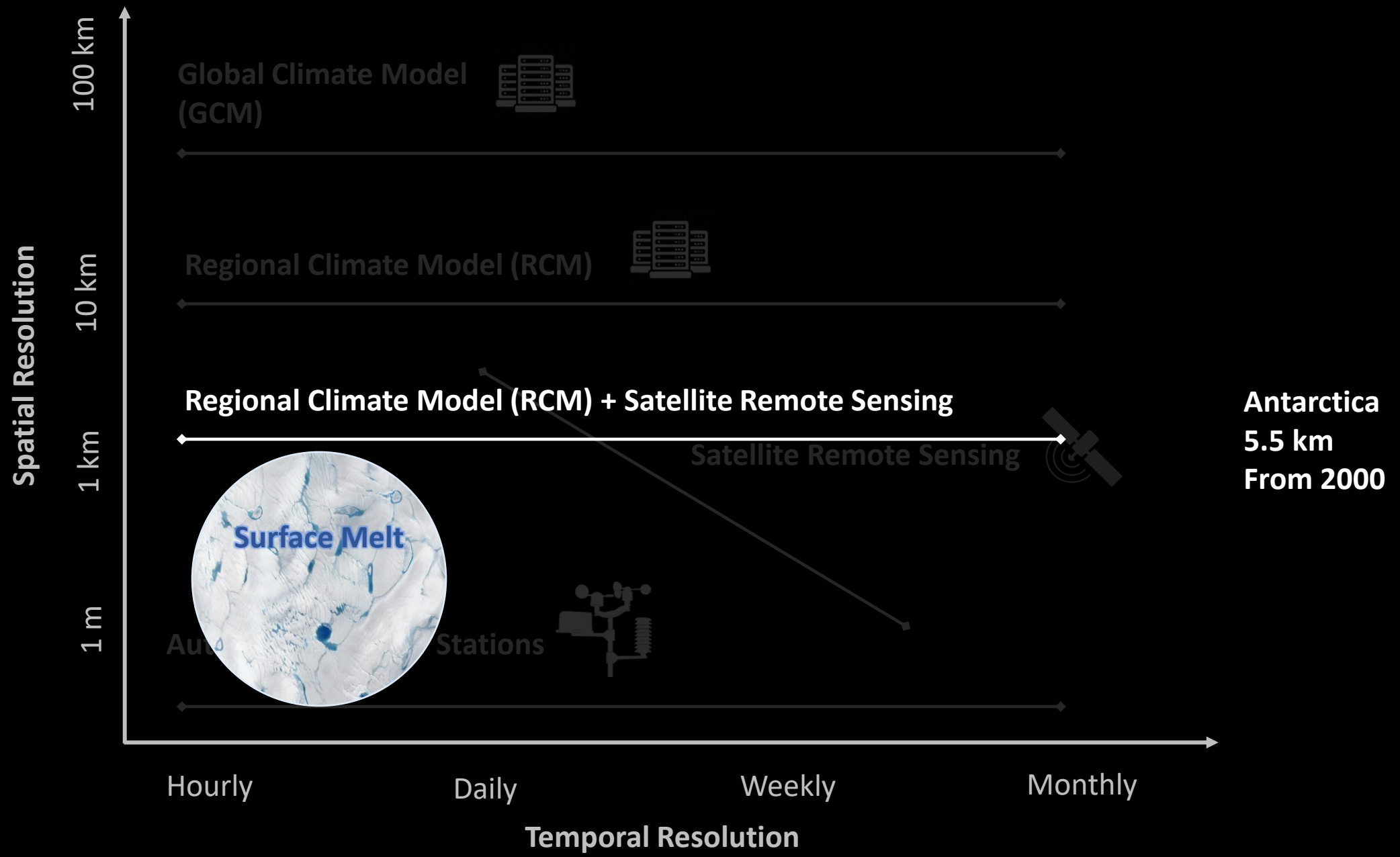
RACMO2 27 km
Antarctica
From 1970s

RACMO2 5.5 km
Peninsula
From 1970s

MODIS
Antarctica
Since 1999/2000

AWS 14
Point-based Measurements
From 2009

Research objective

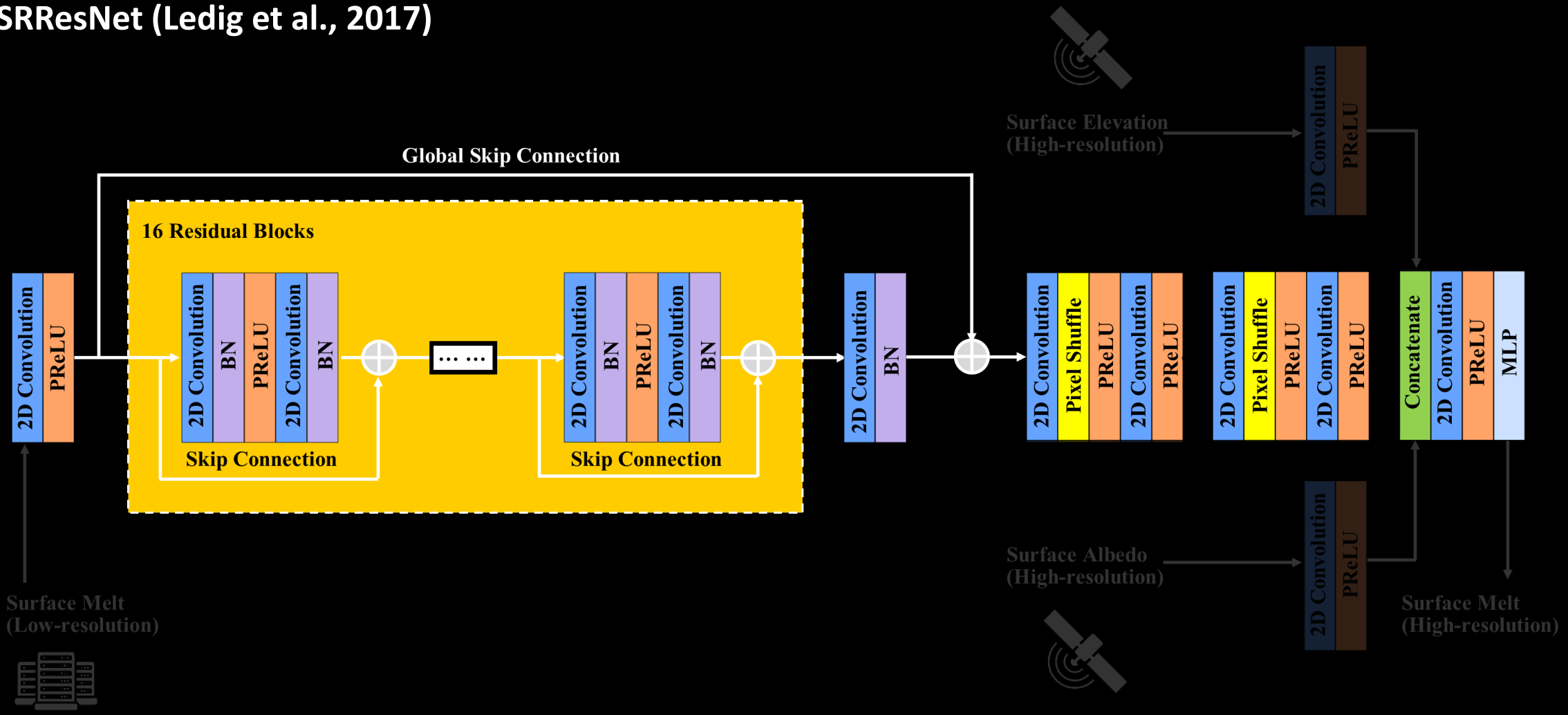


Current Challenges

- Limitation of the high-resolution simulations over the entire Antarctica
- Missing important local geophysical processes
- Methodological transferability
- **Spatial transferability**
- Availability of high-quality satellite product (albedo, elevation, etc)

Downscaling with the super resolution model: modified SRResNet

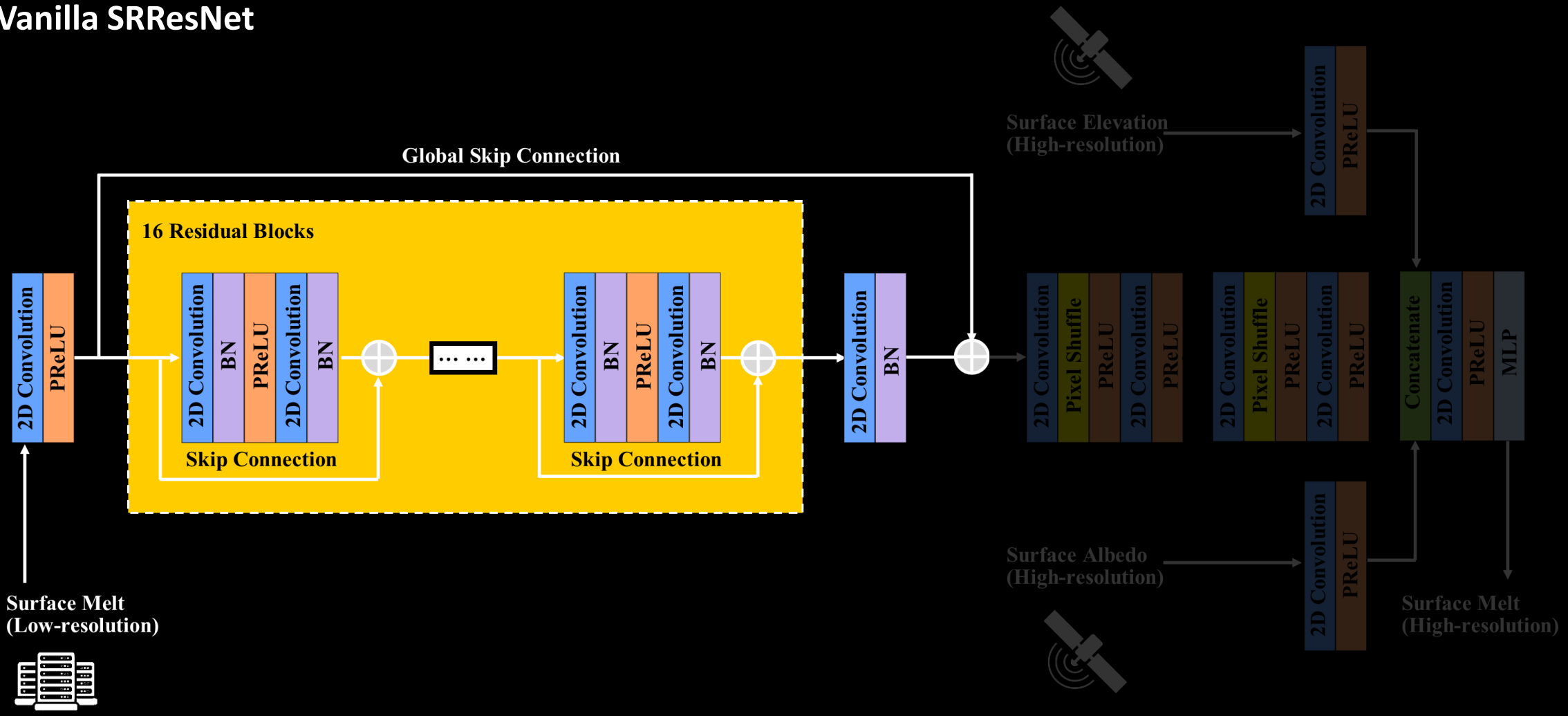
Backbone Architecture:
SRResNet (Ledig et al., 2017)



Ledig, C., Theis, L., Huszár, F., Caballero, J., Cunningham, A., Acosta, A., Aitken, A., Tejani, A., Totz, J., Wang, Z. and Shi, W., 2017. Photo-realistic single image super-resolution using a generative adversarial network. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 4681-4690).

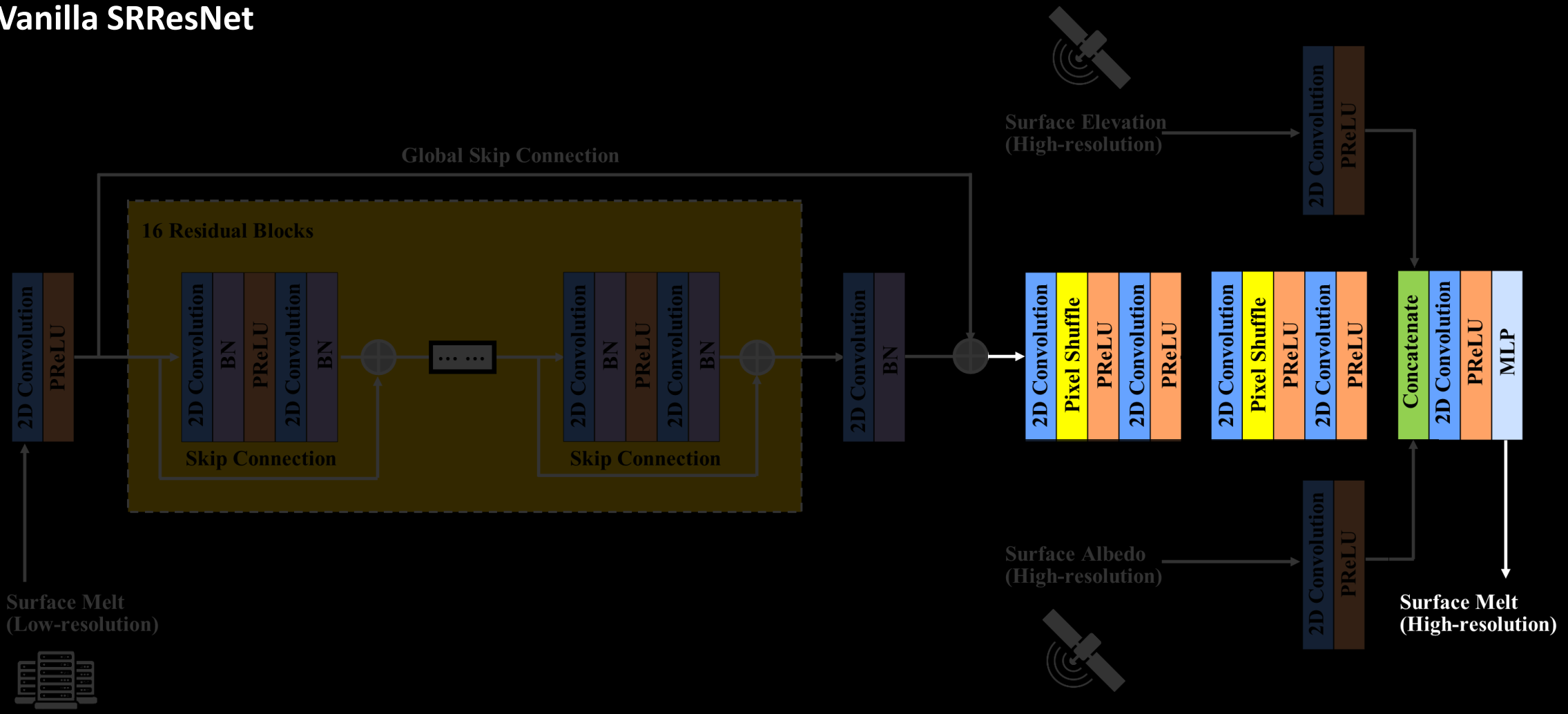
Downscaling with the super resolution model: modified SRResNet

Encoder:
Vanilla SRResNet



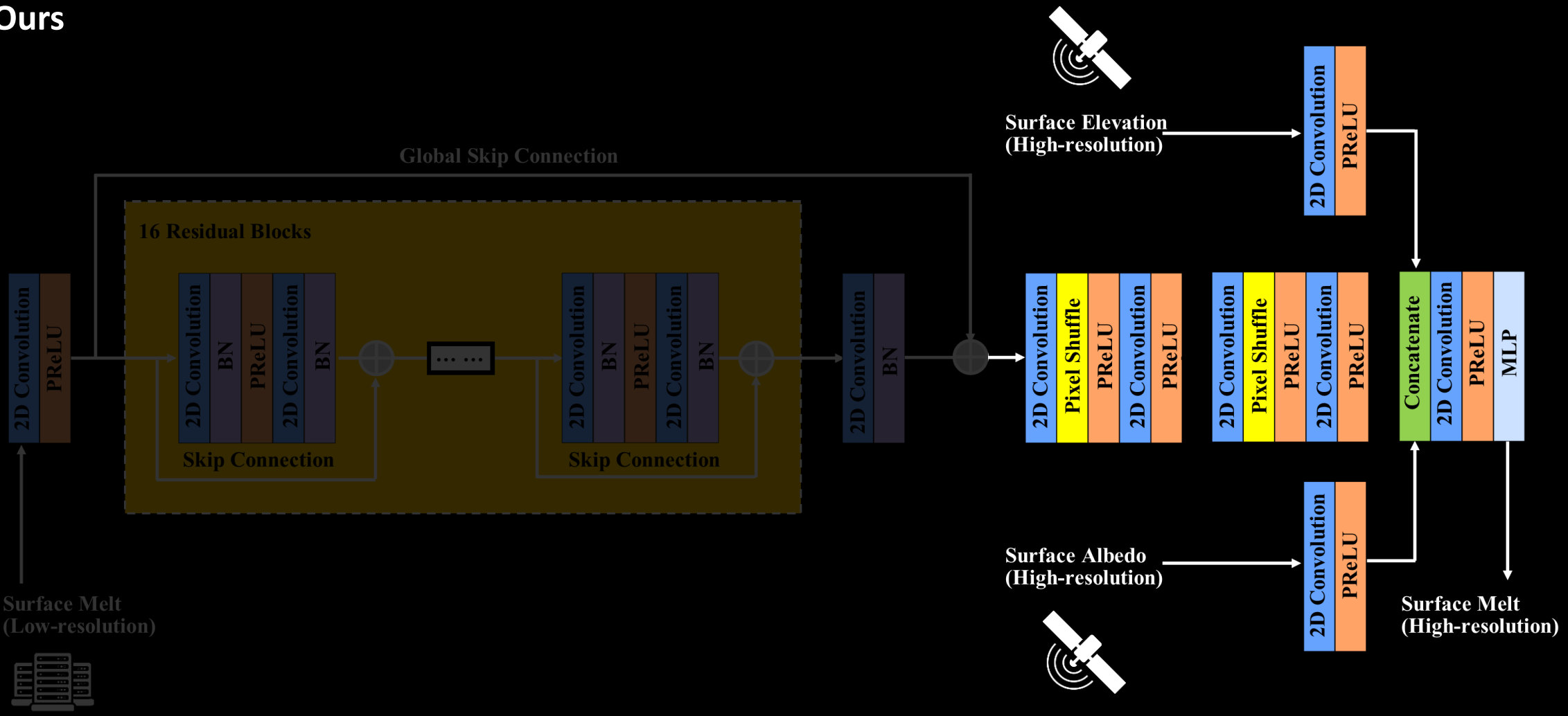
Downscaling with the super resolution model: modified SRResNet

Decoder:
Vanilla SRResNet



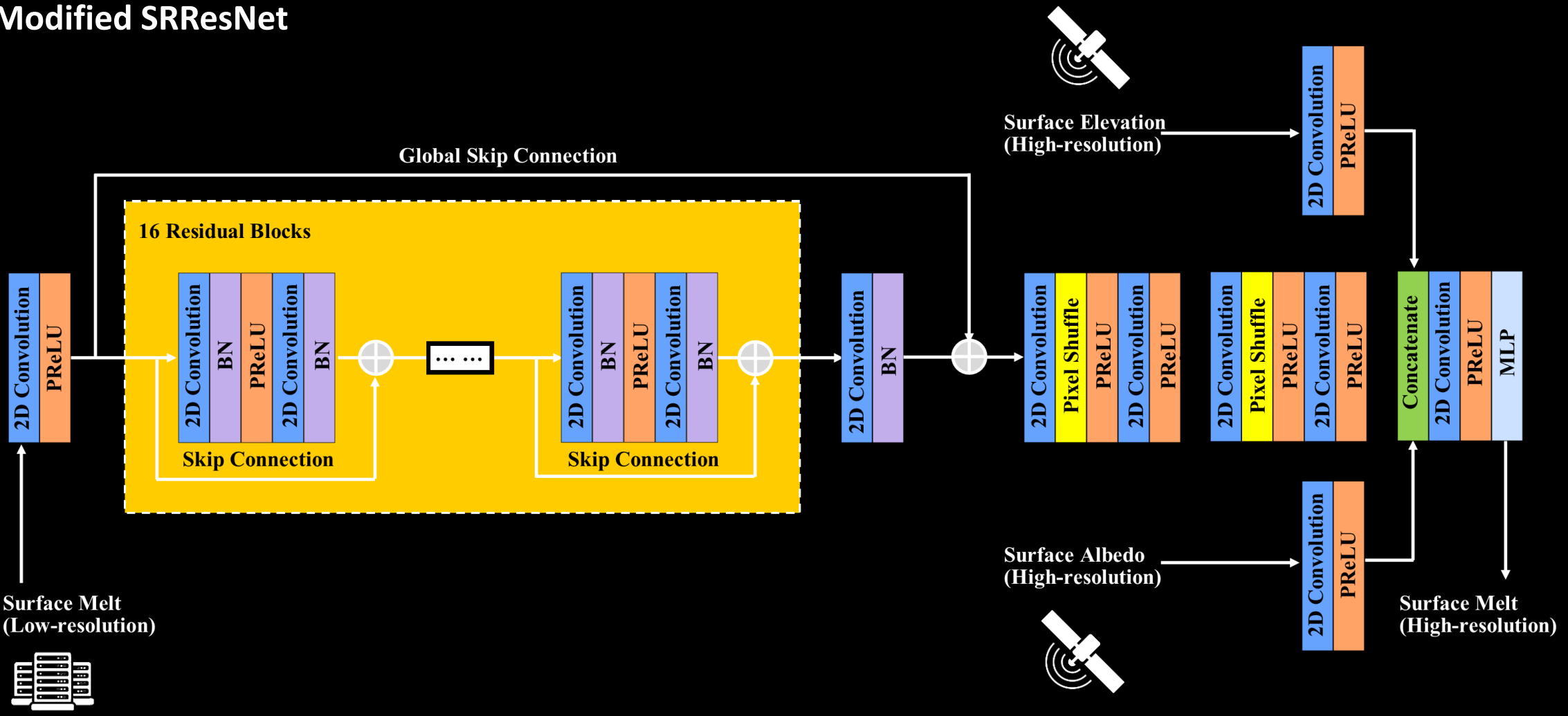
Downscaling with the super resolution model: modified SRResNet

Decoder:
Ours

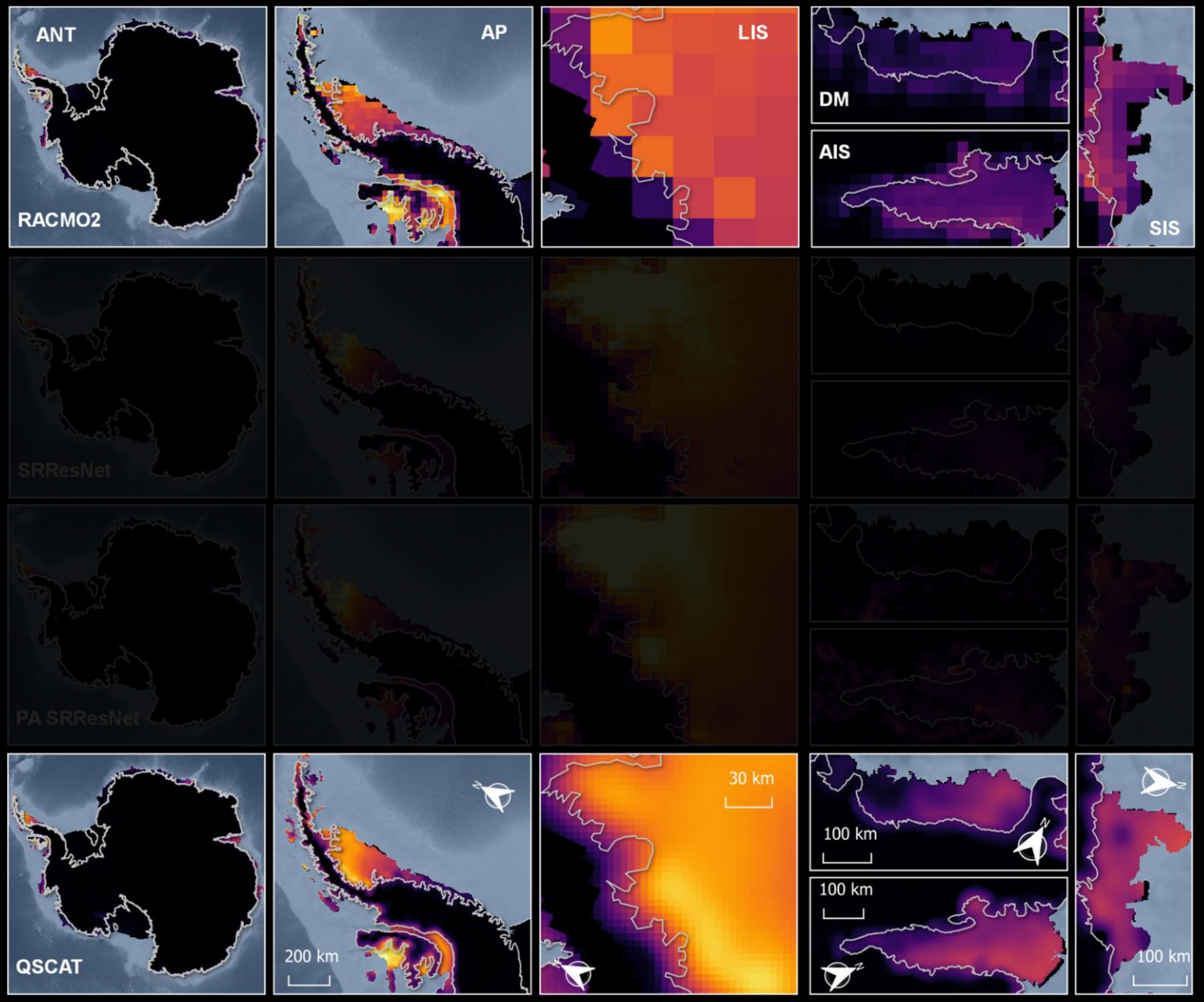


Downscaling with the super resolution model: modified SRResNet

Overall Architecture: Modified SRResNet

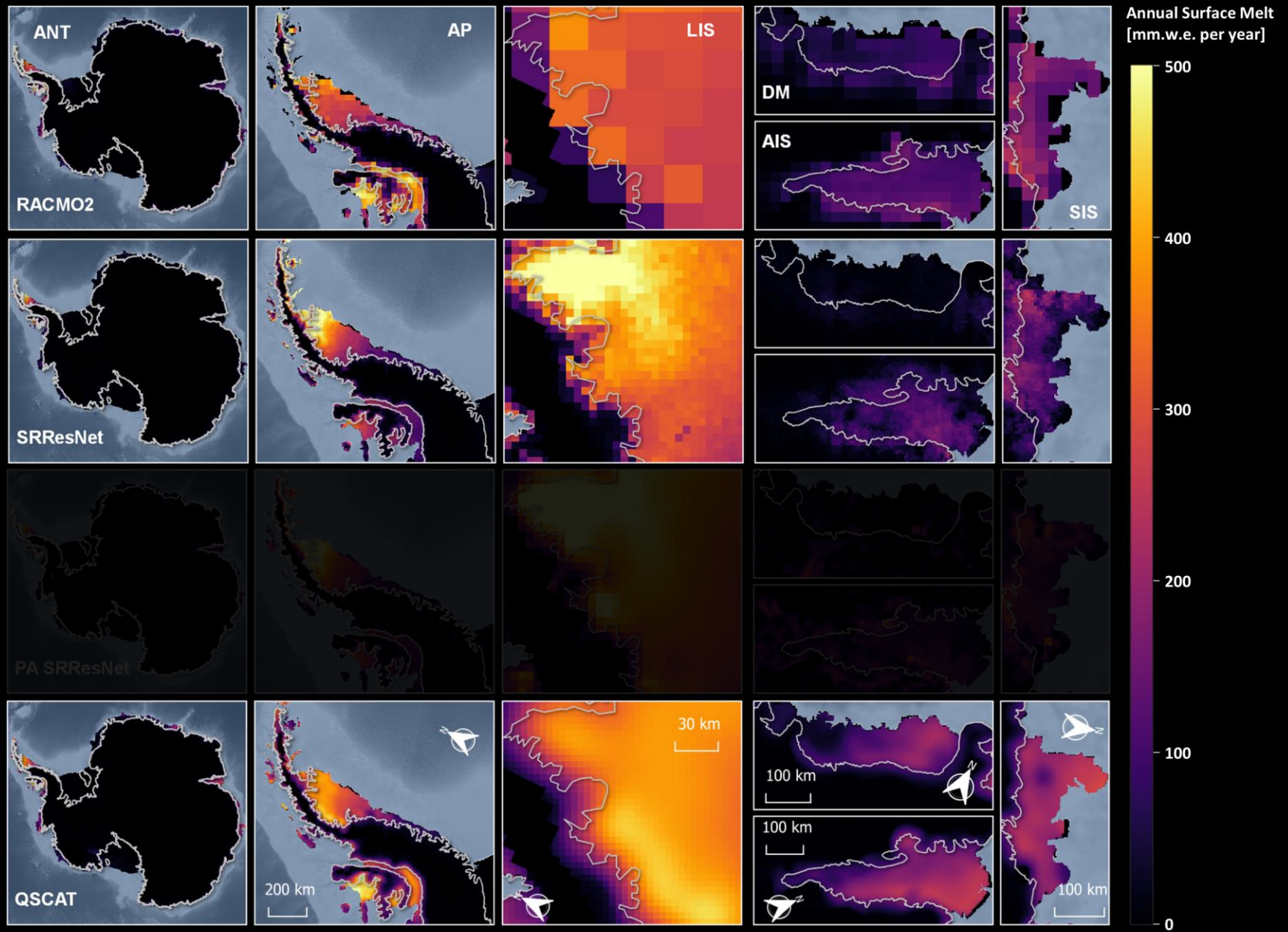


Downscaled surface melt over Antarctica

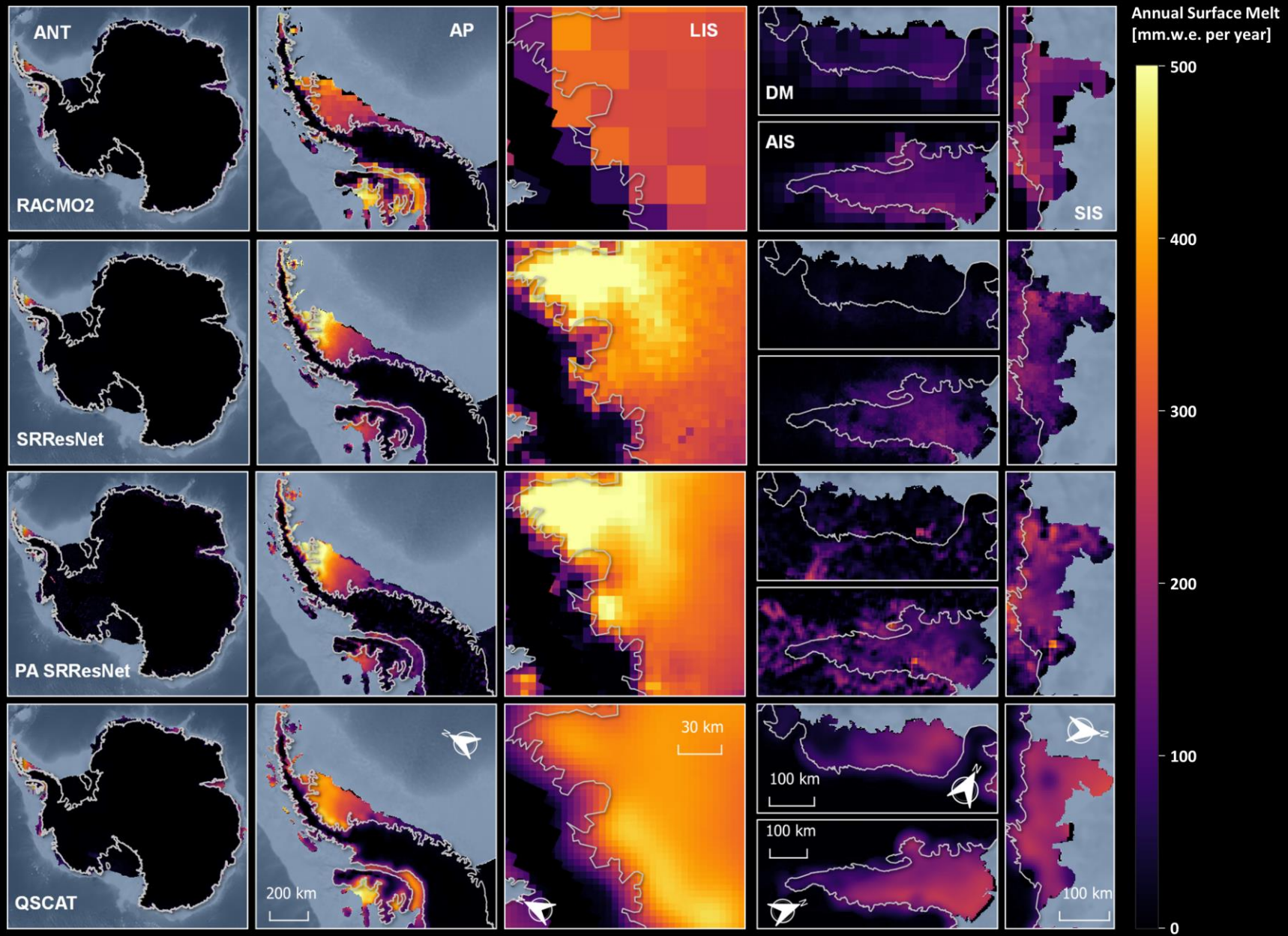


Trusel, L.D., Frey, K.E., Das, S.B., Munneke, P.K. and Van Den Broeke, M.R., 2013. Satellite-based estimates of Antarctic surface meltwater fluxes. Geophysical Research Letters, 40(23), pp.6148-6153.

Downscaled surface melt over Antarctica



Downscaled surface melt over Antarctica



RMSE ≈ 0.51 (0.52)
[mm.w.e. per day]

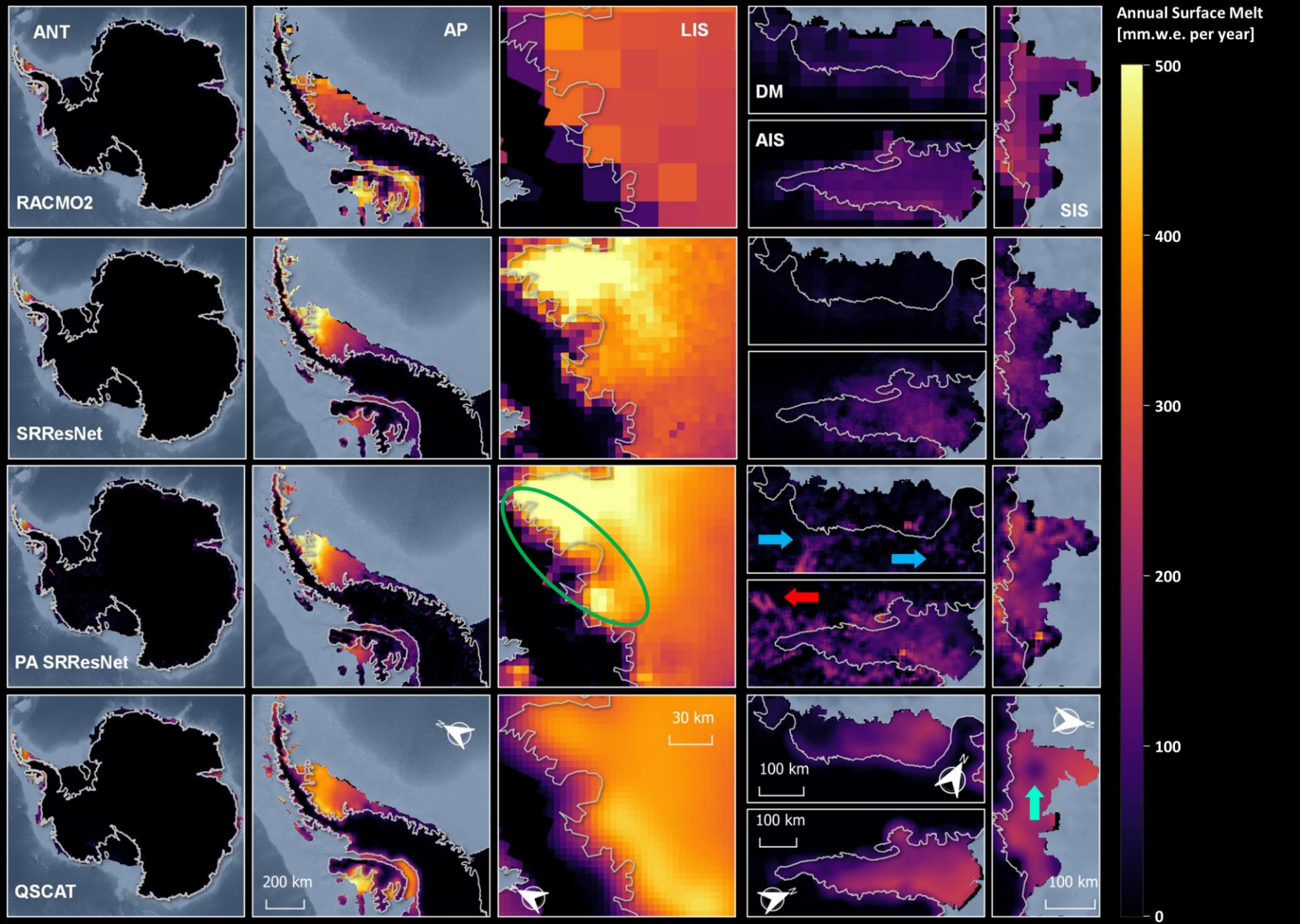
R^2 ≈ 0.89 (0.83)

MAE ≈ 0.10 (0.10)
[mm.w.e. per day]

Structural Similarity Index (SSIM) ≈ (0.99) 0.98

based on training (testing) data sets

Downscaled surface melt over Antarctica



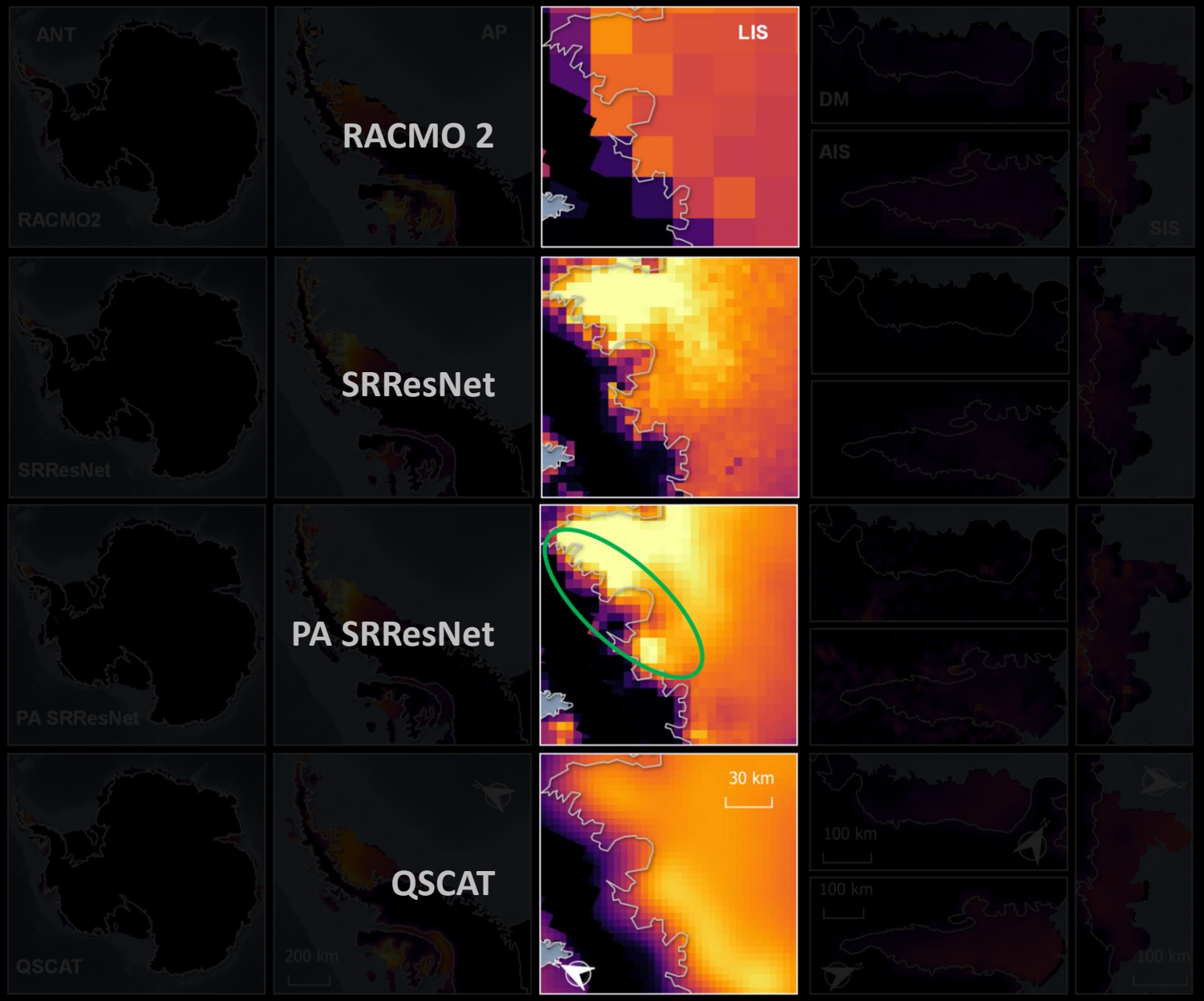
Grounding line

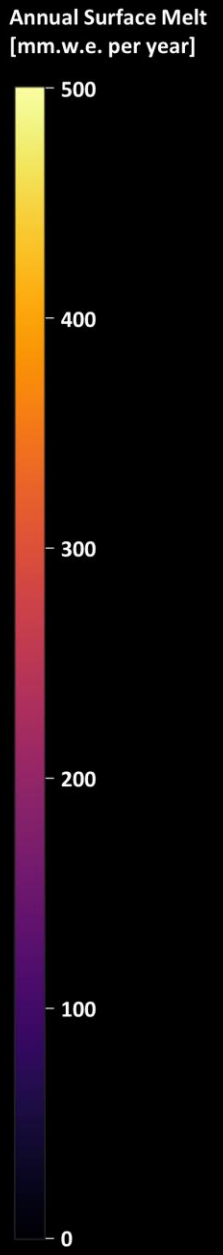
Melt-induced blue ice areas

Wind-induced blue ice areas

Ice rise

Downscaled surface melt over Antarctica





@ Larsen C Ice Shelf

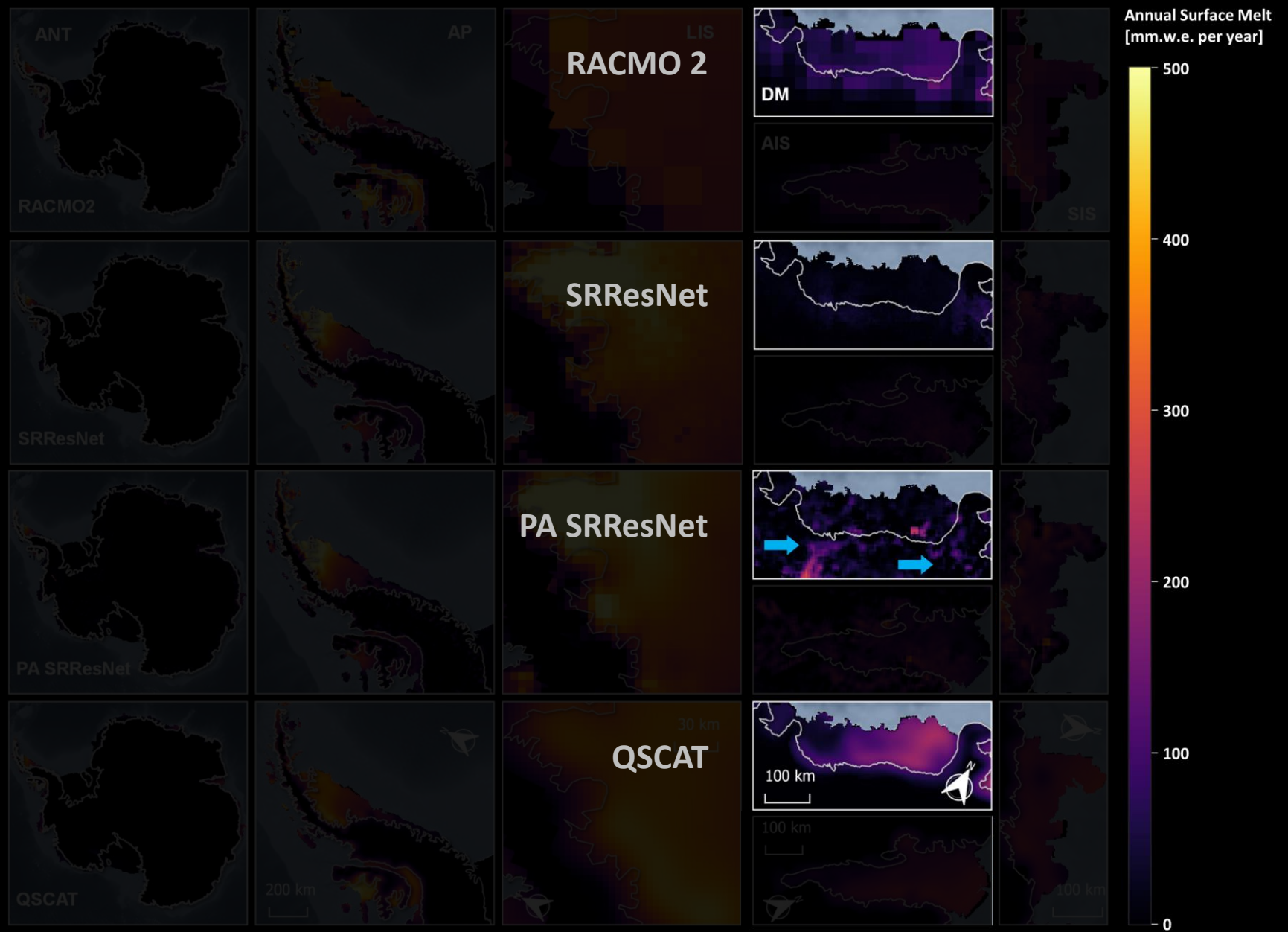
Grounding line

Melt-induced blue ice areas

Wind-induced blue ice areas

Ice rise

Downscaled surface melt over Antarctica



@ Roi Baudouin

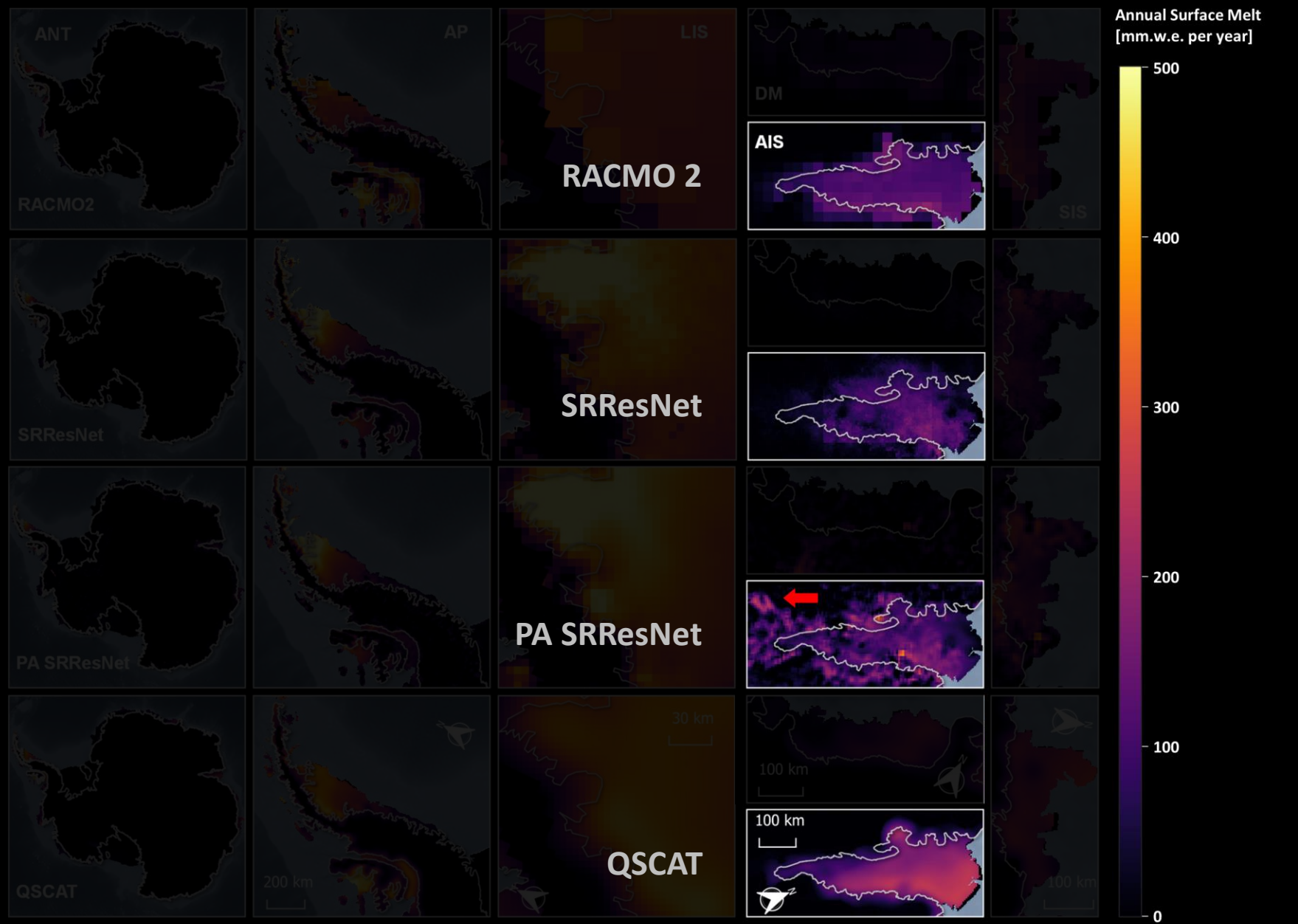
Grounding line

Melt-induced blue ice areas

Wind-induced blue ice areas

Ice rise

Downscaled surface melt over Antarctica



@ Amery Ice Shelf

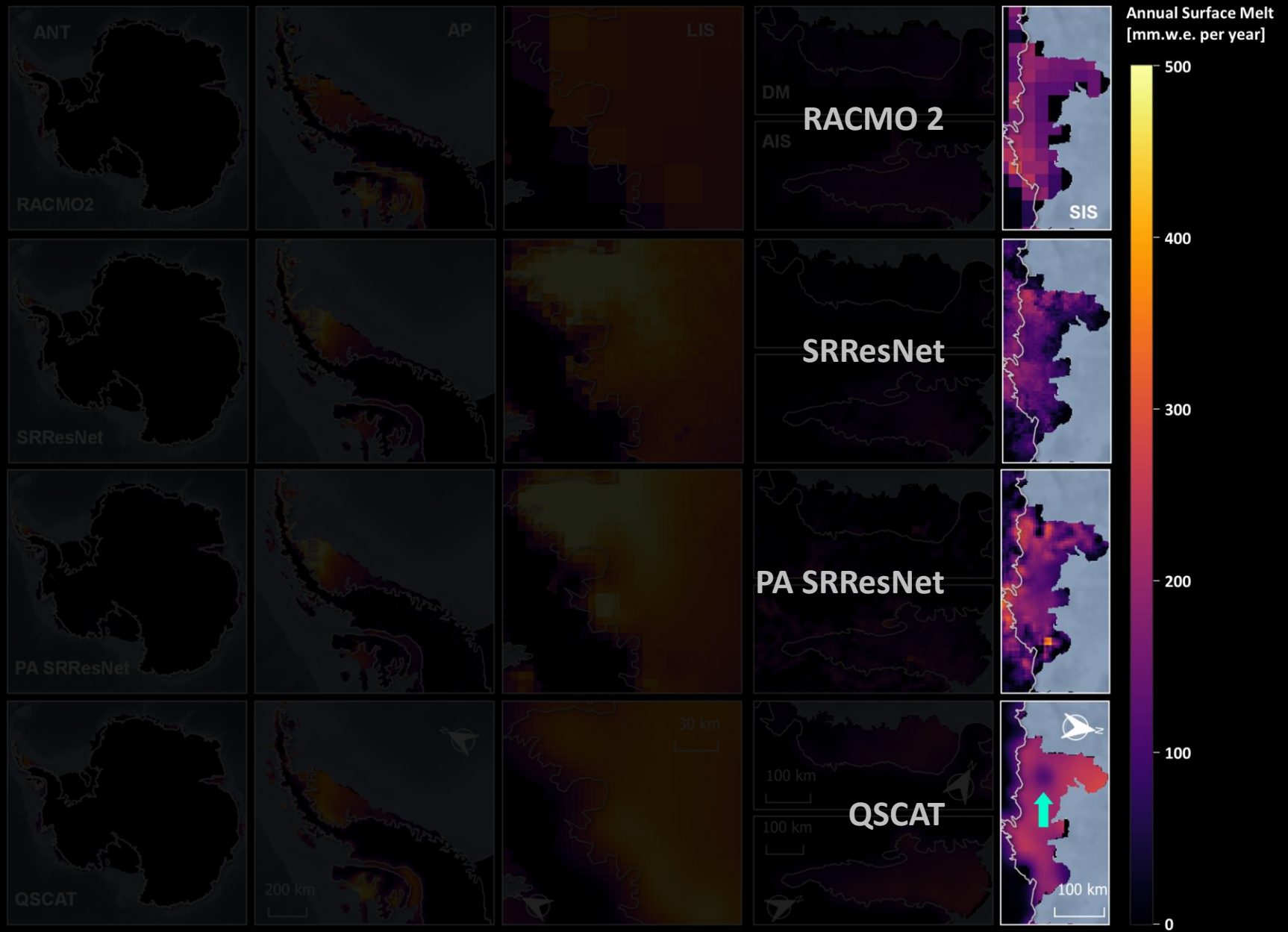
Grounding line

Melt-induced blue ice areas

Wind-induced blue ice areas

Ice rise

Downscaled surface melt over Antarctica



@ Shackleton Ice Shelf

Grounding line

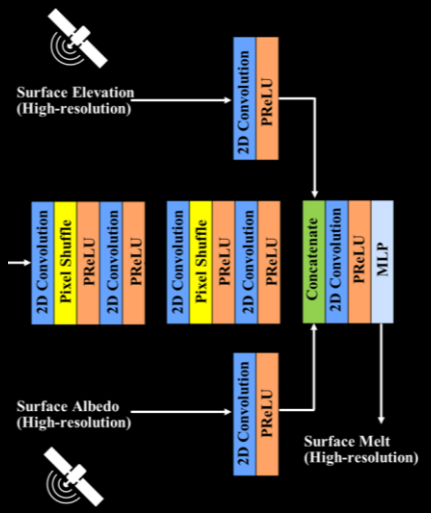
Melt-induced blue ice areas

Wind-induced blue ice areas

Ice rise

Take home messages

Physics-informed

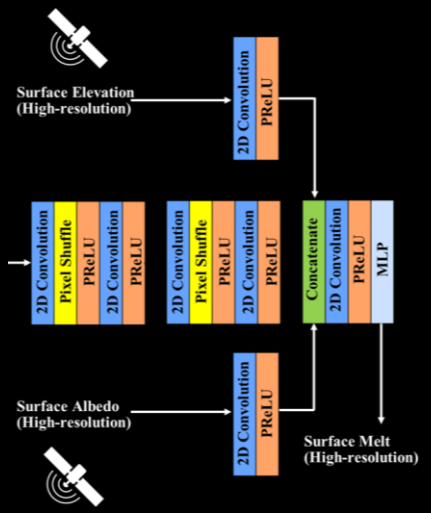


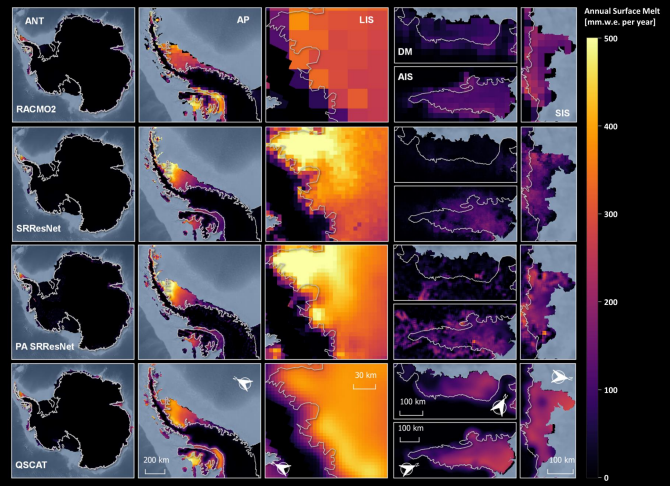
Contact: Zhongyang Hu (z.hu@uu.nl)

Take home messages

Physics-aware

Physics-informed

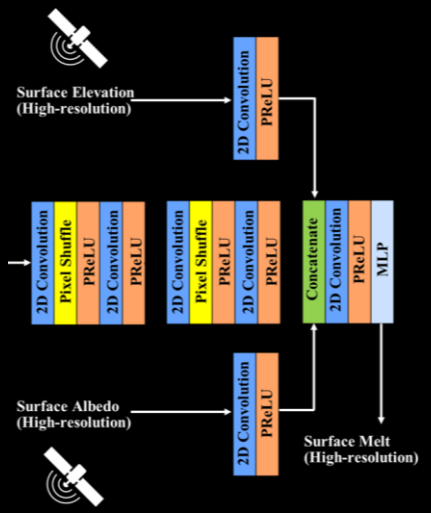




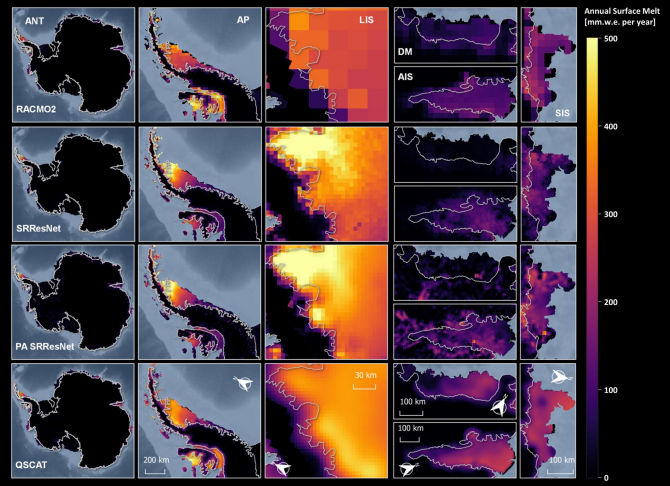
Contact: Zhongyang Hu (z.hu@uu.nl)

Take home messages

Physics-informed



Physics-aware



Physics-understood

Towards a spatially transferable super resolution model for downscaling Antarctic surface melt

Contact: Zhongyang Hu (z.hu@uu.nl)