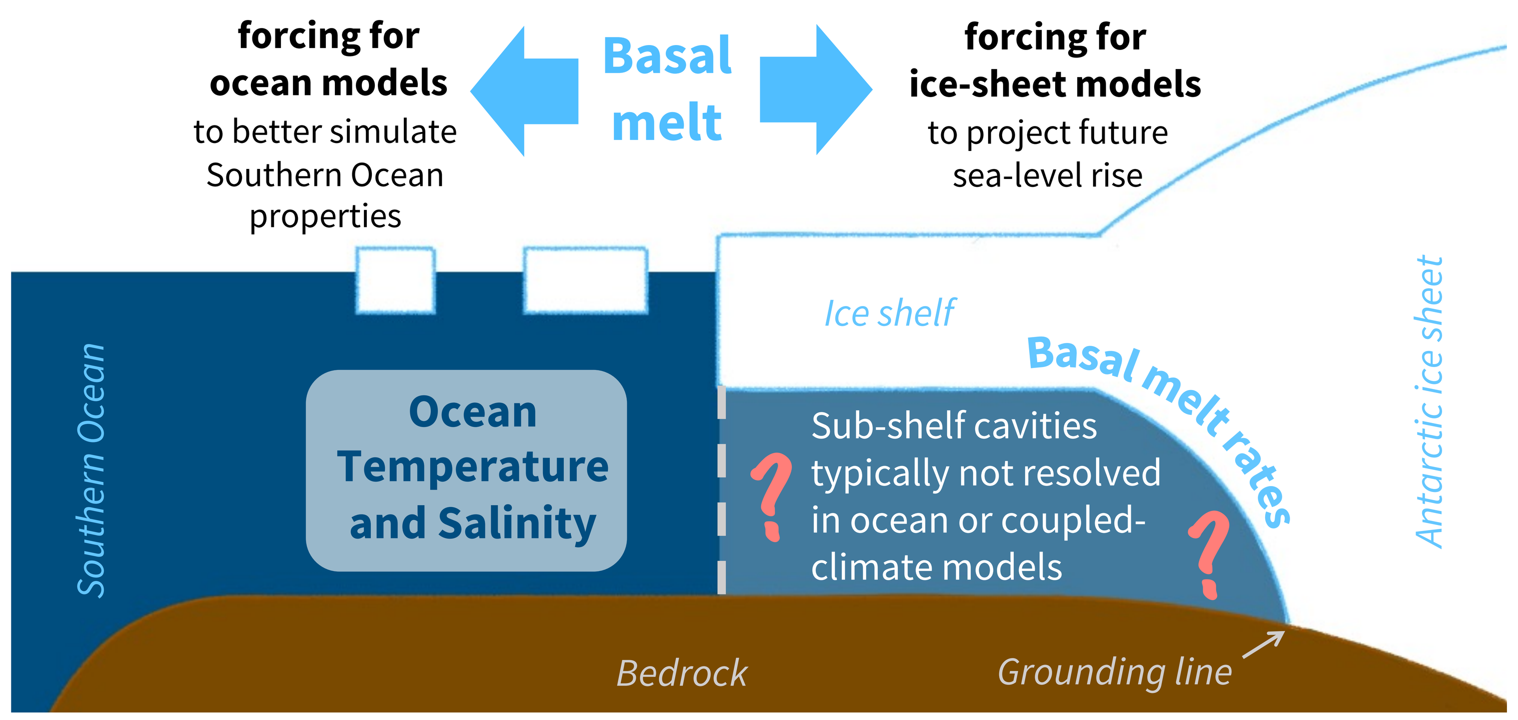
Parameterising melt at the base of Antarctic ice shelves with a feedforward neural network

Clara Burgard
and Nicolas C. Jourdain, Pierre Mathiot, Robin Smith, Rieke Schäfer, Justine Caillet, Tobias S. Finn, J. Emmanuel Johnson

clara.burgard@univ-grenoble-alpes.fr
@climate_clara@mastodon.green

IGE
UGA Université Grenoble Alpes

Introduction and Motivation

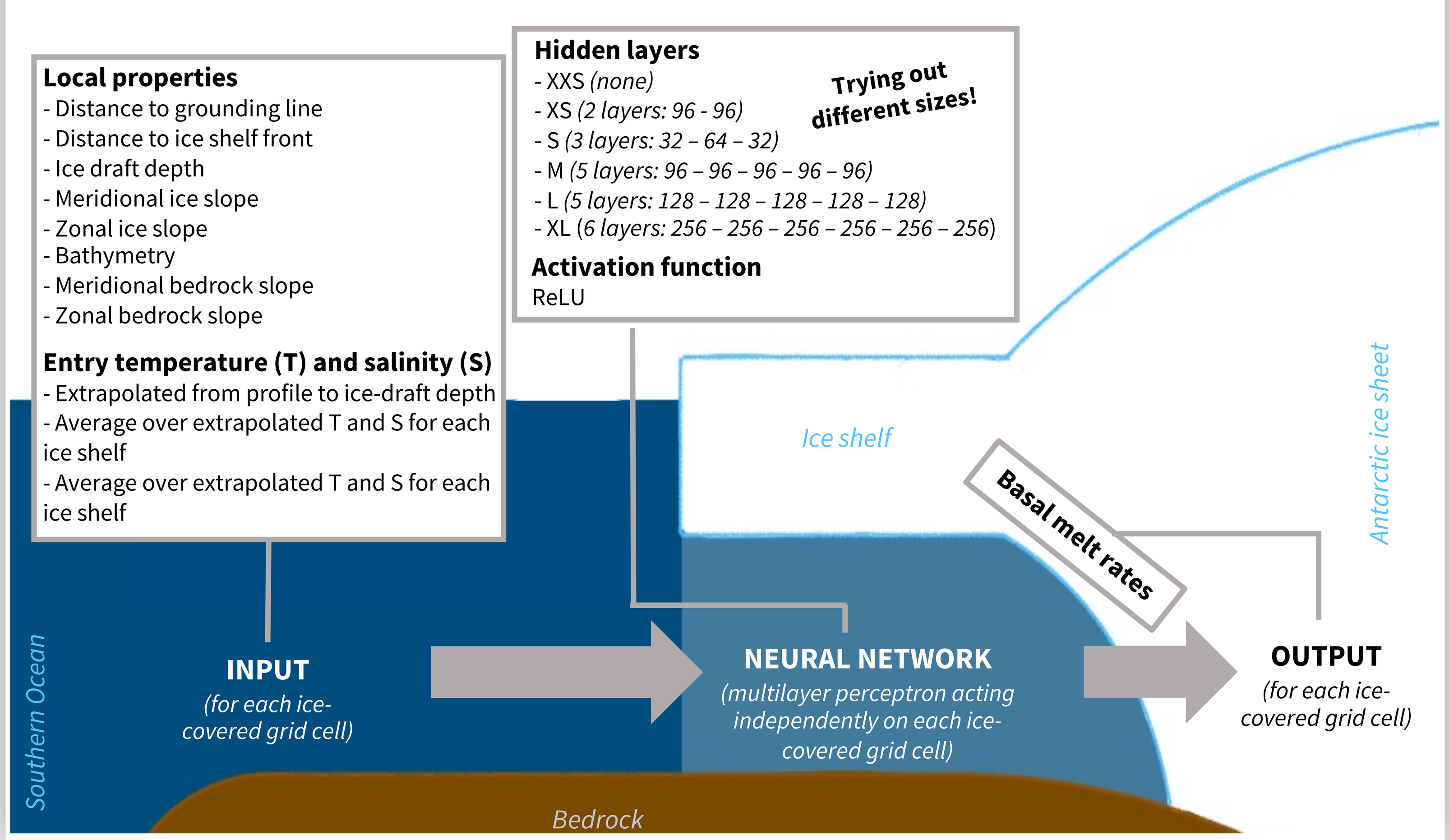


Existing physics-based parameterisations struggle to represent the link between open ocean and basal melt

Idea: Train a neural network to emulate the melt as simulated by a cavity-resolving ocean model (NEMO)

The neural network(s)

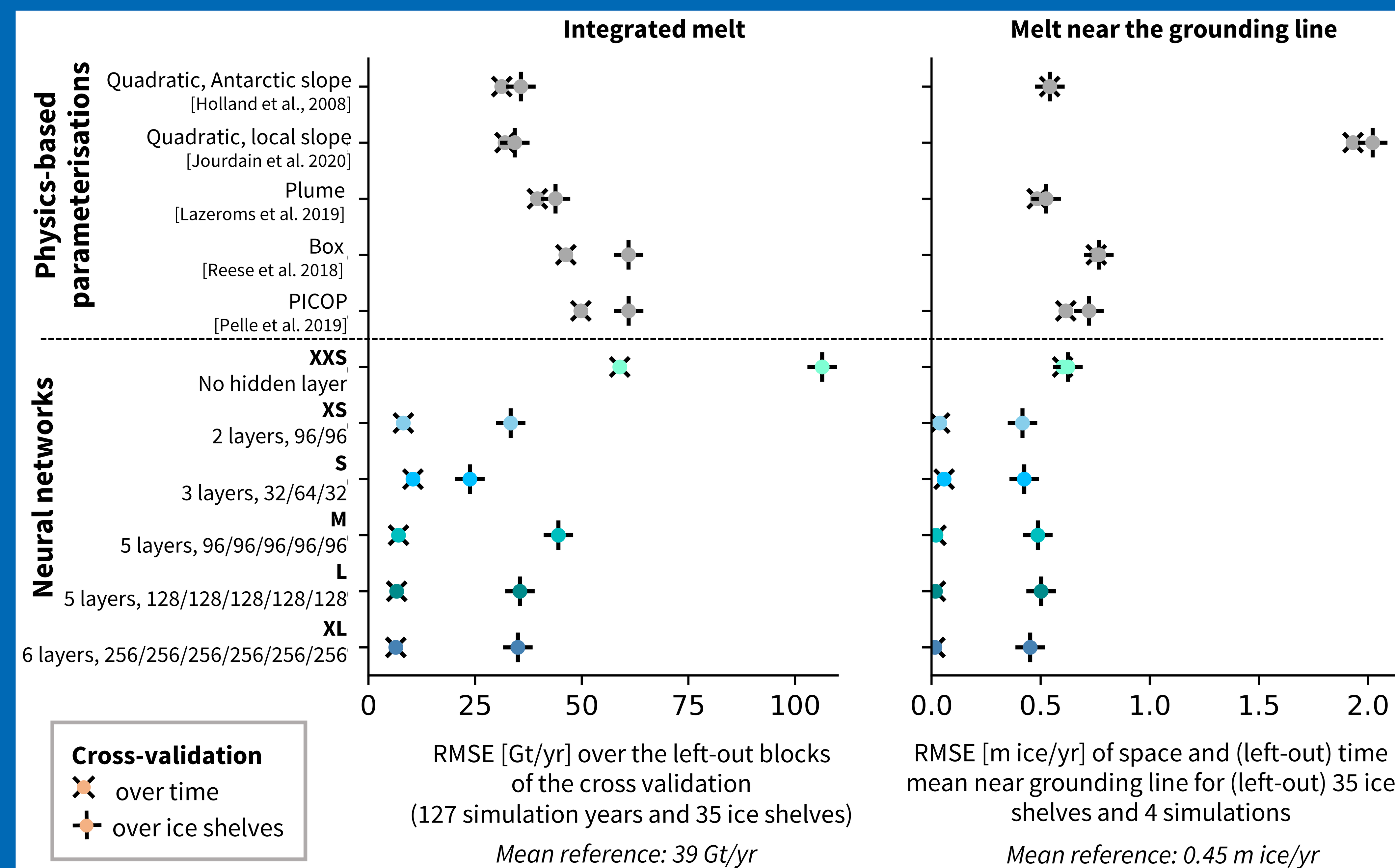
"Simple" multilayer perceptron **acting on the grid-cell level** (in opposition to the convolutional approach from Rosier et al. 2023)



We show that a simple neural network acting on the grid-cell level can infer reasonable circum-Antarctic basal melt rates for ice shelves.

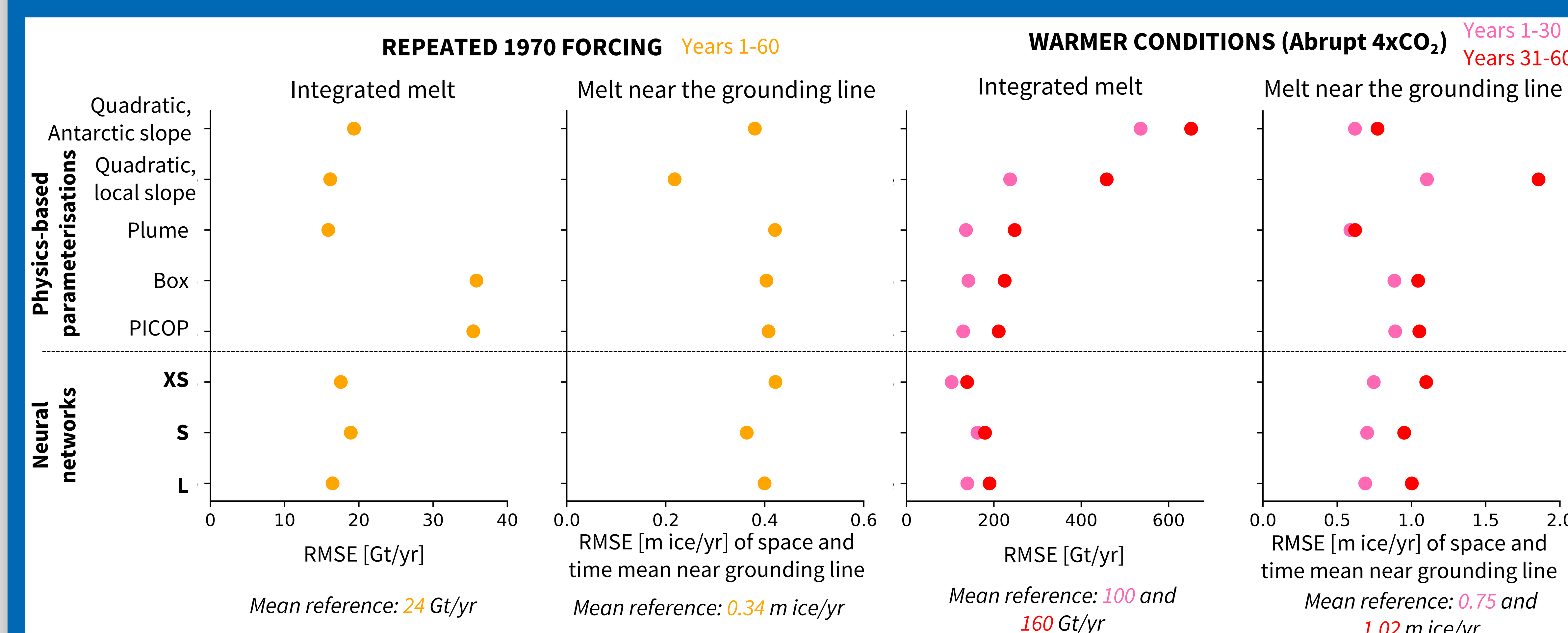
During cross-validation... [training on standalone ocean simulations - Burgard et al. 22]

over time (127 years): trained over 12 ten-year blocks and validated over 1 ten-year block, repeated 13x
over ice shelves (35 shelves): trained over 34 ice shelves and validated over 1 ice shelf, repeated 35x



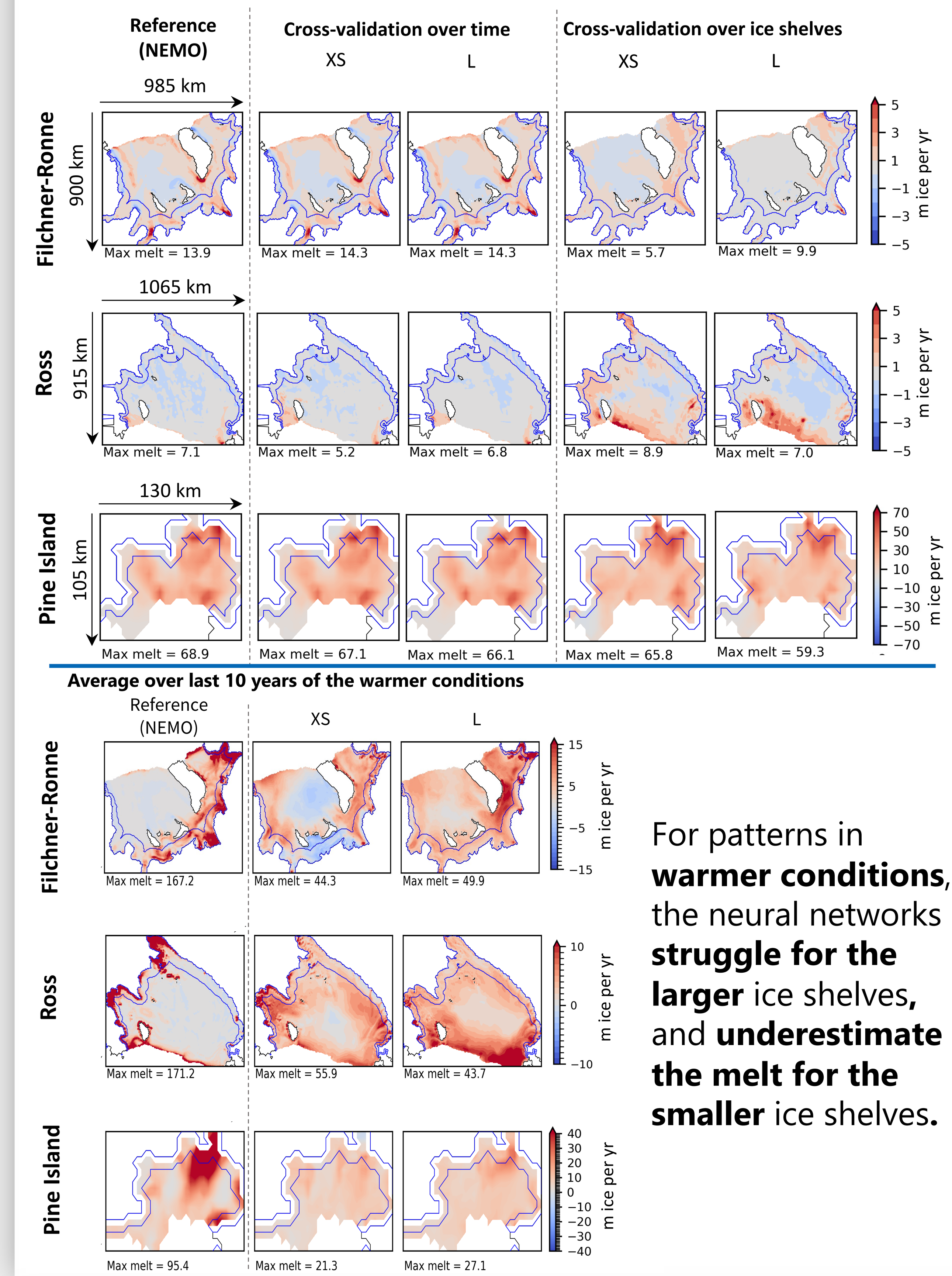
In present and future conditions... [testing on coupled ocean-ice simulations - Smith et al. 21]

Testing on changing ice-shelf geometries and temperature and salinity outside of training range



Look at the patterns!

Neural networks good at representing patterns if ice shelf was included in training! Otherwise, they struggle more...



For patterns in **warmer conditions**, the neural networks **struggle for the larger** ice shelves, and **underestimate the melt for the smaller** ice shelves.

Which input variables matter the most?

With a **permute-and-predict** approach, we explore the influence of the different input variables on the RMSE.

	Integrated melt [Gt/yr] XS	Integrated melt [Gt/yr] L	Melt near grounding line [m ice/yr] XS	Melt near grounding line [m ice/yr] L
Original RMSE	**17.6**	**16.5**	**0.42**	**0.40**
Water column	15.9	7.1	-0.03	-0.01
Position	13.9	13	-0.01	0
Slopes bed	0.5	0.1	-0	0
Slopes ice	1.1	0.9	0.04	0.05
Temperature info	330.6	266.5	0.21	-0.03
Salinity info	20.7	3.2	0.07	0.06

Difference between the RMSE using a random sample of input from the 4xCO2 run and the original RMSE on REPEAT1970

Water column = ice draft depth and bathymetry, Position = distance to ice front and grounding line, Slopes bed = zonal and meridional bedrock slopes, Slopes ice = zonal and meridional ice slopes, Temperature info = local, average and standard deviation of temperature, Salinity info = local, average and standard deviation of salinity

Outlook

Neural networks acting on the grid-cell level can infer similar or even better basal melt rates than physics-based parameterisations ▶ very encouraging!

Improvements to explore in the future:

- ▶ Include warmer simulations in training
- ▶ Use Machine Learning to extract main temperature and salinity characteristics in front of the shelf (≠ only average)?
- ▶ Train without the larger ice shelves to improve patterns?