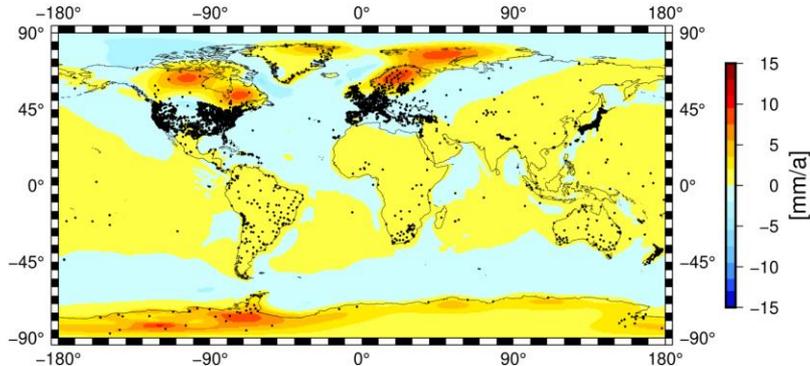


#### Motivation:

- GPS stations are not evenly distributed
- Stations are not necessarily located at “interesting” locations for GIA models
- Different uncertainty of GPS uplift rates
- Different weighting of the GPS Stations in validation

#### Data:

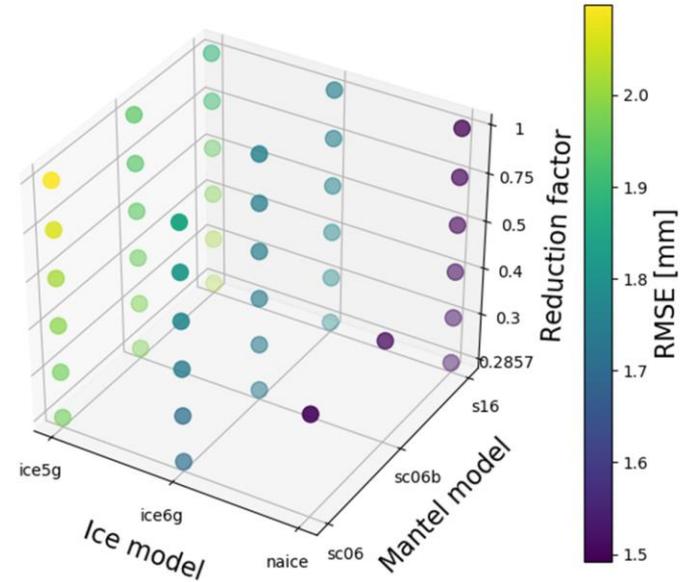
- 4072 GPS uplift rates provided by Schumacher et al. 2018
- 44 GIA models based on 3 ice histories, 3 3D mantle-viscosity models, and 6 reduction factors for converting temperature to viscosity



Location of GPS stations with uplift rates of one exemplary GIA model

#### Results:

Globally best models with naice, worst with ice5g



For more information about the GIA models please see presentation by Meike Bagge (EGU21-13479)



# Validating GIA Models Based on an Ensemble of 3D Earth Structures with Present-Day GPS Uplift Rates

## *Supplementary Material*

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# Data

- 4072 GPS uplift rates provided by Schumacher et al. 2018
- 44 different GIA models, differing in three ice history model (ice5g, ice6g, naice), three mantle model (sc06, sc06b, s16), and six reduction factor (0.2857, 0.3, 0.4, 0.5, 0.75, 1.0)

# Validation Method

Weighted RMSE:

$$RMSE = \sqrt{\frac{\sum_i w_i (r_{GPS} - r_{GIA})^2}{\sum_i w_i}}$$

With  $i = 1 \dots N$ ,  $N$  # of GPS station,  $w_i$  the assigned weight per station, and  $r_{GPS}$  and  $r_{GIA}$  the uplift rates of GPS station and GIA model grid cell containing GPS station

# Weighting Method

Two combined weighting schemes:

1. Weights based on correlations between GPS stations

Estimate correlations between stations based on GIA models

$$w_i^{corr} = \sum_x corr(r_i, r_x)$$

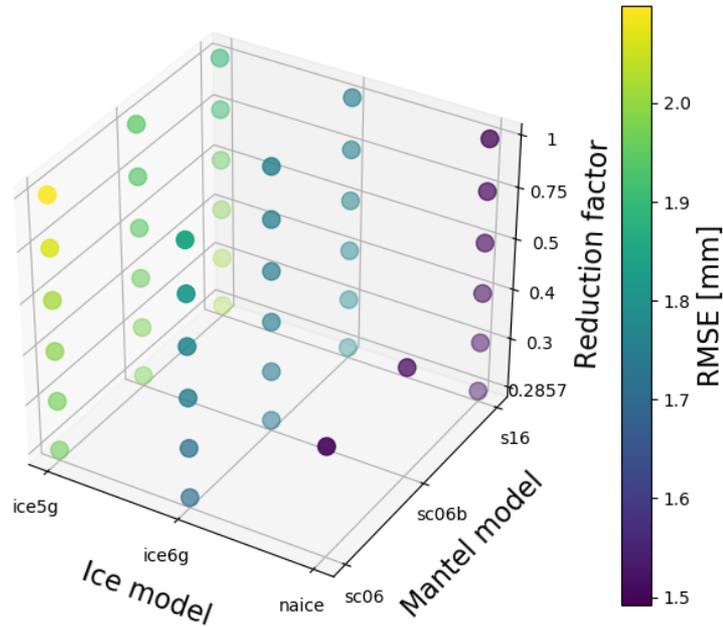
2. Weights based on GPS rate uncertainties

$$w_i^{std} = 1/std_i^2$$

3. Both weights are normalised
4. Final weights is combination

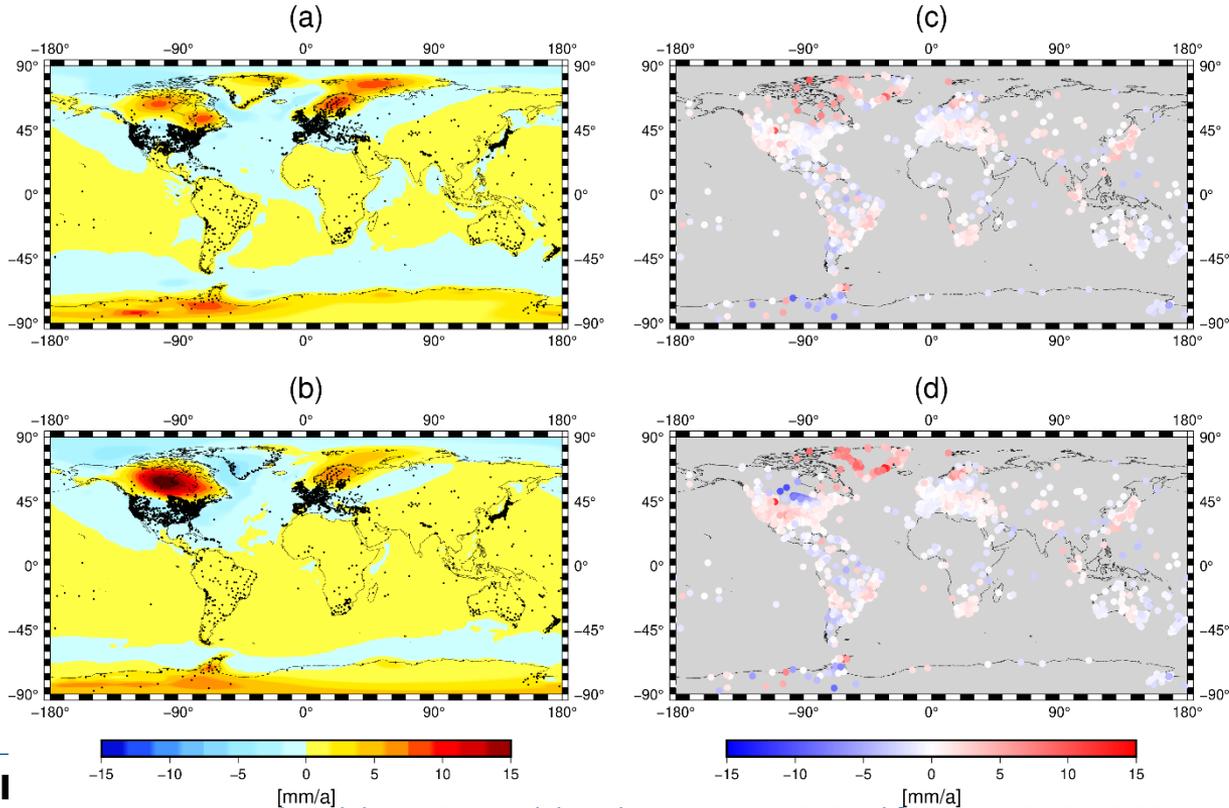
$$w_i = w_i^{corr} + w_i^{std}$$

# Global Result



Best GIA model with Naice, s16, 1.0  
Worst GIA model with Ice5g, sc06, 1.0

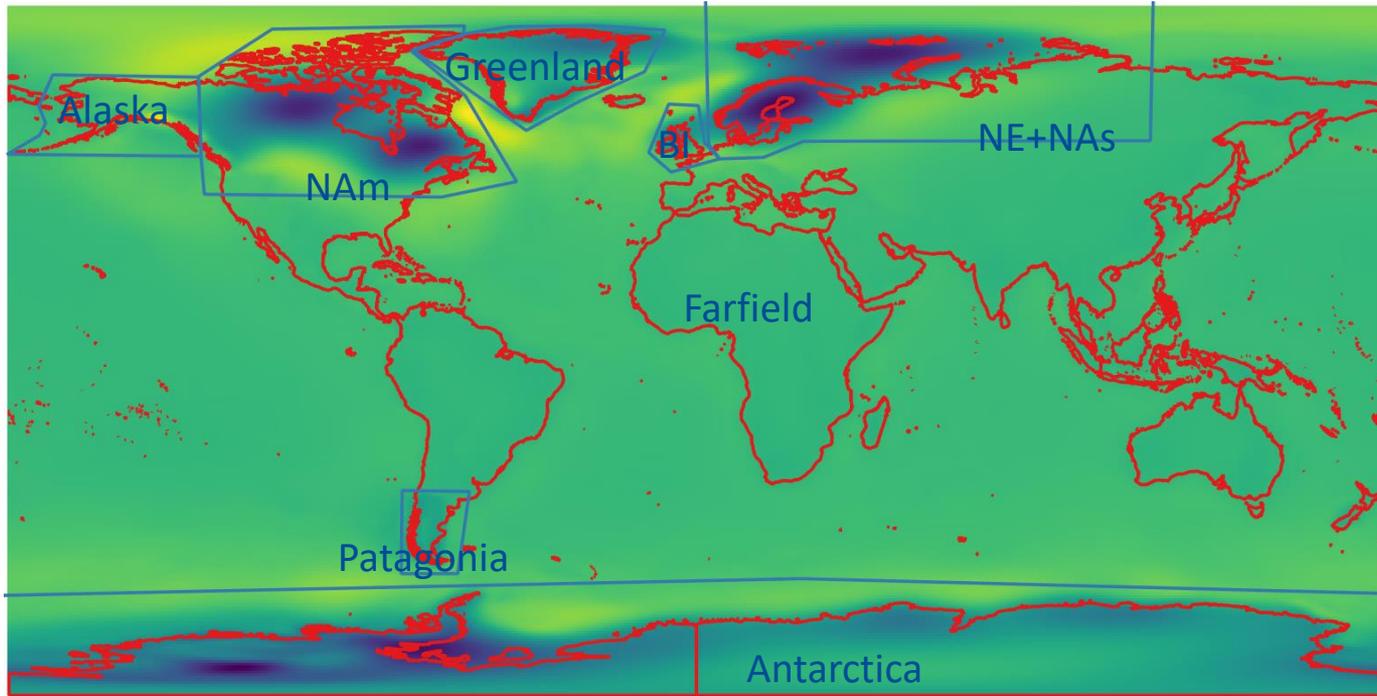
# Best vs. worst performing GIA model



Best (top row): Naice, s16, 1.0  
Worst (bottom): Ice5g, sc06, 1.0

Left: Modelled uplift rate and  
GPS locations  
Right: Differences between GPS  
and modelled uplift rate

# Validation by Regions



Background: Uplift rates of Naice, s16, 1.0

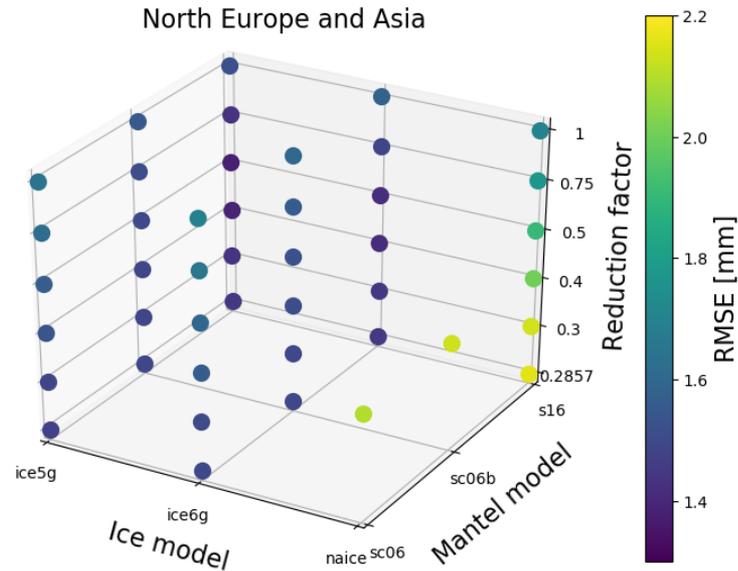
# Validation by Regions

Region (# of obs)	Global (4072)	NE + NAs (215)	BIS (142)	Greenland (54)	NAm (777)	Alaska (5)	Patagonia (13)	Antarctica (65)	Farfield (2081)
<b>With weighting</b>									
<b>Best</b>	Naice, s16, 1.0	Ice5g, s16, 0.5	Ice5g, s16, 0.5	Naice, s16, 0.2857	Naice, sc06, 0.4	Ice5g, s16, 1.0	Naice, s16, 0.3	Ice6g, sc06, 0.2857	Naice, sc06, 0.4
<b>Worst</b>	Ice5g, sc06, 1.0	Naice, s16, 0.2857	Naice, s16, 0.75	Ice5g, sc06, 1.0	Ice5g, sc06, 1.0	Ice6g, sc06, 1.0	Naice, sc06, 0.4	Ice5g, sc06, 0.2857	Ice5g, s16, 0.2857
<b>Without weighting</b>									
<b>Best</b>	Naice, sc06, 0.4	Ice5g, s16, 0.5	Ice5g, s16, 0.5	Naice, s16, 0.2857	Naice, sc06, 0.4	Ice5g, s16, 0.5	Naice, s16, 0.3	Ice6g, sc06, 0.3	Naice, sc06, 0.4
<b>Worst</b>	Ice5g, sc06, 1.0	Naice, s16, 0.2857	Naice, s16, 0.75	Ice5g, sc06, 1.0	Ice5g, sc06, 0.2857	Ice6g, sc06, 1.0	Naice, sc06, 0.4	Ice5g, sc06, 0.2857	Ice5g, s16, 0.2857

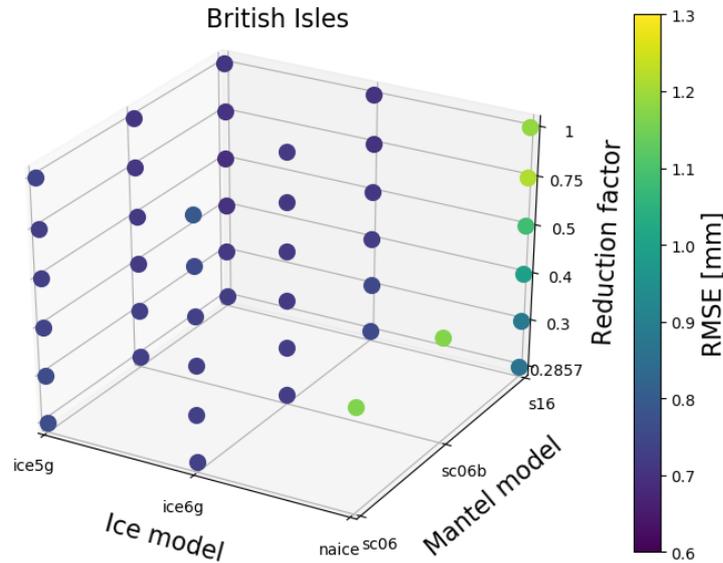
Different model is validated as best or worst

Alaska has too less data points for reliable validation

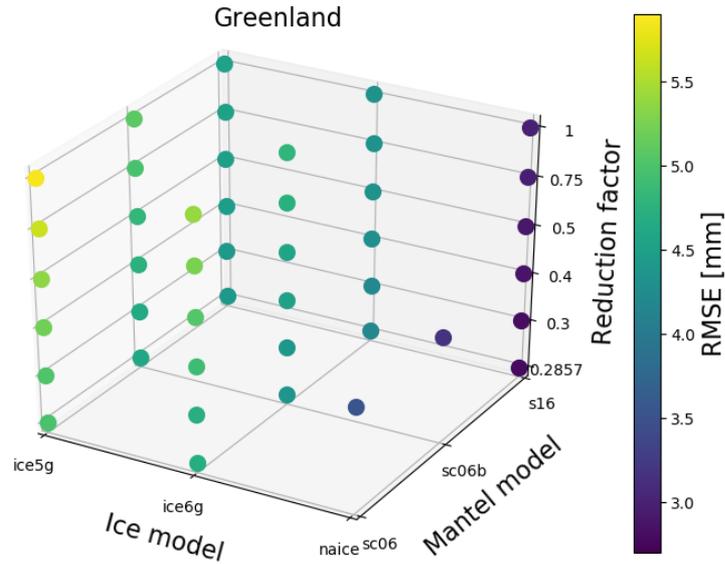
# Validation by Regions – North Europe and Asia (NE+Nas)



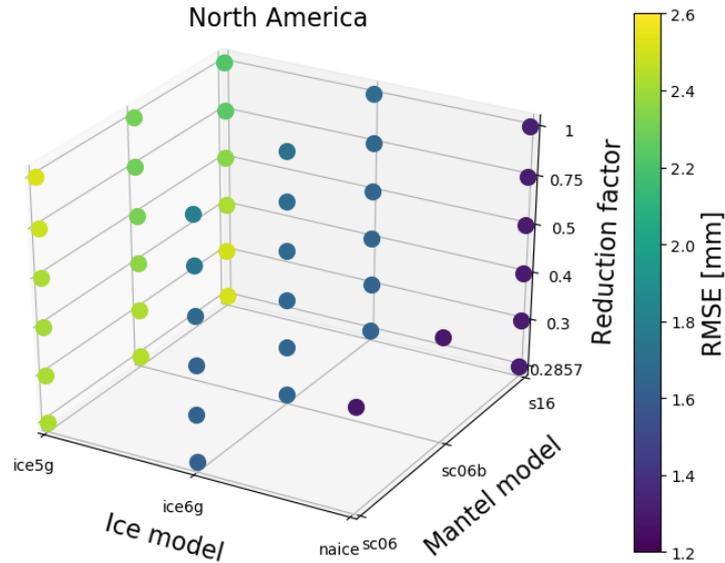
# Validation by Regions – British Isles (BI)



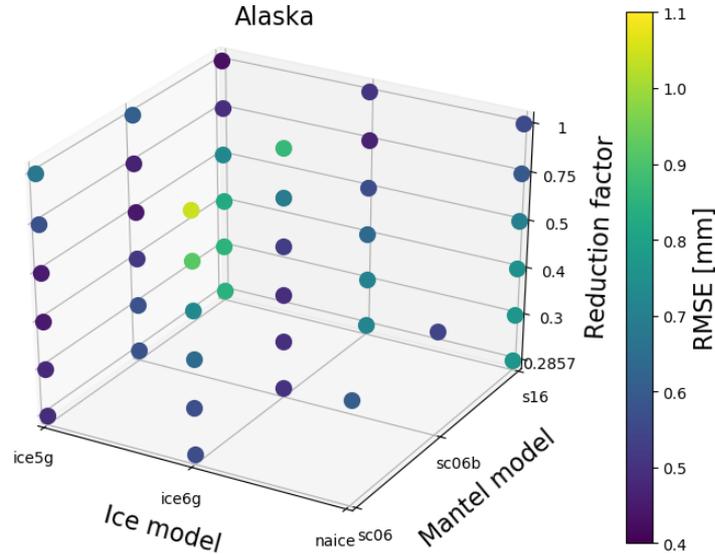
# Validation by Regions – Greenland



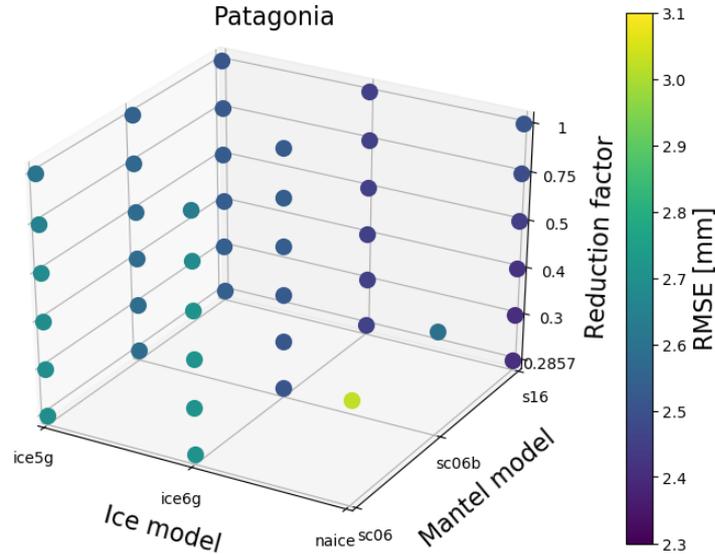
# Validation by Regions – North America (Nam)



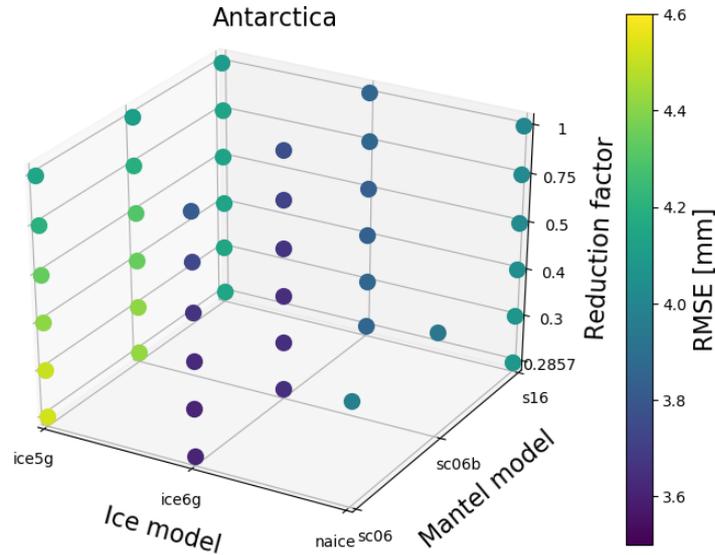
# Validation by Regions – Alaska



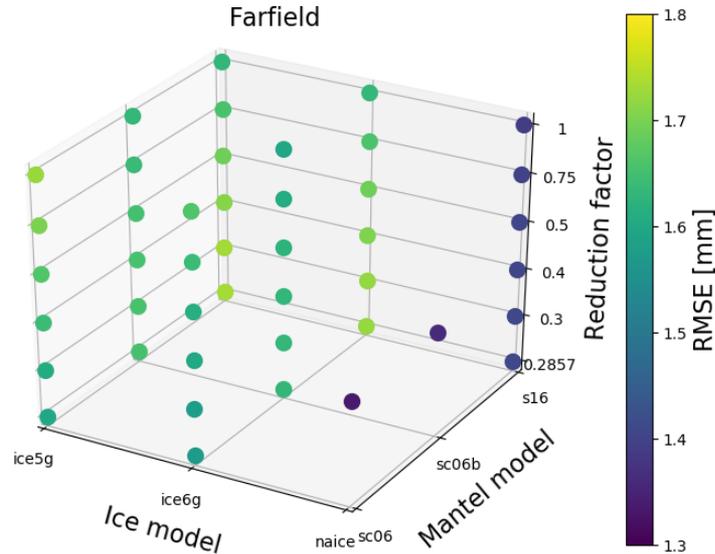
# Validation by Regions – Patagonia



# Validation by Regions – Antarctica



# Validation by Regions – Farfield



# Conclusion

- Newly developed weighting scheme improves validation of global GIA models against unevenly distributed GPS uplift rates
- Validation results strongly depend on the considered regions
- Used ice history model have the largest impact on the performance of the GIA models

For more details on the GIA models used in this presentation see contribution of Bagge et al. (EGU21-13479)

# References

- GIA models: Bagge et al., 3D glacial-isostatic adjustment models using geodynamically constrained Earth structures (EGU21-13479)
- GPS data: Schumacher, M., King, M. A., Rougier, J., Sha, Z., Khan, S. A., & Bamber, J. L. (2018). A new global GPS data set for testing and improving modelled GIA uplift rates. *Geophysical Journal International*, 214(3), 2164-2176.