Quantifying the impact of bedrock uncertainty on ice sheet model simulations by Gaussian Process modelling

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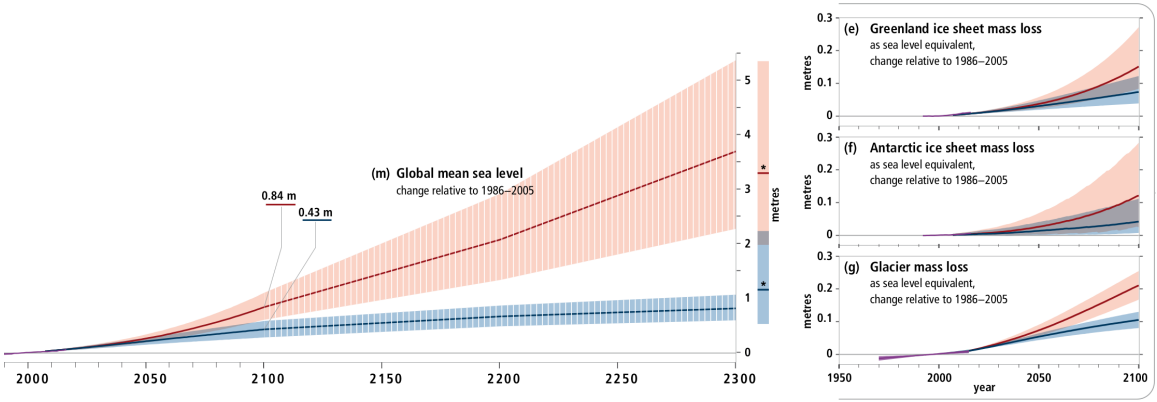
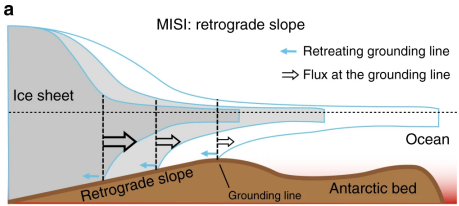
Most work presented here is published in:
https://doi.org/10.21954/ou.ro.0001223d

Predicted sea level rise



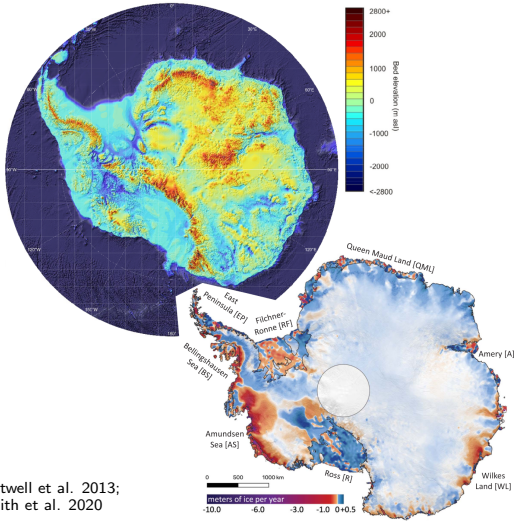
IPCC, 2019: SROCC

Antarctica/Marine Ice Sheet Instability



Pattyn 2018

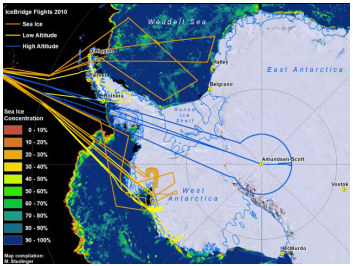
Lena Nicola



Fretwell et al. 2013;
Smith et al. 2020

Antarctic bedrock measurements

NASA



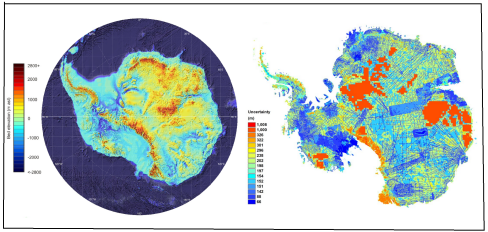
@planeschemerdesign

- Aircraft based Radio Echo Sounding measurements
- High repetition measurements with several 100 m resolution
- Typical flight line intervals 10 km

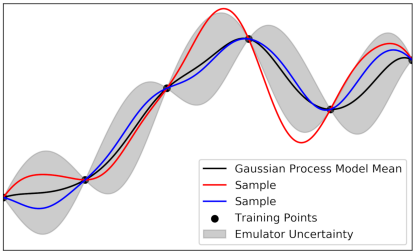
Data

Averaging
&
Interpolation

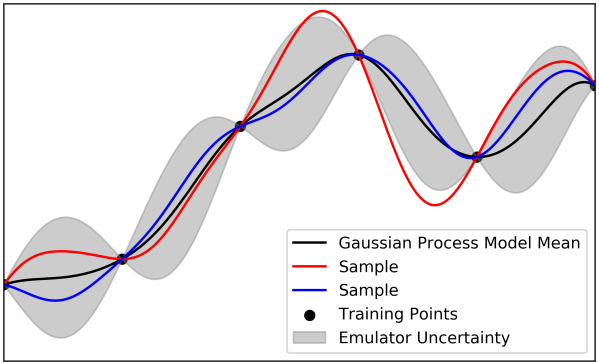
Train statistical model
&
Sample



Fretwell et al. 2013;



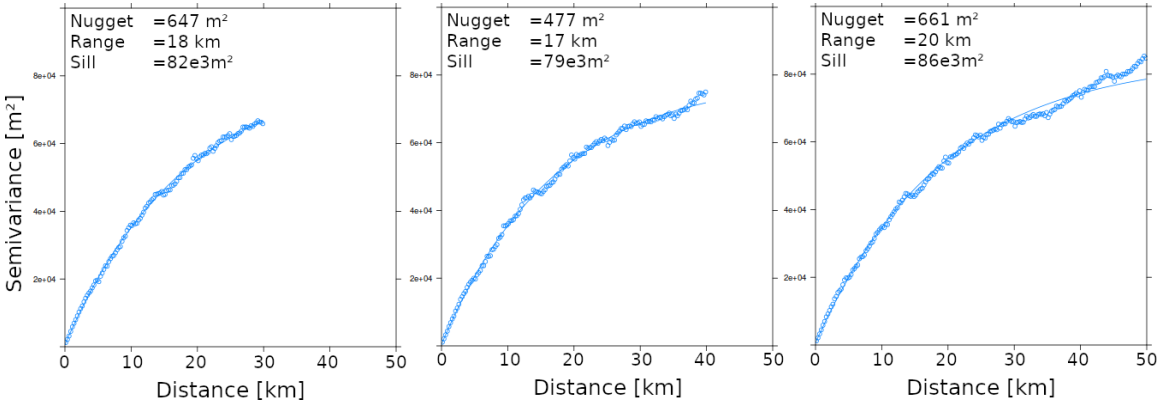
Gaussian Processes



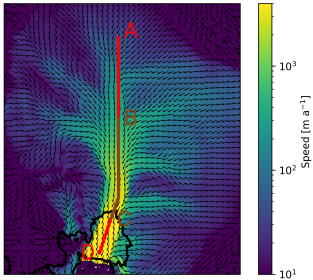
- Multivariate Gaussian Distribution
- Non-Parametric:
  No functional form prescribed
- Instead it uses correlation characteristics:
  Nugget, correlation function and far field variance

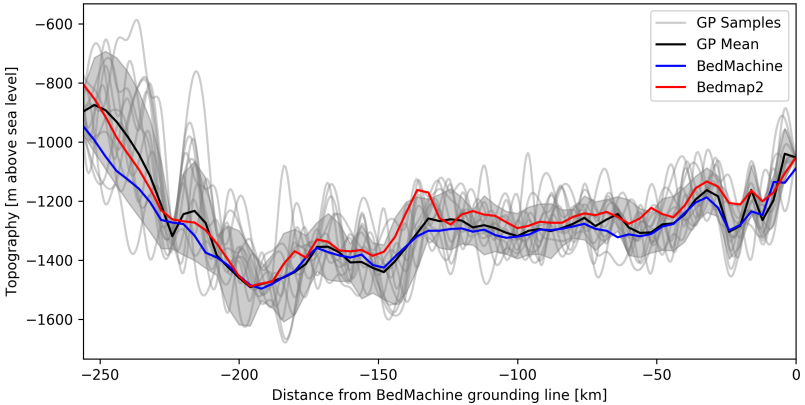
Hyper-paramters

- Randomly select ≈100 000 from 5 million samples
- Fitting exp. function, cutoff at 25 km to 50 km



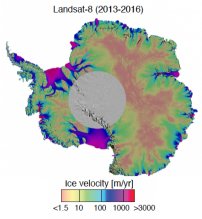
New Topographies for Pine Island Glacier

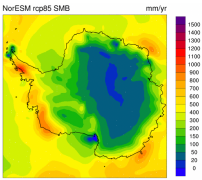


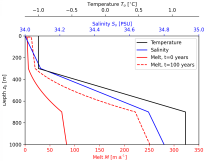


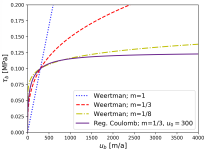
Model setup

- Twenty bedrock samples and basal traction + viscosity inversions (using Rignot et al. 2017 velocities)
- Local quadratic ocean melt forcing (Favier et al. 2019), constant and 200% melt increase (roughly) following Naughten et al. (2018)
- Surface mass balance (NorESM) for RCP2.6 (constant ocean melt) and RCP8.5 (200% melt increase)
- Three Weertman friction laws, total of 120 simulations

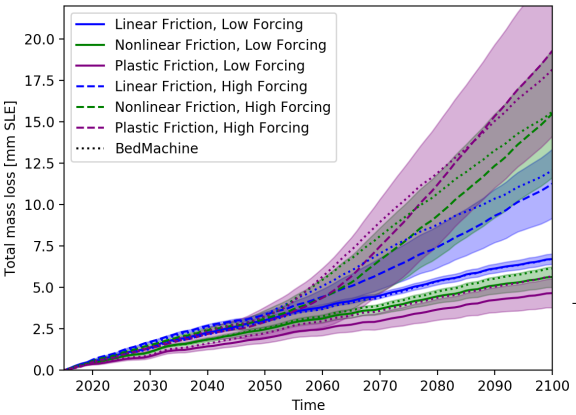








Sea Level Rise Projections



- Change in rate of ice loss around mid of century (high forcing)
- Uncertainties (one sd.) due to bedrock can be >25% of signal

[mm SLE]	Low Forcing	High Forcing
Linear Fric.	6.7 $\pm$0.31	11.3 $\pm$2.08
Nonlinear Fric.	5.6 $\pm$0.62	15.5 $\pm$3.86
Plastic Fric.	4.7 $\pm$0.87	19.4 $\pm$5.15

Conclusion

We derive statistical properties for a Gaussian Process, which has an implicit interpolation uncertainty representation

An representative sample of bedrock topographies for Pine Island Glacier in generated

Bedrock uncertainty alone translates to 5% to >25% predictive uncertainty in 100 year simulations

For more details and contact information, see title page. I look forward to hear from you,
Andreas