Applying Inverse Modeling for Field Work Planning

Alex Robinson
Jason Geck
Leanne Wake

Glaciers Online

Inverse modeling

- Determining values of some modeled parameter from observed data
  - Example: Obtaining information about temperature from known sea level

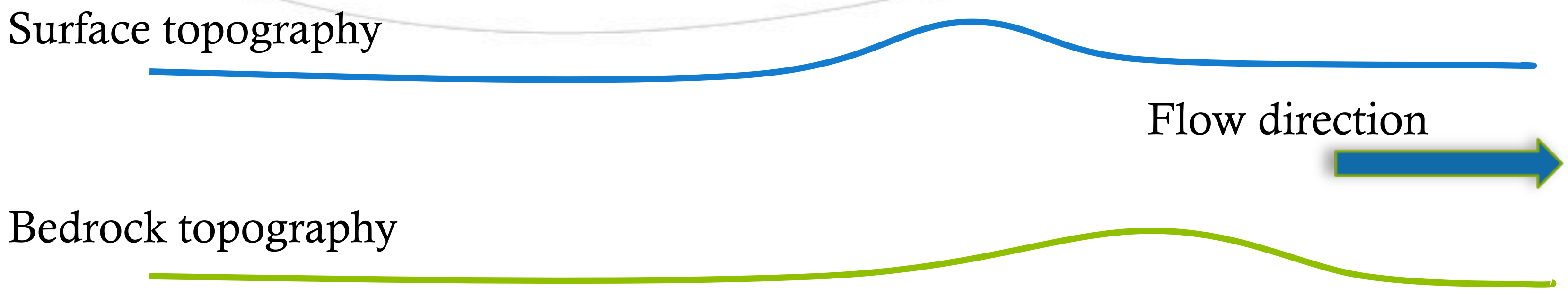
Global sea level → Ice Sheet Model → Temperature

- Our example: bedrock geometry under glaciers from observed surface measurements

How can inverse modeling be used to plan field data collection campaigns?

- Why care?
  - Field work/equipment costs
- What is an acceptable observation error?
- What types of data need to be collected?
  - Surface Topography
  - Horizontal Velocity
- What is optimum sampling rate?

Case study



What do we know (A priori)?

*Bedrock topography map (DEM)

Aim of the survey: improve our estimate of the bedrock topography using surface topography oberservations

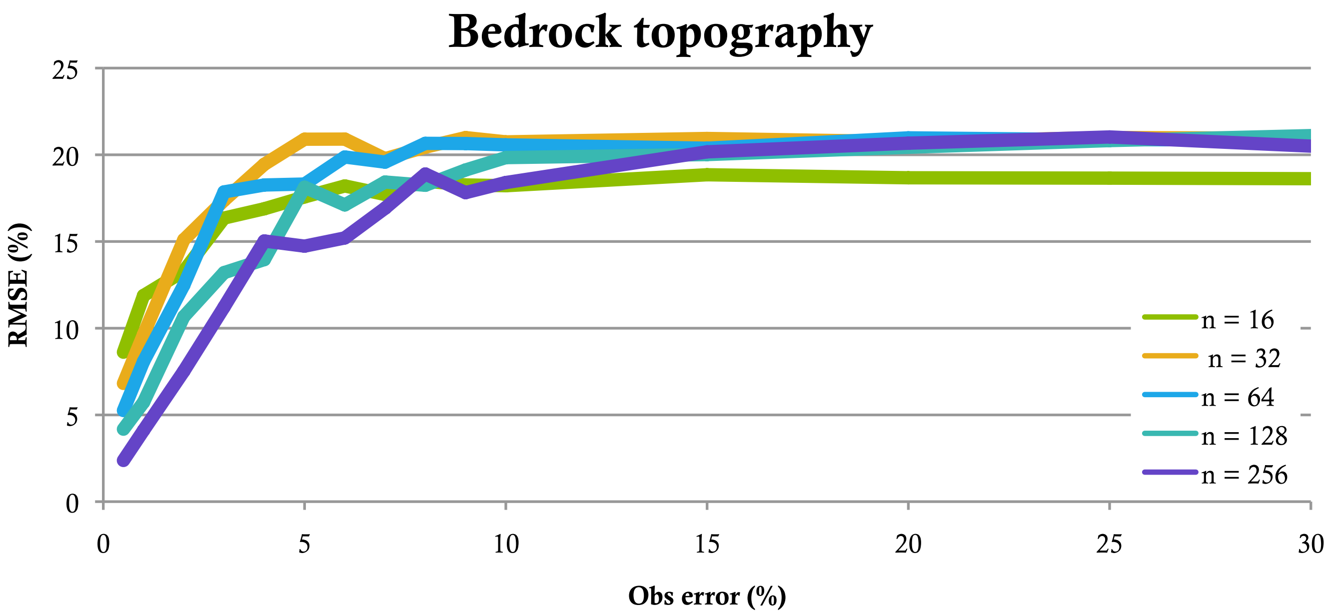
Point of our inverse study: aid the field planning method

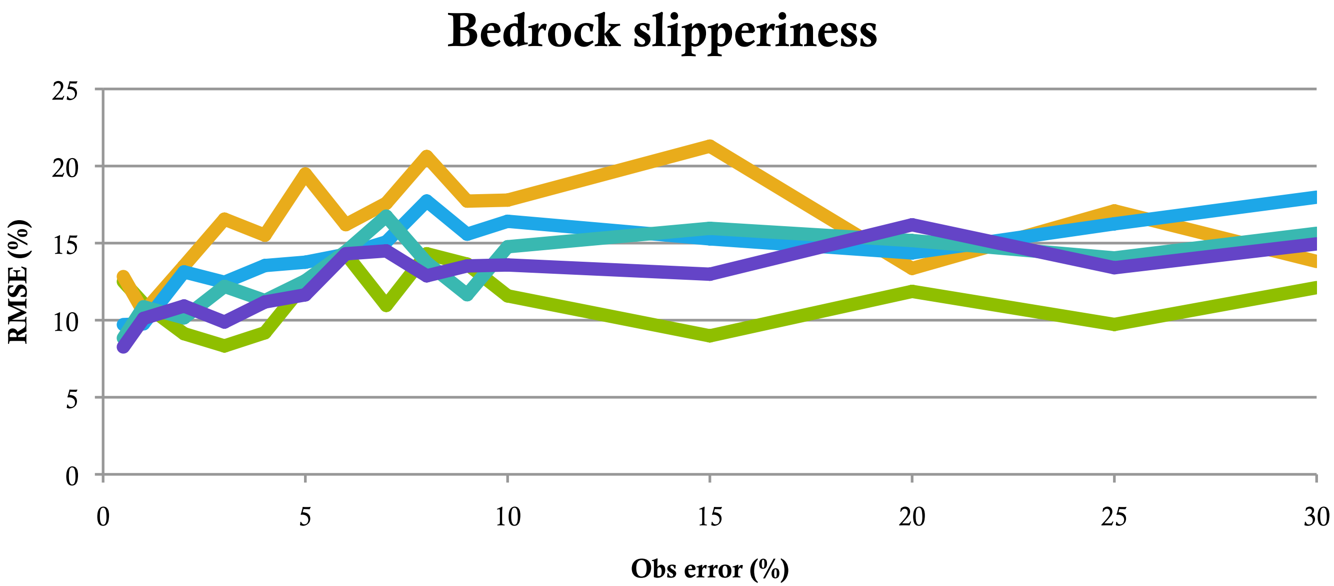
- sampling resolution
- max allowed observation error (cost reduction)
- … figure out what inverse modeling is…

Two experiments with the inverse model

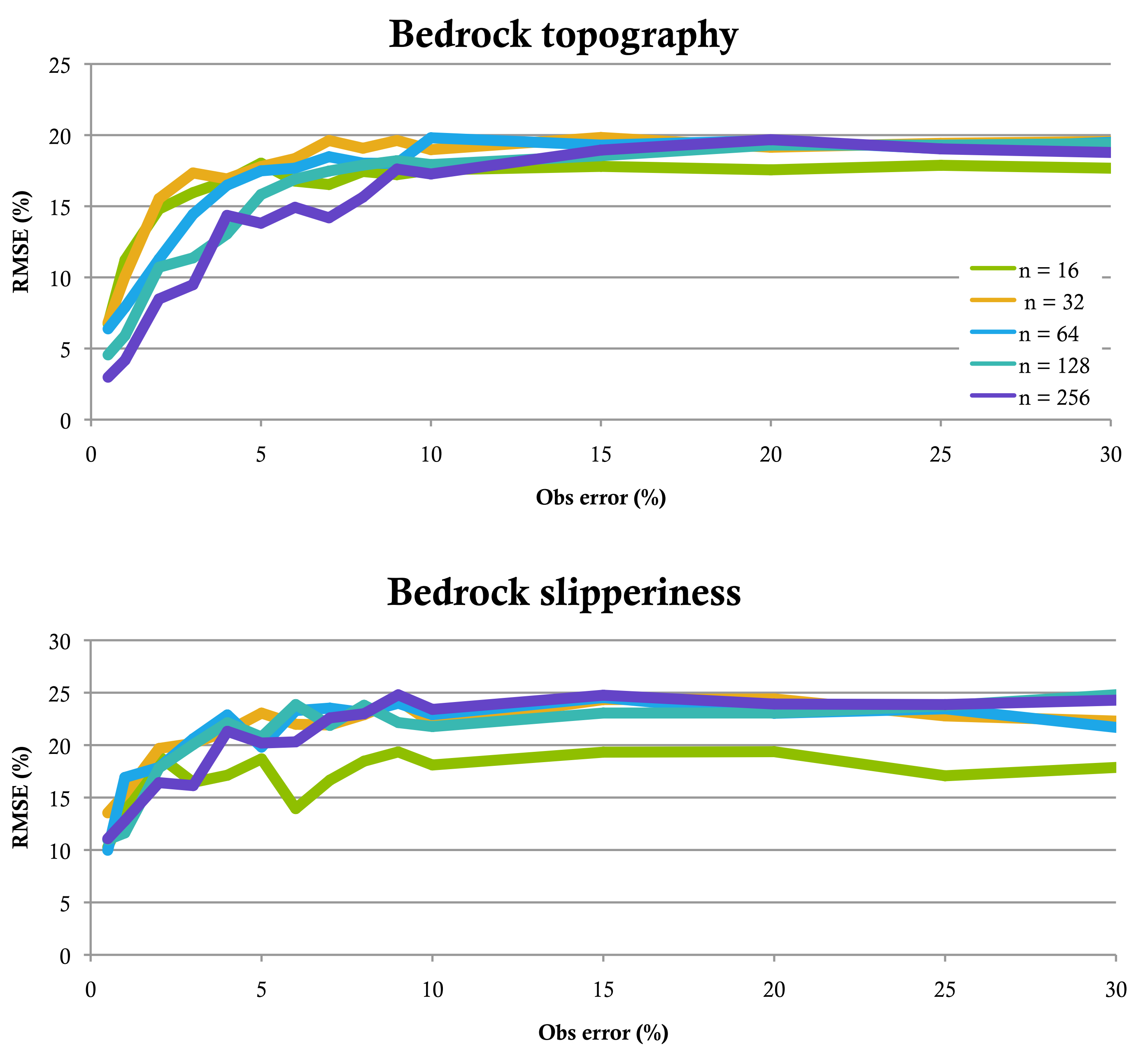
- Goal: To get a better estimate of bedrock topography and idea of slipperiness…
  - Assuming we know surface topography, how well must we know horizontal surface velocity?
  - Assuming we know horizontal surface velocity, how well must we know surface topography?

**How are the errors related to sampling resolution?



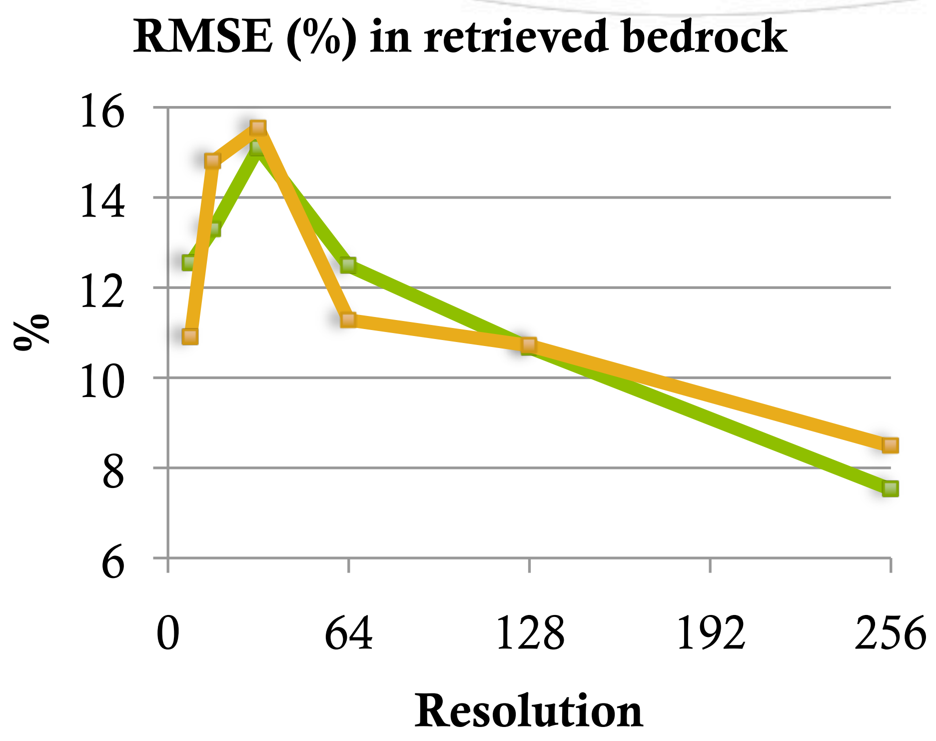


* Horizontal velocity error 0.5%; Varying surface topography error

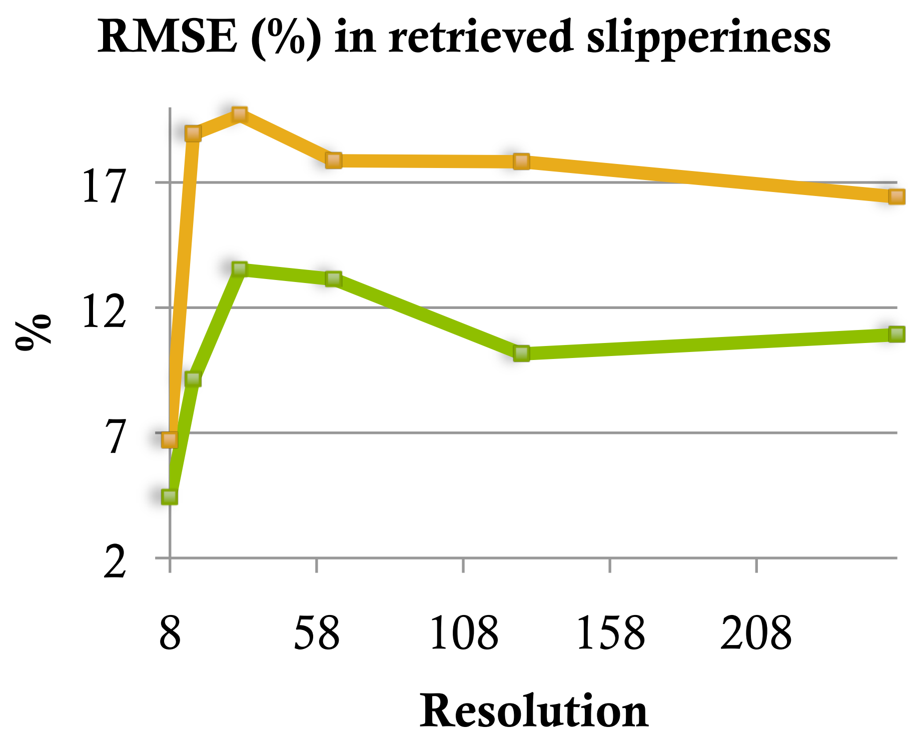


* Surface topography error 0.5%; Varying horizontal velocity error

Effect of sampling resolution



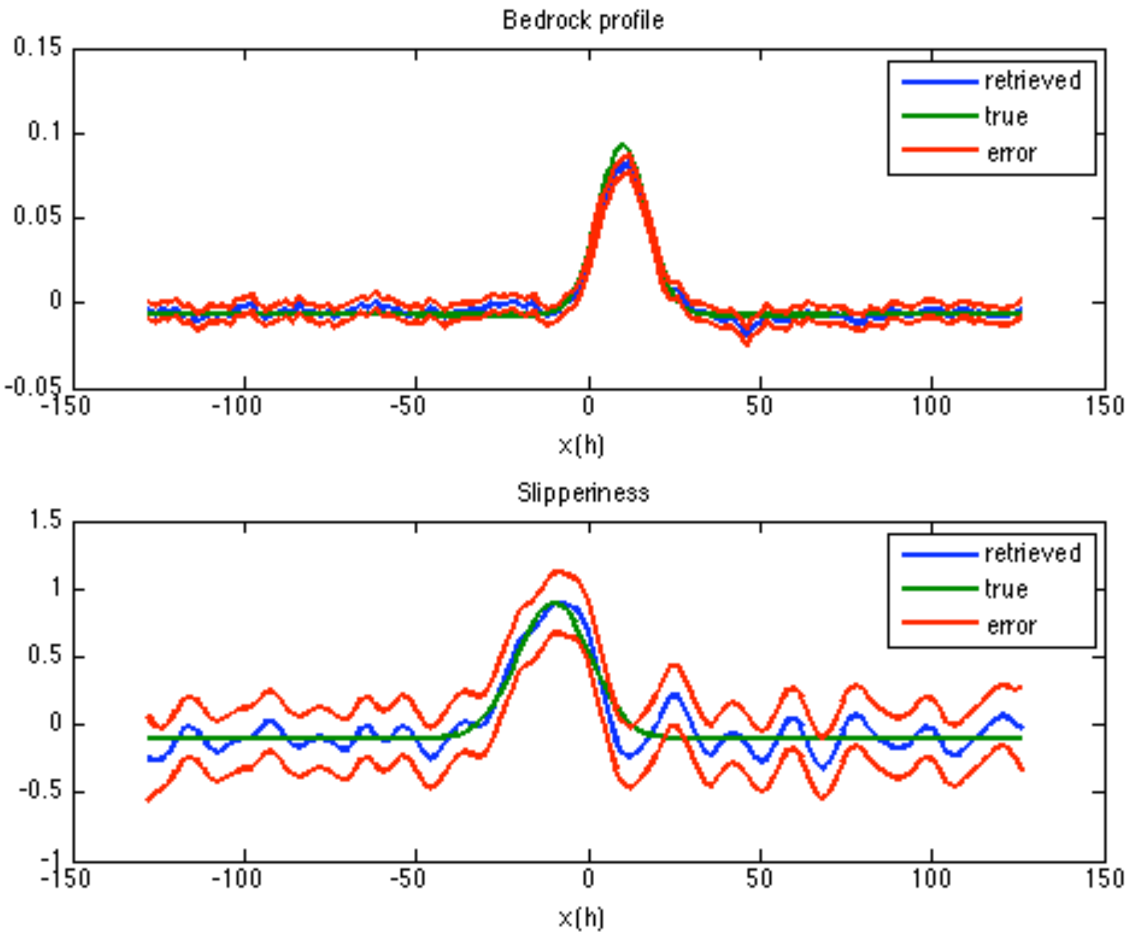
Topo error: 0.5%
Vel. Error: 2.0%



Topo error: 2.0%
Vel. Error: 0.5%

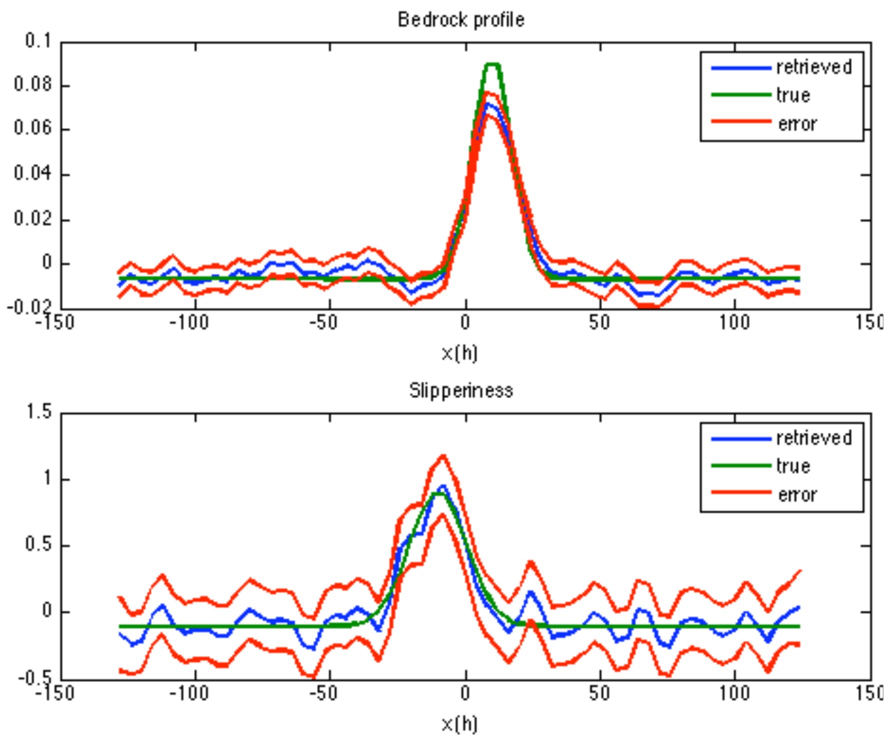
Best estimate

0.5% error; n = 128

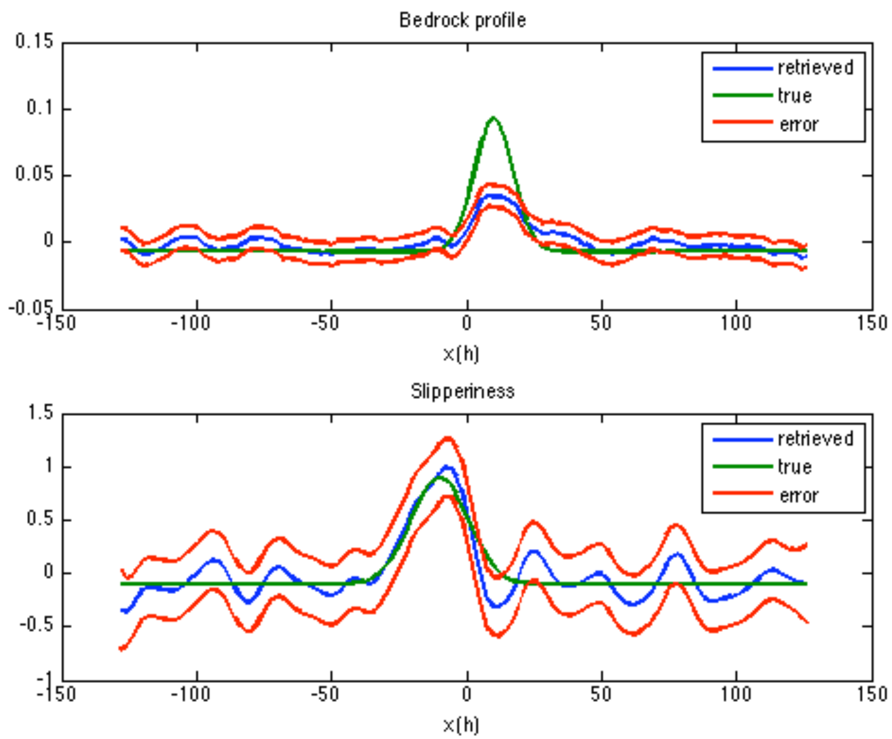


Less ideal cases…

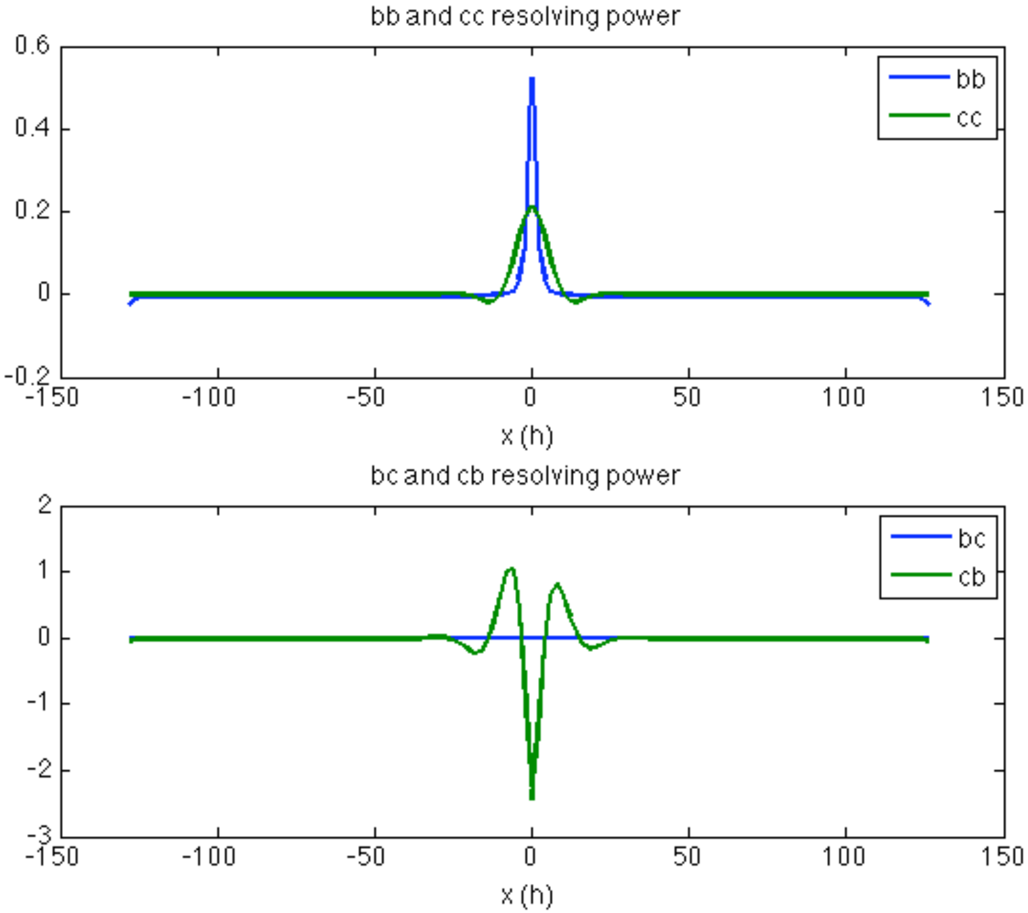
0.5% error; n = 64



2% error; n = 128



Sensitivity of estimates

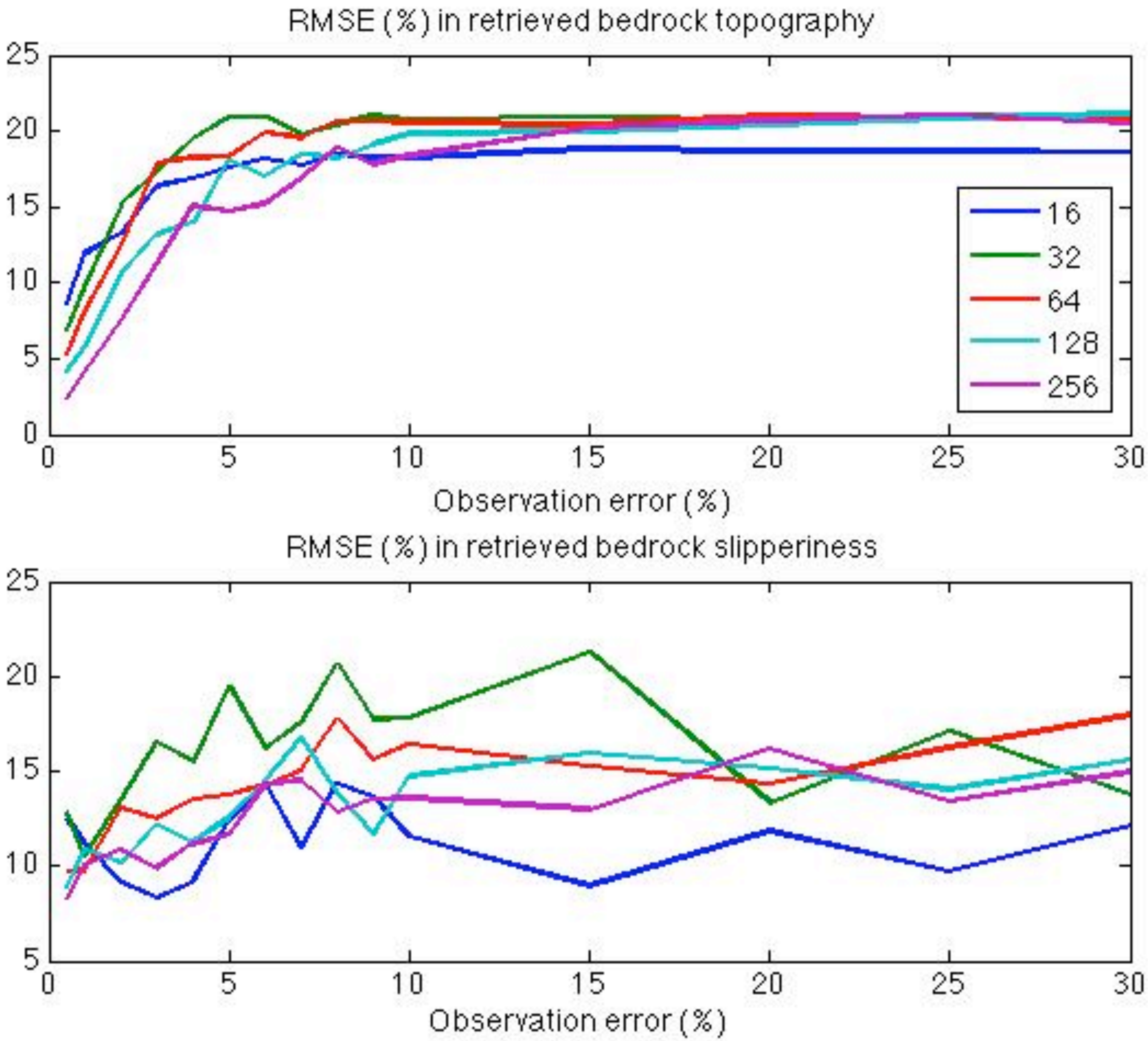


- **bb** : sensitivity of b to actual known bedrock
- **cc** : sensitivity of c to known
- **bc** : sensitivity of bedrock retrieval to known c
- **cb** : sensitivity of slipperiness to known bedrock

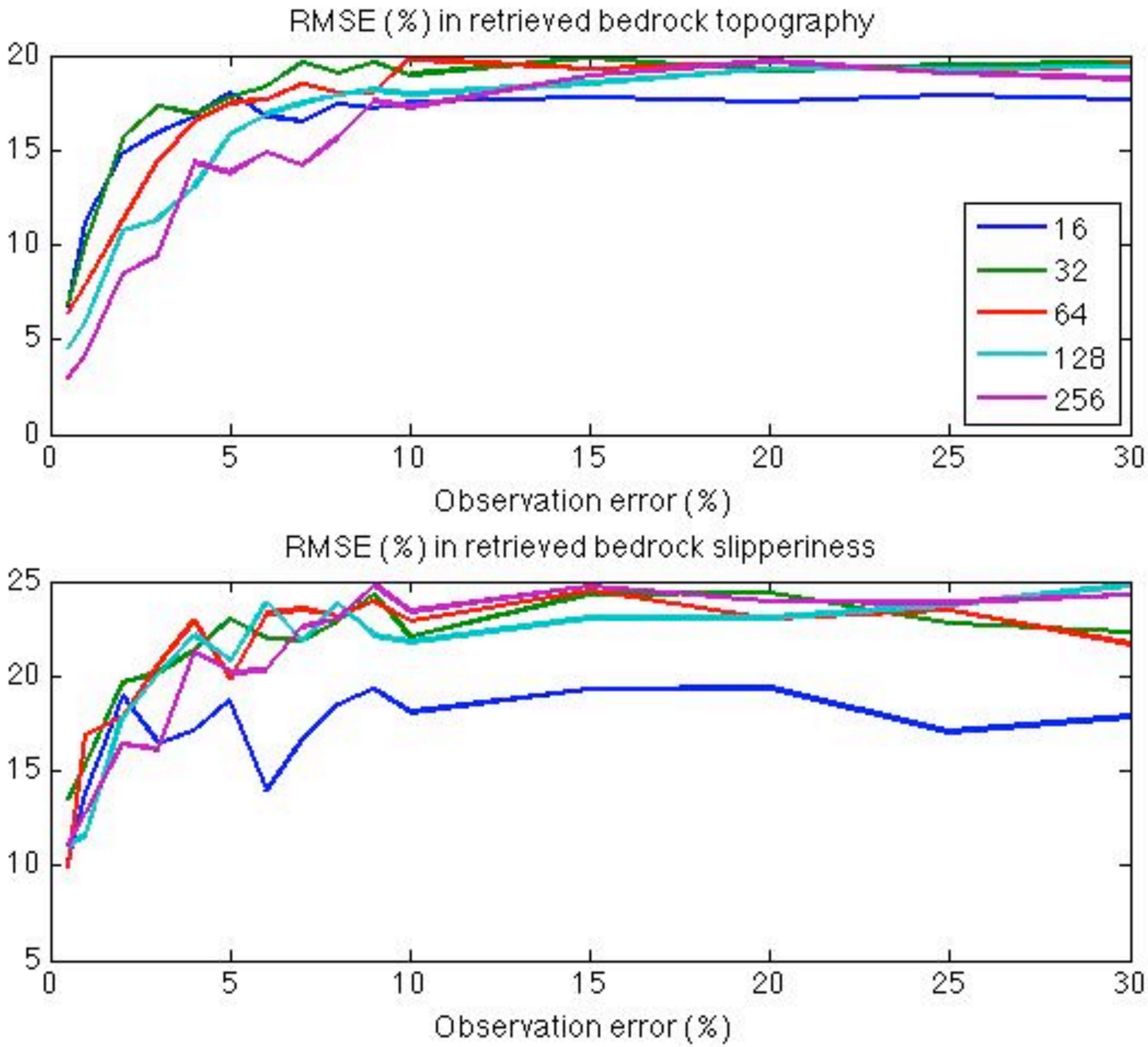
Summary

- Increasing resolution of observations improves estimate of bedrock topography, although is not as helpful with estimate of slipperiness
- Independent of resolution, reducing error in all observations is critical for resolving the bedrock
- Horizontal velocity is useful for resolving the slipperiness of the bed, but less important for resolving the bedrock topography
- Inverse modeling proves to be a useful tool for pre-planning of fieldwork


Thanks!
Karthaus, 2008:
Saving glaciers for the next generation



RMSE (%) in retrieved bedrock topography
Observation error (%)
16
32
64
128
256
RMSE (%) in retrieved bedrock slipperiness
Observation error (%)



* Surface topography error 0.5%; Varying horizontal velocity error