Tracking sediment transport through the Miage Glacier, Italy, combining a Lagrangian approach with luminescence burial dating of englacial clasts

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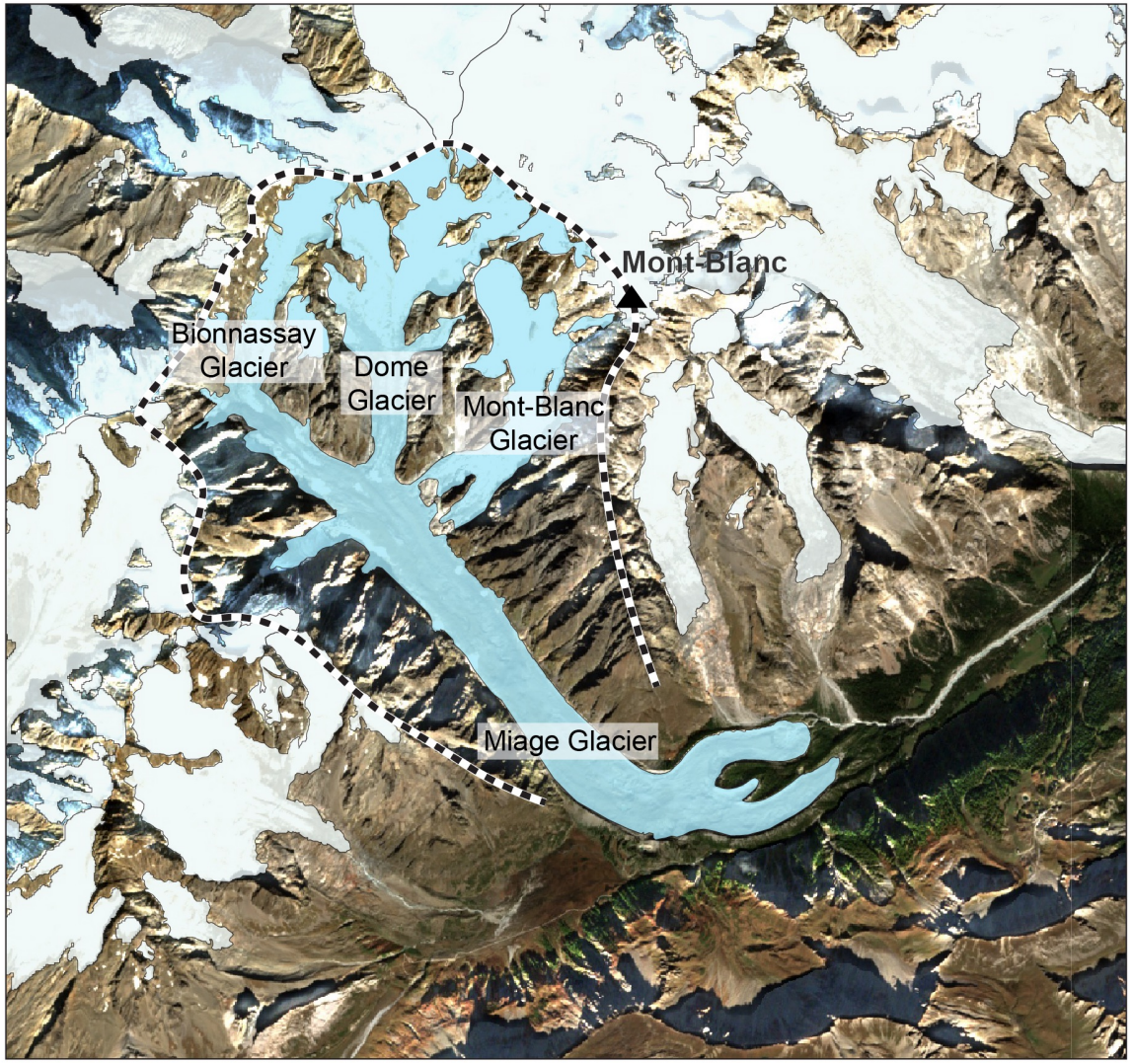
Understanding sediment dynamics in englaciated areas

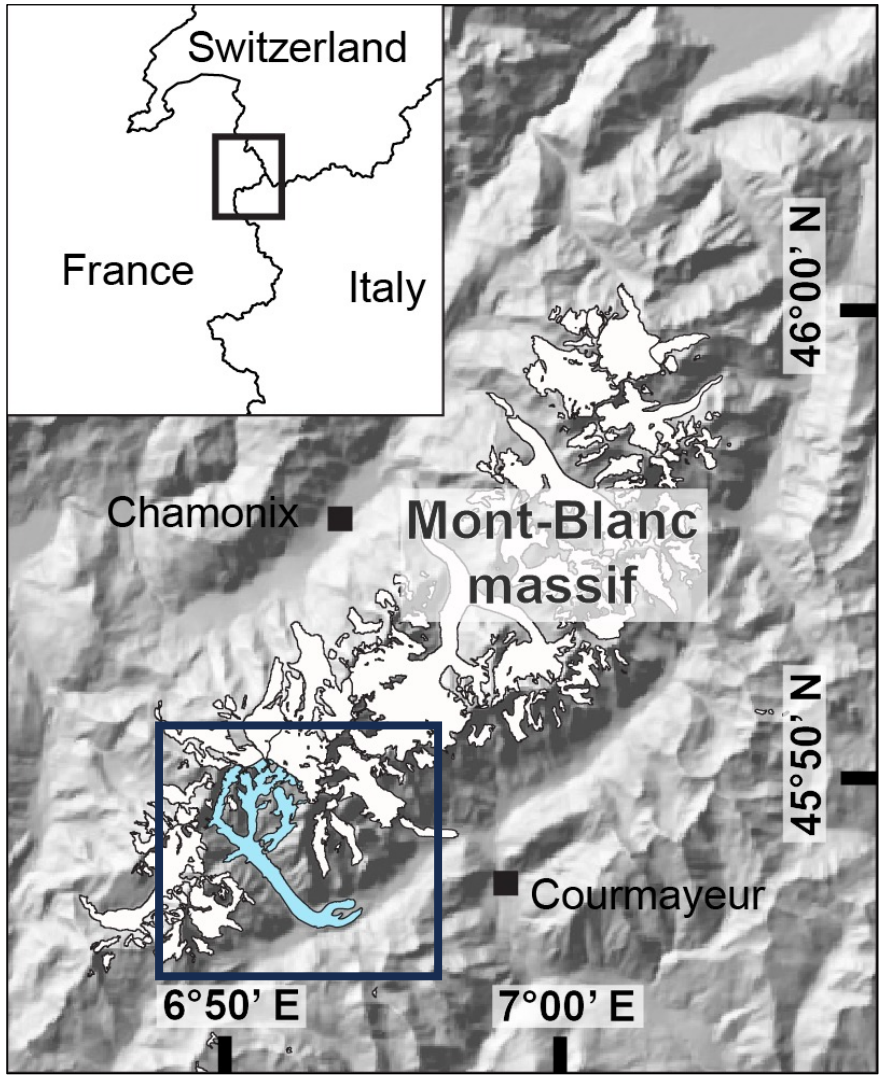

Miage Glacier, Alps, Italy

Current climate change

- Glaciers are retreating
- More debris covered glacier
- No constraints on englacial transport dynamics

Study area: Miage Glacier

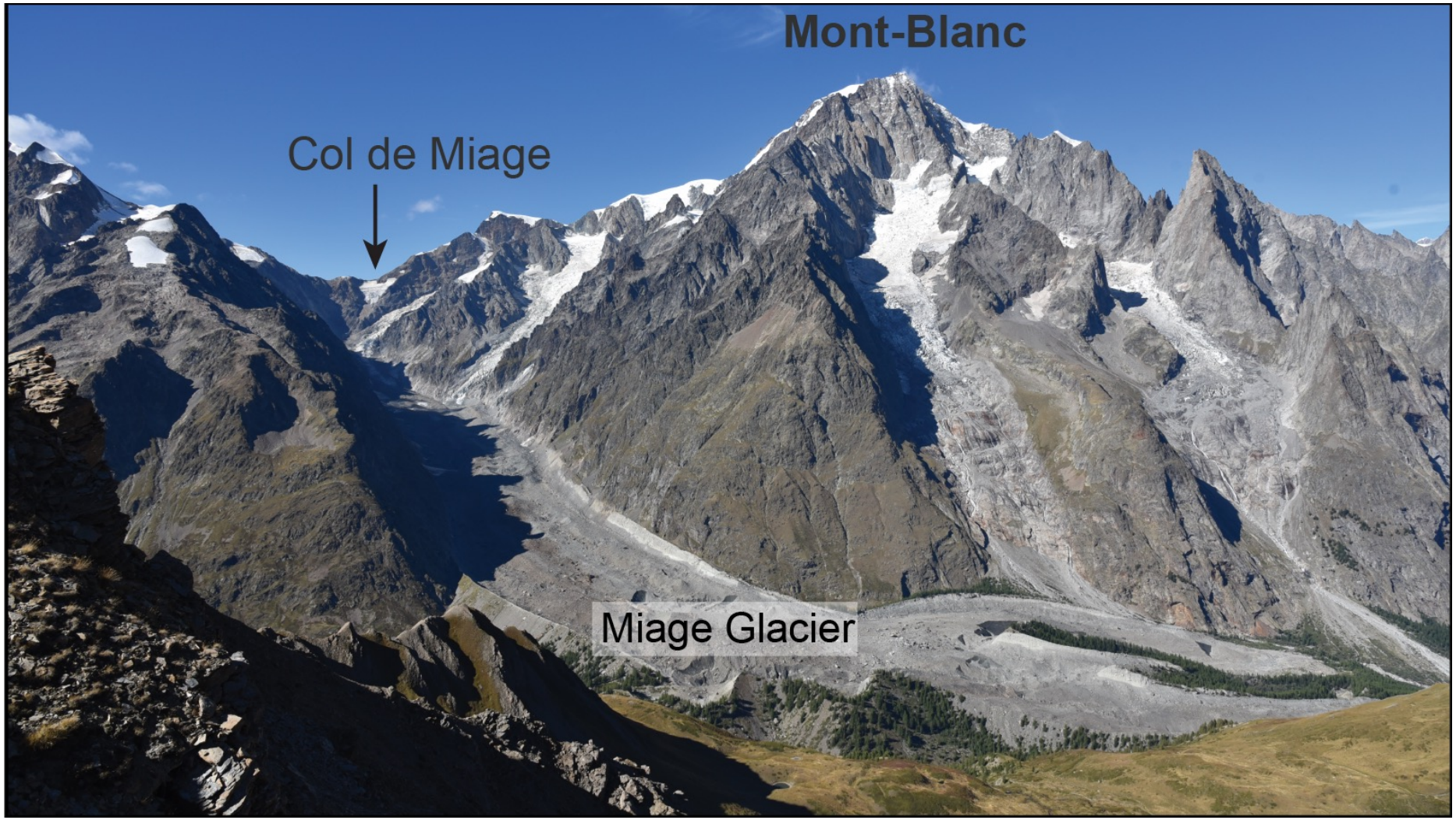




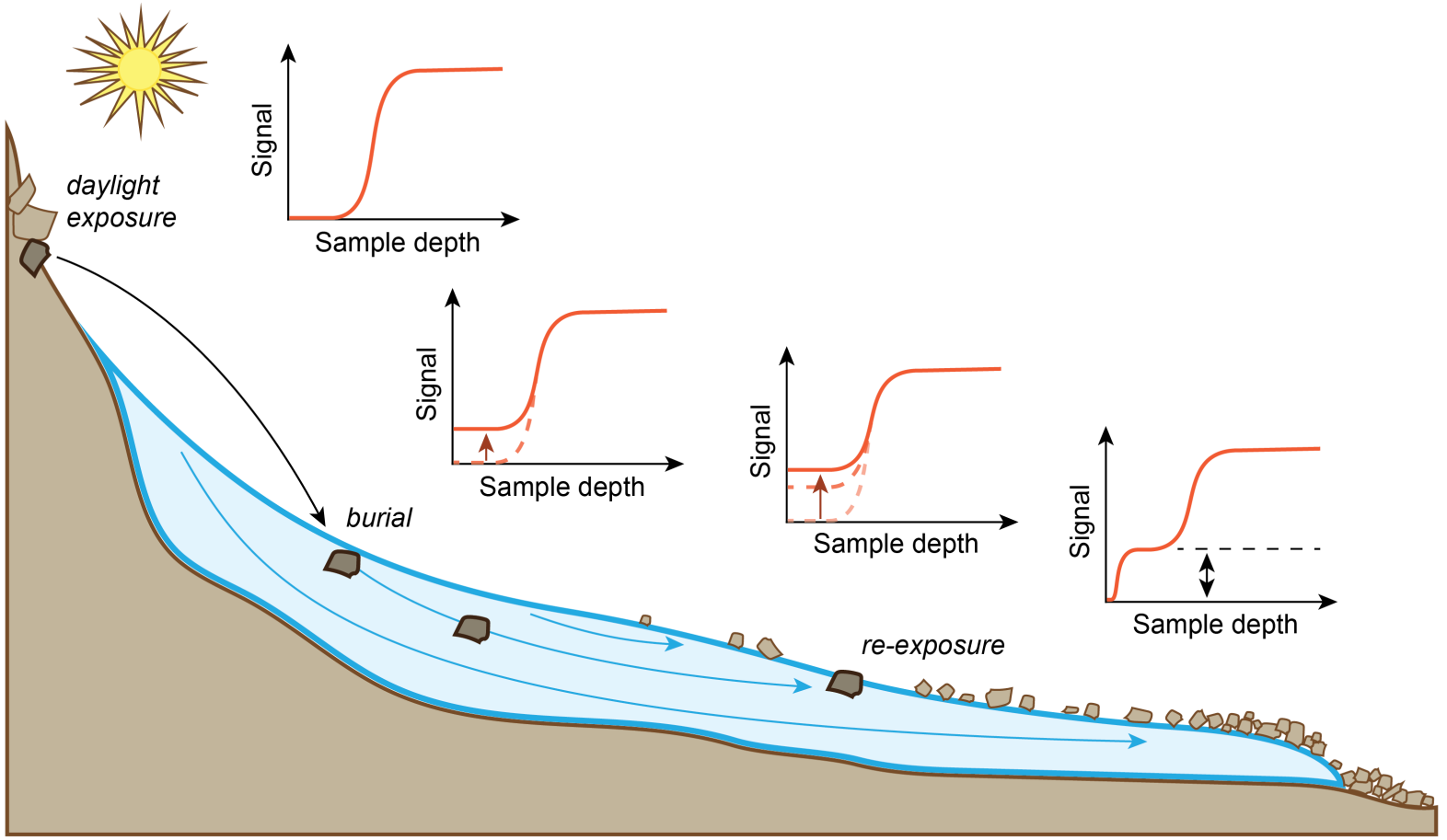
Study area: Miage Glacier

- Debris-covered
- Catchment

= gneiss + schist



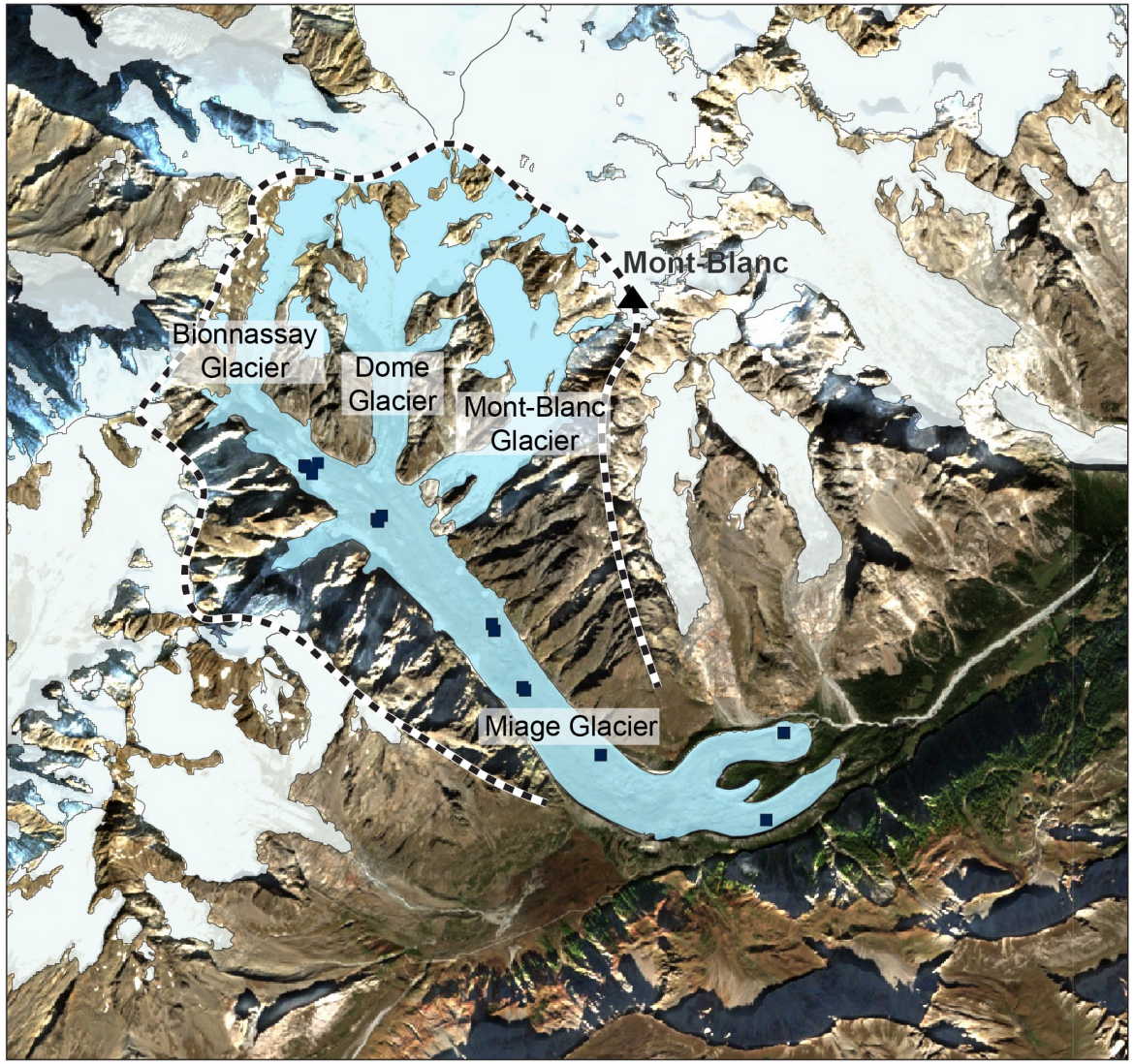
Luminescence dating & Glacier modelling



Luminescence surface burial dating to quantify burial duration of englacial sediments

Samples for luminescence dating

- 18 rock samples embedded in the ice of the Miage Glacier



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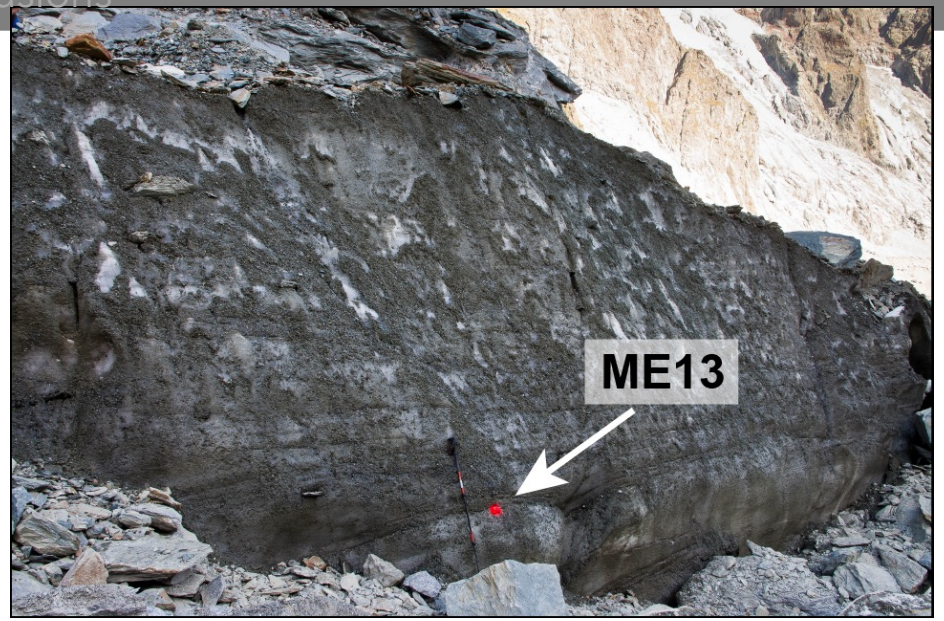
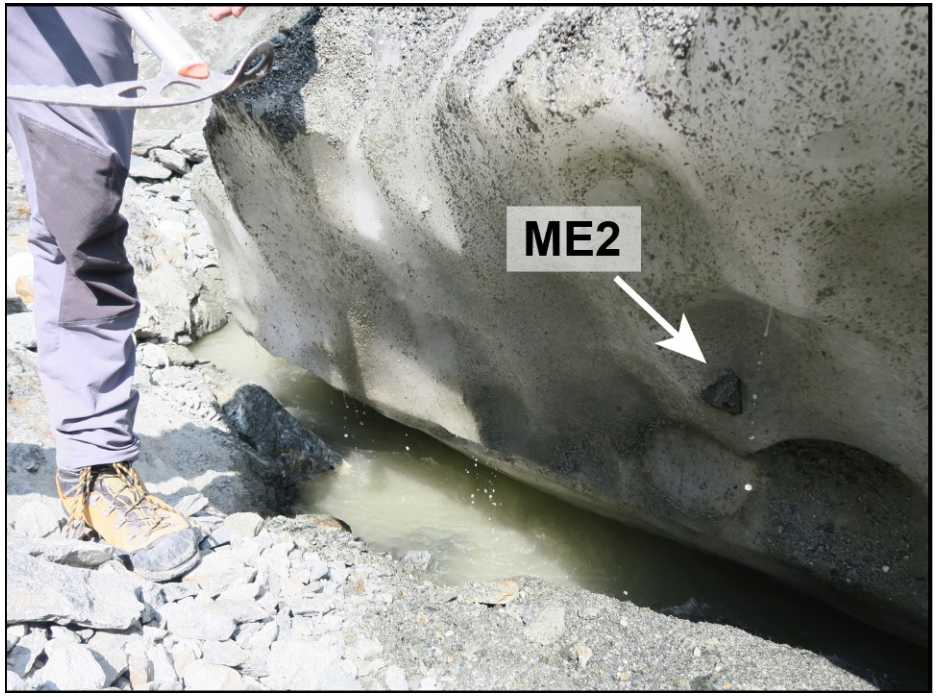
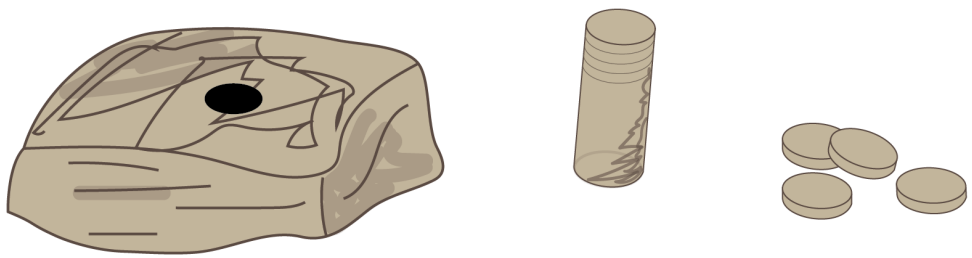




Samples for luminescence dating

- Sample processing
  - Coring
  - Slicing
  - Luminescence measurements

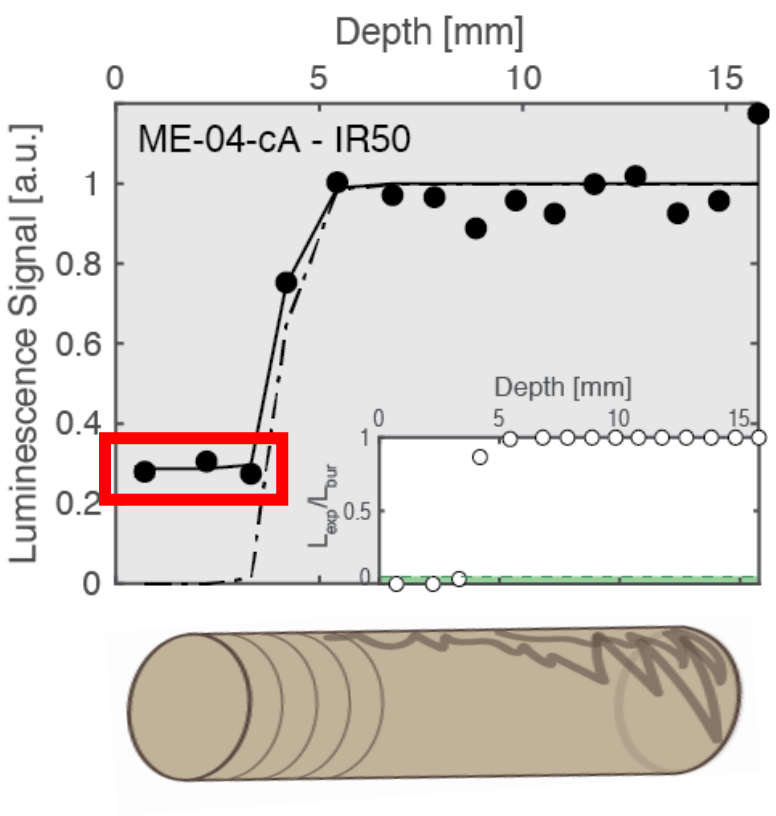


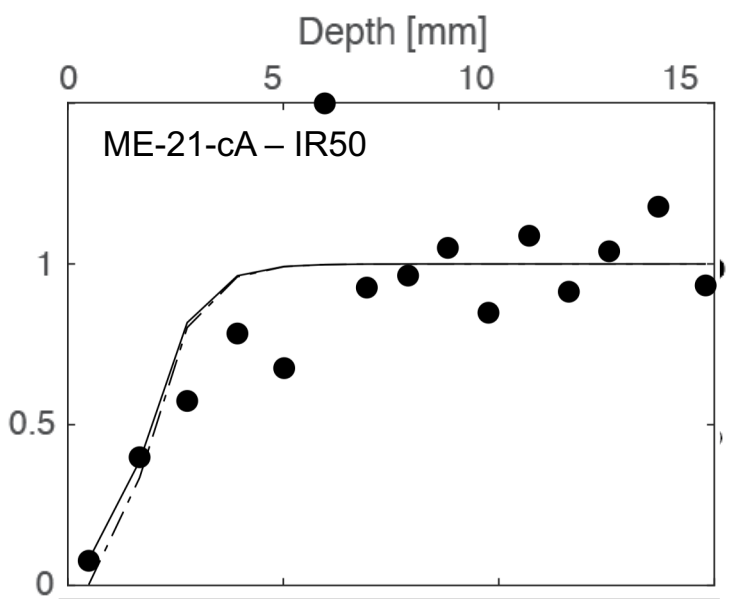
Rock

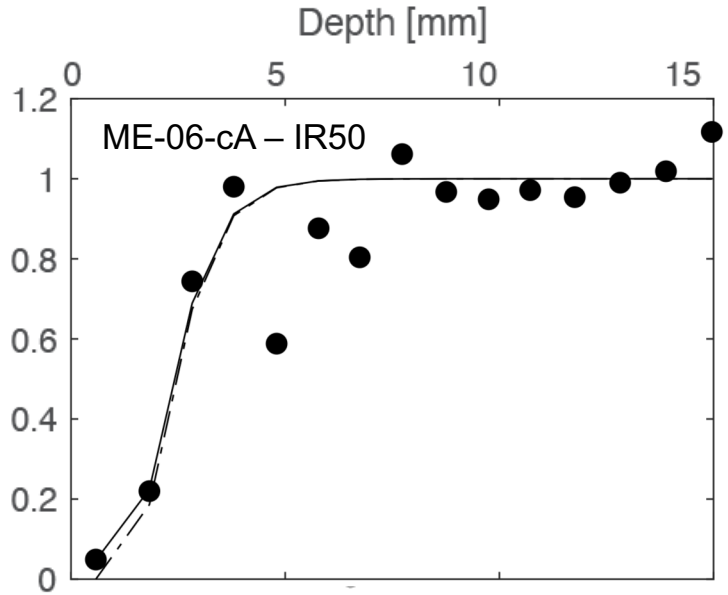
Core

Slices

Luminescence data of different samples





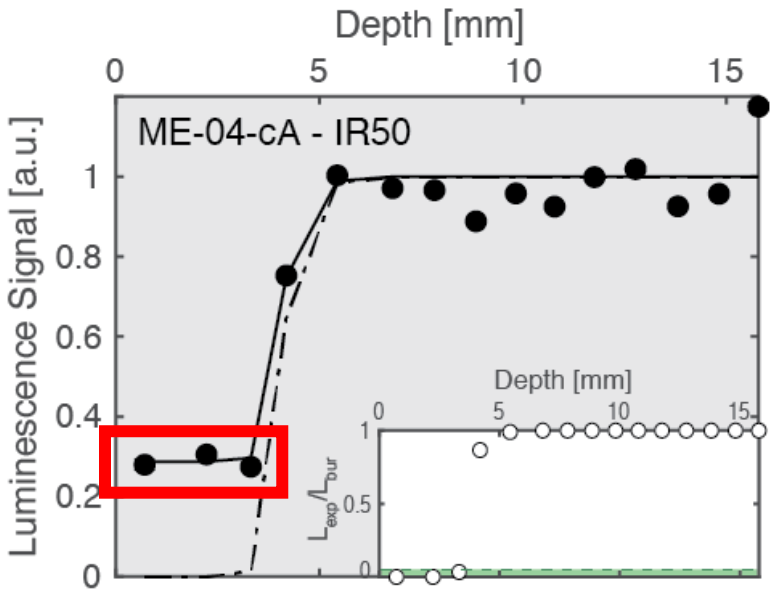


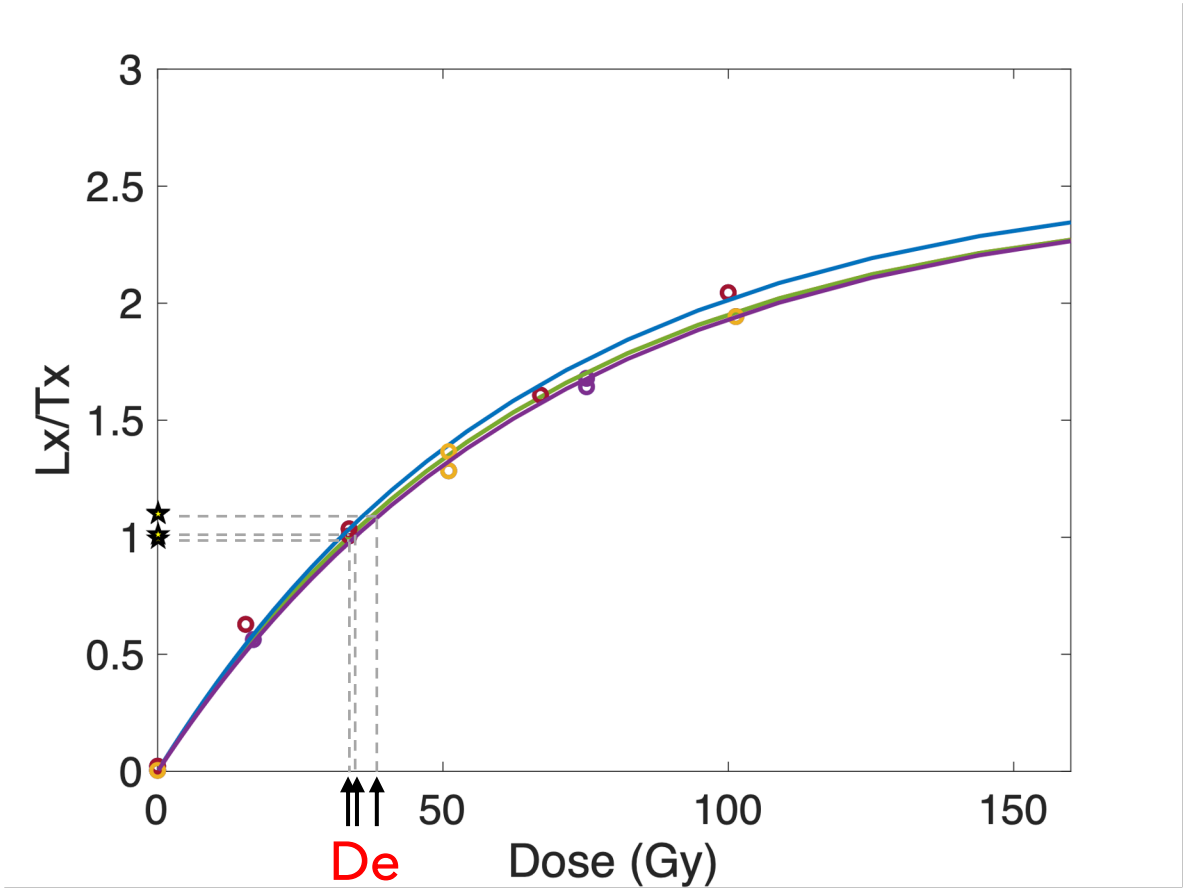
- 18 samples → 9 samples show a plateau (e.g., Rades et al., 2018)

Luminescence data

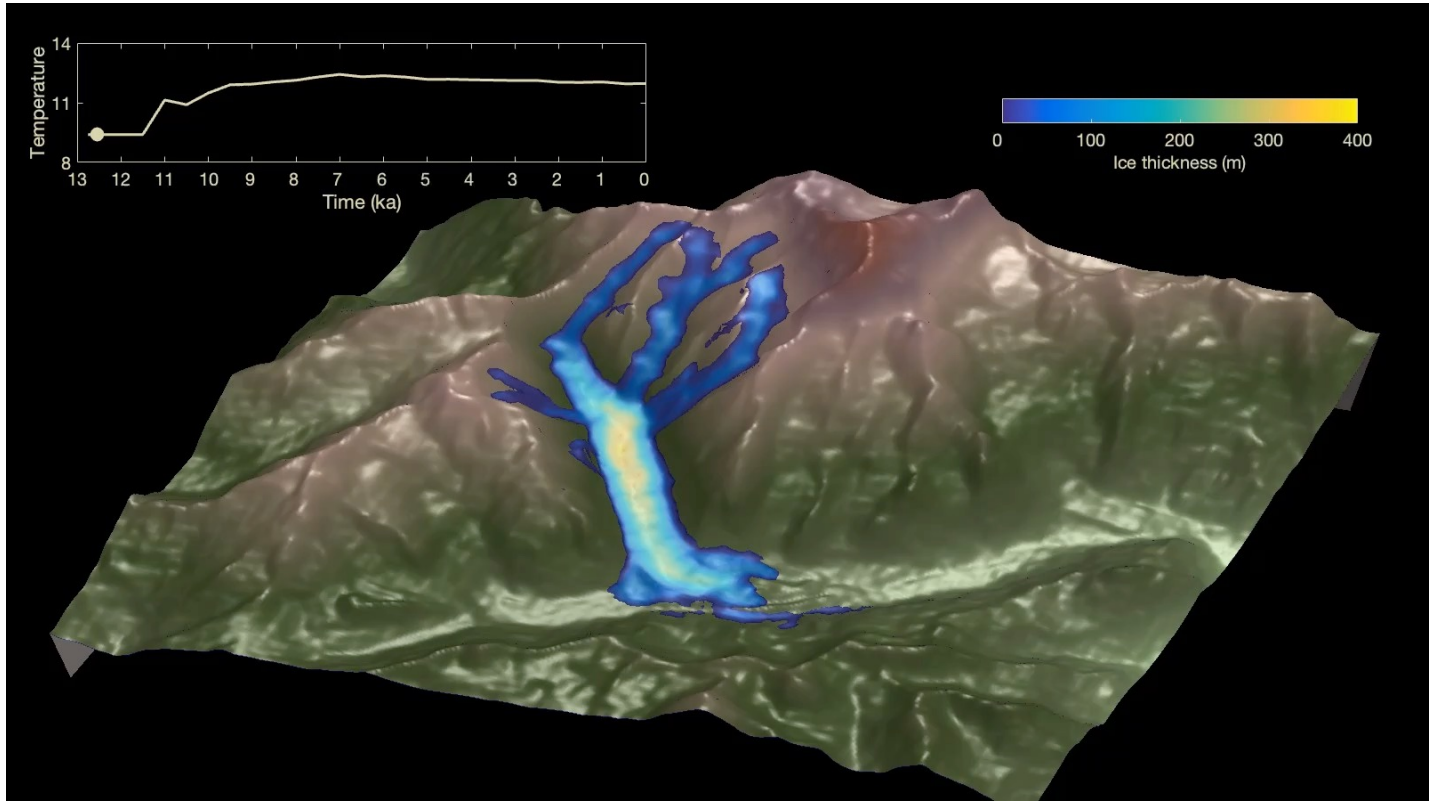
Age = De / Env. dose rate

Dose Response Curve *U, Th, K concentrations*





Luminescence dating & **Glacier modelling**

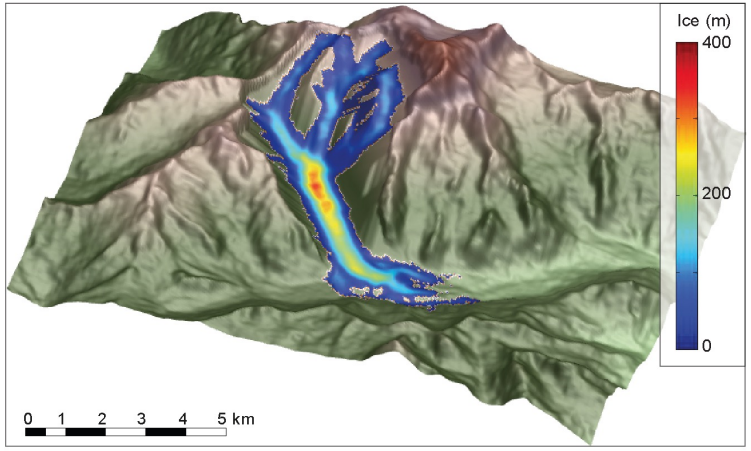


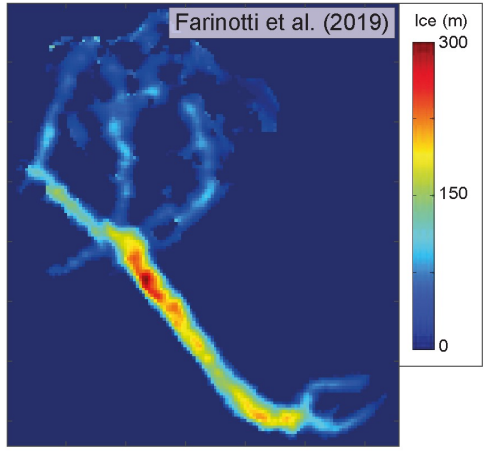
- Simulation of ice-flow and glacier evolution (iSOSIA; Egholm et al., 2011; Scherler and Egholm, 2020)
- Lagrangian particle-tracking scheme to simulate erosion, transport, and deposition of sediments (10^9 particles)
- Simulation runs through the Holocene (12 ka)
- Forced to present day observations (Deline, 2005; Stefaniak et al., 2021) using Temp12k paleotemperatures (Kaufman et al., 2020)

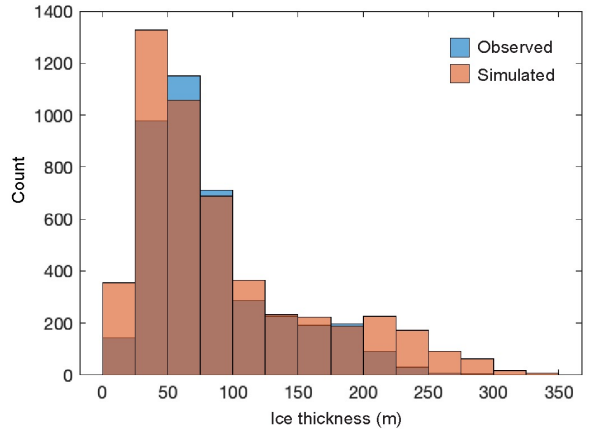
Model of the Miage Glacier

Simulated | Observed | Comparison

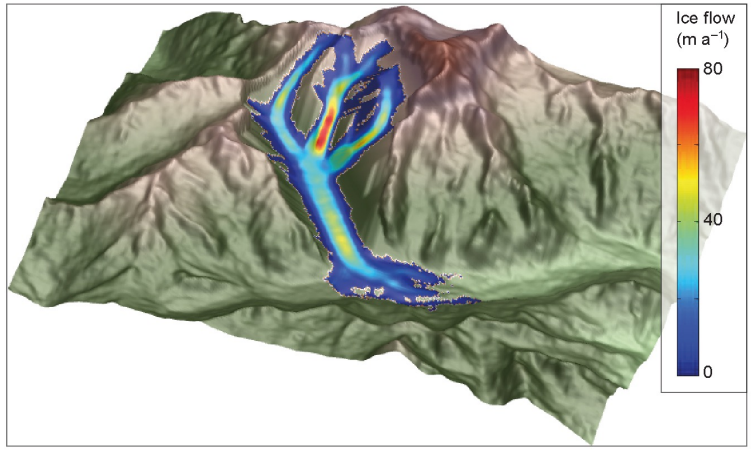
Ice thickness

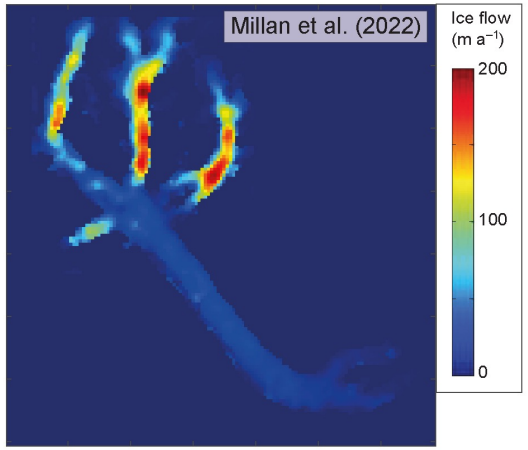


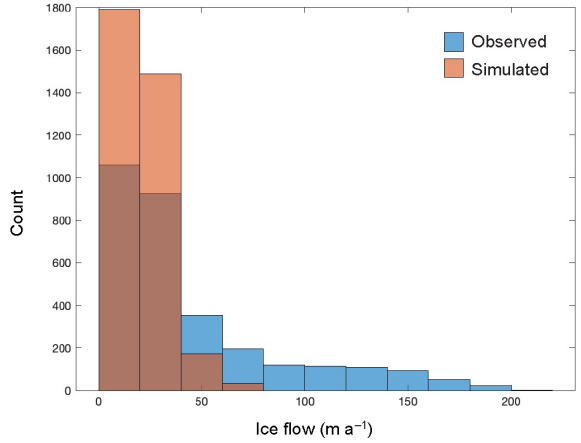




Surface velocity

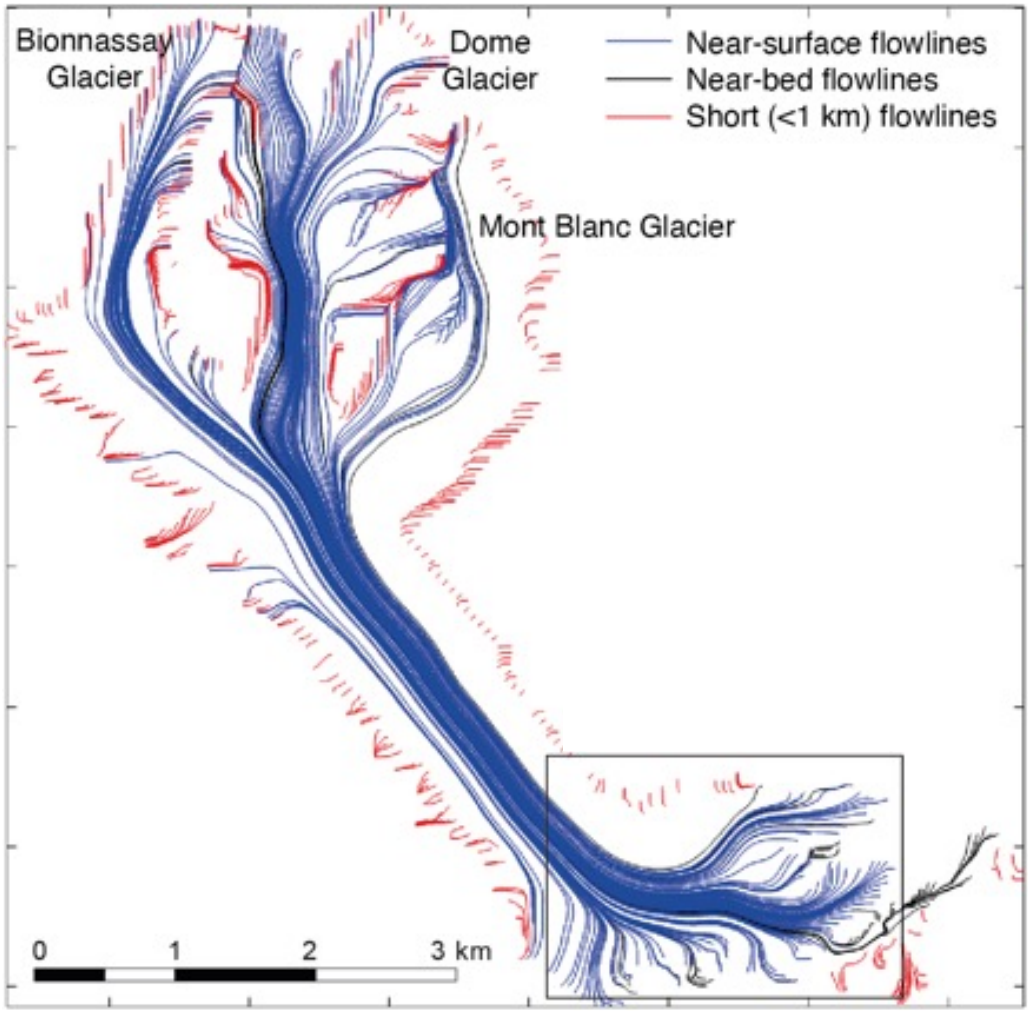


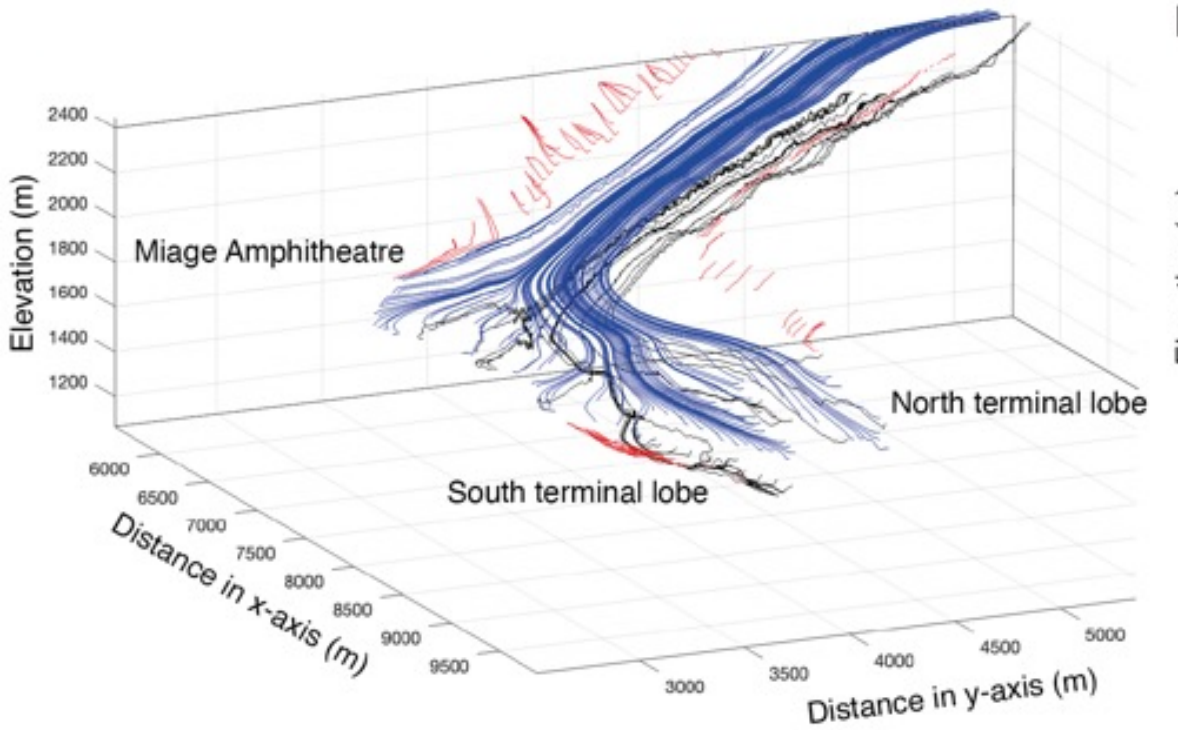




✓ The model fits the present-day observations

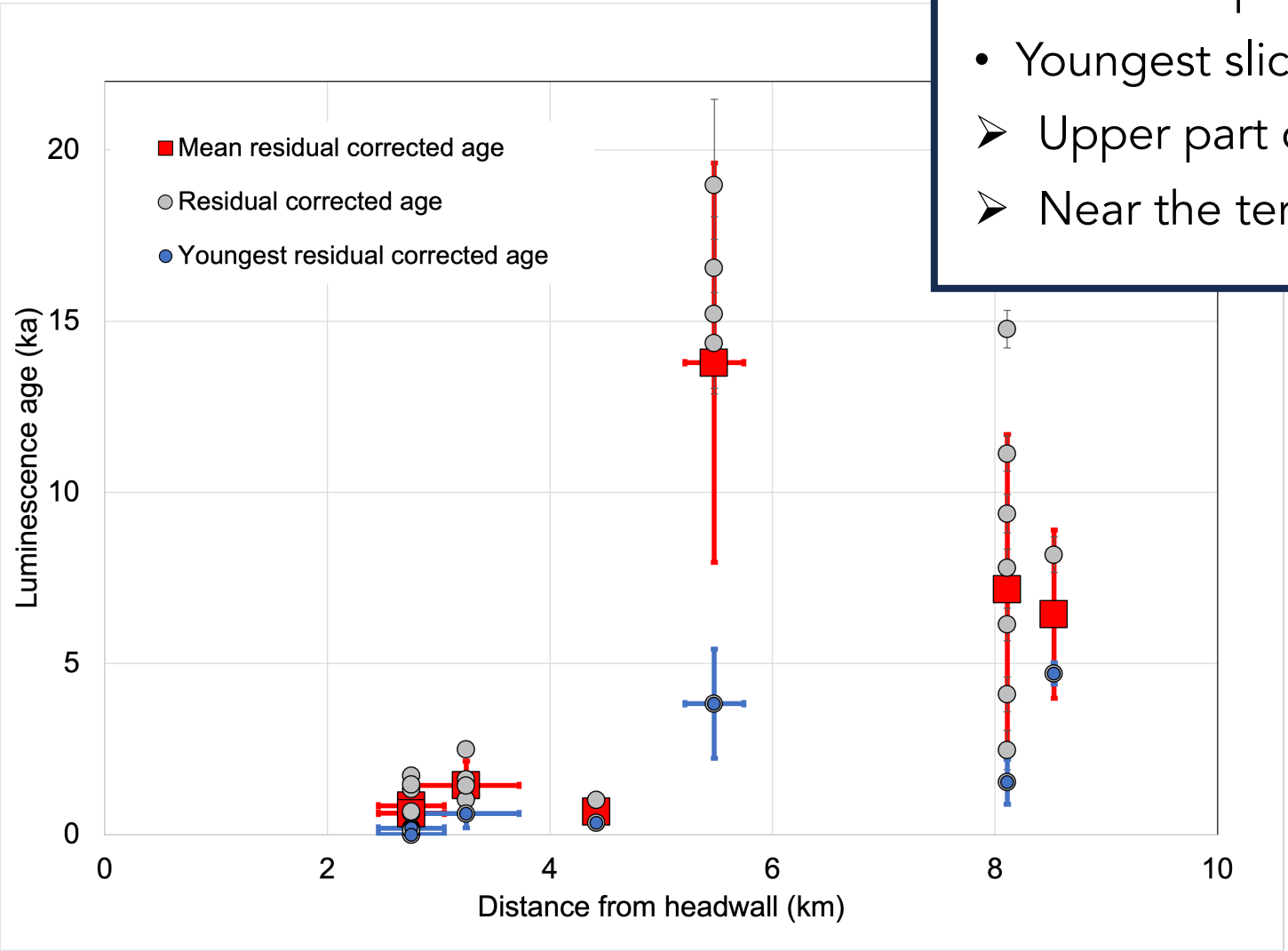
Model of the Miage Glacier





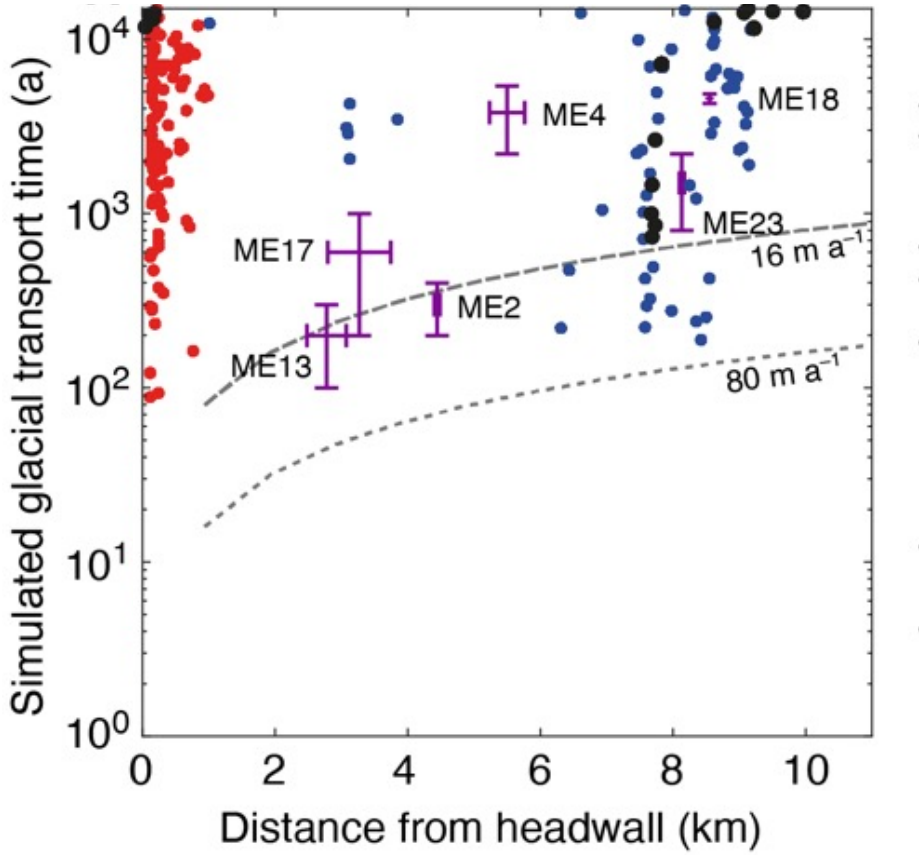
✓Predicted particle flowlines + transport duration

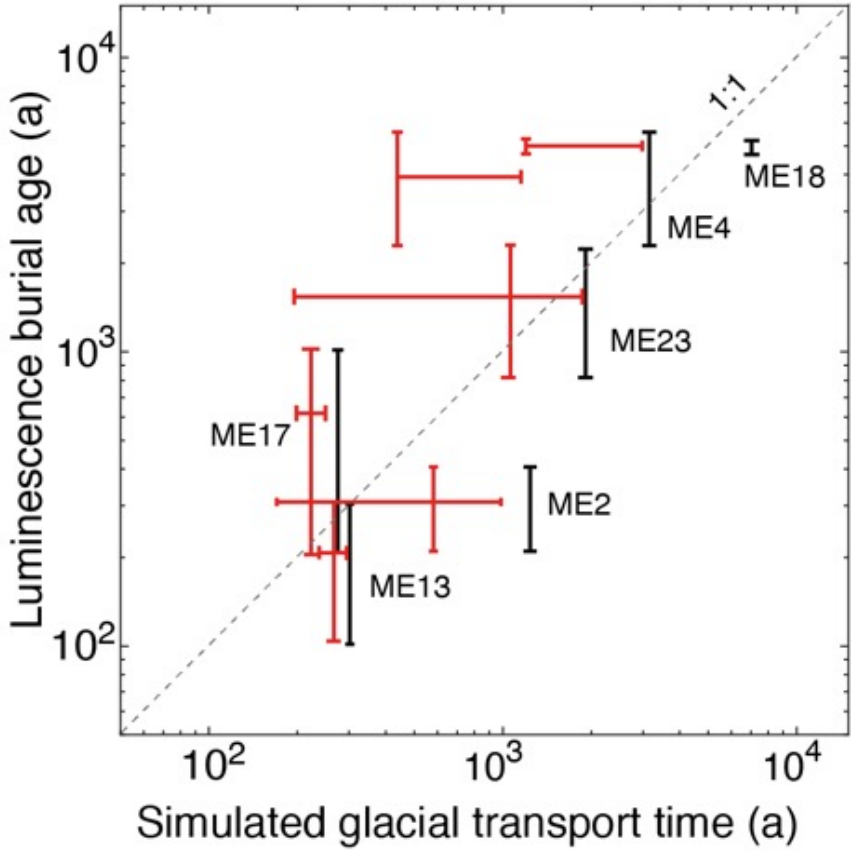
Luminescence ages



- Mean sample ages: 0.6 ± 0.6 to 13.8 ± 5.8 ka
- Youngest slice fragment ages: 0.0 ± 1.0 to 4.7 ± 0.3 ka
  - ➢ Upper part of the ablation zone = younger ages
  - ➢ Near the terminus = older ages

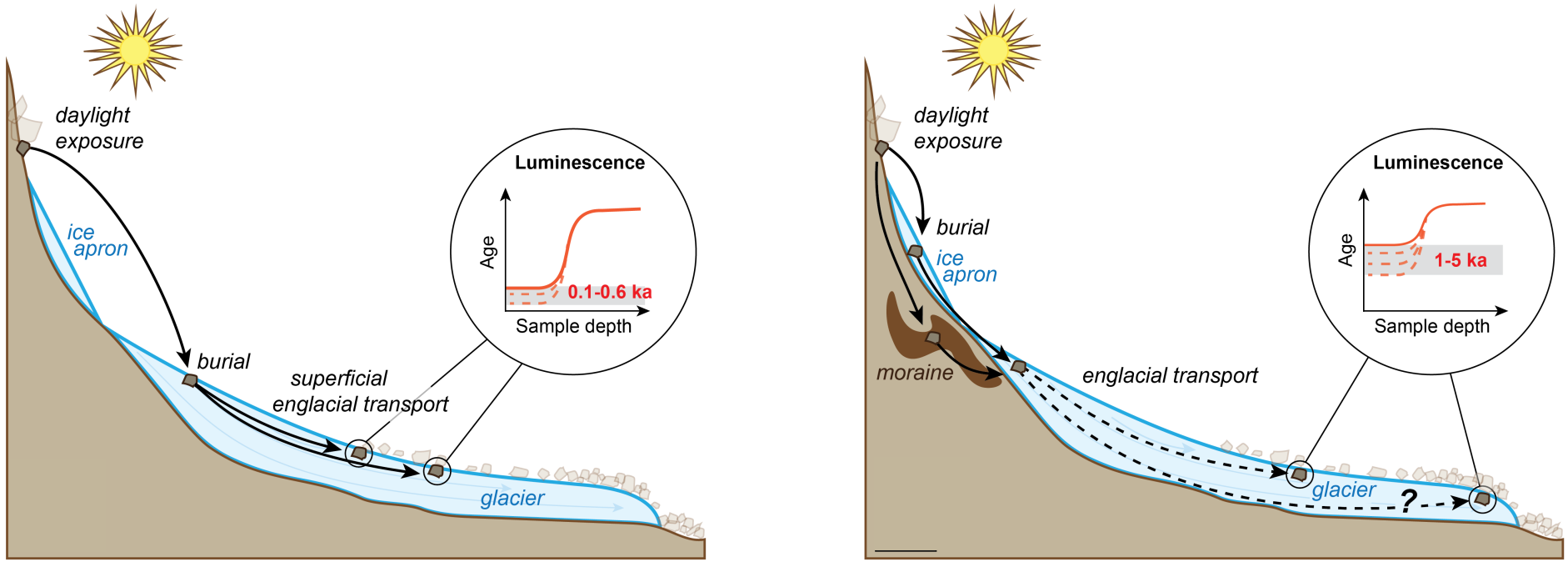
Comparison with glacial model particles





- Luminescence ages // ages predicted by iSOSIA

Conclusions



- **Luminescence rock surface burial dating** constrains duration of **englacial transport** of clasts

- **Duration of rock clasts transport varies** from ~200 years (near-surface ice transport), to ~2,000 years (close to glacier bed transport)
- Total duration of rock clasts transport may encompass **storage phases** within ice aprons or ice-marginal moraines


Thank you!
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