

Recent melt histories of Crosson and Dotson Ice Shelves

David Lilien, Ian Joughin, Ben Smith, and David Shean

Applied Physics Lab, University of Washington

WAIS Workshop

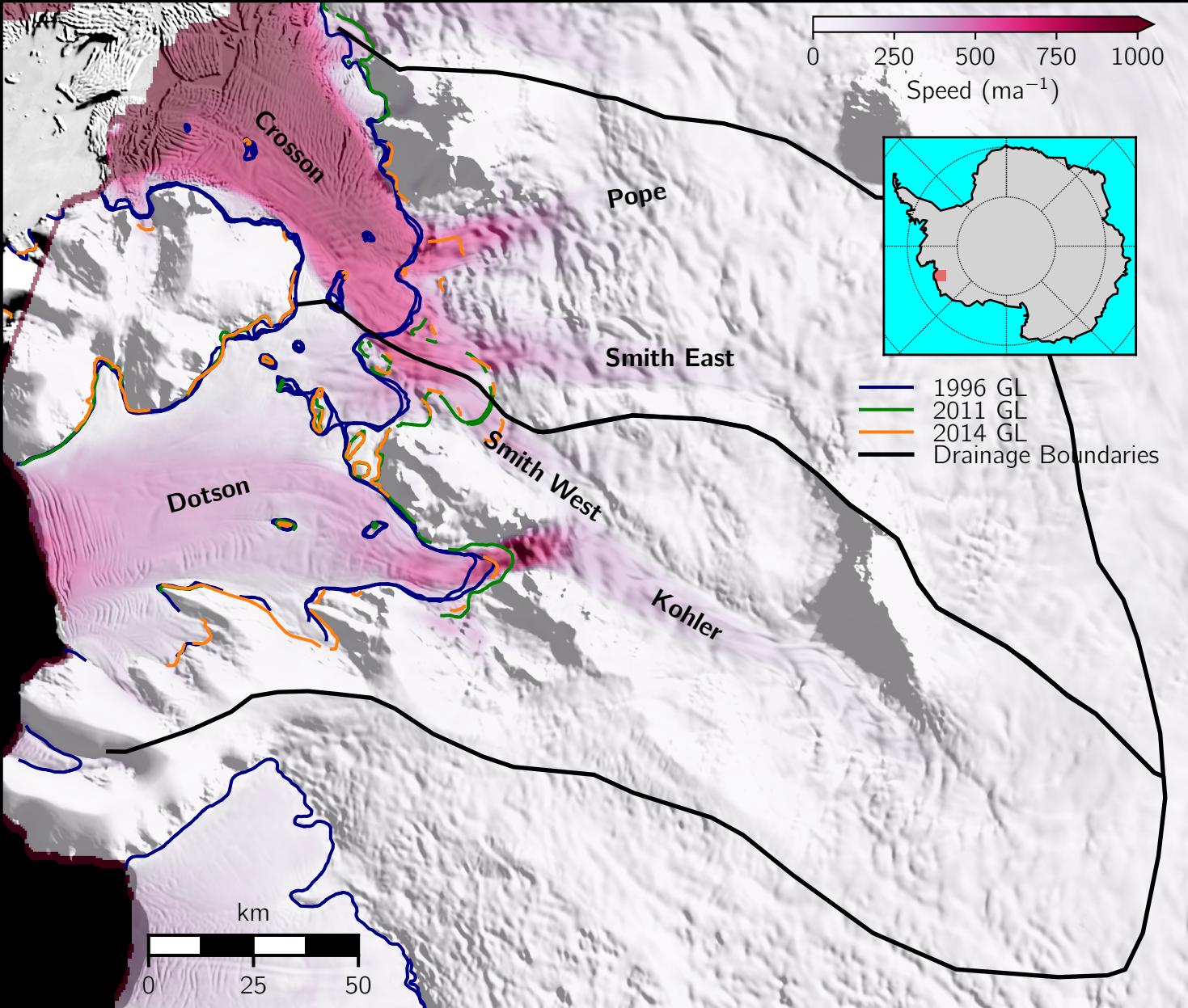
October 10th, 2017



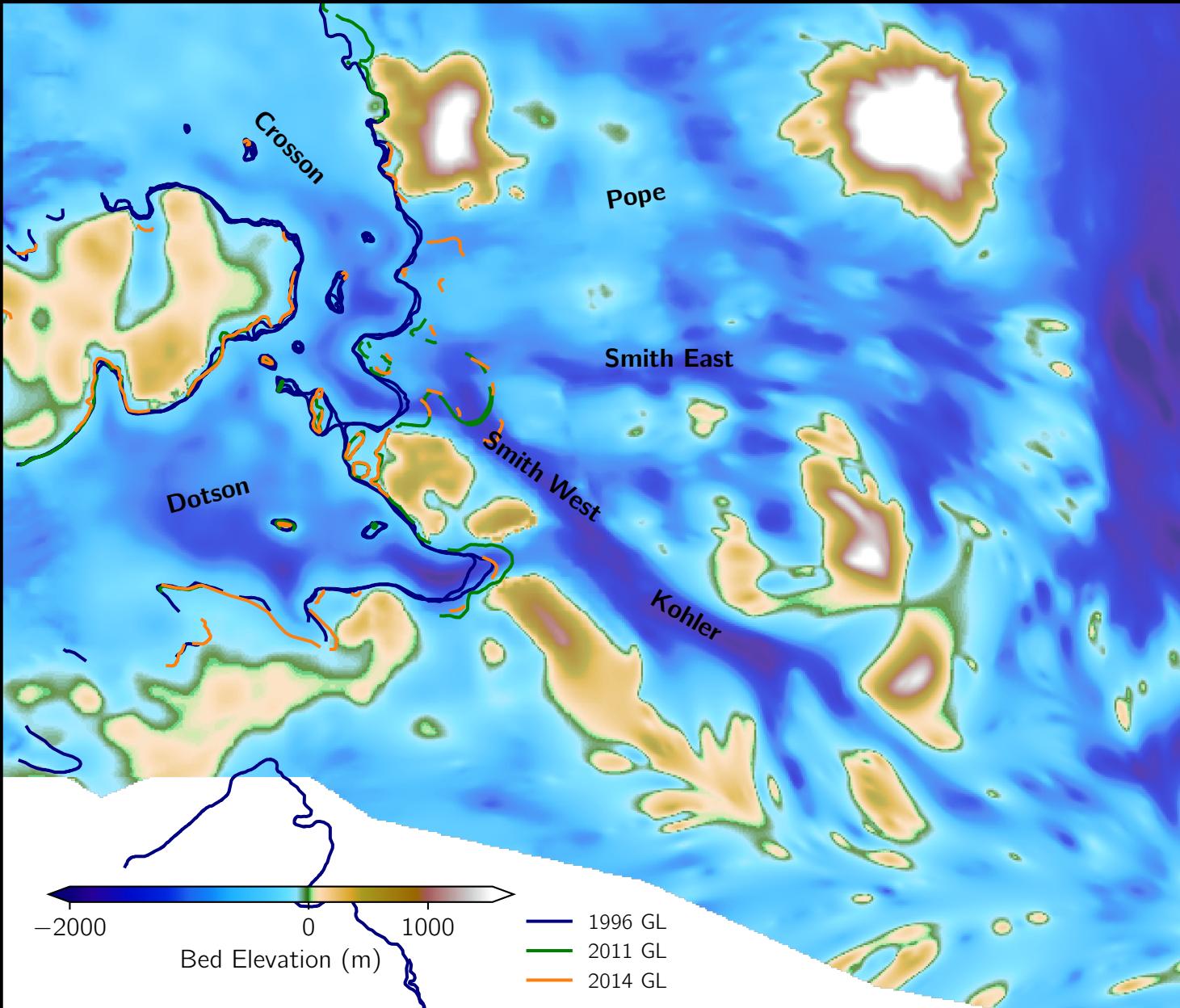
EARTH & SPACE SCIENCES
UNIVERSITY of WASHINGTON
College of the Environment



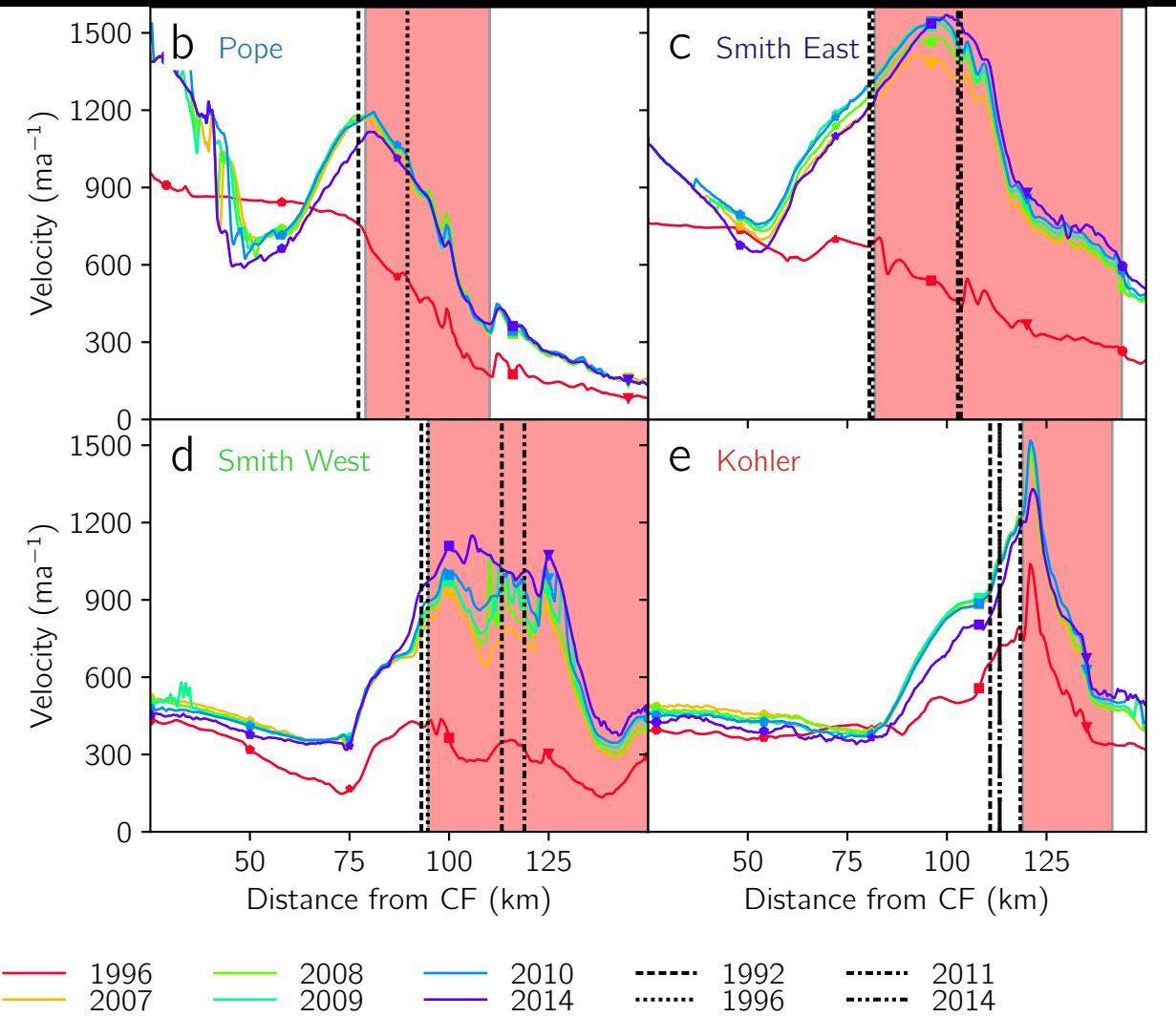
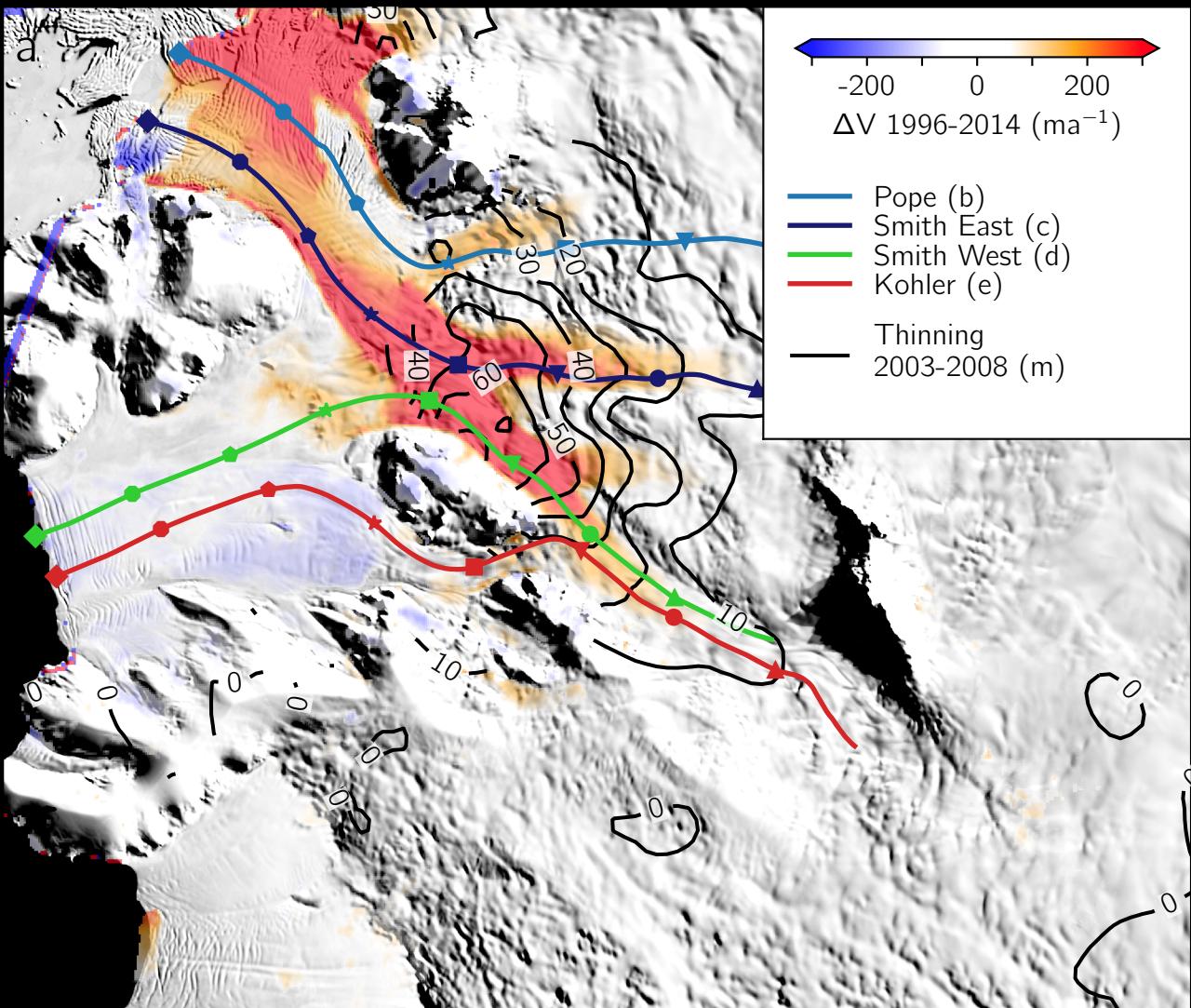
Speed in 1996



Bed elevation

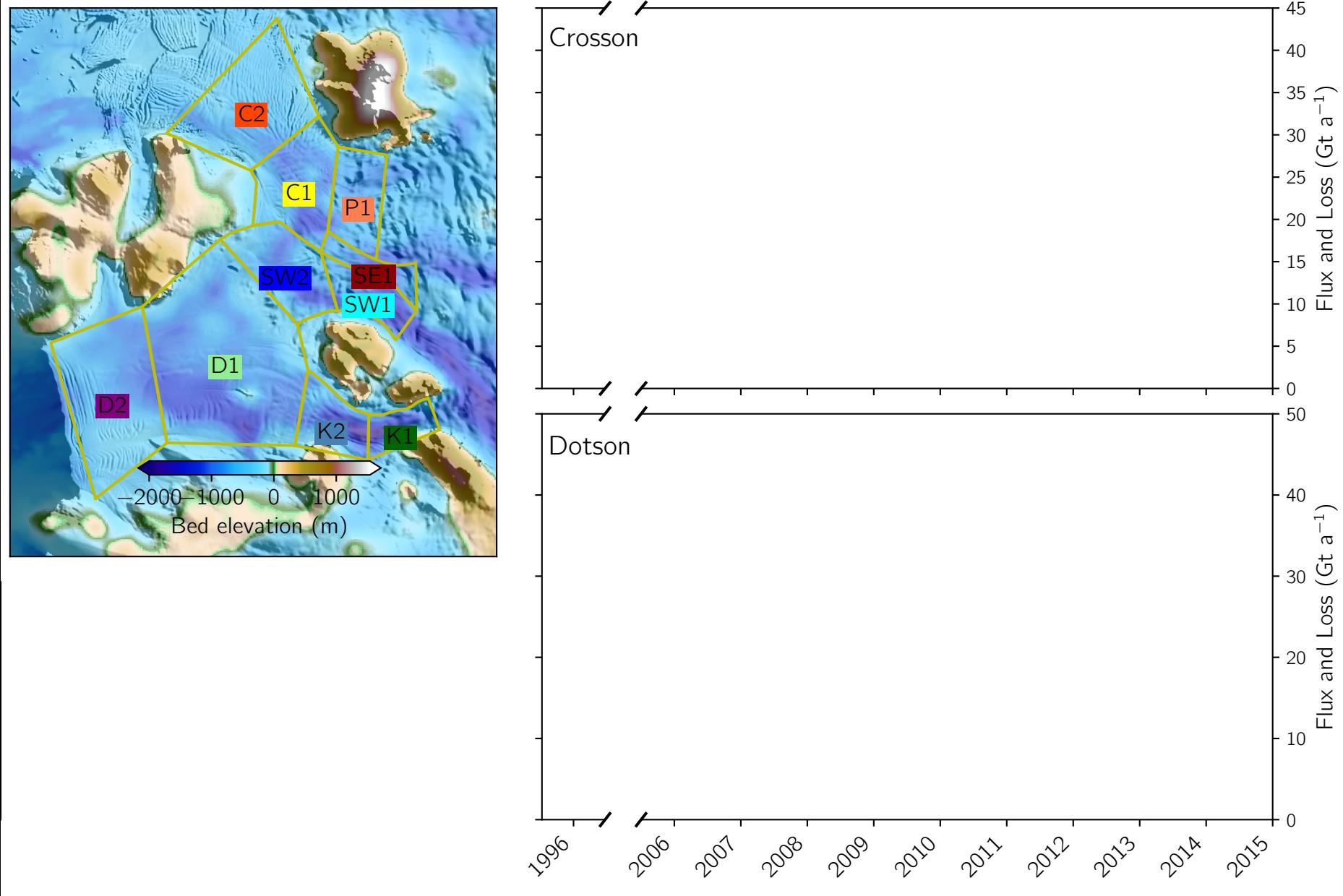


Speedup and thinning

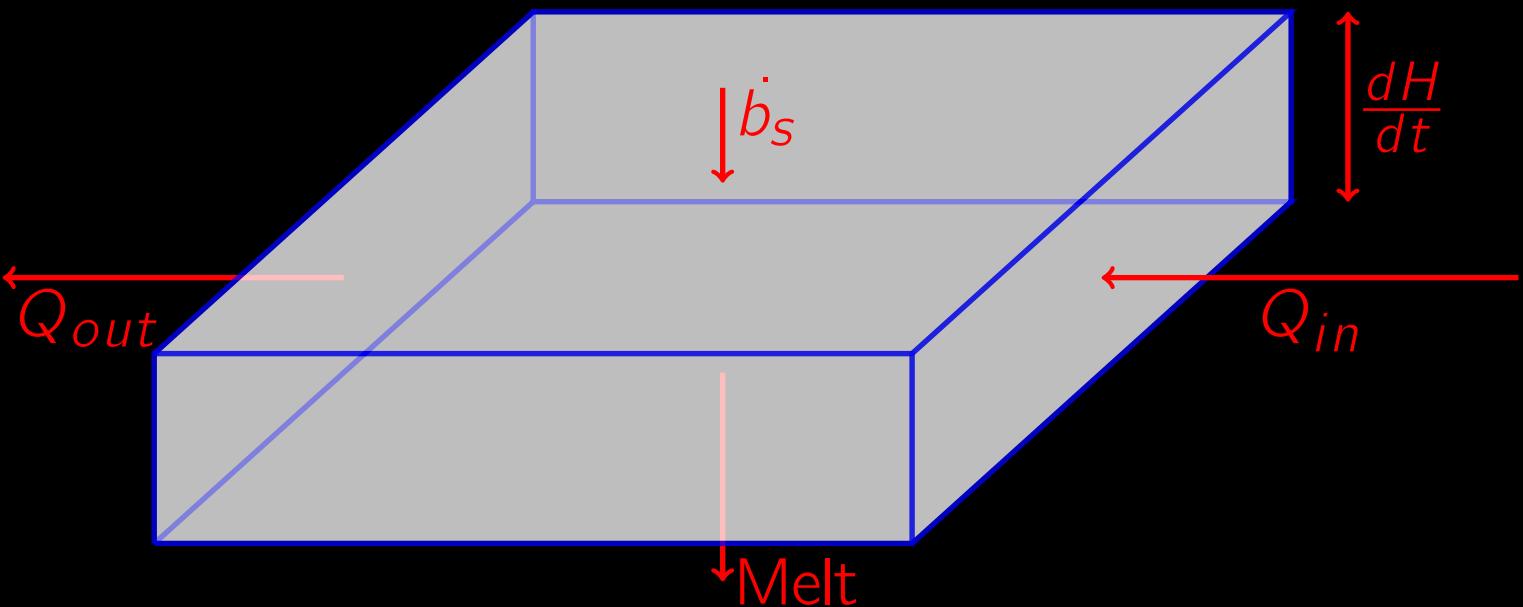


Are the observed speedup and
grounding line retreat the result of
melt variability in the 1990s and
2000s?

Flux balance—Shelf areas for melt calculation

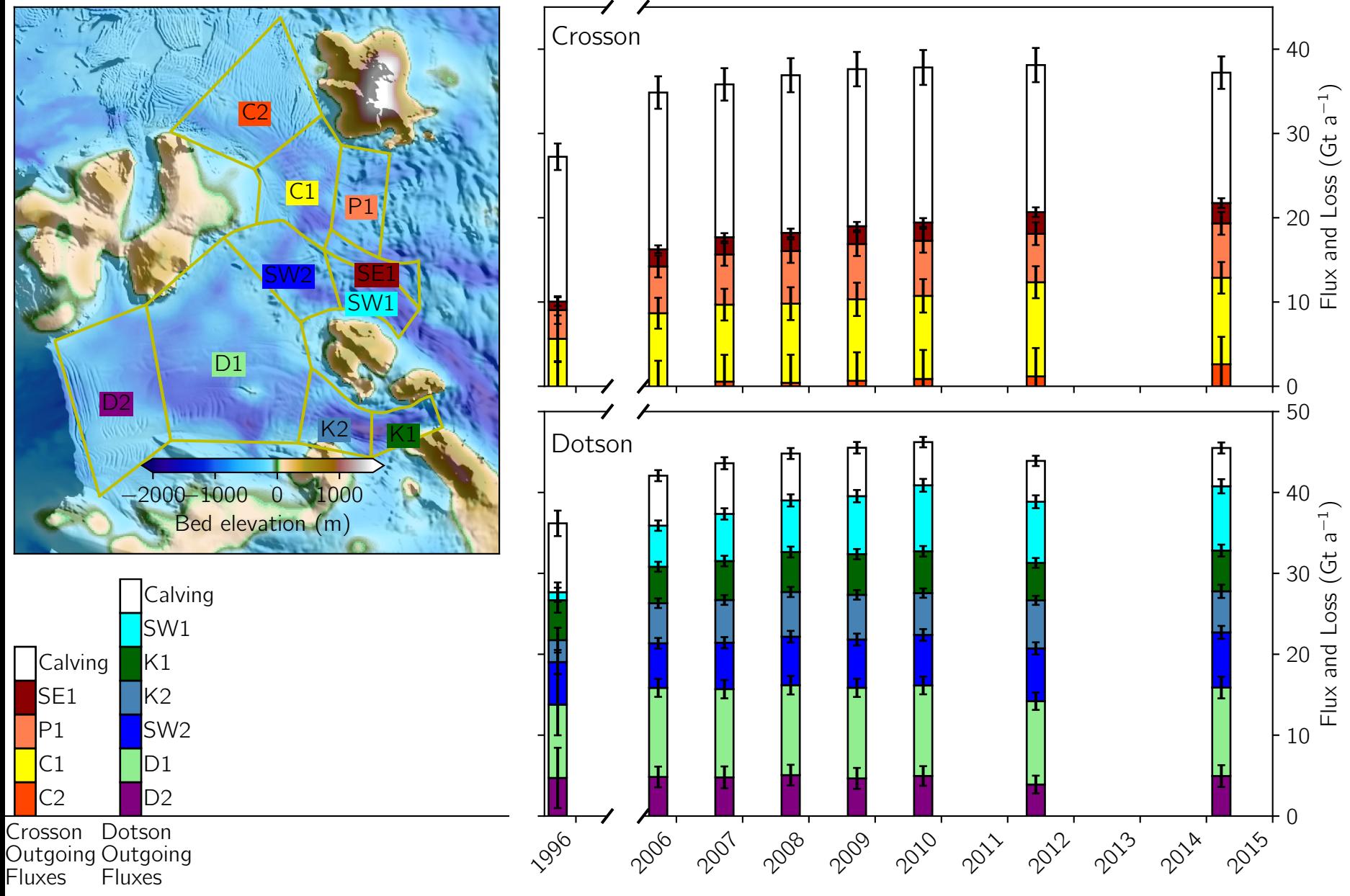


Flux/melt calculation



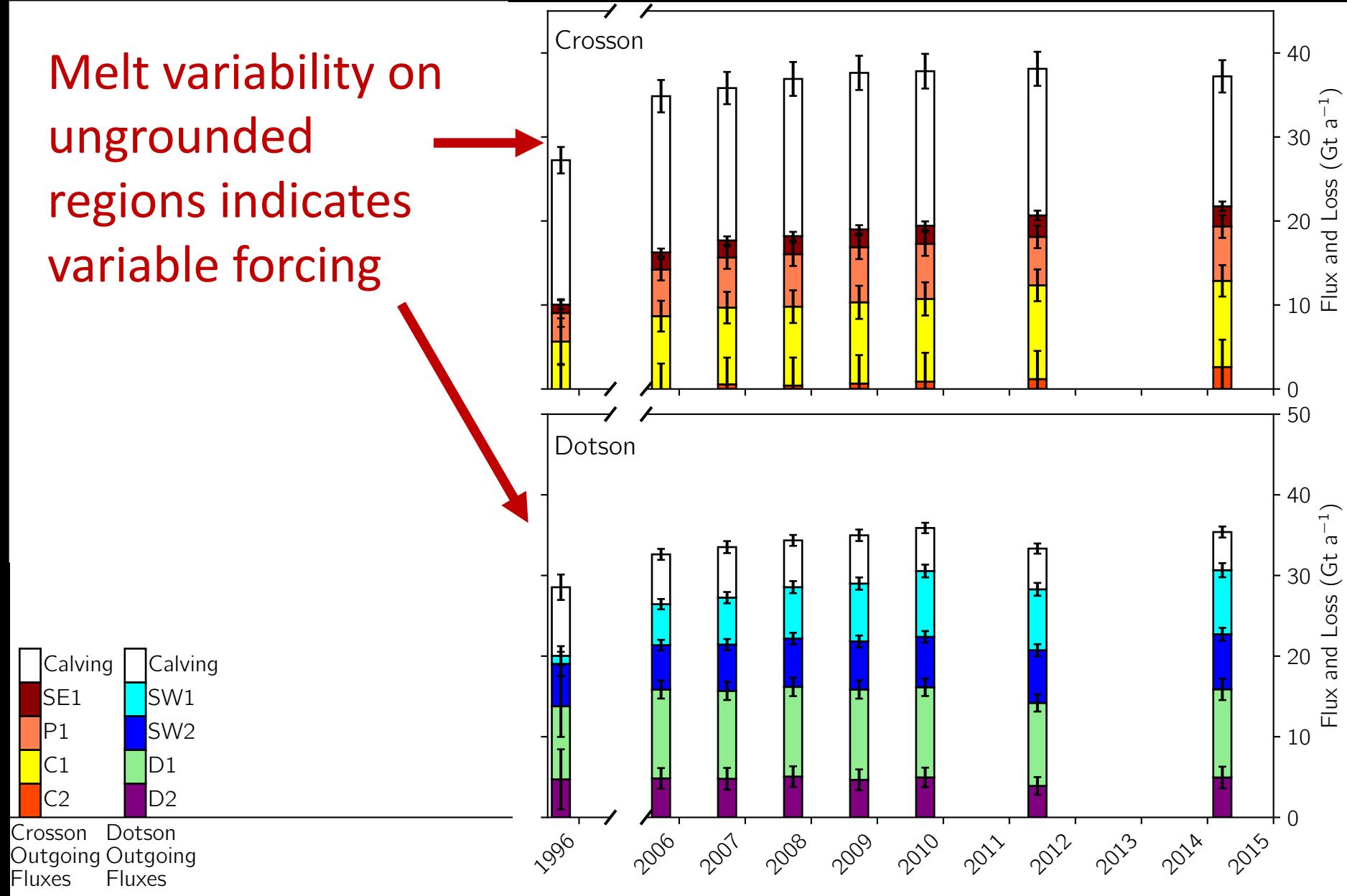
$$\int \text{Melt} = \int \left(-\nabla \cdot \mathbf{Q} + \dot{b}_s - \frac{dH}{dt} \right) \\ = Q_{in} - Q_{out} + \dot{b}_s - \frac{dH}{dt}$$

Flux balance—Outgoing flux



Flux balance – Outgoing flux

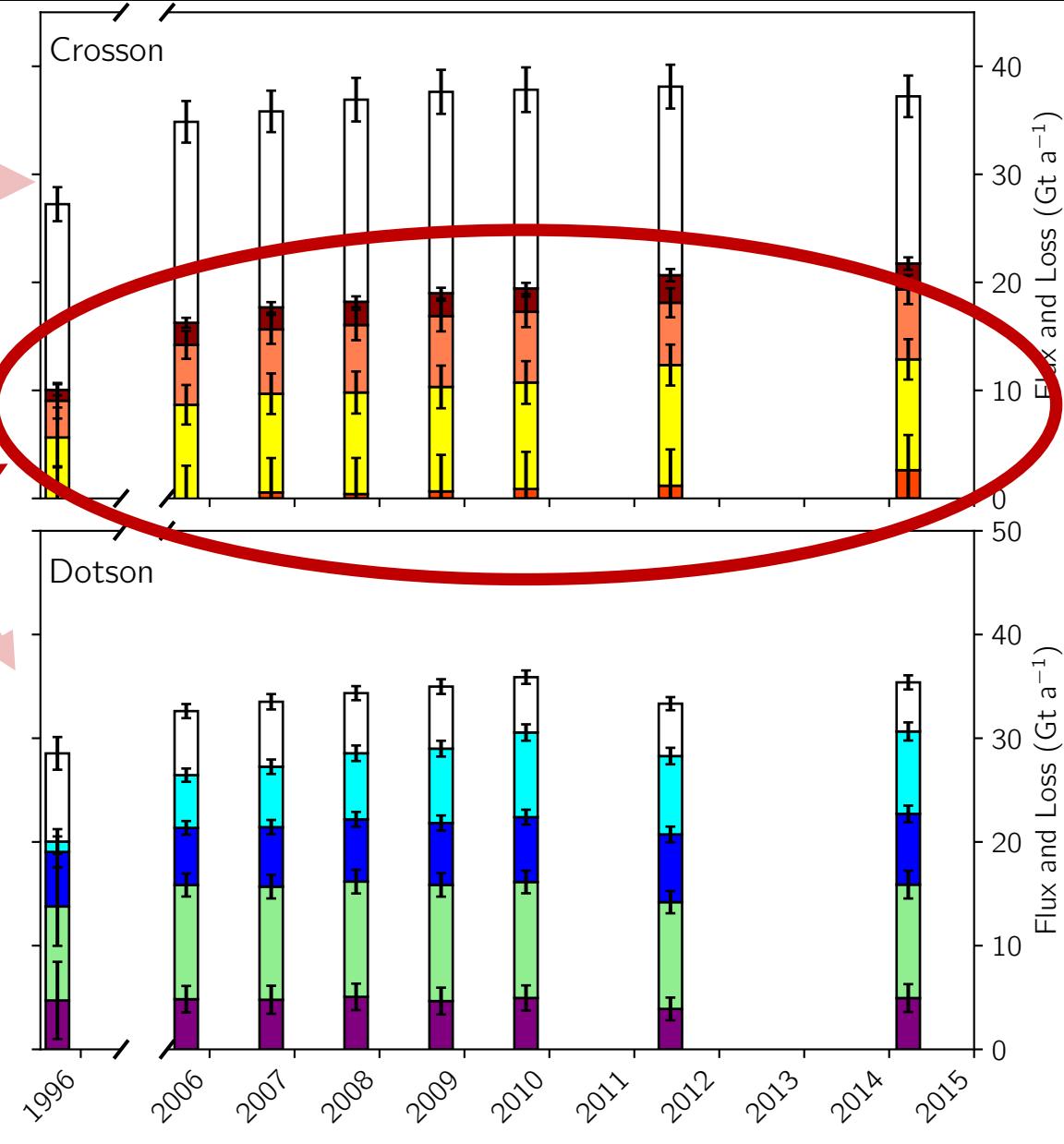
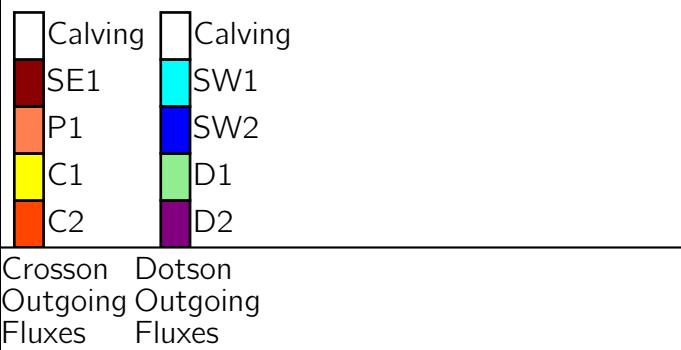
Melt variability on ungrounded regions indicates variable forcing



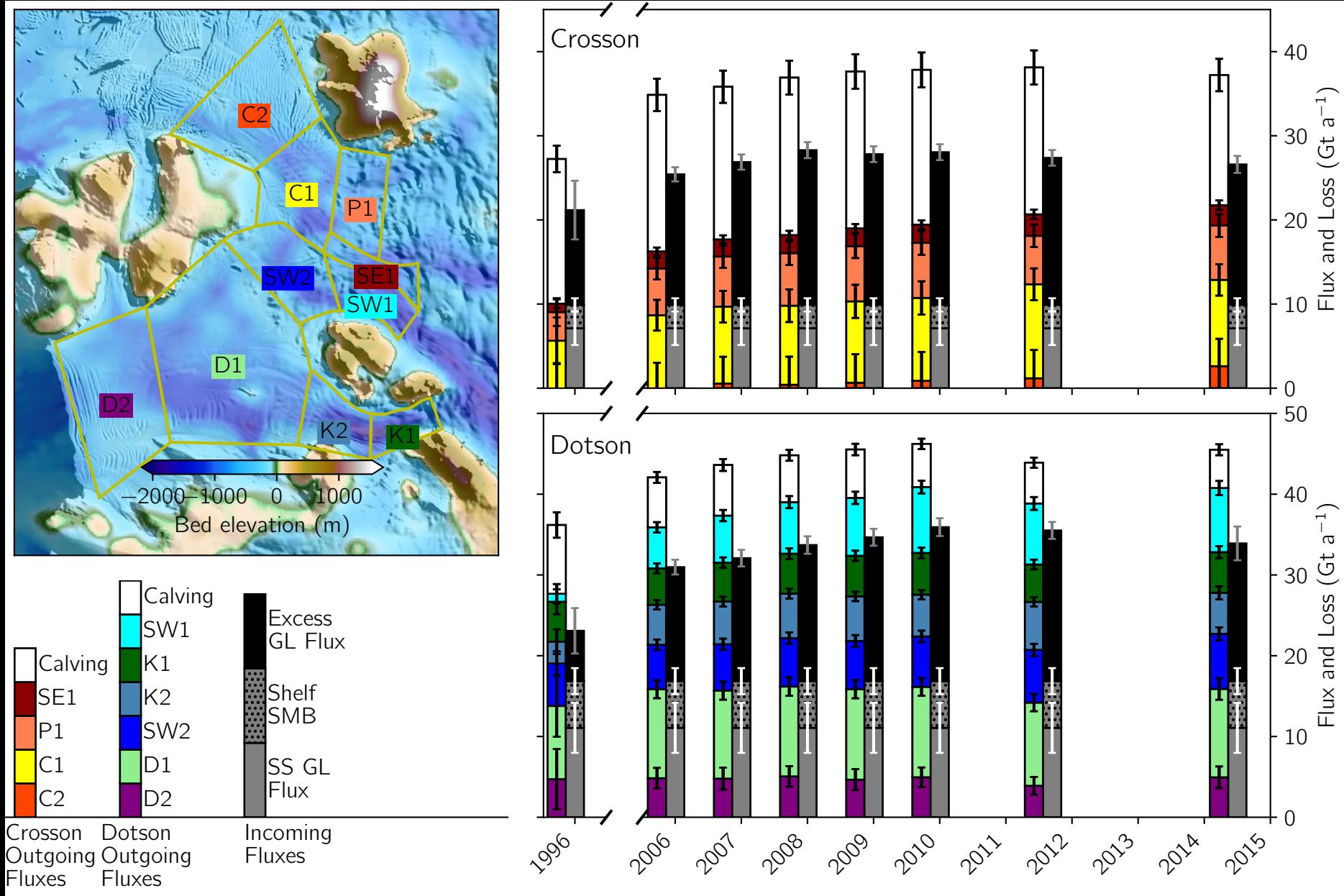
Flux balance – Outgoing flux

Melt variability on ungrounded regions indicates variable forcing

Melt on recently ungrounded regions contributes to outgoing flux

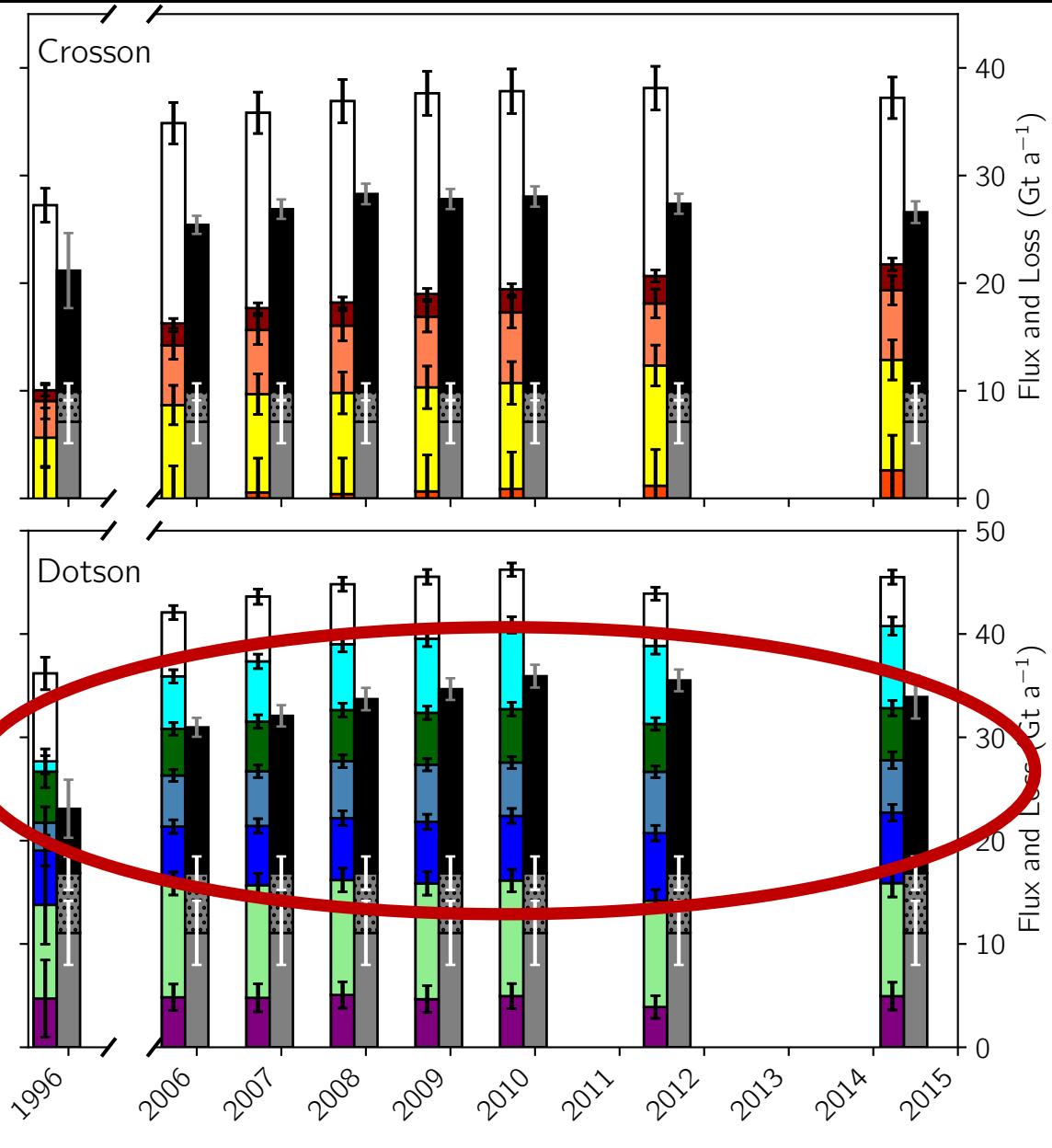
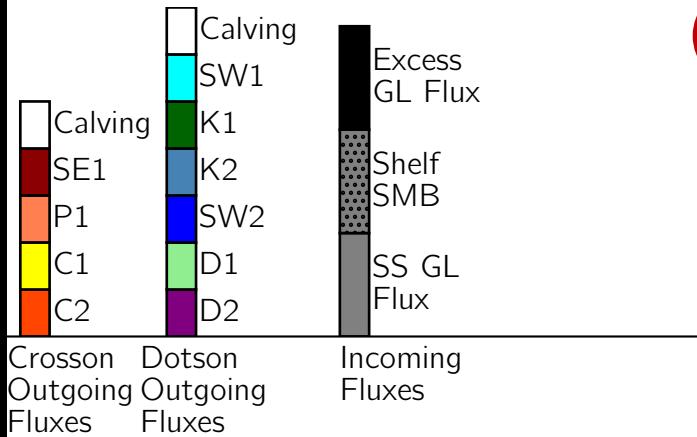


Flux balance – Inputs



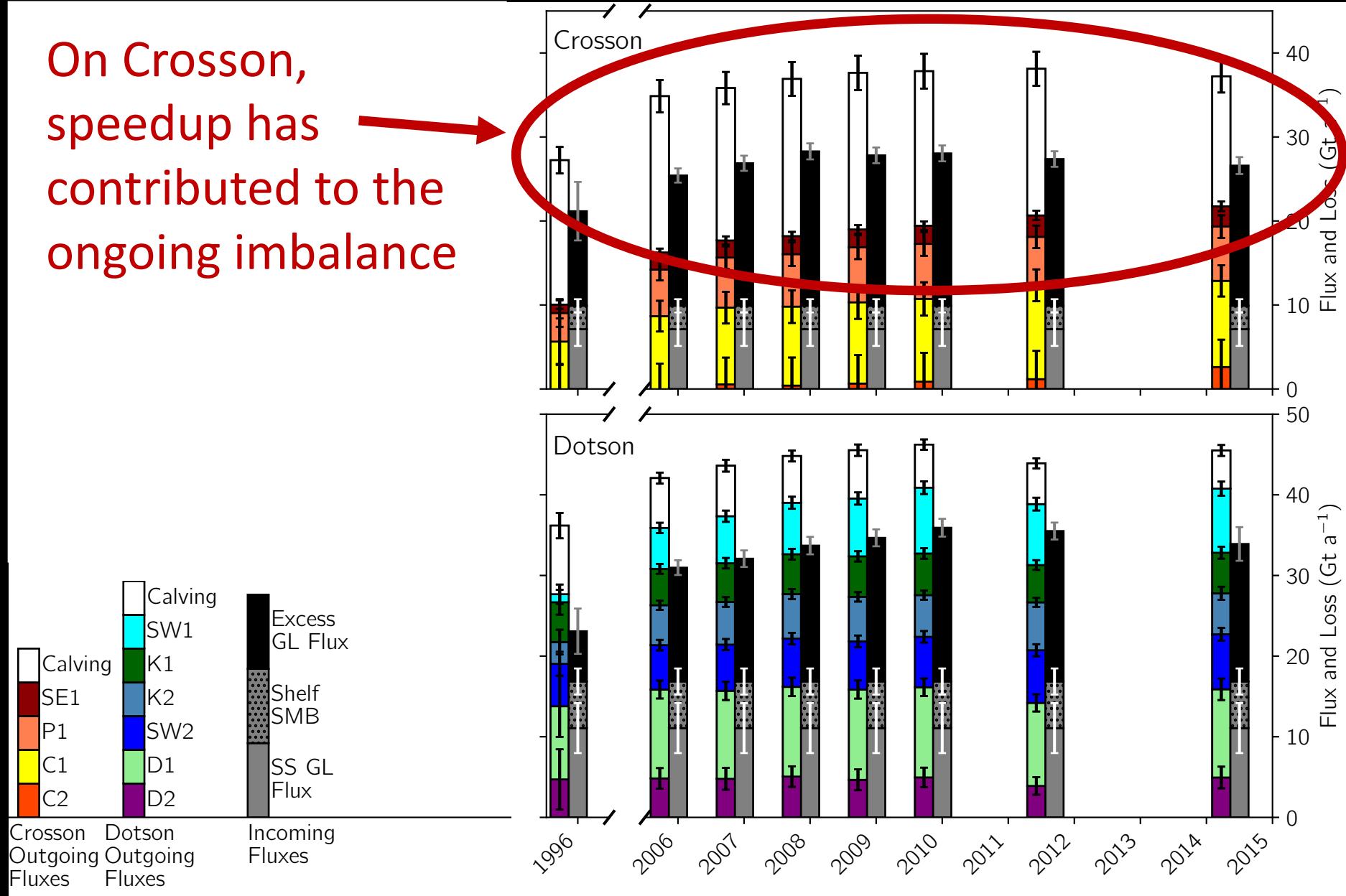
Flux balance – Inputs

On Dotson, melt has been greater than incoming ice since at least 1996, i.e. imbalance irrespective of speedup

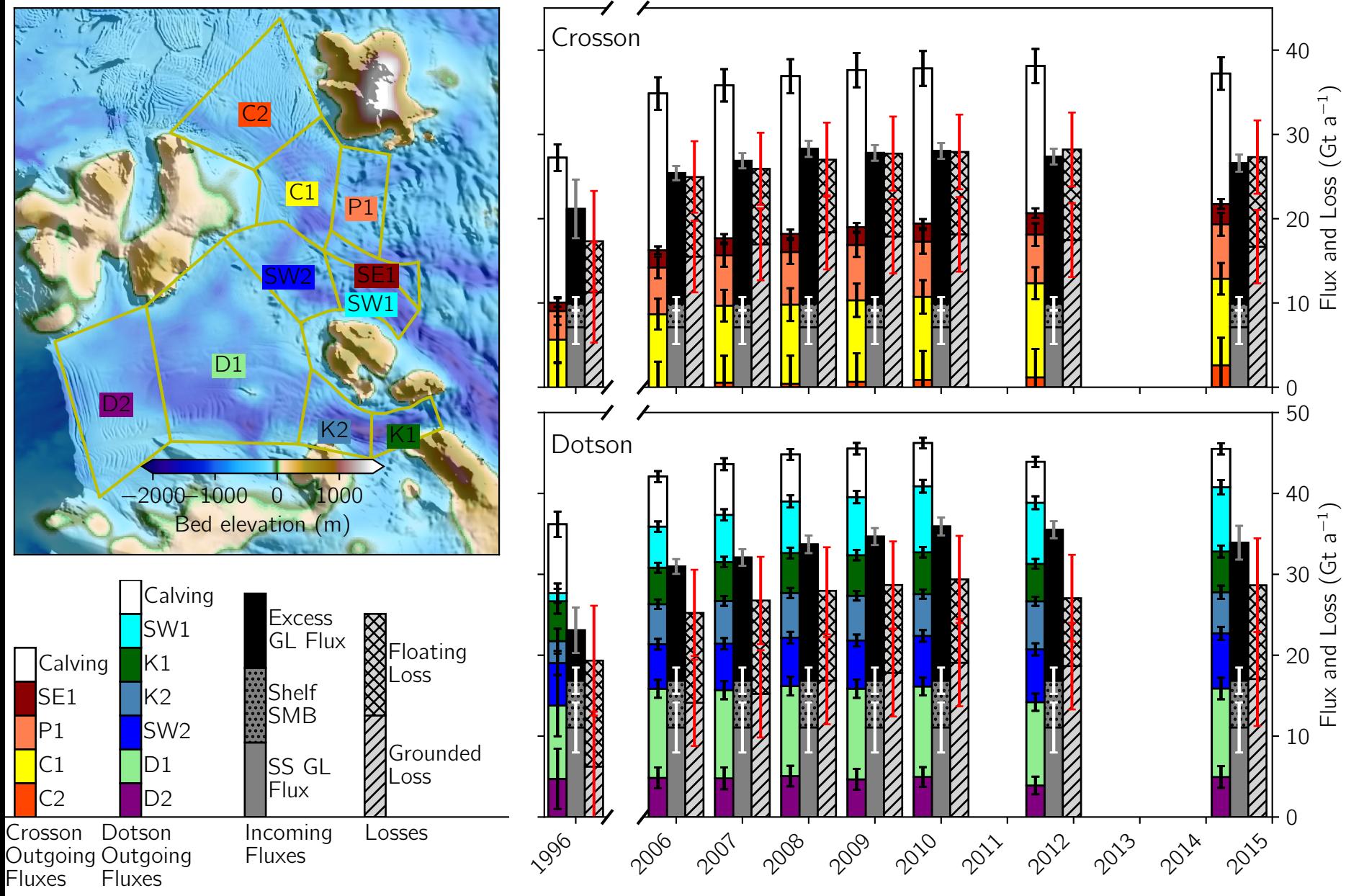


Flux balance – Inputs

On Crosson,
speedup has
contributed to the
ongoing imbalance



Flux balance

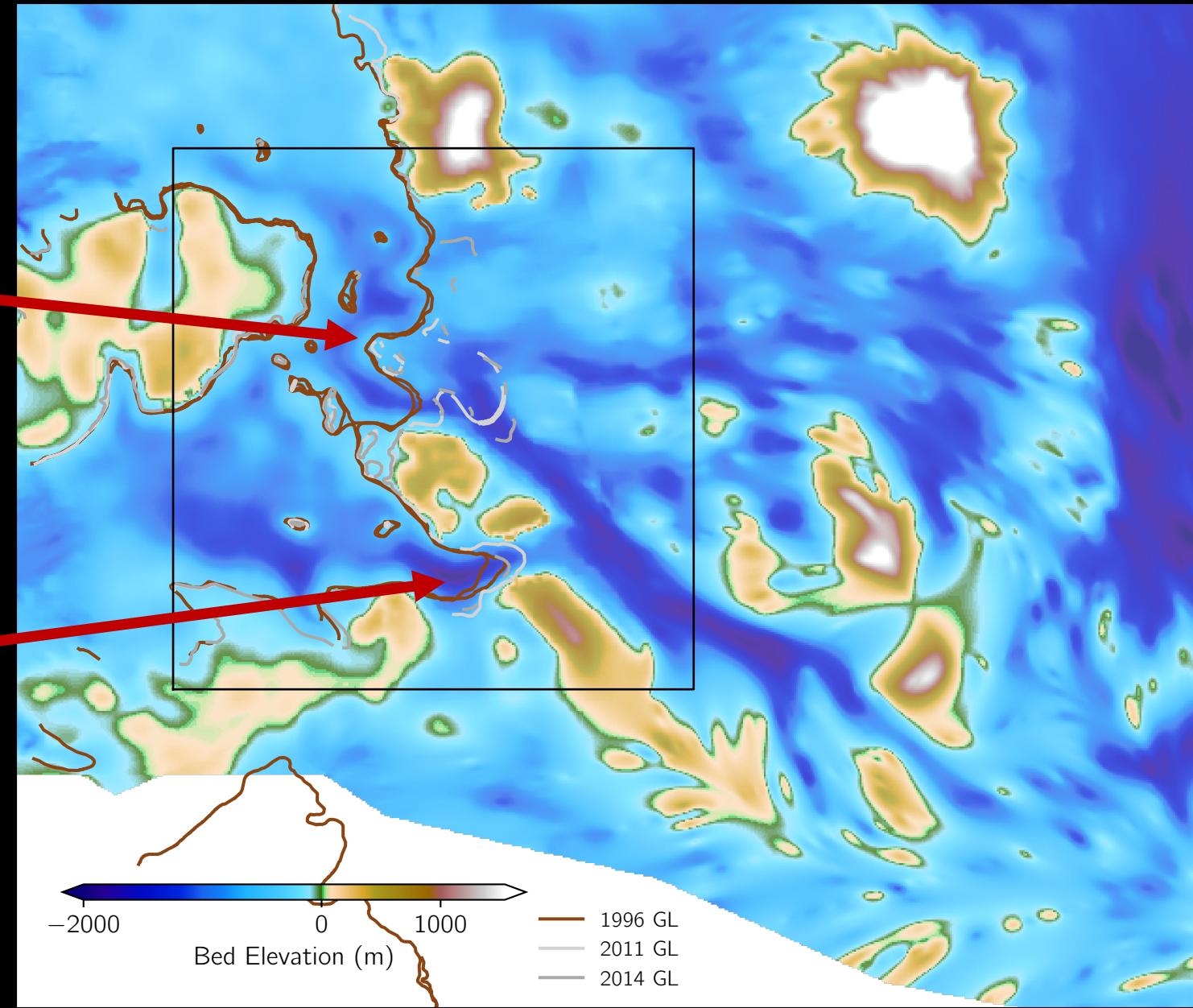


- Some melt variability since 1996
- Dotson already had more melt than GL flux in 1996

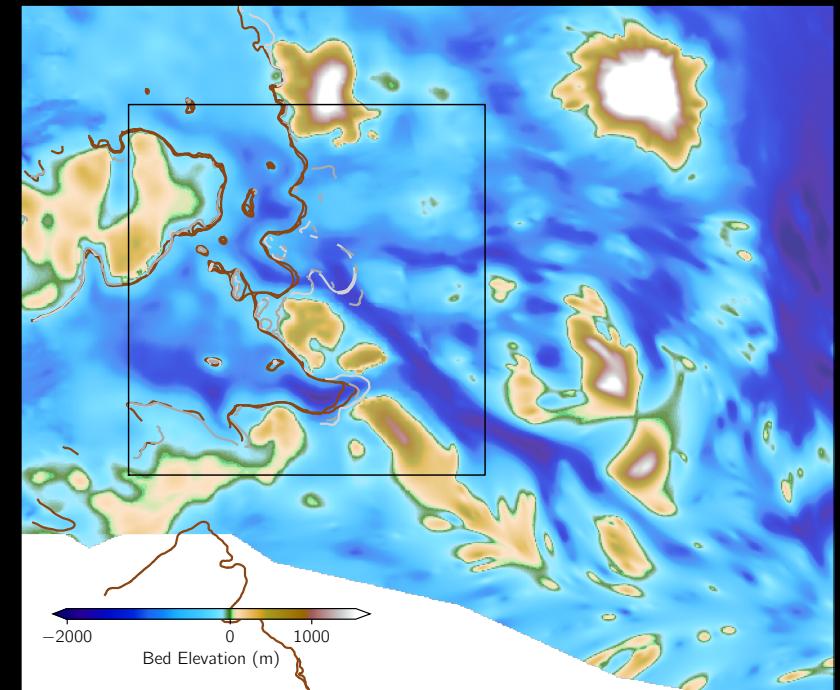
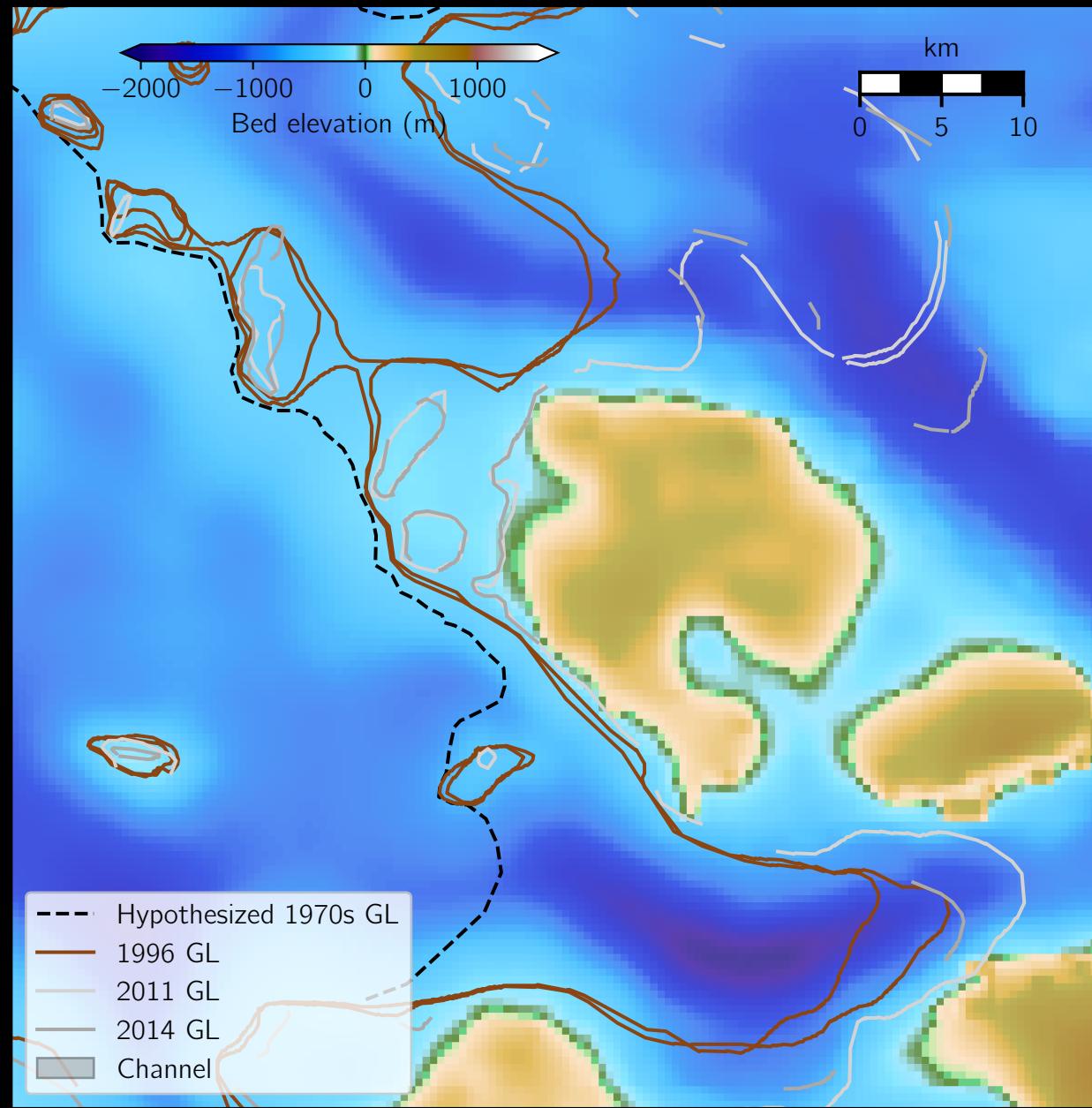
Past grounding line position

1996 GL at bed high

1996 GL just upstream of overdeepening

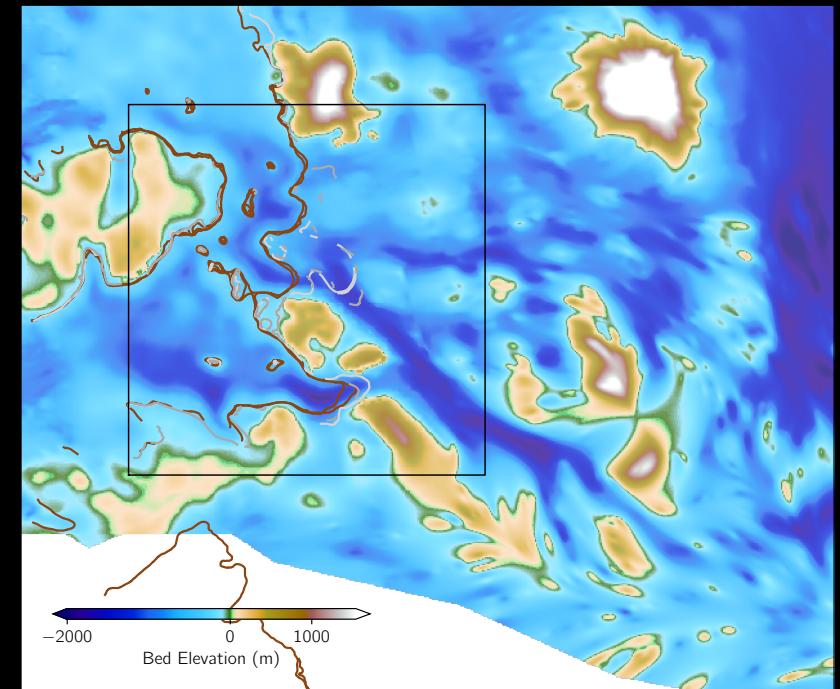
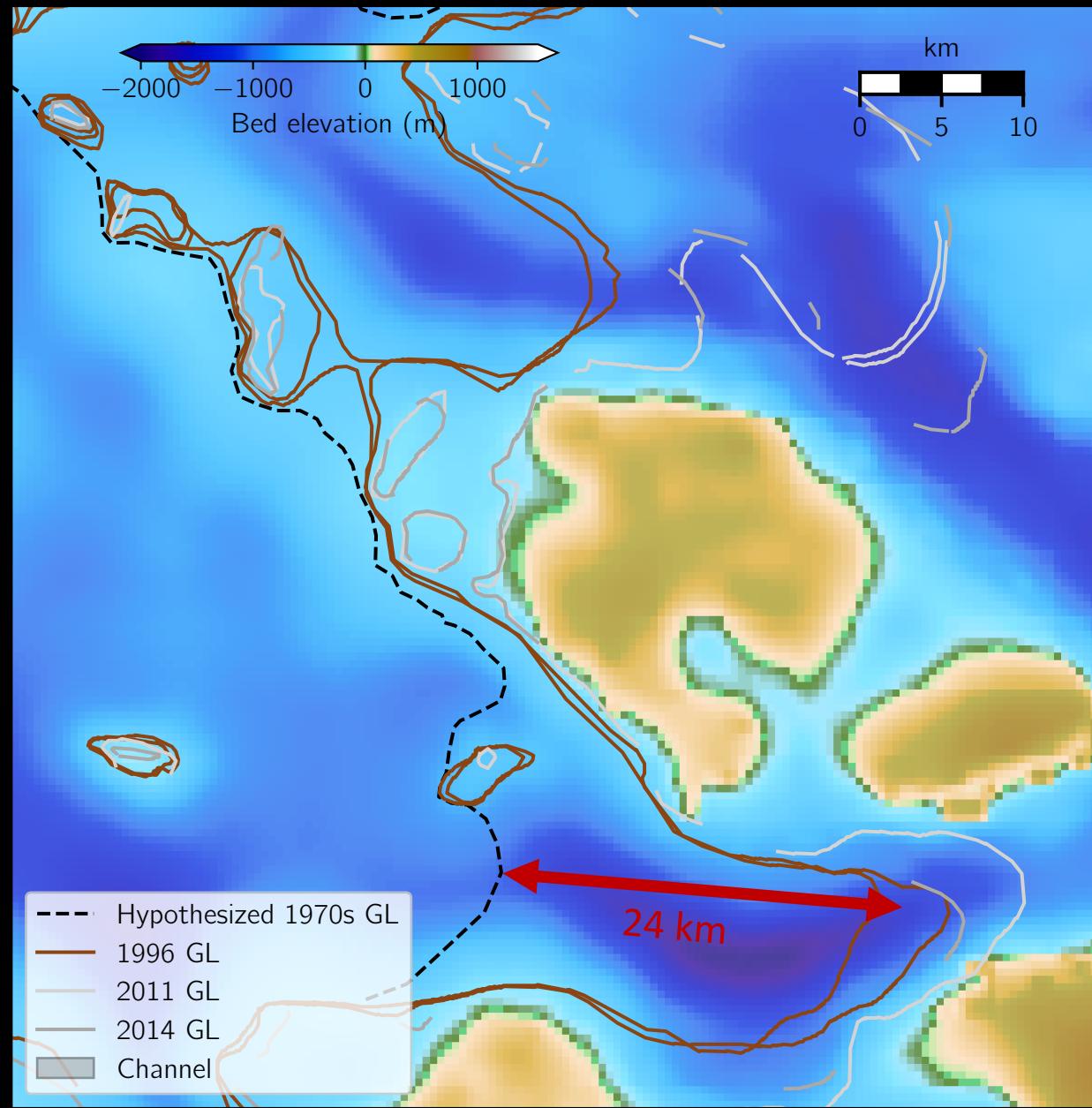


Hypothesized changes in grounding line

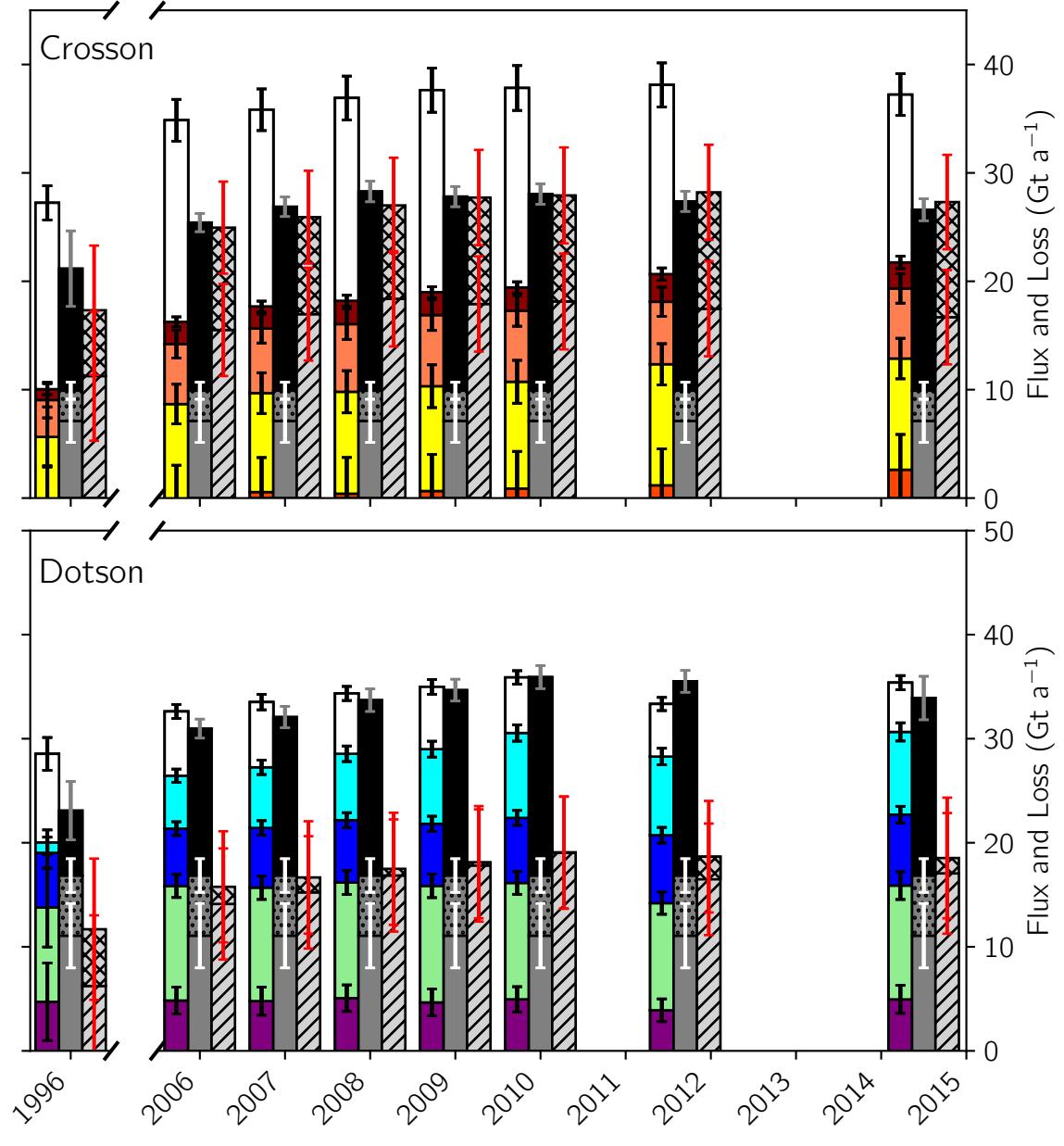
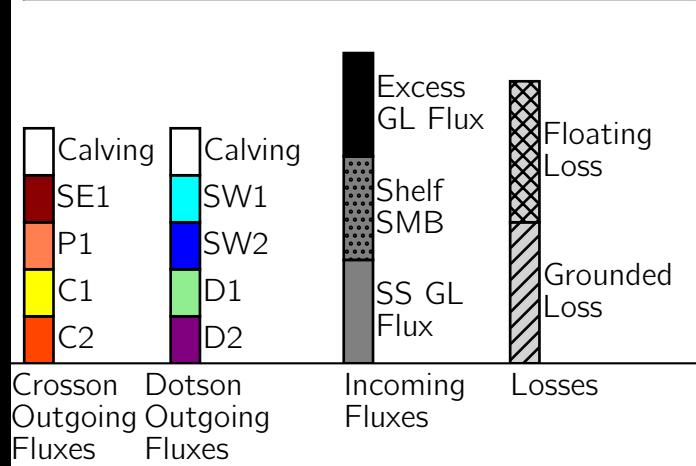
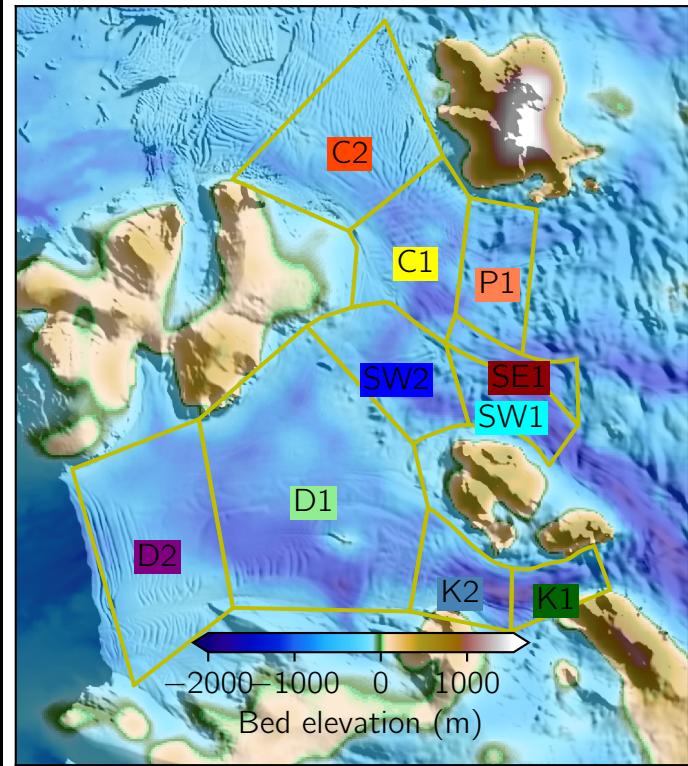


(Bathymetry from
Millan et al. 2017)

Hypothesized changes in grounding line

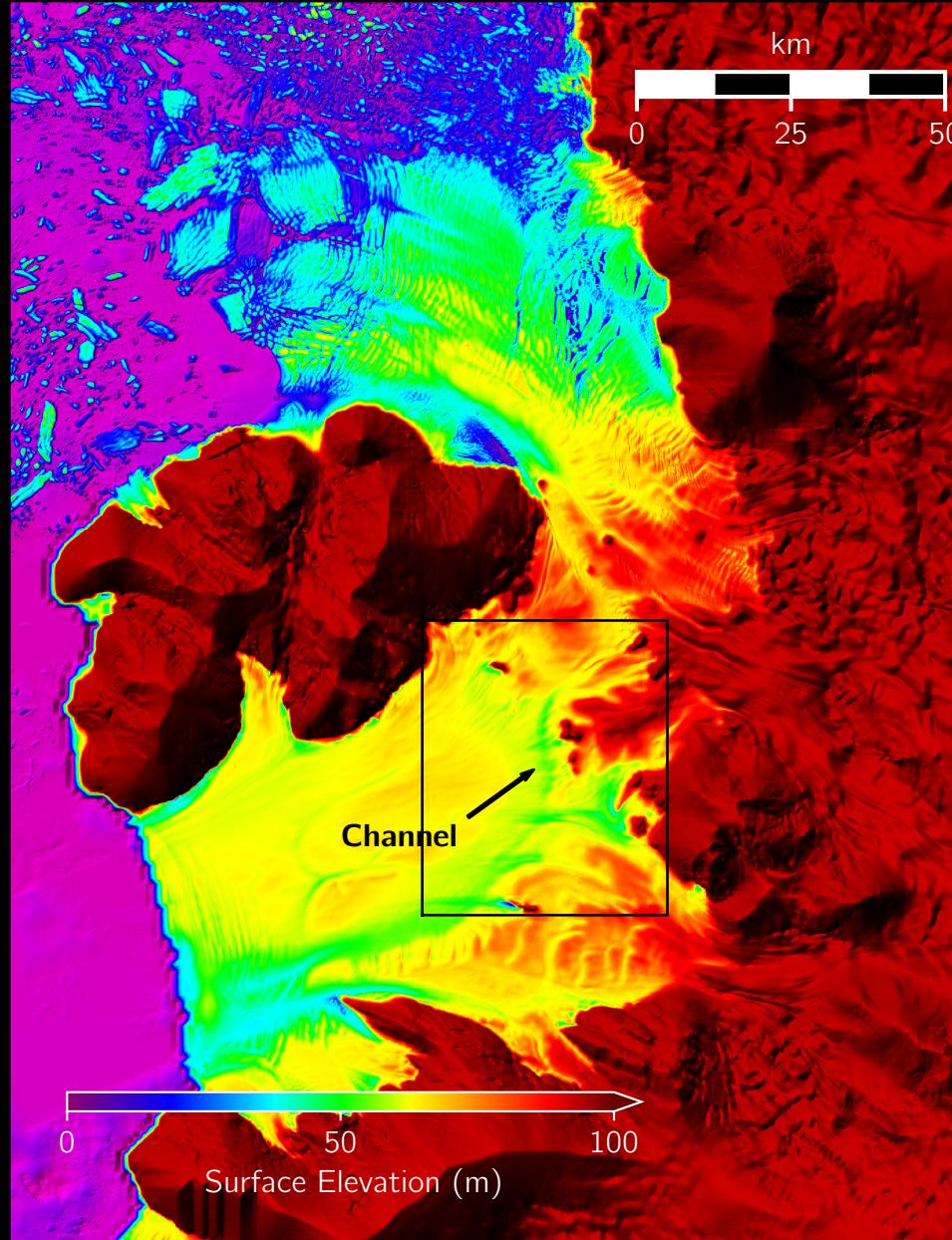


Flux balance – K1 and K2 excluded



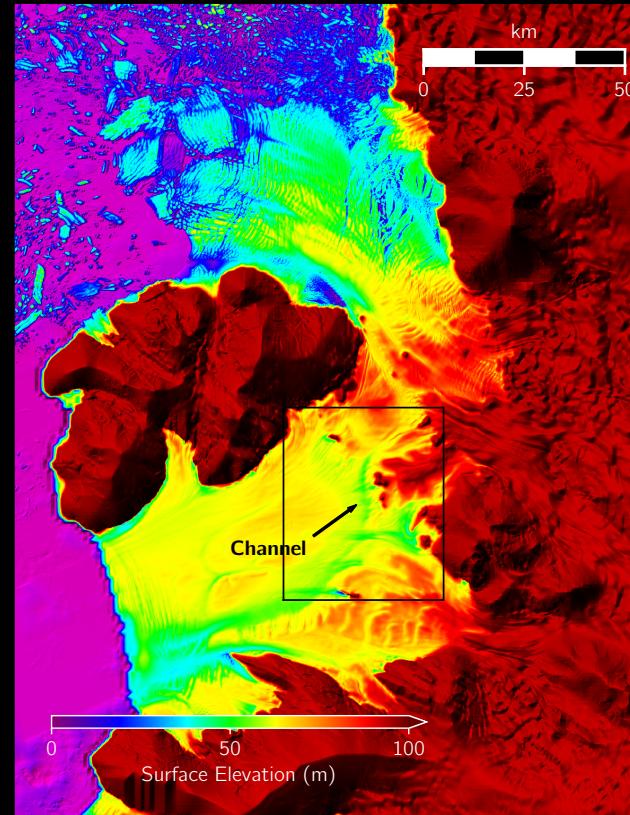
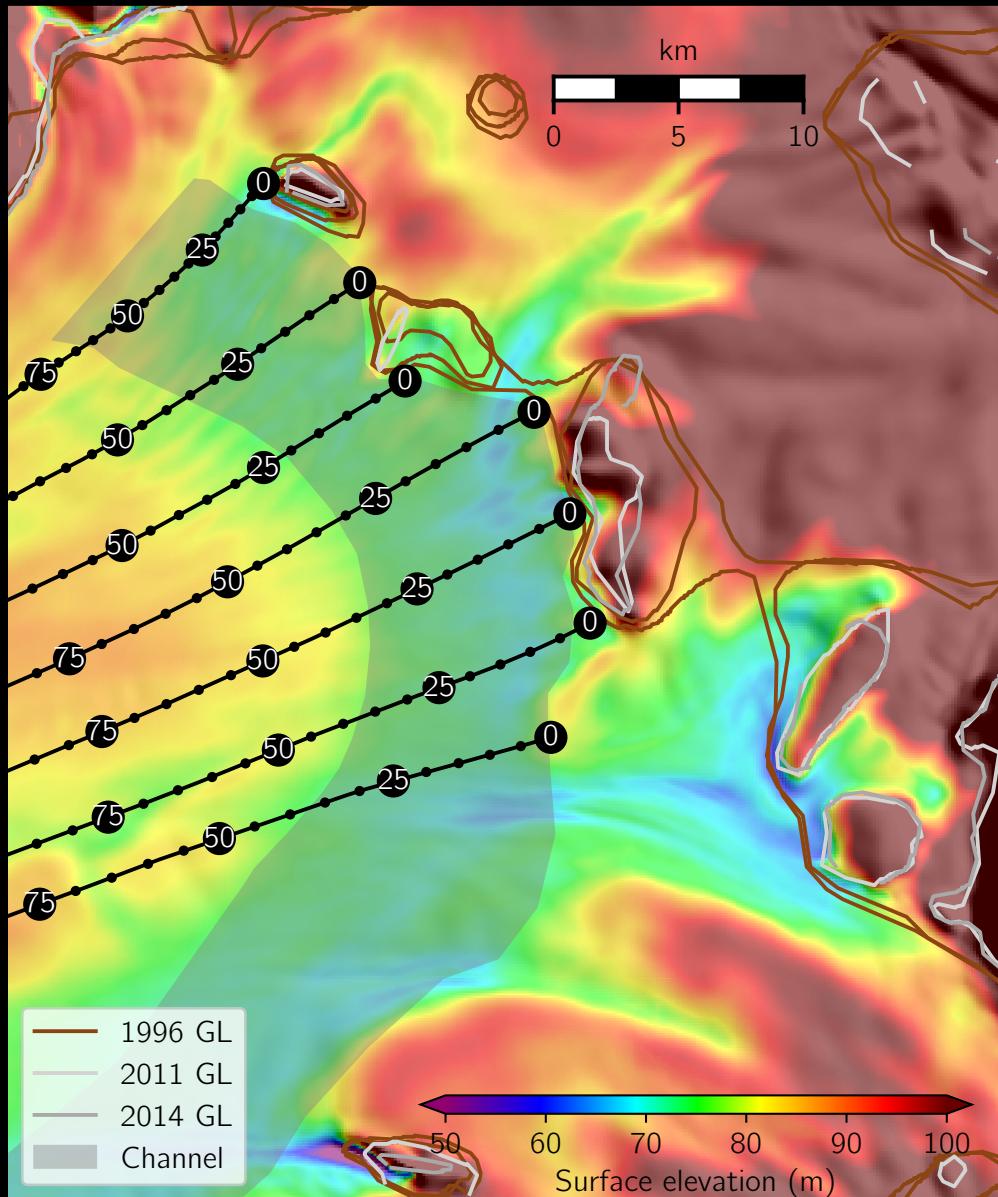
Exclusion of K1
and K2 puts
Dotson
approximately in
balance

Shelf surface elevation



(Shean et al. 2016)

Timing of melt changes



0: 2012

25: 1987

50: 1962

Channel inception likely ~1970

Conclusions

- Crosson and Dotson have both been out of balance since before 1996
- Geometry of Dotson indicates likely dynamic changes and grounding line retreat ca 1970
- Imbalance is likely a continued effect of these prior changes on Dotson