

Mapping Ice Shelf Flow with InSAR Stacking

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**National Centre for
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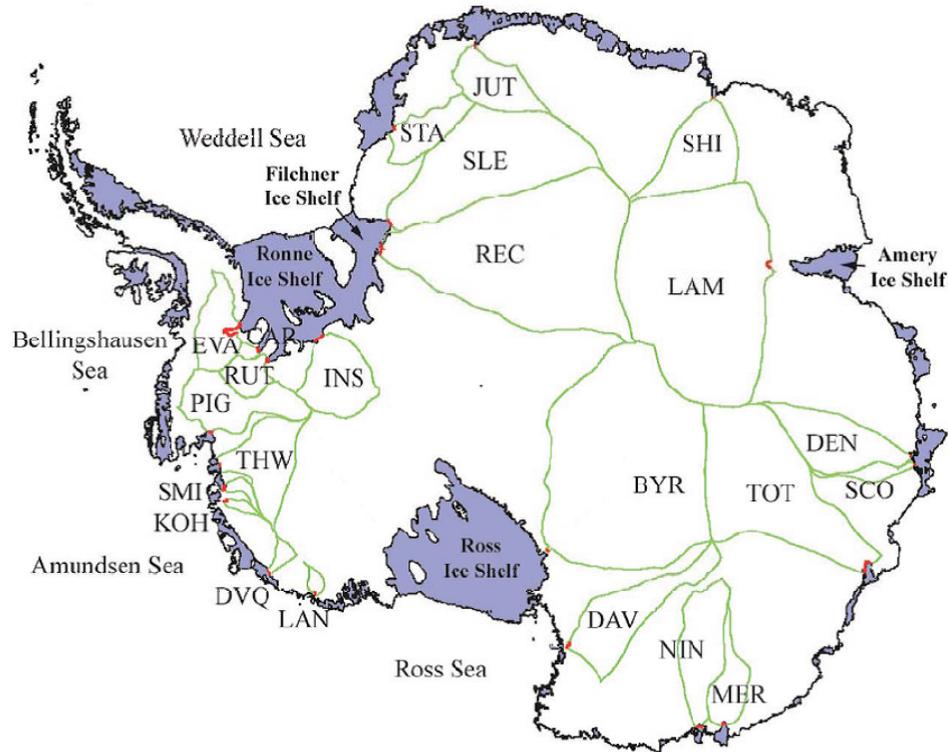
Objectives

1. Utilise InSAR stacking to minimise effect of tides and atmospheric pressure fluctuations on InSAR-based estimates of ice shelf flow.
2. Quantify the across-track velocity error arising from any residual tidal and atmospheric pressure signals.
3. Utilise MAI stacking to determine 2-d velocity vectors from data acquired for a single viewing direction

Motivation



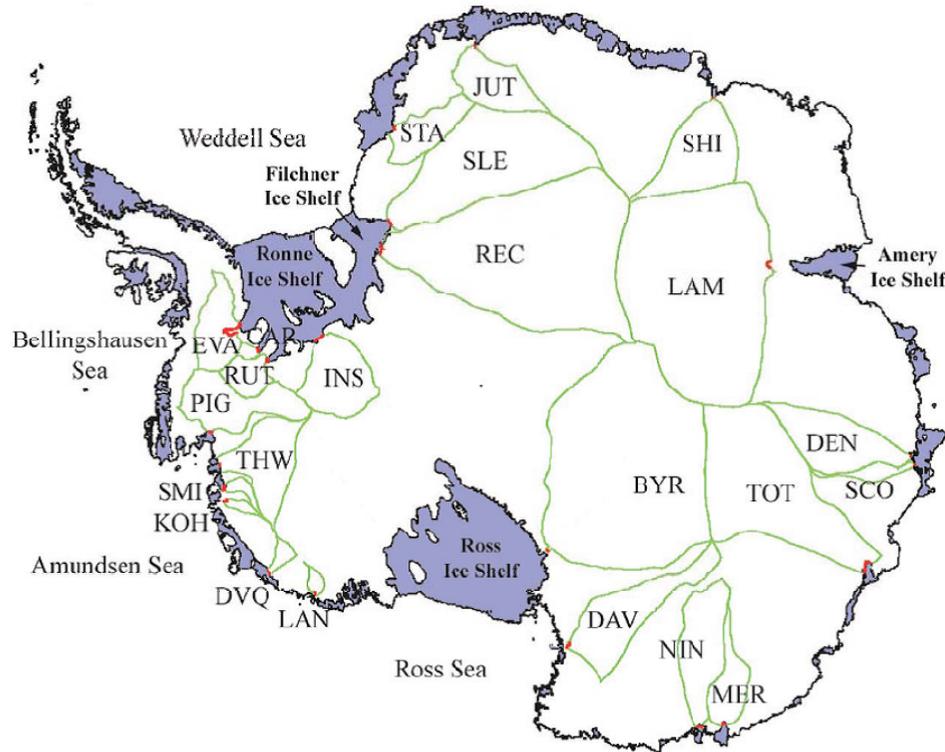
Why Study Ice Shelves?



- Sensitive to changes in surrounding environment.

- Ice shelves regulate mass loss from the Antarctic Ice Sheet.

Why Map Ice Shelf Flow?



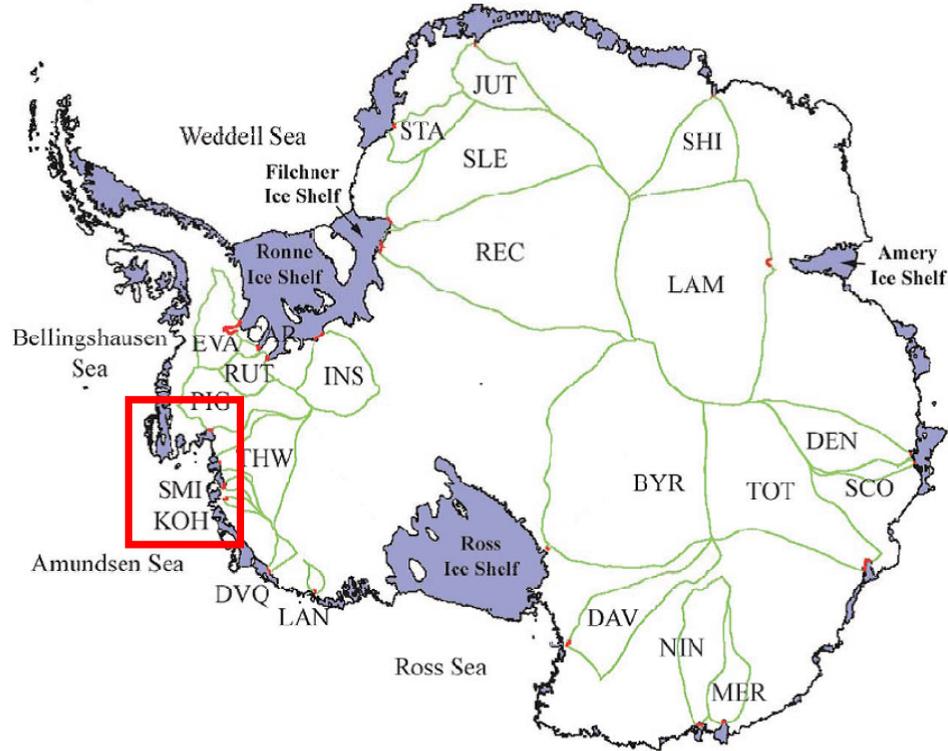
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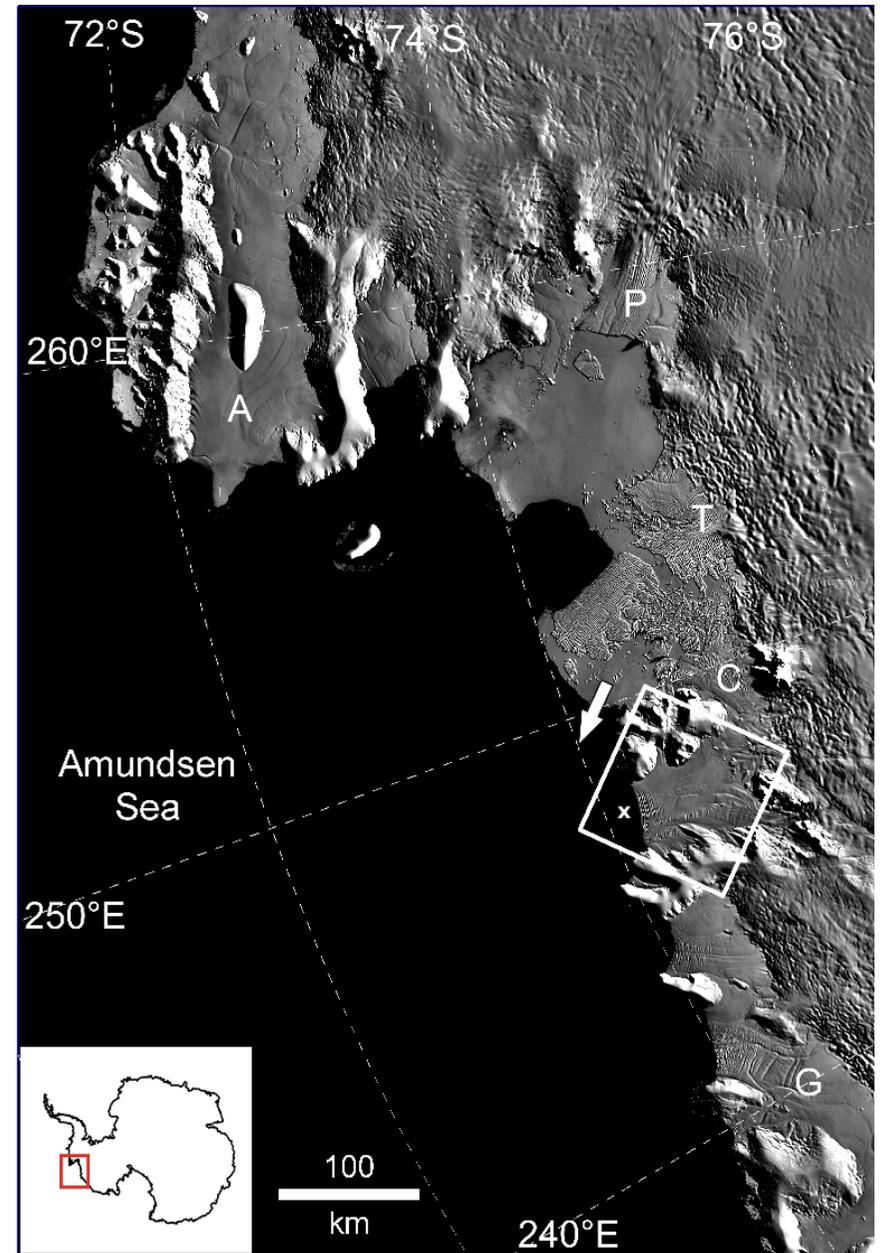
- Flow acceleration can be a precursor to collapse.

- Maps of ice shelf flow used to improve understanding of ice shelf processes.

Why Map Ice Shelf Flow?



- Dotson Ice Shelf
- ERS-1 Ice Phase (1994)



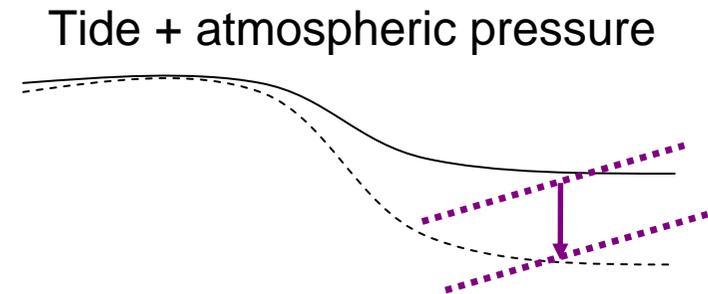
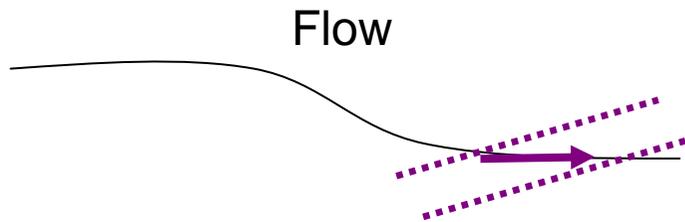
InSAR Observations of Ice Shelves

$$\Delta\varphi = \Delta\varphi_{topo} + \Delta\varphi_{flat} + \Delta\varphi_{displ} + \Delta\varphi_{atm} + \Delta\varphi_{noise}$$

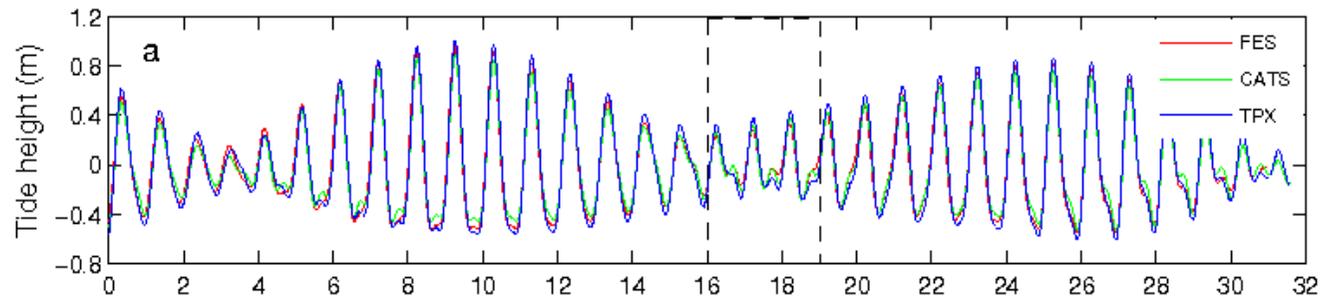
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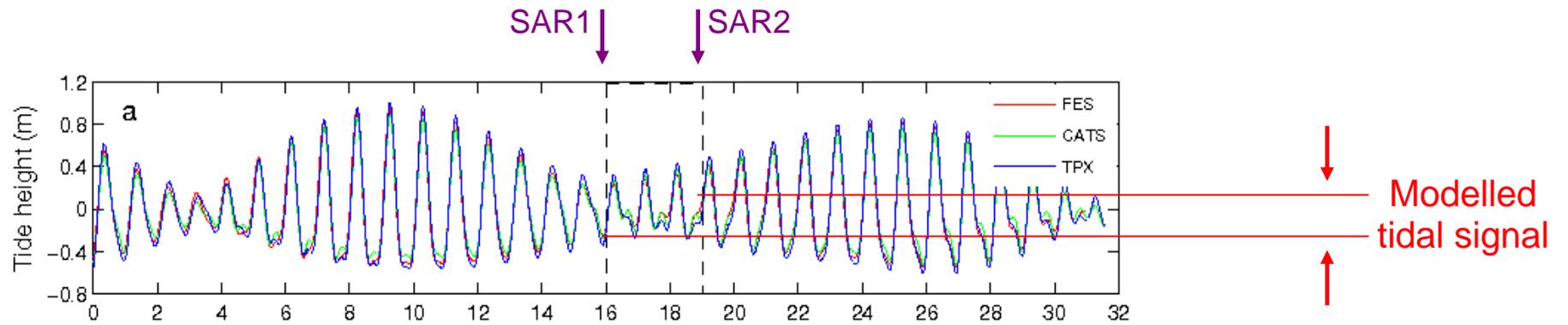
$$\Delta\varphi_{displ} = \Delta\varphi_{flow} + \Delta\varphi_{tide} + \Delta\varphi_{press}$$



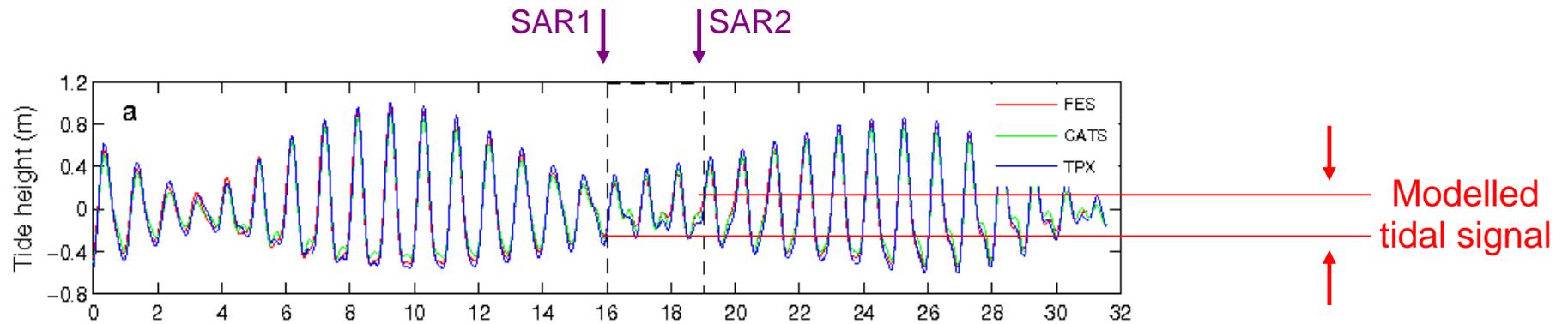
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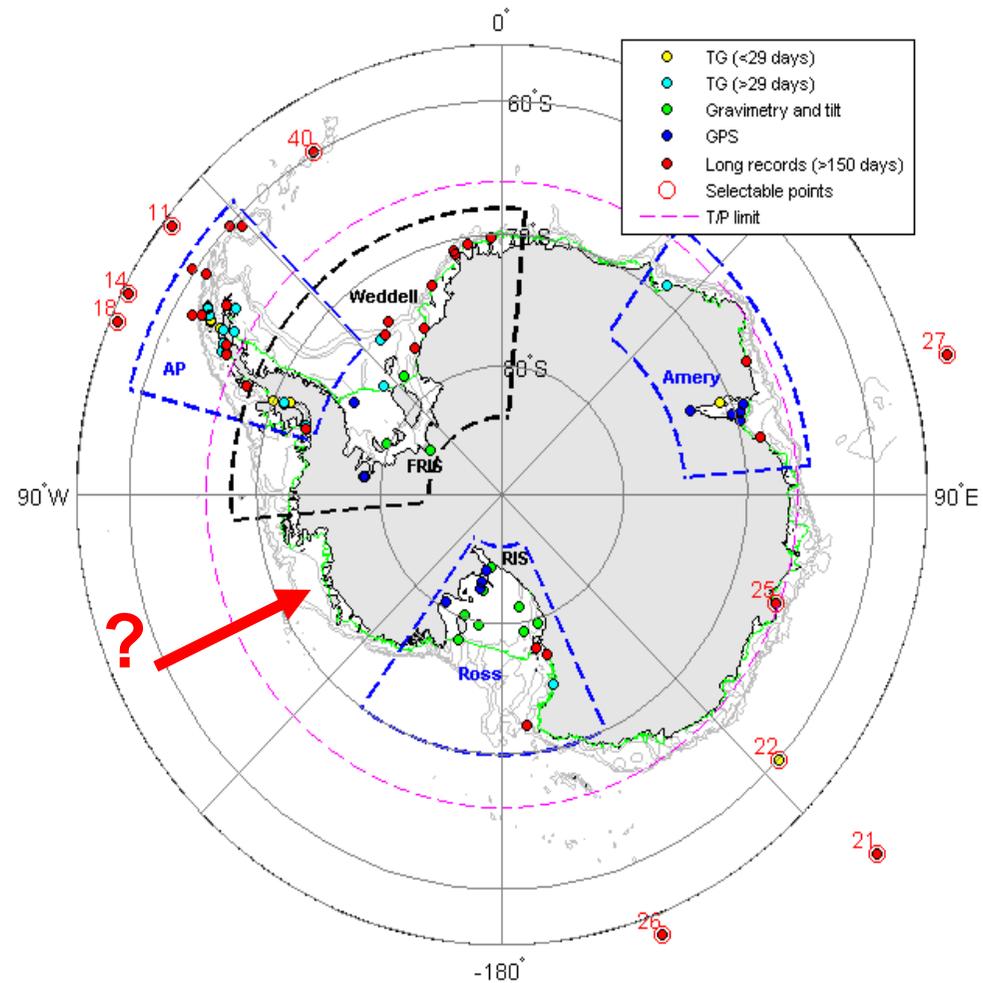


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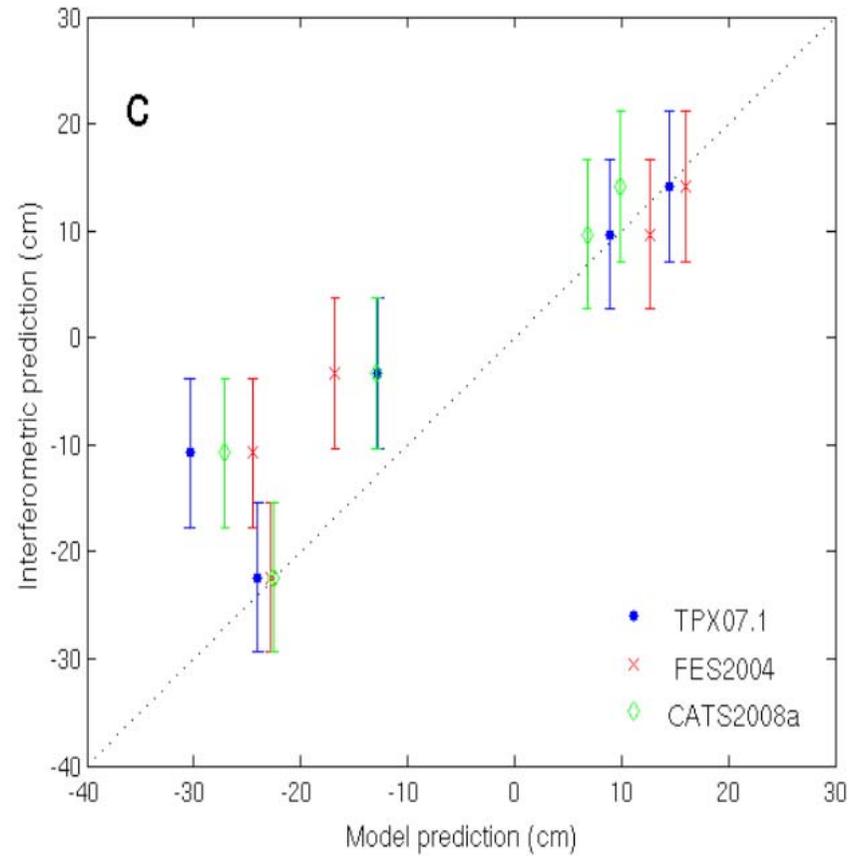
How accurate are model predictions of these signals?

Evaluate tide models using *in situ* records?



Locations of Antarctic tidal records

Evaluate tide models using satellite observations?

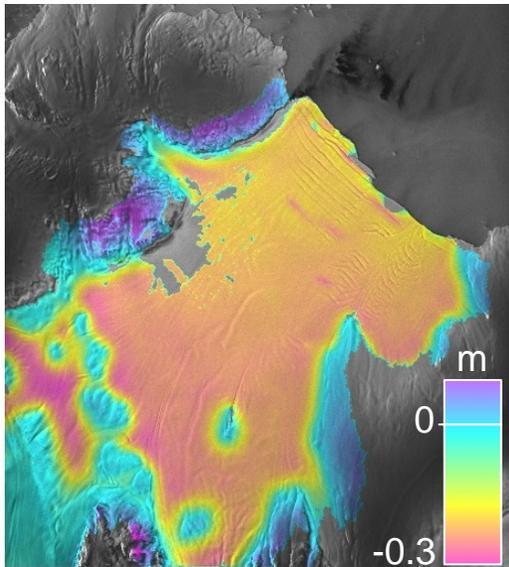


An aerial photograph of a vast, flat ice shelf. In the background, a range of rugged, light-colored mountains stretches across the horizon. The foreground and middle ground show the textured surface of the ice, with various ridges, depressions, and small icebergs scattered across it. The sky is a clear, pale blue.

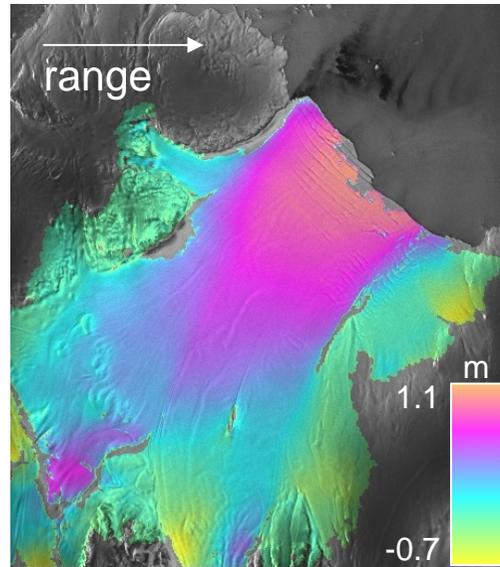
Across-track Ice Shelf Flow from Stacked InSAR

$$\sum_i \Delta\varphi_{i,displ} = \sum_i (\Delta\varphi_{i,flow} + \Delta\varphi_{i,tide} + \Delta\varphi_{i,press})$$

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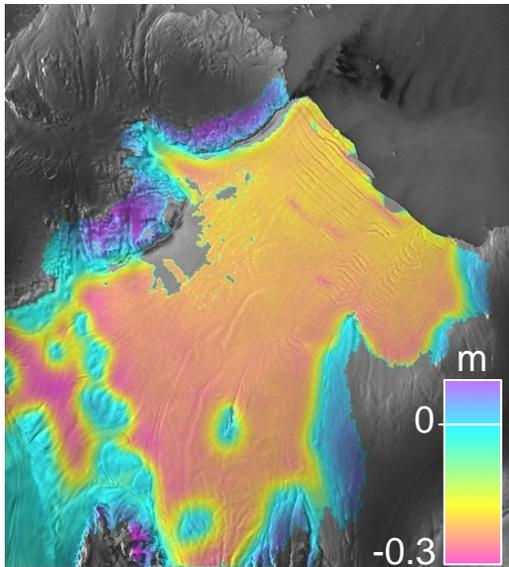
Differential interferogram



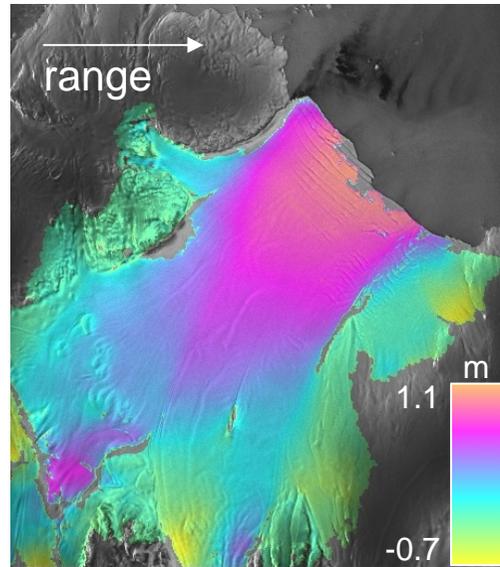
Single interferogram

←
Increasing tidal /
Atmospheric pressure signal

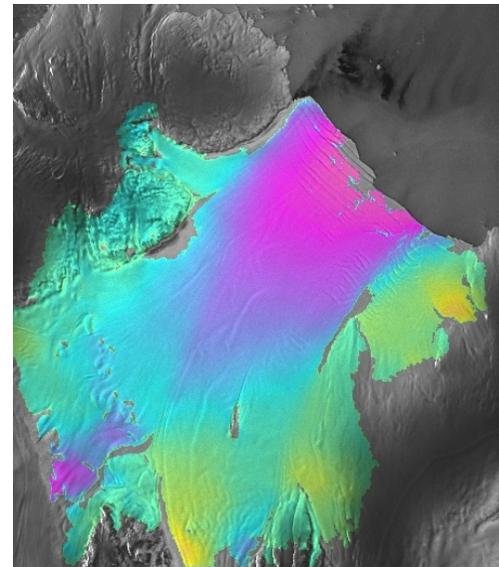
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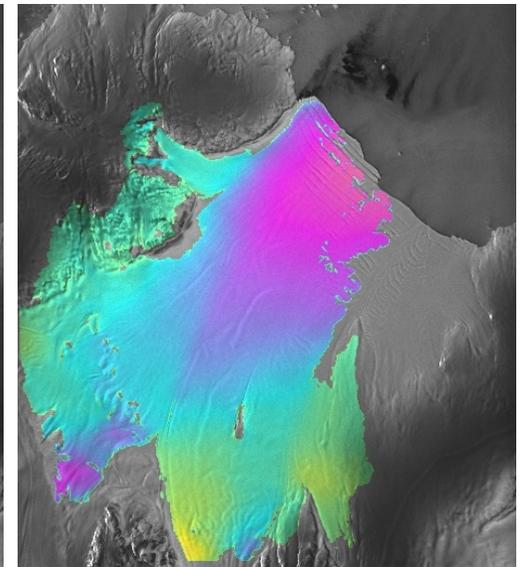
Differential interferogram



Single interferogram

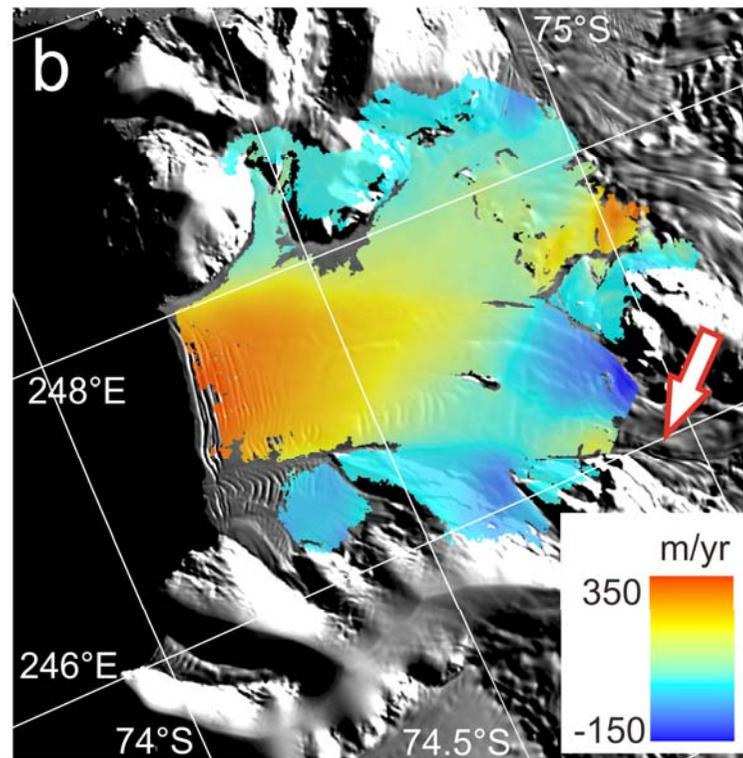
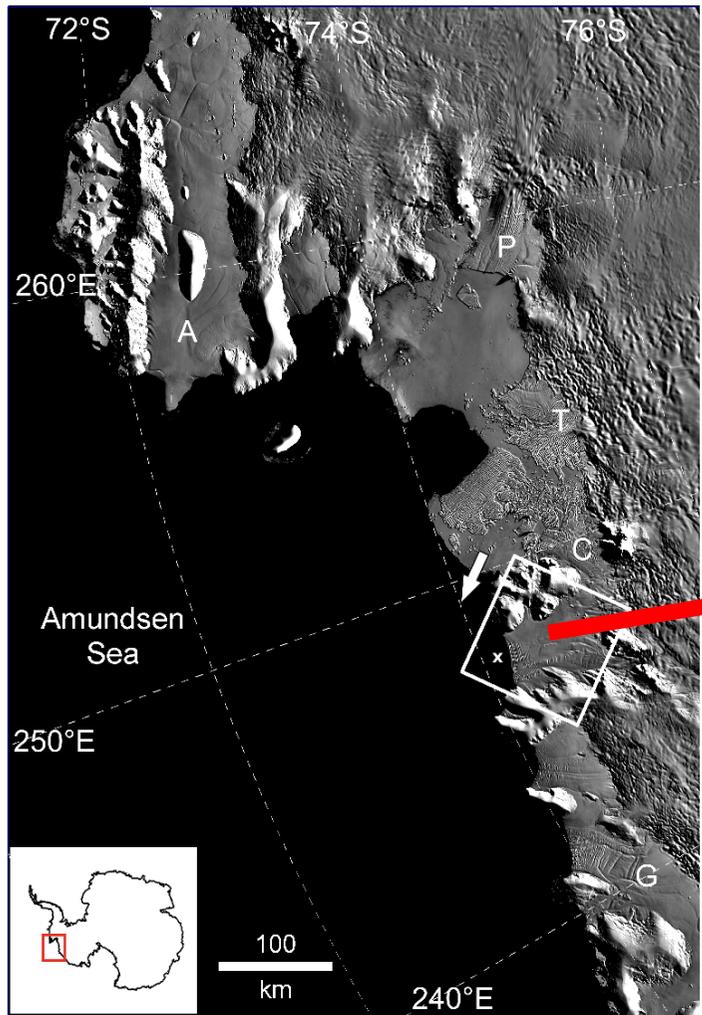


2 stacked interferograms



3 stacked interferograms

Increasing flow signal

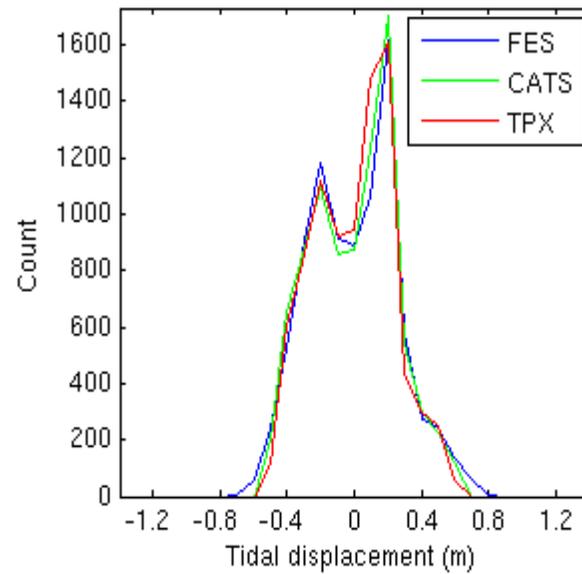


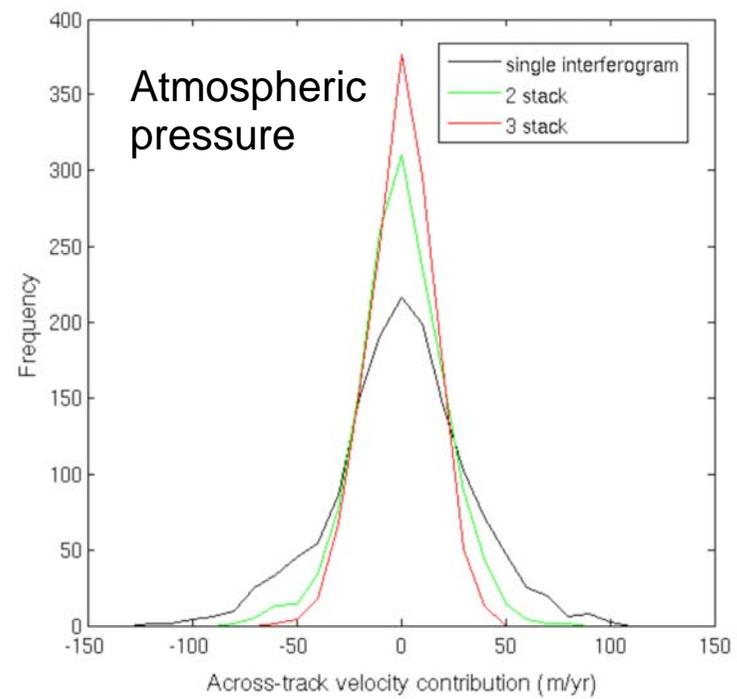
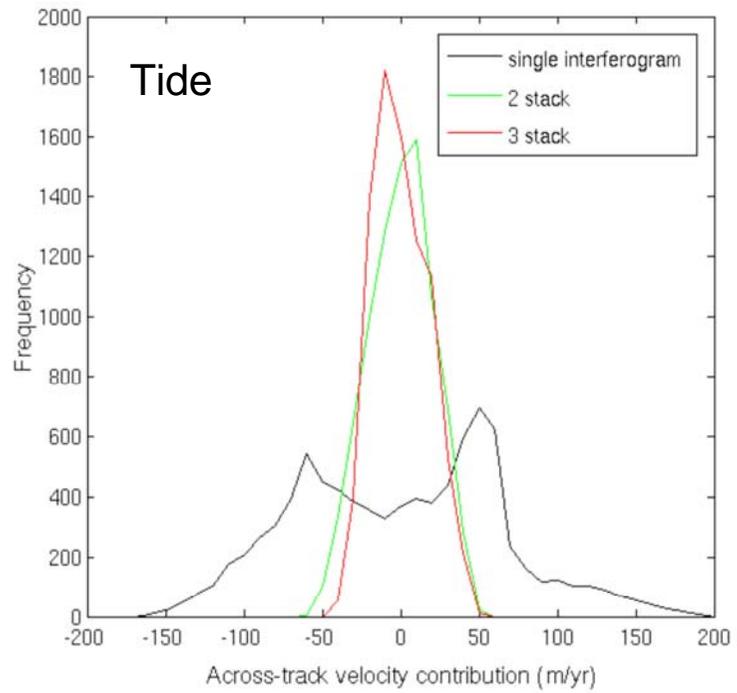
Dotson Ice Shelf:
Stacked across-track flow velocity

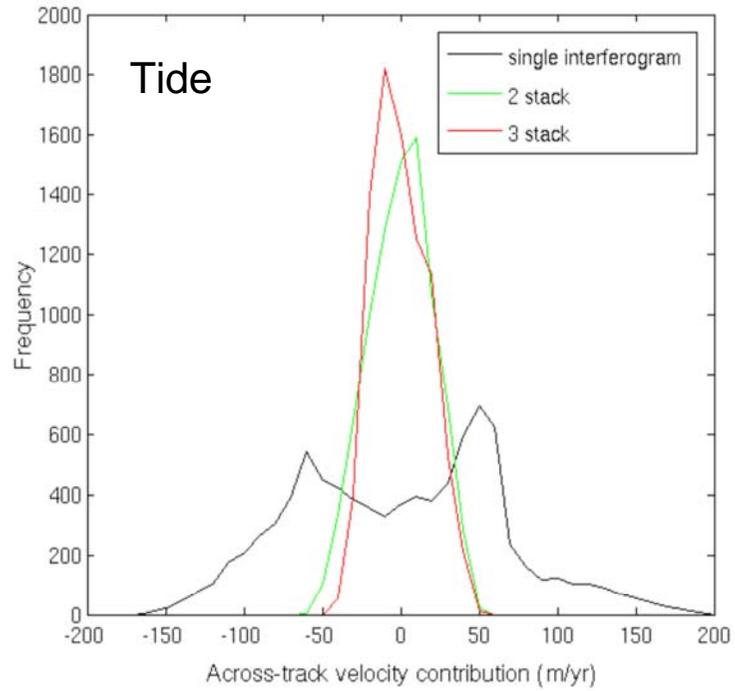
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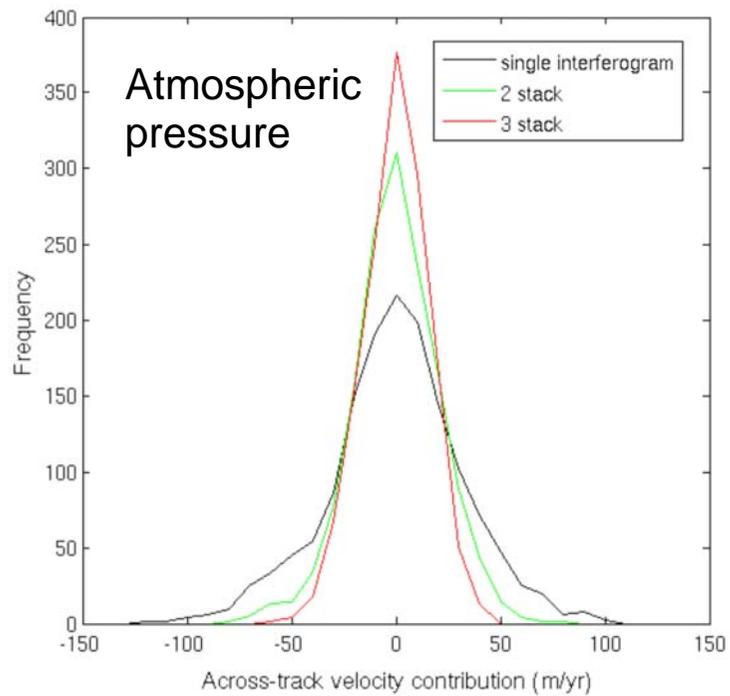
i samples from distribution.





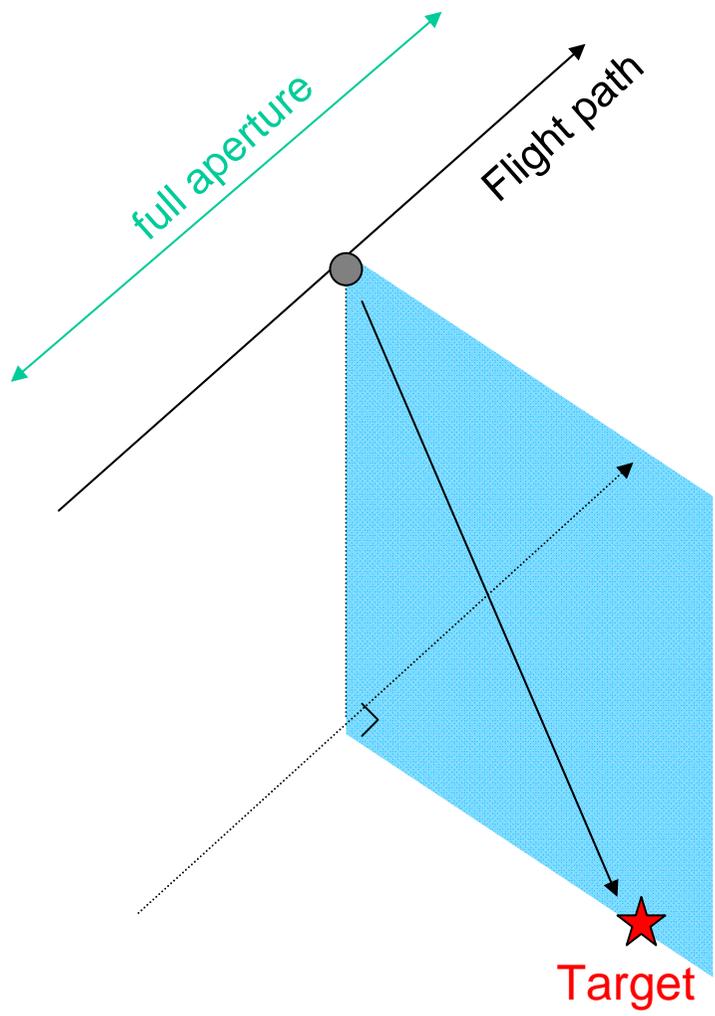


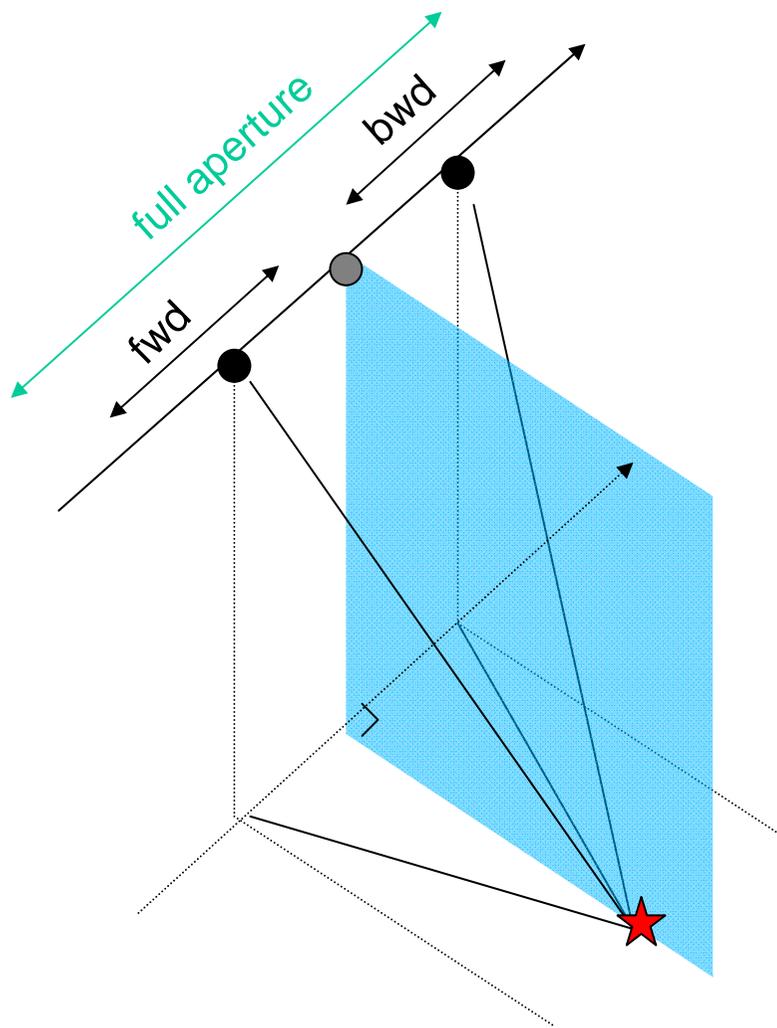
Across-track error ~ 22 m/yr

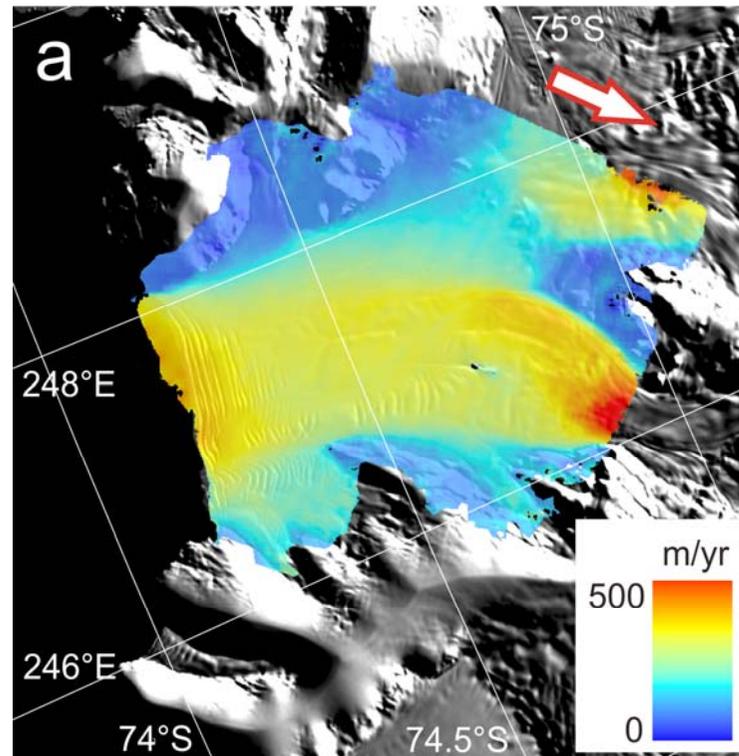
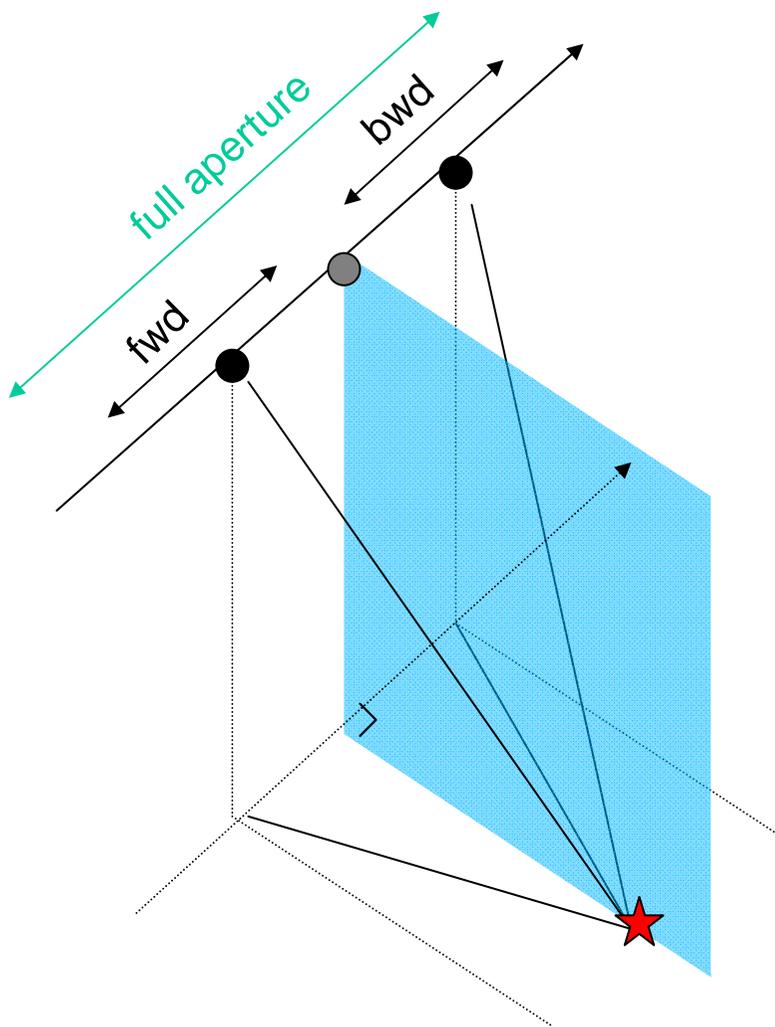


An aerial photograph of a vast, flat ice shelf. A prominent, dark, linear feature, likely a flow line or rift, runs diagonally across the lower half of the image. In the background, a range of rugged, light-colored mountains or plateaus stretches across the horizon under a clear sky. The overall scene is desolate and expansive.

Along-track Ice Shelf Flow from Stacked MAI

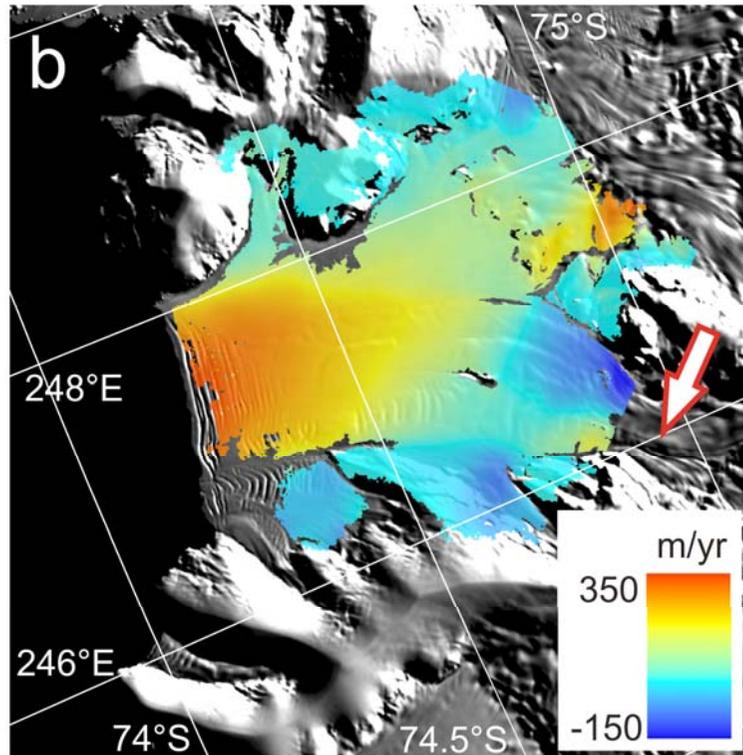




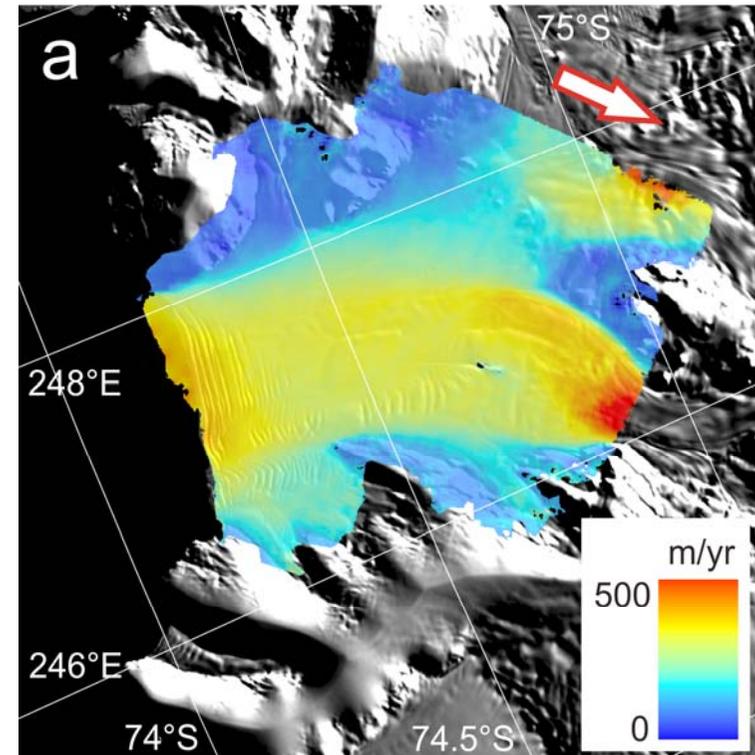


Along-track flow velocity of Dotson Ice Shelf from stacked MAI.

MAI along-track error ~ 21 m/yr



Across-track flow velocity
from stacked InSAR



Along-track flow velocity
from stacked MAI

InSAR across-track error ~ 23 m/yr

+

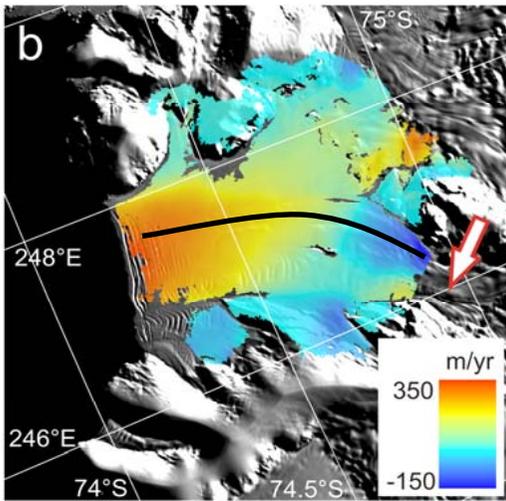
MAI along-track error ~ 21 m/yr



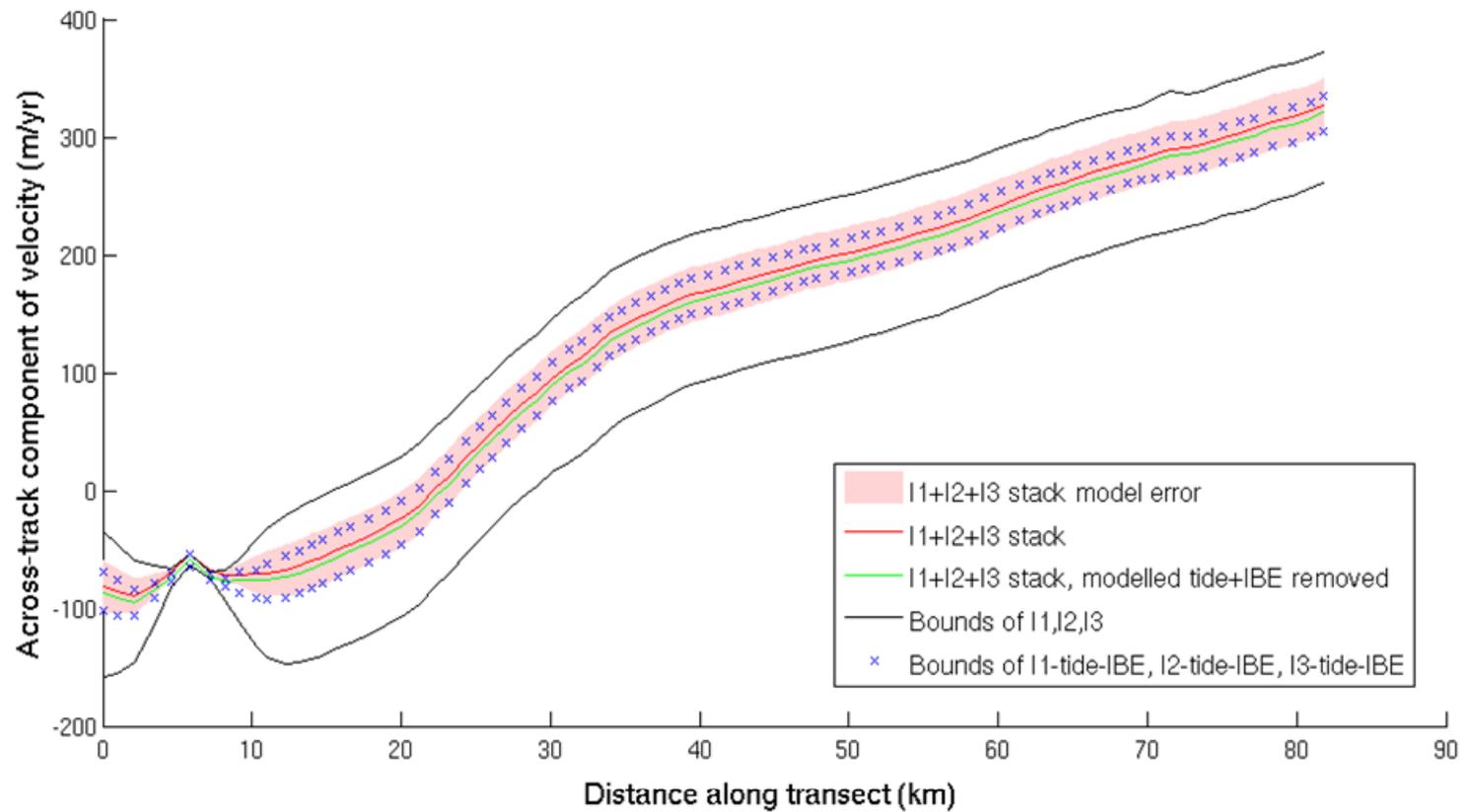
Velocity magnitude error ~ 31 m/yr

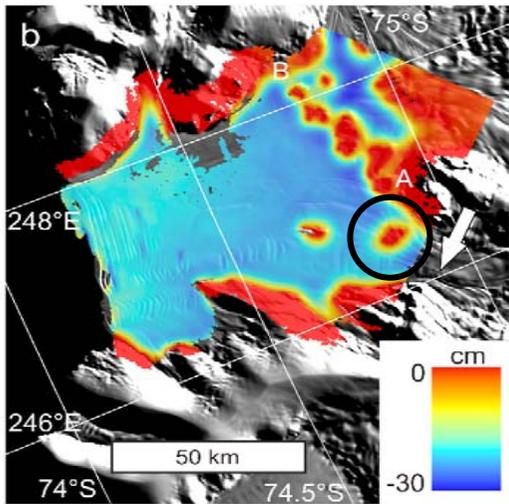


Comparison of Methods for Removing Tide and Atmospheric Pressure

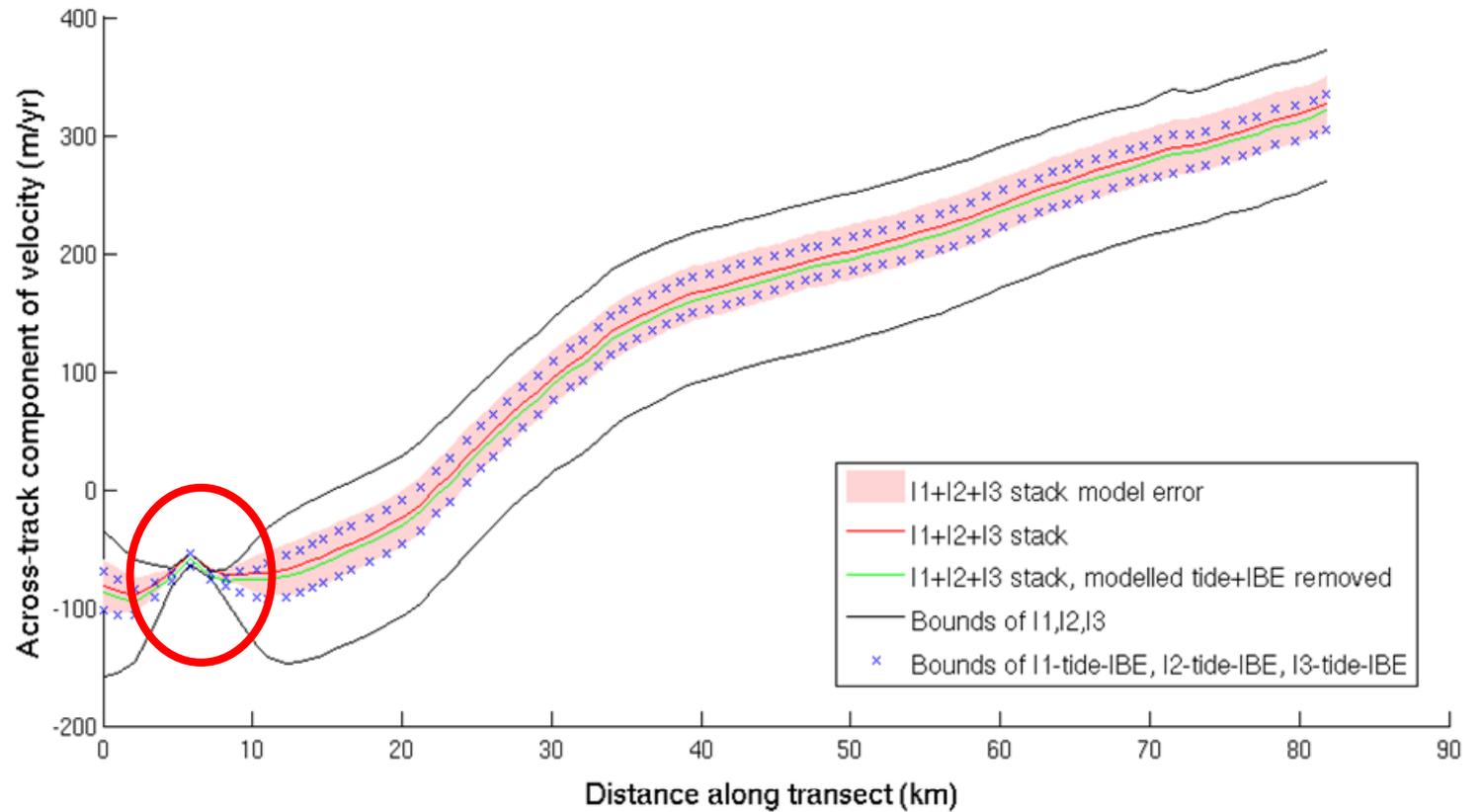


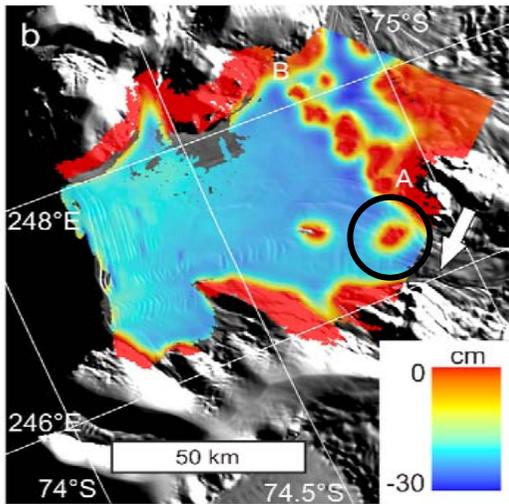
Stacked across-track flow displacement



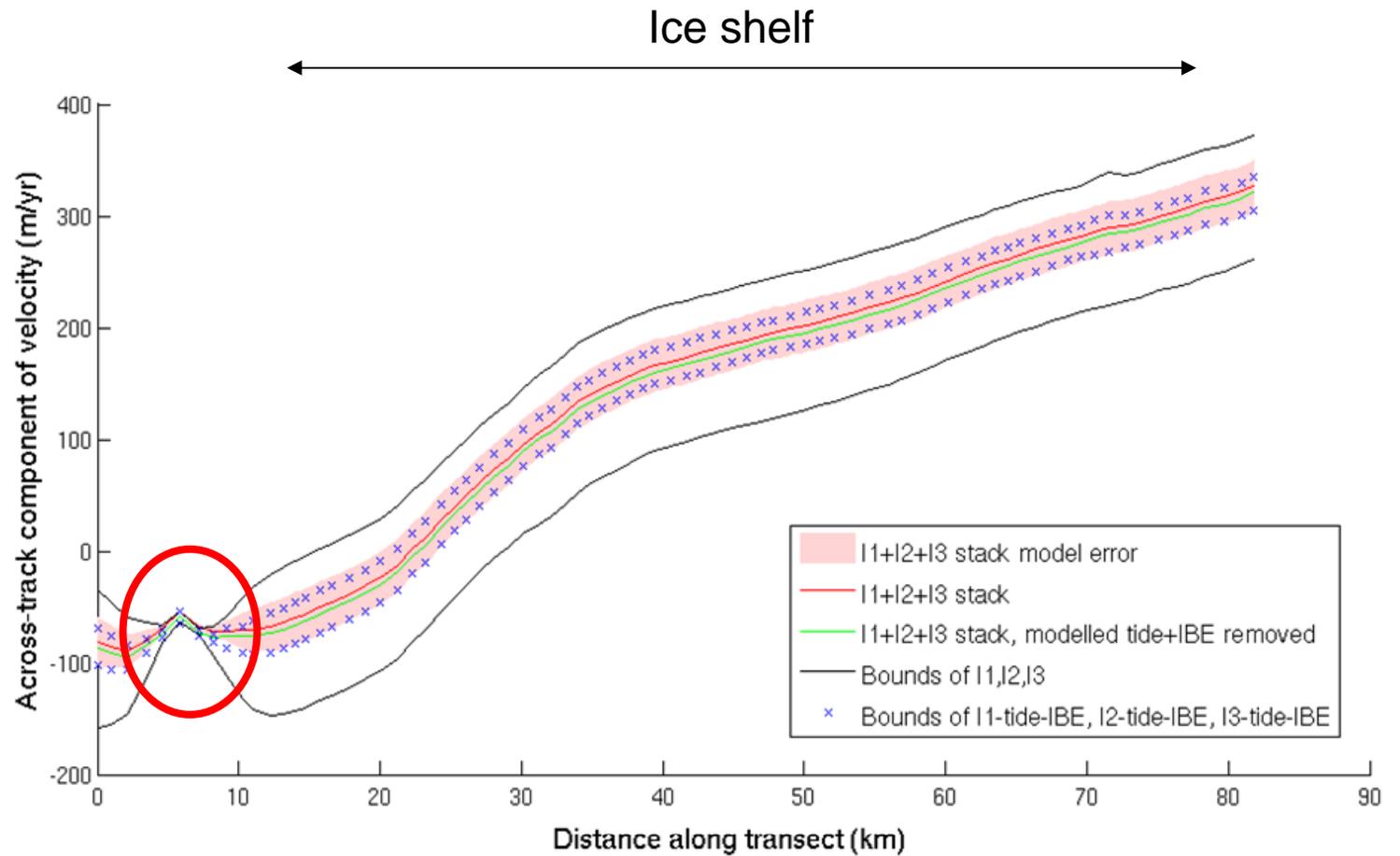


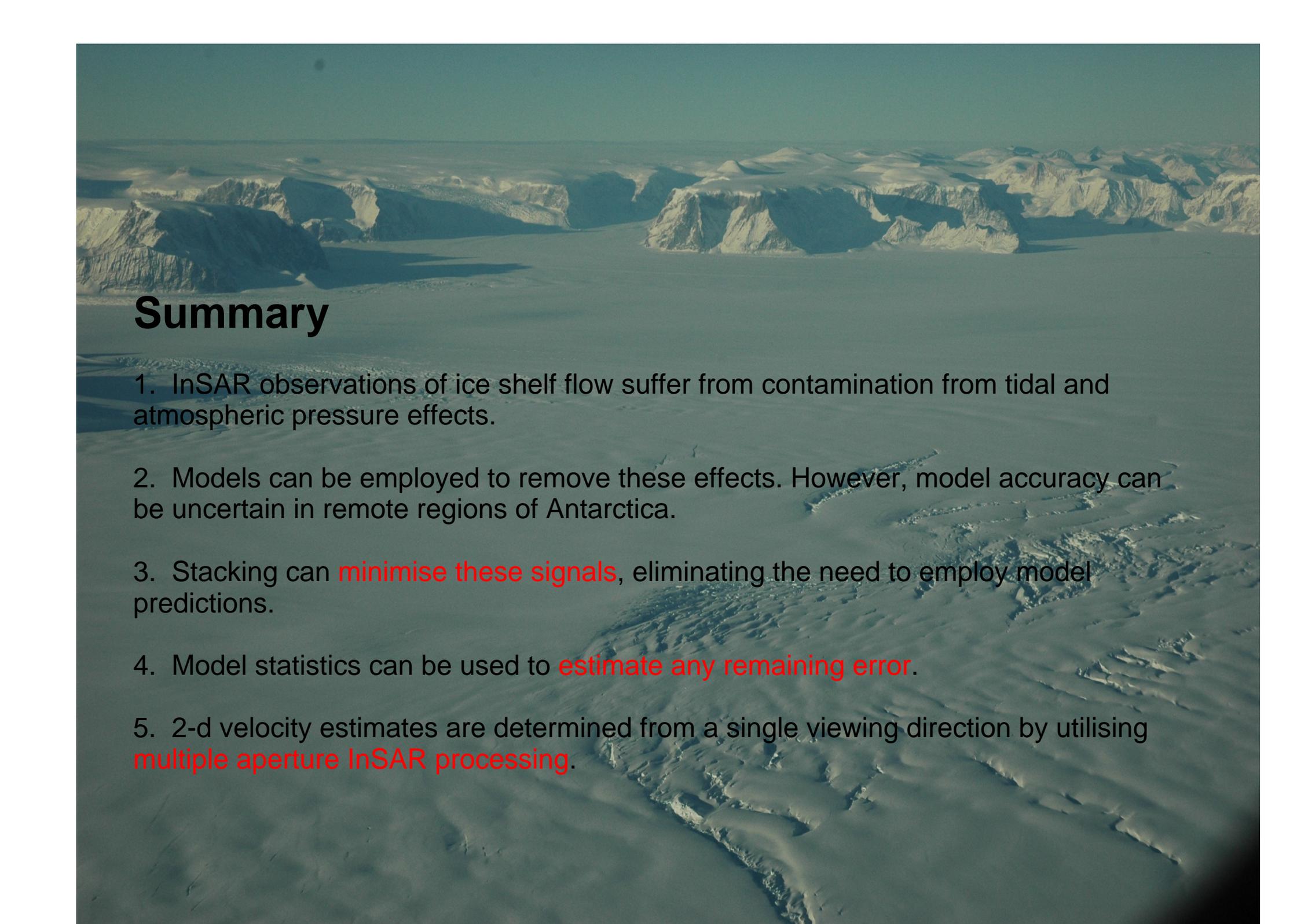
Floating Ice Extent from DInSAR





Floating Ice Extent from DInSAR





Summary

1. InSAR observations of ice shelf flow suffer from contamination from tidal and atmospheric pressure effects.
2. Models can be employed to remove these effects. However, model accuracy can be uncertain in remote regions of Antarctica.
3. Stacking can **minimise these signals**, eliminating the need to employ model predictions.
4. Model statistics can be used to **estimate any remaining error**.
5. 2-d velocity estimates are determined from a single viewing direction by utilising **multiple aperture InSAR processing**.

