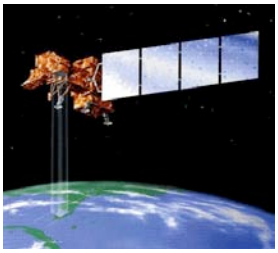
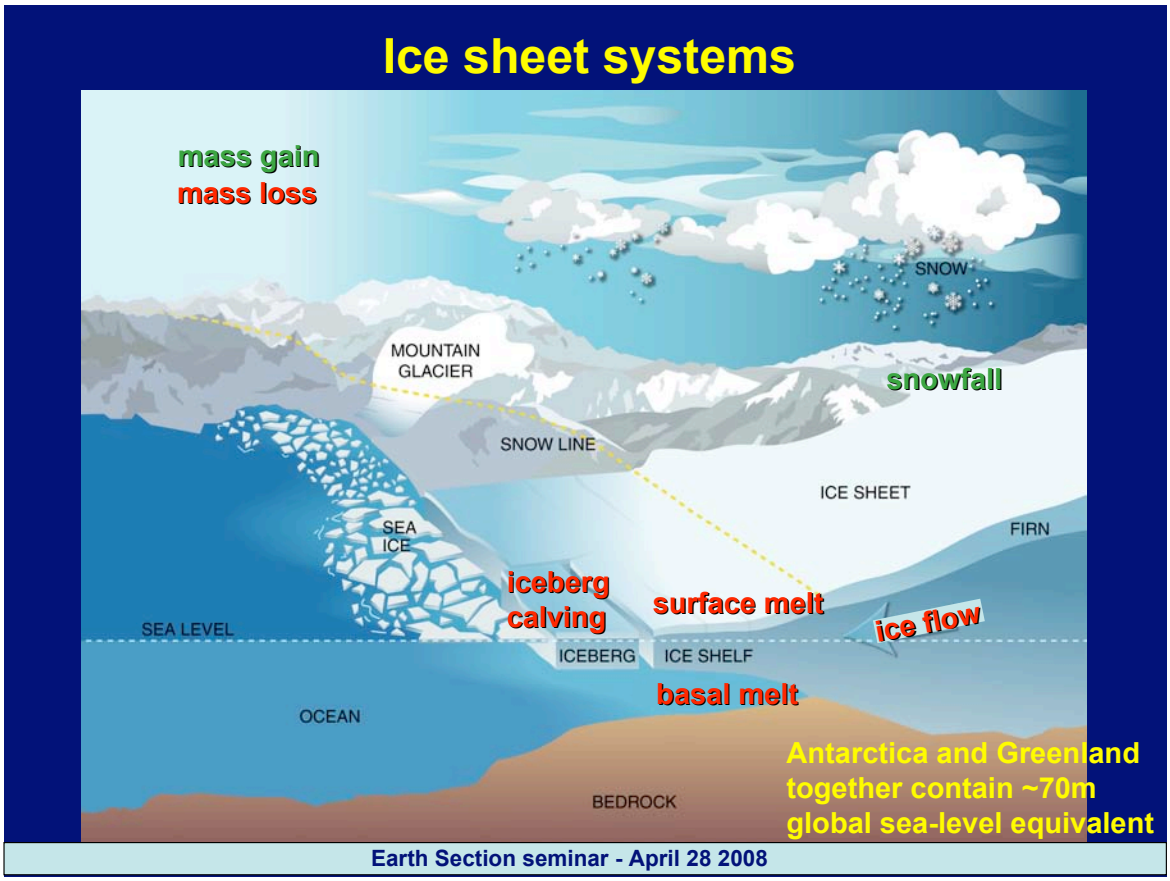
Satellite Remote Sensing
SIO 135/SIO 236

Lecture 16: Applications of SAR and InSAR over ice

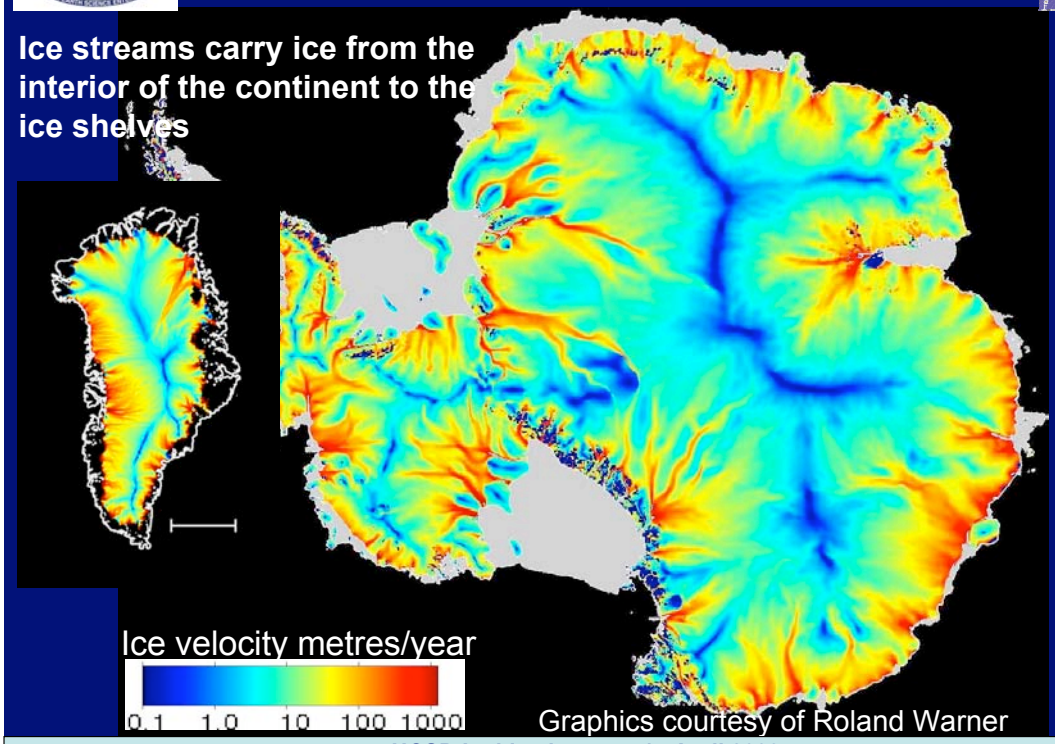
Helen Amanda Fricker





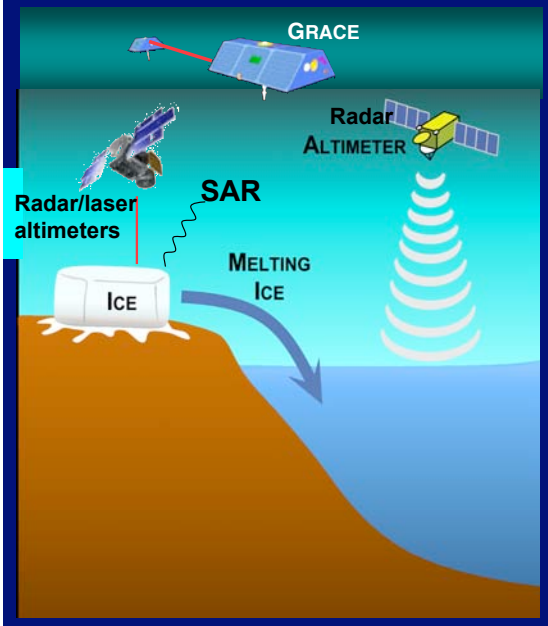
Antarctica's ice streams

Ice streams carry ice from the interior of the continent to the ice shelves



Graphics courtesy of Roland Warner

Measuring ice sheet mass balance (and sea-level rise)



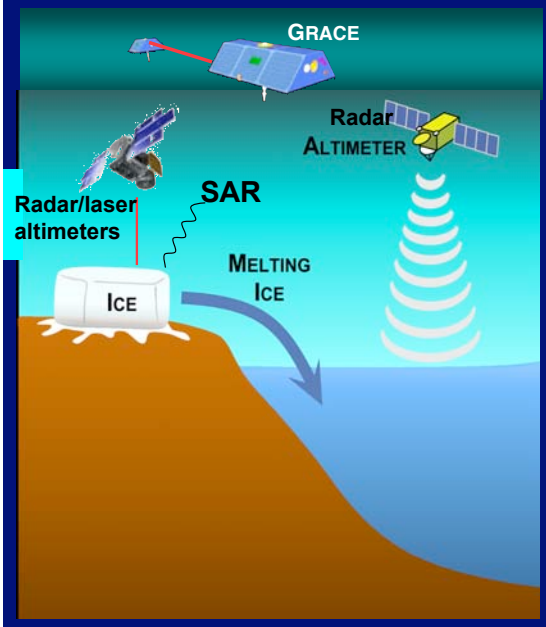
Three methods used to assess "health" of an ice sheet by satellite:

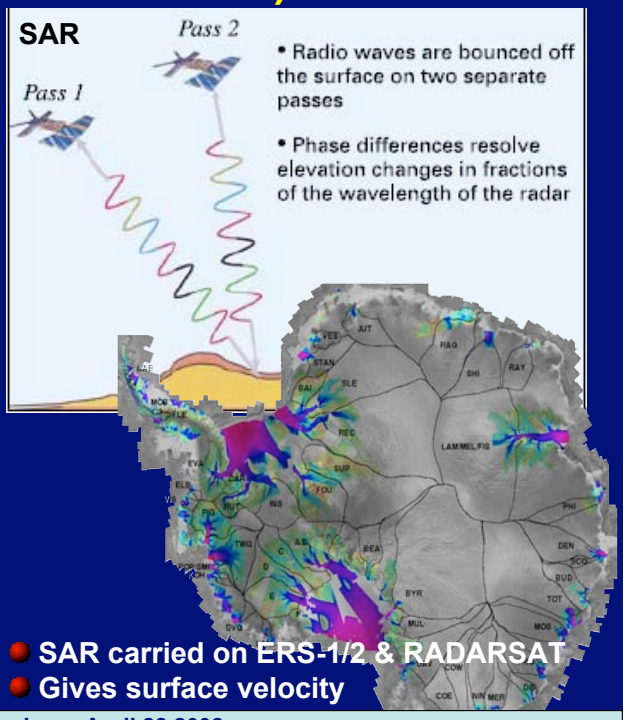
1) Direct measurement of change in elevation with time (using altimeters)

2) Measurement of mass change with time (using GRACE)

3) Estimation of mass fluxes (using SAR-derived velocities & ice thickness from altimetry)

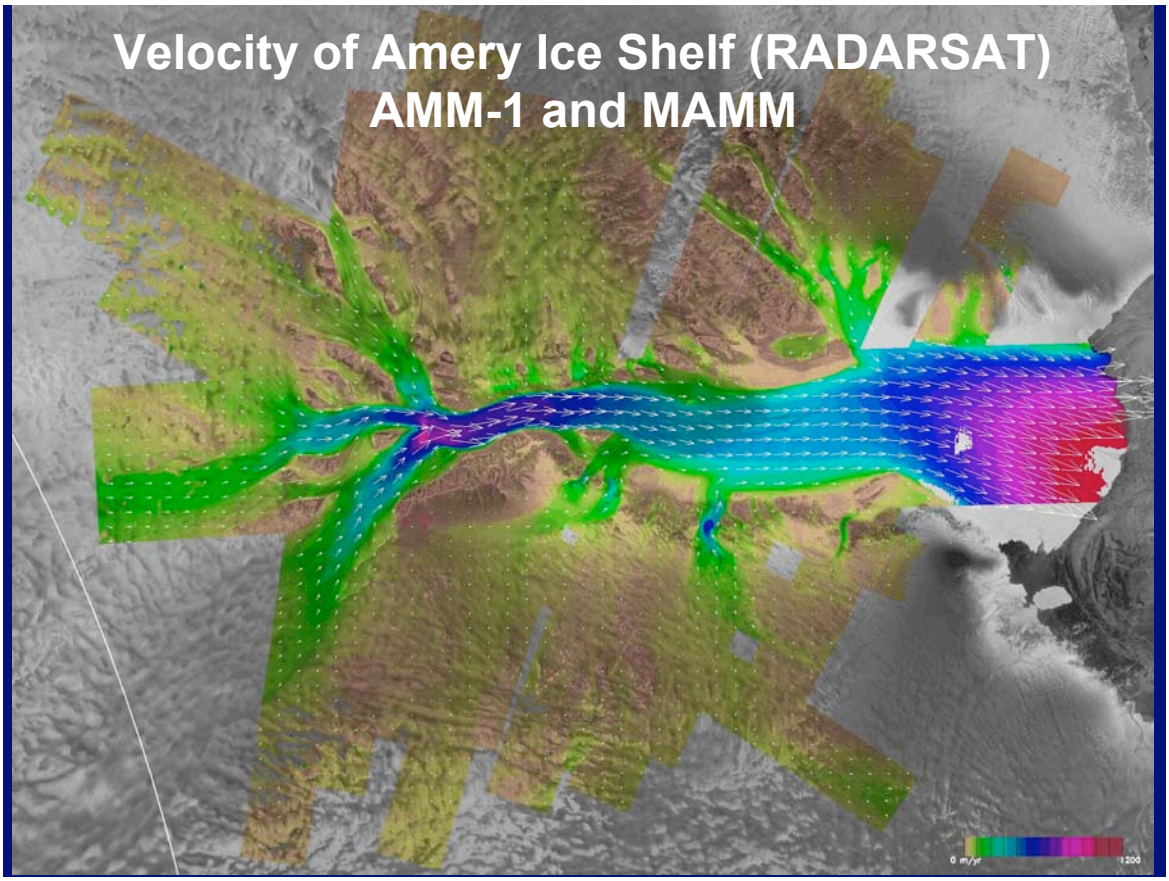
Measuring ice sheet mass balance (and sea-level rise)



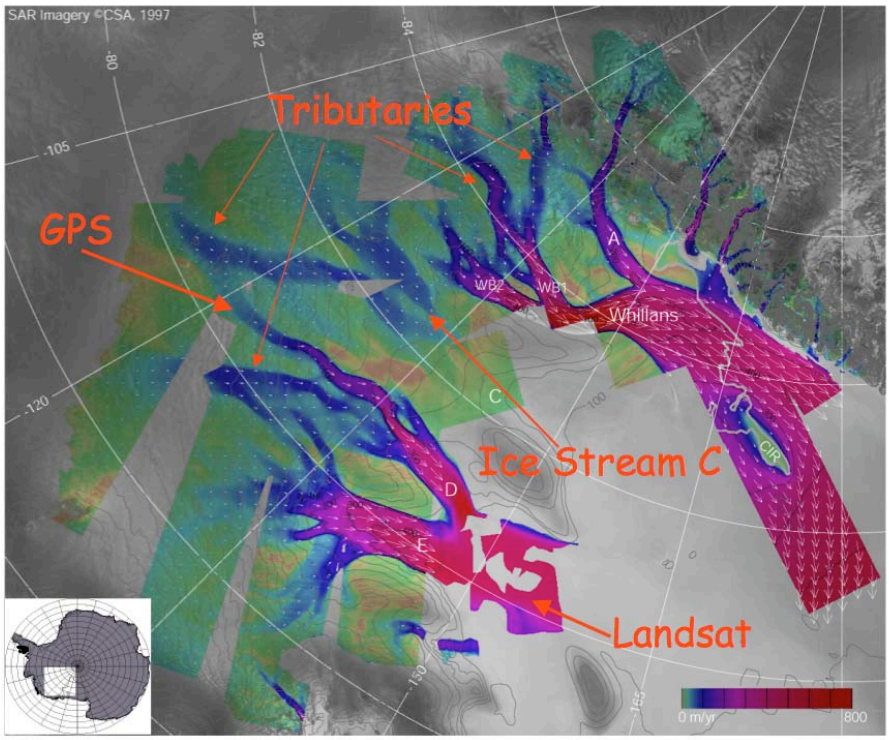


- SAR carried on ERS-1/2 & RADARSAT
- Gives surface velocity

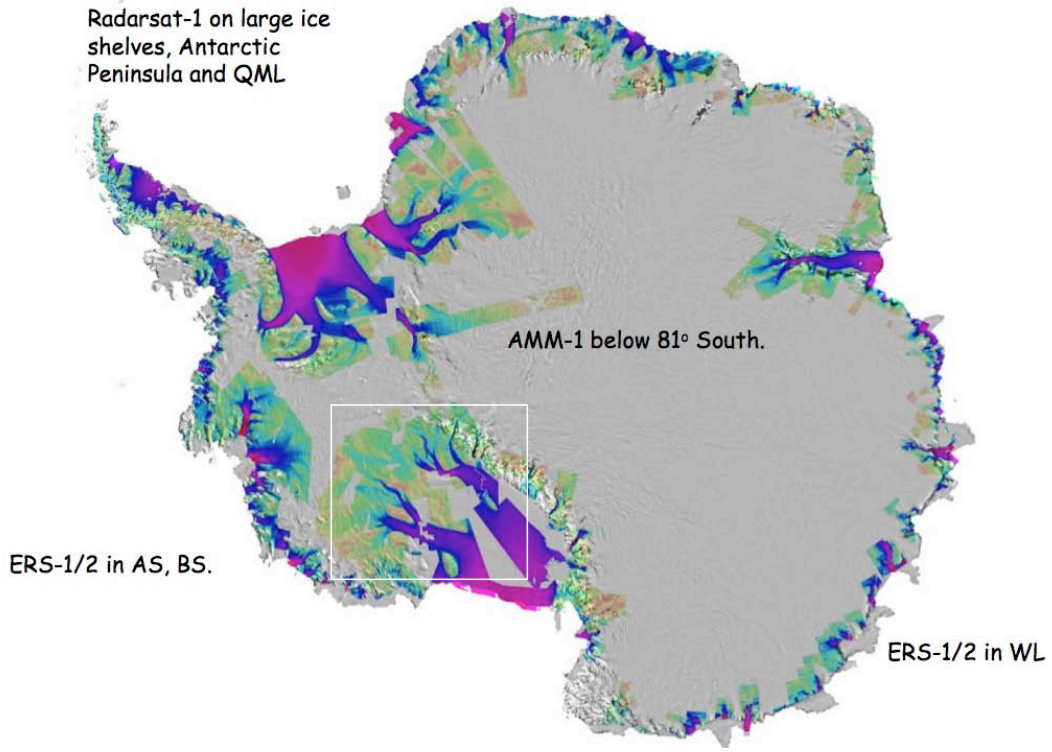
Velocity of Amery Ice Shelf (RADARSAT) AMM-1 and MAMM



Velocity of Siple Coast ice streams



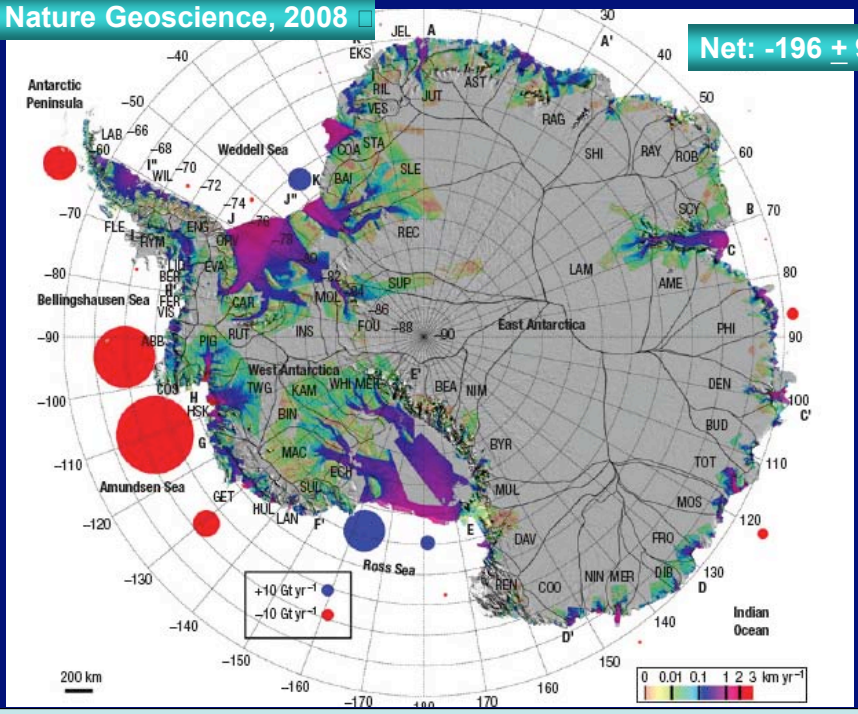
Antarctic ice velocity:
ERS-1/2 (1996), Radarsat-1 (1997/2000), ALOS (2006)



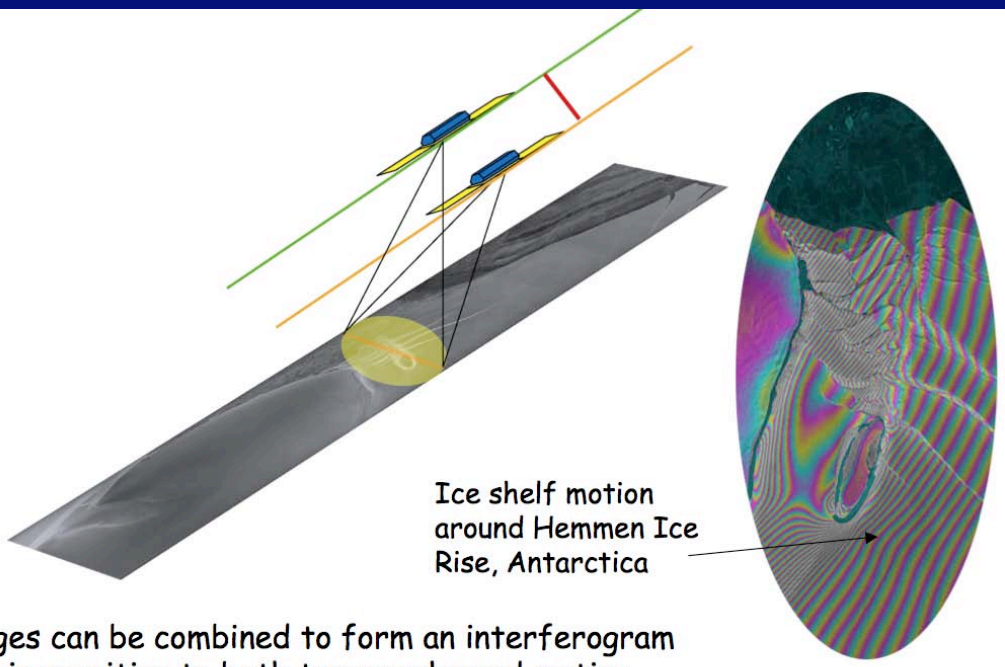
Antarctica mass loss 2006
Mass flux estimates

Rignot et al., Nature Geoscience, 2008

Net: -196 ± 92 Gta^{-1}

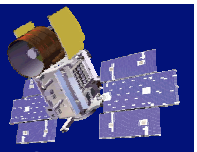


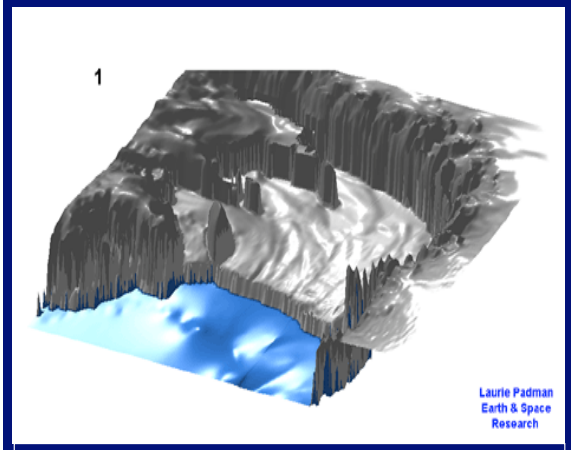
InSAR over ice shef rifts



Images can be combined to form an interferogram that is sensitive to both topography and motion

Ice shelf grounding zone (GZ)

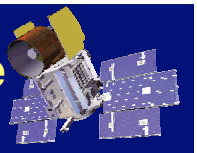




Tide model of Ross Ice Shelf run over 25 hours

- Transition zone between fully floating & fully grounded ice
- Often poorly defined by pre-ICESat datasets
- Regions of significant basal melt
- Complex physics: coupling of bedrock, till, ice & ocean
- Can rapidly evolve in response to changes in ice thickness & sea level
- Monitoring GZs is important part of ice sheet change detection, the primary goal of the ICESat Mission

Features near the grounding zone



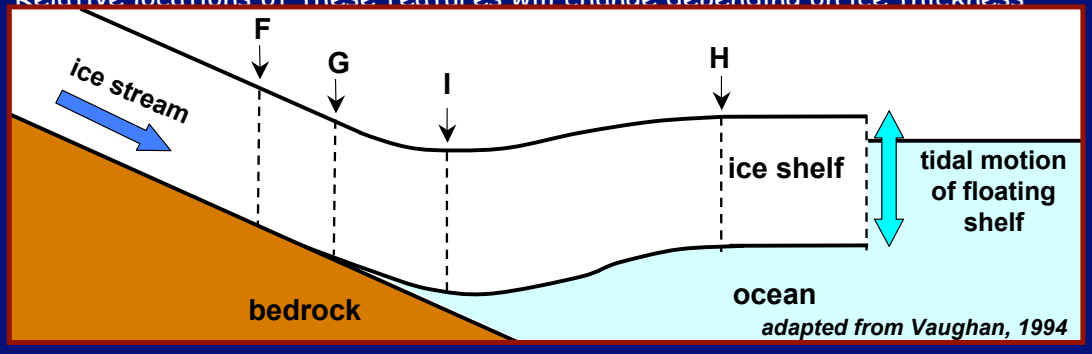
H: inshore limit of the hydrostatic zone of free floating ice shelf ice

I: inflexion point - in some cases this may just be a change in slope

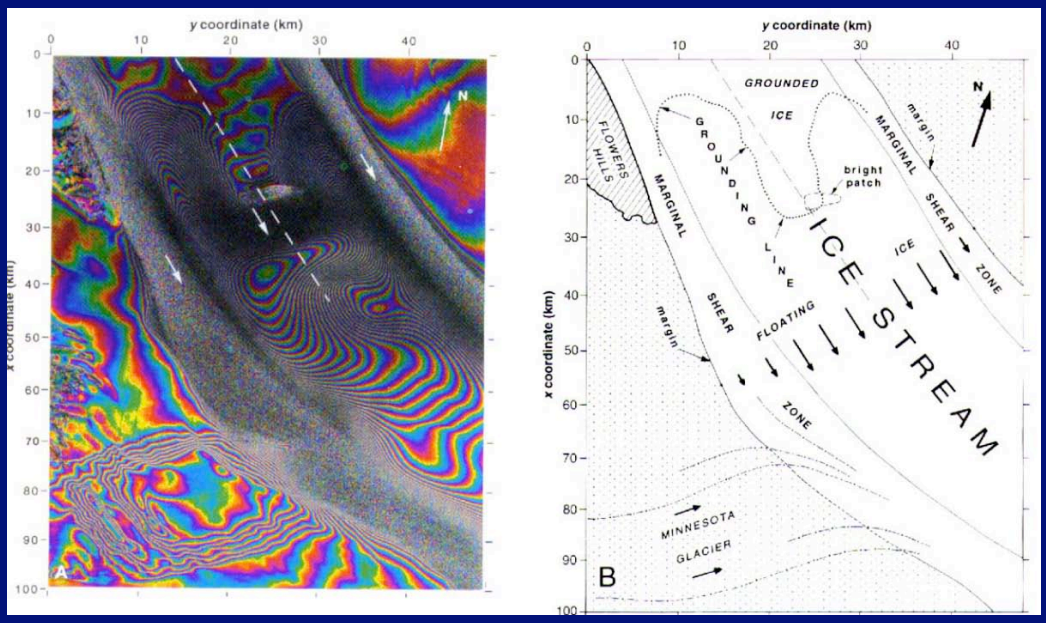
G: limit of ice flotation

F: limit of ice flexure from tidal movement

Relative locations of these features will change depending on ice thickness



InSAR detection of grounding lines

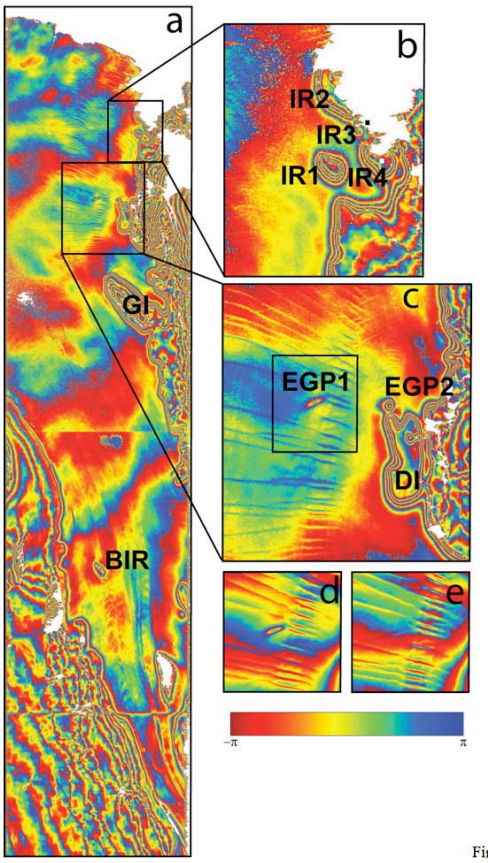


Interferogram of the Rutford Ice Stream, West Antarctica. Both the rapid flow of the ice stream and the location of the grounding line are visible. The fringes show displacements over a 6 day period with each color cycle representing 28mm of LOS displacement. Courtesy D. Goldstein, JPL.

InSAR detection of grounding lines

Differential SAR Interferometry (DSI)

Difference between two interferograms over same time interval (to remove ice flow)



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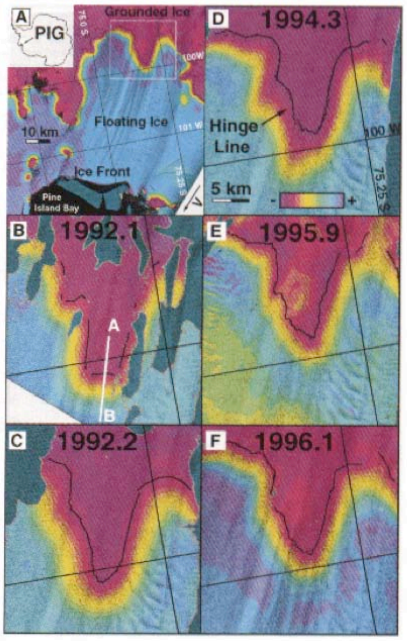
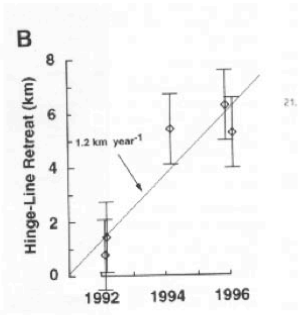
InSAR detection of grounding lines

Example: Glacier Recession, Pine Island Glacier, Antarctica





Reference: Rignot, Science, 1998