

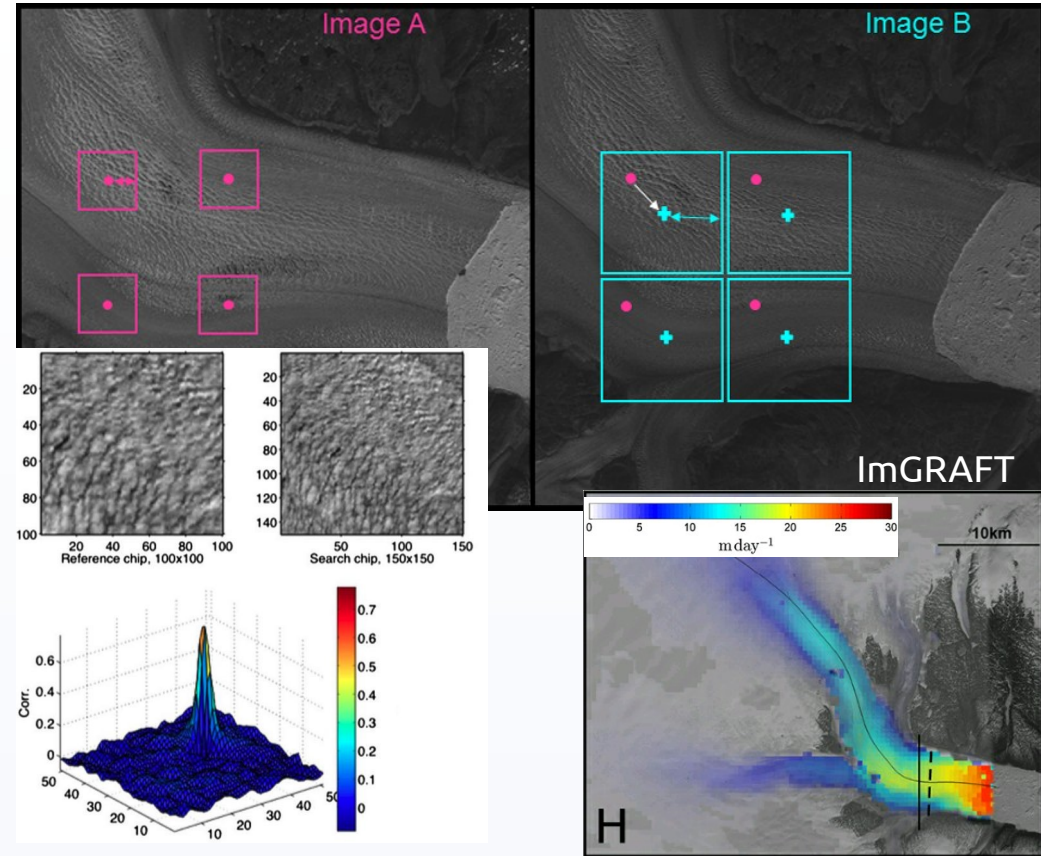
EGM310: GIS and Remote Sensing

Week 12, Part 3: Applications – Observing Surface Motion

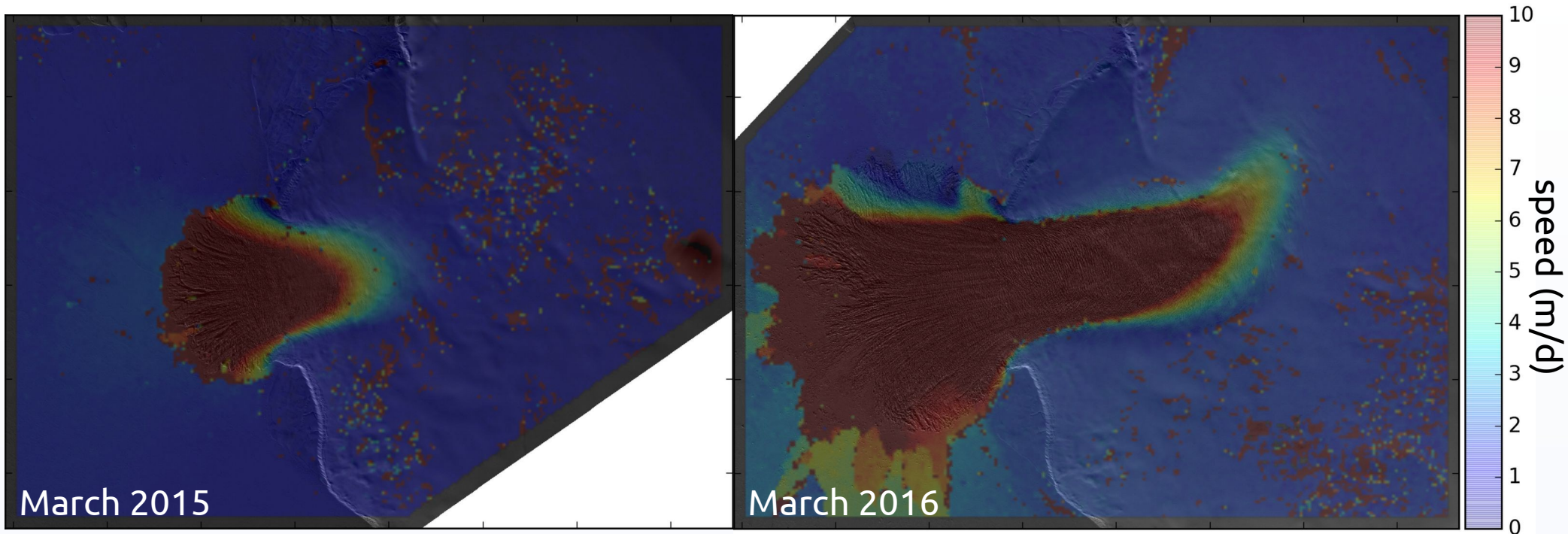
- “Slow” movements can be observed from space:
 - Glaciers
 - Permafrost
 - Landslides*
 - Ground subsidence
 - Volcanoes
 - Earthquakes
- Can use optical, microwave sensors



- Need:
 - Two images spaced enough (in time) to see change
 - Must be orthorectified
- Template matching:
 - Normalized Cross-Correlation
 - Phase correlation

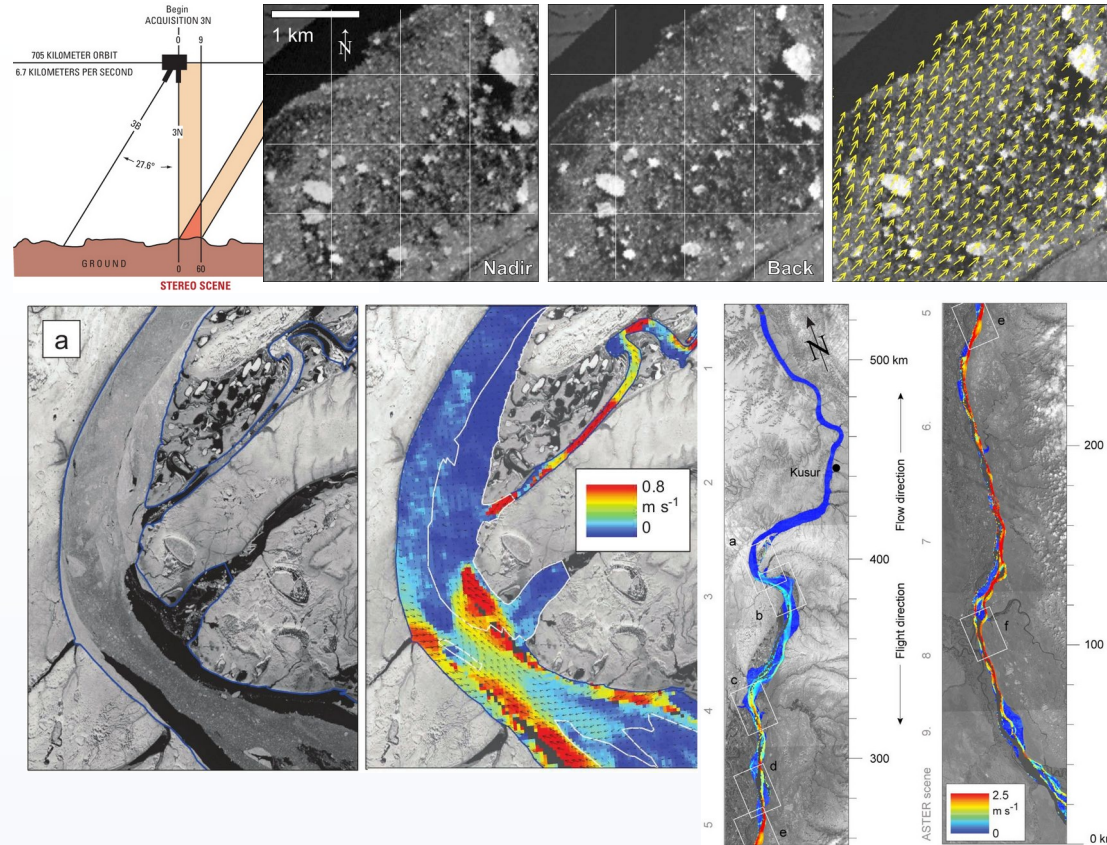


Example: Vavilov Ice Cap

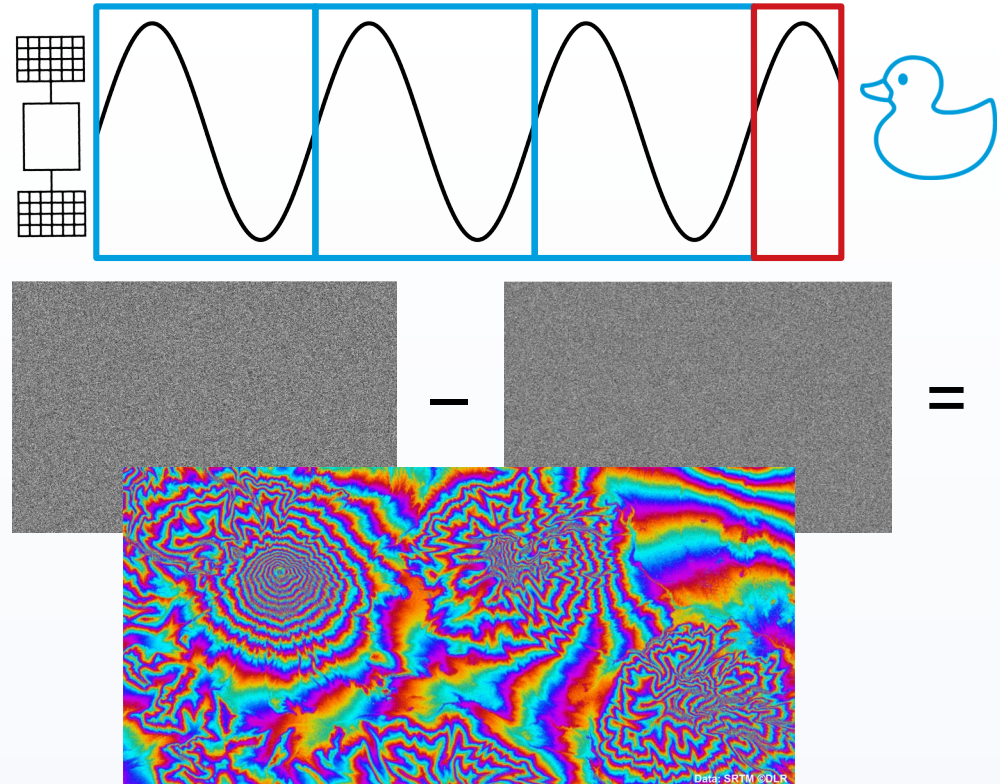


Example: river flow

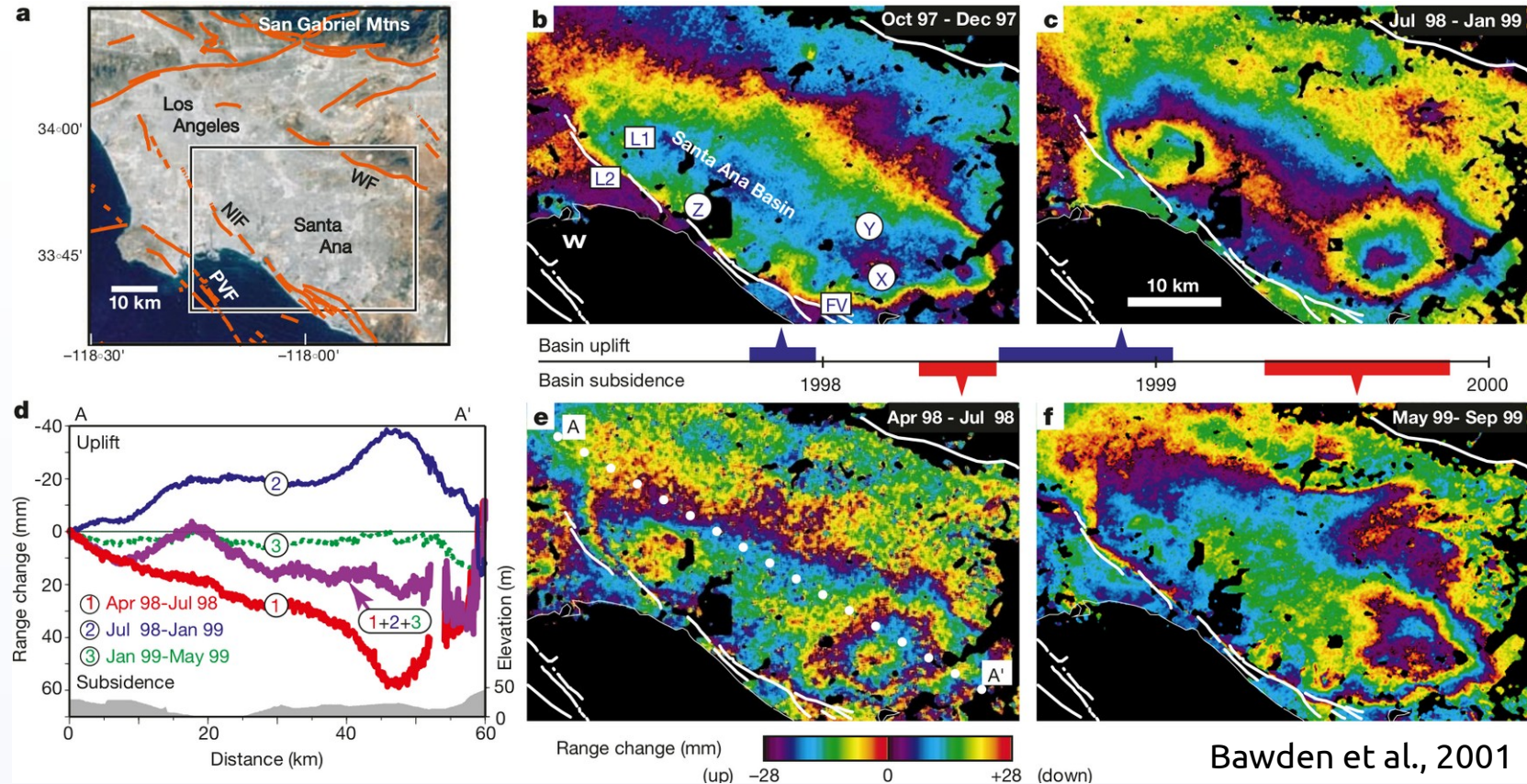
- ASTER has nadir, backward-looking cameras (~60 s difference)
- Can be used to track faster motion, such as river flow
- Need suitable objects (ice floes) to track
 - e.g., Kääb et al. 2013, *Hydrol. Earth Syst. Sci.*



- **Phase:** partial wavelength
- Radar signal phase determined by:
 - Distance between sensor, ground
 - Random **noise** caused by scattering from 'small' objects
- With 2 images*, can remove random component → topography
 - Ambiguous: needs **unwrapping**
- With 3 images* (or 2* + DEM) → deformation (motion)
 - In Line of Sight (LOS) of sensor
 - Great for small deformations

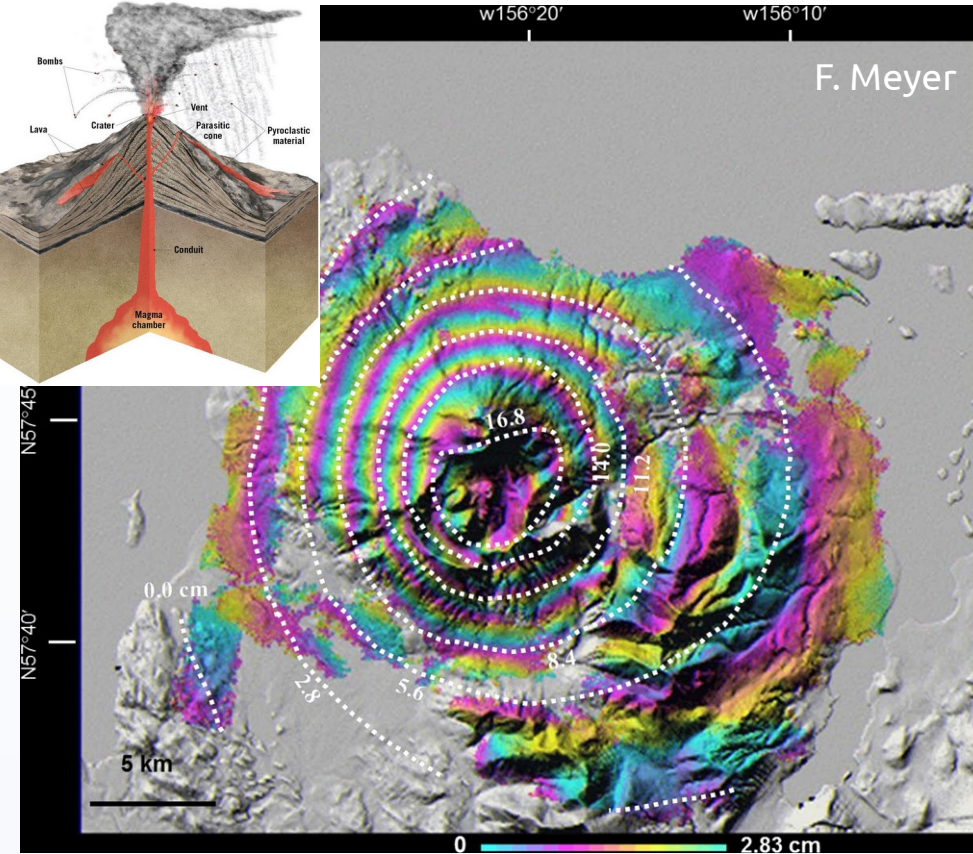
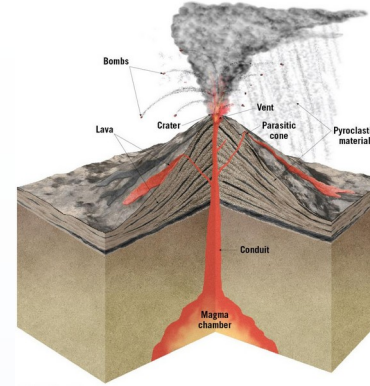


Example: subsidence due to groundwater pumping

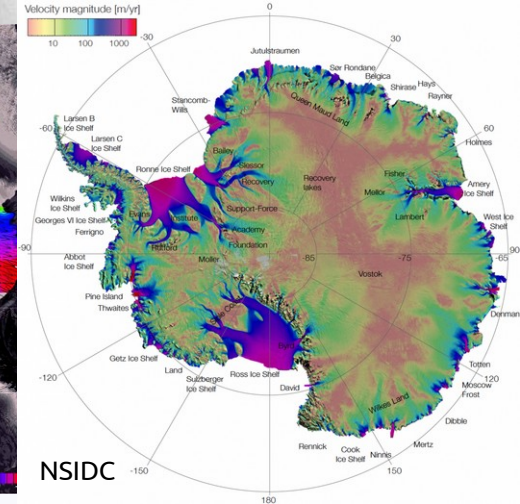
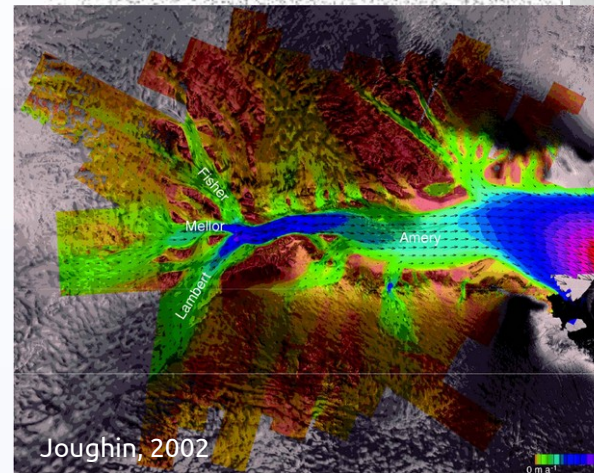
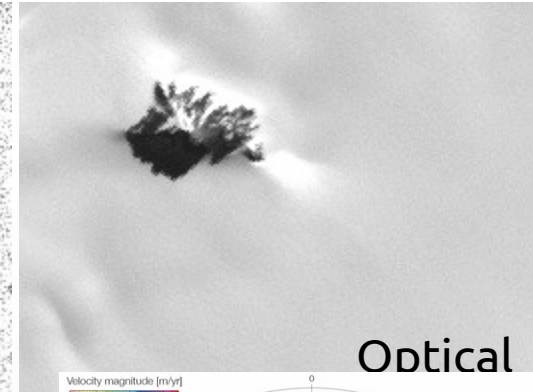


Example: Volcano studies

- Ugashik-Peulik, Alaska (1995-1997)
- Inflation of magma reservoir by $\sim 0.04 \text{ km}^3$ at a depth of $\sim 6 \text{ km}$
- Results in observed ground deformation up to $\sim 17 \text{ cm}$
- No eruption, but activity monitored

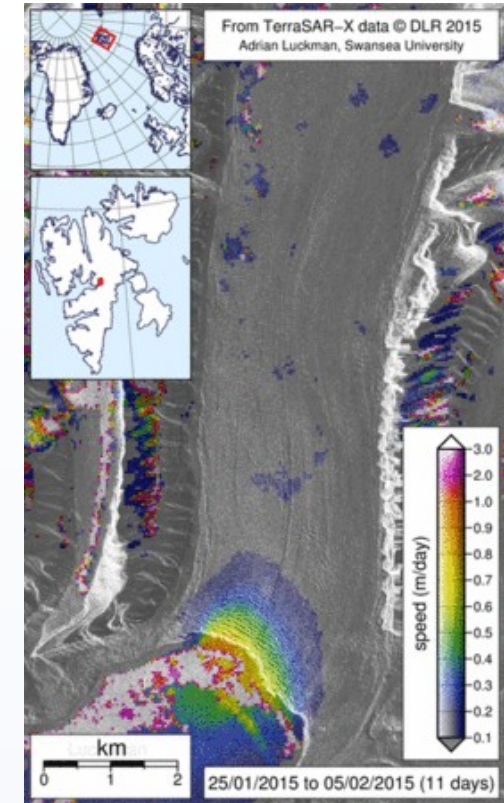
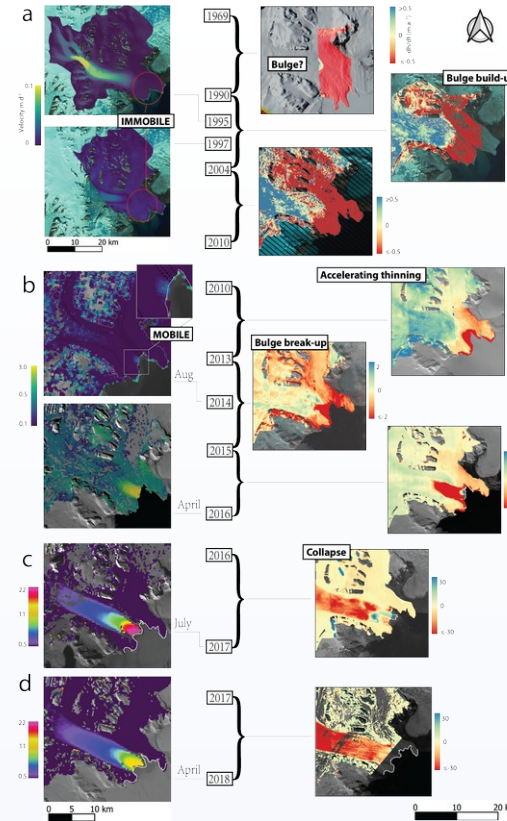


- Radar images have **speckle**
- Can use this for offset tracking (**speckle tracking**)
- Displacement in image coordinates (2-component)
- Works best for larger deformations



Example: glacier acceleration

- Glacier **surge**: periodic acceleration of ~ 10 – 100 times “normal” speeds
- Occur around much of the globe, including high Arctic
- During polar night, SAR satellites help observe, study



- We have a number of tools available to study motion/deformation
 - Optical
 - Microwave
- Technique depends on application, data availability
 - Optical: weather, seasonal limitation
 - InSAR: surface moisture, large deformation
 - Speckle Tracking: surface moisture

- How do glaciers move? Timelapse! [[BBC Earth Lab](#)]
- Landsat's global view of ice velocity [[NASA](#)]
- InSAR [[Michigan Tech](#)]
- Volcano Warning Signs [[Matthew d'Alessio](#)]
- What is going on at Tunabreen? [[Penny How](#)]