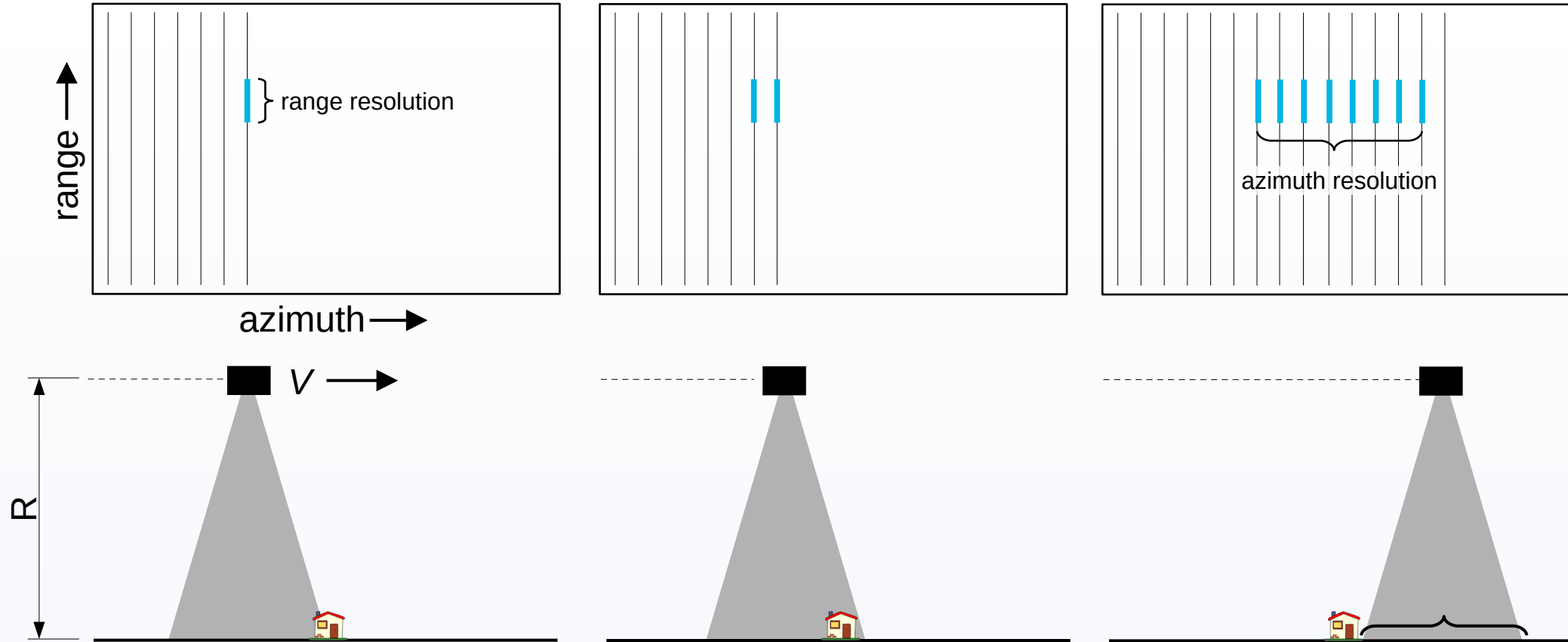


EGM703 – Advanced Active and Passive Remote Sensing

Week 3, Part 4: Synthetic Aperture Radar

Constructing a radar image

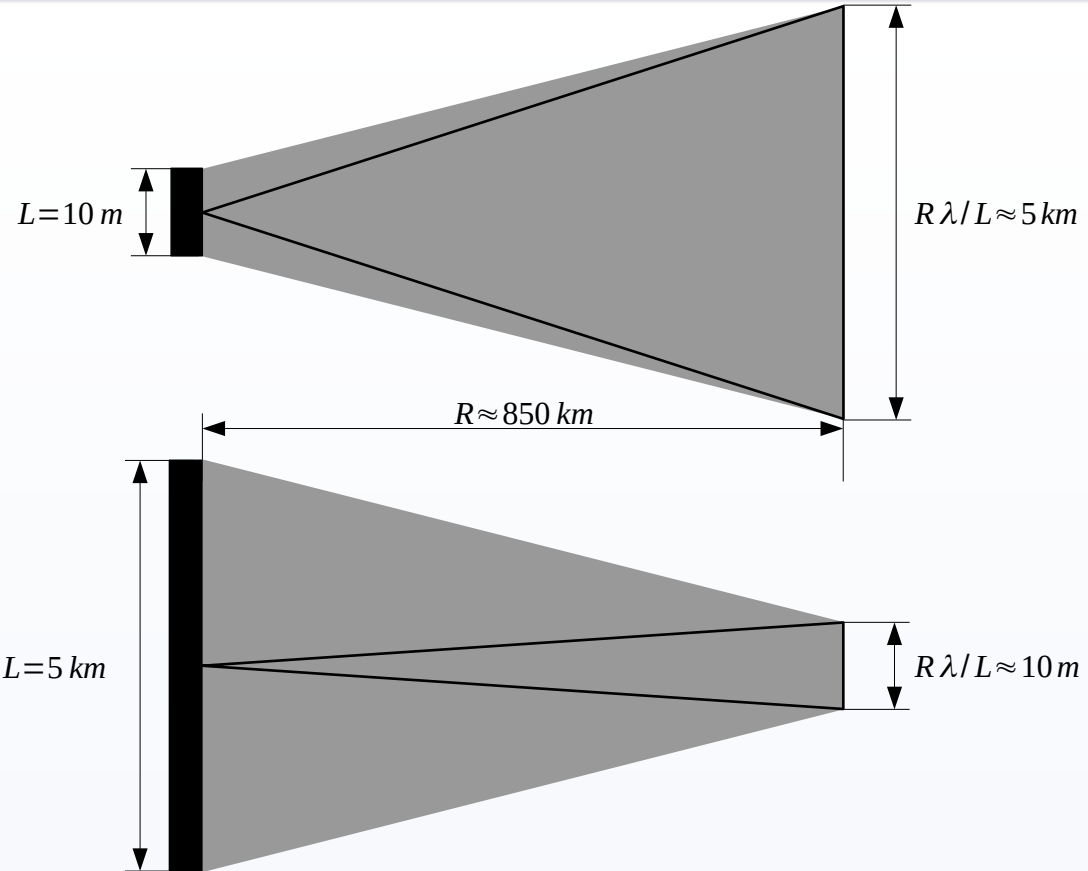


- Azimuth resolution is related to:
 - Antenna width, L
 - Distance to target, R

- Formula:

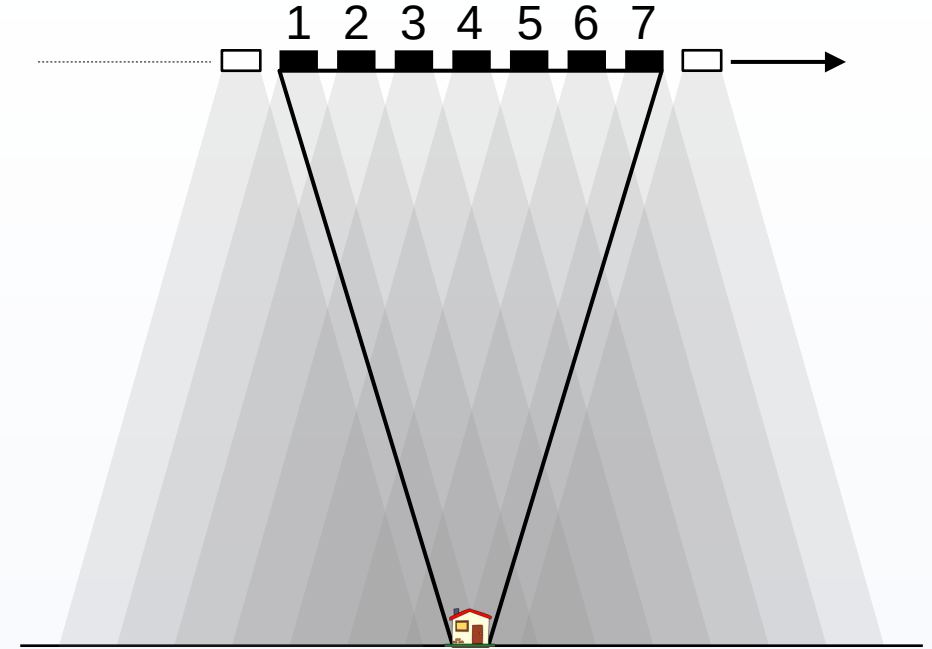
$$\rho_a \approx \frac{R \lambda}{L}$$

- So, to improve resolution, we need to:
 - Decrease λ
 - Increase antenna size

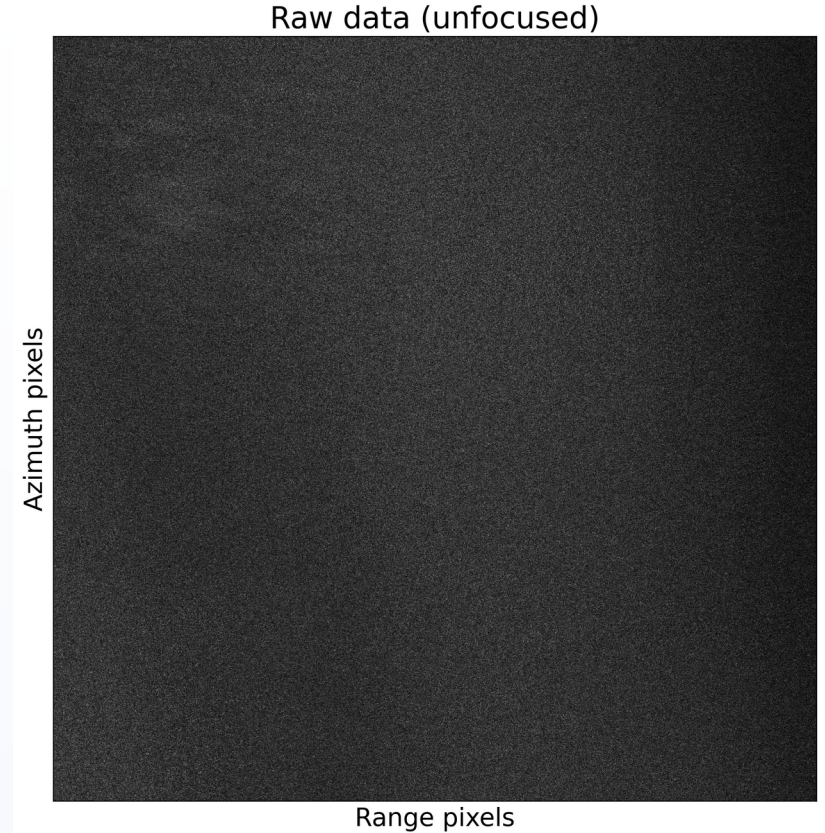


Putting the “synthetic” in SAR

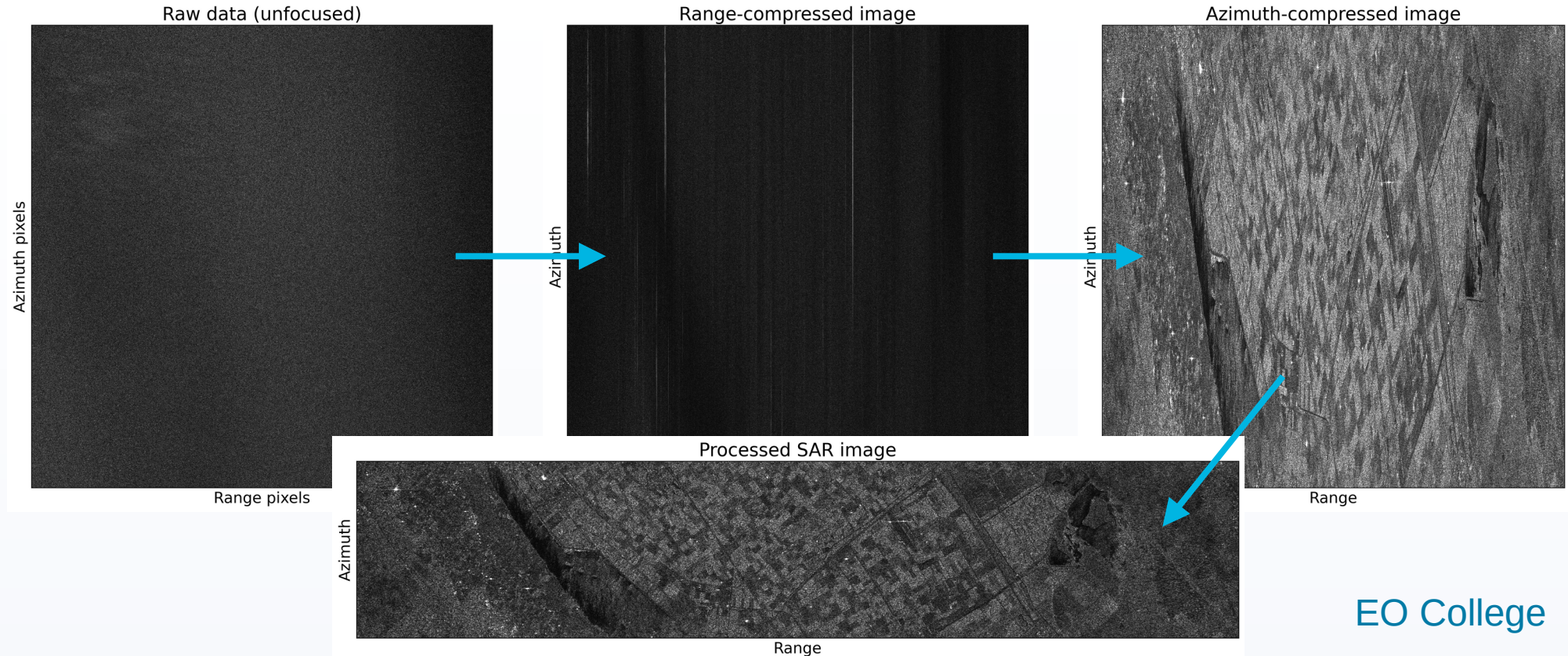
- As platform is moving, returns will be **Doppler shifted**:
 - Area ahead of platform: **higher** frequencies
 - Area behind platform: **lower** frequencies
- By processing returns based on Doppler shift, can simulate (**synthesize**) a large antenna
- Azimuth resolution: $L/2$
 - Independent of range (!)



- Raw SAR images look like noise
 - Many different overlapping returns
- To make sense of this, we have to **focus**
 - Range compression
 - Azimuth compression
- Optional step: multilook
(average azimuth pixels)

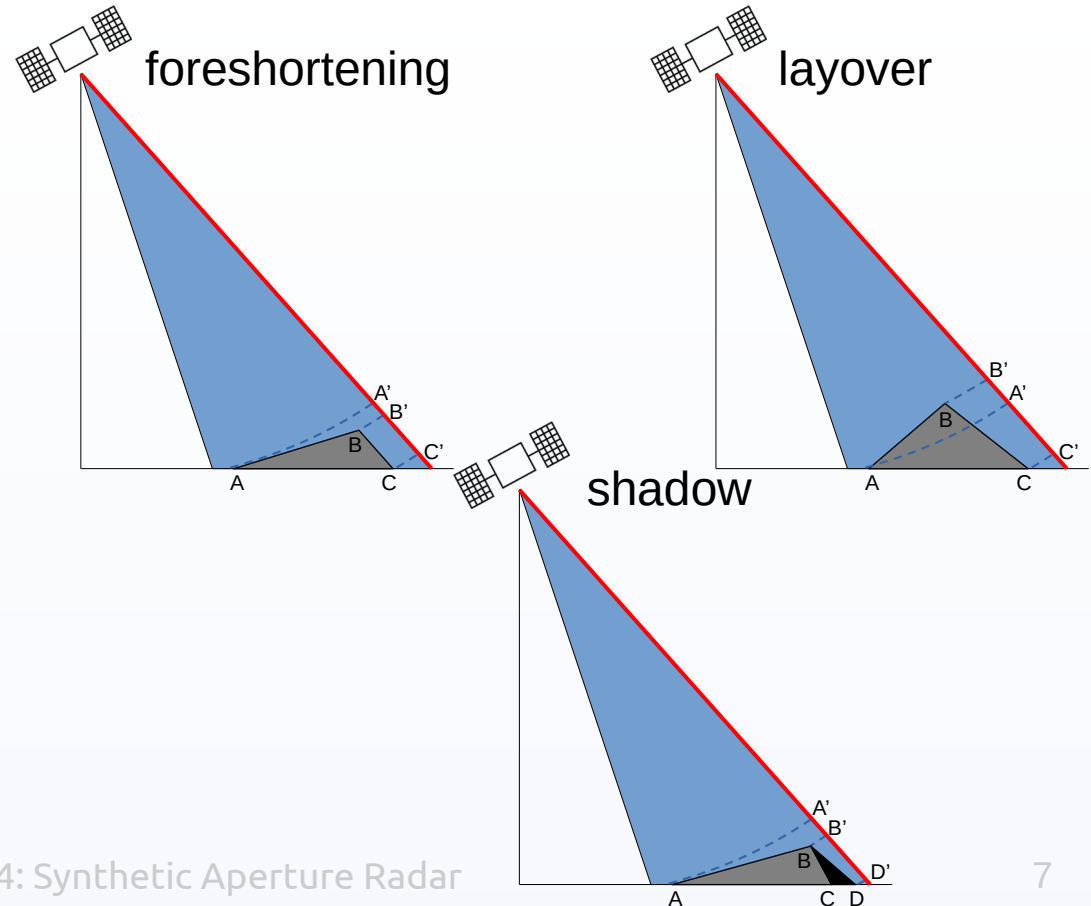


From raw images to multilook images



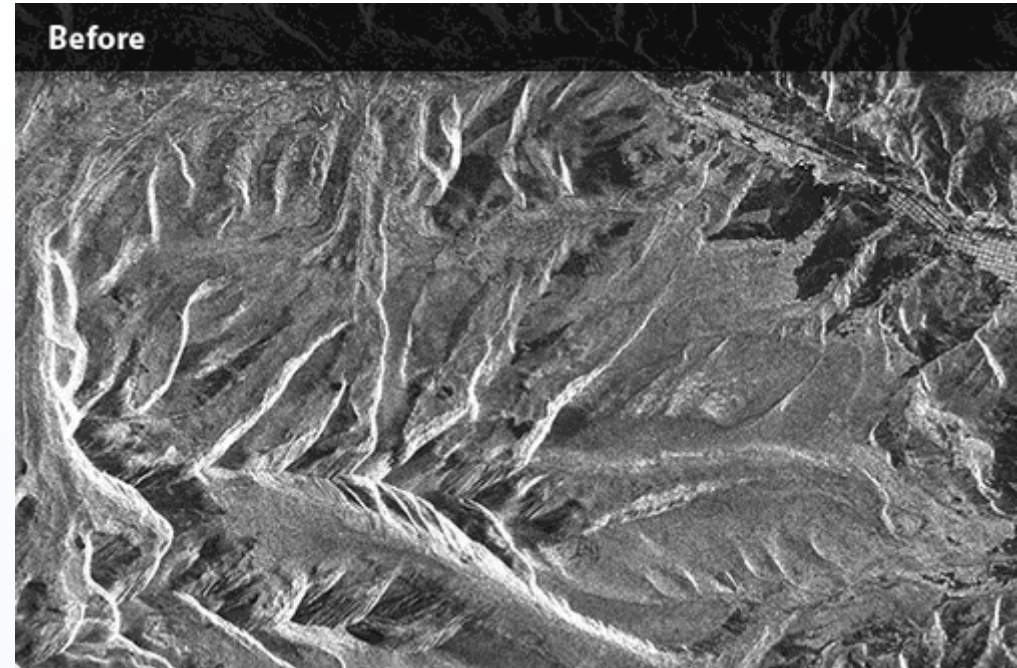
Geometric distortion

- Because radar is side-looking, images are distorted
- Foreshortening
 - AB is shortened to AB' due to slope
 - A and B are at similar distances to sensor
 - Bright pixel values
- Layover
 - Extreme foreshortening
 - B (top of mountain) is closer to sensor
 - Bright pixel values
- Shadow
 - Backslope is entirely hidden from the sensor
 - Dark pixel values



(Geometric) Terrain Correction

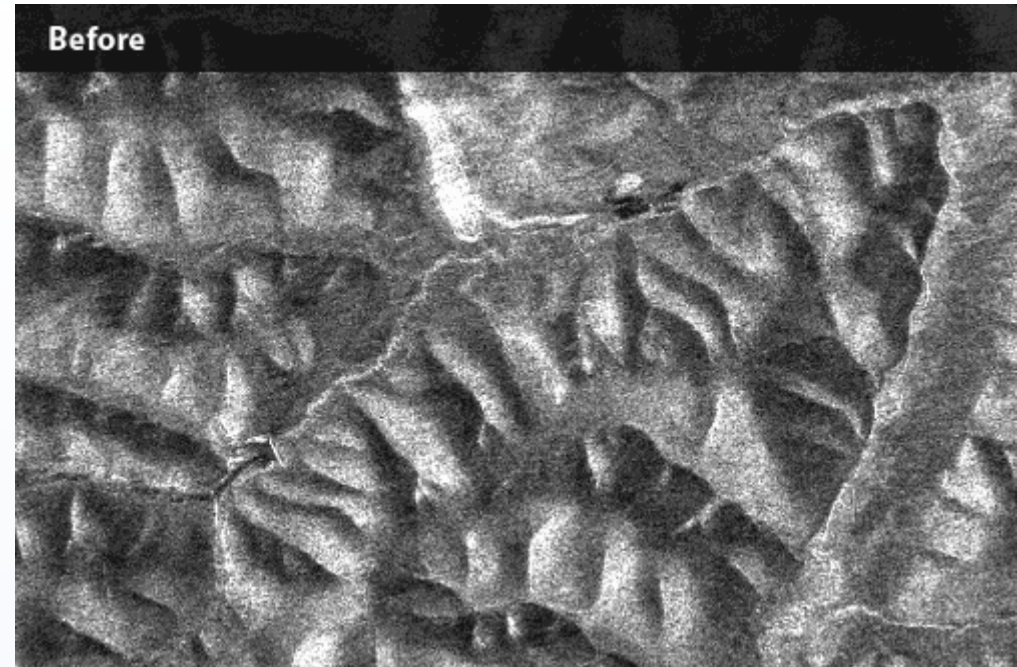
- SAR image, once focused, is in radar geometry (range/azimuth)
 - Image must be georeferenced/geocoded
- Need a DEM to help correct distortion
 - Similar to orthorectification of optical images



ASF & JAXA/METI

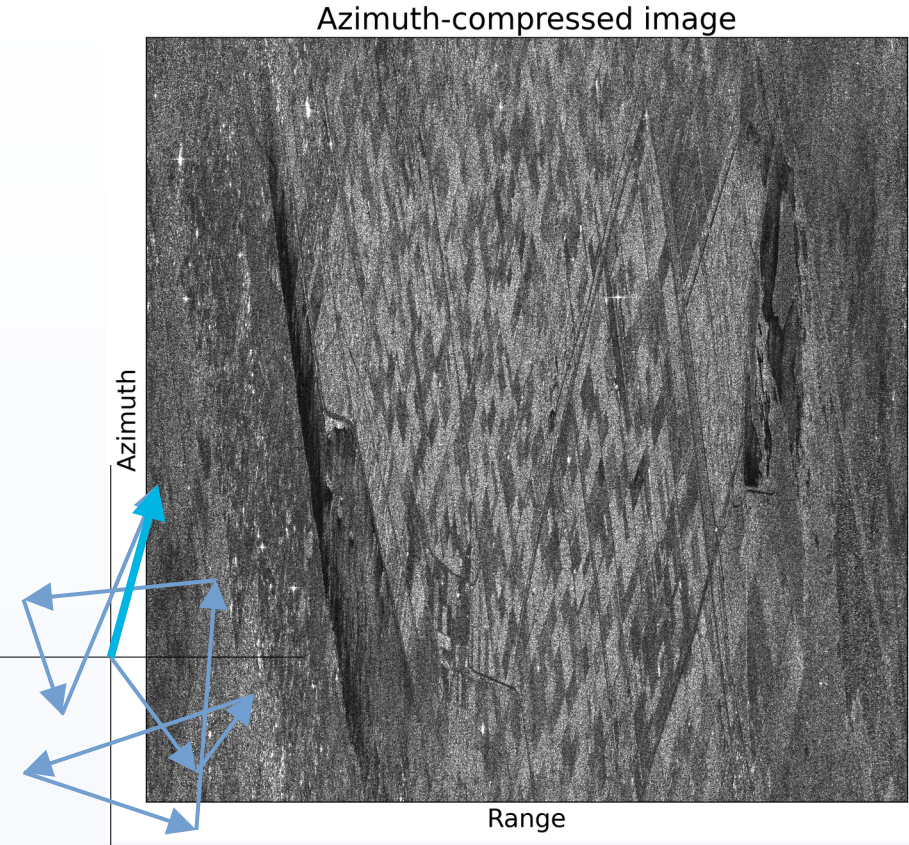
(Radiometric) Terrain Correction

- Slopes:
 - Facing sensor: bright
 - Facing away: dark
- To get the actual backscatter, have to remove terrain effect



ASF & JAXA/METI

- SAR images look “noisy” (speckle)
- Not actually “noise” – it’s an interference pattern!
- Recall:
 - SAR sensor records amplitude, phase
 - Phase of individual pixel: sum (interference) of subpixel scatterers
- Speckle varies with time
 - On average, backscatter is equal to σ^0



- Azimuth resolution of radar image restricted by antenna size
- Solution: fake it till you make it!
- With clever signal processing, can obtain high-resolution radar images from space
- SAR imagery has distortions that we normally want to correct

- Lillesand, Kiefer & Chipman – Chapter 6.4
- Campbell & Wynne – Chapter 7
- radartutorial.eu
- Moreira et al., 2013 [[IEEE Geosci. Rem. Sens. Mag.](#)]
- What is Synthetic Aperture Radar? [[NASA](#)]
- A New Way to View Titan: ‘Despeckle’ It [[NASA](#)]
- Synthetic Aperture Radar: Of Bats and Flying Pianos [[Adrian Schubert](#)]