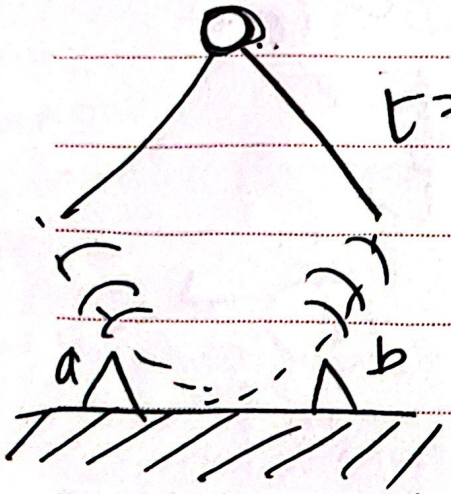
RADAR ⟶ 1) Real Aperture
2) Synthetic Aperture.

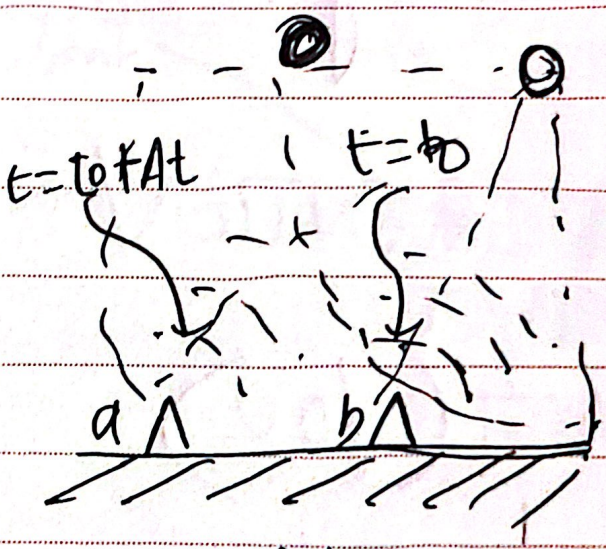
All RADAR.

Image forming → Side looking
eg. SAR.

Non-Image forming → Down looking
eg. Altimeters.



Both 'a' and 'b' appear to be at the same place/ coordinate since t is same



since 'a' & 'b' have different time delays, the sensor can recognise them as different obj/ place.

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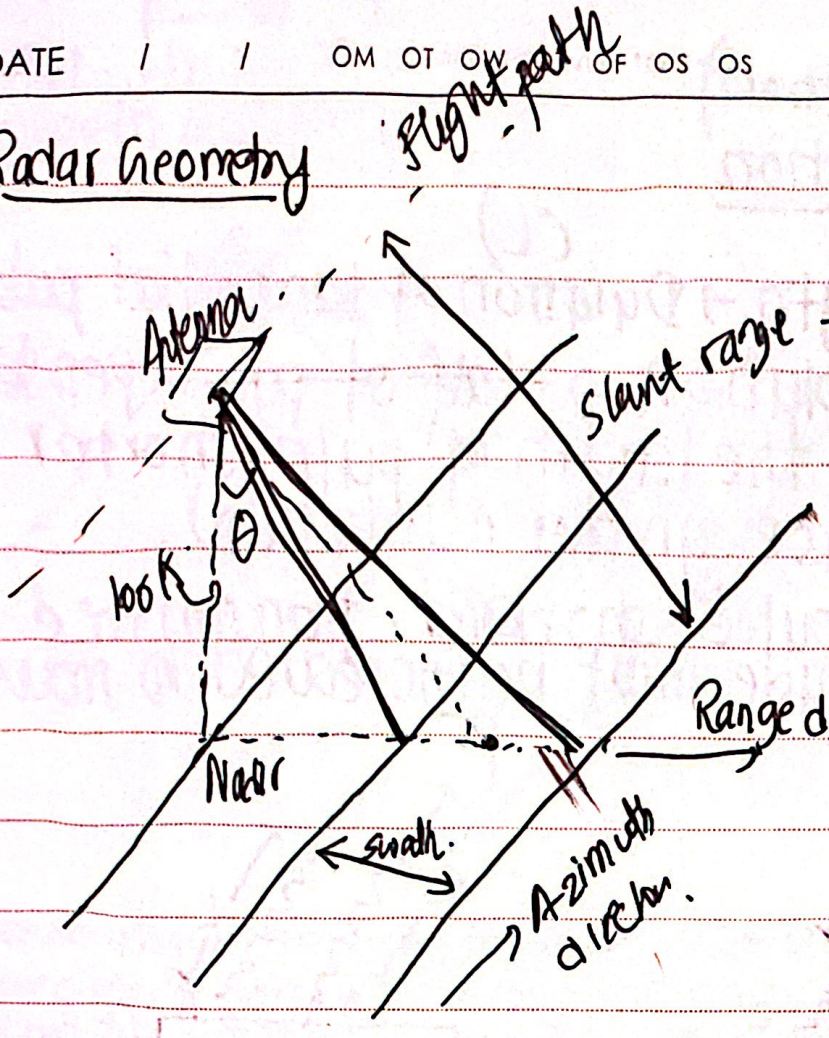
Radar Geometry



Azimuth direction → direction of satellite movement.

Nadir → Point exactly under the satellite.

~~look~~ → ~~an~~

Range direction → direction far to azimuth

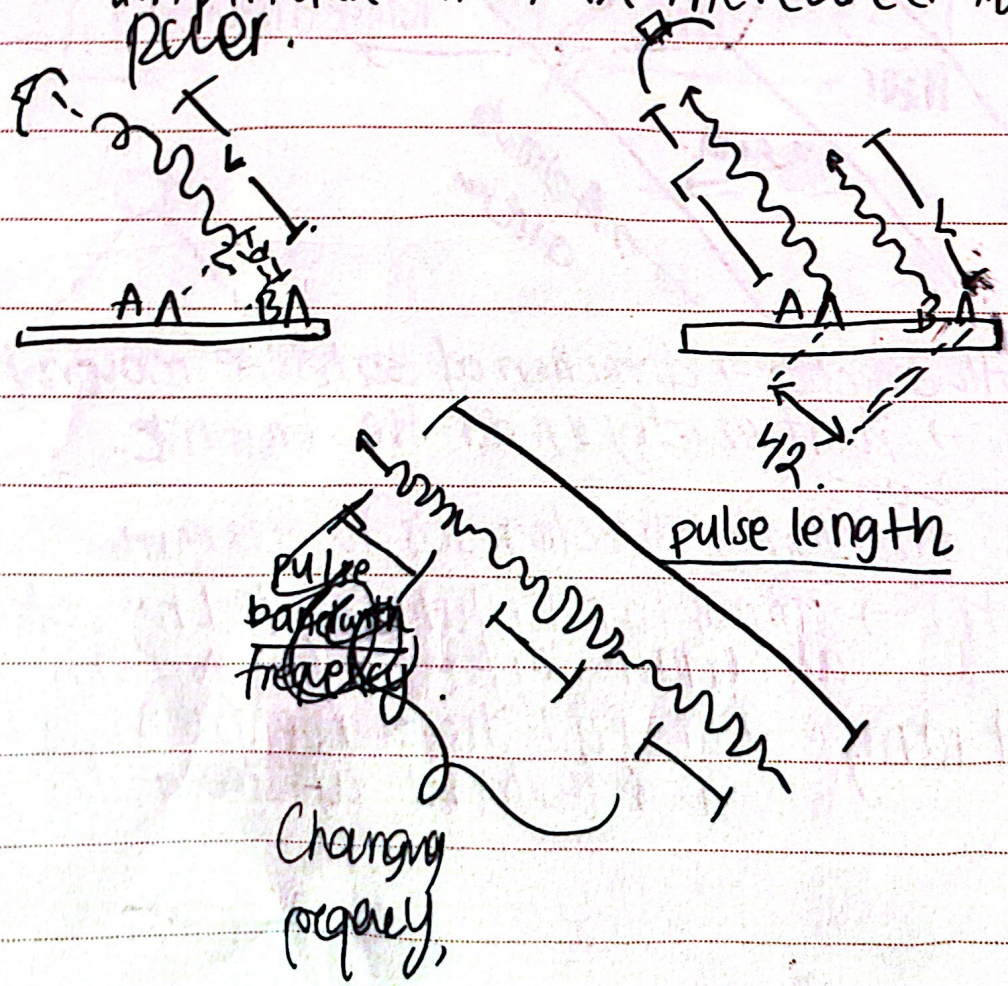
swath → strip of land illuminated by satellite at certain offset to Nadir.

Slant range → actual distance from satellite to feature at swath.

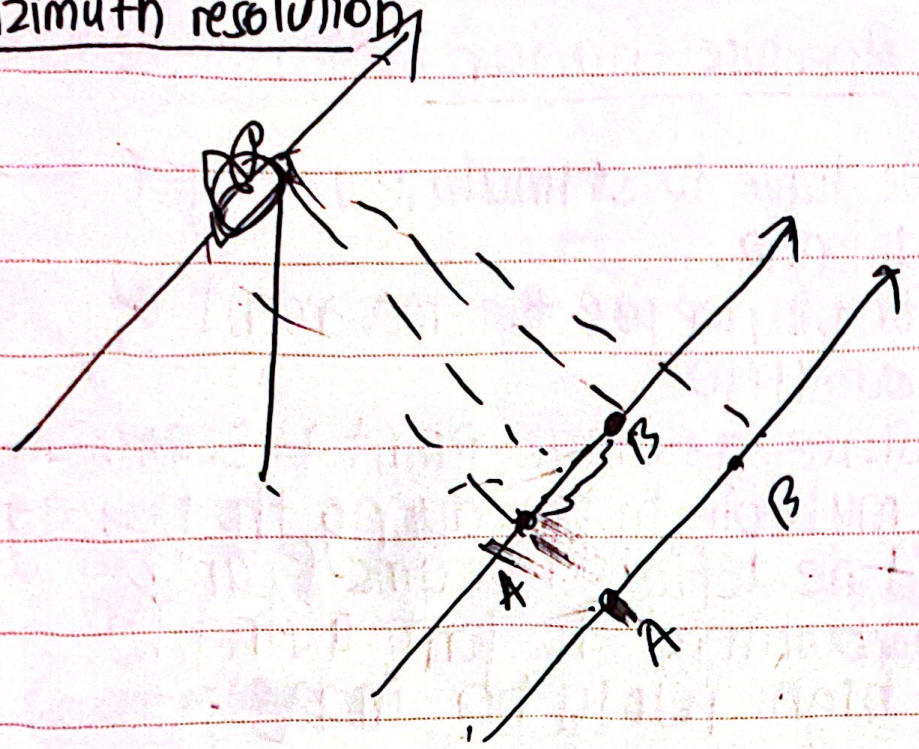
~~(Range Direction)~~

Range Resolution

- Pulse length (L) → Duration of ~~transmitted~~ pulse
- Range resolution → ~~Half of pul.~~ Depends on the length of pule (shorter pulse greater resolution).
- But, if pulse shortened, transmitted amplitude must be increased to maintain power.



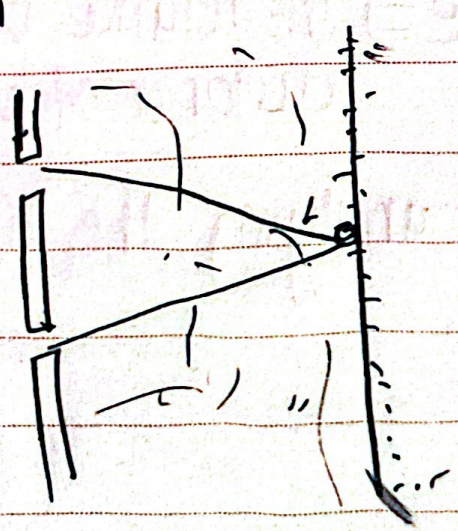
Azimuth resolution



→ Resolution of imaging radar system in the azimuth direction is determined by the angular bandwidth and the slant.

→ The ~~band~~ width of the antenna is of the wavelength of transmitted pulse

α $\frac{1}{\text{length of antenna (aperture)}}$



$\frac{\lambda D}{L}$

⇒ So we need longer antenna, but physical limitations prevail.

⇒ Solution: Synthetic Aperture (Antenna length)

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Synthetic Aperture Radar

- We have to simulate a longer antenna.
- For this, we use the movement of satellite
- since a single point is scanned multiple times during the passage, the reflected beams can be combined to form a very high resolution image.

Backscatter / reflected pulse carries two details: ① Amplitude ⇒ Intensity of backscatter
② Phase ⇒ The relative position / distance of objects.

First lets focus on analysing the first detail i.e. ① Amplitude.

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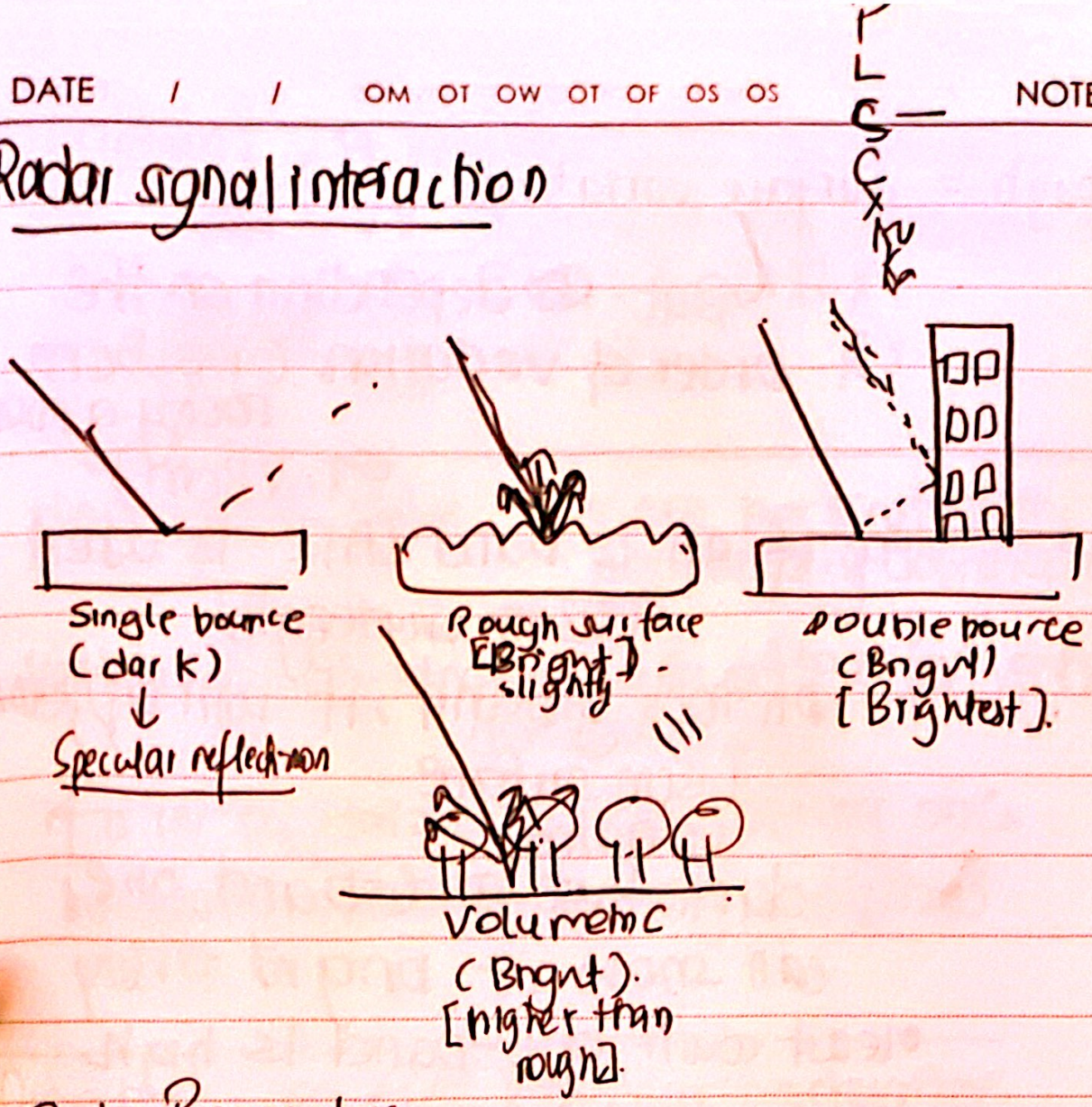
Radar signal interaction



Radar Parameters

- Wavelength
- Polarization
- Incidence Angle.

wavelength →
- Ka → high resolution radar
- K
- Ku → glaciology (snow)
- X → agriculture ocean
- C → ocean, agriculture
- L → agriculture, soil moisture.
- P → biomass, soil moisture penetration.

DATE / / OM OT OW OT OF OS OS NOTES

Rough = Surface variations

↳ But depending on the order of variation (i.e 5cm rocky ground or, 23cm)

i.e. if an L band SAR is used (23 cm wavelength)

on rock ground, it will appear (5cm surface variation) dark. But a C-band one can show it bright.

- least count of L-band is high ∴ ↳ low accuracy
- least count of C-band is low ↳ Higher accuracy

So, high resolution radars use low wavelength bands (Ka, Ku, X)

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Polarization:

Linear polarized:
- HH → Horizontal Tx, ~~Vertical~~ Horizontal Rx.
- VV → Vertical Tx, Vertical Rx

Cross polarized:
- HV → H Tx, V Rx.
- VH → V Tx, H Rx.

Horizontal pulse → more backscatter for horizontally dominating obj.

Vertical pulse → more backscatter for vertically dominating obj.

~~if a HV pu~~ Horizontally dominating objs backscatter more horizontally polarized pulse.

Dielectric constant ↑↑ = More backscatter.

Pure water has high dielectric constant, so, soil mixed with water i.e high moisture content, have higher dielectric than dry soil or snow. So, they appear brighter (more backscattering).

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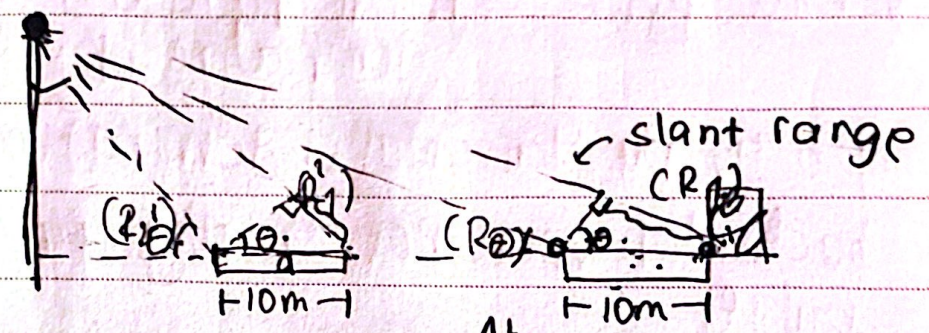
CAXUVIMR.

Distortions

- Slant Range Distortion
- Geometric Distortion
- Shadows
- Radiometric Distortion

Slant Range Distortion



$\Delta R' = (R_1' - R_2')$ $\quad$ $\Delta t \rightarrow \Delta R = (R_1 - R_2)$.

$R_1 = q$

$q = R' \sin\theta_i$

Problem statement — Since $\Delta R' < \Delta R$, the ground 10m field appears compressed / shorter if it's nearer.

Correction — But its correction can be done (almost automatically in all cases) by considering the angle of incidence.

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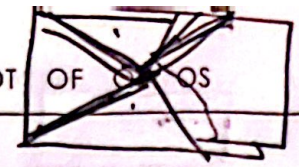
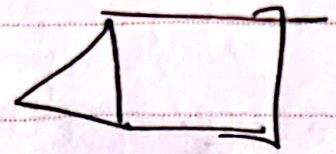
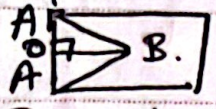


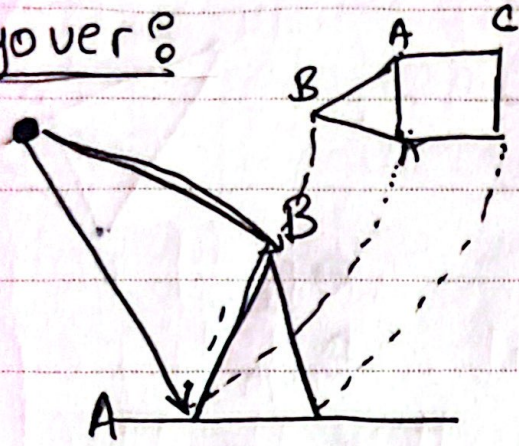


Geometric Distortion

Expected

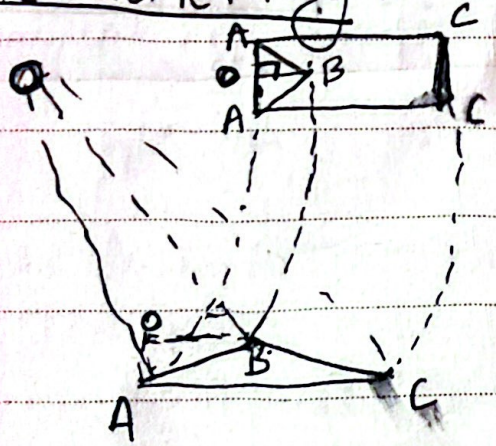


layover:



A → Base of mountain
B → Tip of mountain
Problem:
Slant range for Base of mountain(A) is longer than for B. Thus the image formed is inverted.

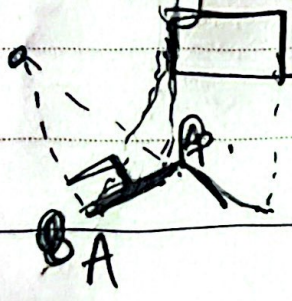
Foreshortening:



Problem

OB → i.e Perpendicular distance from tip to base.
L) x component of mountains slope appears shorter.

Foreshortening is maximum when slant range ⊥ar to slope.



Here, OB = 0, i.e no mountain seen.

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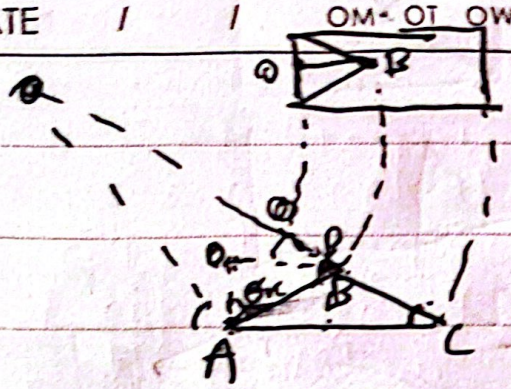
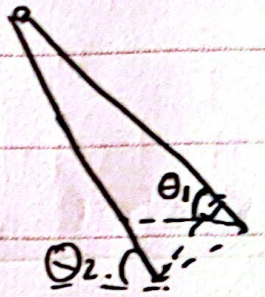
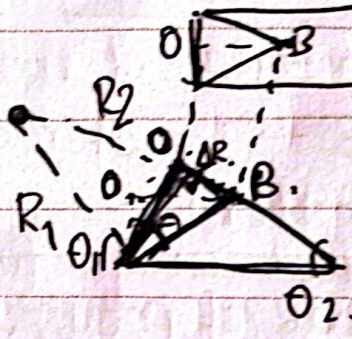
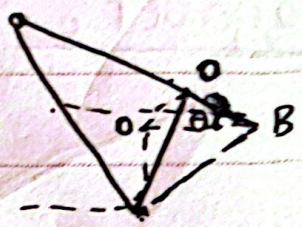
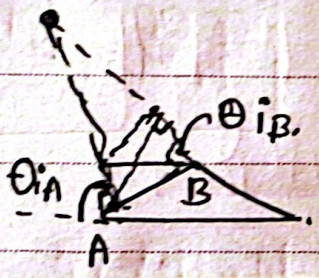


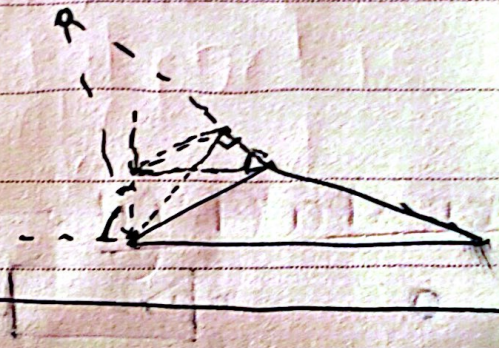






θ i_B
θ i_A





Radiometric Distortions

- Complex topography (rough) areas may appear unnecessarily bright thus hiding the key details related to vegetation etc.
- This is corrected by eliminating high values of backscatter in complex topography.

Speckle (Distortion)

- Topographically similar features appear differently illuminated due to difference/variation in reflection caused by other variables.

Eg. A plain field with same type of grass may appear different due to natural difference in size and orientation of leaf blades.

Corrections: 1) Multi look Processing
2) Spatial Filtering

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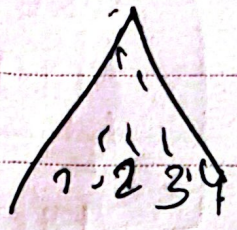
1) Multilook Processing: Each radar beam divided into several narrow sub beams. Each beam is a 'look' at the scene. Each scene is subject to speckle (different intensity). Each sub beam is averaged to reduce speckle in final image.

But spatial resolution decreases.
↳ both x & y axis.



2) Spatial filtering:

Using a moving window over each pixel. Then mathematical calculations (eg. average) is done within the pixel window then the central pixel is replaced by new value.
Spatial resolution decreases.