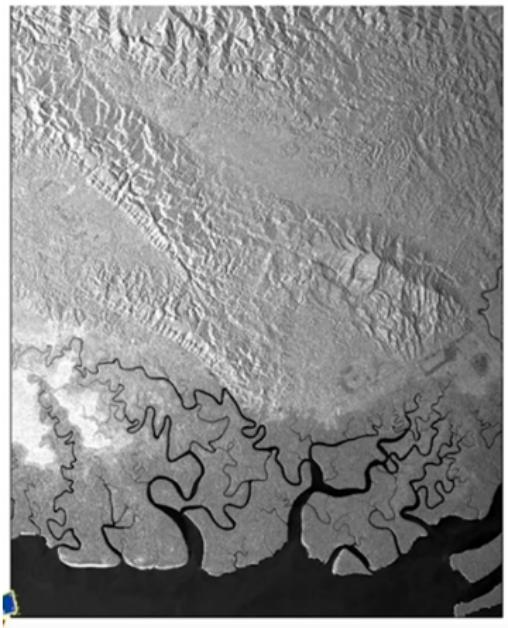


Radar

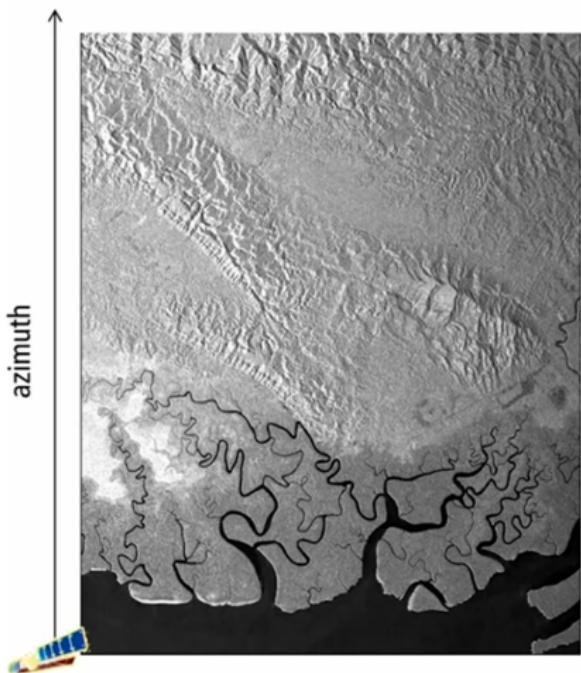


Óptico



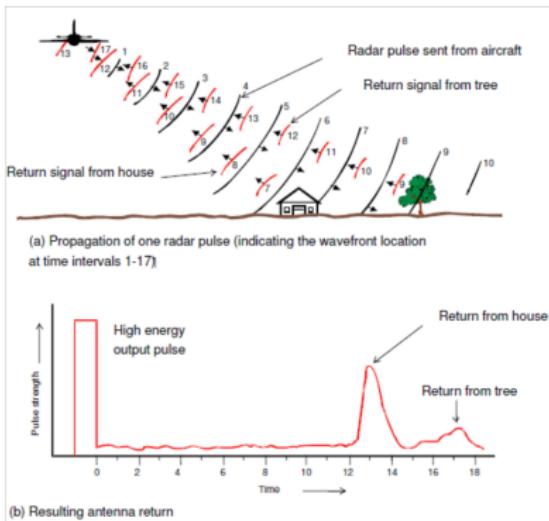
EAGE E-lecture: Satellite InSAR Data by Alessandro Ferretti

# RAdio Detection And Ranging



1. Day/night monitoring  
active system, no need for external illumination
2. All-weather  
It penetrates clouds, rain, dry sand and, partially, vegetation
3. Coherent  
travel path changes can be measured with the accuracy of a fraction of the wavelength

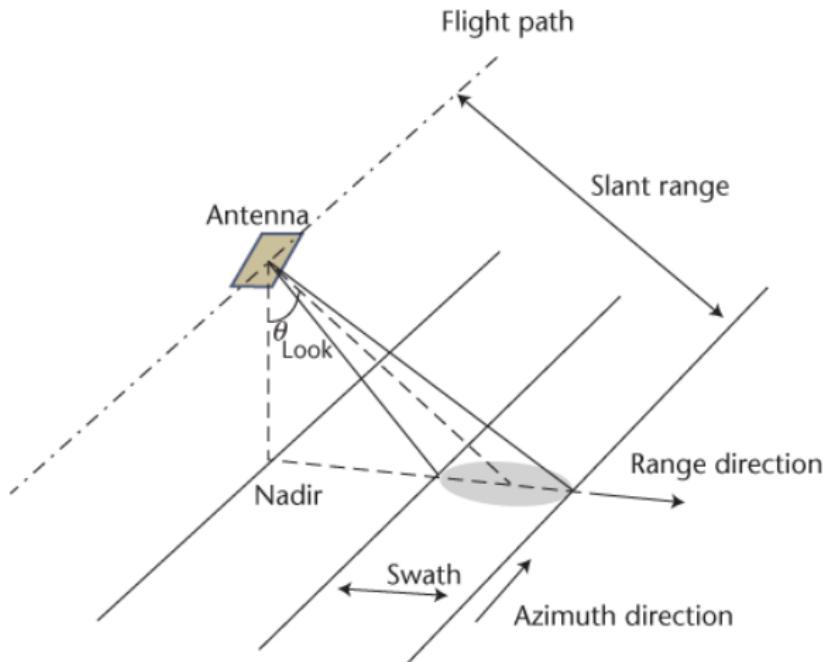
**Radar**—Sensor de rango y radio detección que provee su propia fuente de energía electromagnética. Emite radiación de microondas en una serie de pulsos desde una antena. Cuando la energía alcanza su objetivo parte de la energía se reflejada hacia el sensor. Esta radiación es detectada, medida y se estima el tiempo de viaje.



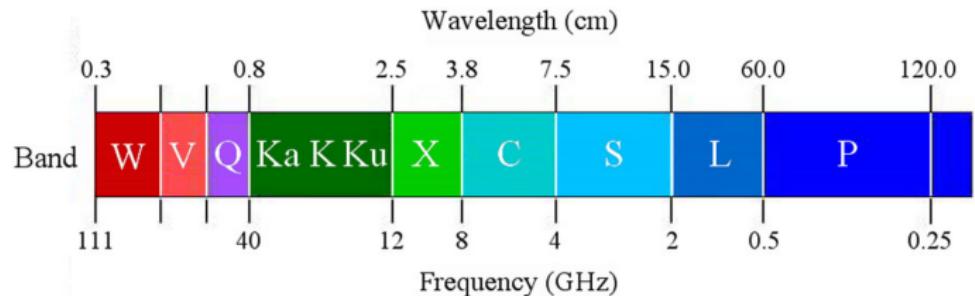
$$\overline{SR} = \frac{ct}{2}$$

$\overline{SR}$  = slant range (direct distance between transmitter and object)  
 $c$  = speed of light ( $3 \times 10^8$  m/sec)  
 $t$  = time between pulse transmission and echo reception

# Imaging Radar Geometry

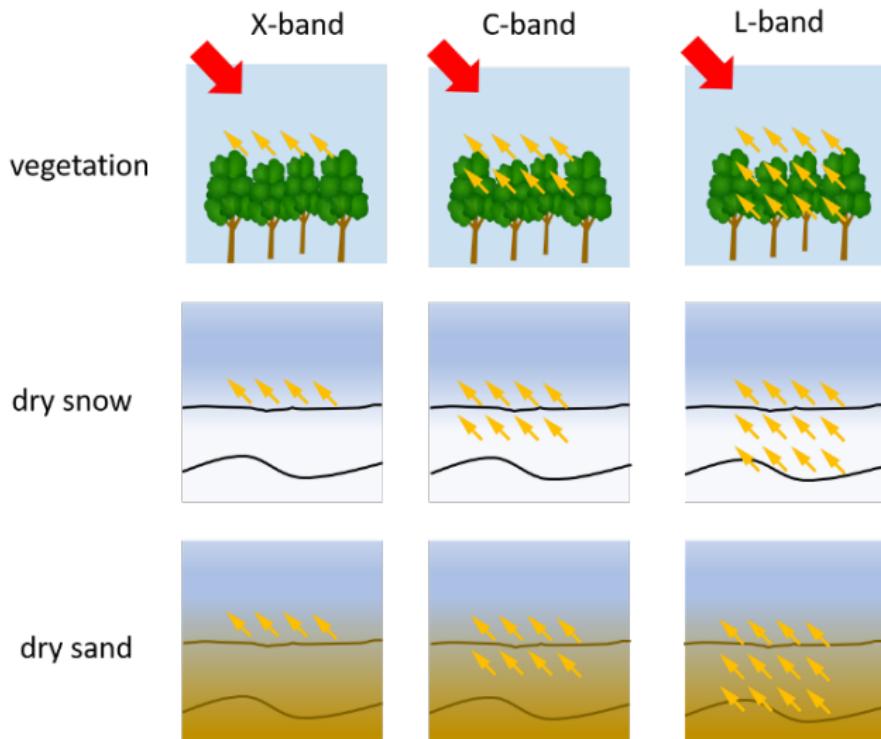


Credit: NASA

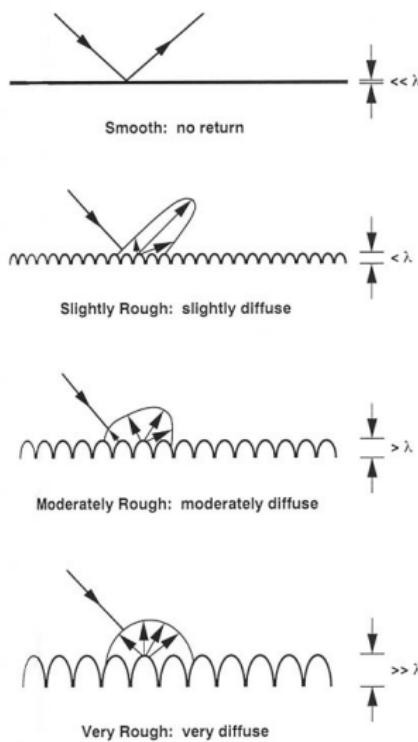


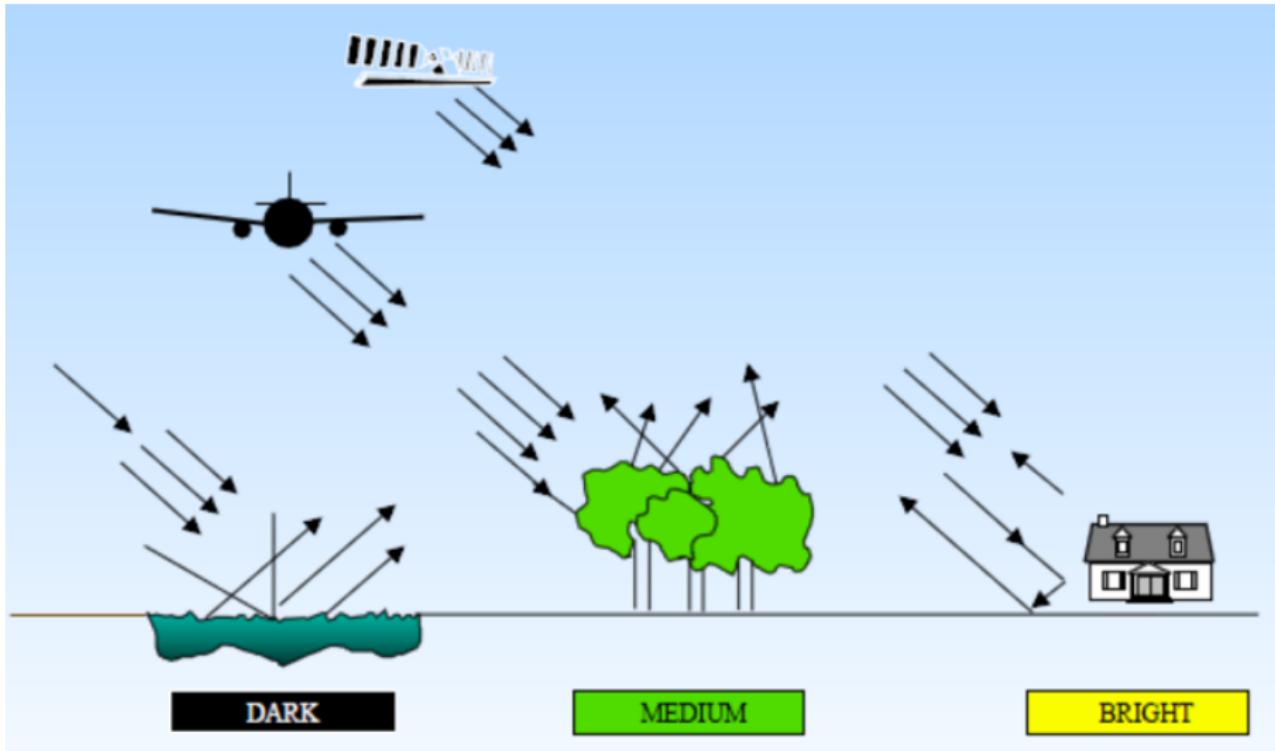
Band	Wavelength (cm)	Frequency (GHz)
K	0.83–2.75	36.0–10.8
X	2.75–5.21	10.9–5.74
C	5.22–7.14	5.75–4.20
S	7.15–19.74	4.21–1.54
L	19.75–76.9	1.55–0.39
P	>76.9	<0.39

# Radar Penetration by Frequency

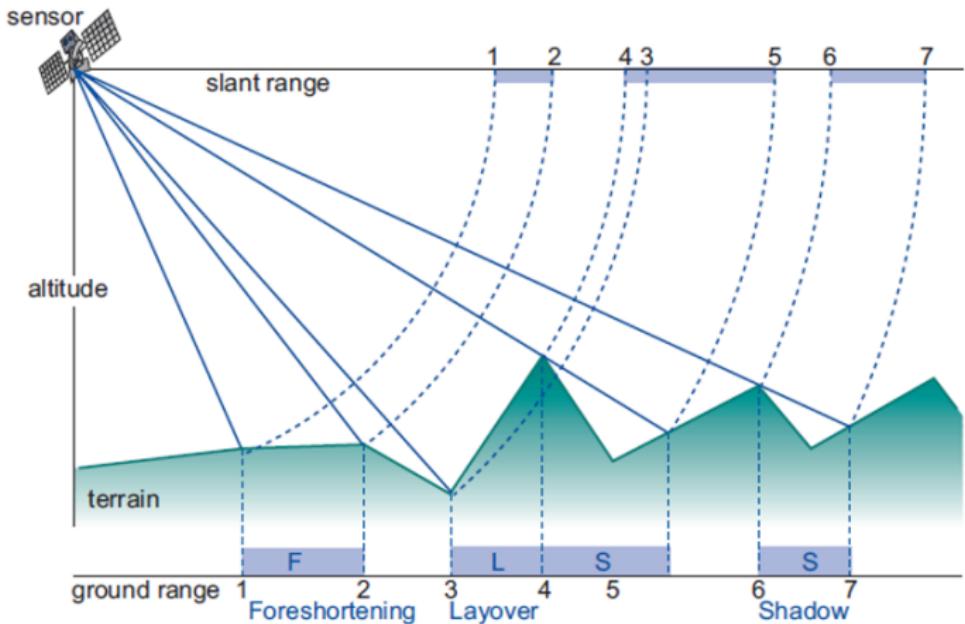


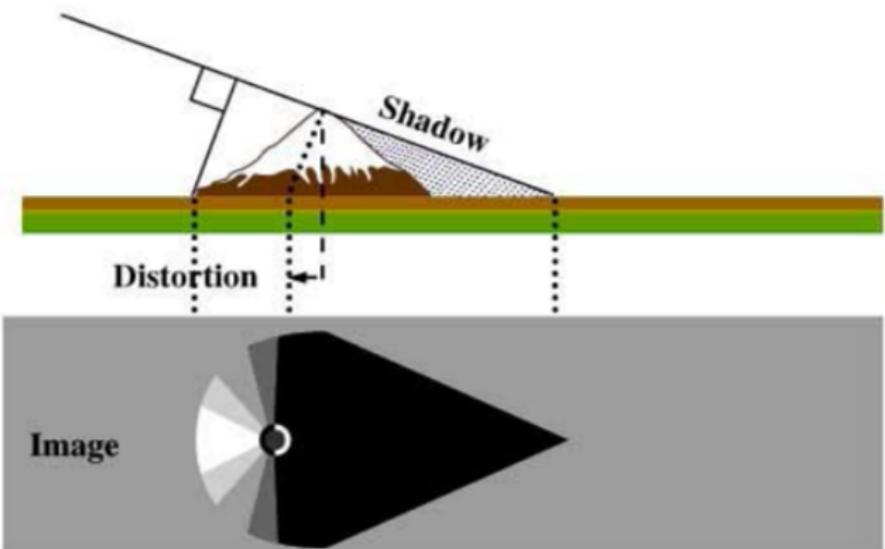
# Surface Roughness Scattering

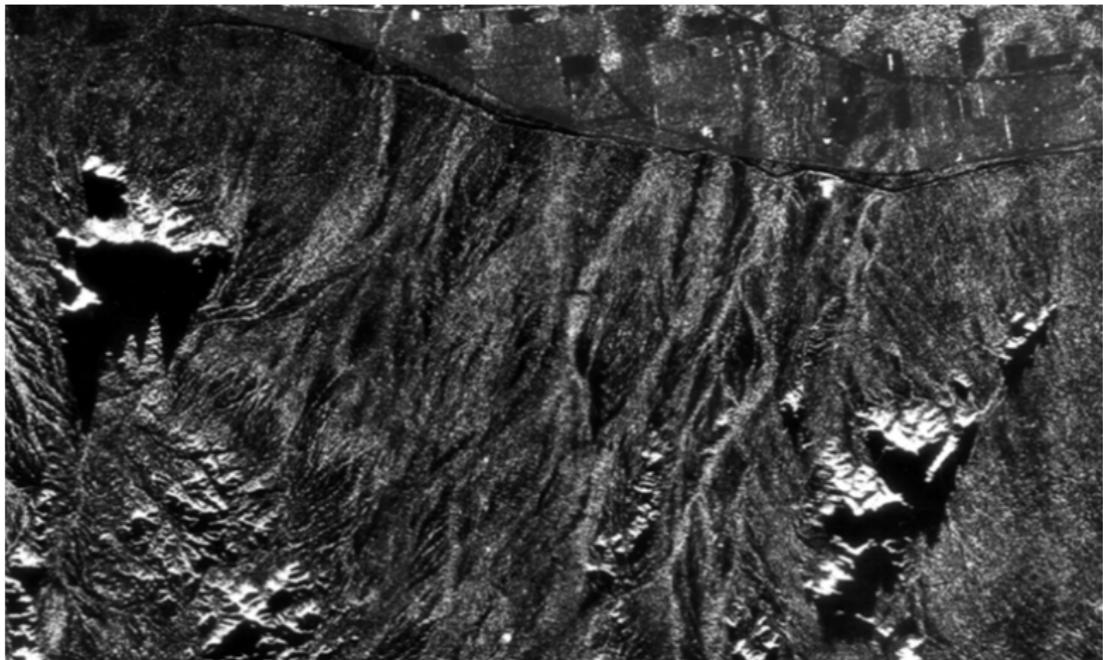




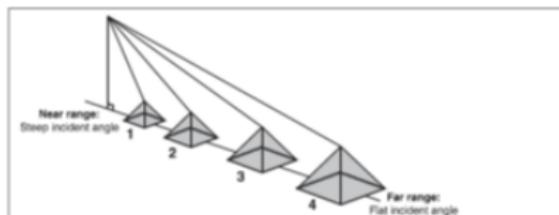




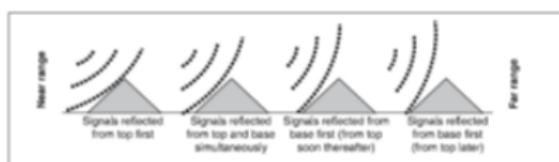




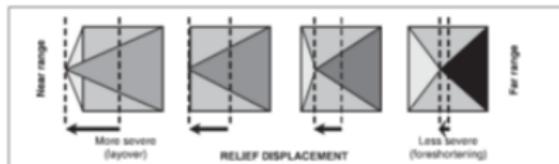
# Desplazamiento del Relieve



(a)

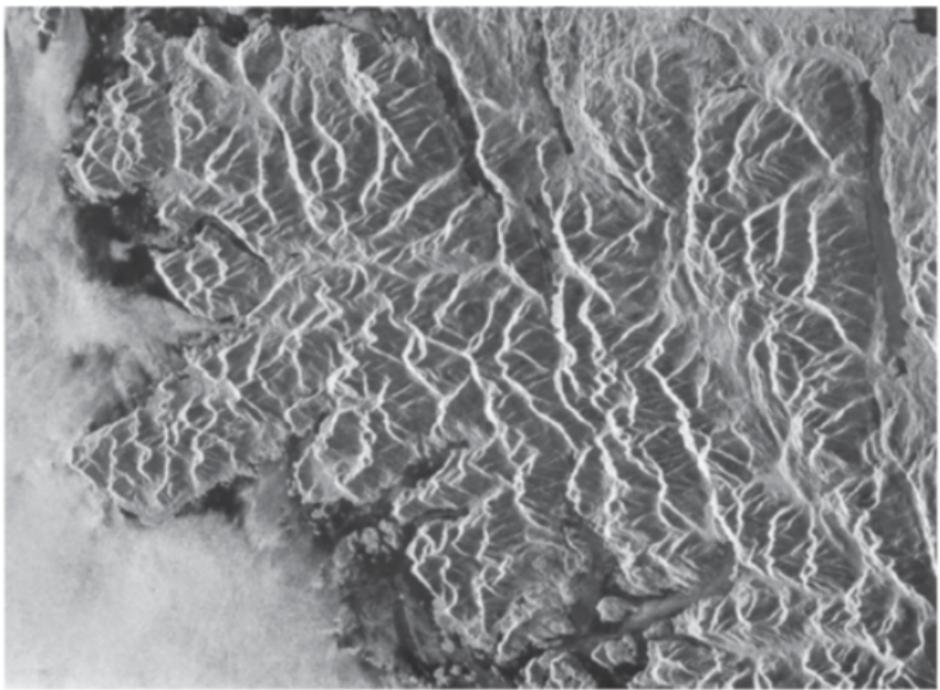


(b)



(c)





**Figure 6.17** ERS-1 radar image, C band, Vancouver Island, British Columbia, midsummer. Scale 1:625,000. (ESA, Courtesy Canada Centre for Remote Sensing.)

# Atenuación

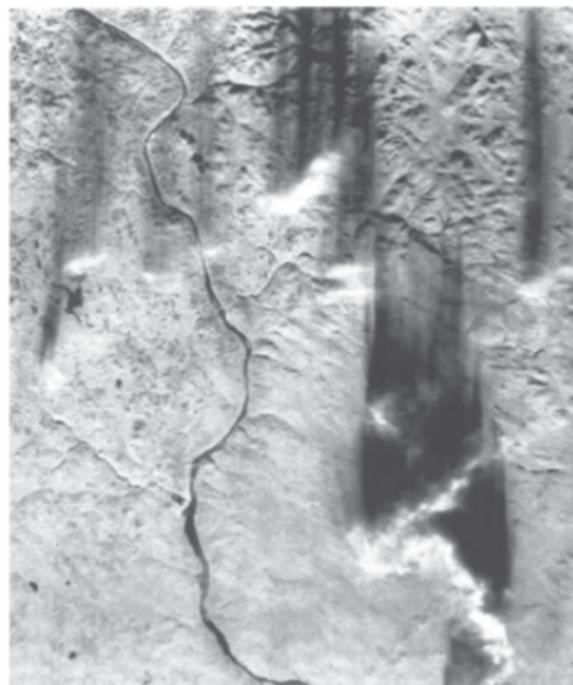


Figure 6.20 X-band airborne radar image acquired near Woodstock, New Brunswick, Canada, illustrating an unusual shadow effect created by severe rainfall activity and radar signal attenuation. (Courtesy Agriculture and Agri-Food Canada, Fredericton, NB, Canada.)

# Geometric Effects in SAR Imagery

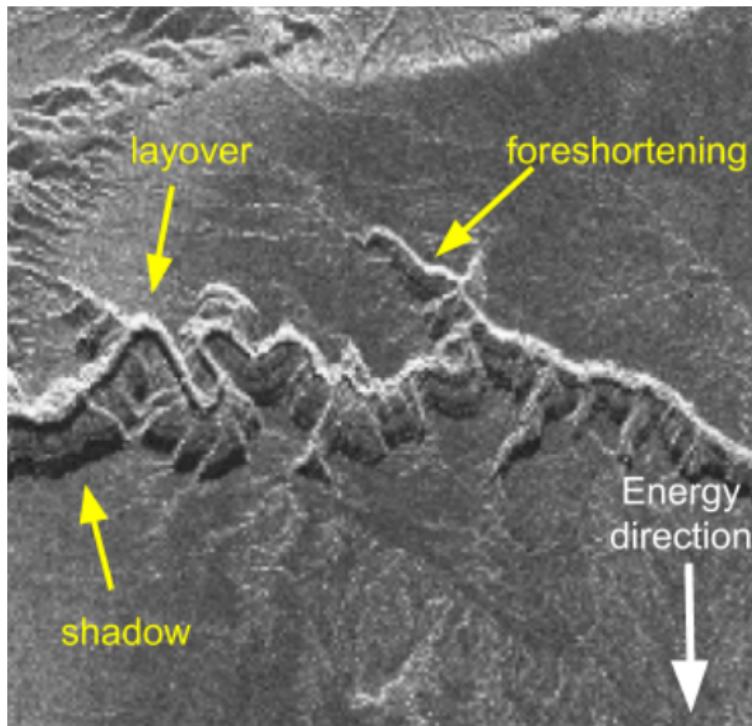
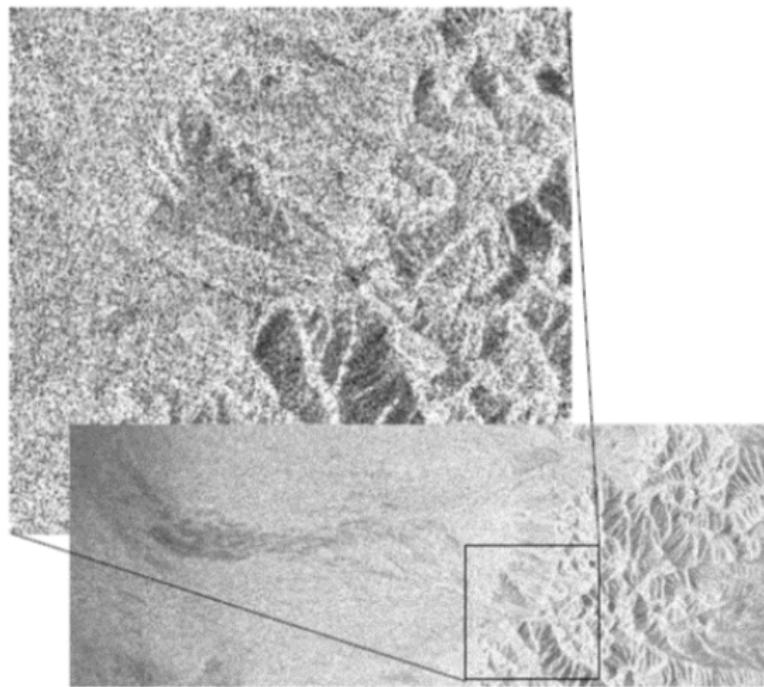


Image Credit: ERS, ESA 2011. Retrieved from ASF DAAC 20 January 2020.

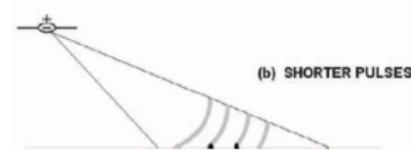
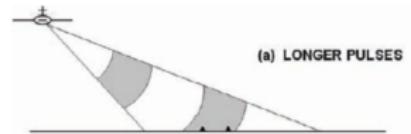
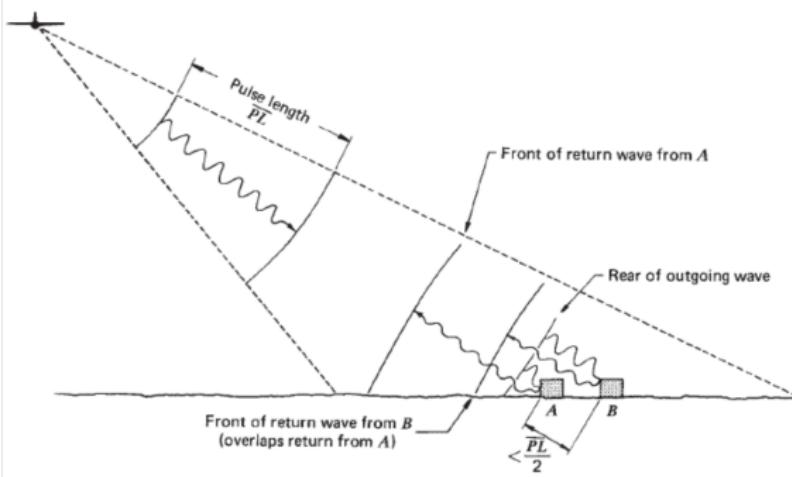
# *Speckle "salt & pepper"*



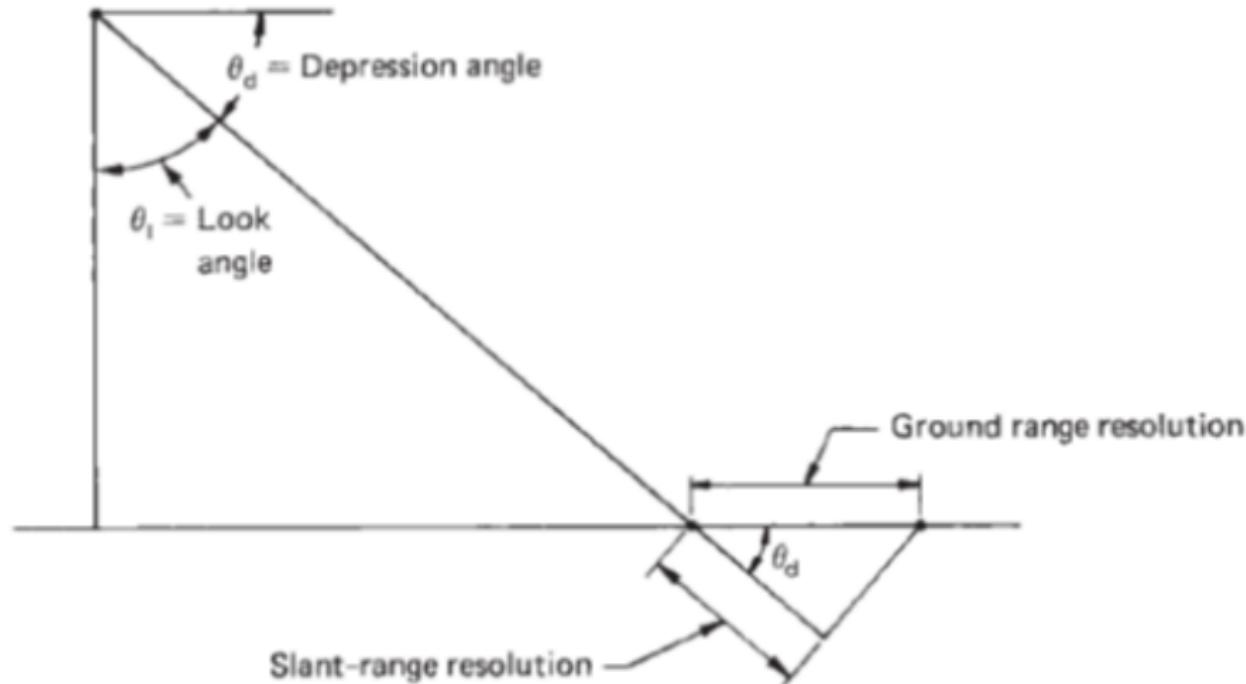
# Resolución Espacial

El tamaño de la resolución de la celda en el terreno está controlado por dos sistemas independientes:

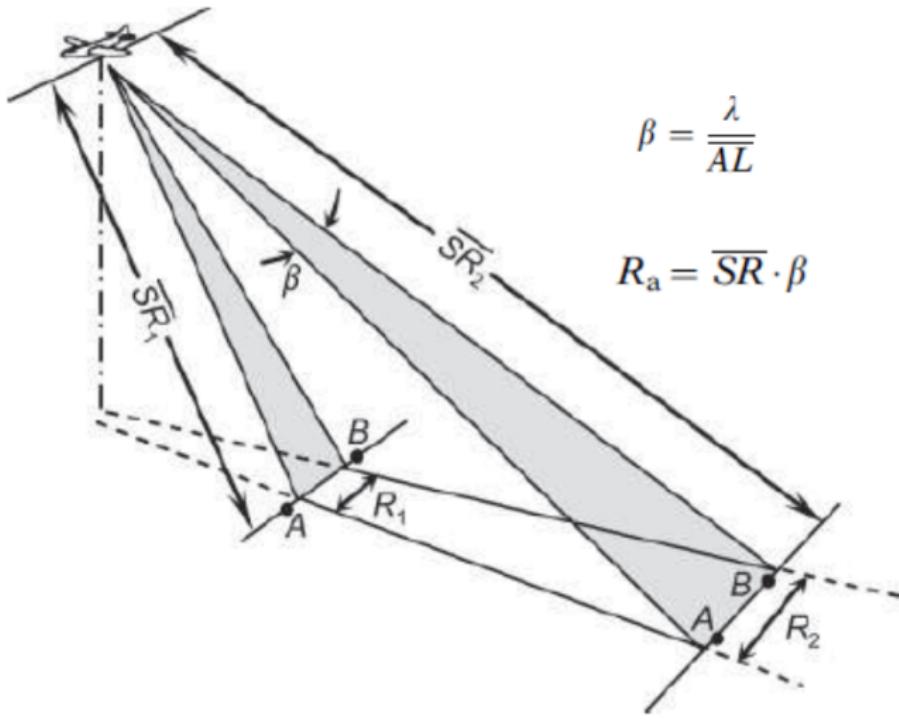
- A. **Longitud del pulso:** determina la resolución espacial en la dirección de la energía de propagación (*range direction*). Esta determinado por la longitud del tiempo que la antena emite el pulso de energía.
- B. **Ancho de banda de la antena.** Determina la resolución del tamaño de celda en el sentido del vuelo o el azimuth.



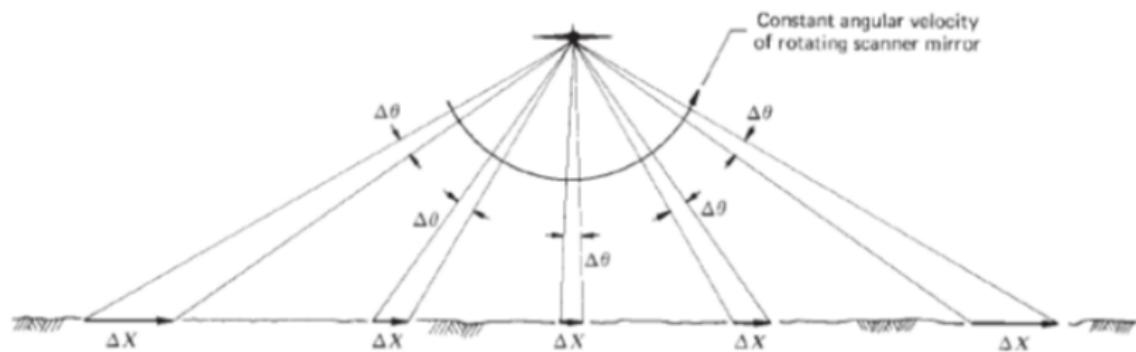
# Range



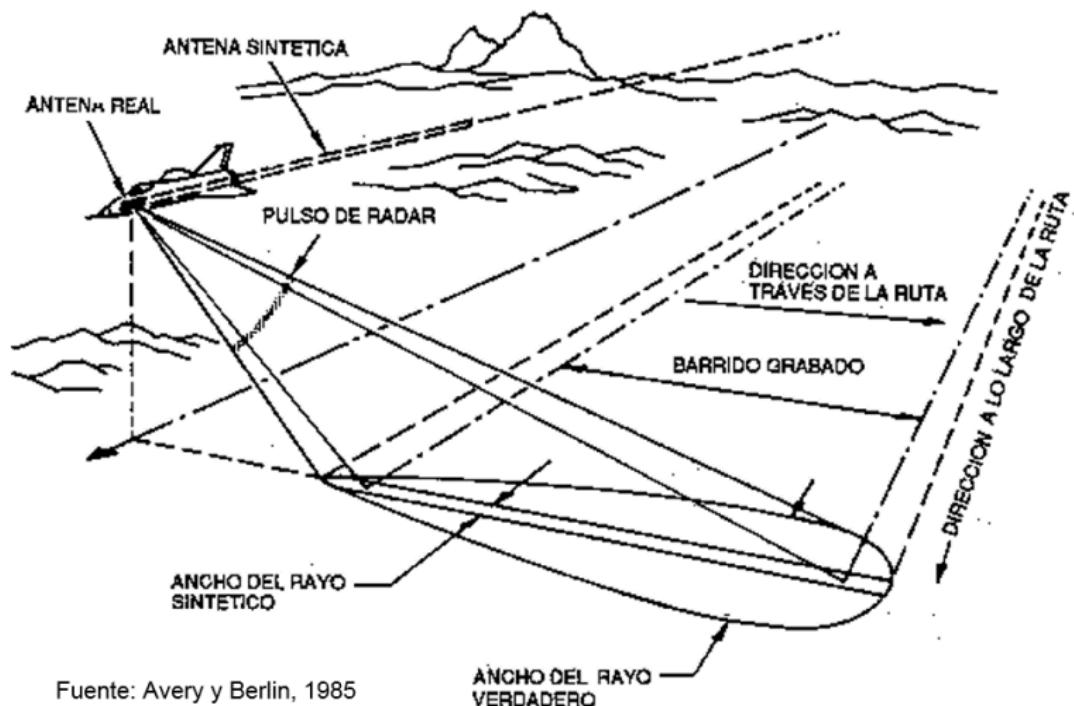
# Azimuth



# Distorsión

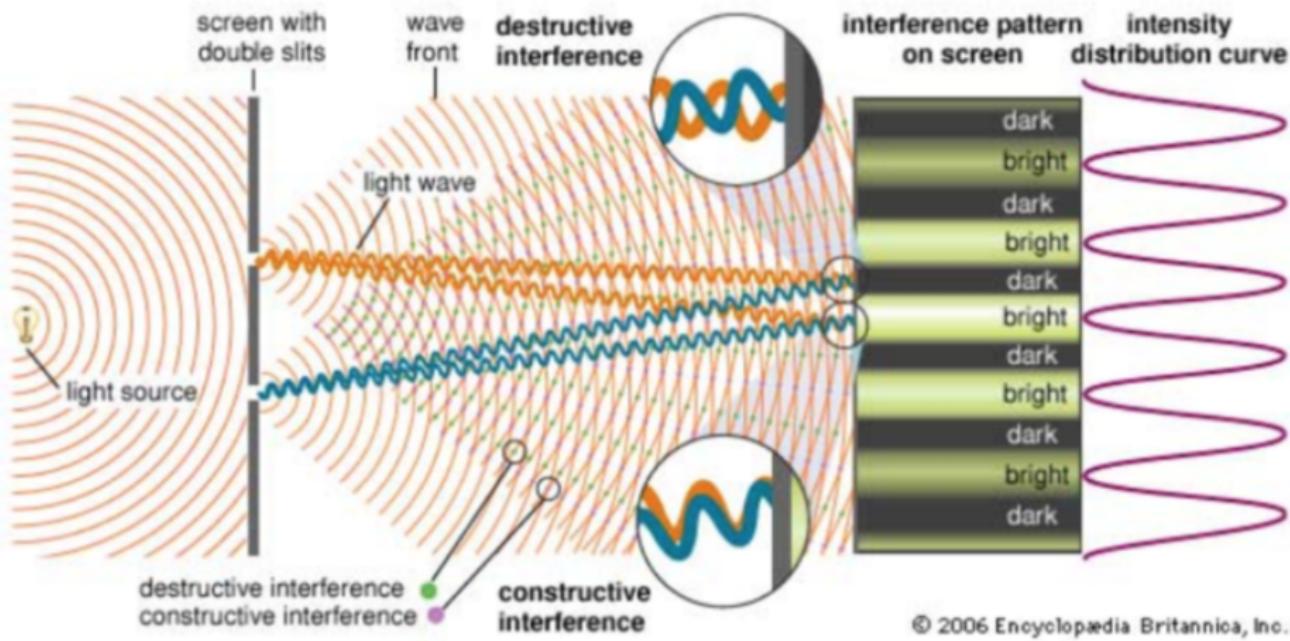


# Apertura Real (SLAR) vs Sintética (SAR)



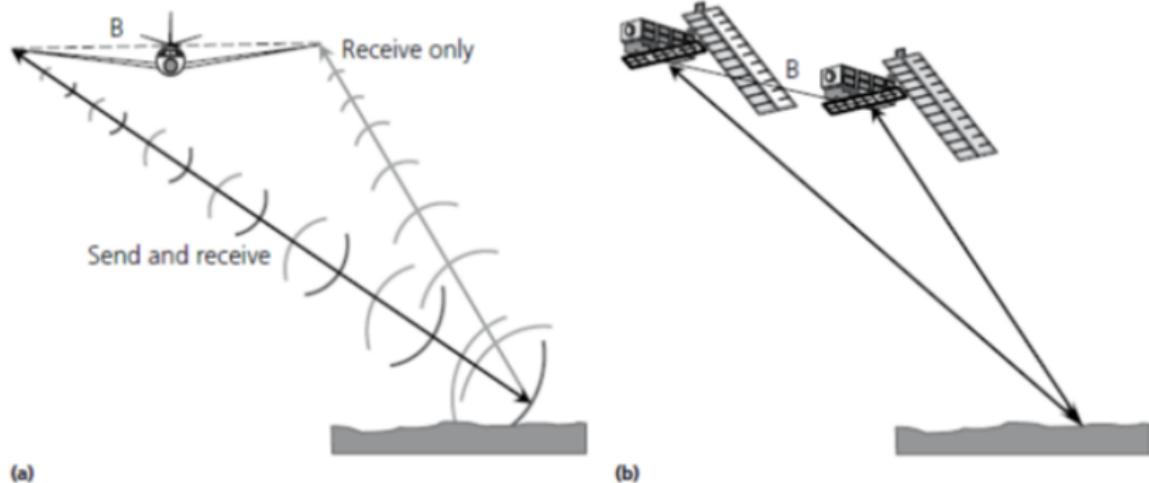
Fuente: Avery y Berlin, 1985

# Interferometría



© 2006 Encyclopædia Britannica, Inc.

# InSAR (Interferometric SAR)

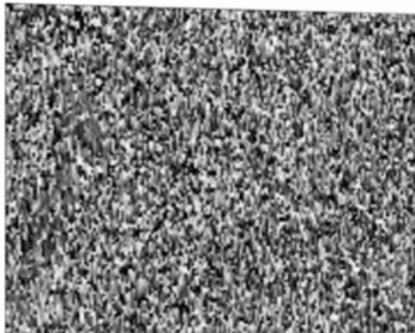


**Fig. 10.1** (a) The single-pass SAR interferometer with both an active antenna, sending and receiving radar signals, and a passive antenna (separated by a distance  $B$ ) to receive signals only; and (b) a repeat pass SAR interferometer to image the same area at two visits with a minor orbital drift  $B$ .

A SAR image is a set of pixels characterized by both amplitude and phase values.



Amplitude

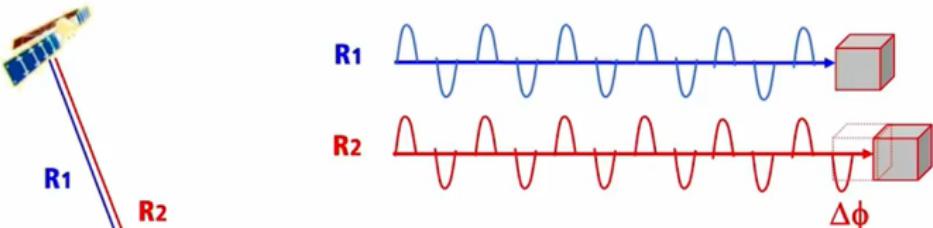


Phase (known modulo  $2\pi$ )

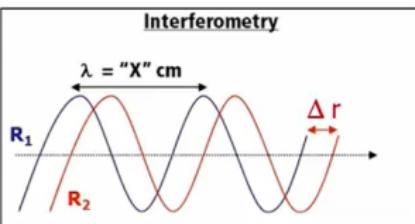
The phase is related to the **sensor-target distance**.



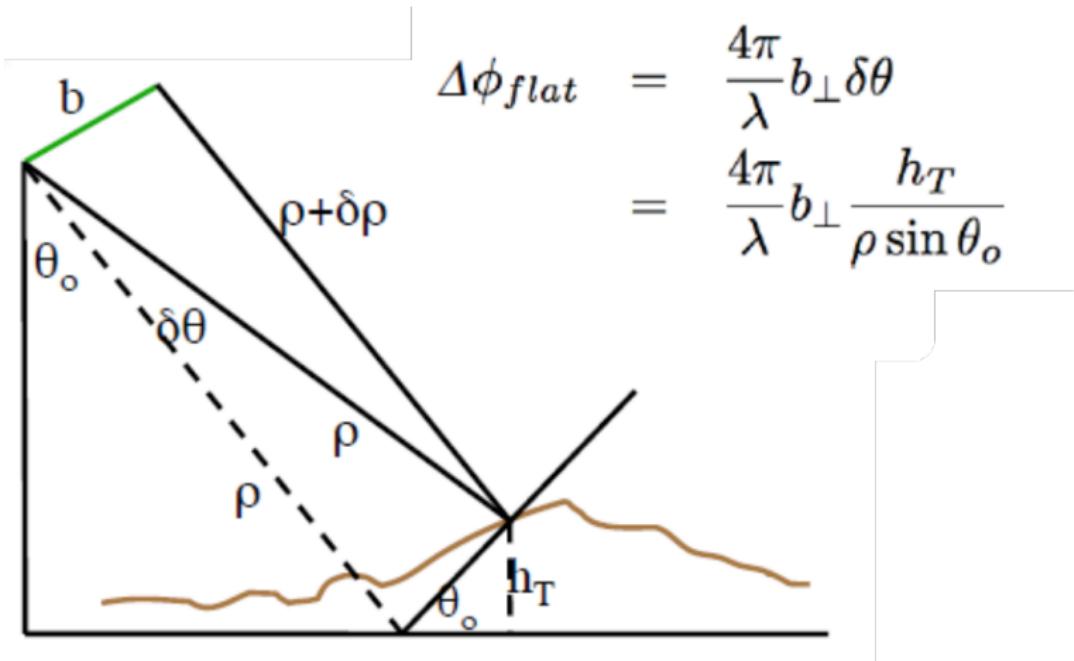
The *unit of length* used in InSAR is the wavelength:

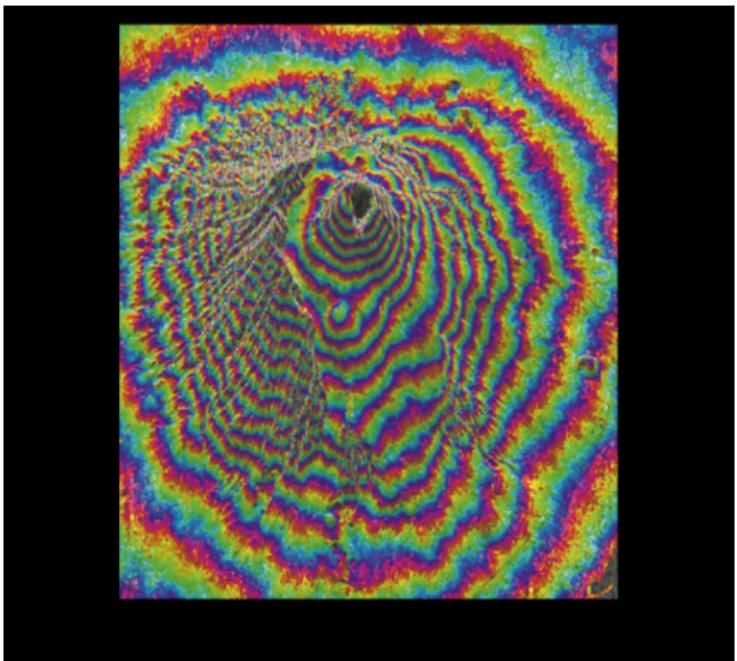


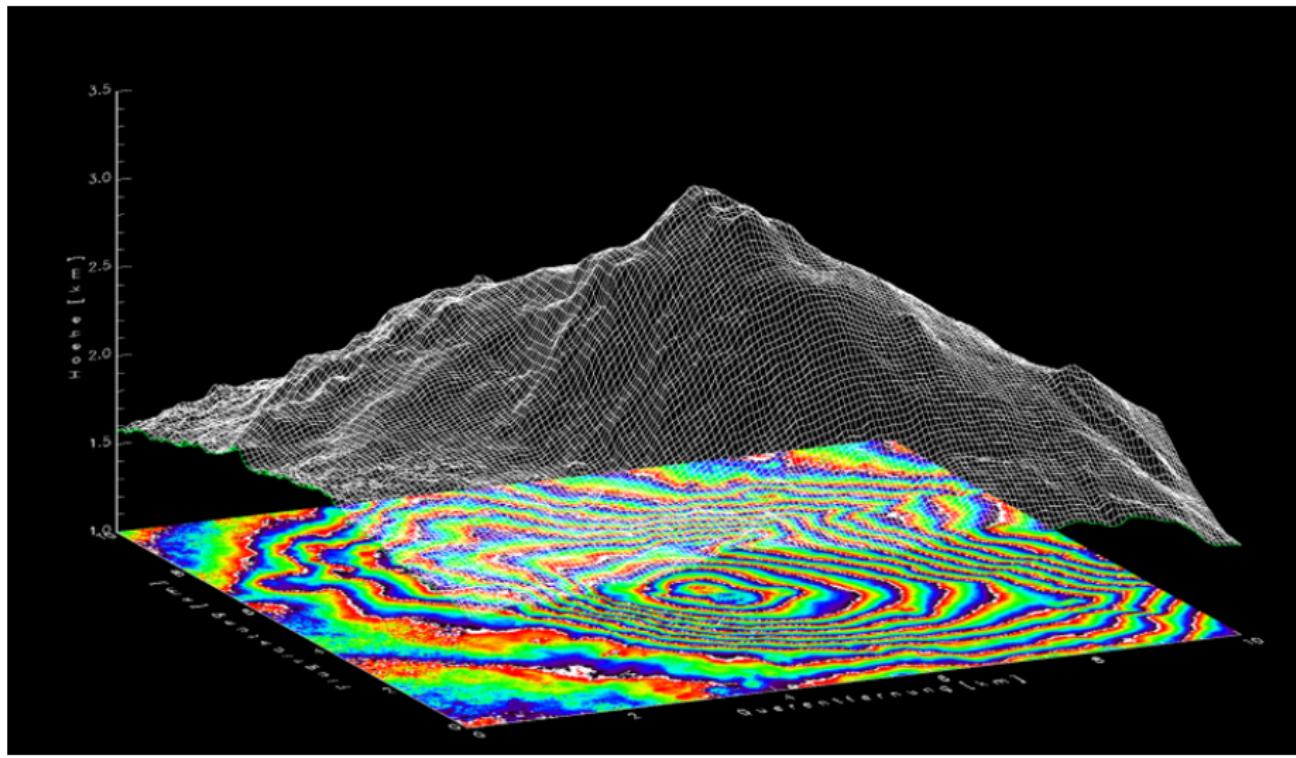
$$\Delta R = c \cdot \Delta \phi$$



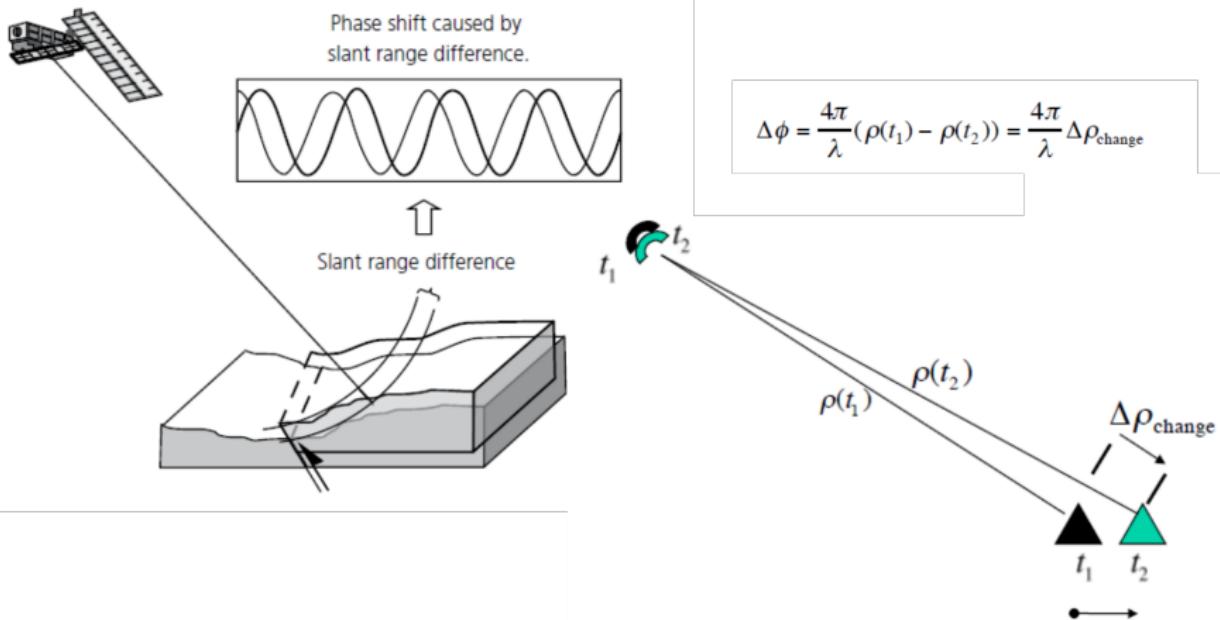
EAGE E-lecture: Satellite InSAR Data by Alessandro Ferretti

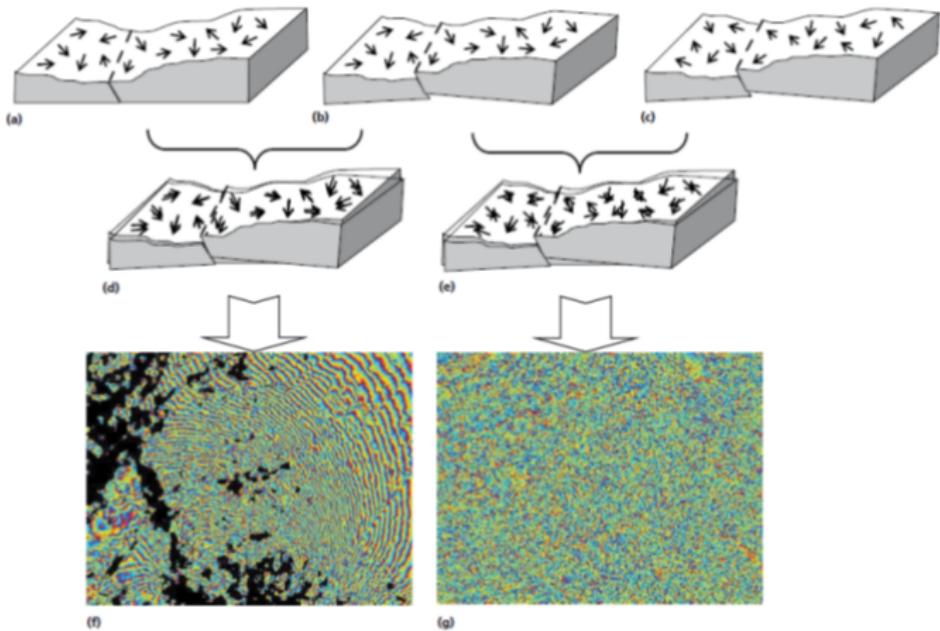




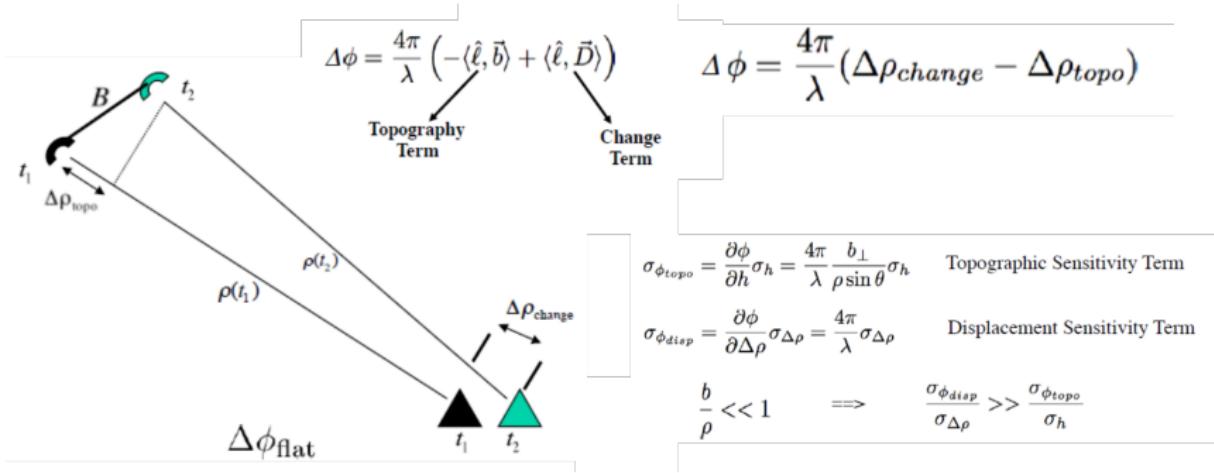


# DInSAR Differential Interferometric SAR





# InSAR vs DInSAR



# LIDAR

Longitud de onda: 55-1,700 nm

Precisión típica: +/- 1.5 cm → 800m-1000m (Manetti & Steinmann, 2007)

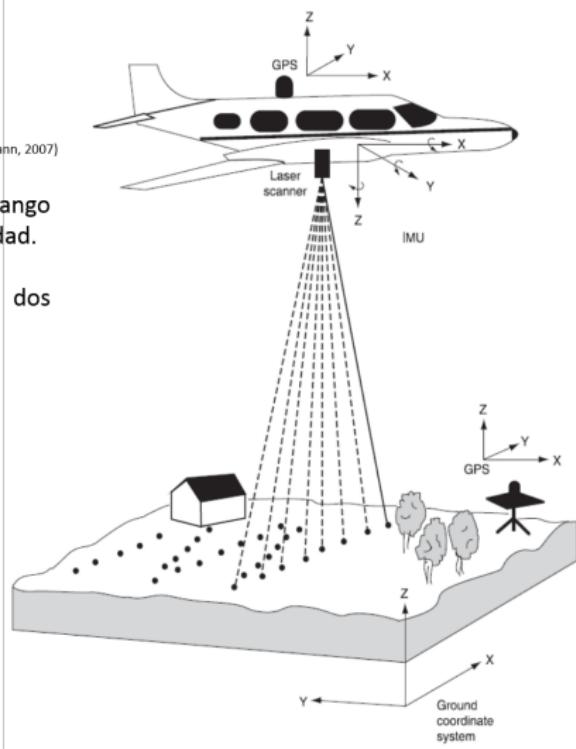
**Resolución de rango:** es la habilidad del buscador de rango en diferenciar dos objetos en la misma línea de visibilidad.

**Resolución angular:** es la habilidad en diferenciar dos objetos en líneas de visibilidad adyacentes.

Densidad de puntos:

ALS: 0,5 – 100 pts/m<sup>2</sup>

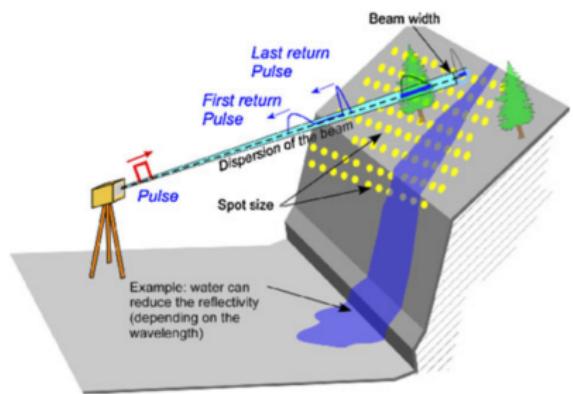
TLS: 50-10,000 pts/m<sup>2</sup>



# LIDAR



Airborne-based sensors



Ground-based sensors

Fuente: <http://learn.arcgis.com/en/arcgis-imagery-book/chapter4/>

# LIDAR

