

"Non est ad astra mollis e terris via" - "There is no easy way from the Earth to the stars"  
— Seneca



*Quidnam est corporibus quibus sit huiusmodi nisi aliquid  
corporum in se habentibus non videtur  
in illis possit. ~~Quibus nihil chim de motu nobis  
distante~~*

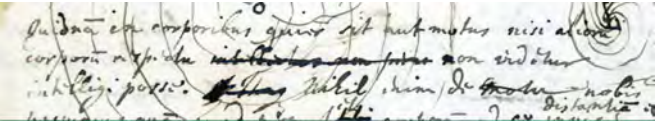
### Radars Interferometry (InSAR); an introduction

25-7-2022

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Delft University of Technology

Second Summer School on Space Research, Technology and Applications,  
National Astronomical Observatory, Rozhen, Bulgaria, 8 July 2022

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Challenge the Future






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### SAR SLC observations




- SLC: Single-Look Complex data
- Single-look: no averaging, finest spatial resolution
- Complex: both real and imaginary (In-phase and quadrature phase) stored

*Coherent imaging*

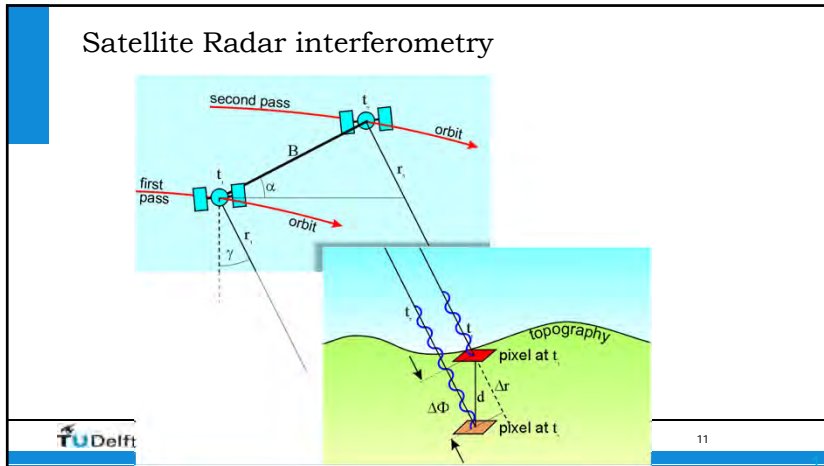
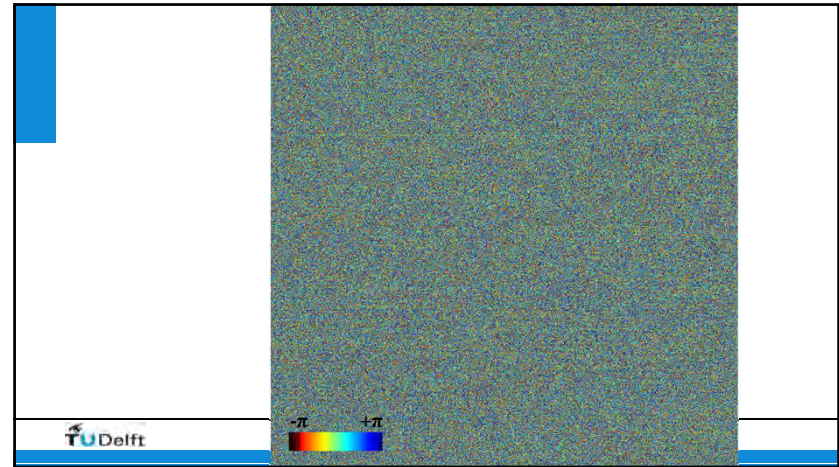
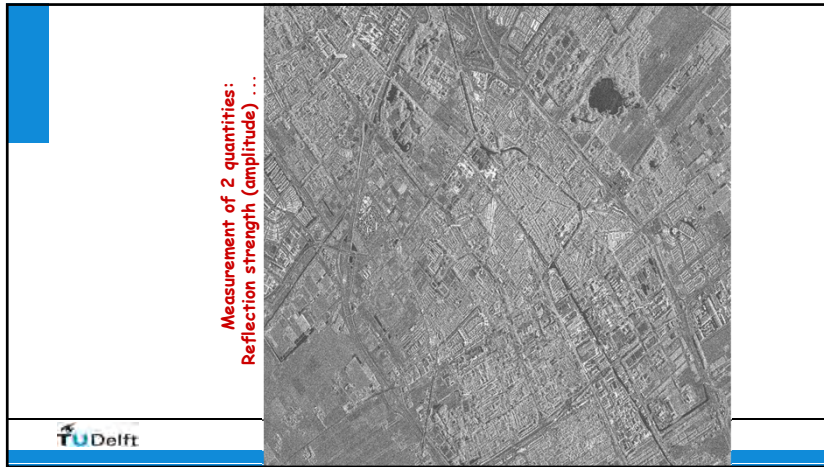
$$y_1 = |y_1| \exp(j\phi_1)$$

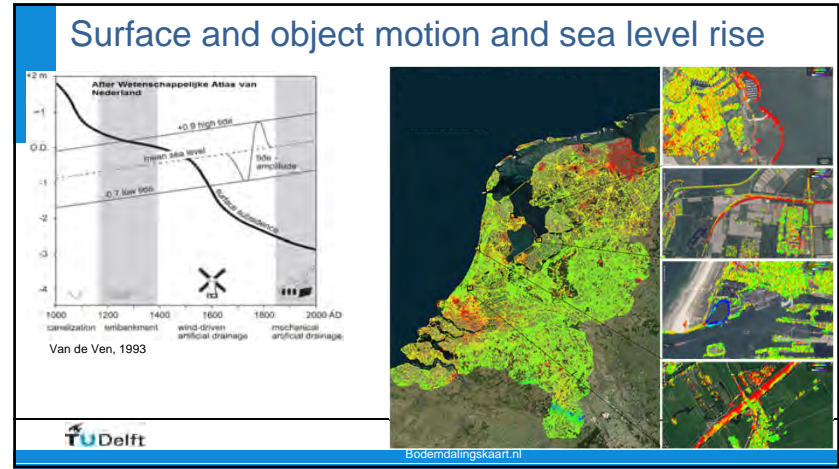
Amplitude      Phase

Uninterpretable, due to scattering mechanism



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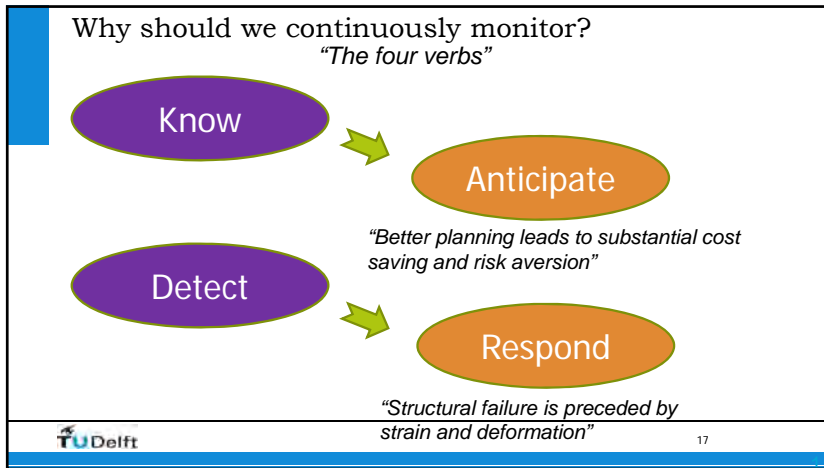


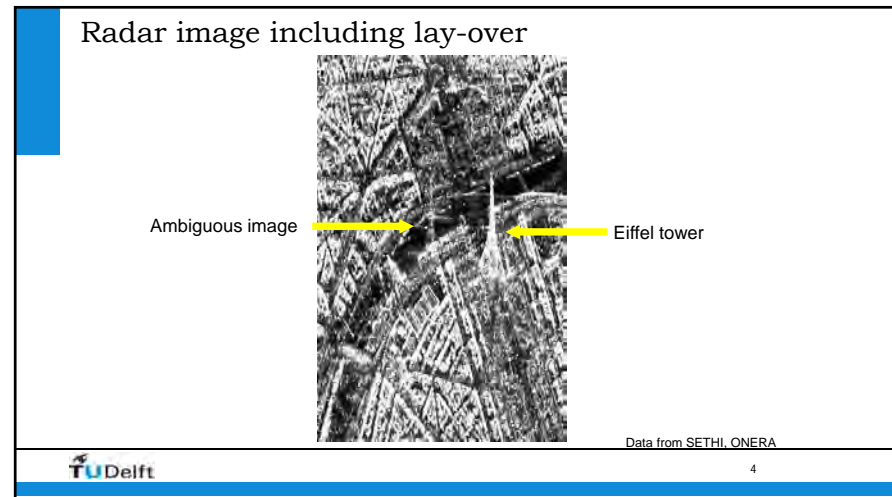
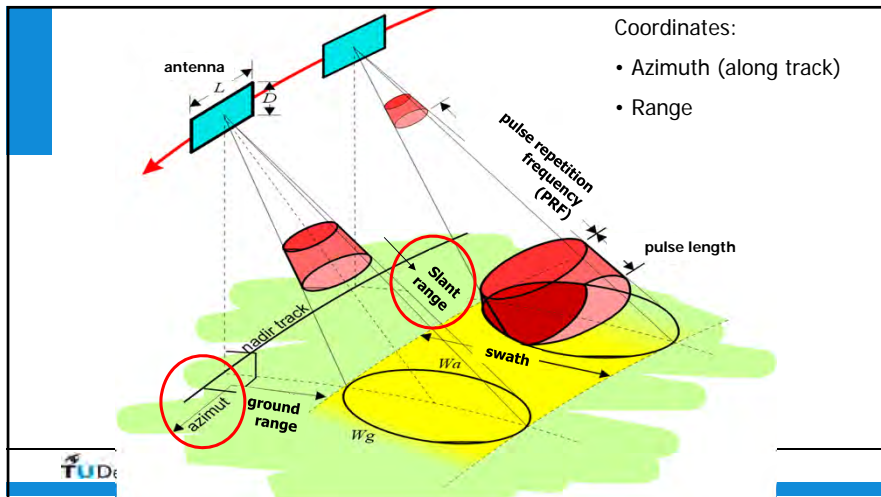
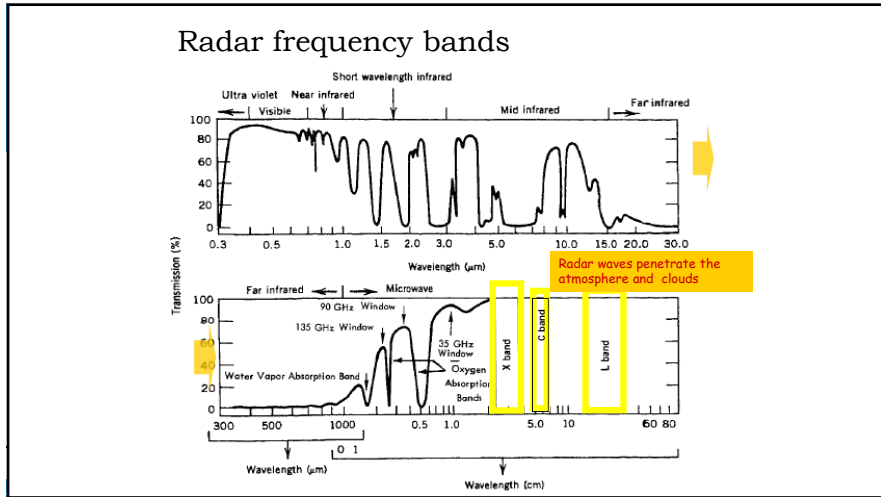


### What can we do with it?

- Measure, estimate, monitor, detect, categorize ...
  - Earthquakes, tectonics, volcanoes, ice, ... and the built environment
  - Geo-objects: the earth's surface and objects on it
  - Past, present and future
  - Position and Changes in position, changes in surface (down to sub-millimetre precision)
- Anticipate, respond, plan, save resources and lives

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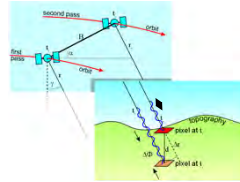




## Imaging radar: Synthetic Aperture Radar (SAR)

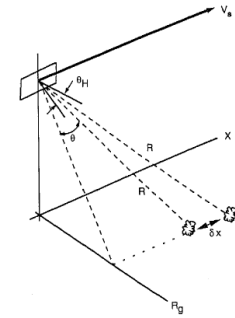
Angular Resolution (Beamwidth) is dependent on

1. Antenna size
2. Wavelength of the radar: C-band, X-band, L-band, S-band



## Resolution I: RAR

- Real Aperture Radar
- Resolution dependent on antenna dimension/pulse length
- Beam width (half power width) is ratio wavelength over antenna size:



$$\theta = \alpha \frac{\lambda}{D} \text{ with } 0.9 < \alpha < 1.4$$

Figure 1.8 Illustration of real-aperture radar capability to resolve two targets separated in azimuth.

1:1 Mock-up!



Calculate Ground Resolution

$$\theta = \frac{\lambda}{D}$$

C-band  $\lambda = \sim 0.05 \text{ m}$

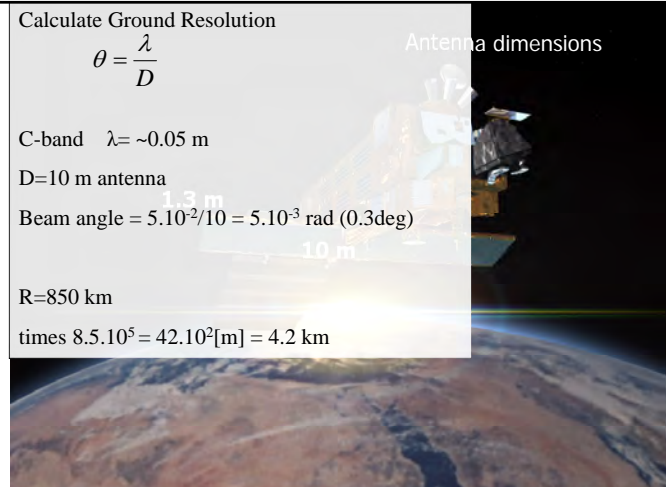
$D = 10 \text{ m}$  antenna

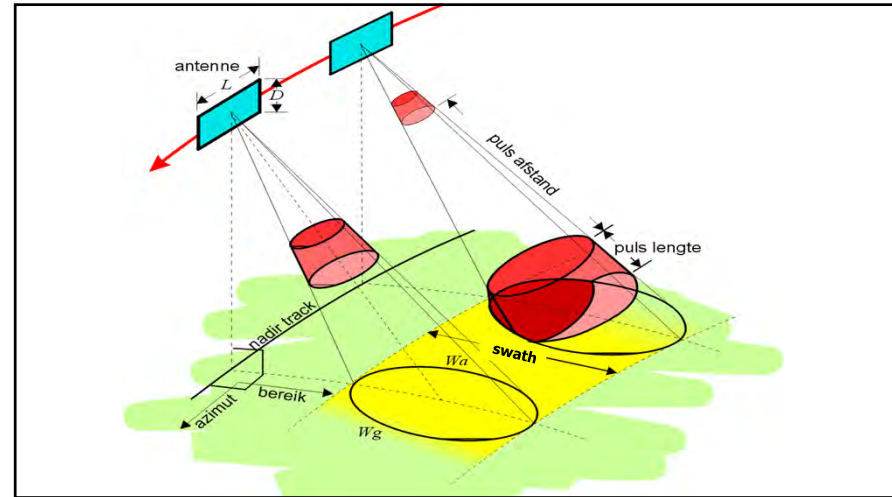
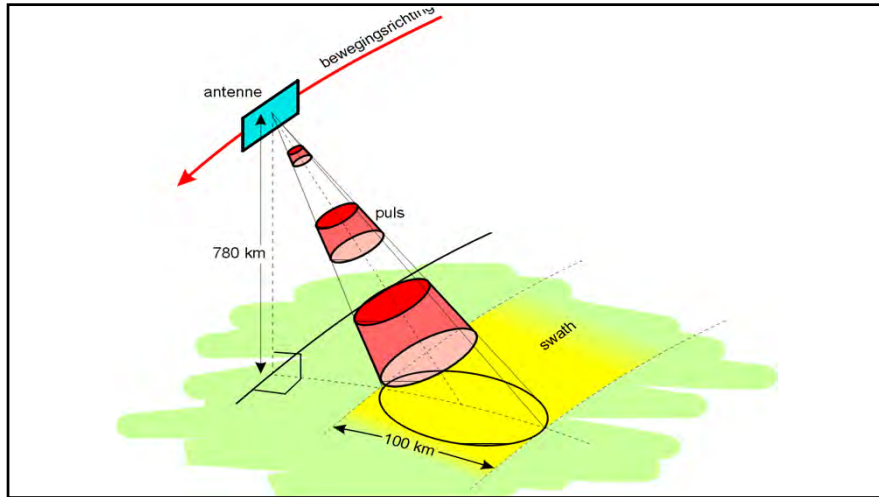
Beam angle  $= 5 \cdot 10^{-2} / 10 = 5 \cdot 10^{-3} \text{ rad}$  (0.3deg)

$R = 850 \text{ km}$

times  $8.5 \cdot 10^5 = 42 \cdot 10^2 \text{ [m]} = 4.2 \text{ km}$

Antenna dimensions





### Improvement in Resolution (Crimea, Ukraine) Real Aperture Radar

5x14 km pixels

Massonnet and Feigl, 1998

### Improvement of along-track resolution: SAR

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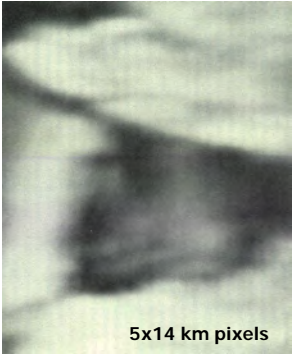
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### Improvement in Resolution

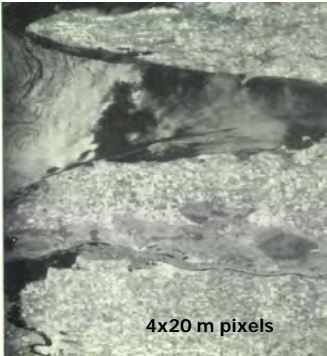
(Crimea, Ukraine)

Real Aperture Radar



5x14 km pixels




Synthetic Aperture Radar



4x20 m pixels

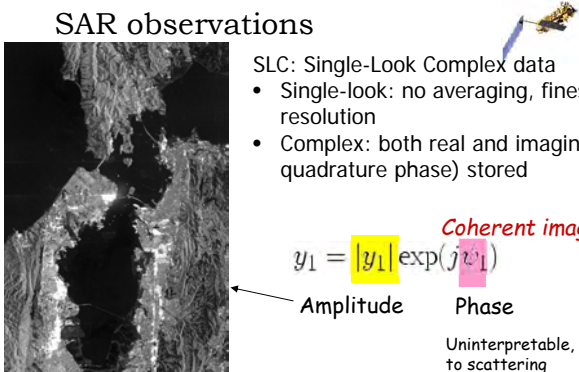
Massonnet and Feigl, 1998



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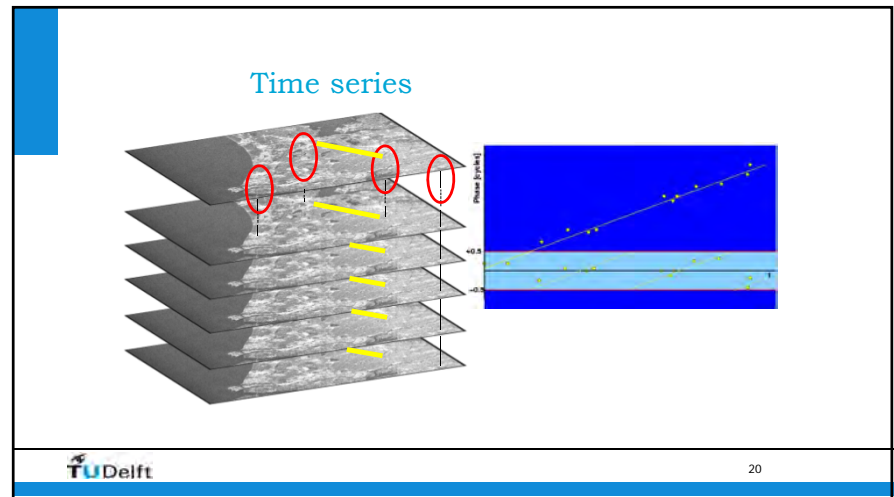
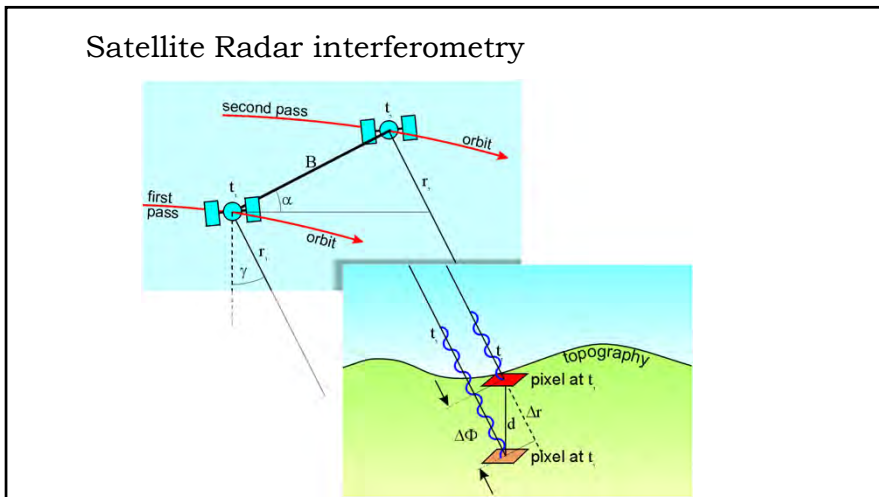
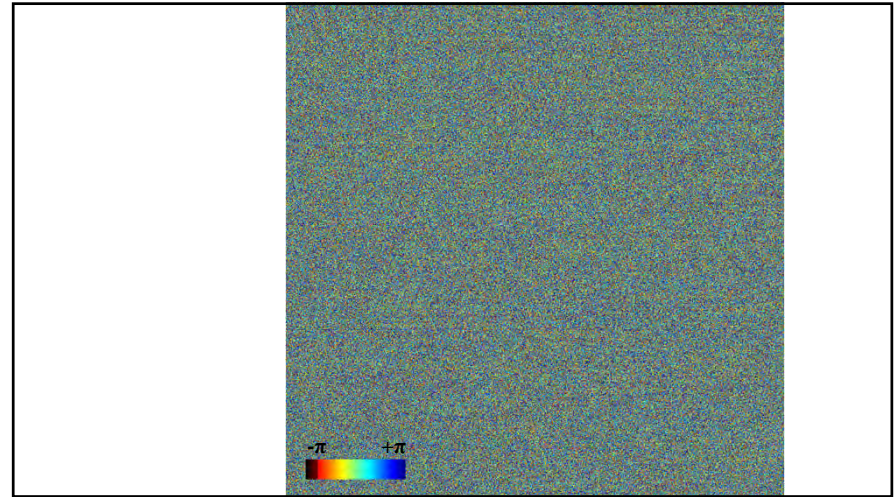
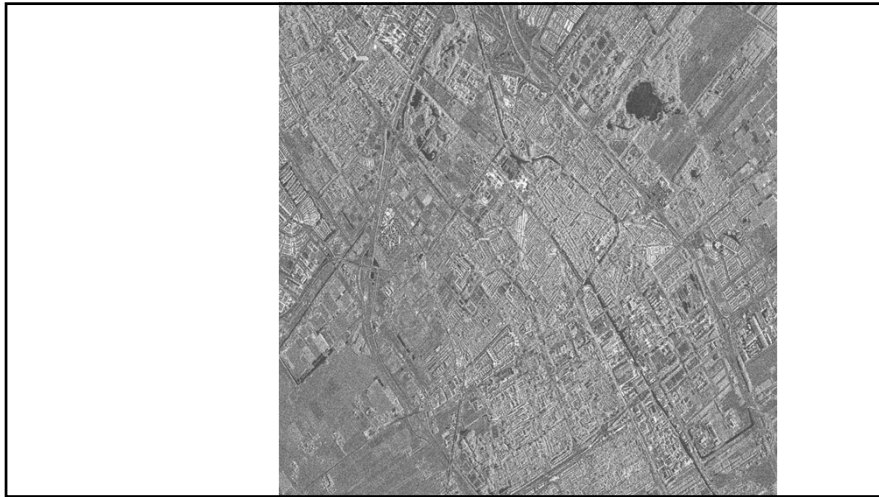
*Coherent imaging*

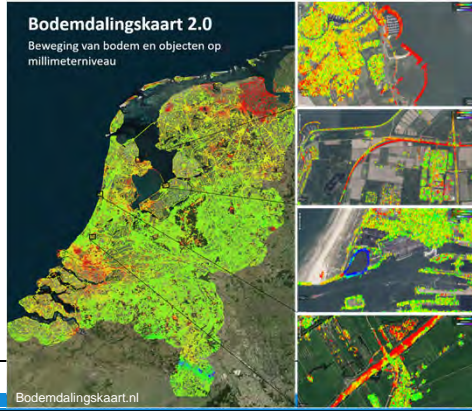
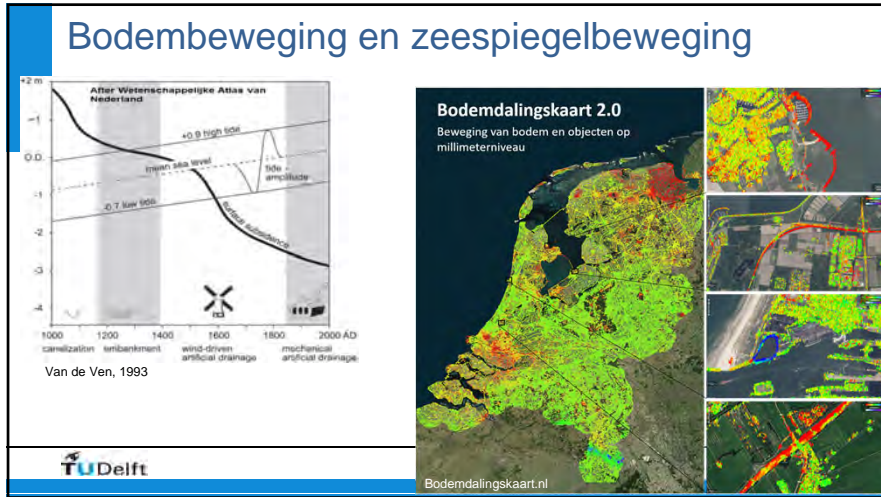
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# InSAR intuitive approach: geometry

# Radar Interferometry

