

# Auf den Millimeter genau – die Erde aus dem Weltraum mit Radar vermessen

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DLR & TUM

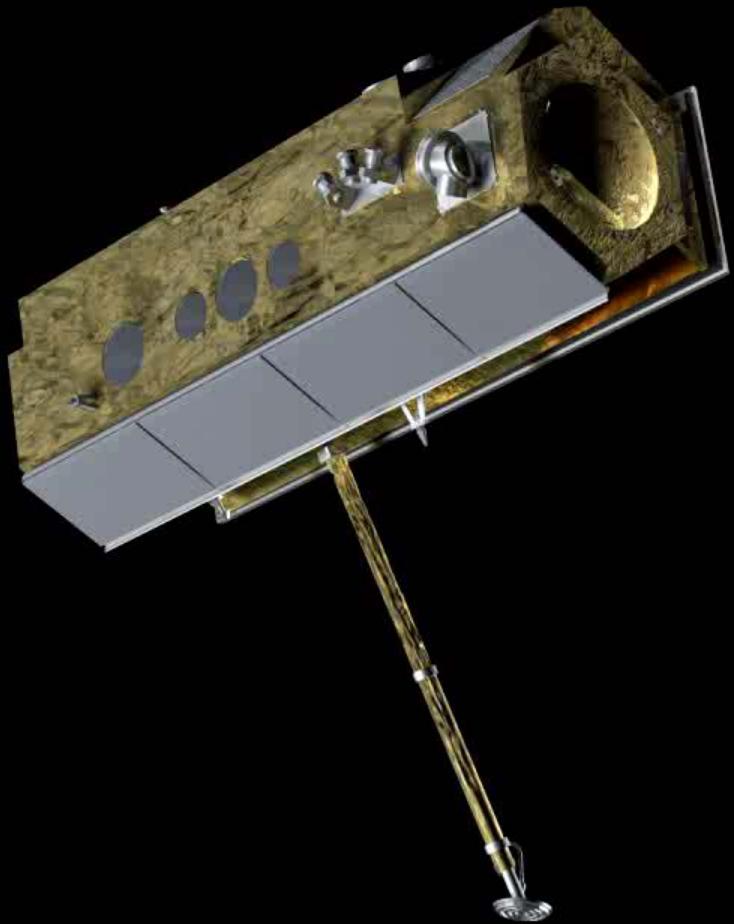


# Fernerkundung = Messen aus der Ferne

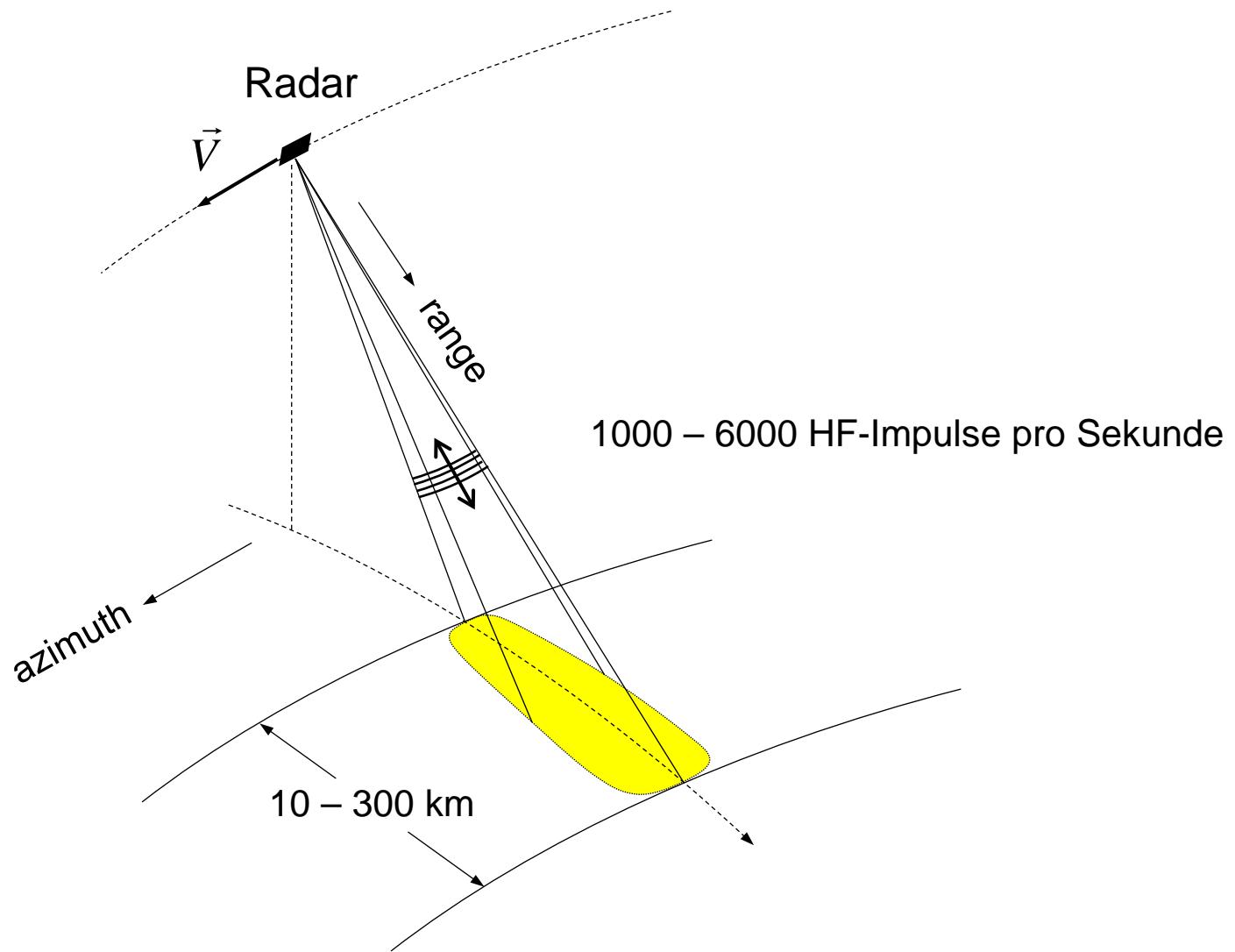
Bilder → Messwerte

- Atmosphäre:  
Spurengase, Aerosole, Wolken, Druck, Temperatur, Wind, Regen,...
- Ozeane:  
Meeresspiegel, Wind, Seegang, Strömungen, Ölverschmutzungen, Schiffsverkehr, Wasserqualität, Primärproduktion,...
- Eis:  
Gletschervolumina und -geschwindigkeiten, Ausdehnung des Meereises,...
- Landoberfläche:  
Kartierung (z.B. Notfall-), Landbedeckung, Landnutzung, Biomasse, Höhenmodelle, Erdbeben, Vulkanismus, Bodensenkungen, Hangrutsche,...
- Schwerefeld und Magnetfeld der Erde



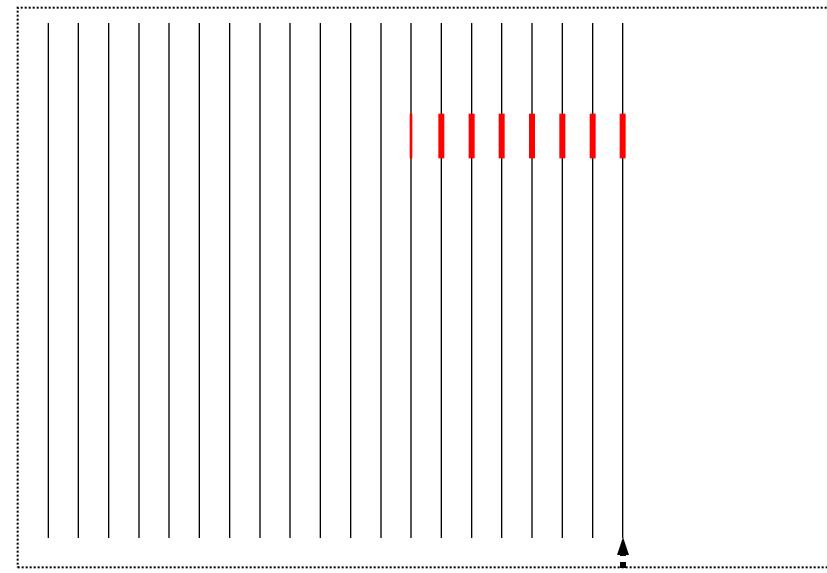
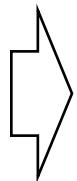


# SAR = Synthetisches Apertur Radar



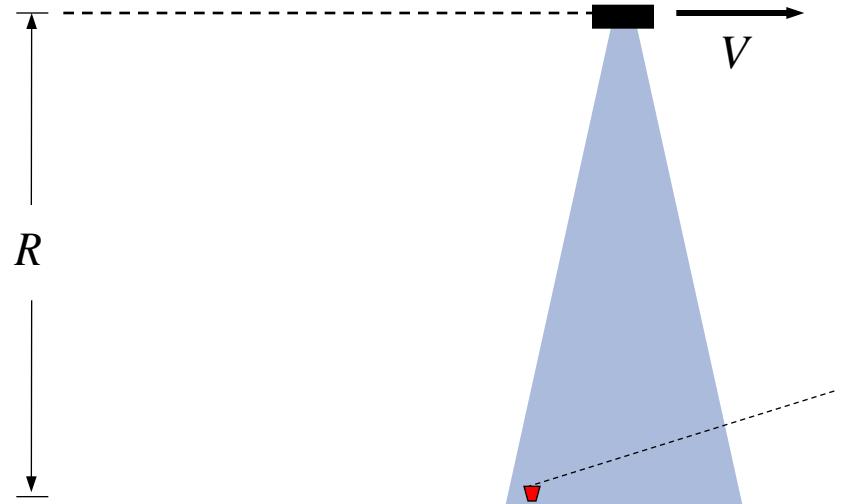
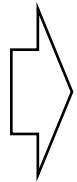
# 2-D Raw Data Matrix

echo signal matrix

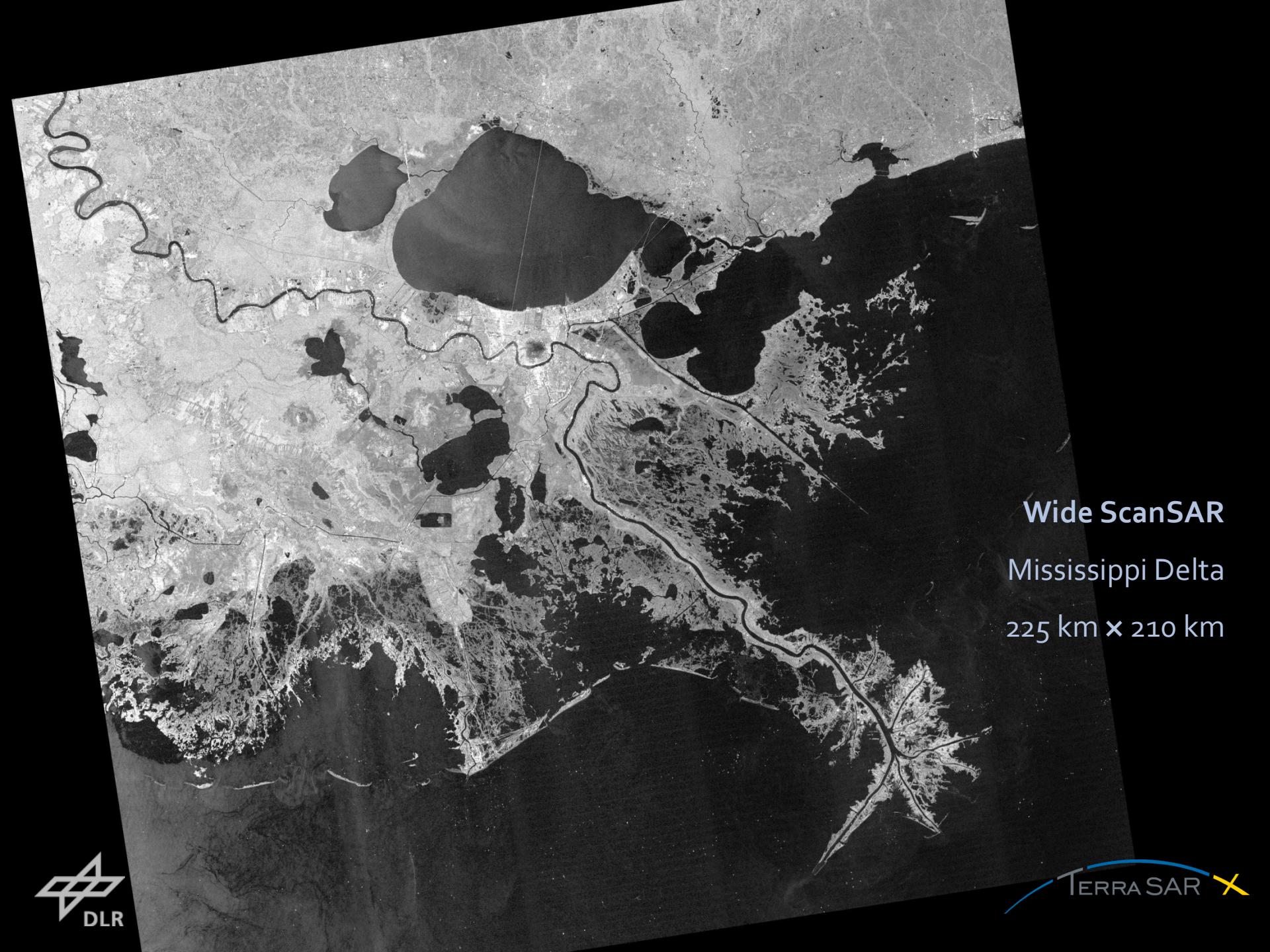


$x$   
 $y$   
 $z$

acquisition geometry  
(top view)



point scatterer

A grayscale satellite image showing the Mississippi River delta. The image captures the complex network of waterways, wetlands, and landmasses. The Mississippi River flows from the bottom right towards the top left, with numerous distributaries branching off. The surrounding land is a mix of lighter gray tones, indicating different types of vegetation or soil. The overall scene is a wide-angle view of a coastal area.

Wide ScanSAR

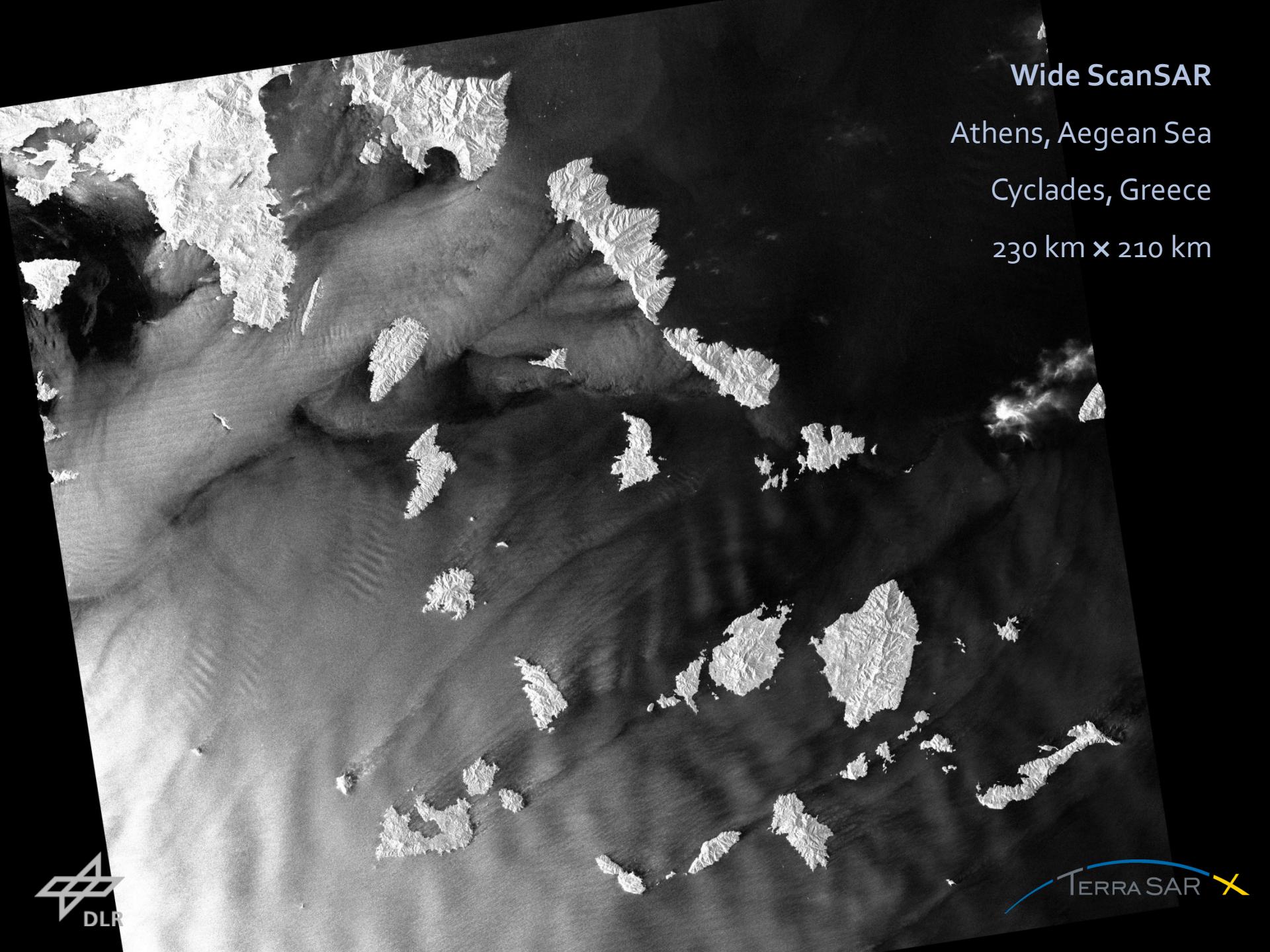
Mississippi Delta

225 km x 210 km

# Deepwater Horizon Accident. Gulf of Mexico



TSX 2010-05-15 12:24 UTC

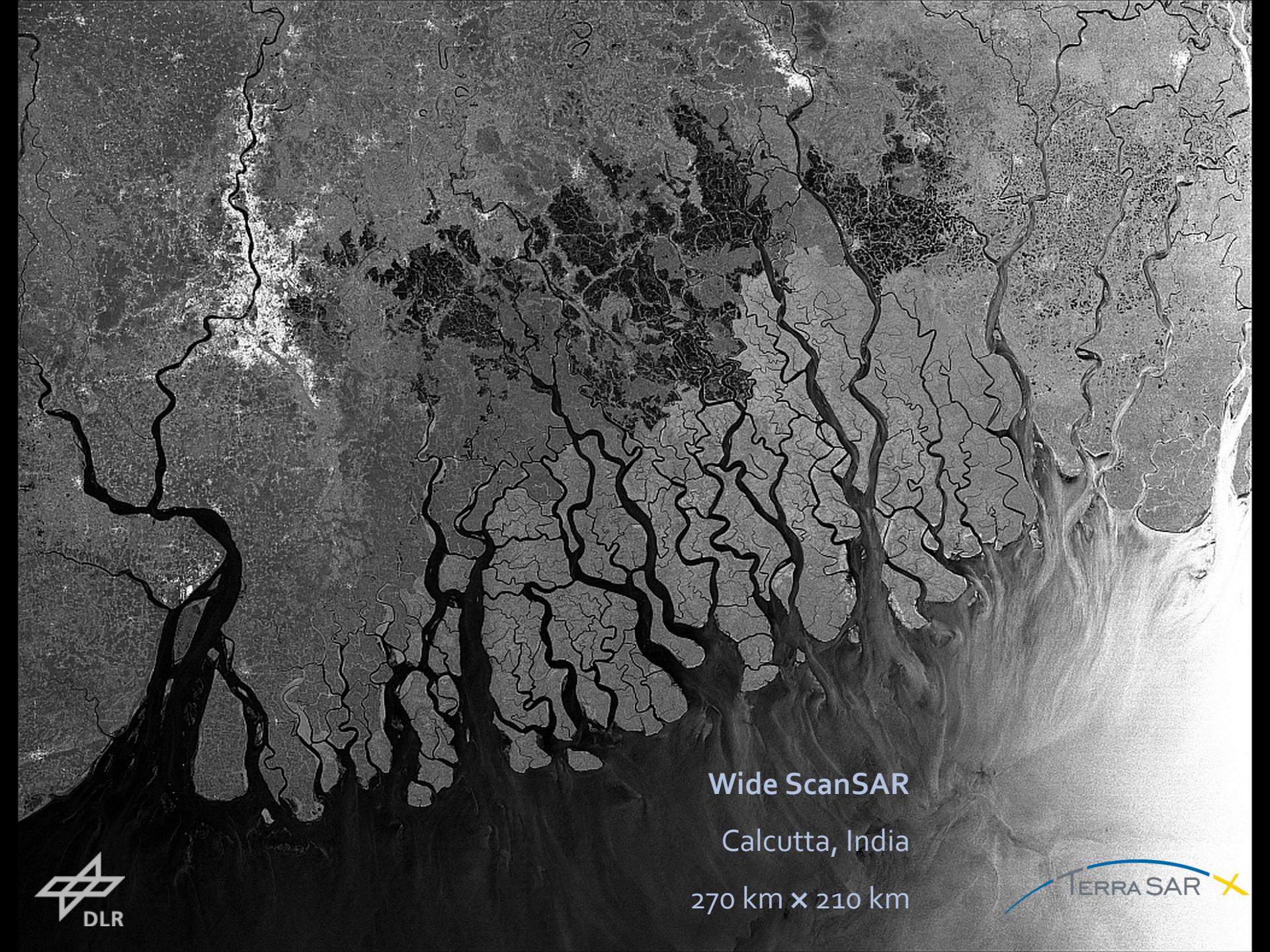


Wide ScanSAR

Athens, Aegean Sea

Cyclades, Greece

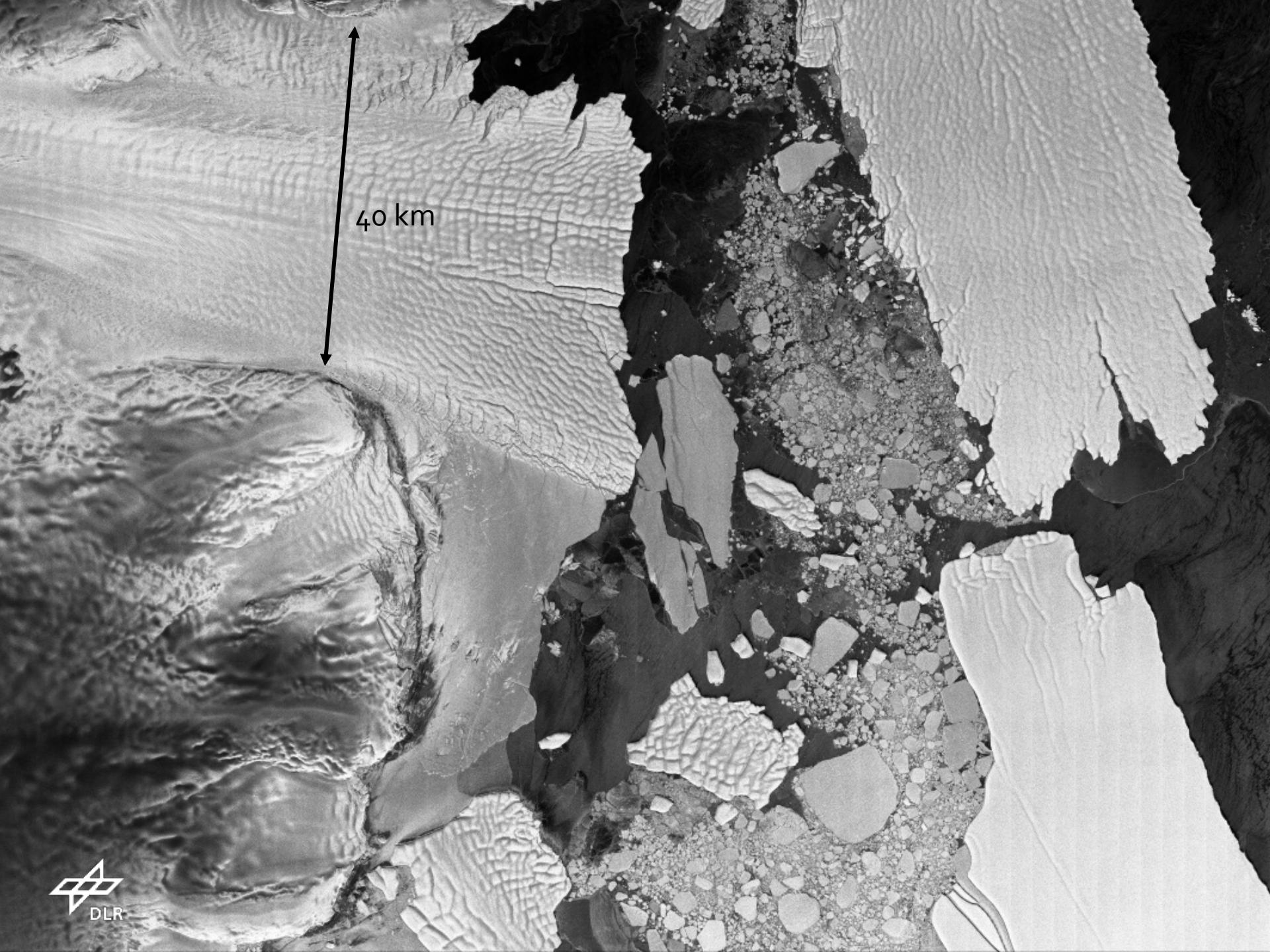
230 km × 210 km



Wide ScanSAR

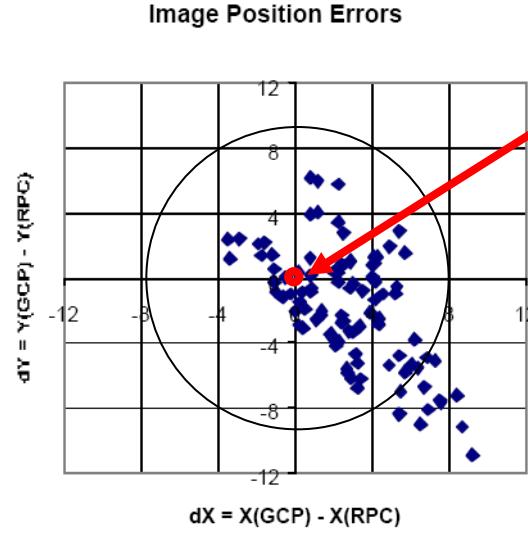
Calcutta, India

270 km x 210 km



40 km

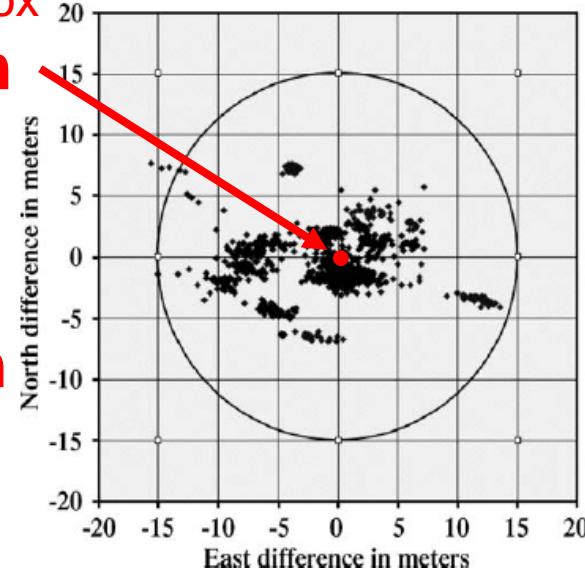
# TerraSAR-X: World Record in Geolocation Accuracy



IKONOS

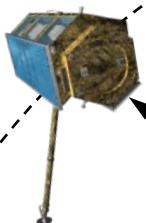
TerraSAR-X  
out of the box  
**< 30 cm**

**new:**  
**≈1-2 cm**

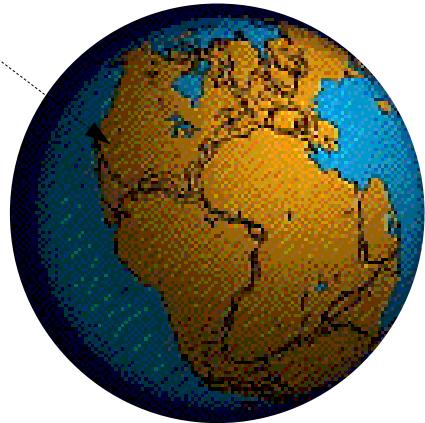
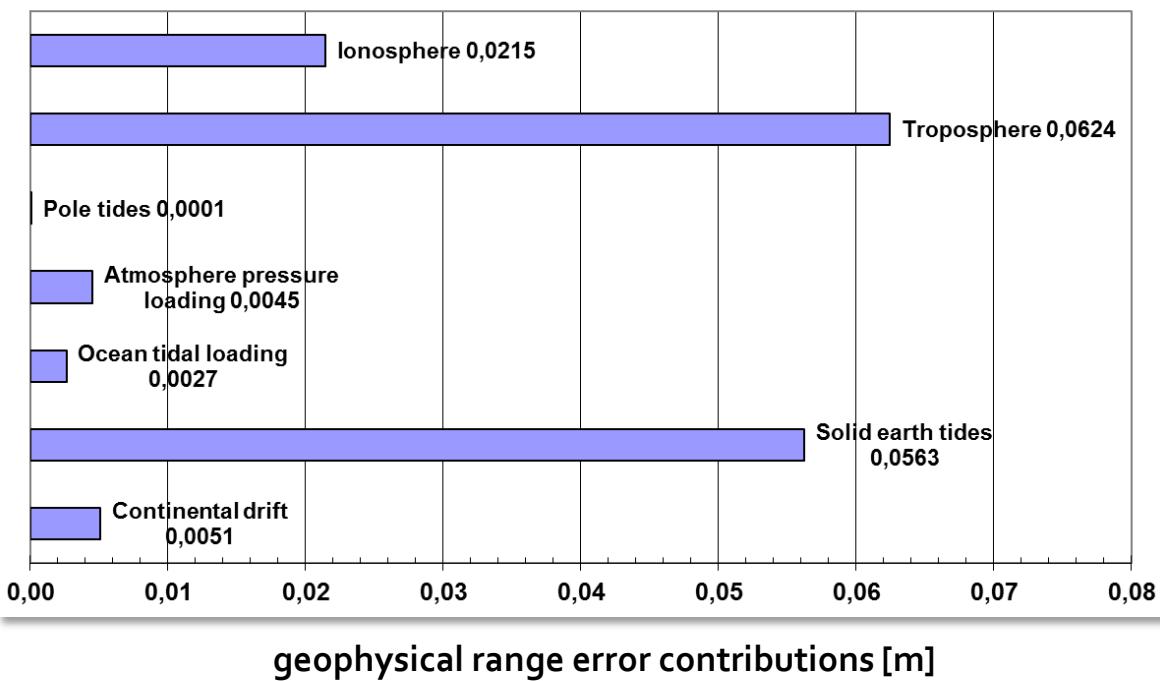


SPOT-5

# SAR Imaging Geodesy

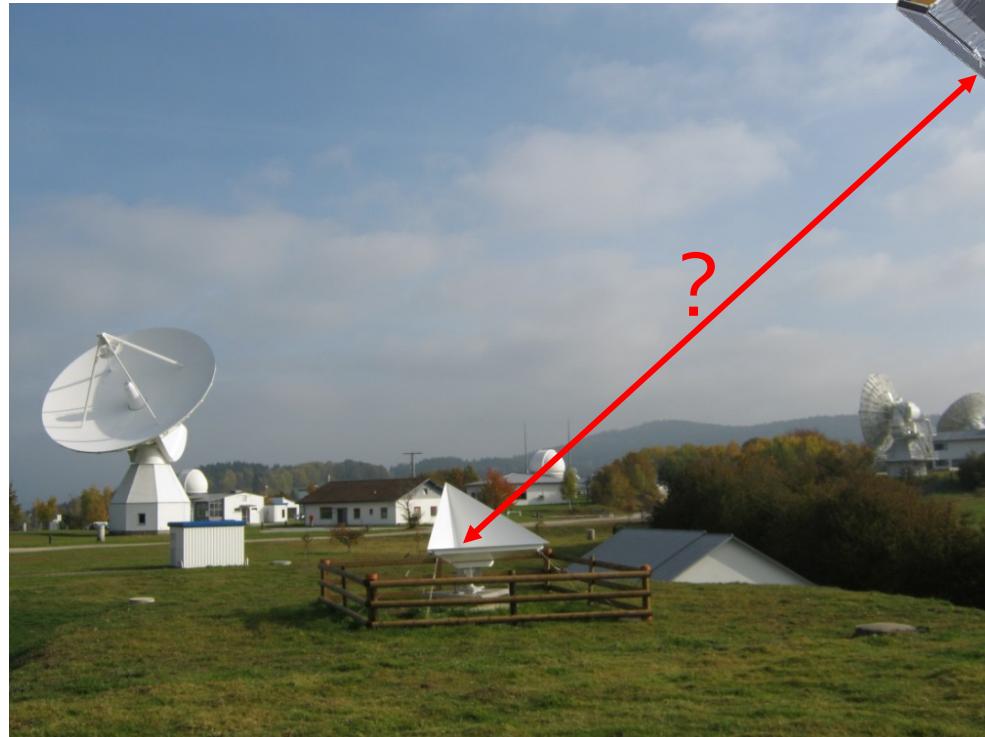


Capturing geodynamic effects by  
sub-pixel SAR measurements



# Imaging Geodesy

“How accurately can we localize an object by SAR imaging?”



Wettzell, D



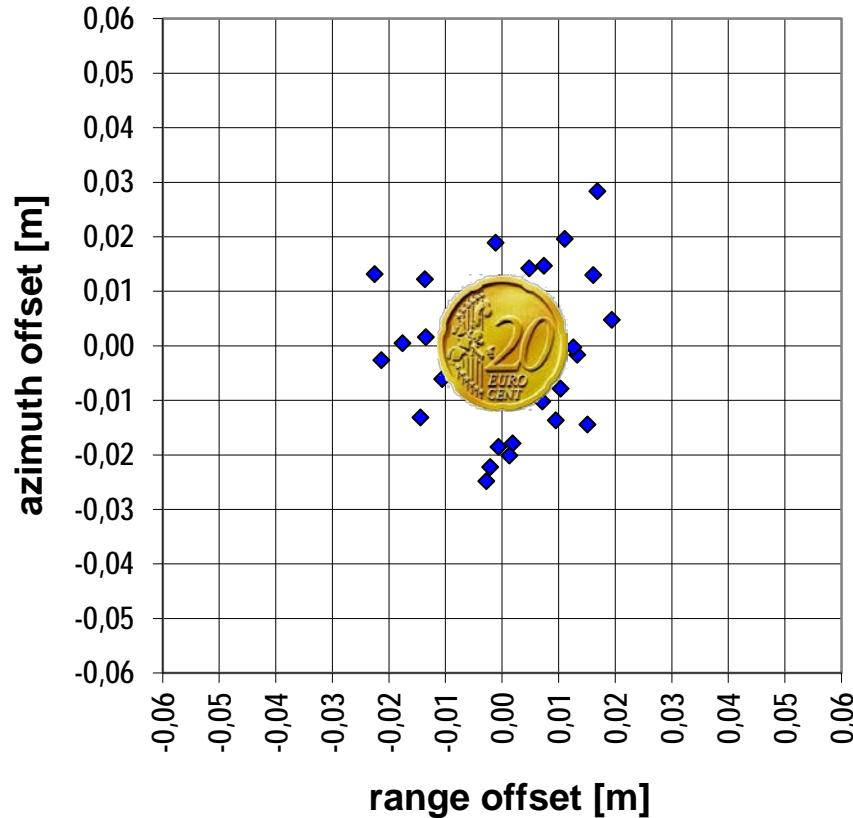
Metsähovi, FIN



O'Higgins

# TerraSAR-X Geolocalization Accuracy

Reflector Wettzell



After correction of  
- solid earth tides  
- atmospheric  
- refraction ( $H_2O$ , TEC)  
- pole tides etc.

◆ TSX (34° asc)

- ◆ Range error:  $\sigma = 11 \text{ mm}$
- ◆ Az. Error:  $\sigma = 13 \text{ mm}$

# Porto Marghera

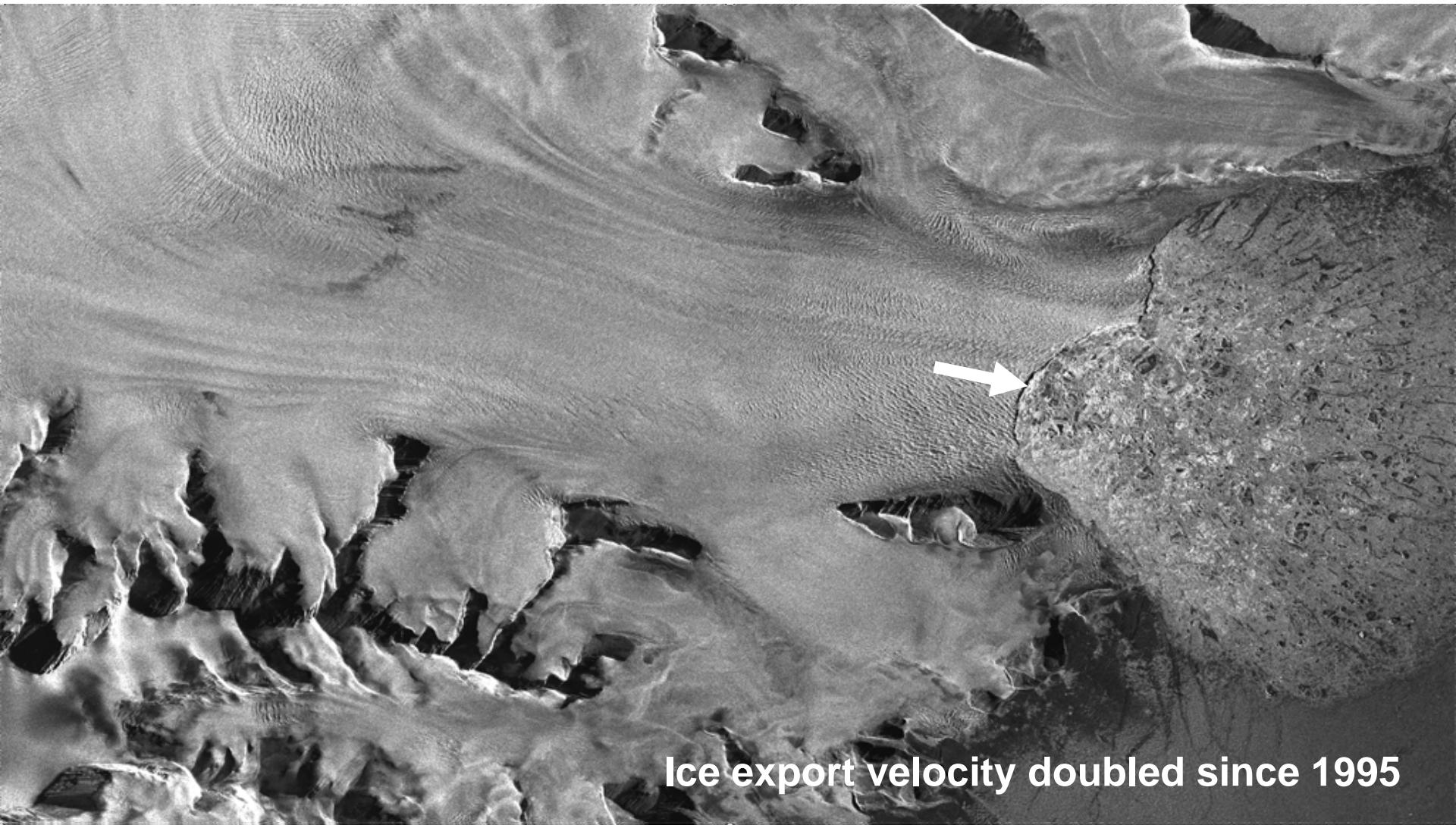


C. Minet, DLR



# Drygalski Gacier: Oct. 2007 – Oct. 2008

TERRA SAR-X

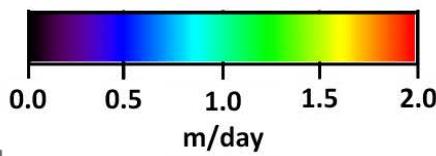
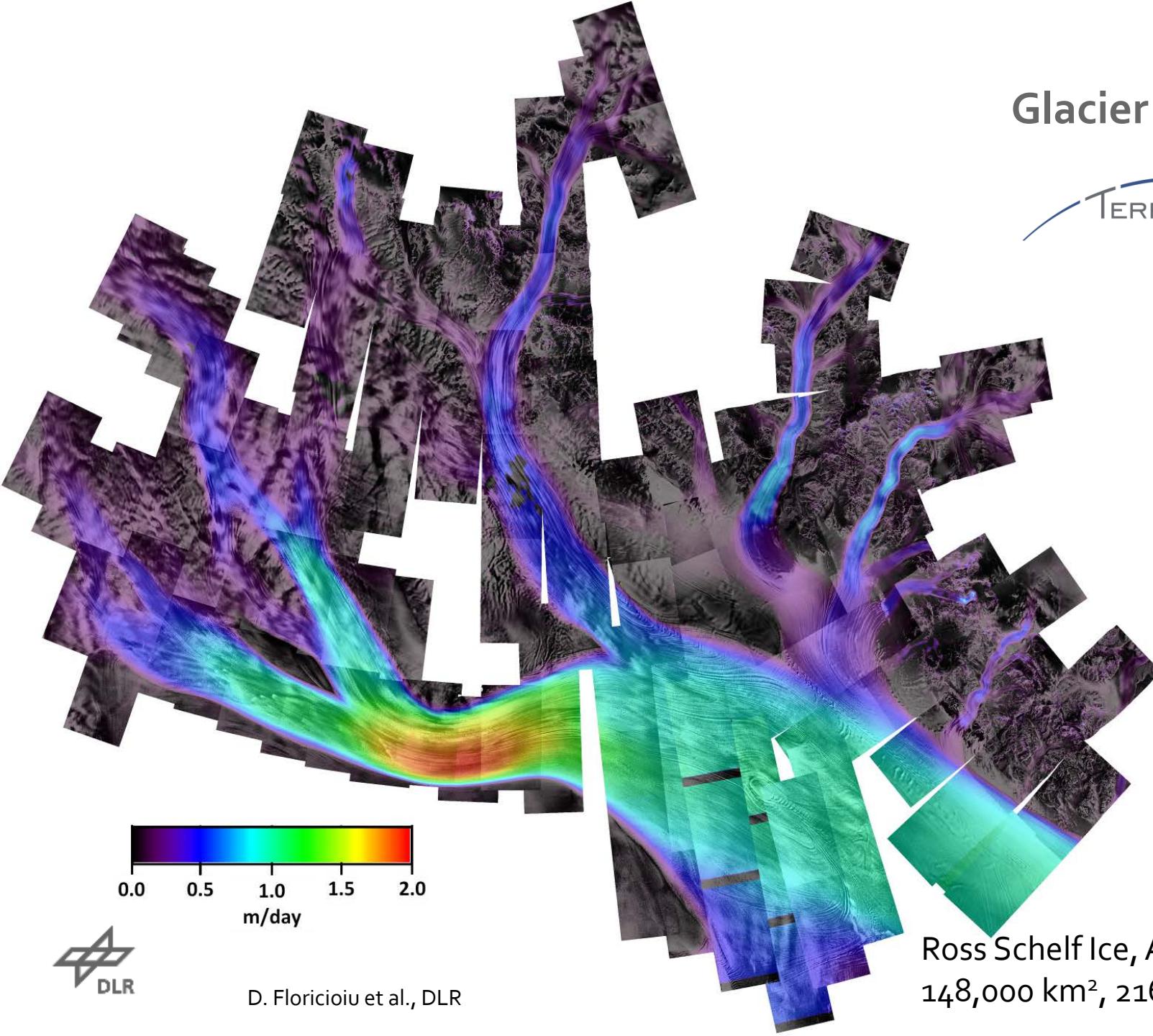


**Ice export velocity doubled since 1995**

M. Eineder, DLR

# Glacier Velocity

TERRA SAR X



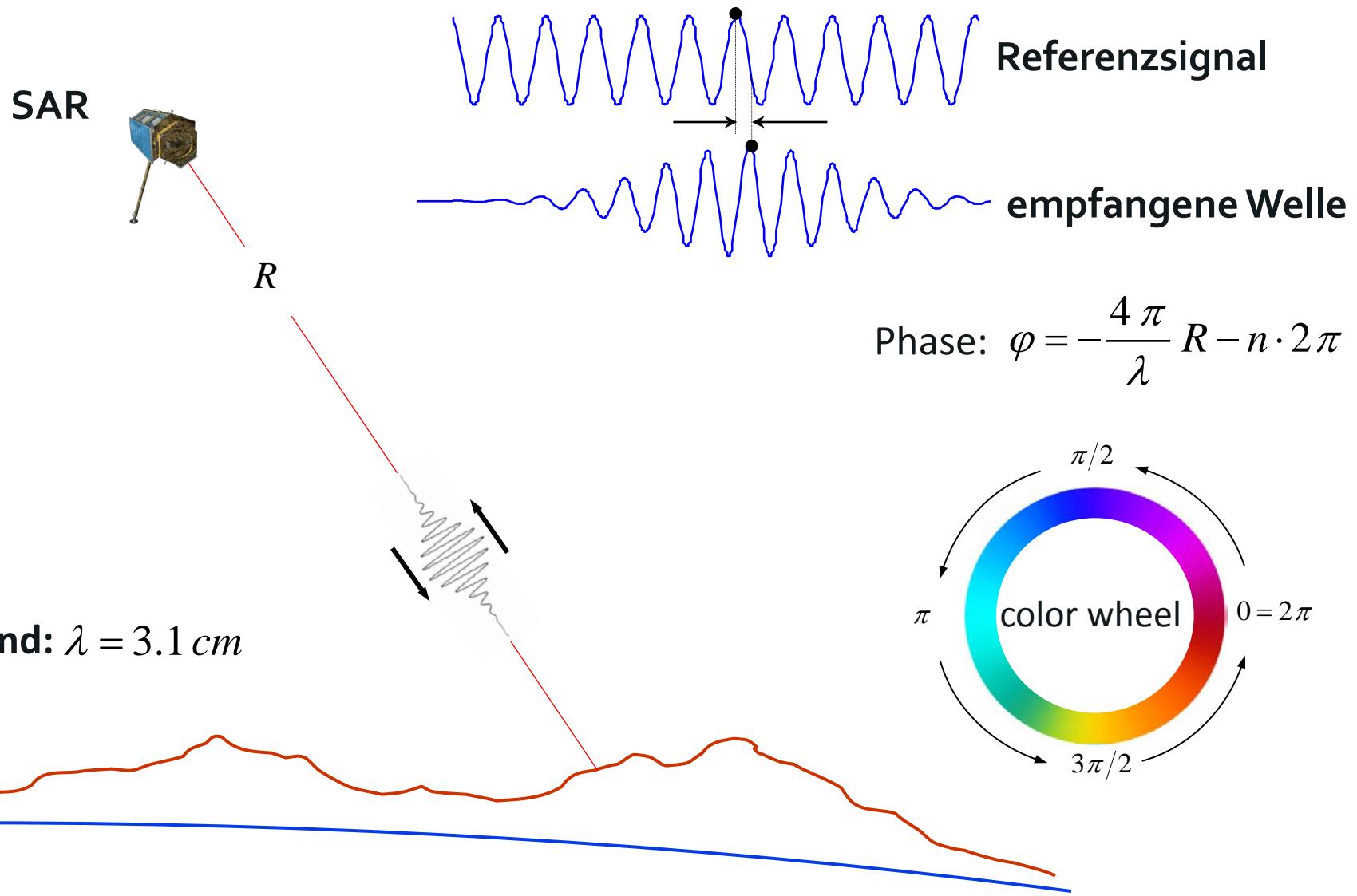
D. Floricioiu et al., DLR

Ross Shelf Ice, Antarctica  
148,000 km<sup>2</sup>, 216 image pairs

# Aber es geht noch genauer.



# Phase eines Pixels im SAR-Bild





# Bam Earthquake 26 Dec, 2003: Coseismic Deformation

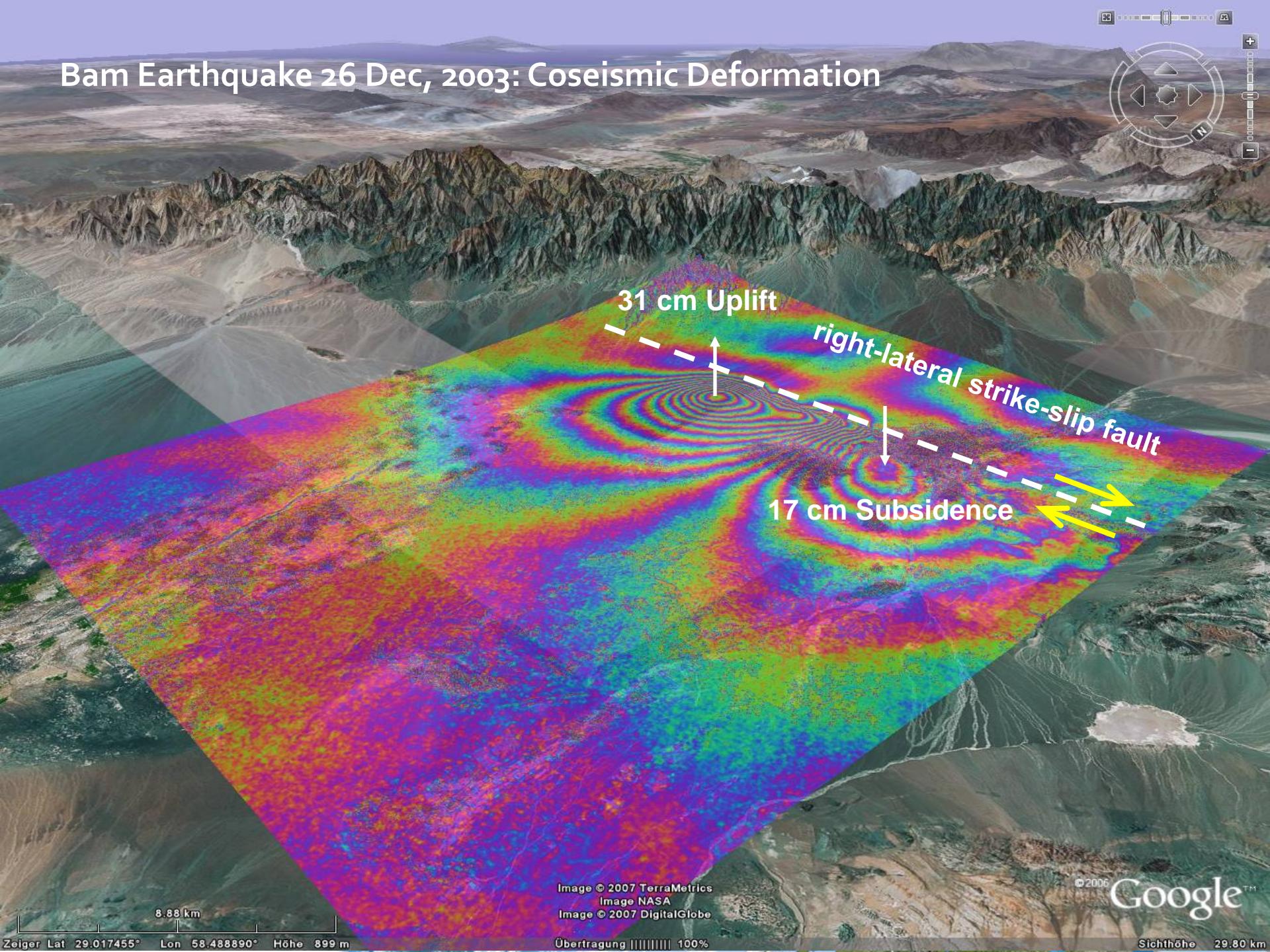


Image © 2007 TerraMetrics  
Image NASA  
Image © 2007 DigitalGlobe

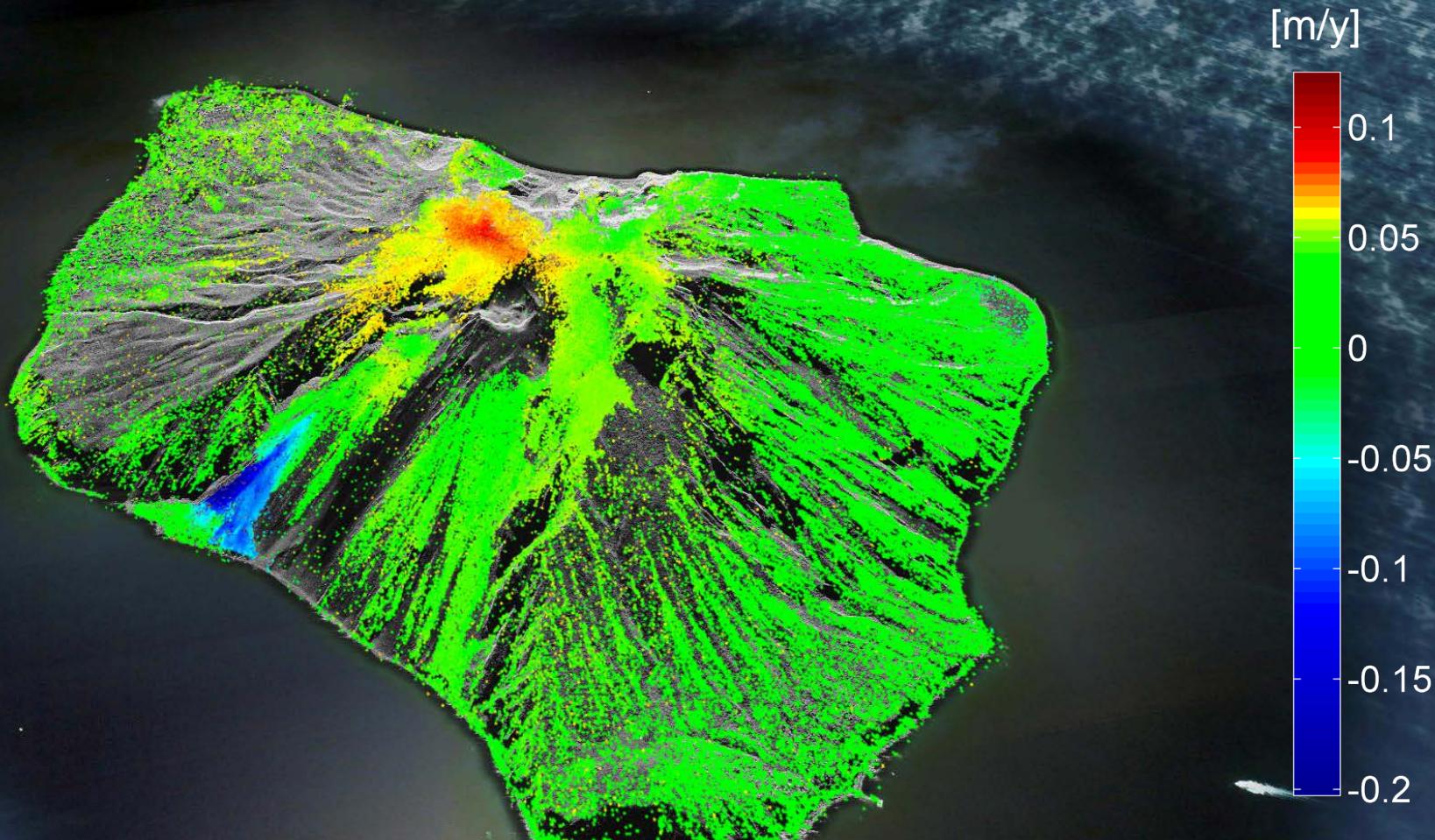
Zeiger Lat 29.017455° Lon 58.488890° Höhe 899 m

Übertragung ||||||| 100%

© 2006 Google™

Sichthöhe 29.80 km

# Deformation Measurements (PS + DS) Stromboli

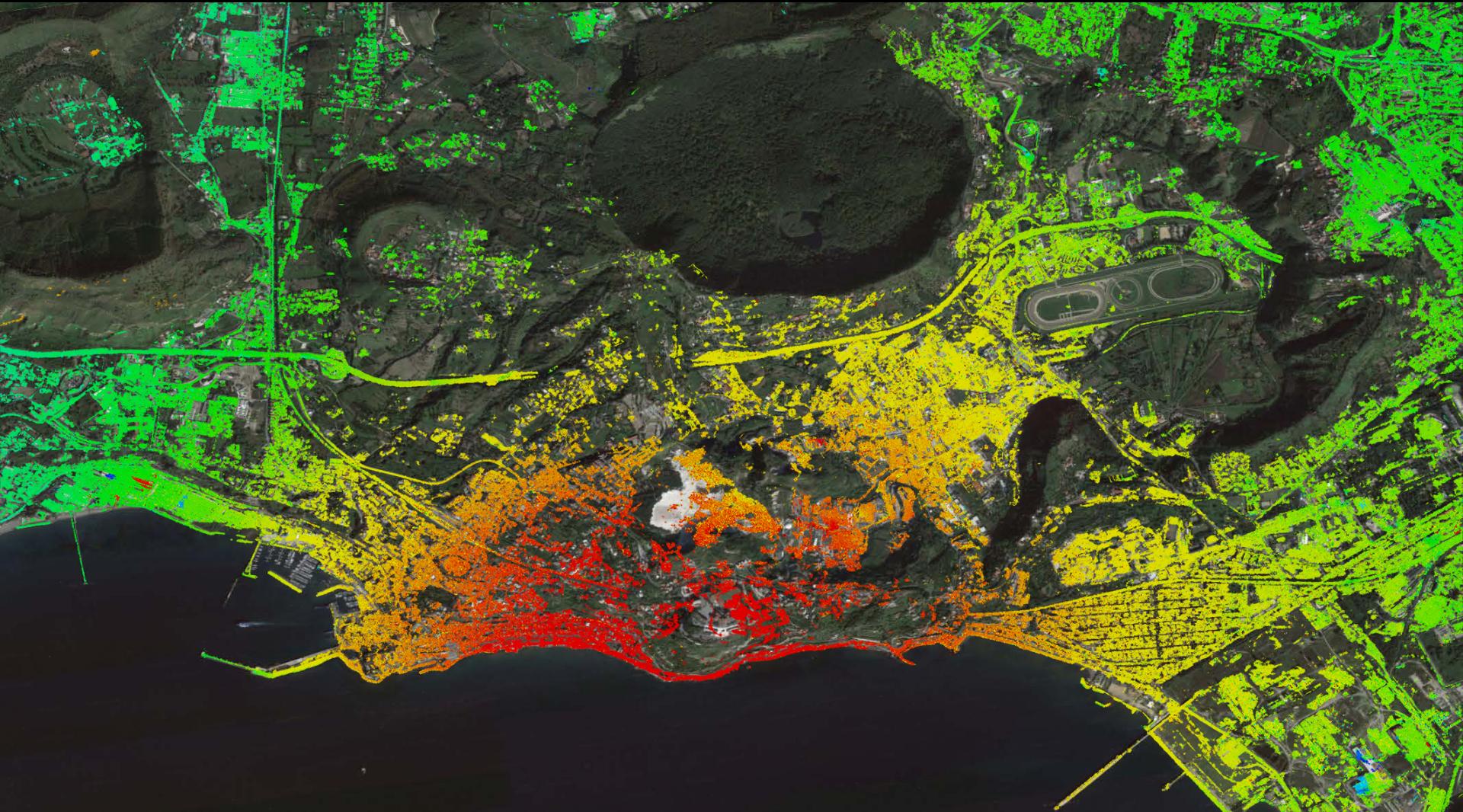


# Campi Flegrei, Italy

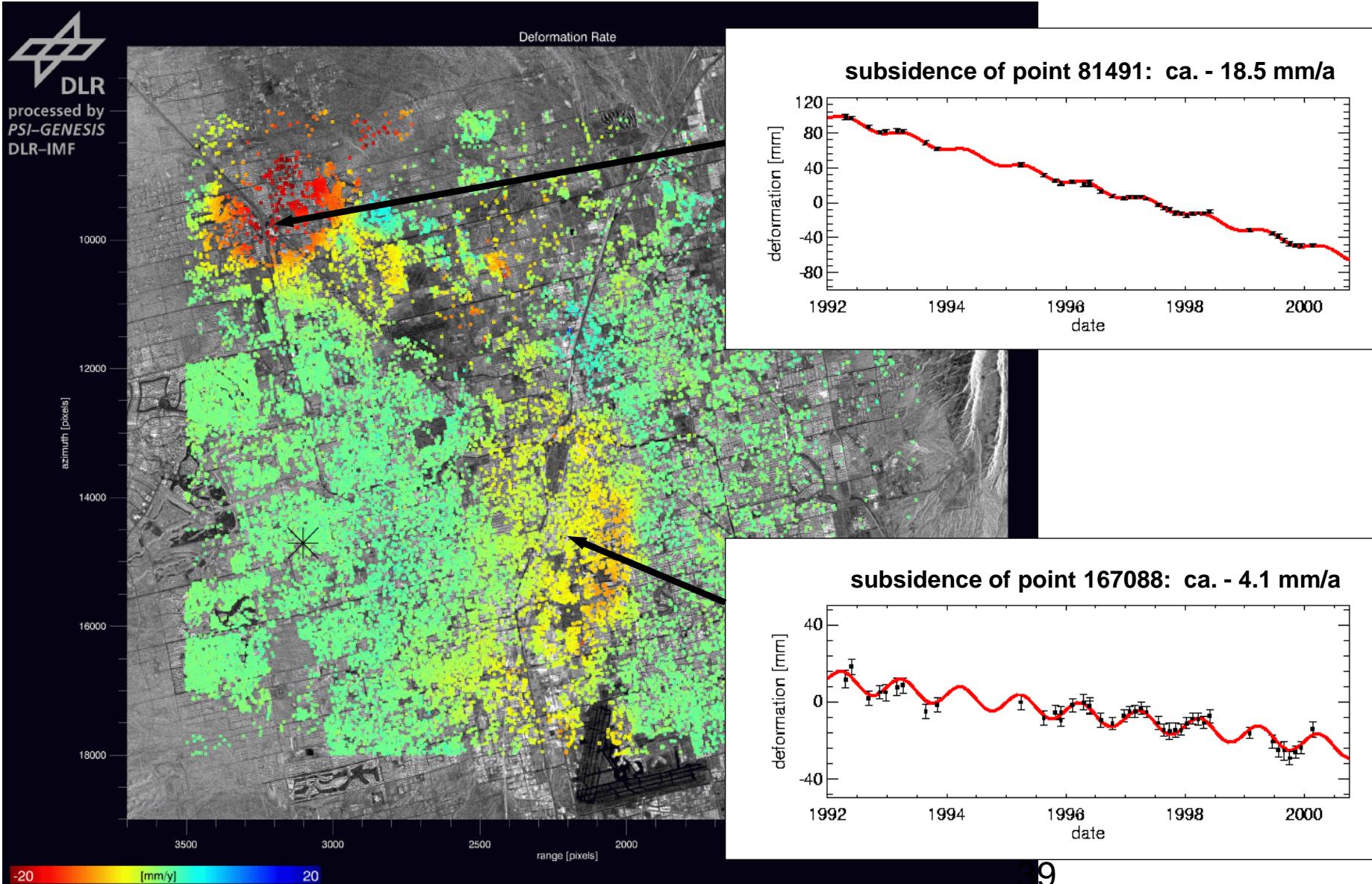


© Google-Earth

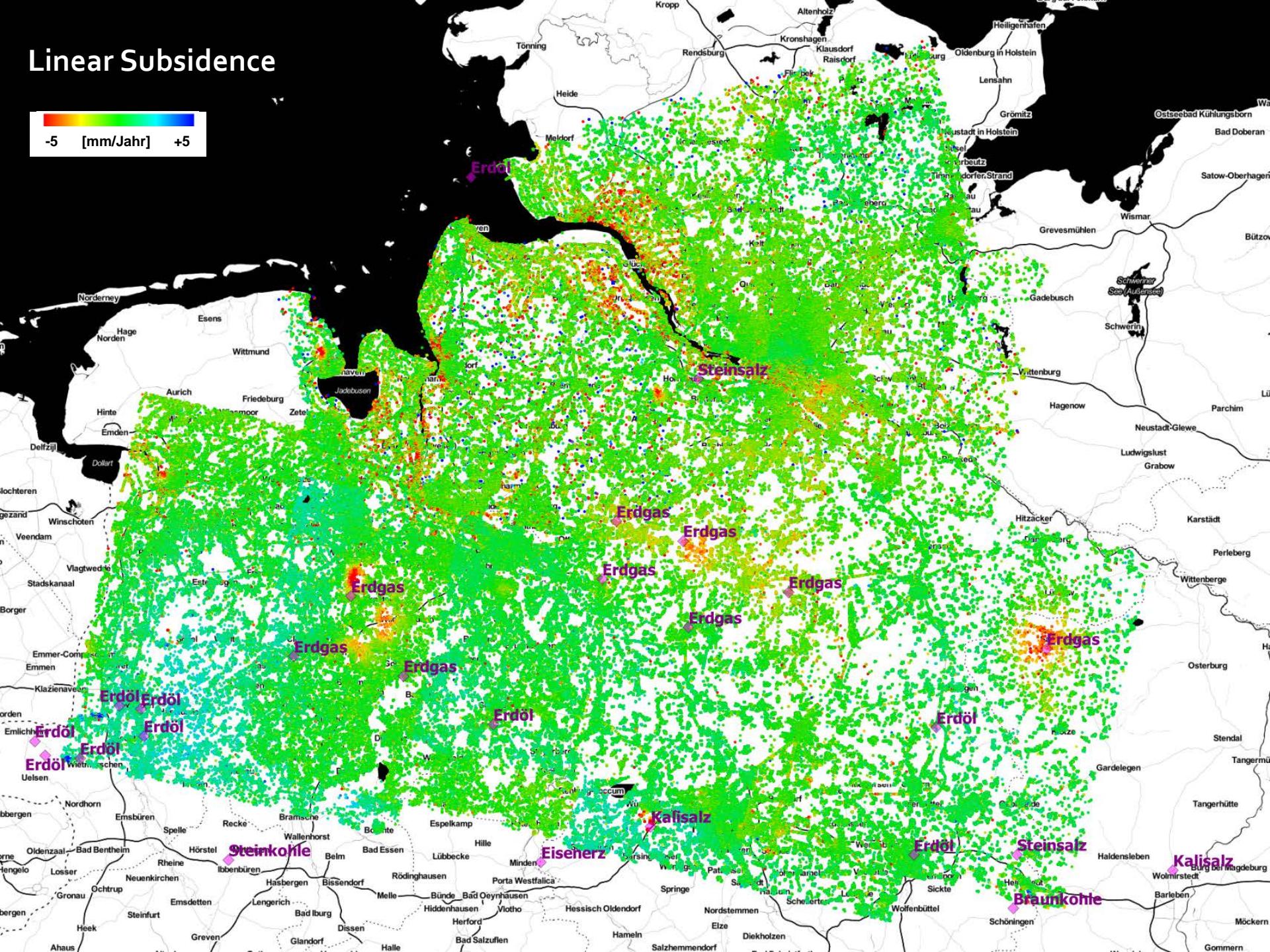
# Campi Flegrei, Italy



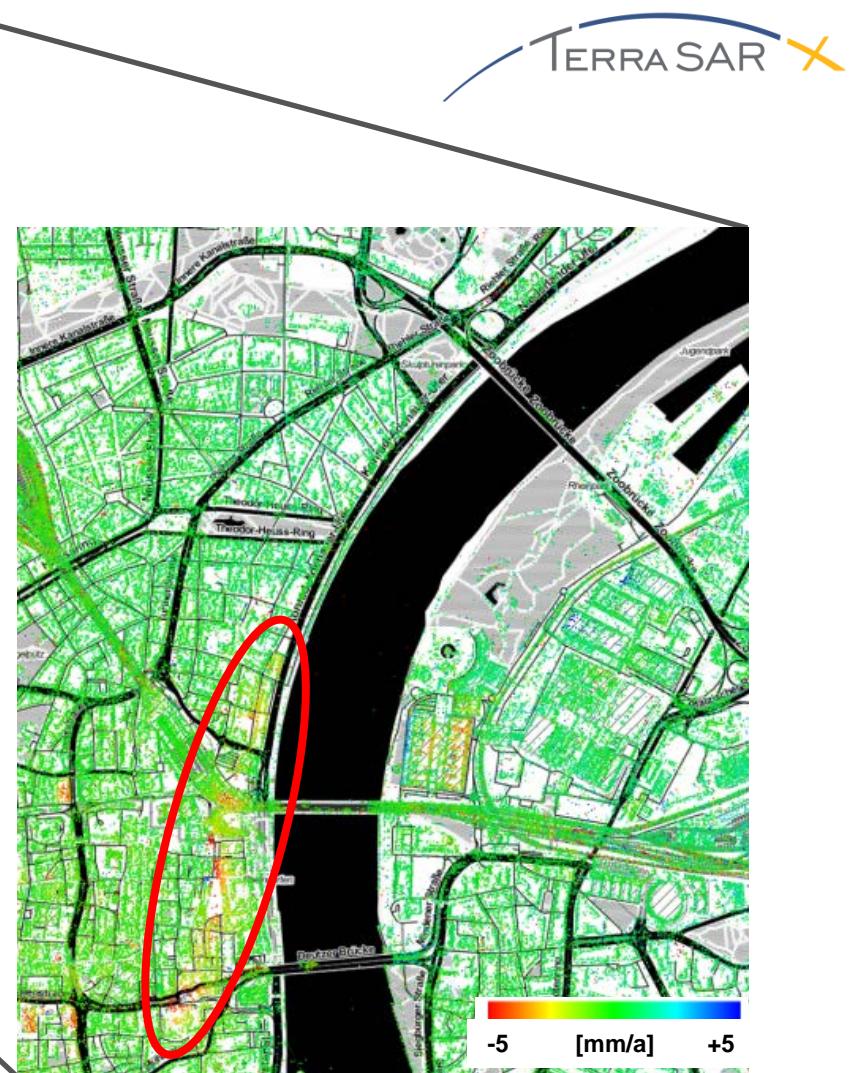
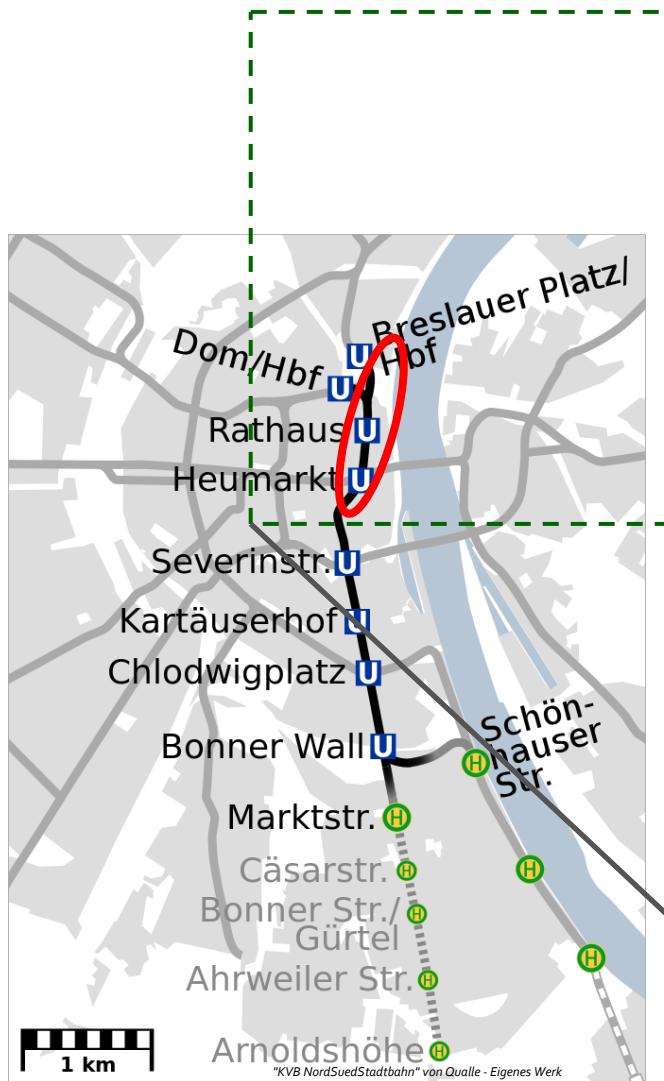
# Linear and Periodic Seasonal Subsidence Measured by PSI



# Linear Subsidence



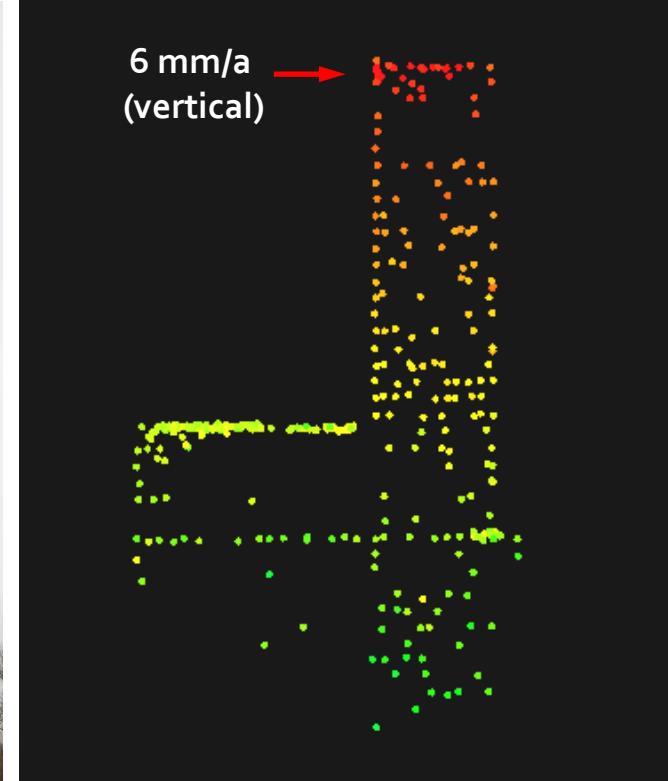
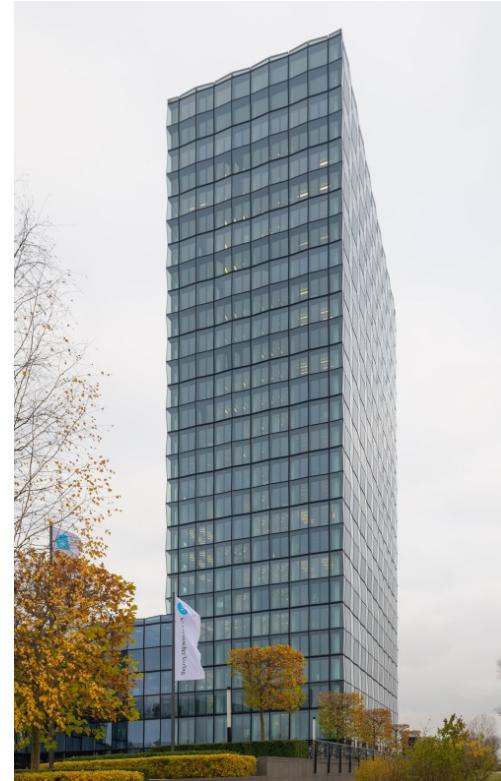
# Subsidence Caused by Subway Construction in Cologne



# Honey, I Shrunk the Kids Building (I)

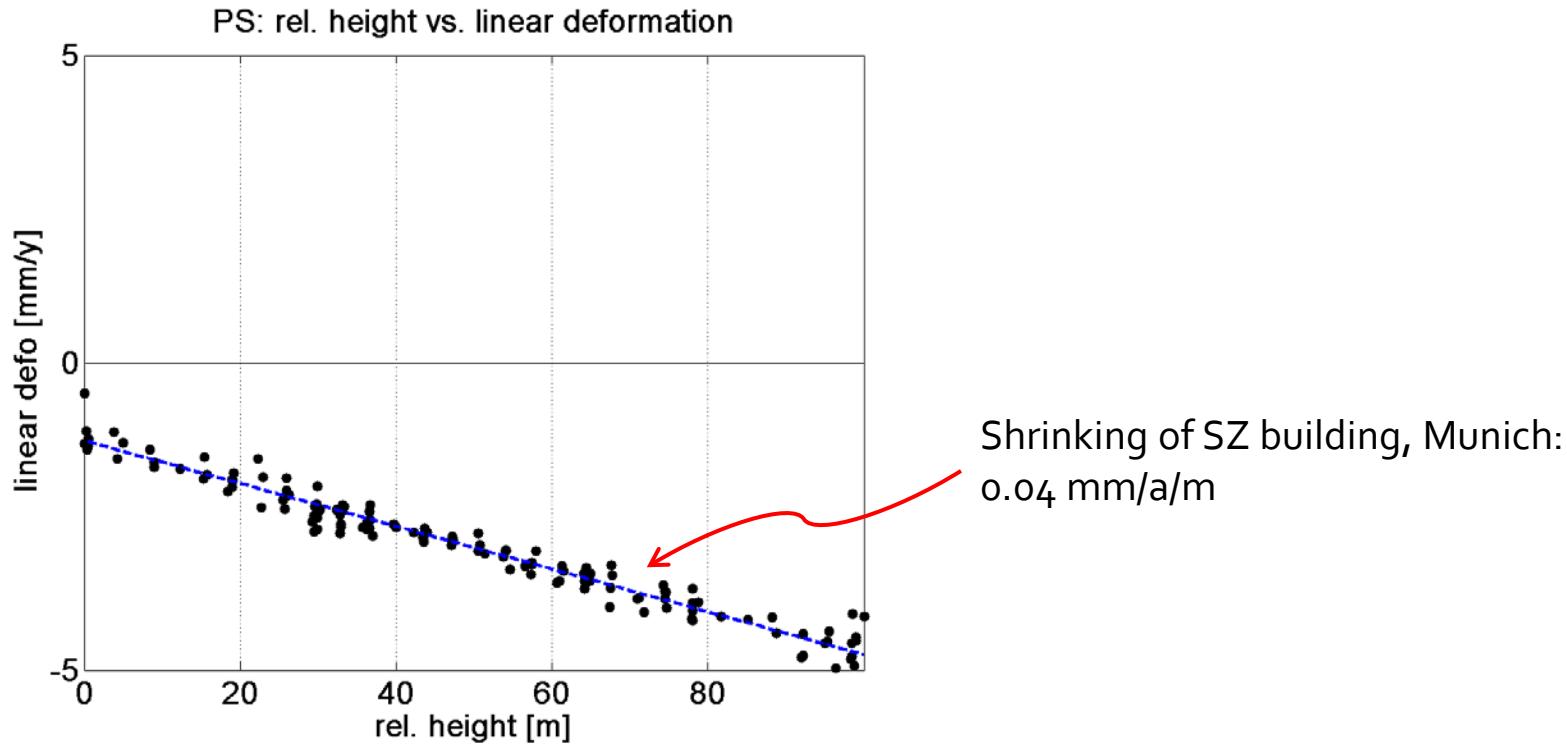
Süddeutscher Verlag, Munich

- new steel-concrete construction
- height-dependent subsidence



color: linear subsidence

# Honey, I Shrunk the Kids Building (II)



Cause: Dehydration and creeping of concrete

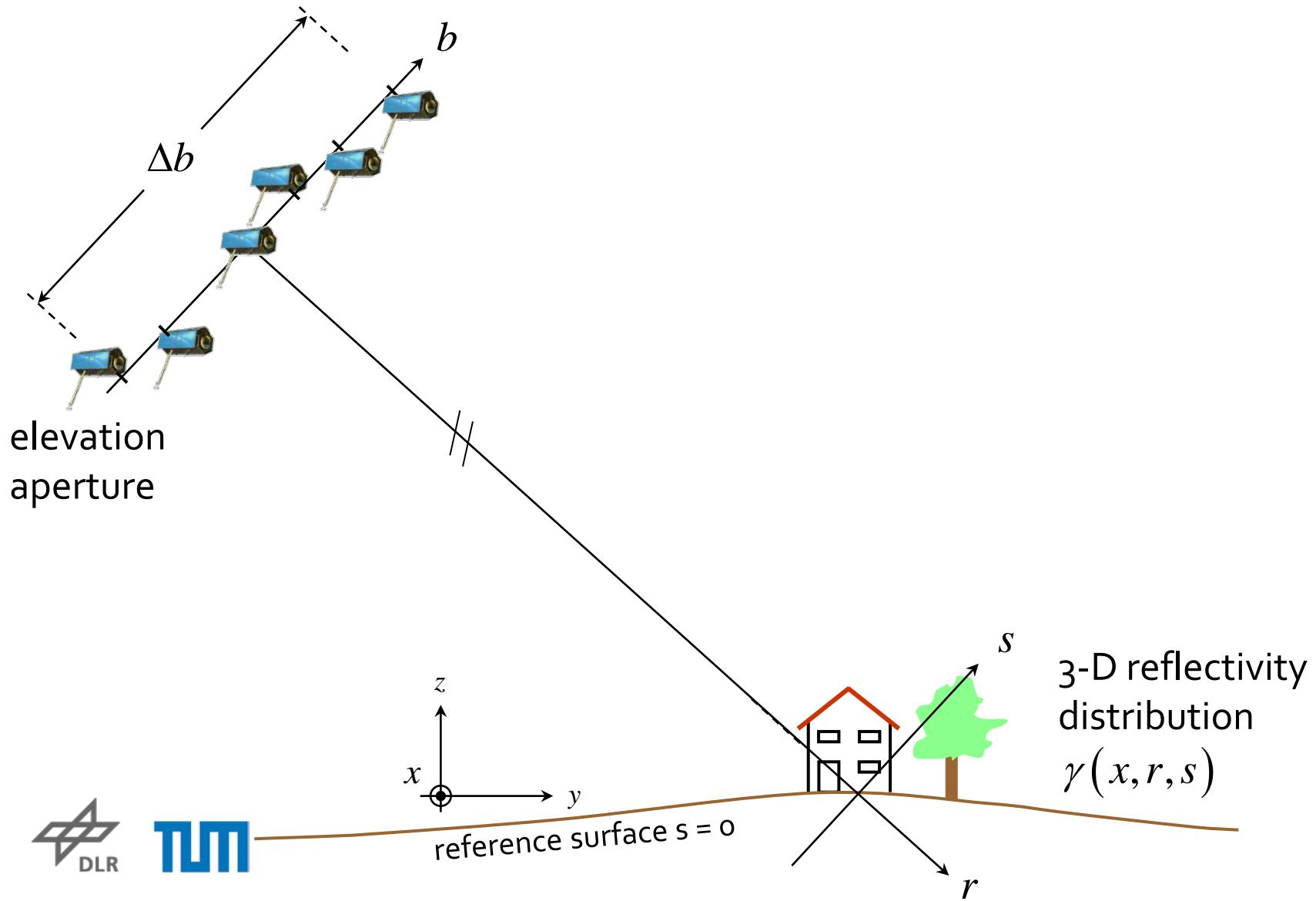


Very High Resolution ( $1.1 \times 0.6 \text{ m}^2$ )

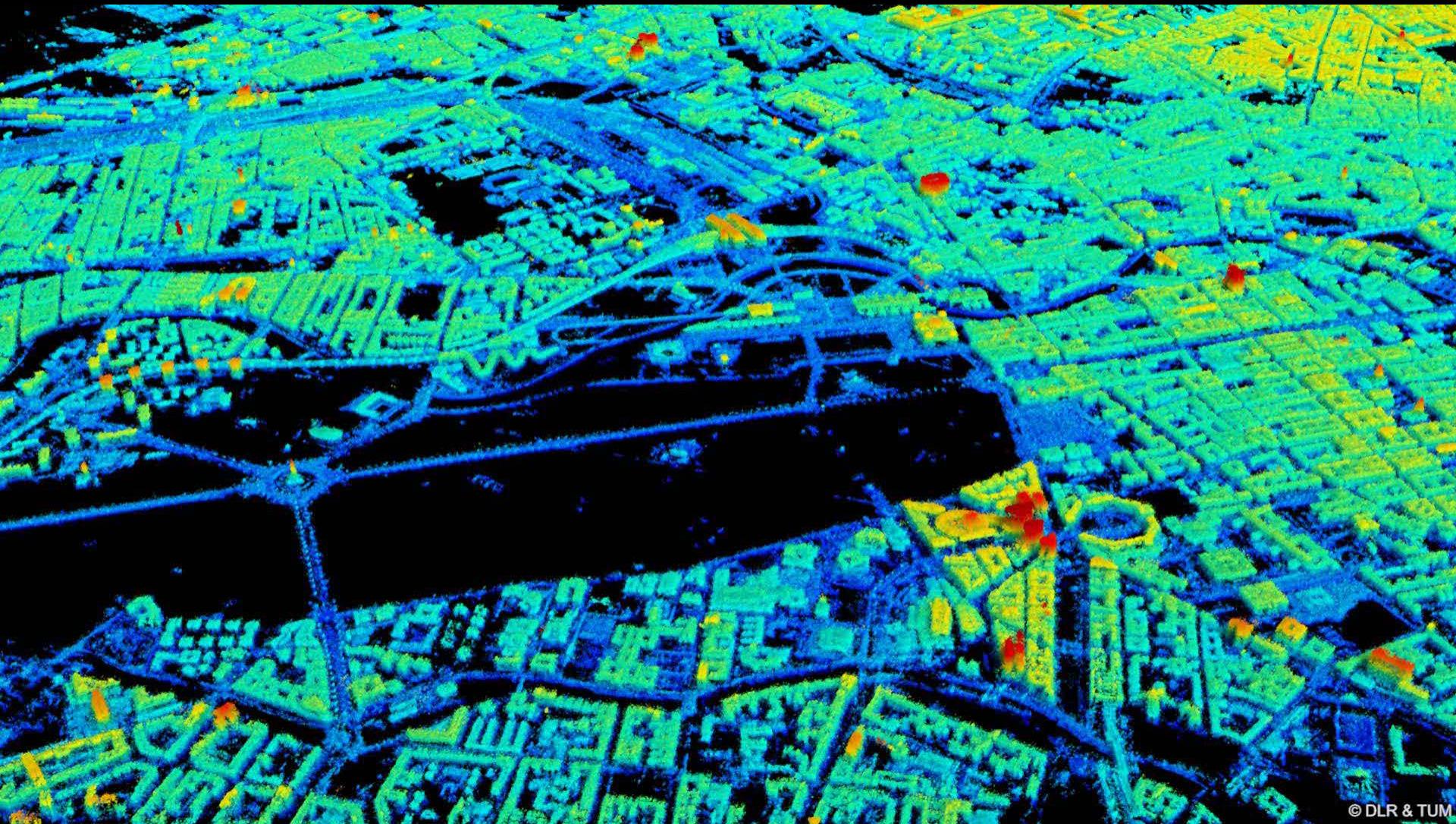
TerraSAR-X



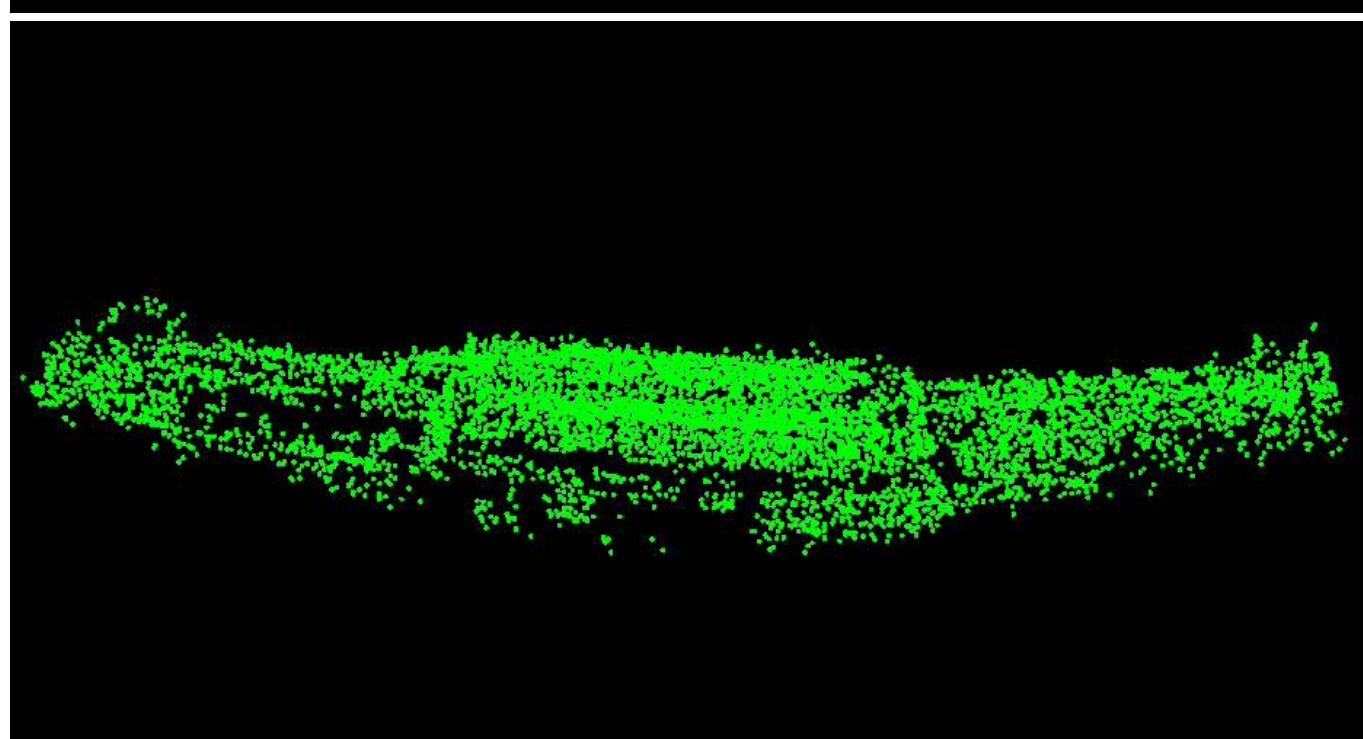
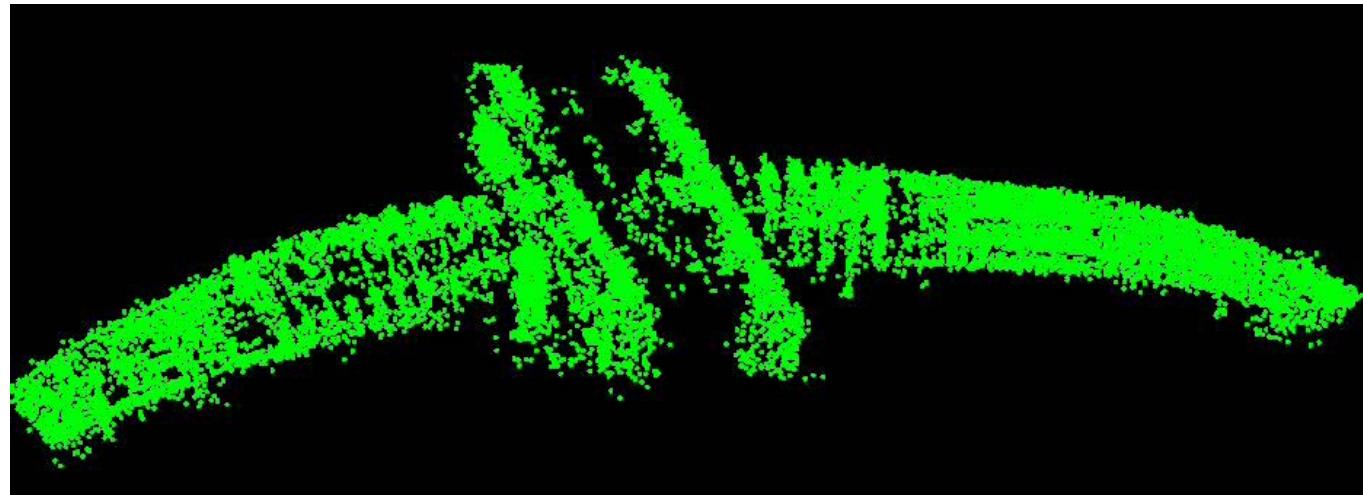
# Tomographic SAR



# SAR-Tomographic City Tour – Berlin



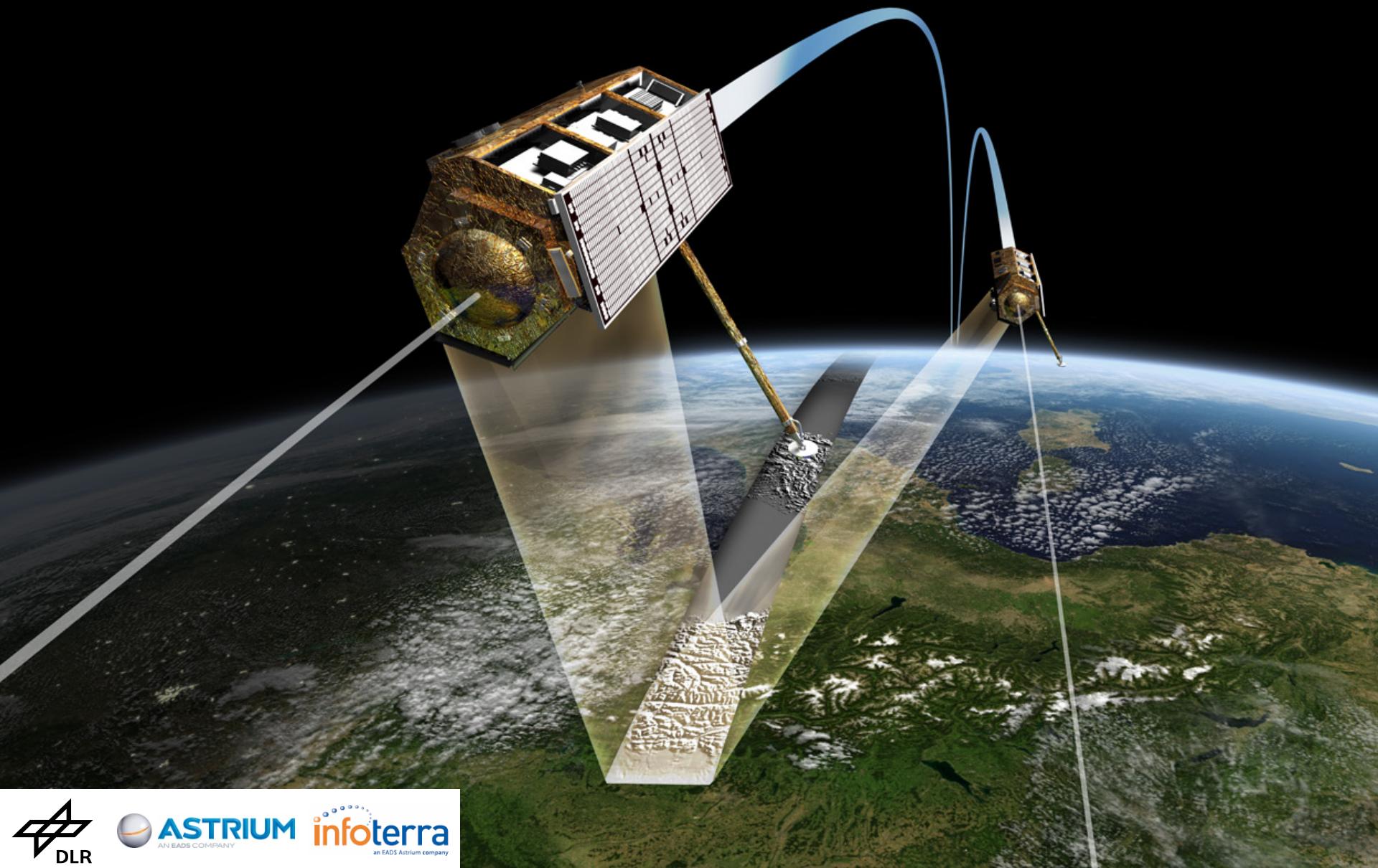
© DLR & TUM



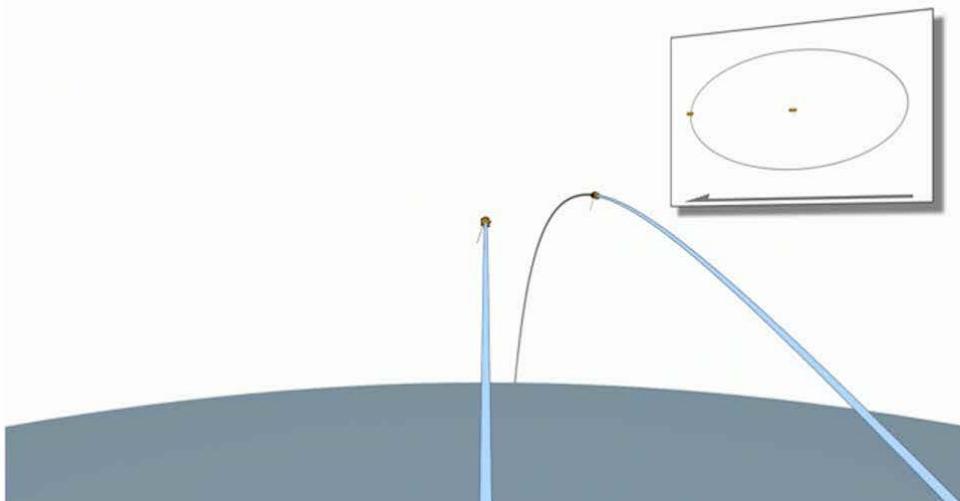
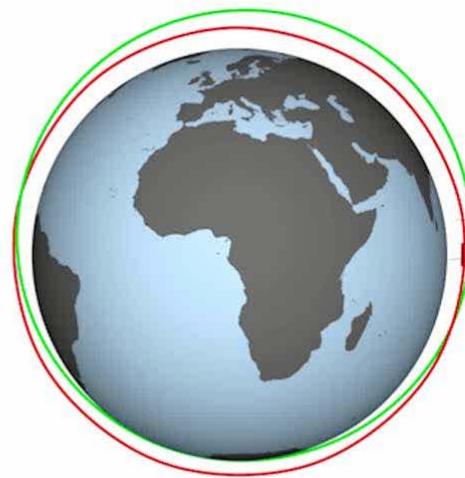
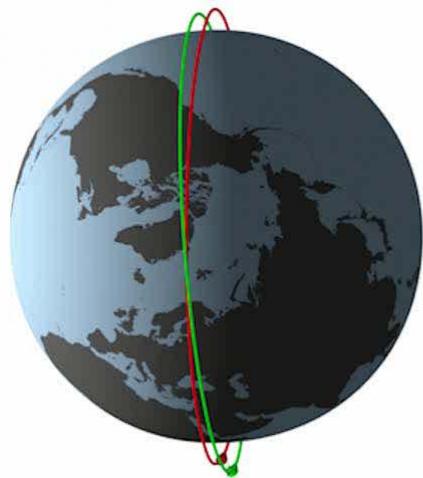
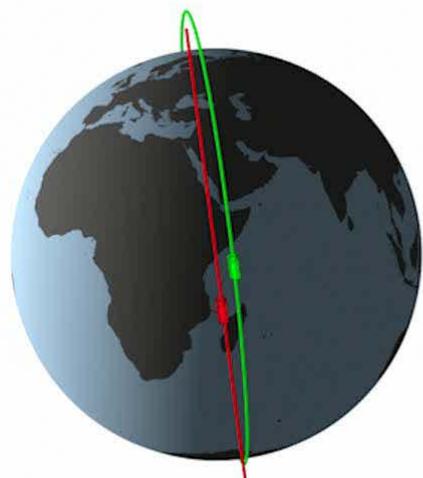
Gernhardt et al., TUM & DLR



# TerraSAR-X-add-on for Digital Elevation Measurements

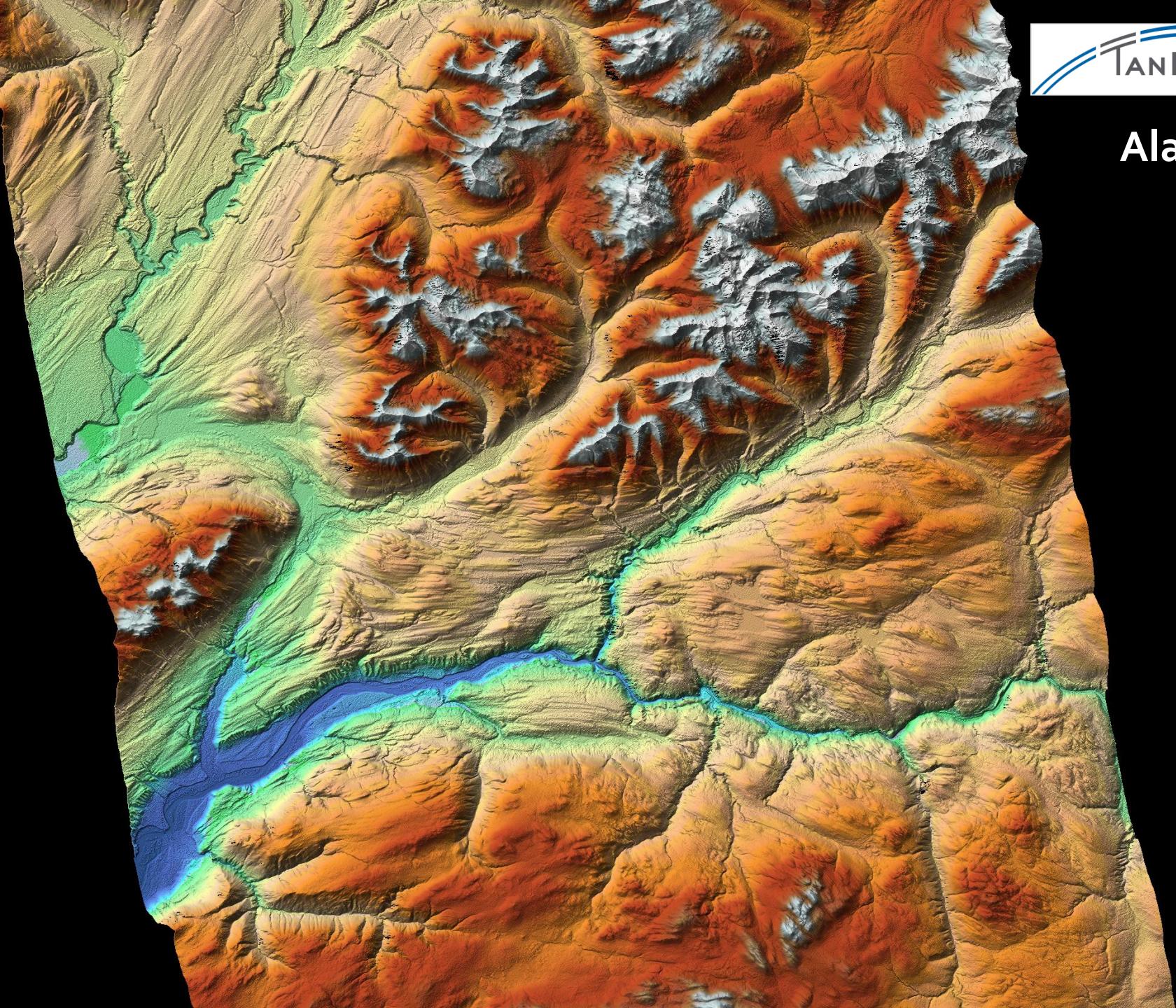


# Helix Formation

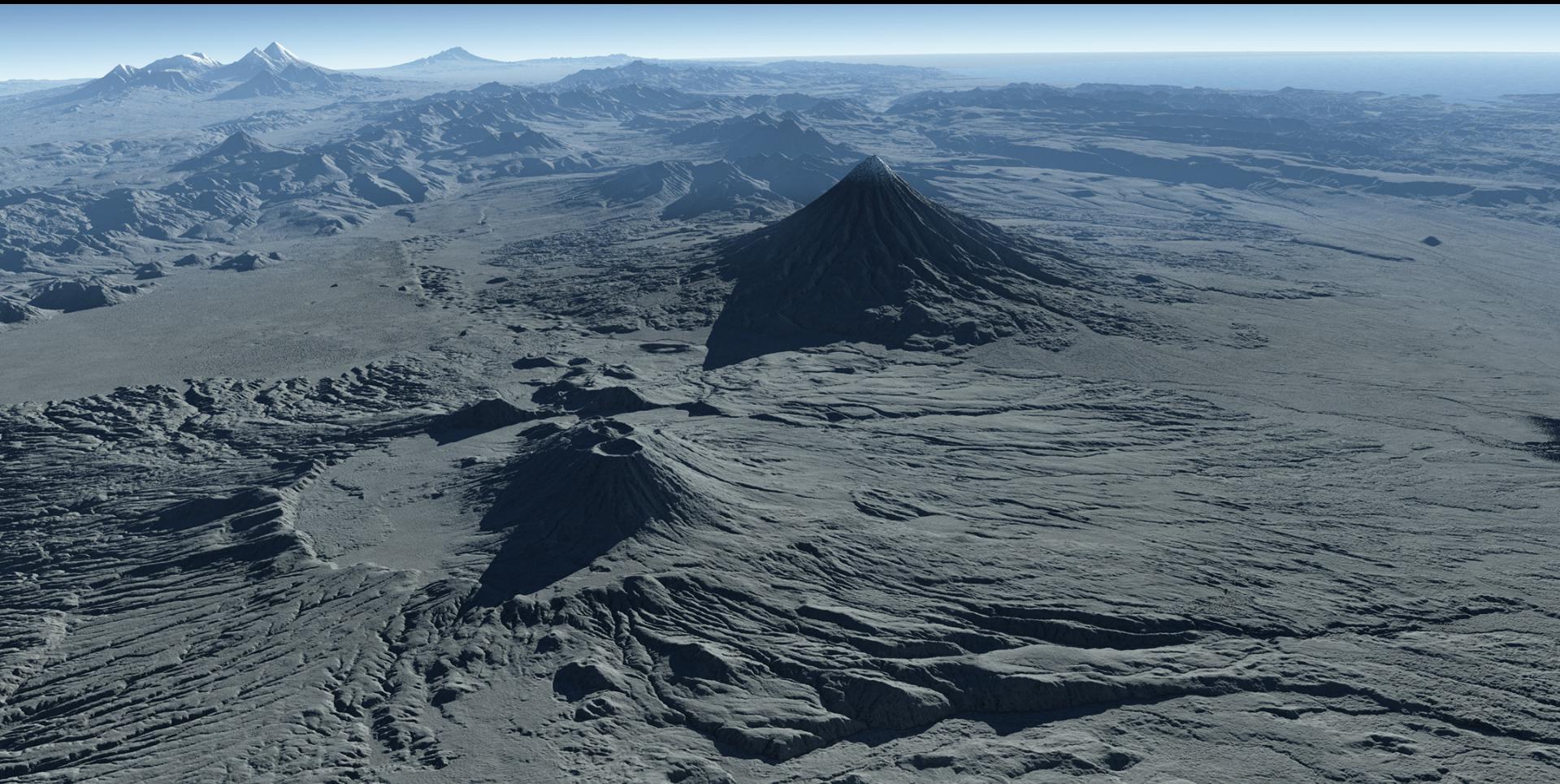




Alaska

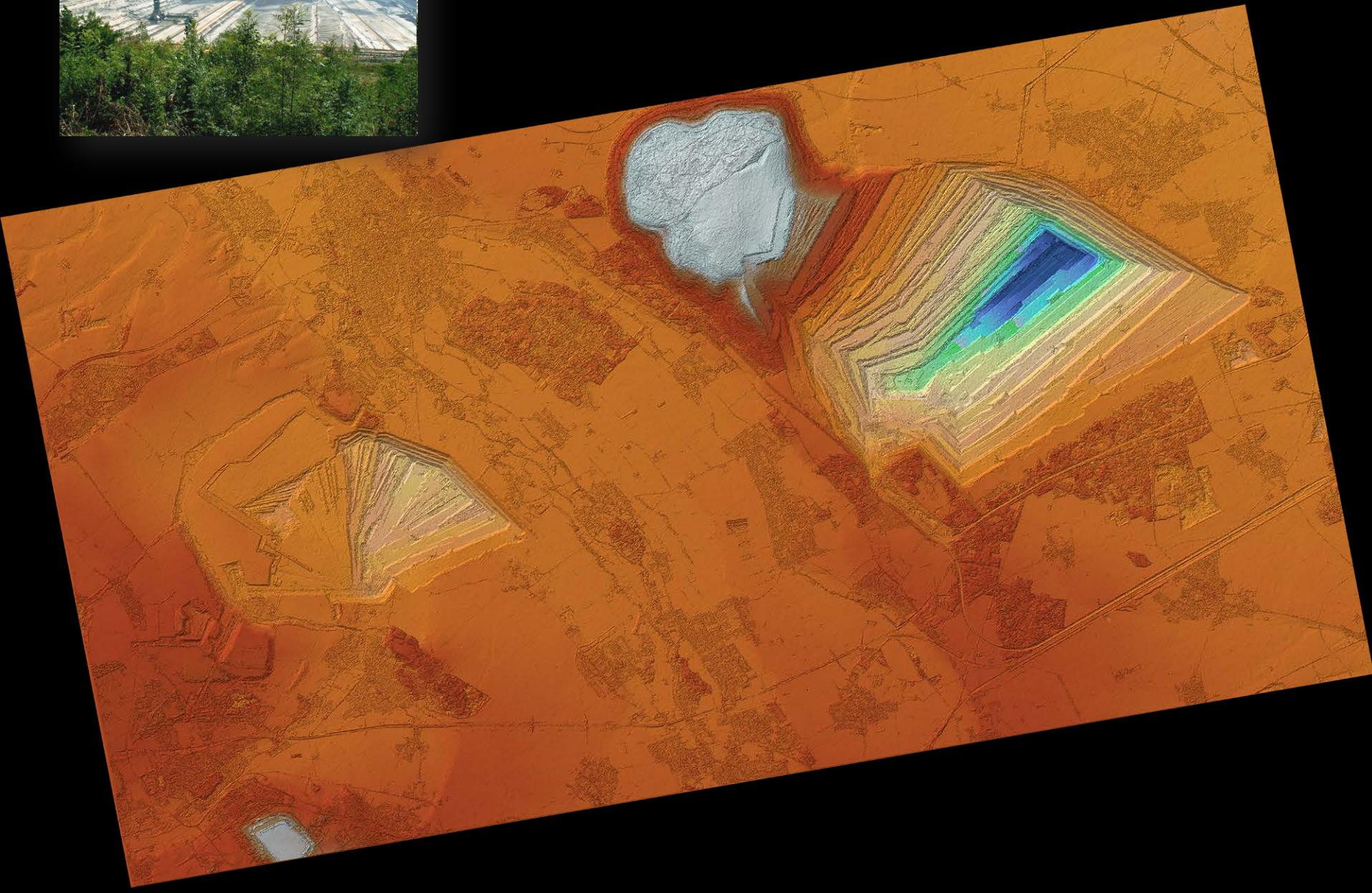


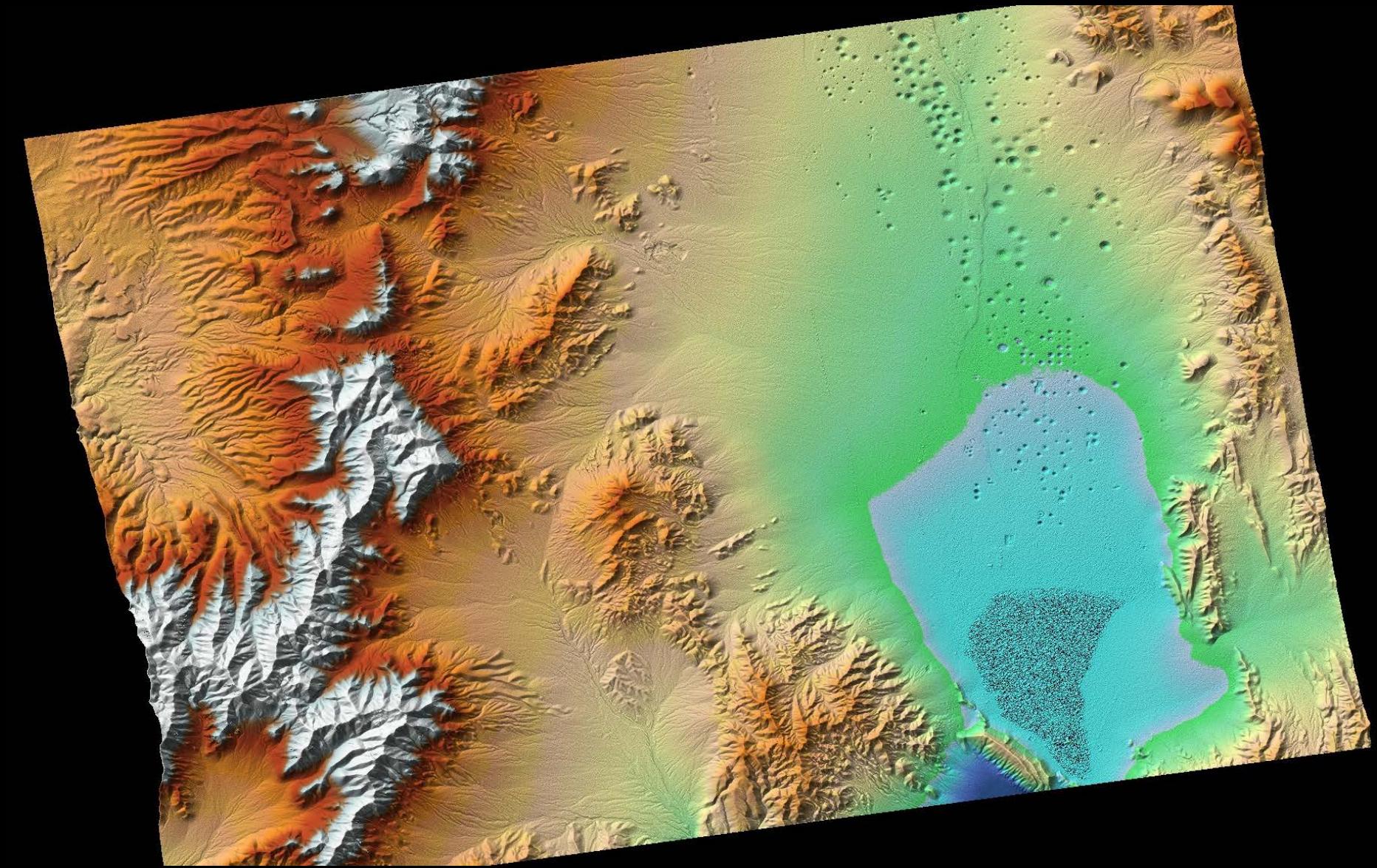
# Kamtschatka

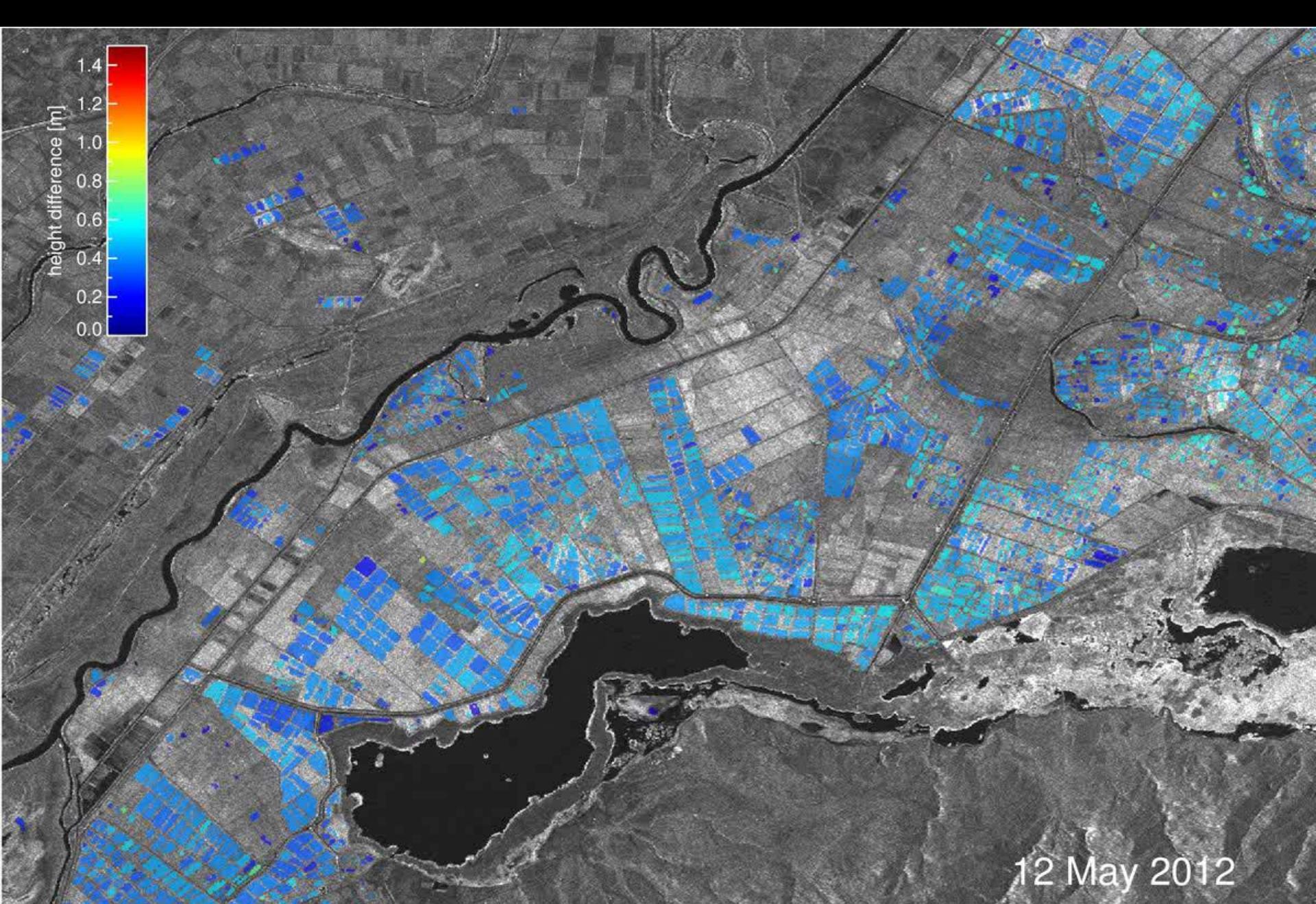




# Coal Mine of Hambach

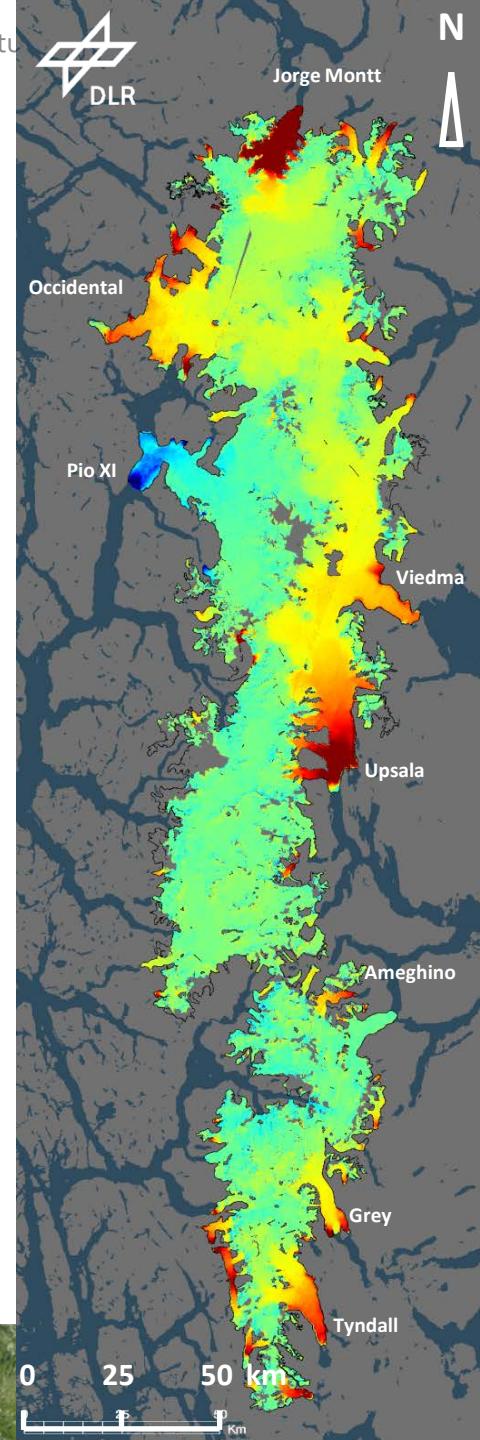
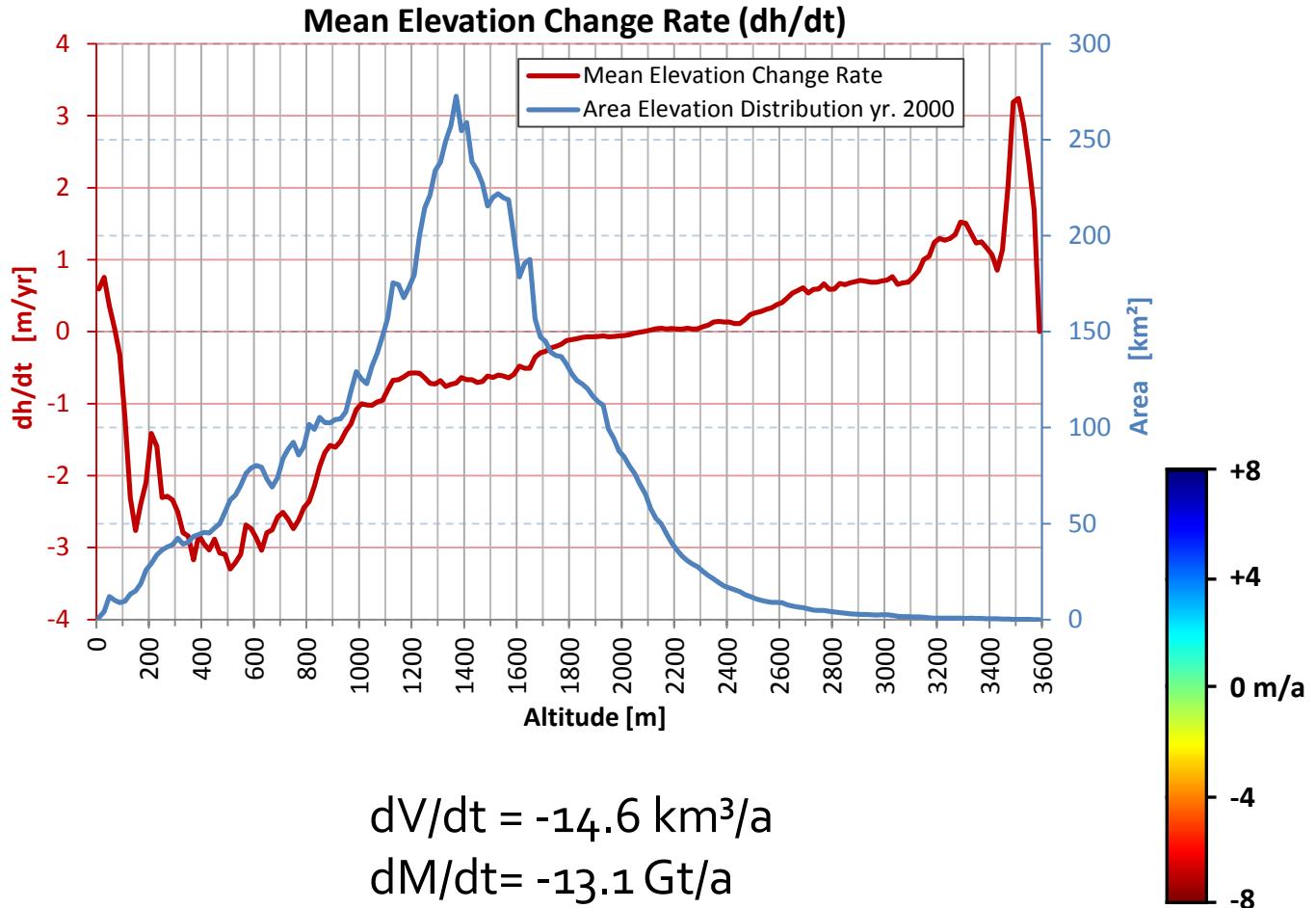




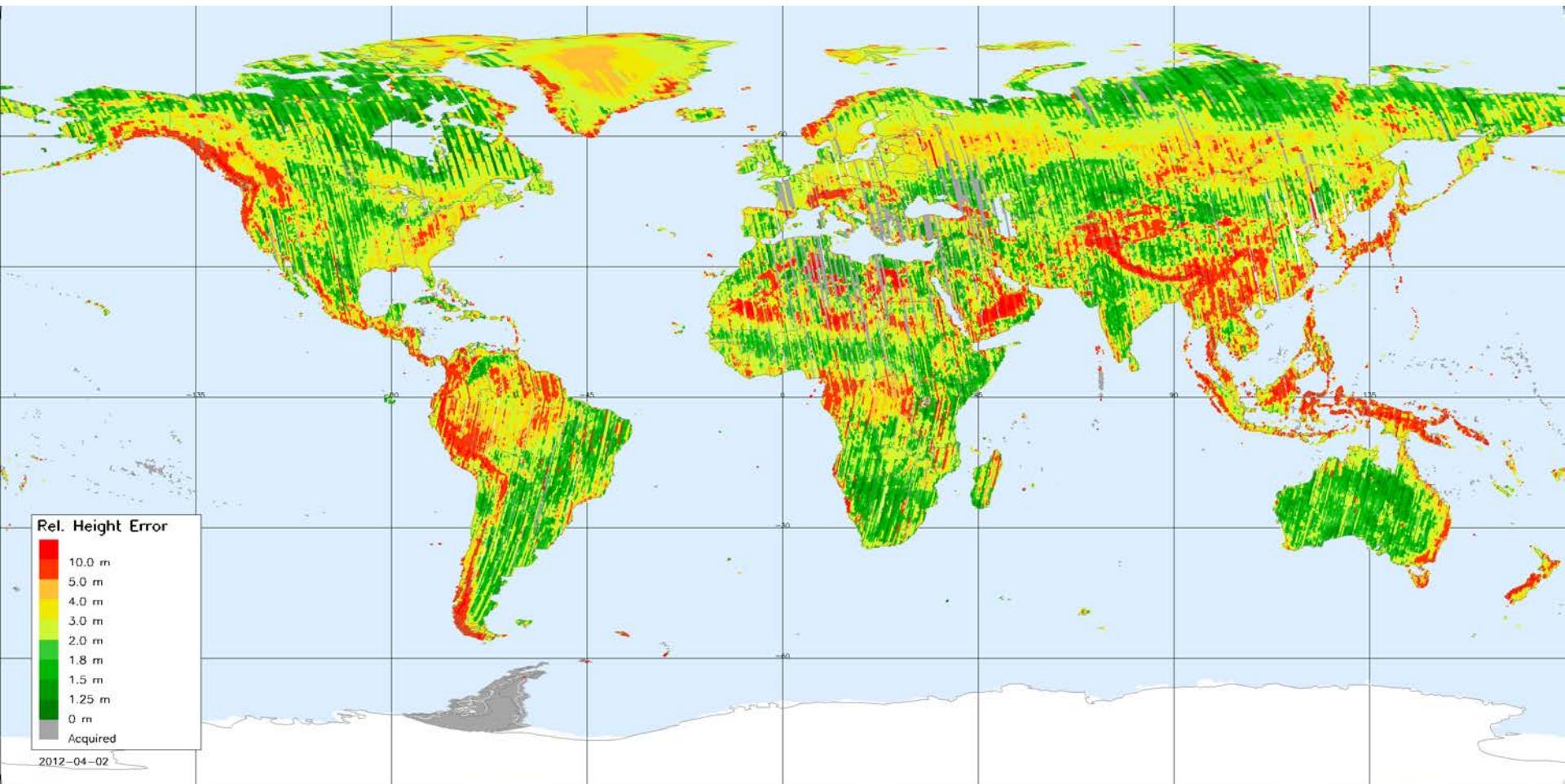




# TanDEM-X (2012) vs. SRTM (2000): Ice Thickness Changes in 12 Years



# 1<sup>st</sup> Global Acquisition (> 1 Year)



# Tandem-L

