

# **Synthetic Aperture Radar Interferometric (InSAR) Data Applications & Case Studies**

*(Lecture IV- Friday 14 May 2010)*

**ISNET/CRTEAN Training Course on Synthetic Aperture Radar (SAR)  
Imagery: Processing, Interpretation and Applications  
3-14 May 2010, Tunis, Tunisia**

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*<http://parviztarikhi.wordpress.com>*

**Mahdasht Satellite Receiving Station, ISA, Iran**

# OUTLINE

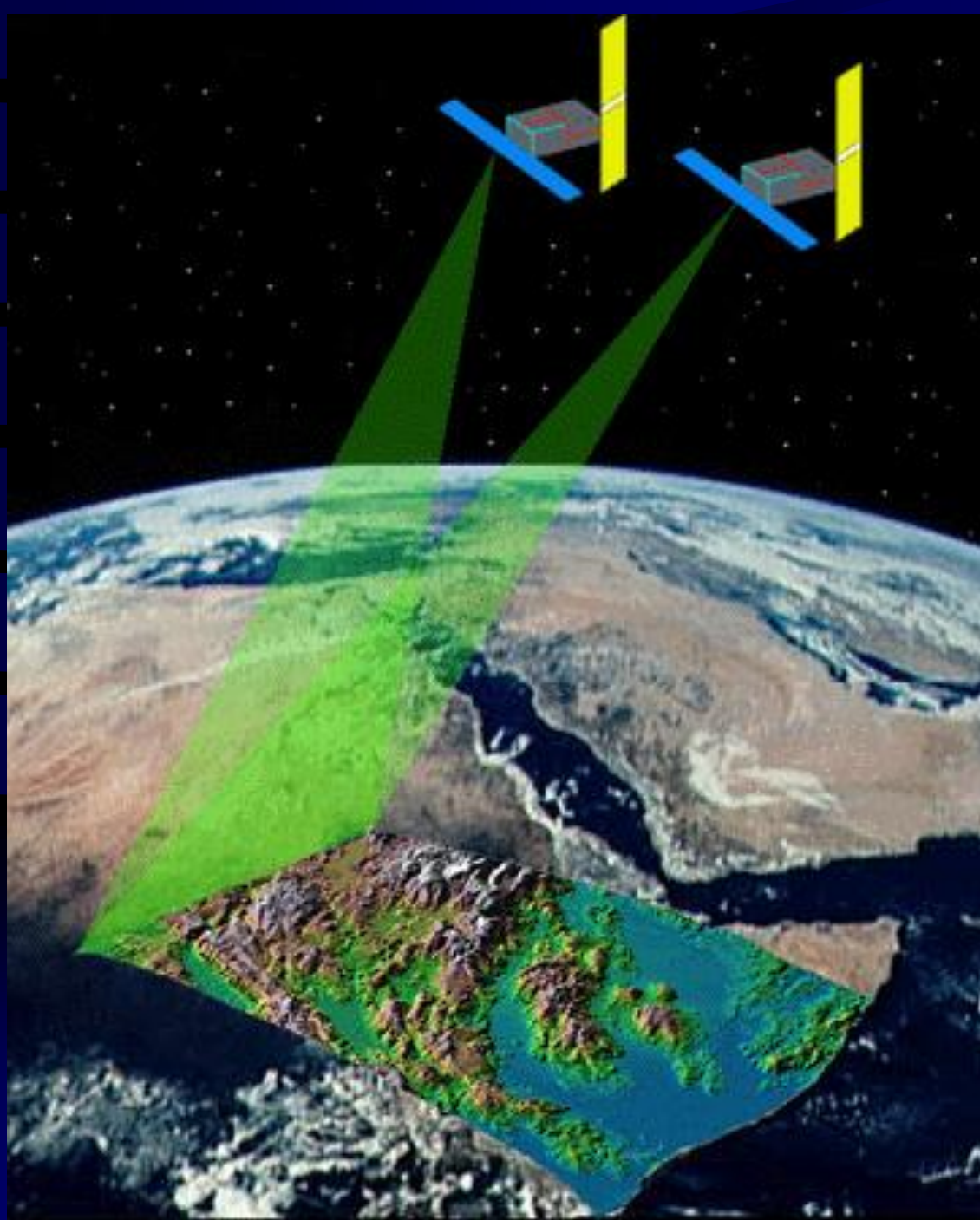
- INTRODUCTION
- INSAR APPLICATIONS
- INSAR CASE STUDIES  
examples

## *InSAR applications*



Thick cloud cover does not obscure radar images, since water droplets and ice crystals can not impede microwave signals. Radar antennas can take images equally well during the day or night, because the system provides its own light source.

## *InSAR applications*

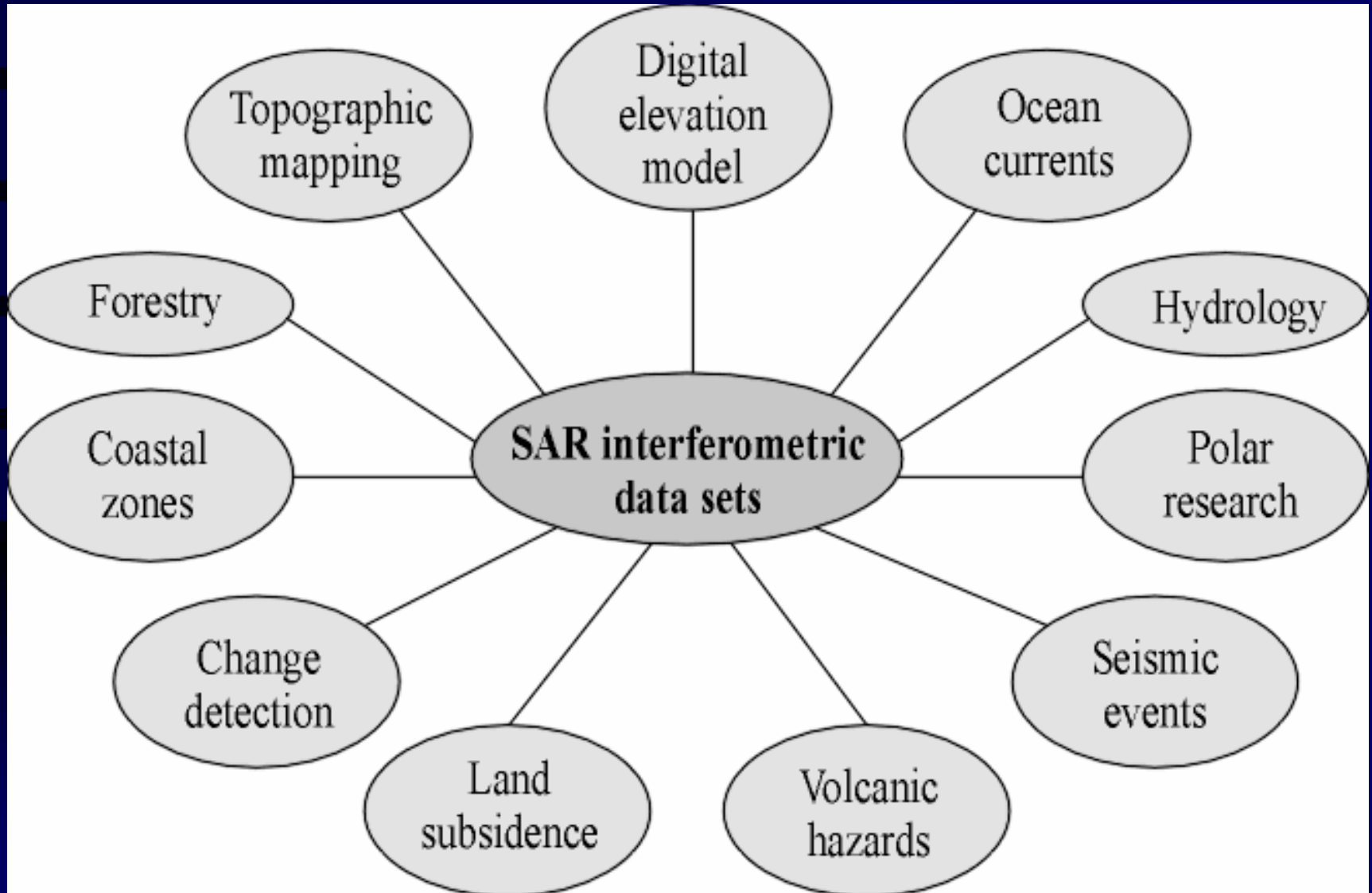


- The fringes are generated due to **slightly different imaging angles**.
- This exists anyway since the repeated satellite orbits and the sensor pointing does not perfectly coincide.

## SAR applications

- **Reconnaissance, surveillance, and targeting**
- **Treaty verification and nonproliferation**
- **Navigation and guidance - Sandia National Lab. 4-inch SAR**
- **Foliage and ground penetration**
- **Moving target detection**
- **target detection and recognition**
- **Oceanography – Ocean wave, ocean currents, wind, circulation, bathymetry**
- **Hydrology – Wetland assessment,**
- **Glaciology – Glacier motion, polar research**
- **Seismology – Co-seismic displacement field**
- **Volcanology – Prediction of volcano eruption**
- **Subsidence and uplift studies**
- **Change detection**
- **coastal zones**
- **Forestry – Forest classification, deforest monitoring**
- **Cartography – DEM, DTM, topographic mapping**
- **Geology – Geological Mapping, tectonic applications**
- **Soil Science – Soil moisture**
- **Agriculture – Crop monitoring**
- **Environment – Oil spill, hazard monitoring**
- **Archaeology – Sub-surface mapping**

## Civil Interferometric applications



# InSAR applications

## SAR applications

- Reconnaissance, surveillance, and targeting



## SAR applications

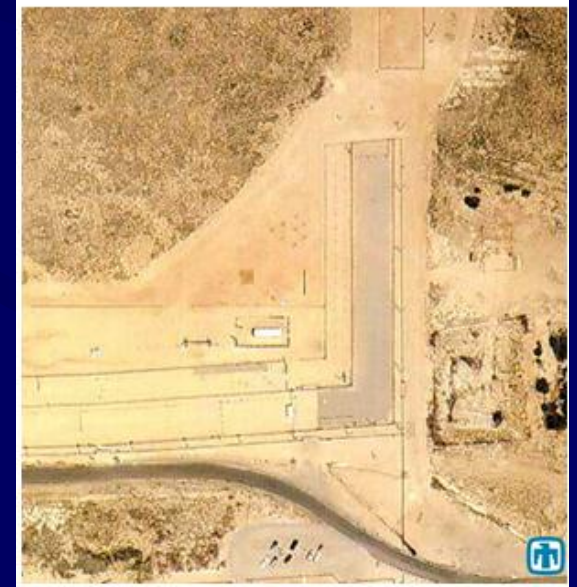
- Treaty verification and nonproliferation

## Random Change Detection

InSAR Coherence Image



Optical Image

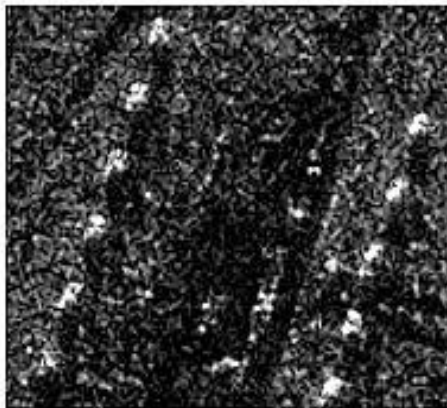
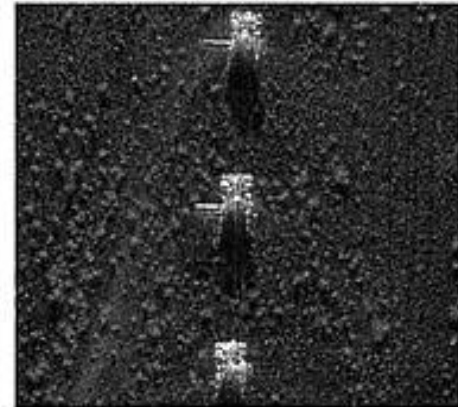
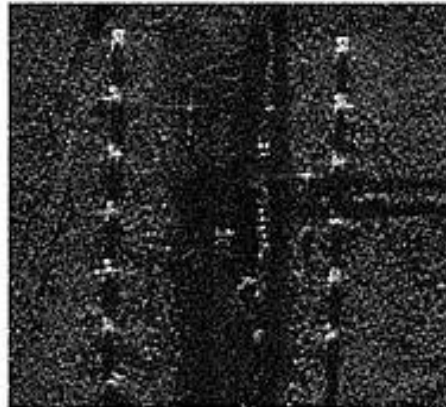
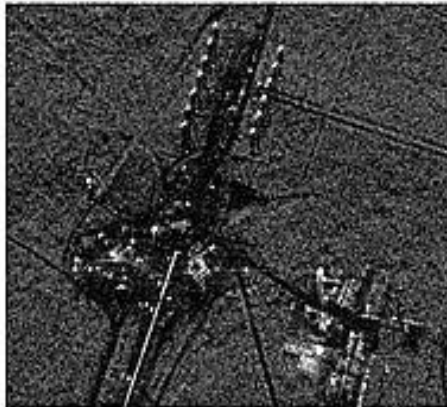




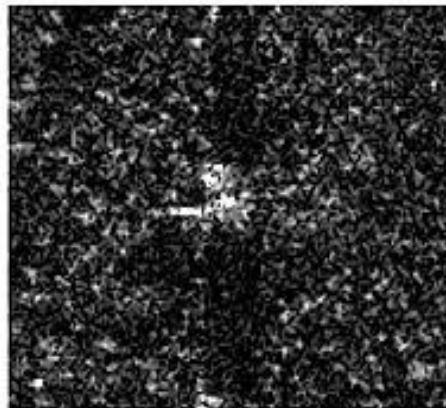
## SAR applications

- **Navigation and guidance - Sandia National Lab. 4-inch SAR**

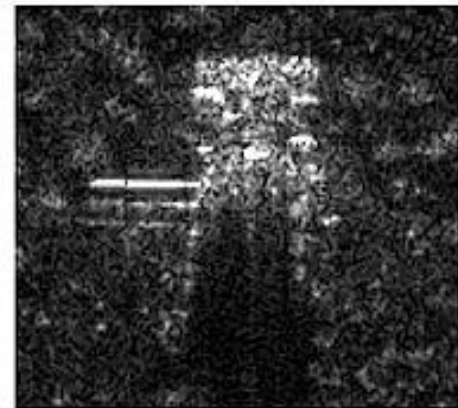
**M-47 Tanks On Kirtland AFB**  
Comparison of Resolutions At Actual and 4x Enlarged Views



Resolution = 1 Meter



Resolution = 1 Foot



Resolution = 4 Inches



## SAR applications

- **Moving target detection**

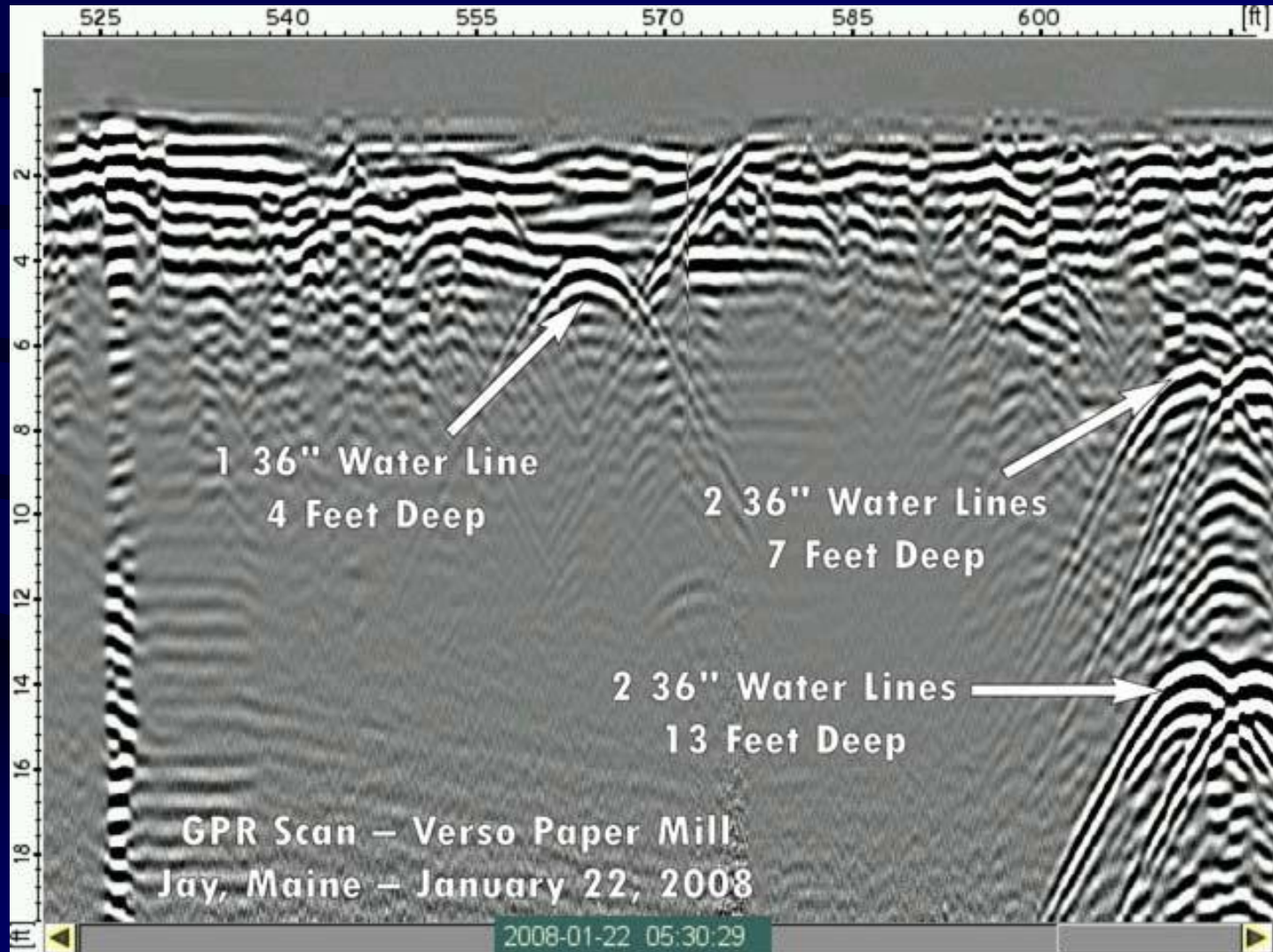


**Ship Wakes over the Bering Sea  
The Calving of Iceberg A-38  
(ERS-1 46 km x 28km)**

## SAR applications

- **Foliage and ground penetration**

Water pipe  
location  
under  
ground

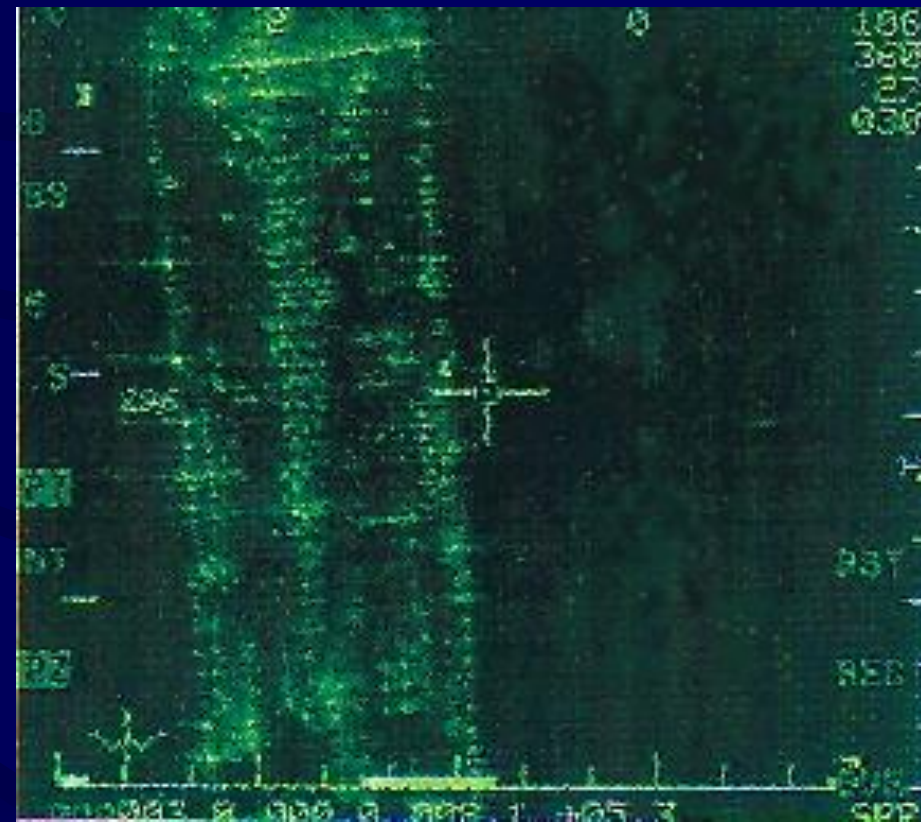


# InSAR applications

## SAR applications

- Target detection and recognition

## Ship targeting



SAR/GMTI Imagery (Northrop-Grumman (Norden) APG-76 MMRS)

Investigating and monitoring natural disasters and other natural phenomena emerges as a vital concern for sustainable development, welfare and safety of community.

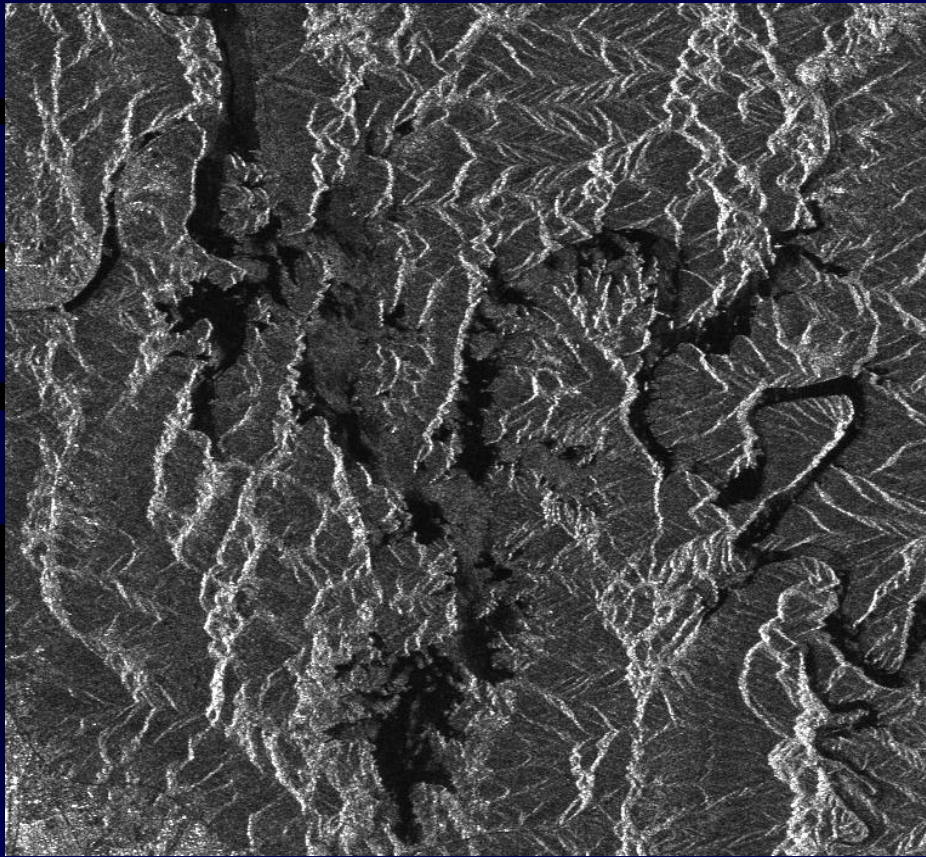
## *InSAR applications*



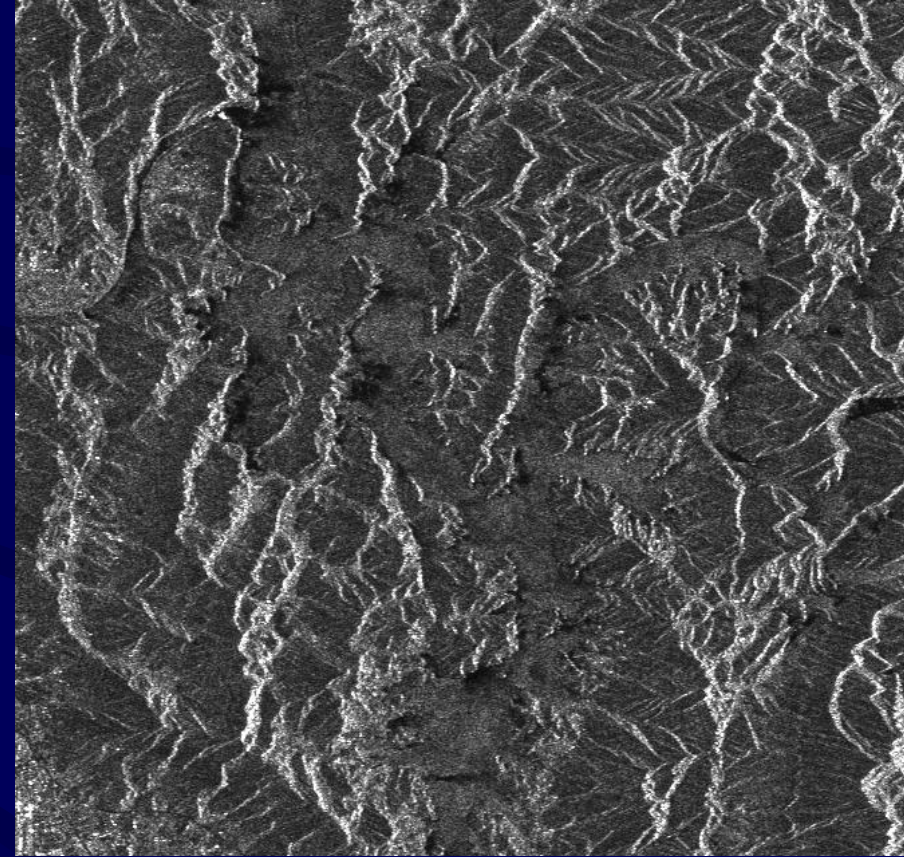
# InSAR applications

## SAR applications

- Oceanography – Ocean wave, ocean currents, wind, circulation, bathymetry



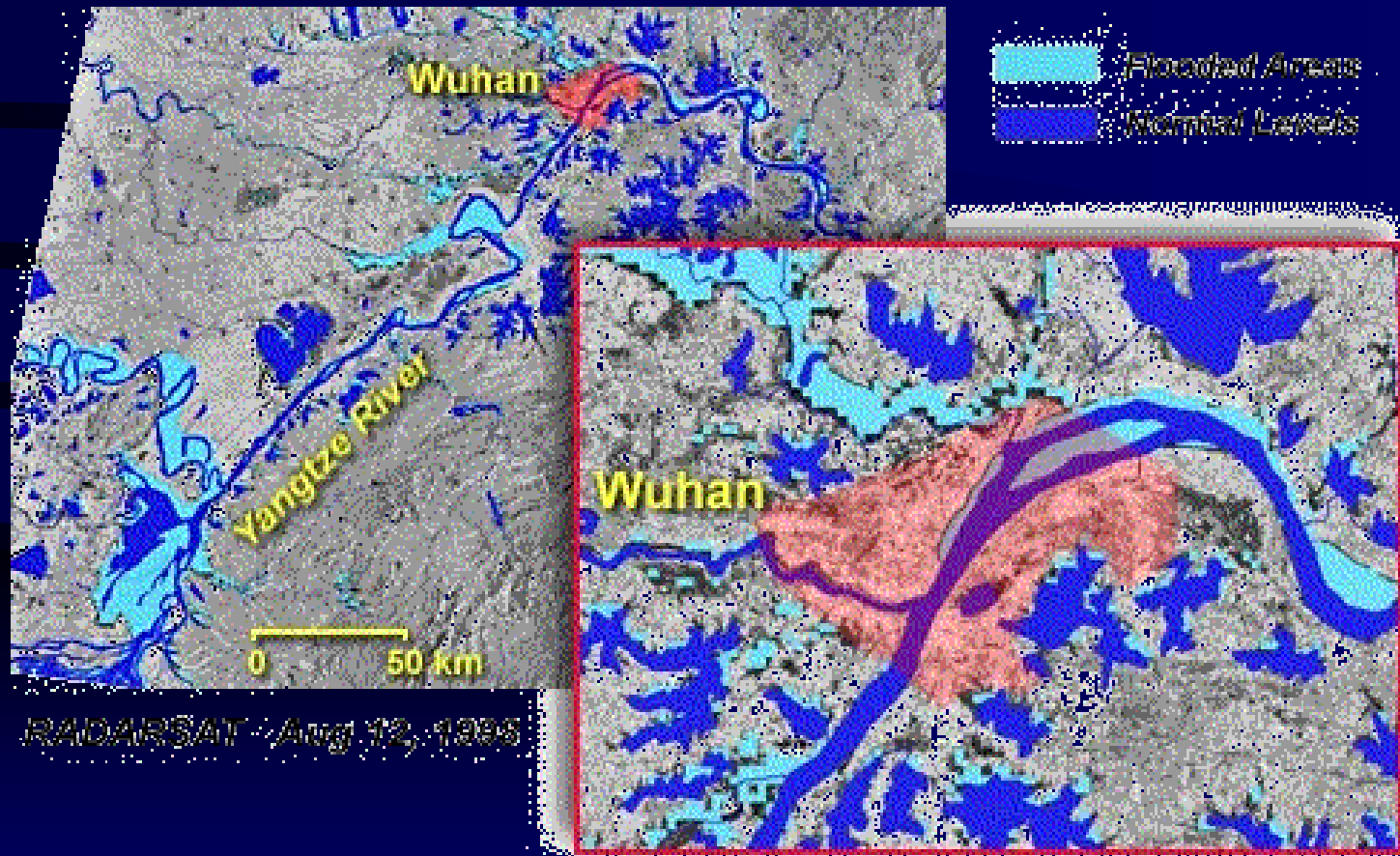
*Calm Water*



*Rough Water*

## SAR applications

- Hydrology – Wetland assessment,



Flooding on the Yangtze River, China

# InSAR applications

## SAR applications

- **Glaciology – Glacier motion, polar research**

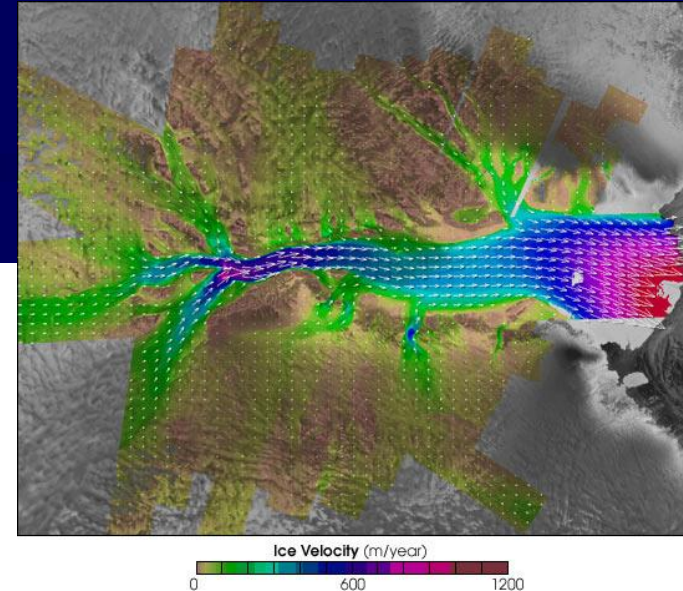
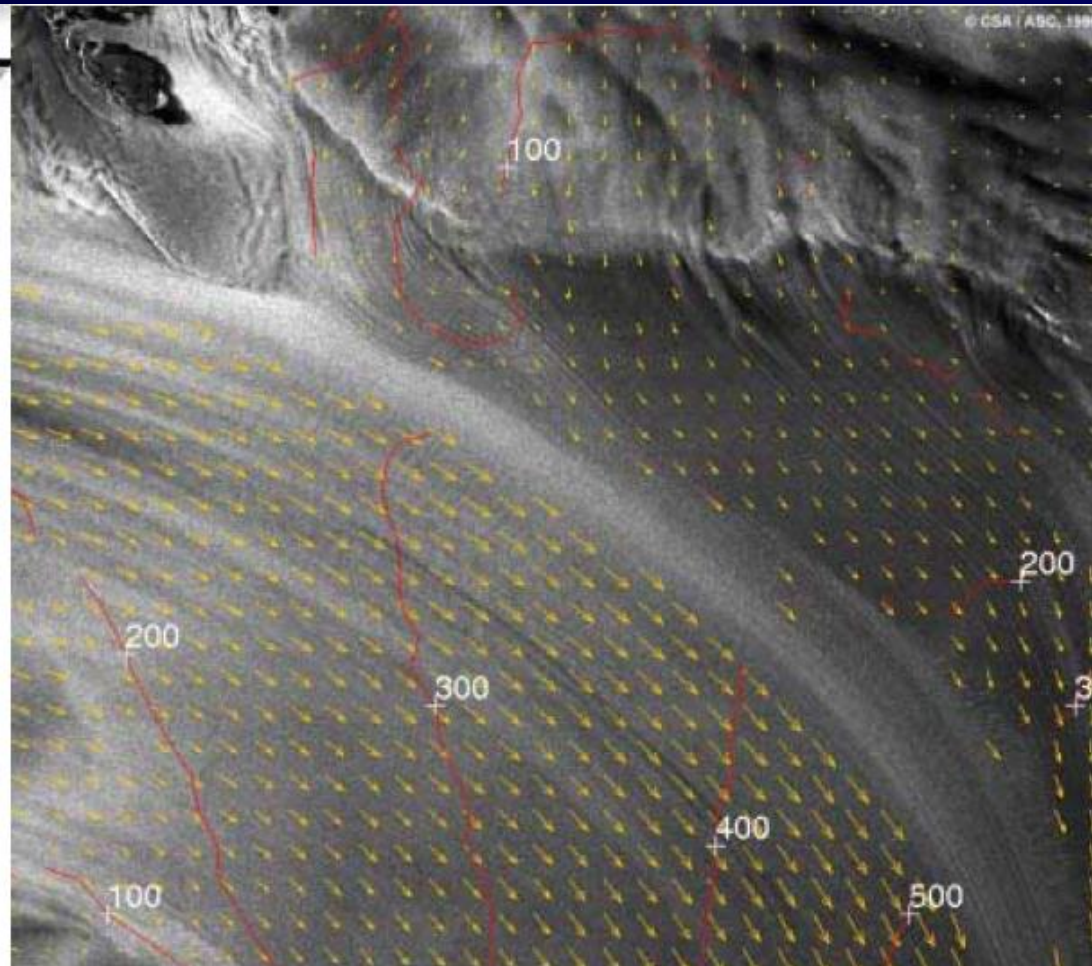


Image Credits:  
Received by CCRS  
Pre-processed by RSI

Interpretation:  
Laurence Gray, CCRS  
Karim Mattar, Intermap  
Paris Vachon, CCRS

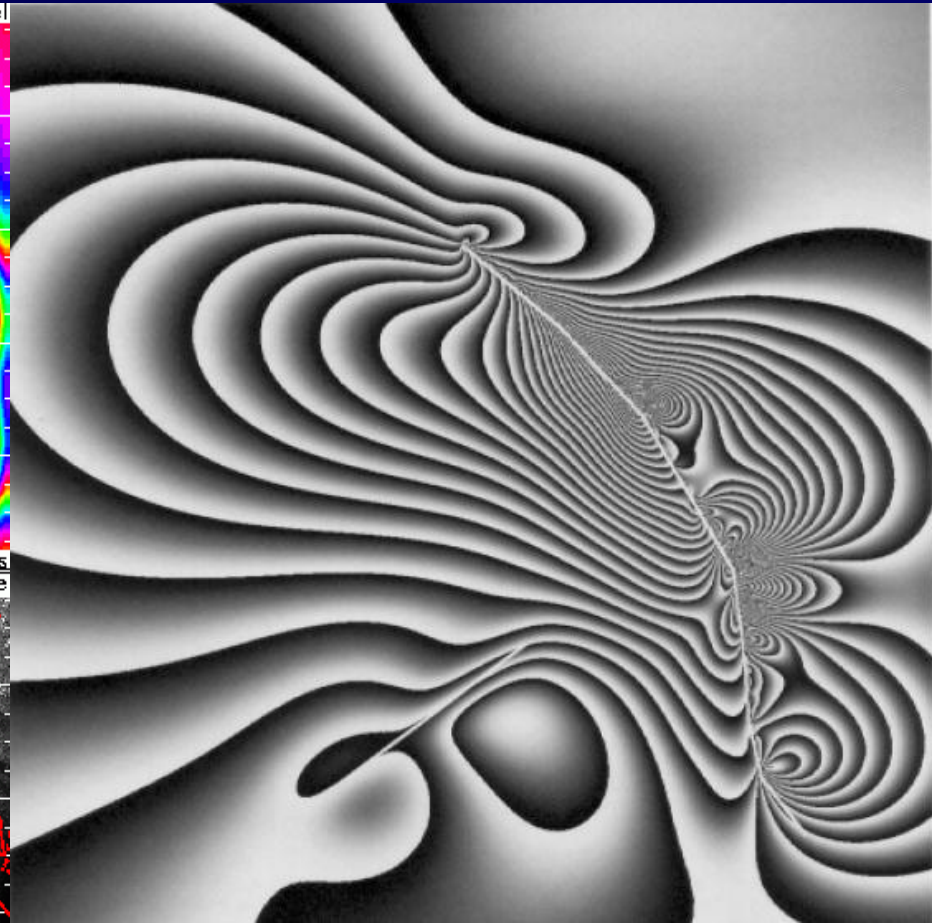
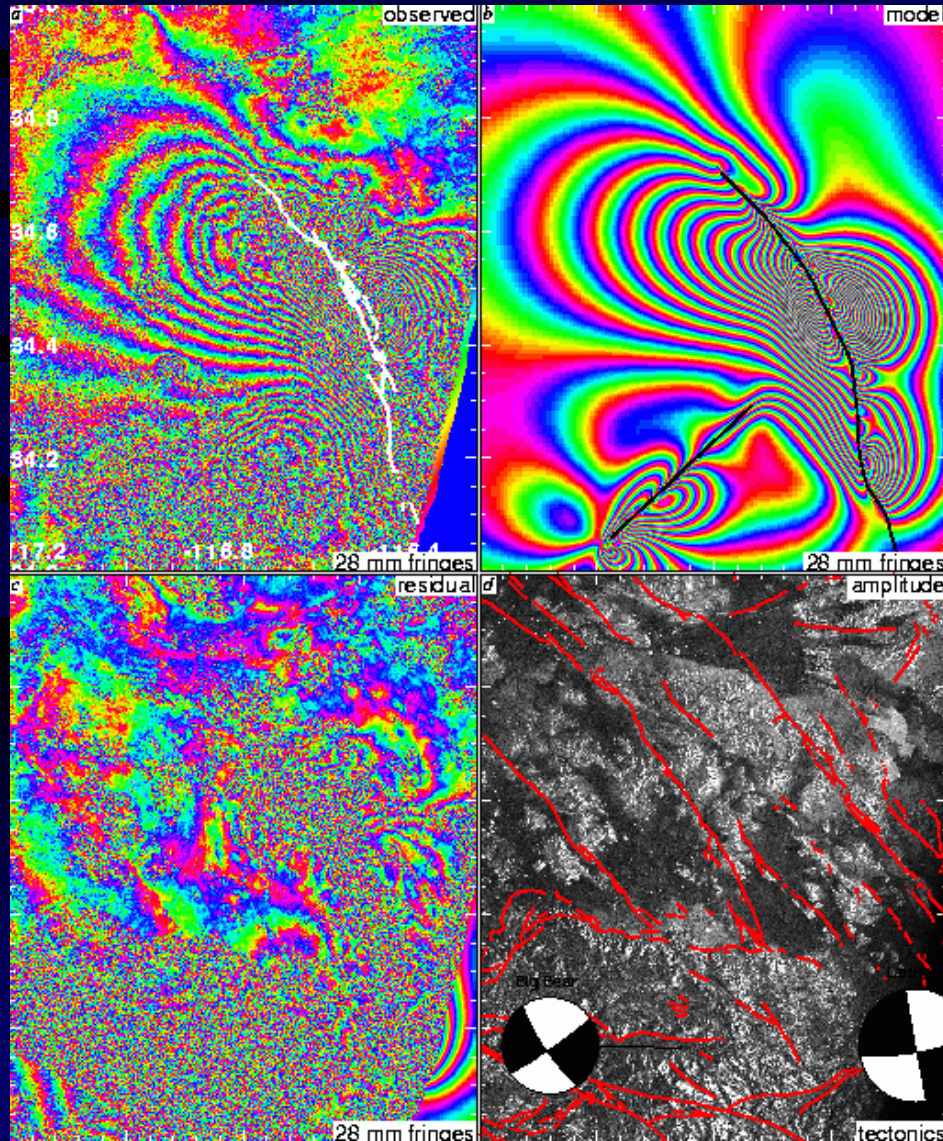
© CSA, 1996



# InSAR applications

## SAR applications

### • Seismology – Co-seismic displacement field

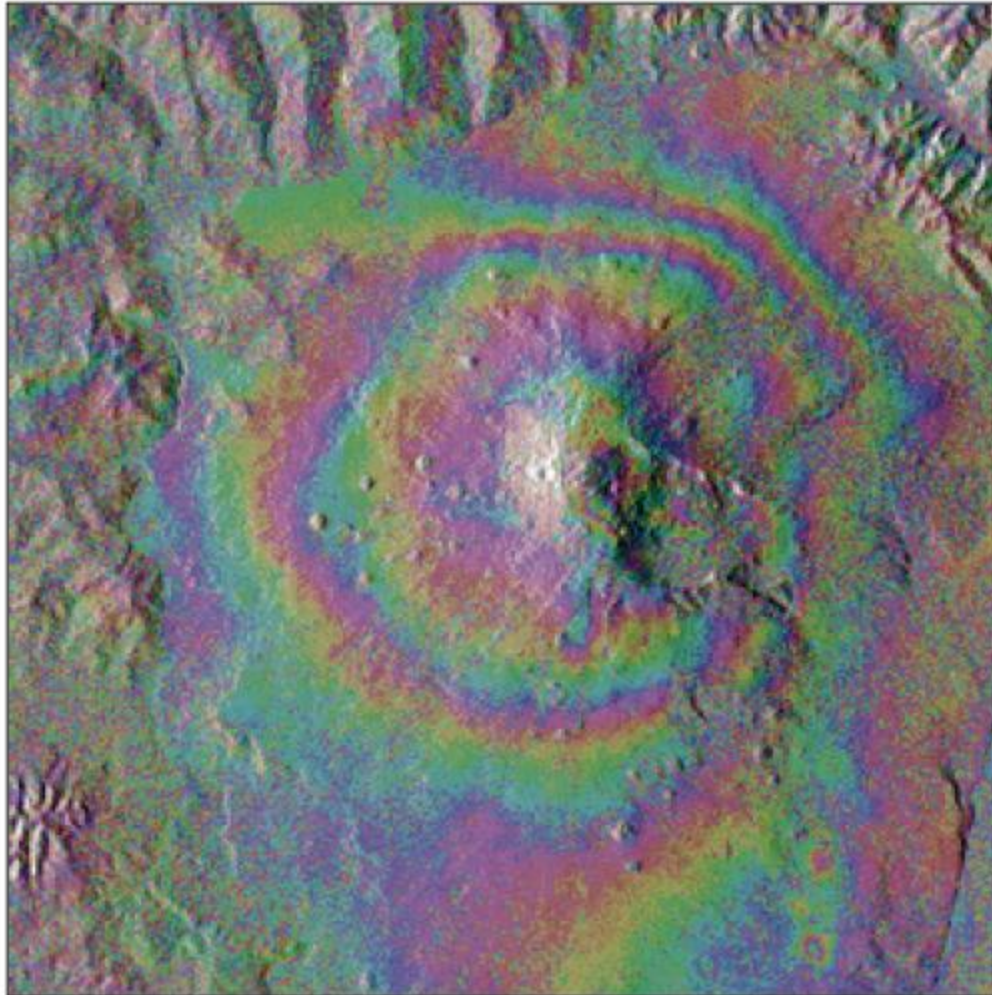


Source: Massonet et al. (1993)

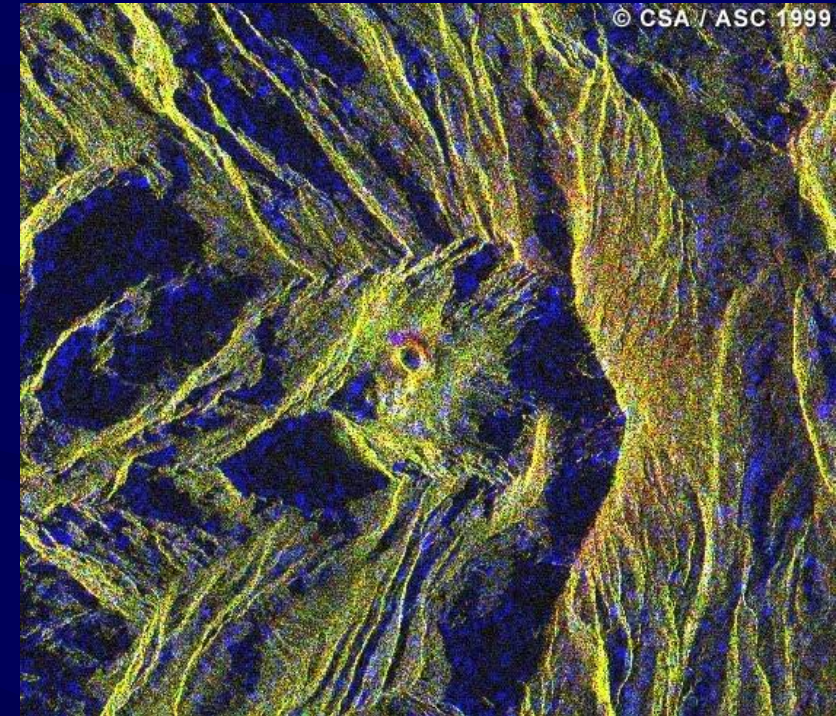
## Landers Earthquake

## SAR applications

- **Volcanology – Prediction of volcano eruption**



Source: Massonnet (1997)



© CSA / ASC 1999

Radarsat Image of Guagua  
Pichincha Volcano near Quito,  
Ecuador.

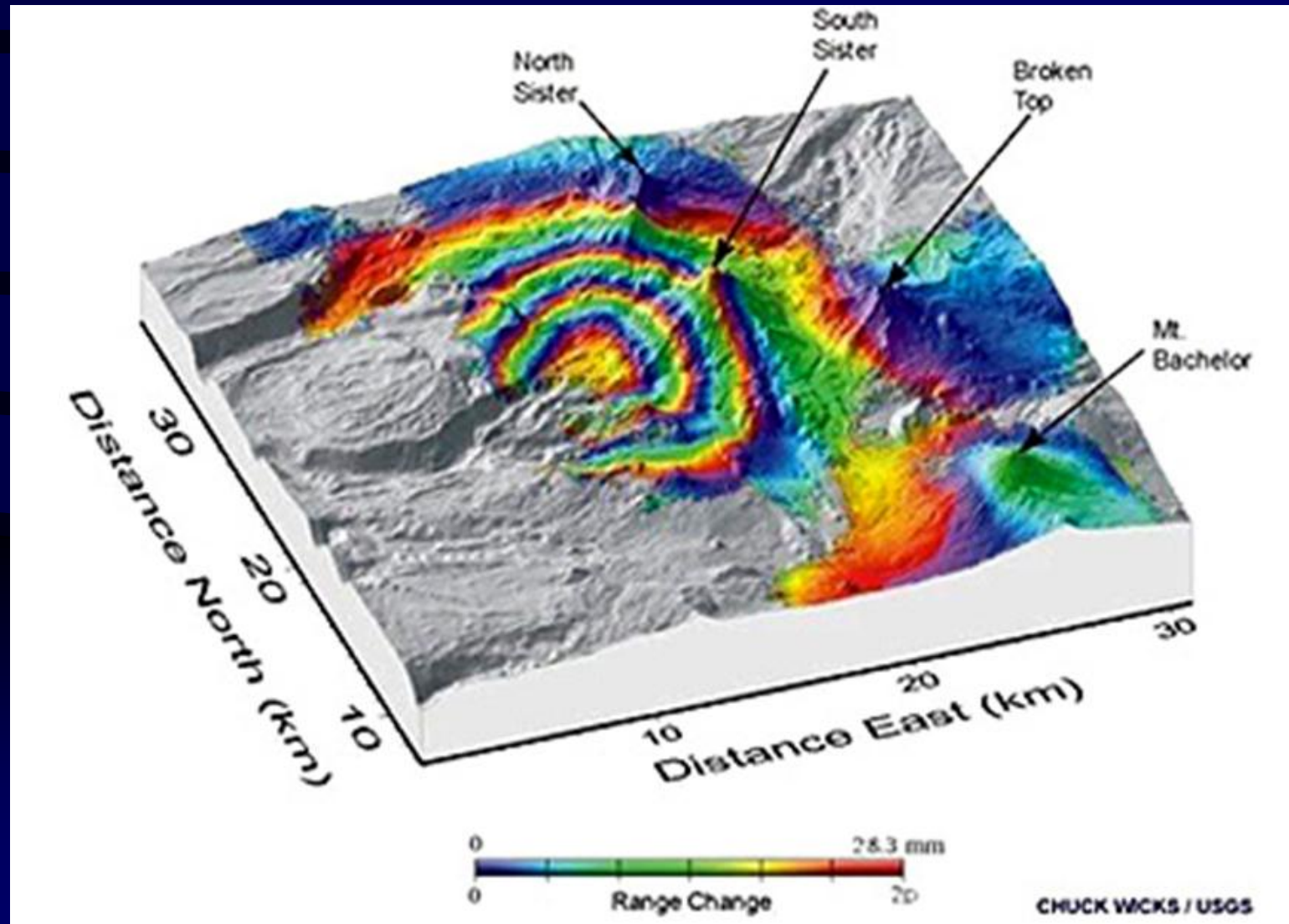
Red: April 18, 1999

Green: March 25, 1999

Blue: Coherence March-April

## SAR applications

- Volcanology – Prediction of volcano eruption, Volcanic applications

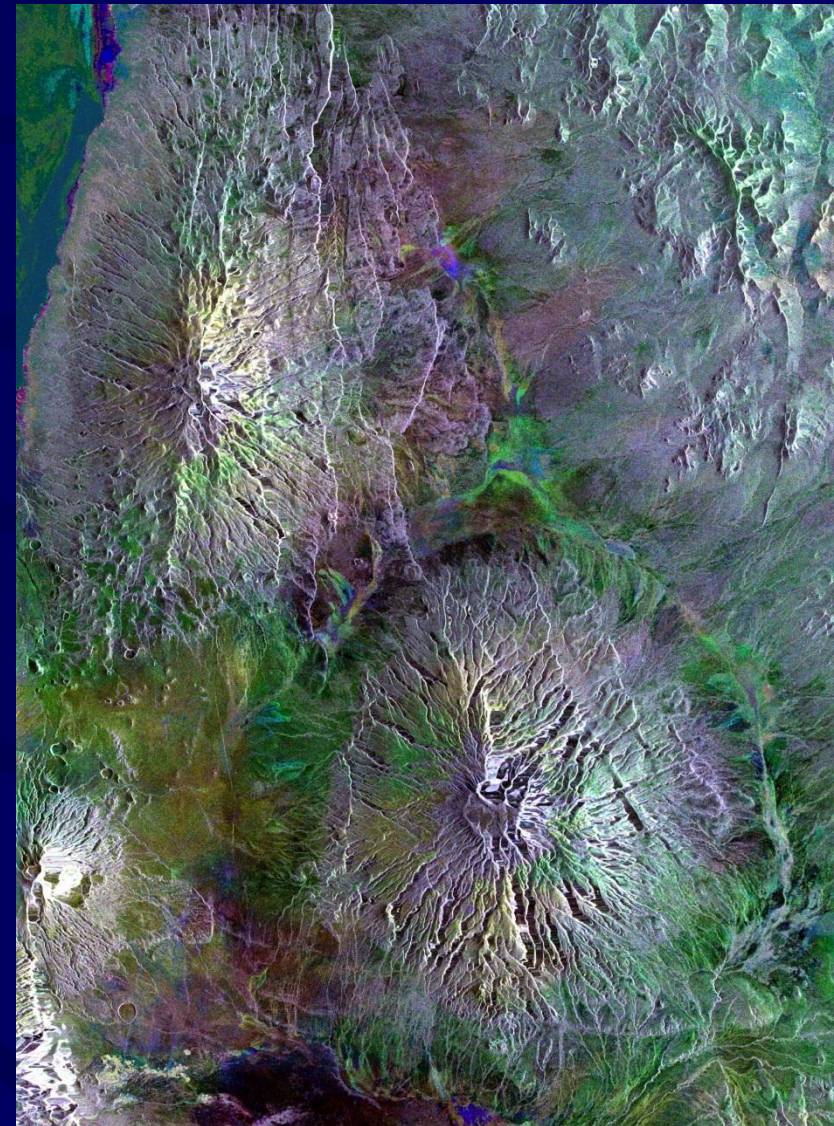


## SAR applications

- **Volcanic applications**

Envisat radar image of volcanoes in Tanzania, including Ol Doinyo Lengai (at lower left). The Gelai Volcano (2942 m) is visible at the top, and the Kitumbeine Volcano (1770 m) is southeast of Gelai.

The image was created by combining three Envisat ASAR acquisitions (3 February 2010, 30 December 2009 and 25 November 2009) of the same area. The colors result from changes in the surface between acquisitions. (Credits: ESA)

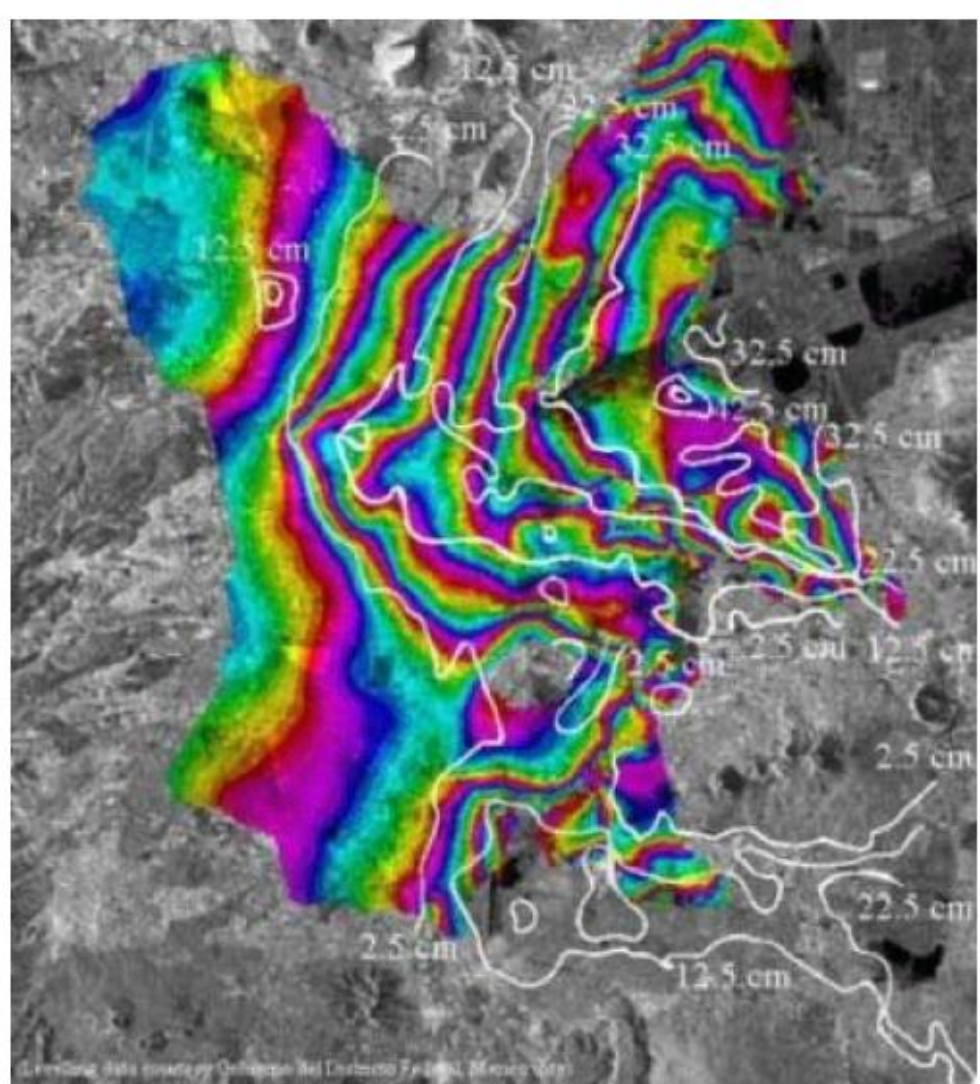


volcanoes in Tanzania

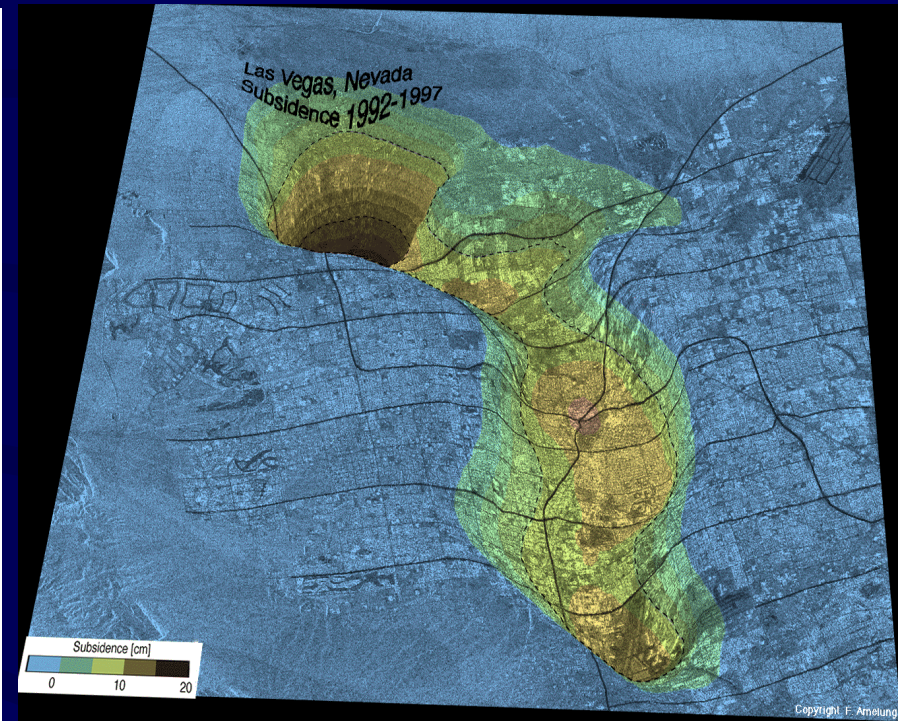
# InSAR applications

## SAR applications

- Subsidence and uplift studies



Source: <http://www.gamma-rs.ch/research/mexico.html>



Las Vegas , USA

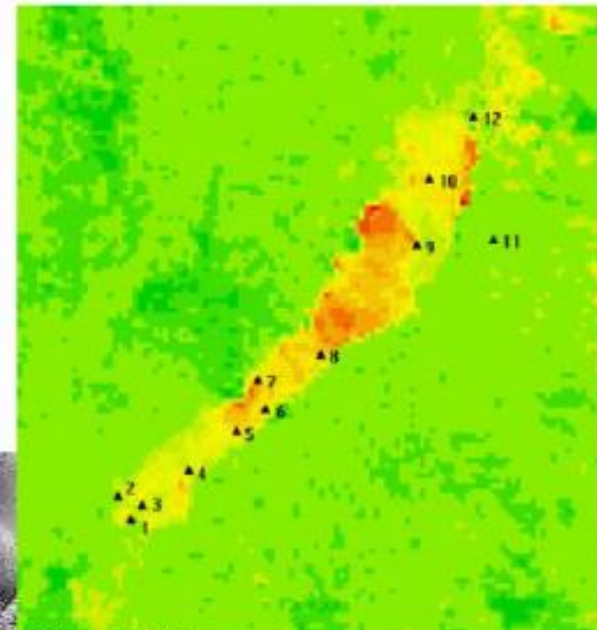
## SAR applications

- Subsidence and uplift studies

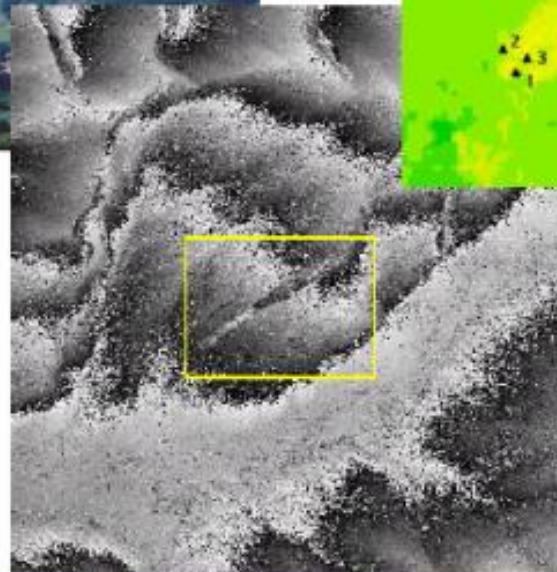
### Monitoring of Landslides by D-InSAR



La Valette/South France



Motion map after removal of topographic phase

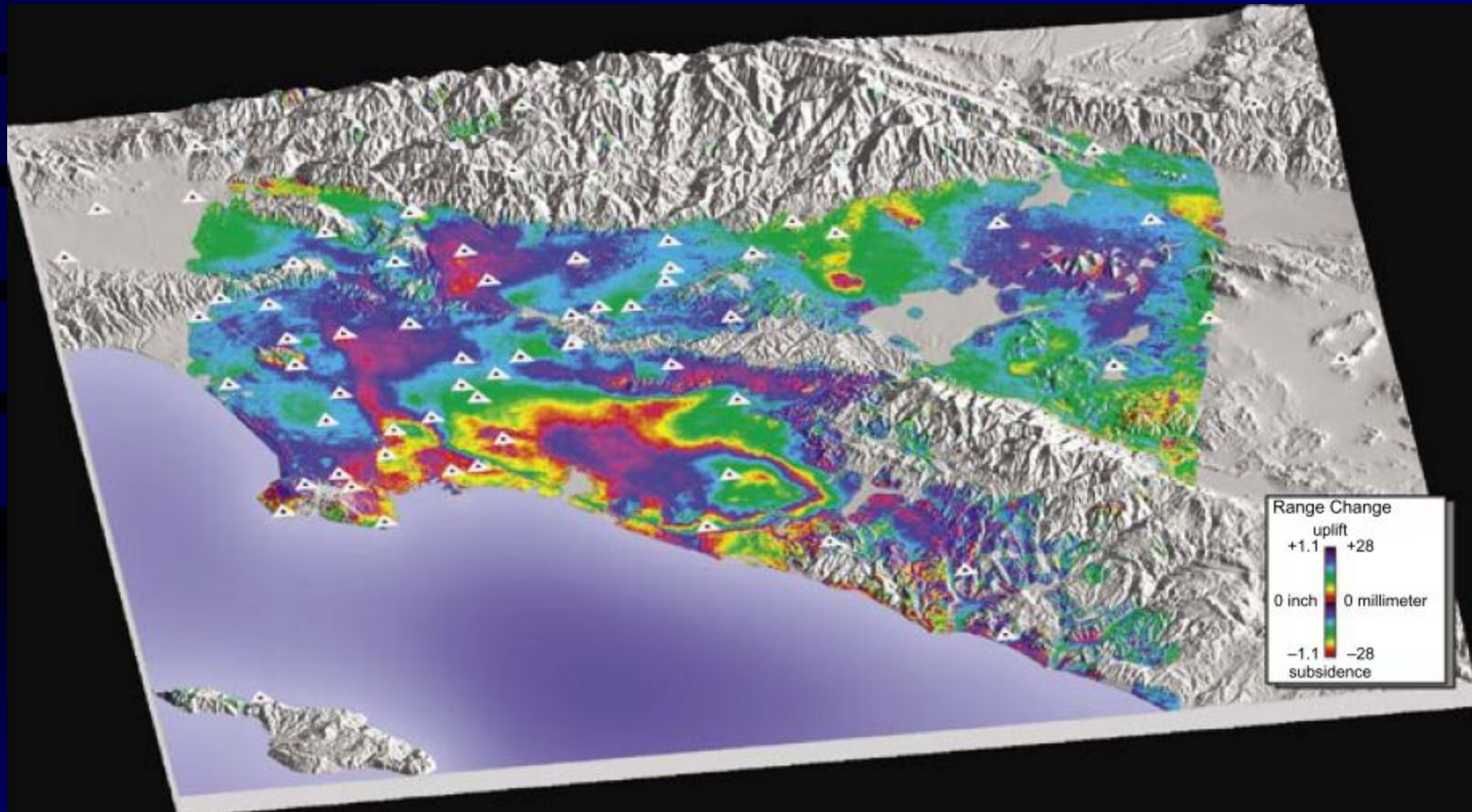


Interferogram

# *InSAR applications*

## SAR applications

- Change detection

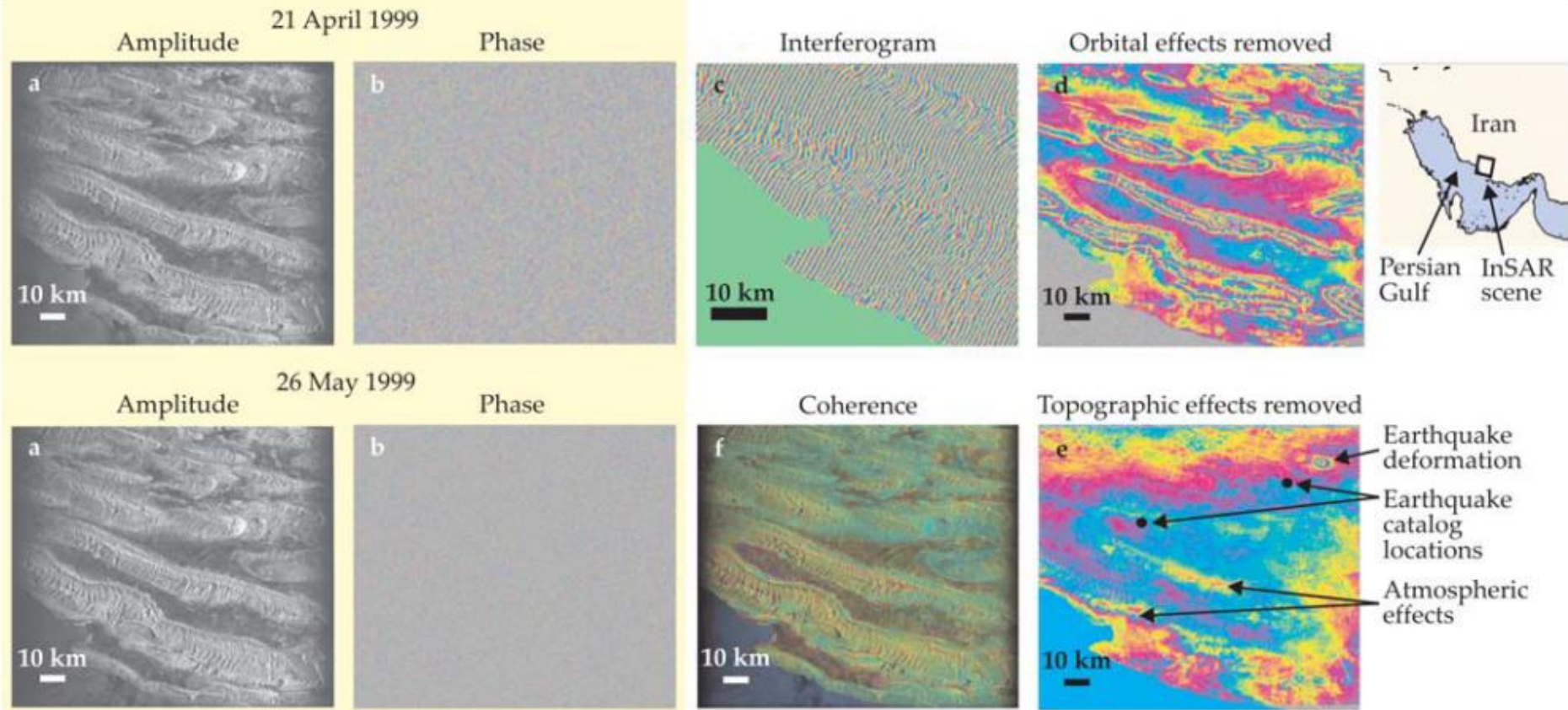


Deformation in Los Angeles basin from April 1998 to May 1999.

# InSAR applications

## SAR applications

- Change detection

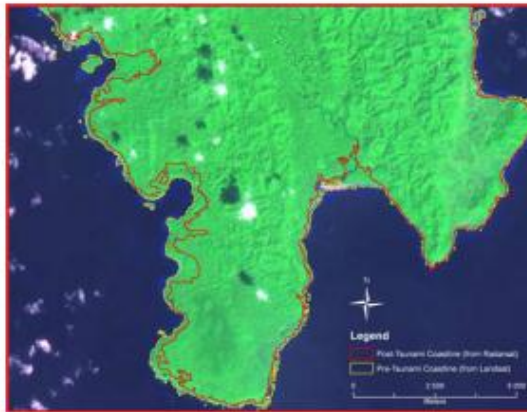


Land surface deformation in southern Iran

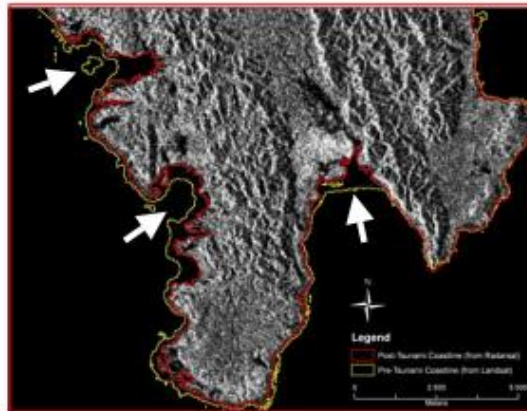


## SAR applications

- Coastal zones

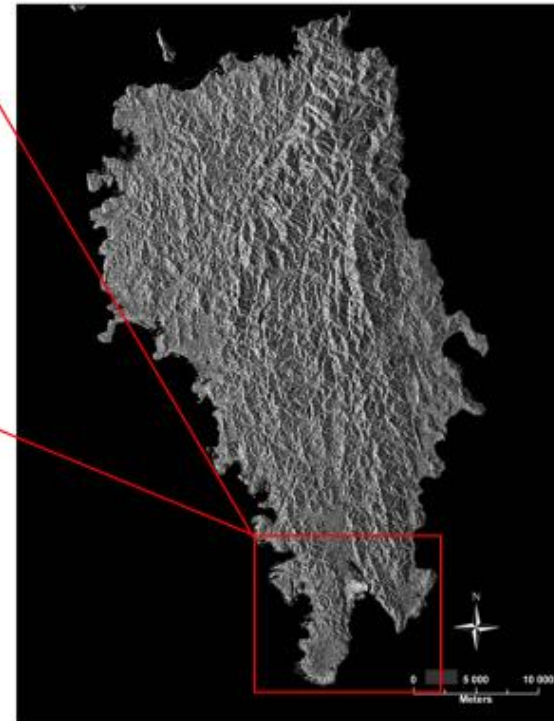


Pre-tsunami Landsat TM image with post-tsunami coastline vector (in red) overlaid.



Post-tsunami RADARSAT-1 image with pre-tsunami coastline vector (in yellow) overlaid. Arrows mark submersed islands and other flooded coastal areas.

## RADARSAT-1 applied to tsunami damage assessment



RADARSAT-1 image showing Great-Nicobar Island (India) following the tsunami (31-Dec-2004)

# InSAR applications

## SAR applications

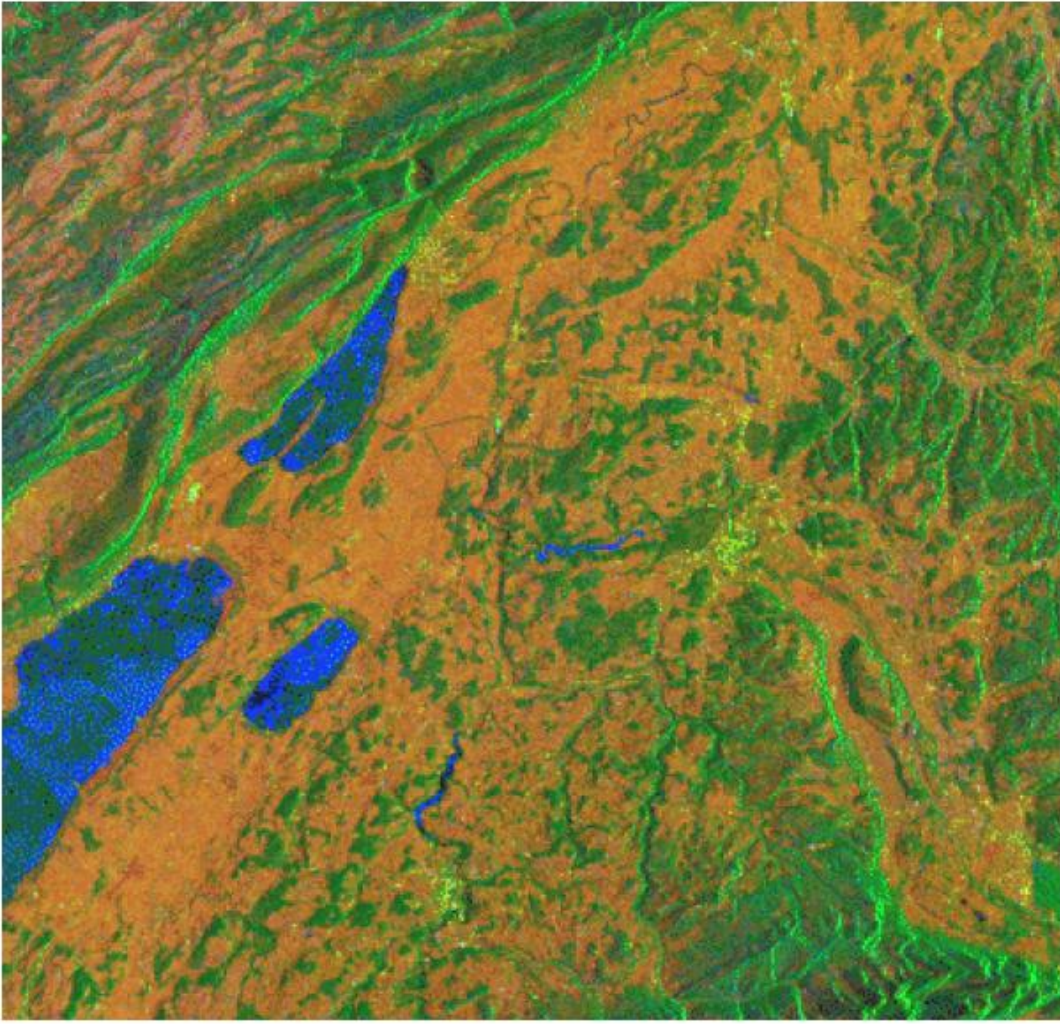



- Coastal zones

### Coastal Erosion: Guyana



## SAR applications

- Forestry – Forest classification, deforest monitoring

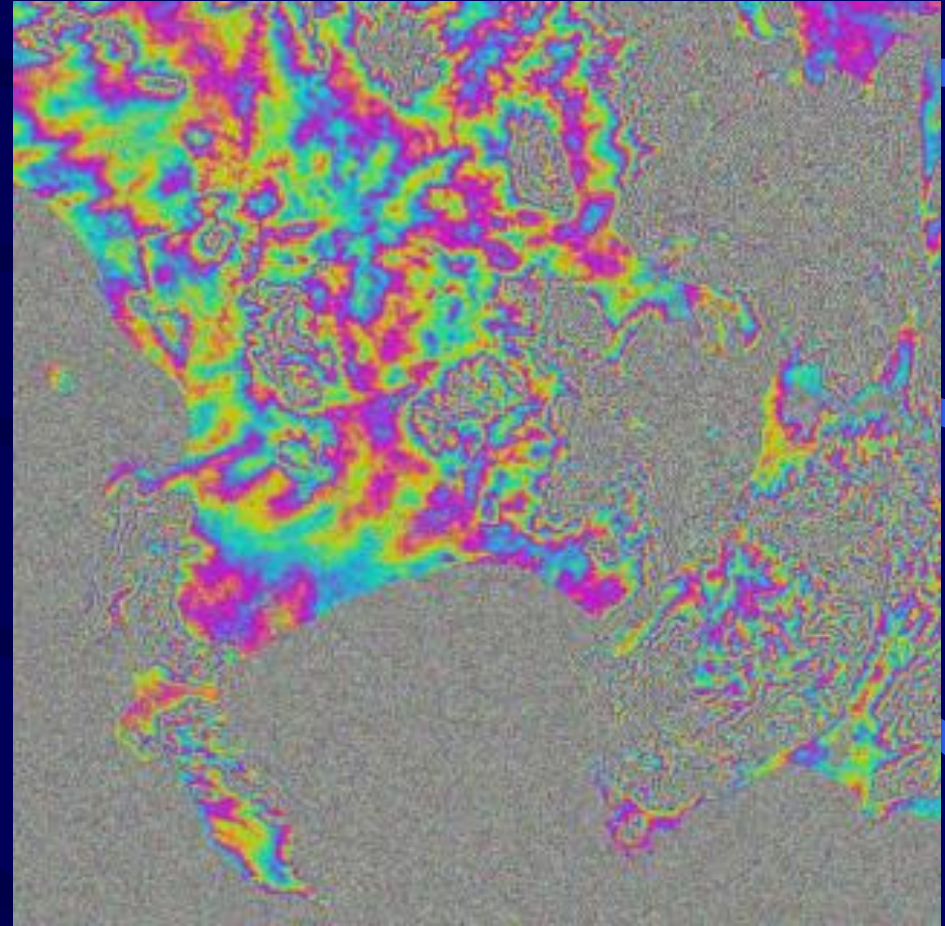
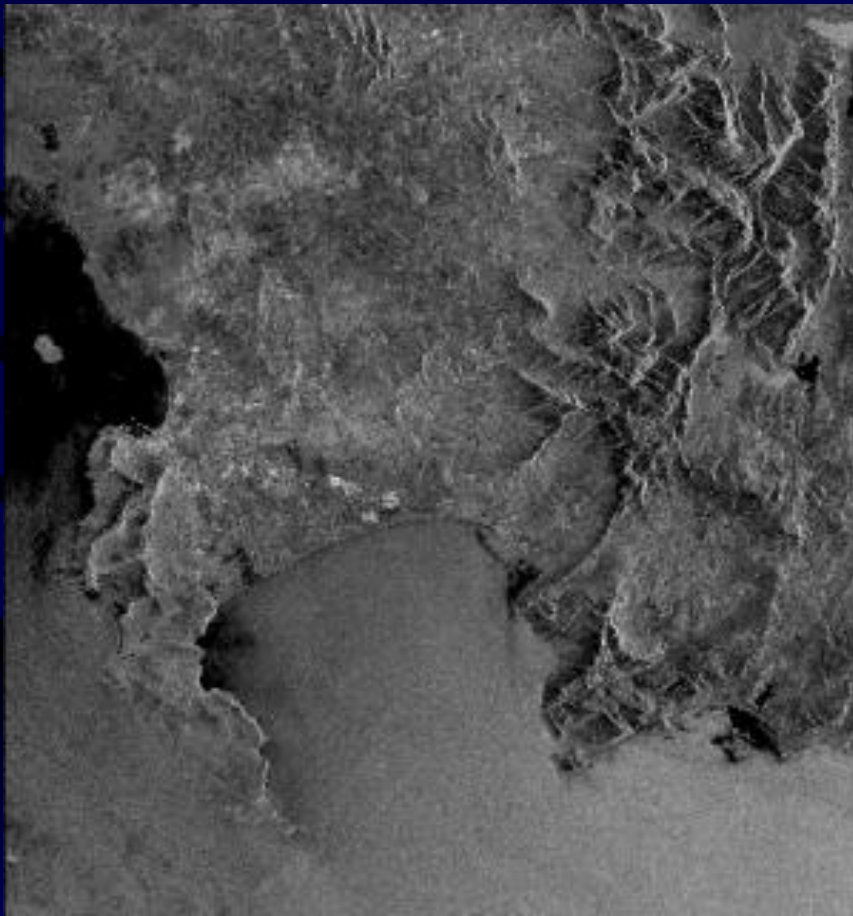
- 
-  interferometric correlation
  -  backscatter intensity
  -  backscatter change

Source: Strozzi and Wegmuller (1997)

# *InSAR applications*

## SAR applications

- Cartography – DEM, DTM, topographic mapping

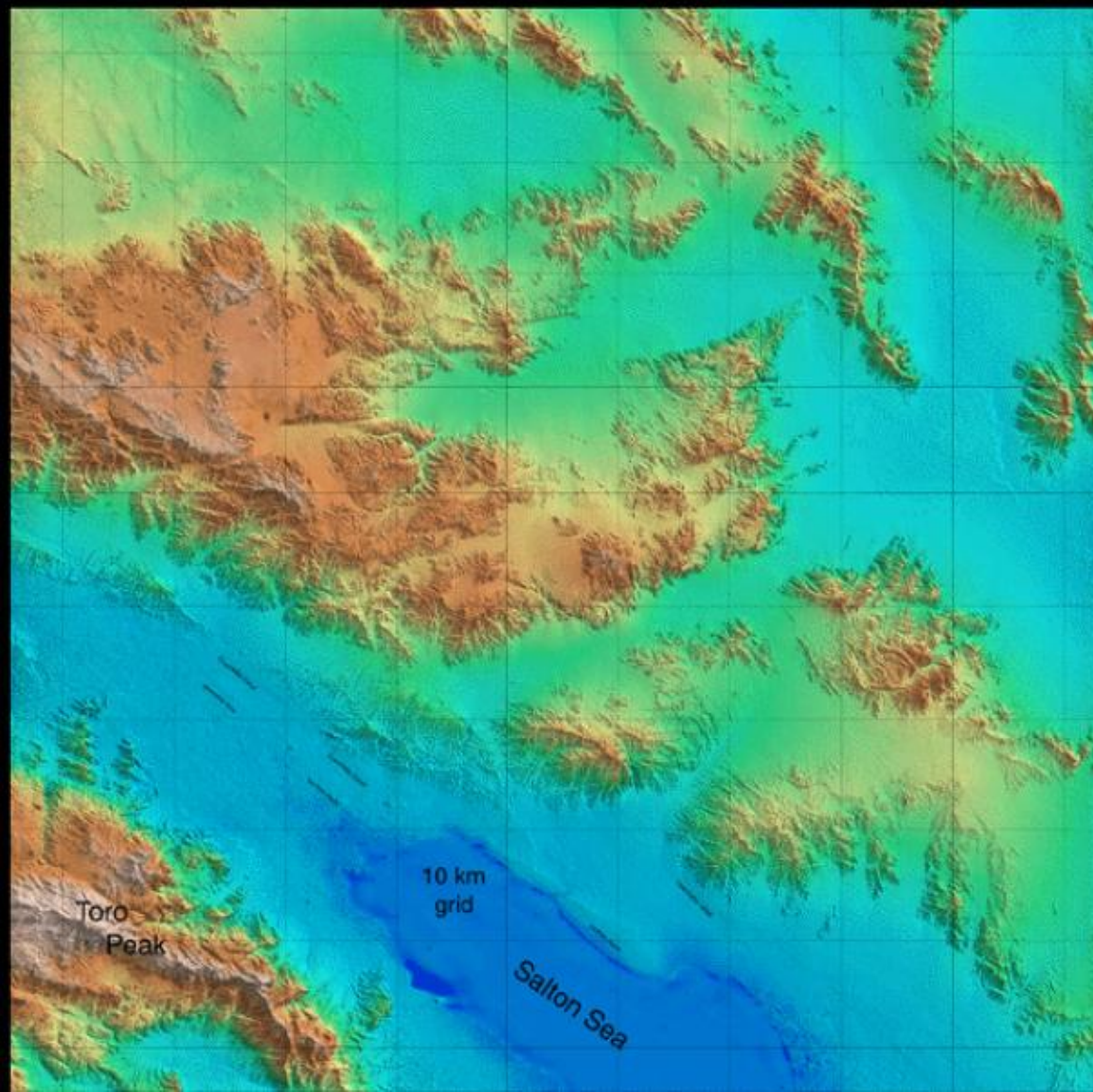


ERS multi-look intensity image and the flattened interferogram of the Western Cape Town region.

# InSAR applications

## SAR applications

- **Geology – Geological Mapping, tectonic applications**

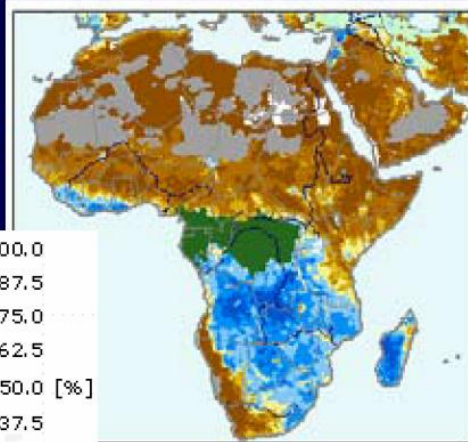
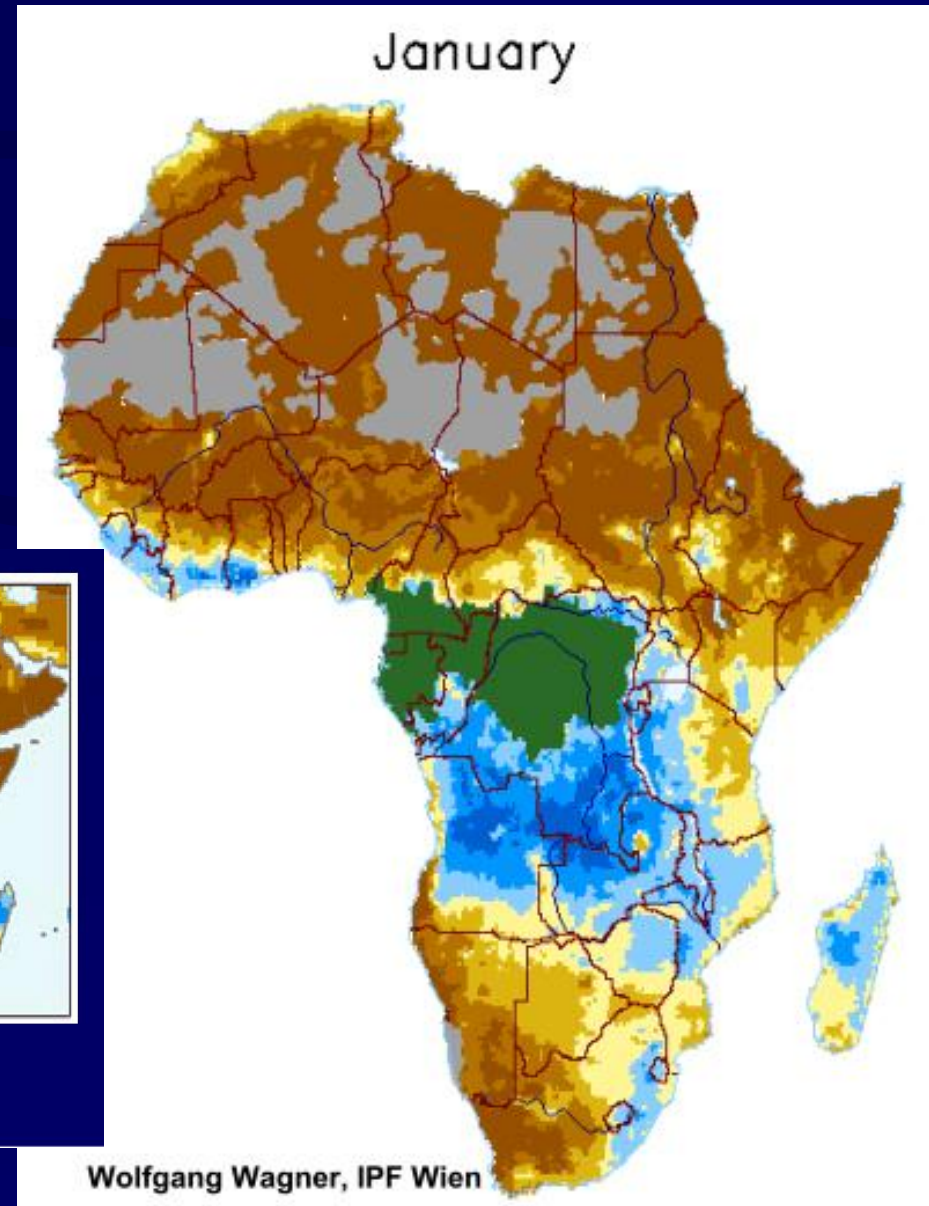


Southern California  
ERS SAR

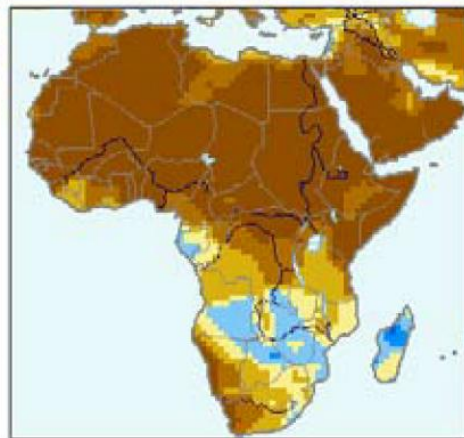
# InSAR applications

## SAR applications

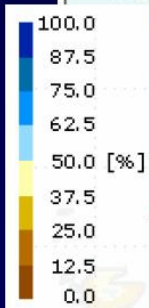
- Soil Science – Soil moisture



Averaged  
Soil Water Index  
January 2000

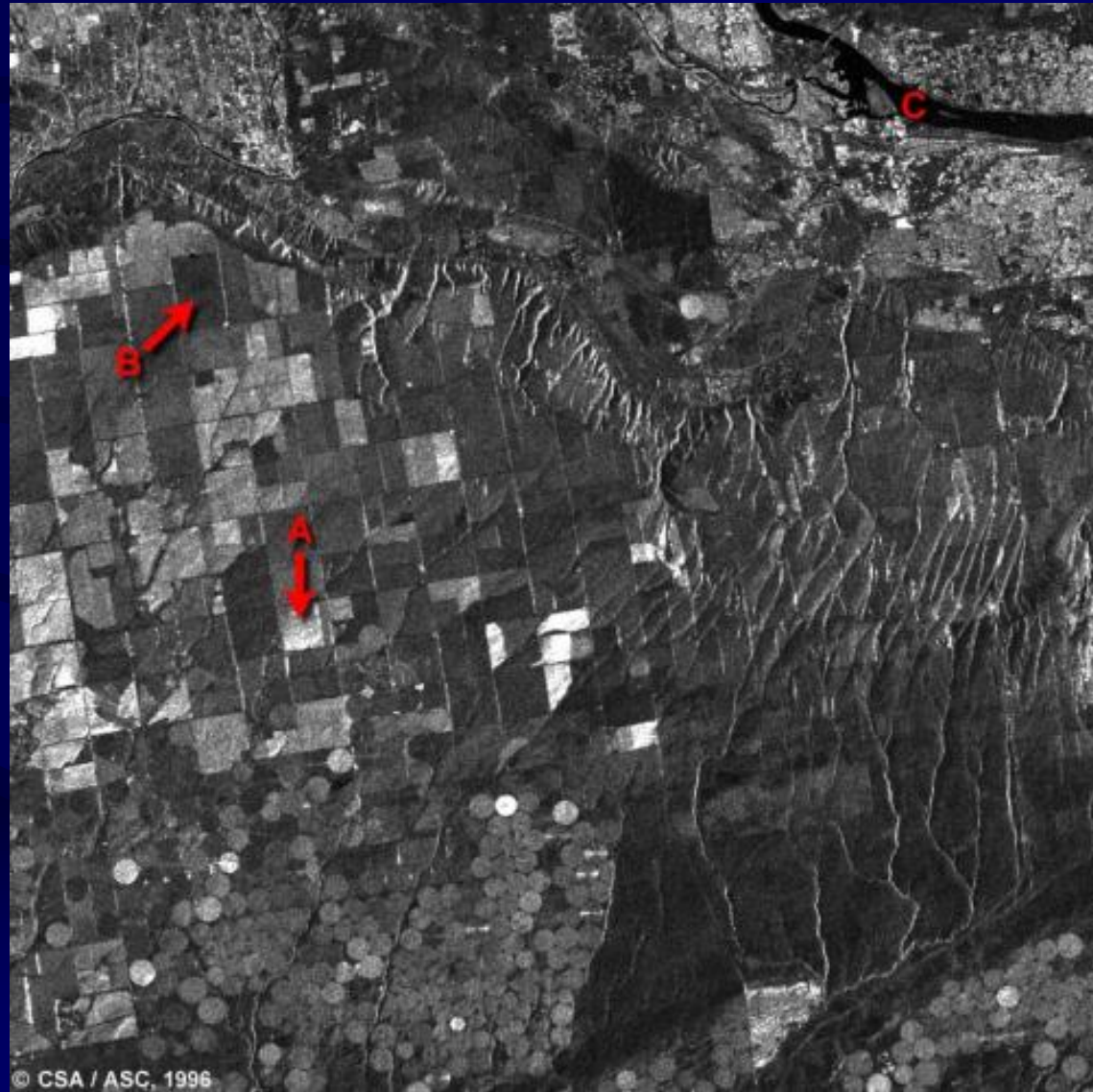


Global Precipitation Data  
(GPPC)  
January 2000



## SAR applications

- Agriculture – Crop monitoring



Agricultural Region in  
the State of  
Washington

### SAR applications

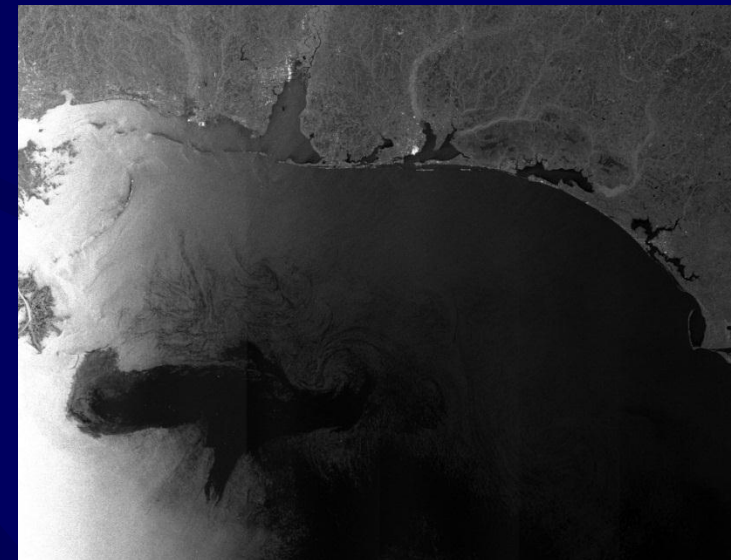
#### •Environment – Oil spill, hazard monitoring

Envisat radar image captures the oil that is spilling into the Gulf of Mexico after a drilling rig exploded and sank off the coasts of Louisiana and Mississippi, USA, on 22 April 2010.

- The oil spill is visible as a dark grey whirl in the bottom right.
- Envisat acquired this image from its Advanced SAR on 26 April 2010 (upper image).

Image acquired by Envisat's Advanced Synthetic Aperture Radar (ASAR) instrument on 28 April 2010 two days after (bottom image).

- The oil spill movement is considerable. It is visible as a lighter grey whirl on the left side of the large black pattern stretching across the Gulf.





## SAR applications

- **Archaeology – Sub-surface mapping**

### Water Harvesting: Jordan

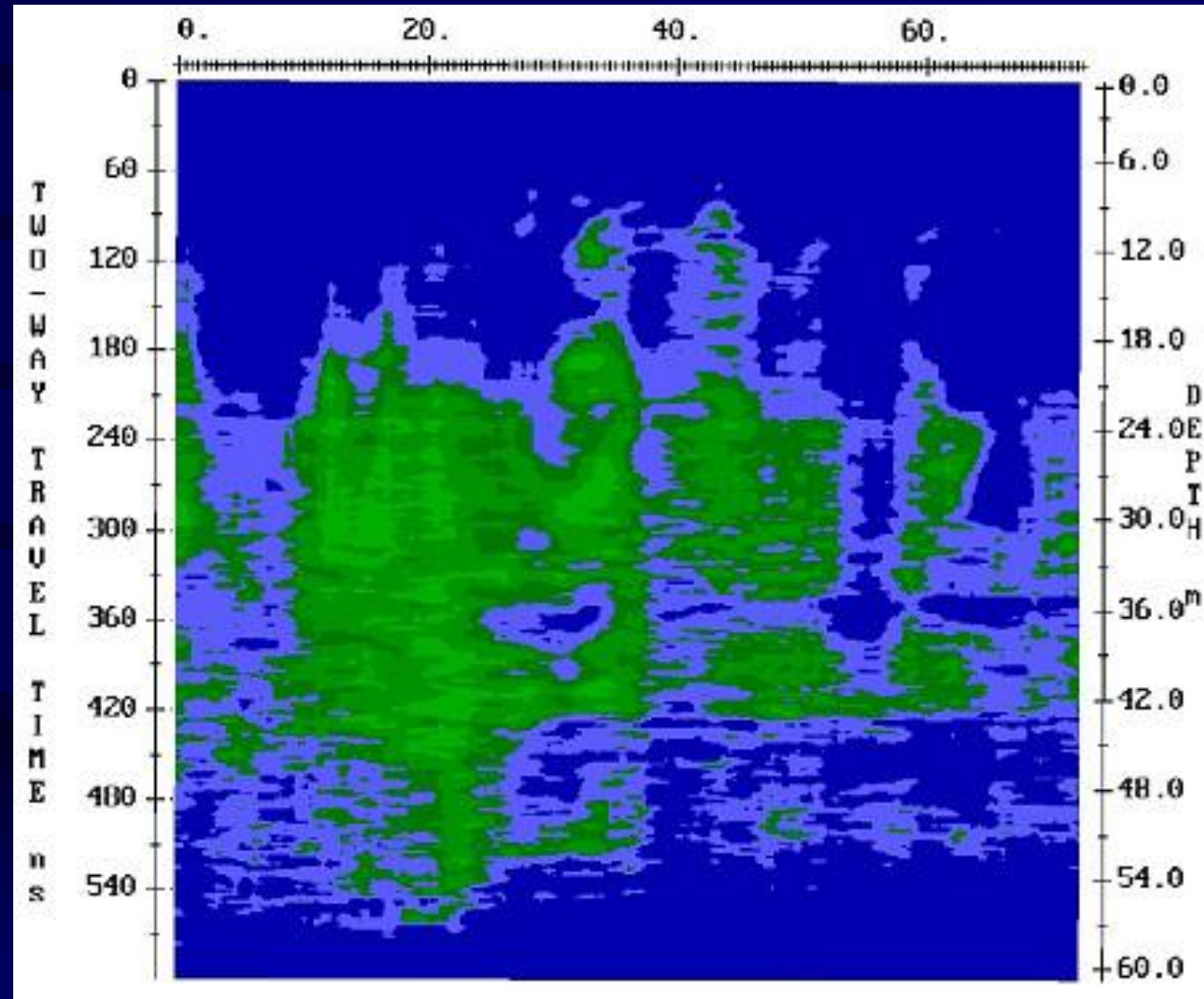
- Mapping Wadis and Playas



## SAR applications

- **Archaeology – Sub-surface mapping**

Radar image of the cavity located at 10 to 30m under ground as the green shading; a very good representation of the great hall of the Harrison Cave systems in Barbados, West Indies.

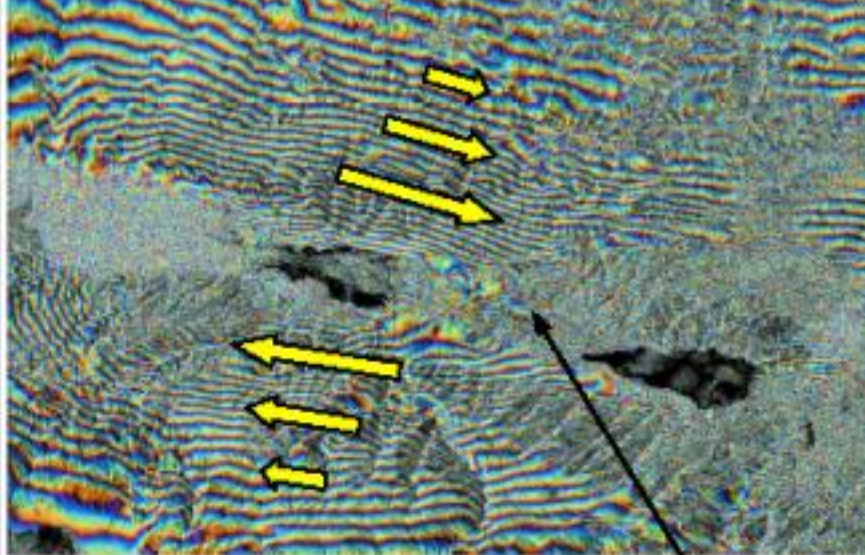
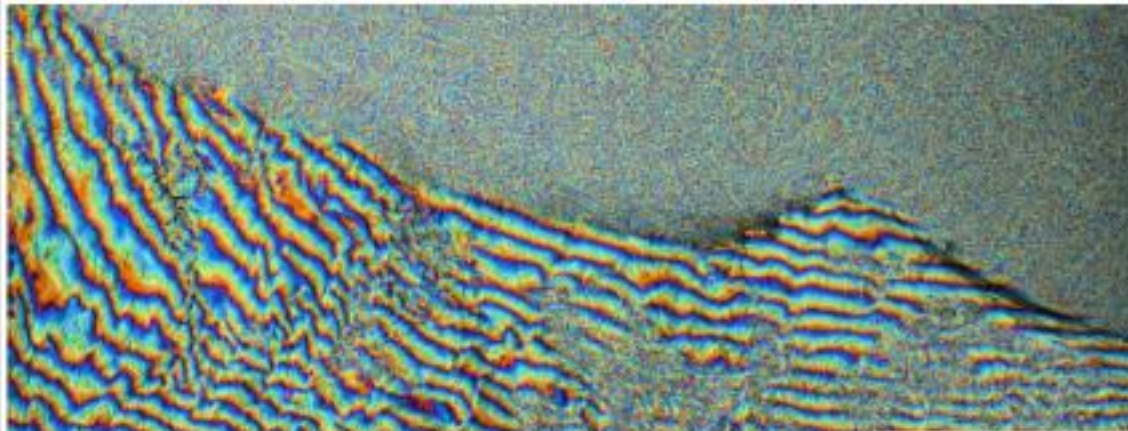


# *Case Studies*

*examples*

## D-InSAR Displacement Pattern of an Earthquake

Izmit/Turkey, 17 August, 1999



Data ERS-1/2 © ESA,  
Acquisition dates: 12.08. and 16.09.1999

Izmit

***New Technologies  
in monitoring and management of  
calamities and  
dynamic changes  
"domestic experiences of a global concern"***

***Parviz Tarikhi***

***[parviz\\_tarikhi@hotmail.com](mailto:parviz_tarikhi@hotmail.com) & <http://parviztarikhi.wordpress.com>***

***Mahdasht Satellite Receiving Station, ISA***

# *our contribution*

ground displacement assessment

*Supported by ESA/ESRIN and IRSC, we carried out a research project entitled:*

**PLATE MOTION ESTIMATES THROUGH  
ERS INTERFEROMETRIC SAR  
IMAGERY CONCERNING THE IZMIT  
QUAKE OF AUGUST 17, 1999**

## *InSAR applications*

Report to ESA/ESRIN

on the research project:

**PLATE MOTION ESTIMATES THROUGH ERS  
INTERFEROMETRIC SAR IMAGERY CONCERNING  
THE IZMIT QUAKE OF AUGUST 17, 1999**

**Parviz Tarikhi  
Mohammed Morabi**

November 2000

A detailed report on the results of the study was submitted to the ESA/ESRIN and IRSC late in 2000.



# Disaster in Western Turkey





# InSAR applications



# Earth Space Data

*Table 1: List of the ERS-SAR data input to the project*

Data name	Date (mm/dd/yy)	Platform	Track	Frame	Orbit	Product type
B0r	06/07/1995	ERS-1	336	2781	20364	RAW
B9s	06/08/1995	ERS-2	336	2781	00691	SLCI
B8r	10/15/1998	ERS-2	336	2781	18226	RAW
B7s	12/24/1998	ERS-2	336	2781	19228	SLCI
B6s	03/04/1999	ERS-2	336	2781	20230	SLCI
B5s	03/20/1999	ERS-2	064	2781	20459	SLCI
B4p	04/05/1999	ERS-2	293	2781+2 nodes	20688	PRI
B3s	04/24/1999	ERS-2	064	2781	20960	SLCI
B2s	08/12/1999	ERS-1	157	819-4 nodes	42229	SLCI
B1s	08/13/1999	ERS-2	157	819-4 nodes	22556	SLCI
	08/17/1999	<b>EARTHQUAKE</b>				
A1p	08/23/1999	ERS-2	293	2781+2 nodes	22692	PRI
A2s	08/25/1999	ERS-1	336	2781	42408	SLCI
A3s	08/26/1999	ERS-2	336	2781	22735	SLCI
A4s	09/10/1999	ERS-1	064	2781	42637	SLCI
A5s	09/11/1999	ERS-1	064	2781	22964	SLCI
A6s	09/16/1999	ERS-1	157	819-4 nodes	42730	SLCI
A7s	09/17/1999	ERS-2	157	819-4 nodes	23057	SLCI

*Table 2: List of the Landsat TM data input to the project*

Data name	Date (mm/dd/yy)	Platform	Sensor	Details
B	03/27/1999	Landsat	TM	Path 179
	08/17/1999	<b>EARTHQUAKE</b>		Row 32
A	08/18/1999	Landsat	TM	

# Optical data

Using available facilities, **optical data** were applied for detecting the changes, and highlighting features.

## *InSAR applications*

The 7-5-1 false color composite image of 18 August 1999 a day after the quake of Izmit area that is lying on northern shore of Izmit Bay. The bright yellow spot on top left is due to the fire caused by the explosion of the fuel tanks after quake. The dense black smoke that comes up can be readily identified in left.





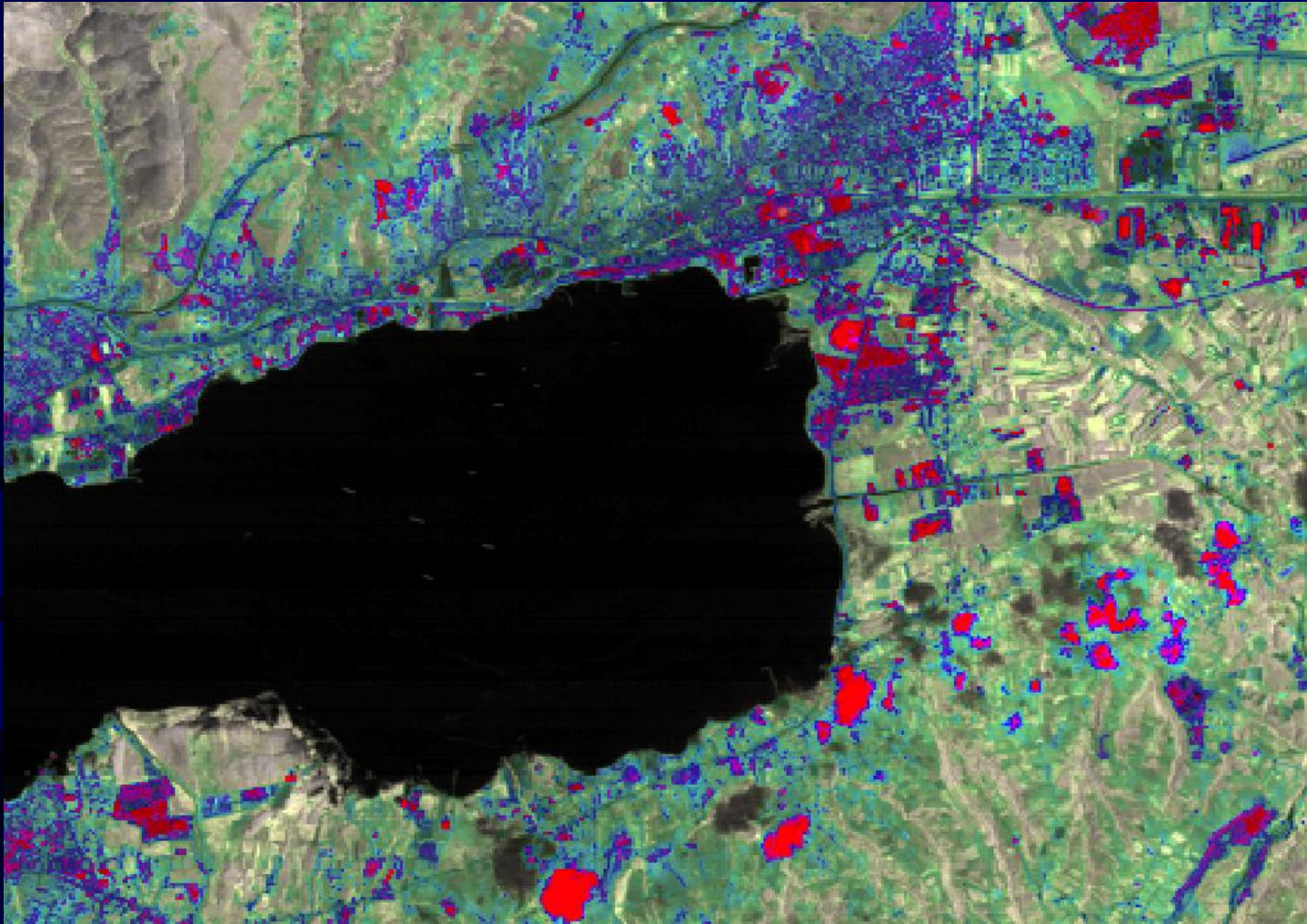
## *InSAR applications*



**This image shows the area on 27 March 1999. It is a false color composite of 4, 3, 2 TM bands.**

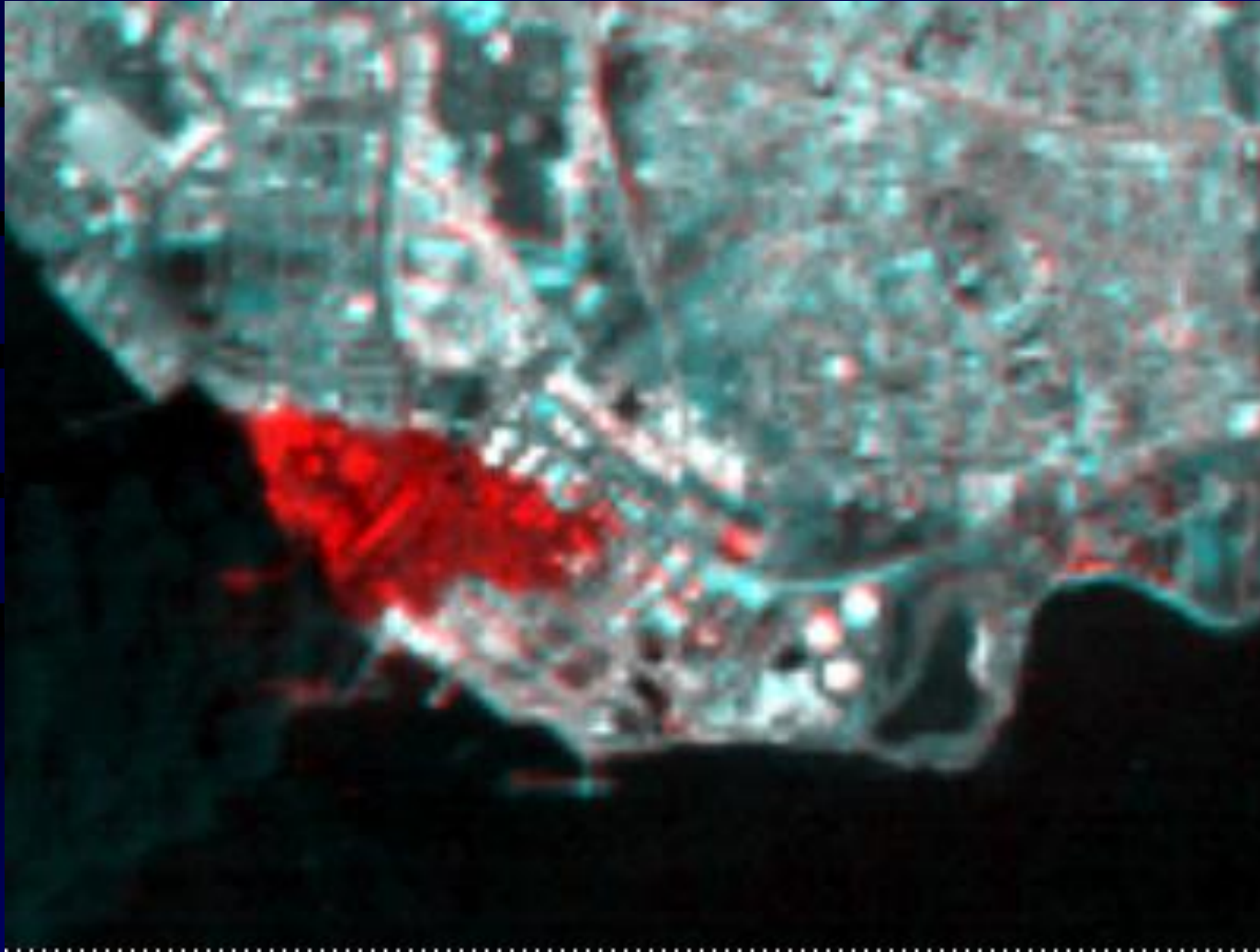
*a sample output of the project*

**InSAR applications**



**The image obtained through assigning the 4, 3, and 2 bands of the Landsat TM image of 18 August 1999 to the intensity, hue and saturation components respectively.**

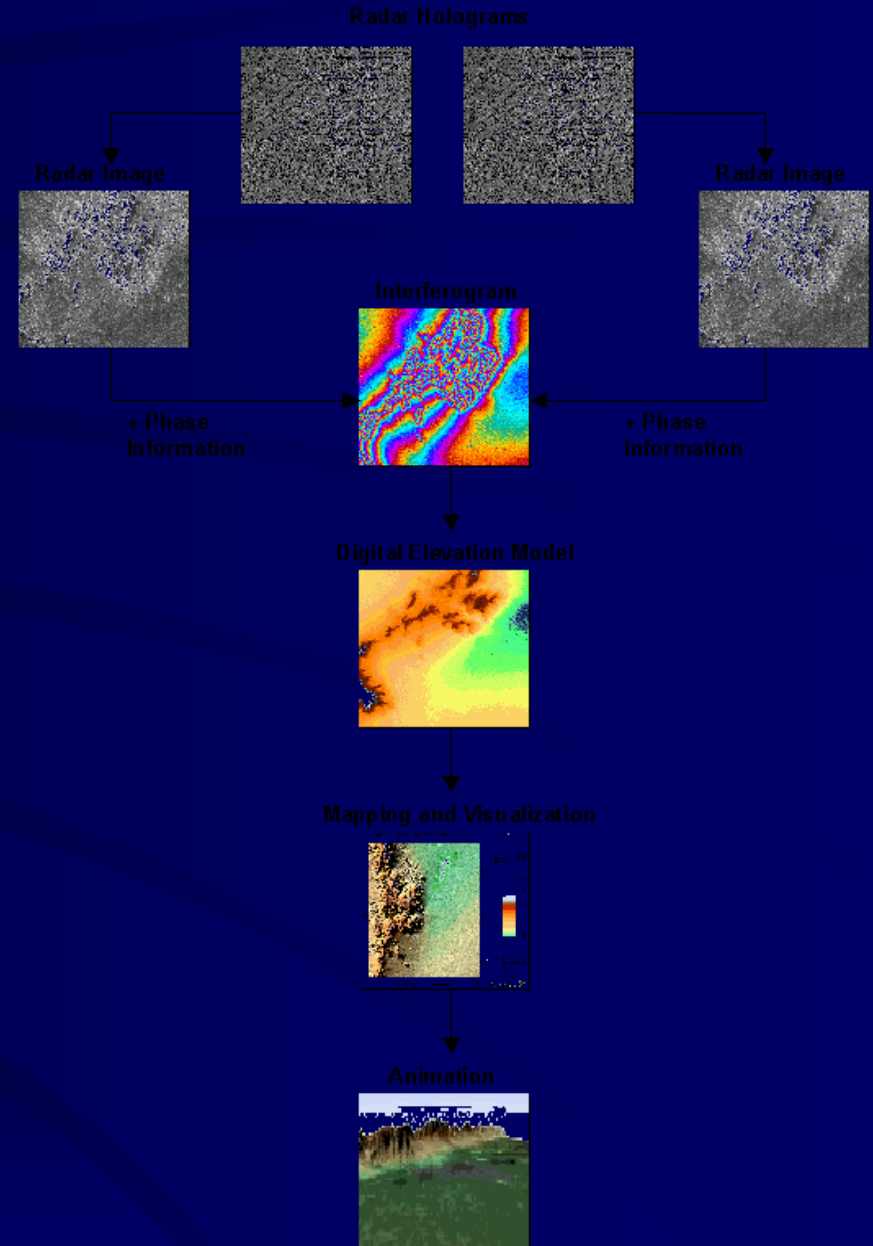
## InSAR applications



*This Image is obtained from the data sets of two dates one before the quake and the other after the quake. In this image the changed sites in the urban area as well as sea water transgression to the urban areas can be seen.*

# InSAR applications

## SAR data Combinations



# InSAR applications

**Table 3:** The information on the status of co-registration of ERS-SAR image pairs and their correspondent baseline

	B0r	B9s	B8r	B7s	B6s	B5s	B4p	B3s	B2s	B1s	A1p	A2s	A3s	A4s	A5s	A6s	A7s
B0r	@@@@@																
B9s		@@@@@		-55.604 -102.390	-1060.226 -461.205							-27.269 16.147	-445.204 -122.945				
B8r			@@@@@														
B7s		64.175 102.392		@@@@@	-1005.453 -265.355							40.250 112.674	-410.253 -21.291				
B6s		1063.360 467.550		1005.254 265.567	@@@@@							1055.152 479.624	625.522 240.265				
B5s						@@@@@		-222.269 -27.607	None Overlap id2	None Overlap id2				-612.951 -217.422	-793.571 -290.704	None Overlap id2	None Overlap id2
B4p							@@@@@				779.090 322.522						
B3s						227.307 27.612		@@@@@	None Overlap id2	None Overlap id2				-327.704 -129.965	-569.447 -263.207	None Overlap id2	None Overlap id2
B2s									@@@@@	224.190 91.097				None Overlap id2	None Overlap id2	-121.640 -67.725	-7
B1s							-779.954 -322.555		-224.191 -91.091	@@@@@				None Overlap id2	None Overlap id2	-222.212 -154.753	-11.401 -53.552
A1p											@@@@@						
A2s		22.979 -16.140		-34.913 -112.706	-1055.915 -472.225								@@@@@	-429.212 -140.725			
A3s		445.251 121.916		411.022 22.122	-625.200 -340.405							429.460 140.926	@@@@@				
A4s						613.056 214.227		327.797 129.929						@@@@@	-122.212 -73.229	None Overlap id2	None Overlap id2
A5s						793.534 290.720		569.706 263.179						122.224 23.229	@@@@@	None Overlap id2	None Overlap id2
A6s									20.912 66.023	7						@@@@@	234.443 100.226
A7s									7	13.921 53.267						-224.419 -100.433	@@@@@

The scientific domain ERS SAR Toolbox was used to generate different combinations.

The software is easily downloadable from the web address <http://earth.esa.int>.



## *InSAR applications*

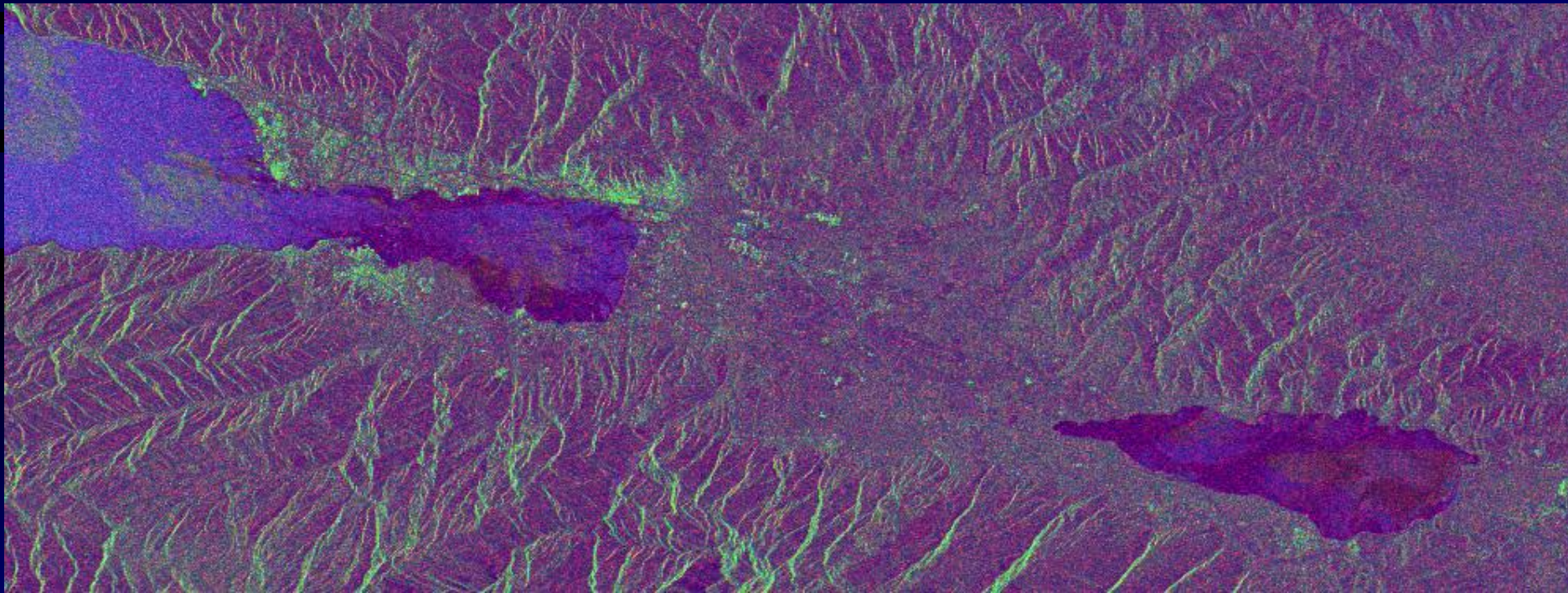
# EarthView

PRECISION IMAGE ANALYSIS  
FOR REMOTE SENSING APPLICATIONS



**We used the Earth View software of the Canadian Atlantis Scientific Inc. as the main and the basic tool to generate interferograms as well as relevant products.**

Composite image generated by the coherence (red), first principal component (green) and second principal component (blue) images of the 13 Aug. and 16 Sept. 1999 ERS SAR images



*a sample output of the project*



# **SAR data Combinations for interferogram generation**

we used different specific image pairs to  
this mean.

## Combinations

- Image pairs of before and after quake
- Image pairs of before quake
- Image pairs of after quake

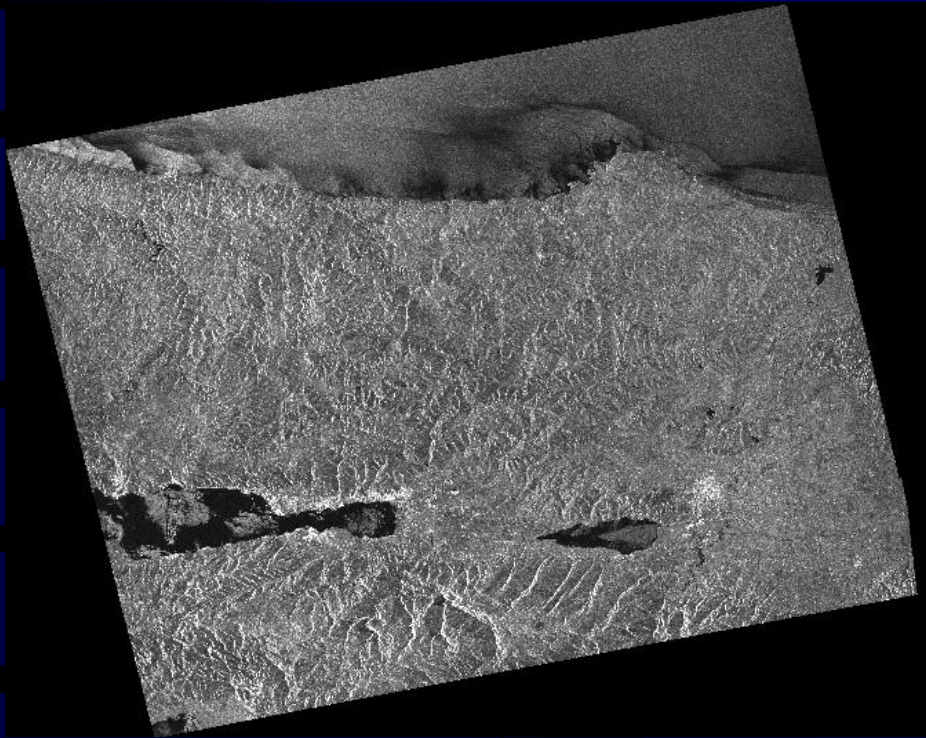
# Combinations

Image pairs of before and after quake

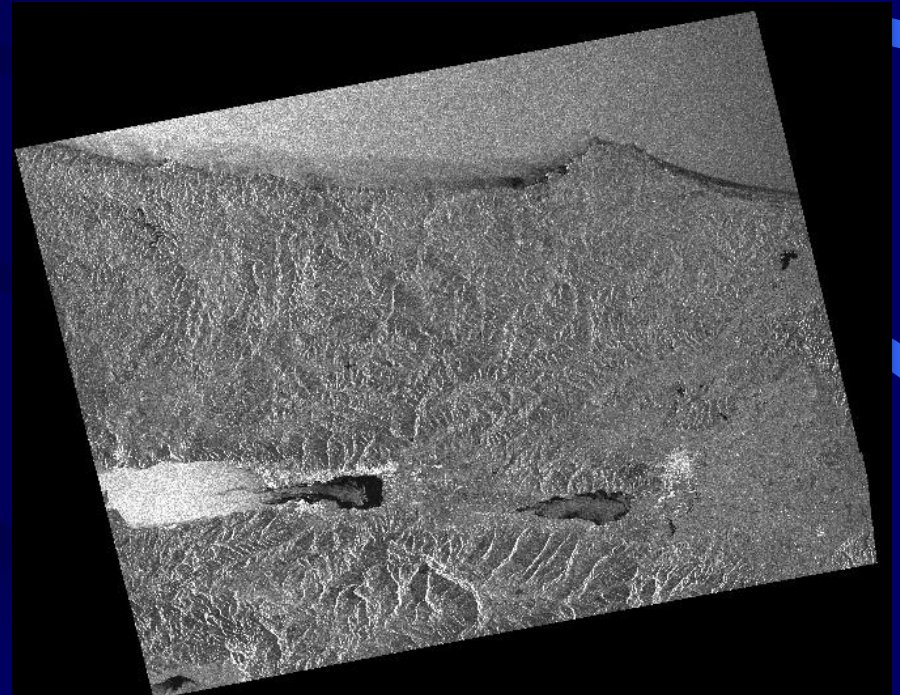
## *InSAR applications*

### **Image pair of:**

- (1) 13 Aug. 1999, and
- (2) 17 Sept. 1999  
(3 days before and a month  
after quake)



*master image*

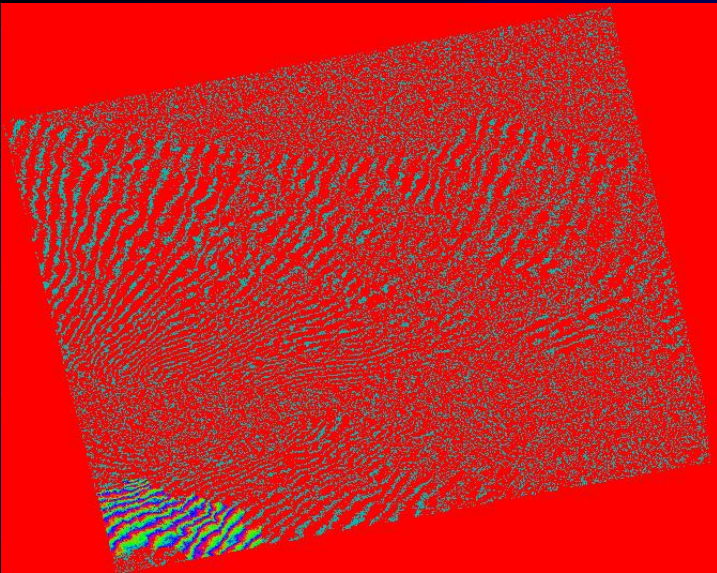


*slave image*

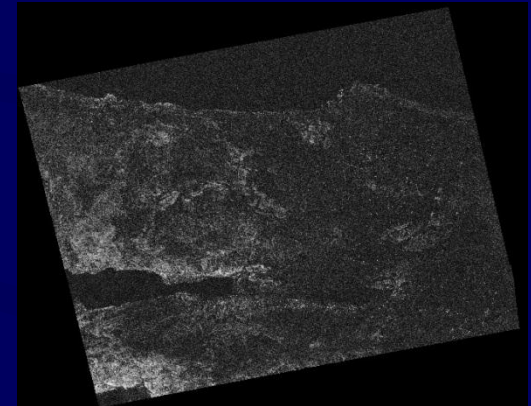
## *InSAR applications*

**Image pair of:** 13 Aug. 1999, and 17 Sept. 1999 (3 days before and a month after quake)

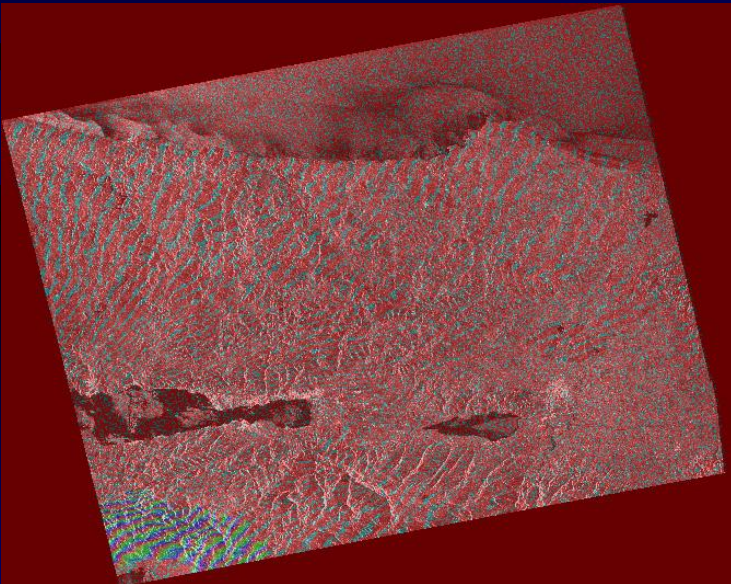
- normal baseline: 11.401m
- parallel baseline: 53.558m
- good coherence
- very small baseline



*phase image*



*coherence image*



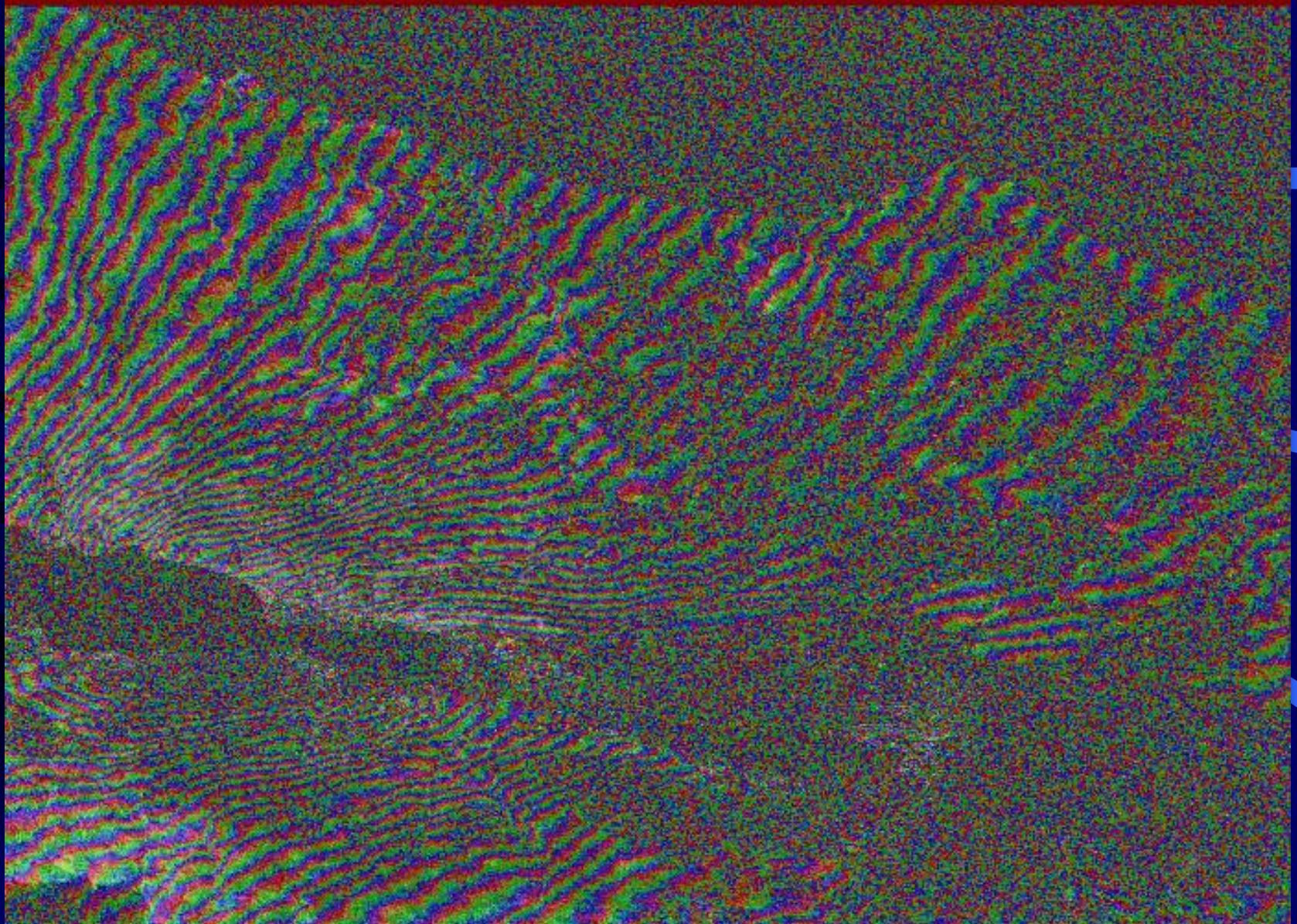
*interferogram*

*phase image overlaid  
on coherence image*



- good interferogram

## *InSAR applications*



*interferogram*

# Combinations

Image pairs of before quake

## *InSAR applications*

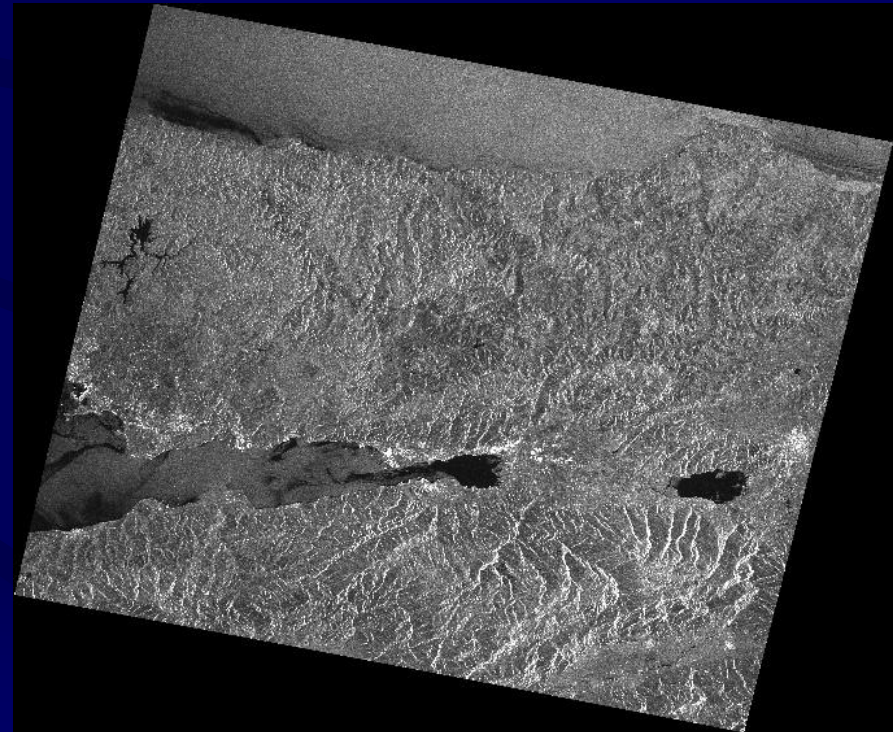
### Images of:

20 Mar. 1999, and 24 Apr. 1999  
(3 months+23 days and 4  
months+24 days before quake)

- normal baseline: 228.264m
- parallel baseline: 27.607m

*master image*

*slave image*

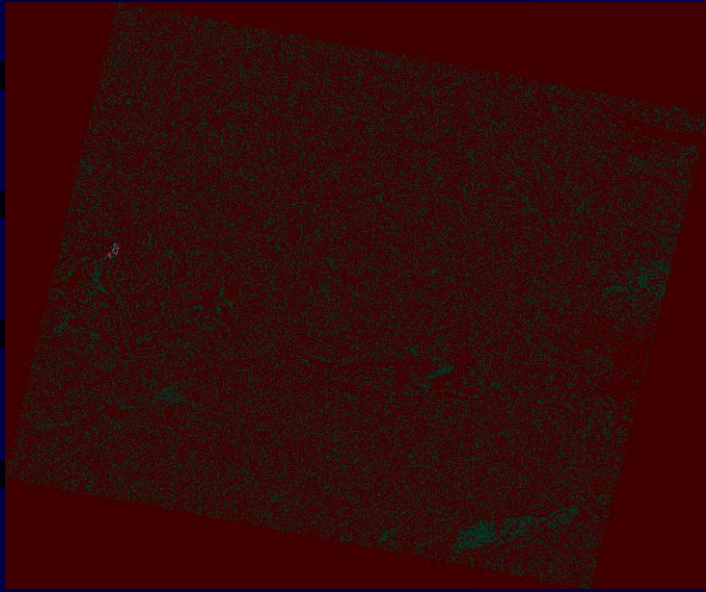




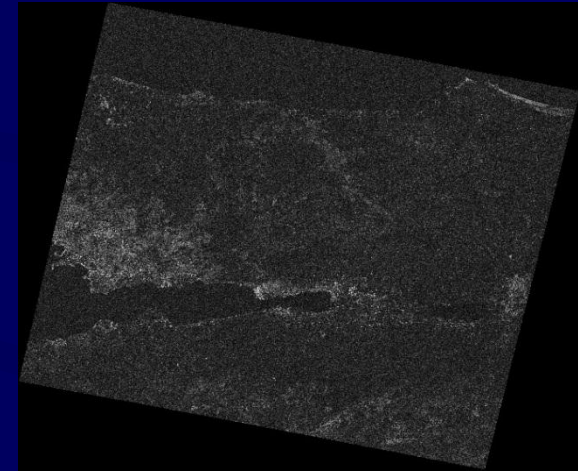
## *InSAR applications*

**Images of:** 20 Mar. 1999, and 24 Apr. 1999  
(3 months+23 days and 4 months+24 days  
before quake)

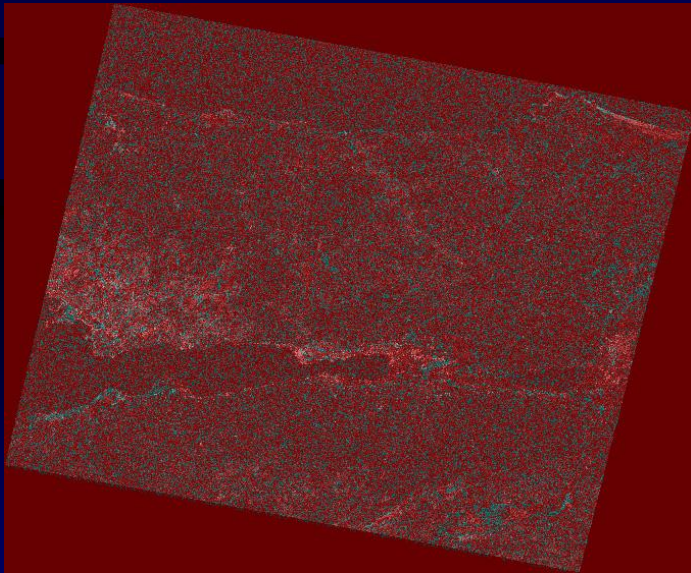
- normal baseline: 228.264m
- parallel baseline: 27.607m
- good coherence



*phase image*

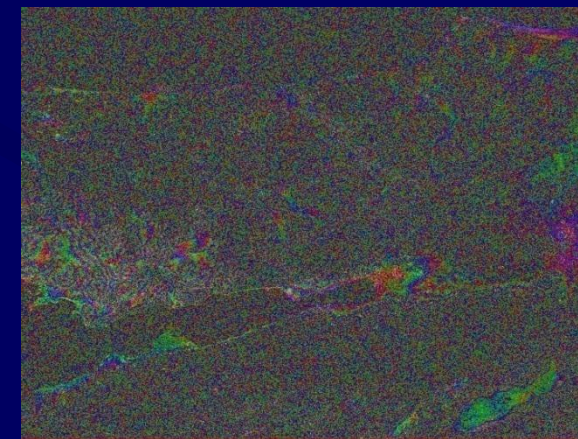


*coherence image*



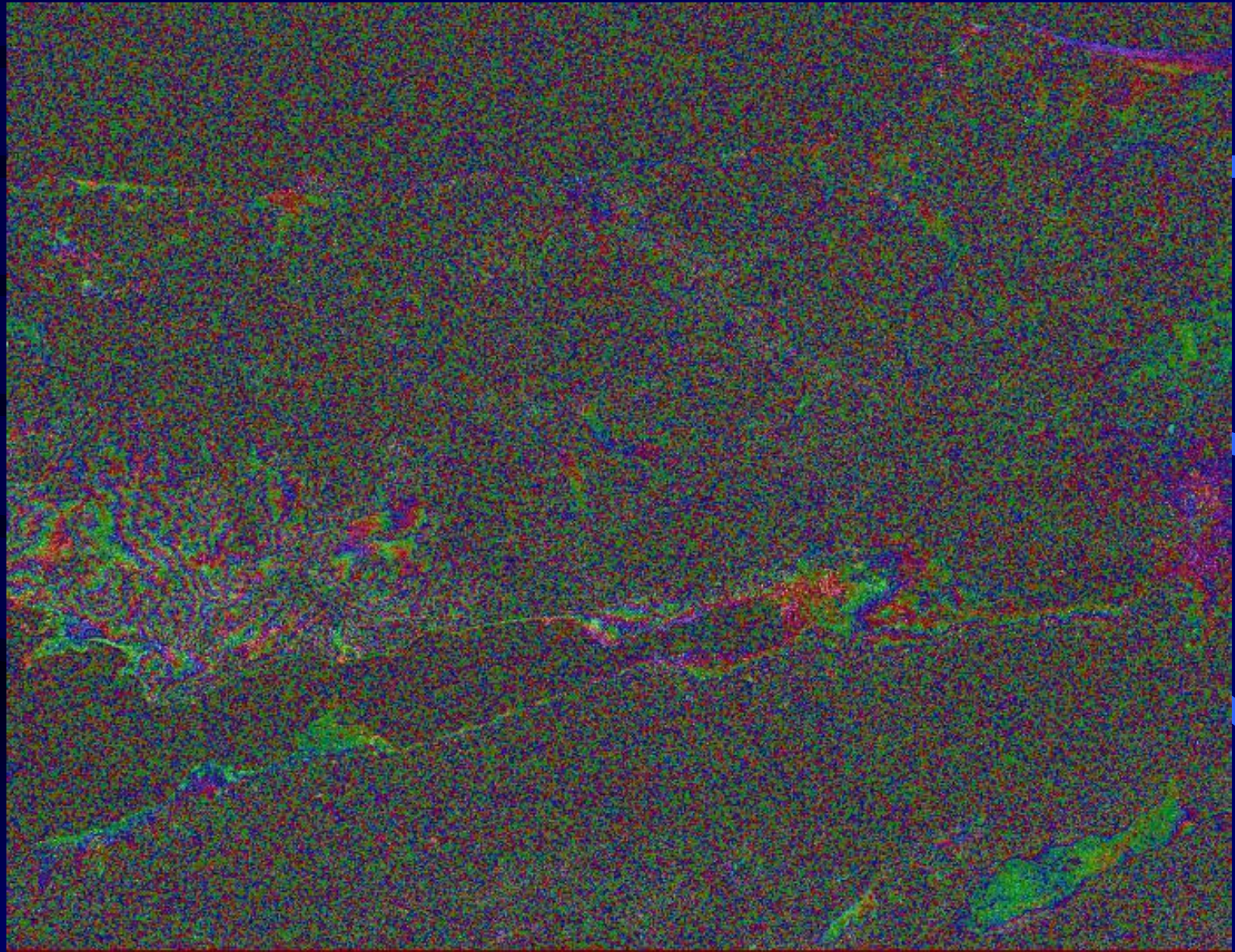
*interferogram*

*phase image overlaid  
on coherence image*



- good interferogram

## *InSAR applications*

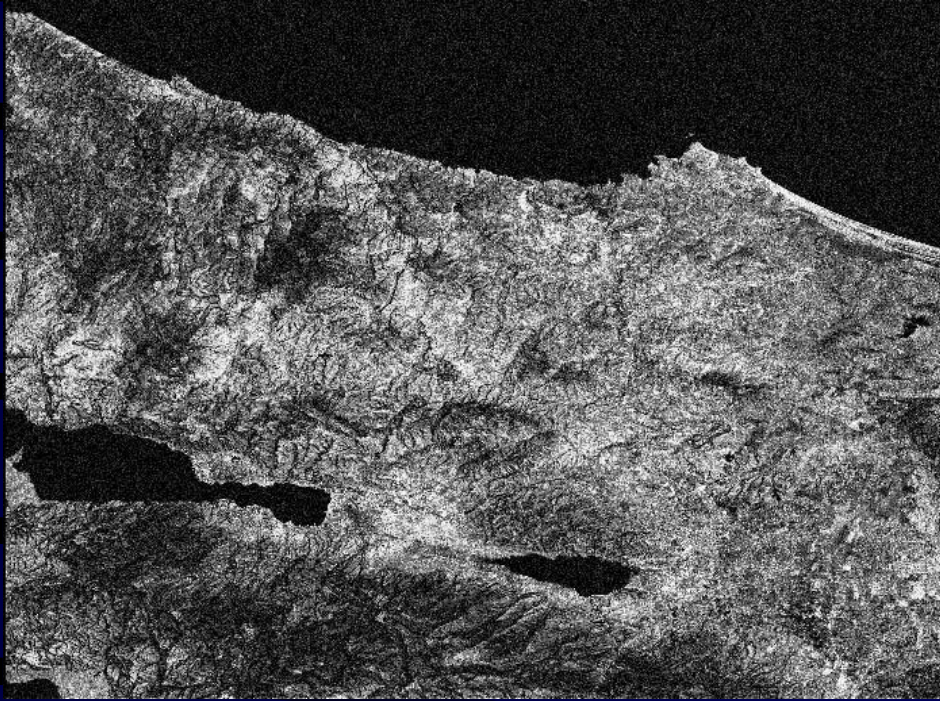


*interferogram*

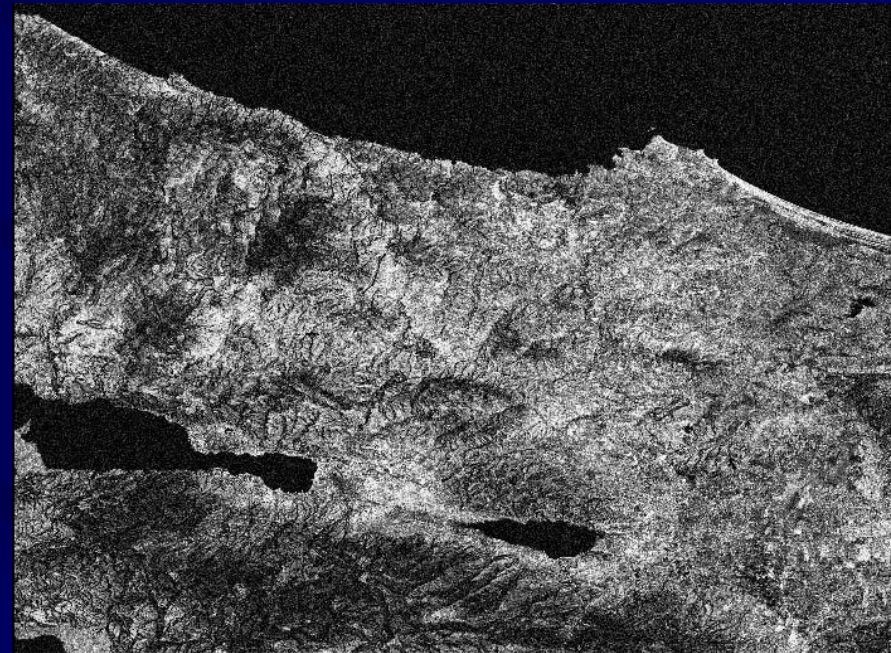
**another pair**

## *InSAR applications*

- **Tandem images of:**  
12 and 13 Aug. 1999  
(4 and 5 days before quake)
- normal baseline: 224.190m
- parallel baseline: 91.097m



*master image*

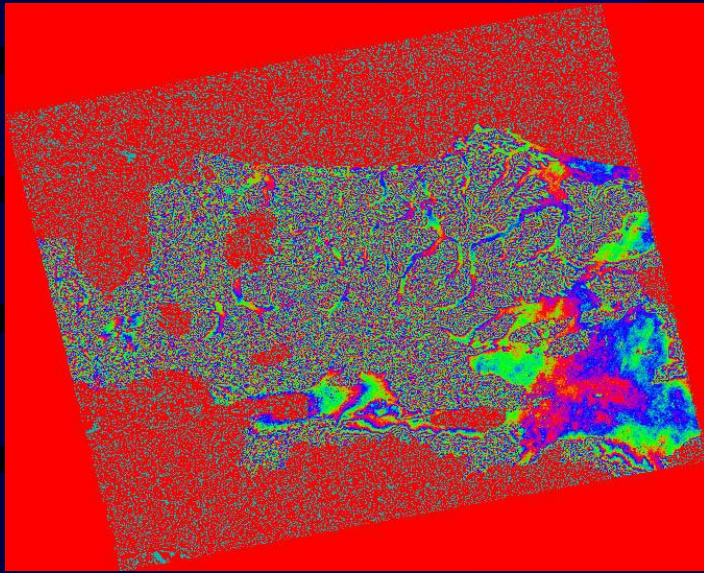


*slave image*

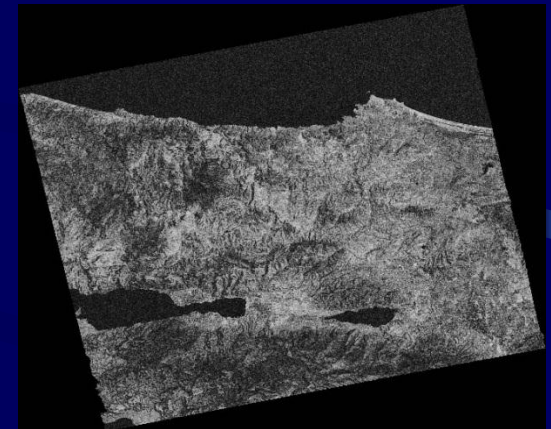
## InSAR applications

**Tandem images of:** 12 and 13 Aug. 1999  
(4 and 5 days before quake)

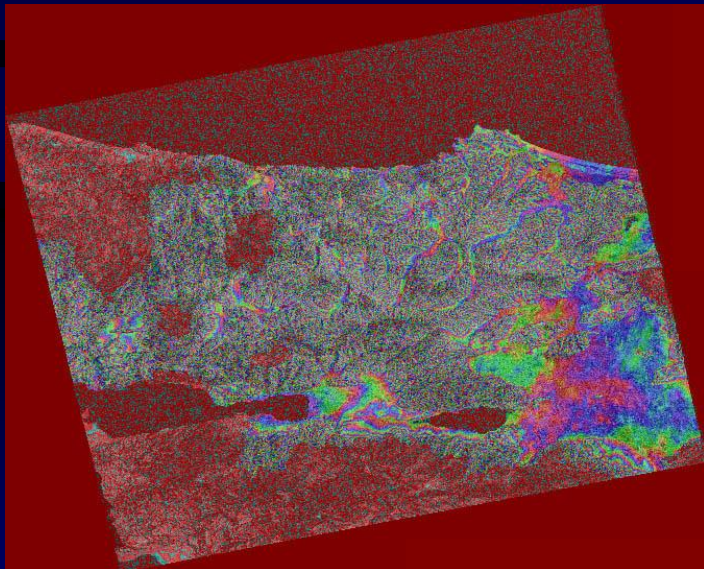
- normal baseline: 224.190m
- parallel baseline: 91.097m
- good coherence



*phase image*

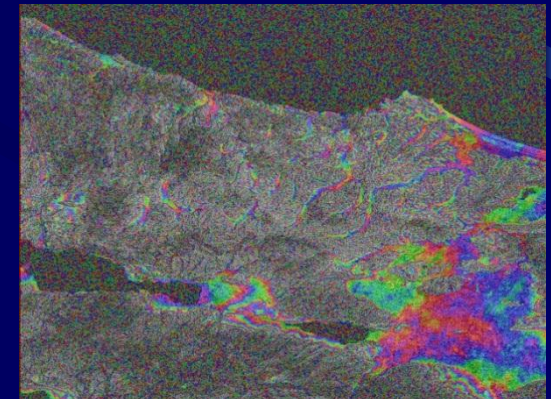


*coherence image*



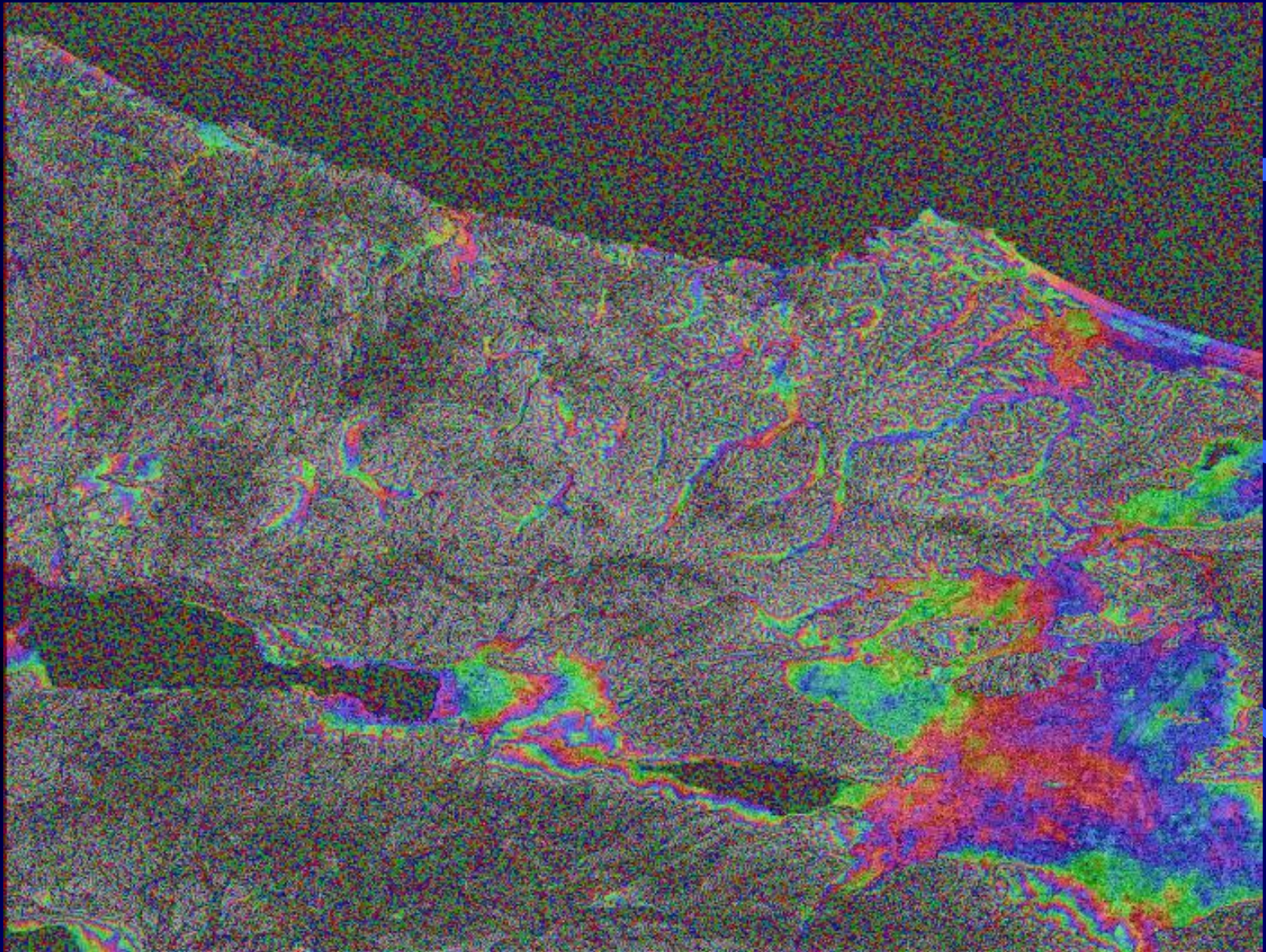
*interferogram*

*phase image overlaid  
on coherence image*



- good interferogram

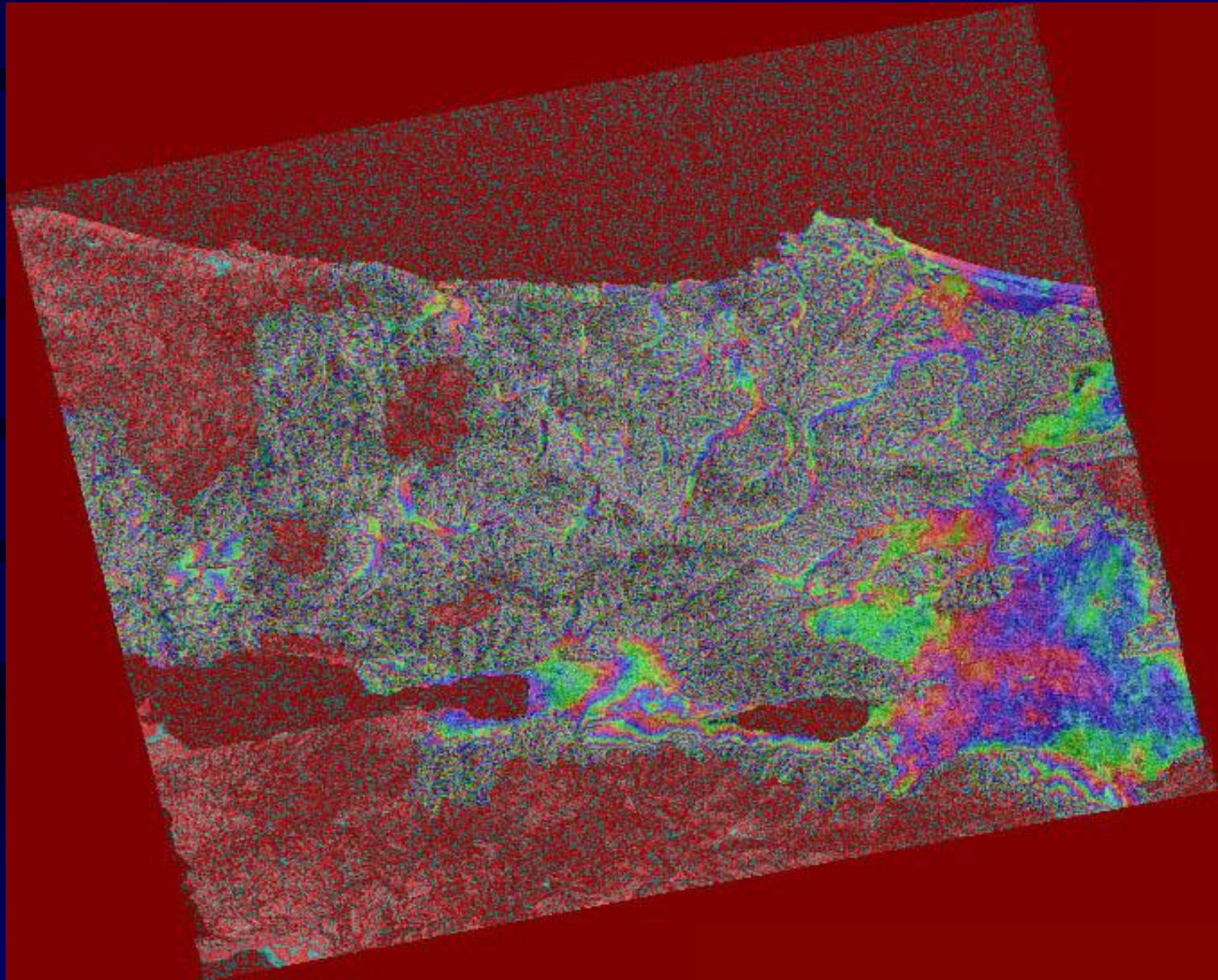
## *InSAR applications*



*interferogram*

- good interferogram

## *InSAR applications*



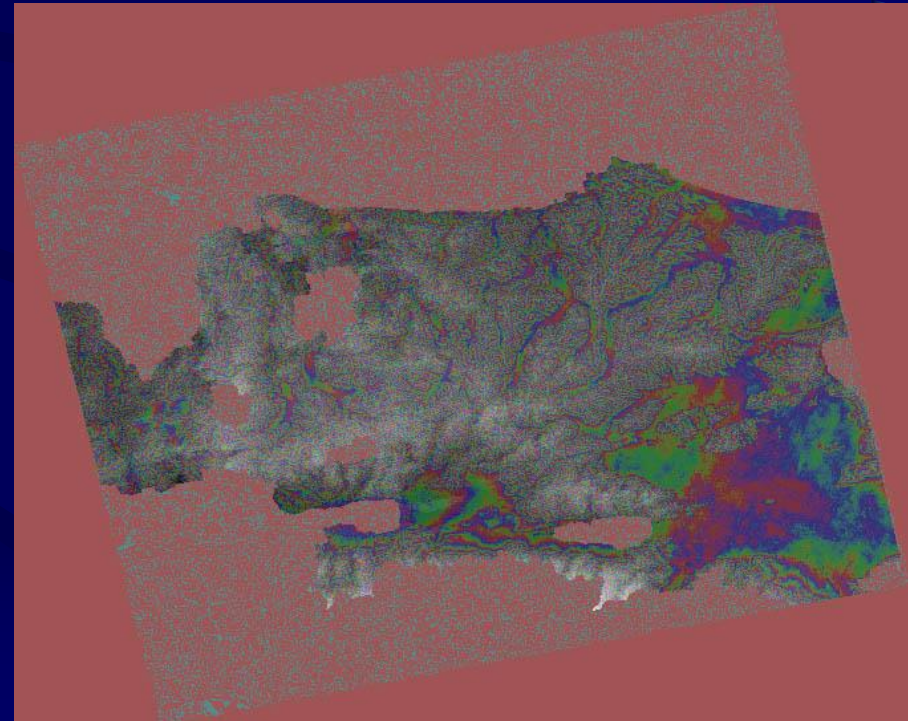
*geocoded  
interferogram*

## *InSAR applications*

- **Tandem images of:** 12 and 13 Aug. 1999 (4 and 5 days before quake)
- normal baseline: 224.190m
- parallel baseline: 91.097m
- good height image or digital elevation model (DEM)

*height image (DEM)*

*(phase image overlaid on height image (DEM))*





# Combinations

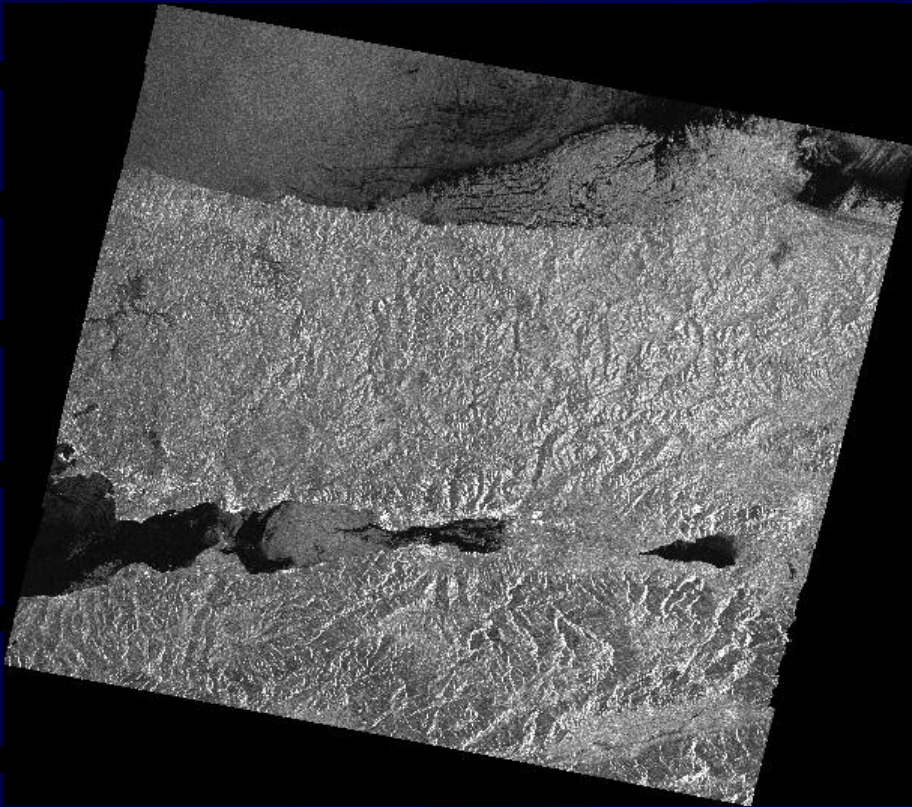
Image pairs of after quake

## *InSAR applications*

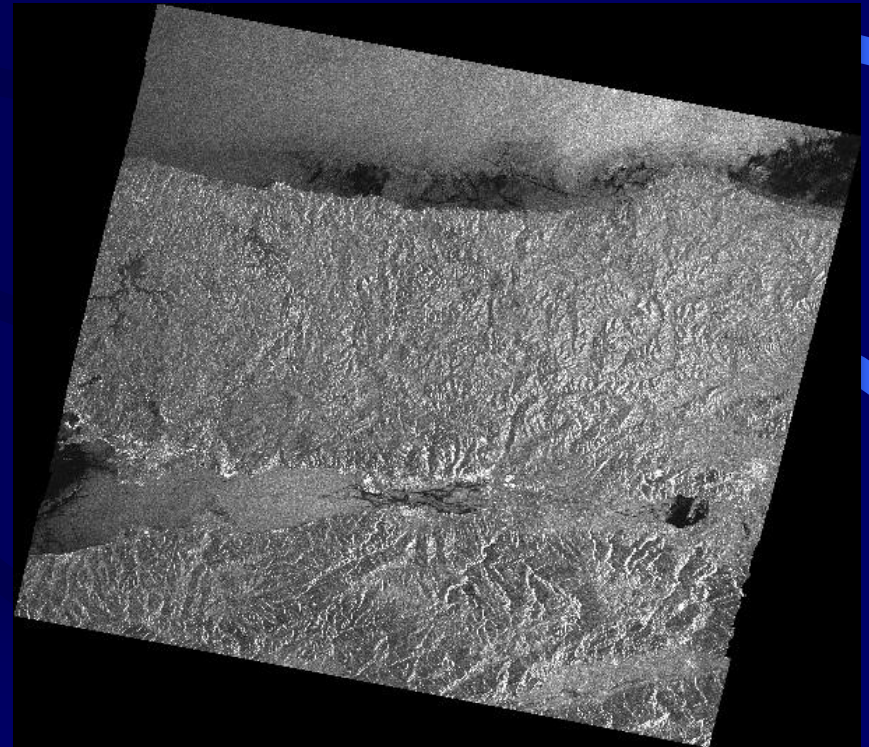
### **Tandem images of:**

10 and 11 Sept. 1999  
(23 and 24 days after quake)

- normal baseline: 183.313m
- parallel baseline: 73.239m



*master image*

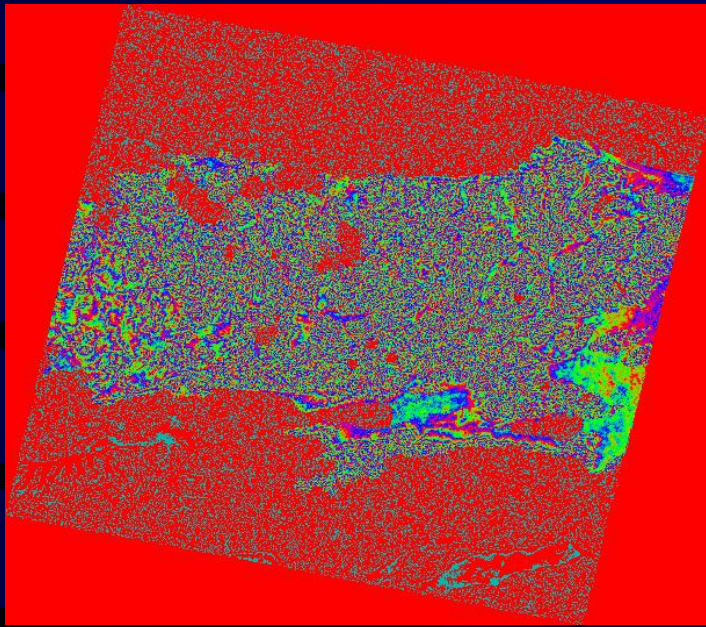


*slave image*

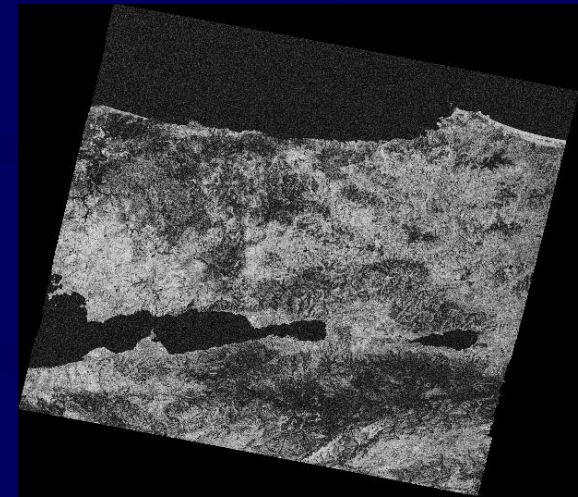
## *InSAR applications*

**Tandem images of:** 10 and 11 Sept. 1999  
(23 and 24 days after quake)

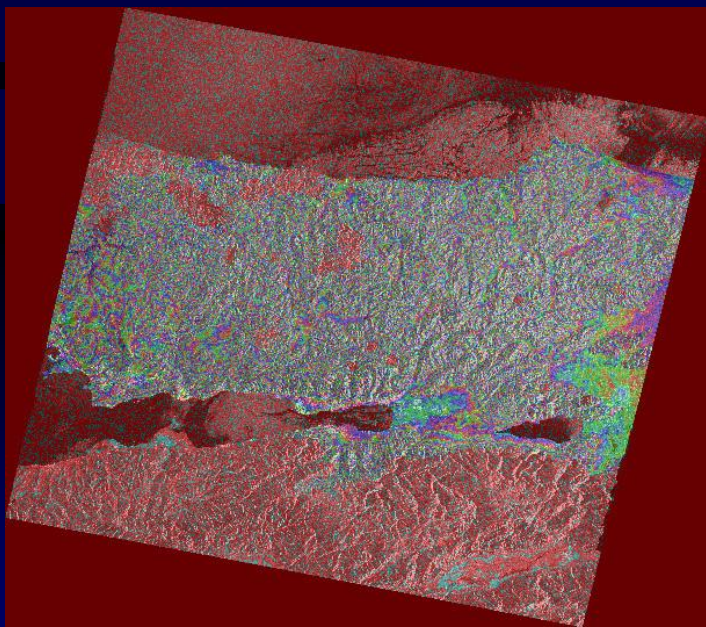
- normal baseline: 183.313m
- parallel baseline: 73.239m
- good coherence



*phase image*

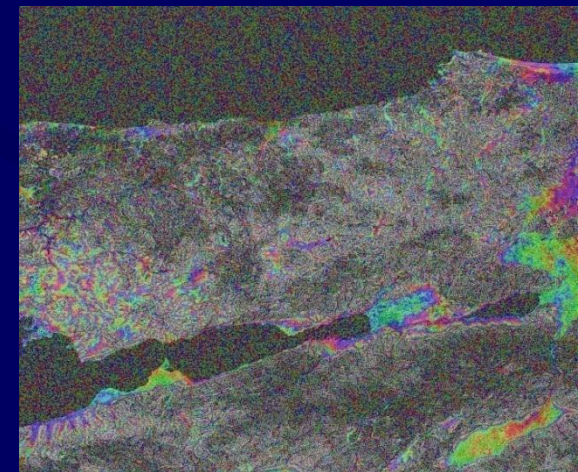


*coherence image*



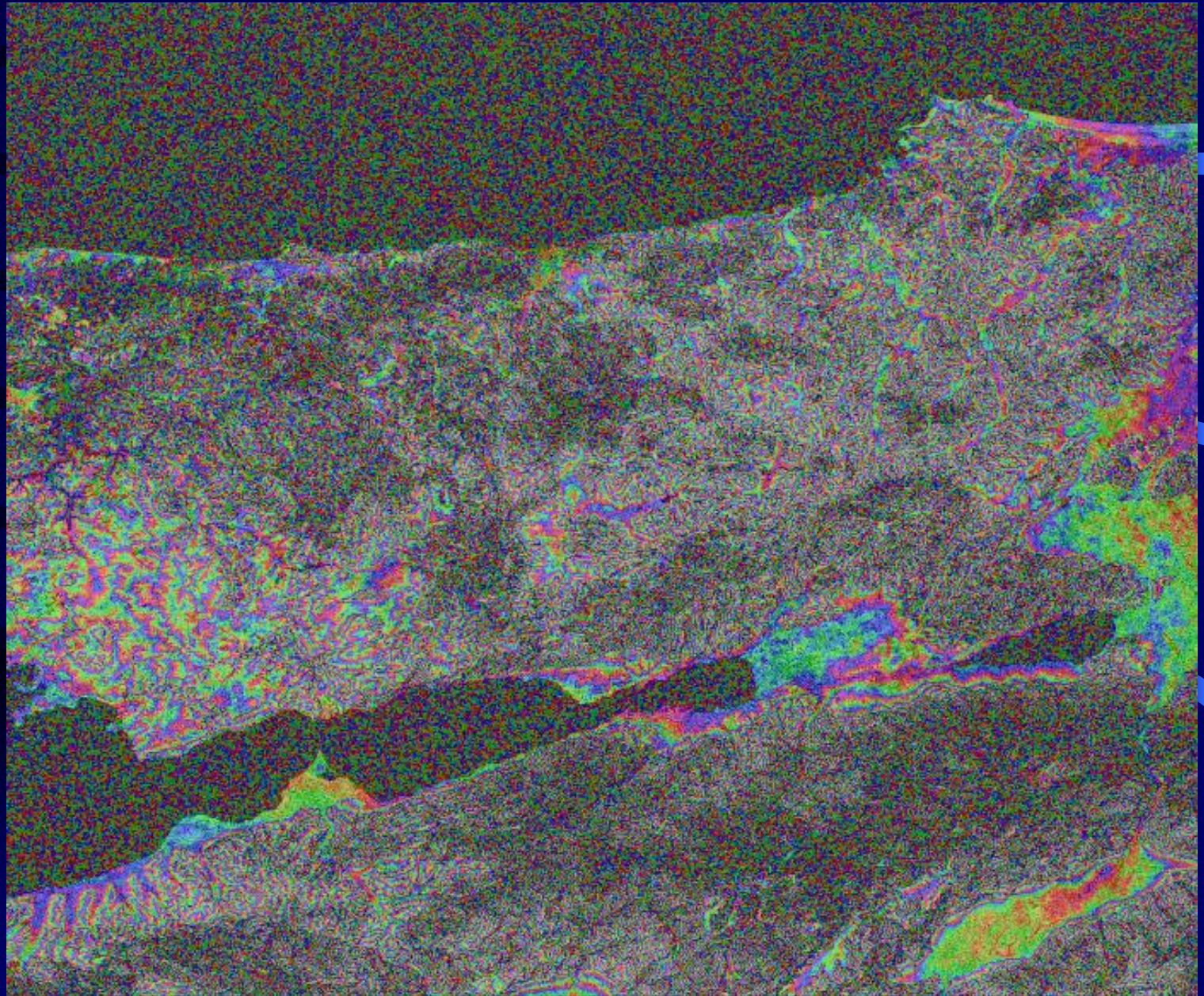
*interferogram*

*phase image overlaid  
on coherence image*



- good interferogram

## *InSAR applications*

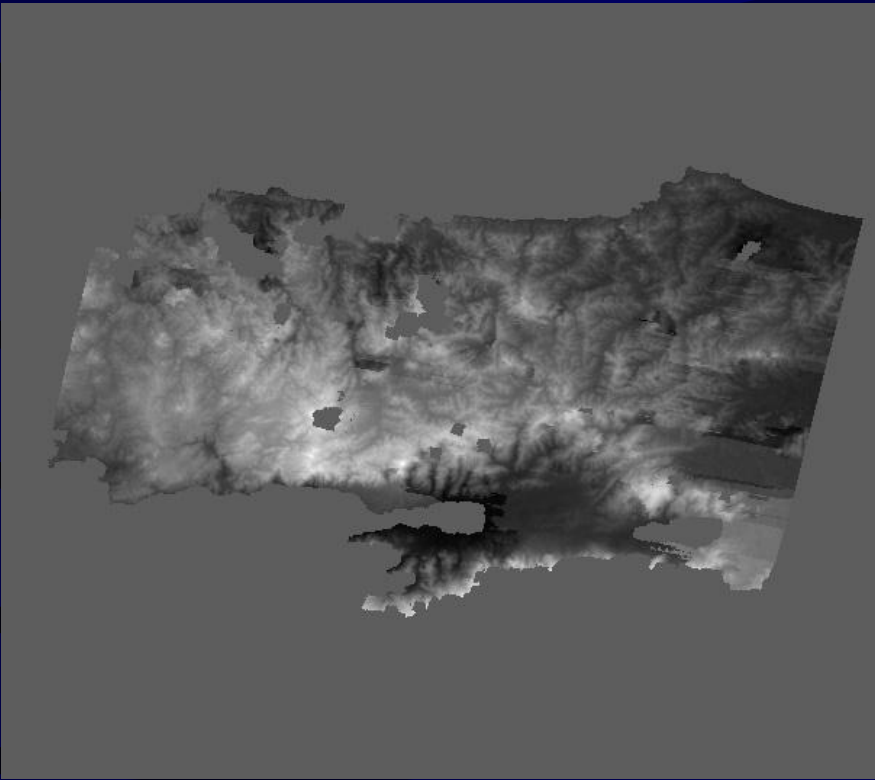


*interferogram*

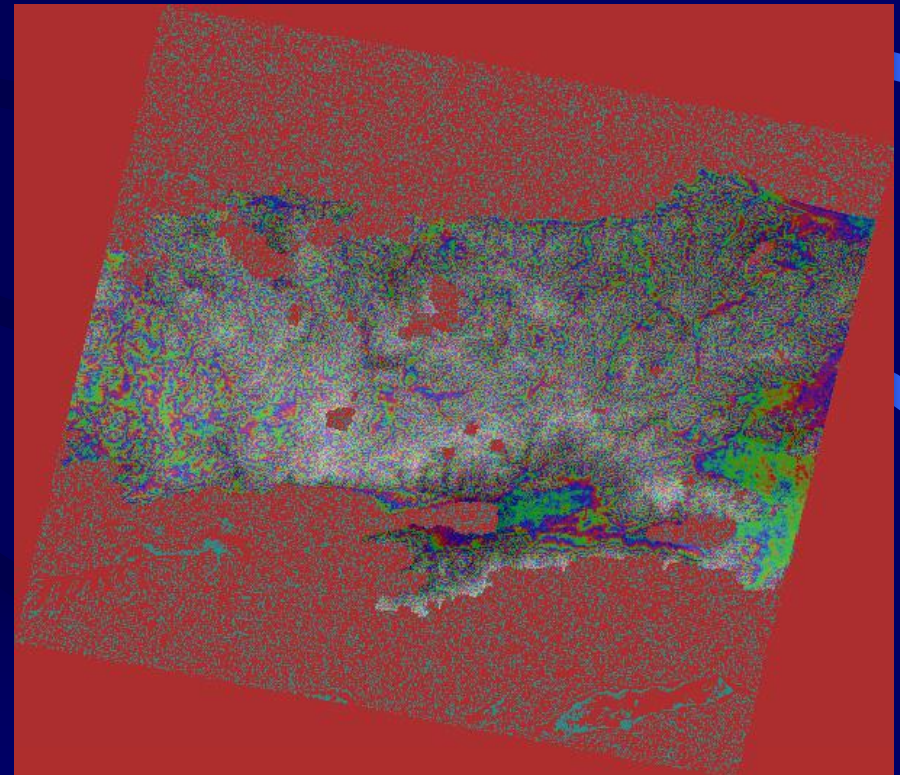
## *InSAR applications*

**Tandem images of:** 10 and 11 Sept. 1999 (23 and 24 days after quake)

- normal baseline: 183.313m
- parallel baseline: 73.239m
- good height image or digital elevation model (DEM)



*height image (DEM)*



*(phase image overlaid on height image (DEM))*

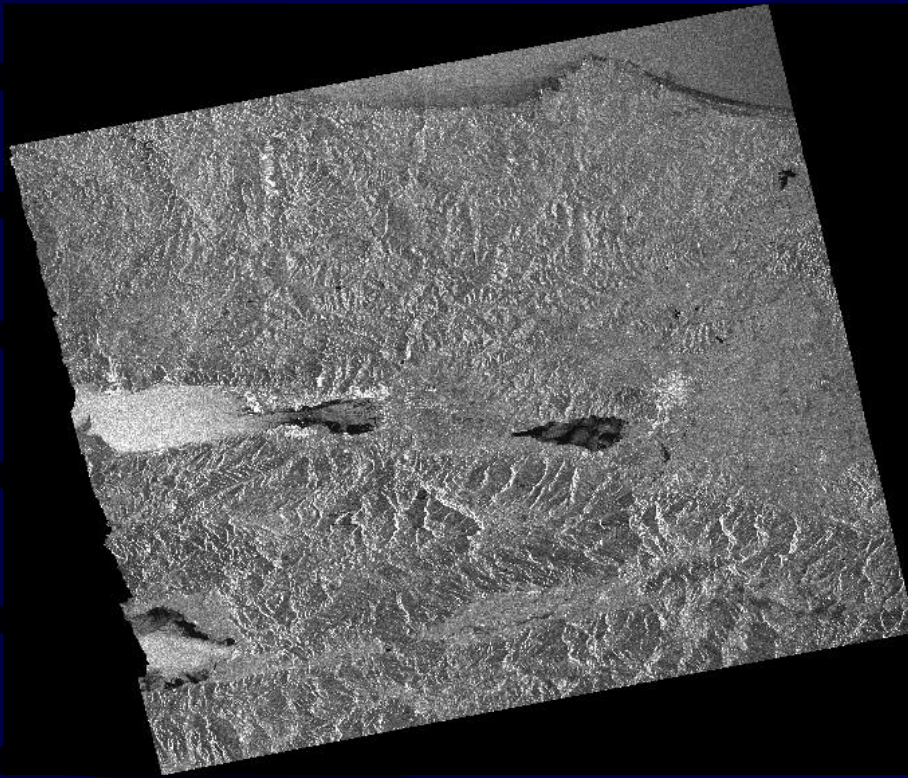
**another pair**

## *InSAR applications*

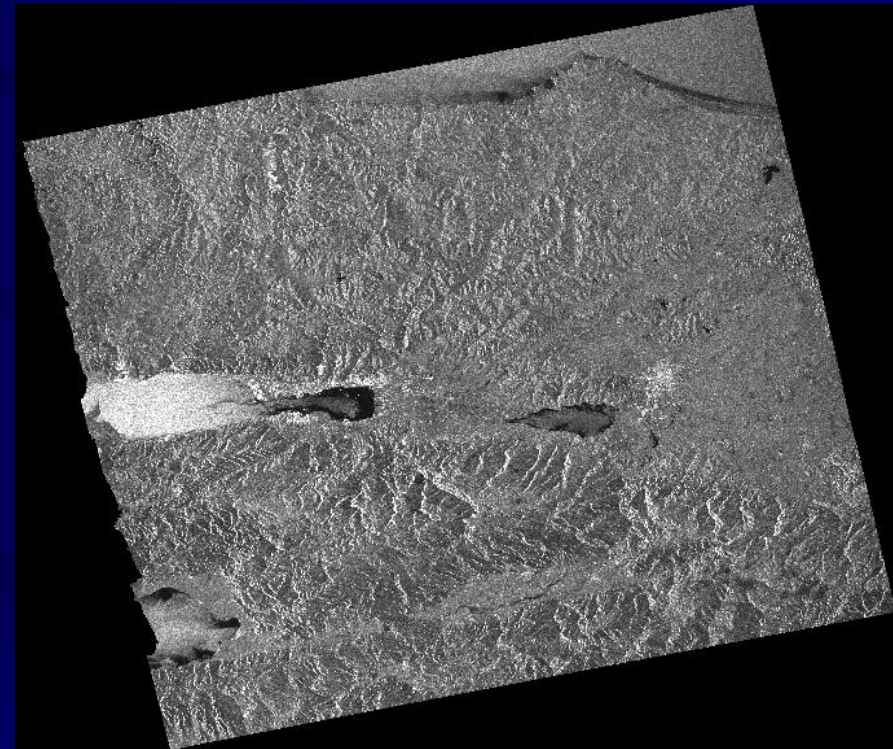
### **Tandem images of:**

16 and 17 Sept. 1999  
(1 month after quake)

- normal baseline: 234.443m
- parallel baseline: 103.386m



*master image*

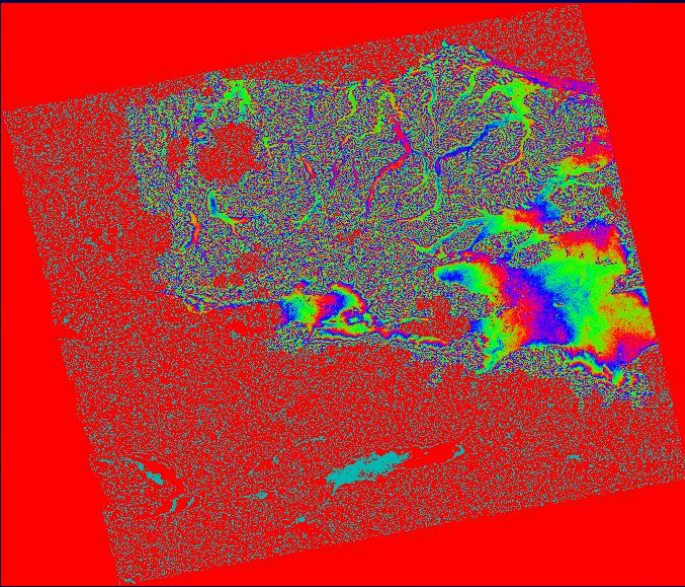


*slave image*

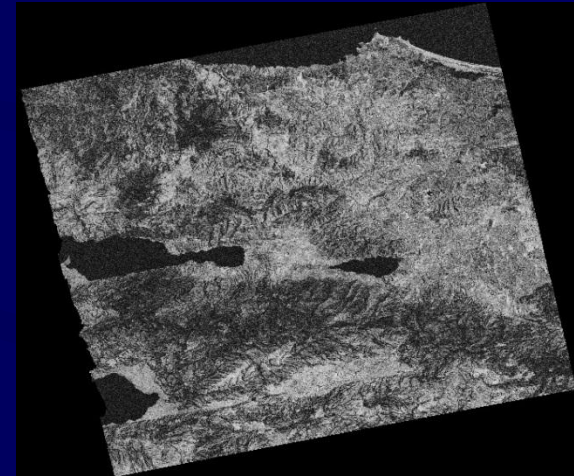
## *InSAR applications*

**Tandem images of:** 16 and 17 Sept. 1999  
(1 month after quake)

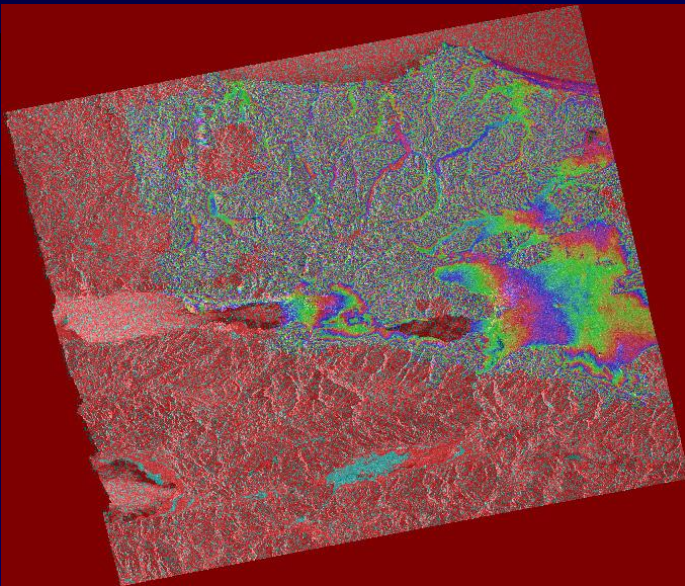
- normal baseline: 234.443m
- parallel baseline: 103.386m
- good coherence



*phase image*

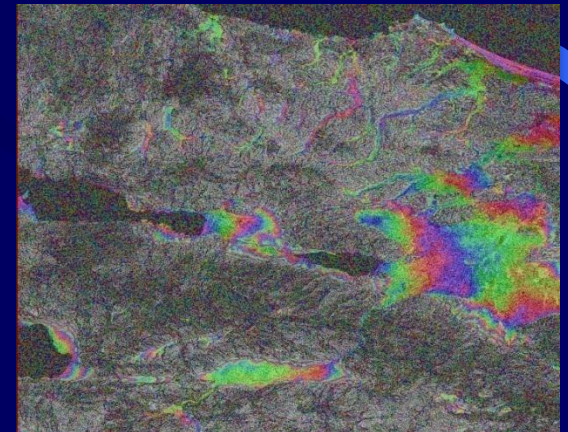


*coherence image*



*interferogram*

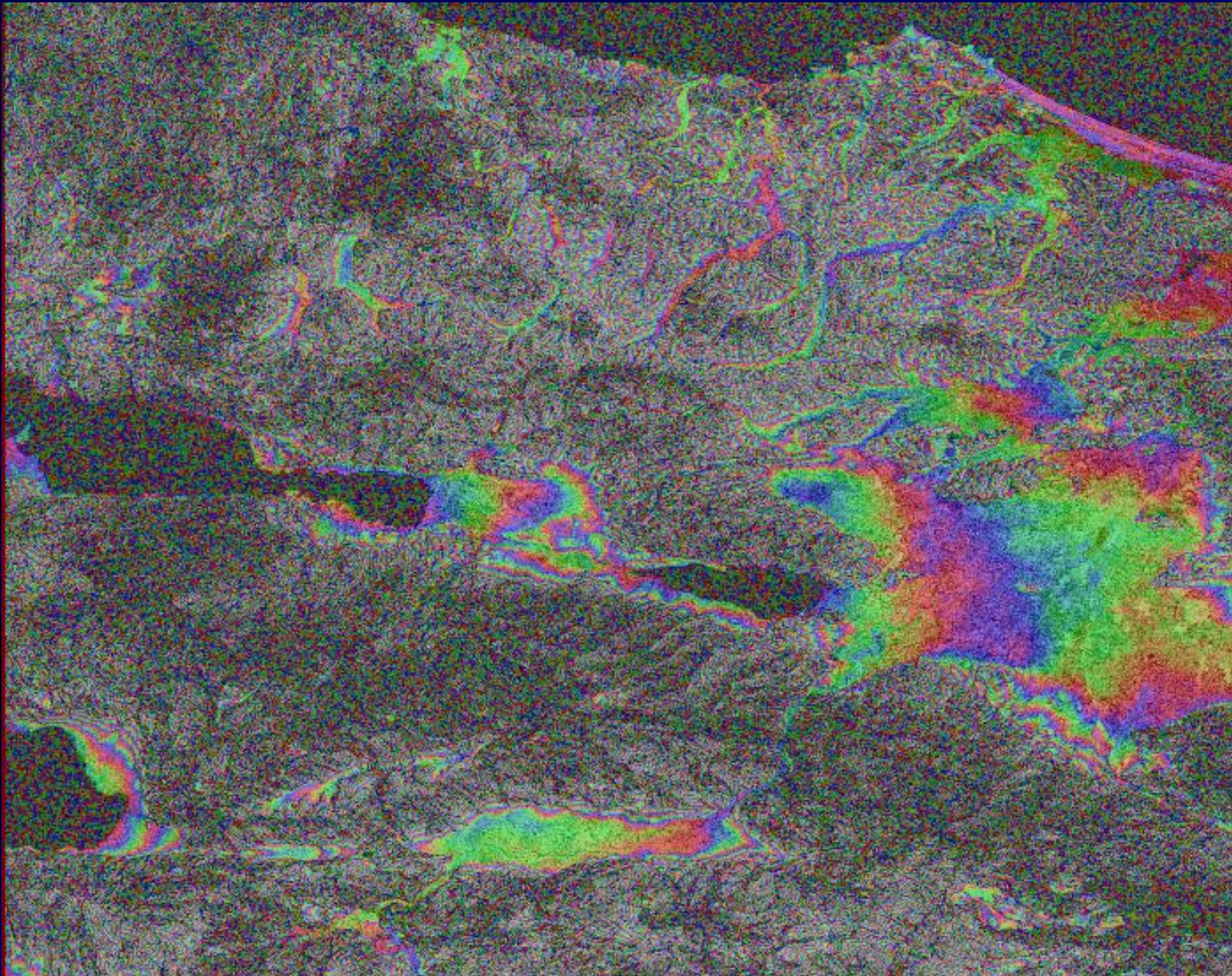
*phase image overlaid  
on coherence image*





- good interferogram

## *InSAR applications*



*interferogram*

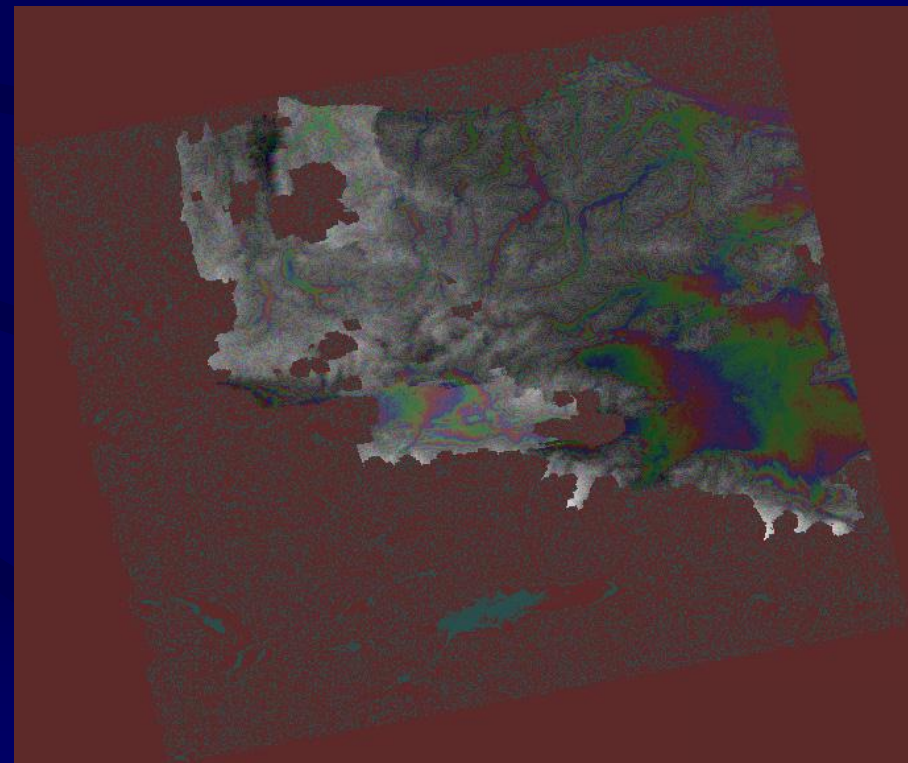
## *InSAR applications*

**Tandem images of:** 16 and 17 Sept. 1999 (1 month after quake)

- normal baseline: 234.443m
- parallel baseline: 103.386m
- good height image or digital elevation model (DEM)

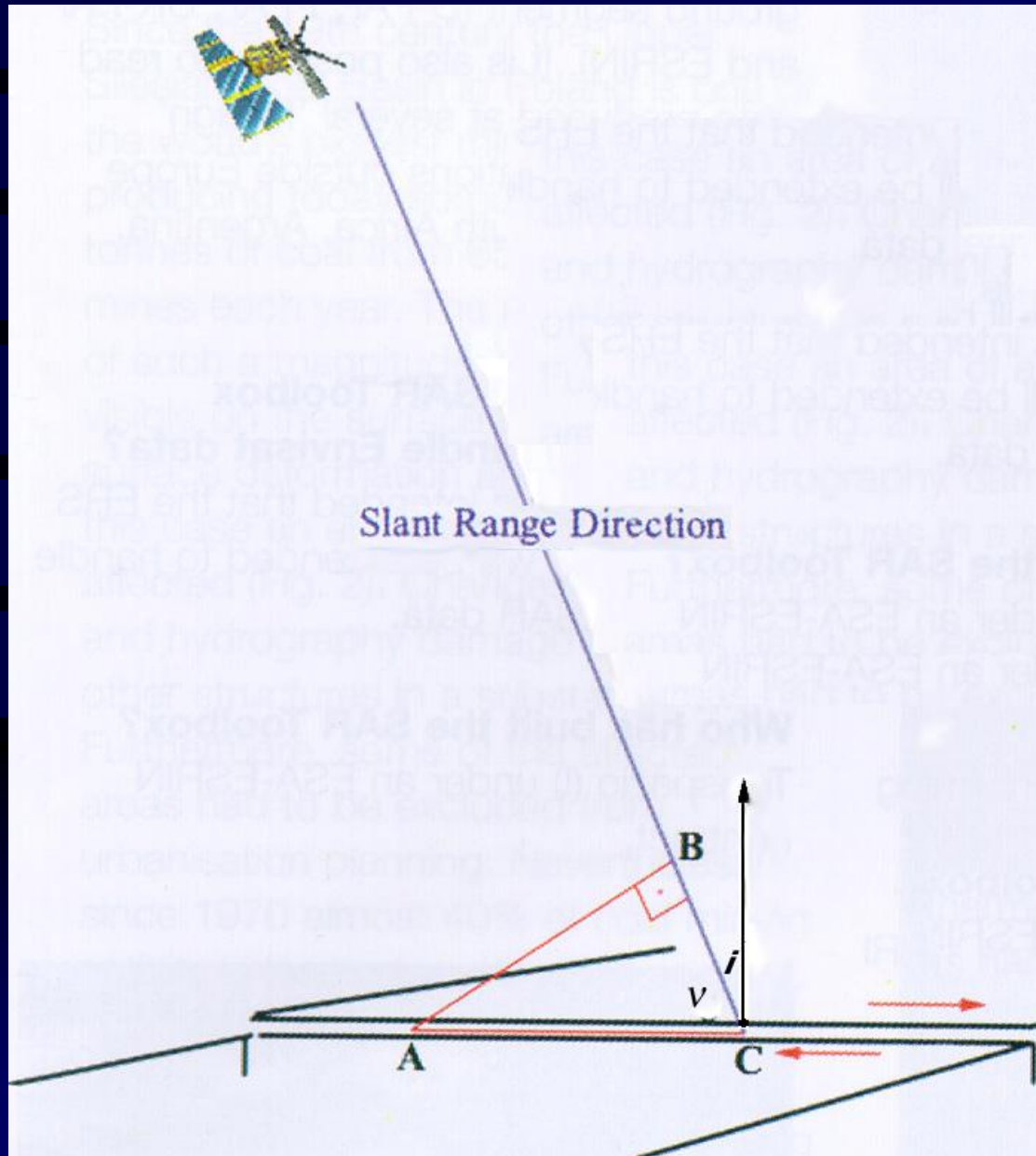
*height image (DEM)*

*(phase image overlaid on height image (DEM))*

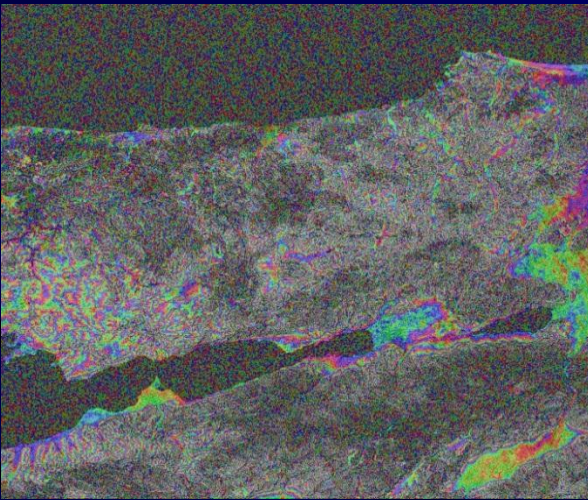


## InSAR applications

Model of the  
surface  
motion in the  
study area

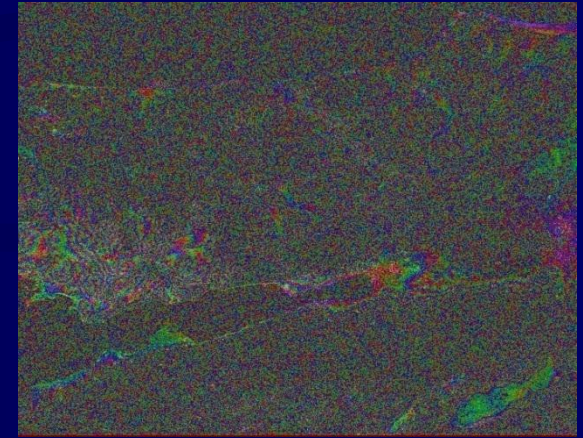


## InSAR applications

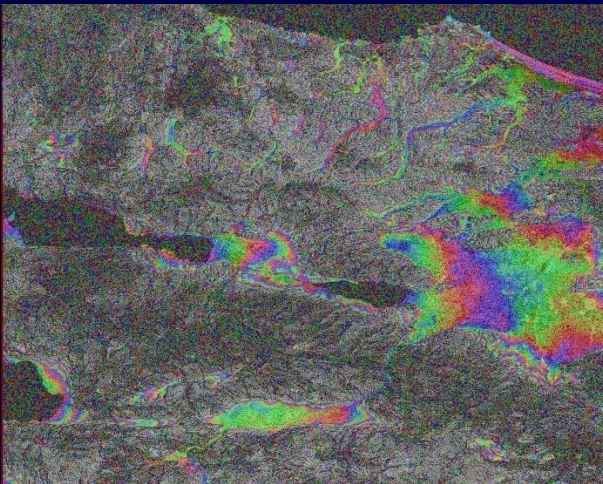


**Tandem images of:** 10 and 11 Sept. 1999  
(23 and 24 days after quake)  
normal baseline: 183.313m  
parallel baseline: 73.239m

**Comparison  
of the image  
pairs of  
before and  
after quake  
(Izmit area)**

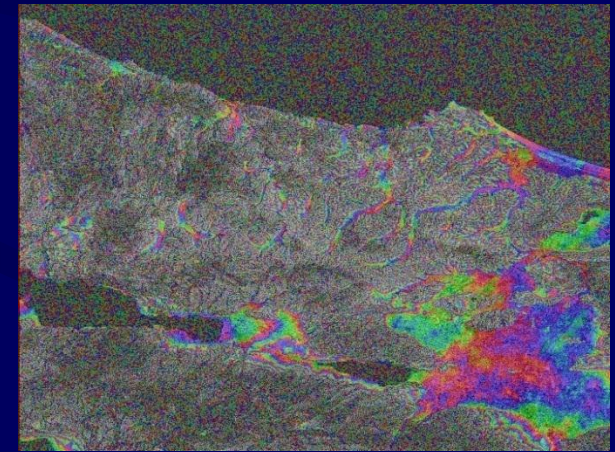


**Images of:** 20 Mar. 1999, and 24 Apr. 1999  
(3 months+23 days and 4 months+24 days before quake)  
normal baseline: 228.264m  
parallel baseline: 27.607m



**Tandem images of:** 16 and 17 Sept. 1999  
(1 month after quake)  
normal baseline: 234.443m  
parallel baseline: 103.386m

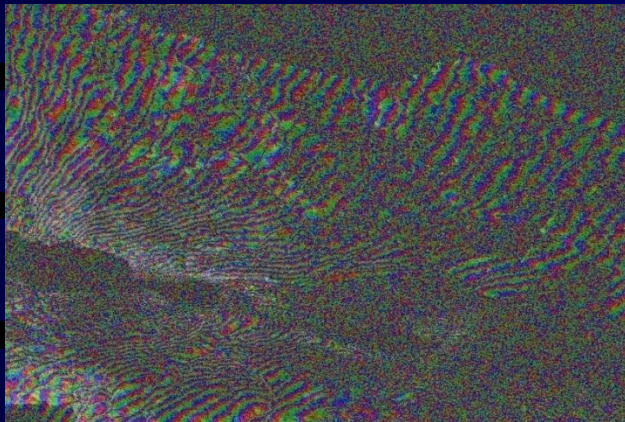
- In all of the cases the anomaly around the place where the quake was occurred is visible apparently.



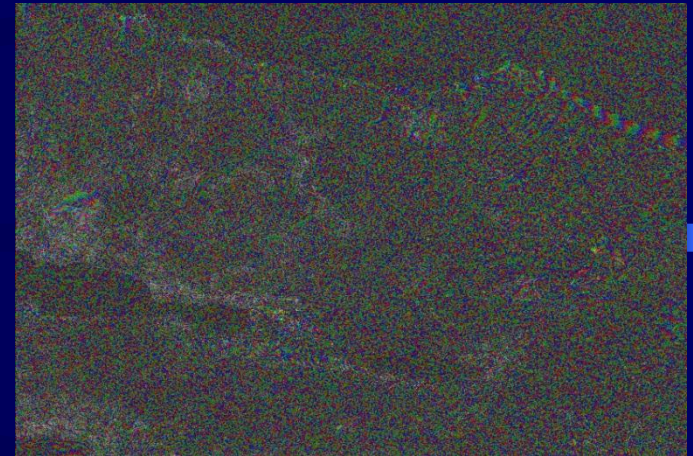
**Tandem images of:** 12 and 13 Aug. 1999  
(4 and 5 days before quake)  
normal baseline: 224.190m  
parallel baseline: 91.097m

## InSAR applications

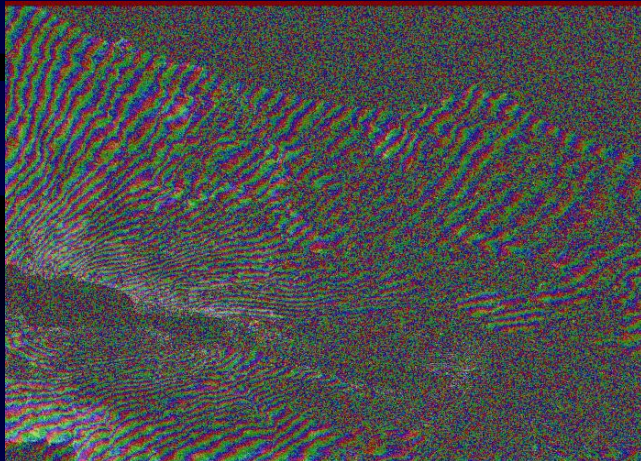
**Comparison of the interferograms of the image pairs of one before and the other after quake (Izmit area)**



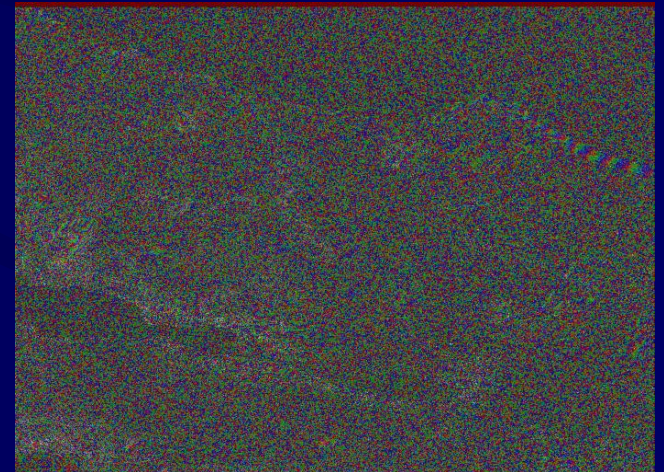
**Image pair of 12 Aug. and 16 Sept. 1999**  
(4 days before and a 29 days after quake)  
normal baseline: 121.640m  
parallel baseline: 67.725m  
fringe number: 40



**Image pair of 12 Aug. and 17 Sept. 1999**  
(4 days before and a month after quake)  
normal baseline: ?  
parallel baseline: ?



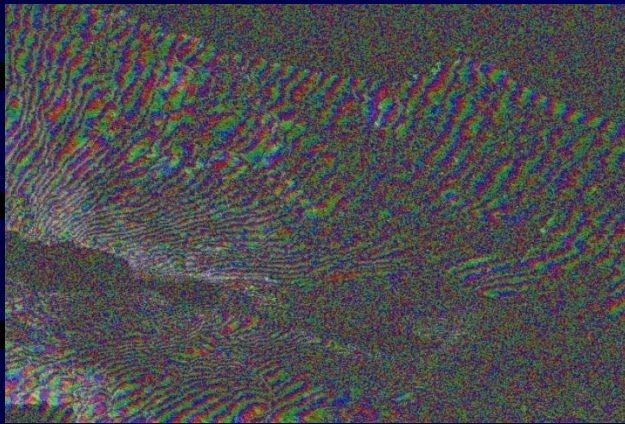
**Image pair of 13 Aug. and 17 Sept. 1999**  
(3 days before and a month after quake)  
normal baseline: 11.401m  
parallel baseline: 53.558m  
fringe number: 43



**Image pair of 13 Aug. and 16 Sept. 1999**  
(3 days before and 29 days after quake)  
normal baseline: 238.318m  
parallel baseline: 154.753m

## InSAR applications

### displacement assessment



**Image pair of** 12 Aug. and 16 Sept. 1999  
(4 days before and a 29 days after quake)  
normal baseline: 121.640m  
parallel baseline: 67.725m  
fringe number: 40

fringe numbers x Half the wavelength

$$40 \times 28\text{mm} = 1120\text{mm} \sim 112\text{cm}$$

slant range displacement = 112cm

slant range displacement / cos 67 =

surface displacement

$$112 / 0.39 = 287.18\text{cm}$$

fringe numbers x Half the wavelength

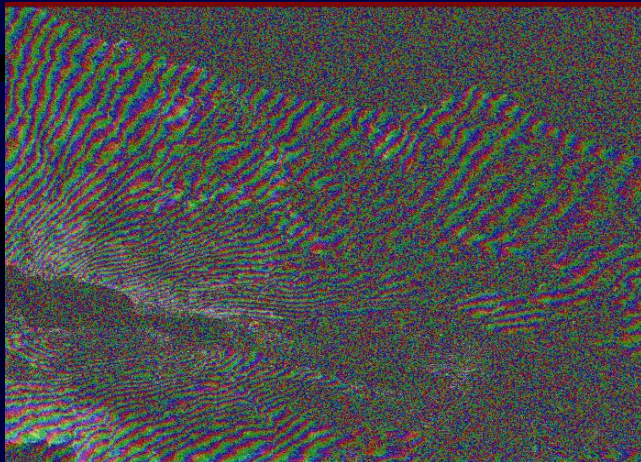
$$43 \times 28\text{mm} = 1204\text{mm} \sim 120.4\text{cm}$$

slant range displacement = 120.4cm

slant range displacement / cos 67 =

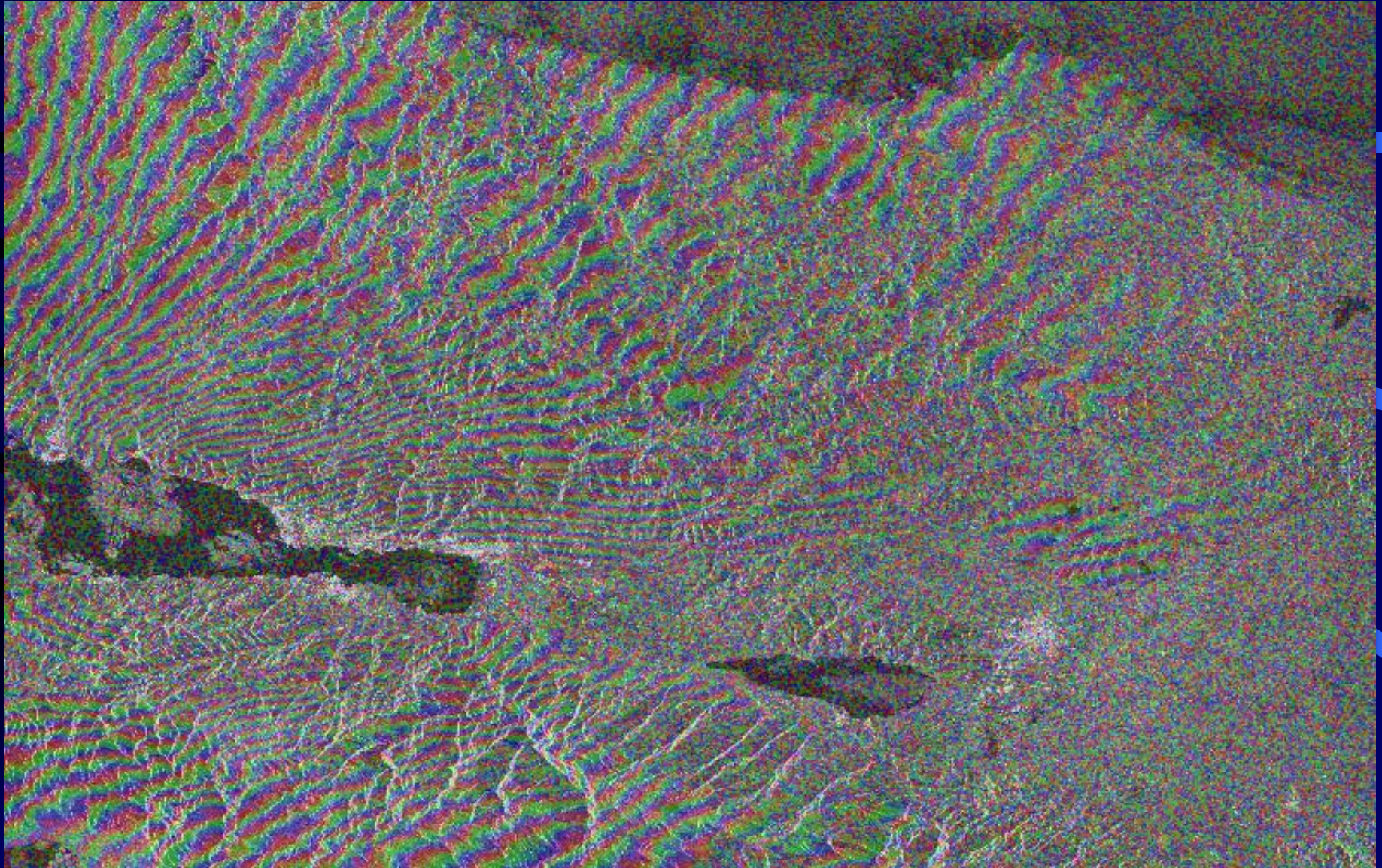
surface displacement

$$120.4 / 0.39 = 308.72\text{cm}$$



**Image pair of** 13 Aug. and 17 Sept. 1999  
(3 days before and a month after quake)  
normal baseline: 11.401m  
parallel baseline: 53.558m  
fringe number: 43

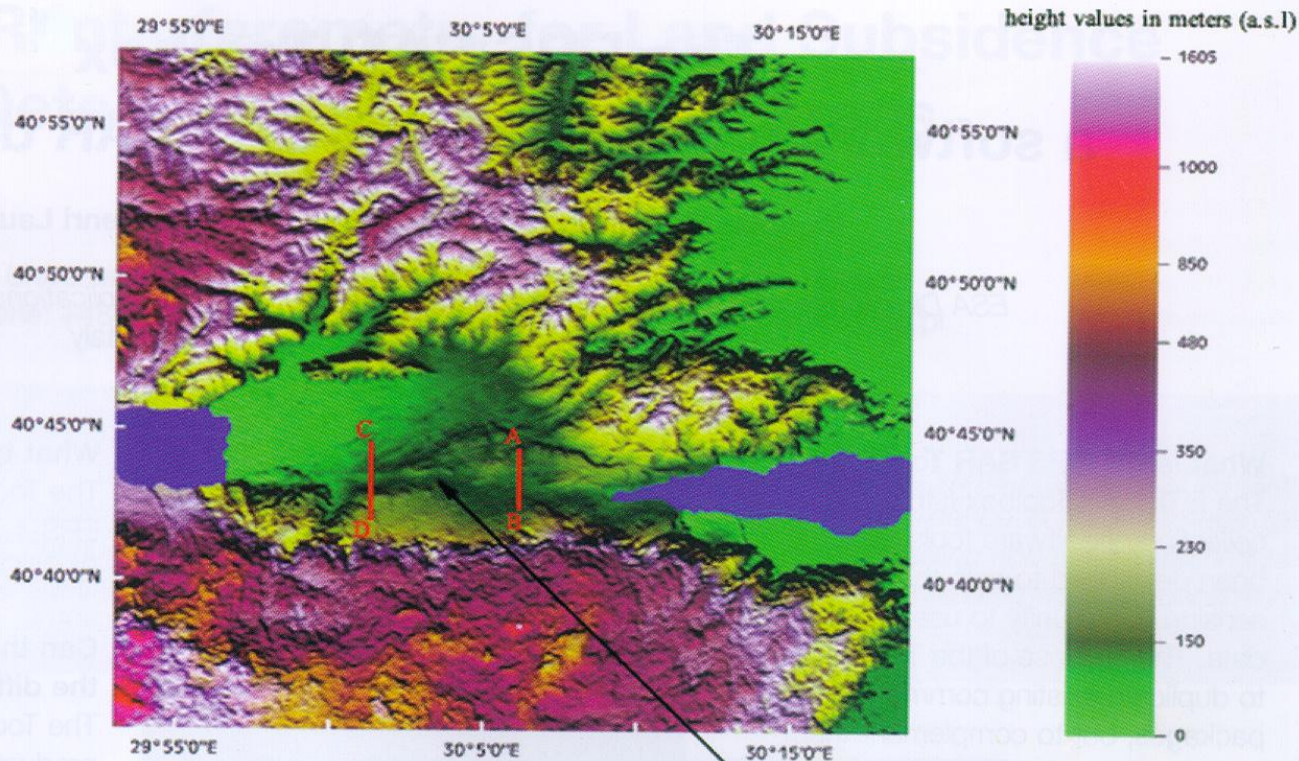
## *InSAR applications*



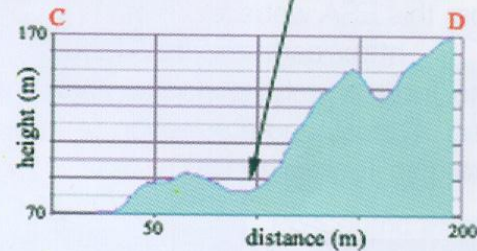
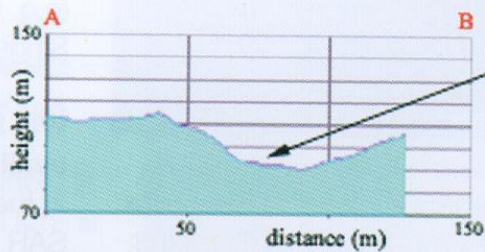
**Differential interferometry  
was used for displacement  
mapping in vertical and  
horizontal directions.**



# InSAR applications

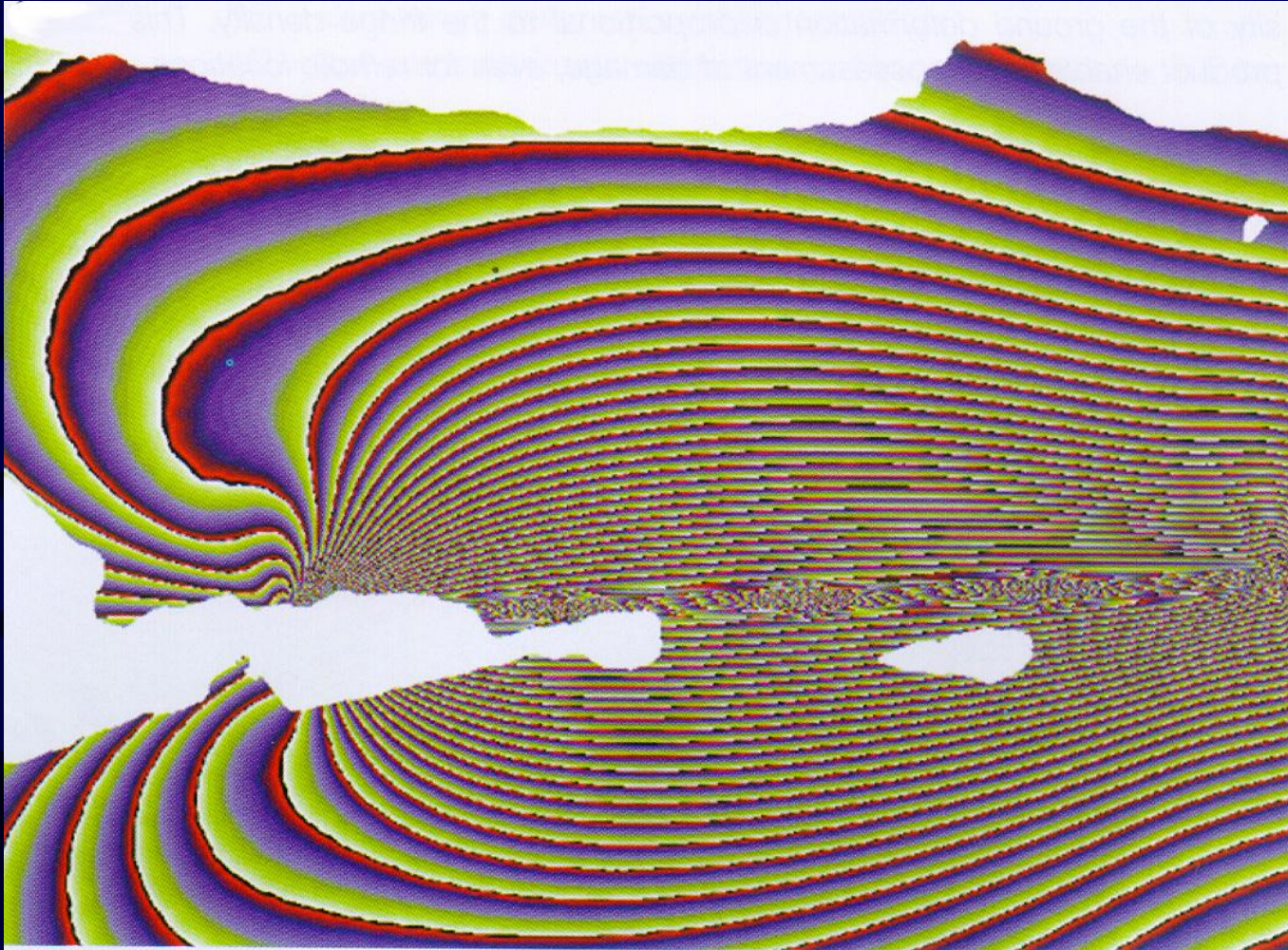


Morphological evidence of fault scarp



topographic sections crossing the fault line

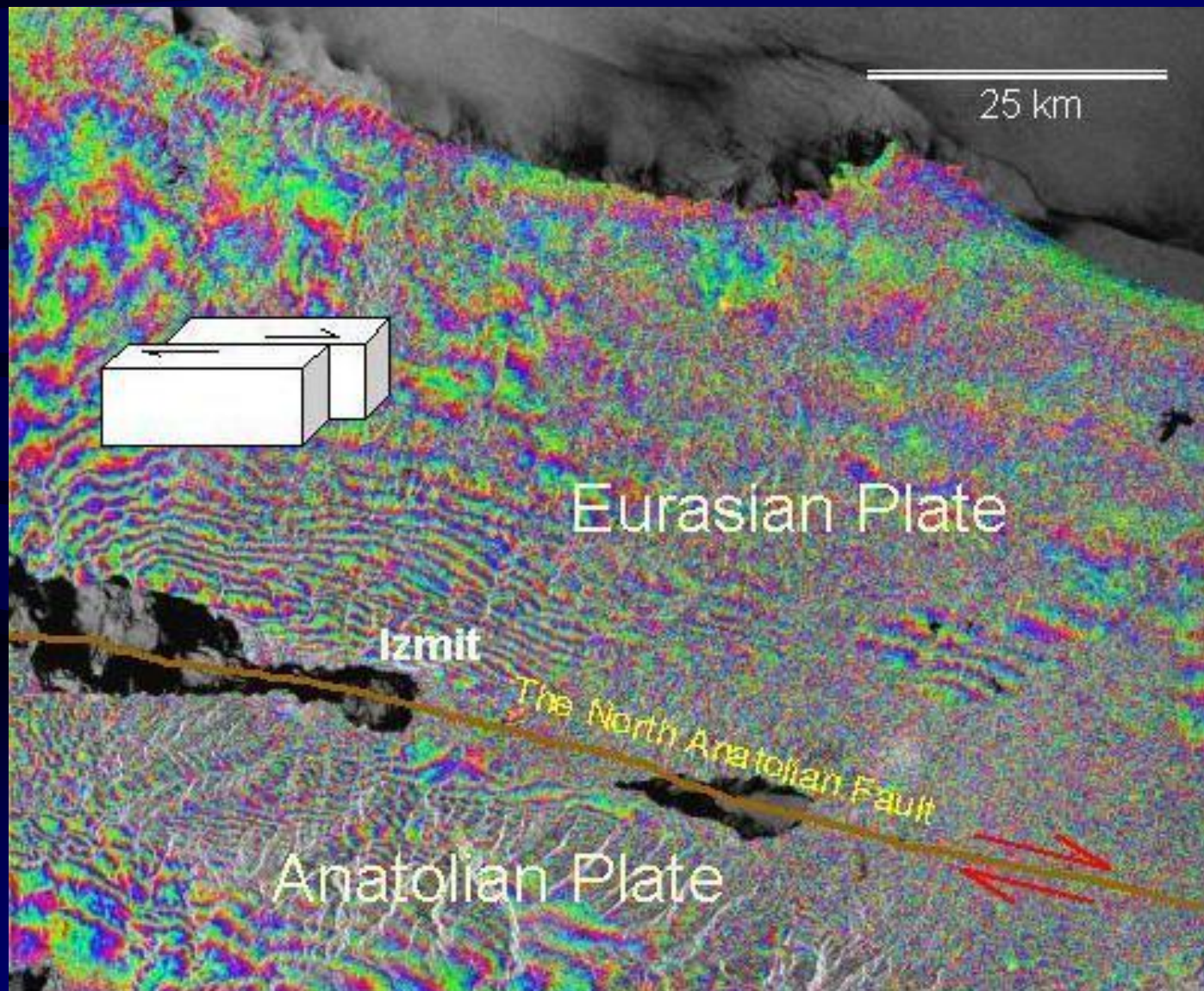
Shaded-relief image that was generated from the ERS SAR interferometric DEM. This image product can be used in studies relating the recognition of tectonic and morphological lineaments.



Deformation model based on field data

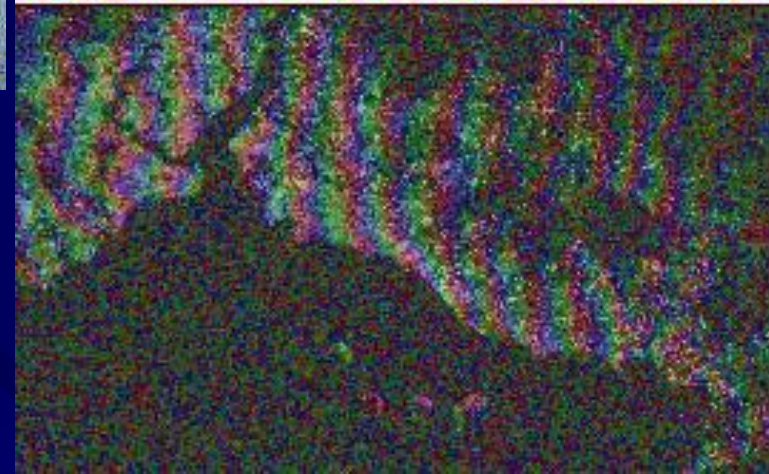
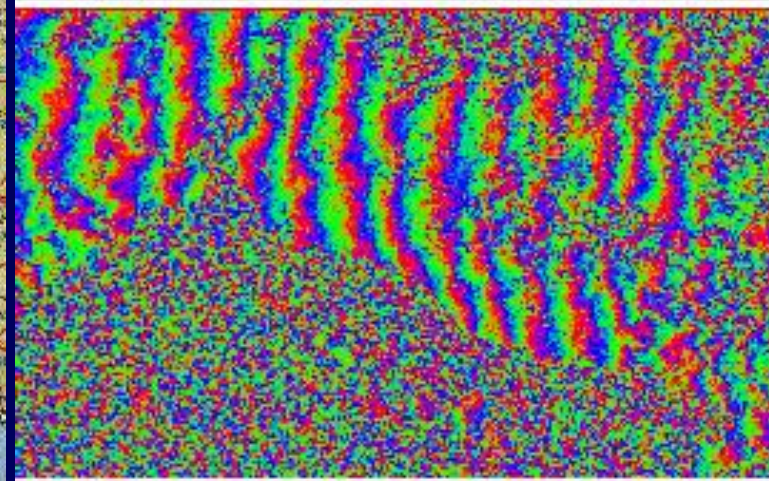
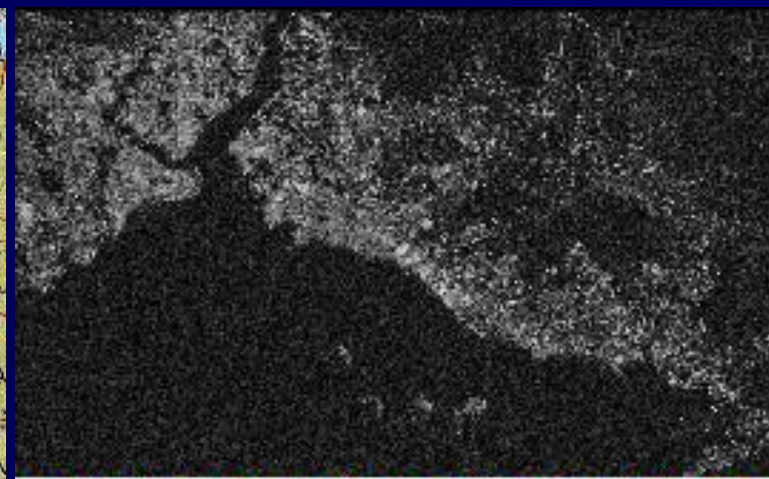
- **high similarity** to the interferograms generated.

# InSAR applications



**New  
Technologies in  
monitoring and  
management of  
calamities and  
dynamic  
changes**

***Bosporus Strait***

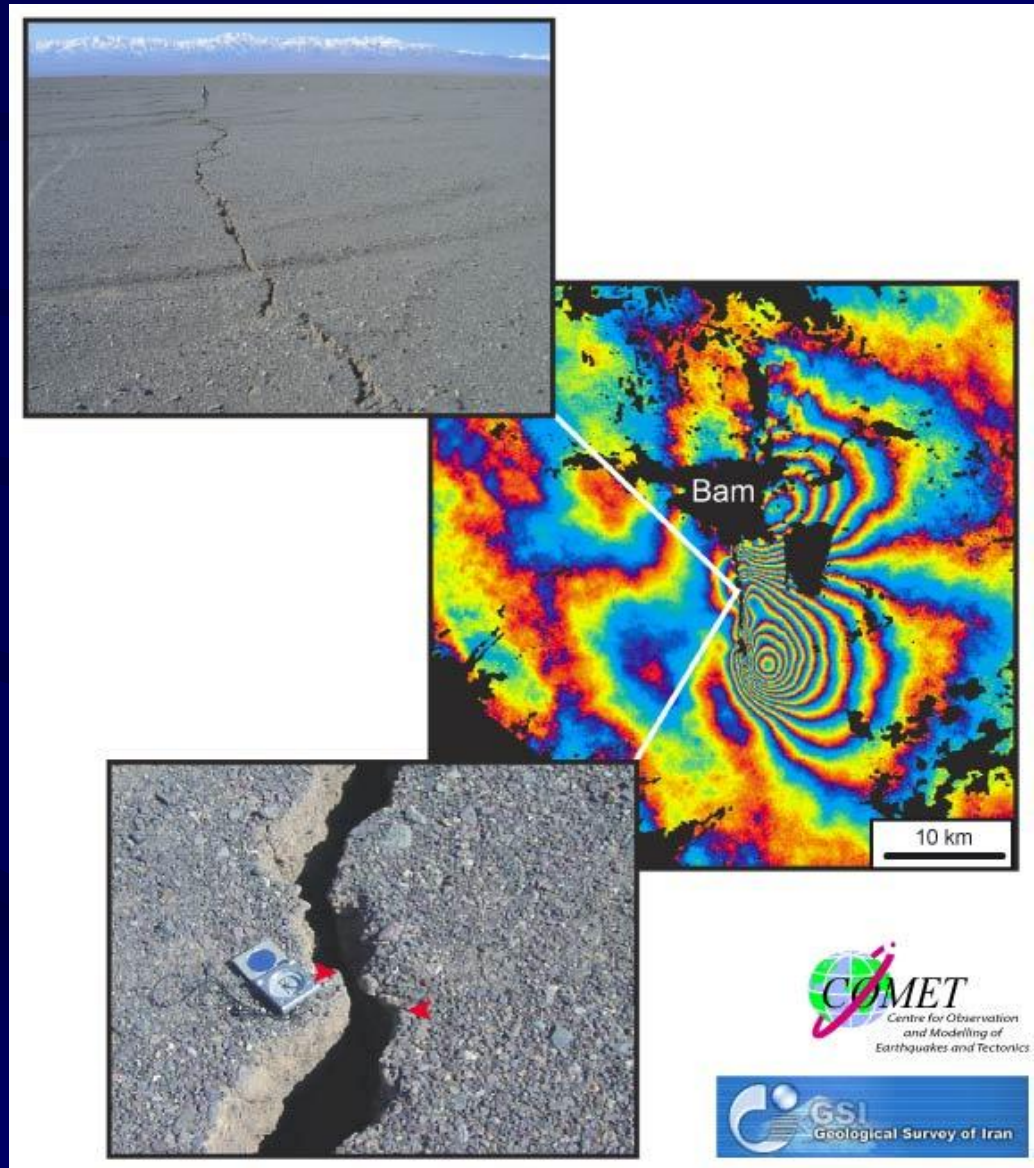


# Bam Quake, 26<sup>th</sup> December 2003

## *InSAR applications*

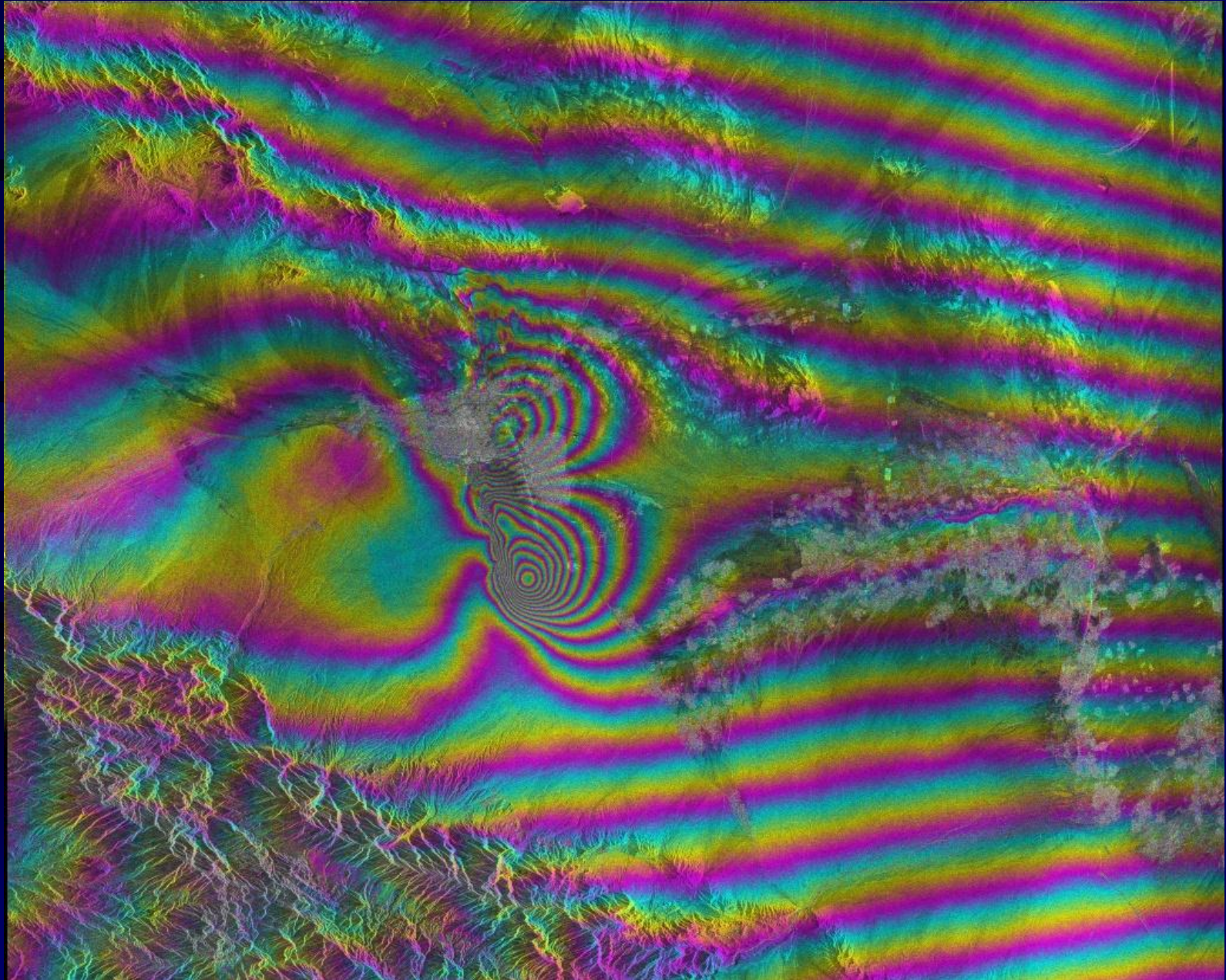


# Bam Quake, 26<sup>th</sup> December 2003



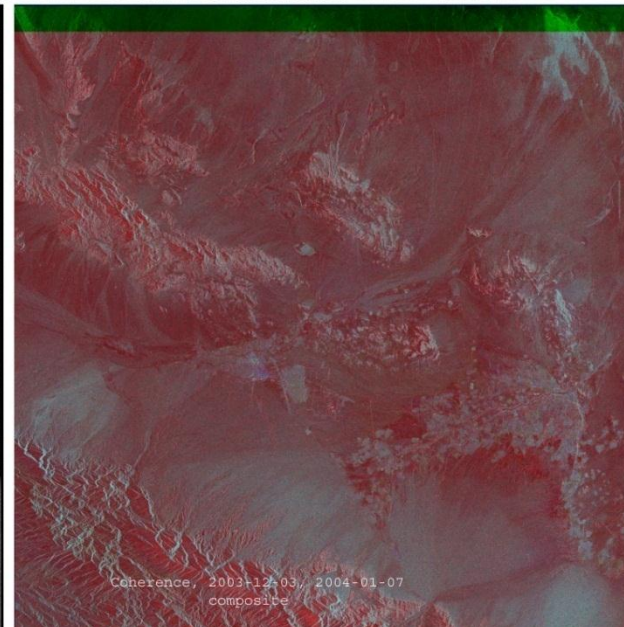
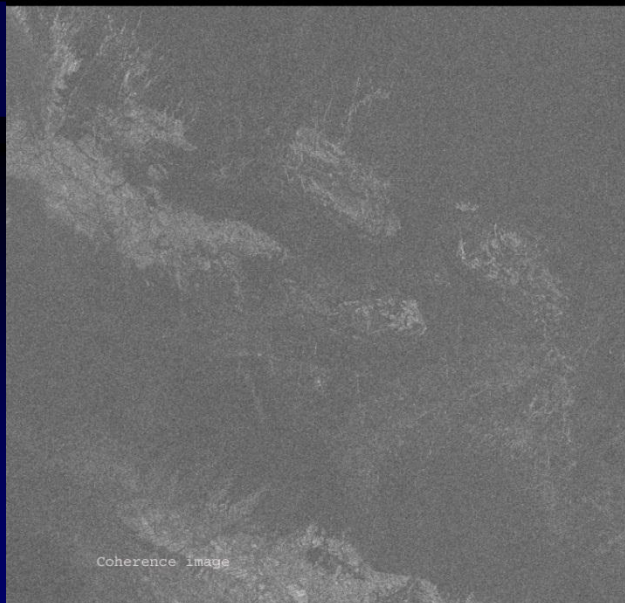
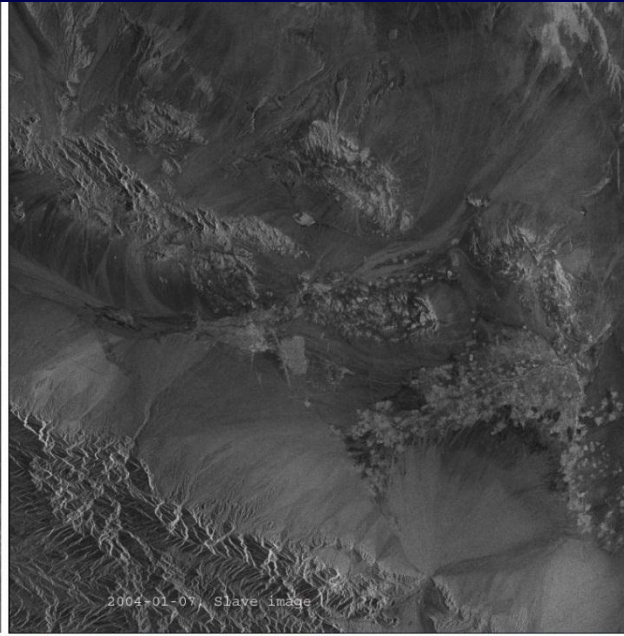
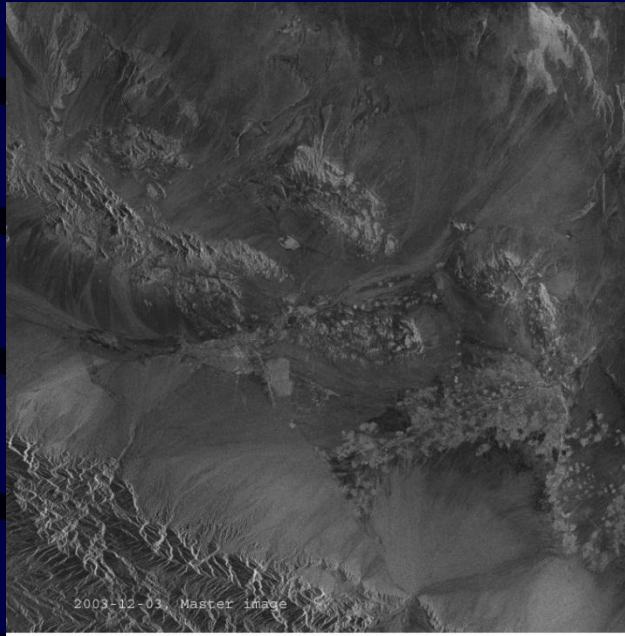
**Bam Quake, 26<sup>th</sup> December 2003**

***InSAR applications***



# Bam Quake, 26<sup>th</sup> December 2003

## InSAR applications



Baseline components:

x= 429.50 m

y= - 386.92 m

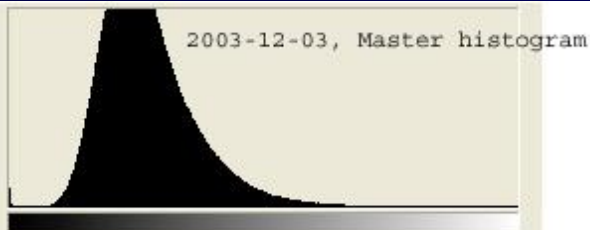
z= 93.67 m

Normal= 519.60 m

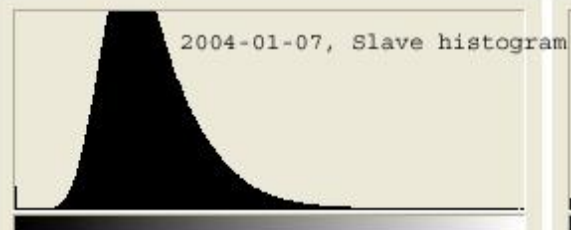
Parallel= 270.13 m

Produced at ISA by  
ESA's Basic Envisat SAR  
Toolbox (BEST)

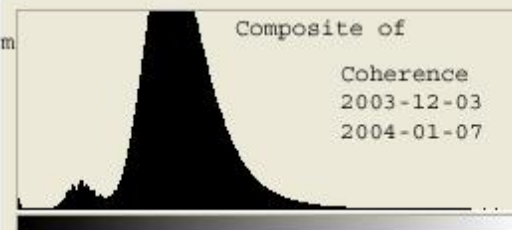




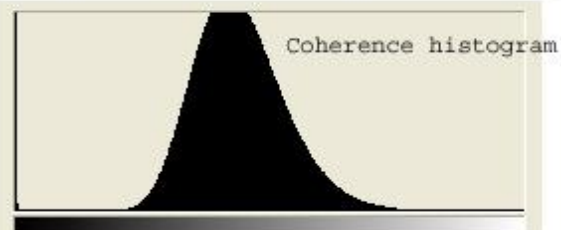
Mean: 69,75                      Level:  
Std Dev: 25,06                    Count:  
Median: 65                        Percentile:  
Pixels: 3214849                  Cache Level: 1



Mean: 68,42                      Level:  
Std Dev: 25,31                    Count:  
Median: 64                        Percentile:  
Pixels: 3139984                  Cache Level: 1



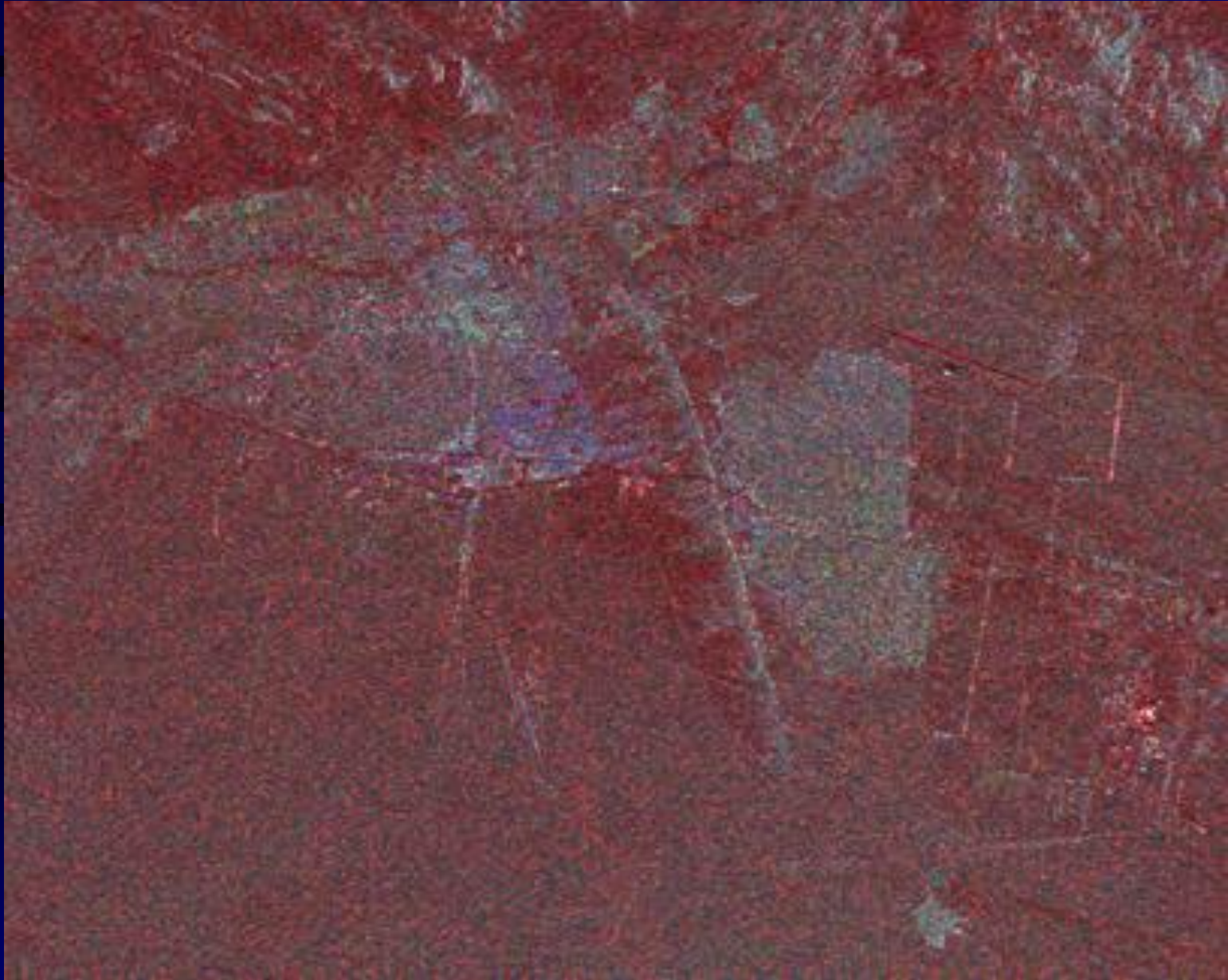
Mean: 81,06                      Level:  
Std Dev: 22,09                    Count:  
Median: 79                        Percentile:  
Pixels: 3214849                  Cache Level: 1



Mean: 107,43                    Level: 184  
Std Dev: 33,05                    Count: 1305  
Median: 109                        Percentile: 99,48  
Pixels: 3214849                  Cache Level: 1

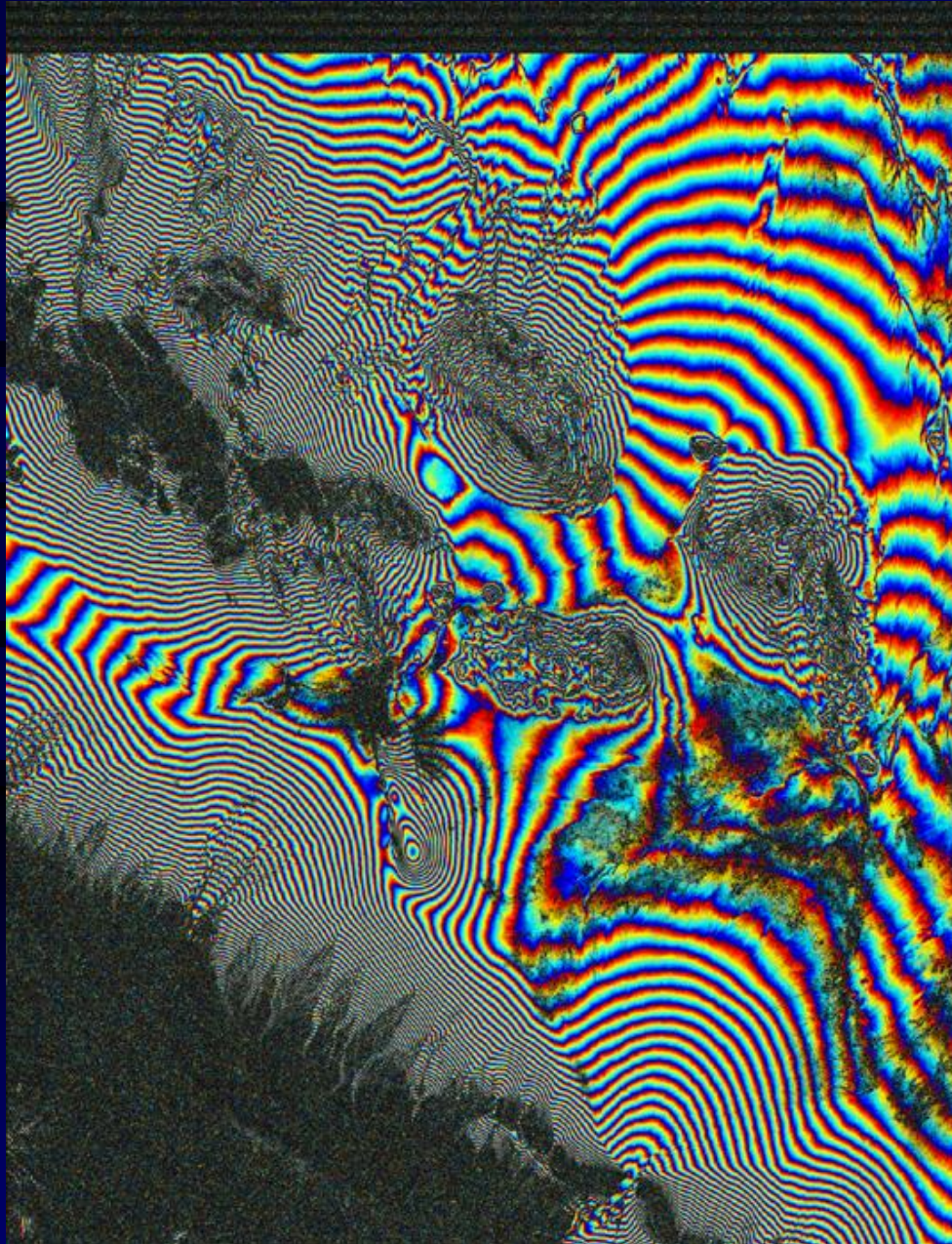
Bam Quake, 26<sup>th</sup> December 2003

*InSAR applications*



# Bam Quake, 26<sup>th</sup> December 2003

## *InSAR applications*



Coherence-DInSAR composite  
of the image pairs of  
3 Dec. 2003 and 7 Jan. 2004

Virtual baseline: 587.2 m  
Vertical baseline: 522.5 m  
Parallel baseline: 267.9 m

Produced at ISA by the InSAR  
Deformation Inspection and  
Observation Tool (IDIOT)

***- Disasters happen frequently and continuously, but they are not as bad as they might have been.***

***- The challenge is to learn from such experiences so that the next time, even fewer people die and causalities and losses reduce as much as possible.***

# Thank you!

**KNOWLEDGE SHOULD BE SHARED,  
OTHERWISE IT IS USELESS.**

*ISNET can play a key role!*