New Technologies
in monitoring and management of

calamities and dynamic changes
"domestic experiences of a global concern"

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- Rapid and dynamic changes in technologies in recent decades

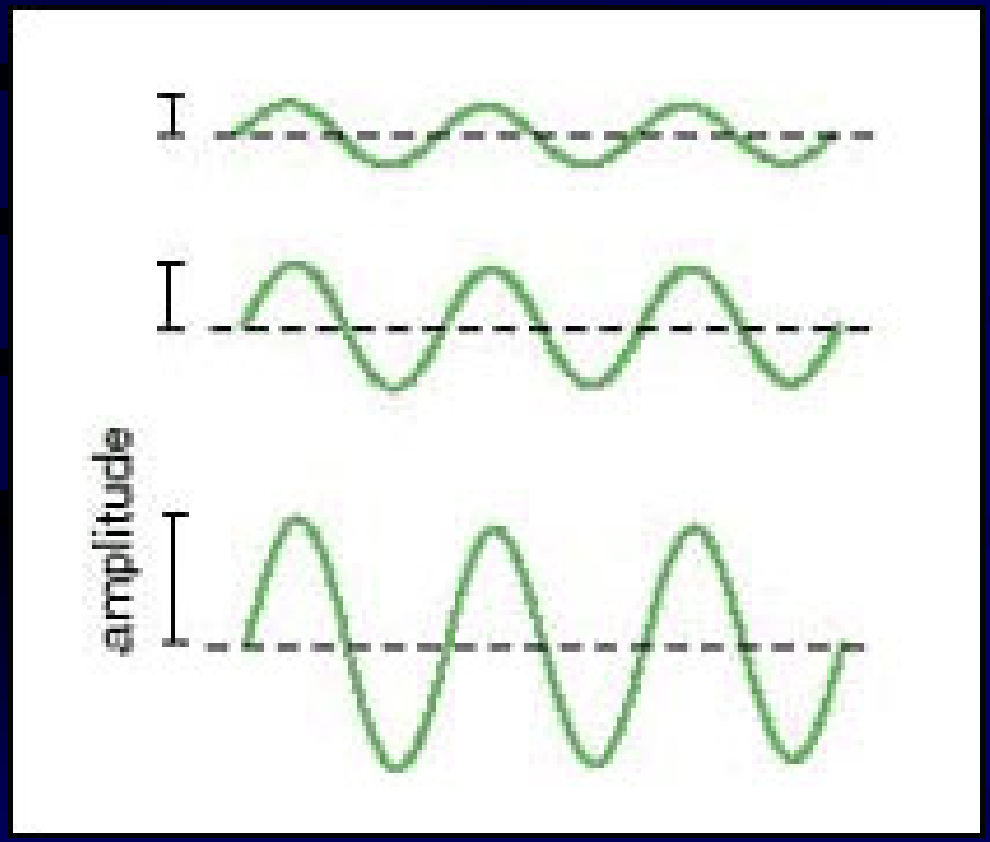
- Space technologies and exploration is avant-garde

- Sensing phenomena from long distance and detecting them are of great importance and effect.

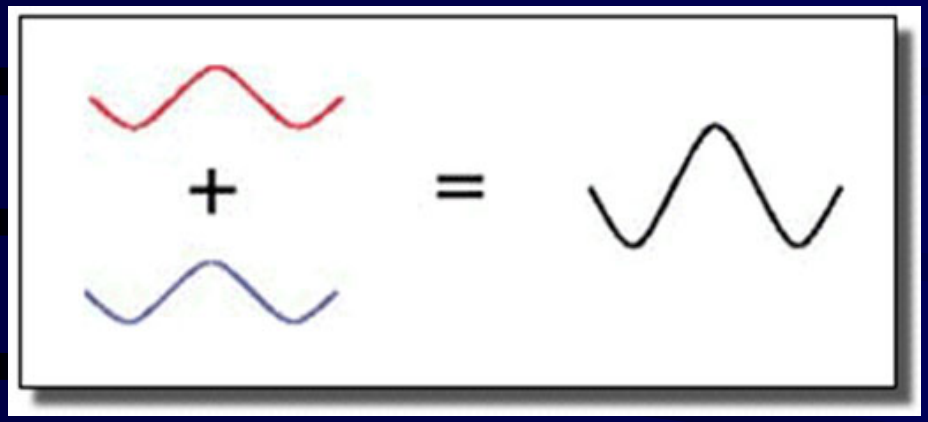
- Electromagnetic waves the tool for

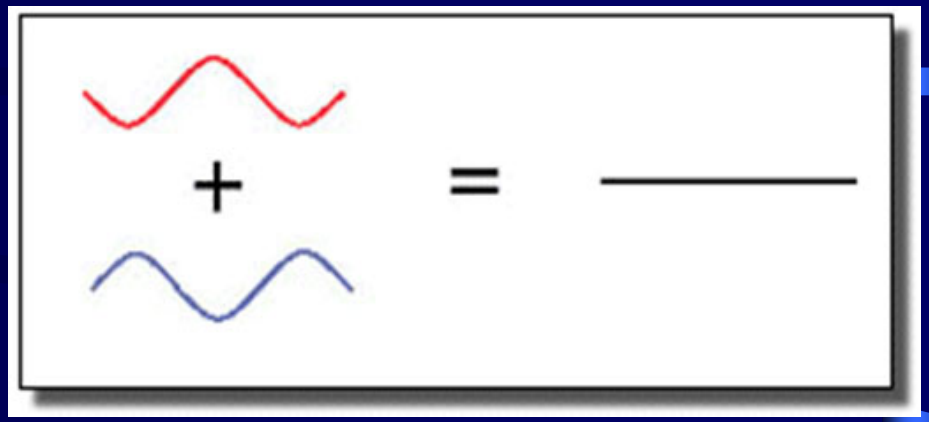
long range sensing of the phenomena

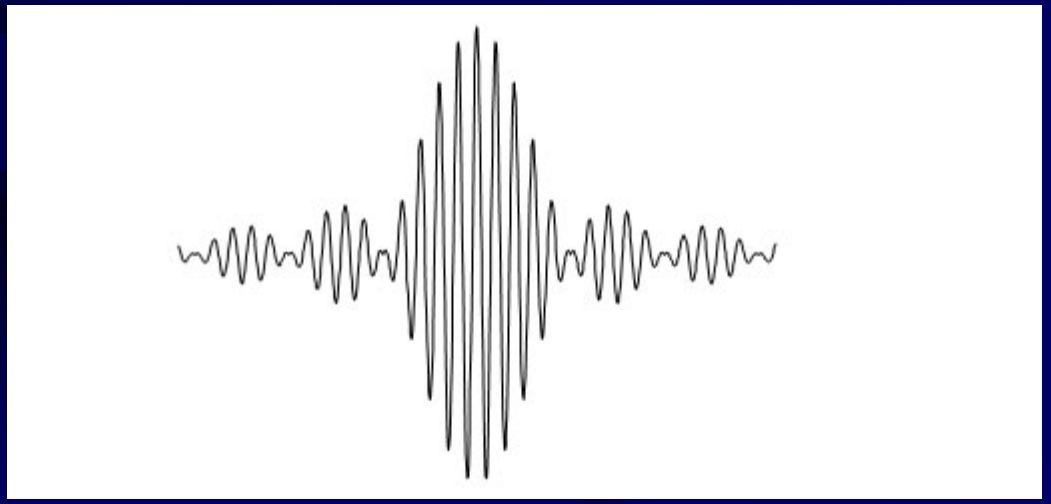
wave propagation



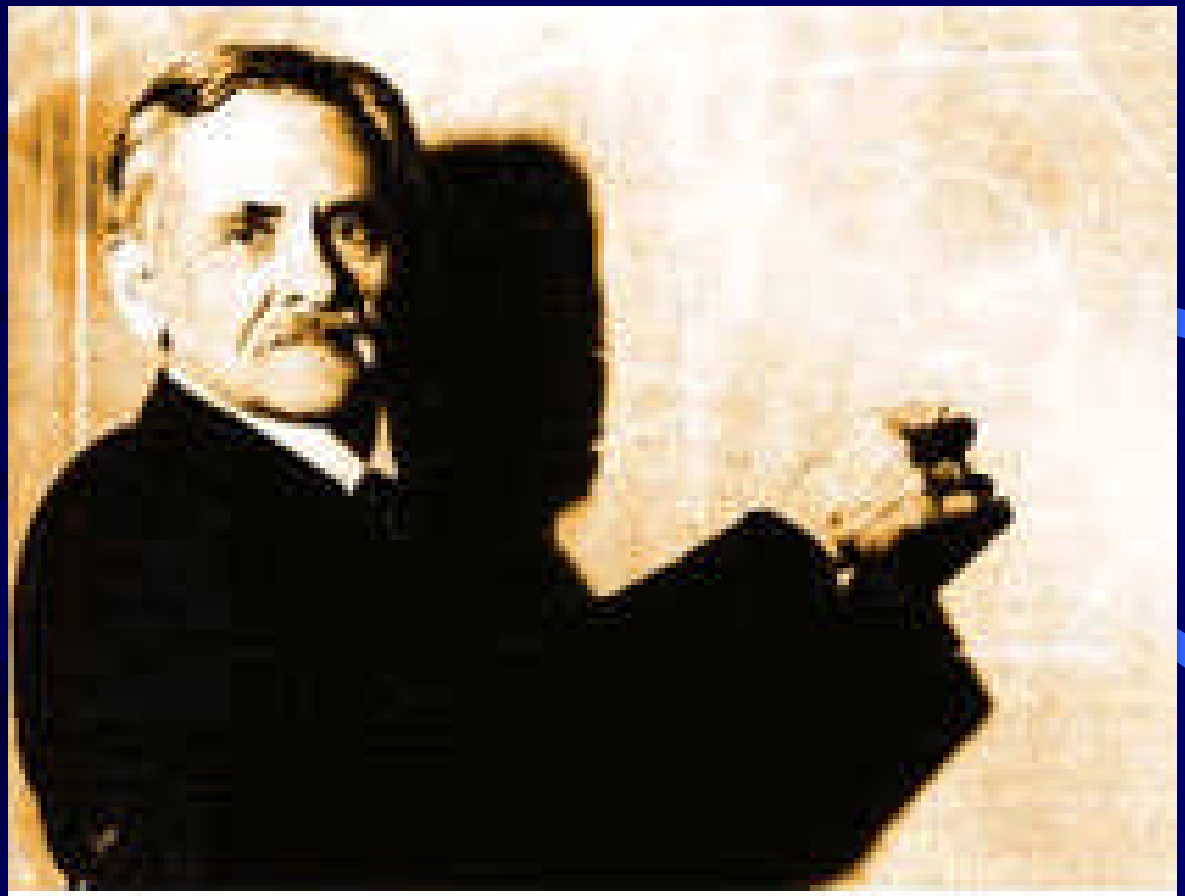
wave propagation principles





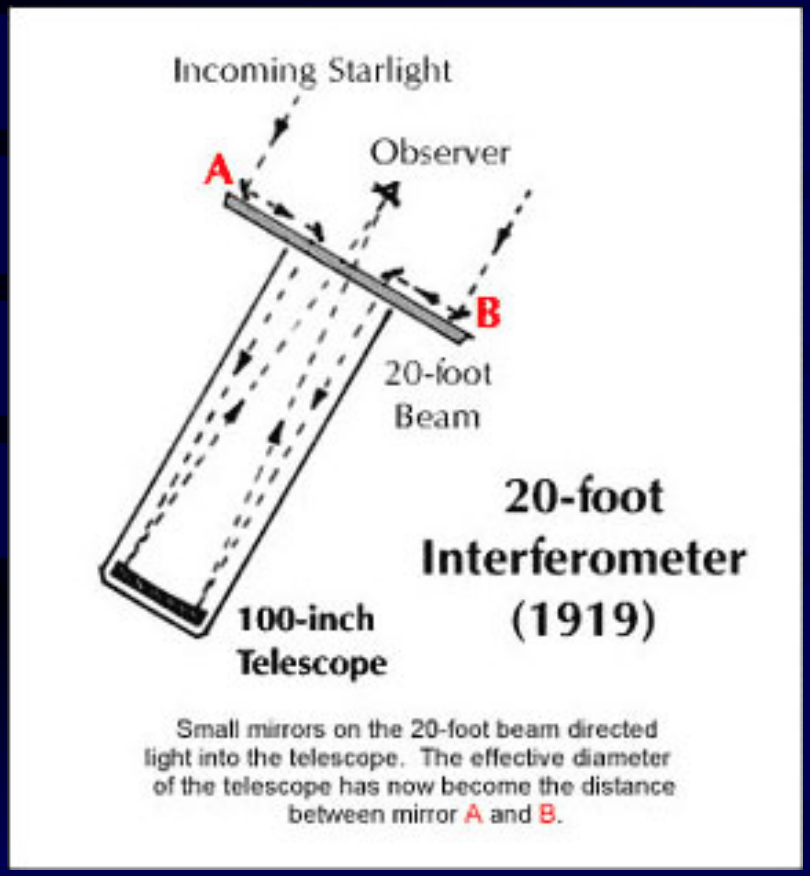


Albert Michelson, born in 1852, Prussia
-the pioneer of interferometry
-in 1882 he used
his interferometer
to measure the
speed of light.



Albert Michelson

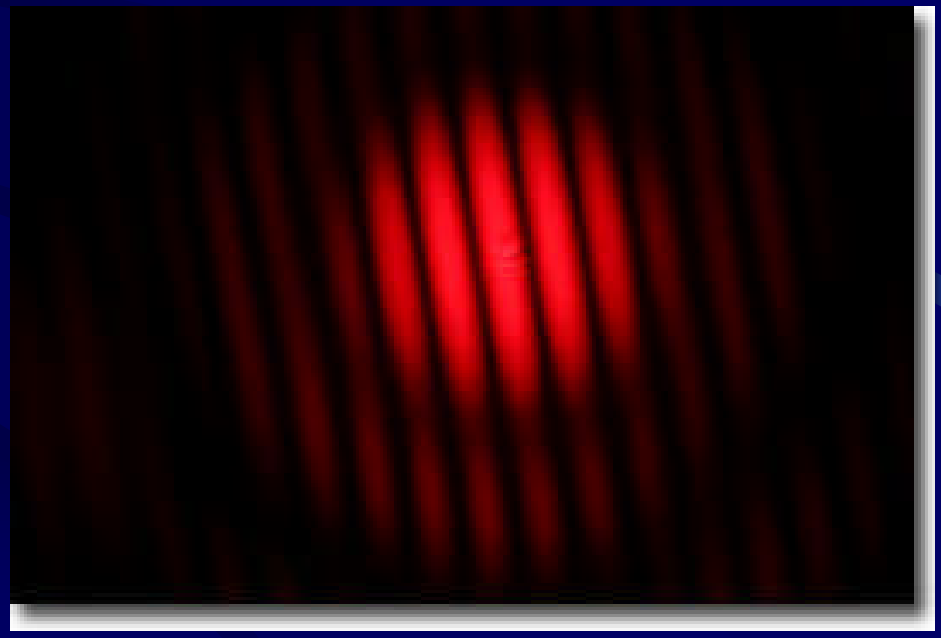
Primary Interferometers;
- in 1919 Michelson developed his 100-inch telescope to measure the diameter of remote stars.



Small mirrors on the 20-foot beam directed light into the telescope. The effective diameter of the telescope has now become the distance between mirror A and B.

The 20-foot beam on top of the 100-inch Hooker Telescope on Mt. Wilson in Southern California.

Generating light firings by interferometry



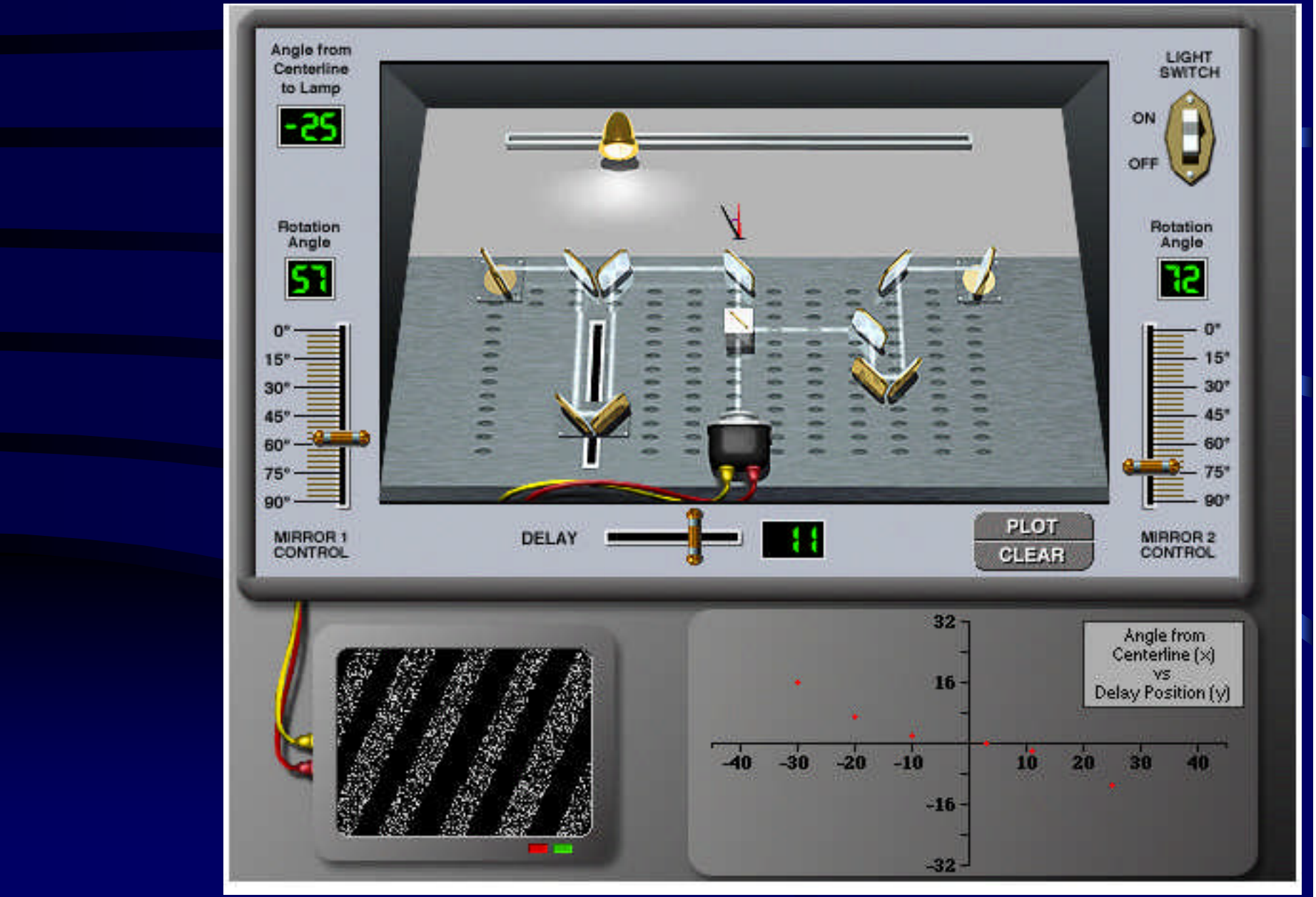
Interferometry

http://planetquest.jpl.nasa.gov/SIM/Demo/simford7.html

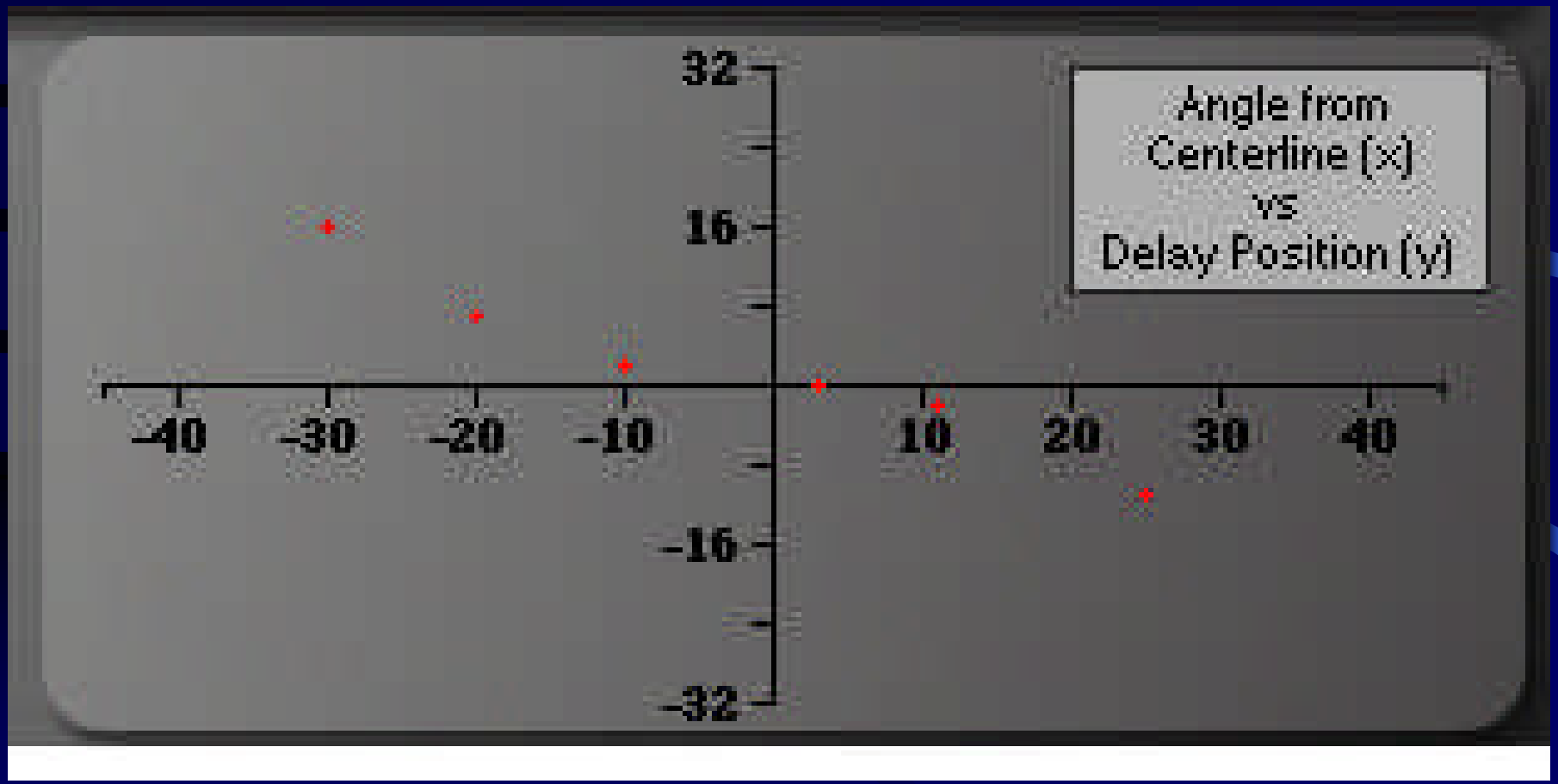
http://planetquest.jpl.nasa.gov/SIM/Demo/index.cfm

http://planetquest.jpl.nasa.gov/SIM/sim_index.cfm

Virtual Interferometer



Virtual Interferometer



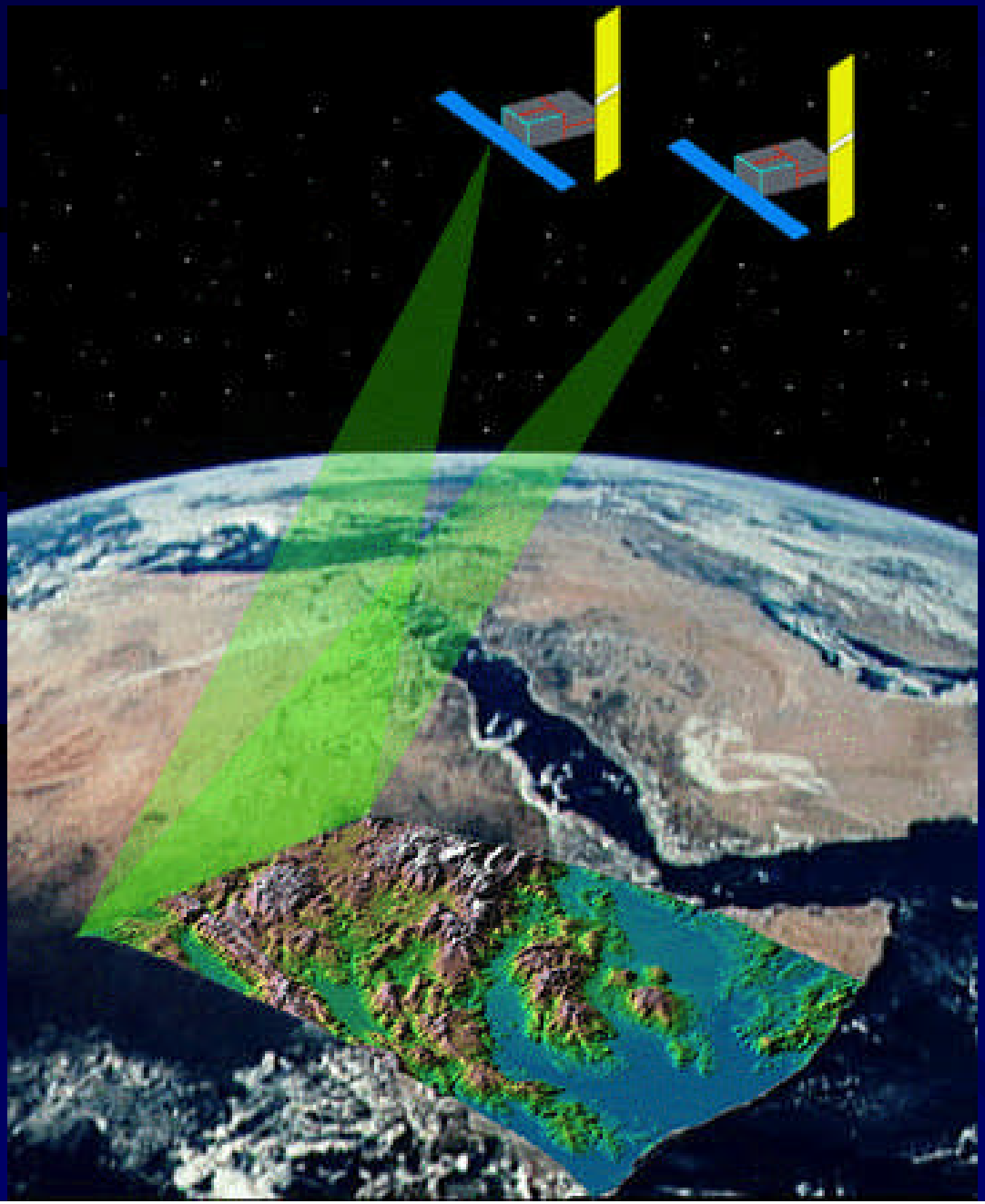
SAR Interferometry applications

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

SAR Interferometry applications

Synthetic Aperture Radar (SAR) technology is an efficient tool for monitoring and investigation of dynamic phenomena on Earth.

SAR Interferometry applications



- SAR interferometry in recent years proves to be a strong method for change detection, DEM generation, classification and…
- For interferometry, two radar images of the same area with slightly different imaging angles is required.

our contribution

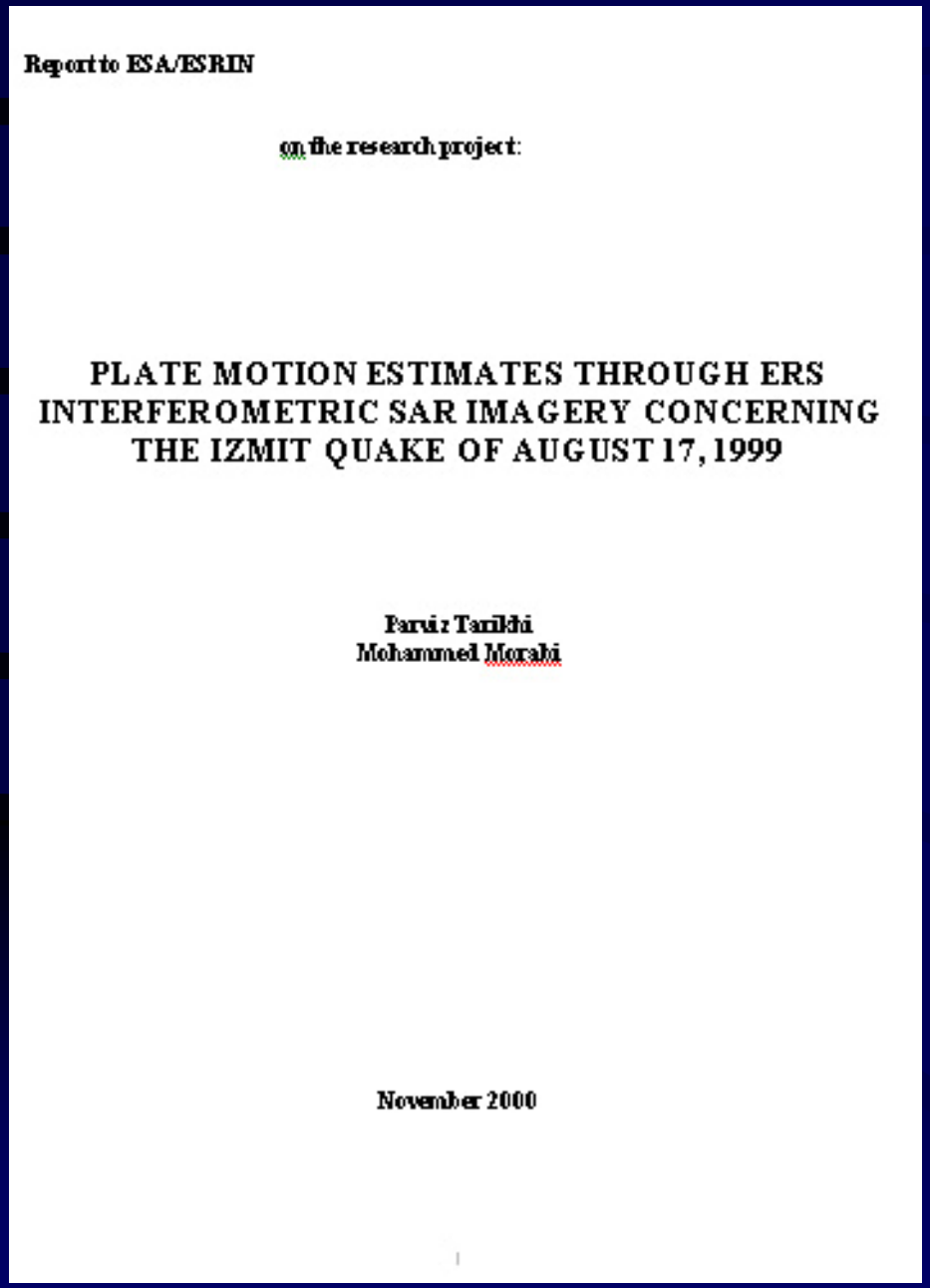
ground displacement assessment

SAR Interferometry applications

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

SAR Interferometry 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.

Earthquake in Western Turkey

SAR Interferometry applications

Earth Space Data secured by ESA/ESRIN

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	**EARTHQUAKE**				
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

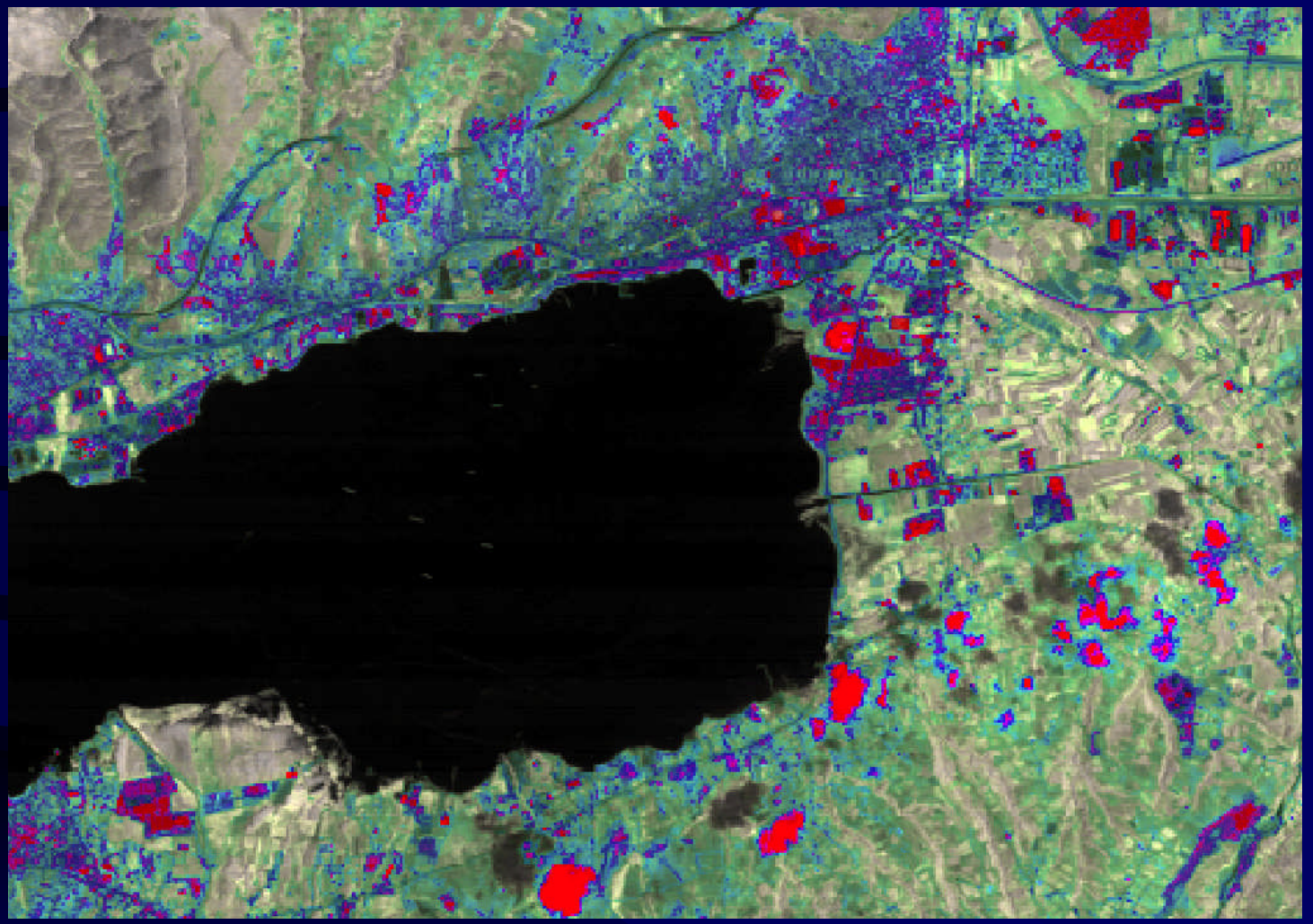
Table 2: *List of the Landsat TM data input to the project*

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

SAR Interferometry applications

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

a sample output of the project **SAR Interferometry 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.

SAR data Combinations

SAR Interferometry applications

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

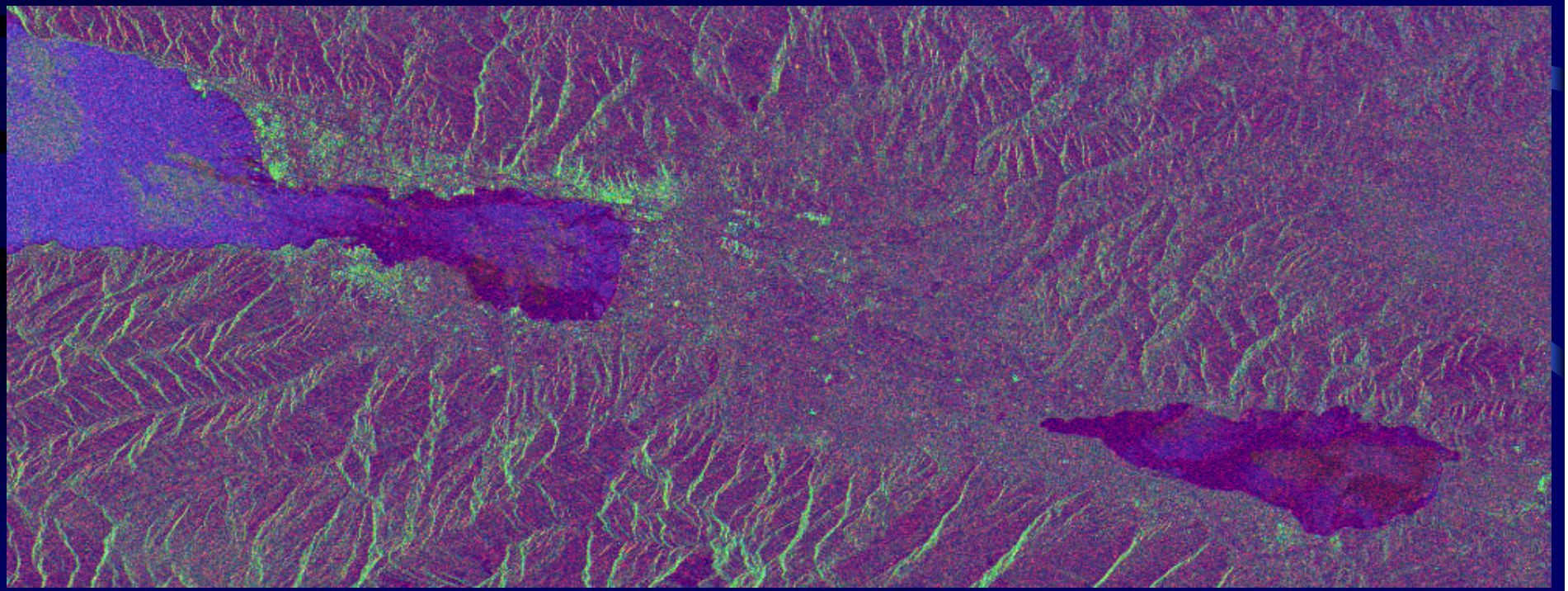
	B0r	B9s	B8r	B7s	B6s	B5s	B4p	B3s	B2s	B1s	A1p	A2s	A3s	A4s	A5s	A6s	A7s
B0r	@@@@																
B9s		@@@@		-55.834 -102.390	-1060.286 -461.205							-87.269 16.147	-445.234 -122.945				
B8r			@@@@														
B7s		64.123 102.392		@@@@	-1003.453 -365.355							40.850 118.674	-410.853 -21.891				
B6s		1060.260 462.550		1003.234 365.367	@@@@							1055.138 479.624	625.382 340.865				
B5s						@@@@		-228.269 -27.607	None Overlapp ing	None Overlapp ing				-612.951 -217.482	-793.571 -290.704	None Overlapp ing	None Overlapp ing
B4p							@@@@				779.090 328.328						
B3s						227.207 27.618		@@@@	None Overlapp ing	None Overlapp ing				-387.704 -139.965	-569.447 -263.207	None Overlapp ing	None Overlapp ing
B2s									@@@@	224.190 91.097				None Overlapp ing	None Overlapp ing	-121.640 -67.725	-7
B1s							-779.914 -328.555		-224.191 -91.091	@@@@				None Overlapp ing	None Overlapp ing	-238.318 -134.755	-11.401 -53.558
A1p											@@@@						
A2s		82.979 -16.140		-34.913 -118.706	-1055.913 -478.225							@@@@	-429.218 -140.735				
A3s		445.251 121.916		411.038 22.122	-625.200 -340.405							429.460 140.986	@@@@				
A4s						613.036 214.287		387.797 139.939						@@@@	-182.313 -73.239	None Overlapp ing	None Overlapp ing
A5s						793.334 290.730		569.706 263.179						182.284 73.239	@@@@	None Overlapp ing	None Overlapp ing
A6s									70.912 66.023	7						@@@@	234.443 100.336
A7s									7	13.971 33.767						-234.419 -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.

SAR Interferometry applications

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 Interferometry applications

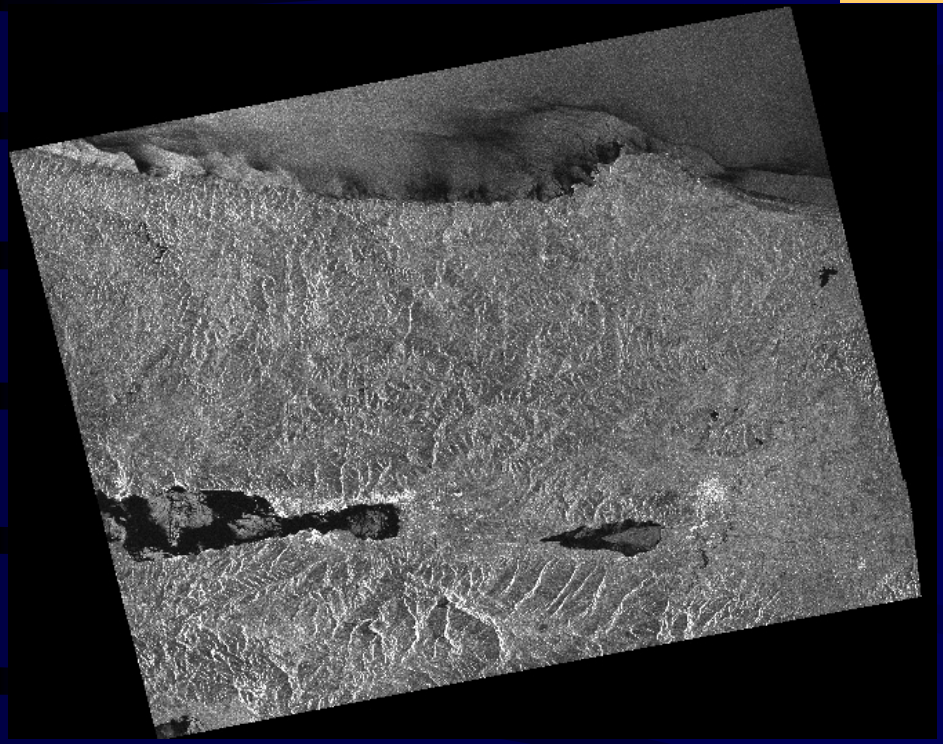
We used the Earth View software of the Canadian Atlantis Scientific Inc. as the main and the basic tool to generate interferograms as well as relevant products.

SAR data Combinations for interferogram generation

we used different specific image pairs to this mean.

Image pairs of before and after quake were used to generate the interferograms to estimate surface displacement.

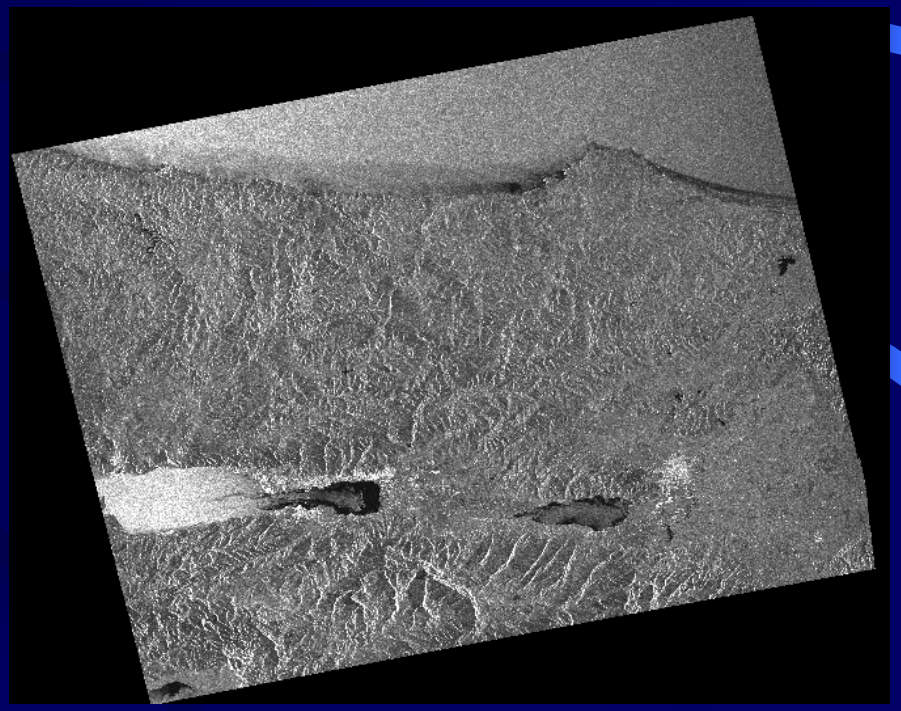
SAR Interferometry applications



master image

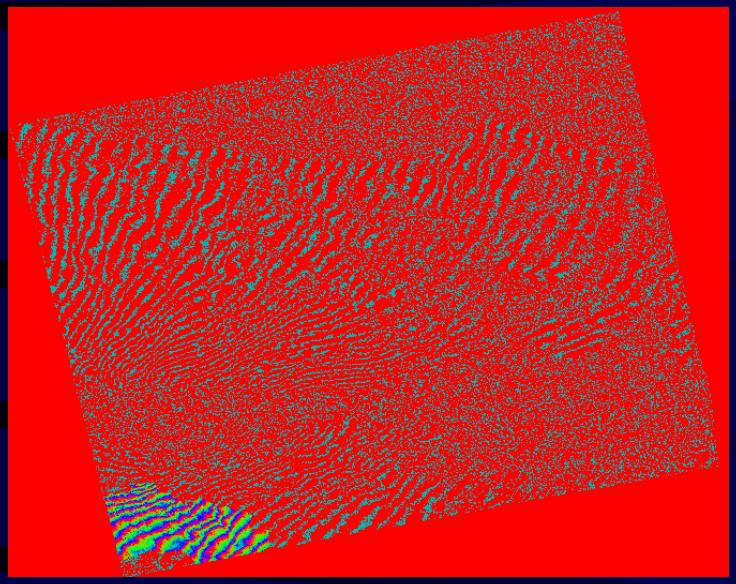
Image pairs of:

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



slave image

SAR Interferometry applications

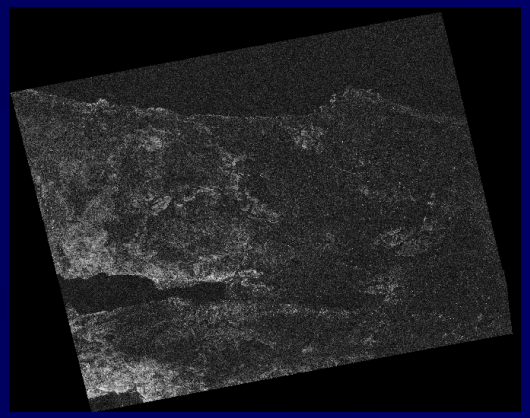


phase image

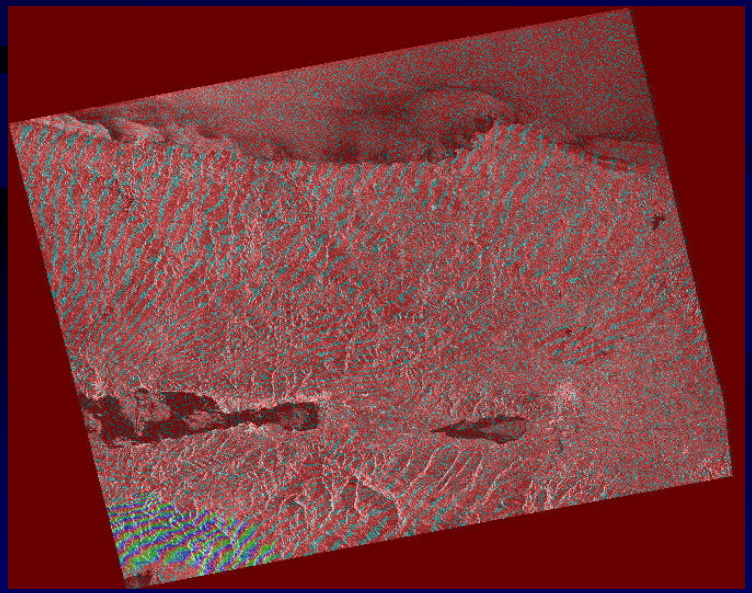
Image pairs of: 13 Aug. 1999, and 17 Sept. 1999 (3 days before and a month after quake)

- normal baseline: 11.401m
- parallel baseline: 53.558m

- good coherence
- very small baseline

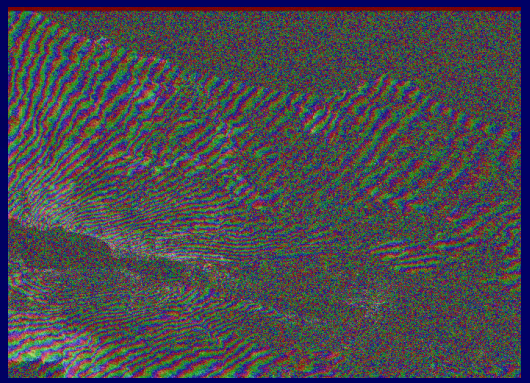


coherence image



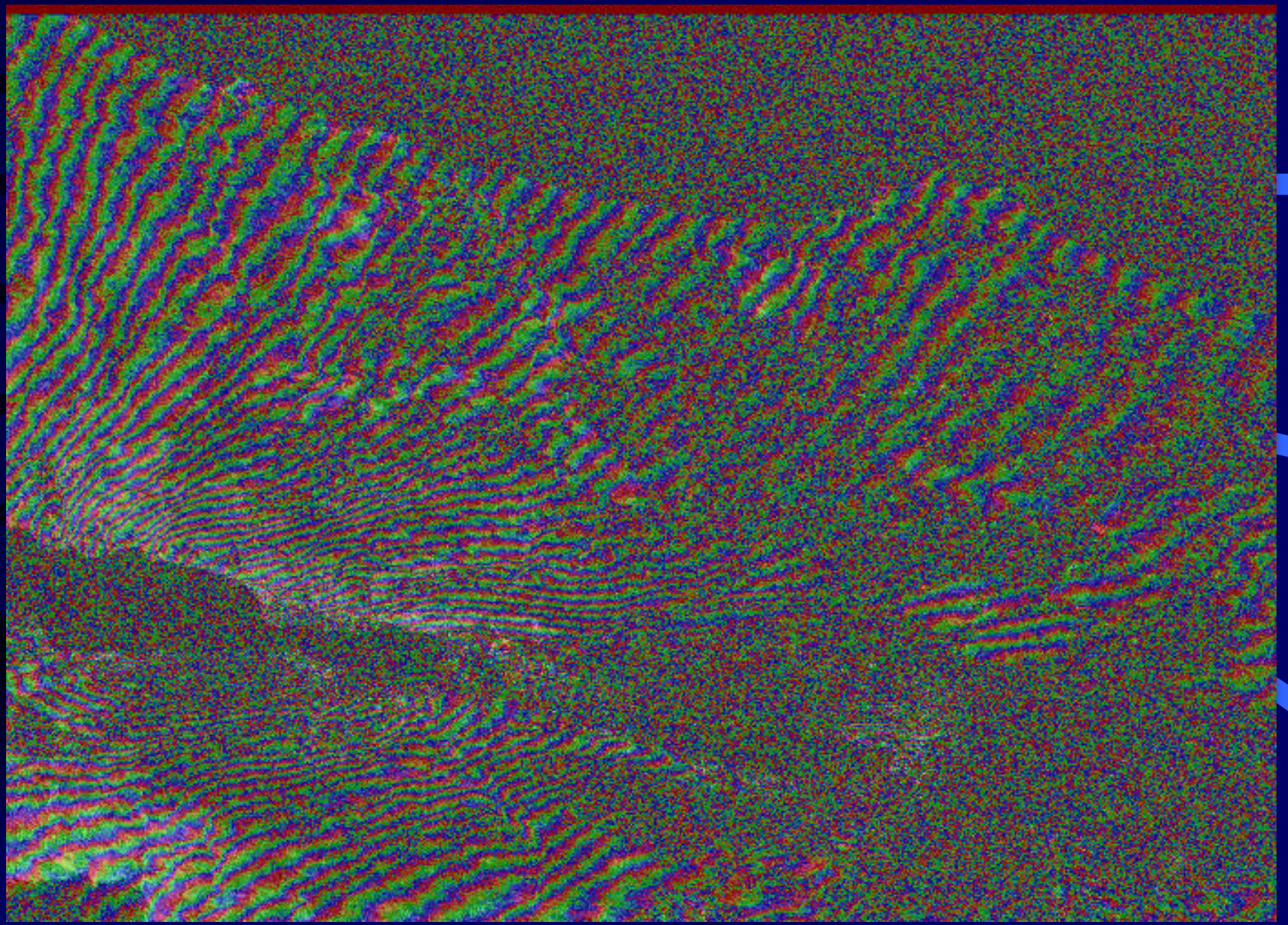
interferogram

phase image overlaid on coherence image



SAR Interferometry applications

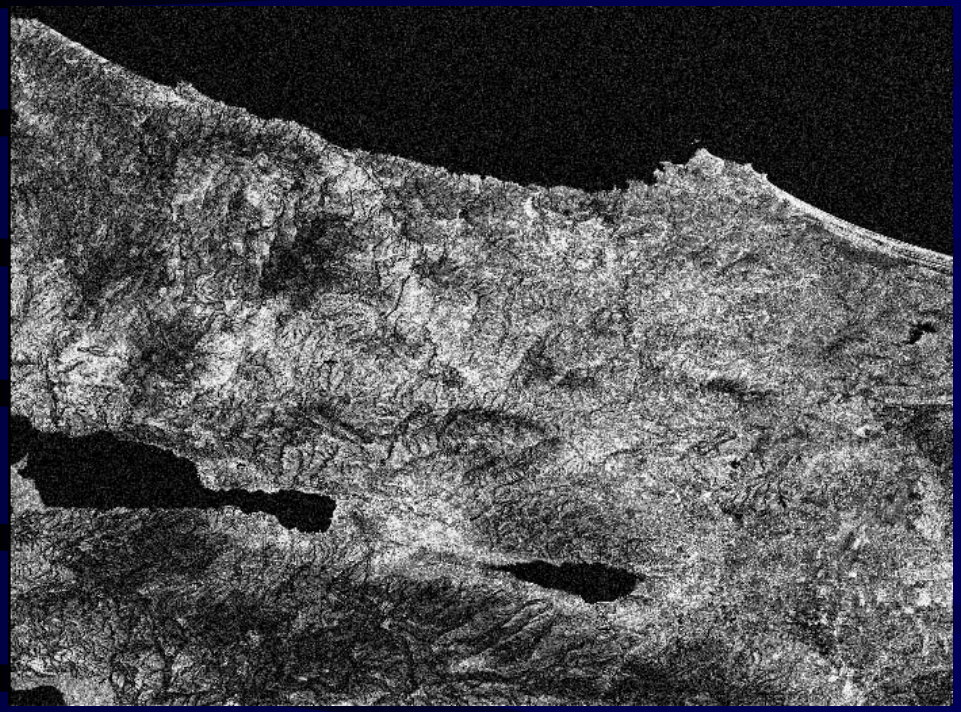
- good interferogram



interferogram

Tandem images of before or after quake used to generate accurate DEMs.

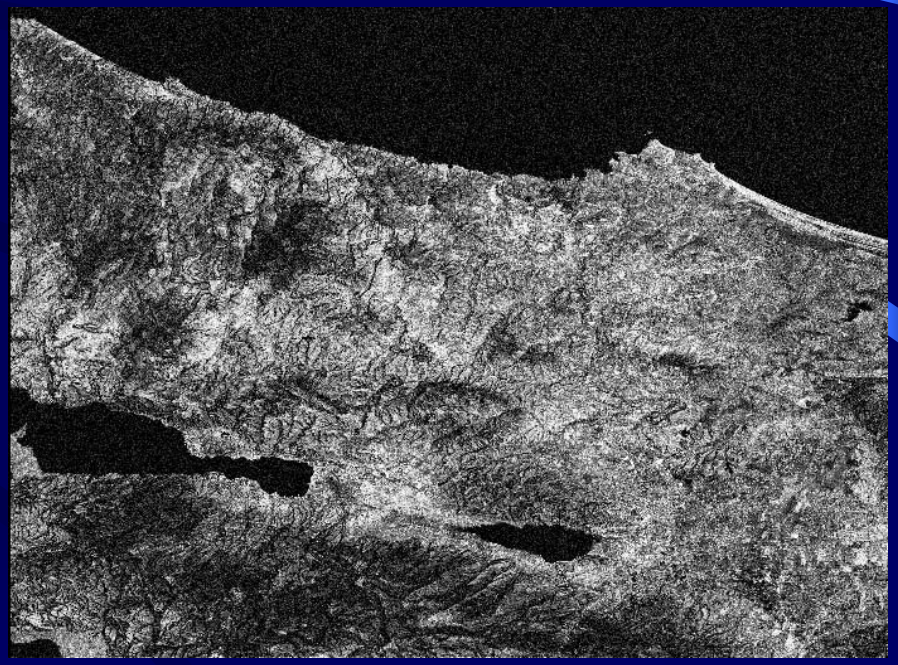
SAR Interferometry applications



master image

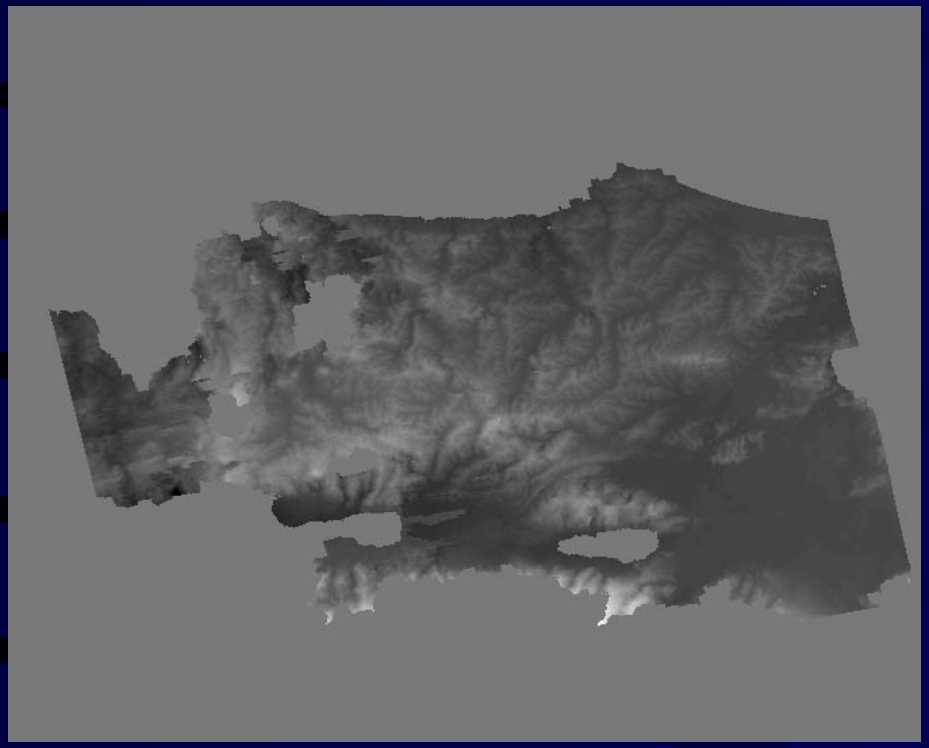
- **Tandem images of:**
  12 and 13 Aug. 1999
  (4 and 5 days before quake)

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



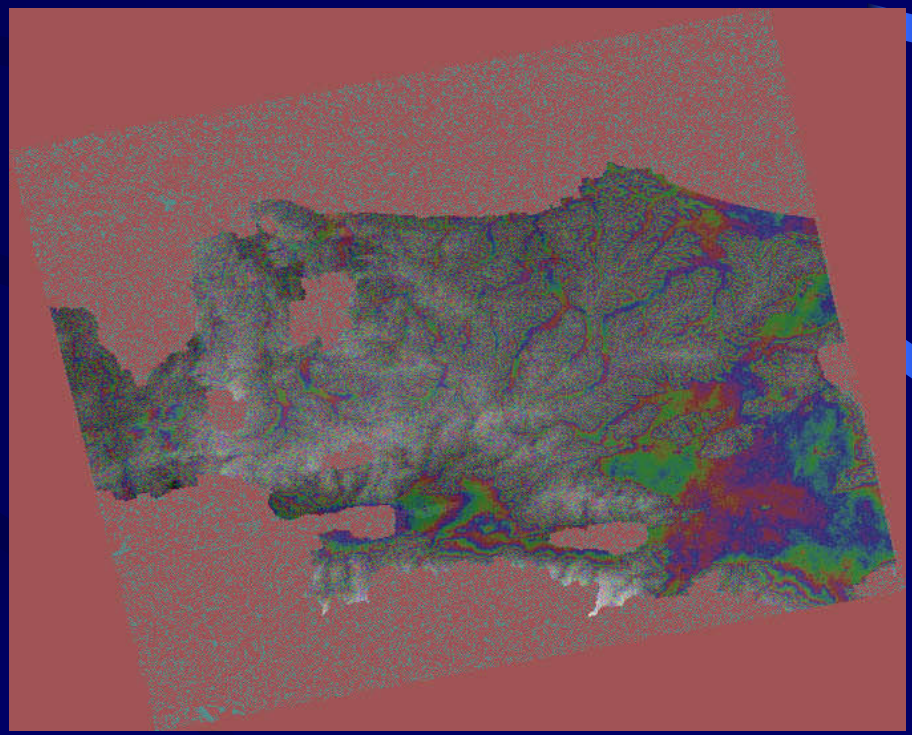
slave image

SAR Interferometry applications



height image (DEM)

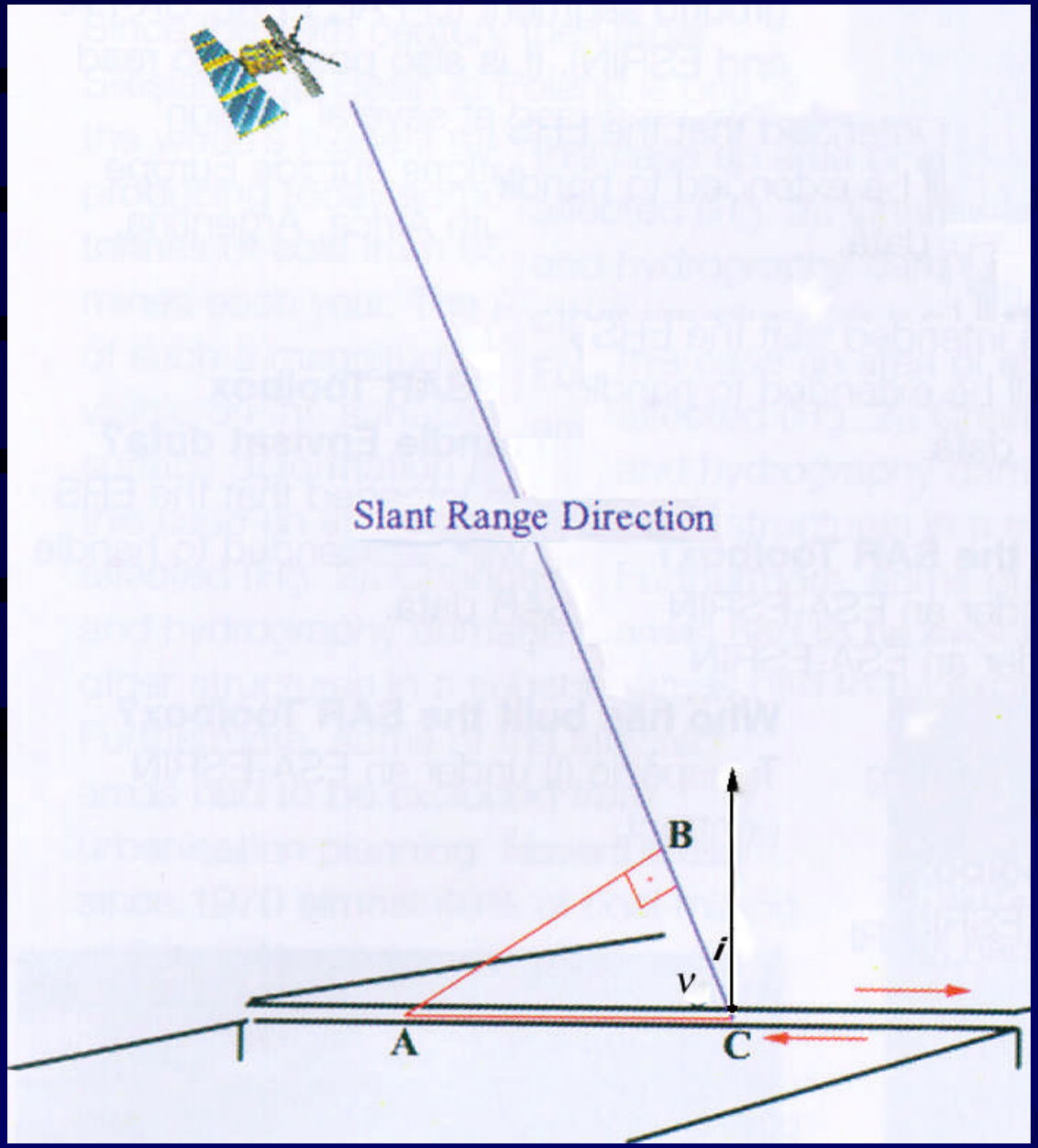
- **Tandem images of:** 12 and 13 Aug. 1999 (4 and 5 days before quake)
- normal baseline: 224.190m
- parallel baseline: 91.097m
- good height image or digital elevation model (DEM)



phase image overlaid on height image (DEM)

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

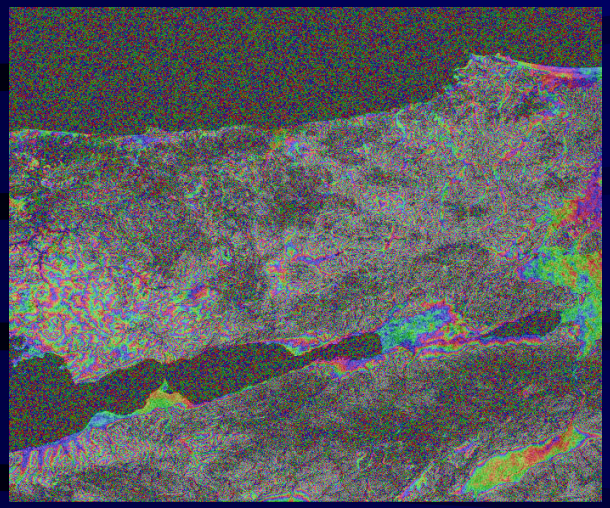
SAR Interferometry applications



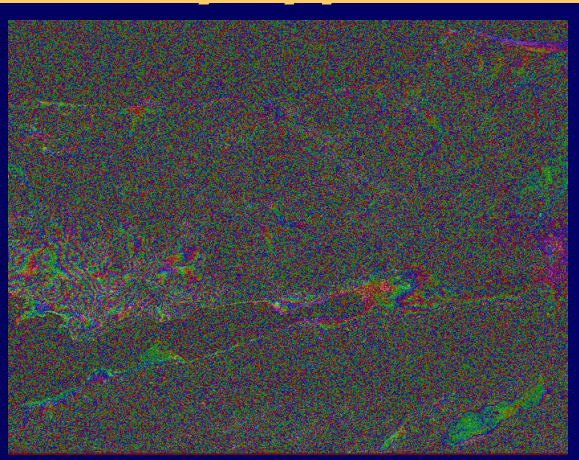
Model of the surface motion in the study area

SAR Interferometry applications

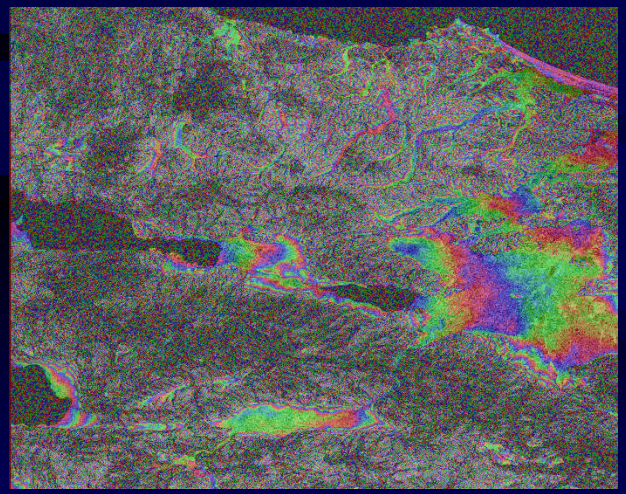
Comparison of the image pairs of before and after quake (Izmit area)



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

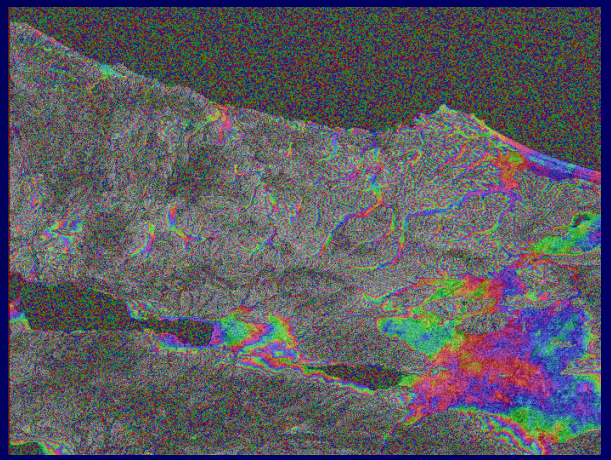


Images of: 20 Mar. 1999, and 24 Apr. 1999 (3 months+23 days and 4 months+24 days before quake)
normal baseline: 228.264m
parallel baseline: 27.607m



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

SAR Interferometry applications

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

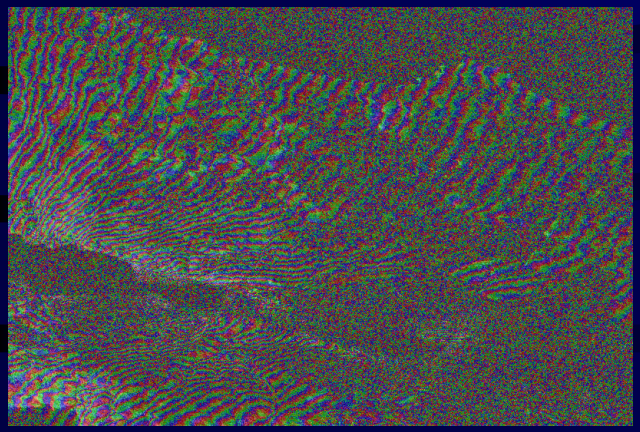


Image pair of 12 Aug. and 16 Sept. 1999
(4 days before and a 29 days after quake)
normal baseline: 121.640m
parallel baseline: 67.725m
fringe number: 40

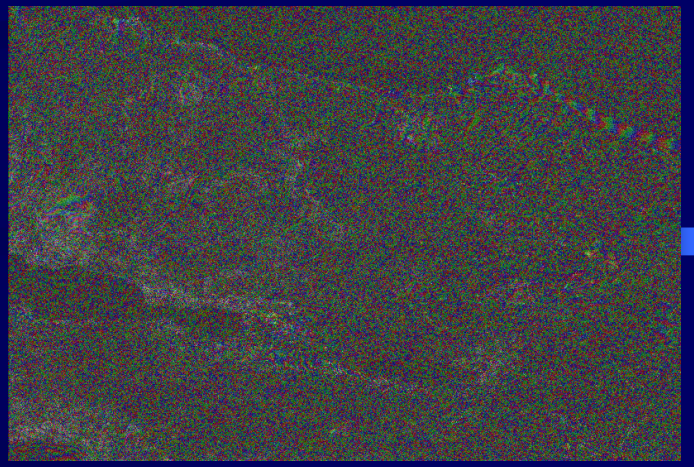


Image pair of 12 Aug. and 17 Sept. 1999
(4 days before and a month after quake)
normal baseline: ?
parallel baseline: ?

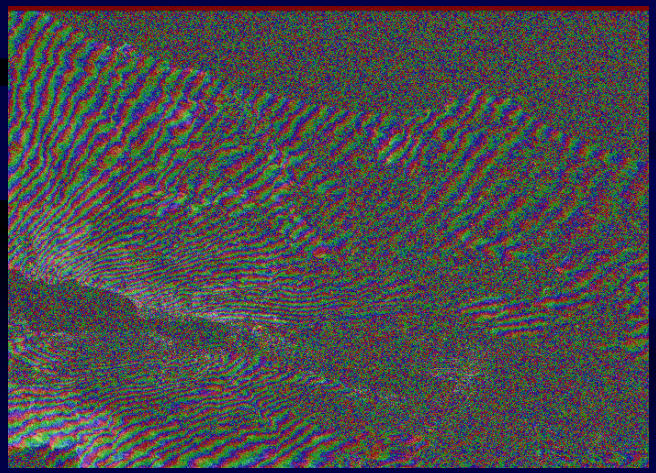


Image pair of 13 Aug. and 17 Sept. 1999
(3 days before and a month after quake)
normal baseline: 11.401m
parallel baseline: 53.558m
fringe number: 43

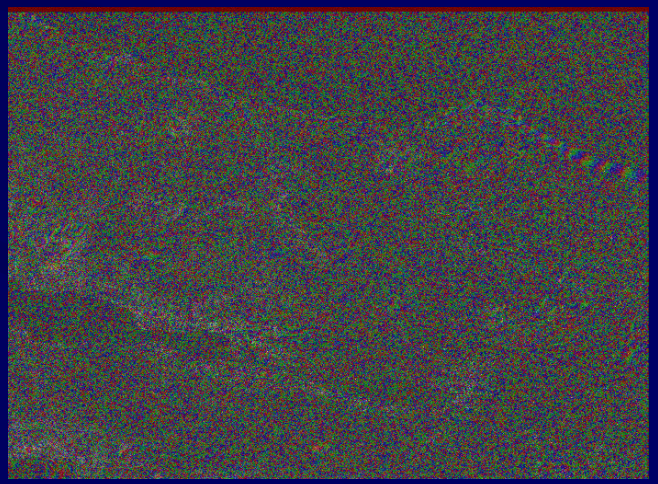


Image pair of 13 Aug. and 16 Sept. 1999
(3 days before and 29 days after quake)
normal baseline: 238.318m
parallel baseline: 154.753m

SAR Interferometry applications

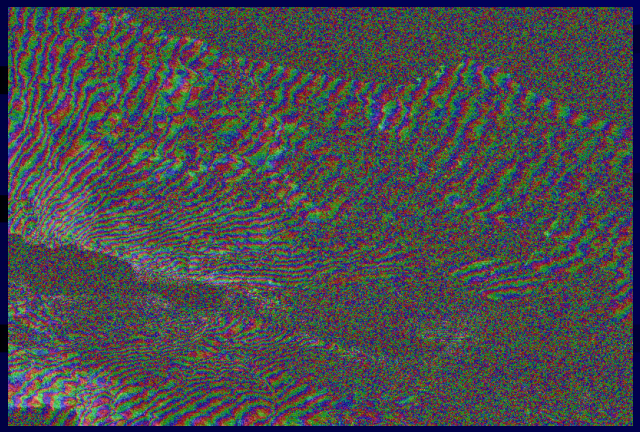


Image pair of 12 Aug. and 16 Sept. 1999
(4 days before and a 29 days after quake)
normal baseline: 121.640m
parallel baseline: 67.725m
fringe number: 40

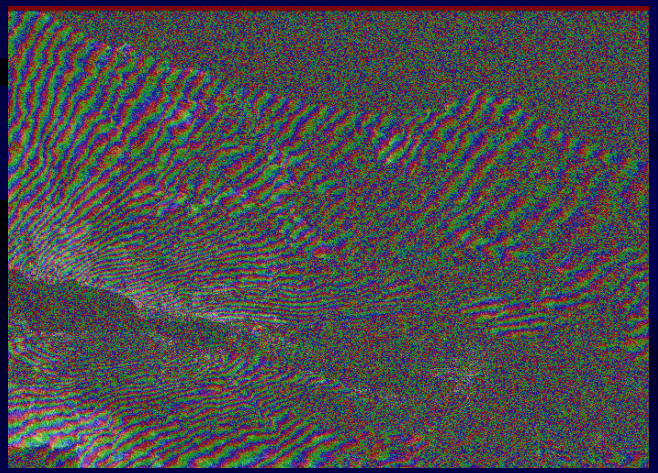


Image pair of 13 Aug. and 17 Sept. 1999
(3 days before and a month after quake)
normal baseline: 11.401m
parallel baseline: 53.558m
fringe number: 43

displacement assessment

fringe numbers x Half the wavelength

40 x 28mm = 1120mm~ 112cm

slant range displacement = 112cm

slant range displacement / cos 67 =

surface displacement

112 / 0.39 = 287.18cm

fringe numbers x Half the wavelength

43 x 28mm = 1204mm~ 120.4cm

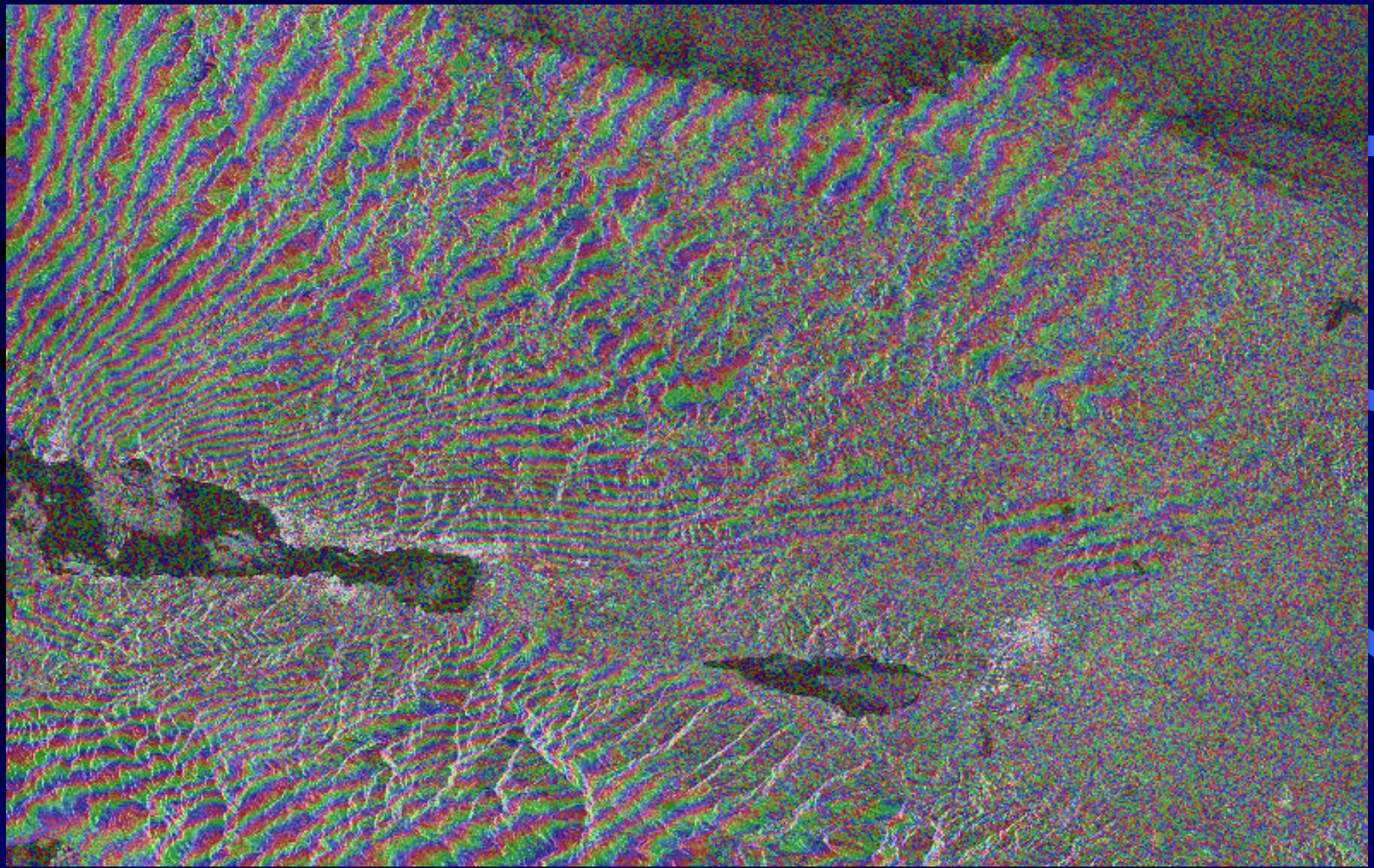
slant range displacement = 120.4cm

slant range displacement / cos 67 =

surface displacement

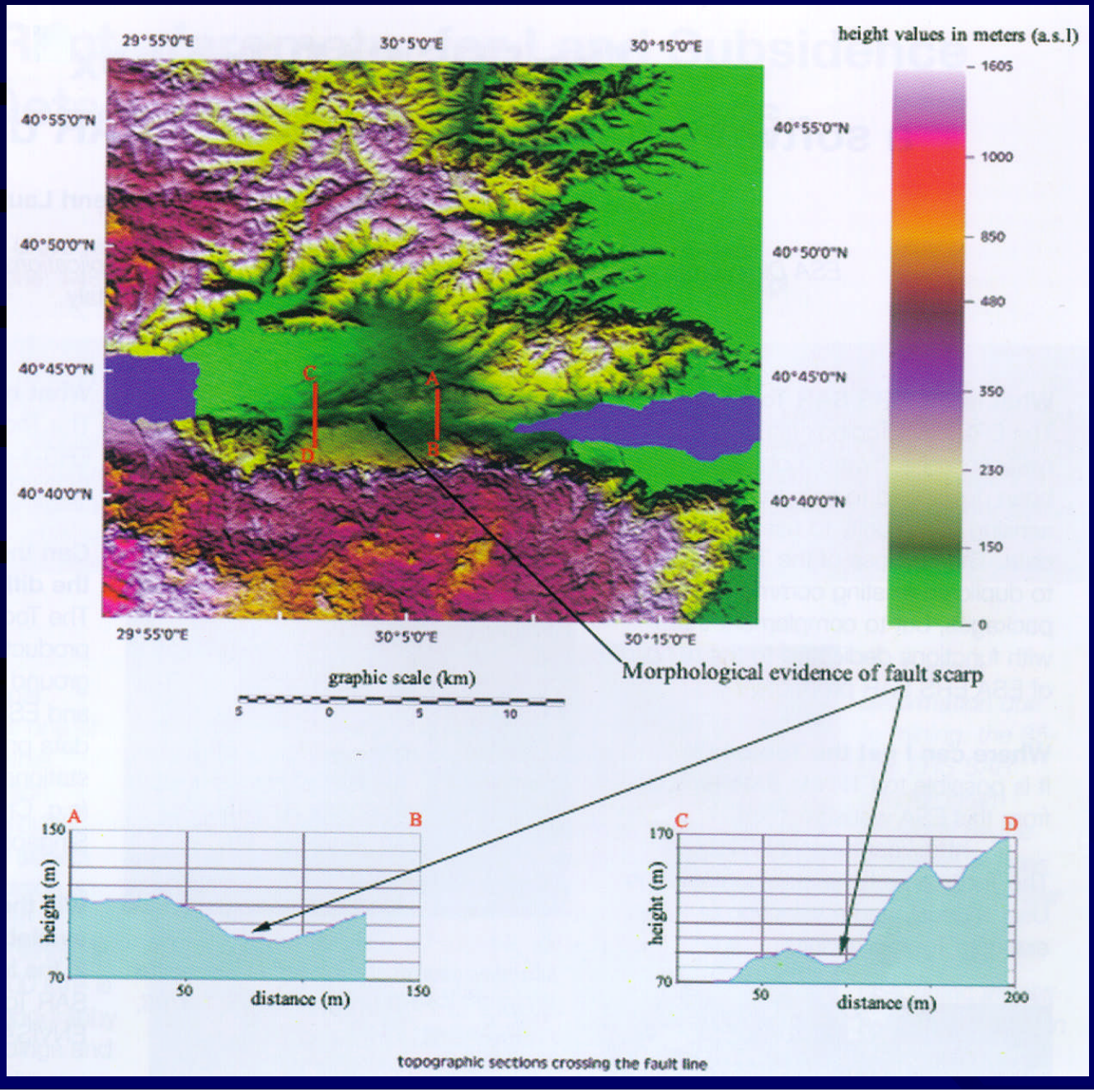
120.4 / 0.39 = 308.72cm

SAR Interferometry applications



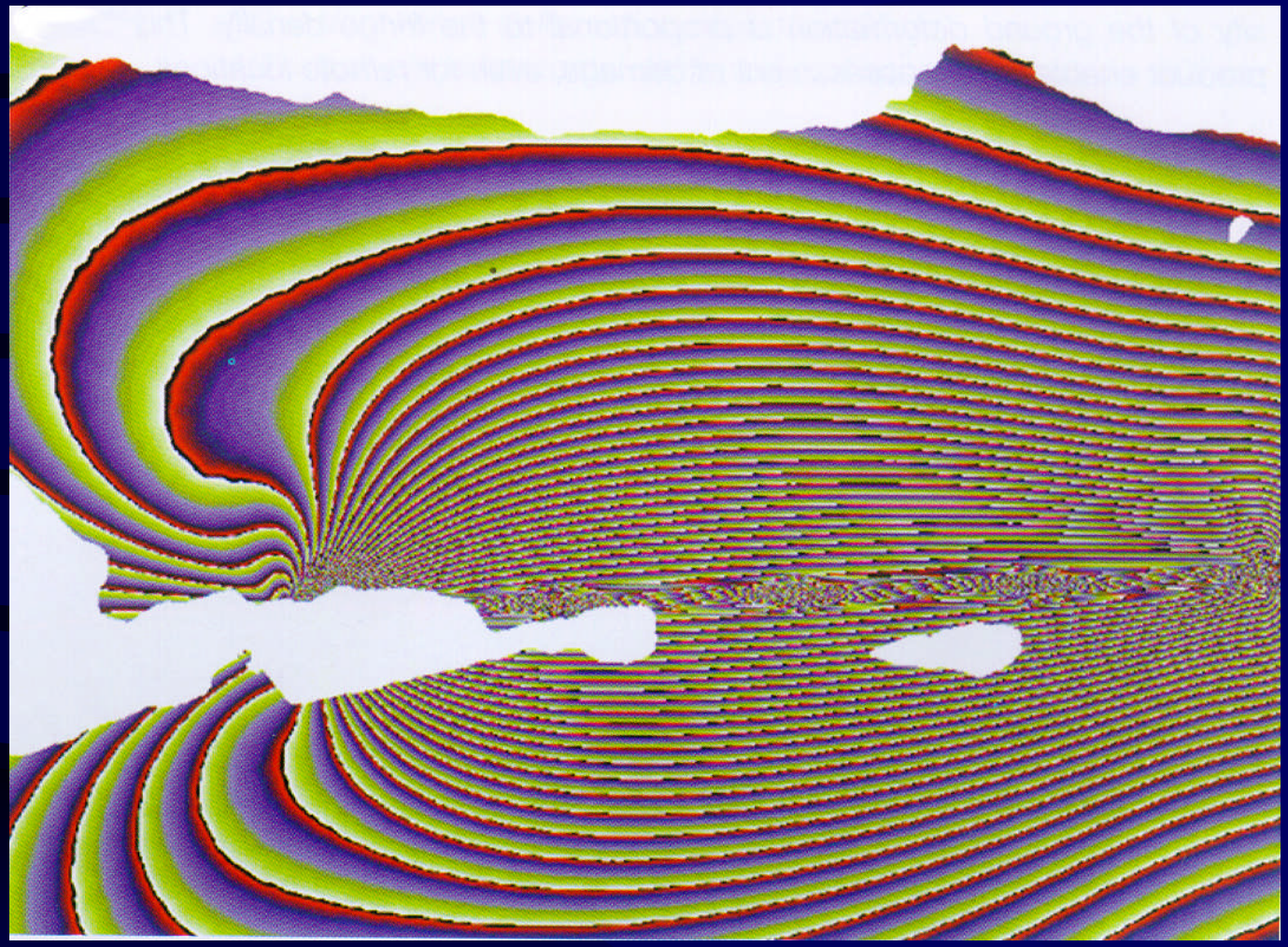
Differential interferometry for displacement mapping

SAR Interferometry applications



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.

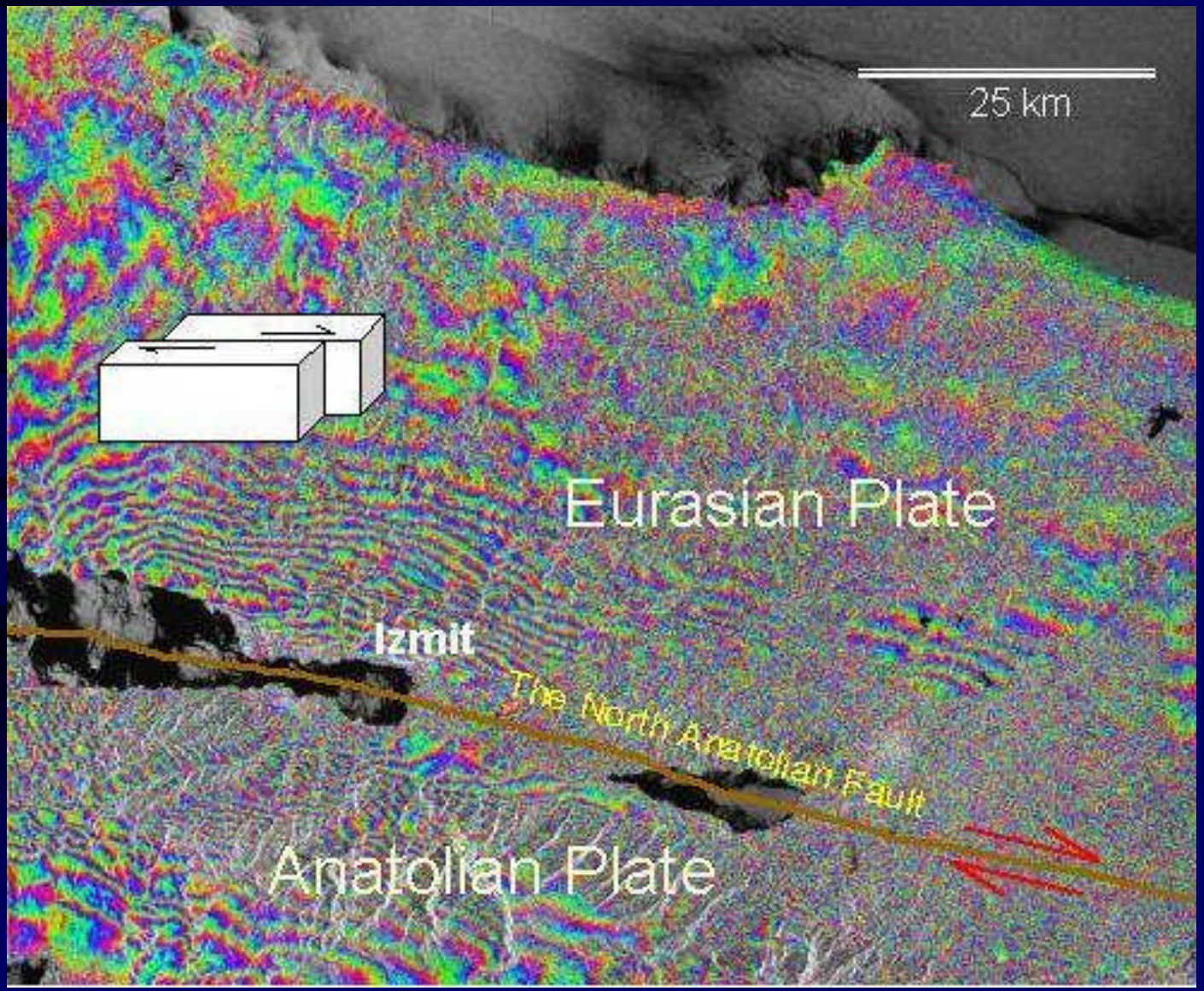
SAR Interferometry applications



Deformation model based on field data

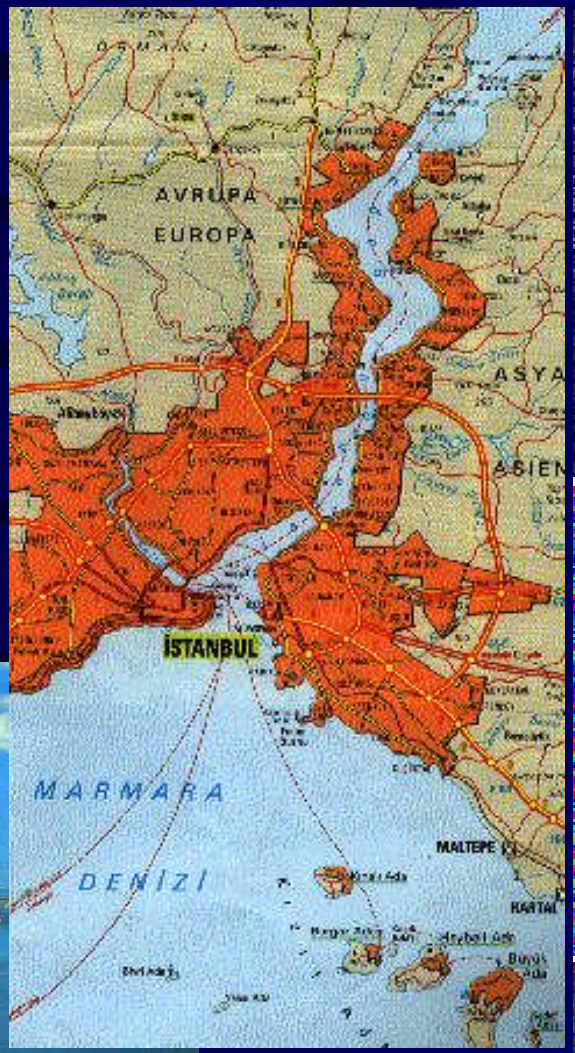
- high similarity to the interferograms generated.

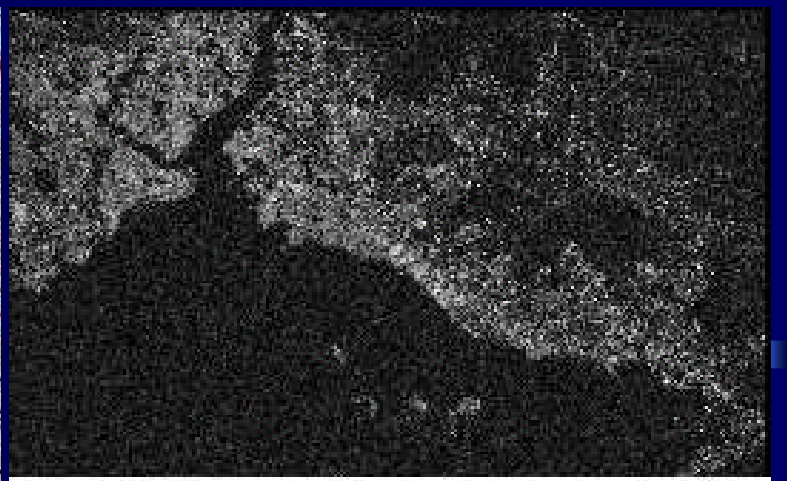
SAR Interferometry applications

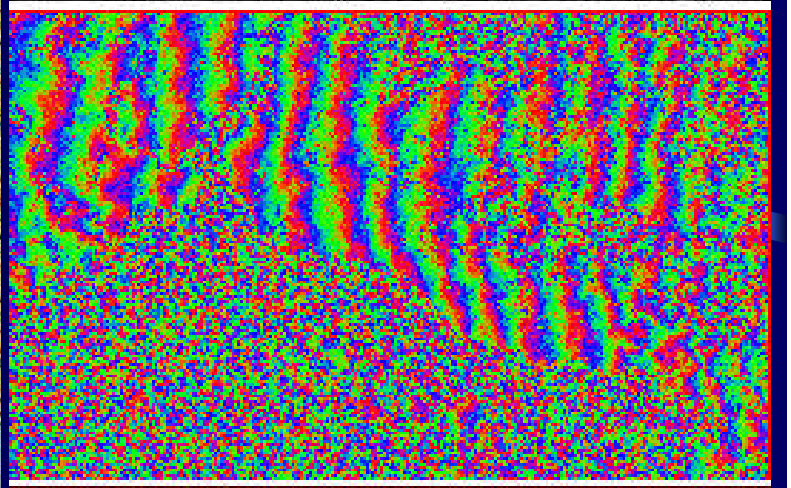


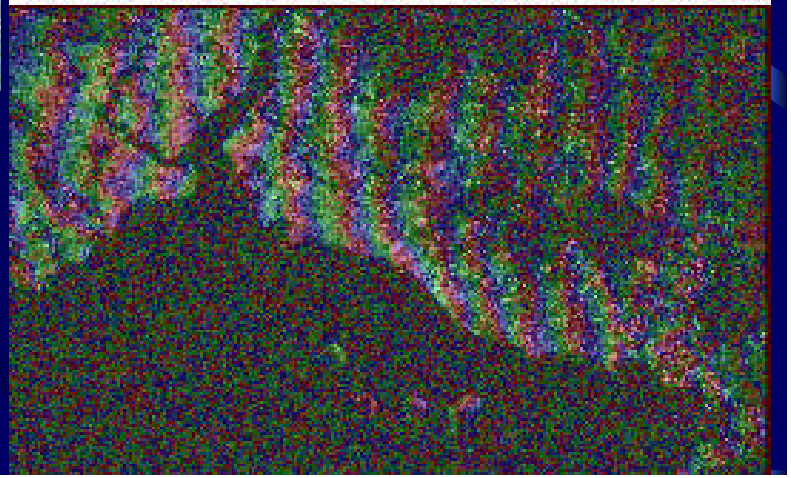
New Technologies in monitoring and management of calamities and dynamic changes

Bosporus Strait





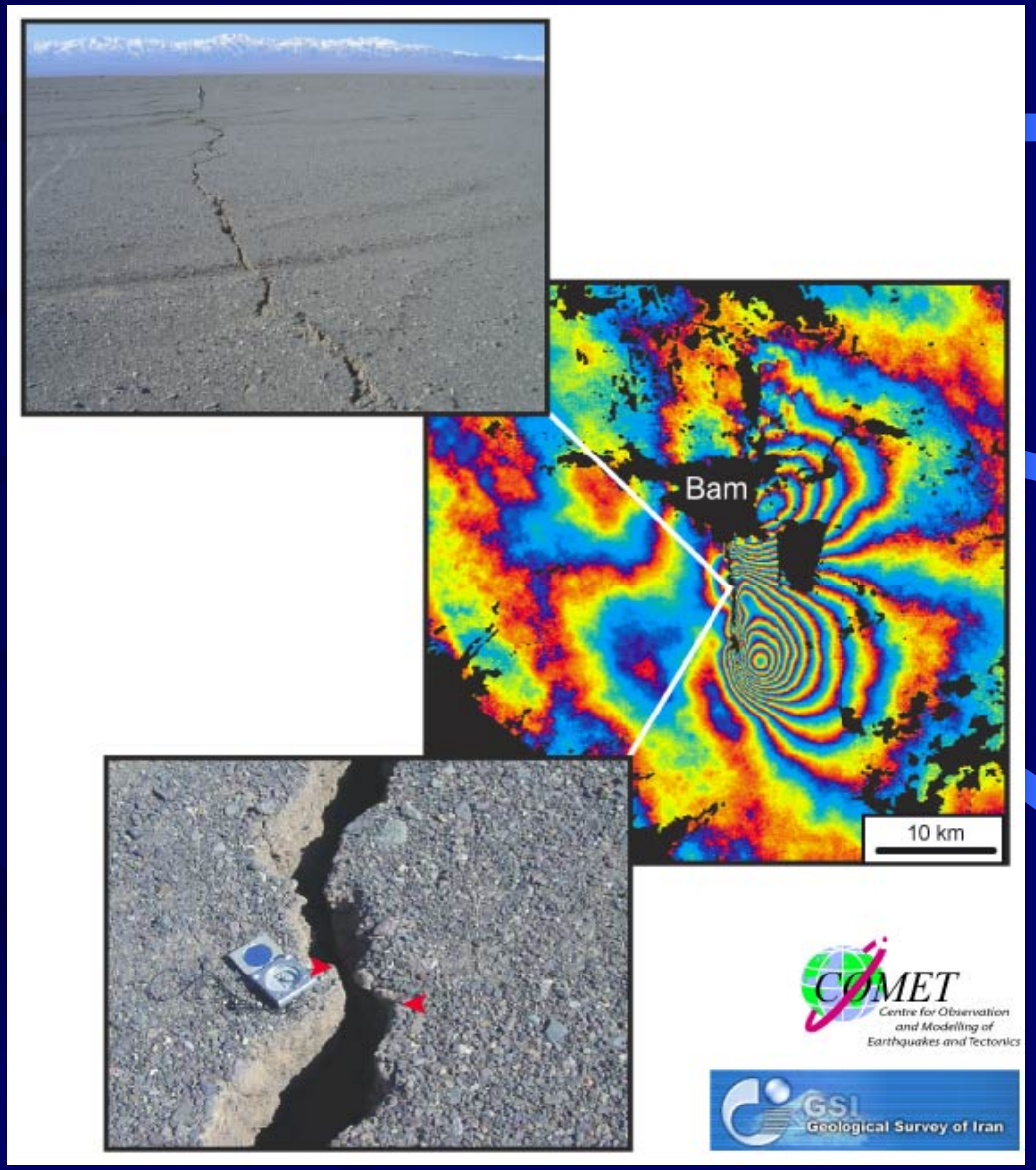




Bam Quake, 26th December 2003

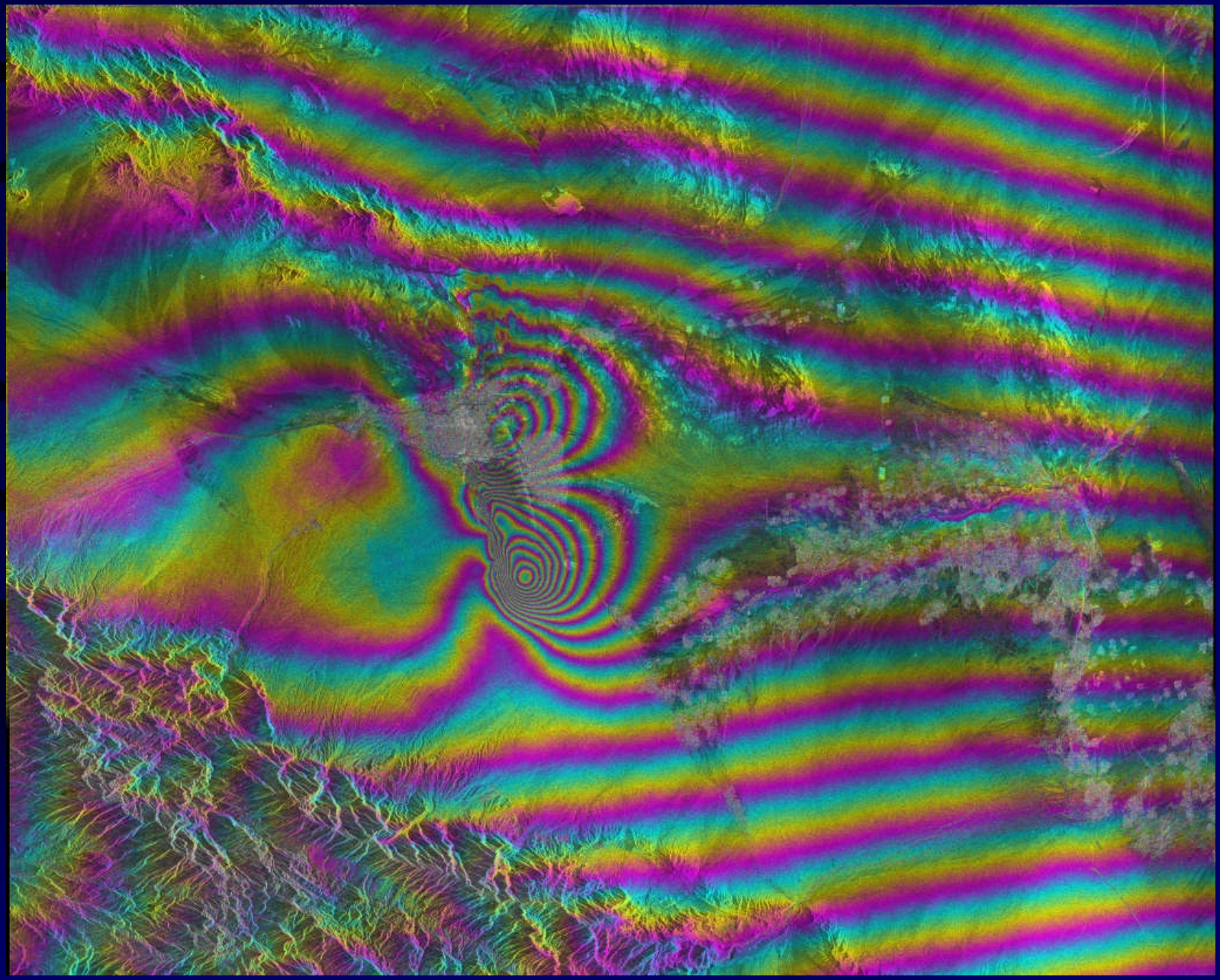
SAR Interferometry

Bam Quake, 26th December 2003



Bam Quake, 26th December 2003

SAR Interferometry



- 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