Cover

Three-dimensional digital elevation model of Mt. Vesuvius from NASA/JPL TOPSAR

G.ALBERTI, S. ESPOSITO
CO.RI.S.T.A., Piazzale V. Tecchio, 80, I-80125 Napoli, Italy

and S. PONTE
Department of Aerospace Engineering, Second University of Naples, Via Roma, 29 - I-81031 Aversa (CE), Italy

The NASA/JPL DC-8 airborne synthetic aperture radar (SAR) is a multi-frequency (P-, L- and C-band), multi-polarimetric SAR system (AIRSAR) which was recently augmented with a pair of C-band antennas displaced across-track, in order to form a radar interferometer sensitive to topographic variations of the illuminated surface (TOPSAR, Topographic SAR, Zebker *et al.* 1992). A large amount of interferometric data have been acquired during U.S. and European campaigns, and extensive validations of the digital elevation models (DEMs) derived from precision interferometric processing have been performed.

The cover photo (Figure 5) is a colour-coded three-dimensional height map of Mt Vesuvius obtained from data acquired during the 1991 European Multi-sensor Airborne Campaign (MAC Europe). The TOPSAR system imaged several Italian test-sites. The C-band interferometric data dealt with in this note were gathered during a north-west ascending flight (June 28, 1991) over the Vesuvius volcano (Southern Italy, figure 1). Table 1 gives the main TOPSAR system parameters relative to the data acquisition.

SAR data processing and height reconstruction from the interferometric phase have been performed by CO.RI.S.T.A. (Consortium for Research on Advanced Remote Sensing, Naples, Italy), a non-profit consortium founded in 1988 for the purpose of establishing in Southern Italy close co-operation between universities and industry in the research field of Remote Sensing. In 1990 CO.RI.S.T.A developed and provided, together with ALENIA, the second C-band antenna mounted onboard the NASA/JPL DC-8 aircraft. Technical details are as follows.

Raw data compression was performed by means of a range-Doppler SAR processor which mimics the range digital chirp transmitted by the sensor and calibrates each range line by means of a calibration tone injected in the radar signal. The Doppler history and the range migration effect are compensated by generating space-variant azimuth matched filters, in order to get a preliminary along-track registration of the two conventional C-band SAR images (figure 2). One-dimensional cross-correlation applied to get sub-pixel registration along the range direction, and, subsequently, the product between the two images (the second-one being complex-conjugated) have given the interferogram of figure 3(*a*). The coherence map (figure 3(*b*)) shows high values of the modulus of the correlation coefficient γ (average value 0.7), due to the low decorrelation typical of simultaneous interferometry.

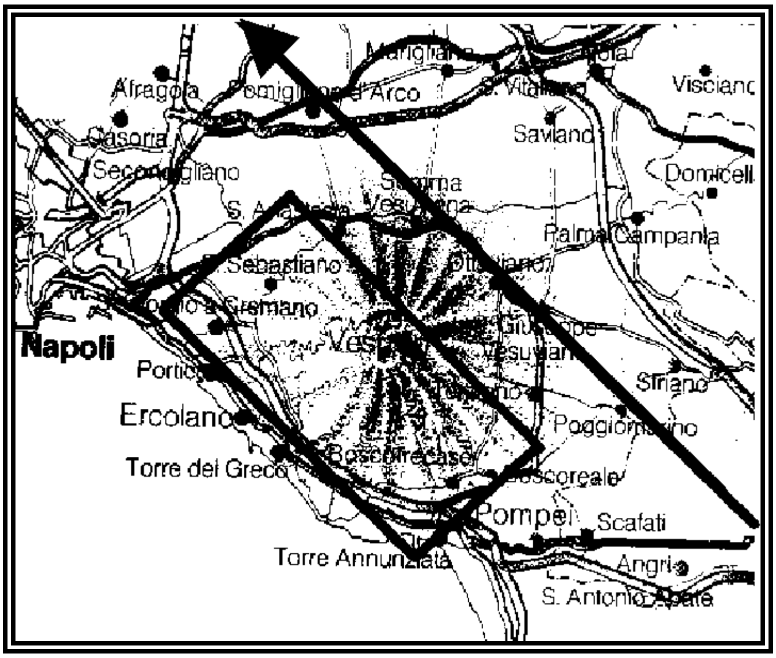


Figure 1. Map of the Vesuvius test-site. The arrow shows the flight direction, and the rectangle represents the illuminated scene.

Frequency	5.2875 GHz
Wavelength	5.67 cm
Baseline modulus	2.583 m
Baseline components:	
along-track	0 m
across-track	1.1821 m
along the local vertical	2.2969 m
Aircraft speed	~ 211 m/s
Aircraft altitude	~ 7650 m
Slant range resoution	3.75 m
Azimuth resolution	0.8 m (1 look)
Chirp bandwidth	40 MHz
Pulse length	5.0 µs
Sampling frequency	90 MHz
Pulse repetition frequency	567 Hz

Table 1. TOPSAR system main nominal characteristics.

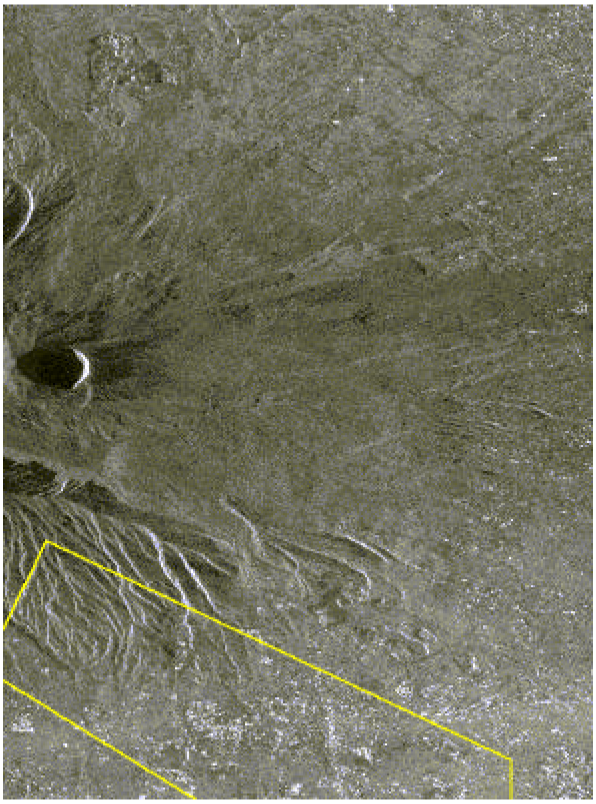
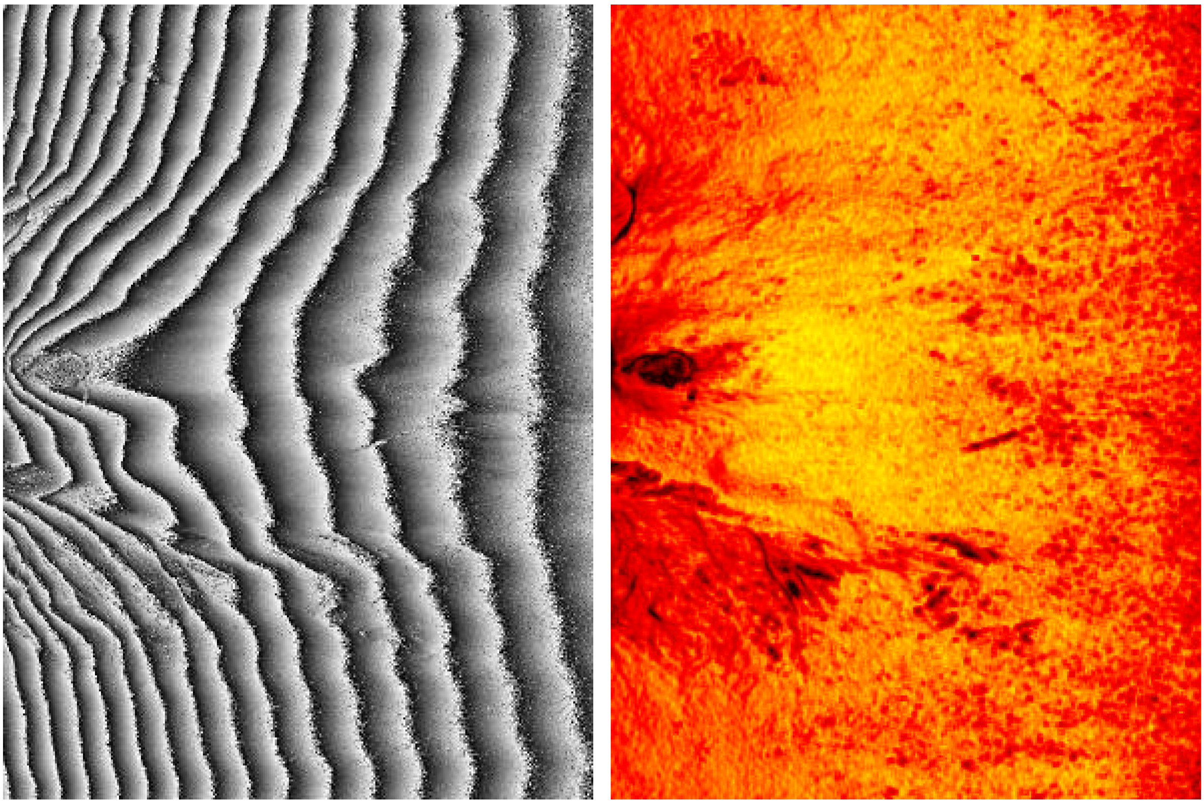


Figure 2. Conventional SAR image of the test-site (Mt Vesuvius, Italy), processed by CO.RI.S.T.A.



(a) (b)

Figure 3. (a) Interferogram of the test-site; (b) Colour-coded coherence map, from black ($|\gamma|$=0.25) to yellow ($|\gamma|$=0.85).

Phase unwrapping has been performed with a consistent, automatic algorithm developed by CO.RI.S.T.A.: phase local errors have been located in connex areas of low coherence, and negative and positive residues have been grouped together by enlarging an adaptive inspection window around each residue. The DEM (figure 4) has been derived by using the position and height of a known ground control point to solve the 2π-ambiguity, and taking into account the aircraft altitude and attitude, the baseline components and the slant range. Figure 4 is a false-colour representation of Mt Vesuvius and Mt Somma (the lower peak of the left), with the backscattering image superimposed, whereas in figure 5 a colour-coded height map of the imaged area is shown in a three-dimensional perspective.

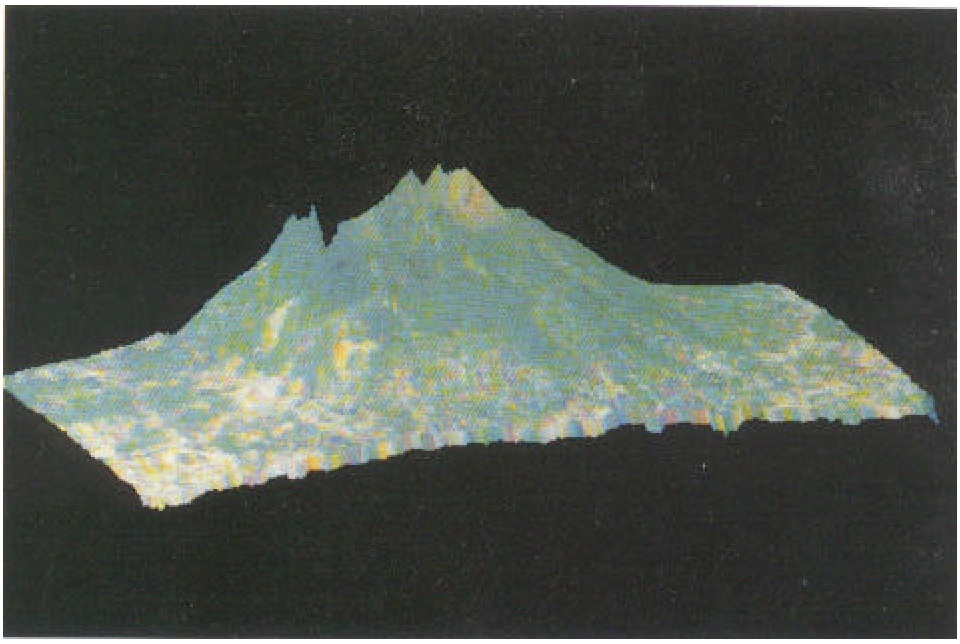


Figure 4. Three dimensional view of the interferometric DEM.

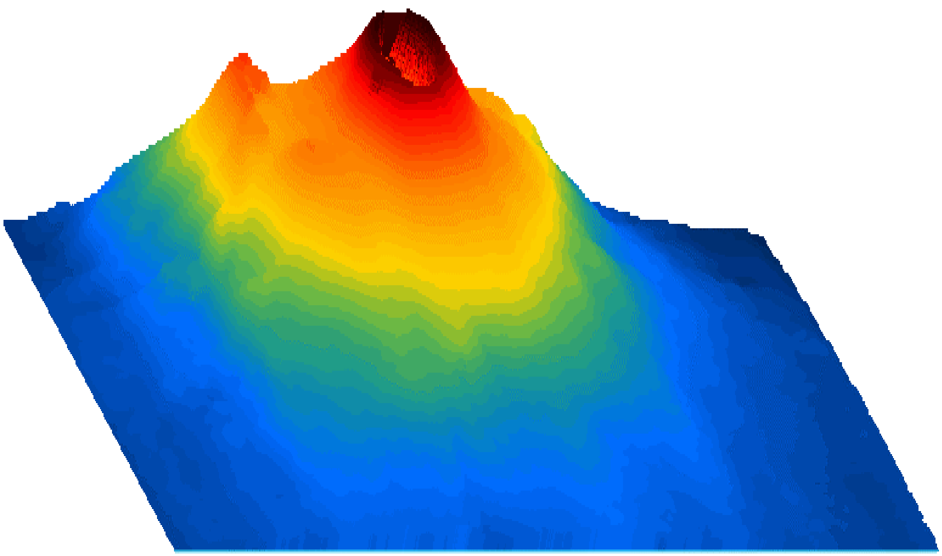


Figure 5. Colour-coded three-dimensional height map of Mt Vesuvius derived from the unwrapped interferogram.

The DEM validation has been performed by comparison with digital topographic data derived from 1:25,000-scale photogrammetric DEMs produced by the Italian Istituto Geografico Militare (IGMI). The r.m.s. error on the height derived from the radar DEM was found to be 25m, whereas the main sources of inaccuracy were found to be aircraft roll and scene coherence (Alberti *et al. 1995)*.

References

ALBERTI, G., ESPOSITO, S., and VETRELLA, S., 1995, The Vesuvius DEM: a test case for the TOPSAR system. *Proceedings of the MAC Europe '91 Final Results Workshop, 4-6 October 1994, Lenggries, Germany,* ESA WPP-88 (Paris: European Space Agency), pp. 49-55.

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