GIIOMOR1'IIIC CIIARACTERISTICS OF '1'111? MT. EVEREST AREA, IIIGIIER IIIMALAYA, FROM S1]11'1''1'1 .E RADAR INTERFEROMETRY[§]

E. J. FIELDING[1], K. V. HODGES[2] AND C. L. WERNER[1]

[1]Jet Propulsion Laboratory, California Institute of Technology,
Mailstop 300-233, 4800 Oak Grove Drive,
Pasadena, California 91109, USA.
[2]Department of Earth, Atmospheric, and Planetary Sciences,
Massachusetts Institute of Technology, Room 54-1120
Cambridge, Massachusetts 02139, USA.

New high-resolution digits] topography has been produced for the Higher Himalaya area around Mt. Everest by interferometric processing of radar data. Analysis of this dataset provides new information on the geomorphic response to the high denudation rates, steep relief, and structural and lithologic variations. The pre.sent topography presumably represents a balance between the tectonic and erosion processes, and the latter have been affected by Quarternary climate changes. The north face of Everest has a fairly uniform hillslope angle of about 42° (with a ~80 m window size), which may be controlled by the shallow northward dip slope of the mylonitic schists, or may represent a maximum sustainable slope for those lithologies. Several other peaks and ridges north of Everest have more uniform, but shallower, slopes in the range of 30--350 which may indicate either rocks of lower strength or less rapid denudation. Future geologic mapping in this area will help to constrain the lithologic contrasts and allow comparisons 10 the geomorphic characteristics.

Interferometric processing of suitable pairs of synthetic aperture radar (SAR) images can produce a high-resolution digital elevation mode] (DEM). Airborne systems can provide the highest resolution DEMs, but spaceborne SAR provides greater data coverage, especially in remote regions such as the Himalaya. We have derived a DEM for the Everest area of the Himalaya from a pair of images from the interferometry phase of the October 1994 Shuttle Imaging Radar (SIR-C) flight. The extreme relief in this area causes some problems for topographic measurements, even with radar. The SIR-C radar instrument can be steered to different incidence angles, and used a 510 incidence angle (measured from the vertical) for these data which works much better in high-relief areas than other radar systems, such as the ERS- 1 SAR (23° incidence angle). The National Geographic Ml. Everest map was used to calibrate the elevations in the DEM extraction on the 1.-band (-24 cm wavelength) channel of the radar. The resulting DEM has a grid spacing of 20 x 20 m, and covers an area that is roughly 25 km wide by 85 km long running NW-SE from north of Everest down to the Arun river. Shadows and decorrelation in the radar image pair prevent the. measurement of elevations in some areas, but 73% of the interferogram was converted to elevations.

[§] Part of the research described in this report was carried out by the Jet Propulsion Laborator y, California Institute of Technology, Pasadena, California under contract with the National Aeronautics and Space Administration.

Several quantitative geomorphic measurements have been derived from the SIR-C interferometric DEM, including hill slope angles, local relief, valley widths, and hypsometry. The hillslope angles and local relief were calculated with analysis windows of varying sizes from (-- 20 m to -1 km across) to characterize their dependence on scale. The slope of a given window size is defined as the slope of the best-fitting plane or linear term of a higher order fit for that window, while the relief is defined as the difference between the maximum and minimum elevations within the window. Statistics such as slope histograms and hypsometry (elevation histograms) were determined for the studied regions.

Hillslope angles measured with -80 m windows appear to reflect the dominance of landsliding in hillslope erosion, at least at the higher elevations. l'here is a significant difference between the slopes in the non-glaciated valleys al lower elevations where steep hillslopes reach the valley centers and the generally higher elevation glaciated areas where the slopes have a bimodal histogram with shallow slopes in the valley bottoms and steep slopes along the valley walls. 1 iven in the glaciated zones, there are still only small areas with slopes greater than about 48°. This suggests that the rock-strength limitation on slope is perhaps 4S- 50° for the medium- to high-grade crystalline rocks and shallower (35- -40°) for low-grade or sedimentary rocks. The relatively narrow range of slopes may reflect a state of self-organiz,cxl criticality where. the rocks on the hillslopes arc everywhere close to slope failure as in sandbox experiments.