PROCESS THRESHOLDS
Report of Working Group Number 3:

Leader - Richard S. Williams Jr.

The Process Thresholds Working Group concerned itself with the same issue that we had previously wrestled with during earlier meetings of the group: that is, whether a geomorphic process to be monitored on satellite imagery must be global, regional, or local in its effect on the landscape. As Prof. Dale Ritter pointed out, major changes in types and magnitudes of processes operating in an area are needed to be detectable on a global scale. One thing the group concluded from review of geomorphic studies which have used satellite images is that they do record change in landscape over time (on a time-lapse basis) that is the result of one or more processes. In fact, this may be one of the most important attributes of space imagery, in that one can document landform changes in the form of a permanent historical record.

The group also discussed the important subject of the acquisition of basic data sets by different satellite imaging systems. Geomorphologists already have available one near-global basic data set resulting from the early Landsat program, especially images acquired by Landsats 1 and 2. Such historic basic data sets can serve as a benchmarks for comparison with landscape changes that take place in the future. They can also serve as a benchmarks for comparison with landscape changes that have occurred in the past (as recorded by images, photography, maps). For instance, we have had reasonably good plane-table maps available of many areas dating back to the early 1900's and modern photogrammetric maps since the 1930's. Therefore, we have a means of using space images to look at certain types of landscape changes; for instance, coastal changes, variations in area and position of glaciers, areas covered by lava flows or tephra falls, etc. Geomorphologists have, for many regions, excellent data sets in the form of maps, aerial photographs, and satellite images. The number and diversity of data sets is expected to multiply in the future, affording more opportunities to monitor and to measure some of the geomorphic changes that have affected the planetary surface. The newly available Large Format Camera photography, although still limited in coverage, is an example of an important new data set to be exploited by geomorphologists.

Prof. Robert Sharp recommended, and the working group members all concurred, that perhaps what should be done is to design a series of natural experiments, dealing with landform changes resulting from desertification, sea level fluctuation, alluvial fan deposition, for example, in which field measurements could be combined with measurements on satellite images. One specific example Prof. Sharp suggested is the measurement of wave refraction along a coast from radar images, looking at the major attack points of erosion. One important recommendation

that could result from this workshop is, with the basic data sets that are already archived, to have NASA put together a series of funded research opportunities (A.O.'s), so that we can broaden the opportunities for research in global geomorphology beyond this group to the larger scientific community.

The members of the working group also discussed whether satellite images can be used to detect evidence of regional tilting of the terrain. Prof. Sharp noted that lakes are excellent tiltmeters, so that using time-lapse measurements of changes in lake basins are a possibility. It was also discussed by working group members that the availability of data from satellite-borne laser altimeters, when combined with the Global Positioning System, will permit precise ($\pm$ a few centimeters) monitoring of regional tilt caused by tectonic and volcanic processes.

We examined the concept of rates of change in geomorphic processes. Can we detect rates of change? Are they fast or are they slow? How far do they deviate from equilibrium conditions? Can we see some of these processes and the effects they produce on satellite images; for example, the effect of climatic change on regional lake levels, on the distribution of vegetation, on glacier advance and recession? What about human interaction with the landscape? One experiment that was discussed repeatedly involved the region of Africa known as the Sahel, especially man's interaction with changes caused by a prolonged period of subnormal rainfall. Is there a feedback function between man and the natural environment that is making conditions worse? There was a recognition that the many natural and cultural variables are very complex, but it was still considered to be the type of geomorphic experiment in regional habitability that could be done with satellite images in which changes in landforms and vegetative cover are related to man's activities.

We also discussed a number of other topics amenable to study with satellite images, including desertification such as in the Sahel, and the effect of rising sea level on coastal landforms, barrier beaches, deltas, etc. Deltas are of special interest, because they are so sensitive to changes in volume of fluvial discharge, in sea level, and in sediment load. The reduction in the area of glacier ice also suggests loss in volume of glacier ice, which is probably the primary contributor to the 15 cm. secular rise in sea level during the past century. There was an extensive discussion concerning alluvial fans. Prof. Sharp recommended another experiment in which the change in morphology of alluvial fans over time can be compared between those in the American Southwest and those in Baja California. In the latter case the regional impact of man's activities is considered to be far less than in the southwest, where road building, dam construction, alteration of vegetative cover, water-reclaimation projects, groundwater withdrawal and urbanization have severely impacted the natural environment.

Prof. Sharp also recommended the novel idea of initiating experiments that were not likely to come to fruition for one hundred years or more. He referred to the idea as the "Century Project" - sort of a time-capsule approach to scientific experimentation. Can we design experiments in which the geomorphic process has a recurrence interval which is so long that a long period of observation by satellite imaging or laser-altimeter systems would be required?

Three questions were posed by conference attendees following the presentation of Process Thresholds:

1. What about the need for indefinite archiving of data?

   To monitor and to measure landscape changes on the Earth's surface, it is extremely important that all basic data sets of image data (and eventually laser altimetry data) be permanently archived for comparative studies.

2. What about the geomorphic significance of short-lived phenomena and rare events?

   Within the resolution and spectral limitations of imaging sensors on satellites many types of short-lived phenomena and rare events can be documented; for example, surges of glaciers, landslides and other mass movements, products from explosive and effusive volcanic eruptions, accelerated erosion, dust plumes, extreme meteorological events, such as floods, tornado tracks, coastal erosion caused by severe cyclonic storms, etc.

3. What about the potential use of satellite-borne laser altimeters?

   The ability to measure profiles of "static" and "dynamic" landforms on a global basis to accuracies of a few centimeters would open a golden age in quantitative geomorphology, including important applications to comparative planetology. Geomorphologists would have a tool to conduct worldwide compartative quantitative studies of all classes of "static" and "dynamic" landforms. In the latter case are included measurements of inflation and deflation of volcanic calderas caused by upwelling and lateral movement of magma, tilt caused by volcanic and tectonic processes, changes in geometry of coastal landforms, etc. In conjunction with satellite images to give areas, laser altimeter data could also be used to determine volumetric measurements of regions covered by new lava flows or tephra falls, changes in relative volume of glaciers (area times change in thickness), etc. Laser altimeters are currently being used on aircraft in support of experiments associated with the crustal dynamics program.