REMOTE SENSING STUDY OF THE HYDROLOGIC HISTORY OF THE EASTERN SAHARA

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The region of the Gilf Kebir has never been thoroughly mapped in terms of the landforms and subsurface signs of past climates conducive to human occupation. As part of ongoing work and through a new proposal to NASA, we are generating new maps of the paleohydrology, topography, geomorphology, and surficial deposits of the area and developing GIS-based models which use the data to pinpoint past resources and travel pathways. The maps we are generating will constitute a unique resource for exploration for archeological sites in the Gilf Kebir and other regions of N Africa.

That the Sahara was favorable for human habitation at times has long been known. With the remarkable paleo-landscape revealed by the L-band (25 cm) Shuttle Imaging Radar-A in 1981, it became clear that ancient humans concentrated along integrated drainage systems dubbed “radar rivers” by McCauley et al. (1986). However SIR-A and subsequent long-wavelength radar coverage was limited and regional understanding of the drainage network has remained elusive. A complete map of the buried channels of the region could also prove useful for development of water resources in southern Egypt and northern Sudan (Robinson et al., 2006; El-Baz et al., 2007).

We are mapping the area with three sensors optimized for mapping and characterizing arid regions: The Japanese PALSAR L-band imaging radar, NASA’s SRTM, and ASTER (Fig. 1). Together these sensors allow characterization of surface and subsurface landforms formed and modified by former wetter climates. A mosaic of PALSAR images uses as a base the topographic map produced by the Shuttle Radar Topography Mission, flown in 2000 (Paillou et al., 2008). SRTM also produced C-band images, similar to those being produced by Europe’s ERS and Envisat and Canada’s Radarsat satellites which, despite their shorter wavelength (5.5 cm) and thus decreased penetration capability, have been used for mapping Sahara drainages (El-Baz et al., 2007). An advantage of the SRTM C-band images is that they are inherently registered to the topographic data and provide full, mosaicked coverage (Fig. 1b).

A third data set, visible-near infrared (VNIR) to thermal IR (TIR) images from ASTER, is being used mainly for mapping surficial landforms and vegetation. These wavelengths are sensitive to surface composition including rock types, weathering phenomena, and soil types (Fig. 1a). Vegetation also shows up well in near IR images. A unique capability of ASTER is the inclusion of several thermal IR bands. These allow increased sensitivity to composition, especially silica content, but also are capable of detecting thermal properties of the near-surface volume. Night-time thermal images have been shown to be sensitive to the bulk properties of the near-surface such as density and moisture content, as these determine the cooling rate (Fig. 1c). Combined with day-thermal images and a measure of the visible-wavelength albedo, thermal inertia, a quantitative measure of the thermal properties of a material can be derived.

Archaeologists have never had a synoptic view of the region around Gilf Kebir. In addition, the national governments of the region need a detailed map of landforms and resources for conservation efforts. The data and maps produced by this study will be unique and will be used for many years as a base for further studies of the archaeology of the region as well as other applications in hydrology, ecology, geomorphology, and tourism.

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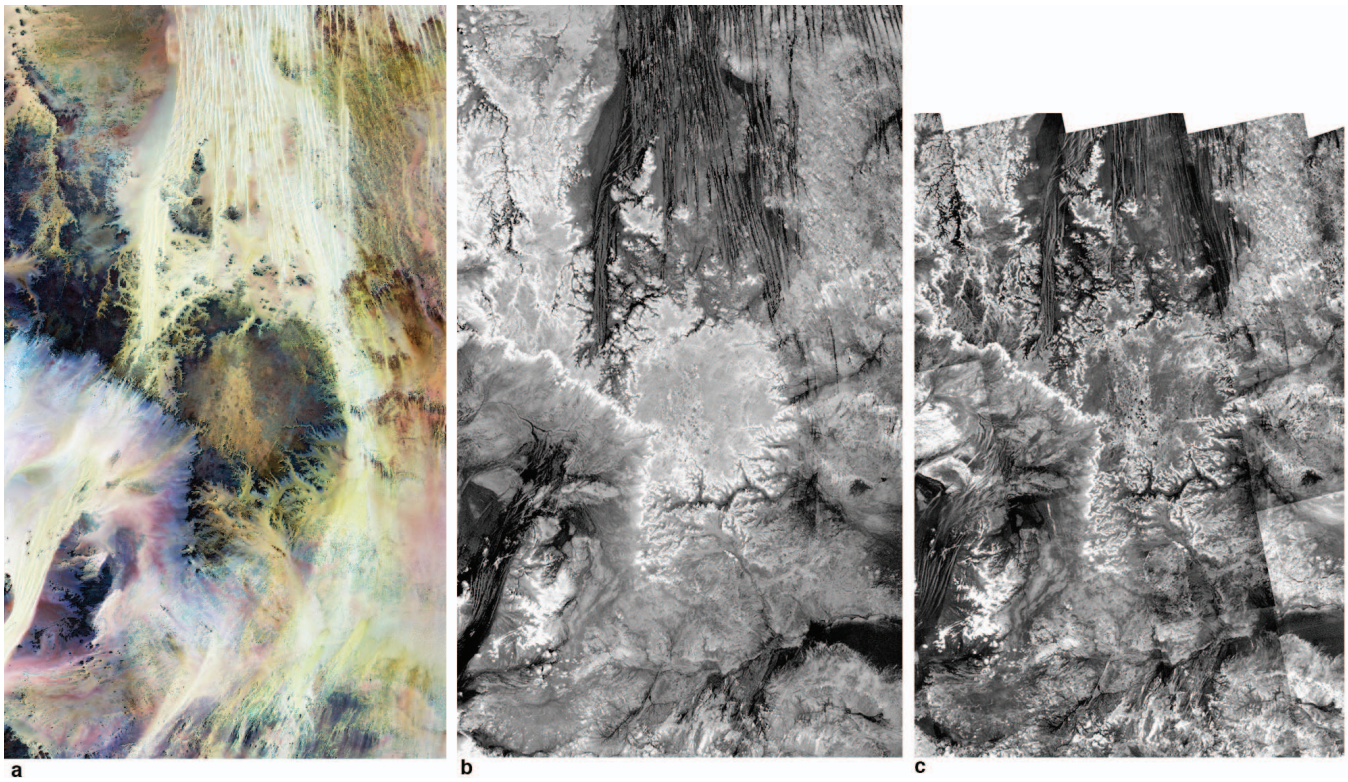

Figure 1. Images of the Gilf Kebir, Egypt.
a) Landsat Thematic Mapper mosaic from GeoCover 1990 (https://zulu.ssc.nasa.gov/mrsid/). Sand covered areas are easily discriminated from rocky areas. Other color variations reflect differences in composition of rocks and weathering products. Area covered is from 22-25° N, 25-27° E.
b) SRTM radar image mosaic of same area as a. Sand areas are generally dark except for thin covers of sand, which are penetrated by C-band (5.5 cm) radar.
c) PALSAR mosaic. Note additional structures visible on the plateau and adjacent sandy areas. In particular, some dark buried river channels are visible at the lower right in both this image and the SRTM image.

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