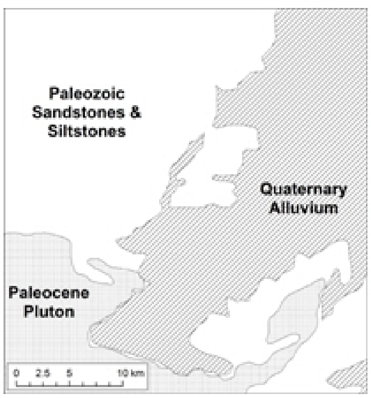
Chapter 5: *Background Information on ASTER TIR Radiance, Emissivity, and Surface Temperature Data of Ghazni, Afghanistan*

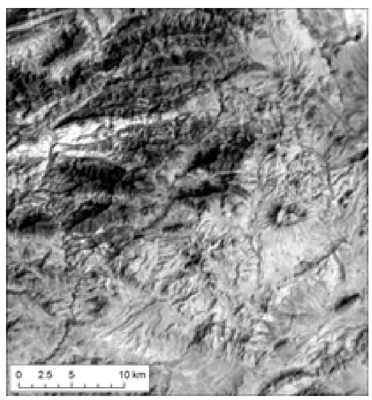
A summary image of the Ghazni TIR imagery with shaded DEM
is provided in the textbook's Figure 5-6.

Radiance Images

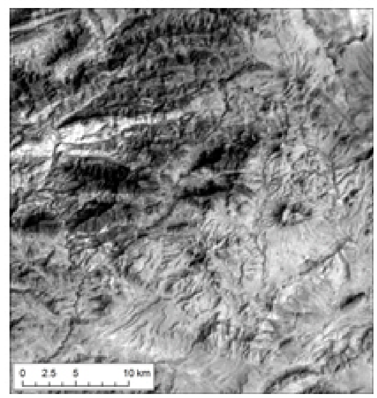
Graphics A-O below are of a subscene in mountainous terrain near Ghazni, Afghanistan. Same-scale ASTER TIR images, NASA Space Shuttle SRTM DEM, and a geologic map are provided in the collection. The ASTER TIR images in B - F and H - L were collected ~10AM local time on August 22, 2000. Topography can be seen on the TIR radiance bands (Figure B-F) because the sun has illuminated the terrain during the morning hours before image acquisition. The SRTM DEM is illuminated from the northwest to highlight the topographic relief (Figure G). The sun illuminates the terrain from the southeast direction (from the lower right), warming slopes that face southeast while slopes facing northwest are shadowed and relatively cool.



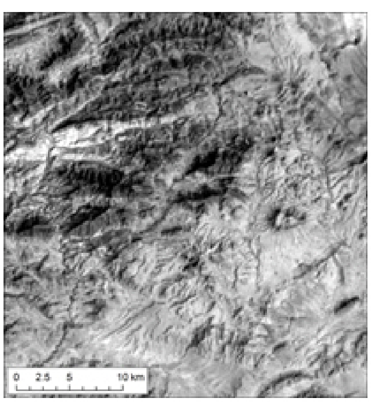
A. Geologic Map



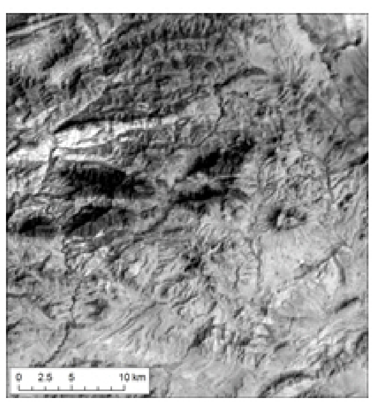
B. Band 10 Radiance



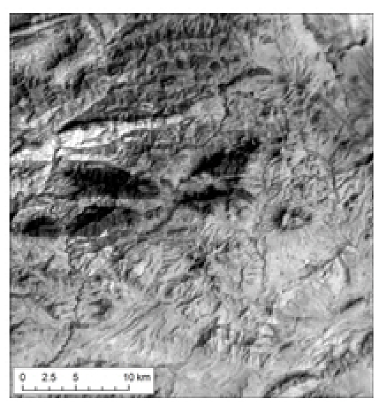
C. Band 11 Radiance



D. Band 12 Radiance

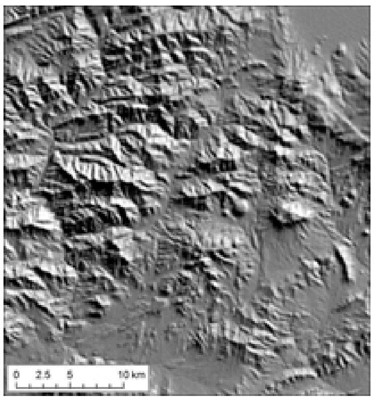


E. Band 13 Radiance

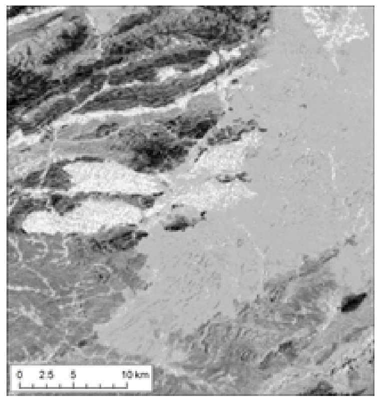


F. Band 14 Radiance

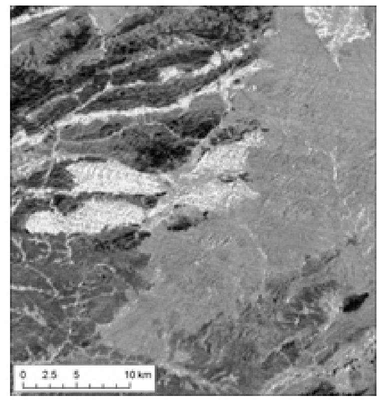
The daytime ASTER TIR bands in Figure B-F display southeast-facing slopes with brighter pixels that reveal the warmer surface temperature compared with the northwest-facing slopes that have darker pixels. The five ASTER TIR images appear very similar indicating that the radiance DN values for each band are highly correlated (Figure B-F). Darker pixels (relatively cooler) dominate the northwest while brighter pixels indicate relatively warmer terrain are widespread toward the southeast of the subscene in Figure B-F.



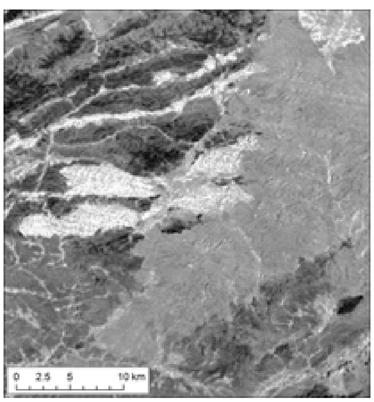
G. Hillshade DEM



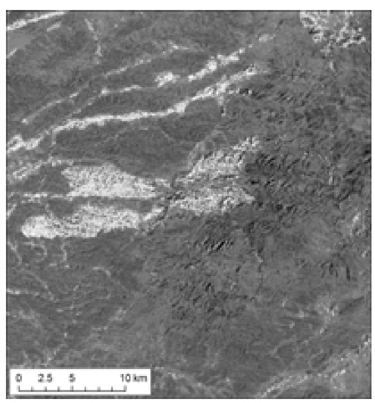
H. Band 10 Emissivity



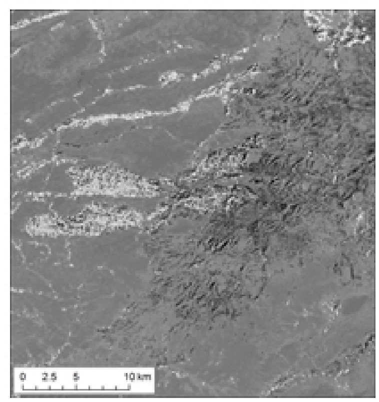
I. Band 11 Emissivity



J. Band 12 Emissivity



K. Band 13 Emissivity



L. Band 14 Emissivity

Emissivity Images

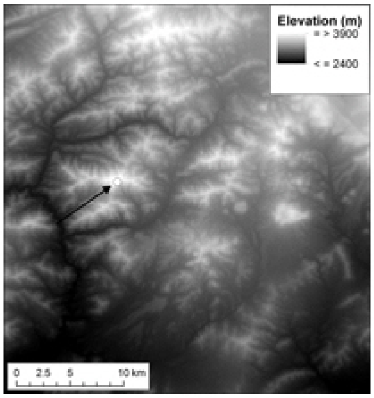
ASTER is a unique spaceborne TIR sensor because it collects 5 bands that enable *direct* surface emissivity estimates after correction for atmospheric conditions (Gillespie and others, 1998). Surface emissivity is required to derive *accurate* land surface temperature data. In addition, surface emissivity images display patterns that are not seen on VNIR, SWIR and TIR radiance images. The ASTER program generates Level 2 products, including 5 thermal emissivity bands (AST-05 product; Figures H-L) and land surface temperature data (AST-08 product; Figures N and O) from the Level 1 AST-L1T data (Gillespie and Rokugawa, 2001).

A geology map (based on Doebrich and Wahl, 2006) of Ghazni, Afghanistan is shown in Figure A. The Paleozoic (~375 million year old) sandstones and siltstones to the northwest are intruded by a granitic pluton (~60 million years old) to the south with unconsolidated sediment (less than 2 million years old) across the center and northeast deposited over the older rocks. The ASTER TIR radiance bands (Figure B-F) do not differentiate the pluton and Quaternary sediments and render the Paleozoic rocks as a dark body with a bright outcrop trending East-West. In contrast, the emissivity images reveal repeating (fault-separated) light and dark units in the Paleozoic rocks and clearly outline the Quaternary fill (Figure H-L). Shadowing due to topographic relief is subdued in the emissivity images. In addition, specific features change from dark to light tones (or vice versa) as the wavelength of the images change revealing unique spectral information about surface materials.

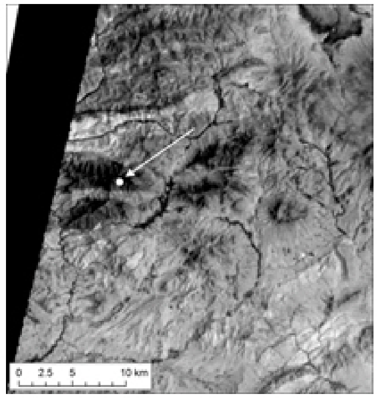
In Chapter 13 (Figure 13-40 and Plate 13-7) the ASTER TIR emissivity bands in a Afghanistan subscene are processed as band ratios (discussed in Chapter 9) to differentiate quartz-rich, carbonate-rich, and mafic-rich rocks.

Surface Temperature Images

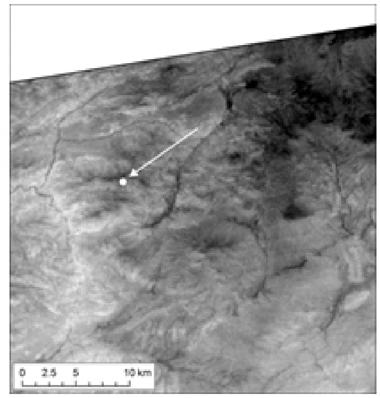
ASTER collects daytime and nighttime data that are converted to surface temperature in Level 2 products. The daytime surface temperature image for May 30, 2016 is shown in Figure N and the nighttime surface temperature image for August 31, 2013 is shown in Figure O. The entire Ghazni subscene is not acquired by these two images as their footprint center is not in the same location as the August 22, 2000 image (Figure B-F and H-L). The daytime surface temperature scene did not cover the western margin and the nighttime scene did not cover the northern margin of the Ghazni subscene (Figure N and O).



M. SRTM DEM.



N. Daytime temperature.



O. Nighttime temperature.

The surface temperature at the white dot (highlighted by the white arrow) is 28.7°C in the daytime image (Figure N) and 11.5°C in the nighttime image (Figure O) The SRTM DEM in Figure M shows the temperature site (white dot with black arrow) is located on a mountain ridge approximately 3900 m above sea level.

The daytime surface temperature image (Figure N) has a similar appearance to the radiance images (Figures B-F). Both show topographic relief as slopes facing southeast are warmer than slopes facing northwest. The northern portion of the daytime and radiance images are less similar. The surface temperature image of flat terrain in the northeast (Figure G) reveals a 30°C cool (dark) arcuate feature surrounded by warm 50°C land toward the south and 40°C land toward the north. The cooler temperatures in the arcuate feature are caused by moist soil, near surface water, and shallow groundwater. The emissivity images (Figure H-L) show this northeast flat terrain has relatively high values.

As expected, the nighttime surface temperature image (Figure O) minimizes the effect of topography and reveals new patterns that are related to soil types, geology, vegetation, surface water and groundwater. The young and relatively unconsolidated Quaternary alluvial deposits in the northeast have a cooler nighttime temperature compared with the denser Paleocene pluton and Paleozoic rocks in the west (compare Figure A to Figure O). The alluvium cools off faster at night compared with the rocks because thermal conductivity and thermal inertia are much lower in unconsolidated deposits compared with igneous and sedimentary rocks.