A SIMPLE APPROACH TO ESTIMATING SURFACE EMISSIVITY WITH THEMIS. J. F. Mustard¹, 
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Introduction: The THEMIS instrument provides unprecedented spatial resolution for investigating the surface composition of Mars [1]. However, there are significant challenges for deriving surface emissivity from the observed radiance observations because of atmospheric influences. An approach to local atmospheric correction is presented here based on the work of [2, 3]. The validity of this approach is demonstrated in a region with two overlapping THEMIS observations separated in time by 30 days or 15° of Ls. The results show that a consistent estimate of surface emissivity is derived that is sufficient to identify differences in emissivity in small outcrops near to the spatial resolution of THEMIS. This approach will be applied to other THEMIS data to explore compositional variations.

Methodology: The approach taken to correct THEMIS data for atmospheric effects and to derive emissivity is termed In-Scene Atmospheric Compensation (ISAC) [2, 3]. It is based on the governing physical equations for thermal infrared observations and a simplifying concept for atmospheric compensation. The effect of the atmosphere in the thermal IR can be approximated by the following equation:

\[ L_{\text{sat}} = T_{\theta}(\varepsilon L_{bb} + (1-\varepsilon) L_{ad}) + L_{au} \]

where \( L_{\text{sat}} \) is the measured radiance, \( T_{\theta} \) is the atmospheric transmission, \( \varepsilon \) is the surface emissivity, \( L_{bb} \) is the black body radiance of the surface, \( L_{ad} \) is the downwelling atmospheric radiance, and \( L_{au} \) is the upwelling atmospheric radiance. I assume that since \( \varepsilon > 0.9 \) for most of Mars, the second term is negligible and can be ignored. Thus atmospheric compensation can be approximated by a linear equation with a gain term (\( T_{\theta} \)) and offset (\( L_{au} \)).

For this implementation, I assume the \( \varepsilon \) of Mars is close to 1.0 in the 7.93 µm band and the atmosphere is clear and transmissive. The 7.93 µm band is then used to estimate the surface kinetic temperature and Plank’s equation is used to predict the temperature at all other THEMIS wavelengths (the 6.78 µm and 14.88 µm bands are not used in this analysis). A region of THEMIS data which has apparently homogeneous emissivity but temperature variations due to illumination is extracted and examined graphically. For each wavelength, the predicted radiance is plotted against the observed \( L_{\text{sat}} \) and for reference a 1:1 line is also plotted (Figure 1). In the absence of an atmosphere and variations in surface emissivity, the data should plot on the 1:1 line. I assume that any difference in slope is due to \( T_{\theta} \) and any difference in the intercept is due to \( L_{au} \).

Results: I applied this approach to two THEMIS data cubes acquired over the same location but approximately 30 days apart (I01687006 and I02049002) located near 16°N, 305°E. The derived atmospheric transmission and upwelling radiance for these two observations are given in Figure 2. The spectral shapes of these components have strong similarities to those derived for atmospheric dust opacity from TES and resampled to THEMIS wavelengths [4] modified by a small contribution of atmospheric ice. There is a difference in the magnitude of the corrections, with the second date indicating a slightly more dusty atmosphere.

Examination of the resulting emissivity data showed that comparable variations in emissivity are observed in the two observations. A small subset of the overlapping region is shown in Figure 3. In this THEMIS band 6, 7, 8 (RGB) color combination, purple zones can be seen (indicated by the white arrows). The cor-
responding emissivity spectra shown in Figure 4 indicate that the purple zones have consistent spectral shapes in these two independently calibrated THEMIS scenes and the surrounding regions of more typical color in this representation have relatively flat spectral shapes.

![Graph of atmospheric transmission and upwelling radiances](image1)

Figure 2. Atmospheric transmission and upwelling radiance derived for THEMIS observations I01687006 and I02049002 using the method shown in Figure 1.

![Comparison of emissivity](image2)

Figure 3. Comparison of emissivity derived for the labeled THEMIS observations, displayed in bands 6, 7, 8 (RGB). The middle image is Band 3 radiance, proportional to temperature. The scene is 12.25 km across.

Some level of confidence in the calibration is derived from the comparison of the emissivity maps to the surface temperature (shown by the middle image in Figure 3). It is evident that the observed spectral variations are not correlated with temperature as the purple regions are found on warm, intermediate, and cool surfaces. This particular emissivity variations follows the walls of the small valley and extends along the valley flow suggesting mass movement and redistribution of compositionally distinct material. The significance of the particular spectral shapes derived for these regions is uncertain at this time.

![Graph of independently derived emissivity](image3)

Figure 4. Independently derived emissivity from purple zones in Figure 3 (green and red spectra) compared to spectra from surrounding regions (blue and purple spectra).

**Conclusions:** This analysis demonstrates that high quality relative, if not absolute, surface emissivity can be derived from THEMIS data using the ISAC approach [2, 3]. It is important to note that the calibration is local in nature, assumes a homogeneous atmosphere, and does not accommodate large changes in elevation. THEMIS data show variations in surface emissivity at the limit of their spatial resolution that are consistent through time. Additional analyses are planned for regions which show significant composition variation at larger regional scales and to assess possible geologic processes.

**References:**