Method to remove illumination effects from multispectral satellite images of mountain areas without using a digital elevation model

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(This work was supported by the Research Training Group 437 at University of Bonn, and DLR-DFD)

The challenge:
In optical satellite images, slopes exposed to the sun appear much brighter than surfaces in shadow (Fig. 1/ Fig. 2).

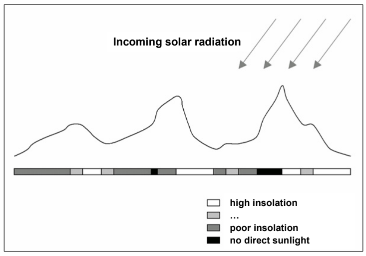


Fig. 1: Schematic illustration of illumination effects in mountain areas.

A **topographic normalisation** is most suitable to level the effects of insolation differences caused by topography. However, an accurate normalisation requires adequate digital elevation model (DEM) data, i.e. the spatial resolution of the DEM should at least be as good as the spatial resolution of the satellite image. Unfortunately, high-quality DEM data of mountain areas is not always available – or quite high-priced. Fig. 3 gives an example of a useless normalisation result of a Landsat-ETM scene due to the use of an inadequate DEM.

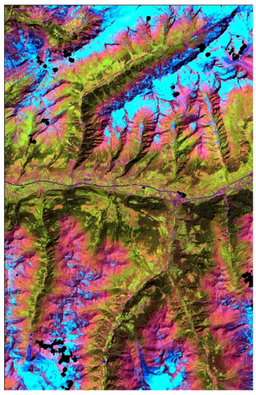


Fig. 2: Landsat-ETM image of a part of the Swiss Alps (the valley of the river Rhone in the centre oriented from East to West) with a spatial resolution of ca. 30m. (ETM bands 7, 4, and 2)

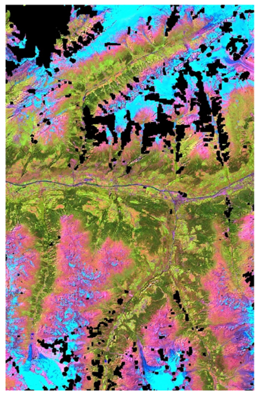


Fig. 3: Result of topographic normalisation based on SRTM C-Band DEM data with a spatial resolution of ca. 90m and numerous void areas (in black).

Alternative method based on the IHS (Intensity-Hue-Saturation) transformation:
The IHS transformation transforms three input image layers (red, green, and blue) into layers of overall light intensity, and colour hue and saturation.
As multispectral images usually include highly correlated data layers, it can be appropriate to use three layers only – in this case, the ETM channels 2, 4, and 7, i.e. visible green light, near-infrared and middle-infrared, respectively, were transformed. Then, a back transformation was carried out using a manipulated Intensity image: all pixels were set to 0.5 (corresponding to a value range of 0 to 1, Fig. 4). Thus, insolation differences were not visible anymore (Fig. 5).

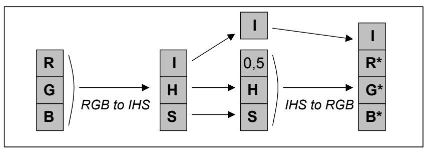
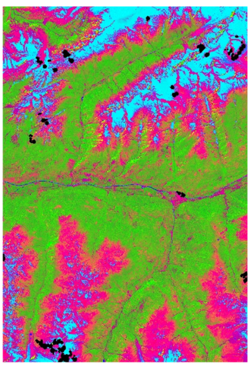


Fig. 4: Scheme of transformations carried out.



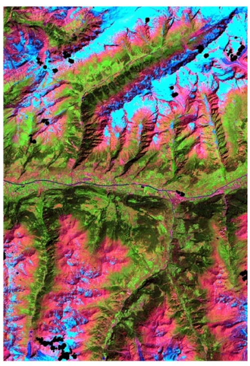


Fig. 5 (left):
Transformed ETM image (bands 7, 4, and 2). Due to the manipulation of intensity (see Fig. 4) all slopes appear equally illuminated.

Fig. 6 (middle):
Intensity image from the IHS transformation.

Fig. 7 (right):
Combined image: band 7 after transformation, Intensity, band 2 after transformation.

Results and discussion:
The transformation described above almost completely removes effects of insolation differences caused by topography (Fig. 5). However, regarding the three transformed spectral image layers, certain landscape patterns also disappear: E.g. forest areas are not anymore distinguishable from adjacent grassland vegetation. In the original image, forests appear darker as they absorb a greater fraction of the incoming solar radiation than low-vegetation surfaces.
By combining the transformed image layers with the additional layer of radiation intensity (Fig. 6), however, all landscape patterns of the original image become visible again (Fig. 7).

The method described here cannot compete with an accurate topographic normalisation which should normally be carried out. But topographic normalisations based on inadequate DEM data produce huge errors.
Interestingly, using the three transformed image layers (Fig. 5) in combination with the Intensity image from the IHS transformation (Fig. 6), better land-cover classification results have been received than based on the original image layers (the Maximum-Likelihood classifier was used). This indicates that the "separation" of light intensity from the multispectral image and the use of three transformed image layers in combination with this intensity layer can indeed facilitate Maximum-Likelihood classifications.