The effect of spatial resolution on the empirical atmospheric correction of airborne remotely sensed imagery

Nicholas Hamm (presenter and corresponding author),
Peter Atkinson and Edward Milton

Department of Geography, Southampton University,
Southampton SO17 1BJ, United Kingdom
Email: n.hamm@soton.ac.uk;
Tel: + 44 7887 578 442;
Fax: +44 23 8059 3295

This paper is to be considered for oral presentation.

This research seeks to evaluate the uncertainty in using the Empirical Line Method (ELM) to atmospherically correct airborne remotely sensed imagery from at–sensor radiance to at–surface reflectance. Specifically, the link between pixel size and accuracy of the atmospheric correction is considered. The ELM is based on a simple linear regression model, where at–surface reflectance is the dependent variable and at–sensor radiance is the predictor variable. A range of ground targets that are identifiable in the image are pre–selected. For each target, at–surface reflectance is derived from field–based measurements, defined on a pseudo–point support, made using a radiometer or spectrometer. At–sensor radiance is derived from the image data, which is defined on a pixel–sized support. Spatially coincident reflectance and radiance data are combined to form a set of data pairs that are used to estimate the parameters of the regression model, which is then used to predict at–surface reflectance over the remainder of the image.

The reflectance of three typical ground targets (concrete, asphalt and short grass) was measured using a nadir viewing multi–band radiometer. Sampling was conducted intensively on a square grid and the location of each measurement was recorded. Exceptional care was given to measuring location, with the aim of creating a 'gold standard' data set. All field measurements were made within 24 hours of a Compact Airborne Imaging Spectrometer (*casi*) and Airborne Thematic Mapper (ATM) flight. These remotely sensed data were geometrically corrected and can be processed to different spatial resolutions (pixel size), using software provided with the data. Hence, a set of images with different pixel sizes (2 m to 8 m) was produced and the accuracy of the parameter estimation and prediction in the ELM was investigated. The effect of positional uncertainty in the location of the field measurements was examined in order to investigate the effect on parameter estimation and prediction, when the ELM is implemented for images with different spatial resolution. Positional uncertainty was introduced by defining a random error term for the position of each field–measurement and simulating different realisations of the spatial distribution of the measurements. It is important to quantify this effect because researchers may not have the time or resources required to accurately and precisely determine position.

Two approaches were adopted to pair the reflectance and radiance measurements. In the first case, field measurements were paired with the spatially coincident, pixel based measurement of reflectance. This approach is straight–forward, but was shown to be conceptually problematical, since the two variables were defined on different spatial supports and, therefore, have different statistical characteristics. This leads to an unrealistically high accuracy for parameter estimation and prediction using the ELM. Furthermore, for the ELM, parameter estimation and prediction were sensitive to positional accuracy of the field data for all sample sizes and particularly ones with less than 20 measurements per target. For 3 m pixels, this was shown to lead to a constant bias of up to 1% (reflectance) and the introduction of variation in the slope of the regression line, which can lead to a deviation of up to 3% (reflectance) in the prediction of reflectance. A plot was constructed demonstrating the relationship between sample size and parameter estimation accuracy for a given pixel size and level of positional uncertainty. This was then extended to compare the impact for images with different pixel sizes. For example, for 6 m pixels, the bias remained but the variation in the slope of the regression line was reduced.

In the second case, the geostatistical techniques of block kriging and block conditional simulation were used to aggregate the field measurements to the same support as the pixels. This was shown to be conceptually more robust, since it explicitly aims to match the statistical properties of the two variables, resulting in a more accurate representation in parameter estimation and prediction, based on the ELM. Furthermore, for the full sample, this approach was shown to be insensitive to positional uncertainty of the field measurements. An apparent disadvantage is that the block kriging and simulation inherently require a large sample size (more than 100 measurements per target). However, it should be noted that, in the presence of positional uncertainty, the former approach also requires a large sample size, in order to achieve accurate estimation and prediction. Early results demonstrate that, for the 6 m pixel size a lower sample size and longer (distance) sampling interval is required to achieve the same level of accuracy as for the 3 m pixel size. Current work is directed at quantifying this effect in greater detail. However, the implication is that higher positional uncertainty can be tolerated, since prediction at short lags is less critical. The practical outcome is that we can determine the required sample size, measurement spacing and positional accuracy for a stated level of prediction accuracy (i.e. from the ELM) and pixel size.