Satellite sensor calibration

Spectral data acquired by satellite sensors are influenced by a number of factors, such as atmospheric absorption and scattering, sensor-target-illumination geometry, sensor calibration, and image data processing procedures, which tend to change through times.

Targets in multi-date scenes are extremely variable and have been nearly impossible to compare in an automated mode. In order to detect genuine landscape changes as revealed by changes in surface reflectance from multi-date satellite images, it is necessary to carry out radiometric correction.

Two approaches to radiometric correction are possible: absolute and relative. The absolute approach requires the use of ground measurements at the time of data acquisition for atmospheric correction and sensor calibration.

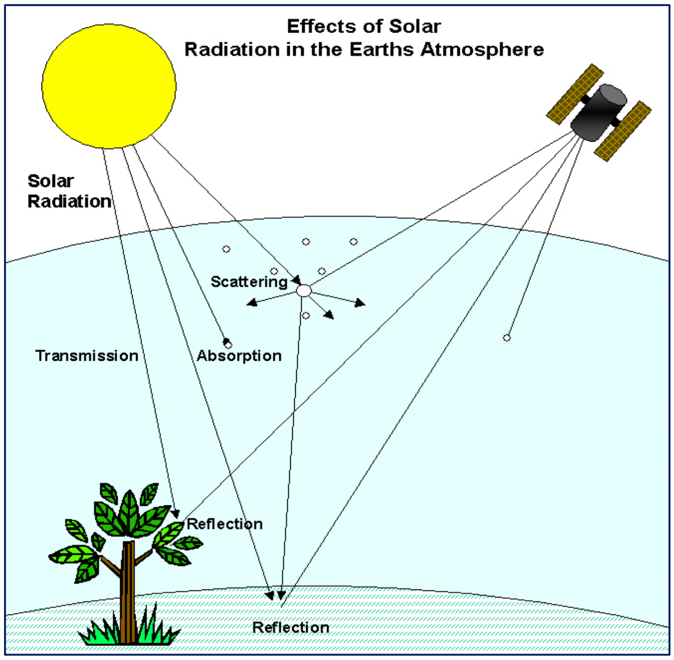
This is not only costly but also impractical when archival satellite image data are used for change analysis. The relative approach to radiometric correction, known as relative radiometric normalization (RRN), is preferred because no in-situ atmospheric data at the time of satellite overpasses are required.

This method involves normalizing or rectifying the intensities or digital numbers (DN) of multi-date images band-by-band to a reference image selected by the analyst. The normalized images would appear as if they were acquired with the same sensor under similar atmospheric and illumination conditions to those of the reference image.

Atmospheric Correction by FLAASH model

Signals recorded by sensor contain noise and not the ground surface value due to atmospheric effects such as scattering, absorption and path radiance while signal transmitting in atmosphere.

It’s essential to remove the noise and correct atmospheric effects, especially, for multi-temporal land use/cover change analysis and land degradation monitoring and classification.



FLAASH (Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubus) Model employs the MODTRAN (MODerate resolution atmosphere TRANsmission) theory to conduct atmospheric correction.

It starts from a standard equation for spectral radiance at a sensor pixel, L that applies to the solar wavelength range and flat, Lambertian materials or their equivalents. The equation is as follows:

$$FLAASH = \left(\frac{A\rho}{1-\rho_e S}\right) + \left(\frac{B\rho_e}{1-\rho_e S}\right) + La$$

Where: ρ is the pixel surface reflectance , ρ_e is an average surface reflectance for the pixel and a surrounding region S is the spherical albedo of the atmosphere L_a is the radiance back scattered by the atmosphere A and B are coefficients that depend on atmospheric and geometric conditions but not on the surface.

Each of these variables depends on the spectral channel; the wavelength index has been omitted for simplicity. The first term in this equation corresponds to radiance that is reflected from the surface and travels directly into the sensor, while the second term corresponds to radiance from the surface that is scattered by the atmosphere into the sensor. The distinction between ρ and ρ_e accounts for the adjacency effect (spatial

mixing of radiance among nearby pixels) caused by atmospheric scattering. To ignore the adjacency effect correction, set $\rho e = \rho$. However, this correction can result in significant reflectance errors at short wavelengths, especially under hazy conditions and when strong contrasts occur among the materials in the scene.

The values of $\{A, B, S \text{ and } La\}$ are determined from calculations of MODTRAN (MODerate resolution atmospheric TRANsmission), an atmospheric radiative transfer model developed by the Air Force Research Laboratory, USA. MODTRAN calculations use the viewing and solar angles and the mean surface elevation of the measurement, and they assume a certain model atmosphere, aerosol type, and visible range.

The values of $\{A, B, S \text{ and } La\}$ are strongly dependent on the water vapor column amount, which is generally not well known and may vary across the scene. To account for unknown and variable column water vapor, the MODTRAN4 calculations are looped over a series of different column amounts, then selected wavelength channels of the image are analyzed to retrieve an estimated amount for each pixel.

The FLAASH Model is developed for moderate resolution data such as MODIS but also suitable for Landsat, SPOT, ASTER and other satellite data. The advantage of this approach lies in its good correction of the shaded area. The correction procedure for Landsat images is unfurled as follows:

1) Calibration of Landsat images into radiance;

2) Conversion from BSQ format into BIP;

3) Import BIP file into FLAASH package, set output files name, all parameters including satellite platform and overflight time, and atmospheric models (see table A8);

4) Multispectral setting and advanced setting, and then “apply”

Application FLAASH model with ENVI as training