

Improvements in Aerosol Retrieval for Atmospheric Correction

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Accurate first-principles atmospheric correction (or compensation) that converts Visible-NIR-SWIR hyperspectral or multispectral imagery data to surface reflectance units requires an estimate of the scene visibility / aerosol optical depth. This paper describes some recent aerosol upgrades to the FLAASH (Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes) code, a MODTRAN-based atmospheric correction algorithm developed by Spectral Sciences, Inc. in collaboration with the US Air Force Research Laboratory. A commercial version of FLAASH is available within the ENVI software package from ITT Visual Information Systems. FLAASH utilizes an automated two-band method based on the work of Kaufman and Tanré for retrieving an average scene visibility from dark pixels such as green vegetation or deep, clear water. This visibility estimate is then combined with a MODTRAN aerosol model to describe the atmosphere. Recently, a research version of FLAASH was upgraded to improve both visibility retrieval and atmospheric correction accuracy, and to enable visibility retrieval in problematic cases where the current FLAASH algorithm fails. These improvements result in better handling of highly off-nadir viewing geometries, scenes with high aerosol optical depth, sensors lacking infrared spectral channels and scenes lacking dark vegetation and water bodies.

The original FLAASH and Kaufman-Tanré methods start with an assumed visibility and identify dark pixels using an infrared wavelength (typically near 2 μm) at which reflectance retrieval is ordinarily insensitive to visibility. However, this method is inaccurate when there is high aerosol loading or a very long path to the sensor, or when the method is applied to shorter wavelengths. In the upgraded algorithm, the pixel selection is visibility-dependent, enabling identification of useful dark vegetation and water bodies in these difficult cases. In addition, the method improves accuracy under more benign conditions, as evidenced by improved consistency between visibility estimates derived from water and land pixels. In very dry (for example desert) scenes, water and vegetation are lacking, and Kaufman-Tanré-type methods fail. Here, an automated linear regression method shows promise for estimating dark-pixel reflectance ratios directly from the data.

An important feature of FLAASH for high-aerosol scenes and off-nadir viewing is its modeling of the adjacency effect that mixes the spectrum of the direct line-of-sight pixel with its neighbors in the diffuse transmittance term of the radiation transport equation. For better treatment of this effect, a more accurate adjacency point spread function (PSF) has been implemented that accounts for wavelength dependence as well as asymmetry in off-nadir viewing.

The FLAASH upgrades are illustrated with applications to a variety of data from multispectral and hyperspectral sensors. Of particular interest is a data set acquired by the Hyperion sensor under extreme off-nadir conditions, which includes archival data taken in 2004 and a custom data collect conducted near Davis, CA in June 2005. These Hyperion images were taken at an off-nadir viewing angle of nominally 63°, corresponding to only a 9° angle above the horizontal at the ground and a viewing line-of-sight through approximately six air masses. While this steep viewing angle severely limits the spatial resolution of the retrieved surface reflectance, the data are useful for aerosol retrieval and as a stressing test of the ability to remove strong atmospheric features.