Pseudo Invariant Calibration Sites (PICS): An overview of calibration methodologies

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Abstract

Radiometric calibration using sites on the Earth's surface that are essentially invariant over time has been used for more than a decade. These sites are commonly referred to as Pseudo Invariant Calibration Sites, or PICS, and are located in regions where rainfall is extremely limited preventing any vegetative growth and, therefore, have very sparse human populations. Thus, these sites are spatially very uniform, have stable spectral responses over time and, with their high surface reflectance, atmospheric effects on upwelling radiance is minimal. Because of these attractive features, these sites have been long considered as a benchmark for on-orbit calibration and are primarily located across the Saharan desert in North Africa. In this paper we identify the best PICS by assessing temporal stability using hundreds of cloud free acquisitions made by the Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and MODIS Aqua and Terra. These instruments have been extremely stable since launch and are still successfully operating for over a decade. Once the top PICS have been identified, it will be shown that these sites can be used to monitor long term stability of satellite sensors and gain changes as small as 0.2% per year can be precisely measured using images acquired from PICS such as the well-known Libya 4 site. This knowledge of PICS can further be extended for cross calibration among various imaging platforms. Cross calibration is a vital step not only to establish the relative calibration of the satellite sensors but also to ensure that data from multiple sensors can be used to provide a consistent set of measurements. This can be achieved using PICS with surprisingly small measurement uncertainties. As an example, results obtained from cross calibration of OLI and ETM+ performed over Libya 4 PICS will be presented. In addition to stability monitoring and cross calibration, PICS alone have the potential to be used for absolute calibration purposes using an empirical approach as well as a first principles method. As an example, a simple empirical model is developed using Libya 4 PICS using observations by Terra MODIS and Hyperion. Results of validation of this model will be presented from several satellite images such as L8 OLI, Aqua MODIS, and UK-2 DMC. It will be shown that it is possible with PICS to develop an empirical absolute calibration model with accuracies of 3% or better across the spectrum from visible to SWIR regions. Finally, the paper will present the use of PICS for first principles based absolute calibration using the sun as the source, a surface reflectance model of the PICS target, and a full atmospheric model using inputs from multiple databases to drive a

MODTRAN radiative transfer model. Thus, use of PICS can provide an independent, low-cost, reliable, and repeatable source for monitoring the on-orbit calibration of optical satellite sensors.