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HJ-1A Thermal Infrared Band Cross-Calibration and Validation

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Abstract

HJ-1A, one satellite of the small satellite constellation for environment and disaster monitoring and forecasting (SSCEDMF), has been launched by China in September, 2008. Calibration and validation is integrant for every quantitative geophysical science applications. Its thermal infrared channel wavelength, covered from 10.5um to 12.5um, is corresponding to the combination of MODIS channels 31(10.78~11.28um) and 32(11.77~12.27um).The MODIS is used as the reference sensor, since their radiometric coefficients is updated by MCST team in time. Cross-calibration is an effective and economical calibration approach for HJ-1A thermal infrared camera, because the calibration coefficients could be acquired without synchronous site measurement[1][3]. The article is based on MODIS channels 31 and 32, using TIGR database to cross-calibrate HJ-1A's thermal infrared channel 4. In the cross-calibration processing, the band matching factor is the key factor that determines the calibration precision[4]. This article applied the MODIS SST (Sea Surface Temperature) product algorithm to calculate the band matching factors, which would improve the calibration precision. Research demonstrates that cross-calibration method is effective to HJ-1A thermal infrared channel.

The study area is a lake in the west of China, and the imaging time is in October and November. There are four steps to cross-calibrate HJ-1A channel 4 using MODIS channels 31 and 32. 1) Select water area that be covered by MODIS and HJ-1A images at the same time or at least the interval time no more than 30 minutes[5]. Since the temperature of water has little changes in half hour, it is regarded that the water conditions are similar when MODIS and HJ-1A pass the common covered areas. 2) Use Modtran 4.0, the radiance translation model, to calculate the apparent radiance on different atmosphere conditions which can be gained from TIGR database. We choose the number 711~1064 datum from TIGR database, which is measured in middle latitude winter put into Modtran4.0. TIGR database contains atmospheric pressures, atmospheric temperatures, water vapor contents, ozone contents and other gases contents at different altitudes which are needed as input parameters to Modtran4.0. The CO_2 content input parameter is set to 365ppm. The observer angle input parameters are set the

same as the common covered area images. 3) Radiant temperature and band matching factors calculation. It's easy to change the simulated apparent radiance acquired at step 2 to radiant temperature with channel spectral replied function. Compare with MODIS channels 31 and 32's bandwidth (0.5um), HJ-1A channel 4 has a large bandwidth (2um), so it's not appropriate to use either MODIS channel 31 or channel 32's radiant temperature to calculate the band matching factors with HJ-1A channel 4. At this time, MODIS SST product algorithm is applied to get the band matching factors between HJ-1A channel 4 and MODIS channels 31 and 32. The formula is that[2]:

$$T_4 = a + bT_{31} + c(T_{32} - T_{31}) + d(T_{32} - T_{31})(\sec(\theta) - 1)$$

T4, T31 and T32 are the simulated radiant temperatures of HJ-1A channel 4, MODIS channels 31 and 32. θ was MODIS zenith angle. a, b, c and d are the band matching factors. 4) Calculate HJ-1A channel 4 calibration coefficients from the images，which have been selected at step 1 with the formula showed at step 3. At this step, the unknown variable in the formula is T_4. After get T_4 value, use formula $T_4 = (DN - offset) / scale$ to get the HJ-1A channel 4 calibration coefficients, offset and scale.

Through cross-calibration method, the HJ-1A channel 4's calibration coefficients are obtained. Validated with the calibration coefficients get by on-satellite-calibration-system using images in other dates, the uncertainty of the apparent radiance is within 6%. Cross-calibration method is feasible and effective.

KEYWORDS: HJ-1A, cross-calibration, validation

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