Converting Advanced Himawari Imager (AHI) Radiance Units

Mathew M. Gunshor
Cooperative Institute for Meteorological Satellite Studies (CIMSS)
University of Wisconsin-Madison
E-mail: matg@ssec.wisc.edu

24 February 2015

Acknowledgements

Thanks to Frank Padula, Changyong Cao, and other GOES-R Calibration Working Group (CWG) members for their help with this subject matter.

Introduction

The Advanced Himawari Imager (AHI) on Japanese Meteorological Administration (JMA) geostationary satellite Himawari-8 uses units based in wavelength space (W/m2 sr um). Software at the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison to convert between radiance and brightness temperature (K) is predicated on radiance units being in wavenumber space (mW/m2 sr cm-1). Additionally, Advanced Baseline Imager (ABI) radiances on GOES-R will be in wavenumber space for the infrared bands (7-16). Converting between the two units was explained in a GOES-R Calibration Working Group (CWG) memo to the GOES-R Imagery Team dated 04 March 2011, by Frank Padula and Changyong Cao (Padula and Cao, 2011). The next section is simply repeating what Padula and Cao (2011) presented in their Appendix A here as "Methodology," which was also documented previously in Cao and Heidinger, 2002.

Methodology

At sensor radiance (L_s) is defined as:

$$L_s = \int_{\lambda_1}^{\lambda_2} L \; R_\lambda^{'} \; d\lambda \qquad \left[\frac{mW}{m^2 sr} \right] \tag{1}$$

where L is the sensor reaching radiance, $R_\lambda^{'}$ is the peak normalized spectral response function for a given band. To obtain the desired effective spectral radiance reaching the sensor, Eq. 1 must be divided by the unique band equivalent width:

$$L_{eff} = \frac{\int_{\lambda_1}^{\lambda_2} L\ R_\lambda^{'}\ d\lambda}{\int_{\lambda_1}^{\lambda_2} R_\lambda^{'}\ d\lambda} \qquad \left[\frac{mW}{m^2 sr\ cm^{-1}}\right]$$

$$L_{eff} = \frac{\int_{\lambda_1}^{\lambda_2} L\ R_\lambda^{'}\ d\lambda}{\int_{\lambda_1}^{\lambda_2} R_\lambda^{'}\ d\lambda} \rightarrow Band\ \ Equivalent\ Width = Eqw = \int_{\lambda_1}^{\lambda_2} R_\lambda^{'}\ d\lambda \qquad (2)$$

where L_{eff} is the effective spectral radiance reaching the sensor, $R_\lambda^{'}$ is the peak normalized spectral response function for a given band. Note that the band Eqw has units which are dependent upon the units provided in the spectral response file either [wave-number or wavelength]. By convention $R_{\lambda\,wn}^{'}$ illustrates an Eqw [wave-number], where $R_{\lambda\,wvl}^{'}$ illustrates an Eqw [wavelength].

To convert band integrated values from wave-number space to wavelength space and vice versa, the band equivalent width (Eqw) is used. Below describes the processing steps that should be followed. The conversion from wavelength to wavenumber is shown; note that the same process can be applied to perform the opposite conversion. The equivalent width values for the SRFs are provided in Table 1.

Converting from Radiance (wavelength) to Radiance (wavenumber)

1. Multiply the Radiance [W/m^2 sr µm] by the Band Eqw [wavelength]
2. Divide by the band Eqw [wavenumber]
3. Multiply by 1,000 to convert from mW to W and end with the units of mW/m^2 sr cm^{-1}

L (mW/m^2 sr cm^{-1}) = 1000 * L (W/m^2 sr µm) * Band Eqw (µm) / Band Eqw (cm^{-1}) (3)

Solving for L (W/m^2 sr µm) in Equation 3 yields the equation for reversing this radiance units conversion.

Results

Table 1: AHI SRF band Eqw's, calculated from SRFs in wavenumber (cm-1) space.

Band	Band Eqw [cm-1]	Band Eqw [µm]
1	1681.7426	0.0372
2	1193.2556	0.0310
3	1959.5901	0.0797
4	454.2692	0.0333
5	156.7802	0.0406

6	86.8886	0.0442
7	128.4881	0.1938
8	202.4208	0.7853
9	83.0784	0.3999
10	34.5939	0.1867
11	50.2733	0.3710
12	39.8769	0.3702
13	35.5892	0.3853
14	54.2544	0.6846
15	62.1522	0.9509
16	31.2614	0.5511

References

Cao, C., and A. Heidinger, 2002, Inter-Comparison of the Longwave Infrared Channels of MODIS and AVHRR/NOAA-16 using Simultaneous Nadir Observations at Orbit Intersections, Earth Observing Systems, VII, Edited by W. Barnes, Proceedings of SPIE Vol. 4814, pp.306-316. Seattle, WA.

Padula, Frank and Changyong Cao, 2011, CWG Analysis: ABI Max/Min Radiance Characterization and Validation, a memorandum to the GOES-R Algorithm Working Group Imagery Team dated 04 March 2011.