TOA REFLECTANCE CONVERSION OF KOMPSAT IMAGERY

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1. DN to TOA reflectance conversion of KOMPSAT imagery

The top-of-atmosphere (TOA) reflectance is an important physical value to compare products from different sensors. In this document, the methodology to convert digital number (DN) of KOMPSAT imagery to TOA reflectance is explained and related parameters are given.

The relationship between the TOA radiance and DN of KOMPSAT imagery is expressed as follows:

$$L_\lambda = Gain \times (DN) + Offset$$

where L_λ is the band-averaged spectral radiance at wave length λ predicted at the sensor ($Wm^{-2}sr^{-1}\mu m^{-1}$) and *Gain* and *Offset* are sensor specific values to be provided.

The TOA reflectance is calculated by following equation:

$$\rho_\lambda = \frac{\pi L_\lambda d^2}{(ESUN_\lambda)\cos\theta_s}$$

where ρ_λ is the TOA reflectance, *d* is the earth-sun distance (astronomical unit), $ESUN_\lambda$ is band-dependent mean solar exo-atmospheric irradiance ($Wm^{-2}\mu m^{-1}$), and θ_s is solar zenith angle.

2. KOMPSAT-3 & KOMPSAT-3A parameters

Following table shows *Gain* to be used for the calculation of TOA radiance from DN of KOMPSAT-3 imagery updated through filed campaign in 2014 and ESUN to be used for TOA reflectance calculation. The *Offset* for each band equals to zero due to dark current compensation.

The given parameters are verified by comparing the TOA reflectance from KOMPSAT-3 products and Landsat-8 products over well-known radiometric cal/val sites. The average difference in TOA reflectance between KOMPSAT-3 and Landsat-8 imagery over Libya 4, Libya and Railroad Valley Playa, USA in the visible (red, green, blue) region was under 3% [1].

Band	Gain ($Wm^{-2}sr^{-1}\mu m^{-1}$)	ESUN ($Wm^{-2}\mu m^{-1}$)
MS1 (Blue)	0.01811	2001.28
MS2 (Green)	0.02541	1875.46
MS3 (Red)	0.02023	1524.52
MS4 (NIR)	0.01300	1027.38
PAN	0.02023	1441.00

Table 1. Gain and ESUN for KOMPSAT-3 (2014)

Band	Gain ($Wm^{-2}sr^{-1}\mu m^{-1}$)	ESUN ($Wm^{-2}\mu m^{-1}$)
MS1 (Blue)	0.024860	2001.28
MS2 (Green)	0.017997	1875.46
MS3 (Red)	0.017881	1524.52
MS4 (NIR)	0.010677	1027.38
PAN	0.032926	1471.88

Table 2. Gain and ESUN for KOMPSAT-3A (2015)

3. KOMPSAT-2 parameters

Following tables show *Gain* to be used for the calculation of TOA radiance from DN of KOMPSAT-2 imagery and ESUN to be used for TOA reflectance calculation. For the detailed information, please refer [2]. Because two TDI sets are used for KOMPSAT-2, proper *Gains* shall be selected in accordance to MS TDI index in auxiliary file. However, in most cases, the TDI set of 3-4-1-2 is used for KOMPSAT-2. Also, it is noted that the order of bands is different from that of KOMPSAT-3 products.

Band	TDI Index	Gain ($Wm^{-2}sr^{-1}\mu m^{-1}$)	ESUN ($Wm^{-2}\mu m^{-1}$)
MS1 (Green)	3	0.124692	1838
MS2 (Blue)	4	0.117581	1915
MS3 (NIR)	1	0.135002	1075
MS4 (Red)	2	0.157563	1534

Table 3. Gain and ESUN for KOMPSAT-2 (TDI High)

Band	TDI Index	Gain ($Wm^{-2}sr^{-1}\mu m^{-1}$)	ESUN ($Wm^{-2}\mu m^{-1}$)
MS1 (Green)	2	0.249385	1838
MS2 (Blue)	3	0.235162	1915
MS3 (NIR)	0	0.486010	1075
MS4 (Red)	1	0.315127	1534

Table 4. Gain and ESUN for KOMPSAT-2 (TDI Low)

4. Reference

[1] Kim, Jinsoo *at al*, “Radiometric characterization and validation for the KOMPSAT-3 sensor” in International Journal of Remote Sensing, accepted, doi: http://dx.doi.org/10.1080/2150704X.2015.1054043

[2] Lee, Sungu *at al*, “Absolute radiometric calibration of the KOMPSAT-2 multispectral camera using a reflectance-based method and empirical comparison with IKONOS and QuickBird images” in Journal of Applied Remote Sensing, Vol. 6, 2012