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Newsletter–Spring 2017 Issue

Manik Bali, Editor

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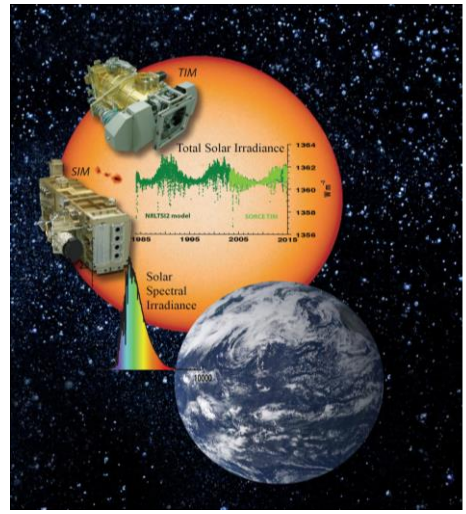
GSICS-Related Publications

Himawari-8 and -9 (image courtesy of JMA)



The TSIS TIM and SIM instruments (scheduled for launch Nov, 2017, image curtesy of Odele Coddington).

Inter-comparison of Himawari-8/-9 AHI using a GEO-GEO approach

by Hidehiko Murata, Tasuku Tabata, Arata Okuyama and Masaya Takahashi (JMA)

The Japan Meteorological Agency's new-generation Himawari-8 geo-stationary meteorological satellite began operation in July 2015. The identically configured Himawari-9 was launched on 2 November 2016 and was put into in-orbit standby as backup for Himawari-8 on 10th March 2017 after in-orbit testing. This set-up will help to ensure the stability of satellite observation for the East Asia and Western Pacific regions for 15 years. Himawari-8 and 9 feature new Advanced Himawari Imager units (referred to here as AHI-8 and AHI-9) with a sensor configuration similar to that of the Advanced Baseline Imager (ABI) on the GOES-16 satellite.

For calibration of observation data, the AHI has a solar diffuser serving as a solar calibration target for six visible and near-infrared bands (i.e., those with central wavelengths of 0.47, 0.51, 0.64, 0.86, 1.6 and 2.3 microns), and a blackbody serving as an internal calibration target for ten infrared bands (i.e., those with central wavelengths of 3.9, 6.2, 6.9, 7.3, 8.6, 9.6, 10.4, 11.2, 12.4 and 13.3 microns). JMA has been validating AHI-8 data quality based on the GEO-LEO technique (involving inter-calibration and vicarious calibration [1]), lunar calibration and other approaches.

These calibration and validation methods have been developed via

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international collaboration with NOAA [2], EUMETSAT and GSICS member agencies in addition to collaborative research with the Atmosphere and Ocean Research Institute at the University of Tokyo. This article reports on AHI-9 validation using some of these approaches. Tables 1 and 2 summarize the results for all 16 AHI-8 and -9 bands. For visible and near-infrared bands (Table 1), radiances were validated based on 1) comparison with top-of-atmosphere radiance computed via radiative transfer simulation (vicarious calibration) and 2) a ray-matching approach with reference to S-NPP/VIIRS. Estimated radiance biases of AHI-9 from the vicarious calibration approach were +2.9 and -5.5% for Band 1 and Band 6, but the biases for other bands were less than +/- 2.0%. The ray-matching approach provided results consistent with those of the vicarious calibration approach for Band 1 and Band 6. Infrared inter-calibration (Table 2) with reference to hyperspectral infrared sounders such as Metop-A/IASI showed that brightness temperature biases for AHI-9 are in the same order as those validated for AHI-8 [less than 0.25 K for standard scenes (i.e., simulated brightness temperature for the US standard atmosphere)] in all ten infrared bands.

The frequent full-disk observations conducted by AHI-8 and -9 (with a repeat cycle of 10-minutes) also enable application of the highly useful GEO-GEO comparison approach. Although the GEO-GEO approach is a relative comparison method without accurate reference sensor such as IASI and VIIRS, the huge amounts of collocated data enable identification of calibration issues (such as diurnal variation of biases, stray light and banding) on a real-time basis. In this study, AHI-8 and -9 Himawari Standard Data from the same observation time and the same

Instrument	Method	B01	B02	B03	B04	B05	B06
AHI8 [%]	Vicarious cal.	-1.6	-2.6	+0.7	+1.6	+4.6	-3.0
	Ray-matching	-2.5	+1.1	+1.9	+0.6	+6.6	-4.5
AHI9 [%]	Vicarious cal.	+2.9	-1.9	-1.8	+0.0	-1.2	-5.5
	Ray-matching	+3.2	+2.8	+0.4	-0.0	+0.6	-6.2
AHI9/AHI8 [%]	Vicarious cal.	+4.6	+0.7	-2.5	-1.6	-5.5	-2.5
	Ray-matching	+5.8	+1.7	-1.5	-0.7	-5.6	-1.8
	GEO-GEO	+4.8	+1.0	-2.2	-1.5	-5.8	-2.0

Table 1(Above). Estimated observation biases of AHI-8 and -9 for visible and near-infrared bands (in scaled radiance [%] for vicarious calibration and GEO-GEO approaches, and in reflectance [%] for ray-matching approach). Observation data for the period from 14 to 28 February 2017 for AHI-8 and AHI-9 are used in these approaches. AHI-9 calibration coefficients other than offset terms were determined based on pre-launch ground testing whereas AHI-8 calibration slopes were updated on 8 June 2015 to reflect the solar diffuser viewing data collected in orbit.

GEO	Reference Transfer Instrument	B07	B08	B09	B10	B11	B12	B13	B14	B15	B16
AHI8 [K]	IASI-A	-0.13	-0.24	-0.25	-0.14	-0.09	-0.25	-0.01	0.00	-0.08	+0.05
	(Std. scene)	286.0	234.7	243.9	254.6	283.8	259.5	286.2	286.1	283.8	269.7
AHI9 [K]	IASI-A	-0.08	-0.25	-0.04	-0.15	-0.12	-0.20	-0.10	-0.11	-0.13	-0.23
	(Std. scene)	286.0	234.8	244.2	254.8	283.9	259.3	286.2	286.2	283.9	268.5
AHI9-AHI8[K]	IASI-A	+0.05	-0.01	+0.21	-0.01	-0.03	+0.05	-0.09	-0.11	-0.04	-0.28
	GEO-GEO	+0.05	-0.03	+0.19	-0.02	-0.02	+0.06	-0.05	-0.08	-0.02	-0.25
	(SRF offset)	+0.15	-0.03	+0.16	-0.03	-0.01	-0.14	+0.00	+0.03	+0.04	-1.35

Table 2(Above). Estimated observation biases of AHI-8 and -9 in brightness temperature [K] at standard scene for infrared bands. Observation data for the period from 14 to 28 February 2017 for AHI-8 and AHI-9 are used in these approaches. Only results from nighttime Metop-A/IASI (10 – 14 UTC) and corresponding AHI data are shown.

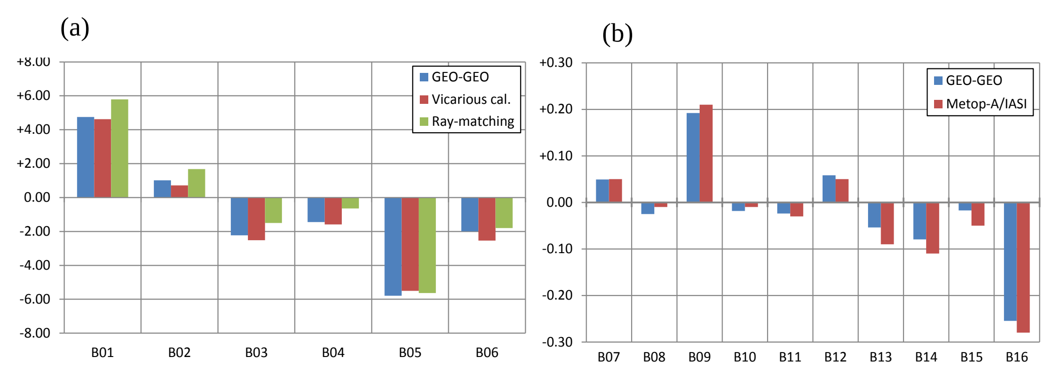

Figure 1. Consistency of different approaches in terms of (a) ratios of AHI-9/AHI-8 [%] for visible and near-infrared bands, and (b) differences in AHI-9 and AHI-8 biases [K] for infrared bands.

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band were averaged for areas of 19 x 19 pixels and compared in terms of scaled radiance (for visible and near-infrared bands) and brightness temperature (for infrared bands).

The difference in optical path length is not taken into account since the satellites are located approximately 0.1 degrees apart at 140.7 degrees east). For verification of consistency between the GEO-LEO and GEO-GEO approaches mentioned above, the relative differences between AHI-8 and -9 of the GEO-LEO approaches are shown at the bottom of Tables 1 and 2 along with GEO-GEO approach results. Ratios of AHI-9/AHI-8 are shown for visible and near-infrared bands in Table 1, and differences in biases for AHI-9 minus AHI-8 in AHI-8's standard scenes for infrared bands are shown in Table 2. For infrared bands, the differences are obtained by picking up the AHI-8 Tb data within 1 K of AHI-8 standard scenes. Then the Tb differences between AHI-9 and -8 are averaged assuming the relation of radiance and Tb is liner within the small range for the picked up data. The effects of spectral response function difference (shown as "SRF offset" in Table 2) were removed from GEO-GEO results using AHI-8 and -9 pseudo data from Metop-A/IASI for a particular scene (14 January 2015, latitude within 30 deg., longitude within 80 deg. from the Himawari-8/-9 sub-satellite point (140.7°E, 0.0°N)). Close correspondence between the comparison results for each approach is observed in Figure 1.

In summary, all bands of AHI-9 are well calibrated on the same level with that of AHI-8. The GEO-GEO validation approach is consistent with the other approaches and offers a promising solution for the generation of a new inter-calibration product combining GEO-LEO and GEO-GEO comparison results to account for diurnal calibration variations.

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Discuss the Article

Newly Released Climate Data Records of Total and Spectral Solar Irradiance Are Based on SORCE Observations

by Odele Coddington (LASP), Judith Lean (NRL), Peter Pilewskie (LASP) and Tom Woods (LASP)

The Sun is Earth’s dominant energy source. The total solar irradiance (TSI) provides Earth with 3000 times more energy than all other external (to the atmosphere) inputs [1]. This energy determines Earth’s surface temperature, atmospheric structure, and drives land, ocean, and atmosphere interactions.

Solar irradiance variability is due to magnetic activity emerging from the Sun’s interior. Visible features of magnetic activity are dark sunspots that reduce irradiance for most visible wavelengths and bright regions, called faculae that enhance irradiance. At 11-year solar cycle maxima, facular brightening exceeds sunspot darkening and net TSI variability is in-phase with the solar cycle. On shorter (monthly) rotational time scales, the distribution of the sunspots and faculae on the solar disk projected toward Earth change and sunspot reduction may exceed facular enhancement. Observations of TSI and solar spectral irradiance (SSI) lack sufficient length and SSI lacks the stability to properly quantify solar variability over multiple solar cycles. Therefore, solar irradiance models are valuable for constraining the observations and in interpolating and extrapolating them, over time and wavelength, into the past and future. Newly constructed records of TSI and SSI produced by an updated version of the Naval Research Laboratory’s (NRL) solar variability models [2,3, and 4] are now publically available [5]. These new records, associated documentation, and ancillary data, are collectively called the Solar Irradiance Climate Data Record (CDR)[1] (Table 1)

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Table 1: Products delivered with the Solar Irradiance CDR.

Product	Type	No. of Wavelength bins	Time range, update cadence
TSI composite	Observational composite	-	1978-2016, periodic
TSI (daily and monthly avg)	NRLTSI2 model output	-	1882-2016, quarterly
TSI (yearly avg)	NRLTSI2 model output	-	1610-2016, yearly
SSI (daily and monthly avg)	NRLSSI2 model output	3,785 (variable width)	1882-2016, quarterly
SSI (yearly avg)	NRLSSI2 model output	3,785 (variable width)	1610-2016, yearly
SSI baseline reference spectrum SSI reference spectra	Observation-based NRLSSI2 model output	 99,884 (1-nm width)	Quiet Sun Low, moderate, high solar activity Maunder Minimum
Facular brightening and sunspot darkening indices	NRLTSI2/NRLSSI2 model input	-	1882-2016, quarterly

The new version 2 of the NRL models for TSI and SSI are designated NRLTSI2 and NRLSSI2, respectively. These models assume that magnetic variability drives irradiance variability. Estimates of irradiance variability are obtained from empirical relationships between observed TSI and SSI and indicators (proxies) of sunspots and faculae. Then, given knowledge of the baseline quiet Sun total and spectral irradiance and time-varying information about sunspots and faculae, TSI and SSI are constructed by using the empirical relationships that scale incremental changes in the proxies to equivalent solar irradiance changes.

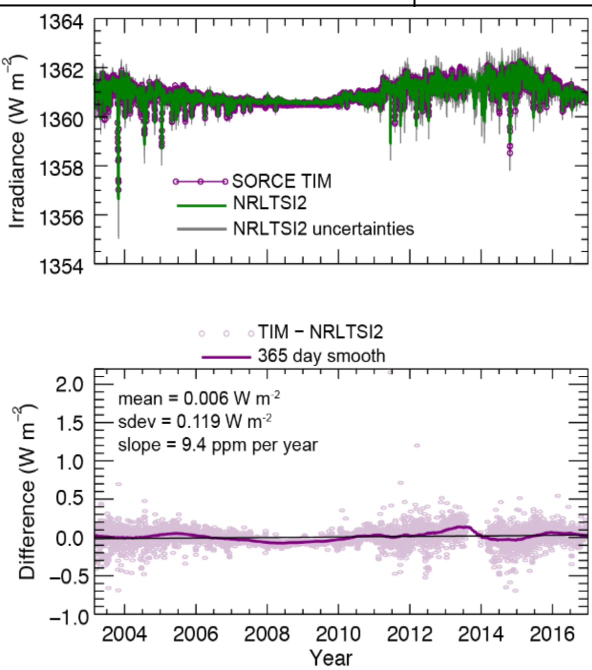

Figure 1: Solar cycle TSI variability. (top) Comparison of NRLTSI2 (green) with associated uncertainties (grey) and SORCE TIM (purple) measurements (ver. 17) [14]. (bottom) Measurement-model residual differences: daily (circles), annually smoothed (purple line), and linear fit to slope of residual difference (black).

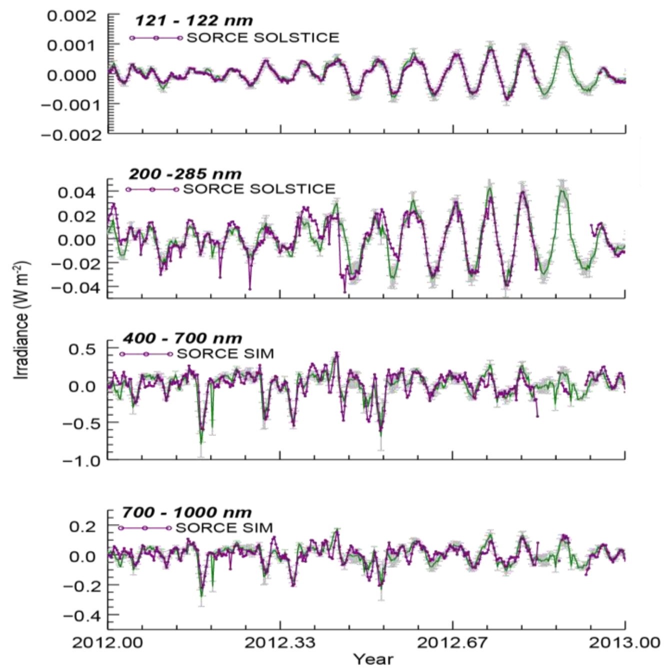

Figure 2: Detrended (removal of 81-day running mean) solar rotational SSI variability. Comparisons of SORCE SSI observations (purple) from the SOLSTICE instrument (ver. 15) [15] and SIM instrument (ver. 22) [16] and NRLSSI2 (green) with associated uncertainties (grey) for 2012 in four wavelength bins. SORCE data are from sorce_ssi_L3_c24h_0000nm_2413nm_20030301_20170306.txt.

TSI and SSI measurements by the SOlar Radiation and Climate Experiment (SORCE) mission [6] between 2003 and 2014 are used to derive the empirical relationships. The sunspot darkening index is derived from sunspot area and location recorded by the US Airforce Solar Observing Optical Network[2] (SOON) and the facular brightening index from irradiance measurements of the Magnesium II index[3]. Because of uncertainties in SORCE SSI long-term degradation corrections, the NRLSSI2 empirical relationship is determined over solar rotational periods where solar variability exceeds instrumental trends. An adjustment factor "corrects" the modeled SSI variability from rotational to solar cycle scales, adding uncertainty. The magnitude of the adjustment factor is determined by using SORCE TSI observations. Evaluating the wavelength dependence of the adjustment factor requires a long, stable SSI observational record. Such information is expected from the Total and Spectral Solar Irradiance Sensor (TSIS) Spectral Irradiance Monitor (SIM), planned for launch in late 2017. TSIS SIM is the next generation SSI radiometer, designed and calibrated to meet the stringent SSI accuracy and stability requirements over solar cycle timescales through technological improvements over SORCE SIM and an additional channel to improve long-term stability.

The adopted quiet Sun irradiance of the Solar Irradiance CDR is based on SORCE measurements during a quiet solar period [7]. The SORCE SSI observations span 115 to 2400 nm, and these are augmented between 300 and 1000 nm with observations made by the SOLSPEC instrument on the ATLAS-1 mission [8]. Above 2400 nm, where no space-borne SSI observations exist, a theoretical spectrum is used [9]. The integrated quiet Sun reference spectrum is normalized to 1360.45 W m^{-2}, the quiet Sun TSI [10].

Figures 1 compares NRLTSI2 and SORCE TSI observations over the duration of the SORCE mission. Figure 2 compares de-trended SORCE SSI observations and NRLSSI2 in four wavelength bands. The results exemplify the model utility for filling data gaps, specifically, the 7-month TSI gap from 07/2013- 03/2014 and the shorter duration SSI gap in late 2012. The model output shown is from a recent revision of the NRL model (v02r01; anticipated release date 06/2017) that has been utilized as part of the solar forcing input for an international climate model project [11]. The v02r01 model improves the cross-calibration of the SOON (since ~1978) and Royal Greenwich Observatory (from 1882 to ~1978) sunspot area and location databases for systematic offsets due to different instrumentation and methodology, which results in differences between v02r01 and v02r00 prior to 11/1978. The v02r01 model also provides two estimates of historical (pre-1882) solar irradiance based on different records of sunspot number[4].

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Discuss the Article

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[2] Available from http://www.ngdc.noaa.gov/stp/spaceweather.html
[3] The University of Bremen's composite is available from http://www.iup.uni-bremen.de/gome/gomemgii.html
[4] The group sunspot number [12] and the Sunspot Index and Long-term Solar Observations (SILSO) sunspot number [13].

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Improvements to the HIRS channel 12 intercalibration for ice supersaturation studies

by Klaus Gierens (DLR) and Kostas Eleftheratos (University of Athens, Greece)

Ice supersaturation is a frequent phenomenon in the upper troposphere. Formation of cirrus clouds by homogeneous nucleation of aqueous aerosol particles needs relative humidity with respect to ice exceeding 145%. Long-lasting condensation trails can only exist in ice supersaturated air; they thus signify ice supersaturated conditions. Channel 12 of the High-Resolution Infrared Sounder (HIRS) is used to retrieve the upper tropospheric humidity with respect to ice, UTHi, using coefficients provided by Jackson and Bates (2001). Unfortunately, the central wavelength of channel 12 changed from 6.7µm to 6.5µm in the transition from version 2 to version 3 of the HIRS instrument, a change that occurred with the launch of NOAA 15 in 1998. The atmosphere is 50% more opaque at 6.5µm than at 6.7µm. Channel 12 on HIRS 3 is thus sensitive to a layer in the upper troposphere about 1 km higher than the corresponding channel on HIRS 2. The intercalibration of Shi and Bates (2011) applies a temperature-dependent correction to the measured brightness temperatures and leads to a homogeneous time series of channel 12 brightness temperatures *in the mean*. However, it turns out that very low brightness temperatures (say, <235 K) are much more frequently recorded by HIRS 3 than by HIRS 2 and this leads to an overestimation of the frequency of ice supersaturation cases by HIRS 3 and its successor HIRS 4.

Figure 1 shows the time series of the fractional occurrence (i.e. number of favourable cases divided by all cases) of retrievals of high UTHi values, exceeding 70%, 80%, 90%, and 100%, respectively. The time series is produced using channel 12 brightness temperatures from the intercalibrated data of Shi and Bates (2011). Evidently there is a strong increase of high UTHi cases after approximately 1998, that is, after the change to HIRS 3. This demonstrates a need for improvements of the intercalibration at the low end of the channel 12 brightness temperature range.

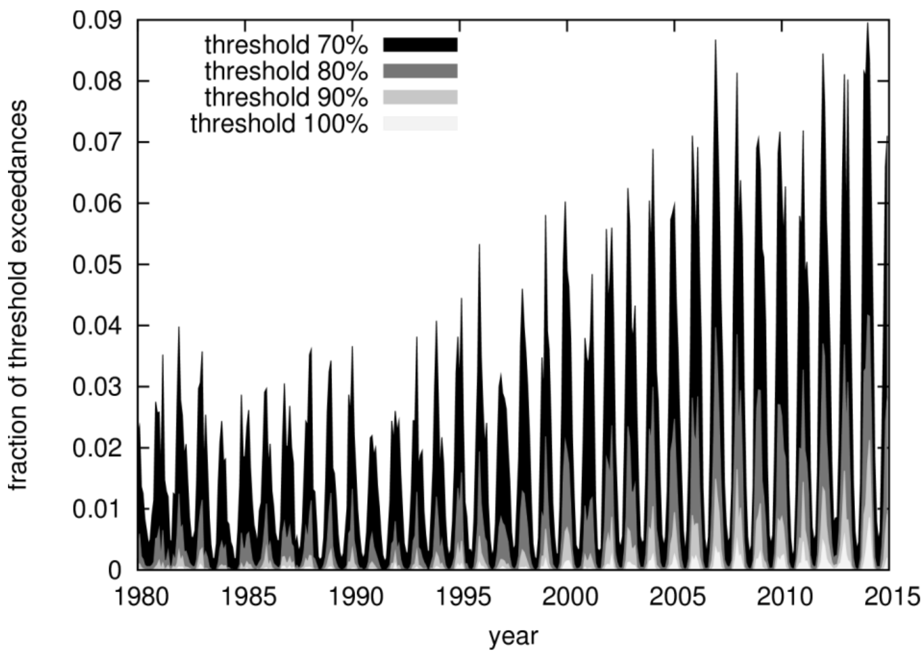

Figure 1. Time series of the fractional occurrence of high values of UTHi retrieved from HIRS channel 12 brightness temperatures in the northern midlatitude zone 30° to 70°. Use has been made of the data intercalibrated by Shi and Bates (2011). Note the strong increase that occurred with the transition from HIRS 2 to HIRS 3 around 1999.

An intercalibration method that leads to more homogeneous time series has been devised by the authors (Gierens and Eleftheratos, 2017). It starts with the consideration of the two cumulative distribution functions (cdfs) of channel 12 brightness temperatures, that of HIRS 2 on NOAA 14 and that of HIRS3 on NOAA 15, for a set of 1004 common days of operation, and pairs of daily averages in 2.5°x2.5° grid cells in the northern mid-latitudes. In total there are more than 700.000 of such data pairs consisting of the data that had been already intercalibrated by Shi and Bates (2011). The ratio of the two cdfs is of the order of three at low brightness temperatures, but approaches unity at brightness temperatures in excess of 240 K. The new intercalibration method consists in determination of minimal additive temperature corrections to the HIRS 3 data that makes the ratio of the two cdfs unity. These corrections are shown in Table 1 for 1K bins of channel 12 brightness temperatures. Above 240 K no correction is necessary since the ratio already approaches unity in the original data (for purely mathematical reasons).

Table 1. Recommended corrections at channel 12 brightness temperatures in order to bring HIRS 3 levels down to HIRS 2 levels. No correction is needed above 240K.

T_{12} interval (K)	Correction (K)
(228-229]	0.32
(229-230]	0.55
(230-231]	0.69
(231-232]	0.73
(232-233]	0.77
(233-234]	0.77
(234-235]	0.78
(235-236]	0.69
(236-237]	0.62
(237-238]	0.50
(238-239]	0.33
(239-240]	0.13
(240-241]	0
(241-242]	0
(242-243]	0
(243-244]	0
(244-245]	0

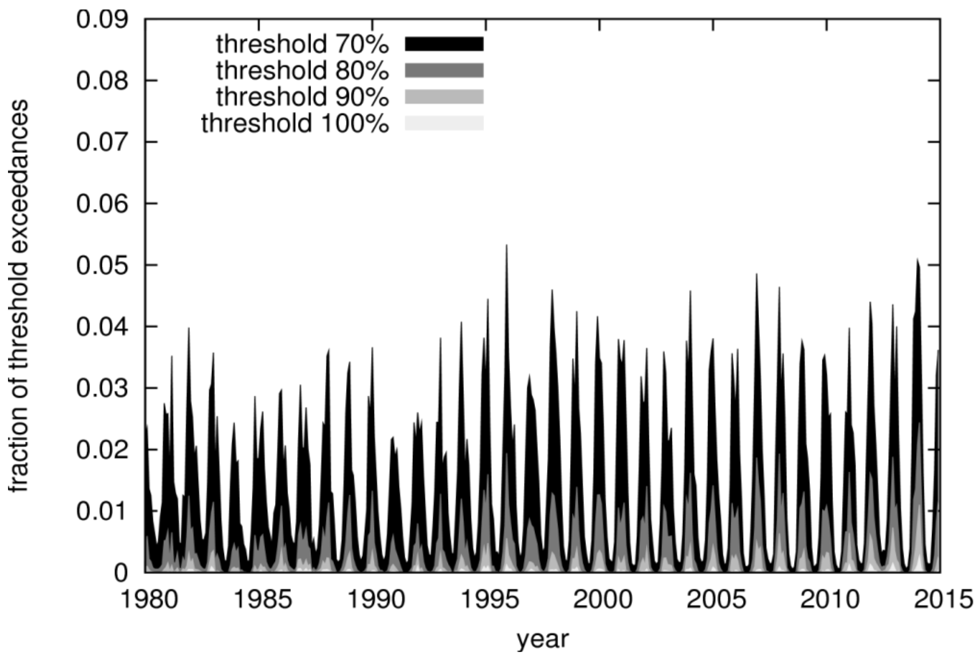

Figure 2. As Figure 1, but using the data of Shi and Bates (2011) with the additional correction of the authors, applying a cdf-nudging method for all data from NOAA 15 on (i.e. 1998 and later). The strong increase evident in Figure 1 is no longer present and the time series is more homogeneous.

Thus the new method changes the data in a minimal way; it is a conservative method. Nevertheless, it is successful: the mean brightness temperature difference between the data pairs is almost halved, and the corresponding mean UTHi difference is even reduced by a factor of 6.

The new intercalibration is also successful in rendering a more homogeneous time series of the fractional occurrence frequencies of high values of UTHi, see Figure 2.

Many very important processes in nature are of non-linear character. Cloud formation is even a threshold process, commencing at water saturation for warm clouds or at a high supersaturation value for cirrus clouds.

Clouds strongly influence the radiative energy exchange between the Earth, the universe and the atmosphere. It is thus obvious that changes in cloud formation conditions, that is, frequency of occurrence and distribution of saturation and supersaturation values, are of utmost influence on climate change. Monitoring climate change thus requires not only homogeneous time series in the mean values. We need homogeneous time series also in the higher moments of the distributions of humidity and other variables, and we need to know reliably how the high and low tails of these distributions evolve with a changing climate. This work is a step forward in this direction.

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Discuss the Article

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Radiometric Capability of Chinese Optical Satellite Sensors

by Aixia Yang, Bo Zhong, Shanlong Wu , and Qinhuo Liu, Chinese Academy of Sciences

Since the polar orbiting meteorological satellite, the FengYun 1 (FY-1, the first satellite in FY series) launched on July 9, 1988, signifying an unprecedented milestone in Chinese satellite remote sensing history, several series of Chinese optical satellites have been developed, for example, the China Brazil Earth Resource Satellite (CBERS), HuanJing (HJ), ZiYuan (ZY), HaiYang (HY), and GaoFen (GF).

However, unlike the MODIS, most of Chinese remote sensing satellite sensors in VNIR bands lack onboard calibrators and their radiometric calibration has been updated once a year based on a vicarious calibration procedure. This was the process for the HJ series and FY series. The accuracy of these updates has a great influence on the application of the data. Therefore, a comprehensive evaluation of each sensor's radiometric capability is essential before quantitative applications.

The objective of this study is to propose a comprehensive procedure for evaluating radiometric capability of Chinese optical satellite sensors and evaluate two major indicators for radiometric capability: the long-term radiometric stability and the radiometric accuracy. Three Chinese sensors including Charge-Coupled Device (CCD) camera onboard Huan Jing 1 satellite (HJ-1), Visible and Infrared Radiometer (VIRR) and Medium-Resolution Spectral Imager (MERSI) onboard Feng Yun 3 satellite (FY-3) are evaluated in visible and infrared bands based on this procedure. The Badain Jaran Desert test site is selected because of its temporally stable surface condition, which minimizes the impacts of the surface and atmosphere variation. Long time series clear data (out of cloud and haze contamination) are selected, which guarantee a continuous and high frequency monitoring.

The procedure for evaluating radiometric capability of Chinese optical satellite sensors includes three parts: 1) calculating the TOA reflectance; 2) spectral matching to eliminate the influence of different spectral response; 3) evaluating the radiometric capability of the sensors using the long-term series TOA reflectance between sensors and MODIS after spectral matching. The radiometric accuracy is determined by comparing with the TOA reflectance from MODIS after spectrally matching.

Firstly, the long-term TOA reflectance of MODIS is plotted in Figure 1 and the stability of MODIS is analyzed. The long-term tendency of the TOA reflectance remains consistent and the slope values of the fitted lines for different bands ranged from 10^{-7} to 10^{-5}, which indicates a very small variation in trending. The units for the slope are inverse days. The standard deviations of the TOA reflectance are within 0.02. All of the above shows that the radiometric capability of both Terra/MODIS and the Aqua/MODIS are stable, and can be used to evaluate other sensors as the reference data. Secondly, plotting the long-term TOA reflectance of each reflective

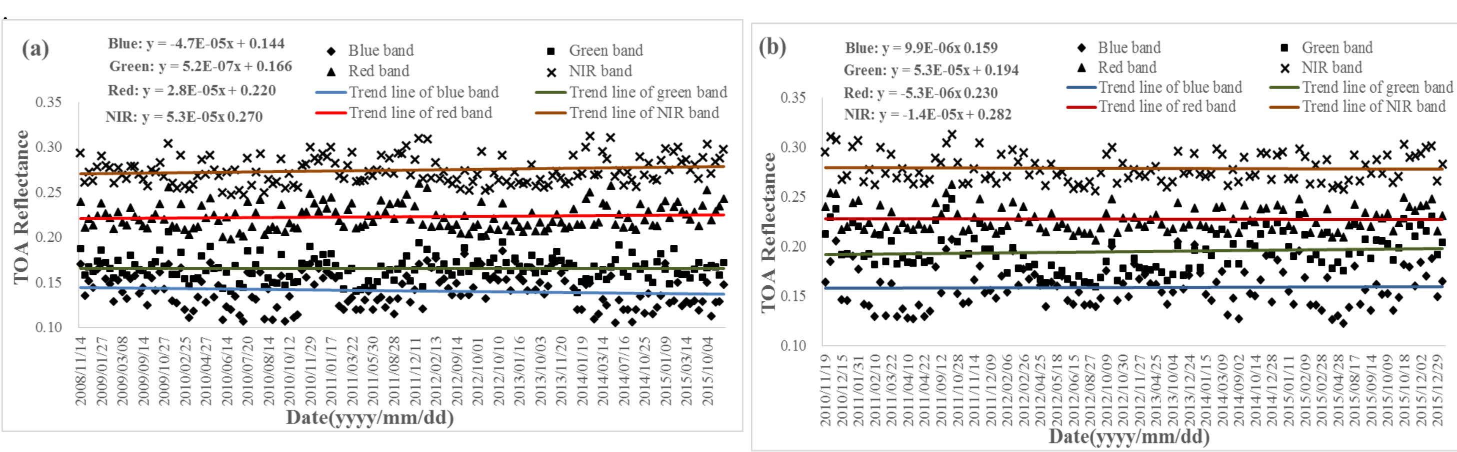

Figure 1. Time series of TOA reflectance of MODIS in reflective bands. The color lines are the trend lines of the bands. (a) Terra/MODIS. (b) Aqua/MODIS.

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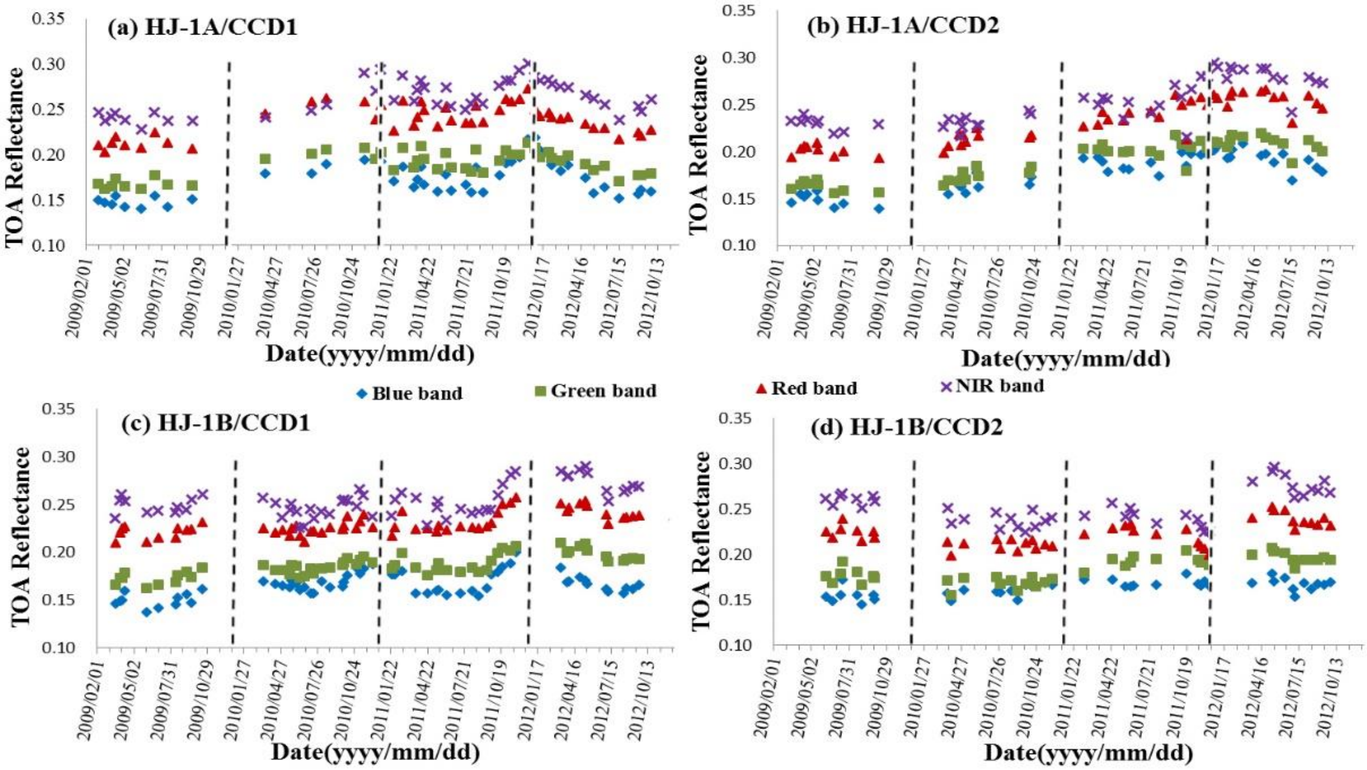

Figure 2. Time series of TOA reflectance of HJ-1/CCDs from 2008 to 2012 in reflective bands: (a) HJ-1A/CCD1; (b) HJ-1A/CCD2; (c) HJ-1B/CCD1; (d) HJ-1B/CCD2. The black lines indicate the time points at which the calibration factors are updated.

band for every sensor illustrates the radiometric stability very intuitively (Figure2~3).

Thirdly, comparing the TOA reflectance from the test sensors with MODIS evaluates their relative radiometric accuracy. By employing some indices including maximum, minimum, mean, and standard deviation of TOA reflectance, the accuracy of the sensor can be quantified. Take HJ-1A/CCD1 for example, the statistics of these indices are shown in Table 1.

After the evaluation of eight Chinese satellite optical sensors, the following conclusions are made. First of all, almost all of the Chinese satellite optical sensors are not stable as the MODISs and the radiometric accuracy is less than that of the MODISs.

Year	Band	Slope#	Maximum	Minimum	Mean	Mean_a*	Standard deviation
2009	Blue	3E-07	0.155	0.141	0.148	0.1678	0.005
	Green	9E-06	0.178	0.162	0.167	0.185	0.005
	Red	7E-06	0.225	0.203	0.212	0.217	0.007
	NIR	2E-05	0.247	0.228	0.240	0.240	0.006
2010	Blue	6E-05	0.195	0.179	0.188	0.214	0.007
	Green	2E-05	0.208	0.195	0.201	0.222	0.005
	Red	-2E-06	0.263	0.239	0.253	0.259	0.009
	NIR	2E-04	0.294	0.241	0.267	0.267	0.022
2011	Blue	--	0.219	0.159	0.180	0.204	0.018
	Green	3E-05	0.214	0.181	0.196	0.216	0.011
	Red	6E-05	0.273	0.226	0.248	0.253	0.013
	NIR	--	0.301	0.250	0.272	0.272	0.015
2012	Blue	-2E-04	0.205	0.152	0.174	0.198	0.019
	Green	-1E-04	0.202	0.171	0.188	0.207	0.010
	Red	-9E-05	0.247	0.217	0.233	0.238	0.010
	NIR	-1E-04	0.283	0.239	0.265	0.265	0.014

Table 1. The statistics from the time series of the TOA reflectance of HJ-1A/CCD1. The units for the slope are inverse days. Mean of the TOA reflectance after spectral matching with MODIS, and the same below.

doi:10.7289/V5BK19F0

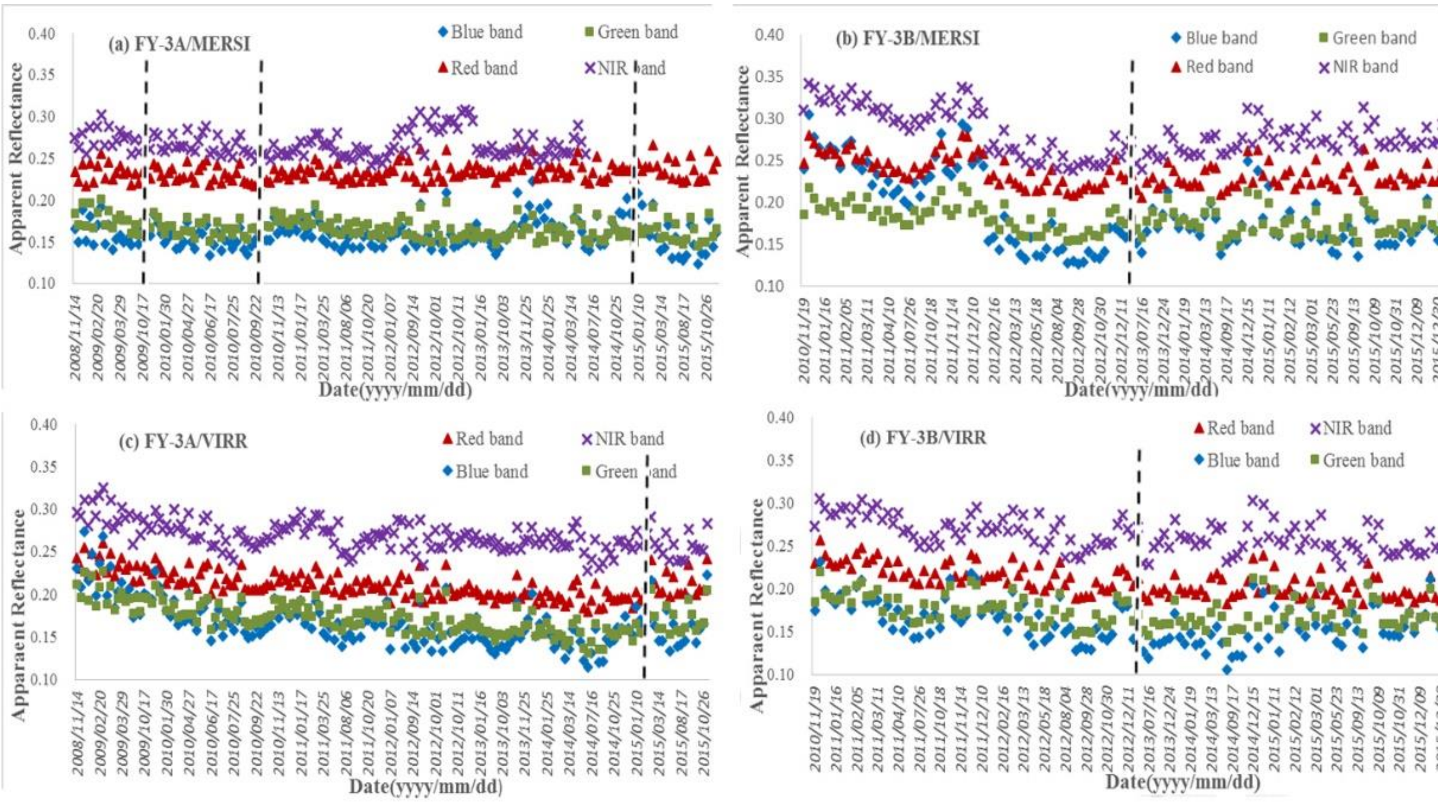

Figure 3. Time series of TOA reflectance of MERSIs and VIRRs in reflective bands: (a) FY-3A/MERSI from 2008 to 2015; (b) FY-3B/MERSI from 2010 to 2015; (c) FY-3A/VIRR from 2008 to 2015; (d) FY-3B/VIRR from 2010 to 2015. The black lines indicate the time points at which the calibration factor are updated.

Secondly, among all the evaluated sensors, the VIRRs have the best stability through its lifetime until now, although they have an obvious decreasing trend induced probably by the instruments' degradation; the MERSIs have the best radiometric performance on both stability and accuracy at their later stages.

Thirdly, a vicarious calibration procedure carried out only once a year or less has been performed by the surveillance departments of the sensors. This has resulted in the lower-quality radiometric capability of the Chinese satellite optical sensors. Therefore, a more frequent calibration procedure urgently needs to be developed and applied in the future in the absence of onboard calibrators. Moreover, in order to fully take advantages of the wealth of Chinese satellite data, the re-calibration of the historical data also needs to be carried out.

Fourthly, the co-application of multi-source remote sensing data relies on continued and consistent calibration. This study provides reliable reference for the co-application, and as such it will promote the development of the Chinese satellite data.

In the near future, we will evaluate the radiometric capability of other Chinese optical satellite sensors, such as the Gao Fen (GF) and Zi Yuan (ZY) series of satellites; subsequently, more abundant and reliable data from Chinese optical satellite sensors are expected, which will greatly contribute to the research and applications.

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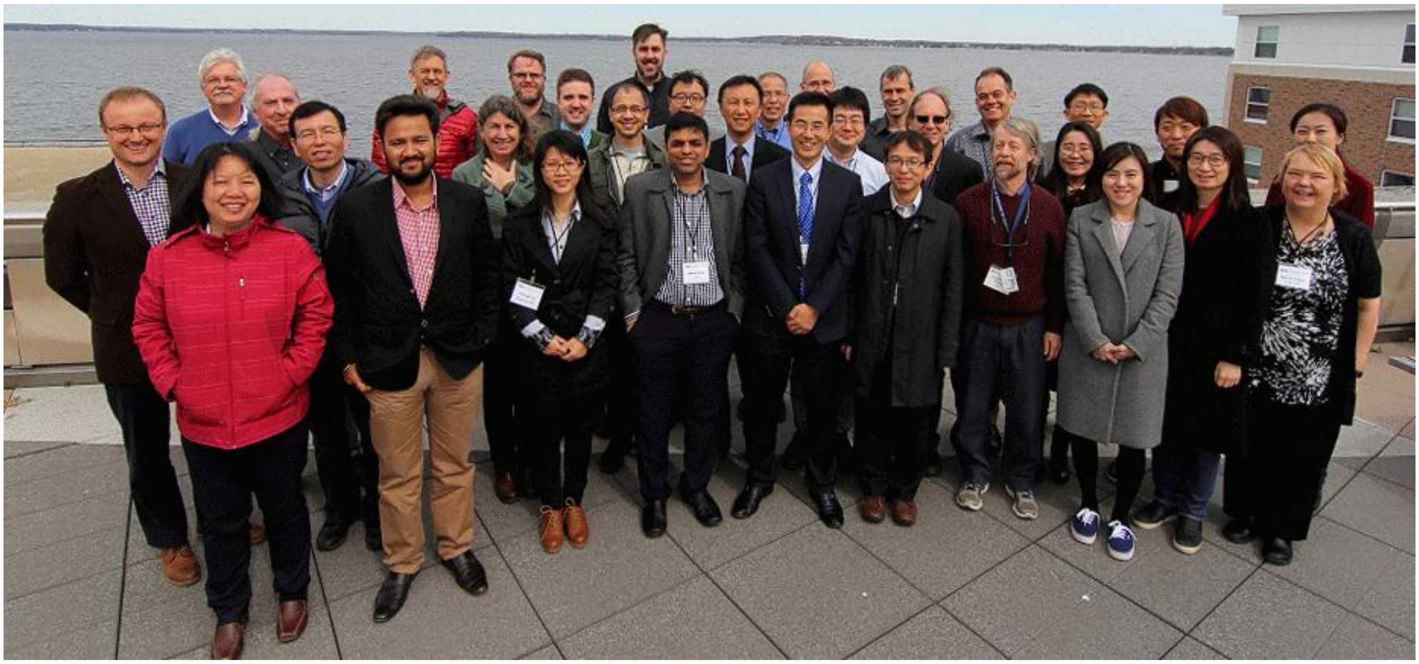
News in this Quarter

Highlights on 2017 Annual GRWG/GDWG Meeting

By Manik Bali, Lawrence E Flynn (NOAA), Tim Hewison (EUMETSAT), Dohyeong Kim (KMA), Dave Tobin (SSEC), Peter Miu (EUMETSAT) and Masaya Takahashi (JMA)



Participants of the GSICS Annual Meeting 2017

This year's meeting of the GRWG and GDWG was hosted by NOAA, at CIMSS, University of Wisconsin, Madison, USA on 20 - 24 March 2017. Local hosts were Andy Heidinger and Dave Tobin, with administrative support from Maria Vasys. Members from IMD, JMA, NASA, NOAA, CMA, CNES, KMA, USGS, EUMETSAT, and University of Wisconsin attended the meeting in person while, ISRO presented remotely and JAXA was represented by Arata Okuyama from JMA.

After an impressive opening ceremony, including a welcome speech by Paul Menzel from SSEC, the meeting started with a Mini Conference which was kick started by Tim Hewison and Dave Tobin. The Mini Conference covered topics vital to GSICS in the near future. The first one was the CLARREO Pathfinder mission. This mission is designed to provide SI traceable radiances that could be used as in-orbit reference for calibration. Constantin Lukashin gave an overview of a reflected solar pathfinder mission, followed by observation accuracy demonstration and inter-calibration talks for the infrared by Joe Taylor and Dave Tobin. The current path finder mission is delayed due to cuts in spending. The next GSICS annual meeting was proposed to be held in China, in conjunction with a workshop on CLARREO-like instruments.

Tony Reale described the GCOS reference upper air network radiosondes for satellite calibration validation. This was explored later in the meeting, leading to the request to submit a draft uncertainty analysis to show how the comparisons could be applied to IR and MW instruments, due to concerns about the limiting effects of atmospheric variability and the small number of collocations with radiosondes. Wes Berg, Bob Holz and Andy Heidinger gave key insights into GPM-X CAL, PATMOS-X products and Inter-calibration activities in SSEC.

The next session was the Plenary Session. Reports on the following member agencies, NOAA, NASA, CMA, CNES, JMA, JAXA, IMD, ISRO, KMA and USGS were provided. The Plenary session also had annual reports by the GCC (Lawrence E Flynn), GDWG (Masaya Takahashi) and GRWG (Dohyeong Kim).

The IR Sub-group of the Research

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Working Group addressed the further development of GEO-LEO IR products. These are now available (at different levels of maturity) for all current GEO imagers. This allows them to be inter-compared as part of the GEO-ring initiative. The diurnal calibration variation is also now becoming more and more important as most of the platforms are now 3-axis stabilised. Techniques are being developed to characterise the diurnal variations using multiple reference instruments and GEO-GEO comparisons. The group is also starting to develop GSICS deliverables for the LEO-LEO IR and scoping out the potential for defining spectral corrections or retrieving SRFs. Another key activity is the development of a report on the traceability and uncertainty of the current GSICS IR reference instruments, building on Dave Tobin's analysis of the CrIS calibration error budget, and a series of comparisons between different reference instruments based on different techniques.

The VIS/NIR session covered the further development of the Deep Convective Cloud (DCC) method to improve the characterization of the seasonal variations and plans to publish a paper or special issue on the subject. There was involved discussion on plans to combine different inter-calibration methods, which is clearly the subject for further work. Additionally, the decision was made to move now from Aqua/MODIS to S-NPP/VIIRS as the inter-calibration reference. Lunar calibration is another main focus of this sub-group, members are now developing methods to generate inter-calibration products using lunar observations. EUMETSAT's achievement of licensing the GIRO and GLOD, was greatly appreciated, as it now allows the distribution of source code for the lunar irradiance model and contribution to the GSICS lunar observation dataset, which will be used to further improve lunar calibration. Detailed plans were also defined for the next Lunar Calibration Workshop, which will take place in China in autumn 2017.

There was also growing interest in the UV Sub-group activities. There is most interest in the Reference Solar spectrum project, which will continue to collect more spectra from participants and expand the analysis. The aim is to make a recommendation for a high spectral resolution reference solar spectrum to be accepted by the community as a standard. The White Paper on "On-ground Calibration and Characterization" is also of interest to the broader GSICS community, and relate to the workshop on this topic planned jointly with CEOS WGCV.

For the first time the meeting had a separate breakout session for the Microwave. The session was remotely chaired by Ralph Ferraro and covered topics on Lunar Calibration (Martin Bergdorf), updates on JPSS-1 ATMS (Ed Kim) and candidate GSICS products in Window (Karsten Fennig) and Oxygen Channels (Cheng-Zhi Zou). The breakout session was interactive and had discussions on In-orbit references (lead by Manik Bali) and RTM issues (lead by Wes Berg). In addition, Derek Houtz provided vital leads on blackbody targets and reference standards.

In order to deepen the collaboration between GSICS and the international Satellite Cloud Climatology Project (ISCCP), Tim Hewison (GRWG Vice Chair) invited Ken Knapp who is leading the reprocessing activities in the ISCCP. Ken's presentation opened up the prospect of extended use of GSICS algorithms and cross calibration products in improving the quality of ISCCP cloud products.

The GCC is at the crossroads of many of the GSICS activities. Larry Flynn (GCC Director) and Manik Bali (Deputy Director) led the GCC discussions. In addition to the publication of the GSICS Newsletter, Meeting Support GCC also has established a New Action Tracker. This action tracker displays GSICS actions on the GCC website and uses Google Cloud to store and edit actions. Larry also updated members about the GPPA status of submitted products and new clauses (such families of instruments). In the past year GCC also contributed to the trustworthiness of GSICS Anchor references (IASI-A and AIRS) and developed consensus on the use of FCDR as in-orbit references. Larry also updated the members about the format of the GSICS Users Workshop that will be organized in Vladivostok (16-21 Oct 2017) as part of the AOMSUC. Manik Bali also held discussions with GSICS members (KMA, EUMETSAT and ISRO) who had submitted their products to the GPPA for review and acceptance. This interaction helped get a firsthand knowledge of the problems faced by producers during the review process. Pathways were worked out to enable less cumbersome acceptance of products into GSICS fold.

In the Data Working Group sessions, 15 topics such as GDWG Terms of Reference (ToR) updates, resources for GDWG activities, clarification of GDWG co-chairs, chairing of the GDWG, repositories of GSICS documentation, mirroring GSICS Collaboration Servers, use of GitHub for GSICS activities, standardization of the GSICS netCDF convention for instruments' spectral response functions were discussed.

One of the most important collaboration issues is the mirroring of GSICS products across the GSICS collaboration servers (EUMETSAT,

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NOAA and CMA) now that MSG/SEVIRI vs. IASI IR inter-calibration products have become available as Operational Products. Manik Bali mentioned that the mirroring of GSICS products was implemented at NOAA however the mirror server is temporarily stopped due to security issues in NOAA. The group agreed to use product downloading scripts provided by NOAA in such servers. The scripts were shared within the groups, and they would be reviewed for operational implementations.

To improve collaboration developments, a discussion to bring GitHub into GSICS activities was led by KMA. An overview of Git and other version controlling systems (i.e. GitLab, GitHub and Bitbucket) were compared. The group agreed that Git is an ideal version controlling system for collaboration developments and GitHub is preferable because there are more free-user licenses (10 people). It was also agreed that KMA will take the lead in creating GitHub project for GDWG activities. Further details on maintaining the project will be discussed via GSICS web meeting.

Satellite instrument event logging to outline the set of parameters, the nomenclature, and the standards to be used for reporting on instrument calibration across space agencies is one of the long-standing activities in GDWG. A draft white paper to be submitted to CGMS-45 (Korea, June 2017) was presented by EUMETSAT. The topic has been discussed for some time, and an addition of "Calibration related documents" as one of the categories required for the instrument landing pages was agreed in order to provide useful information to GSICS product users (e.g. GSICS product user guides).

Report on the Committee on Earth Observation Satellites (CEOS) - WGCV 42nd meeting held in Sioux Falls, South Dakota

by Taeyoung (Jason) Choi (NOAA) and Nigel Fox (NPL)

The 42nd Working Group on Calibration Validation (WGCV) meeting was hosted by USGS EROS data center from May 16th to 19th, 2017. There were approximately 20 attendees from EROS, NASA, BelSpo, JAXA, CSIRO, GA, ISRO, NSSC, DLR, UKSA, NPL, CNES, ESA, NOAA, USGS, and EUMETSAT. Dr. Kurtis Thome (NASA) who is current CEOS WGCV chair led the whole meeting along with Dr. Cindy Ong (CSIRO) who is vice chair.

On the first day, the meeting was hosted at the EROS data center and there was a welcome accouchement from the CEOS chair Frank Kelly. He addressed the importance of cal/val group providing standards to remote sensing community and the vision of satellite interoperability providing seamless (analysis ready data streams for the international user community. The WGCV chair reviewed the overview of the meeting and expected outcomes. He wanted to clarify the roles of agencies and subgroups including areas of cooperation across sub-groups, discuss on RadCalNet issues as it moves to operational status, assess next steps on DEM task group, review progress on nt Actions, and improve interactions and progress between the WGCV meetings. Since the first day meeting was hosted at EROS, there were a number of USGS and EROS data center personal related presentations and reports by J. Lacey (LSI-VC co-shair), G. Fonsnight (MRI co-lead), S. Labanhn (FDA co-lead), and J. Dwyer (WG-Climate). Kevin Gallo who is Land Product Characterization System (LPCS co-lead) reported higher level scientific programs from VIIRS, MODIS, Landsat, Sentinel satellites. Using more than 100 sites, he monitors multi sensors based on the PICS observations and the data sets are expending with newly added sensors.

An action which stemmed from the discussions on MRI was that CEOS WGCV would provide guidelines for inclusion in the study on 1/ how to achieve TOA Level 1 interoperability (over ideal sites) 2/ How to achieve and assess interoperability at BOA (for ideal sites) and 3/ how to assess interoperability for BOA reflectances for more complex vegetated sites.

On the second day, the meeting was hosted by Dr. Dennis Helder at South Dakota State University. The second day was filled up with subgroup presentations and the agency reports. N. Fox reported IVOS report and indicated that in addition to radiometry activities they are forming a set of MTF targets which will become CEOS recommended and listed on the CalVal

Portal. Results of the recent comparisons on surface Temperature validation were also summarized. This

Moon. A new focus group on PICS led by P Henry of CNES for IVOS called PICSCAR was also described in the LPV (Land Product Validation) group report, they are building the supersites which are fully characterized to allow RT model. There are specific requirements to be a supersite. After the sub-group reports, there were agency reports from BelSpo, JAXA, CSIRO, GA, and NASA. The agency reports described their specific on-going and new missions and status of their sensors. There was an extensive discussion on the RadCalNet over the existing and well-known Landnet. RadCalNet has more specific formal criteria, with site owners agreeing to a set of guidelines to operationally and automatically deliver data in a common format and with documented evidence of traceability to a common processing chain and ultimately to a portal to deliver TOA reflectances every 30 minutes. The CEOS group decided to continue with the broadbased Landnet concept as an overarching structure for land based test sites in general (potentially reviewing its name) but emphasized that RadCalNet was a specific entity (under Landnet) but that would be publicized independently to reduce confusion. A publication by the RadCalNet team is currently in draft format and planned for submission in the next few weeks.

On the third day, the RadCalNet discussion was continued to define procedures to enable new sites to join. There was a mutual agreement on the creation of a 'RadCalNet admission panel' to evaluate a range of Landnet sites on a yearly basis to identify the non-active sites. There will be further

report emphasized the number of collaborations taking place between GSICS VIS and TIR sub-groups and

WGCV discussion to define membership and terms of reference of the admission panel with a view to being in place by September/October in readiness for the formal operational release of RadCalNet in November 2017. After the RadCalNet discussions, agency reports were presented by DLR, CNES, ESA, USGS, and EUMETSAT. Our NOAA report was presented after the ESA's presentation and it was well received by the WGCV group. Because the agenda schedule was behind, the CEOS chair asked attendees to hold questions for the break time. During the Micro Wave (MV) sub-group reports by X. Dong, CEOS is looking for Passive Micrometer sensor coordination personnel such as chair, co-chair or vice chair. X. Dong and K. Thome (WGCV Chair) suggested informing to NOAA that WGCV is looking for a MV chair or co-chair. Later in the afternoon, there was a report on global DEM discussions by D. Gesch from the EROS data center. He reported current Status of DEM model in the currently dormant Terrain Mapping subgroup. There was in-depth discussion on the DEM data validation with the current DEM data sets from ASTER, SRTM+, Global Multi-resolution Terrain Evaluation Data 2010. The CEOS/GSICS solar irradiance reference discussions were led by N. Fox and presented that the recently agreed SOLID composite together with the COSI based solar irradiance model (following discussions with T Stone) should form the basis of the CEOS recommended spectrum for wavelengths longer than ~350 nm (to aid with satellite interoperability and radiance to reflectance conversions) until any

CEOS WGCV IVOS related to sensor to sensor interoperability, use of PICS and the

longer term temporally variant version is derived.. The spectrum will be available for download at a resolution of 0.005 nm in both Ascii and NetCDF formats from an FTP site in the near future. The third day meeting was ended with a review of Carbon Actions and progress by M. Roman. He reported progress on the implementation of the CEOS strategy for the carbon observation from space. The related topics can be found at https://lpvs.gsfc.nasa.gov.

On the fourth day, there was discussion on the prelaunch calibration workshop by Thome. This workshop will cover cutting-edge techniques on the prelaunch and on-board calibration for the on-orbit sensor with lessons-learned from international remote sensing agencies. There will be announcements by 3/1/2018. The workshop will focus on passive optical EO sensors initially with follow-on workshops to cover other domains.. The intended audiences will be CEOS related agencies. (industrial/academic) instrument providers, agency instrument scientists, and metrology labs and calibration vendors. The outcome of the workshop would be an accessible report and could also be a journal paper. Another final topic was cloud mask. There were discussions on definitions on cloud and cloud free condition. The WGCV chair requested sub-group leads for the work plans by midsummer. The meeting was adjourned after short discussion on telecon schedules and WGCV newsletter. The next WGCV meeting will be around spring of 2018 and the schedule will be notified by July 31, 2017.

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Announcements

Second Joint GSICS/IVOS Lunar Calibration Workshop – China 2017

By S. Wagner (EUMETSAT), X. Hu (CMA), T. Stone (USGS), X. Wu (NOAA), X. Xiong (NASA) and S. Wang (XIOPM).

In the recent years, significant efforts have been made to promote and develop lunar calibration activities within GSICS and CEOS WGCV IVOS. In December 2014 experts from 14 agencies and departments attended the joint GSICS – IVOS Lunar Calibration Workshop organized by EUMETSAT in collaboration with USGS, CNES and NASA. In total potentially more than 25 instruments capable of observing the Moon were represented, covering a spectral range from 0.4µm to 2.3µm. One of the major achievements of the workshop was to work on a common lunar irradiance model: the GSICS Implementation of the ROLO (GIRO) model. The GIRO was endorsed as the established publicly-available reference for lunar calibration, directly traceable to the USGS ROLO model. More recently, other initiatives were undertaken by the members of the Lunar Calibration Community with for instance dedicated lunar measurement campaigns, development of radiance models, or new algorithms to develop new lunar inter-calibration products. In order to pursue the efforts of sharing knowledge and expertise on lunar calibration, the Second Joint GSICS/IVOS Lunar Calibration Workshop will be hosted by the China Meteorological Administration (CMA) in Xi'an, China November 13-17, 2017.

This workshop is being organized by CMA, Xi'an Institute of Optics and Precision Mechanics (XIOPM), Chinese Academy of Sciences (CAS), EUMETSAT, USGS and NOAA. The main objectives of the workshop are:

a) To share knowledge and expertise on the latest dedicated ground-based lunar observation campaigns, and also space-based lunar datasets, that can help with refining the current lunar calibration reference.
b) To share knowledge and expertise in the preparation of lunar irradiance measurements from observations by the instruments to be monitored.
c) To work jointly on algorithms to compare and inter-calibrate instruments with lunar observation capabilities, even from different eras, supporting the generation of Fundamental Climate Data Records.
d) To explore further alternative applications of lunar observations for calibration purposes or post-launch assessments, such as geometric and MTF characterization.

This workshop will lead to an updated assessment of the current lunar observation dataset that can either support refining the accuracy of the current version of the ROLO/GIRO or be part of the GSICS Lunar Observation Dataset (GLOD). It will also contribute to defining recommendations or methodologies to compare and inter-calibrate instruments using the Moon. Finally it is intending to provide more insight on the use of lunar observations in satellite mission Cal/Val plans and for sensor monitoring activities.

A series of preparatory activities is currently being defined for which participants are expected to present their results for discussion at the workshop. A list of topics is available on the GSICS Development Wiki topic dedicated to the 2017 Lunar Calibration Workshop (http://gsics.atmos.umd.edu/bin/view/Development/20171106). Presentations about the latest progress on lunar measurements and Moon observations, using the ROLO/GIRO, inter-calibration using the Moon and alternative lunar methods and applications are also welcome. The workshop aims at triggering activities to enhance the current lunar calibration capabilities, while strengthening further the interactions between the members of the Lunar Calibration Community. Two web meetings were organized in order to define the topics that will be covered by the workshop. All information and documentation regarding the preparation of the workshop, together with the contact details of the organizers can be found under the GSICS Lunar Calibration wiki topic at http://gsics.atmos.umd.edu/bin/view/Development/LunarWorkArea. Additional web meetings will be organized in preparation of the workshop. Announcements will be made through the GSICS Developers mailing list at https://groups.google.com/forum/#!forum/gsics-dev .

CALCON Technical Meeting on Characterization and Radiometric Calibration for Remote Sensing will be held in Logan, Utah, USA

by Xiaoxiong (Jack) Xiong, NASA

The Characterization and Radiometric Calibration for Remote Sensing (CALCON) annual meeting provides a forum for scientists, engineers, and managers to present, discuss, and learn about calibration, characterization, and radiometric issues within the microwave, IR, visible, and UV spectral ranges. This year this meeting will be held in Logan, Utah **August 22–25, 2017**
Individuals developing measurement requirements for current and future sensor systems are encouraged to participate in the meetings to foster continuity and advancement within the community. CALCON attendance enables interaction with other experts, helps close the gap between expectations and real-world experiences, and may result in the discovery of solutions to individual program challenges. Important dates and deadlines about this meeting can be found at https://calcon.sdl.usu.edu/conference/dates

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SPIE Remote Sensing Symposium will be held in Warsaw, Poland, September 11-14, 2017.

by Xiaoxiong(Jack) Xiong, NASA

The SPIE Remote Sensing Symposium will be held in Warsaw, Poland, **September 11-14, 2017.**
http://spie.org/conferences-and-exhibitions/remote-sensing/conferences
This year's Symposium will offer eleven conferences covering a broad range of areas in the field of remote sensing:

- Remote Sensing for Agriculture, Ecosystems, and Hydrology
- Remote Sensing of the Ocean, Sea Ice, Coastal Waters, and Large Water Regions
- Sensors, Systems, and Next-generation Satellites
- Remote Sensing of Clouds and the Atmosphere
- Optics in Atmospheric Propagation and Adaptive Systems
- Active and Passive Microwave Remote Sensing for Environmental Monitoring
- Image and Signal Processing for Remote Sensing
- Remote Sensing for Environmental Monitoring, GIS Applications, and Geology
- Lidar Technologies, Techniques, and Measurements for Atmospheric Remote Sensing
- High-Performance Computing in Geoscience and Remote Sensing
- Remote Sensing Technologies and Applications in Urban Environments

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GSICS-Related Publications

Yang, A.; Zhong, B.; Wu, S.; Liu, Q. Evaluation on Radiometric Capability of Chinese Optical Satellite Sensors. *Sensors* 2017, *17*, 204.doi: 10.3390/s17010204

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Submitting Articles to GSICS Quarterly Newsletter:

The GSICS Quarterly Press Crew is looking for short articles (~800 to 900 words with one or two key, simple illustrations), especially related to cal/val capabilities and how they have been used to positively impact weather and climate products. Unsolicited articles may be submitted for consideration anytime, and if accepted, will be published in the next available newsletter issue after approval/editing. Note the upcoming spring issue will be a general issue. Please send articles to manik.bali@noaa.gov.

With Help from our friends:

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