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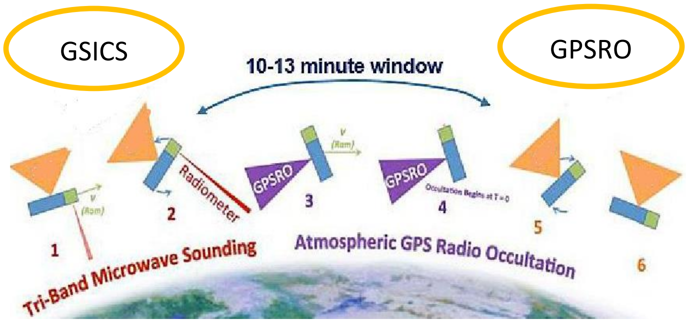

Image, courtesy Marinen et al 2016, showing GSICS- GPSRO inter-operability

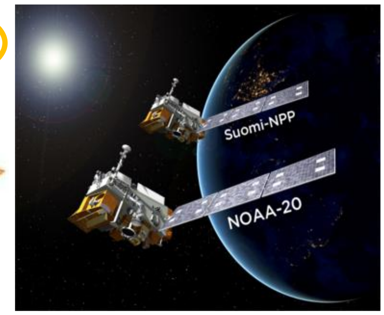

Image above : NOAA transitions SNPP to NOAA-20

Achieving inter-operability between Global Navigation Satellite System (GNSS) and GSICS: using GPS-RO as an on-orbit reference for Microwave Satellite sounders

By Shu-peng Ho, NOAA

Global Positioning System (GPS) radio occultation (RO) is the only self-calibrated satellite remote sensing technique whose raw measurements can be traced to International System of Units of time (Ho et al., 2009, 2010). The precision of GPS RO is as small as 0.05 K in the upper troposphere and lower stratosphere (i.e., UTLS, Ho et al. 2009,2010). Studies from Ho et al., (2009) have demonstrated that RO data have no mission-dependent biases. Ho et al., (2017) showed that RO derived atmospheric variables can be used as references to identify RAOB sensor-dependent biases. Many studies (Ho et al., 2009, 2010, 2012) have demonstrated that RO data can serve as benchmark datasets to identify climate trends.

1. Using GPS RO data as on-orbit references to calibrate and correct Temperatures in the Lower Stratosphere obtained from Satellite Microwave Sounders

The current long-term variations of atmospheric vertical thermal distributions are mainly constructed from passive satellite microwave and infrared sounders. On board the NOAA series of polar-orbiting satellites, the Microwave Sounding Unit (MSU) and the Advanced Microwave Sounding Unit (AMSU) have provided near all-weather temperature measurements at different atmospheric vertical layers since 1979 and 1998, respectively. However, because these satellite instruments are not built for climate monitoring, the inter-satellite biases can be of the order of one Kelvin and show variability with changing conditions ranging from a few tenths to several Kelvins when they are collocated.

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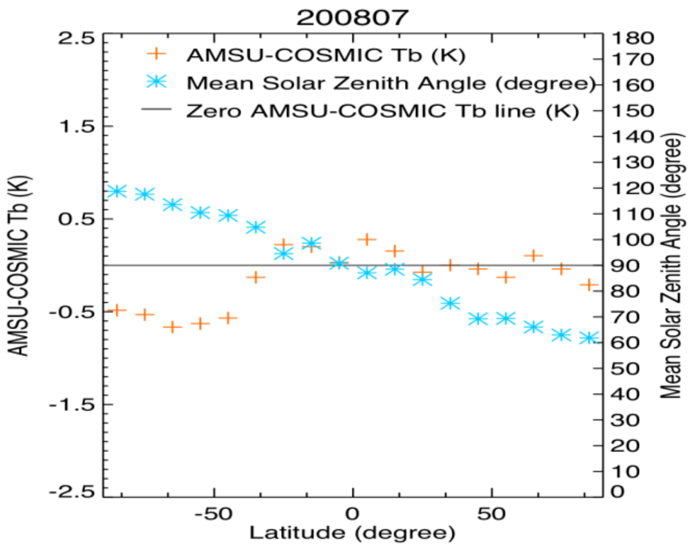

Figure 1. The variations in the binned N15-COSMIC AMSU Ch9 Tb differences for each 10-degree latitudinal bin.

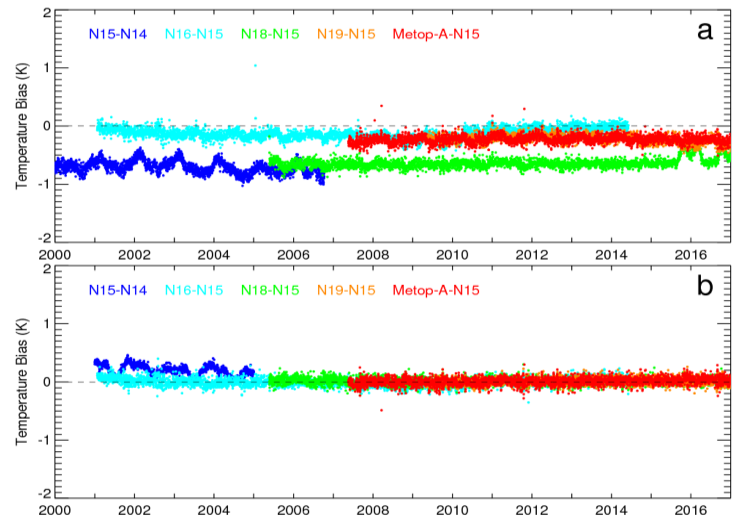

Figure 2. Use of GPS RO data to reduce biases in other satellite sounding systems. (a) Temperature biases in MSU/AMSU satellites before calibration with RO. (b) Temperature biases after calibration with GPS RO data from 2001 to 2013 used for calibration references.

Because the quality of GPS RO data is not affected by the surrounding environment (e.g., geo-location, day and night, etc.), GPS RO data are very useful to identify the possible radiative biases of microwave measurements in the lower stratosphere (from 8 km to 30 km altitudes).

In the past decade, many studies have shown that GPS RO data can be readily made into a benchmark dataset, especially for climate studies (Ho et al., 2012) such as on atmospheric variability modes (Ho et al., 2018) and climate trend detection. Comparisons of lower stratospheric temperatures revealed differences between the microwave record and GPS RO (Ho et al., 2006). The method to use GPS RO simulated TLS to distinguish the subtle inter-satellite biases among AMSU missions is detailed in Ho et al. (2009).

Launched in 2006, the six constellation micro-satellites Formosa Satellite Mission 3–Constellation Observing System for Meteorology, Ionosphere, and Climate (FORMOSAT-3/COSMIC) had provided more than 6.9 million RO soundings at the end of 2018. Ho et al. (2009) demonstrated that because COSMIC data, unlike MSU/AMSU data, do not contain orbit drift errors and are not affected by on-orbit heating and cooling of the satellite components, and convert uniform local time, they are very useful for identifying the AMSU time-/location-dependent biases for different missions.

In Fig. 1, we plot the binned N15-COSMIC AMSU Ch9 Tb differences for each solar zenith angle bin (10-degree bins) and the binned latitude variation for the N15 orbit in July 2008. It shows that, in general, the variation in the N15-COSMIC AMSU Tb biases is highly correlated with the N15 orbit change with the solar zenith angle bin, where the N15 satellite may be warmed up during the day and cooled down during the night. Figure 1 shows that the N15-COSMIC Tbs are, in general, lower during the Southern Hemispheric winter where N15 is under the shadow of the Earth (solar zenith angle is larger than 80 degrees) and are higher in the Northern Hemisphere (for solar zenith angles less than 80 degrees). Because GPS RO data are not affected by the temperature variation of the satellite components, the mean N15-COSMIC AMSU Tb biases originate mainly from AMSU Tb anomalies caused by the heating or cooling of the AMSU satellite components.

Ho et al., (2009) detailed the calibration and merging procedures used to calibrate AMSU TLS and construct the TLS climate data records. Figure 2 depicts the variation of inter-satellite TLS difference between missions, where we compare the daily global 2.5°×2.5° gridded mean TLS for N16-N15 pairs, N18-N15 pairs, N19-N15 pairs, and Metop-A - N15 pairs from 2001 to 2014. The daily TLS measurements from each individual missions (i.e., N15, N16, N17, N19 AMSU, and Metop-A AMSU-A) are first binned into 2.5°×2.5° grid. Only those daily grids containing two AMSU missions are used in this comparison. Fig. 2a depicts that inter-satellite TLS differences have subtle and complex dependencies on i) the temperature

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being measured, ii) the season, iii) the age of the sensor, and vi) peculiarities of individual sensors. Although it is not shown, the inter-satellite TLS differences also contain subtle dependencies on the particular scene, and geographical locations. After applying the calibration and merging algorithms using GPS RO data as references, the consistent AMSU TLS climate data records from 2001 to 2014 are constructed.

Conclusions

Contributions and the remaining challenges of COSMIC and other RO observations to weather, climate, and space weather since 2011 are summarized in a recent BAMS paper (Ho et al., 2019).

A COSMIC follow-on constellation, COSMIC-2, is scheduled to be launched into Equatorial orbit in 2019. COSMIC-2 has higher Signal-to-Noise ratio (SNR) performance than that of COSMIC, and is expected to produce at least 5,000 high-quality RO profiles daily in the tropics and subtropics. The potential impacts of COSMIC-2 data to advance climate, weather, and space weather science studies are also summarized in Ho et al. (2019).

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Discuss the Article

GEO-GEO Inter-Calibration of Elektro-L#2 Imager IR Channels

By Rublev, A., V. Golomolzin, E. Borisov, Ju. Kiseleva (State Research Center for Space Hydrometeorology "Planeta", Roshydromet), Yu. Gektin. and A. Zaitsev (JSC "Russian Space Systems", Roscosmos)

The MSU-GS imager is a key instrument on board the Russian Geostationary Earth Orbit (GEO) satellite Elektro-L# 2. Since the launch (December 11, 2015), the radiation cooler of MSU-GS has been operating in an abnormal mode, so the calibration of the IR channels of the imager differed from that pre-flight and, in general, could have a daily variability. The use of the GEO-LEO (Low Earth Orbit) scheme allows for inter-calibration only twice daily per LEO reference. This frequency is not sufficient to set the parameters of the amplitude functions (AF) of the imager channel (i.e., the dependencies of measured radiance or its brightness temperature (BT) at the channel output on optical signal power at the input of the light sensor) daily changes or to verify their stability. In view of this, we developed the GEO-GEO inter-calibration scheme under which both the calibrated and reference instruments were located on-board geostationary satellites (Rublev et. al., 2018). SEVIRI/Meteosat-10 imager was chosen as a reference instrument. Inter-calibration was performed for the simultaneous measurement sessions of both imagers. The maximum number of inter-calibrations per day reached 48. The development of inter-calibration methodology was carried out by comparing the measurement data in the 9th channel of both instruments located near 10.7μm. All MSU-GS IR channels (#4-#10) have identical structure. We selected channel #9 as the most important one for various thematic tasks. Besides, its spectral band is in the IR atmospheric window, so the range of measured BTs is over 100K.

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The main feature of this GEO-GEO inter-calibration was that we simultaneously had to calibrate at low BTs (220K and below), which are typical for the cloud tops at altitudes of about 15km, and had to take into account the large (76°) distance in longitude between Sub-Satellite Points (SSPs) of Elektro-L# 2 and Meteosat-10. Therefore, due to large uncertainties introduced by cloud parallax, it was impossible to use pixel-to-pixel comparison of the radiances or BTs measured MSU-GS and SEVIRI, as was done during the inter-calibration of the AHI imagers (Takahashi, 2017) installed on Himawari -8 and -9. Besides, comparing the intensities averaged over large areas, as was done for imagers (Hillger and Schmit, 2011) installed on GOES, significantly reduces the dynamic range of the compared BTs because radiation from cold tops of high clouds is mixed with radiation coming from warm clouds of lower layers and the underlying surface.

For inter-calibration processing, it is necessary to establish correspondence between uniform fragments of the different atmospheric scenes on the images obtained by both instruments.

The developed approach involves the following basic steps:

- determination of the inter-calibration area on the Earth's surface located in the middle between the SSP;
- establishment of a one-to-one correspondence between subsets of image fragments from both instruments;
- elimination of geolocation errors and gross errors that arise when two BTs of fragments, which belong to different cloud formations, are being compared;
- obtaining regression relationships for inter-calibration in a wide range of BTs.

The SSPs of satellites and inter-calibration area are shown in the (**Figure 1**). The land-free area of the Indian Ocean off the southwest coast of Madagascar was specially selected from the entire region for its high BT (290-300K) inter-calibration. The use of the warm ocean surface is necessary to eliminate the calibration error due to the non-uniform daily variations of land surface temperature observed from east to west for the right-hand satellite and from west to east for the left-hand satellite. The average BT value T_{max}^{MSU} or T_{max}^{SEV} in the range $[T_{max} - 5, T_{max}]$ is found. The corrected BT T_{MSU}^{corr} by MSU-GS for measured $T_{MSU} > T_{max}$ is calculated using the equation

$$T_{MSU}^{corr} = T_{MSU} + (T_{max}^{SEV} - T_{max}^{MSU}).$$

In the low BT region (200-220K) these scenes are constituted by deep convection clouds with the flat top that reaches the tropopause. To eliminate cloud parallax errors, which can reach 40km, minimum values of BT in every image row (practically in the East-West direction) are picked for collocated pairs.

To minimize the impact of geolocation errors, the maximum of correlation coefficient between two different BT columns was found shifting one of them on ± 3 positions in the North-South direction The regression relationship between BT SEVIRI and MSU-GS passing through the point $\{T_{max}^{MSU}, T_{max}^{SEV}\}$ is $T_{SEV}(T_{MSU}) = a + b \cdot T_{MSU} + c \cdot \exp\left(-\frac{T_{MSU}}{K_T}\right)$,where a, b and c are constants which were found with least squares method for the same session

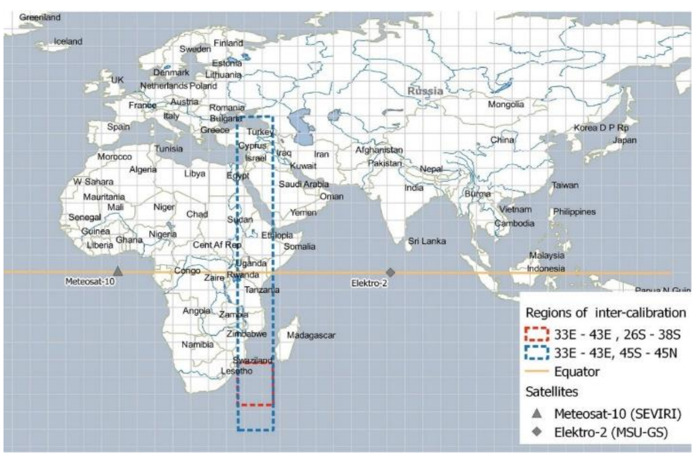

Figure 1. Inter-calibration regions MSU-GS/Elektro-2 (at 76°E) and SEVIRI/Meteosat-10 (at 0°E)

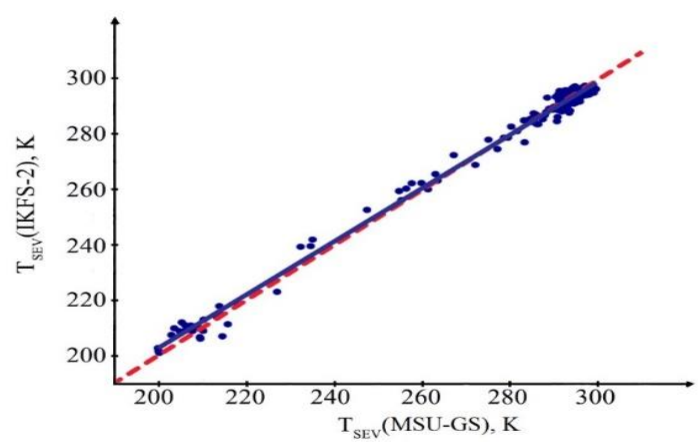

Figure 2. Comparison of SEVIRI 10.8µm BT estimates from GEO-GEO and GEO-LEO inter-calibrations, accordingly T_{SEV}(MSU-GS) and T_{SEV}(IKFS-2), April, 2018

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of MSU-GS and SEVIRI measurements; $K_T = 30K$ – constant dimensional coefficient.
Regressions are statistically significant in the interval (T_{min}, 275K) when 7% of the values of the measured BTs are less than T_{min}. The level of significance of 7% is found empirically and ensures the stable behavior of the obtained curves. Differences $\Delta T = T_{MSU} - T_{SEV}$ for every image using the obtained relationships were calculated and saved on the fixed grid with step 5K for BT more than T_{min}.

The accumulated ΔT were averaged during the month for every image time and used to estimate the diurnal variation of AF at different BT. It turned out that amplitude of diurnal variation from December 2017 does not exceed 0.2K for high BTs and gradually increases to 1K for low temperatures. This result allowed to use the GEO-LEO calibration scheme to verify the developed method. The Fourier spectrometer IKFS-2 on board Meteor-M-2 (Russian LEO satellite) was used as the reference.

In SSP region of Elektro#2, MSU-GS BT were recalculated to T_{SEV}(MSU-GS) by using the obtained calibration relationship. In the same region, to obtain estimates of T_{SEV}(IKFS-2), the radiance spectra measured by IKFS-2 were convolved with SRF of SEVIRI ch. 9 for MSU-GS pixels collocated with central pixels of IKFS-2.The result of the comparison of SEVIRI band 9 BT estimations is shown in **Figure 2**. The correlation coefficient R= 0.996, the mean and standard deviation of the bias between the estimates equal 0.2±0.14K.

A good match of the calibration relationships confirms the correctness of the developed GEO-GEO inter-calibration scheme and its applicability in a wide range of measured BTs. Despite the specifics of the situation on board Elektro-L#2, the proposed method of GEO-GEO inter-calibration can be applied to radiometers of other neighboring GEO satellites with different SSP.

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NOAA-20 VIIRS RSB Calibration Update

By Taeyoung (Jason) Choi, Slawomir Blonski, Xi Shao, Wenhui Wang, Sirish Uprety and Changyong Cao, NOAA

The Visible Infrared Imaging Radiometer Suite (VIIRS) on NOAA-20 satellite was launched on November 18, 2017. It was activated on November 29th and started collecting data from the On-Board Calibrators (OBCs) such as Solar Diffuser (SD) and Solar Diffuser Stability Monitor (SDSM) for Reflective Solar Band (RSB) calibration. The SDSM includes eight detectors that monitor SD degradation (or H-factor) over time and the H-factors are used to calculate the RSB calibration scaling coefficients known as F-factors. A series of Post Launch Tests (PLTs) were performed to ensure the quality of VIIRS products approximately within 100 days after launch [1, 2]. The initial H-factors using the prelaunch version of the SDSM Sun screen transmittance function and SDSM SD view Bidirectional Reflectance Function (BRF) showed abnormal oscillations up to 1 to 1.5% in all of the eight SDSM detectors [1]. The source of oscillation was the SDSM Sun view Screen transmittance function, and the NOAA VIIRS Sensor Data Record (SDR) team developed an adaptive methodology to resolve the oscillation patterns by combining yaw-maneuver data and regular on-orbit SDSM data sets [3]. In this report, NOAA VIIRS SDR team provides a summary of the updated SD degradation (H-factor) and RSB calibration coefficient (F-Factor) updates which have been used for the operational SDR product generation at NOAA.
After the yaw maneuvers from January 25th to 26th of 2018, the initial version of the SDSM Sun transmittance function was derived and compared to the prelaunch version of the function. There were some differences and oscillations in the ratio between the prelaunch and initial yaw maneuver derived versions. To be able to normalize all of the H-factors at the time of orbit insertion, the oscillation

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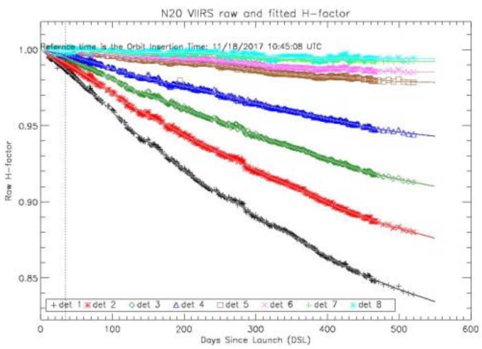

Figure 1. NOAA-20 VIIRS raw H-factors.

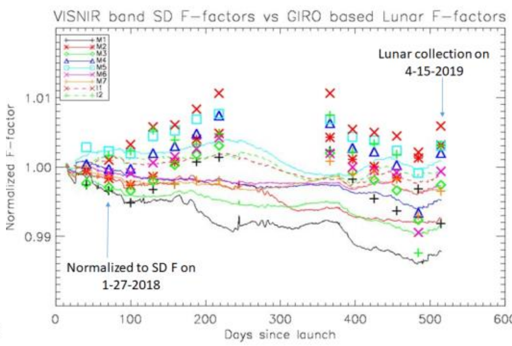

Figure 2. NOAA-20 VIIRS normalized offline SD F-factors and lunar F-factors.

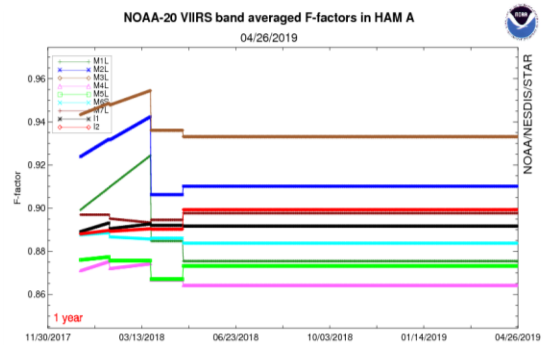

Figure 3. NOAA-20 VIIRS operational F-factor LUTs from the ICVS webpage.

problem of H-factor needed to be resolved. Therefore, on-obit regular SDSM data sets were added in between the yaw maneuver points to reconstruct much higher variability of the SDSM Sun transmittance function responses along with the linear difference correction in SDSM detector 6,7, and 8 [3]. Reasonable H-factors were achieved which could be used in the operation as shown in Figure 1. It should be noted that the frequency of the SDSM collections were reduced from once per day to once per week (on Mondays) starting from March 1, 2019 to extend SDSM lifetime.

In Figure 2, the offline version of VIIRS radiometric calibration coefficients are compared with the lunar F-factors using the scheduled lunar collections. For better comparisons, the SD F-factors (solid line) are normalized to the first point and the lunar F-factors are also normalized to the SD F-factors at the 2nd lunar collection (the second symbol) on January 27, 2018. The lunar F-factors are calculated by using the GSICS Implementation of ROLO (GIRO) model [4]. As seen in the figure, the SD and lunar F-factors agree well within the 2 percent range.

Similar to the SNPP case [5], the NOAA-20 RSB calibration is calculated with the RSBAutoCal code using all on-orbit SD and SDSM observations. Because of the F-factor uncertainties visible in Figure 2, current operational SDR production is based on the F-factor LUT instead of directly using the RSBAutoCal outputs. The current operational F-factors are shown in Figure 3 from the ICVS webpage at https://www.star.nesdis.noaa.gov/icvs/status_N20_VIIRS.php.

The operational F-factors remain unchanged since April 2018 because the SD F-factors changes in Figure 2 seem not to be true detector gain degradations. As shown in Figure 4, our RSB detector degradation trend monitoring using Deep Convective Cloud (DCC) and SNO-based cross-calibration over the deserts do not show strong evidence to add slopes in the operational F-factors yet. The long-term DCC and other calibration sites trending results can be found in the NOAA Calibration Center (NCC) Webpage at https://ncc.nesdis.noaa.gov/NOAA-20/VSTS.php. Nevertheless, all of the possible calibration sources such as SD F-factors, lunar F-factors, long-term DCC trends and cross-calibration results are being monitored by the NOAA VIIRS SDR team to provide the

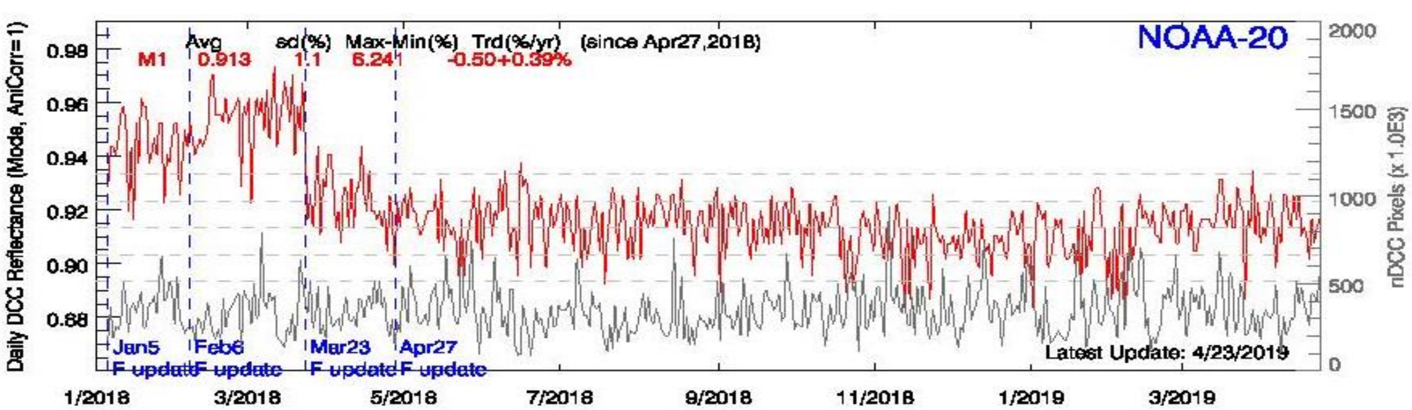

Figure 4. NOAA-20 VIIRS DCC trending result in band M1.

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NOAA-20 VIIRS SDR products with the best quality. Acknowledgment: Authors thank EUMETSAT for sharing the GIRO v1.0 lunar irradiance model with the NOAA VIIRS team.

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Discuss the Article

Comparing Atmospheric Profiles between Reanalysis and Satellite Observation for 183 GHz Calibration

By John Xun Yang and Hu Yang, ESSIC/CICS

We compare the performance of three different datasets for calibrating the 183 GHz channels of the Advanced Technology Microwave Sounder (ATMS) aboard Suomi NPP. Among the three datasets, two are climate reanalyses and the other one is from observation based retrieval. Although climate reanalyses produced by numerical weather prediction (NWP) models and data assimilation have been used for satellite calibration with radiative transfer model (RTM) results, they have biases and uncertainties due to NWP model mechanism, parametrization, boundary conditions and data assimilation skills. Reanalyses are derived with spaceborne radiometer data and other in situ datasets. They are not independent from these radiometers and should be used with caution when used as a reference for radiometer calibration. Climate reanalyses also have coarse spatial (~100 km horizontally) and temporal resolution (~6 hour). An independent dataset with high spatiotemporal resolution can be very useful to diagnose reanalyses and might improve calibration.

A recent dataset based on satellite observation appears to be a promising candidate for validation. It is from The Global Precipitation Measurement (GPM) and GPM core observatory which measures atmospheric water signatures with an onboard dual-frequency precipitation radar (DPR) and a microwave imager (GMI). A GPM dataset including atmospheric water vapor, cloud liquid water and precipitation has been produced based on observational retrievals with high spatiotemporal resolution (~5 km horizontally, 250 m vertically) (Olson et al. 2016). We have developed a scheme to ingest the high-resolution GPM profiles and perform rigorous simulation for ATMS validation (Yang et al. 2018). In addition to DPR/GMI dataset, two reanalysis datasets are used in ATMS validation for performance comparison. The Global Data Assimilation System (GDAS) produces operational model data NCEP FNL by National Center for Environmental Prediction (NCEP). The ERA Interim (ERA-I) data are from European Centre for Medium-Range Weather Forecasts (ECMWF). GDAS and ERA-I have been widely used in RTM simulation for radiometer validation.

The atmospheric profiles and weighting functions at 183 GHz are compared for the three datasets (Figure 1). The water vapor profiles of DPR/GMI are most distinct from the reanalyses. GDAS and ERA-I show more significant bumps in tropic zones. There is a clear boundary near the intertropical convergence zone (ITCZ) with large standard deviation. For all the three datasets, the weighting function lifts up to higher altitude from 183±7 to 183±1 GHz. This is anticipated as surface and low-altitude emission is absorbed at strong absorption channels. The weighting function is slightly higher in northern hemisphere than in southern hemisphere. There is a jump at ±15° latitude zones with large standard deviation due to the thicker troposphere with more water vapor in tropics. Despite the common features, there are noticeable differences between the DPR/GMI and the reanalyses. GDAS and ERA-I have higher, smoother

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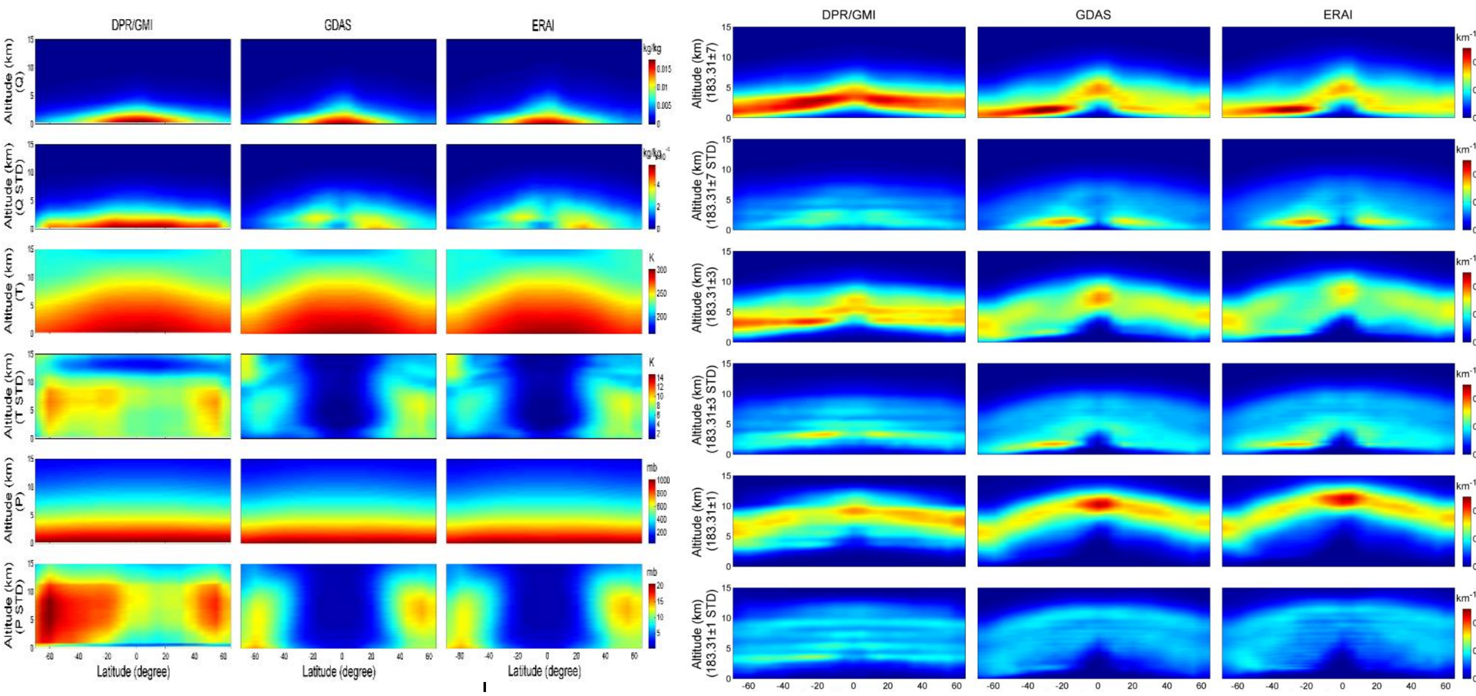

Figure 1. Panel A shows profiles and standard deviations of atmospheric water vapor (Q as specific humidity), temperature (T) and pressure (P) for DPR/GMI, GDAS, and ERAI, respectively. Panel B shows the weighting functions and standard deviations at nadir view for DPR/GMI, GDAS and ERAI. The DPR/GMI exhibits different water vapor profiles and weighting functions from GDAS and ERA-I.

weighting function. The jumps at central tropics are more pronounced. GDAS and ERA-I show similarity with model-tuned characterizations. The three datasets are compared for GMI/ATMS validation. The observation/simulation difference (O-B) and inter-sensor bias are compared and shown in Figure 2. Among the three data, DPR/GMI produces the smallest inter-sensor biases with the minimum standard deviation. The inter-sensor biases are -0.29 and -1.0 K for DPR/GMI, -1.02 and -1.18 K for GDAS, and -0.62 and -1.1 K for ERAI at 183±7 and 183±1 GHz respectively. The standard deviations are 1.42 and 1.6 K for DPR/GMI, 2.01 and 1.89 K for GDAS, and 1.50 and 1.62 K for ERA-I, respectively. DPR/GMI show small deviation in terms of both 25-75th and 10-90th percentiles. Its mean and median values are more consistent, indicating more symmetric distribution of probability density function DPR/GMI outperforms GDAS in both

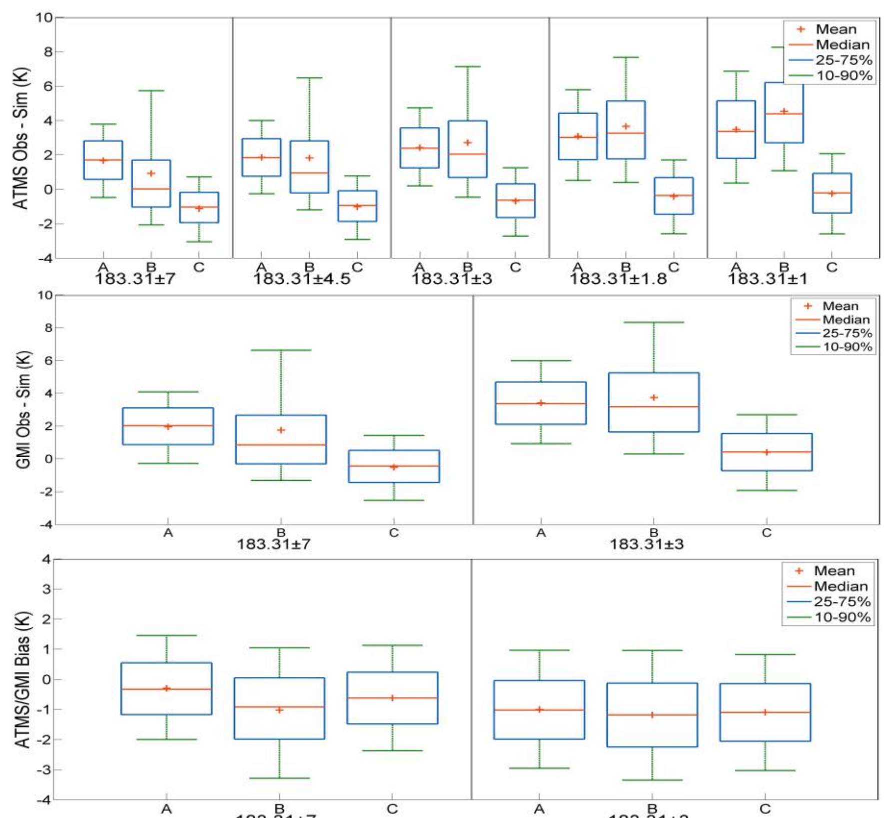

Figure 2. The calibration results in terms of observation/simulation differences and ATMS/GMI inter-sensor biases (A, B, C for DPR/GMI, GDAS, and ERAI, respectively). DPR/GMI produces inter-sensor biases closest to zero with the least standard deviation. DPR/GMI outperforms GDAS with smaller deviation and more consistent mean and median.

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O-B and inter-sensor biases. ERA-I shows quality close to DPR/GMI. Compared to GDAS, ERA-I are produced with frozen models and include more observational data in adjusting observation with modeling and is expected to have better performance in calibration.

The DPR/GMI exhibits atmospheric profiles and weighting functions different from the reanalysis. GDAS and ERAI have more water vapor in tropics and less in higher latitude zones than DPR/GMI. DPR/GMI profiles show more water vapor near the ground. The weighting functions of the two reanalyses are relatively low and smooth and show model-tuned characterization and similarity. DPR/GMI outperforms reanalysis by producing the inter-sensor biases closest to zero with the least standard deviation.

DPR/GMI outperforms GDAS and shows the same level of quality as ERAI. As the DPR/GMI data is independent from NWP, it can be a useful alternative for radiometer calibration. It can help diagnose reanalysis and NWP models and reconcile simulation and observation.

Reference

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NEWS IN THIS QUARTER

Highlights of the 2019 Annual GRWG/GDWG Meeting

By M. Bali (UMD), L. Flynn (NOAA), Philippe Goryl (ESA), S. Hu (CMA), T. Stone (USGS), D. Doelling (NASA), R. Ferraro (NOAA), T. Hewison (EUMETSAT), F. Yu(UMD), D. Kim (KMA) and M. Takahashi (JMA)

This year's meeting of the GSICS Research and Data Working Groups (GRWG and GDWG) was hosted by the European Space Agency (ESA) in Frascati, Italy 04-08 March 2019. Members from ACRI, CMA, CAS, CNES, ECMWF, EUMETSAT, ESA, ISRO, JAXA, JMA, KMA, LASP, NIST, NASA, NOAA, NPL, RAL, Rayference, ROSHYDROMET, ROSCOSMOS, UKMO, USGS, VITO and WMO attended the meeting. Nicolaus Hanowski (ESA) and Mitch Goldberg (GSICS EP Chair) opened the meeting and welcomed the participants. Nicolaus pointed out that inter-operability of sensors achieved in GSICS can help ESA EO missions and that ESA inclusions in GSICS as a full member would go a long way in sharing best practices to achieve this. Mitch welcomed ESA and SITP as new members of GSICS fold.

Mini Conference

The first session of the meeting was a Mini Conference, Chaired by Philip Goryl (ESA) and covered topics vital to GSICS in the near future. ESA used the mini-conference to cover their past, present and future missions for Earth Observations (EOs) and their advances in contributing to climate and weather monitoring. Topics included the following: Climate Change Initiative (CCI), Fiducial Reference Measurements, Fundamental Climate Data Records (including altimetry), and Lunar Calibration. NOAA provided updates on GOES-16/17 ABI calibration and ECMWF provided updates on Copernicus activities related to intercalibration.The Mini conference ended with a talk by Nigel Fox (NPL) on the Quality Assurance for EO and CEOS activities.

Plenary

The Mini Conference was followed by a plenary session. The first part of which was chaired by Tim Hewison (EUMETSAT) and focused on the re-calibration and re-processing to support the generation of Fundamental Climate Data Records (FCDRs).
This importance of this session was recognized and a special session was proposed before or after the 2020 annual meeting, which may result in the formation of a dedicated sub-group on this topic. Rob Roebeling (EUMETSAT) provided an overview of the FIDUCEO project, which systematically applies metrology principles to EO climate data records, and summarised methods deployed for VIS, IR and WV calibration applied to the GEO-Ring as part of SCOPE-CM/ IOGEO. Masaya Takahashi described

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Participants of the GSICS Annual Meeting

the recalibration of WV/IR channels of JMA imagers using HIRS, AIRS and IASI, which included the application of the *Prime GSICS Correction* concept by Tasuku Tabatha during his stay as a visiting scientist at EUMETSAT. Ken Knapp then provided valuable user perspectives on the application of GSICS products to the climate monitoring system and comparison with ISCCP. He highlighted issues with accessibility, ATBD usefulness, data contents and design of the GSICS websites, which were followed up in GDWG discussions. Srirish Uprety presented the main difference between S-NPP/VIIRS v1 and v2 processing at NOAA and Scott Hu presented the recalibration and reprocessing activities at CMA. Roger Saunders (UK Met Office) described the benefit of long-term calibration monitoring using Numerical Weather Prediction models. This was a recurring theme throughout the meeting, and the interaction between recalibration and NWP reanalysis was also discussed.

The second part of the plenary was chaired by Mitch Goldberg (NOAA) covered cross-cutting topics. Masaya Takahashi provided state of the observing system report and sought feedback from members. Toshiyuki Kurino provided updates on the maturity of the WMO CIMO guide and Guide to WIGOS and future prospects of WIGOS manual. Toshi suggested that GSICS review the latest version of the WMO CIMO guide Chapter 6. Toshi also covered topics on Space Weather and introduced the new GSICS portal to members and sought feedback. The session finished with Manik Bali and Masaya Takahashi introducing the GSICS Deliverable acceptance matrix to the members.

UV Sub-Group Session Summary

The session included summaries of the UVSG projects (solar reference spectra, reflectivity channel inter-calibration, ozone profile channel inter-calibration, and ground-based characterization / calibration) activities at NOAA (by L. Flynn) and EUMETSAT (R. Munro), and a discussion on changing the subgroup name to cover Reflective Solar Spectrometers. The UVSG will have opportunities for GEO-LEO inter-calibration beginning with the launch of the Korean GEMS instrument. Odele Coddington (LASP) gave background and updates on solar UV irradiance measurements. She reported that the TSIS team performed extensive error breakout analysis and are planning to release a “Quiet Sun” Spectrum. Julian Gröbner (PMOD) described the main asset of the World Radiation Center – the portable Quality Assurance of Spectral UV Measurements in Europe. QASUME provides a standard to monitor the calibration of 200 ground-based solar UV measurements at 1% for simultaneous spectra measurement comparisons.

Special Session on SWIR Spectrometers

Dave Crisp (NASA) provided an extensive and very interesting overview of the challenges and opportunities in (inter-)calibration of SWIR spectrometer. GSICS can make a contribution to SWIR spectrometers inter-calibration, and it was agreed that inter-calibration of SWIR spectrometers will be addressed in “UVSG”. The Subgroup will host a web meeting to discuss specific opportunities and priorities for SWIR spectrometer inter-calibration within GISCS with related activities at the CEOS AC-VC.

IR Sub-Group Session Summary

The session chairs Likun Wang and Tim Hewison divided Thursday’s infrared break-out session between Cal/Val activities, hyperspectral and multi-spectral inter-calibration methods. Highlights included the improved calibration reported by CMA of their new LEO and geostationary IR sounders, HIRAS and GIIRS, a new

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AIRS re-calibration and improved error budget, which will contribute to the GSICS IR Reference Uncertainty & Traceability report (“IRRefUTable”) and will be complemented by a counterpart analysis for IASI by CNES, once the commissioning of Metop-C/IASI is successfully completed. This report will also include numerous inter-comparisons between IASI, CrIS and AIRS - and eventually HIRAS.

The group also agreed to migrate from IASI-A to IASI-B as common “anchor” reference to be processed by all agencies. The group also discussed the coordination of activities under new chair (Likun Wang), aiming to define baseline algorithms for GEO-GEO and LEO-LEO and develop an improved version of the current GEO-LEO IR algorithm, whilst progressing the current products toward operational status. The agreed approach was to build a library of tools for *collocation* - consolidating LOS/projection approaches; *conversion* - progress with gap-filling for CrIS (PCA regression) and to extend IASI coverage for SWIR channels; and *comparison* - including uncertainty on reference in regression and better handling of diurnal calibration variations.

MW Subgroup Session

The session was opened by ESA who presented their Cal/Val activities of SMOS (Soil Moisture and Ocean Salinity). SMOS has reached high quality and stability. Bill Bell (ECMWF) described the use of microwave sensor data in C3S to produce ERA reanalysis. Tim Hewison (EUMETSAT) provided an update on MetOp-C AMSU which has completed post-launch check out and is now operational. Ed Kim (NASA) provided a review of NOAA-20 ATMS; NeDT is well within design specifications. He later spoke on MW calibration references that are under development. Misako Kachi (JAXA) provided an update on AMSR-2 and plans for AMSR-3. Other speakers in the session included Shengli Wu (CMA) on GSICS-CEOS/WGCV and FY-3D cal/val; Cheng-Zhi Zhou (NOAA) on In-Orbit references; and Isaac Moradi (Univ. of Maryland) on RTM inter-comparison. Mitch Goldberg (NOAA) gave an overview of MW Imager constellation, gap risks, and noted that CIMR and AMSR-3 are critical to reduce the gap of the international constellation. Two talks followed on NWP - Alan Geer (ECMWF) and Fabien Carminati (UKMO). The session ended with a discussion on WIGOS integration with GSICS community

VIS/NIR Sub Group Session Summary

The Vis/NIR Subgroup session had two parts, with the morning dedicated to lunar calibration. Results were reported on lunar calibrations using the GIRO with SGLI, Sentinel-3B OCLI, and GOES-16 and 17. Updates were given on several projects for new measurements of the Moon, including air-LUSI on the NASA ER-2 high-altitude aircraft and the ongoing ground-based work by CMA. A discussion of solar spectra concluded that GSICS work requires a static solar spectrum with TSIS high accuracy and traceability, but with higher spectral resolution than Thuillier. The group delivered a request to LASP to create a reference solar spectrum.

The afternoon session discussed the NPP-VIIRS onboard RSB calibration from both the NASA and NOAA perspective, which differed slightly. The NOAA NPP-VIIRS V2 is the official GSICS VIS/NIR reference and NOAA will be making the V2 dataset available this summer. NOAA has asked other organizations to host the V2 dataset, which is not available at NOAA CLASS. AHI, OLCI-A/B, SLSTR-A/B S2A, S2B, L8, Deimos-1, ProbeA-V vicarious calibration results were presented using multiple approaches. Radiative transfer model and SBAF suited for inter-calibration were also presented.

GSICS Data Working Group (GDWG) Session Summary

The GDWG session started with a review of the status of GDWG actions. ESA kindly gave three talks relevant to their data management activities. All the presentations were highly appreciated by the group, and further collaboration such as a nomination of ESA GDWG member and close communication with CEOS/WGISS were discussed. The group also welcomed an active involvement of ROSHYDROMET who launched their GSICS website and Landing Page for satellite and instrument Event Logging. Issues on the Event Logging such as an entity maintaining the pages and a way to achieve the goal to adopt nomenclature and data standards were raised and further will be discussed with GSICS-EP. One of the most important collaboration activities for GDWG is GSICS Collaboration Servers, which provide a set of services to support data exchange and access to relevant inter-calibration datasets. In addition to the current servers operated by CMA, EUMETSAT and NOAA, ISRO reported their progress on building THREDDS server which is expected to be 4th Collaboration Server. The collaborative works among the member agencies for updating server configuration and data synchronization are ongoing. A need of adding a new value (Spectral Response Functions – SRF) for Common Table C-13 of WMO Manual on Codes was raised to satisfy the GSICS Convention for Spectral Response Function files. The group agreed the needs and is further presented to EP for their endorsement. CMA's proposal to share L1 subsets over PICS and SNO Prediction could be useful for GRWG activities, so it was

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agreed to be reported to GRWG. The group also agreed to continue other collaborative activities such as GSICS Product download scripts, Quicklooks on Product Catalog, GSICS Plotting Tool and Action Tracking Tool.

Cross cutting discussions

In response to an EP Action (EP-18.A01), D. Kim opened the session with a discussion on specific methodologies that should be used for instrument monitoring. This was followed by a talk from X. (Scott) Hu who discussed the forthcoming GSICS meetings such as the Lunar Workshop, GSICS Prelaunch workshop and GSICS CEOS SI Traceability workshop. Scott also spoke about Re-calibration as one of the foci of GSICS. This was followed by a live demo of Action Tracker and a presentation on MICMIC by S. Wagner. L. Flynn announced that the GSICS Users Workshop 2019 would be held as part of the International TOVS Study Conference in Canada.

Detailed Minutes of the Annual Meeting can be obtained from GCC at http://gsics.atmos.umd.edu/bin/view/Development/AnnualMeeting2019

Discuss the Article

Announcements

NOAA-20 CrIS attains Validated Maturity

By Flavio Iturbide-Sanchez, NOAA

The Joint Polar Satellite System-1 (JPSS-1) was successfully launched on November 18, 2017 and renamed NOAA-20 after reaching polar orbit. Forty-eight days after launch, on January 5, 2018, the NOAA-20 Cross-track Infrared Sounder (CrIS) started collecting science data. The NOAA-20/CrIS SDR data product was declared Beta Maturity on January 17, 2018. After one-month of intensive Cal/Val activities, the NOAA-20/CrIS SDR data product was declared Provisional Maturity on February 16, 2018. Based on more than six months of continuous intensive evaluation and monitoring of CrIS data, the NOAA-20/CrIS SDR data product was transitioned to the Validated Maturity level effective August 14, 2018.

Table 1: NOAA-20 CrIS Noise (NEdN), Frequency, Geolocation and Radiometric Uncertainties. The attained values (in blue) are well below specs (in black) thereby showing high quality of spectral measurements of NOAA-20 CrIS sensor (Reference: *F. Iturbide-Sanchez, S et al 2018*, The NOAA-20 CrIS SDR Validated Maturity available at https://www.star.nesdis.noaa.gov/jpss/documents/AMM/N20/CrIS_SDR_Validated.pdf)

Band	Spectral Range (cm^{-1})	Resolution (cm^{-1})	Number of Channels	NEdN* ($mW/m^2/sr/cm^{-1}$)	Frequency Uncertainty (ppm)	Geolocation Uncertainty** (km)	Radiometric Uncertainty @287K BB (%)
LWIR	650-1095	0.625	713	0.086 (0.14)	2 (10)	0.22 (1.6)	0.15 (0.45)
MWIR	1210-1750	0.625	865	0.0315 (0.084)	2 (10)	0.22 (1.6)	0.18 (0.58)
SWIR	2155-2550	0.625	633	0.00766 (0.014)	2 (10)	0.22 (1.6)	0.36 (0.77)

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GSICS User's Workshop 2019 to be held on 1 Nov 2019 as a component of the ITSC in Saint-Sauveur, Québec, Canada

By Lawrence E. Flynn (Director GCC)

The 8th GSICS Users' Workshop will be held at Manoir Saint-Sauveur in the town of Saint-Sauveur, Québec, Canada on the evening of **1 November 2019.** This year's GSICS Users' Workshop will be a part of the International TOVS Study Conference (ITSC-XXII: Saint-Sauveur, Québec, Canada, 31 October - 6 November 2019).

Registration for the ITSC meeting is now open through links at: https://cimss.ssec.wisc.edu/itwg/itsc/. We are inviting attendees of the ITSC and GSICS researchers, developers, and product users to volunteer to give talks as part of the workshop. The agenda topic areas for the workshop are:

- Introduction to GSICS (Purpose, organization, WMO documents)
- Summary of GSICS products (From agency annual reports) including GEO-Ring
- Applications of GSICS products
- GSICS Research Working Groups (purpose and activities)
- GSICS Data Working Group (purpose and activities)
- GSICS at the agencies and WMO (GPRCs, Instrument landing, event and monitoring pages, OSCAR)
- GSCIS Coordination Center (Products, Meetings, GUMS, Newsletter, Actions, Wiki)

If you are willing to give a talk, please let us know which area it would be in. If you want to provide a short abstract with more details, send that to Larry as well (lawrence.e.flynn@noaa.gov).

Note: the GCC is organizing the workshop agenda separately from the meeting program. Do not use the meeting abstract submission process to volunteer for a talk in the workshop. You will need to register for the meeting to participate in the workshop.

Some ideas for specific topics:

- GPRC resources (e.g., Calibration/Validation Systems, Long Term Monitoring, Instrument Landing Pages, and monitoring notices, alerts and summaries);
- Interactions between data assimilation groups and measurement calibration, characterization and monitoring teams. (For this item, we are encouraging data assimilation groups to present information on their capabilities to identify measurement biases and/or to make use of GSICS inter-calibration bias estimates.);
- Introduction to upcoming GSICS products and research and calibration areas (e.g., GEO Ring, GOES-R on-orbit calibration, Lunar, Deep Convective Cloud, Reference Migration, Best Practices), and
- Practical experience in the use of JPSS Mission and other instruments as references for Monitoring GEO/LEO instrument measurements in Near Real-Time and Climate Data Record applications.

GSICS-Related Publications

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Submitting Articles to the 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 calibration / validation 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. Please send articles to manik.bali@noaa.gov.

With Help from our friends:

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