VALIDATION OF AMSR2 OCEANIC ENVIRONMENTAL DATA RECORDS USING TROPICAL CYCLONE COMPOSITE FIELDS

Suleiman Alsweiss[1, 2, 4], Joseph Sapp[1, 2], Zorana Jelenak[1, 3], and Paul Chang[1]

NOAA/NESDIS/STAR[1], Global Science & Technology, Inc.[2], University Corporation for Atmospheric Research (UCAR)[3], Florida Polytechnic University[4]

ABSTRACT

The Advanced Microwave Scanning Radiometer-2 (AMSR2) on board the Global Change Observation Mission-Water (GCOM-W) launched in May 2012 by the Japanese Exploration Agency (JAXA) is acquiring earth electromagnetic radiation for the purpose of monitoring Earth's environmental and climate system. The ocean vector winds team part of the National Oceanic and atmospheric administration (NOAA), National Environmental Satellite, Data, and Information Service (NESDIS), Center for Satellite Applications and Research (STAR), has exploited AMSR2 observations of brightness temperature (T_b) to develop an environmental data record (EDR), which includes several oceanic parameters. The purpose of this paper is to show the validation results for these geophysical parameters when compared to other active and passive microwave sensors and numerical weather models.

Index Terms— AMSR2, brightness temperature, oceanic measurements, microwave radiometry, validation

1. INTRODUCTION

Passive microwave radiometry is a special application of microwave communications technology for collecting Earth's electromagnetic radiation. With the use of radiometers onboard earth orbiting satellites, scientists are able to monitor the Earth's environment and climate system on both short- and long-term temporal scales with near global coverage (e.g. [1], [2]).

The Global Change Observation Mission (GCOM) is part of the Japanese Aerospace Exploration Agency (JAXA) broader commitment toward a global and long-term observation of the Earth's environment. It consists of two polar-orbiting satellite series [GCOM-W (Water) and GCOM-C (Climate)] with 1-year overlap between them for inter-calibration. As payloads for these missions, two instruments were selected to cover a wide range of geophysical parameters: the Advanced Microwave Scanning Radiometer–2 (AMSR-2) on GCOM-W, and the Second-Generation Global Imager (SGLI) on GCOM-C. The AMSR2 instrument, follow on to the AMSR-E [3], will perform observations related to the global water and energy cycle, whereas the SGLI will conduct surface and atmospheric measurements related to the carbon cycle and radiation budget.

The National Oceanic and Atmospheric Administration (NOAA) GCOM-W1 product development and validation project is providing NOAA's users access to critical geophysical products derived from AMSR-2. These products include calibrated microwave brightness temperature, total precipitable water (TPW), cloud liquid water (CLW), precipitation type/rate (PT/R), sea surface temperature (SST), and Sea Surface Wind Speed (SSW).

The scope of this paper will focus on validating oceanic environmental data records (EDRs) obtained from calibrated AMSR2 brightness temperatures (T_bs) [4]. We start with a brief description of AMSR2 and NOAA's GCOM-W acquisition system in Section II, and then a description of AMSR2-derived oceanic EDRs followed by validation results in Sections III and IV, respectively. Conclusions are presented in Section V.

2. AMSR2 AND NOAA'S GCOM-W DATA ACQUSITION SYSTEM

AMSR2 onboard GCOM-W1 is a microwave radiometer system that measures dual polarized [vertical (V-pol) and horizontal (H-pol)] radiances at 6.9, 7.3, 10.65, 18.7, 23.8, 36.5, and 89.0 GHz. A sun-synchronous orbiter acquires microwave radiances by conically scanning the Earth's surface to obtain measurements along a semicircular pattern in front of the spacecraft. It operates at a nominal earth incidence angle (EIA) of 55 degrees which results in a wide swath of 1450 km. The aperture diameter of the AMSR2 antenna is 2.0 m with an instantaneous field of view (IFOV) spatial resolution that varies inversely with frequency.

GCOM-W1 data is being captured at the KSAT Svalbard Ground Station and assembled into application process identifier (APID) packets. Using the Joint Polar Satellite System (JPSS) NPOSES Preparatory Project (NPP) infrastructure, the GCOM raw data (APID packets) are routed in near-real time to NOAA Interface Data Processing System (IDPS). Once received at the IDPS, the APID packets are reformatted into Raw Data Records (RDRs) and

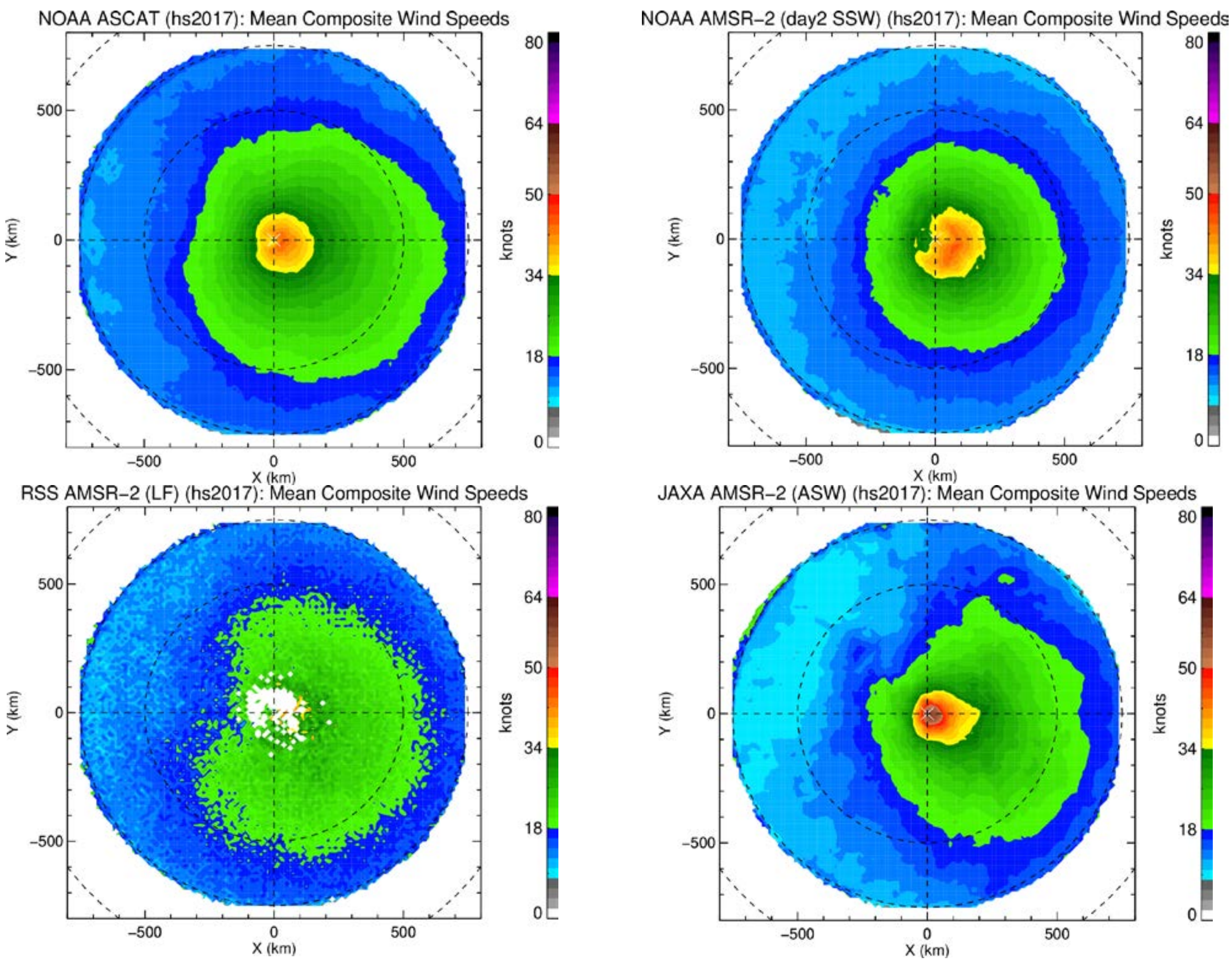

Figure 1: Mean surface wind speed composites for the 2017 hurricane season. From left to right and top to bottom the products are: NOAA ASCAT (from both MetOp-A and -B), NOAA AMSR2 all-weather SSW, RSS low-frequency SSW, and JAXA AMSR2 all-weather SSW (ASW).

sent to the NPP Data Exploitation (NDE) system for distribution to the Environmental Satellite Data Processing System where further processing to brightness temperatures (Level-1 sensor data records [SDRs]) and geophysical products (Level-2 EDRs) is performed. The RDRs are processed to SDRs utilizing software provided by JAXA. Afterwards, the operational EDRs are generated utilizing NOAA's AMSR2 product processing system.

3. AMSR2 OCEANIC EDR

The operational EDRs processing algorithms utilize the calibrated AMSR2 brightness temperatures [4] in a robust multi-stage regression based retrieval algorithm. A near real time demonstration of these advanced satellite data products can be obtained from [5]. The inferred parameters were validated with other models and satellite products to make sure they meet the requirements. A detailed description of the NOAA AMSR2 SST product is given in [6].

Currently, as a continuation of NOAA's GCOM-W project, a revised version of AMSR-2 oceanic EDRs is being developed using more robust inversion algorithms to retrieve geophysical parameters with better accuracy and under all weather conditions. A follow on paper is in preparation to describe the development and validation of NOAA's AMSR2 all-weather SSW product with special emphasis on extreme wind events such as tropical and extra-tropical cyclones. A summary of the validation results of AMSR2 EDRs over ocean is presented in the following section.

4. VALIDATION RESULTS

Fig. 1 shows a sample of validation results using composites of SSW sampled in tropical cyclones during the 2017 hurricane season. For each sensor or product, the "best-track" information from the Automated Tropical Cyclone

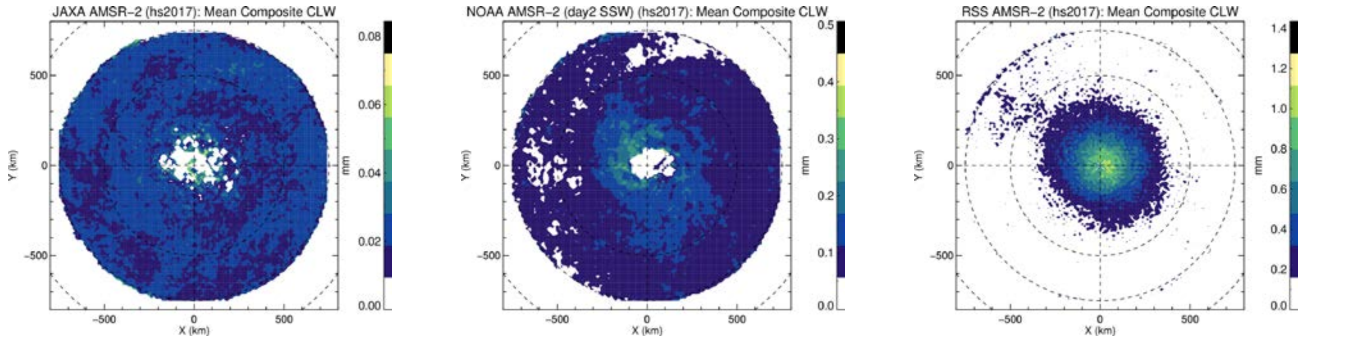

Figure 2: Mean cloud liquid water (CLW) composites for the 2017 hurricane season. From left to right the products are: JAXA AMSR2, NOAA AMSR2, RSS.

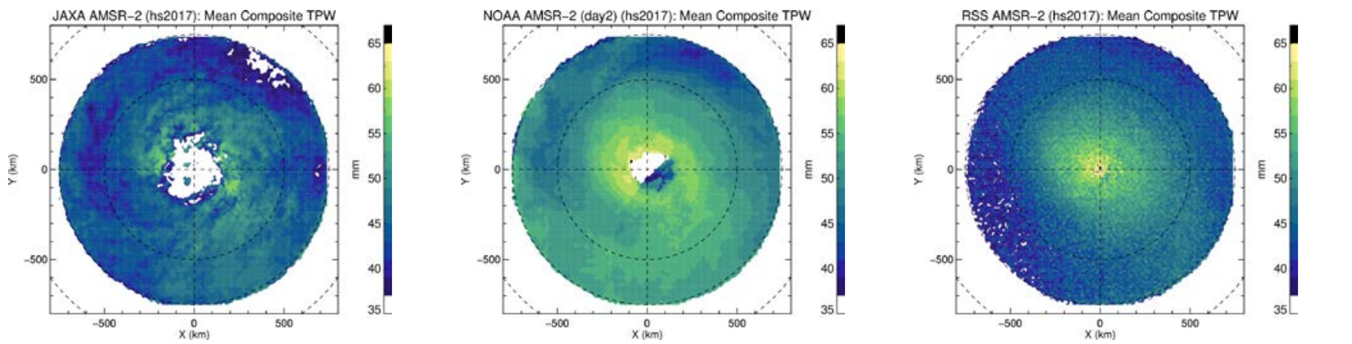

Figure 3: Mean total precipitable water (TPW) composites for the 2017 hurricane season. From left to right the products are: JAXA AMSR2, NOAA AMSR2, RSS.

Forecast (ATCF) system [8] was used to determine the center of each tropical cyclone in the 2017 hurricane season. These center points are only available at 6 hour intervals, so they were interpolated to 3 hour intervals along with the estimated intensity. Data within a 700 km radius of the center of a storm with a maximum wind speed estimate of at least 40 kts were gridded onto a 12.5 km^2 Cartesian grid. Based on the estimated storm motion, each of these snapshots were rotated so that the direction of storm motion is at the top of the plot. Statistics including maximum, mean, median, and fraction of wind speed above certain levels (e.g., gale, storm, and hurricane force) were collected within each grid cell from all the snapshots for a given sensor/product.

The top left panel of Fig. 1 shows the composite field from the NOAA ASCAT products. This is the best representation of the storm field since it has been well-validated for high SSW [9]. It is not expected to exactly match other sensors due to differences in coverage, but they will all be close.

The top right panel shows the NOAA AMSR2 all-weather SSW. The shapes and maxima of the 18–34 and 34–50 kt ranges are similar to the ASCAT field.

The bottom left panel is the Remote Sensing Systems (RSS) low-frequency wind product. This product is provided on a 0.25° grid, so the appearance is speckled compared to the others. Much of the core of the cyclone has been rain flagged, resulting in no data.

The bottom right panel is the JAXA all-weather SSW. This product has very high mean winds near the center of the composite (50–64 kts) and a different shape of >34 kt mean winds. However, the extent of 18 kt winds on the right of the storm is close to the NOAA ASCAT and RSS plots.

Fig. 2 shows mean cloud liquid water (CLW) composites for the 2017 hurricane season, taken in the same conditions as in Fig. 1. The left panel shows the JAXA product, the middle NOAA, and the right is from RSS. The NOAA and RSS products suggest that CLW is oriented diagonally from the forward-left to the rearward-right quadrant. The JAXA product does not indicate any structure. Note the scale differences in each product required to observe the information.

Fig. 3 shows mean total precipitable water (TPW) composites for the 2017 hurricane season, taken in the same conditions as in Figs. 1 and 2. The NOAA and RSS products again show some structure along the forward-left to rearward-right diagonal, but the RSS TPW is better defined. The JAXA product may be showing some similar structure, but it is not as defined or uniform as either of the other two.

The NOAA and JAXA CLW and TPW products flag the core of the hurricane more than RSS does; the latter provides TPW and CLW samples within the hurricane core. This may be because the 0.25° gridding provides sufficient samples to fill in the core in many cases. The NOAA products flag fewer points near the eye of the storm than the JAXA products.

5. CONCLUSIONS

AMSR2 calibrated brightness temperatures were used to derive several geophysical parameters to be included in AMSR2 environmental data record. In this paper, we demonstrated the validation of AMSR2 EDRs over ocean using several independent satellite products and models. The performance of NOAA's AMSR2 EDR is comparable to other satellite products and meets the requirements detailed in NOAA's Joint Polar Satellite System (JPSS) Requirements Document Supplement [7].

6. ACKNOWLEDGMENT

The authors thank F. Saïd and S. Soisuvarn for their assistance in developing the methodology for generating these storm composites.

7. REFERENCES

[1] N. C. Grody, "Remote sensing of atmospheric water content from satellites using microwave radiometry," IEEE Trans. Antennas Propag., vol. 24, no. 2, pp. 155–162, Mar. 1976.

[2] T. T. Wilheit and A. T. C. Chang, "An algorithm for retrieval of ocean surface and atmospheric parameters from the observations of the scanning multichannel microwave radiometer," Radio Sci., vol. 15, pp. 525–544, 1980.

[3] T. Meissner and F. Wentz, "Intercalibration of AMSR-E and Windsat brightness temperature measurements over land scenes," in Proc. IEEE Int. Geosci. Remote Sens. Symp. (IGARSS), Jul. 2010, pp. 3218–3219.

[4] S. O. Alsweiss, Z. Jelenak, P. S. Chang, J. D. Park, and P. Meyers, "Intercalibration results of the advanced microwave scanning radiometer-2 over ocean," IEEE J. Sel. Topics Appl. Earth Observ. Remote Sens., vol. 8, no. 9, pp. 4230–4238, 2015.

[5] NOAA's GCOM-W program products webpage: https://manati.star.nesdis.noaa.gov/gcom/datasets/GCOM2Data.php

[6] S. O. Alsweiss, Z. Jelenak, and P. S. Chang, "Remote Sensing of Sea Surface Temperature Using AMSR2 Measurements," IEEE J. Sel. Topics Appl. Earth Observ. Remote Sens., vol. 10, no. 10, pp. 3948–3954, 2017.

[7] NOAA JPSS program web page: http://www.jpss.noaa.gov

[8] Automated Tropical Cyclone Forecast (ATCF) best-track comma delimited files: http://ftp.nhc.noaa.gov/atcf/btk/

[9] S. Soisuvarn, Z. Jelenak, P. S. Chang, S. O. Alsweiss, and Q. Zhu, "CMOD5.H—A High Wind Geophysical Model Function for C-Band Vertically Polarized Satellite Scatterometer Measurements," IEEE Trans. Geosci. Remote Sens., pp. 1–17, Nov. 2012. doi: 10.1109/TGRS.2012.2219871.