Assessment of the Near Real-Time Validation for the AQUA Satellite Level-2 Observation Products

Min-Sil Yang[a], Jeongsoon Lee[a], Chol Lee[a], Jong-Seo Park[b], and Hee-Ah Kim[b]
(msyang@satrec.kaist.ac.kr)
a. Satellite Technology Research Center (SaTReC), Korea Advanced Institute of Science and Technology (KAIST), Daejon, 305-701,.S. Korea
b. Remote Sensing Division, Korea Meteorological Administration (KMA), Seoul, 156-720, S. Korea

Abstracts: We developed a Near Real-Time Validation System (NRVS) for the Level-2 Products of AQUA Satellite. AQUA satellite is the second largest project of Earth Observing System (EOS) mission of NASA. This satellite provides the information of water cycle of the entire earth with many different forms. Among its products, we have used five kinds of level-2 geophysical parameters containing rain rate, sea surface wind speed, skin surface temperature, atmospheric temperature profile, and atmospheric humidity profile. To use these products in a scientific purpose, reasonable quantification is indispensable. In this paper we explain the near real-time validation system process and its detail algorithm. Its simulation results are also analyzed in a quantitative way. As reference data set *in-situ* measured meteorological data which are periodically gathered and provided by the Korea Meteorological Administration (KMA) is processed. Not only site-specific analysis but also time-series analysis of the validation results are explained and detail algorithms are described.

Keywords: AQUA satellite, validation, level-2 products, geophysical parameters, meteorological data

I. Introduction

Aqua, *Latin for water*, is a major satellite mission of the Earth Observing System (EOS) centered at the National Aeronautics and Space Administration (NASA). It is the second of the large satellite observatories of the EOS program, a sister satellite to Terra which is the first of the large EOS observatories. Launched on May 4 2002, the satellite has provided information on water in its many forms with the mission include enhanced understanding of the global water cycle. Among the six distinct earth-observing instruments onboard Aqua, the Atmospheric Infrared Sounder (AIRS) and the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) are used to estimate several geophysical parameters. These geophysical parameters include skin surface temperature (SST), sea surface wind speed (WS), rain rate (RR), vertical atmospheric temperature profile (3D-T), and vertical atmospheric relative humidity profile (3D-H). In order to properly and reasonably utilize the meteorological satellite-derived geophysical products, these parameters are being analyzed and validated for their accuracy and reliability through numerous validation efforts. In this study, meteorological daily observations (radiosondes, buoys, and AWS data) which are compiled by the Korea Meteorological Administration (KMA) are used to statistically validate the Aqua Level 2 geophysical products. Namely, "Near Real-time Validation System (NRVS)" is introduced and the detail method of this algorithm is explained in this paper.

II. Methodology

Daily AWS (Automatic Weather System), radiosonde, and buoy data are processed for this experiment. Radiosondes are routinely launched two times a day at 0000 UTC and 1200 UTC simultaneously in 6 sites (Baengnyungdo, Sokcho, Osan, Pohang, Kwangju, and Jeju). It gathers the information of pressure, dew point, geopotential height, wind direction and is used for the atmospheric temperature profile, and the atmospheric relative humidity profile validation procedure. Five moored buoys (2 in the West Sea, 2 in the South Sea, and 1 in the East Sea) around the Korean peninsula is processed to acquire the information of sea surface wind speed, sea surface temperature, direction of the waves in every hour. The buoy data are used to validate the wind speed and skin surface temperature. AWS network throughout the Korean peninsula with nearly regular interval gathers every-minute wind, temperature, precipitation, and rain rate data. Rain rate is validated based on the in-situ AWS data. Every observation is arranged by its station id and geographical location, and only suitable observation components for the validation process are extracted.

"Level-2 Products Generation System (L2PGS)" which has developed by the remote sensing team of the SaTReC generated the water related geophysical parameters (accumulated water vapor, accumulated cloud liquid water, sea surface wind speed, sea surface temperature, etc) from the radiance calibrated level 1B radiance values. This system is now under developing. The characteristics of the level-2 data is described in Table 1.

The statistical Root Mean Square Errors (RMSEs), and Bias of five geophysical parameters are calculated with reference to the location of the *in-situ* meteorological observation stations. Differences between the ground measured meteorological values and the satellite measured values of each station are firstly calculated and its bias and RMSEs are derived. Both the time-series analysis of each site and the time-series analysis of one granule are statistically analyzed based on the derived bias, and RMSEs. This equation is explained in (1) and (2), and Table 2.

$$Bias = A_{11} - A_{12} \qquad (1)$$

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n}(A_{11t} - A_{12t})^2}{n-1}} \qquad (2)$$

where, A_{11} is the *in-situ* meteorological data value, A_{12} is the satellite measured data value, and n is the number of observations. Daily site-specific differences, bias and its RMSE of one granule, period-specific bias and RMSE of each site, and period-specific bias and RMSE of each granule are calculated for the numerical analysis and the validation of the meteorological data. Fig 1. shows the schema of the NRVS (Near Real-time Validation System) on Aqua level 2 products.

III. Results

Since the construction of the level-2 products generation system (L2PGS) has now under progress, we used sample Aqua level-2 products to simulate the validation algorithm. By using these sample data set we tested the validation algorithm and performed the quality assessment. AMSR-E wind speed and rain rate data are provided by the NASA website, AIRS skin surface temperature, temperature profile, and humidity profile data are generated from the L2PGS. Fig. 2. represents the Aqua AIRS level-2 skin surface temperature products and Fig. 3. shows its profile. This retrieval becomes the input of the NRVS with the meteorological observations. We used 15-minute interval AWS data in rain rate validation process to consider the scanning time of one granule of the Aqua satellite image. To determine the retrieval accuracy 6 sites of radiosonde data, 5 sites of buoy data, and over than 400 sites of AWS data are compared and bias and RMSEs are calculated. Firstly only available parameters are extracted from the meteorological data and sorted with reference to its geographical location. To colocate the point by point meteorological data to the level-2 pixels, all *in-situ* meteorological data is relocated to the 5*5km grid which is based on the Lambert conformal conic projection. We followed the standard digital map system provided by the KMA.

Relative humidity is derived from the dew point and temperature of the radiosonde data by using simple transformation equation. AIRS Kelvin (K) temperature is revised to Celsius and the all of the other units are standardized.

Fig. 5(a). shows the simulation graph of AMSR-E wind speed daily differences, and its bias, and RMSE. AMSR-E data is compared with buoy data and plotted according to the number of observations. The daily RMSE is slightly high but this is not concerned with the validation algorithm but concerned with the low correlation of the sample level-2 data and the buoy data. Fig. 5(b). also shows the example of the AMSR-E rain rate validation result. Since the distribution of the AWS station is very dense, the validation result can also be acquired in high spatial resolution. In addition, these plots show the example of the time-series analysis of the validation results. Further in-depth investigations of these validation statistics are ongoing with a longer-term Korean dataset around the Korean peninsula.

VI. Discussions

We have constructed a near real-time validation system of Aqua level-2 data and its algorithm simulation is performed by using the NASA provided sample AMSR-E data and AIRS data. By combining the data from the meteorological observations, we can be able to observe and analyze the Earth's water cycle more effectively. Not only this can provide the continuous meteorological analysis information around the Korean peninsula, but can provide the numerical meteorological archiving.

Acknowledgement

This research is supported by the "Analysis and Application System of the AQUA Level 2 Observation Products" of Korea Meteorological Administration (KMA). We also gratefully thank to Dr. Allen Huang of the Space Science and Engineering Center (SSEC) of the University of Wisconsin, Madion for his fruitful help and advice.

References

[1] Fetzer E., and McMillin M., "AIRS/AMSU/HSB Validation", *IEEE Trans. Geoscience and Remote Sensing*, Vol. 41., No.2., pp. 418~428, February 2003.

[2] Kim S. B., and Im Y. J., "Brightness Temperature Retrieval using Direct Broadcast Data from the Passive Microwave Imager on Aqua Satellite", *Korean Journal of Remote Sensing*, Vol 20, No. 1., pp. 47~55, February 2004.

[3] Parkinson C., "Aqua: An Earth-Observing Satellite Mission to Examine Water and Other Climate Variables", *IEEE Trans. Geoscience and Remote Sensing*, Vol. 41, No. 2, pp. 173~183, February 2003.

[4] Shibata A., and Imaoka J., "AMSR/AMSR-E Level 2 and 3 Algorith Developments and Data Validation Plans of NASDA", *IEEE Trans. Geoscience and Remote Sensing*, Vol. 41., No.2., pp. 195~203, February 2003.

[5] URL: Goddard Space Flight Center, The Earth Observing System Project Science Office. Available at http://eospso.gsfc.nasa.gov/validation/

[6] URL: NASA Aqua website. Available at http://aqua.nasa.gov/

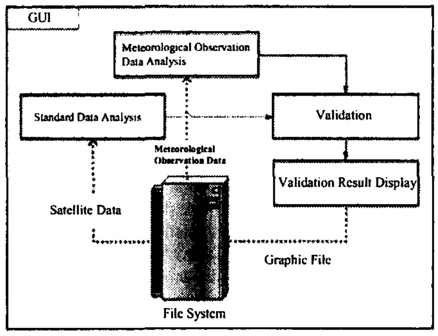
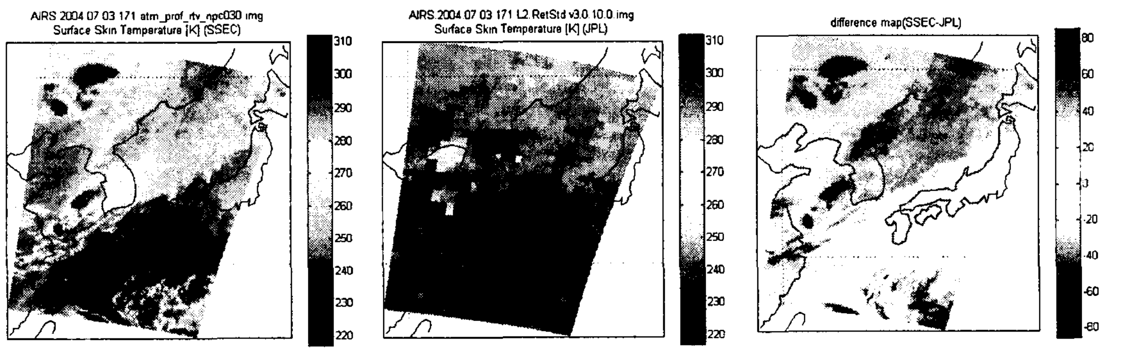


Figure 1. Schema of the NRVS (Near Real-time Validation System) on Aqua level 2 products

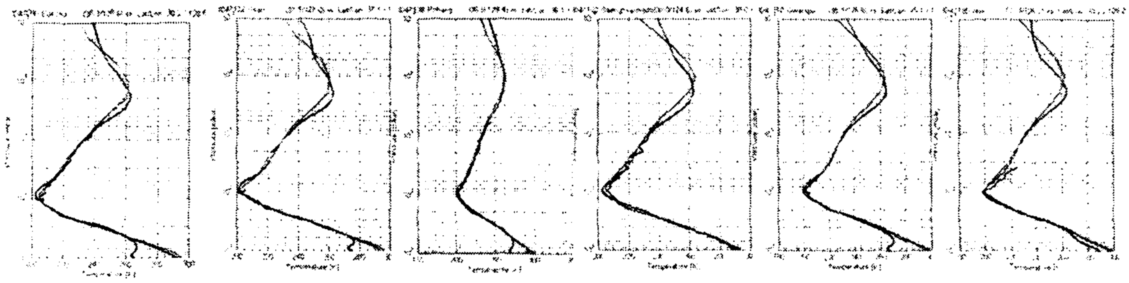
Table 2. The Validation Algorithm of NRVS

	Difference/bias	RMSE
One Point	Δ=A11-A12	
One Scene	$BS = \frac{\sum_{i=1}^{n}(A_{11i} - A_{12i})}{n}$	$RS = \sqrt{\frac{\sum_{i=1}^{n}(A_{11i} - A_{12i})^2}{n-1}}$
Period/One Scene	$BSP = \frac{\sum_{i=1}^{period}(BS)}{period}$	$RSP = \frac{\sum_{i=1}^{period}(RS)}{period}$



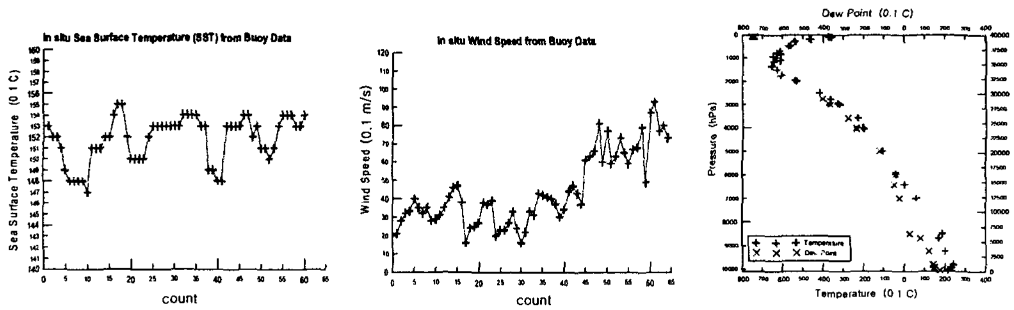
(a) (b) (c)

Fig. 2. Aqua AIRS Level 2 Products (Skin Surface Temperature) of (a) the Products from the SSEC, Univ. of Wisconsin, Madison, (b) the Products from the NASA/JPL, and (c) difference map of (a) and (b)



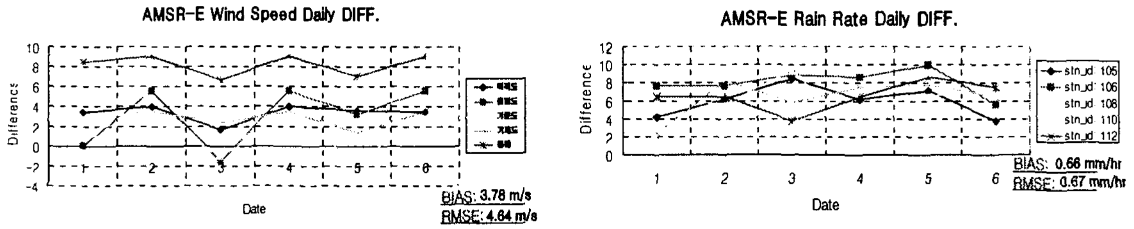
(a) (b) (c) (d) (e) (f)

Fig. 3. Temperature Profile of AIRS level 2 data (a) Sokcho, (b) Osan, (c) Pohang, (d) Baengnyungdo, (e) Kwangju, and (f) Jeju station



(a) (b) (c)

Fig. 4. Analysis of the in-situ meteorological observation data (a) SST from Buoys (b) WS from Buoys and (c) vertical temperature profiles and vertical dew point profiles



(a) (b)

Fig. 5. (a) Example of the graph of AMSR-E Wind Speed Daily Differences and its bias and RMSE (b) Example of the graph of AMSR-E Rain Rate Daily Differences and its bias and RMSE

Table 1. The Characteristics of Level 2 Data

Type	Accuracy	Measurement	Horizontal Resolution	Vertical Resolution	Reference Meteorological Data
T	1K RMS	2/day	50 km : Global	Goal: 1 km, surface to 100mb	Radiosonde
H	20% required, 10% goal	2/day	50 km : Global	goal: 1 km, surface to 100mb	Radiosonde
SST	1K	2/day	50 km : Global	N/A	Buoy
RR	1mm/hr or 20% 2mm/hr or 40%	2/day	12 km : Global Ocean	N/A	AWS
WS	1-1.5 m/sec	2/day	24/38 km : Global Ocean	N/A	Buoy

(T: 3D Atmospheric temperature profile, H: 3D Atmospheric Humidity profile, SST: Sea Surface Temperature, RR: Rain Rate, WS: Sea Surface Wind Speed)