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DEVELOPMENT AND UTILIZATION OF AHI SIMULATION DATA ON HIMAWARI-8

This paper reports on the activities of the Japan Meteorological Agency (JMA) regarding the development and utilization of AHI simulation data on Himawari-8.

The Himawari-8 and -9 satellites will carry a new unit called the Advanced Himawari Imager (AHI). Its functions and specifications are notably improved from those of the imager on board MTSAT, and enable better nowcasting, improved numerical weather prediction accuracy and enhanced environmental monitoring.

Using AHI data, JMA plans to improve its current satellite products such as Atmospheric Motion Vectors (AMVs) and cloud grid information as well as developing new products related to volcanic ash and instability indices.

To support these developments, simulated AHI data are generated using radiative transfer computation based on the provisional response functions of Himawari-8. Numerical Weather Prediction (NWP) data used in the simulation provide the “truth” of the atmosphere. Simulation data can be used as proxy information for the pre-launch satellite as well as to improve products generated from existing satellite observation.

JMA plans to establish the use of simulated imagery for algorithm studies and product development.

DEVELOPMENT AND UTILIZATION OF AHI SIMULATION DATA ON HIMAWARI-8

1 Introduction

JMA plans to launch Himawari-8 in 2014 and begin its operation in 2015. The launch of Himawari-9 is also scheduled for 2016 to ensure the robustness of the satellite observation system. Himawari-8 and -9 will carry a new unit called the Advanced Himawari Imager (AHI), which has capabilities comparable to those of the ABI imager on board GOES-R. Its functions and specifications are notably improved from those of the imager on board MTSAT as listed in Table 1.

Himawari-8 and -9 will offer high observation potential, which will enable users to develop and improve a wide range of products. Using AHI data, JMA plans to develop new products related to volcanic ash and instability indices. Current satellite products such as Atmospheric Motion Vectors (AMVs), cloud grid information, clear sky radiance and sea surface temperature will also be improved. In particular, significant improvement of the AMV product is foreseen because higher spatial and temporal resolutions are expected to provide better target tracking accuracy, and the increased number of observation channels will enhance AMV height assignment.

To support research and development for products derived from AHI observation on Himawari-8, simulation-based proxy data have been created. Numerical Weather Prediction (NWP) data used in the simulation provide the ”truth” of the atmosphere. Simulation data can be used as proxy information for the pre-launch satellite as well as to improve products generated from existing satellite observation.

Table 1: Specifications of imagers on board Himawari-8/9 and MTSAT-1R/2

	Himawari-8/9	MTSAT-1R/2
# of channels	16 (VIS: 3; NIR: 3; IR: 10)	5 (VIS: 1; IR: 5)
Spatial resolution at sub-satellite point	VIS: 0.5 – 1.0 km IR: 1 – 2 km	VIS: 1 km IR: 4 km
Spatial coverage	- Full disk every 10 minutes - 5 small sector observations	Full disk every 30 minutes

2 Simulation of AHI observation

Figure 1 shows the estimated SRFs (spectral response functions) of AHI as of June 2012. True-color images can be obtained from a combination of the three visible channels (blue: 0.46 μm; green: 0.51 μm; red: 0.64 μm). Using radiative transfer computation with these SRFs, AHI 16-band simulation data are generated. In this work, RSTAR (Nakajima and Tanaka 1986) is adopted as the Radiative Transfer Model (RTM). Table 2 and Figure2 show its calculation design and simulated images for AHI. Atmospheric fields were given by analysis and forecasts from JMA’s global NWP model (GSM, Global Spectral Model) with a horizontal resolution of approximately 20 km. Surface parameters are derived from a MODIS product provided by NASA. For ozone and aerosol parameters, climatological values are currently adopted. Since February 2013, simulated AHI data have been made available online for use in AHI research and development during the pre-launch phase.

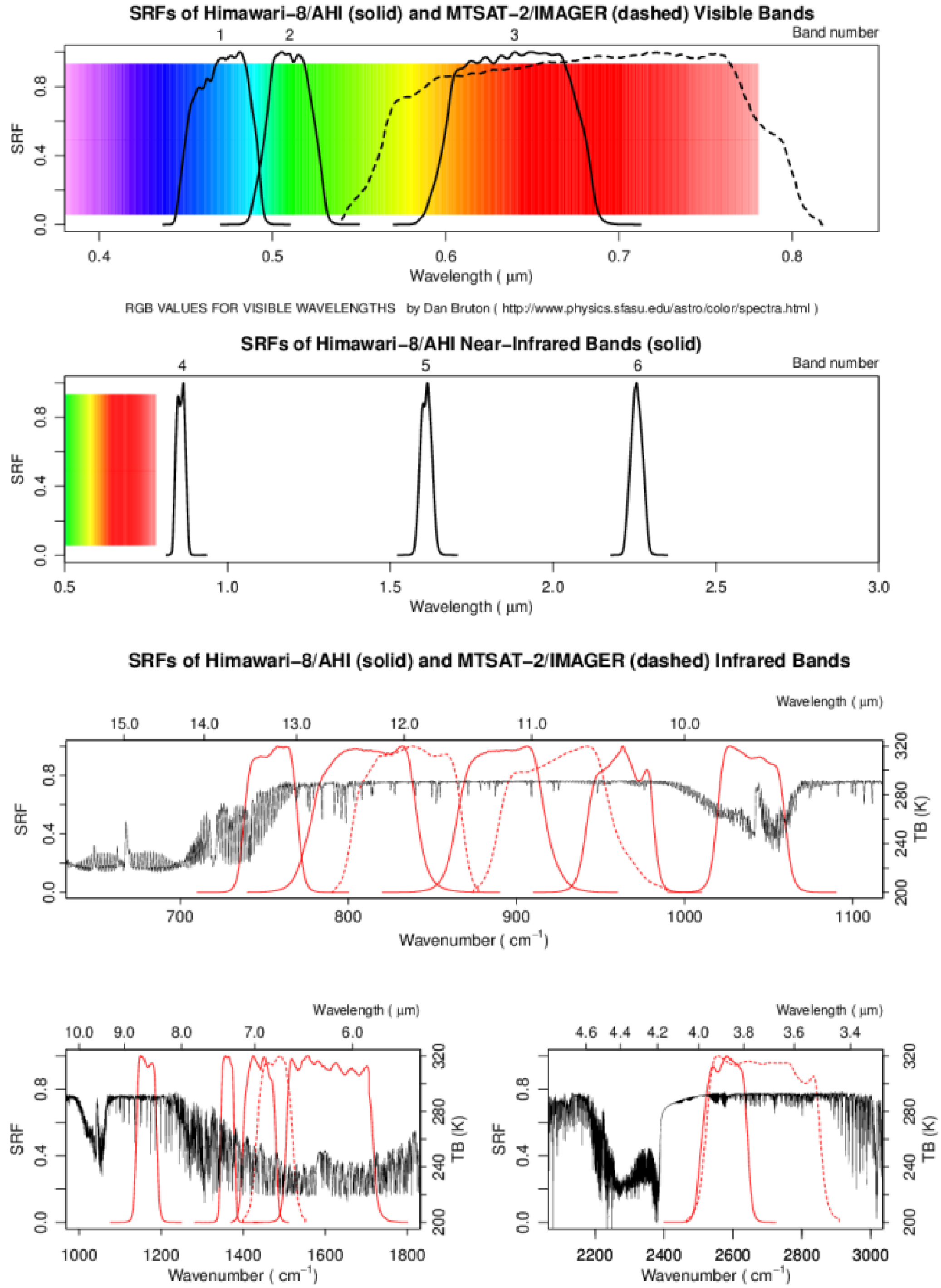

Figure 1: Spectral response functions (SRFs) of AHI on Himawari-8 and Imager on MTSAT-2. The solid and dashed curves represent the SRFs of AHI and Imager, respectively. The black lines in the infrared figures represent the brightness temperatures of up-welling radiances at the top of the atmosphere simulated by the radiative transfer model (LBLRTM) with HITRAN2000 (AER updates) line parameters based on the US standard atmosphere. The RGB spectra in the visible/near-infrared figures are generated by the program at http://www.physics.sfasu.edu/astro/color/spectra.html.

Table 2: Radiative transfer calculation design

RTM	Rstar6b (Nakajima and Tanaka 1986)
Longitude of sub-satellite point	140°E
SRF	Polygonal line expressed with five points
# of vertical layers in RTM	14
Atmospheric profiles	GSM
Wind speed	GSM
Surface reflectance	MODIS product (MOD09)
Aerosol and ozone	Climatology value used in GSM
Cloud	Retrieved from GSM

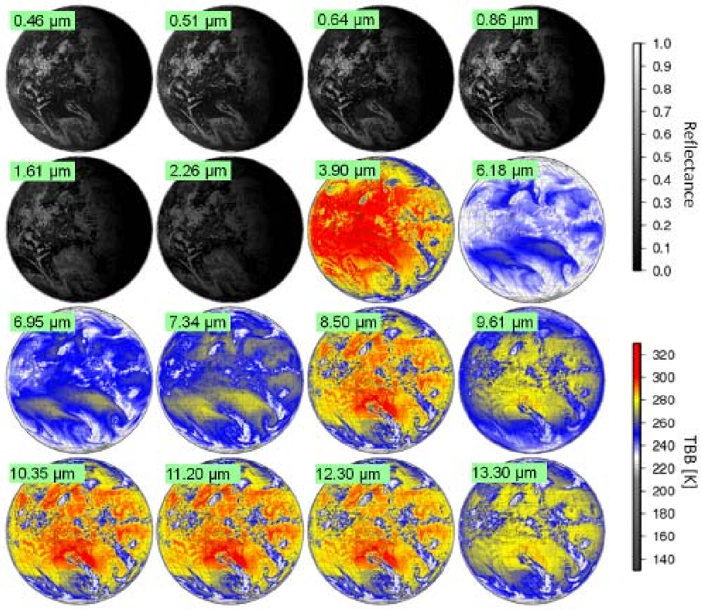

Figure 2: Simulated images for Himawari-8's 16 AHI bands based on RSTAR

3 Utilization of simulated AHI data for development

JMA/MSC currently uses simulated satellite data for product development. This approach is expected to improve the accuracy of satellite-derived products such as Atmospheric Motion Vectors (AMVs). The retrieval algorithm of satellite-derived products can be interpreted as involving inverse functions against observation functions. To construct an inverse function (or observation function), it is necessary to know the input and output of these functions. However, in most cases, it is difficult to obtain independent co-located observation data at observable areas, and co-located data are also often from a retrieved dataset. In addition, such data comparable to observation data do not always exist for the targets of interest. Accordingly, satellite product developers must have detailed knowledge of other observation methods and extensively collect co-located data until a specific meteorological situation of interest is well covered. Figure 3 shows conceptual diagrams highlighting the benefits of using simulated satellite data. The utilization of simulated observation data provides one solution to the construction of a consistent retrieval algorithm (inverse function), as true data can be obtained in a simulated system.

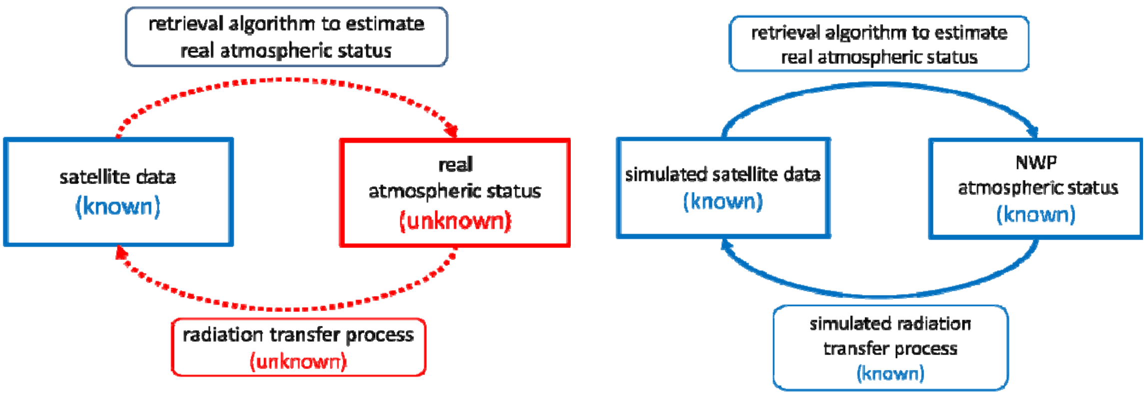

Figure 3: Conceptual diagram showing the benefits of using simulated satellite data. The panel on the left shows the processes involved in estimating the real atmospheric status from real satellite data using a retrieval algorithm. Satellite data are naturally generated from an unknown atmospheric status and an unknown radiation transfer process. After the retrieval process, the estimated atmospheric status is obtained. However, there are no real atmospheric data to compare with the estimated status. The panel on the right shows a case in which NWP atmospheric data are used as a substitute for real data. Here, the atmospheric status determined and the radiation transfer processes are explicitly described. The presence of product input and output is useful in product developments because the values to be retrieved are explicitly given.

4 AMV derivation from simulated Himawari imagery

JMA has started to generate AMVs from simulated AHI data for a Himawari-8 AMV algorithm study. As discussed in Section 1, AMVs are derived from simulated imagery with a spatial-temporal resolution of 0.5 degrees and 60 minutes. Figure 4 shows AMVs derived from simulated Himawari-8 data. Although the spatial resolution of the NWP dataset used for the simulation is coarser than that of AHI, it can be seen that atmospheric motion vectors of synoptic scales are well derived. In the next step, JMA plans to check consistency between wind vectors and allocated heights against the NWP vertical profile.

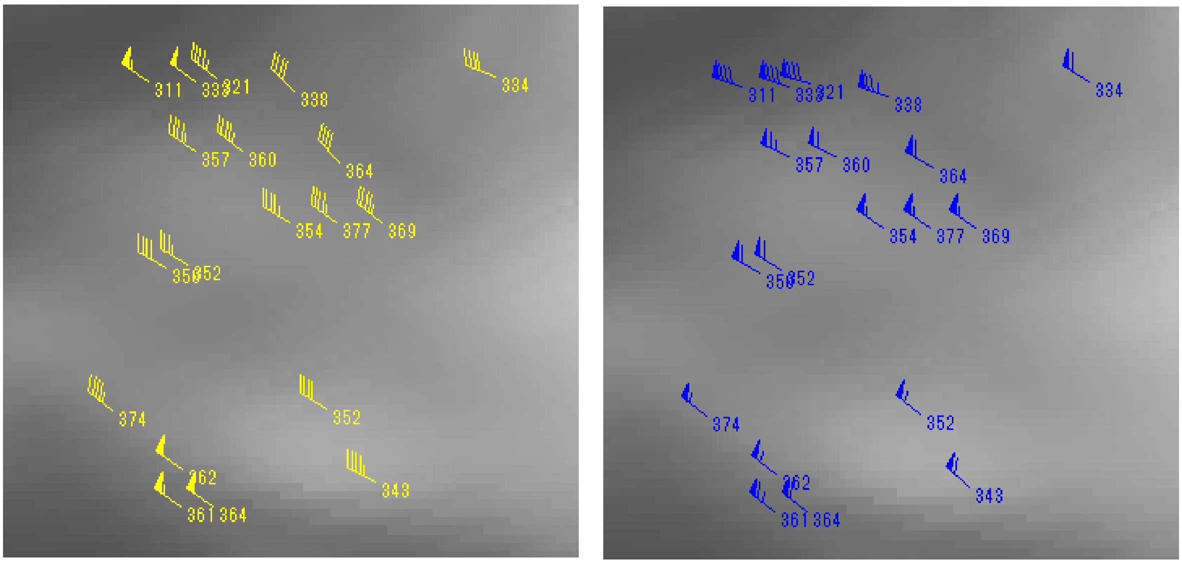

Figure 4: Comparison of IR upper-level AMVs computed from 60-minute-interval Himawari-8 simulated imagery (yellow arrows) and co-located NWP wind vectors (blue). The numbers under arrow indicate heights (hPa). The AMVs show lower speeds than that of NWP data. This result indicates that JMA's AMV tracking algorithm derives lower wind speeds than true winds for IR AMVs from simulated imagery.

5 CONCLUSION

This paper reports on the activities of JMA regarding the development and utilization of AHI simulation data. To support research and development for Himawari-8 satellite products, JMA is currently generating simulated AHI data using radiative transfer computation software (RSTAR). As a first step, the Agency used its global NWP model data as input to generate full disk images. This simulated imagery can be used in the development of satellite-derived products such as AMVs, but some limitations apply due to their coarse temporal and spatial resolution compared with AHI.

To address the low-resolution problem, JMA plans to generate high-resolution AHI imagery simulated from a regional NWP model. Simulated AHI data will also be applied to other satellite products in addition to AMVs.

6 REFERENCE

Nakajima, T. and M. Tanaka, 1986: Matrix formulation for the transfer of solar radiation in a plane-parallel scattering atmosphere. *J. Quant. Spectrosc. Radiat. Transfer*, **35**, 13 – 21.