JAXA Himawari Monitor Aerosol Products

JAXA Earth Observation Research Center (EORC)

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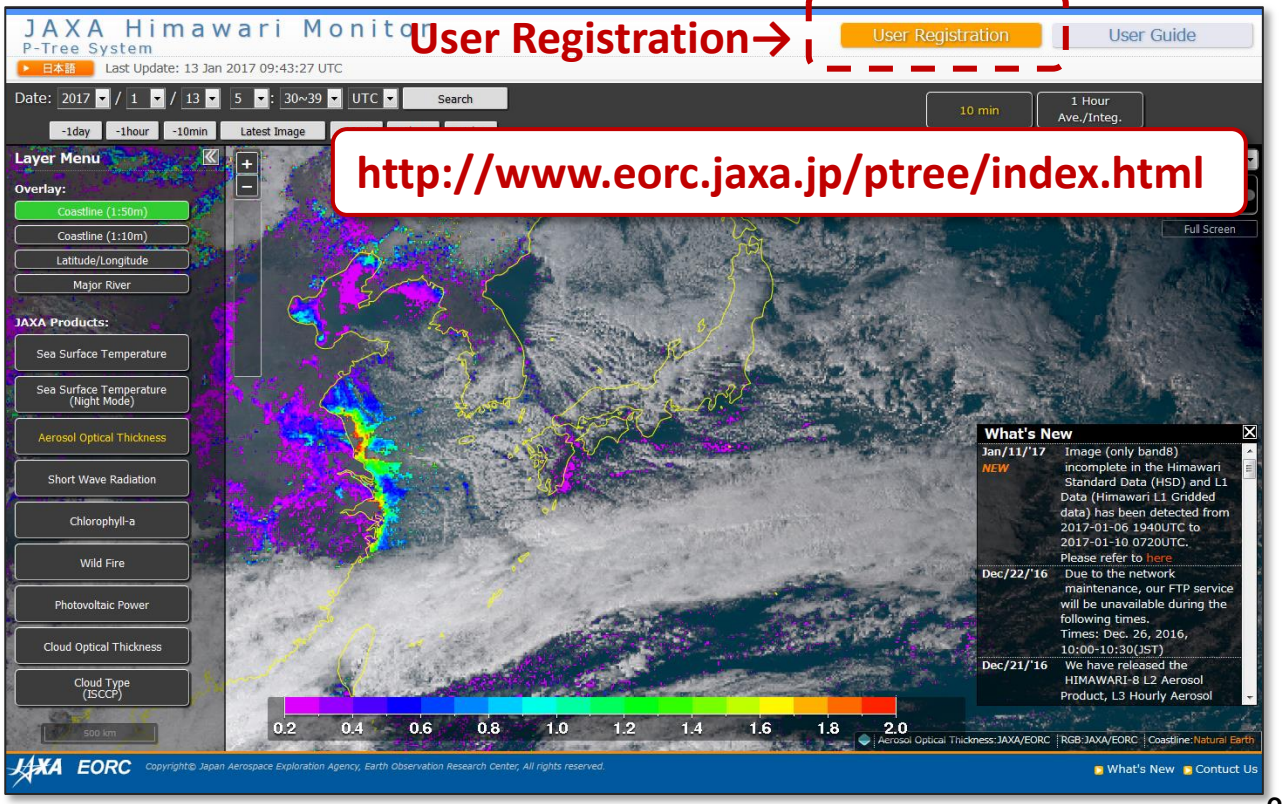
JAXA Himawari Monitor

- JAXA has been developing Himawari-8 products using the retrieval algorithms based on the upcoming Japanese earth observation missions (GCOM-C, GOSAT-2 and EarthCARE) to seek synergies between the geo- and leo-satellites
- JAXA Himawari Monitor website site was opened in August 2015 to distribute Himawari original (Level 1) and geophysical (Level 2-4) products via FTP
- Over 1000 registrations from domestic and international users until today
- Data can be downloaded with simple user registration



Himawari-8 Satellite

(JMA webpage)

- Himawari-8 is a Japanese Geostationary Satellite operated by Japan Meteorology Agency (JMA)
- 7 Oct 2014 : Launched from Tanegashima Space Center, Japan
- 7 July 2015 : Official Operation Started
- Loads a multiwavelength imager called Advanced Himawari Imager (AHI)
- 16 band in visible to infrared wavelength range (5 bands in previous Himawari)
- Spatial Resolution increased 2 times (e.g. from 1km to 0.5 km in visible band)
- Observation frequency of full-disk also increased from 30 minutes interval to 10 minutes interval

Visible – NIR wavelength :
Optically sensitive
to aerosol particles
↓
Potential to retrieve
aerosol optical properties

Center Wavelength of Himawari-8/AHI

Band	Wavelength (μm)	Resolution (km)	Band	Wavelength (μm)	Resolution (km)
1	0.47	1	9	6.9	2
2	0.51		10	7.3	
3	0.64	0.5	11	8.6	
4	0.86	1	12	9.6	
5	1.6	2	13	10.4	
6	2.3		14	11.2	
7	3.9		15	12.4	
8	6.2		16	13.3	

Aerosol Product Definition

Product Name	Primary Parameters	Spatial Resolution	Temporal Resolution	Approximate Latency after Observation
L2ARP	• AOT at 500 nm • Angstrom Exponent	0.05 deg	10 min	40 minutes
L3ARP Hourly	• Mean L2 AOT and AE within 1 h • L2 AOT and AE with strict cloud screening (AOT_Pure, AE_Pure) • Spatiotemporal interpolation of AOT_Pure and AE_Pure within 1 h (AOT_Merged, AE_Merged)	0.05 deg	1 hour	1 hour
L3ARP Daily	• Mean L2 and L3 AOT and AE within 1 day	0.05 deg	1 day	1 day
L3ARP Monthly	• Mean L2 and L3 AOT and AE within 1 month	0.05 deg	1 month	1 month

Note : Aerosol estimation cannot be retrieved at cloudy pixels, AOT = Aerosol Optical Thickness , AE = Angstrom Exponent

L2 Aerosol Product

- Parameters

Index	Description
latitude	Latitude
longitude	Longitude
Hour	Observation hours (UT)
AOT	Aerosol optical thickness at 500 nm
AE	Angstrom exponent
AOT_uncertainty	Uncertainty of aerosol optical thickness (c.f. P8)
QA_flag	Quality flag
SSA	Single scattering albedo at 500 nm
RF	Optical depth ratio of fine mode

L3 Hourly Aerosol Product

- Parameters

Index	Description
latitude	Latitude
longitude	Longitude
Hour	Observation hours (UT)
AOT_Merged	Spatiotemporal interpolation of AOT_Pure (c.f. P9)
AOT_Pure	L2 AOT with strict cloud screening (c.f. P9)
AOT_L2_Mean	Average of L2 AOT for each pixel
AOT_L2_SDV	Standard deviation of AOT_L2_Mean within an hour
AOT_L2_Num	Total Number of L2 AOT within an hour ($0 \leq$ AOT_L2_Num ≤ 6)
AOT_Merged_uncertainty	Uncertainty of AOT_Merged
AOT_Pure_uncertainty	Uncertainty of AOT_Pure
AE_Merged	Spatiotemporal interpolation of AE_Pure
AE_Pure	L2 AE with strict cloud screening
AE_L2_Mean	Average of L2 AE for each pixel
AE_L2_SDV	Standard deviation of AE_L2_Mean within an hour
AE_L2_Num	Total Number of L2 AE within an hour ($0 \leq$ AE_L2_Num ≤ 6)
QA_flag_merged	Quality flag of AOT/AE Merged (c.f. P8)
QA_flag_pure	Quality flag of AOT/AE Pure (c.f. P8)

L3 Daily/Monthly Aerosol Product

- Parameters

Index	Description
latitude	Latitude
longitude	Longitude
AOT_L2_Mean	Temporal Average of L2 AOT for each pixel (Daily/Monthly). Specifically, sum(AOT_L2_Mean * AOT_L2_Num) / sum(AOT_L2_Num) for a day or a month
AOT_L2_Num	Total Number of L2 AOT within a day or a month. Specifically, sum of AOT_L2_Num for a day or a month
AOT_L3_Merged_Mean	Temporal Average of L3 AOT_Merged for each pixel (Daily/Monthly)
AOT_L3_Merged_Num	Total Number of L3 AOT_Merged within a day or a month
AE_L2_Mean	Temporal Average of L2 AE for each pixel (Daily/Monthly). Specifically, sum(AE_L2_Mean * AE_L2_Num) / sum(AE_L2_Num) for a day or a month
AE_L2_Num	Total Number of L2 AE within a day or a month. Specifically, sum of AE_L2_Num for a day or a month
AE_L3_Merged_Mean	Temporal Average of L3 AE_Merged for each pixel (Daily/Monthly)
AE_L3_Merged_Num	Total Number of L3 AE_Merged within a day or a month

L2 Aerosol Product: QA flag

- Quality Assurance Flag (QA_flag)

Bit Field<contami	Description key	Result	Comment
0 (LSB)	Data availability	0 = available / 1 = no data	
1	Land / Water flag	0 = land / 1 = water	
2	Cloud flag	0 = clear / 1 = cloud	
3	Retrieval status	0 = successful / 1 = failed	
4 – 5	AOT confidence	00 = very good 01 = good (not used) 10 = marginal (not used) 11 = no confidence (or no retrieval)	VERY_GOOD : AOT uncertainty<0.5 （However GOOD when observed TOA reflectance is lower than that for only Rayleigh scattering.） GOOD : 0.5< AOT uncertainty<1.0 NO_CONF : 1.0< AOT uncertainty * MARGINAL when turbit water flag is 1
6 – 7	AE confidence	00 = very good 01 = good (not used) 10 = marginal (not used) 11 = no confidence (or no retrieval)	VERY__GOOD : AOT>0.1 （However GOOD when observed TOA reflectance is lower than that for only Rayleigh scattering.） NO_CONF : AOT<0.1 * MARGINAL when turbit water flag is 1
8	Additional Cloud Flag	0 = clear / 1 = cloud	Near-by-cloud test within 12.5 km
9	Sunglint	0 = not sunglint / 1 = sunglit	
10	Solz > 70, Satz > 70	0 = no / 1 = yes	Solar/satellite zenith angle threshold
11	Surface Reflectance Confidence	0 = good / 1 = no confidence	
12	Snow/Ice	0 = no / 1 = yes	
13	Turbit water	0 = no / 1 = yes	
14 – 15	TBD		

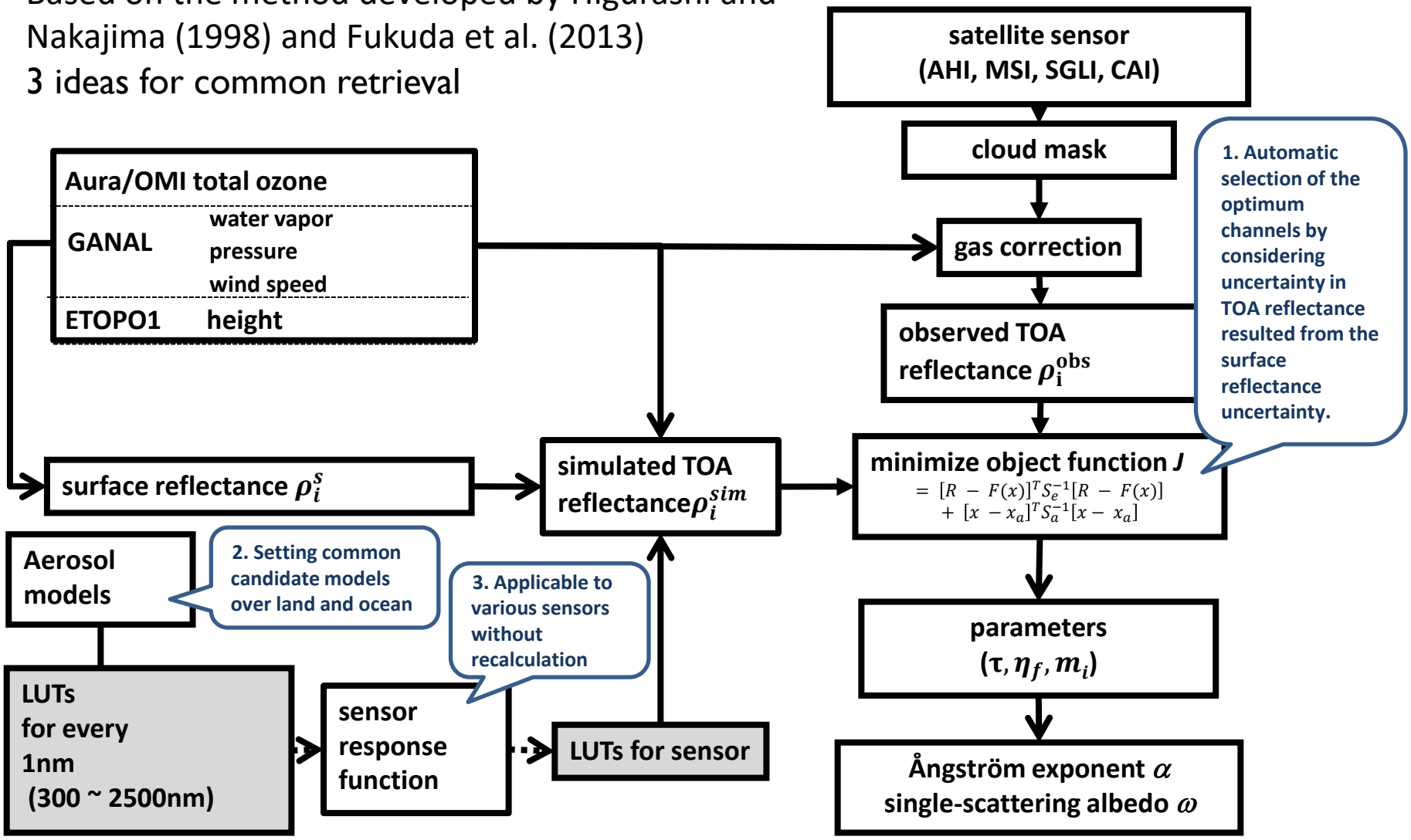
L3 Hourly Aerosol Product: QA flag

- Quality Assurance Flag (QA_flag_pure, QA_flag_merged)

Bit Field<contami	Description key	Result	Comment
0 (LSB)	Data availability	0 = available / 1 = no data	AOT_pure : Availability of L2ARP AOT_merge : Availability of AOT_pure
1	Land / Water flag	0 = land / 1 = water	
2	Cloud flag	0 = clear / 1 = cloud	
3	Retrieval status	0 = successful / 1 = failed	
4 – 5	AOT confidence	00 = very good 01 = good (not used) 10 = marginal (not used) 11 = no confidence (or no retrieval)	Set as “very good” if AOT retrieval was not missing.
6 – 7	AE confidence	00 = very good 01 = good (not used) 10 = marginal (not used) 11 = no confidence (or no retrieval)	Set as “very good” if AE retrieval was not missing.
8	Additional Cloud Flag	0 = clear / 1 = cloud	Near-by-cloud test within 12.5 km
9	Sunglint	0 = not sunglint / 1 = sunglit	
10	Solz > 70, Satz > 70	0 = no / 1 = yes	Solar/satellite zenith angle threshold
11	Surface Reflectance Confidence	0 = good / 1 = no confidence	
12 – 15	TBD		

L2 Algorithm

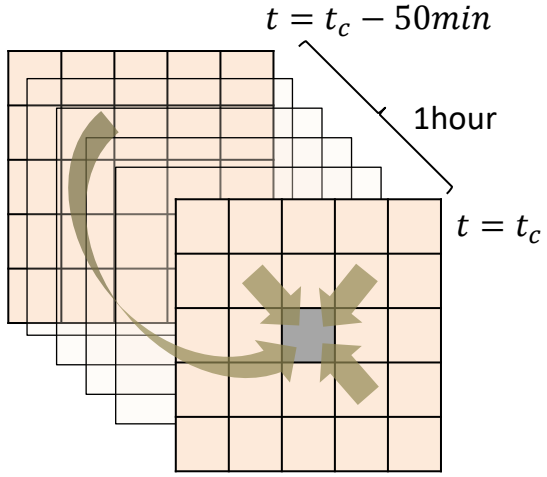
- Based on the method developed by Higurashi and Nakajima (1998) and Fukuda et al. (2013)
- 3 ideas for common retrieval

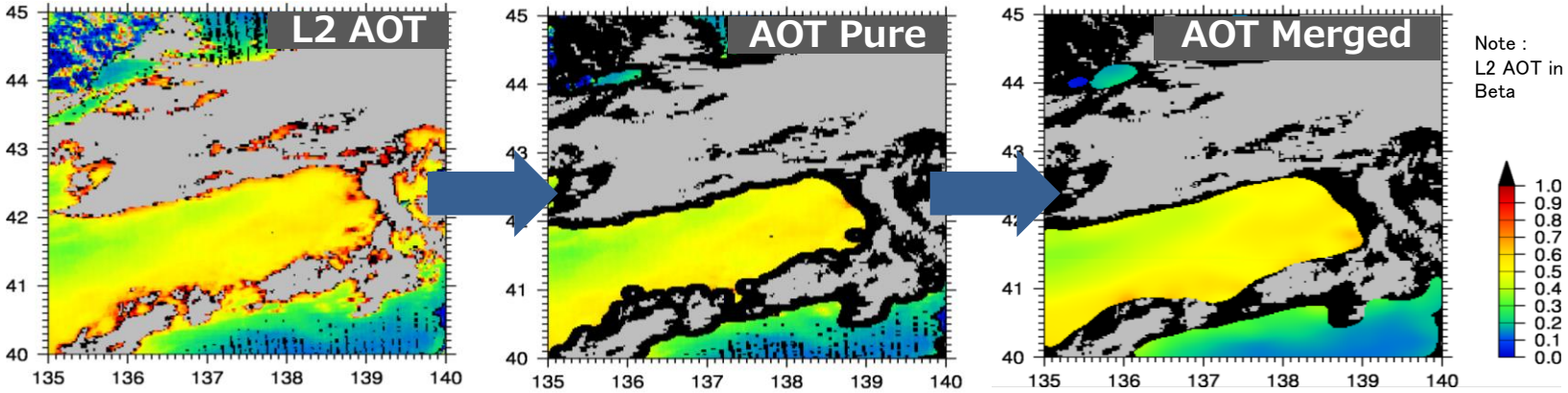


Yoshida, M, M. Kikuchi, T. M. Nagao, H. Murakami, T. Nomaki, A. Higurashi, Common retrieval of atmospheric aerosol properties for imaging satellite sensors, *Journal of the Meteorological Society of Japan*, 2018, doi:10.2151/jmsj. 2018-039

L3 Hourly Algorithm

- Hourly combined retrievals (AOT_{pure} and AOT_{merged}) are AOTs with strict cloud-screening using differences in spatiotemporal variability characteristic of aerosol and cloud
- Optimal estimation of AOT at a certain time, rather than an estimate of the average state over an hour
- AOT_Pure : a subset of L2 AOT with strict quality control of cloud contamination
- AOT_Merged : the spatial and temporal optimum interpolation of AOT_pure within an hour (i.e. AOT_Merged is derived by 6 slots of 10-min AOT_pure).





Note :
L2 AOT in this figure is Version Beta

Kikuchi, M., H. Murakami, K. Suzuki, T. M. Nagao, and A. Higurashi, Improved Hourly Estimates of Aerosol Optical Thickness using Spatiotemporal Variability Derived from Himawari-8 Geostationary Satellite, *IEEE Trans. Geosci. Remote Sensing*, 2018, doi: 10.1109/TGRS.2018.2800060.

FTP Directory and File Name Convention

- Directory : ftp://ftp.ptree.jaxa.jp/pub/himawari/LX/ARP/VVv/YYMM/DD/hh/
- File Name
  - L2 : NC_H08_YYYYMMDD_hhmm_PPPPPVVv_FLDK.NNNNN_NNNNN.nc
  - L3 : H08_YYYYMMDD_hhmm_PPPPPVVv_FLDK.NNNNN_NNNNN.nc

Index	Description	L2	L3 Hourly/Daily/Monthly
X	Level	2	3
YYYYMM	Year, Month	-	-
DD	Day	-	-
hh	Hour	-	-
mm	Minute	-	-
PPPPP	Product name	L2ARP	1HARP/1DARP/1MARP
VVv	Version (VV: major, v:minor)	021	030
FLDK	Full Disk	-	-
NNNNN	Pixel number (2401 = 5° resolution)	2401	2401
nc	NetCDF	-	-

- Example
  - L2: NC_H08_20180205_0000_L2ARP021_FLDK.02401_02401.nc
  - L3 hourly: H08_20180202_0000_1HARP030_FLDK.02401_02401.nc
  - L3 daily: H08_20180202_0000_1DARP030_FLDK.02401_02401.nc
  - L3 monthly: H08_20180201_0000_1MARP030_FLDK.02401_02401.nc

Major Changes from Version 1.0

- L2
  - Ver2.0
    - ✓ Updated aerosol model based on the aerosol model by Omar et al., 2005 and Sayer et al., 2012
    - ✓ Changed object function based on optical estimation method (Rodgers 2000)
    - ✓ Changed the method to estimate surface reflectance based on Fukuda et al., 2013
    - ✓ Expanded the range of AOT to 5.
    - ✓ Fixed minor bugs
  - Ver2.1
    - ✓ improved the implementation of the iteration of optical estimation
    - ✓ added turbit water to QA flag
    - ✓ Fixed minor bugs for land/water flag
    - ✓ Added netcdf internal compression
- L3 Hourly
  - Ver2.0
    - ✓ Updated look-up-table based on L2ARP Version 2
  - Ver3.0
    - ✓ Added AOT_Mean, AOT_rmsd, AOT_num
    - ✓ Included L2 AOT_uncertainty information in L3 AOT_Merged_uncertainty and AOT_Pure_uncertainty (from Version 3)
  - Fixed minor bugs

Documentation History

- 2018.08.10　　Version 5
- 2018.09.10　　Version 6