



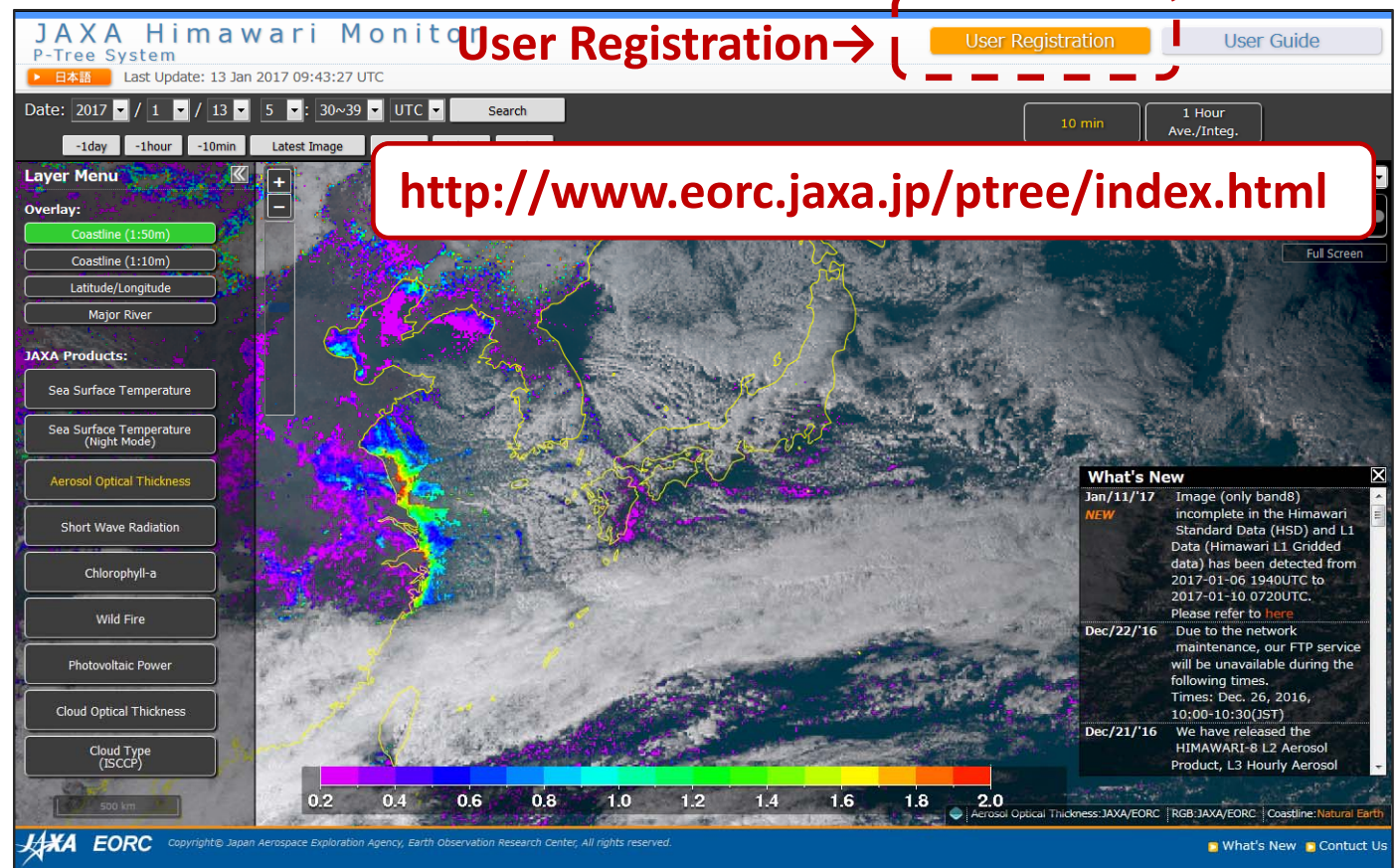
JAXA Himawari Monitor Aerosol Products

JAXA Earth Observation Research Center (EORC)

August 2018

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		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 ($0 \leq \text{AOT_L2_Num} \leq 6$)
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 ($0 \leq \text{AE_L2_Num} \leq 6$)
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, $\text{sum}(\text{AOT_L2_Mean} * \text{AOT_L2_Num}) / \text{sum}(\text{AOT_L2_Num})$ 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, $\text{sum}(\text{AE_L2_Mean} * \text{AE_L2_Num}) / \text{sum}(\text{AE_L2_Num})$ 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)	
6 – 7	AE confidence	00 = very good 01 = good (not used) 10 = marginal (not used) 11 = no confidence (or no retrieval)	
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		

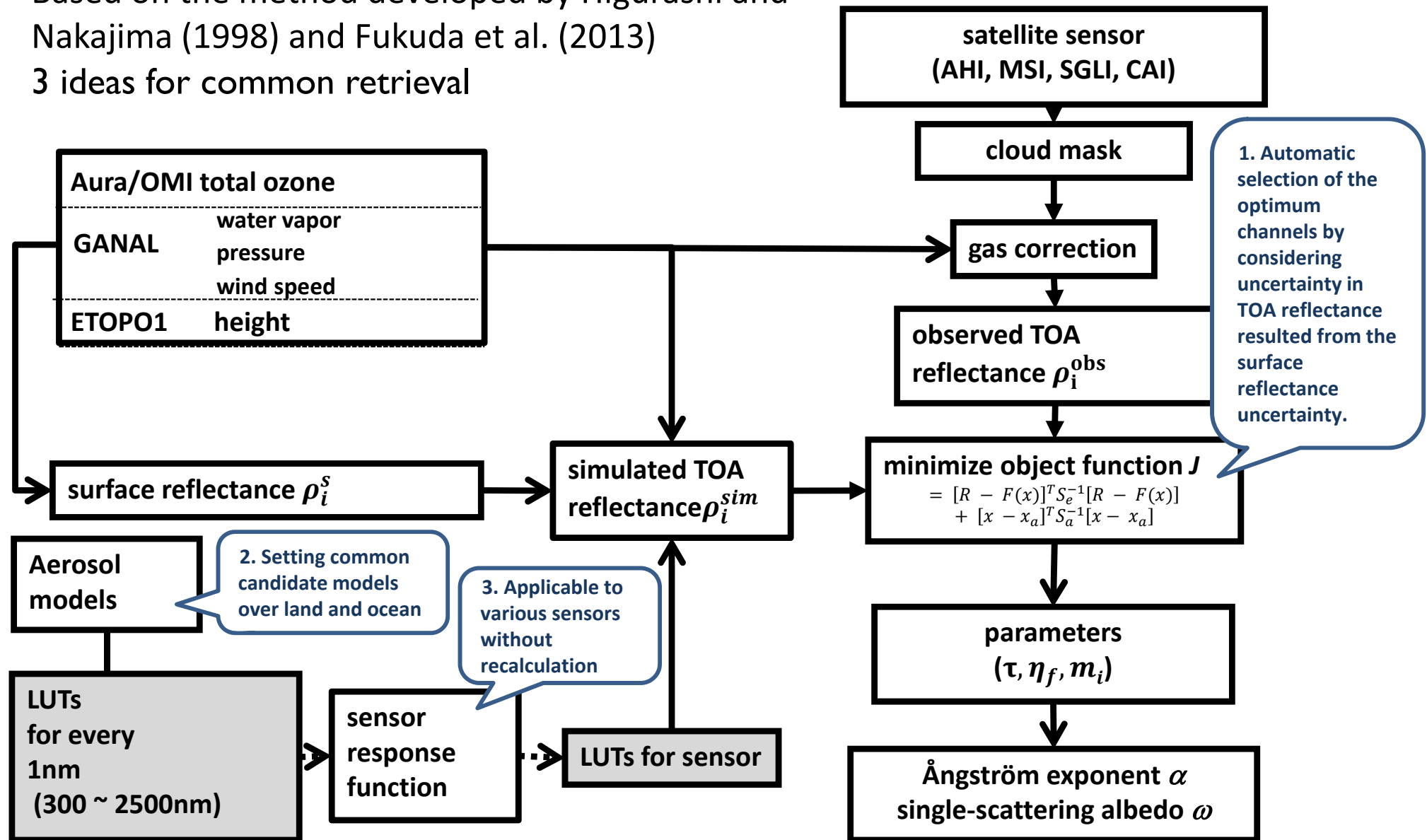
L3 Hourly Aerosol Product: QA flag

- 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_perge : 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)	
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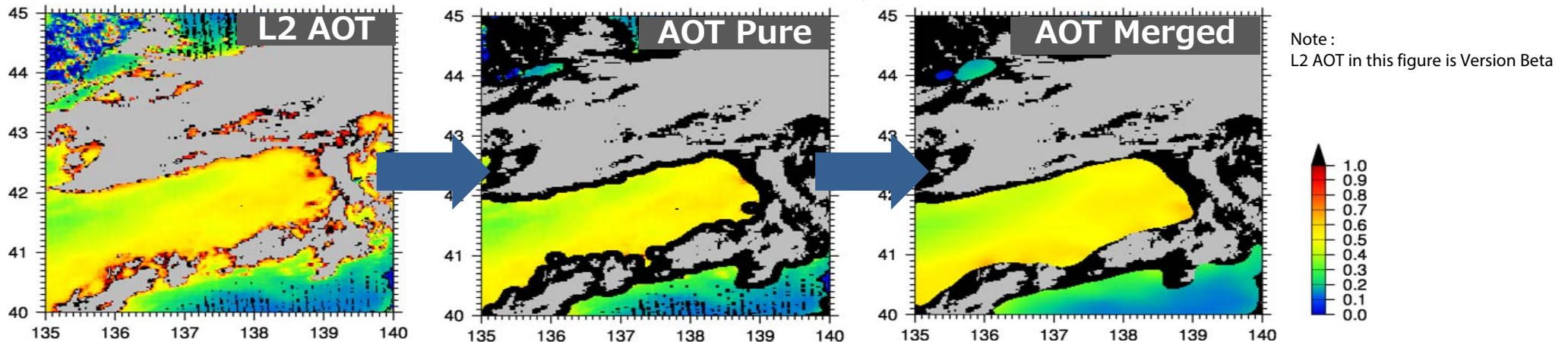
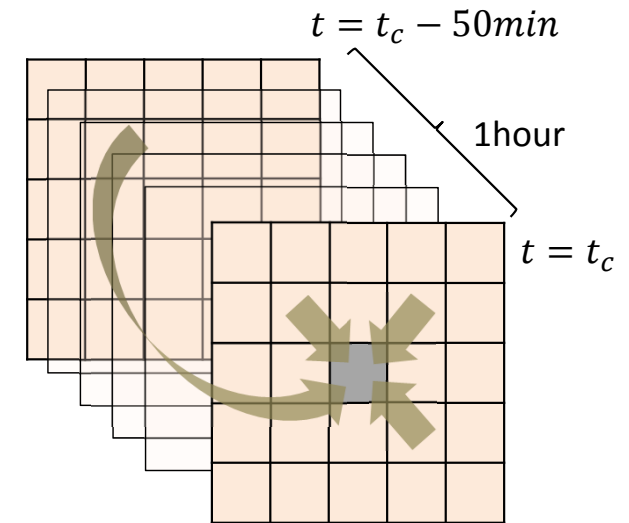
L2 Algorithm

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



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}).



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 turbid 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