Summary of the GLI Atmosphere Analyses

GLI Algorithm Integration Team (GAIT)
Atmosphere Group

NASDA EORC

Contents:

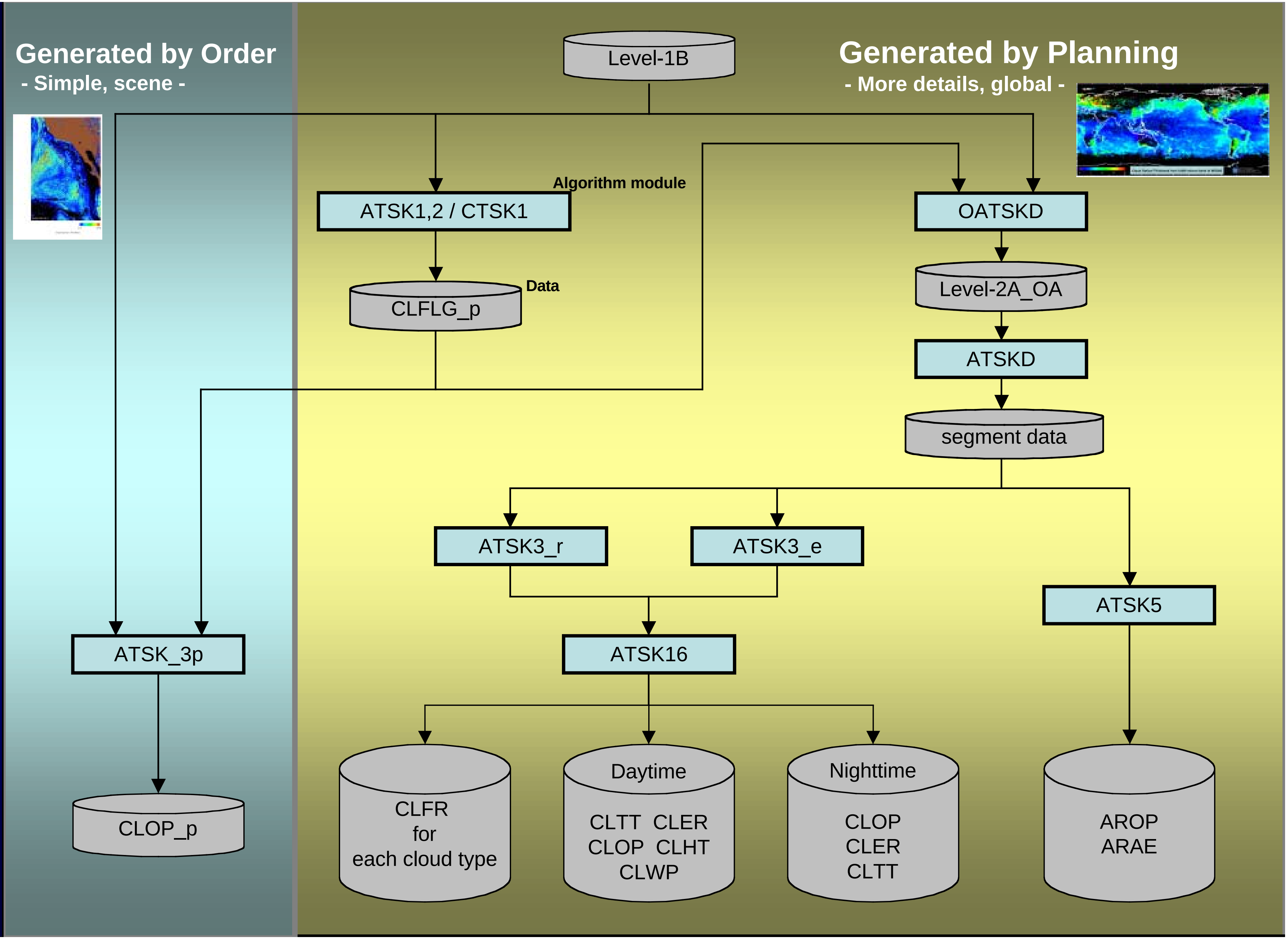
Abuot GLI atmosphere analyses

Cloud, aerosol, and water vapor parameters

Our inability to adequately model cloud processes is a major obstacle in accurate simulations of global warming scenarios. Low-level clouds and upper-level clouds play different roles in the climate system. How they change through the global warming process is, at present, not fully understood. Aerosols are also important for the global warming issue, as revealed by several recent studies on direct aerosol and indirect cloud-aerosol interaction effects on the Earth's climate. It is, therefore, important to generate global archives of geophysical parameters related to cloud, aerosol, and water vapor fields. Using these data sets, we should study the global distribution, annual variability, and feedback mechanisms of the climate field.

***Water vapor algorithms and products will be appeared in future.**

System Flow of GLI Atmosphere



GLI Algorithms (Atmosphere)

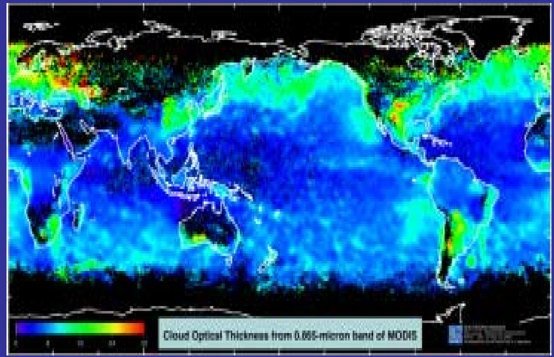
Category
A: Standard Algorithm (Scene Analysis, approx.1600kmx1600km)
B: Standard Algorithm (Global Segment Analysis, 0.25degs lat. lon.)

	Category	Principal Investigator	Product Code Name	Remarks
ATSKD	A	NASDA	Atmospheric Segment Data	Global Segment Data Generation
ATSK1, 2	A	Steven Ackerman	CLFLG_p	Cloud Mask (Scene)
ATSK3_p	A	Teruyuki Nakajiima	CLOP_p	Cloud Properties (Scene)
ATSK3_r	B	Teruyuki Nakajima	CLOP, CLER, CLHT, CLTT, CLWP	Cloud Properties (Global, water cloud)
ATSK3_e	B	Teruyuki Nakajima	CLOP, CLER, CLTT	Cloud Properties (Global, thin ice cloud)
ATSK5	B	Teruyuki Nakajima	AROP, ARAE	Aerosol Properties (Global)
ATSK16	B	Tamio Takamura	CLFR	Cloud Fraction

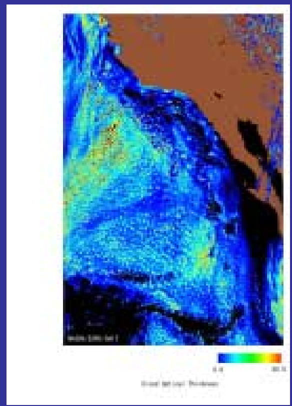
GLI Standard Product List (Atmosphere)

	Product Name	Global(4days)	Global(16days)	Global(1 month)	Scene	Unit
CLFLG_p	**Cloud Flag**	-	-	-	o	-
CLFR	**Cloud Fraction for each cloud type**	o	o	o	-	-
CLOP(_p)	**Cloud Optical Thickness**	o	o	o	o (_p)	-
CLER	**Cloud Effective Particle Radius**	o	o	o	-	micron
CLHT	**Cloud Top Height**	o	o	o	-	km
CLTT	**Cloud Top Temperature**	o	o	o	-	K
CLWP	**Cloud Liquid Water Path**	o	o	o	-	g/m^2
AROP	**Aerosol Optical Thickness at 500 nm**	o	o	o	-	-
ARAE	**Aerosol Angstrom Exponent**	o	o	o	-	-

Data aviilability
Global : Global distribution (0.25degs resolution), generaged by planning
4days : 4 days average
16days : 16days average
1 month : 1 month average
Scene : 1 scene product (approx.1600km x 1600km), generated by order



Sample:
CLOP by Global (1 month)



Sample:
CLOP_p by Scene

GLI channel specification

VNIR and SWIR channels

CH	Wave-length	Band-width	Lmax (H/L gains)	Lstd	SNR	IFOV	Primary Targets
	nm	nm	$W/m^2/sr/\mu m$	$W/m^2/sr/\mu m$		m /rad.	
1	380	10	683	59	467	1000/ 1.25	DOM (Dissolved Organic Matter) absorption, Land Aerosol
2	400	10	162	70	1286		Baseline of DOM
3	412	10	130	65	1402		Chlorophyll absorption, DOM absorption, Land Aerosol
4	443	10	110/680	54	893		Chlorophyll absorption
5	460	10	124/769	54	880		Carotinoid absorption, Snow impurity
6	490	10	64	43	1212		Plankton (Carotinoid, Phycobiline)
7	520	10	92/569	31	627		Pigment
8	545	10	96/596	28	611		Phycobiline absorption, Vegetation
9	565	10	39	23	1301		Fluorescence Minimum Absorption
10	625	10	39	17	1370		Phycobiline absorption
11	666	10	31	13	1342		Baseline of Fluorescence, Atmospheric Correction
12	680	10	33	12	1293		Natural Fluorescence
13	678	10	522	12	235		Chlorophyll abs., Aerosol Optical Thickness, Vegetation
14	710	10	24	10	1404		Baseline of Fluorescence
15	710	10	369	10	300		Sea Ice Monitoring, Vegetation
16	749	10	17	7	991		Atmospheric Correction
17	763	8	473	6	293		Cloud Geometrical Thickness
18	865	20	13	5	1309		Atmospheric Correction
19	865	10	339	5	386		Cloud and Aerosol Optical Thickness, Snow Grain Size
20	460	70	691	36	241	250/ 0.3125	Vegetation Classification etc.
21	545	50	585	25	141		Vegetation Classification etc.
22	660	60	156	14	255		Vegetation Classification etc.
23	825	110	287	21	218		Vegetation Classification etc.
24	1050	20	227	8	381	1000/ 1.25	Moisture, Snow Cover, Cloud Optical Thickness
25	1135	70	184	8	412		Waver Vapor Amount
26	1240	20	208	5.4	303		Moisture, Snow Grain Size
27	1380	40	153	1.5	192		Water Vapor Amount, Upper Cloud Detection
28	1640	200	76	5	298	250/ 0.3125	Cloud Effective Radius, Cloud Phase, Snow Grain Size
29	2210	220	32	1.3	160		Cloud Effective Radius

MTIR channels

CH	Wave-length	Band-width	Dynamic Range	Target Temp.	NEdT (Cold/Hot TV)	IFOV	Primary Targets
	µm	µm	K	K	K	m /rad.	
30	3.715	0.33	345	H: 300	0.07/0.07	1000/ 1.25	Cloud Effective Radius
				L: 250	0.71/0.78		
31	6.7	0.5	307	285	0.02/0.03		Water Vapor Index
				200	0.27/0.32		
32	7.3	0.5	322	300	0.02/0.03		Water Vapor Index
				200	0.24/0.27		
33	7.5	0.5	324	300	0.02/0.02		Water Vapor Index
				200	0.21/0.24		
34	8.6	0.5	350	300	0.03/0.05		Water Vapor Amount, Temperature
				180	0.47/0.49		
35	10.8	1.0	354	300	0.04/0.05		Temperature
				180	0.24/0.30		
36	12.0	1.0	358	300	0.04/0.06		Temperature
				180	0.23/0.27		

ATSK1,2

Cloud Mask (Scene)

<Acronyms>
P.I. : Principal Investigator
A.D. : Algorithm Developer
A.I. : Algorithm Integrator

Abstract

The GLI cloud mask will indicate whether a given view of the earth surface is unobstructed by clouds or optically thick aerosol, and whether that clear scene is contaminated by a shadow. The cloud mask will be generated at 1-km resolution. Input to the cloud mask algorithm is assumed to be calibrated and navigated Level-1B radiance data.

The strategy for this cloud mask algorithm is to start with single pixel (1-km field of view) tests. Many of the single pixel tests rely on radiance (or temperature) thresholds in the infrared and reflectance thresholds in the solar. These thresholds vary with surface emissivity, with atmospheric moisture and aerosol content, and with GLI viewing scan angle. The 32bits of Cloud flags were obtained from ATSK1,2 together with CTSK1 in cryosphere analyses.

Input : Level-1B data
Output : CLFLG_p
P.I. : Steven A. Ackerman (SSEC,University of Wisconsin)
A.D. : Richard Frey (SSEC, University of Wisconsin)
A.I: Masaru Tairadate (Fujitsu)

Table CLOUD MASK BIT CONFIGURATION

bit field	Algorithm	Description		Key
0-1	ATSK1,2	Unobstructed FOV Quality Flag		00 = cloud 01 = 66% prob. clear 10 = 95% prob. clear 11 = 99% prob. clear
2		Processing Path Flags	Day / Night Flag	0 = Night / 1 = Day
3			Sunglint Flag	0 = Yes / 1 = No
4			Snow / Ice Background Flag	0 = Yes/ 1 = No
5-6			Land / Water Flag	00 = Water/ 01 = Coastal 10 = Desert / 11 = Land
7		Additional Information	Non-cloud obstruction Flag	0 = Yes / 1 = No
8			Thin Cirrus Detected (solar)	0 = Yes / 1 = No
9			Shadow Found	0 = Yes / 1 = No
10		1-km Cloud Flags	Result from Group I Tests	0 = Yes / 1 = No
11			Result from Group II Tests	0 = Yes / 1 = No
12			Result from Group III Tests	0 = Yes / 1 = No
13			Result from Group IV Tests	0 = Yes / 1 = No
14			Result from Group V Tests	0 = Yes / 1 = No
15		*reserved for ATSK4*		
16				
17				
18				
19		Dummy Flag		0 = not dummy / 1 = dummy (valid for bit 1-20)
20		Using Channel Flag	Used channel 28 and 29	0 = not used / 1 = used (valid for bit 1-20)
21	CTSK1	Snow/Cloud descrimination	Execution flag	0 = not executed / 1 = executed (valid for bit 21-26)
22-23			Cloud confidence level flag	00 = clear sky 01 = high-confidence cloudy confidence = 100% 10 = middle-confidence cloudy 50% < confidence < 100% 11 = low-confidence cloudy 0% < confidence < 50%
24-26			Surface classification flag	000 = snow over ice 001 = sea ice 010 = cloud shadow 011 = land 100 = open water 101 = snow over land 111 = spare
27-31		Spare		

ATSK3_p Cloud Properties (Scene)

Abstract

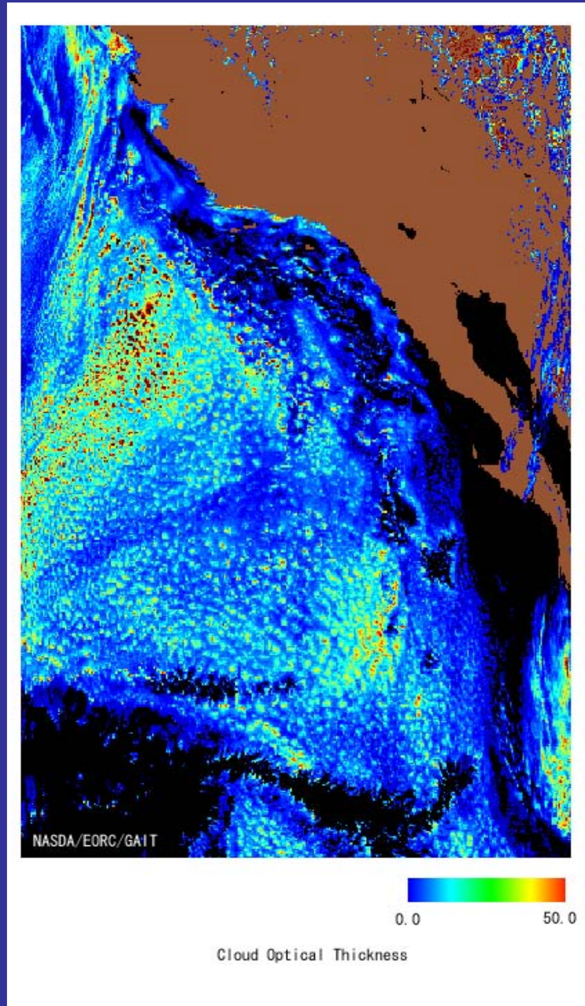
A method for satellite remote sensing of cloud microphysics has been developed to apply to GLI/ADEOS-II multispectral radiance data. This algorithm is an enhanced algorithm of AVHRR/NOAA data analysis (Nakajima and Nakajima1995; Kawamoto 2000), which has an active thermal collection in absorption channel.

Undesirable radiation components such as ground-reflected solar radiation and thermal radiation are guessed from satellite-received radiances in channels 13 or 19 (678 or 865 nm), 30 (3.715 µm) and 35 (10.8 µm) of GLI and subtracted from radiances in channels 13 and 30 to derive the reflected solar radiation of a cloud layer which includes information about cloud microphysical properties. This method can be applied to a broad range of water clouds from semi-transparent to thick clouds.

The ATSK3_p is designed to analyze every scene of Level-1B data.

Input :	Level-1B data, CLFLG_p (from ATSK1,2/CTSK1)
Output :	CLOP_p
Principal Investigator :	Teruyuki Nakajima (CCSR, University of Tokyo)
Algorithm Developer :	Takashi Y. Nakajima (EORC, NASDA)
Algorithm Integrator :	Masaru Tairadate (Fujitsu)

Sample View:
Cloud optical thickness retrieved from MODIS/Terra data (off the coast of California). This result was obtained using GLI/ADEOS-II analysis system developed in EORC/NASDA. MODIS data were provided by NASA.



ATSK3_r

Cloud Properties (Global)

<Acronyms>
P.I. : Principal Investigator
A.D. : Algorithm Developer
A.I. : Algorithm Integrator

Abstract

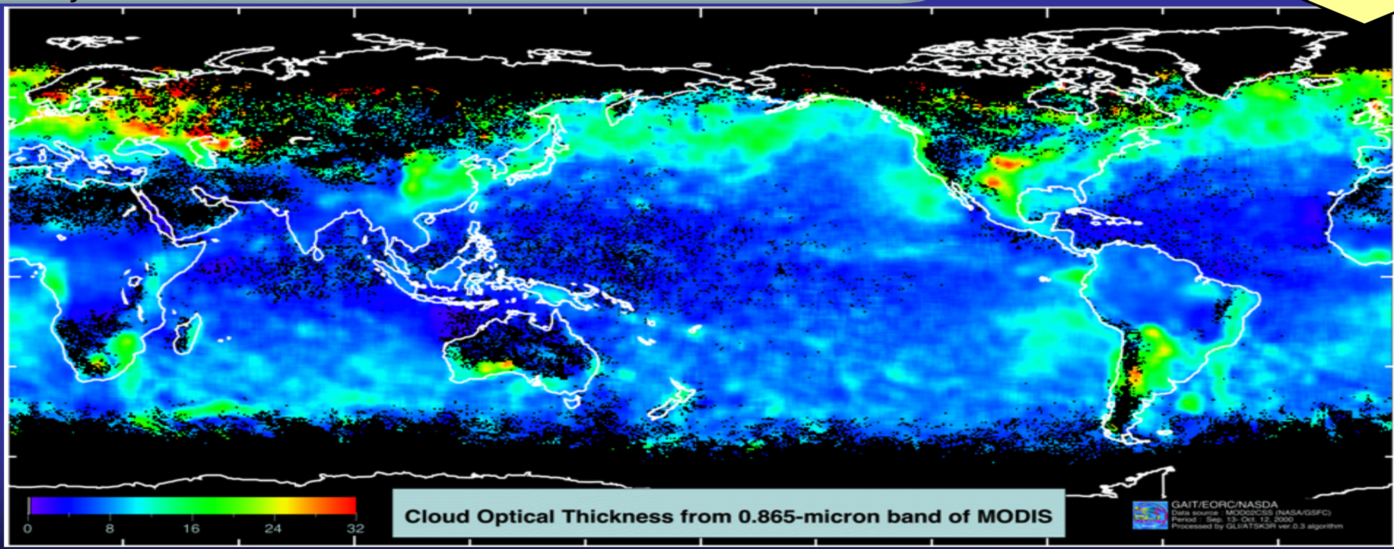
A method for satellite remote sensing of cloud microphysics has been developed to apply to GLI/ADEOS-II multispectral radiance data. This algorithm is an enhanced algorithm of AVHRR/NOAA data analysis (Nakajima and Nakajima1995; Kawamoto 2000), which has an active thermal collection in absorption channel.

Undesirable radiation components such as ground-reflected solar radiation and thermal radiation are guessed from satellite-received radiances in channels 13 or 19 (678 or 865 nm), 30 (3.715 µm) and 35 (10.8 µm) of GLI and subtracted from radiances in channels 13 and 30 to derive the reflected solar radiation of a cloud layer which includes information about cloud microphysical properties. This method can be applied to a broad range of water clouds from semi-transparent to thick clouds.

The ATSK3_r is designed to analyze the atmospheric segment data.for global scale analyses.

Input : Segment data
Output : work_r_w, work_r_i
P.I.: Teruyuki Nakajima (Univ. Tokyo)
A.D. : Takashi Y. Nakajima (NASDA)
A.I. : Masaru Tairadate (Fujitsu)

Sample View:
Global distribution of cloud optical thickness retrieved from MODIS/Terra data. Monthly mean values from September13 to October 12 in 2000. These results were obtained using GLI/ADEOS-II analysis system developed in EORC/NASDA. MODIS data were provided by NASA.

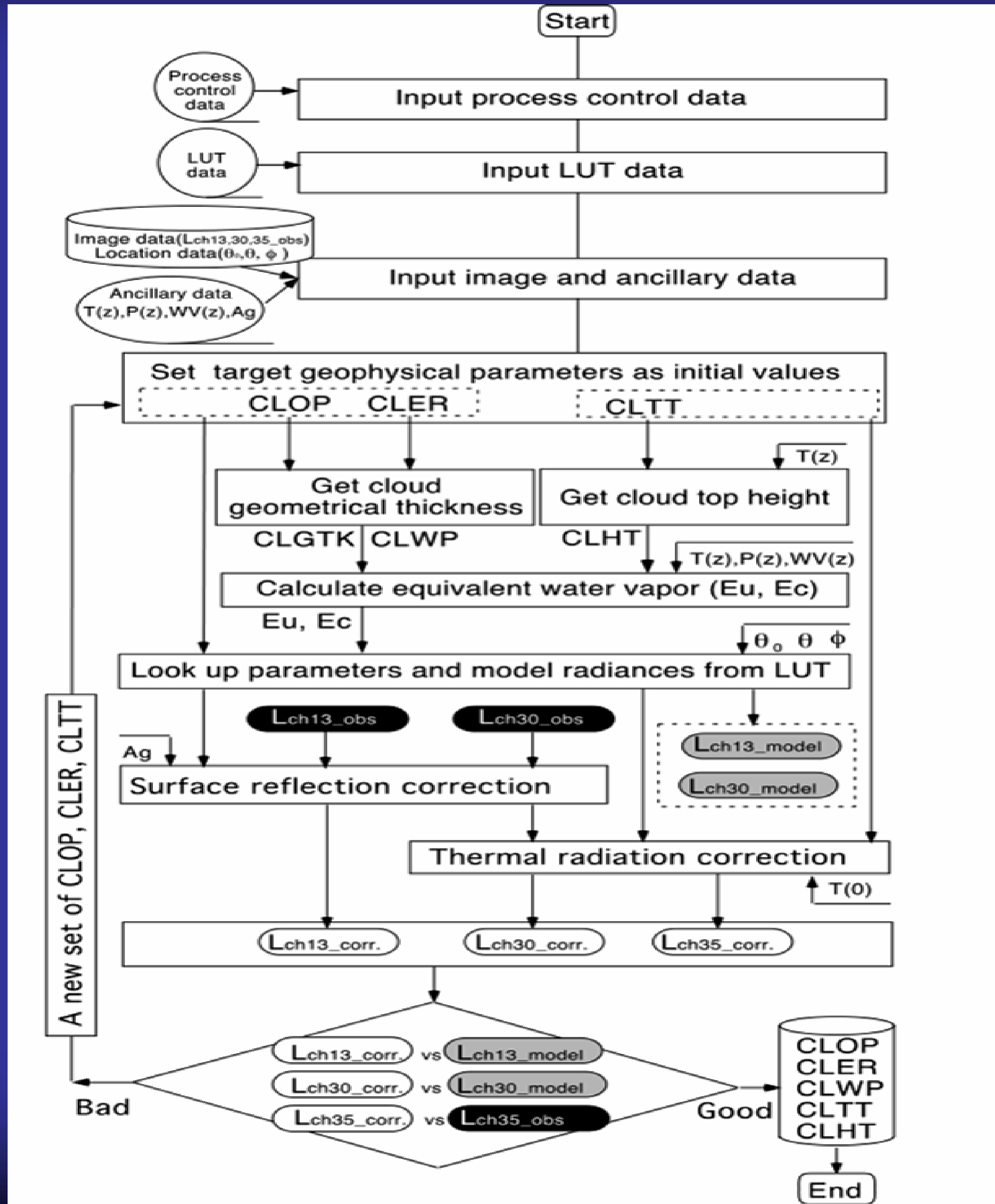


ATSK3_p & ATSK3_r flow chart

In the ATSK3_p process, radiance of non-absorbing channel (L_{ch13}, or L_{ch19}), ground albedo (*Ag*), and scan geometries are used to calculate cloud optical thickness (CLOP_p).

On the other hand, the ATSK3_r process needs non-absorbing channel (L_{ch13}, or L_{ch19}), absorbing channel (L_{ch30}), and thermal channel (L_{ch35}), ground albedo (*Ag*), and some objective analysis data such as vertical profiles of temperature, pressure, and relative humidity, to obtained optical thickness (CLOP), effective radius (CLER), cloud liquid water path (CLWP), cloud top temperature (CLTT) and cloud top height (CLHT).

Pre-process and post-process program are required to select target pixels from radiance dataset and select suitable results from all outputs.



ATSK3_e Cloud Properties (Global, thin ice cloud)

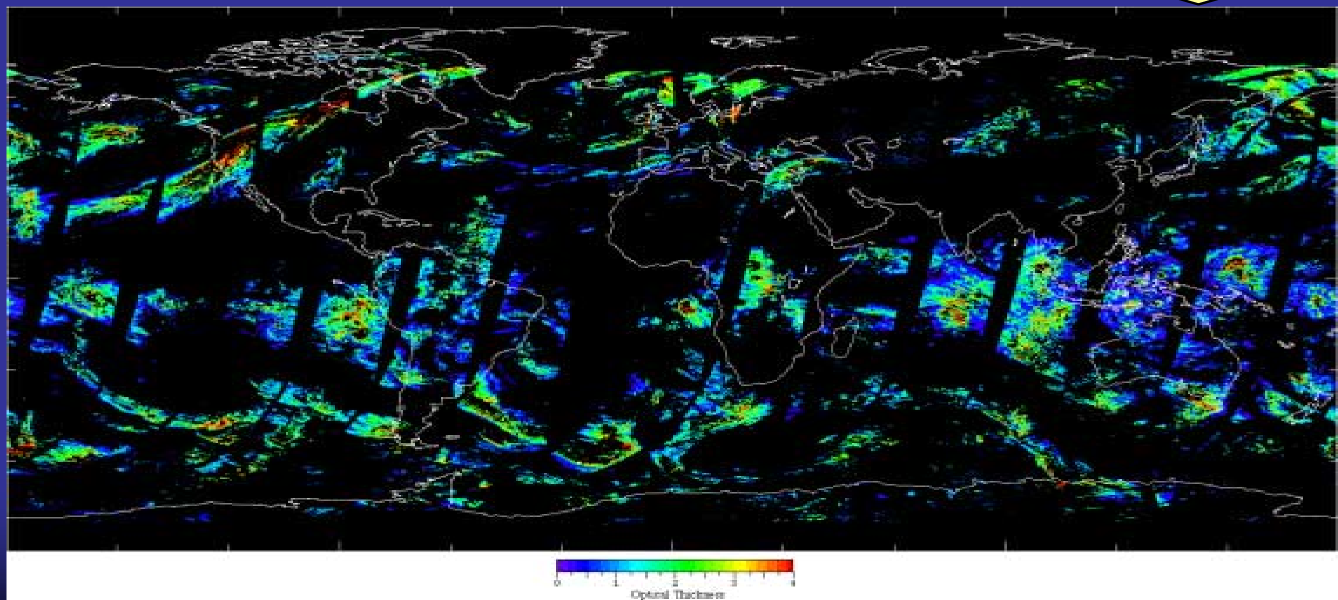
<Acronyms>
P.I. : Principal Investigator
A.D. : Algorithm Developer
A.I. : Algorithm Integrator

Abstract

This algorithm will retrieve thin cirrus cloud microphysical parameters, effective particle radius, optical thickness and cloud top temperature from channels (3.715 μm), 35 (10.8 μm), and 36 (12.0 μm). Figure 1 (next page) illustrates the flow of the algorithm. And Figure 2 illustrates the finding process (Processing A in Fig.1) of cloud top temperature and the surface temperature (or the cloud top temperature of the cloud lying under the high cloud). Fig.3 shows examples for the Look-Up Table in the algorithm and the row data in test-run (using AVHRR/NOAA data).

Input : Segment data
Output : work_e
P.I : Teruyuki Nakajima (CCSR, University of Tokyo)
A.D.: Shuichiro Katagiri (EORC, NASDA)
A.I. : Shuichiro Katagiri (EORC, NASDA)

Sample View:
Global distribution of cirrus cloud optical thick-ness retrieved from MODIS/Terra data. Result of one day analysis in December, 2000. This result was obtained using GLI/AEOS-II analysis system developed in EORC/NASDA. MODIS data were provided by NASA.



ATSK3_e flow chart

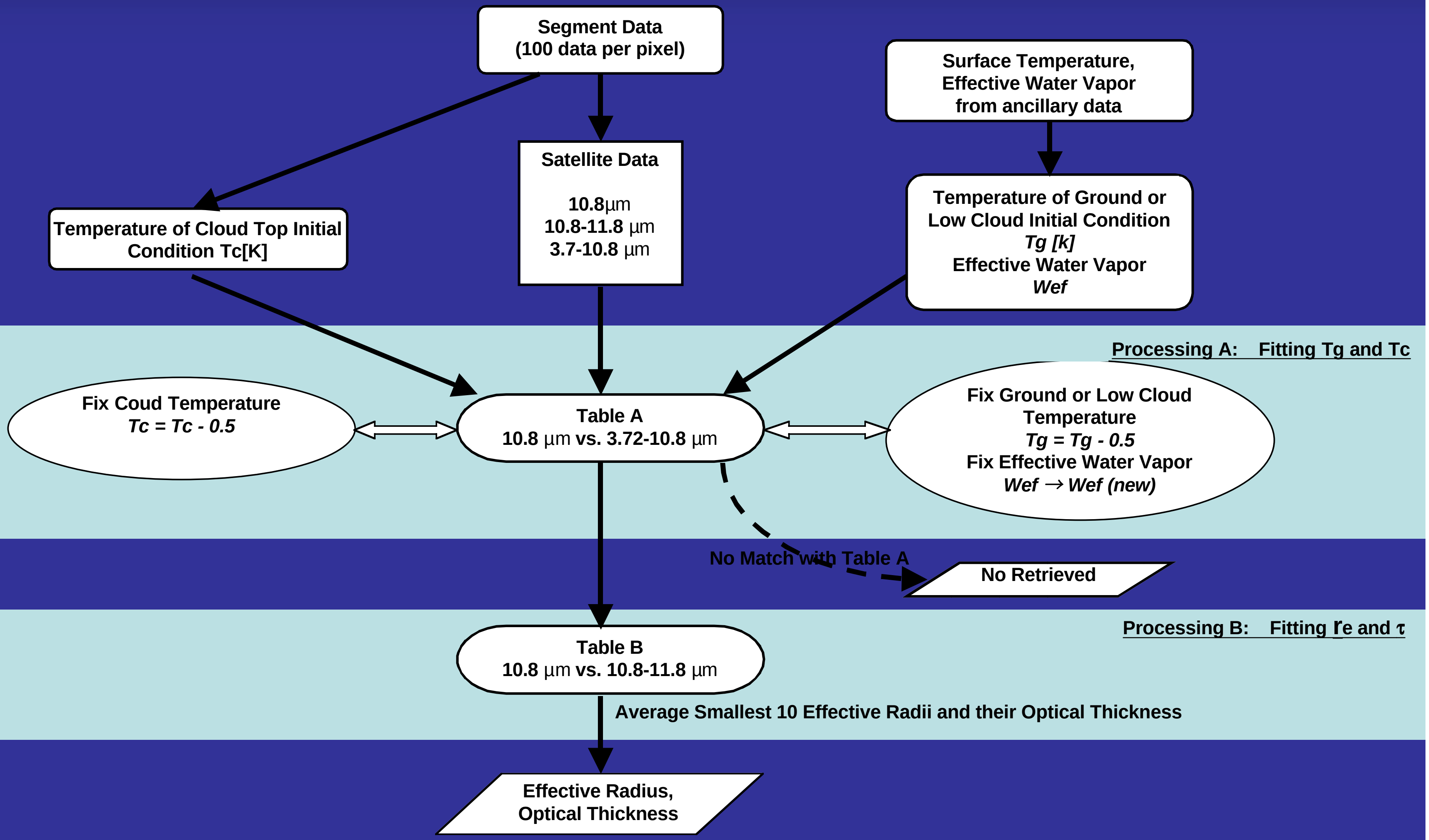


Fig.1 The flow chart of the retrieval algorithm.

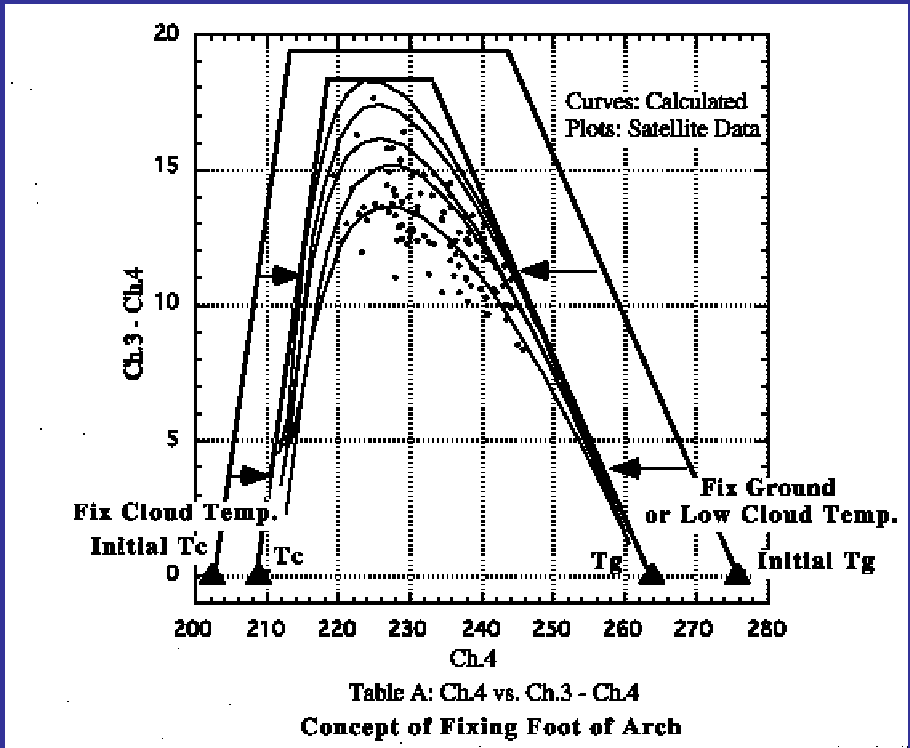


Fig.2 The concept of the table fitting
The example of processing A in Fig. 1, here,
AVHRR's ch3=3.7µm, ch4=10.8µm, ch5=11.8µm

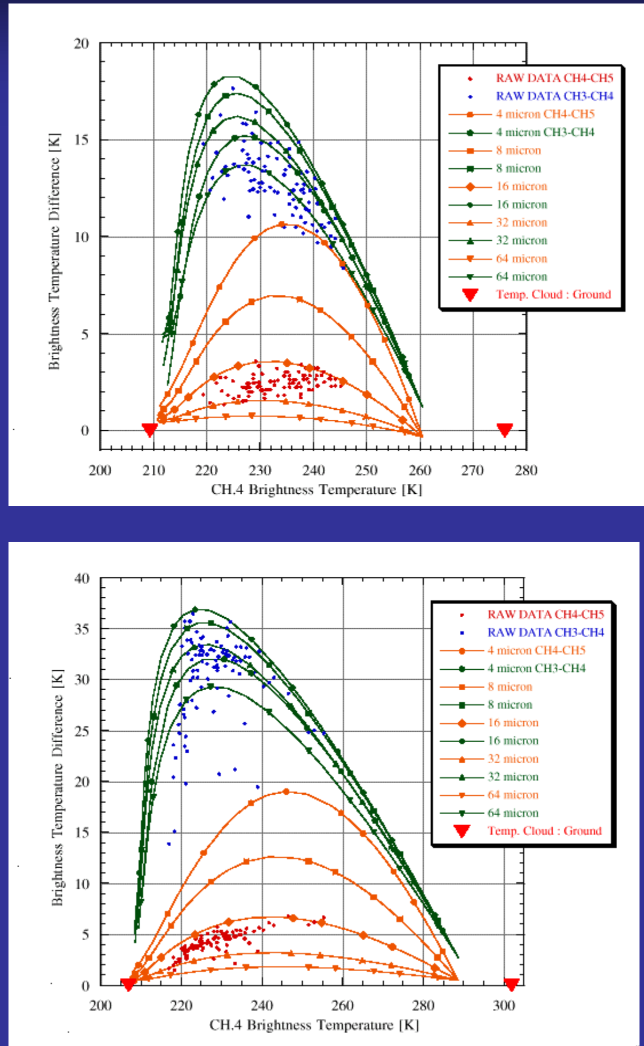


Fig.3 Examples for the table in Algorithm and the raw data in Testrun (AVHRR)
here, AVHRR's ch3=3.7µm, ch4=10.8µm, ch5=11.8µm

ATSK5

Aerosol Properties (Global)

<Acronyms>

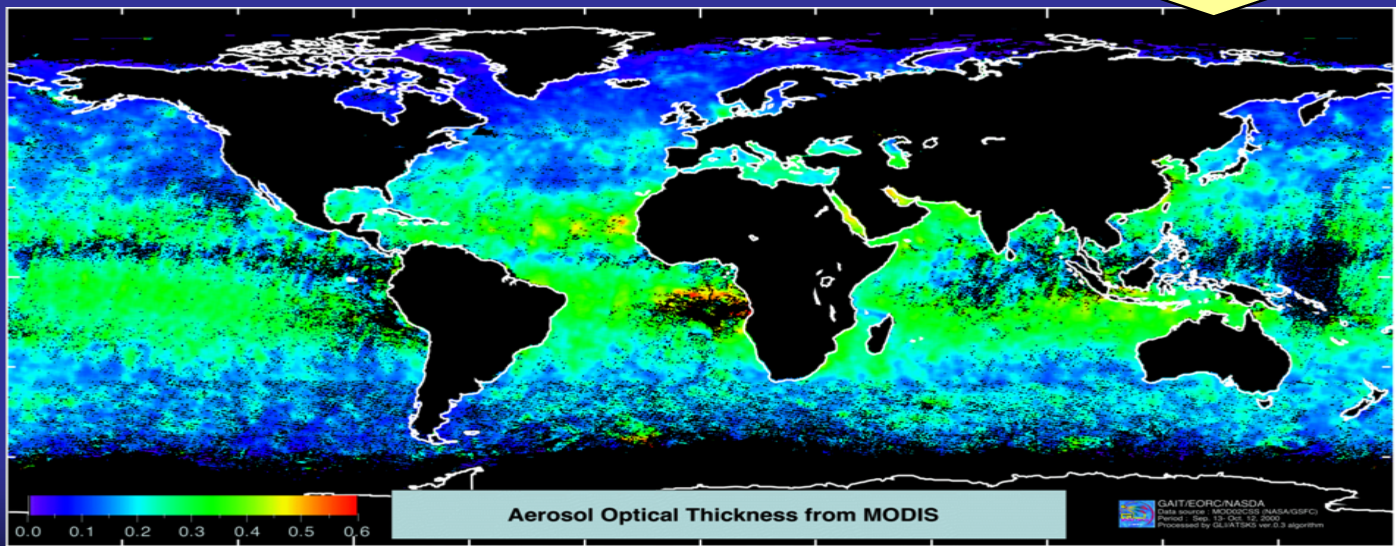
P.I. :	Principal Investigator
A.D. :	Algorithm Developer
A.I. :	Algorithm Integrator

Abstract

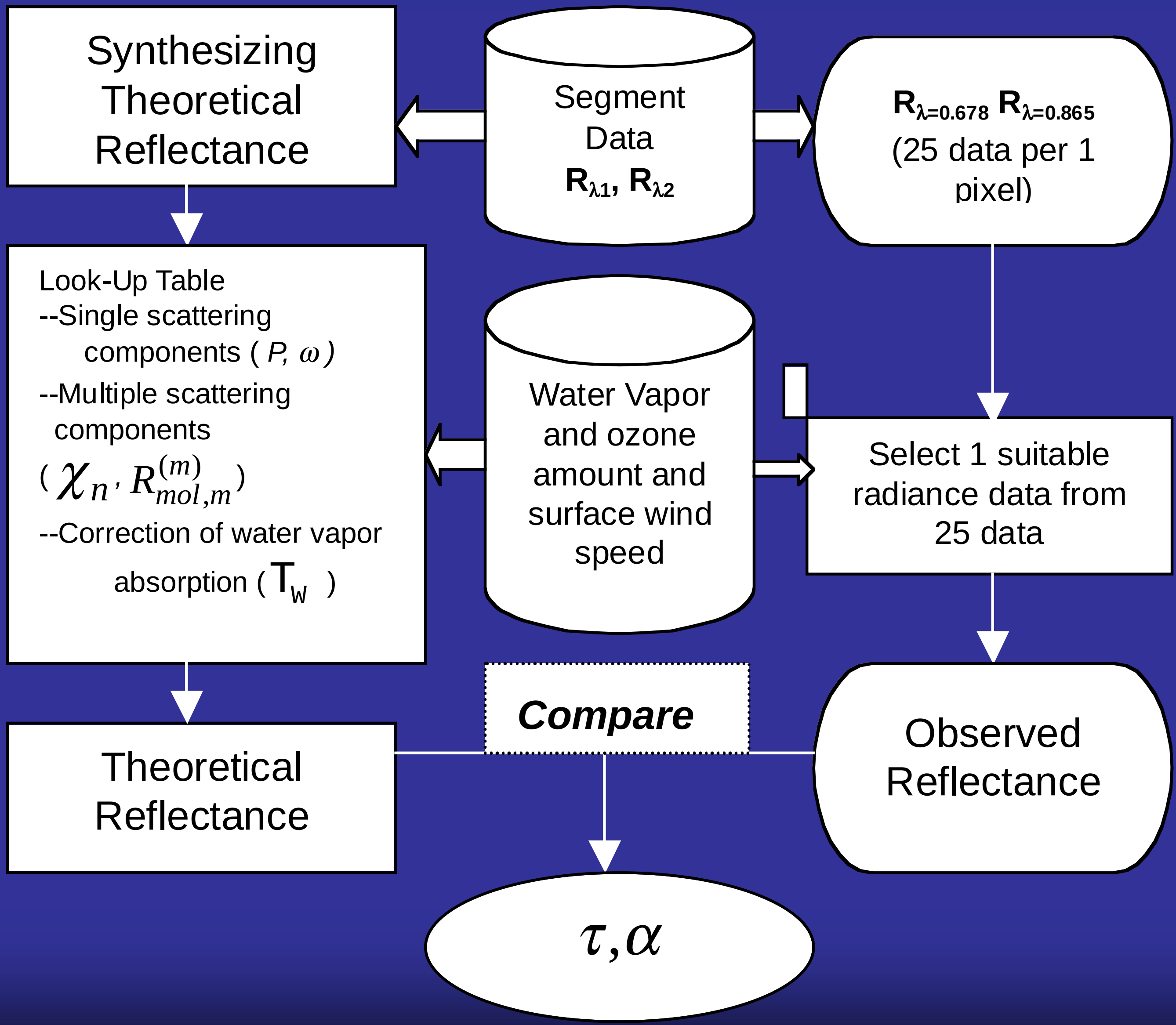
This satellite remote sensing algorithm retrieves aerosol optical thickness at 500nm and Angstrom exponent from two channel radiant data, that is, visible (channel 13, 678nm) and near-IR (channel 19, 865nm) satellite data. Satellite-received radiance is synthesized with four Look-Up Tables (LUTs). For retrievals, ancillary data are needed, which include wind velocity at 10 meter height, ozone and water vapor amount to correct radiance for surface reflectance, ozone and water vapor absorption.

Input :	Segment data
Output :	AROP, ARAE
P.I. :	Teruyuki Nakajima (CCSR, University of Tokyo)
A.D. :	Akiko Higurashi (NIES, Ministry of Environment)
A.I. :	Yi Liu (EORC, NASDA)

Sample View:
Global distribution of aerosol optical thickness retrieved from MODIS/Terra data. Monthly mean values from September 13 to October 12 in 2000. These results were obtained using GLI/ADEOS-II analysis system developed in EORC/NASDA. MODIS data were provided by NASA.



ATSK5 flow chart



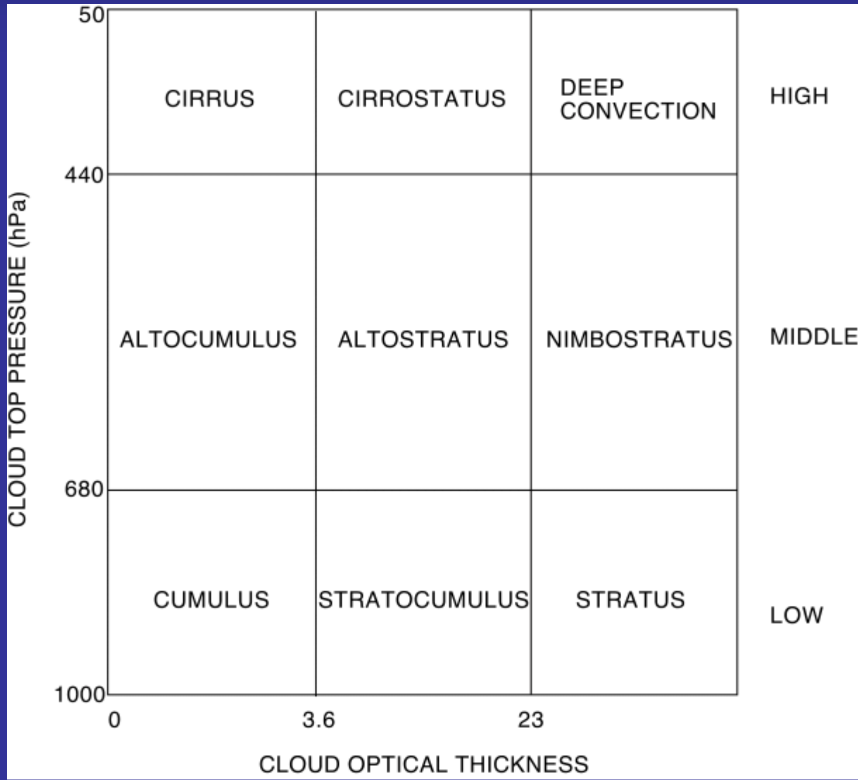
ATSK16 Cloud Fraction

Abstract

The algorithm will classify clouds into several types using output data from **ATSK3_r** and **ATSK3_e** (The work files. See the corresponding pages for details), based on the ISCCP categories. The characteristics of this algorithm have an index of cloud shape and an additional classification of cirrus. The cloud shape can be determined by sum of spatial differences between each pixel in an area of 0.25 degrees square in latitude and longitude, so a high difference means cumulus-type and a low one stratus-type. The split window technique will separate a cirrus cloud from other clouds.

The cloud information by the ATSK16 algorithm will be used for estimation of surface radiation budget as a research product.

The ATSK16 also generates averaged cloud parameters such as CLOP, CLER and so on from work files of ATSK3_r and ATSK3_e.

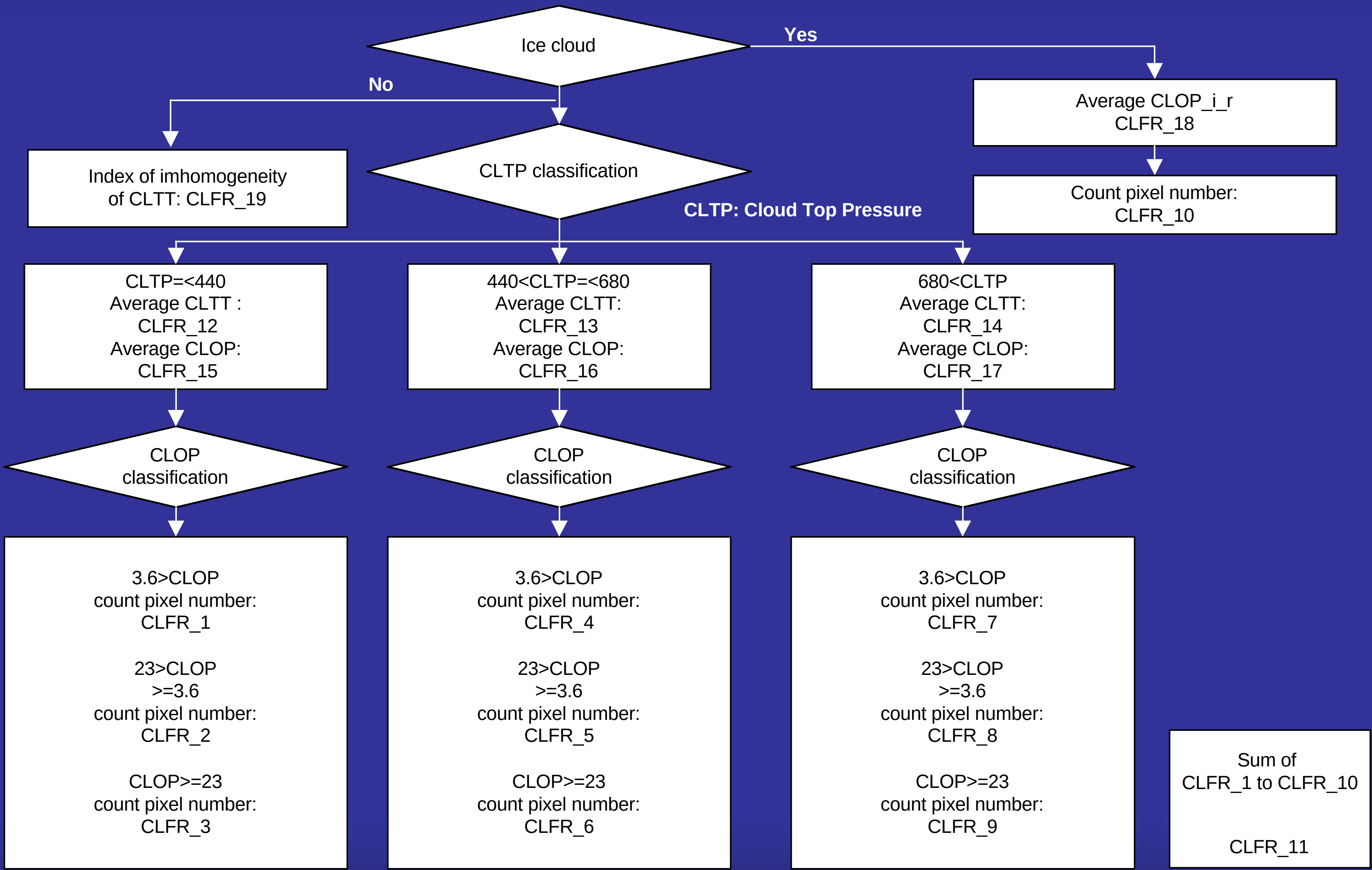


Rossow et al. 1996, ISCCP Documentation of New Cloud Dataset

Input : work_r_w(by ATSK3_r), work_r_i(by ATSK3_r), work_e(by ATSK3_e)
Output : CLFR_1-19,
CLOP_w_r, CLER_w_r, CLTT_w_r, CLHT_w_r, CLWP_w_r, CLOP_i_r,
CLOP_i_e, CLER_i_e, CLTT_i_e

Principal Investigator : Tamio Takamura (CEReS, Chiba University)
Algorithm Developer : Itaru Okada (CEReS, Chiba University)
Algorithm Integrator : Yi Liu (EORC, NASDA)

ATSK16 flow chart



References

ATSK1,2

Ackerman, S. A., W. L. Smith and H. E. Revercomb, 1990: The 27-28 October 1986 FIRE IFO cirrus case study: Spectral properties of cirrus clouds in the 8-12 micron window, *Mon. Wea. Rev.*, **118**, 2377-2388.

Ackerman, S. A., 1997 : Discriminating clear-sky from cloud with GLI. Development status report to NASDA.

Ackerman, S. A., K. I. Strabala, W. P. Menzel, R. A. Frey, C. C. Moeller and L. E. Gumley Discriminating Clear-sky from Clouds with MODIS, 1998: *J. Geo. Res.*, **103** , D24, p. 32,141

ATSK3_p, ATSK3_r

Nakajima, T. and M. D. King, 1990: Determination of the optical thickness and effective radius of clouds from reflected solar radiation measurements. Part I: Theory. *J. Atmos. Sci.*, **47**, 1878-1893.

Nakajima T. Y. and T. Nakajima, 1995: Wide-area determination of cloud microphysical properties from NOAA AVHRR measurement for FIRE and ASTEX regions, *J. Atmos. Sci.*, **52**, 4043-4059.

Kawamoto, K., T. Nakajima, and T. Y. Nakajima, 2000: A global determination of cloud microphysics with AVHRR remote sensing, *J. Climate*, **14**, 2054-2068.

ATSK3_e

Katagiri, S., 2001: 赤外射出法を用いた上層雲の長期衛星モニタリングに関する研究, thesis for doctor degree., University of Tokyo.

ATSK5

Nakajima, T., and A. Higurashi, 1998: A use of two-channel radiances for an aerosol characterization from space. *Geophys. Res. Lett.*, **25(20)**, 3815-3818.

Higurashi, A., and T. Nakajima, 1999: Development of a two Channel aerosol retrieval algorithm on global scale using NOAA/AVHRR. *J. Atmos. Sci.*, **56**, 924-941.

Higurashi, A., and T. Nakajima, 2000: A study of global aerosol optical climatology with two channel AVHRR remote sensing. *J. Climate*, **13**, 2011-2027.

ATSK16

Rossow, W.B., A. W. Walker, D. E. Beuschet. M. D. Roiter, 1996: International Satellite Cloud Climatology Project documentation of new cloud dataset. pp39.