Global observations of cloud area and properties from GCOM-C SGLI for improving climate change study and cloud science

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Tokai University

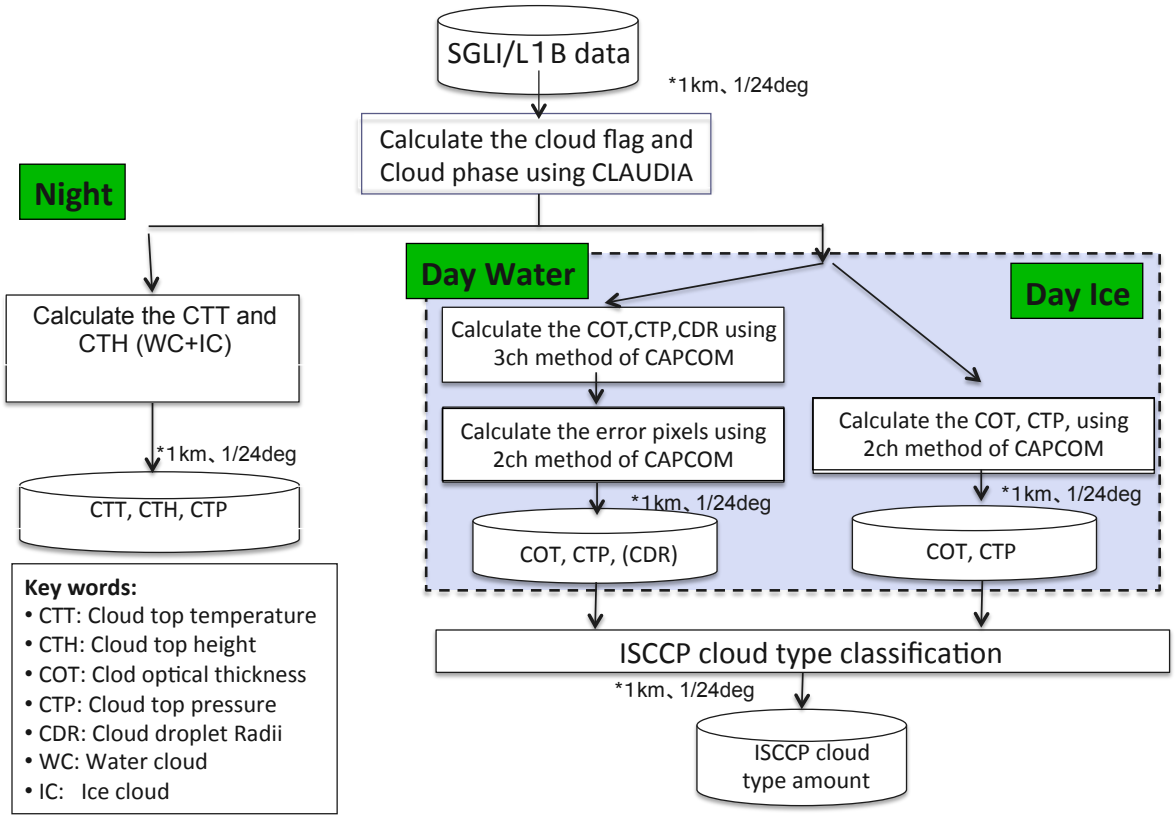
10:10-10:30

SGLI workshop 2014.1.17 in Tokyo

Contents

1. Data flow and algorithm overview
2. Importance of clouds
3. Towards ice clouds observation
4. Validation (JAXA sky camera)
5. Results in 2013
6. Summary

SGLI data analysis flow for Clouds

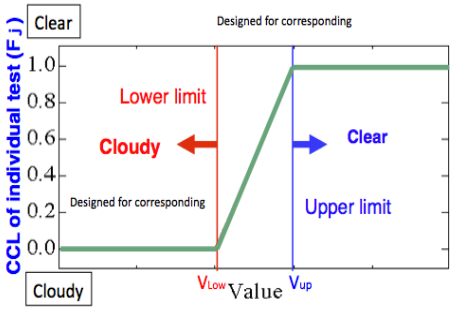


➢ Cloud detection algorithm (CLAUDIA):

Ishida and Nakajima (JGR 2010)

Concept of the Clear Confidence Level (CCL)

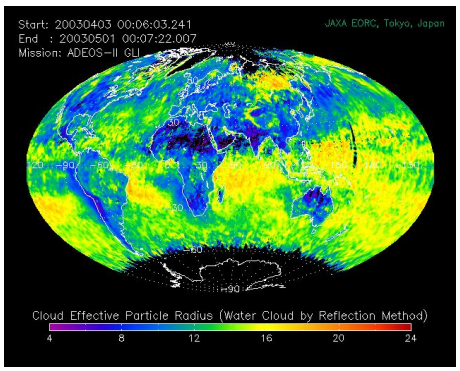
- **Quantitatively evaluate cloud existence by the CCL (value of 0 to 1)**
- **Two thresholds (Upper limit and Lower limit) for each individual test**



➢ Retrieval algorithm for the cloud properties (CAPCOM):

Nakajima and Nakajima (JAS 1995) etc.

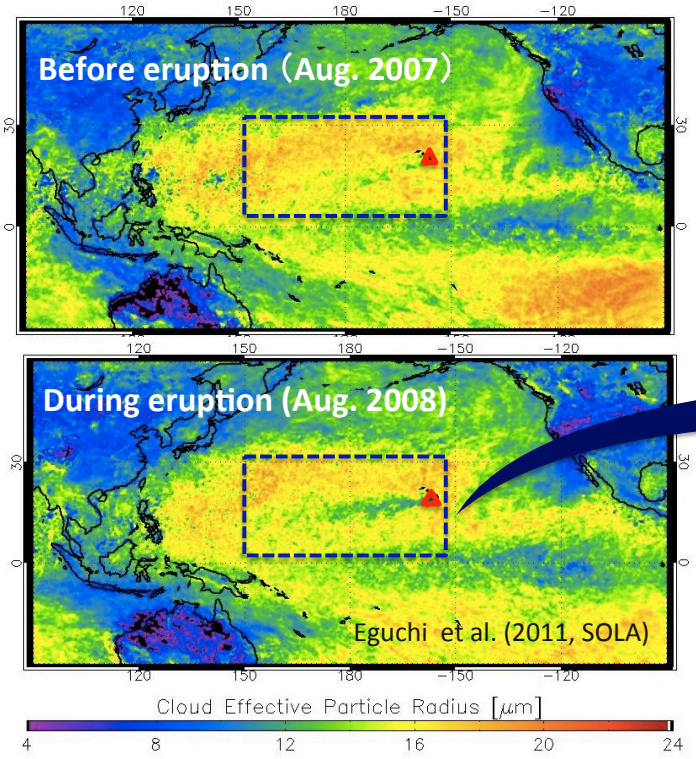
• The CAPCOM uses LUT (Look up Table)-Iteration Method (LIM) to retrieve the cloud optical and microphysical properties from satellite-derived non-absorption, absorption band data.

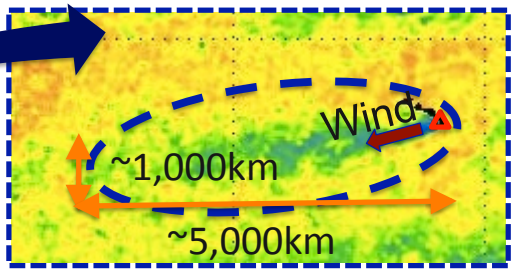


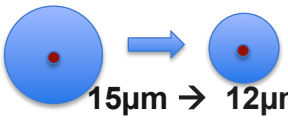
Eguchi et al. (2011)

Evidence of the *aerosol indirect effect*

Hawaii Mt. Kilauea eruption in 2008







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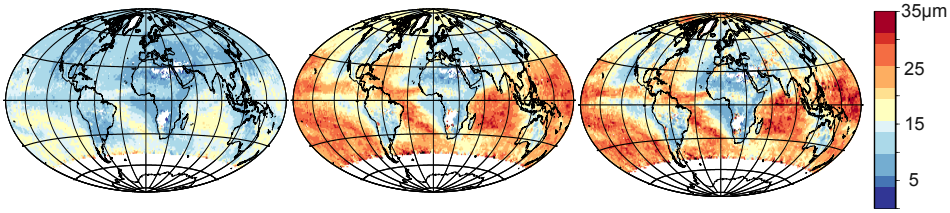
Water Cloud Property: New Study

1. The significant differences are among three cloud effective radii for water

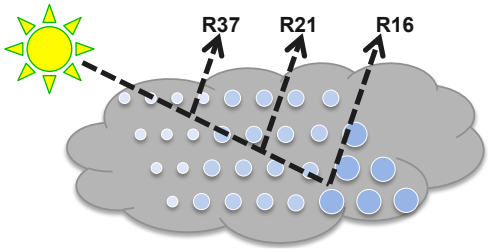
R37 (3.7μm) **R21** (2.1μm) **R16** (1.6μm)



What induce these differences among R37, R21 and R16?

2.

In-cloud vertical inhomogeneity (Platnick, 2000; Nakajima et al., 2010a)
Sub-pixel horizontal inhomogeneity (Zhang et al. 2011, 2012)
3-D radiative transfer (Zinner et al., 2010)



Can we retrieve the information about cloud vertical structure ?

Water Cloud Property: New Study

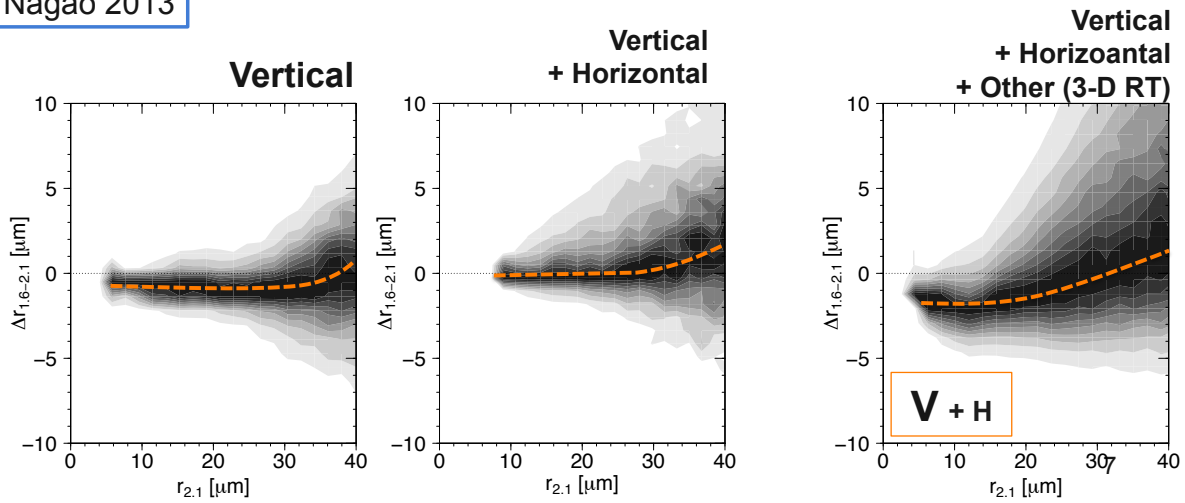
- However, satellite-retrieved R16, R21, R37 seem to be contaminated by the impact of Horizontal inhomogeneity and etc. (Nagao et al. 2013, JAS)

$$r_{retrieval} = r_{verical} + \Delta r_{horizontal} + \Delta r_{other}$$

Nagao 2013

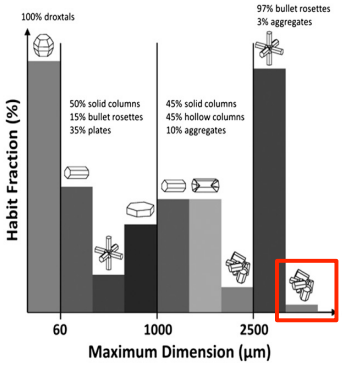
[Model Simulation]

[MODIS Observation]



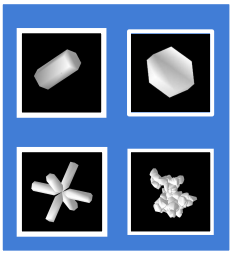
Developing the ice crystal scattering database

MODIS C5 product:



Baum et al. 2005

SGLI product:



*Calculating

Size parameter resolution selected in light scattering DB:

Solvers	Adapted size parameter	Calculation method	Reference
Lisas/SIEMM	1 - 20	Maxwell equation	Nakajima T. Y et al. 2009
FDTD	20 - 30	Maxwell equation	Ishimoto et al. 2010
GOM2	30-300	Ray-tracing + Electromacnetic theory	Ishimoto et al. 2012
GOM1	More than 300	Ray-tracing technique	Nakajima T Y et al 1997

Flow chart of the ice crystal scattering database

INPUT DATA:

1). SGLI calculating wavelength
2). Radii of the corresponding equivalent volume spheres
3). Particle shape
4). Aspect rate

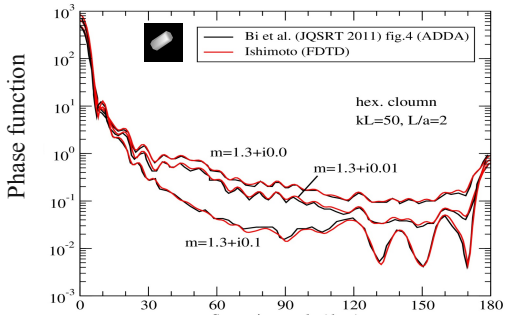
Light scattering solvers
(SIEMM, FDTD, GOM2, GOM1)

OUTPUT:
- Phase function, Phase matrix Extinction efficiency, SSA (Light scattering properties DB →RSTAR radiative transfer code)

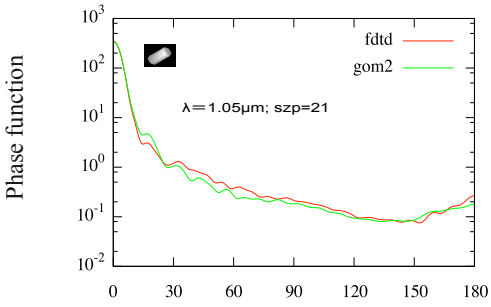
***DB: database**

Validation of the FDTD and GOM2 method by comparing the phase function

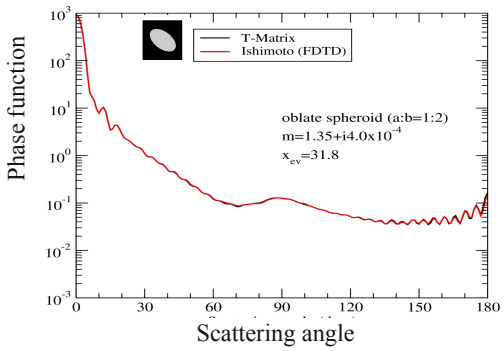
FDTD VS ADDA (Bi et al. 2011)



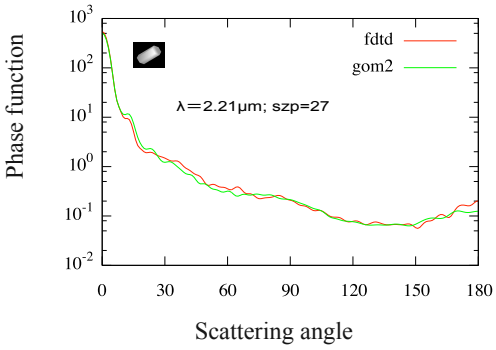
FDTD VS GOM2



FDTD VS T-Matrix



FDTD VS GOM2



Radiative property of the cirrus with varies ice crystal shapes

Particle size distribution:

$$n(r) = \frac{N}{\sqrt{2\pi}\sigma} exp\left[-\frac{(\ln r - \ln r_0)^2}{2\sigma^2}\right]$$

INPUT
- **Cloud particle scattering property**
  - **-Spherical (Mie Theory: KRNL.OUT)**
  - **-Non-spherical (KRNL.OUT)**
    1. **GOM1 (300<SZP)**
    2. **GOM2 (50<SZP<300)**
    3. **FDTD (1<SZP<50)**

↓

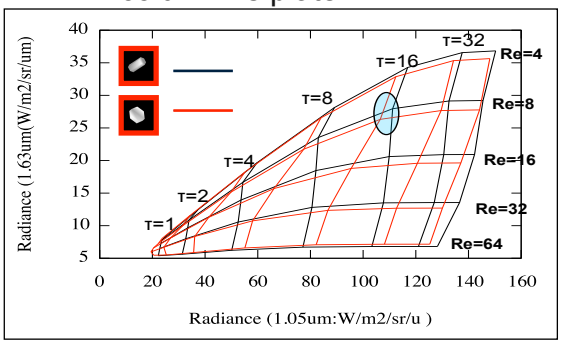
Radiative Transfer Program
(RSTAR*) **Nakajima et al**

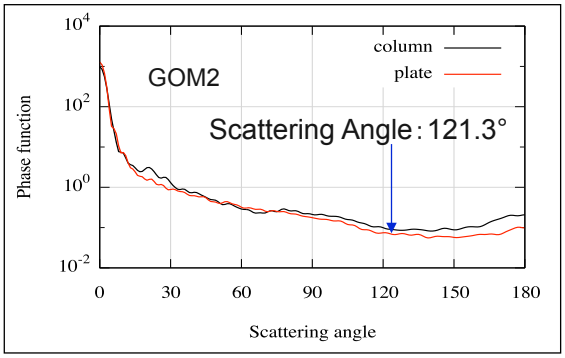
↓

OUTPUT
(Radiance)

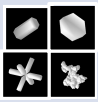
40° : TH0
30° : TH1
90 ° : FI

column vs plate





Roadmap for developing GCOM-C/SGLI ice crystal scattering database

Step \ Date	2013		2014			
	Jan.-Jun.	Jul.-Des.	Jan.-Mar.	Apr.-Jun.	Jul.-Sep.	Oct.-Dec.
1. Optimizing scattering database (DB)	→		Now			
2. Developing Scattering DB 	→	→				
3. Making kernel to input in RSTAR7 code		→				
4. Calculating LUT & improving CAPCOM			→			
5. Determining effect shapes & validating CAPCOM			→	→	→	→

Cloud masking using BI-SI method

Date:

- 2012.10.12 – 2013.10.12, 10:30 a.m.& 01:30 p.m.

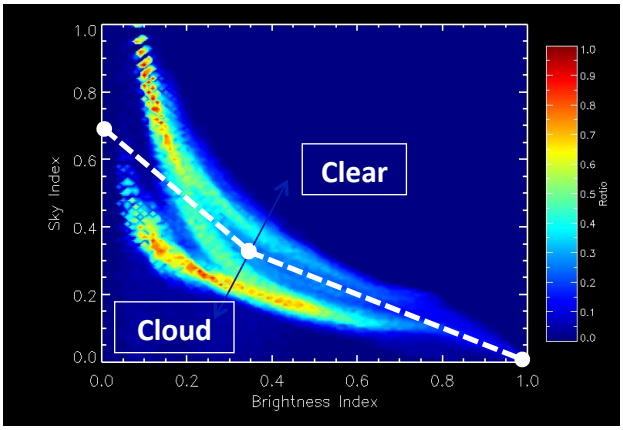
Threshold value:

- Sun: BI > 0.95
- Clear/Cloud: (BI, SI) = (0.0, 0.6), (0.35, 0.35) , (0.97, 0.0)

Issue:

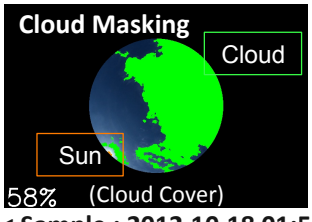
- Miss masking: Clear pixels near sun, Thin cirrus
- Dependency of optimal threshold value on sun zenith angle

Tokai University Space Information Center（TSIC）, Kumamoto



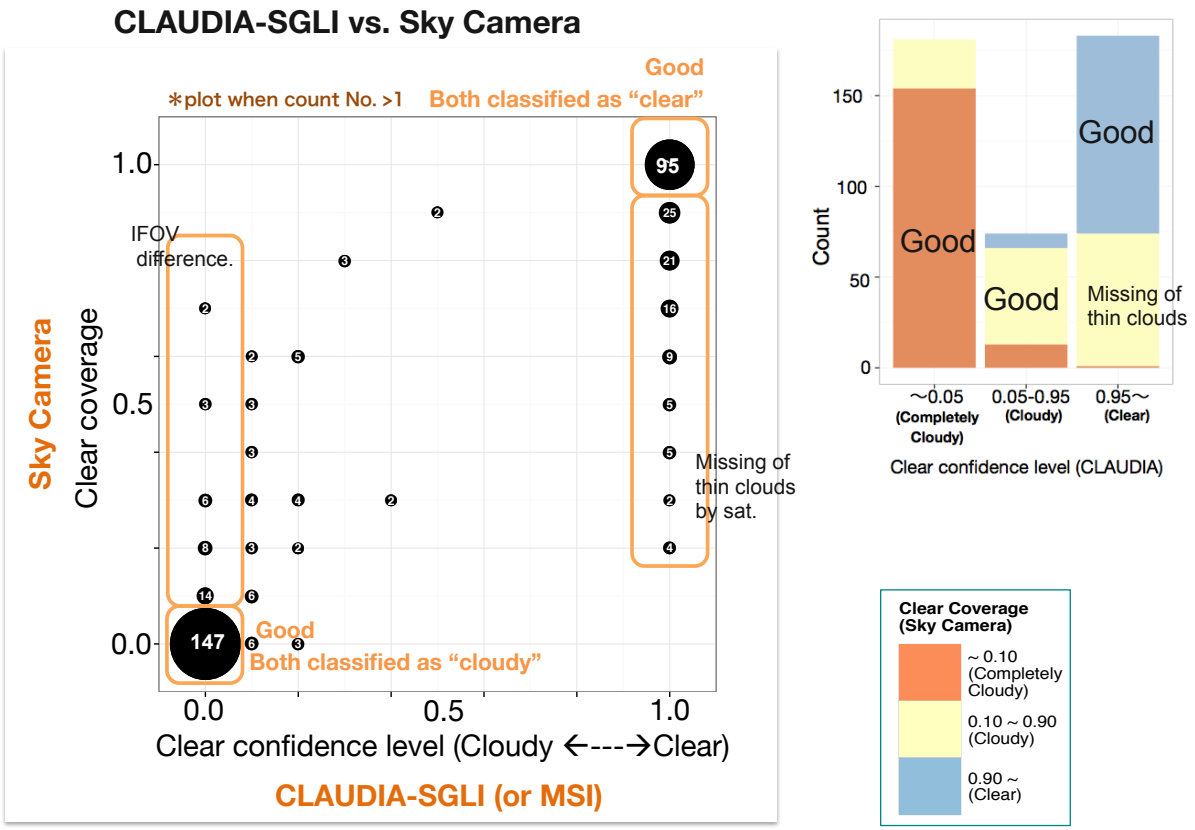
< BI-SI 2-D Histogram >

Inspired from Yamashita M. et al., RSSJ, 2008, 2010)



< Sample : 2012.10.18 01:50 p.m. >

Validation of cloud screening algorithm



Events and results, from 2009 to 2013

	2009	2010	2011	2012	2013	Total
Research activity	▲JMS ▲AMS ▲AGU ▲EGU ▲CEReS Symp	▲JMS	▲IGARSS ▲JMS	▲AGU ▲AMS ▲SPIE ▲WCRP ▲IRS	▲JpGU ▲MSJ ▲AGU ▲JSASS	
Cloud screening algorithm	← investigation, Developing Ver1 →				|→ improving, validating Ver2	
Cloud retrieval algorithm	← investigation, development Ver1 →				|→	
	← Scattering data base, calculation and development →				|→ improving, optimizing Ver2	
Conferences	7	14	21	29	19	Total, 90
Refereed papers	6	11	7	7	7	Total, 38

5 Invited presentations
- The 15th CEReS International Symposium on Remote Sensing, 2009
- SPIE Asia-Pacific Remote Sensing Symposium, 2010
- French-Japanese Workshop on the Scientific Utilization of Space-based Earth Observation Data, 2011
- American Meteorological Society (AMS), Annual Meeting, 2012
- American Geophysical Union (AGU) fall meeting, 2012

4 Awards
- Matsumae Shigeyoshi award (2011, Nakajima)
- Rem-Sen. Society of Japan award, best paper (2011, Nakajima)
- Met. Soc. of Japan, Horiuchi award (2011, Nakajima)
- Japan-China Sci. & Tech Exchange Association Award (2011, Letu)

Publications in 2013 (7 papers)

Letu. H., **T. M. Nagao.**, **T.Y. Nakajima.**, Validation of Multi-wavelength-derived Cloud Mask in terms of Cloud Contamination in Clear Sky Radiances Using All-sky Camera Observations, Applied Optics. (In preparation)

Nakajima, T., H. Takenaka, D. Goto, S. Misawa, J. Uchida, and **T.Y.Nakajima,** 2013: Measurements and Modeling of the Solar Radiation Budget. *Journal of the Japan Society for Simulation Technology*, 199-207.

Nagao. T. M., **T. Y. Nakajima.**, **H. Letu.**, **K. Suzuki., and H. Okamoto.**, Cloud microphysical properties as seen from spaceborne passive multi-spectral imagers: interpretation in term of vertical and horizontal inhomogeneity by using numerical cloud models, high spatial resolution measurements, and active instruments, Transactions of the Japan Society for Aeronautical and Space Sciences.（In print）

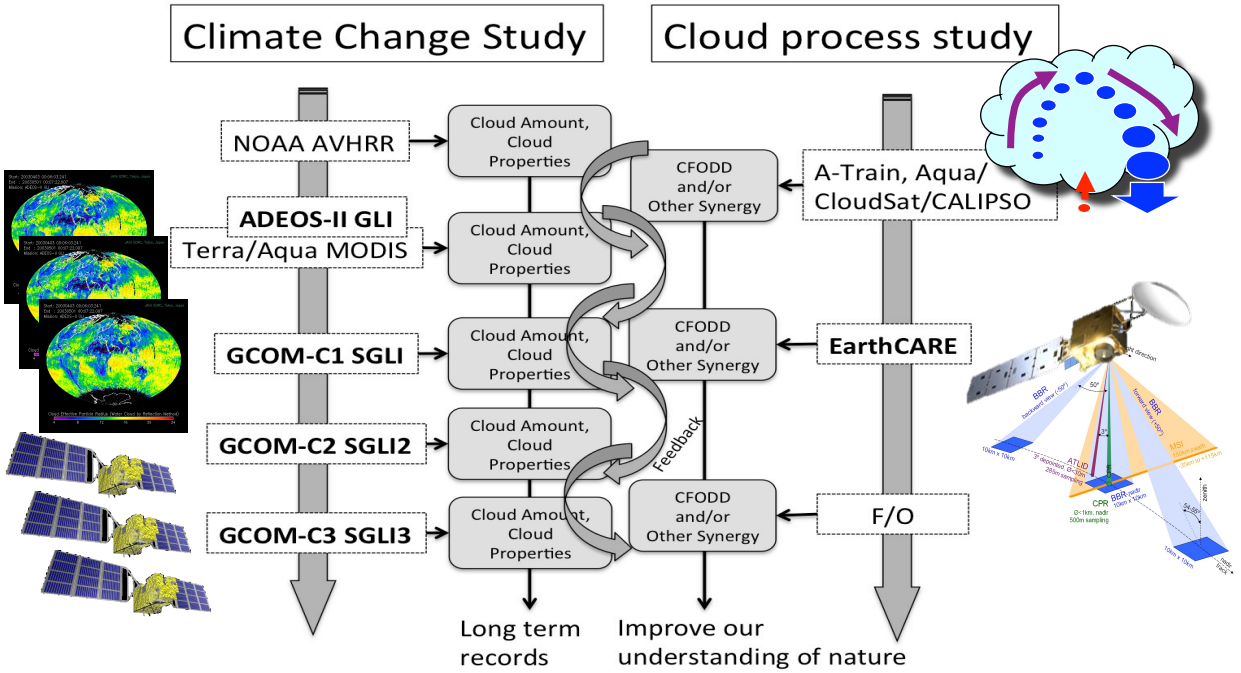
Nakajima. T. Y., **T. M. Nagao.**, **H. Letu.**, **K. SUZUKI., and H. OKAMOTO.**, Synergistic use of spaceborne active sensors and passive multispectral imagers for investigating cloud evolution processes, Transactions of the Japan Society for Aeronautical and Space Sciences.（In review）

Nagao, T. M., K. Suzuki, and T. Y. Nakajima, 2013: Interpretation of multiwavelength-retrieved droplet effective radii for warm water clouds in terms of in-cloud vertical inhomogeneity by using spectral bin microphysics cloud model. J. Atmos. Sci., 2376–2392.

Fukuda, S., T. Nakajima, H. Takenaka, A. Higurashi, N. Kikuchi, **T. Y. Nakajima**, and **H. Ishida**, 2013: New approaches to removing cloud shadows and evaluating the 380 nm surface reflectance for improved aerosol optical thickness retrievals from the GOSAT/TANSO-Cloud and Aerosol Imager, J. Geophys. Res. 12/2013; DOI:10.1002/2013JD020090.

Jules R. Dim, **T. Y. Nakajima**, Tamio Takamura, Performance of the GCOM-C/SGLI satellite prelaunch phase cloud properties' algorithm, J. Appl. Remote Sens. 7(1), 073693 (Sep 25, 2013).

Importance of Climate Change Study and Cloud Process Study



Summary of Takashi Nakajima's group

- Algorithm development
  - CLAUDIA (Ishida) … on schedule: *Adjustment for the SGLI.*
  - CAPCOM (Nakajima) … on schedule: *Adjustment for the SGLI.*
  - Non-spherical Database (Letu, Ishimoto) … Hexagon, Plate, Bullet Rosette, Voronoi (4 shapes) completed. *Make LUT for the retrieval, on going* (Letu, Ishimoto, Riedi)
  - Influence of SGLI radiance uncertainties on retrieval of cloud microphysical properties(Letu).
- Science
  - Synergistic use of Passive and Active, & Bin model (Nagao, Suzuki, Nakajima, Okamoto, Sato, Seiki..)
- Results in 2013
  - 7 papers published, 19 Conferences.
- Leading GCAST (GCOM-C Atmospheric Science Team)

Than you for your attention!