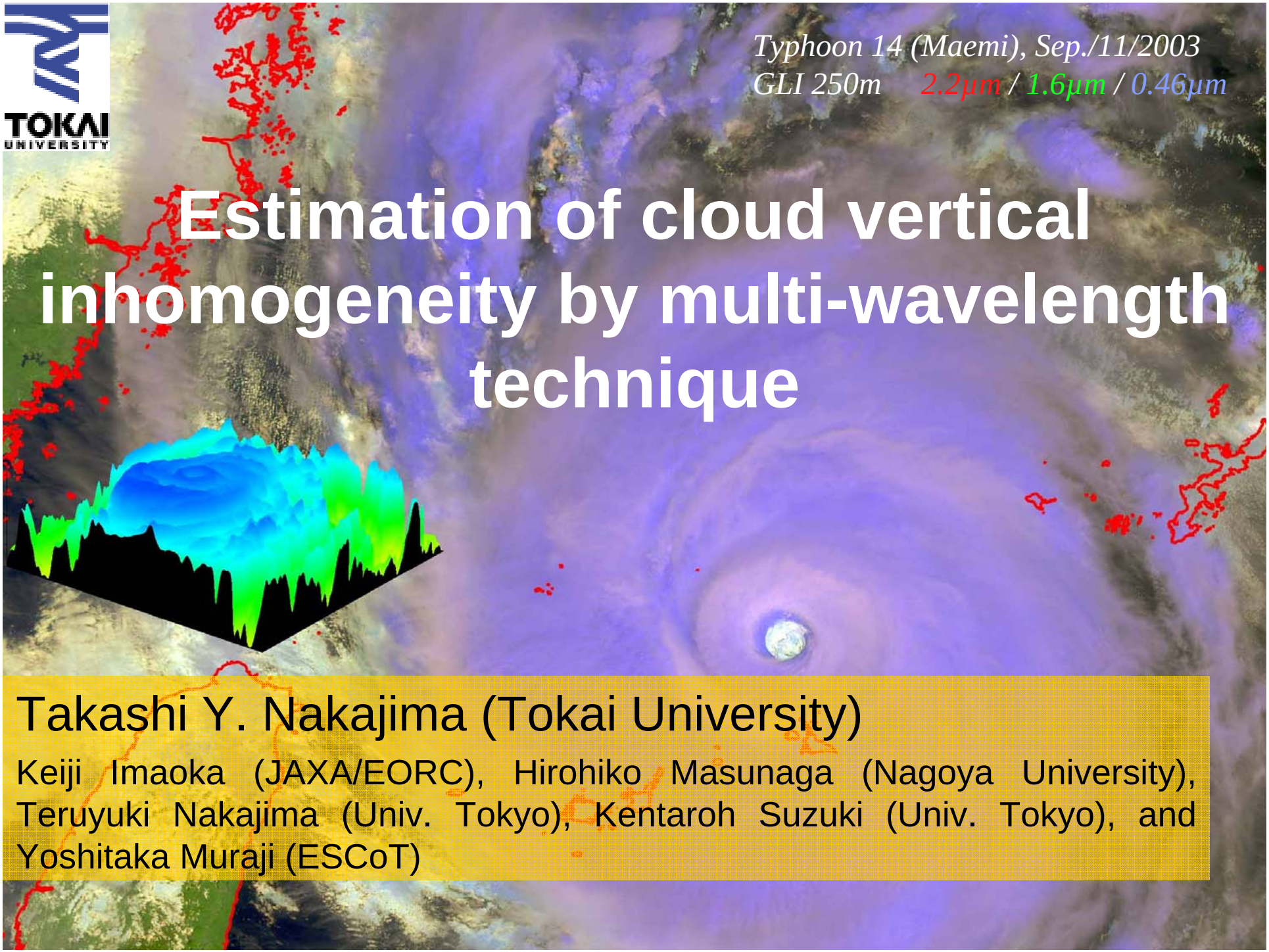
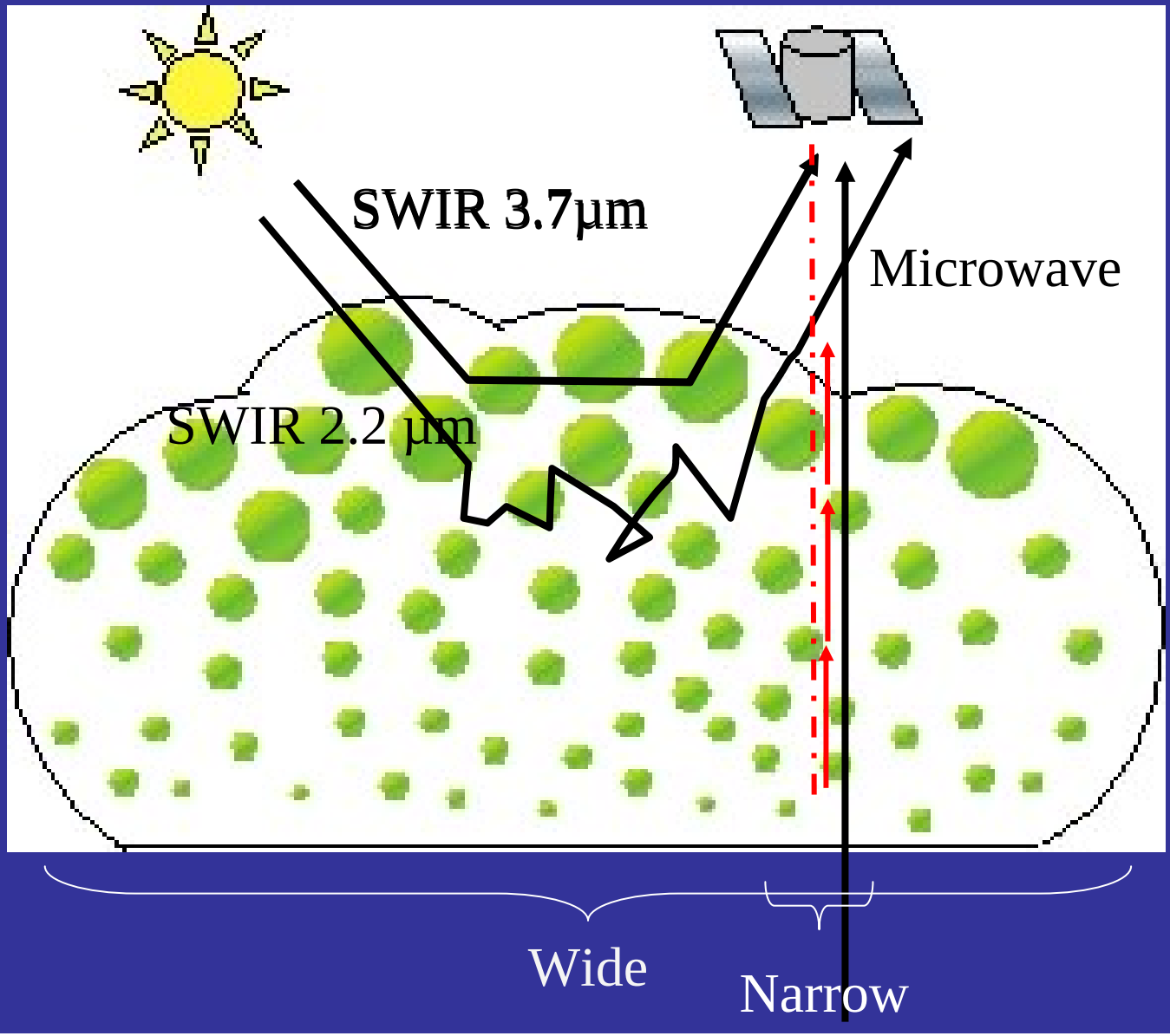


Estimation of cloud vertical inhomogeneity by multi-wavelength technique

Takashi Y. Nakajima (Tokai University)

Keiji Imaoka (JAXA/EORC), Hirohiko Masunaga (Nagoya University), Teruyuki Nakajima (Univ. Tokyo), Kentaroh Suzuki (Univ. Tokyo), and Yoshitaka Muraji (ESCoT)


SWIR 3.7µm
Microwave
SWIR 2.2 µm
Wide
Narrow

Contents

- Motivations
- Cloud observations by Passive Sensors
  - GLI global scale analysis of clouds. (ATSK3R)
  - GLI-AMSR combined analyses
  - GLI SWIR Sounding Technique
- Application for the cloud droplet growing process studies.
  - Observation VS Model, optical thickness (τ_c) and effective radius (r_e),
- Summary

Motivation

Revealing…

cloud-aerosol interactions

Observing….

Horizontal and Vertical distributions of **cloud properties**

Better understanding the role of aerosols and clouds for climate change.

Modeling…

Simulates **them** by Cloud Model

Validating…

Cloud model *v.s.* Remote sensing

Cloud observations by Passive Sensors

- Horizontal Inhomogeneity for **wide area**
  - Column quantity of cloud optical and microphysical properties using passive imagers.

    (AVHRR, ADEOS-II/GLI, Terra/MODIS, etc..)

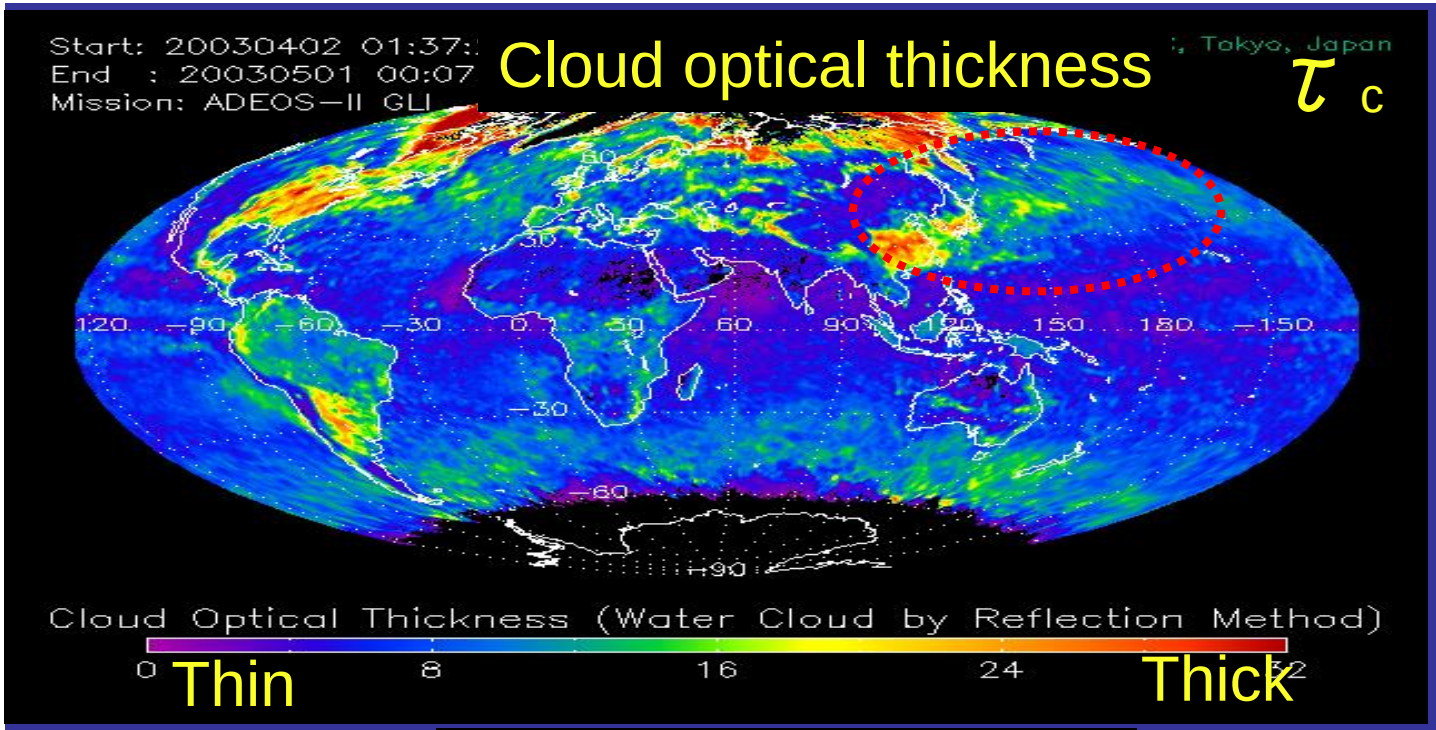
    Han et al. 1994, N and N 1995, Kawamoto et al. 2000 and others.

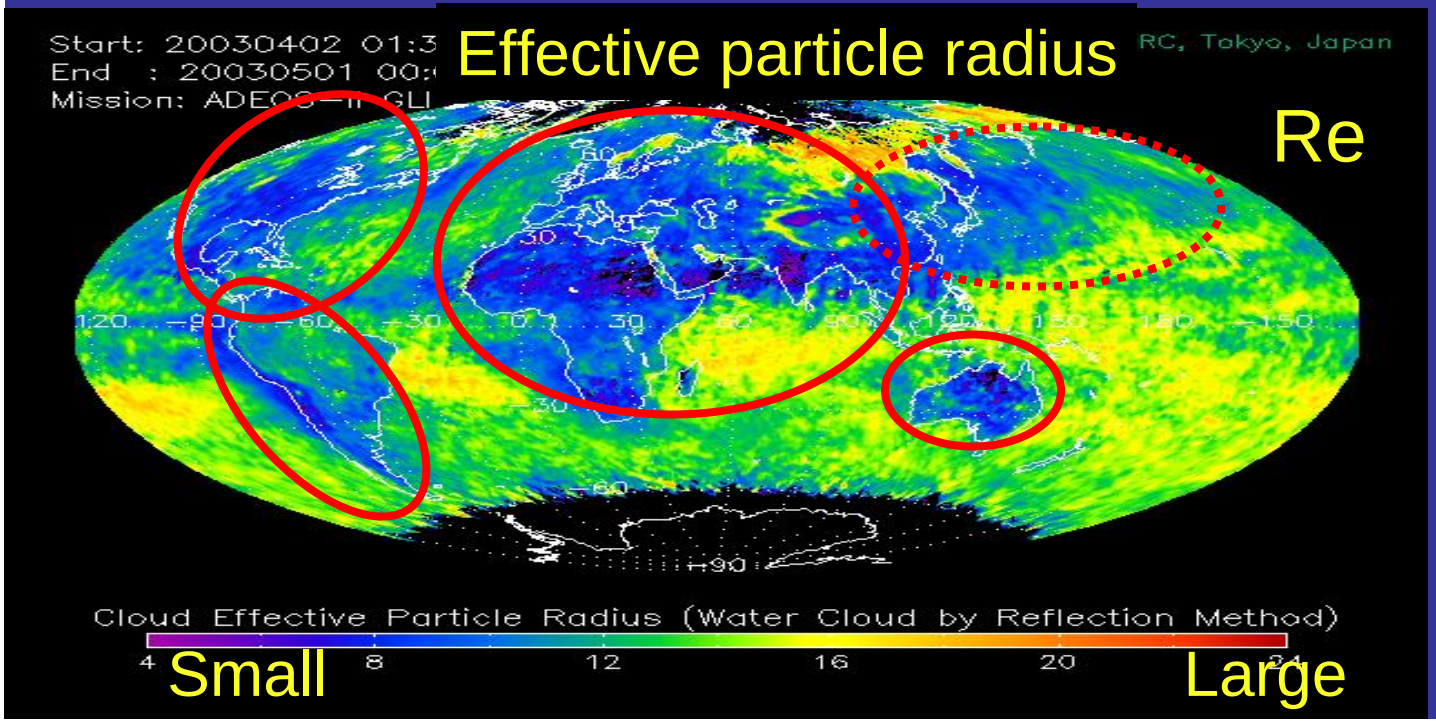
- Vertical Inhomogeneity for **wide area**
  - Combined use of visible-infrared imager and microwave scanners (VIRS-TMI on TRMM, GLI-AMSR on ADEOS-II)

    Masunaga et al. (2002), Today's talk.

  - SWIR Sounding Technique (MODIS, GLI, etc..)

    Suggested by Nakajima and King (1990), Today's talk.



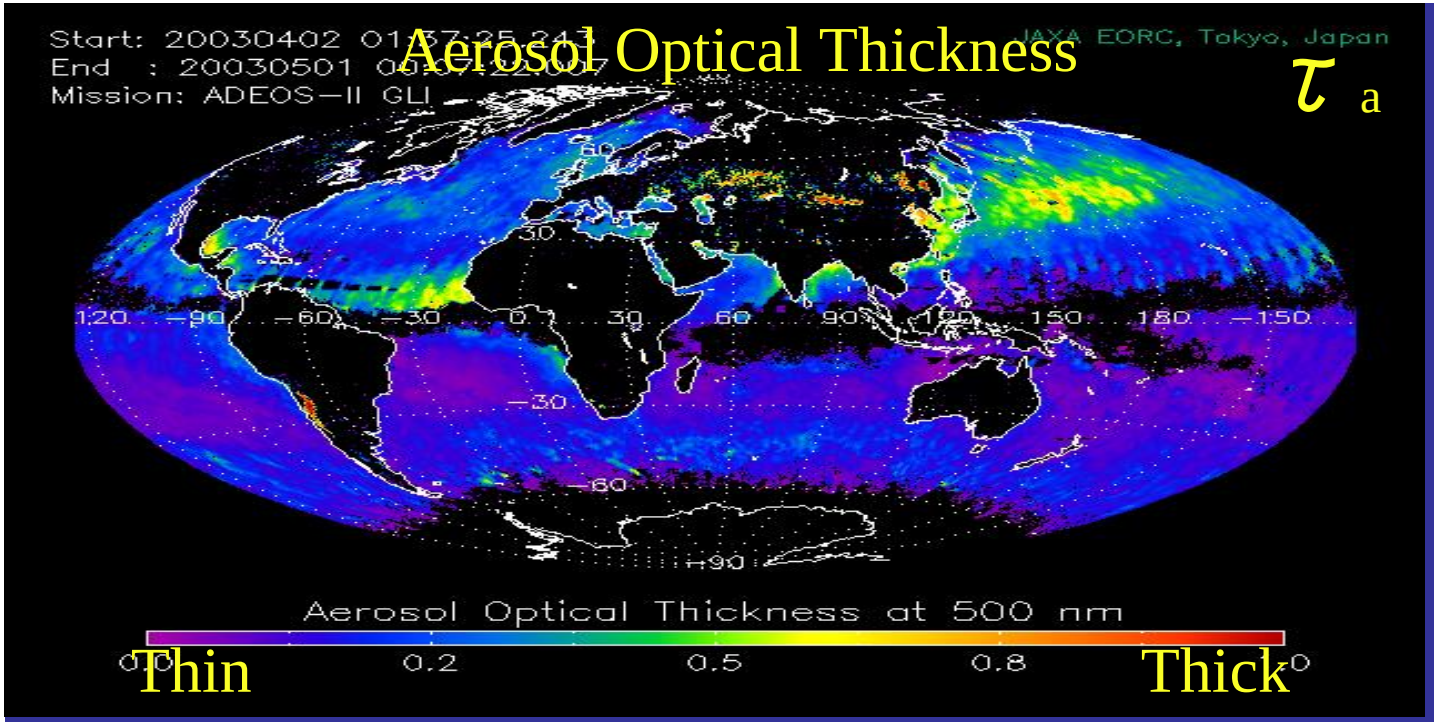


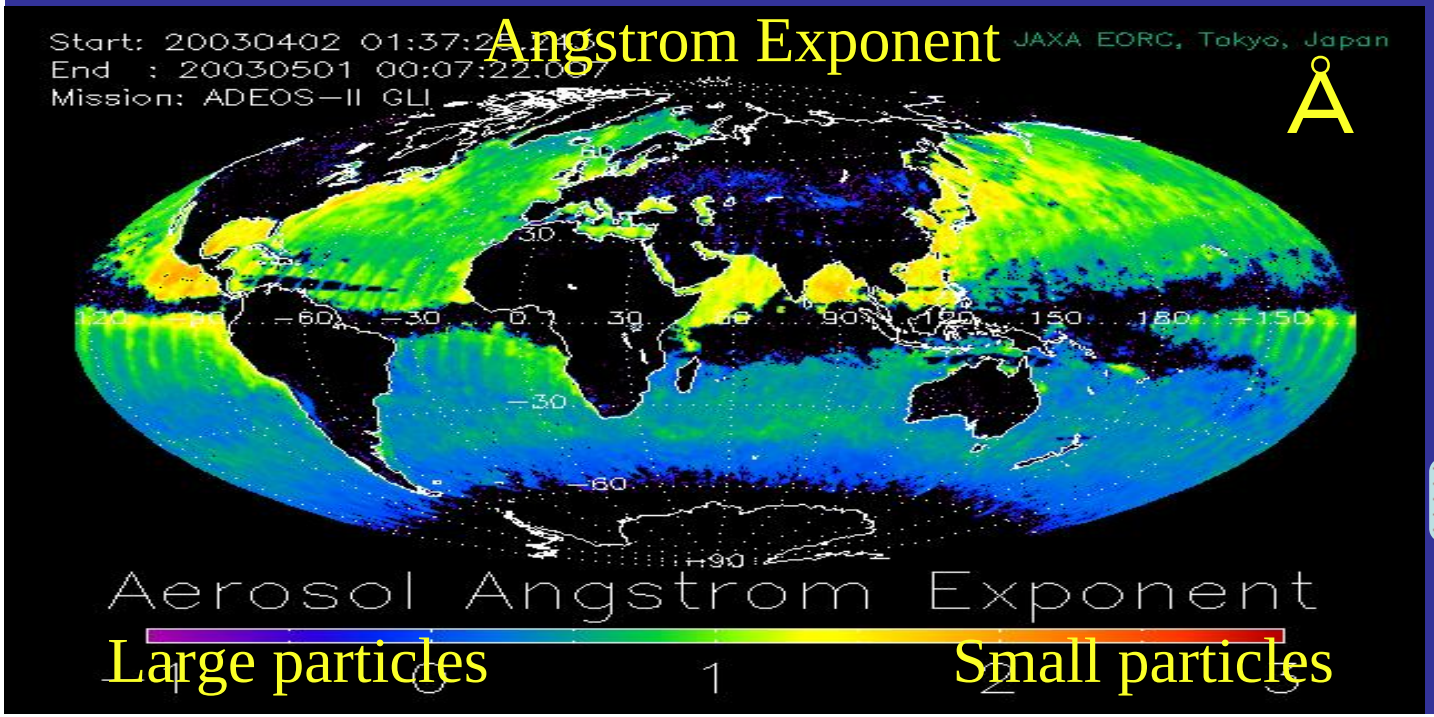
Apr. 2003

Warm Water Cloud

Version2

Nakajima and Nakajima (2005, SPIE)



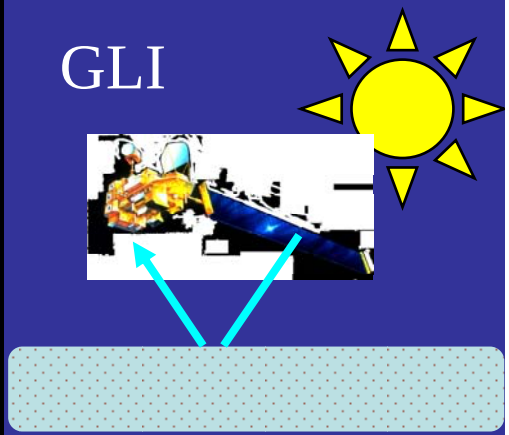


Apr. 2003

Aerosol

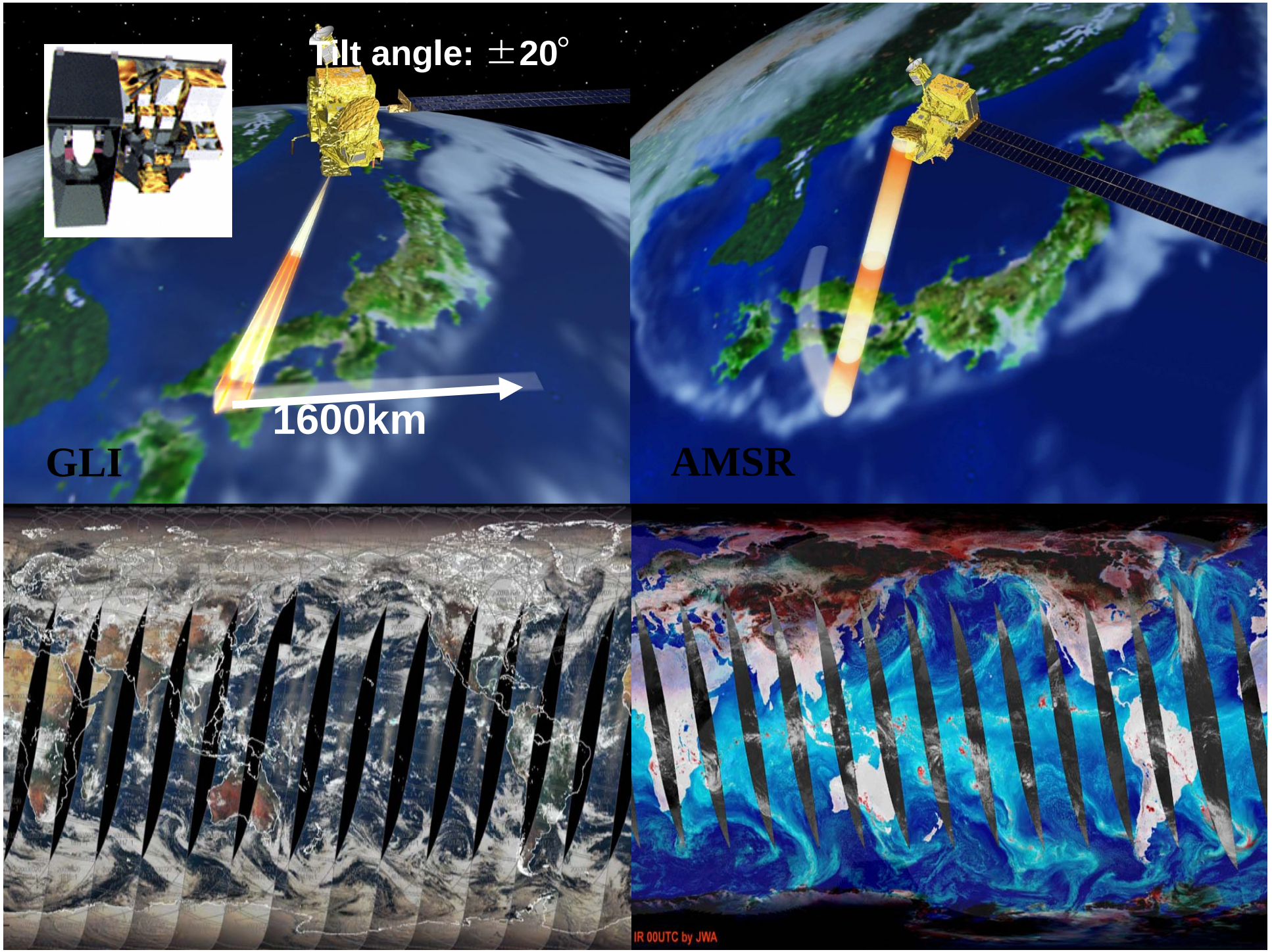
Version2

GLI

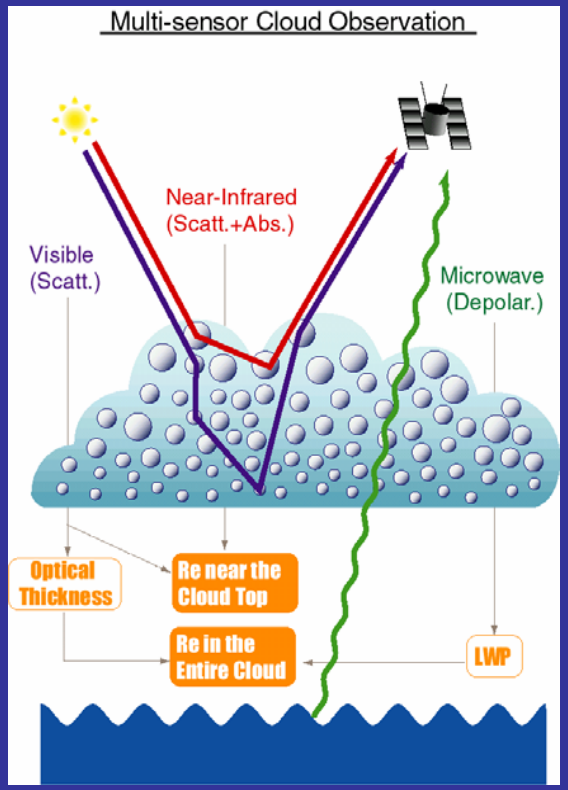


2ch method by Higurashi

Estimations of the *VERTICAL* inhomogeneity of wide- area cloud properties using **passive** sensors.

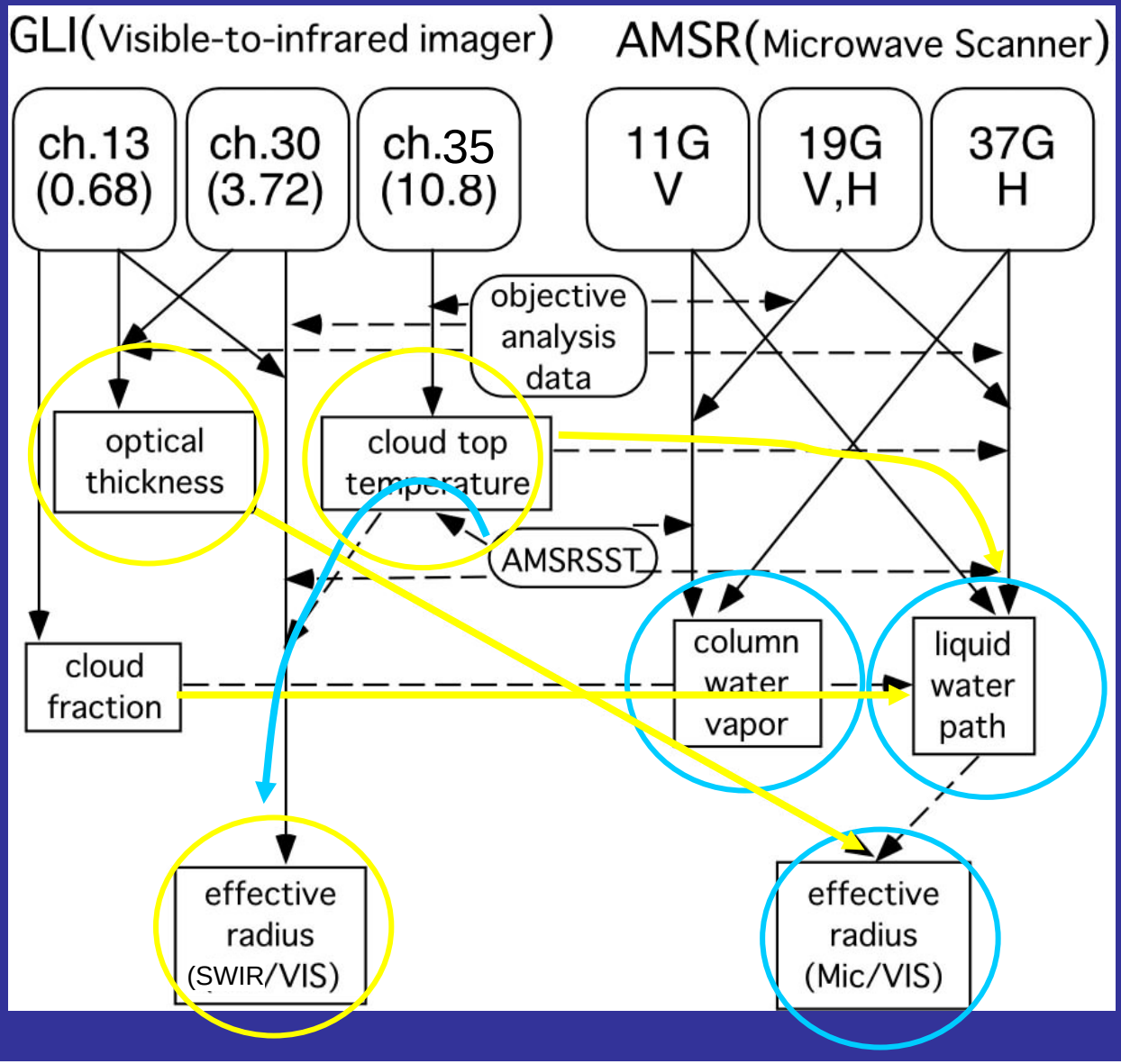

Tilt angle: ±20°
1600km
GLI
AMSR
IR 00UTC by JWA

Flow Chart



Ratio

$$\frac{Re(Mic/VIS)}{Re(SWIR/VIS)}$$



$$\frac{Re(Mic/VIS)}{Re(SWIR/VIS)} < 1$$

Non-precipitating

Re(Mic&Vis) < Re(SWIR&Vis) < 15micron

Drizzling

Re(Mic&Vis) ≦ Re(SWIR&Vis) > 15micron

$$\frac{Re(Mic/VIS)}{Re(SWIR/VIS)} > 1$$

Precipitating

Re(Mic&Vis) > Re(SWIR&Vis)

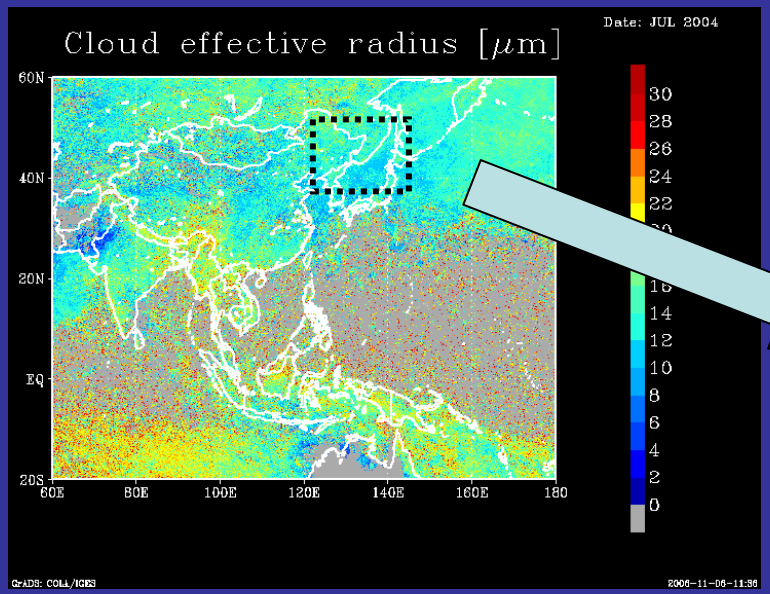
New aspects in GLI/AMSR combination

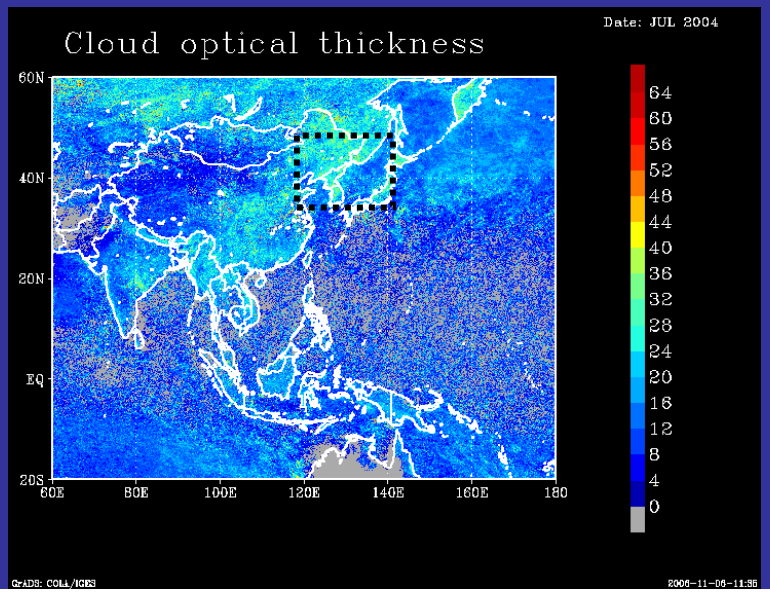
Algorithm and concept from Masunaga et al. (JGR 2002)

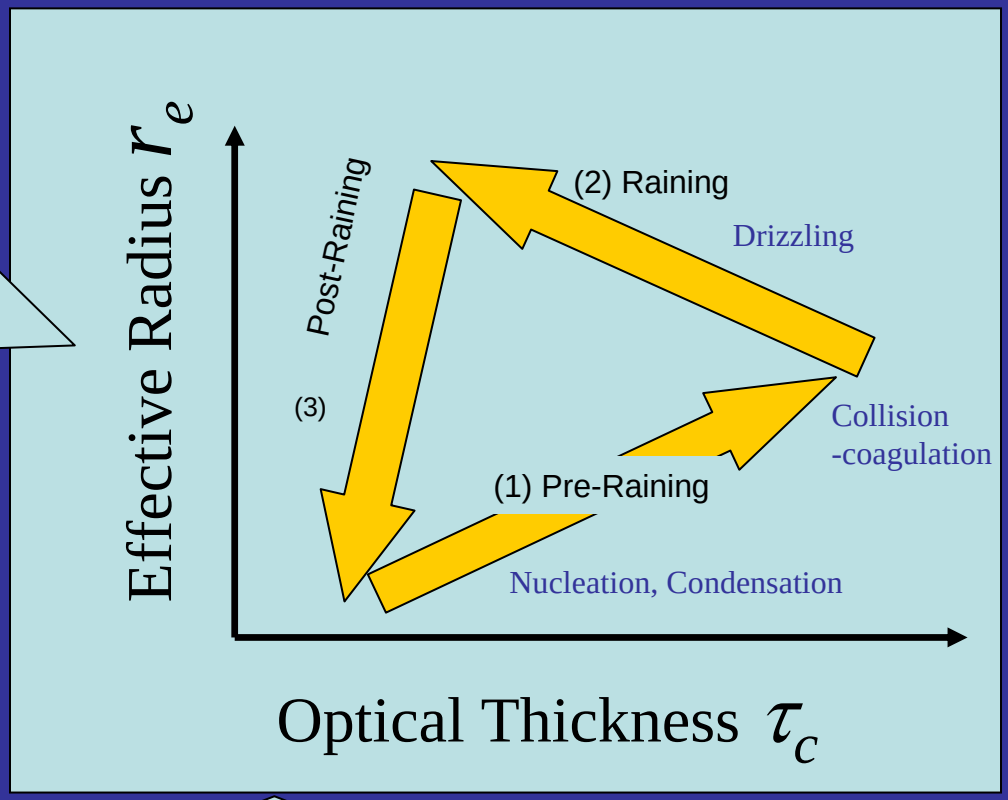
	Passed study (Masunaga et al.)	Present study
Satellite (Sensor)	**TRMM** (VIRS+TMI)	**ADEOS2** (GLI+AMSR)
Latitude Region	+- 35 degs.	> **+- 60 degs**
Sensor Swath	720km	**1,600km**
Nadir IFOV	2km	1km
Orbit (Sun synchronous ?)	NO Diurnal Cycle	YES (10:30 LT) AM

Applications of satellite measured data for process studies of CLOUD DROPLET GROWING

I will show r_e-τ_c plots in the following viewgraphs







r_e-τ_c diagram
is a correlation between r_e
& τ_c in a selected area

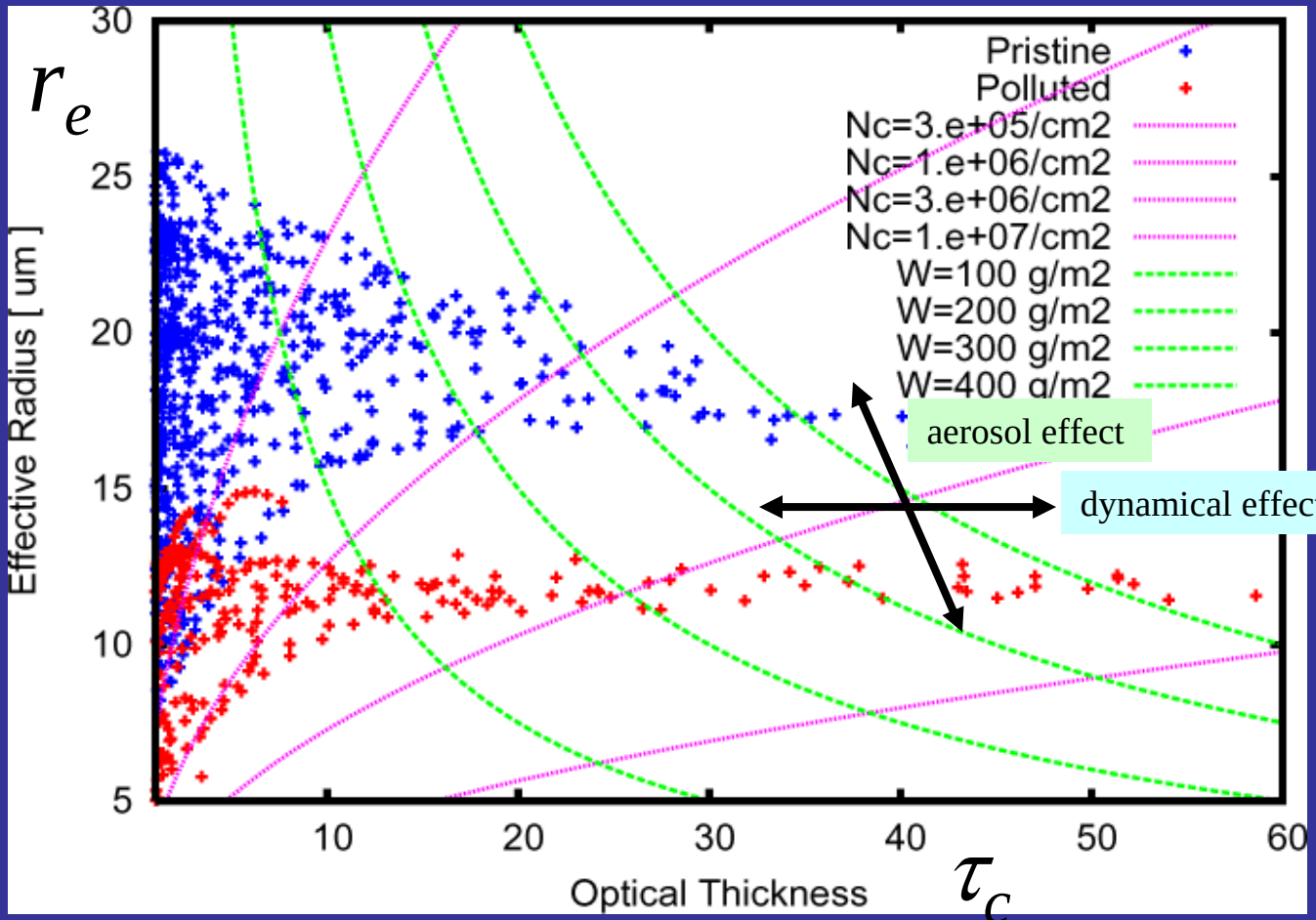
r_e-τ_c diagram (Simulated by Bin Model)

$$\tau_c = Q_{ext}\pi r_e^{\,2} N_c \quad (Q_{ext} \approx 2)$$

$$W = \frac{2}{3}\rho_w r_e \tau_c$$

N_c=3 × 10^5/cm^2

N_c=1 × 10^6/cm^2



N_c=3 × 10^6/cm^2

W=400g/m^2

W=300g/m^2

W=200g/m^2

Suzuki,K. et al. (2006)

Summary

- Horizontal and Vertical inhomogeneity of cloud properties.
  - (H) Consistent with previous results such as AVHRR and MODIS.
  - (H) Strong aerosol-cloud interaction appeared in Eastern Asia.
  - (V) Combined analyses of GLI and AMSR are tentatively presented.
    Advantage : Wider latitude area than passed study by TRMM
  - (V) SWIR sounding technique using 1.6, 2.2, 3.7 is presented.

- r_e-τ_c scatter plots comparisons (Observation VS Model).
  - Typical scatter plots that present, pristine, polluted and mixture, were found.

Future works

- Long term data analyses (AVHRR,GLI,MODIS…)
  - To monitor the variability of cloud (and aerosol) coverage and properties more than decades-long period.
  - To give more sample data for model development studies.
- More detailed investigations (by pixel by pixel analyses)
  - To make the most practical understanding of cloud growing process.

  → Higher spatial and temporal resolution of cloud dataset.
  (ATSEG analysis -> L2A_OA analysis)
- Comparison with, aerosol products, cloud radar data.

Contribute better forecasting of global climate change.

Thank you very much!

Conferences & Publications in 2006

- Kikuchi et al. (JGR, 2006)…….. cloud observation
- Nakajima TY et al. (SPIE@GOA, 2006)…… cloud and model
- Nakajima T et al. (SPIE@GOA, 2006)…….. observation vs model
- Suzuki et al. (SOLA, 2006)…….. cloud bin-method
- Nakajima TY. (“Tenki” by JMA, 2006)……. GSS simulator
- Nakajima TY. (APMS@Kanazawa, 2006)……. vertical structure
- Suzuki et al. (AMS@Wisconsin, 2006)…….. cloud bin-method
- Nakajima T. (AMS@Wisconsin, 2006)…….. observation vs model
- Nakajima TY. (AMS@Wisconsin, 2006)……horizontal distribution
- Nakajima TY. (“Parity” by Maruzen, 2007)……showing GLI image