Current Status of eCARE Science Studies in Japan

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What did we learn about climate effects of aerosols and clouds?

- Cloud forcing for doubling CO2 has a large model dependence: Warming (TAR) vs cooling (AR4) (some related with aerosol CCN modeling)
- Direct, 1st indirect, and other indirect aerosol forcings: Fraction differences
- Problems in aerosol GCM modeling
  - Model AOT < Satellite AOT (AEROCOM, Schulz et al., 2006)
  - Long-range transportation is still weak (AEROCOM)
  - Wet boundary and upper layers; dry in the middle (Okamoto et al., JGR2007)
- Large surface cooling by aerosols
- Large precipitation change (~1mm/day) due to aerosol direct surface cooling
  - Tele-connection between continents and tropics
  - Large future uncertainties due to uncertainty in the future emission scenario

Vertical stratification of aerosol and cloud layers; relation between the two layers
Positive RF over clouds cancel negative RF in clear sky (Clear sky: –0.70 Wm\(^{-2}\) vs all sky: –0.04 Wm\(^{-2}\)).

- But aerosol RF over clouds largely depend on models.
- MIROC simulates more absorbing aerosols above clouds than other GCMs.
CALIPSO lidar detection of clouds and aerosols
(E. Oikawa, 2009; Courtesy NASA-CALIPSO team)

Clear sky

Overcast

Global -3.64 W/m², Ocean -4.08 W/m²

全球平均：-2.56 W/m²、海上：-3.77 W/m²
Some updates in SPRITARS sulfate process

D. Goto (2009)

Using Schulz et al. (2006) and Textor et al. (2007)
Next-generation precipitation, cloud and aerosol measurement satellites: Imager, active, and spectrometer
Japanese contribution

Figure 1. Structure of research activities in the Japanese Science Plan
Remote sensing products

Horizontal aerosol properties
- MSI: AOTocean, ANGocean, AOTland

Horizontal cloud properties

Horizontal rain properties
- MSI: FlagC, COT, CDR16, CDR21, CTT, CTH
- MSI+CPR+ATLID: FlagC, COT

Vertical properties

Multi aerosols?
- ATLID: Caero, EXT(ws, dust, ssalt, bc)
- ATLID+MSI: EXT(ws, dust, ssalt, bc), ER(ws, dust, ssalt, bc)

IPA +diffusion correc.
- 3D simple
- 3D iteration

Vertical properties

Vertical properties

CPR: Zinteg, DV, Zcorrect, DVcorrect, Zmulti;
A{Type, ER(liquid, ice), WC(liquid, ice, rain, snow) (Ze/Ze-Vd)}
CPR+ATLID: A; B{RR, RRsnow, Vair}
CPR+ATLID+MSI: A; B; LWP, IWP
ATLID: Type, C{EXT, BACK, LDR,DPOL}cloud

Scene generator

J-EarthCARE simulator

ECSIM

Make sure at least one path has to be secured

10 W/m²

Flux profile/Heating rate profile

ESA+Japan!

Need high resolution!

MSI+Active?
Comparison of sensitivity factors of low-level cloud parameters ($CDR$ and $LWP$) vs aerosol number $Na$ (Nakajima and Schulz, 2009)

$COT$: Cloud optical thickness  
$CDR$: Effective cloud droplet radius  
$LWP$: Cloud liquid water path

$$CDR = \frac{3LWP}{2\rho_w COT}, \quad b(y) = \frac{dy}{d\log N_a}$$

$b(\log LWP) = b(\log COT) + b(\log CDR)$

### Sensitivity of cloud parameters to aerosol number vary depending on studies:
- Good agreement over ocean between satellite and GCMs.
- Very warm clouds have negative $LWP$ sensitivity (Matsui06).
- Difficult to simulate the positive $CDR$ sensitivity (anti-Twomey effect) over land.

<table>
<thead>
<tr>
<th>Study</th>
<th>Global ocean</th>
<th>GCM</th>
<th>Glabal land</th>
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<tbody>
<tr>
<td>Sekiguchi03, AVHRR</td>
<td>Tc &gt; 273K</td>
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<tr>
<td>Quaas04, POLDER</td>
<td>Tc &gt; 273K</td>
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<td>Matsui06, MODIS</td>
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<tr>
<td>Matsui06, GOCART</td>
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### Equations

$$y = CDR$$

$$y = LWP$$
Comparison of upper cloud ice and snow simulation by NICAM (b) vs GOES split window result (a) (Inoue et al., 2009).

MJO Simulation by NICAM 3.5km model (B) vs (A) MTSAT-1R satellite OLR (31 Dec 2006) (Miura et al., 2007).

High clouds

Relation of CDR vs cloud optical thickness (COT) by MIROC-GCM, NICAM, and ADEOS-II/GLI satellite (Suzuki and Stephens, 2008)

Low clouds

NICAM 7km Amazon basin
main_SDSU.F
Main driver of SDSU
MPI process
Flow control

module_simulator.F
CRM input options (NICAM-SPRINTERS, JMA-NHL, MIROC)
Microphysics options (1- and 2-moment bulk, spectra bin)

VisIR Optics Module
RSTAR
[Nakajima and Tanaka 1988]
[Sekiguchi and Nakajima 2008]

1D MSI simulator
RSTAR
[Nakajima and Tanaka 1986 & 1988]

1D ATLID Simulator
Single Scattering
Empirical MS correction

3D MSI ATLID simulators
MCARaTS
[H. Iwabuchi]

1D BBR Simulator
MSTRN
[Nakajima et al.200]
[Sekiguchi and Nakajima 2008]

Broadband LUT of Optical properties

Doppler CPR Simulator
H. Okamoto

3D Scene Generator
[????]

J-EarthCARE Simulator
(T. Matsui, GSFC)
**Model:** 2D Goddard Cumulus Ensemble (GCE) model with Spectra-bin Microphysics

**Simulation:** Continental MCS case using PRESTORM sounding

**Observations:** Ground-based C-band radar & TRMM PR (14GHz) and TMI Tb (85GHz)

**Goal:** Evaluate and improve simulation using satellite simulators.

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**Radiance-Based Model Evaluation**

6 months later...

Reference
From Li et al. (2009)
Some estimates for CDR sensitivity for NICAM model (Suzuki et al., 2008)

\[ \frac{\partial \log_{10} r_e}{\partial \log_{10} AI} \approx -0.176 \quad \Rightarrow \quad \frac{\partial \ln r_e}{\partial \ln N_a} \approx -0.153 \]

Low clouds

\[ N_a \propto (AI)^{0.87} \]

(Nakajima et al., 2001)

~ -0.138 (AVHRR, Nakajima et al., 2001)

~ -0.097 (POLDER, Breon et al., 2002)

Rosenfeld (Science 2000)

High resolution modeling is giving new aerosol-cloud interaction simulation results

- Cloud amounts for all types OK
- Microphysics for stratus OK
- Positive correlation of CDR-AI for convective clouds, but not enough by NICAM
- Discrepancy in absolute values

Cloud temperature at CDR= 14 micron (T14, Rosenfeld, 2000) vs CDR and Aerosol index (AI) relation by AVHRR and NICAM (Suzuki et al., 2008).
Ancillary and model products

- Met data (forecast)
  - T(z), RH(z)
  - Surface wind
- Sat data (-1day)
  - O3
- MIROC-forecast (T106)

+7 days processing
Semi-real time?

Constraints

Horizontal aerosol properties
Horizontal cloud properties
Horizontal rain properties

Vertical properties

MIROC-aerosol assimilated (T106)

Constraints

NICAM (7km); IOF run (30 days?); Regional model runs

Scene generator
J-EarthCARE simulator

ECSIM

Flux profile/Heating rate profile
Japanese contribution to eCARE mission

- Japanese community of remote sensing
  - Passive remote sensing (ADEOS/OCTS, ADEOS-II/GLI, GOSAT; TRMM, GPM etc)
  - Active remote sensing (NIES lidar system, MIRAI lidar and 94GHz radar system etc)
  - SKYNET surface network for GEOSS
  - Capacity building needed

- Japanese community of modeling
  - CCSR-NIES-FRGC/MIROC GCM
  - FRGC/CCSR/NICAM
  - ES and Peta-flops machine (2012)

- JAXA needs an open system based on a RA
  - Core science activities have to be defined for internal review
  - Have a responsibility to build L2 and L3 products
  - Task share with JADE, ESA/CASPER is subject for discussion; Optimal task share should be made