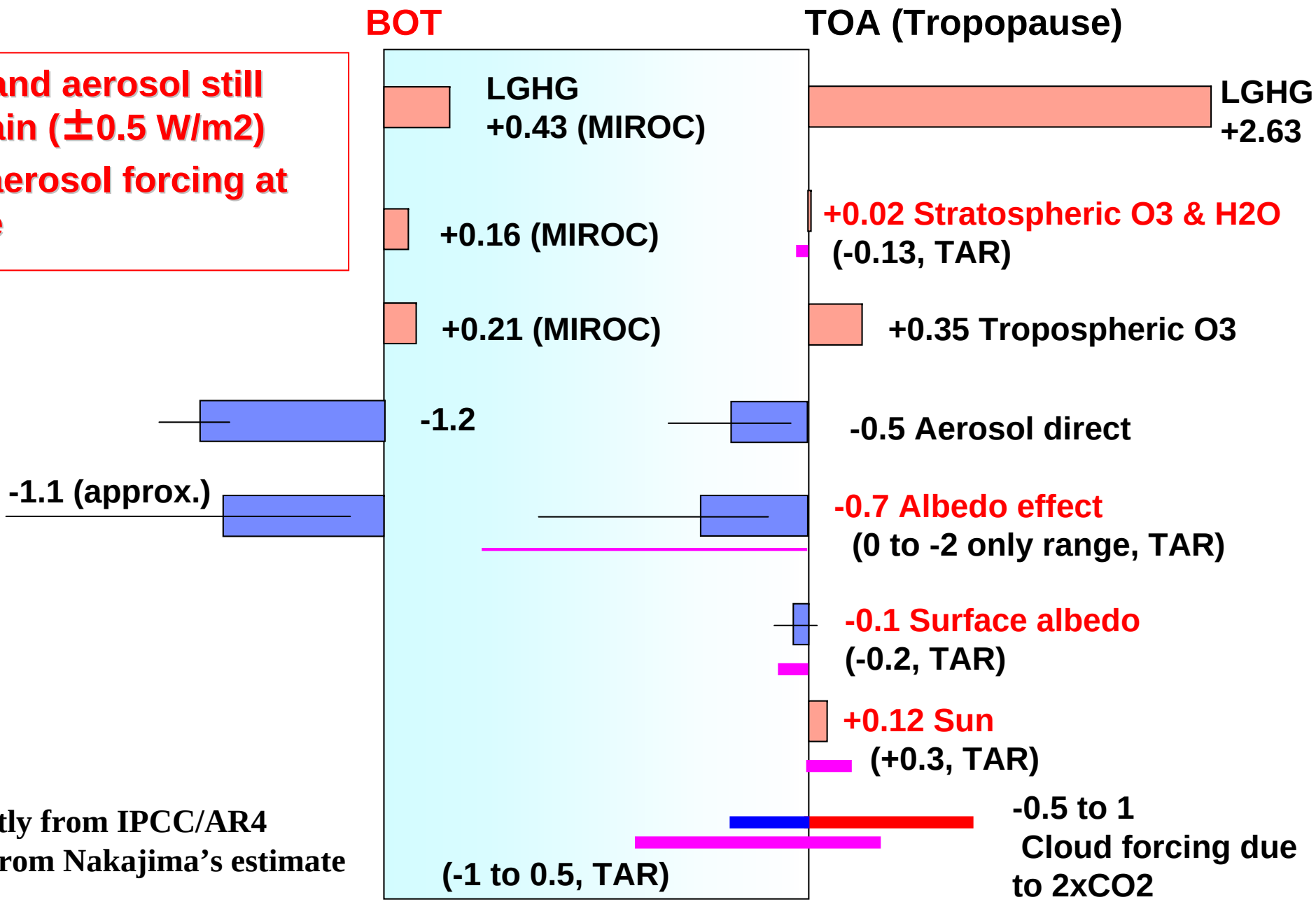
2008.4.15 GEOSS-Ap/Tokyo

Earth Observation of Clouds and Aerosols for Climate Modeling

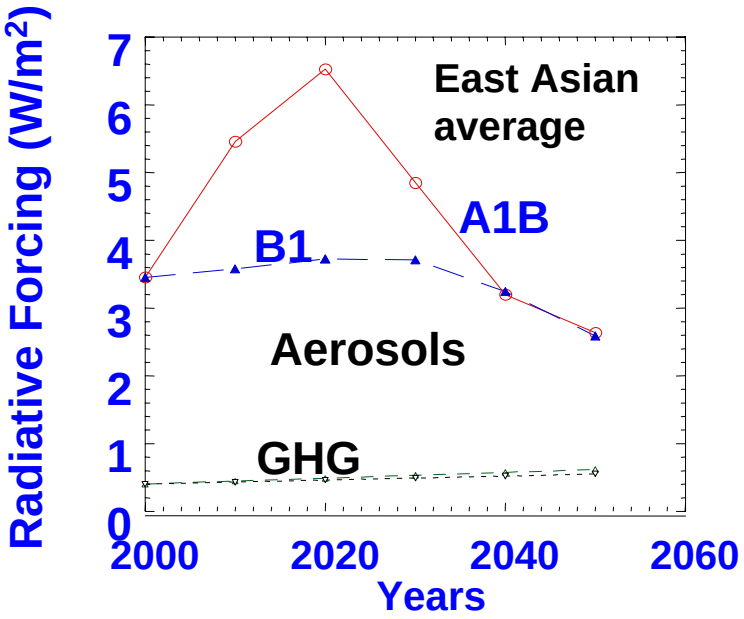
Teruyuki Nakajima
teruyuki@ccsr.u-tokyo.ac.jp
Center for Climate System Research
The University of Tokyo

Radiative forcings since 1750

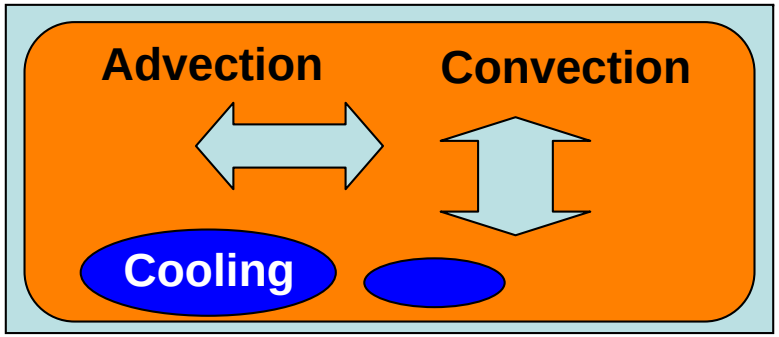
- Cloud and aerosol still uncertain (±0.5 W/m2)
- Large aerosol forcing at surface



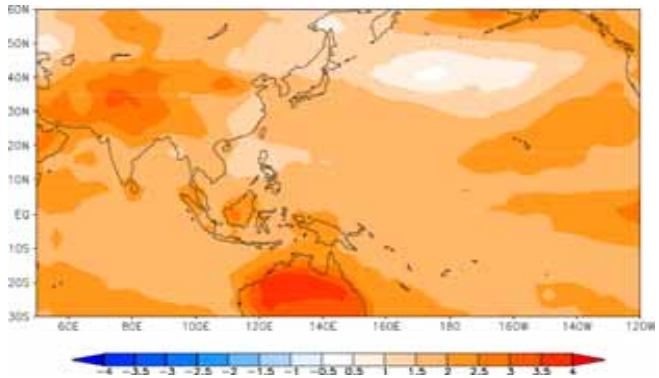
Values mostly from IPCC/AR4
with some from Nakajima's estimate



- **Aerosol change important to monitor**



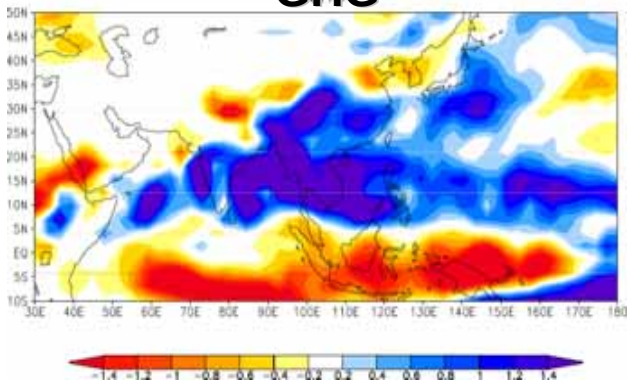
Surface air temperature change due to GHG



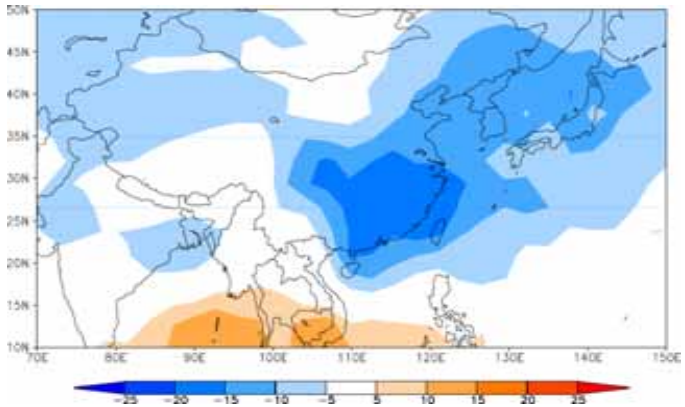
Warming

Precipitation change [mm/day](JJAS)

GHG

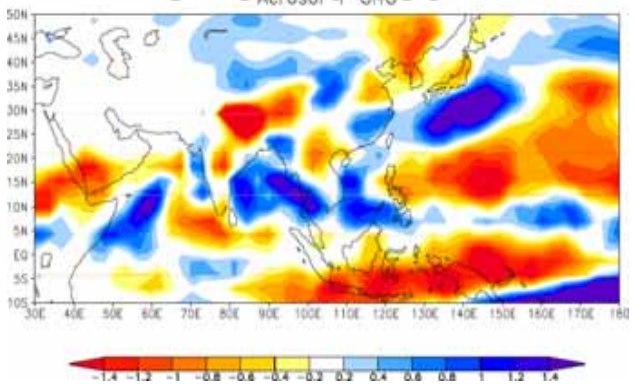


Surface forcing by man-made aerosol (W/m2)

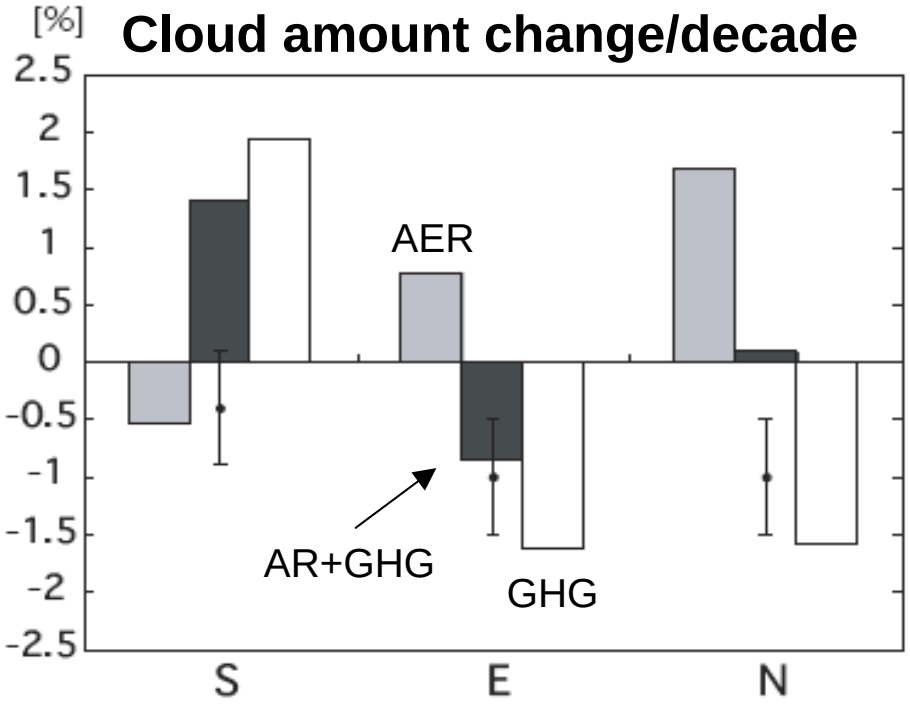


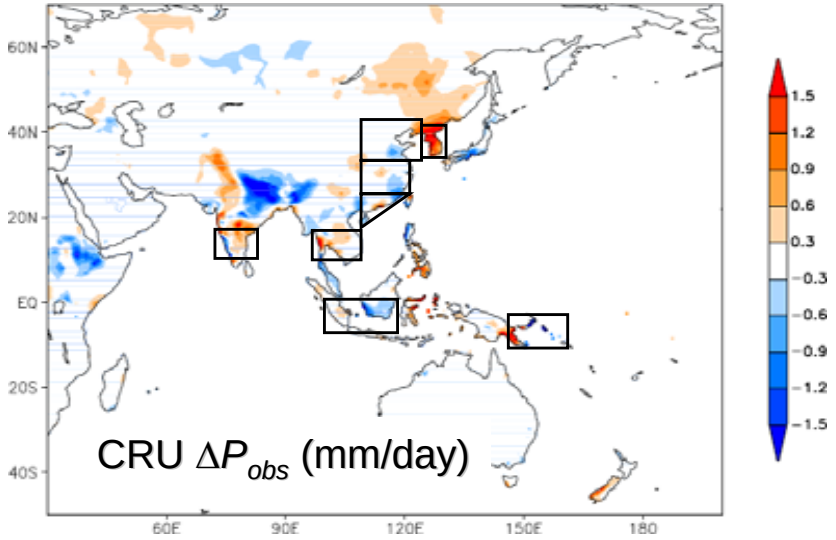
Cooling

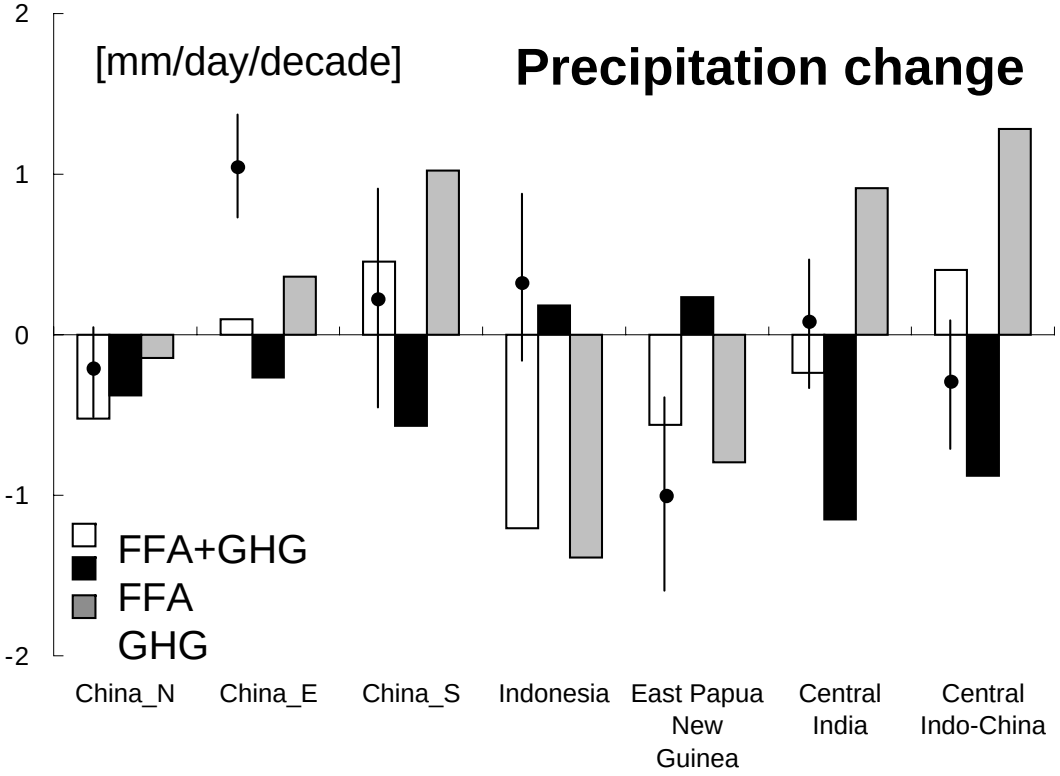
GHG+Aerosol



Model vs observation: Cloud and precip



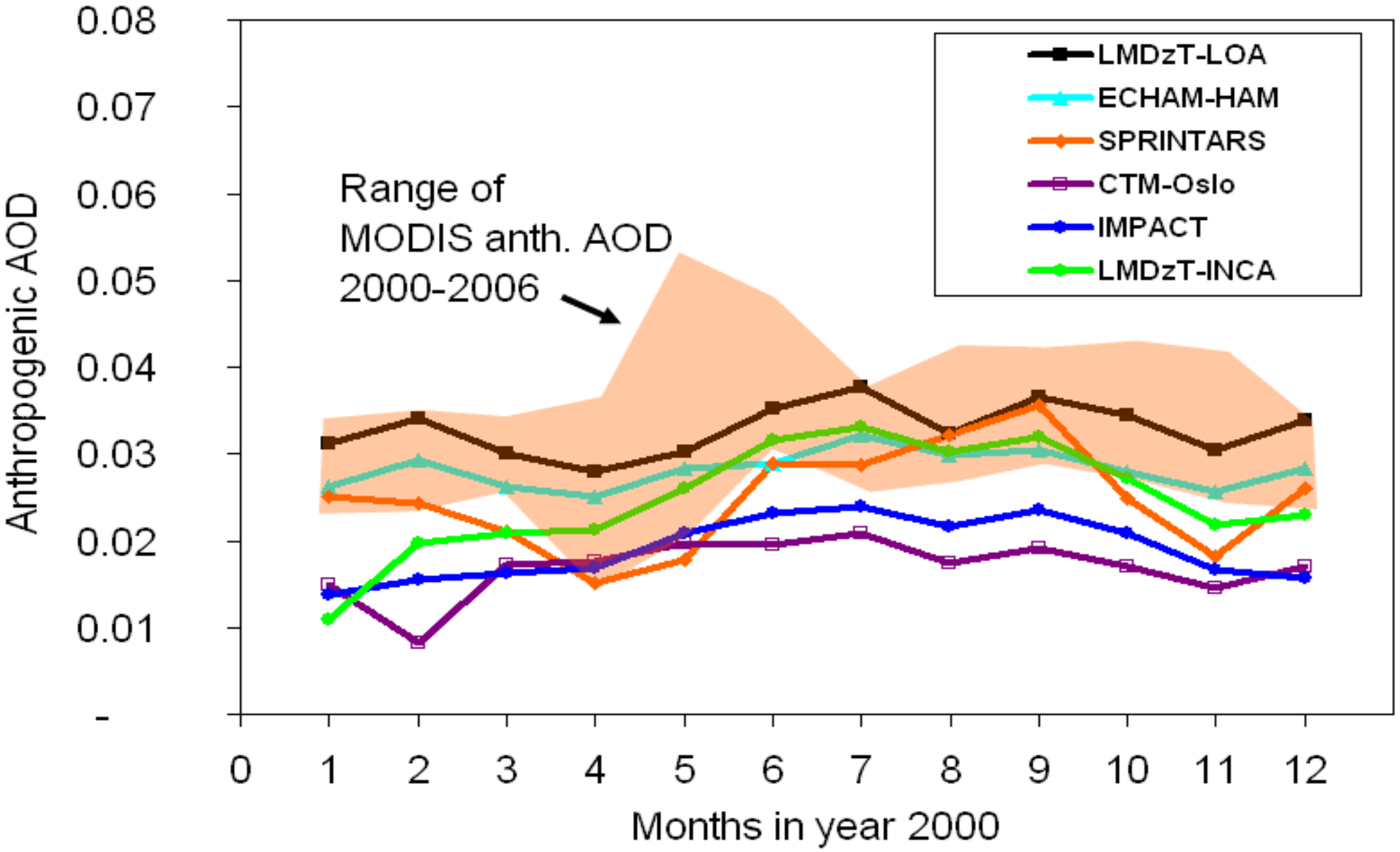




- Some similarity
- Need both GHG and aerosols
- Low and high cloud difference

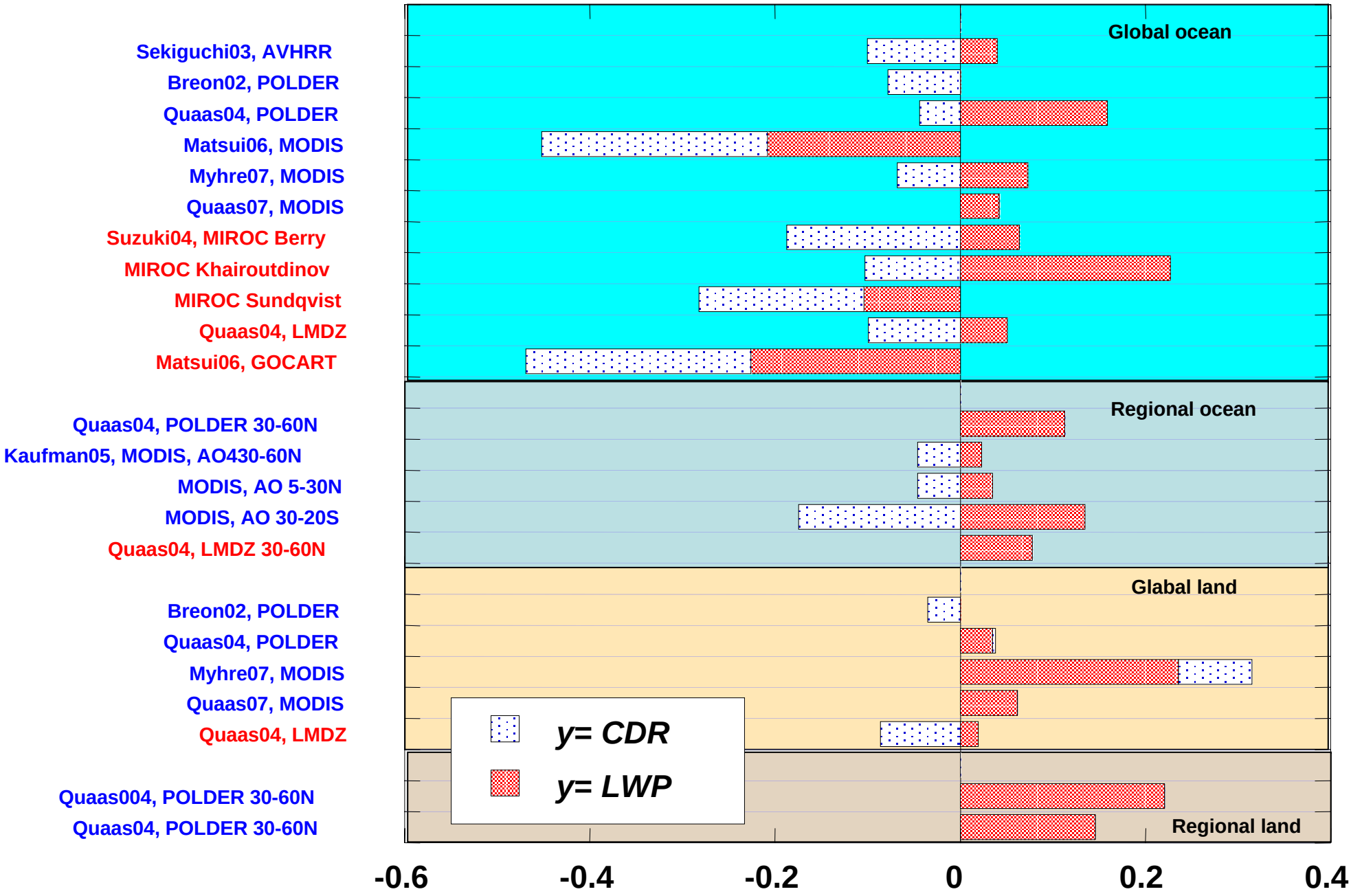
M. Mukai et al. (2008, xxxx)

Global monitoring and simulation of aerosols



- **Model underestimation of AOT**

Nakajima and Schulz (FIAS 2008)



Nakajima et al. (FIAS 2008)

$$b = \mathrm{d}\,log\,(y)/\,\mathrm{d}\,log(Na)$$

Observation systems for climate change study

1. GEO 10-year implementation plan; GEO.information.kit
2. 2008 (H20) Japanese plan for Earth Observation
3. NASA Earth Science Decadal Survey Implementation
4. ESA home page: http://earth.esa.int/missions/

GHGs and CO2	Radiation budget, Clouds, and Aerosols	Meteorology/ocean dynamics	Earth's surface
Surface networks (FLUXNET, AsianFLUX, GAW)	Surface networks (BSRN, SKYNET, AERONET, Lidar etc)	Surface networks (Meteorological networks, wind profiler, GLOSS-sea level height etc)	Monitoring of vegetation, forest and ecological systems
Moving platforms: RV, commercial ship and aircraft	Satellite-borne imager (GCOM)	Vertical ocean profiling (RV, Triton buoy, ARGO)	Satellite-borne high resolution imager (ALOS, LDCM, Sentinel-2)
Satellite-borne spectrometer (GOSAT, OCO)	Vertical sounding by active satellite sensing (CLOUDSAT, CALIPSO, EarthCARE)	Satellite-borne imager (GEOs and polar orbitors, GCOM, NPP, NPOESS)	Surface measurements by satellite-borne SAR (Sentinel-1)
	Satellite-borne radiative budget radiometer (EarthCARE, NPP, NPOESS, Glory, CLARREO)	Satellite-borne precip radar (TRMM, GPM)	Vegetaion and cryosphere surface topology by lidar/radar altimeter (ICEsat, ICEsat-II, Cruosat-2, DESDynI)
		3D wind by satellite-borne Doppler lidar (ADM)	Soil moisture and SSS by L-band radiometer (SMOS, Aquarius, SMAP)
		Sea surface altimeter and scattrometer (OSTM, Sentinel-3)	Gravity field (GOCE) and geomagnetic field (Swarm) measurements

Some programs

- Chemical and optical measurements
  - Single particle measurements
  - CCN measurements
- Skyradiometer & flux radiometer
  - NASA/AERONET
  - WMO/GAW, WCRP/BSRN
  - MEXT/Earth Observation/SKYNET: Takamura
- Lidar
  - MPL, Earlinet, GALION
  - NIES (Sugimoto)
- 35&95GHz cloud radar
  - DOE/ARM
  - NICT-Chiba U Spidar, Falcon
- NIES/Hedo observatory
- Program
  - UNEP/ABC (Atmospheric Brown Clouds) Phase-II
  - MOE Kosa Network
- JAXA: GPM, EarthCARE, GCOM-W, C


Mandalgovi
Dalanzadgad
Ussuriysk
Ochi-Ishi
Sapporo
Kanazawa
Toyama
Tateyama
Tsukuba
Tokyo
Chiba
Xianghe
Beijing
Anmyon
Aksu
Dunhuang
Yinchuan/
Shapatou
Taishang
Gwangju
Qira
Fukue
Osaka
Shirahama
Gosan
Nepal
Nagqu
Hefei
Huanshang
Amami
Chichijima
Taipei
Hedo
Wan-Li
Minami
-Torishima
Kampur
Miyako
Chao-Jou
Hateruma
Lu-Lin
Kao-Hsiung
Hok Tsui
Om Koi
Bac Giang
Pune
Sri-Samrong
Mukdahan
Phimai
Bangkok
Hanimaadhoo
ABC
SKYNET
AERONET
ADEC, CEOP
ABC-EAREX

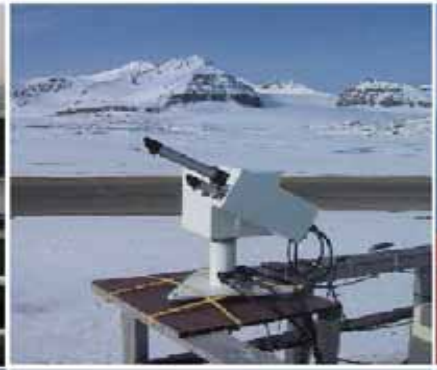












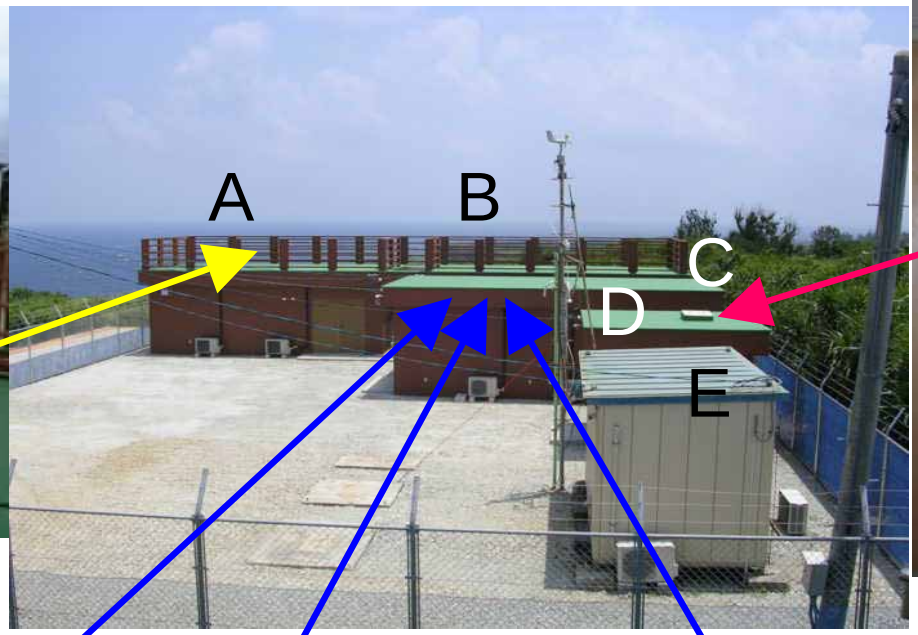




SKYNET
Sky radiometers
Self-calibration system

Akinawa/Hedo Observatory (NIES, Universities, ...)

Radiometers (bldg-A)



Lidar

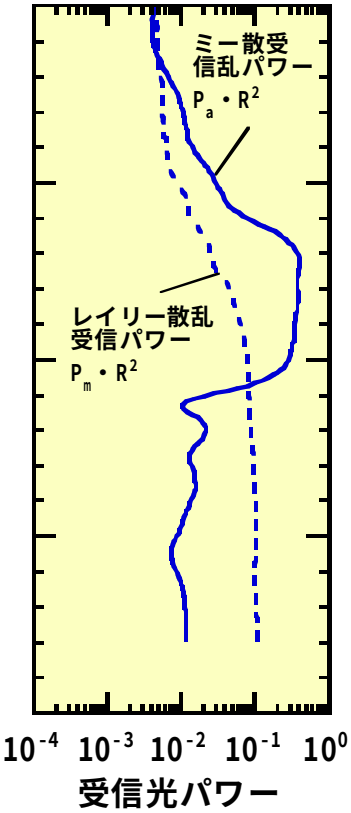
Aerosol Mass Spectrometer (bldg-B)

TEOM&EC/OC meters

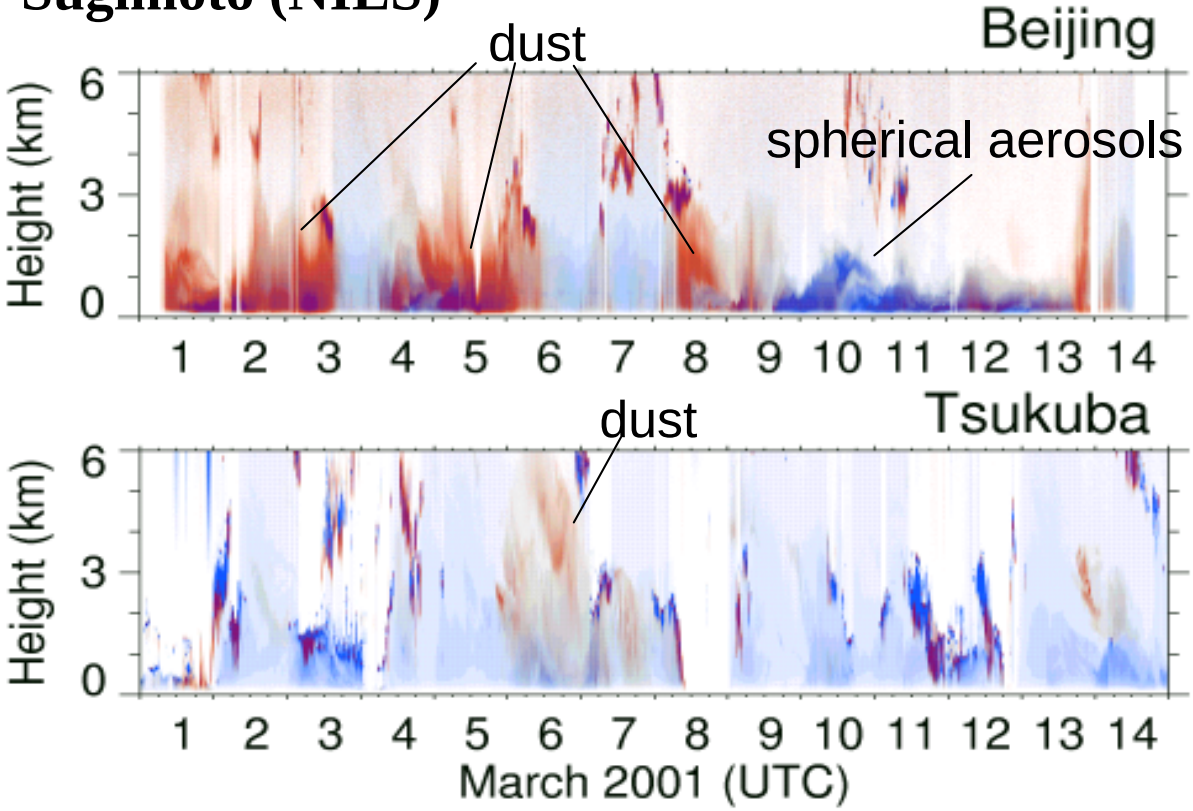
NO_3-meter

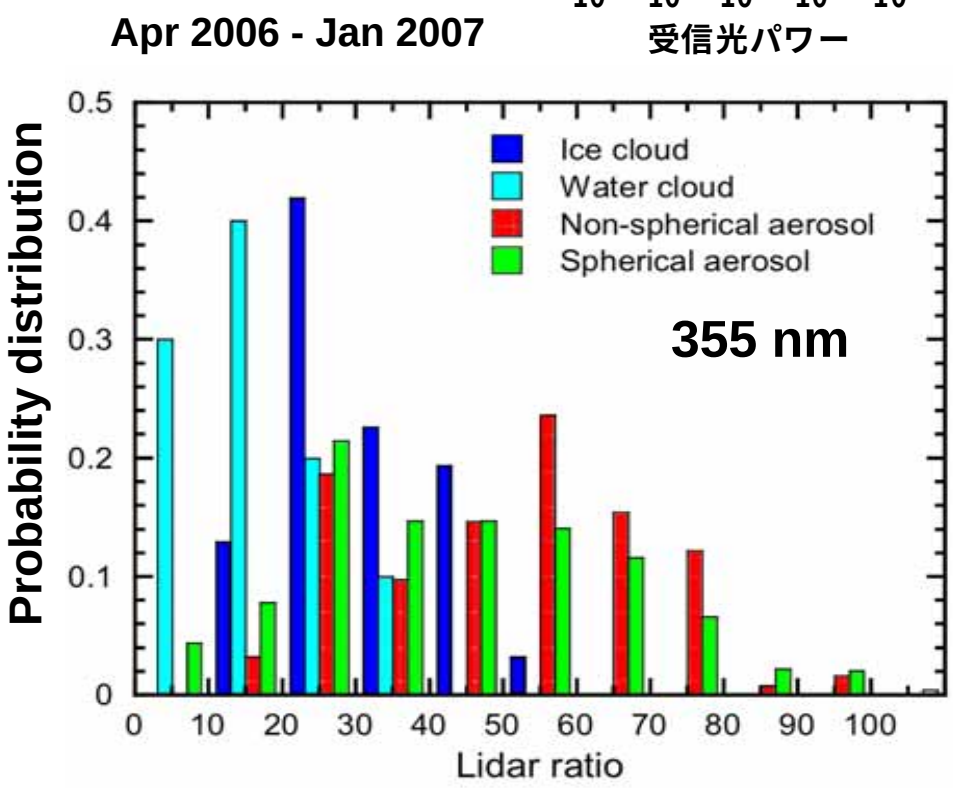
Aerosol climatology by lidar systems

- Lidar ratio statistics by HSRL (532 nm & 355nm)
- Aerosol classification by dual frequency polarizaion
- Large-scale distribution of aerosol and cloud statistics by SKYNET and R/V Mirai

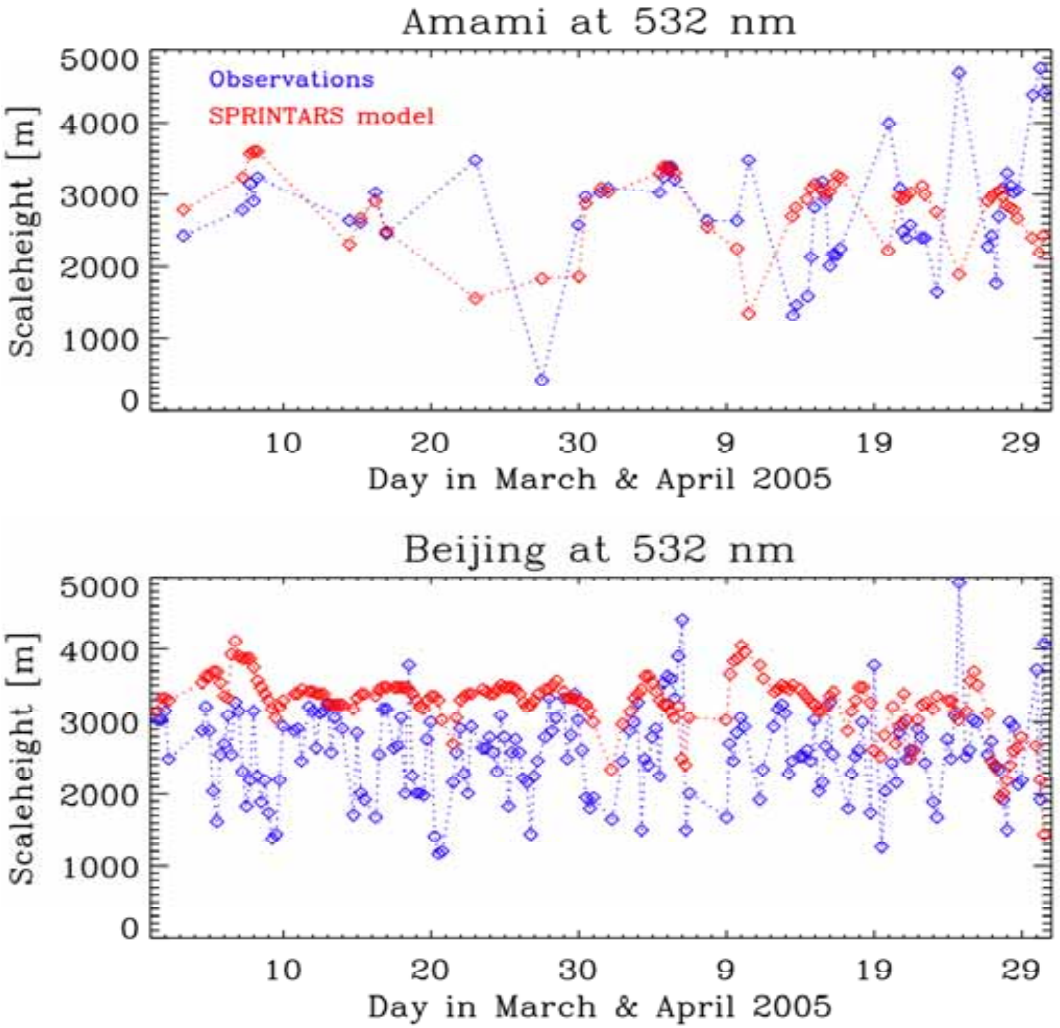


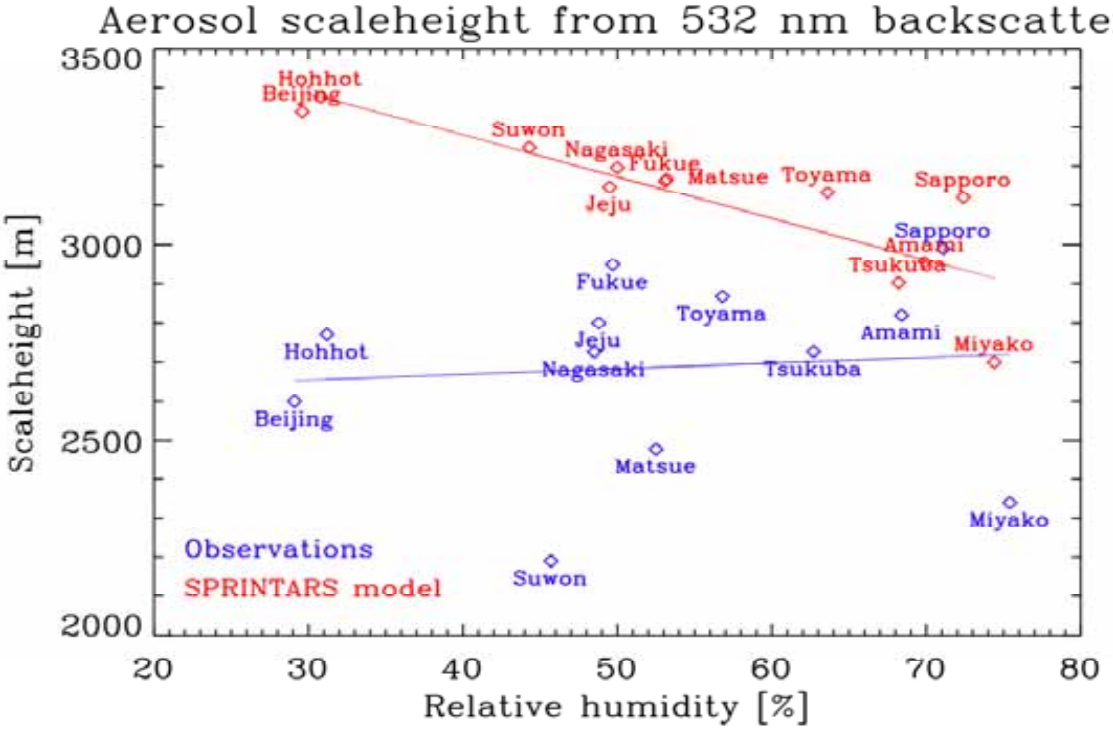
Sugimoto (NIES)





Aerosol scale height for observations and simulations



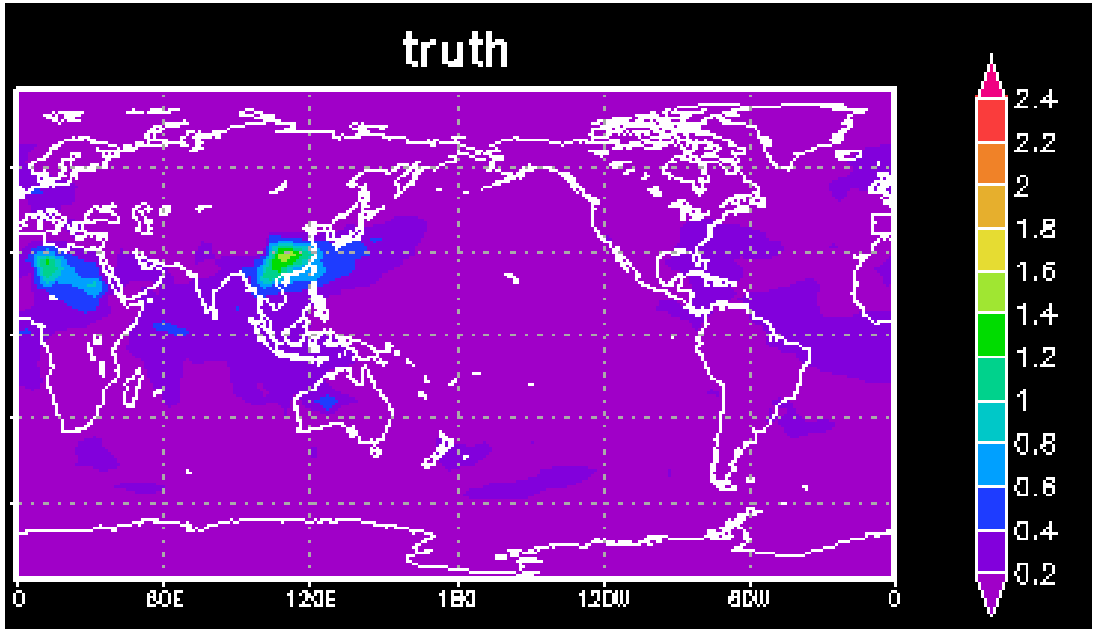


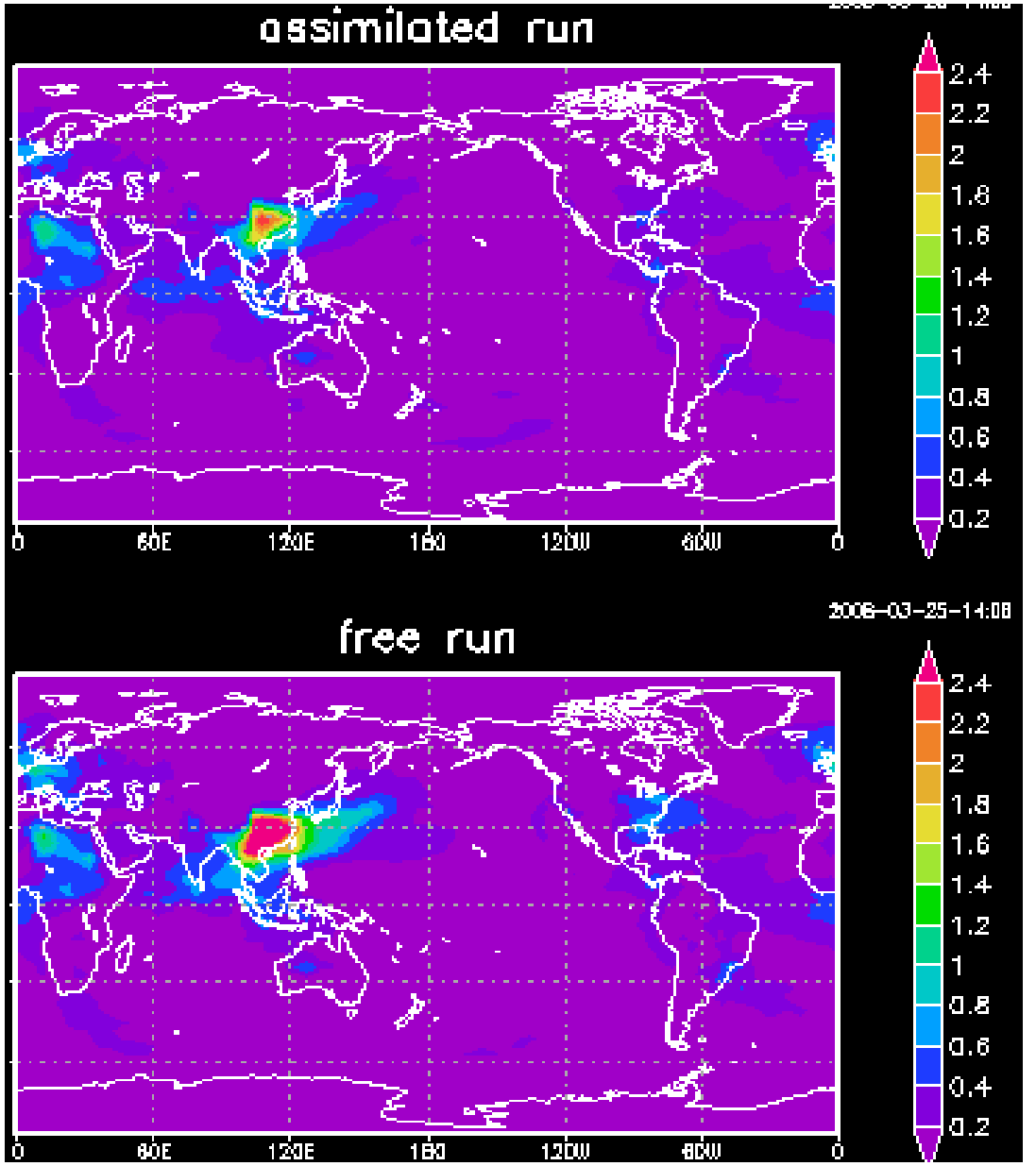
- **Hygroscopic growth model improvement needed**

N. Schutgens

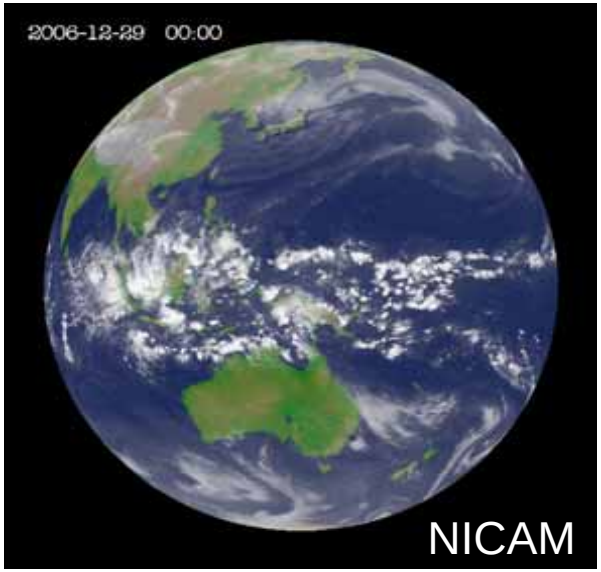
MIROC+SPRINTARS/AOD at AERONET sites (simulation)

40-member ensemble with modified emission fluxes
2006.3.25(After 25 days)





N. Schutgens (2008)



Miura et al. (Science 2007)

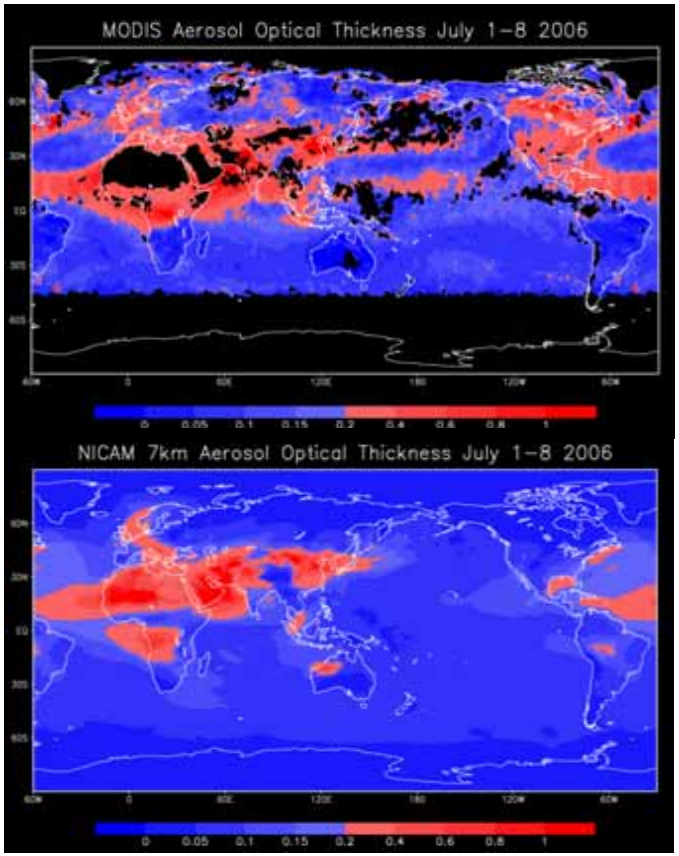
without cumulus parameterization...

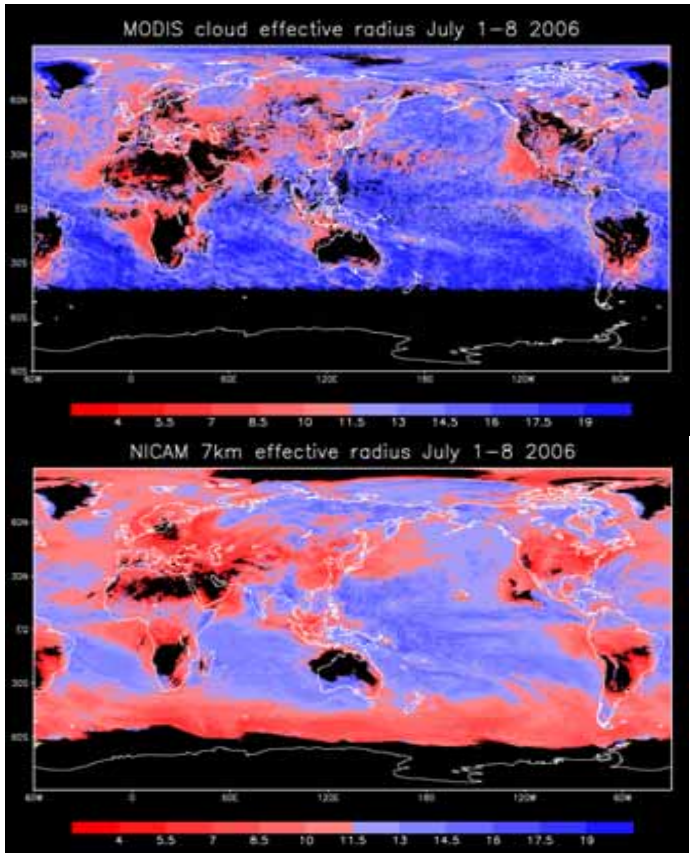
AOT

CDR

MODIS

NICAM



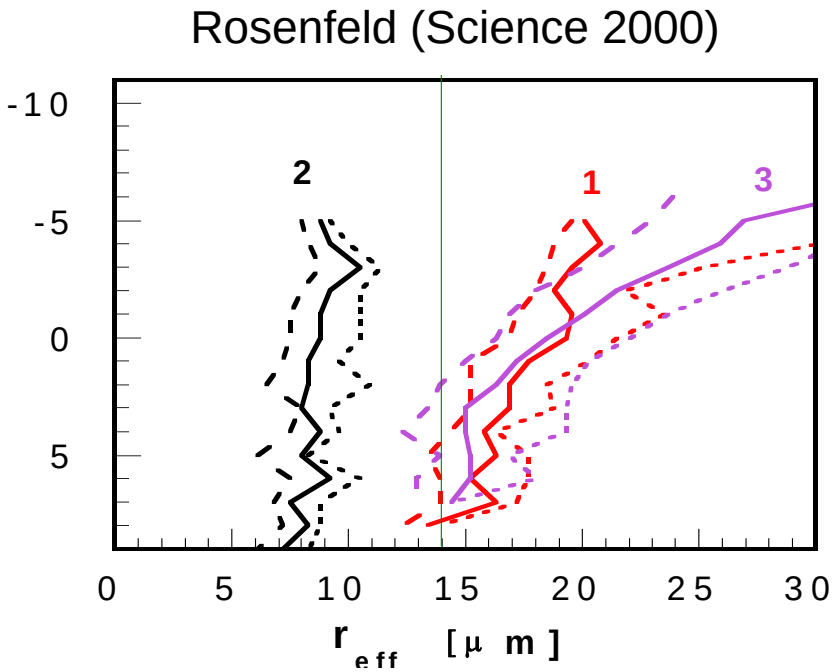


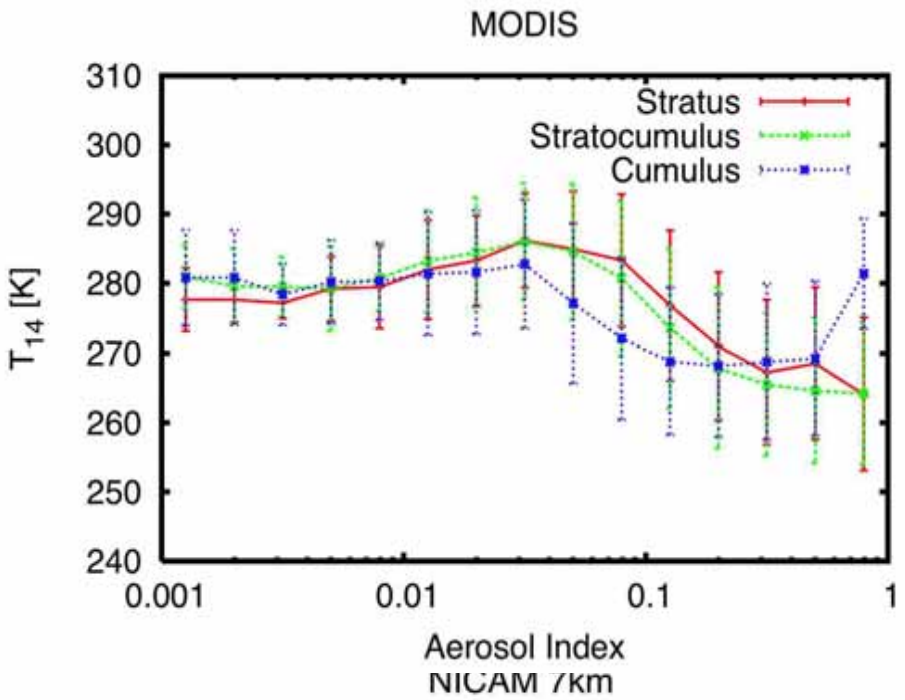
K. Suzuki (2008)

Vertical growth pattern of cloud droplets in convective system

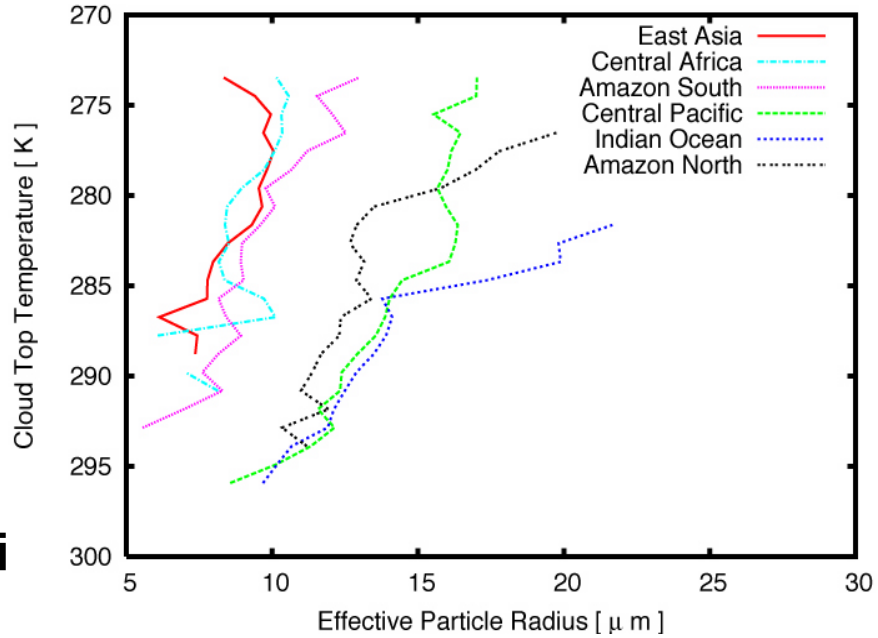
AVHRR

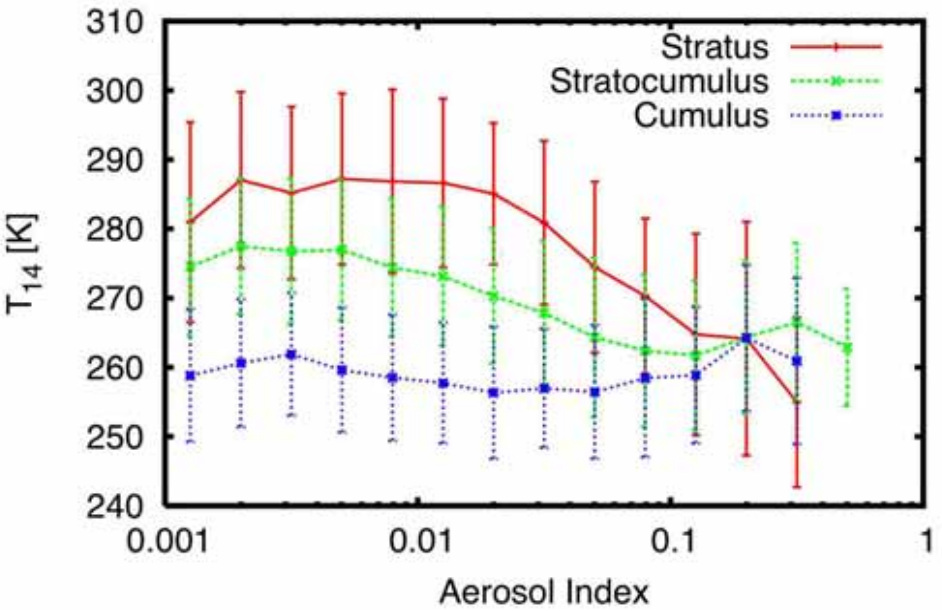
T14





NICAM

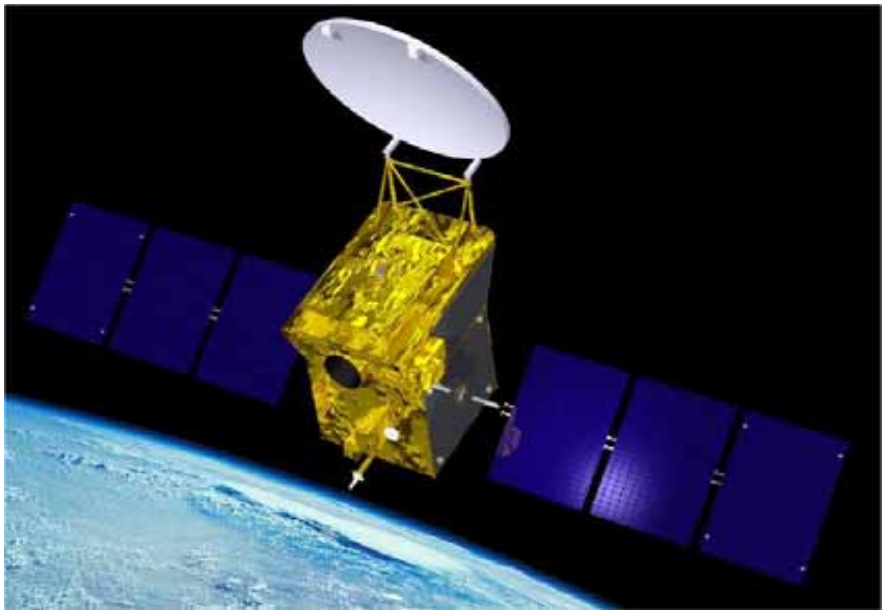




K. Suzuki

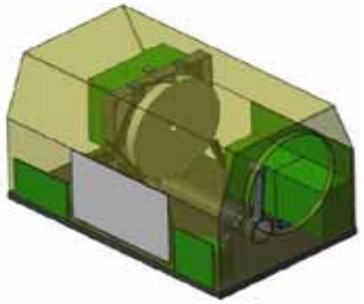
ESA-JAXA-NICT/EarthCARE
Earth Clouds, Aerosols and Radiation Explorer

LT: 10:30
Launch 2012



95GHz Doppler Cloud Radar

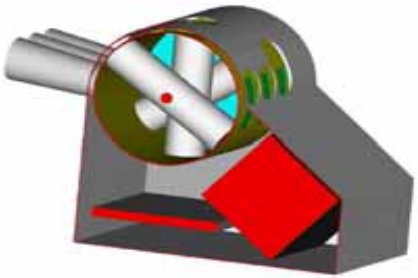
HSR lidar (ATLID)

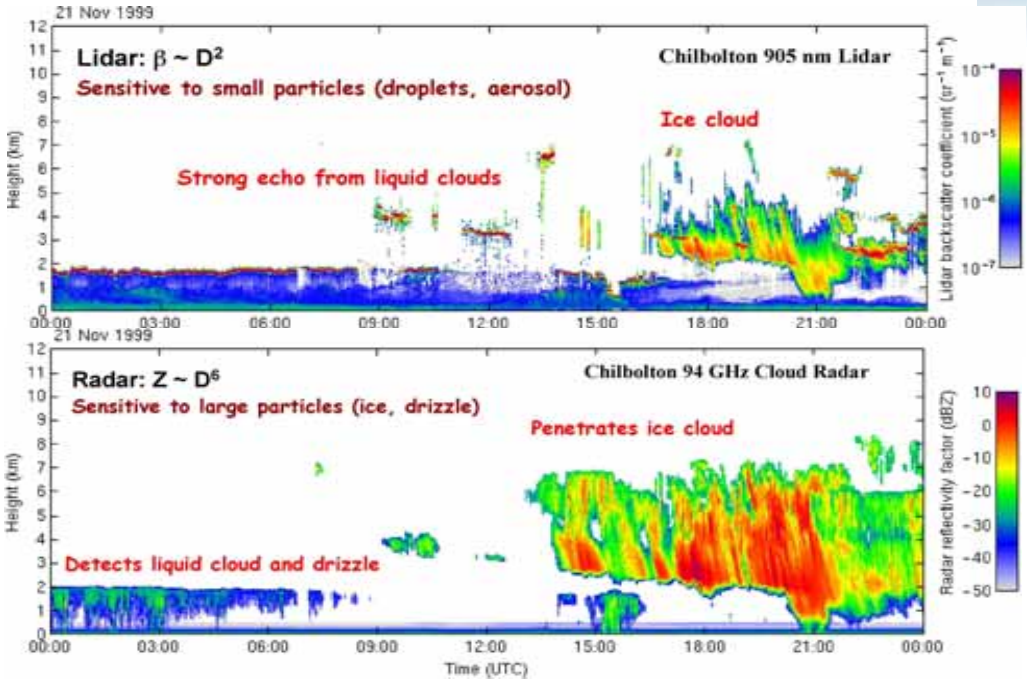


MSI
Ch1: 0.659 µm
Ch2: 0.865 µm
Ch3: 1.61 µm
Ch4: 2.2 µm
Ch5: 8.9 µm
Ch6: 10.9 µm
Ch7: 11.9 µm
Swath: 150km
IFOV: 500m

Multi-Spectral Imager

Broad band radiometer



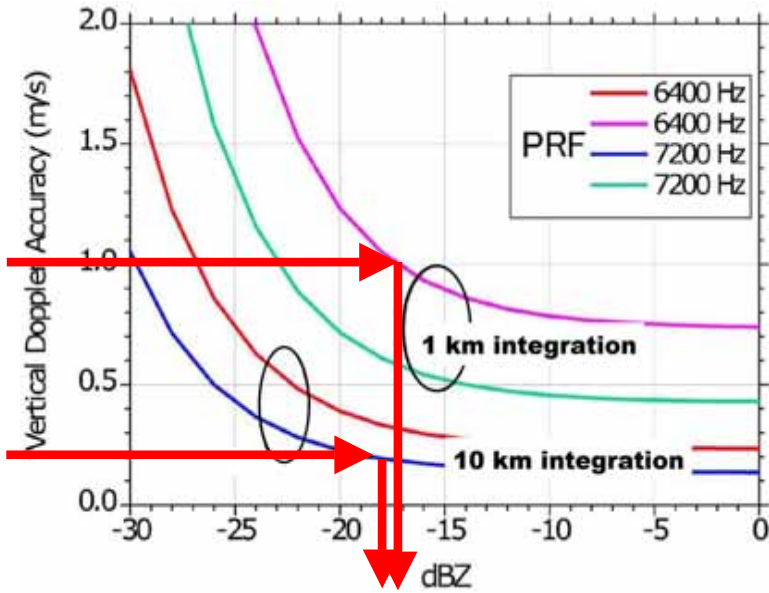


ドップラー計測

Convection: 1 m/s

Ice falling: 0.2 m/s

Drizzling: 0.2 m/s



Summary

- Large model uncertainties in cloud, aerosol, and radiation budget
  - Climate sensitivity
  - Effect on precipitation
- Cloudsat&CALIPSO, eCARE...
  - Data continuation for climate study
  - Doppler velocity measurements
  - Beyond 1012: ACE?
- GOSAT-GPM-eCARE-GCOM synergy
  - GHG-aerosol-cloud-precipitation
  - Capacity building for algorithm development
- AERONET, BSRN, and SKYNET site data use
  - Japanese contribution to GEOSS
  - Aerosol assimilation (GOSAT, MOE Kosa-project)
- Cloud modeling
  - NICAM, NHM, CRESS...
  - clouds, aerosol-clouds-precipitation