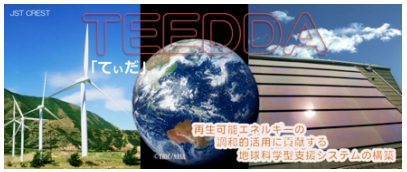
facebook
"TEEDDA"



Cloud properties retrieved from passive imagers and application to the shortwave flux estimation, regarding renewable energy

Takashi NAKAJIMA (Tokai U.), Terry NAKAJIMA (U Tokyo)

T. TAKAMURA (Chiba U), H. IRIE (Chiba U)

H. TAKENAKA (U.Tokyo), T. NAGAO (Tokai U.), H.LETU (Tokai U.)

T. WATANABE (Tokai U.), T. KURINO (JMA)

and

TEEDDA team members

(Terrestrial Energy Estimation by Diurnal Data Analyses)

CREW4 in Grainau, Germany, SESSION 3: NOWCASTING AND SEVERE WEATHER APPLICATIONS
Thursday 6 March 2014, 9:15-9:30

Satellite Data

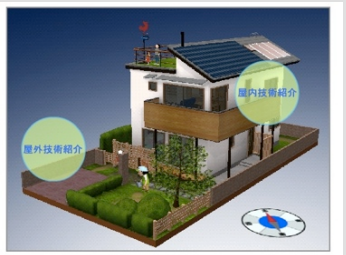
Japan Met. Agency
Numerical Weather Prediction

Validation System

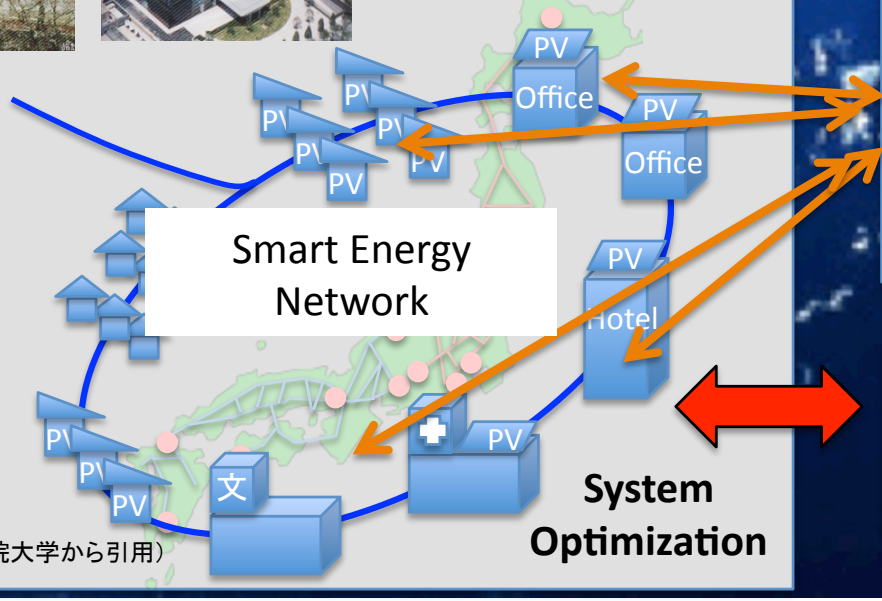
Our Goal

Geophysical Systems

Sat.Obs. ・Model・Val.



バーチャルエコ住宅の事例（品川区＋工学院大学から引用）



Smart Energy Network

System Optimization

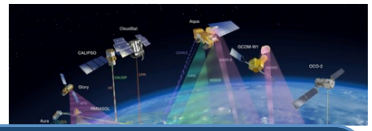
Estimation of,

- Radiation
- Wind Vector
- Surface Temperature

Electric Power Control Package

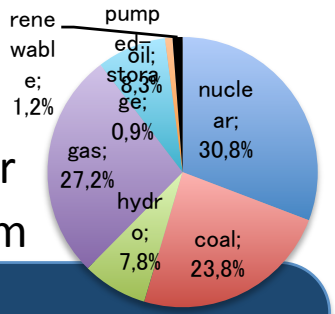
History of our interests, motivation

2000’- Cloud Observation Technique



- A-Train (radar/lidar/imager)
- 2nd generation GEO
- Non-hydrostatic model

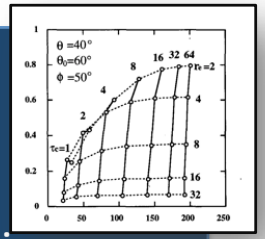
2010’- Electric Power source problem



- Climate Change
- Anomaly of Nuclear Pwr Plnt
- Control System Community
- Electric Power Community
- Renewable Energy Community

Supply & Demand

1990’- Cloud Retrieval

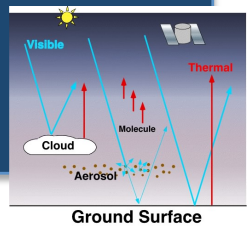


- Nakajima&King
- Han&Rossow
- Nakajima et al.
- Scattering theories

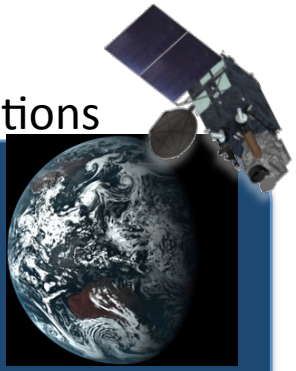
Earth science community can contribute to the energy problem !

1980’- Progress of radiative Transfer

- MODTRAN
- DISORT
- RSTAR
- 6S…



2015’- Near real time estimations



- Cloud properties
- Aerosol properties
- Water vapor
- Solar flux, Wind, Ground Temp.
- 3rd Generation GEO from 2015

Funding: CREST by JST
Energy Management System (EMS)

Geoscience Team

＊**Takashi Nakajima (PI)**, K. Cho
H. Yokotsuka, T. Kurino, K. Bessho,
K. Aoki…

Leading Group
(Tokai University)

JMA
Met. Sat. Center

- Overall
- Improve sunlight estimation system
- Satellite data receiving, analysis

- Usability of the satellite data
- Operational system research

＊Tamio Takamura
H. Irie, H. Kuze
K. Pradeep…

Collaboration Group
(Chiba University)

- Validation
- Satellite data collections

＊Teruyuki Nakajima
H. Takenaka
T. Inoue

Collaboration Group
(University of Tokyo)

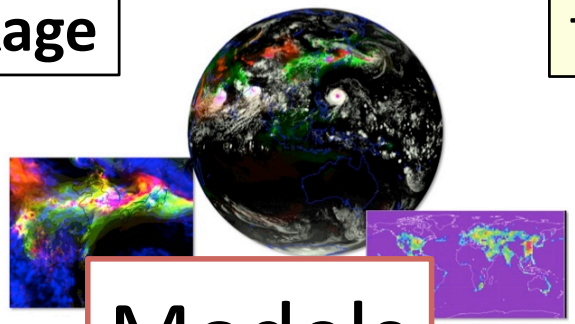
- Improve sunlight estimation system
- Model development

Concept

Satellite

Suite package

Validation



Models

Physical theories, no empirical.

Estimation of the Geophysical parameters ,on any moments at any places, considering future climate on the globe.

1st Physical Principle approach

Scattering theory and Radiative transfer

Mie scattering

Rayleigh scattering

→ Radiative Transfer Model (RTM) →

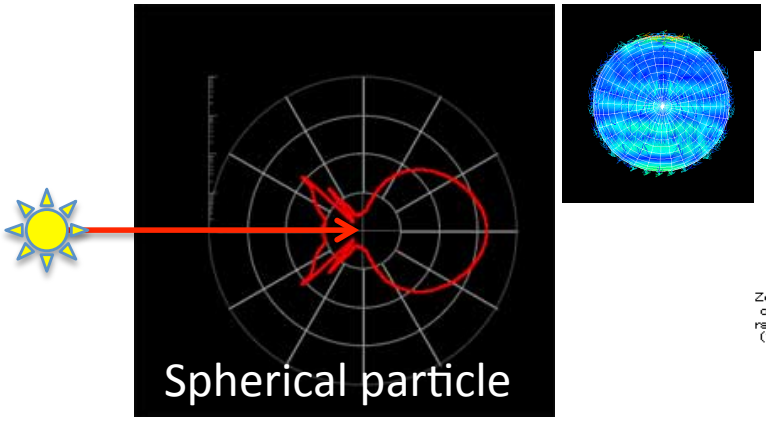
Exact spectral radiance, *L* →

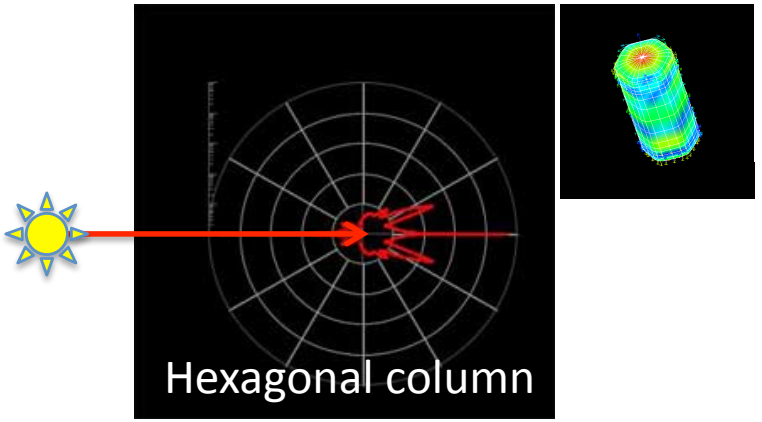
$\int L(t, \lambda)\ dt$

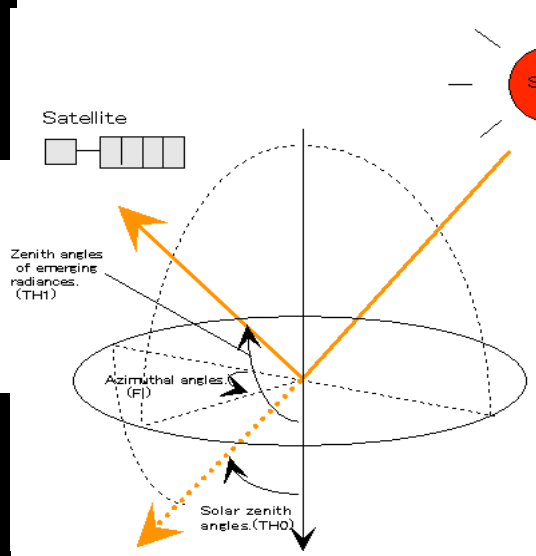
$\int L(t, \lambda)\ d\lambda$

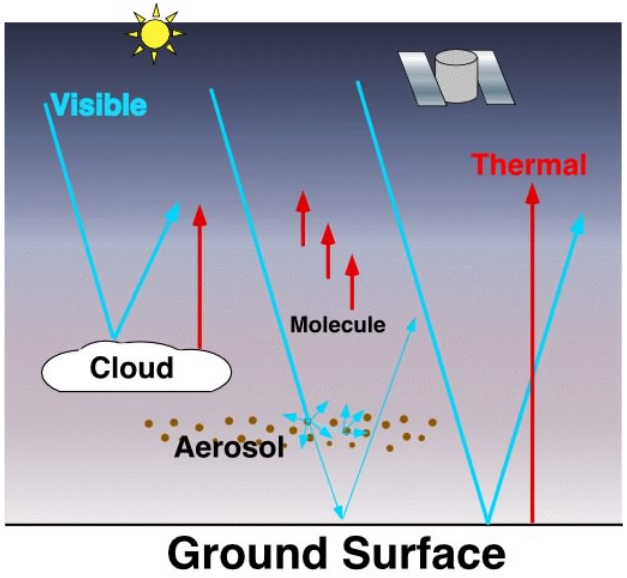
$\int L(t, \lambda) r(\lambda)\ d\lambda$

We can integrate *L* as we like !





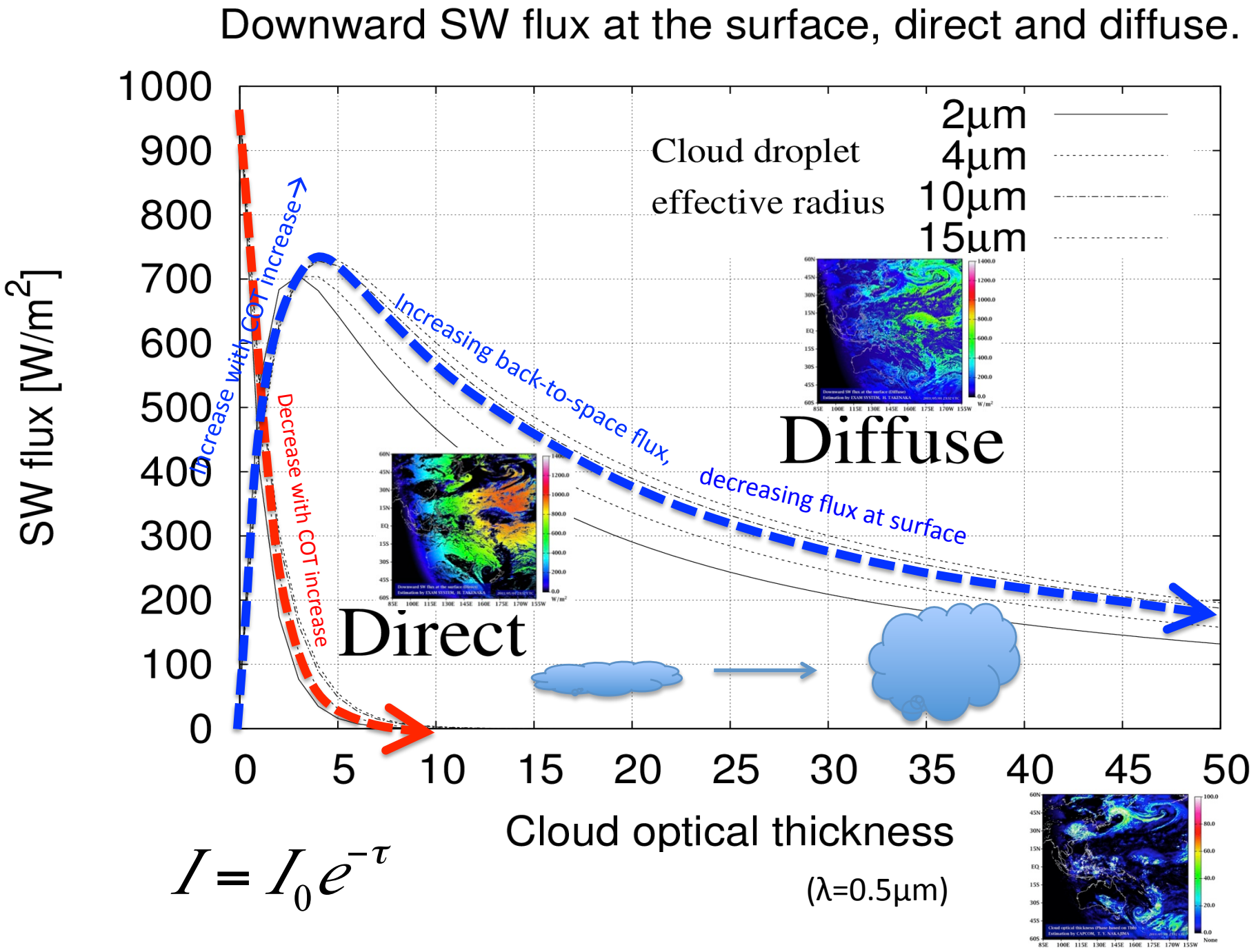




Scattering theory…

Radiative Tranfer Model (RTM)…
Nakajima et al. 1986, 1988 and so on…

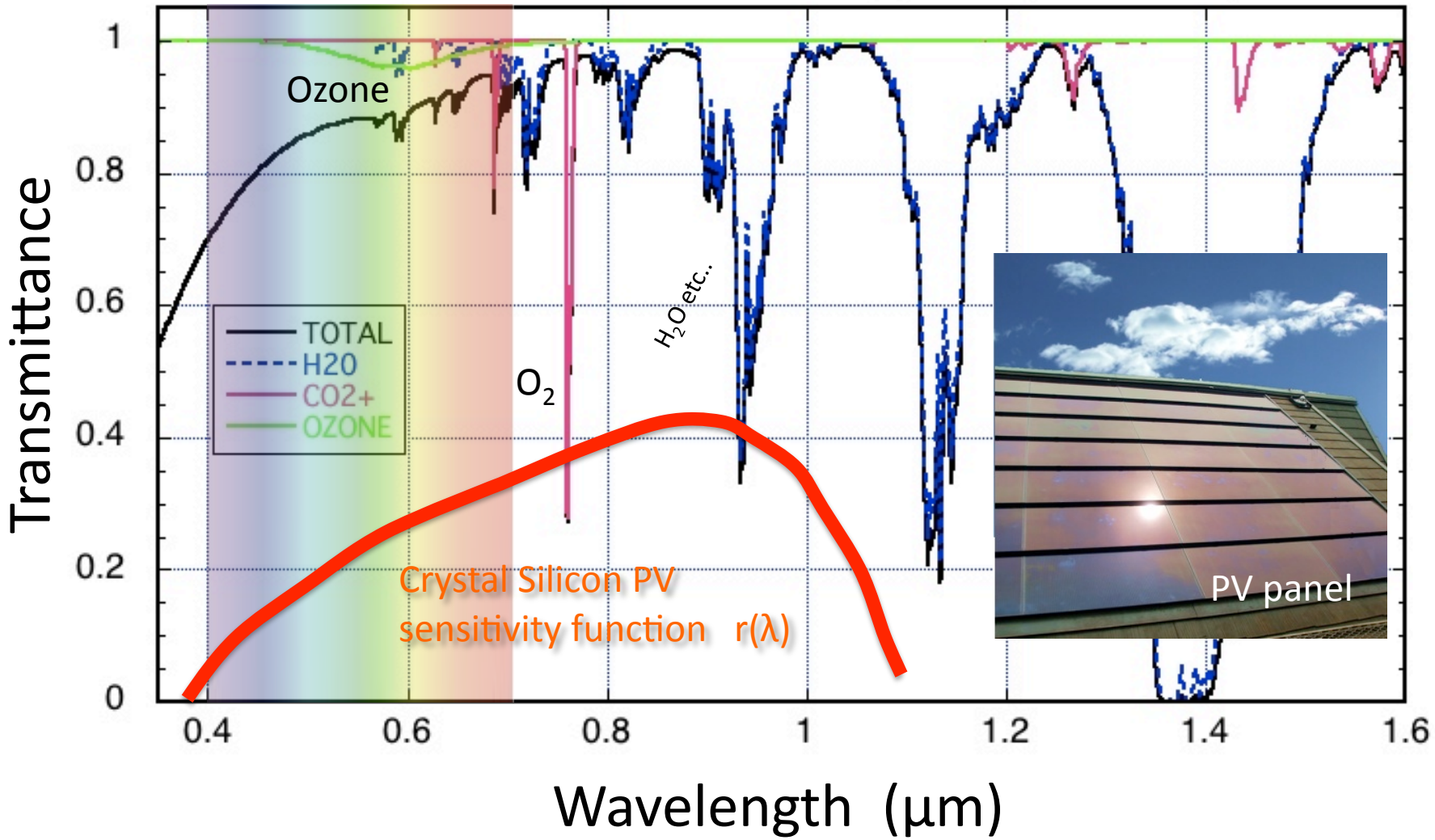
Simulation by 1st Physical Principle approach



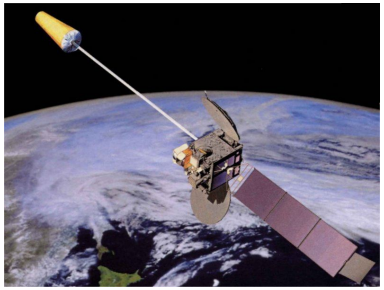
A Case of Clear Sky

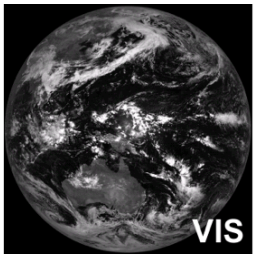
PV panel captures sunlight from 0.38 ~ 1.1 μm

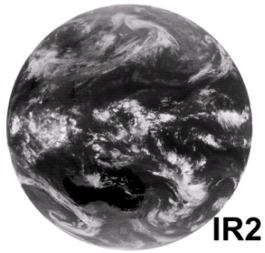
Transmittance of atmosphere (US Standard)

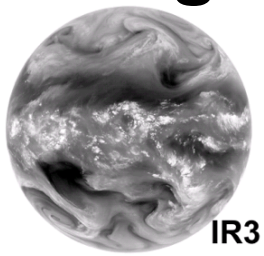


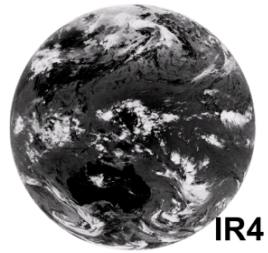
Geostationary satellite images





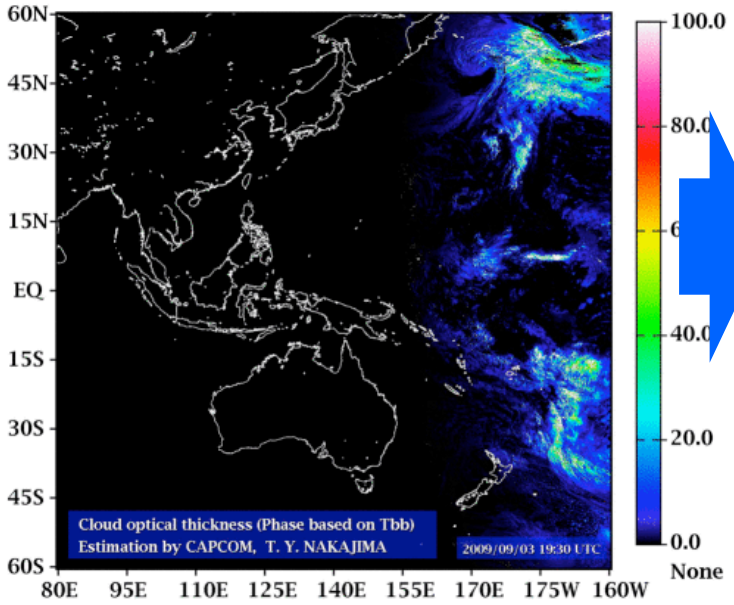






Takenaka et al (2011)

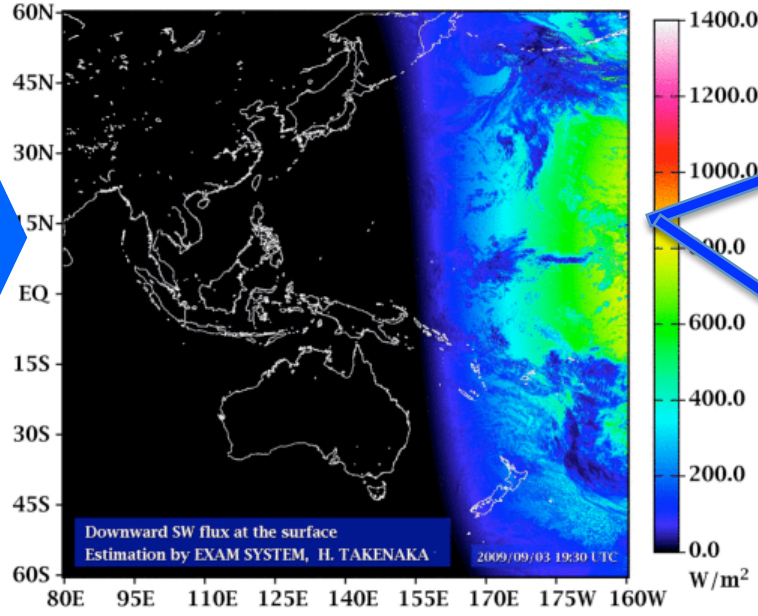
Cloud properties

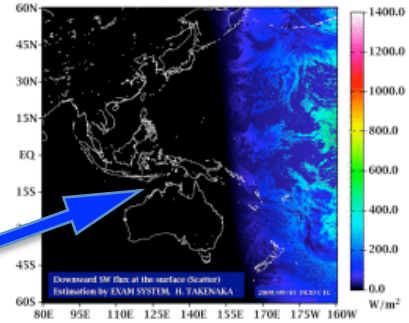


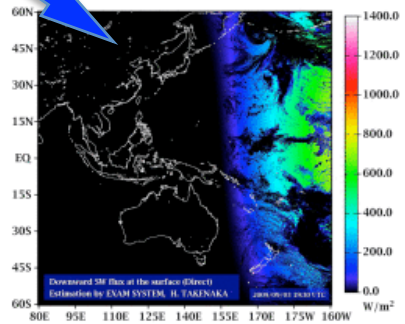
by CAPCOM

Nakajima & Nakajima

SW Flux







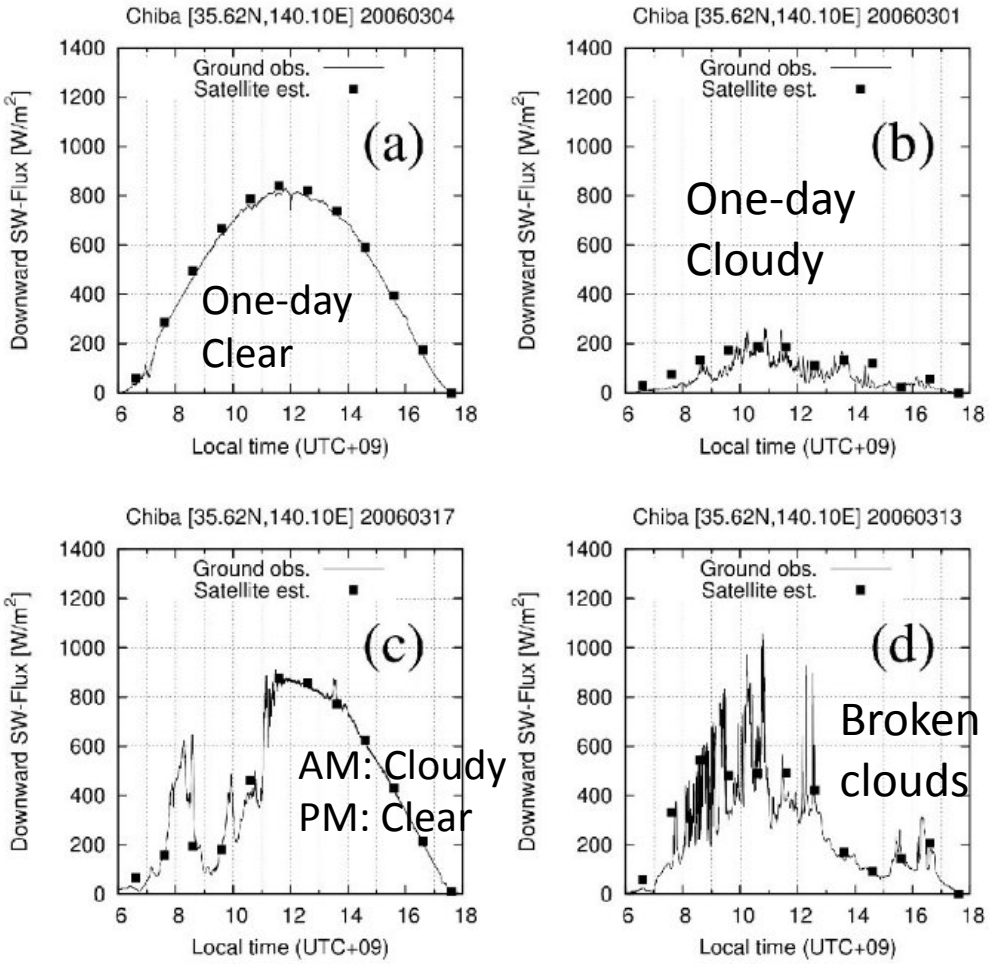
by EXAM SYSTEM (NN technique)

Takenaka et al.

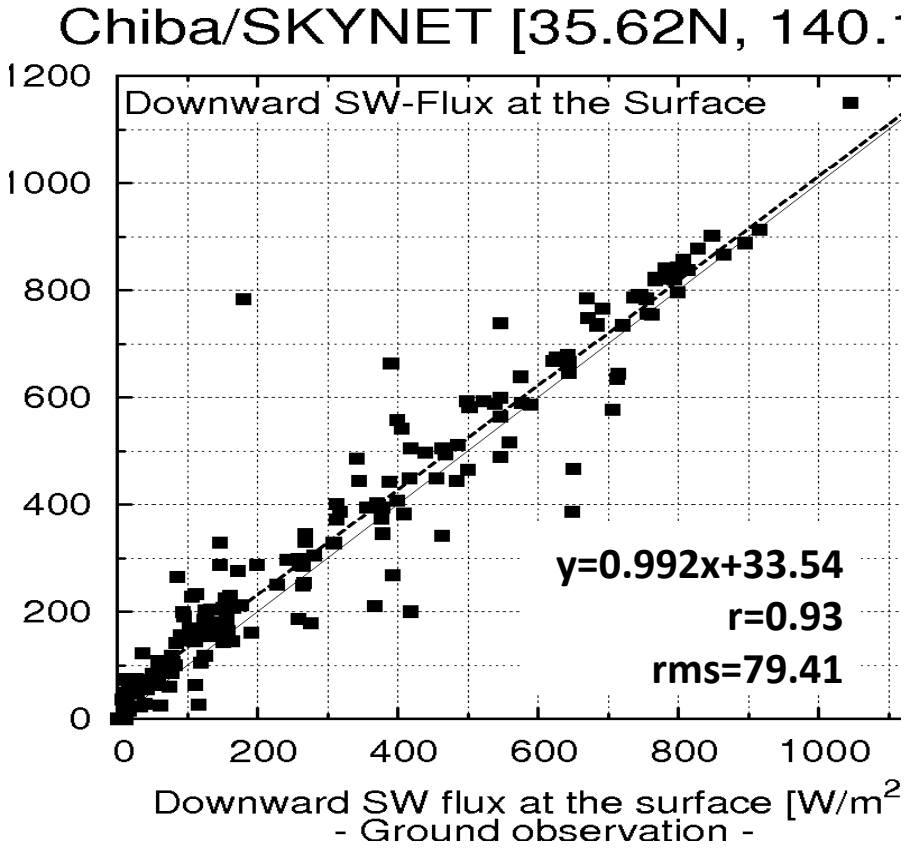
Validation

Validation of sunlight

Validation of downward Shortwave flux at the surface, SKYNET/Chiba site



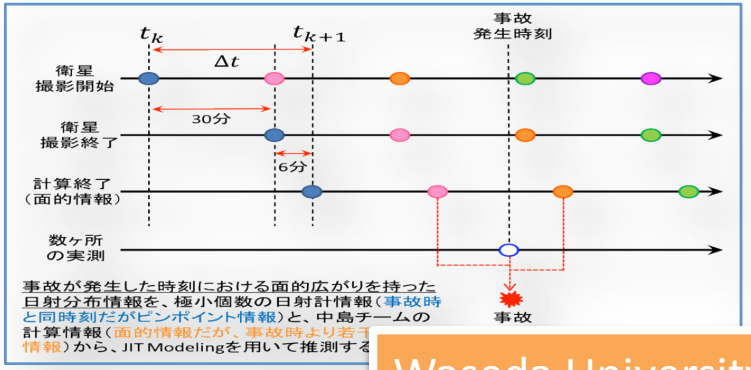
SKYNET @Chiba Univ. (2006/3)



Large discrepancy due to fractional cloud cover. We will investigate validation strategy.

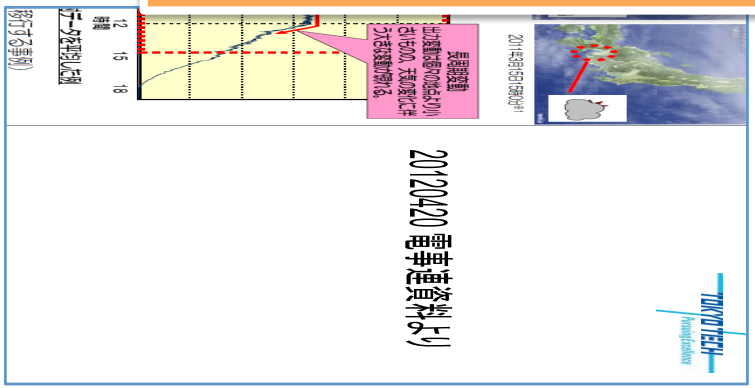
Takenaka et al. 2011

Use of solar irradiance data for estimating PV powers in town-to-city-size area, when recovering from anomaly of power supply.



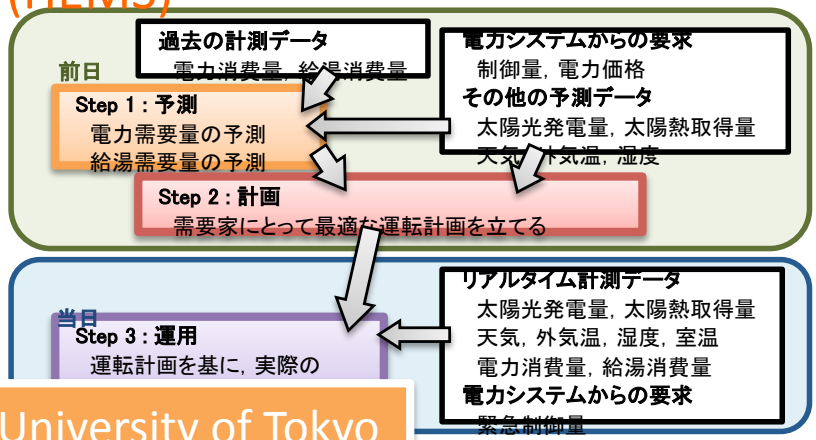
Waseda University

Tokyo Institute of Technology



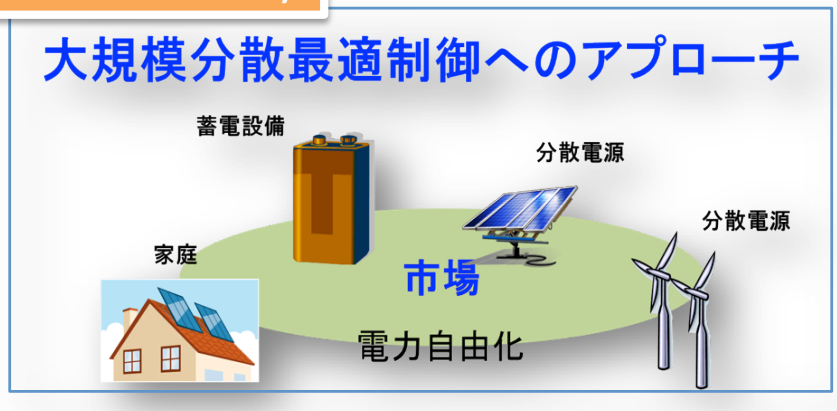
Control the power system based on minute-to-day prediction.

Optimizing the power supply system in Home Energy Management System (HEMS)



University of Tokyo

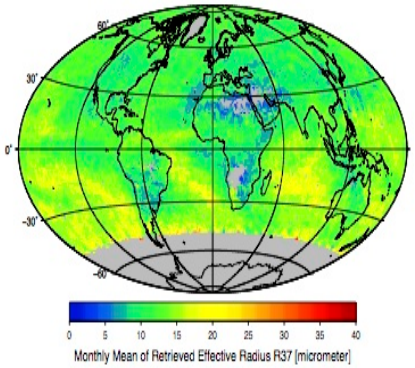
Keio University



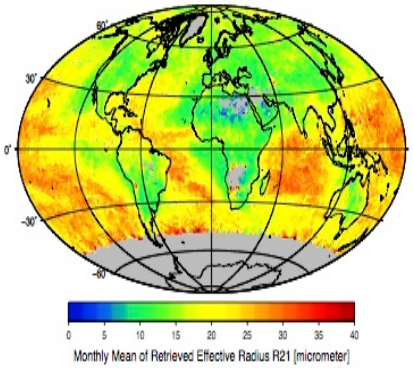
Control of the distributed energy management systems with 70% power from renewable energy.

Vertical Slicing of Re using SWIR bands ? → Challenging

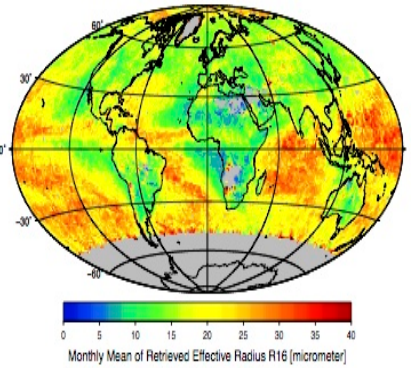
Re37 (3.7μm)



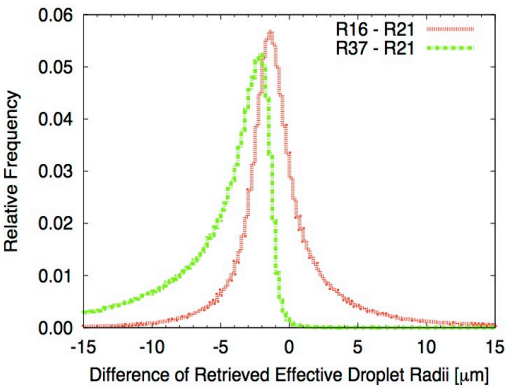
Re21 (2.1μm)



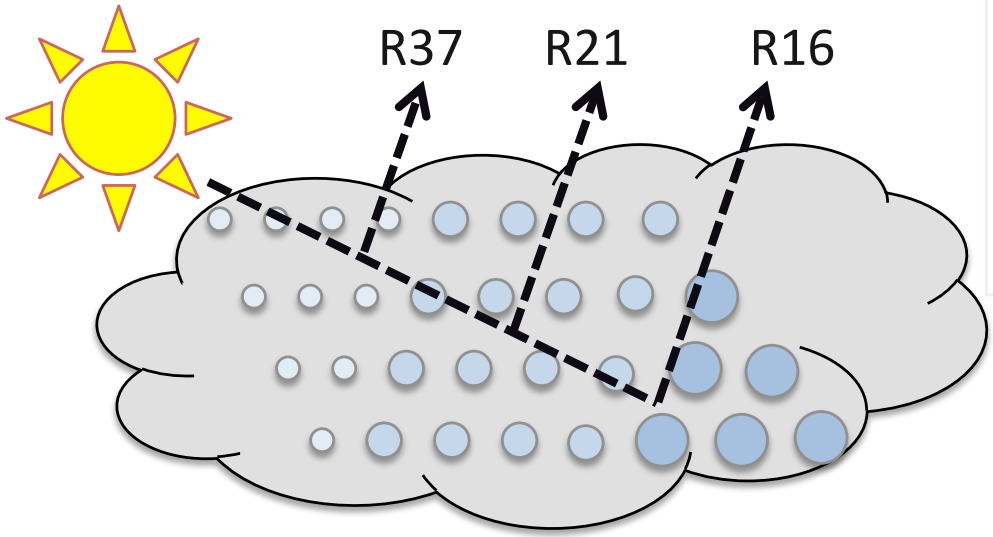
Re16 (1.6μm)



*MODIS/Terra over ocean in July 2006



Different **depth** & Different **sensitivities to droplet size** may induce the differences.



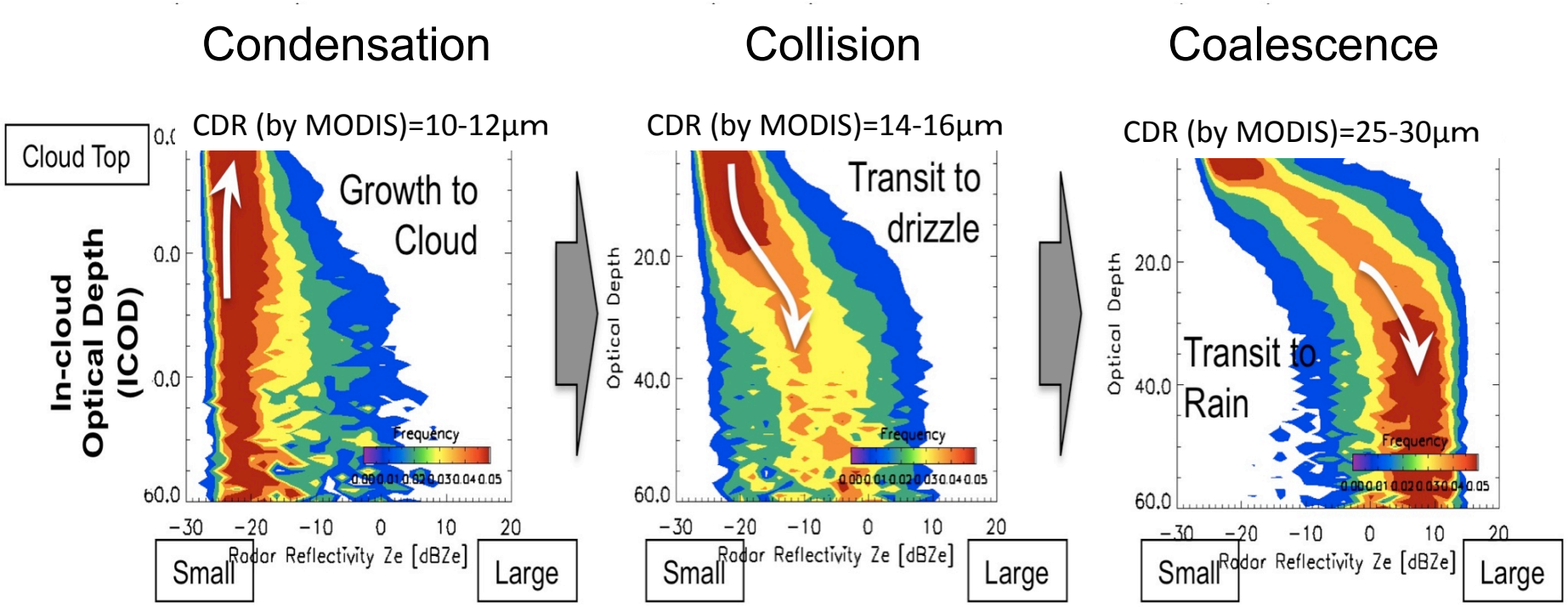
More investigations,

- Need separating, Vertical inhomogeneity, Horizontal inhomogeneity effects, 3D RT effect.
- Simulate cloud remote sensing using a spectral-bin microphysical cloud model.

Visualizing the cloud growth process from space

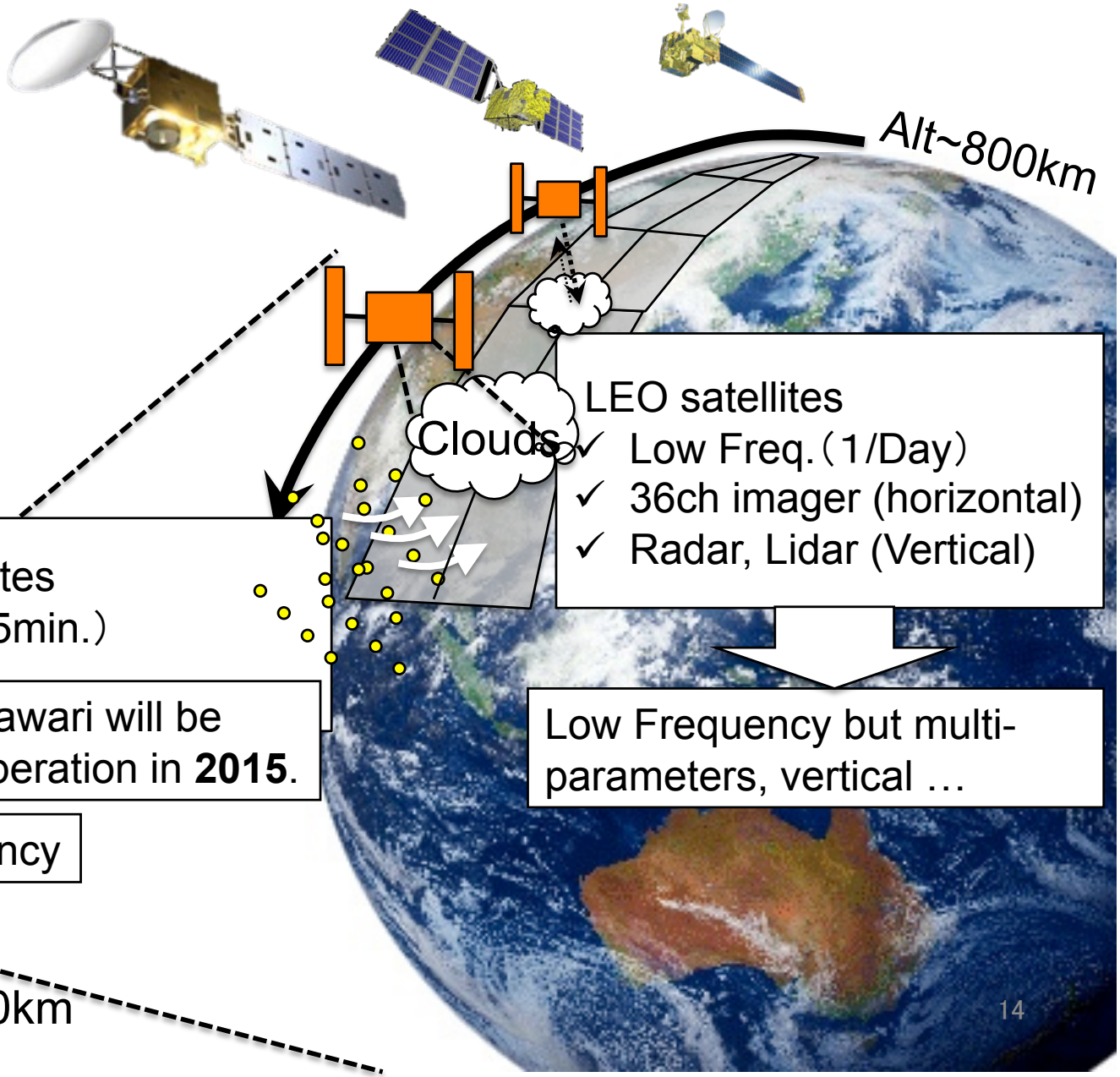
Nakajima et al. (JAS, 2010b), Suzuki et al. (JAS, 2010b)

Contoured Frequency by Optical Depth Diagram (CFODD)



July 2006, One month data of the Aqua/MODIS and CloudSat/CPR

3rd generation GEOs + LEOs



LEO satellites
- ✓ Low Freq.（1/Day）
- ✓ 36ch imager (horizontal)
- ✓ Radar, Lidar (Vertical)

Low Frequency but multi-parameters, vertical …

3rd generation GEO satellites
- ✓ High Freq.（10 min - 2.5min.）
- ✓ 16chs. imager

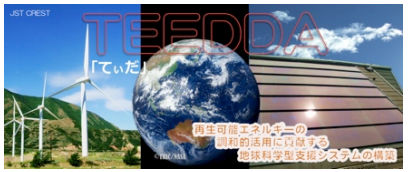
Himawari will be in operation in **2015**.

High frequency

Altitude= 35,800km

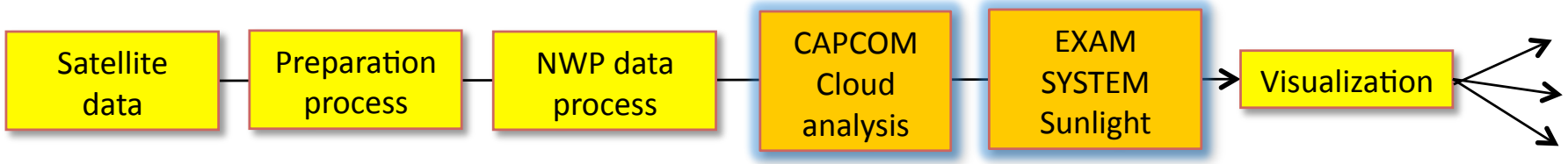
Summary

Facebook "TEEDDA"



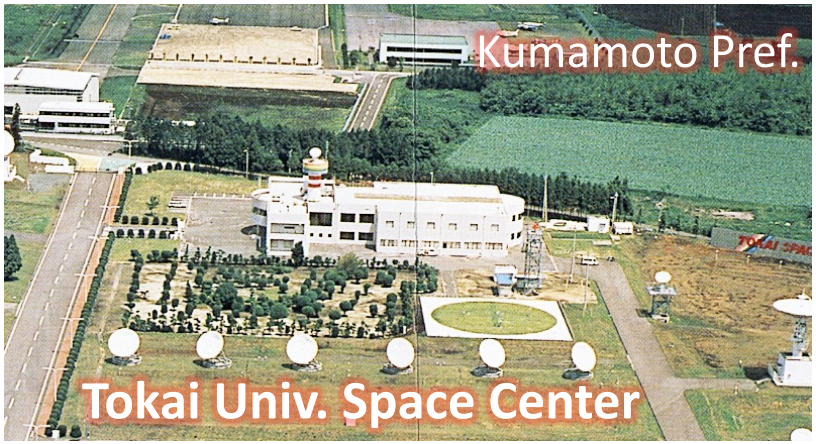
1, Near realtime solar energy estimation for global scale

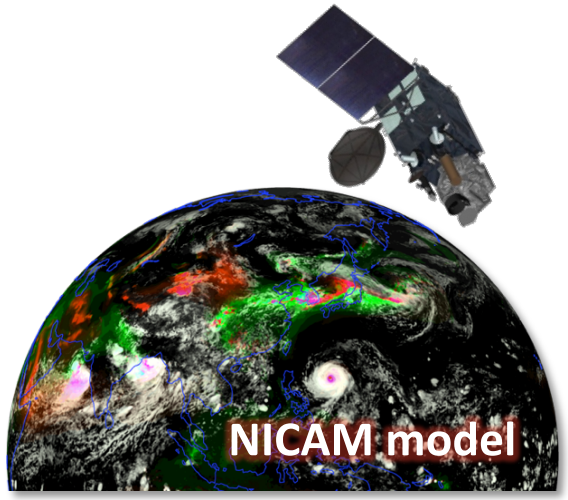
- Less than **10 minutes for full disk**, after the data receiving (very fast).
- Estimates spectrum L(t, λ) of the sunlight → We can integrate L(t, λ) as we like.



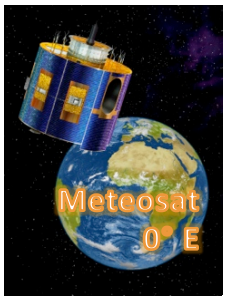
2, More understanding of cloud evolution process for prediction… using, CloudSat, Calipso, EarthCARE, GCOM, 2nd and 3rd GEOs

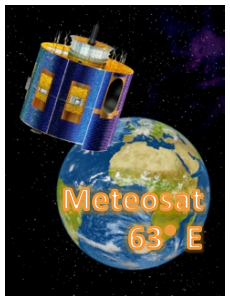
3, Model calculates not only clouds but also air pollutants.

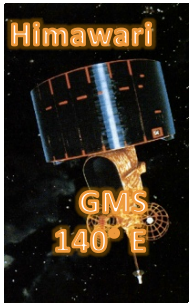


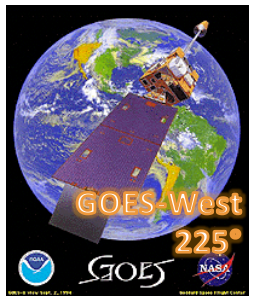


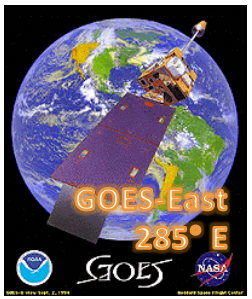
Than you very much !

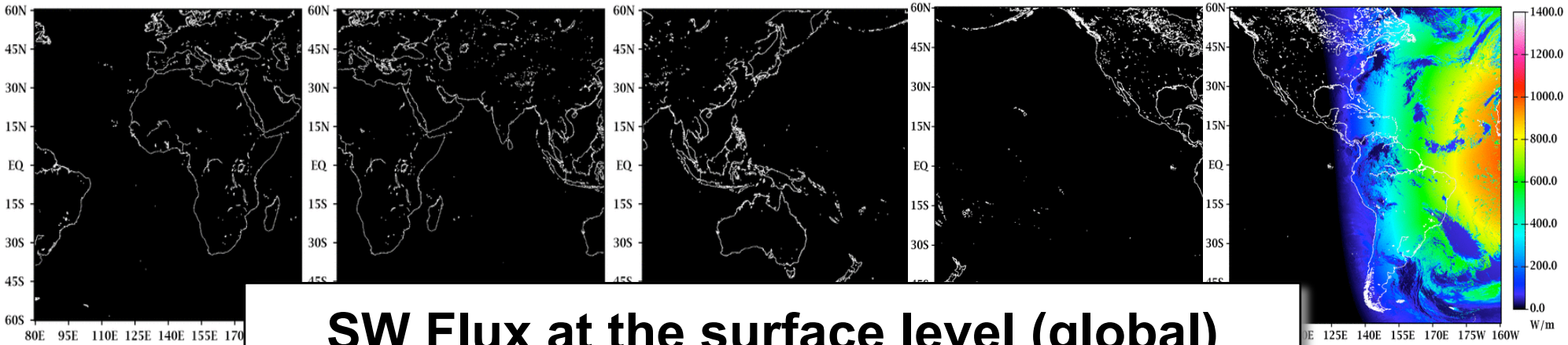






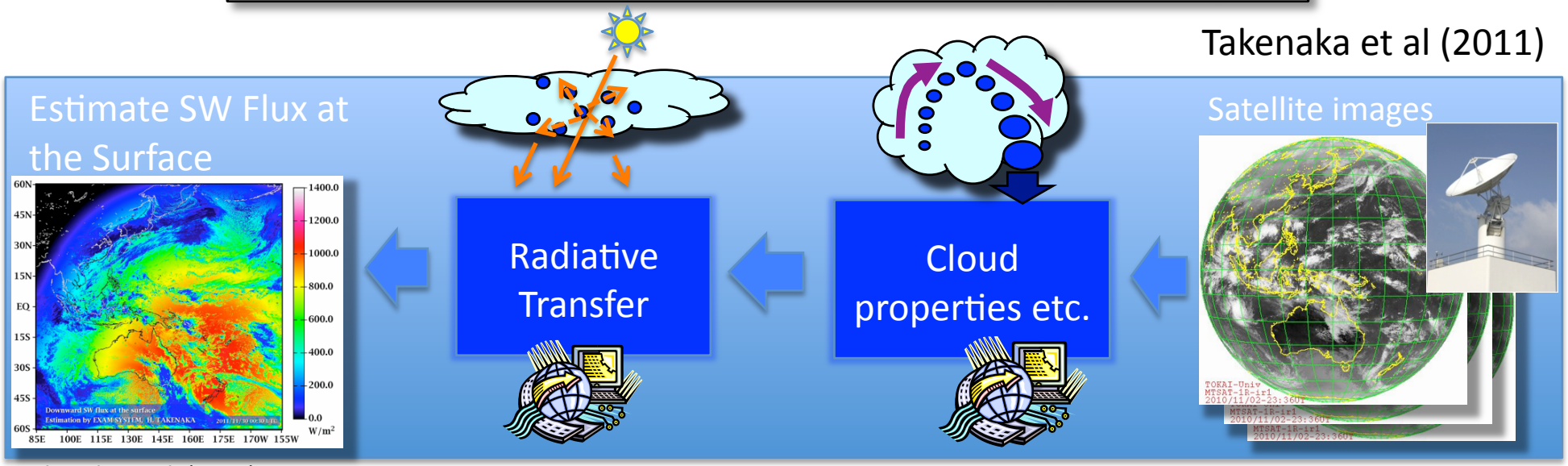






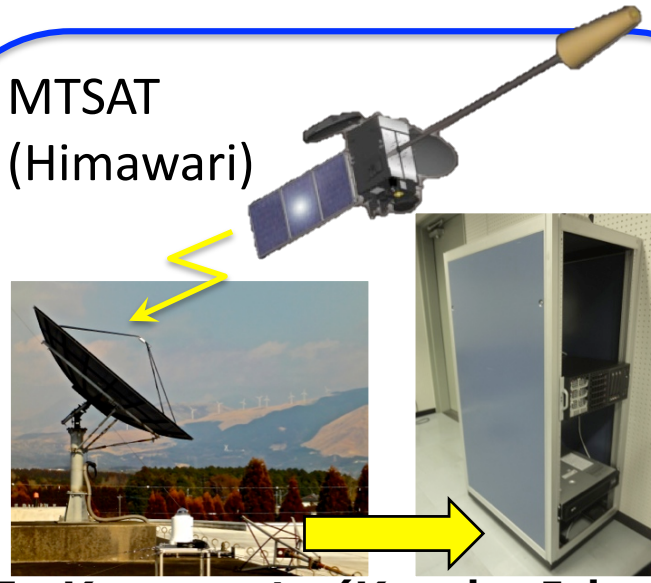
SW Flux at the surface level (global)

Takenaka et al (2011)

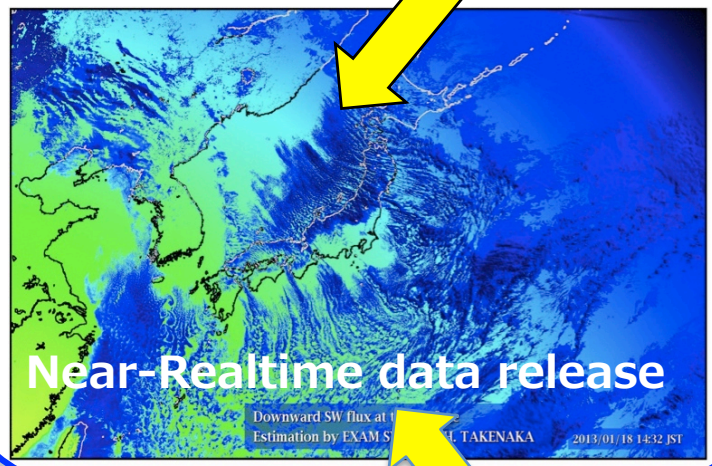


Takenaka et al. (2011)

MTSAT
(Himawari)



In Kumamoto (Kyushu Island)



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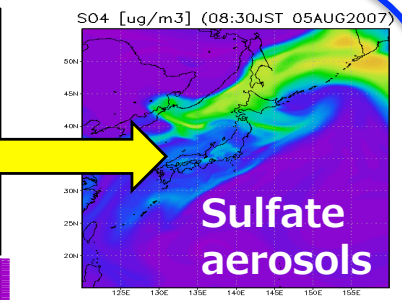
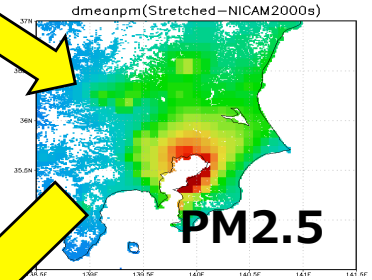
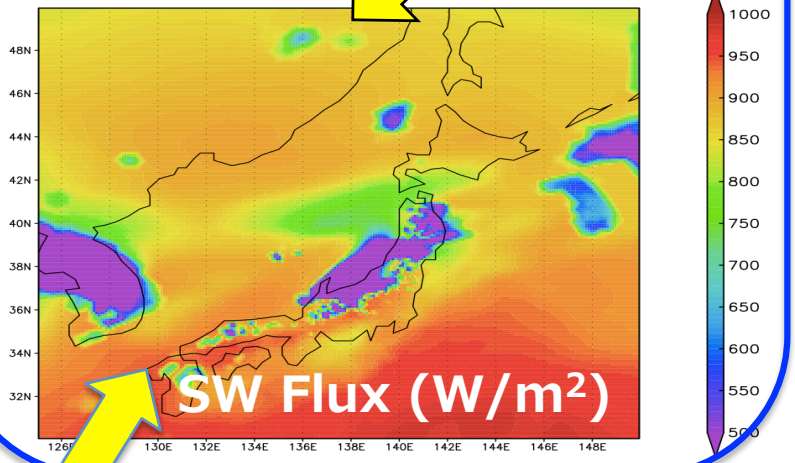
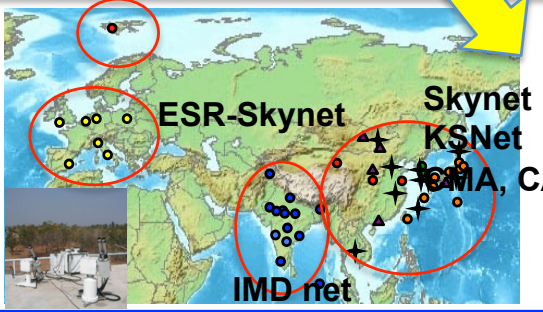
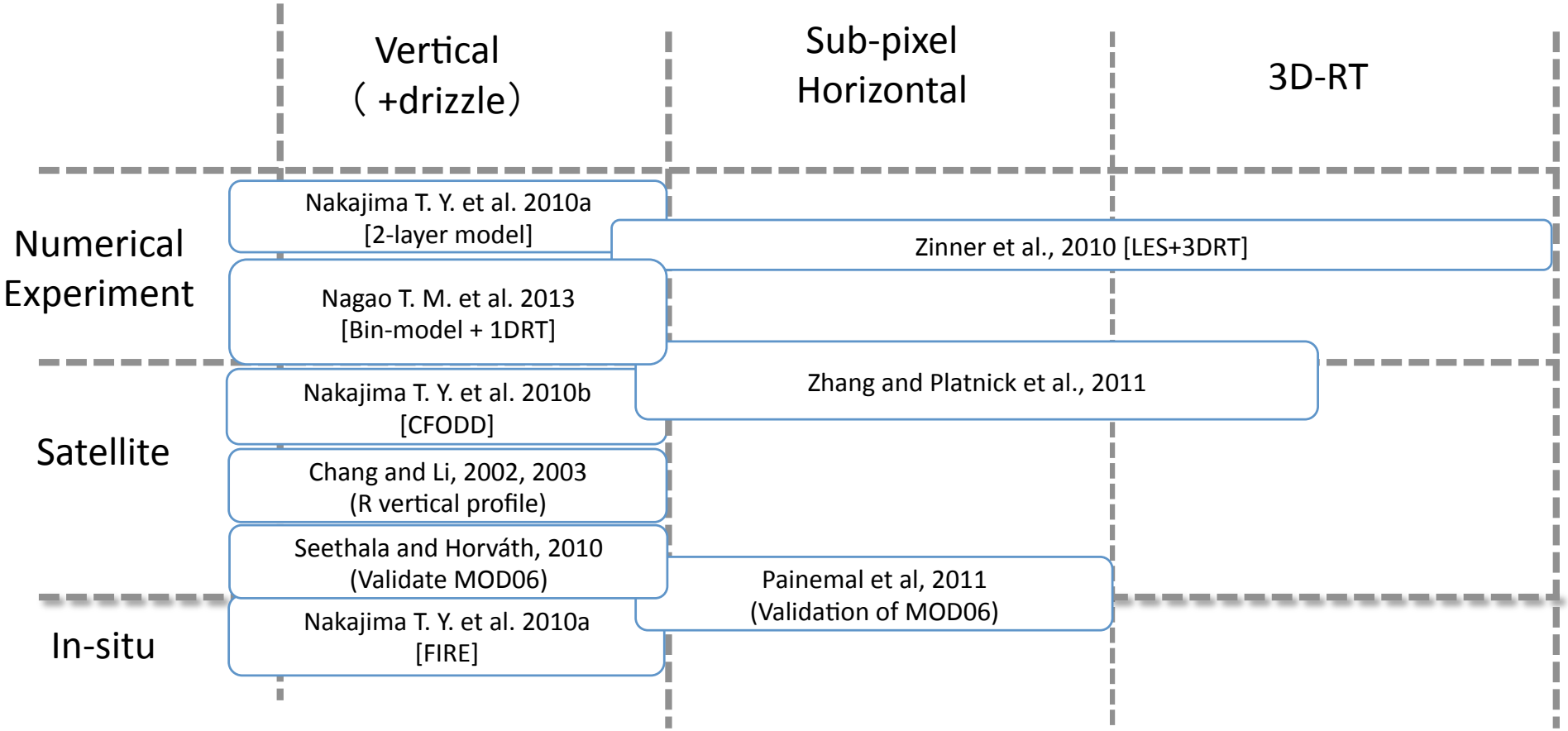








Research plots
for interpret observed cloud properties



Satellite obs.

EXAM SYSTEM, a neural network

- Very fast, ~100,000 times faster than general RTM like “MODTRAN”, “Rstar”.
- Distortion- Back Propagation method
  - ✓ Optimizing number of neurons by frequent access neuron surviving
  - ✓ Simple and Fast.

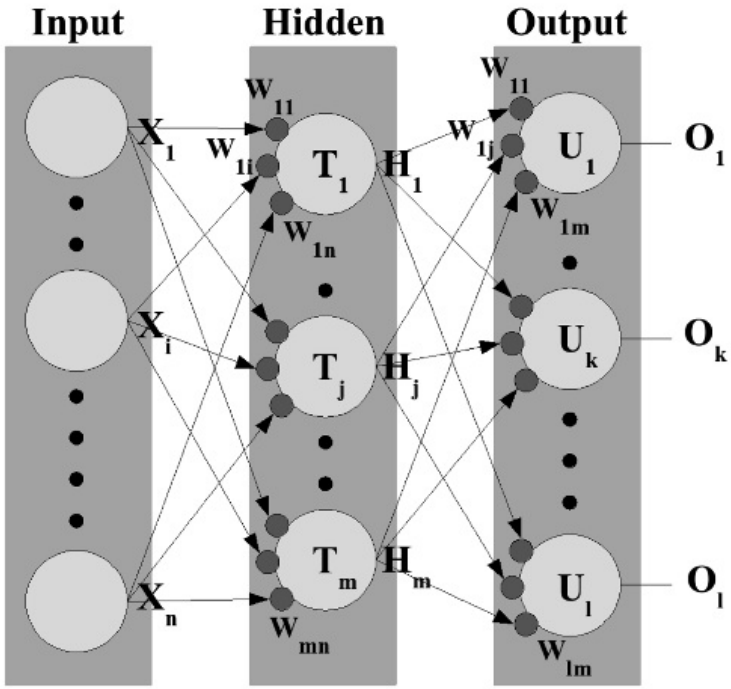
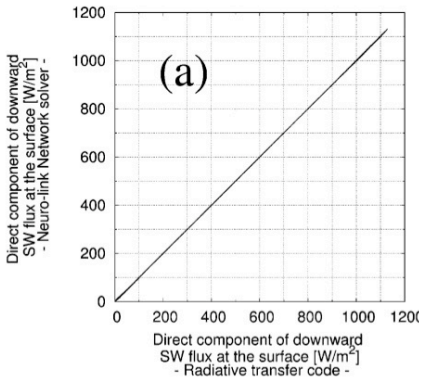
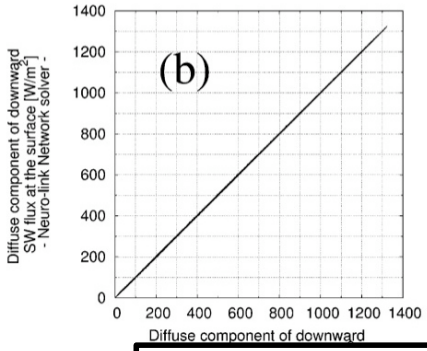


Figure 6. Schematic illustration of the three-layer network structure. Each layer neuron is connected by a synaptic weight. A complex system is composed of sets of simple neurons.

Table 1. Input Parameters of NN Solver for Geostationary Satellite MTSAT-1R/JAMI

Parameter	Symbol	Unit
Solar zenith angle	θ_0	deg
Water cloud optical thickness	$\tau_c w$	none
Water cloud effective radius	$r_e w$	μm
Ice cloud optical thickness	$\tau_c i$	none
Ice cloud effective radius	$r_e i$	μm
Cloud top pressure	P_c	hpa
Surface albedo	A_g	none
Surface pressure	P_0	hpa
Total column ozone	OZN	DU
Total column water vapor	PWV	g/m^2





Takenaka et al. 2011