Estimation of renewable energy by geophysical approach and future collaboration with demand sciences.

PI Takashi Y. Nakajima (TRIC, Tokai University)

【Team Members】

(Tokai-U) Nakajima Ta, Watanabe, Yamamoto, Cho, Kurino, Bessho, Troccoli, Ono, Funayama

(JAXA/UT) Nakajima Te, Takenaka, Sakashita, Yamada, Hashimoto, Inoue, Suzuki

(Chiba-U) Irie, Khatri, Higuchi, Takamura

(Osaka-U) Shimoda, Yamaguchi, Taniguchi, Inoue, Itagaki, Okamoto, Otsuki Hamada, Banba, Miyachi

(UT-IIS) Iwafune, Ogimoto, Ikegami, Yagita

(Titech) Hidaka, Aramaki, Tsujimoto, Nishikiori

(UT-Info.) Suzuki (from Imura Team)

NSF-JST Washington WS
21, Apr, 2015 16:40-17:00 (20min)

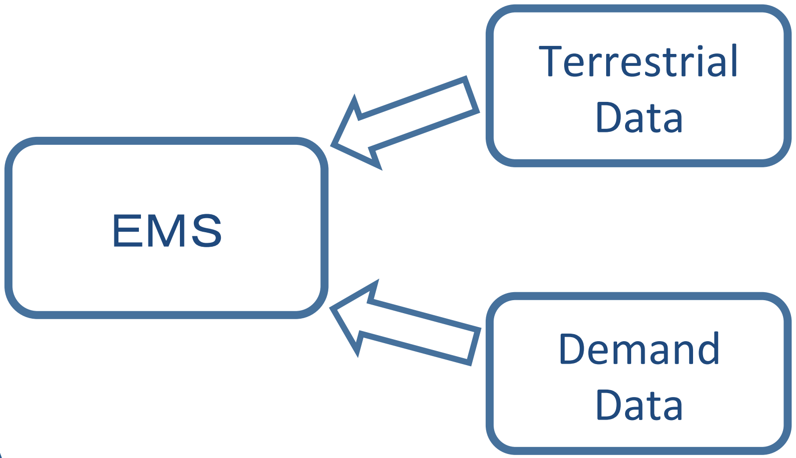
Research Background

Need a EMS that allows big amount of **renewable energy** input.

Factors to be studied,

(1) Meteorology, (2)Energy Supply System, and (3) Energy Demand.

However, monitoring and modeling of **meteorology** and **energy demand** are **not sufficient**.



e.g. Solar irradiance varies temporally and spatially.

"Need to understand the current status, short term prediction, uncertainty, of the renewable energy"

Energy demand varies temporally due to many kinds of factors.

"Need to understand elements and variables of energy demand, then need modeling."

→ Our team commits to understand Terrestrial Data and Demand Data

Part 1: Demand Science

Monitoring:
Understanding of consumer's behavior

Modeling:
Development of a reliable Demand Model

Hidaka 2014

Objective

Understand how do content and presentation of information affect the consumer's energy saving behavior in the EMS.

Research topic : Understanding information effect

- Effect by real-time feedback of energy consumption

RESULT: Real-time feedback of energy consumption did not have the clear impact on consumer behavior change.

- Reference dependence

RESULT: Average information of **the consumer cluster** had the impact on the energy consuming behavior change of the consumer in that cluster.

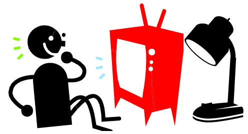
Osaka-U : Modeling of Residential Energy Demand (1)

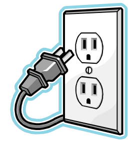
Daily Schedule of Family Members

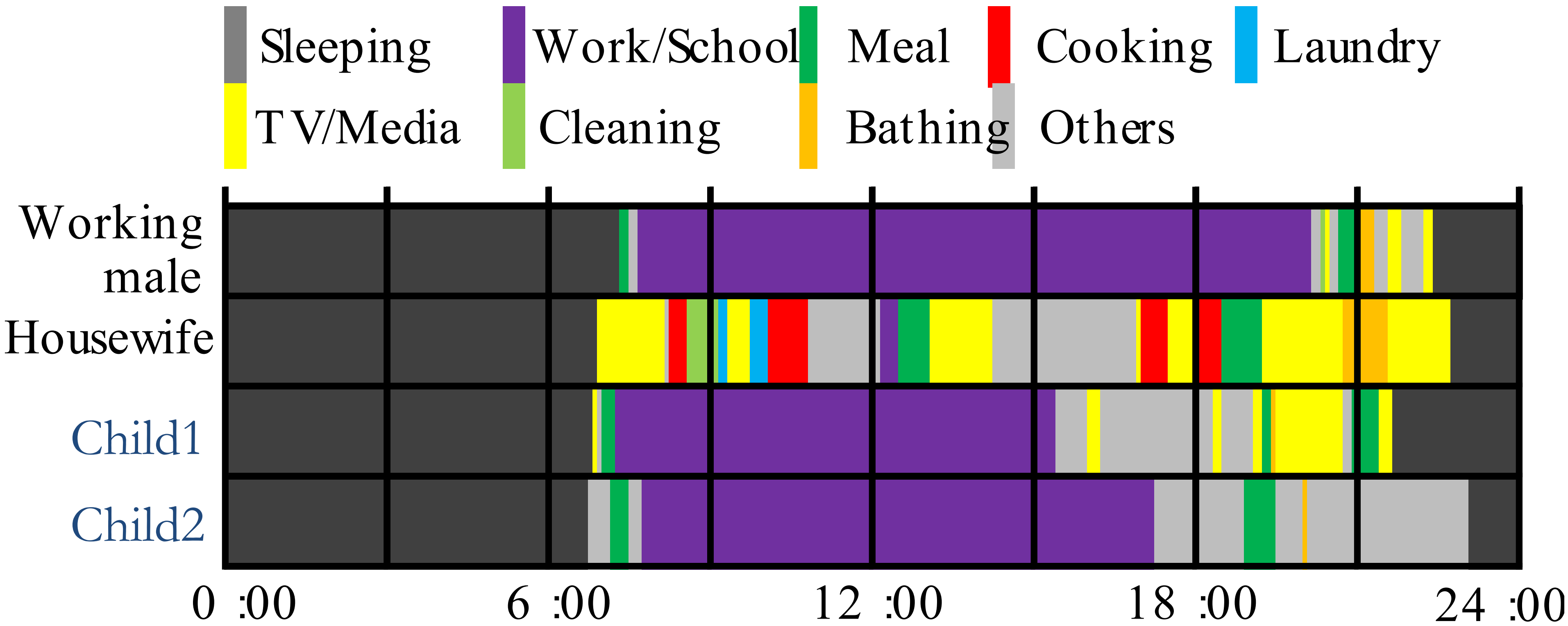
Shimoda 2014

Flow chart

Time use → Operation of home appliances → Status and spec → Energy consumption



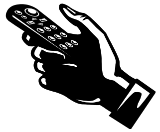
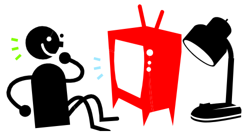
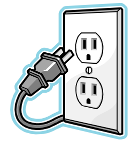




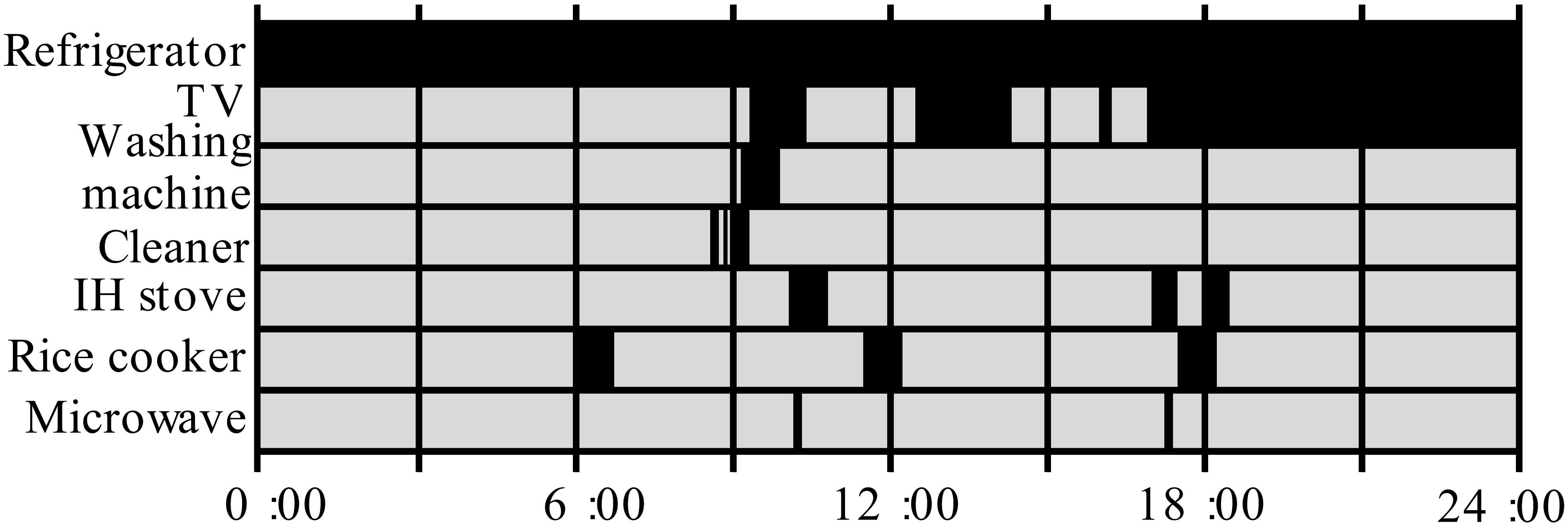
Osaka-U : Modeling of Residential Energy Demand (2)

Operation Schedule of Home Appliances

Shimoda 2014

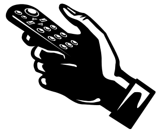
Time use ⇨ **Operation of home appliances** ⇨ **Status and spec** ⇨ **Energy consumption**

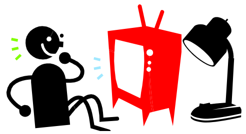


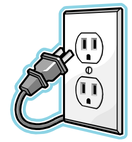
Osaka-U : Modeling of Residential Energy Demand (3)

Time Series of Electricity Demand

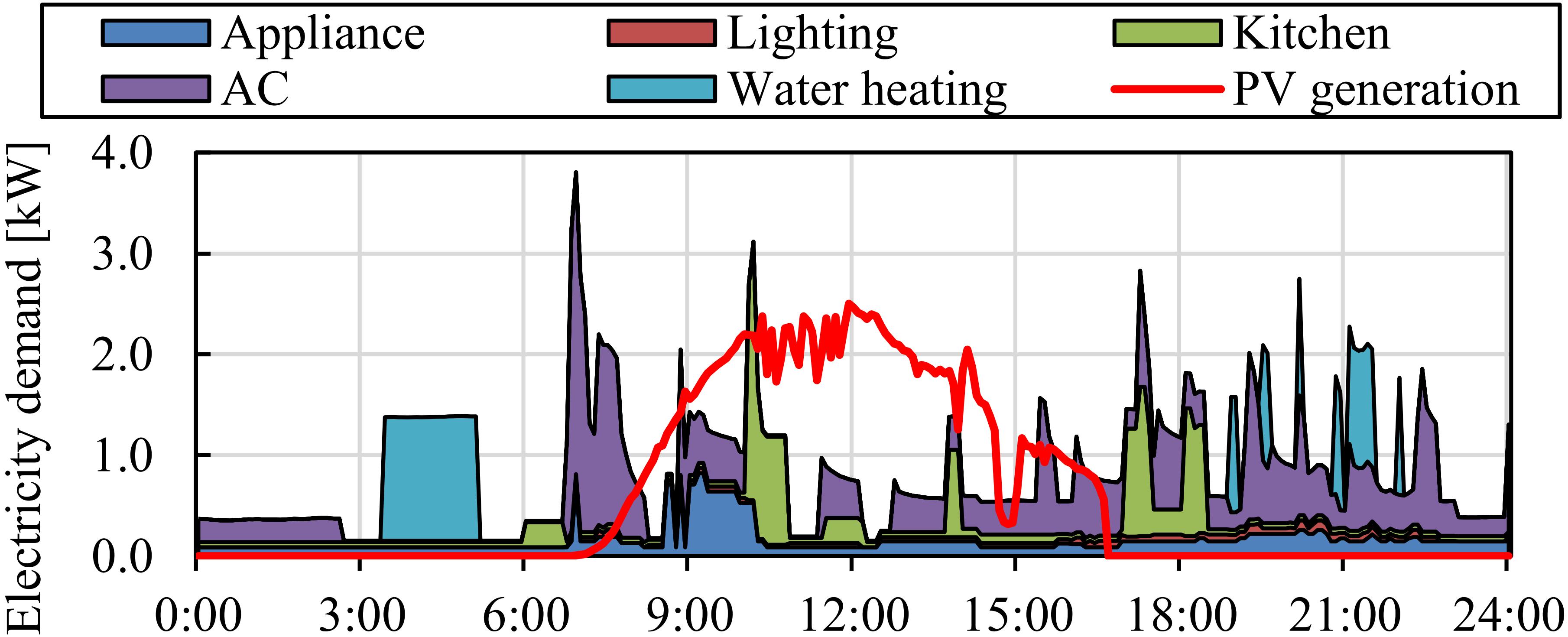
Shimoda 2014

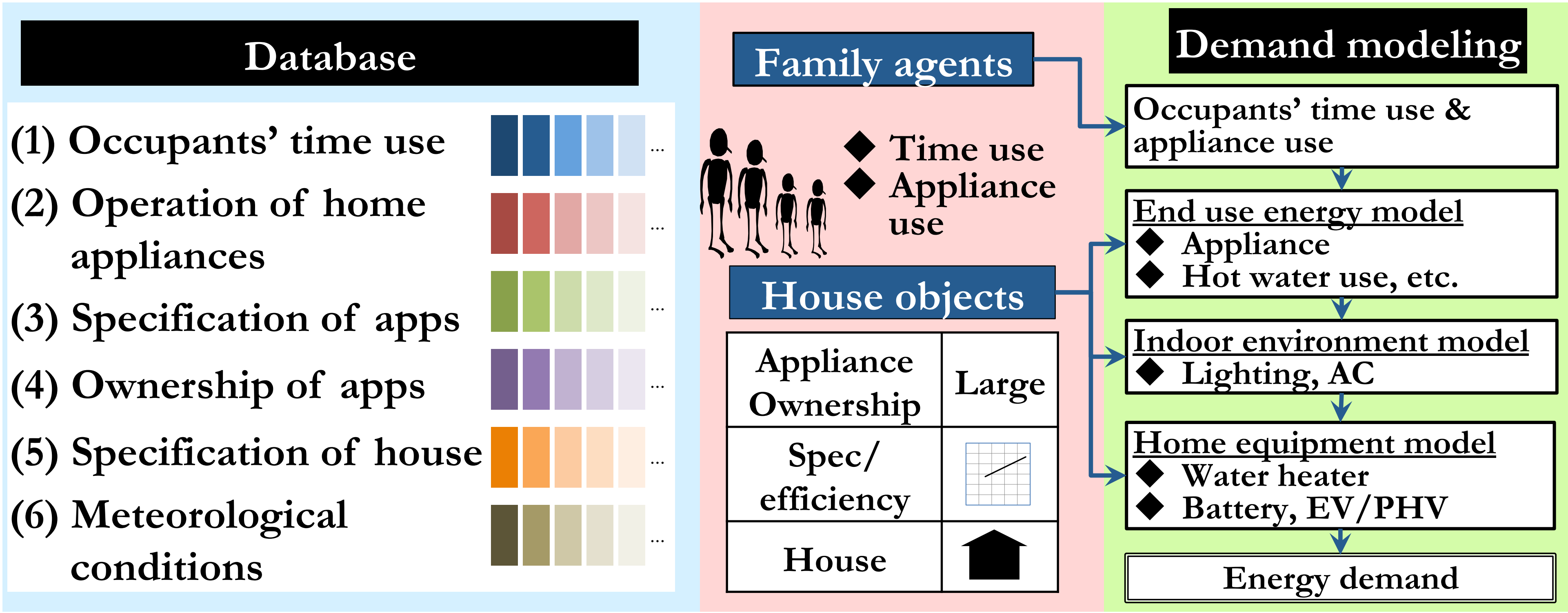






Time use ⇨ **Operation of home appliances** ⇨ **Status and spec** ⇨ **Energy consumption**



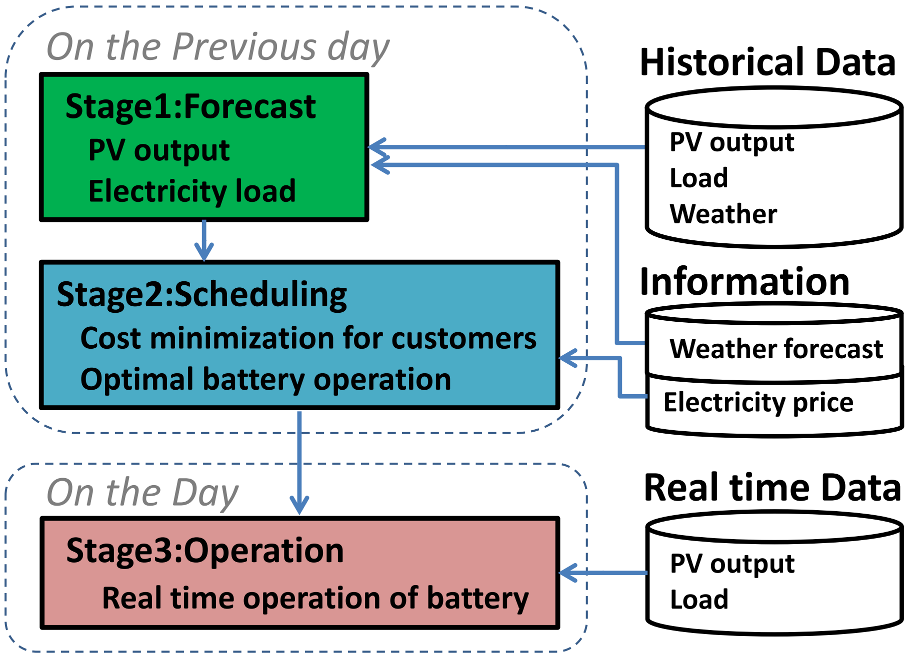


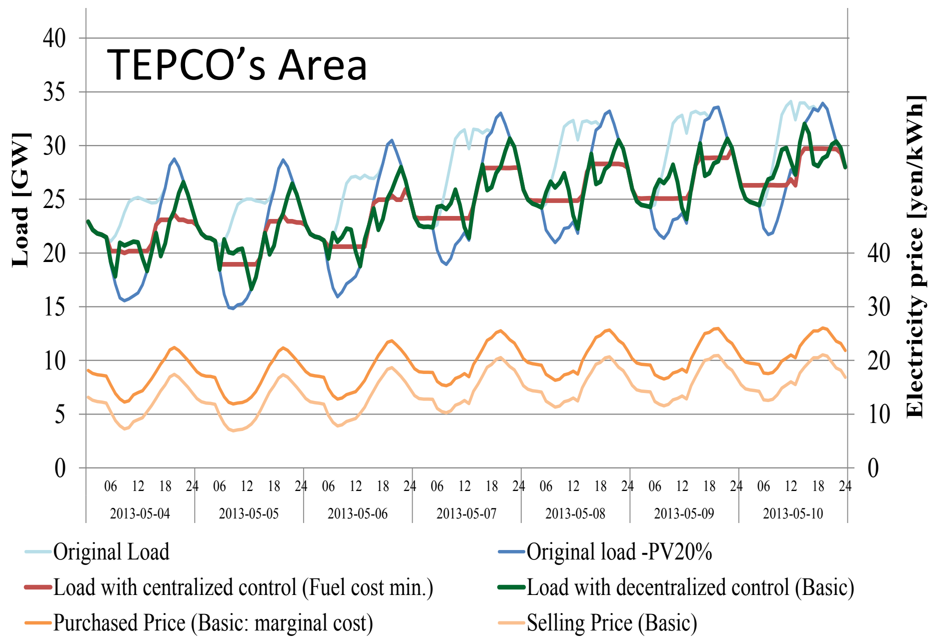
Database
(1) Occupants' time use
(2) Operation of home appliances
(3) Specification of apps
(4) Ownership of apps
(5) Specification of house
(6) Meteorological conditions
Family agents
Time use
Appliance use
House objects
Appliance Ownership
Large
Spec/ efficiency
House
Demand modeling
Occupants' time use & appliance use
End use energy model
Appliance
Hot water use, etc.
Indoor environment model
Lighting, AC
Home equipment model
Water heater
Battery, EV/PHV
Energy demand

Iwafune 2014

Cooperative Home Energy Management Using Batteries for a Rooftop PV System

- ✓Construction of forecast, scheduling and operation model
- ✓Impact of forecast errors on household economics is examined by real HEMS data from 160 households
- ✓Contribution to the entire power system is examined using the model under the dynamic pricing system





System load change by the battery operation of an uncoordinated HEMS

Iwafune 2014

To investigate the consumer acceptance of HEMS・・・

- ✓ 39 depth interviews were conducted
- ✓ 10,188 valid answers were collected by web-based survey

Individuals who are likely to accept HEMS have・・・

- ✓ Higher intention regarding energy saving
- ✓ Higher intention to improve their living environment
- ✓ Desire to keep high indoor comfortability

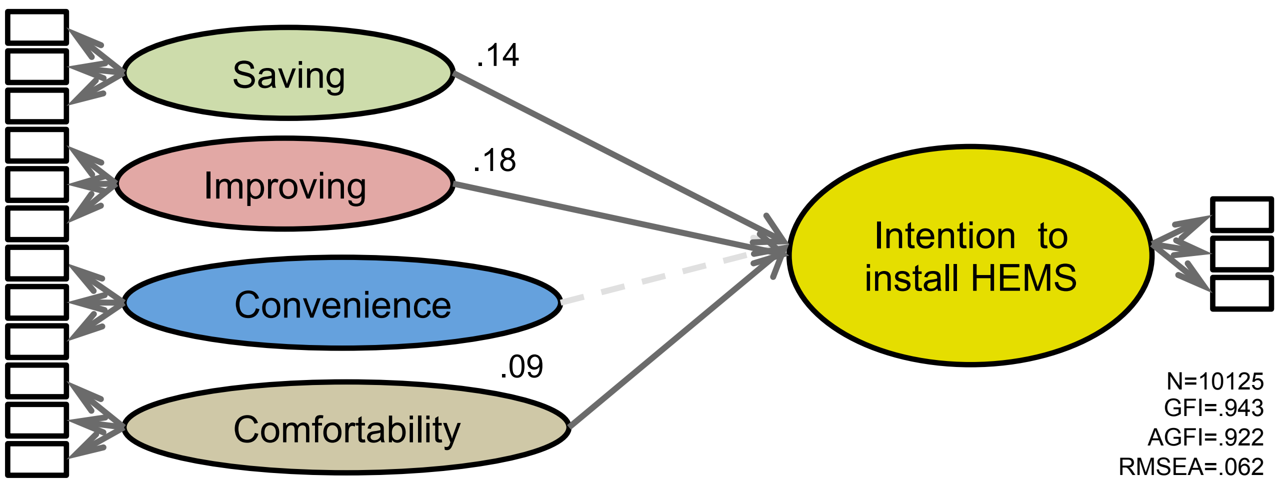


Fig. Covariance Structure Analysis for HEMS installing Intention

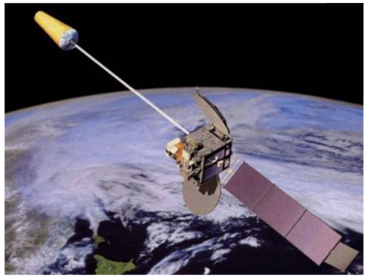
The solid line indicates significant causality at $p<.01$
Path coefficients are standardized parameter estimates

Part 2: Terrestrial Science

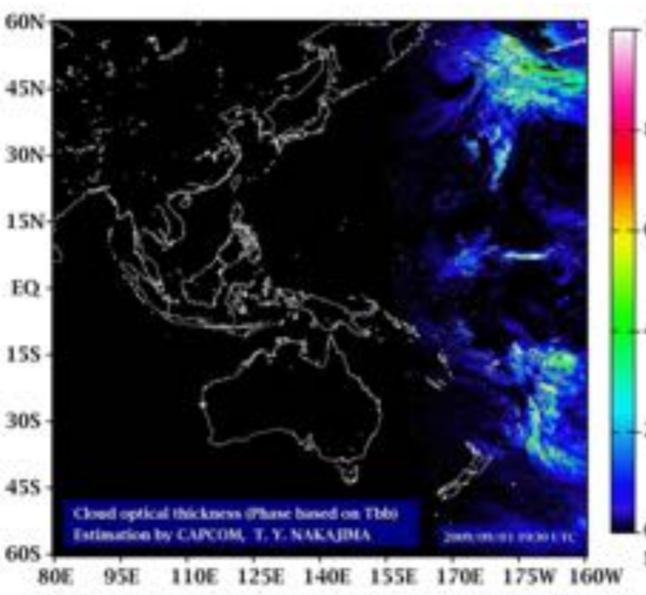
Monitoring: Use of Geostationary Satellites
Prediction: Development of Global Models
Validation: Ground-based measurements

Himawari images

Takenaka et al. 2012-2014

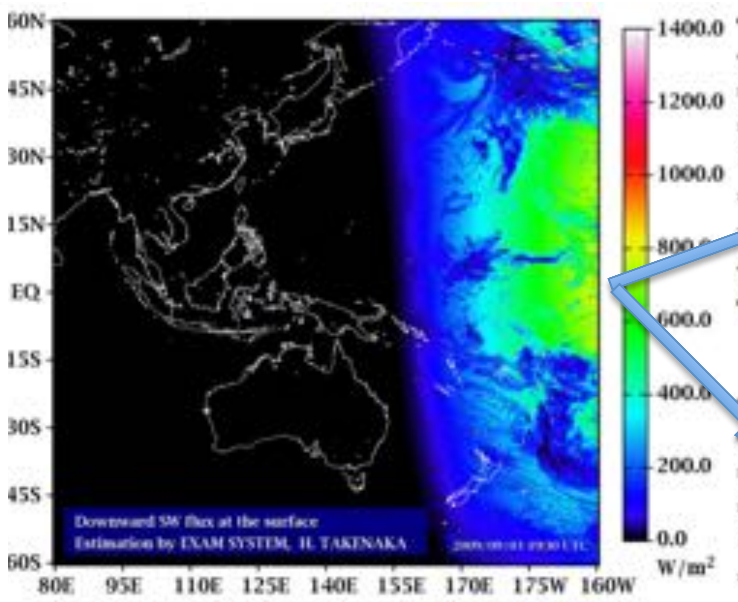


Inversion, then Forward



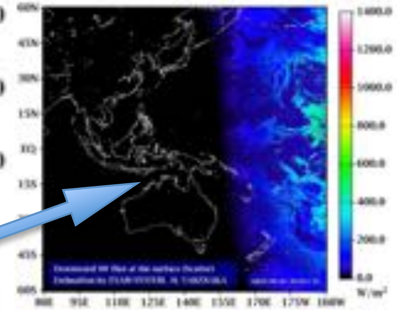
Cloud properties

by CAPCOM

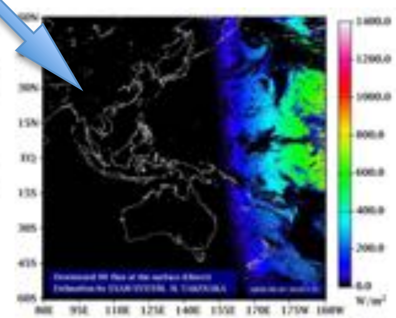


Solar radiation

by EXAM SYSTEM



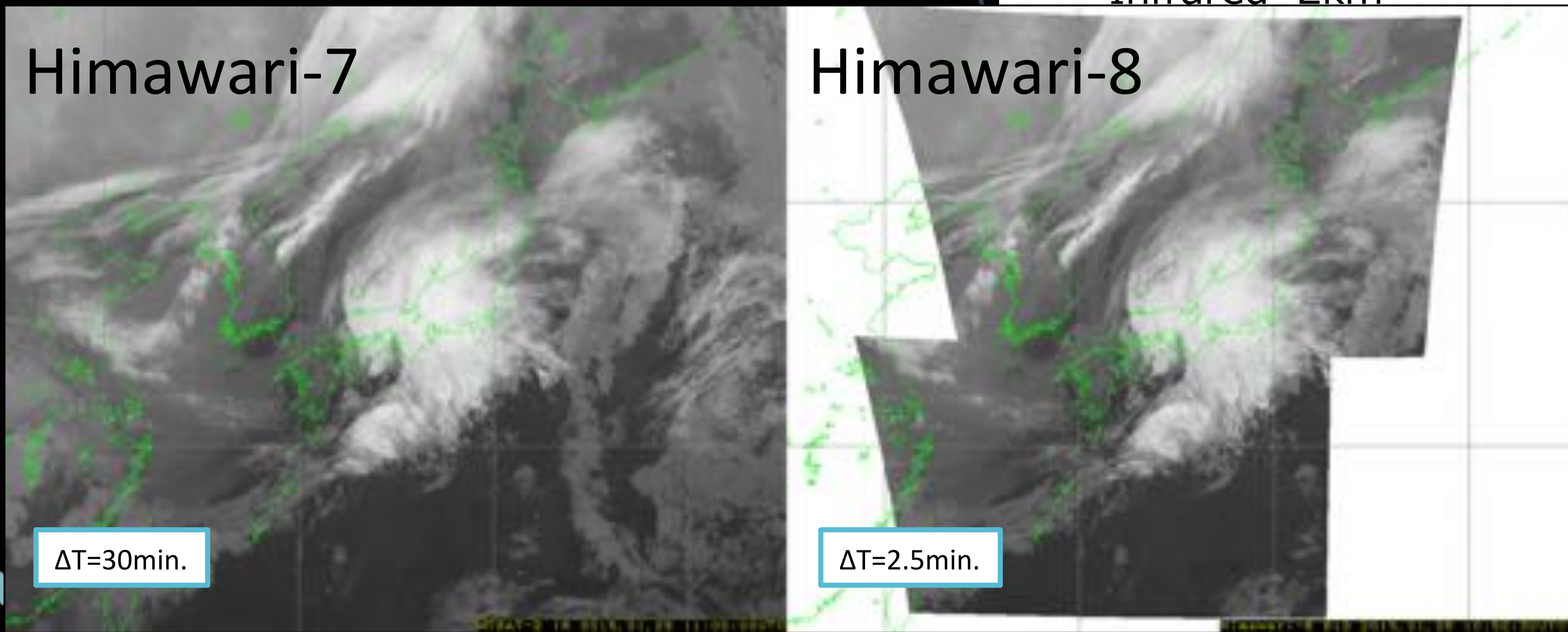
Diffuse



Direct

New Geostationary Satellite (Himawari-8)

- World first 3rd generation.
  Launch Oct, 7, 2014
  First-light Dec, 12, 2014
  Start Operation July 2015
- Observation Frequency
  Every 10 min (2.5min)
- Spatial Resolution
  Visible 1km (0.5km)
  Infrared 2km



2014 HIMAWARI-8

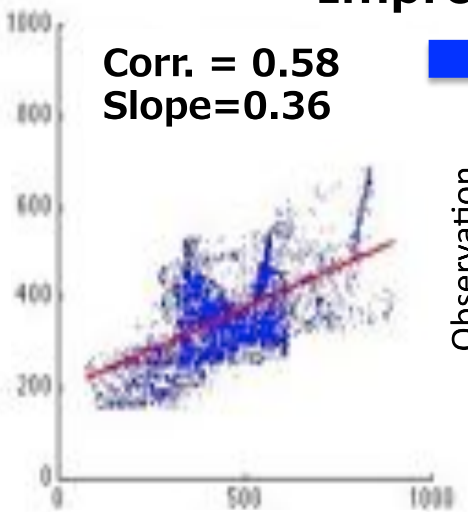
Uchida, Inoue, Te Nakajima 2014

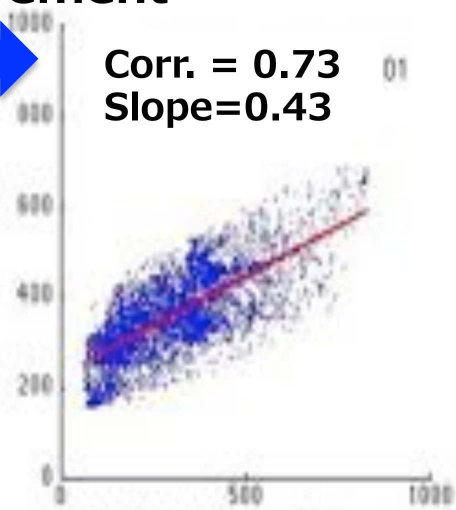
- Cloud Assimilation is important for short term prediction of solar irradiance.
- This is a big challenge because cloud assimilation conflicts thermal dynamics conservations.
- We developed semi-empirical method

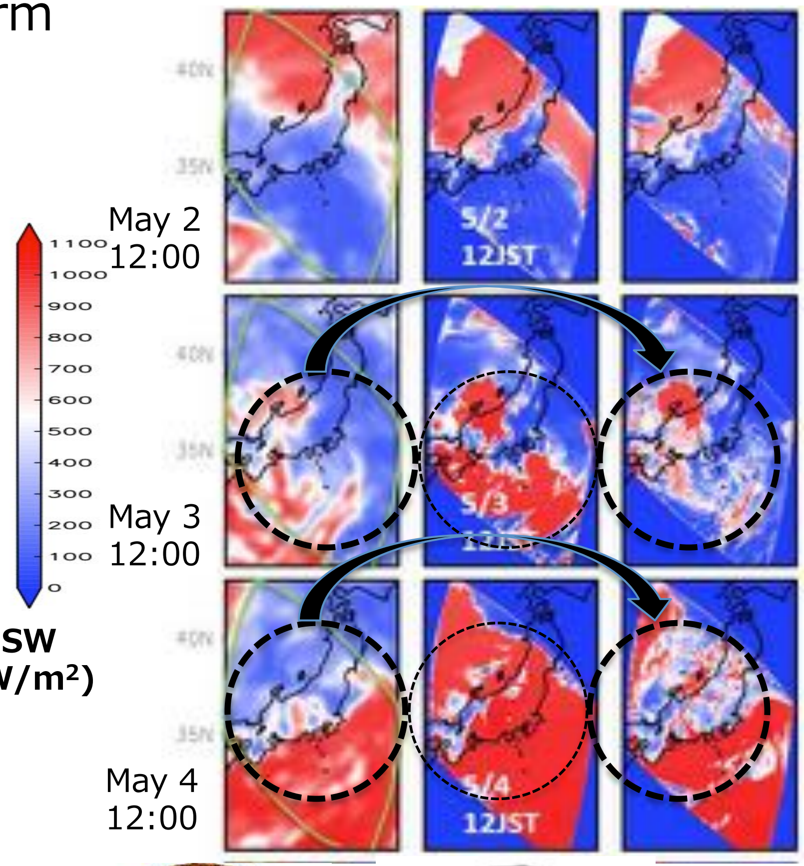
Nudging cloud water path (Qc) obtained from satellite in Diamond NICAM model.

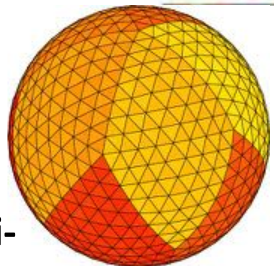
- **Results:** improve cloud field in the model !

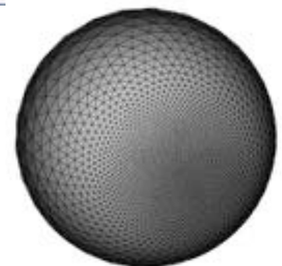
Improvement

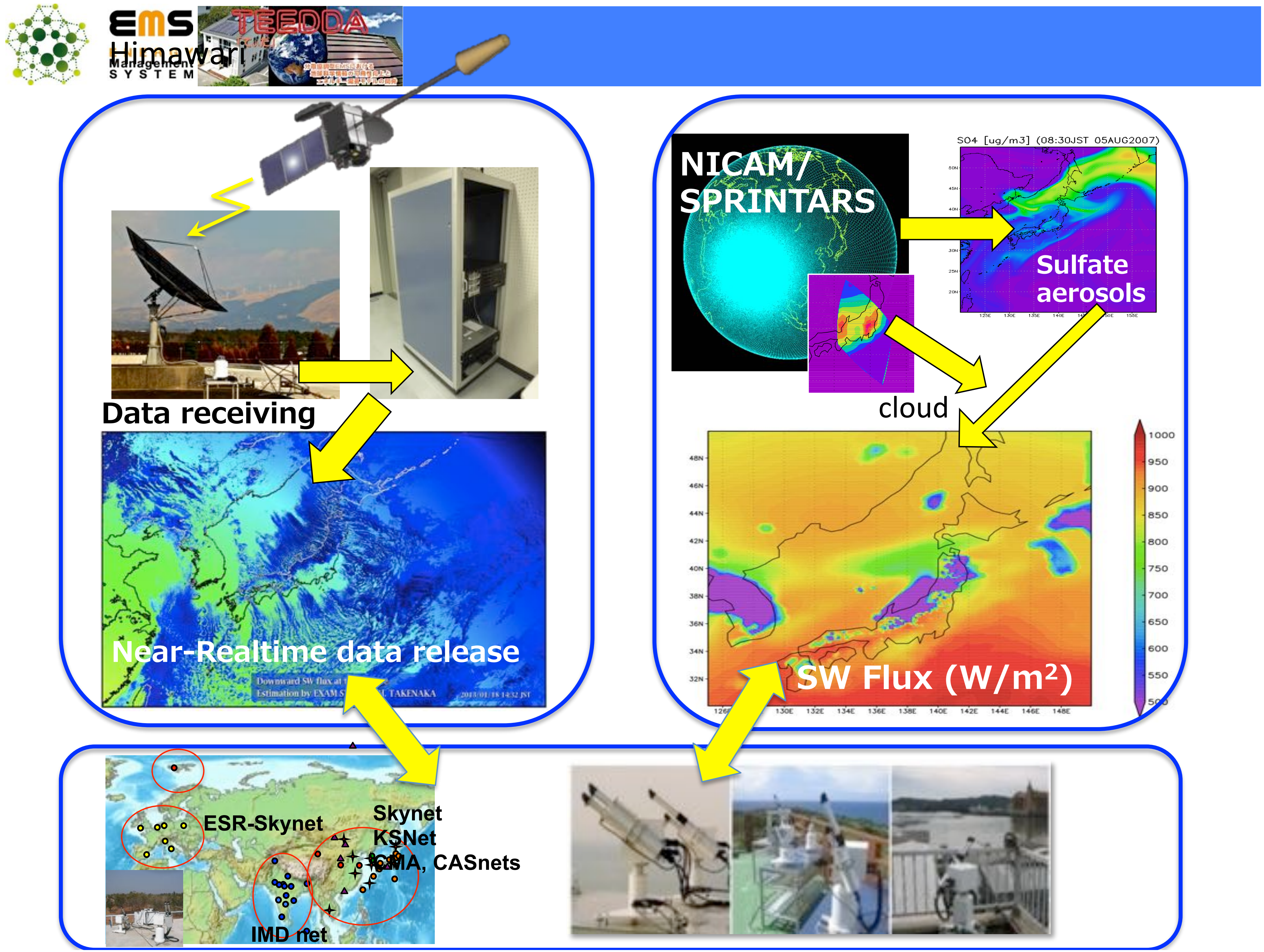







Quasi-homogeneous grid


Stretched grid



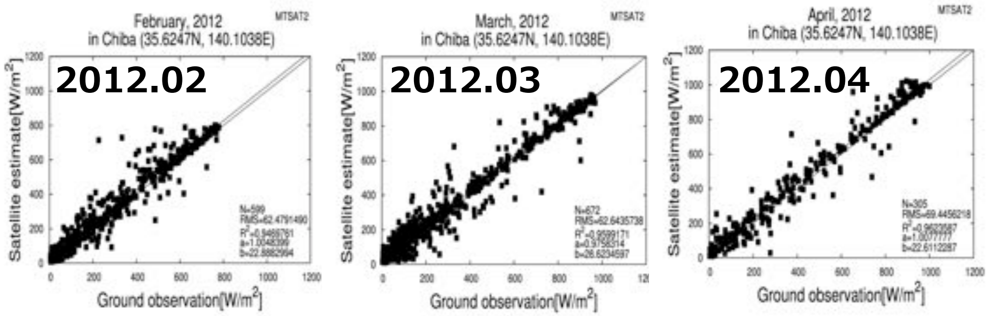
EMS
Himawari
Management SYSTEM
TEEDDA
NICAM/ SPRINTARS
SO4 [ug/m3] (08:30JST 05AUG2007)
Sulfate aerosols
cloud
Data receiving
Near-Realtime data release
SW Flux (W/m²)
1000
950
900
850
800
750
700
650
600
550
ESR-Skynet
Skynet
KSNet
CMA, CASnets
IMD net

Chiba-U : QA and Detection of data anomaly

Irie 2015

Ground base VS Satellite base

Satellite



Ground measurements

Uncertainty : Partial cloud, aerosols
Need quantification.

An application is detection of data anomaly
※anomaly of sensor, severe weather, heavy air pollution

Satellite, Model

Ground Observation

- **Comparison**
- **Validation**
- **Detect anomaly**

Development of detection system for data anomaly

User
- **Demand groups**
- **EMS Teams**
- **Others**

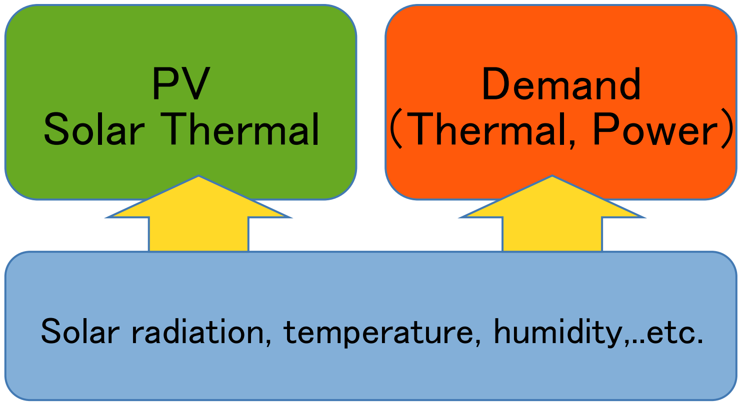
Lessons learned from solar irradiance study

Knowledge from Terrestrial Science

e.g. Around **Japan**,

- Large solar irradiance in May.
- Small direct and large diffuse component in June and July.
- Large annual variability in June and July. (Unstable)
- Similar pattern from Sep. to Mar. (Stable)

➢ One may understand trends of solar irradiance in East Asia using middle to long term dataset.



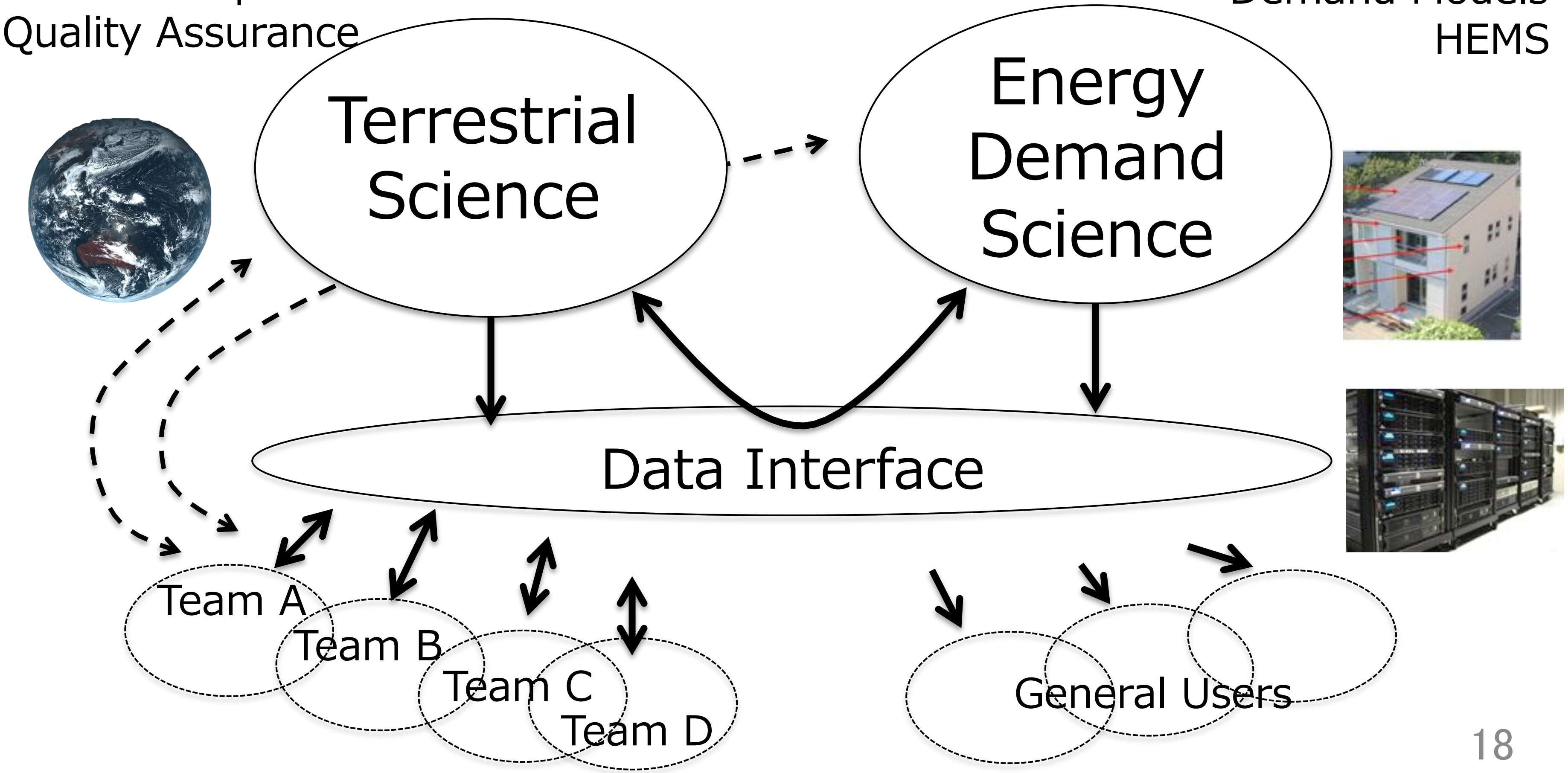
- ✓ **Contribute to renewable energy use.**
- ✓ **Important information to demand science**

Summary and Future Studies

Q. Uncertainty of Terrestrial Data ?
Q. How does Terrestrial Data affect demands ?
Q. How do terrestrial and demand data affect EMS ?

Solar irradiance estimation
Short term prediction
Quality Assurance

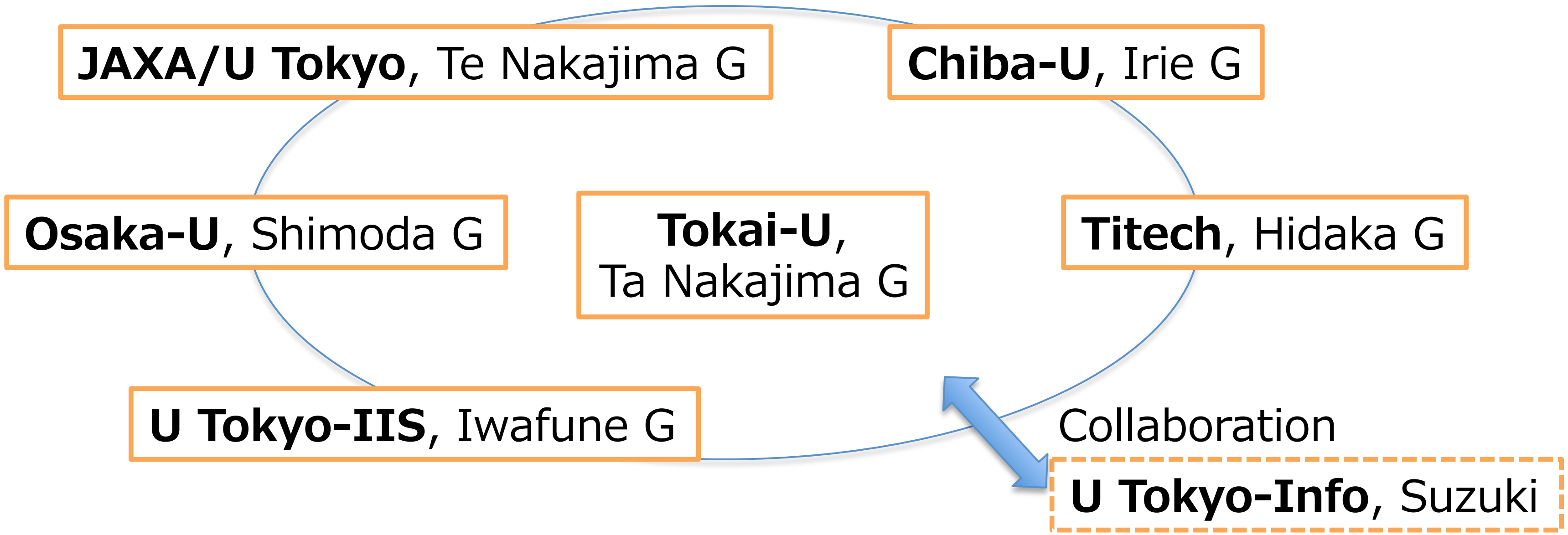
Behavior modification
Demand Models
HEMS



Vision of Nakajima Team

[Terrestrial Science], [Energy Demand Science]
+
[Data Interface]

1. Fusion of Energy Demand Science and Terrestrial (Earth) Science
2. Development of GeoSimWORLD database
3. Implementation, International collaboration and clarification of future studies



Our team

Tokai U.

TRIC (Yoyogi)

Shonan

Project Lab.

Kumamoto

Receiving station at Space info. Center

Iriomote

Okinawa Regional Research Center

JAXA/U. Tokyo

Tsukuba

Chiba U.

CEReS

SKYNET
30 sites

Osaka U.

Suita Campus

U. Tokyo, IIS

Komaba-II Campus

Titech

Tamachi Campus

Thank you so much.