Advancing Data Assimilation as a Science Hub
Weather prediction and beyond

Takemasa Miyoshi

Ph.D. (Meteorology)
Data Assimilation Scientist

Data Assimilation Research Team

RIKEN

Who am I?

B.S. from Kyoto U
↓
JMA administration (2y)
↓
JMA NWP (1.25y)
↓
UMD (2y, M.S. and Ph.D.)
↓
JMA NWP (3.5y)
↓
UMD (4y)
↓
RIKEN (5.5y+)

Takemasa Miyoshi, Ph.D.

Team Leader
Data Assimilation Research Team
RIKEN Center for Computational Science

Deputy Director
RIKEN interdisciplinary Theoretical and Mathematical Sciences
(iTHEMS) Program

Chief Scientist
Prediction Science Laboratory
RIKEN Cluster for Pioneering Research

Visiting Professor
University of Maryland, College Park

Affiliate Professor
Graduate School of Science, Kyoto University

Visiting Principal Scientist
Application Laboratory, JAMSTEC

Research Counselor
Servicio Meteorológico Nacional (National Meteorological Service),
Argentina

JSTnews

Education

- **2005** Ph.D. in Meteorology, University of Maryland, College Park, Maryland, USA (Dissertation PDF)
- **2004** M.S. in Meteorology, University of Maryland, College Park, Maryland, USA (Scholarly Paper PDF)
- **2000** B.S. in Physics, Faculty of Science, Kyoto University, Kyoto, Japan

TEDx
Sannomiya

Japan's flagship institute for computational science

Missions:

1) Development & operation of the Japanese flagship supercomputer

2) Center of Excellence for research on computational science

Japan's flagship institute for computational science

Missions:

1) Development & operation of the Japanese flagship supercomputer

2) Center of Excellence for research on computational science

"Post-K" is under development
"FLAGSHIP2020 project"

Data Assimilation Research Team
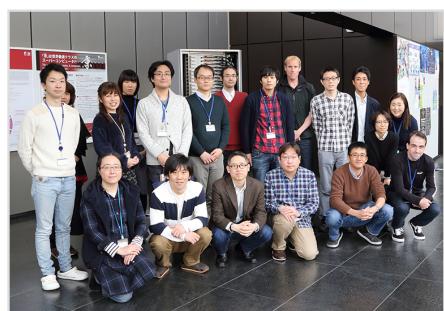
Data Assimilation Research Team

Data Assimilation Research Team was launched in October, 2012, in RIKEN Advanced Institute for Computational Science (AICS), conveniently located in the beautiful and historic city of Kobe. RIKEN is known as the flagship research institution in Japan. On April 1, 2018, RIKEN AICS was renamed RIKEN Center for Computational Science (R-CCS). R-CCS is operating the world's leading K computer, and also has a strong Research Division. R-CCS takes the lead in advancing the computational science and aims to be an international center of excellence for computational science in collaboration with a wide range of research organizations. R-CCS integrates the computer science and computational science to conduct most advanced research and development of a wide range of applied scientific computation, as well as of high performance computing technologies.

Data assimilation is a cross-disciplinary science to synergize numerical simulations and observational data, using statistical methods and applied mathematics. As computers become more powerful and enable more precise simulations, it will become more important to compare the simulation with actual observations.

Data Assimilation Research Team ("DA team") performs cutting-edge research and development on advanced data assimilation methods and their applications, aiming at integrating computer simulations and observational data in the wisest way. Particularly, the DA team will tackle challenging problems of developing efficient and accurate data assimilation systems for high-dimensional simulations with large amount of data. The specific aims include 1) research on parallel-efficient algorithms for data assimilation with the super-parallel K computer, 2) research on data assimilation methods and applications by taking advantage of the world-leading K computer, and 3) development of most advanced data assimilation software optimized the K computer.

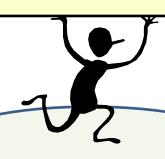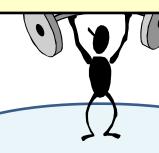February 21, 2018 at R-CCS

http://www.data-assimilation.riken.jp/

Team Leader	Research Scientist	Research Scientist	Research Scientist (Excellent Young Researcher)
Takemasa Miyoshi	Koji Terasaki	Shigenori Otsuka	Shunji Kotsuki

Postdoctoral Researcher	Postdoctoral Researcher	Special Postdoctoral Researcher	Postdoctoral Researcher	Postdoctoral Researcher	Research Associate
Guo-Yuan Lien	Takumi Honda	Atsushi Okazaki	Kohei Takatama	James Taylor	Yasumitsu Maejima

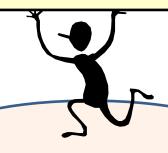| Technical Staff	Technical Staff	Technical Staff	Technical Staff	Technical Staff
Hazuki Arakida	Taeka Awazu	Hideyuki Sakamoto	Marimo Ohhigashi	Kenta Kurosawa

Data Assimilation Research Team
To be a world's leader in DA research

Core

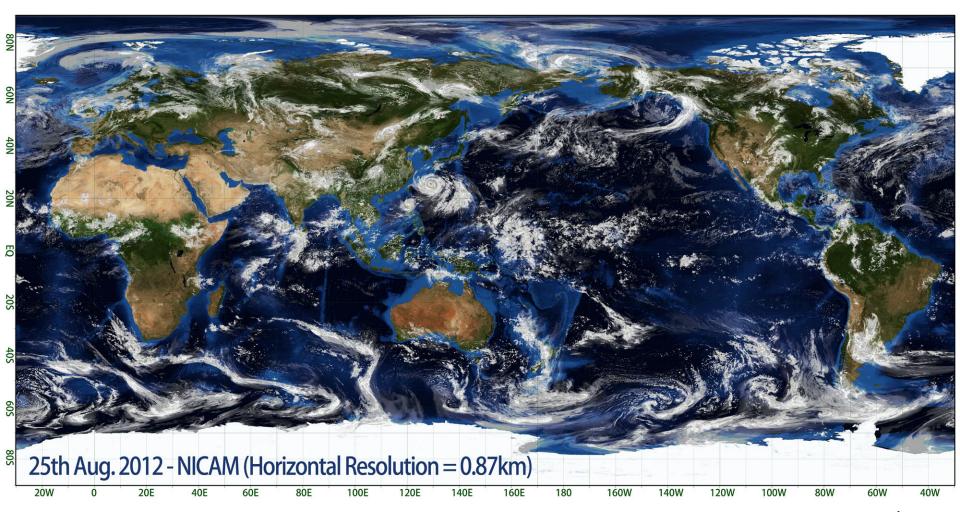DA theory

Algorithm

Computation

Lead

Leading research in NWP

Toward the world's top level

Pioneer

Cross-cutting research beyond NWP

Broader applications

Global 870-m simulation *(Miyamoto et al. 2013)*

25th Aug. 2012 - NICAM (Horizontal Resolution = 0.87km)

©JAMSTEC・AORI (SPIRE Field3), RIKEN/AICS
Visualized by Ryuji Yoshida

©RIKEN

TimeStep: 7

WOW

©JAMSTEC・AORI (SPIRE Field3), RIKEN/AICS
Visualized by Ryuji Yoshida

cf. TEDxSannomiya
http://tedxsannomiya.com/speakers/takemasa-miyoshi/

Press Release

← Previous | ↑ Index | → Next

January 18, 2018

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Himawari-8 data assimilated simulation enables 10-minute updates of rain and flood predictions

Using the power of Japan's K computer, scientists from the RIKEN Advanced Institute for Computational Science and collaborators have shown that incorporating satellite data at frequent intervals—ten minutes in the case of this study—into weather prediction models can significantly improve the rainfall predictions of the models and allow more precise predictions of the rapid development of a typhoon.

Weather prediction models attempt to predict future weather by running simulations based on current conditions taken from various sources of data. However, the inherently complex nature of the systems, coupled with the lack of precision and timeliness of the data, makes it difficult to conduct accurate predictions, especially with weather systems such as sudden precipitation.

As a means to improve models, scientists are using powerful supercomputers to run simulations based on more frequently updated and accurate data. The team led by Takemasa Miyoshi of AICS decided to work with data from Himawari-8, a geostationary satellite that began operating in 2015. Its instruments can scan the entire area it covers every ten minutes in both visible and infrared light, at a resolution of up to 500 meters, and the data is provided to meteorological agencies. Infrared measurements are useful for indirectly gauging rainfall, as they make it possible to see where clouds are located and at what altitude.

News & Media

Press Release

January 18, 2018

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Himawari-8 DA papers published (*Honda et al. 2018a,b*, JGR & MWR)

Assimilation of Himawari-8 All-Sky Radiances Every 10 Minutes: Impact on Precipitation and Flood Risk Prediction

T. Honda[1], S. Kotsuki[1], G.-Y. Lien[1], Y. Maejima[1], K. Okamoto[2,1], and T. Miyoshi[1,3,4]

[1]RIKEN Advanced Institute for Computational Science, Kobe, Japan, [2]Meteorological Research Institute, Japan Meteorological Agency, Tsukuba, Japan, [3]Department of Atmospheric and Oceanic Science, University of Maryland, College Park, Maryland, USA, [4]Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan

Correspondence to:
T. Honda and T. Miyoshi,
takumi.honda@riken.jp;
takemasa.miyoshi@riken.jp

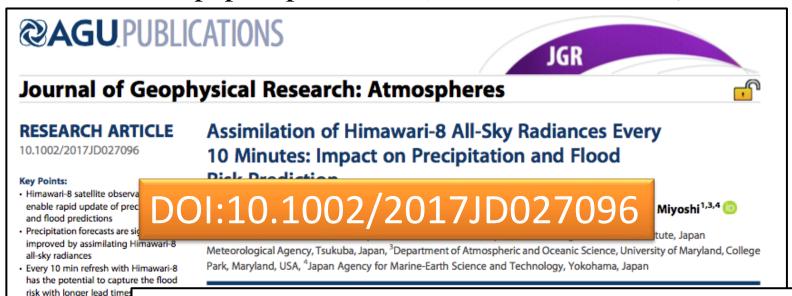## Assimilating All-Sky *Himawari-8* Satellite Infrared Radiances: A Case of Typhoon Soudelor (2015)

TAKUMI HONDA,[a] TAKEMASA MIYOSHI,[b] GUO-YUAN LIEN,[a] SEIYA NISHIZAWA,[a] RYUJI YOSHIDA,[a] SACHIHO A. ADACHI,[a] KOJI TERASAKI,[a] KOZO OKAMOTO,[c] HIROFUMI TOMITA,[a] AND KOTARO BESSHO[d,e]

[a] RIKEN Advanced Institute for Computational Science, Kobe, Japan
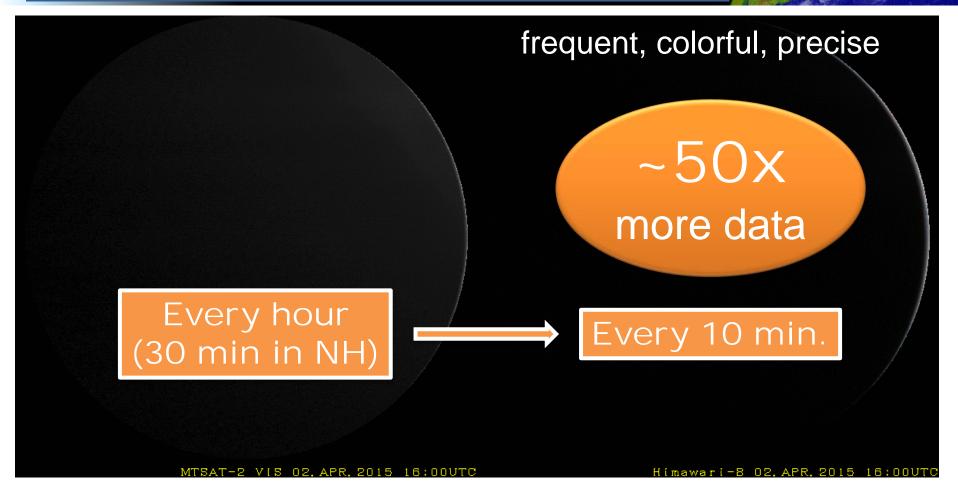[b] RIKEN Advanced Institute for Computational Science, Kobe, Japan, and Department of Atmospheric and Oceanic Science, University of Maryland, College Park, College Park, Maryland, and Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan
[c] Meteorological Research Institute, Japan Meteorological Agency, Tsukuba, and RIKEN Advanced Institute for Computational Science, Kobe, Japan
[d] Meteorological Satellite Center, Japan Meteorological Agency, Kiyose, Japan

(Manuscript received 15 September 2016, in final form 18 November 2017)

Himawari-8 DA papers published (*Honda et al. 2018a,b*, JGR & MWR)

Assimilation of Himawari-8 All-Sky Radiances Every 10 Minutes: Impact on Precipitation and Flood Risk Prediction

DOI:10.1002/2017JD027096

Miyoshi[1,3,4]

...tute, Japan
Meteorological Agency, Tsukuba, Japan, [3]Department of Atmospheric and Oceanic Science, University of Maryland, College Park, Maryland, USA, [4]Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan

Correspondence to:
T. Honda and T. Miyoshi,
takumi.honda@riken.jp;
takemasa.miyoshi@riken.jp

Assimilating All-Sky *Himawari-8* Satellite Infrared Radiances: A Case of Typhoon Soudelor (2015)

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DOI:10.1175/MWR-D-16-0357.1

...of
Atmospheric and Oceanic Science, University of Maryland, College Park, College Park, Maryland, and Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan
[c] Meteorological Research Institute, Japan Meteorological Agency, Tsukuba, and RIKEN Advanced Institute for Computational Science, Kobe, Japan
[d] Meteorological Satellite Center, Japan Meteorological Agency, Kiyose, Japan

Himawari-8: a new generation geostationary meteorological satellite

frequent, colorful, precise

~50x more data

Every hour (30 min in NH) → **Every 10 min.**

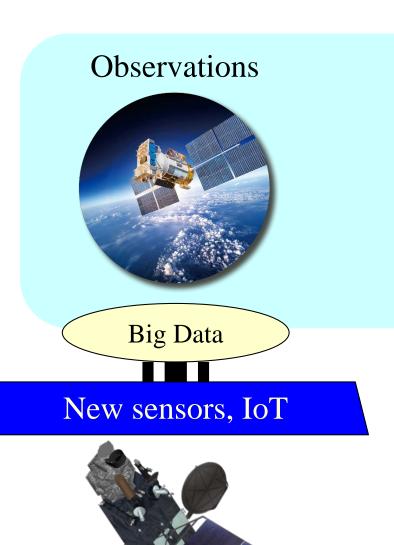MTSAT-2 VIS 02. APR. 2015 16:00UTC   Himawari-8 02. APR. 2015 16:00UTC

16UTC 2 to 13UTC 3 April 2015
MTSAT-2 (VIS)
Every 1 hour

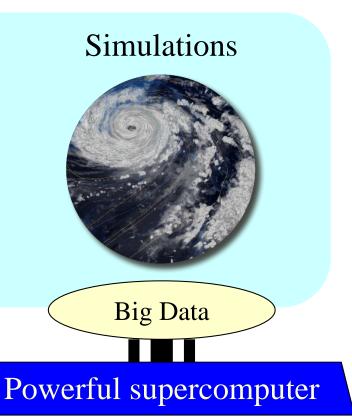16UTC 2 to 13UTC 3 April 2015
Himawari-8 (True Color)
Every 10 minutes

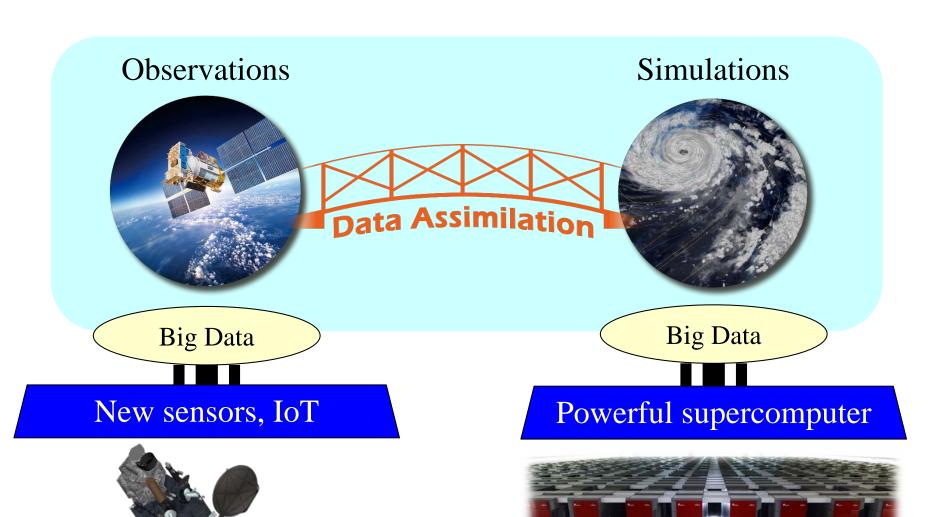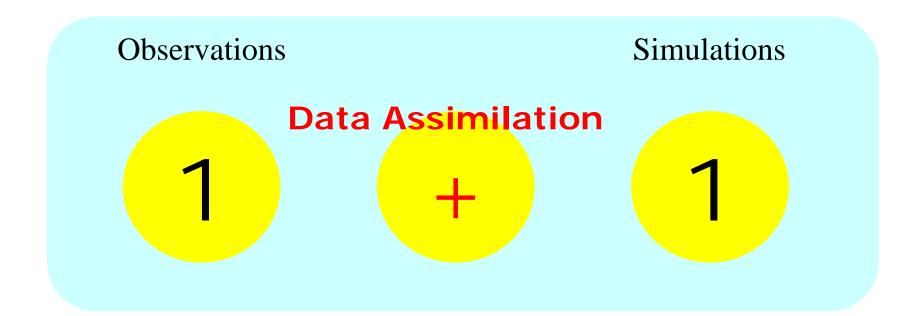(Courtesy of JMA)

Sources of Big Data

Observations

Big Data

New sensors, IoT

Sources of Big Data

Observations

Simulations

Big Data

Big Data

New sensors, IoT

Powerful supercomputer

©RIKEN

Big Data Assimilation

Observations

Simulations

Data Assimilation

Big Data

Big Data

New sensors, IoT

Powerful supercomputer

©RIKEN

Data Assimilation (DA)

Data Assimilation (DA)

Data-driven
Induction
Real world

Process-driven
Deduction
Cyber world

Observations

Simulations

Data Assimilation

1 **+** **1**

>2

SCALE-LETKF system

Himawari-8

Regional weather model

LETKF

Data Assimilation

(JMA)
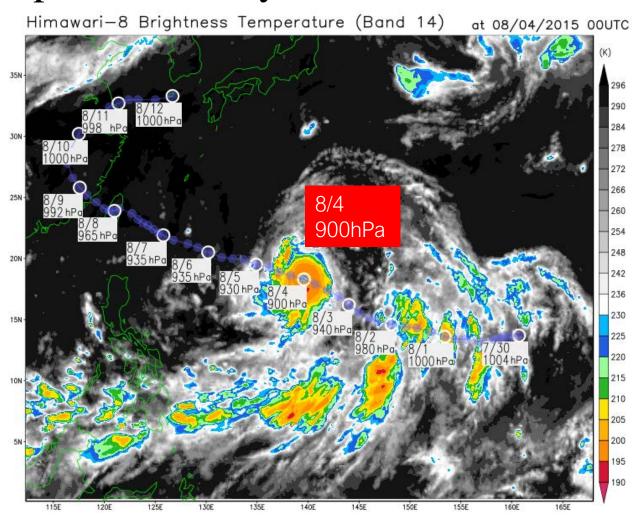
Local Ensemble Transform Kalman Filter
(Hunt et al. 2007)

SCALE-LETKF
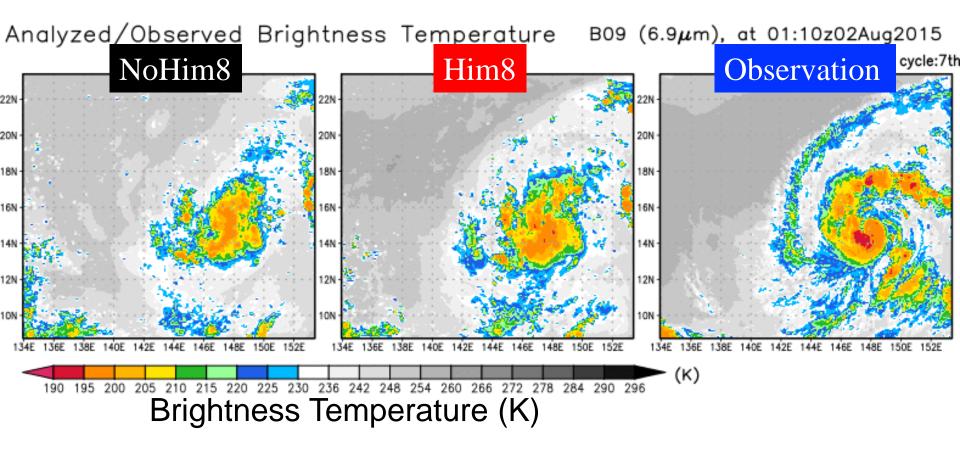
A Regional Numerical Weather Prediction System
developed at RIKEN
(Lien et al. 2017, DOI:10.2151/sola.2017-001)

Typhoon Soudelor (2015)
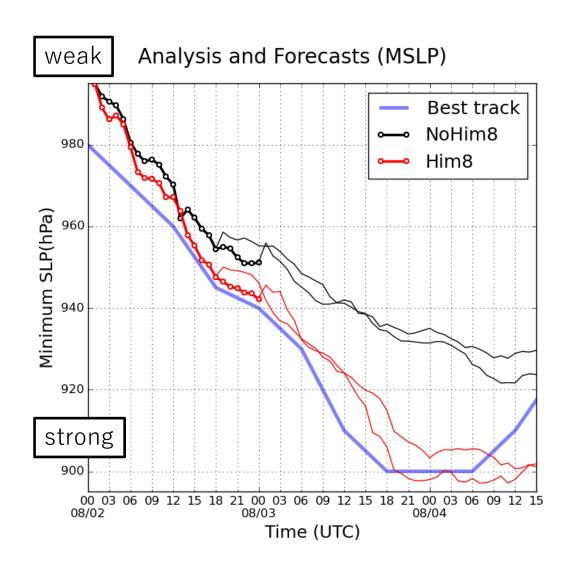
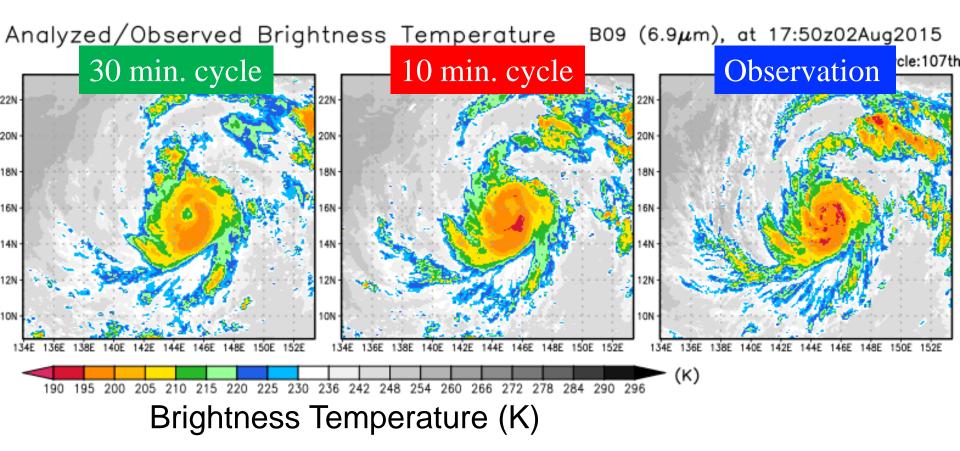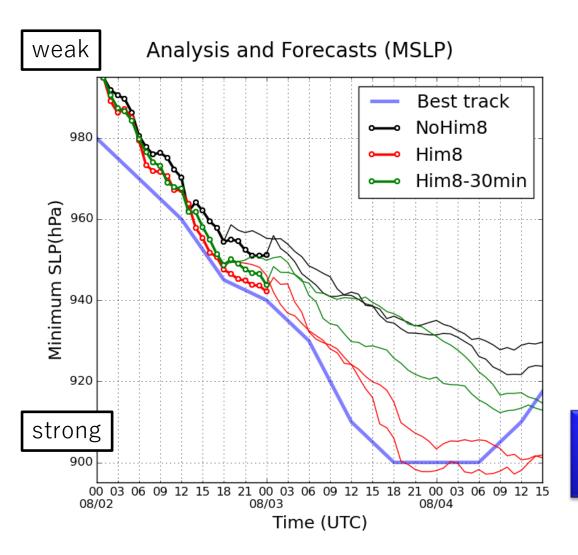- The strongest western north Pacific typhoon in 2015 captured well by Himawari-8

Himawari-8 Brightness Temperature (Band 14)   at 08/04/2015 00UTC

Himawari-8 impact

Analyzed/Observed Brightness Temperature   B09 (6.9μm), at 01:10z02Aug2015

NoHim8   Him8   Observation

cycle:7th

Brightness Temperature (K)

190 195 200 205 210 215 220 225 230 236 242 248 254 260 266 272 278 284 290 296 (K)

Himawari-8 impact on intensity fcst

Every 10 min. vs. 30 min. DA

Analyzed/Observed Brightness Temperature   B09 (6.9μm), at 17:50z02Aug2015

30 min. cycle   10 min. cycle   Observation

Brightness Temperature (K)
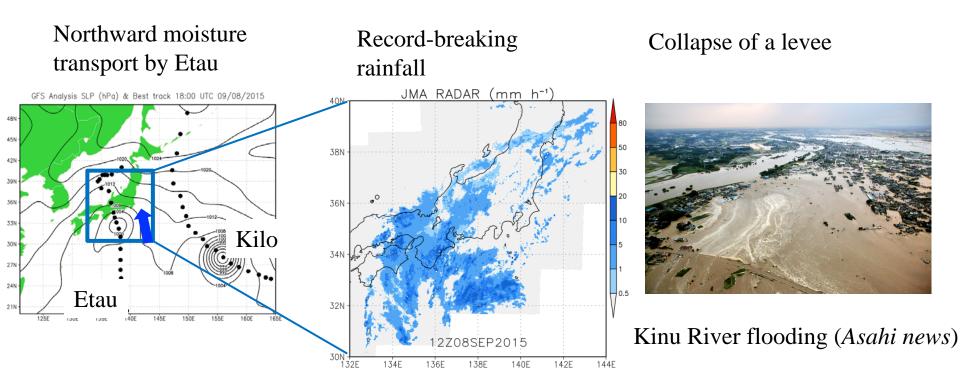
Intensity forecast (30 min. vs. 10 min.)

weak

strong

Analysis and Forecasts (MSLP)

Minimum SLP(hPa)

Legend:
- Best track
- NoHim8
- Him8
- Him8-30min

Time (UTC)

00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15
08/02 · 08/03 · 08/04
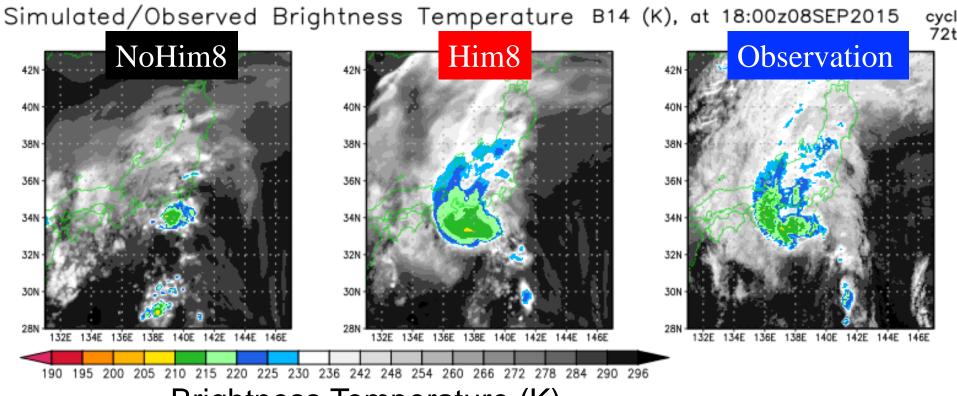
Assimilating every 10-min. is essential.

Another case: September 2015

Northward moisture transport by Etau

Record-breaking rainfall

Collapse of a levee

Kinu River flooding (*Asahi news*)

Himawari-8 impact

Simulated/Observed Brightness Temperature B14 (K), at 18:00z08SEP2015 cycl
72t

NoHim8   Him8   Observation

Brightness Temperature (K)

190 195 200 205 210 215 220 225 230 236 242 248 254 260 266 272 278 284 290 296
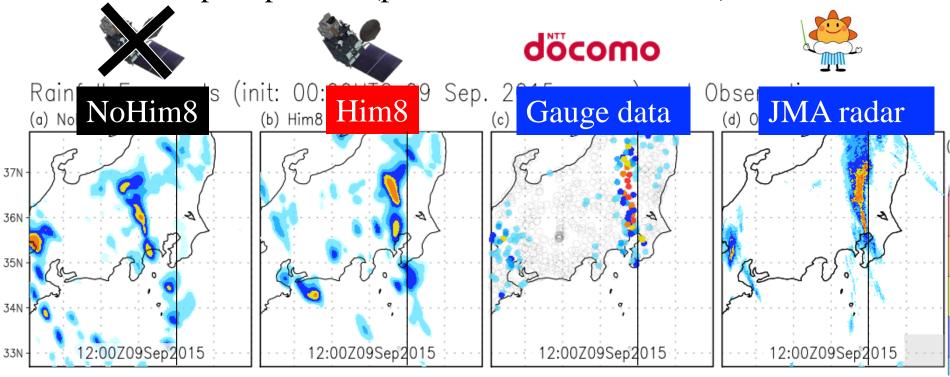
High clouds   Low clouds/clear sky

Himawari-8 impact
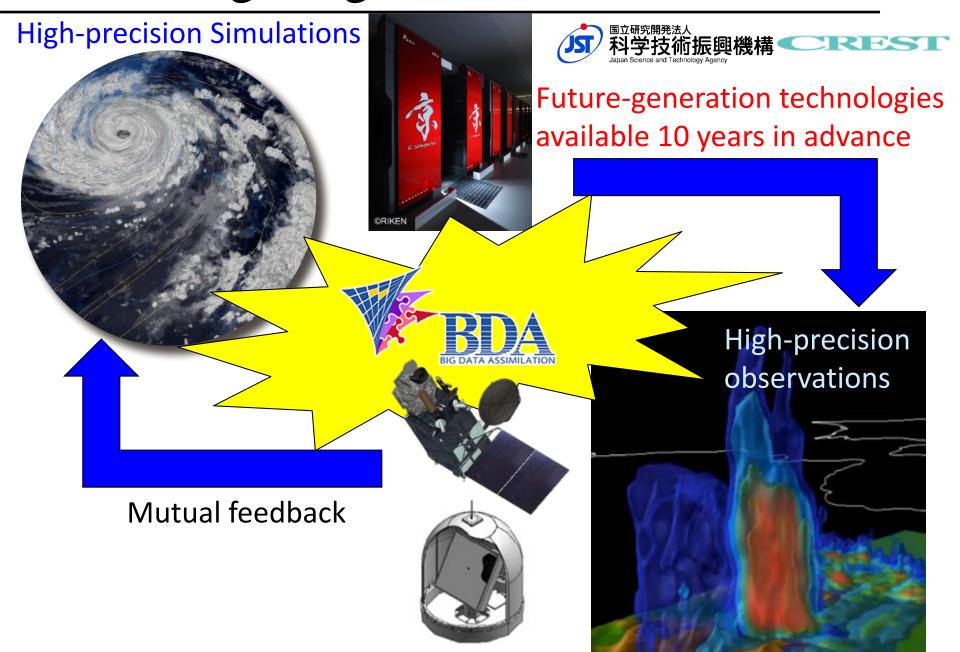
12-h forecast precipitation (previous 1 h accumulation)

NoHim8   Him8   Gauge data   JMA radar

(Honda et al. 2017)

12-h forecast rain location much improved
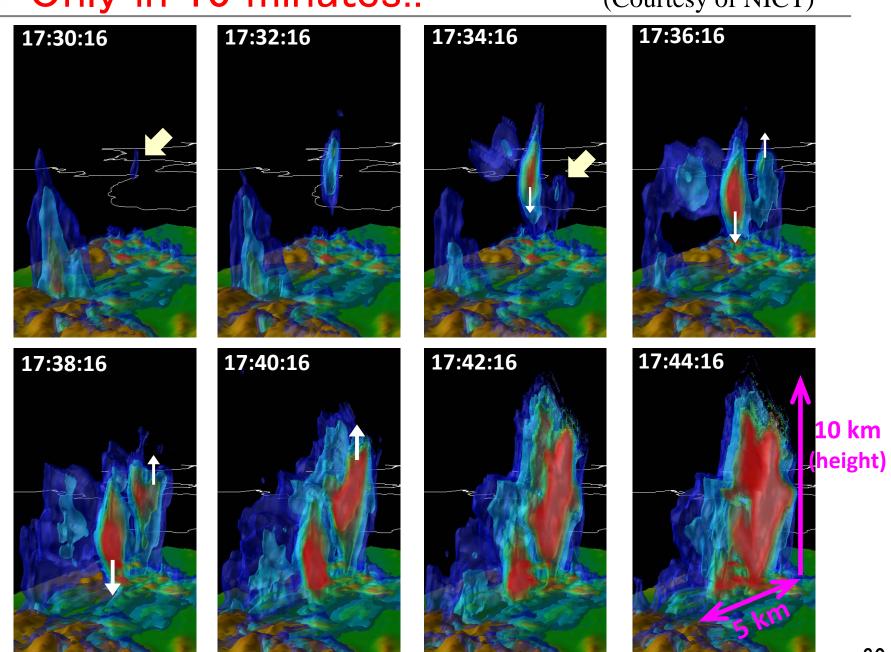
Pioneering "Big Data Assimilation" Era

High-precision Simulations

Future-generation technologies available 10 years in advance

High-precision observations

Mutual feedback
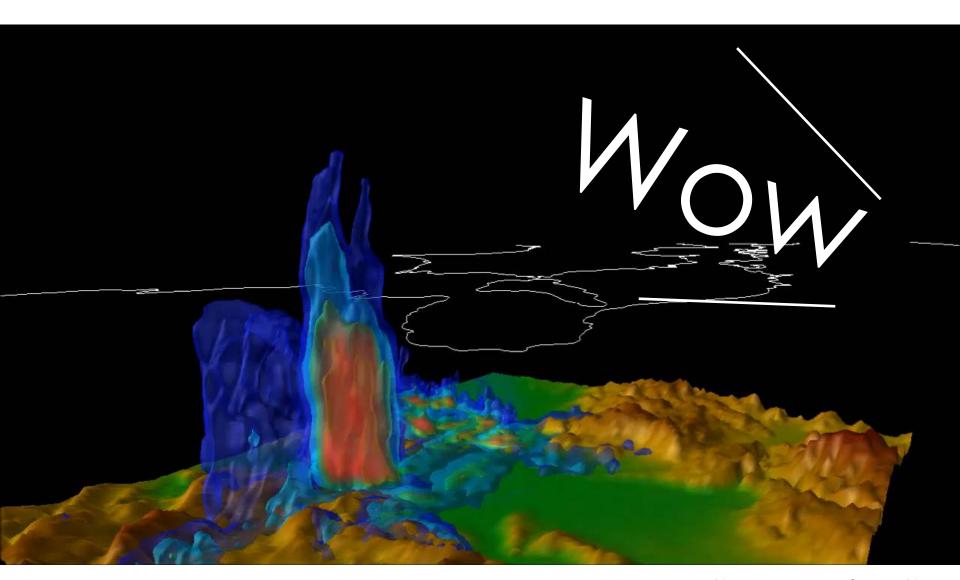
Phased Array Weather Radar (PAWR)

3-dim measurement using a parabolic antenna (150 m, 15 EL angles in 5 min)

100x more data!
10x more data in a 1/10 period

約2m

約2m

無線装置の外観

方位角　仰角

アンテナ走査の概念
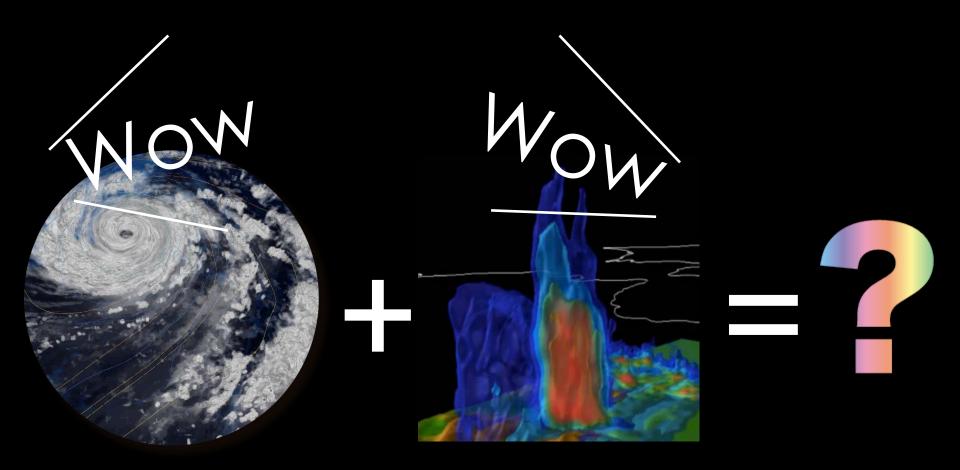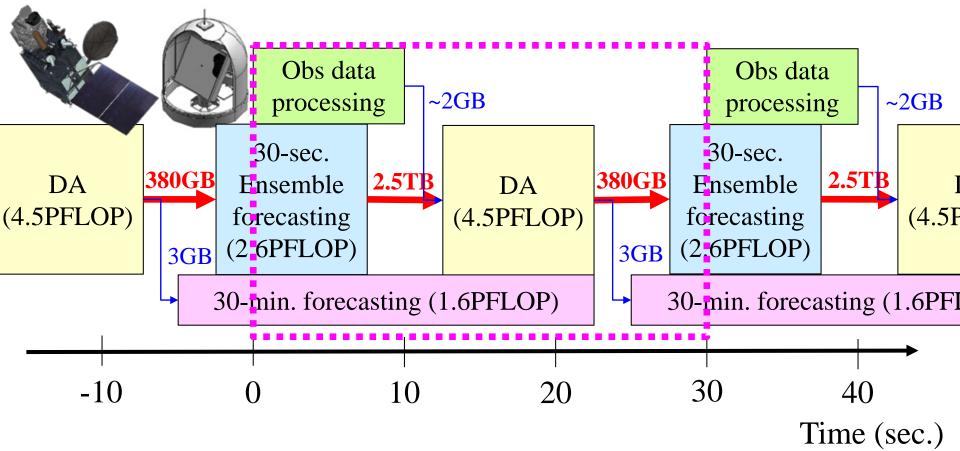
3-dim measurement using a phased array antenna (100 m, 100 EL angles in 30 sec)

Phased Array Radar (every 30 sec.)

(Courtesy of NICT)

Wow + Wow = ?
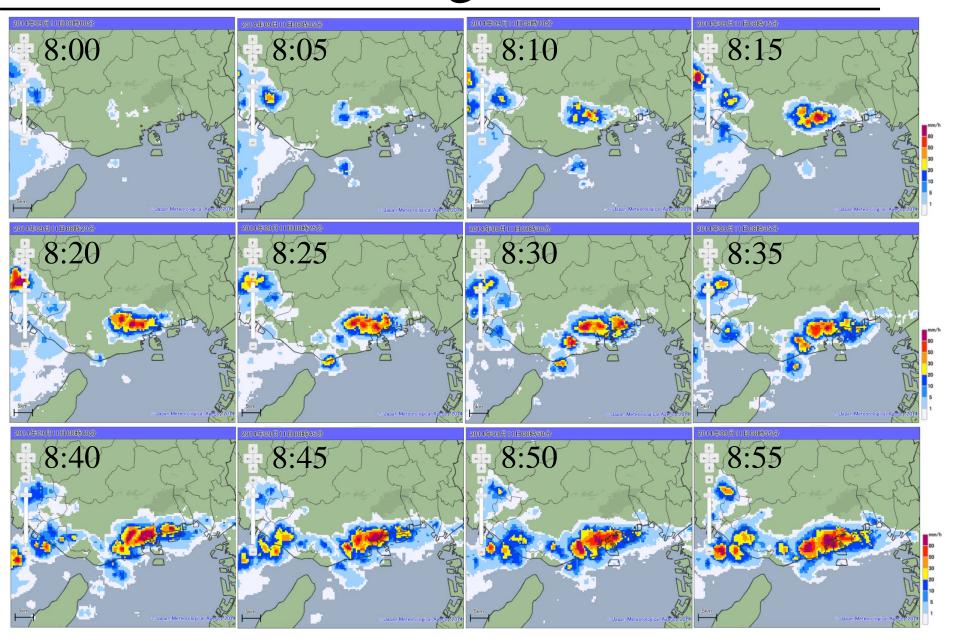
Revolutionary super-rapid 30-sec. cycle

120 times more rapid than hourly update cycles

9/11/2014 morning, sudden rain

9/11/2014, sudden local rain

Google earth

9/11/2014, sudden local rain

RIKEN Advanced Institute for Computational Science
Data Assimilation Research Team

2014.09.11 08:01:00

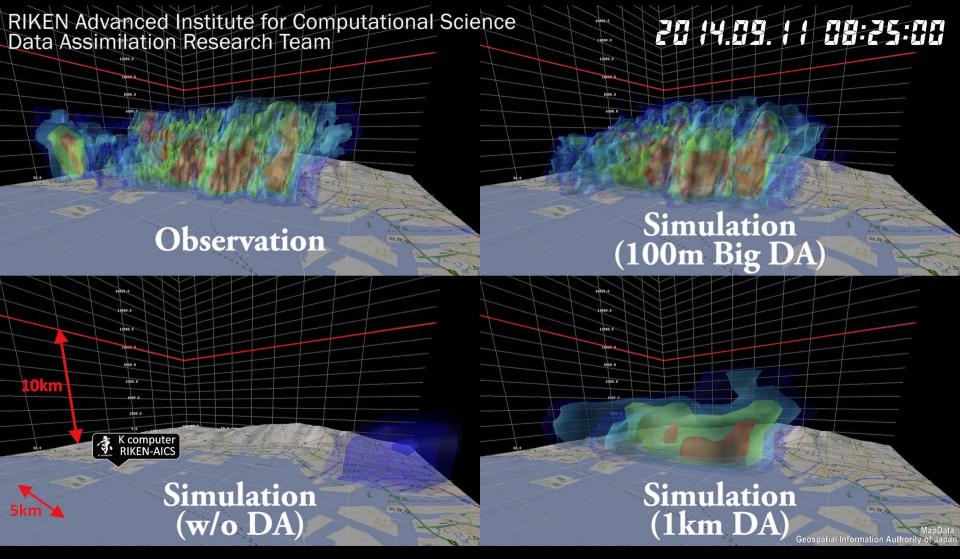**Observation**

Simulation (100m Big DA)

10km

Simulation (w/o DA)

K computer RIKEN-AICS

Simulation (1km DA)

>40,000 views
#9 of RIKEN channel

MapData:
Geospatial Information Authority of Japan

9/11/2014, sudden local rain

RIKEN Advanced Institute for Computational Science
Data Assimilation Research Team

2014.09.11 08:25:00

Observation

**Simulation
(100m Big DA)**

10km

K computer
RIKEN-AICS

5km

**Simulation
(w/o DA)**

**Simulation
(1km DA)**
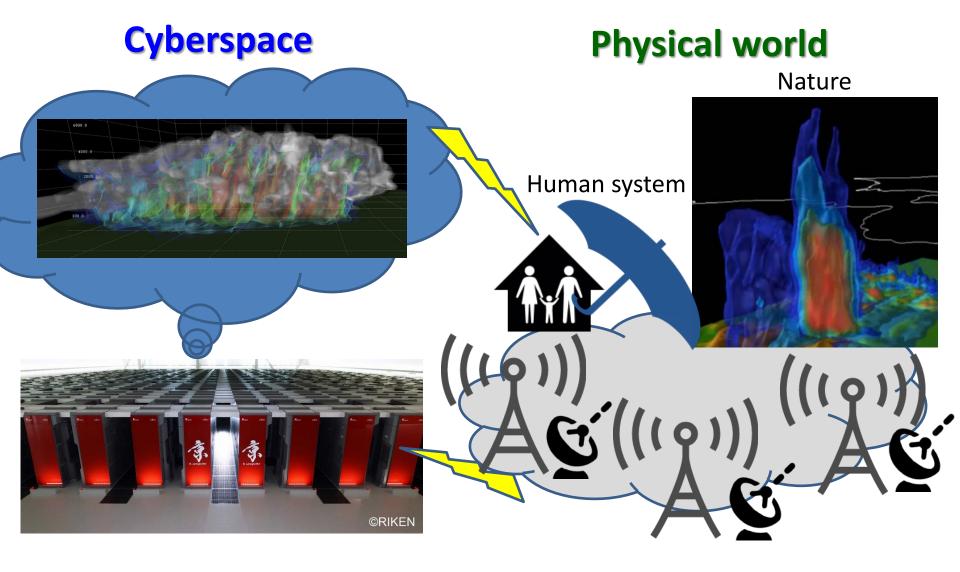
MapData:
Geospatial Information Authority of Japan
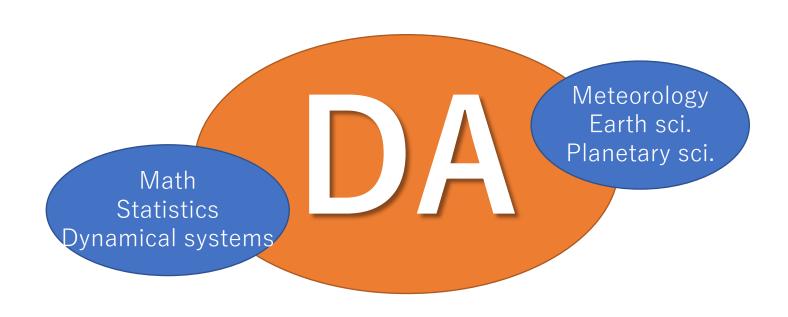
Cyber-Physical fusion for weather prediction
Data Assimilation is the key

Cyberspace

Physical world

Nature

Human system

©RIKEN

Data Assimilation (DA)

Real-world data   Simulations

Data Assimilation
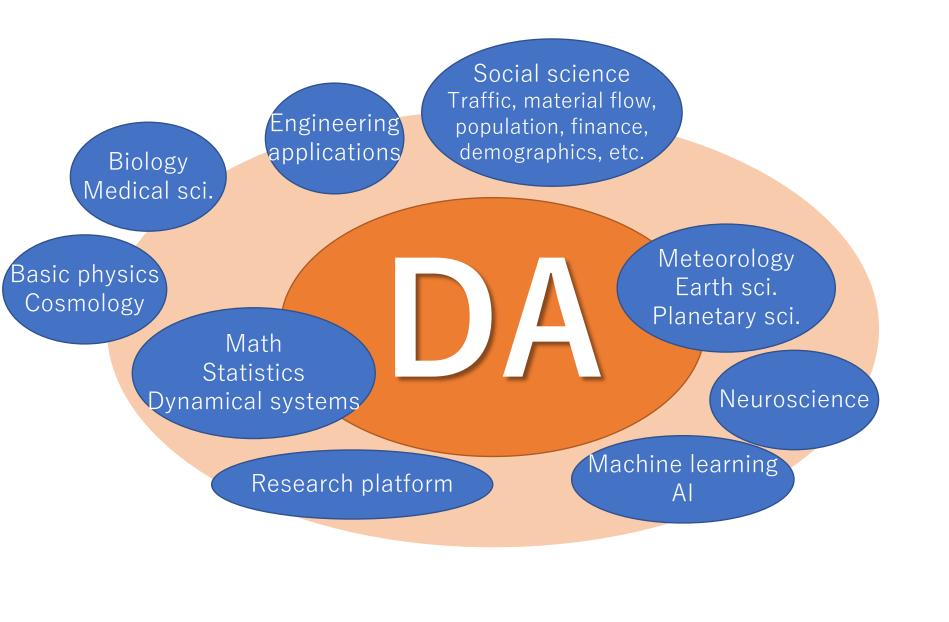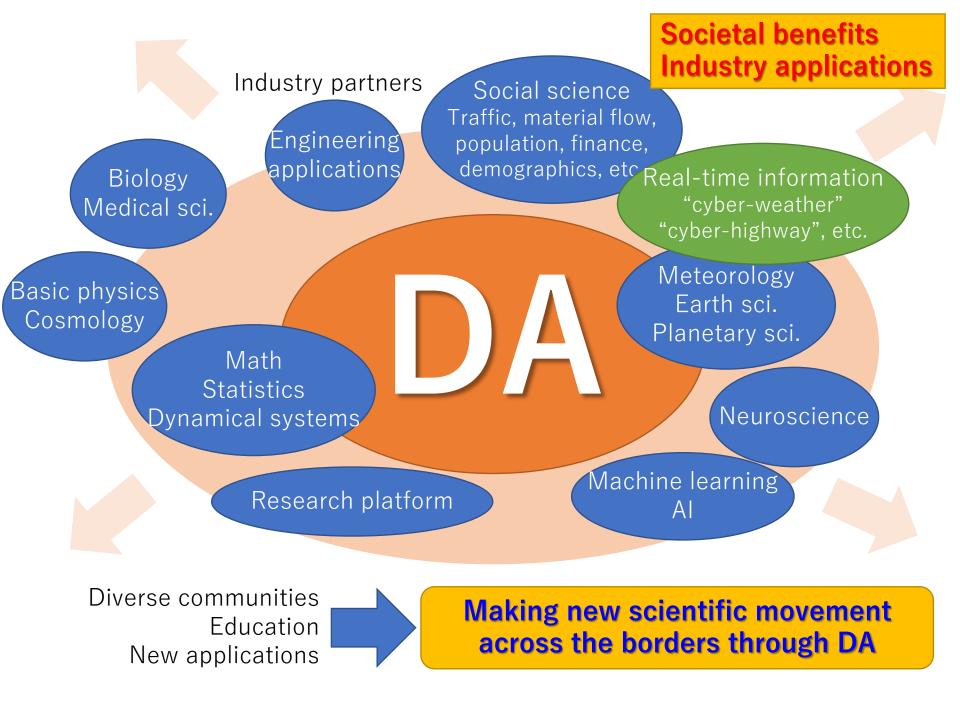
Data assimilation best combines real-world data and a model, and brings synergy.

DA

Math
Statistics
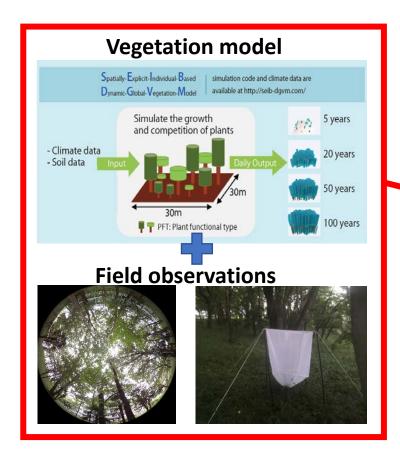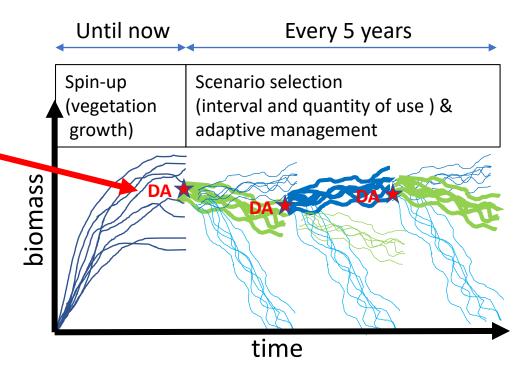Dynamical systems

Meteorology
Earth sci.
Planetary sci.

Data Assimilation as a tool for vegetation management

Arakida, H., S. Otsuka, S. Kotsuki, T. Miyoshi (RIKEN AICS), S. Moriya (RIKEN CSRS), N. Kobayashi (RIKEN ACCC), J. Aikawa (RIKEN Chief Scientist Laboratories)

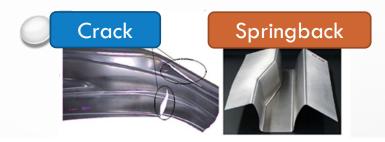## Optimizing an individual-based vegetation model for better prediction of forest evolution.

Data assimilation: Application for press forming simulation

Hideyuki Sakamoto, Takemasa Miyoshi (RIKEN AICS)
Masato Takamura (RIKEN Center for Advanced Photonics)

Body Side Outer Panel

Crack

Springback

Optimizing press forming conditions by predicting strain to suppress cracks, crumpled, and springback
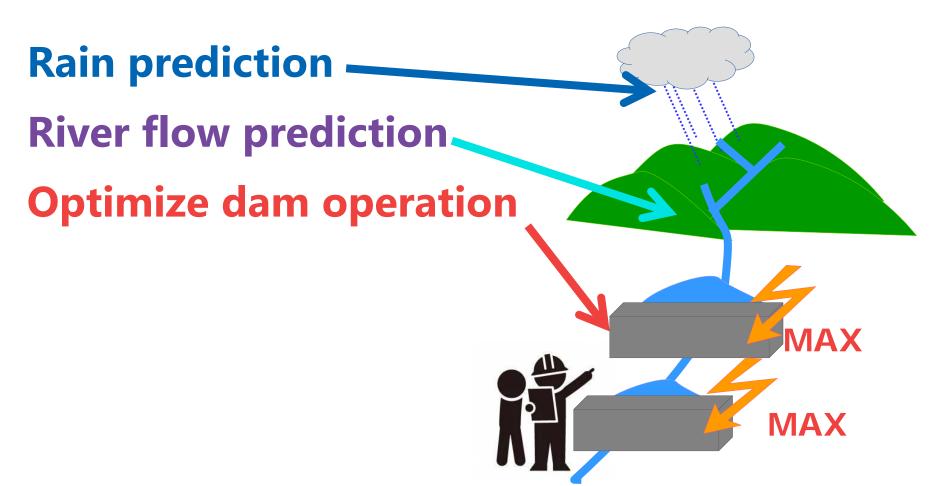
Data Assimilation aims to improve a press forming simulation using measurements of surface strain！

Observations

Simulations
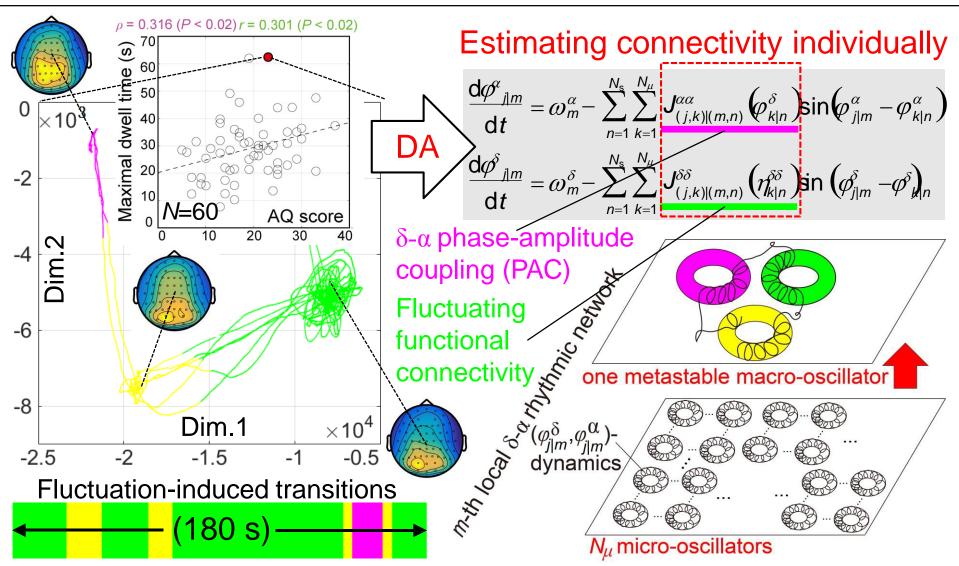
Data Assimilation

Stree-Strain Curve

?

Surface strain measured by ARAMIS

Industry applications

Toward smart hydroelectric dam operations

with **TEPCO** Tokyo Electric Power Company
Japanese leading power company

Rain prediction
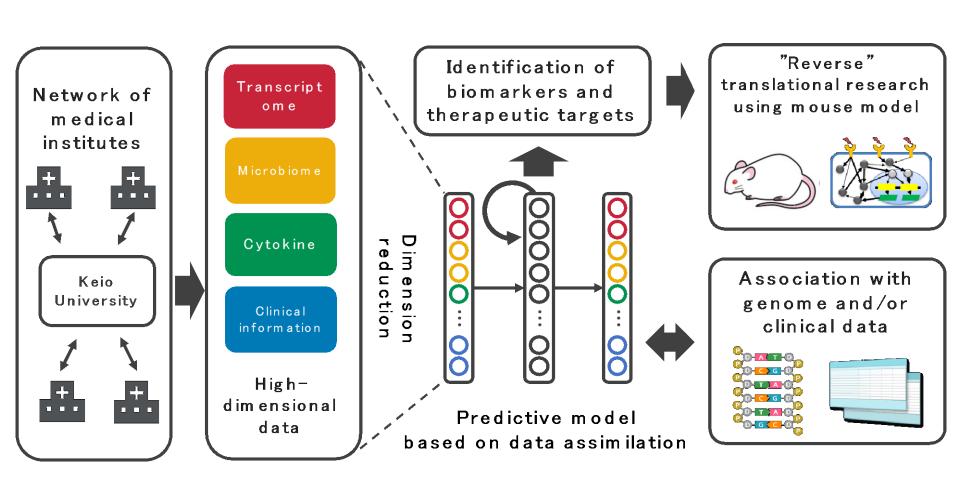
River flow prediction

Optimize dam operation

MAX

MAX

Modelling rhythms of the brain individually by a data assimilation approach

Takumi Sase & Keiichi Kitajo (RIKEN BSI)

Estimating connectivity individually

DA

$$\frac{d\varphi^{\alpha}_{j|m}}{dt} = \omega^{\alpha}_m - \sum_{n=1}^{N_s}\sum_{k=1}^{N_\mu} J^{\alpha\alpha}_{(j,k)|(m,n)}\left(\varphi^{\delta}_{k|n}\right)\sin\left(\varphi^{\alpha}_{j|m}-\varphi^{\alpha}_{k|n}\right)$$

$$\frac{d\varphi^{\delta}_{j|m}}{dt} = \omega^{\delta}_m - \sum_{n=1}^{N_s}\sum_{k=1}^{N_\mu} J^{\delta\delta}_{(j,k)|(m,n)}\left(\eta^{\delta\delta}_{k|n}\right)\sin\left(\varphi^{\delta}_{j|m}-\varphi^{\delta}_{k|n}\right)$$

δ-α phase-amplitude coupling (PAC)

Fluctuating functional connectivity

one metastable macro-oscillator

m-th local δ-α rhythmic network

$(\varphi^{\delta}_{j|m}, \varphi^{\alpha}_{j|m})$-dynamics

N_μ micro-oscillators

Fluctuation-induced transitions

(180 s)

Data assimilation in medicine and biology: towards preventive and personalized medicine
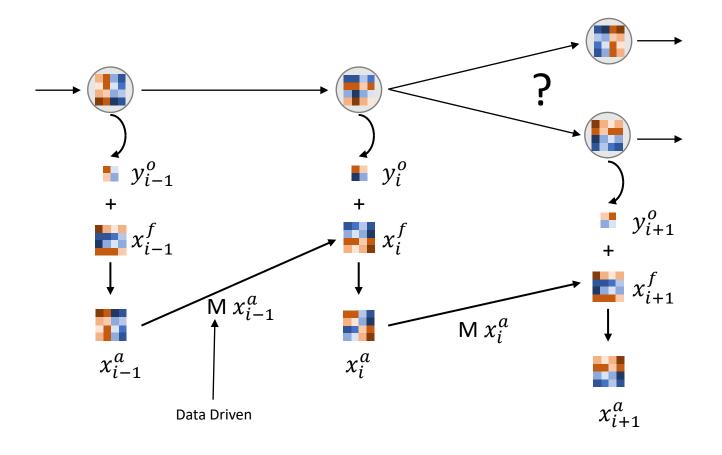
Eiryo Kawakami
Medical Sciences Innovation Hub Program, RIKEN

Forecast Cell Fate by Data Assimilation of Gene Expression Profile

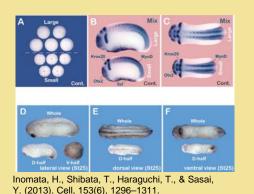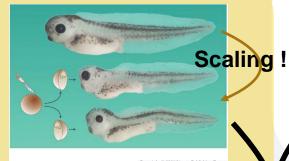Jun Seita, M.D., Ph.D.

RIKEN MIH / IMS / AIP, Stanford University

Development of mathematical model in biology with Approximate Bayesian Computation (ABC)

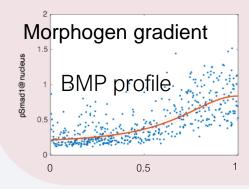## Tatsuo Shibata (RIKEN Quantitative Biology Center, QBiC)

Embryonic patterning is so robust.

Scaling !

Inomata, H., Shibata, T., Haraguchi, T., & Sasai, Y. (2013). Cell, 153(6), 1296–1311.

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Nature Reviews | Molecular Cell Biology

Scaled patterning with proportionality

Mathematical model of DV pattern formation

Inomata, H., Shibata, T., Haraguchi, T., & Sasai, Y. (2013). Cell, 153(6), 1296–1311.

Question?

What is the mechanism that underlies the scaling behavior for different size of embryo?

Morphogen gradient

BMP profile
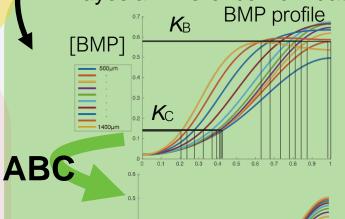
=> What is the mechanism that make the BMP profile independent of embryo size?

Bayesian inference from data
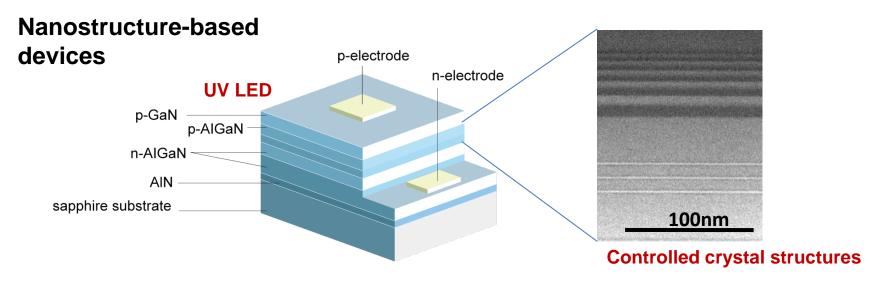
BMP profile

K_B

[BMP]

K_C

ABC

The BMP profile is independent of embryo size
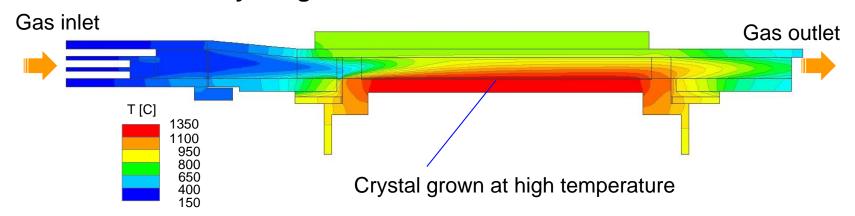
Scaling !

K_C K_B

Crystal growth with data assimilation

Quantum Optodevice Lab., RIKEN

M. Jo

Producing the desired structures
based on the growth history data

Nanostructure-based devices

UV LED

p-electrode

n-electrode

p-GaN
p-AlGaN
n-AlGaN
AlN
sapphire substrate

100nm

Controlled crystal structures

Simulation model of crystal growth

Gas inlet

Gas outlet

T [C]
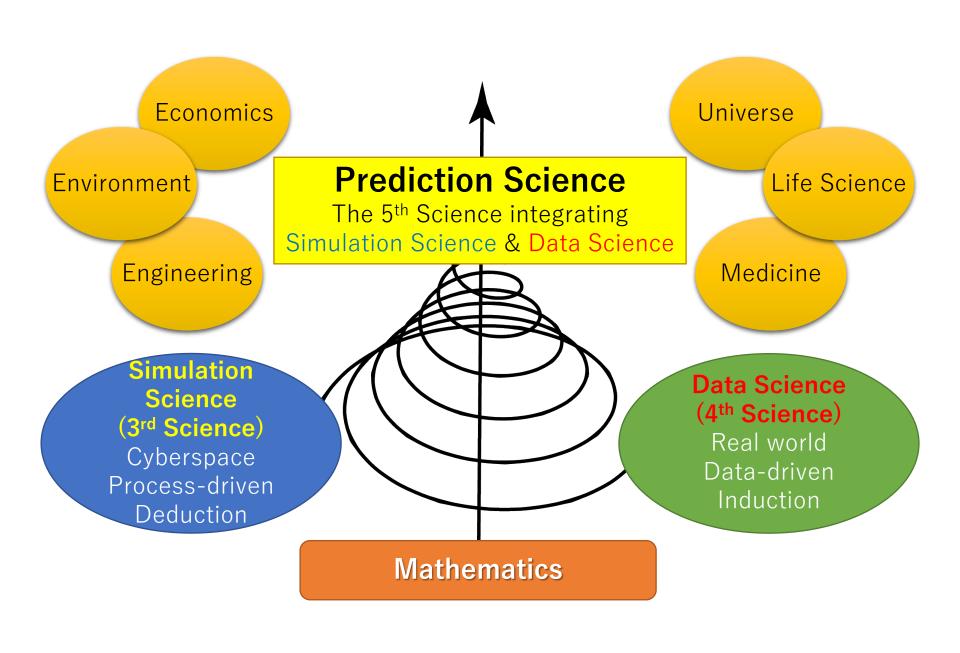1350
1100
950
800
650
400
150

Crystal grown at high temperature
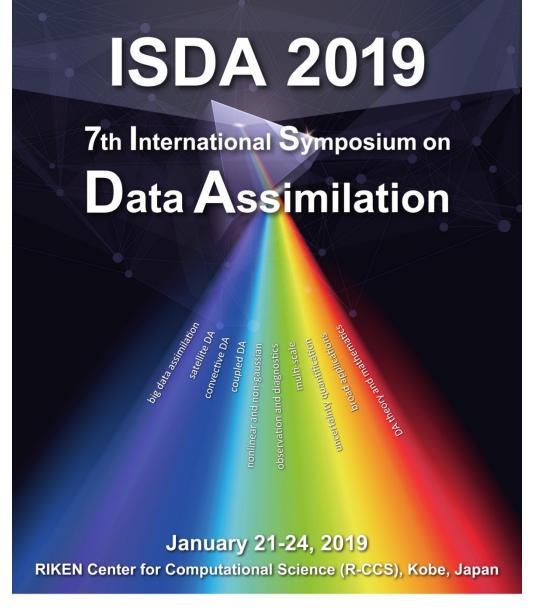
Invited Speakers
- Youssef Marzouk (MIT)
- Omar Knio (KAUST)
- Loic Giraldi (KAUST)
- Olivier Le Maitre (LIMSI-CNRS)
- Pierre Tandeo (IMT-Atlantique)
- Mohamed Iskandarani (University of Miami)
- Serge Guillas (University College London)

7 lecturers + 32 participants from 6 countries

ISDA 2019

7th International Symposium on
Data Assimilation

big data assimilation

satellite DA

convective DA

coupled DA

nonlinear and non-gaussian

observation and diagnostics

multi-scale

uncertainty quantification

broad applications

DA theory and mathematics

January 21-24, 2019
RIKEN Center for Computational Science (R-CCS), Kobe, Japan

http://www.data-assimilation.riken.jp/isda2019/

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