"Big Data Assimilation" for Revolutionizing Weather Prediction

Takemasa Miyoshi

RIKEN Advanced Institute for Computational Science

Takemasa.Miyoshi@riken.jp

RIKEN

CREST JST 独立行政法人 科学技術振興機構 Japan Science and Technology Agency

K computer

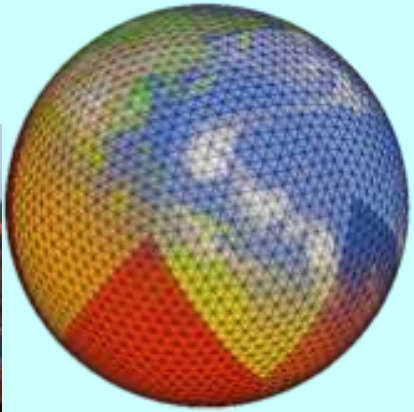
K. Bessho, S. Satoh, T. Ushio, H. Tomita, Y. Ishikawa, H. Seko

Data Assimilation (DA)

Observations

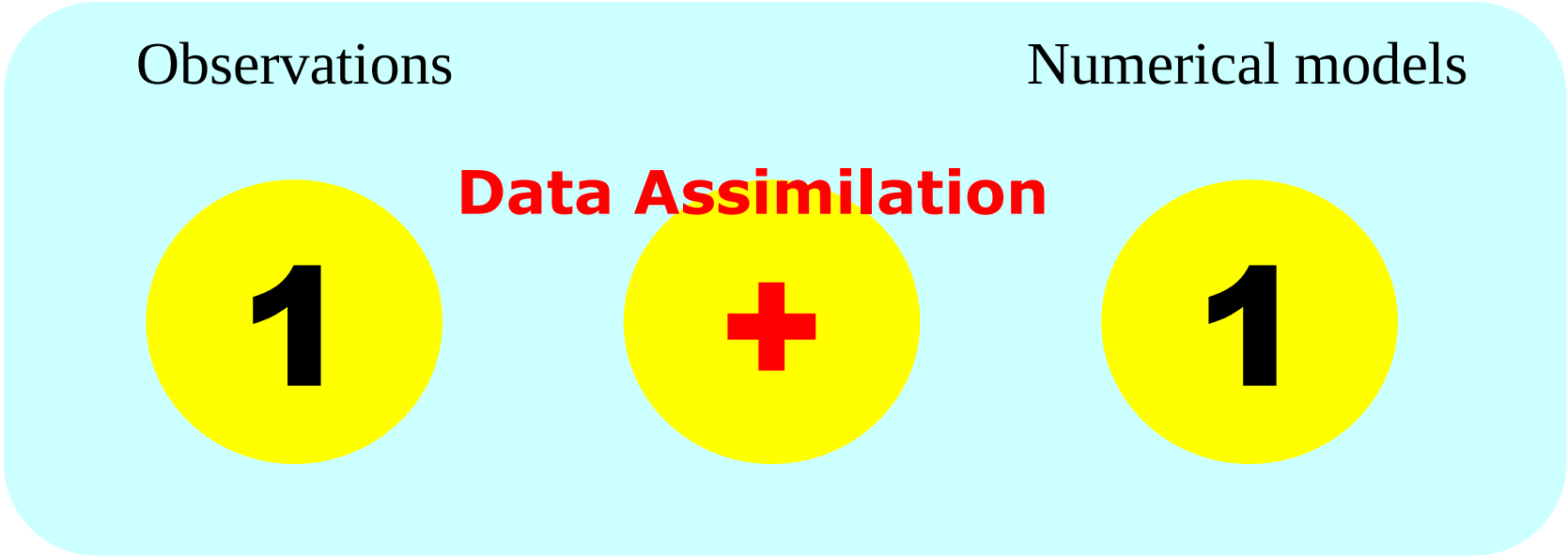
Data Assimilation

Numerical models



Data assimilation best combines observations and a model, and brings synergy.

Data Assimilation (DA)



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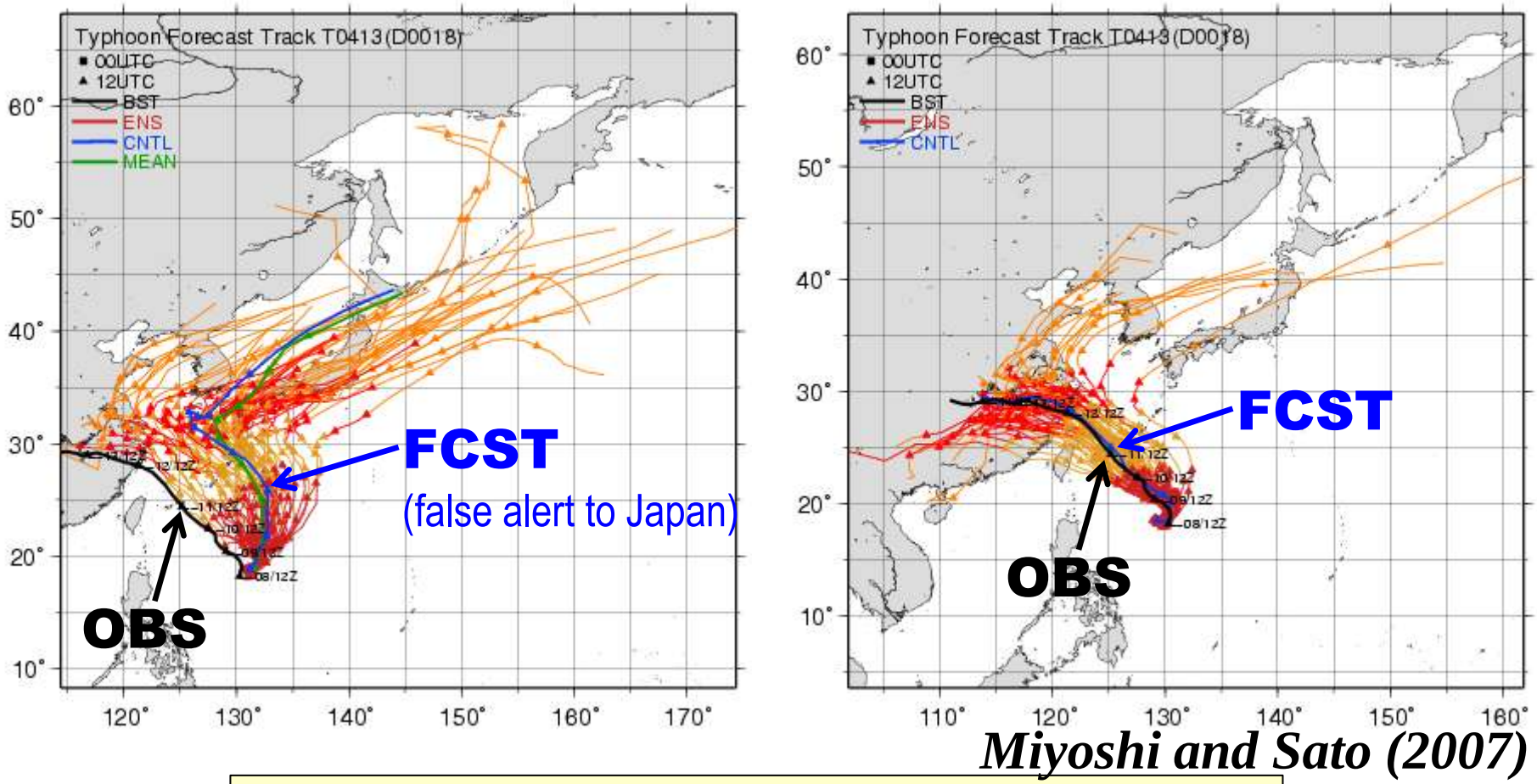
DA has an impact.

Two forecasting systems, the only difference in the DA method



Miyoshi and Sato (2007)

Using the same NWP model and observations.

DA matters!

DA as Chaos Synchronization (*Yang et al. 2006*)

Master (drive) system

Slave (response) system

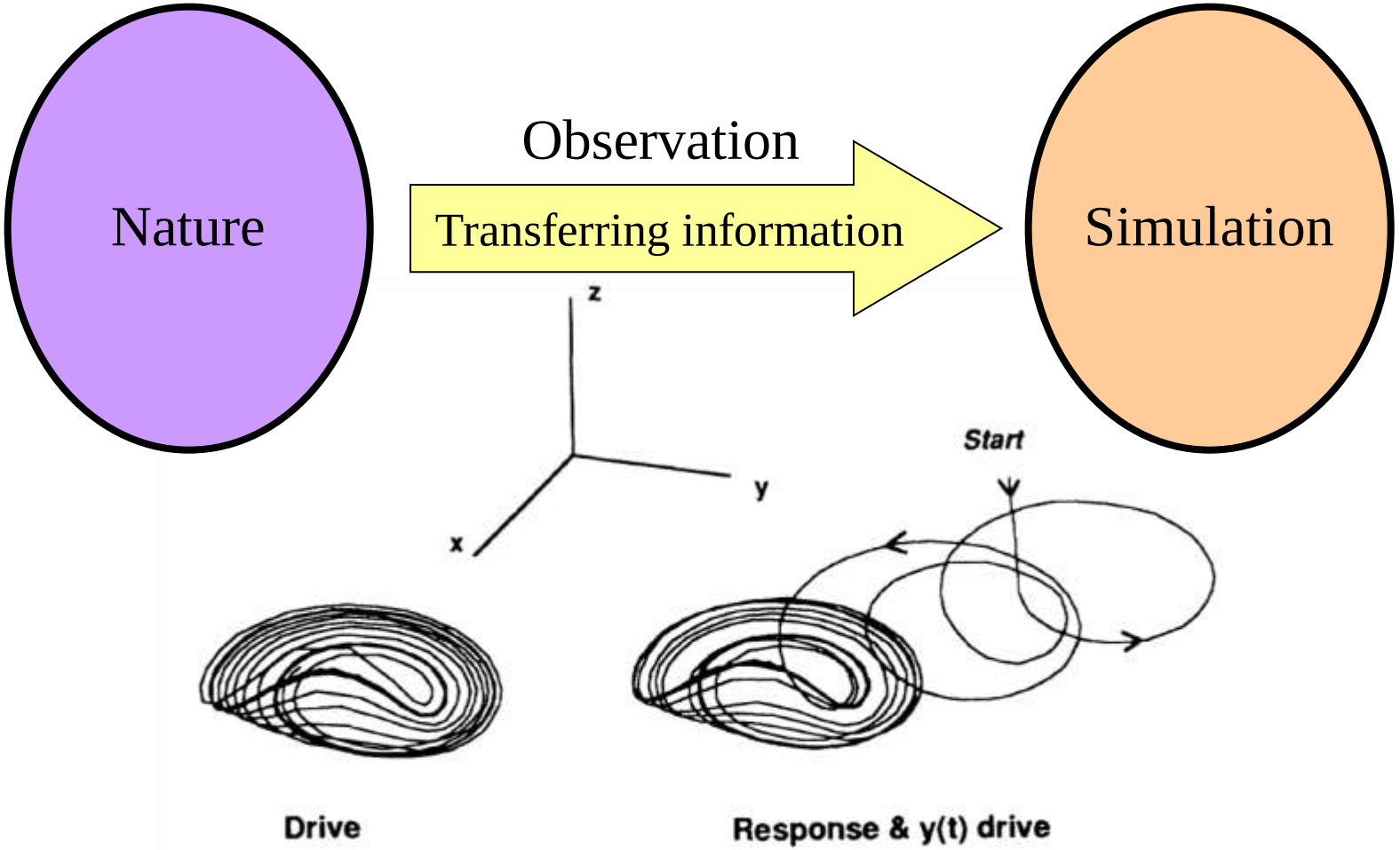
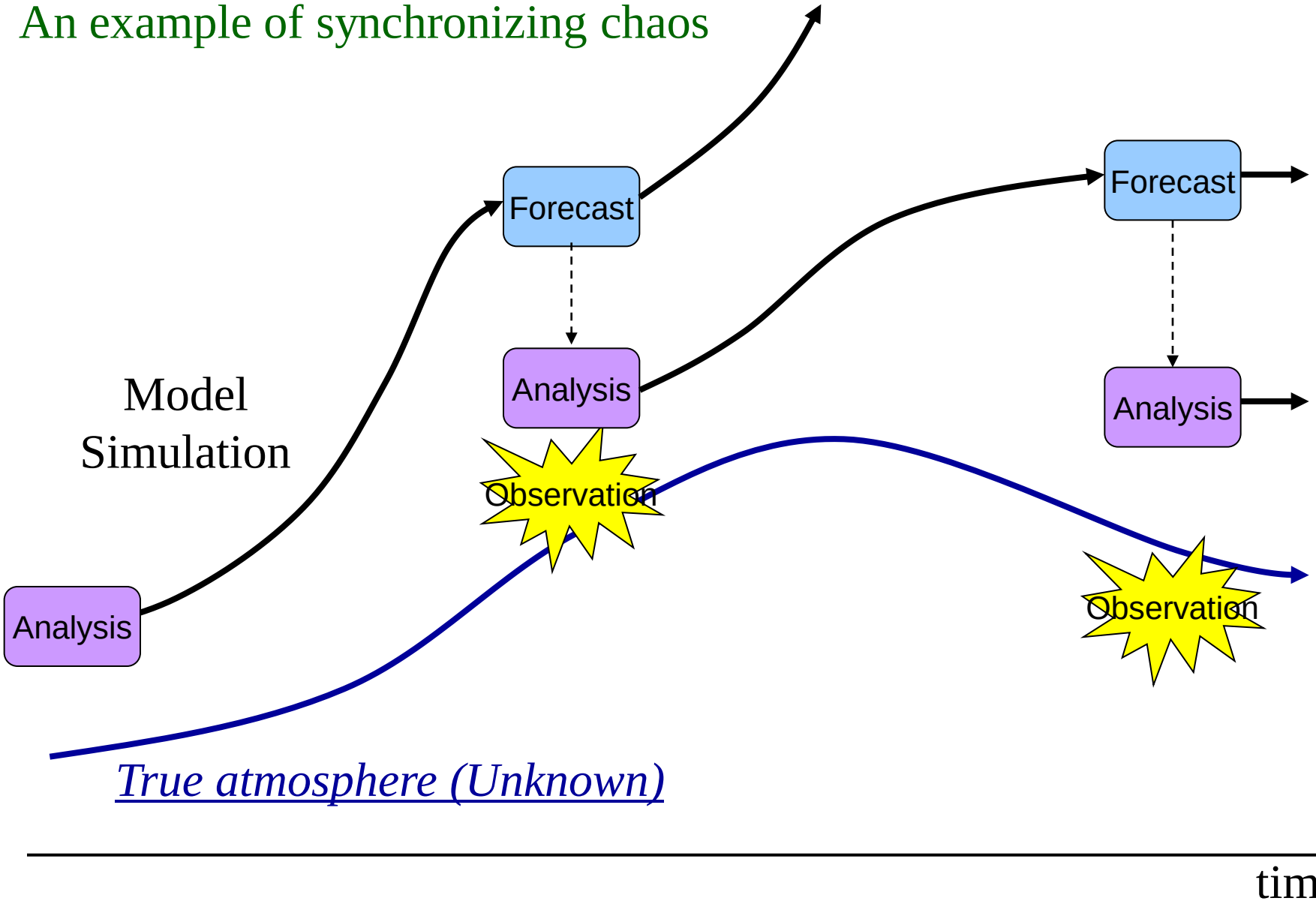


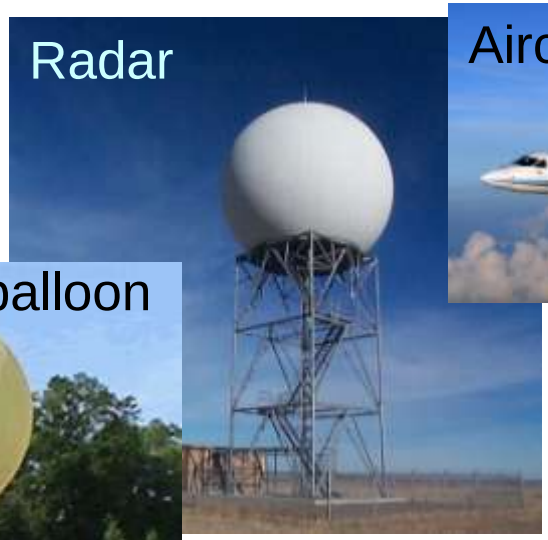
FIG. 1. The attractors for the Rössler drive system and the $(x'\text{-}z')$ response system and $y(t)$ drive variable.

Numerical Weather Prediction

An example of synchronizing chaos

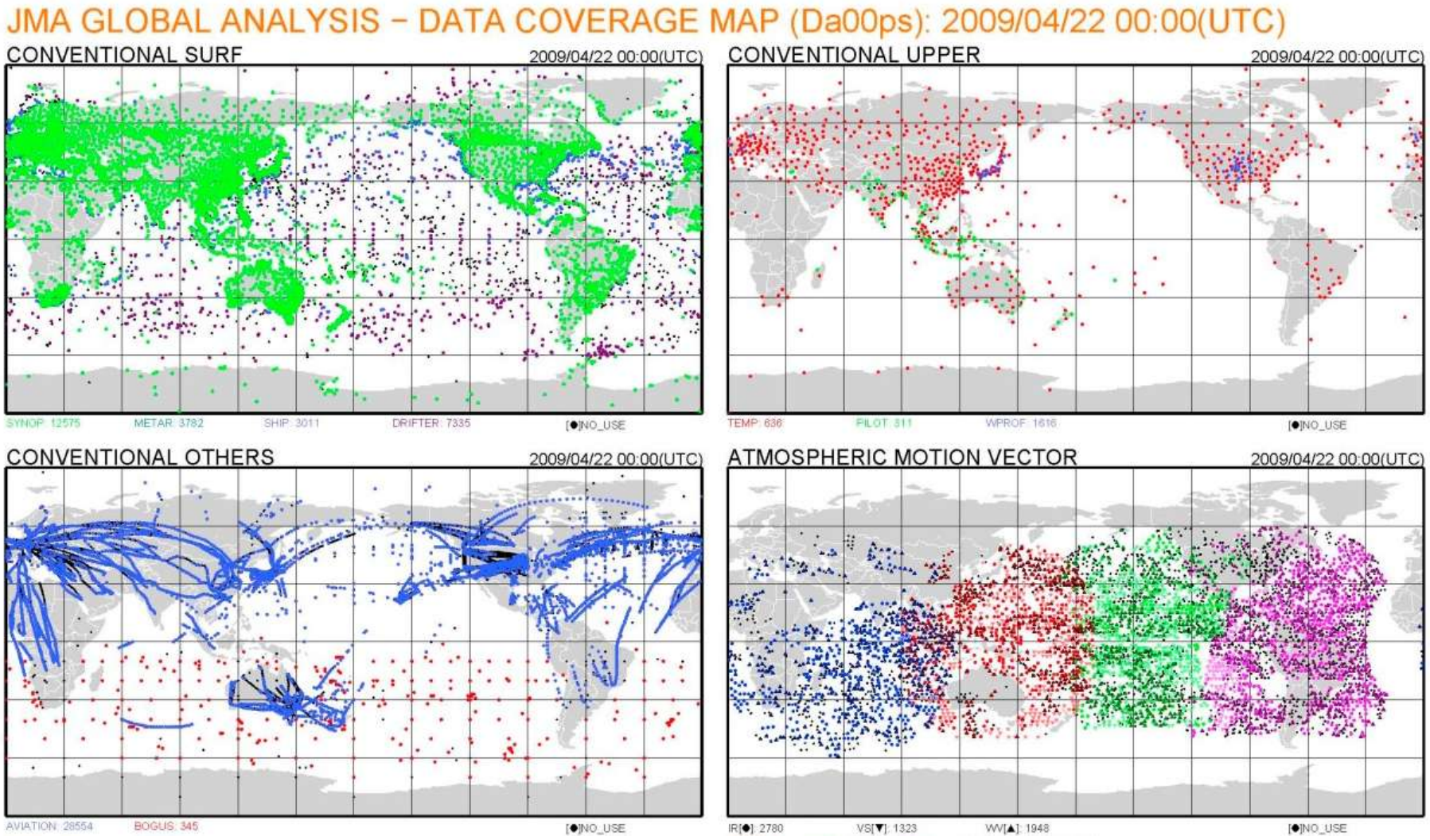


Global Observing System



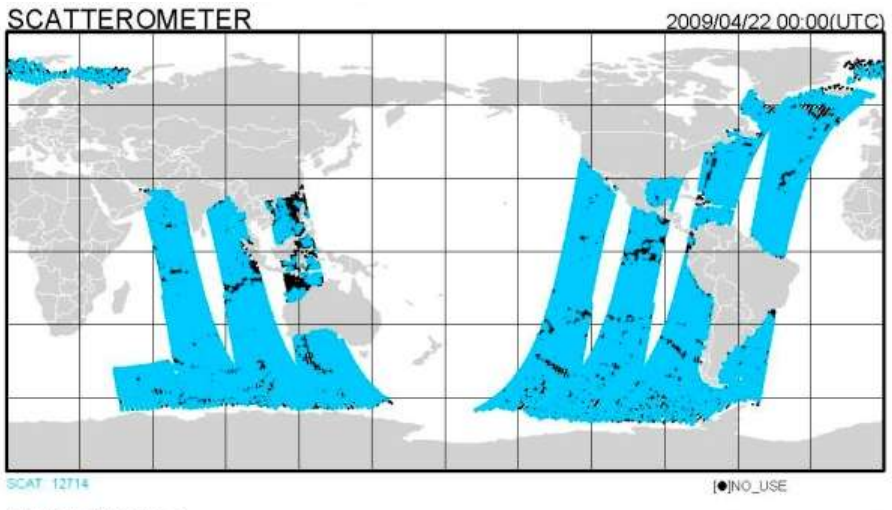
Satellite

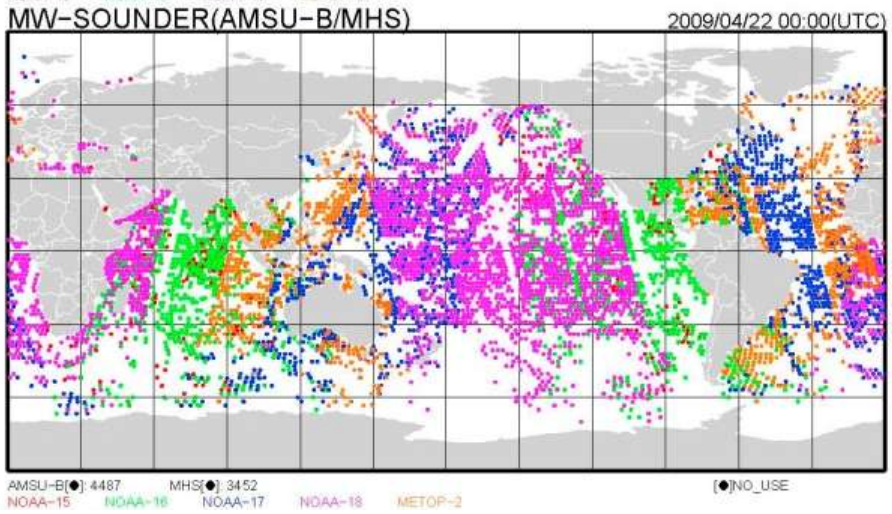
Observation data (6-h period) *(Courtesy of JMA)*

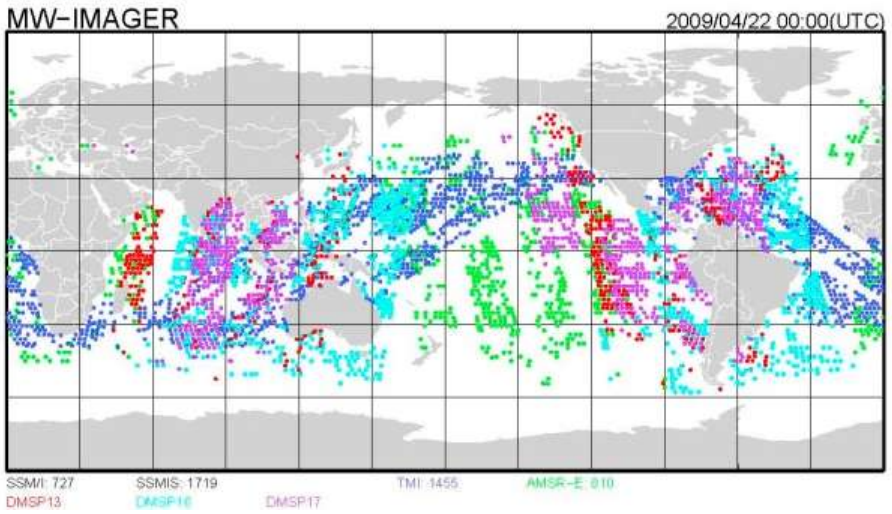


World's effort! (no border in the atmosphere)

Observation data (6-h period) *(Courtesy of JMA)*

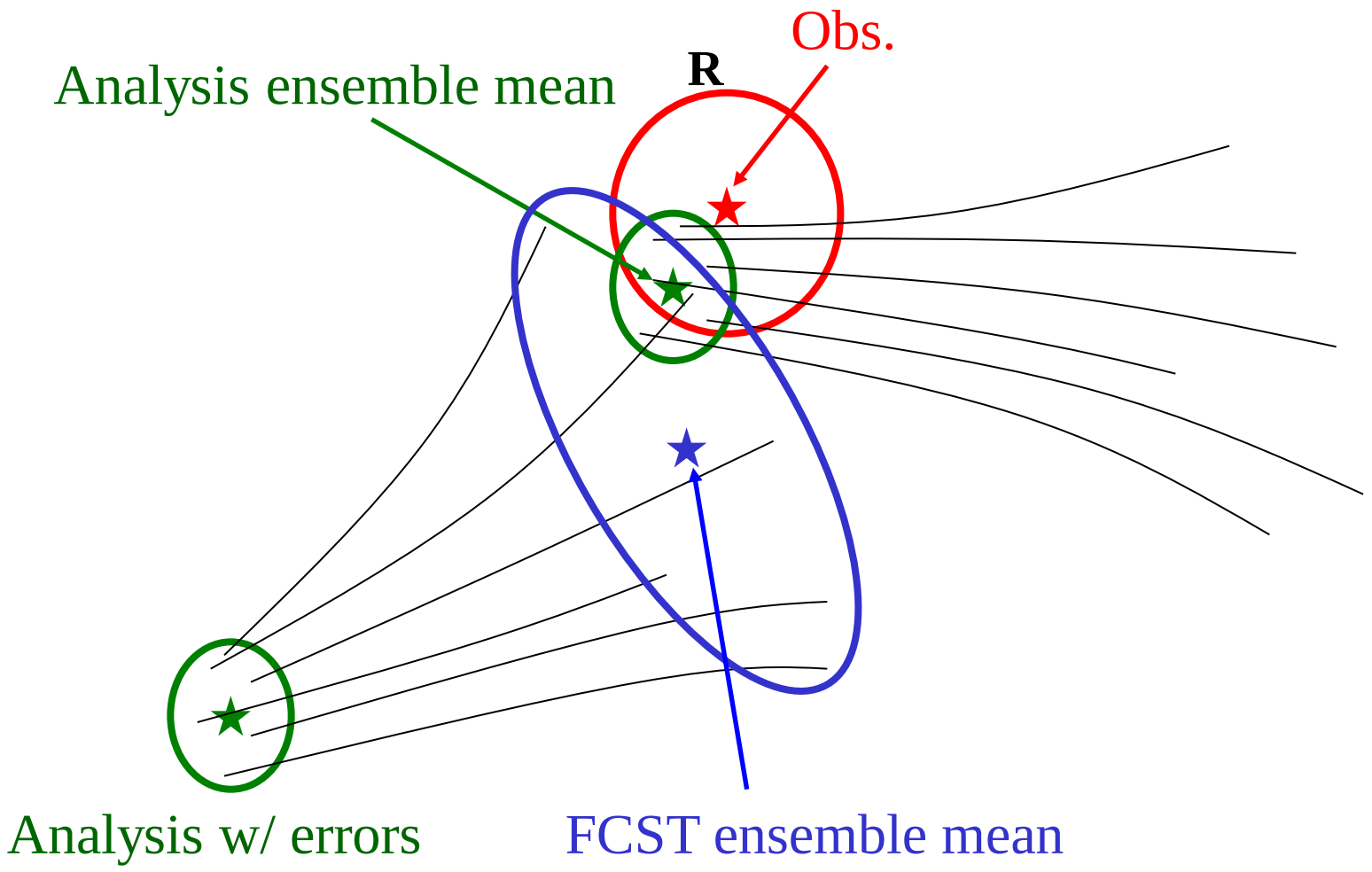




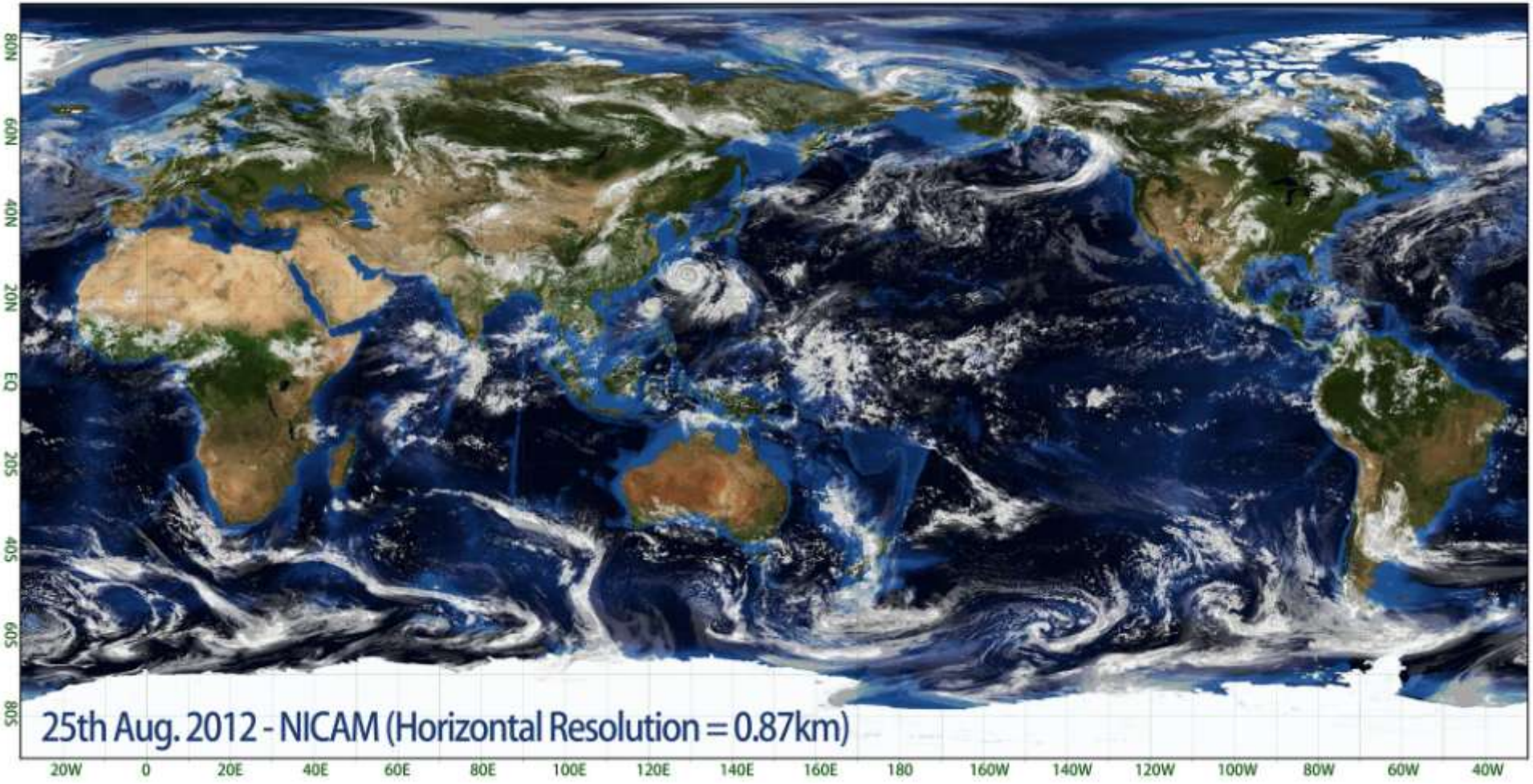


NWP has been pioneering “Big Data” science!

We consider the evolution of PDF



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



Visualized by Ryuji Yoshida

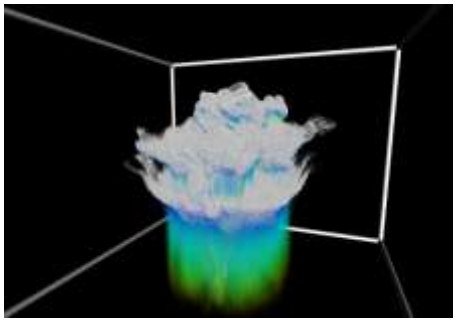
Computers getting more powerful…

- With an Exa-scale supercomputer (~2020), we can afford 100 members of global 870-m simulation.

The Japanese 10-Peta-Flops K computer

Toward next 20 years of DA

"Big Data Assimilation" Era



Courtesy of S. Shima

Exploding data

Enabling effective use

Big Data

Big Data

High-resolution simulation

High-resolution obs

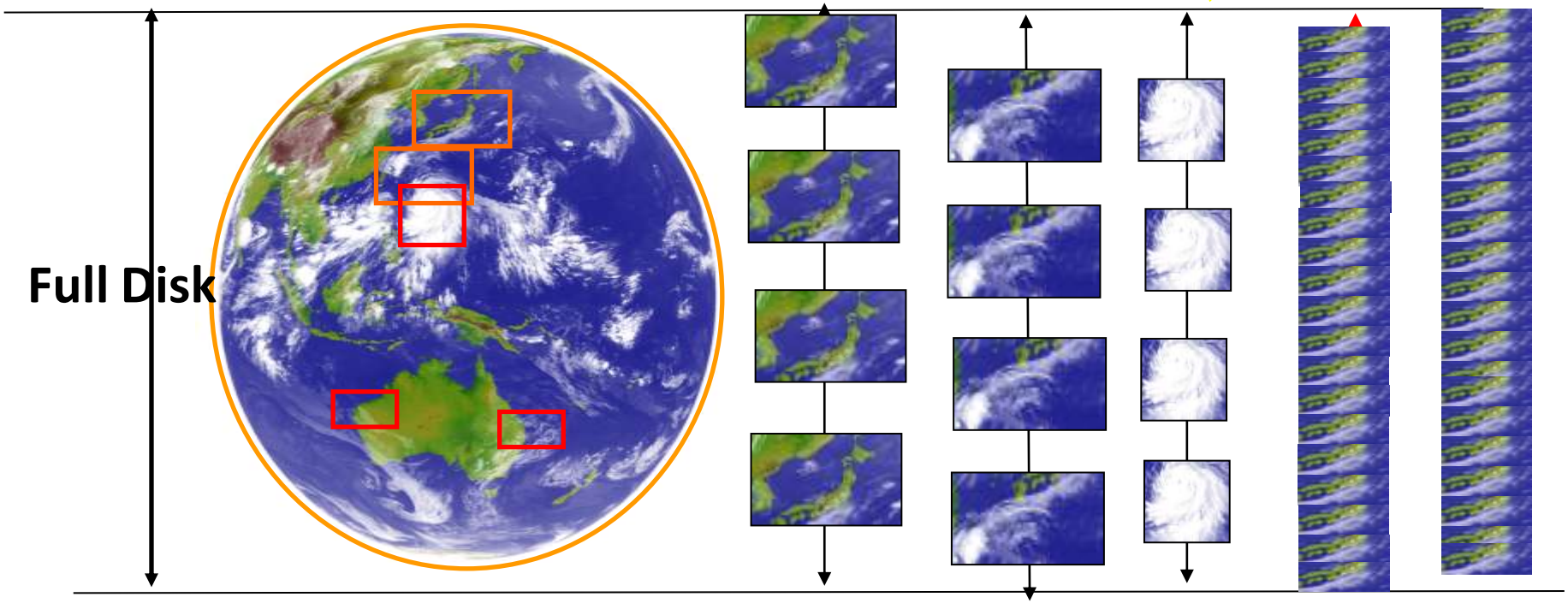
More computational power

Advanced obs technology

Next-generation geostationary satellite

Himawari 8 will be launched in 2014.
Himawari 9 will be launched in 2016.

Super Rapid Scan
every 30 seconds

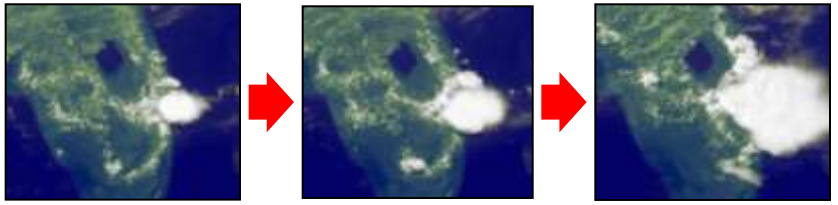


(Courtesy of JMA)

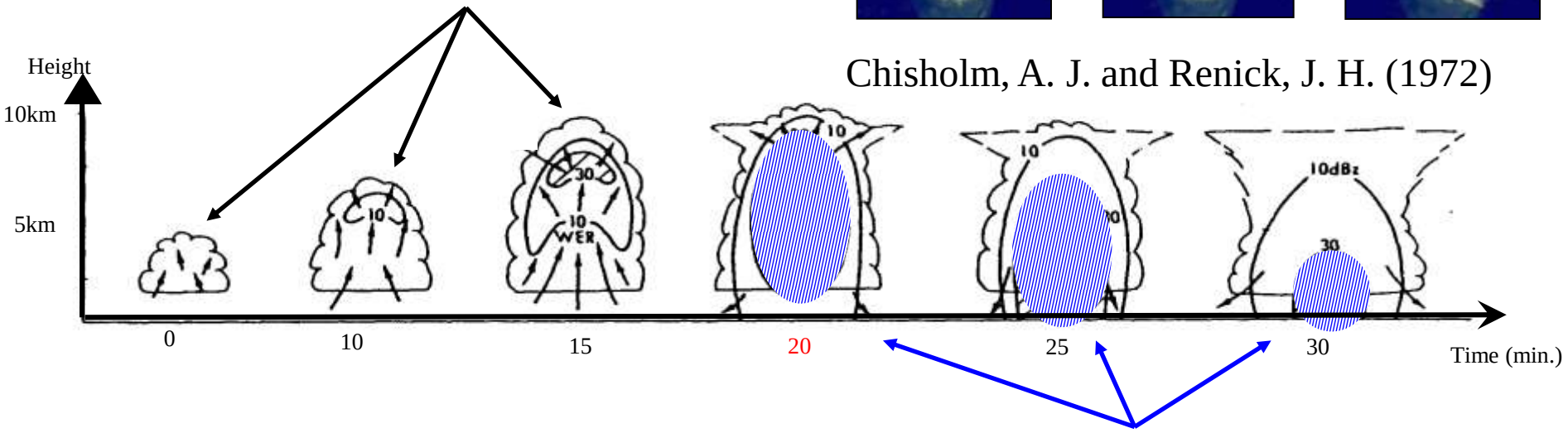
Rapid scan effective for convections

Typical lifetime of a convective system ~30 min.

Satellite imagery can capture developing convections.

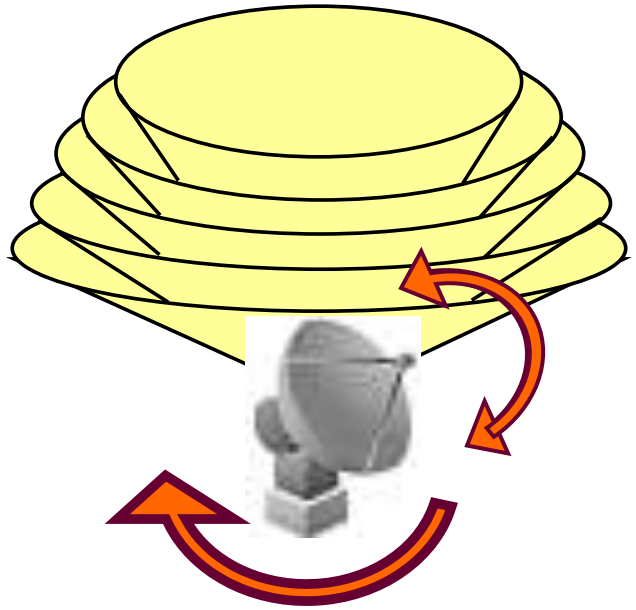


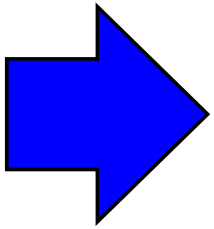
Chisholm, A. J. and Renick, J. H. (1972)



Radar can capture rain particles after the developing stage.
(may be too late…)

Phased Array Radar





(courtesy of NICT)

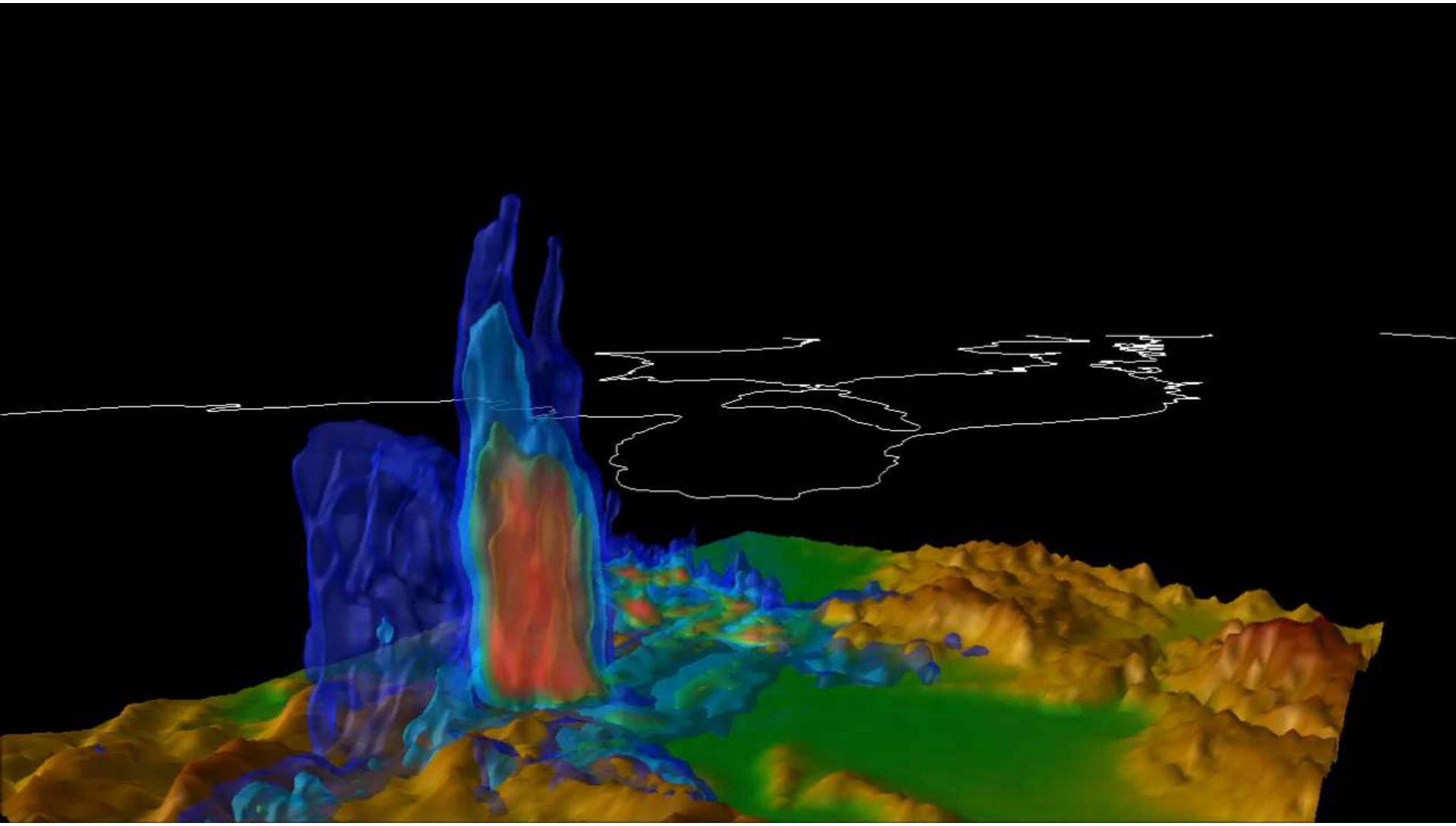
Conventional Radar

~15 scan angles
Every 5-10 minutes

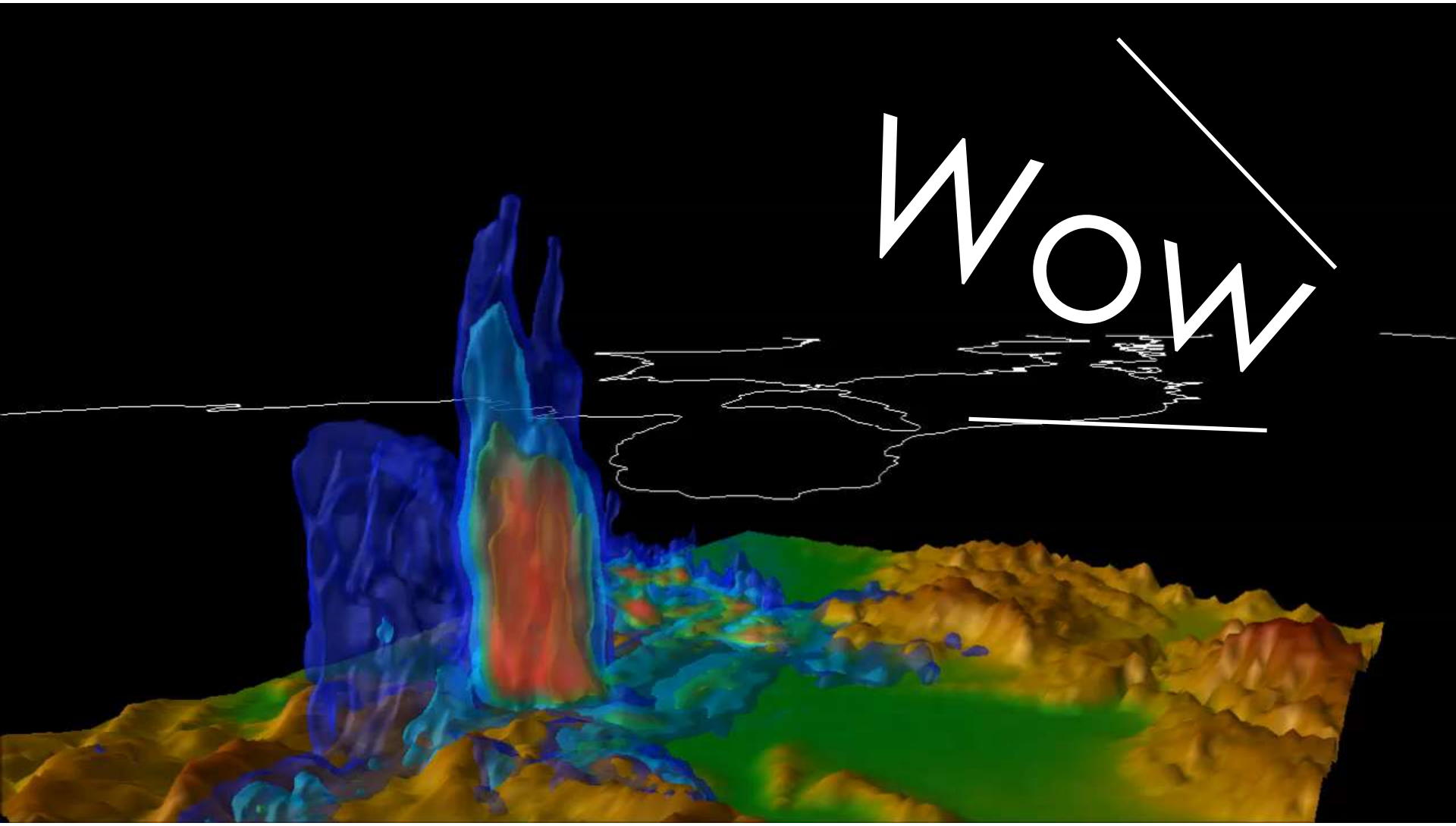
Phased Array Radar

~100 scan angles
Every 10-30 seconds

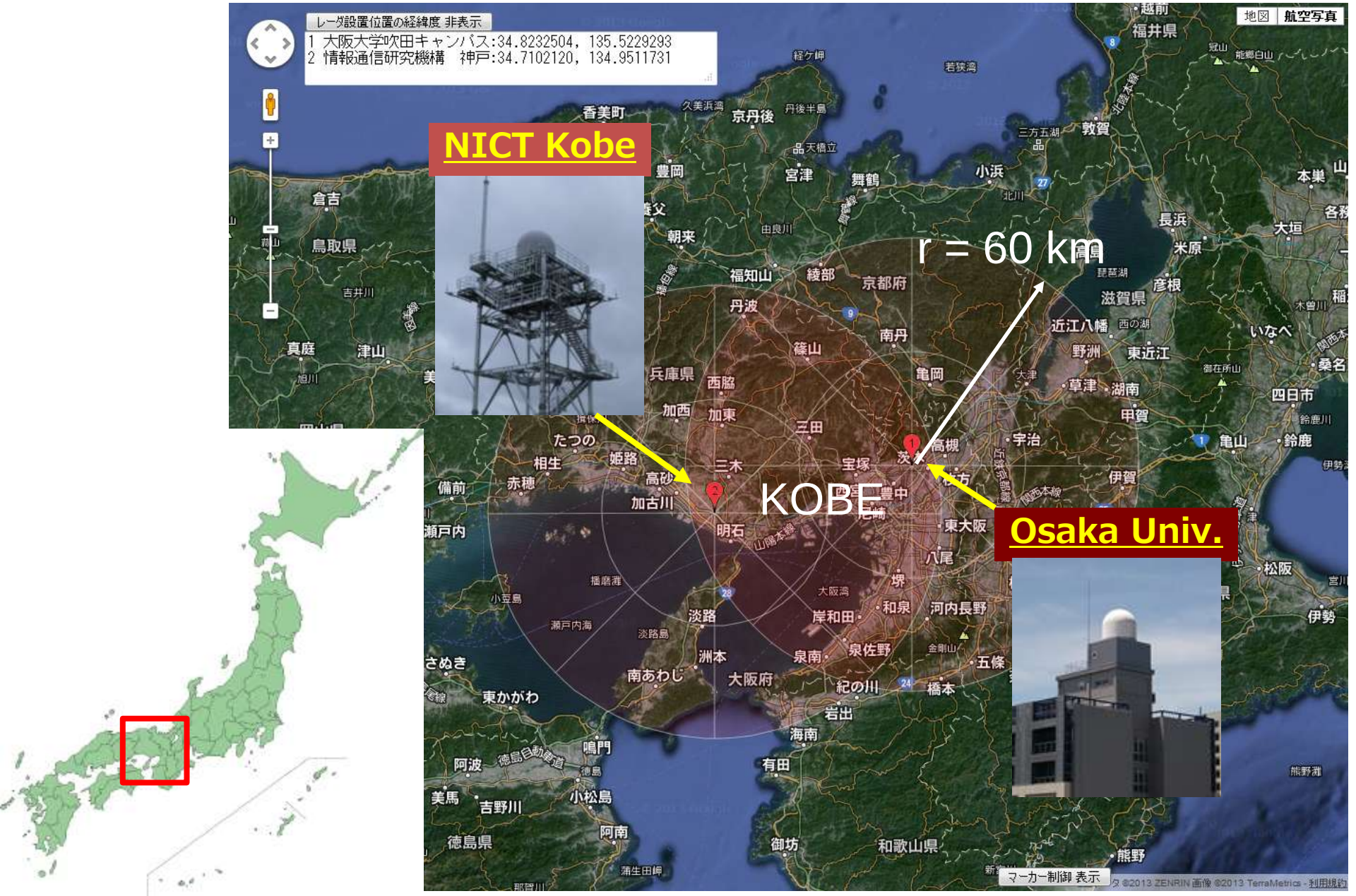
Conventional Radar (every 5 min.)



Phased Array Radar (every 30 sec.)



Two PAR in Kobe area

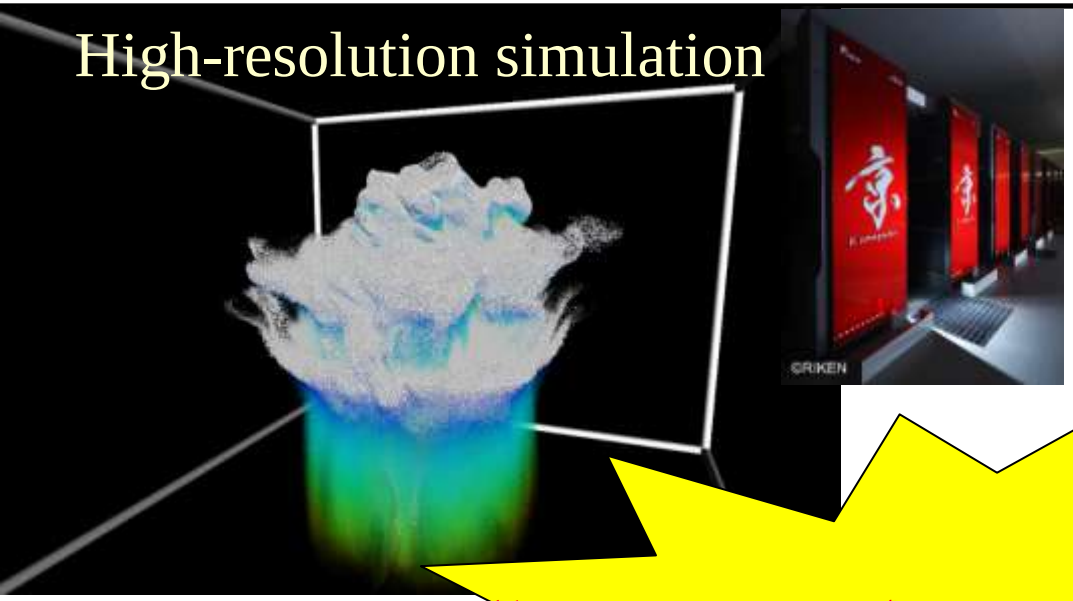


New data: can we use live-camera images?

1. Reduced/extracted information (e.g., weather type, visibility)
   (challenge) Automated image processing

2. Simulating images from model outputs
   (challenge) precise 3-dimensional radiation model

Towards “Big Data Assimilation”



Combination of
next-generation technologies

“Big Data Assimilation”

Improving simulations

Storm forecasting with Big Data Assimilation

Goal: 30-min forecasting of local severe weather through Big Data Assimilation innovations.

Revolutionary super-rapid 30-sec. cycle

Phased Array Radar
1GB/30sec/2 radars

Himawari
500MB/2.5min

A-1. Quality Control
A-2. Data Processing

B-1. Quality Control
B-2. Data Processing

①30-sec Ensemble
Forecast Simulations
2 PFLOP

②Ensemble
Data Assimilation
2 PFLOP

Analysis Data
2GB

Ensemble Forecasts
200GB

Ensemble Analyses
200GB

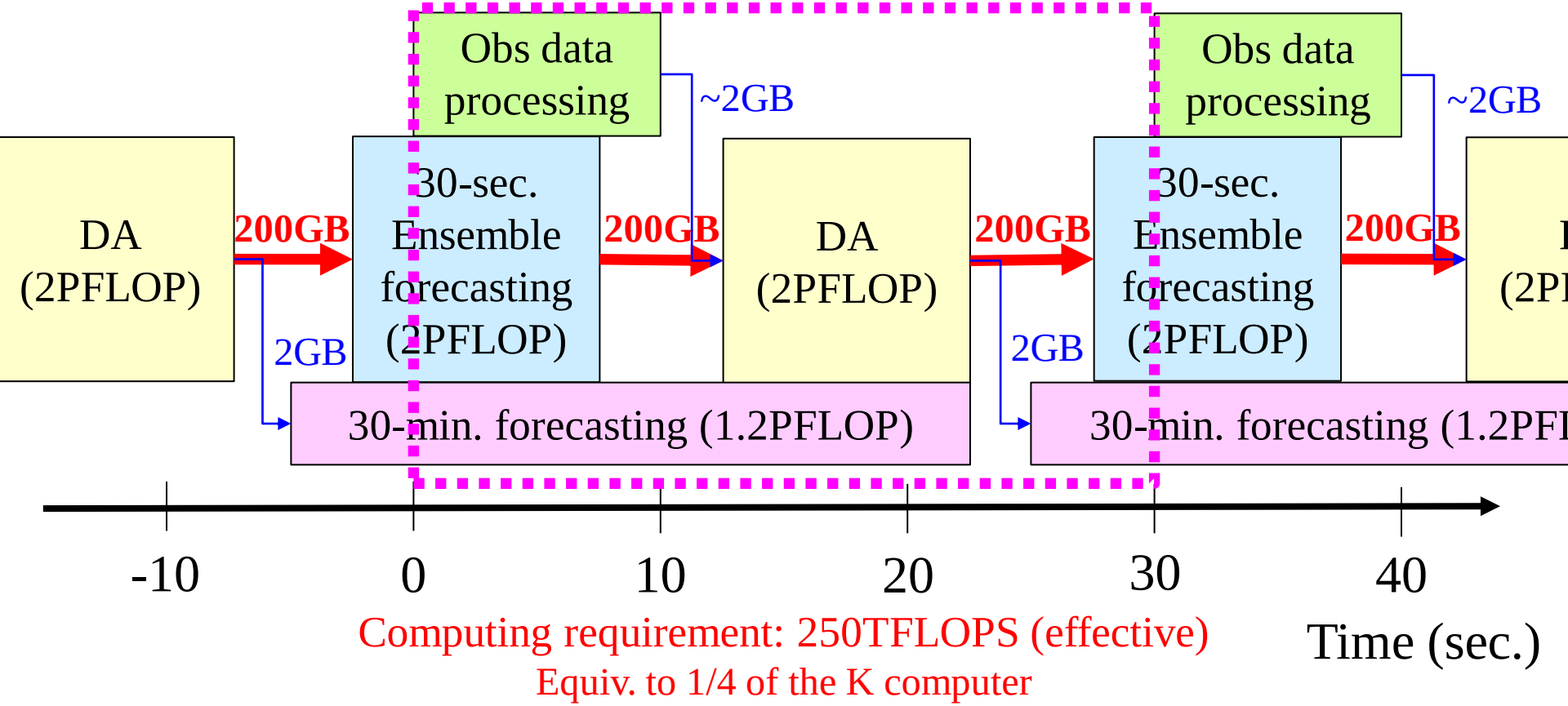
③30-min
Forecast Simulation
1.2 PFLOP

30-min Forecast
2GB

Repeat every 30 sec.

120 times more rapid than the hourly "Rapid Refresh"

A lot of challenges to make it happen…



Computing requirement: 250TFLOPS (effective)

Equiv. to 1/4 of the K computer

Challenges

- New DA algorithm for fast I/O
- Fast QC and data processing at observing sites

Future perspectives

- Explore a 30-sec. super-rapid DA cycle through innovating the "*Big Data Assimilation*" technology.
  - Funded by CREST JST 独立行政法人 科学技術振興機構 Japan Science and Technology Agency
- Japanese Exa-scale supercomputer planned in 2020
  - May "Tokyo 2020" be a good place to demonstrate?