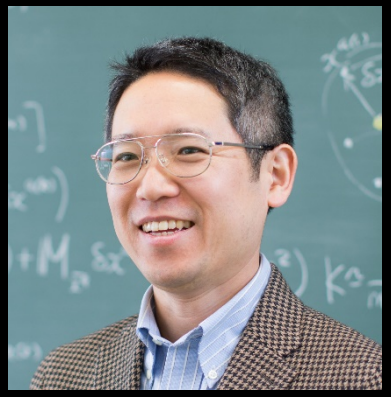
# Big Data Assimilation

## in Weather Prediction:

## *From K to Fugaku*



Takemasa Miyoshi

Ph.D. (Meteorology)
Data Assimilation Scientist

Data Assimilation Research Team

RIKEN

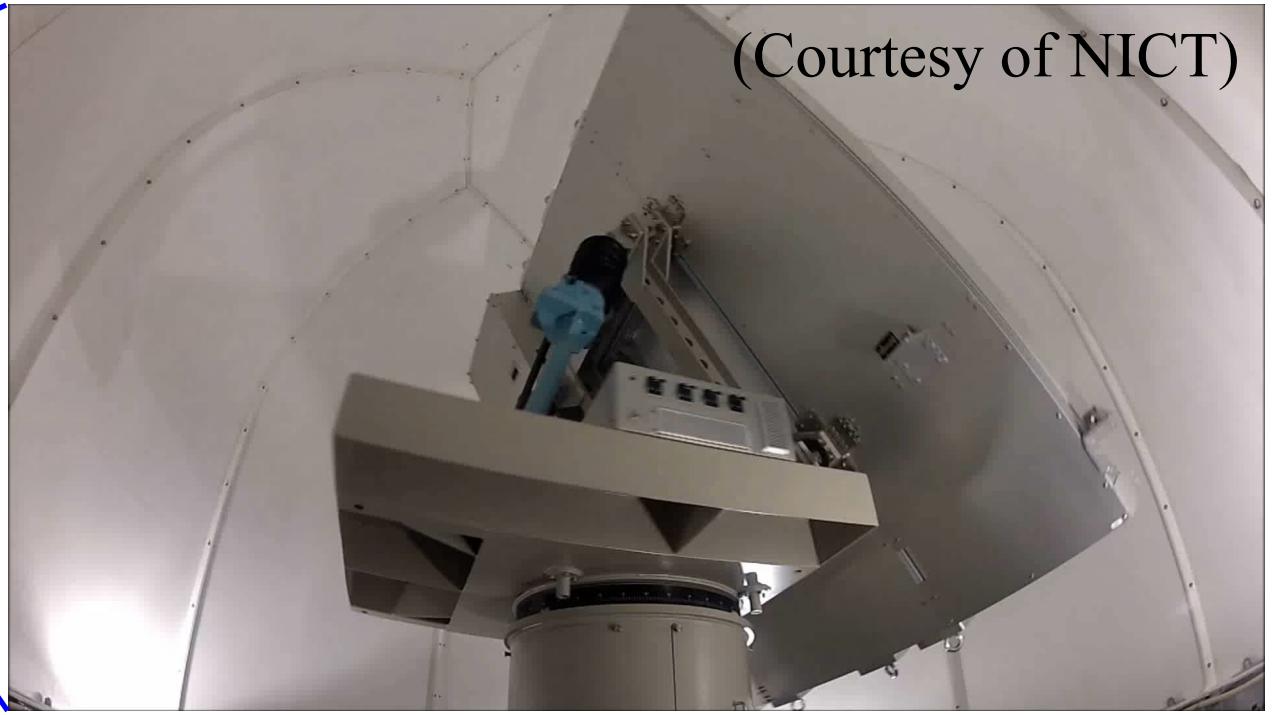
# Only in 10 minutes!!

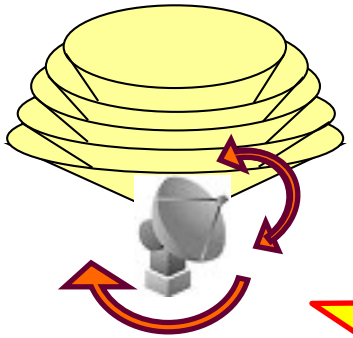
Kobe newspaper (https://www.kobe-np.co.jp/news/kobe/201807/0011486822.shtml)

1.34 m in 10 minutes!!

5 people died in River Toga in Kobe on July 28, 2008

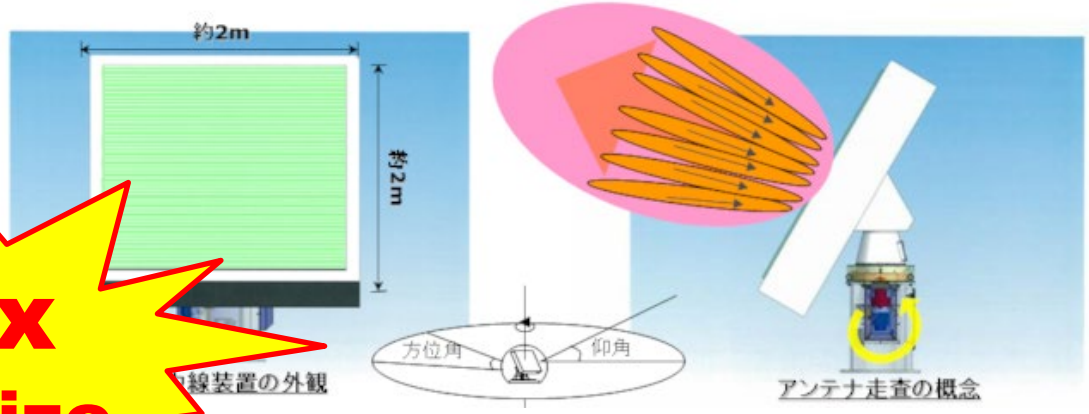
# Phased Array Weather Radar (PAWR)



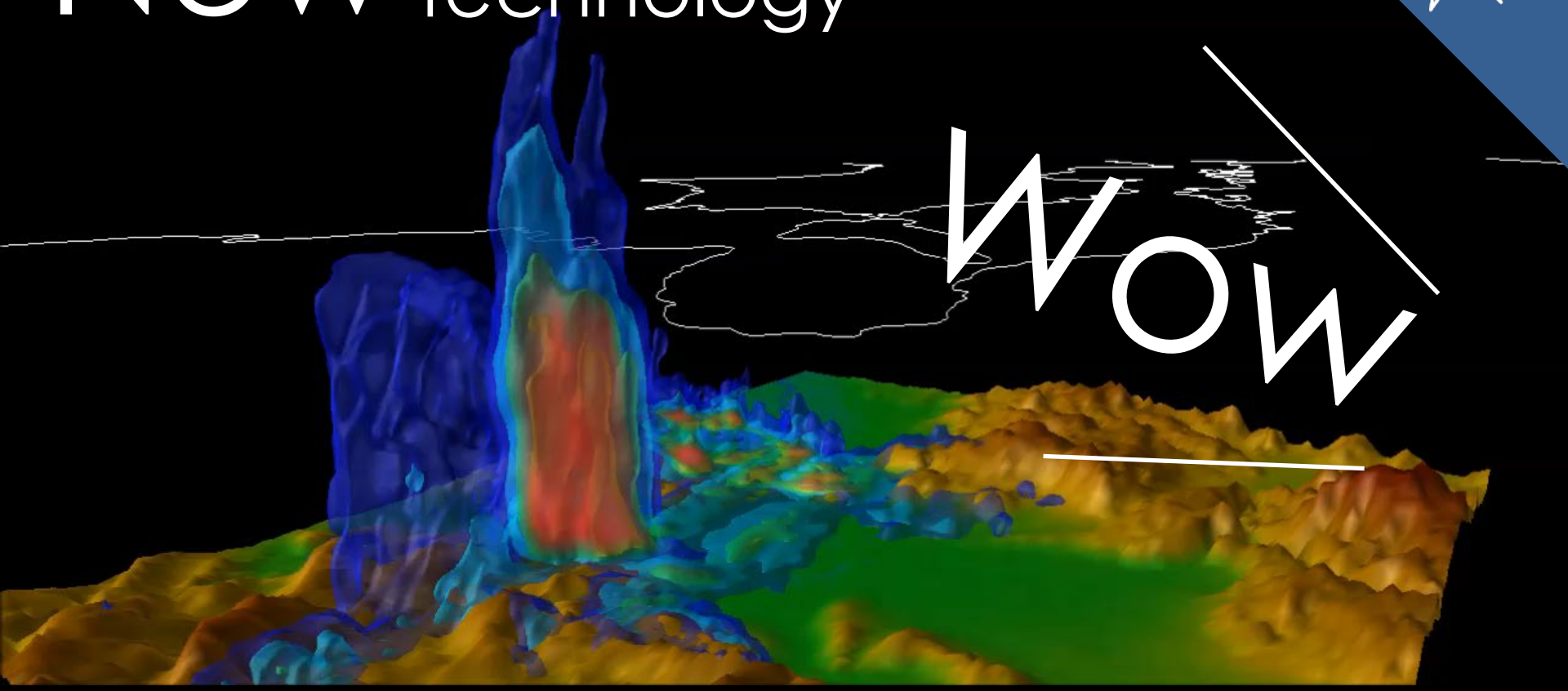
3-dim measurement using
a parabolic antenna (150 m,
15 EL angles in 5 min)

**100x data size**




3-dim measurement using a phased array antenna
(100 m, 100 EL angles in 30 sec)

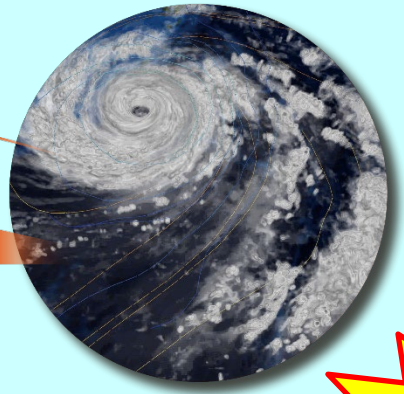
# New radar technology



# Big Data Assimilation

Observations

Simulations



Data Assimilation

100x

Big Data

New sensors, IoT

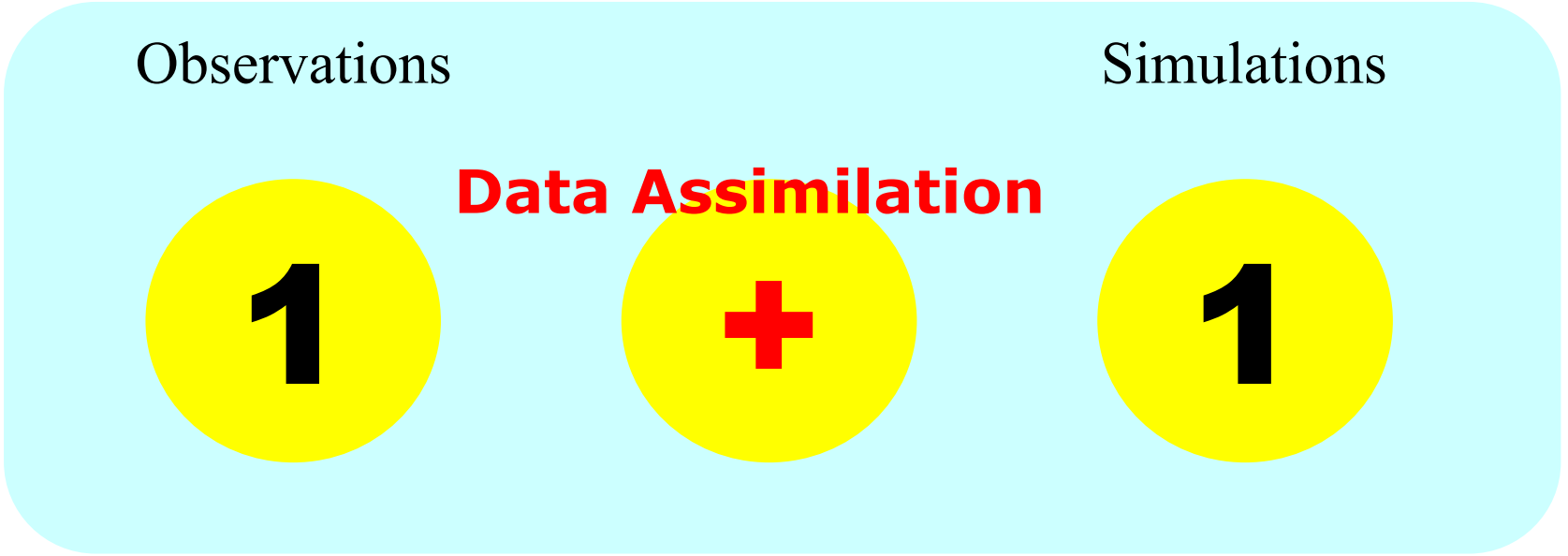
Big Data

100x

Powerful supercomputer

©RIKEN

# Data Assimilation (DA)




**>2**

# Data Assimilation (DA)

**Data-driven**
**Induction**
**Real world**

**Process-driven**
**Deduction**
**Cyber world**

Observations

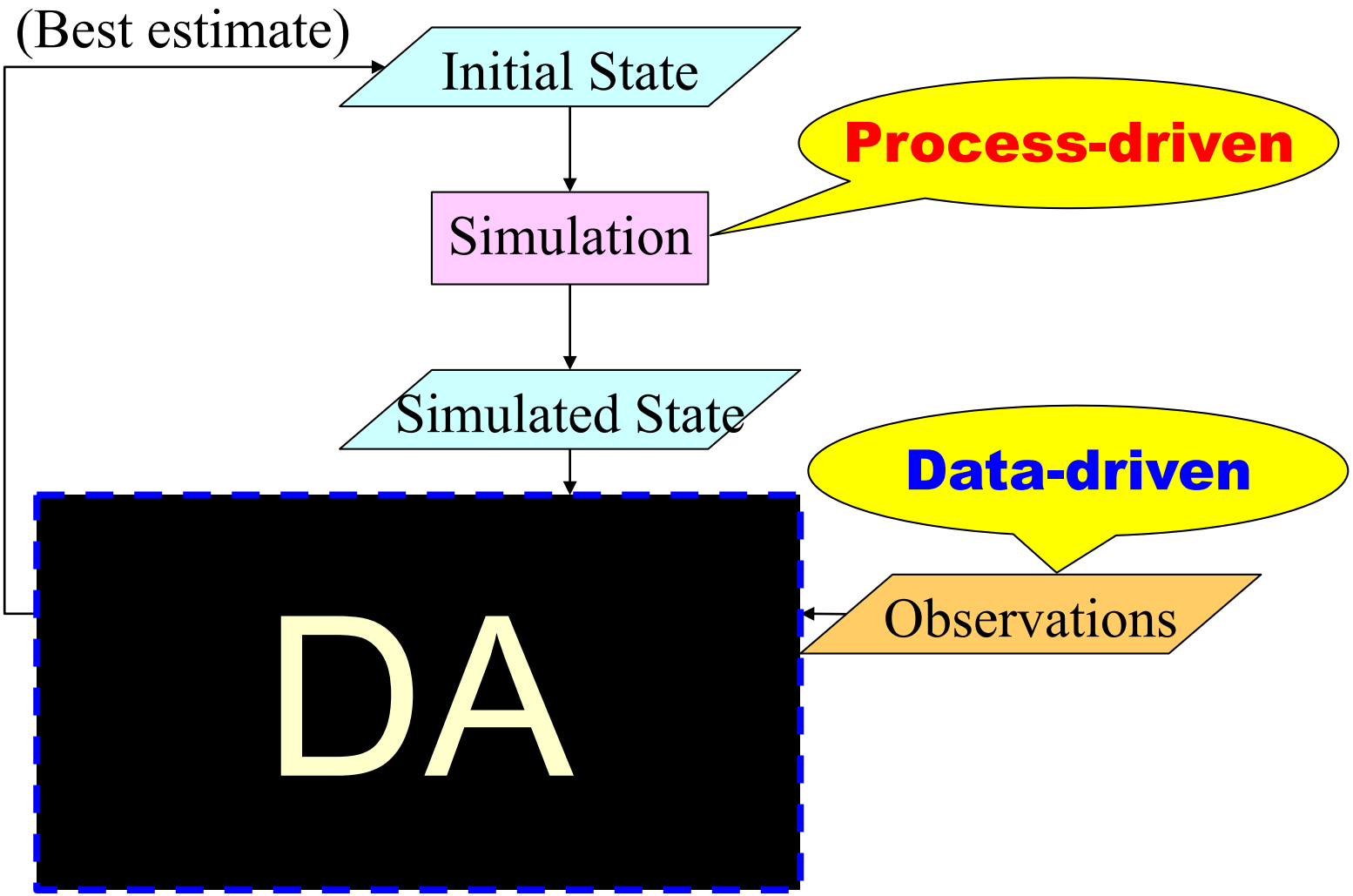
Simulations

**Data Assimilation**

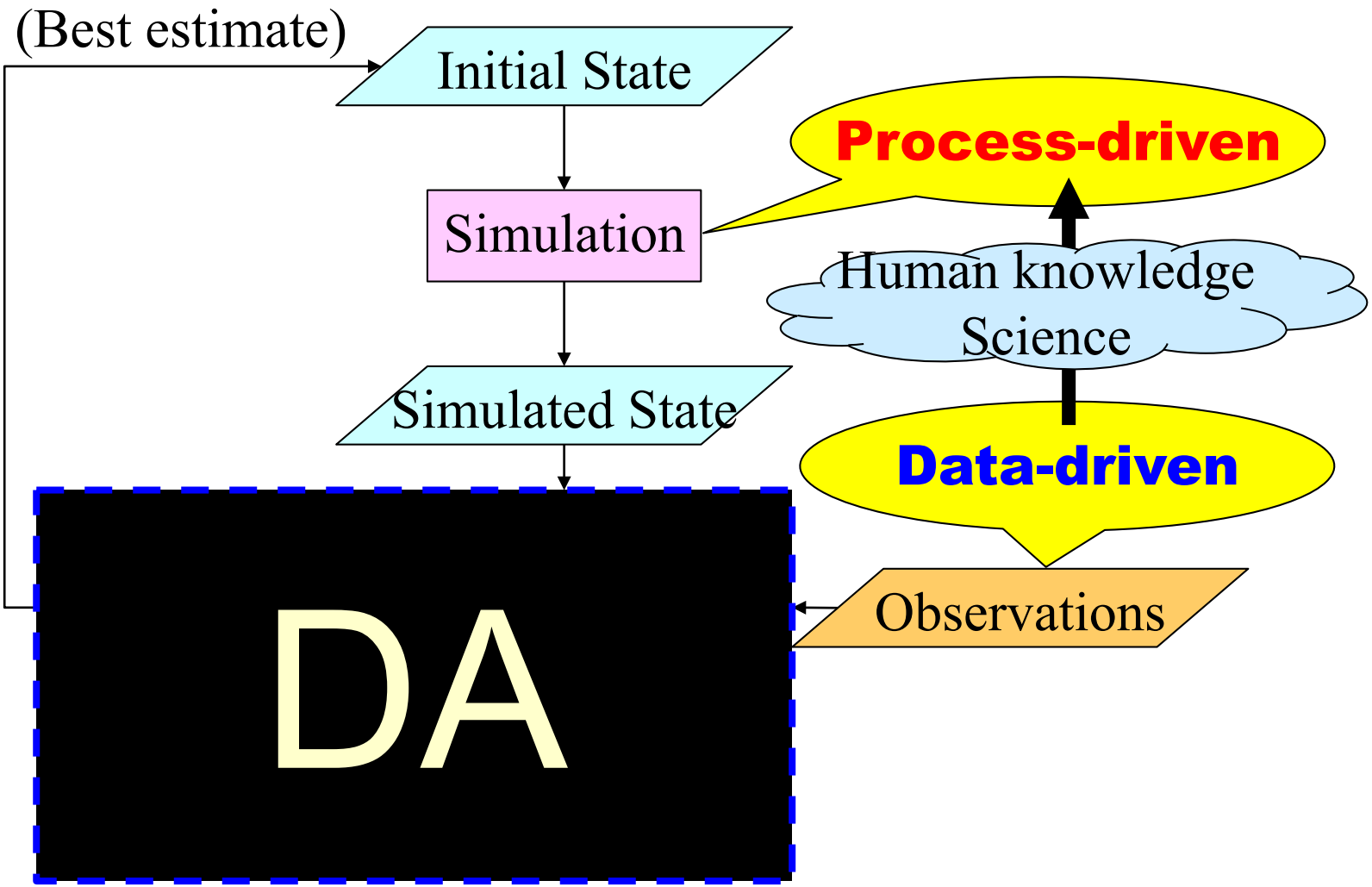
**1** **+** **1**

**>2**

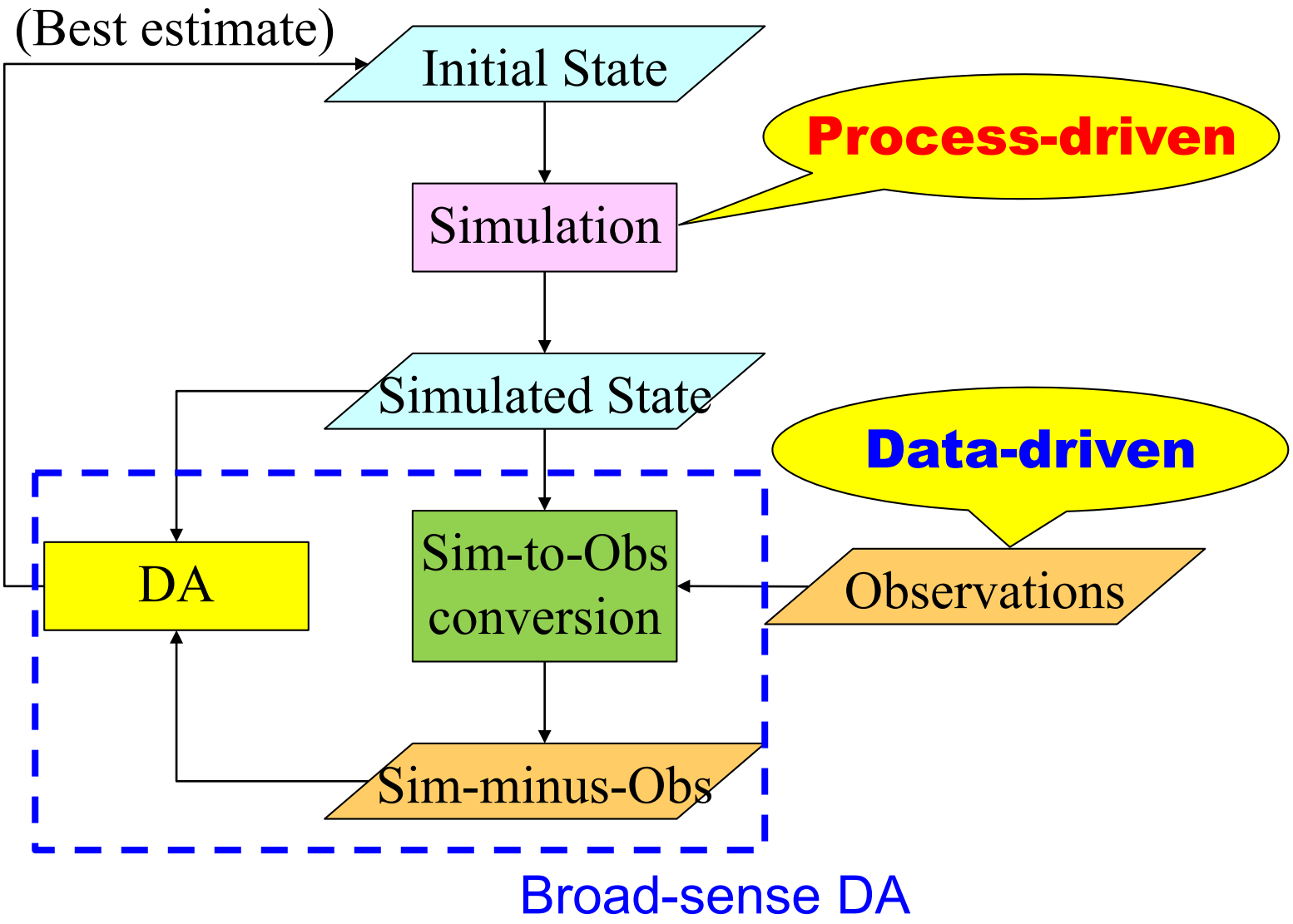
# DA workflow


(Best estimate)
Initial State
Process-driven
Simulation
Simulated State
Data-driven
DA
Observations

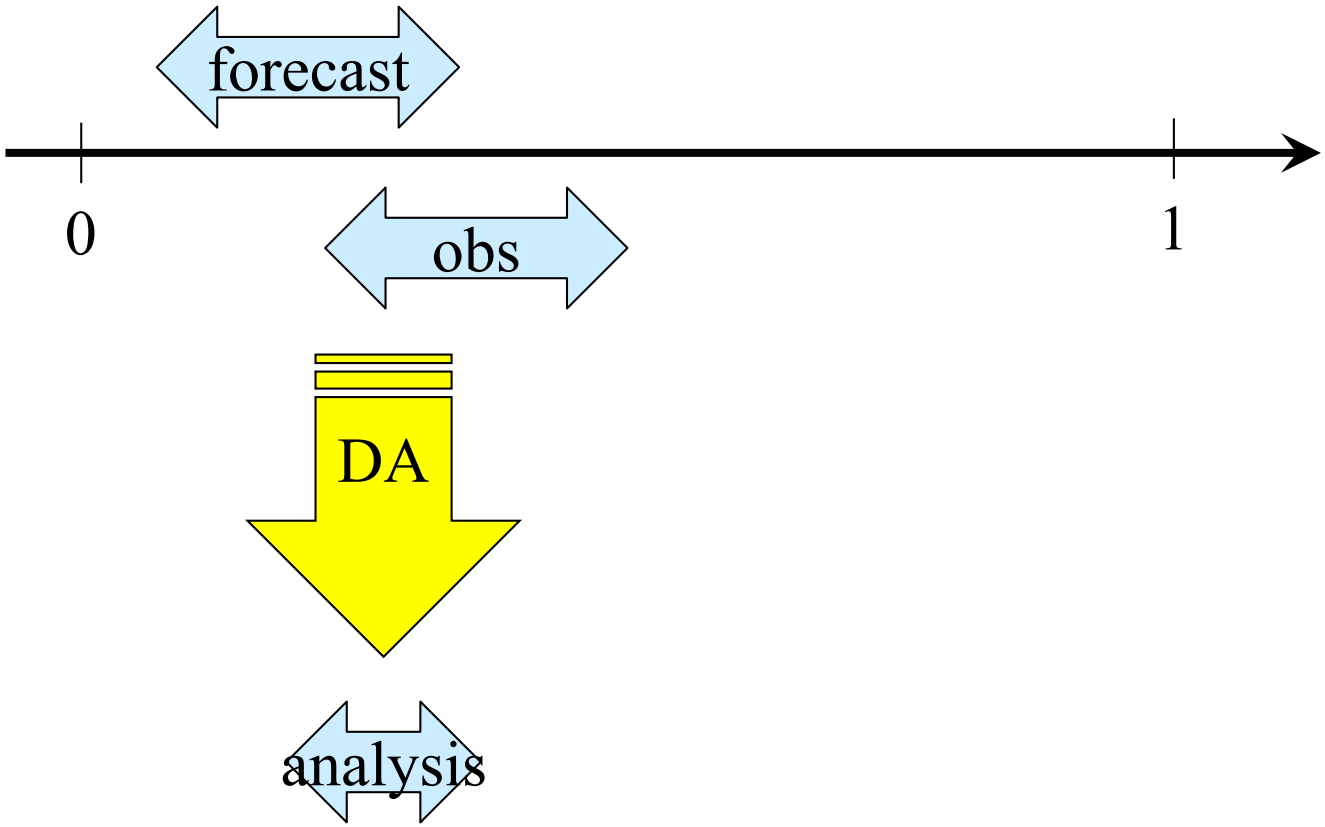
# DA workflow


(Best estimate)
Initial State
Simulation
Simulated State
DA
Process-driven
Human knowledge
Science
Data-driven
Observations

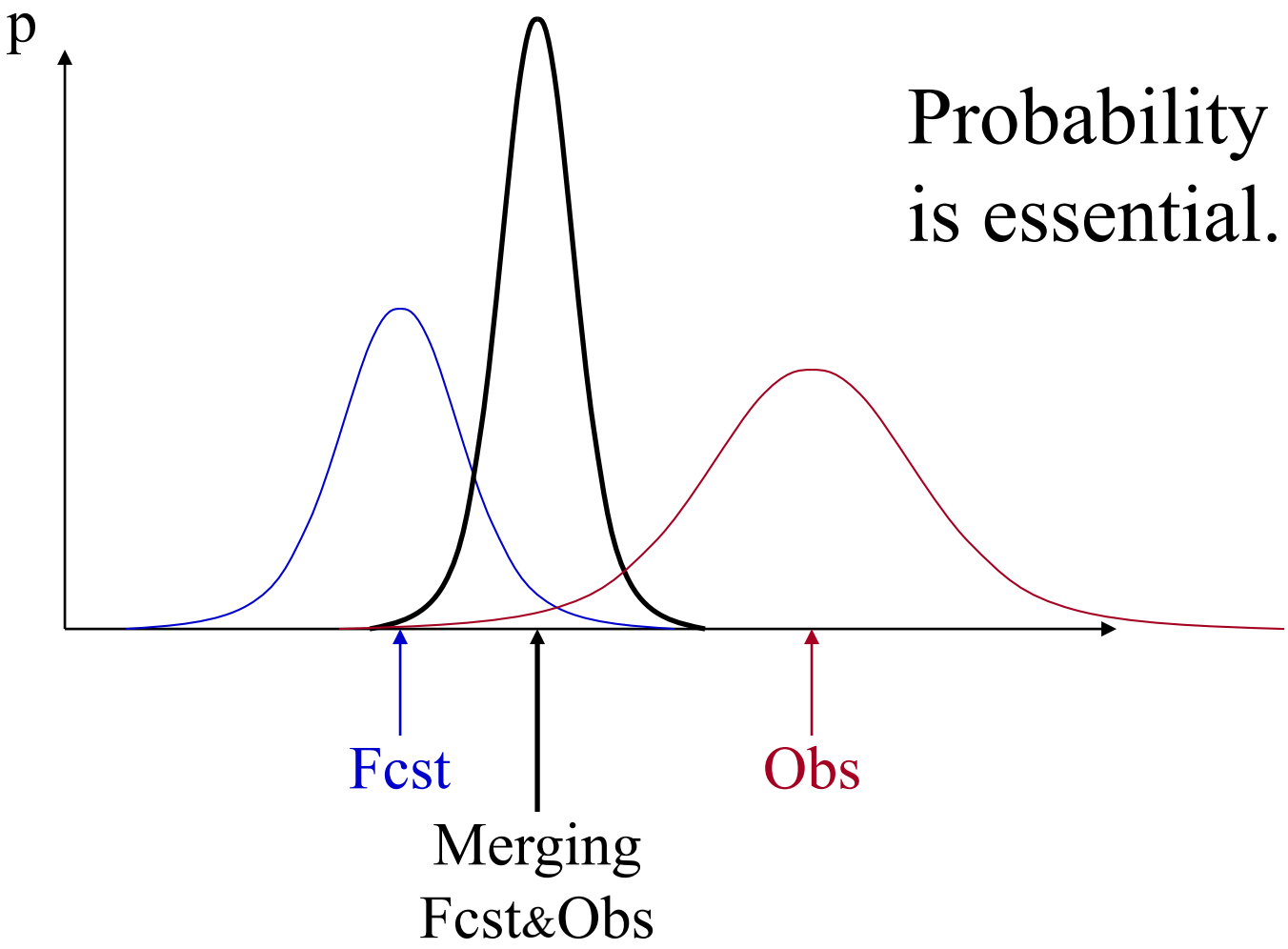
# DA workflow


(Best estimate)
Initial State
Process-driven
Simulation
Simulated State
Data-driven
DA
Sim-to-Obs conversion
Observations
Sim-minus-Obs
Broad-sense DA

# DA = math of errors

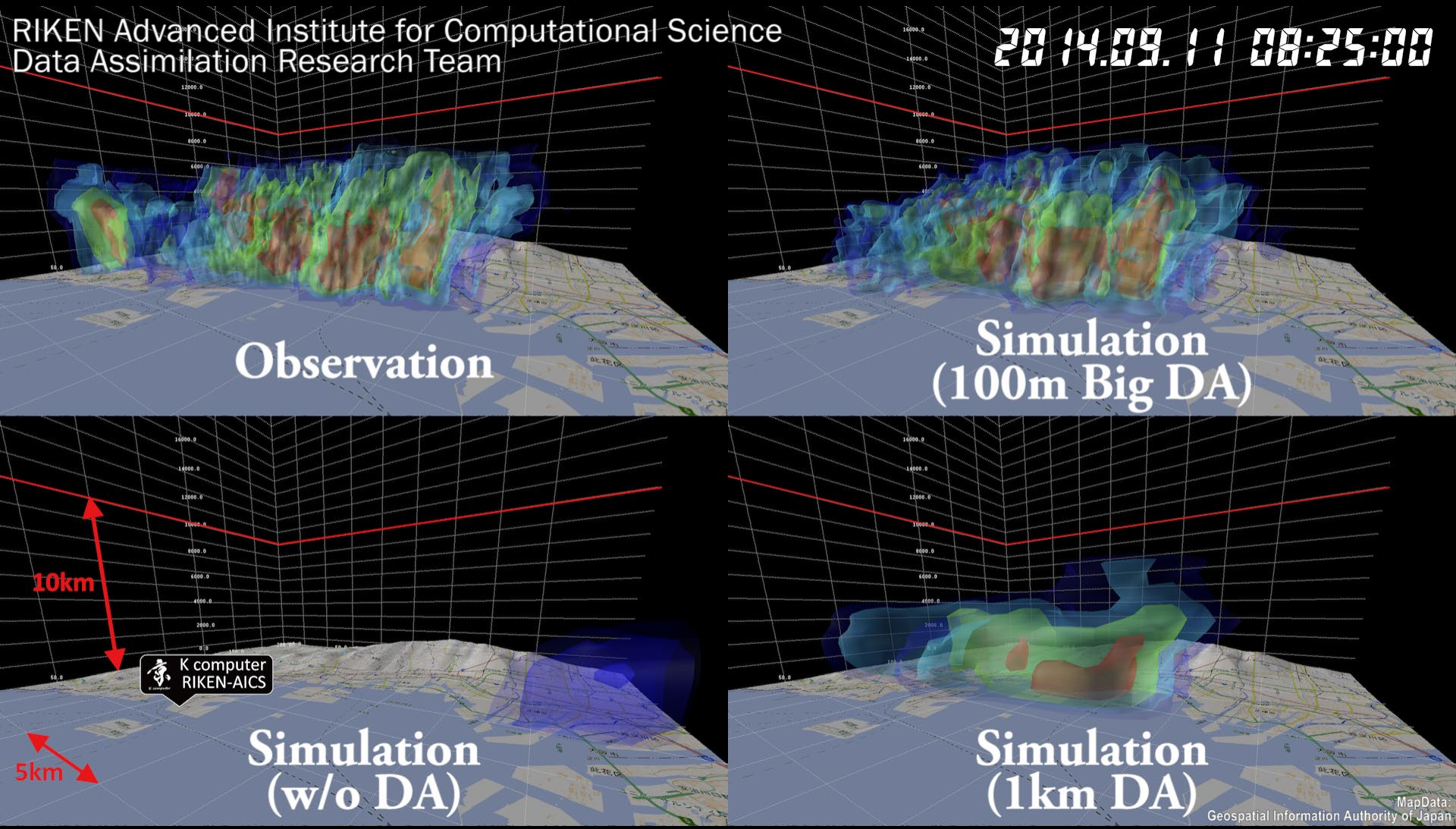


# Merging 2 information (Bayesian estimation)



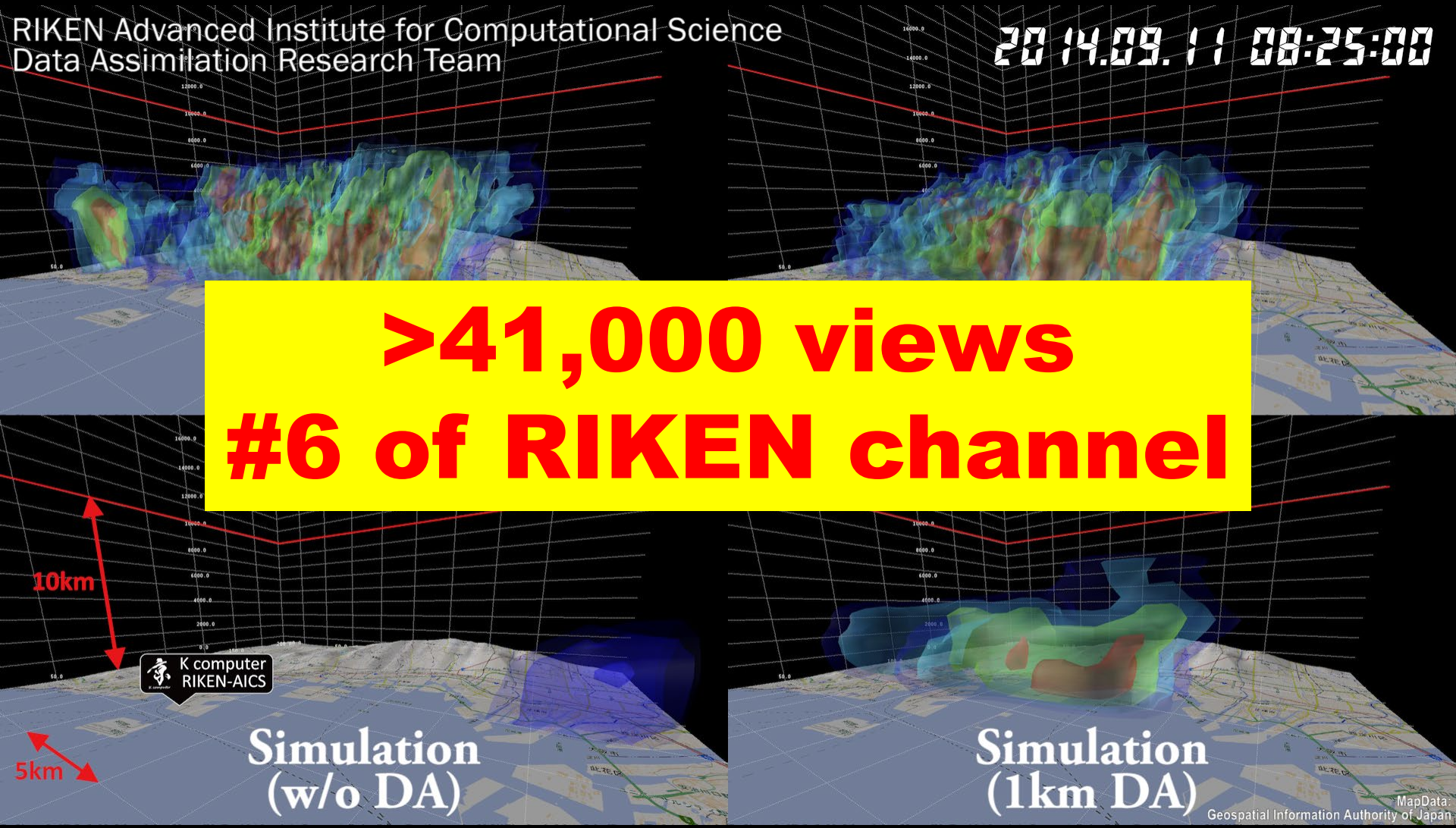

Probability distribution is essential.

# 9/11/2014, sudden local rain




Youtube: https://www.youtube.com/watch?v=42NZTGdp1Js

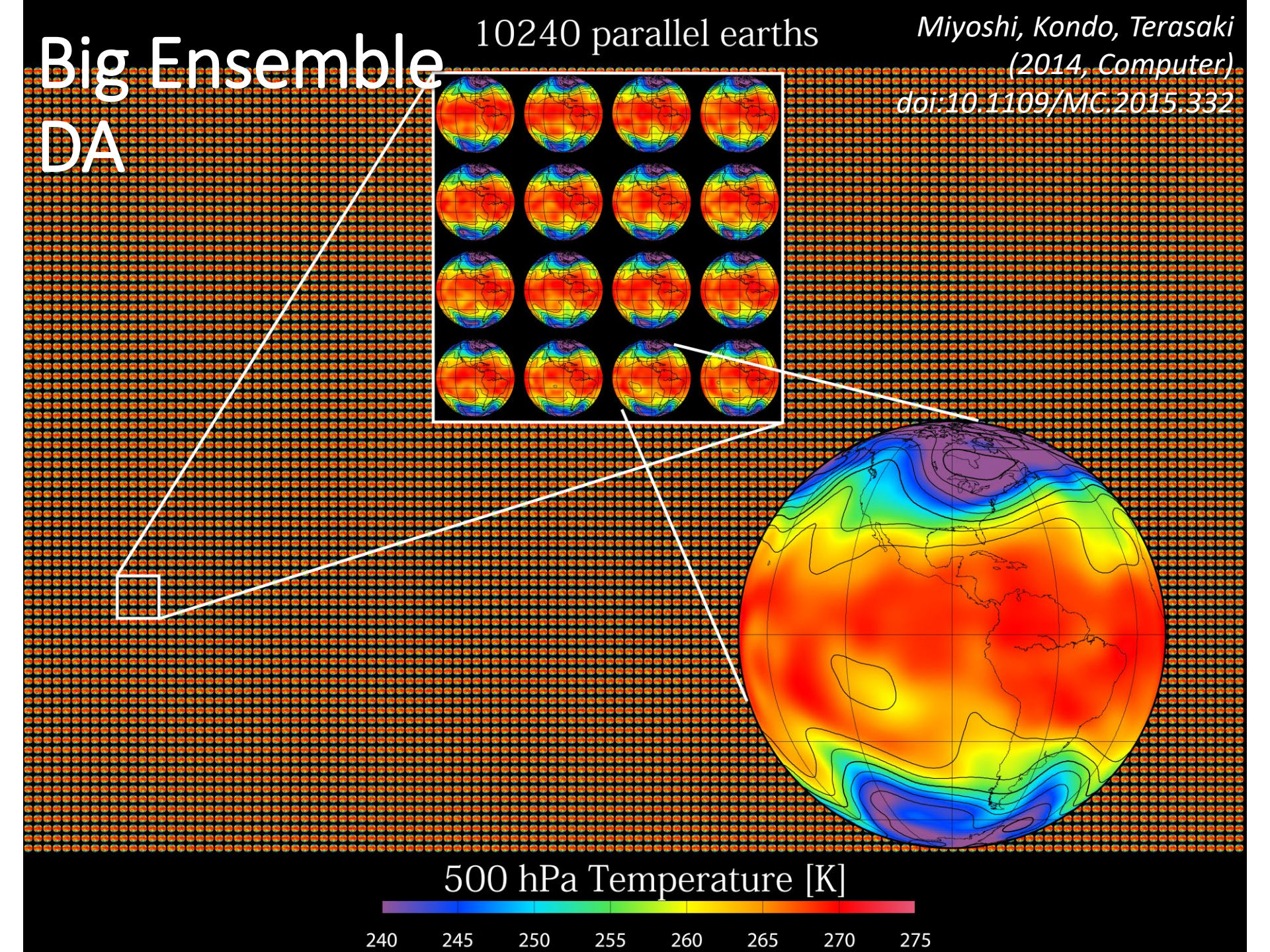
# 9/11/2014, sudden local rain



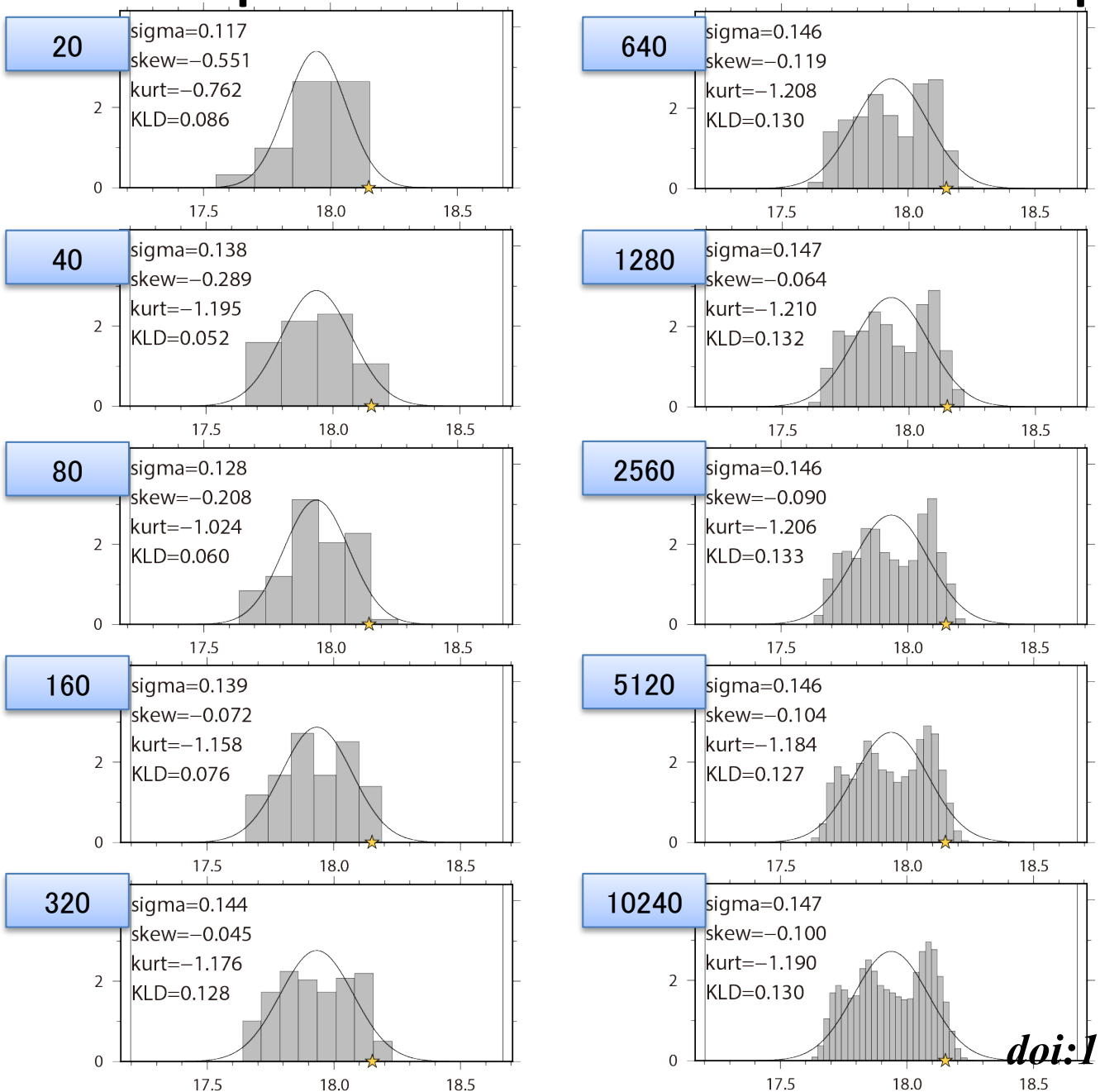

**>41,000 views**
**#6 of RIKEN channel**

Youtube: https://www.youtube.com/watch?v=42NZTGdp1Js

# Big Ensemble DA



# Sample size = Resolution of probability

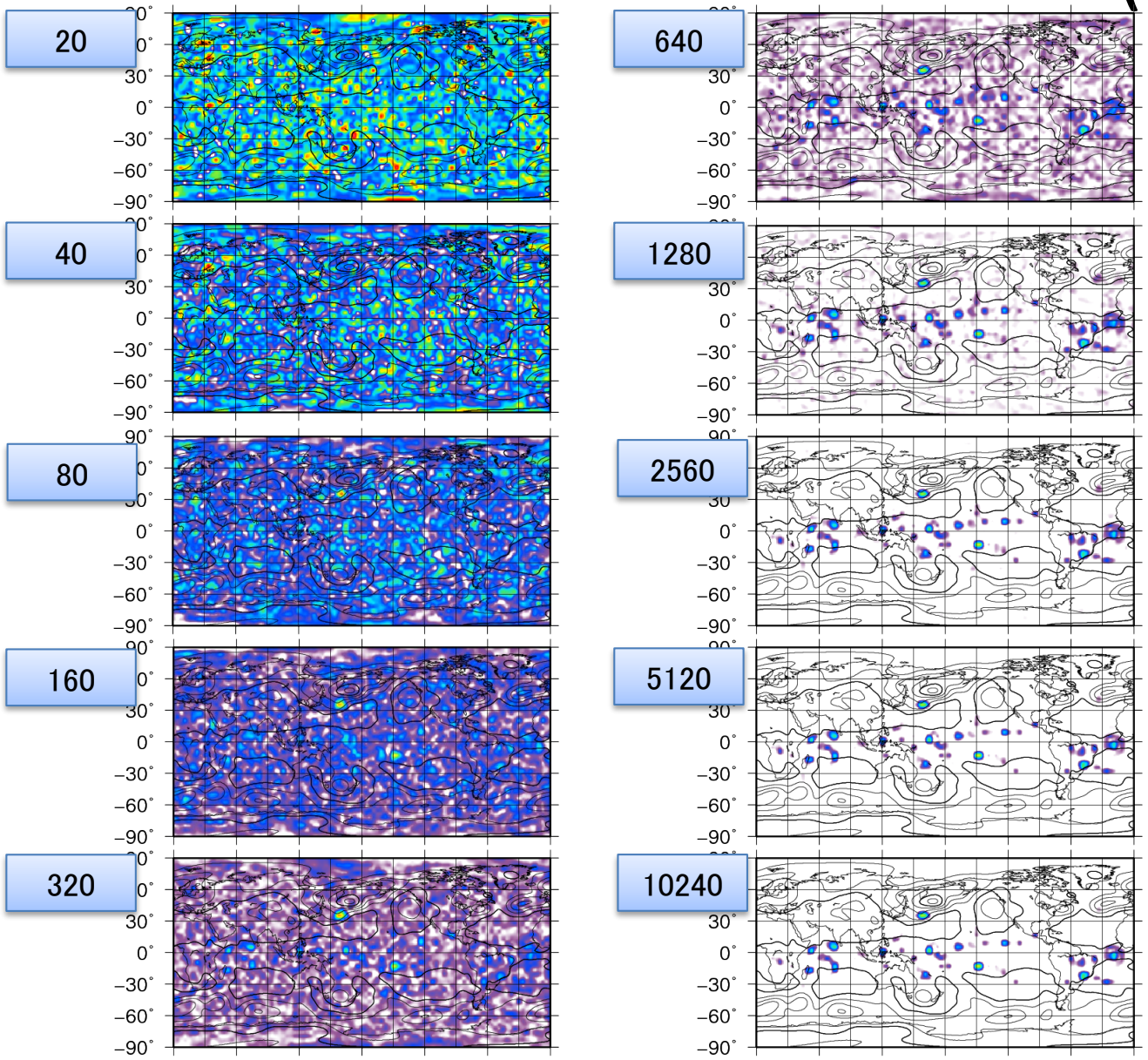


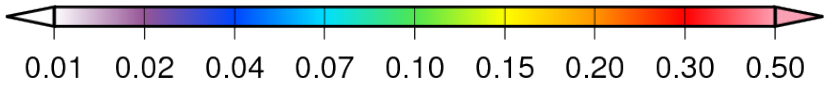

1.856N, 176.25E

***Kondo&Miyoshi (2019, NPG)***

***doi:10.5194/npg-26-211-2019***

# Non-Gaussian metric (KLD)

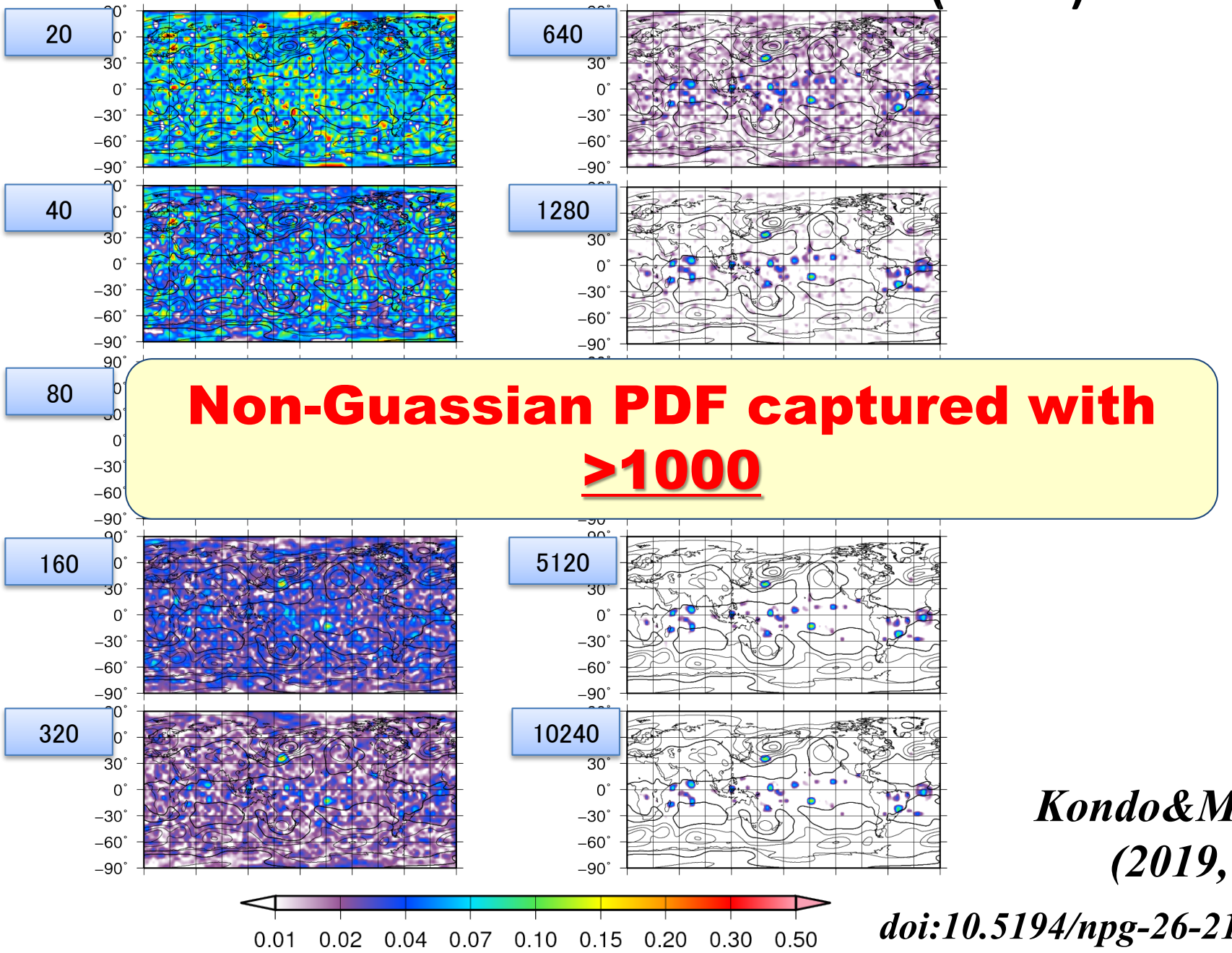



***Kondo&Miyoshi (2019, NPG)***

***doi:10.5194/npg-26-211-2019***

# Non-Gaussian metric (KLD)

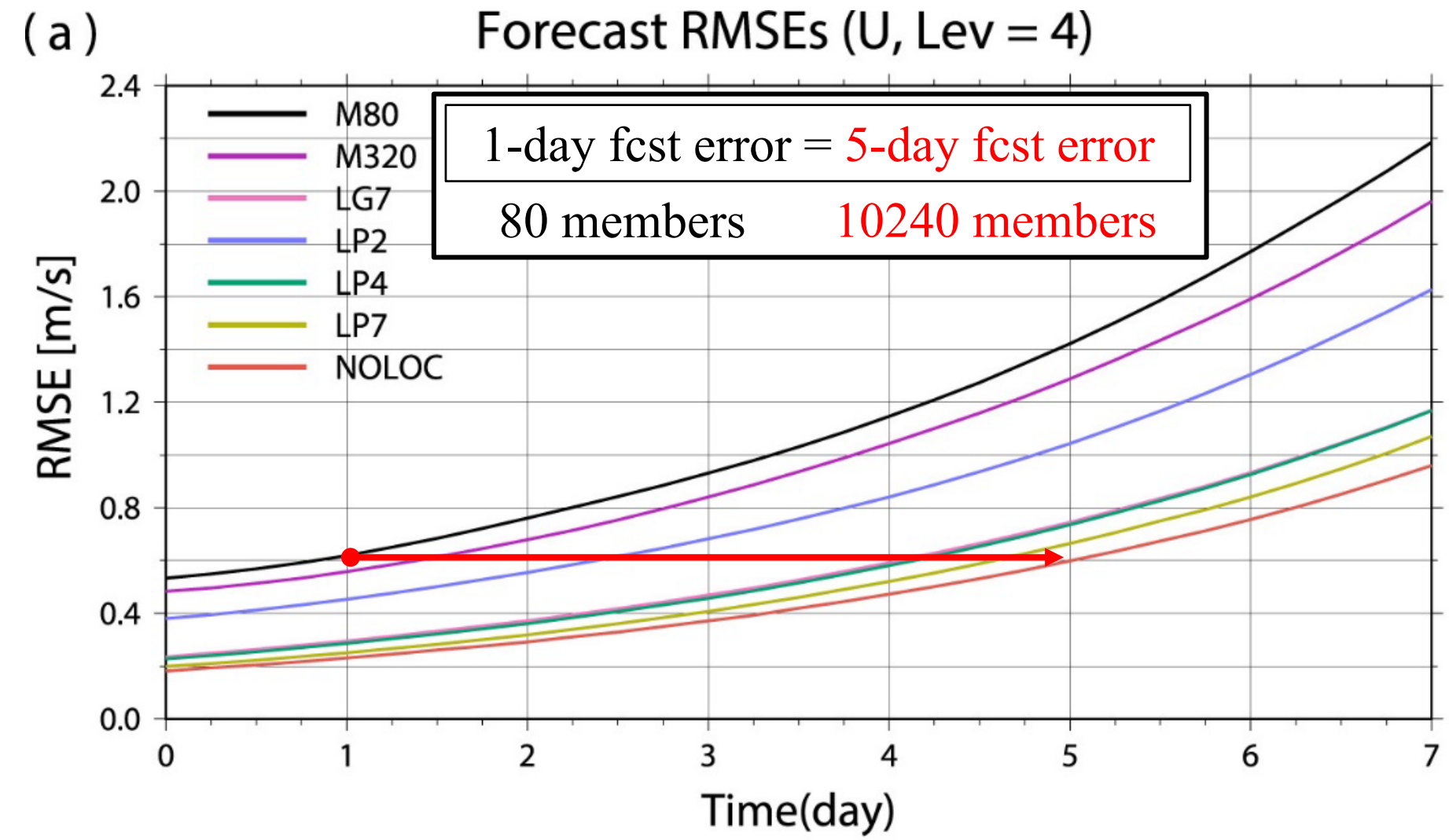



**Non-Guassian PDF captured with >1000**

*Kondo&Miyoshi (2019, NPG)*

*doi:10.5194/npg-26-211-2019*

# Improving NWP




***Kondo and Miyoshi (2016, MWR, doi:10.1175/MWR-D-15-0388.1)***

# Pushing the limits

## *Big Data* × *Big Simulations*

Big ensemble (10240 ensemble members)

Rapid update (30-second update)

High resolution (100-m mesh)

➔ Future Numerical Weather Prediction

**Fugaku**
**Global 3.5-km mesh**
**1000 samples**

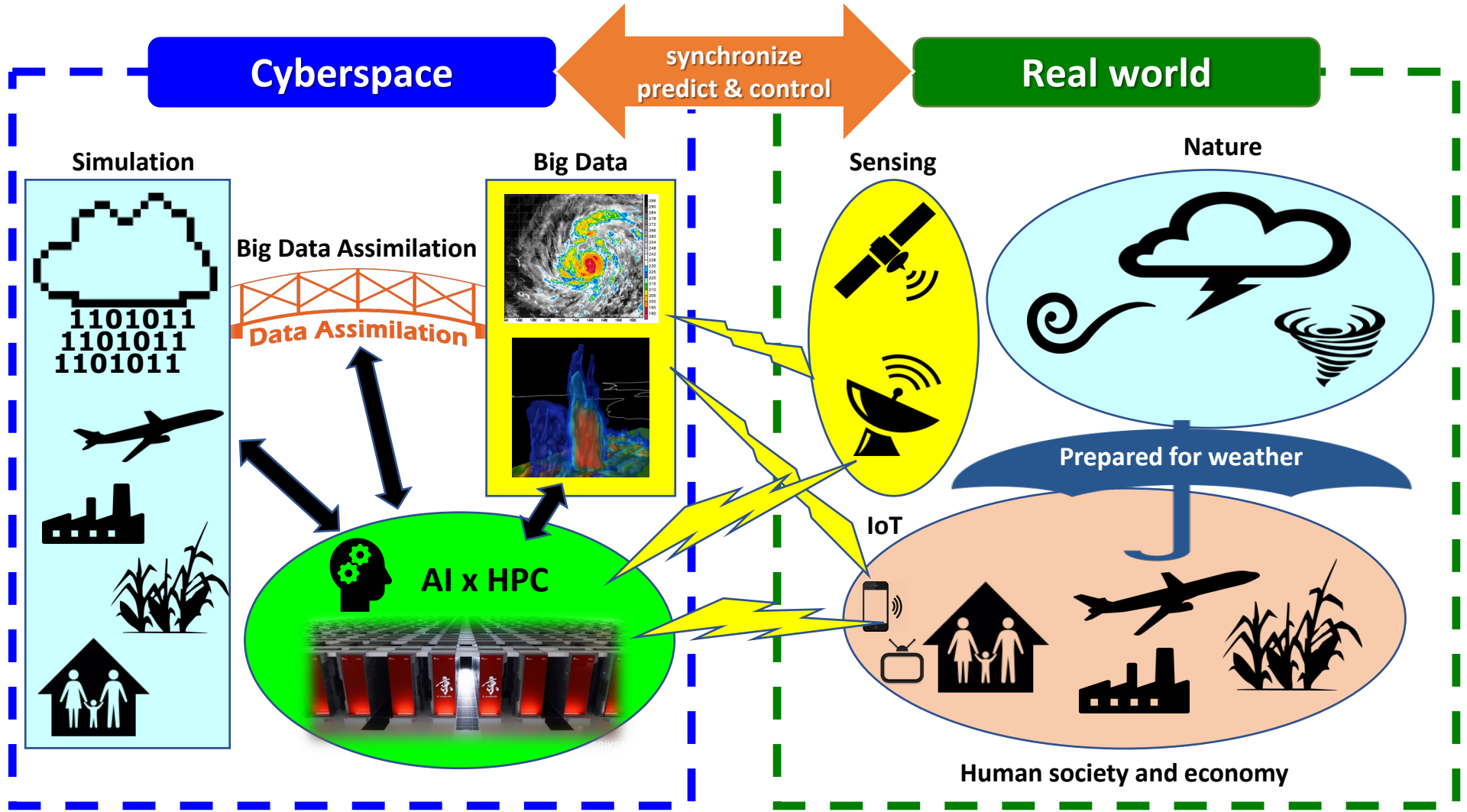
**K**
**Global 112-km mesh**
**10240 samples**

**Fugaku : K = 100 : 1**

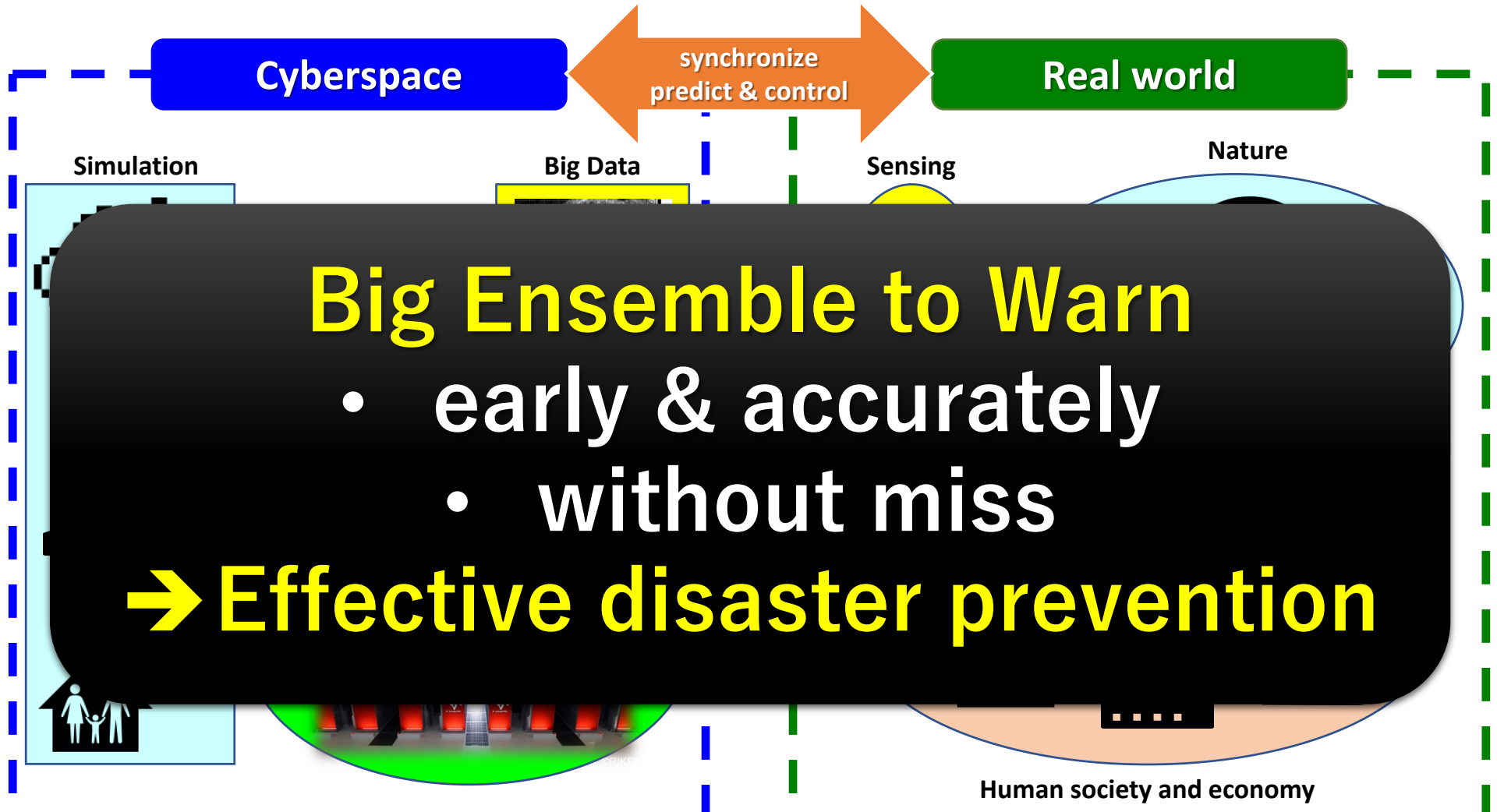
Mesh size: 32x
(Grid points: 1024x)

Sample size: 0.1x

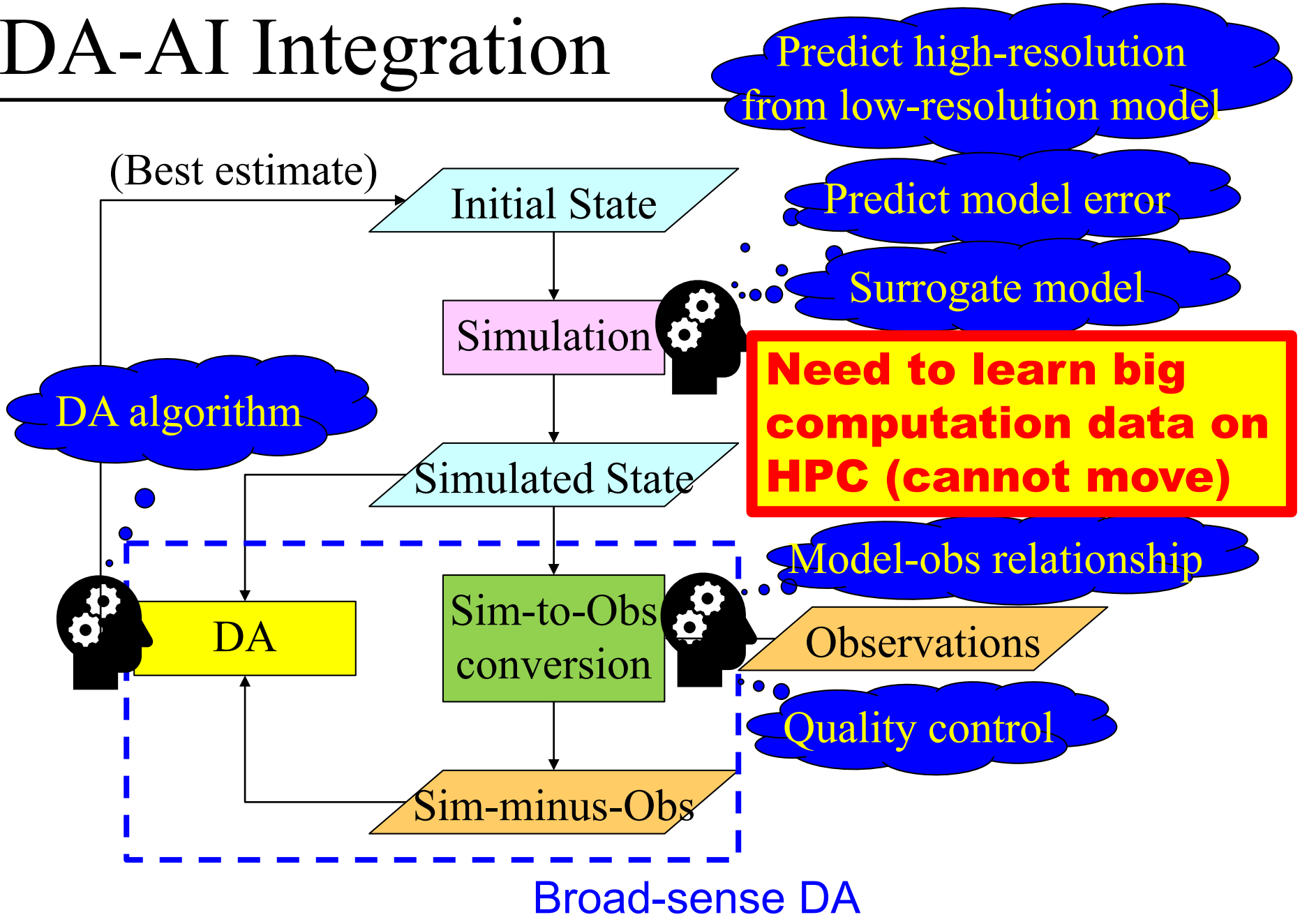
# Toward Weather-Ready Society5.0 with BDA



# Toward Weather-Ready Society5.0 with BDA

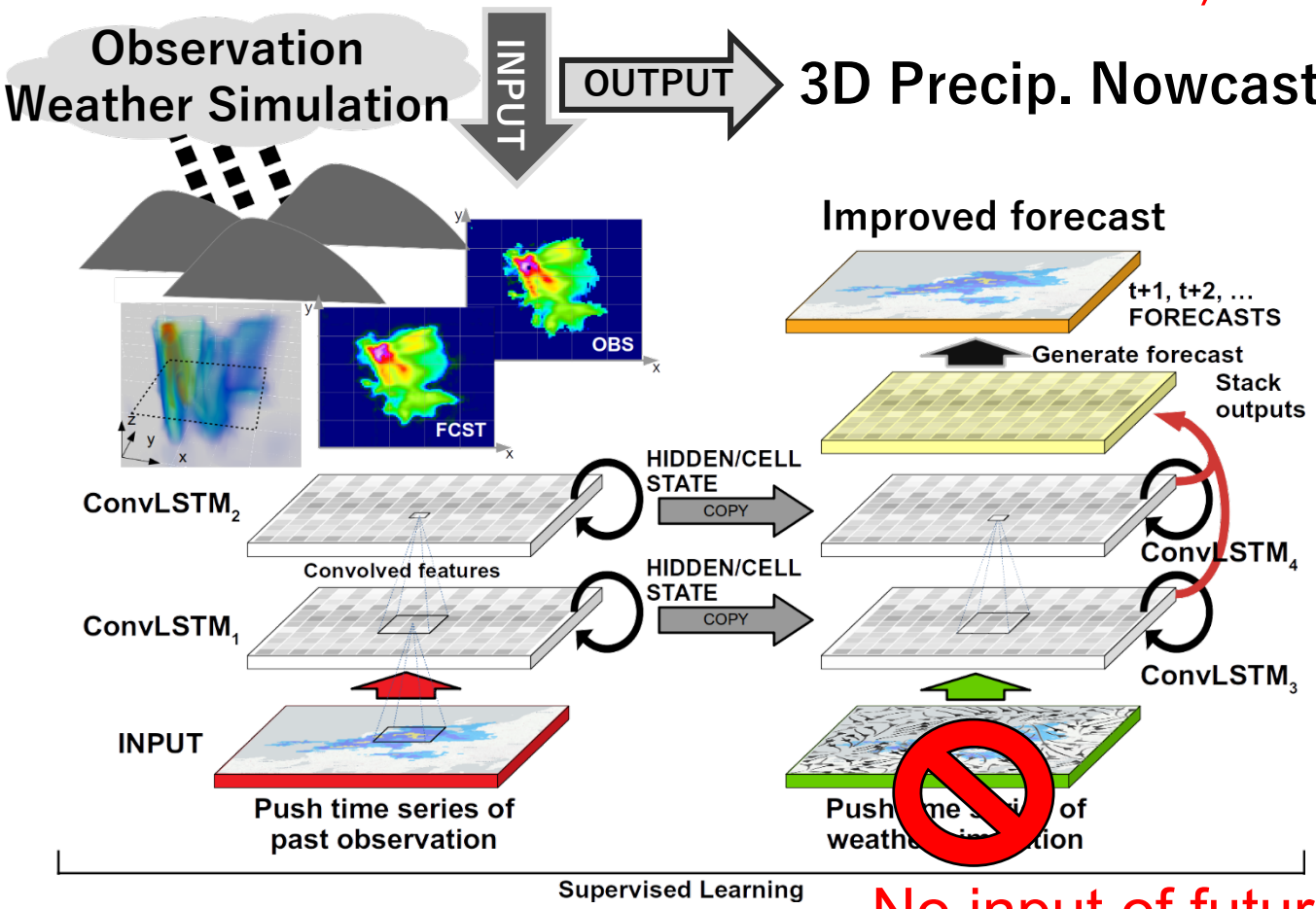


# DA-AI Integration



# PAWR 3D Nowcasting

**Parallel test of real-time nowcasting w/ ConvLSTM since June 6, 2019!!**

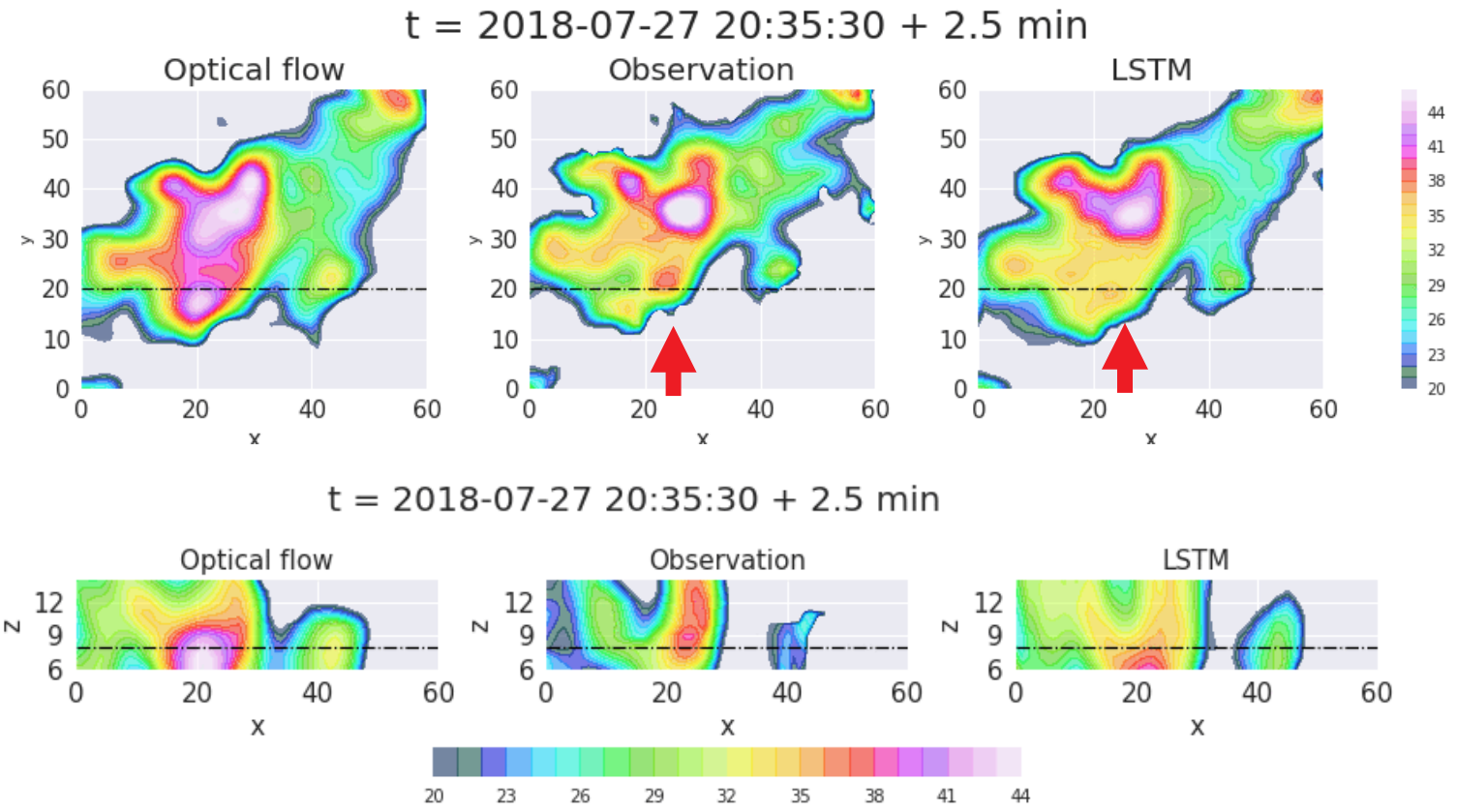



No input of future data at this moment

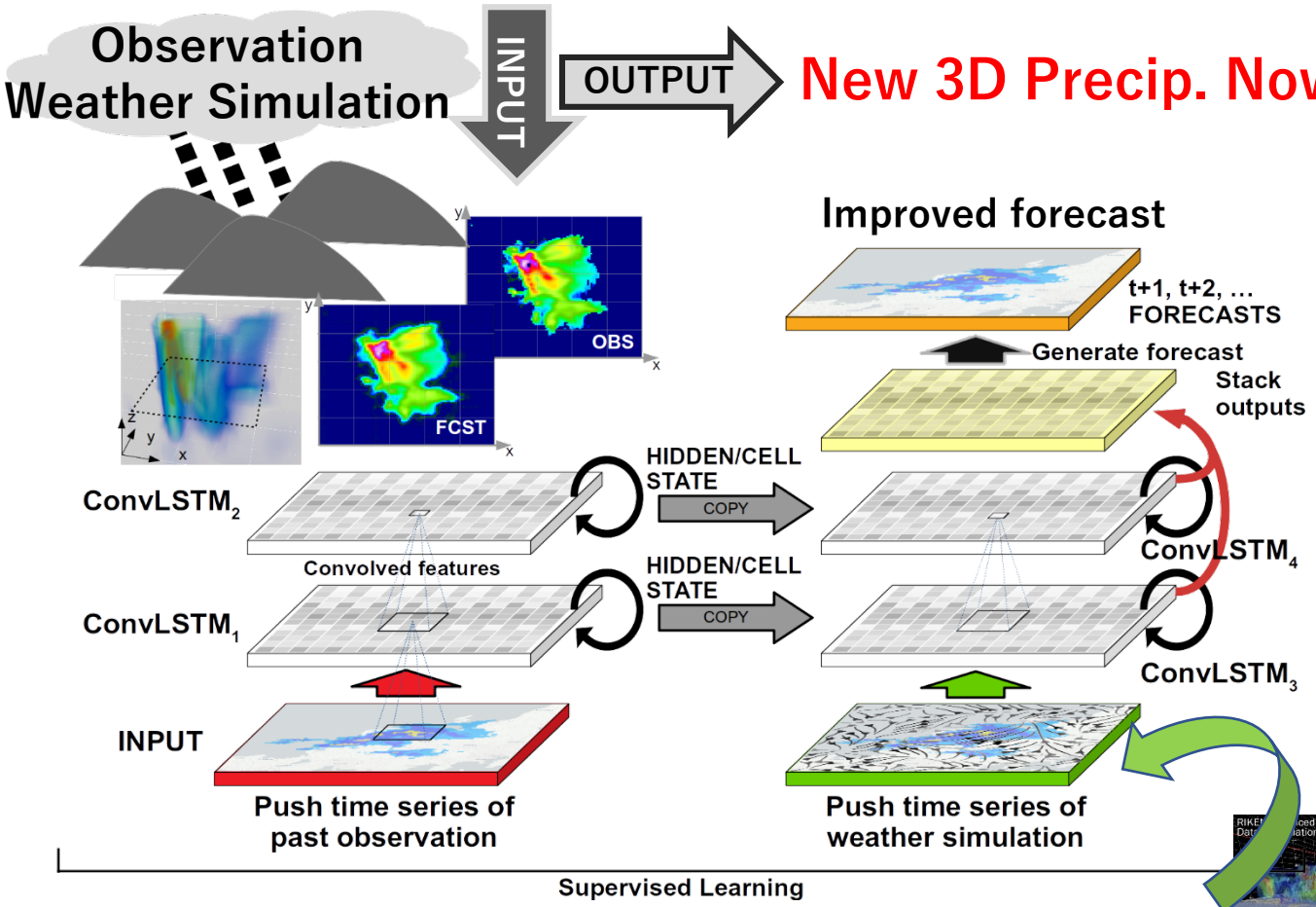
# Conv-LSTM is effective.

(Work with Mr. Viet Phi Huynh and Prof. Pierre Tandeo)

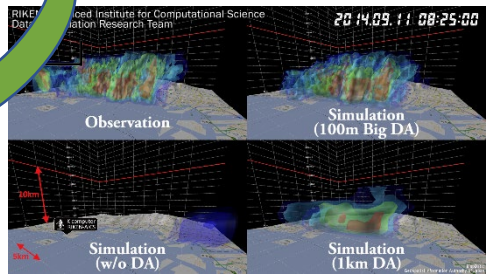
**2.5-min prediction**



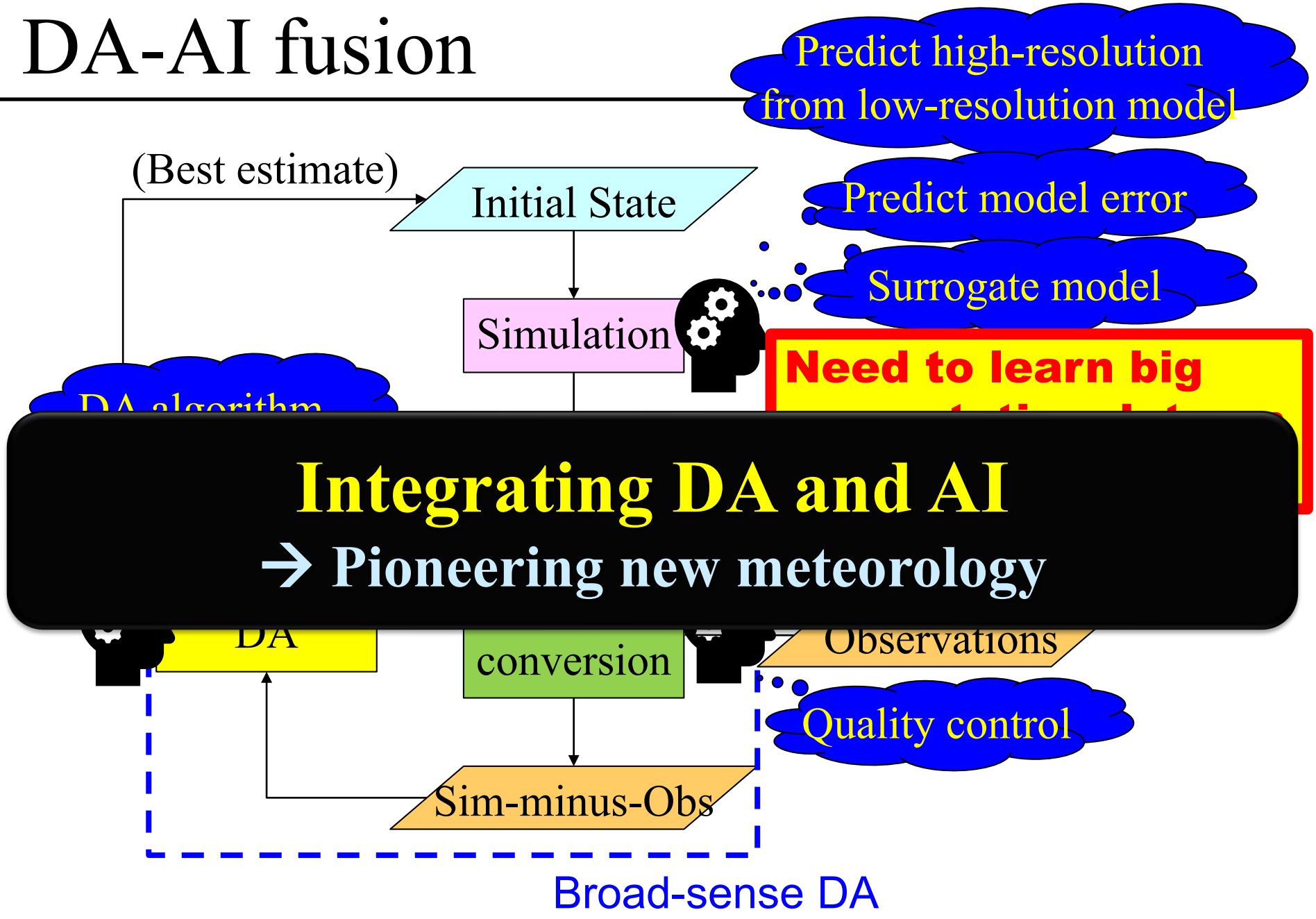
# Future direction: **Fusing ML+DA+Simulation**




Input of future data from NWP!!



# DA-AI fusion


Predict high-resolution from low-resolution model
(Best estimate)
Initial State
Predict model error
Surrogate model
Simulation
Need to learn big
DA algorithm
Integrating DA and AI
→ Pioneering new meteorology
DA
conversion
Observations
Quality control
Sim-minus-Obs
Broad-sense DA