RIKEN R-CCS

Data Assimilation Team

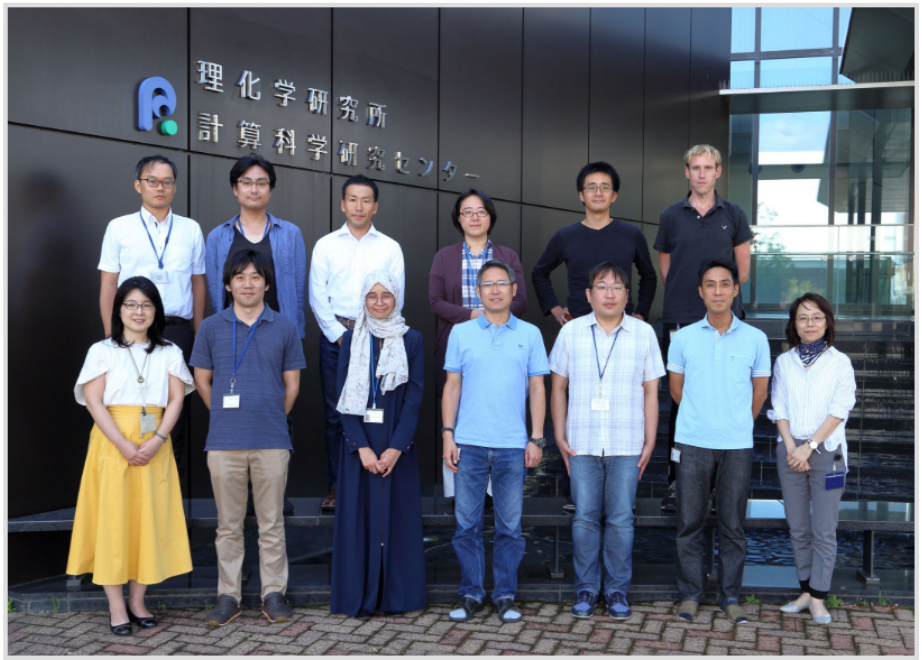
http://www.data-assimilation.riken.jp/

Data Assimilation Research Team

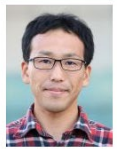
Data Assimilation Research Team was launched in October, 2012, in RIKEN Advanced Institute for Computational Science (AICS), conveniently located in the beautiful and historic city of Kobe. RIKEN is known as the flagship research institution in Japan. On April 1, 2018, RIKEN AICS was renamed RIKEN Center 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 methodsand their wide 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 areas 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 for the K computer.



Team Leader	Research Scientist	Research Scientist
		
Takemasa Miyoshi	Koji Terasaki	Shigenori Otsuka

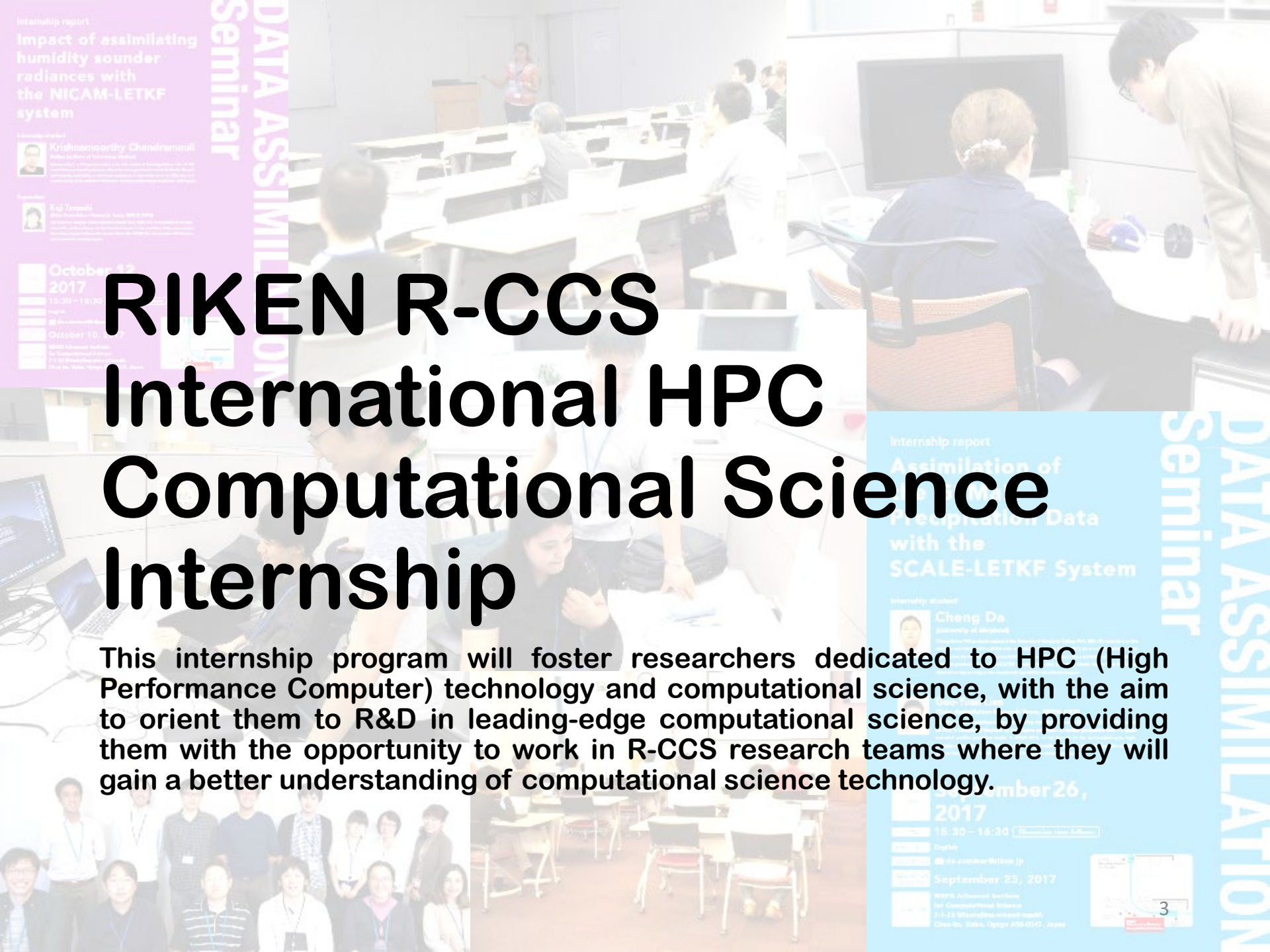
Postdoctoral Researcher	Postdoctoral Researcher	Postdoctoral Researcher	Postdoctoral Researcher
			
Takumi Honda	Kohei Takatama	James Taylor	Arata Amemiya

Postdoctoral Researcher	Postdoctoral Researcher	Research Associate	Technical Staff
			
Maha Mdini	Shun Ohishi	Yasumitsu Maejima	Hideyuki Sakamoto

Programs for Students and Early-career Scientists

Special Academic Experience in Japan

Data Assimilation Research Team
RIKEN Center for Computational Science (R-CCS)



RIKEN R-CCS International HPC Computational Science Internship

This internship program will foster researchers dedicated to HPC (High Performance Computer) technology and computational science, with the aim to orient them to R&D in leading-edge computational science, by providing them with the opportunity to work in R-CCS research teams where they will gain a better understanding of computational science technology.

RIKEN R-CCS International HPC Computational Science Internship

- **Internship period**
  - Up to 90 days between May and October.
- **Qualification**
  - Ph.D student.
  - Master student/Postdoctoral Fellow may be considered under special occasions. Contact the intern hosting desk.
- **Calls for application**
  - Usually November -February
- **Application documents**
  - Registration form(CV)
  - Research Achievement List
  - The reason why you apply

Financial Support

Travel expenses	Airfare (1 round-trip ticket)
Commuting expenses	Daily commuting fares between the intern's lodging and R-CCS for the number of working days
Lodging expenses	To be provided (shared house)
Living expenses	3,000 yen per day for the number of working days

https://www.r-ccs.riken.jp/en/events/200501.html

RIKEN International Program Associate (IPA)

IPAs conduct research at RIKEN under the supervision of RIKEN scientists as part of work toward obtaining a PhD. RIKEN's joint graduate school program is based on agreements with a number of domestic and overseas universities and aims to identify and foster talented young scientists capable of contributing to the advancement of science for the global community.

RIKEN International Program Associate (IPA)

- **Internship period**
  - 1 to 3 years, in principle.
- **Qualification**
  - Graduate student(doctoral) enrolled/to be enrolled in a PhD program at a university having a partnership program with RIKEN.
    - Universities having the program with RIKEN are shown here.
    - If your university is not included, a partnership program should be newly established with RIKEN.
  - The lab head of the hosting laboratory must interview the candidate prior to application.
- **Calls for application**
  - Twice a year (April and October)

RIKEN International Program Associate (IPA)

Financial Support

Travel expenses	Airfare (1 round-trip ticket)
Lodging expenses	Actual amount up to a maximum of 70,000 JPY/month
Living expenses	5,200 JPY/day
Accident insurance premium	To be covered

https://www.riken.jp/en/careers/programs/ipa/index.html

RIKEN International Program Associate (IPA-short)

- Internship period
  - Exceeding 3 months and within six months
- Qualification
  - Graduate student(doctoral/masters) enrolled/to be enrolled in a PhD program at a university having a MOU with RIKEN
    - IMT Atlantique – MOU with R-CCS ✔
    - NCU – MOU with R-CCS ✔
  - The lab head of the hosting laboratory must interview the candidate prior to application.
- Calls for application
  - Twice a year (April and October)

RIKEN International Program Associate (IPA-short)

Financial Support

Travel expenses	To be paid by the student's university
Lodging expenses	Actual amount up to a maximum of 70,000 JPY/month
Living expenses	5,200 JPY/day
Accident insurance premium	To be paid by the student's university

https://www.riken.jp/en/careers/programs/ipa/index.html

JSPS* International Fellowships for Research in Japan

JSPS provides fellowship programs for overseas researchers who have an excellent record of research achievements to conduct collaborative research, discussions, and opinion exchanges with researchers in Japan. The programs are intended to help advance the overseas researchers' research activities while promoting science and internationalization in Japan.

***Japan Society for the Promotion of Science (JSPS)**

JSPS International Fellowships for Research in Japan-Summer Program

- **Internship period**
  - June – August (fixed date)
- **Qualification**
  - Be a citizen or permanent resident of the UK, France, Germany, Canada and Sweden
  - Candidates must fulfill one of the following conditions:
    - Be enrolled in a university graduate program.
    - Hold a doctorate degree when the program goes into effect
  - Candidates must receive in advance acceptance from their host researcher.
- **Calls for application**
  - Around October

JSPS International Fellowships for Research in Japan-Summer Program

Financial Support

Travel expenses	Airfare (1 round-trip ticket)
Living expenses	534,000 JPY
Accident insurance premium	To be covered
Research support	Up to 158,500 JPY

https://www.jsps.go.jp/english/e-summer/index.html

JSPS International Fellowships for Research in Japan-Short term Program

- **Internship period**
  - 1 to 12 months
- **Qualification**
  - Citizen or permanent resident of the US, Canada, European Union countries , Switzerland, Norway and Russia.
  - Who have been engaged in research continuously for at least three years at a university or research institution in the above countries.
  - Candidates must have obtained their doctoral degree at a university outside Japan within six years of the date the fellowship goes into effect. Or must be currently enrolled in a doctoral course at a university outside Japan, and scheduled to receive a Ph.D. within two years from the time that their research starts in Japan.
- **Calls for application**
  - 4 times a year

JSPS International Fellowships for Research in Japan-Short term Program

Financial Support

Travel expenses	Airfare (1 round-trip ticket)
Living expenses	362,000 JPY/month (PhD holders) 200,000 JPY/month (non-PhD holders)
Accident insurance premium	To be covered
Setting-In Allowance	200,000 JPY (only more than 3 months tenure)

https://www.jsps.go.jp/english/e-oubei-s/index.html

Past international students in our team

(D: Doctoral student M: Masters student)

2019 Yanqing Shen: University of Iowa (D)

2018 Huynh Viet Phi: Eurecom (M)
Andrew Pensoneault: University of Iowa (D)
Tobias Necker: Ludwig-Maximilians-Universität München (M)

2017 Stefan Geiss: Ludwig-Maximilians-Universität München (M)
Cheng Da: University of Maryland (D)
Paula Maldonado: Universidad de Buenos Aires (D)
Krishnamoorthy Chandramouli: Indian Institute of Technology (D)
Sam Hatfield: University of Oxford (D)

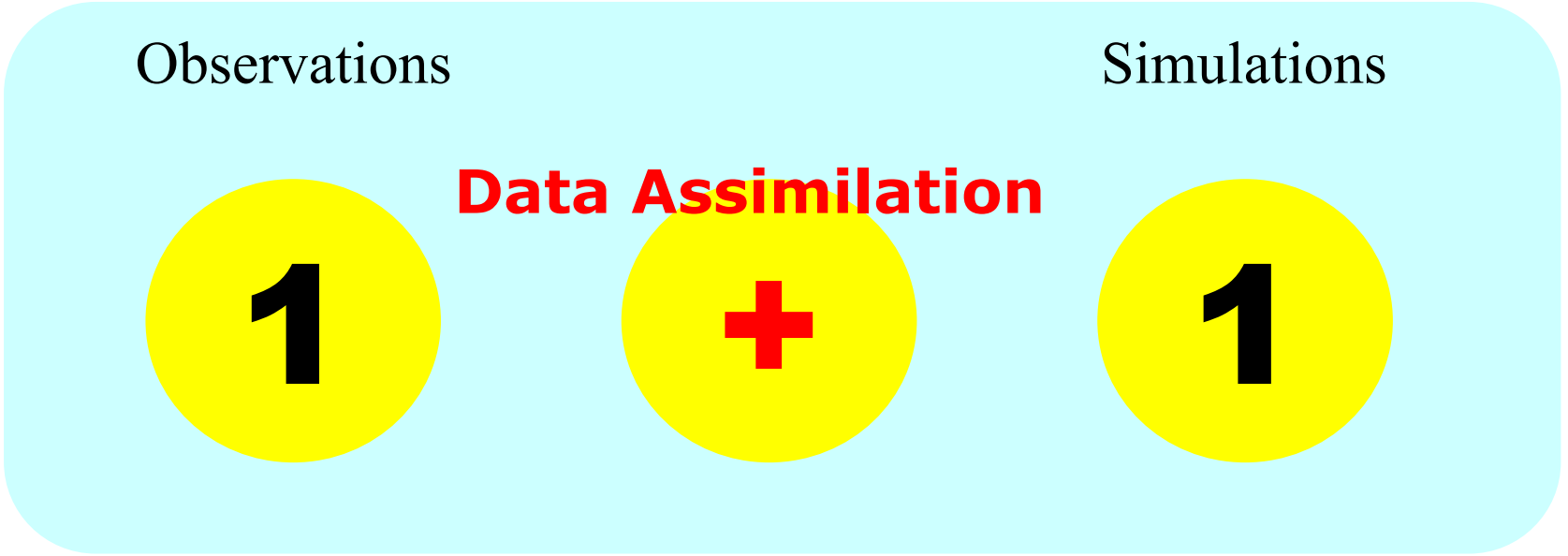
2016 Stefan Geiss: Ludwig-Maximilians-Universität München (M)

2015 Yaping Chang: University of Chinese Academy of Sciences (M)

Data Assimilation (DA)

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

Data Assimilation (DA)



>2

Data Assimilation (DA)

Data-driven
Induction
Real world

Process-driven
Deduction
Cyber world

Observations

Simulations

Data Assimilation

1 **+** **1**

>2

Logistic map

A simple system: $x_{n+1} = ax_n(1 - x_n)$

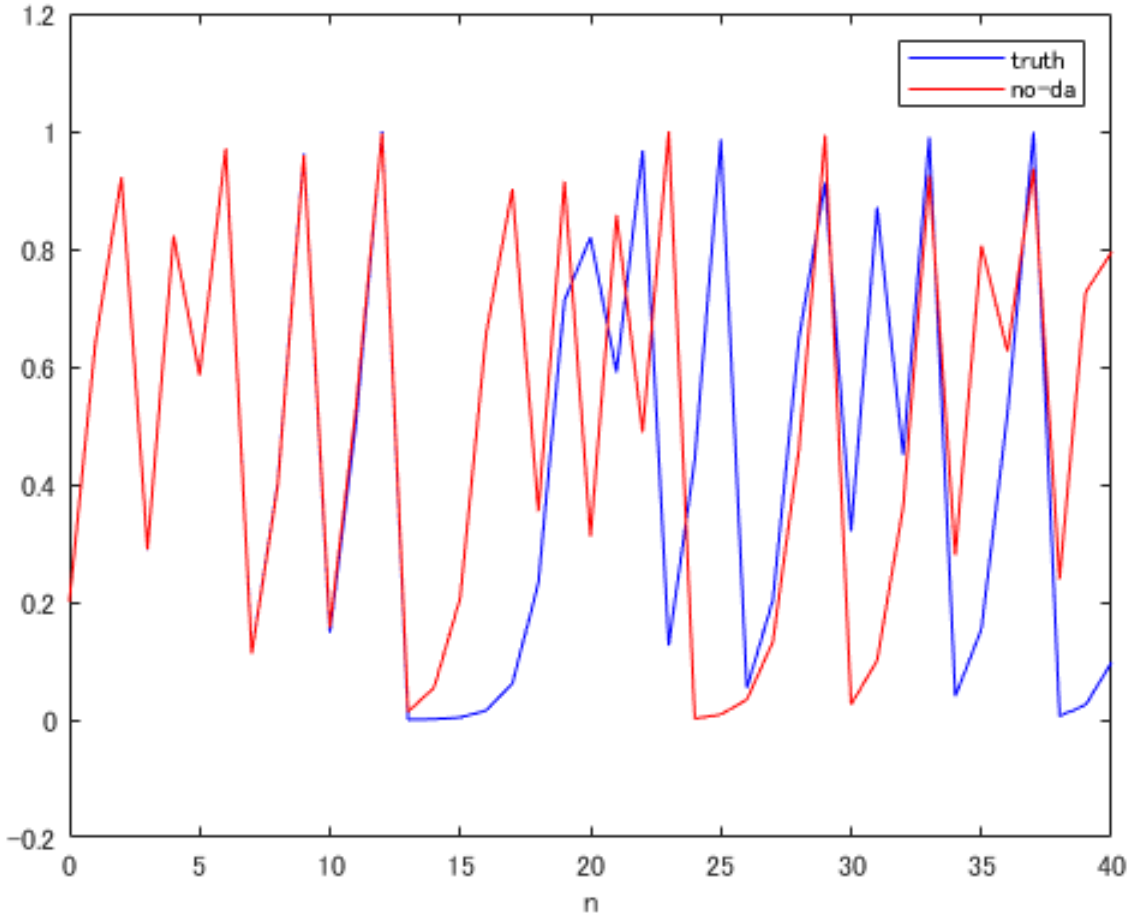
Assume $a = 4$

1	0.200000	0.200010
2	0.640000	0.640024
3	0.921600	0.921573
4	0.289014	0.289104
5	0.821939	0.822092
6	0.585421	0.585026
7	0.970813	0.971082
8	0.113339	0.112327
9	0.401974	0.398838
10	0.961563	0.959065
11	0.147837	0.157037
12	0.503924	0.529506
13	0.999938	0.996518
14	0.000246	0.013881
15	0.000985	0.054755
16	0.003936	0.207027
17	0.015682	0.656668
18	0.061745	0.901820
19	0.231730	0.354162
20	0.712124	0.914925

Logistic map

A simple system: $x_{n+1} = ax_n(1 - x_n)$

Assume $a = 4$



	truth	no-da
1	0.200000	0.200010
2	0.640000	0.640024
3	0.921600	0.921573
4	0.289014	0.289104
5	0.821939	0.822092
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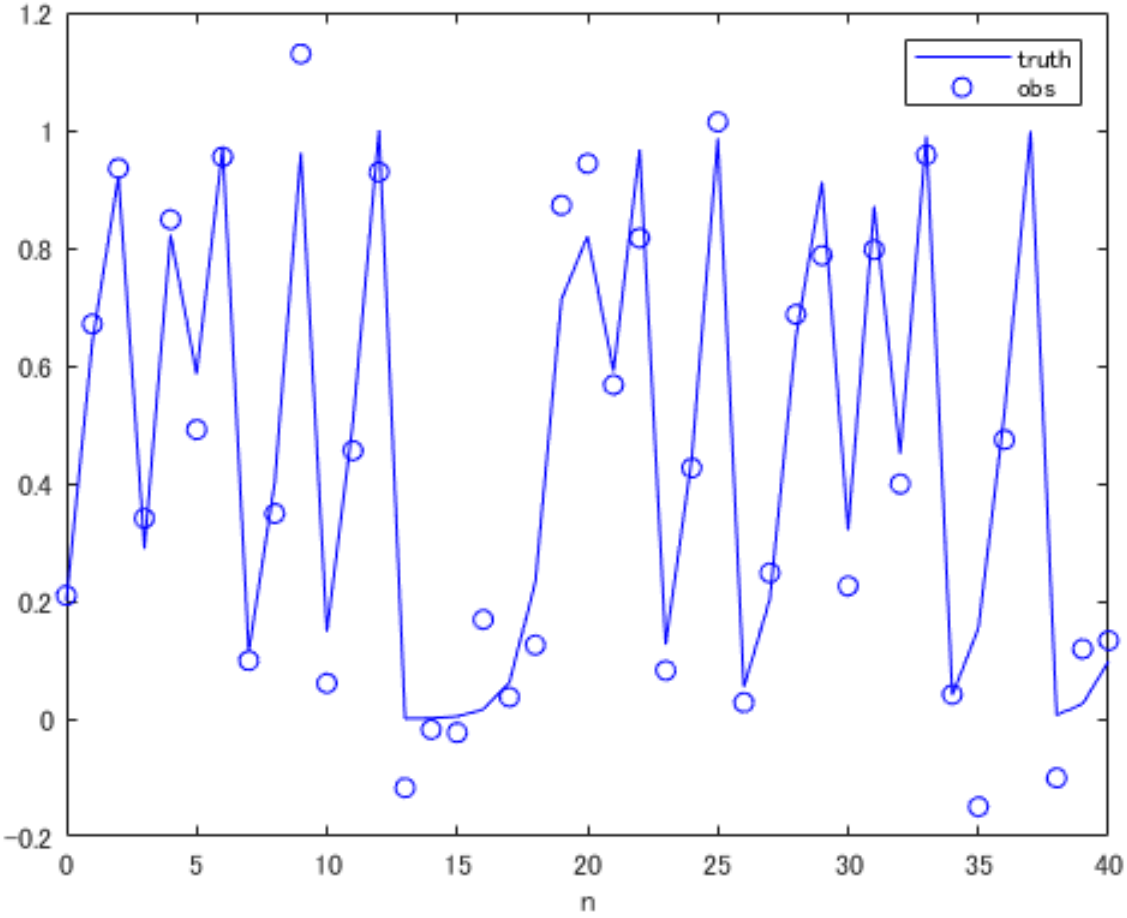
18	0.061745	0.901820
19	0.231730	0.354162
20	0.712124	0.914925

Logistic map

Noisy observations ○ are generated with random numbers.



	truth	no-da
1	0.200000	0.200010
2	0.640000	0.640024
3	0.921600	0.921573
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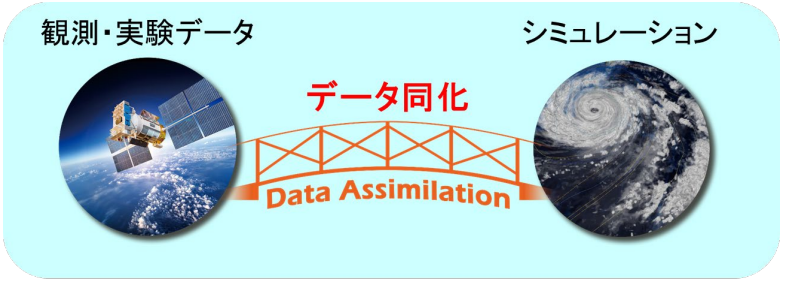
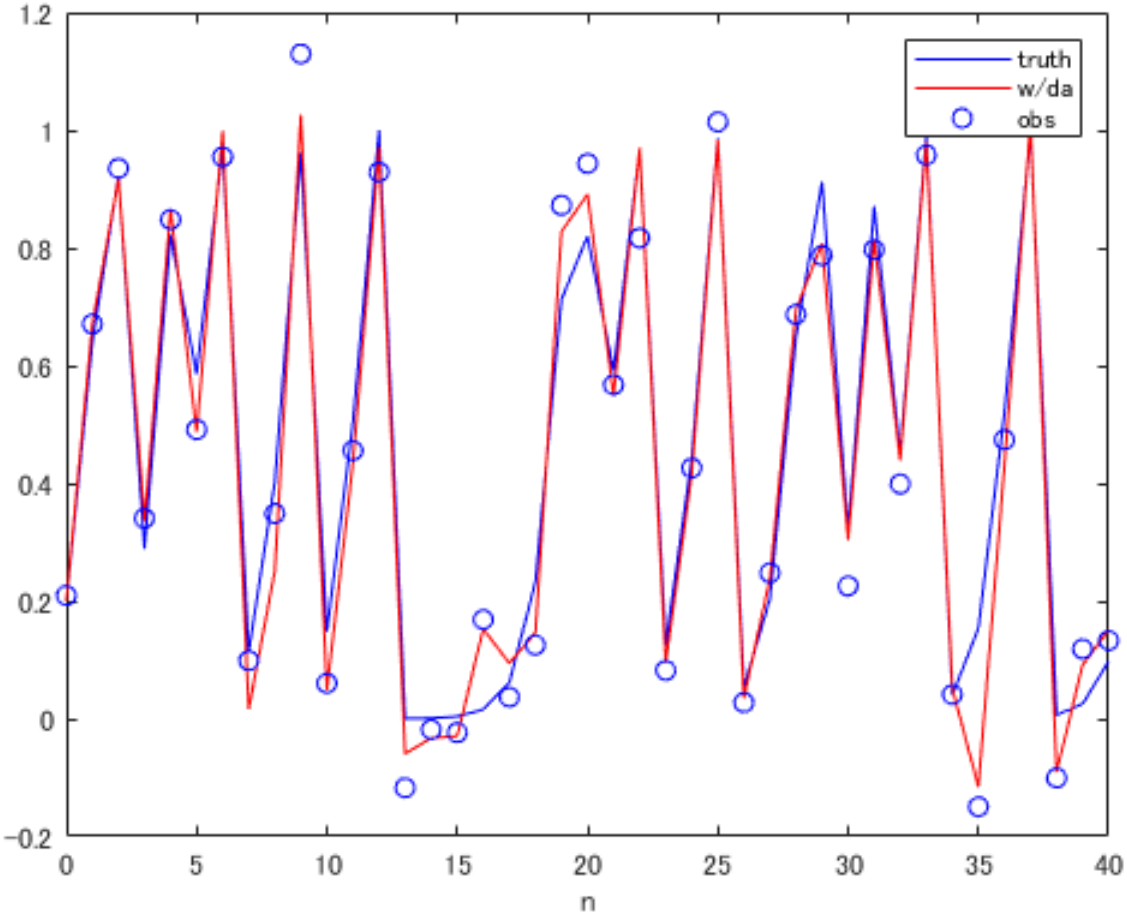
19	0.231730	0.354162
20	0.712124	0.914925

Logistic map: DA experiment

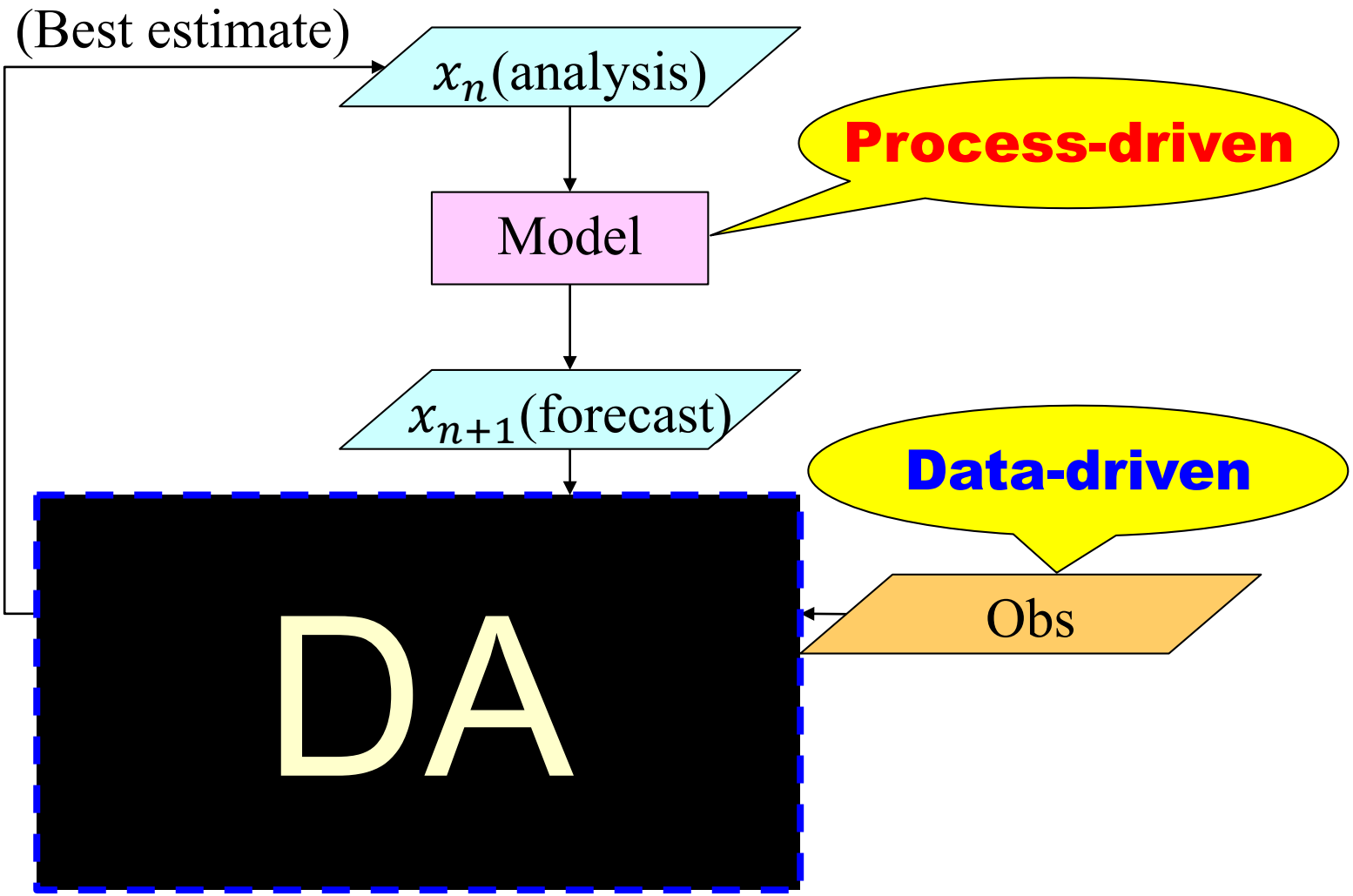
Noisy observations ○ are assimilated.



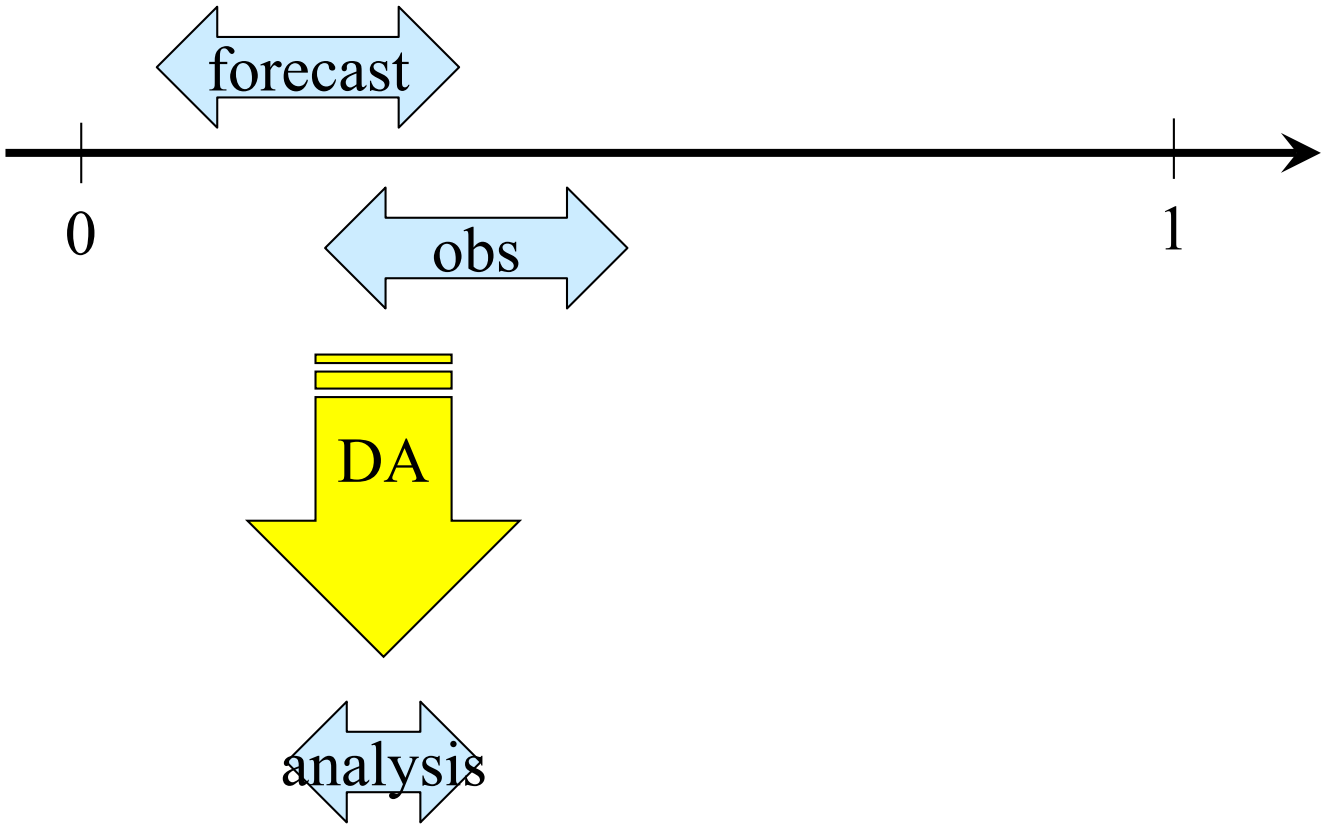


➔ Synchronized chaos!

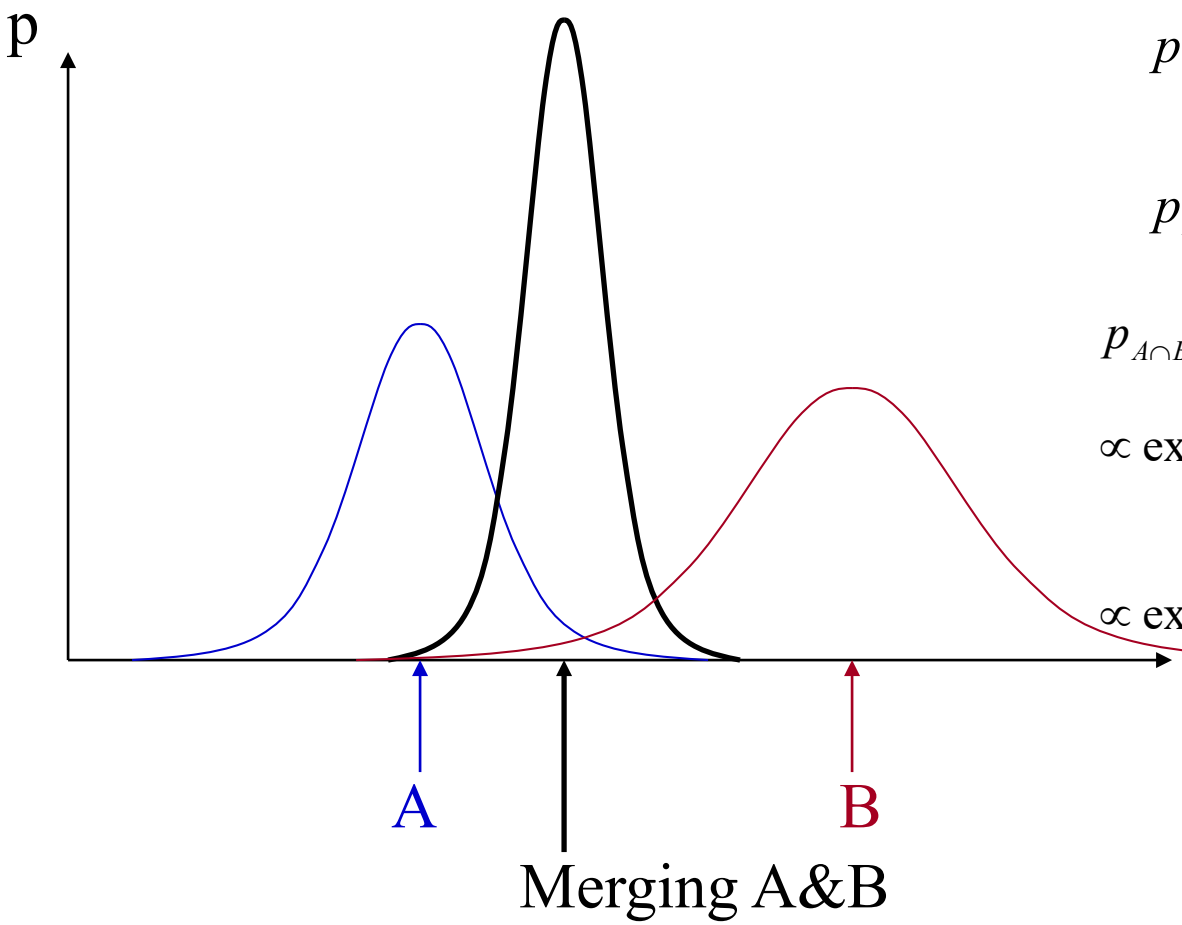
DA workflow


(Best estimate)
x_n(analysis)
Process-driven
Model
x_{n+1}(forecast)
Data-driven
DA
Obs

DA = math of errors



Merging 2 information (Bayesian estimation)



$$p_A(T) \propto \exp\left[-\frac{(T-T_A)^2}{2\sigma_A^2}\right]$$

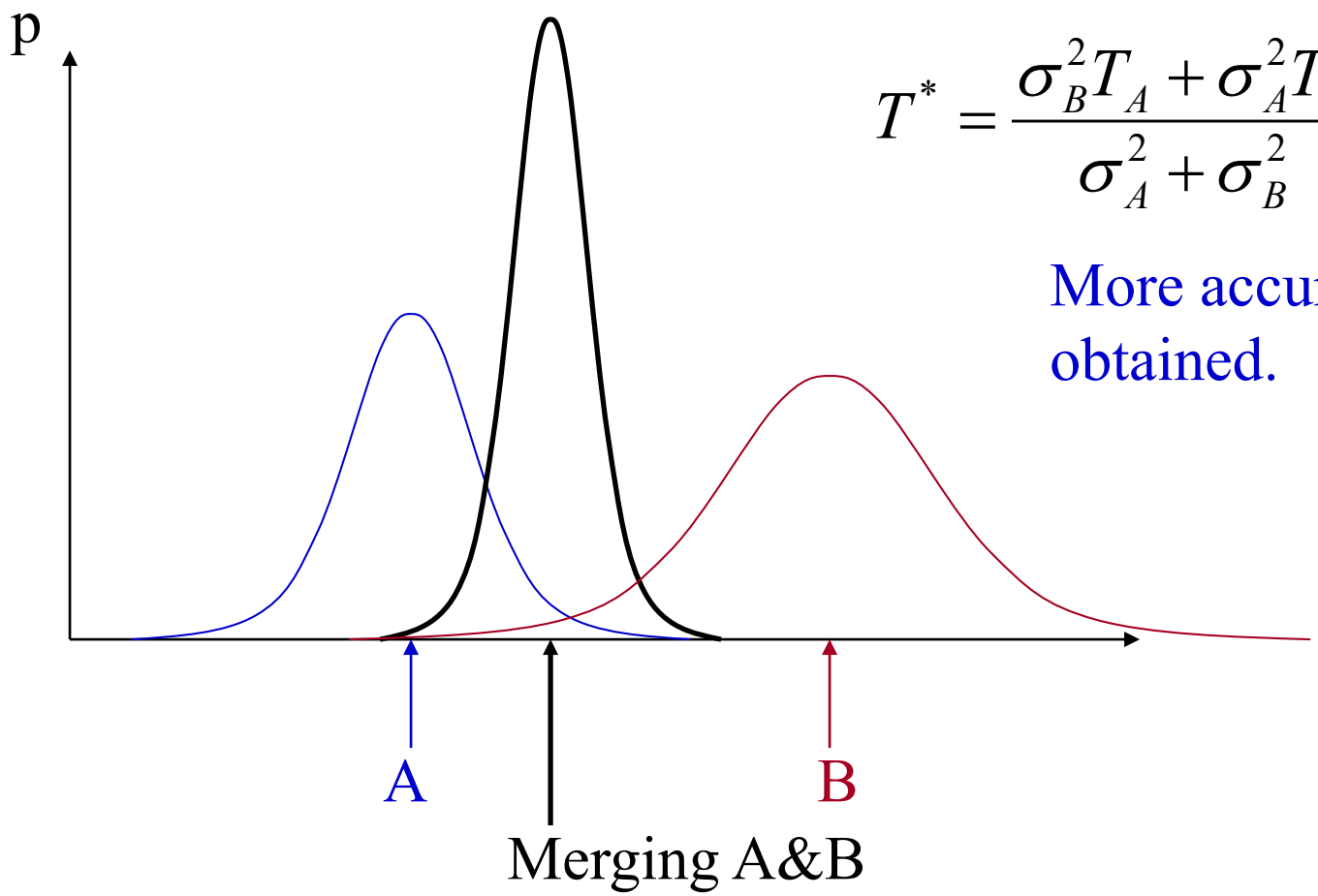
$$p_B(T) \propto \exp\left[-\frac{(T-T_B)^2}{2\sigma_B^2}\right]$$

$$p_{A\cap B}(T) = p_A(T) \bullet p_B(T)$$

$$\propto \exp\left[-\frac{(T-T_A)^2}{2\sigma_A^2} - \frac{(T-T_B)^2}{2\sigma_B^2}\right]$$

$$\propto \exp\left[-\frac{\sigma_A^2+\sigma_B^2}{2\sigma_A^2\sigma_B^2}\left(T - \frac{\sigma_B^2 T_A + \sigma_A^2 T_B}{\sigma_A^2+\sigma_B^2}\right)^2\right]$$

Merging 2 information (Bayesian estimation)

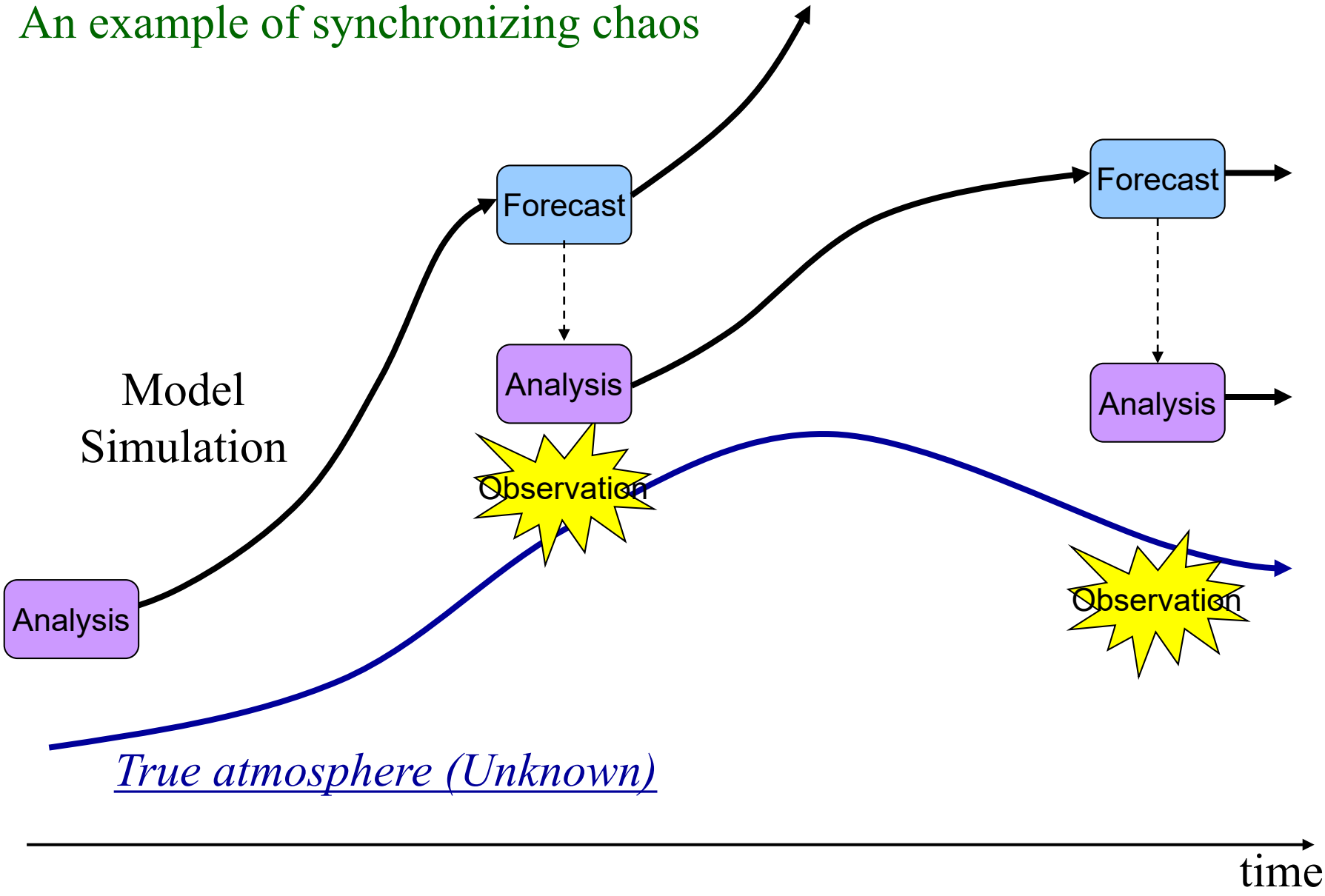


$$T^* = \frac{\sigma_B^2 T_A + \sigma_A^2 T_B}{\sigma_A^2 + \sigma_B^2}, \sigma^* = \frac{\sigma_A^2 \sigma_B^2}{\sigma_A^2 + \sigma_B^2}$$

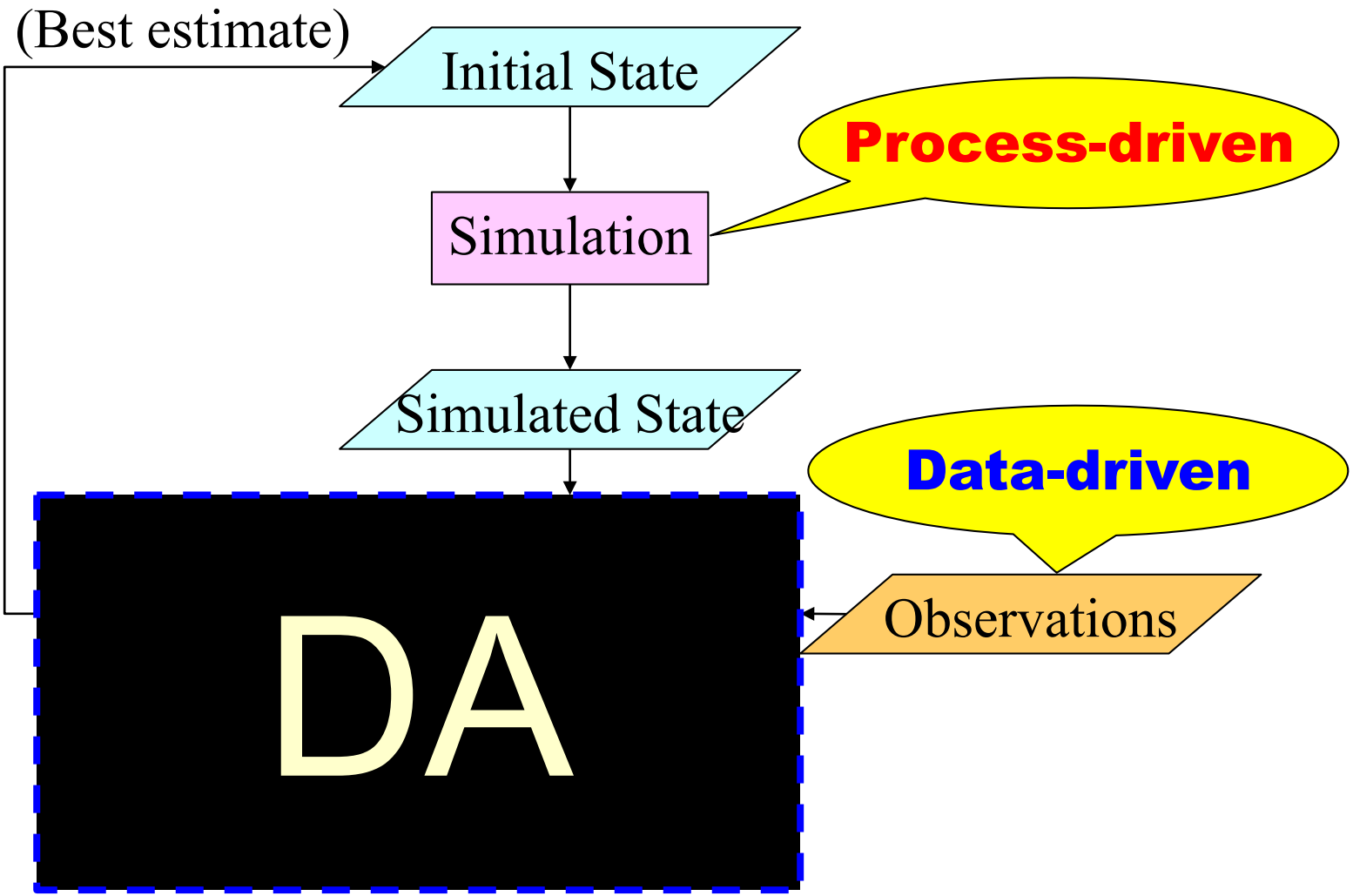
More accurate analysis is obtained.

Numerical Weather Prediction

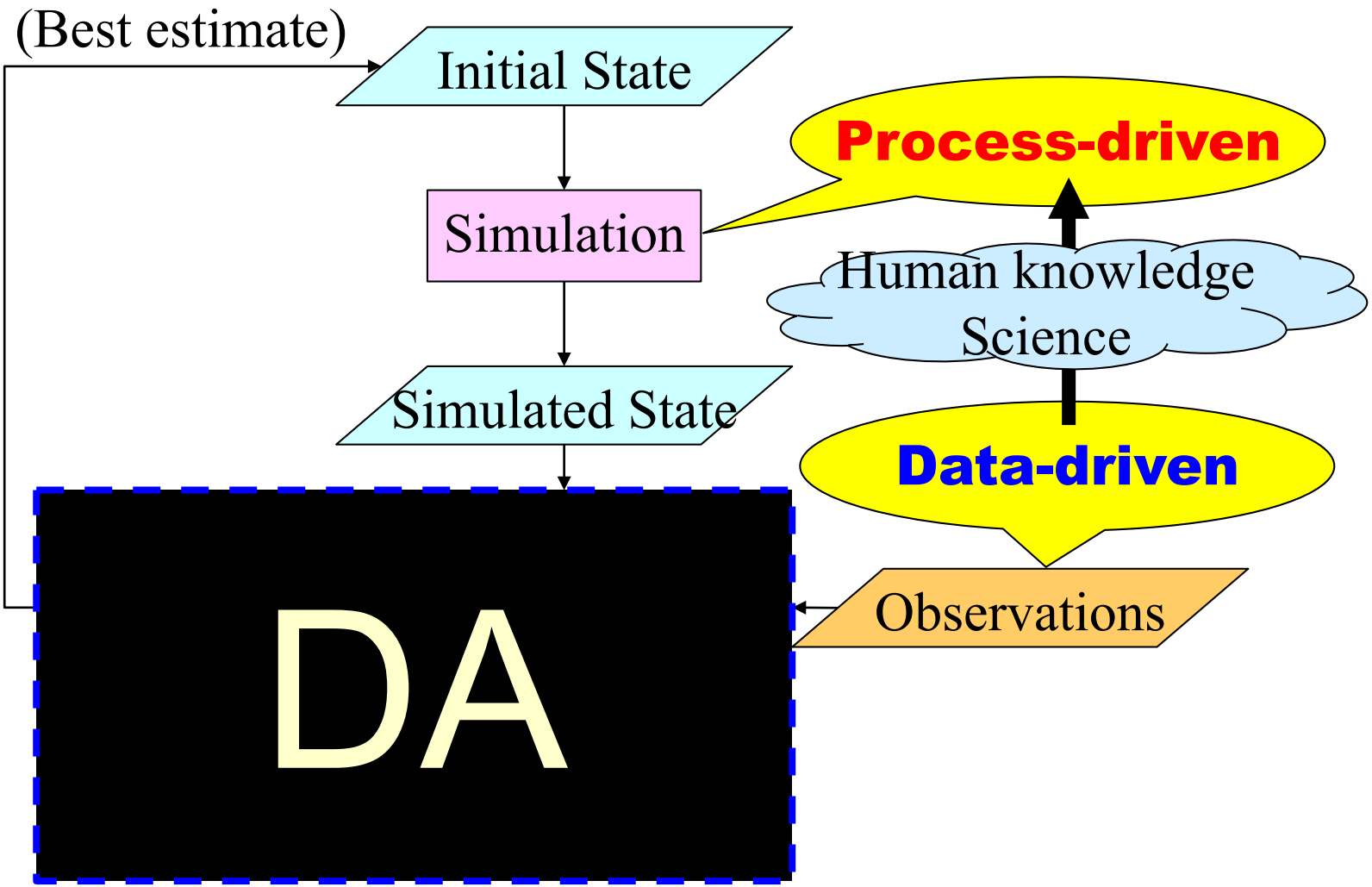
An example of synchronizing chaos



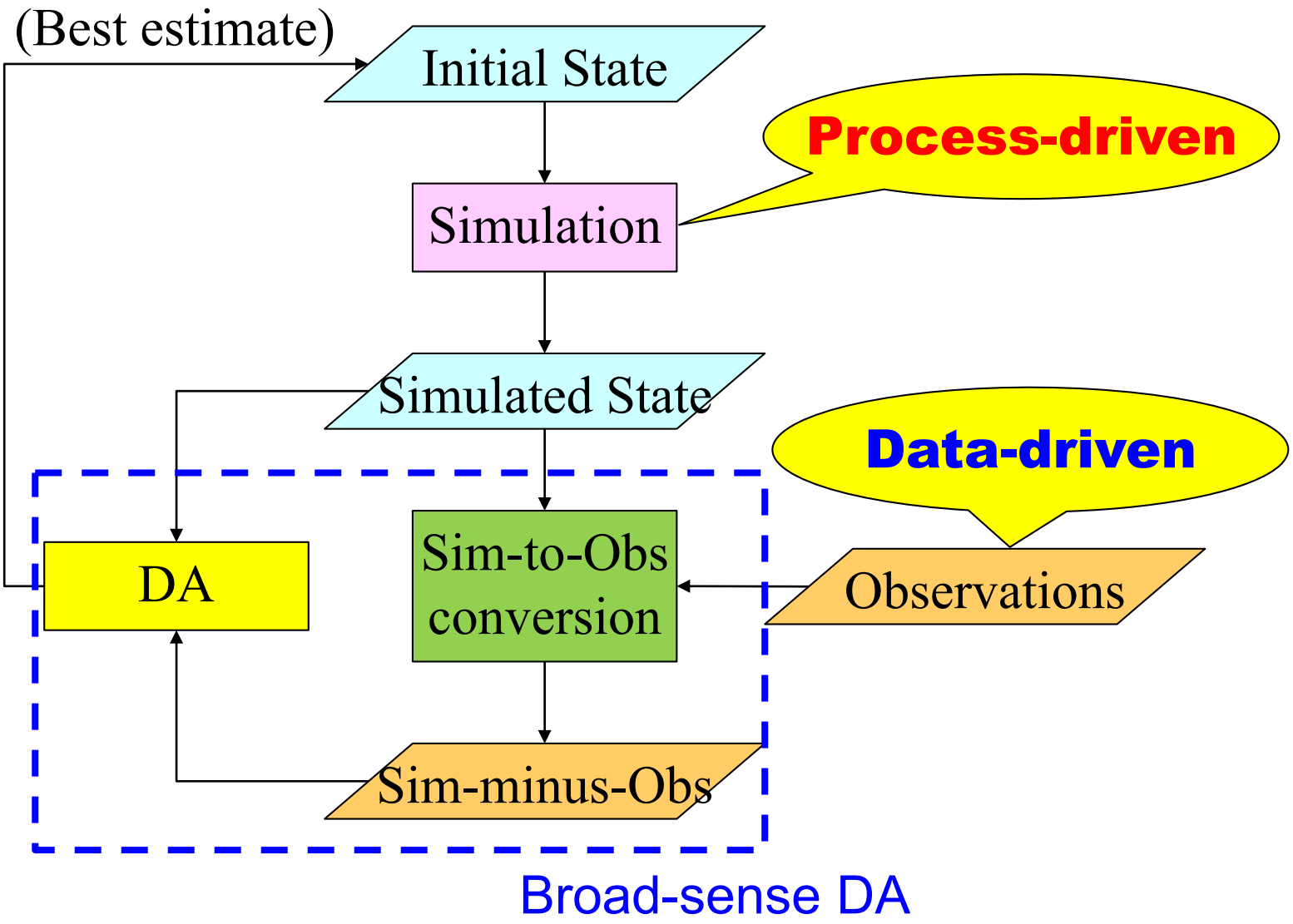
DA workflow


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

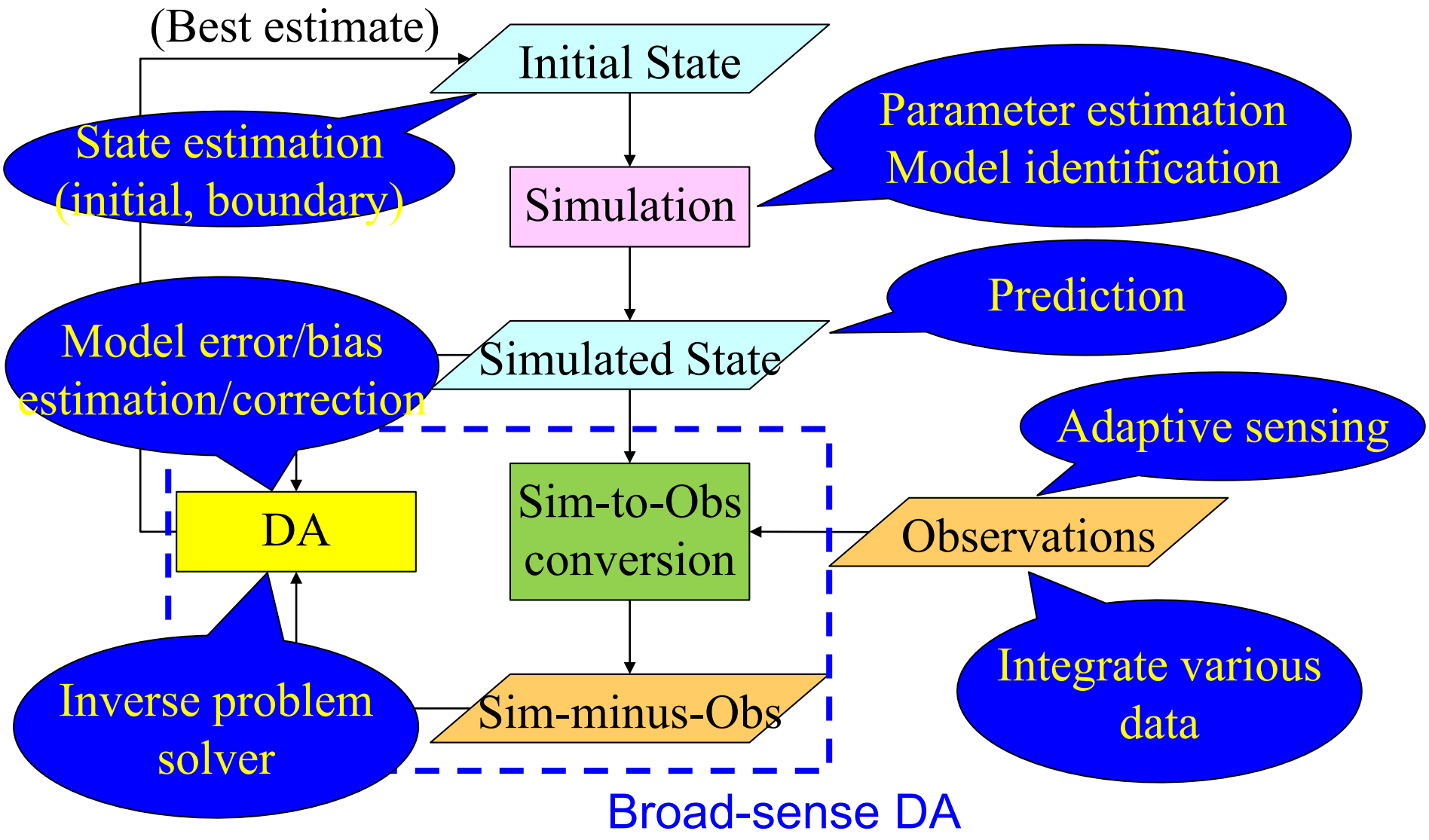
DA workflow


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

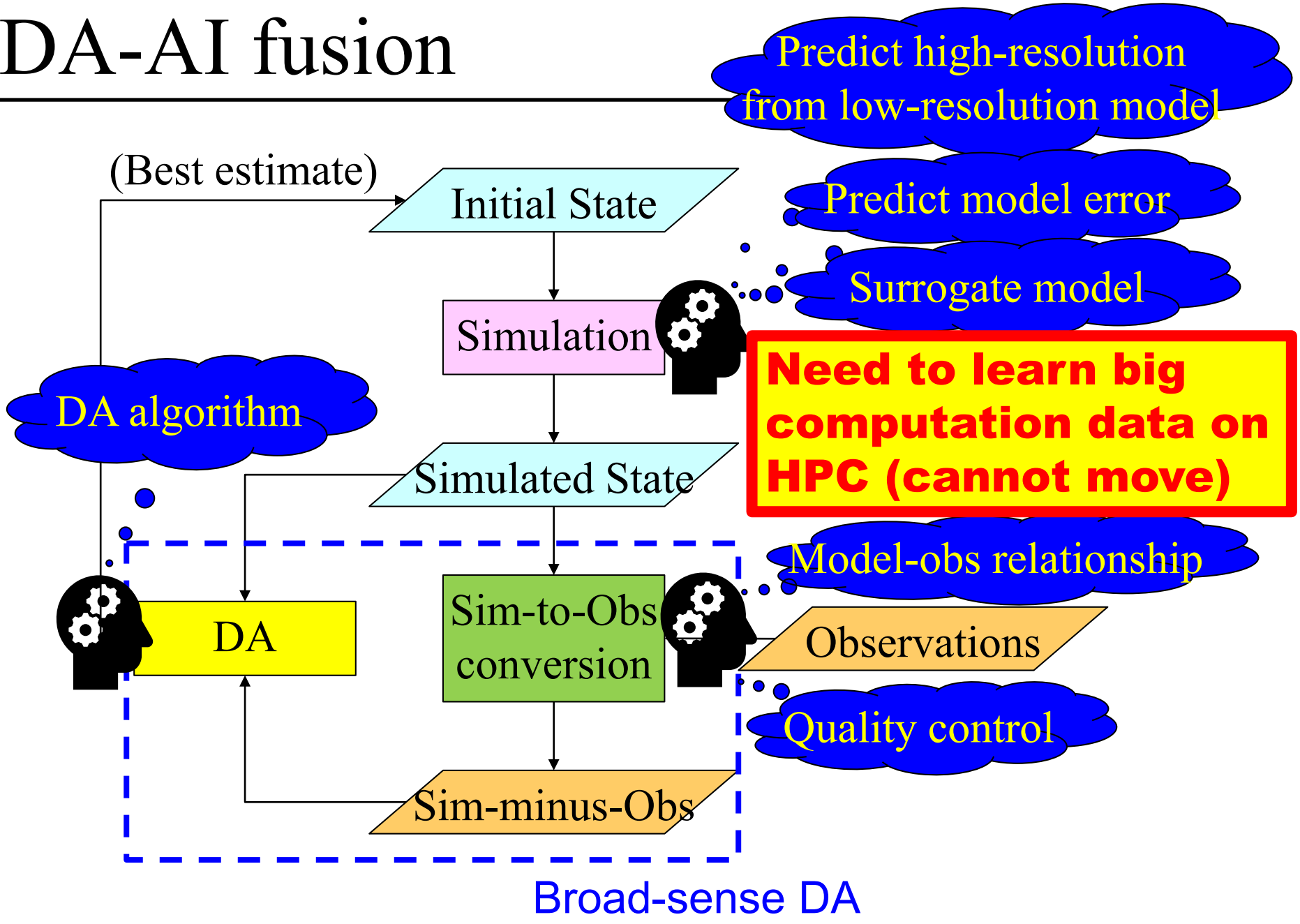
DA workflow


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

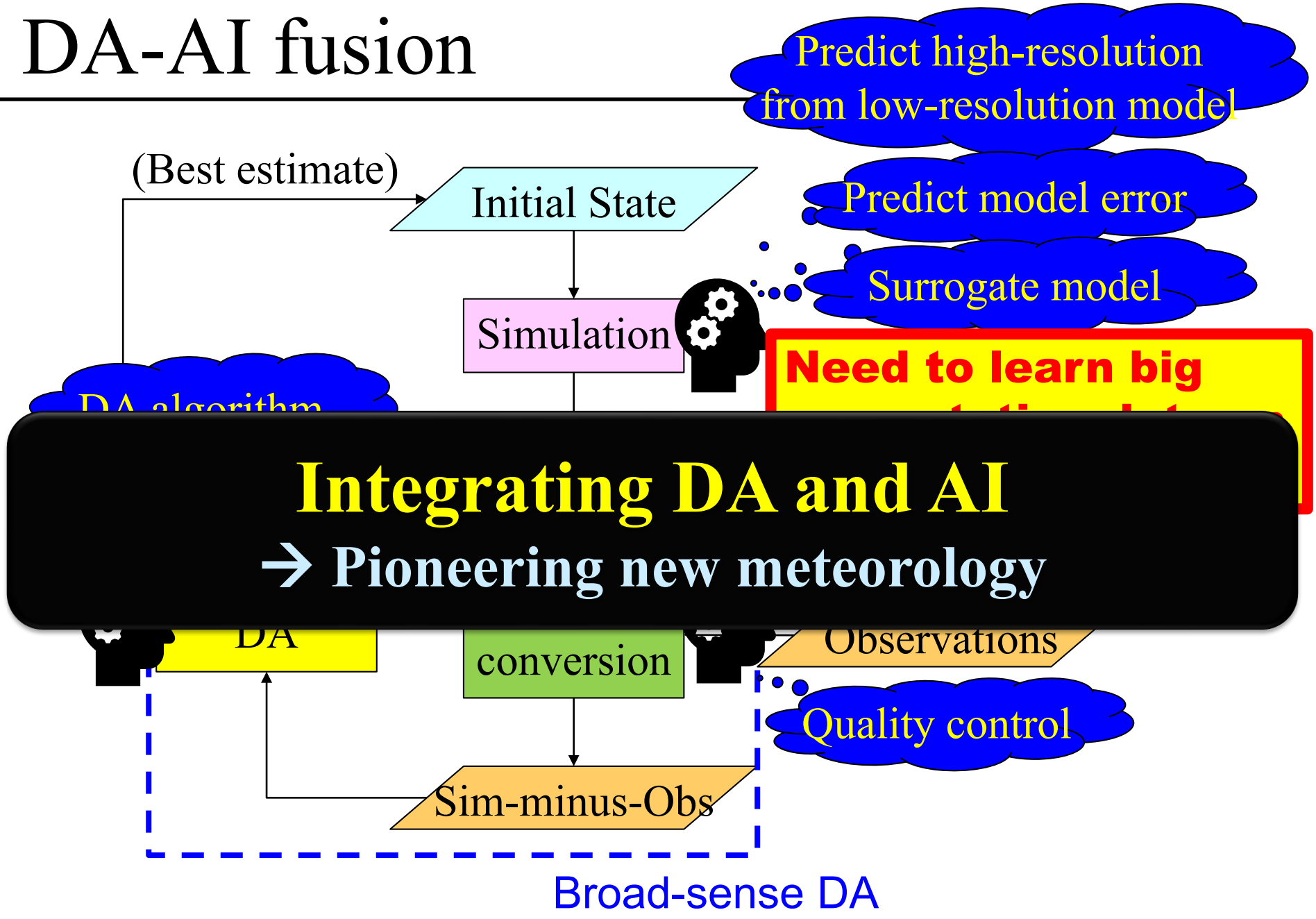
What DA can do



DA-AI fusion


Predict high-resolution from low-resolution model
(Best estimate)
Initial State
Predict model error
Surrogate model
Simulation
Need to learn big computation data on HPC (cannot move)
DA algorithm
Simulated State
Model-obs relationship
DA
Sim-to-Obs conversion
Observations
Quality control
Sim-minus-Obs
Broad-sense DA

DA-AI fusion


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

The Second IMT-Atlantique & RIKEN Joint Workshop: "Statistical Modeling and Machine Learning in Meteorology and Oceanography"

- **Date: Feb. 10-13, 2020 (Mon-Thu)**
- **Place: IMT Atlantique, Brest, France**
- **Language: English**

Day 1: Feb. 10

Time	Speaker	Title
9:30-9:45	Takemasa Miyoshi & Pierre Tandeo	Opening (Perspective toward DA-AI fusion)
9:45-10:45	Michele Alessandro Bucci	Keynote
10:45-11:00	-	Break
11:00-11:30	Naonori Ueda	AI approach for advanced weather forecasting
11:30-12:00	Pierre Tandeo	Selection of dynamic model using analog data assimilation
12:00-13:30	-	Lunch break
13:30-14:00	Paul Platzer	Analog forecasting errors from a dynamical systems point of view
14:00-14:30	Arata Amemiya	Model bias correction by ML
14:30-15:00	Shigenori Otsuka	Toward hybrid NWP-AI system for precipitation nowcasting
15:00-15:15	-	Break
15:15-15:45	Maha Mdini	Toward model acceleration by ML
15:45-16:15	Maxime Beauchamp	A geostatistical journey through data and modeling in air quality
16:15-16:30	-	Introduction to breakout discussion
16:30-17:00	-	Breakout discussion

The Second IMT-Atlantique & RIKEN Joint Workshop: "Statistical Modeling and Machine Learning in Meteorology and Oceanography"

● Day 2: Feb. 11

Time	Speaker	Title
9:30-10:00	Chen Wang	Classification of global ocean SAR images for broader applications
10:00-10:30	Tsuyoshi Yamaura	The parameter estimation system in SCALE for reduced-precision floating-point numbers
10:30-10:45	-	Break
10:45-11:15	Kenta Sueki	Estimation of key parameters in cloud microphysics using ensemble Kalman filter
11:15-11:45	Koji Terasaki	Accounting for the horizontal observation error correlation of satellite radiances in data assimilation
11:45-13:15	-	Lunch break
13:15-13:45	Marie Boutigny	Using precipitation radar for urban hydrology: motion interpolation and merging with rain gauges
13:45-14:15	Zhen Yicun & Jean-Marie Vent	Application of analog data assimilation to the spatial-temporal interpolation of sea-surface sediment concentration and sea-surface height
14:15-14:30	-	Break
14:30-15:00	Jules Guillot	Data-Model Coupling for SST-DA
15:00-15:30	Said Ouala	Data-driven identification of geophysical dynamics: incorporating stability constraints in neural networks models
15:30-16:00	-	Breakout discussion
16:00-17:00	-	Plenary discussion

Discussion sessions for brain storming about new research ideas for DA-AI fusion, leading to new collaborative researches

Day 1: 30-min BOS

16:15-16:30	-	Introduction to breakout discussion
16:30-17:00	-	Breakout discussion

Day 2: 30-min BOS + 1-h plenary

15:30-16:00	-	Breakout discussion
16:00-17:00	-	Plenary discussion