“Big Data Assimilation”

Real-time Workflow for 30-second-update Forecasting and Perspectives toward DA-AI Integration

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Phased Array Weather Radar (PAWR)

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

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

(Courtesy of NICT)

100x data size
Big Data Assimilation

Observations

Simulations

Data-driven
Real world

Process-driven
Cyber world

Big Data

New sensors, IoT

100x

Big Data

Powerful supercomputer

100x
9/11/2014, sudden local rain

RIKEN Advanced Institute for Computational Science
Data Assimilation Research Team

Observation

Simulation (100m Big DA)

Simulation (w/o DA)

Simulation (1km DA)
9/11/2014, sudden local rain

RIKEN Advanced Institute for Computational Science Data Assimilation Research Team

1-h-lead downpour forecast refreshed every 30 seconds at 100-m mesh

Simulation (w/o DA)

Simulation (1km DA)
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
Toward **Weather-Ready Society 5.0** with

- **Cyberspace**
  - Simulation
- **Big Data**
  - Big Data Assimilation
- **Sensing**
  - IoT
- **Real world**
- **Nature**
- **Human society and economy**

**AI**

**synchronize predict & control**
Toward Weather-Ready Society 5.0 with

Toward demonstration at
TOKYO 2020
CREST BDA achievement

Online, real-time (Lien et al. 2017, SOLA)

Offline (Miyoshi et al. 2016a,b, BAMS, PIEEE)
Computational time <30-sec.

D1 (18-km mesh) DA
D1 (18-km mesh) 5-day forecast
D1 (18-km mesh)
D3 (1-km mesh)
D2 (6-km mesh)
D4 (250-m mesh) every-30-second DA
D4 (250-m mesh) for past cases
PAWR obs
D4 (250-m mesh) forecast
Goal: fully online, real-time workflow

D1 (18-km mesh) DA

D1 (18-km mesh) ensemble forecast

D2 (6-km mesh) ensemble forecast

D3 (1-km mesh) ensemble forecast

D4 (250-m mesh) every-30-second DA

D4 (250-m mesh) every-30-second forecast

PAWR obs via JIT-DT
Test with U.Tokyo OFP on 29 August

17:46 NCEP GFS (boundary)
19:18 PREPBUFR (obs)

19:25-20:07 D1 DA

D1 (18-km mesh) ensemble forecast
D2 (6-km mesh) ensemble forecast
D3 (1-km mesh) ensemble forecast

20:15-21:21 D1&D2 forecast
21:31-22:41 D3 forecast

23:00 D4 (250-m mesh) every-30-second DA

PAWR obs for a past case

Large-scale HPC Challenge

D4 (250-m mesh) every-30-second forecast
Test with U.Tokyo OFP on 30 Nov.

17:46 NCEP GFS (boundary)
19:18 PREPBUFR (obs)

Large-scale HPC Challenge

Computation time (6528 nodes)
64 DA cycles + 50 forecasts

64 DA cycles (for 32 minutes)

50 forecasts

PAWR obs for a past case

D1 (18-km mesh)
D2 (6-km mesh)
D3 (1-km mesh)
D4 (250-m mesh)
every-30-second DA
Use JIT-DT in real time
Multi-parameter phased array weather radar (MP-PAWR) was developed by SIP (Cross-ministerial Strategic Innovation Promotion Program) in 2014-2018 as a research subject of “torrential rainfall and tornadoes prediction.”

Early forecasting by water vapor, cloud, and precipitation observation

MP-PAWR observation area

MP-PAWR installed at Saitama Univ. on Nov 21, 2017, and observation began in July 2018.
PAWR Data Utilization System (in NICT cloud)

Okinawa
- Okn PAWR
- db-panda-okn
- ql-panda-okn

Kobe
- Kobe PAWR
- db-panda-kob
- ql-panda-kob

Suita
- Suita PAWR
- pawr-data-trans
- Handai-AP
- L3-SW
- JGN AP Kinki-2
- JGN AP Kanto-3
- JGN AP Kinki-3
- Handai-AP
- Osaka Univ. LAN

Suita- Keihanna
- JGN AP Kanto-3
- ncloud AP
- 6-gou SW
- M2M
- JOSE VM
- panda-VM00

Koganei
- dfsuc-panda-kgn
- trans-panda-sc
- pawr-dp01 ~ dp05
- NICT cloud FW
- panda-gw
- vlans

Kobe - Keihanna
- JGN AP Kanto-3
- NICT cloud FW
- vlans

Koganei - Keihanna
- JGN AP Kanto-3
- vlans

Keihanna
- JGN AP Kinki-3
- VIPE

Saitama
- RSPU
- DS01
- MP-PAWR FW
- SINET AP

Okanawa PAWR
- homepage: https://pawr.nict.go.jp

Kobe PAWR
- homepage: https://weather.riken.jp

Saitama MP-PAWR
- homepage: https://weather.riken.jp

NICT cloud FW

Panda-gw

NICT Res. NW LAN

Riken Kobe
- hibiki
- Web server

Univ of Tokyo
- Oakforest-PACS
- Web server

Saitama MP-PAWR
- homepage: https://weather.riken.jp

Internet

Opened on 5 Sep. 2019

Saitama- Koganei Network opened on 17 Dec. 2019
Phased-Array Weather Radar
3D precipitation nowcasting

30-second-update, 10 minute forecast

App by MTI

(NICT)
REAL-TIME 30-second-update nowcasting

Working continuously in REAL-TIME
Real-time dissemination started on 7/27/2017 with MTI Ltd.

>247,000 DL
Ranked #3!

Making societal impact

RIKEN’s 3D Nowcast
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

t = 2018-07-27 20:35:30 + 2.5 min
Future direction: **Fusing ML+DA+Simulation**

![Diagram showing the process of fusing ML, DA, and simulation for improved 3D precipitation nowcasting.](image)

- **Observation**
- **Weather Simulation**
- **INPUT**
- **OUTPUT**

New 3D Precip. Nowcasting

**Input of future data from NWP!!**
DA-AI Integration

(Best estimate) → Initial State → Simulation → Simulated State → Sim-to-Obs conversion → Sim-minus-Obs → DA

DA algorithm

Sim-to-Obs conversion

Predict high-resolution from low-resolution model

Predict model error

Surrogate model

Need to learn big computation data on HPC (cannot move)

Model-obs relationship

Observations

Quality control

Broad-sense DA
DA-AI Integration

Initial State

Simulation

(Best estimate)

DA algorithm

Simulation

Predict high-resolution from low-resolution model

Predict model error

Surrogate model

Need to learn big computation data

DA

conversion

Sim-minus-Obs

Integrating DA and AI

→ Pioneering new meteorology

Observations

Quality control

Broad-sense DA

DA algorithm

Surrogate model
Toward Weather-Ready Society 5.0 with

Goals

1. “Big Data Assimilation” × AI
2. International collaborations
3. Demonstration at Tokyo 2020
4. Societal impacts