March 7, 2018, ISDA, Munich

Is 30-second update fast enough ??

for convection-resolving data assimilation

Data Assimilation Team

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RIKEN AICS

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With many thanks to

JMA

UMD Weather-Chaos group

JST CREST "Big Data Assimilation" project

JAXA PMM "Ensemble Data Assimilation" project

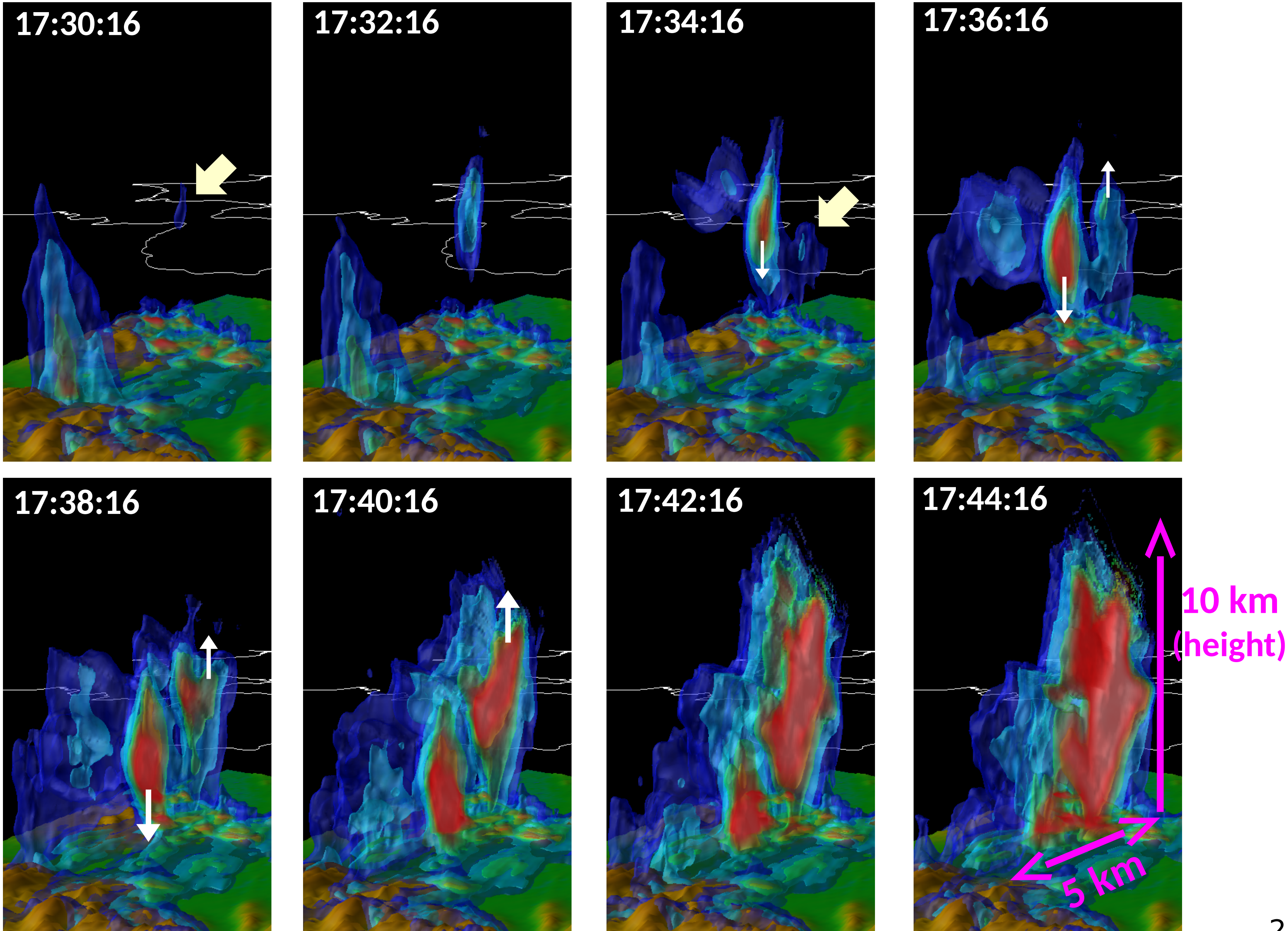
Japan's FLAGSHIP 2020 project

RIKEN Data Assimilation Research Team

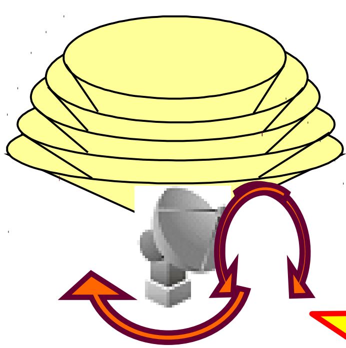
CREST JST

Only in 10 minutes!!

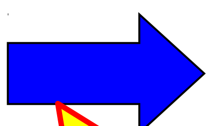
(Courtesy of NICT)



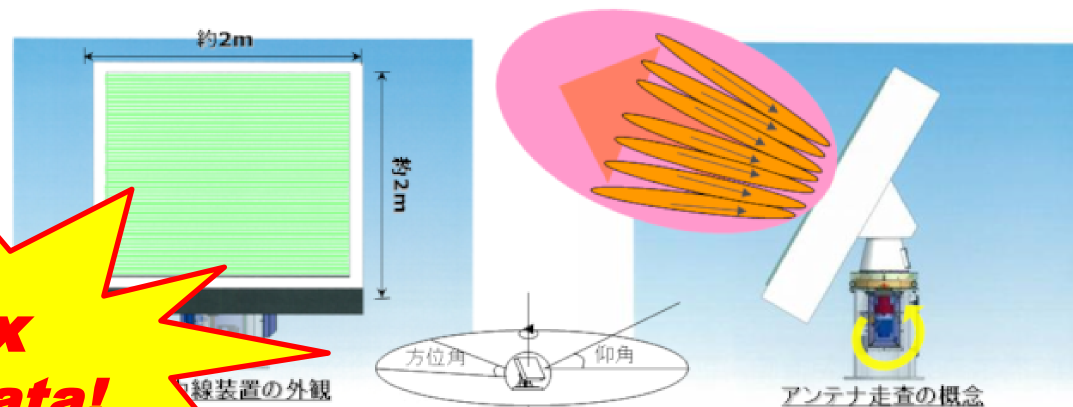
Phased Array Weather Radar (PAWR)



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

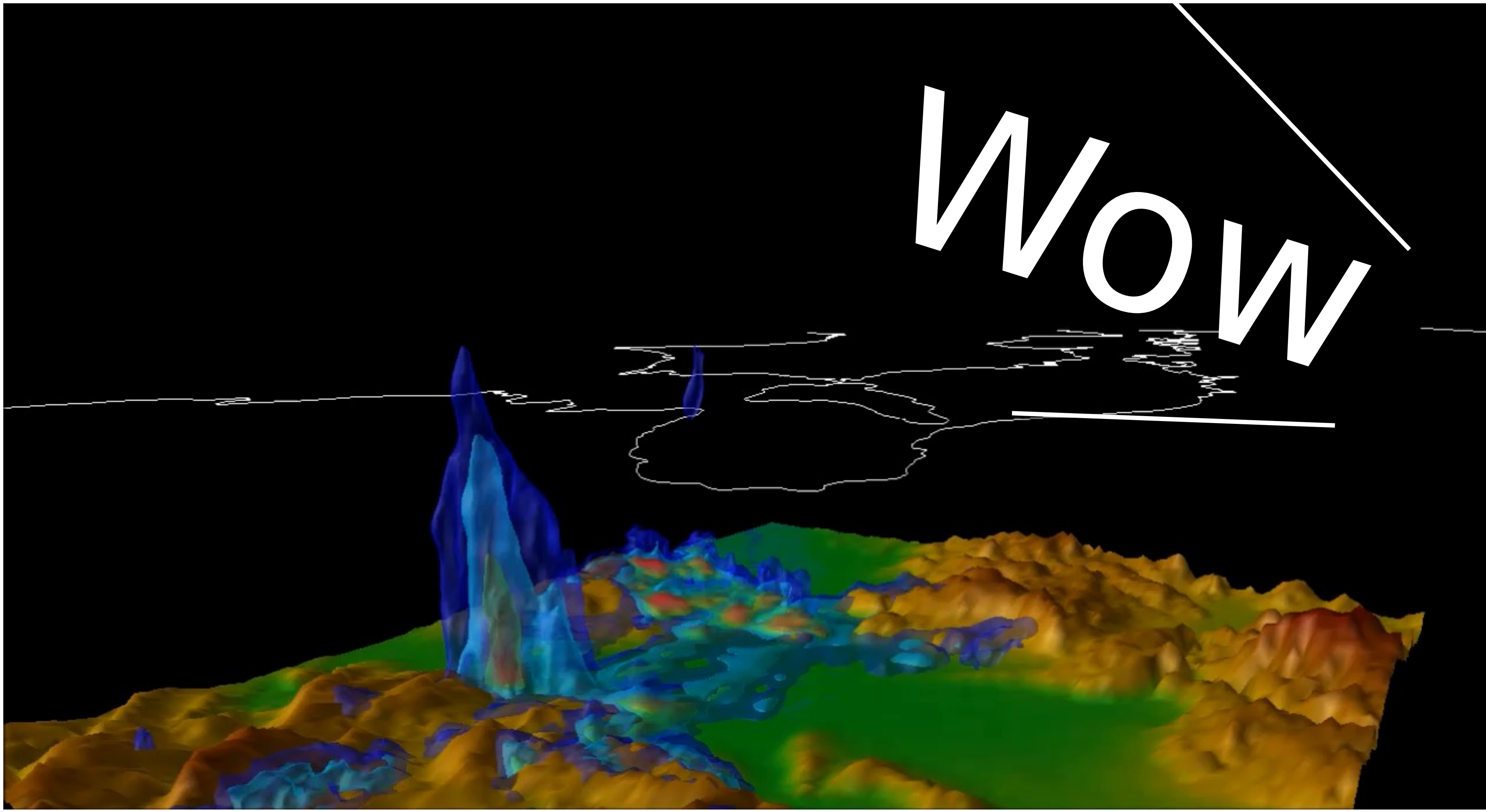


100x
more data!
10x more data
in a 1/10 period



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

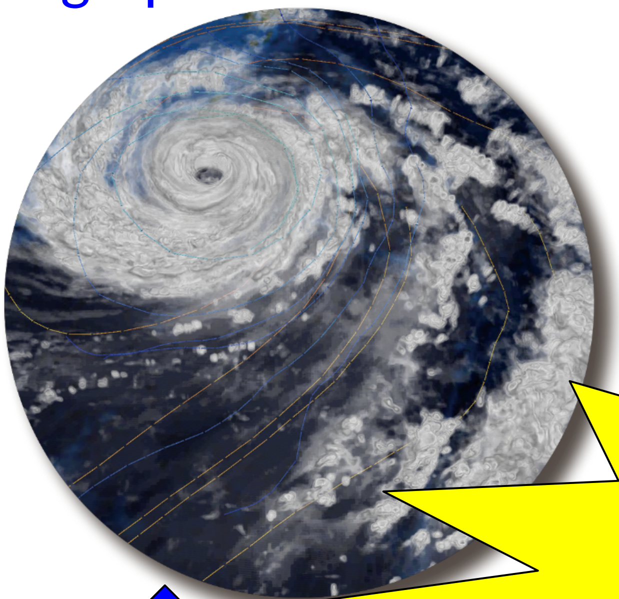
Phased Array Radar (every 30 sec.)



(Courtesy of NICT)

Pioneering "Big Data Assimilation" Era

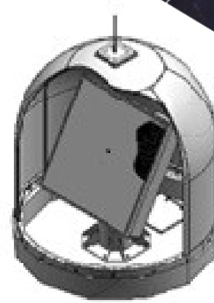
High-precision Simulations

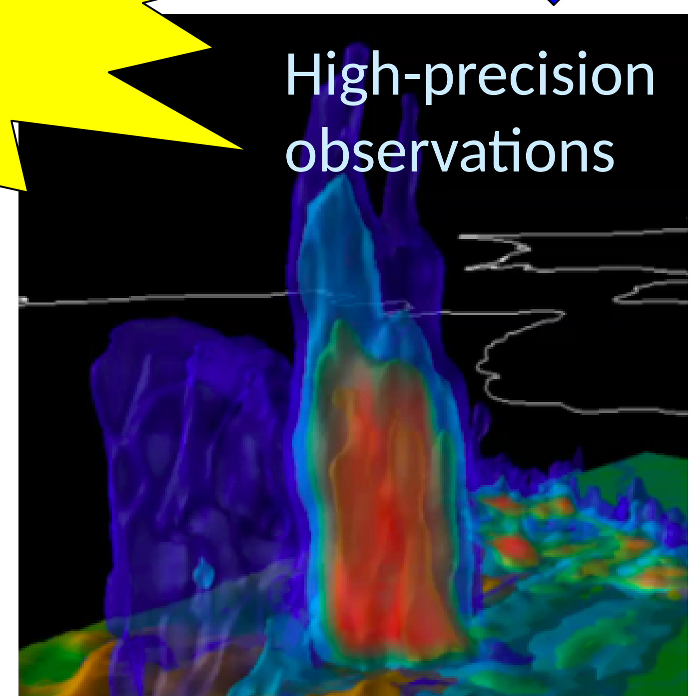


国立研究開発法人 科学技術振興機構
Japan Science and Technology Agency
CREST

Future-generation technologies available 10 years in advance

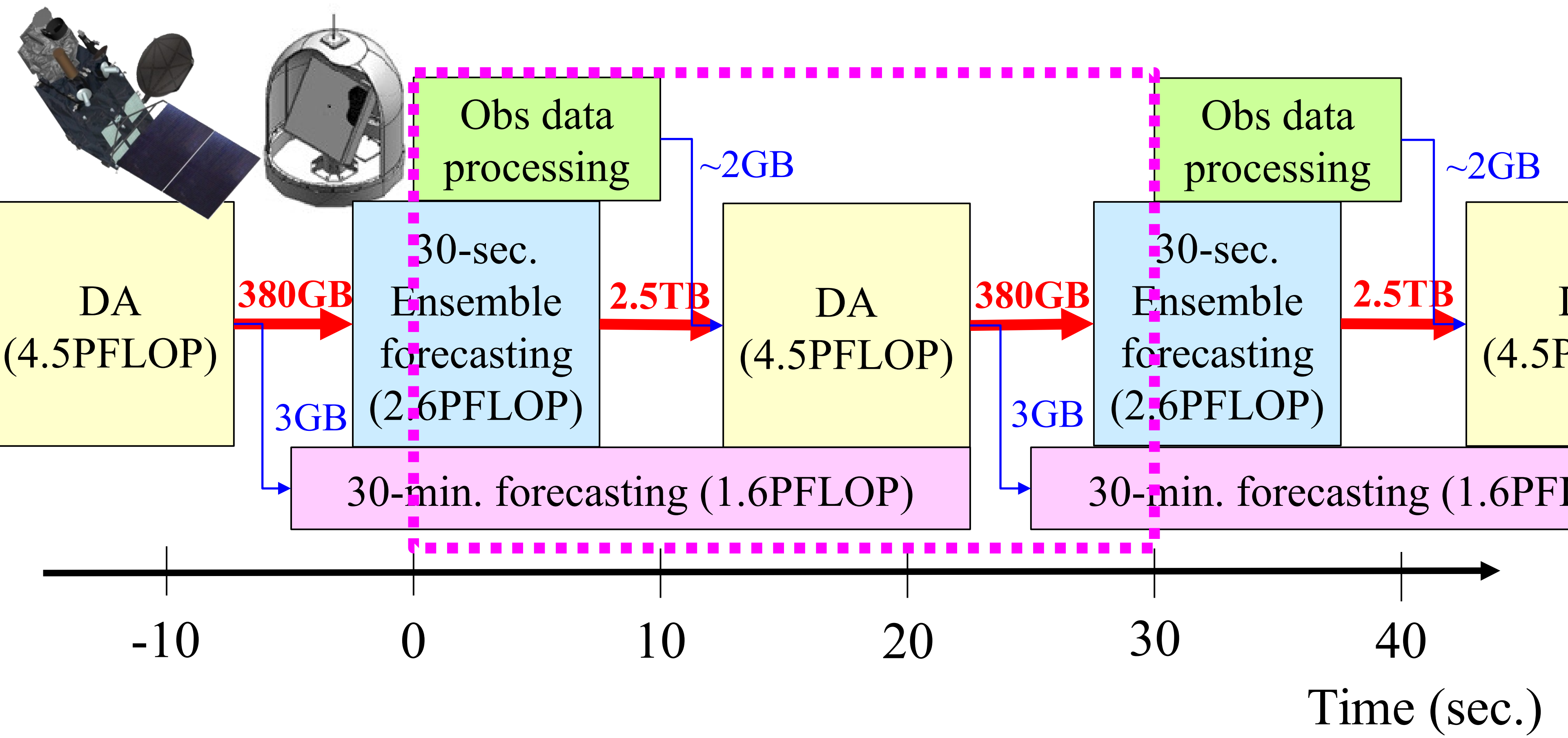
BDA
BIG DATA ASSIMILATION





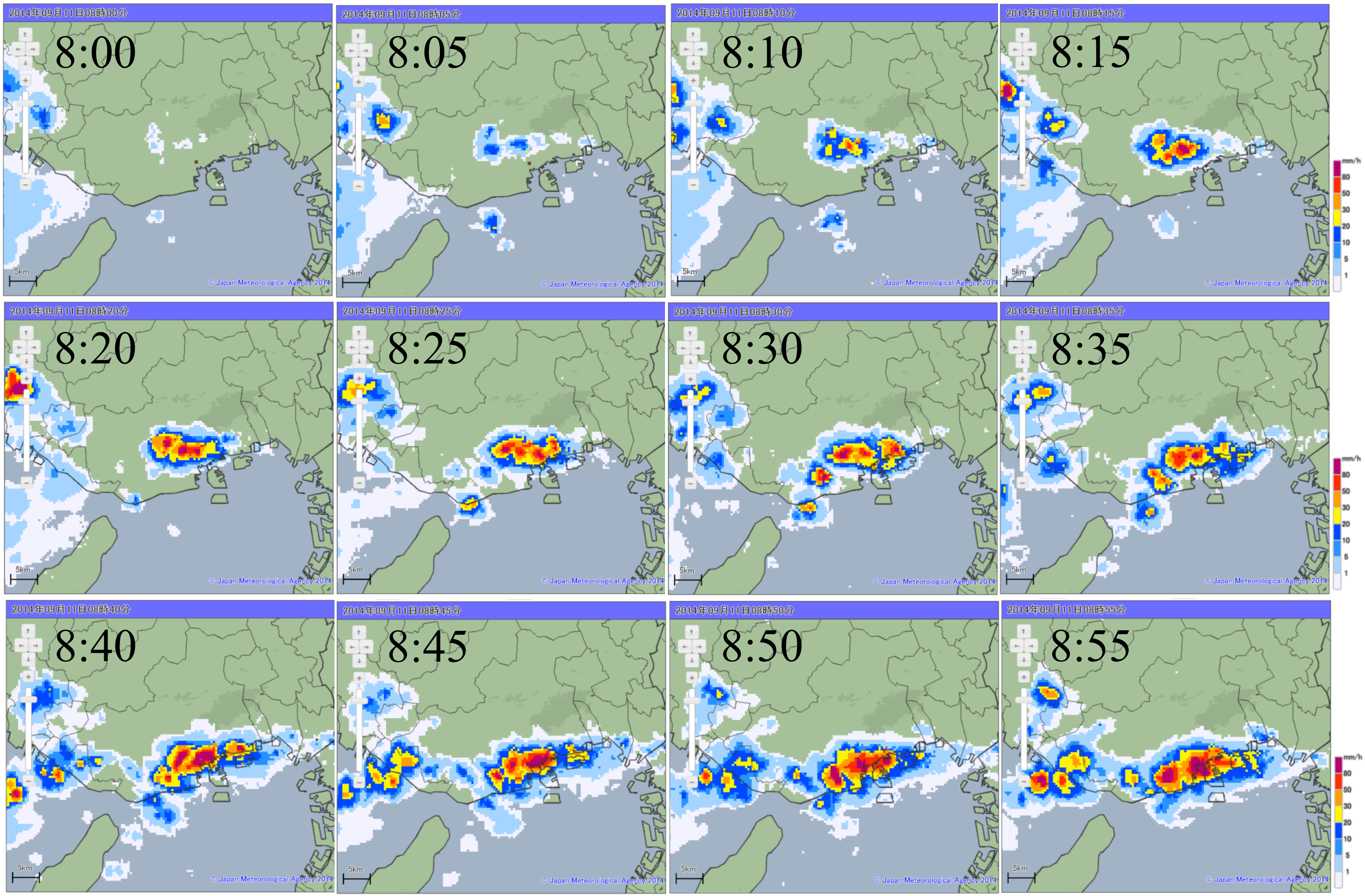
Mutual feedback

Revolutionary super-rapid 30-sec. cycle

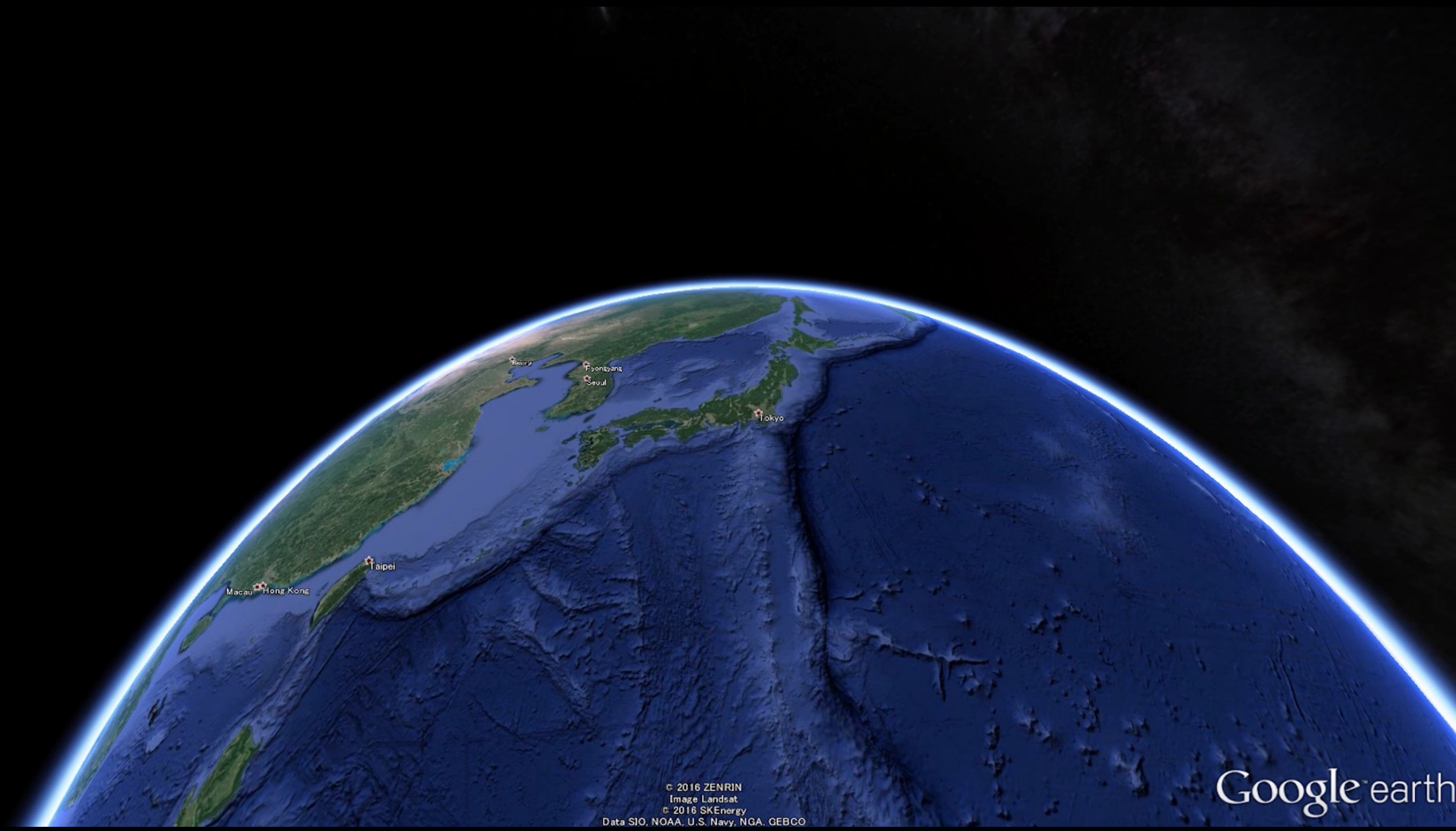


120 times more rapid than hourly update cycles

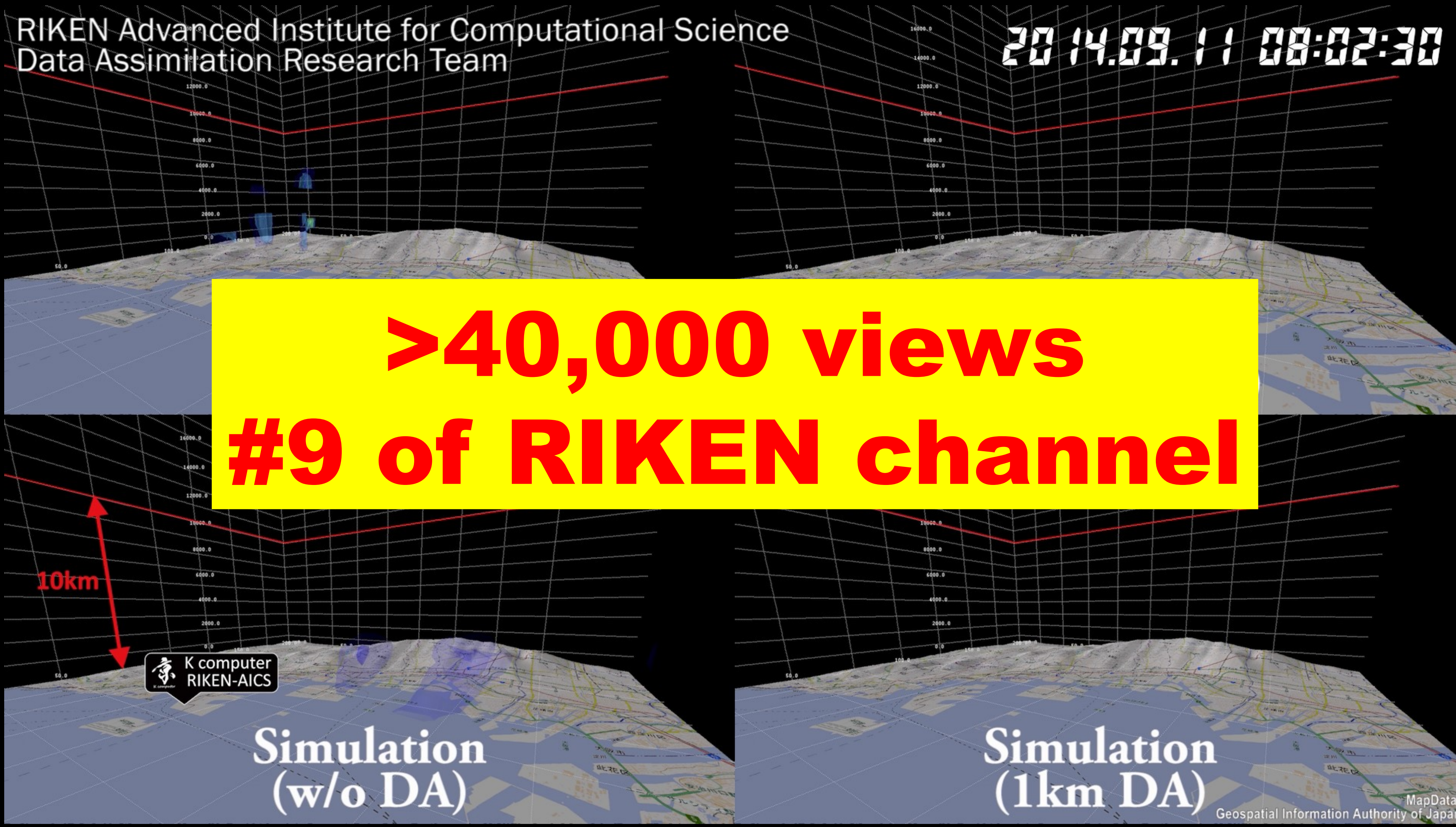
9/11/2014 morning, sudden rain



9/11/2014, sudden local rain

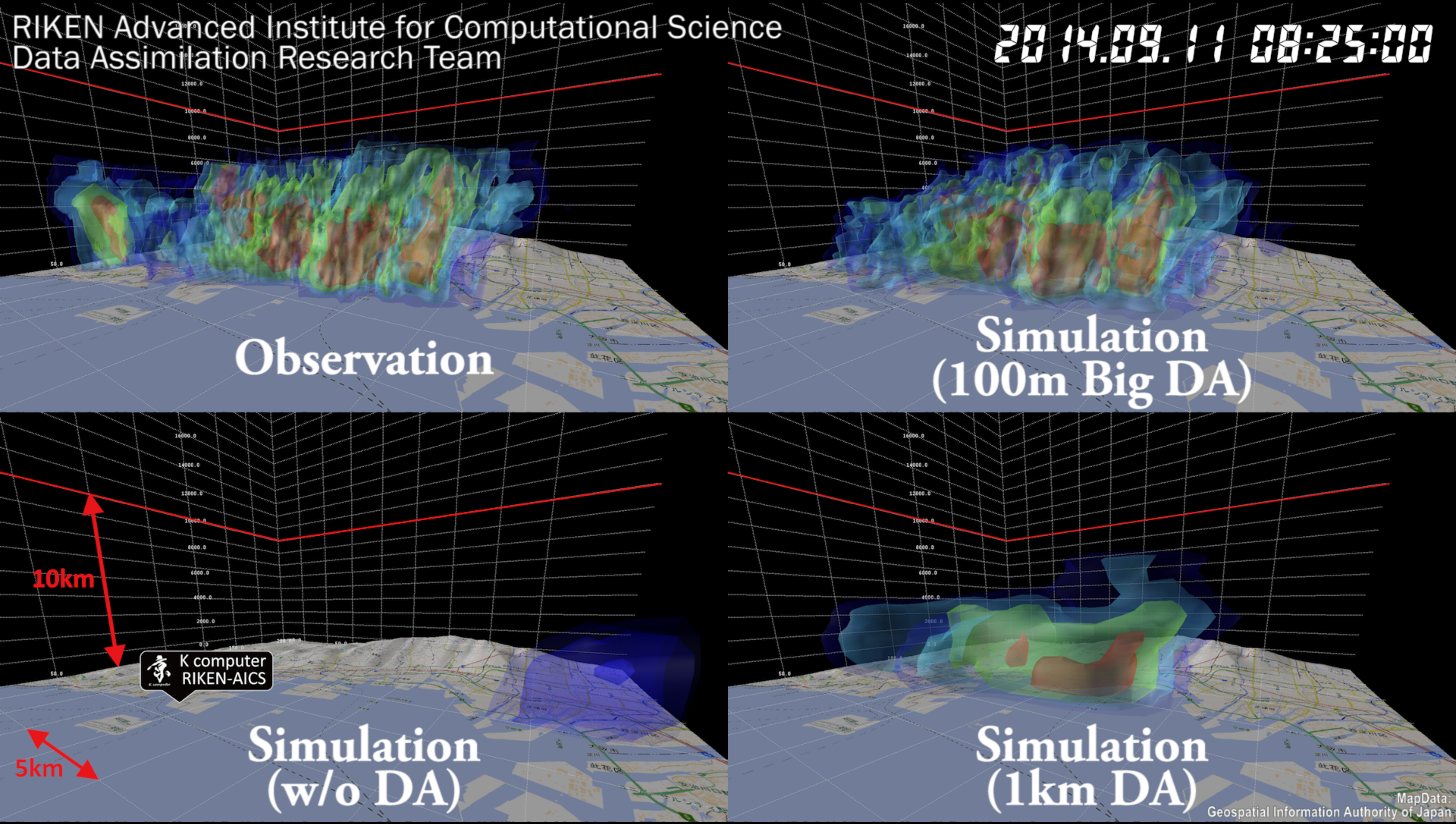


9/11/2014, sudden local rain



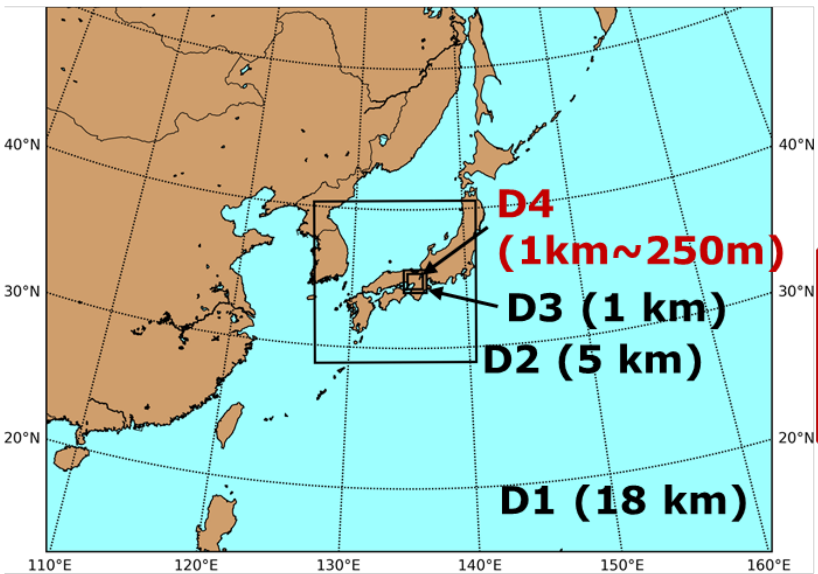
>40,000 views
#9 of RIKEN channel

9/11/2014, sudden local rain



Another case study (July 16, 2017)

Lien et al. (in prep.)

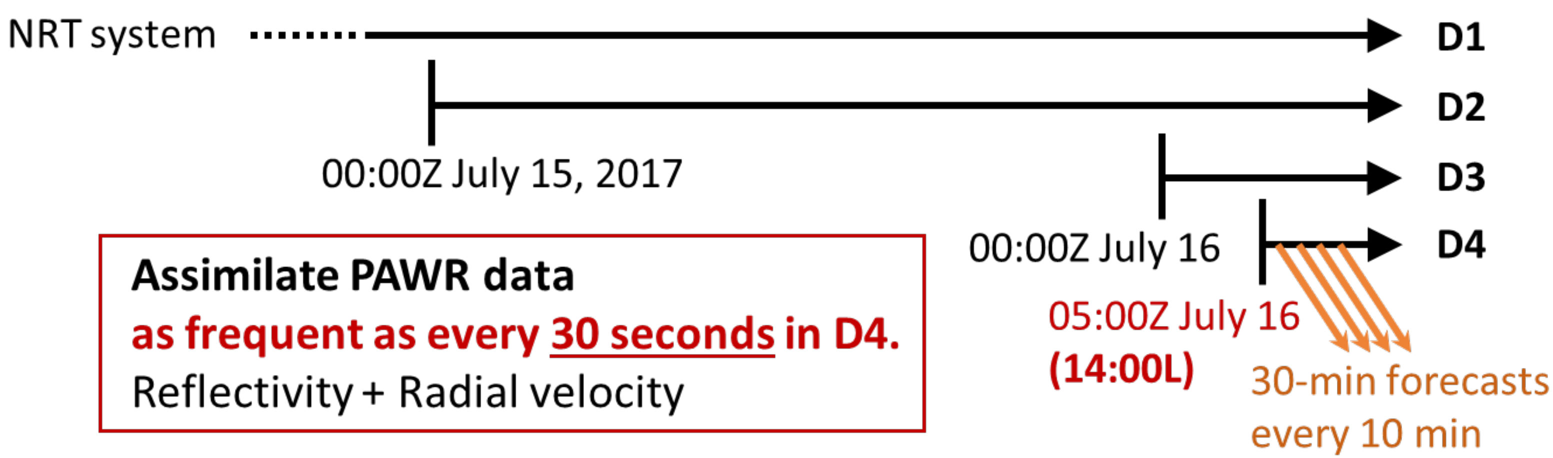


	Resolution	Size	Observation	Cycle length
D1	**18 km**	**5760 x 4320 km**	**PREPBUFR**	**6 h**
D2	**5 km**	**1280 x 1280 km**	**PREPBUFR**	**6 h**
D3	**1 km**	**180 x 180 km**	**PAWR**	**5 m**
D4	**1 km**	**120 x 120 km**	**PAWR**	**5 m 2 m 1 m 30 s**

Ensemble size: **50**

State variables: U, V, W, P, T, Q, Qc, Qr, Qs, Qi, Qg

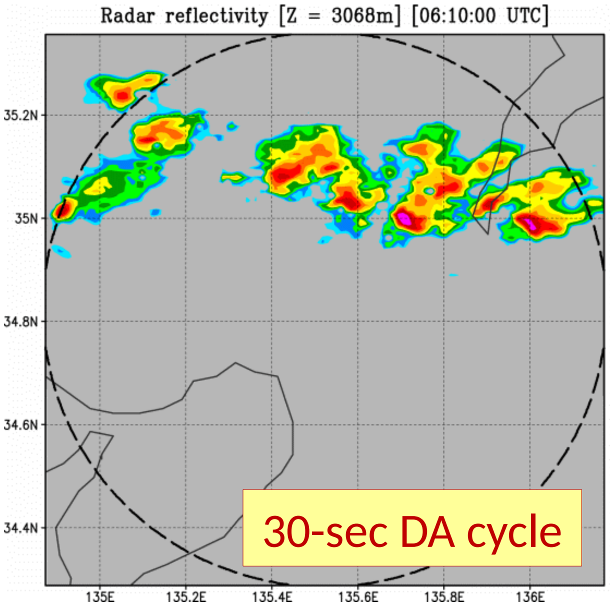
Observations superobed to model resolution



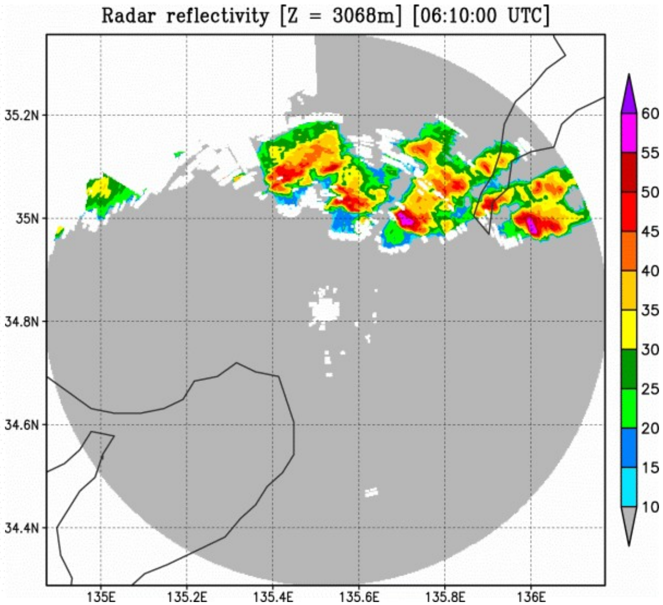
Assimilate PAWR data
as frequent as every <u>30 seconds</u> in D4.
Reflectivity + Radial velocity

30-min **forecast**: 15:10L – 15:40L

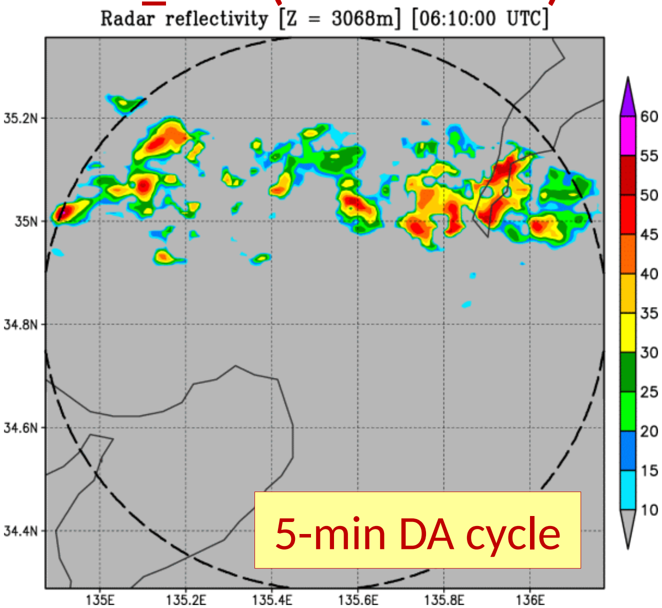
D4_1KM (deterministic)



OBS after QC



D4_1KM (deterministic)

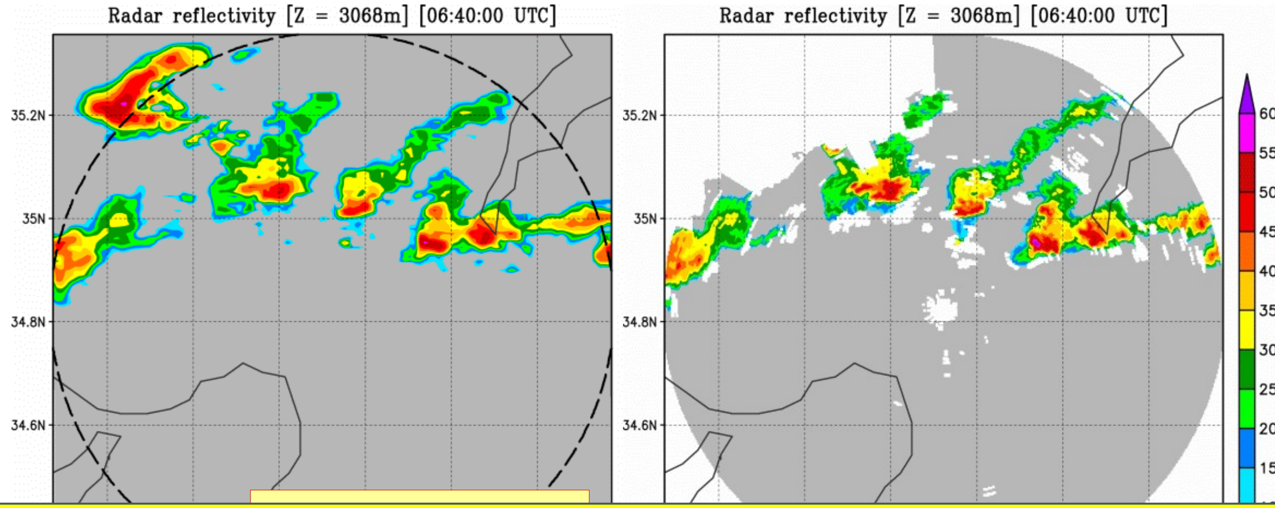


Lien et al. (in prep.)

30-min **forecast**: 15:40L – 16:10L

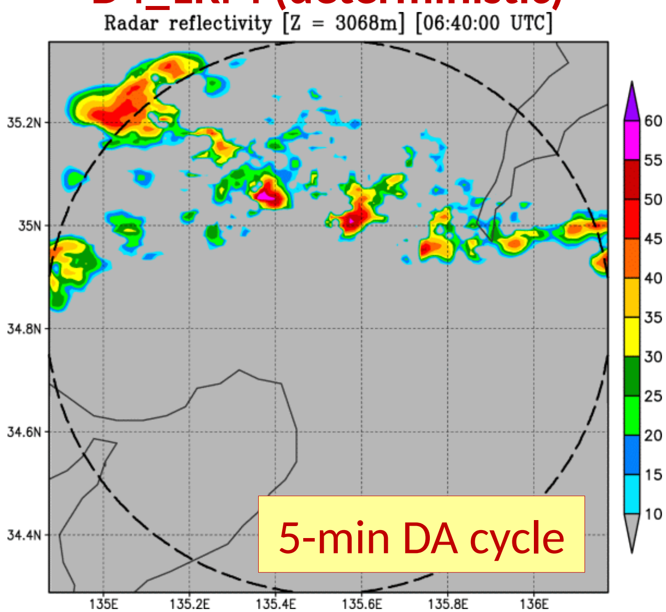
D4_1KM (deterministic)

OBS after QC



30-sec. update certainly helps.

D4_1KM (deterministic)

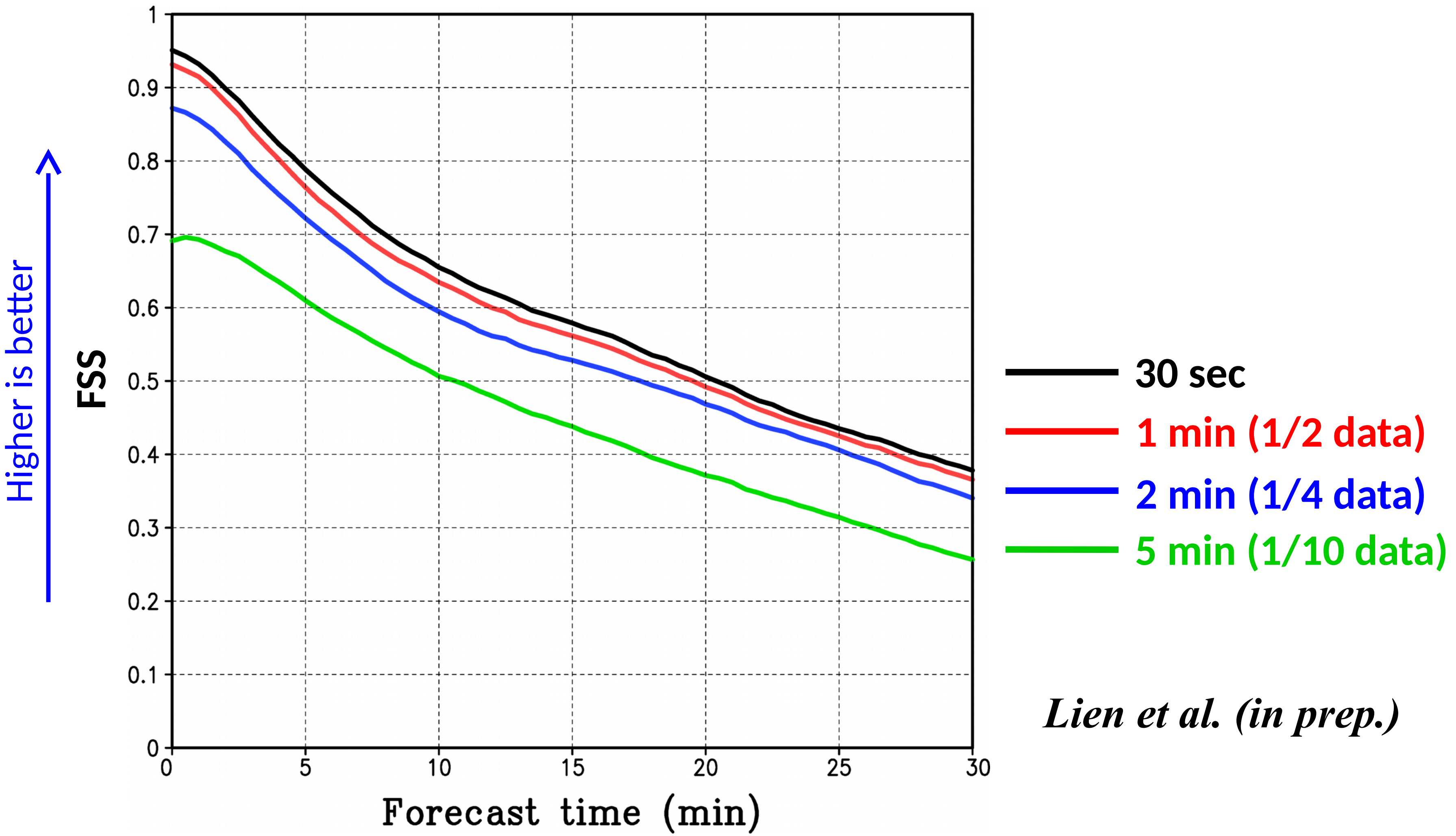


Lien et al. (in prep.)

Impact of update frequency:
30-min-forecast

1 KM resolution

Threshold = 15 dBZ;
horizontal length scale = 1 km (18-fcst average)



Lien et al. (in prep.)

Impact of update frequency:
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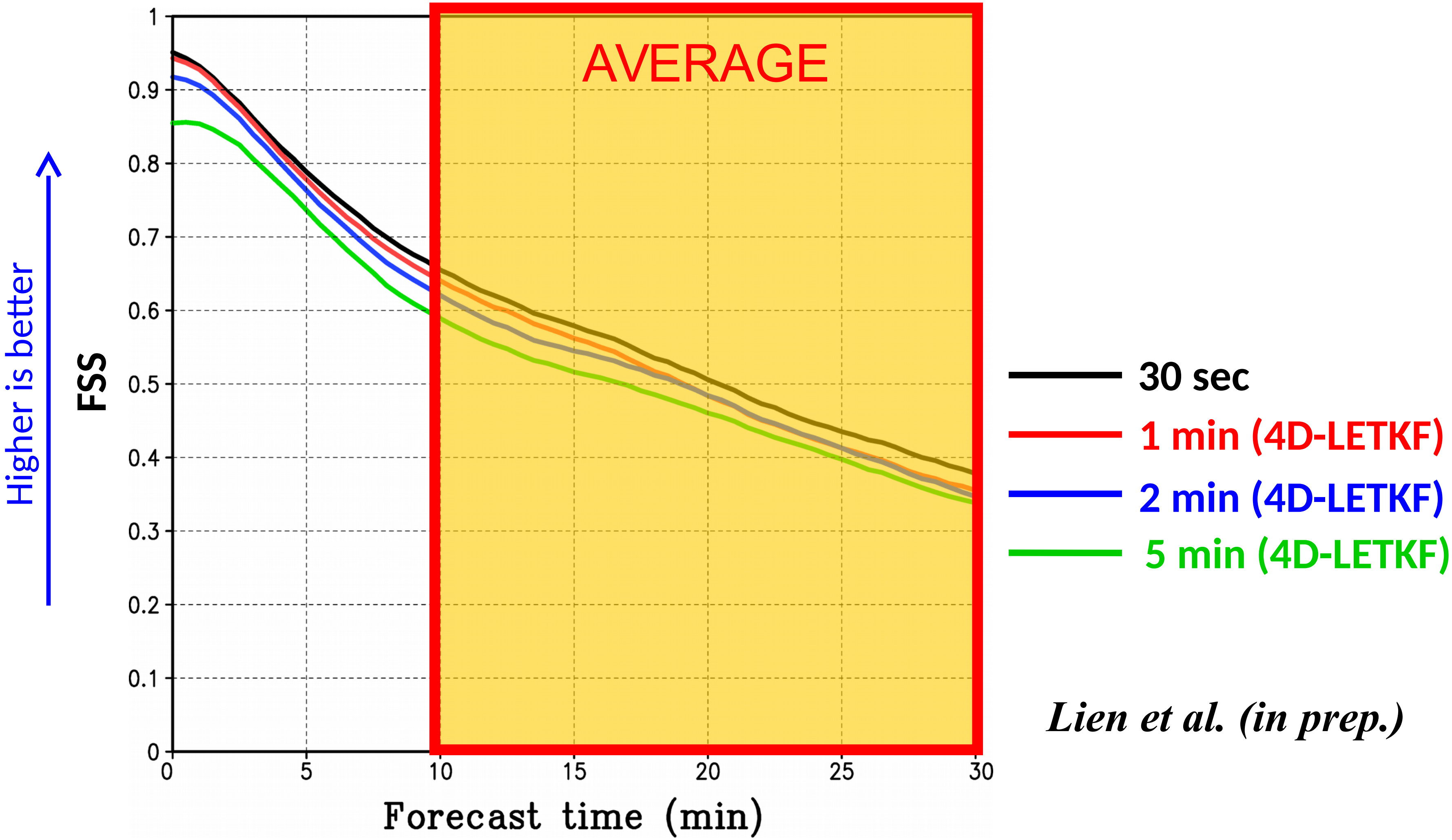


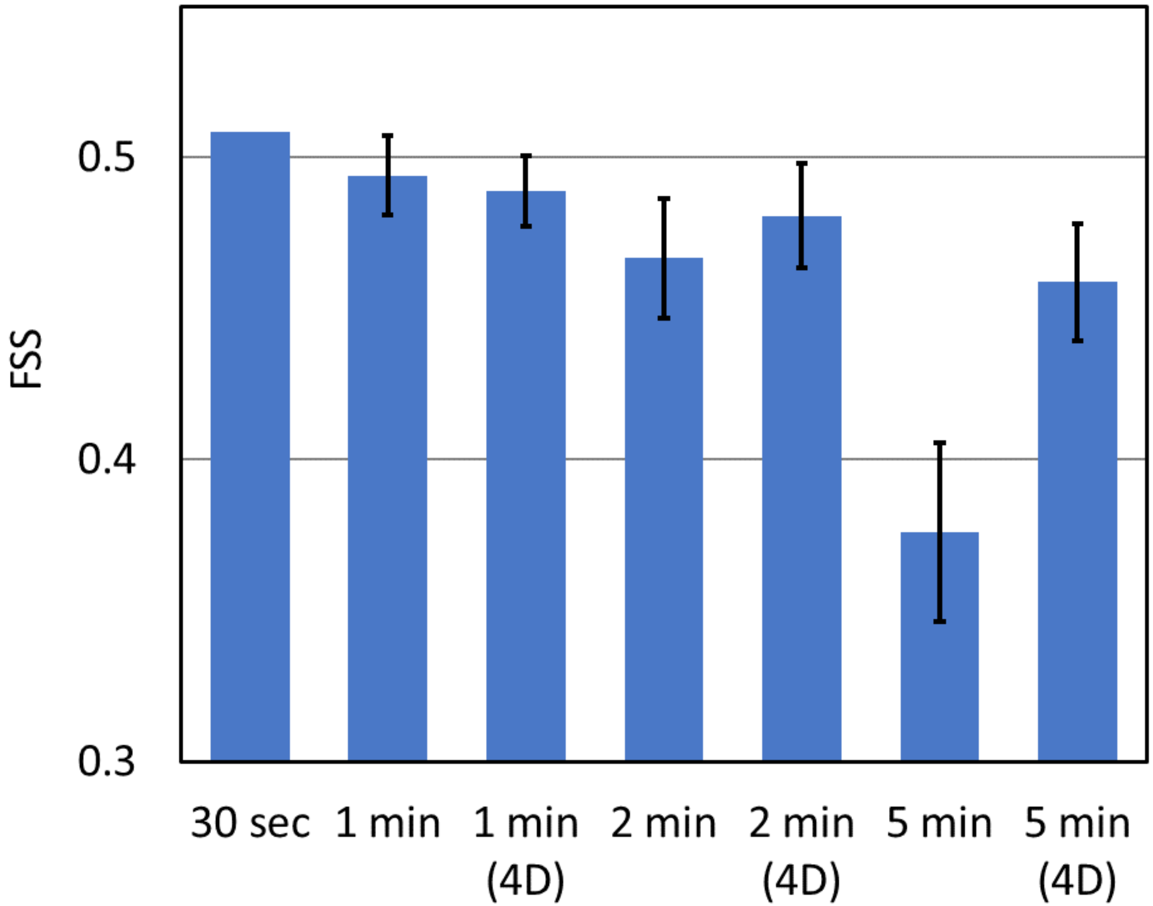
Lien et al. (in prep.)

Impact of update frequency: Forecast FSS

1 KM resolution

Threshold = 15 dBZ;
horizontal length scale = 1 km (18-fcst average)

Mean FSS in the 10- to 30-min forecasts



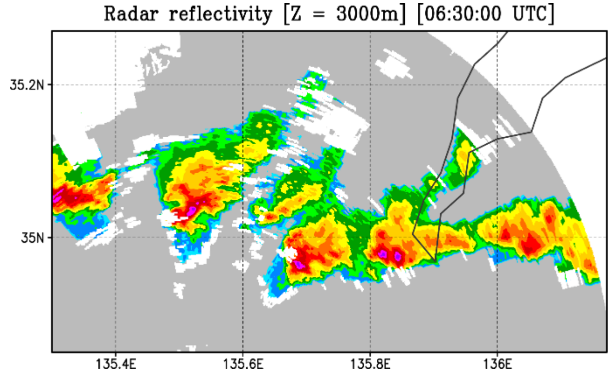
Error bars:
95% confidence interval using a pair-difference *t*-test compared to the 30-sec-cycle experiment

Lien et al. (in prep.)

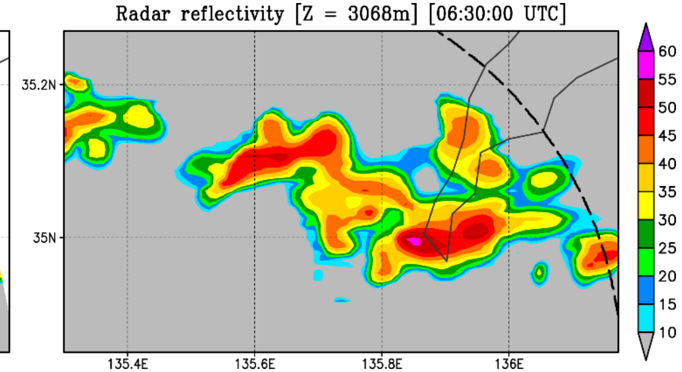
20-min forecast: 15:30L

Lien et al. (in prep.)

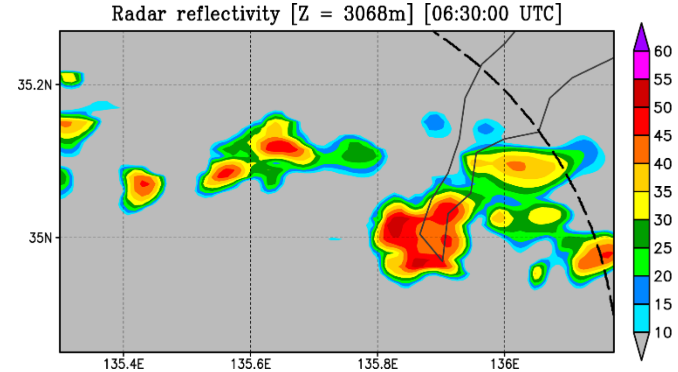
OBS after QC



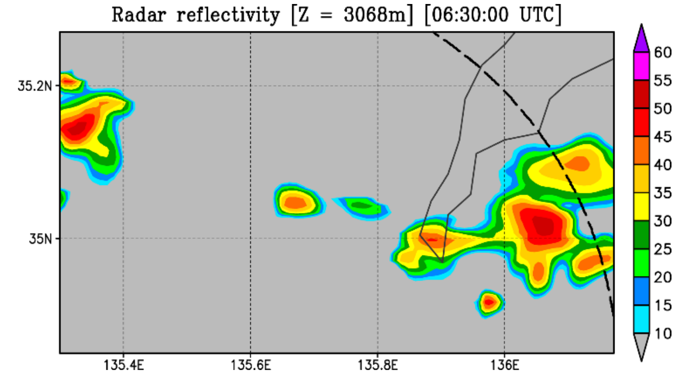
30 sec



5 min (4D)

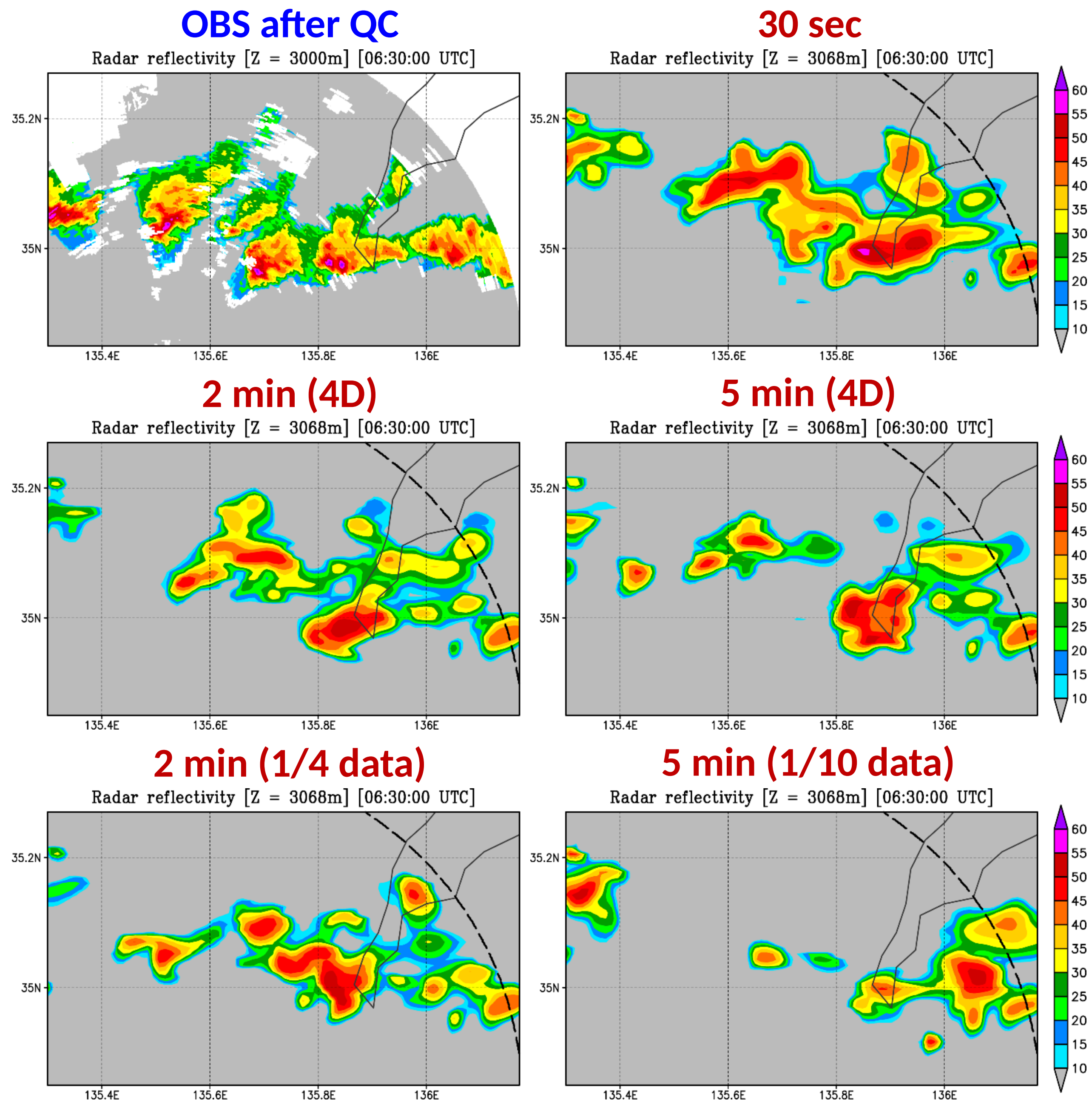


5 min (1/10 data)



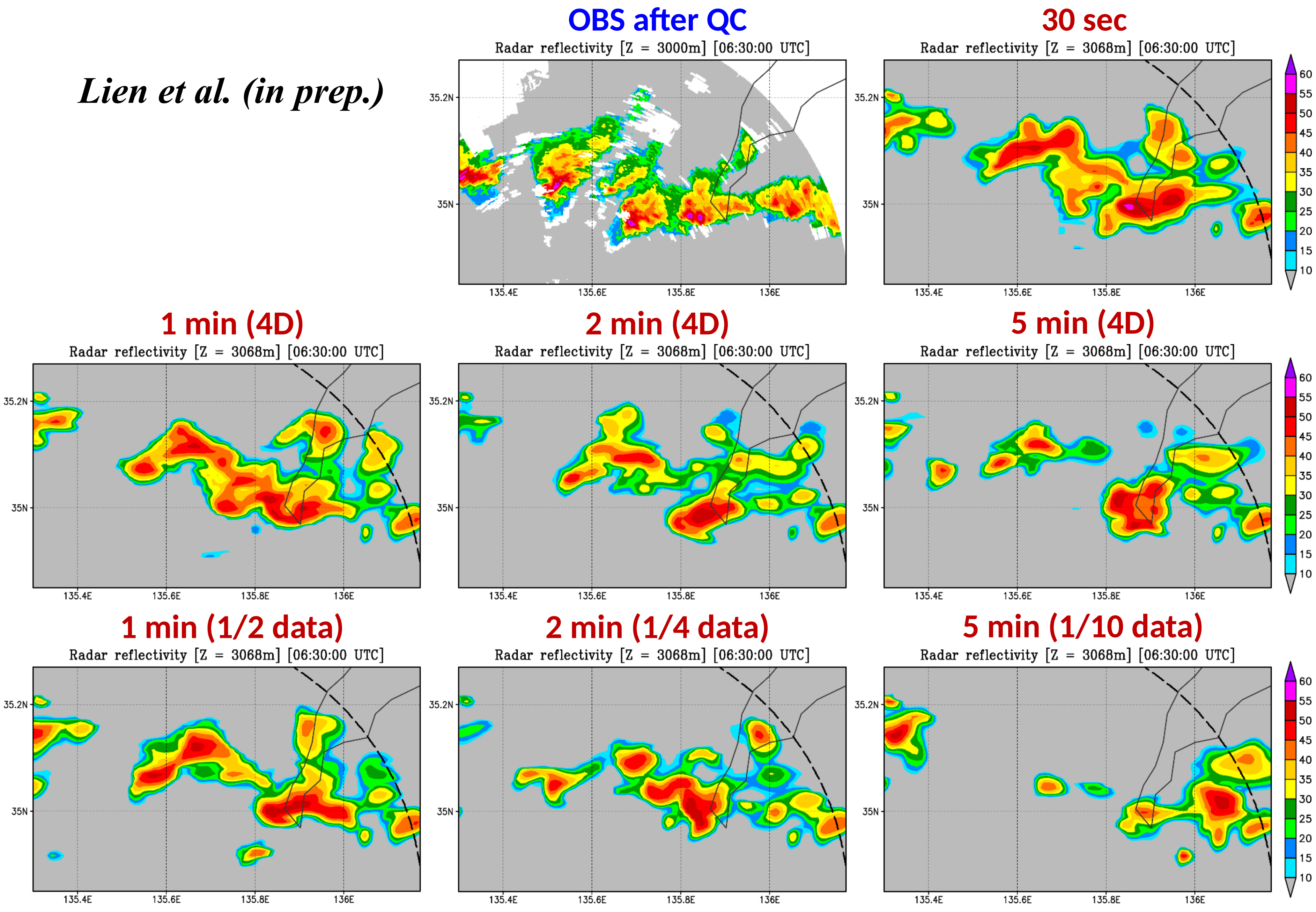
20-min forecast: 15:30L

Lien et al. (in prep.)



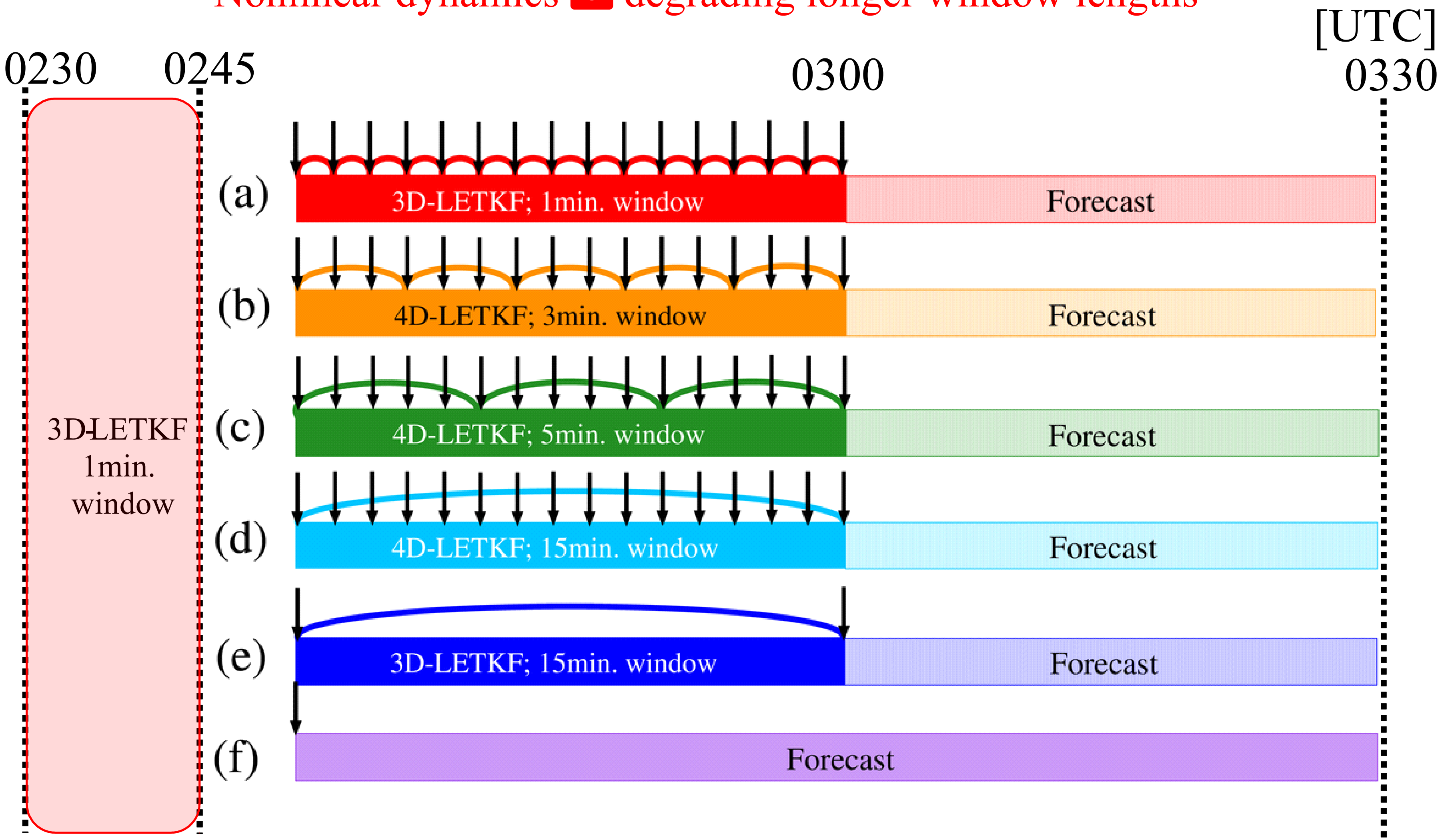
20-min forecast: 15:30L

Lien et al. (in prep.)



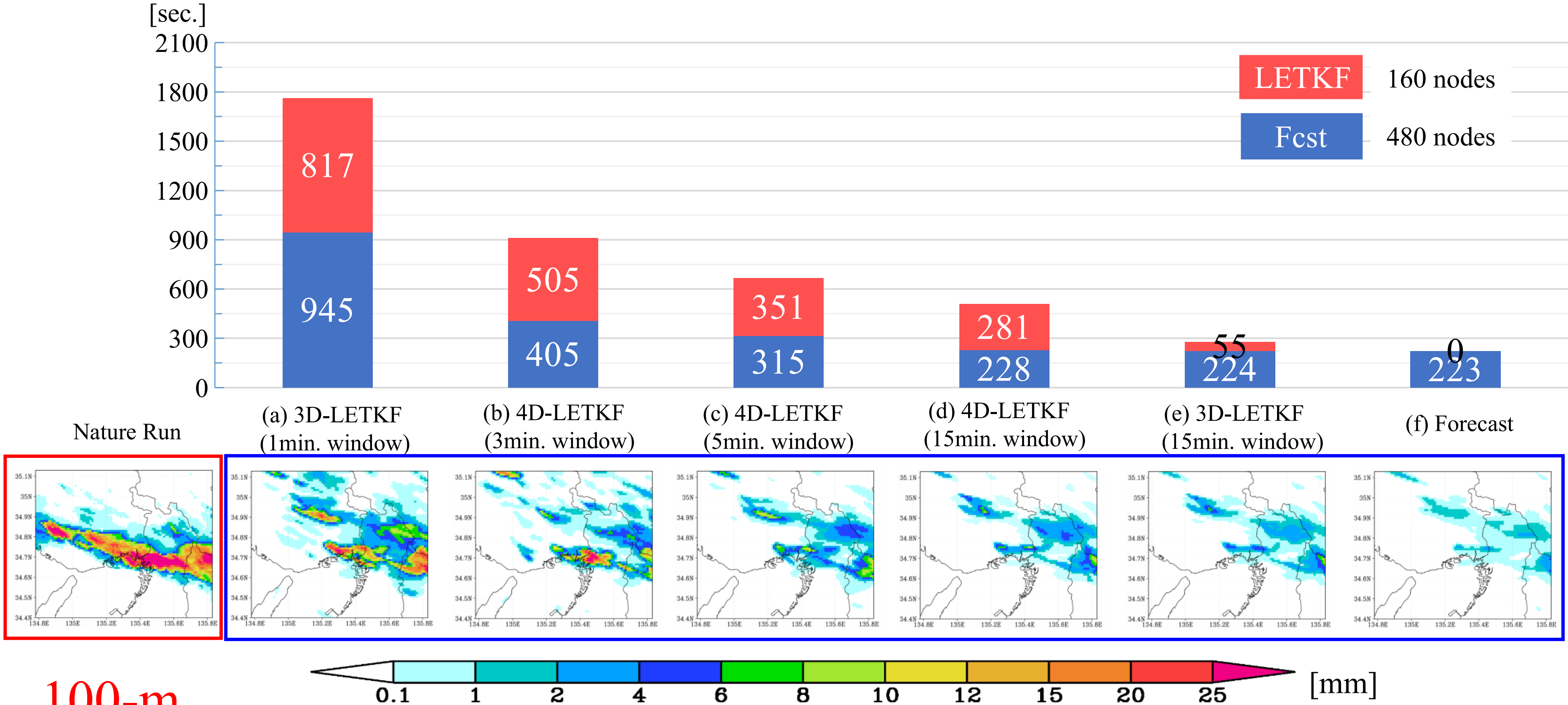
OSSE comparing different window lengths of 4D-LETKF

Nonlinear dynamics ✉ degrading longer window lengths



Maejima et al. (in prep.)

Computational time and **Surface rainfall intensity** (Analysis)

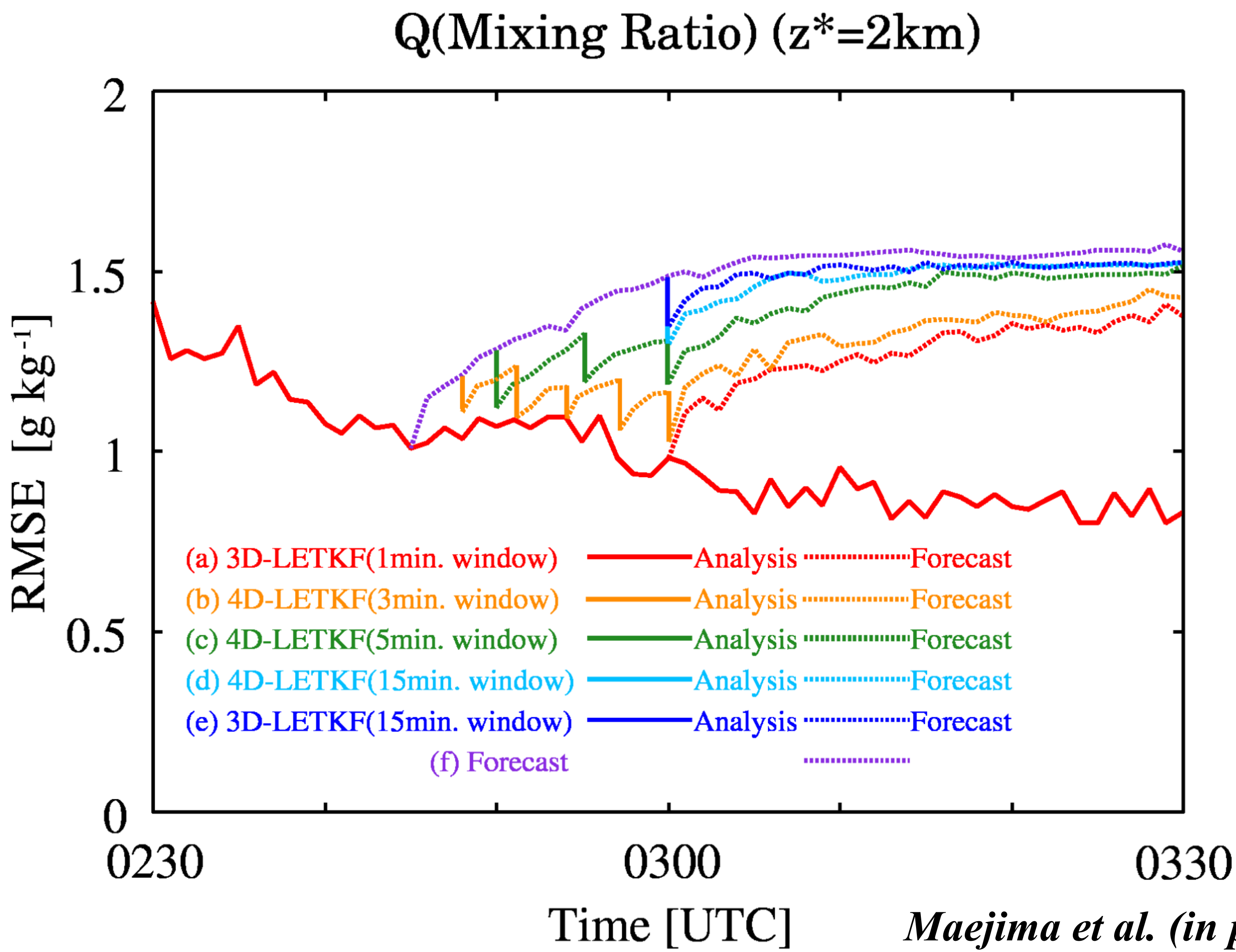


100-m mesh NR

1-km mesh DA

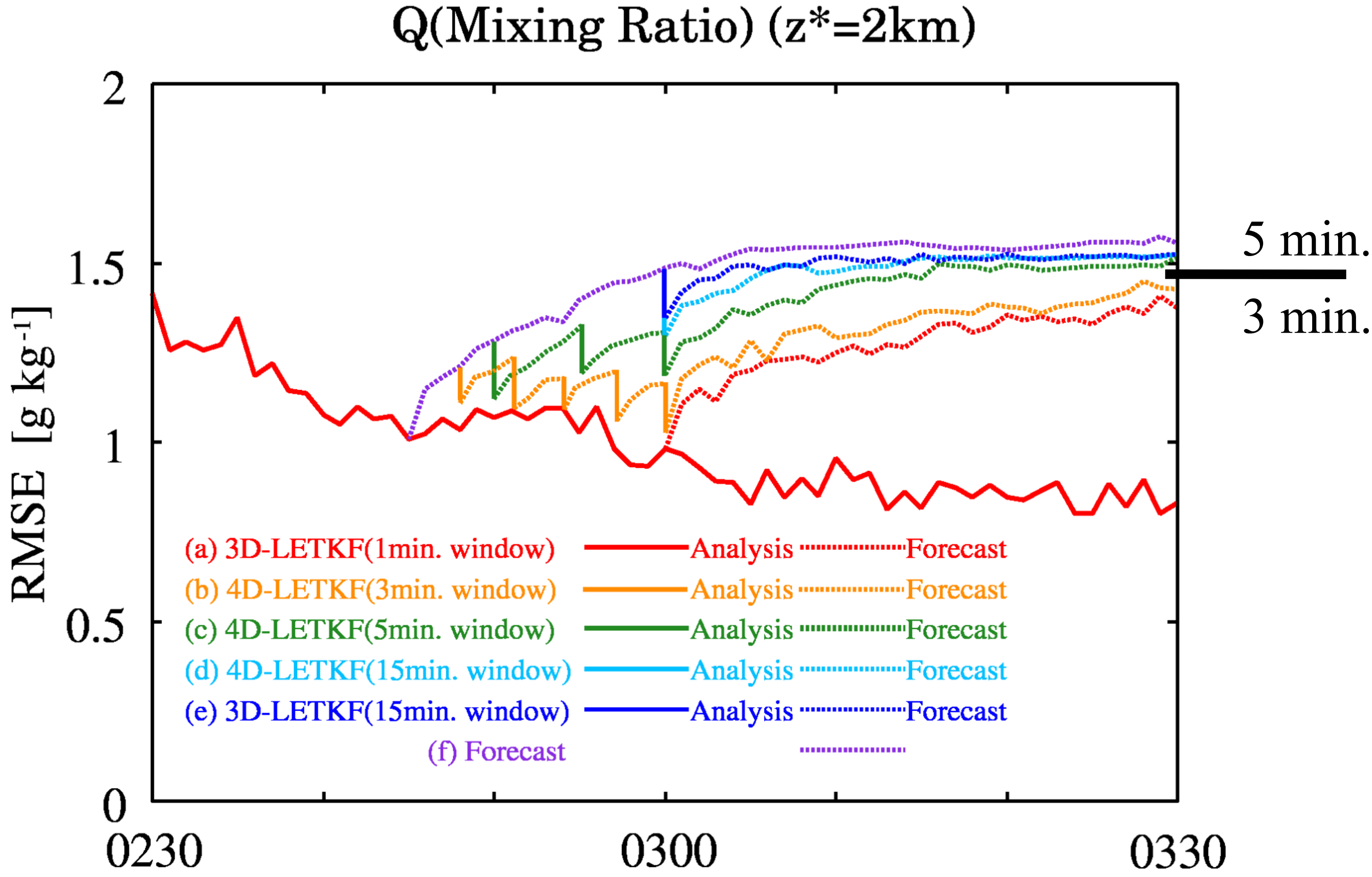
Maejima et al. (in prep.)

Time series of RMSE of water vapor mixing ratio at $z^* = 2$ km.



Maejima et al. (in prep.)

Time series of RMSE of water vapor mixing ratio at $z^* = 2$ km.

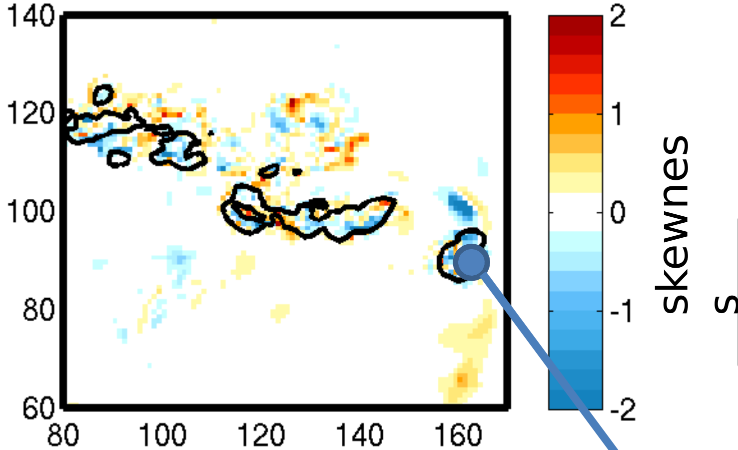


Maejima et al. (in prep.)

1-km-mesh, 1000-member LETKF

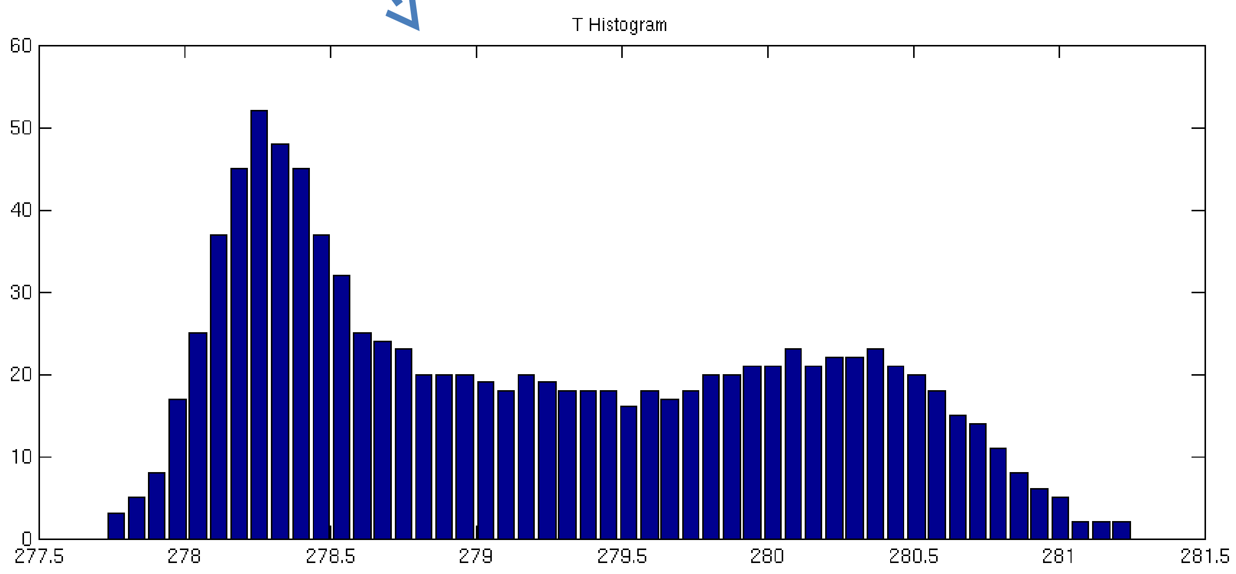
T skewness at z=3845 m

(Ruiz et al. in prep.)



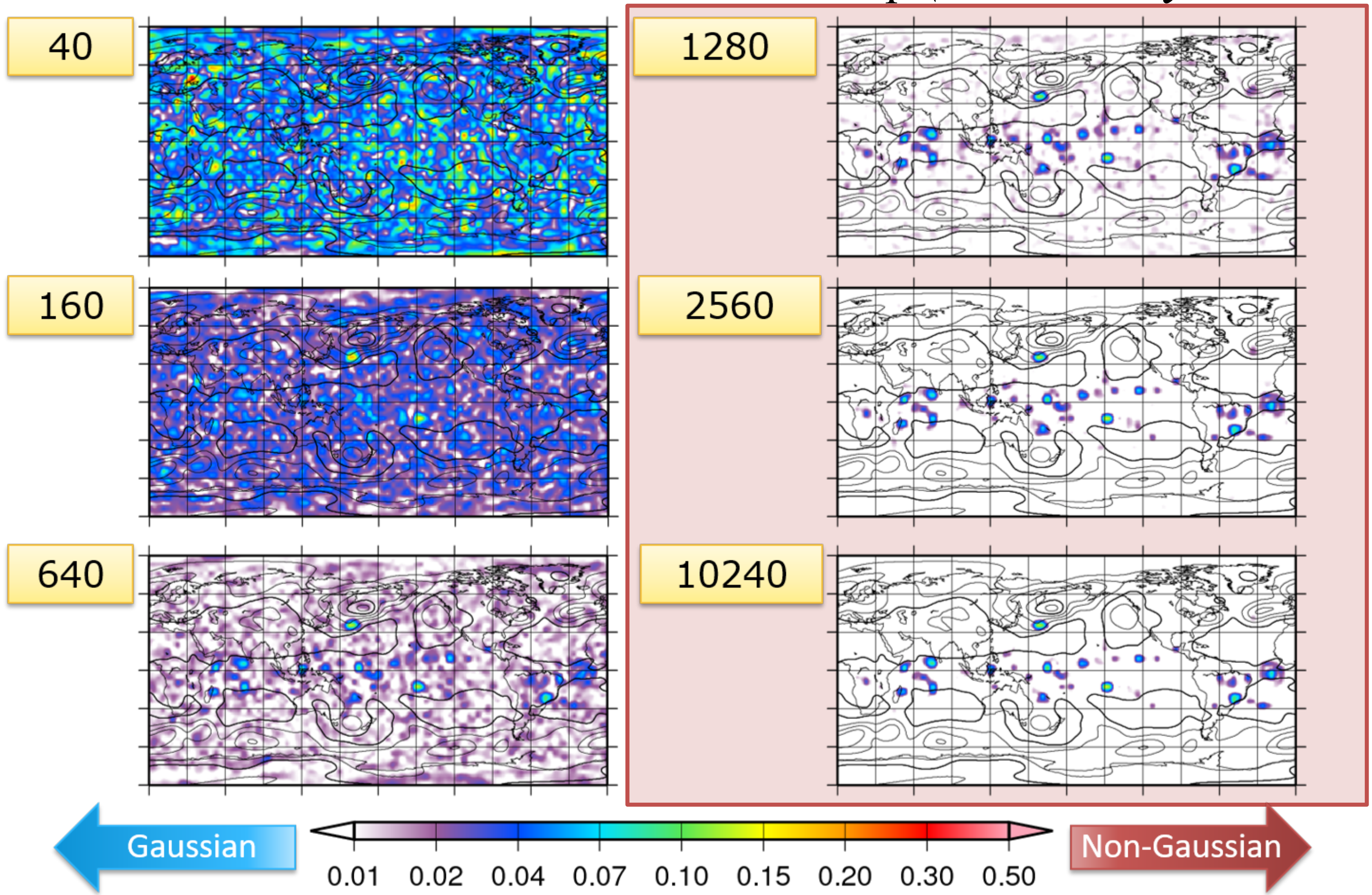
contours: 30 dBZ reflectivity

Even 30-second update shows strong non-Gaussianity with 1000 members.



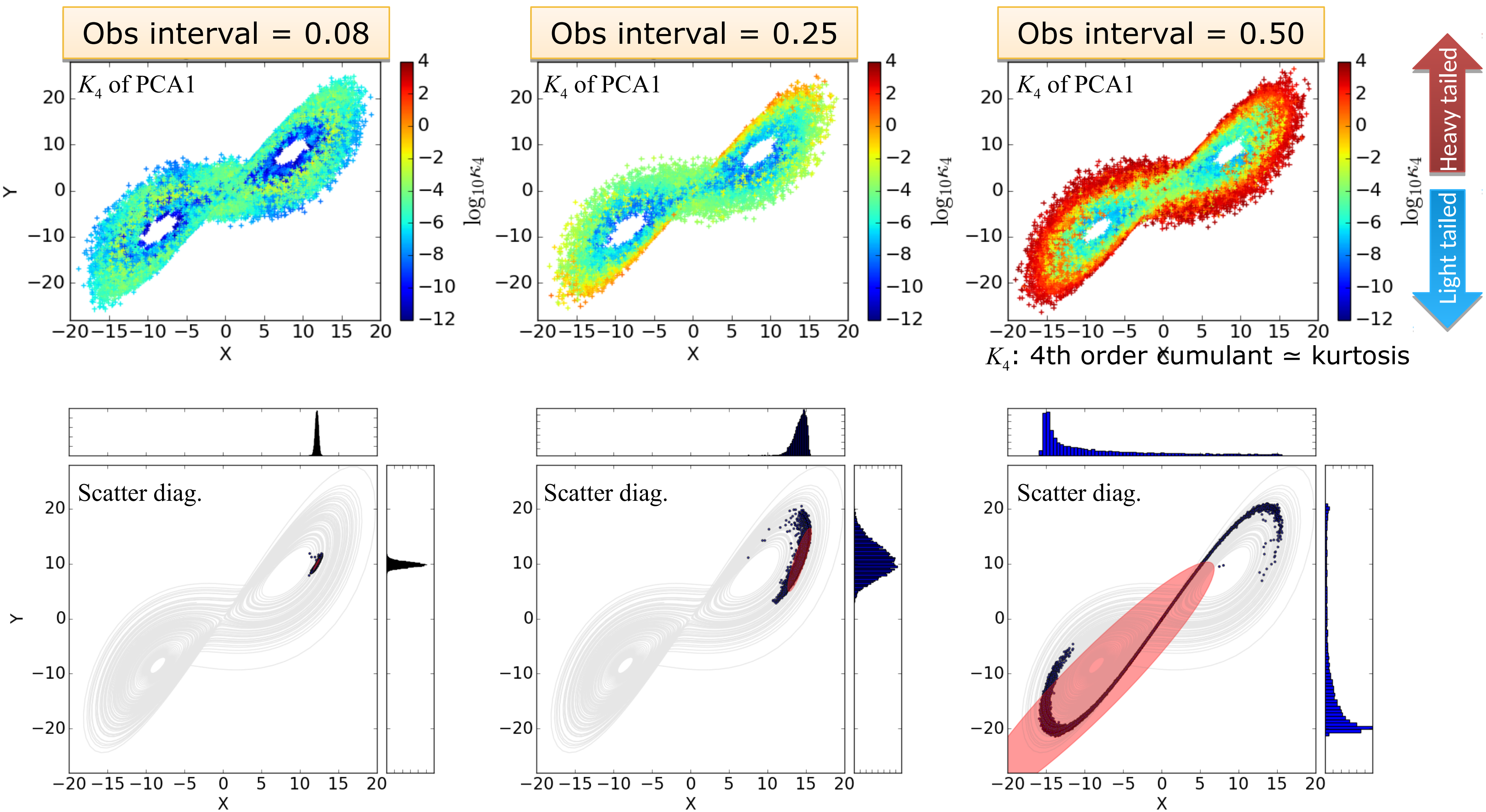
~1000 members good for capturing non-Gaussianity

based on 10240-member SPEEDY-LETKF exp. ***(Kondo&Miyoshi 2016)***



What do we expect with rapid updates?

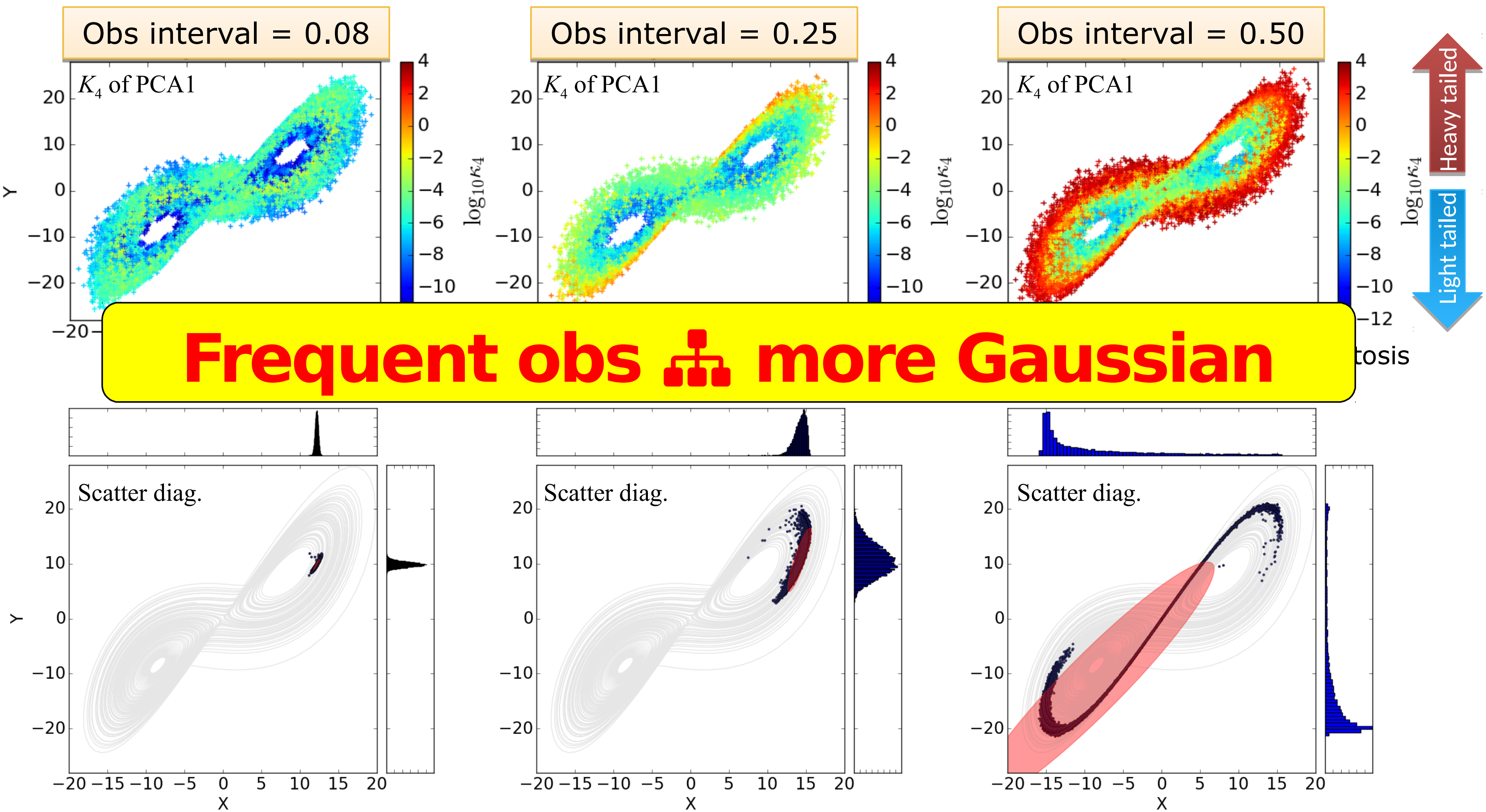
based on Lorenz-model exp. ***(Teramura&Miyoshi 2016)***



K_4: 4th order cumulant ≃ kurtosis

What do we expect with rapid updates?

based on Lorenz-model exp. ***(Teramura&Miyoshi 2016)***

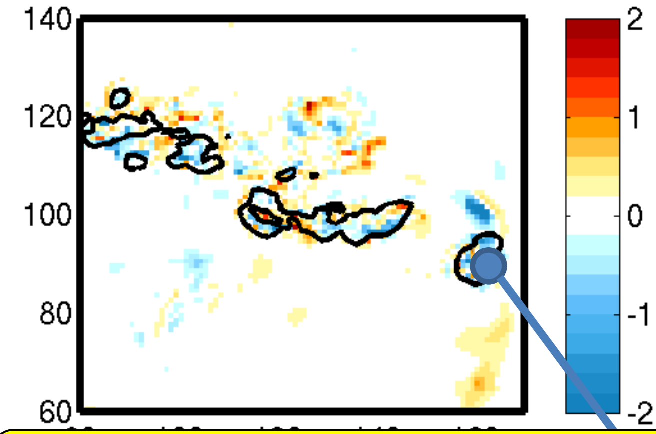


Frequent obs more Gaussian

1-km-mesh, 1000-member LETKF

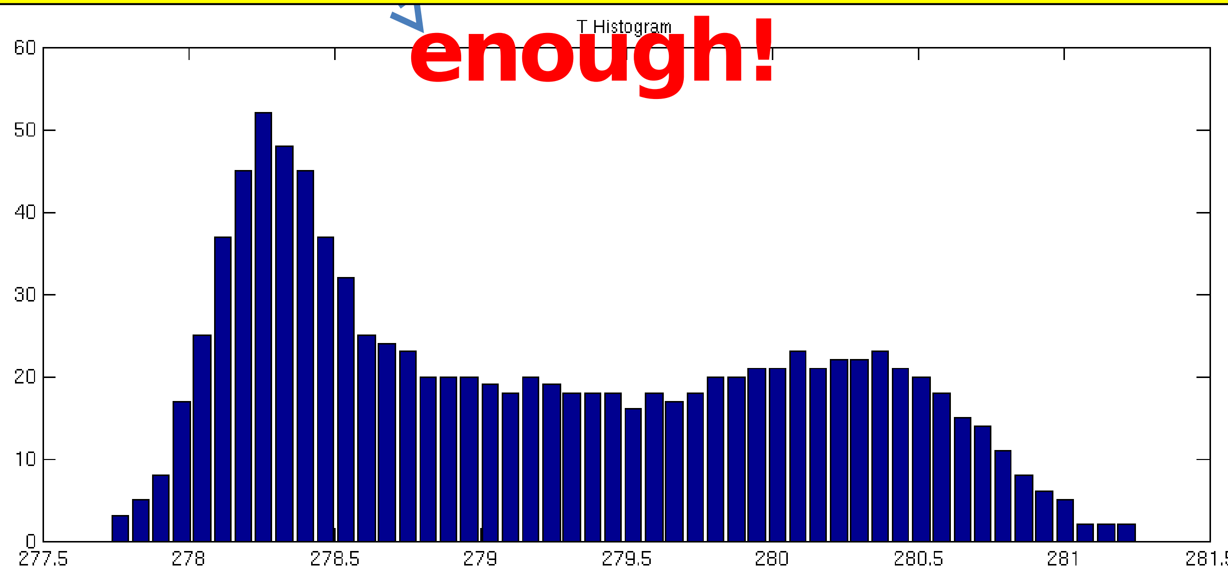
T skewness at z=3845 m

(Ruiz et al. in prep.)



Even 30-second update shows strong non-Gaussianity with 1000 members.

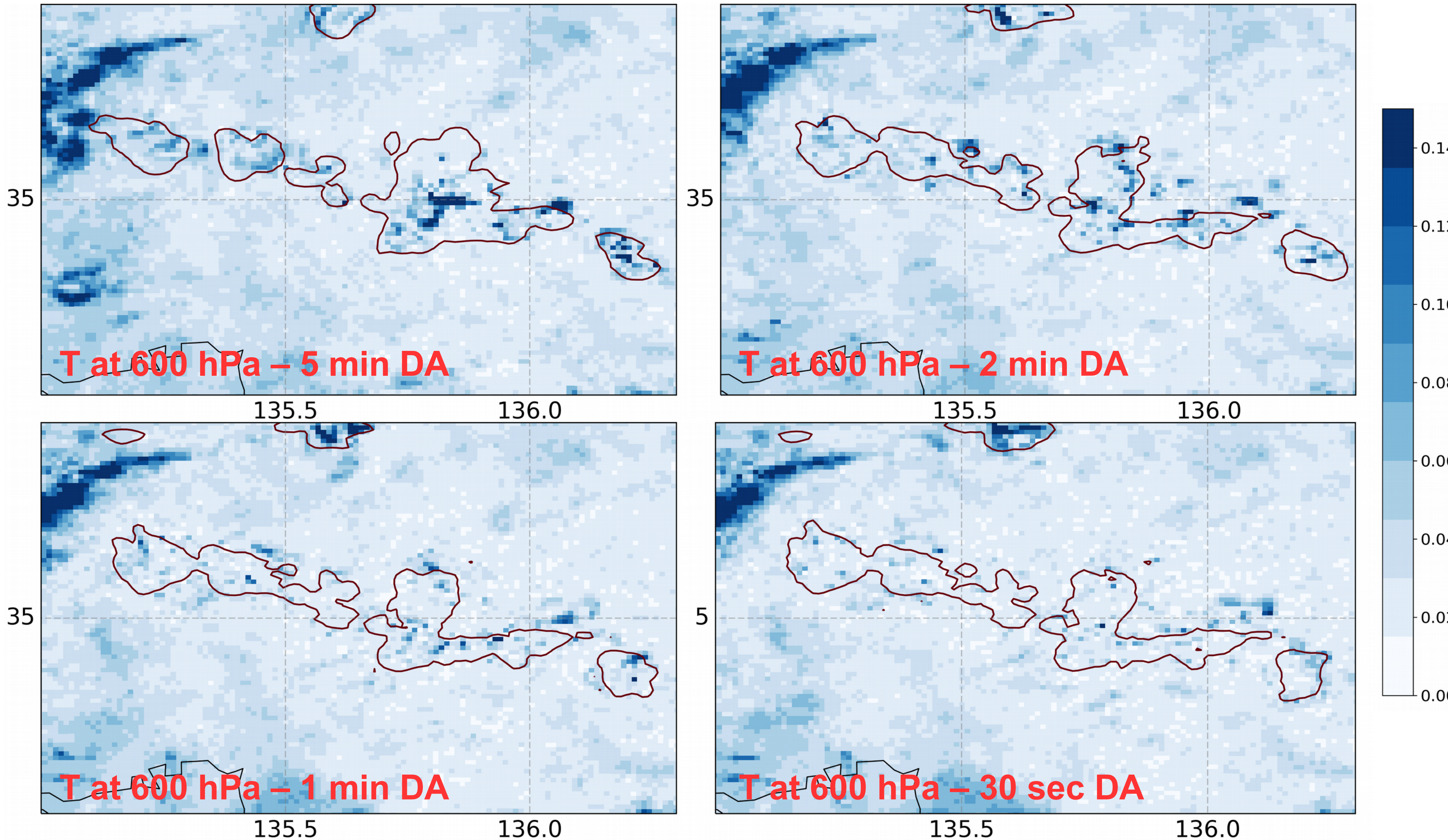
30-sec. update may not be fast enough!



Non-Gaussianity and data assimilation frequency

w/ 1000 members, 1-km mesh

Comparison of KLD for different assimilation frequencies
At 05:15 UTC (15 minutes after the end of the spin-up)



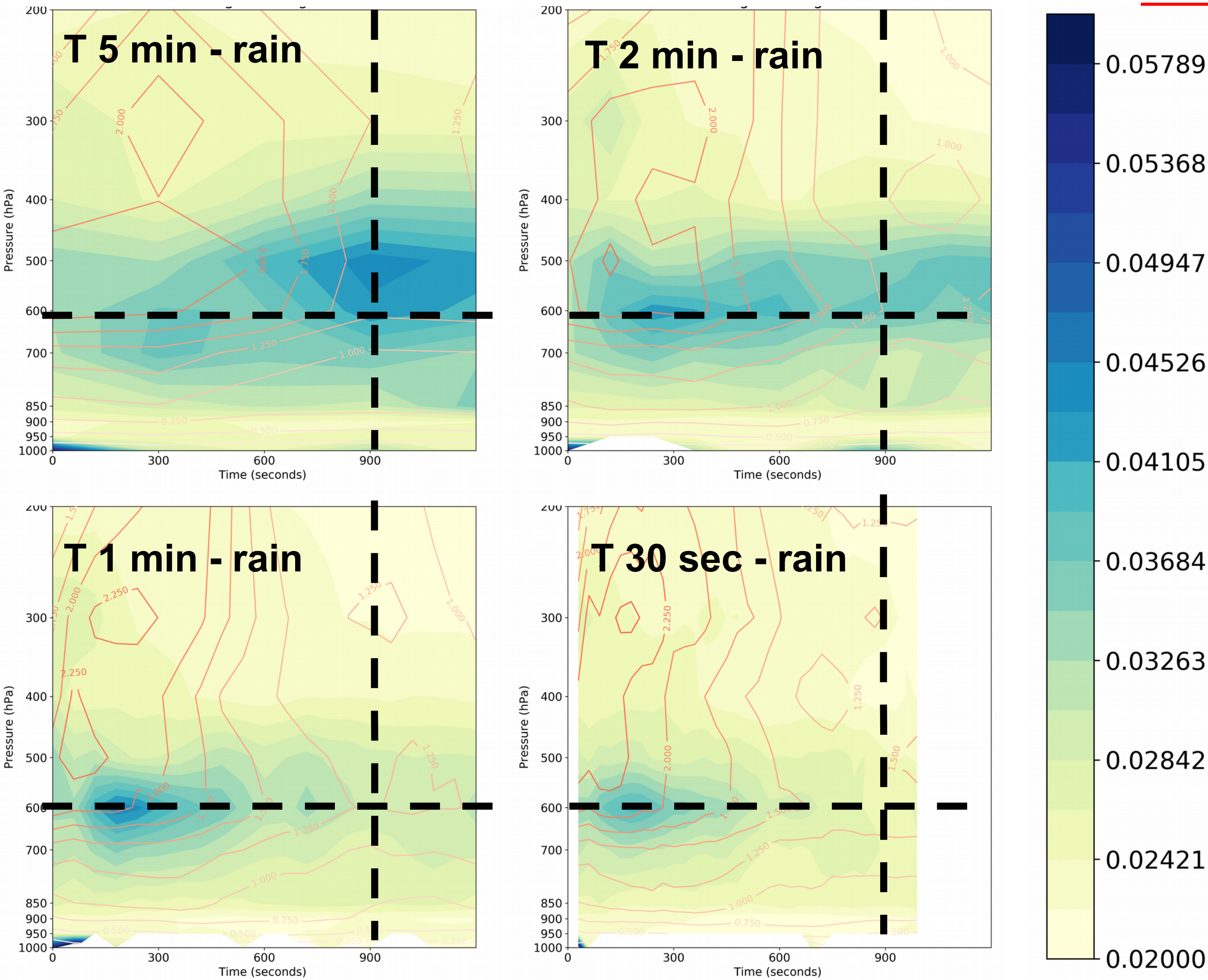
Contours: 30 dBZ

(Ruiz et al. in prep.)

Non-Gaussianity and data assimilation frequency

w/ 1000 members, 1-km mesh

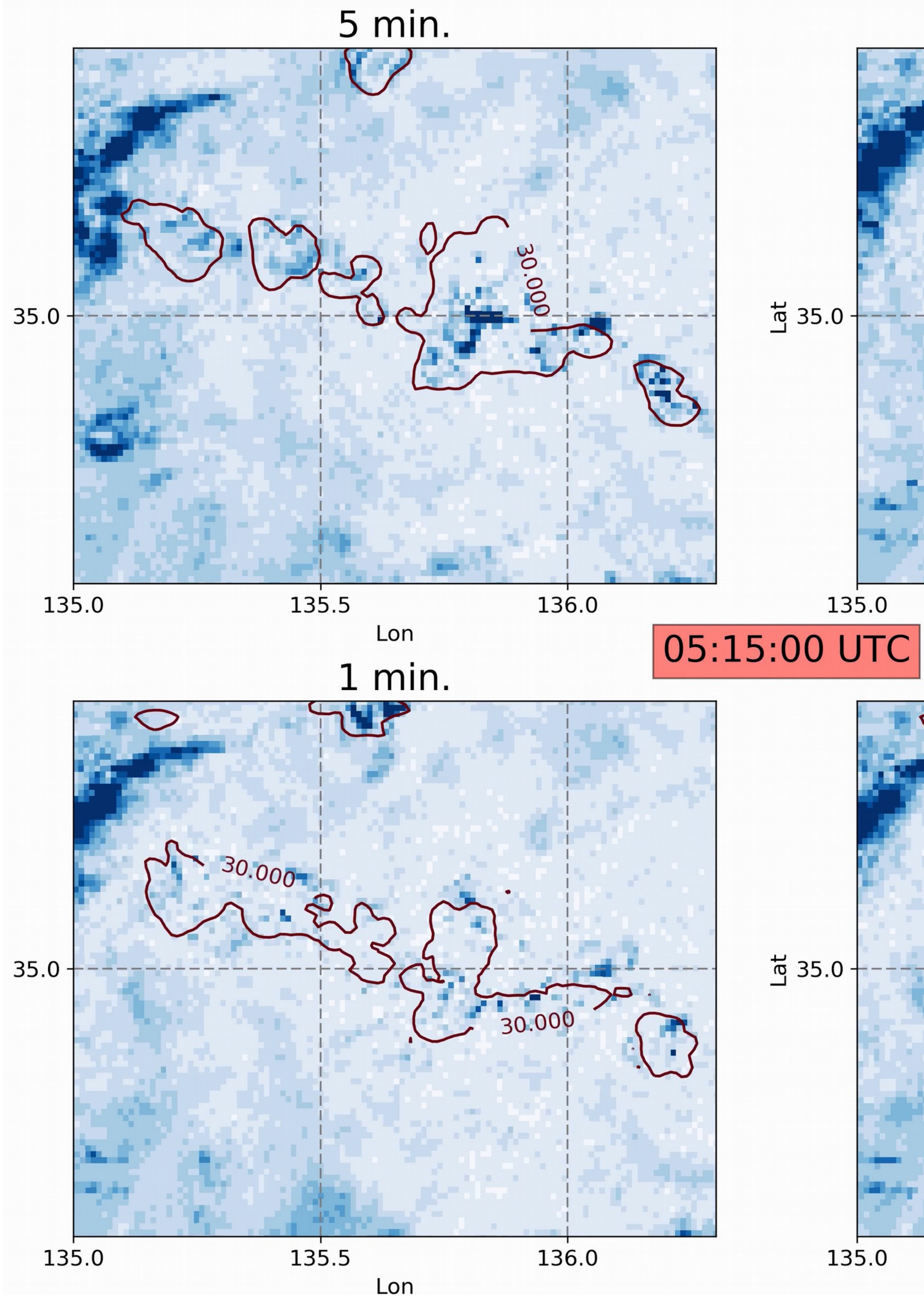
Comparison of KLD for different assimilation frequencies.



(Ruiz et al. in prep.)

Averaged area > 30 dBZ

more Gaussian with faster cycles



(Ruiz et al. in prep.)

Summary

30-second update certainly helps,

but faster updates may help reduce the non-Gaussianity further (for active convection).

How fast, what performance? – work in progress