Data Assimilation of Side-looking Radio Occultation by Observing System Simulation Experiment

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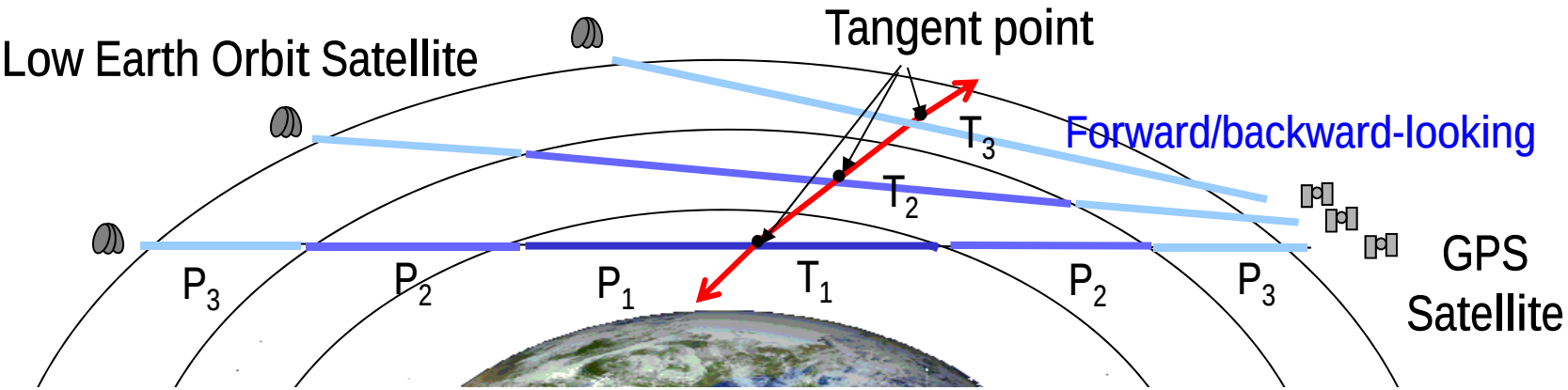
and

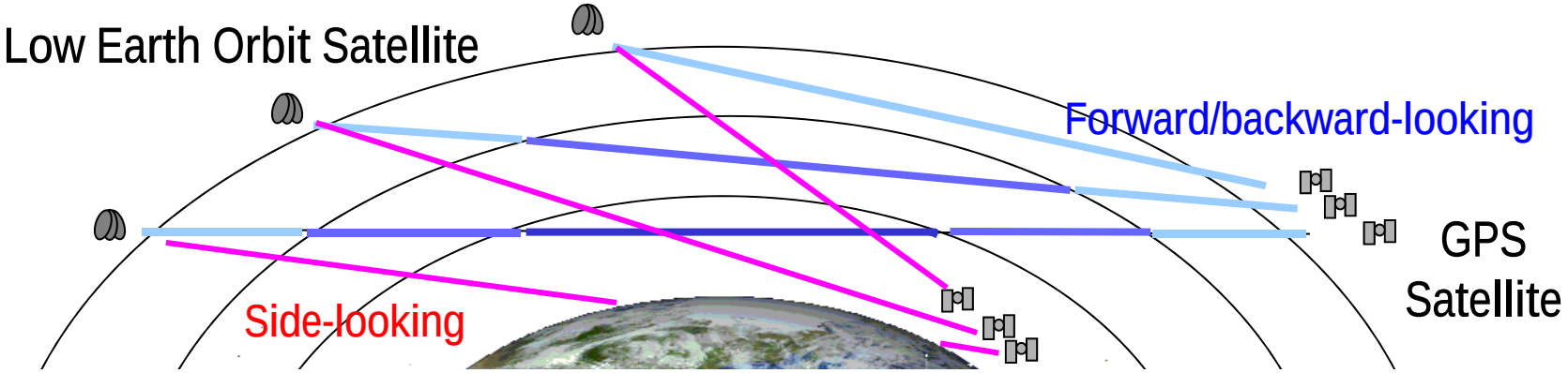
Bill Kuo (UCAR)

Concept of the side-looking observation



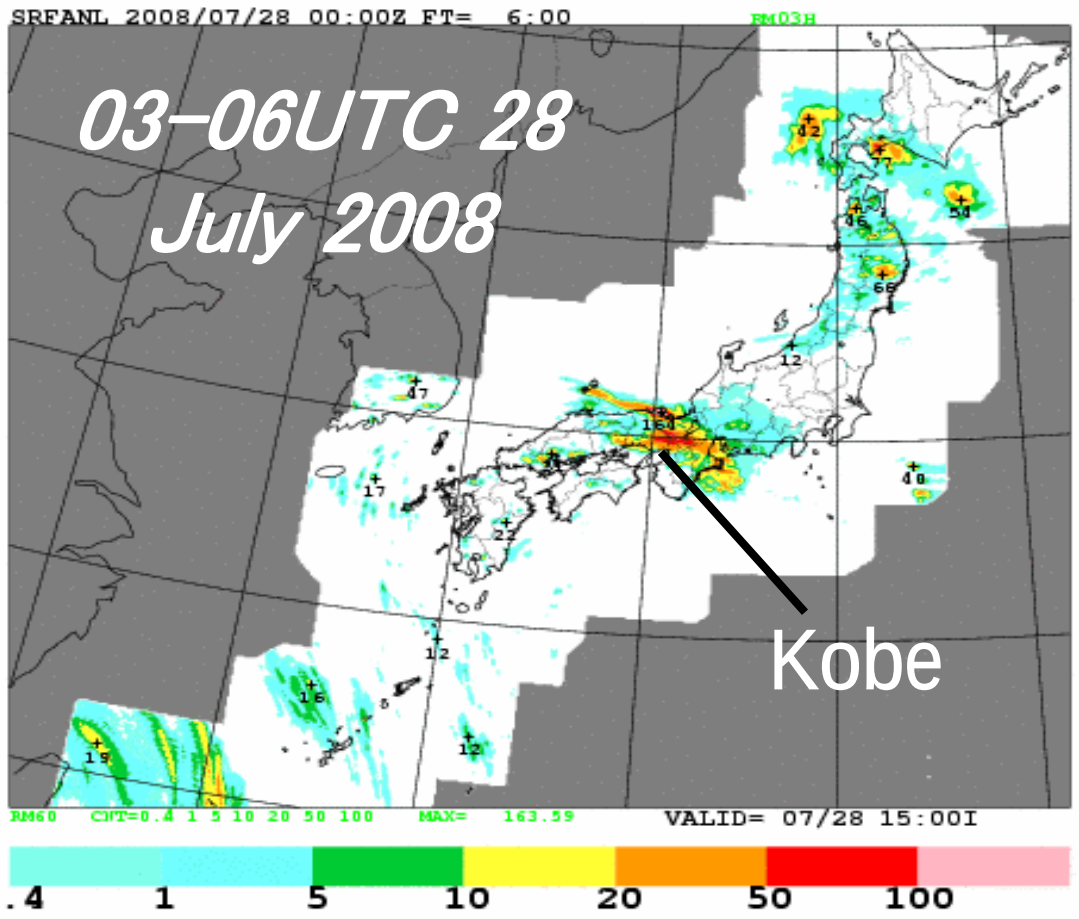
- Low earth orbit satellite (LEO) observes the signal of GPS satellite from the moving direction of the LEO satellite, because the short shift of the tangent point is required for the precise estimation of the tangent point profiles.
- If slant path data is used in the assimilation, it is not necessary to use the data which have the small angle from the moving direction of LEO satellite.

Concept of the side-looking observation



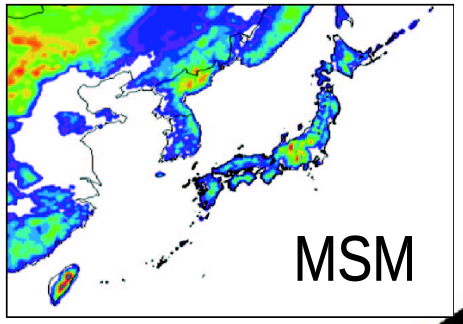
- In general, impact of RO data is weak because the slant path data extends several hundred kilometers. For this reason, the total amount of assimilated data should be increased by using ‘side-looking’ data.
- In this study, the assimilation experiment of side-looking data is performed by ‘Observing System Simulation Experiment’.

Intense rainfall occurred in the city of Kobe



- We have focused on the intense rainfall that occurred in the city of Kobe.
- Intense rainfall raised the water level of Toga river, and five people drowned in the riverside park.

Flow chart of Assimilation of conventional data



Initial: Operational Meso-analysis
18UTC 27 July

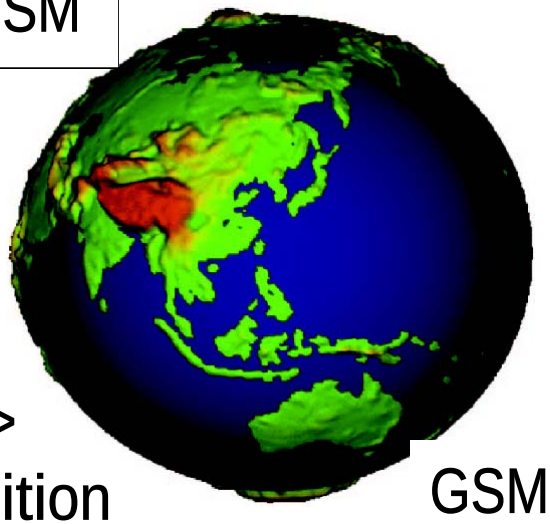
Boundary: GSM output

00 UTC
28 July

21UTC

18UTC
27 July

Meso-4DVar system



Analysis =>
initial condition

Boundary: GSM output

Conventional data

Conventional data

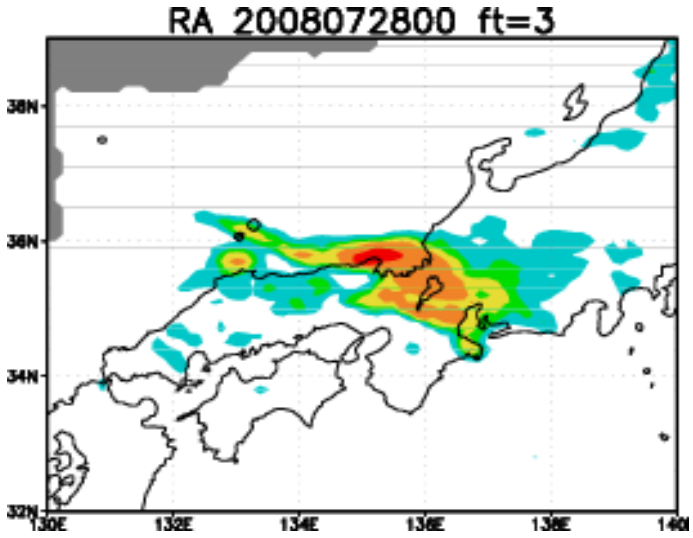
JMA-NHM(Δx=10km)

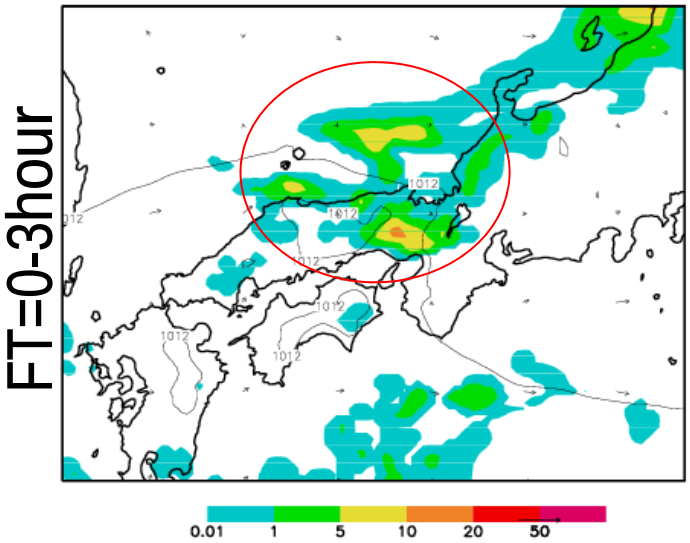
Assimilation results using conventional data

Observation

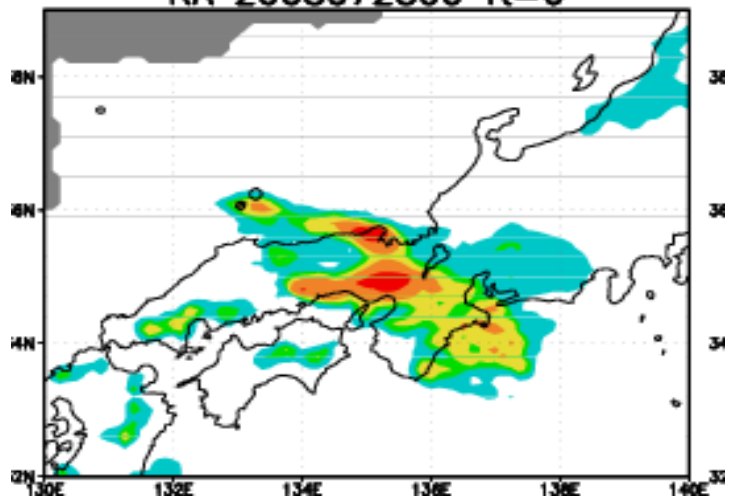
NoRO (Conventional data)

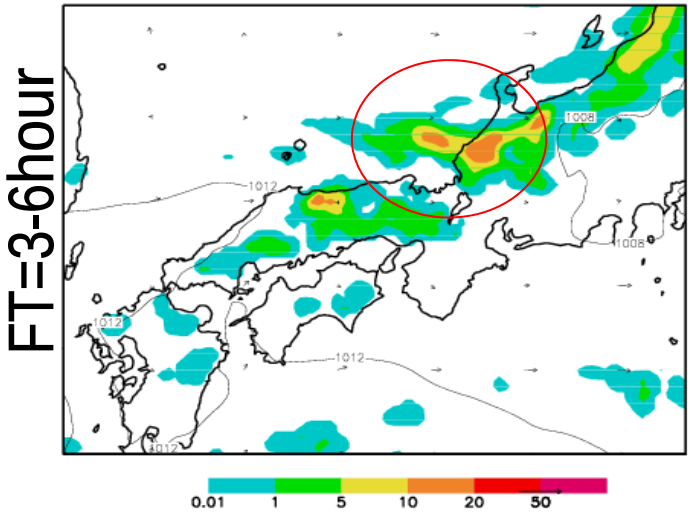
FT=0-3hour





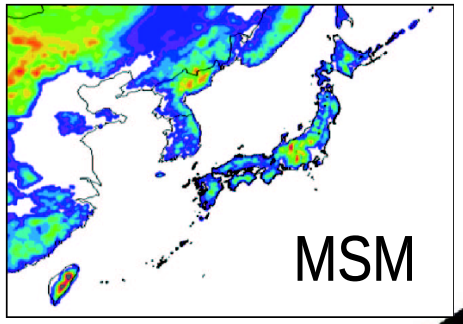
FT=3-6hour





Conventional data is not enough to reproduce the intense rainfall.

Flow chart of Observation System Simulation Experiment



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28July

21UTC

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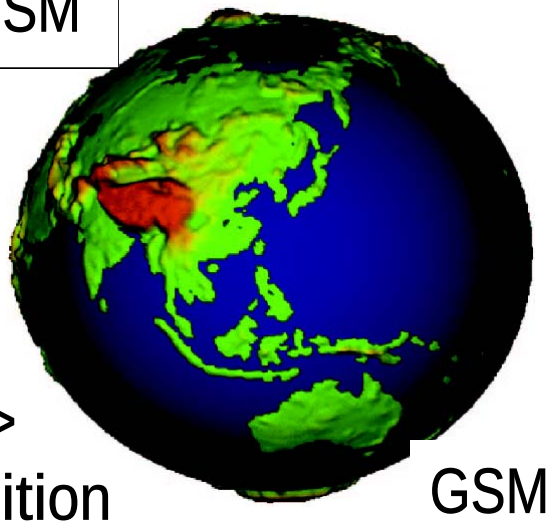
27 July

Meso-4DVar system



Analysis =>
initial condition

Boundary: GSM output

Conventional data

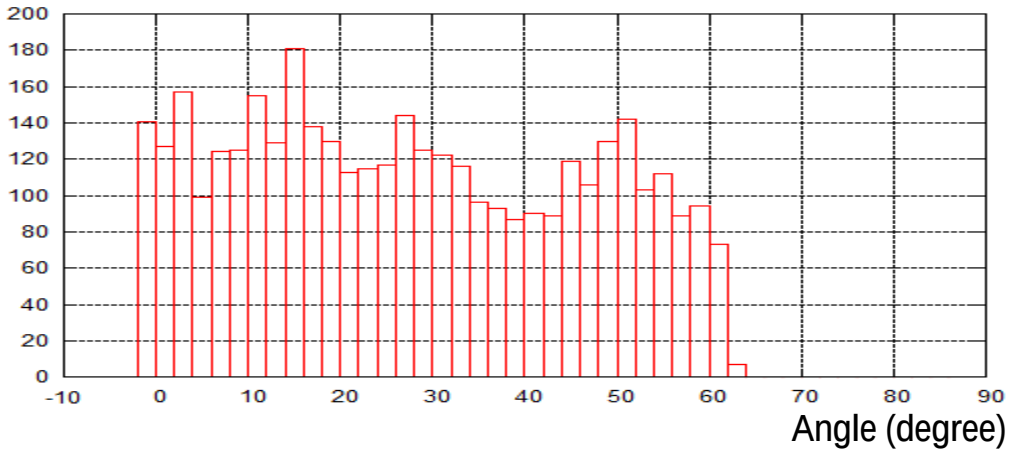
True data

First guess

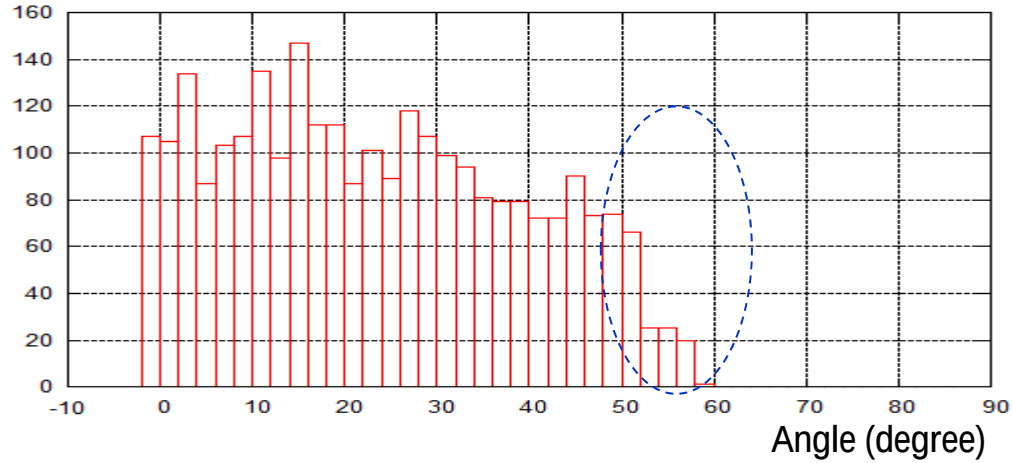
Conventional data +
Simulated occultation
data (slant path data)

JMA-NHM(Δx=10km)

Number of OC
All received data
(28 July 2008)



Number of OC
occ-type=44
(28 July 2008)

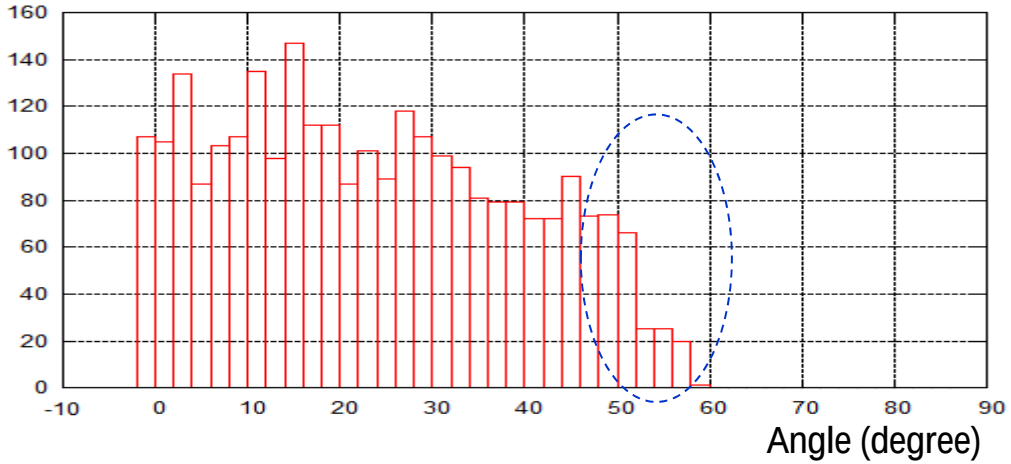


We checked the occultation data.

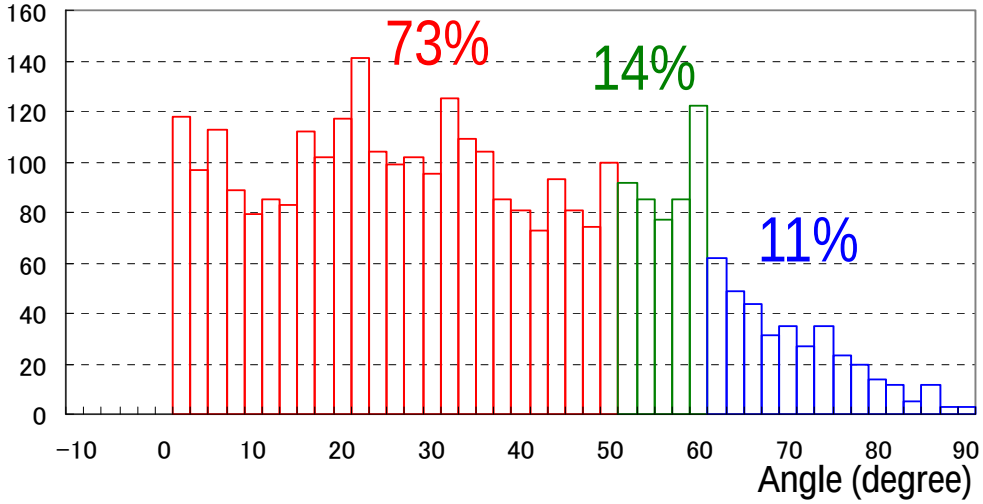
-Signal of data of which the angles from the moving direction are less than 60 degrees are received.

-However the half of data, of which the angles were larger than 50 degrees, did not become the profile.

Number of OC
occ-type=44
(28 July 2008)



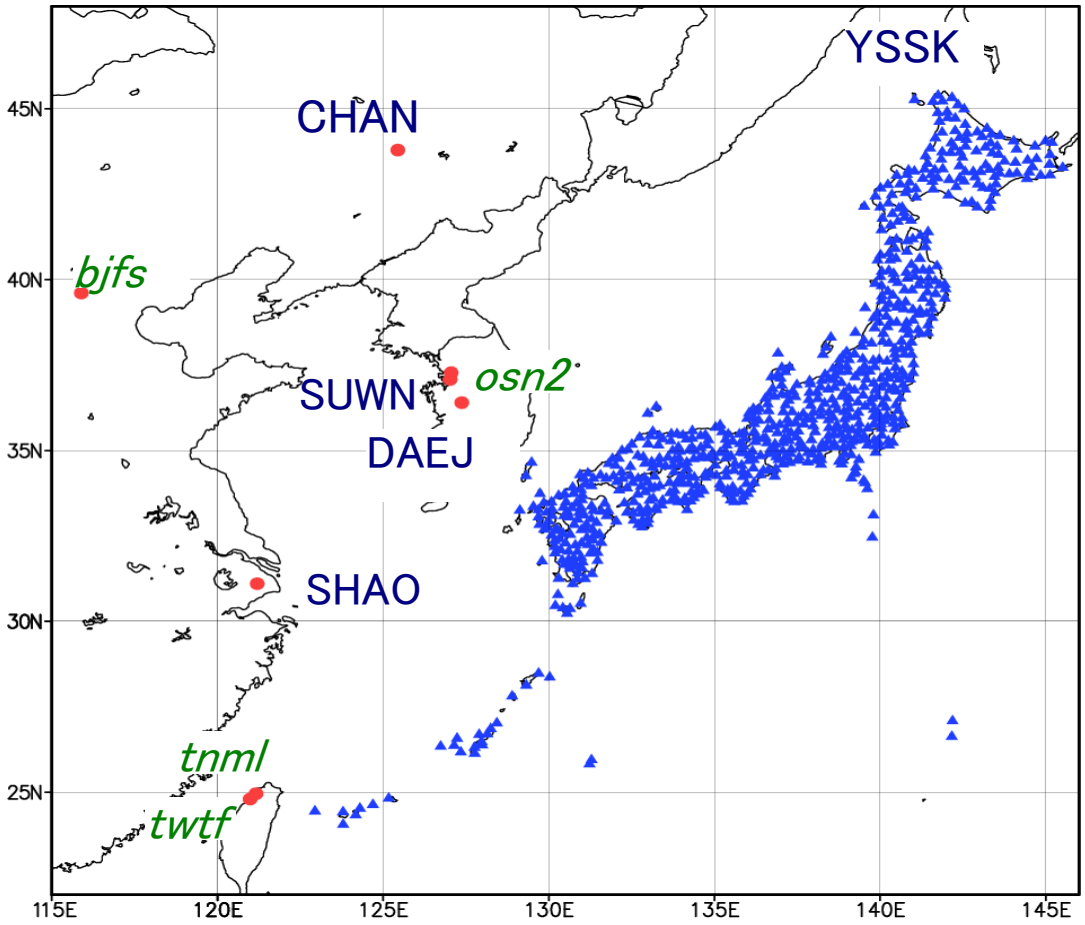
Number of OC
obtained from
satellite positions
(28 July 2008)



Number of occultation where the angle from moving direction is larger than 60 degrees is about 11% when the same day's data is used.

The data that is expected to be increased by side-looking observation becomes about 18%.

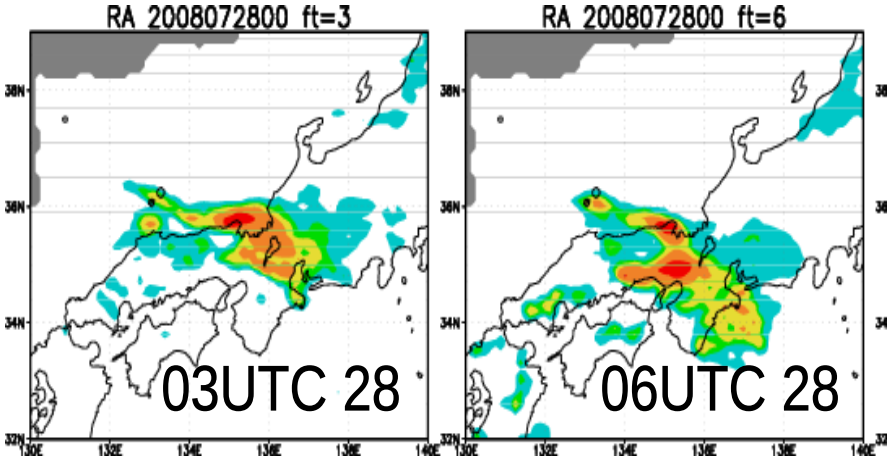
Assimilation of ground GPS (Shoji et al. 2009)



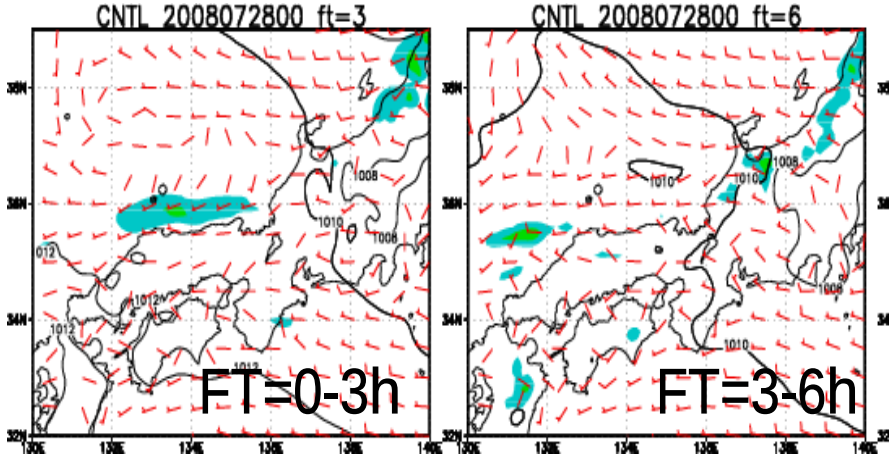
- Assimilation period: 30hour (06UTC 27- 00UTC 28)
- Assimilated data: Conventional data , Analyzed rainfall, PWV obtained by satellites, Wind profiler etc.
  + GPS (GEONET(blue triangles)
  + Korean and Chinese GPS data(red dot)

Assimilation of ground GPS (Shoji et al. 2009)

Observation



NoGPS (only Convection data)

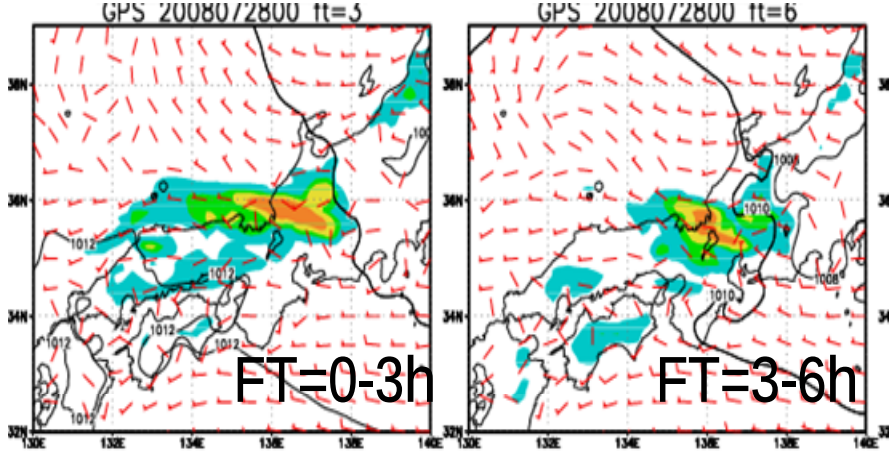


- Intense rainfall reproduced when GPS data were assimilated.

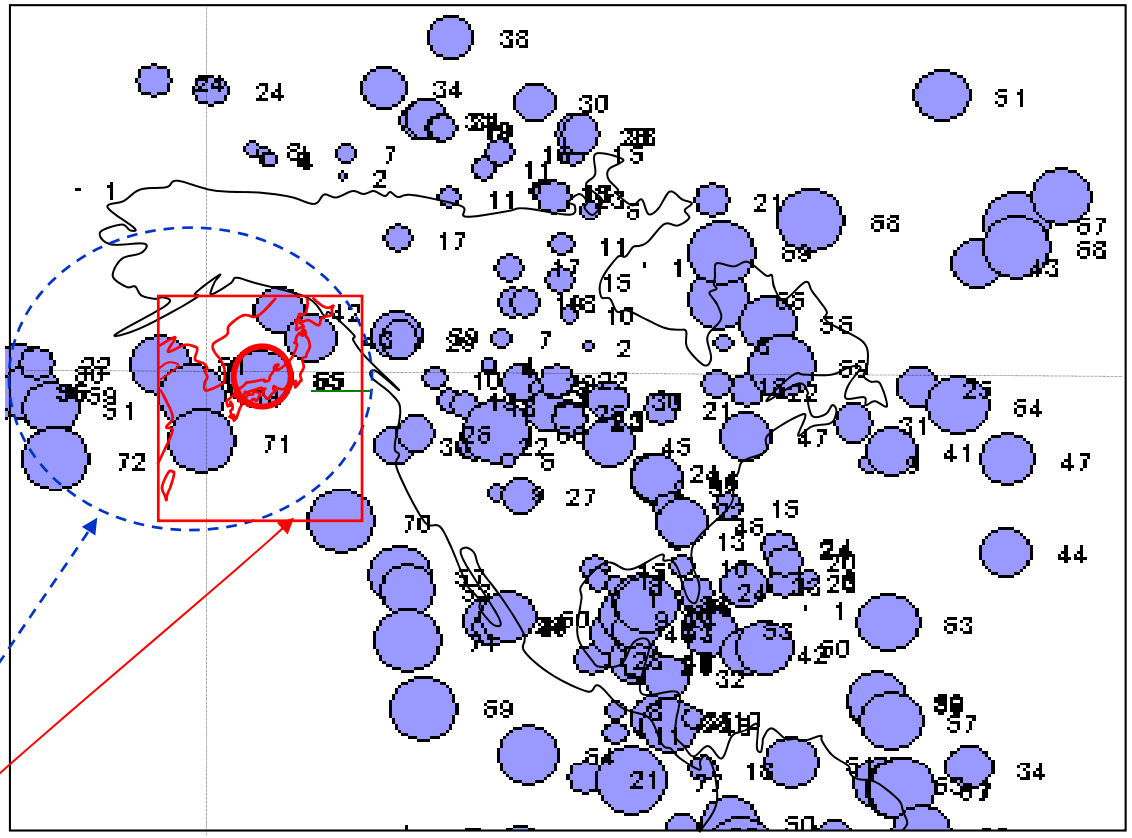
⇓

- Analyzed fields were used as true data

GPS+Convection data



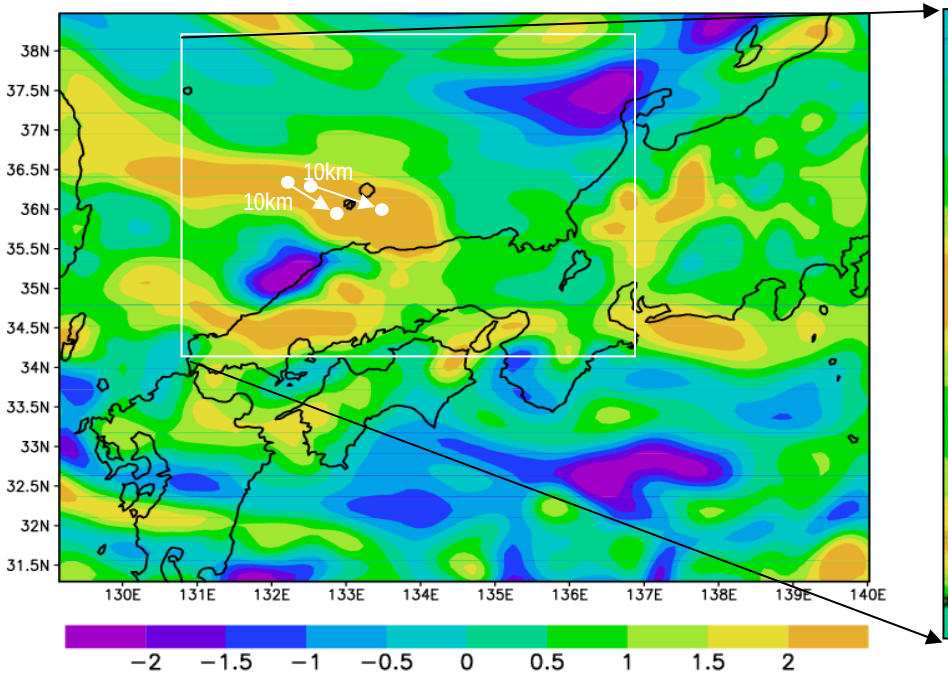
Positions of Occultations
during 12-15 UTC 13 September 2006



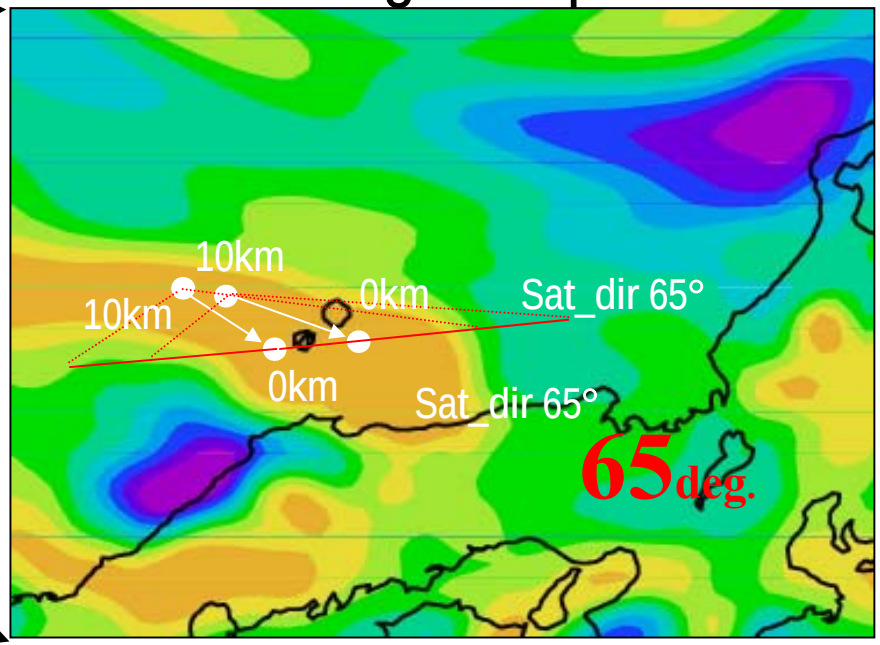
There are several occultations of which the angle from moving direction were larger than 60 degrees.

These occultation data were shifted to Japan.

True data - NoRO
water vapor at lowest layer

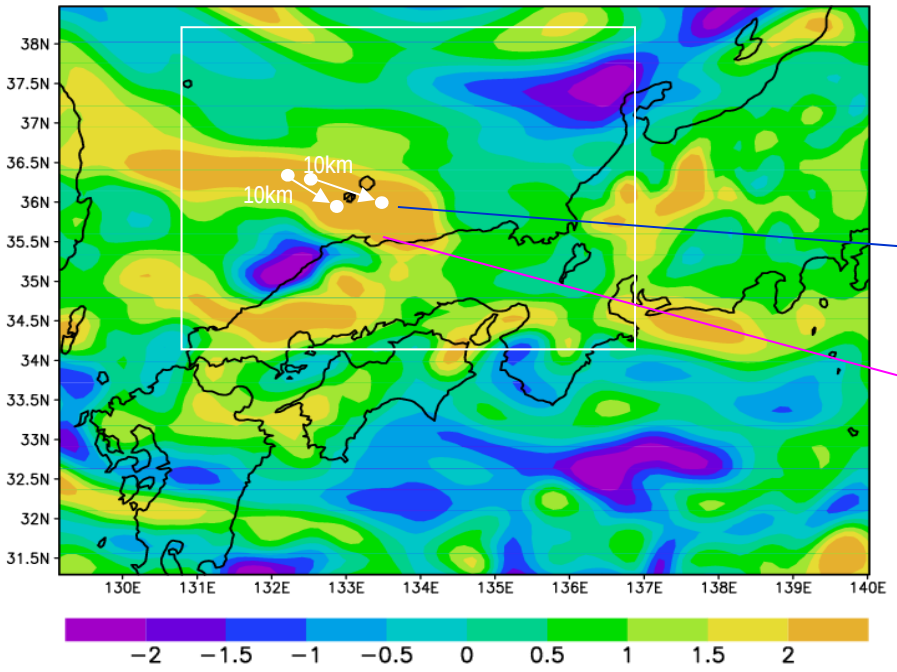


Enlarged map

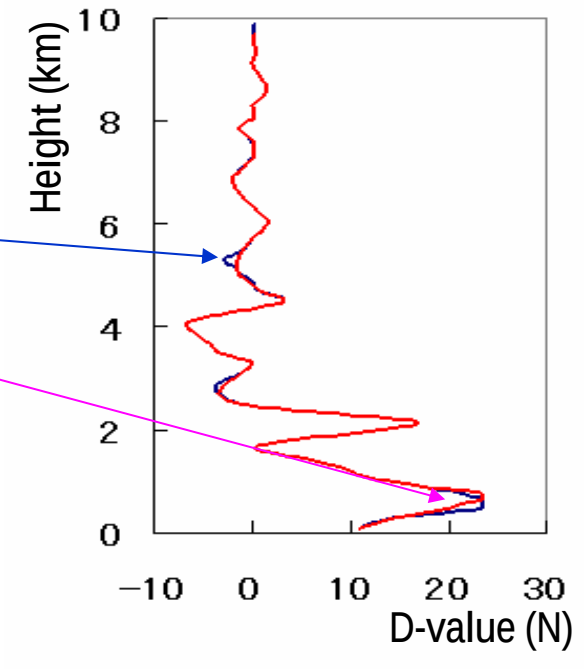


Because the region where the occultations were shifted to are positive, the rainfall is expected to be higher when this data is assimilated.

True data - NoRO
water vapor at lowest layer

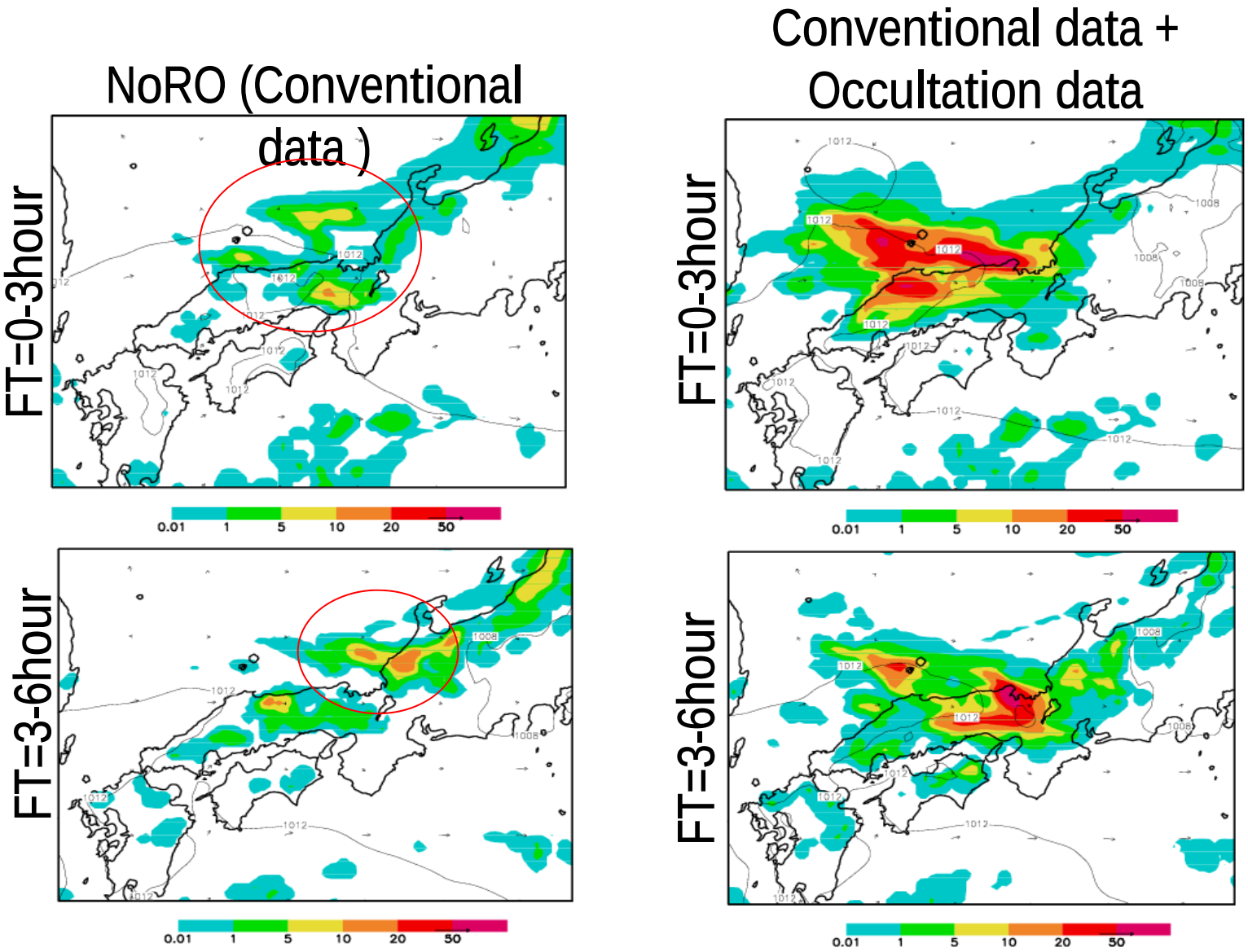


Vertical profiles of D-value
(Obs. - First guess)



Below the height of 3km, path-averaged refractivity of true data is larger than that of first guess.

The enhancement of the rainfalls is expected, when the lowest level of simulated slant path data is less than 2 km.

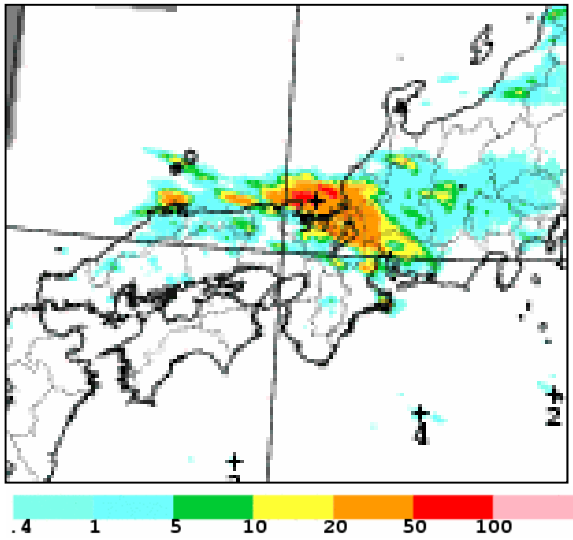


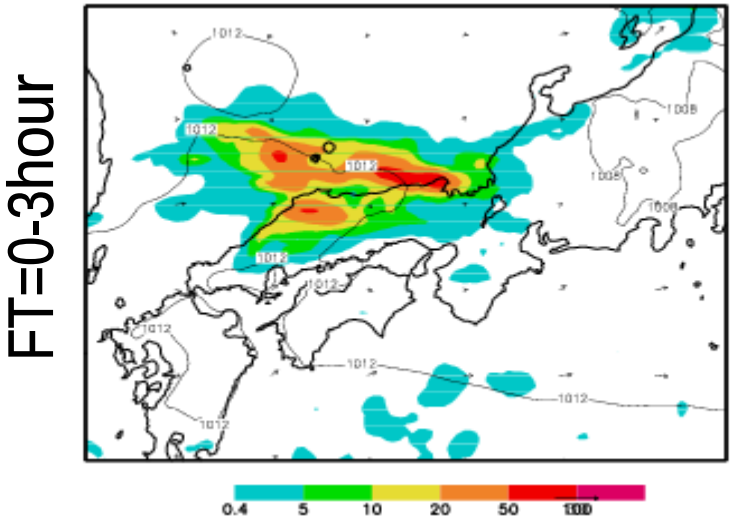
As it is expected, the rainfall became more intense when the forecast was performed from the analyzed fields, which were obtained by assimilation of conventional data and simulated occultation data.

Observation

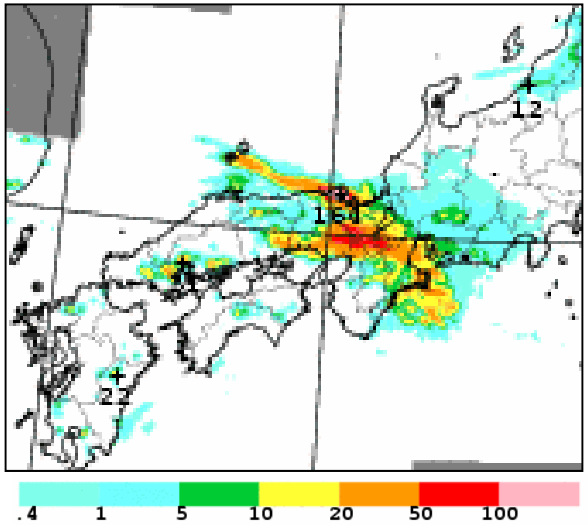
Conventional data +
Occultation data

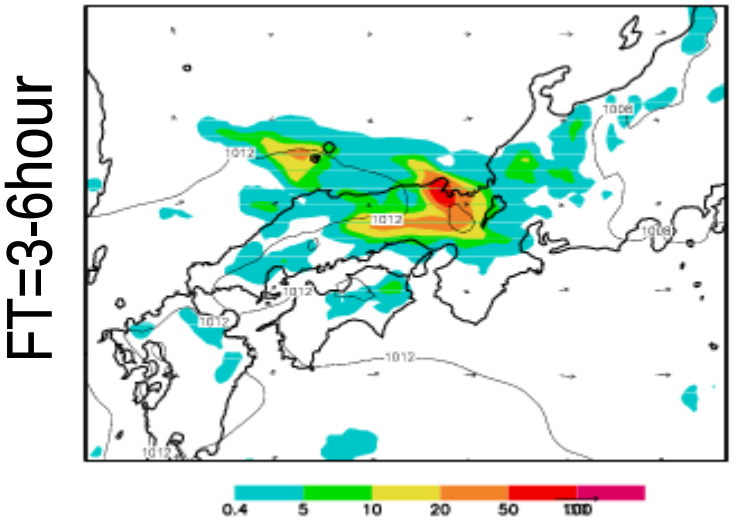
FT=0-3hour





FT=3-6hour





Intensity and area of the heavy rainfall was similar to the observed one, although the position shifted westward at FT=0-3hour.

FT=0-3hour

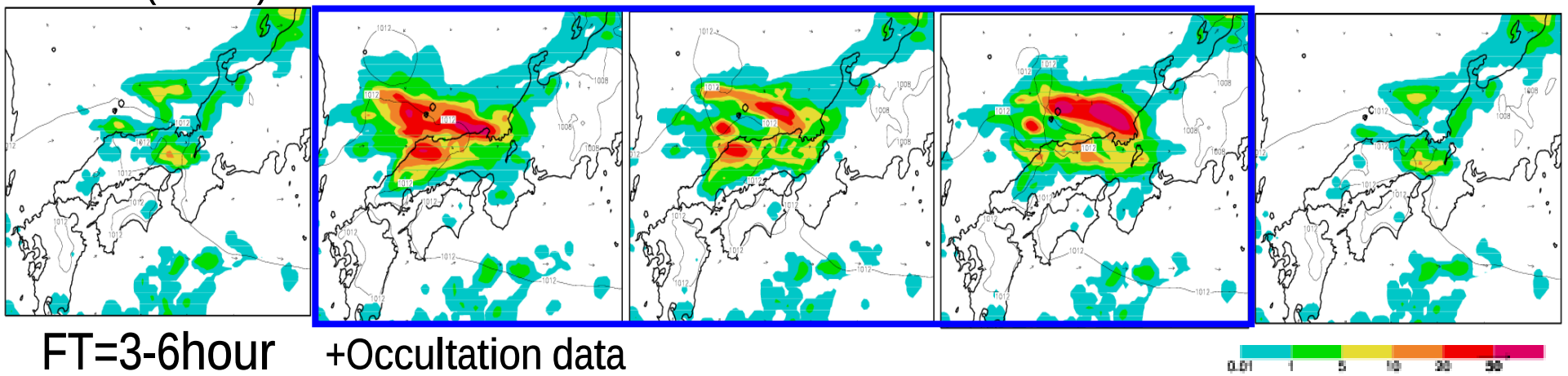
Conventional data (NoRO)

+Occultation data lowest data: 0km

1km

2km

3km



FT=3-6hour

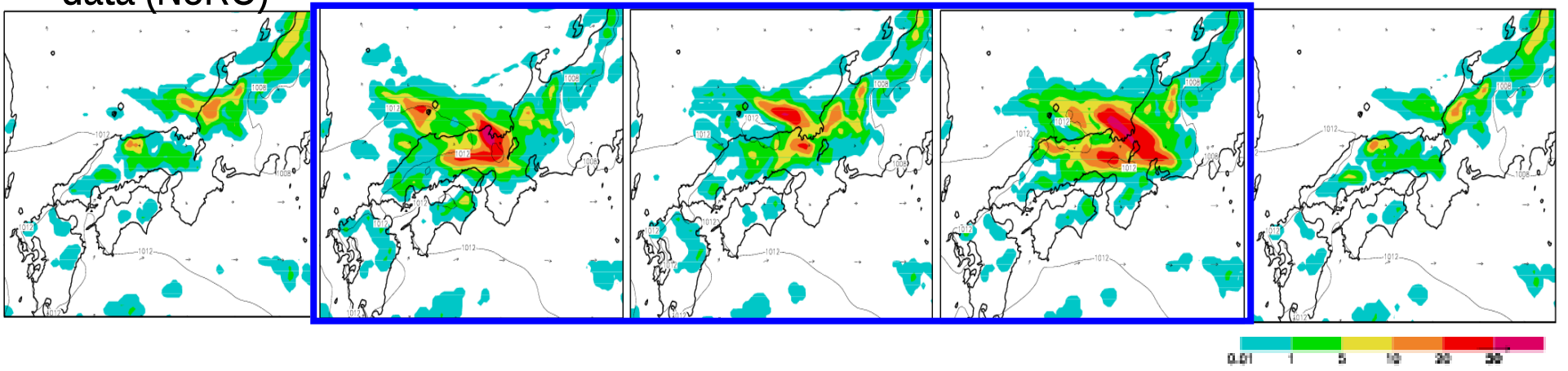
Conventional data (NoRO)

+Occultation data lowest data: about 0 km

1km

2km

3km



In this case, the improvement of forecast is expected, if the lowest data reached the height of 2km.

FT=0-3hour

Conventional data (NoRO)

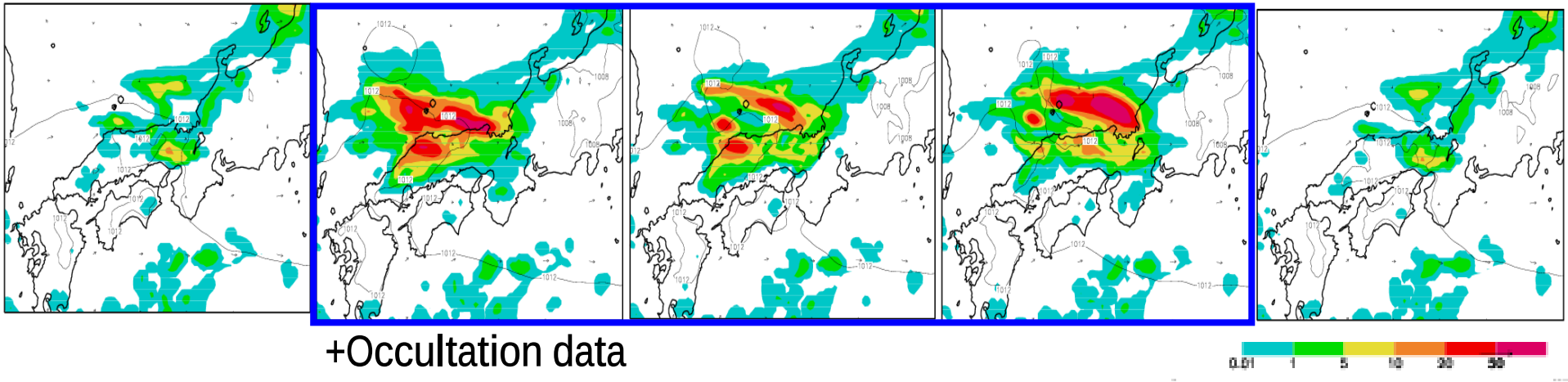
+Occultation data lowest height:

0km

1km

2km

3km



+Occultation data lowest height:

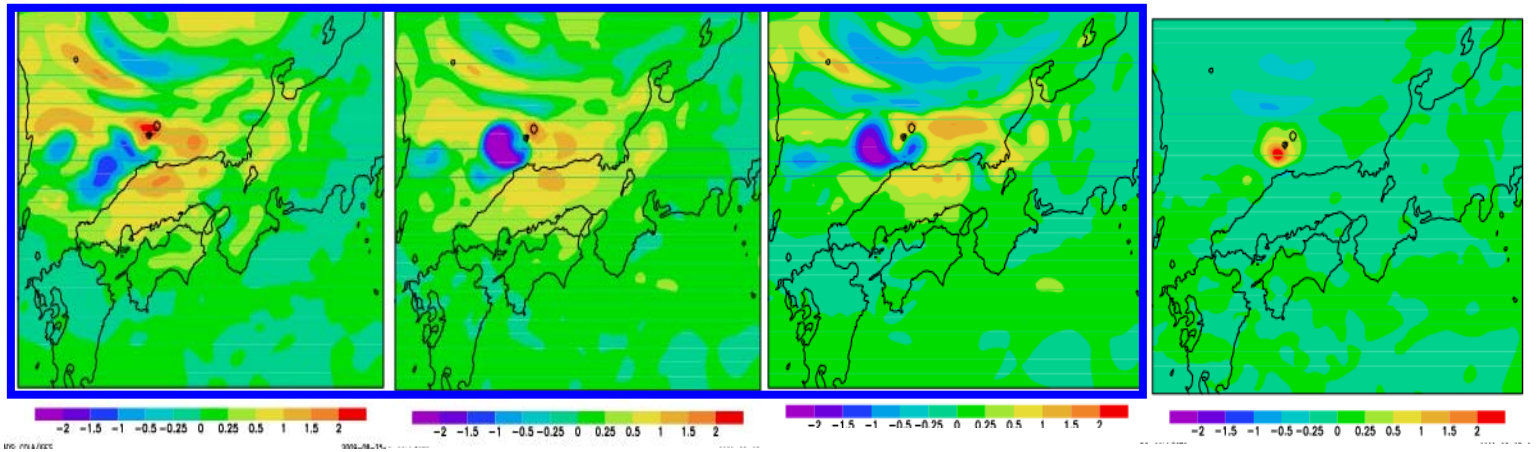
0 km

1km

2km

3km

Increment of lowest water vapor



The improvement of rainfall was confirmed by the increment of water vapor at the lowest layer of the model.

Summary of preliminary results

1. When the side-looking data, of which angles from the moving direction of LEO are large, are included in assimilation data, analyzed fields are further improved.
2. However, the problems including hardware are not considered. So, more experiments are needed under the more actual condition.

Thank you for your kind attention.