Super high resolution experiment of heavy rain in large area using the K computer

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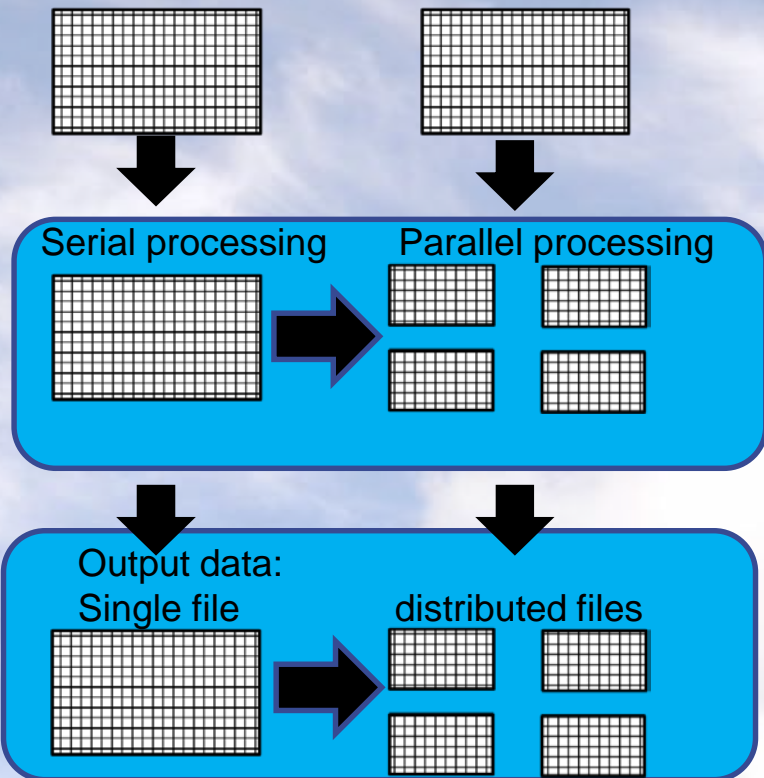
2015/03/09

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This year's main works

1. Preprocess program parallelization
2. Visualization utilize the AVS
3. Super high-resolution experiment of a heavy rainfall in Hiroshima and Izu Ohshima

Parallelize the preprocessing

Input data: DEM, land use, boundary data.

Serial processing   Parallel processing

Output data:
Single file   distributed files

Performance test condition

NX=6400   # grid number in x-direction
NY=4400   # grid number in y-direction
NZ=168   # grid number in z-direction
DX=250m   # horizontal resolution in x-direction
DY=250m   # horizontal resolution in y-direction

To make 9 hour initial and boundary data.

Serial processing   parallel processing

Cluster computer
CPU: 1
Memory: 1TB
ELAPSE: 22 hour

K computer
CPU: 4608
Memory：4608nodes x 14GB
ELAPSE: 1 hour

22 times faster !!

Back ground

- In Japan, localized torrential rainfalls sometimes cause severe disasters which impact on the society.

- To prevent and mitigate localized weather-related disaster, weather prediction for a wide region in high resolution is very important.

Objectives

- This study aims to clarify the impact of model resolution on the accuracy of the numerical weather prediction (NWP) model.

- Many previous researches carried out numerical experiments in higher resolution than this study, such as tornado, heavy rain event.

- In comparison with those previous researches, one of the features of this experiment was to compute a wide region in super high-resolution.

- This study computed an entire region of Japan in horizontal resolutions in 2 km, 500 m and 250 m.
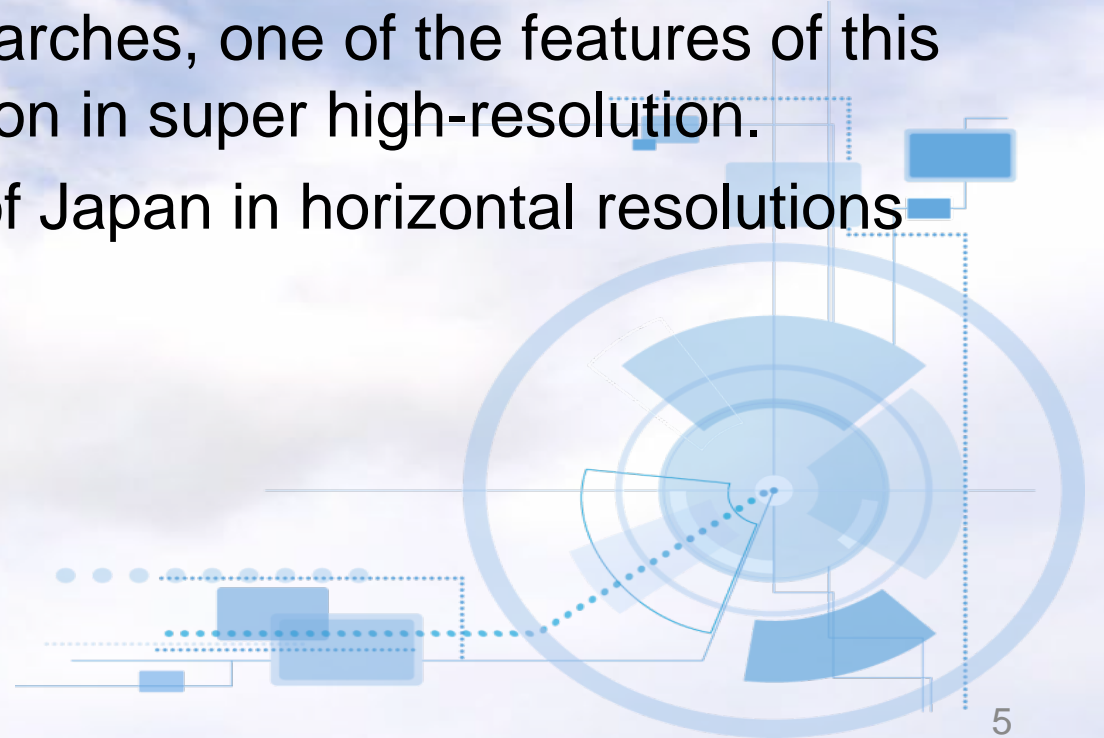
Hiroshima heavy rain in 2014

- The research targeted the heavy rain event in Hiroshima city in August 19 to 20, 2014.

- The 24 hours precipitation of an observation point Miiri is the highest value in history.

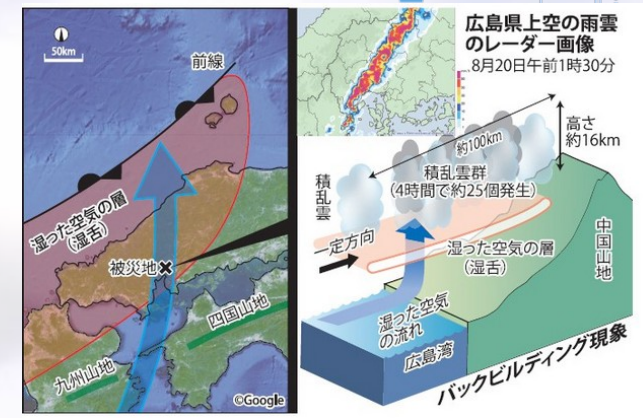- The "building phenomenon" was observed in this event.
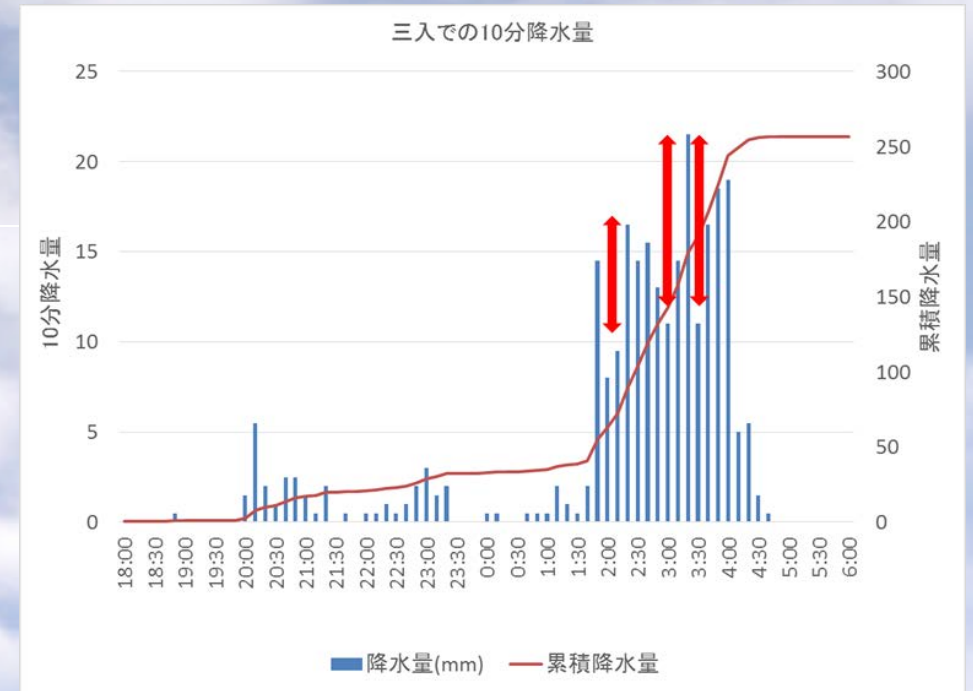
10 minutes observed precipitation at Miiri
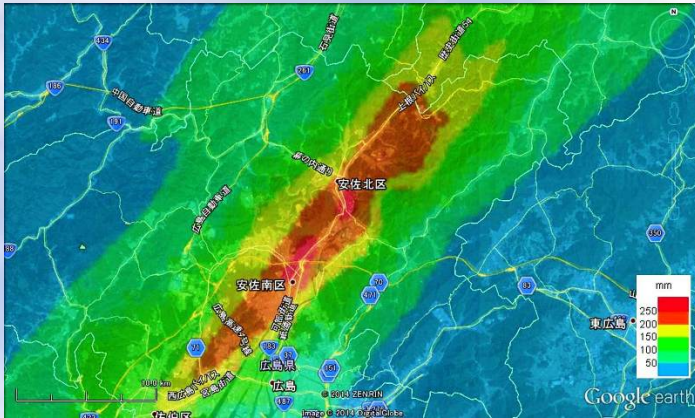
Refer from the NIED: The 12 hours precipitation map using the MLIT's X-band rader "XRAIN" and the MRI C-band rater. (Period August 19, 18:00 – August 20 06:00)
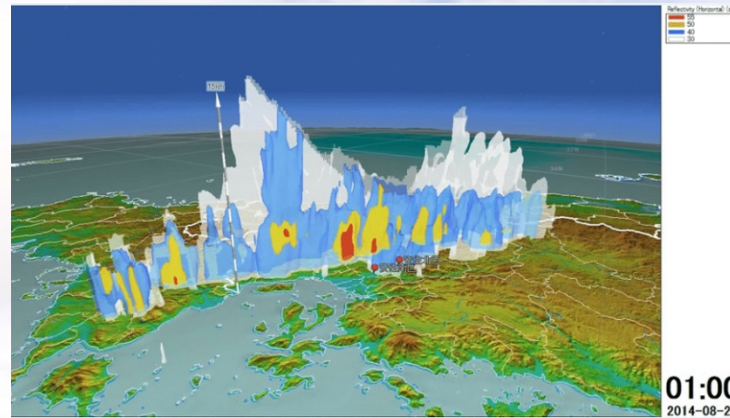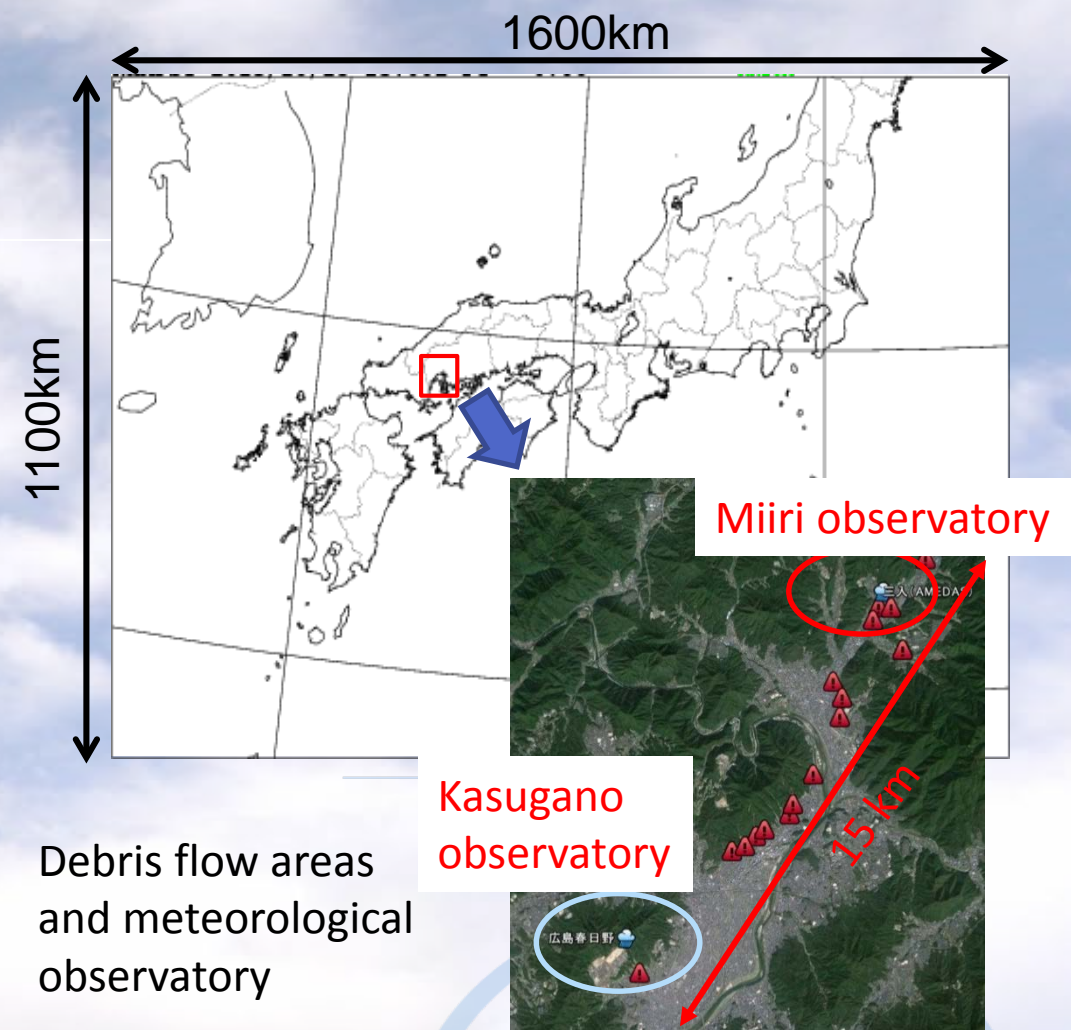

Refer from the NIED： MLIT's X-band rader "XRAIN"

Refer: from the Mainichi news paper: about building phenomenon

6

Experimental conditions

- Tuned JMA-NHM（Japan Meteorological Agency Non Hydrostatic Model） for K
- Parameter and number of the Z layer are given for each horizontal resolution.
- Simulation periods were August 19, 2014, 21:00 to August 20 6:00.
- Initial and boundary condition were JMA Meso-scale analysis.

1600km

1100km

Miiri observatory

Kasugano observatory

15km

Debris flow areas and meteorological observatory

Horizontal resolution	Time Step	XYZ Grids			Turbulence closure model
		NX	NY	NZ	
2 km	10	800	550	60	Mellor-Yamada level3
500 m	2	3197	2197	85	Deardorff
250 m	1	6393	4393	168	

Time for the computation (9hour simulation)

	Number of nodes	Parallel preprocessing	Tuned NHM	Peak performance(%)
2 km	72	0:03:23	0:32:11	4.70%
500 m	1152	0:25:48	4:12:55	2.74%
250 m	4608	0:59:43	18:57:34	2.49%

Results: JMA prediction and super high resolution simulation

Initial time August 19, 21:00 (JST)

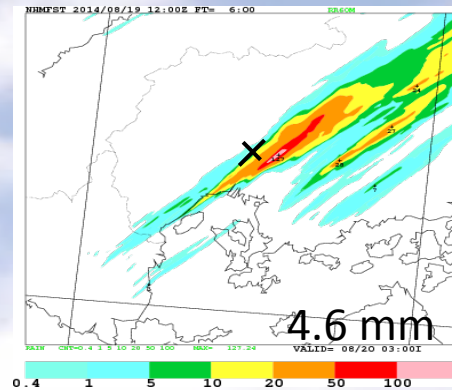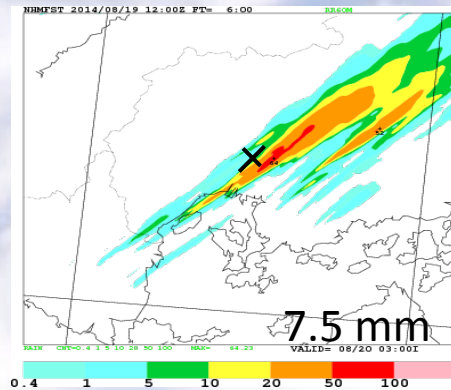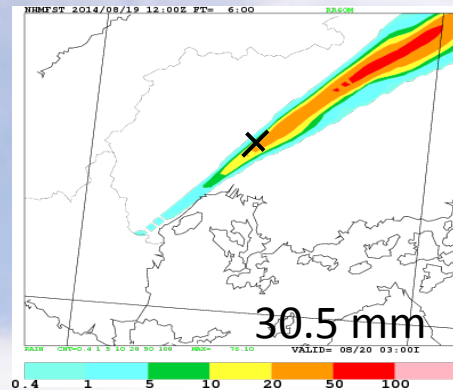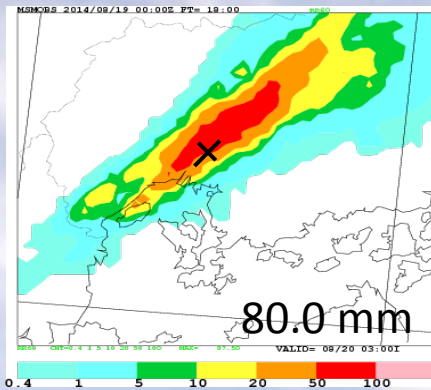| Observation | MSM | LFM | 2 km | 500 m | 250 m |
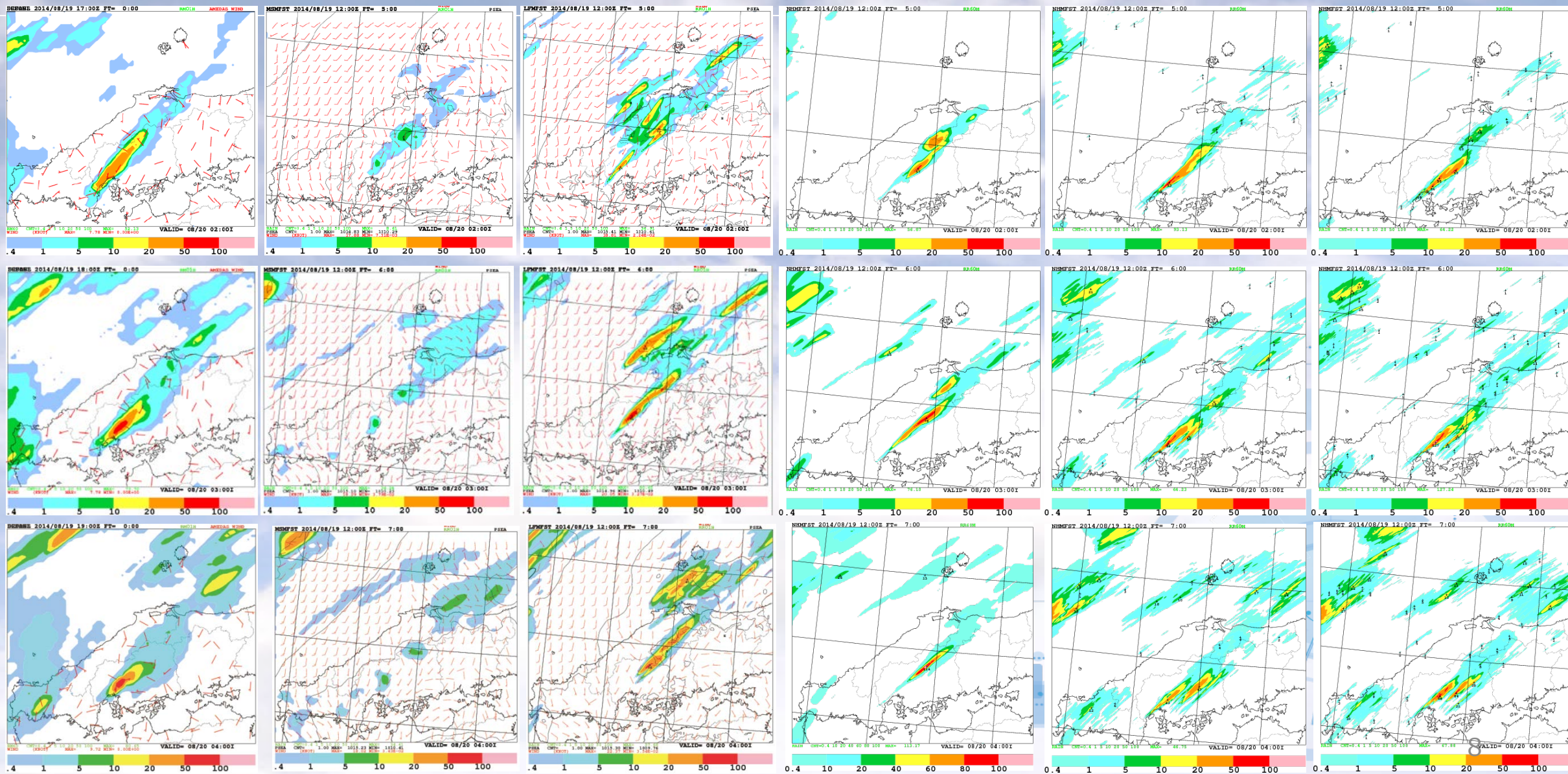
9hours simulation
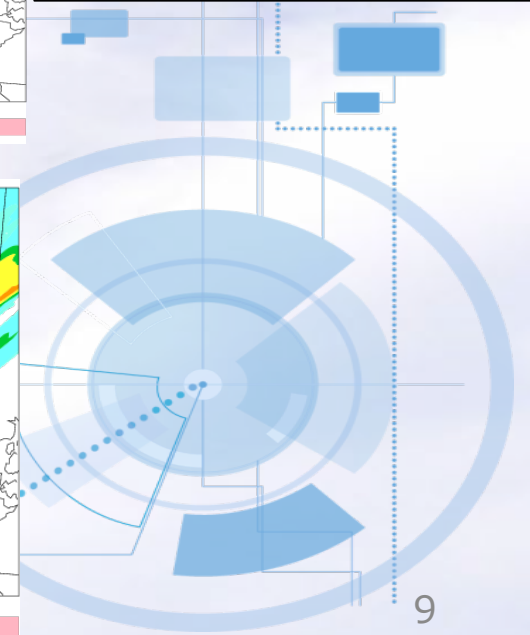
Rader-AMeDAS | 2 km resolution | 500 m resolution | 250 m resolution

08/20 02:00
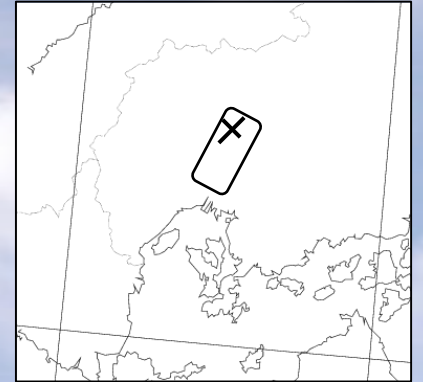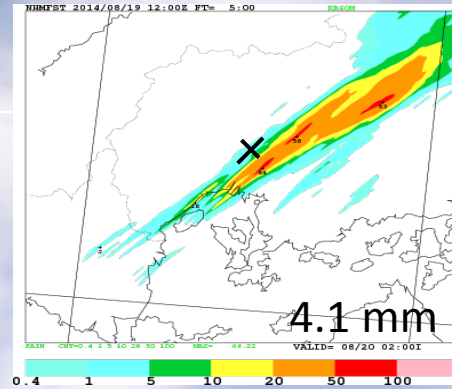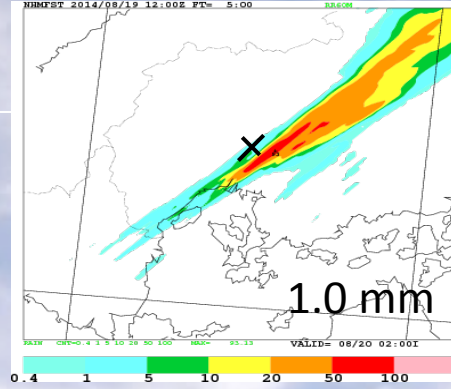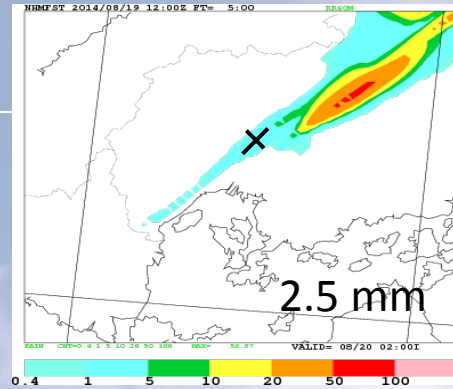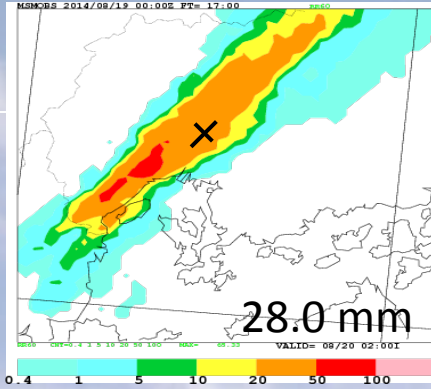
28.0 mm | 2.5 mm | 1.0 mm | 4.1 mm

08/20 03:00

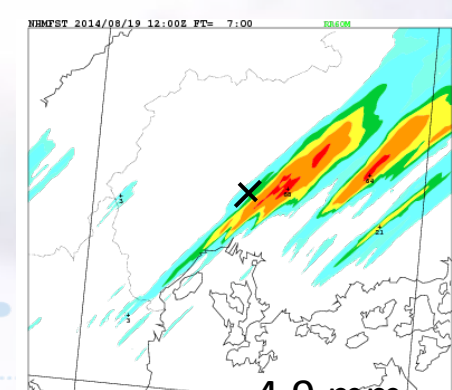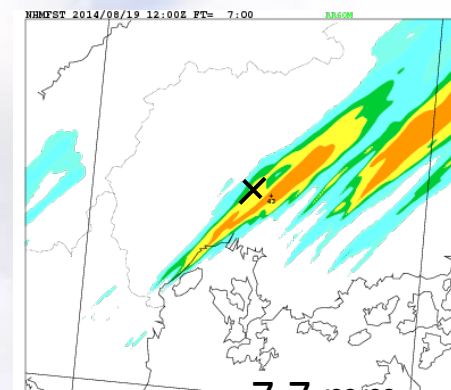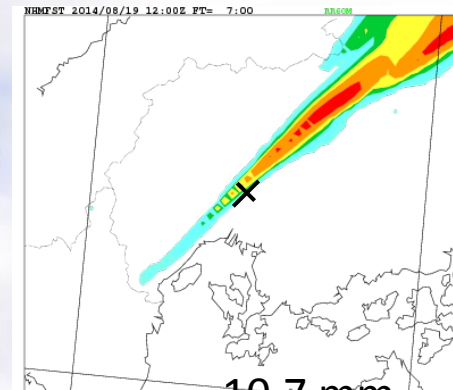80.0 mm | 30.5 mm | 7.5 mm | 4.6 mm

08/20 04:00

101.0 mm | 10.7 mm | 7.7 mm | 4.9 mm

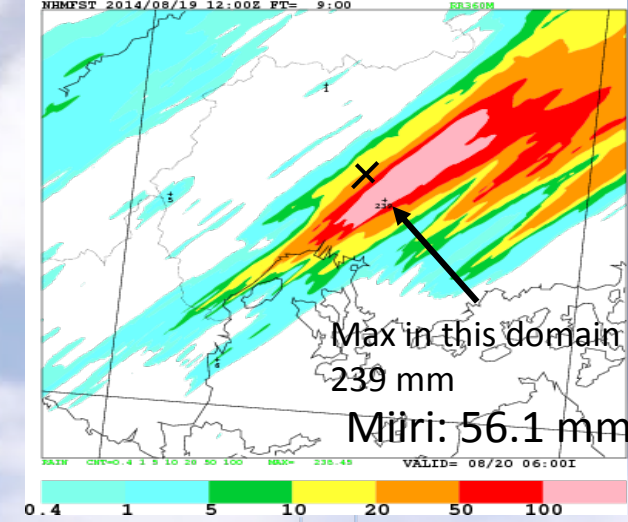X-mark is Miiri meteorological observatory. Inside the square is debris. flow areas
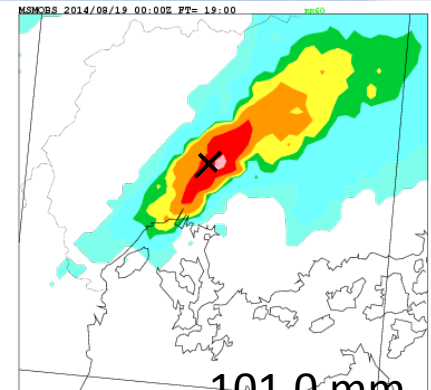
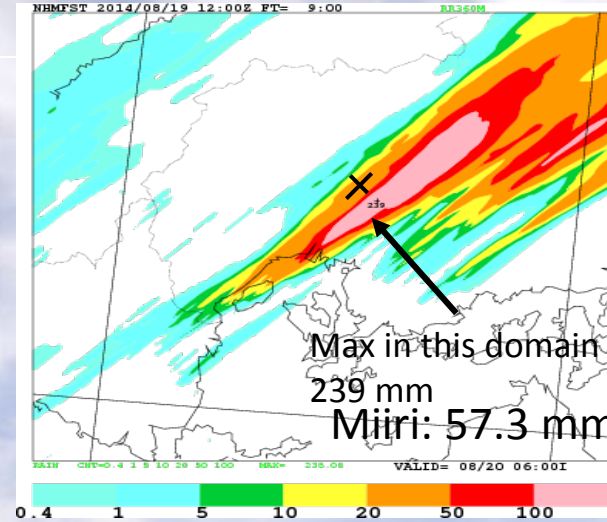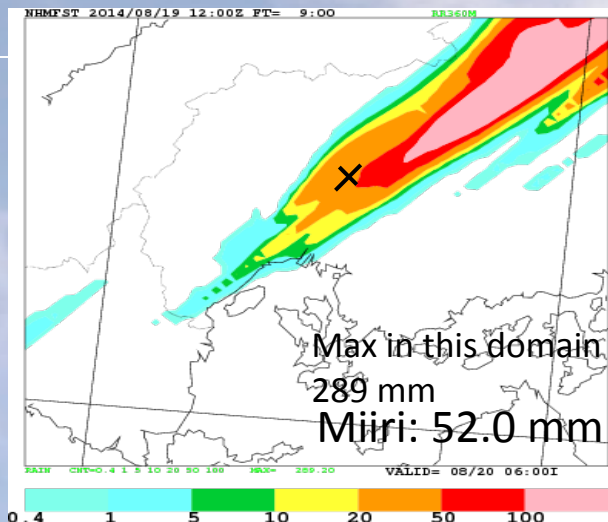# 6 hours precipitation（August 20 0:00 - 06:00）

Rader-AMeDAS　　　　　**2 km resolution**　　　　　**500 m resolution**　　　　　**250 m resolution**

Max in this domain
229 mm
Miiri: 228.0 mm

Max in this domain
289 mm
Miiri: 52.0 mm

Max in this domain
239 mm
Miiri: 57.3 mm

Max in this domain
239 mm
Miiri: 56.1 mm

Observation and silulation（6hours precipitation : Aug 20, 0:00-6:00)
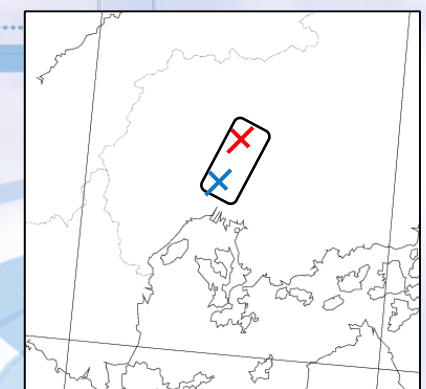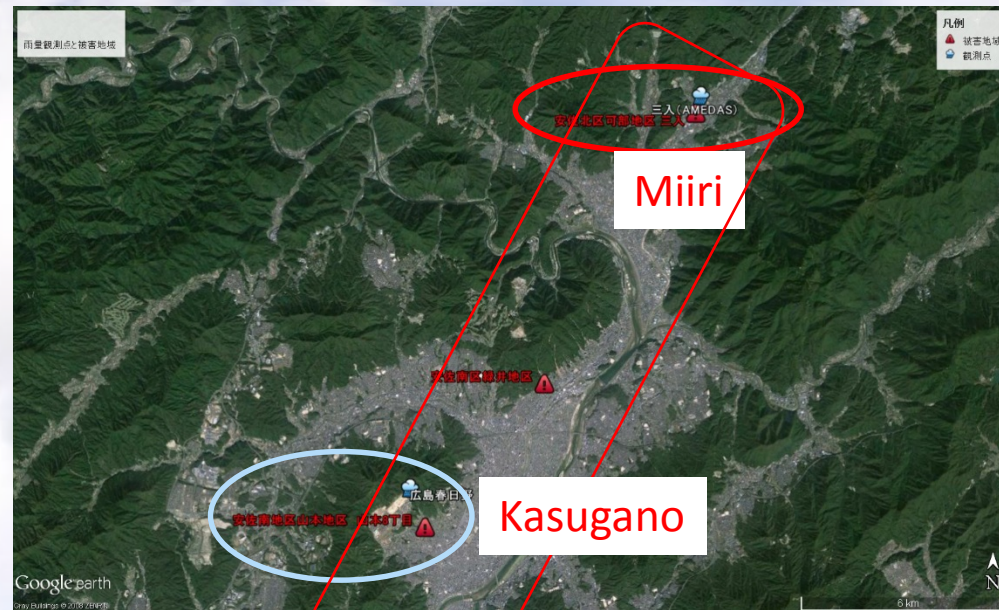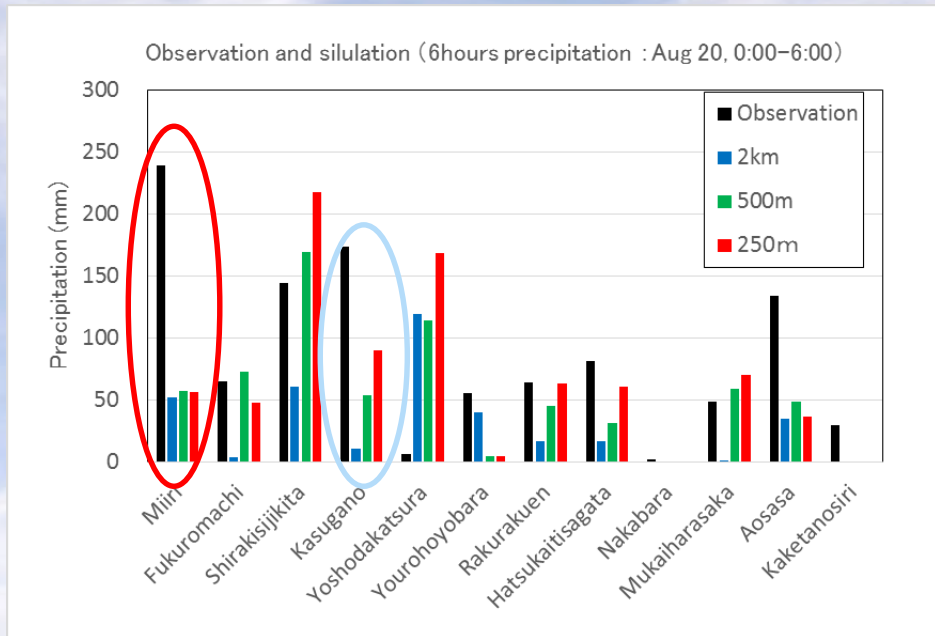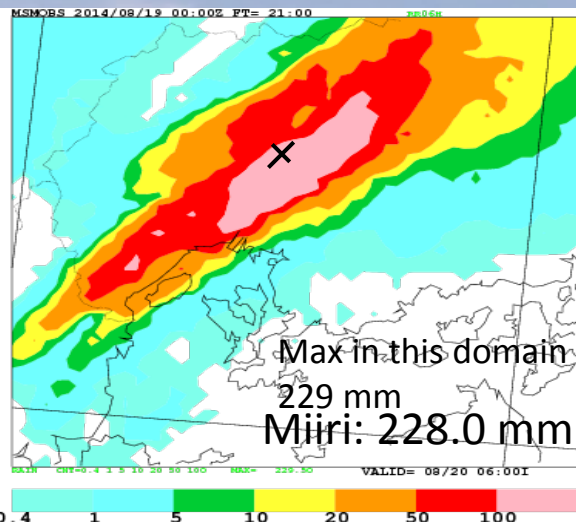
Red X-mark is Miiri
meteorological observatory.
Blue X-mark is Kasugano
meteorological observatory.
Inside the square is debris.
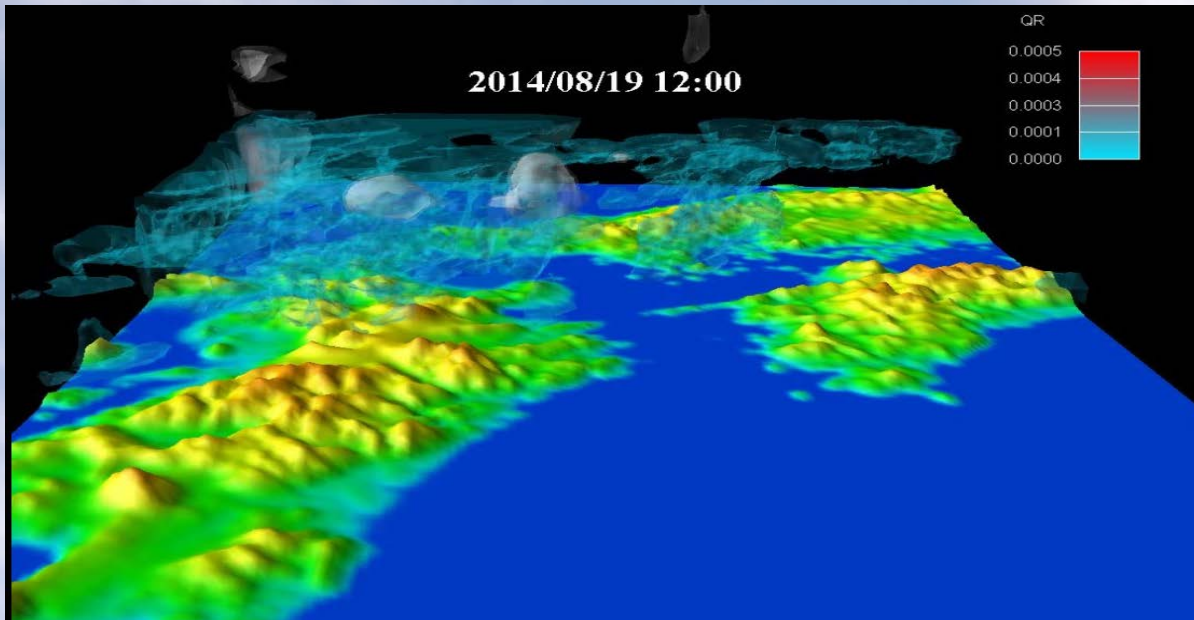flow areas

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Impact on turbulence closure model : Izu Ohshima and Hiroshima
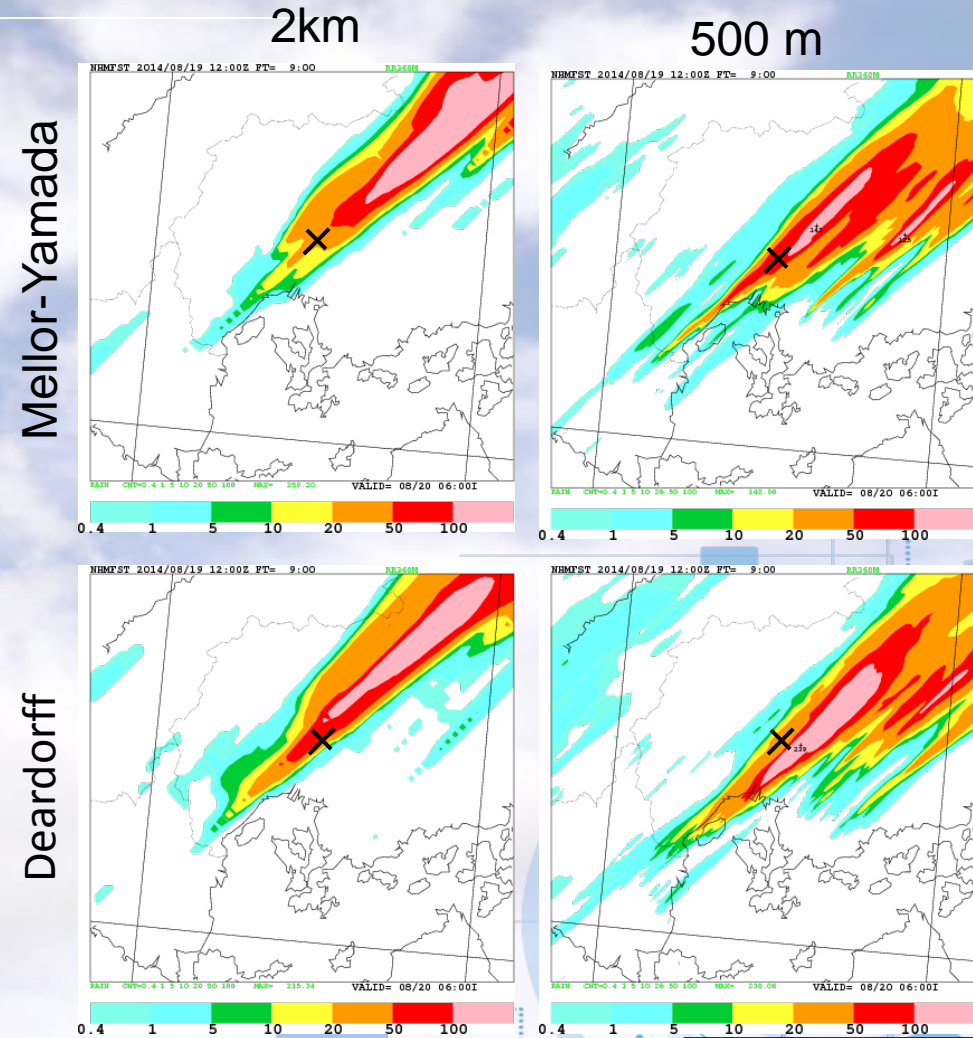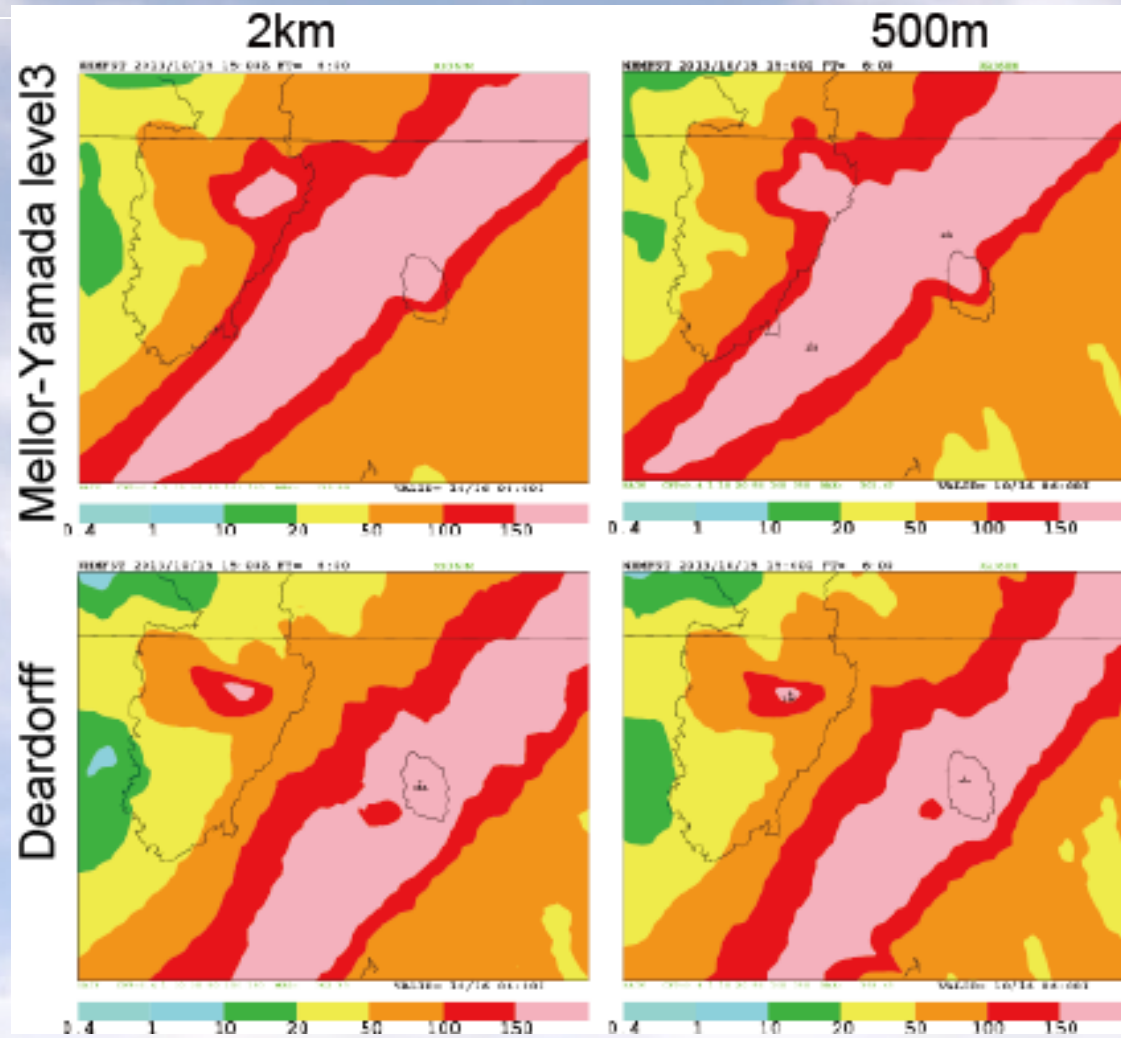
In the Izu Ohsima case, turbulence closure model impacted on squall line position.
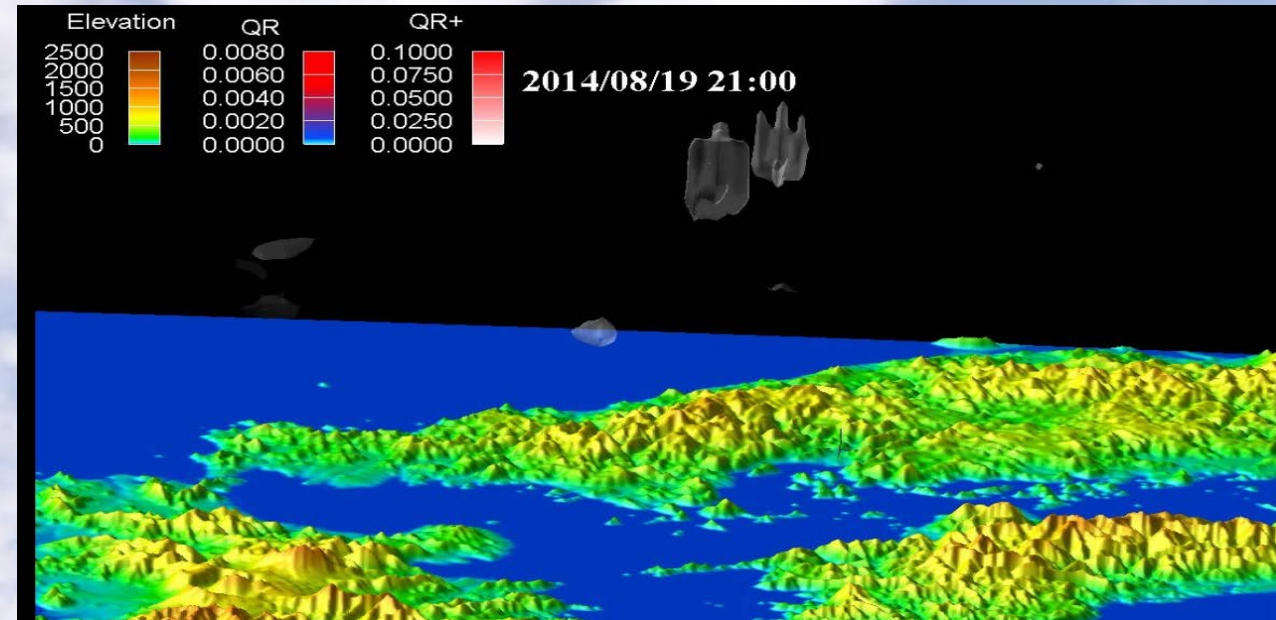In this study, also turbulence closure model impact on squall line position.

X-mark is Mirir
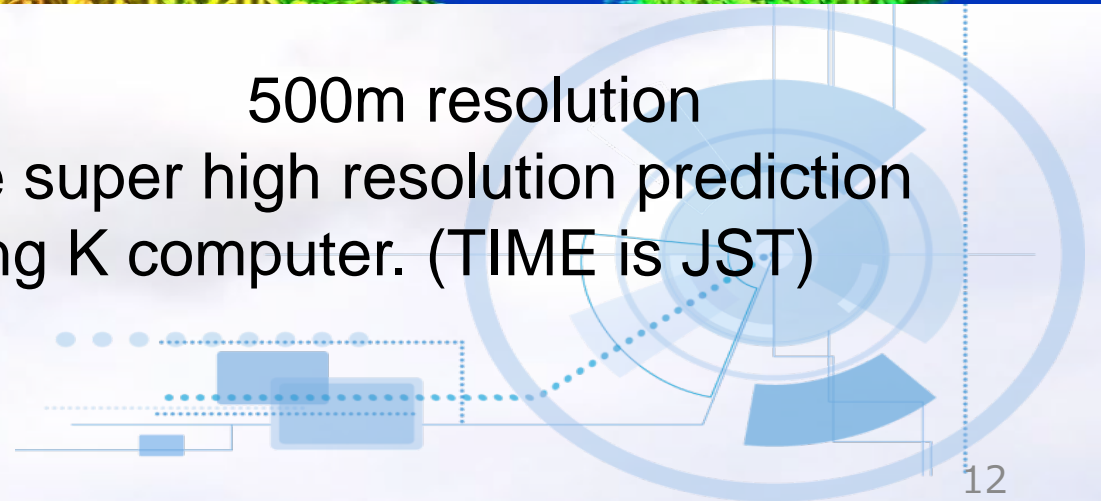
2 km simulation vs 500 m simulation

2 km resolution
The resolution and model setting were as same as the operational setting of the Japan meteorological agency. (TIME is UTC, JST ＋9 hours)
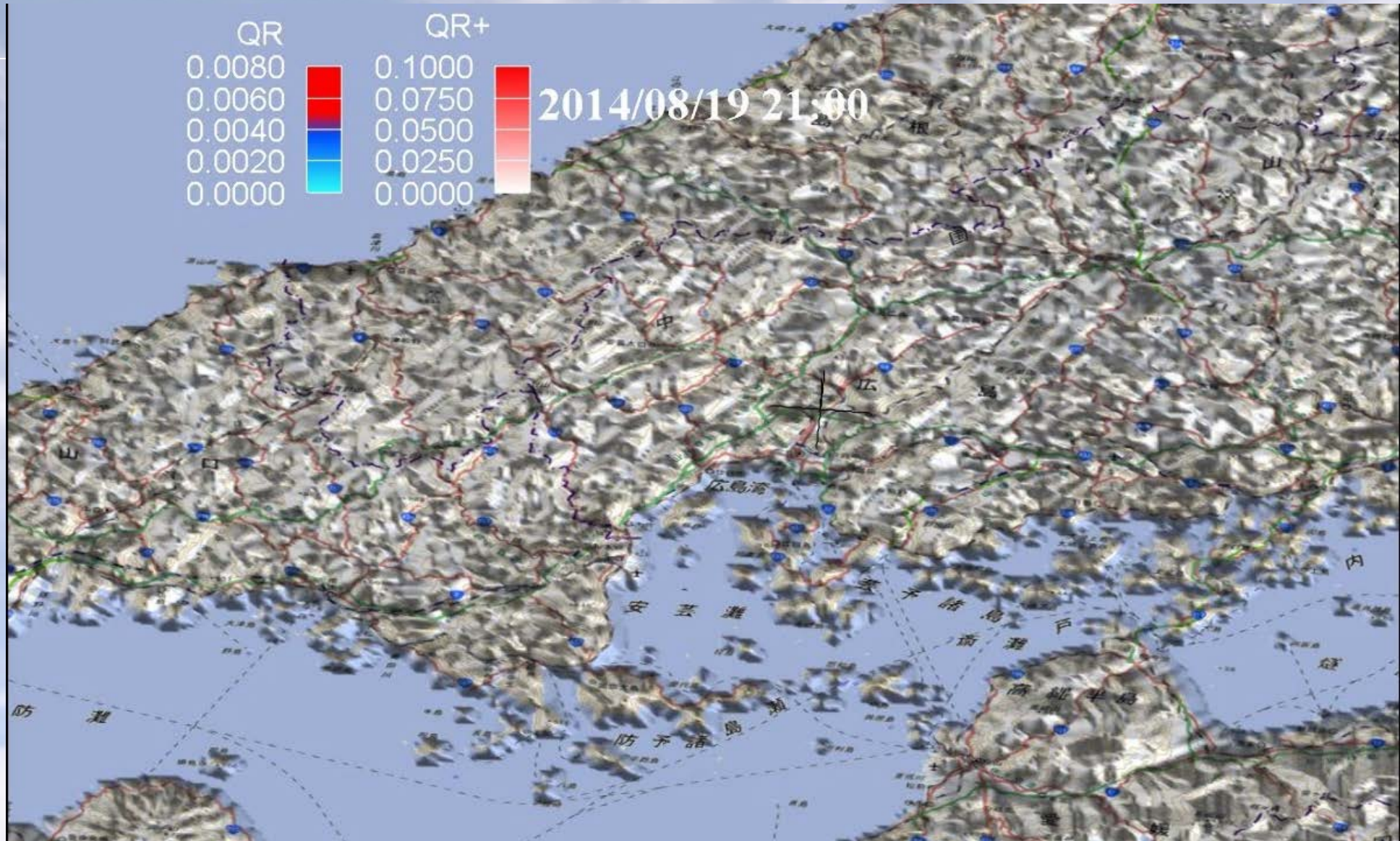
500m resolution
The super high resolution prediction using K computer. (TIME is JST)

Accumulated precipitation on the ground


Cross is damaged area

Conclusion and future works

Conclusion

- This study conducted super high resolution simulation in multi resolutions.
- The results indicate higher resolution results are better than 2 km resolution simulation.

Future Works

- What impact on simulation accuracy in higher resolution?
- To clarify influence of relationship between computational domain and simulation results.
- To understand the turbulence closure model impact on to Izu Oshima and Hiroshima cases.
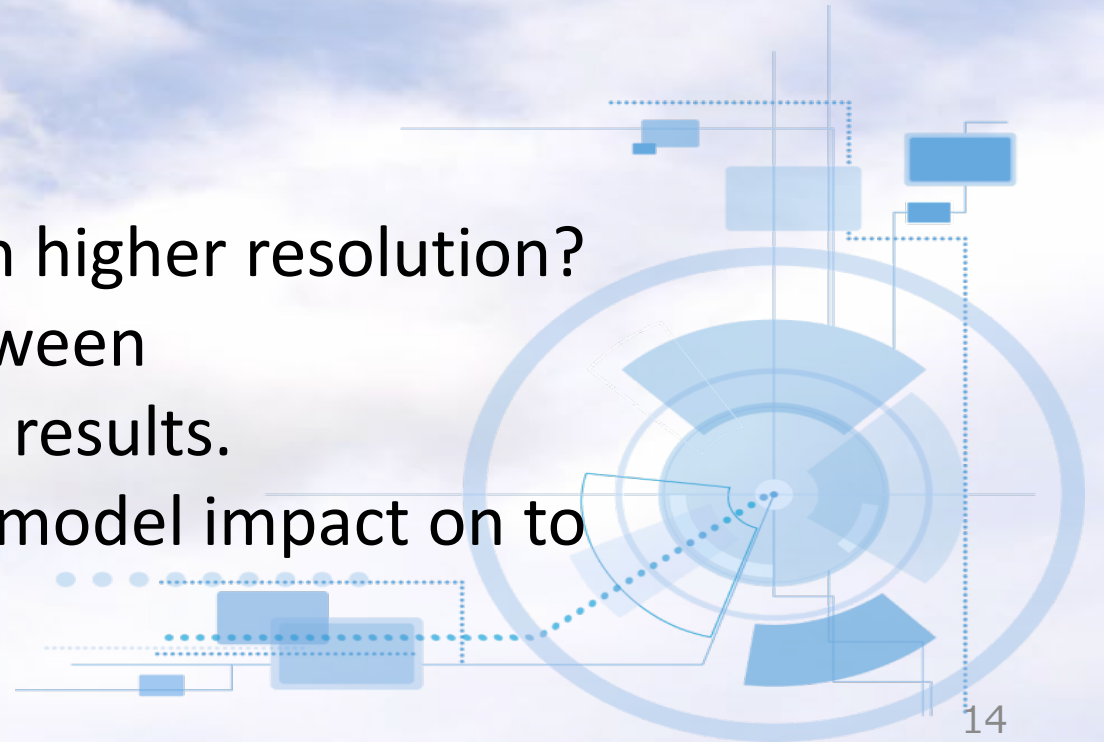
Thank you for your attention

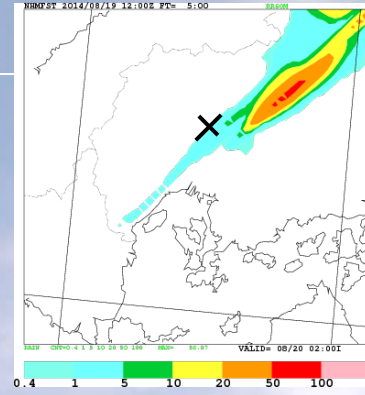# Impact on turbulence closure model : 9 hours simulation

Rader-AMeDAS   2 km（MY）   2 km（Deardorff）   500 m（MY）   500 m（Deardorff）

08/20 02:00

08/20 03:00

08/20 04:00

X-mark is Mirir

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