

Ultra high-resolution meteorological simulation using the K computer

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OUTLINE

- This year's work for Ultra high-resolution meteorological simulation using the K computer
- Heavy rain high-resolution simulation in Izu Oshima Island

This year's work

Motivation

- To simulating Ultra high-resolution meteorological using the K computer and JMA-NHM
- Collaborating with hydrological research field.

Process to the ultra high-resolution meteorological experiment

- To optimize the NHM to the K computer.
- Organizing parallel files input and output system for the NHM.
- Preparing the data for ultra high-resolution experiment environment using huge numbers of nodes of K computer.

Simulation

Ultra high-resolution simulate of heavy rainfall disasters in Izu Ohshima Island.

Preparatory process of ultra high-resolution experiments

Optimization of the NHM to the K computer.

- Top 160 of load loops in the NHM have been improved SIMD and thread parallelization.
- The peak performance of the latest NHM is 5.8%.
- The performance of the NHM improves 23% than a former NHM.

Process to ultra high-resolution experiments

- Organizing the parallel input and output system.
- Developing a unify system for the divided output files.
- To improve MPI process for the K computer system.
- Validating the accuracy of result from the NHM using 82,944 nodes of the K computer.

Objectives of ultra high-resolution experiments

Objectives

- Objective of this research is to study about impact on a heavy rain simulation under conditions of less than 500m horizontal resolution.
- To survey impact on NHM of topography data of GTOPO (1km) and KTOPO (50m) by Geospatial Information Authority of Japan.

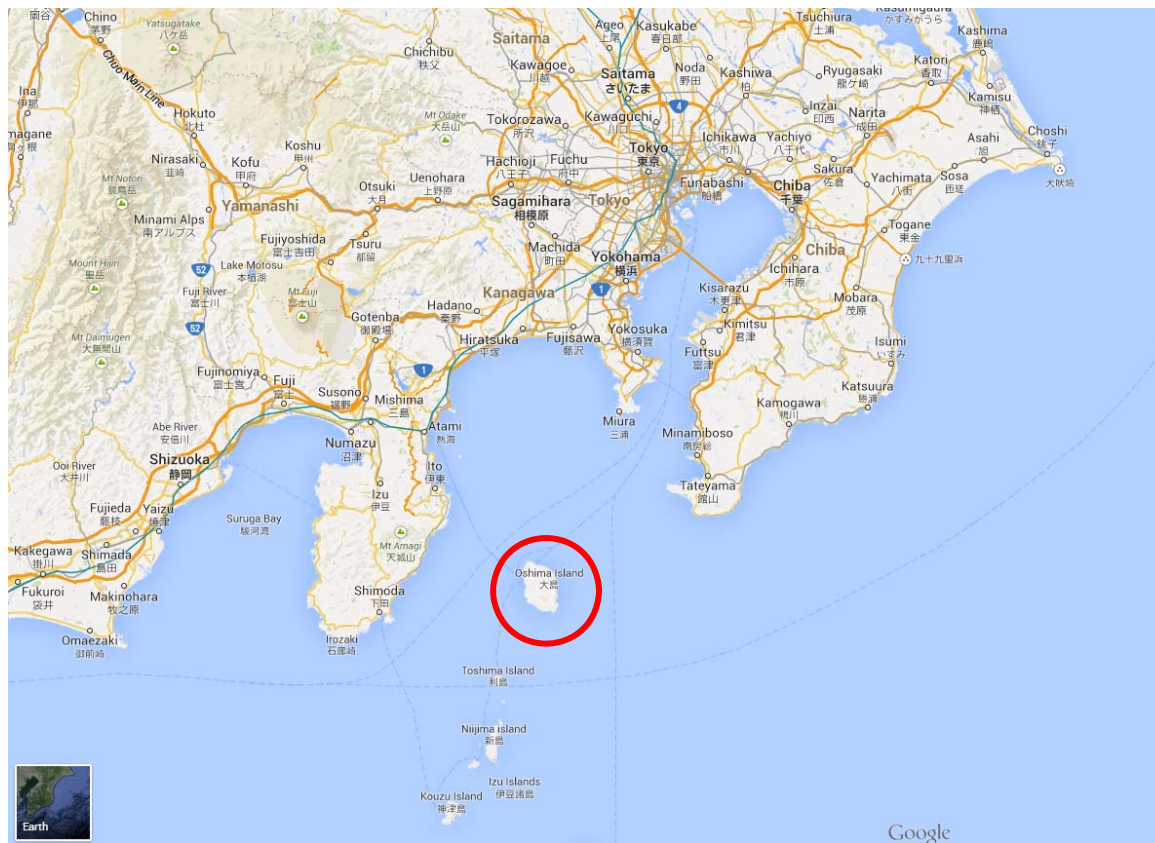
Study site: Izu Ohshima

The Izu Ohshima Island is located at south west from Tokyo.

Area: 91km²

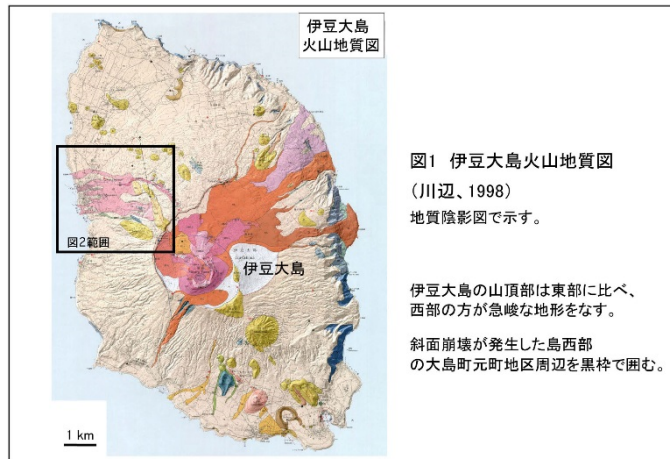
Length: North-South 15km, East-West 9km

Elevation: 758m mt.Mihara



Heavy rain disaster in Izu Ohshima 16 October 2013

- Typhoon No.26 hit Izu Ohshima and observed 24 hours accumulated rainfall was 824mm.
- This rainfall caused debris flow, and Oshima town was damaged including 39 victims.



出典:産業技術総合研究所 地質調査総合センターHP



出典:共同通信



P1 ヘリ調査 (下流方向を望む)



P2 ヘリ調査 (崩壊地)

出典:国土技術政策総合研究所、砂防研究室「台風26号による伊豆大島災害調査結果」

Observation results in Izu Ohshima Island

- There are two observatories in the island.
- Distance between both observatory is 4km.
- The Ohshima observatory is located near the Ohshima town.
- The Ohshima observatory recorded about double amount of the precipitation from the other observatory (Fig. 2).
- Table 1 shows 3 hour precipitation and 6 hour precipitation of the Rader-AMeDAS in the both observatories. The value of the Rader-AMeDAS is maximum value in the domain of Fig.1.
- Table 1 shows the Rader-AMeDAS value is close to Ohima observatory.

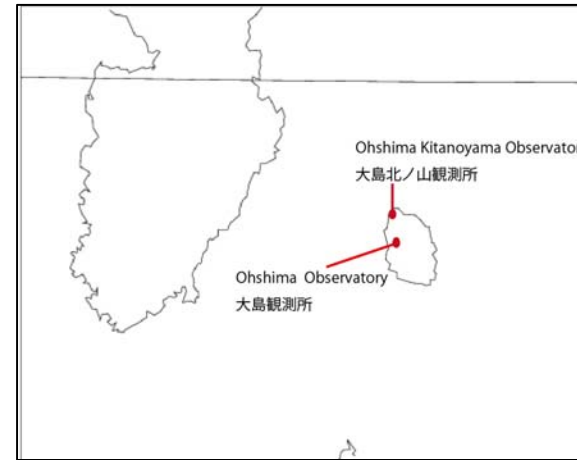


Fig.1 The observatory in the island

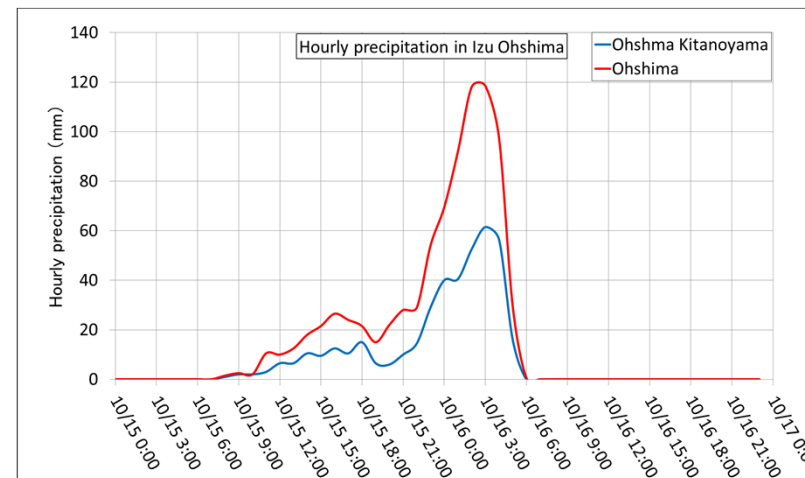


Fig.2 Hourly precipitation

Table 1 Accumulated precipitation

Data		The total amount of precipitation in the domain (mm)	
		3HOUR (10/16 0:00-03:00)	6HOUR (10/16 0:00-06:00)
Radar-AMeDAS precipitation	Observed	243	500
AMeDAS Ohshima Kitanoyama	Observed	154	328
AMeDAS Ohshima	Observed	227	456

Experimental condition

- Fig.1 shows the domain of the experiment.
- Table 1 shows experimental condition.
- Parameter and number of the Z layer are given for each horizontal resolution.
- Simulation initial time is 7 hours, 10 hours and 13 hours before 10/16 07:00.
- Initial and boundary condition is JMA Meso-scale analysis.
- Fig. 2 shows topography of the island in each resolution.
- The elevation in the model is lower than real topography.

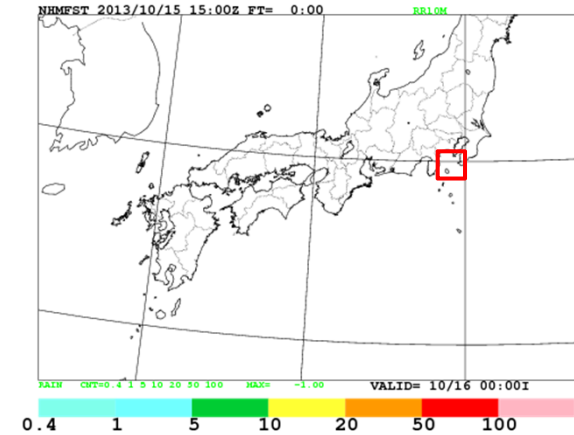


Fig.1 domain for the simulation

Table1 Experimental condition (As same as the LFM domain)

Horizontal resolution	Time Step (second)	XYZ Grids			Planetary Boundary Layer schemes
		NX	NY	NZ	
2 km	10	800	550	60	Mellor-Yamada level3
1 km	5	1600	1100	60	
500 m	2	3200	2200	85	Deardorff
250 m	1	6400	4400	168	

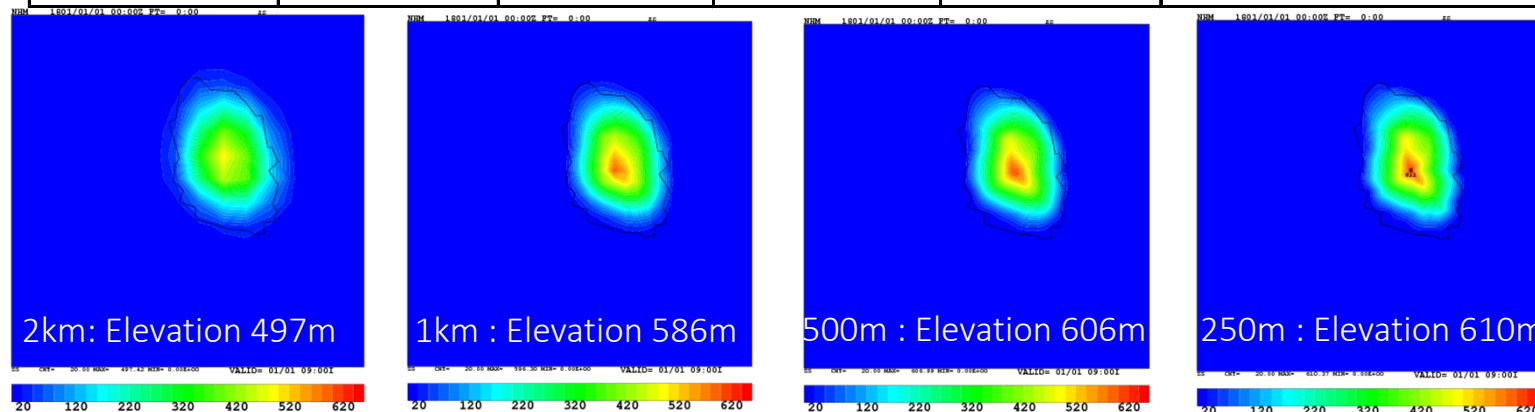


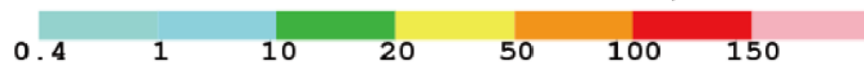
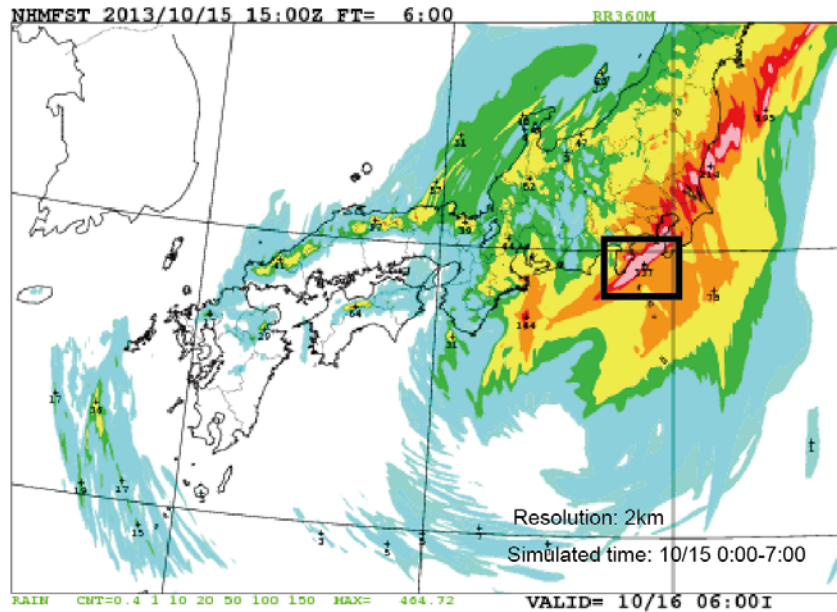
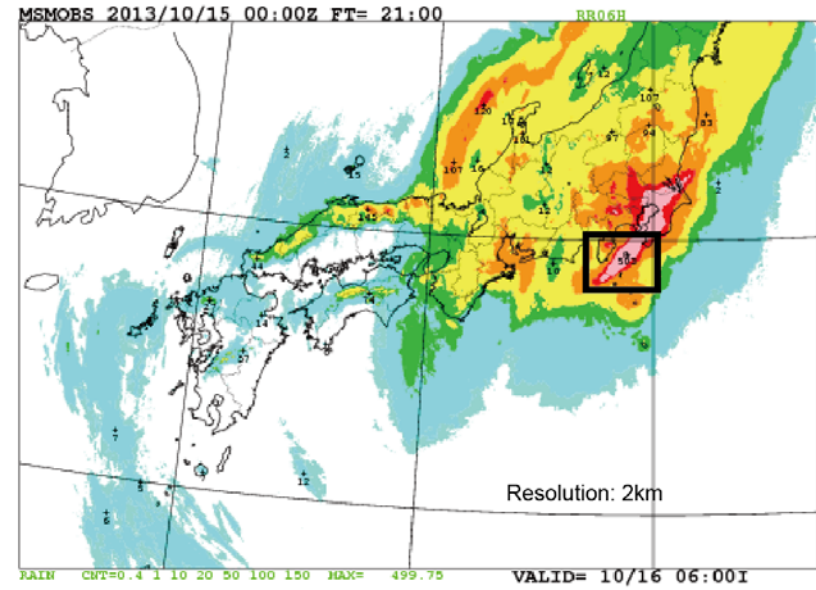
Fig. 2 The highest elevation in the each resolution

results :

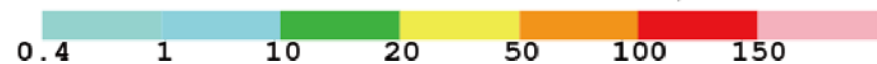
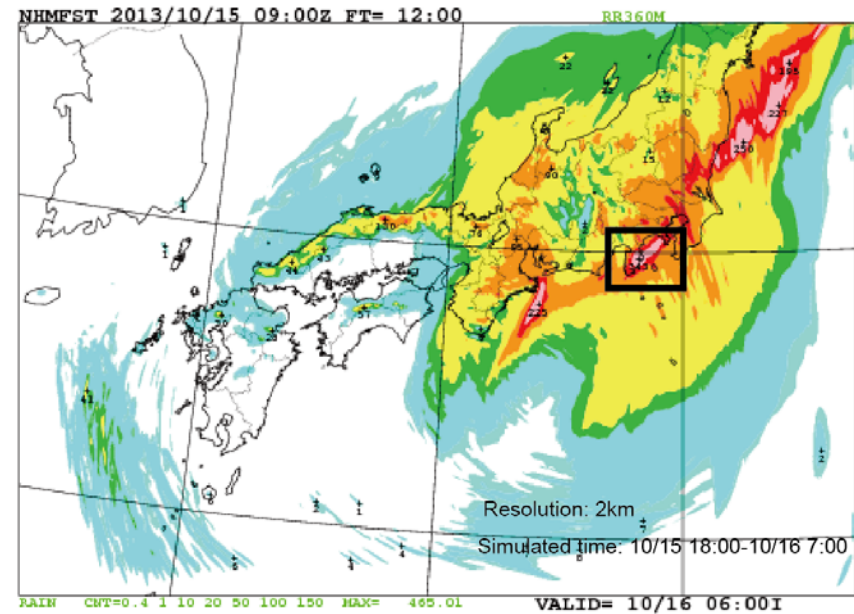
Observed data (Radar-AMeDAS) show rain band covers entire the island.

Results of 7 hour simulation also covered the Island.

In the 13 hour simulation of 2km resolution case, the rain band is appeared on west of the island



2km resolution, 7 hour simulation



2km resolution, 13 hour simulation

Result: 7hour simulation 2km and 1km cases

- The rain band dose not covered the island in 3 hour case, and the rain band is weaker than observed cases.
- Strong rain band does not completely cover the island in 6hour cases.
- Simulated precipitation is less than observed value in both cases.
- The strong rain is simulated north part of the island.

Table 1 Results of observed and simulated results

Data		The total amount of precipitation in the domain (mm)		
		3HOUR (10/16 0:00-03:00)	6HOUR (10/16 0:00-06:00)	
Radar-AMeDAS precipitation	Observed	243	500	
AMeDAS Ohshima Kitanoyama	Observed	154	328	
AMeDAS Ohshima	Observed	227	456	
NHM	2 km	7 Hour Simulation	146	336
	1 km	7 Hour Simulation	153	322

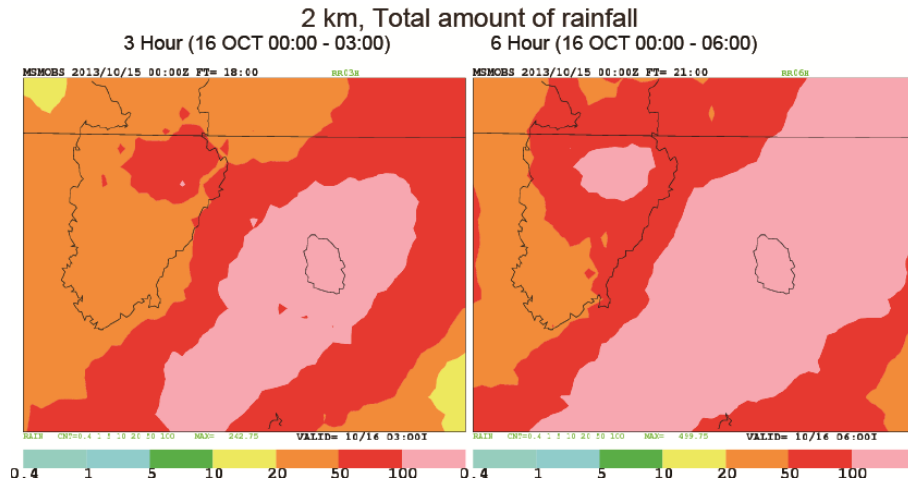


Fig. 1 Rader-AMeDAS

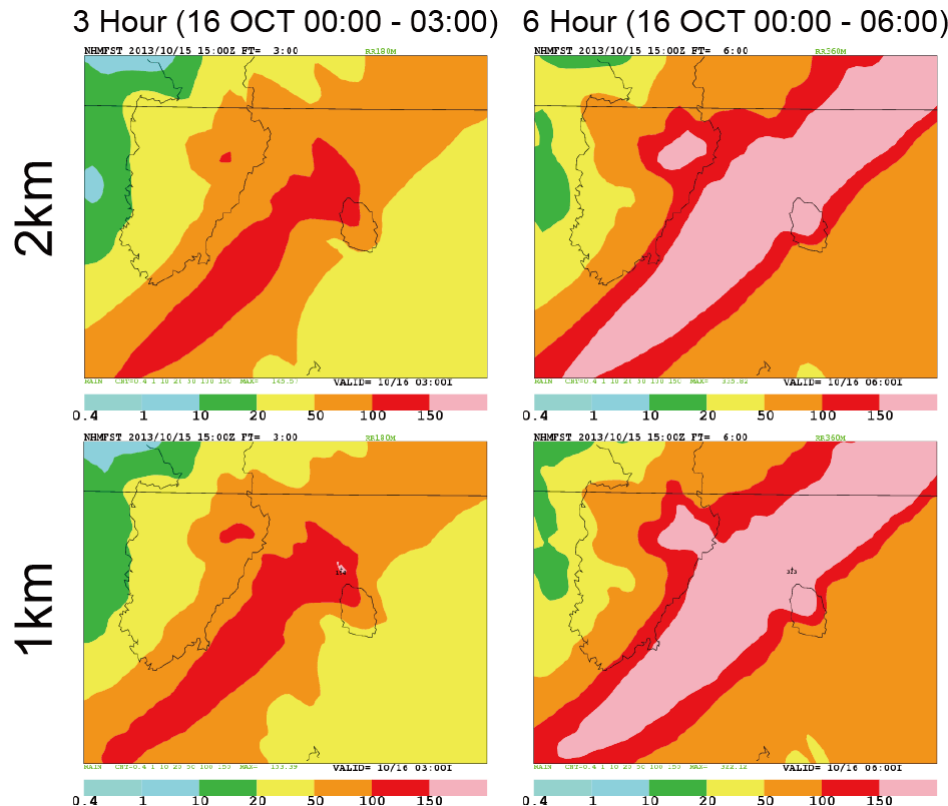


Fig.2 Simulation result

Result: 7hour simulation 500m and 250m cases

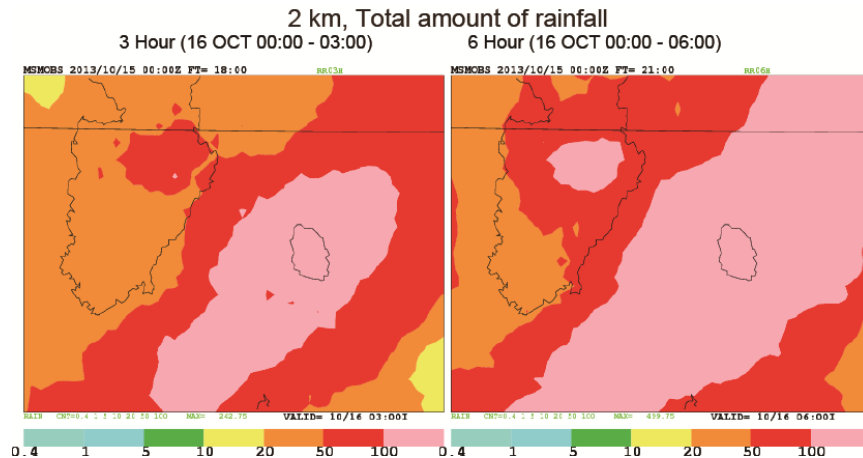


Fig. 1 Rader-AMeDAS

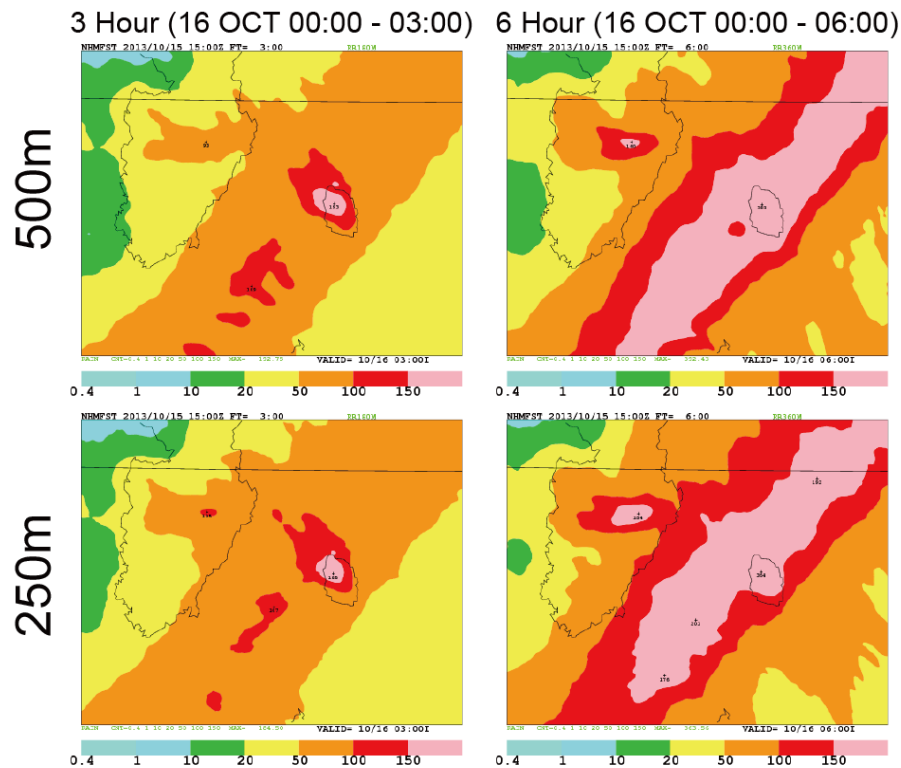


Fig.2 Simulation result

- Fig.2 shows both 6hour cases of 500m and 250m shows the island completely covered by strong rain band.
- Value of the maximum precipitation are increased than 2km and 1km cases(Table 1).
- The strongest rain in the domain are appeared on the place that is origin of the debris flow.
- Case of the 250m shows weaker rain than case of 500m case. I think it is due to a mistake in parameter setting, the number of the Z layer should be 168 for this resolution, but the layer is only 60 in this case.

Table 1 Results of observed and simulated results

Data			The total amount of precipitation in the domain (mm)	
			3HOUR	6HOUR
Radar-AMeDAS precipitation		Observed	243	500
AMeDAS Ohshima Kitanoyama		Observed	154	328
AMeDAS Ohshima		Observed	227	456
NHM	2 km	7 Hour Simulation	146	336
	1 km	7 Hour Simulation	153	322
	500m	7 Hour Simulation	193	392
	250m	7 Hour Simulation	185	364

Result: 10 hour simulation

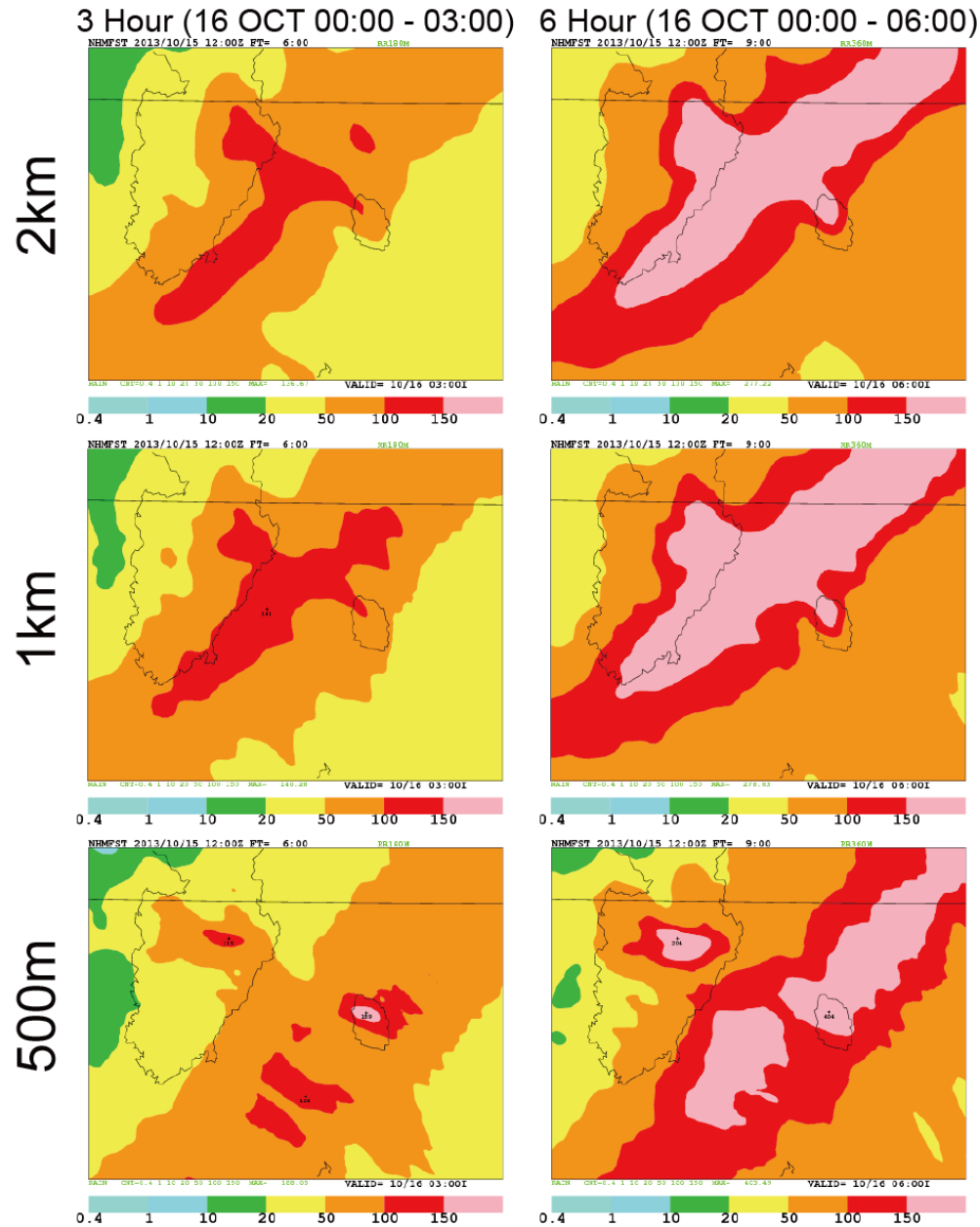


Fig.1 Simulation result

- The rain band is appeared west side of the island in the cases of 2km and 1km. In the 500m case, the island is covered by rain band.
- The total amount of the precipitation of 13 hour simulation cases are less than 7 hour simulation cases.
- The strongest rain in the domain is shown on the island in the case of 500m.

Table 1 Results of observed and simulated results

Data		The total amount of precipitation in the	
		3HOUR (10/16 0:00-03:00)	6HOUR (10/16 0:00-06:00)
Radar-AMeDAS precipitation	Observed	243	500
AMeDAS Ohshima Kitanoyama	Observed	154	328
AMeDAS Ohshima	Observed	227	456
NHM	2 km 7 Hour Simulation	146	336
	1 km 7 Hour Simulation	153	322
	500m 7 Hour Simulation	193	392
	2km 10 Hour Simulation	137	277
	1km 10 Hour Simulation	140	279
	500m 10 Hour Simulation	188	403

Result: 13 hour simulation

3 Hour (16 OCT 00:00 - 03:00) 6 Hour (16 OCT 00:00 - 06:00)

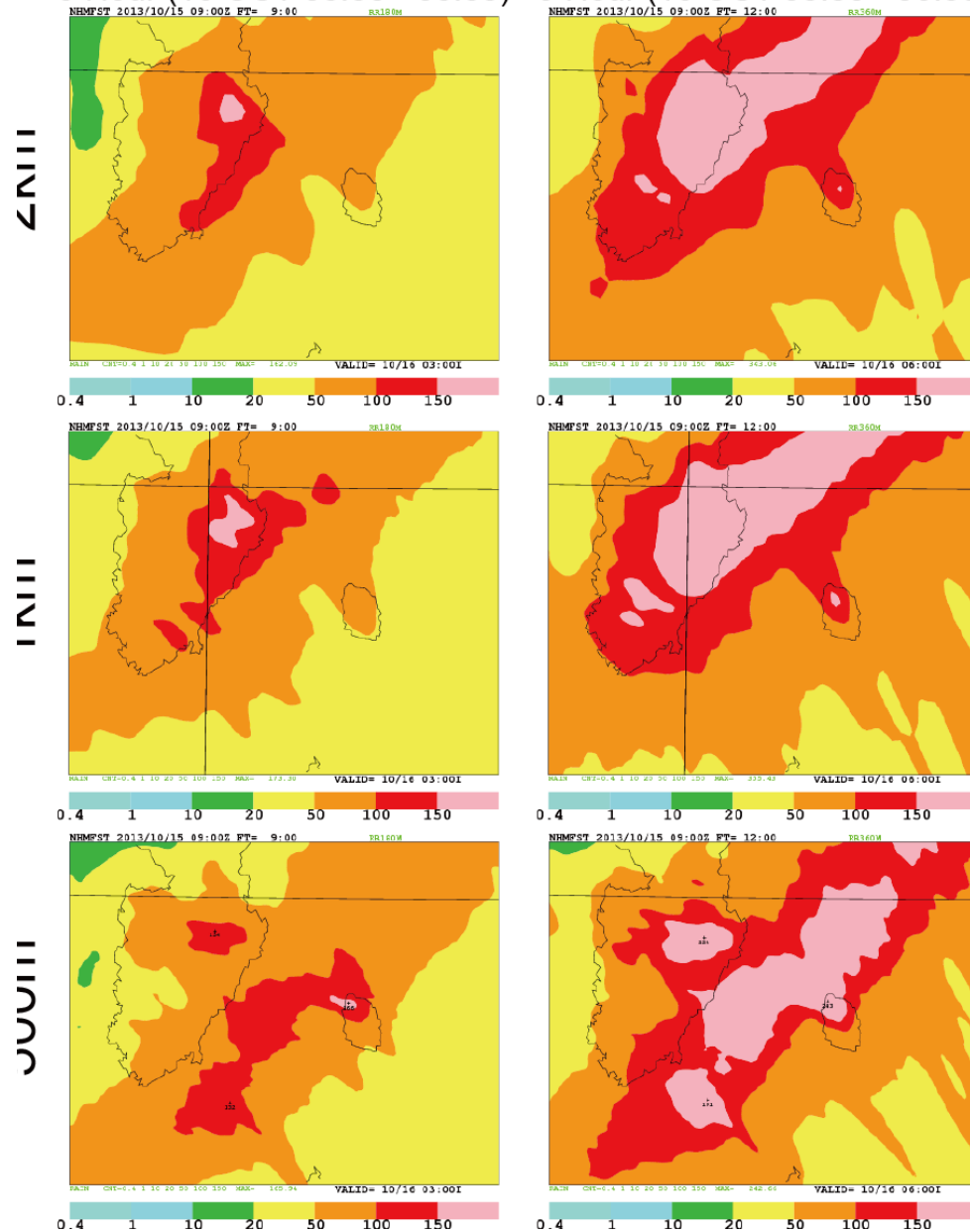


Fig.1 Simulation result

- The rain band is appeared out side of the island in the cases of 2km and 1km.
- In the 500m case, the part of island is covered by rain band.
- The strongest rain in the domain is shown on the island in the case of 500m.
- The total amount of precipitation of 500 case is the least in the al cases.

Table 1 Results of observed and simulated results

Data		The total amount of precipitation in the		
		3HOUR (10/16 0:00-03:00)	6HOUR (10/16 0:00-06:00)	
Radar-AMeDAS precipitation	Observed	243	500	
AMeDAS Ohshima Kitanoyama	Observed	154	328	
AMeDAS Ohshima	Observed	227	456	
NHM	2 km	7 Hour Simulation	146	336
	1 km	7 Hour Simulation	153	322
	500m	7 Hour Simulation	193	392
	2km	13 Hour Simulation	162	343
	1km	13 Hour Simulation	173	355
	500m	13 Hour Simulation	165	242

Conclusion

- This research results show that the high resolution may impact to the place of the heavy rainfall.
- The location of the rain band is improved with high resolution parameter setting.
- To predict amount of the rainfall is difficult.
- Finding optimized parameter for the each resolution is necessary.

Future Work

- Testing more high resolution (eg. 100m, 50m) and long simulation.
- Survey impact on NHM of topography data of GTOPO (1km) and KTOPO (50m) by Geospatial Information Authority of Japan.
- Simulating localized torrential rainfall in Kobe in (2008, 2012 and 2013).
- Collaborate with hydrological model, debris model and agriculture research field for disaster prevention and mitigation.

Thank you