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Explicit prediction experiment of tornadoes associated with a typhoon using a cloud-resolving model

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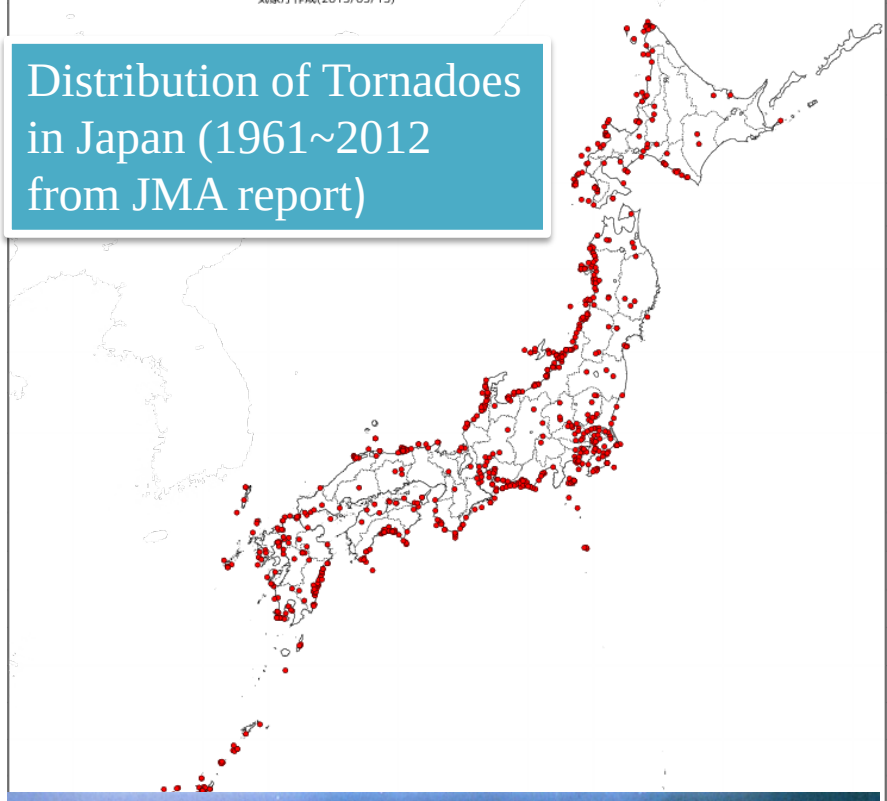
Introduction

- Since most tornadoes in Japan occur along coast lines and occurrence is less frequent, tornadoes and waterspouts are not distinguished and both are called as "***tatsumaki***" in Japanese.
- Typhoon is one of main weather systems for tornadogenesis in Japan. (About 20 %)
- The characteristics of typhoon-related tornadoes and their parent clouds are not clarified sufficiently yet.
- In the present study, we performed explicit prediction experiment of tornadoes in a typhoon.

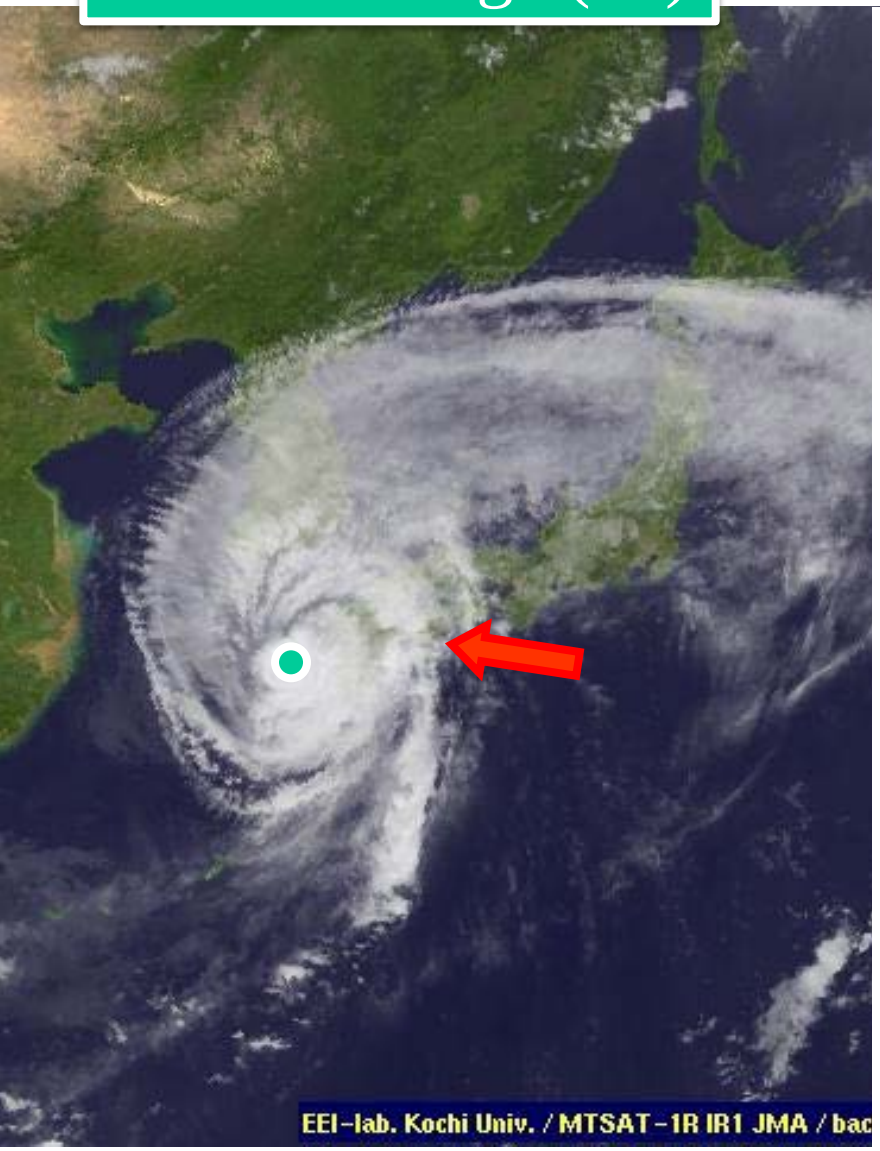


Distribution of Tornadoes in Japan (1961~2012 from JMA report)

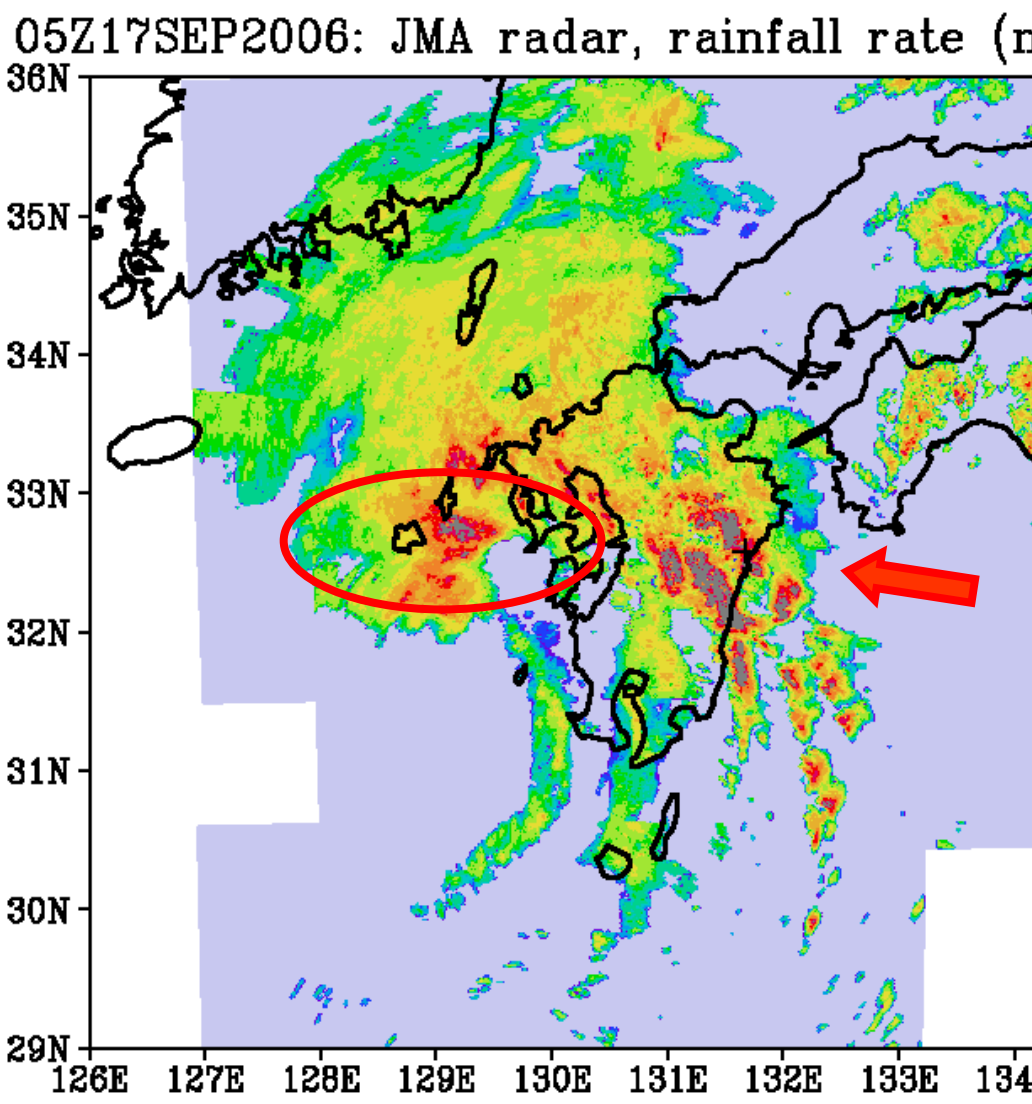
Tatsumaki **in Toyohashi city, near Nagoya , Japan in 1999**

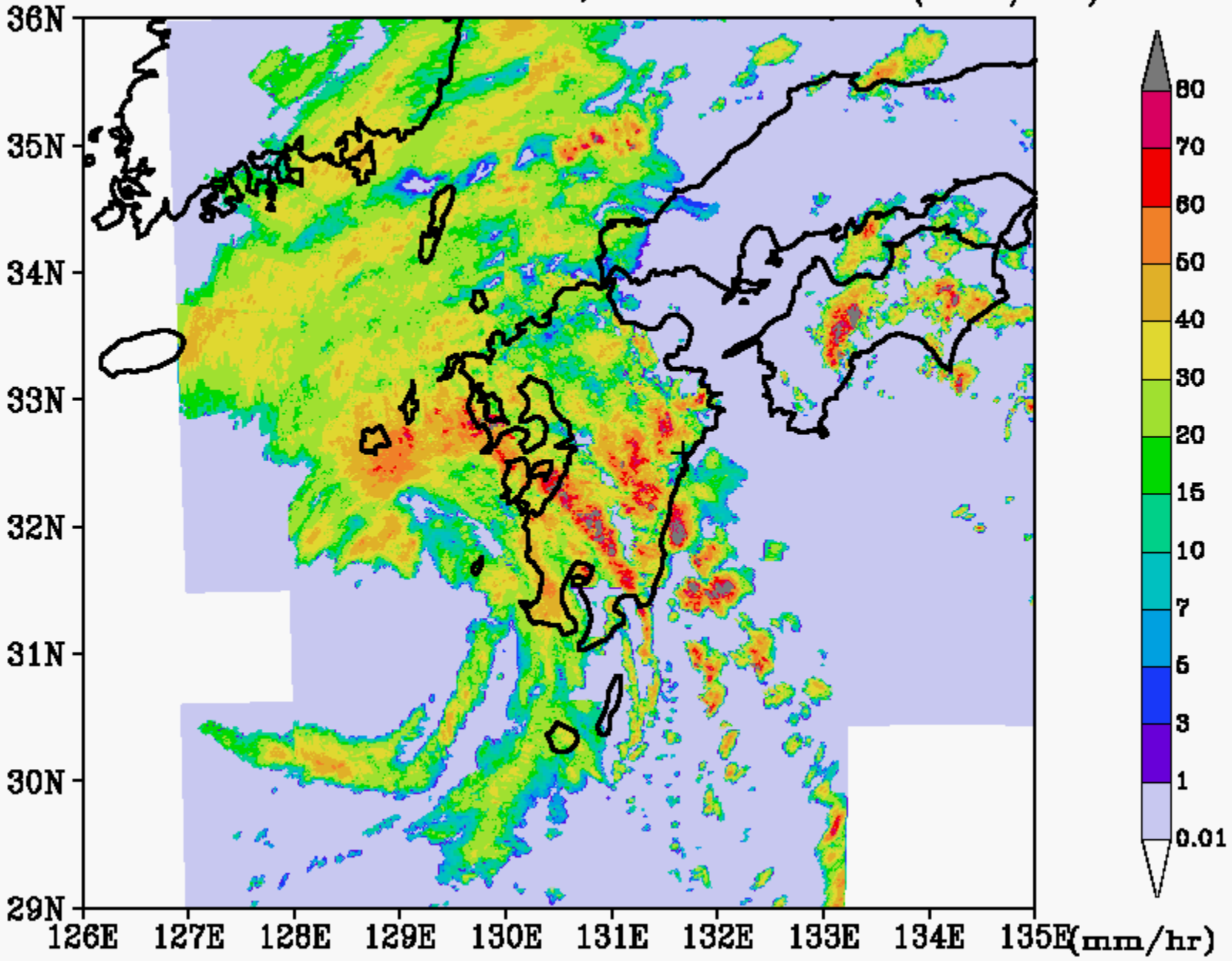
September 17, 2006, 14JST; Typhoon Shanshan (T0613)

Satellite image (IR)

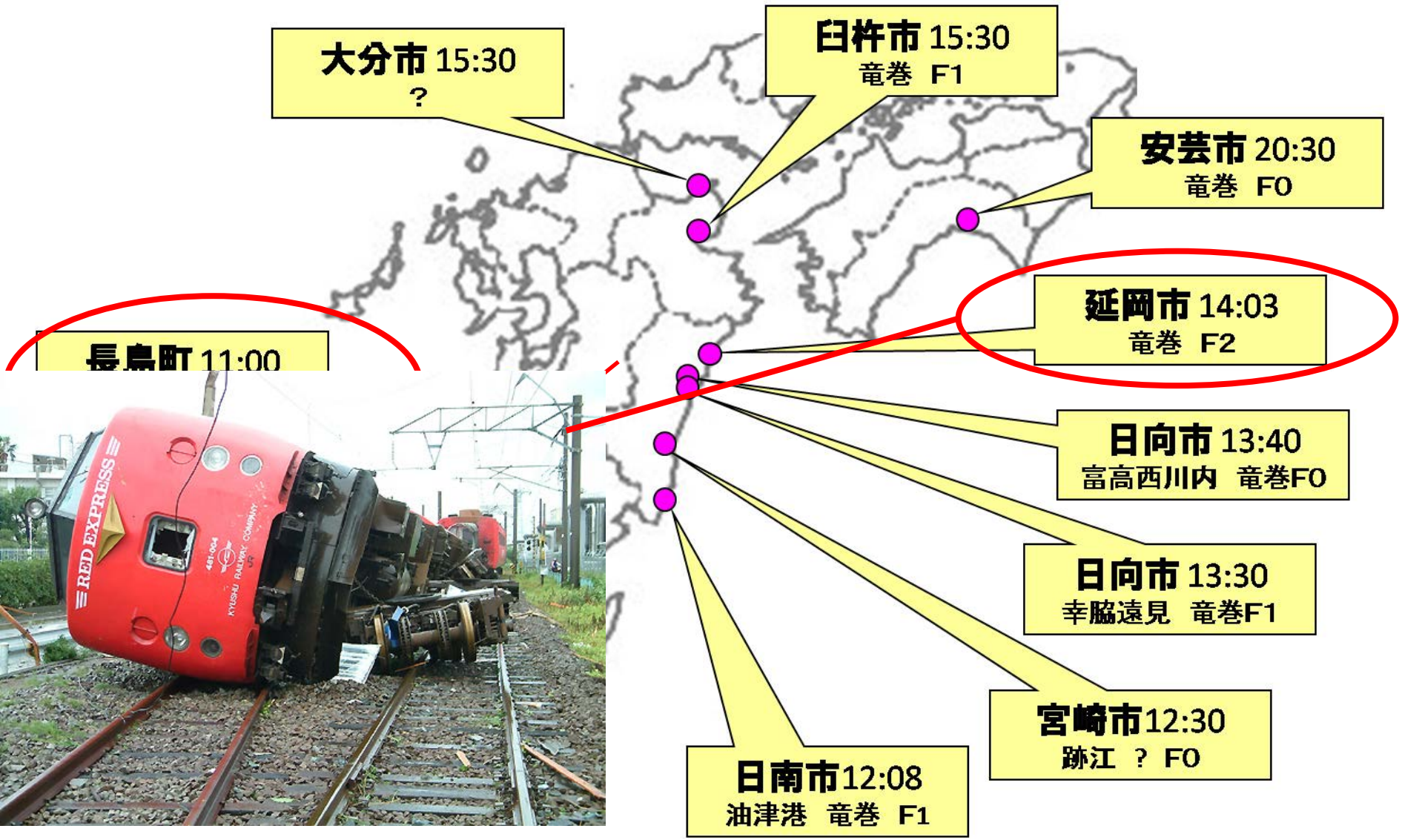


JMA radar image




04Z17SEP2006: JMA radar, rainfall rate (mm/hr)
36N
35N
34N
33N
32N
31N
30N
29N
126E
127E
128E
129E
130E
131E
132E
133E
134E
135E
80
70
60
50
40
30
20
15
10
7
5
3
1
0.01
(mm/hr)

Tornadoes associated with Typhoon 13 on October 17, 2006



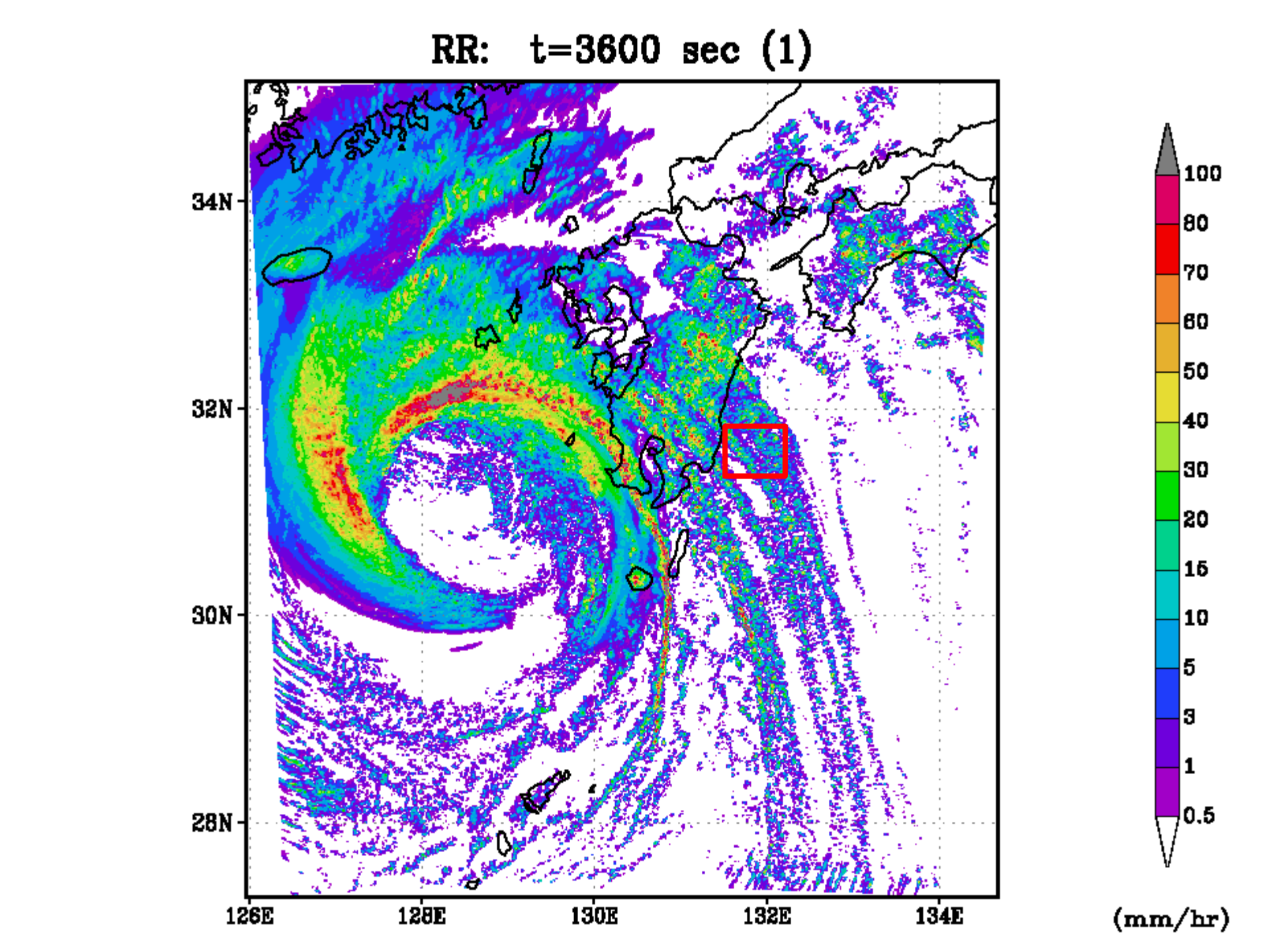
Courtesy of Professor F. Kobayashi at National Defense Academy

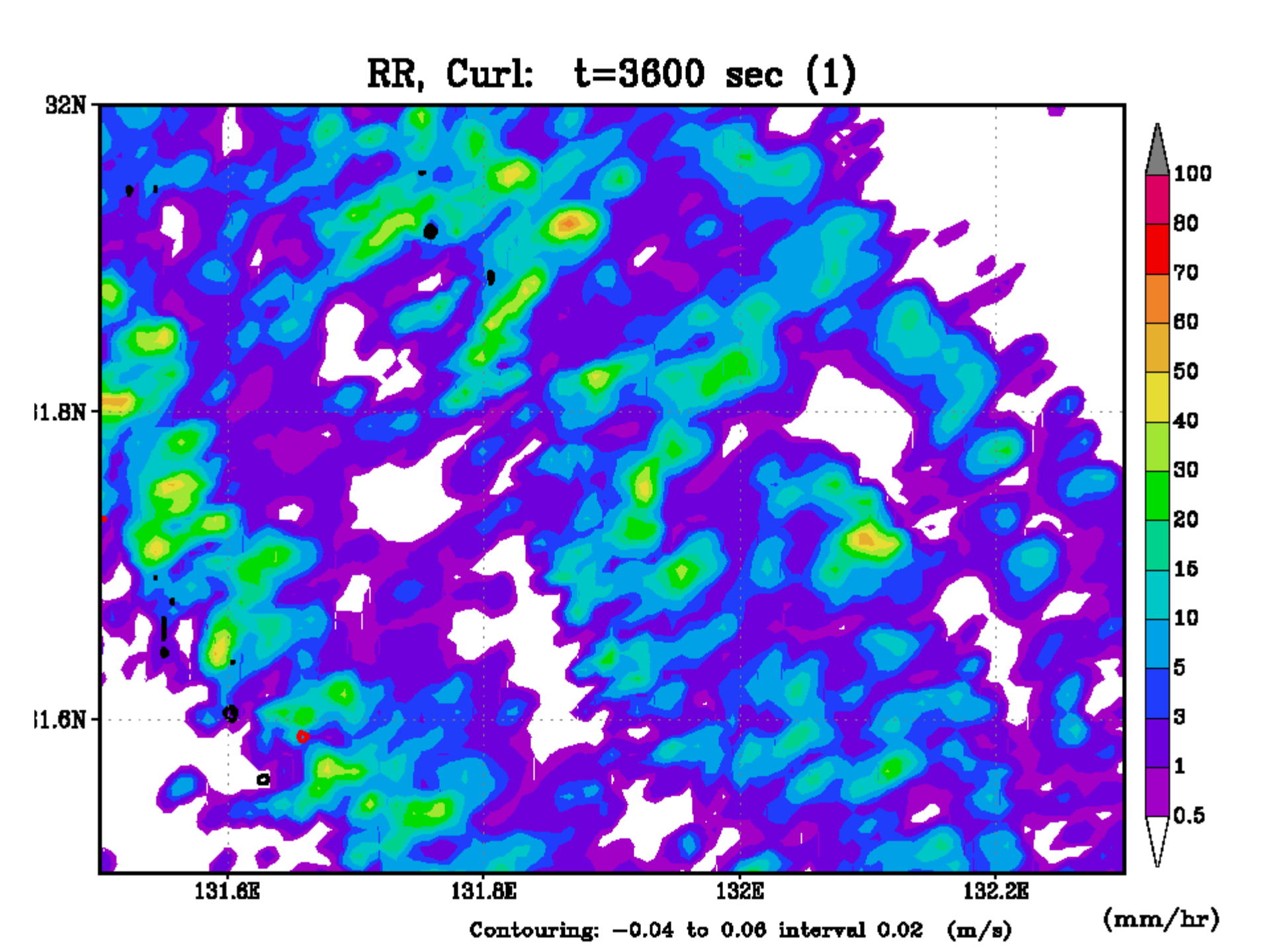
Characteristics of the CReSS (Cloud Resolving Storm Simulator) model

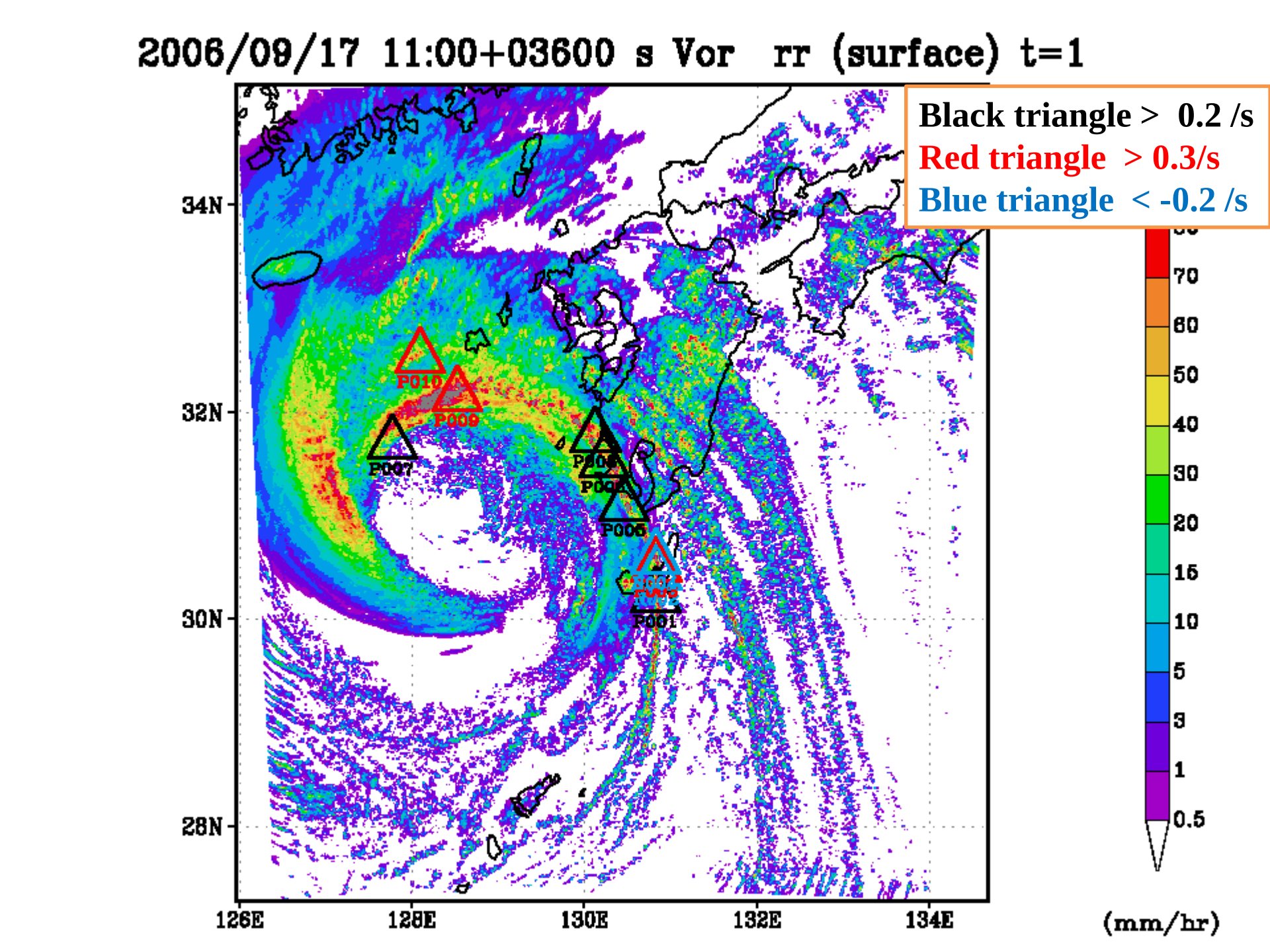
- Basic equations: **a three-dimensional, non-hydrostatic and compressible equation model.**
- Coordinate system: **a terrain-following in a two or three dimensional domain.**
- Spatial representation: **finite difference schme (Arakawa C grid in horizontal, Lorenz grid in vertical).**
- Time integration: **mode-splitting scheme (acoustic terms implicit in vertical)**
- Ground model: ***n*-layer 1-dim. thermal conductivity model.**
- Ocean model: ***n*-layer 1-dim. diffusion model.**
- Surface process: **bulk scheme (Louis scheme).**
- Map projections: **Lambert, Polar stereo, Mercator, Lat-lon.**
- Parallel processing: **inter-node: the Message Passing Interface (MPI) , intra-node: OpenMP.**
- **The CReSS model is optimized for parallel computers (parallel and serial versions).**

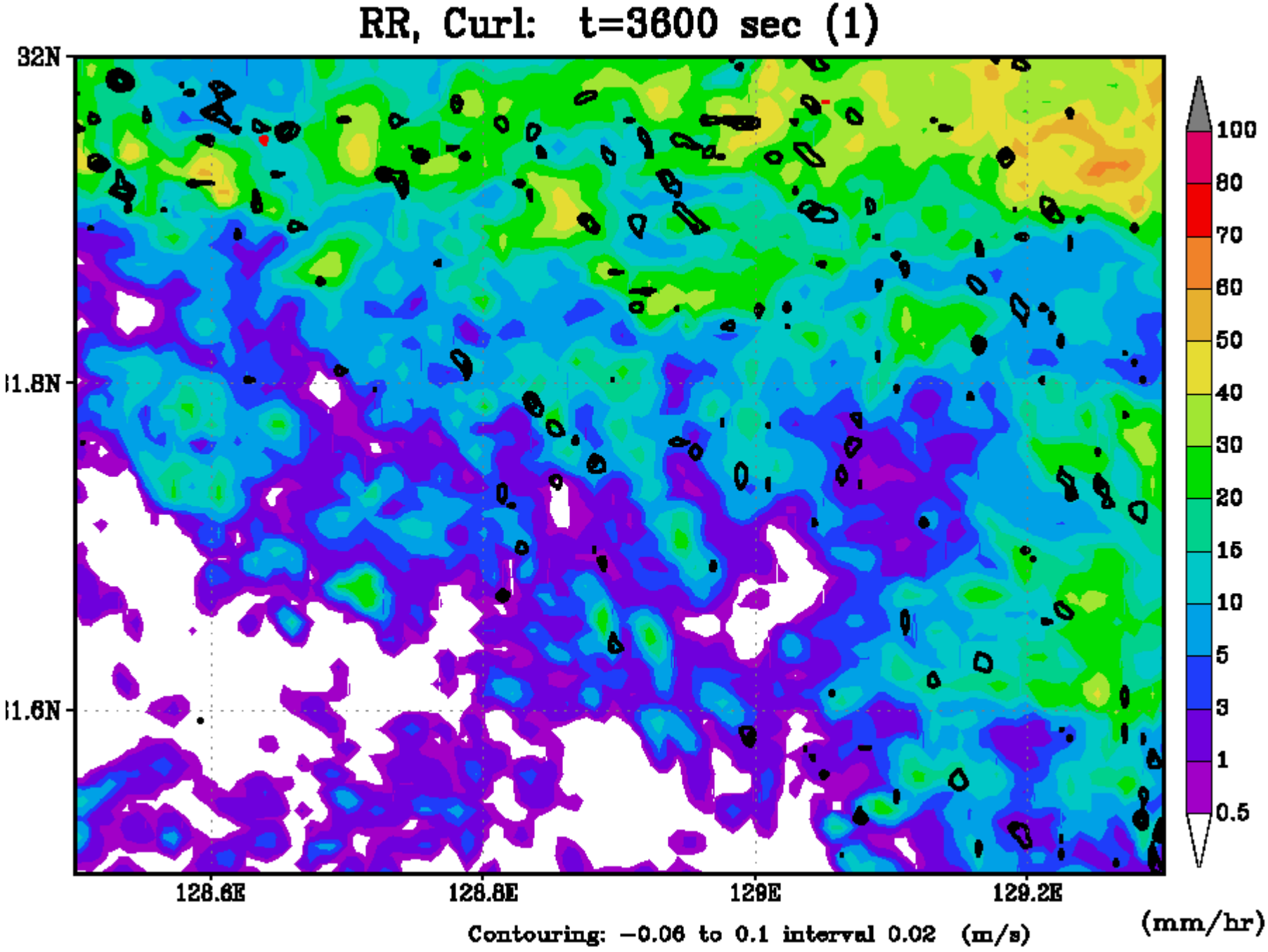
Experimental design of tornadoes in Typhoon T0613

	Coarse model exp.	High-reso. Model exp.
objective	Convective clouds	Tornadoes
H-resolution	400m	75m
domain	All part of typhoon	All part of typhoon
Grid number	x:3075, y:3075,z:103	x:10371,y:11523, z:99
Node number	Kei 4096 node	Kei 9216 node
Integration	6 hours	4 hours
Initial value	JMA-RSM(40km)	CReSS 400m
B. C	JMA-RSM(40km)	CReSS 400m
Cloud physics	cold rain	cold rain


RR: t=3600 sec (1)
34N
32N
30N
28N
126E
128E
130E
132E
134E
100
80
70
60
50
40
30
20
15
10
5
3
1
0.5
(mm/hr)


RR, Curl: t=3600 sec (1)
32N
31.8N
31.6N
131.6E
131.8E
132E
132.2E
100
80
70
60
50
40
30
20
15
10
5
3
1
0.5
(mm/hr)
Contouring: −0.04 to 0.06 interval 0.02 (m/s)


2006/09/17 11:00+03600 s Vor rr (surface) t=1
Black triangle > 0.2 /s
Red triangle > 0.3/s
Blue triangle < -0.2 /s
34N
32N
30N
28N
126E
128E
130E
132E
134E
P010
P009
P007
P006
P001
70
60
50
40
30
20
15
10
5
3
1
0.5
(mm/hr)


RR, Curl: t=3600 sec (1)
32N
31.8N
31.6N
128.6E
128.8E
129E
129.2E
100
80
70
60
50
40
30
20
15
10
5
3
1
0.5
(mm/hr)
Contouring: −0.06 to 0.1 interval 0.02 (m/s)

- Since a typhoon is one of weather systems for tornadoes in Japan, the simulation was performed for tornadoes in a typhoon.
- We tried an explicit prediction experiment of tornadoes using the CReSS model on the Kei computer.
- On September 17, 2006, Typhoon Shanshan (T0613) moved northeastward to the west of Kyushu, Japan and several tornadoes were observed in association with the typhoon.
- We performed simulation experiment of tornadoes with a horizontal resolution of 75 m in a large domain using the cloud-resolving model (CReSS).
- In the high-resolution (75 m) experiment, many tornadoes were predicted. The most intense tornado reached a maximum vorticity of about 0.3 /s. Some negative vorticities were also found.
- Some tornadoes were also found around the eyewall. This may coorepond to the tornadoes observed near the west coast of Kyushu.