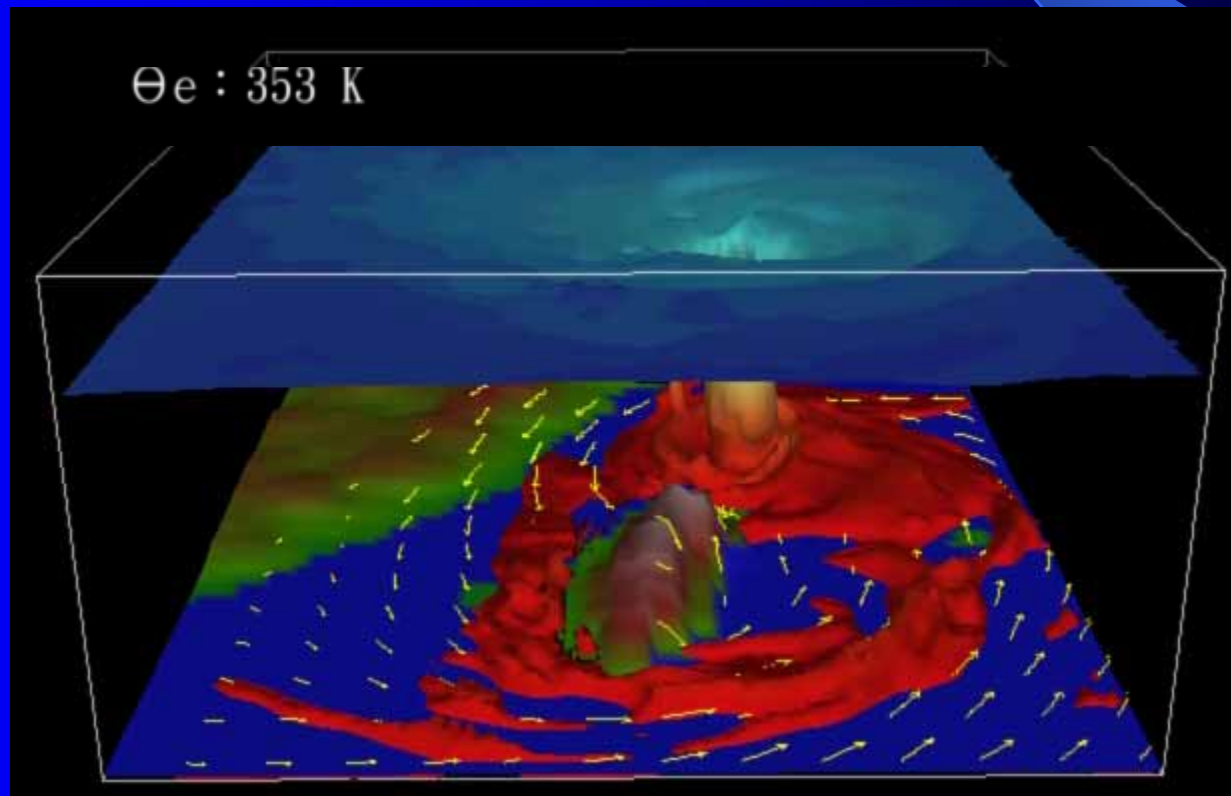# Precipitation Processes of the Landfalling Typhoon Nari (2001)

Ming-Jen Yang

Institute of Hydrological Sciences

National Central University, Taiwan
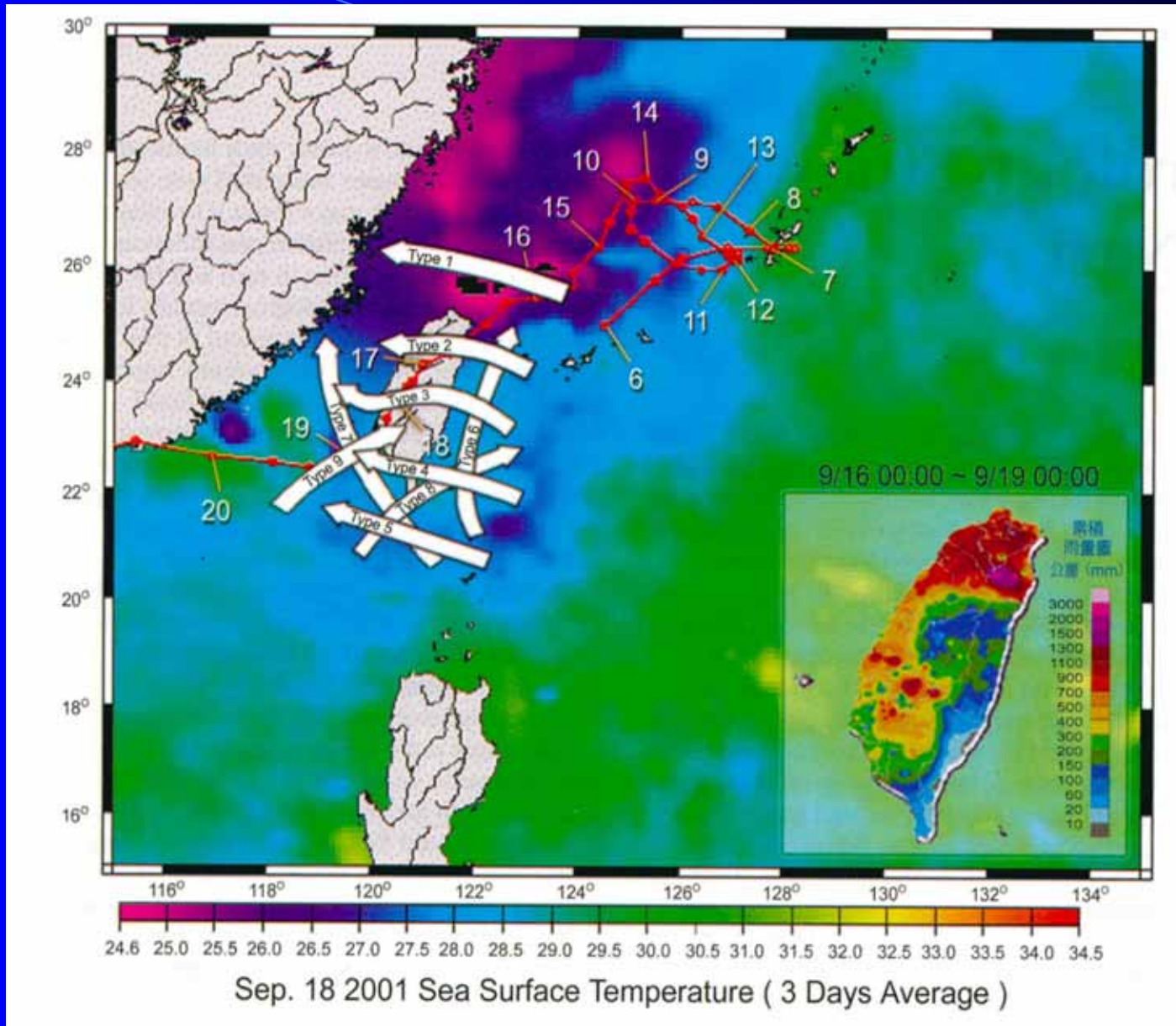
Heavy rainfalls induced severe flooding and societal damage !

黑夜來臨、暴雨驟降，台灣
在瞬間成為災難史上，真實的…
水世界

Even Budda cannot save you!

Water World !

Track and SST

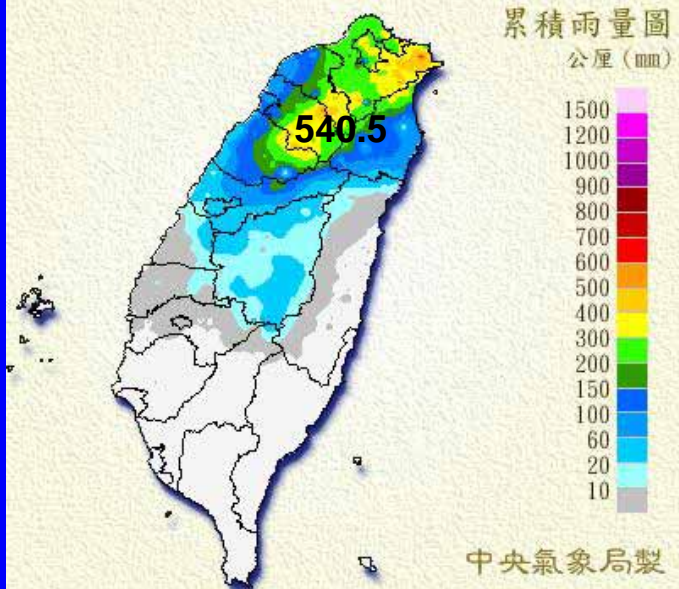Sep. 18 2001 Sea Surface Temperature (3 Days Average)

Sui et al. (2002) EOS article

Why study Nari?

- Unique typhoon track
- Very slow moving speed
- Very long duration
- Warm SST
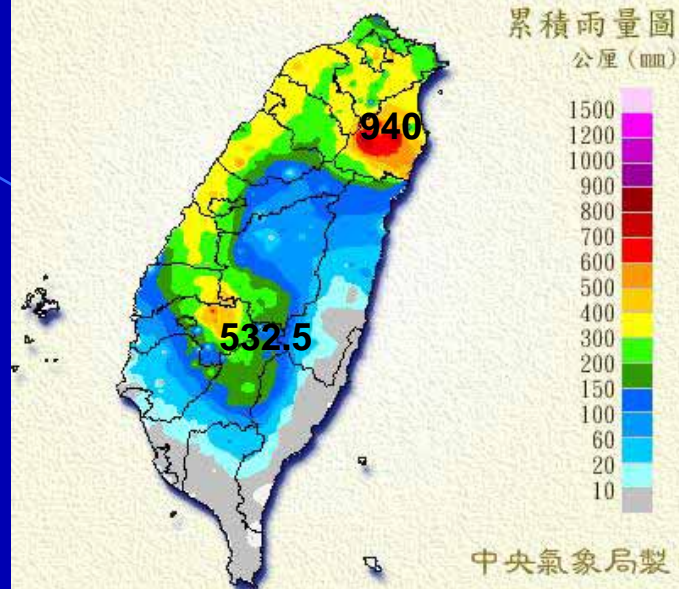- Extremely heavy rainfall
- Severe flooding
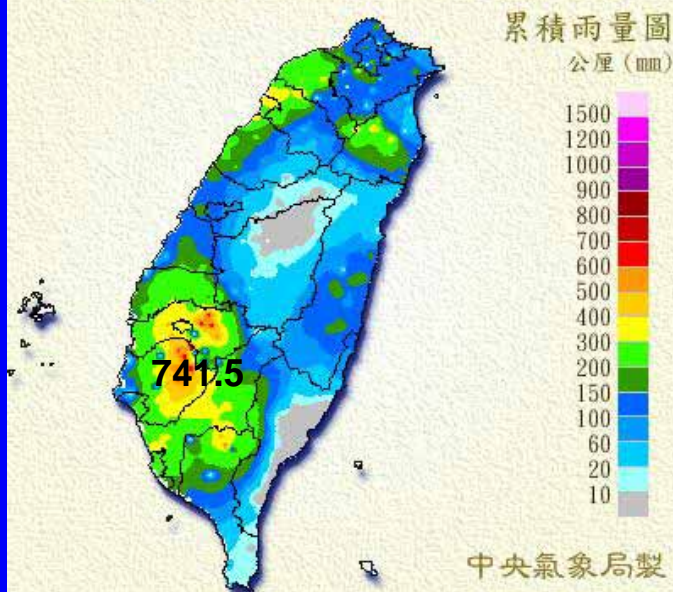
9/16

9/16 00:00 至 9/17 00:00
累積雨量圖
公厘(mm)
540.5

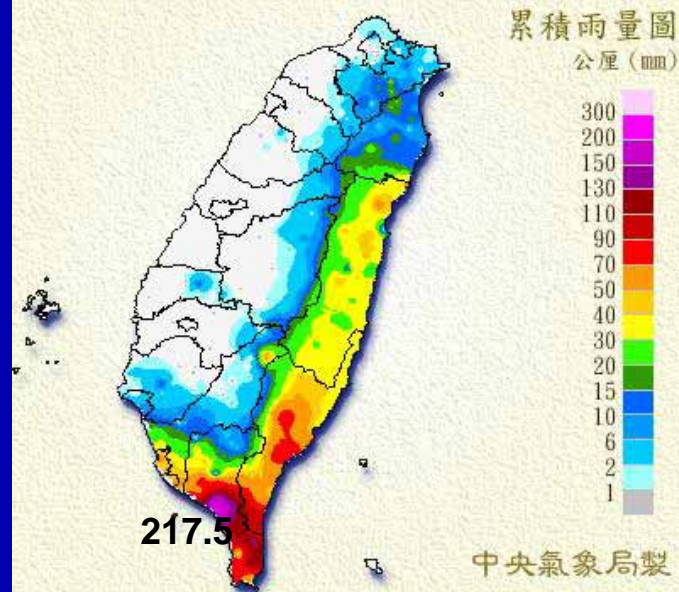9/17 00:00 至 9/18 00:00
累積雨量圖
公厘(mm)
940
532.5

9/17

9/18

9/18 00:00 至 9/19 00:00
累積雨量圖
公厘(mm)
741.5

9/19 00:00 至 9/20 00:00
累積雨量圖
公厘(mm)
217.5

9/19
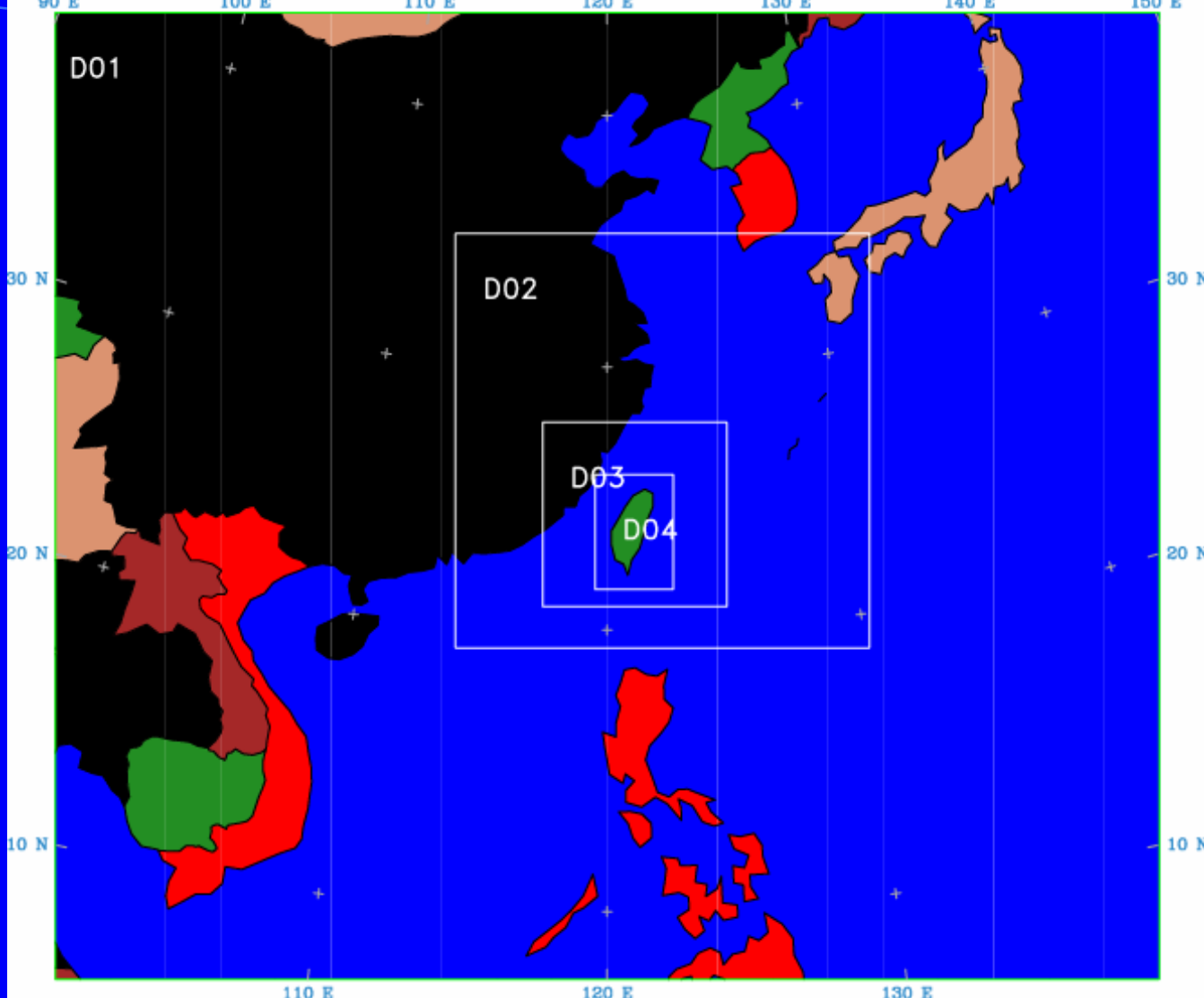
MM5 Domains

D1: 60 km (81x 71x 31) in x-, y-, z-directions

D2: 20 km (91x 91x 31)

D3: 6.67 km (121x 121x 31)

D4: 2.22 km (154x 226x 31)

MM5 model physics (Control)

| Item	Description
Version	Version 3.5
Cumulus	Grell (1993)
Microphysics	Reisner et al. 1998
PBL	MRF (Hong and Pan 1996)
Radiation	Dudhia (1989
I.C.	ECMWF advanced analysis
B.C.	ECMWF advanced analysis

Simulated Track vs. Observed Track
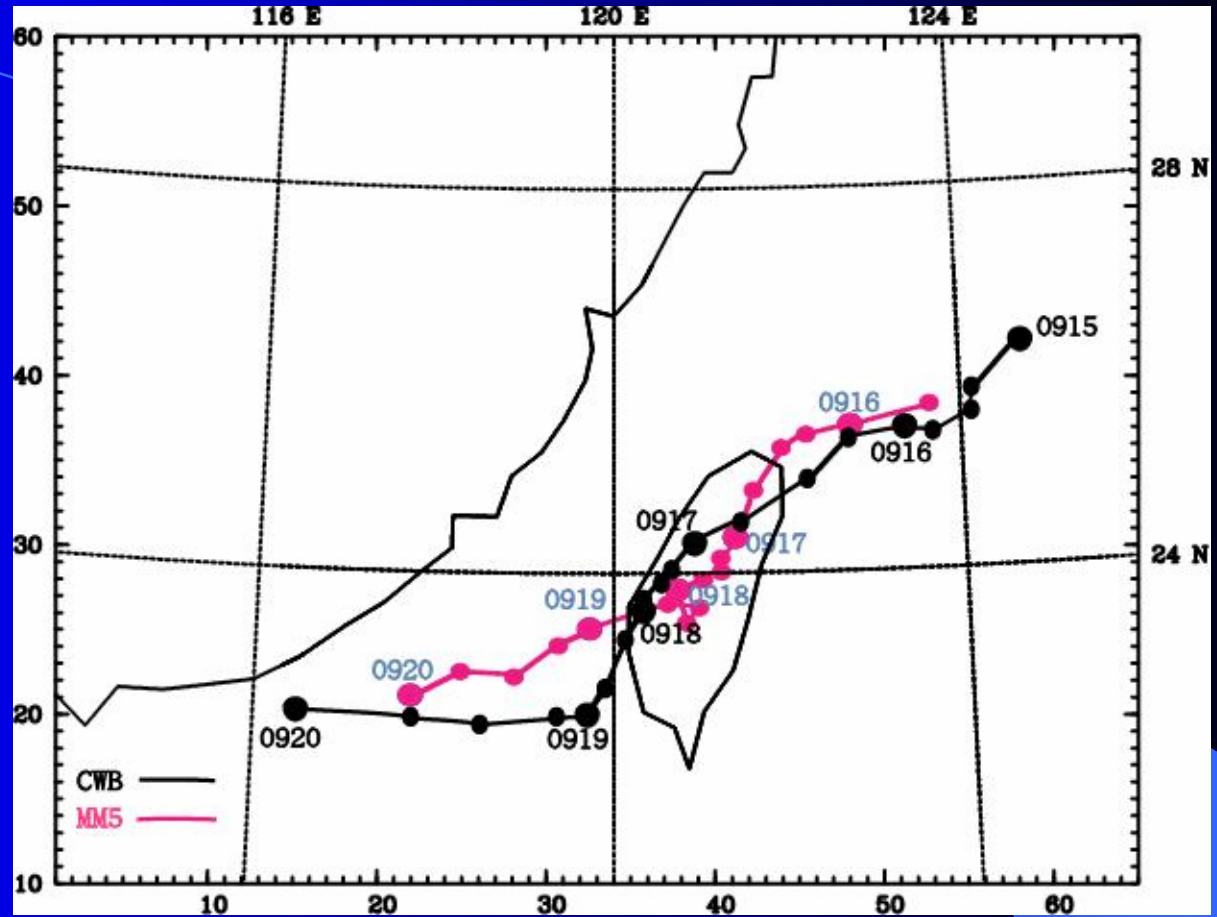
Simulated Intensity vs. Observed Intensity

Resolution Dependence

Simulated 24-h Rainfall

Observed 24-h Rainfall

60-km
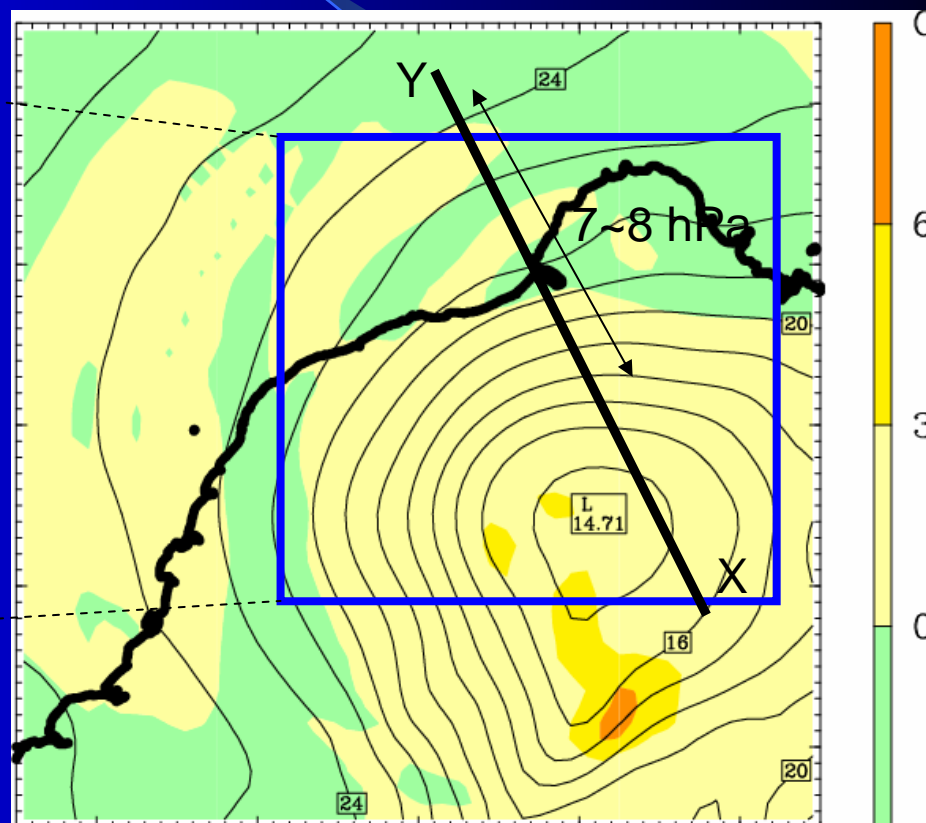
20 km

6.67 km

2.22 km
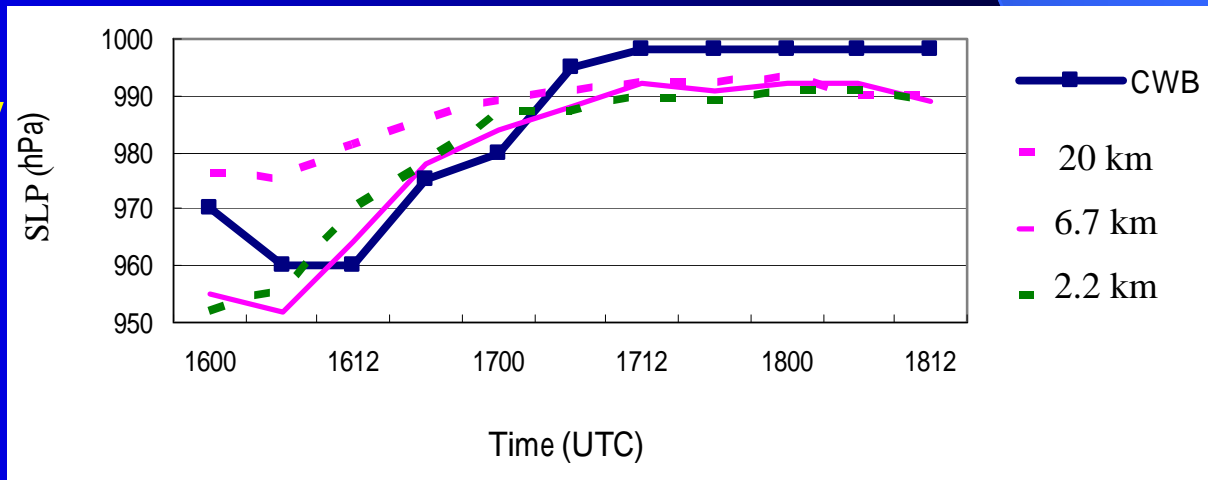
Horizontal Cross Section of Pressure and Temperature Perturbations

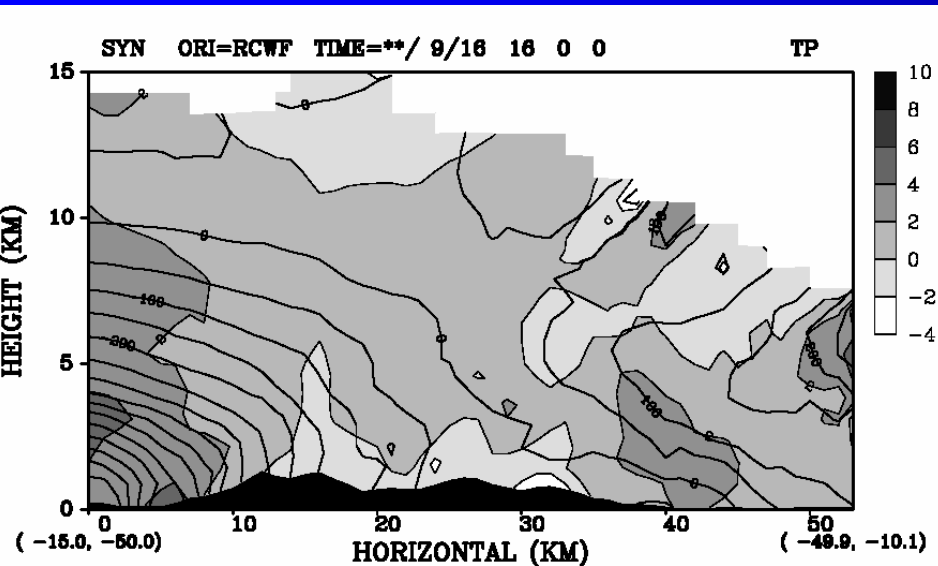**Radar Retrieval (wrt. a Station Sounding)**
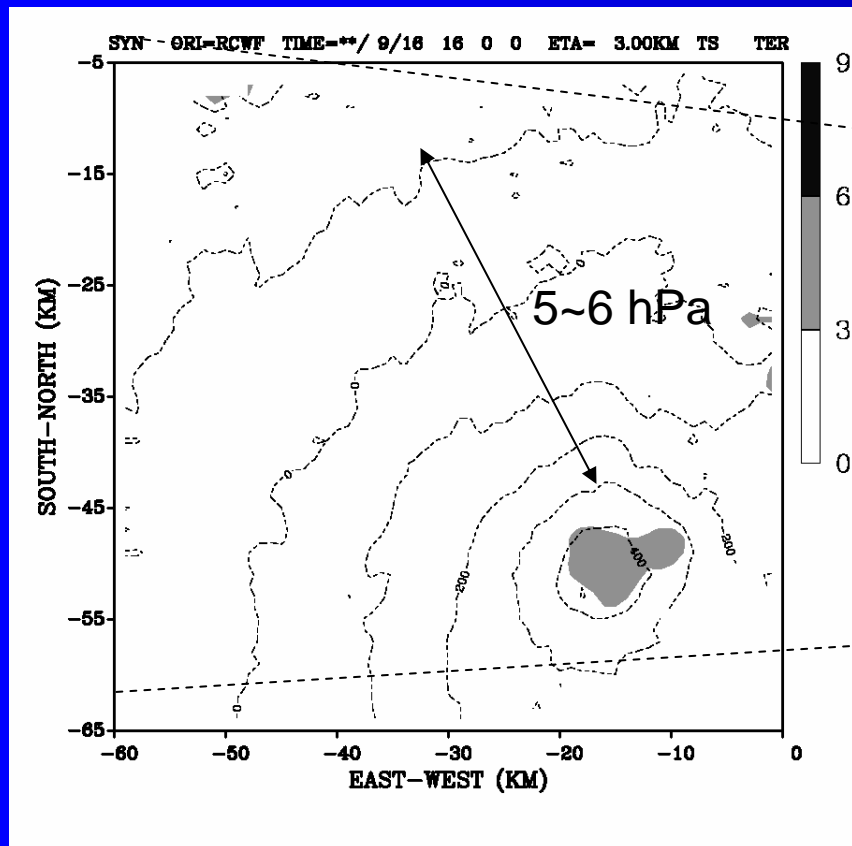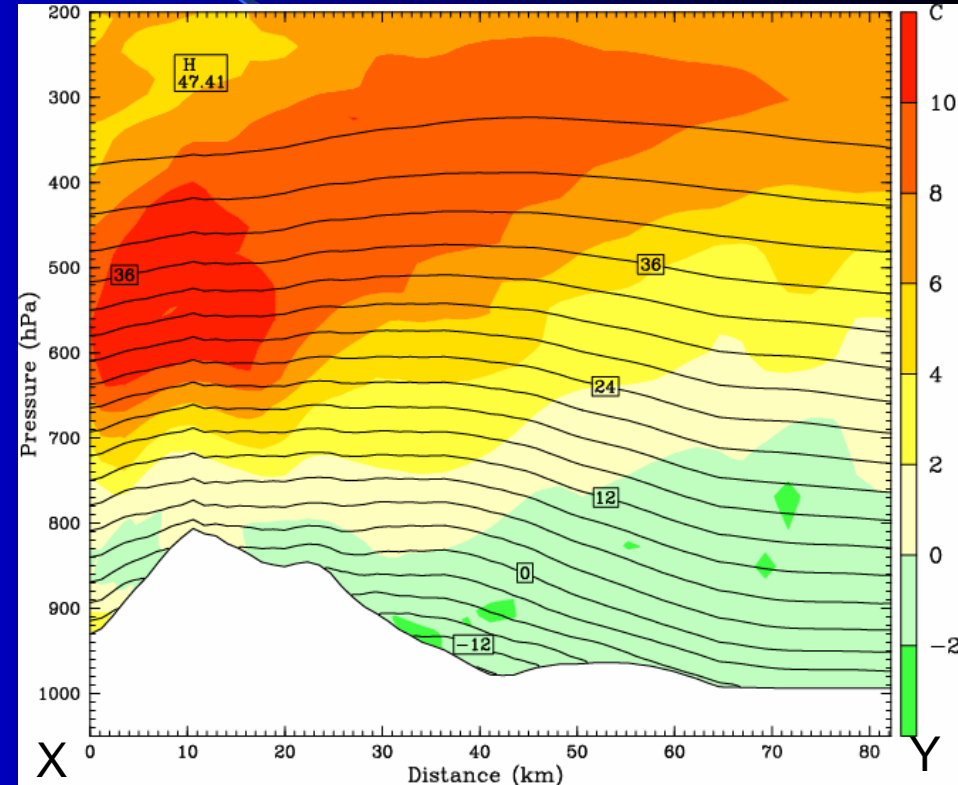
MM5 Simulation (wrt. a Horizontal Area Mean)

5~6 hPa

7~8 hPa

Courtesy of T.-C. Chen Wang
and Y.-C. Liou
Ref: Liou et al. (2003; JAM)

Vertical Cross Section of Pressure and Temperature Perturbations

MM5 Simulation (wrt. a Horizontal Area Mean)

Radar Retrieval (wrt. a Stational Sounding)

Courtesy of T.-C. Chen Wang
and Y.-C. Liou
Ref: Liou et al. (2003; JAM)

Vertical Profile of Horizontal Divergence

Radar VAD Analysis

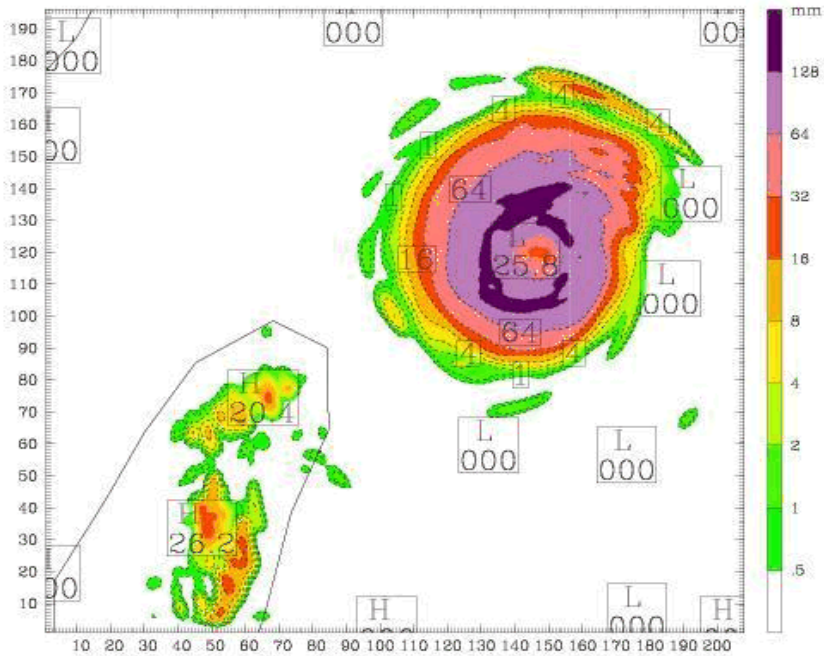## MM5 Divergence Profile
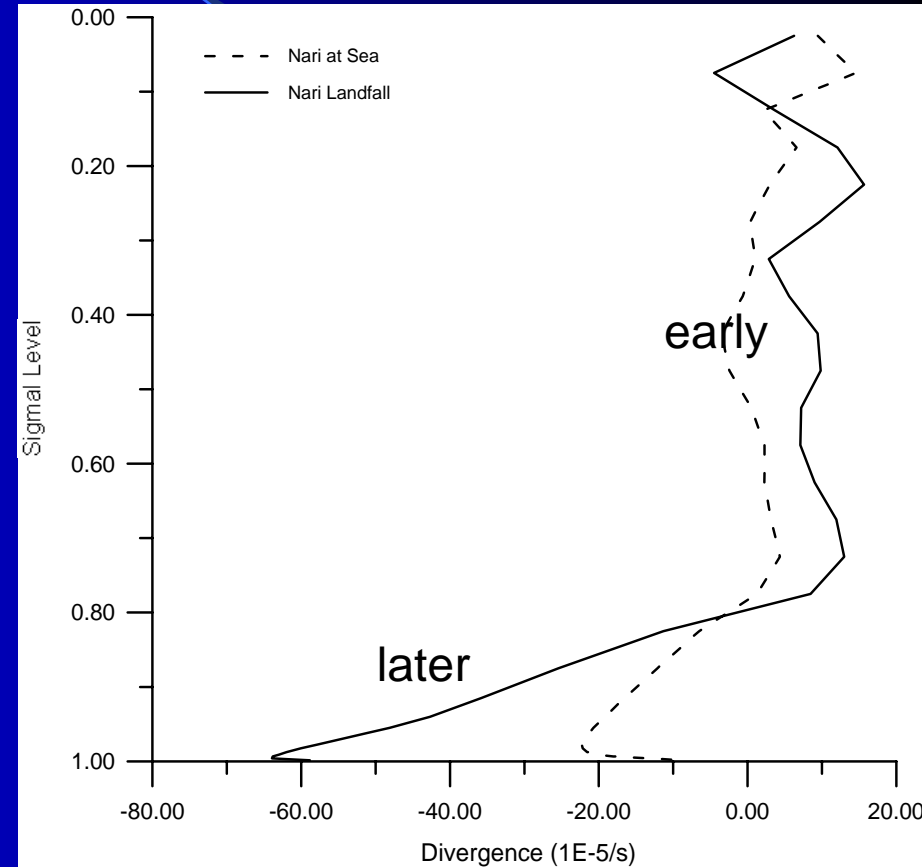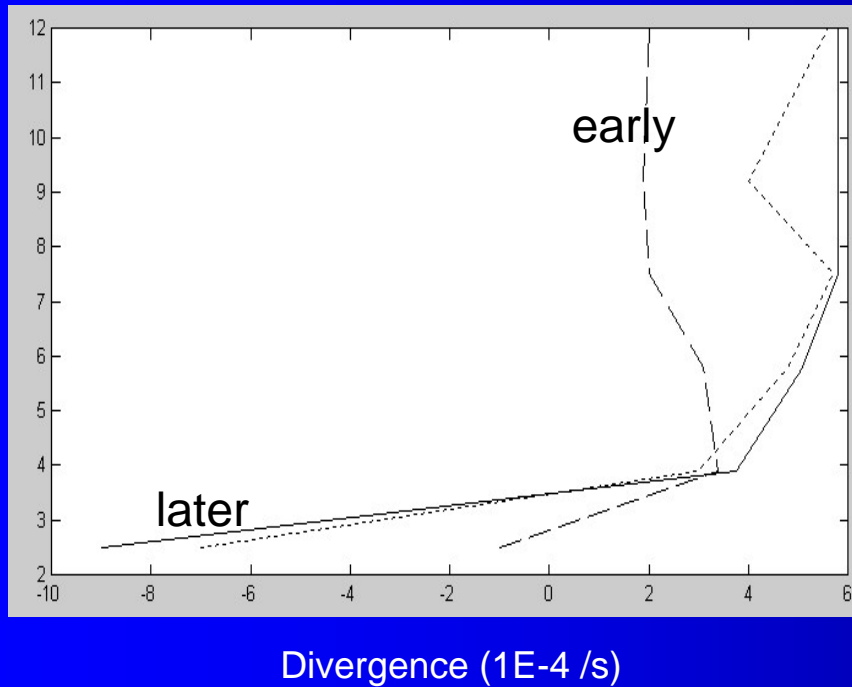
Courtesy of T.-C. Chen Wang and Y.-C. Liou

Simulated 3-h Rainfall
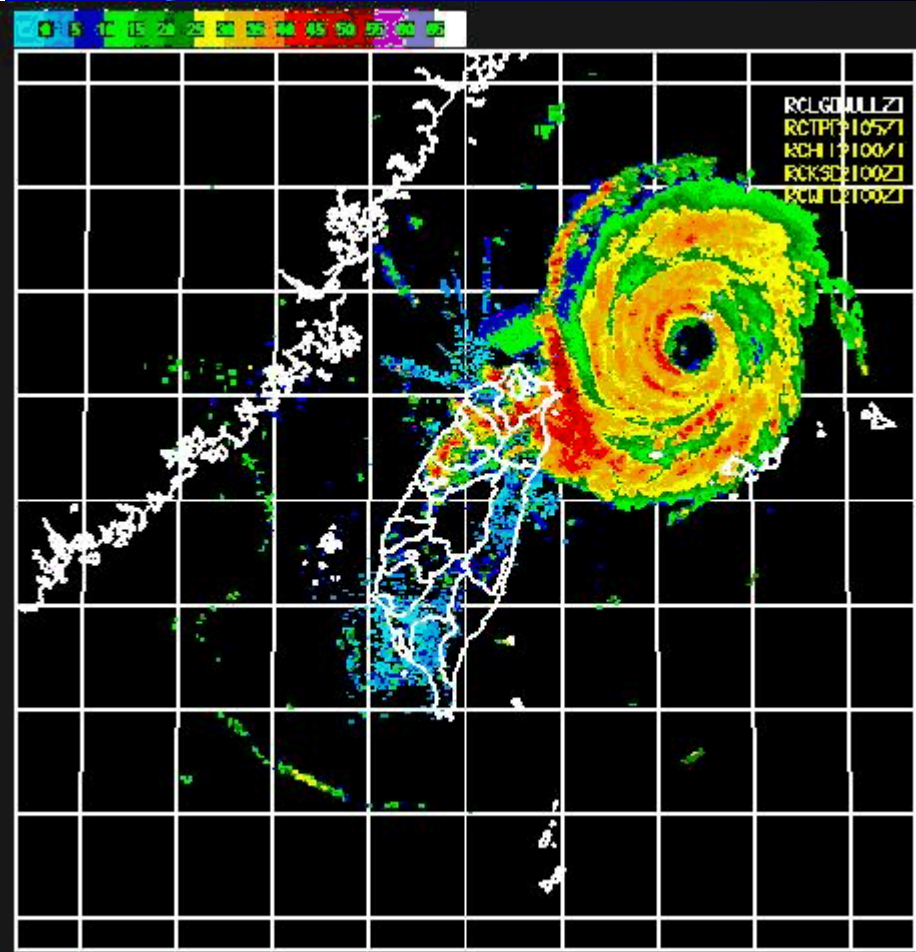
Observed Radar Echo (CV

091518_091521 UTC

Dataset: D4   RIP: rip rt 00 03   Init: 1800 UTC Sat 15 Sep 01
Fcst: 3.00   Valid: 2100 UTC Sat 15 Sep 01 (1500 MDT Sat 15 Sep 01)
Total precip. since h 0   sm= 1
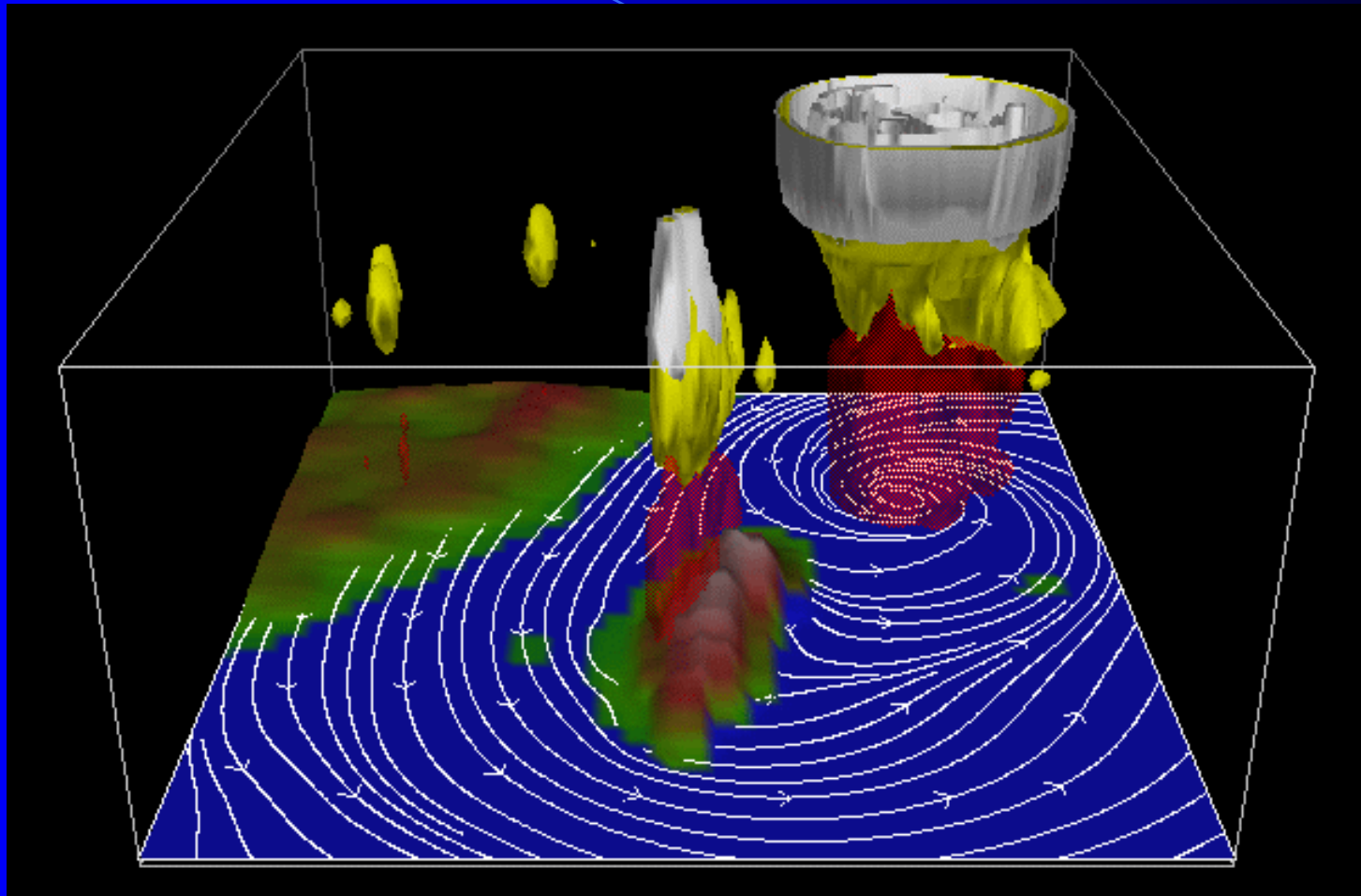Total precip. since h 0   sm= 1

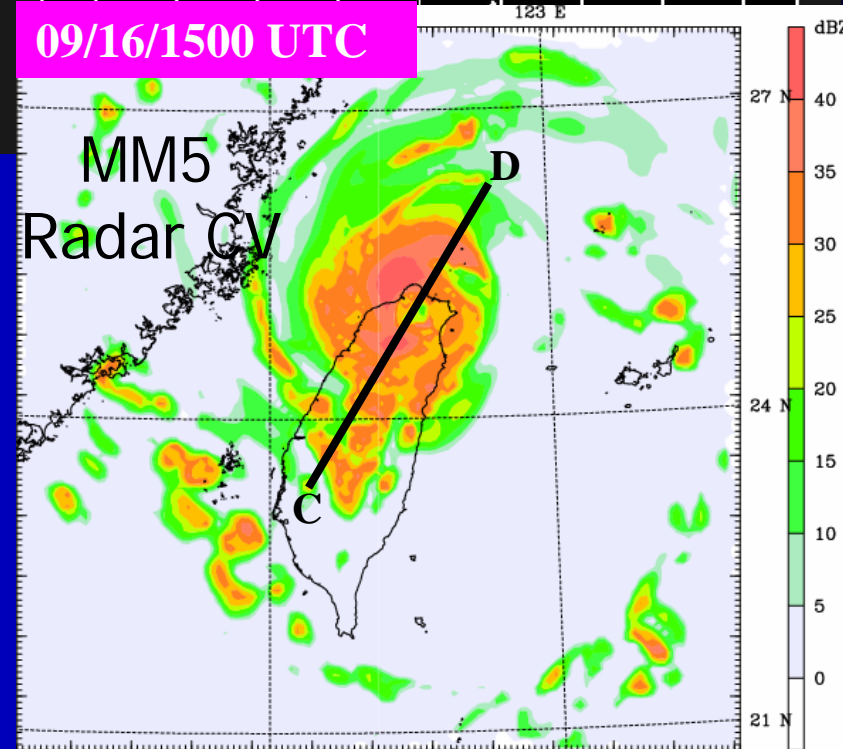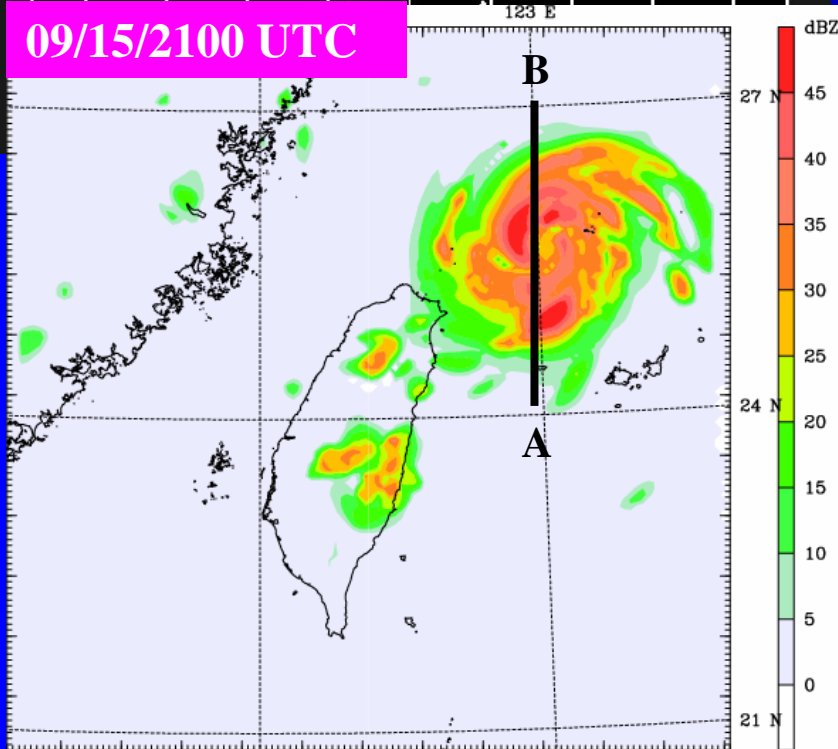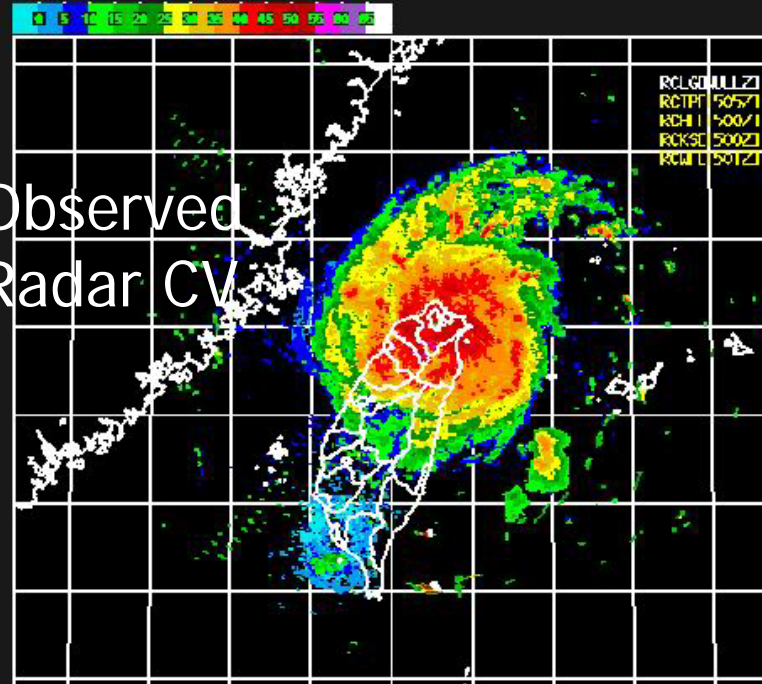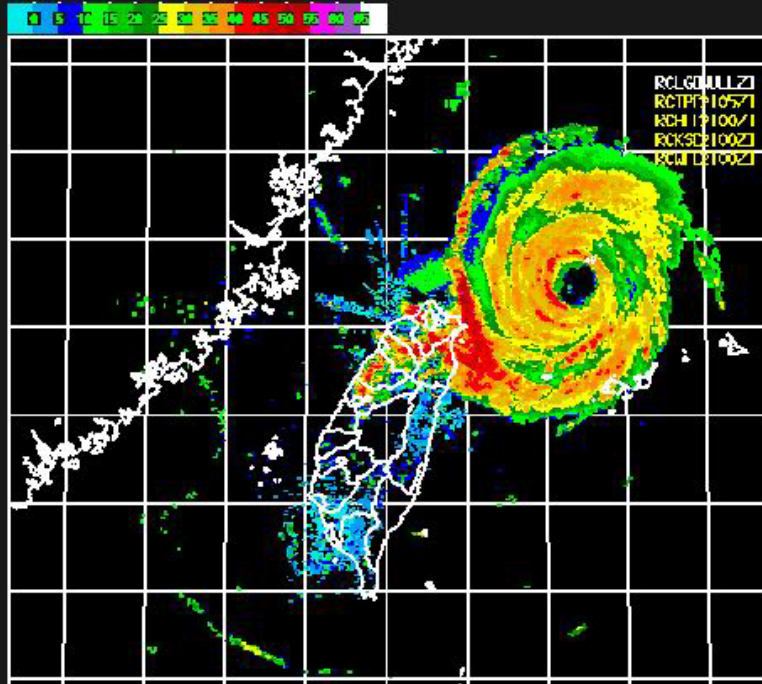Model info: V3.5.0 No Cumulus MRF PBL.   Reisner 2   2 km, 23 levels,   0 sec

MOSAIC CV(dBZ) 21:00Z 15-SEP-01

6.67-km MM5 Grid

Gray: Ice Yellow: Snow Light Red: Rain

Observed Radar CV

09/15/2100 UTC

09/16/1500 UTC

MM5 Radar CV
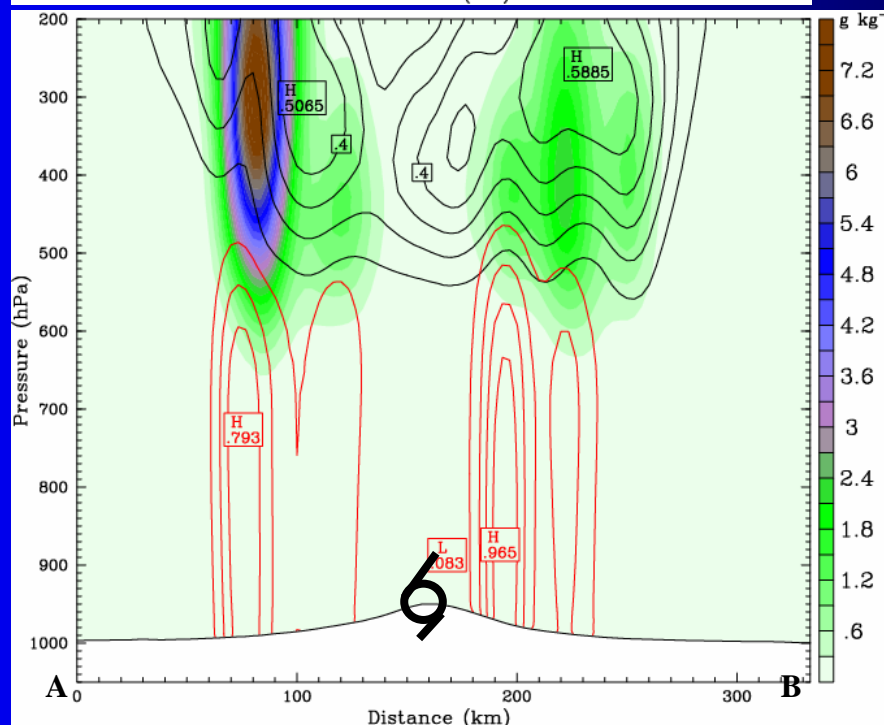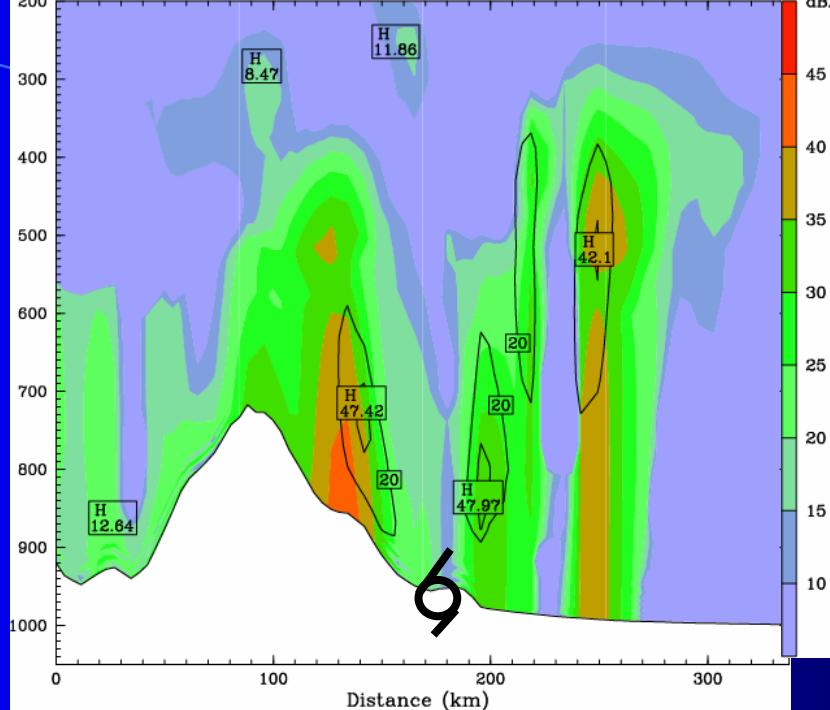
Vertical Cross Section over Ocean
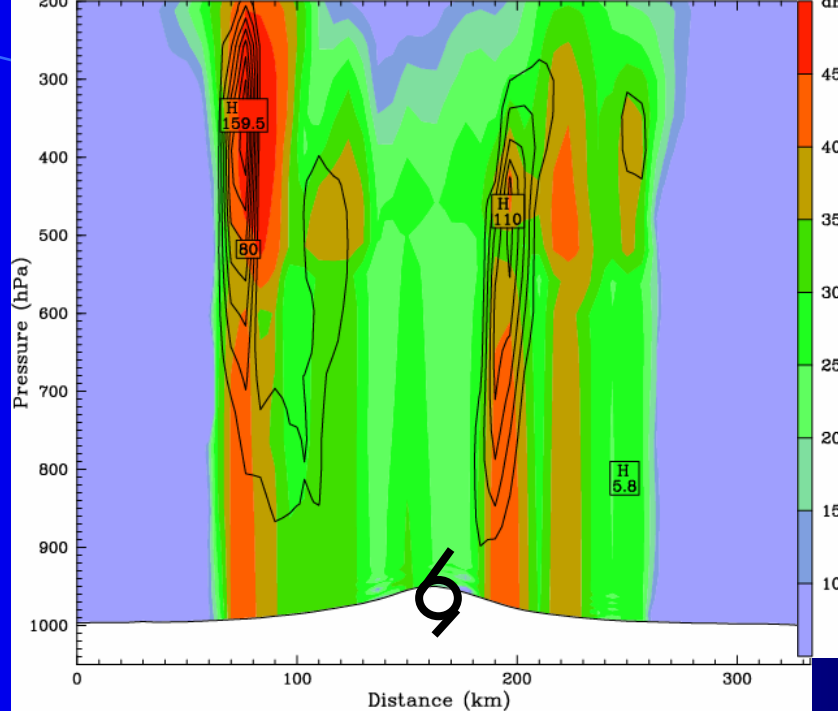
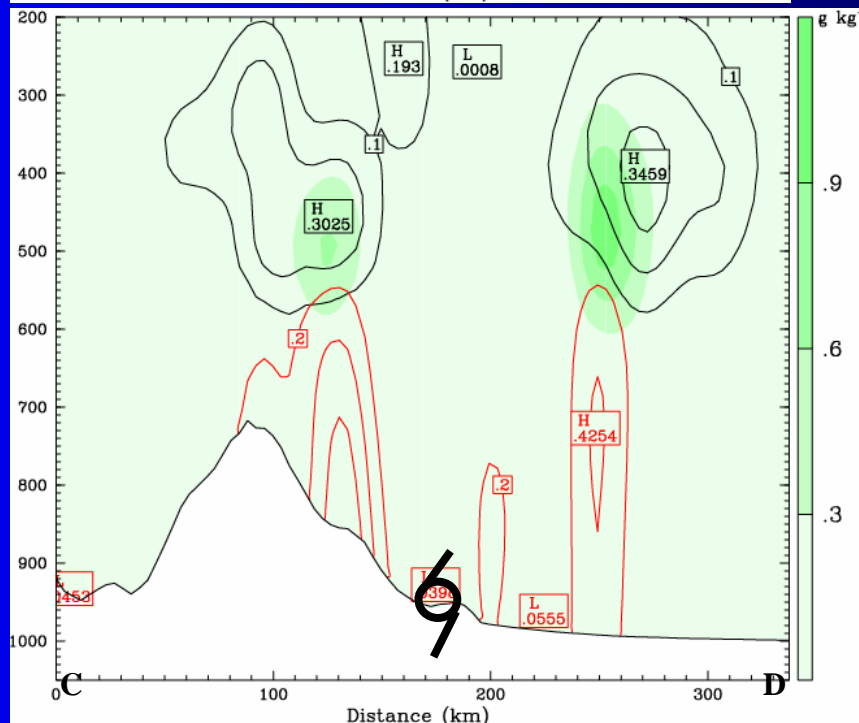Radar echo (color) Condensational Heating (contour)

Snow (black contour) Rain (red contour) Graupel (color)
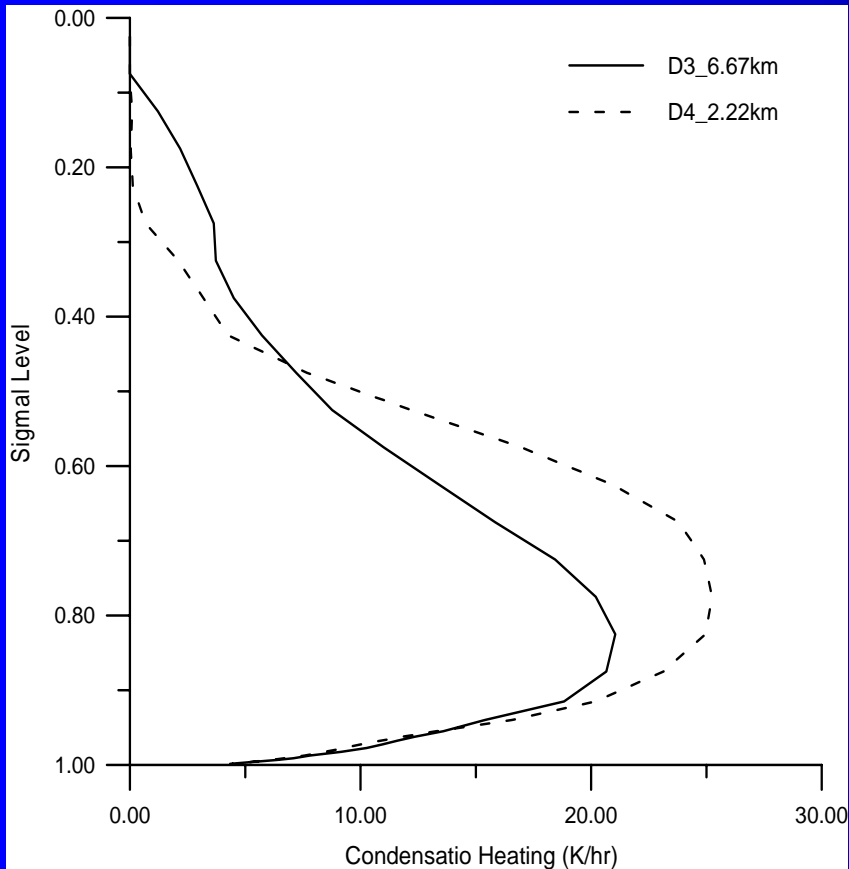
Vertical Cross Section after Landfall

Radar echo (color)
Condensational Heating (contour)

Snow (black contour)
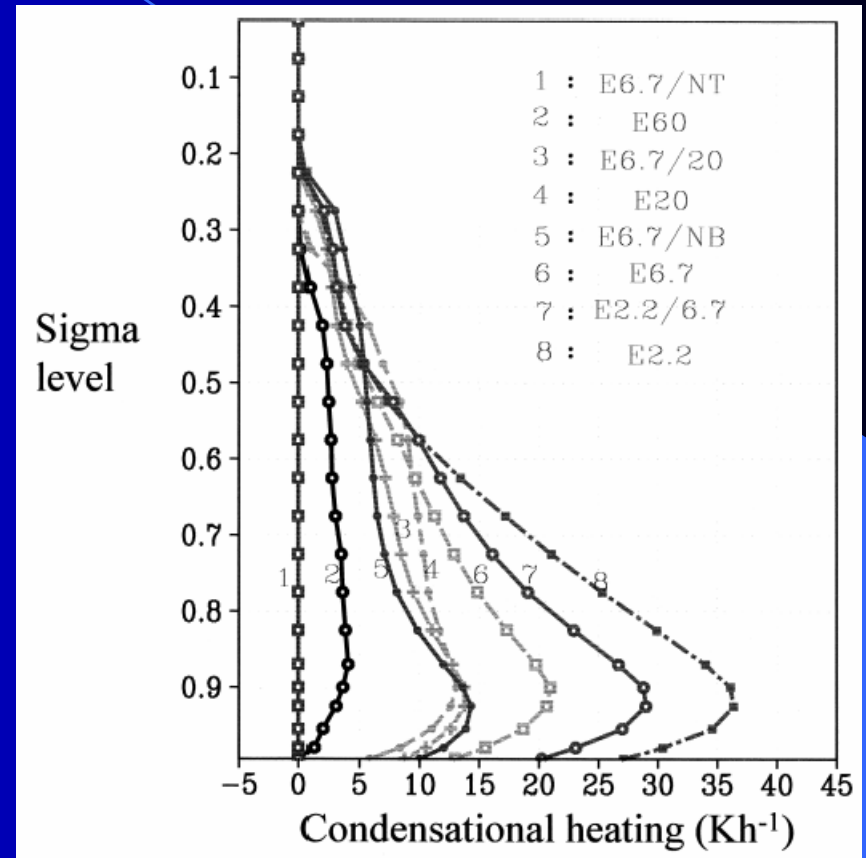Rain (red contour)
Graupel (color)

Vertical Profile of Condensational Heating

Nari (2001)

40 km x 40 km area avg.
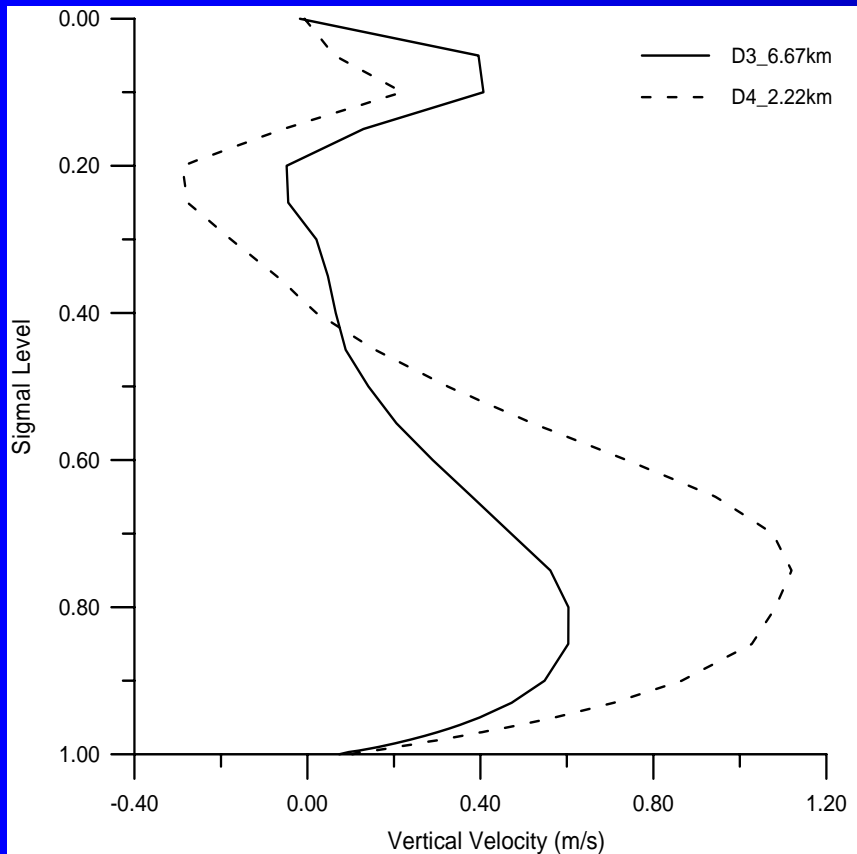
Herb (1996)

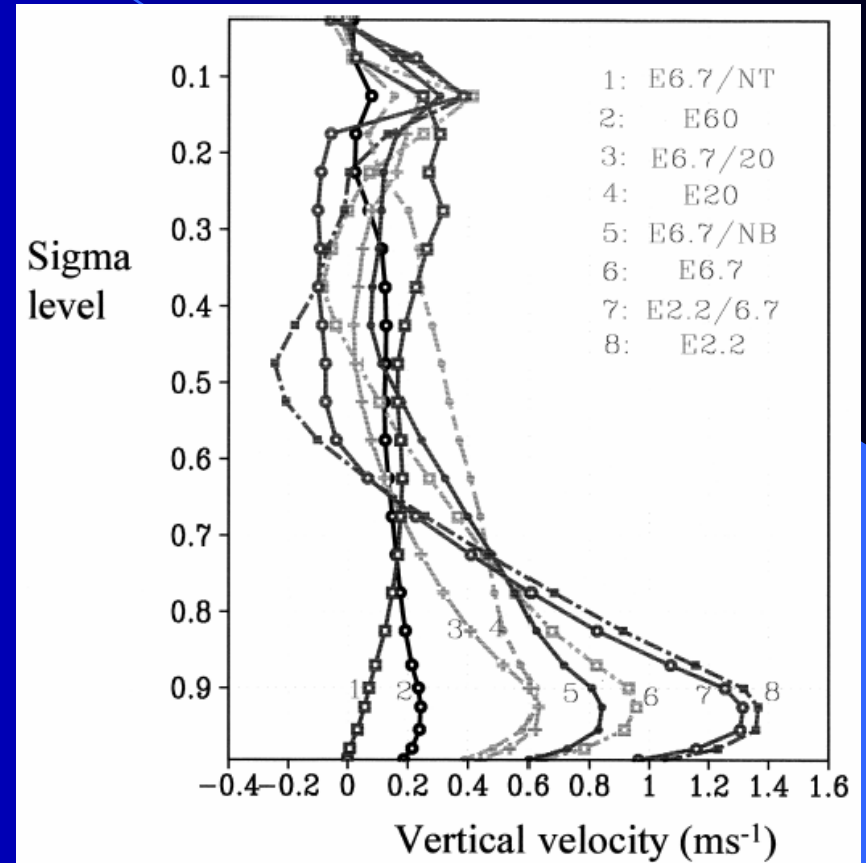Wu et al. (2002; WAF)

40 km x 40 km area avg.

24-h time avg.

Vertical Profile of Vertical Velocity

Nari (2001)
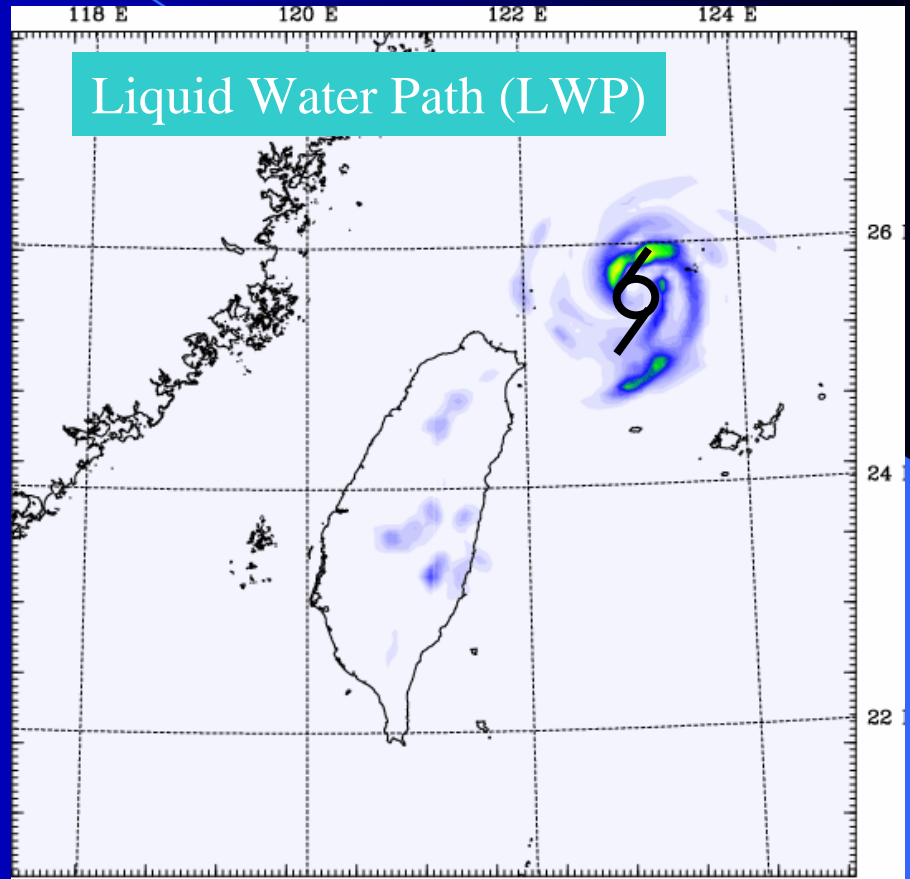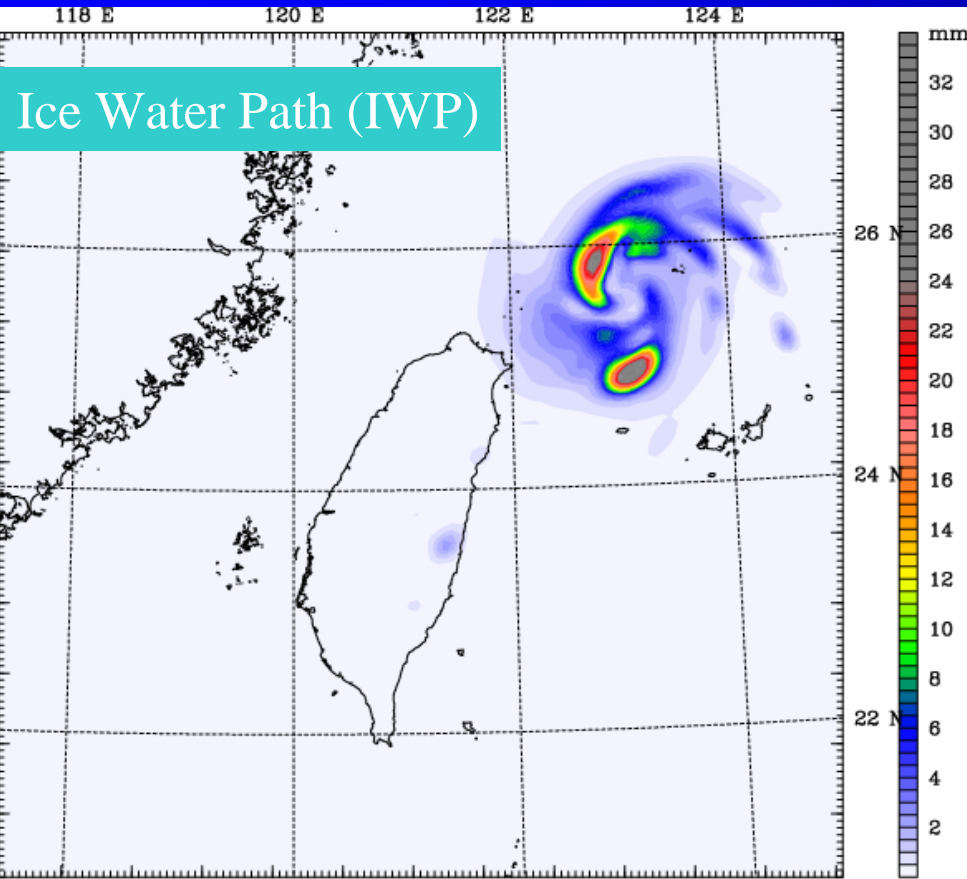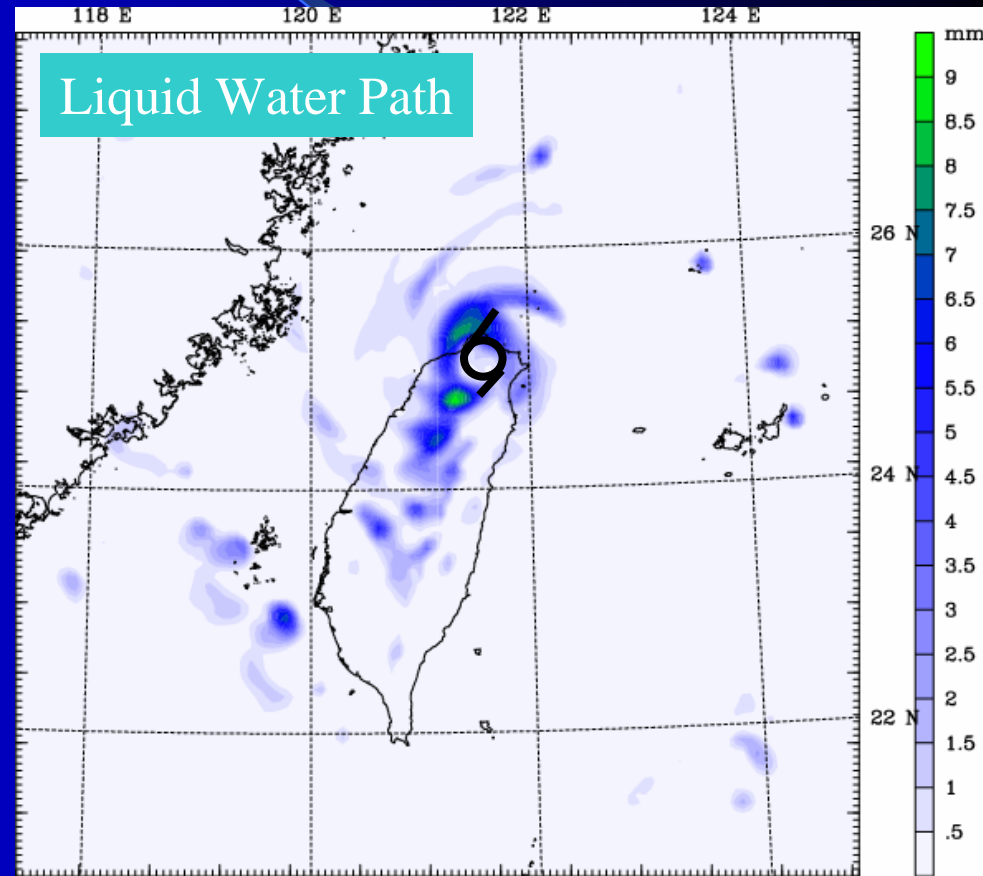

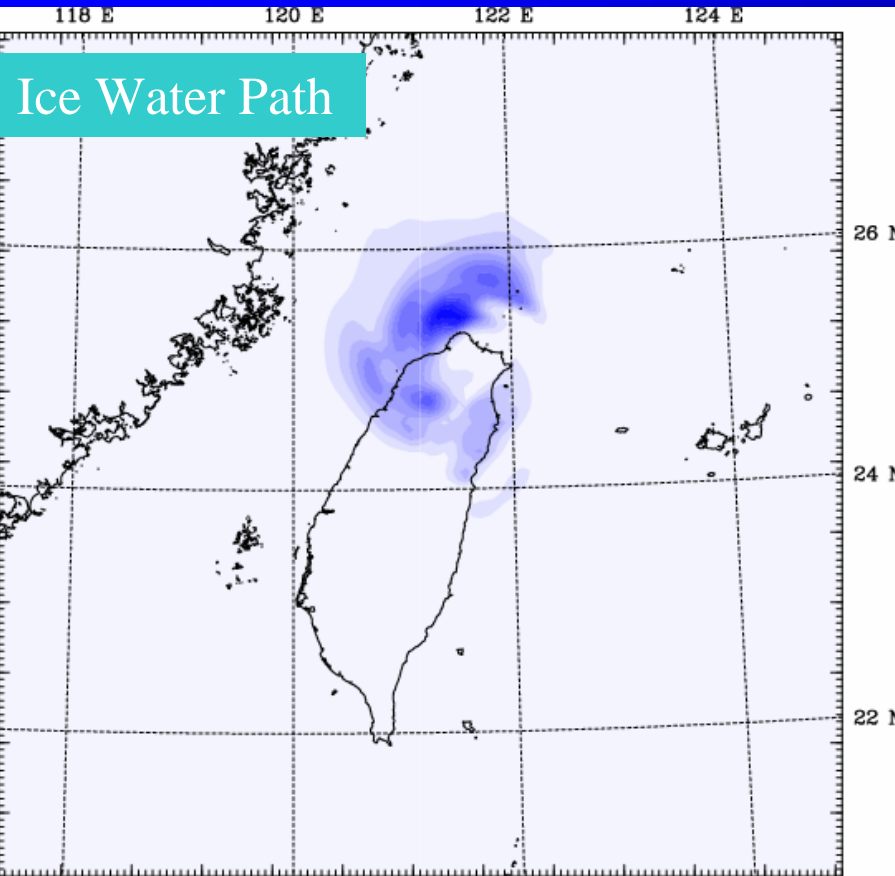40 km x 40 km area avg.

Herb (1996)

Wu et al. (2002; WAF)
40 km x 40 km area avg.
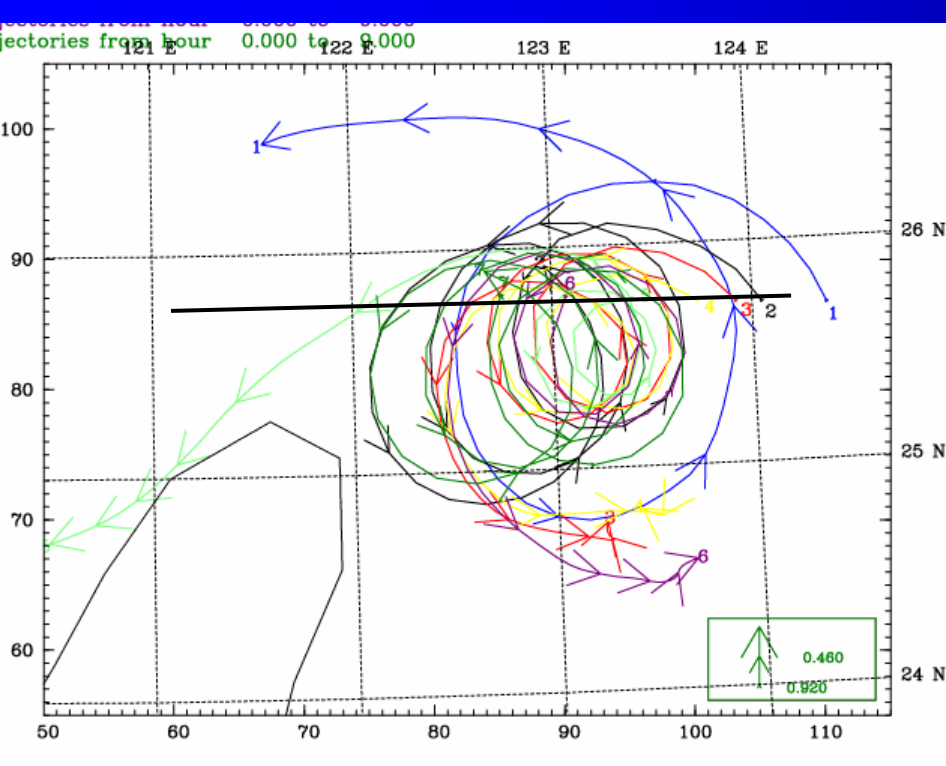24-h time avg.

09/15/2100 UTC
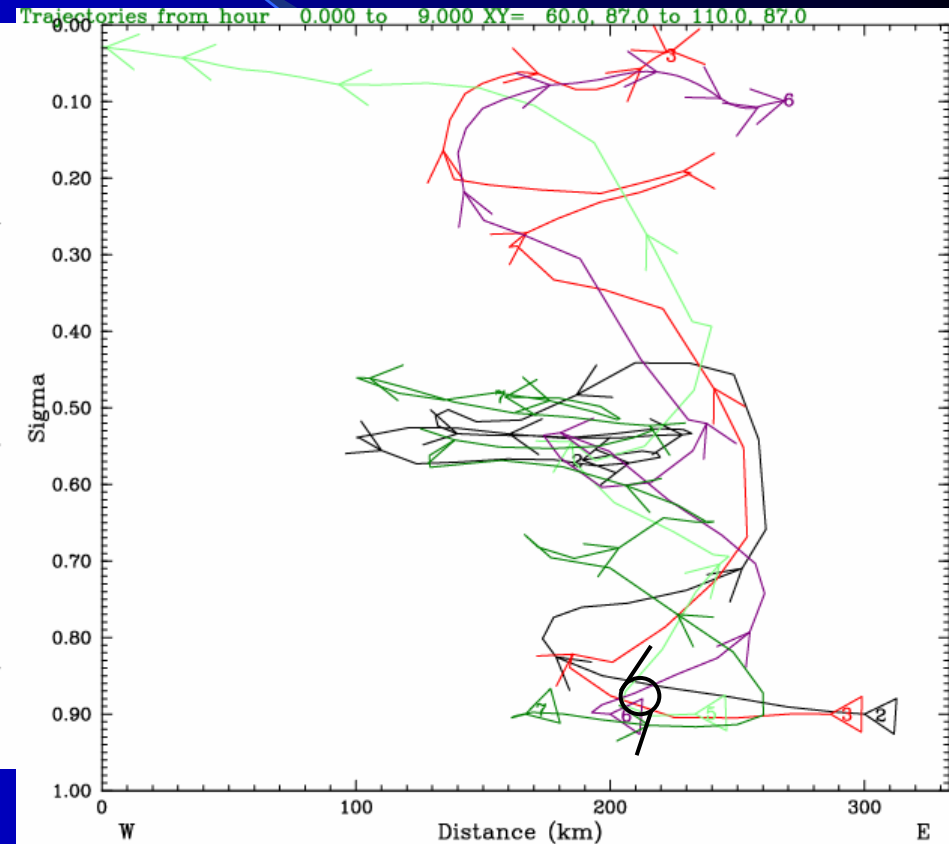
09/16/1500 UTC

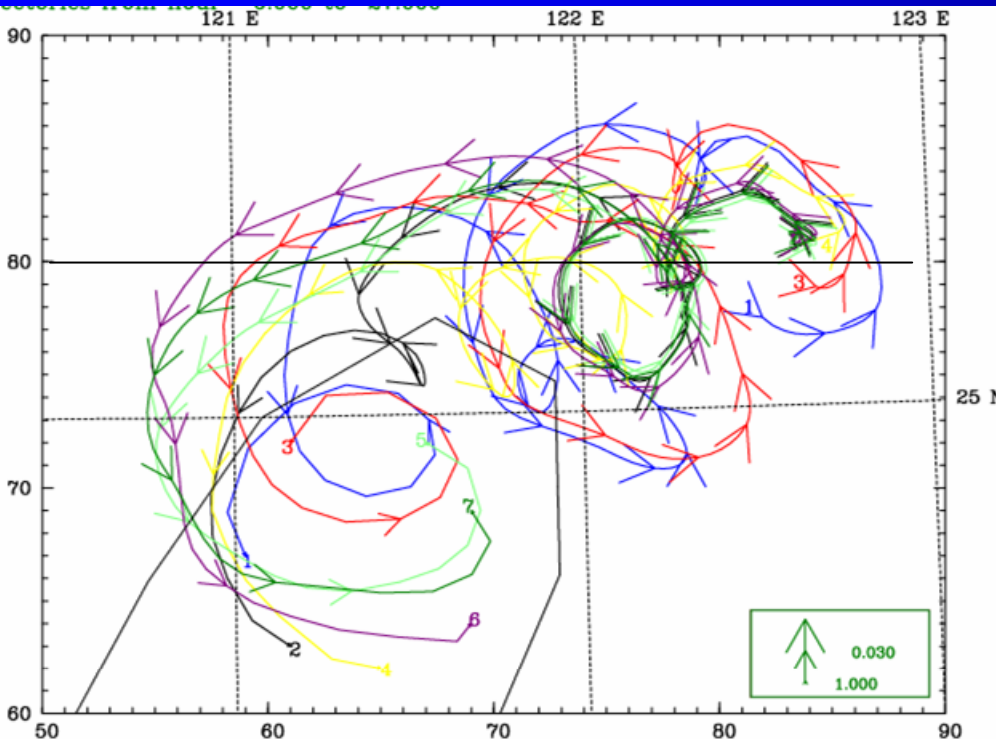# Nine-Hour Air-Parcel Trajectories when Nari is over Sea

Horizontal Cross Section
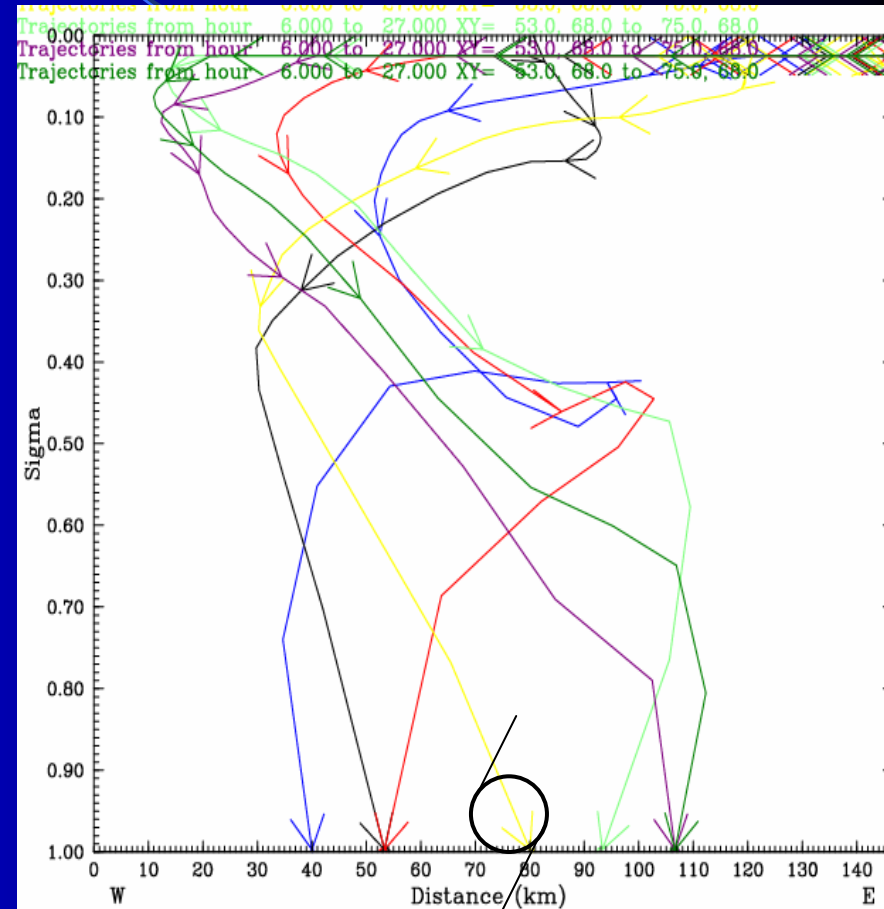
Vertical Cross Section

Twenty-One-Hour Backward Hydrometeor Trajectories

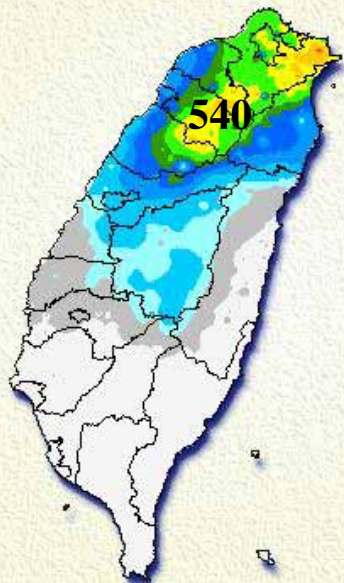## Horizontal Cross Section

Vertical Cross Section

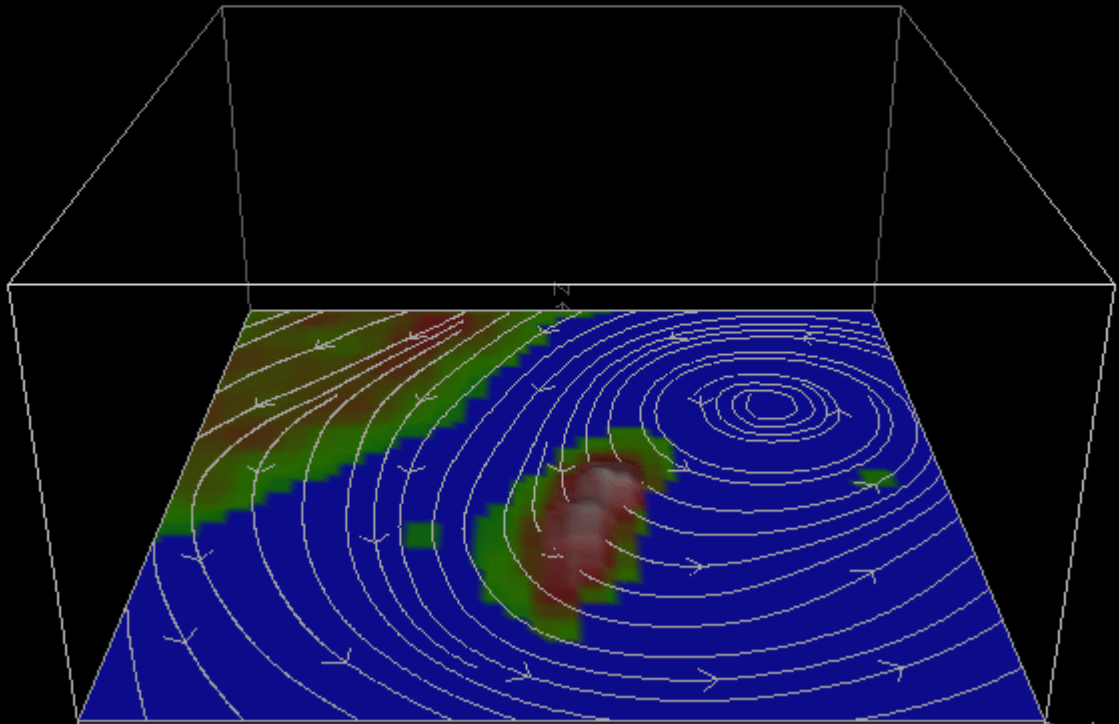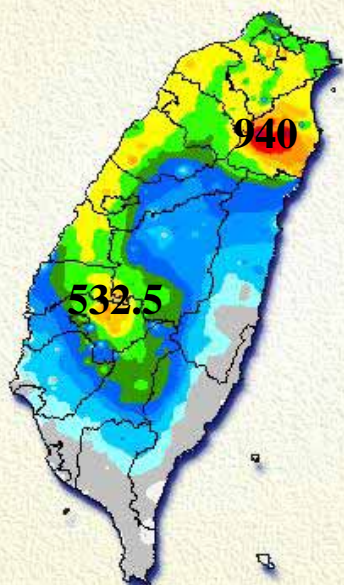# 24-h Hydrometeor Trajectory ending at Mt. Snow

48-h Hydrometeor Trajectory ending at I-Lan County

9/17 00:00 至 9/18 00:00

累積雨量圖
公厘（mm）

940

532.5

中央氣象局製

18:00:00
15 Sep 01
1 of 100
Saturday
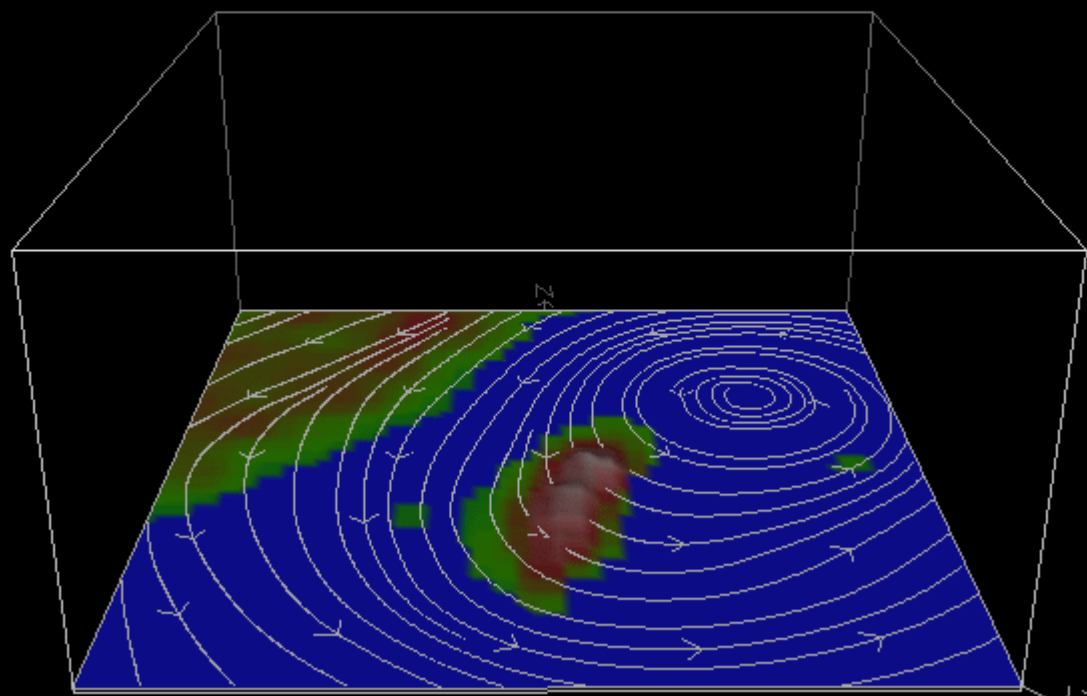
Summary

(1) With proper TC initialization and fine enough resolution, the MM5 can accurately simulate the track of Typhoon Nari, its landfall over northern Taiwan, and its weakening of central pressure after landfall.

(2) The ability of the model to successfully predict the observed rainfall maximum is increased with the refinement of grid size.

(3) Simulated temperature and pressure perturbations are in good agreement with those retrieved by radar data. Simulated vertical divergence profile also compares fairly with that estimated by radar observations.

Summary (cont.)

(4) Liquid-phase precipitation mainly occurs within eyewall and mountain slopes, and ice-phase precipitation occurs mostly in spiral rainbands.

(5) Hydrometeor trajectory analysis may shed some lights on the high precipitation efficiency over Mt. Snow.