A comparison study of precipitation simulation using different WRF microphysics schemes for the SoWMEX IOP-4 case

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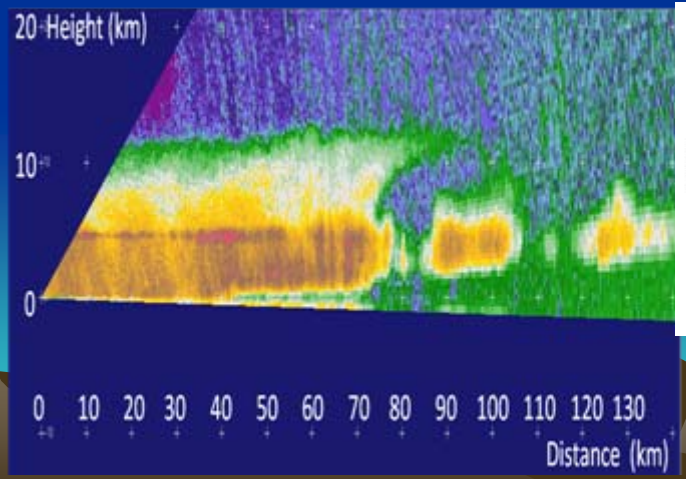
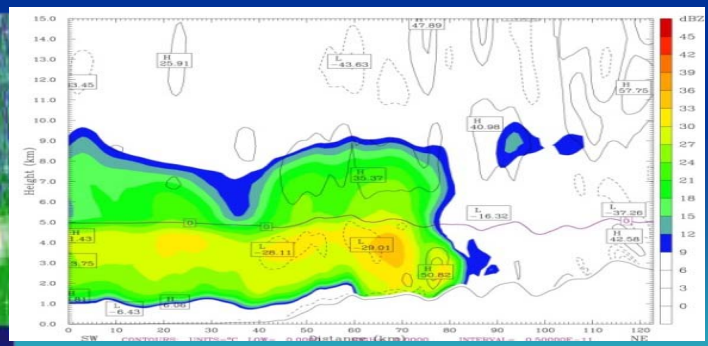
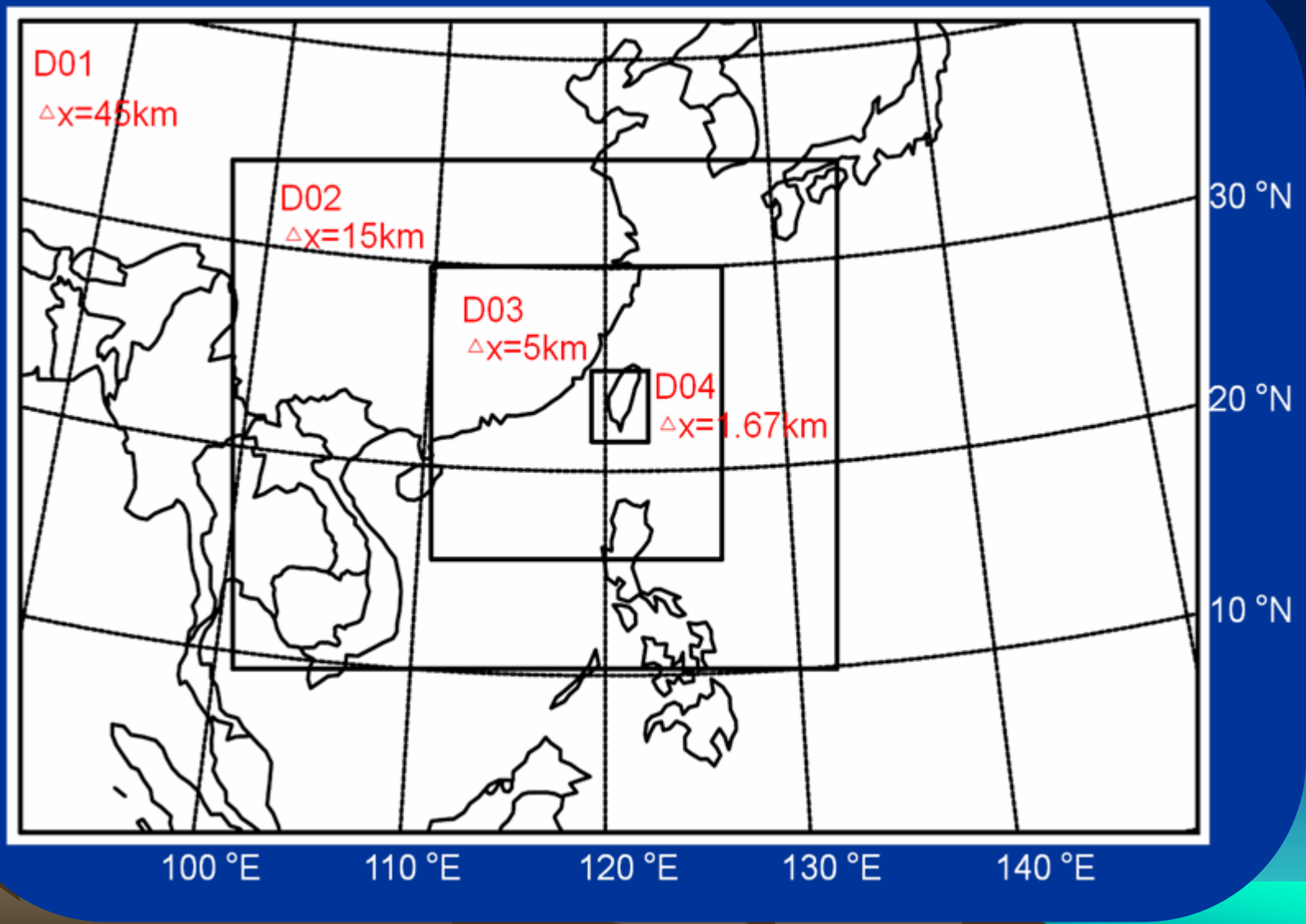




Objectives

1) To investigate the capability of WRF model with the finest resolution of 1.67 km to simulate the synoptic environment, kinematic and precipitation characteristics associated with the SoWMEX IOP-4 event
2) To examine the sensitivity of different microphysics schemes on the simulated precipitation features

WRF Domains


D01
△x=45km
D02
△x=15km
D03
△x=5km
D04
△x=1.67km
30 °N
20 °N
10 °N
100 °E
110 °E
120 °E
130 °E
140 °E

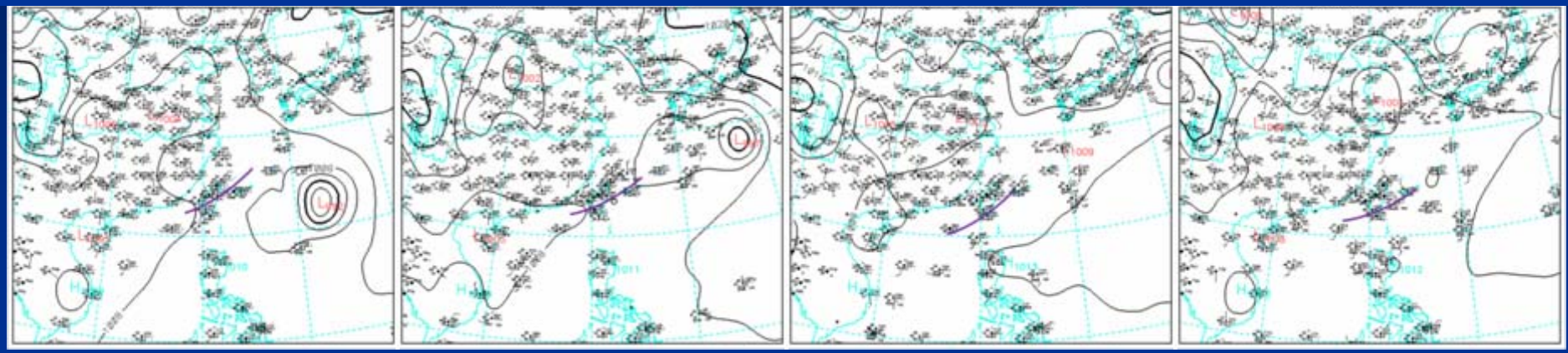
Model Configuration

Version	WRF V3.1
Fcst Period	60 h
Cumulus	Grell-Devenyi (2002)
Microphysics	WSM6, Morrison, Thompson, WDM6
PBL	YSU
Radiation	RRTM for longwave Dudhia (1989) for shortwave
I.C.	NCEP/FNL analysis $1^{\circ} \times 1^{\circ}$ (2008/06/01 1200 UTC)
B.C.	NCEP/FNL analysis $1^{\circ} \times 1^{\circ}$

Synoptic Evolution

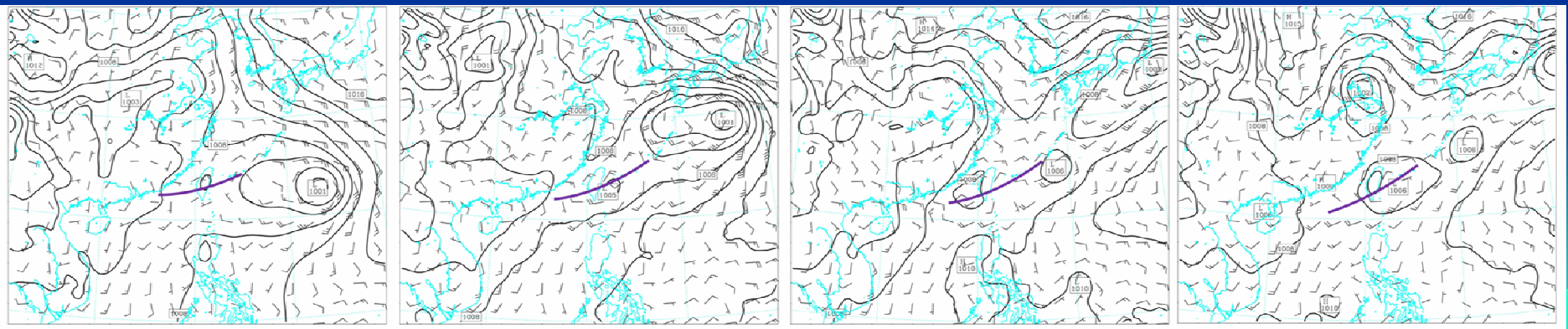
CWB Analysis

2008/6/1 1200UTC 2008/6/2 1200UTC 2008/6/3 1200UTC 2008/6/4 0000UTC



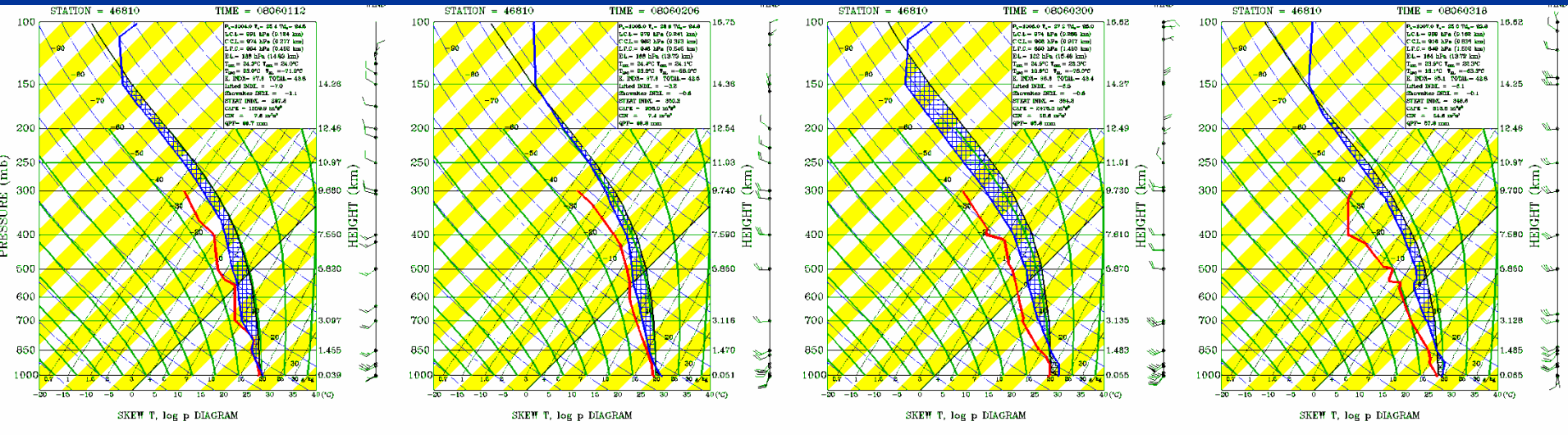
WRF Forecast

2008/6/1 1200UTC 2008/6/2 1200UTC 2008/6/3 1200UTC 2008/6/4 0000UTC



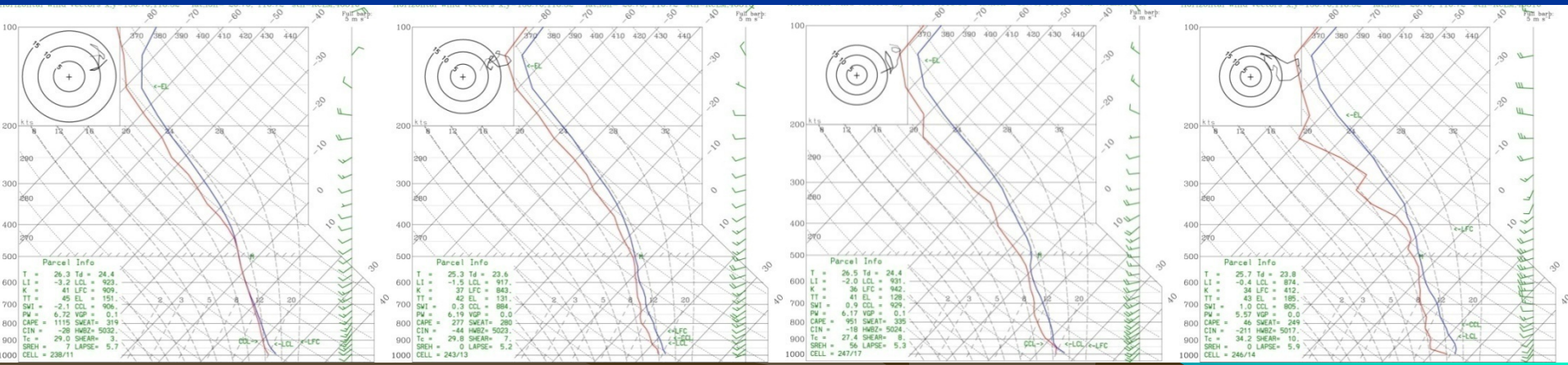
Dongsha Sounding (Observed)

2008/6/1 1200UTC 2008/6/2 0600UTC 2008/6/3 0000UTC 2008/6/3 1800UTC



Dongsha Sounding (Simulated)

2008/6/1 1200UTC 2008/6/2 0600UTC 2008/6/3 0000UTC 2008/6/3 1800UTC



Wind speeds below 700 hPa for the Dongsha Sounding

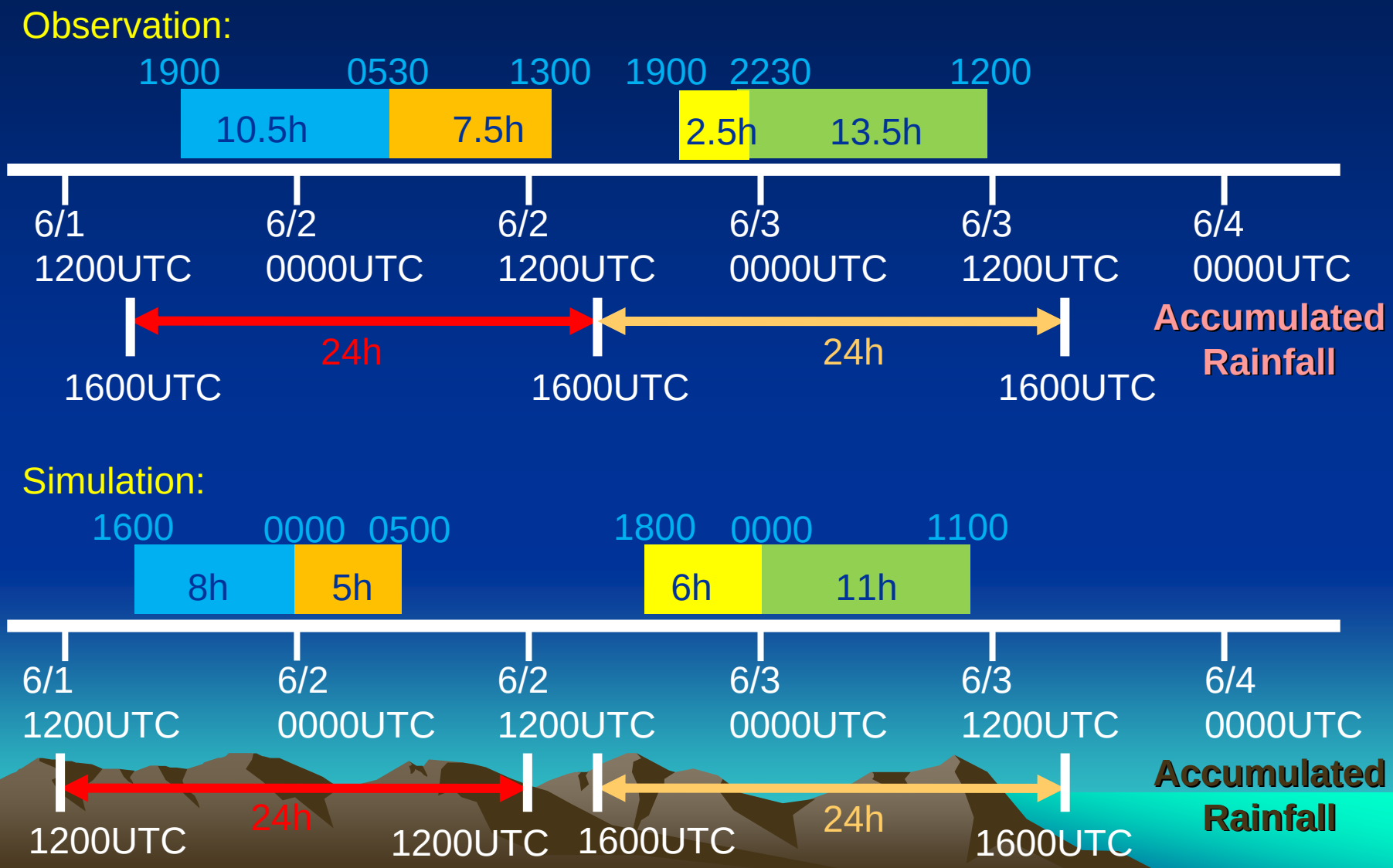
東沙島探空 700hPa以下 觀測風速與模擬風速平均值

	6/1		6/2				6/3				6/4	AVG
	1200	1800	0000	0600	1200	1800	0000	0600	1200	1800	0000	
O	20.00	16.67	21.67	24.00	25.71	22.50	32.14	-	20.71	13.86	20.71	21.80
S	14.00	22.00	16.00	12.50	13.00	17.00	22.50	15.50	11.50	11.00	18.00	15.73
S/O	0.70	1.32	0.74	0.52	0.51	0.76	0.70	-	0.56	0.79	0.87	*0.72*

=> 模擬風速較觀測風速弱約30%　　(unit: kts)

➔Simulated wind speed is weaker than the observed speed by ~30%!

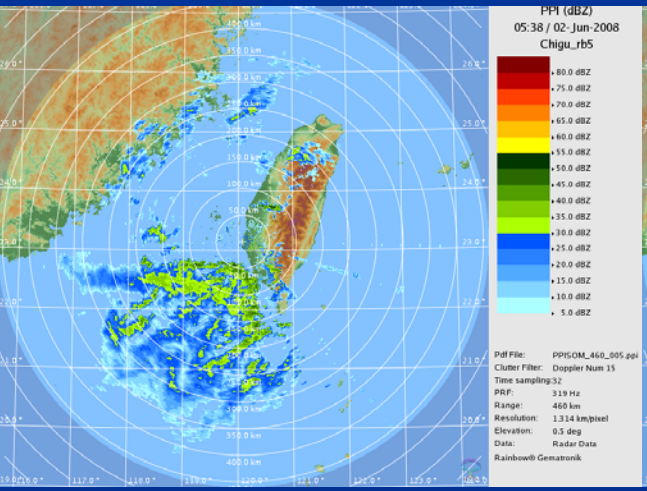
Rainfall Episode Periods



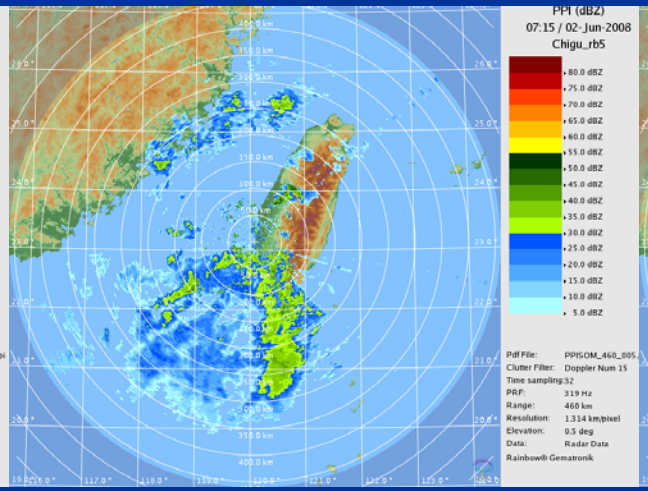
Precipitation Evolution

Observed Reflectivity from Chi-Ku Radar

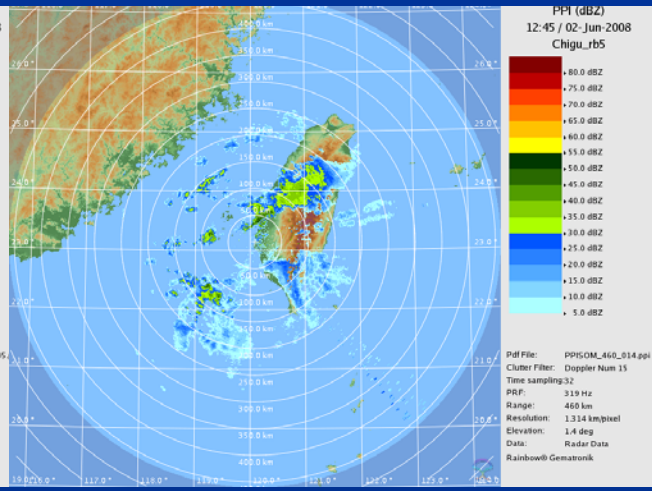
2008/6/2 0538UTC



2008/6/2 0715UTC

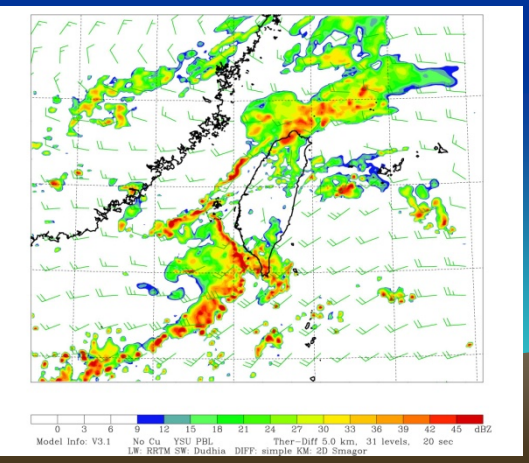


2008/6/2 1245UTC

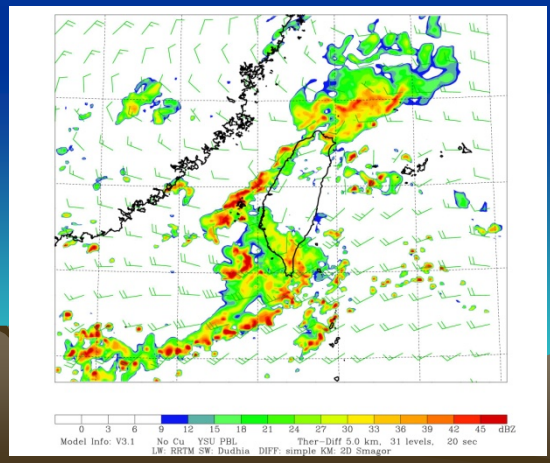


Simulated Reflectivity on the WRF 5-km grid

2008/6/2 0000UTC



2008/6/2 0200UTC



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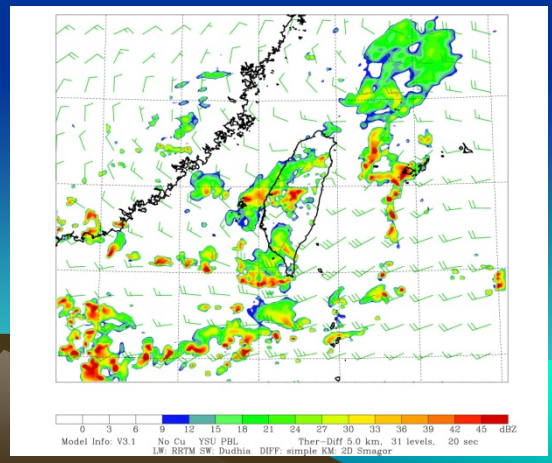
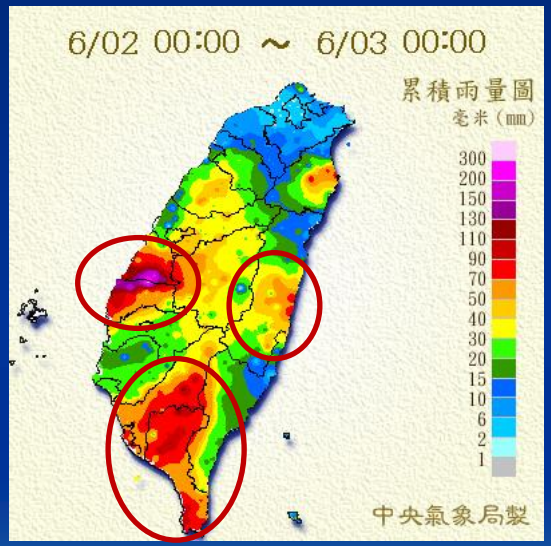
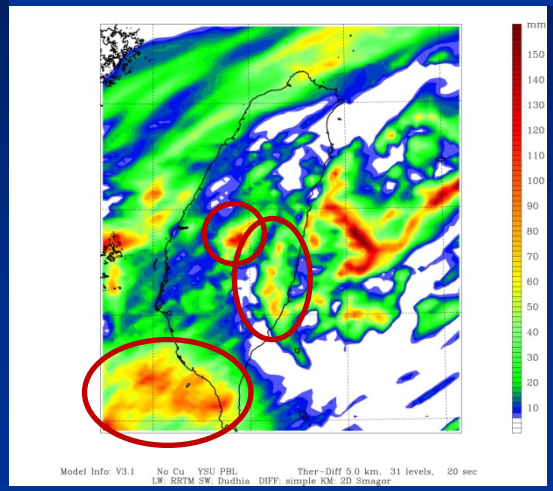


24-h rainfall for the first rainfall episode

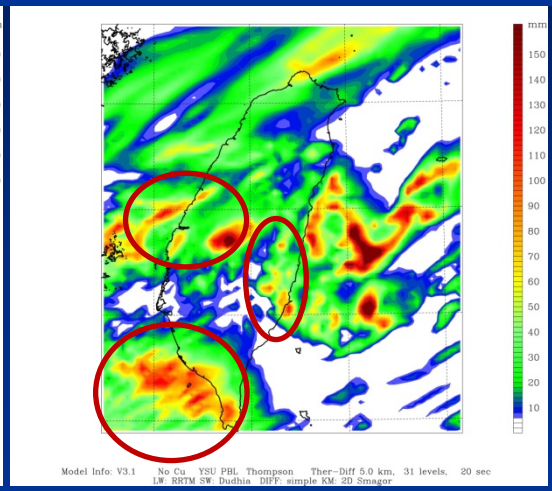
OBS



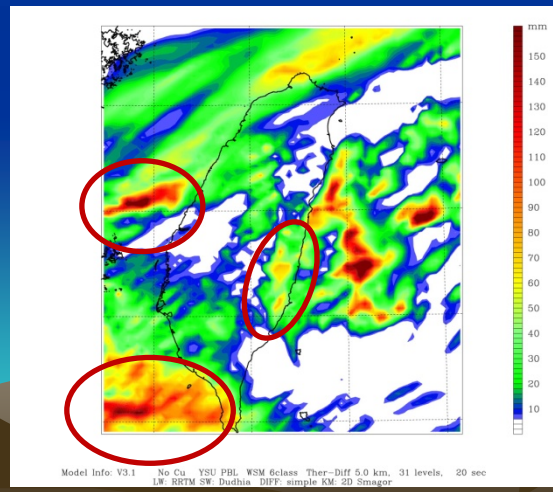
MORI



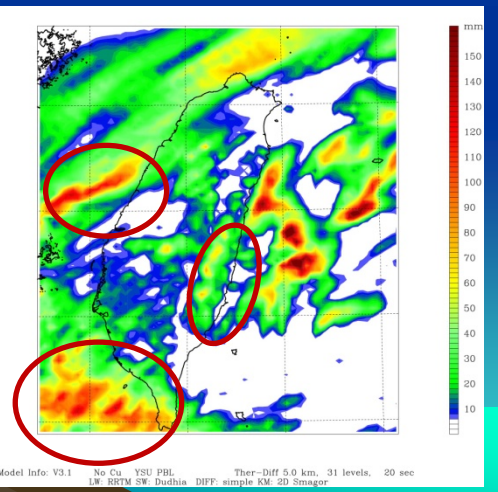
THMN



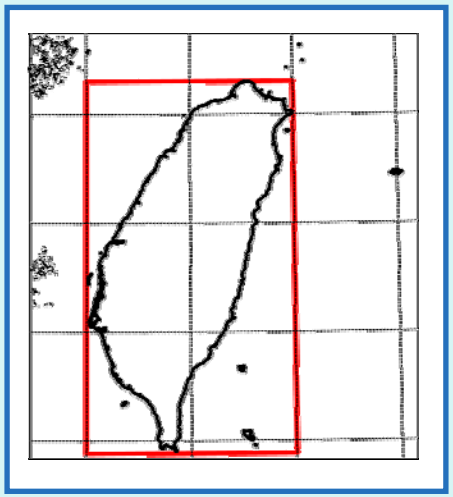
WSM6



WDM6



Accumulated rainfall on the island is under-predicted by the WRF.



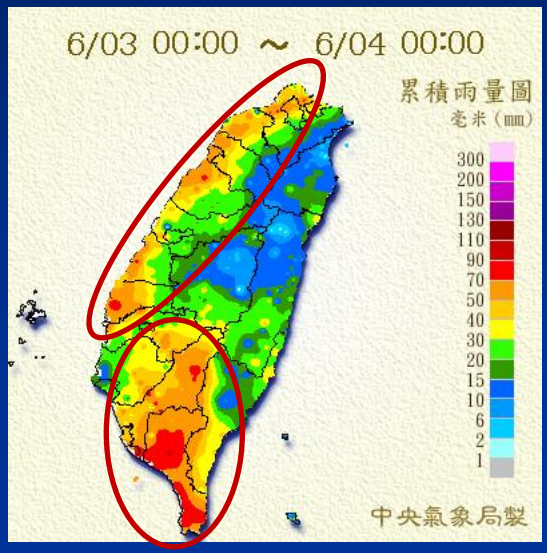
模式低估雨量之百分比

OBS	SIM_avg	SIM_avg/OBS×100%
36.08mm	24.86mm	69%

	MORI	THMN	WSM6	WDM6
Simulated rainfall	24.64mm	27.56mm	24.63mm	22.60mm
SIM/OBS× 100%	68.29%	76.39%	68.26%	62.64%

24-h rainfall for the second rainfall episode

OBS



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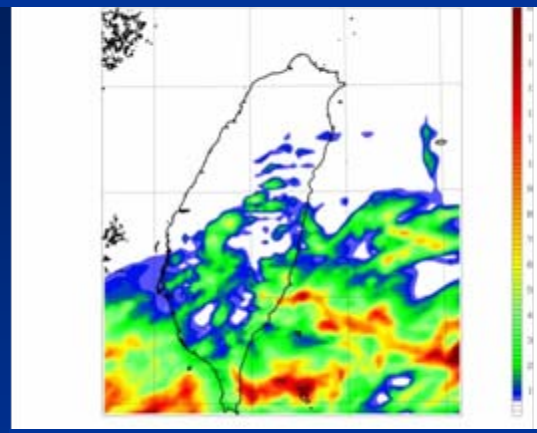
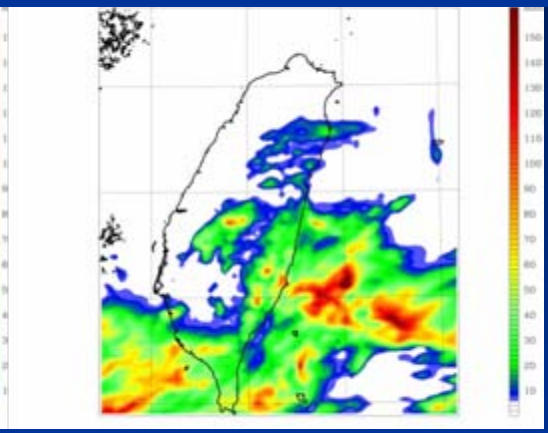


THMN



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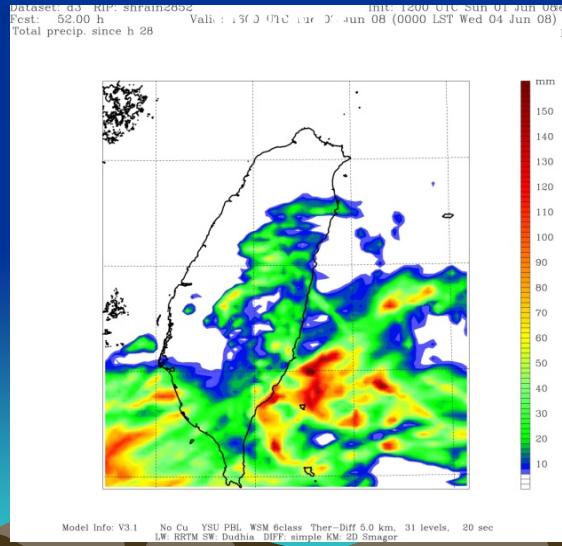

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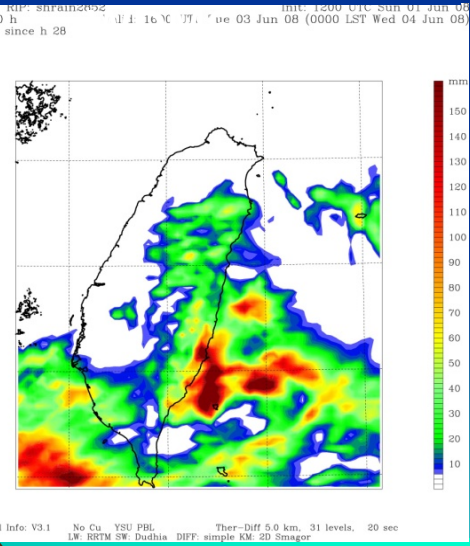
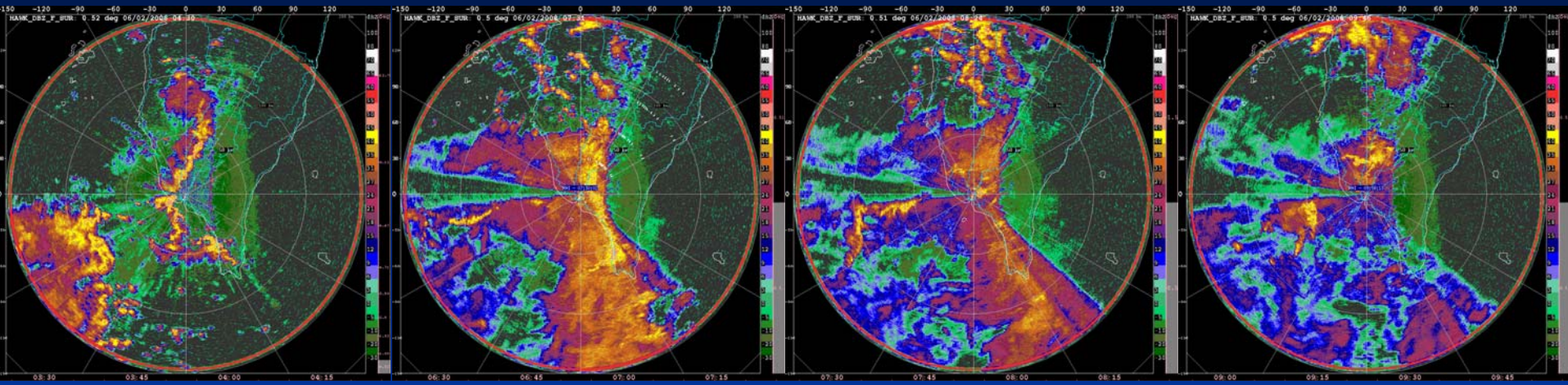
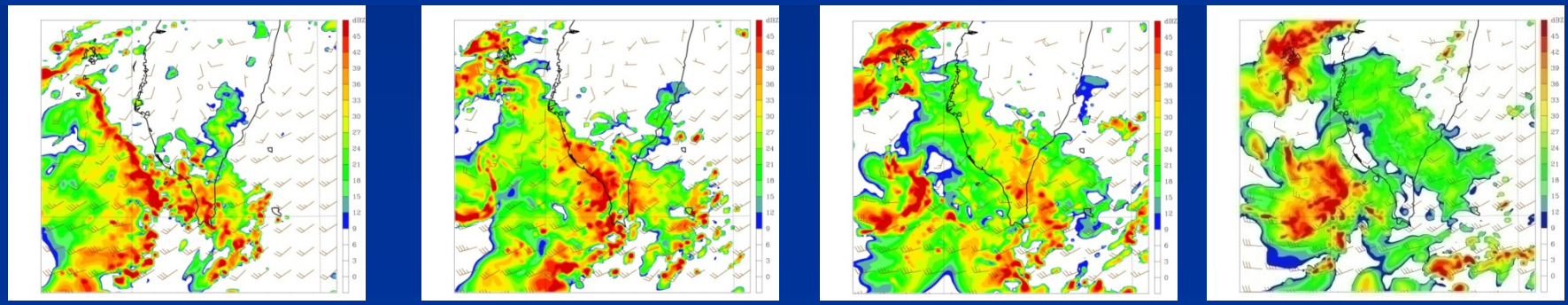


S-Pol Observation vs. WRF Simulation

6/2 0430UTC | 6/2 0731UTC | 6/2 0824UTC | 6/2 0946UTC



MORI 6/2 0000UTC | 6/2 0100UTC | 6/2 0200UTC | 6/2 0300UTC



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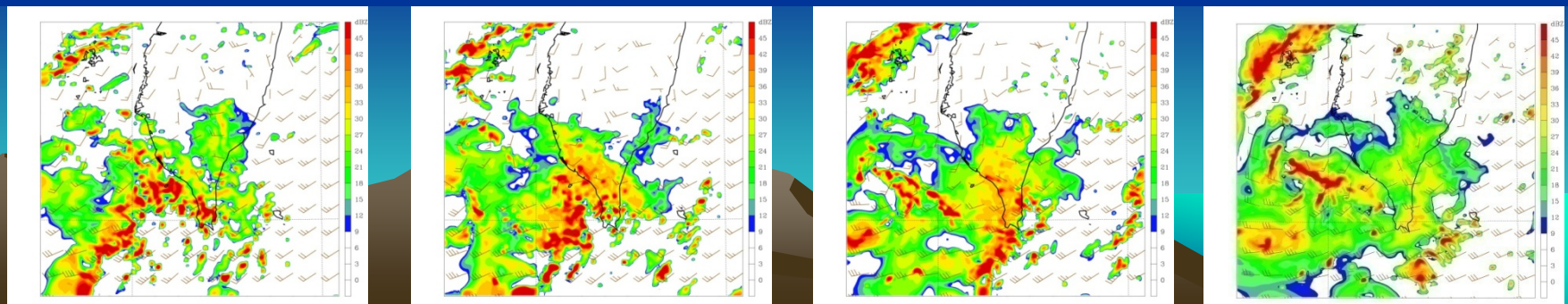

S-Pol Observation vs. WRF Simulation

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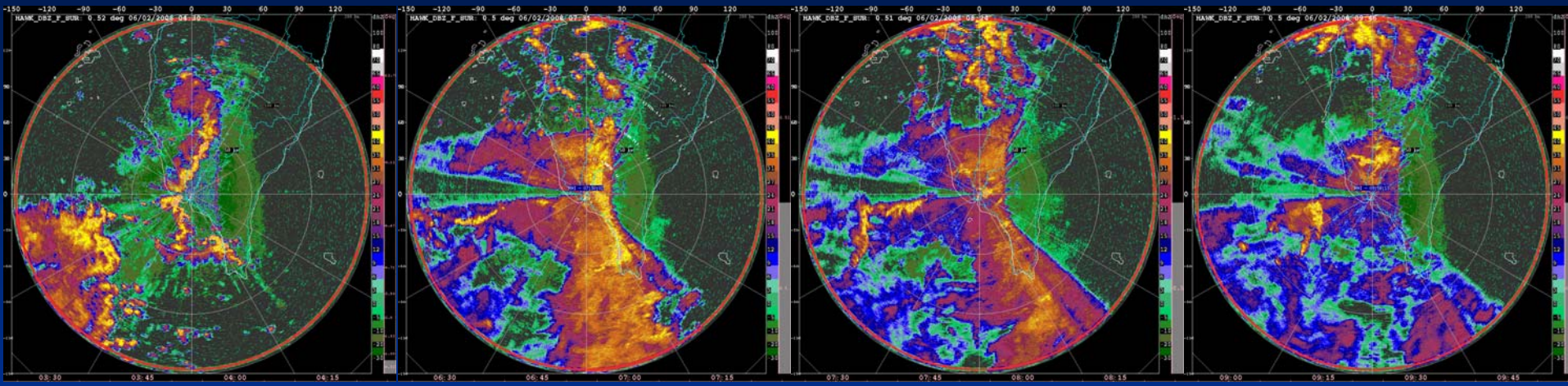
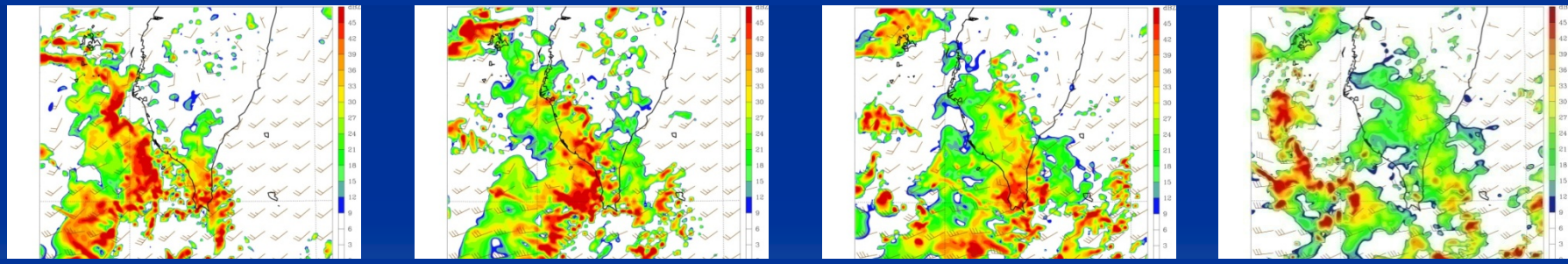


WSM6 6/1 2300UTC | 6/2 0000UTC | 6/2 0100UTC | 6/2 0200UTC



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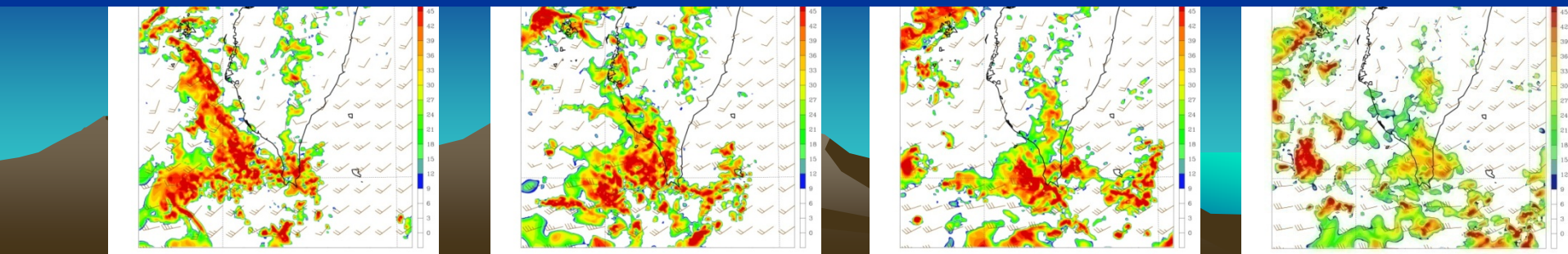
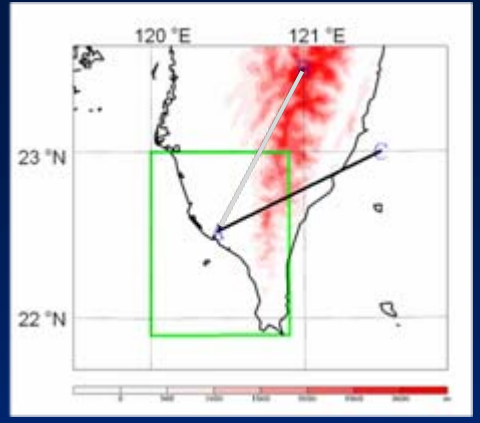
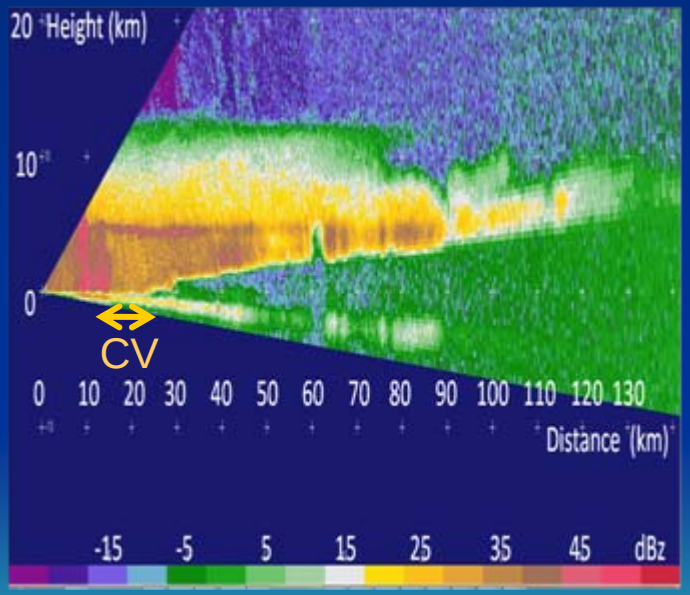


Convective Precipitation

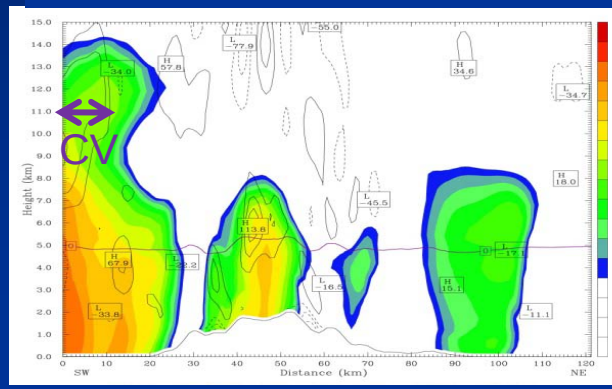


AC Cross Section

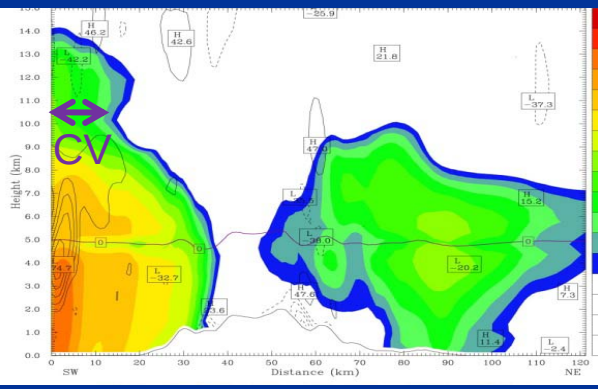
6/2 0729UTC 60°



MORI



THMN



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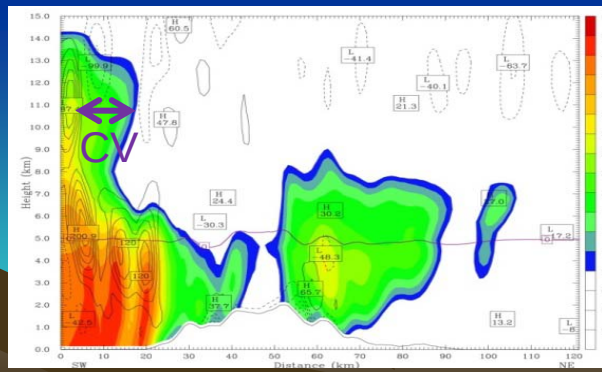

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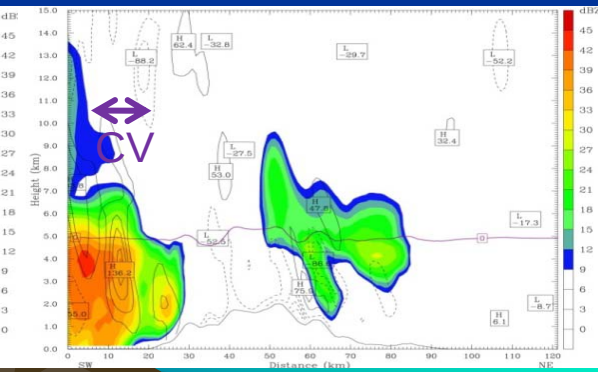
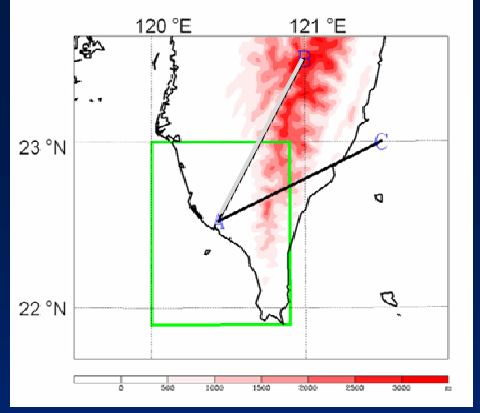
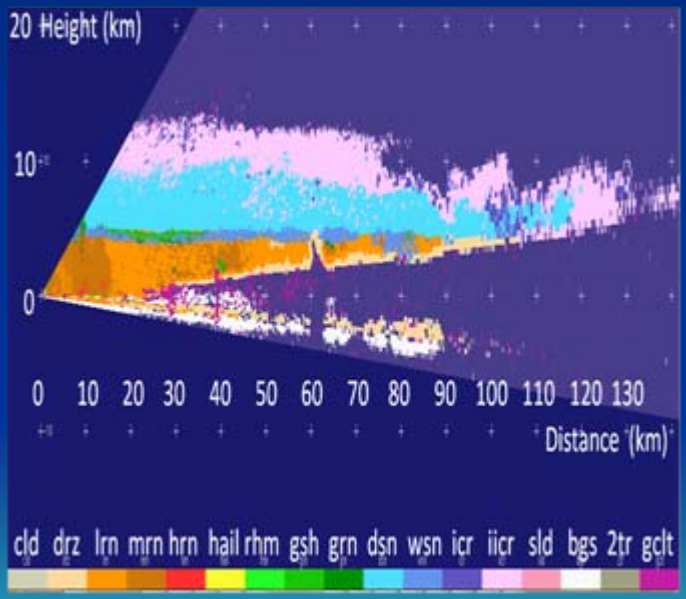


Hydrometeor Classification



AC Cross Section

6/2 0729UTC 60˚



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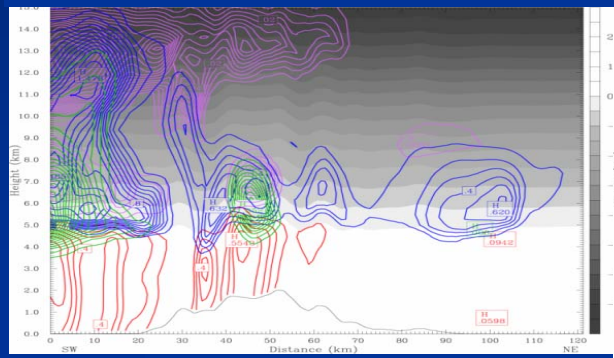

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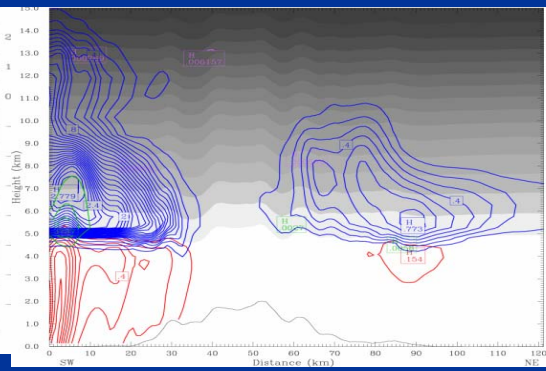

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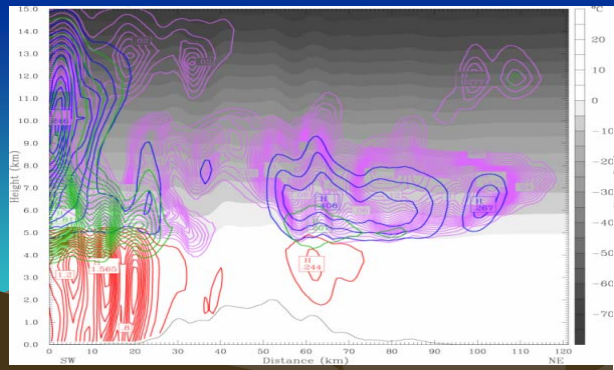

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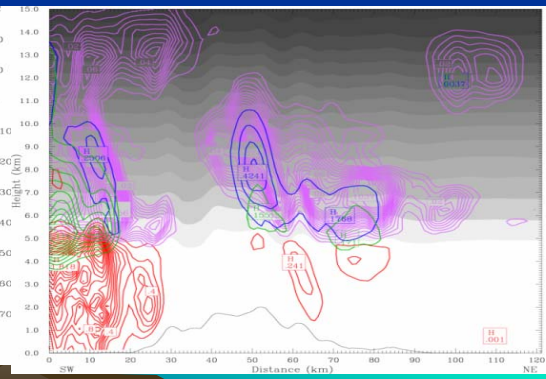

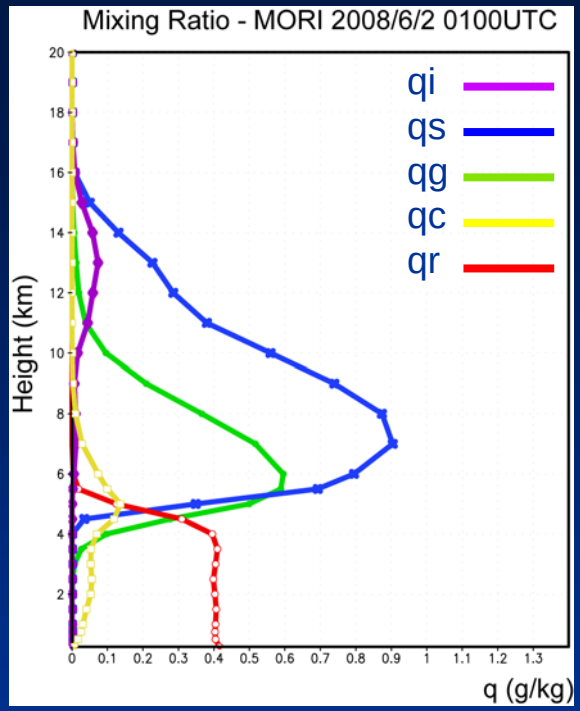
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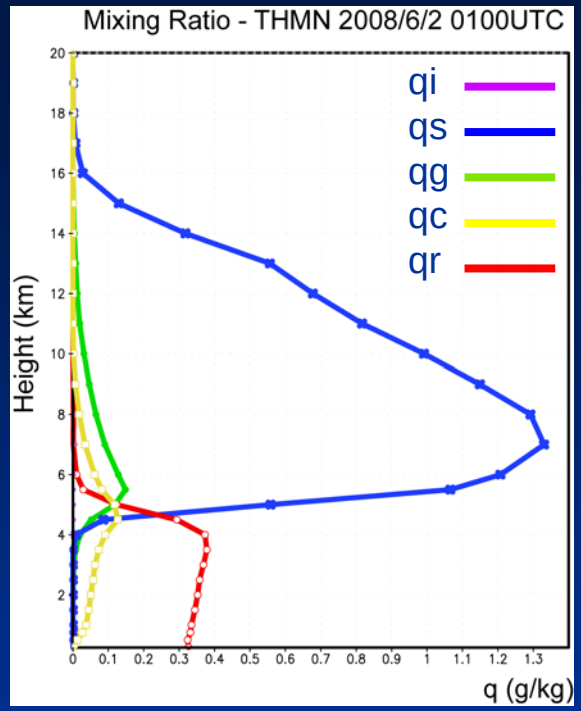
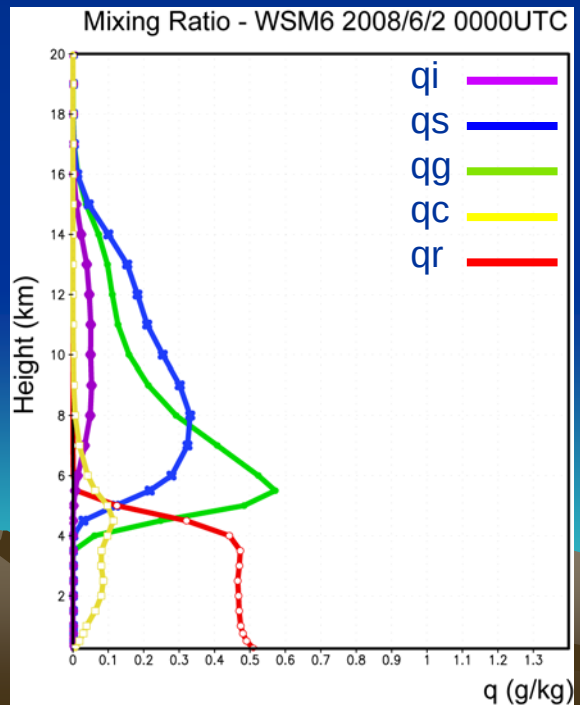
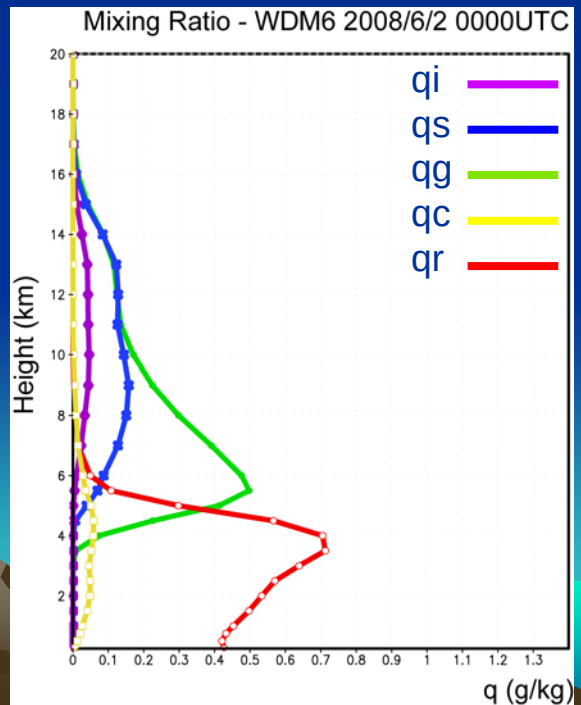
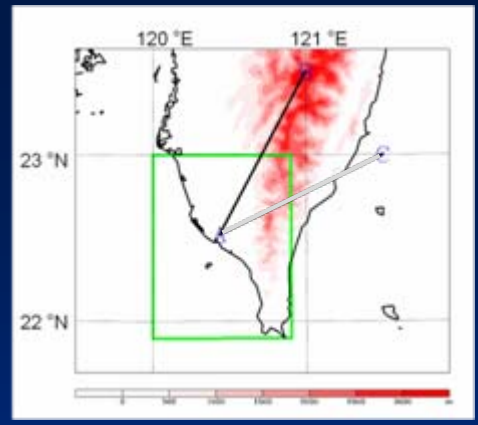
qi
qs
qg
qc
qr
Height (km)
q (g/kg)


Mixing Ratio - THMN 2008/6/2 0100UTC
qi
qs
qg
qc
qr
Height (km)
q (g/kg)


Mixing Ratio - WSM6 2008/6/2 0000UTC
qi
qs
qg
qc
qr
Height (km)
q (g/kg)

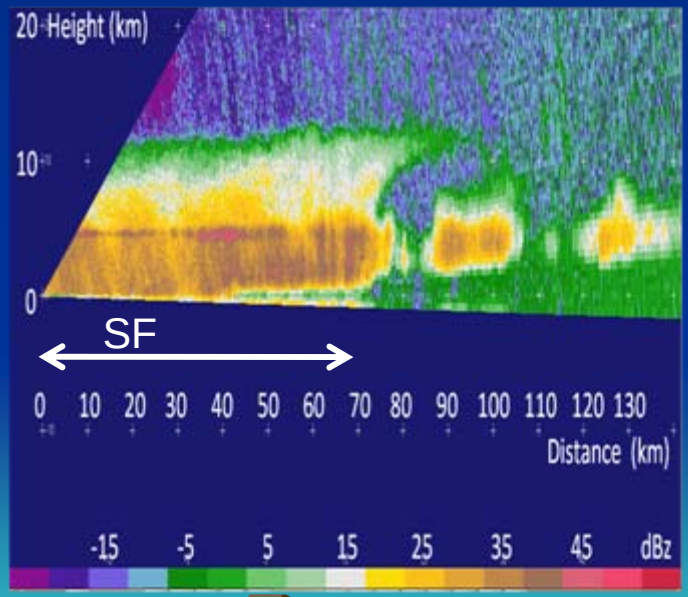

Mixing Ratio - WDM6 2008/6/2 0000UTC
qi
qs
qg
qc
qr
Height (km)
q (g/kg)

Stratiform Precipitation

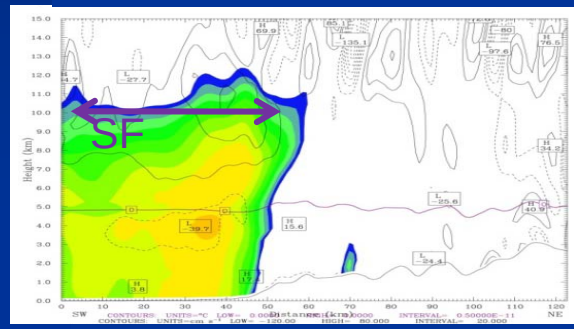


AB Cross Section

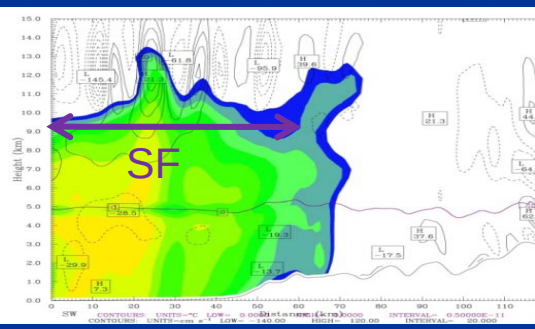
6/2 0750UTC 30˚



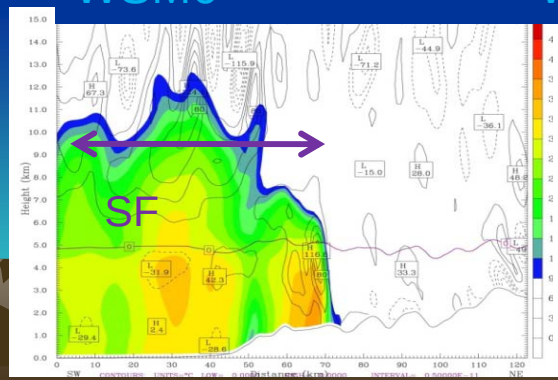
MORI



THMN



WSM6



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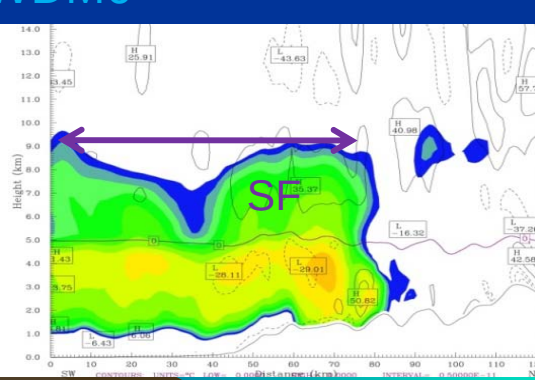
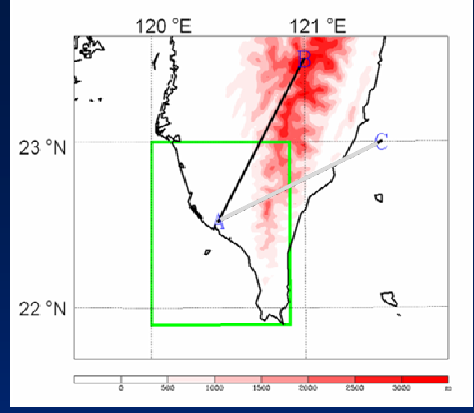
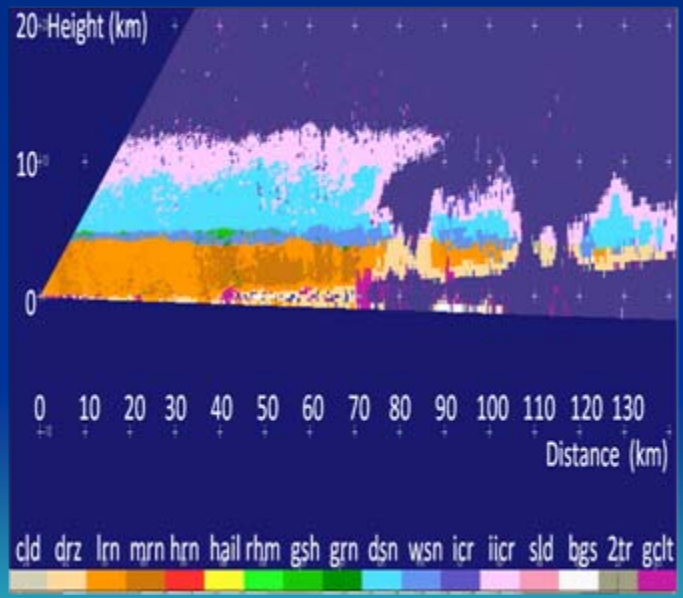


Hydrometeor Classification

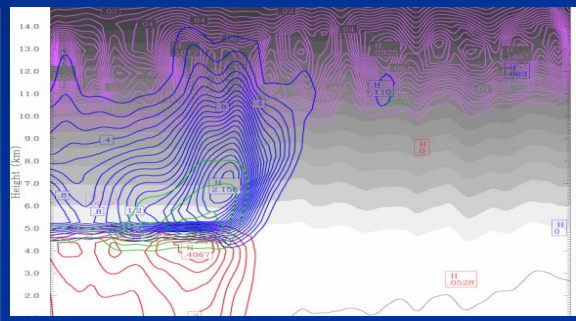


AB Cross Section

6/2 0750UTC 30˚

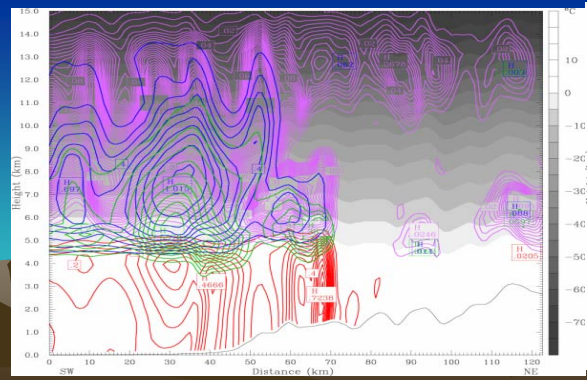


MORI



THMN

WSM6



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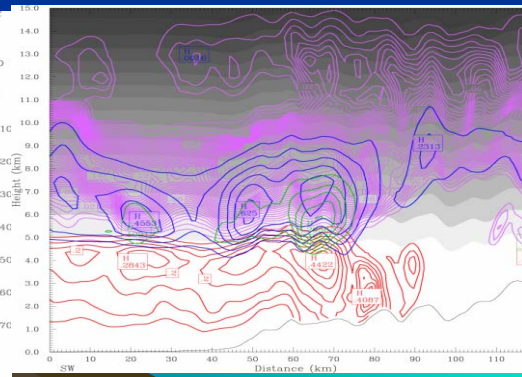
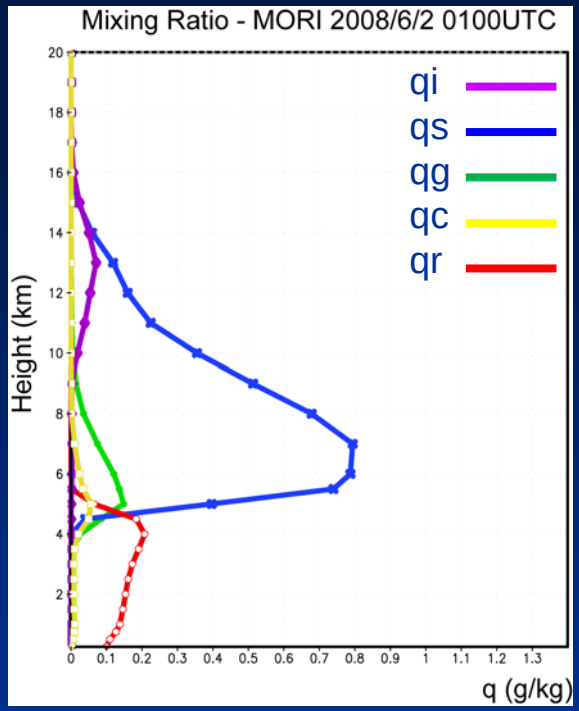
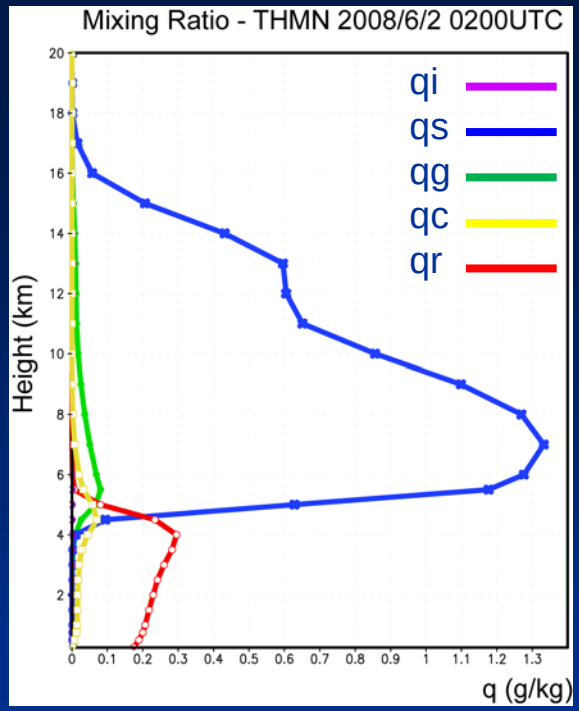
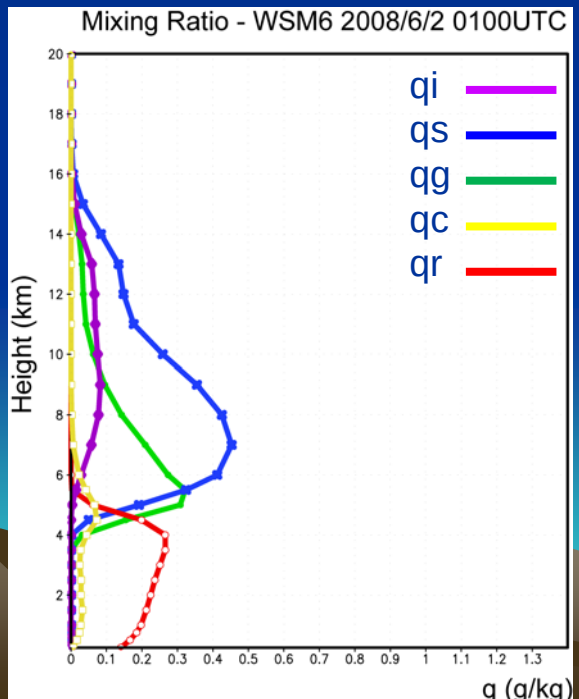
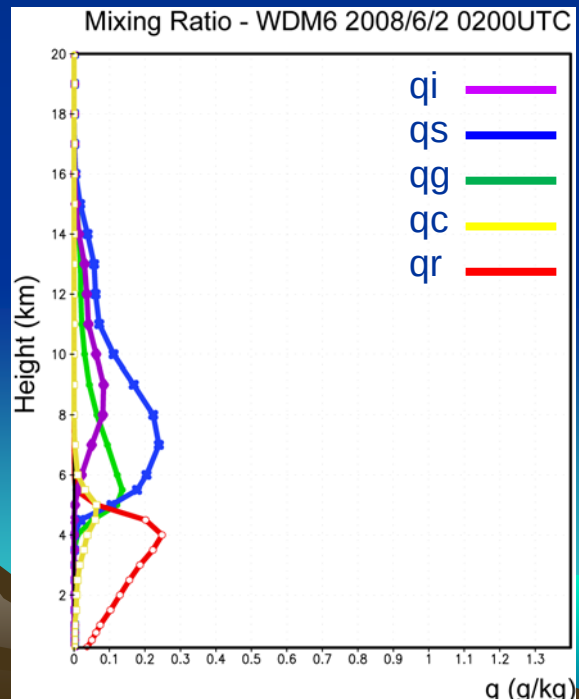



Mixing Ratio - MORI 2008/6/2 0100UTC
qi
qs
qg
qc
qr
Height (km)
q (g/kg)

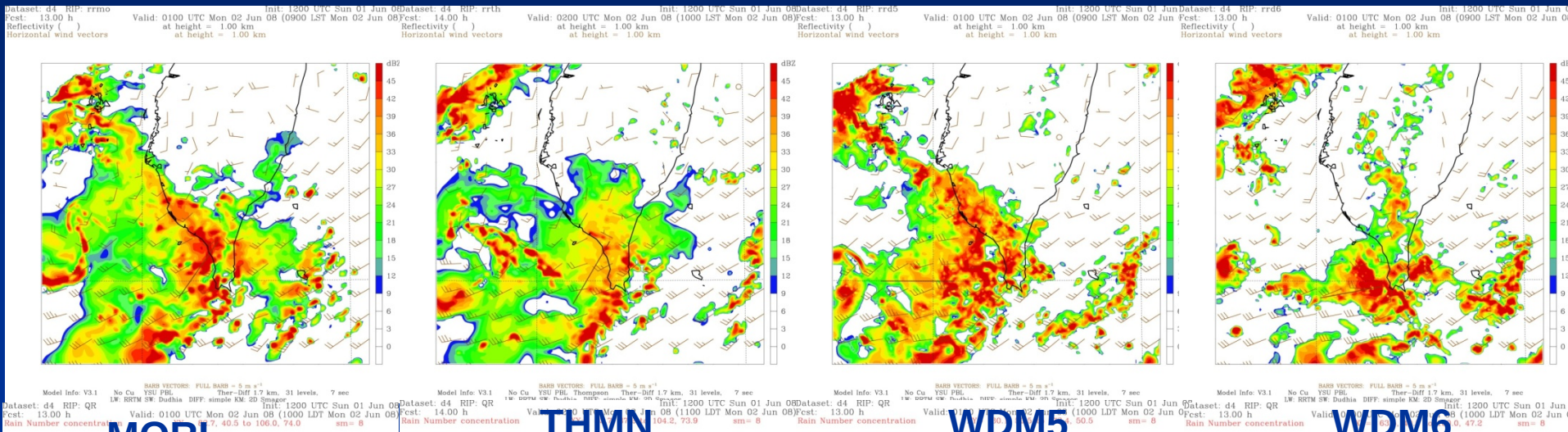

Mixing Ratio - THMN 2008/6/2 0200UTC
qi
qs
qg
qc
qr
Height (km)
q (g/kg)


Mixing Ratio - WSM6 2008/6/2 0100UTC
qi
qs
qg
qc
qr
Height (km)
q (g/kg)

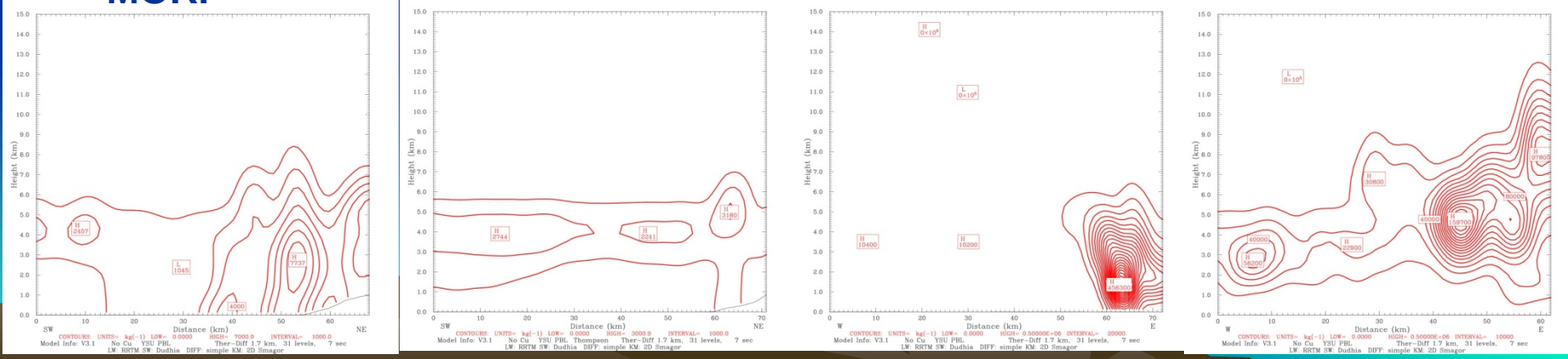

Mixing Ratio - WDM6 2008/6/2 0200UTC
qi
qs
qg
qc
qr
Height (km)
q (g/kg)

Vertical Cross Section of Raindrop concentration

MORI **THMN** **WDM5** **WDM6**



MORI **THMN** **WDM5** **WDM6**



Summary

- The WRF model can simulate the synoptic evolution of the IOP4 event reasonably well, but the simulated upstream SW flow speed is weaker than the observed by 30%.
- The simulated 24-h accumulated rainfall on the island is also less than the observed accumulated rainfall by 25-35%.
- The simulated vertical profiles of radar reflectivity and hydrometeor mixing ratios are in general agreement with the S-Pol observations.
- The two-moment schemes can simulate the increase of raindrop concentration over the convective region.
- The simulated graupel particles are located at lower levels, compared to the observation; the simulated radar bright band over the stratiform region is less evident.

- Comparison among the four microphysics schemes:
  - THMN produces too much snow aloft.
  - With the inclusion of graupel particles, WSM6 and WDM6 produce less snow at mid-levels.
  - MORI produces medium amounts of snow and graupel particles, compared to other three schemes.

- Future work:
  - To improve the upstream wind-speed under-estimation of the SW flow by assimilating extra dropsondes over the ocean.
  - To verify the number concentration predictions with the available raingauge data.