Subtropical Oceanic Mesoscale Convective Vortex Observed during SoWMEX/TiMREX

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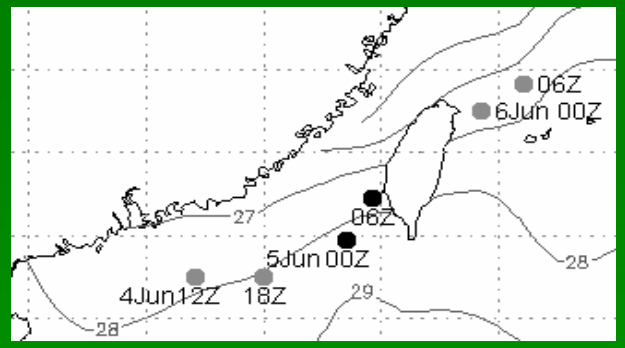
Outline

1. Overview of the IOP6 mesoscale disturbances (Satellite)
2. Synoptic situation (NCEP-FNL)
3. Mesoscale analyses (sounding & QPESUMS)
4. Inner meso-vortex (Cigu radar)
5. Vorticity budget (WRF model)
6. Summary

Overview of the IOP6 mesoscale disturbances



20080603 2313Z VIS

20080604 1130Z IR

20080604 1830Z IR

reestablished

revealed a comma-shaped convective system and a clear spiral cloud pattern associated with cyclonic circulation

dispersed as it migrated eastward

remnant cyclonic disturbance reorganized again

a cyclo… evidenced … observati… …om the Hong-K… …g radar

2008…

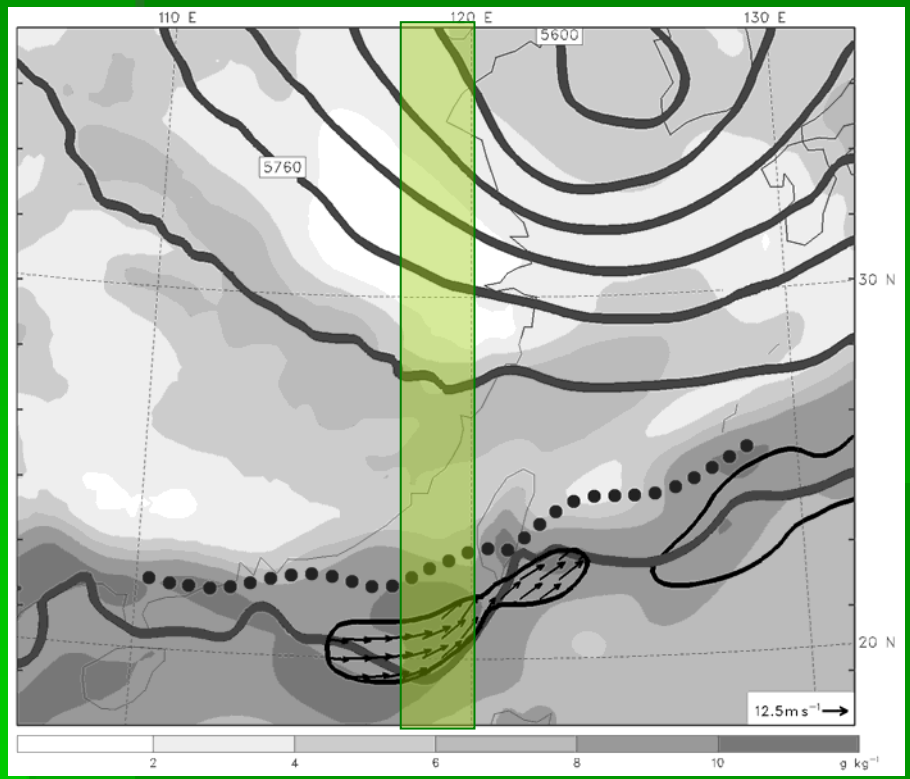
…0630Z VIS

20080606 0157Z …S

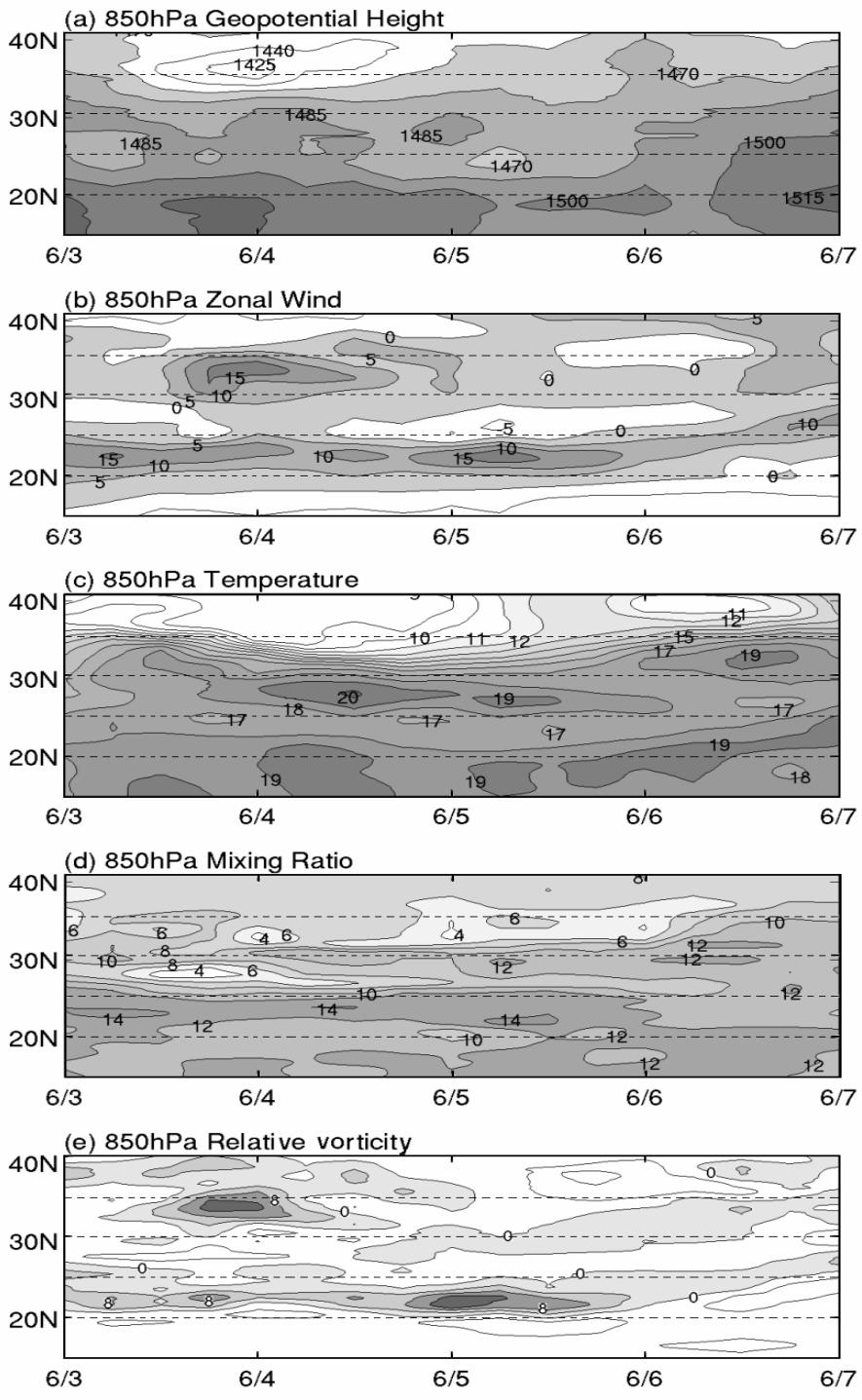
200 mm in 2 hrs

Synoptic situation

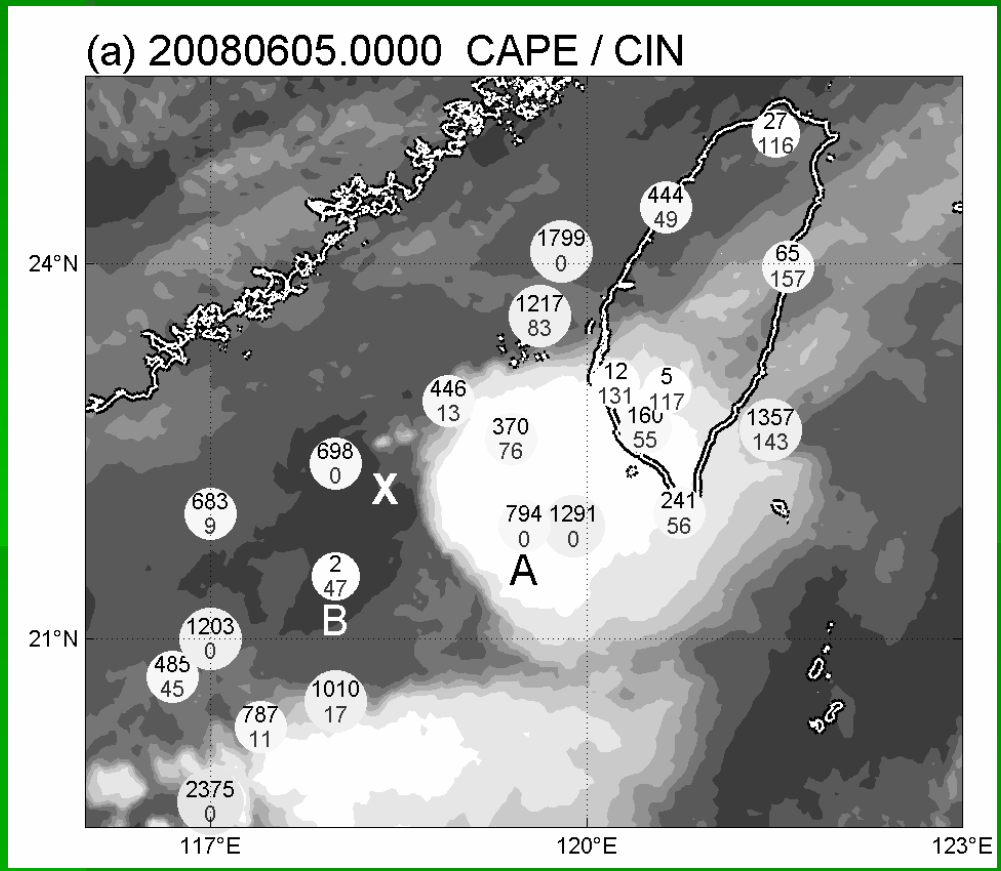
1800 UTC 4 June 2008

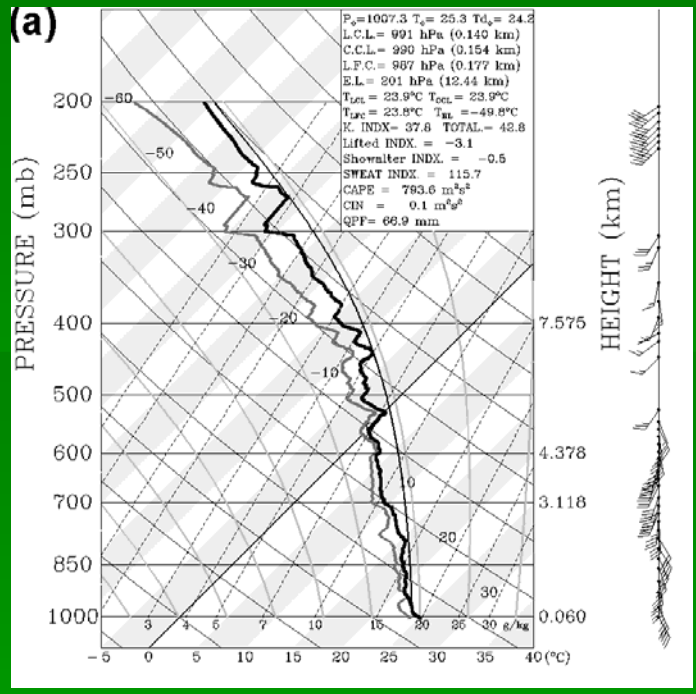


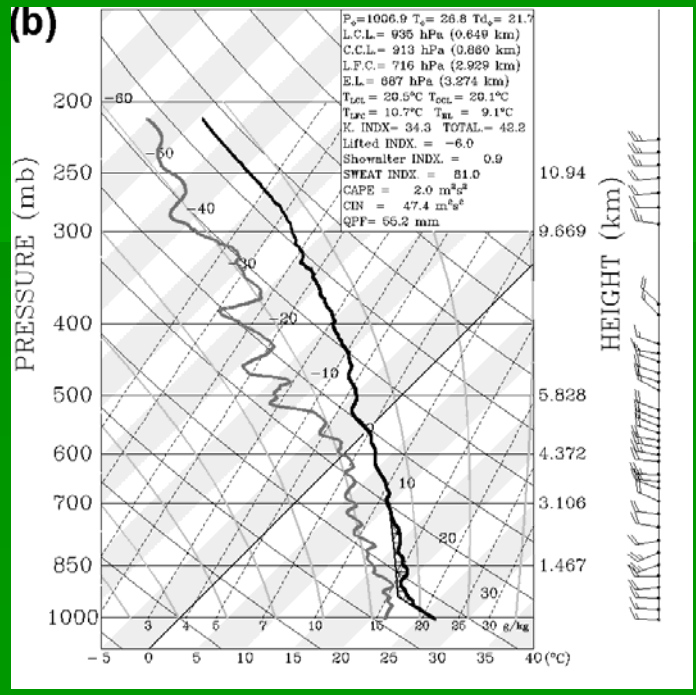
500hPa geopotential height
700hPa mixing ratio
850hPa LLJ

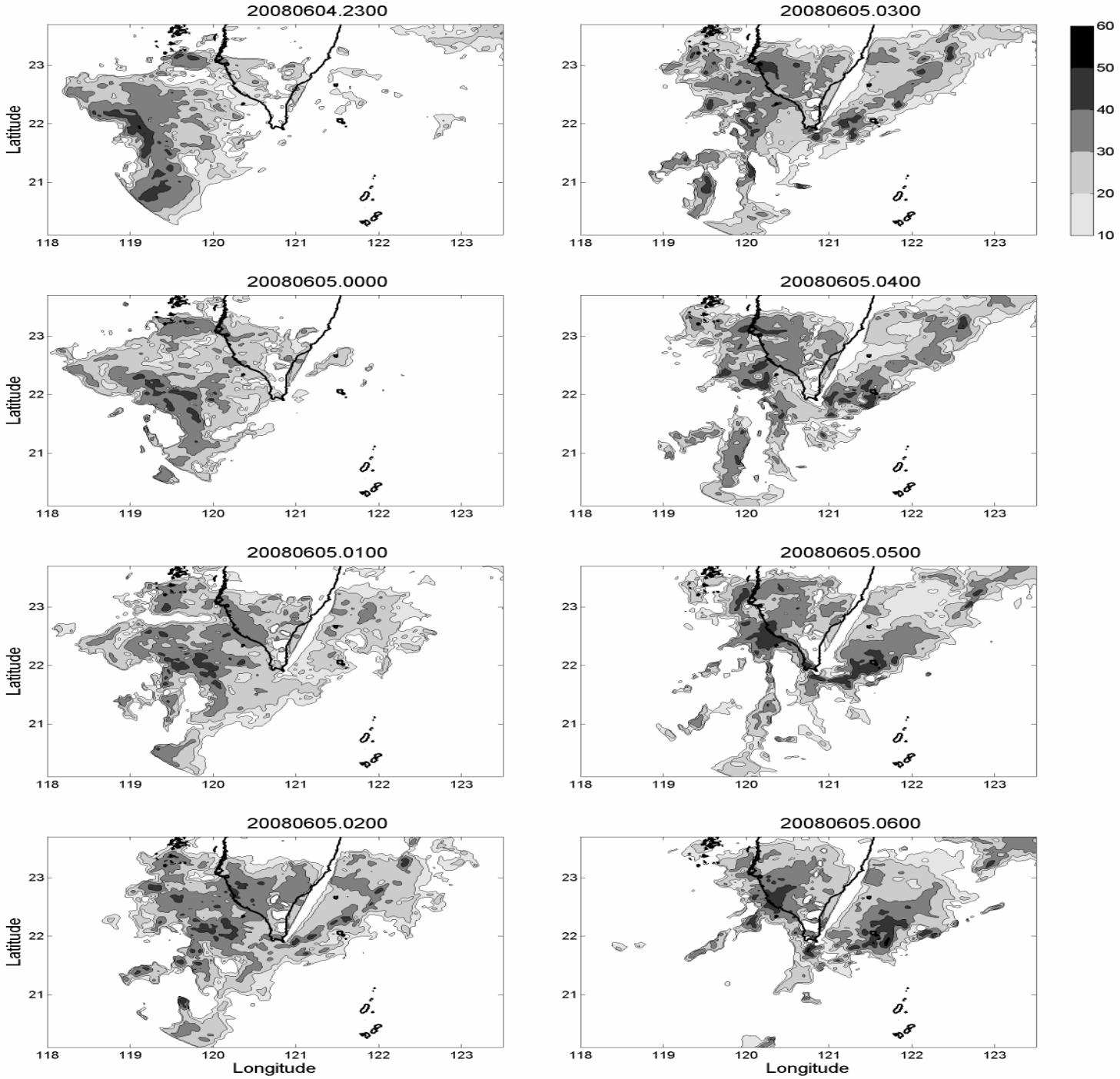


Dropsonde characteristic








20080604.2300
20080605.0300
20080605.0000
20080605.0400
20080605.0100
20080605.0500
20080605.0200
20080605.0600
Latitude
Longitude
118
119
120
121
122
123
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30
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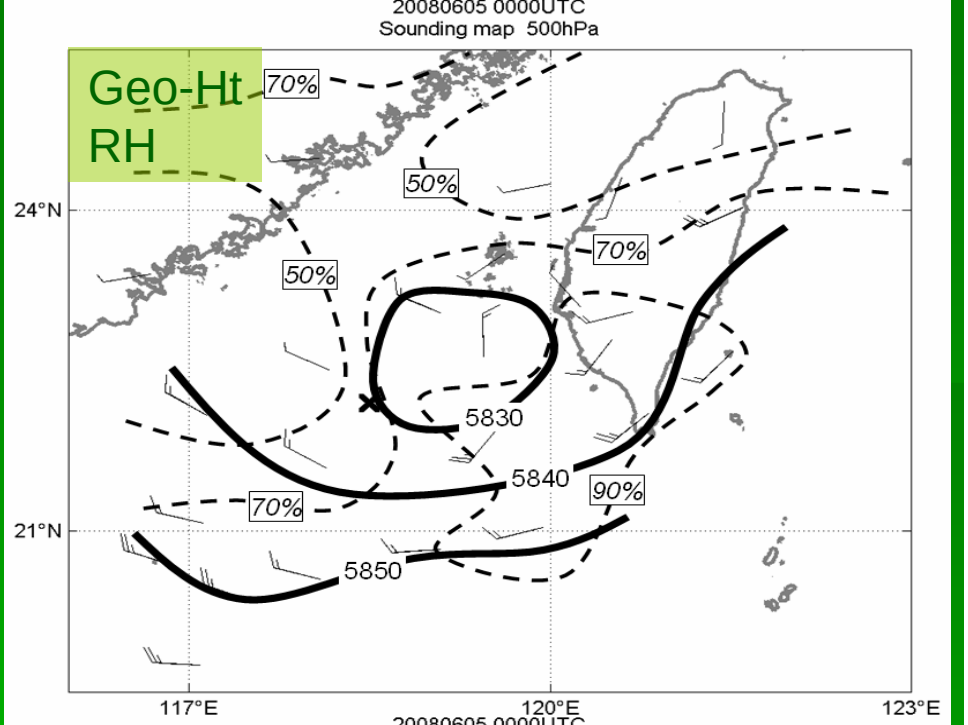
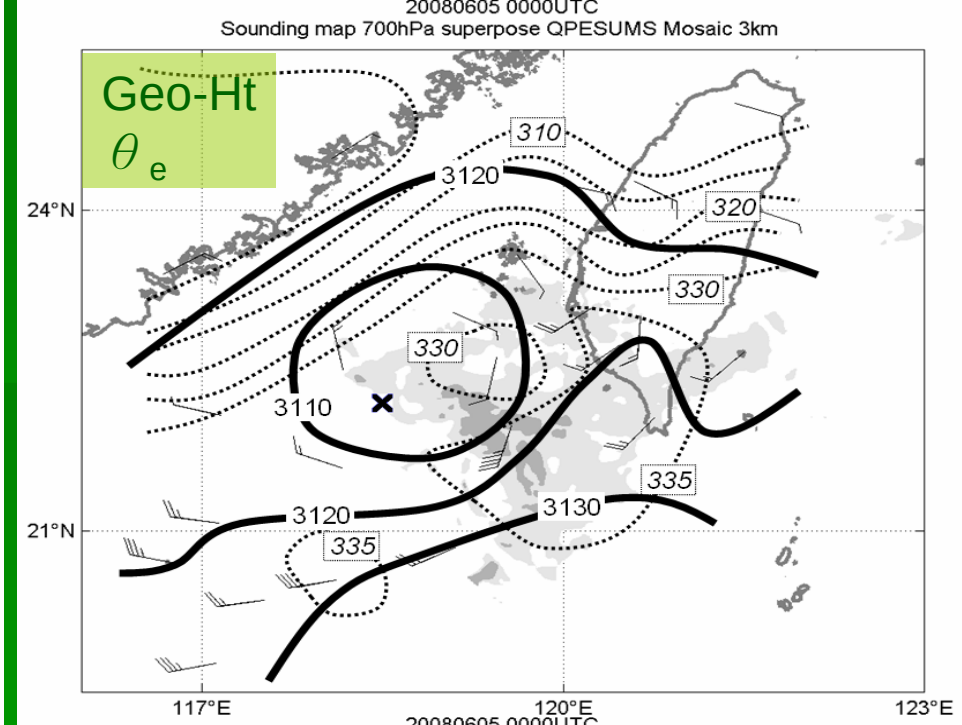
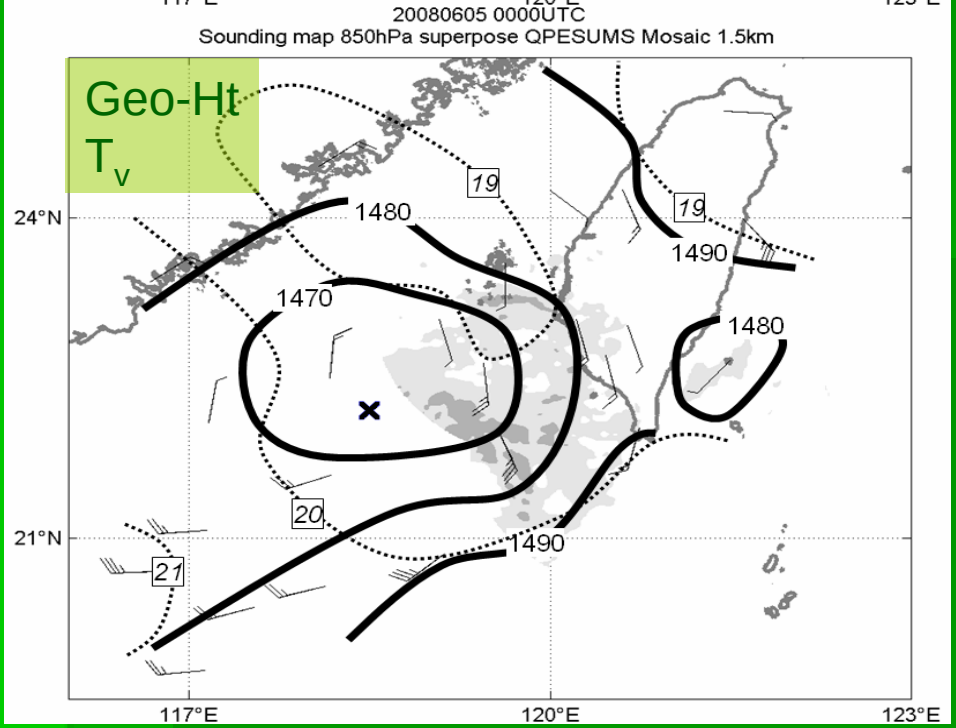
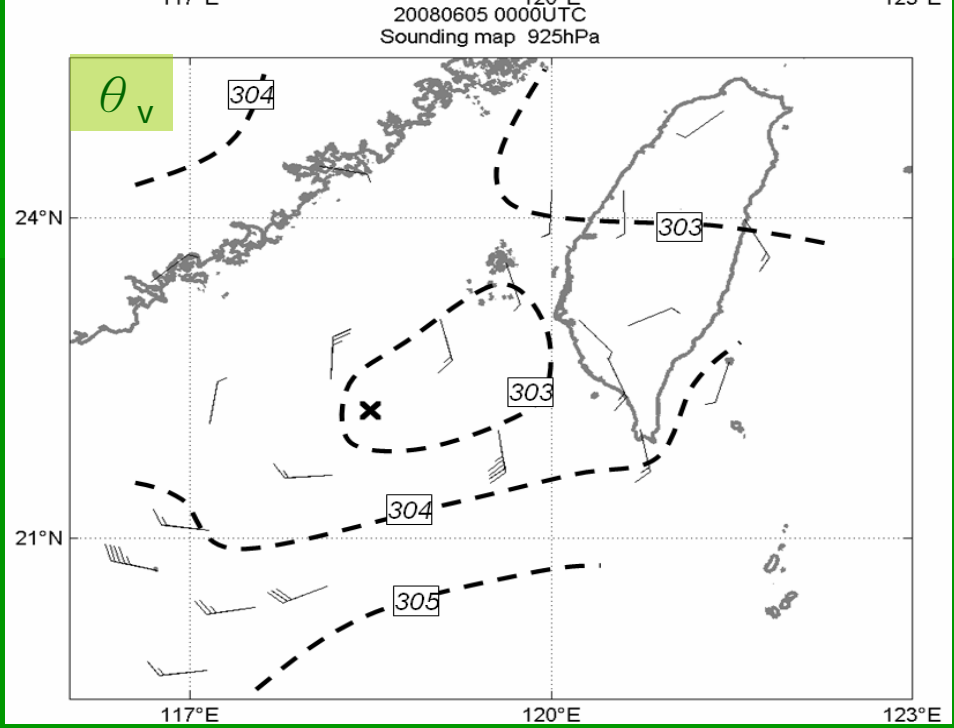
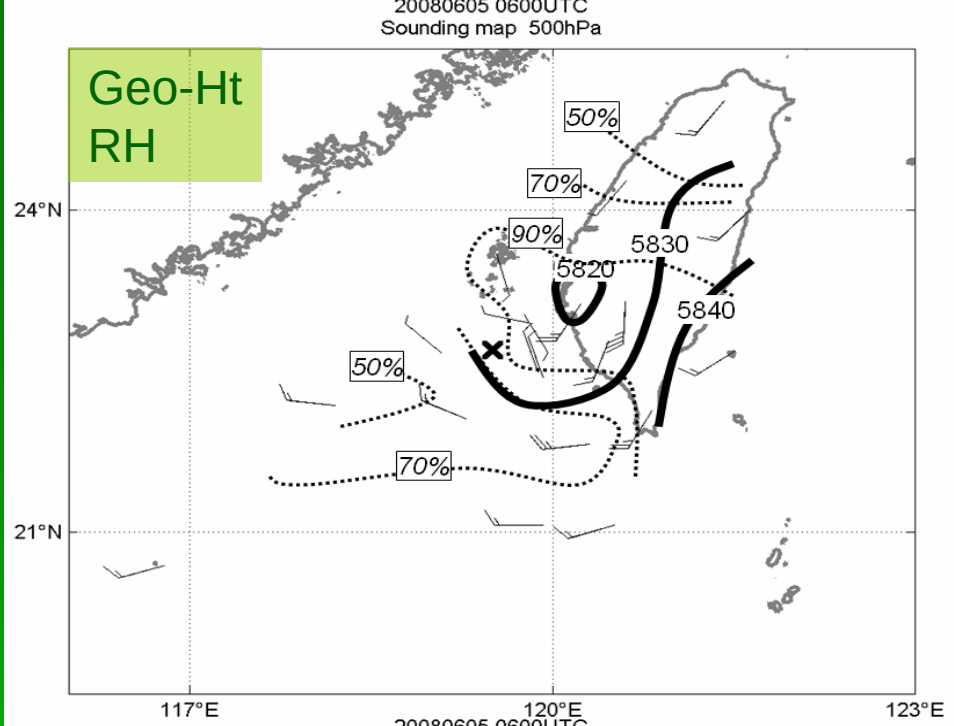
50
60

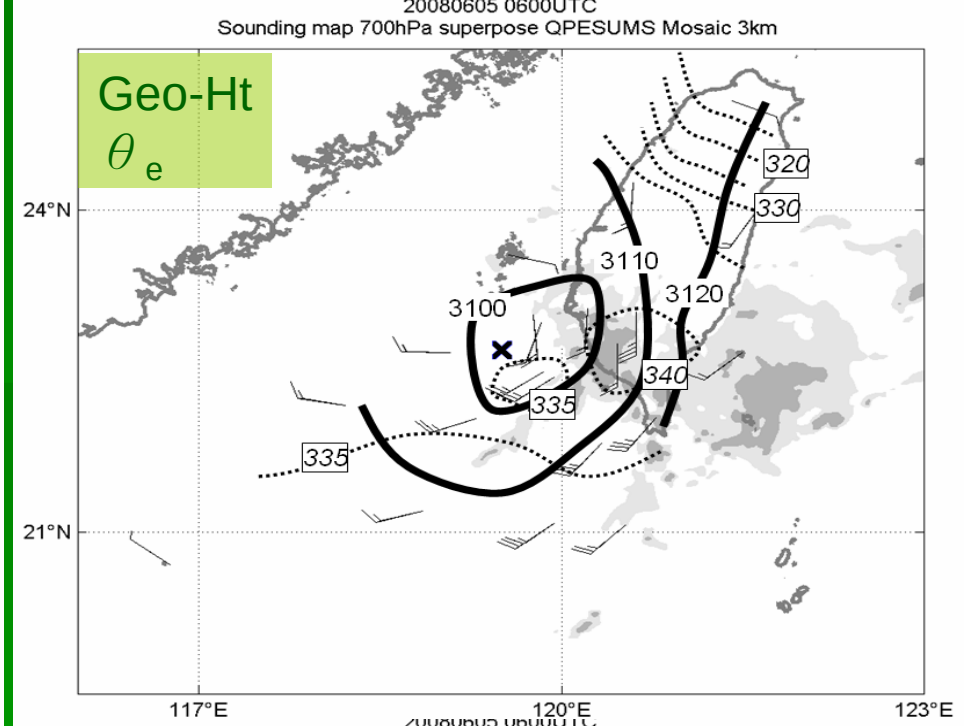

20080605 0000UTC
Sounding map 500hPa
Geo-Ht
RH
70%
50%
50%
70%
70%
90%
5830
5840
5850
24°N
21°N
117°E
120°E
123°E

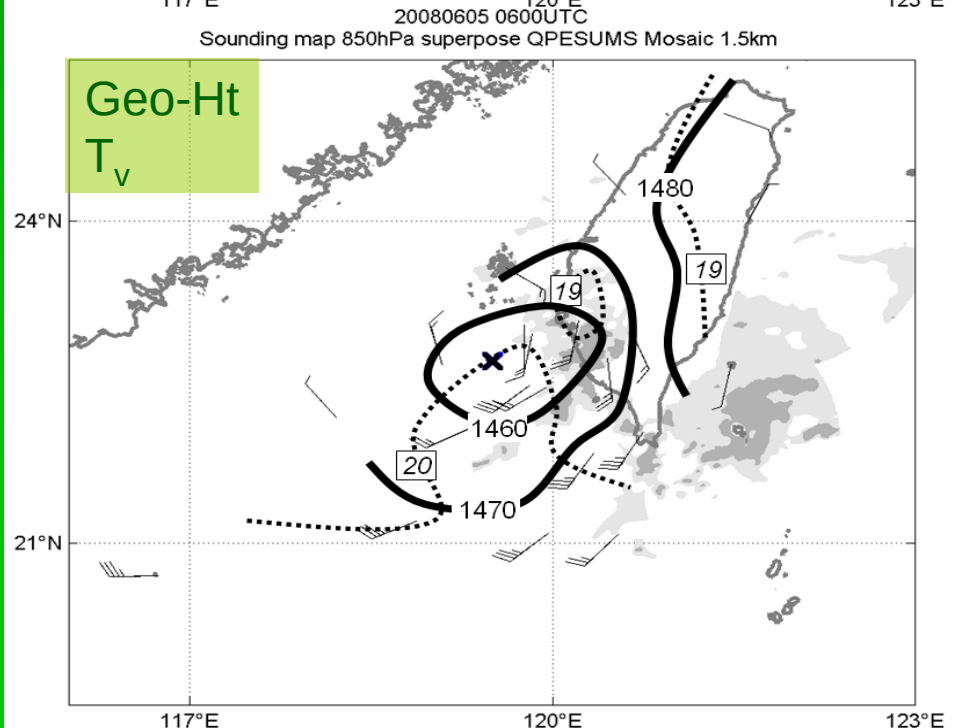

20080605 0000UTC
Sounding map 700hPa superpose QPESUMS Mosaic 3km
Geo-Ht
θe
310
320
330
330
335
335
3120
3110
3120
3130
24°N
21°N
117°E
120°E
123°E


20080605 0000UTC
Sounding map 850hPa superpose QPESUMS Mosaic 1.5km
Geo-Ht
Tv
19
19
20
21
1480
1470
1480
1490
1490
24°N
21°N
117°E
120°E
123°E


20080605 0000UTC
Sounding map 925hPa
θv
304
303
303
304
305
24°N
21°N
117°E
120°E
123°E


20080605 0600UTC
Sounding map 500hPa
Geo-Ht
RH
50%
70%
90%
5830
5820
5840
50%
70%
24°N
21°N
117°E
120°E
123°E


20080605 0600UTC
Sounding map 700hPa superpose QPESUMS Mosaic 3km
Geo-Ht
θ e
320
330
3110
3120
3100
340
335
335
24°N
21°N
117°E
120°E
123°E


20080605 0600UTC
Sounding map 850hPa superpose QPESUMS Mosaic 1.5km
Geo-Ht
T v
1480
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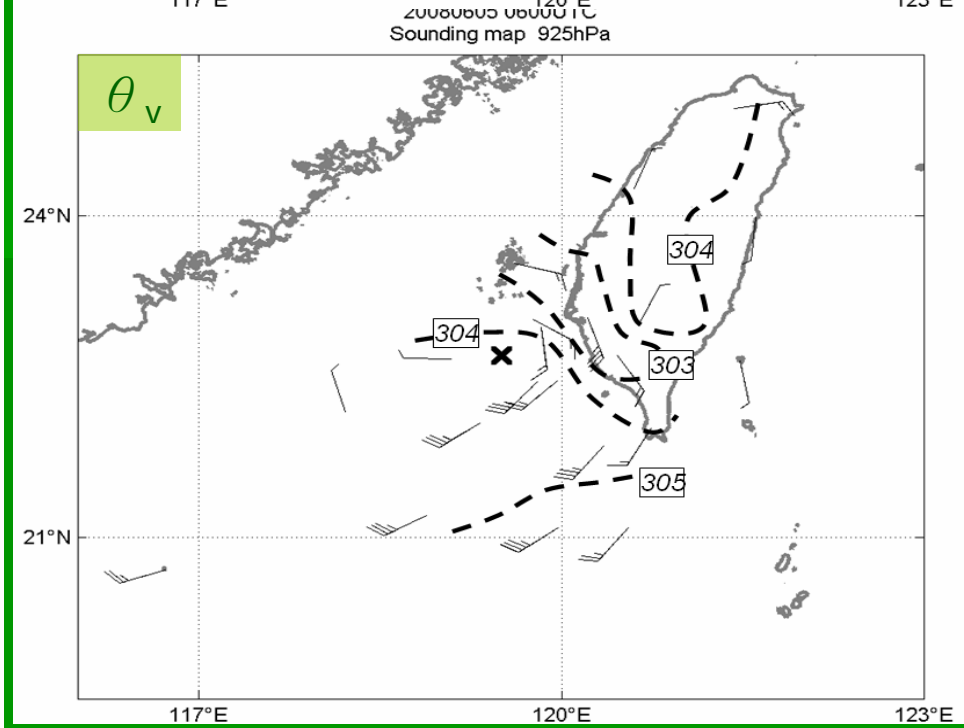
24°N
21°N
117°E
120°E
123°E


20080605 0600UTC
Sounding map 925hPa
θ v
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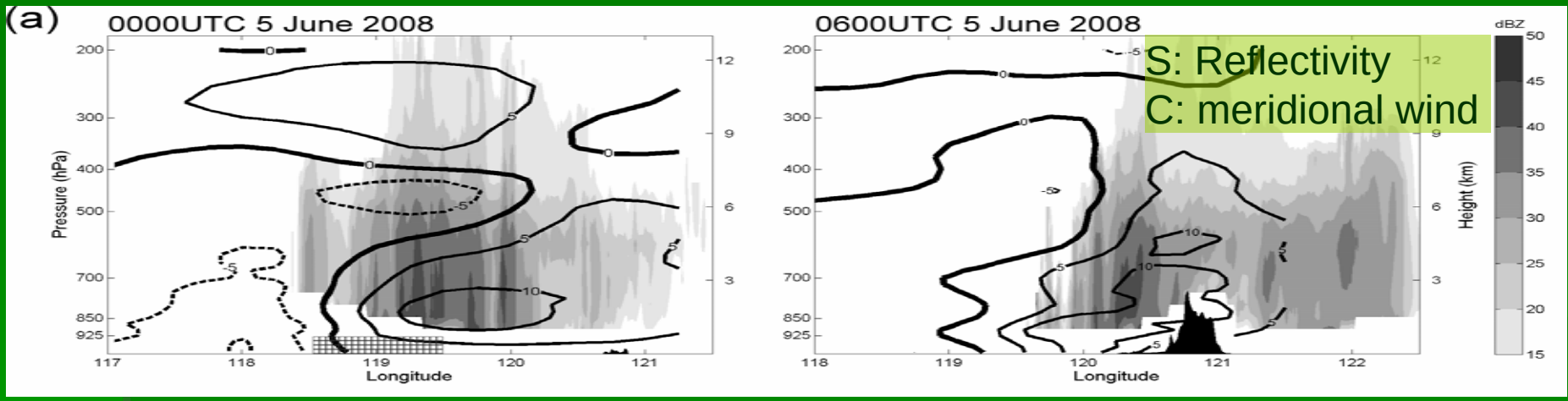
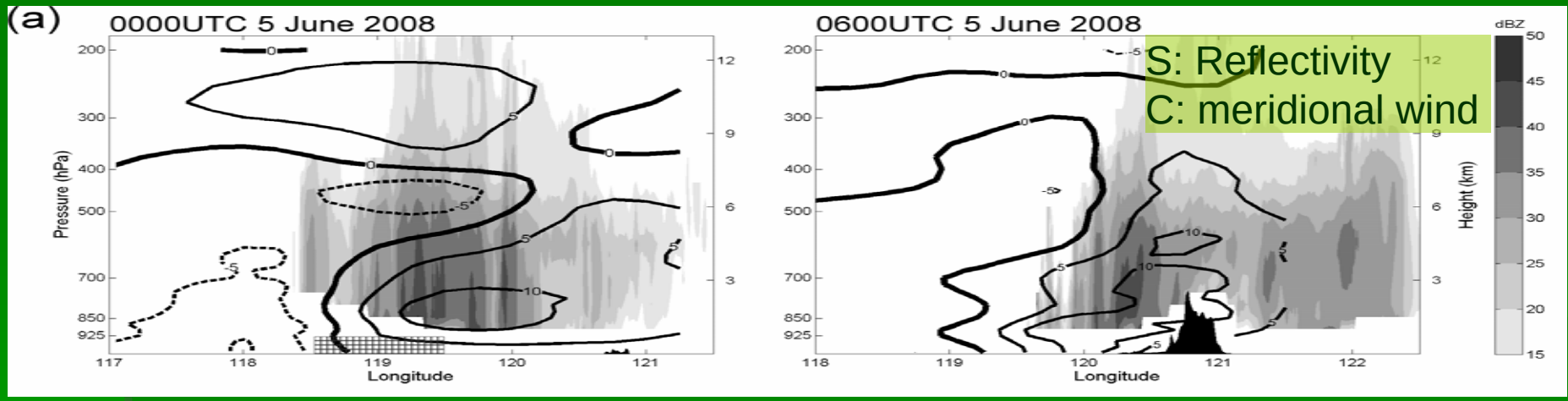
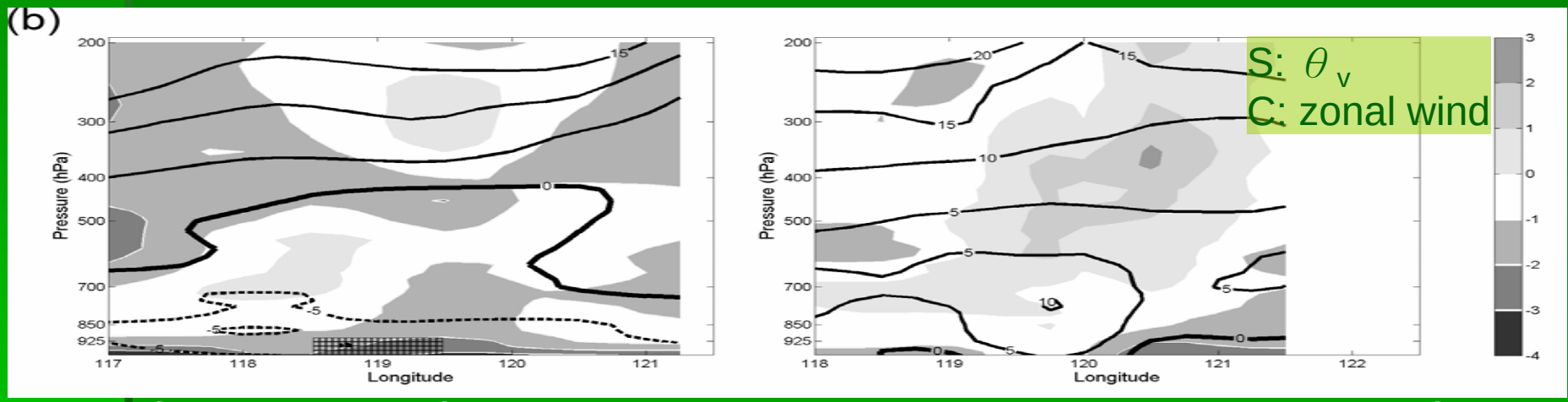
24°N
21°N
117°E
120°E
123°E

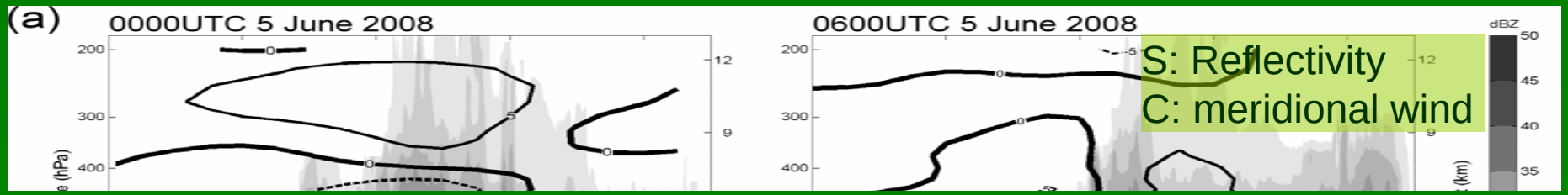


- An east-west vertical cross section of the meridional wind component exhibited a distinct tangential velocity couplet between 5 km MSL and the boundary layer at 0000 UTC, stretching to 8 km at 0600 UTC June 5. An asymmetric tangential velocity couplet appeared between 3 km MSL and the boundary layer with a diameter of about 200 km.
- The main convection, in which the 25-dBZ echo extended up to 8 km MSL, was collocated with southerly flow. The southerly wind at 10–11 km MSL is likely the signature of the convective outflow. The main convection moved ahead of the MCV center at 0600 UTC, and heavy precipitation occurred over coastal areas. An eastward-tilted cyclonic circulation above the mountain level was evident at 0600 UTC.

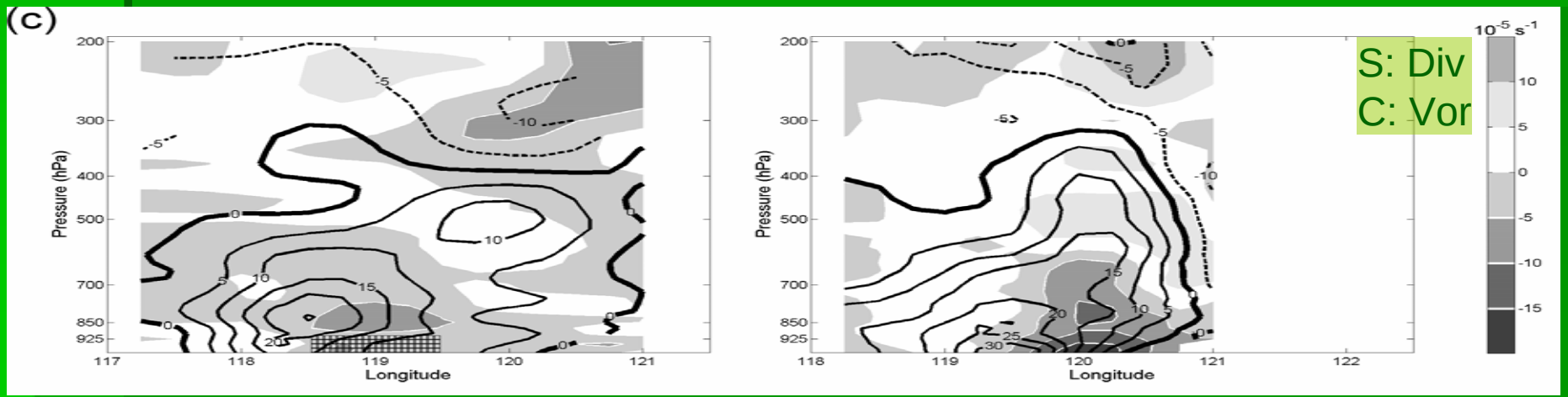


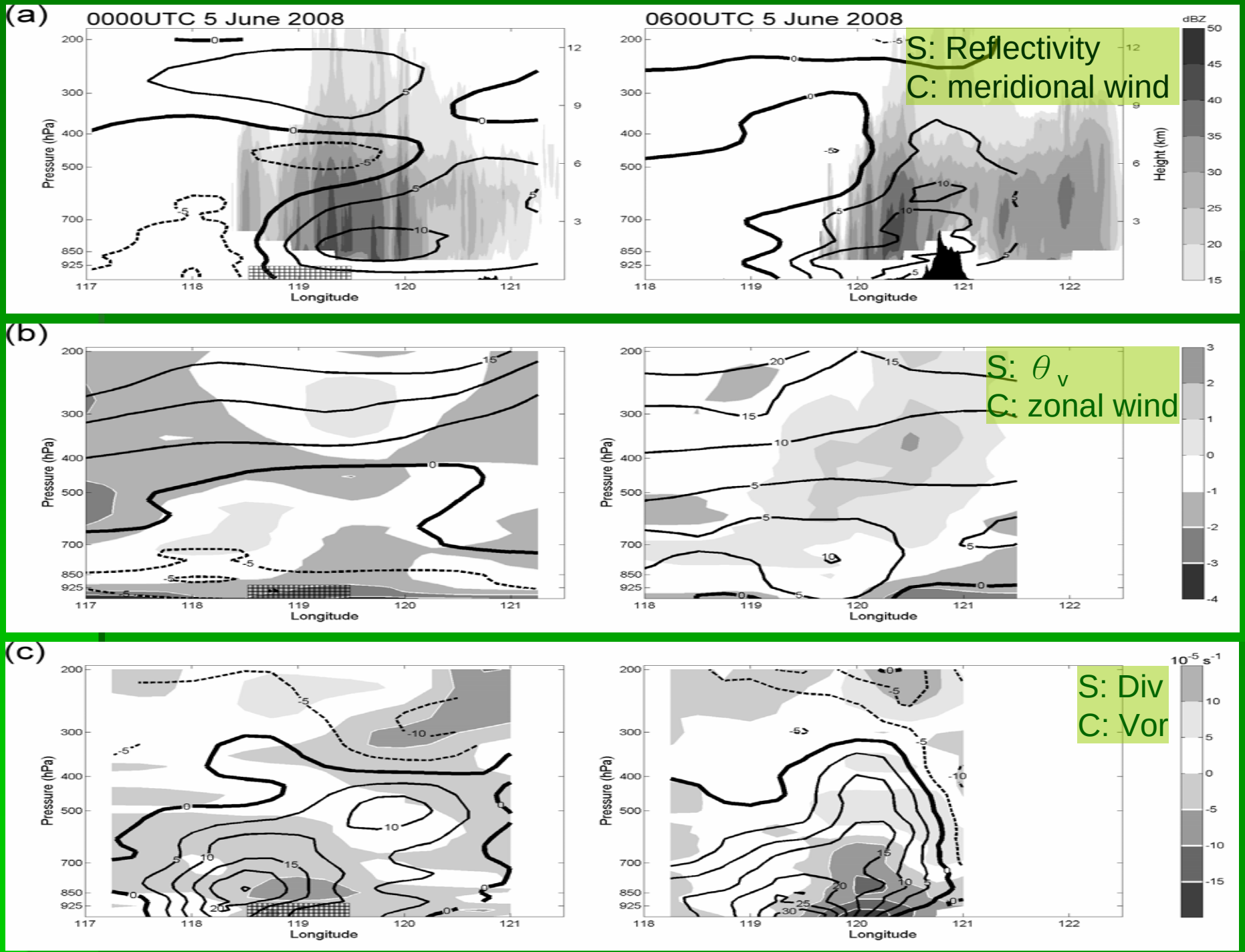


- The front-to-rear flow penetrating through the lower portion of the vortex at 0000 UTC. As the low-level θ v deviation decreased westward isentropic ascent of the easterly flow below 850 hPa appeared.
- The westerly flow above the front-to-rear flow at 0600 UTC was stronger and deeper in contrast to 0000 UTC and penetrated into the MCV center. Above 500 hPa, the westerly flow increased with height with vertical wind shear between 500–200 hPa.



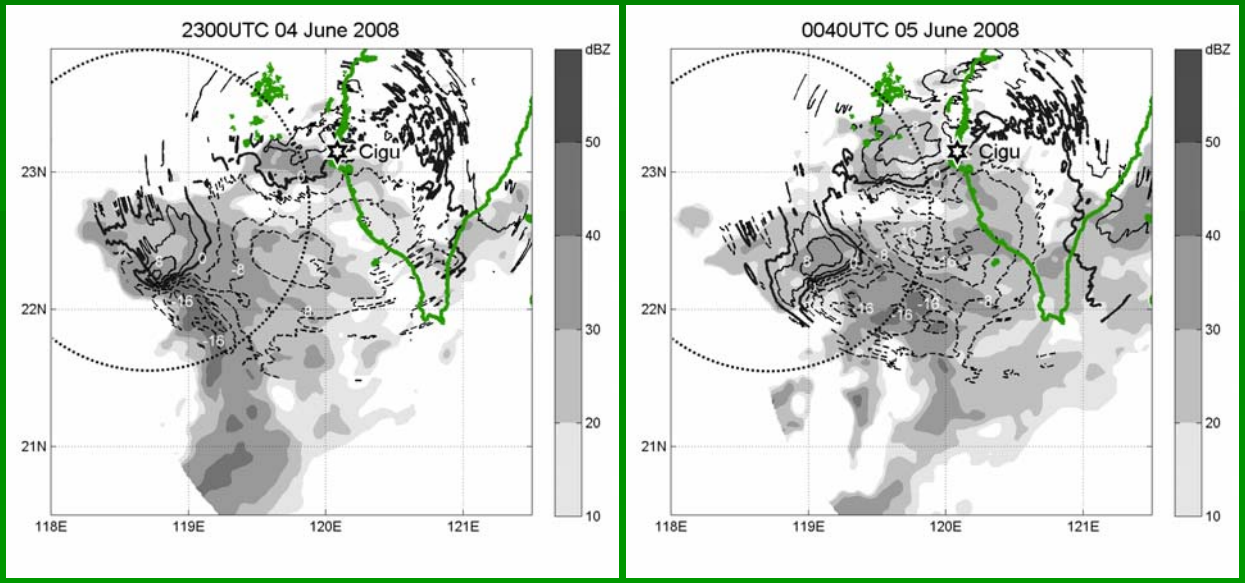
- The maximum mesoscale vorticity exceeded 2.5x10^{-4} s^{-1}. At 0000 UTC, the strong cyclonic vorticity extended nearly to 500 hPa with a nearly upright structure, six hours later, the cyclonic vorticity strengthened and the maximum penetrated down into boundary layer. The vorticity structure associated with the MCV was translated eastward above 700 hPa, yet remained upright throughout the mid-troposphere.
- Low-level convergence with a magnitude of about one-quarter of the vorticity was slightly ahead of the vortex center at 0000 UTC. Stronger mid-tropospheric divergence over the coastal region was evident at 0600 UTC.




(a)
0000UTC 5 June 2008
0600UTC 5 June 2008
S: Reflectivity
C: meridional wind
dBZ
Pressure (hPa)
Height (km)
Longitude
(b)
S: θ_v
C: zonal wind
(c)
S: Div
C: Vor
10^{-5} s^{-1}

Inner meso-vortex

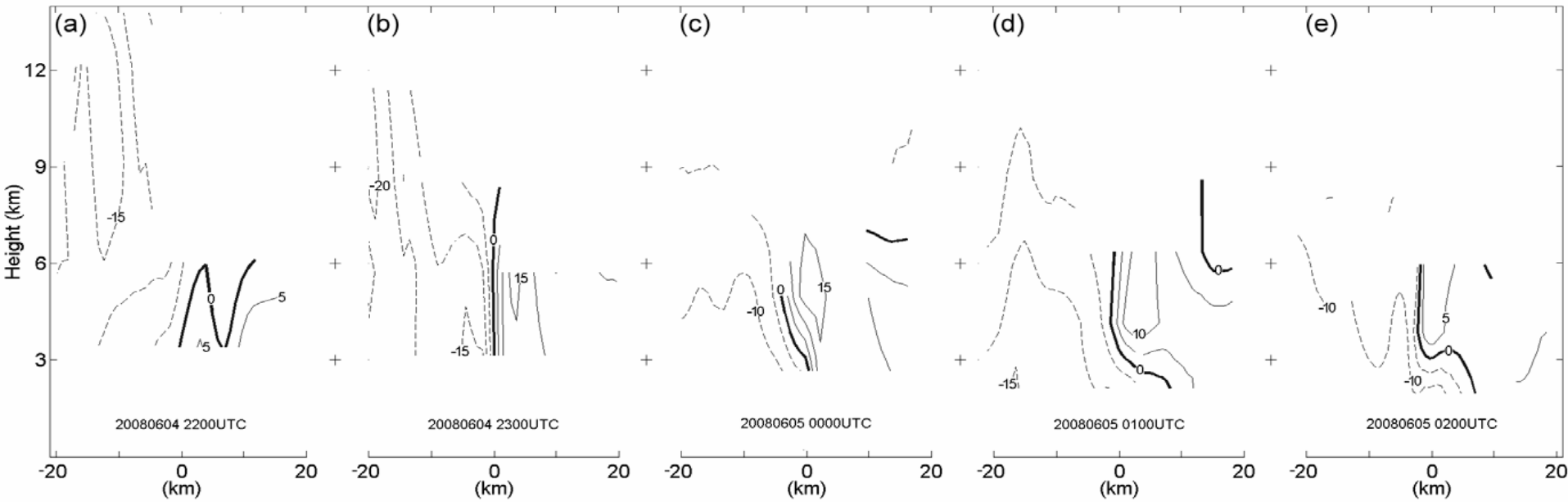
QPESUMS 3km CAPPI
Cigu radar 1.4º PPI Vr



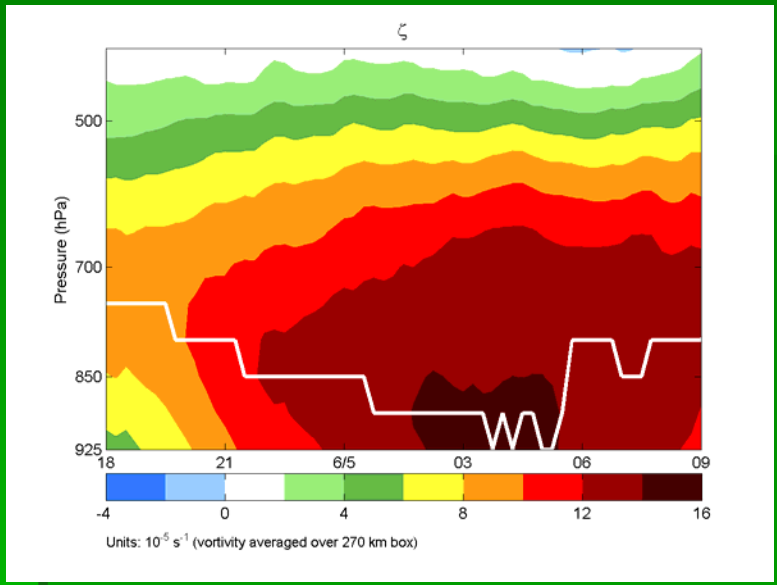
- A sub-vortex appears embedded in the MCV circulation. Two horizontal scales are evident in the dipole pattern of radial velocity. Within the MCV circulation, an inner dipole, with a horizontal scale of only 30 km, was first observed at 2200 UTC June 4 and became indistinct after 0230 UTC June 5. The inner sub-vortex moved eastward.
- The incipient inner meso-vortex was embedded in the northern end of the stronger convective line segment (>40 dBZ) at the back edge of the mesoscale rainband. Just behind the intense convection, a weakly bow-shaped reflectivity pattern accompanied the stronger approaching flow on the southern side of the inner meso-vortex.

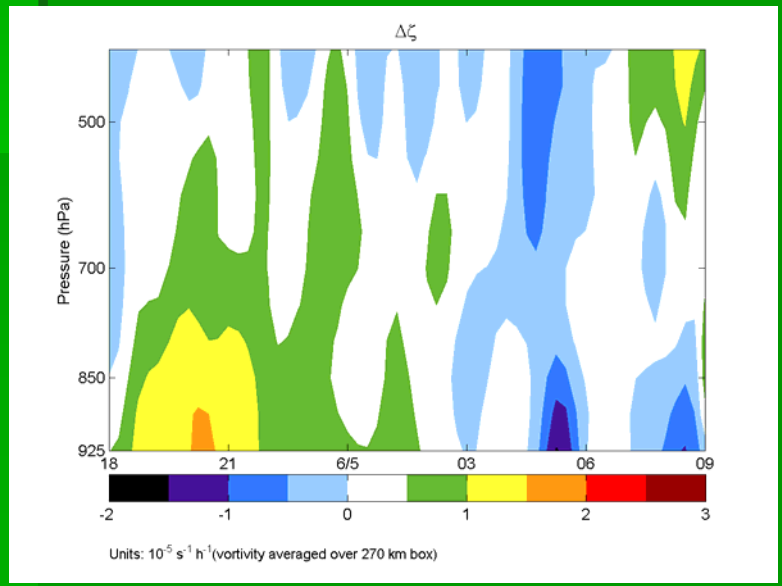
Inner meso-vortex

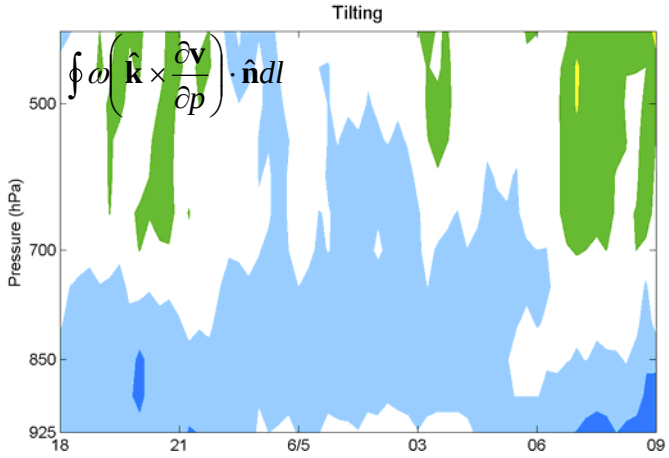
- The velocity dipole of the inner sub-vortex was asymmetric, similar to the tangential wind structure of the MCV. A stronger receding branch dominated at higher altitudes with stronger flow approaching the radar at lower levels. The maximum shear vorticity of about 3×10^{-3} s^{-1} occurred at 2300 UTC June 4 at 4.5 km MSL. Later yet, as the small-scale vortex gradually grew in scale, the reflectivity in the convective line weakened and became less organized.

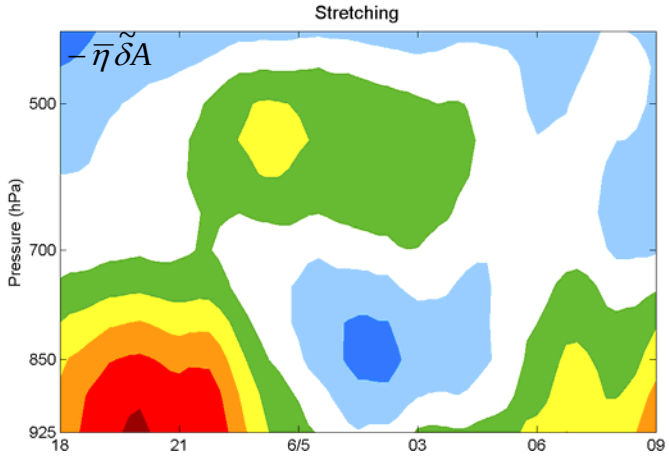


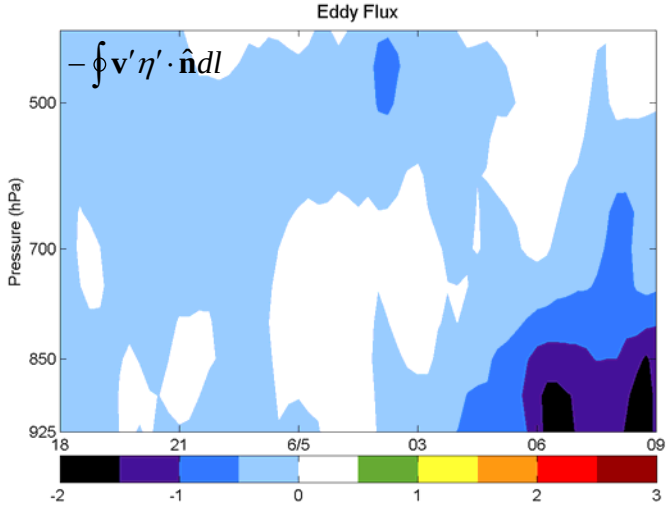
Vorticity budget via WRF simulation







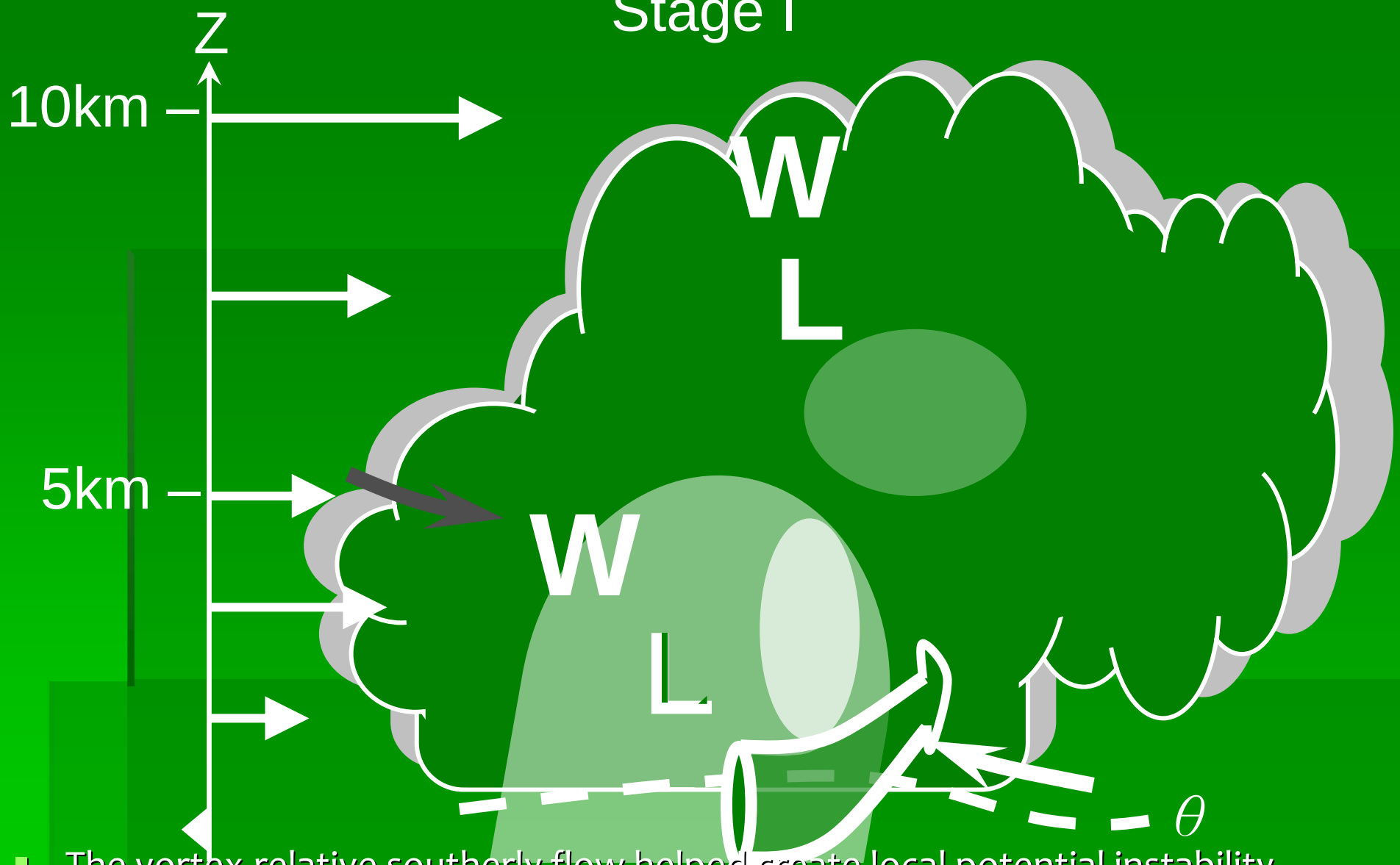




Summary

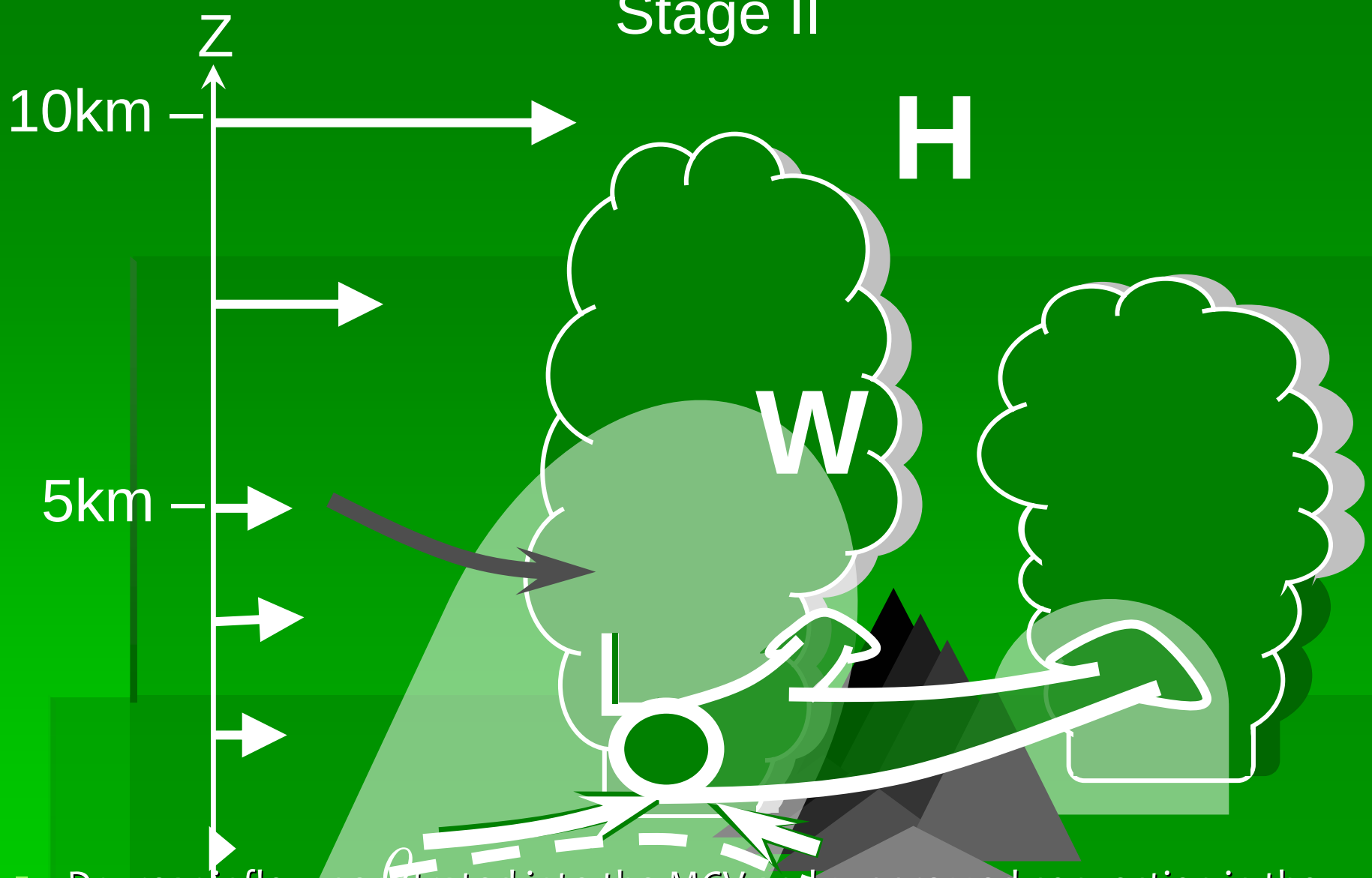
- This study examines a subtropical oceanic mesoscale convective vortex (MCV) that occurred from 1800 UTC 4 June to 1200 UTC 6 June 2008 during Intensive Observing Period (IOP) 6 of the Southwest Monsoon Experiment (SoWMEX) and the Terrain-influenced Monsoon Rainfall Experiment (TiMREX).
- A dissipating mesoscale convective system reorganized within a nearly barotropic vorticity strip, which formed as a southwesterly low-level jet developed to the south of subsiding easterly flow over the southern Taiwan Strait.
- A cyclonic circulation was revealed on the northern edge of the mesoscale rainband with a horizontal scale of 200 km. An inner sub-vortex, on a scale of 25–30 km with maximum shear vorticity of 0.003 s^{-1}, was embedded in the stronger convection.

Stage I



- The vortex-relative southerly flow helped create local potential instability favorable for downshear convection enhancement.
- Low-level convergence and associated stretching contributed to the MCV development.

Stage II



- Dry rear inflow penetrated into the MCV and suppressed convection in the upshear direction.
- The presence of intense vertical wind shear in the higher troposphere limited the vortex vertical extent to about 6 km.