

Preliminary analysis of heavy rainfall in the southwest Taiwan induced by typhoon circulation

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2009 / 10 / 21

motivation

loss increase in last two years



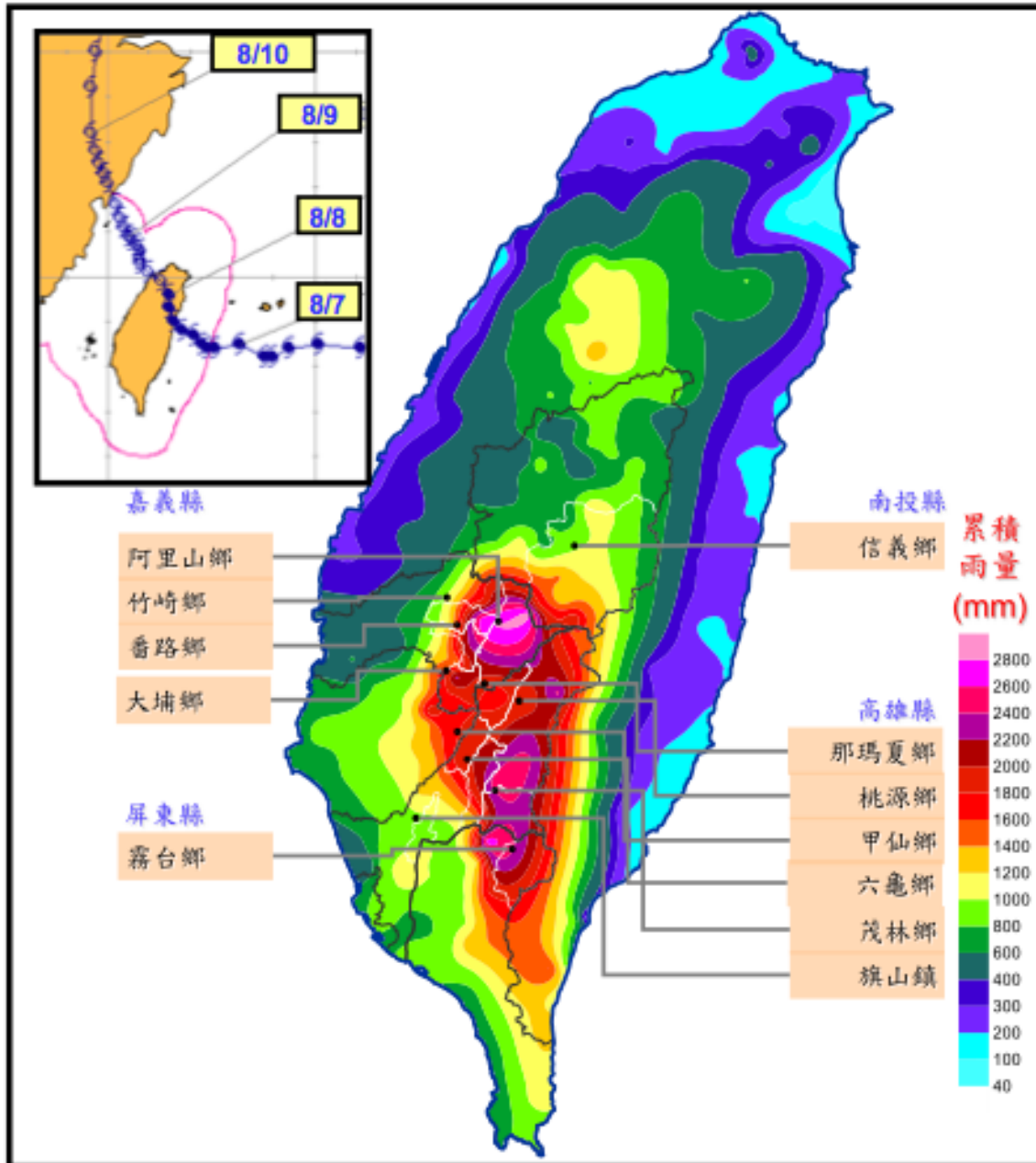
event	max. rain rate	total rainfall	evacuation	deaths
颱風事件	最大降雨強度(mm/hr)	總累積雨量(mm)	疏散撤離(人)	死亡與失蹤(人)
90.7.28 桃芝颱風	147 花蓮縣光復鄉	757 南投縣信義鄉	----	214
90.9.17 納莉颱風	142 宜蘭縣大同鄉	1,462 宜蘭縣大同鄉	24,000	104
93.6.30 敏督利颱風	167 南投縣國姓鄉 九份二山站	2,005 高雄縣桃源鄉	9,500	41
94.7.18 海棠颱風	177 屏東縣三地門鄉	2,124 屏東縣三地門鄉	1,208	15
94.9.1 泰利颱風	119 嘉義縣阿里山	766 高雄縣桃源鄉 御油山站	1,207	5
95.7.12 碧利斯颱風	95 屏東縣鹽埔鄉	1,013 屏東縣三地門	409	3
96.08.16 聖帕颱風	122 屏東縣瑪家鄉 瑪家	1,399 屏東縣瑪家鄉 瑪家	2531	1
97.07.16 卡玫基颱風	161 台南縣南化鄉 北寮	1,027 高雄縣六龜鄉 新發	179	26
97.09.10 辛樂克颱風	97 南投縣中寮鄉	1,608 台中縣太平鄉 雪嶺	1,987	22
98.08.08 莫拉克颱風	139.5 嘉義縣番路鄉 內埔	3060 嘉義縣阿里山鄉 阿里山	24,950	698

搶被
救動

主動研判預警疏散

災害規模擴大
複合性災害

陸上颱風警報期間累積雨量分佈(1/2)



累計最大降雨量**2,965mm(阿里山)**

From: Central Emergency Operation Center report

屏東：林邊、佳冬、東港、新園



From: Central Emergency Operation Center report

<http://www.nownews.com>

台東太麻里



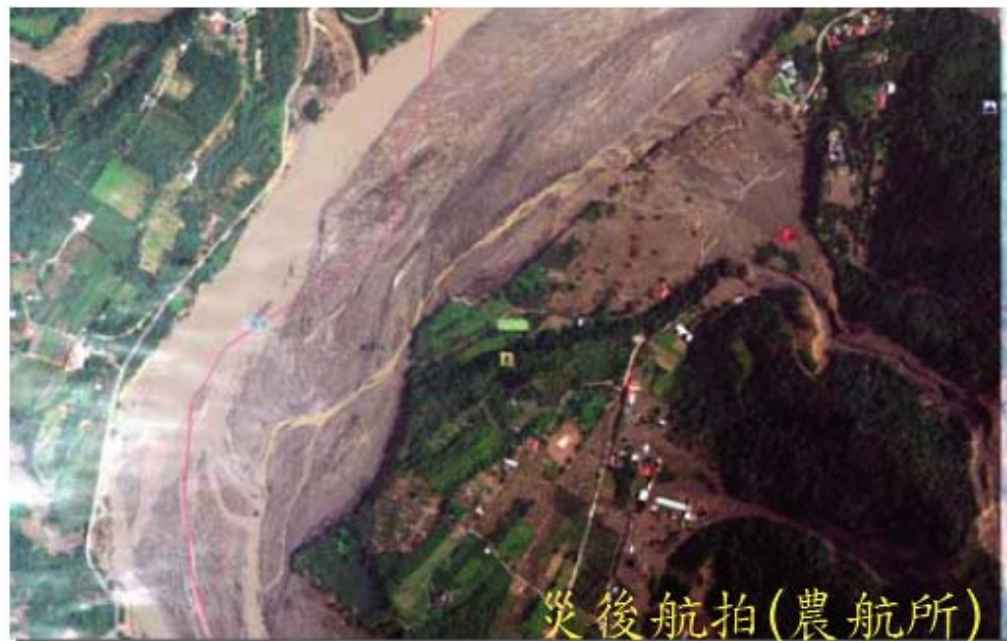
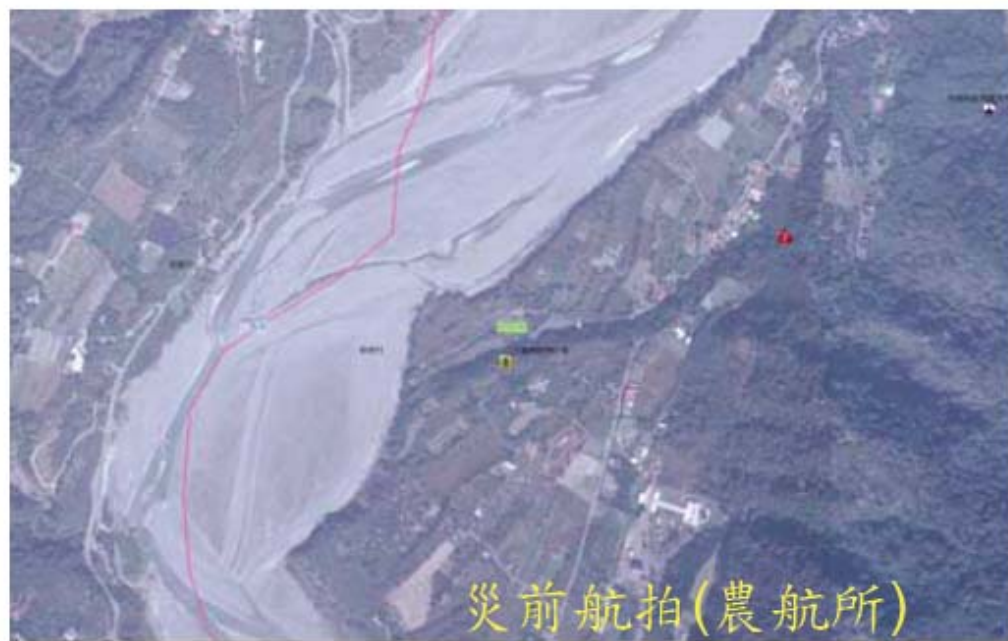
資料來源：屏東科技大學

小林村災害前後影像



- 災害地點：高雄縣甲仙鄉小林村
- 流域：旗山溪
- 掩沒戶數：約169戶
- 死亡：238人 失蹤：186人

新發村災害前後影像



- 災害地點:高雄縣六龜鄉新發村新開部落
- 流域:荖濃溪
- 掩沒戶數:約30戶
- 死亡:29人 失蹤:3人



影像來源:飛虎、元智大學

heavy rainfall
orographic heavy rainfall
how much we known ?

heavy rainfall

total rainfall = rain rate \times duration

$$P = RD$$

$$P = E(\mathbf{V}_H \cdot \nabla h + w_{env})qL_s/c_s$$

$$D = L_s/c_s$$

$$R = E(wq)$$

Water content

$$w = w_{oro} + w_{env}$$

vertical velocity

綜觀尺度
(短波槽)

$$w_{oro} = \frac{Dh}{Dt} = \mathbf{V}_H \cdot \nabla h$$

Precipitation Efficiency

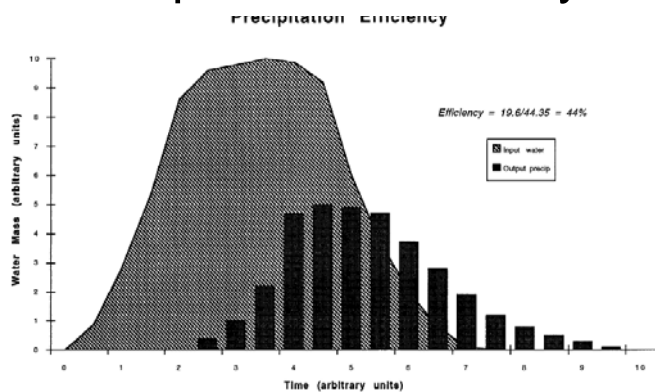
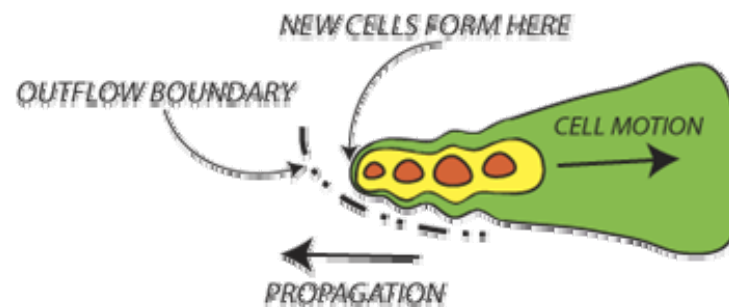
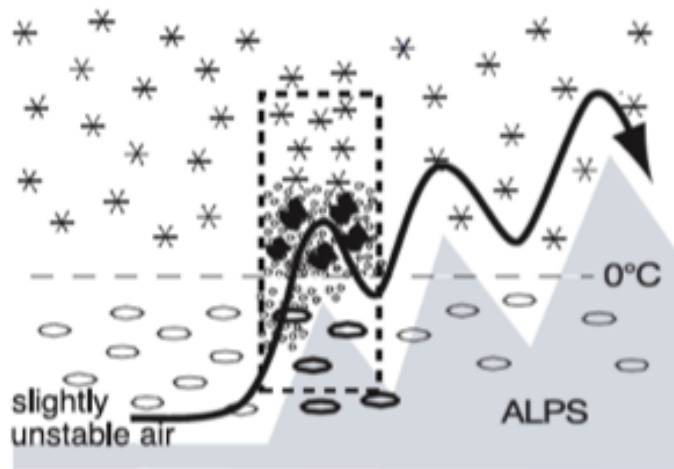


FIG. 1. Schematic illustration of the time variation of water vapor input (cross-hatched area) and the precipitation output (vertical bars) over the lifetime of a precipitation system. The units are arbitrary, so the system being portrayed can be any precipitating process with a developing phase (time = 0–3 units), a mature phase (time = 3–6 units), and a dissipating phase (time = 6–10 units). For this example, the areas under the respective curves give a precipitation efficiency of about 44%.

B) BACKBUILDING / QUASI-STATIONARY (BB)

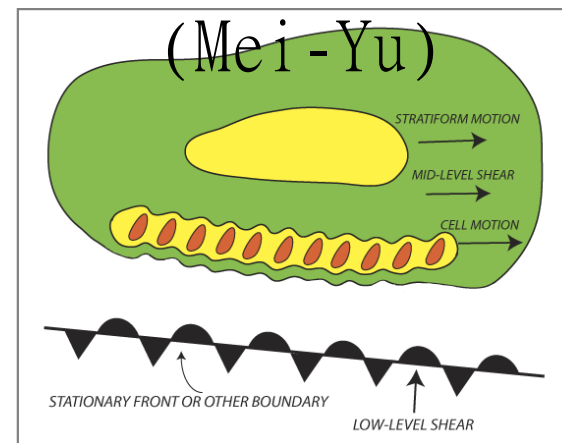


(a) Unblocked and unstable case



stationary front

(Mei-Yu)



orographic heavy rainfall



總雨量 = 降雨率 × 延時

$$P = RD$$

效率 × 垂直速度 × 水汽 × 延時

$$P = E(\mathbf{V}_H \cdot \nabla h + w_{env})qL_s/c_s$$

TABLE 1. An estimate of the contributions from some common ingredients.

Event	NLLJ (U in m s)	Mountain slope ($\delta h/\delta x$)	q (g kg ⁻¹)	Index [$U (\delta h/\delta x) q$]	w_{env} (synoptic system)	Max rainfall rate	CAPE (J kg ⁻¹) (selected)
Taiwan 1999	10.0	0.033	21	6.9	No	200 mm day ⁻¹	2099
Taiwan 1959	17.5	0.033	22	12.7	No	500 mm day ⁻¹	2406
Japan	17.5	0.020	19	6.7	No	150 mm day ⁻¹	1149
Big Thompson, CO	12.5	0.025	16	5.0+*	Trough	915 mm day ⁻¹ [305 mm (4 h) ⁻¹]	2526
Rapid City, SD	12.5	0.020	13.5	3.4+	Trough	1143 mm day ⁻¹ [381 mm (4 h) ⁻¹]	— (<2180)
Fort Collins, CO	10	0.021	13	2.7+	Trough	519 mm day ⁻¹ [259 mm (6 h) ⁻¹]	628
Madison County, VA	12.5	0.025	16	5.0+	Trough	600 mm day ⁻¹	286
Vaison-la-Romaine, France	15	0.027	15	6.1+	Trough	300 mm day ⁻¹	2662
Piedmont, Italy	13	0.033	11	4.7+	Trough	250 mm day ⁻¹	212
South Ticino, Switzer- land	10	0.033	9.3	3.1+	Trough	260 mm day ⁻¹ [130 mm (6 h) ⁻¹]	383
Lago Maggiore, Italy (IOP2)	12.5	0.033	11.5	4.74+	Trough	300 mm (36 h) ⁻¹	90

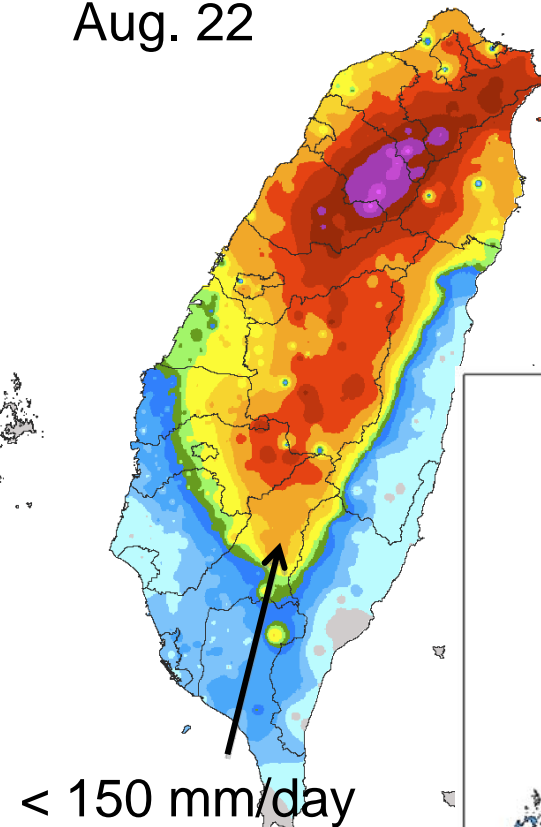
* Plus signs indicate that the index may be higher with the addition of w_{env} associated with an approaching synoptic system.

1987 Nelson typhoon



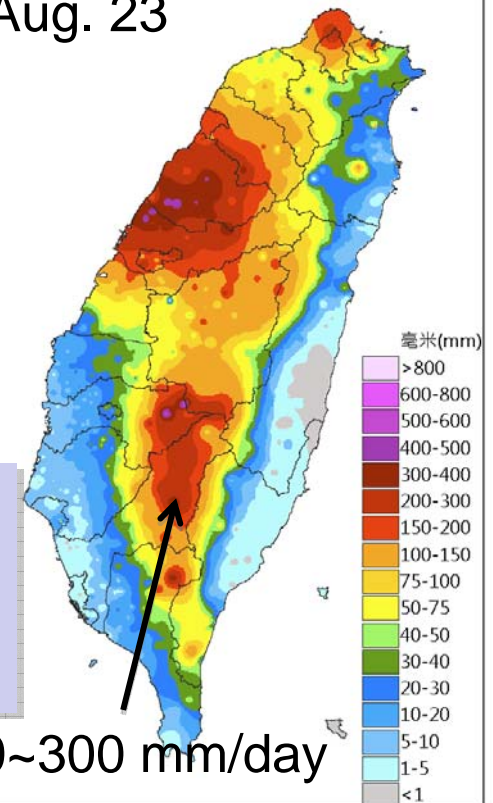
1985年尼爾森颱風8/22日雨量圖

Aug. 22

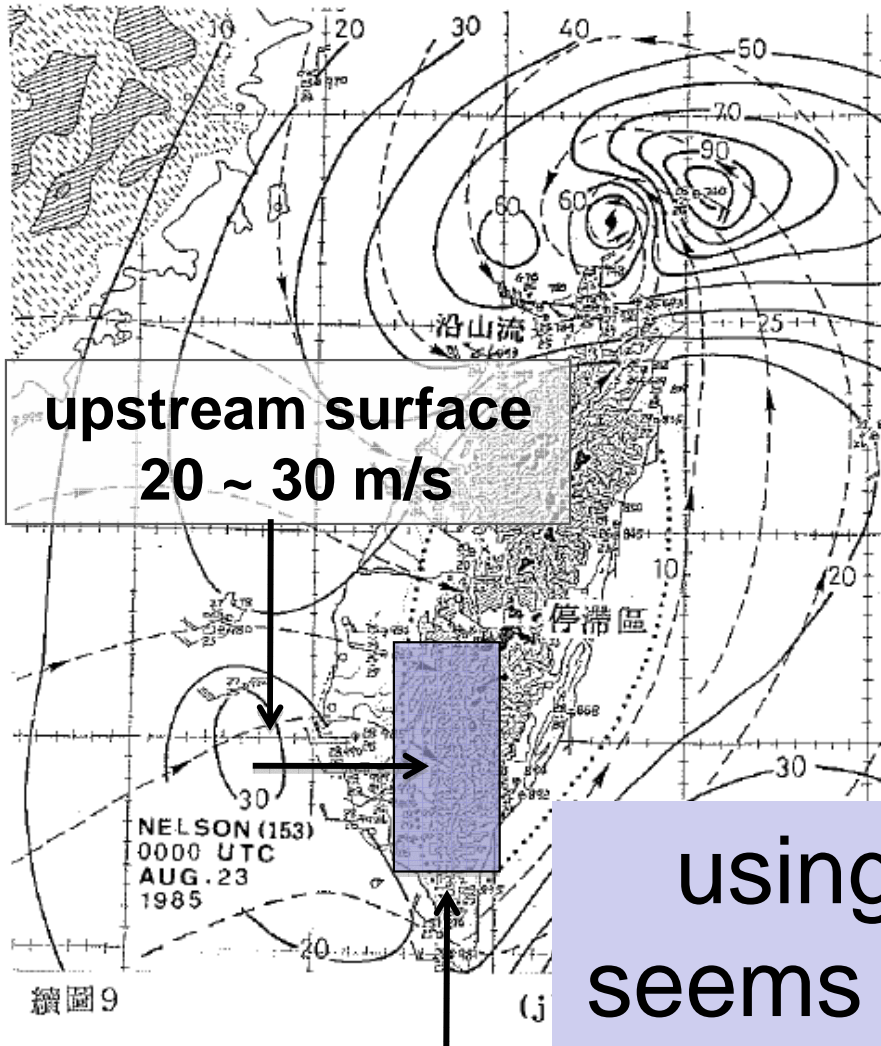


1985年尼爾森颱風8/23日雨量圖

Aug. 23



00 UTC Aug. 23



續圖9

(j)

target terrain area

using surface wind seems work for Nelson

200~300 mm/day

Questions 1 ?



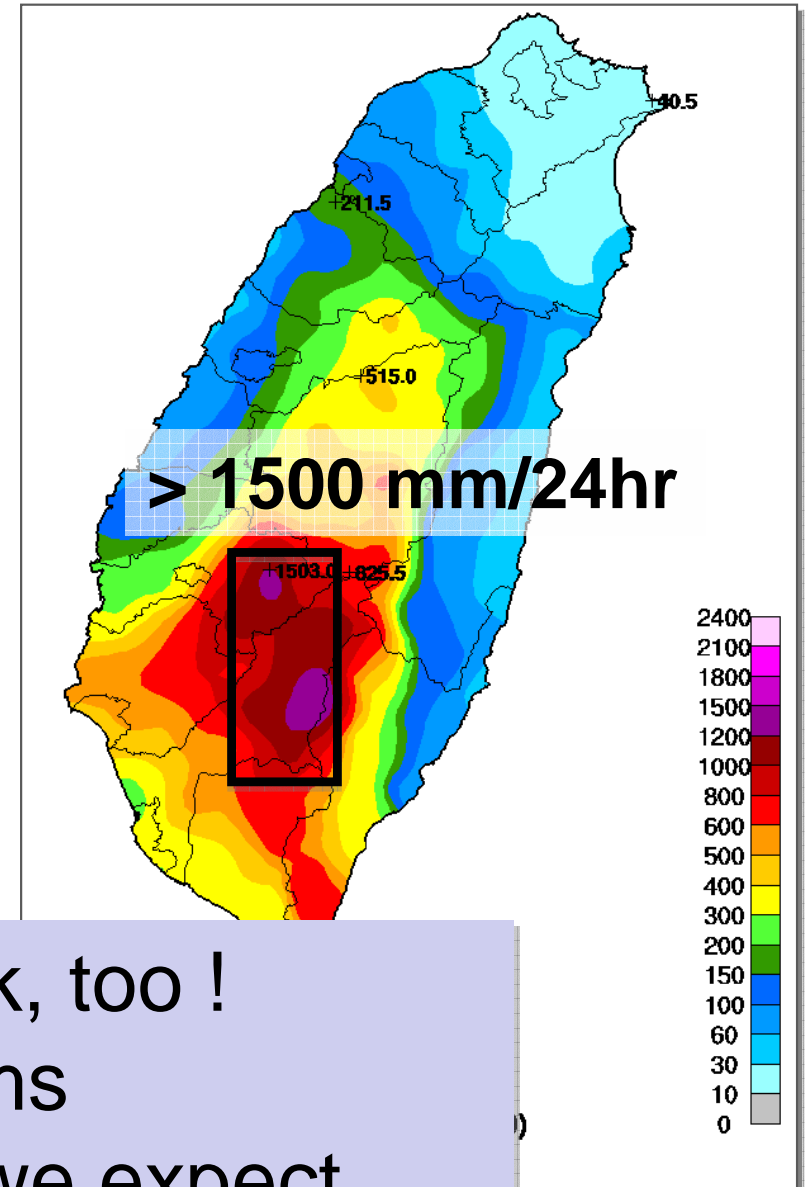
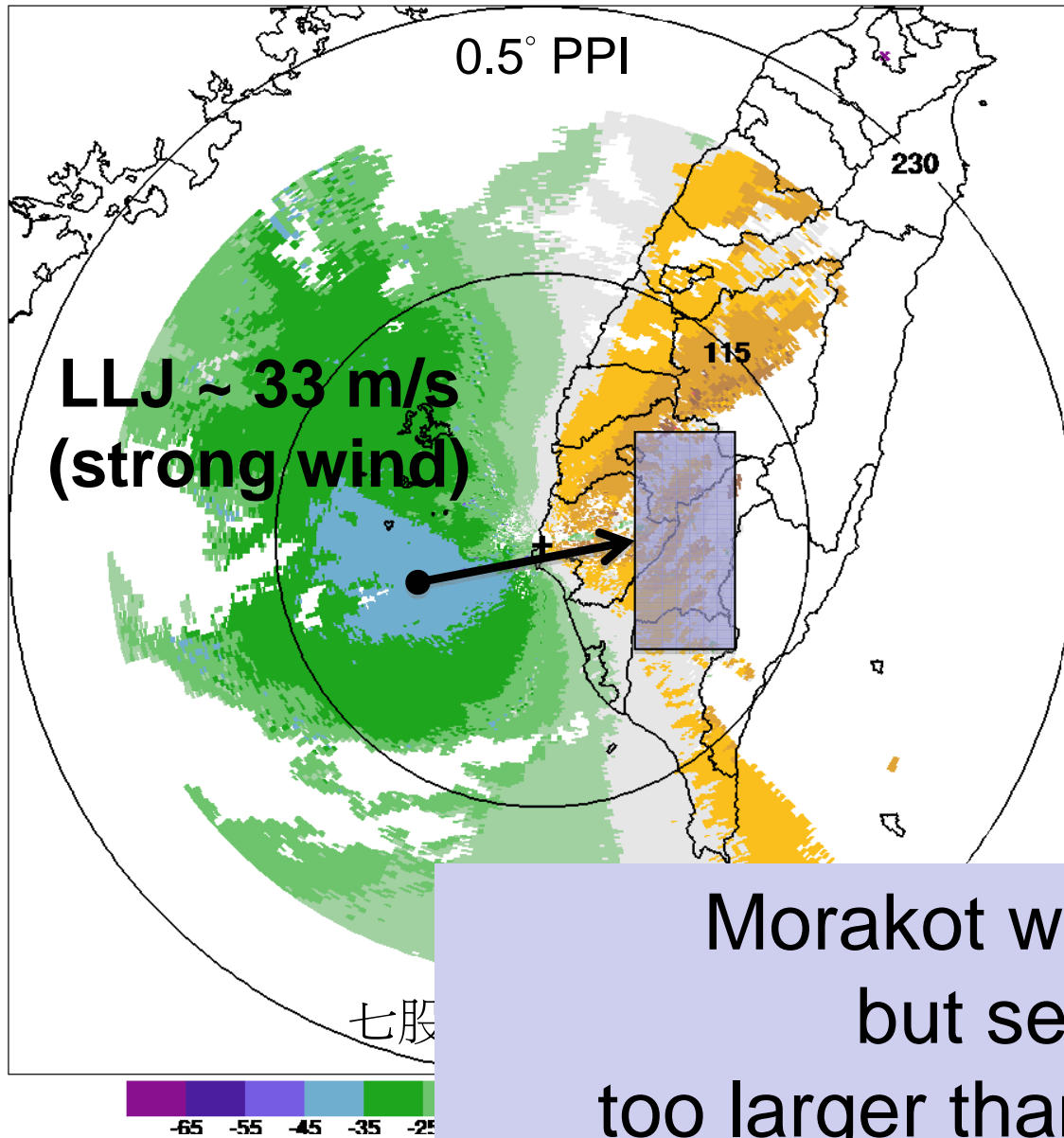
- Does all strong westly wind cause orographic heavy rainfall in south-west part of Taiwan ?

Morakot typhoon (2009)



8月8日 20:00 LST

RCCG200908081206_ppi_da01



Morakot work, too !
but seems
too larger than we expect

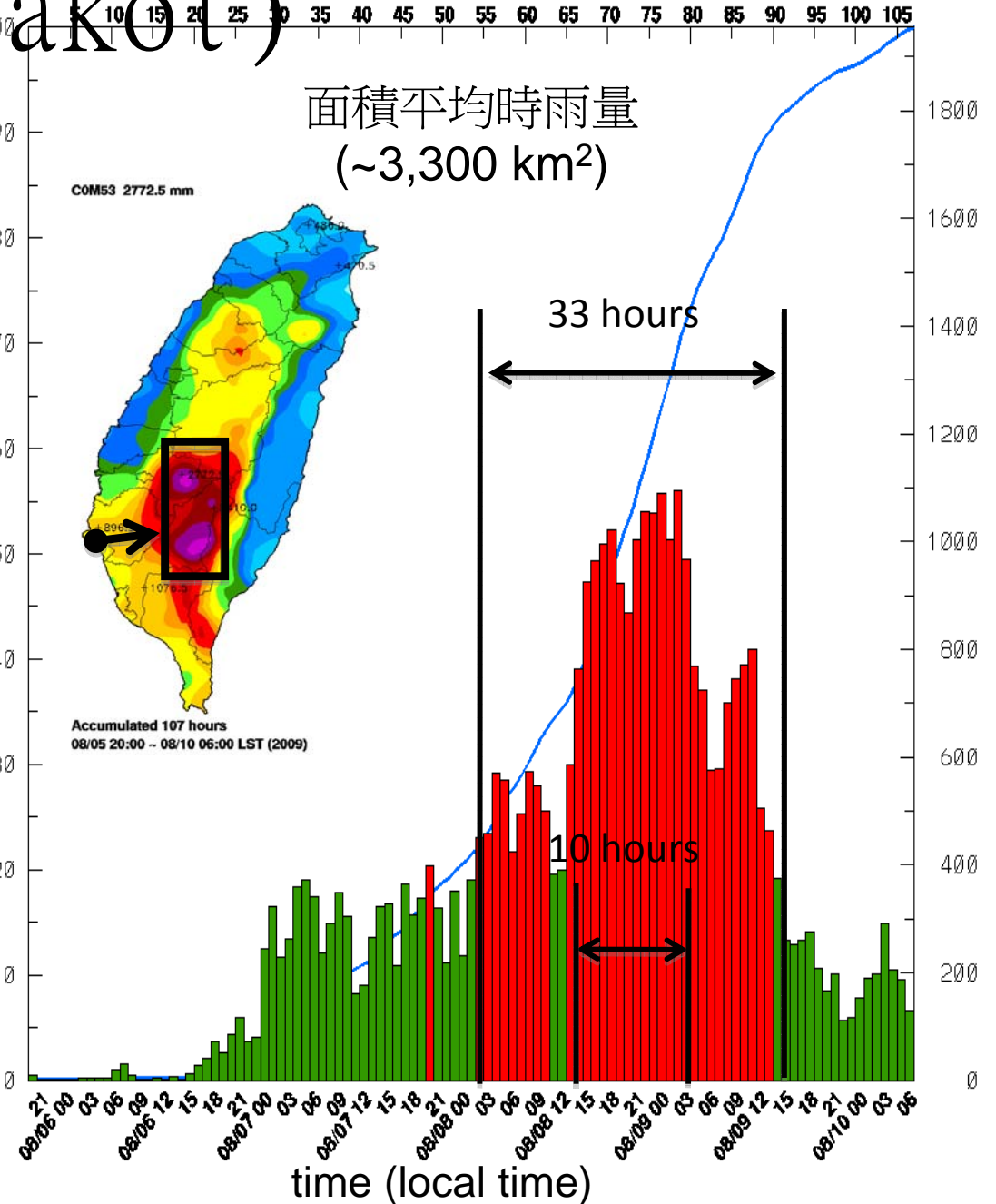
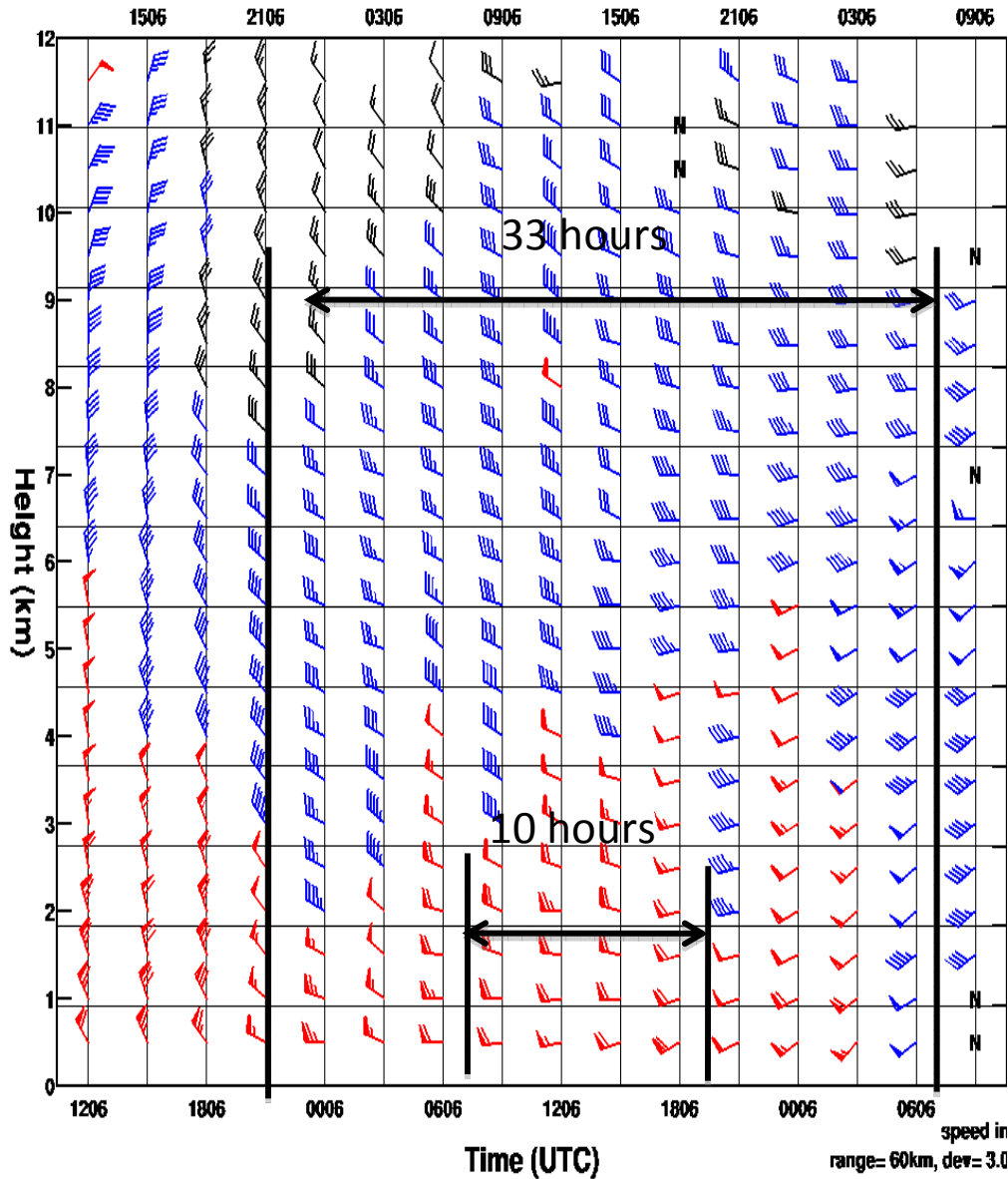
orographic rainfall



08/07/2009
1206

VAD time-series RCGG (Morakot)

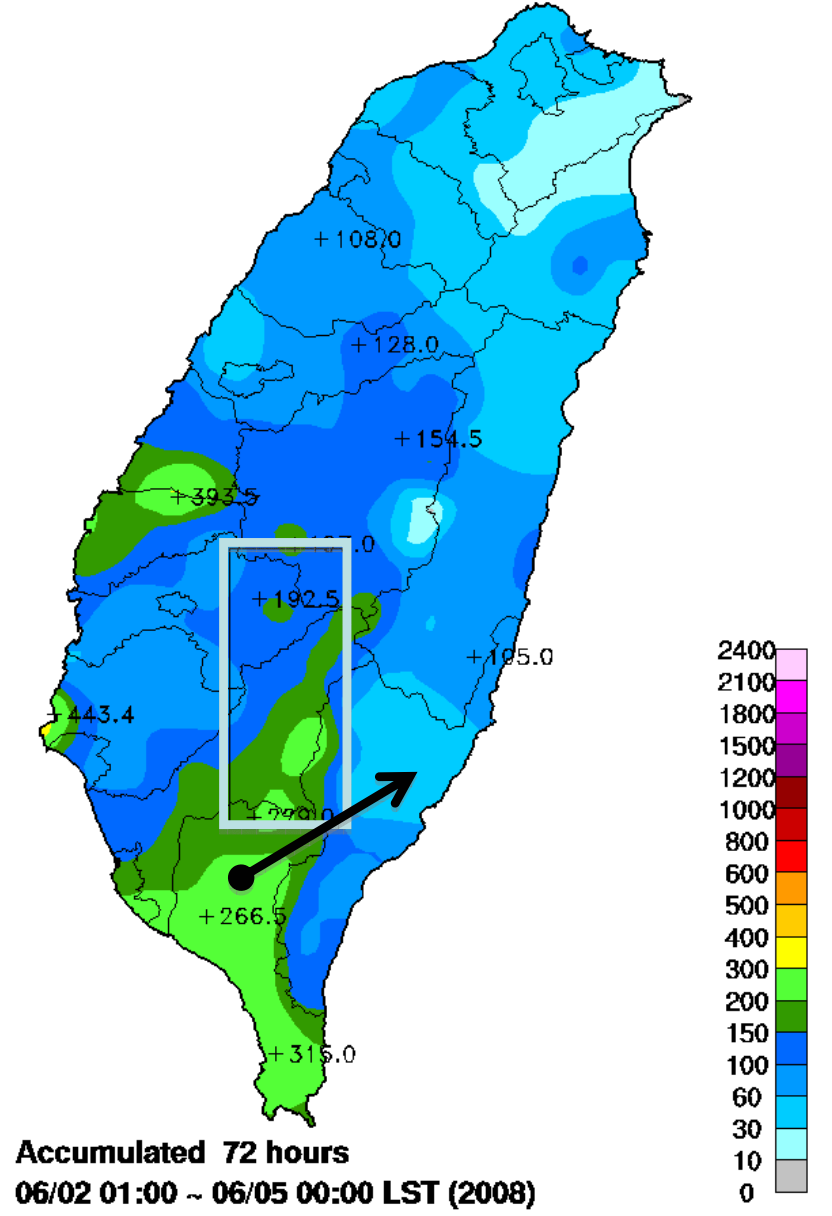
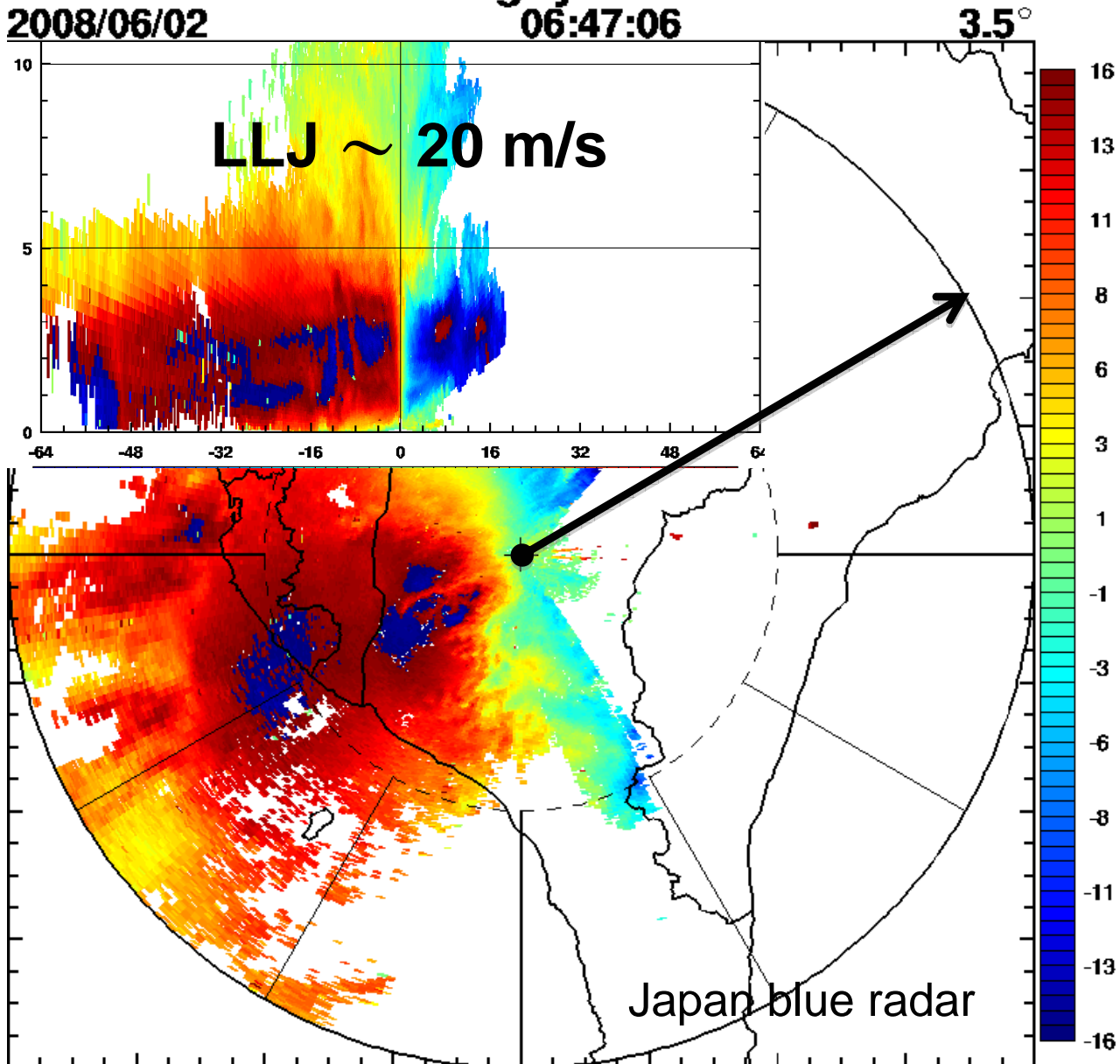
08/09/2009
0906



Mei-Yu front (IOP#4)



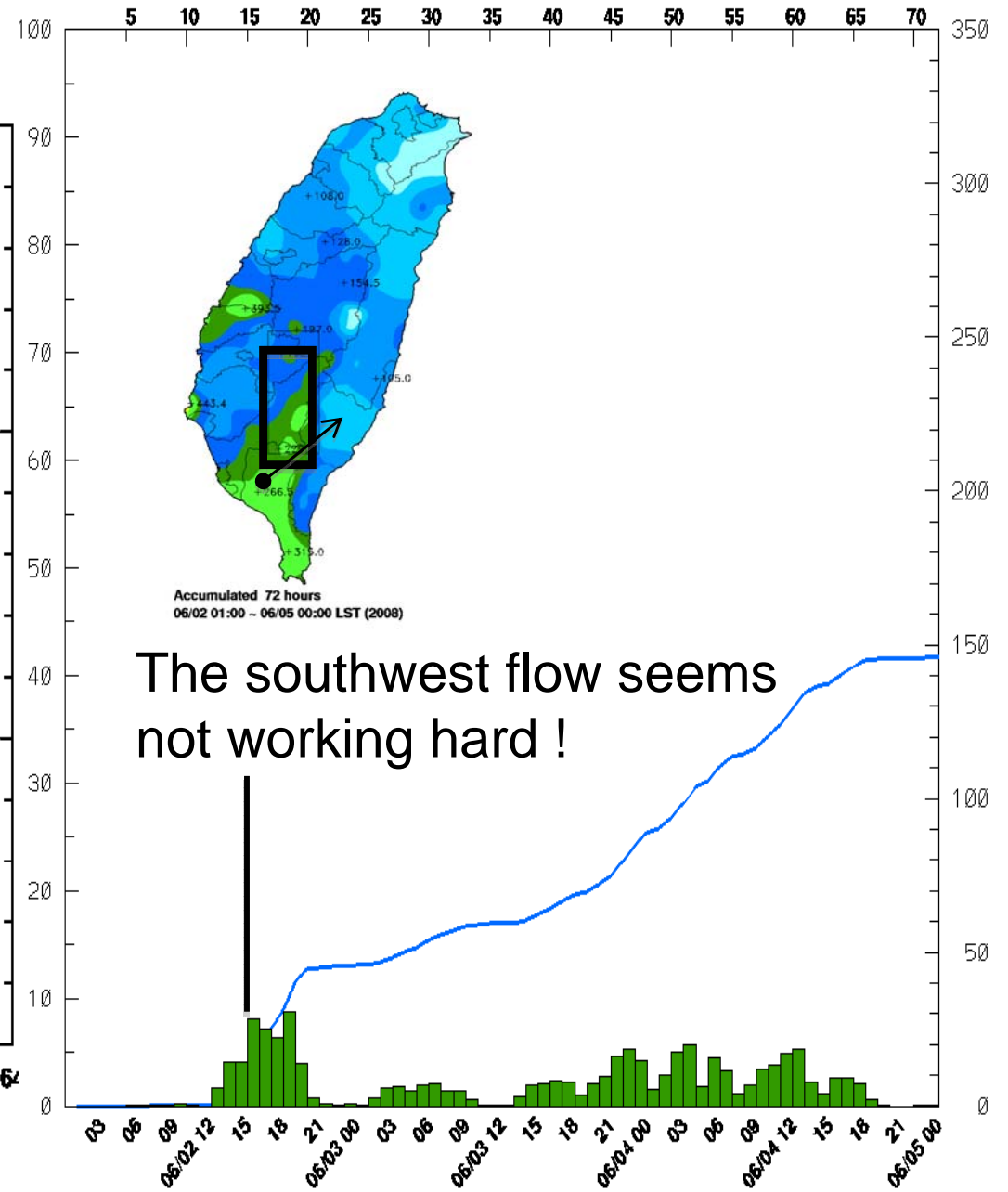
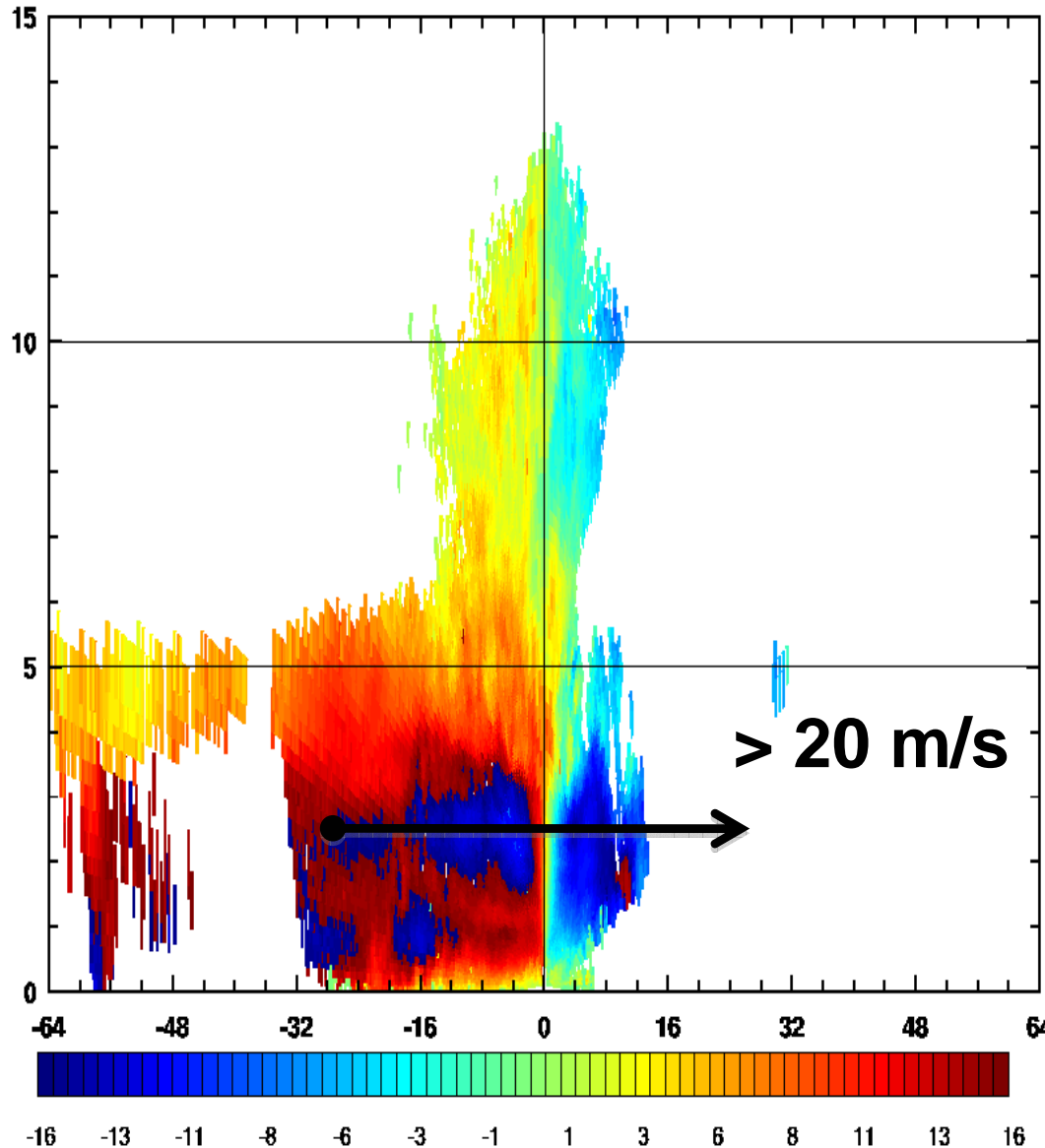
SoWMEX/TiMREX Nagoya Blue Radar
2008/06/02 06:47:06



orographic rainfall (IOP#4)



SoWMEX/TiMREX Nagoya Blue Radar
2008/06/02 06:36:03 239.9°



Questions 2 ?



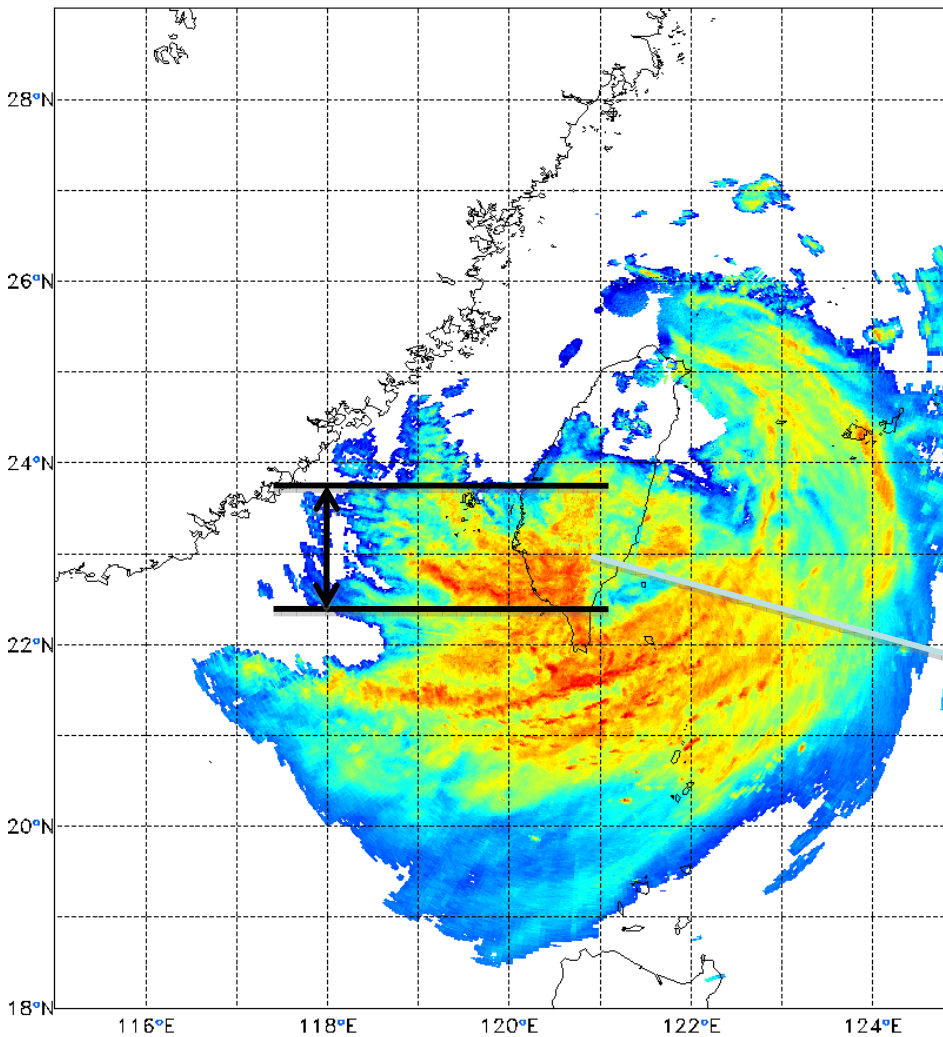
- Is there any other information such as reflectivity pattern that can indicate that there will occur high rainrate in the mountain area ?

2009 Morakot

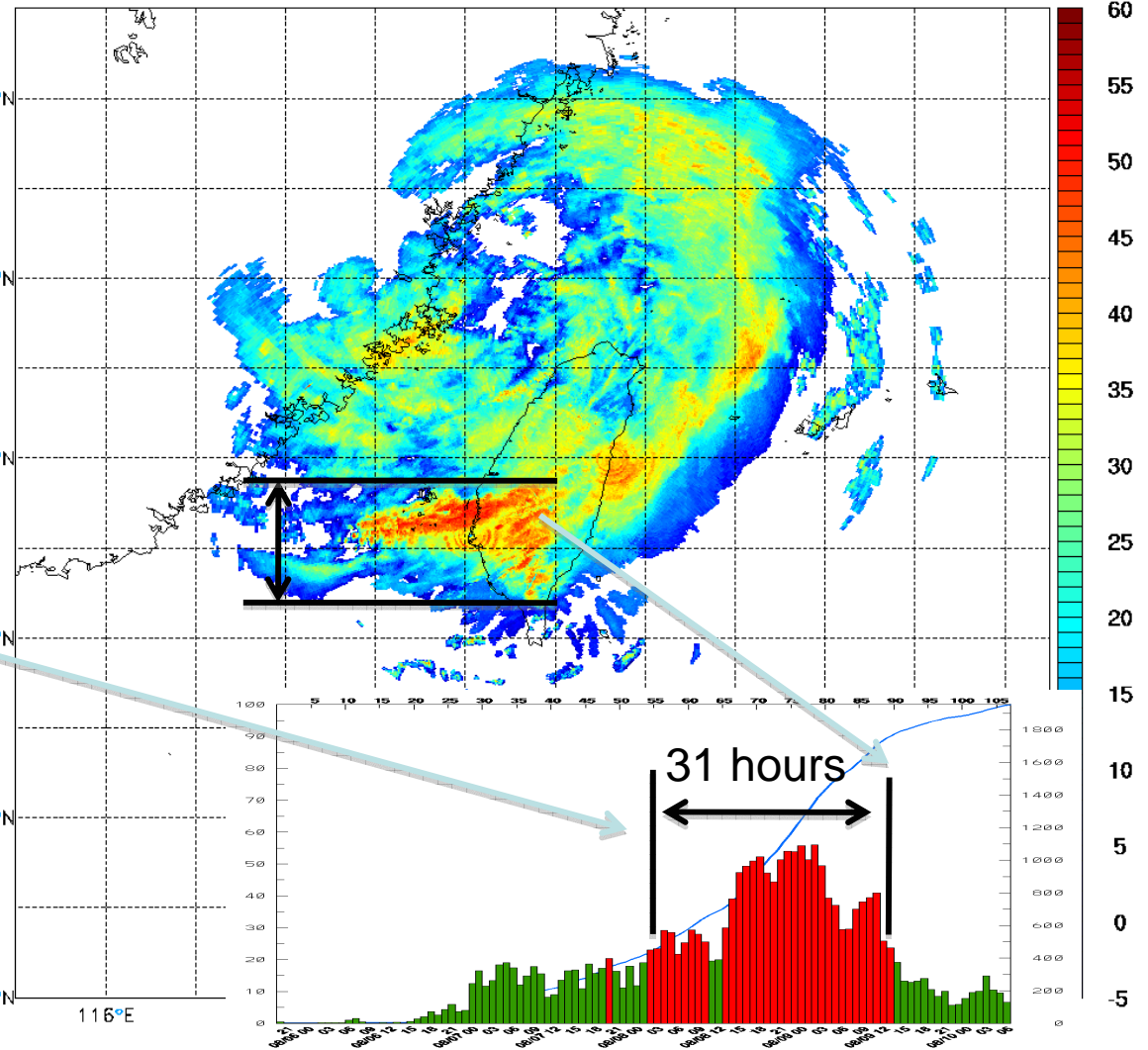


upstream horizontal rainband persistent more than 31 hours

CWB QPESUMS COMPOSITE REFL
2009/08/07 20:00 UTC



CWB QPESUMS COMPOSITE REFL
2009/08/09 03:00 UTC



Questions 3 ?



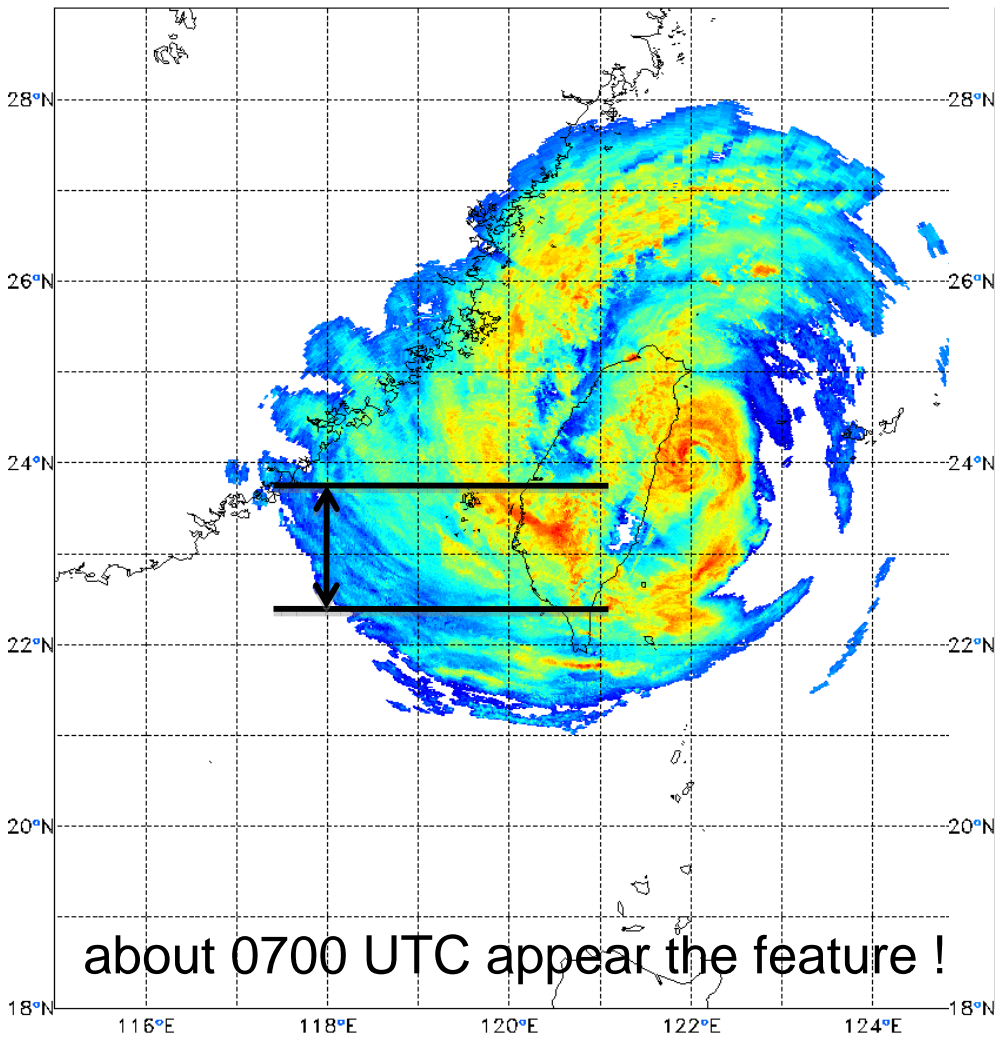
- Is the upstream rainband common for other typhoons ?
- Is upstream rainband associate with strong and deep westly wind ?

2007 Krosa

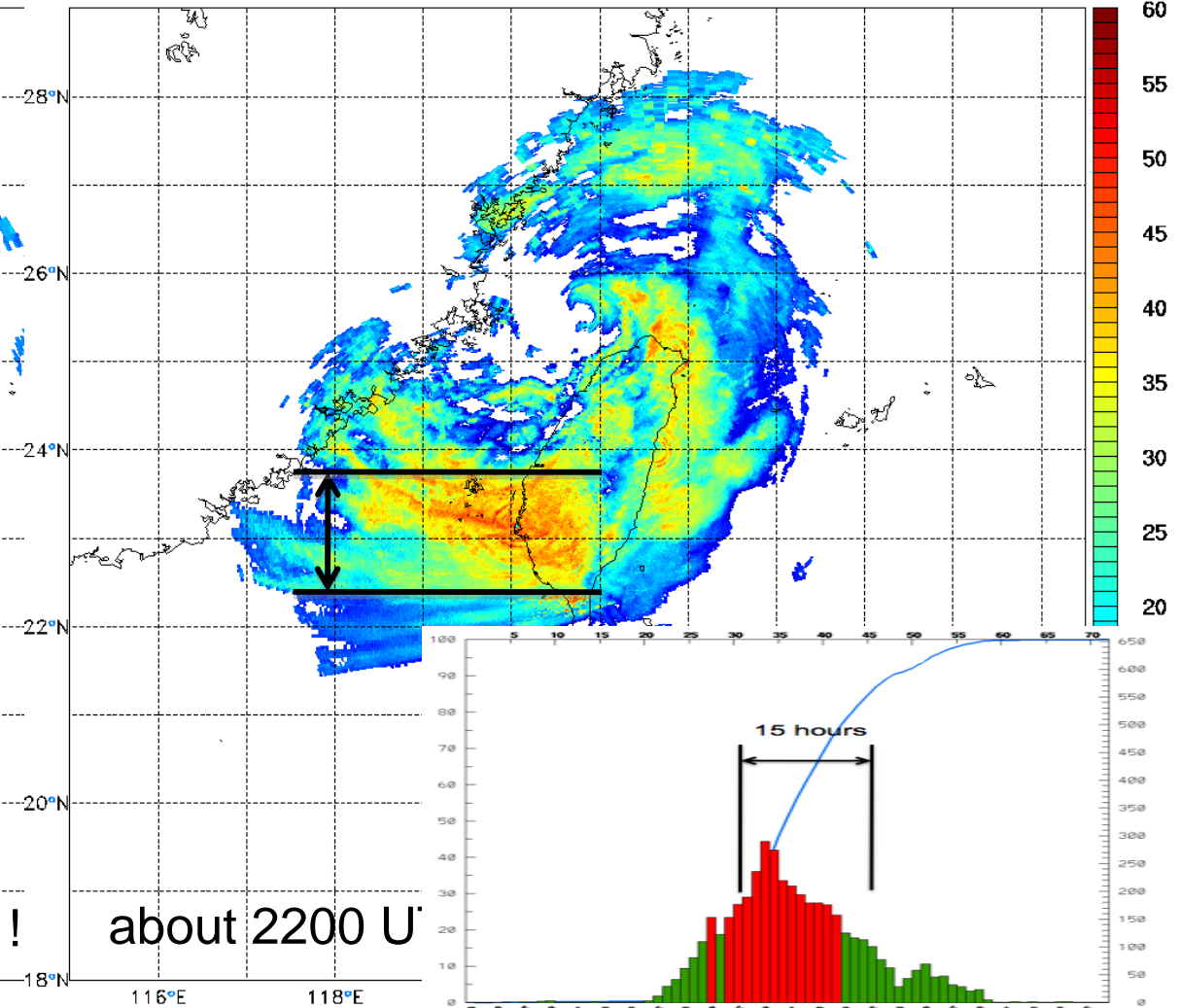


upstream horizontal rainband persistent more than 15 hours

CWB QPESUMS COMPOSITE REFL
2007/10/06 11:30 UTC



CWB QPESUMS COMPOSITE REFL
2007/10/06 20:00 UTC

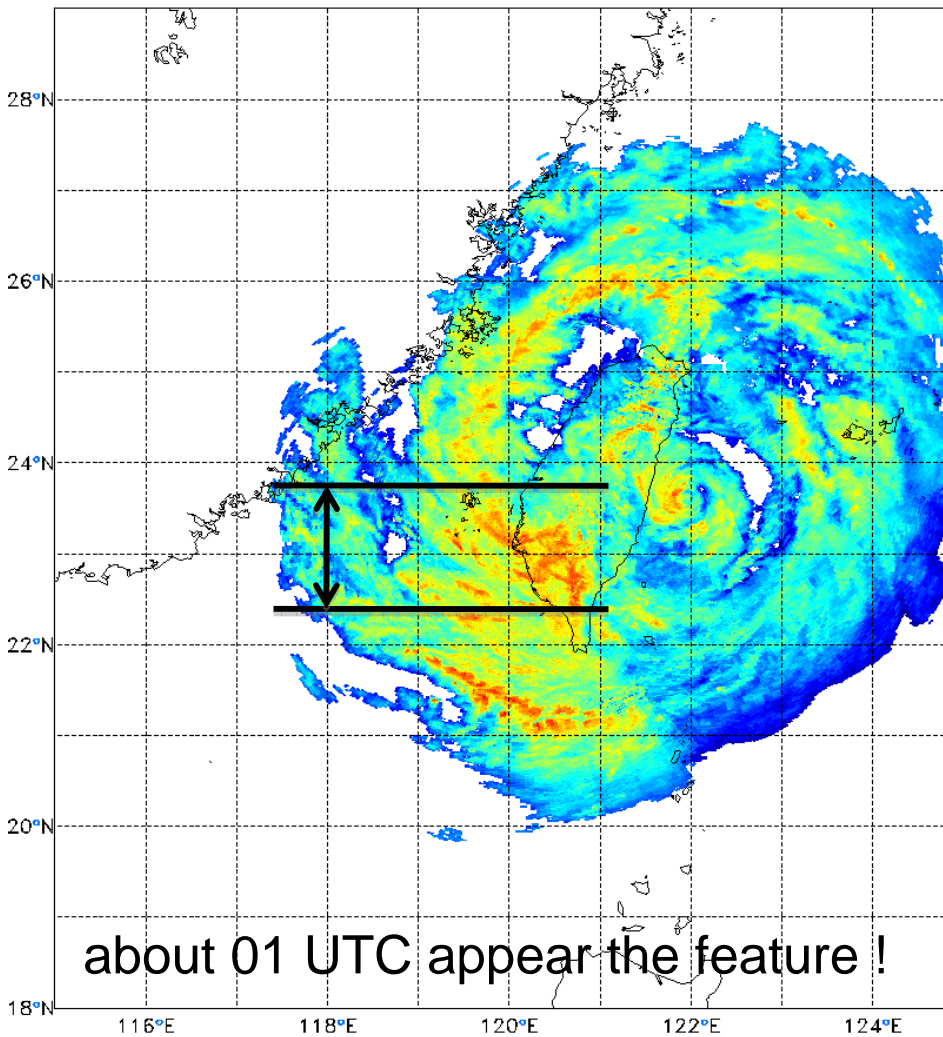


2005 Haitang

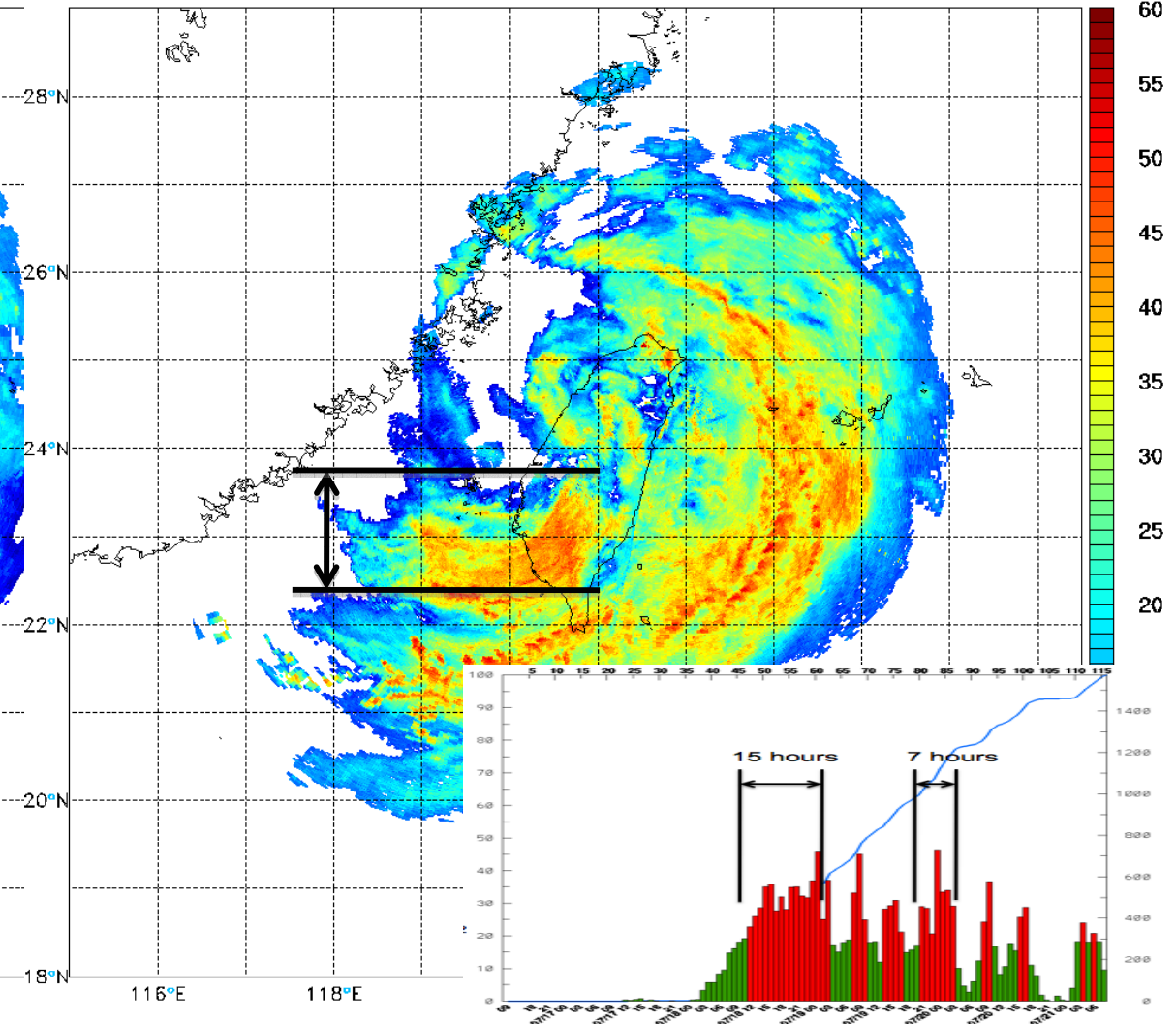


upstream horizontal rainband persistent more than 15 hours

CWB QPESUMS COMPOSITE REFL
2005/07/18 04:00 UTC



CWB QPESUMS COMPOSITE REFL
2005/07/18 16:00 UTC



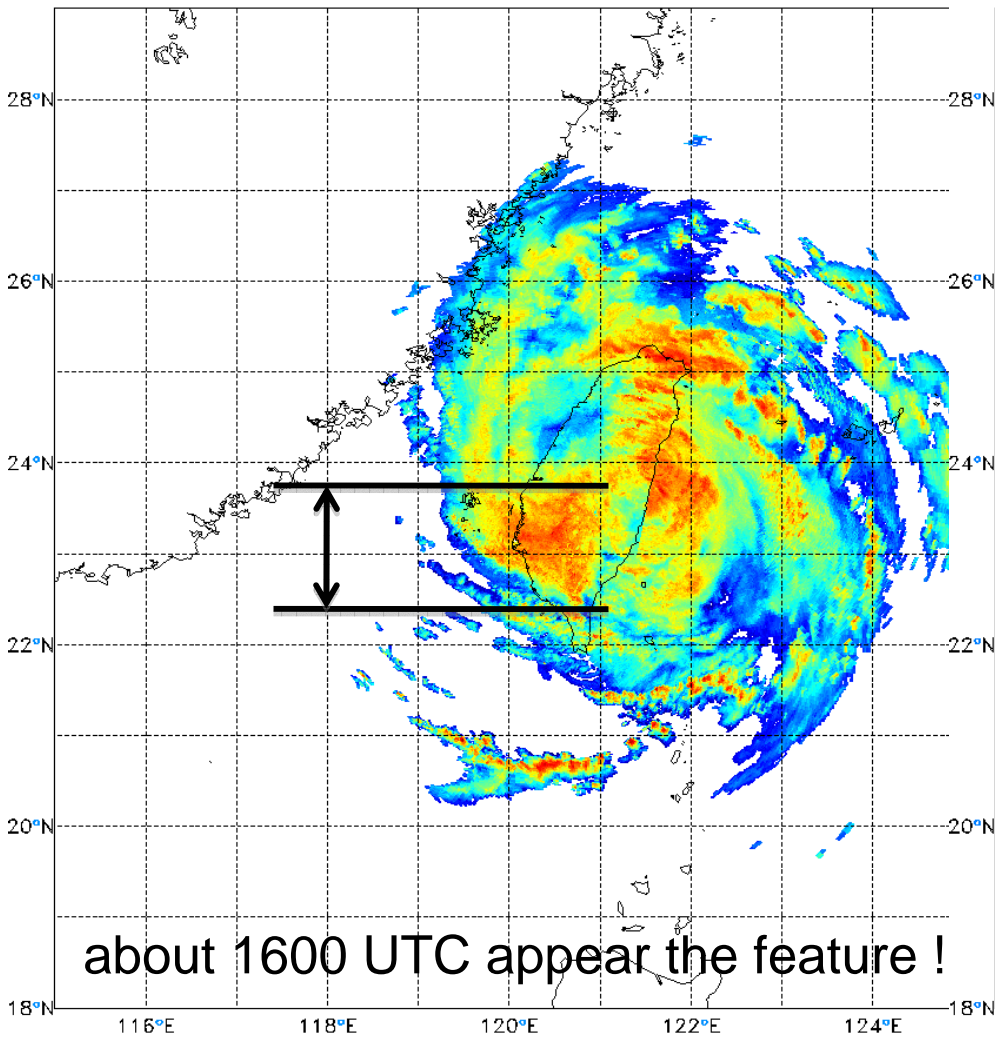
about 01 UTC appear the feature !

2005 Talim

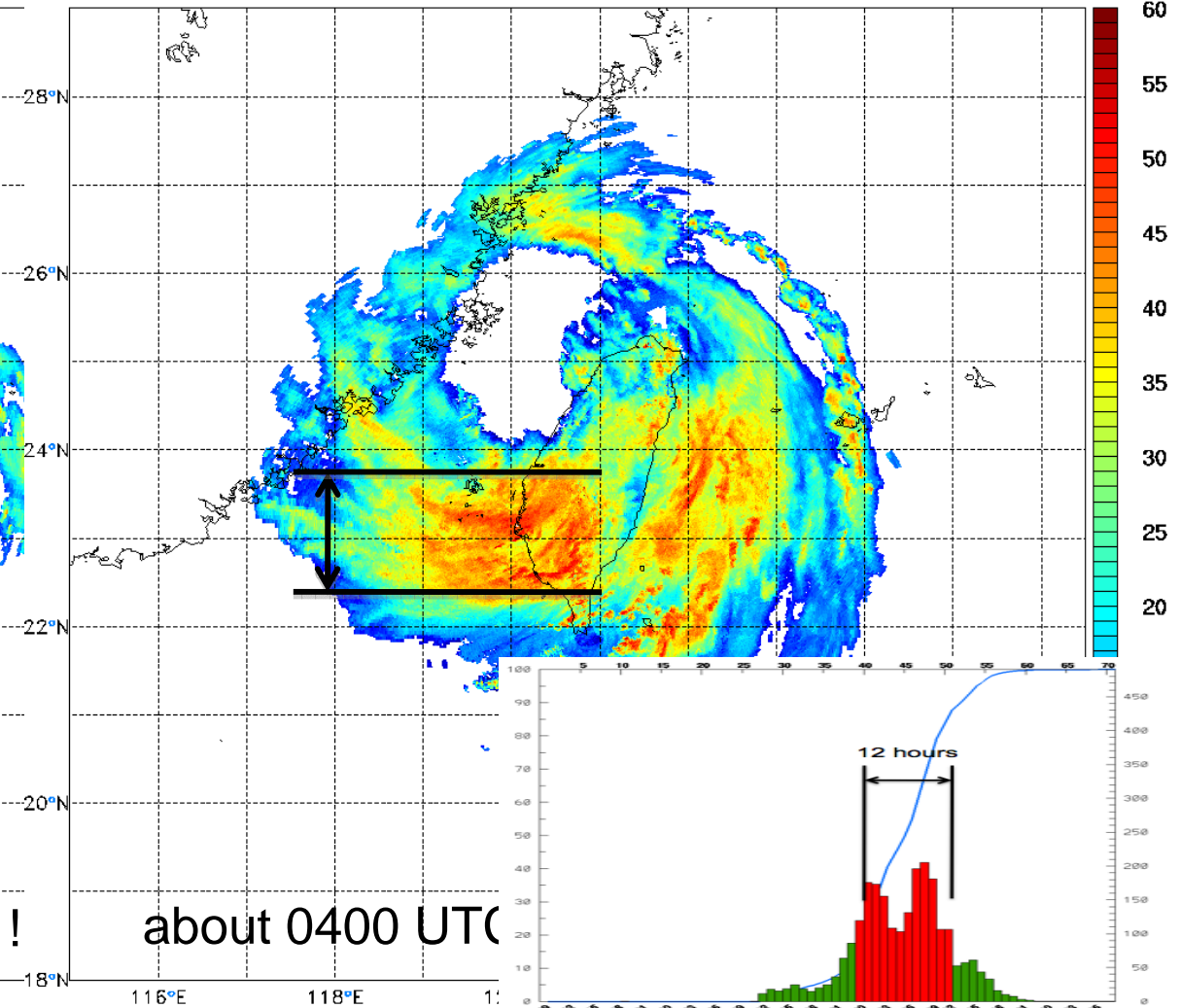


upstream horizontal rainband persistent more than 12 hours

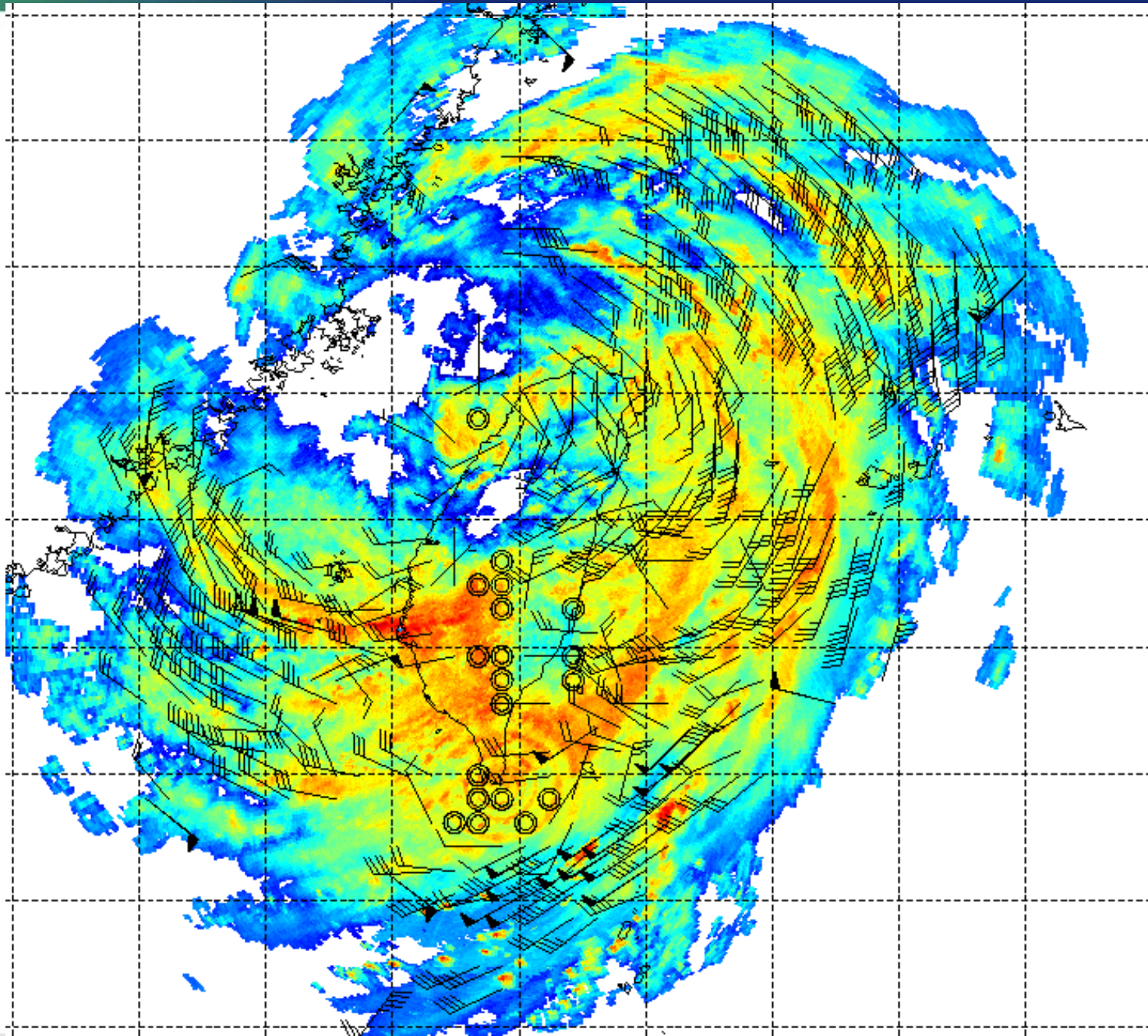
CWB QPESUMS COMPOSITE REFL
2005/08/31 17:30 UTC



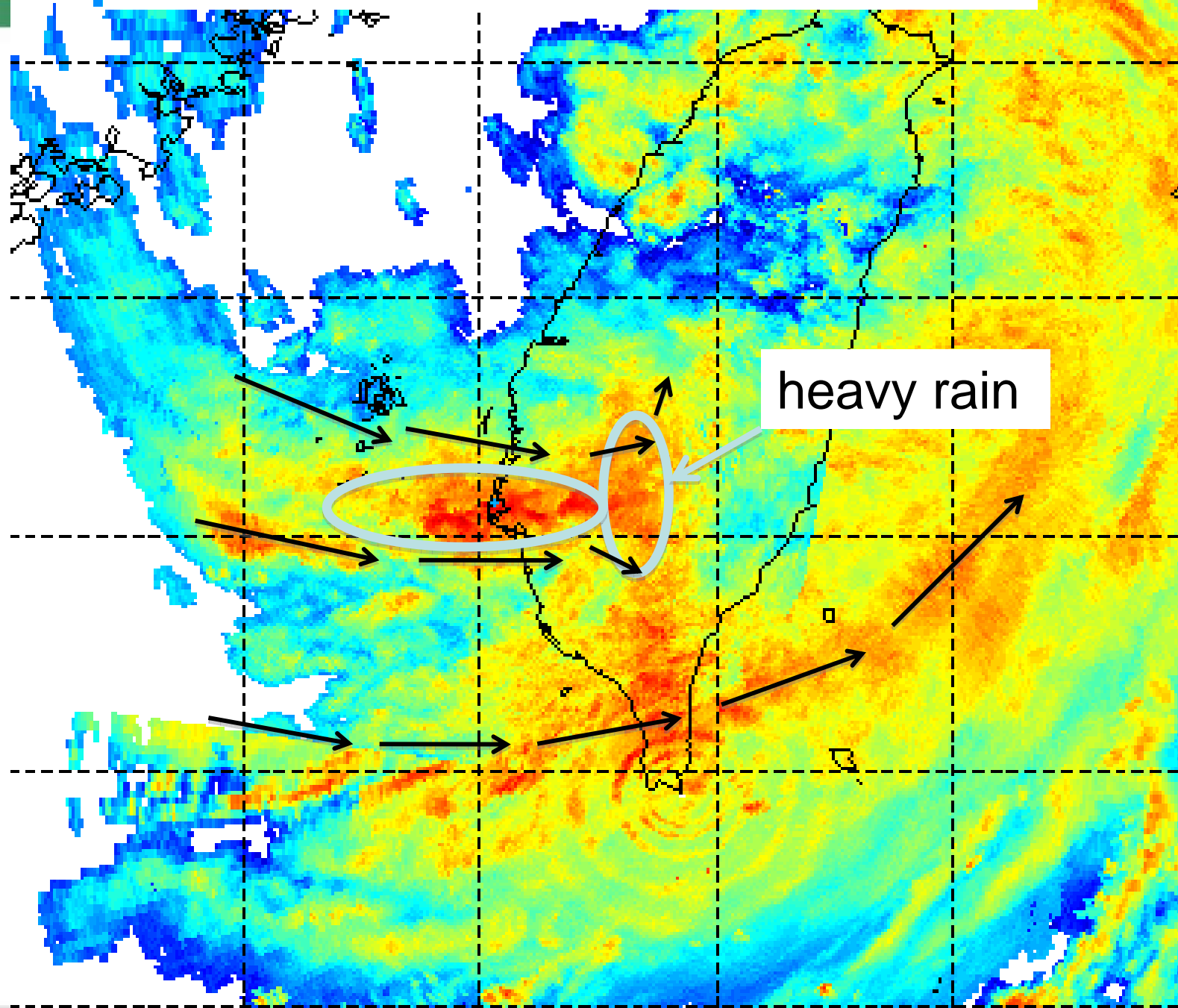
CWB QPESUMS COMPOSITE REFL
2005/09/01 01:30 UTC



Conceptual model



Typhoon circulation form a upstream convergence line



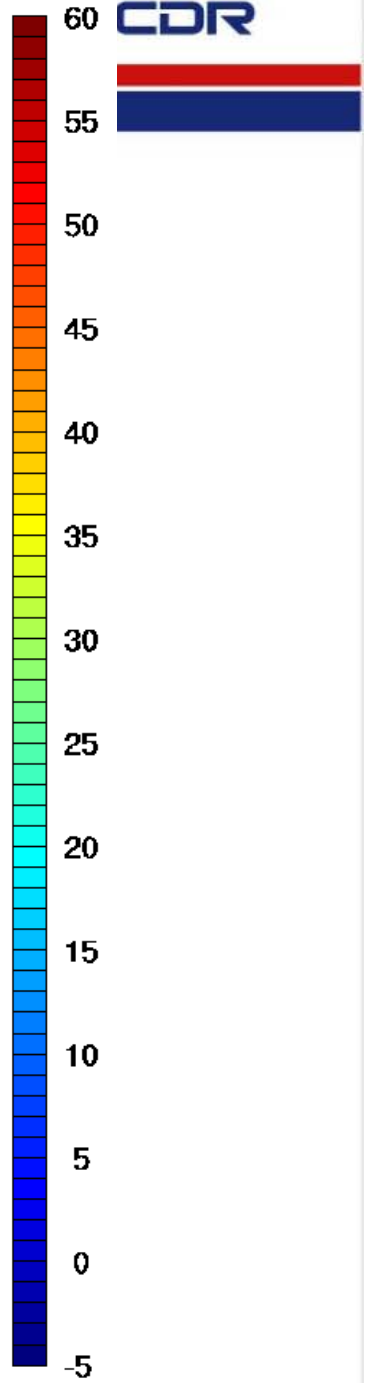
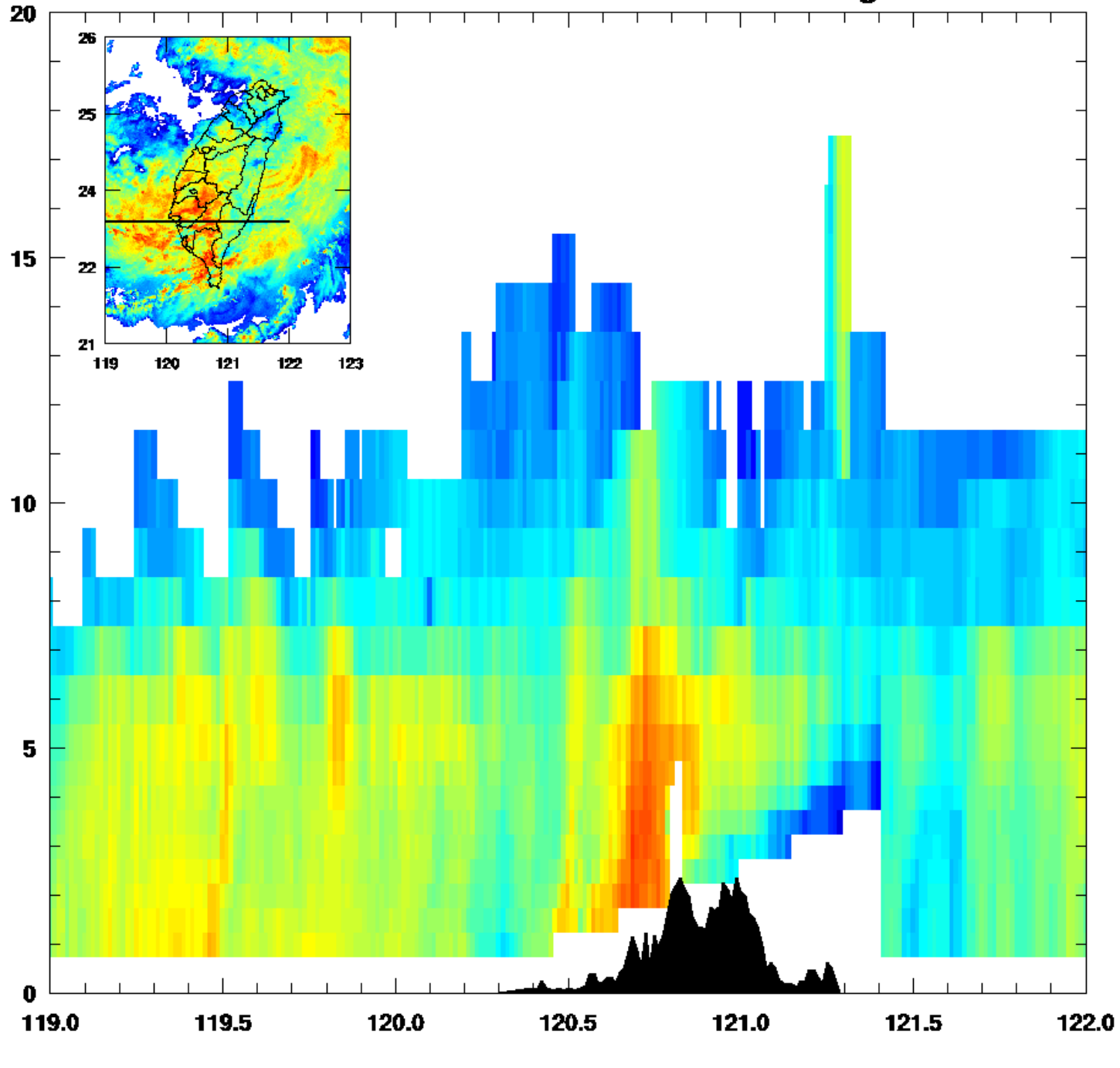
CWB QPESUMS

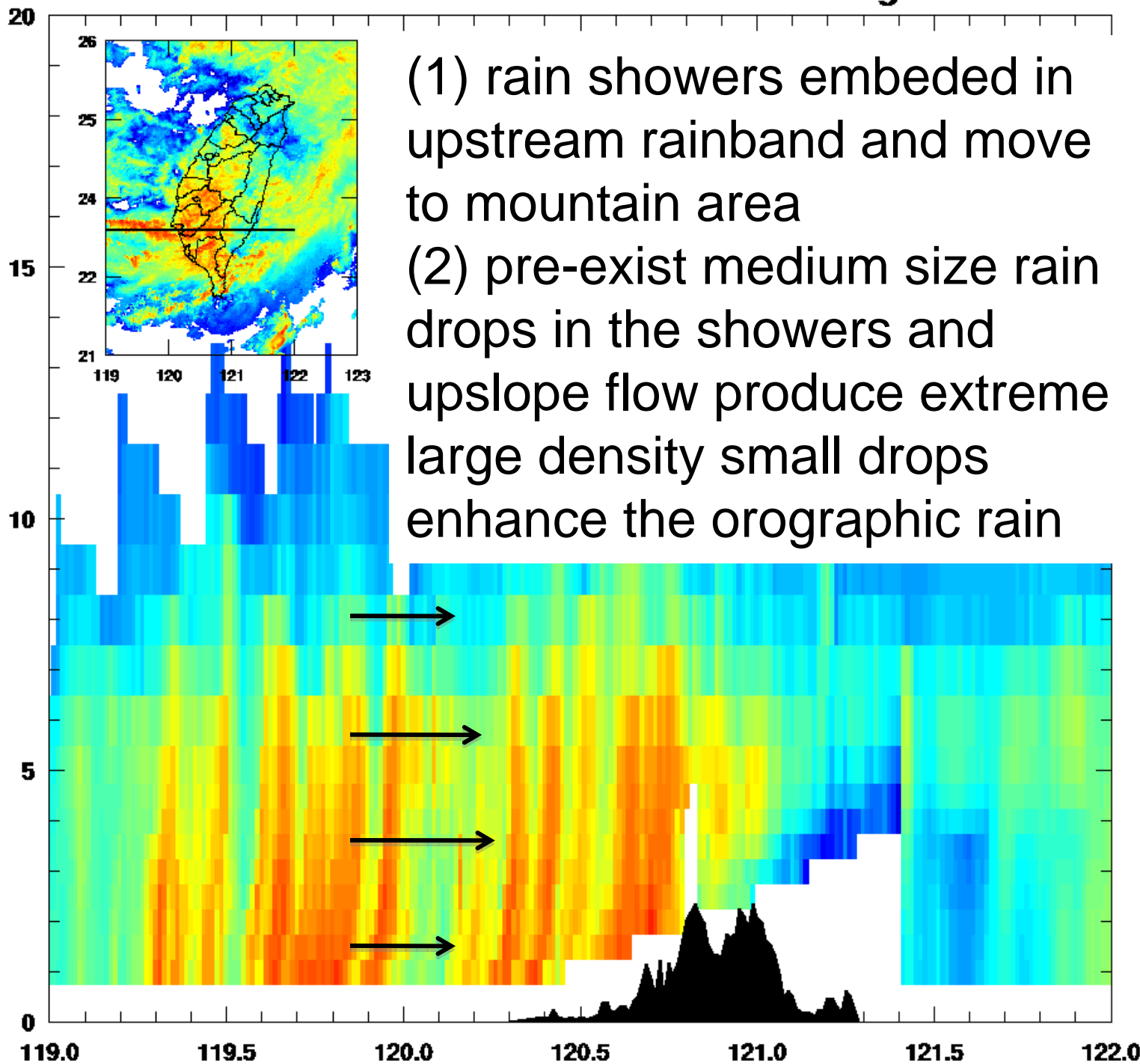
2009/08/08 20:00

Composite 3D Refl X Cross

Lat = 23.00

AvgNum = 5





conclusion



We need collaboration to develop a robust forecast system for (orographic) heavy rainfall.



National Science and Technology Center
for Disaster Reduction

報告完畢

敬請指正

CWB QPESUMS

COMPOSITE REFL

2009/08/07 10:00

