

超强台风天鸽最高强度的 再分析

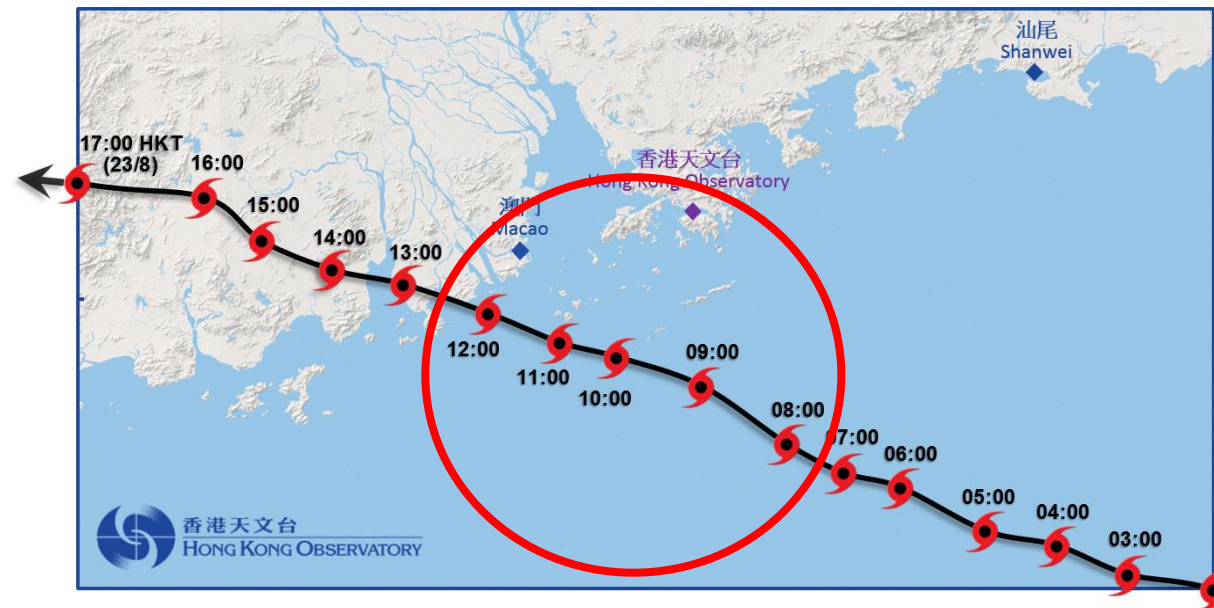
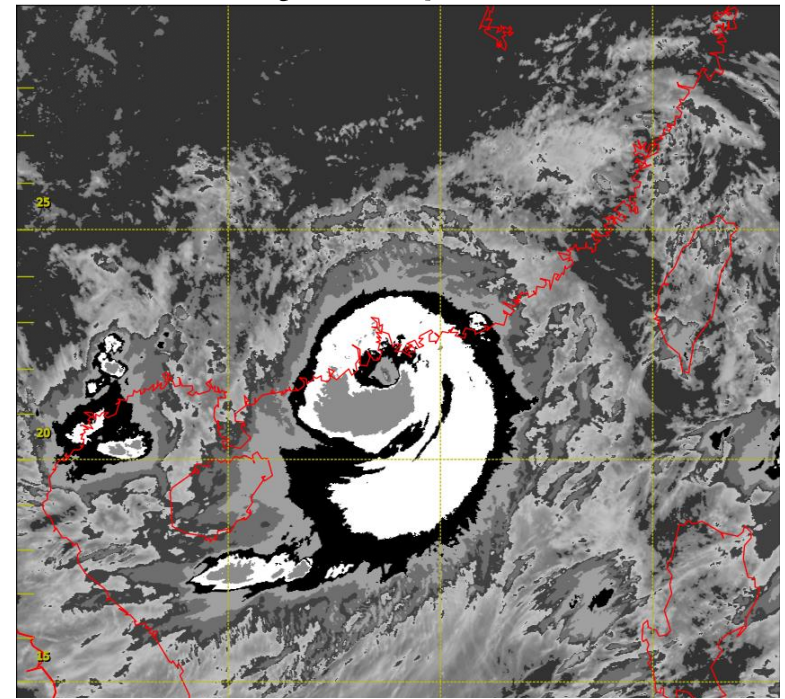
蔡振荣 江伟 刘保宏
香港天文台

德沃夏克主观分析 (Subjective Dvorak analysis)

- DT 由8月23日上午9时至上午10时急速上升，大约在上午10时左右达到最高6.5
- DT 在10时50分下跌至 5.5

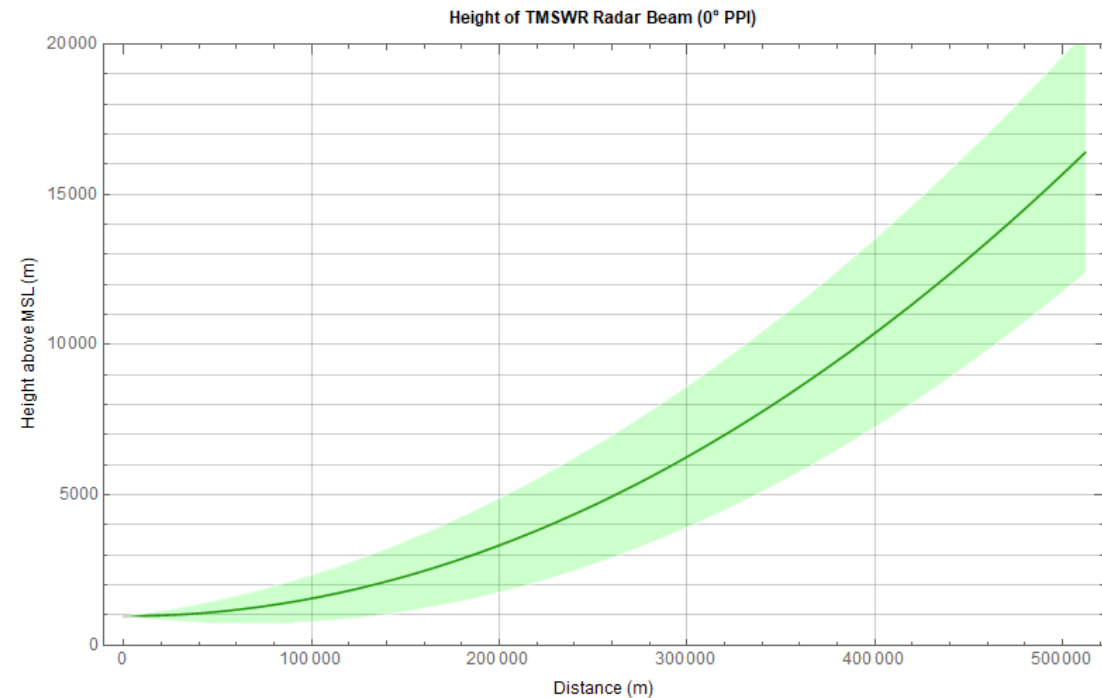
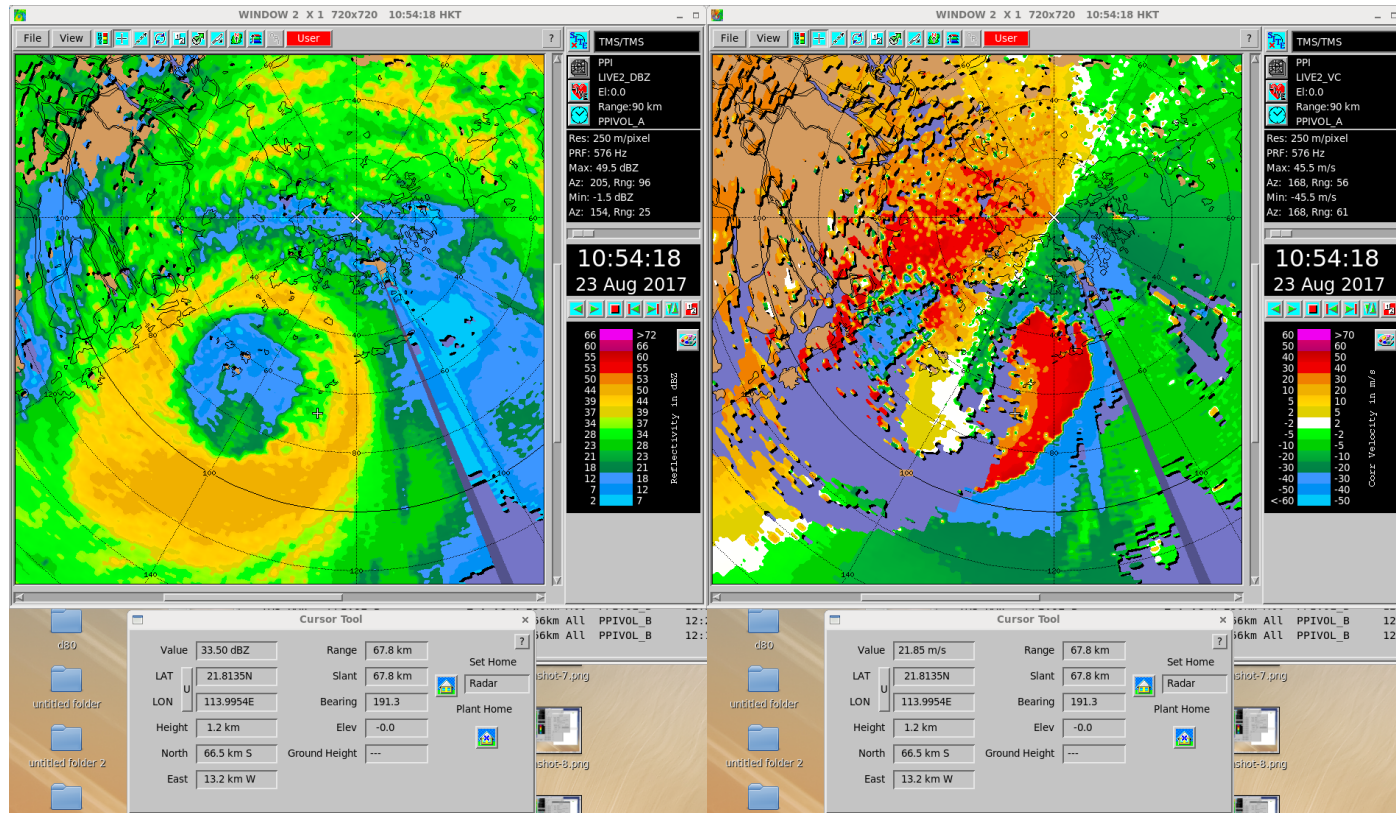
DT at 0850 (white + black) = 5.0 -> 85 kt
 DT at 0900 (white + LG) = 6.0 -> 107 kt
 DT at 0950 (white + MG) = 6.0 -> 107 kt
 DT at 1000 (white + OW) = 6.5 -> 118 kt
 DT at 1010 (black + OW) = 6.0 -> 107 kt
 DT at 1050Z (Black+ DG) = 5.5 -> 95 kt

CI/T	MSLP	10-min max wind		TC cat
		knots	km/h	
5	954	84	156	ST
5.5	941	95	176	ST
6	927	107	198	SuperT
6.5	914	118	219	SuperT

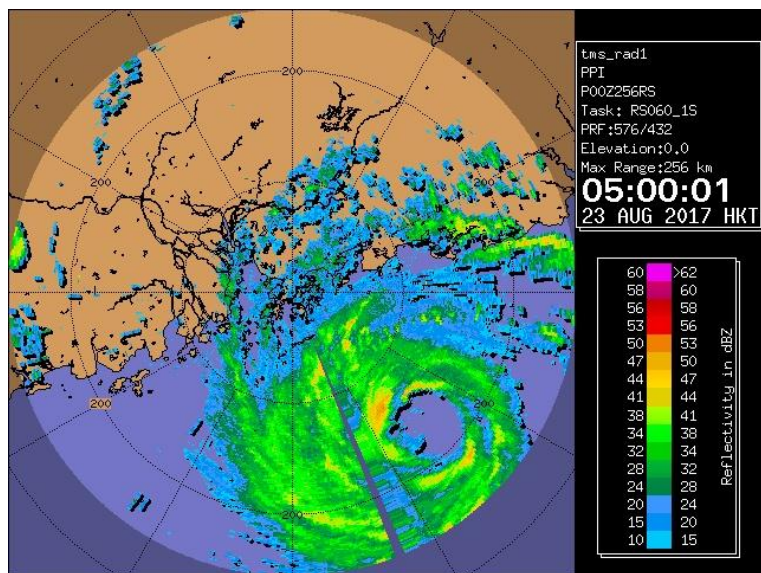


多普勒雷达分析

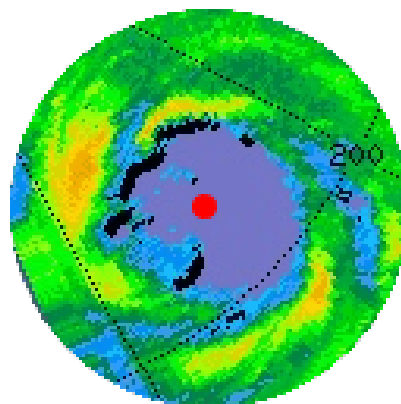
- 最大 0° PPI多普勒径向风 = $45.9 + 21.9 = 67.8$ m/s (当时天鸽在香港100公里的范围内， 0° PPI的大概到探测1 km的高度)
- 用0.7的因子转换为10 米风 = 92 kt, 95%可信区间 (0.6 – 0.8) -> (79 kt – 105 kt) (Reference 1, 利用 0° PPI)



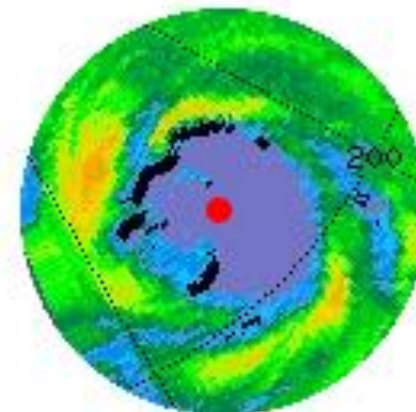
- 利用rapid scan 雷达(每1分钟1张)的角速度(angular velocity)去估算中心风力的增加:
由上午5时 -> 10时:角速度(angular velocity)增加了26% (05H: 80 kt -> 10H: ~100 kt)



0500 - 0509



Rotating Frame of Reference



$$\omega = \sim 3 \text{ deg/min}$$

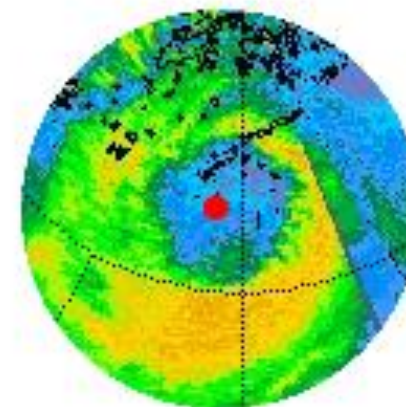
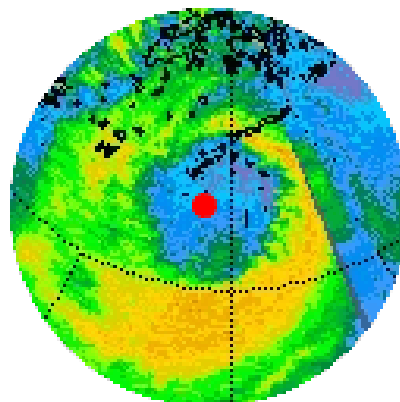
$$R_{\text{eye}} = \sim 40 \text{ km}$$

$$V_{\text{eye}} = \sim 126 \text{ km/h}$$

V_{eye} increased by 26%

风眼半径亦减少

0935 - 0944

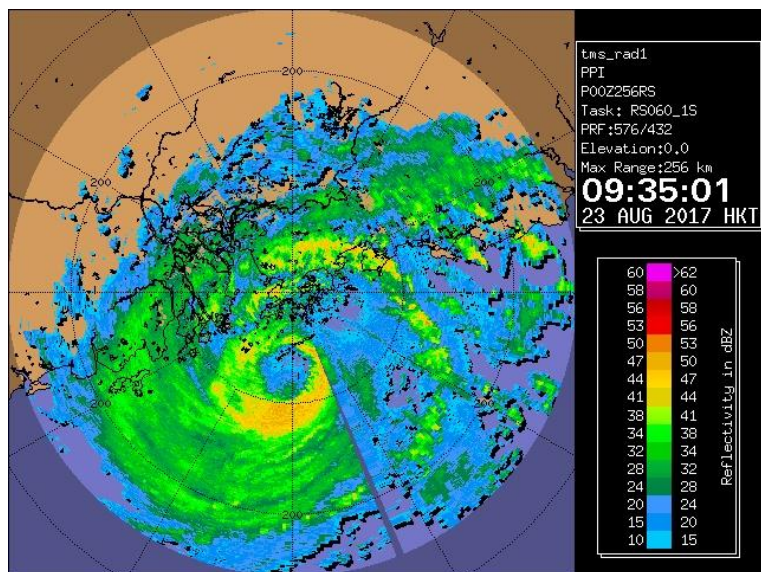


$$\omega = \sim 6.5 \text{ deg/min}$$

$$R_{\text{eye}} = \sim 25 \text{ km}$$

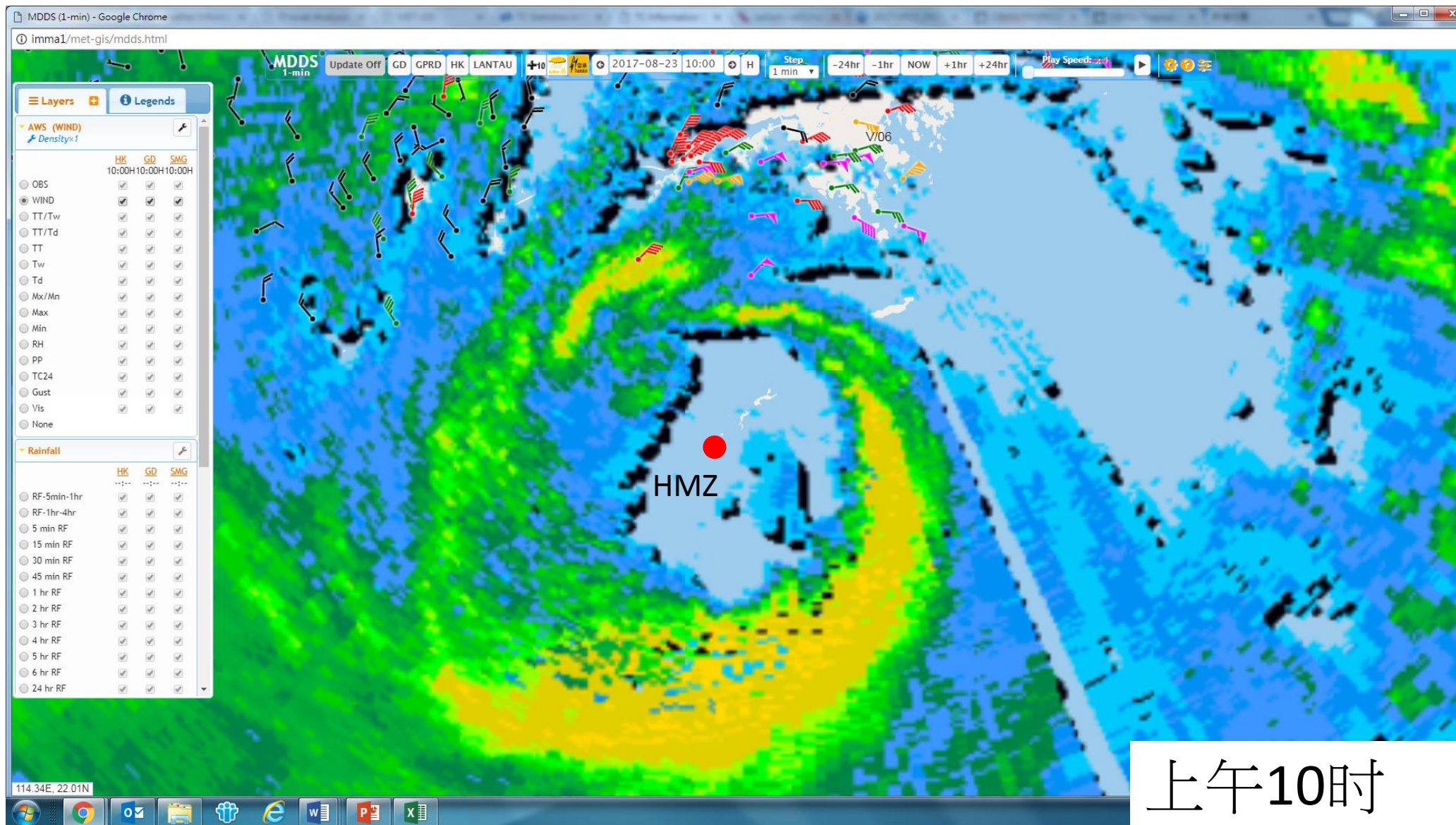
$$V_{\text{eye}} = \sim 170 \text{ km/h}$$

Courtesy of W Kong



黄茅洲 (HMZ) 的观测 – 位于香港以南约50公里

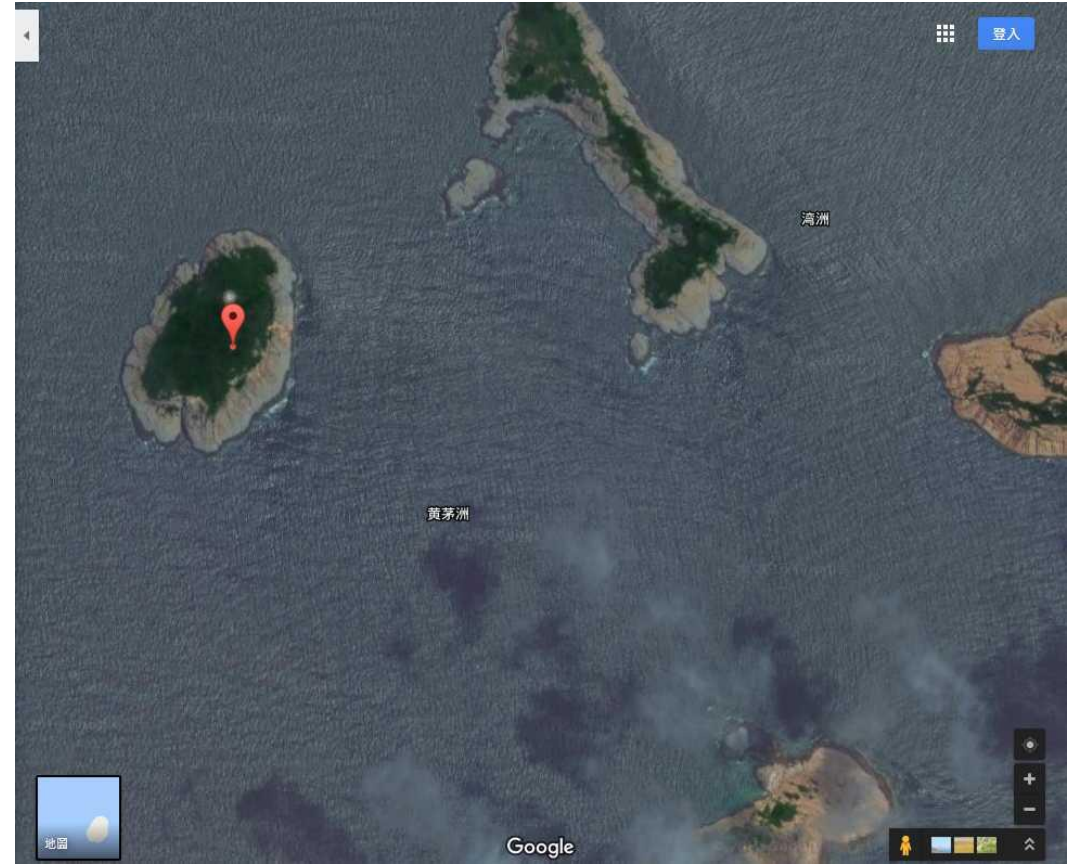
天鸽的风眼在9时30分至10时30分经过黄茅洲(0130-0230 UTC)



上午10时

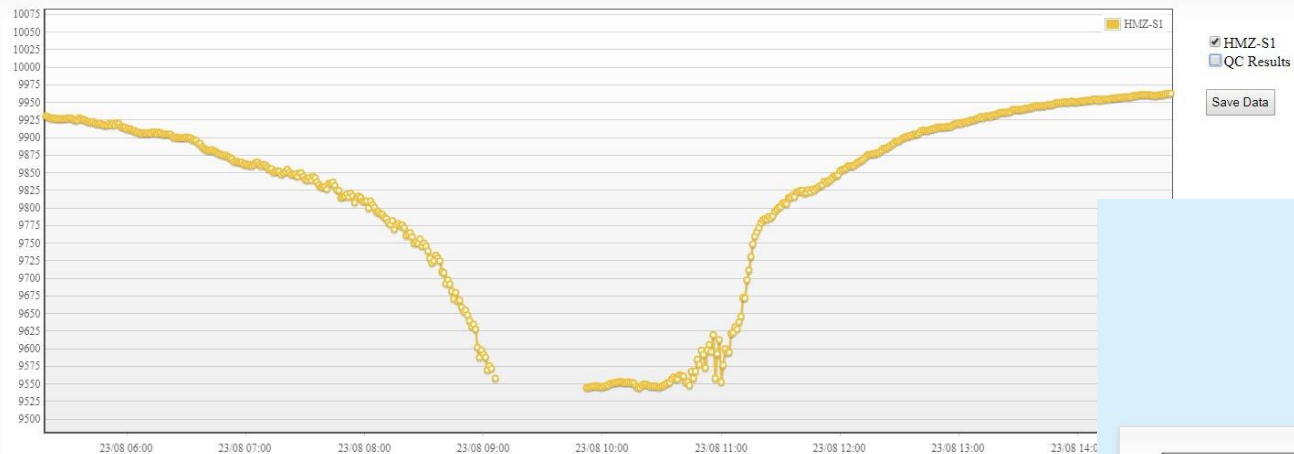
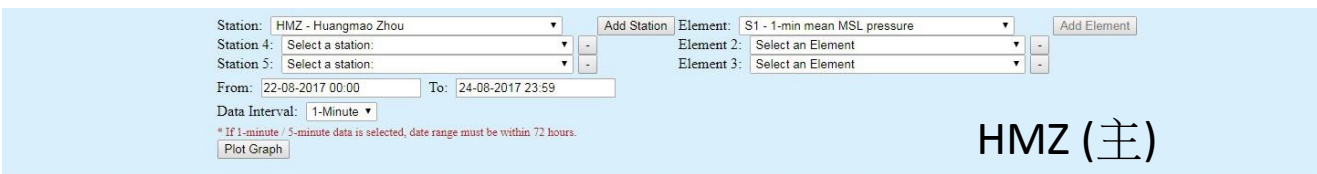
黄茅洲的风速表

两个风速表(HMZ and HM2)
HMZ (主风速表, 离海平面67米)
HM2 (副风速表, 离海平面66米)



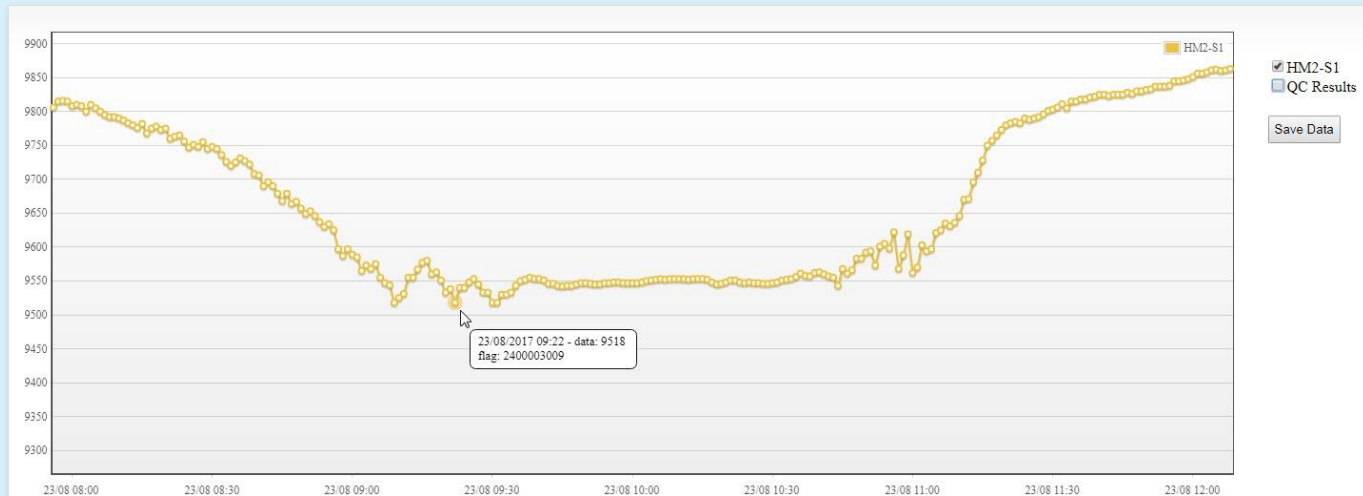
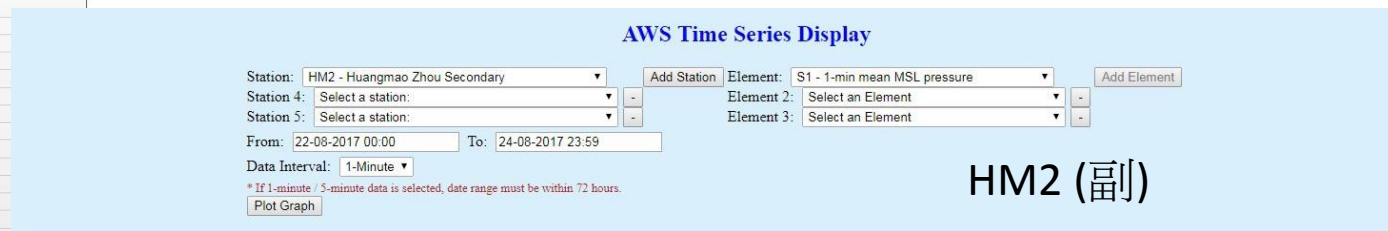
黄茅洲的海平面气压

- HMZ: 954.5 hPa
(有数据缺失)



- HM2: 0909,0922,0930-31 – 951.8 hPa

当黄茅洲在天鸽的风眼内，海平面气压大致平稳



AWS Time Series Display

Station: HM2 - Huangmao Zhou Secondary Add Station Element: E1 - 10-min mean wind speed Add Element

Station 4: HMZ - Huangmao Zhou Element 2: Select an Element

Station 5: Select a station Element 3: Select an Element

From: 22-08-2017 00:00 To: 24-08-2017 23:59

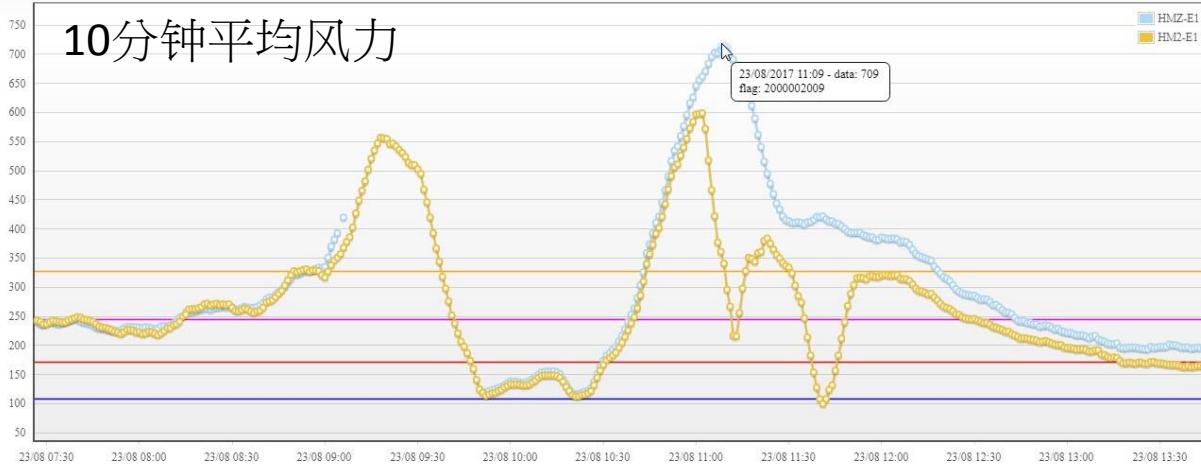
Data Interval: 1-Minute

* If 1-minute / 5-minute data is selected, date range must be within 72 hours.

Plot Graph

蓝线: HMZ, 黄线: HM2

10分钟平均风力



- HM2-E1
 - HMZ-E1
 - QC Results
- Save Data
- Hurricane 32.7m/s
 - Storm 24.5m/s
 - Gale 17.2m/s
 - Strong 10.8m/s

最大10分钟平均风力:

HMZ(主) – 70.9 m/s or 137.6 kt at 11:09H
(0906H – 0952H没有数据)

HM2(副) – 59.9 m/s or 116.2 kt at 11:02H

[但随数据起伏不定，而在24日上午10时后的数据更显示HM2 (副)风速表已损坏]

Station: HM2 - Huangmao Zhou Secondary Add Station Element: C1 - 1-min max wind gust (3-second) Add Element

Station 4: HMZ - Huangmao Zhou Element 2: Select an Element

Station 5: Select a station Element 3: Select an Element

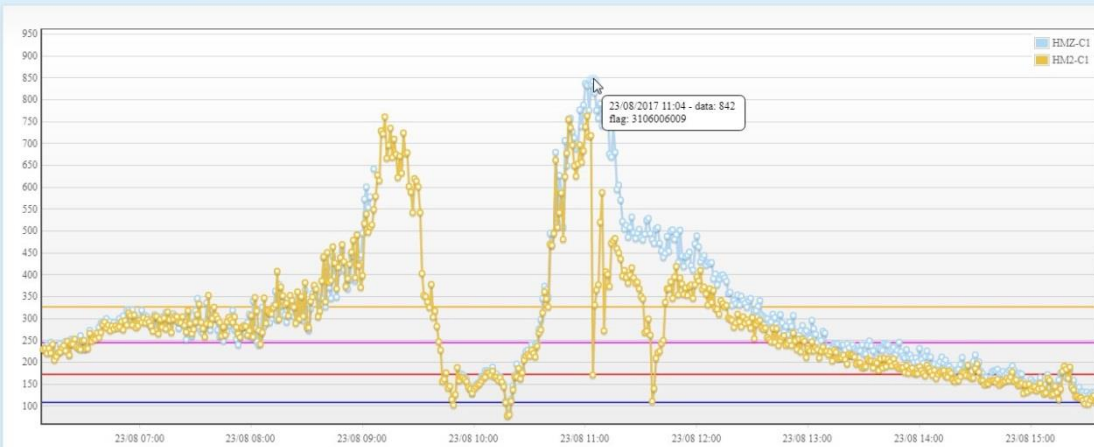
From: 22-08-2017 00:00 To: 24-08-2017 23:59

Data Interval: 1-Minute

* If 1-minute / 5-minute data is selected, date range must be within 72 hours.

Plot Graph

一分钟阵风

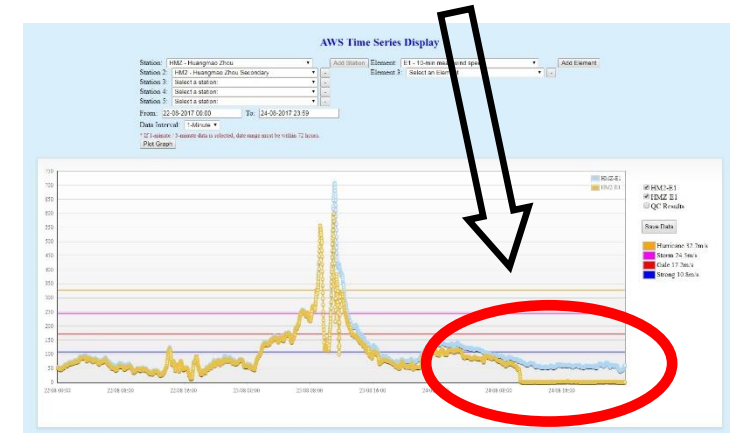


- HM2-C1
 - HMZ-C1
 - QC Results
- Save Data
- Hurricane 32.7m/s
 - Storm 24.5m/s
 - Gale 17.2m/s
 - Strong 10.8m/s

最大的一分钟阵风:

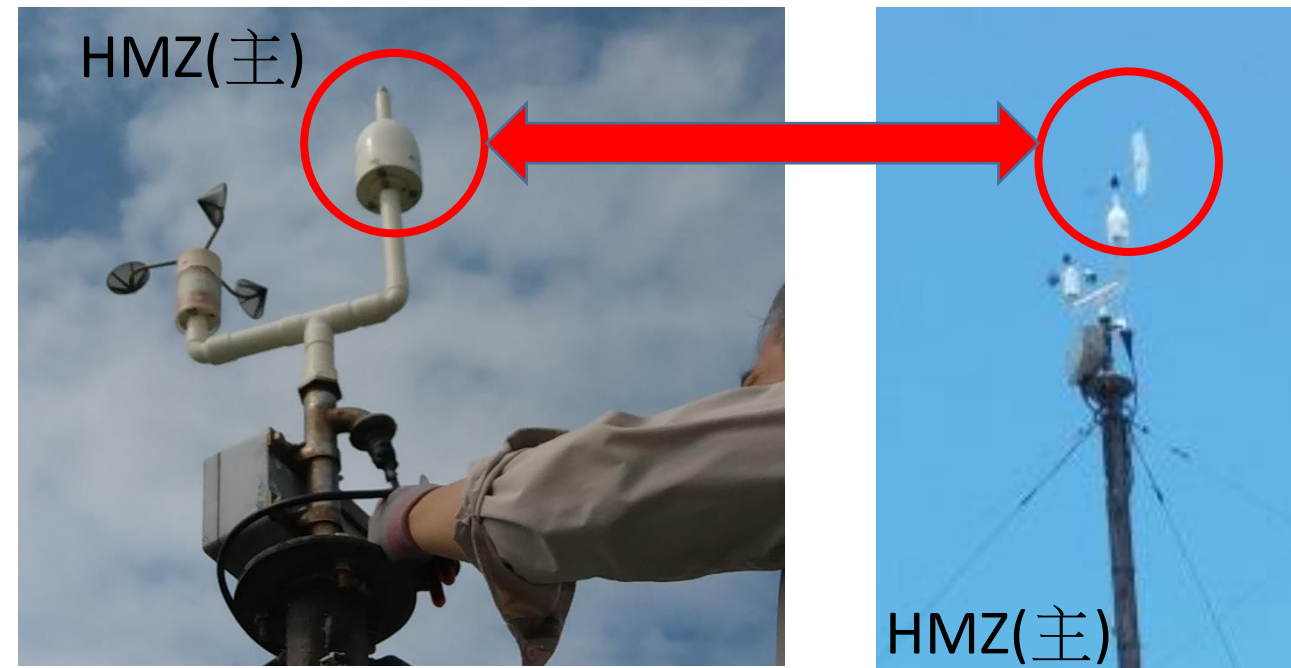
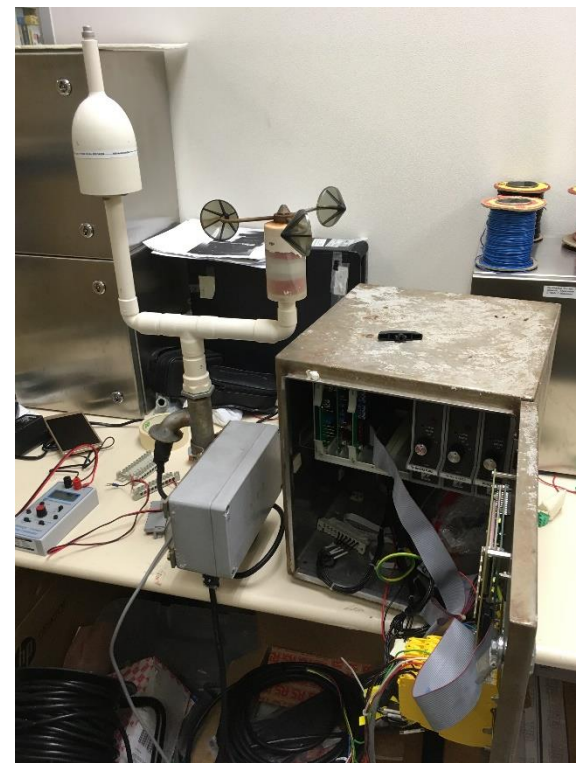
HMZ (主) – 84.2 m/s at 11:04H (有数据缺失)

HM2 (副) – 76.3 m/s at 11:01H

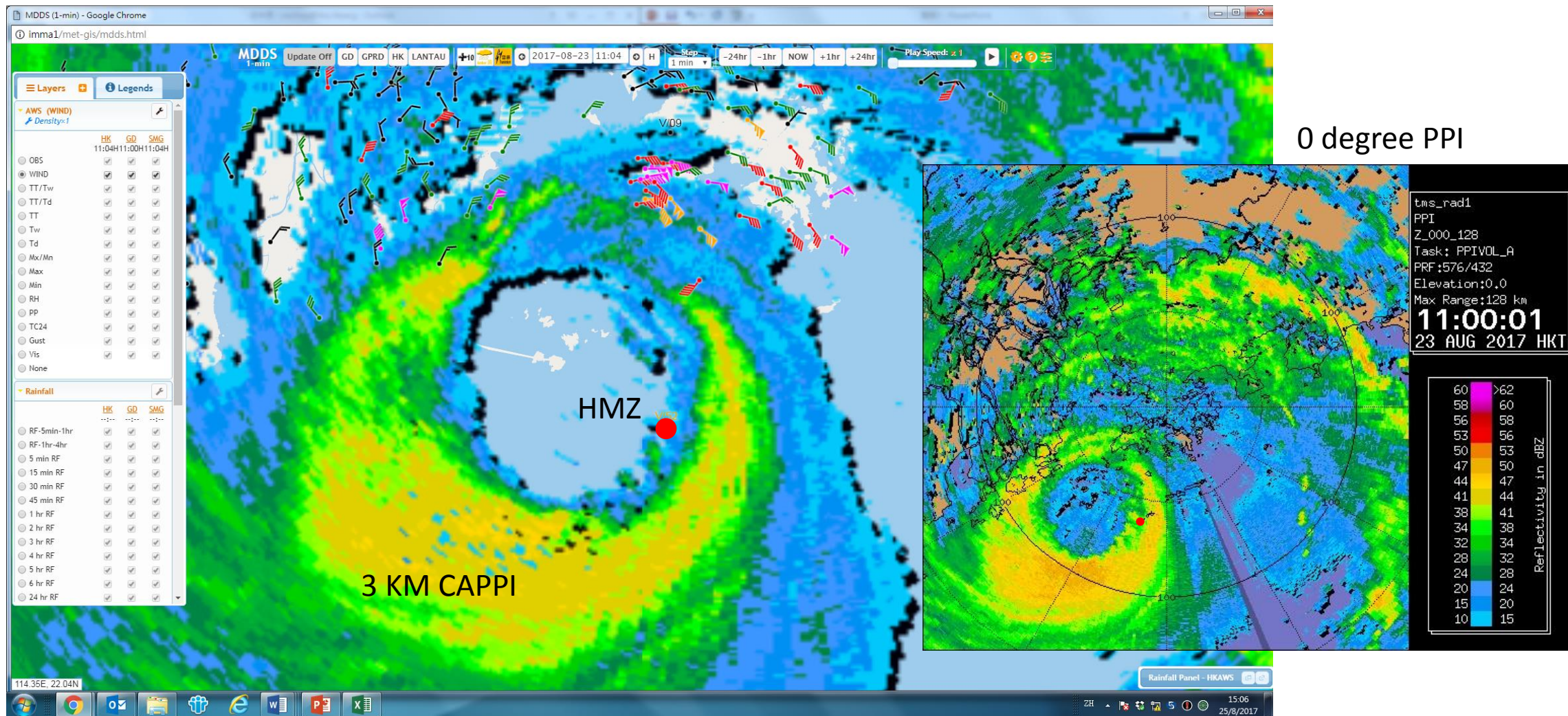


黄茅洲风暴后的情况

- 初步分析黄茅洲主风速表(HMZ) 運作正常
- 黄茅洲副风速表(HM2)受到嚴重損壞，只剩下一個風杯
- 两个风向仪在大风过后受损



黄茅洲在上午11时左右进入东面的眼壁，最大风力在当时录得



转换为10米风速的转换因子

- 因黄茅洲(HMZ)的风速表在海平面67米左右，我们需要利用log wind profile 去转换为10米风速
- 当中的粗糙系数(roughness length) 最为关键
- 因黄茅洲(HMZ) 位于海岛，而风速表在建筑物的顶部，我们利用0.005 及 0.03 的粗糙系数(roughness length)作为初步估算

Table 1 Roughness length for different terrains as recommended by WMO (2012).

Terrain description	Roughness length z_0 (m)
Open sea, fetch at least 5 km	0.0002
Mud flats, snow; no vegetation, no obstacles	0.005
Open flat terrain; grass, few isolated obstacles	0.03
Crops, bushes, parkland	0.10 – 0.5
Regular large obstacle coverage (suburb, forest)	1.0
City centre with high- and low-rise buildings	≥ 2

$$\frac{u(z_1)}{u(z_2)} = \frac{\ln(z_1/z_0)}{\ln(z_2/z_0)}$$

利用0.005 及 0.03 的粗糙系数(roughness length)

HMZ(主)最大10米风 ~ 104-110 kt,

Roughness Length (m)	0.0002	0.005	0.03
Reduction Factor	0.85	0.80	0.75
Hato - HMZ (137.55 kt)	116.98	110.02	103.62

澳门及珠海的地面观测

- 大潭山的最低站气压= 945.4 hPa at 12:02 HKT (换算为海平面气压 957.8 hPa)，当时大潭山位于天鸽风眼的北部
- 珠海的最低海平面气压普遍高于 960 hPa，桂山岛的海平面气压大约是956-957 hPa

最低海平面氣壓 (hPa)



澳門及珠海的最大風速

最高平均風速 (km/h)



最高陣風(km/h)



澳門

最高一分鐘平均風速

友誼大橋北峰 (風速計高度: 47米)

180.7 km/hr (98 kt, or 50.2 m/s)

最高陣風

大潭山 (風速計高度: 125米)

217.4 km/hr (117 kt or 60.4 m/s)

珠海

- 廣昌(站高15米)錄得最大平均10分鐘風力40.3 m/s -> 78 kt
- 桂山島 (站高178米)錄得最大平均2分鐘風力41.7 m/s -> 81 kt
- 九州島(站高<50米)錄得最大平均2分鐘風力 47.8 m/s -> 89 kt

Knaff and Zehr 风压关系

K-Z_calculator [相容模式] - Excel

檔案 常用 插入 版面配置 公式 資料 校閱 檢視 ACROBAT

貼上 剪貼簿

Arial 11 A A

B I U

通用格式 設定格式化的條件 插入 刪除 格式 儲存格 樣式 儲存格 編輯

E5 : X ✓ fx 90

Calculating Pressure from wind				
Input Parameters	Calculation 1	Calculation 2	Calculation 3	
Latitude (N)	21.8	21.8	21.8	
Translation speed (knots)	14	14	14	
Radius of Gales (nm)	90	90	90	
Mean Max Wind (knots)	95	100	105	(in 10 minute)
Pressure OCI (hPa)	1006	1006	1006	
Calculated Parameters				
Pressure (hPa)	955.1	950.7	946.3	
V storm relative motion	94.2	99.6	105.0	(in 1 minute)
V c	22.5	22.1	21.5	
V 500	7.0	7.0	7.0	
Storm Size parameter	0.4	0.4	0.4	
Delta P (<18S)	-48.6	-53.1	-57.9	
Pressure (<18S)	959.4	954.9	950.1	
Delta P (>18S)	-52.9	-57.3	-61.7	
Pressure (>18S)	955.1	950.7	946.3	

Note: The excel is amended so that 0.93, instead of 0.88, is used to convert 1-min mean wind to 10-min mean wind

Instructions

1. Cells like this are for data entry → Cells like this display results → 950.5

2. Enter the cyclone details latitude, translation speed, radius of gales, mean max wind and pressure of the outer closed isobar (POCI).

3. Pressure OCI (Outer Closed Isobar) is required to calculate the environmental pressure which is POCI + 2

4. The radius of gales is determined as the average non-zero quadrant gales. If there are no gales in any quadrant then enter 0. The size parameter only changes once

5. Cells that shaded a darker blue with greyed text/numbers are calculated parameters and users are not required to use these values.

6. In the event that a central pressure is observed, enter lat., translation speed, R34, POCI then vary Vmax until the calculated pressure is the observed value.

7. References:

30 Courtney, J.B. and Knaff, J. A. 2009. Adapting the Knaff and Zehr Wind-Pressure Relationship for operational use in Tropical Cyclone Warning Centres, submit

31 See: http://www.wa.bom.gov.au/sect_info/sewx/tc/index.htm

32 Knaff, J.A., and Zehr, R. M. 2007. Reexamination of tropical cyclone wind-pressure relationships. *Wea. Forecasting*, 22, 71-88.

33

The adjusted min pressure
945-955 hPa

<http://journals.ametsoc.org/doi/abs/10.1175/WAF965.1>

Atkinson 风压关系

Effective From: 1 February 2013

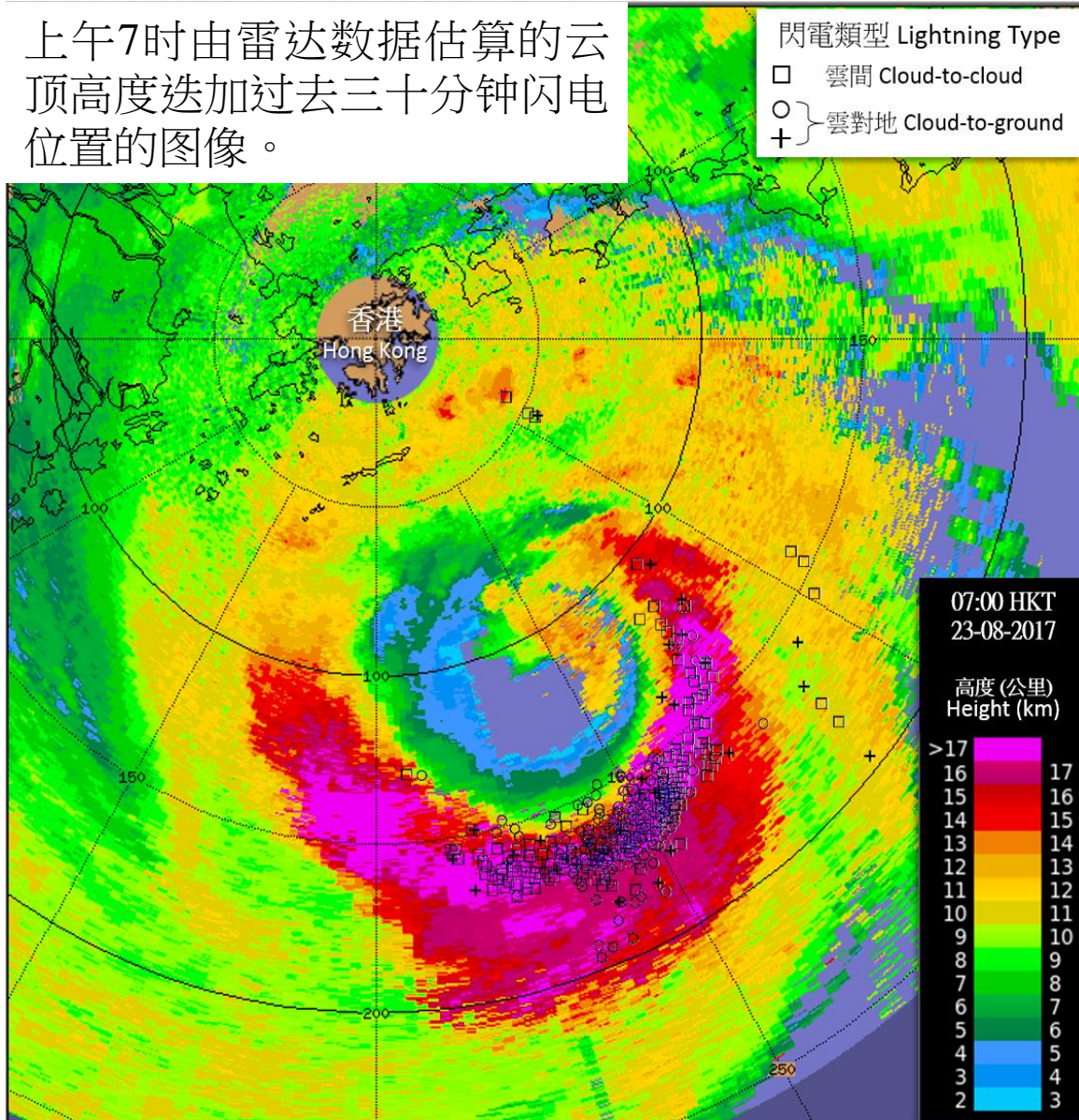
CI/T	MSLP	10-min max wind		TC cat
		knots	km/h	
1	-	23	43	TD
1.5	-	23	43	TD
2	1000	28	52	TD
2.5	997	33	61	TD
3	991	42	78	TS
3.5	984	51	94	STS
4	976	60	111	STS
4.5	966	72	133	T
5	954	84	156	ST
5.5	941	95	176	ST
6	927	107	198	SuperT
6.5	914	118	219	SuperT
7	898	130	241	SuperT
7.5	879	144	267	SuperT
8	858	158	293	SuperT

(93% of JTWC)

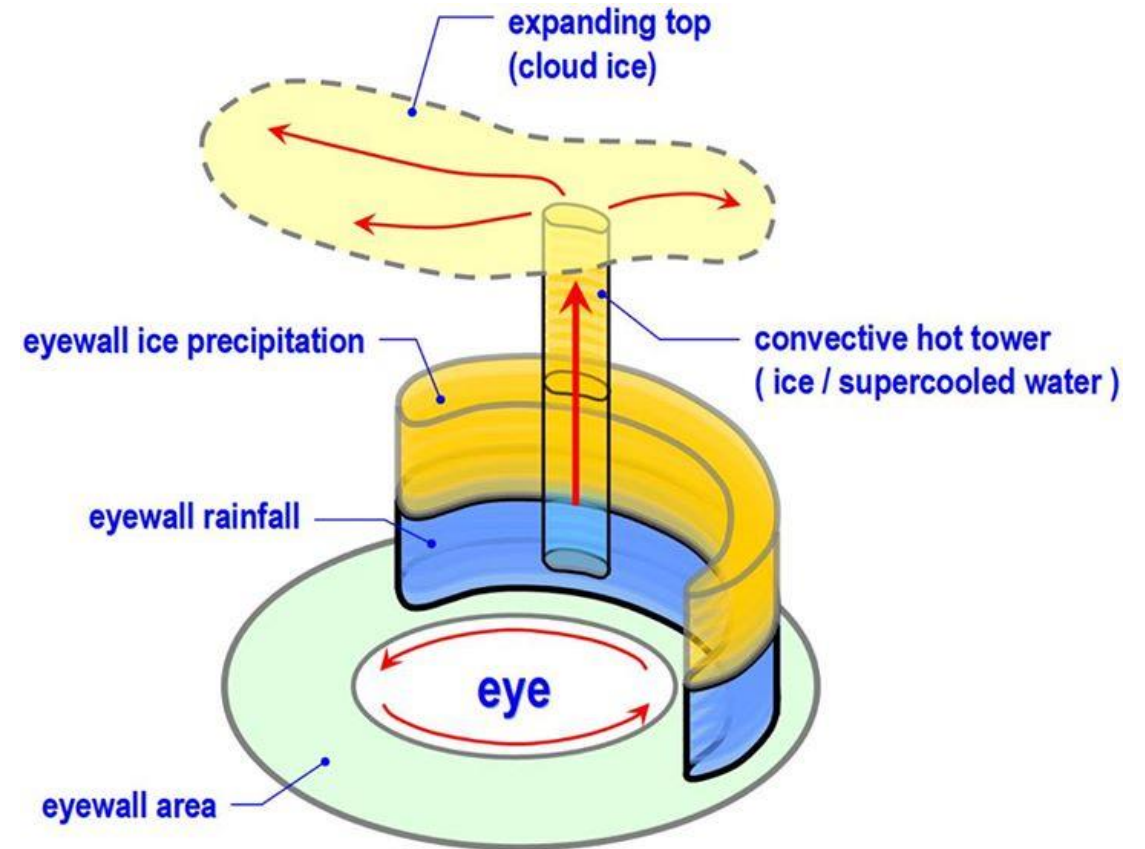
< 900 > 1304

对流热塔现象

上午7时由雷达数据估算的云顶高度迭加过去三十分钟闪电位置的图像。



眼壁附近出现非常强烈的对流和频密闪电，云顶高度超过16公里，直达对流层顶部。



Kelley, O.A., J. Stout & J.B. Halverson, 2004: Tall precipitation cells in tropical cyclone eyewalls are associated with tropical cyclone intensification. *Geophysical Research Letters*, Vol. 31, L24112

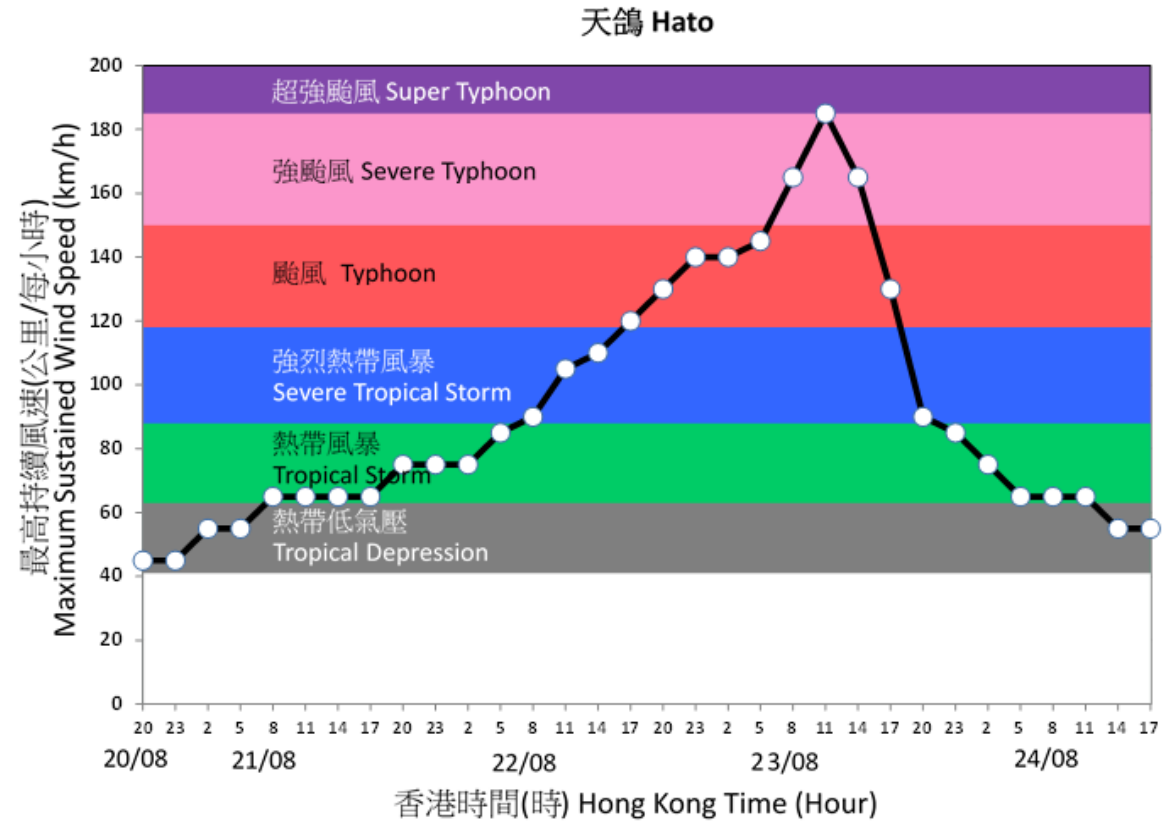
讨论

- 卫星分析显示天鸽在**23**日早上迅速增强，曾短暂达到超强台风强度。
- 多普勒雷达图像估算的强度为**92 kt** 至 **113 kt**。基于**rapid scan**雷达的变化，**05H-10H**期间风眼收缩，风速增加**26%**（**10**时相当于大约**100 kt**，达到超强台风强度）。
- 黄茅洲 (HMZ) 在上午**11**时录得的最高**10**米風约 **104-110kt**，取决于不同的粗糙系数(roughness length)。
- 澳门的最大**1**分钟平均风速达 **180.7 km/hr (98 kt, or 50.2 m/s)**，珠海风力普遍在**90kt**以下
- 有关最低海平面气压方面，黄茅洲、澳门及珠海录得的气压在**950hPa** 以上。

结论

根据以上资料和分析：

- 天鸽在**08时**及**14时**的强度维持在强台风级别，而在**11时**的强度由**95kt**提升到**100kt** (即**49m/s** 到**52m/s**)。最高强度由强台风升至超强台风
- 基于黄茅洲、澳门和珠海的实测，天鸽的最低气压由**935hPa**升至**950hPa**



谢谢！