Forecast of tropical cyclone wind and rainfall in Hong Kong

L.S. LEE

Hong Kong Observatory
Outline

• Tropical cyclone warning system in Hong Kong
• Wind Forecast
• Rain Forecast
• Track Forecast
• Operational Tools
Hong Kong Observatory

The Hong Kong Observatory is a government department responsible for

• forecasting weather and issuing warnings on weather-related hazards.
• monitoring and assessing radiation levels in Hong Kong.
• providing other meteorological and geophysical services, to meet the needs of the public and the shipping, aviation, industrial and engineering sectors.
Hong Kong’s Tropical Cyclone Warning Signals – A number-coded system

1. A tropical cyclone is centred within about 800 kilometres (km) of Hong Kong and may affect the territory.

3. Strong wind is expected or blowing generally in Hong Kong near sea level, with a sustained speed of 41-62 kilometres per hour (km/h), and gusts which may exceed 110 km/h, and the wind condition is expected to persist.

8. Gale or storm force wind is expected or blowing generally in Hong Kong near sea level, with a sustained wind speed of 63-117 km/h from the quarter indicated and gusts which may exceed 180 km/h, and the wind condition is expected to persist.

9. Gale or storm force wind is increasing or expected to increase significantly in strength.

10. Hurricane force wind is expected or blowing with sustained speed reaching upwards from 118 km/h and gusts that may exceed 220 km/h.
The 800-km region
Hong Kong’s Tropical Cyclone Warning Signals - a number-coded system

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9. Gale or storm force wind is increasing or expected to increase significantly in strength.

10. Hurricane force wind is expected or blowing with sustained speed reaching upwards from 118 km/h and gusts that may exceed 220 km/h.
Network of reference anemometers in the tropical cyclone warning system
Information to the public
Example – Molave (July 2009)
Daily weather forecast bulletin

A RIDGE OF HIGH PRESSURE IS BRINGING GENERALLY FINE WEATHER TO EASTERN GUANGDONG.

AT 8 P.M., SEVERE TROPICAL STORM MOLAVE WAS CENTRED ABOUT 280 KILOMETRES SOUTH-SOUTHEAST OF GAOXIONG. IT IS FORECAST TO MOVE NORTHWEST OR WEST-NORTHWEST AT ABOUT 20 KILOMETRES PER HOUR TOWARDS THE NORTHERN PART OF THE SOUTH CHINA SEA.

WEATHER FORECAST FOR TONIGHT AND TOMORROW

MAINLY FINE. THE MINIMUM TEMPERATURE WILL BE ABOUT 28 DEGREES. VERY HOT TOMORROW WITH A MAXIMUM TEMPERATURE OF AROUND 33 DEGREES. MODERATE WEST TO NORTHWESTERLY WINDS. WINDS WILL STRENGTHEN WITH SQUALLY SHOWERS TOMORROW EVENING.

OUTLOOK: RATHER WINDY WITH FREQUENT HEAVY RAIN ON SUNDAY. SUNNY PERIODS EARLY NEXT WEEK.
Tropical cyclone warning bulletin

THE STANDBY SIGNAL, NO. 1 WAS ISSUED AT 10:15 P.M.

THIS MEANS THAT A TROPICAL CYCLONE NOW CENTRED WITHIN ABOUT 800 KILOMETRES OF HONG KONG MAY AFFECT US.

AT 10 P.M., SEVERE TROPICAL STORM MOLA VE WAS ESTIMATED TO BE ABOUT 700 KILOMETRES EAST-SOUTHEAST OF HONG KONG (NEAR 20.7 DEGREES NORTH 120.7 DEGREES EAST) AND IS FORECAST TO MOVE WEST-NORTHWEST AT ABOUT 20 KILOMETRES PER HOUR CROSSING THE NORTHEASTERN PART OF SOUTH CHINA SEA.

ACCORDING TO THE PRESENT FORECAST TRACK, SQUALLY SHOWERS ASSOCIATED WITH MOLA VE WILL BEGIN TO AFFECT THE COASTAL AREAS OF GUANGDONG SATURDAY AFTERNOON.

AS MOLA VE IS STILL SOME DISTANCE AWAY FROM HONG KONG, THE CHANCE OF ISSUING THE STRONG WIND SIGNAL NO. 3 OVERNIGHT IS NOT HIGH.
Tropical cyclone warning bulletin

THE STRONG WIND SIGNAL, NO. 3 WAS ISSUED AT 2:15 P.M.

THIS MEANS THAT WINDS WITH MEAN SPEEDS OF 41 TO 62 KILOMETRES PER HOUR ARE EXPECTED.

AT 10 P.M., TYPHOON MOLAVE WAS ESTIMATED TO BE ABOUT 150 KILOMETRES EAST OF HONG KONG (NEAR 22.2 DEGREES NORTH 115.6 DEGREES EAST) AND IS FORECAST TO MOVE WEST-NORTHWEST AT ABOUT 22 KILOMETRES PER HOUR IN THE GENERAL DIRECTION OF THE PEARL RIVER ESTUARY.

WINDS LOCALLY WILL STRENGTHEN FURTHER. THE GOVERNMENT ADVISES MEMBERS OF THE PUBLIC WITH LONG OR DIFFICULT HOME JOURNEYS OR HAVING TO RETURN TO OUTLYING ISLANDS TO BEGIN THEIR JOURNEYS NOW.

(PRECAUTIONARY ANNOUNCEMENTS WITH NO. 3 SIGNAL)

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Tropical cyclone warning bulletin

THE NO. 8 NORTHWEST GALE OR STORM SIGNAL IS IN FORCE.

THIS MEANS THAT WINDS WITH MEAN SPEEDS OF 63 KILOMETRES PER HOUR OR MORE ARE EXPECTED FROM THE NORTHWEST QUARTER.

AT 1 A.M., TYPHOON MOLAVE WAS CENTRED ABOUT 70 KILOMETRES EAST-NORTHEAST OF HONG KONG OBSERVATORY (NEAR 22.5 DEGREES NORTH 114.8 DEGREES EAST) AND IS FORECAST TO MOVE WEST-NORTHWEST AT ABOUT 25 KILOMETRES PER HOUR ACROSS DAPENG PENINSULA.

MOLAVE IS EXPECTED TO ENTER MIRS BAY, AND WILL BE VERY CLOSE TO HONG KONG IN THE NEXT FEW HOURS. GALE FORCE WINDS WILL GENERALLY AFFECT HONG KONG AND THERE WILL BE HEAVY RAIN WITH SQUALLS. ACCORDING TO THE PRESENT TRACK, LOCAL WINDS WILL TURN SOUTHWESTERLY BEFORE DAYBREAK. PLACES PREVIOUSLY SHELTERED FROM THE WINDS WILL BECOME EXPOSED. MEMBERS OF THE PUBLIC SHOULD TAKE PRECAUTIONS AS SOON AS POSSIBLE.
Wind information bulletin

Wind speed data for strong winds or above recorded by the Hong Kong Observatory in different regions from 10:31 p.m. to 11:30 p.m. on 18 July 2009:

Maximum sustained wind speed reaching strong force (Force 6–7)  

<table>
<thead>
<tr>
<th>Location</th>
<th>Maximum Sustained Wind Speed</th>
<th>Maximum Gust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap Mun</td>
<td>60 km/h</td>
<td>100 km/h</td>
</tr>
<tr>
<td>Tate's Cairn</td>
<td>59 km/h</td>
<td>81 km/h</td>
</tr>
<tr>
<td>Green Island</td>
<td>53 km/h</td>
<td>69 km/h</td>
</tr>
<tr>
<td>Cheung Chau</td>
<td>49 km/h</td>
<td>69 km/h</td>
</tr>
<tr>
<td>Peng Chau</td>
<td>48 km/h</td>
<td>66 km/h</td>
</tr>
<tr>
<td>Waglan Island</td>
<td>48 km/h</td>
<td>62 km/h</td>
</tr>
<tr>
<td>Chek Lap Kok</td>
<td>44 km/h</td>
<td>54 km/h</td>
</tr>
<tr>
<td>Lau Fau Shan</td>
<td>44 km/h</td>
<td>53 km/h</td>
</tr>
<tr>
<td>Sha Chau</td>
<td>43 km/h</td>
<td>66 km/h</td>
</tr>
</tbody>
</table>
Rainstorm warning bulletin

AMBER RAINSTORM WARNING SIGNAL

AMBER RAINSTORM WARNING SIGNAL SPECIAL ANNOUNCEMENT ISSUED AT 1:45 A.M.

THE RAINSTORM WARNING SIGNAL IS NOW AMBER. THIS MEANS THAT HEAVY RAIN HAS FALLEN OR IS EXPECTED TO FALL GENERALLY OVER HONG KONG, EXCEEDING 30 MILLIMETRES IN AN HOUR, AND IS LIKELY TO CONTINUE.

THERE WILL BE FLOODING IN SOME LOW-LYING AND POORLY DRAINED AREAS. PEOPLE WHO ARE LIKELY TO BE AFFECTED SHOULD TAKE NECESSARY PRECAUTIONS TO REDUCE THEIR EXPOSURE TO RISK POSED BY THE HEAVY RAIN AND FLOODING.
Landslip warning bulletin

LANDSLIP SPECIAL ANNOUNCEMENT ISSUED BY THE HONG KONG OBSERVATORY AT 3:00 A.M. ON 19 JULY 2009:

THE HONG KONG OBSERVATORY HAS ISSUED THE LANDSLIP WARNING. KEEP AWAY FROM STEEP SLOPES OR RETAINING WALLS.

MOTORISTS SHOULD AVOID DRIVING IN HILLY AREAS OR ON ROADS WITH LANDSLIP WARNING SIGNS.

CANCEL NON-ESSENTIAL APPOINTMENTS, STAY AT HOME OR REMAIN IN A SAFE SHELTER.

IF YOU SEE SIGNS OF LANDSLIP DANGER, KEEP AWAY FROM THE AREA AND REPORT TO THE POLICE.

TEMPORARY SHELTERS PROVIDED BY DISTRICT OFFICES ARE NOW OPEN. IF YOU RECEIVE A NOTICE TO EVACUATE BECAUSE OF LANDSLIP DANGER, OR BELIEVE THAT YOUR HOME IS ENDANGERED, YOU SHOULD MAKE IMMEDIATE ARRANGEMENTS TO MOVE TO A SAFE SHELTER.
Flooding warning bulletin

SPECIAL ANNOUNCEMENT ON FLOODING IN THE NORTHERN NEW TERRITORIES UPDATED BY THE HONG KONG OBSERVATORY AT 3:30 A.M. ON 19 JULY.

HEAVY RAIN IS AFFECTING THE NORTHERN PART OF THE NEW TERRITORIES, ESPECIALLY IN PAT HEUNG AND KAM TIN, SHEUNG SHUI AREA(S). MORE THAN 90 MILLIMETRES OF RAINFALL HAVE BEEN RECORDED IN THE PAST 2 HOURS.

RESIDENTS IN THE NORTHERN NEW TERRITORIES, WHO ARE LIKELY TO BE AFFECTED, ARE ADVISED TO TAKE NECESSARY PRECAUTIONS.

TO AVOID POSSIBLE FLOOD DAMAGE. THEY SHOULD ALSO PAY ATTENTION TO THE FLOOD SIRENS IF THEY ARE NEARBY.
Wind forecast
Wind forecast for Hong Kong

Direct read-out from NWP surface chart

- Grid position
- Time resolution
- Grid representation
Extrapolation of model wind field analysis

• Using model analysis to deduce wind/MSLP estimates in the next 24 hours at tropical cyclone reference stations.
• Extrapolating the whole 3D wind field analysis generated by HKO-LAPS (10km resolution) along the forecaster's warning track.
• Updated every 3-hourly as new warning track becomes available.
Time Series product vs actual

[Graph showing Time Series data for LAPS and Actual, with specific timestamps and pressure readings.]
TC probability isopleths

A set of diagrams of probability isopleths of occurrence of the wind speed criteria in Hong Kong during tropical cyclone scenarios

Probability of occurrence of gales in the harbour area of Hong Kong for typhoons
Probability of occurrence of gales in the harbour area of Hong Kong for severe tropical storm
TC probability isopleth
Points to note

• In the above example, the isopleths of probability of occurrence of gales in the harbour are elongated towards the southwest with very tight gradient on the eastern and southeastern sides. This is due to the harbour being exposed to winds from the east and sheltered from winds from the north.

• Larger tropical cyclones could give rise to gales in the harbour when they crossed isopleths of smaller probability.

• The arrival or presence of northeast monsoon during the approach of a tropical cyclone could result in early onset of gales in the harbour.
Onset and cessation time of strong/gale wind
Statistical method to forecast wind direction
Rain forecast
Frequently asked questions

- When will the TC rain band reach Hong Kong, tonight, tomorrow morning?
- When will the rain be heaviest?
- How much rainfall shall we get for tomorrow? 50, 100 or 200 mm?
# Quantitative Precipitation Forecast (QPF) from NWP

## Table 1. Summary of QPF of Global Models for 21 May 2010 (FRI)

<table>
<thead>
<tr>
<th>Model</th>
<th>Product</th>
<th>19/12 Z</th>
<th>20/00 Z</th>
<th>20/12 Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensemble</td>
<td>Automatic Forecast</td>
<td>A few showers (Light)</td>
<td>Showers (Moderate)</td>
<td>A few showers (Light)</td>
</tr>
<tr>
<td>JMA</td>
<td>Automatic Forecast</td>
<td>A few showers (Light)</td>
<td>A few showers (Light)</td>
<td>A few showers (Light)</td>
</tr>
<tr>
<td></td>
<td>East grid</td>
<td>4 mm</td>
<td>3 mm</td>
<td>2 mm</td>
</tr>
<tr>
<td></td>
<td>West grid</td>
<td>4 mm</td>
<td>2 mm</td>
<td>2 mm</td>
</tr>
<tr>
<td>ECMWF</td>
<td>Automatic Forecast</td>
<td>A few showers (Light)</td>
<td>A few showers, heavy at first (Heavy)</td>
<td>A few showers, heavy at first (Heavy)</td>
</tr>
<tr>
<td></td>
<td>NW grid</td>
<td>11 mm</td>
<td>20 mm</td>
<td>19 mm</td>
</tr>
<tr>
<td></td>
<td>SE grid</td>
<td>Trace</td>
<td>3 mm</td>
<td>2 mm</td>
</tr>
<tr>
<td>NCEP</td>
<td>Grid Point (22 N,114 E)</td>
<td>N/A</td>
<td>Trace</td>
<td>Trace</td>
</tr>
</tbody>
</table>

## Table 2. Summary of Regional Models for 21 May 2010 (FRI)

<table>
<thead>
<tr>
<th>Model</th>
<th>Product</th>
<th>20/06 Z</th>
<th>20/12 Z</th>
<th>20/18 Z</th>
</tr>
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<tbody>
<tr>
<td>Mceso-NHM</td>
<td>Time Series</td>
<td>0 mm</td>
<td>Trace</td>
<td>0 mm</td>
</tr>
<tr>
<td>MPRISM 60-km</td>
<td>Time Series</td>
<td>10 mm</td>
<td>1 mm</td>
<td>1 mm</td>
</tr>
<tr>
<td>MPRISM 20-km</td>
<td>Time Series</td>
<td>31 mm</td>
<td>3 mm</td>
<td>5 mm</td>
</tr>
<tr>
<td>MPRISM 60-km TLE Mean</td>
<td>Time Series</td>
<td>1 mm</td>
<td>1 mm</td>
<td>1 mm</td>
</tr>
<tr>
<td>MPRISM 20-km TLE Mean</td>
<td>Time Series</td>
<td>8 mm</td>
<td>7 mm</td>
<td>9 mm</td>
</tr>
<tr>
<td>NHM 5-km (12-h acc. RP)</td>
<td>Time Series</td>
<td>13 mm</td>
<td>2 mm</td>
<td>Trace</td>
</tr>
</tbody>
</table>
Rainfall nowcasting tool – SWIRLS

• Movement of individual radar echo between two consecutive CAPPI scans at 6-minute interval is derived using the TREC (Tracking Radar Echoes by Correlation) method.

• To obtain a better estimate, SWIRLS makes use of raingauge data over Hong Kong to calibrate radar reflectivity in real time. In other words, the Z-R relationship will be adjusted in time.
TREC analysis of a typhoon over Hong Kong
Calibration of radar reflectivity using real-time raingauge measurements
One hour rainfall forecast by SWIRLS and corresponding rainfall reported by rain gauges.
New tracking method under trial

• based on “MOVA” tracking method:
  – multi-scale, optical-flow, variational analysis
• significant improvement in rainstorm alerts
Resulting QPF

- squall line on 5 March 2009
  - 1-hr MOVA & TREC QPFs vs actual rainfall distribution
Assumptions of Optical Flow

• no change in intensity
• small displacement
• tracking will tend to be underestimated or even fail if:
  – motion speed too fast
  – tracking time interval too wide
    • resulting in little or no overlapping of images pattern
RAPIDS – Blending SWIRLS & NWP output

• When the rainstorm motion is erratic or when echoes develop or dissipate rapidly, SWIRLS becomes less skillful with time.

• On the other hand, NWP models usually suffer from the intrinsic 'spin-up' problem, hence hindering reliability of numerical prognoses in the first couple of hours.

• To achieve an optimal performance in the 1 to 6 hours range, a nowcasting rainstorm forecasting system called RAPIDS (Rainstorm Analysis & Prediction Integrated Data-processing System) incorporating the best features of SWIRLS and NWP forecasts was developed.

• The goal of RAPIDS is to blend or merge the SWIRLS with NWP to generate an optimal QPF for operational guidance in rainstorm situations.
RAPIDS output

2009-03-05 1500 H

RAPIDS T+3h  1-hour accumulated rainfall

SWIRLS
QPF from TREC

Rainfall (mm)

NHM

RAPIDS base time = 20090305 0400 UTC
Max rainfall = 53.792 mm
NHM base time = 20090305 0300 UTC
QMORPH

- Microwave: Provides **good estimates** of rain rate but **poor sampling** (a few times a day)

- Geostationary IR: Provides **great sampling** but **poor rain rate estimates**

- Merging the two: IR cloud motion vector to transport microwave precip. features (for increased temporal resolution)
QMORPH

- The microwave precip. features are propagated forward in time
- The features are “morphed” by linearly interpolating in time
TC Rainfall Forecast based on QMORPH

- By extrapolation of QPE along forecast TC track
- QMORPH estimates available at ~3 hours past real time

Assumptions:
- Satellite derived rain rates accurately
- Rain area moves in direction/speed of storm
- Magnitude/area of rain rates remains unchanged during forecast period

Limitations:
- Outside influences on the storm are not considered
  - frontal and/or upslope → increase QMORPH values
  - dry air and/or shear → decrease QMORPH values
QMORPH TC Rainfall Forecast

Select TC

- 2008 Hsues
- 2008 Hargust
- 2008 Karen
- 2008 Paraden
- 2008 Negul

Base Time

2008081921

- Get 24-hr rainfall accumulation
- TRaP by NOAA/NESDIS (Discontinue on 1 Jul 2009)
- cTRaP by NOAA/NESDIS (Operational 1 Jul 2009)

Guide & Descriptions (Powerpoint)

Microwave rain rate estimates (QPE) at base time

Areal rainfall f/c for day 2. The black line indicates the track forecast used for extrapolation

Time-series of f/c hourly rainfall at HKO up to T+72

Areal rainfall f/c for day 1 & day 3
Enhancement of the QMORPH tool using ECMWF EPS tracks
QMORPH + EPS Tracks

- Rain rates + 51 EPS tracks $\rightarrow$ 51 rainfall maps
  $\rightarrow$ Averaged rainfall map
  $\rightarrow$ Rainfall probability map
QMORPH + EPS Tracks

- Limitations:
  - Light rain areas over-predicted due to averaging procedures
  - Peak rainfall also dampened when compared with prediction based on deterministic track
Product

Probability of PPT reaching 50, 100, 150 & 200 mm on day 1
Paper:

Application of Satellite Rain Rate Estimates to the Prediction of Tropical Cyclone Rainfall, S.T. Chan & M.Y. Chan

Climatological method

- Mean and maximum 24-hour rainfall in Hong Kong Observatory when tropical cyclones were centred in each 1° square of a certain month.
Track Forecast
Ensemble Track

- Position Consensus
- Motion Vector Consensus
Create Ensemble Track

Motion Vector Consensus

- JMA
- ECMF
- Ensemble
- NCEP
- EGRR
Create Ensemble Track

Motion Vector Consensus
Motion Vector Consensus vs Position Consensus
Strike Probability Maps
Operational Tools
Tropical Cyclone Information Processing System (TIPS)
Rainstorm & Severe Weather Panel

### SWIRLS Panel for Integrated Display of Alerts on Severe Storms

Based on SWIRLS-2 for CFO

Real-time alert status auto-updated at: 3:42 PM 20100413

### Forecast Valid Date/time (HKT)

<table>
<thead>
<tr>
<th>System</th>
<th>Product</th>
<th>Updated at</th>
<th>20100413</th>
<th>20100413</th>
<th>20100413</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWIRLS (TREC)</td>
<td>Actual + FIC</td>
<td>201004131542</td>
<td>14</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>SWIRLS-2</td>
<td>Actual + FIC</td>
<td>201004131542</td>
<td>14</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>RAPIDS</td>
<td>Rainstorm in 1h</td>
<td>201004131542</td>
<td>14</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>NHM</td>
<td>Rainstorm in 1h</td>
<td>201004131542</td>
<td>14</td>
<td>15</td>
<td>16</td>
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<td>ORSM (UTC)</td>
<td>2010041303</td>
<td>2010041306</td>
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</table>

### Forecast Base Time (HKT)

<table>
<thead>
<tr>
<th>Product</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainstorm in 1h</td>
<td>SWIRLS (TREC)</td>
</tr>
<tr>
<td>Rainstorm in 1h</td>
<td>SWIRLS-2</td>
</tr>
<tr>
<td>Actual (10 min)</td>
<td>SWIRLS-2 QPE</td>
</tr>
<tr>
<td>Rainstorm in 3h</td>
<td>SWIRLS-2</td>
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<tr>
<td>Actual (30 min)</td>
<td>SWIRLS-2 QPE</td>
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<tr>
<td>Rainstorm in 6h</td>
<td>RAPIDS (hourly QPF)</td>
</tr>
<tr>
<td>Rainstorm in 9h</td>
<td>RAPIDS (hourly QPF)</td>
</tr>
<tr>
<td>PPI (Green)</td>
<td>SWIRLS-2RAPIDS</td>
</tr>
<tr>
<td>PPI (Amber)</td>
<td>SWIRLS-2RAPIDS</td>
</tr>
<tr>
<td>PPI (Red)</td>
<td>SWIRLS-2RAPIDS</td>
</tr>
<tr>
<td>PPI (Black)</td>
<td>SWIRLS-2RAPIDS</td>
</tr>
<tr>
<td>Storm Track</td>
<td></td>
</tr>
<tr>
<td>Squalls</td>
<td></td>
</tr>
<tr>
<td>Lightning</td>
<td></td>
</tr>
<tr>
<td>Hail</td>
<td></td>
</tr>
<tr>
<td>Landslip (Issue)</td>
<td>SWIRLS-2</td>
</tr>
<tr>
<td>NT Flooding</td>
<td>SWIRLS-2</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Legend

- **Rainfall**
  - Light Rainfall: 20 mm in 1 hour
  - Moderate Rainfall: 50 mm in 1 hour
  - Heavy Rainfall: 100 mm in 1 hour

- **Flood Threat**
  - Low threat
  - Medium threat
  - High threat

- **Severe Squall Threat**
  - Light threat
  - Moderate threat
  - Severe threat

- **Lightning Threat**
  - Severe threat

- **Tornado Threat**
  - Severe threat
Rainstorm Probability
# Integrated Weather Monitoring Panel

![Image of the Integrated Weather Monitoring Panel](image)

- **Any**: 15 min 15 mm, 30 min 20 mm, 1 hr 35 mm, 2 hr 50 mm, 3 hr 60 mm, 4 hr 70 mm, 5 hr 75 mm, 6 hr 80 mm
- **Thunder**: 15 mm 20 mm 30 mm 50 mm 60 mm 70 mm 75 mm 80 mm
- **Boiling**: 20 mm 35 mm 50 mm 70 mm 85 mm 95 mm 105 mm 110 mm
- **Fog**: 25 mm 45 mm 70 mm 100 mm 120 mm 135 mm 150 mm 160 mm
- **< 100 mm Past 24 hour**: 70 mm 90 mm 110 mm 115 mm
- **> 100 mm Past 24 hour**: 60 mm 80 mm 90 mm 100 mm
- **24 hr**: 75 mm 100 mm
- **24hr**: Any 10 stations

- **Data Time**: 17:15H - 23 Mar 2007

![Map of Hong Kong with rainfall data](image)
End ........

.....and more
Review of the Tropical Cyclone Warning System in Hong Kong after the passage of Typhoon Prapiroon in 2006
Tropical Cyclone Warning System in Hong Kong

The Hong Kong Observatory operates a number-coded Tropical Cyclone Warning System to give warnings to the local public of wind conditions in Hong Kong.

<table>
<thead>
<tr>
<th>Signal number</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A tropical cyclone is centred within about 800 km of Hong Kong and may later affect Hong Kong</td>
</tr>
<tr>
<td>3</td>
<td>Strong wind is expected</td>
</tr>
<tr>
<td>8</td>
<td>Gales are expected</td>
</tr>
<tr>
<td>9</td>
<td>Gales increasing significantly</td>
</tr>
<tr>
<td>10</td>
<td>Hurricane force wind expected</td>
</tr>
</tbody>
</table>
Since the 1970’s, wind speeds in the Victoria Harbour of Hong Kong have been used as the reference for the issue of both No.3 and No.8 signals because the areas on both sides of the harbour were the centre of all major economic and social activities.
Typhoon Prapiroon in 2006
Track of Prapiroon on 31 July - 4 August 2006
Infra-red imagery at around 2 p.m. on 3 August 2006 of Prapiroon
The southern part of Hong Kong was affected by gales while the harbour area and the northern part generally experienced strong winds.
Casualties and damage caused by Prapiroon

• A number of containers were blown down, leading to one injury.
• Another seven people in various places in Hong Kong were wounded by fallen objects.
• There were numerous reports of signpost with imminent danger of falling.
• There were two vessel collisions.
• About seven hundred trees were blown down, and another 1600 damaged.
• At the Hong Kong International Airport, 381 flights were cancelled and another 725 delayed.
• There were five reports of flooding and seven cases of landslides.
• Over 200 hectares of farmland were damaged.
Complaints received

• The HKO issued No.3 signal based on the prescribed criterion on 3 August.

• Some members of the public experienced severe wind condition and the resulting disruption in various parts of Hong Kong

• The Observatory received a lot of complaints and comments that the criterion for the issue of No.8 signal should be updated to reflect the much dispersed population nowadays and to alert the public to potential significant disruptions to air traffic due to tropical cyclones.
Review of the warning system

• Against this background, the HKO conducted a comprehensive review of the Tropical Cyclone Warning System.

• The HKO formed an academic advisory committee comprising scholars and experts to advise it from the perspectives of physical and social sciences disciplines.

• To reach out to different sectors of the community, the HKO held many seminars and focus group meetings with representatives of different industries, public bodies and weather enthusiasts to consult their views.

• The HKO also commissioned a public opinion survey to gauge the needs and expectations with respect to the Tropical Cyclone Warning System.
New measures

Expanding the reference for the issue of No.3 and No.8 signals from the Victoria Harbour to a network of eight near sea level reference anemometers covering the whole of Hong Kong.
Enhancing the dissemination of regional wind information

• Highlight in media broadcast of the tropical cyclone bulletins those areas with wind speeds significantly higher than the general wind condition of Hong Kong.

• Promote understanding of the modified warning system and the uneven wind distribution during tropical cyclones, and to encourage the public to make good use of the full range of weather information on the HKO website and its telephone-based Dial-a-Weather system.
Minimal adjustment by the public

• The new measures involve only revising the technical reference the HKO uses in deciding on the issue of No.3 and No.8 signals.

• To the general public, the same set of signals continues to be used. There is no need for changes to tropical cyclone-related response plans or guidelines by both the Government and the private sector.
Thank you