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HONG KONG OBSERVATORY

Joint Meeting of RA II WIGOS Project and RA V TT-SU

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Hong Kong, China

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2. Short description of HKO
3. Current Observation systems
4. Satellite data collection and processing capabilities
5. Observations for forecasts and warnings
6. Future Work
7. Challenges

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Abstract

The Hong Kong Observatory receives data and products of the following satellites round-the-clock via ground reception systems, the Internet and the Global Telecommunications System (GTS) to support its weather forecasting and warning services.

- Feng Yun (FY) 2 series and FY4A experimental geostationary satellites (GEOS) of the China Meteorological Administration (CMA);
- Himawari series GEOS of the Japan Meteorological Agency (JMA);
- Geostationary Operational Environmental Satellite (GOES) series of GEOS and series of polar orbiting satellites (POS) of the U.S. National Oceanic and Atmospheric Administration (NOAA);
- Communication, Ocean and Meteorological Satellite (COMS) of the Korea Meteorological Administration (KMA);
- METEOSAT series GEOS and METOP series POS of the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT);
- Suomi National Polar-orbiting Partnership (NPP) and Earth Observing Systems (EOS) series POS of the National Aeronautics and Space Administration (NASA);
- Haiyang 2A POS of the State Oceanic Administration (SOA) of China.

Satellite data are used for day-to-day weather watch of inclement weather such as tropical cyclones and rainstorms as well as environmental monitoring including fog, haze, sandstorms, hill fire, volcanic eruption, etc. Applications of diagnosing icing and severe turbulence to support aviation weather services have been developed. HKO also makes available global mosaics of satellite imageries on its website and MyObservatory smartphone application. In addition, data are used for nowcasting of convection development, tropical cyclone intensification and inclusion in numerical models' data assimilation schemes.

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Satellite data and product requirements, training needs and infrastructure

Satellite data and product requirements:

1 Cloud services or redirect broadcast for accessing high resolution data and Level2 products of new generation of satellites. e.g. FY4-series satellite data and future KOMPSAT-2 data.

2. DVB-S2 broadcast via CMACast for global satellite data and imageries.
   e.g. GOES-S and next generation of METEOSAT satellites from EUMETCast and GeoNetCast.

3. Use and applications of next generation of advanced weather satellites.
   e.g. convection initiation, rapid thunderstorms development, use of temperature and humidity profiles derived from satellite sounding data for improving NWP performances, stability indices for severe weather forecast, icing and turbulence for enhancing aviation safety.

4. Training on verification and analysis of satellite products.
   e.g. QPE derived from satellite imageries and comparison with surface raingauge data, LMI for thunderstorm development.

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Appendix

1. Introduction

1. Country overview

I. Basic information of Hong Kong, China

- Area: 1 104 km^2;
- Population: 7. 449 m (as of mid-2018)
- Sub-tropical climate

II. Major historical meteorological disaster events

- Typhoon and storm surge
- Flooding and landslide due to severe thunderstorms and rainstorms

III. Major national economic sectors relying on Met Services

- The whole economy, including financial, public utilities, shipping, transportation, tourism, ...

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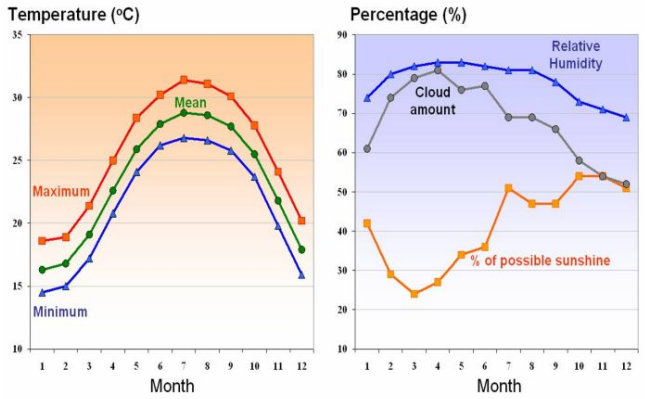
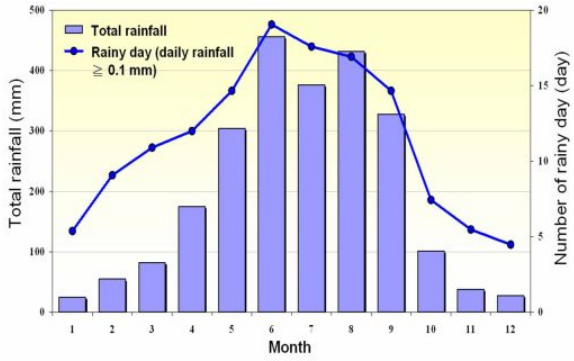
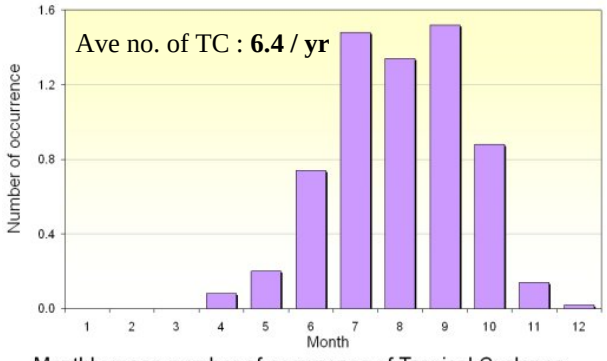
Weather of Hong Kong



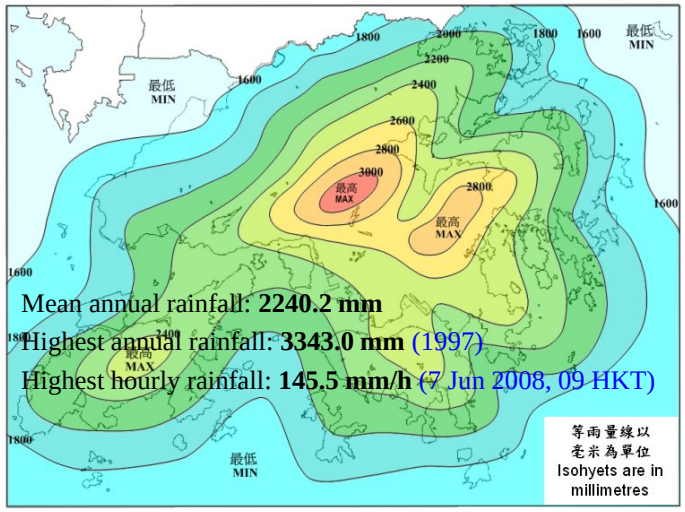
Monthly means of daily maximum, mean and minimum temperature (left), relative humidity, cloud amount recorded at the Hong Kong Observatory and percentage of possible sunshine at King's Park (right) between 1981-2010



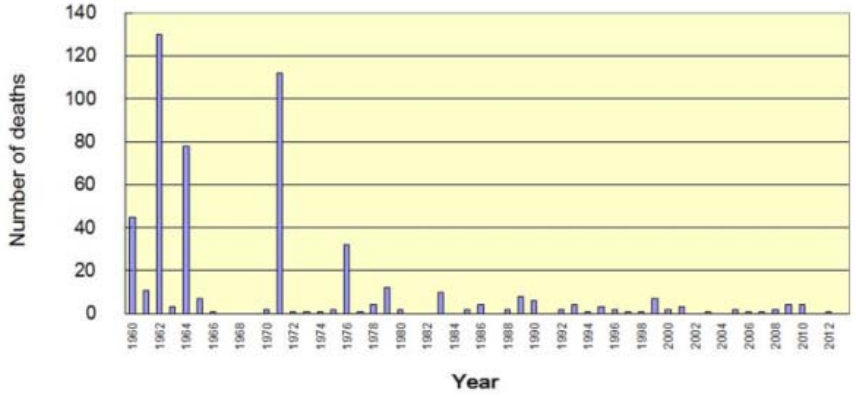
Monthly means of total rainfall and number of rainy day recorded at the Hong Kong Observatory between 1981 and 2010.



Monthly mean number of occurrence of Tropical Cyclones affecting Hong Kong (1961-2010)



Mean annual rainfall: **2240.2 mm**
Highest annual rainfall: **3343.0 mm** (1997)
Highest hourly rainfall: **145.5 mm/h** (7 Jun 2008, 09 HKT)



Recent typhoon casualties (after 1960)
(but >10,000 deaths in 1906 and in 1937, >2,000 in 1874)

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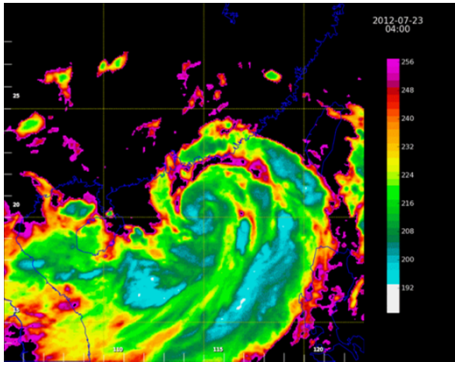
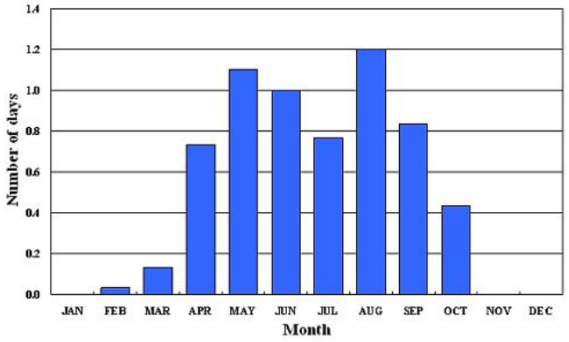
Top hazardous weather of concern in HK (monitored by satellites)

- Tropical cyclones

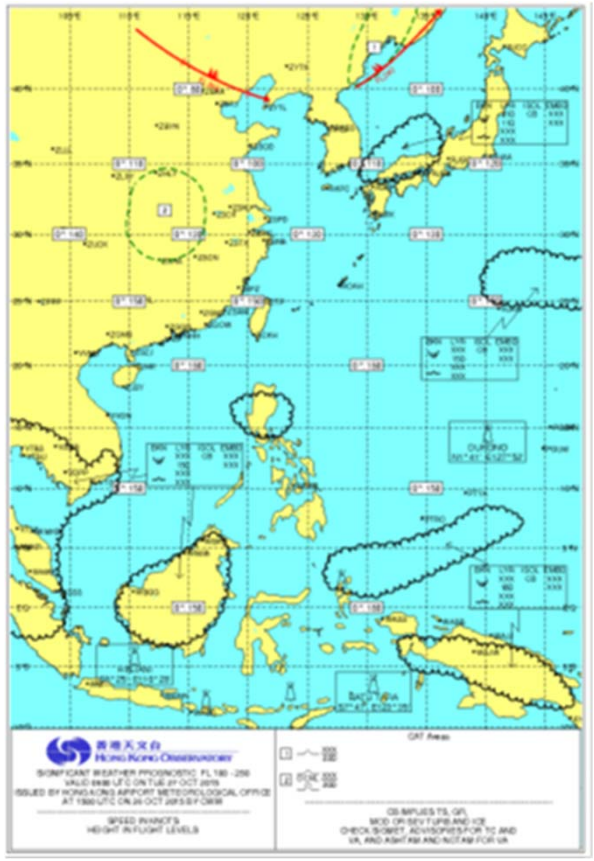


- Severe thunderstorms and rainstorms



Average number of heavy rain days with hourly rainfall ≥ 30 mm in each month (1971-2000) – flooding and landslides

- Aviation safety



- thunderstorms
- tropical cyclones
- turbulence
- icing
- mountain wave
- volcanic ash

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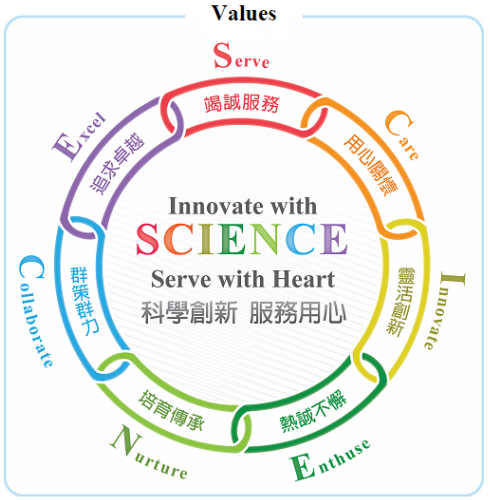
b. Mission and Short Description of NMHS

i) HKO's Mission, Mandate

- Weather services and warnings
- Climatological services
- Aviation weather services
- Marine weather
- Radiation monitoring and assessment
- Geophysical service, i.e. Astronomy and tide, earthquake and tsunami
- Time standard

Vision-Mission-Values



Serve	Care	Innovate	Enthuse	Nurture	Collaborate	Excel
竭誠服務	用心關懷	靈活創新	熱誠不懈	培育傳承	群策群力	追求卓越

Vision

Be a model of excellence
in protecting lives and building together a better society
through science.

Mission

To provide people-oriented quality services in meteorology and related fields,
and to enhance the society's capability in natural disaster prevention and response,
through science, innovation and partnership.

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b. Mission and Basic Info of NMHS

ii) Historical development of observing networks

- Hong Kong Observatory established in 1883
- Routine surface observations began in 1884
- Break during WWII
- Upper-air sounding operation since 1950s
- Satellite reception since early 1960s
- AWS introduced in 1984
- Since 1985 – collaboration with Guangdong Met Bureau to set up AWS in offshore islands beyond HK territory
- Nowadays, HKO operates a wide variety of observation networks, including radars, satellite reception stations, lidar, microwave radiometer, wind profilers, upper-air station, AWS, tide gauges, lightning network, solar radiation station, visibility metres, evaporation pans and lysimeters, CO_2 measurement, radiation monitoring network .....

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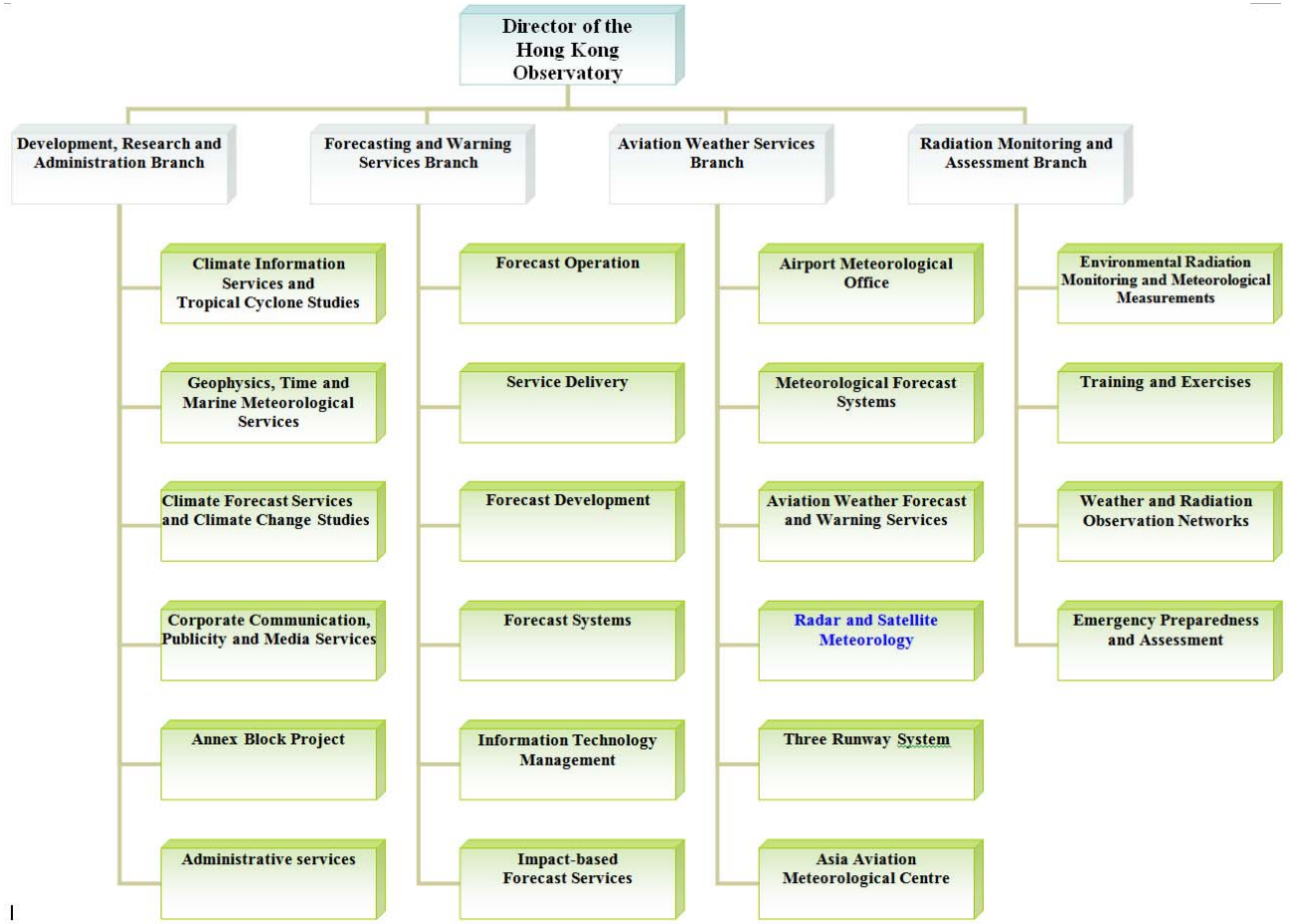
iii) Staff composition



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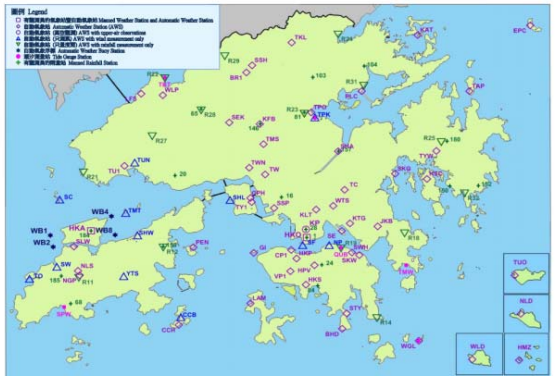
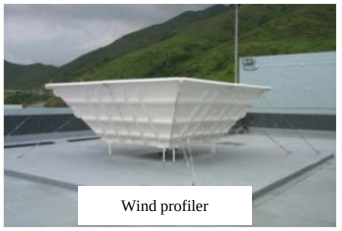
c. Network of Observations of HKO

3.1 Surface stations, upper-air, remote sensing, etc

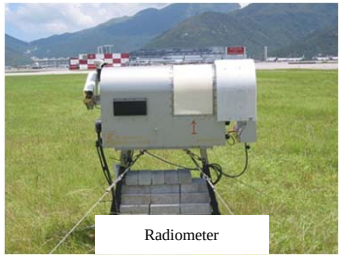


Locations of Weather stations, Rainfall and Tide Gauge Station as at 31 Dec 2013

LIDAR for windshear detection



Wind profiler

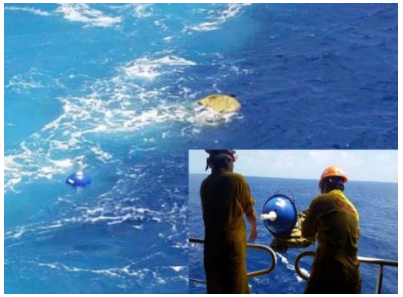


Radiometer

Tide gauge station

Automatic sounding station

Lightning network



Drift buoy

Weather buoy

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Aircraft-based observations

- Aircraft Meteorological Data Relay (AMDAR)
  - HKO has set up AMDAR program since 2001
  - Meteorological elements reported: (1) air temperature and (2) winds
  - Number of AMDAR-enabled aircraft: 53 (in December 2017)
  - Future work: (1) enlarge the AMDAR fleet and (2) enable in-situ Eddy Dissipation Rate (EDR) reporting

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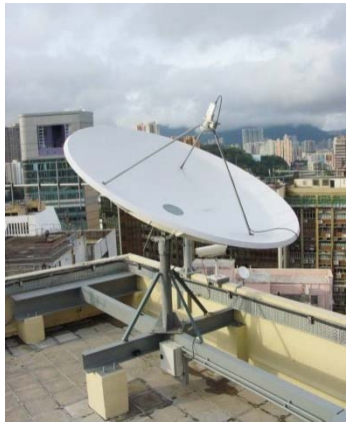
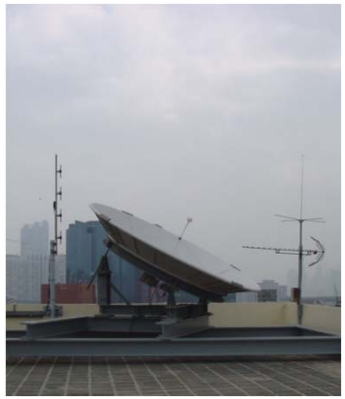
Satellite Reception Systems

MTSAT/HimawariCast antenna at the HKOHQ HimawatiCloud

FY4 Satellite Reception System at King's Park Met. Station



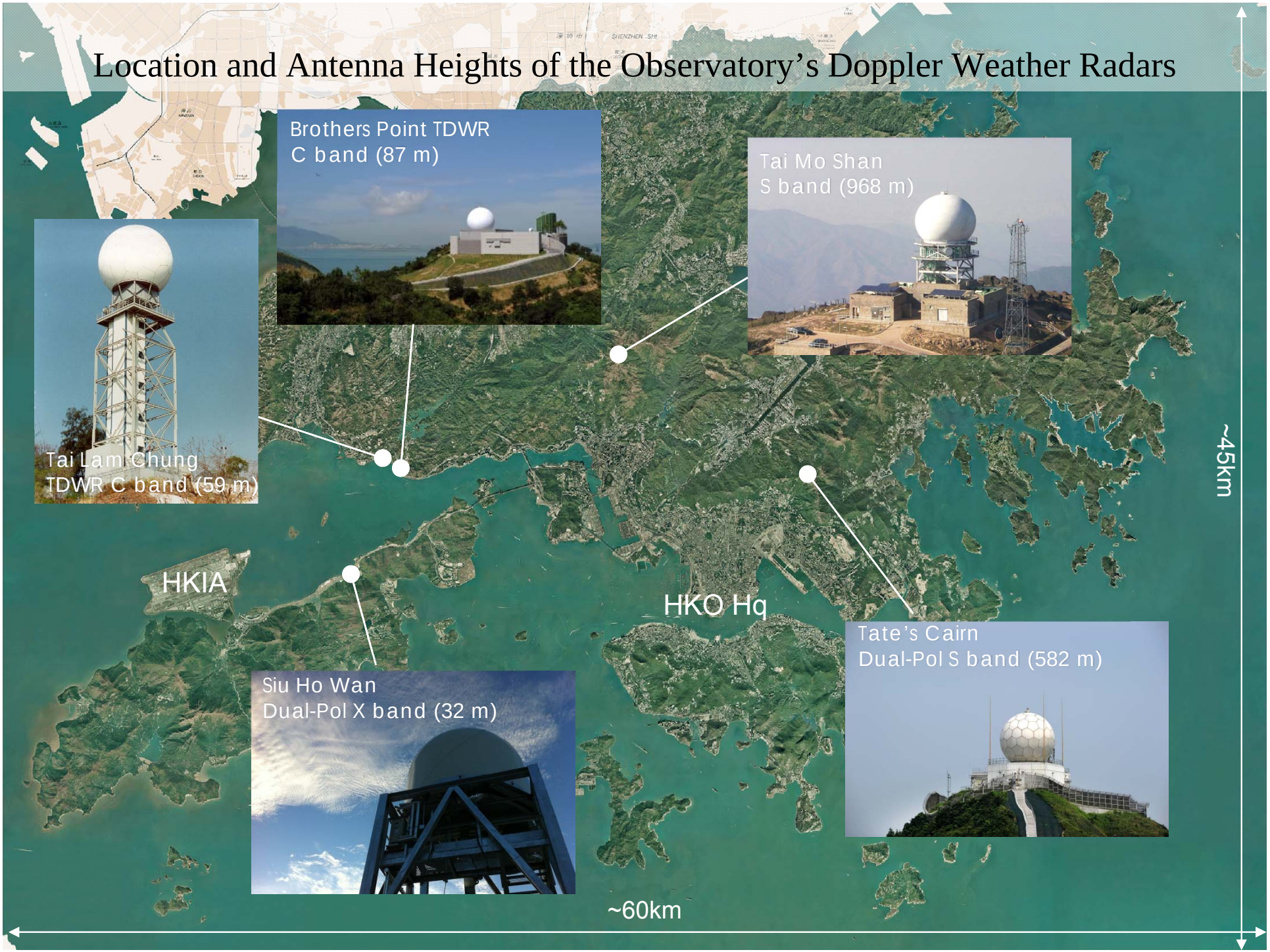
CMACast Reception antenna at HKOHQ



FY-2 antenna at the HKOHQ

Tracking antenna for MODIS/POES at King's Park Met. Station

Location and Antenna Heights of the Observatory's Doppler Weather Radars



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4. Satellite data collection and processing capabilities

4.1 Satellite Data Sources

- Fengyun 4 system Reception System (2018)
  - AGRI, GIIRS, LMI satellite Level 1 and 2 data
- Himawari-8 Reception System (since 2015)
  - HimawariCast (upgrade of MTSAT system), receiving 14-band HRIT satellite data from JCSAT-2B
  - HimawariCloud - Internet download of 16-band Standard Data (HSD) from JMA
- FYCast/CMACast Reception System (since 2008/2012)
  - Re-broadcast satellite data from AsiaSat4, including FY2E/FY2G, FY2F (rapid scan), NOAA-series, MODIS, METEOSAT and GOES-series satellite data
- MTSAT Reception System (since 2007)
  - HRID, HRIT data from MTSAT (cease operation Mar 2016)
  - VISSR data from FY-2G
  - Himawari-8 HRIT data converted from HSD download from JMA as backup
  - COMS-1 data from KMA
- MODIS Reception System (since 2004)
  - AQUA and TERRA + NPP
- POES Reception System (since 2002)
  - NOAA + Metop
- Haiyang-2A Reception System (since 2013)
  - Internet download from CNSA and VSAT

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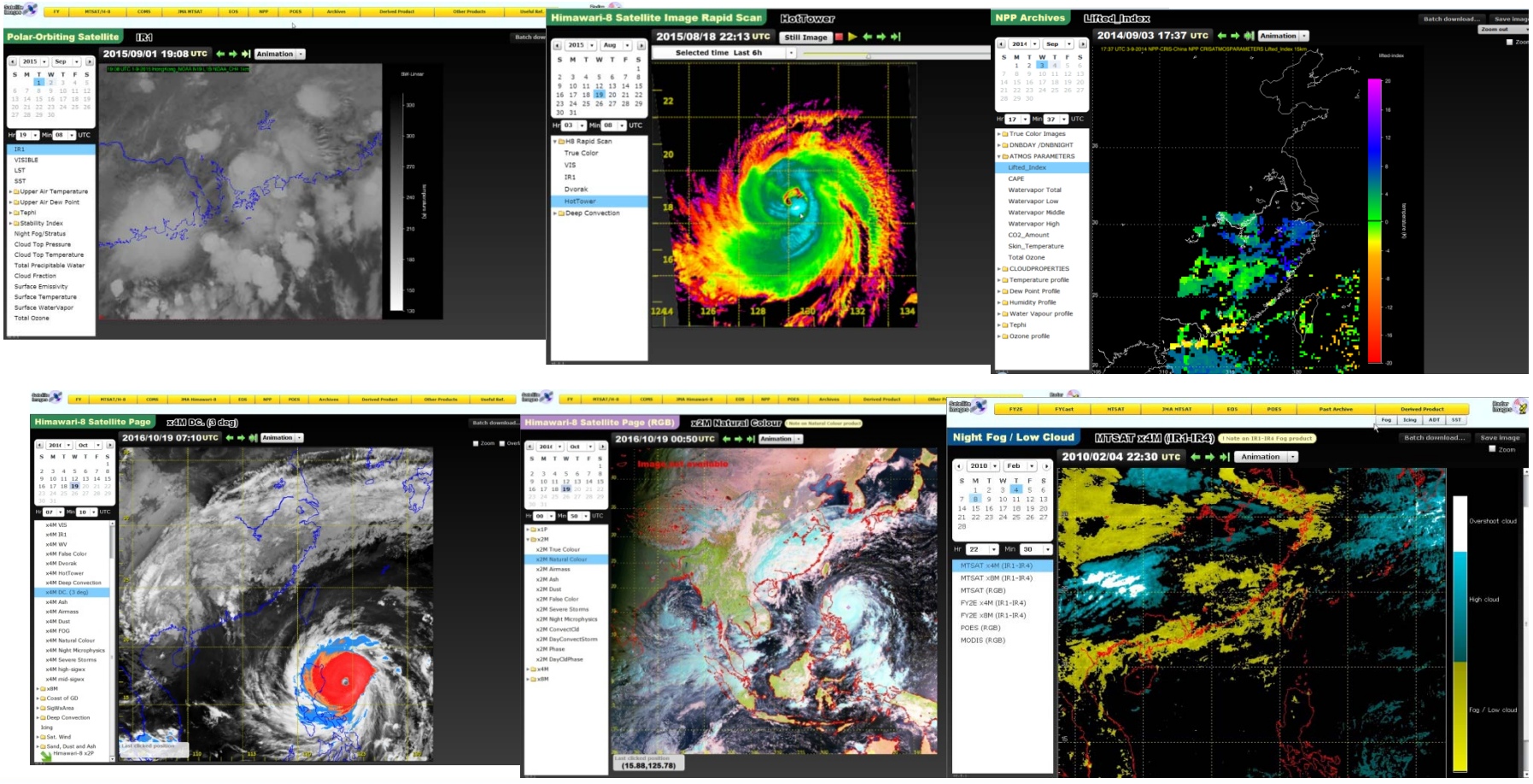
4.3 Data visualization and processing

4.3.1 Display of satellite image all-in-one on intranet



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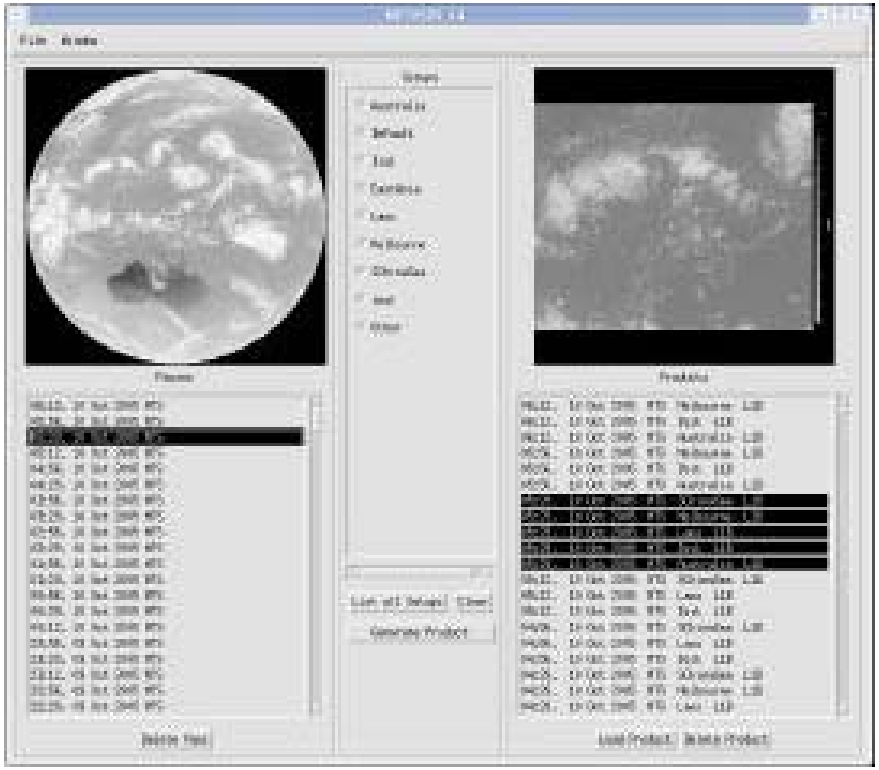
4.3.2 Dedicated display for forecaster



METEOR is used to display and analyse the satellite image products.

Provides a range of display and analysis functions, including:

- zoom and pan;
- histogram equalisation;
- manual brightness and contrast controls;
- distance and bearing between two points;
- define and load new colour tables;
- RGB and channel combination.

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4.4 Satellite data applications

4.4.1 POES and MODIS satellites are mainly for atmospheric and environmental monitoring and research studies:

(i) Profile temperature and dew points
(ii) Cloud properties
(iii) Chlorophyll Concentration
(iv) Vegetation index
(v) AOD
(vi) SST, and etc

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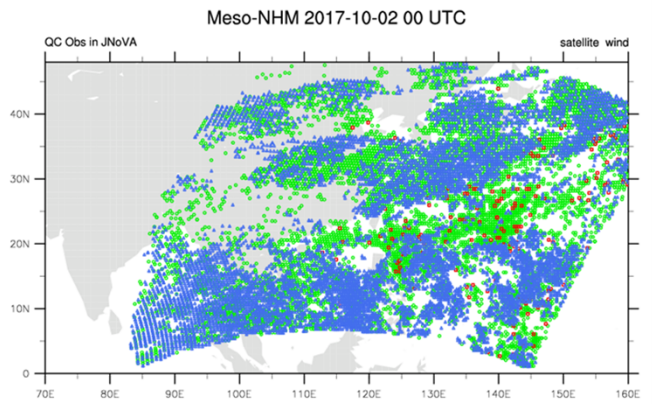
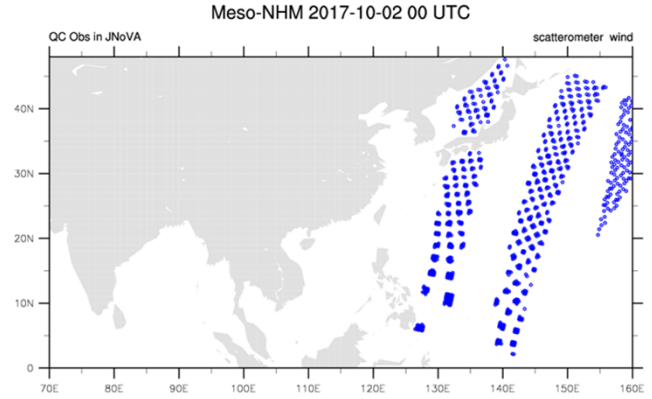
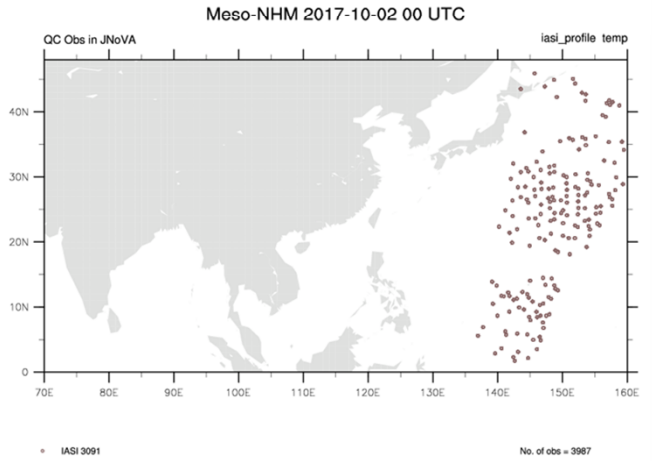
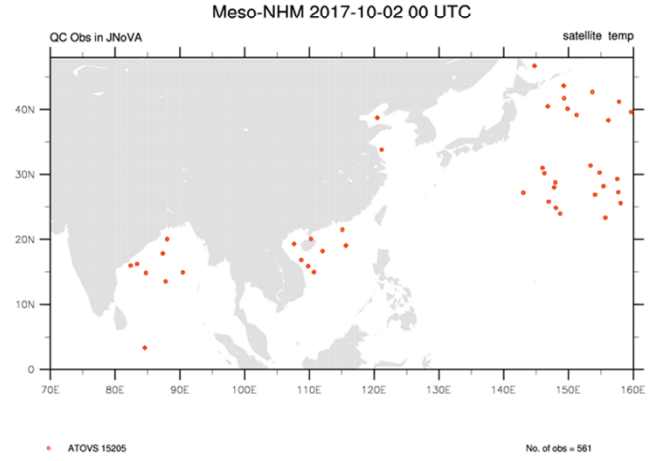
4.4 Satellite data applications

4.4.2 NWP Data Assimilation :









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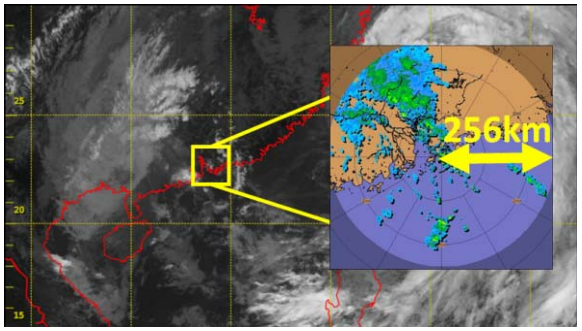
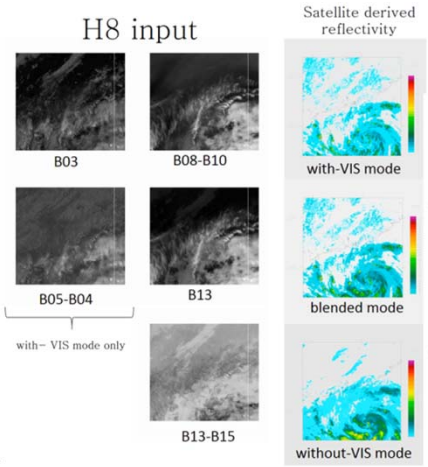
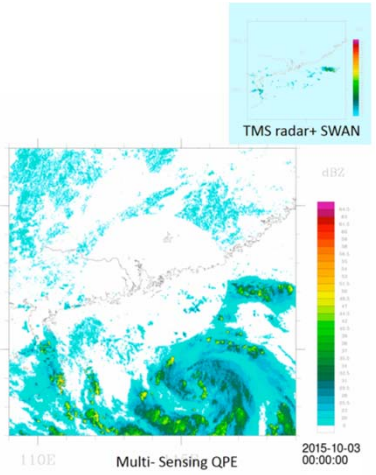
4.5 Satellite data applications examples

4.5.1 Himawari-8 Satellite derived Reflectivity using Multi-layer perceptron artificial neural network(MLPANN)

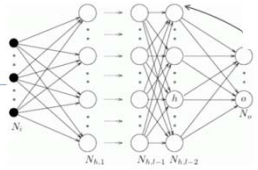


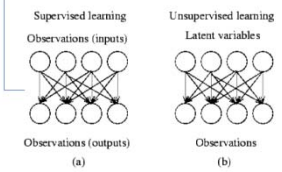




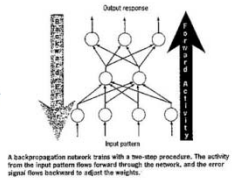
- Features of MLPANN implemented in HKO:

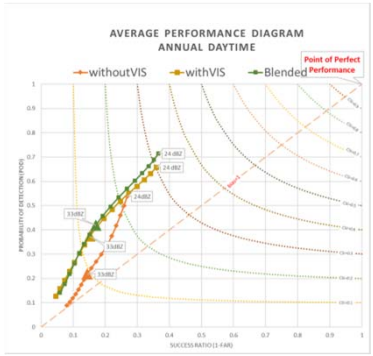
Neural Network Architecture	Deep neural networks
Training Algorithm	Backpropagation
Learning Strategy	Supervised learning





Reference:
http://www.turingfinance.com/misconceptions-about-neural-networks/





- Period: July 2015- June 2016 (12 months)
  - Odd Hours
  - On-the-hour
  - Daytime
- Results
  - POD at 24 dBZ > 70%
  - POD at 33 dBZ > 40%

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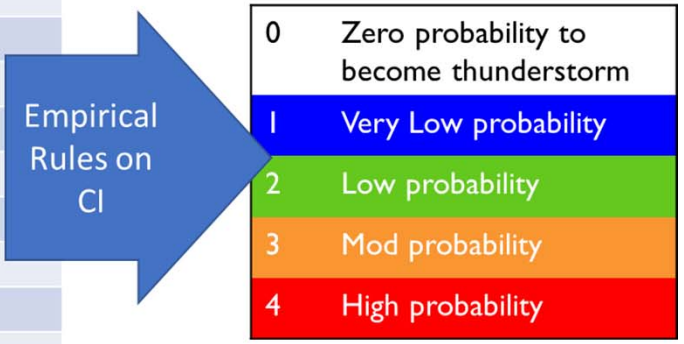
4.5 Satellite data applications examples

4.5.2 Satellite Nowcasting of Significant Convection and Tropical Cyclone Rapid Intensification)

Convection Initiation and Rapid Developing Thunderstorm using Advanced Himawari Imager (AHI) data

(A) Convective Initiation (CI) Nowcasting

Group	CI Parameter
Cloud-top glaciation	IR10.8 Brightness Temperature
Cloud-top glaciation	Time spent since crossing freezing level
Cloud-top glaciation	IR10.8-IR8.7
Cloud depth / height	WV6.2-IR10.8
Cloud depth / height	IR13.4-IR10.8
Cloud depth / height	IR12.0-IR10.8
Cloud depth / height	WV6.2-WV7.3
Cloud growth	Change rate of IR10.8 Brightness Temperature
Cloud growth	Change rate of (WV6.2-IR10.8)
Cloud growth	Change rate of (IR10.8-IR8.7)
Cloud growth	Change rate of (IR12.0-IR10.8)
Cloud growth	Change rate of (IR13.4-IR10.8)



(B) Rapid Developing Thunderstorm – Convective Warning (RDT-CW)

- Analysis to identify intense or rapidly developing convective cloud cells
- Cloud-free pixel ➔ Cloudy ➔ CI ➔ RDT-CW

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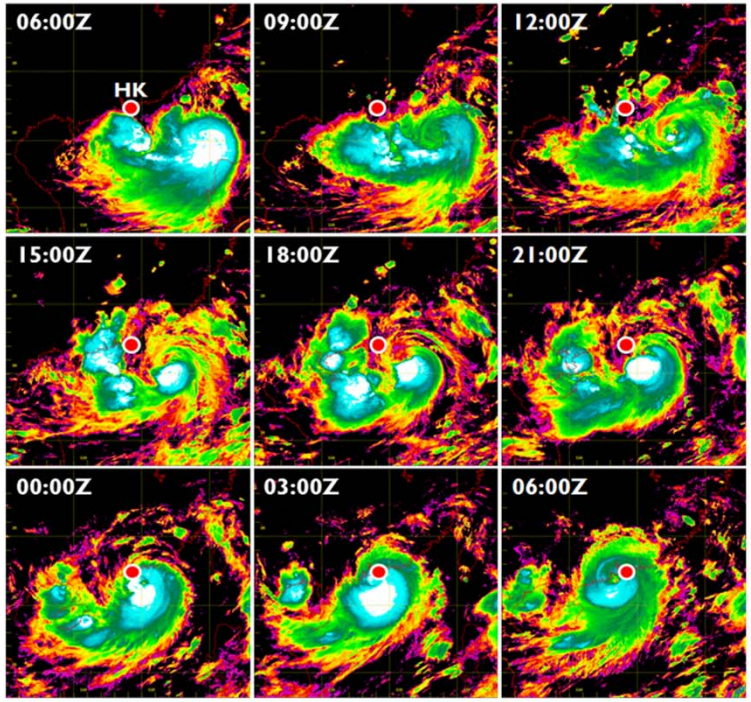
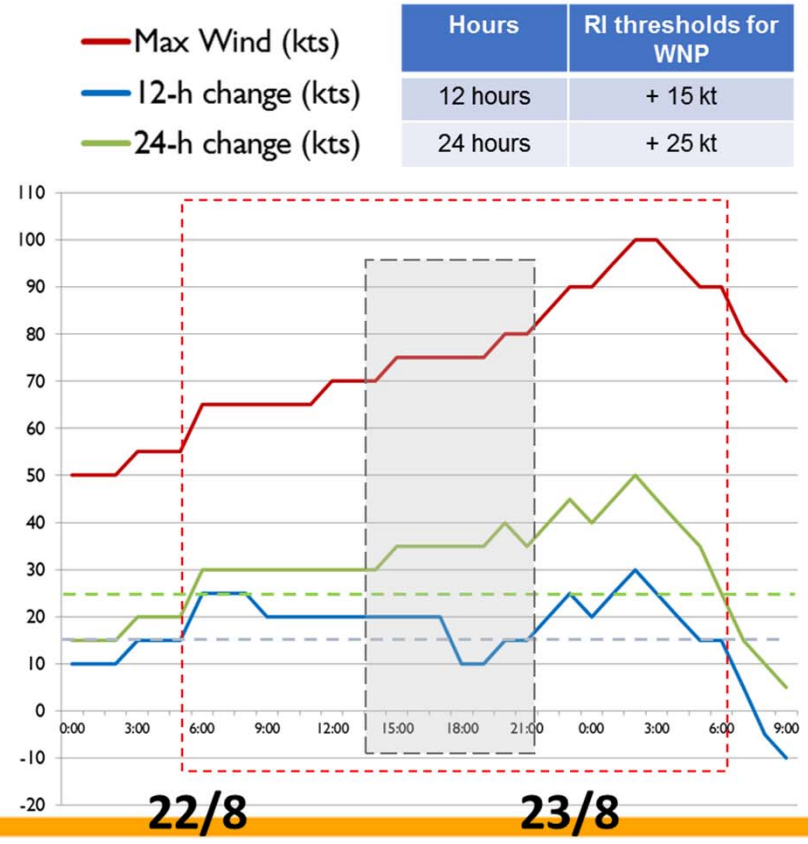
4.5 Satellite data applications examples

4.5.2 Satellite Nowcasting of Significant Convection and Tropical Cyclone Rapid Intensification) –cont'd

Nowcasting RI of Hato from Himawari-8 data





Hours	RI thresholds for WNP
12 hours	+ 15 kt
24 hours	+ 25 kt

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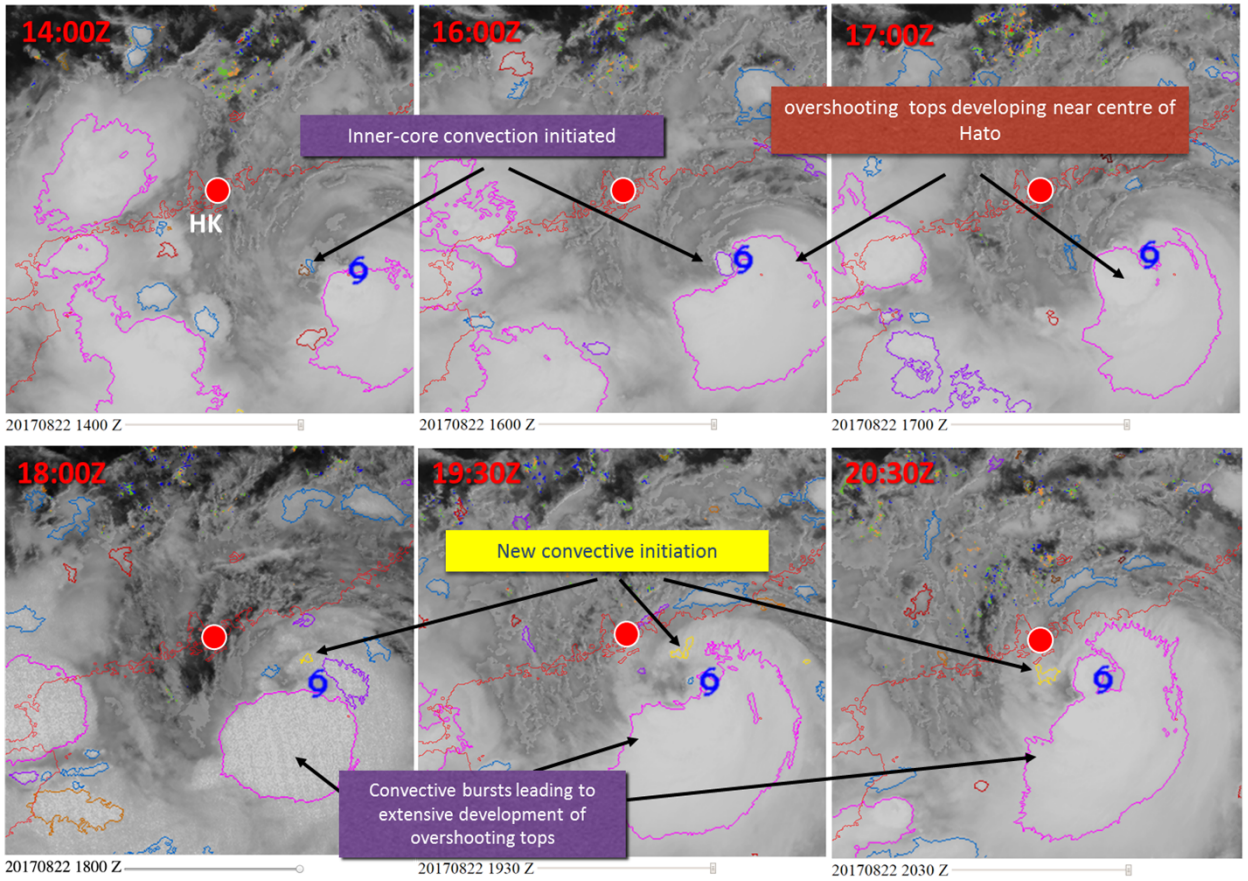
4.5 Satellite data applications examples

4.5.2 Satellite Nowcasting of Significant Convection and Tropical Cyclone Rapid Intensification) –cont'd



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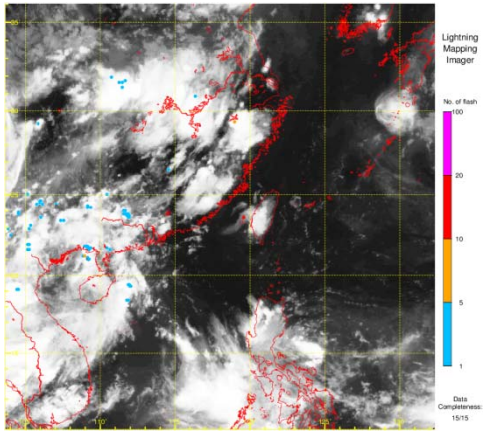
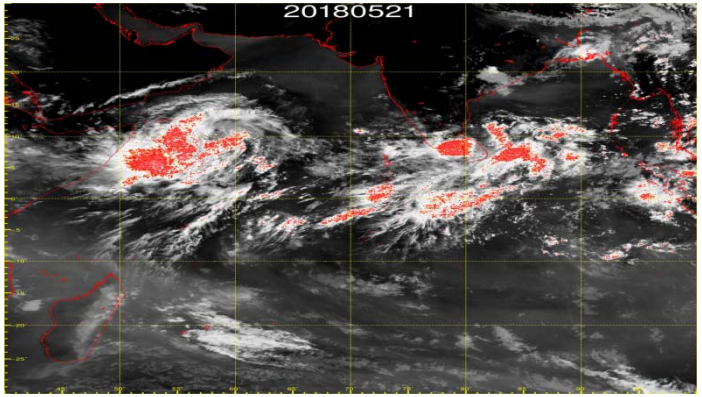
4.5.3 Weather monitoring and diagnosis

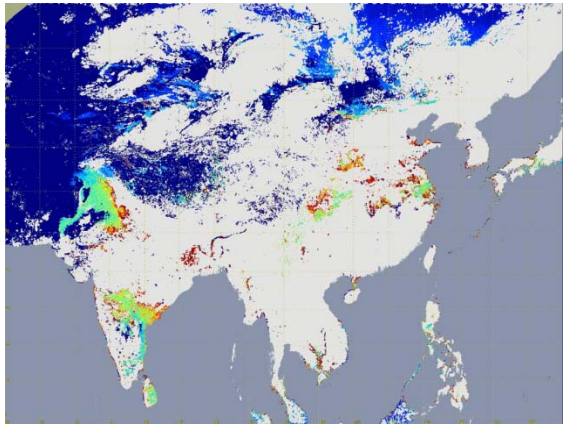
LMI for thunderstorms monitoring



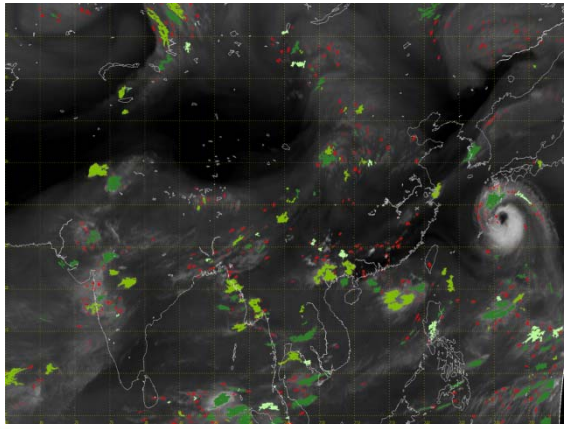
Tropical Cyclone and Deep Convection Monitoring
(To enhance Indian Ocean Monitoring using FY4)



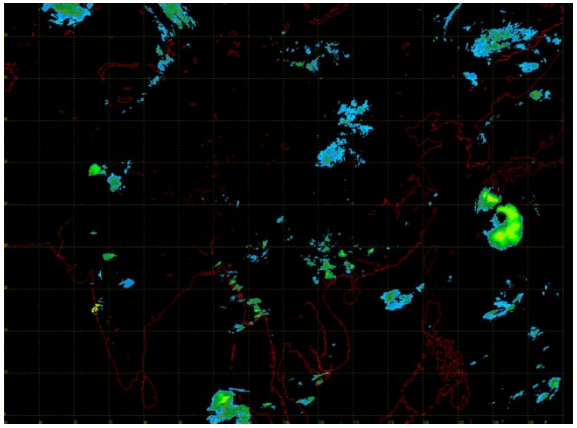
AOD for suspended particles



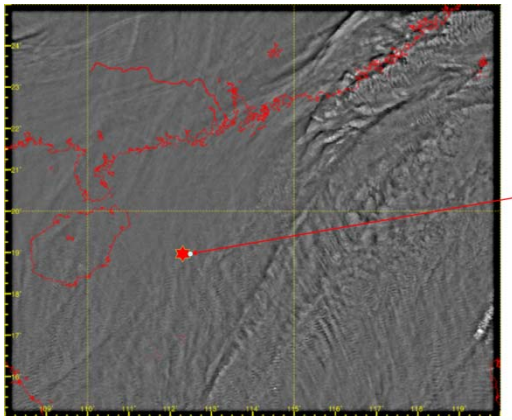
CI for convection development



QPE for rainfall estimation



High pass filter water vapour imageries for turbulence



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5. Observations for forecasts and warnings

Tropical Cyclone Warning Signals

■ **Standby Signal No.1**

■ **Strong Wind Signal No.3**

■ **Gale or Storm Signal No. 8**

■ **Increasing Gale or Storm Signal No. 9**

■ **Hurricane Signal No. 10**

Rainstorm Warning Signals

Other Warnings

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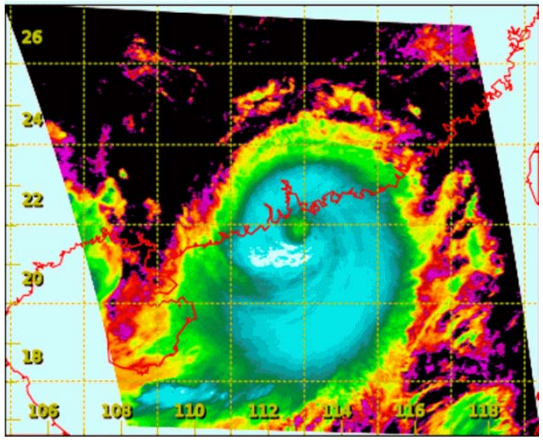
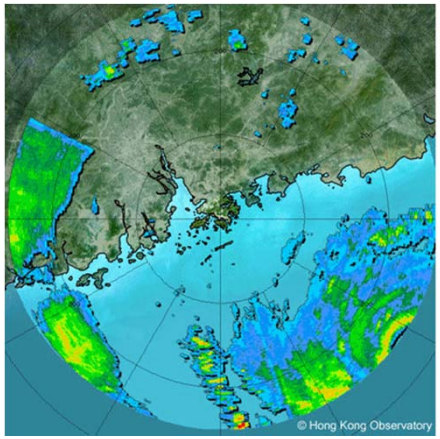
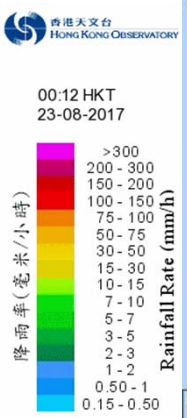
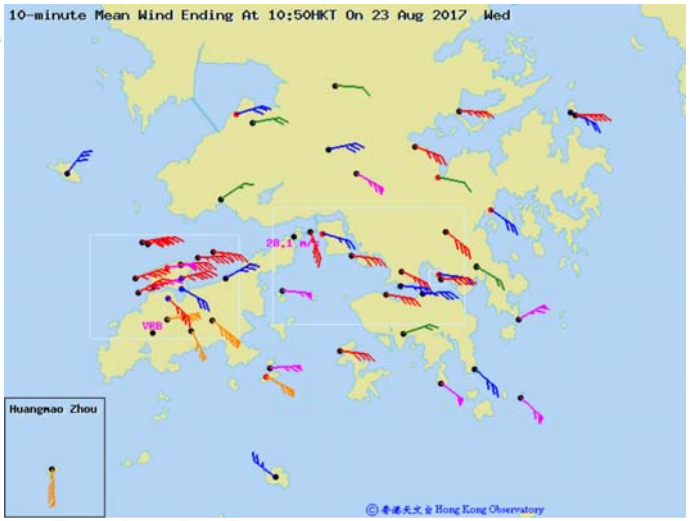
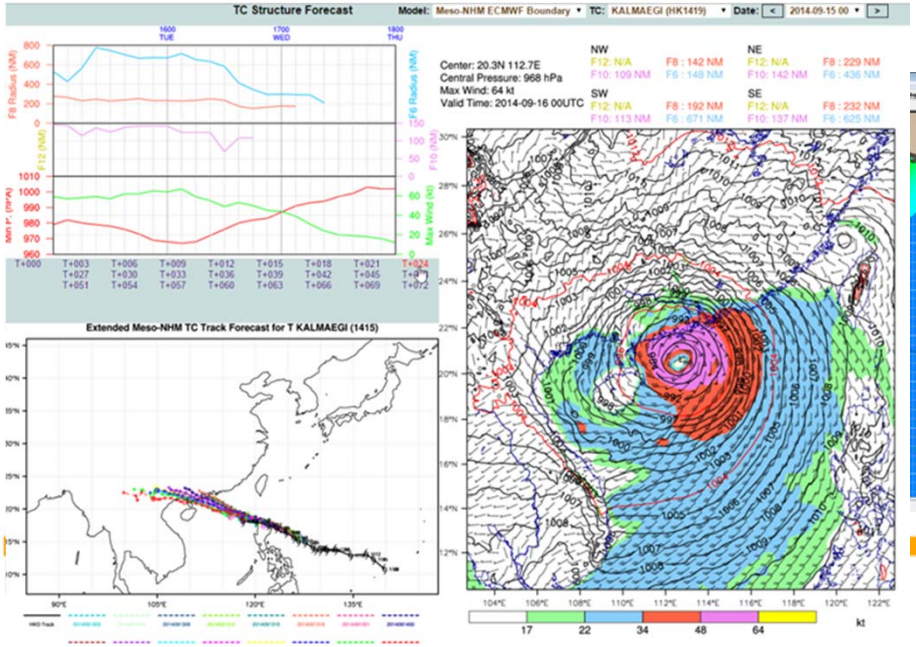
5. Observations for forecasts and warnings

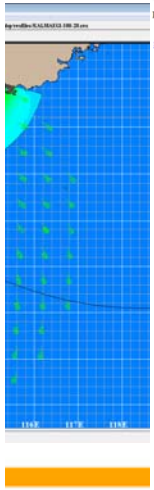


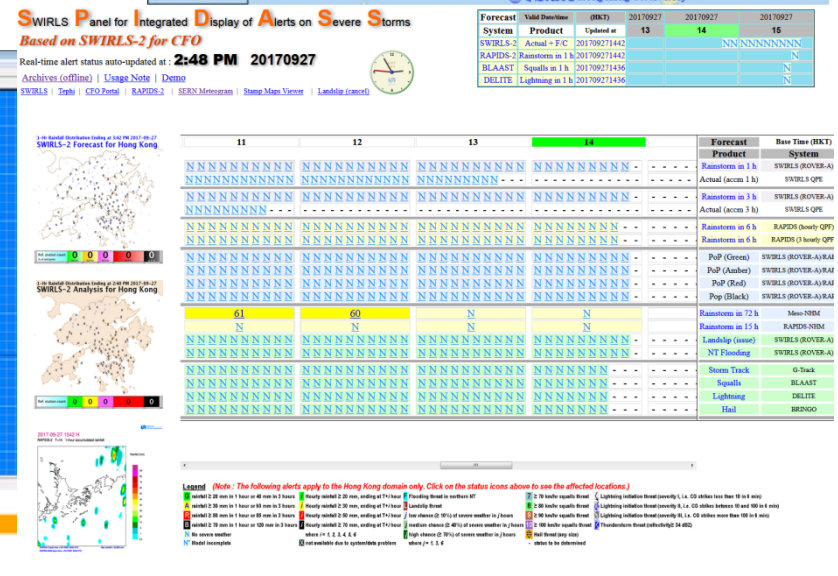












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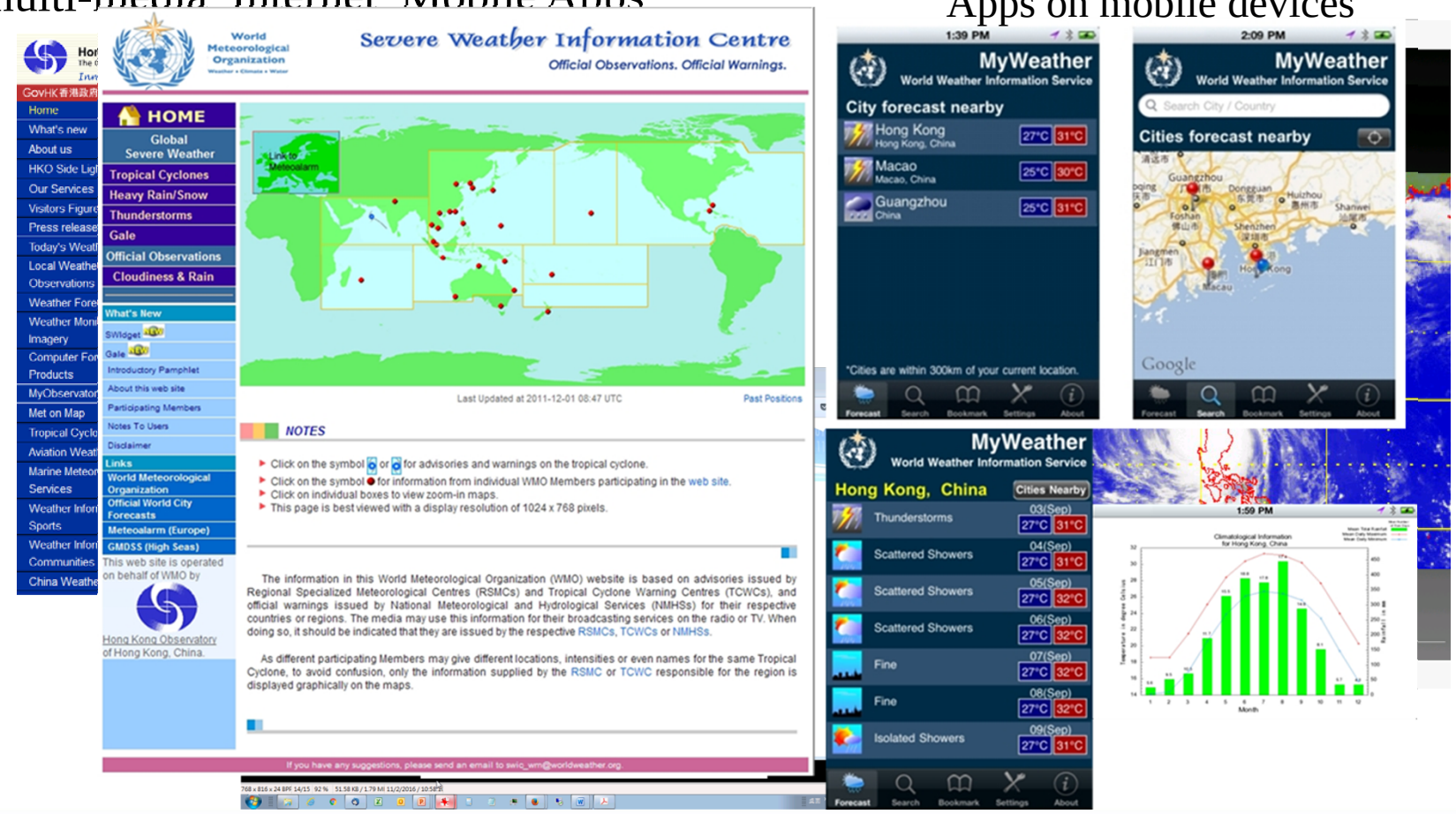
5. Observations for forecasts and warnings

Information for the public and special users via different channels – multi-media, Internet, Mobile Apps

Apps on mobile devices



Severe Weather Information Centre
operated on behalf of WMO by HKO

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6. Future Work

- Enhance Indian Ocean Monitoring using FY4-series satellite
- Evaluate FY4A LMI for thunderstorm and severe weather monitoring
- Reception of FY4A GIIRS data to enhance NWP works
- Reception of new generation satellites, e.g. GEO-KOMPSAT-2A /2B, etc. to enhance weather monitoring
- Upgrade of MODIS/POES for reception of more POS data e.g. NOAA-20, METOP-C and FY3C/3D.

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7. Challenges

- Support Asian Aviation Meteorological Centre (AAMC) with more frequent global mosaic imageries (from 3-hourly to hourly) and new applications, e.g. deep convection, icing, turbulence, and volcanic ash

- Develop new applications using higher spatial and temporal resolution data of new satellites

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Thank you!