

Application of Fengyun Satellite Products at the Hong Kong Observatory

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Outlines

- Introduction to Hong Kong Observatory
- FY satellite reception in HKO
- Data visualization and processing
- Examples of FY satellite images and products
- Satellite data applications
- Future work on FY satellites

Introduction

1. Country overview

I. Basic information of Hong Kong, China

- Area: 1 104 km²;
- Population: 7. 389 m (as of mid-2017)
- Sub-tropical climate

II. Major historical meteorological disaster events

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

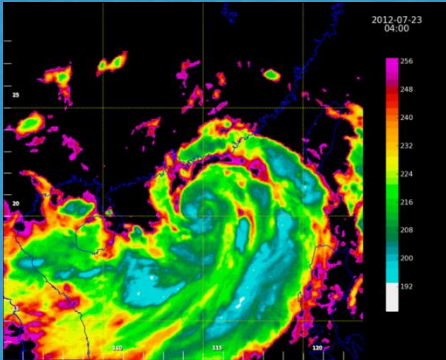
III. Major national economic sectors relying on Met Services

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

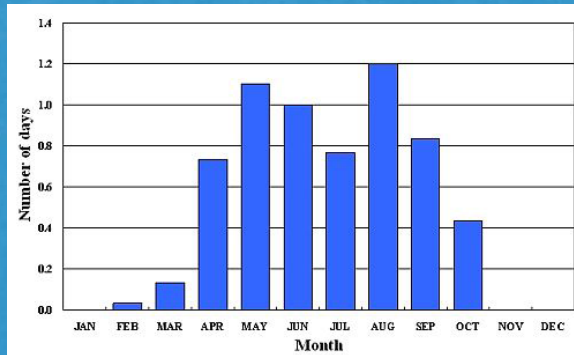


Top hazardous weather of concern in HK (monitored by satellites)

- 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

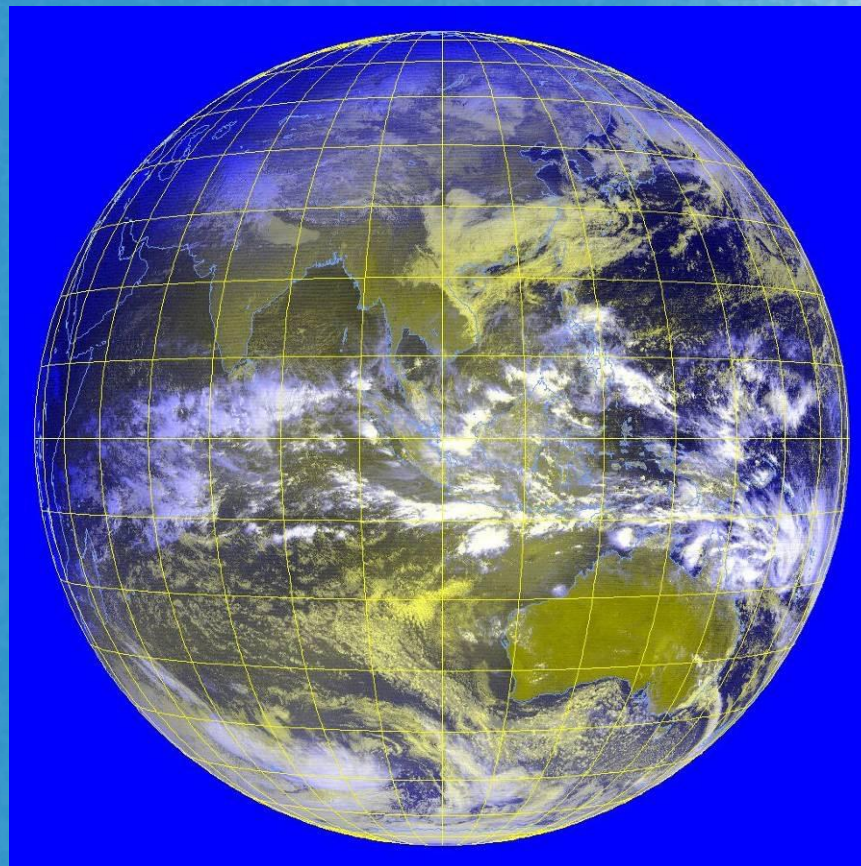
Fengyun Satellite Reception in HKO

- Fengyun-2 Direct Reception System (since 1999)
 - FY-2 VISSR data
- FYCast/CMACast Reception System (since 2008/2012)
 - Re-broadcast satellite data from AsiaSat4, including FY2F, FY2G, FY2H, NOAA-series, MODIS, METEOSAT and GOES-series satellite data
- Fengyun 4 Direct Reception System (2018)
 - AGRI, GIIRS, LMI Level 1 data and Level 2 Products
- Fengyun3 reception enhancement (2019)
 - Upgrade polar orbiting satellite reception system to receive FY3B/FY3C/FY3D data in addition to NOAA, METOP, SNPP, JPSS, MODIS data

FY-2 Ground Reception System



FY-2 antenna at the HKOHQ

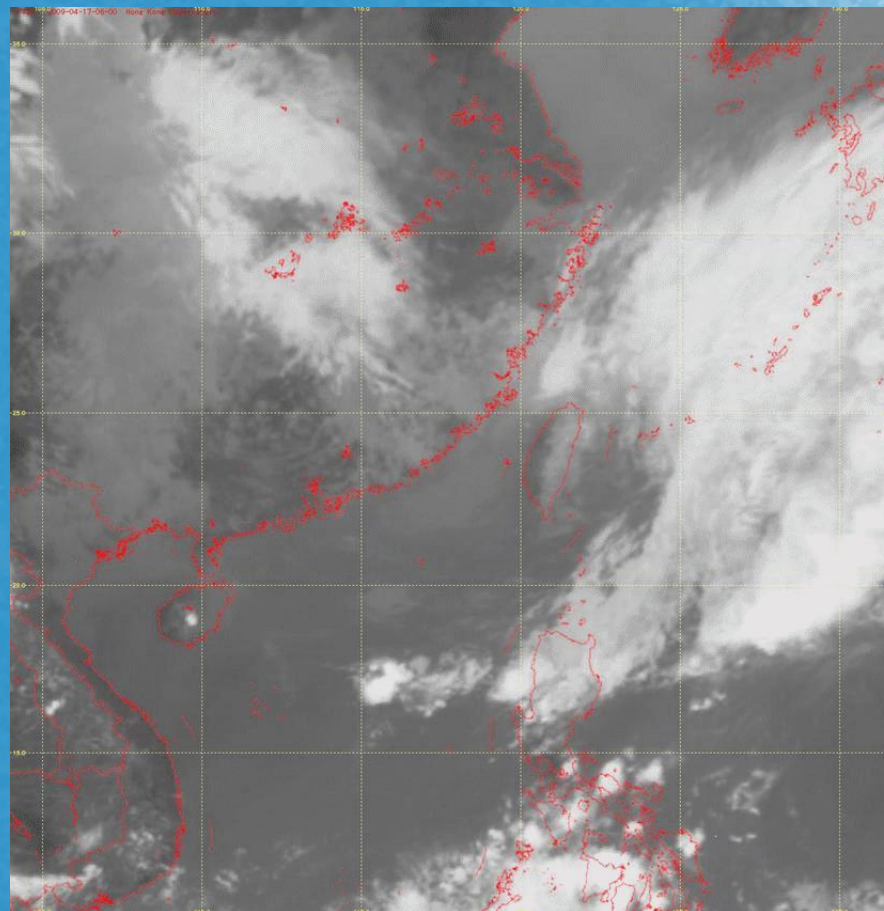


**First FY2 Image received
by HKO on 20 January 1999**

CMACast Reception System



Reception antenna at
HKO Headquarters



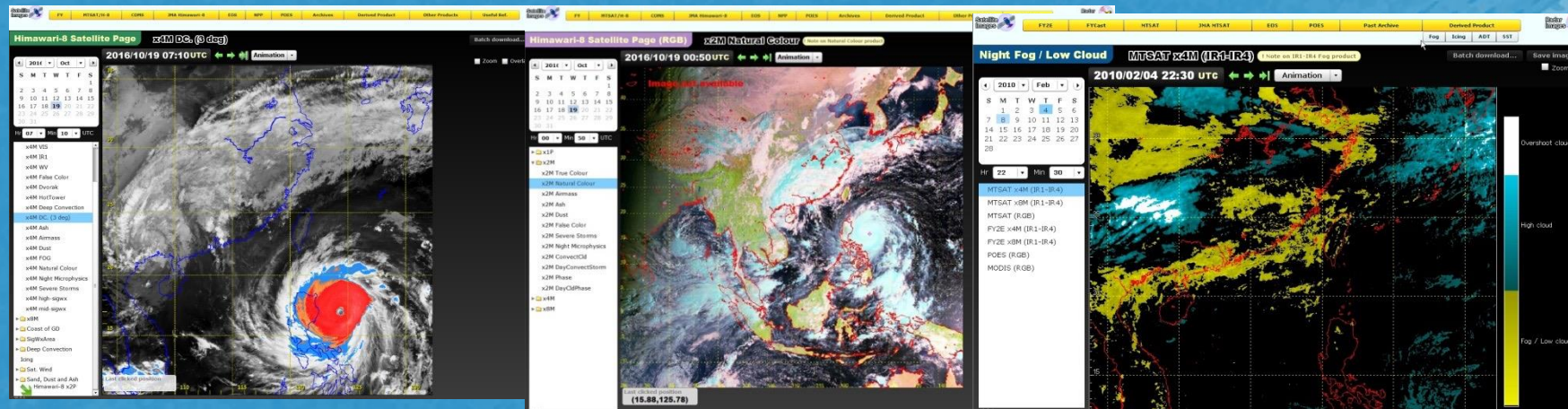
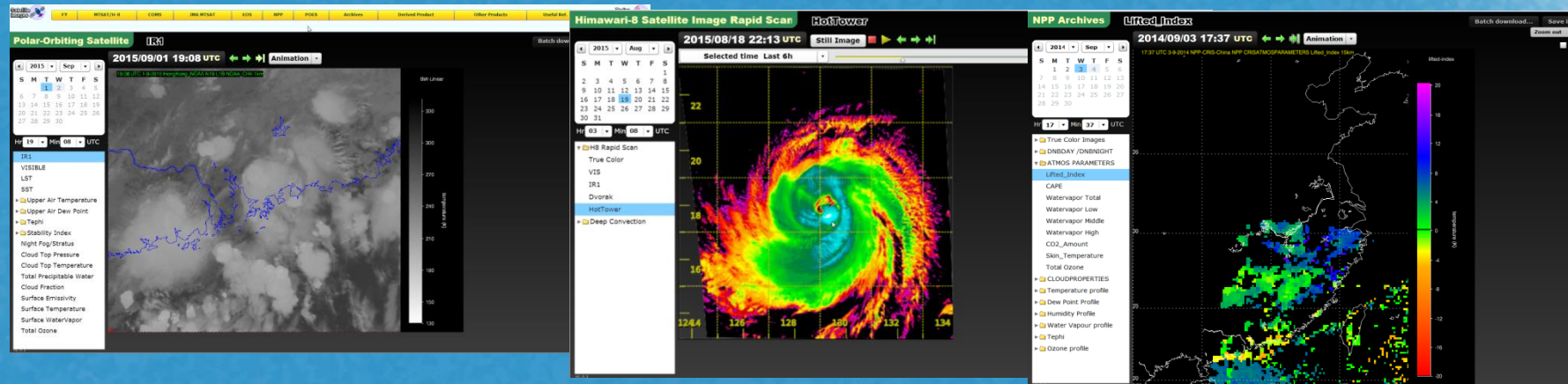
FYCast Combined Imagery



FY4 Satellite Reception System at King's Park Met. Station in 2018

Data visualization and processing

Display of satellite image all-in-one on intranet



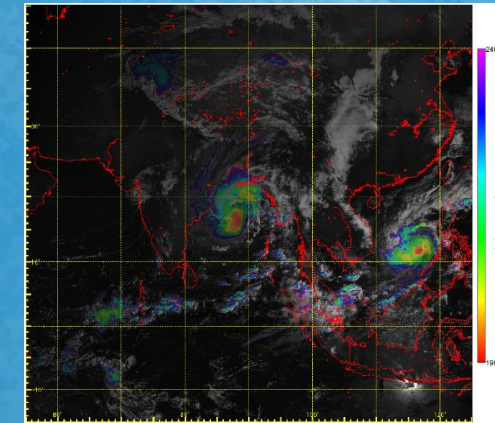
Data visualization and processing

FY4A-series images

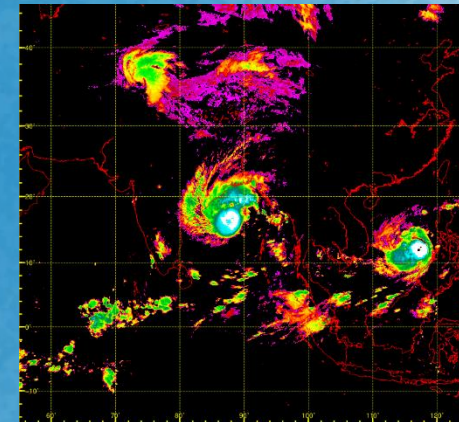
The screenshot shows the 'FY4A Satellite Page' for 'WA Hybrid True Color'. The page includes a navigation menu with options like 'FY4A (RGB) Satellite Image', 'GEOA', 'JMA Himawari-8', 'F05', 'NPP/JPSS1', 'POES', 'Archives', 'Derived Product', 'Other Products', and 'Useful Ref.'. Below the menu, there are tabs for 'FY4A', 'FY4A (RGB)', 'FY3', 'FY2M', 'FY2G', 'FY2P', 'FY2E', and 'Notification'. The main content area displays a satellite image of West Asia with a grid overlay. The image is labeled '2019/11/08 03:00 UTC' and has an 'Animation' control. A calendar shows the date '11' is selected. A dropdown menu for 'West Asia' lists various image processing options: 'WA Hybrid True Color', 'WA VIS', 'WA IR 1', 'WA WV', 'WA False Color', 'WA Dvorak', 'WA Hot Tower', 'WA Enhanced IR 1', 'WA Blended Sandwich', 'WA Deep Convection', 'WA DC_ (3 deg)', 'WA high-sigwx', and 'WA mid-sigwx'. The Windows taskbar at the bottom shows the time as 10:48 PM on 11/11/2019.

FY4 Hybrid true colour images

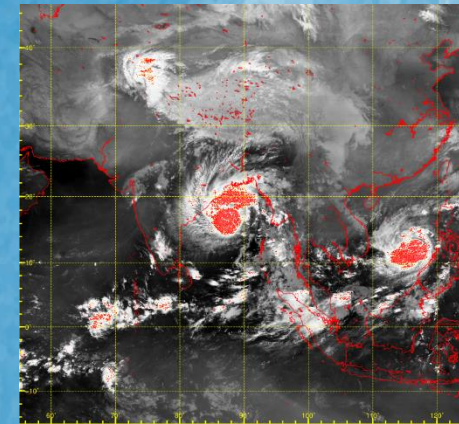
Blended sandwich image



Hot tower image



Deep convection

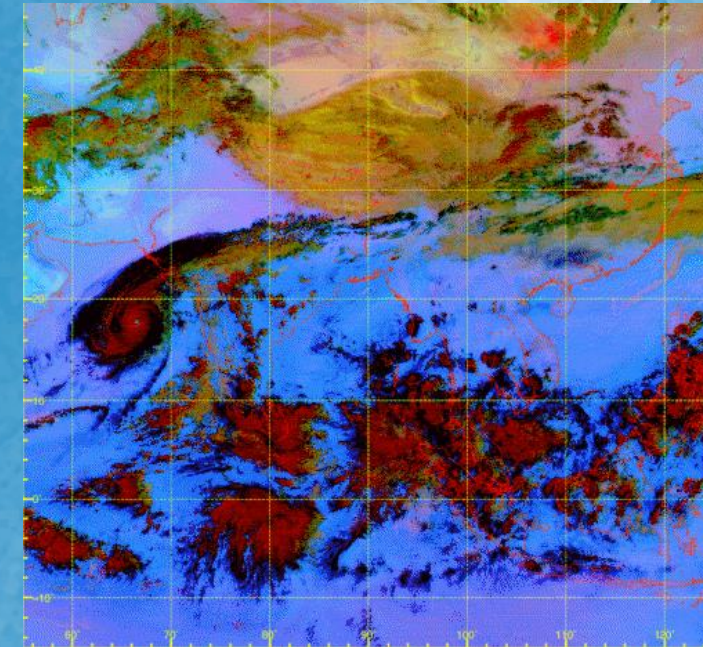


Data visualization and processing

FY4A RGB images

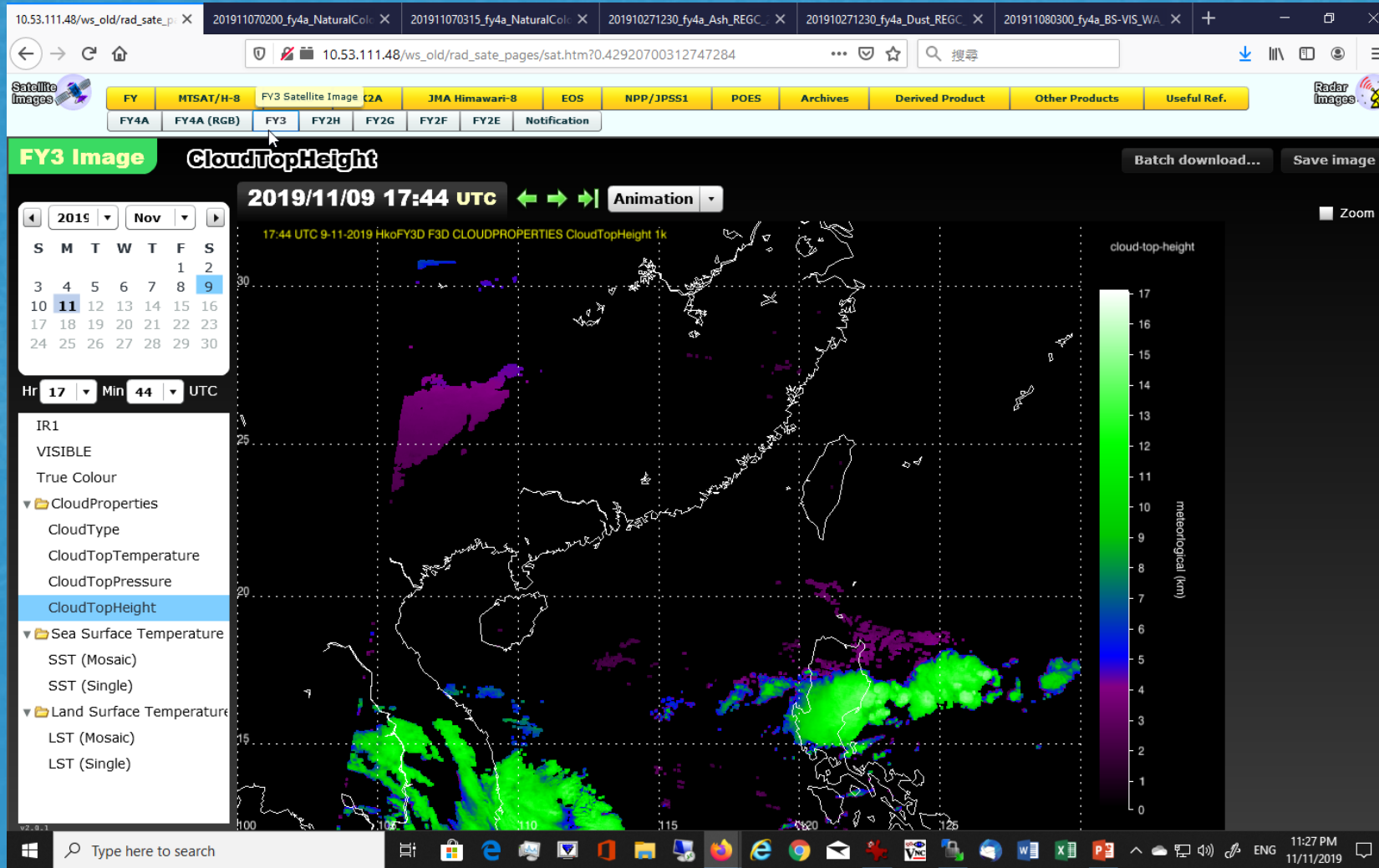
The screenshot displays the Satellite Images website interface. At the top, there are navigation tabs for various satellite products: FY, MTSAT/H-8, COMS, GK2A, JMA Himawari-8, EOS, NPP/JPSS1, POES, Archives, Derived Product, Other Products, and Useful Ref. Below these, a sub-menu highlights 'FY4A' and 'FY4A (RGB)'. The main content area is titled 'FY4A RGB Page' and 'WA Natural Colour'. It shows a calendar for November 2019, with the 11th selected. The time is set to 05:00 UTC. A large satellite image of West Asia is displayed, showing natural colors. A sidebar menu on the left lists various products, with 'WA Natural Colour' selected. The Windows taskbar at the bottom shows the system tray with the time 11:24 PM on 11/11/2019.

Dust RGB image



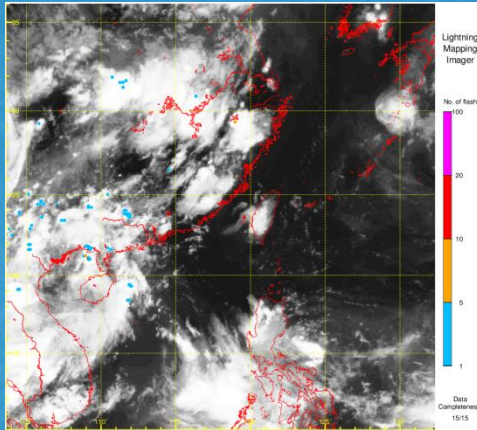
Data visualization and processing

FY3 images

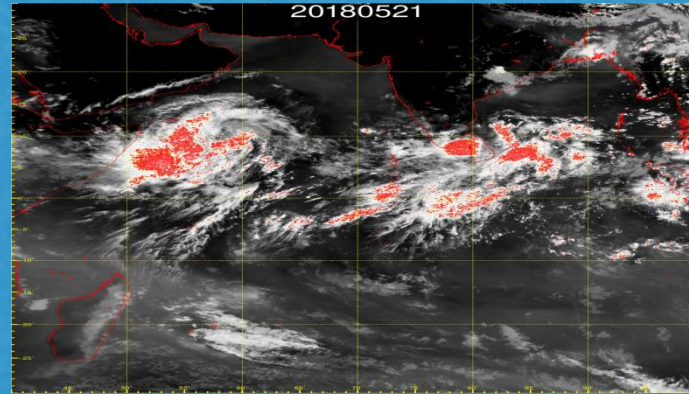


Weather monitoring products

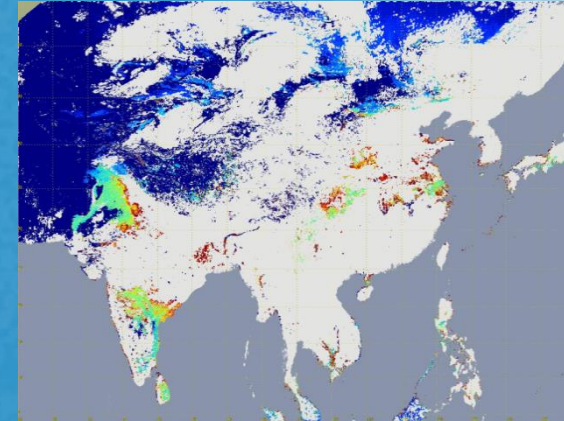
LMI for thunderstorms monitoring



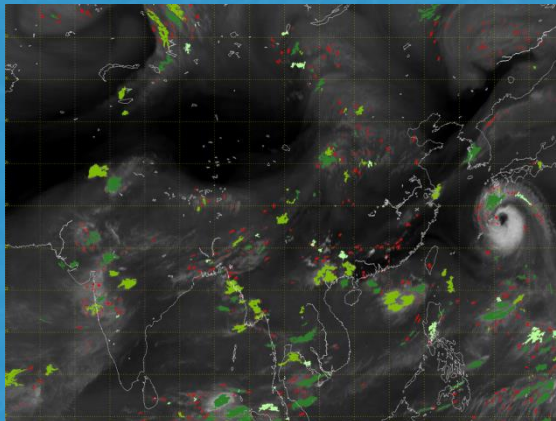
Tropical Cyclone and Deep Convection Monitoring (To enhance Indian Ocean Monitoring using FY4)



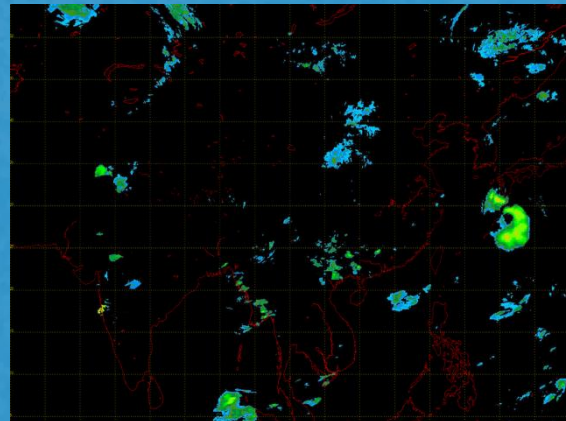
AOD for suspended particles monitoring



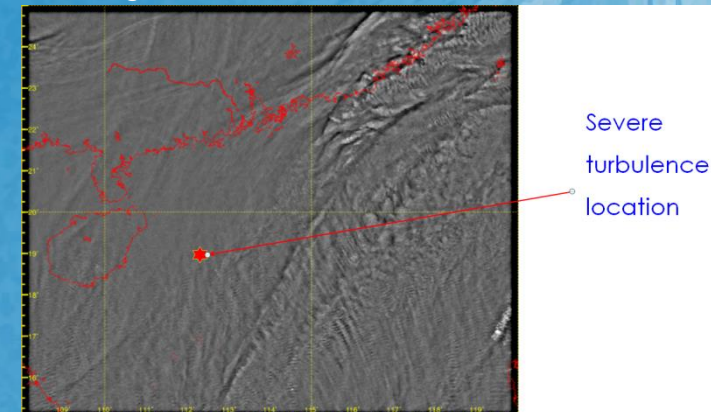
CI for convection development



QPE for rainfall estimation

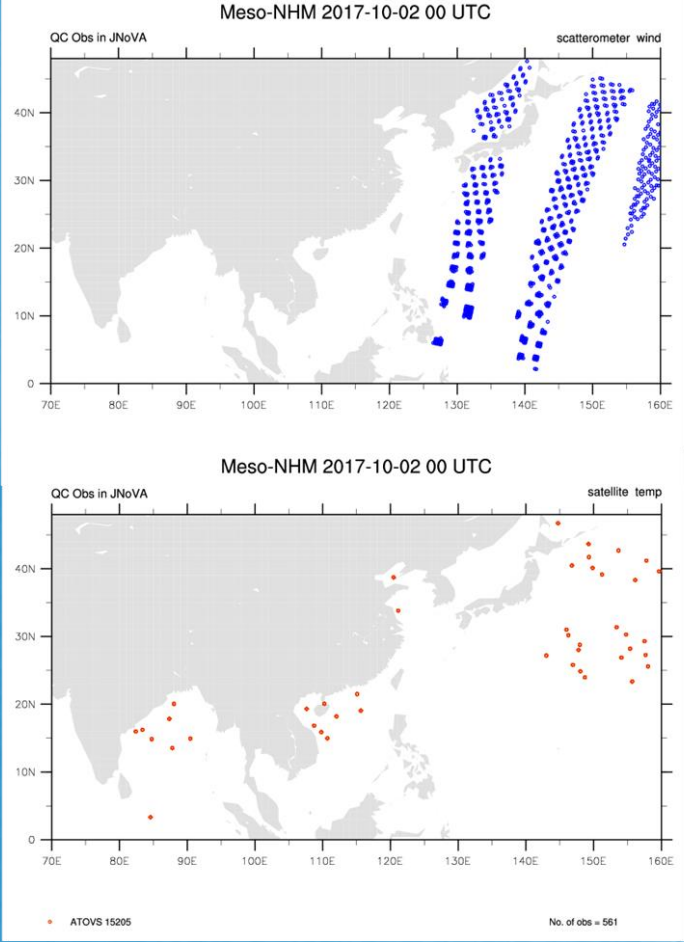
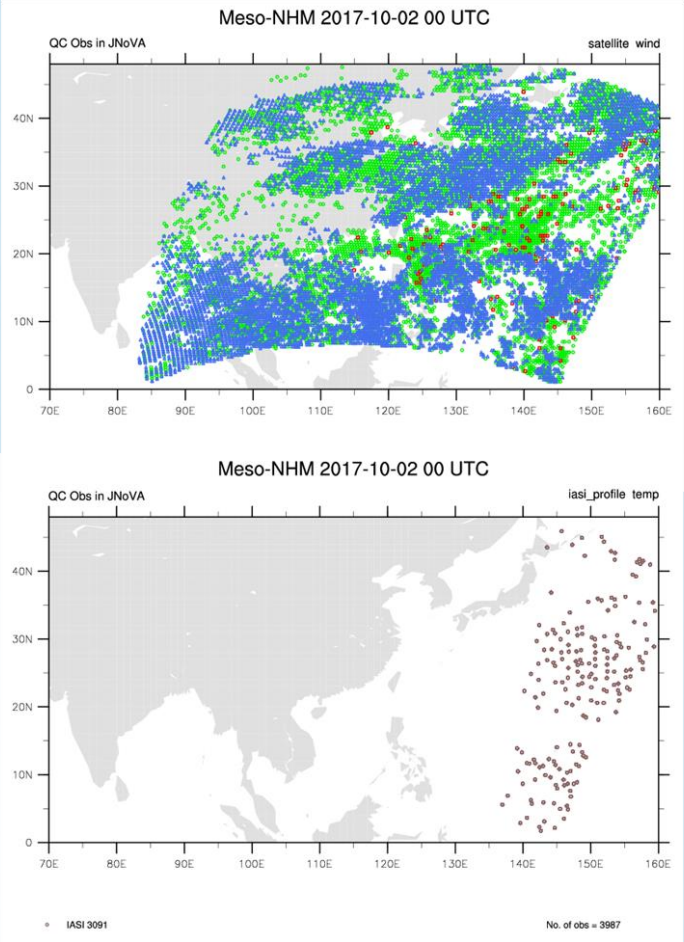


High pass filter water vapour imageries for turbulence



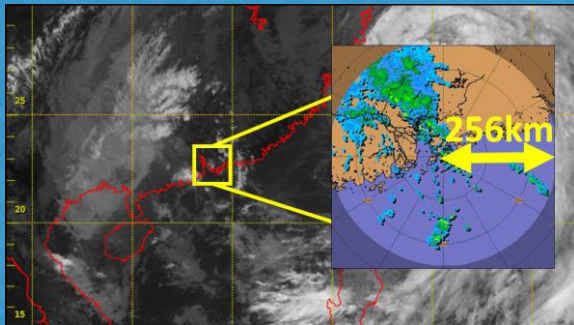
Satellite data applications

NWP Data Assimilation :

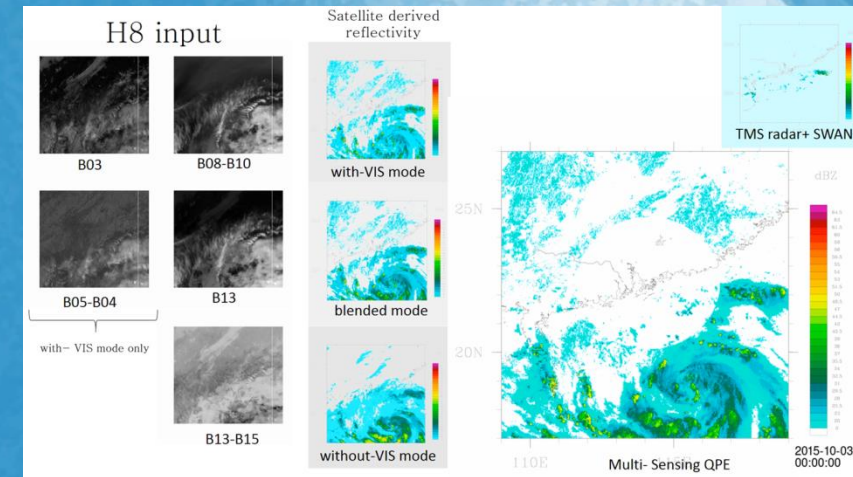


Satellite data applications

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

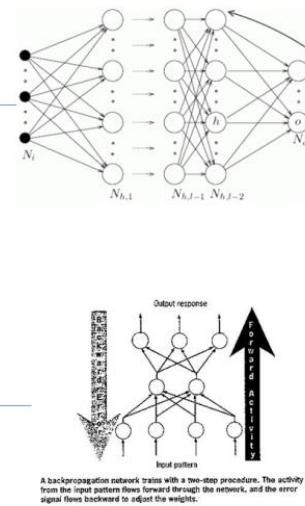
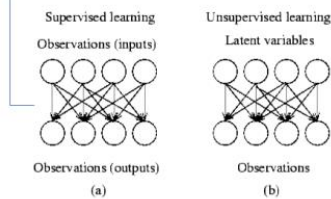


- High Temporal Resolution (10mins per snapshot) of satellite data → alleviate dependent on Extrapolation
- Increase accuracy in deriving motion field and short-range forecast
- Provide Precipitation Observation for other regions
- Ability to provide higher spatial coverage Rainfall Reflectivity Map

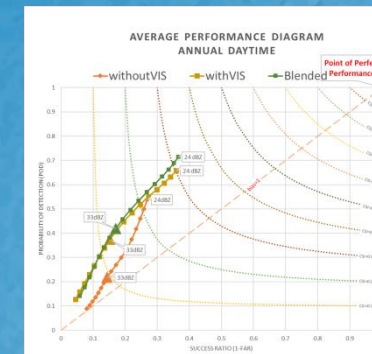


- Features of MLPANN implemented in HKO:

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%

Satellite data applications examples

Satellite Nowcasting of Significant Convection and Tropical Cyclone Rapid Intensification)

Convection Initiation and Rapid Developing Thunderstorm using satellite 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)

Empirical Rules on CI

Probability of Convective Initiation in the next 30min

0	Zero probability to become thunderstorm
1	Very Low probability
2	Low probability
3	Mod probability
4	High probability

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

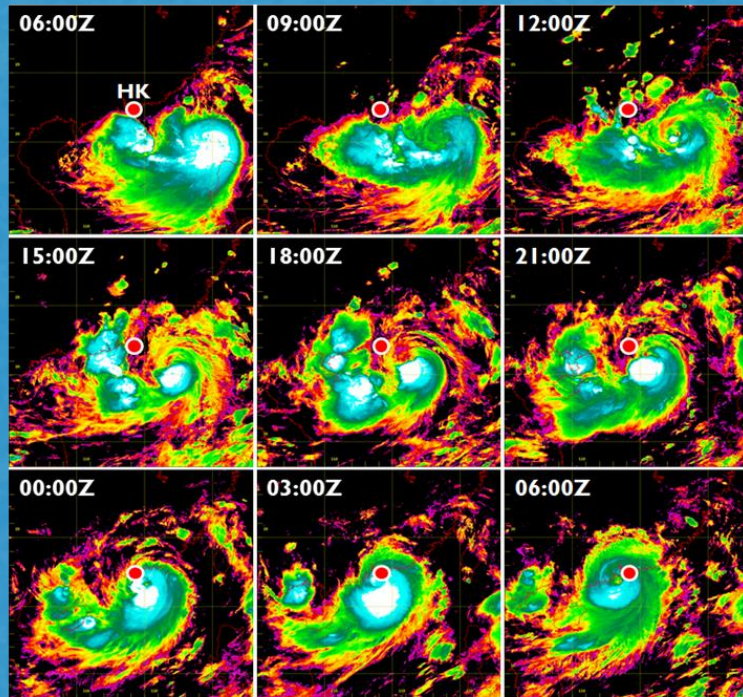
- Analysis to identify intense or rapidly developing convective cloud cells
- Cloud-free pixel ☉Cloudy ☉CI ☉RDT-CW

Satellite data applications examples

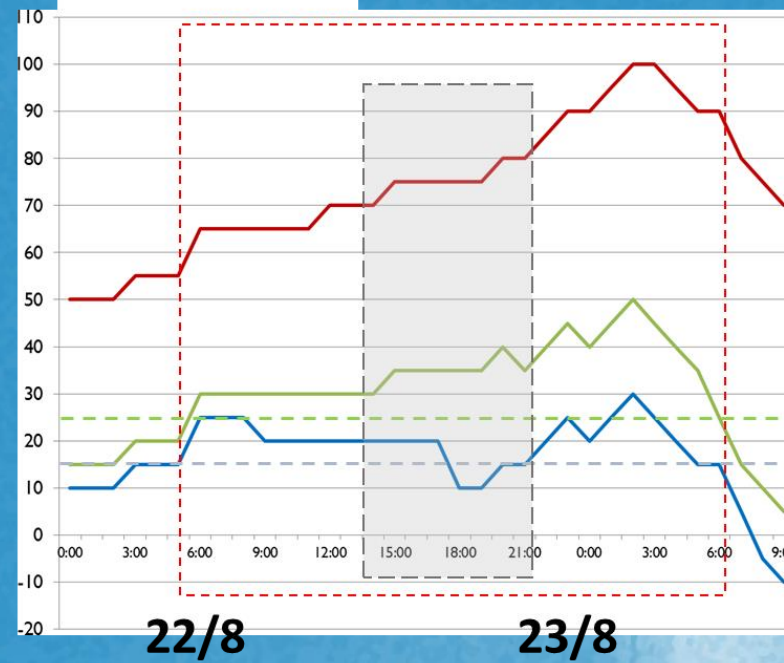
Satellite Nowcasting of Significant Convection and Tropical Cyclone Rapid Intensification) -cont'd

Nowcasting RI of Hato

Hot-Tower Color Enhancement of AHI IR1 channel
22/8

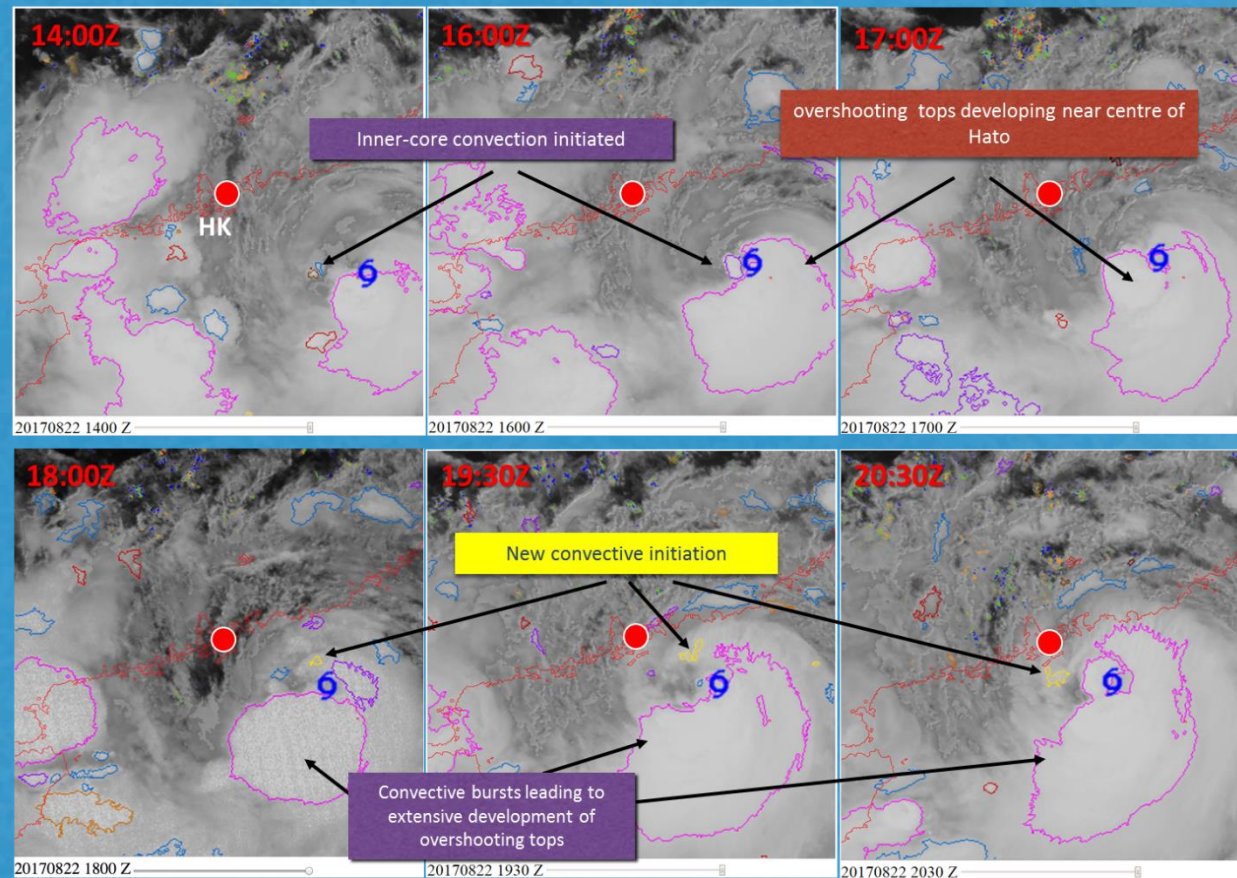


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Satellite data applications examples

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

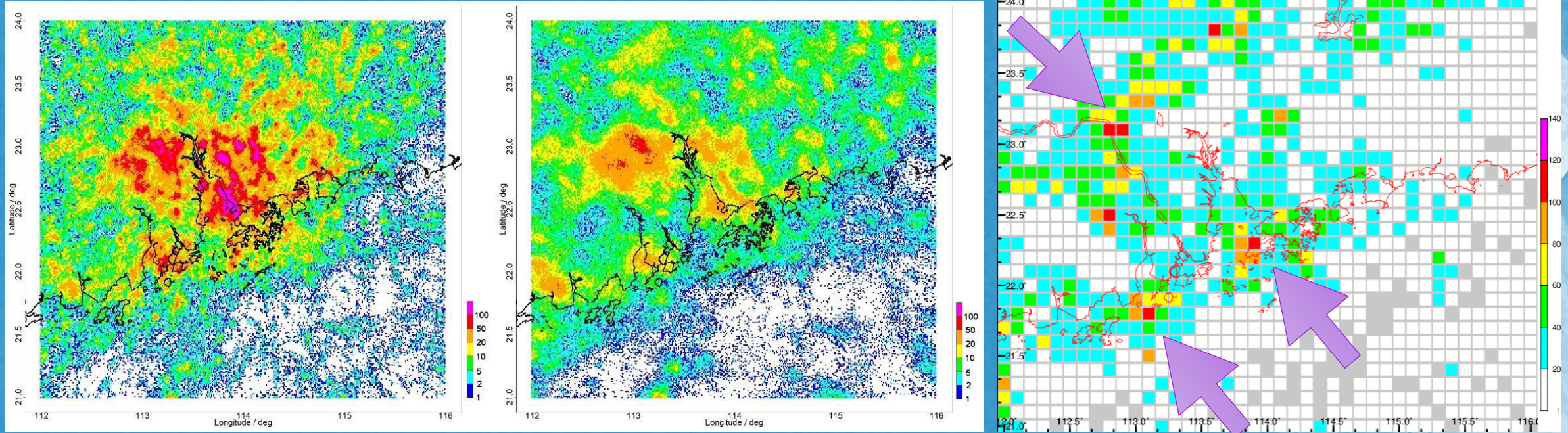


Satellite data applications examples

LLIS

GLD360

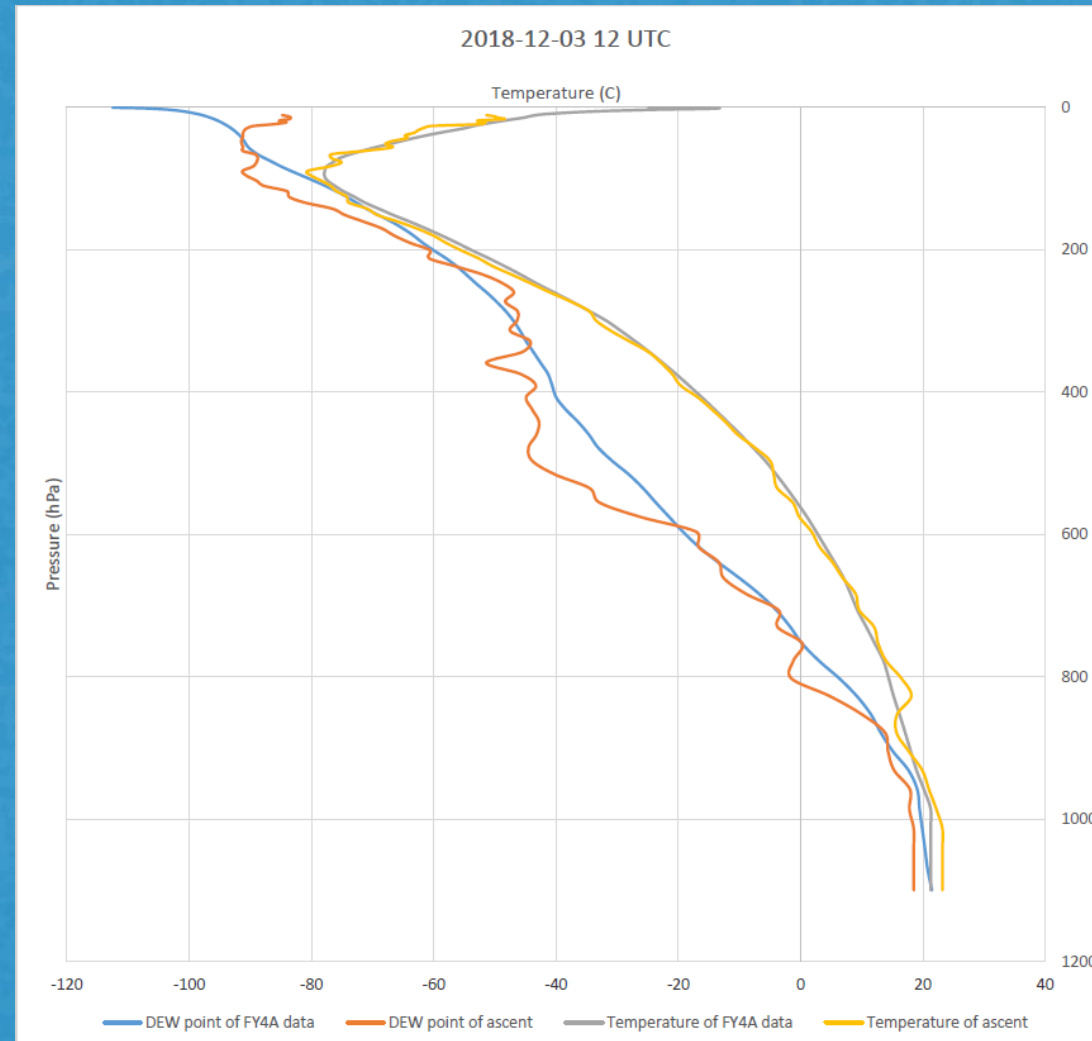
FY4A LMI



- Lightning density maps covering the Pearl River Delta region bounded by 21°N- 24°N, 112°E- 116°E for the month of August 2018 based on LLIS [panel(a)], GLD360 [panel(b)] and FY4A's LMI [panel(c)] data.
- The coloured arrows indicated the suggested displacements of the LMI lightning clusters for better matching with the LLIS and GLD360 lightning clusters patterns.

Satellite data applications examples

Comparison of FY4A GIIRS and radiosonde data at 12 UTC on 3 December 2018



Future Work on Fengyun Satellites Data

- Developments of more applications using FY satellite data for weather monitoring
- Processing FY-3D data, e.g. retrieval of microwave sounding and profile data (with support software package from CMA), for data assimilation and nowcasting
- Reception new generation of FY satellites, e.g. FY4B, and FY3E, to enhance weather monitoring and performance of regional NWP model
- Explore using CMACloud to backup some essential data of CMACast



Thank You!