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 km\(^2\);
      • 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

Blended sandwich image
Hot tower image
Deep convection

FY4 Hybrid true colour images
Data visualization and processing

FY4A RGB images

Dust RGB image
Data visualization and processing

FY3 images

Cloud Top Height

2019/11/09 17:44 UTC

Animation
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

Severe turbulence location
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.hongkongweather.com/hko/conceptual/
understanding_neural_networks/
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

<table>
<thead>
<tr>
<th>Group</th>
<th>CI Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud-top glaciation</td>
<td>IR10.8 Brightness Temperature</td>
</tr>
<tr>
<td>Cloud depth / height</td>
<td>WV6.2-IR10.8</td>
</tr>
<tr>
<td>Cloud depth / height</td>
<td>IR13.4-IR10.8</td>
</tr>
<tr>
<td>Cloud growth</td>
<td>Change rate of IR10.8 Brightness Temperature</td>
</tr>
<tr>
<td>Cloud growth</td>
<td>Change rate of (WV6.2-IR10.8)</td>
</tr>
<tr>
<td>Cloud growth</td>
<td>Change rate of (IR10.8-IR8.7)</td>
</tr>
<tr>
<td>Cloud growth</td>
<td>Change rate of (IR12.0-IR10.8)</td>
</tr>
<tr>
<td>Cloud growth</td>
<td>Change rate of (IR13.4-IR10.8)</td>
</tr>
</tbody>
</table>

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

23/8

<table>
<thead>
<tr>
<th>Hours</th>
<th>RI thresholds for WNP</th>
</tr>
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<tbody>
<tr>
<td>12 hours</td>
<td>+ 15 kt</td>
</tr>
<tr>
<td>24 hours</td>
<td>+ 25 kt</td>
</tr>
</tbody>
</table>
Satellite data applications examples

Satellite Nowcasting of Significant Convection and Tropical Cyclone Rapid Intensification) - cont’d
Satellite data applications examples

- 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!