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Development of NWC SAF/GEO in support of severe weather nowcasting in the Hong Kong Observatory

Wai-kin Wong
Forecast Development Division
(E-mail: wkwong@hko.gov.hk)

NWCSAF CDOP3 Users' Workshop 2020
12 March 2020

WORLD METEOROLOGICAL ORGANIZATION

WMO 臨近預報區域專業氣象中心 RSMC for Nowcasting

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Hong Kong Observatory has been designated by WMO as the RSMC for Nowcasting since June 2018

WMO Designated Global Data-processing and Forecasting System Centres

Updated on 24 August 2018

Legend

- World Meteorological Centres* (9)
- Atmospheric Transport Modelling (10)
- Global Producing Centres for Long-Range Forecasts (13)
- Global Producing Centres for Annual to Decadal Climate Prediction (3)
- RSMCs Geographic (25)
- RSMC Nowcasting (3)
- RSMCs TC (6)
- RSMCs Sand/Dust (2)
- Regional Climate Centres (11)
- RSMCs Nuclear Emergency Response (9)
- RSMCs Non-Nuclear Emergency Response (2)
- RSMCs Volcano watch services for international air navigation (1)
- RSMCs Severe Weather Forecasting (2)
- RSMCs marine meteorological services (24)

* World Meteorological Centres are also Global Producing Centres for a) Deterministic Numerical Weather Prediction, b) Ensemble Numerical Weather Prediction, and c) Long-Range Forecasts.

DESIGNATIONS USED
The depiction and use of boundaries, geographic names and related data shown on maps and included in lists, tables, documents, and databases on this web site are not warranted to be error free nor do they necessarily imply official endorsement or acceptance by the WMO.

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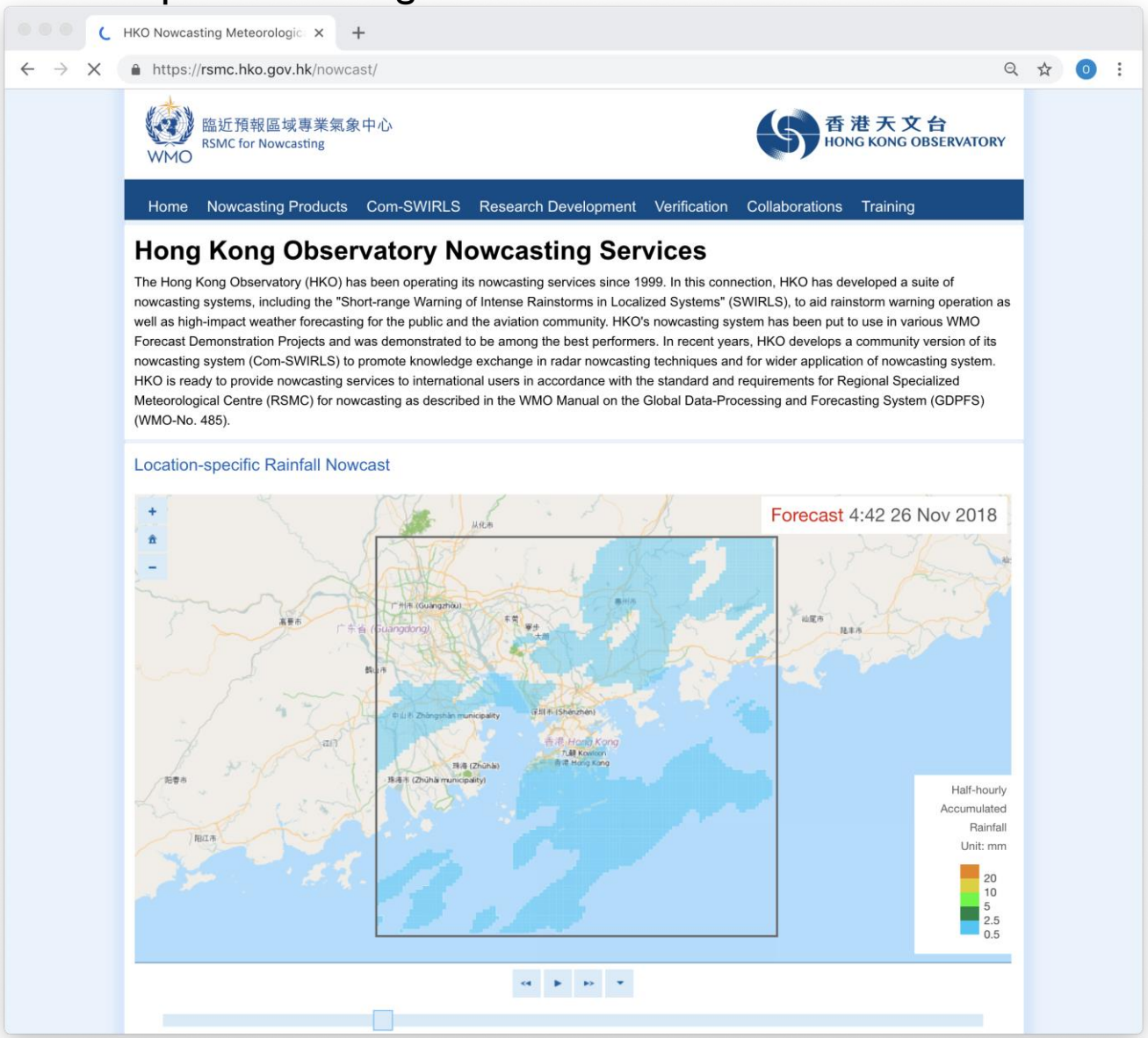
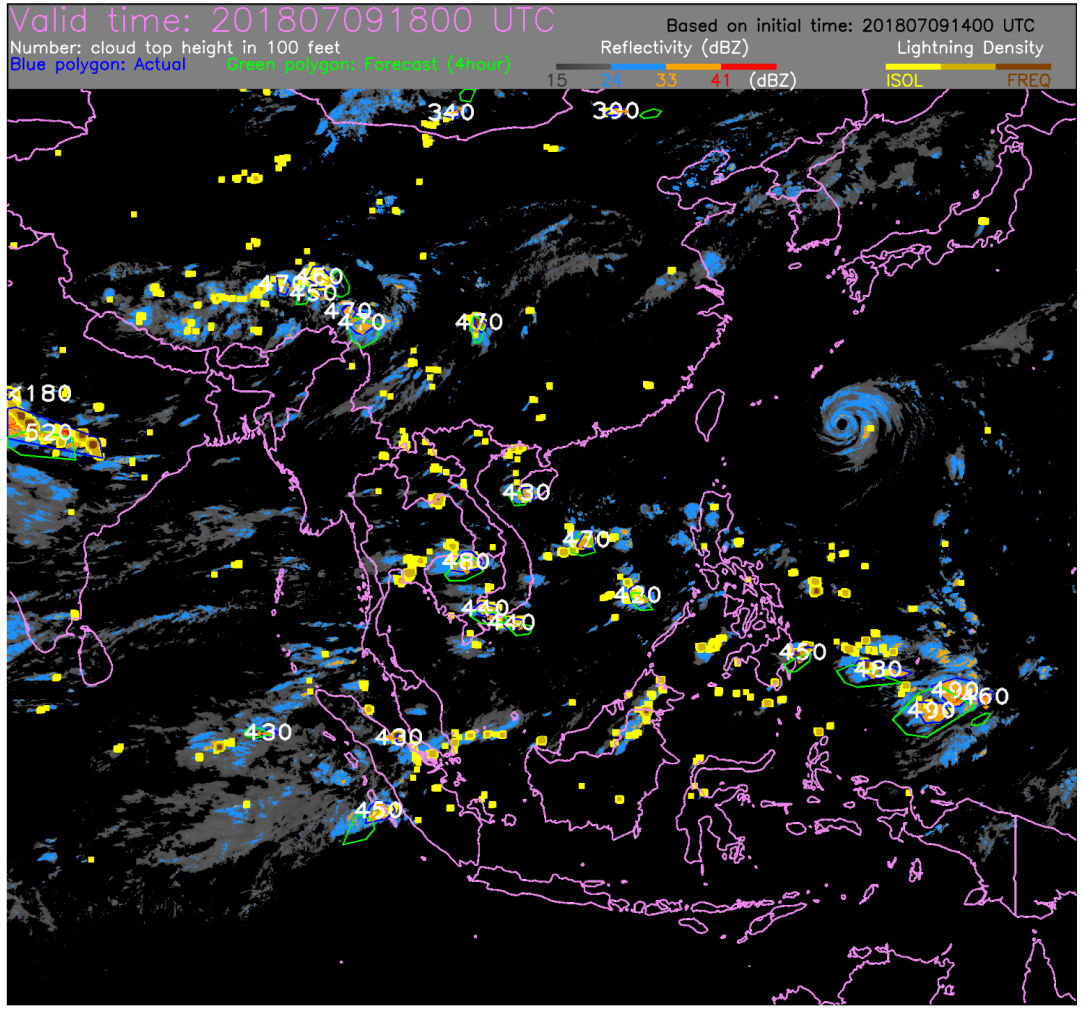
HKO's RSMC for Nowcasting website

https://rsmc.hko.gov.hk/nowcast/



Rainfall and significant convection nowcast products based on HKO's nowcasting systems using radar and Himawari-8 satellite are provided to users on RSMC website

Significant Convection Nowcast over East Asia



Significant convection nowcast at the fourth hour (in UTC) using retrieved reflectivity (blue ≥24 dBZ, orange ≥33 dBZ and red ≥41 dBZ) from Himawari-8 data and updated every 10 minutes. Lightning counts are marked in yellow (sparse) to brown (dense) with green polygons on areas with high reflectivity or dense lightning.

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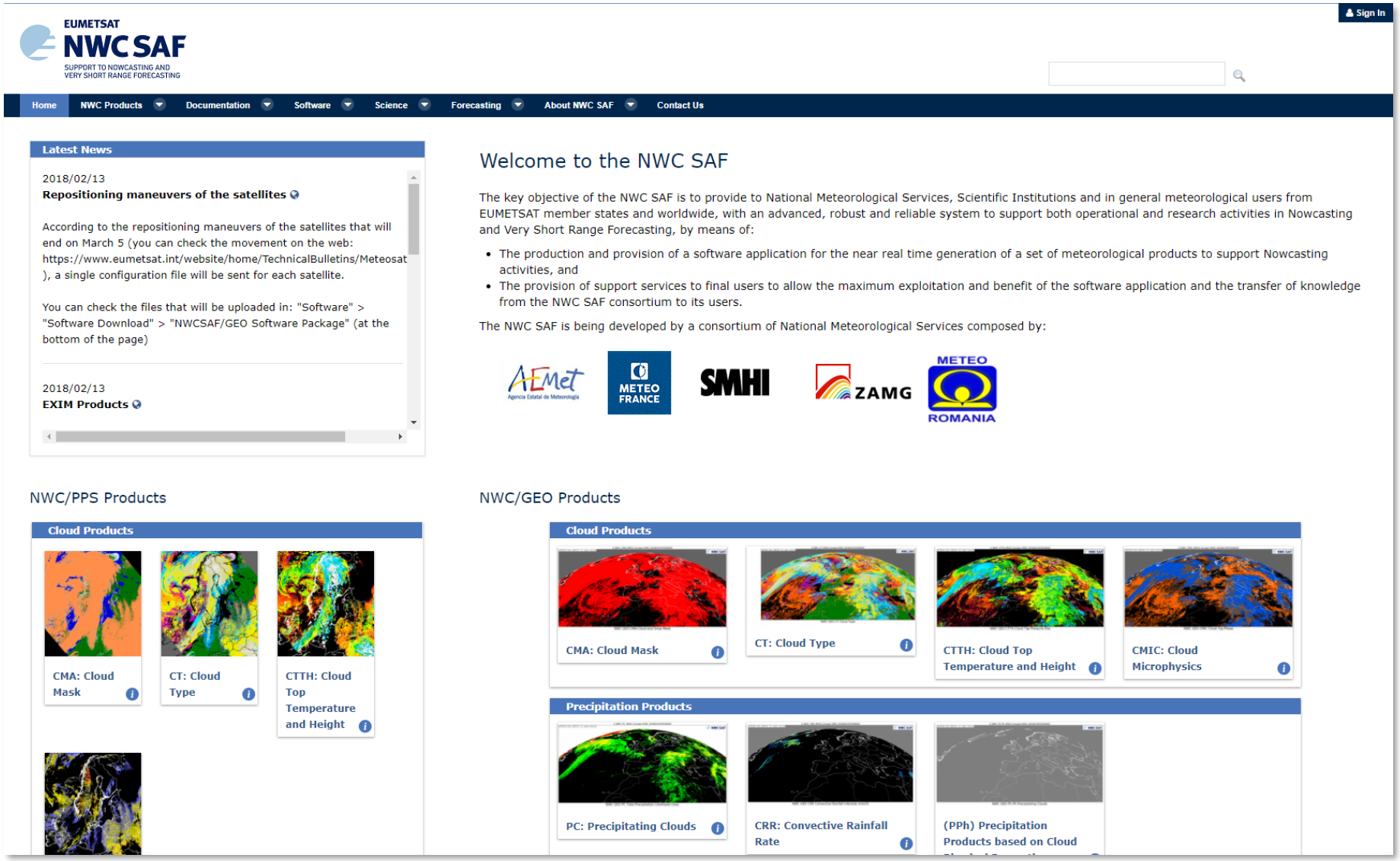
Advanced satellite nowcasting

HKO commenced R&D activities on adapting NWCSAF since 2017 to enhance nowcasting techniques and application of new generation satellite data (Himawari-8/9 and FengYun 4) in support of collaborations with NHMSs, aviation weather services in SE Asia



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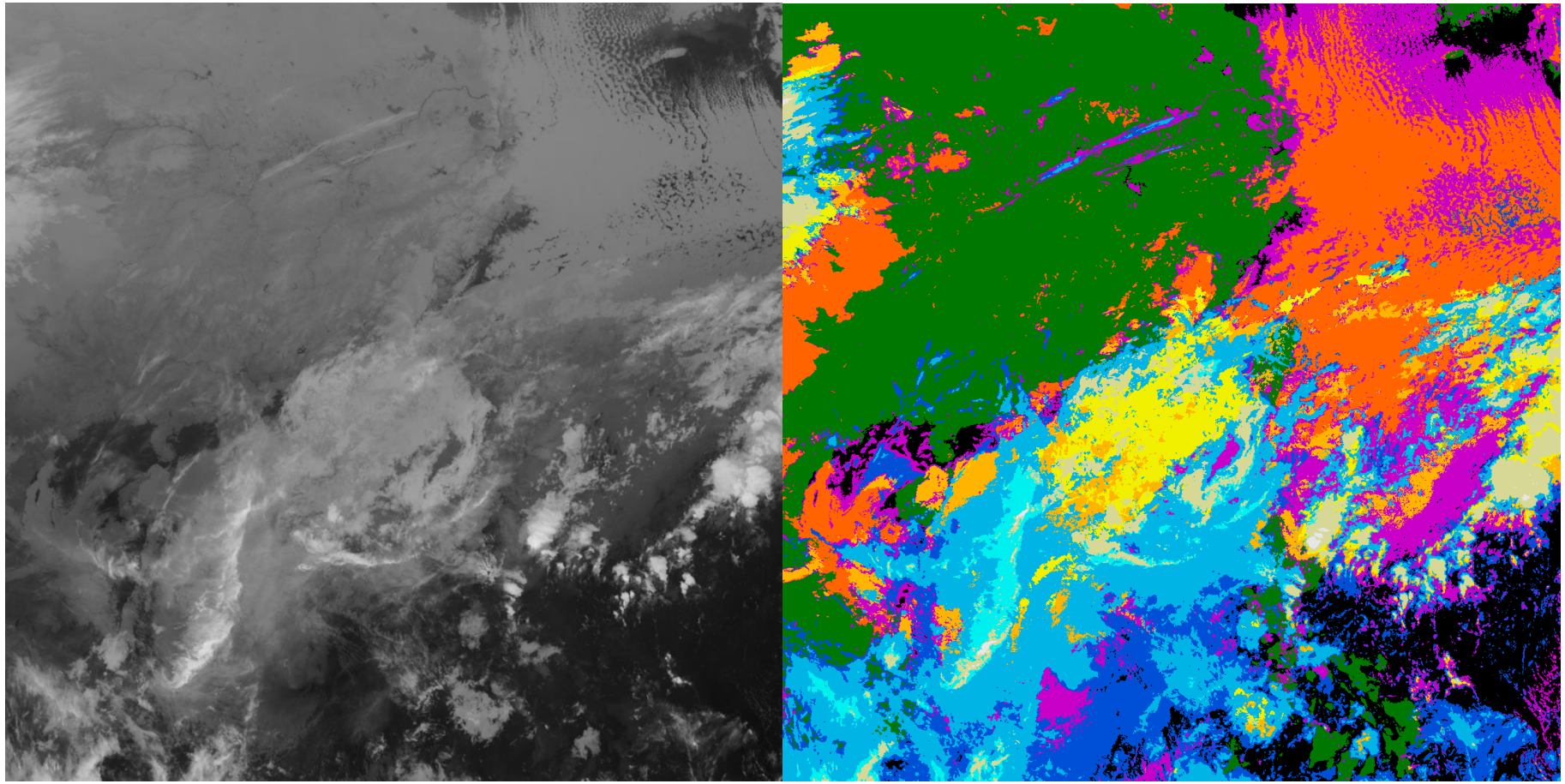
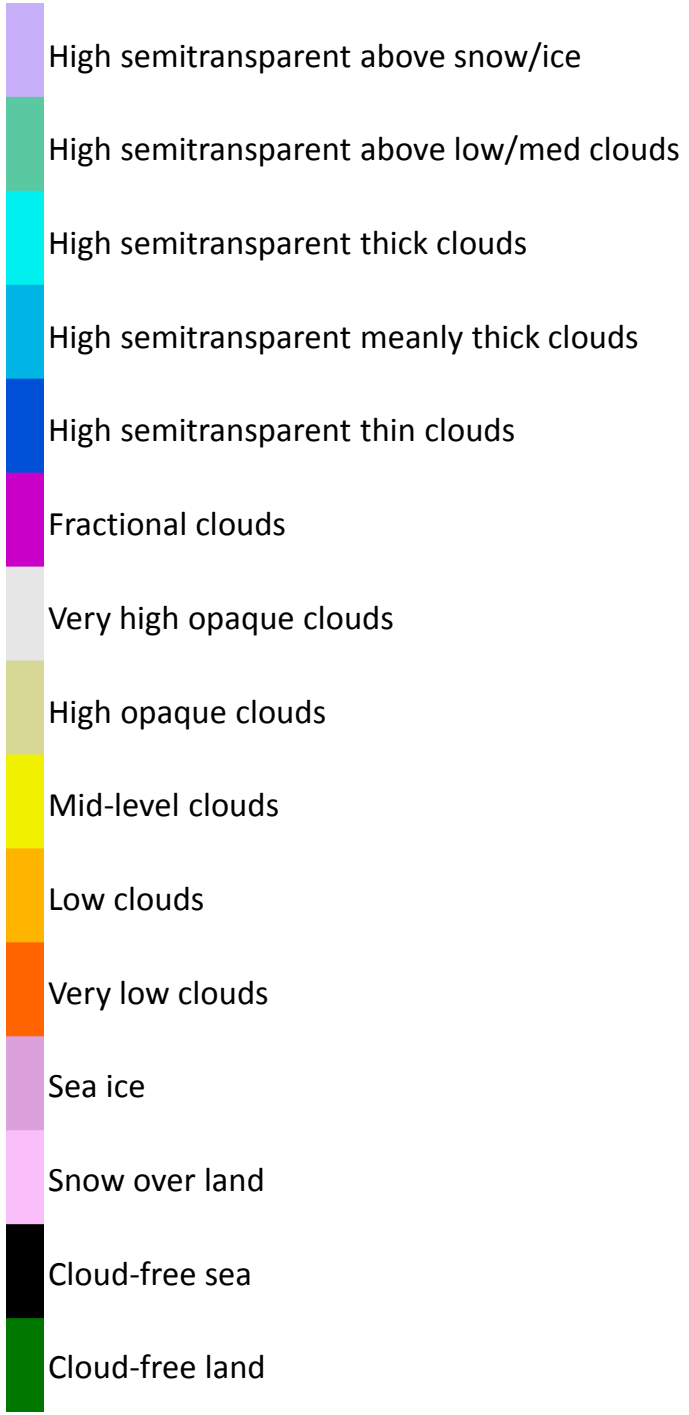
Example: 2016-12-27 18:30Z





Good performance both in daytime and nighttime after tuning the threshold tables.

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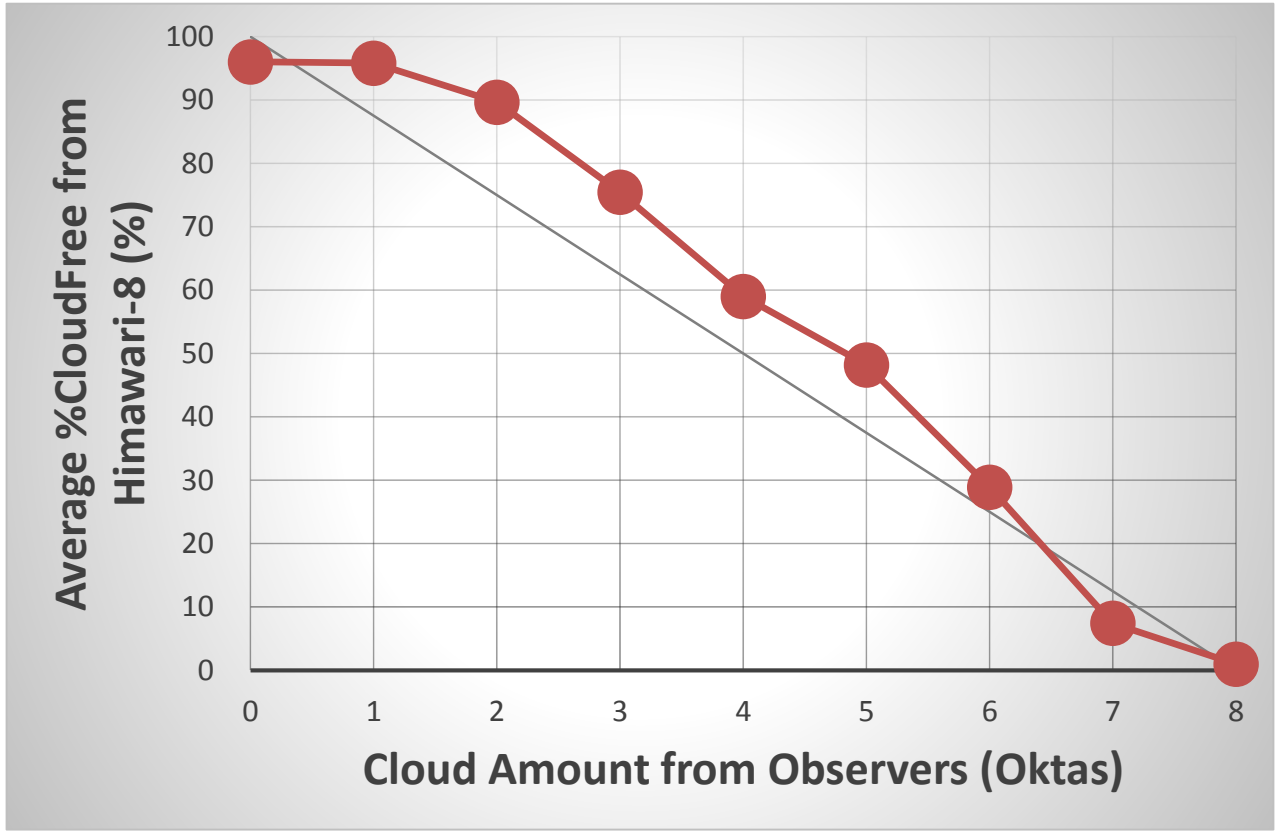
Verification of cloud amount from NWC cloud products

Himawari-8 % of "CloudFree" grid and Observed Cloud Amount

- Data period: ~ 1 years of hourly observed cloud amount at HKO

Cloud Amount from Observers	Average %CloudFree from Himawari-8
0 oktas	96.03%
1 okta	95.82%
2 oktas	89.65%
3 oktas	75.44%
4 oktas	59.00%
5 oktas	48.19%
6 oktas	28.91%
7 oktas	7.44%
8 oktas	1.00%



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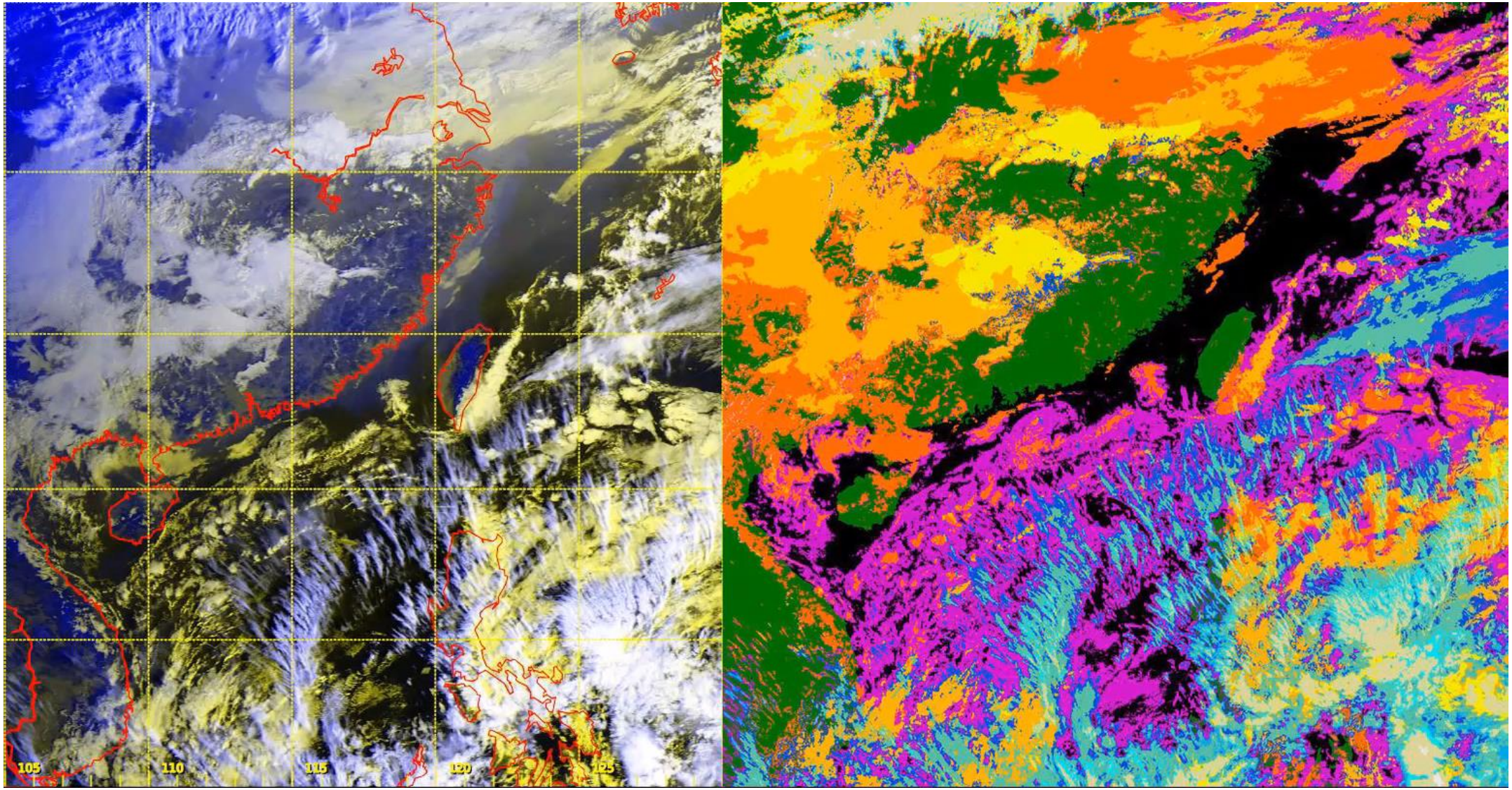
Cloud Type loop from 2017-02-17 00:00Z to 2017-02-18 23:50Z

Captured very well the Kelvin wave associated with the easterly airstream along the coast of southeastern China that travelled for thousands of kilometers!



- High semitransparent above snow/ice
- High semitransparent above low/med clouds
- High semitransparent thick clouds
- High semitransparent meanly thick clouds
- High semitransparent thin clouds
- Fractional clouds
- Very high opaque clouds
- High opaque clouds
- Mid-level clouds
- Low clouds
- Very low clouds
- Sea ice
- Snow over land
- Cloud-free sea
- Cloud-free land

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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)

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

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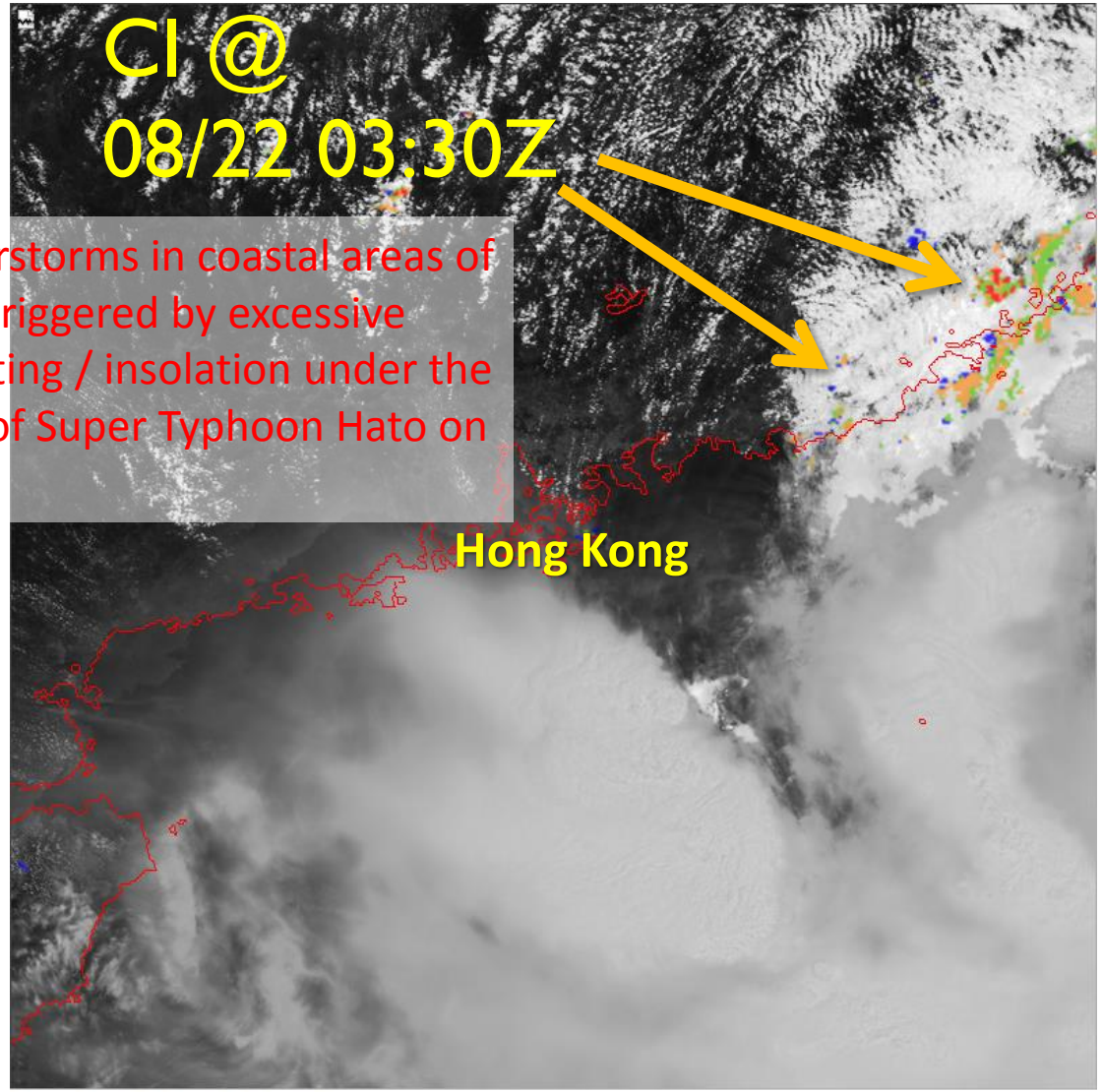
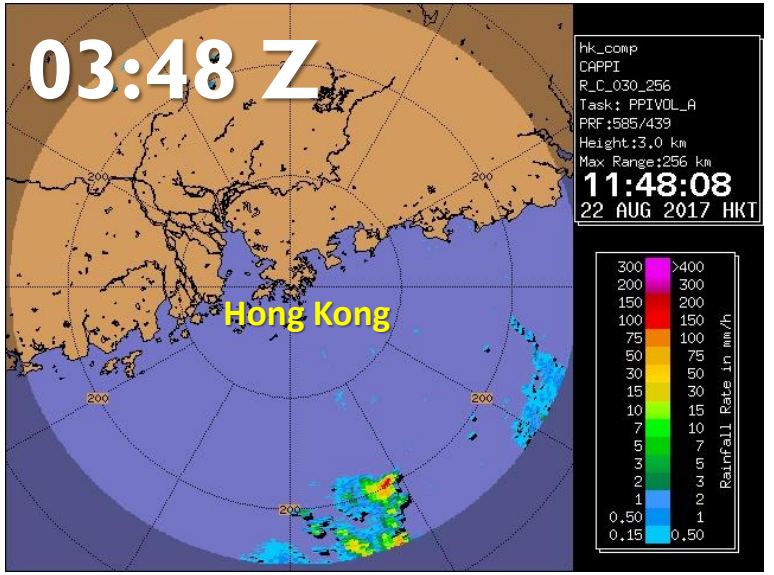
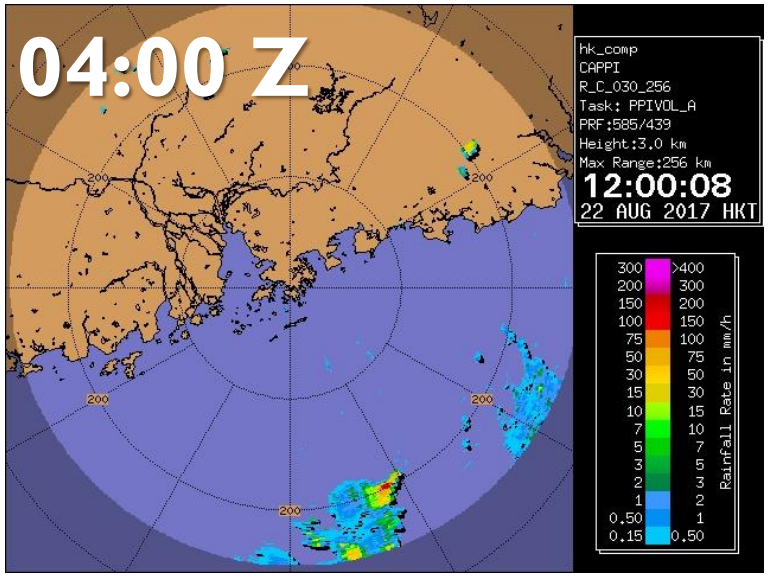
Convective Initiation

Heat thunderstorms in coastal areas of Guangdong triggered by excessive daytime heating / insolation under the subsistence of Super Typhoon Hato on 22 Aug 2017







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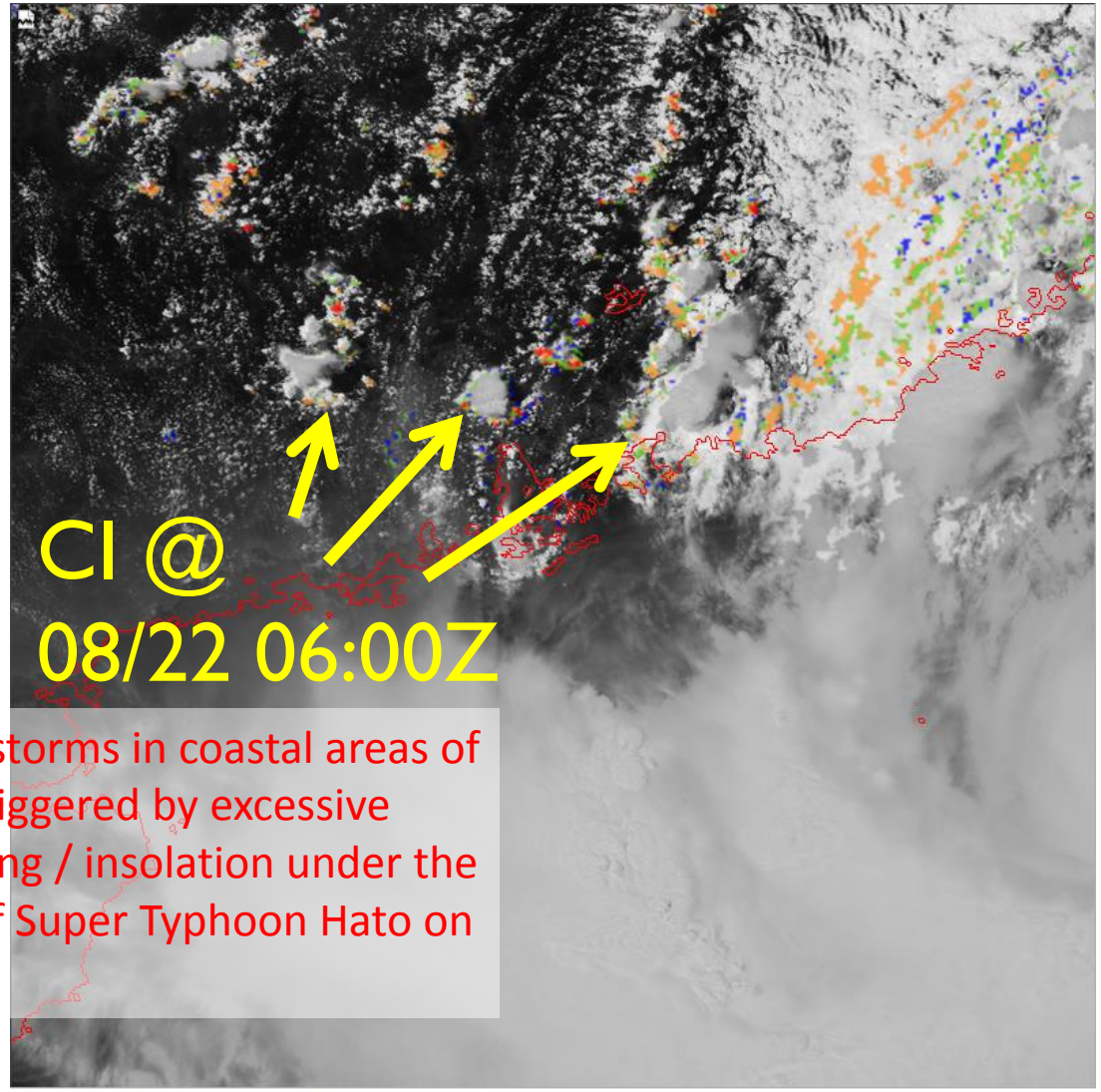
Convective Initiation



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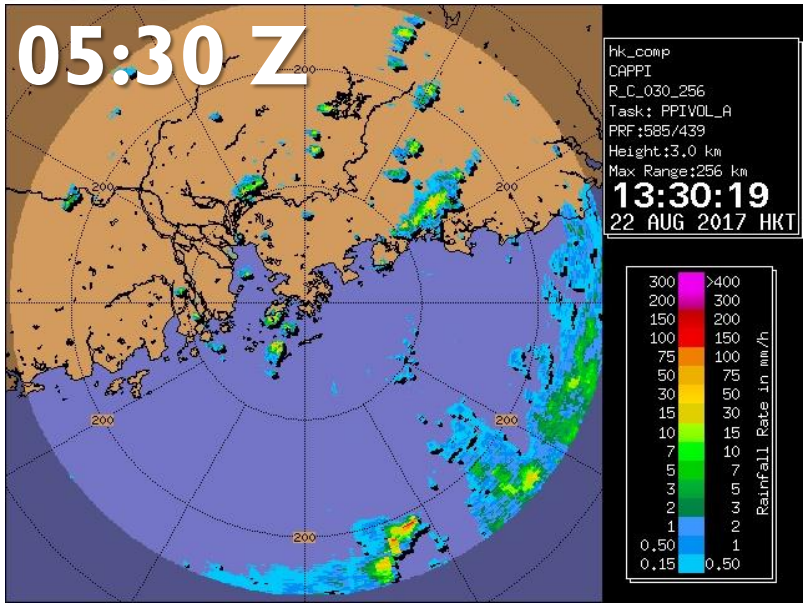

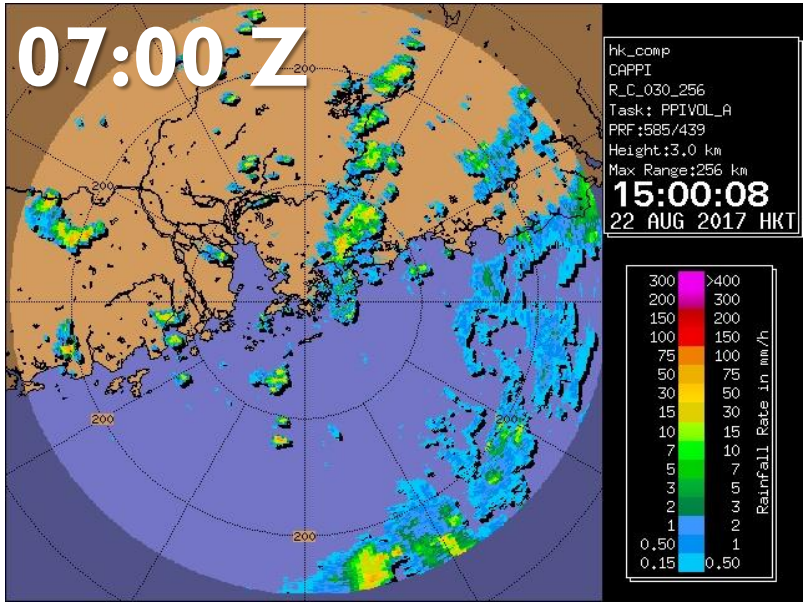

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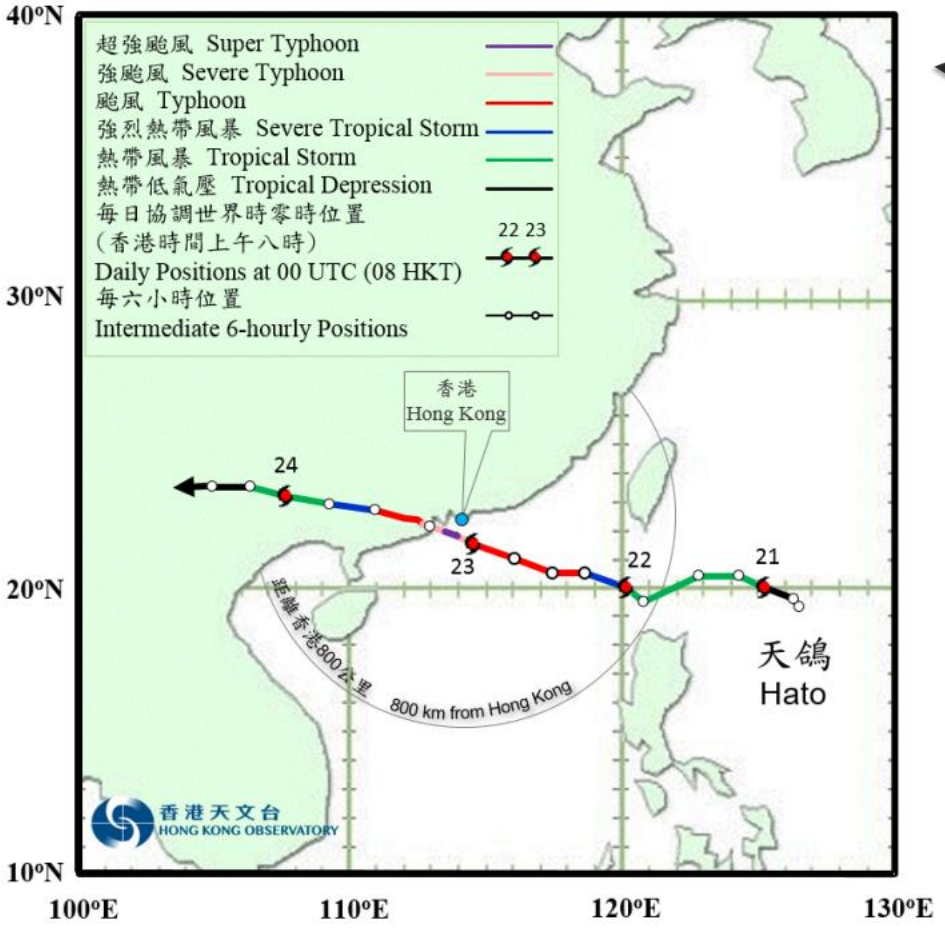
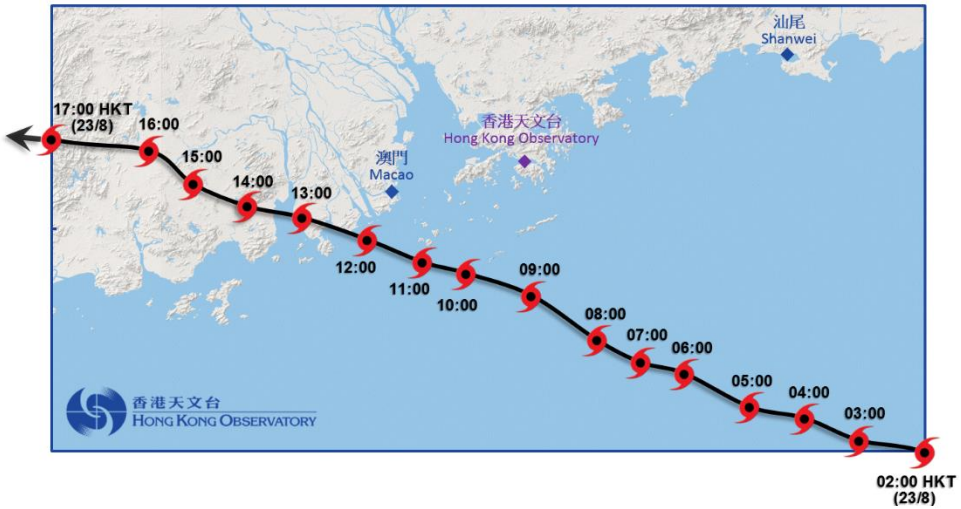
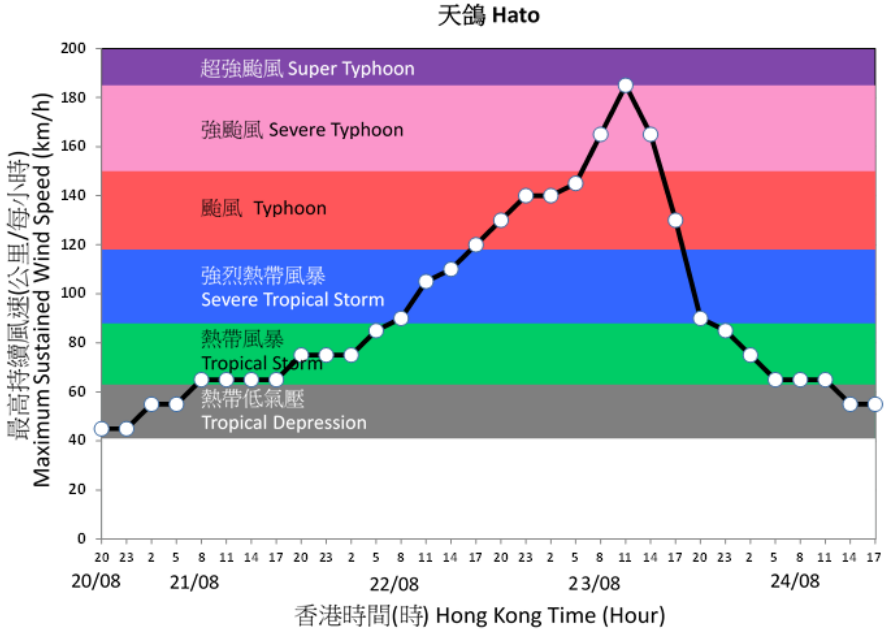
Super Typhoon Hato (1713)

20-24 August 2017







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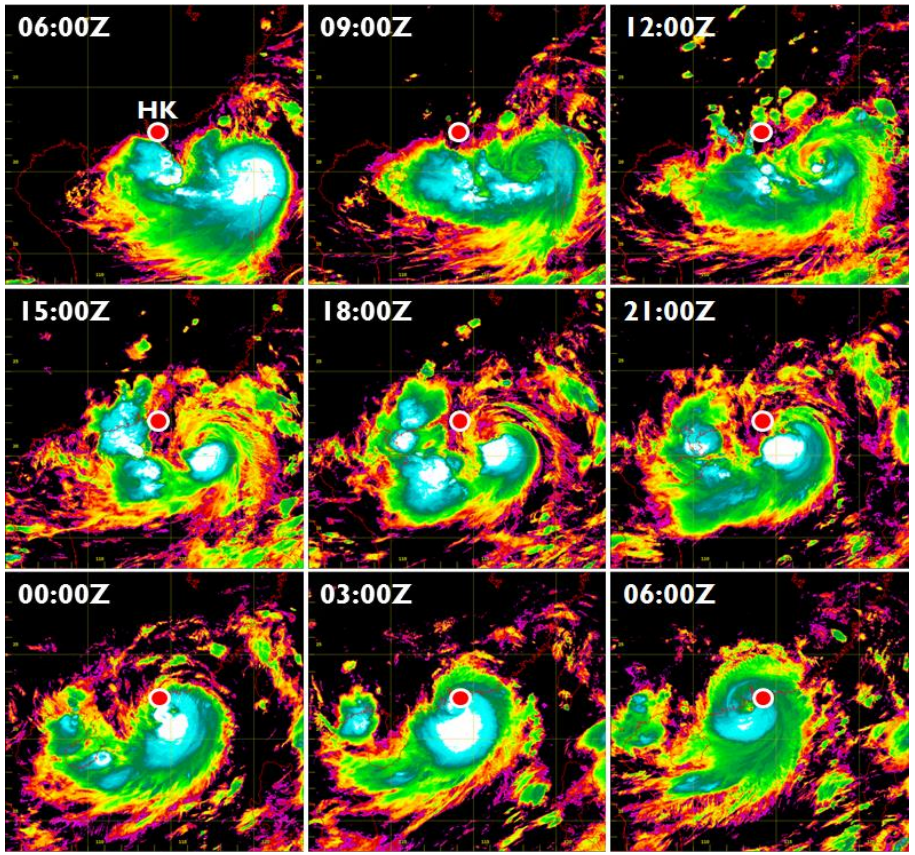
Nowcasting RI of Hato from Himawari-8 data

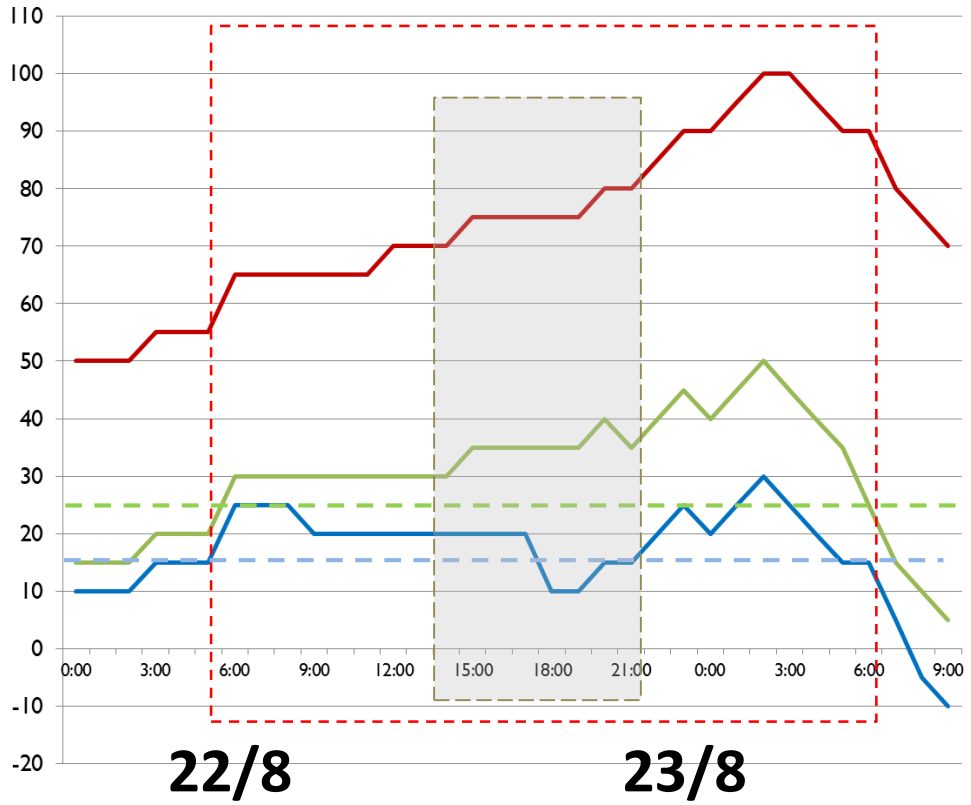
22/8

Hot-Tower Color Enhancement of AHI IR1 channel



23/8

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



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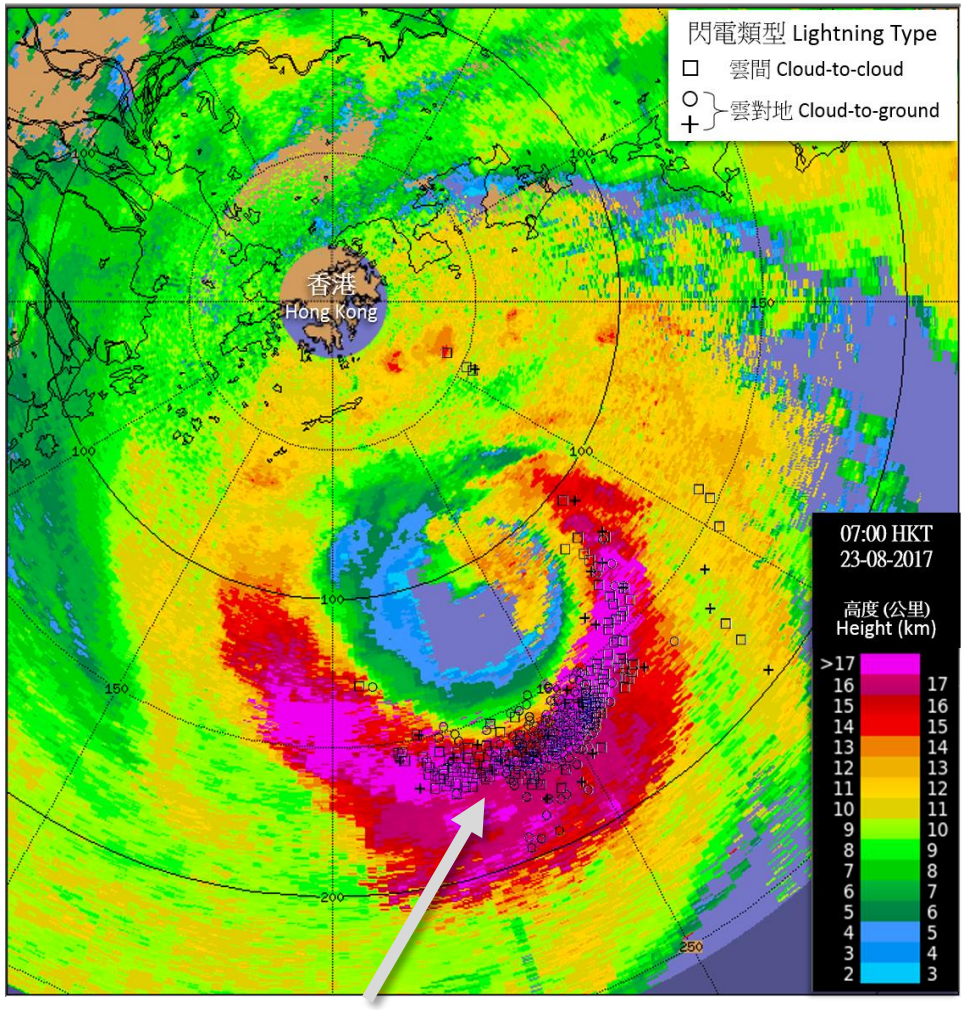
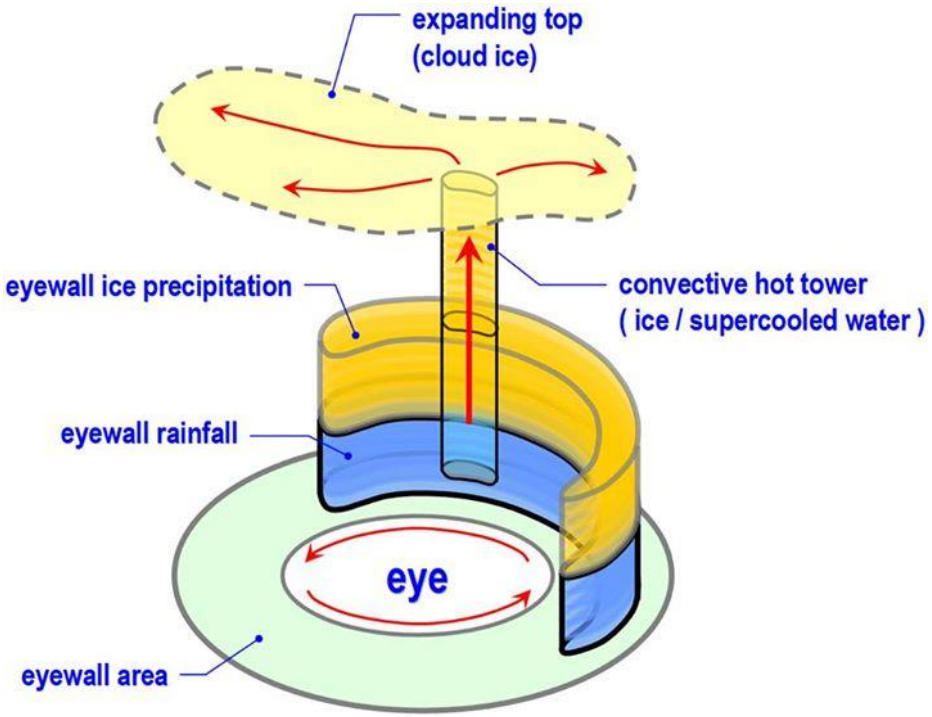
Rapid intensification of Super Typhoon Hato



Past 30-min lightning overlaid on radar echo top at 7:00 HKT 23 Aug



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

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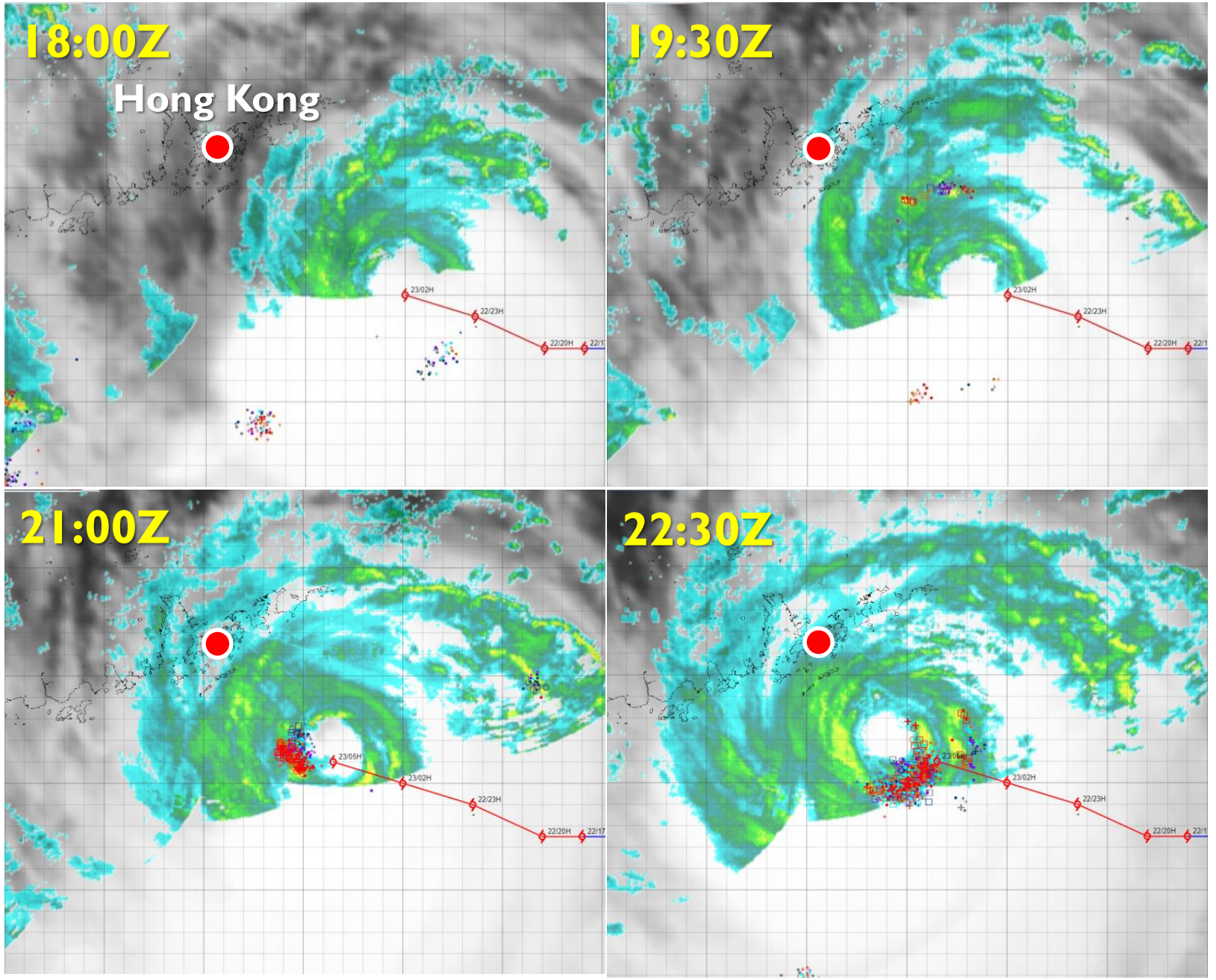

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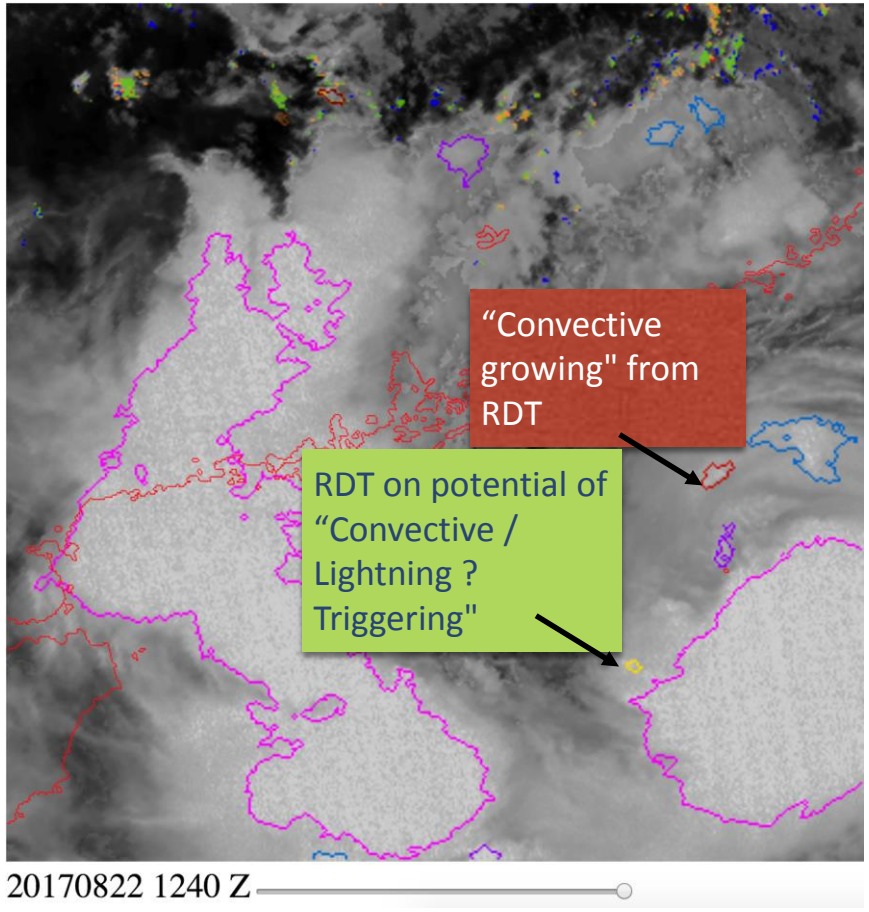
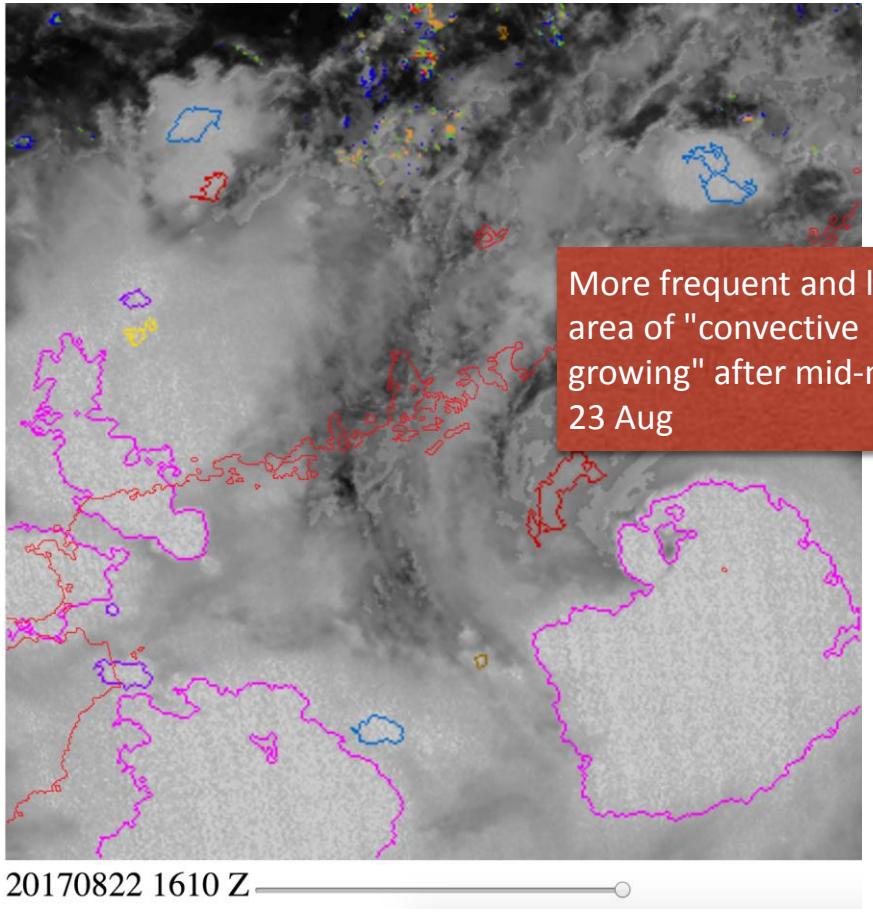
12:40 UTC 22 August 2017



16:10 UTC 23 August 2017



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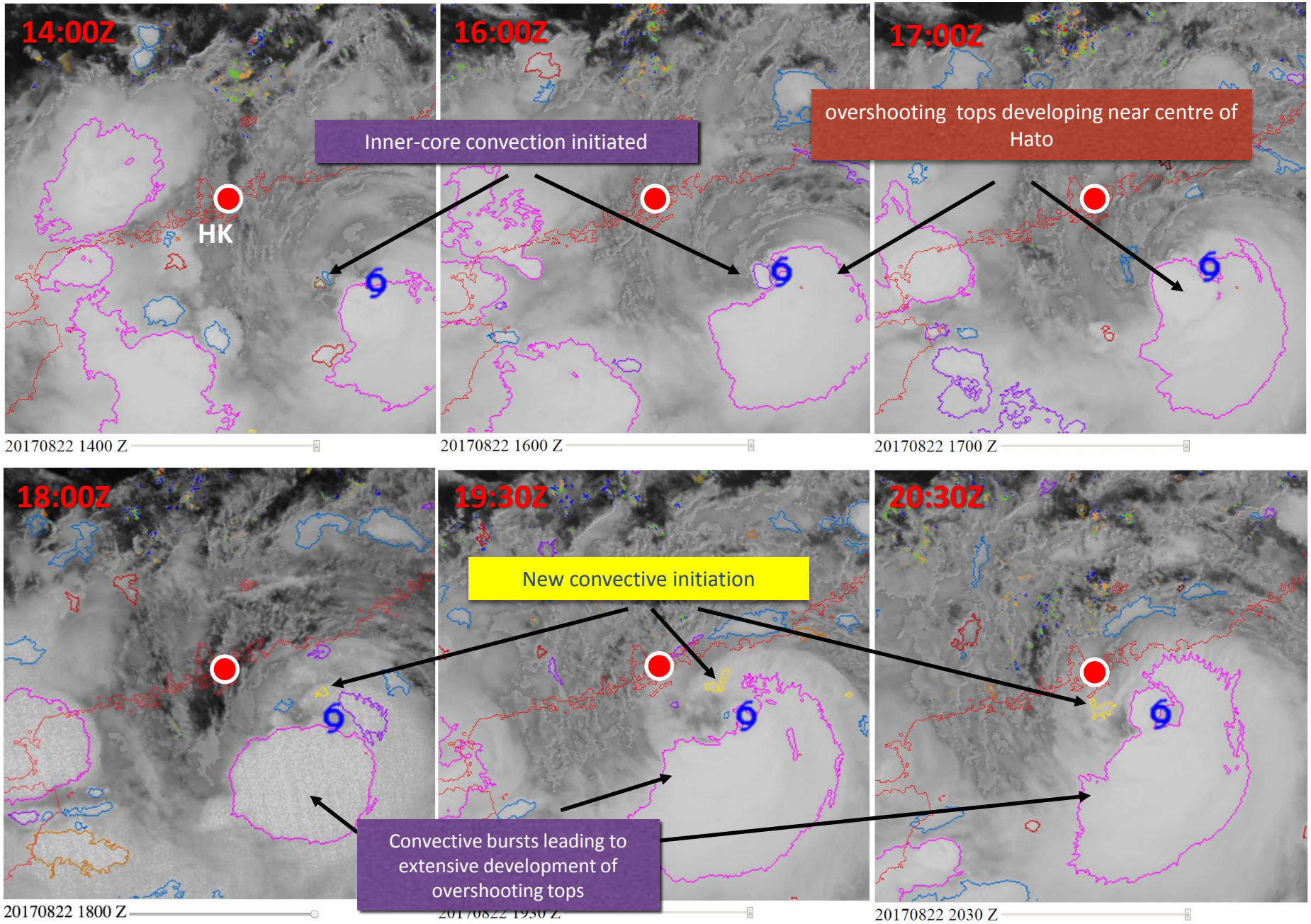

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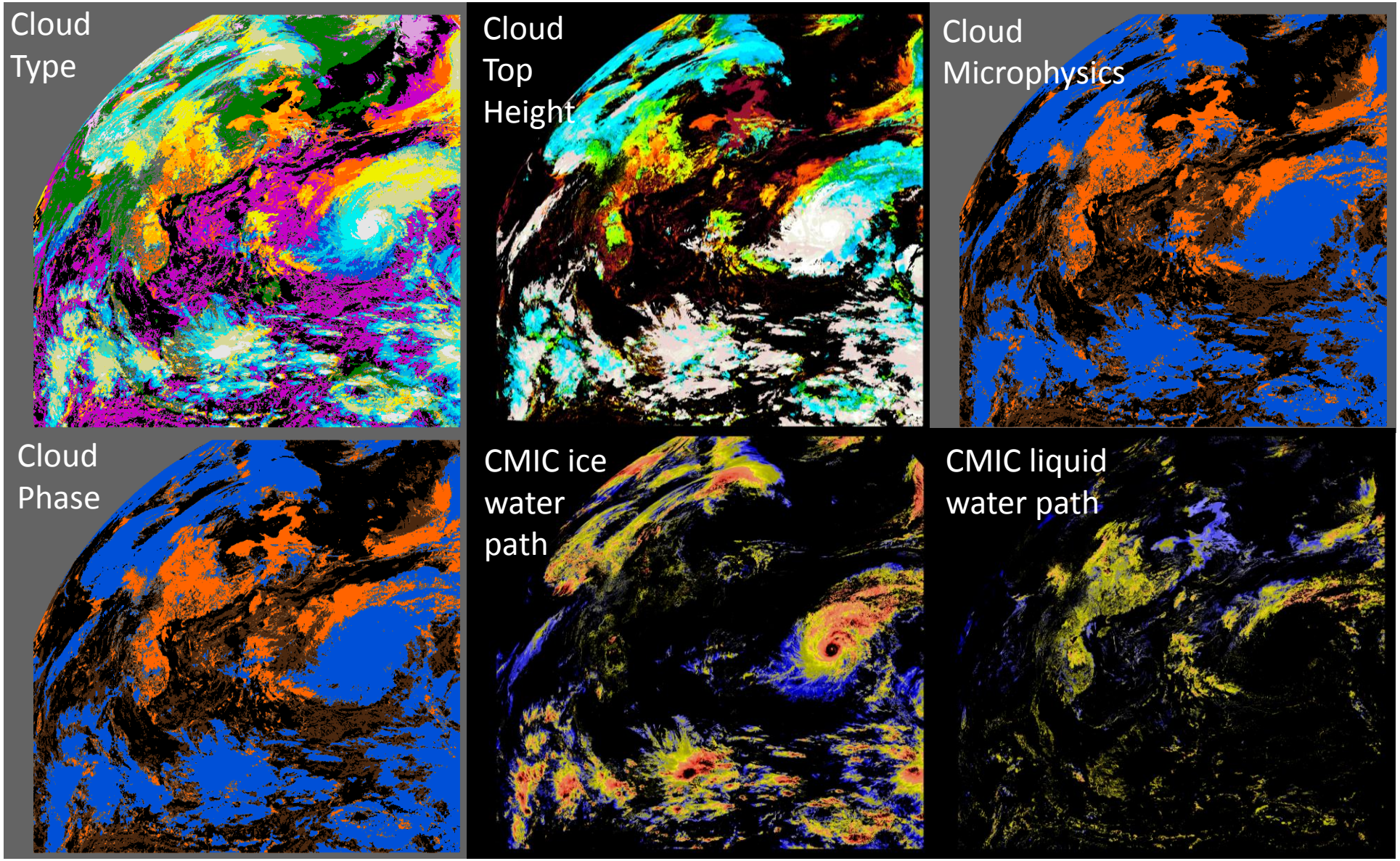
Real-time NWC SAF over East Asia region based on GEO-v2018

20180330 06:00Z



Potential application of the cloud microphysics product on the determination of precipitation rate and storm growth and development being explored.

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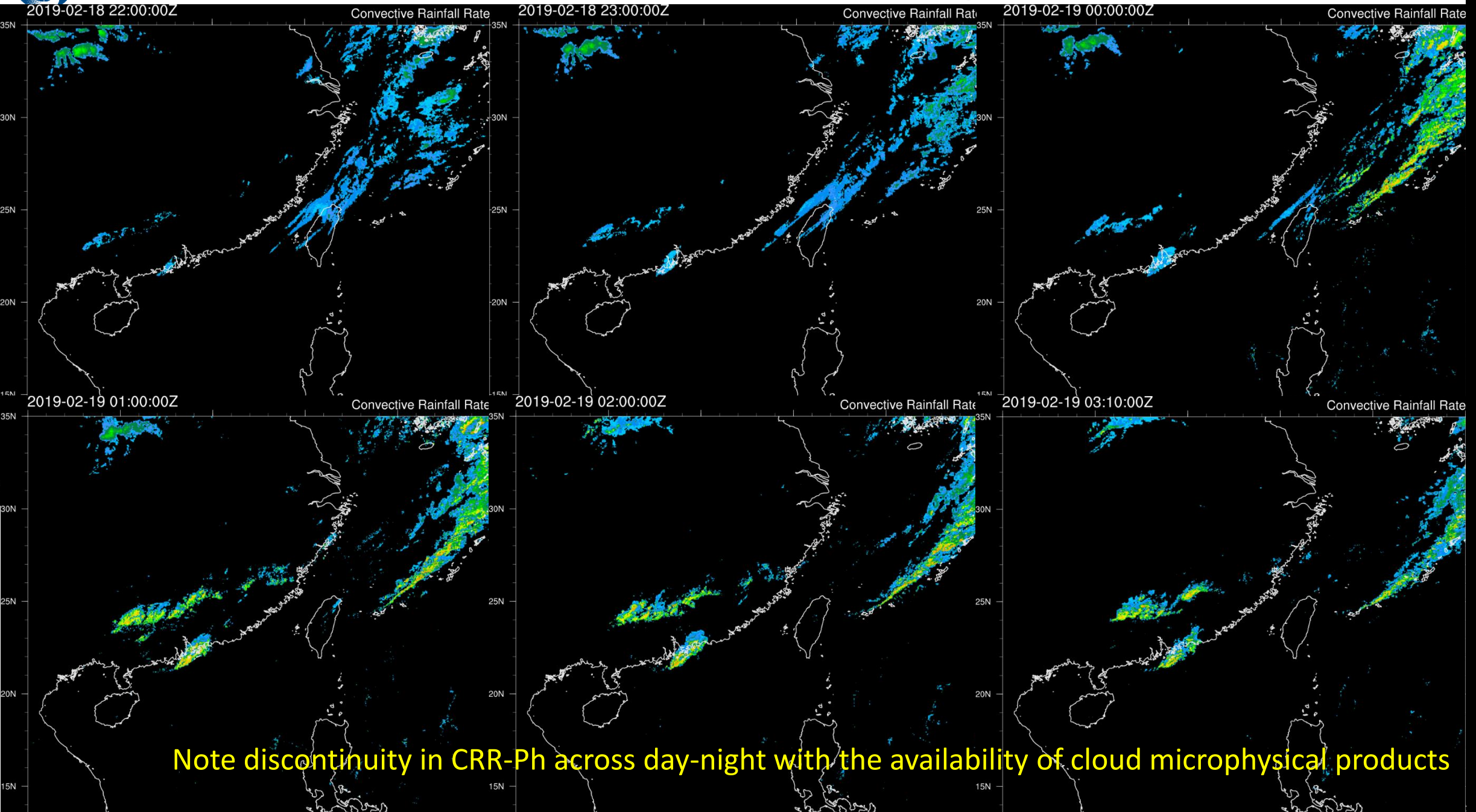
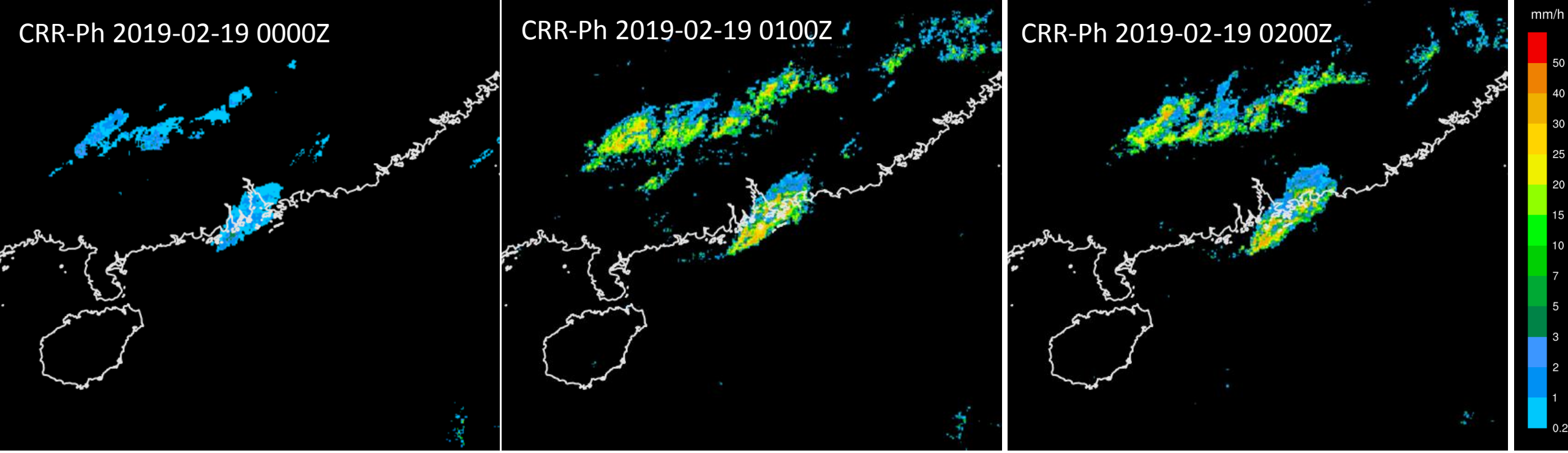
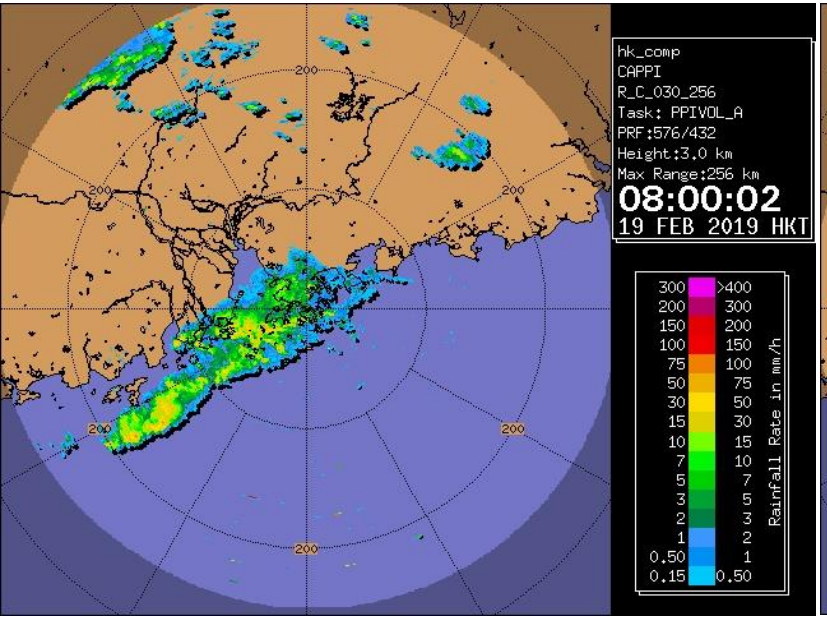
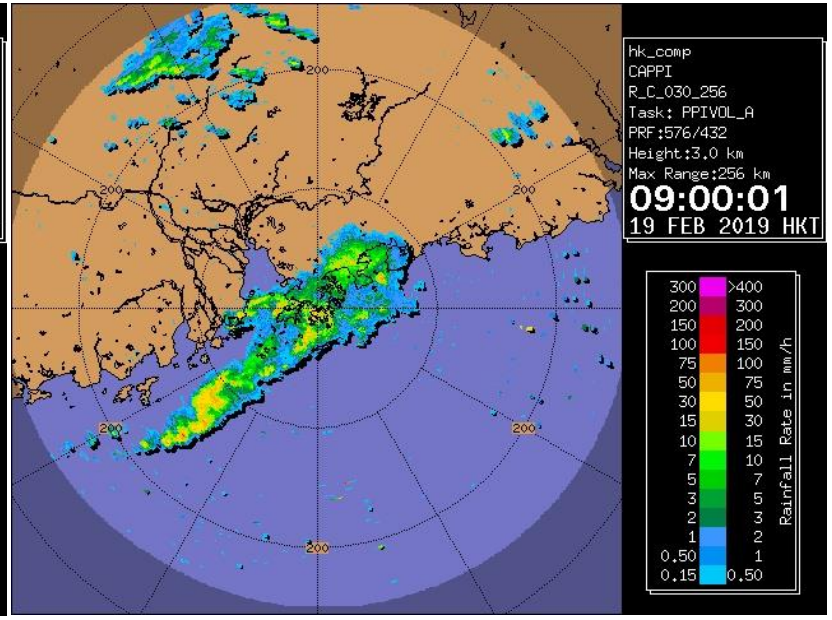
Convective Rainfall Rate (CRR-Ph)



Note discontinuity in CRR-Ph across day-night with the availability of cloud microphysical products


CRR-Ph 2019-02-19 0000Z
CRR-Ph 2019-02-19 0100Z
CRR-Ph 2019-02-19 0200Z
mm/h
50
40
30
25
20
15
10
7
5
3
2
1
0.2


hk_comp
CAPPI
R_C_030_256
Task: PPIVOL_A
PRF:576/432
Height:3.0 km
Max Range:256 km
08:00:02
19 FEB 2019 HKT
Rainfall Rate in mm/h


hk_comp
CAPPI
R_C_030_256
Task: PPIVOL_A
PRF:576/432
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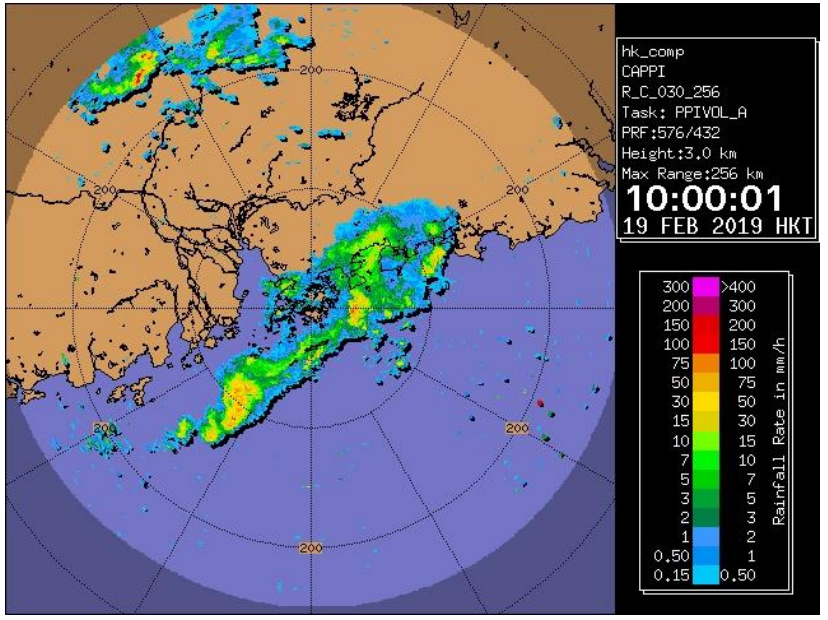
Max Range:256 km
09:00:01
19 FEB 2019 HKT
Rainfall Rate in mm/h


hk_comp
CAPPI
R_C_030_256
Task: PPIVOL_A
PRF:576/432
Height:3.0 km
Max Range:256 km
10:00:01
19 FEB 2019 HKT
Rainfall Rate in mm/h

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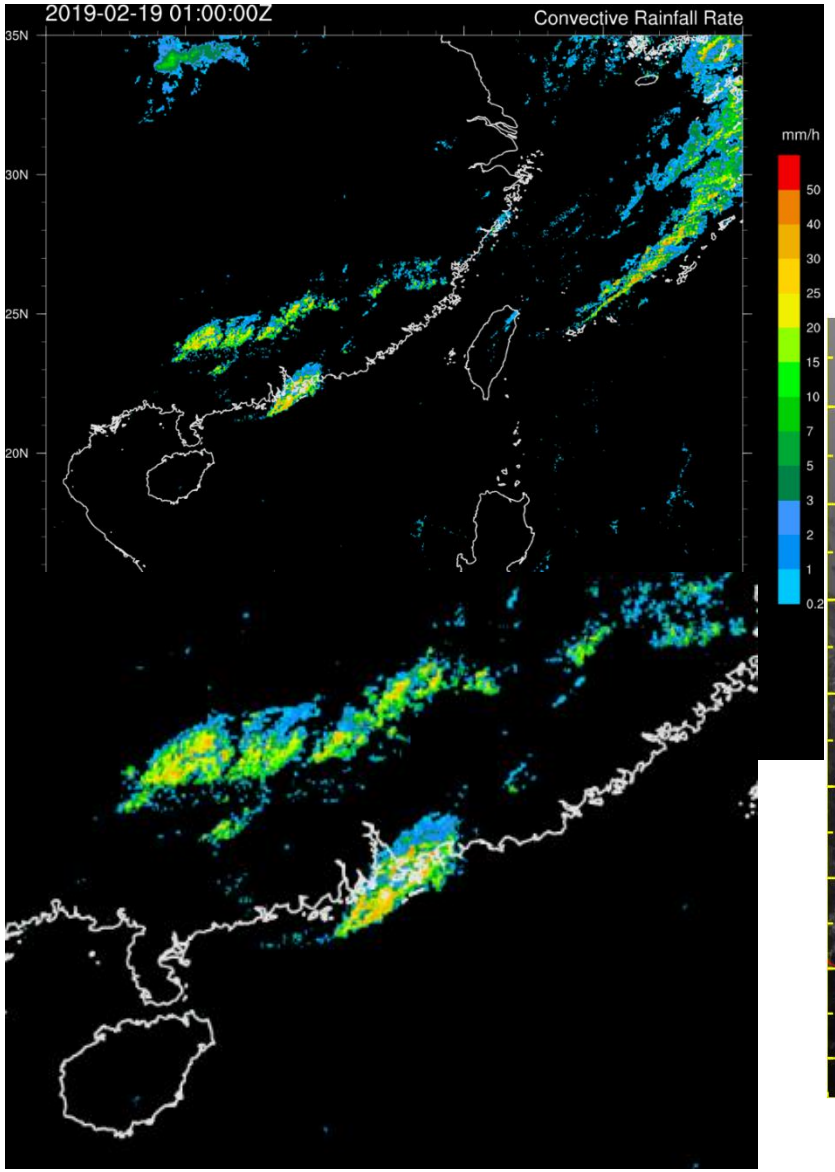
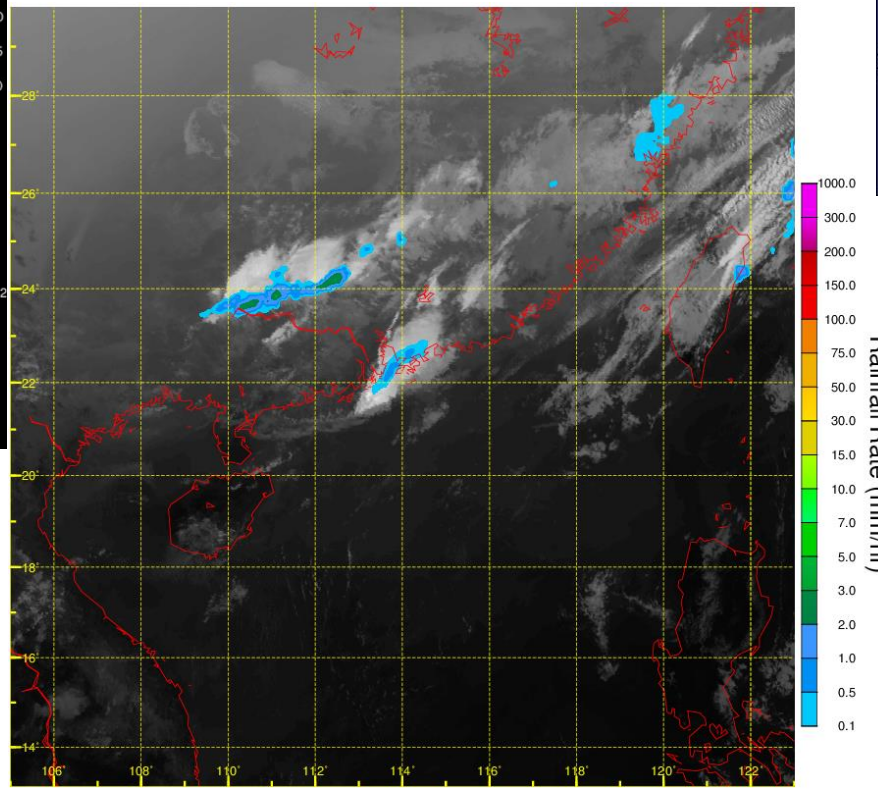
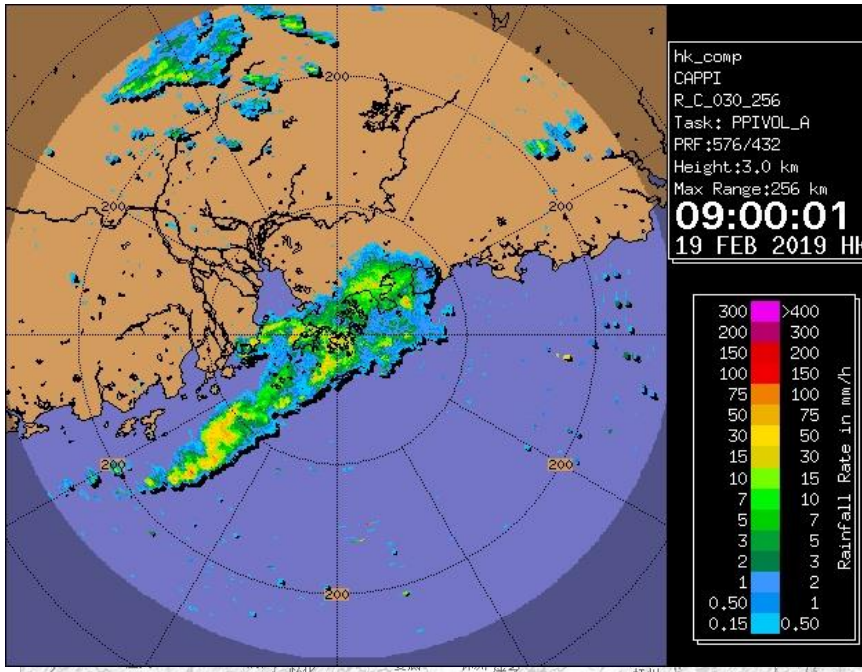
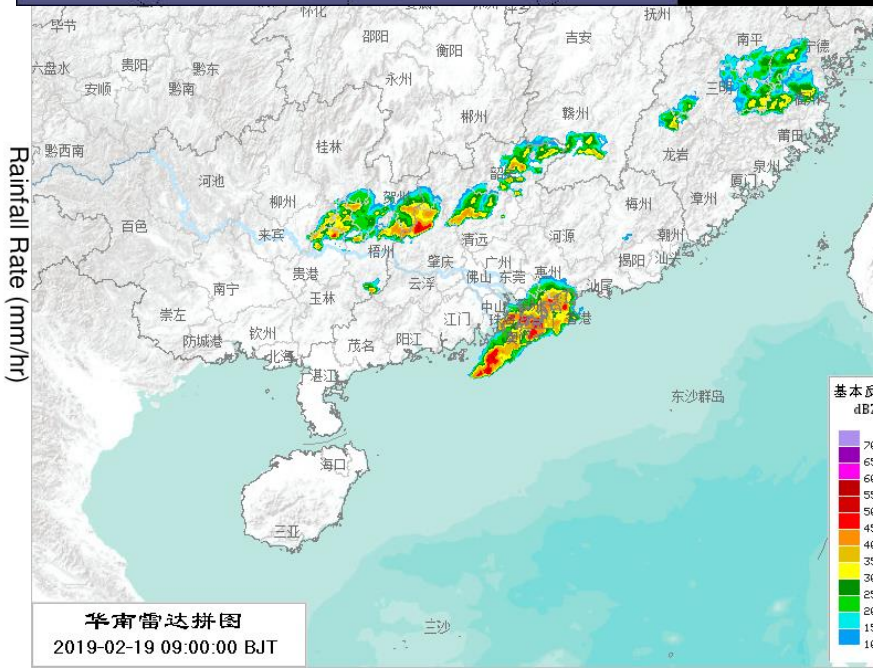
CRR-Ph vs QPE (GPM+IR) and radar



QPE (JAXA)







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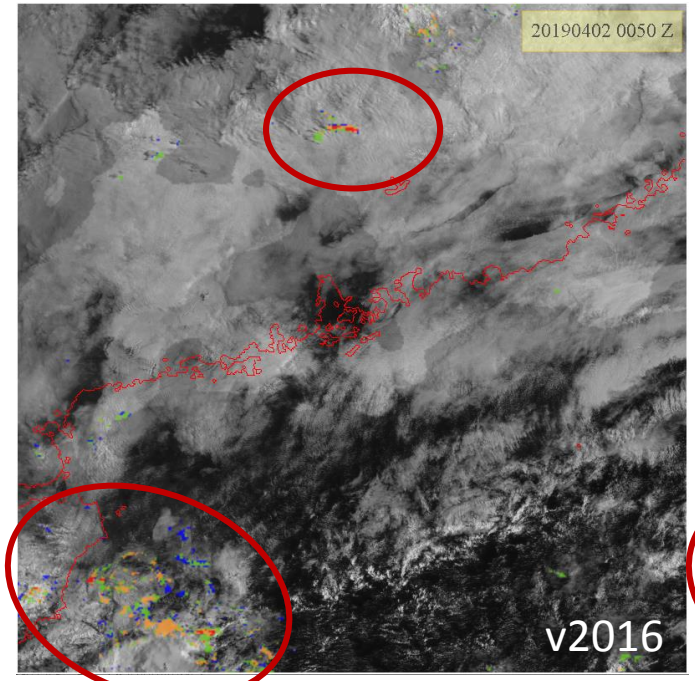
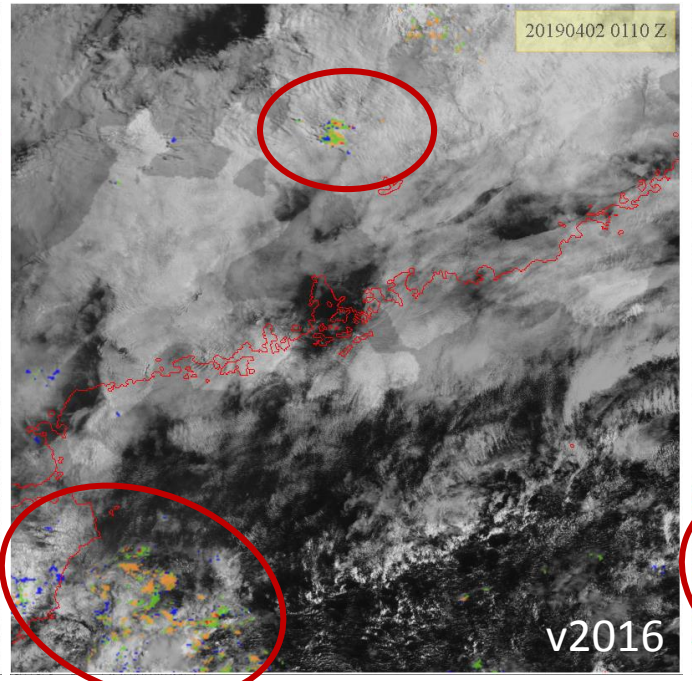
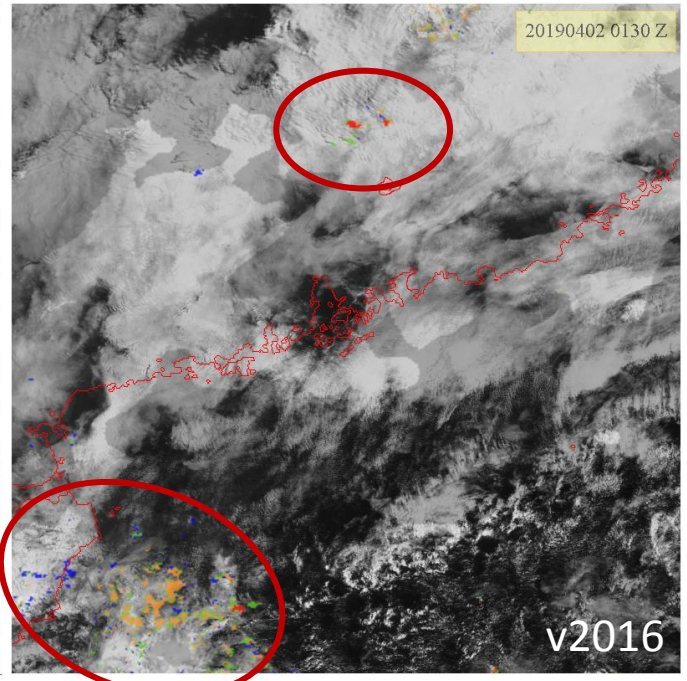
Improvement in the new version of CI

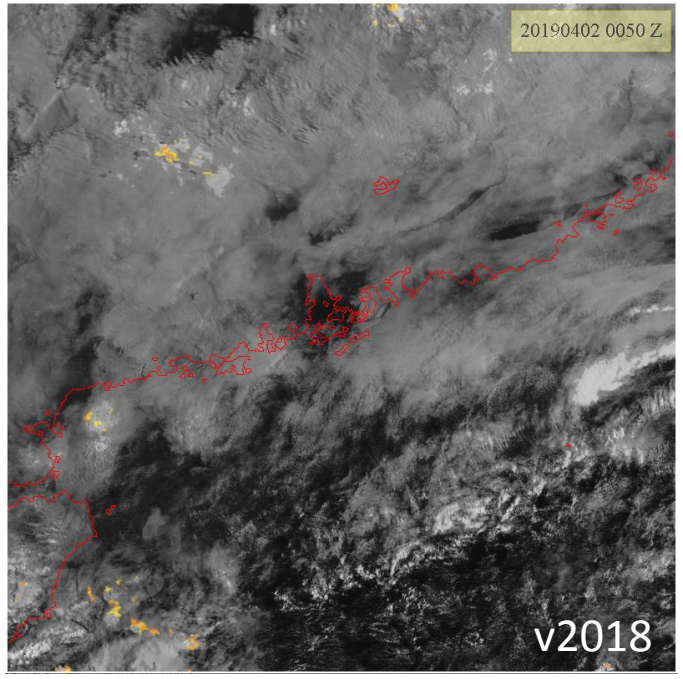
- Improved masking using microphysics (CMIC, daytime only) and cloud type (CT)
  - Use of cloud top phase, cloud optical thickness, liquid water path and ice water path as additional filters to focus on the relevant areas.
  - Use of cloud type to filter out those low clouds which are superimposed with thin cirrus. Significant improvement for the multi-layer issue.
- Differentiate the thresholds for daytime and for nighttime, depending on the availability of CMIC mask
  - Stricter rules when the CMIC mask is not available
- Cloud cell tracking improvement
- The ability to extrapolate the CI pixels up to T+30/60/90 min
- Stricter CI diagnosis rules to reduce false alarm and better highlight areas of high probability
  - Less "noisy" than the previous version
  - New color scale to highlight areas of interest

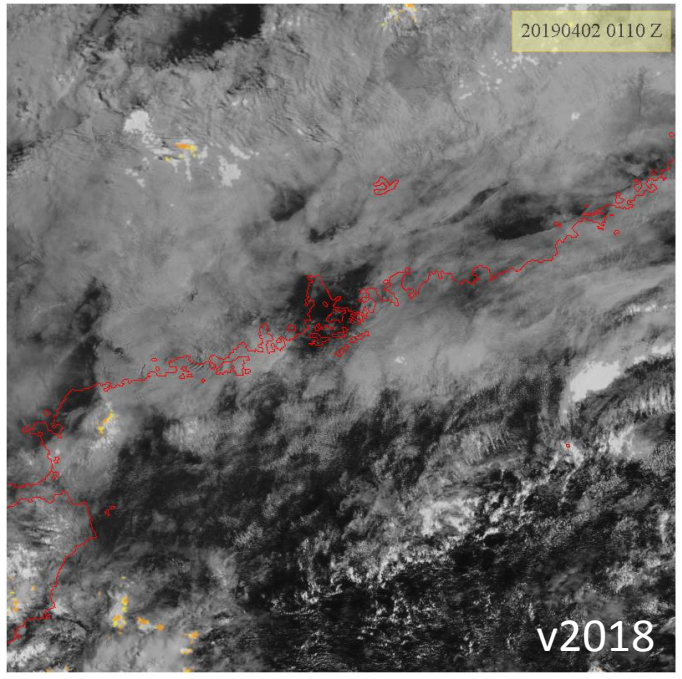


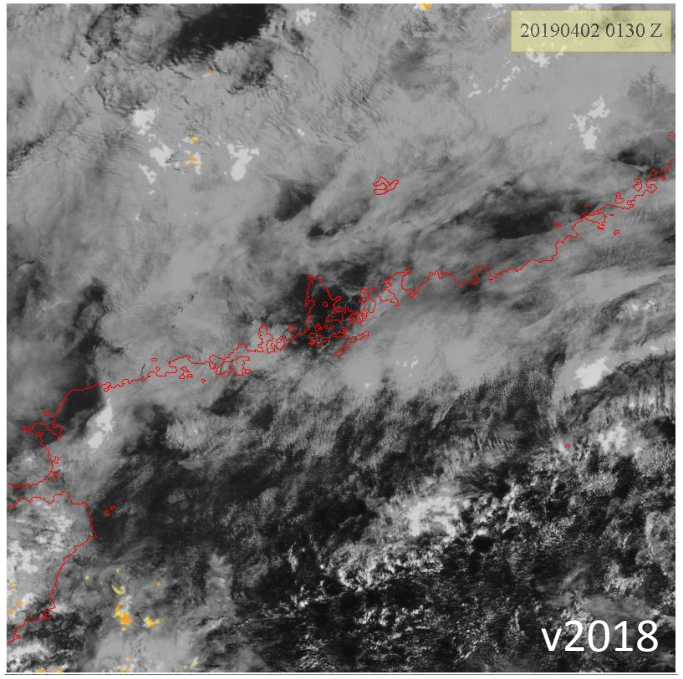




v2016
0 No Prob
1 VLow
2 Low
3 Mod
4 High

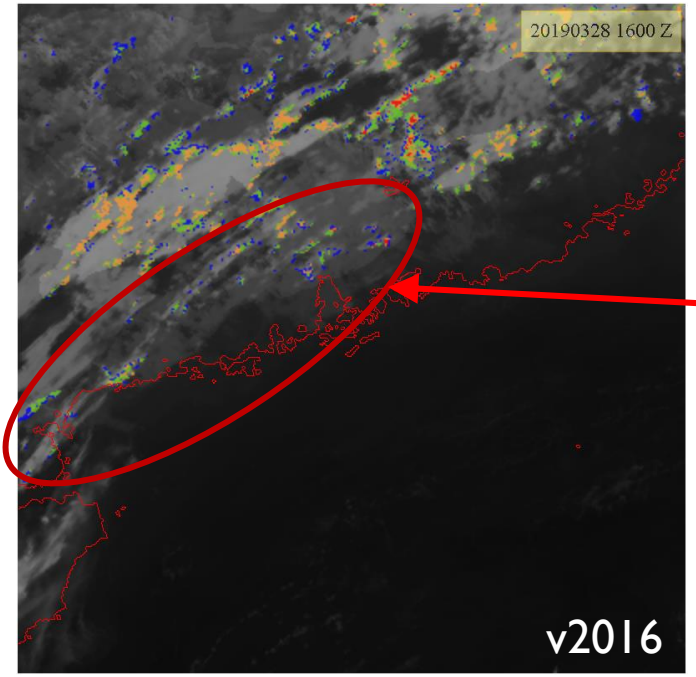




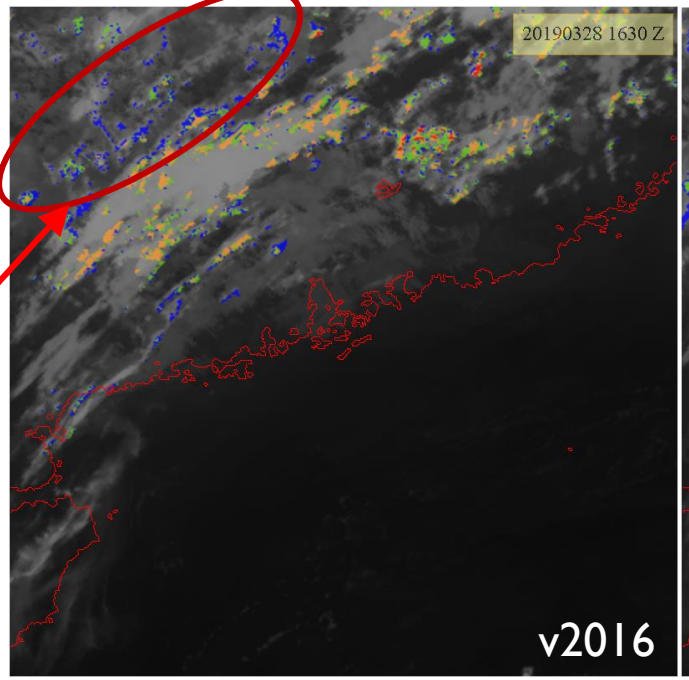


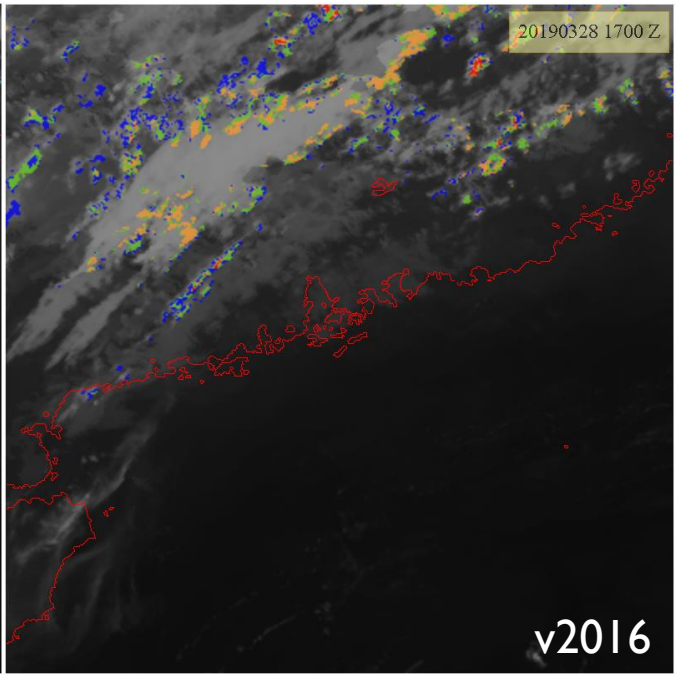
Much less false alarm in NWCSAF v2018

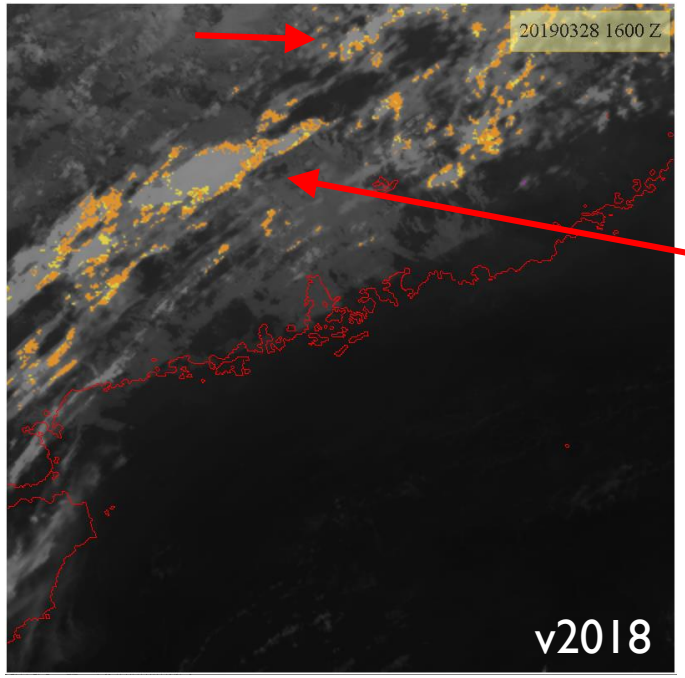
v2018
0 No Prob
1 VLow
2 Low
3 Mod
4 High



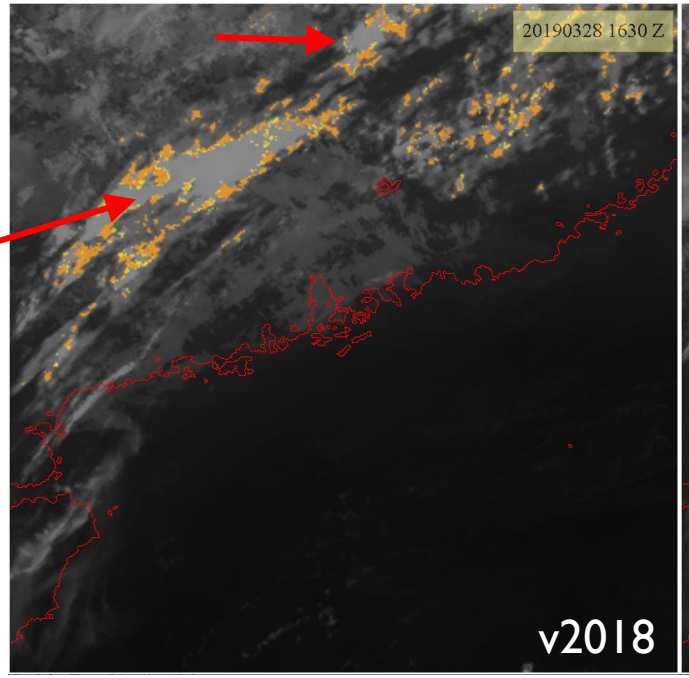
Reduced false alarm from high semitransparent clouds moving over low clouds

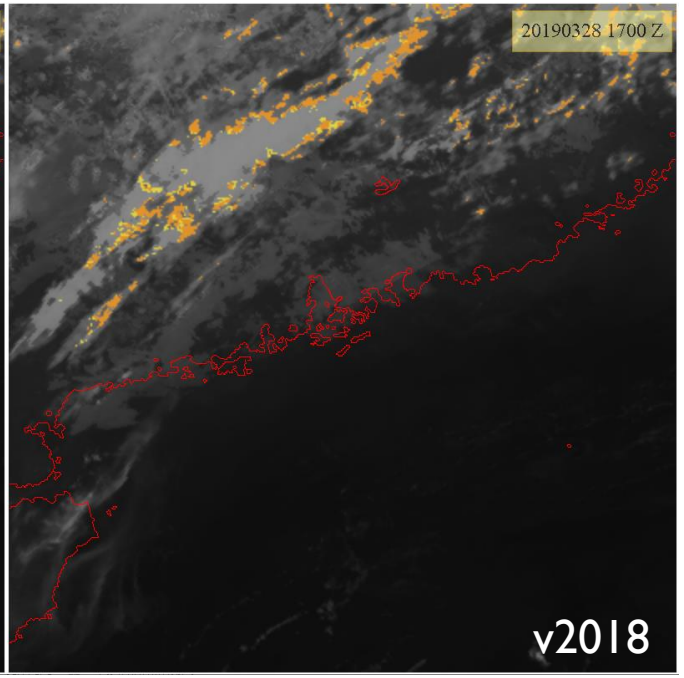


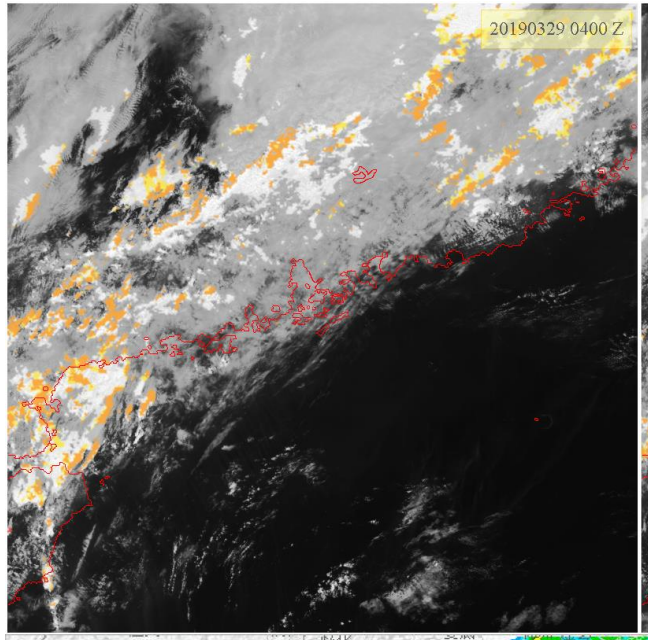


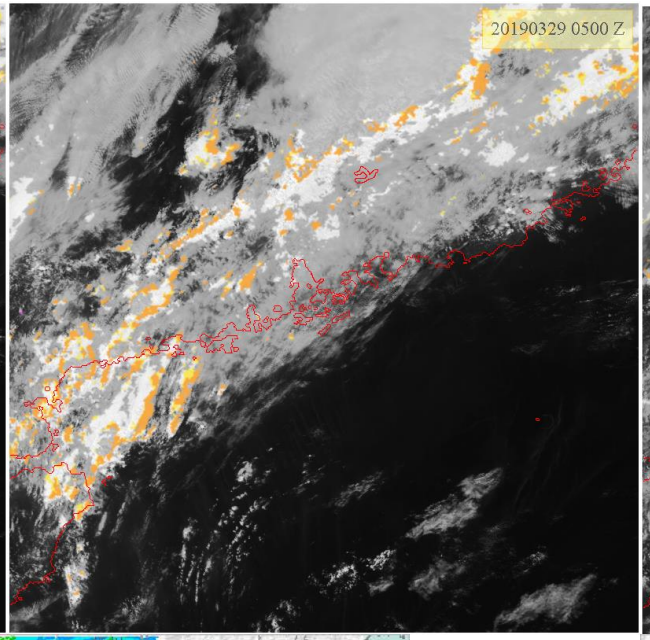


Stronger and clearer signals over the real development zones






20190329 0400 Z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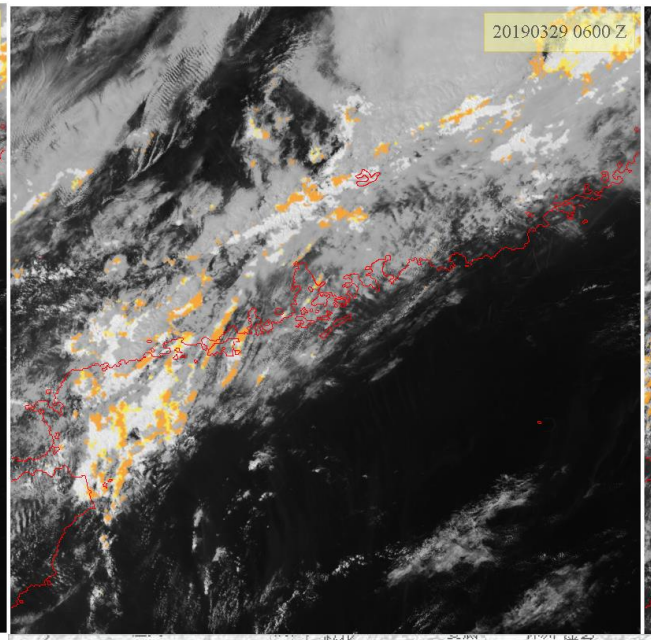
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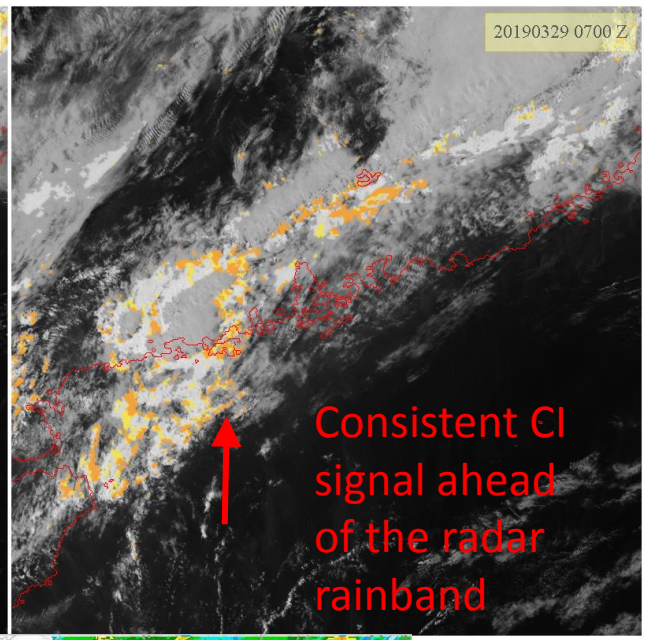
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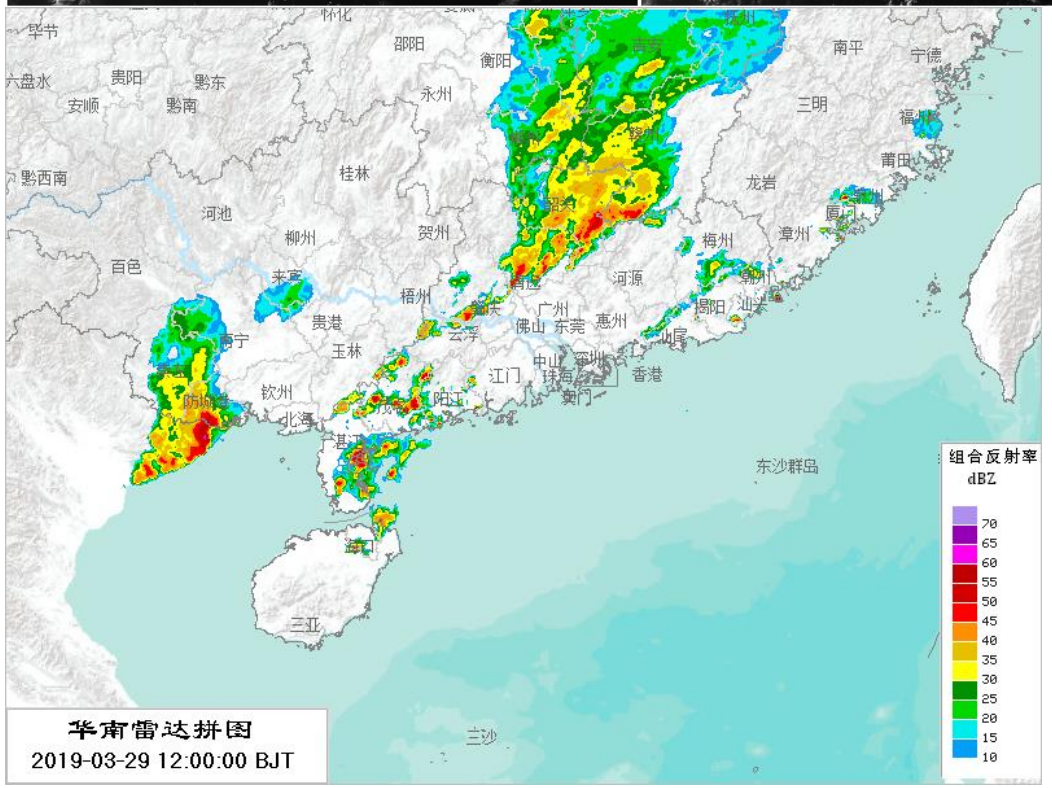
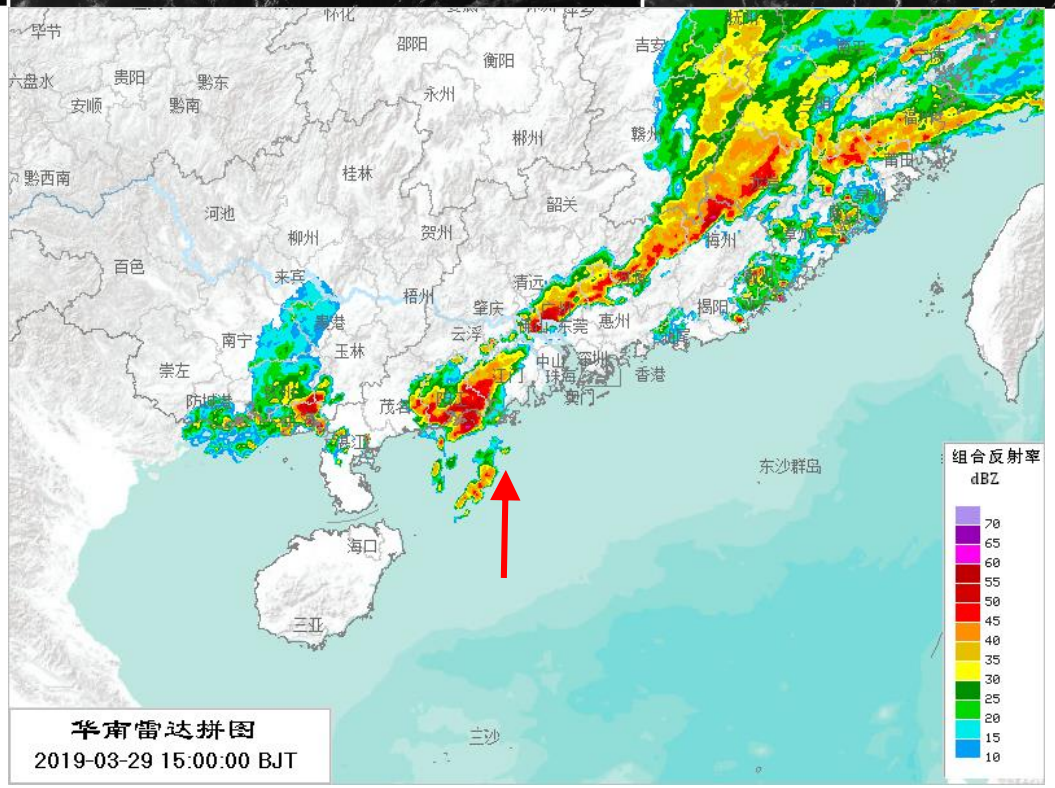
Consistent CI signal ahead of the radar rainband


华南雷达拼图
2019-03-29 12:00:00 BJT
组合反射率 dBZ
70 65 60 55 50 45 40 35 30 25 20 15 10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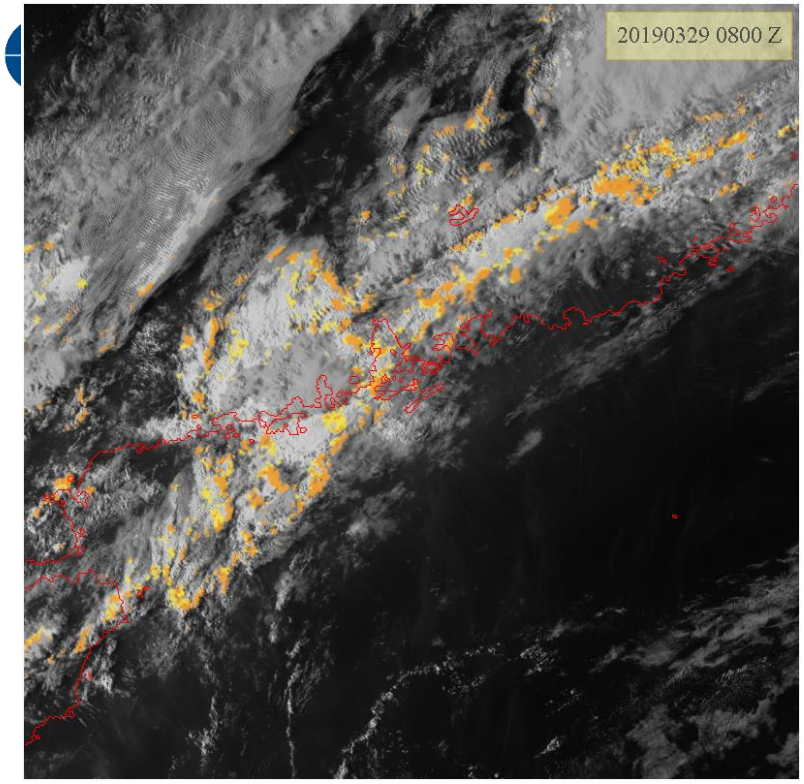
2019-03-29 15:00:00 BJT
组合反射率 dBZ
70 65 60 55 50 45 40 35 30 25 20 15 10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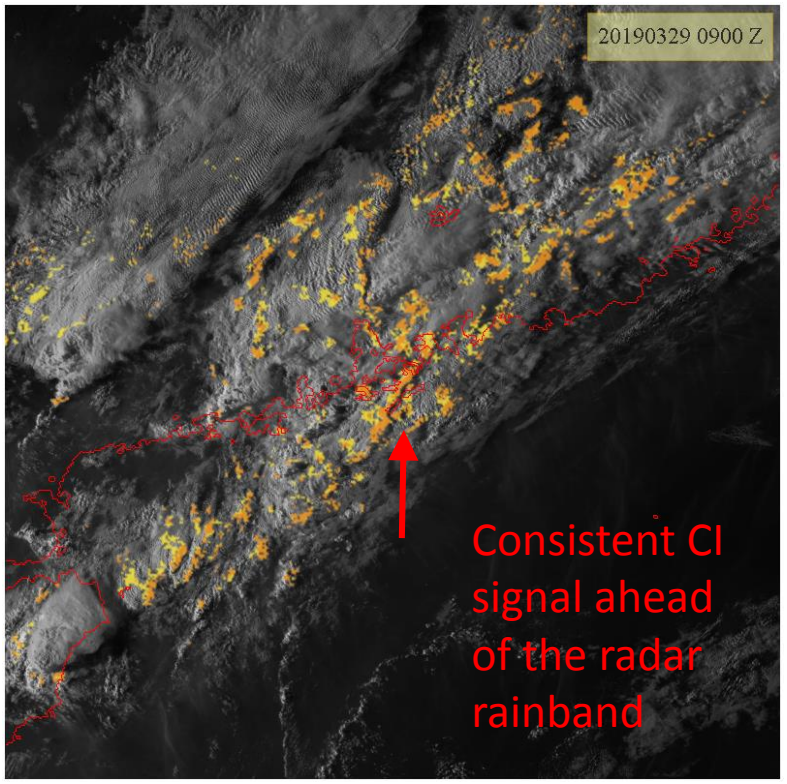
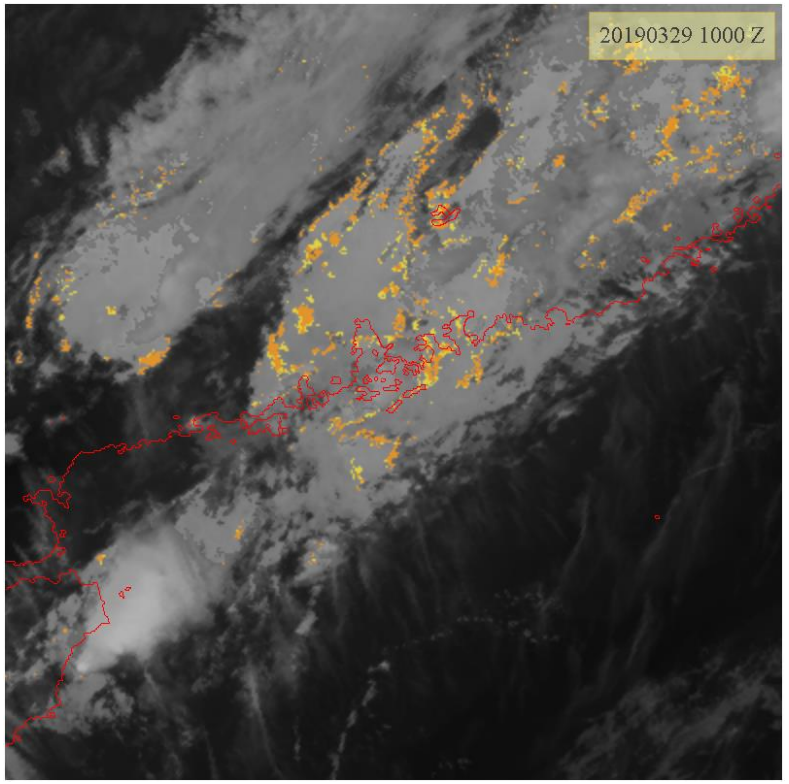

20190329 0900 Z
Consistent CI signal ahead of the radar rainband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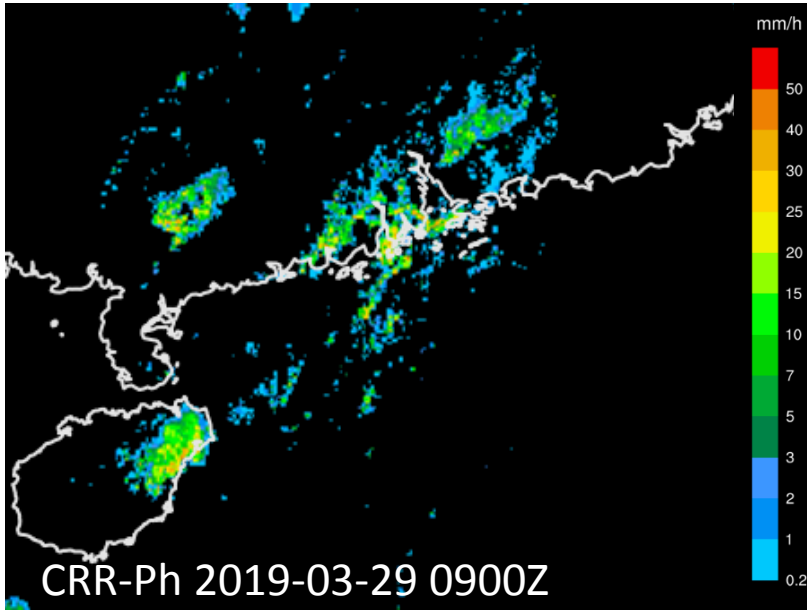
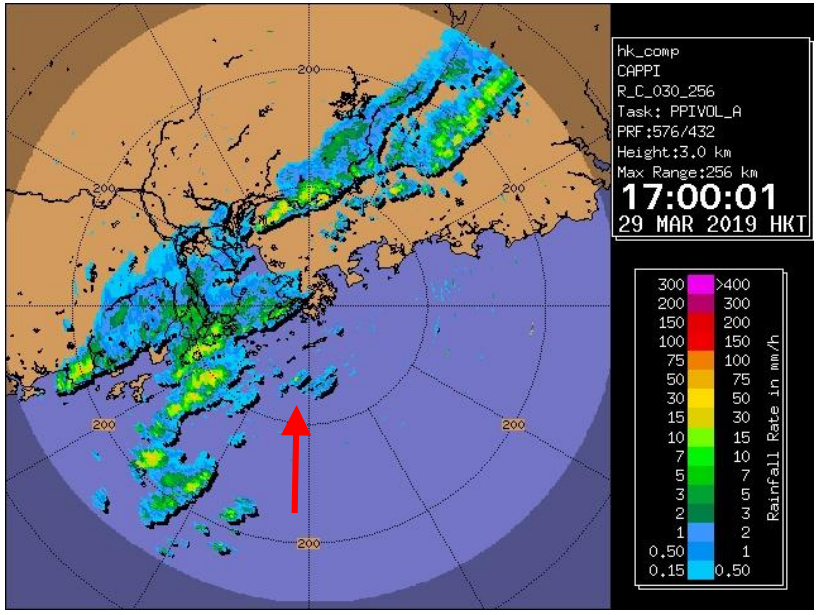

mm/h
50
40
30
25
20
15
10
7
5
3
2
1
0.2
CRR-Ph 2019-03-29 0900Z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CAPPI
R_C_030_256
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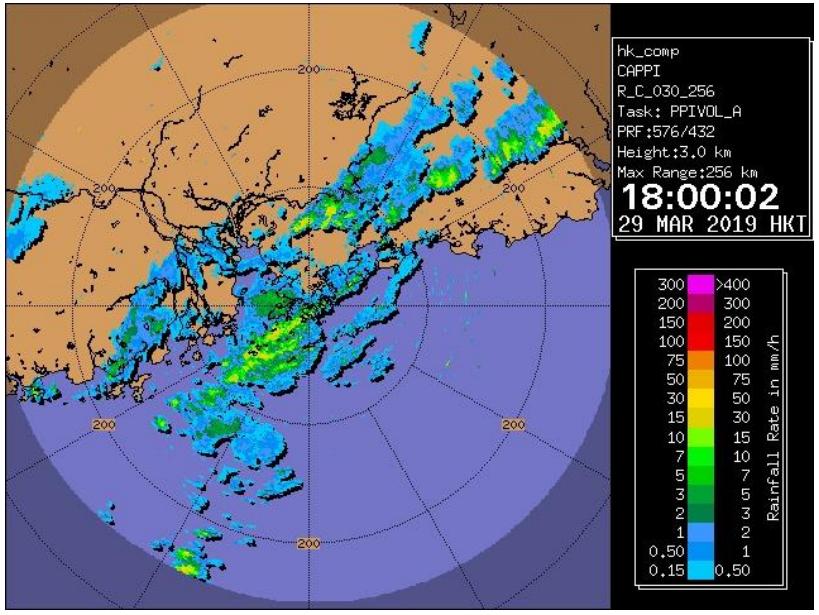
PRF:576/432
Height:3.0 km
Max Range:256 km
17:00:01
29 MAR 2019 HKT
Rainfall Rate in mm/h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CAPPI
R_C_030_256
Task: PPIVOL_A
PRF:576/432
Height:3.0 km
Max Range:256 km
18:00:02
29 MAR 2019 HKT
Rainfall Rate in mm/h

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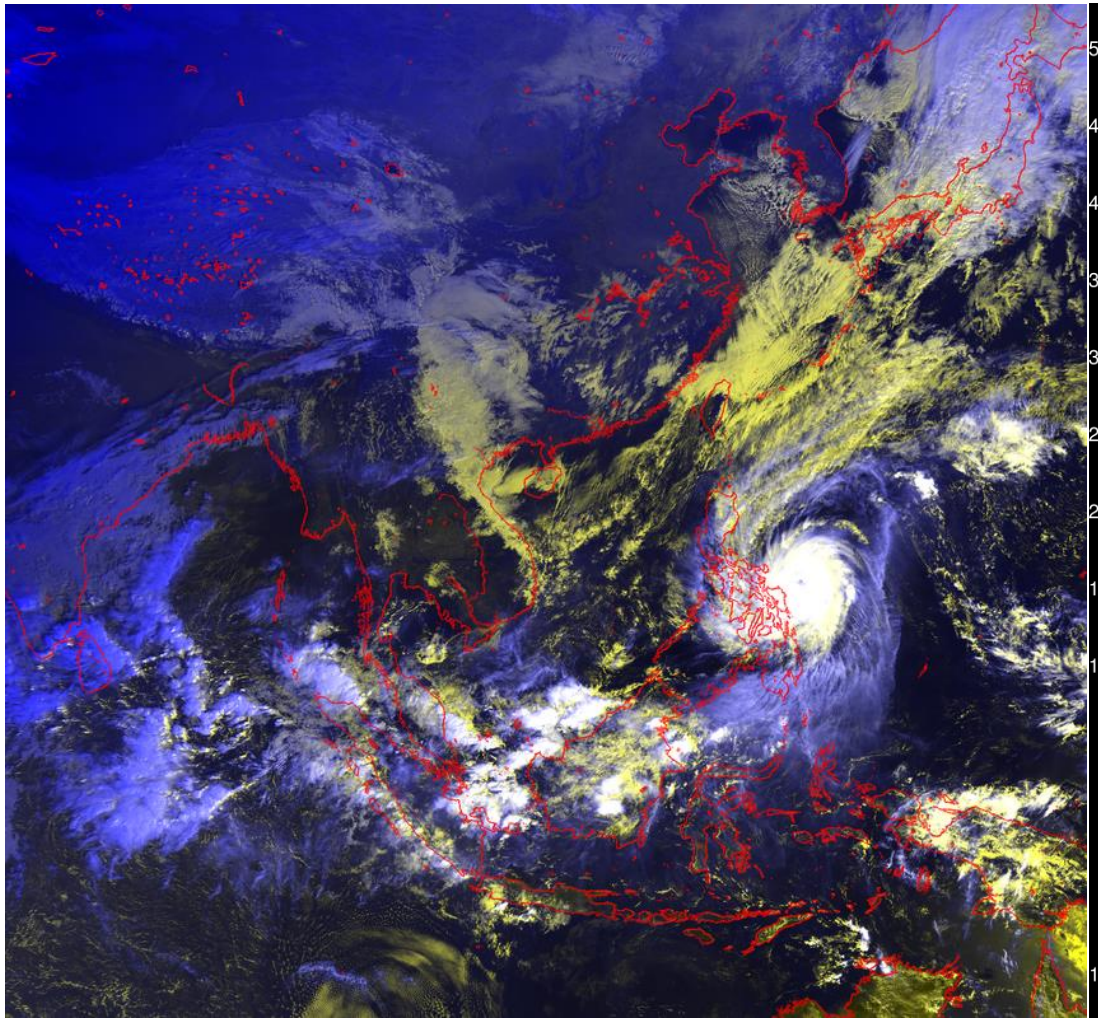
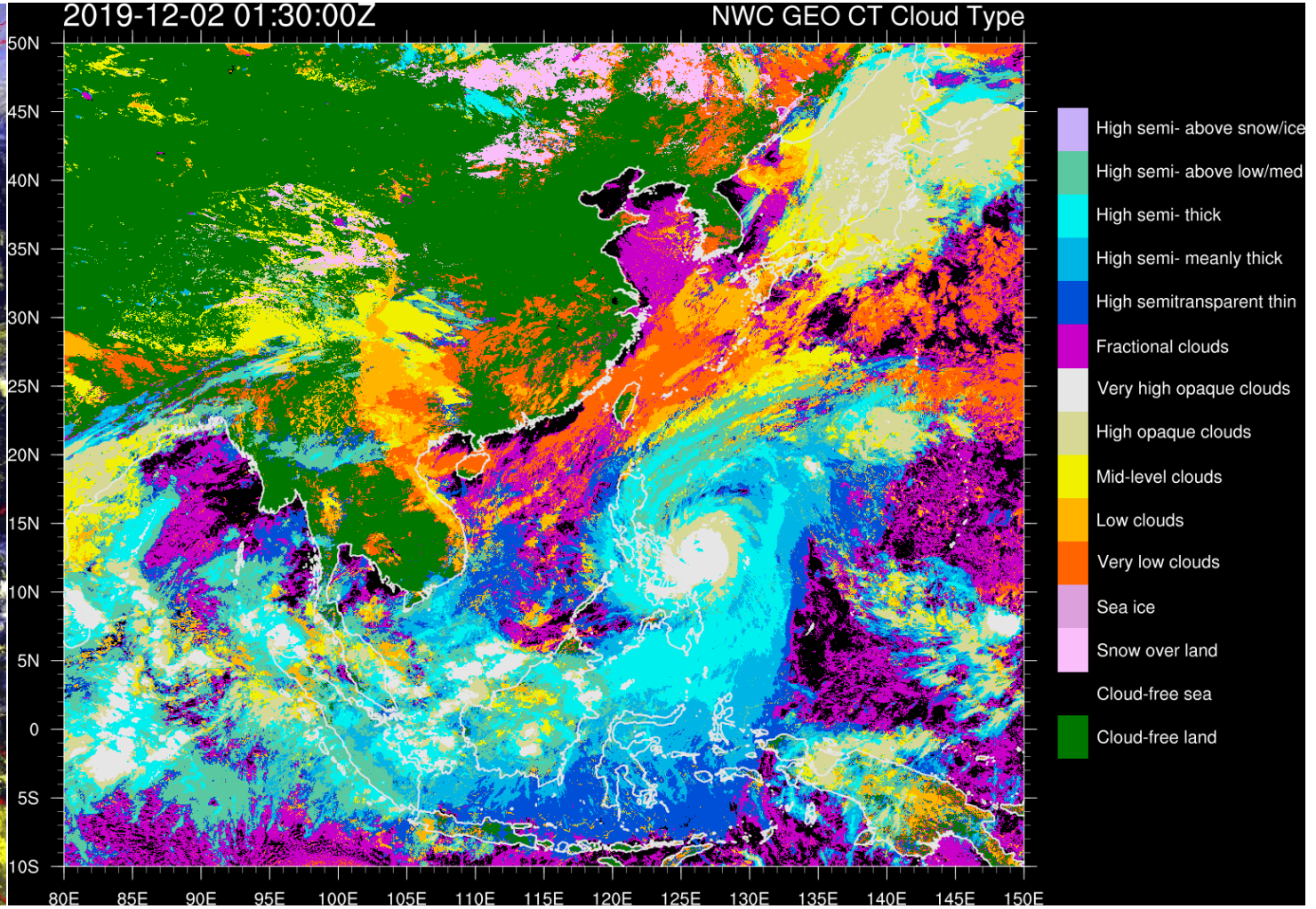
Another Example: Kammuri (2 Dec 2019)





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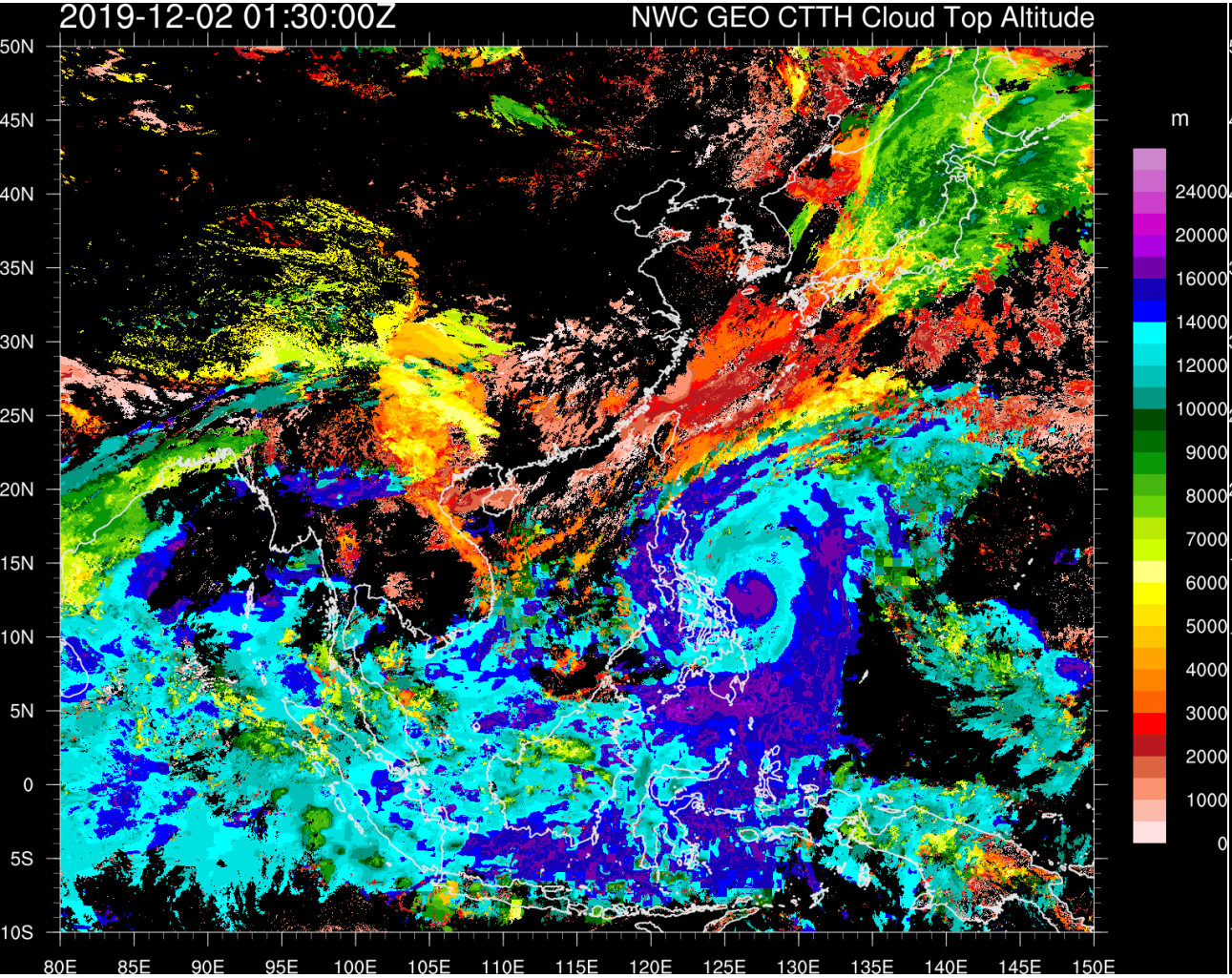

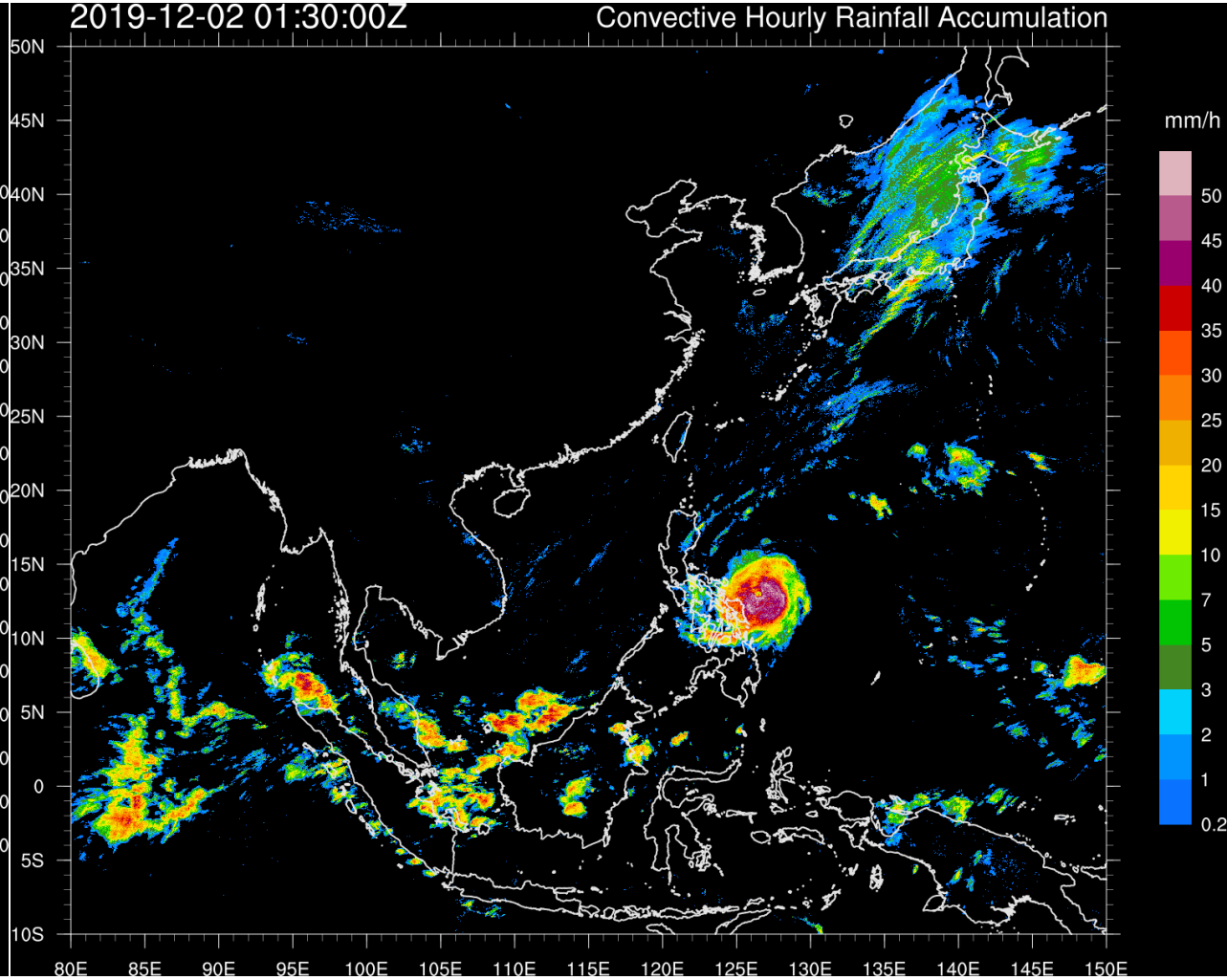

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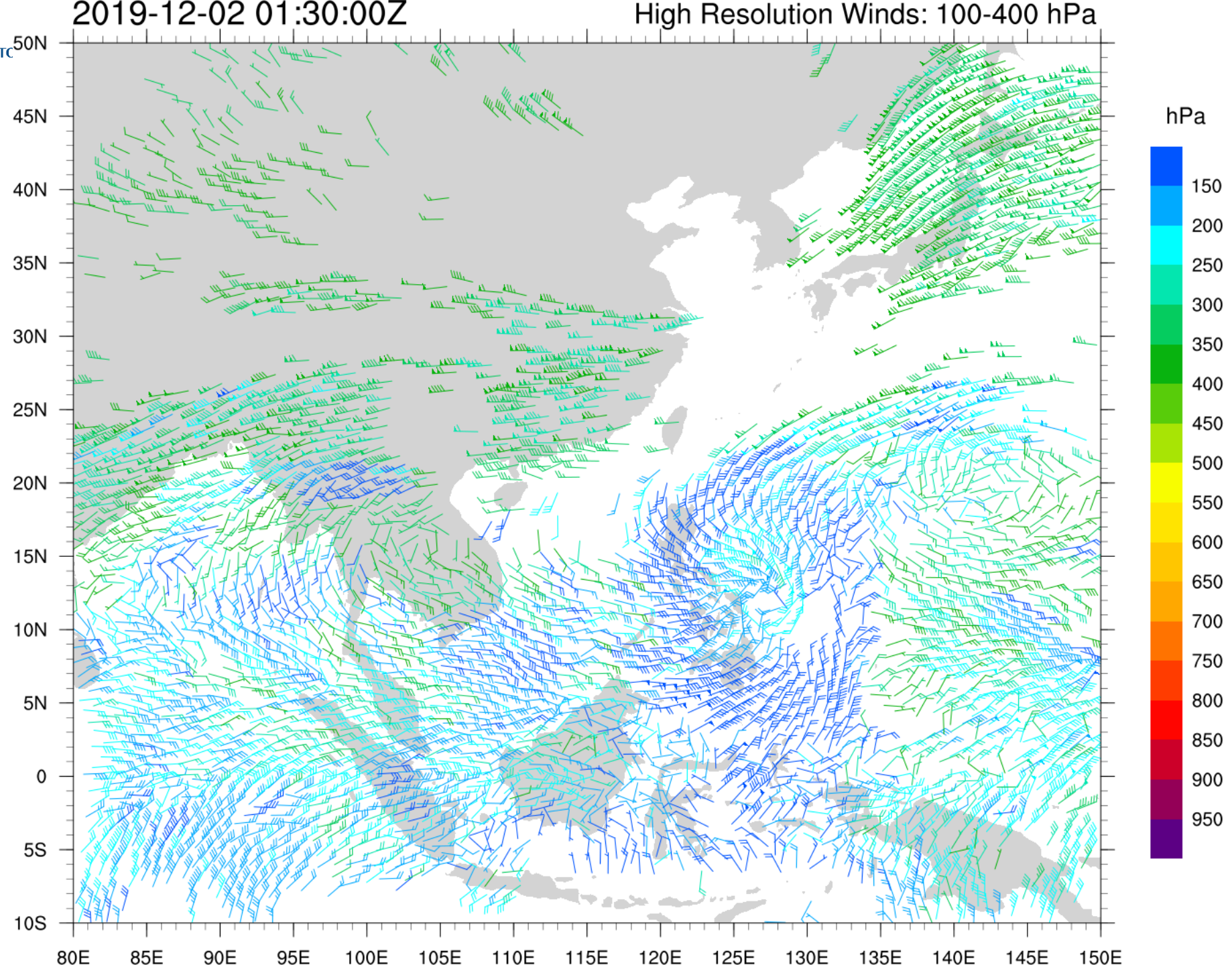

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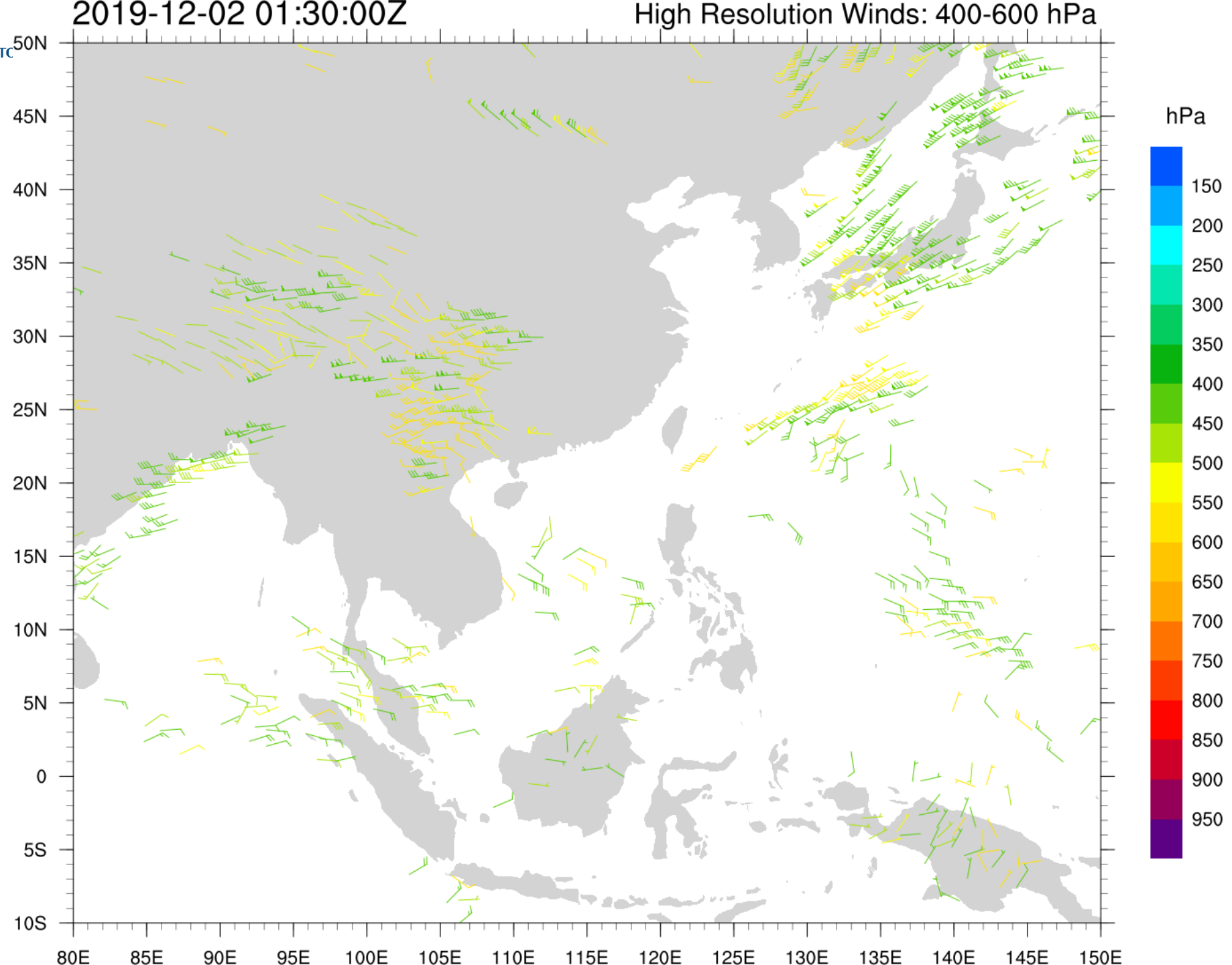

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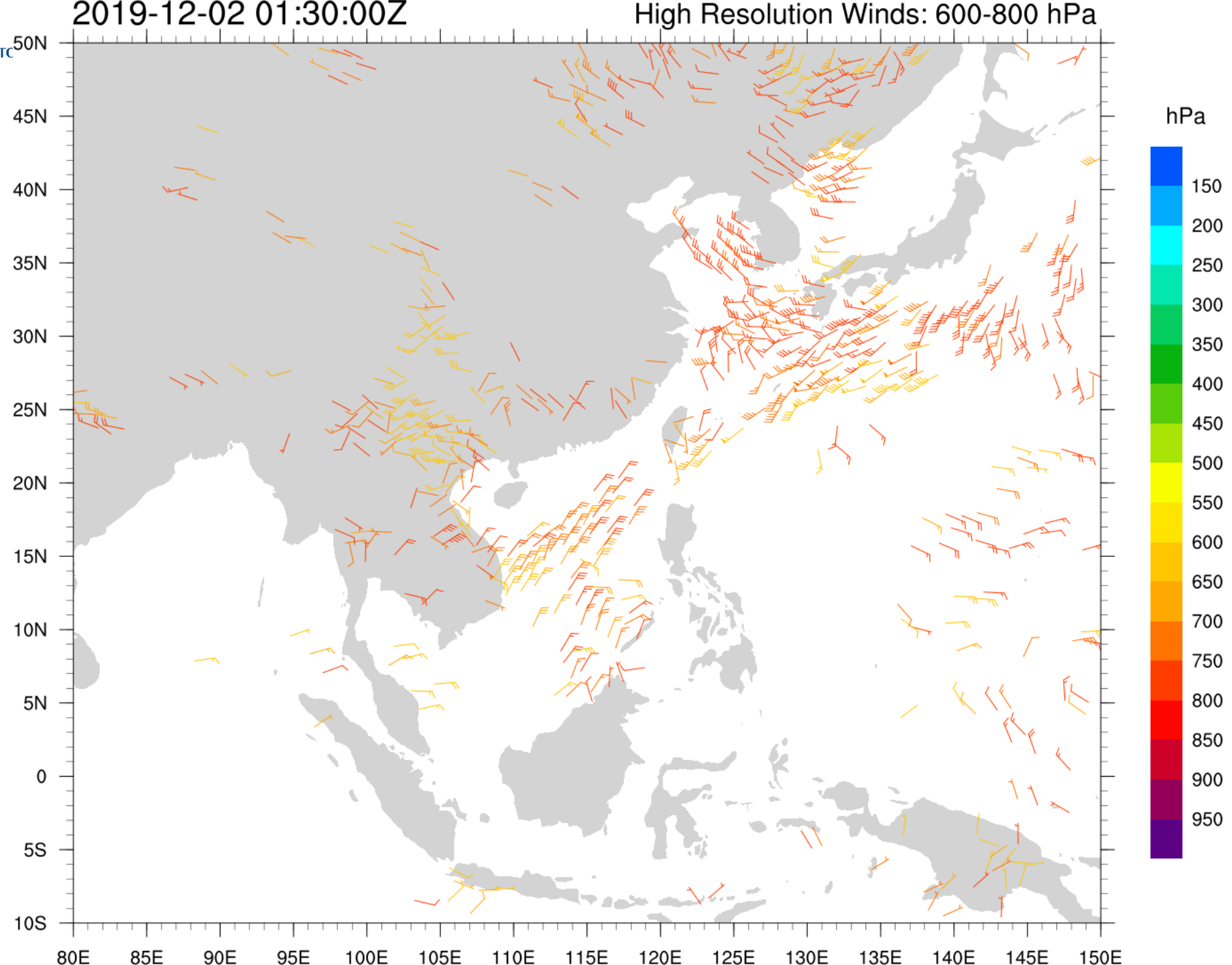

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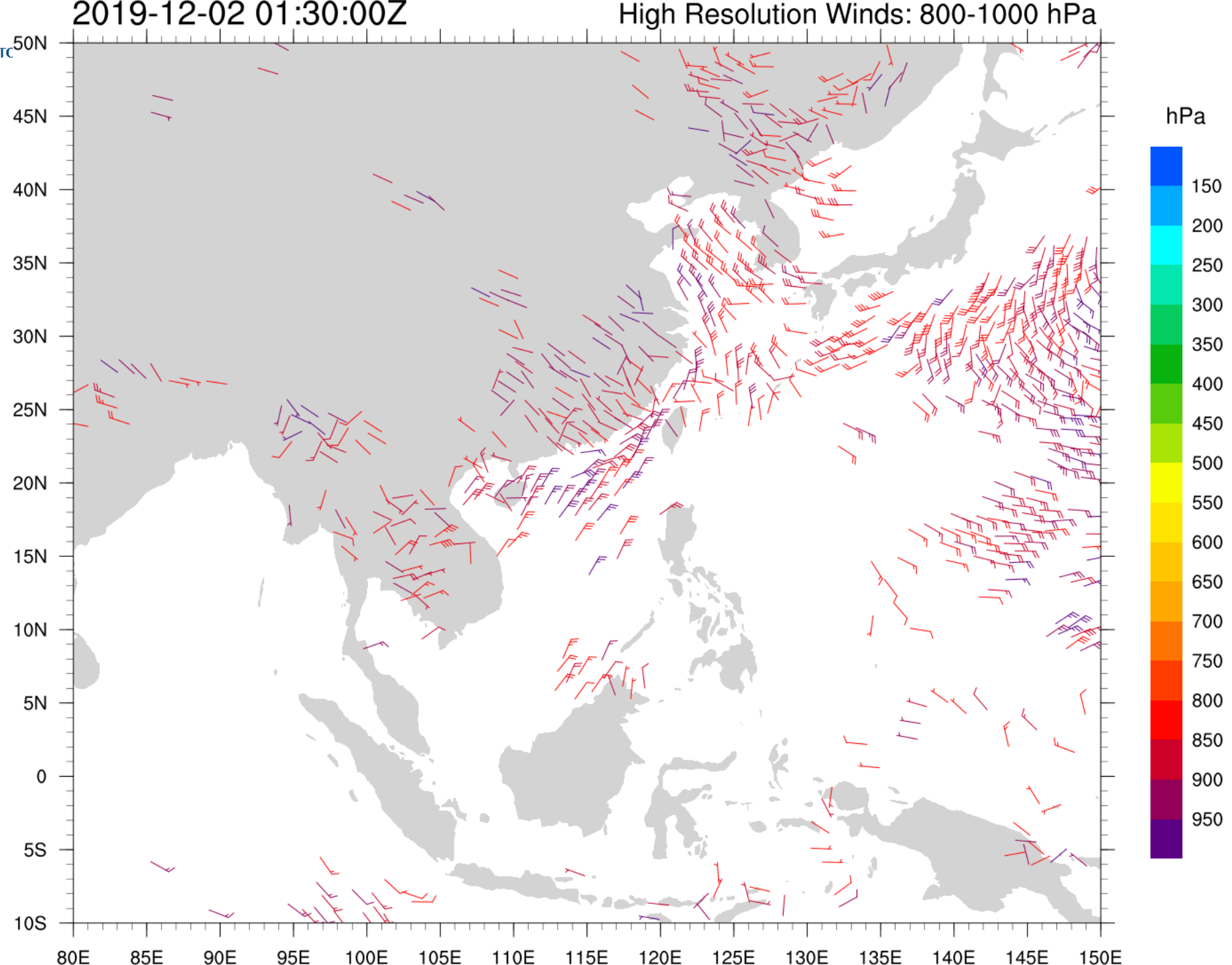

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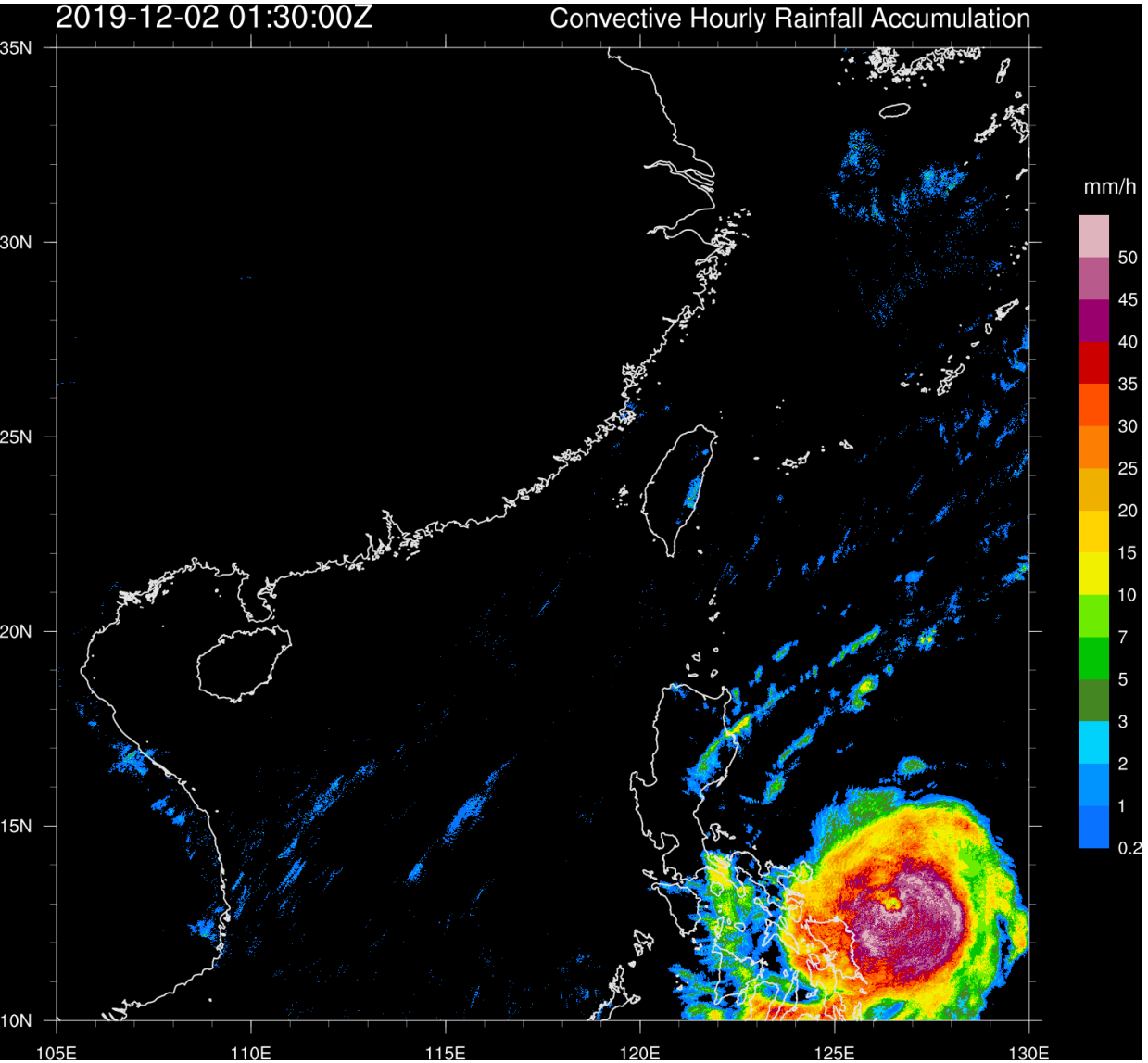

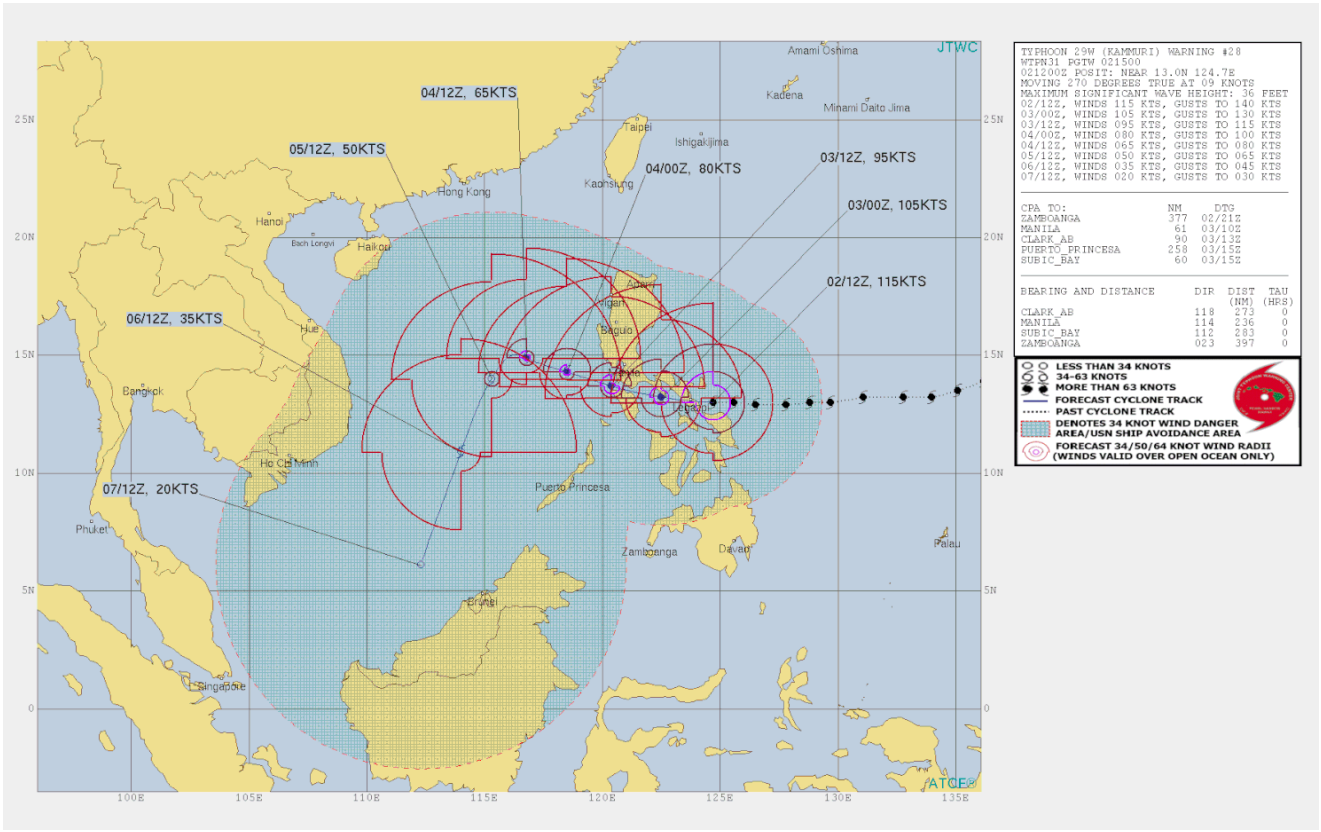

Extrapolation of CRR-Ph hourly rainfall accumulation using forecast tracks from major TC Warning Centers (e.g. HKO and JTWC above) suggested the daily rainfall on 2-3 Dec would reach a maximum of around 100 – 150 mm over the central part of the Philippines

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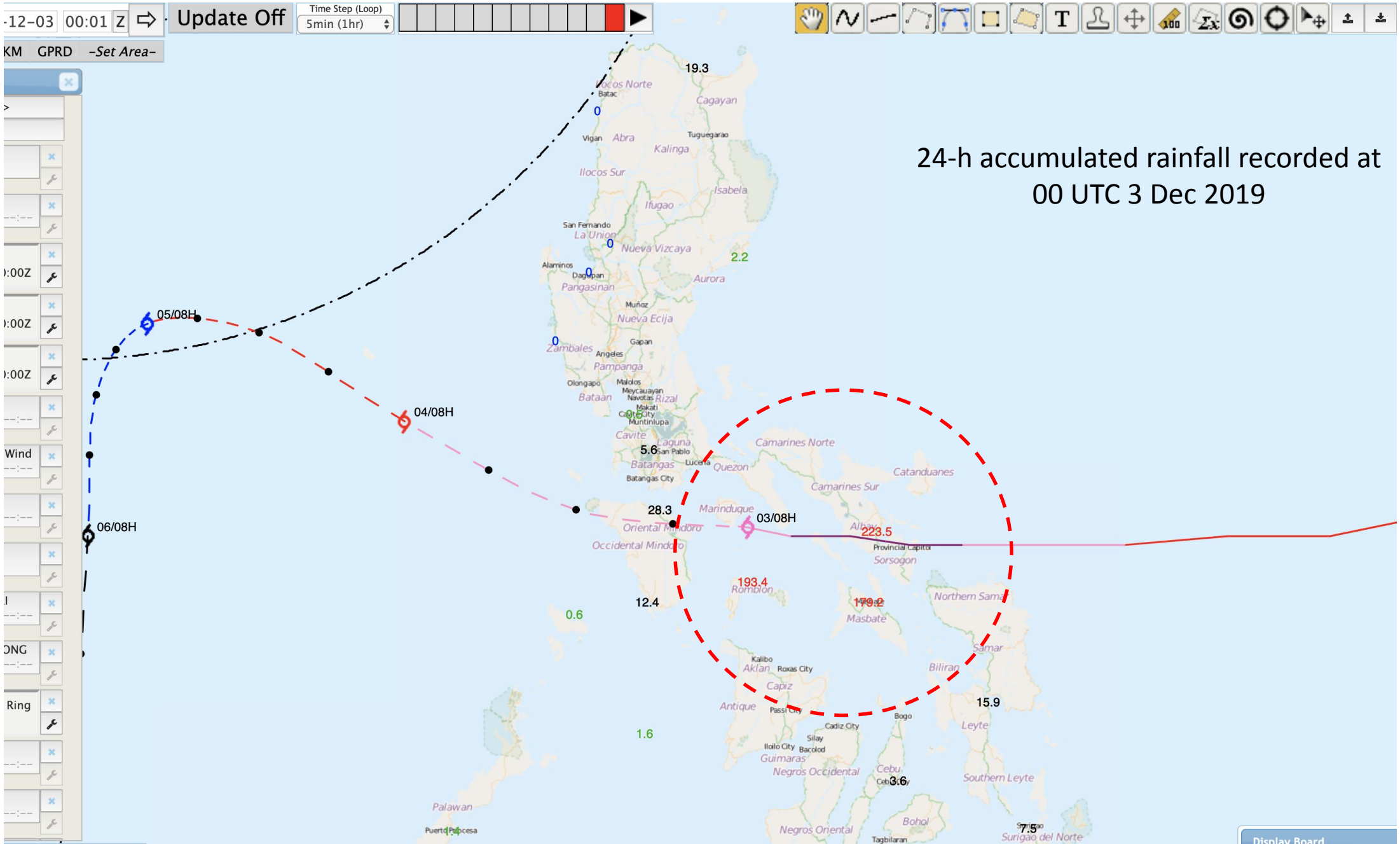

24-h accumulated rainfall recorded at
00 UTC 3 Dec 2019

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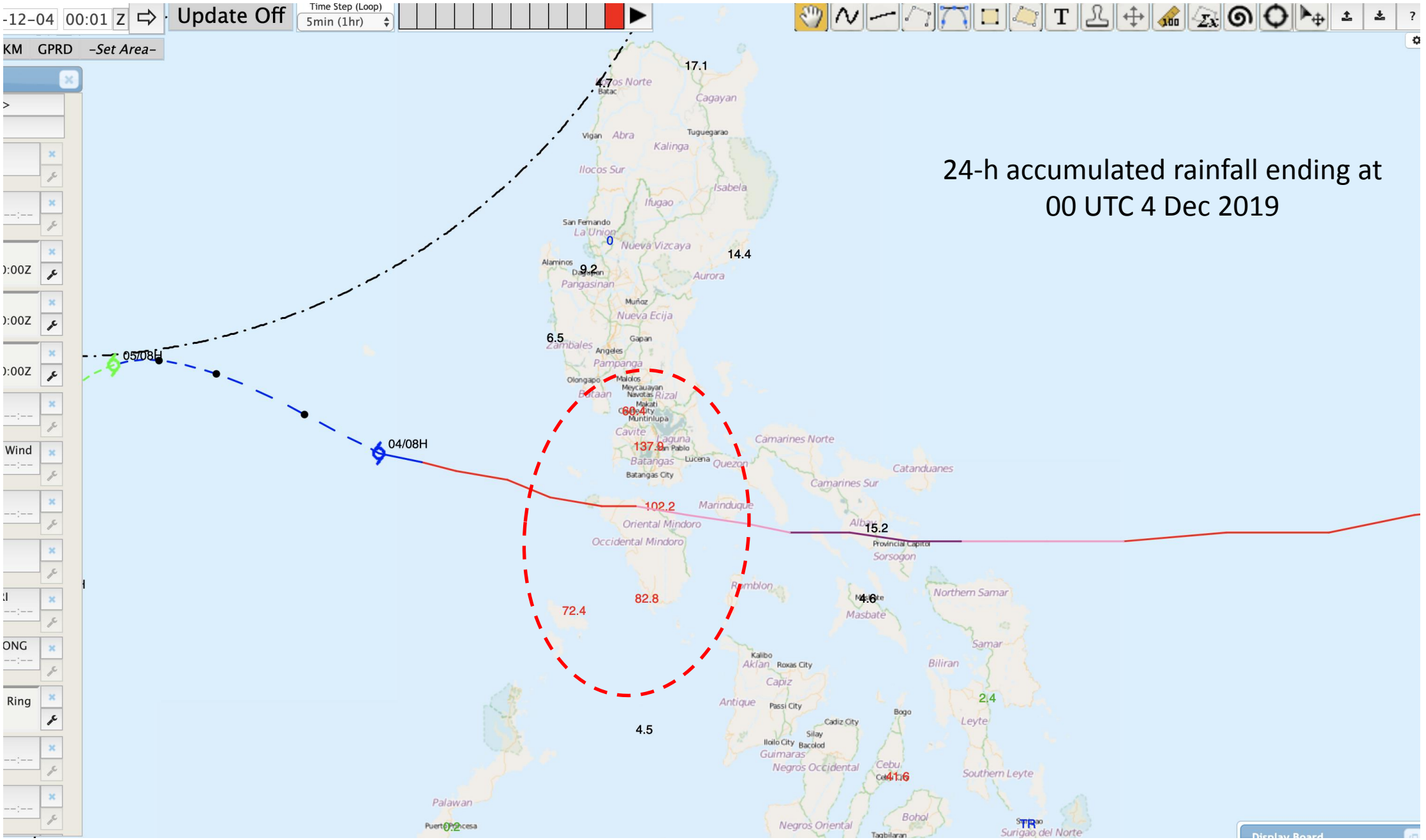

24-h accumulated rainfall ending at
00 UTC 4 Dec 2019

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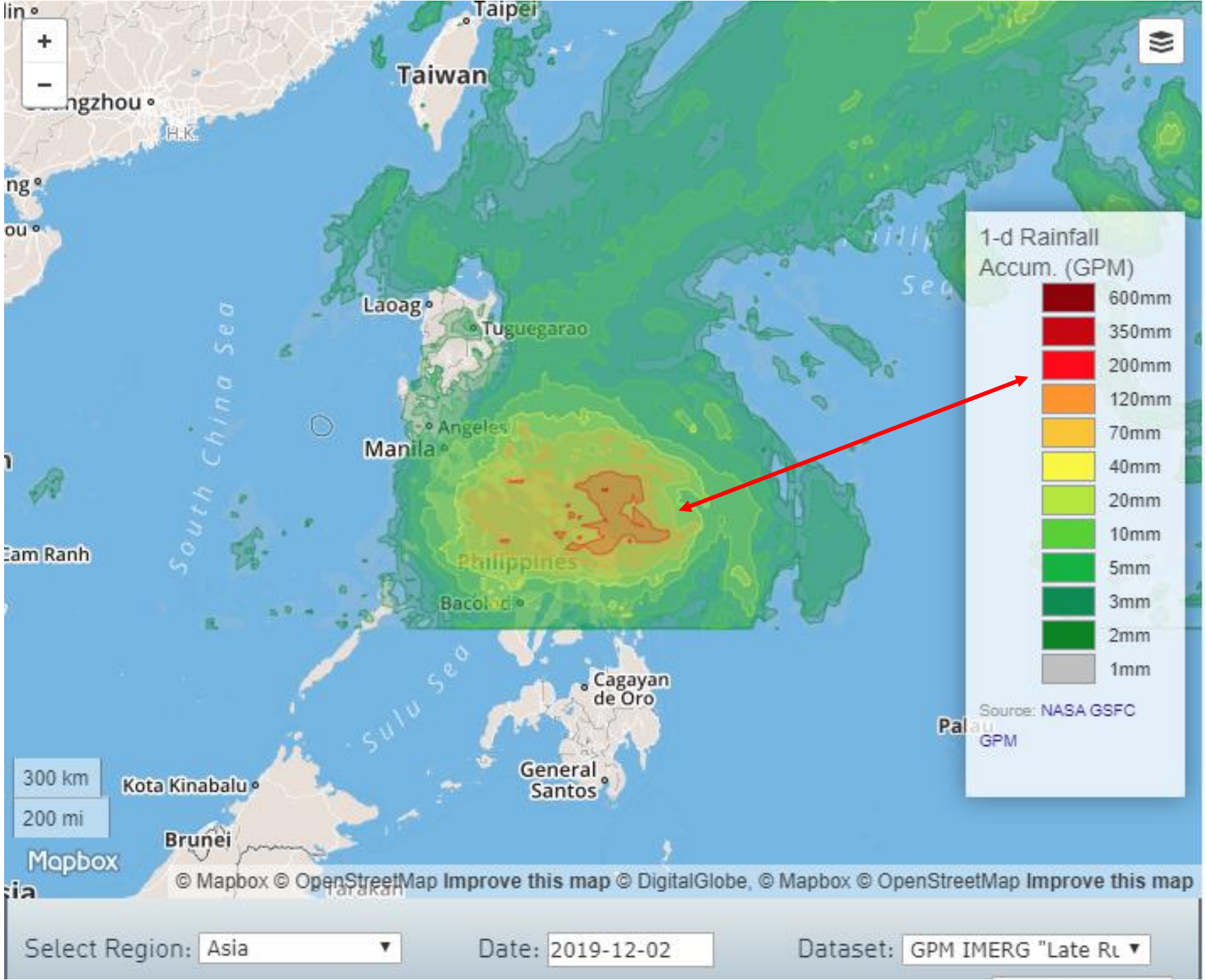
24 hr rainfall estimates on 2 Dec 2019 from GPM



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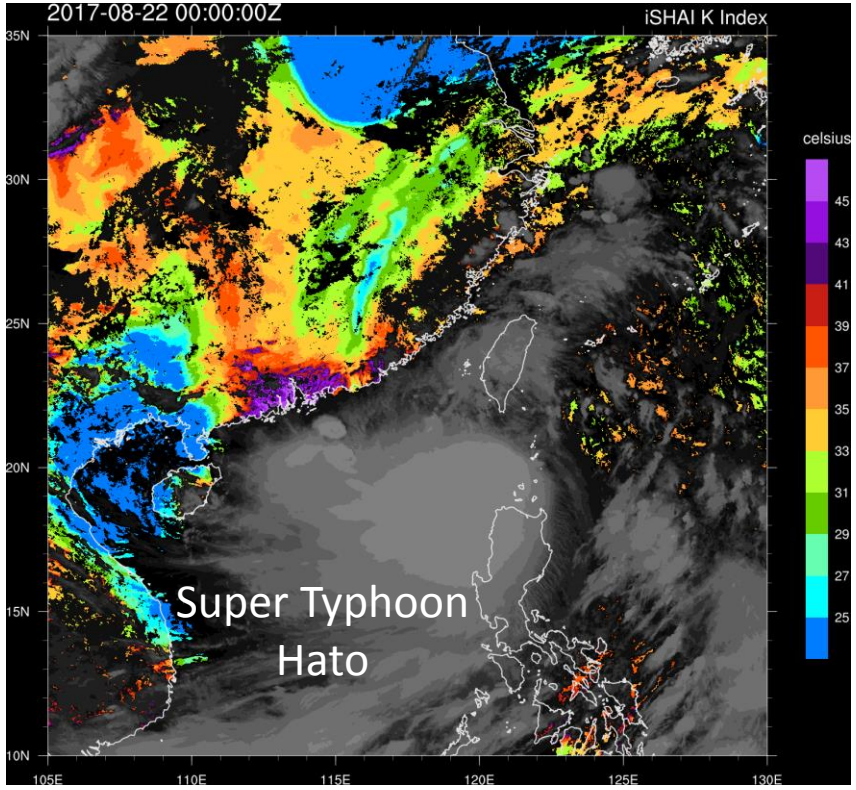
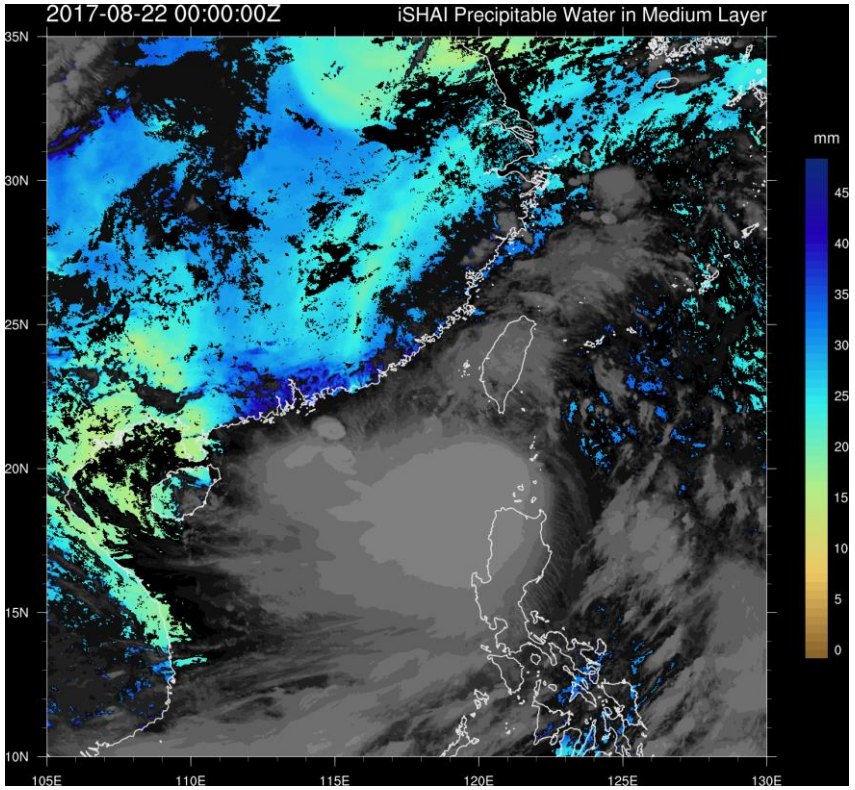
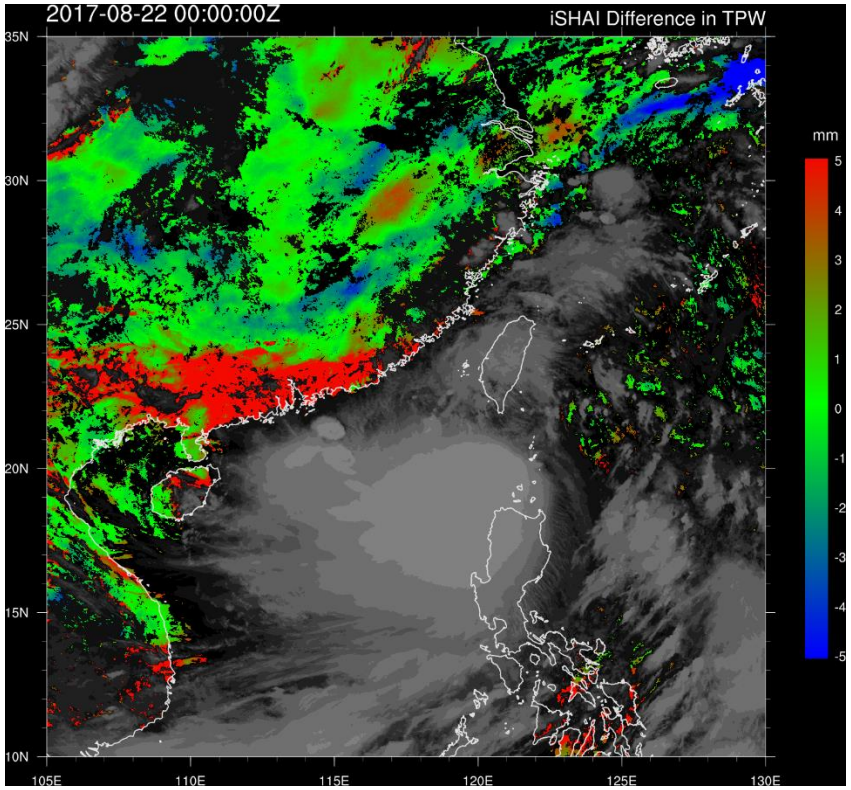
New Products under Development

iSHAI retrieved profiles and derived products on stability (K-index) and precipitable water to aid forecasters' assessment of the chance of convective development







Tuning of bias BT is being studied to investigate performance of iSHAI using more vertical levels of ECMWF model forecast

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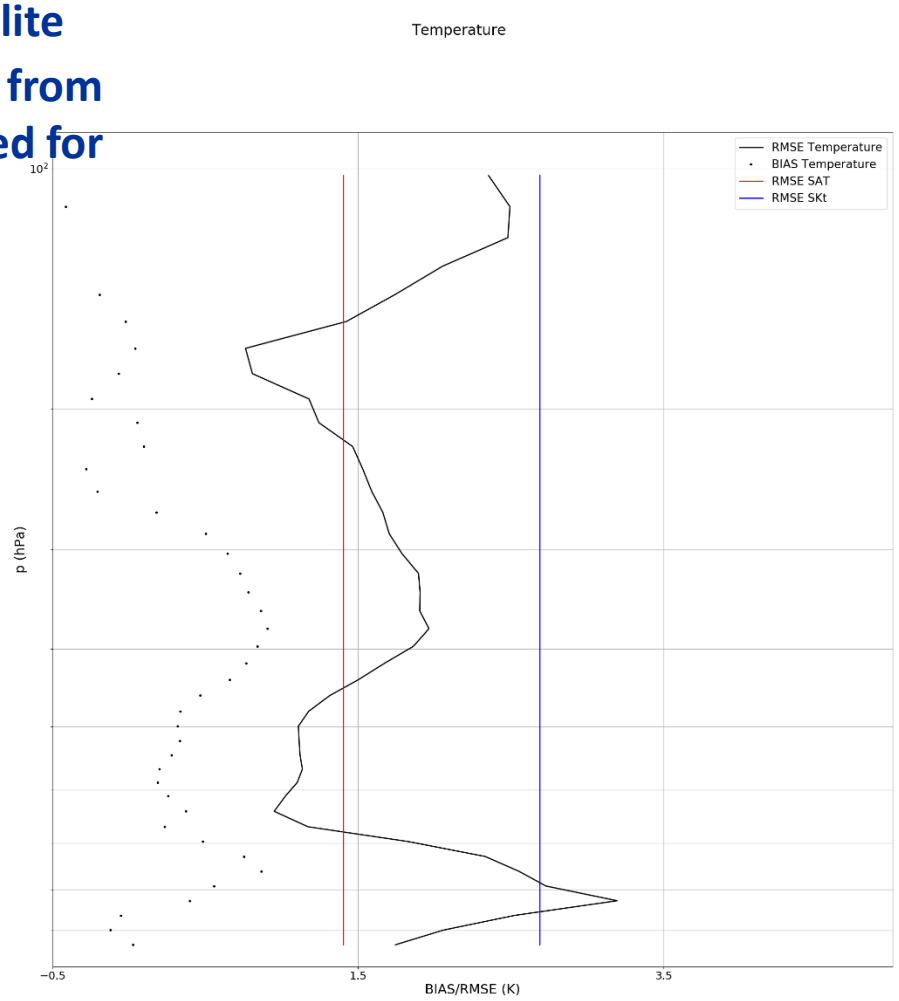
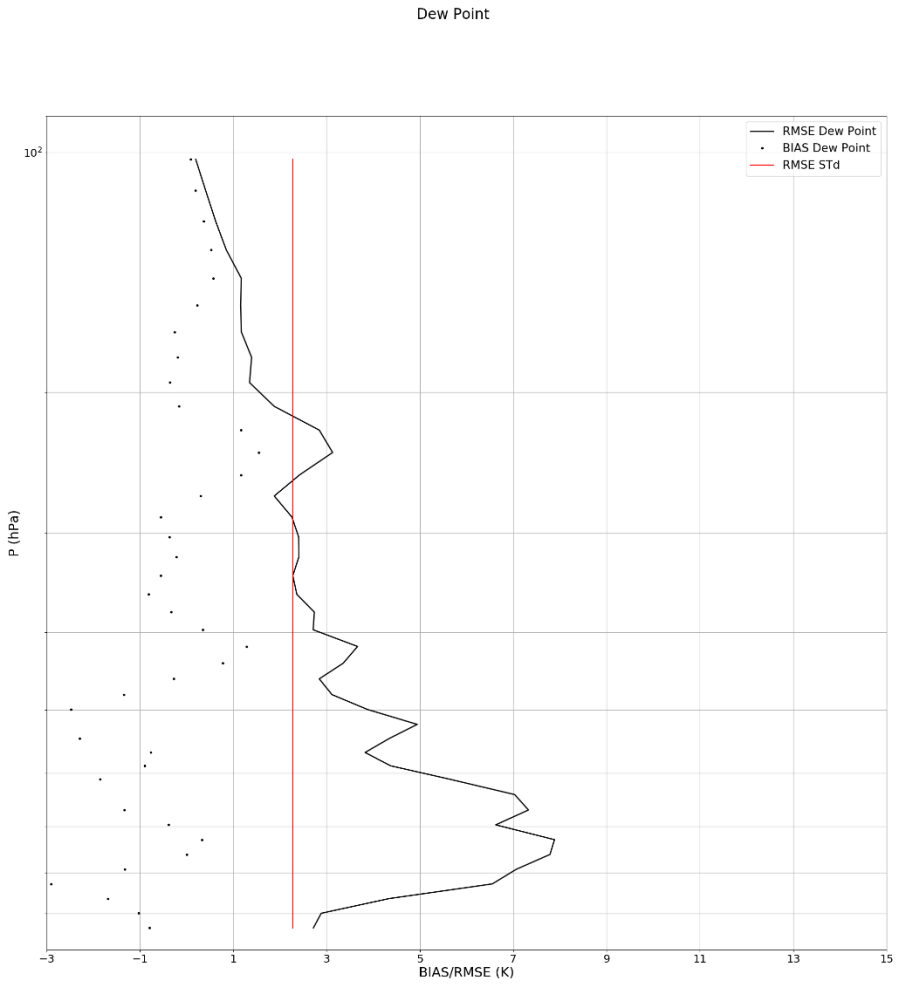
Collaboration with AEMET to develop retrieval products of infrared sounder of FY4A (GIIRS)

sSHAI: sounder Satellite Humidity And Instability from NWC SAF is being adapted for FY4A GIIRS





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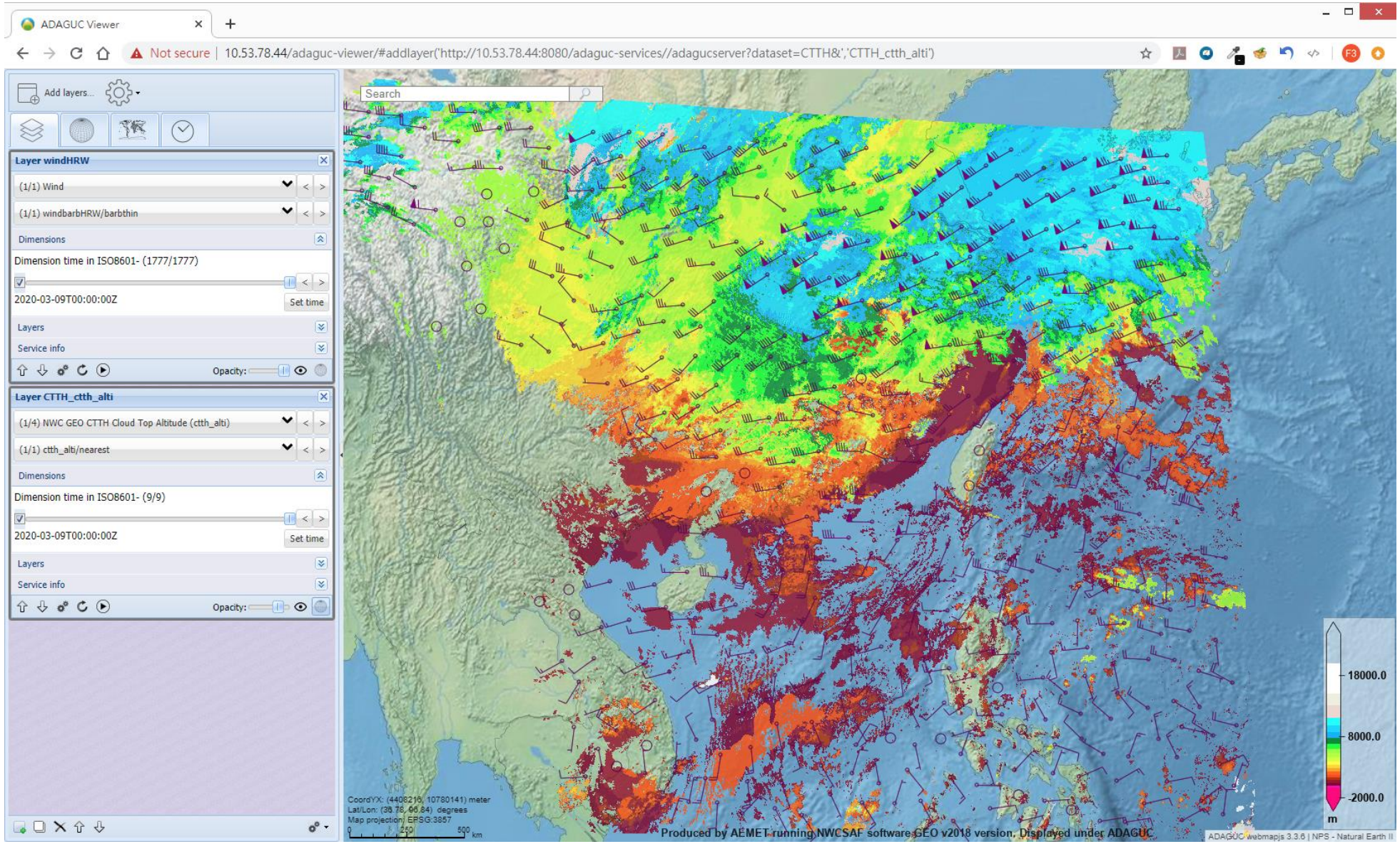
Adaguc visualization platform

Adaguc Viewer is being adapted to visualize NWC GEO products

Thanks to support from Llorenc Lliso.



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Concluding remarks

- NWC SAF/GEO has been implemented for trial operation in HKO using JMA Himawari-8 to support monitoring and nowcast of convective weather with much extensive coverage compared to available radars or regional mosaic
- Forecasters at HKO and Aviation Meteorological Office find the products very useful such as cloud top height, cloud types, CI/RDT, HRW and CRR-Ph
- Several SAF/GEO products demonstrated potential applications in monitoring of intensity changes of tropical cyclones; HRW data are assimilated to generate upper-air wind analysis with increased temporal resolution
- New developments and collaborations with AEMET are underway:
  - iSHAI
  - Adaguc Viewer
  - sSHAI
  - Satellite-radar blended QPE