The Validation and Application of FORMOSAT-7/COSMIC-2 Radio Occultation Data from Taiwan Team

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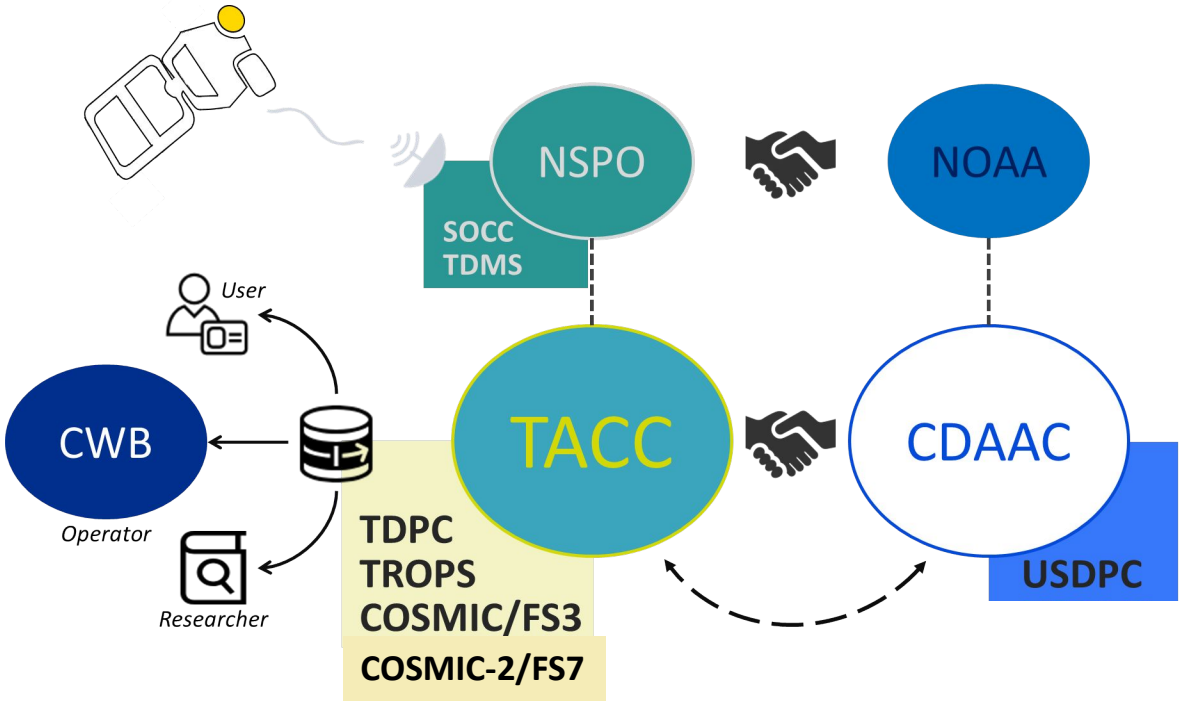
GPSARC GPS Science and Application Research Center

Outline

- Analysis of FORMOSAT-7/COSMIC-2 Radio Occultation Data in the Troposphere
- Data Validation against Other Observations
- Data Assimilation of the FORMOSAT-7/COSMIC-2 RO Data

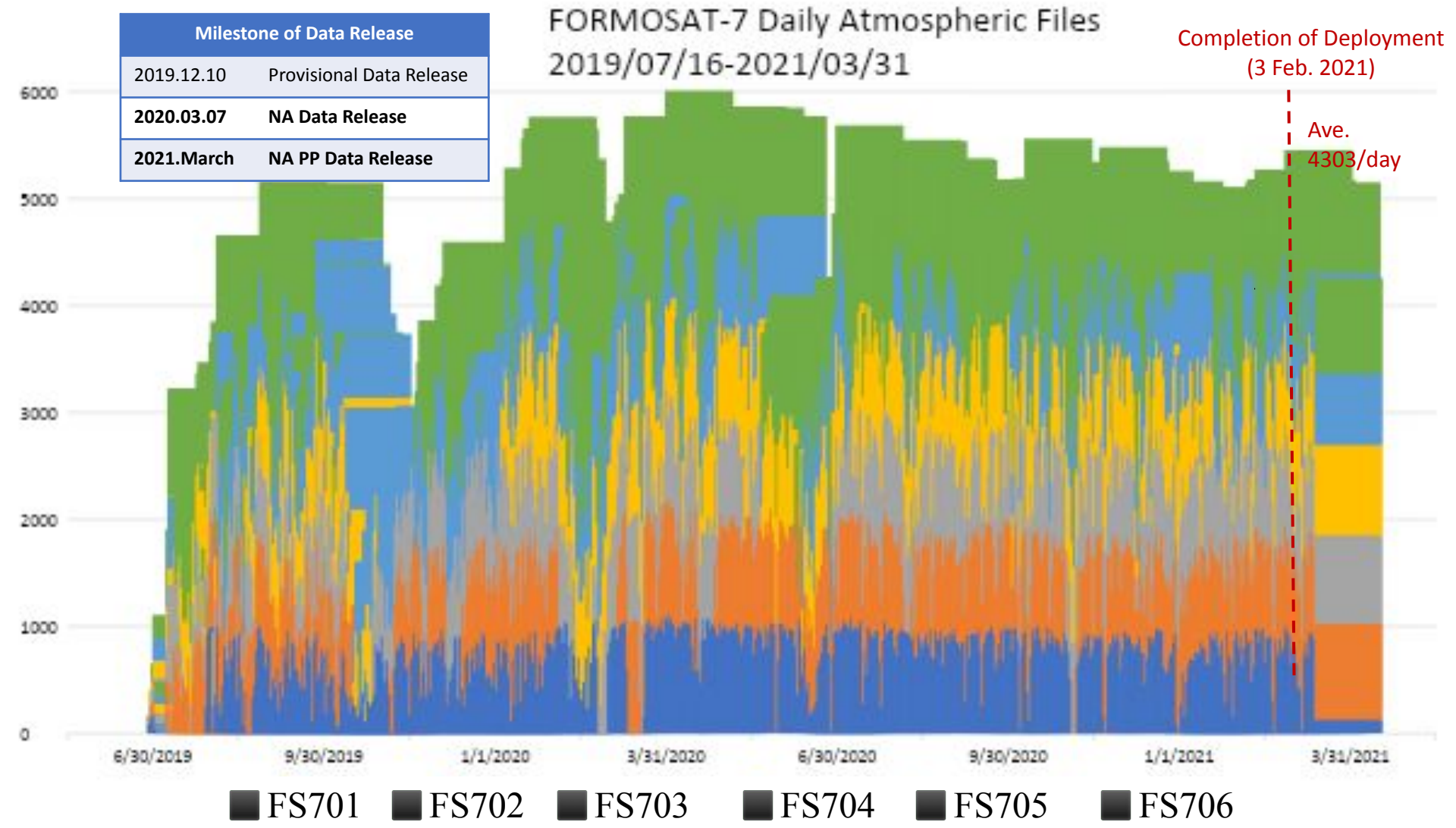
Taiwan Data Processing Center (TDPC)

- TDPC is operating normally in the CWB since FORMOSAT-7 TGRS ON on July 16, 2019.
- TDPC routinely archives FORMOSAT-7 real-time and post-processed raw data and products, software, system configuration and documentation to CWB Mass Storage System.
- TDPC is in charged by Taiwan Analysis Center for COSMIC (TACC).



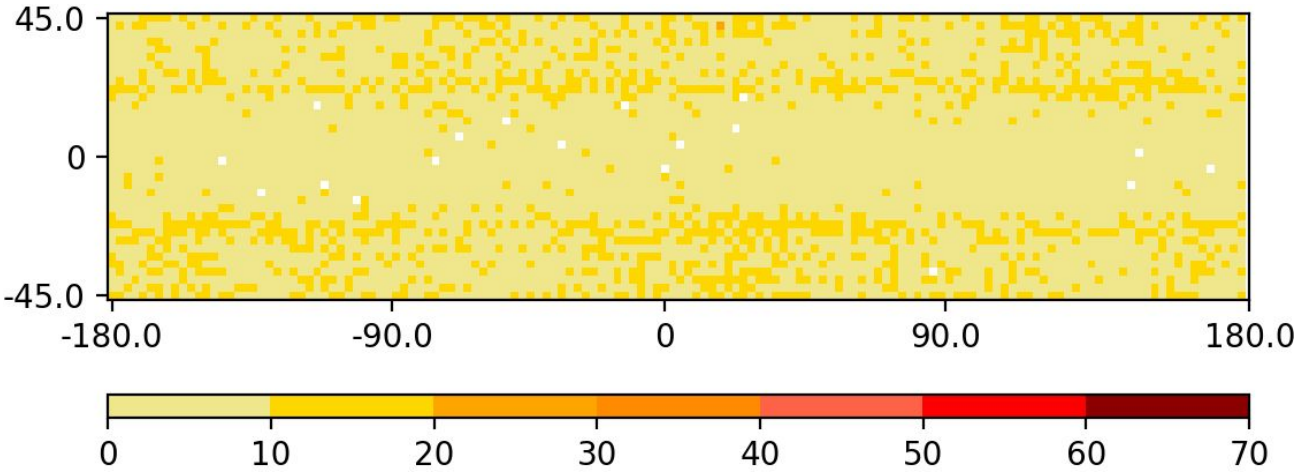
FORMOSAT-7 Daily Atmosphere Files by TDPC

Milestone of Data Release	
2019.12.10	Provisional Data Release
2020.03.07	**NA Data Release**
2021.March	**NA PP Data Release**

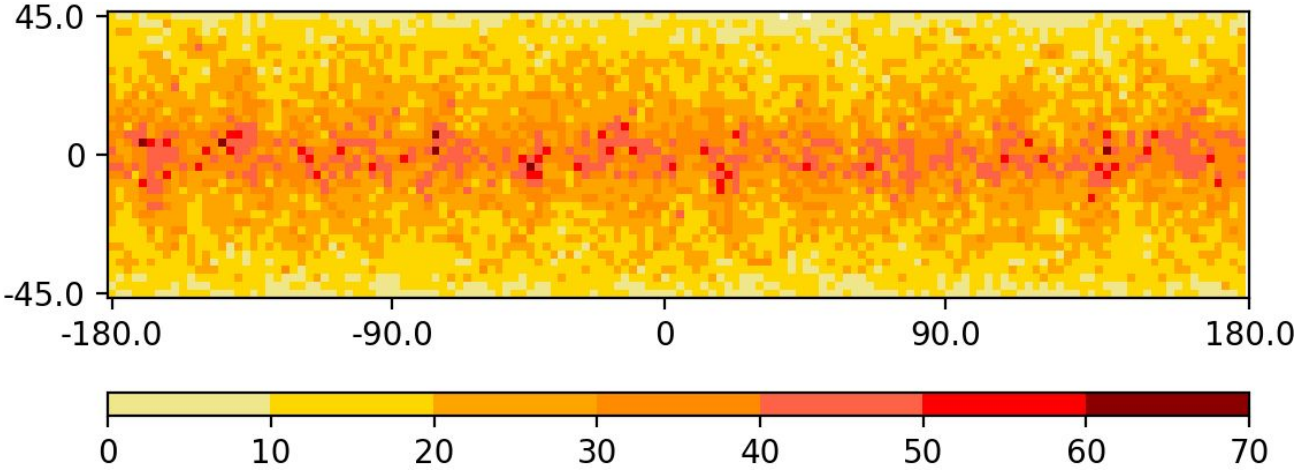


Data density during one month

FS3
Mar. 2009

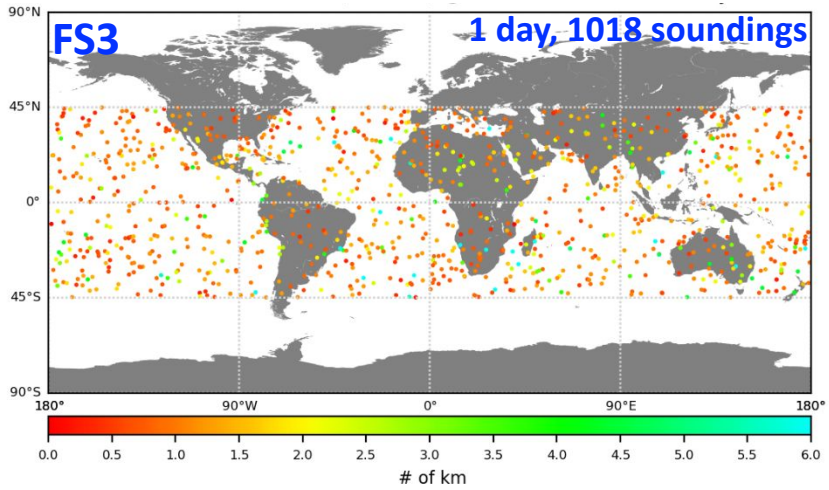


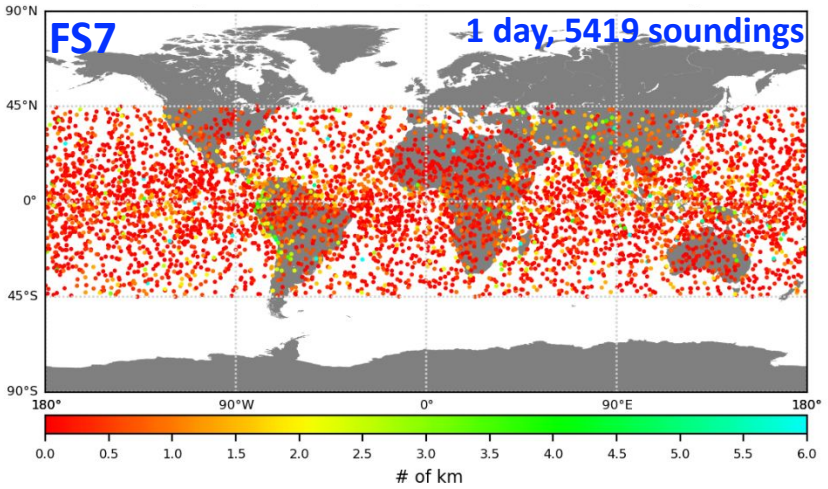
FS7
Mar. 2020

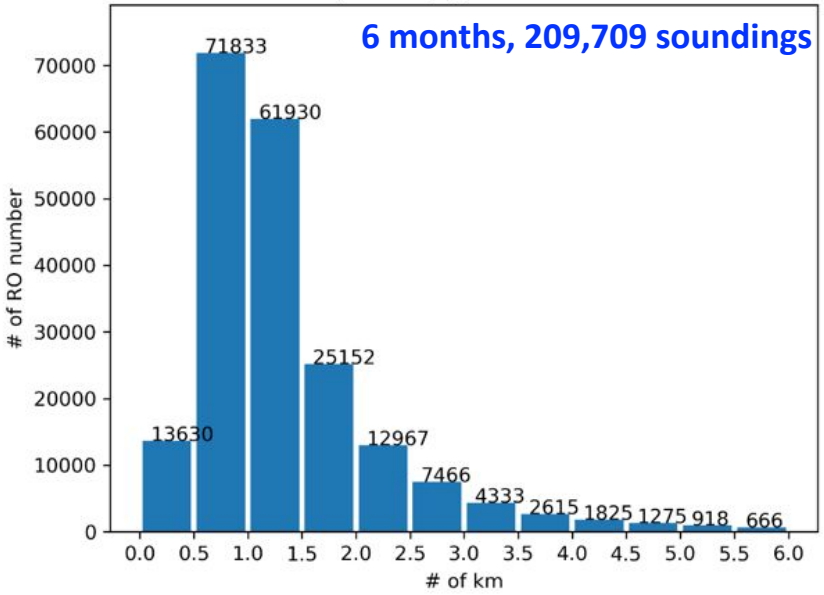


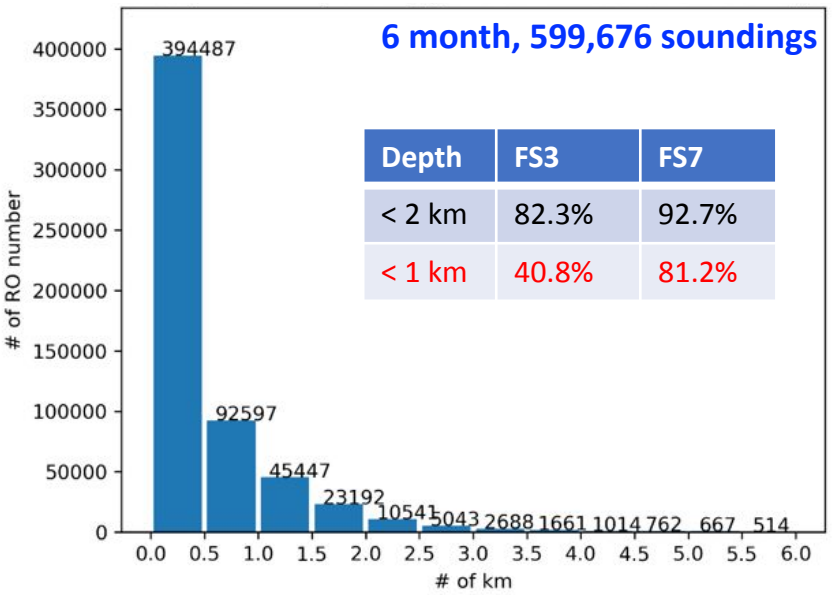
The data are counted on 2.5° by 2.5° bins.

Spatial Distribution and Penetration Depth









Depth	FS3	FS7
< 2 km	82.3%	92.7%
< 1 km	40.8%	81.2%

Verification against Radiosonde

(Oct. 2019-Mar. 2020)

(FS7– RAOB)

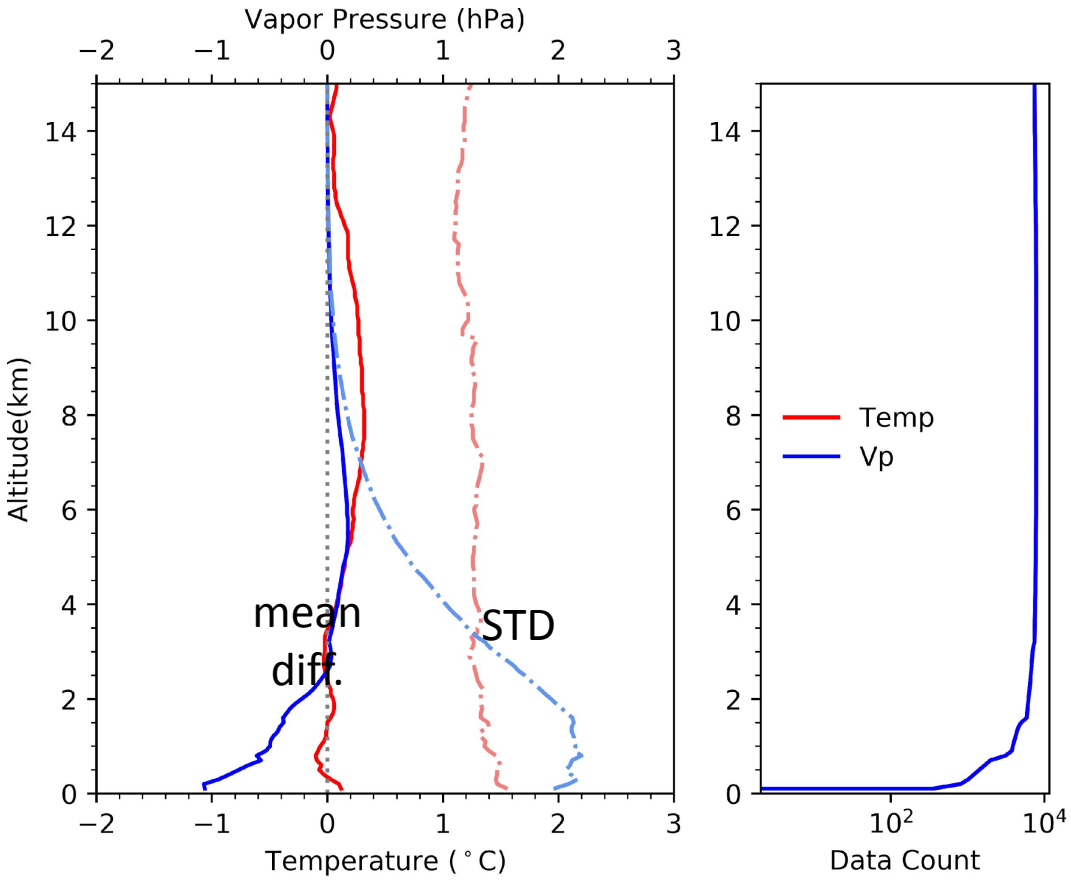
$|\bar{T}| < 0.5℃$

$|\bar{e}| < 1\ hPa$

Average from 0-15 km		
	T (^{o}C)	Vp (hPa)
Diff.	0.14	-0.03
STD	0.12	0.24

Collocation:

± 3 h and $\pm$ 100 km



Chen, S.-Y., C.-U. Liu, C.-Y. Huang, S.-C. Hsu, H.-W. Li, P.-H. Lin, J.-P. Cheng, and C.-Y. Huang, 2021: An analysis study of FORMOSAT-7/COSMIC-2 radio occultation data in the troposphere. *Remote Sens.*,**13**, 717. https://doi.org/10.3390/rs13040717

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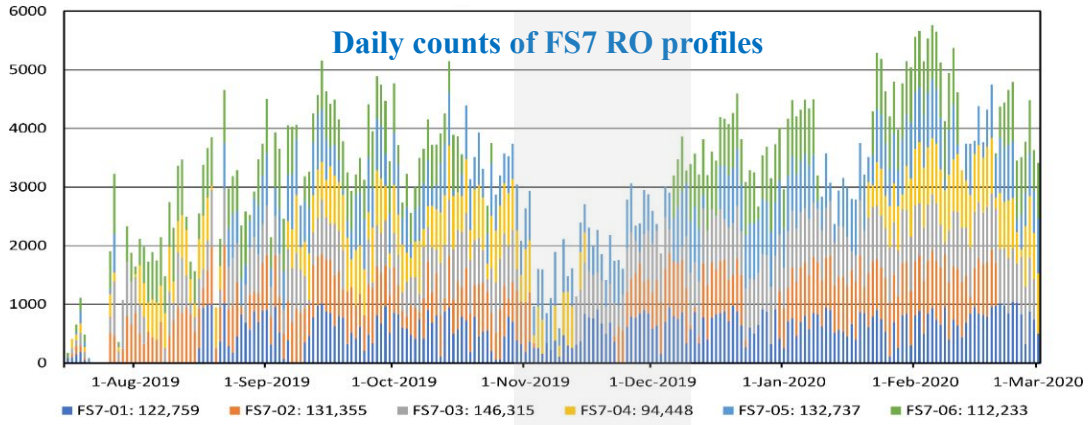
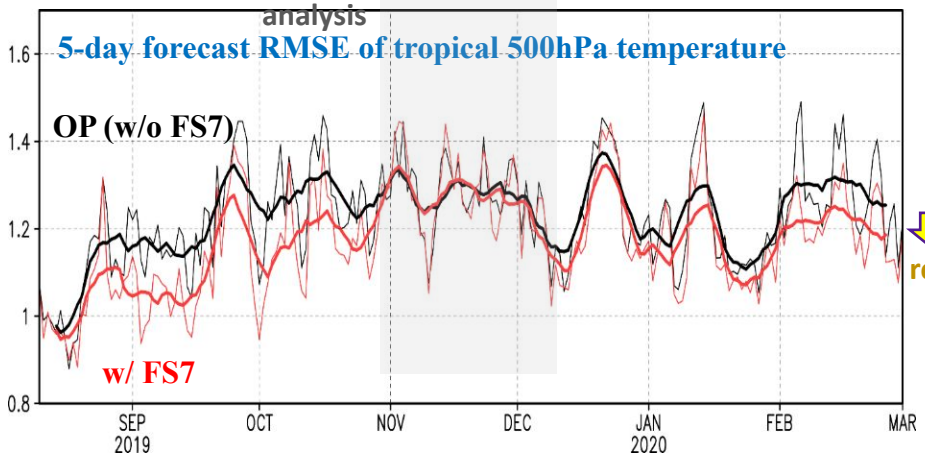
FS7/C2 RO assimilation in the CWB Global Forecast System (CWBGFS)

Period: 4 Aug 2019 – 1 Mar 2020

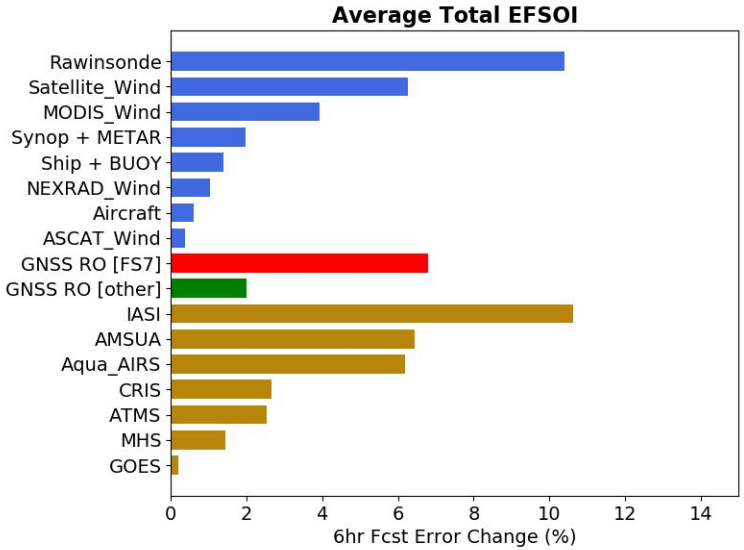


Verified against the NCEP analysis



reduced

4 Aug – 6 Oct 2019



The contributions of FS7/C2 RO data for the total impacts of observations used in the DA system are about 6~8%.

Lien, G.-Y, C.-H. Lin, Z.-M. Huang, W.-H. Teng, J.-H. chen, C.-C. Lin, H.-H. Ho, J.-Y. Huang, J.-S. Hong, C.-P. Cheng, C.-Y. Huang, 2021: Assimilation impact of early FORMOSAT-7/COSMIC-2 GNSS radio occultation data with Taiwan's CWB global forecast system. *Submitted to Mon. Wea. Rev.* (under minor revision).

FS7/C2 Data Impact

Scorecard (22 Oct. 2019 – 1 Mar. 2020)

Green/Red : FS7 is better/worse than OP

Globe NH SH Tropics

			Globe				N. Hemisphere				S. Hemisphere				Tropics			
			Day 1	Day 3	Day 5	Day 7	Day 1	Day 3	Day 5	Day 7	Day 1	Day 3	Day 5	Day 7	Day 1	Day 3	Day 5	Day 7
Anomaly Correlation	Height	250hPa	▲															
		500hPa									▾							
		700hPa									▼							
		1000hPa	▾								▼							
	Vector Wind	250hPa	▲	▲			▲				▲	▲						
		500hPa	▲	▲														
		850hPa	▲	▲														
	Temp	250hPa	▼	▼			▵				▼	▼						
		500hPa		▲							▲	▵						
		850hPa	▲	▲							▾							
RMSE	Height	50hPa	▲	▲	▲	▲	▲	▲	▲		▲	▲	▲	▲	▲	▲	▲	▲
		100hPa	▲	▲	▲	▲	▲	▲	▵		▲	▲	▲	▵	▲	▲	▲	▲
		200hPa	▲	▲	▵		▲	▲			▲	▲			▲	▲	▲	▲
		500hPa	▼								▼				▼	▲	▲	▲
		700hPa	▼								▼				▲			
		850hPa									▼				▲	▲		
		1000hPa	▾								▼				▲	▲	▲	
	Vector Wind	50hPa	▲	▲			▲				▲				▲	▲	▲	▲
		100hPa	▵	▲	▲			▵			▲	▲			▵	▲	▲	▲
		200hPa	▲	▲			▲				▲	▲			▲	▲	▲	
		500hPa	▲	▲											▲	▲	▲	▵
		700hPa	▲	▲											▲	▲	▲	▵
		850hPa	▲	▲											▲	▲	▲	
		1000hPa	▵												▲	▲	▲	
	Temp	50hPa	▲	▲	▲	▲	▵	▵							▲	▲	▲	▲
		100hPa		▲	▲	▲	▲	▲			▲	▲	▵			▲	▲	▲
		200hPa	▲	▲			▲	▲			▲	▵			▲	▲	▲	▲
		500hPa		▲							▲	▲				▲	▲	▲
		700hPa	▲				▲				▲				▲			▲
		850hPa	▲	▲							▾				▲	▲	▲	▵
		1000hPa									▼					▾	▼	

▲	Better at 99.9% significance level
▵	Better at 99% significance level
	Better at 95% significance level
	Not statistically significant
	Worse at 95% significance level
▾	Worse at 99% significance level
▼	Worse at 99.9% significance level
	Not applicable

Statistically significant positive impact in tropics; Neutral-to-positive impact in other areas

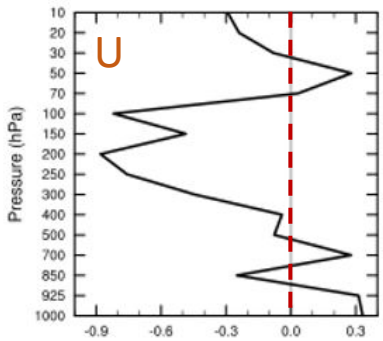
The FS7/C2 RO data have been operationally used in CWBGFS since 15 September 2020.

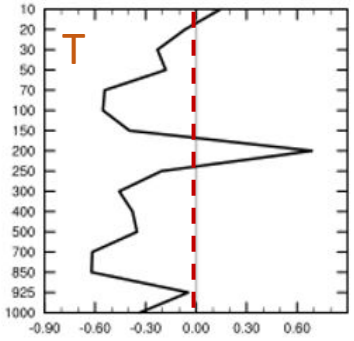
FS7/C2 Data Impact

Data assimilation with FV3GFS system in CWB

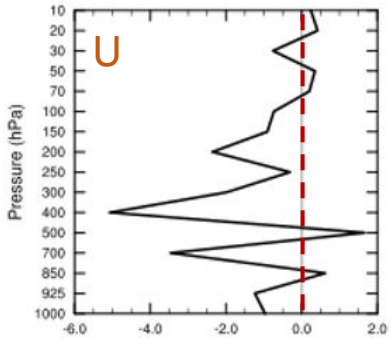
- Data period: 2020 Jan
- Verification against Radiosonde

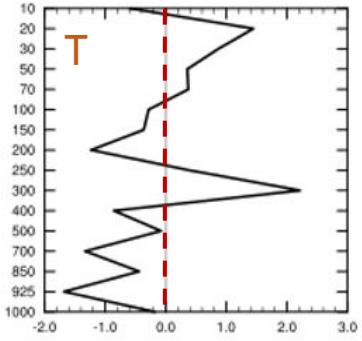
N. Hemi.



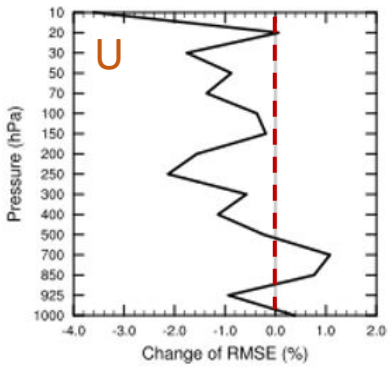


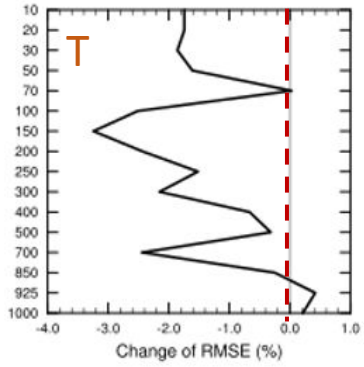
S. Hemi.





Tropics





Reduction in fit-to-observations relative to Control

$$\frac{EXP - CTL}{CTL} * 100\%$$

EXP: w/ FS7

CTL: w/o FS7

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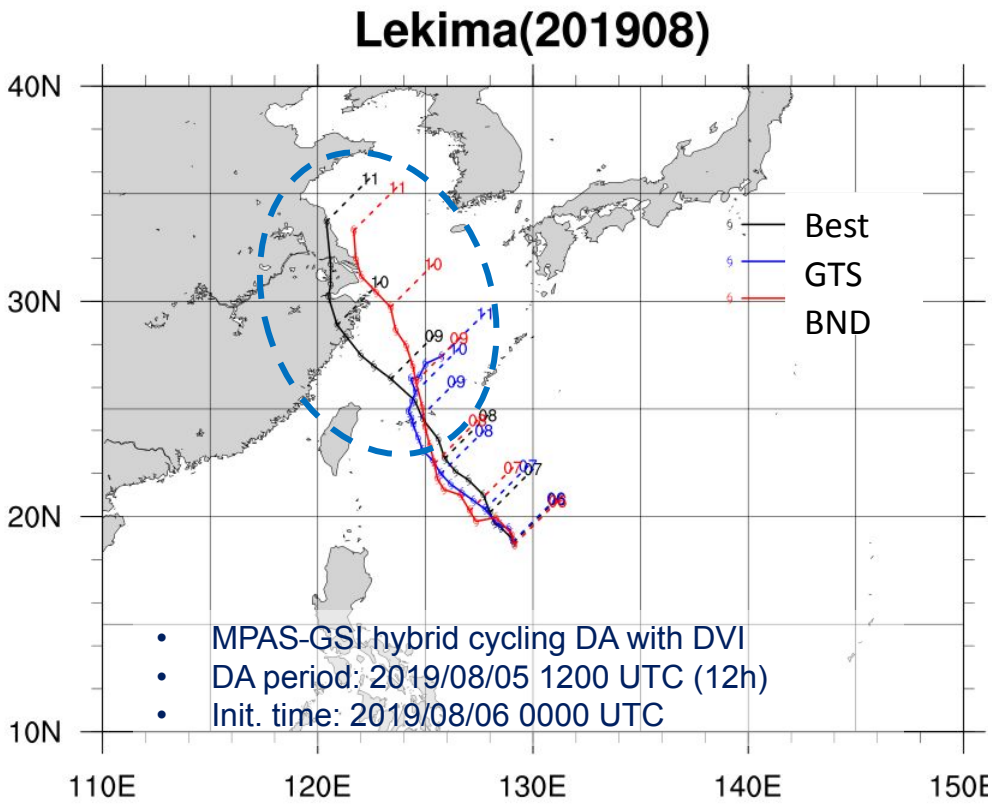
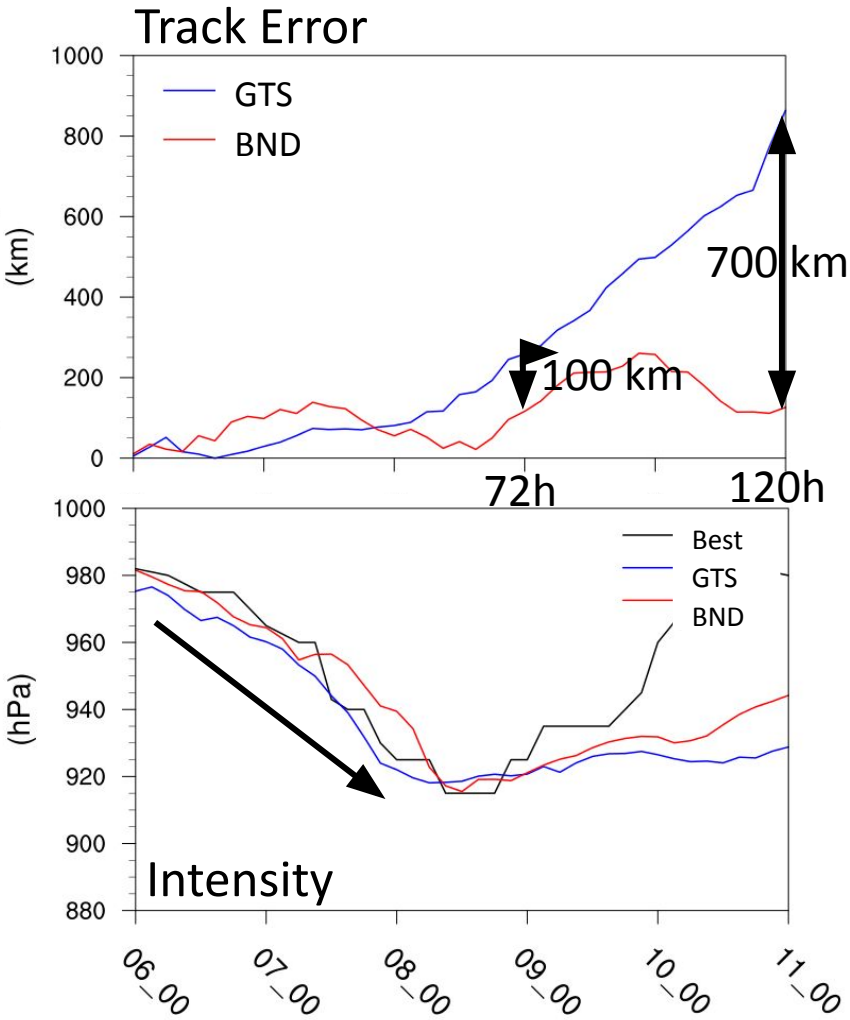
Typhoon Lekima (2019)

TC prediction with the global model (MPAS)

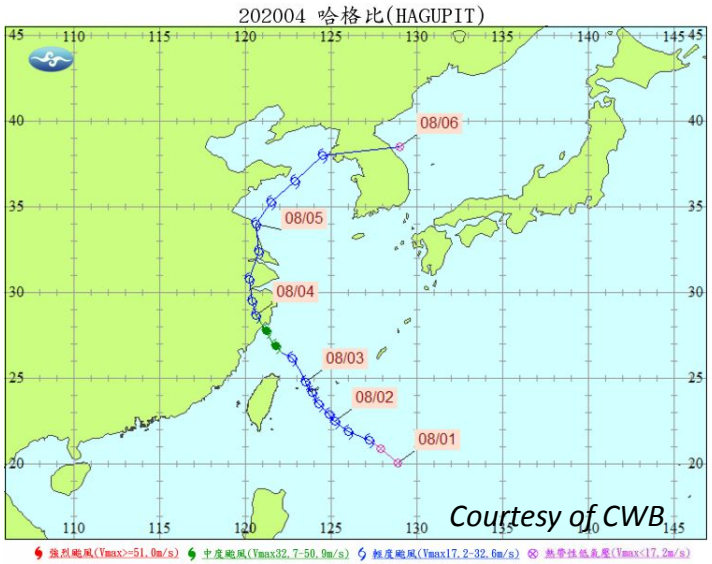
GTS: DA with conventional and satellite data
BND: DA with both GTS and GNSS RO

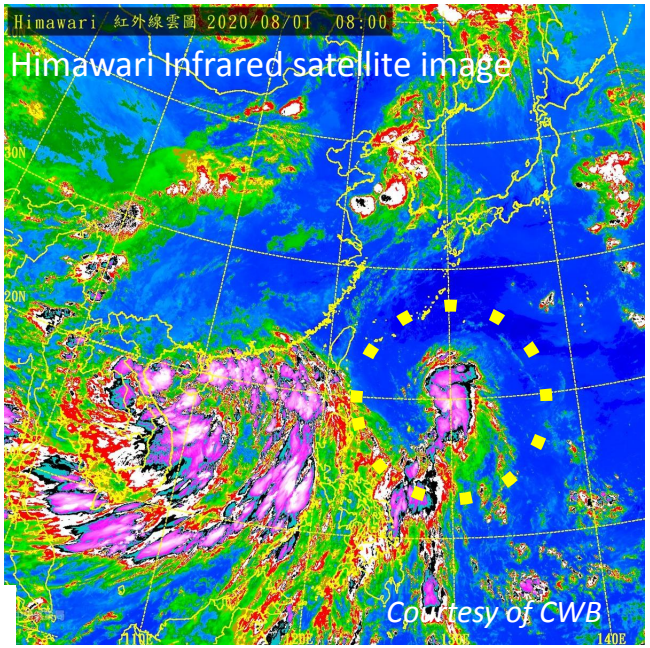


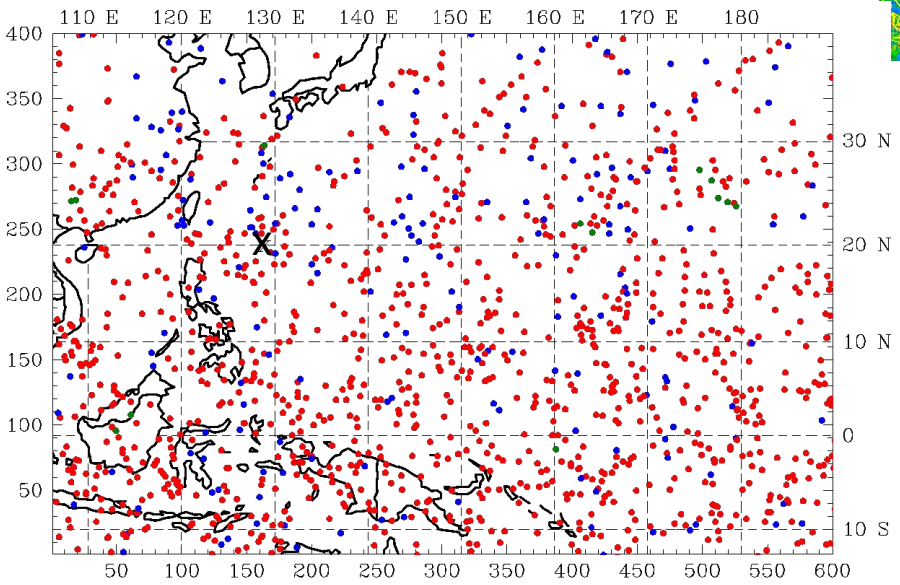


Typhoon Hagupit (2020)

Genesis of Hagupit at 0000 UTC 1st Aug. 2020







Experimental design:

WRF-WRFDA hybrid cycling DA

DA period: 2020/07/27 0000 UTC (3d)

Init. time: 2020/07/30 0000 UTC

● : FORMOSAT-7/COSMIC-2
● : METOP
● : KOMPSAT-5
X : Hagupit

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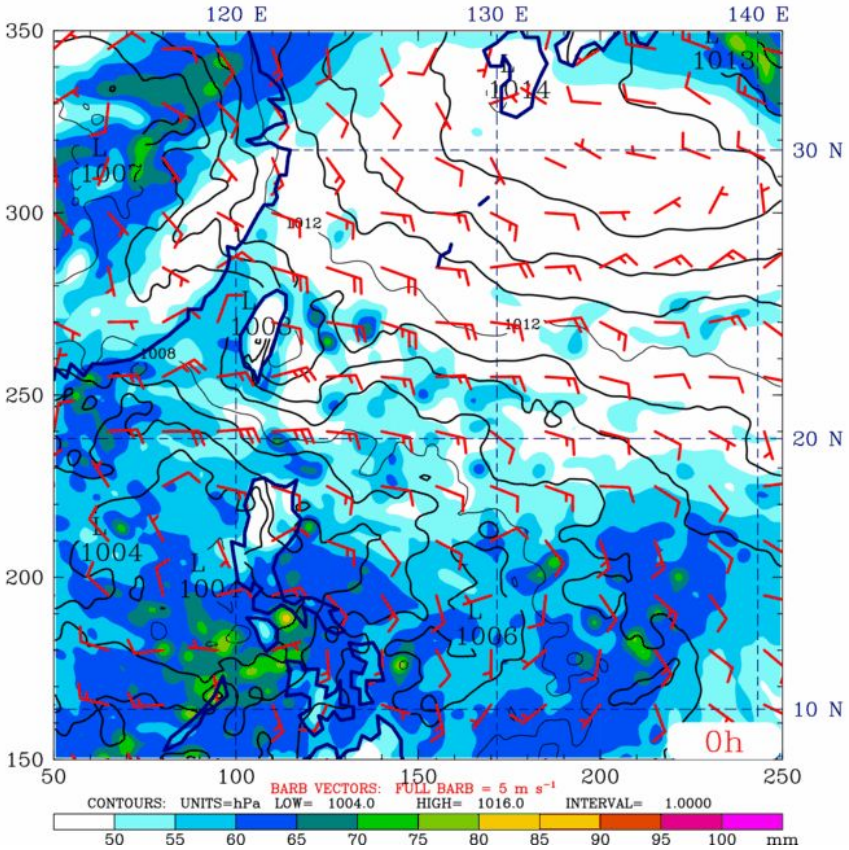
Genesis of Typhoon Hagupit (2020)

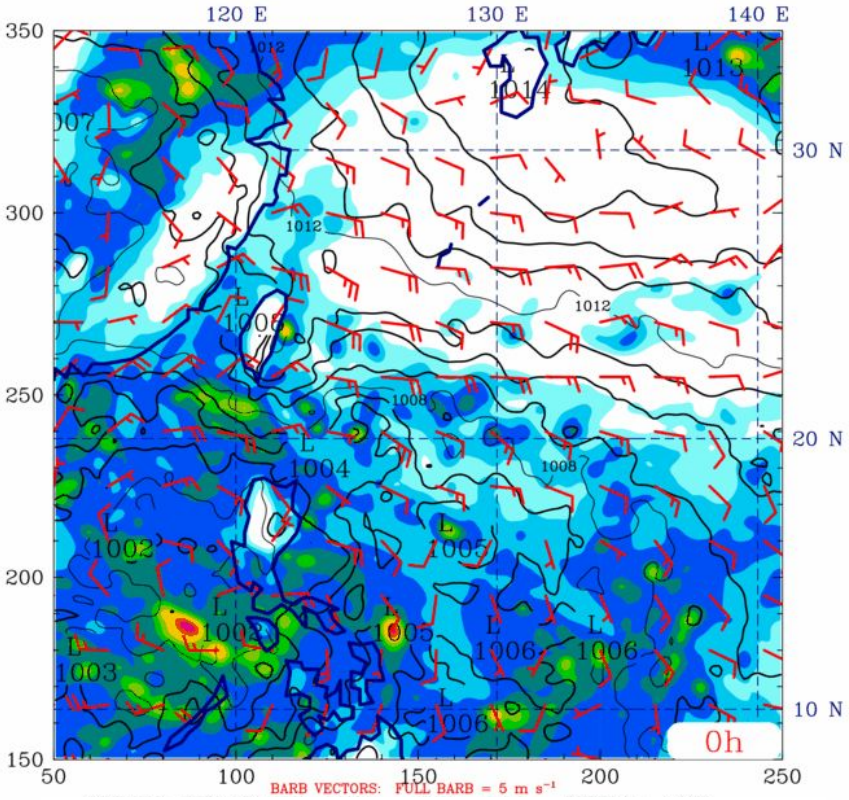
TC prediction with the regional model (WRF)

without RO



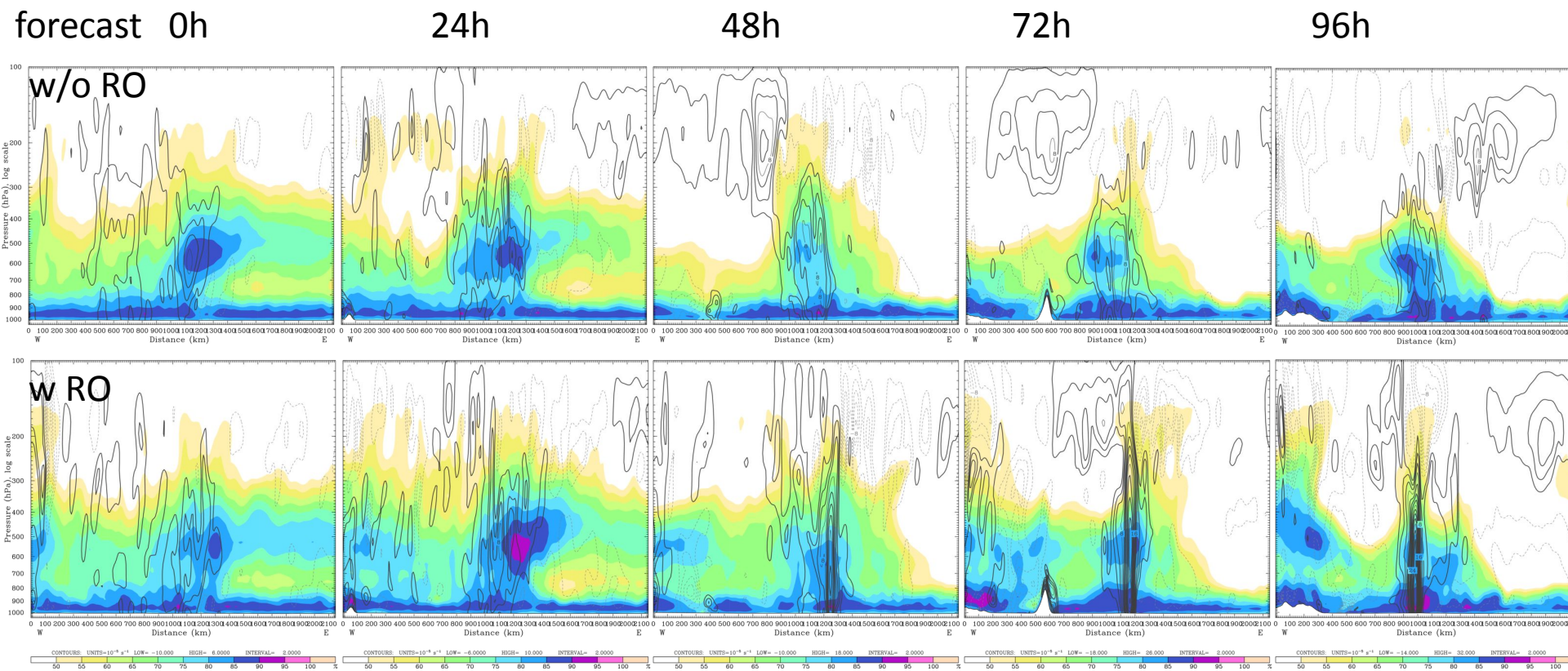
color: Total precipitable water (mm)
contour: Sea-level pressure (hPa)

with RO



Genesis of Hagupit after 48-h WRF simulation

Relative Humidity and Vorticity



color: relative humidity (%)
contour: relative vorticity ($2x10^{-5}s^{-1}$)

Summary

- Abundant FS7/C2 data (average > 4,000) are provided daily and have better penetration depth, with more than 80% of data reaching below 1 km.
- FS7 verifications against radiosonde show the absolute mean difference and STD of temperature profiles less than 0.5 ^{o}C and 1.5 ^{o}C, respectively, and deviations of water vapor pressure within 2 hPa in the lower troposphere.
- FS7/C2 data used in the CWB operation performs statistically positive impacts on the model forecast, especially in the tropical region.
- The model simulations with GNSS RO data (including FS7) assimilation for two case studies, i.e., Typhoon Hagupit (2020) and Typhoon Lekima (2019), show significant improvements on the predictions of cyclogenesis and track, respectively.

Invitation to submit

https://www.mdpi.com/journal/atmosphere/special_issues/typhoon_prediction_models

atmosphere

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Guest Editors

Dr. Ching-Yuang Huang, Dr. Shu-Ya Chen

Deadline

24 September 2021

Special Issue

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