Impact of TRITON R-windspeed assimilation on severe weather prediction and recent investigation of GNSS RO/R observations in deep troposphere

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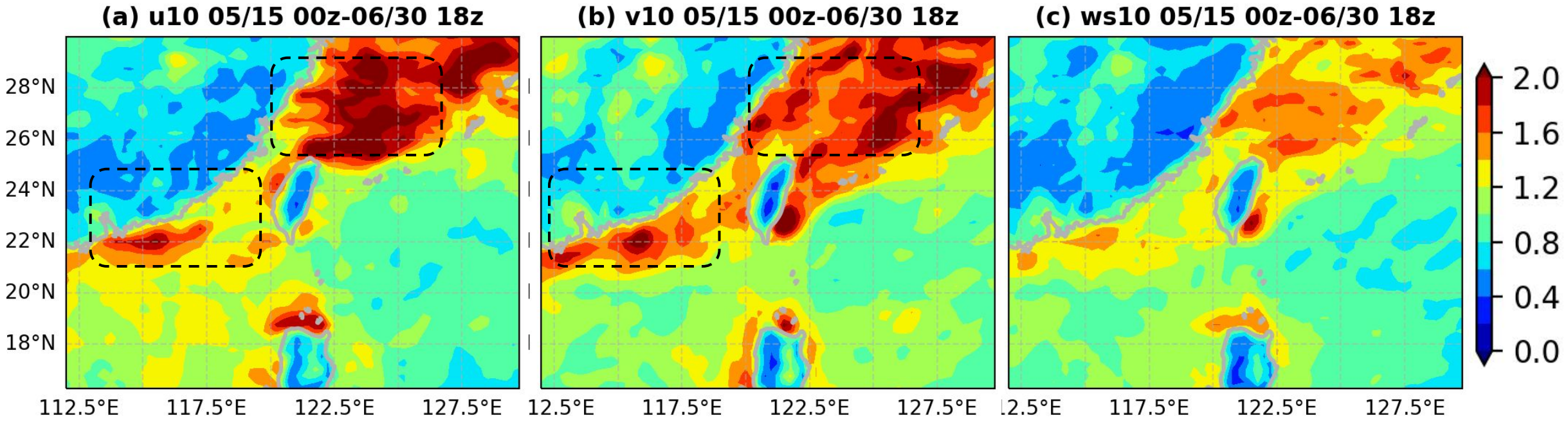
COSMIC/JSDA workshop, IROWG—10, 12-18 September, NCAR

Difference between ERA5 and FNL analyses

Data period (May and June 2024)

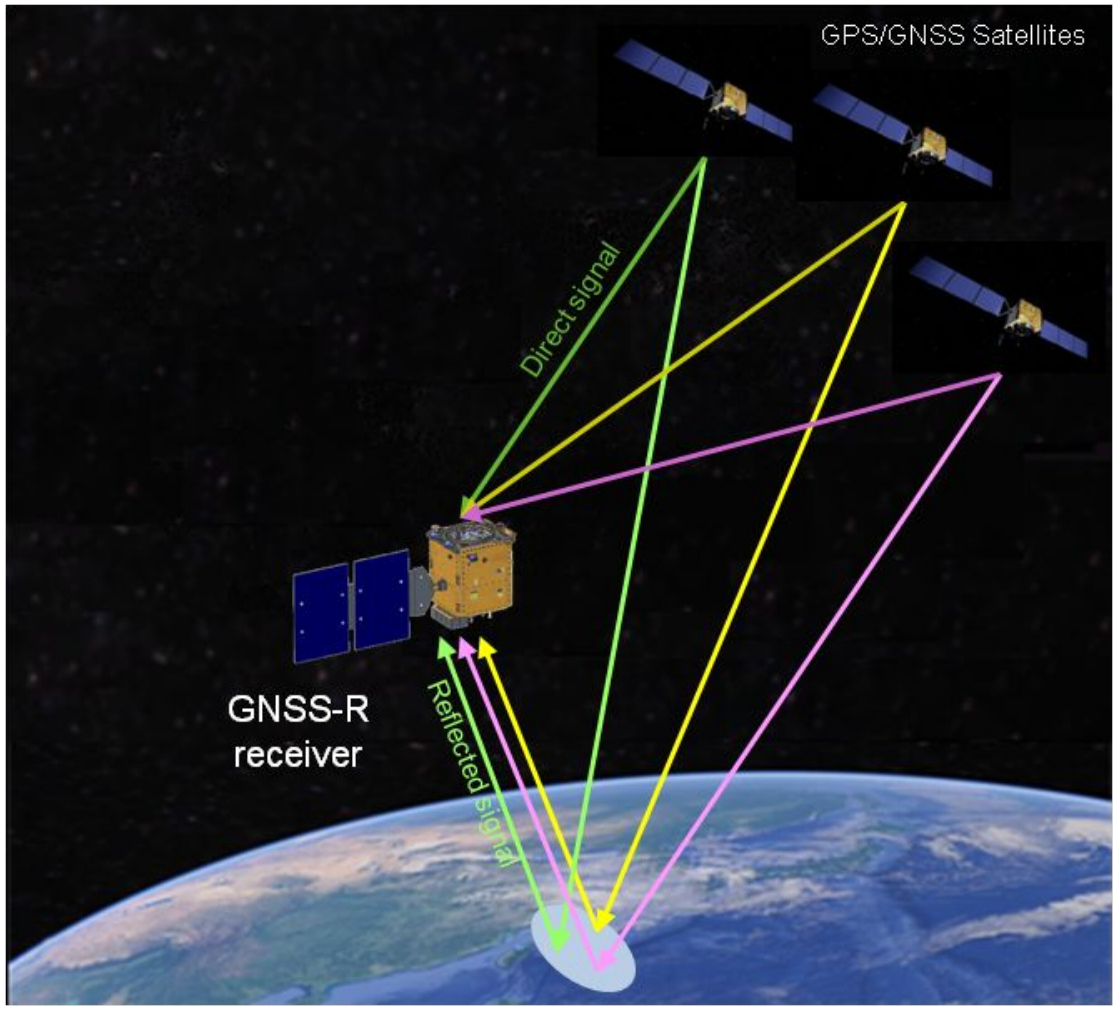


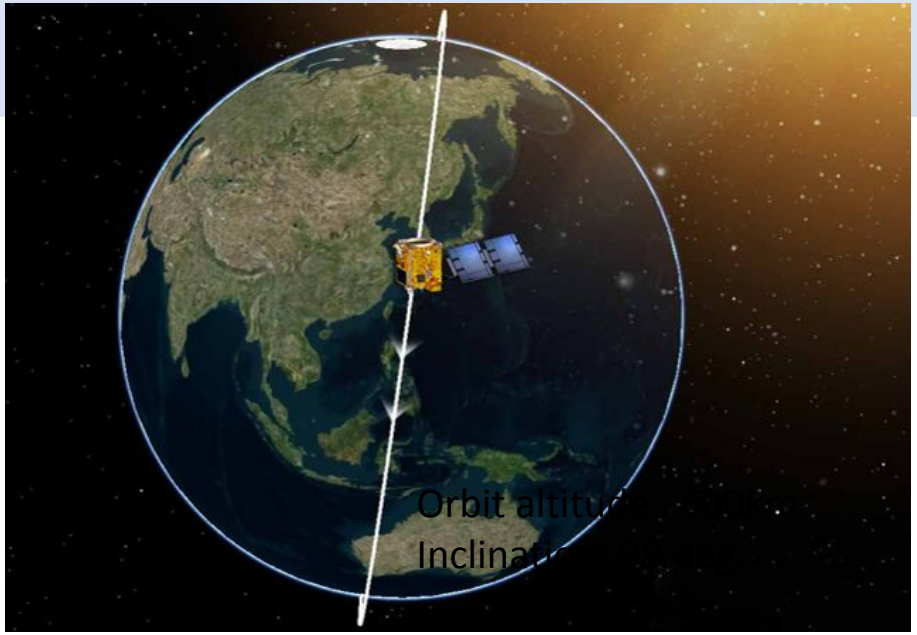
- Large differences in the front area and northern part of the South China Sea
- Ocean surface wind is critical for moisture transport and rainfall location.

TRITON mission

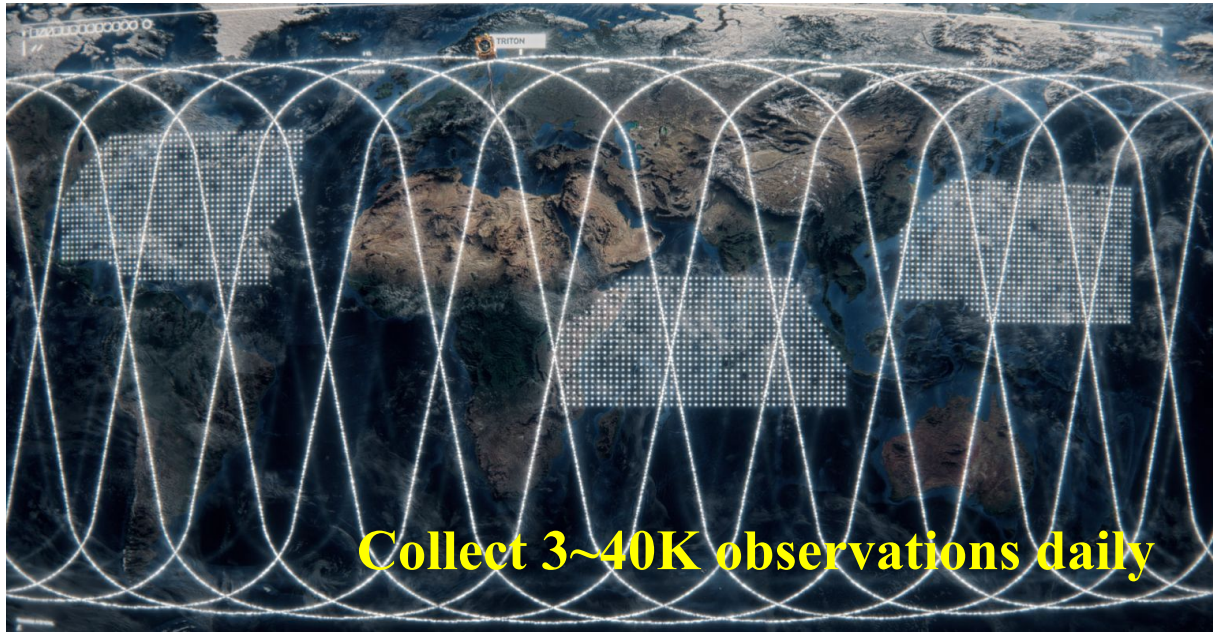
(launched in Oct. 2023)

Triton provides Earth surface reflected signals from GNSS satellites for remote sensing applications (GNSS-R).



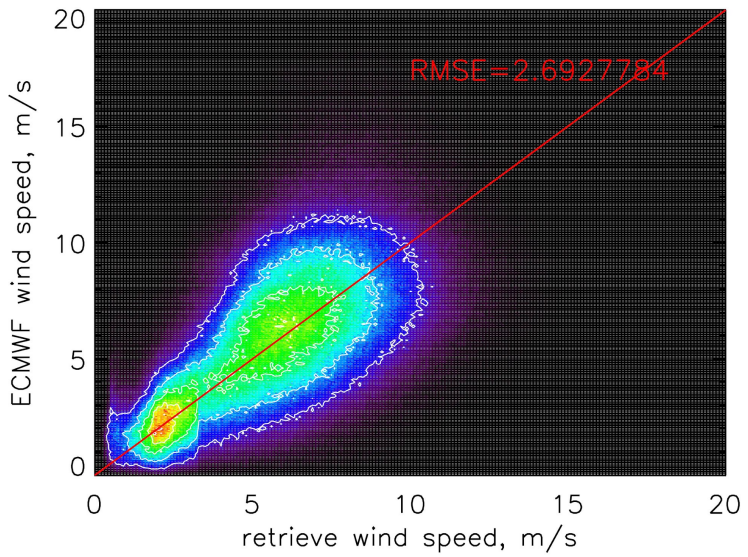


Areas of observation : Pacific, Atlantic, and Indian oceans



Current status of TRITON data

Data Cal/Val



RMSE=2.7 m/s

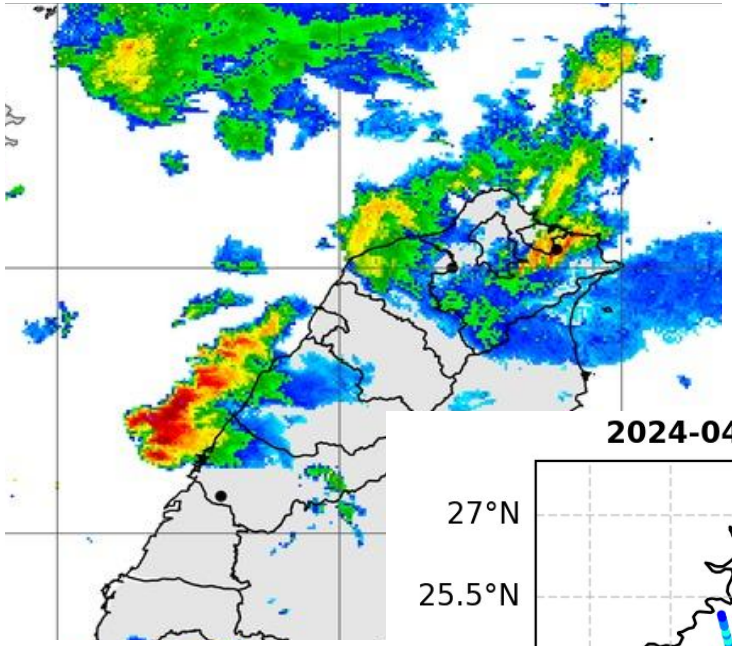
Products

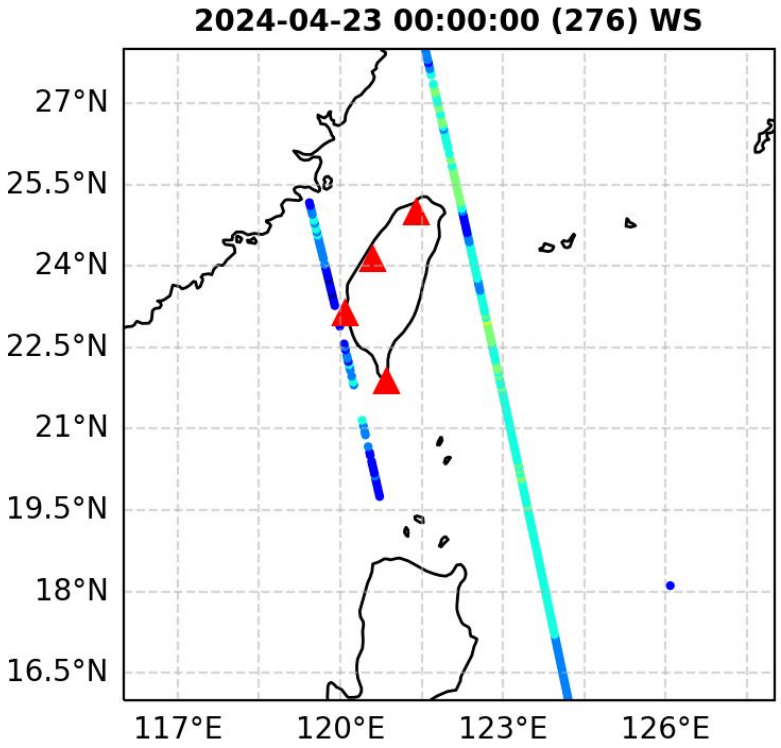
2024/05/31 Wind speed (<20m/s) is released

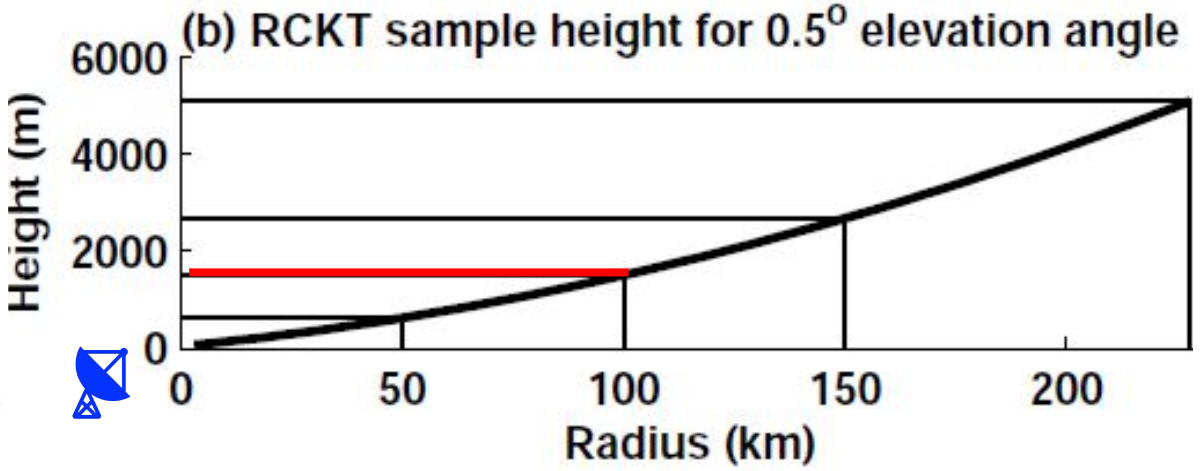
7000-8000 data per day

data	note
Auxiliary data	Associated parameters for retrieval
DDM	Original and calibrated
Ocean wind speed	**<20m/s ± 3m/s**
Ocean surface roughness	Mean Square Slope, MSS
	Significant Height, Hs

Incorporating the R-Wind data with radar data for convective-scale data assimilation

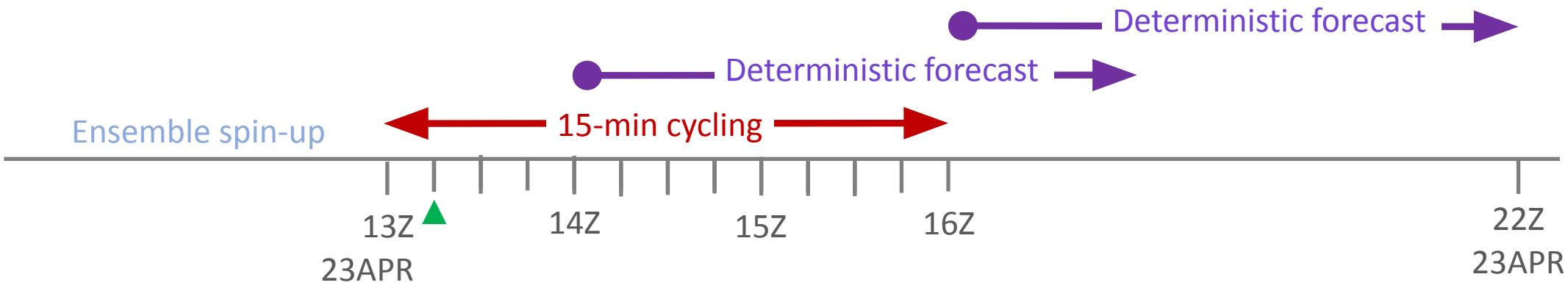






R-Wind can compensate for the near-surface limitation of the coastal ground-based radar.

Data assimilation and experiments



- WRF V4.0 (27-9-3km)
- WRF-LETKF convective-scale ensemble data assimilation system
- 3-h DA period with a 15-min rapid-update
- Observation
  - Radial velocity and reflectivity of four radar (12-km localization)
  - Ocean surface wind speed from TRITON (150-km localization)

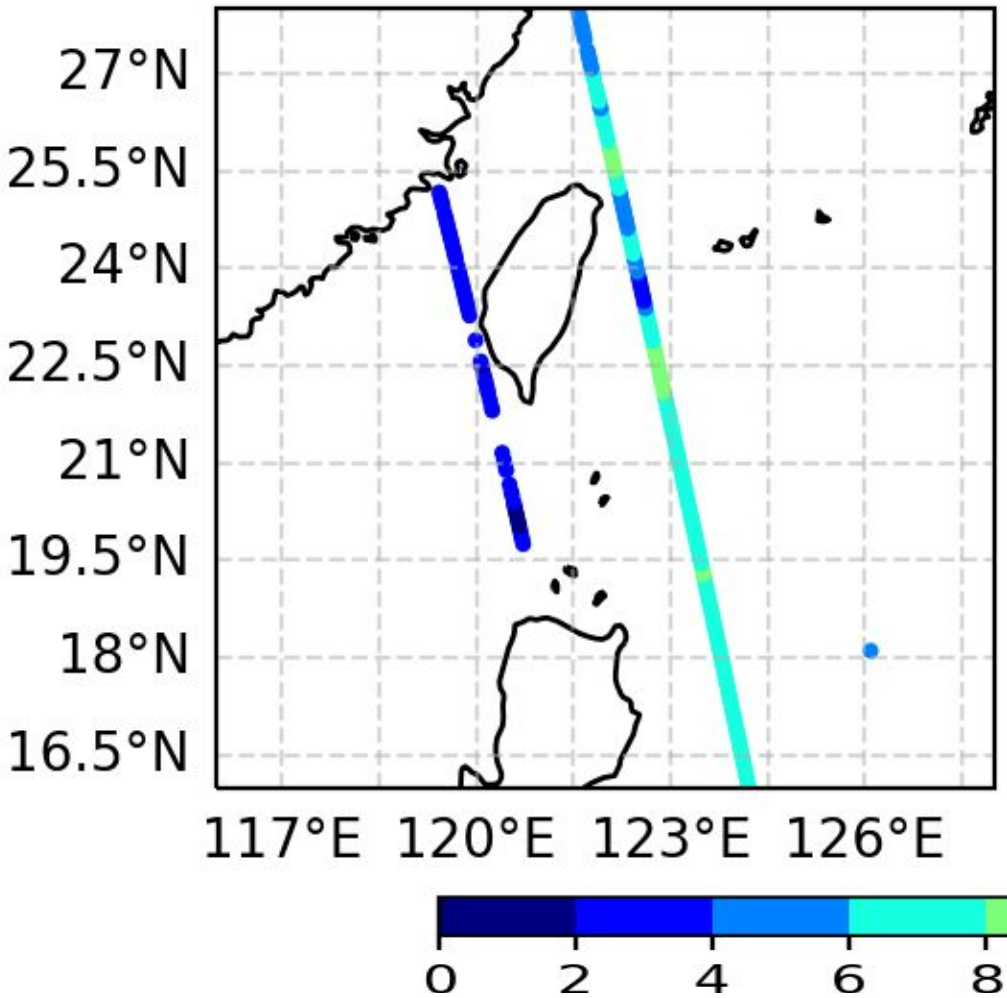
Experiments:

Radar: Radar Vr+Zh

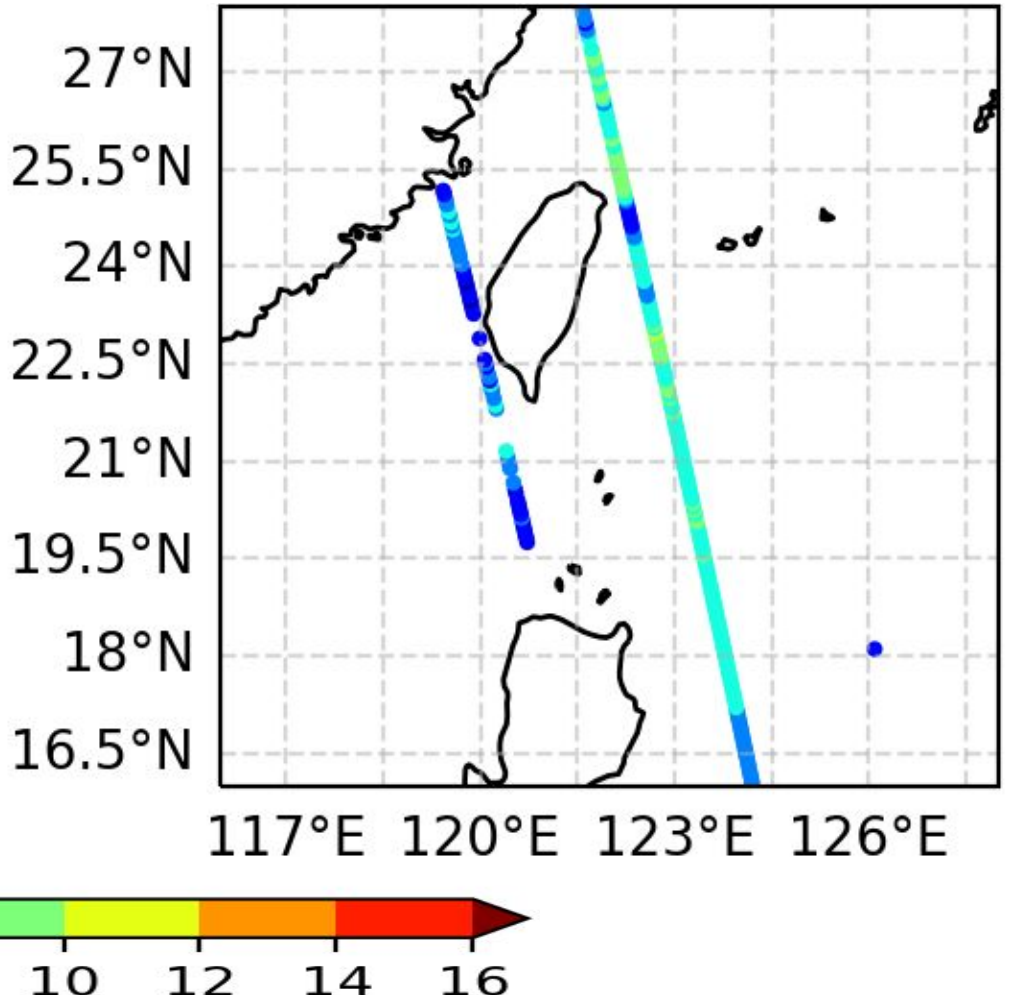
RW: Radar + Triton WS (at 1315)

RW-thin: Radar + Triton thinning (assimilate 25% data at 1300,1315,1330,1345)

2024/04/23 ERA5 wind speed

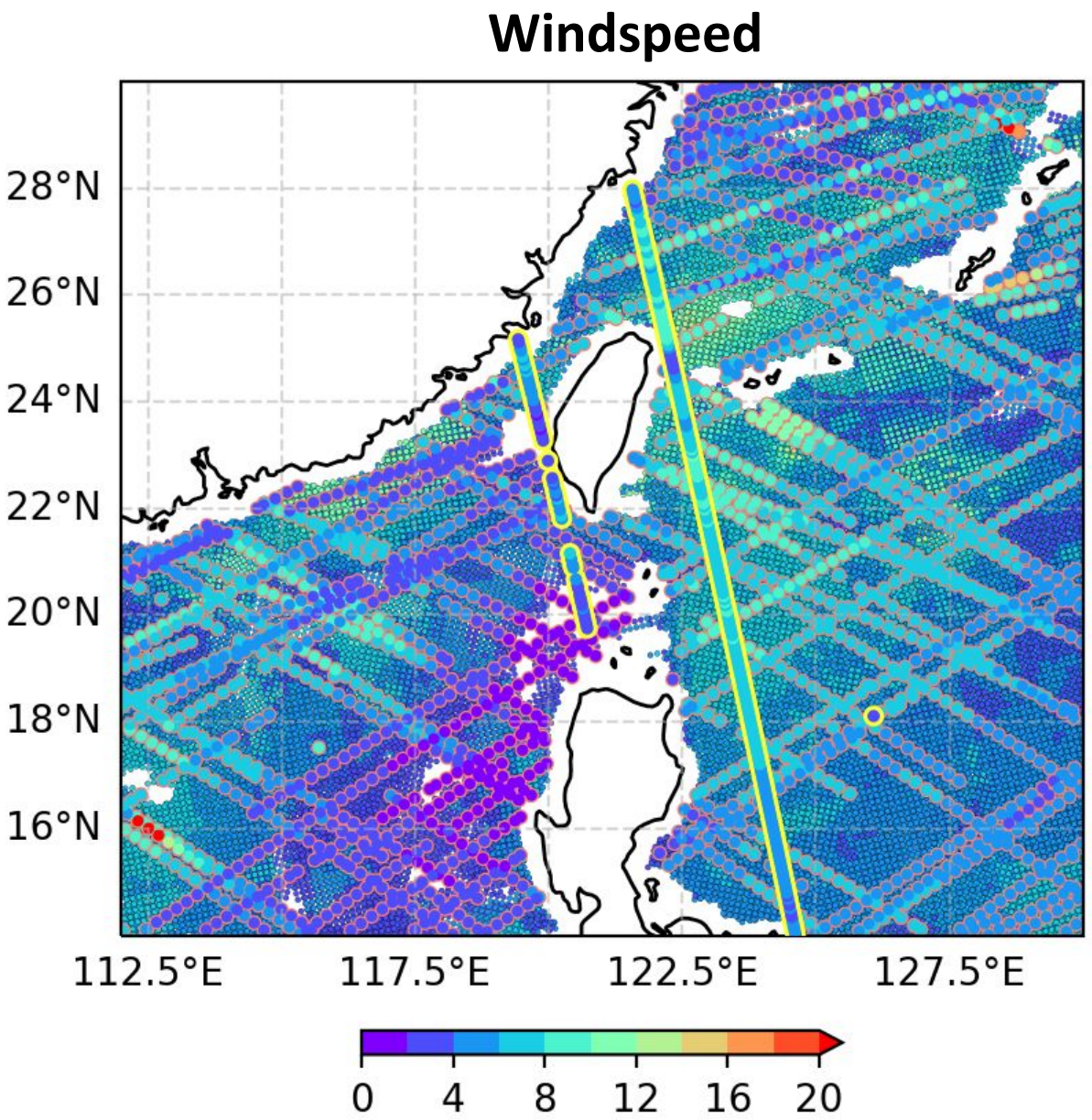


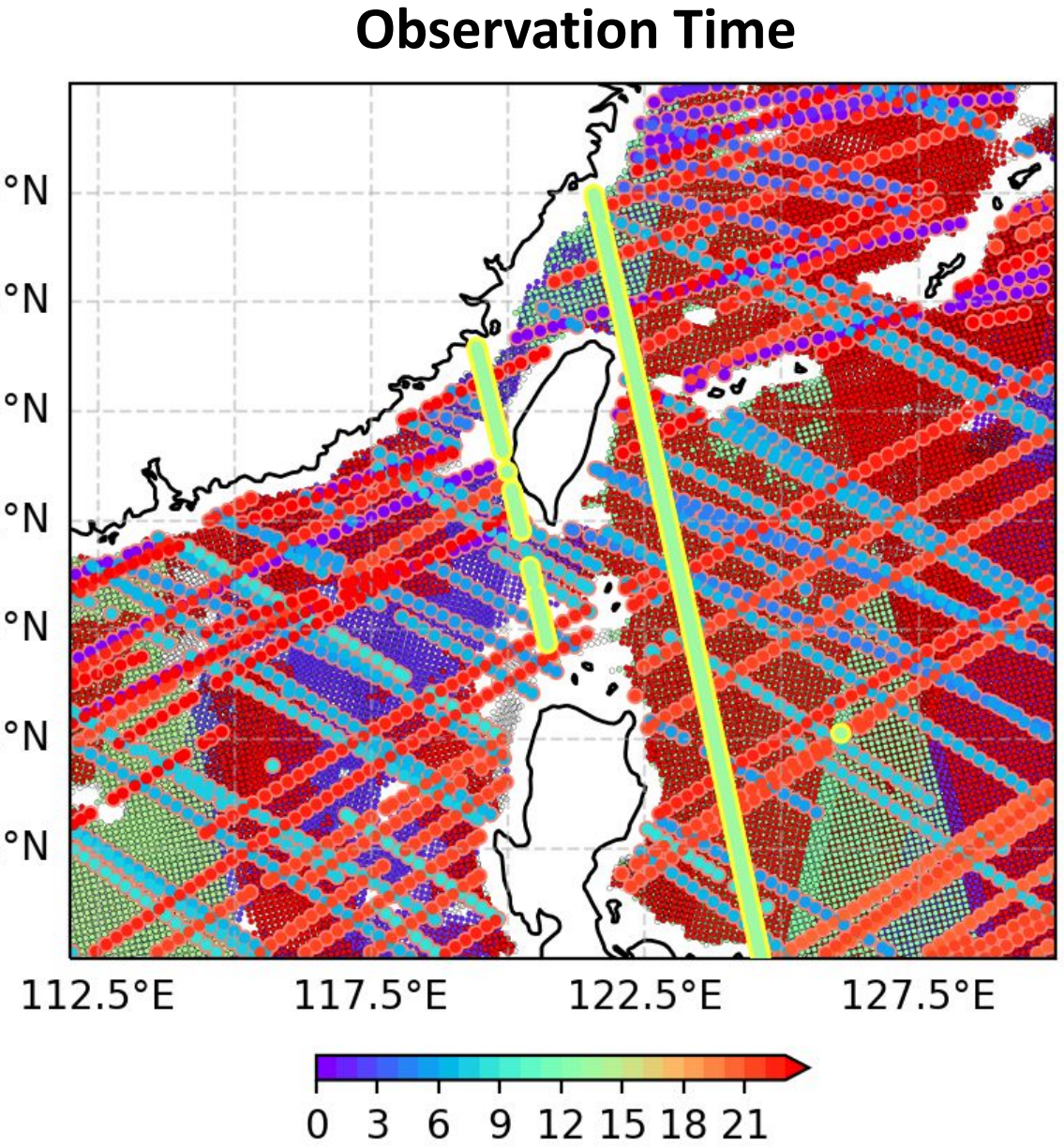
2024/04/23 TRITON wind speed



Triton wind speed is consistent with the ERA reanalysis!

TRITON, CYGNSS and ASCAT on 23 April



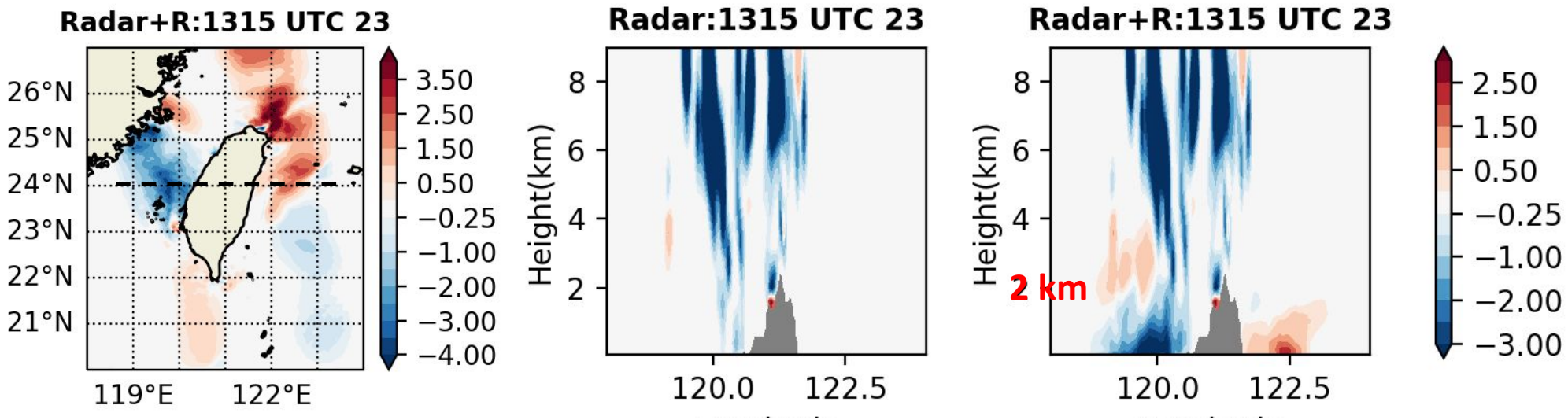


Analysis Correction

Surface

Vertical Cross-section

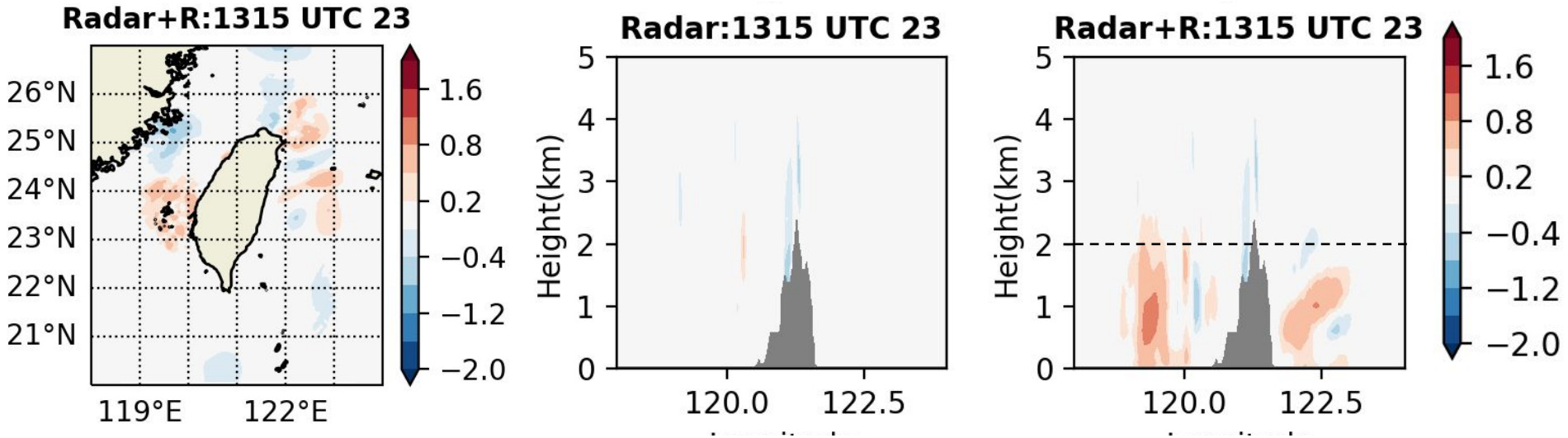
Windspeed correction



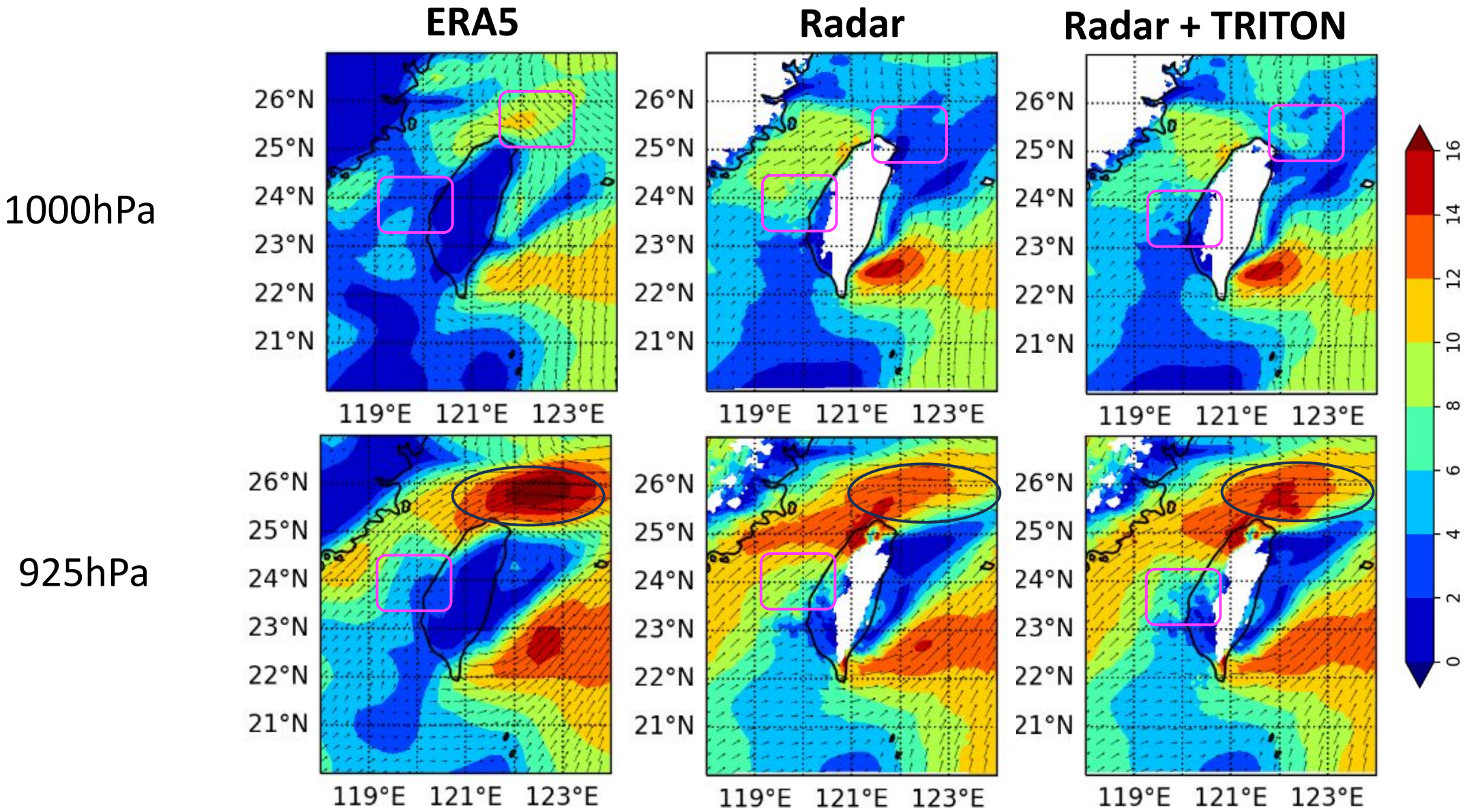
Surface

Vertical Cross-section

Moisture correction

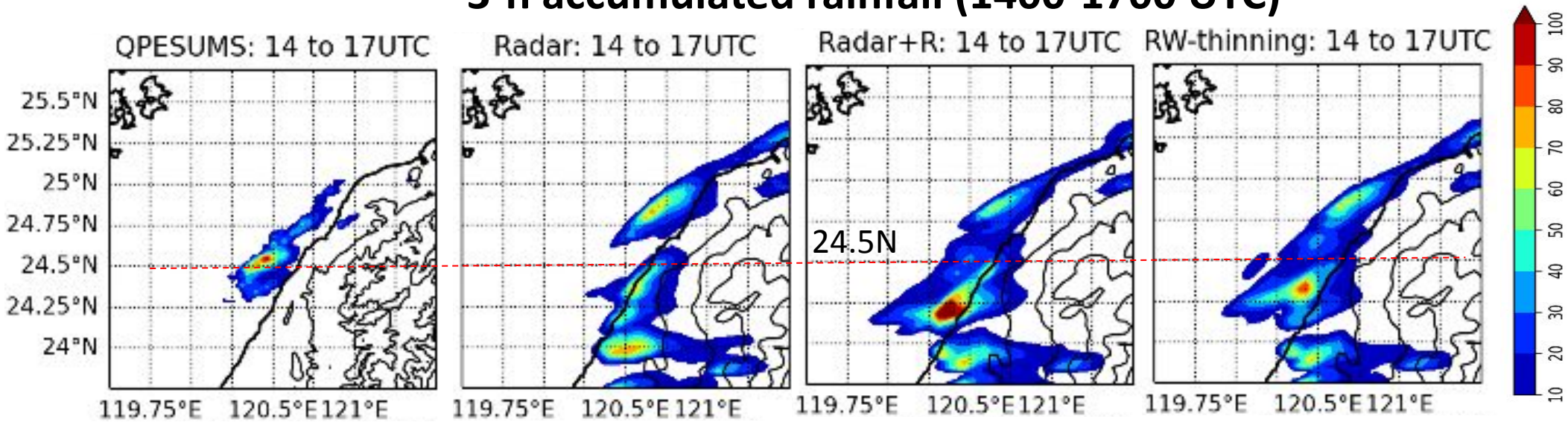


Low-level windspeed (6/24 2100 LST)



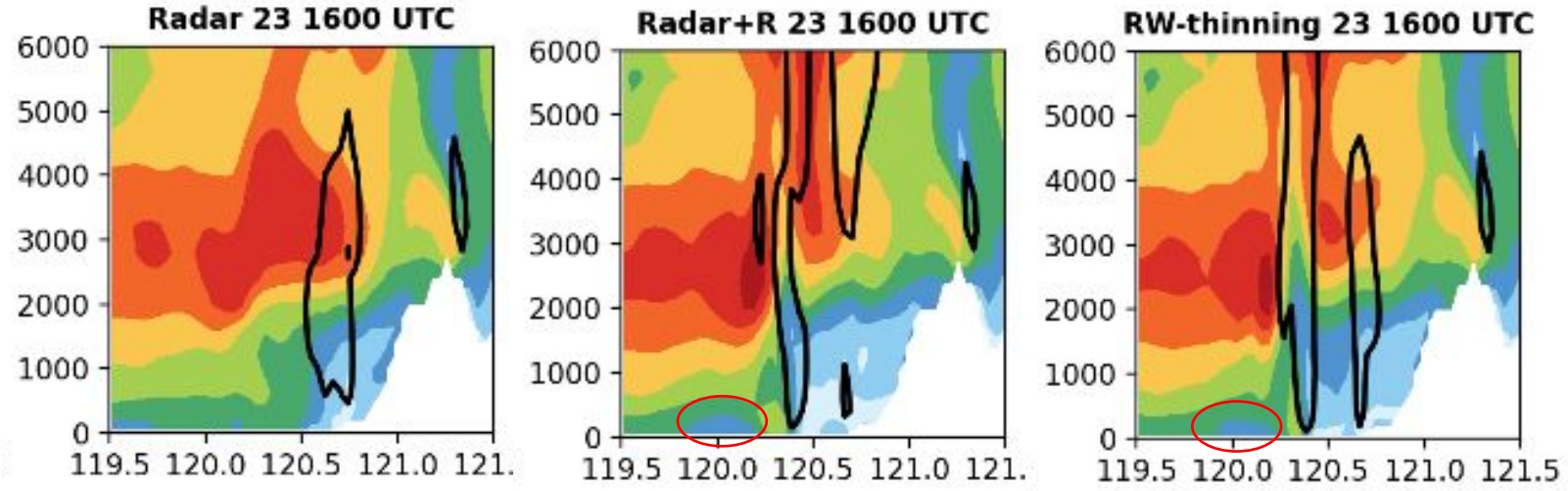
Forecast initialized at 1400 UTC

3-h accumulated rainfall (1400-1700 UTC)



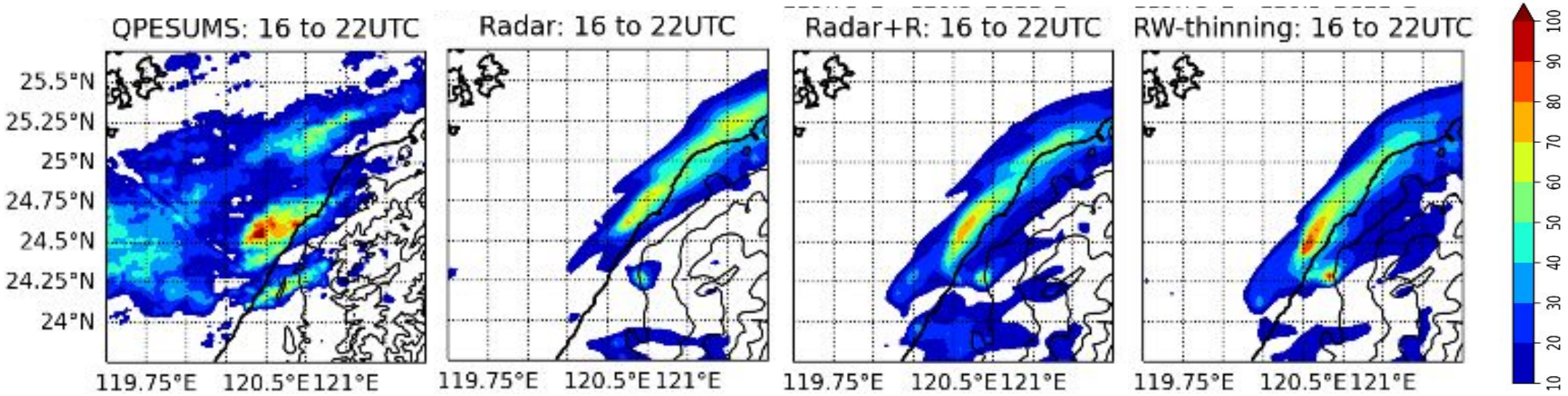
Cross-section of wind speed (color) and vertical motion (contour)

Improve the location and intensity of the rainfall



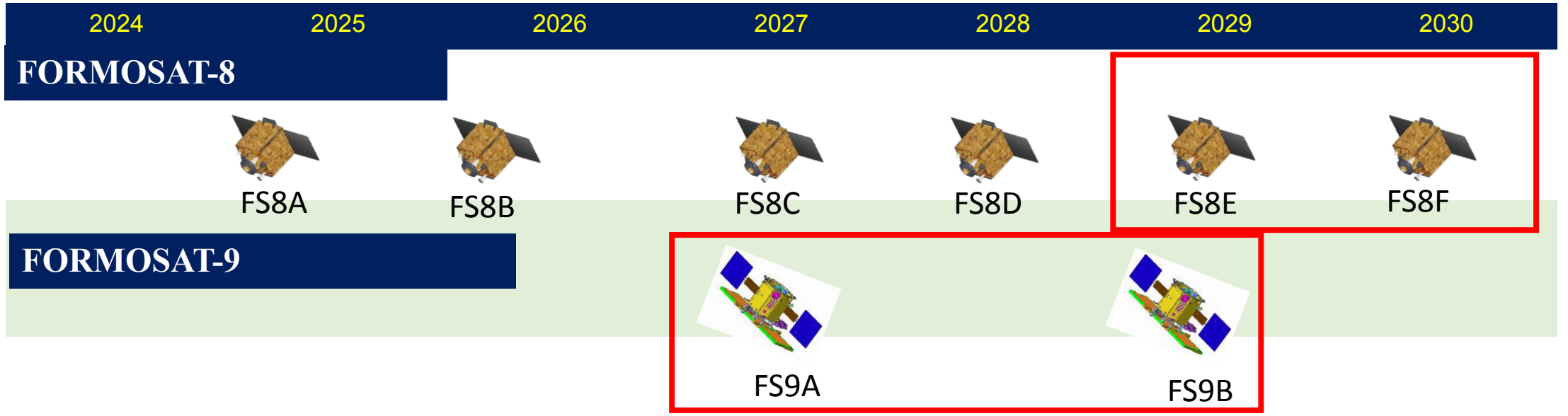
Forecast initialized at 1600 UTC

´6-h accumulated rainfall (1600-2200 UTC)



R-Wind can compensate for the near-surface limitation of radar observations and improve rainfall prediction!

FS8 and FS9 Schedule

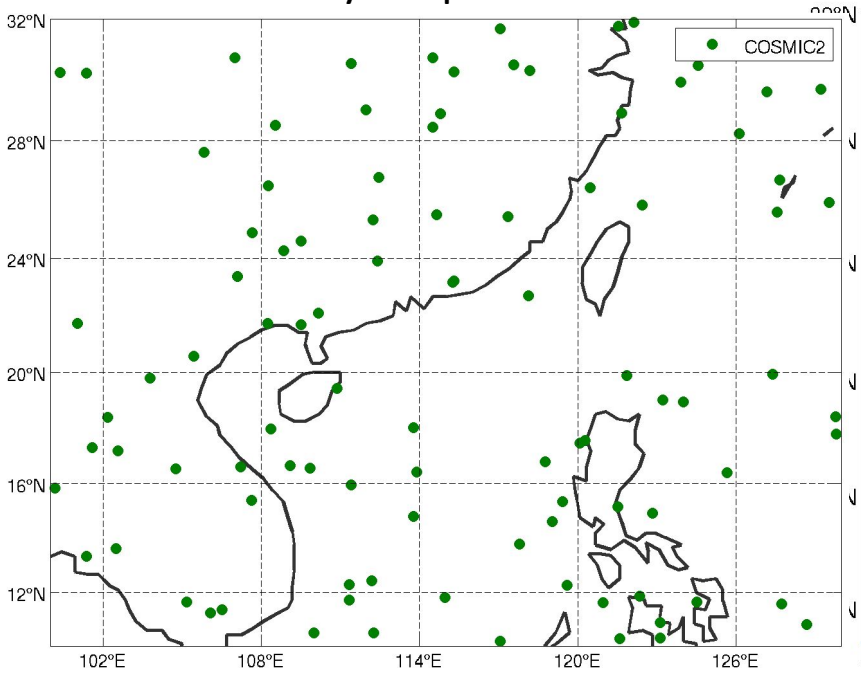


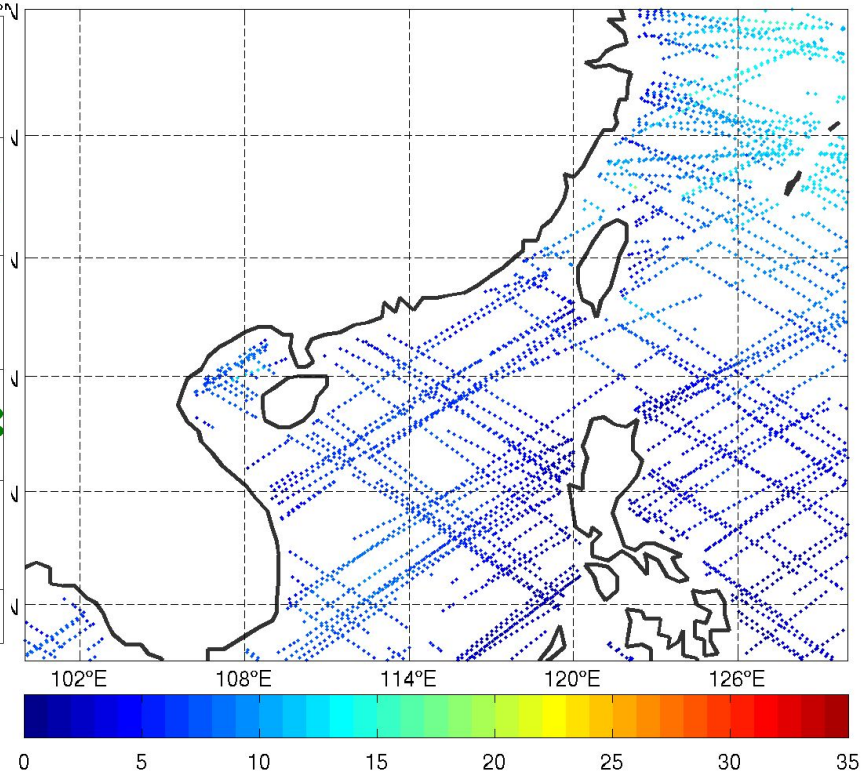
SAR (FORMOSAT-9A)		A	B
Mission life	5 Years		
Mission Orbit	514±5 km Sun Synchronous	LTDN 11:30 [TBD]	~LTDN 11:30 [TBD]
Attitude Accuracy	Pointing Knowledge: within 0.012 deg (3axis, 3σ); Pointing Accuracy: within 0.022 deg (3axis, 3σ)		
Launch Year		2027	2029
2nd PL		GNSS-RO/R	GNSS-RO/R

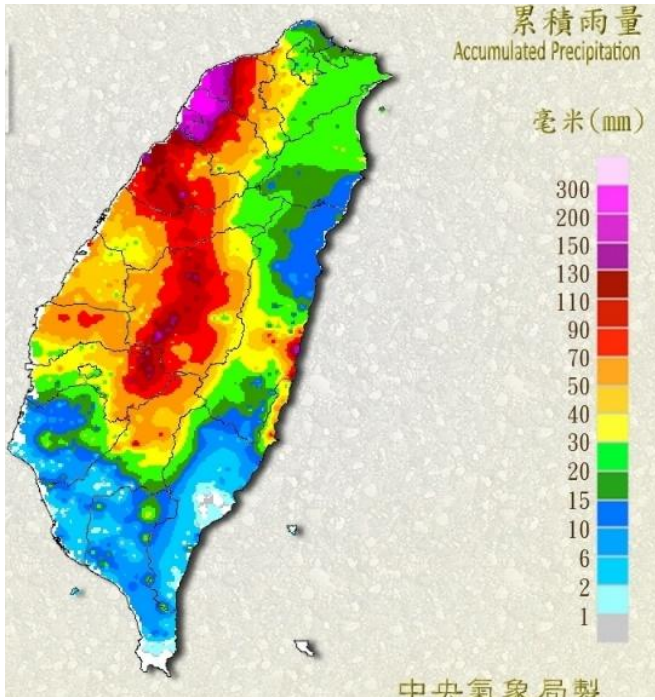
Impact of RO+R assimilation on rainfall prediction

- **WRF-LETKF**
  - WRF V4.0 (15-3 km grid spacing), 63-member
- 3-h assimilation interval/window for 5 days
- RO: FS7/COSMIC-2 Bending angle
- R: CYGNSS NOAA windspeed (V1.2)

1-day RO profiles

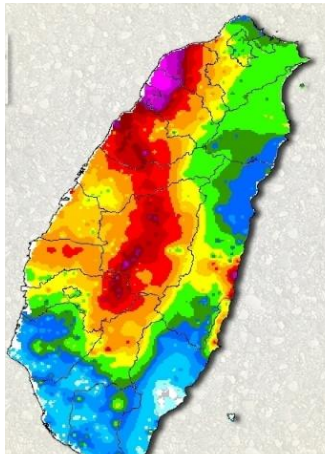




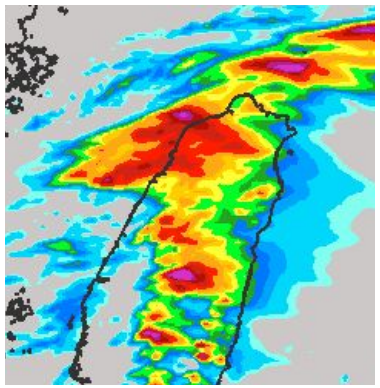


Impact of RO+R assimilation on rainfall prediction

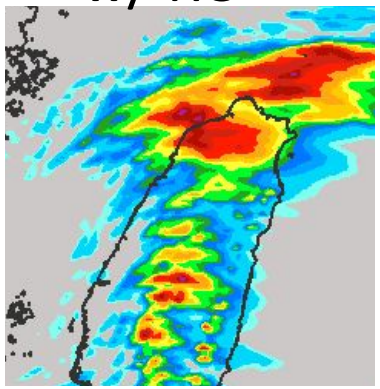
One-day Acc. Rain (05/19/2022, initialized at 05/18 12 UTC)



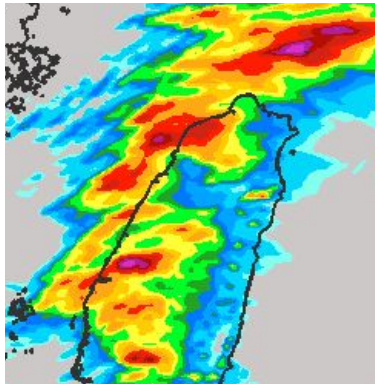
CNTL



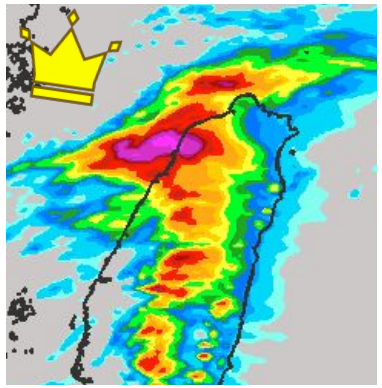
w/ RO

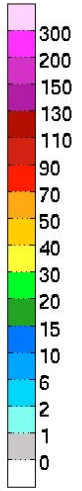


w/ R

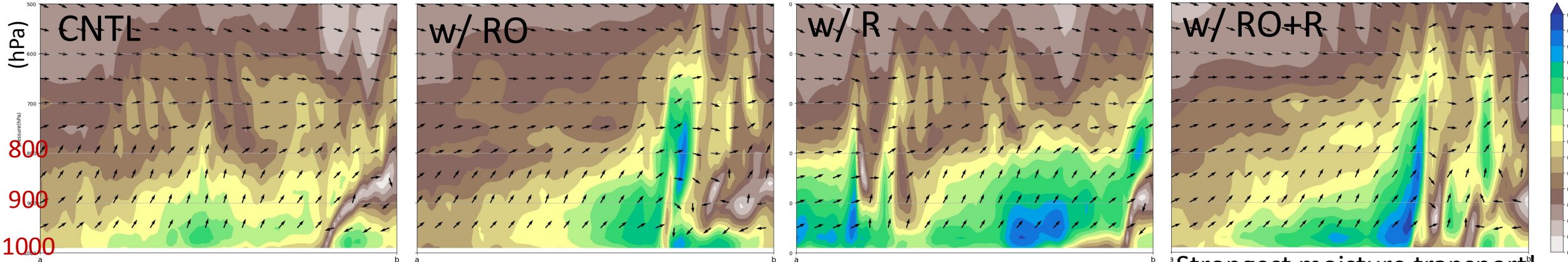


w/ RO+R





Vertical cross-section of moisture flux at 00 UTC 05/19

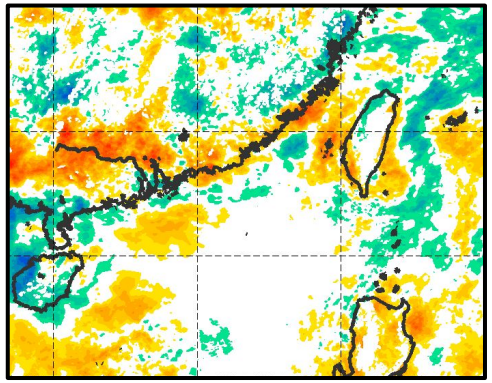


Strongest moisture transport!

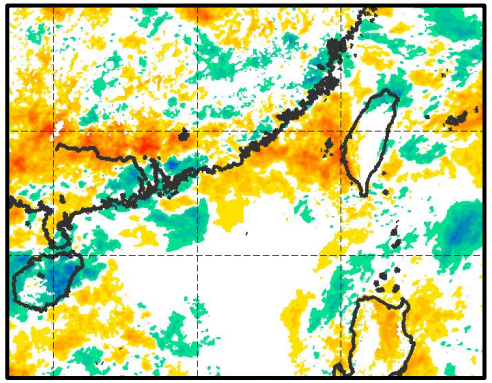
Impact on the moisture analysis

Moisture increment at 925hPa

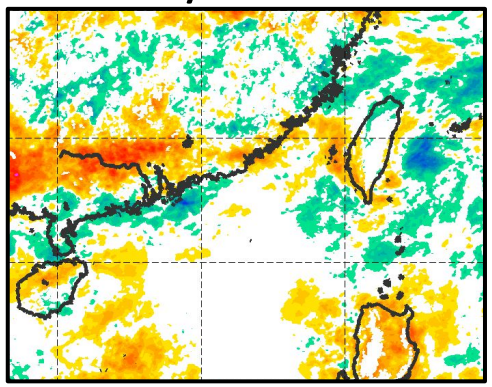
CNTL



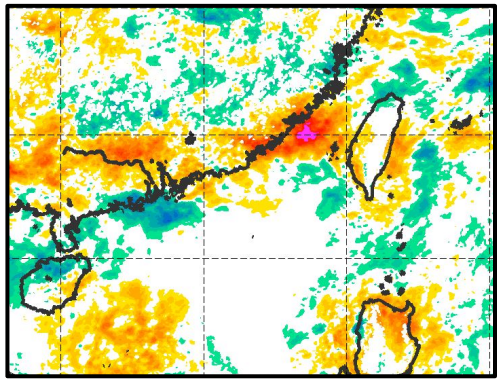
w/ RO

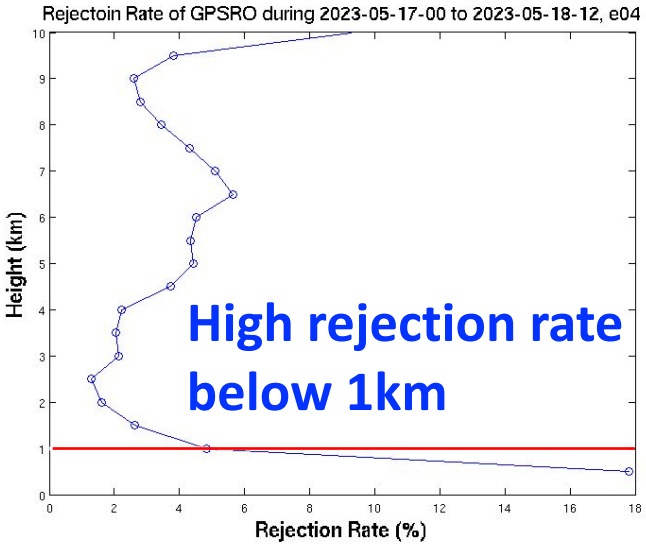


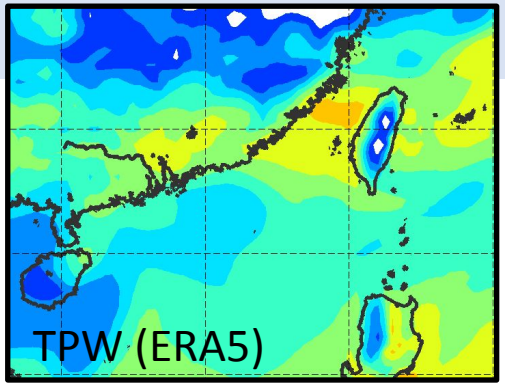
w/ R

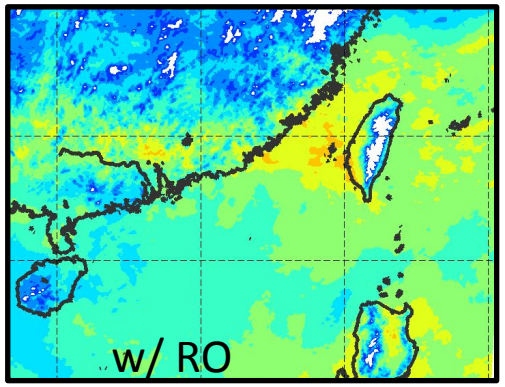


w/ RO+R

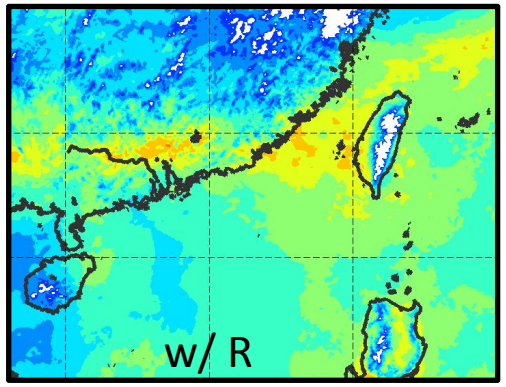


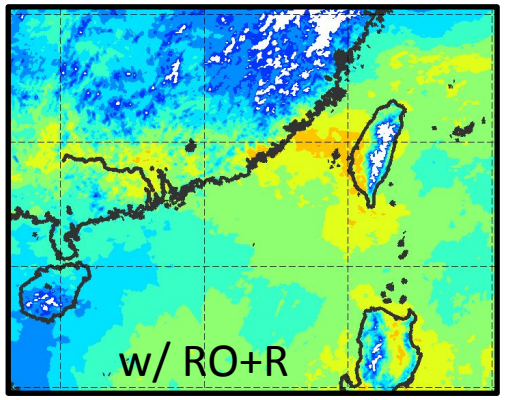






1 km

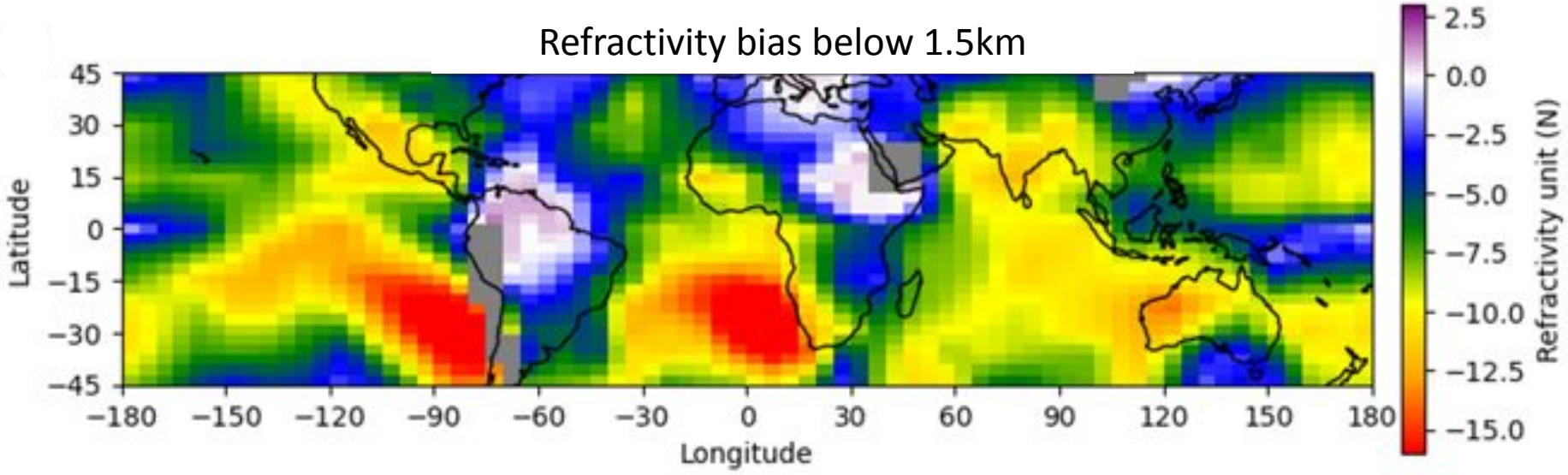




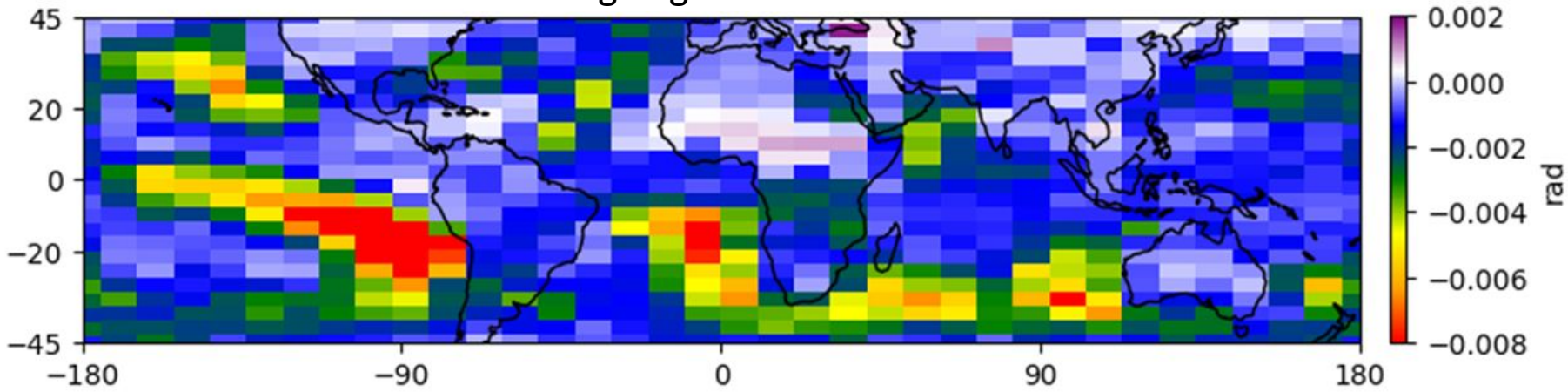
RO bias in the deep troposphere

Bias is defined as the mean difference between obs and ERA5 reanalysis

Refractivity bias below 1.5km



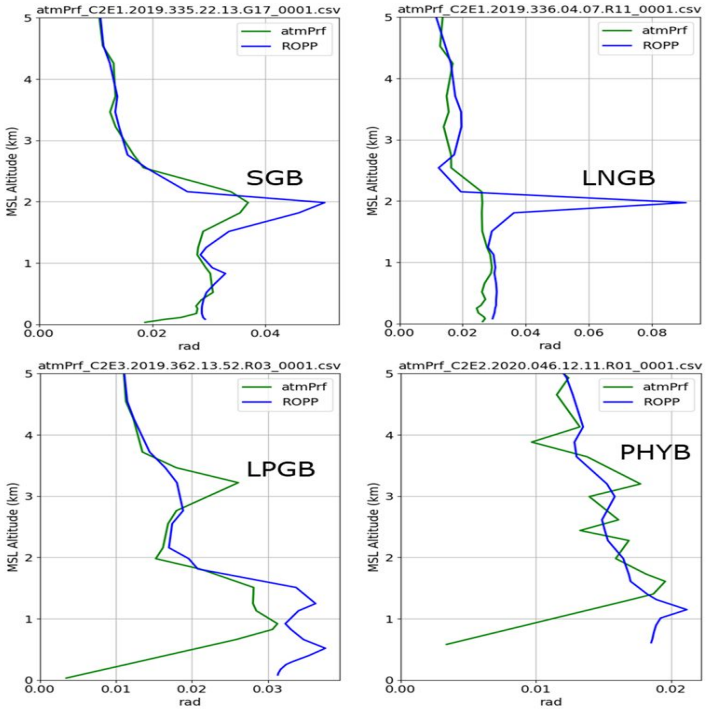
Bending angle bias at 925hPa

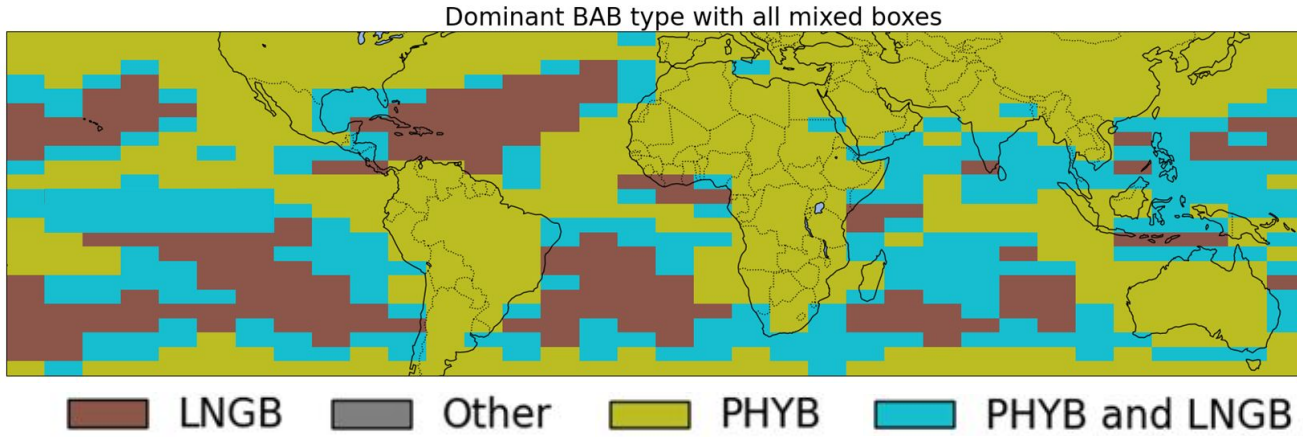


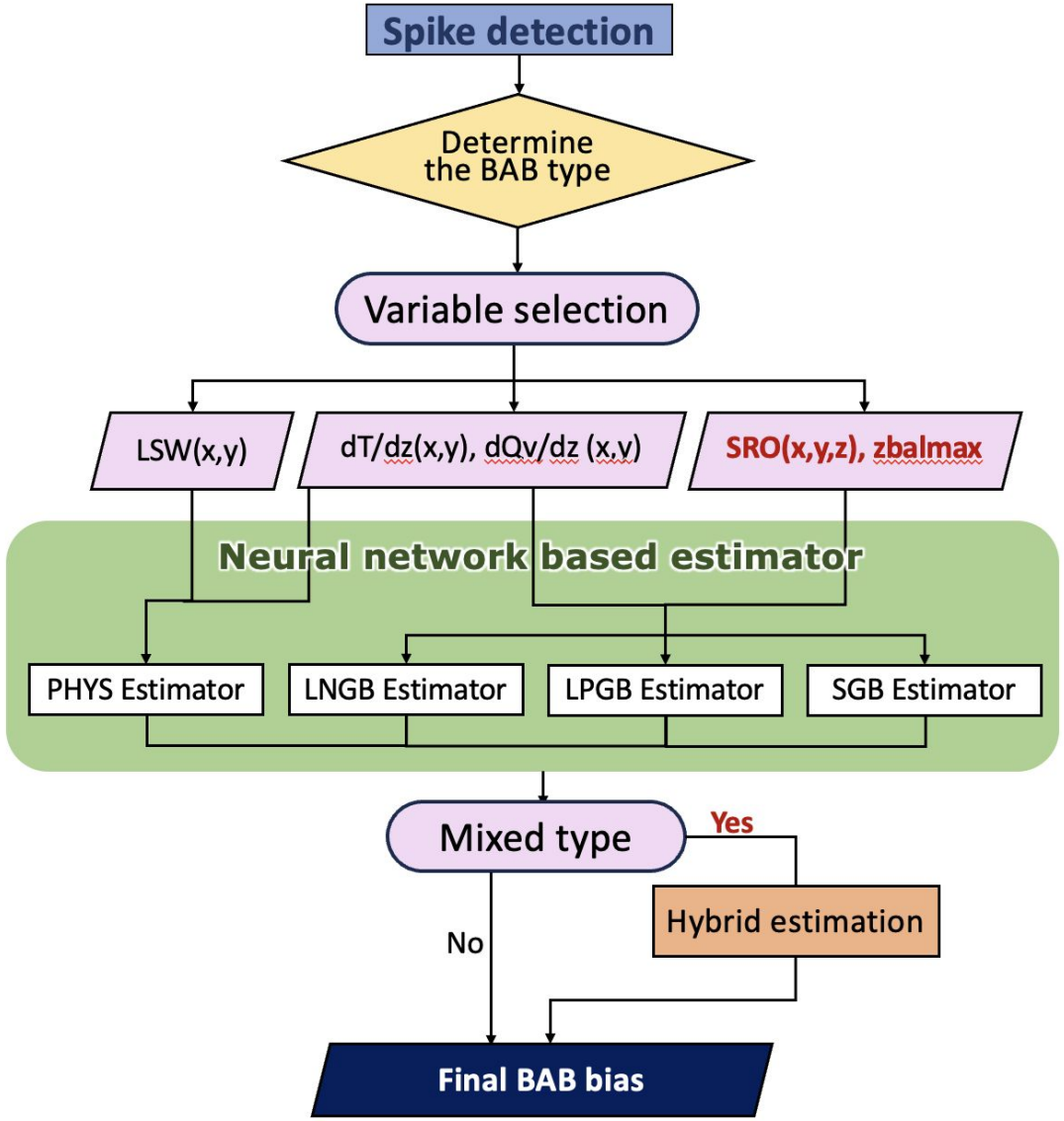
- Large negative bias in the cold SST region.
- Characteristics of the REF and BA biases are different.

NN-based bias estimation

Classification of the bending angle bias (geometrical or physical)





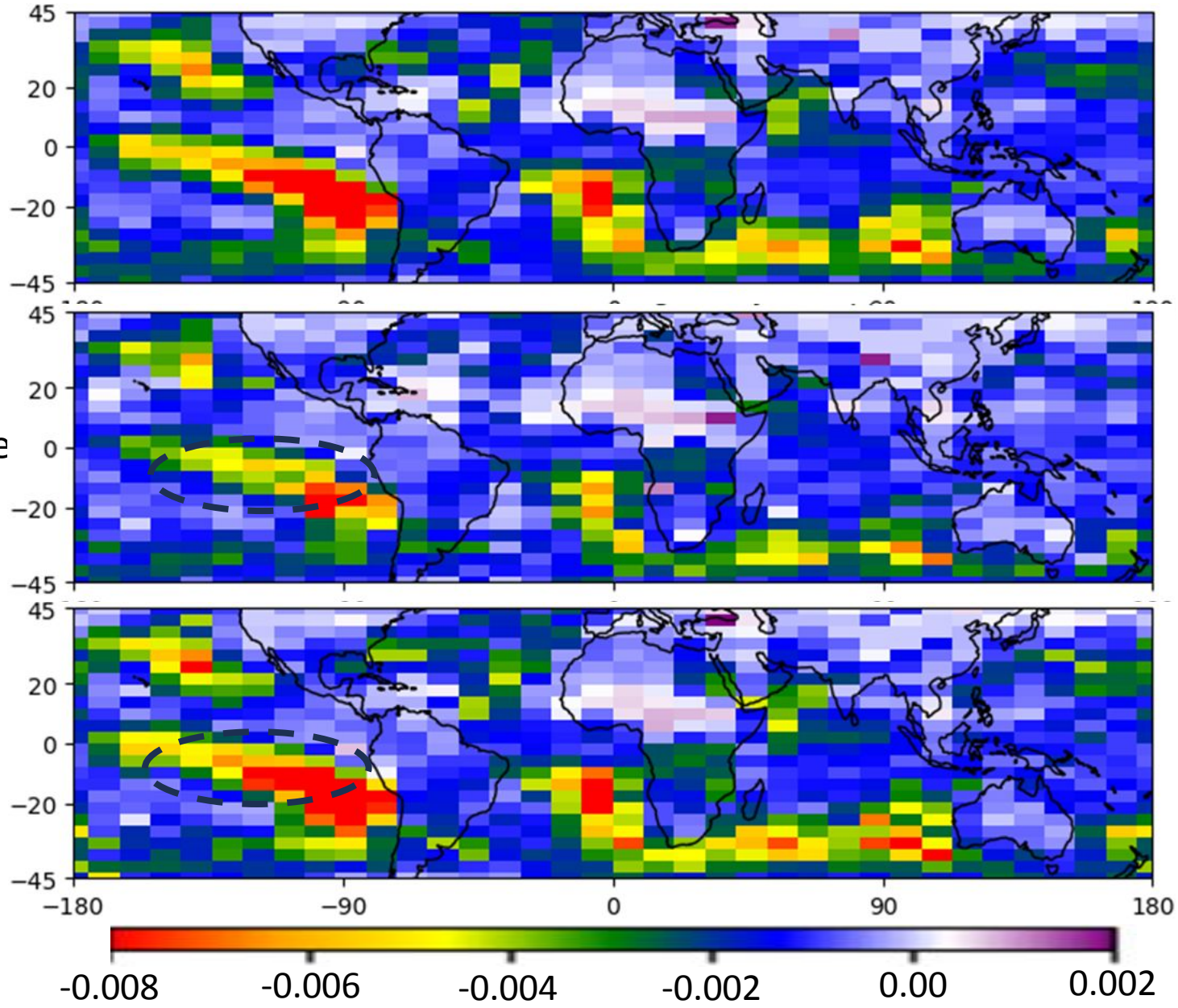


Bias estimation of bending angle

Original bias

Bias estimate (Single)

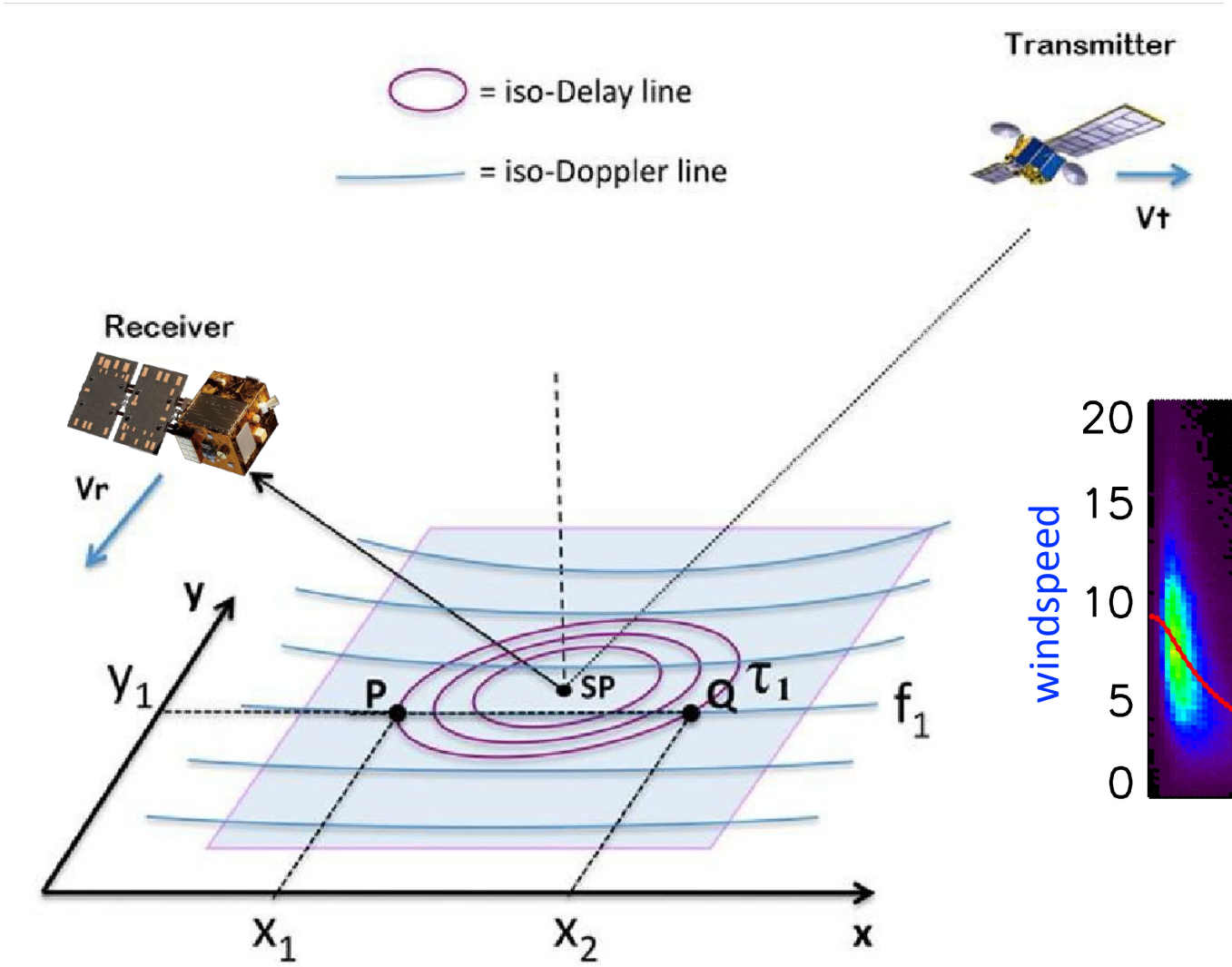
Bias estimate (Hybrid)

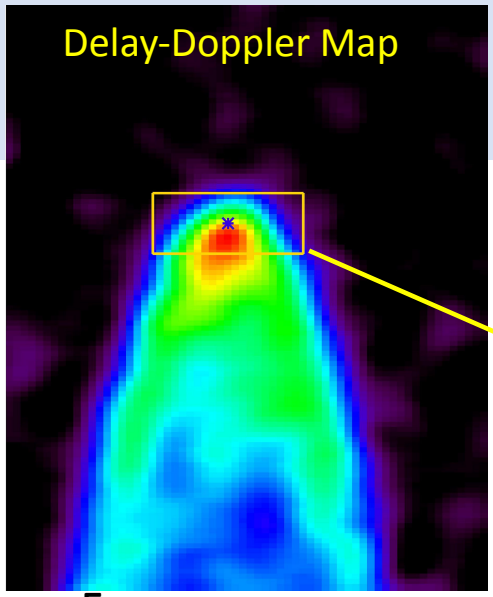


Summary

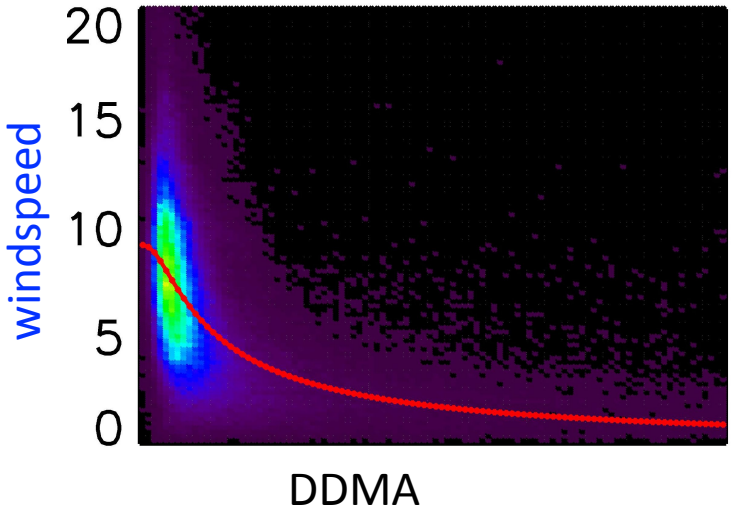
- Preliminary result of TRITON ocean windspeed assimilation shows positive impact on the short-term precipitation prediction.
- Joint impact from RO+R assimilation has a great potential in improving the moisture transport in PBL and thus, rainfall prediction.
- Bias of bending angle in the deep troposphere can be estimated with a NN-based algorithm, considering the geometric and physical type bias.

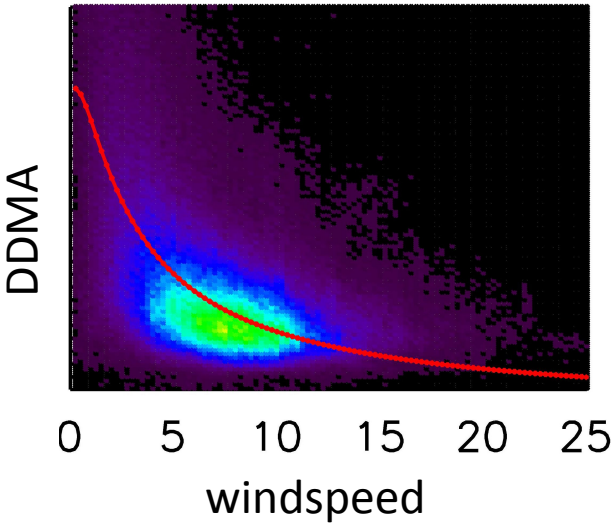
Wind speed retrieval





DDMA
(13x21)





Two-way GMF between WS and DDMA