Comparison of Precipitation Measurement Radar onboard FY-3G Satellite with the Ground-based Radar over China

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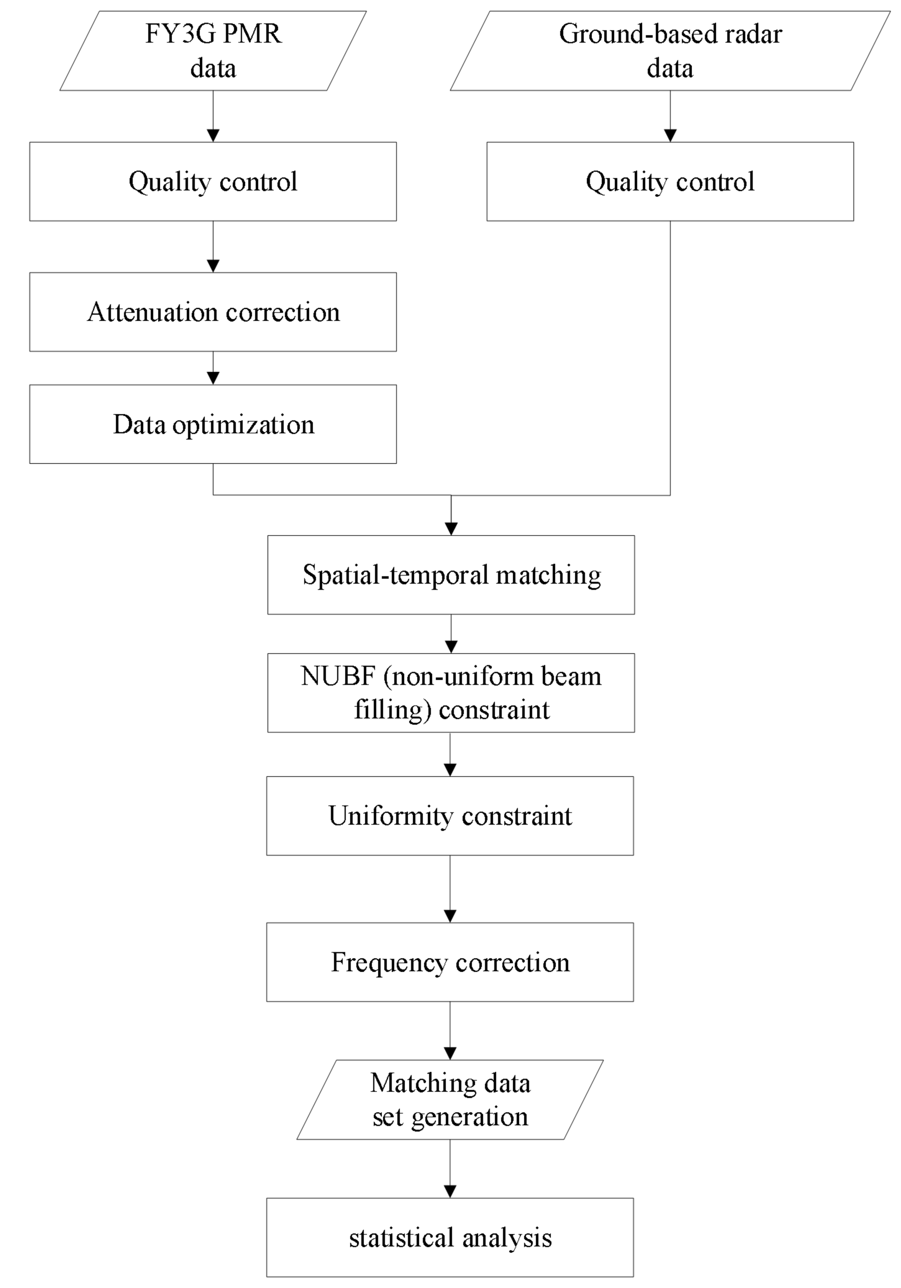
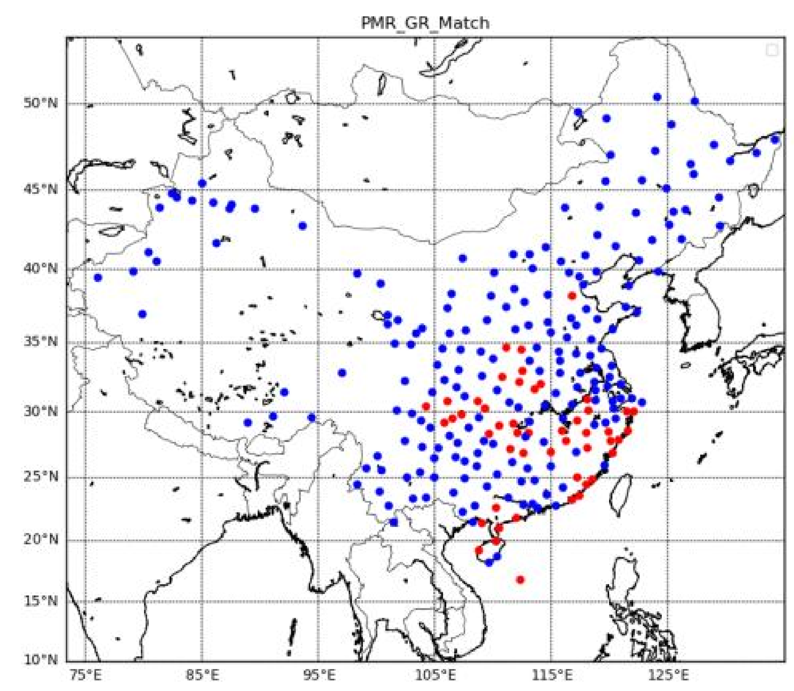
Introduction:

China launched its first precipitation measurement satellite in 2023, dedicated to measure the three-dimensional precipitation system with active radar. Meanwhile, China operated 252 Doppler weather radars over Chinese mainland. The spaceborne radar can be used to realize the intensity calibration of the national networked weather radars and trace them back to the reference radar.

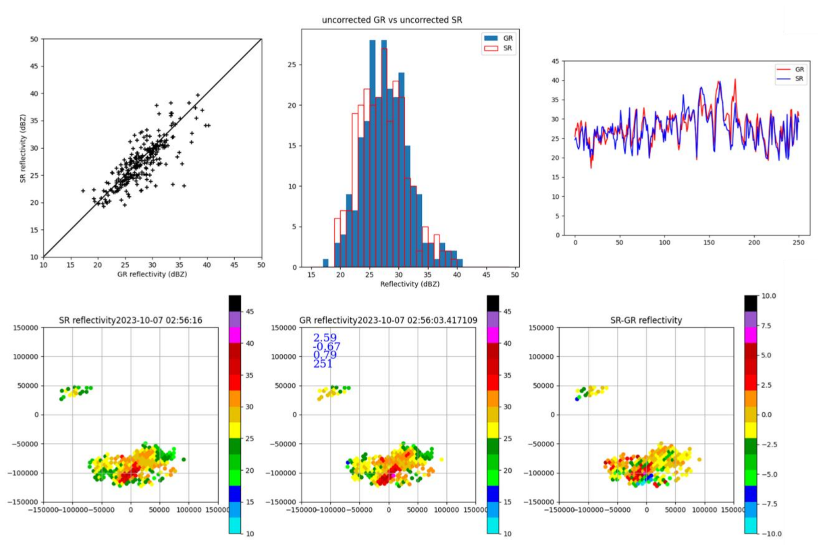
Thiswork focuses on comparing FY-3G core instrument precipitation measurement radar (PMR) with ground-based weather radars (GRs). The comparison algorithm between the PMR and the GRs is developed with the detailed quality control, attenuation correction, data optimization, spatial-temporal matching, non-uniform beam filling constraint, uniformity constraint, and frequency correction. The data consistency between PMR and GRs is analyzed.

Processing flow of satellite-ground radar data comparison

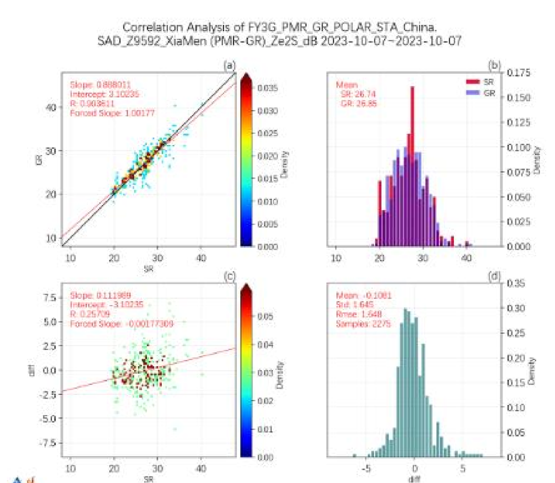




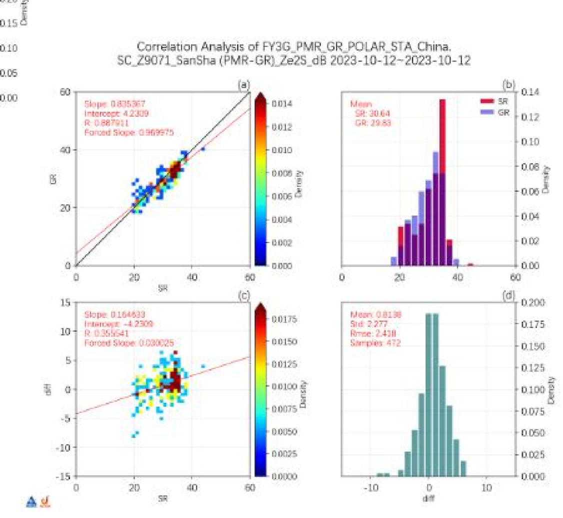
The distribution of matched stations for the PMR and GRs in China (October, 2023).
Red: stations matched;
Blue: stations not matched.



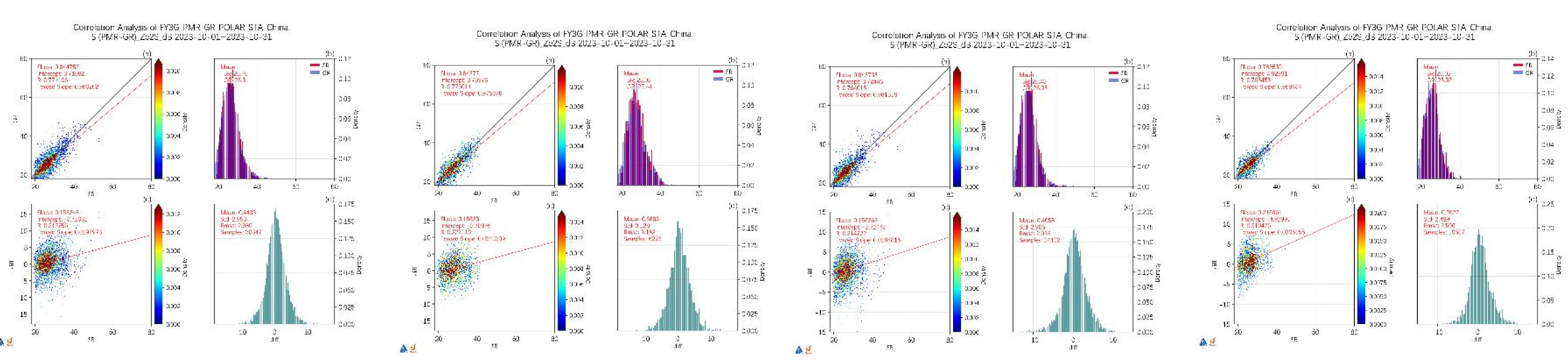
Detailed display diagram of one layer for Xiamen station



Xiamen station



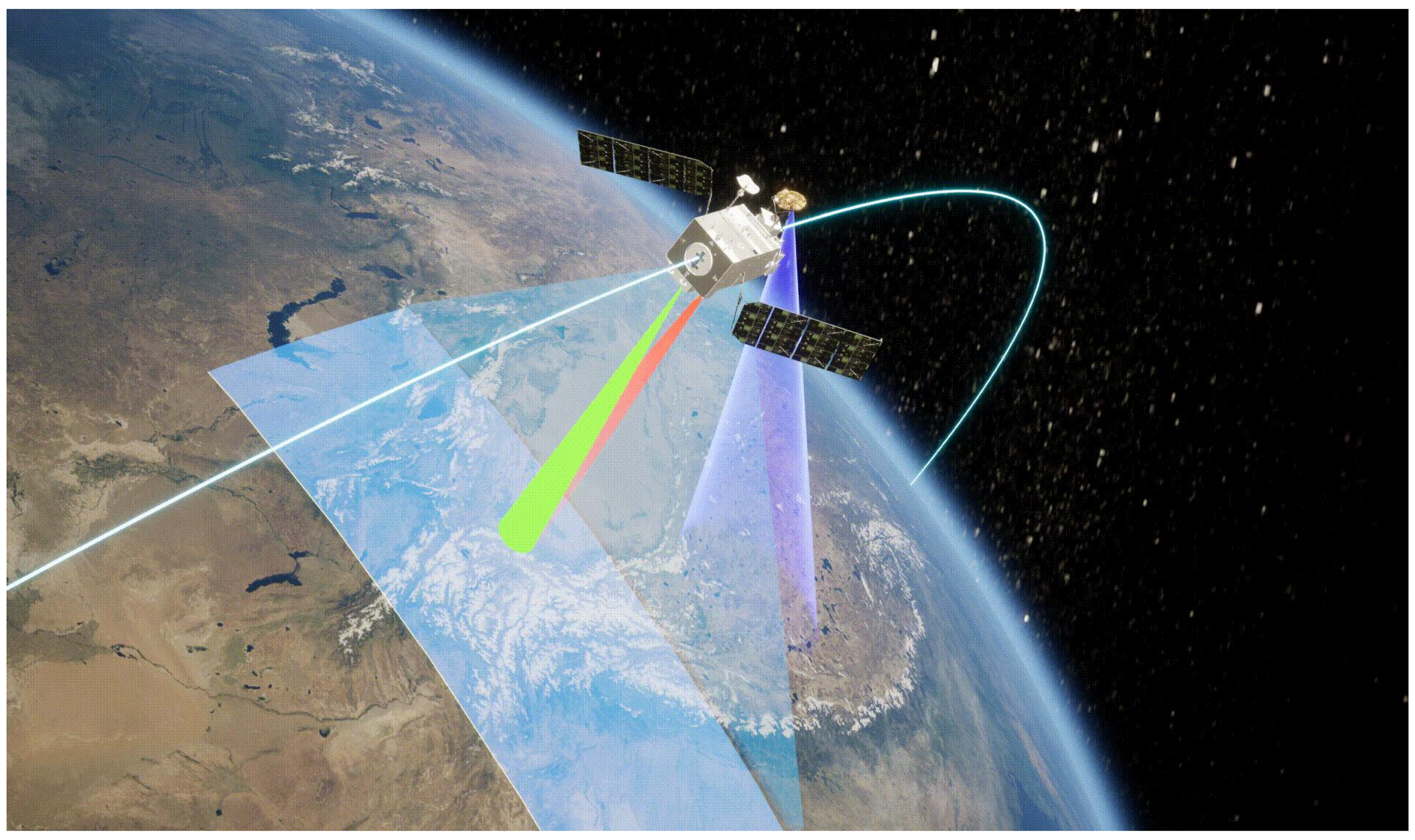
Sansha station



Comparison results with different data screening scheme.
(a) data of all precipitaion types; (b) convective precipitation data; (c) stratiform precipitation data; (d) with bright band screening.

Statistical results with different data screening (October, 2023)

Precipitation type	No. of matching points	Correlation coefficient	Deviation / dB	Standard deviation / dB
all data	30347	0.77	0.44	2.95
convective	6225	0.77	0.59	3.13
stratiform	24122	0.76	0.41	2.90
bright band screening	10587	0.76	0.70	2.50



After 6 months of commissioning test and 6 months of trial operation, FY-3G transferred to the operational stage on May 1, 2024, providing continuous precipitation measurement data to the worldwide users.

Main characteristics of FY-3G PMR

Item		Specification	
Radar type		One-dimensional active phased array	
Band		Ku	Ka
Polarization		HH	
Scan angle		Precipitation observing mode：±20.3°	
Antenna	Type	128-element slot waveguide array	
	Aperture	2.1 m×2.1 m	0.9 m×0.9 m
	Beam width	0.71° (nadir)	
	Peak sidelobe	＜ -30 dB	
Transmitter/ Receiver	Peak power	720 W	360W
	Pulse width	1.67 μs×4	
	Bandwidth	0.6 MHz×4	
	PRF	3700～4700 Hz	
Mode		observation, internal calibration, external calibration, stand-by, health check, analysis	

Concluding remarks:

Using the proposed method in this study, validation of PMR radar reflectivity factor with that of the ground-based operational weather radars was implemented using the observation data of October, 2023.

38 ground stations were matched successfully with the PMR and generated 10587 matching points. The correlation coefficient is 0.76, the deviation is 0.70 dB, and the standard deviation is 2.50 dB. The comparison results between PMR and GRs are quite satisfying, proving PMR in-orbit performance and the potential for unified correction of different ground-based radars using the spaceborne radar data as the transitional data. This work lays the foundation for data fusion and joint application of satellite-ground radars in the future.

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