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Analysis of severe weather detection in the metropolitan area of Korea using X-Band weather radar

Korea Meteorological Administration

WRC Weather Radar Center

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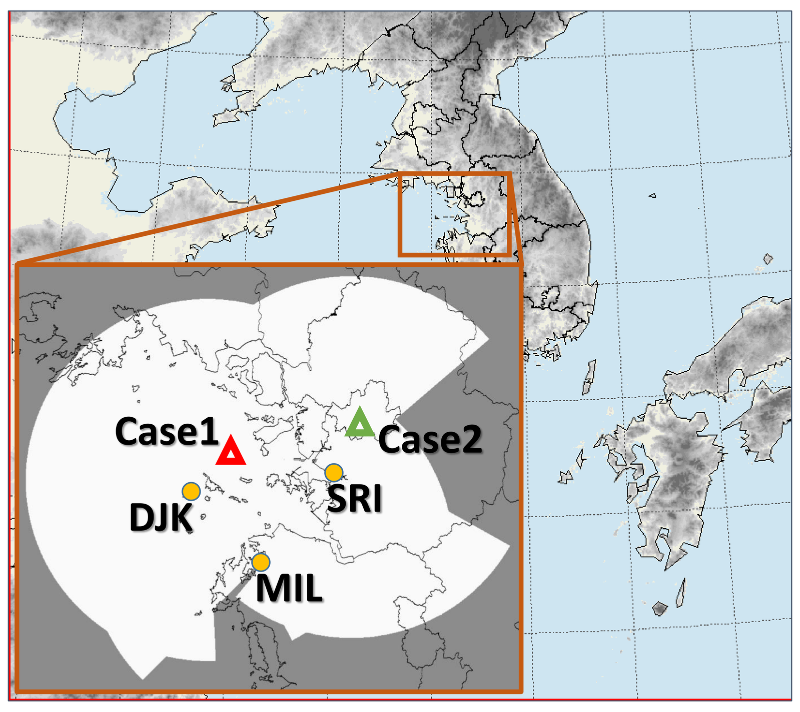
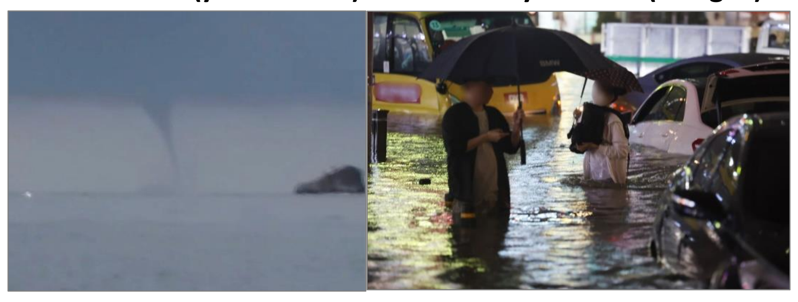
1. Introduction



<X-Band radar (yellow circles) and case study locations (triangles)>



<Photos from the actual event: Waterspout (L), Localized heavy rain (R)>

Severe weather causes serious loss of life and property in densely populated areas. Accordingly, it is important to minimize damage by detecting and monitoring severe weather events. Existing weather radars have limitations in detecting small-scale severe weather phenomena with high spatial and temporal resolution.

However, X-Band radar operates at a higher frequency, providing higher temporal/spatial resolution, making it more suitable for detecting small severe weather events.

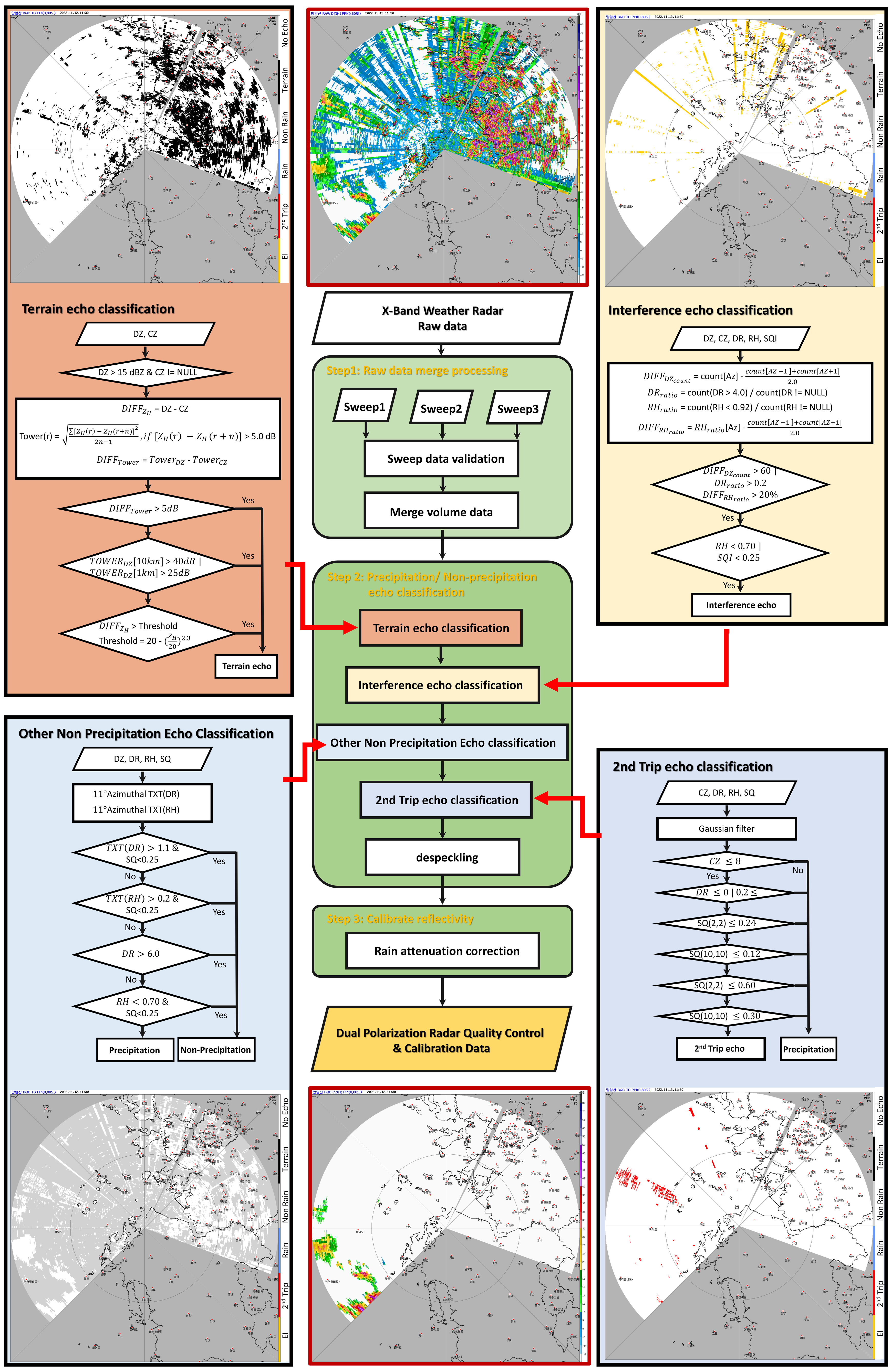
In October 2018, Weather Radar Center of KMA installed an X-Band radar network throughout the metropolitan area to monitor local weather phenomena and provide information on severe weather.

In this study, two severe weather events occurred in the Seoul metropolitan area were analyzed.

The first case is a waterspout occurred in September 2020, which is a rare event on the Korean Peninsula and the second case is a strong convective phenomenon caused flash floods and numerous casualties in the center of Seoul in August 2022.

Data quality control was conducted and compared with S-band radar data for effective analysis.

2. Data processing flow chart

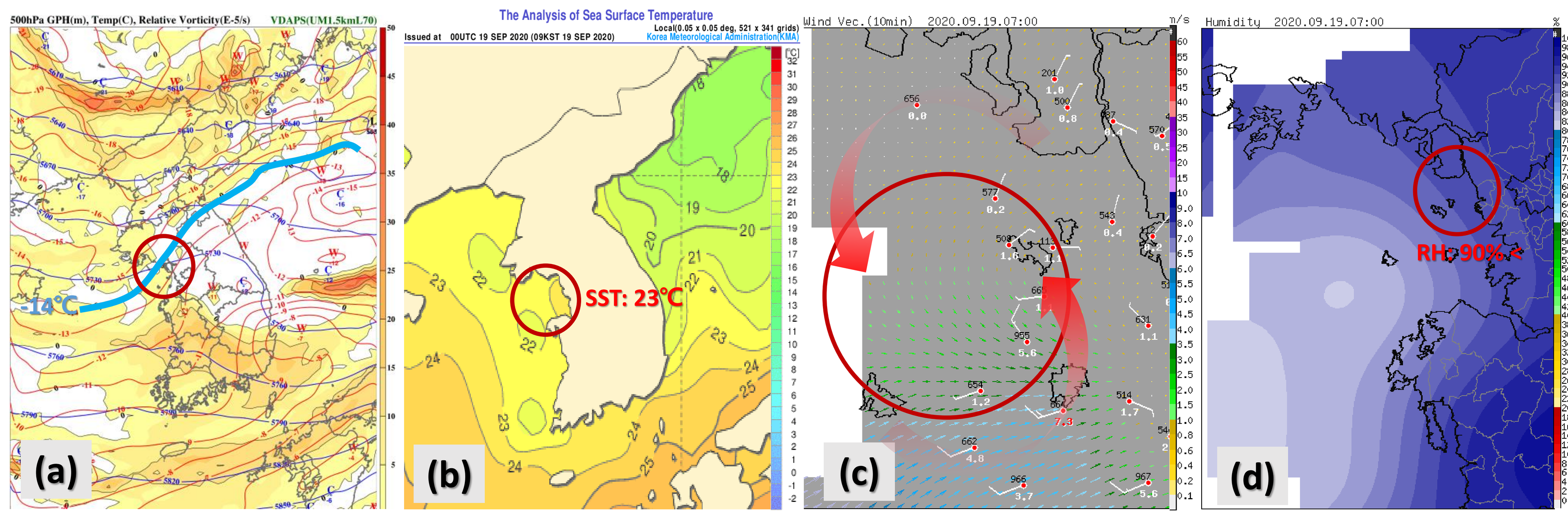


<X-Band weather radar QC flow chart>

3. Case Study

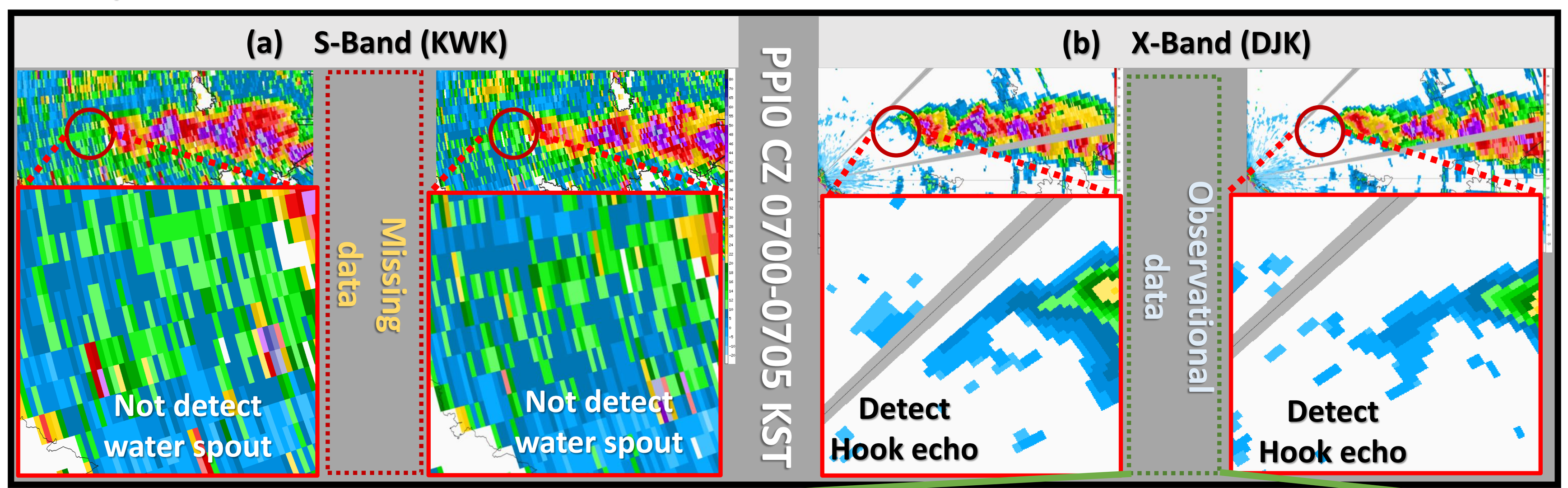
<Case 1> WaterSpout 2020.09.19.

■ Synoptic meteorological analysis

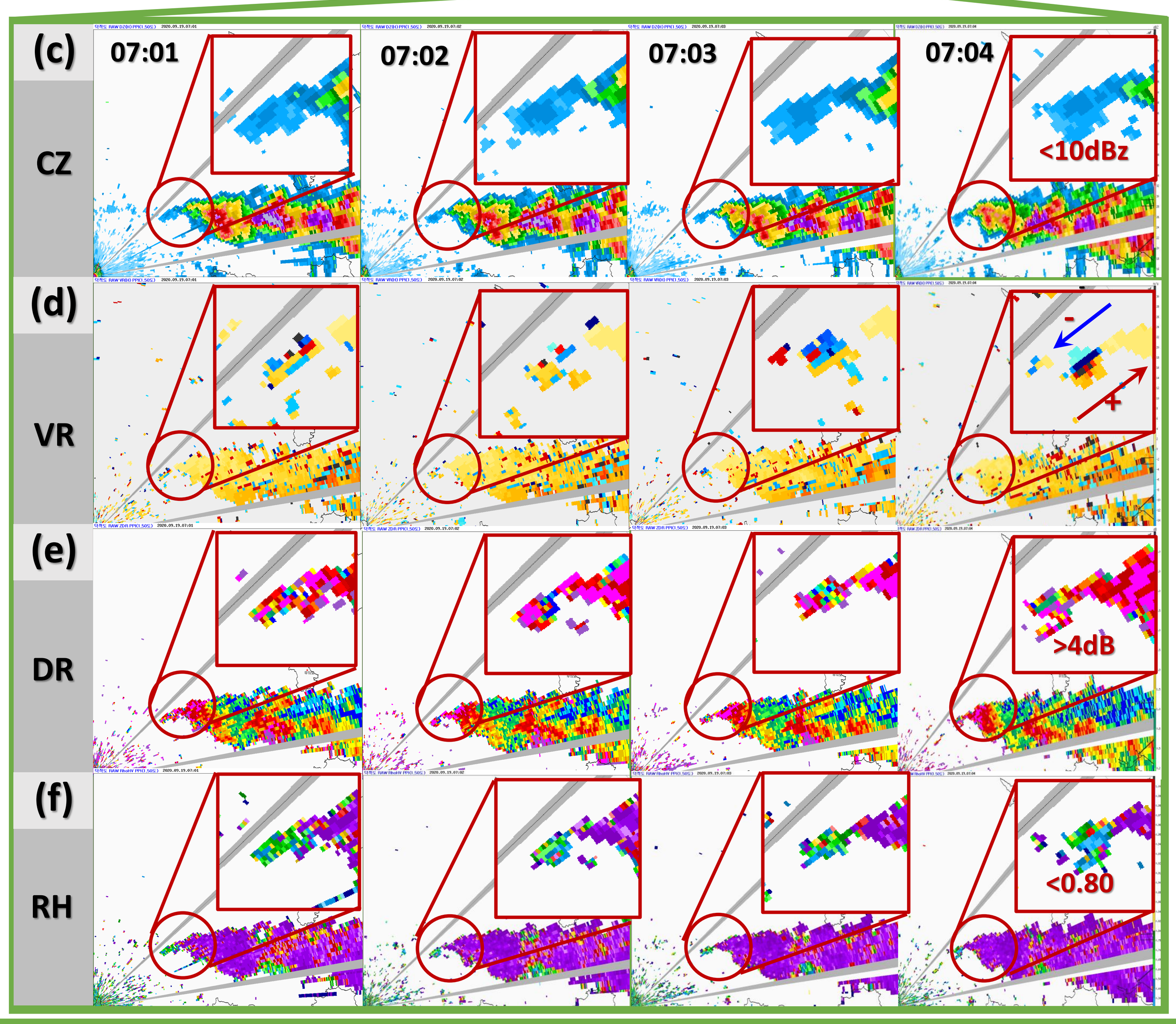


(a) Cold air at -14℃ is distributed in the upper atmosphere (5km) where the waterspout occurred.
(b) distributed under warm sea level conditions (23℃), (c) low-level winds are cyclonic circulation (d) moist air inflow → Atmospheric instability caused by cold, dry air above and warm, moist air below

■ Comparison of S-Band vs X-Band weather radar

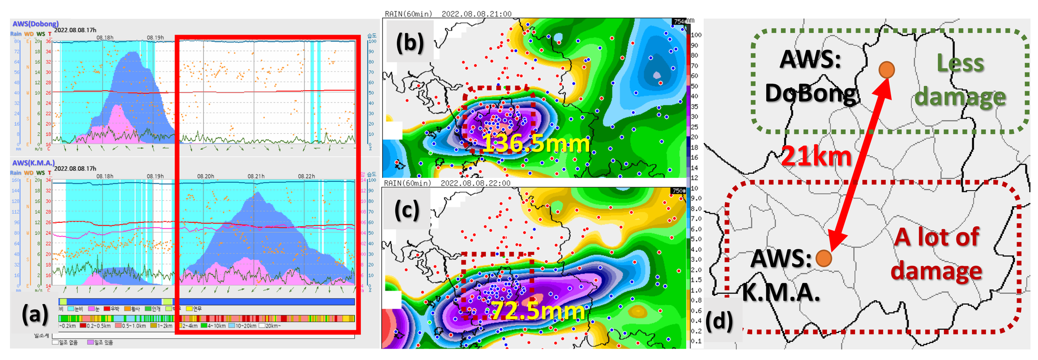


- S-Band (gate size: 250 m) did not observe significant waterspout echo.
- X-Band (gate size: 150m) succeeded in observing echoes showing waterspout characteristics by various radar variables



- CZ: Weak reflectance (<15 dBZ) as compared to precipitation zone reflectance
- VR: The overall radial velocity of the precipitation zone is getting farther away, but the +/- rotational component is confirmed in the tornado area.
- DR: Particles with strong rotation show vertical component (>4dB).
- RH: Seawater droplet observed due to strong updraft (<0.8).

<Case 2> Localized heavy rain 2022.08.08.~09.



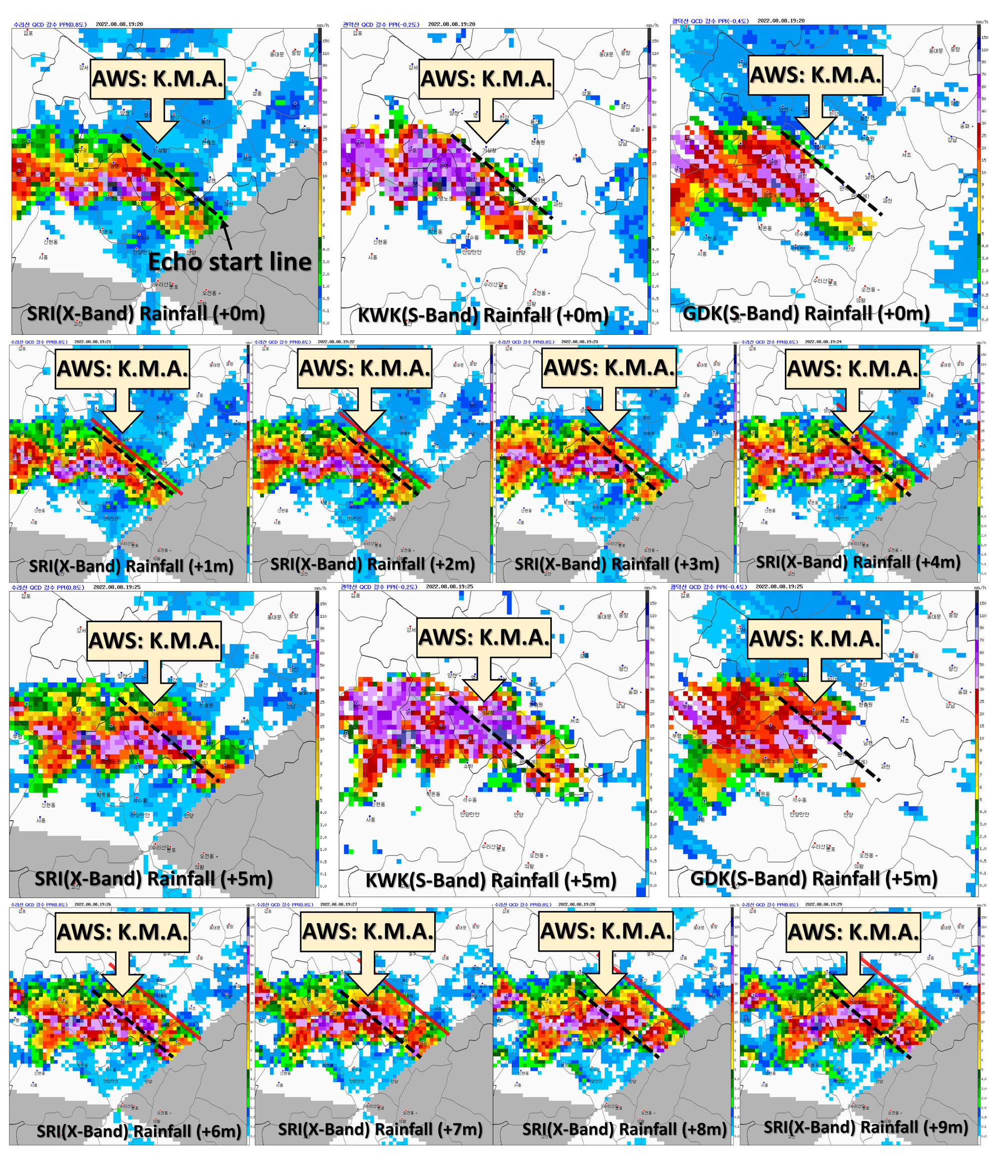
■ AWS Cumulative Precipitation Analysis:

Although the distance between the Korea Meteorological Administration(K.M.A.) and the Dobong AWS point was only 21 km, there was a clear difference in the observed precipitation. A large amount of precipitation of up to 136.5 mm per hour was recorded in a small area for a short period of time.

■ Comparison of S-Band vs X-Band weather radar

The K.M.A AWS point has the same PPI0 beam height of SRI (X-Band) and KWK (S-Band), so it is easy to analyze the same precipitation system echo.

Compared to the S-Band, the X-Band has excellent temporal/spatial resolution, so it can monitor the weather situation similar to the operation situation of the AWS precipitation sensor.



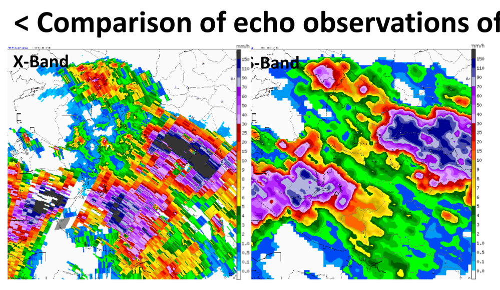
< Comparison of echo observations of X-Band and S-Band weather radars >

RADAR (Unit: km)	Distance from K.M.A AWS	Radar beam height at AWS
SRI(X-B.)	14.8	0.66
KWK(S-B.)	6.6	0.64
GDK(S-B.)	80.7	1.47

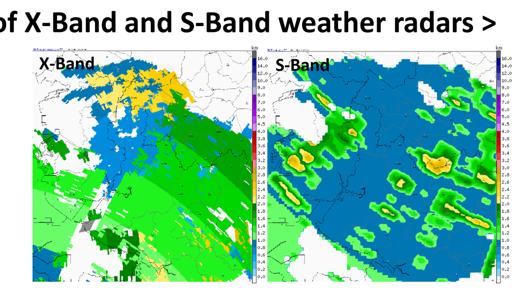
< Distance and beam height between KMA AWS points and each radar >

Time	Rainfall	Cumulative precipitation(mm)
Min:Sec	T/F	10 Min.
19:29	●	8
19:28	●	6
19:27	●	3.5
19:26	●	2.5
19:25	●	1.5
19:24	●	0.5
19:23	●	0
19:22	○	0
19:21	○	0
19:20	○	0

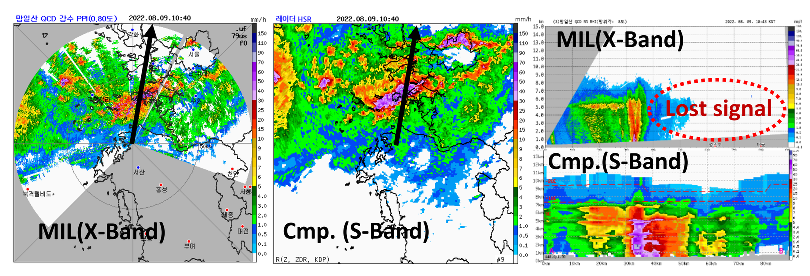
< 10-minute cumulative precipitation for KMA AWS >



<Comparison of X-Band and S-Band spatial resolution>



<Comparison of X-Band and S-Band beam height>



< Limitation of Attenuation of X-band radar >

4. Conclusion

This study demonstrates the potential benefits of using X-Band radar data to detect and monitor severe weather events in densely populated areas. The high spatiotemporal resolution of X-Band radar data can provide important information about the dynamics and evolution of severe weather events, which can help predict and mitigate their impacts. However, issues related to the use of X-Band radar data, such as echo loss due to strong rainfall, still need to be addressed. The results of this study provide valuable insights for future research to improve the performance of X-Band radar data for weather monitoring and forecasting.

Acknowledgement

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