SToRM SAR

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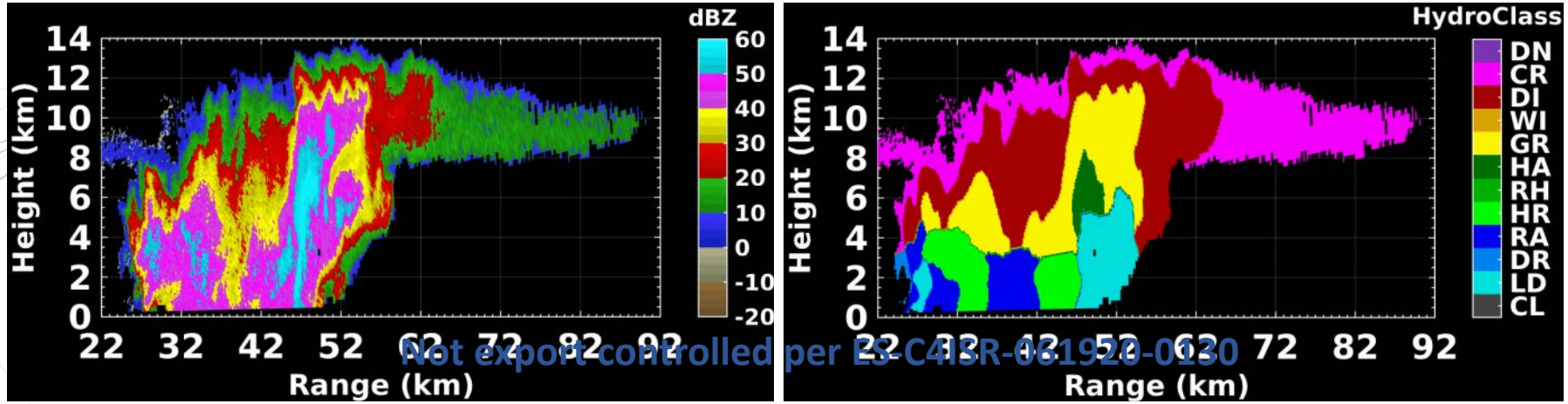
Program: IIP 19-0012

What Spatial Resolving Power Is Needed to Observe Intense Mid-Latitude Storms From Space?



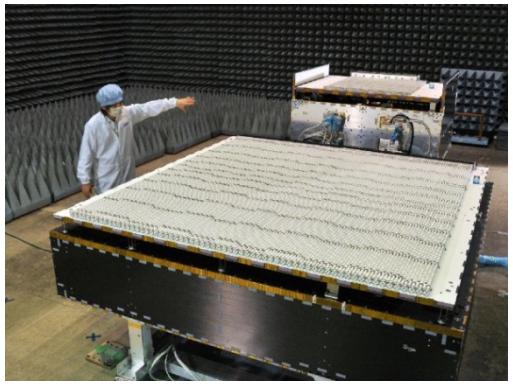
Radar Reflectivity Cross Section and Hydrometeor (classified) Cross-Section for a Precipitation Event Observed at 23:43UTC, May 29, 2013 by NPOL during the IFLOOD Field Campaign (HydroClass: CL: Clear Air, LD: large drops, DR: drizzle, RA: rain, HR: heavy rain, RH: rain plus hail, HA: hail, GR: graupel, WI: wet ice, DI: dry ice, CR: crystals)

Ground-Based Radar Observations Illustrate that ~ 1 km Horizontal Resolution Needed to Characterize Intense Storms

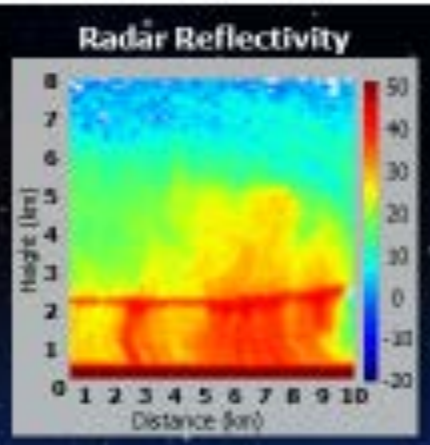
Problem to Solve-Providing 1 km Horizontal Resolution Precipitation Observations from Space

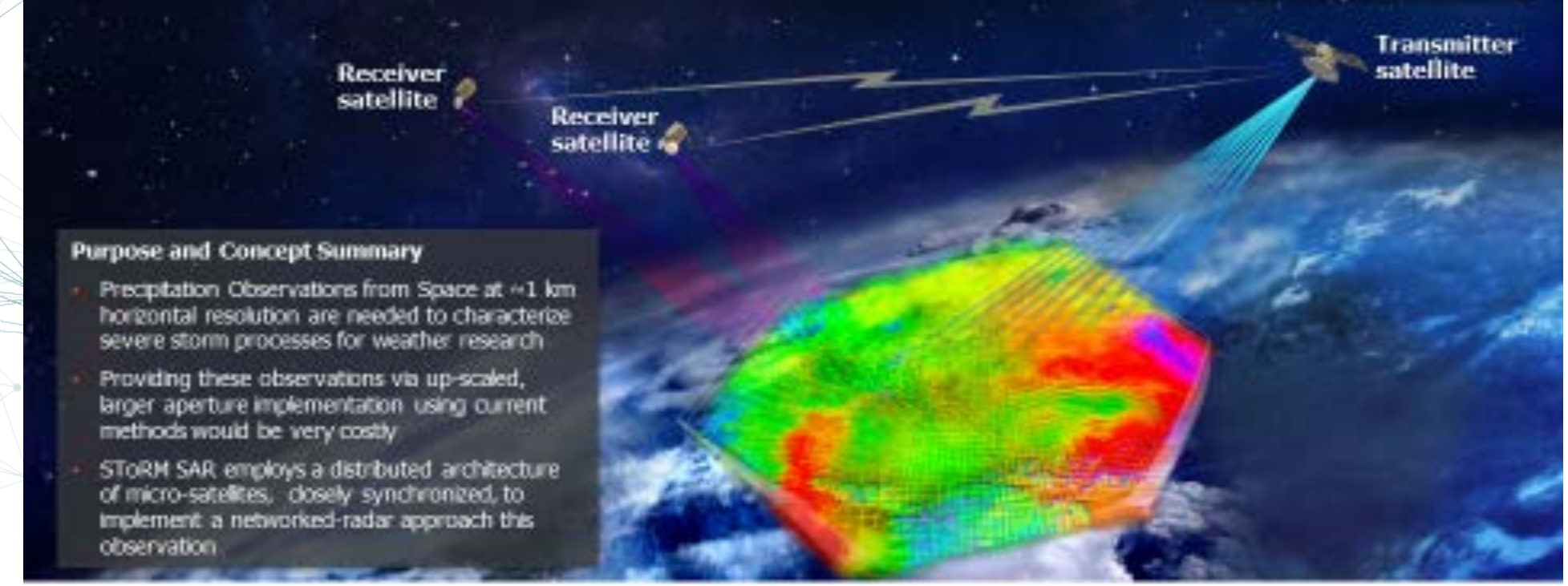
NASA/JAXA's Premier Space-Based Precipitation Radar:

- ~$1B Mission, a Decade in Development
- Its 5 km Spatial Resolution at Ku-Band is 5x Coarser than Needed For Many Intense Storms



SToRM - Remote sensing of precipitation using multi-static radar interferometry & tomography





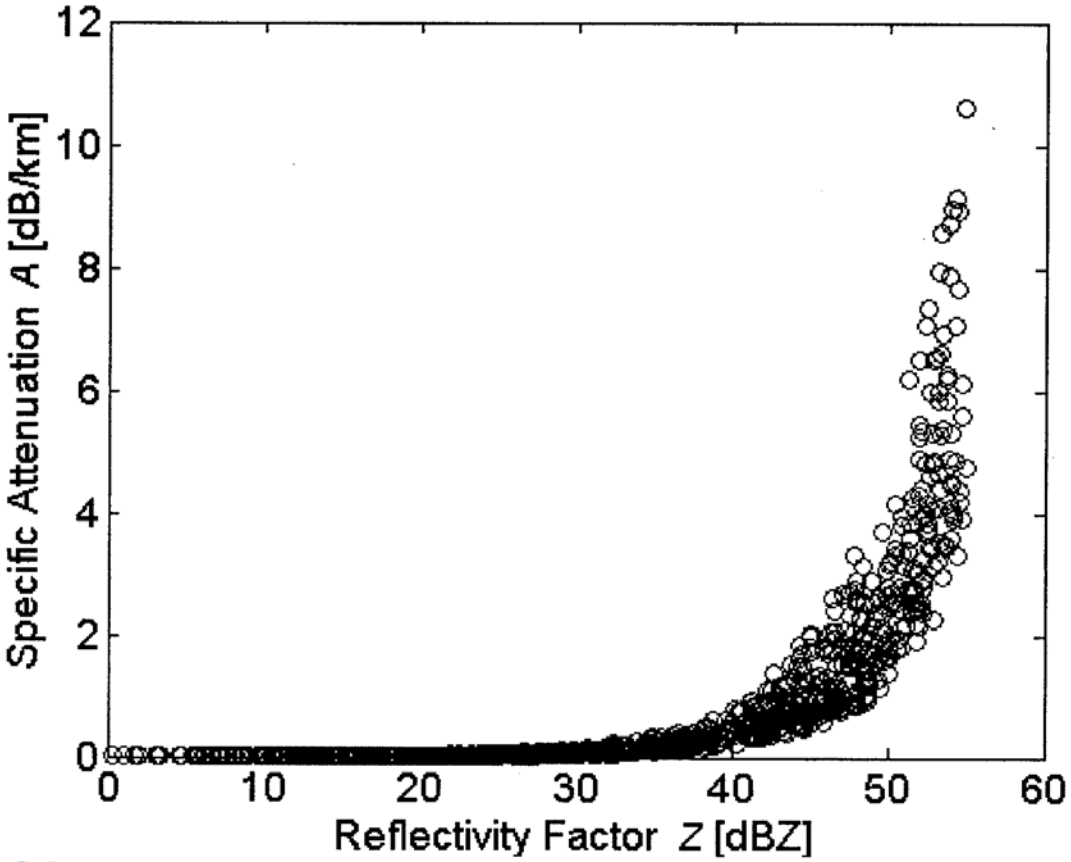
Purpose and Concept Summary

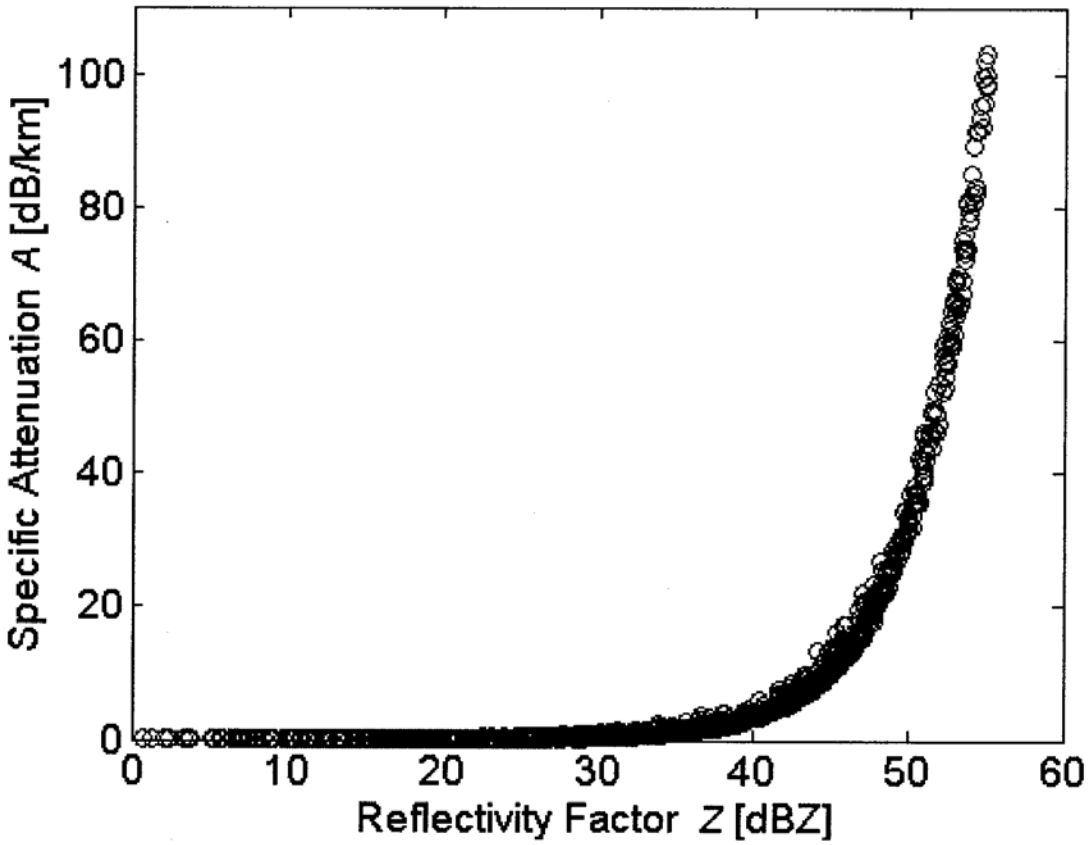
- Precipitation Observations from Space at ~1 km horizontal resolution are needed to characterize severe storm processes for weather research
- Providing these observations via up-scaled, larger aperture implementation using current methods would be very costly
- SToRM SAR employs a distributed architecture of micro-satellites, closely synchronized, to implement a networked-radar approach this observation

Colorado State University

BAE SYSTEMS

Specific Attenuation at Ka and Higher Frequencies Limits Vertical Profiling of Intense Convective Storms





Global Mapping of Attenuation at Ku- and Ka-Band

V. Chandrasekar, Hiroki Fukatsu, and K. Mubarak

IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 41, NO. 10, OCTOBER 2003

While Real-Aperture Diffraction-limited Footprints (and Antennas) are Smaller at Ka, Path Attenuation is Much Larger

SToRM Multi-Static/SpotLight Observation Geometry

Key Multi-Static Observation Variables	
Observation Parameter	***Symbol***
Transmitter → Reference Receiver Separation	B
Receiver → Receiver Separation	b
Orbital Height	H
Altitude of Observed Field	A
Cross-Track Position (relative to Transmitter)	ζ
Cross-Track Position-Relative to Tx-Rcv_1 Specular Point	$\Delta\zeta$
Range Difference—The Difference in Distance between Observation Field Element and the Receivers	ΔR

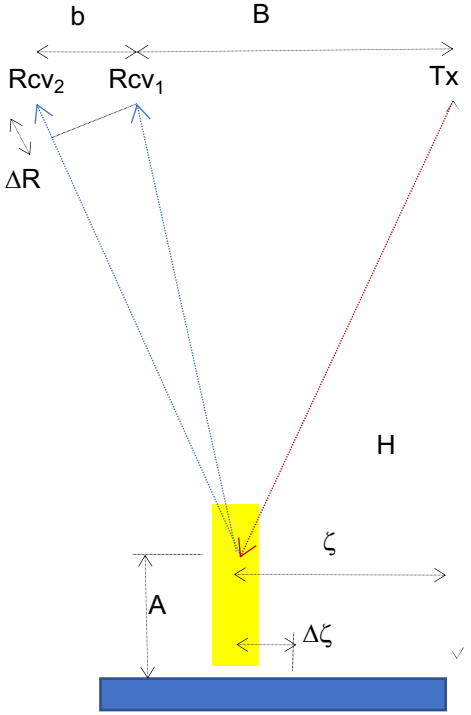
$$R_1^2 = (H - A)^2 + (B/2 - \Delta\zeta)^2$$

$$R_2^2 = (H - A)^2 + (\frac{B}{2} + b - \Delta\zeta)^2$$

$$\Delta R = R_2 - R_1$$

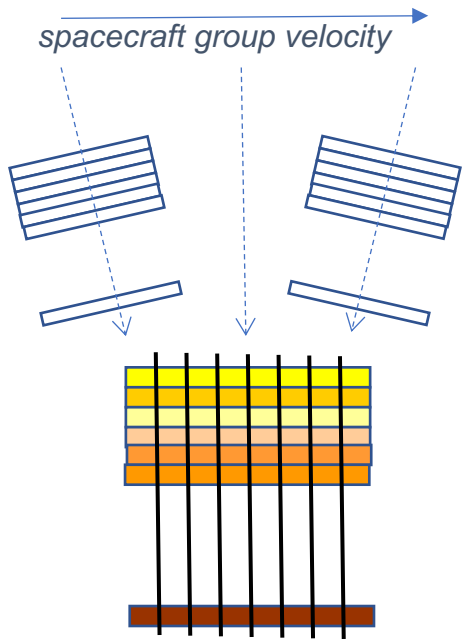
For Large R,
$\Delta R \approx const. \times \Delta\zeta$

Cross-Track Observation



For Typical LEO Orbital Heights, ΔR Varies Linearly with Cross-range Position, and is Largely Independent of Altitude, A

Along-Track Observation

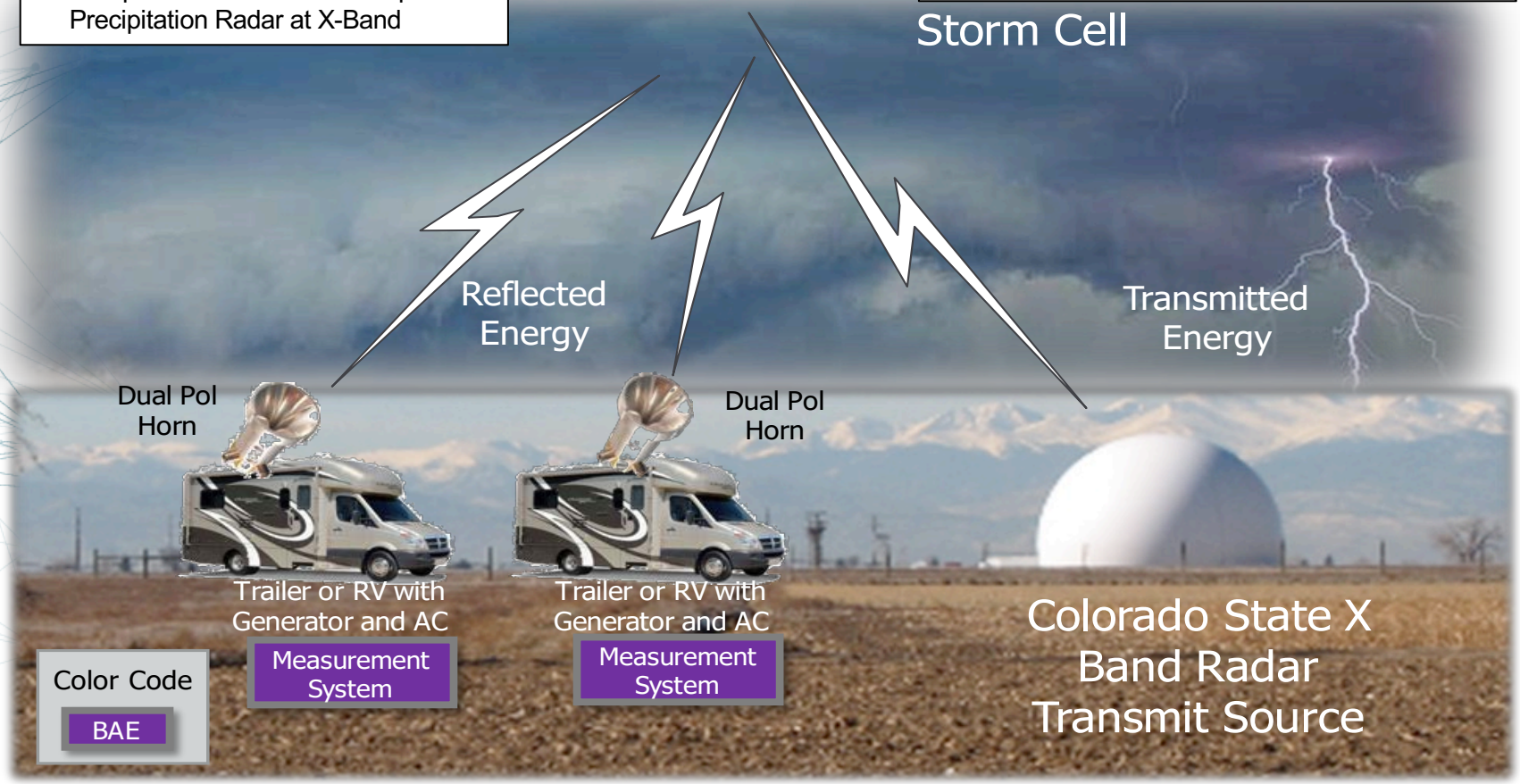


Employing SAR Spotlight-Mode Methods, Layered Structure is Seen over a Range of Angles-Enabling a Form of Tomography

Next Steps

Key Field Test Purpose
- Demonstrate Multi-Static Cross-Track Interferometry Method on Real Storms
- Compare Results with Real-Aperture Precipitation Radar at X-Band

Key Field Test Requirements:
- Capture Timestamped Coherent 2 Pol (V/H)
- X Band Data with > 10MHz Bandwidth at Two Remote Self Powered Locations



SToRM SAR Instrument Incubator

- Multi-static Micro-satellite-Based Concept & Imaging Method Development
- High Fidelity Precipitation Simulation and Observing Performance Modeling
- RF Field Test of Cross-Track Interferometry Method Develop-ment and Comparison with X-Band Observations with NSF/CHILL

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