38th Conference on Environmental Information Processing Technologies

# 8A.2 - A Progress Report on the Design of a Dual-Doppler 3D Mobile Ka-Band Rapid-Scanning Volume Imaging Radar for Earth System Science

Tuesday, January 25, 2022

4:00 PM - 4:15 PM

*George R. Brown Convention Center - Remote*

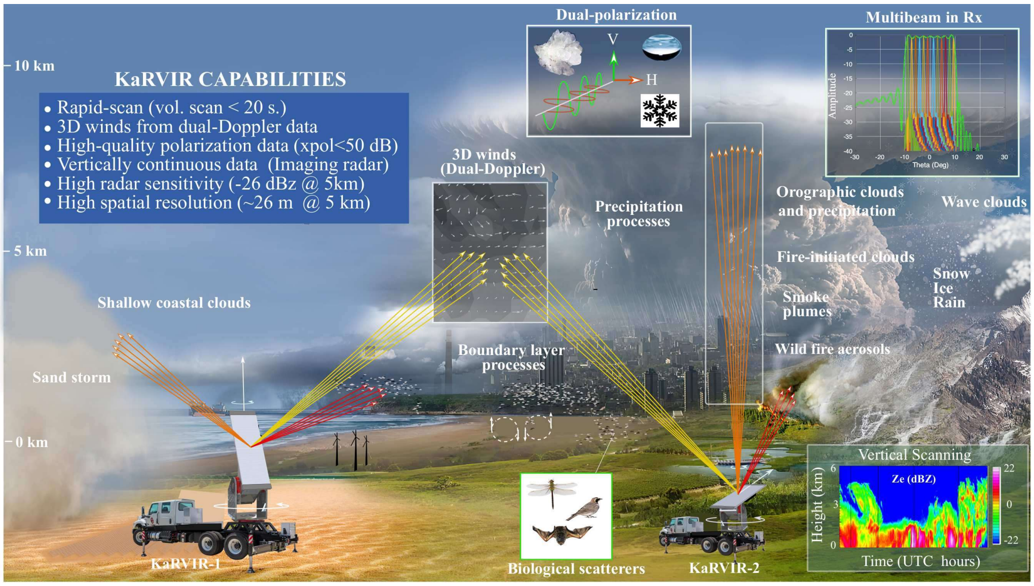
## Abstract

Clouds play a critical role in the atmosphere by modulating the Earth's radiative balance, deter-mining precipitation location, and intensity, and producing shallow to deep vertical circulations that redistribute heat, moisture, and momentum. Many aspects of cloud processes remain poorly understood, creating large uncertainties in numerical weather prediction (NWP) forecasts and climate models. Millimeter (mm)-wavelength radars have contributed immensely to the scientific understanding of cloud and precipitation processes, dynamics, and turbulence. Compared to longer wavelength radars used primarily for precipitation studies (S-, C-, and X-bands), existing mmWave radars that rely on parabolic dish antennas have enhanced sensitivity to small particles such as cloud drops and ice crystals. This sensitivity to cloud particles enables microphysical retrievals of ice distribution properties. Analyses of dual-polarization and Doppler spectral data have enabled better discrimination of ice hydrometeor types. Vertically pointing mm-wavelength radars have been used to obtain distributions of vertical velocities and turbulence in convective and stratiform clouds and the convective boundary layer. Climatological studies from ground-based and spaceborne mm-wavelength radars have also provided a timely critical understanding of clouds and precipitation globally.

To investigate candidate radar technologies to address this need, a trade study of different rapid-scan cloud radars has been undertaken. One result of this effort is a concept called the Ka-band Rapid-scanning Volume

Imaging Radar (KaRVIR). This new concept builds upon the emerging use of digital beamforming with weather radars, such as the Atmospheric Imaging Radar (AIR) and C-band Polarimetric Atmospheric Imaging Radar (PAIR), to obtain vertically continuous, rapid-scan radar observations of clouds. KaRVIR will be composed of two polarimetric mobile ground-based Ka-band rapid-scan volumetric imaging radar systems that will enable unprecedented science research capabilities. The combination of unique radar architecture, using mature Ka-band phased array antenna technology with digital beamforming on reception, makes the proposed radar systems feasible and cost-effective. The proposed system allows multiple simultaneous beams in elevation with mechanical scanning in azimuth that will provide excellent temporal resolution (<20 s), spatial resolution (24 m at 5 km), and radar sensitivity (-26 dBz at 5 km) due to the continuous-wave (CW) transmitter design. High-quality polarimetric radar products can be ensured since electronic scanning is not required. Leveraging the expertise of the team in the design and calibration of high isolation array antennas, unprecedented cross-polarization isolation (better than -50 dB) can be obtained using slotted waveguide antenna arrays and high isolation (better than -90 dB) between transmit and receive subsystems. Different phase centers of the separated arrays on transmit, receive, and for the Horizontal (H) and Vertical (V) polarizations will be corrected appropriately during the radar calibration process.

This paper will discuss the concept of a new development of a dual-polarized Ka-band mobile rapid-scanning volumetric imaging radar system, the first ground-based millimeter-wavelength phased array radar for Earth system science. With unprecedented four-dimensional views from high-temporal resolution, volumetric imaging at Ka-band will enable transformative studies of clouds, precipitation, and boundary layer processes, and unleash innovative applied environmental research to study fires plumes, and insect migration.

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