Spectral polarimetry for microphysical studies of rain and hail during the RELAMPAGO campaign

Amit Dutta[1], Chandrasekar Venkatachalam[1], Sounak Biswas[1], and Ivan Arias[1]

[1]Colorado State University

November 29, 2022

Abstract

This paper presents microphysical inference retrievals obtained from spectral polarimetry during the Relampago (Remote sensing of Electrification, Lightning, And Mesoscale/Microscale Processes with Adaptive Ground Observations) campaign. Spectral processing has been an essential part of weather radar moments estimation for a long period of time. Various processing can be performed in the spectral domain including precipitation detection in presence of strong clutter and noise, clutter & interference mitigation by algorithms such as GMAP, object-oriented filters and many more. However spectral applications to polarimetry have been rare. The C band CSU-CHIVO radar that was deployed in Cordoba region in Argentina between June 2018 and April 2019 during the Relampago campaign, recorded some of the tallest storms in the world characterized by strong wind shear, updrifts, turbulence and occurrence of severe hail and rain. The polarimetric spectrum in precipitation with rain and hail mixtures were characterized. This Spectral polarimetry revealed different spectral characteristics including multi-modal spectrum, spectral broadening, slopes in spectral differential reflectivity and lowering of coherency spectrum. These results characterized occurrence of mixed hydrometeor types in a radar resolution volume such as presence of rain and hail mixture, large drops formation and size sorting. Spectral displays are inherently noisy, and the paper also presented methodology to obtain clean quality spectrum implementing spectral quality index, that is used to process the observations and the results are presented.

Authors - Amit Dutta,
V. Chandrasekar,
Sounak Kumar Biswas, Ivan Arias

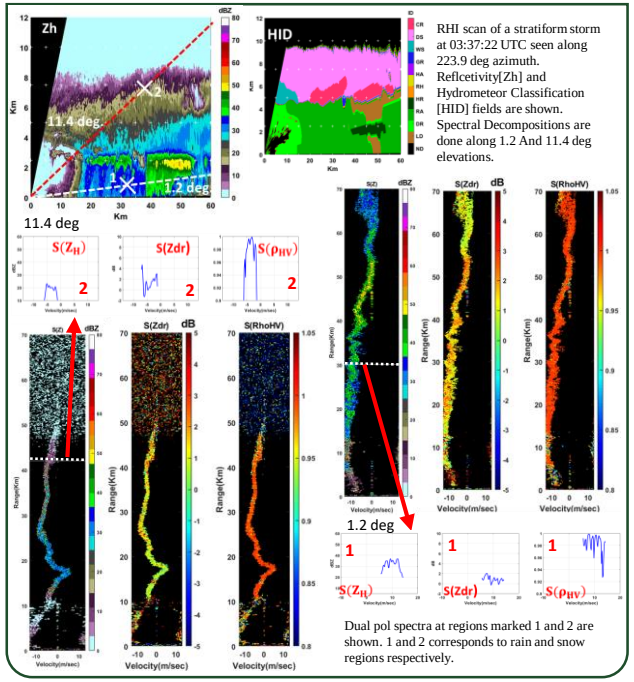
Spectral polarimetry for microphysical studies of rain and hail during the RELAMPAGO campaign

Introduction

- The C-Band CSU-CHIVO radar was deployed in the Cordoba region in Argentina between June 2018 and April 2019 during the Relampago (Remote sensing of Electrification, Lightning, And Mesoscale/Microscale Processes with Adaptive Ground Observations) field campaign. It recorded some of the tallest storms in the world which is characterized by strong wind shear, updrift motion, turbulence and occurrence of severe hail and rain.

- The polarimetric spectrum in precipitation with rain and hail mixtures are characterized. Spectral polarimetry revealed different spectral characteristics including multi-modal spectrum, spectral broadening and lowering of coherency spectrum [1].

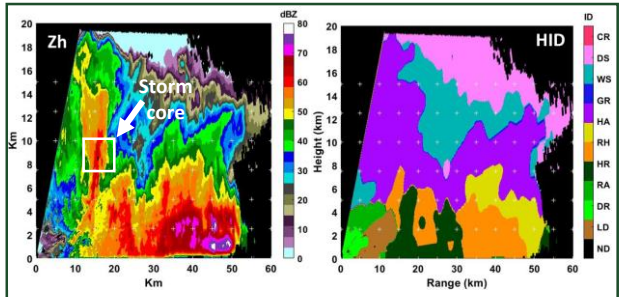
Rain event observed by CSU - CHIVO radar on 30th Nov 2018



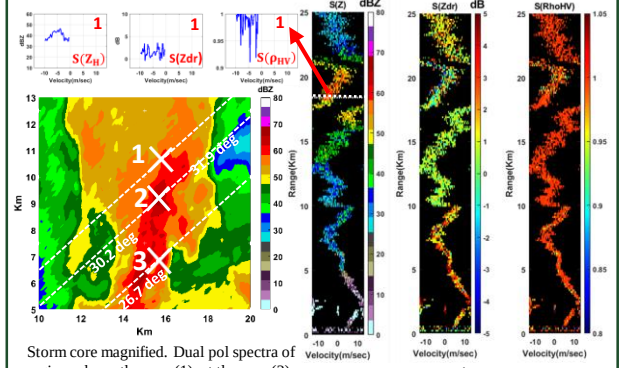
RHI scan of a stratiform storm at 03:37:22 UTC seen along 223.9 deg azimuth. Reflcetivity[Zh] and Hydrometeor Classification [HID] fields are shown. Spectral Decompositions are done along 1.2 And 11.4 deg elevations.

Dual pol spectra at regions marked 1 and 2 are shown. 1 and 2 corresponds to rain and snow regions respectively.

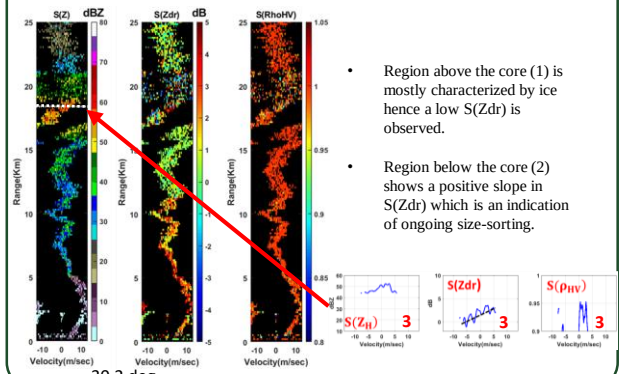
Rain & Hail event observed by CSU - CHIVO radar on 25th Jan 2019



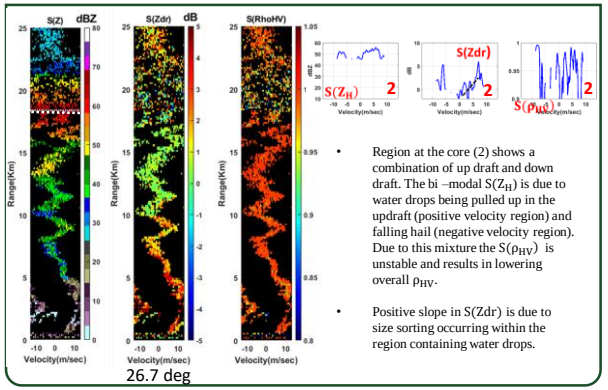
RHI scan of a convective storm at 21:09:14 UTC seen along 282.5 deg azimuth. Reflectivity and Hydrometeor Classification fields are shown.



Storm core magnified. Dual pol spectra of regions above the core (1), at the core (2) and below the core(3) are studied



- Region above the core (1) is mostly characterized by ice hence a low S(Zdr) is observed.
- Region below the core (2) shows a positive slope in S(Zdr) which is an indication of ongoing size-sorting.



- Region at the core (2) shows a combination of up draft and down draft. The bi –modal $S(Z_H)$ is due to water drops being pulled up in the updraft (positive velocity region) and falling hail (negative velocity region). Due to this mixture the $S(\rho_{HV})$ is unstable and results in lowering overall ρ_{HV}.
- Positive slope in S(Zdr) is due to size sorting occurring within the region containing water drops.

Observations

- Hydrometeor classification algorithm [2] performed on the radar data showed presence of different types of hydrometeors including rain, hail, large drops, mixture of rain & hail, snow, graupel and dendrites. Spectral analysis were done at different range bins and the properties are reported.
- Spectral broadening and bi-modal spectra are observed in $S(Z_H)$ regions of rain mixed with hail/graupel
- Slope in S(Zdr) indicates size sorting in hail

Conclusion

Spectral polarimetry can be used to characterize the microphysics and dynamics of a storm at a particular radar resolution volume. Spectral properties reveal important information about the microphysics of a storm observed by a dual-pol weather radar during the RELAMPAGO campaign.

Acknowledgements: We thank the large team of engineers and scientists that contributed to the RELAMPAGO data collection program.

References

[1] Wang, Y., T. Yu, A.V. Ryzhkov, and M.R. Kumjian, 2019: Application of Spectral Polarimetry to a Hailstorm at Low Elevation Angle. J. Atmos. Oceanic Technol., 36, 567–583, https://doi.org/10.1175/JTECH-D-18-0115.1

[2] Bechini, R. and V. Chandrasekar, 2015: A Semisupervised Robust Hydrometeor Classification Method for Dual-Polarization Radar Applications. J. Atmos. Oceanic Technol., 32, 22–47, https://doi.org/10.1175/JTECH-D-14-00097.1

This research is funded by the US National Science Foundation, RELAMPAGO project.