Atmósfera 27(1), 21-34 (2014)

Detection of hail through the three-body scattering signatures and its effects on radar algorithms observed in Romania

DANIEL VICTOR CARBUNARU, MONICA SASU and SORIN BURCEA
National Meteorological Administration, Bucharest, Romania
Correponding author: D. V. Carbunaru; e-mail: daniel.carbunaru@meteoromania.ro

AURORA BELL
Bureau of Meteorology, Melbourne, Australia

Received October 10, 2012; accepted September 5, 2013

RESUMEN

La red de radares de la Administración Meteorológica Nacional de Rumania (NMA, por sus siglas en inglés) integra cinco radares de la banda S y cuatro radares de la banda C. La observación de procesos de convección en Rumania mediante la red de radares Doppler ofrece una nueva perspectiva para comprender el riesgo climatológico de ciertas regiones y entornos de mesoescala. Se observan mejor los sistemas convectivos altamente organizados, como las supercélulas, y su amenaza subsiguiente puede predecirse mejor durante el pronóstico a muy corto plazo (*nowcasting*) utilizando campos de velocidad Doppler y algoritmos de detección como mesociclones (MESO) y firmas de vórtice de tornados (TVS, por sus siglas en inglés). Sin embargo, para fines de prevención, estas herramientas no pueden utilizarse sin una validación subjetiva debido a los errores asociados y limitaciones de las observaciones de radar. En este trabajo se presentan varios casos en que la presencia de granizo de gran tamaño dentro de la tormenta produjo un artefacto de radar llamado "pico de granizo" (*three-body scatter spike*, TBSS) que alteró el campo de velocidad Doppler. Los casos presentados se observaron con radares de banda S y se compararon con informes de granizo sobre el terreno. El primer caso muestra un TBSS cuyas velocidades Doppler radiales son negativas debido a la presencia de hidrometeoros. El segundo exhibe una situación menos frecuente, cuando las velocidades Doppler en la región TBSS son positivas debido a la corriente ascendente. El tercer caso muestra valores positivos y negativos en la región TBSS; representa una supercélula con granizo de gran tamaño que afectó a la ciudad de Varna, en Bulgaria. Los valores positivos se asociaron con la región sobresaliente de la corriente rotacional ascendente a alturas superiores, en tanto que los valores negativos en las regiones externas de la corriente rotacional ascendente a alturas inferiores, se asociaron con las corrientes descendentes. Algunas anomalías producidas por el TBSS han alterado los resultados de los algoritmos TVS y MESO, introduciendo valores falsos de viento de gradiente fuerte que se han interpretado como rotación. De esta manera se generaron firmas falsas de mesociclones y vórtices de tornado. En algunos casos se reportaron tornados débiles y granizo de gran tamaño, por lo que la presencia de TBSS fue un reto para quienes realizan predicciones de muy corto plazo. En la parte final de este trabajo se analiza el vínculo entre la aparición de TBSS con informes de 2009 sobre granizo de gran tamaño en tierra en el área de cobertura de los radares de banda S en Rumania, que también abarcan zonas de Hungría, Bulgaria, Moldavia y Serbia. Los resultados muestran que la distorsión ocasionada por el TBSS es un fuerte indicador de granizo de gran tamaño.

ABSTRACT

The Romanian National Meteorological Administration (NMA) radar network consists of five S-band and four C-band radars. Observation of convection in Romania through the Doppler radar network offered a new perspective in understanding the climatologic risk of certain regions and mesoscale environments. Highly organized convective systems, such as supercells, are better observed and their subsequent threat can be better anticipated during the nowcasting process using Doppler velocity fields and detection algorithms

such as mesocyclones (MESO) and tornadic vortex signature (TVS). However, for warning purposes, these tools cannot be used without a subjective validation because of the associated errors and limitations of radar observations. In this paper several cases are presented where the presence of large hail inside the storm produced a radar artifact named three-body scatter signature (TBSS) that disturbed the Doppler velocity field. The cases presented were observed with S-band radars and were associated with hail reports on the ground. The first case shows a TBSS whose radial Doppler velocities are negative due to the falling hydrometeors. The second case is a less frequent event; there the Doppler velocities in the TBSS region are positive due to the updraft. The third case has both positive and negative values in the TBSS region; it ocurred in a supercell that affected the city of Varna in Bulgaria with large hail. The positive values were associated with the overhang region in the rotational updraft at upper heights, while the negative values in the regions outside the rotational updraft at lower heights, were associated with the downdrafts. Features produced by the TBSS have perturbed the output of the MESO and TVS algorithms by introducing false strong values of wind shear that have been interpreted as rotation. Thus false mesocyclonic and tornadic vortex signatures were generated. In some of the cases large hail and weak tornadoes were reported, so the presence of a TBSS was a challenge for the nowcasters. In the last part of the paper we analyze the link between the TBSS appearance with reports of large hail at the ground in 2009 within the coverage area of the Romanian S-band radars, which also cover parts of Hungary, Bulgaria, the Republic of Moldova and Serbia. The results show that the TBSS artifact is a strong indicator of large-size hail.

Keywords: Three-body scatter signature, radial Doppler velocity field, hail, downdraft, updraft.

1. Introduction

In November 2000, the Romanian National Institute of Meteorology and Hydrology (INMH), today National Meteorological Administration (NMA), began to modernize its capabilities for detecting, monitoring and predicting meteorological and hydrological phenomena, by implementing the National Integrated Meteorological System – SIMIN project. SIMIN integrates five WSR-98D S-band radars with four existing C-band Doppler radars, to form a nine-unit Doppler radar network (Fig. 1). The WSR-98D is a clone version of the WSR-88D systems used in the US National Weather Service network. Currently, SIMIN produces individual site and national composite radar products every 6 minutes.

Advances in computer and radar technology, coupled with a dramatic increase in meteorological data sets, were not the only challenges to the forecasters. New conceptual models had to be learned and assimilated in operational practice as S-band radar allows the detection of severe weather associated with convective storms. Thus, mesocyclones (MESO), tornadic vortex signatures (TVS), low level and mid altitude convergence zones, became *nolens volens* usual terminology in nowcasting activities, despite a general belief that tornadic storms did not occur in Romania. Observing convection in Romania through the new S-band radar network provides a sharper perspective on mesoscale environments and the storms these environments create. Highly organized convective systems, such as supercells, can be better anticipated using useful radar pattern recognition software routines such as the MESO (Stumpf *et al.*, 1998) and the TVS (Mitchell *et al.*, 1998) algorithms. However, while these algorithms do demonstrate some skill they also are susceptible to radar artifacts and sampling limitations. Moreover, they sometimes fail to detect critical signatures that may be subtle or fail to meet certain thresholds. For this reason the meteorologist must carefully examine

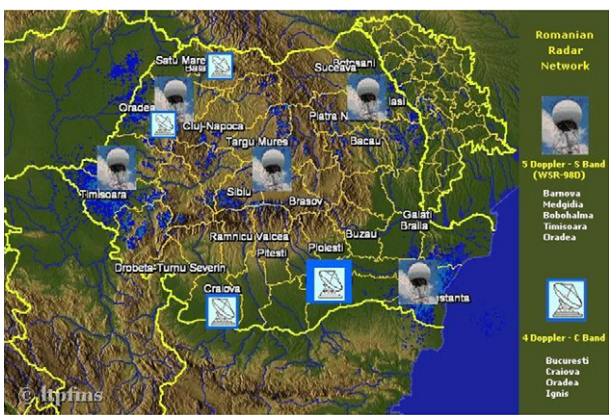

Fig 1. The SIMIN radar network: five WSR-98D S-band radars (an upgraded version of the WSR-88D radar used in the US NWS network) and four C-band radars (two from EEC –DWSR-2500C type and two from Gematronik–METEOR 500C type).