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Atmospheric Research 83 (2007) 162–175

ATMOSPHERIC RESEARCH

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Case study of the 9 May 2003 windstorm in southwestern Slovakia

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Accepted 28 September 2005

Abstract

May 9, 2003 thunderstorm in southwest Slovakia is considered one of the most severe convective events to have happened in Slovakia during the past ten years. The majority of the reported damage was caused by very strong outflowing winds and hail. The downburst (macroburst) nature of the event was confirmed by a damage survey carried out in the area hit by the thunderstorm. The supercell nature of the storm was inferred from radar measurements, with the fields of radar reflectivity and radial Doppler velocity showing typical supercell features (e.g. BWER echo). The satellite imagery (from METEOSAT 7) indicated a large-scale dry air intrusion as a possible factor of downdraft enhancement. Aspects of the storm environment were inferred from soundings, numerical analysis of the ALADIN model and Velocity Azimuth Display data from radar. The results enable comparison of the outputs of several instability indices, such as CAPE, DCAPE and Storm to Relative Environmental Helicity (SREH). It was concluded based on structure and development that the storm showed many similarities to the so called High Precipitation (HP) supercell type.

Keywords: Slovakia; Supercell thunderstorm; Windstorm

1. Introduction

Supercell thunderstorms have been defined, classified and widely studied during the past forty years. Several papers, documents and presentations have been given concerning the presence of supercells in Europe starting with the pioneer work of Browning (1964). Case studies that are more recent can be found in Höller et al. (1994), Schmid et al. (1997), Gregorič et al. (2003) and Lemon et al. (2003). In the Slovak Republic, the possibility of operational detection and scientific studies of supercell thunderstorms has existed for only a few years. Despite the fact that the Slovak Hydrometeorological Institute (SHMÚ) has provided radar measurements since 1975, it was mainly the use of the Doppler radar (DWSR92c) at Malý Javorník station since 1997, that enabled recognition of the characteristic radar echoes for this type of thunderstorm (summarized, for example, by Burgess and Lemon, 1990).

The case of the May 9, 2003 windstorm in southwest Slovakia was the first one in Slovakia that was recognized as a supercell. It caused considerable damage, mainly in the district of Levice. The storm affected at least 11 villages of this district, situated in an agricultural region with flat terrain in the south and small hills in the northeast (150–300 m above sea level).

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doi:10.1016/j.atmosres.2005.09.012

The overall financial losses related to the storm were estimated to exceed 300,000,000 Slovak crowns which is approximately 7,000,000 Euro (personal communication with J. Lészkó from Regional Chamber of Agriculture and Food in Levice and J. Havran from Office of Civil Protection in Levice). Fortunately, no casualties or serious injuries are known or reported for this event. The major part of the damage (and financial losses) was related to extreme winds, and to hail appearing during the final stage of the thunderstorm. Lesser damage was attributed to heavy rainfall.

The purpose of the study presented in this paper was to specify characteristic features of the storm from radar products and to compare them with widely recognized types of supercell thunderstorms. The work further concentrated on the study of the thunderstorm environment to find possible precursors of the storm type and severity. Information about local impact of the storm was obtained from damage survey. Finally the study demonstrates the possibilities of operational detection and nowcasting of thunderstorms similar to the May 9, 2003 case.

2. Description of radar measurements

The DWSR92c (C-band) Doppler radar at Malý Javorník station is situated in western part of Slovakia (48° 15′ of latitude and 17° 9′ of longitude), at 600 m above sea level. Operational measurements are provided every 15 min at 240 km range, on 600 Hz pulse repetition frequency, 0.8 μs pulse width and 1000 m gatewidth. Between operational observations (e.g. at times 1700, 1715 UTC...), experimental scans are provided on the same range, and with the same setup of parameters, with the purpose of testing and developing the nowcasting system at SHMÚ. These data are available every 15 min, between 1707 and 1922 UTC, specifically for this case study. Further, short 60 km range observations were operationally running at that time. These measurements were used as input for the Velocity Azimuth Display (VAD) algorithm, profiting from high resolution (125 m gatewidth) and increased Doppler velocity folding limit (32 m/s).

The radar data obtained from the Hungarian Meteorological Service were also measured by DWSR92c type of Doppler radar situated at Budapest Lőrinc (48°15′ of latitude and 17°9′ of longitude) in the same time intervals as the operational observations at SHMÚ. Nevertheless, some parameters (e.g. gatewidth) and the setup of elevation angles differed from the scanning strategy used by the Malý Javorník radar. The data exchange also included high resolution Plan Position Indicator (PPI) scans at 120 km range and elevation 1.4°.

The forecaster at SHMÚ has access to nowcasting tools based on extrapolation of both radar and satellite images. These tools are being developed in cooperation with other European weather institutes taking part in the CEI collaboration (Zwatz-Meise, 2004). The tracking algorithm for radar data used by the CEI nowcasting system is described in the article of Kaňák and Jurašek (2004).

3. Numerical weather prediction tools

Output from the ALADIN numerical weather prediction (NWP) model was used to analyse the macro- and meso-synoptic situation during May 9, 2003. ALADIN is a spectral, hydrostatic, limited-area model (LAM), developed in cooperation with Mètèo-France and several other European and African weather services. A more detailed description is available in the articles of Radnóti et al. (1995) and Horányi et al. (1996). The versions of the model that were used for the case study had a regular grid and uniform spatial resolution of 12.2 km (ALADIN-LACE domain for central Europe) and 7.2 km (ALADIN-SLOVAKIA domain). The most useful model output data were the vertical cross-sections of humidity fields and analysis/18 h forecasts of spatial distribution of convective instability parameters (e.g. Convective Available Potential Energy — CAPE), and parameters of wind shear and helicity. Density profiles and buoyancy calculations from the ALADIN model were also combined with wind measurements from the VAD algorithm of the Malý Javorník radar. This allowed computation of parameters as density-averaged mean wind, BRN (Bulk Richardson Number) or EHI (Energy Helicity Index).

4. Synoptic situation on 9 May 2003

The analysis of surface pressure from May 9, 2003 12 UTC showed a shallow trough of low pressure over a large part of central Europe, including Slovakia. In the mid-troposphere (850–500 hPa) and upper troposphere (300 hPa), a widespread trough was situated with its axis over the British Isles, France and the Iberian Peninsula. An anticyclonic ridge was present in the upper air analysis. The ridge extended from the south towards the Balkan Peninsula. At low tropospheric levels, the flow was weak, mostly westerly, bringing colder and relatively moist air to the region of southwest Slovakia. A moderate southwesterly flow, with wind speeds from 10 to 17 m/s, dominated at mid-