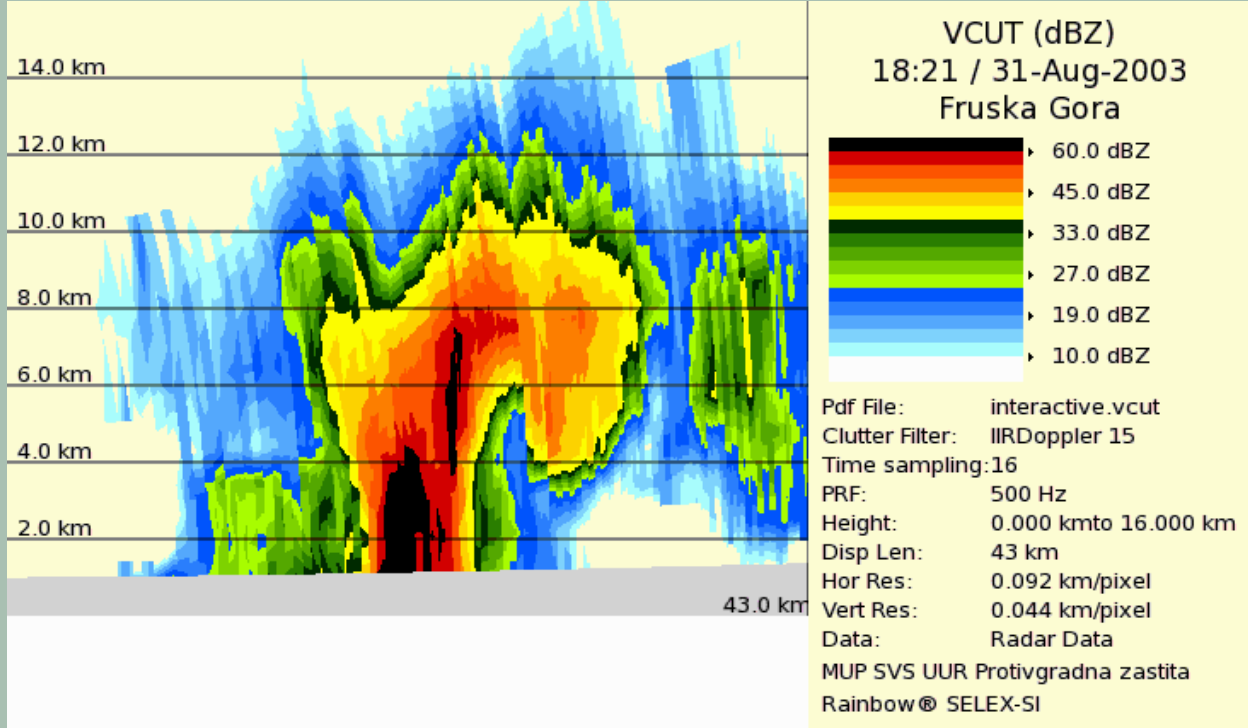
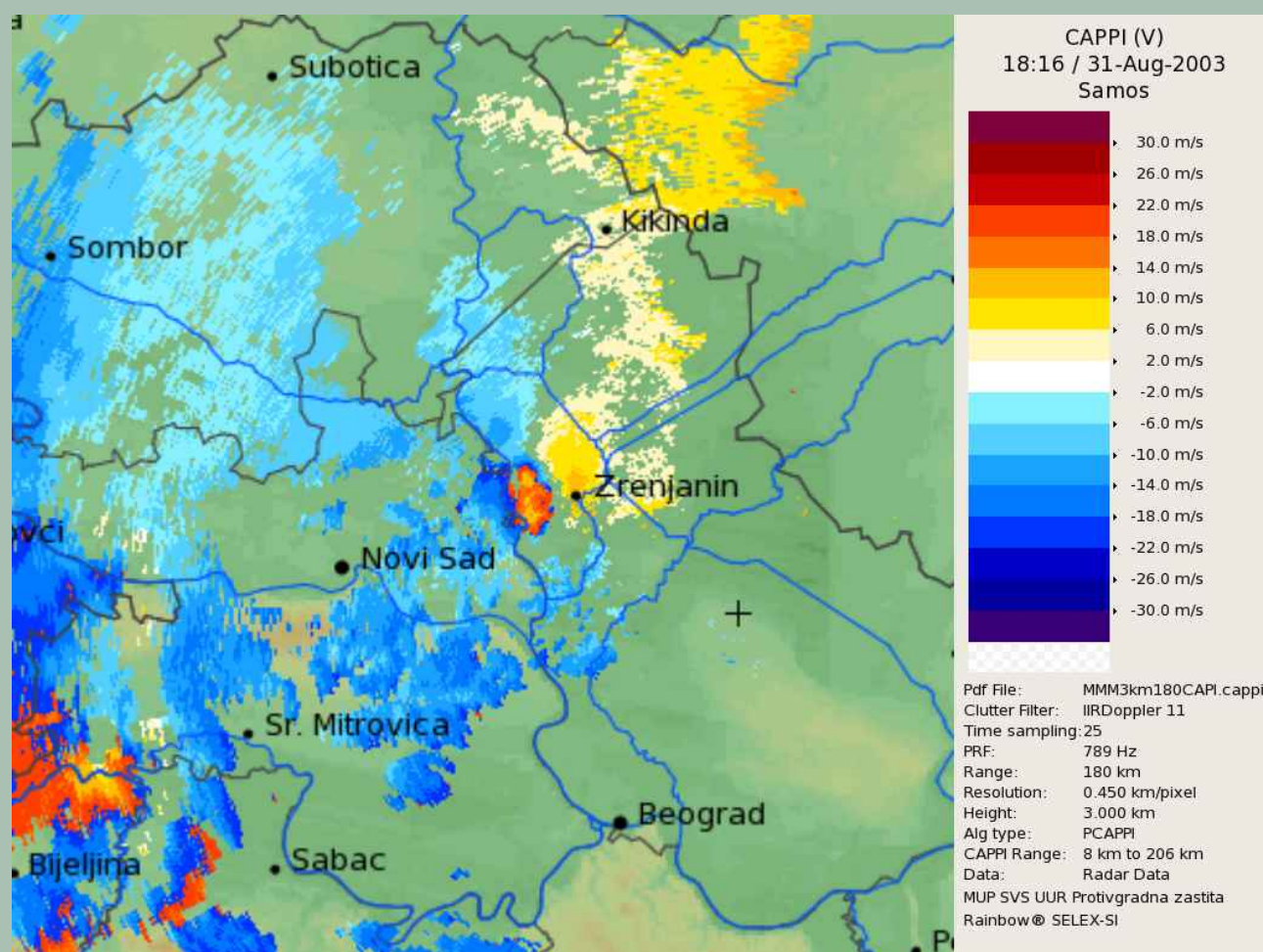
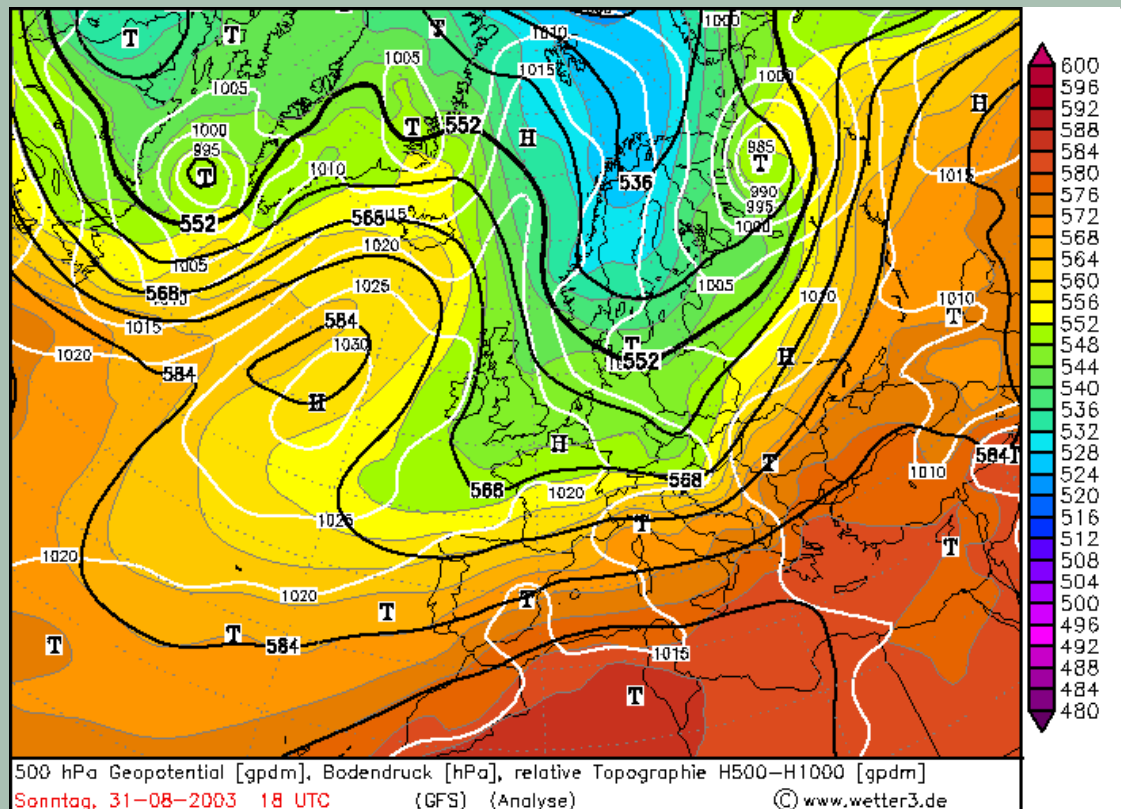
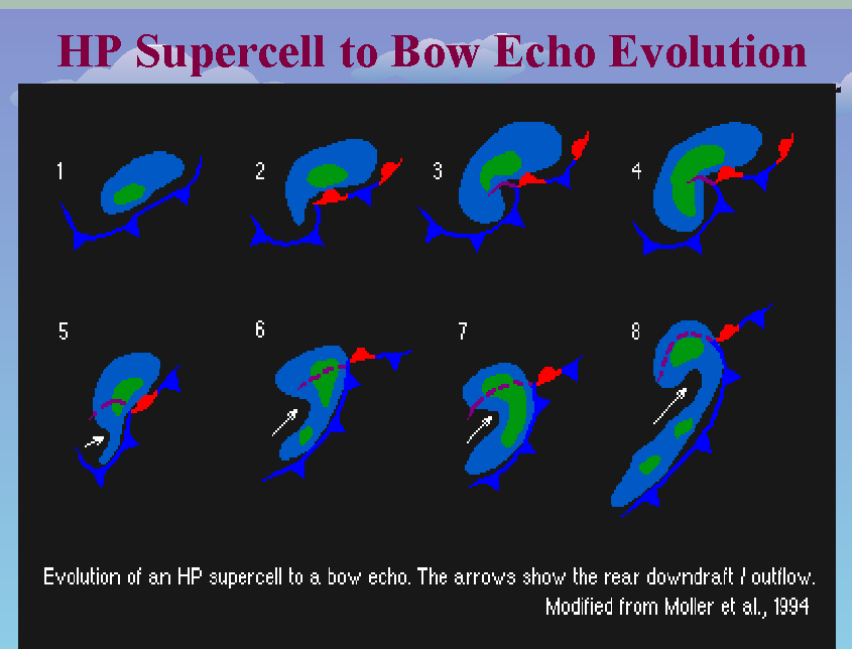
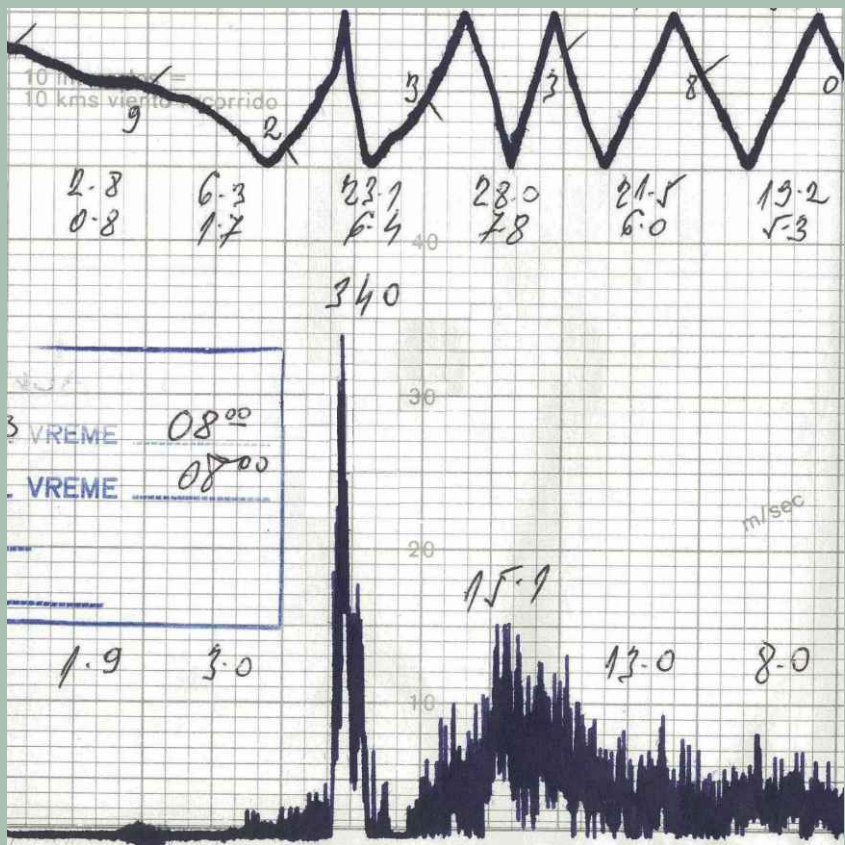
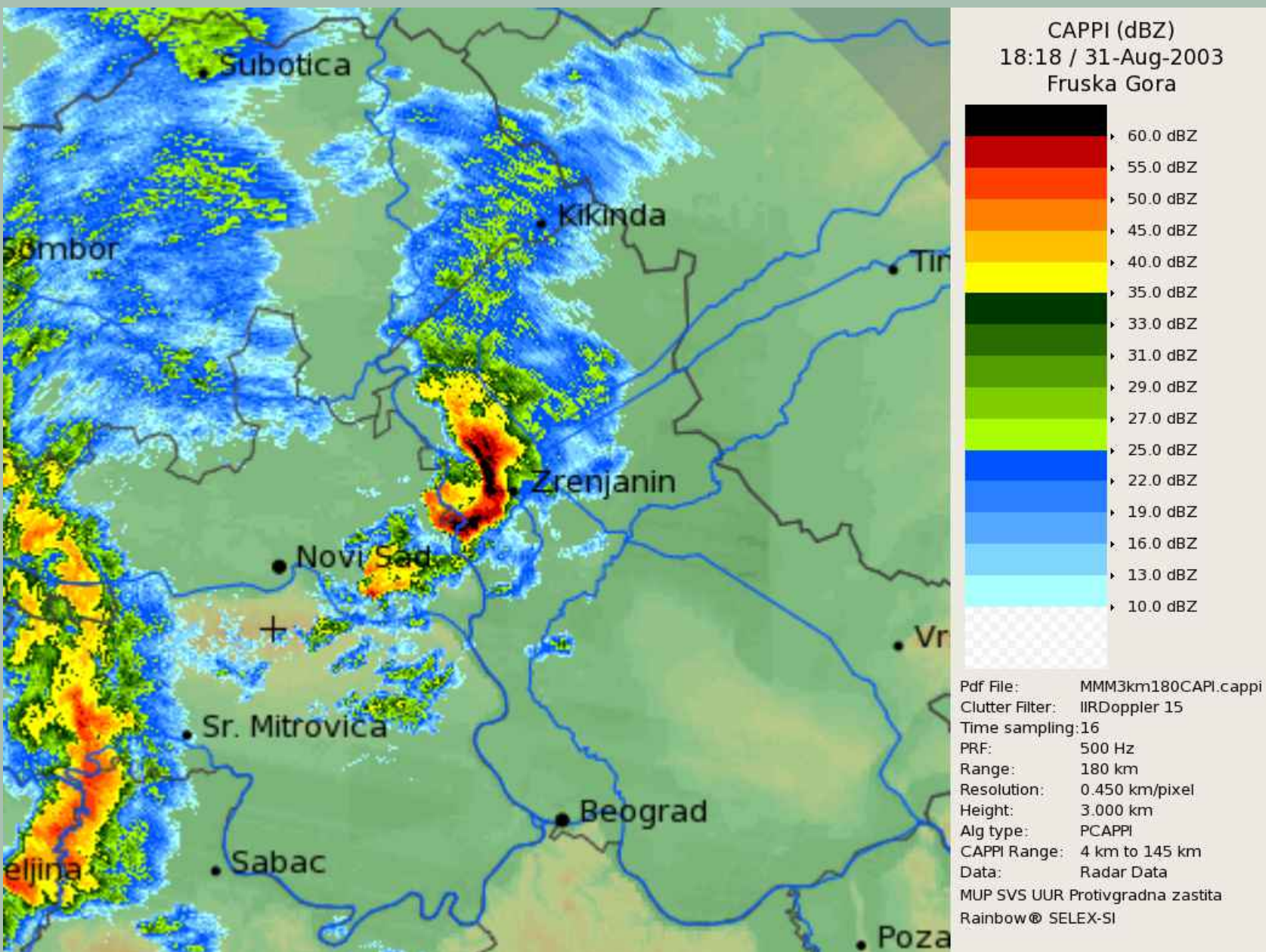


Comparison of Three Summer Bow Echoes in Serbia

Maja Rabrenovic, Ministry of Interior, Sector for Emergency Management, Belgrade, Serbia

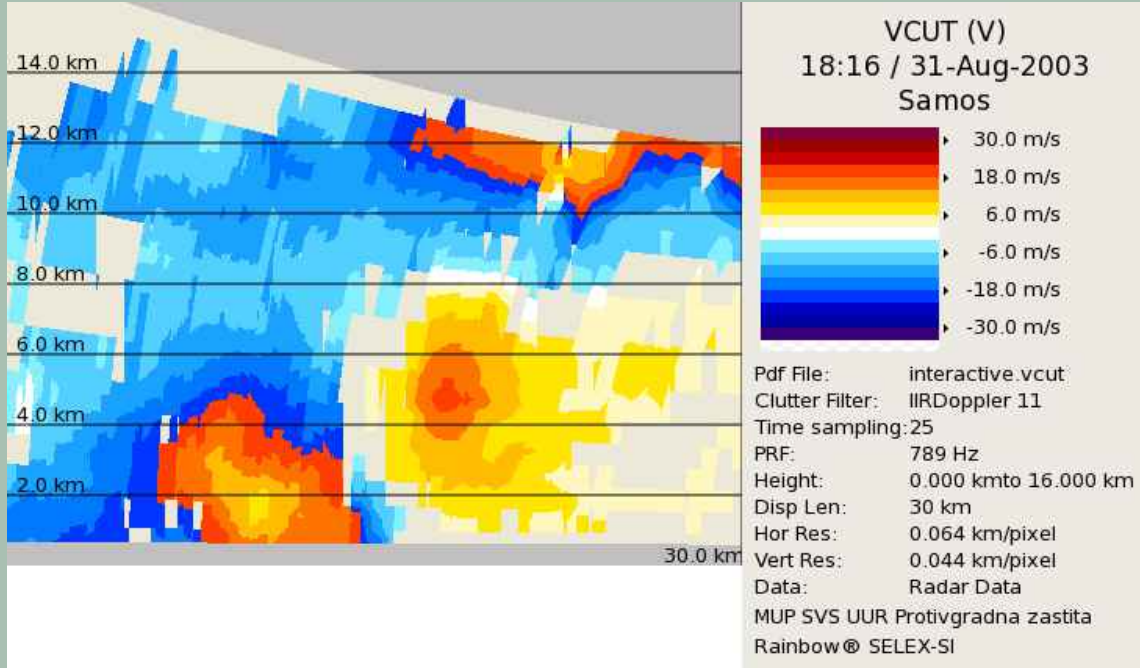
The objective of this paper is to examine meteorological factors that affect bow echo development. Here are presented and compared three summer bow echoes that appeared on the Serbian territory in the period 2003-2008: the first, which was developed from single supercell and observed on 31 August 2003; the second that occurred from stagnant weather pattern with weak synoptic-scale features on 19 June 2007; and the third that emerged from low-pressure frontal system on 8 August 2008. Although all three bow echoes contained elements of severe weather with supercells, heavy rain, large hail and strong straight-line winds, they evolved from different synoptic-scale situations. These events shall be examined and presented using satellite and radar images in the area of Northern, Central and Southern Serbia.

Bow echo occurred 31 August 2003

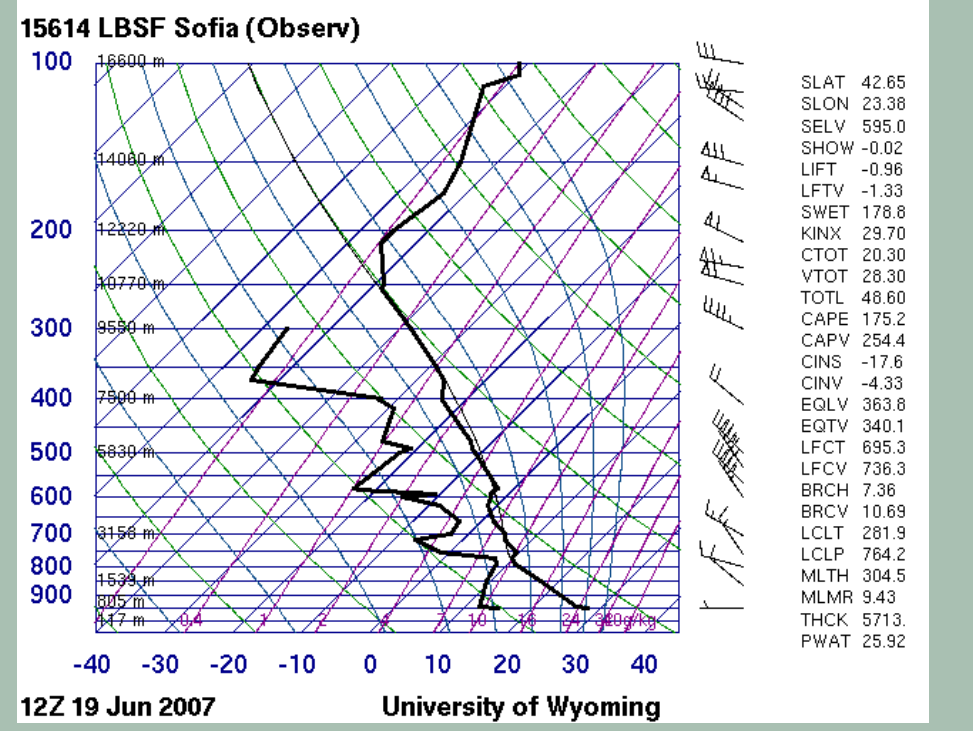
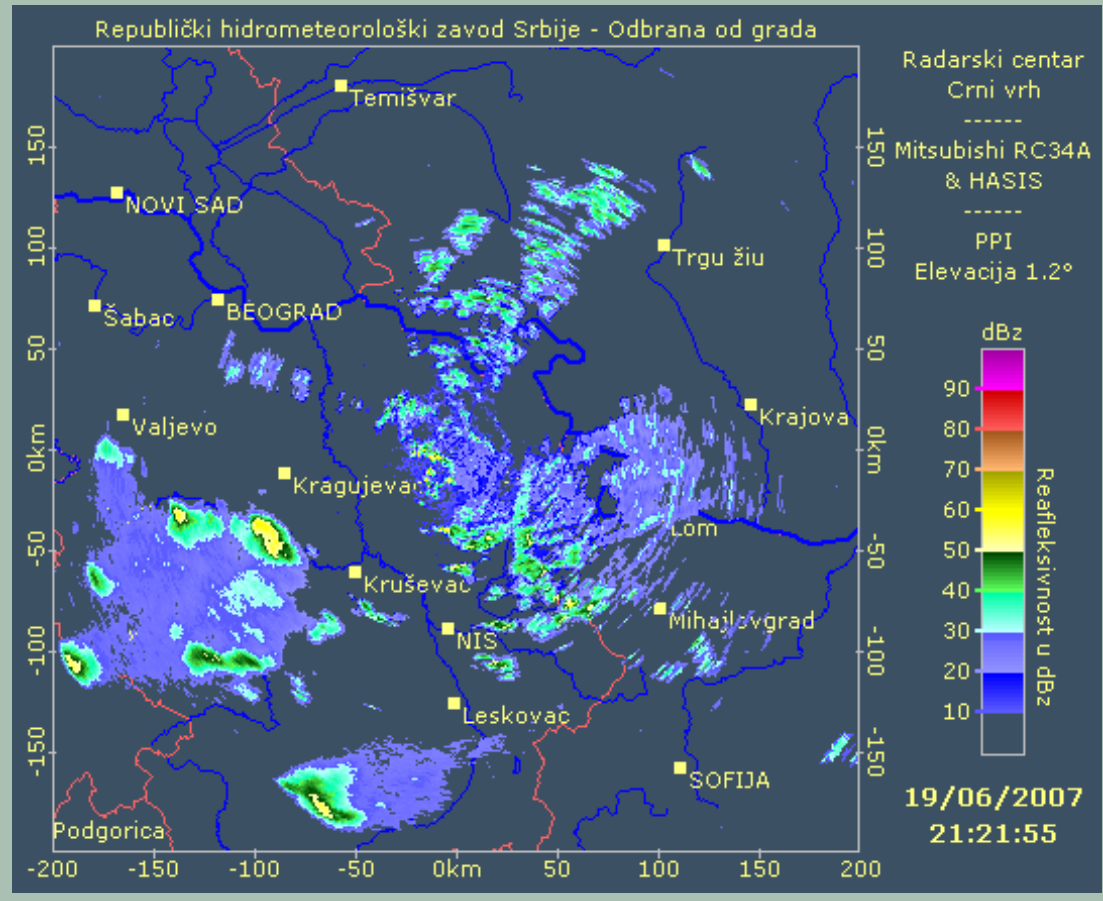
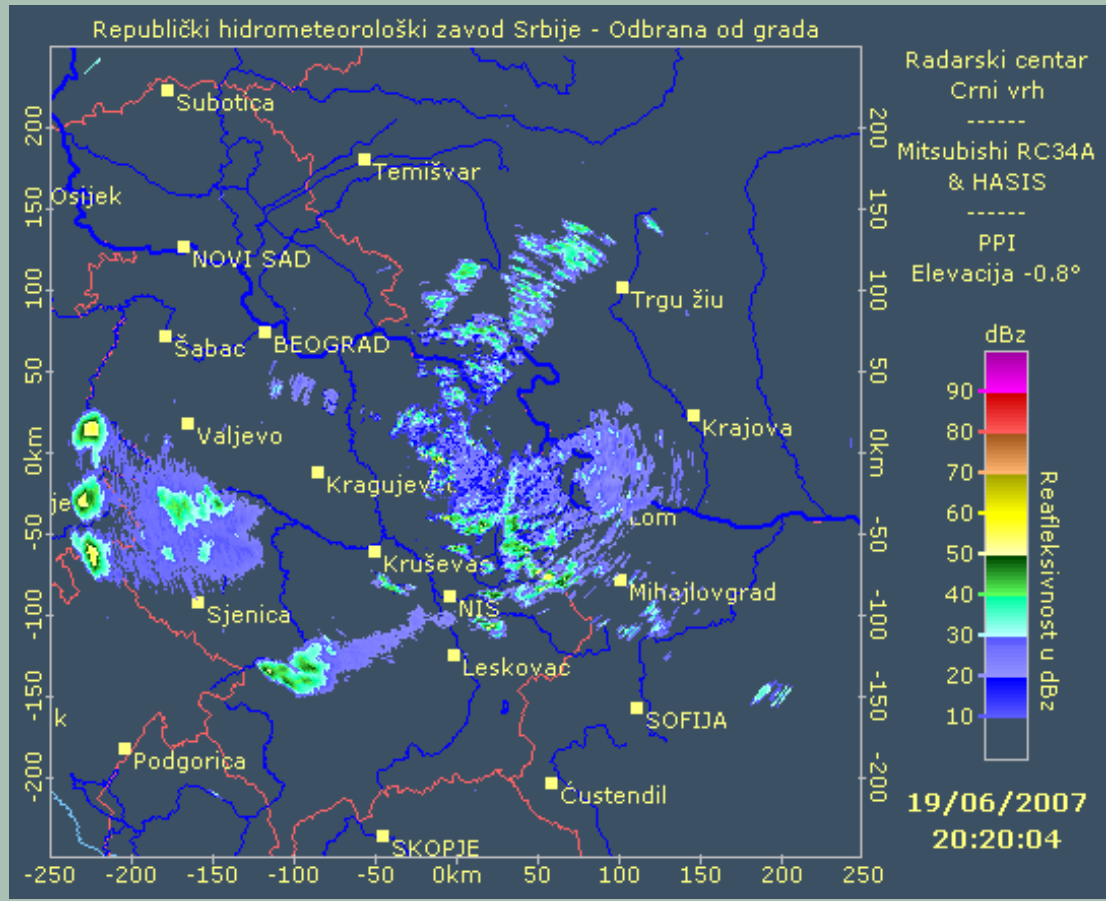
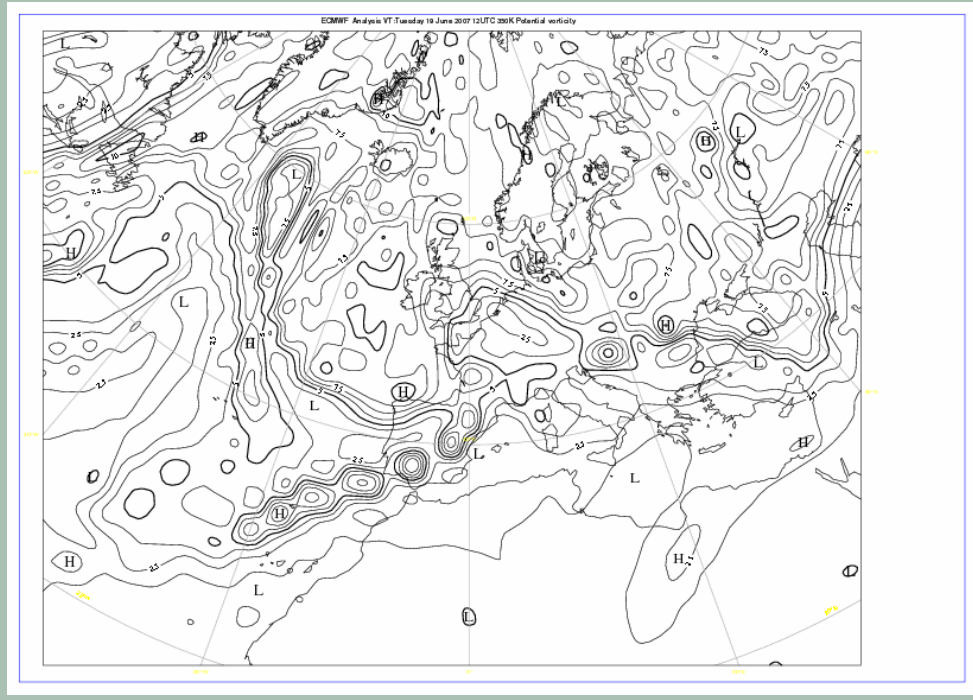
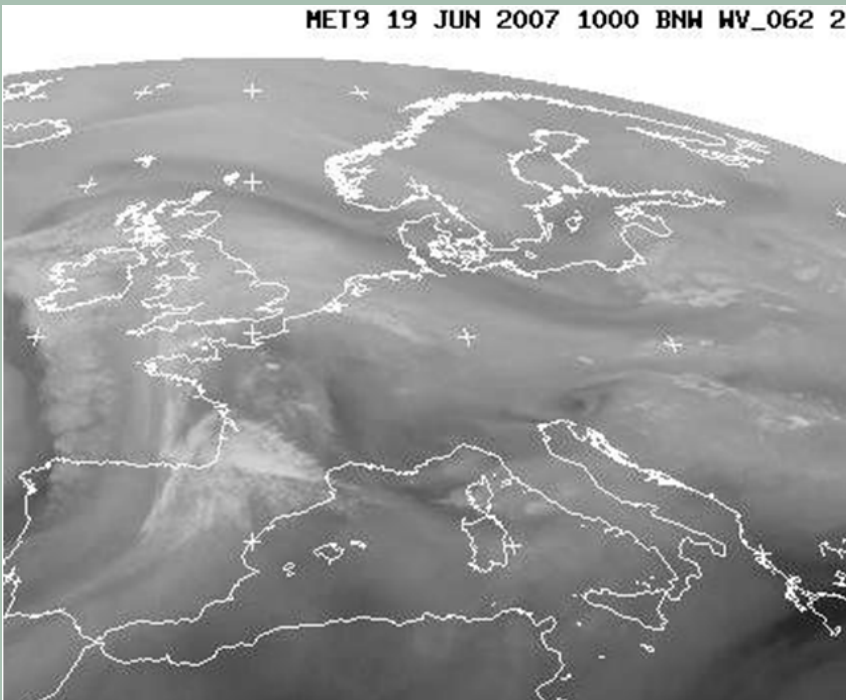
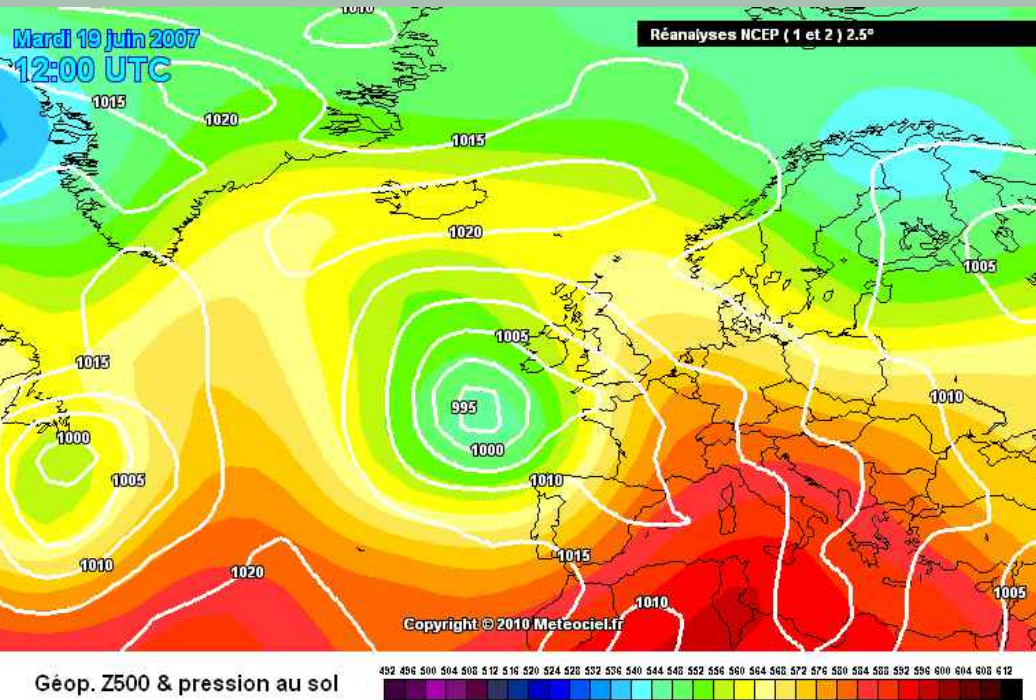


With passage of the frontal system, strong MCS moved on territory of Serbia on 31 August 2003, first in the form of two strong convective cells, then changing its characteristics to multicell and supercell storm. Very strong gradients in pressure field on 500 mb could be observed. Cross sections clearly show supercell characteristics with WER and BWER during its passage through Vojvodina. MCS's speed was from 70 to 80 km/h and in front of City of Zrenjanin the whole mass changed its shape to bow echo with strong microbursts. On that day 23 people were injured, there was a lot of damage on houses and trees.

Meteorological station Zrenjanin is located just on the path of recently formed bow echo. While the frontal border line of the storm was passing, strong gusts in the interval of 10 min strong gusts over 20 m/s were blowing and gave maximum of 34 m/s. On the most of the path pure rotation of MCS was clearly seen. Storm gave heavy precipitation with showers and hail along its trajectory. Hail made a lot of damage both on crops and building objects, especially in town Zrenjanin where hail and violent winds crashed many windows, roof tiles etc. Hail reached size of an egg and at some places connected grains reached the size of a tennis ball.



Bow echo on 10 June 2007

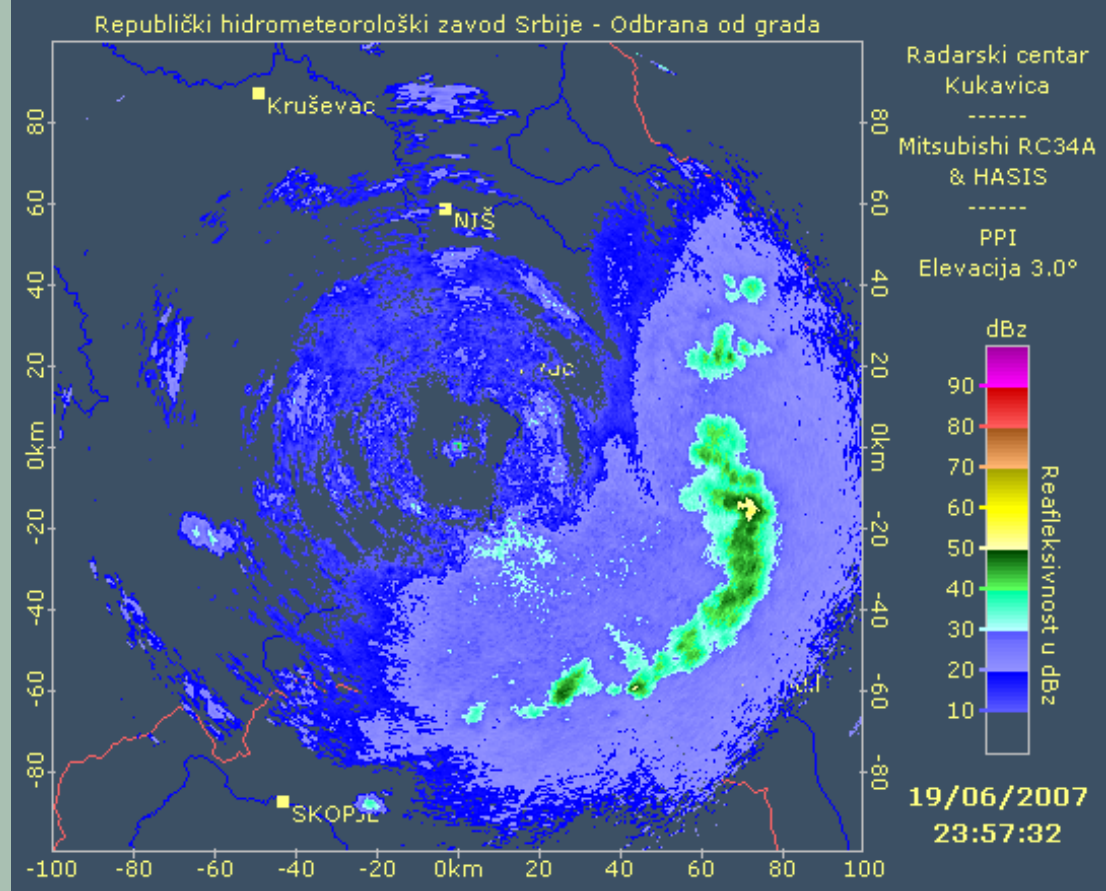


On June 19, bow echo evolved in more stagnant synoptic pattern. Strong flow was created by a low pressure system southwest of Ireland with thermal trough that moved northward over western France. Trough intensified the front from the Atlantic. Moderate deep layer shear and moderate low level shear and storm-relative helicity were forecasted through a tongue of marginally to moderately unstable air mass (where Eye is initiated).

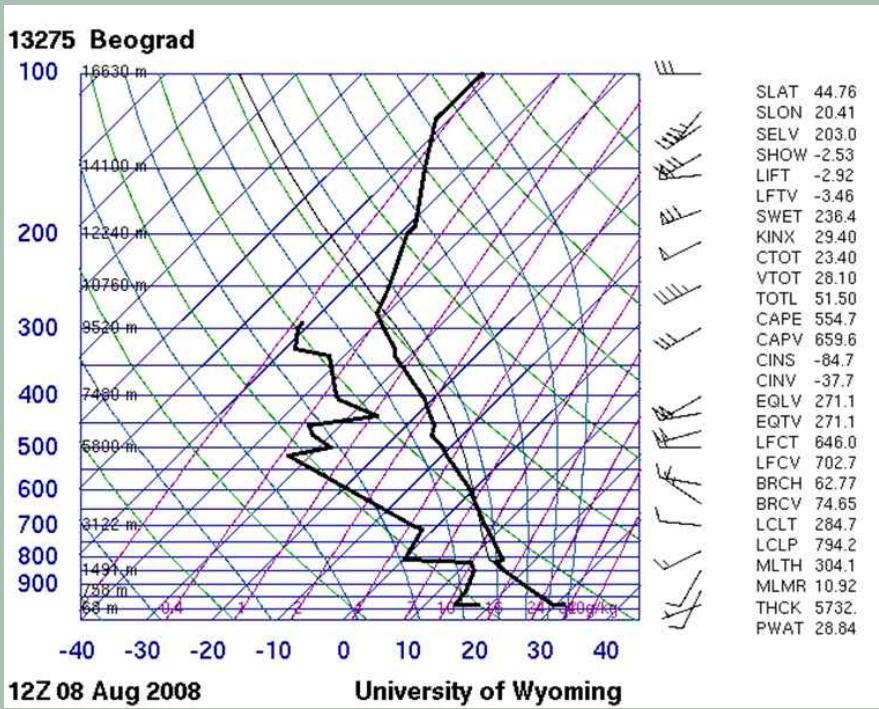
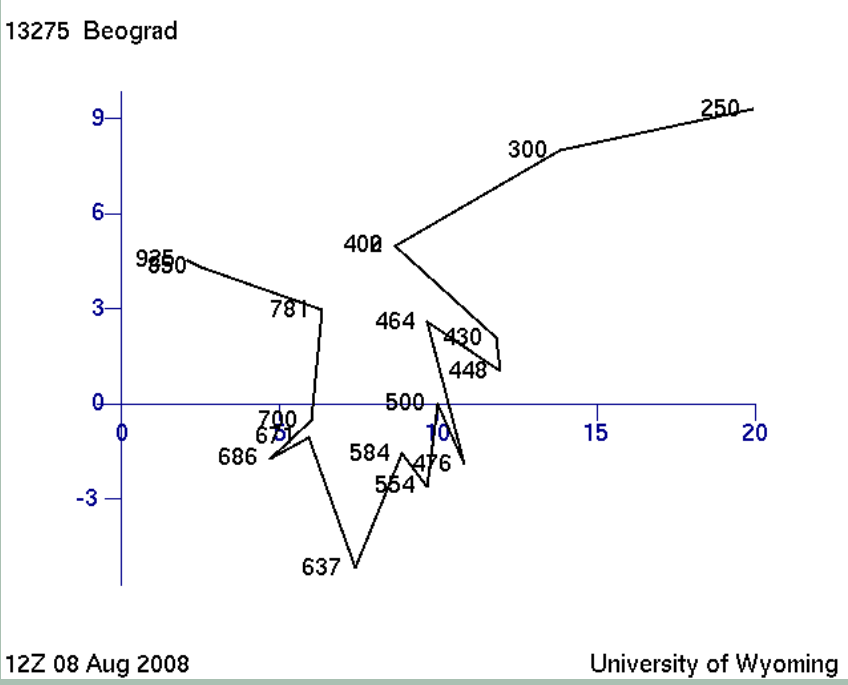
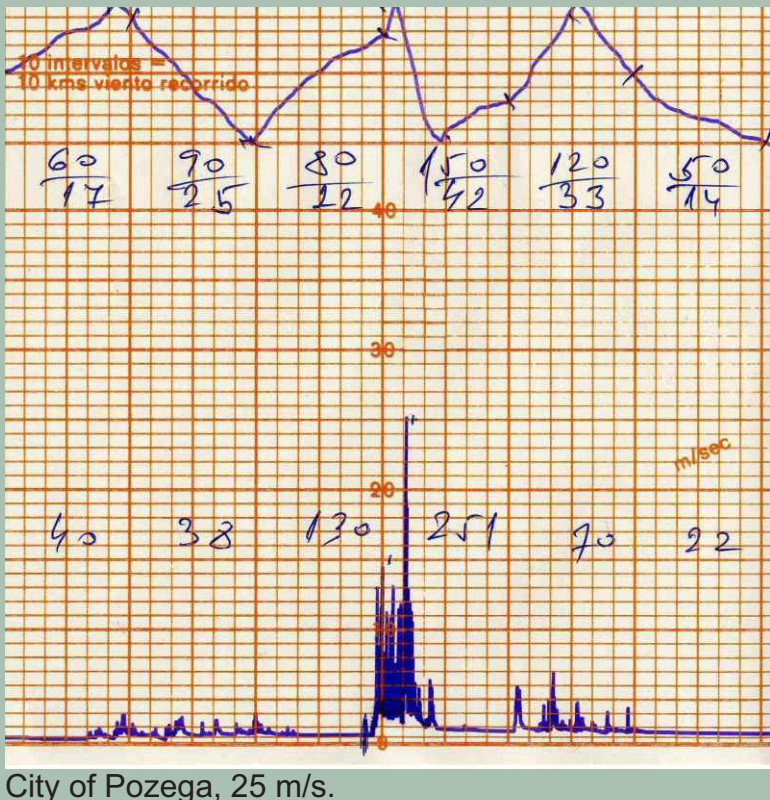
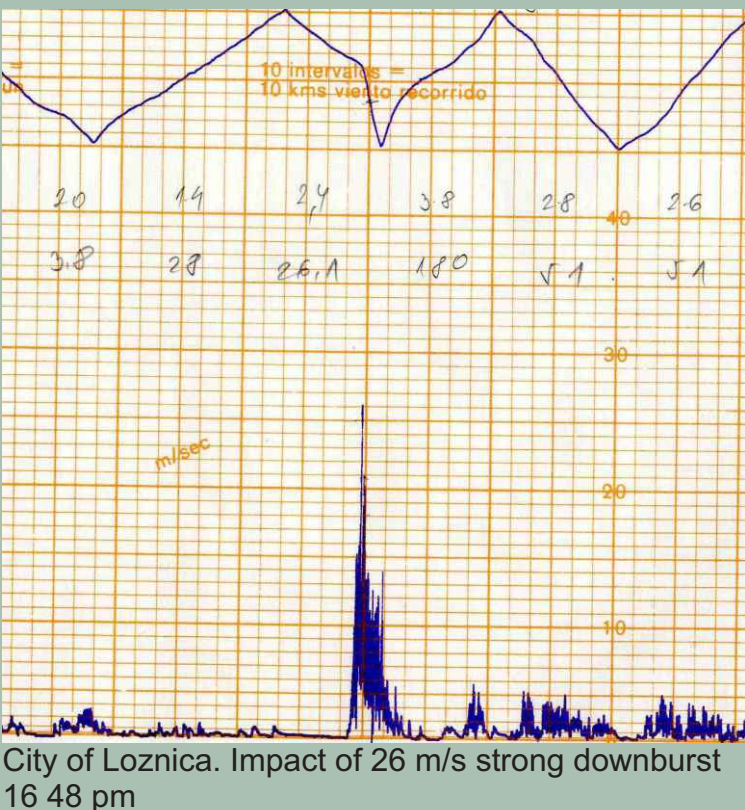
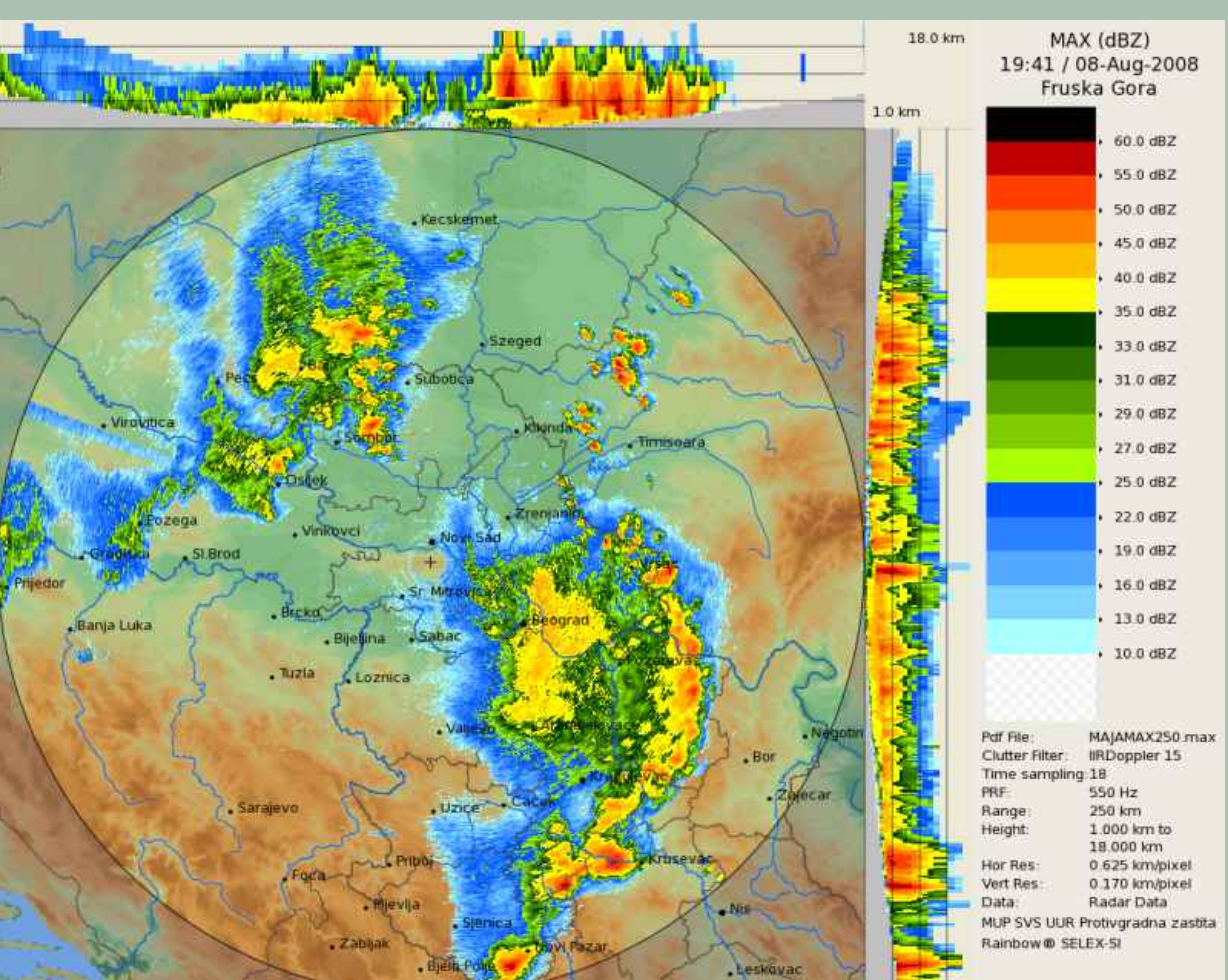
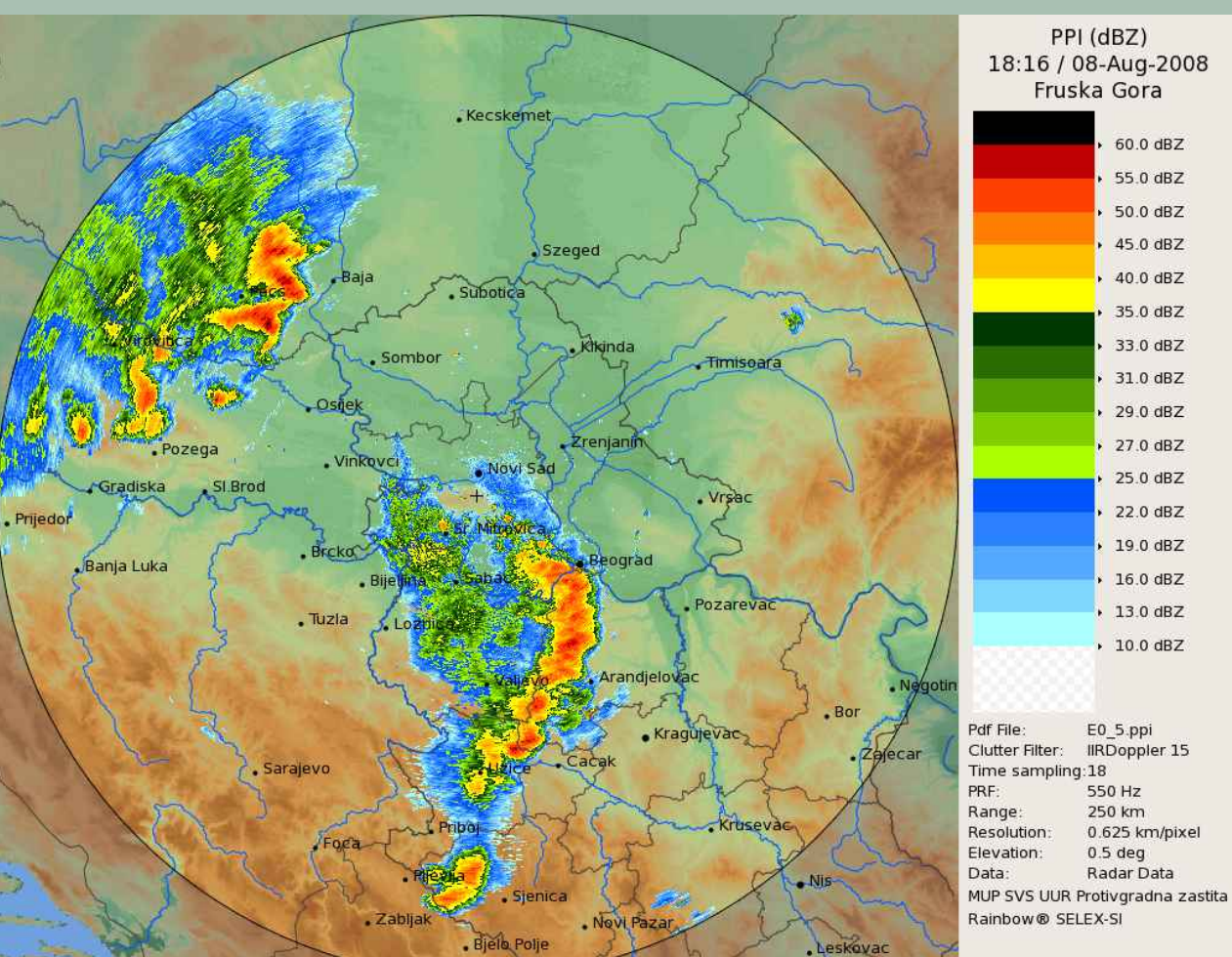
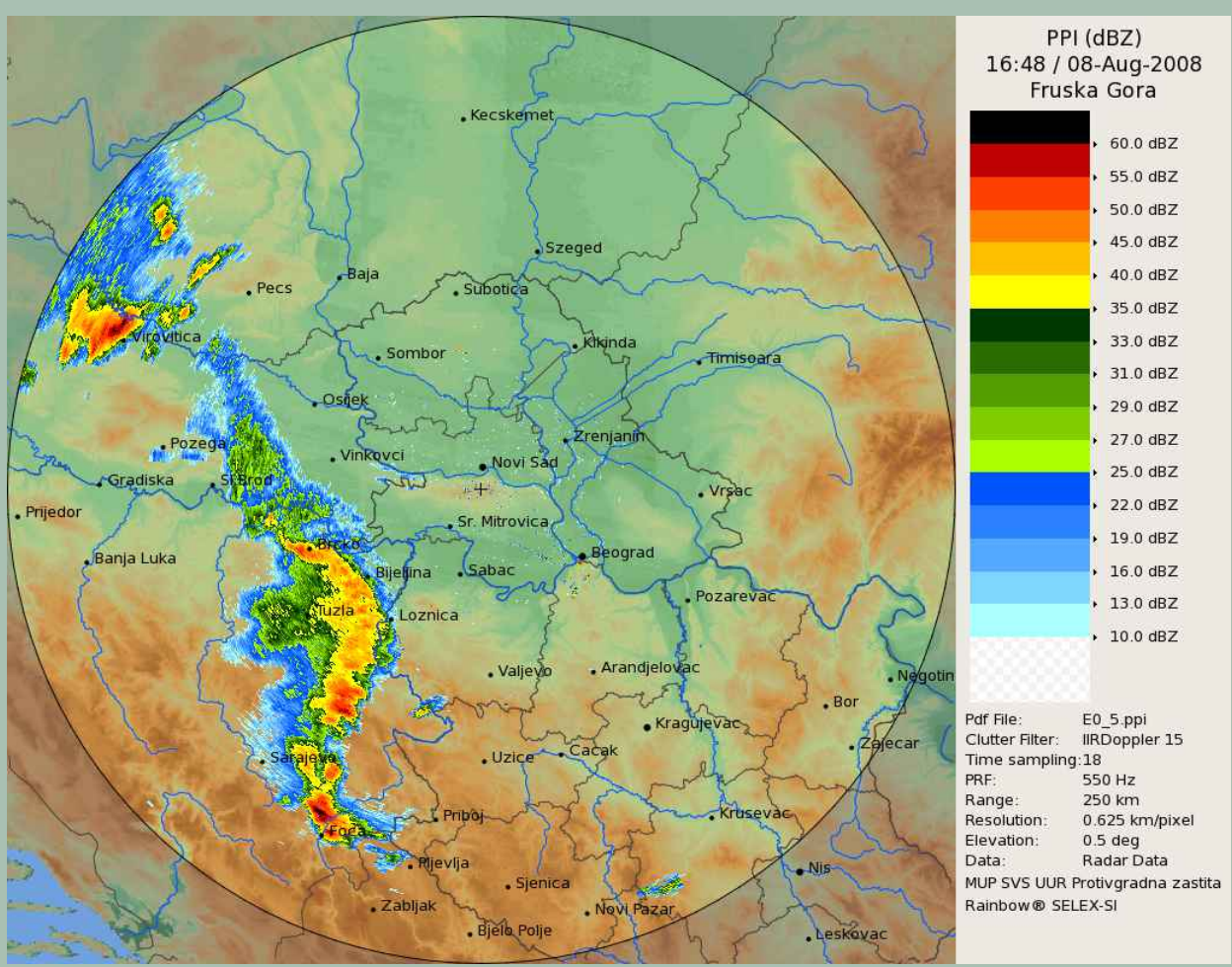
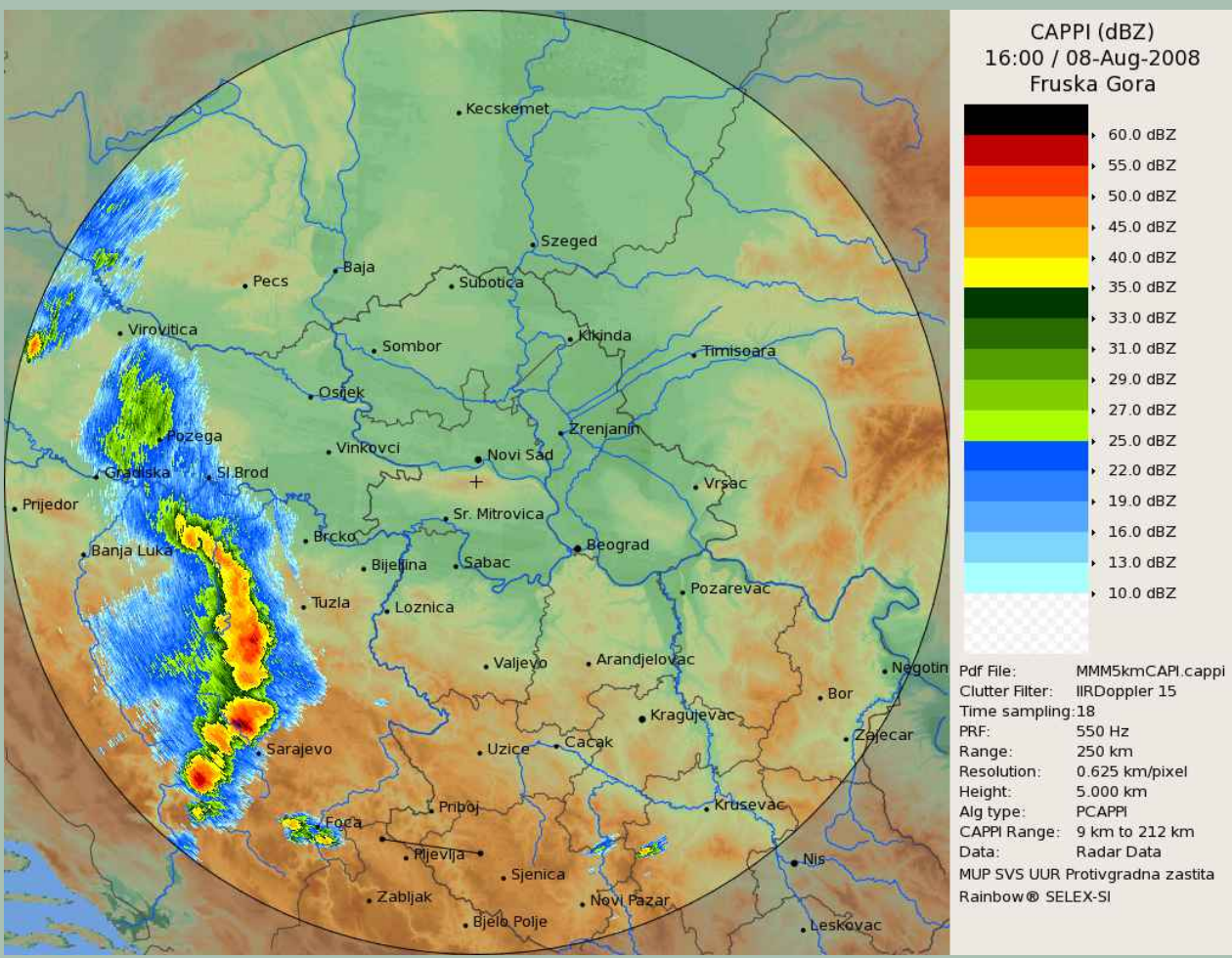
Weak anticyclonic surface circulation over Western Balkan peninsula and upper thermobaric ridge with west-northwest flow over Serbia. Forecasted 0-6 km shear was to be higher than 15 m/s and SREH3 around 200 m²/s². Locally perhaps higher due to flow over complex terrain. With several hundred J/kg CAPE (Udine) and weak orographic forcing, we could expect isolated severe multi/marginal supercells with a chance of large hail, mainly, but also isolated severe gusts.

WV Eye forming around 18 00 UTC on the previous day, between Perinees and Alps followed by high positive values of potential vorticity (PV). WV eye moves zonally with the flow on the northern part of the ridge. Maximum values of potential vorticity follows Eye circulation all along its part over Alps finally to Slovenia, with little or no major cloudiness, but with distinct features in the water vapour field.

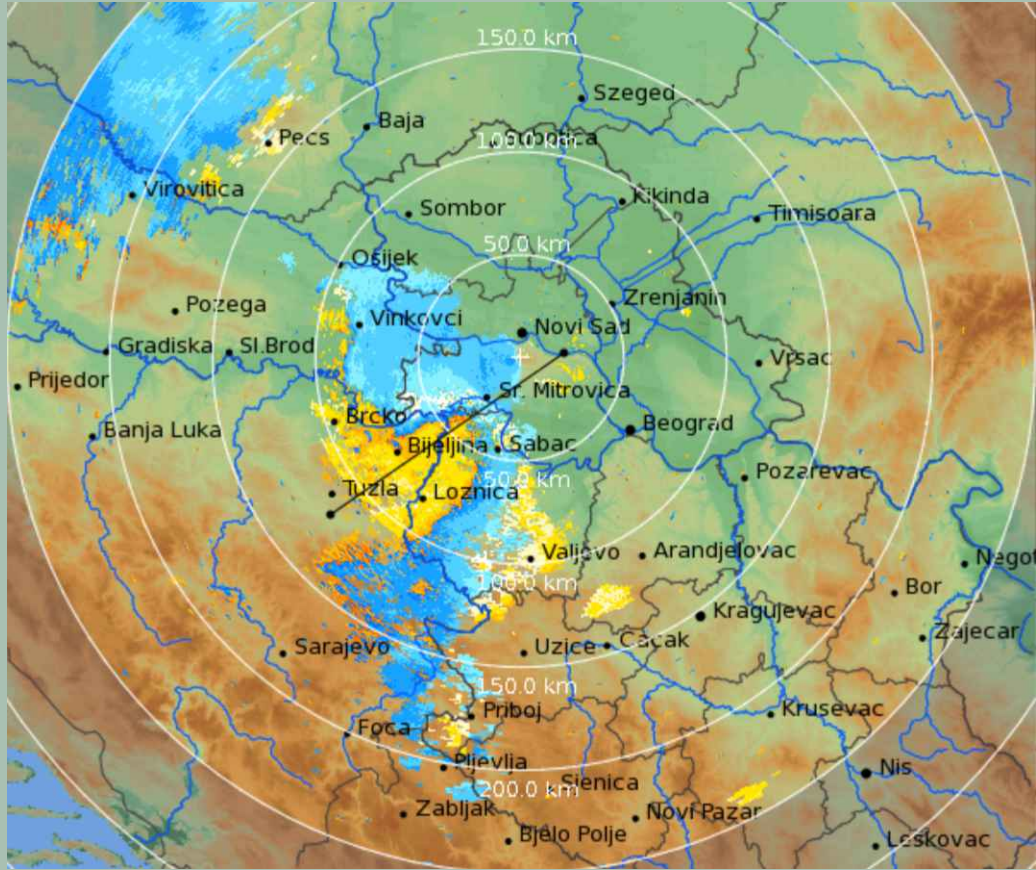
At 22 30 local time from previous MCS we have formed squall line that later exhibited bow echo characteristics in the next two ours, with strong straight - line winds, strong hail... During some period of time all three cells in MCS shows three body scatter spike (TBSS) - characteristics of radar indication of strong hail. From local observers we found that it was 'hail of unusual shape and dimensions' - conglomerate of hail. Formed mecoscale convection system in Eastern Bosnia, later transformed to bow echo, passed over the whole territory of Serbia and it weakened and moved to South-Southwest Bulgaria.



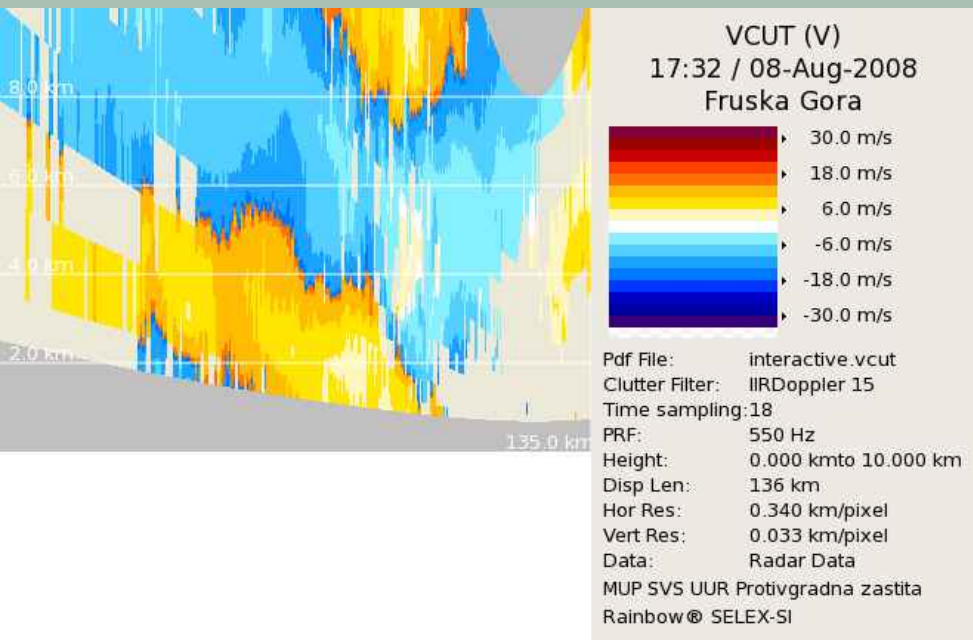
Development of bow echo occurred on 8 August 2008



frontal zone passing Adriatic sea. The same MCS coming to the coast of Croatia where it started to grow and at 16 UTC strong squall line is formed moving zonally, following preexisting convergence boundary line oriented east-west along Dinar mountains. Severe squall line contained few supercells that later dissipated upon arriving on the Serbian territory, keeping only southern part with stronger convection and moving with a speed of 60 km/h.



Squall line producing very strong winds on the whole territory of Serbia. It arrived on the Serbian territory near City of Loznica with 26 m/s strong downburst. During the passage cells were formed very quickly to very strong cells and dissipated very quickly. Later there was no very deep convection except in the south, but the gust winds were produced all over territory of Serbia, from 10 m/s to 26 m/s. A large storm cluster lasted many hours and produced a lot of damage.



Vertical section of observed rear inflow jet with its impact on the ground. 8 August 17 32 Radar Center Fruska Gora