



# Close Future of Slovak Weather Radar Network



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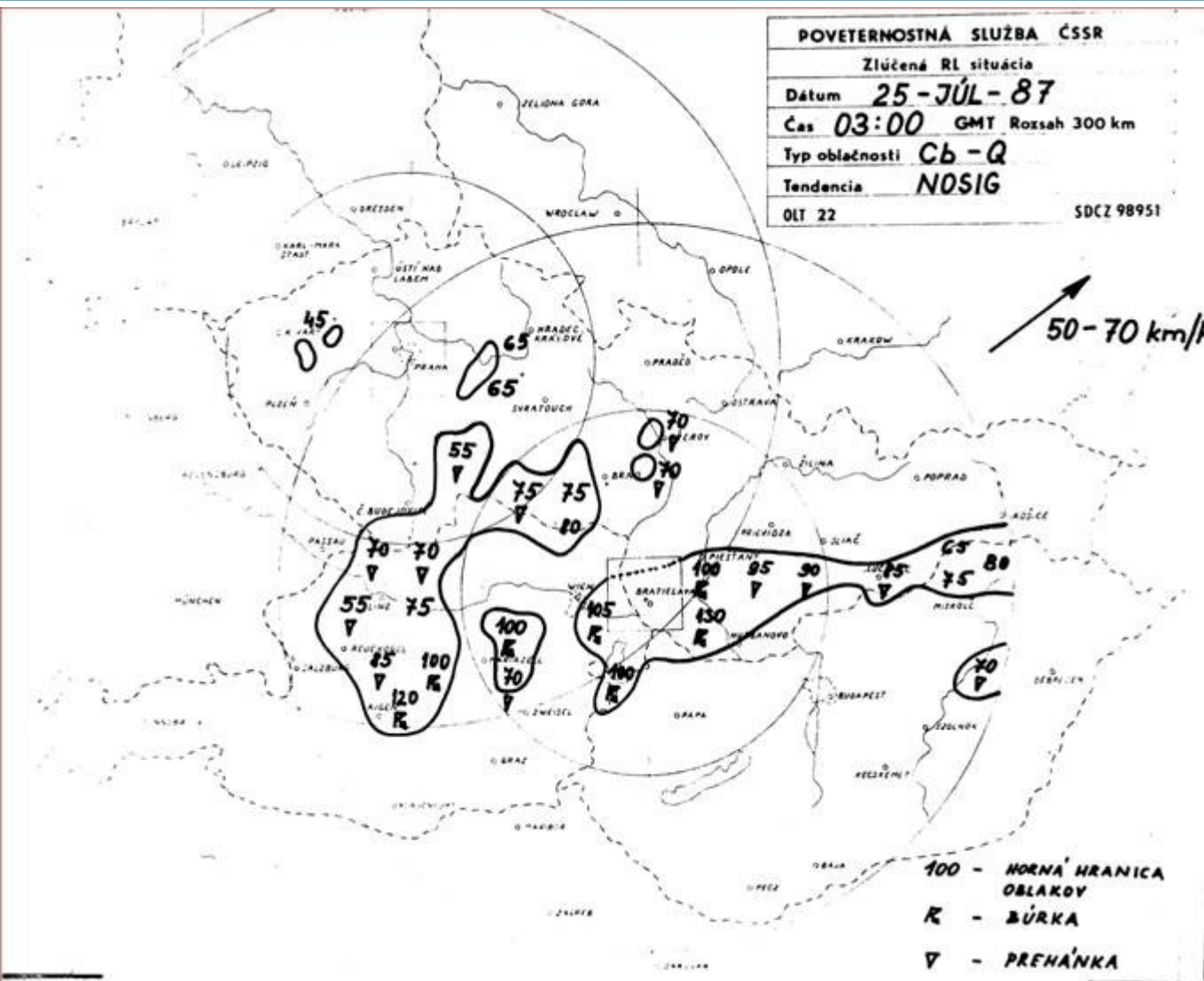
## Short History

History of radar meteorology in Slovakia started in 1972. The first radar point was built at Malý Javorník near Bratislava where the Russian radar MRL-2 was placed. Organisation guidelines, measurement technique and rainfall intensity estimation were adopted from American references while processing and analyses were accepted from Russian guidelines.

In 1974, the meeting of directors of hydrometeorological and meteorological services of socialist countries was held in Bratislava. This assembly granted to Malý Javorník the status of the Regional Centre for Radar Meteorology of the socialist countries.

First Czechoslovak composite information was created in December 1979 and it was distributed to the users through a longwave facsimile transmitter. The primary information was measured manually once per hour at the range 300km and 150km.

In the 80's both Czech and Slovak radars were replaced by dual wavelength radars MRL-5. These radars were also operated in manual mode.



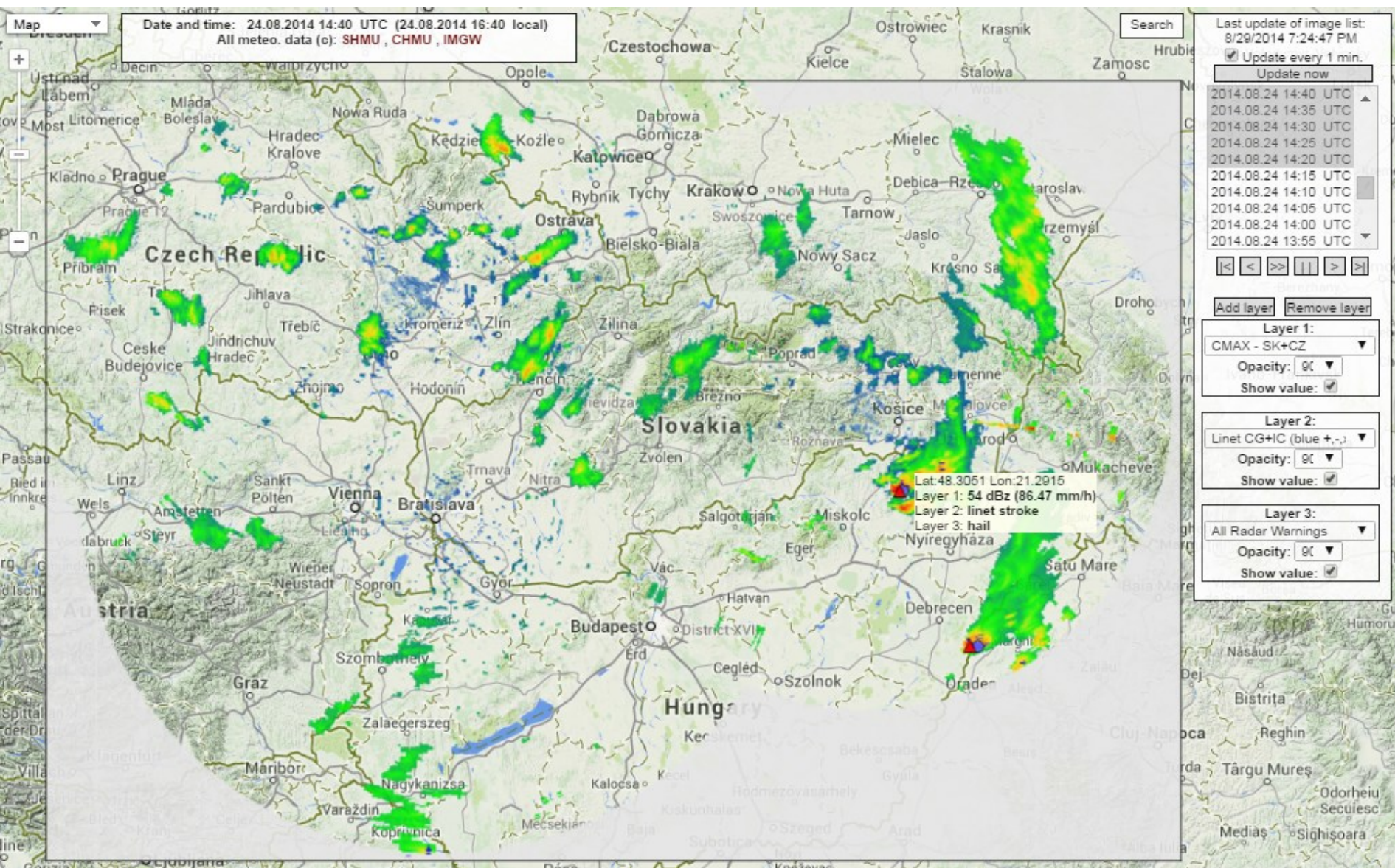
F.1: Example of historical Czechoslovak manual radar composite

In 1985, SHMU started to develop a system for automatic processing of radar signal. The construction of a new radar point was started on the hill Kojšovská hoľa in the Eastern part of Slovakia at the same time.

Both the automatic processing system and the new radar site with MRL-5 were put into operation in 1990.

In the year 1993, when Czechoslovakia was splitted, Slovak weather radar network was established.

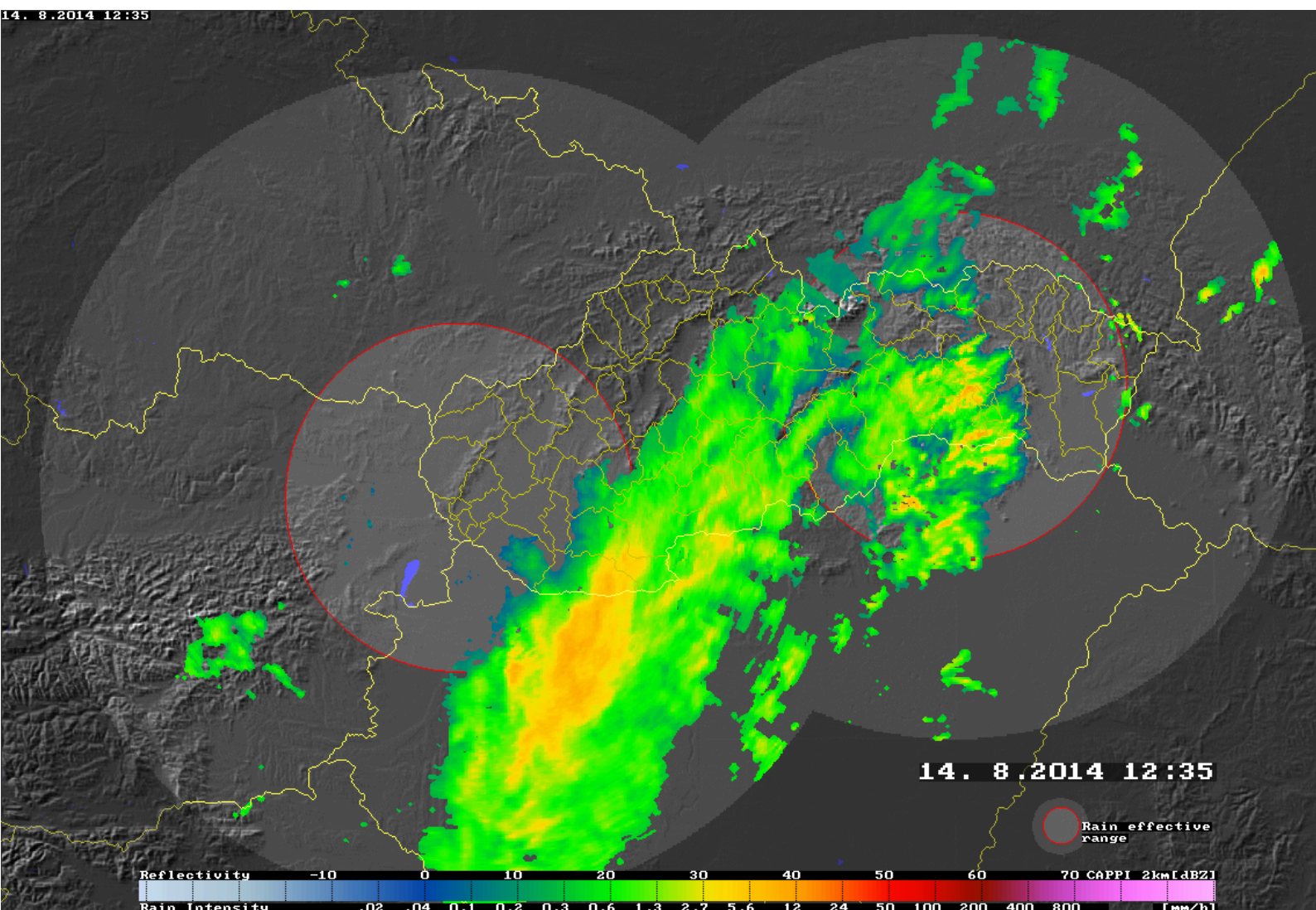
In September 1997, new EEC Doppler weather radar was installed at Malý Javorník. The last MRL-5 at Kojšovská hoľa was replaced by Radtec weather radar with GAMIC signal processor in 2004.



F.3: Intranet visualisation tool using google maps

### Basic facts:

- networks consists of 2 radars (figure F.2):
  - Malý Javorník – DWSR-92C doppler weather radar
  - Kojšovská hoľa – RDR250-GC dual-pol doppler weather radar
  - both radars are C-band
  - 250 kW magnetron
  - raw volume data are centrally processed to product, archived and recoded to ODIM HDF5 for international exchange and OPERA data center
  - products are automatically distributed to users, archived and online available at intranet over visualisation tool based on google maps (figure F.3)
- scan strategy:
  - 5 minutes full volume scan with 11 sweeps for Malý Javorník range 240km
  - 5 minutes full volume scan with 10 sweeps for Kojšovská hoľa range 200km
  - pulse 0.8 μs
  - measurement oriented only for reflectivity
- radar data are used directly as images in weather forecasting and nowcasting; and binary as input to the system INCA, hydrological models (by river subcatchments) and experimentally to the NWP models



F.2: Current Slovak radar network composite

### Problems:

- network is not enough dense for hydrological purposes: red circles at F.2 are not overlapping
- complicated orography, radar shadow in highly populated area
- radar at Malý Javorník is old and needs replacement
- radar at Kojšovská hoľa is already 10 years old and also renovation is needed

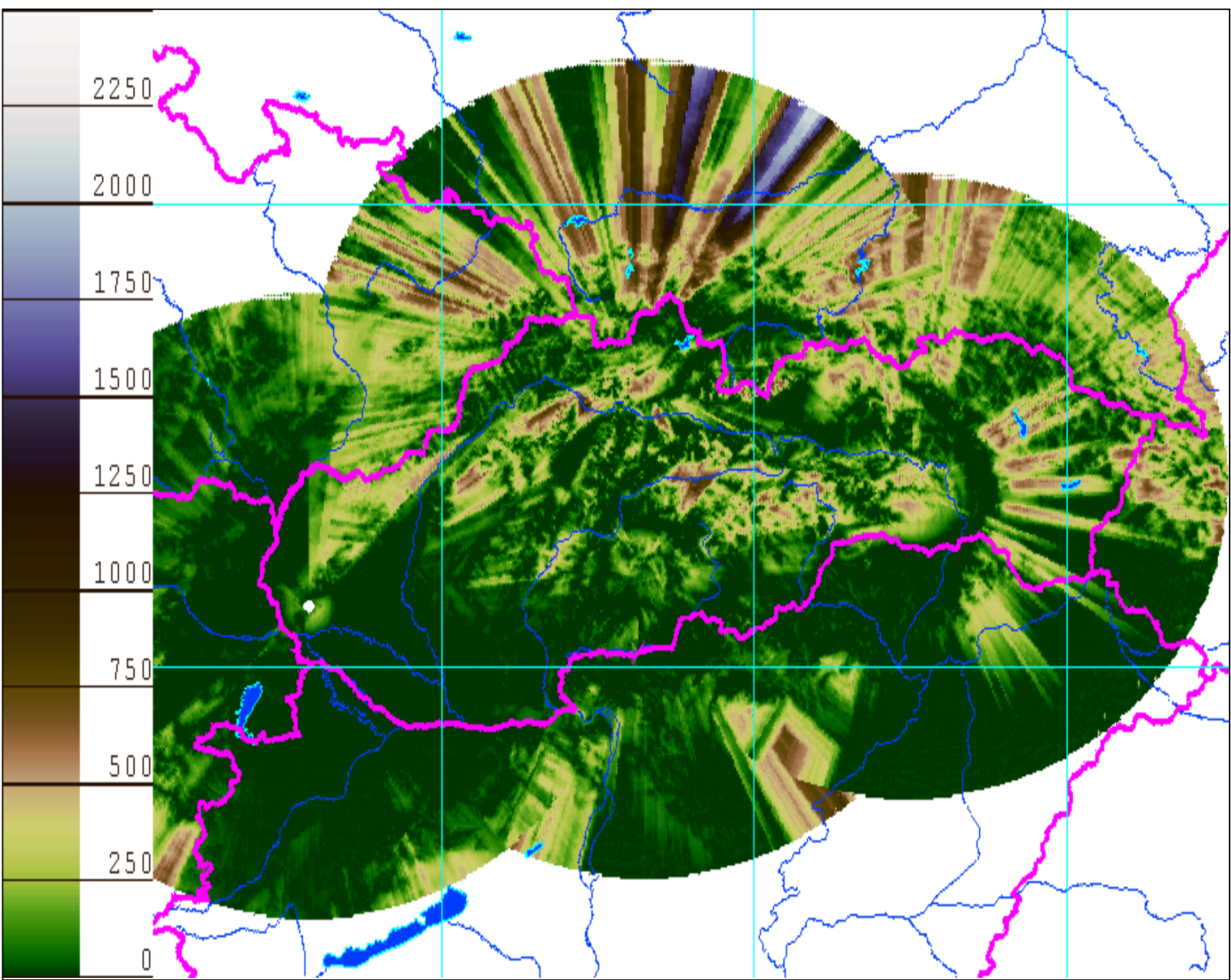
=> radar network has to be extnded and renovate!!!

## Close Future

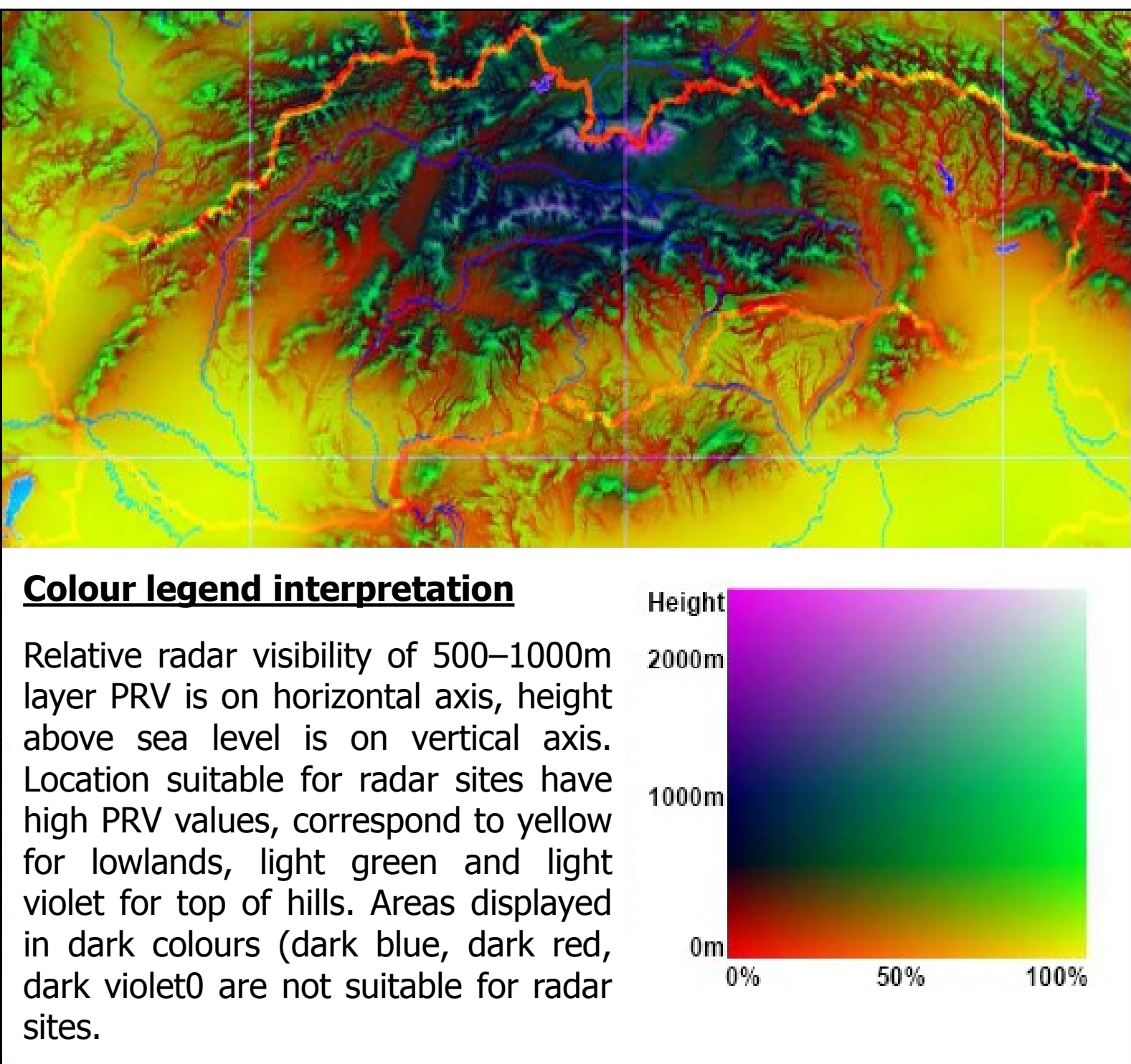
In the late 90's SHMU's specialists started with Slovak radar network extension preparation. Selection of places for 2 new radars covering valleys in Orava and Liptov region and central part of Slovakia has been initiated. Tool for the radar horizon simulation was developed (Kotlířková, D. and Kaňák, J. and Strmiska, I., 2000).

Steps of search for possible locations of new radar sites:

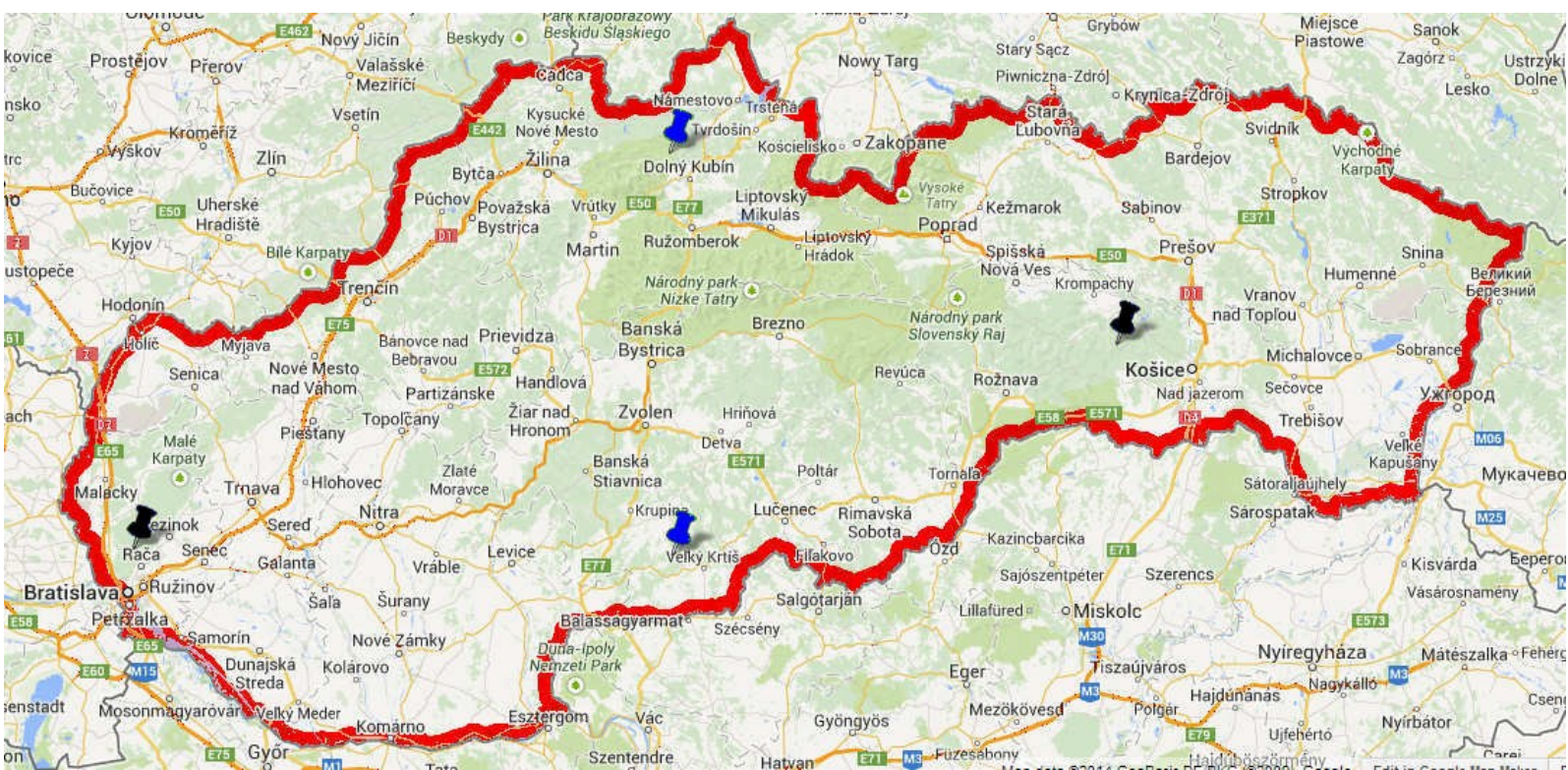
- examination of complete territory of Slovakia by simulating radar horizon using digital topography model GTOPO30 (result at figure F.4)
- examination of possible locations from step 1 for the local environment, road accessibility and available infrastructure
- examination of possible locations from step 2 for the effective compositing with existing 2 radars (example of result at figure F.5)



F.5: Composite map of minimum detectable height in meters above terrain for MJ, KH, SL and KB



F.4: Map of relative radar visibility PRV



F.6: Position of radars in Slovak network. Black – existing radar sites, blue – new radar sites.

Locations for 2 new radar sites were chosen in 2002 -2003 and Sovak radar network will consist of 4 radars:

- Malý Javorník (MJ) - existing radar site, only radar replacing
- Kojšovská hoľa (KH) - existing radar site, only radar replacing
- Kubínska hoľa (KB) - new radar site, new 23 m tower
- Španí laz (SL) - new radar site, new 43 m tower

In 2012, the call for a project from European funds has been issued for Flood Warning and Forecasting System and SHMU revived the idea of a new weather radar network consisting of 4 radars. In 2013, SHMU received building permission for Španí laz (for Kubínska hoľa already in 2004) and SHMU has successfully applied for grants from EU funds and is running new project. In parallel, international tenders for construction work and for technology were published. In July 2014, construction of both new towers has been started and contract including new radar network was signed. New radar network has to be operational in October 2015.

### New radar technology

Winning consortium for technology tender offered **SELEX** dualpolarization radars **METEOR 735 CDP**.

Some of 163 required specifications:

- 4 identical dualpolarization radars (except local specific requirements)
  - C-band (5600 – 5650 MHz)
  - peak power  $\geq 350$  kW or equivalent signal processing
  - peak power stability  $\pm 0.2$  dB / month
  - PRF 250 – 2000MHz
  - pulse width selectable in min. 4 steps in range 0.5- 2μs
  - pseudorandom sandwich type radome
  - hydrophobic radome surface
  - radome 1.4 x antenna
  - one way losses of dry radome  $\pm 0.3$  dB
  - antenna gain  $\geq 45$  dB
  - beam width (H/V)  $\geq 1^\circ$
  - noise figure  $\leq 3$  dB
  - linear dynamic range  $\leq 100$ dB at longest pulse
  - sensitivity better than -113 dBm at longest pulse
  - high stability digital STALO and COHO
  - min. 16 bit 2 channel digitizer
  - maximum number of processed range bins per polarization  $\geq 8000$
- 1 central processing unit for preprocessing, processing, postprocessing, distribution and archive managing of radar data from 12 radars (4 own 8 surrounding from bilateral exchange)
  - full support of ODIM HDF5 (also for import and processing)
  - central monitoring and command of all 4 radars
  - composite generation and composite postprocessing
  - digital elevation model of Europe
  - map underlayer of Europe
  - LINUX based
- 12 visualisation terminals
  - ON-line and OFF-line products visualisation
  - animation of time sequences
  - definition and visualisation of interactive cross sections
  - exact value and coordinates reading from products
  - print and export of selected products

### Other new infrastructure at SHMU

During implementation of projects "Flood Warning and Forecasting System" and "Improving technical infrastructure for research and development purposes at SHMU regional offices", supported from structural funds, SHMU will renew its IT infrastructure; purchase almost 140 automatic raingauge stations, almost 80 automatic weather stations, 20 weather cameras, 4 big and 4 small acoustic Doppler current profiler, replace all instruments at 200m mast and instruments for radiation (direct sun, global, FAR, short wave, long wave, albedo, ..) monitoring.

In remote sensing field, besides new weather radar network, the new reception system for data from geostationary and circumpolar satellites, new LINET based lightning detection system, new aerosol micropulse lidar and ozone brewer spectrophotometer are being installed.

New infrastructure of SHMU will bring new quality and some new quantities of atmosphere observation and will provide new inspiration for research.

## References

Kaňák J. (1998): *Digitálny model terénu a interpretácia rádiolokačných meraní* (Digital terrain model and interpretation of radar measurements). Bull. SMS pri SAV, IX, 3, 5-9.

Kotlířková, D. and Kaňák, J. and Strmiska, I. Radar Horizon Modelling as a Requirement of SHMI Radar Network Enhancement // Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere - September 2000 - Vol. 25, Issues 10-12. First European Conference on Radar Meteorology, Bologna/Italy - pp. 1153-1156.