Challenging forecast of a mesocyclonic tornado on 3rd October 2018 in Slovakia

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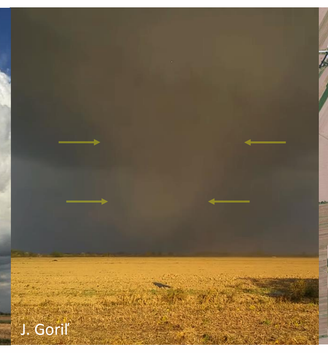
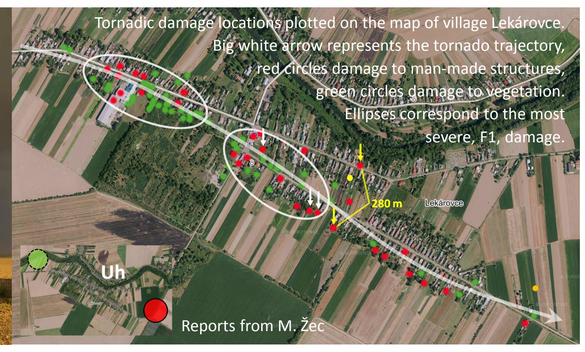
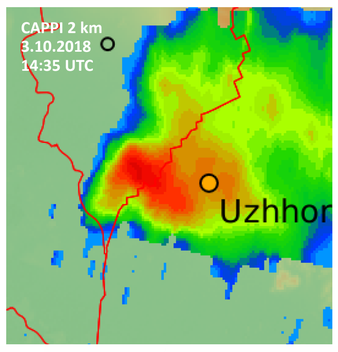
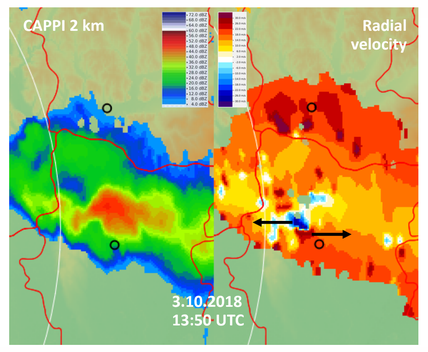
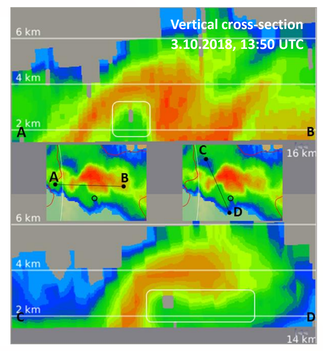
Tornadoes are a rare in Slovakia with only a few documented cases. Until 3rd October 2018, no clear photo and video-documentation of a tornado was captured here. On this day tornado hit Lekárovce in eastern Slovakia with multiple photos and videos of the event. Tornado was rated F1 based on the damage survey performed by a local storm spotter. Radar imagery clearly identified the presence of a strong mesocyclone at the time of a tornado. Operative NWP did not simulate strong shear and we attempt to reconstruct hodograph using real observations and a high resolution simulation of the event with focus on low level wind shear and storm motion vector.





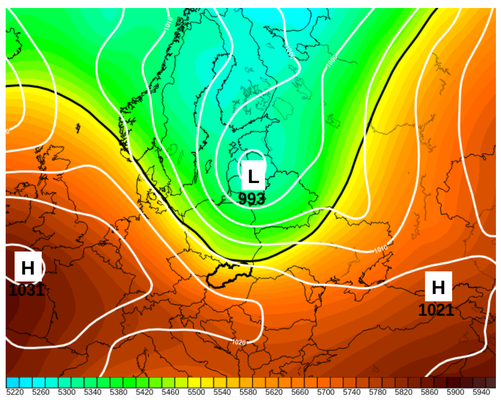






Analysis of MSLP (white isolines) and Geopotential height 500 hPa (color scale), 3.10.2018, 12:00 UTC.

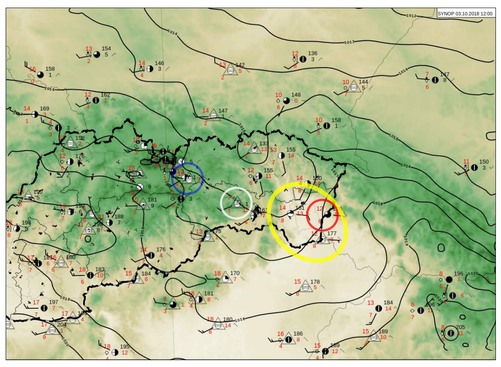
A deep trough over Poland, Belarus, partly Slovakia and Ukraine.



MSLP + SYNOP, 3.10.2018, 12:00 UTC.

The low level trough over eastern Slovakia. Easterly wind ahead of the trough in Východoslovenská nížina (yellow ellipse).

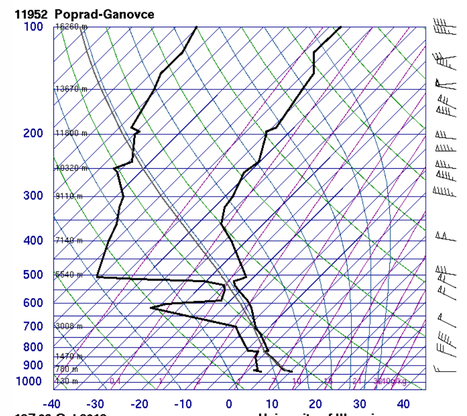
White circle corresponds to radar and SYNOP station Kojšovská hoľa (altitude 1242 m), blue circle is sounding and SYNOP station Gánovce (altitude 700 m), red circle is the area of a tornado event.



Tornado Radar

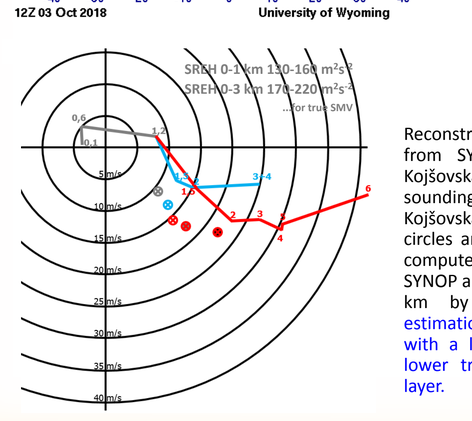
Synoptic situation

Sounding & hodographs



Gánovce Sounding (700 m altitude), 3.10.2018, 12:00 UTC. Stable inversion layer in altitude 5,2 – 5,5 km stopped further development of deep moist convection (agreement with radar vertical cross-section). **And what about wind shear?**

Station Gánovce too far from tornado area



Reconstruction of hodograph needed

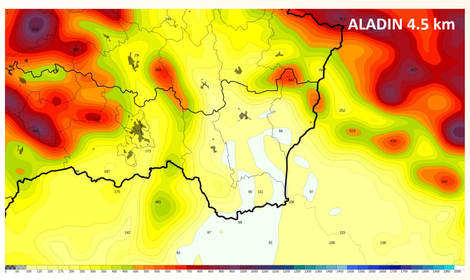
Reconstructed hodographs using wind data from SYNOP stations (gray line), radar Kojšovská hoľa (blue line) and Gánovce sounding above the altitude of radar Kojšovská hoľa 1.2 km (red line). Hatched circles are SMVs, gray is true SMV, blue is computed from SYNOP and radar, red from SYNOP and sounding (from 1,2 till 4, 5 and 6 km by Bunkers method). The best estimation of SMV was SYNOP and radar with a lot of streamwise vorticity in the lower troposphere, the most in 0-1 km layer.

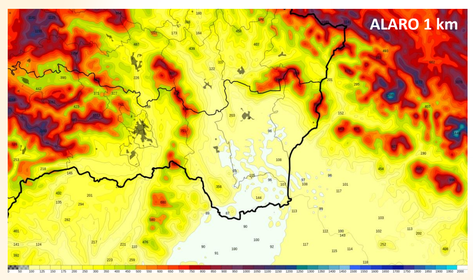
Good conditions for supercell formation and mesocyclonic tornadogenesis

NWP Models

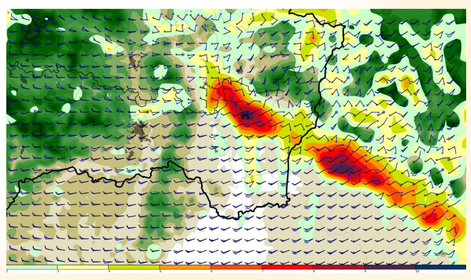
Wind shear difference

Operative model ALADIN vs. non-hydrostatic ALARO

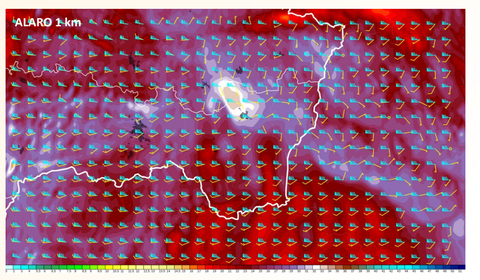


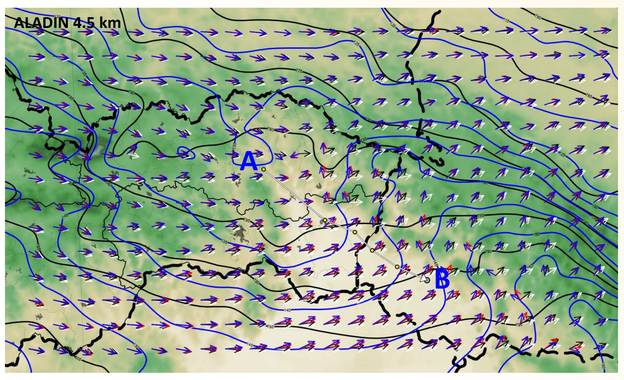


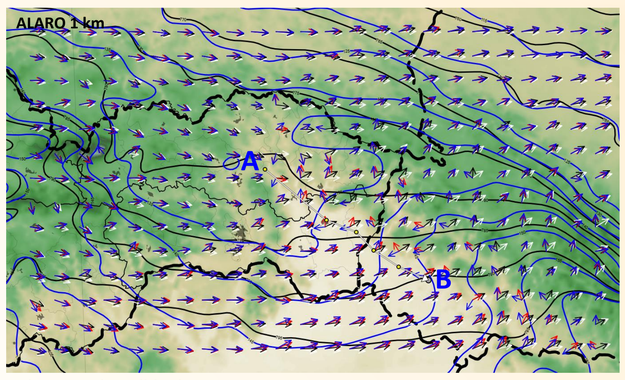
Topography of NWP models. Left – hydrostatic ALADIN 4.5 km resolution; right – non-hydrostatic ALARO, 1 km resolution.



Left - 6h forecast of 1000 hPa wind from ALARO 1 km (blue wind barbs), ALADIN 4.5 km (black wind barbs) and their difference, 3.10.2018, 12:00 UTC. Incorrect forecast over Východoslovenská nížina in comparison with SYNOP data, better results are from ALARO 1 km near mountains, where we identified the strongest wind shear in the area supercell was born (right).

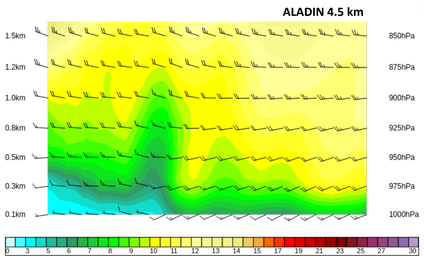


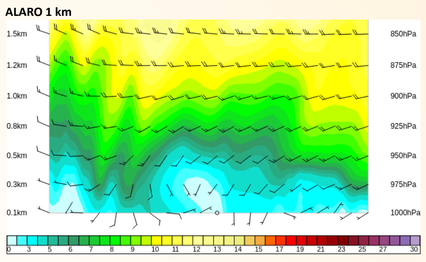




Above - Geopotential height 1000 hPa (blue) and 925 hPa (black isolines), wind arrows 1000 hPa (blue), 975 (red), 925 (black), 875 hPa (white). Very shallow trough, different shape & movement in each version of model -> different wind. A comparison with SYNOP data is needed.

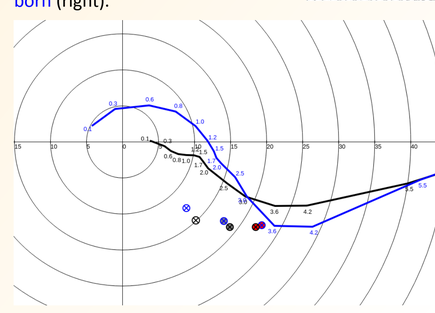
Vertical cross-section through AB (line marked in the pictures above). Wind shear in low layers ahead of the trough was stronger in ALARO 1 km (right) than in ALADIN 4.5 km (left).





Right – Hodographs in area, where supercell was born, at 12:00 UTC from NWP ALADIN 4.5 km (black line) and ALARO 1 km (blue line) with SMV computed for layer 0-4, 0-5 and 0-6 km (last one is the strongest). SMV and hodograph from ALARO 1 km is closer to reality than ALADIN 4.5 km. The main part of streamwise vorticity is in the lowest 1 km with SREH about 230 m^2s^{-2}, which is also very close to a real situation.

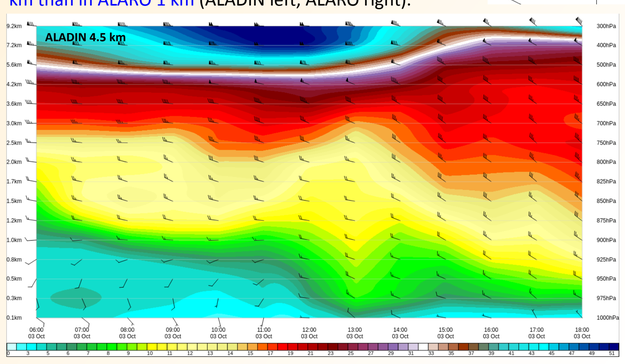
Below – Temporal development of wind profiles. Wind in the lowest troposphere changed sooner and wind shear in the lowest 1 km was weaker all the time in ALADIN 4.5 km than in ALARO 1 km (ALADIN left, ALARO right).

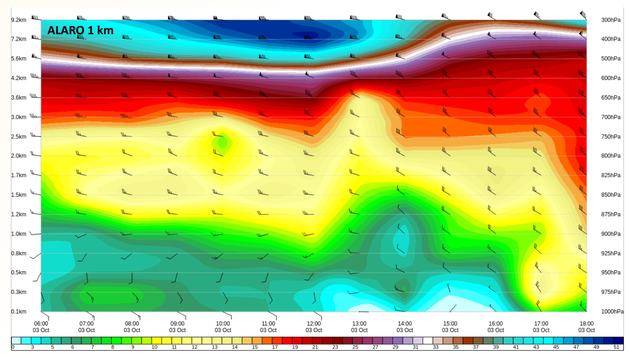


ALADIN 4.5 km
SREH 0-0.5 km 20-40 m^2s^{-2}
SREH 0-1 km 40-80 m^2s^{-2}
SREH 0-3 km 110-140 m^2s^{-2}

ALADIN 4.5 km
SREH 0-0.5 km 130-140 m^2s^{-2}
SREH 0-1 km 220-240 m^2s^{-2}
SREH 0-3 km 300-320 m^2s^{-2}

...for 0-4 km SMV





Conclusion

Tornado occurrence was not expected due to the NWP simulating rather weak vertical wind shear in the lowest 1 km. Slightly better conditions were found by experimental 1 km resolution run near the mountains. However, the true extent of the shear could only be recognizable to the forecaster using observational data.

Thus, it is important for forecasters to confront models with observations on duty all the time. Or, as Chuck Doswell says: **„Live by models, die by models...“**

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