Case of extreme wind occurrence at High Tatras on 19th November 2004

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1. Summary

High Tatras are the highest mountains of Slovakia. They are located at the border between Slovakia and Poland. They are one of the most attractive touristic destinations in the Slovak republic. The area was hit by strong northern wind on 19th of November 2004. The wind has been orographically strengthened and the wind gusts at the lee side have been measured greater than 50m/s. The period of strongest wind started at 14 UTC and it lasted approximately 10 hours.

Fig.1 Photo of damages caused by the severe wind gusts in High Tatras area on 19.11.2004

Wind of such speed occurred in the region several times in the past, but it has rarely reached the altitudes around 700-800 m above sea level where the spruce monocultures grows. 100 km^2 of forest was destroyed at the lee side of the mountains (figure 1). There was one casualty.

This extreme weather event was excellently predicted by the operational model ALADIN at SHMI [1]. The position of the driving small-scale cyclone has been already well predicted by ARPEGE and operational ALADIN model (resolution 9 km) described well the impact of the orography on the flow. It provided very good guidance for our forecasters. The first warning has been issued one day ahead and it was based on the 18.11.2004 00 UTC run, although the location of maximum wind has been predicted more to the west. Later, on 19.11.2004 00 UTC, the position of the cyclone has been improved and the model prediction of this extreme event was very realistic.

2. Operational prediction of ALADIN/SHMI

The wind has been associated with a rapid developing cyclone moving over South Poland towards Ukraine. The mean-sea-level pressure from SYNOP measurements is shown on figure 2. The equivalent prediction of model ALADIN available to forecasters, based on 19.11.2004 00 UTC operational run, is on figure 3. The situation is valid at 15 UTC, on the initial stage of the event. The position and intensity of the cyclone are very well predicted.

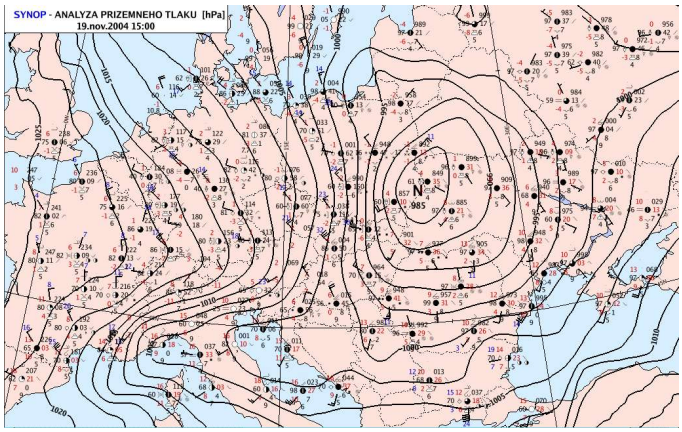

Fig.2 : Mean-sea-level pressure, analysed from SYNOP 19.11.2004 at 15 UTC.

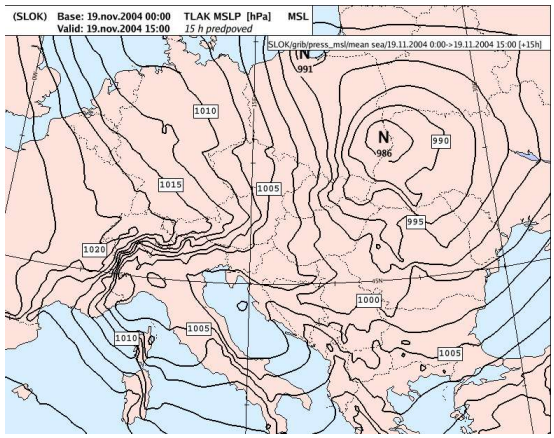

Fig.3 : Mean-sea-level pressure, 15h ALADIN forecast, from 19.11.2004 00 UTC

As the cyclone was moving, the wind direction changed from western to northern wind. During the period of the strongest wind, the flow was almost perpendicular to the mountain ridge. The model has simulated an effect similar to hydraulic jump (more in the next section) and the downslope windstorm has been formed at the lee side with strong turbulence. The maximum wind gusts in the operational prediction exceeded 40 m/s while average wind was around 20 m/s.

The prediction of wind gusts is shown in figures 4 and 5. It is the +16h and +17h operational model forecasts from 19.11.2004 00 UTC. The green color represents the wind gusts above 25 m/s, the yellow color above 30 m/s and the red color above 40 m/s.

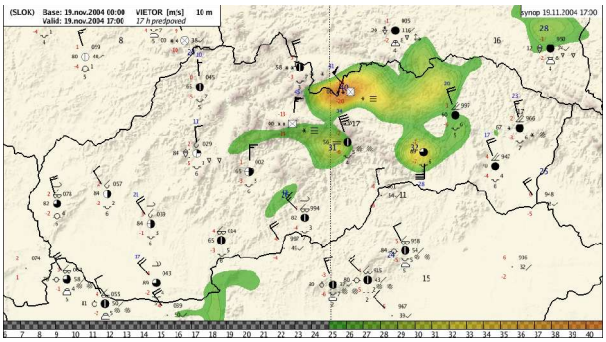

Fig.4: Instantaneous wind gust +17h prediction from ALADIN/SHMI operational run from 19.11.2004 00UTC

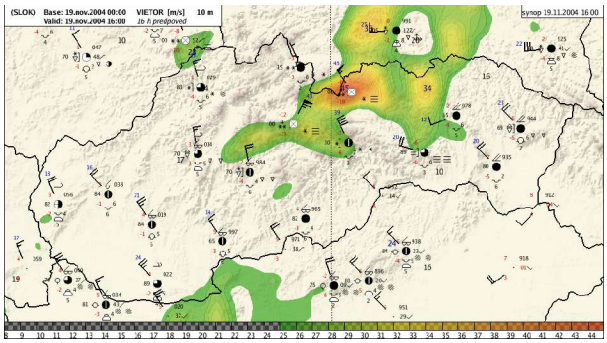

Fig.5:Instantaneous wind gust +16h prediction from ALADIN/SHMI operational run from 19.11.2004 00UTC

3. High resolution prediction of ALADIN

The operational prediction was not detailed enough to capture exactly the areas where the forest has been destroyed. To further improve model prediction of wind we ran the ALADIN model with a 2.5 km resolution in order to describe orography more realistically. The model was integrated hydrostatically with the same model settings as the operational model except that convection was turned off, horizontal diffusion was adjusted to the new resolution and the model time-step was 100 s.

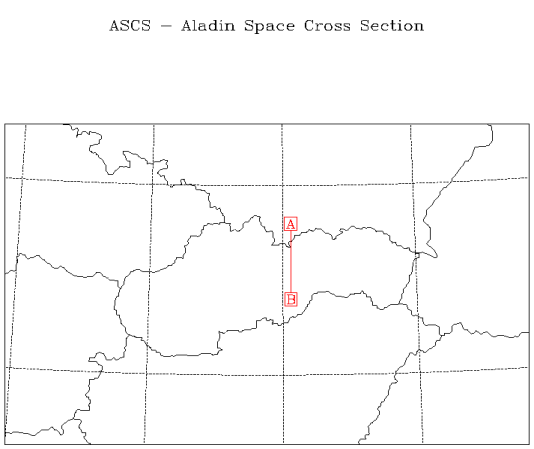

Fig.6: The direction of vertical cross section on figure 7.

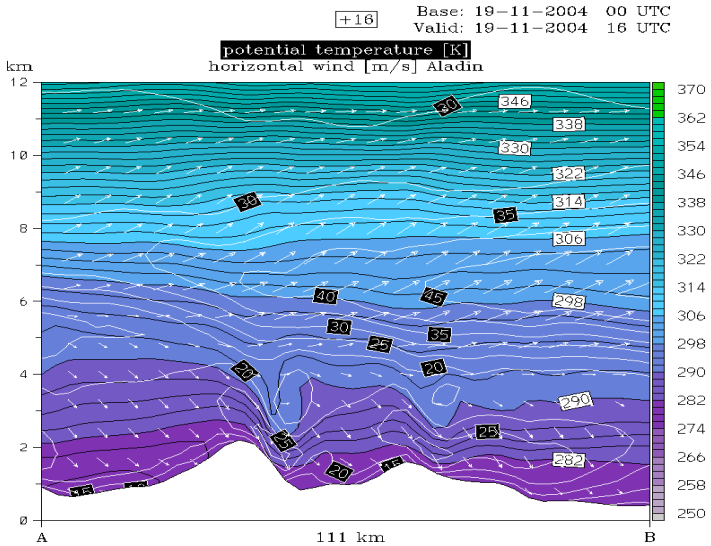

Fig.7: Vertical cross-section perpendicular to High Tatras and Low Tatras ridges. Hydraulic jump is visible in the field of potential temperature (coloured isolines). The wind speed (white contours) is locally strengthened in the area of jump. From high resolution experimental run, 19.11.2004 00 UTC +16h.

The effect of hydraulic jump was very apparent in the high-resolution run. It is clearly visible in the potential-temperature field on figure 7. If we consider almost adiabatic processes, then the air particles follow the potential-temperature isolines, descending very deep along the lee side of the mountains and successively after on ascending very quickly to its original altitude. This forms the shallow high velocity, very turbulent flow at the lee side near the surface, because streamlines density is very high in this region. Another but less intensive jump has been predicted behind Low

Tatras ridge. The direction of the vertical cross section is shown on figure 6.

The area with the strongest wind gusts coincides with the area of observed wind breakages at the lee side of High Tatras. The wind gusts from the high-resolution run are shown on figure 8 for the 16 h forecast range, when the strongest wind gusts were predicted. The maximum values of gusts are greater than 50 m/s. The area of observed forest damages, provided by Slovak environmental agency, is depicted by red color on figure 9. Although the density of the observing stations is not sufficient to verify all the features predicted by ALADIN, we assume that the prediction was very precise, because the area of maximum wind gusts is almost identical to the area with observed breakage.

The second maximum of wind gusts was predicted to the South of High Tatras (figure 8). It is the area of Low Tatras mountain, where wind gusts above 50 m/s were really observed. However, we do not have available the map with damages in this area.

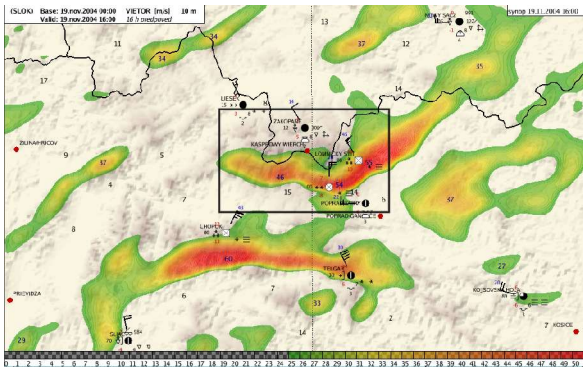

Fig. 8: Instantaneous wind gust +16h prediction from ALADIN high resolution (2.5km) run from 19.11.2004 00UTC. Zoom over High Tatras.The frame selects the area showed on figure 9.

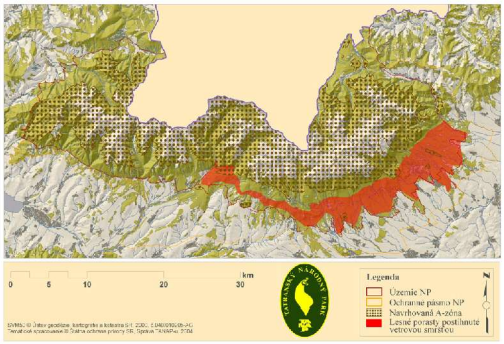

Fig.9: The High Tatras with the area of destroyed forest (red color). Courtesy of Slovak Environmental Protection Agency (http://www.sopsr.sk)

4. References

Derková, Belluš, Mašek, Španiel and Vivoda : New Operational ALADIN setup at SHMI, ALADIN Newsletter 27, 2005

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