Downslope windstorm in High Tatras 19 November 2004

high resolution study

by

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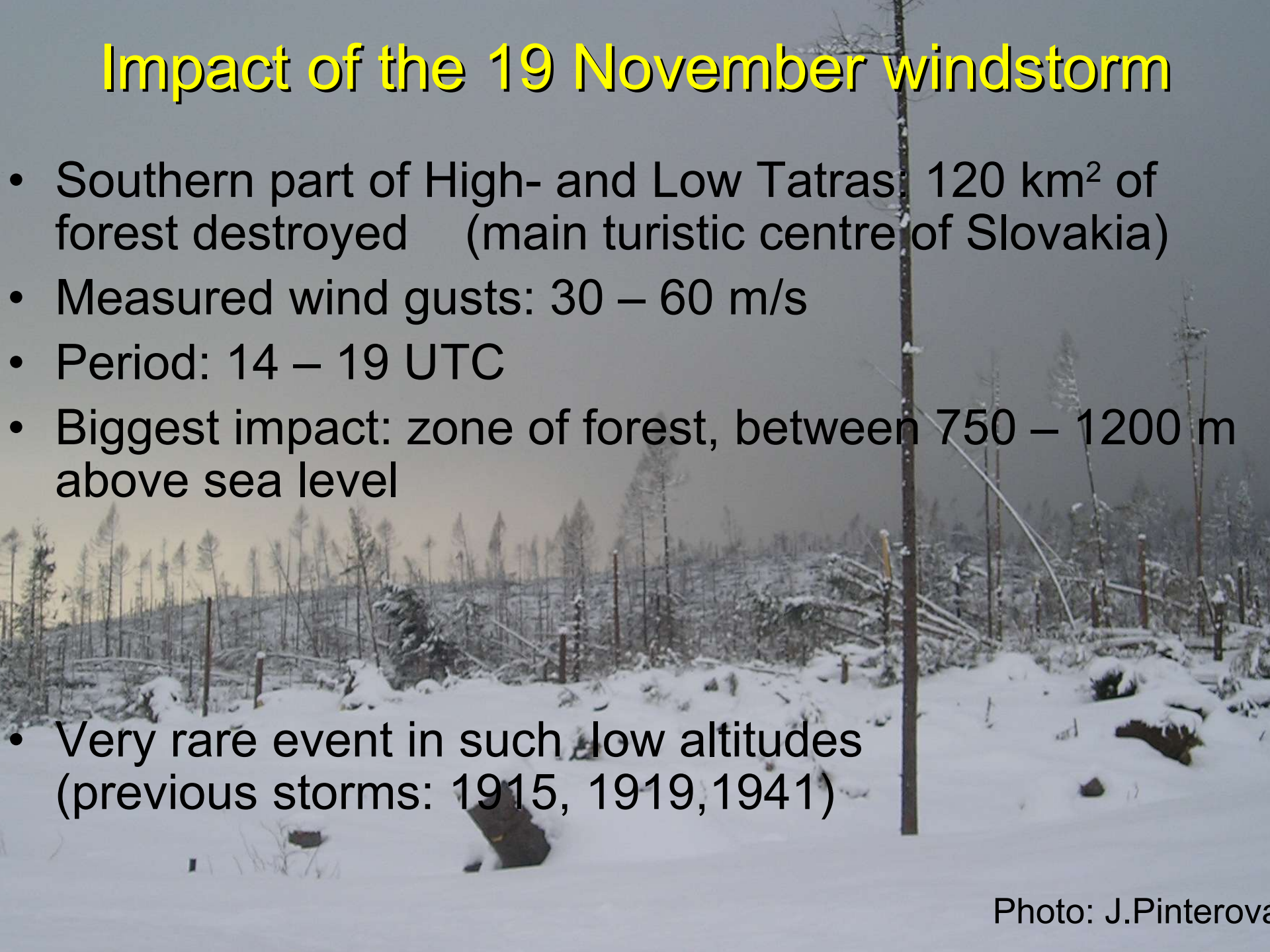
SHMÚ

Impact of the 19 November windstorm

- Southern part of High- and Low Tatras: 120 km^2 of forest destroyed (main turistic centre of Slovakia)
- Measured wind gusts: 30 – 60 m/s
- Period: 14 – 19 UTC
- Biggest impact: zone of forest, between 750 – 1200 m above sea level

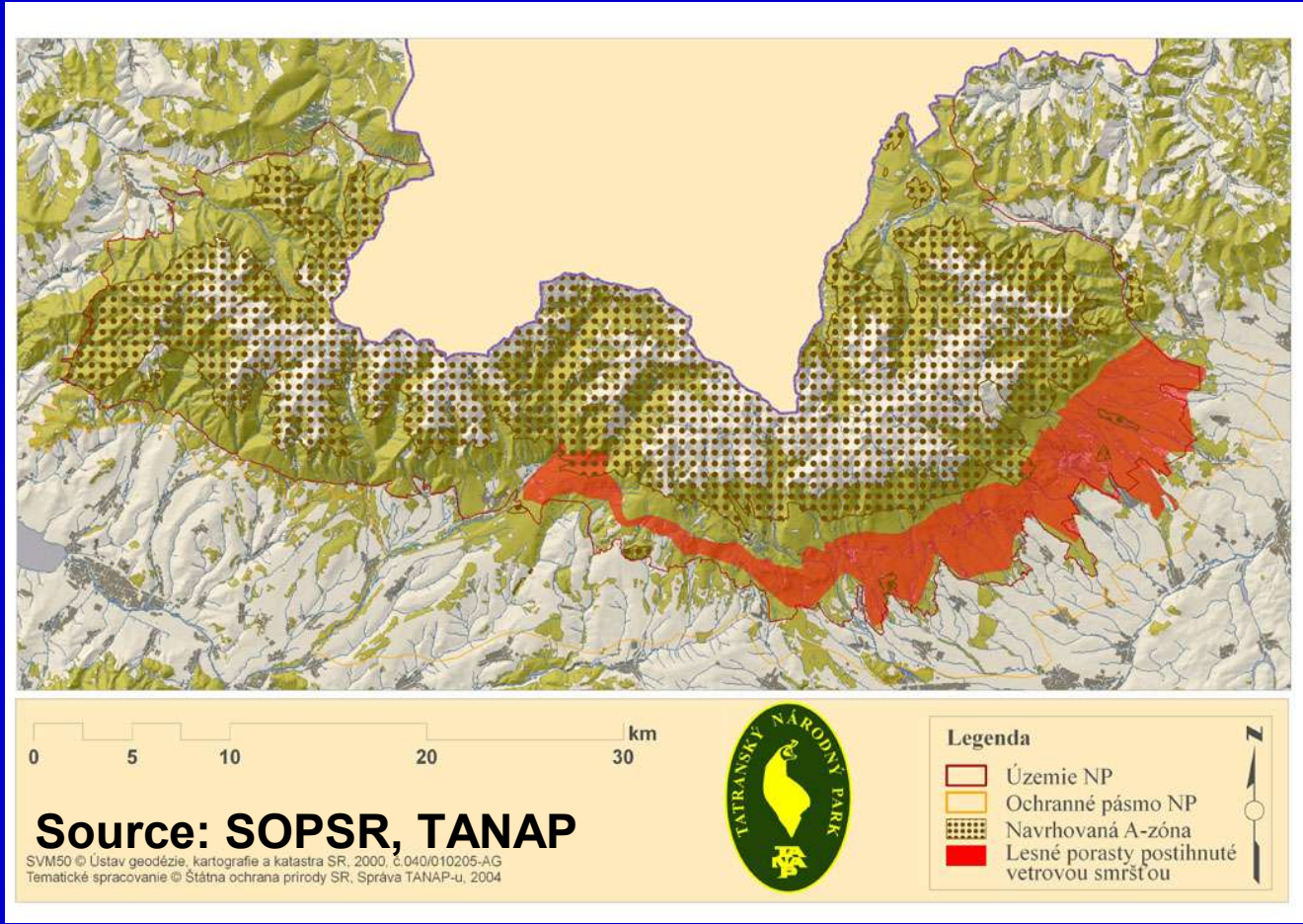


- Very rare event in such low altitudes (previous storms: 1915, 1919,1941)

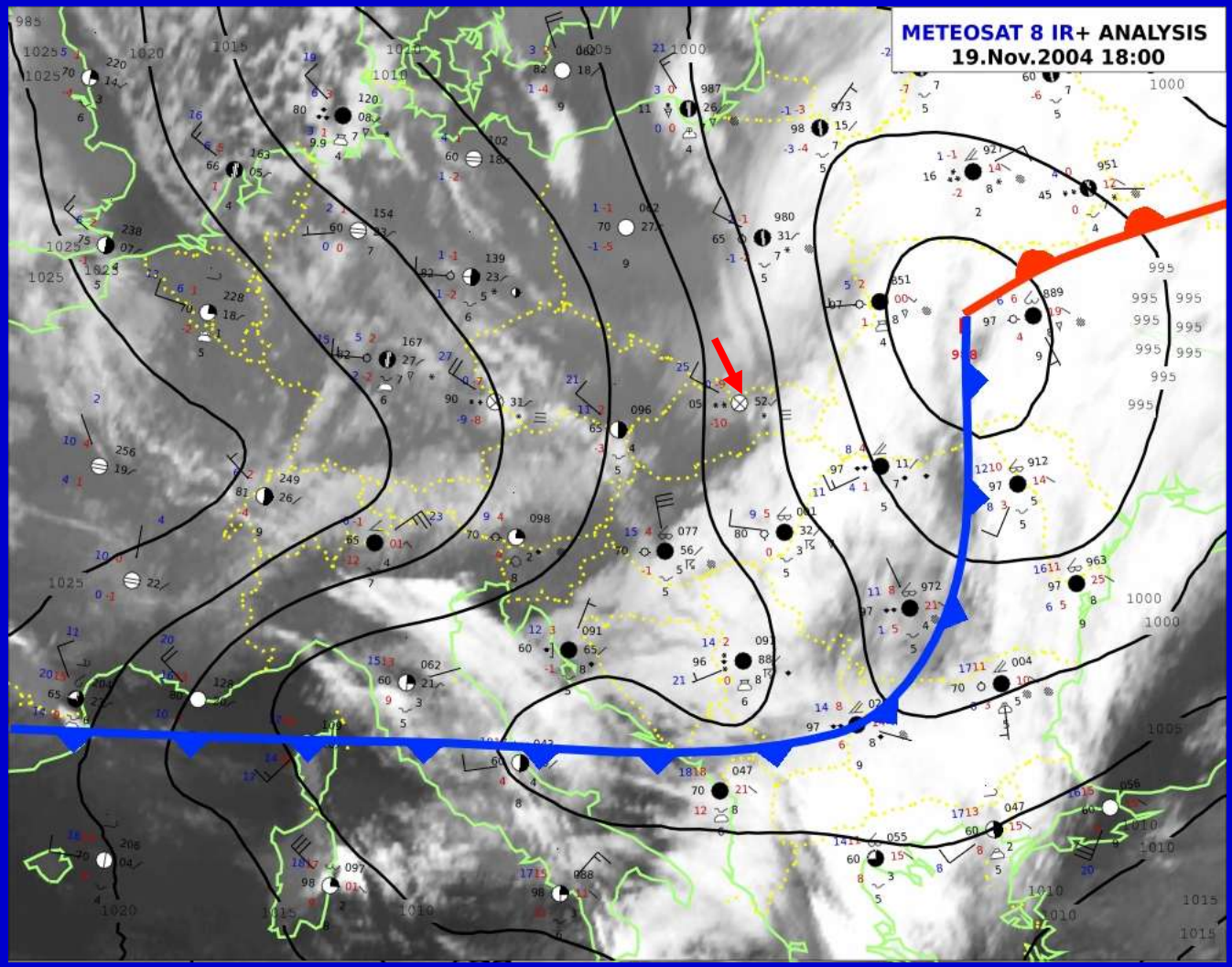
Photo: J.Pinterova

Impact of the 19 November windstorm

- Belt of destroyed forest on the southern (lee) side of the High Tatras



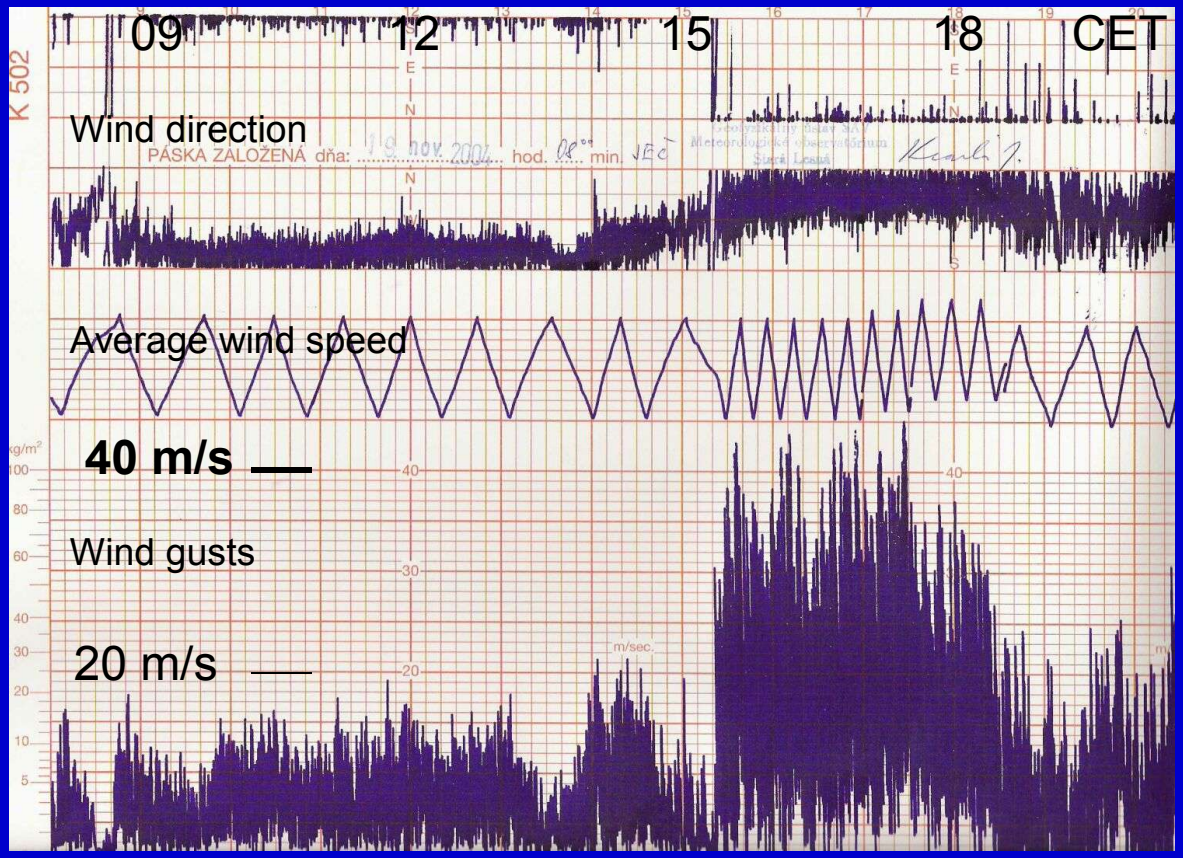
Synoptic analysis



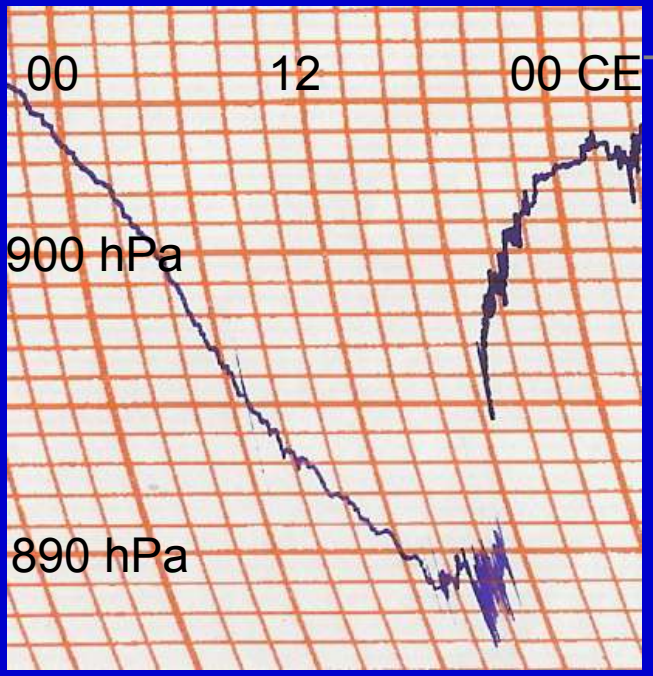
Satellite infrared channel, MSLP (hPa) and fronts

Local observations

- Gusty character of wind, hourly average wind speeds almost 20 m/s, gusts over 50 m/s



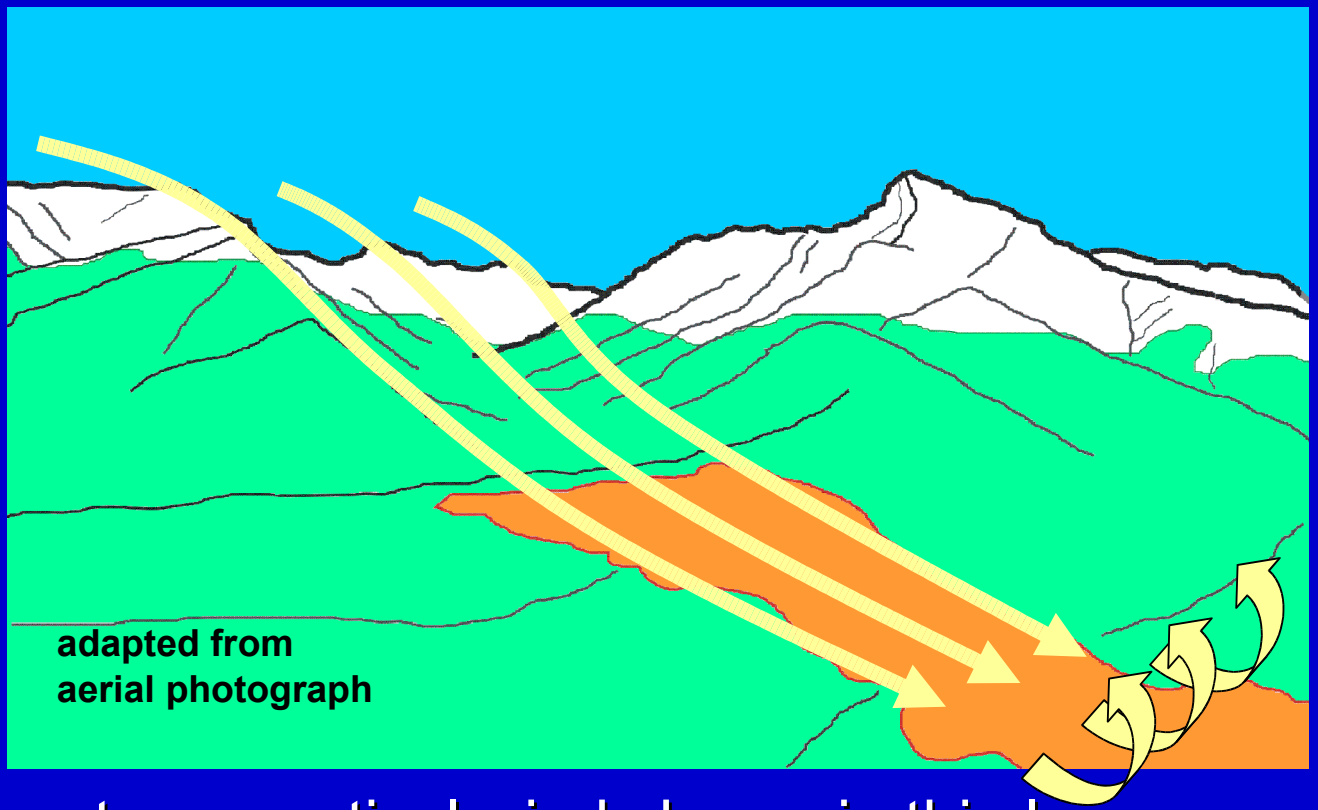
Remarkable pressure oscillations: high turbulence



Station Stará Lesná, Slovak Academy of Sciences
Anemogram+barogram

Microscale features

- Aerial photographs: evidence of strong downslope winds (orientation of fallen trees)

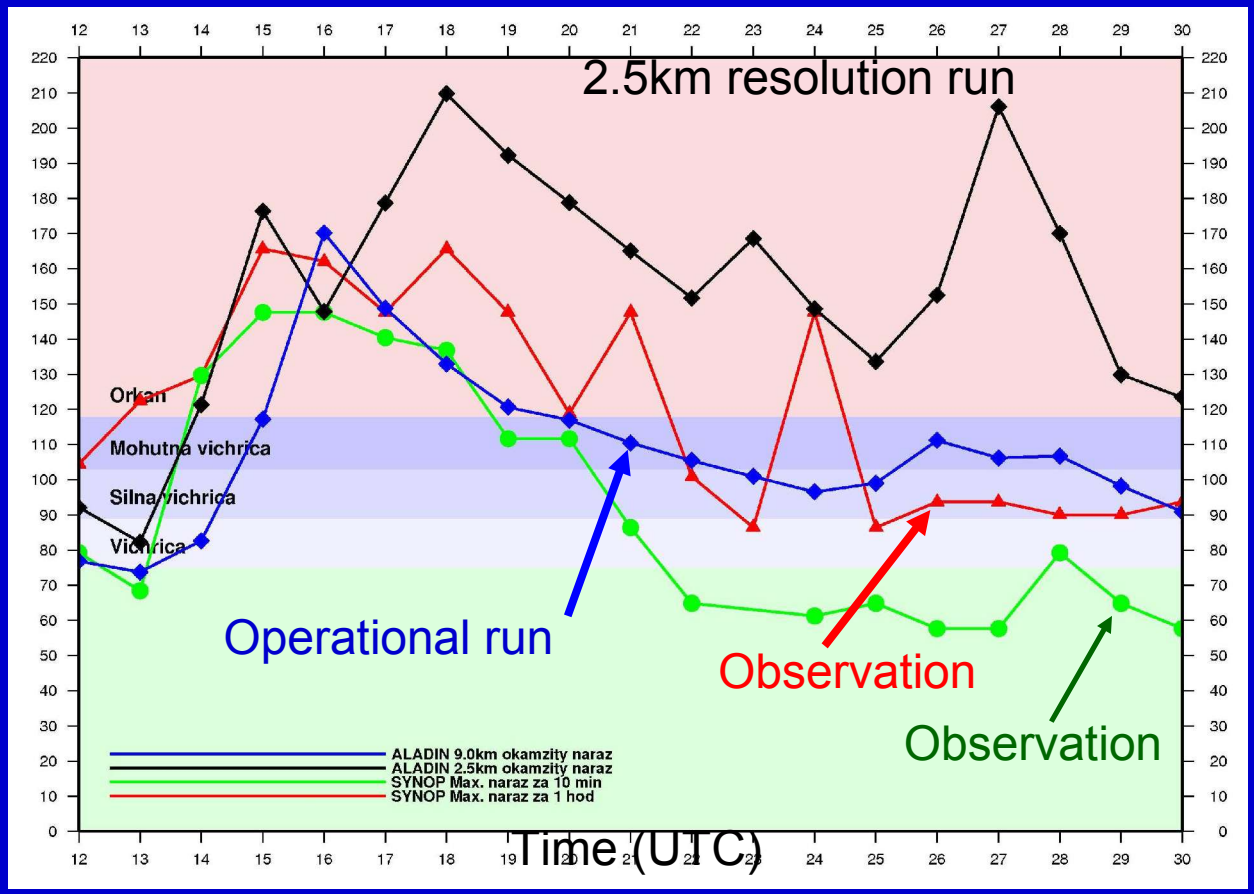


Biggest damage: foots of the slopes, exits of valleys

- strong vertical wind shears in thin layer
  $\Rightarrow$ generation of extremely high horizontal vorticity
- analogical to flow in travelling microbursts

Success of the operational forecast

- ALADIN SLOVAKIA, cycle 25, 9.0 km resolution



Time course of observed and forecasted wind gusts, station „Lomnický Štít“

Based: 19/11/2004 00 UTC run

Why to do high resolution modelling ?

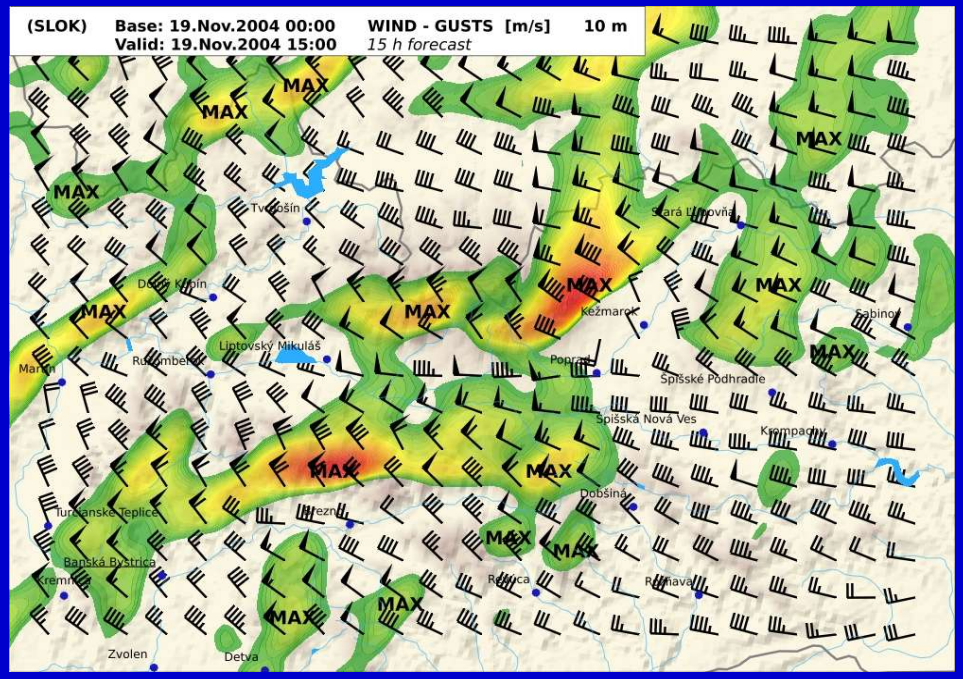
- Improved spatial distribution of wind gusts and better localization of the wind speed maxima
- More information about the nature of the event – important for the forecasters

- Tool: 2.5 km hydrostatic ALADIN model with physics
  2.5 km dynamic adaptation of ALADIN SLOVAKIA
  2.5 km non-hydrostatic model
  (ALADIN NH dynamics+physics, cycle 29)

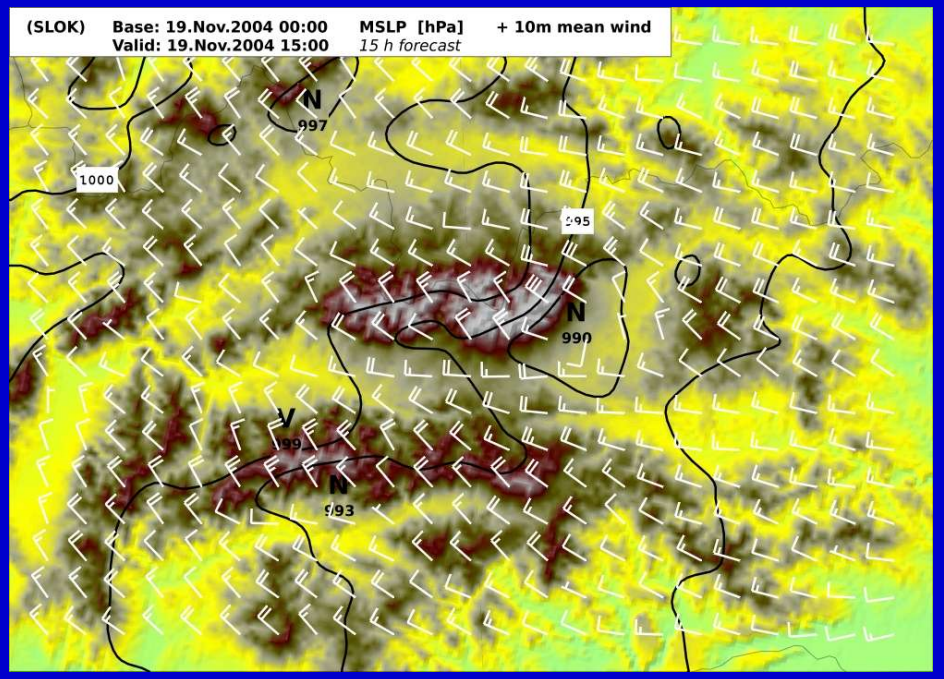
- We concentrated on short range forecasts of wind and pressure distribution (00h – 24 h range)

2.5 km hydrostatic run with physics

- Areas of predicted max. gusts coincide with the damage observations, better performance for low Tatra region
- Big pressure gradient and strong crossisobaric wind (lee cyclone due to blocking of air)



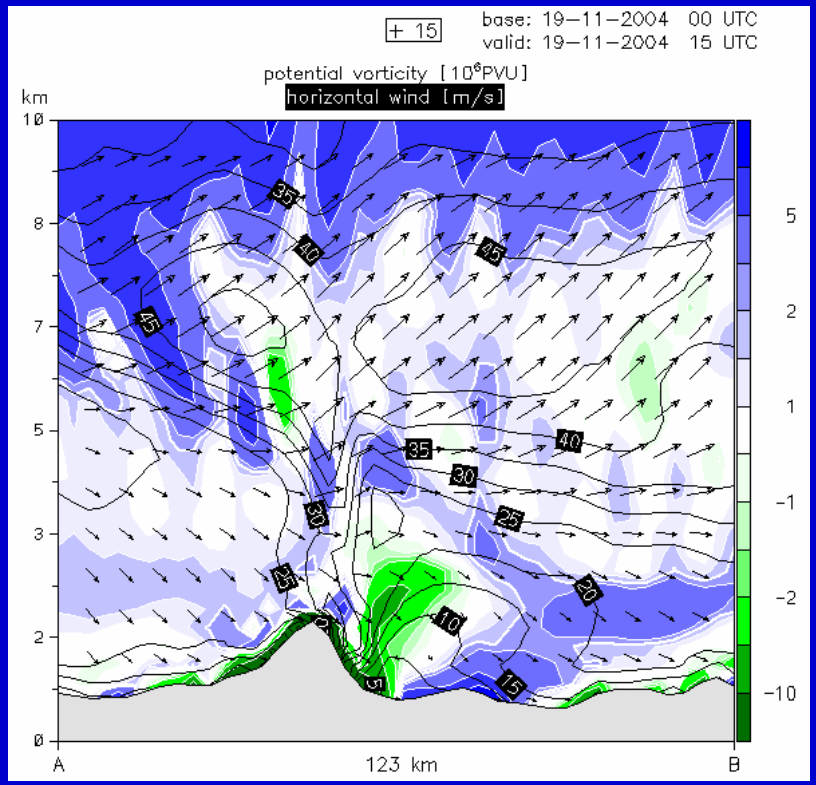
15 h forecast of wind gusts



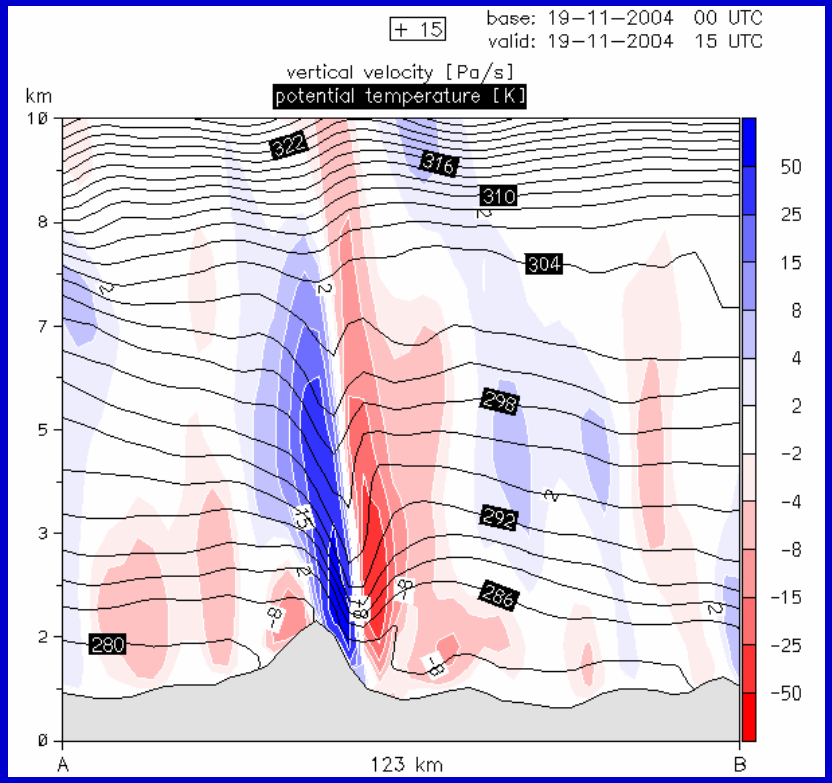
15 h forecast of 10m wind and MSLP

2.5 km hydrostatic run with physics

- Extreme wind speeds on the lee side: area of increased static stability and downsloping isotherms of „θ“
- Vertical velocities: effect similar to “hydraulic jump”



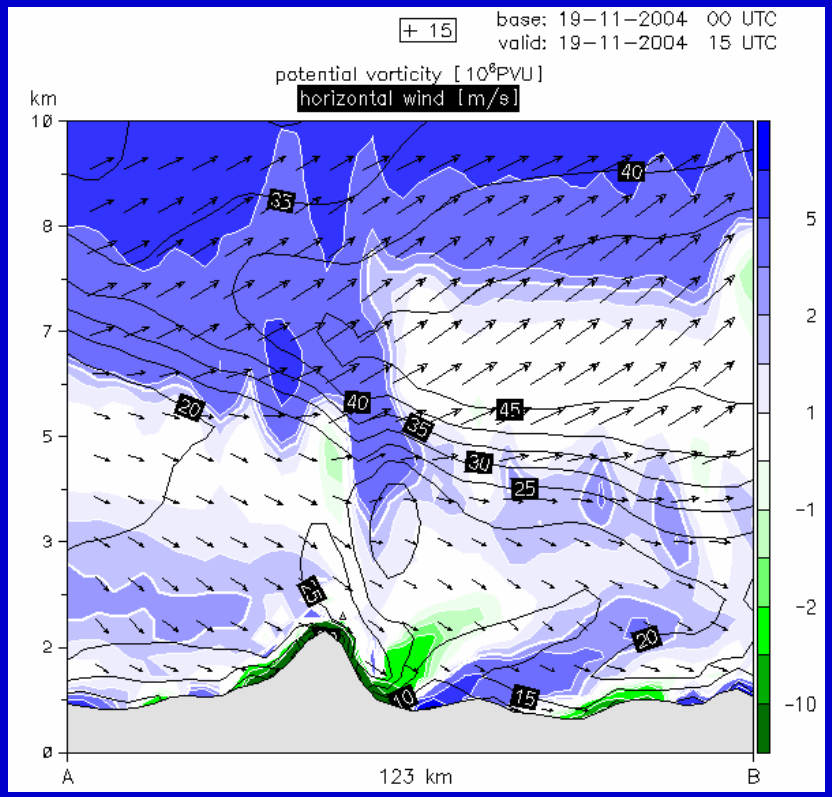
NW Potential vorticity + wind **SE**



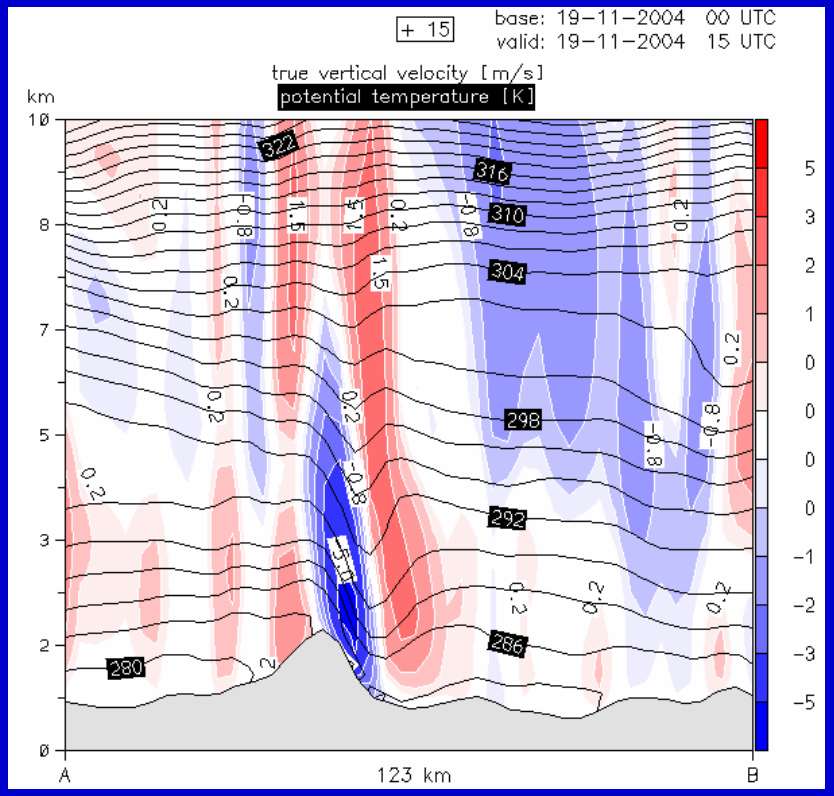
Pot. Temperature + Vertical velocity (Pa/s)

2,5 km non- hydrostatic run

- Time shift of the event (max. wind speeds 3 h later)
- main structure of the flow similar to hydrostatic run

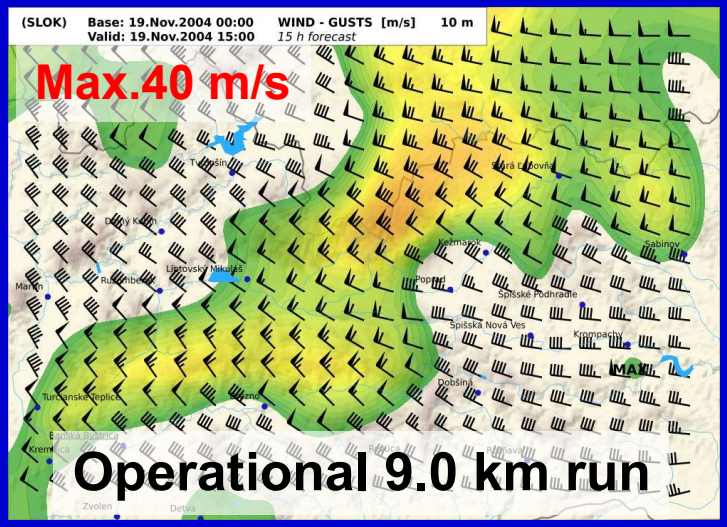


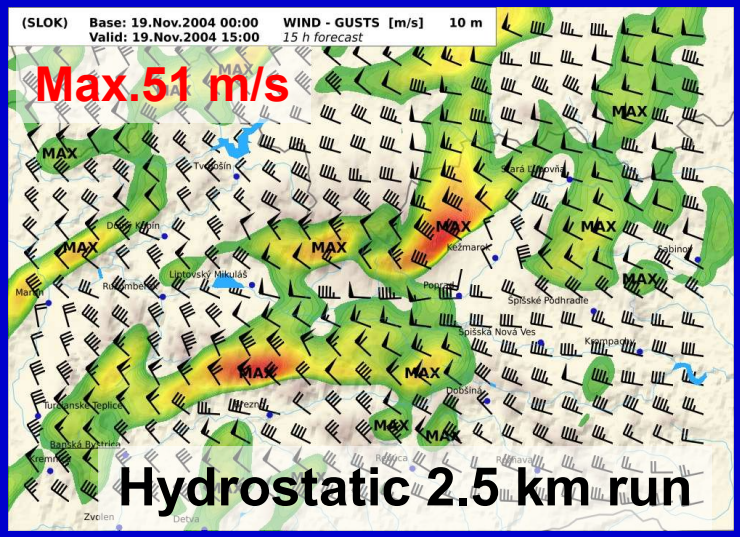
Potential vorticity + wind

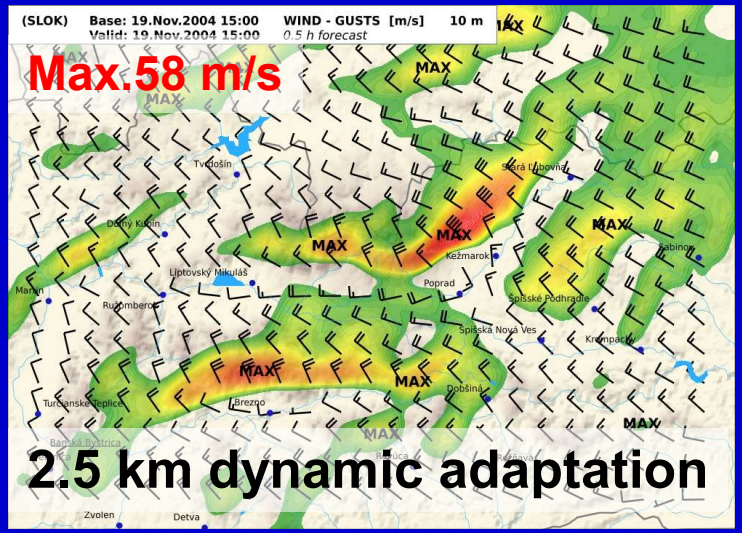


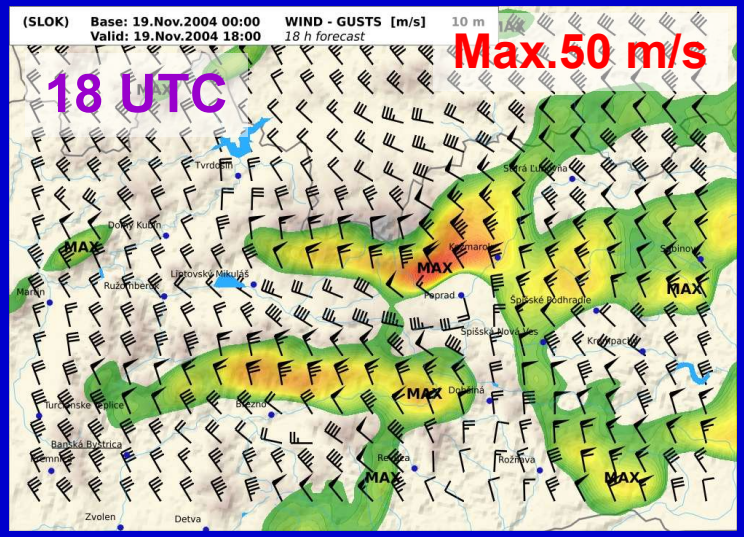
True vertical velocities (m/s)

Comparison of all runs



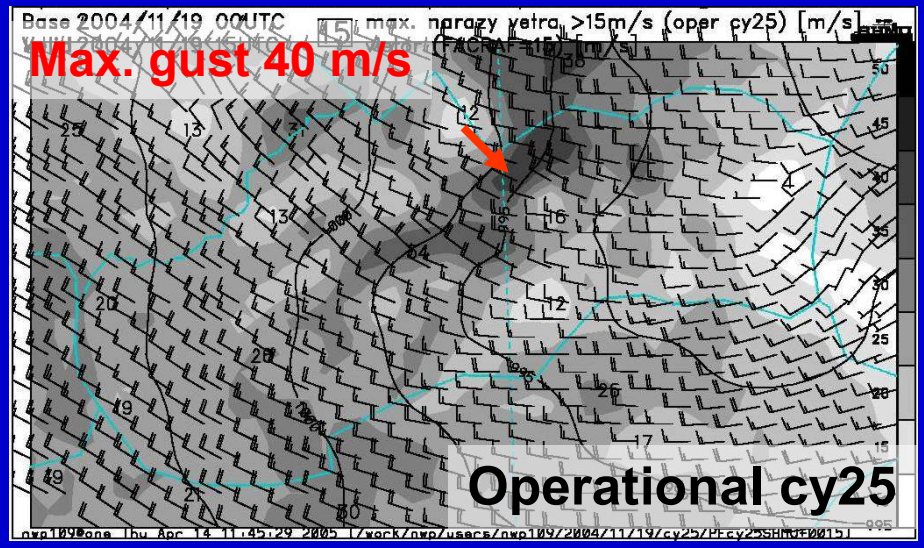


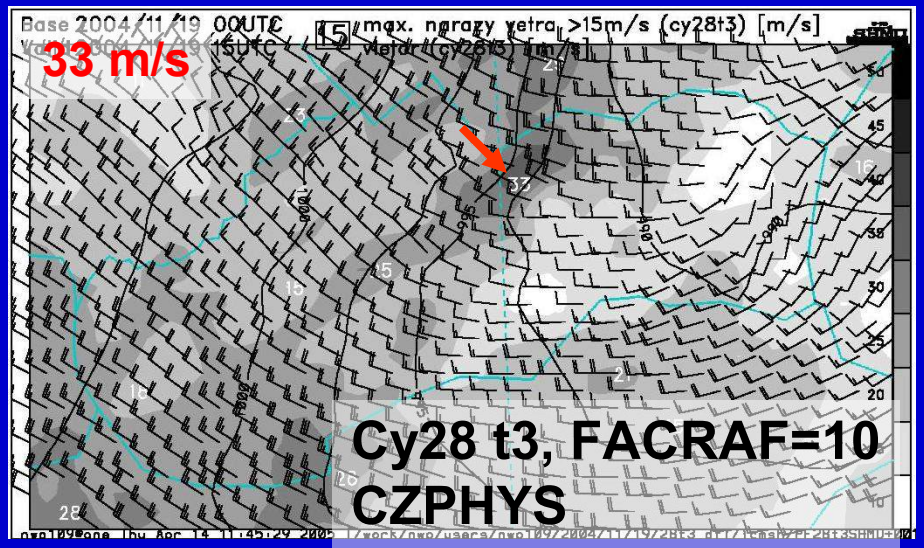


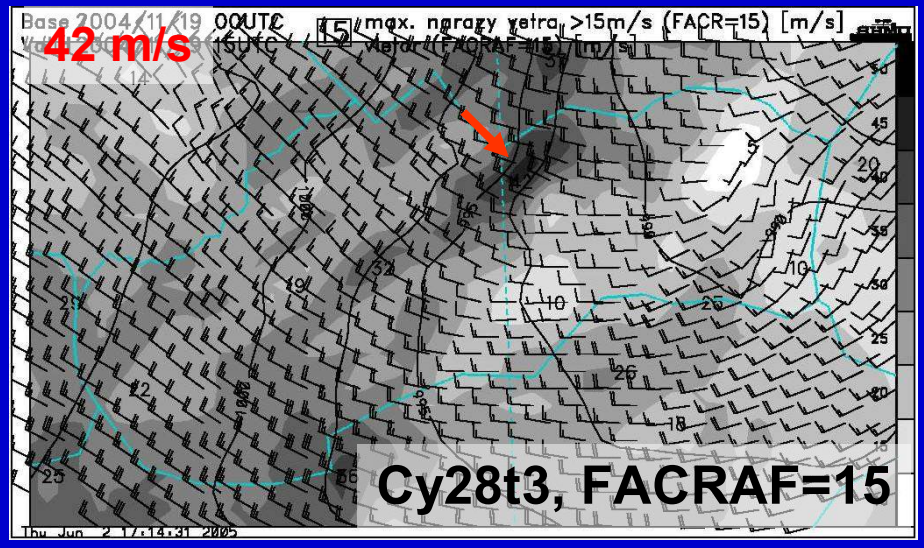


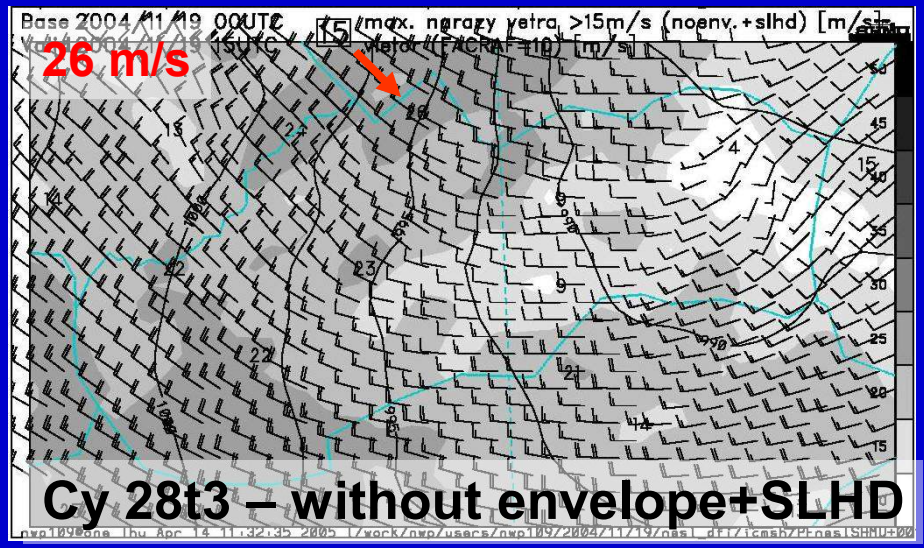
15 h forecast of wind gusts: direction + speed (m/s)

Sensitivity tests







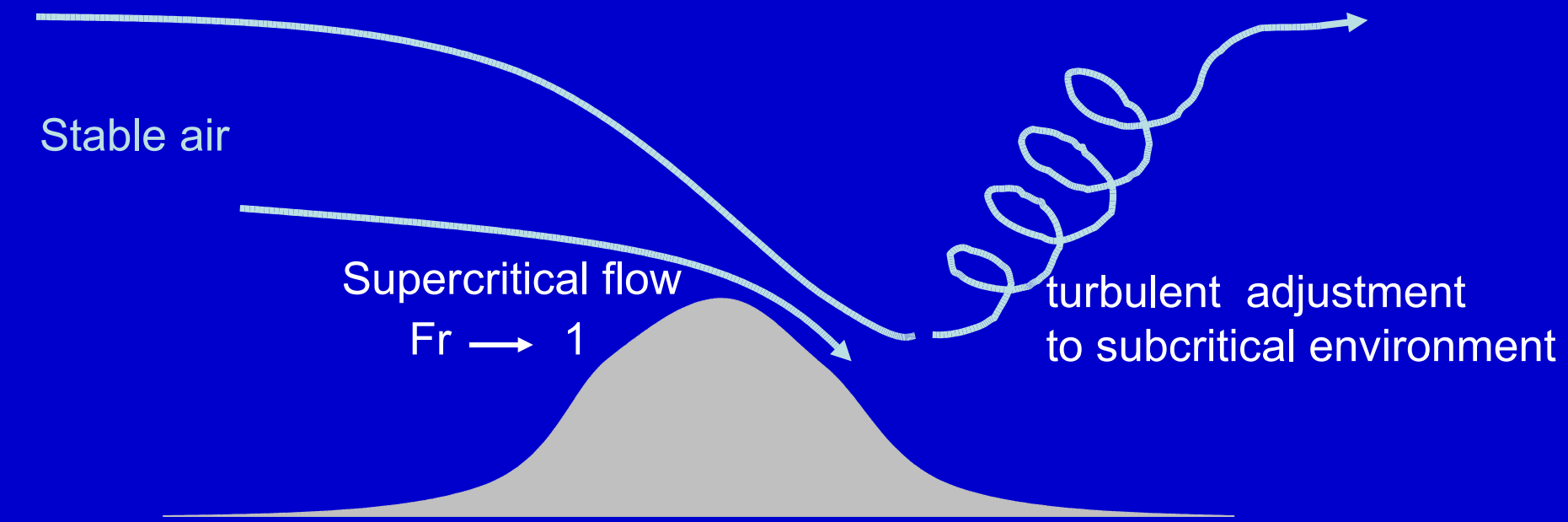


10 m wind, wind gusts (shades), MSLP (hPa)

Mesoscale diagnostics

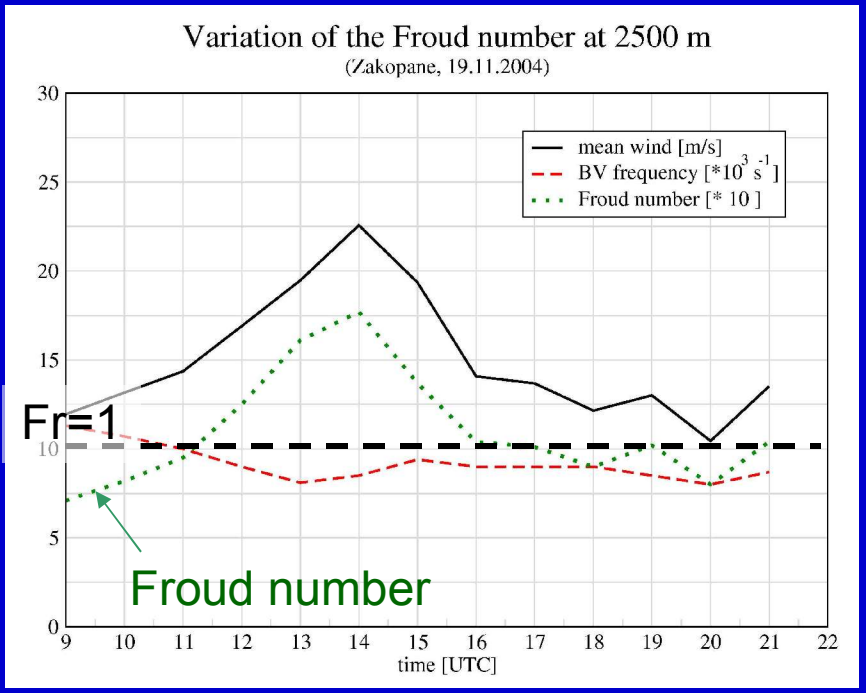
- Theory of downslope windstorms:
- Supercritical flow: Froud number $\longrightarrow$ 1
- Several analytical models an criterions …
- Mostly: $Fr = \dfrac{U}{N\,H}$

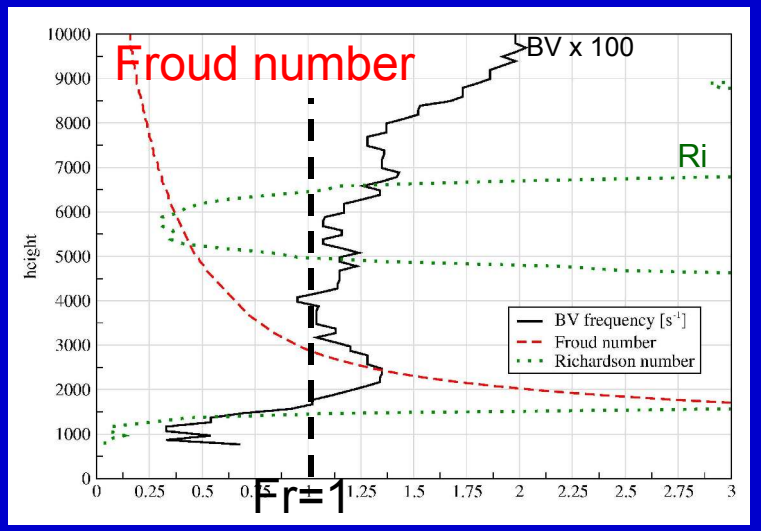
Shallow water hydraulic model:
adapted from Holton (1992)

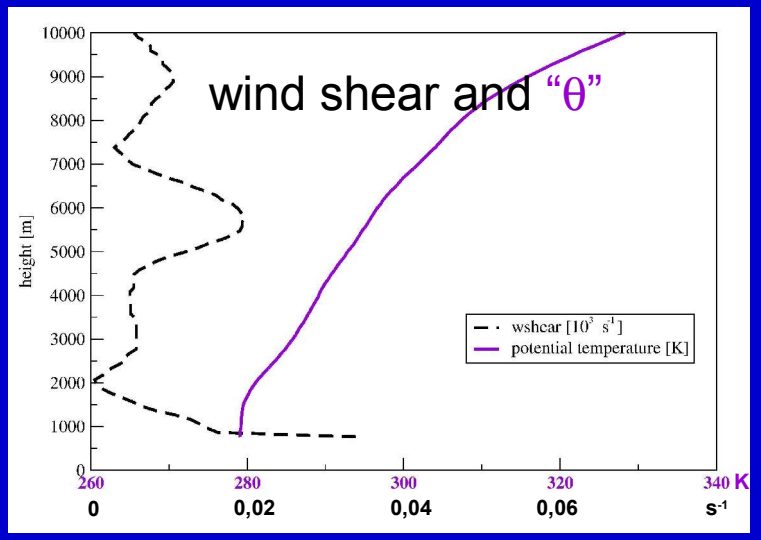


Mesoscale diagnostics

- Increase of stability with height
- Below 3000 m Froud number > 1 (air can flow over mountains)

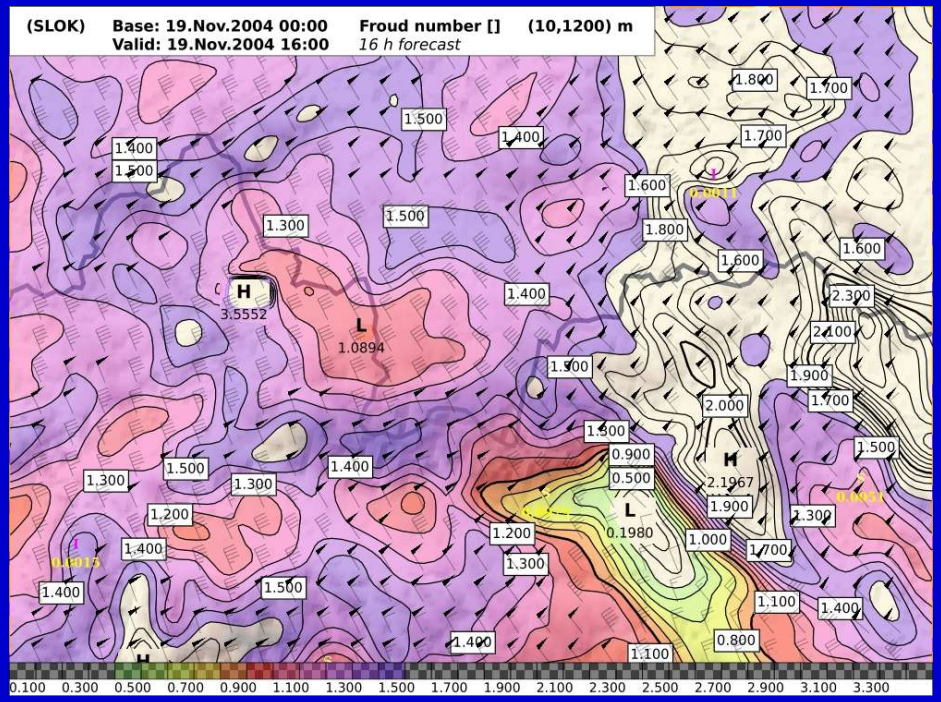




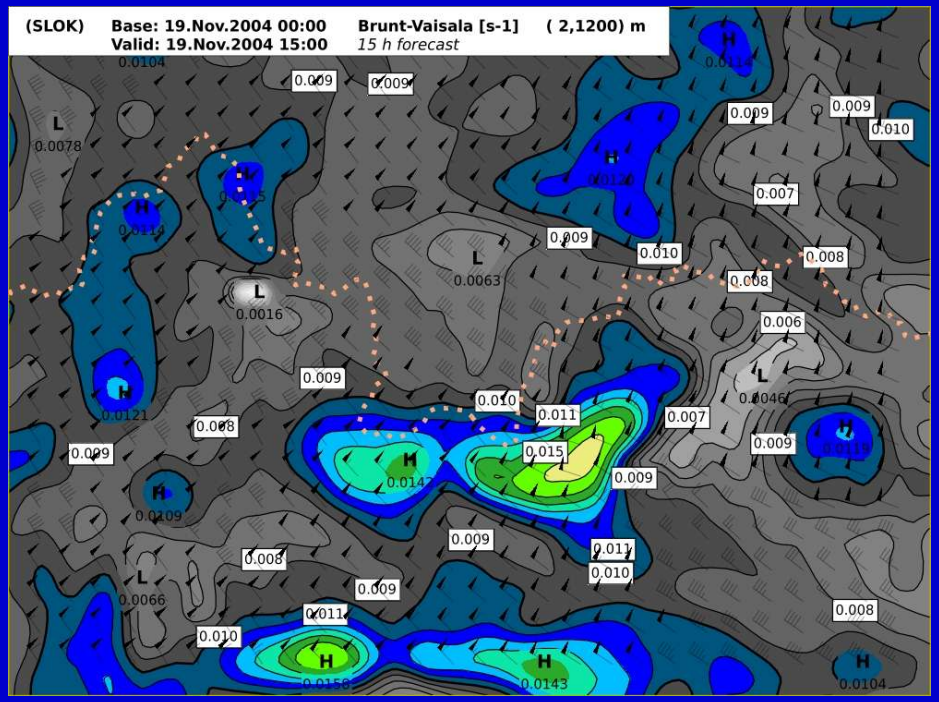


Mesoscale diagnostics

- Increase of stability on the lee side – indicates a strong downslope wind



Approximate Froud number



Mean Brunt Vaisala frequency

Conclusions: points of view

- NWP Operation: High resolution models, even hydrostatic, enable to forecast such unusual severe event, dynamic adaptation seems to be sufficient
- Forecasting: All HR runs forecast the main characteristics of downslope windstorms (e.g. hydraulic jump)
- NWP Development: A case study necessary to test in new cycles, probably high dependence on physical parameterisation (turbulence scheme ?)
- Science: needs for better analytical model + higher resolution model to simulate microscale effects

Acknowledgements

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- to all colleagues who helped us and contributed to this study