Do we need NH model at 2.5 km resolution? (3D real cases)

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Introduction

- our goal for the near future is to run operational NWP model with horizontal resolution 2.5 km

- both theoretical analyses and 2D academic experiments indicate, that at kilometric scales NH effects start to play an important role

- but since these results were obtained in idealized (and sometimes meteorologically unrealistic) situations, it is important to evaluate impact of NH effects in full 3D model

- for the moment it is not sure, whether NH model at 2.5 km resolution is inevitable

Selected 3D cases

- only two 3D cases will be presented:

  1. wind storm in High Tatra mountains (19.11.2004)
  2. ordinary cold front passage through Central Europe (16.11.2005)

Cascade of models

- double nesting was used, driving model for high resolution integrations was operational ALADIN/SHMU (cycle al25t2, resp. al28t3_czphys):

horizontal resolution	$\Delta x = 9.0\,\mathrm{km}$
spectral truncation	quadratic
domain size (C + I + E)	320×288 points
number of vertical levels	37
coupling frequency	3 h

- high resolution integrations used cycle al25t2 with back-phased NH developments (memory problem occured with cycle al29t2):

horizontal resolution	$\Delta x = 2.5\,\mathrm{km}$
spectral truncation	quadratic
domain size (C + I + E)	300×200 points
number of vertical levels	37
coupling frequency	1 h

Integration settings

- common settings: SL2TL temporal scheme, LADVF = .T.

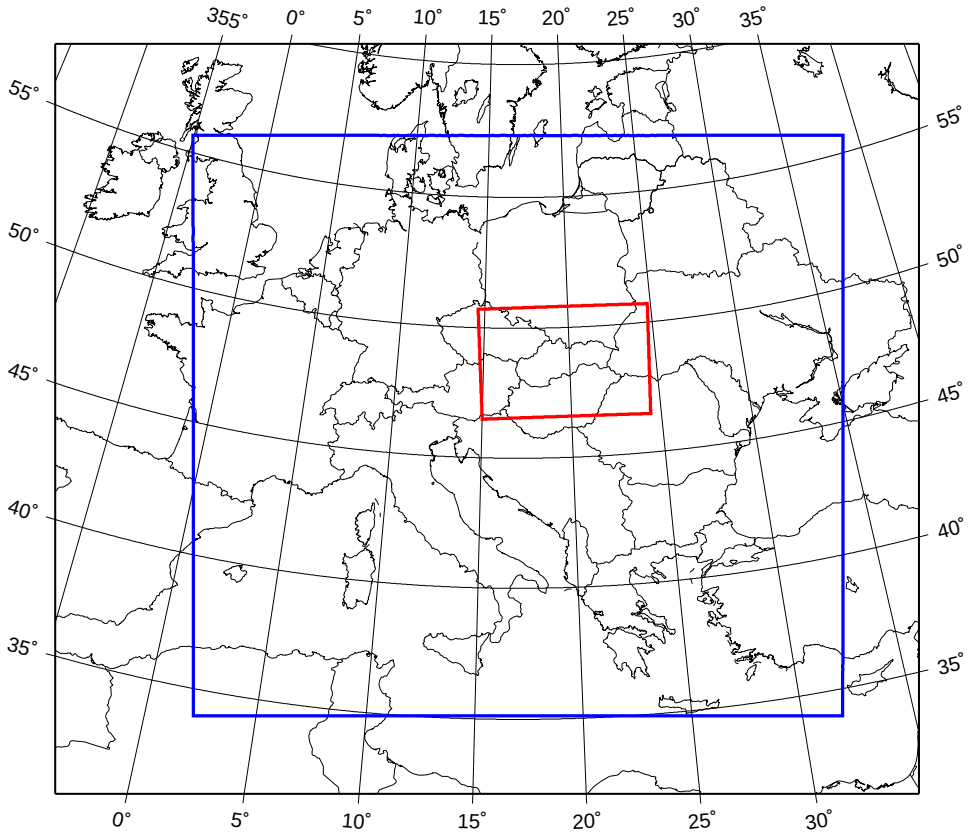
- model dependent settings:

	9 km, H	2.5 km, H	2.5 km, NH
LNHDYN	.F.	.F.	.T.
NVDVAR			(3), 4
ND4SYS			1
extrapolations	SETTLS	SETTLS	LPC_NESC
NSITER	0	0	1
TSTEP [s]	400.	60.	60.
SITR [K]	300.	300.	350.
SITRA [K]			100.
XIDT	0.05	0.05	0.

Integration domains

ALADIN/SHMU, $\Delta x = 9.0\,\mathrm{km}$

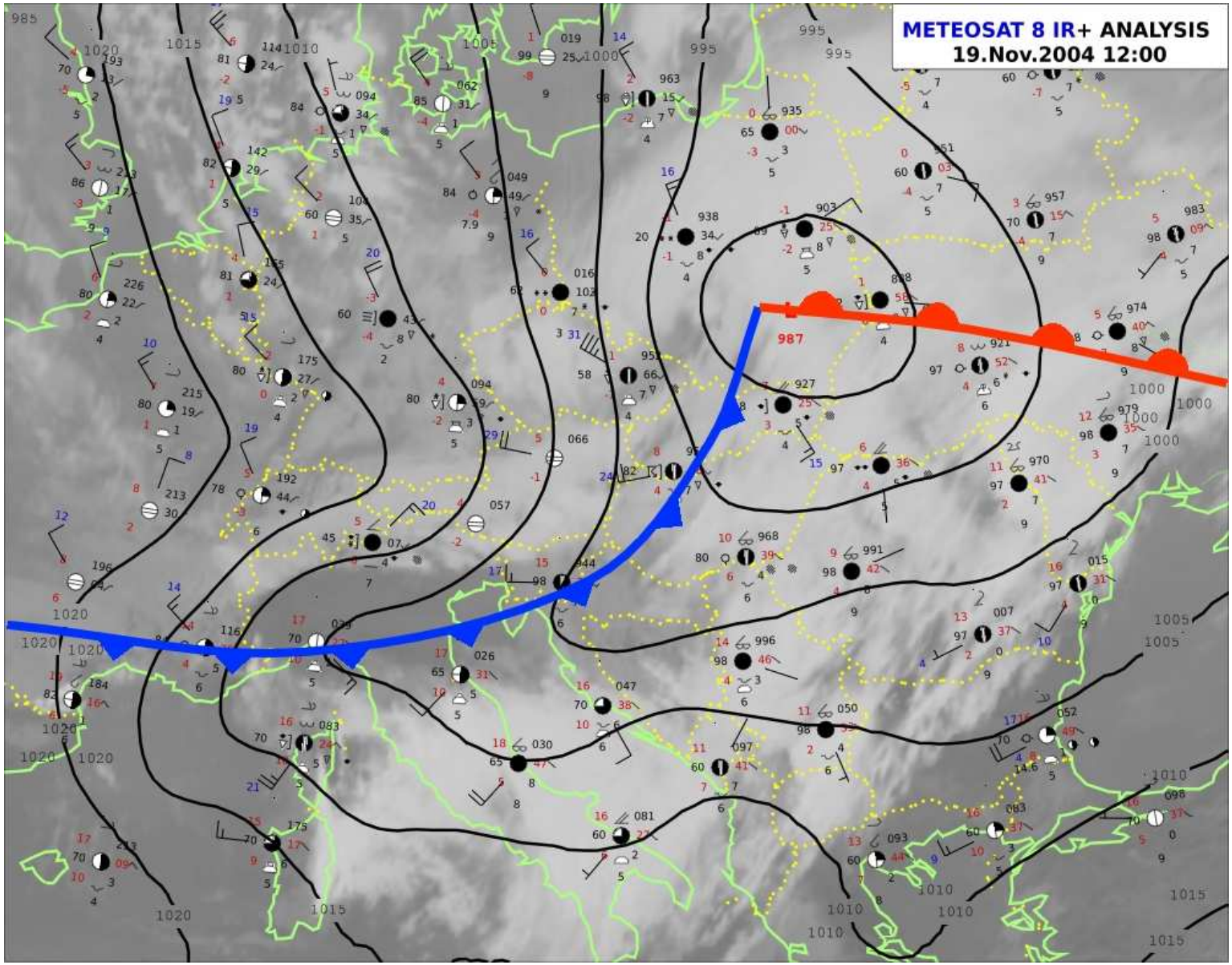
ALADIN/SK25, $\Delta x = 2.5\,\mathrm{km}$



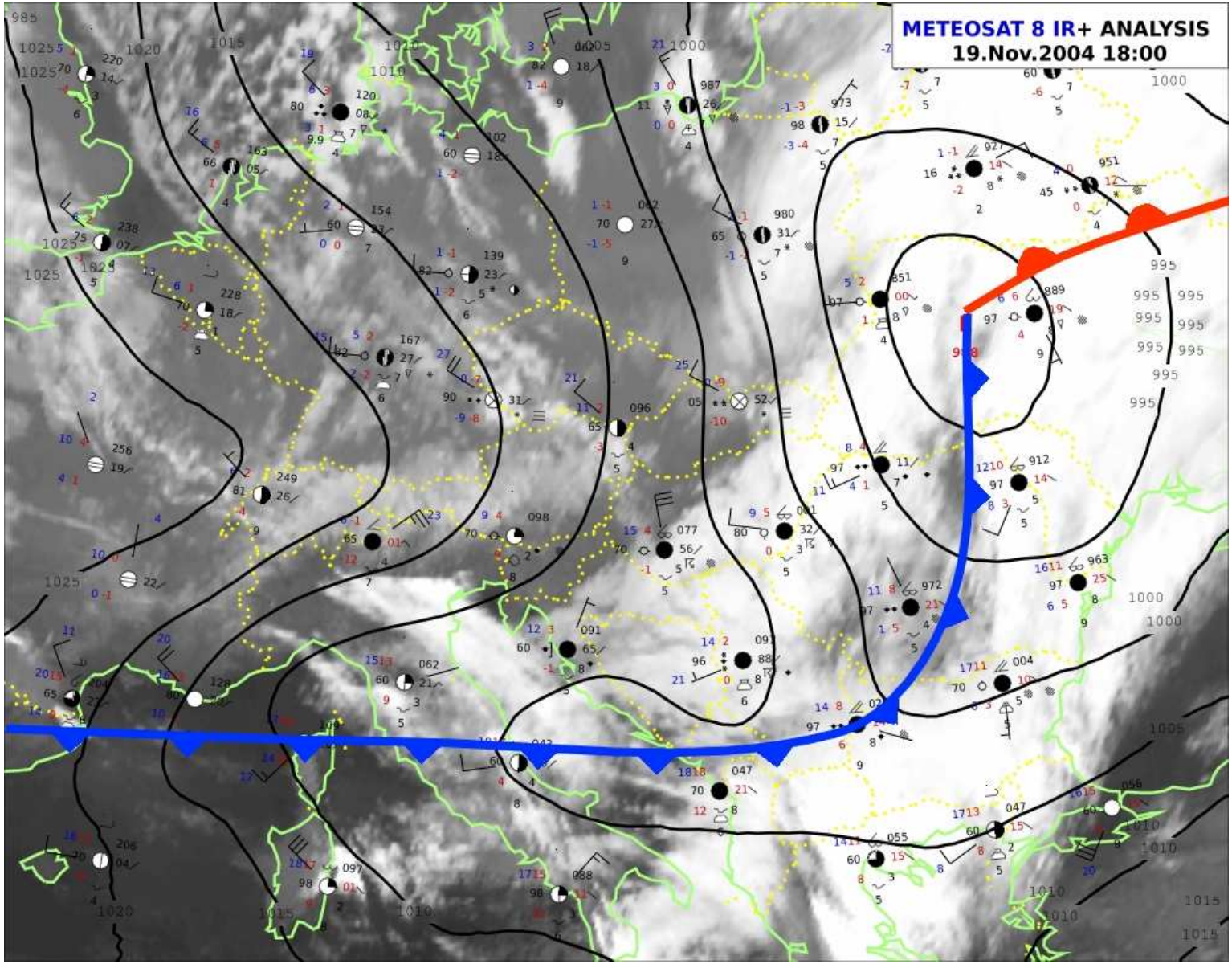
Wind storm in High Tatra mountains (19.11.2004)

- rapidly developing cyclone moving quickly over south Poland to the east
- advection of cold and dry air on its rear side (after front passage) caused a wind storm on leeward slopes of High Tatra mountains
- wind blowing from NW reached its maximum strength around 15 UTC, causing extensive damage on S and SE slopes (broken trees, destroyed buildings, . . .)
- wind gusts reaching 45 and 54 ms^{-1} were reported
- dry flow with strong winds over steep mountains is an ideal test case for comparison of H and NH dynamics

Analysis at 12 UTC



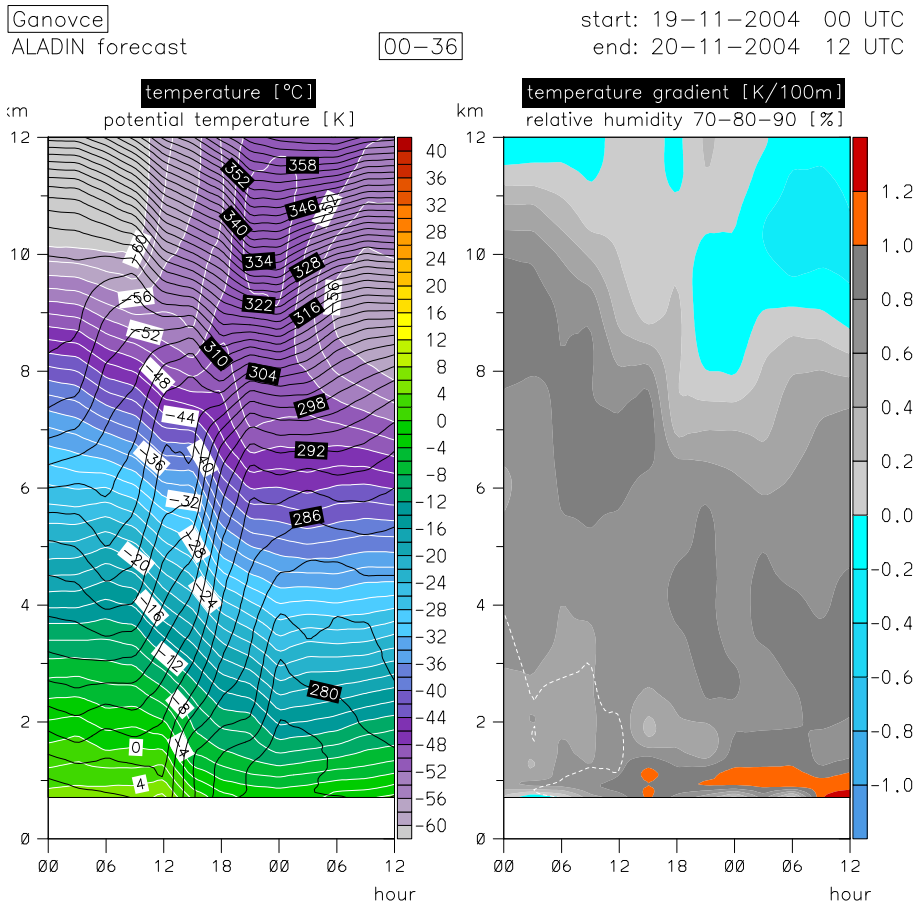
Analysis at 18 UTC



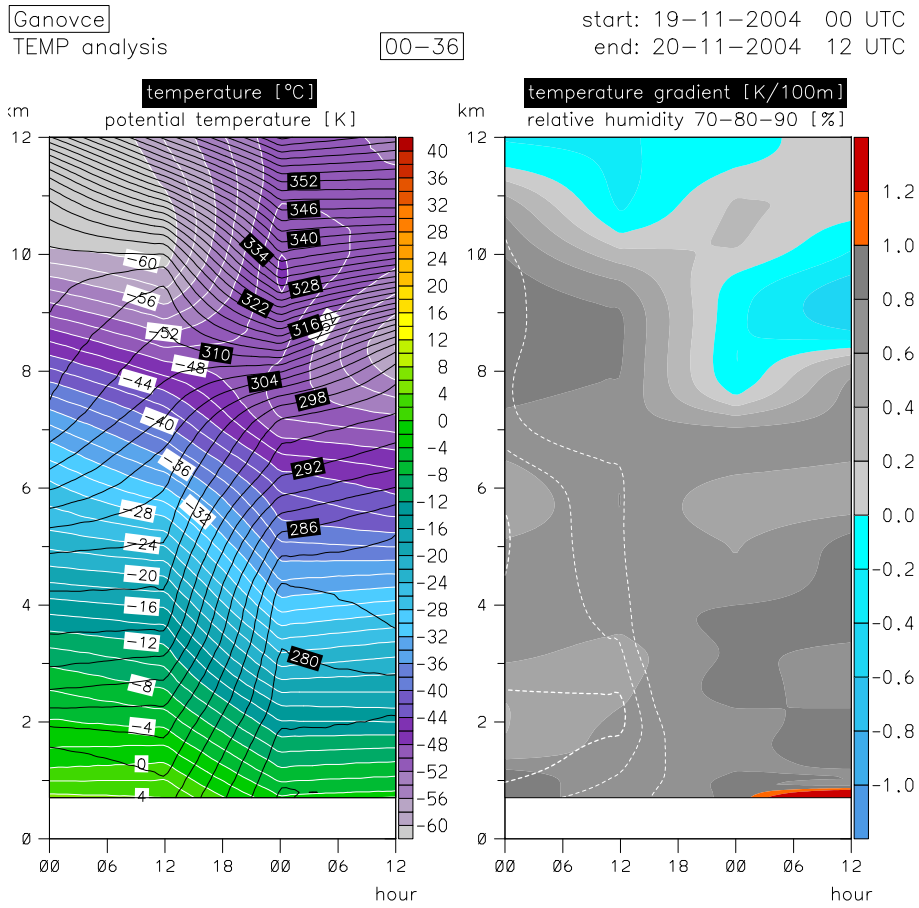
Time cross sections – 9.0 km run versus TEMP

(T, θ) and (Γ, r), station Gánovce

hydrostatic, 9.0 km



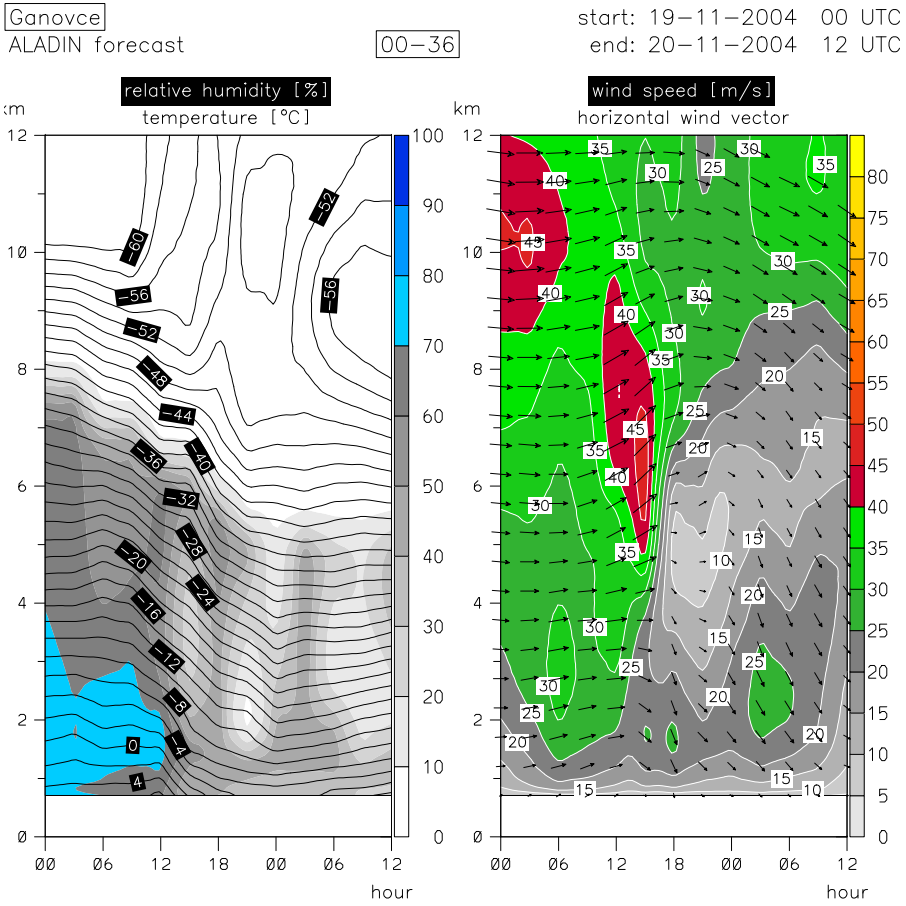
TEMP analysis



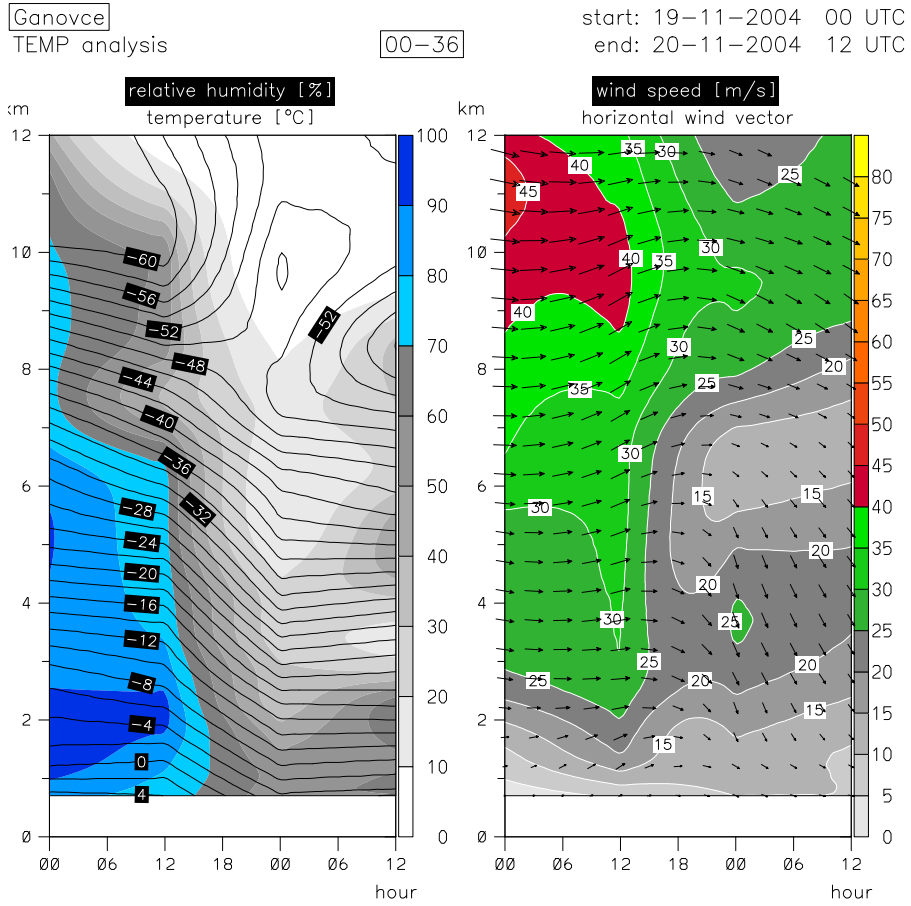
Time cross sections – 9.0 km run versus TEMP

(T, r) and (u, v), station Gánovce

hydrostatic, 9.0 km



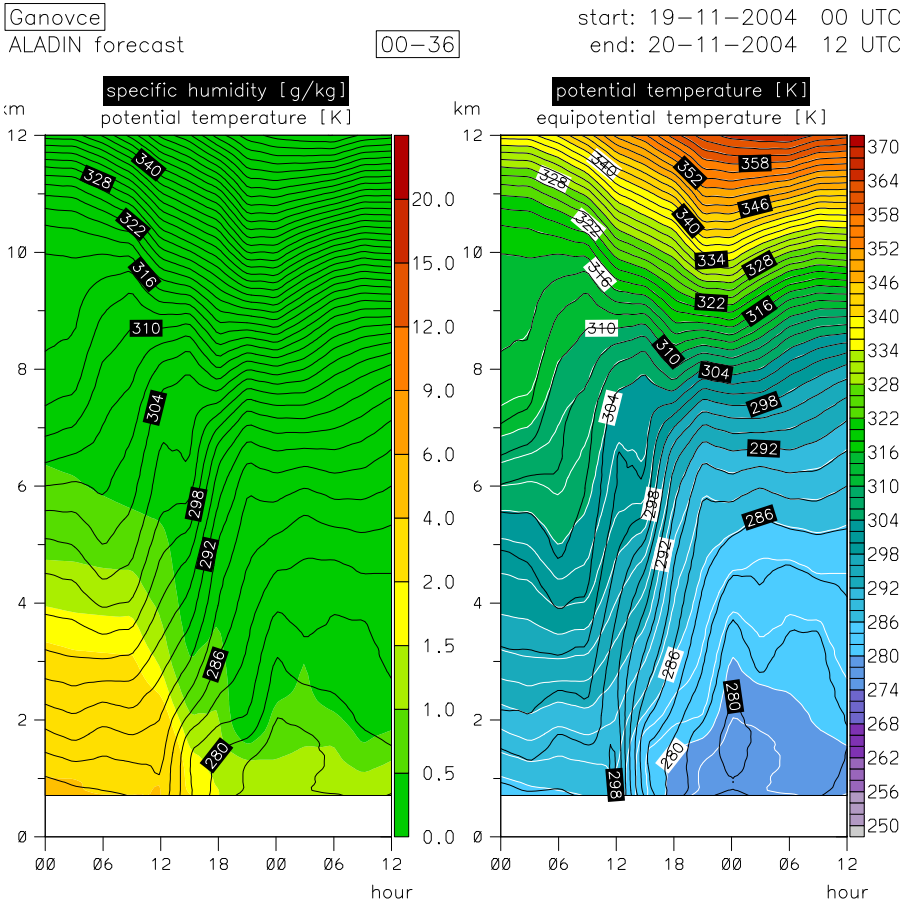
TEMP analysis



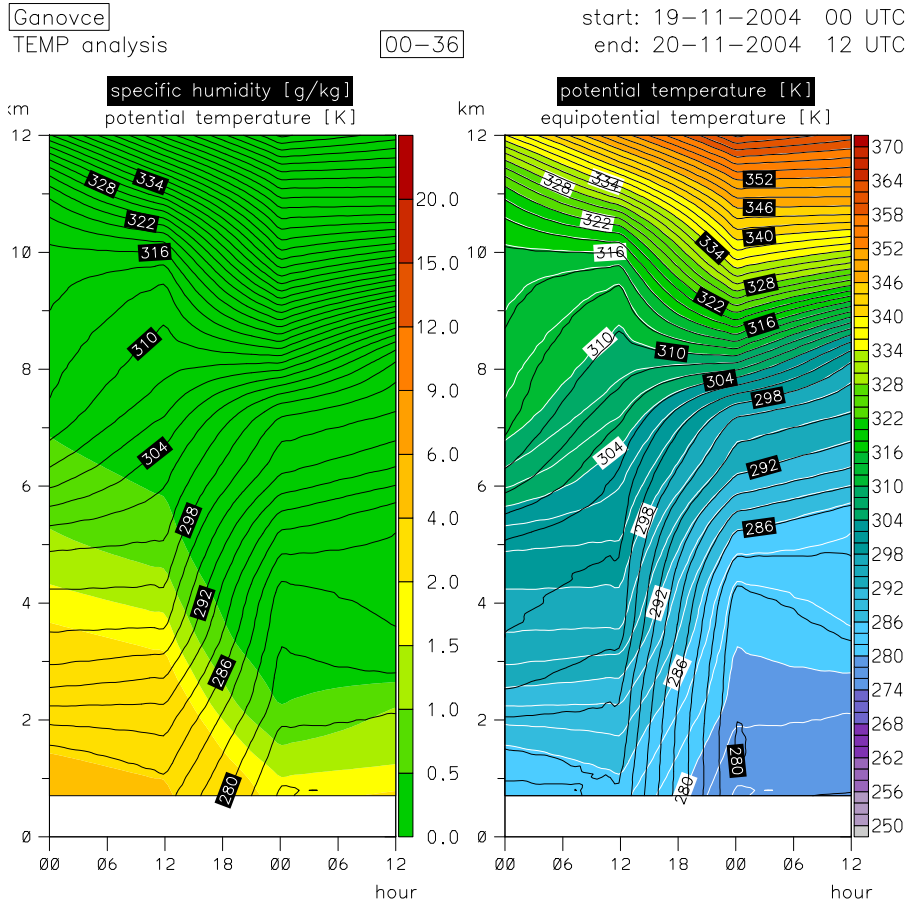
Time cross sections – 9.0 km run versus TEMP

(q, θ) and (θ, θ_e), station Gánovce

hydrostatic, 9.0 km



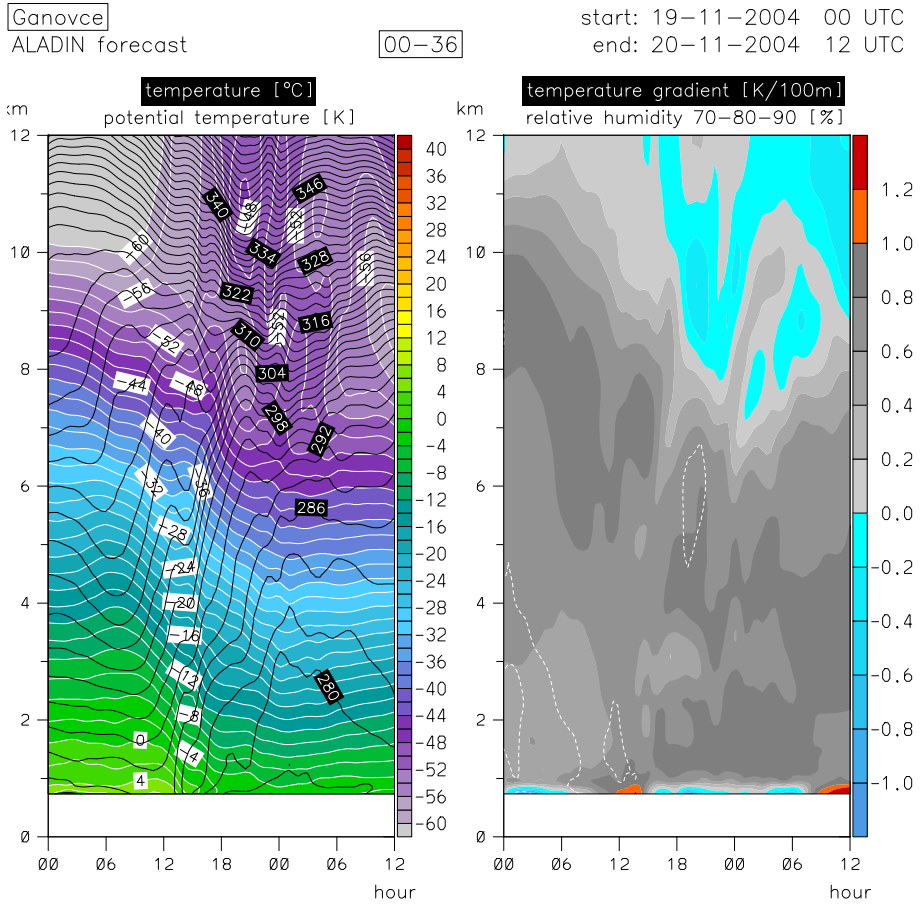
TEMP analysis



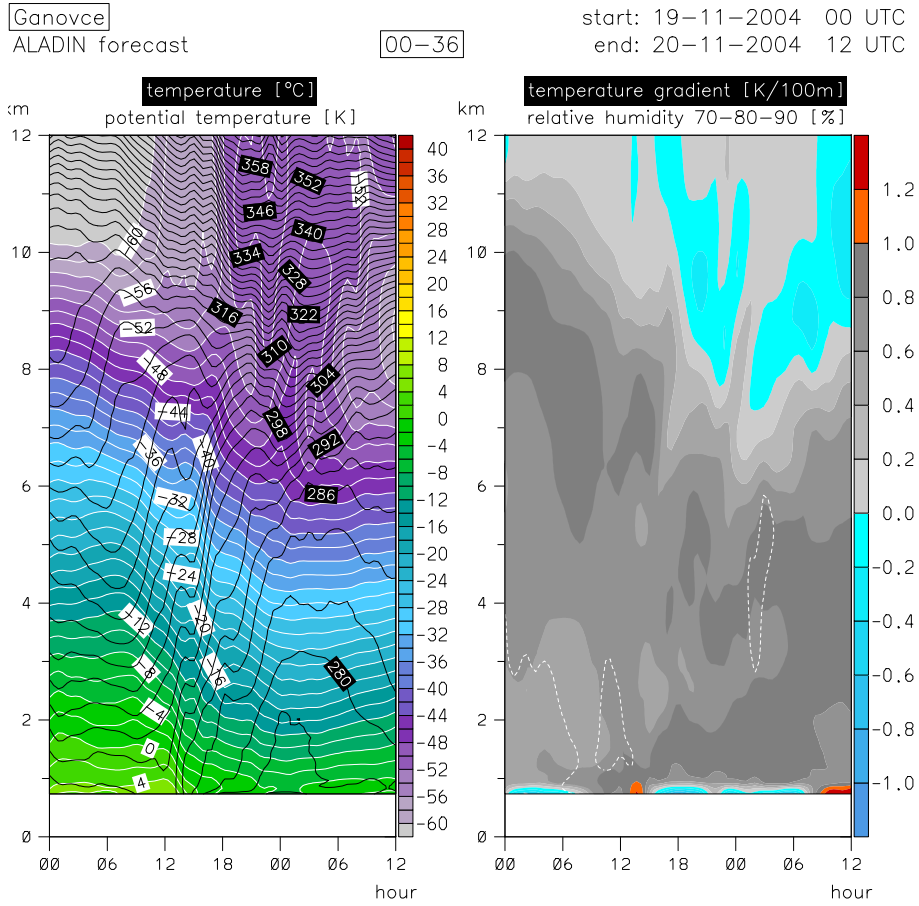
Time cross sections – H versus NH at 2.5 km

(T, θ) and (Γ, r), station Gánovce

hydrostatic, 2.5 km



non-hydrostatic, 2.5 km



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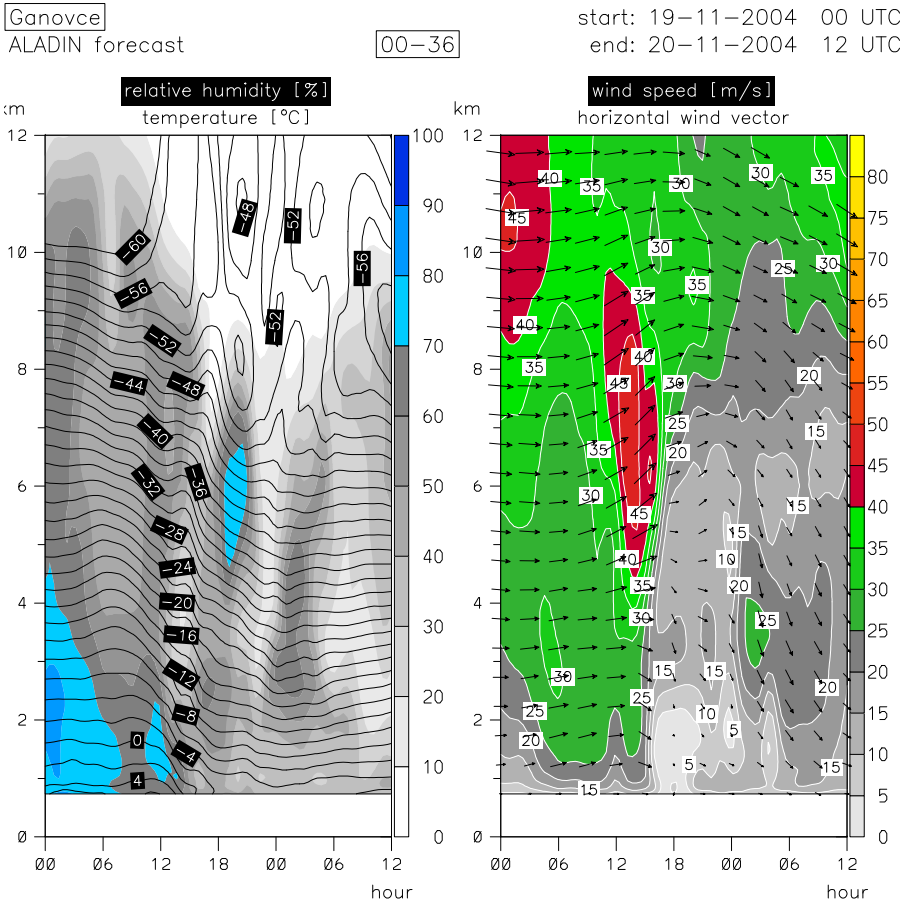
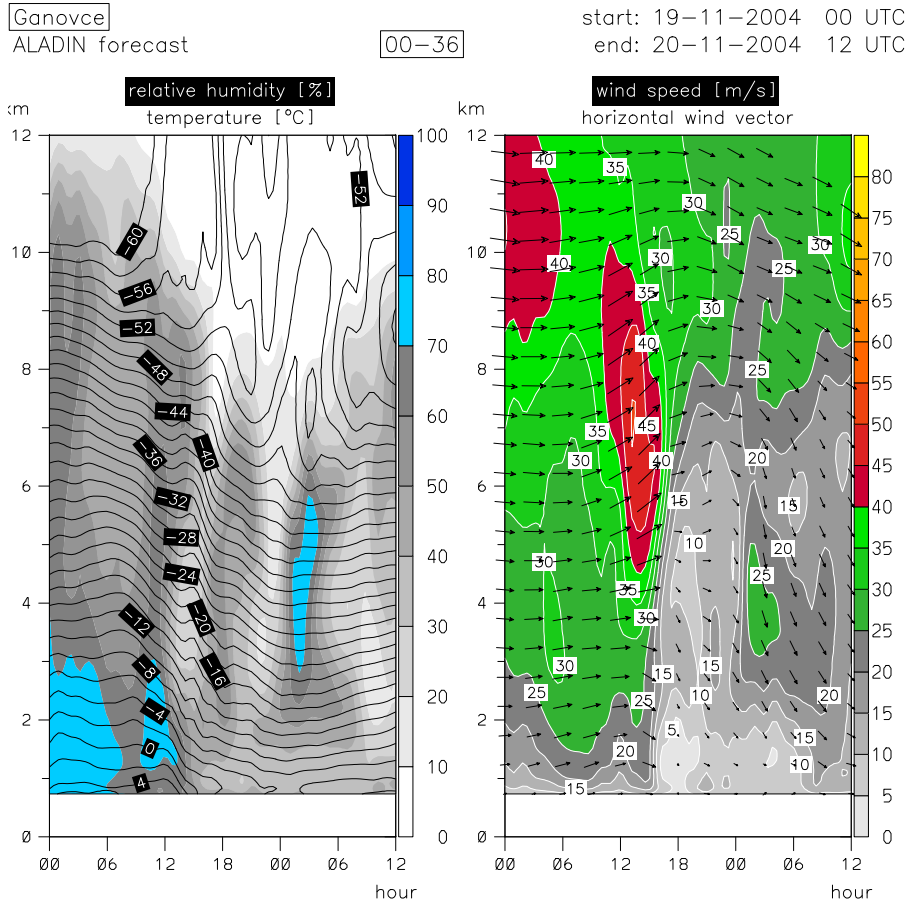


non-hydrostatic, 2.5 km



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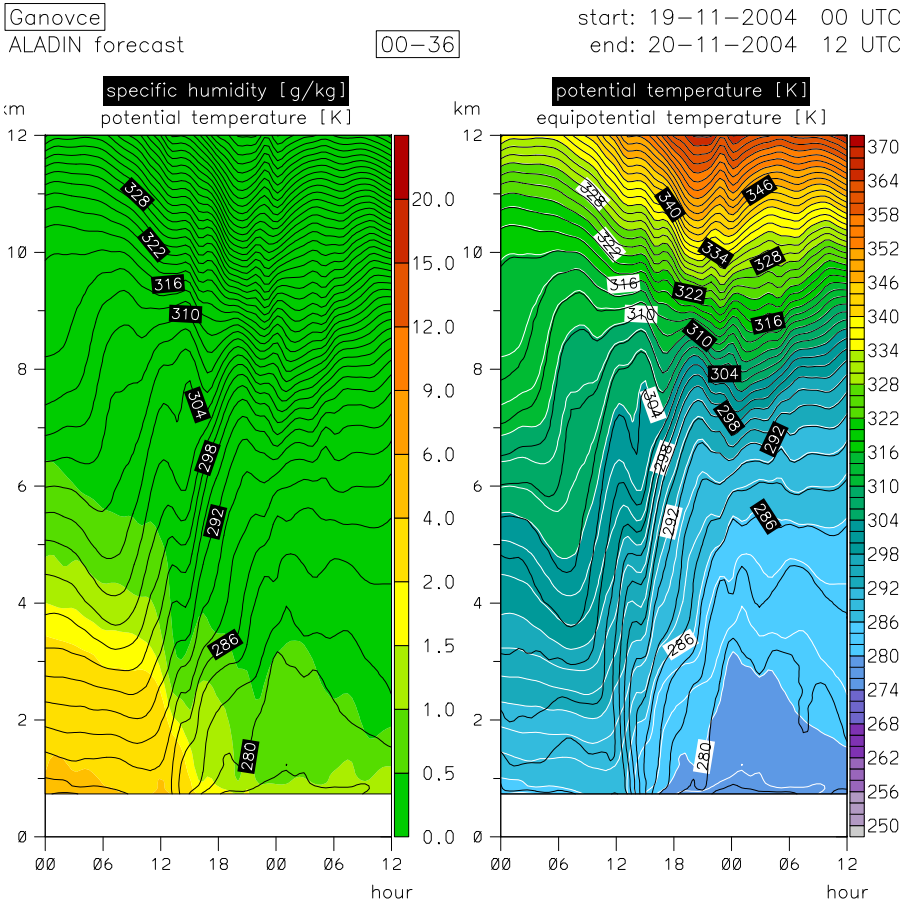
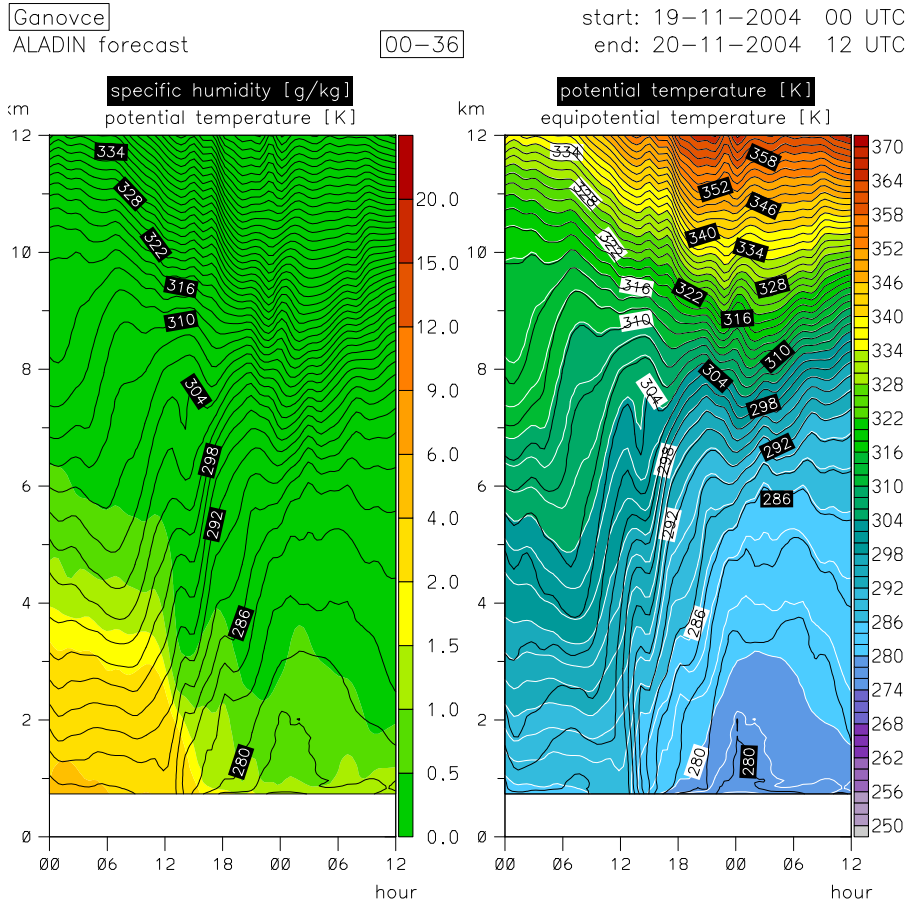
(q, θ) and (θ, θ_e), station Gánovce

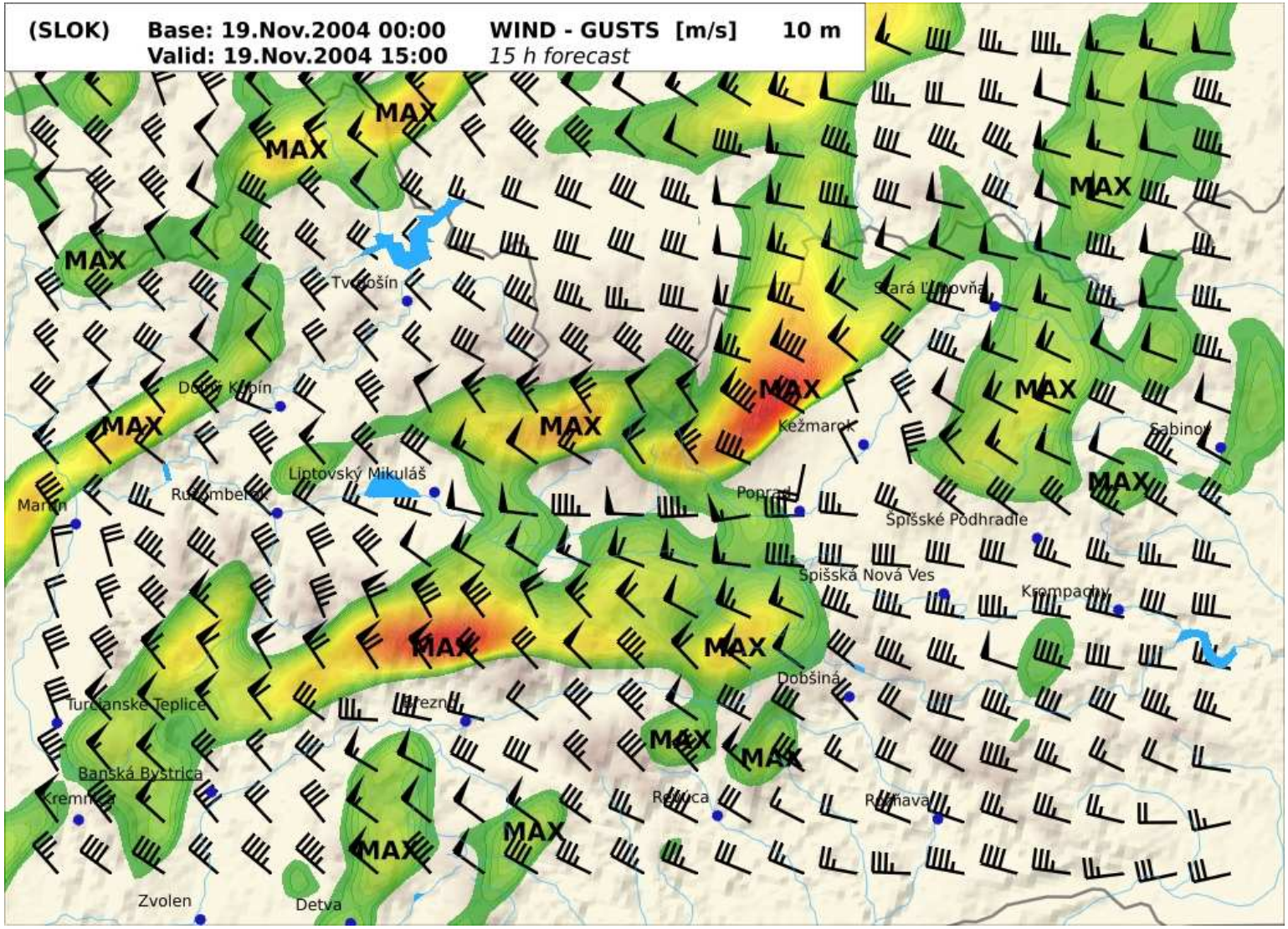
hydrostatic, 2.5 km



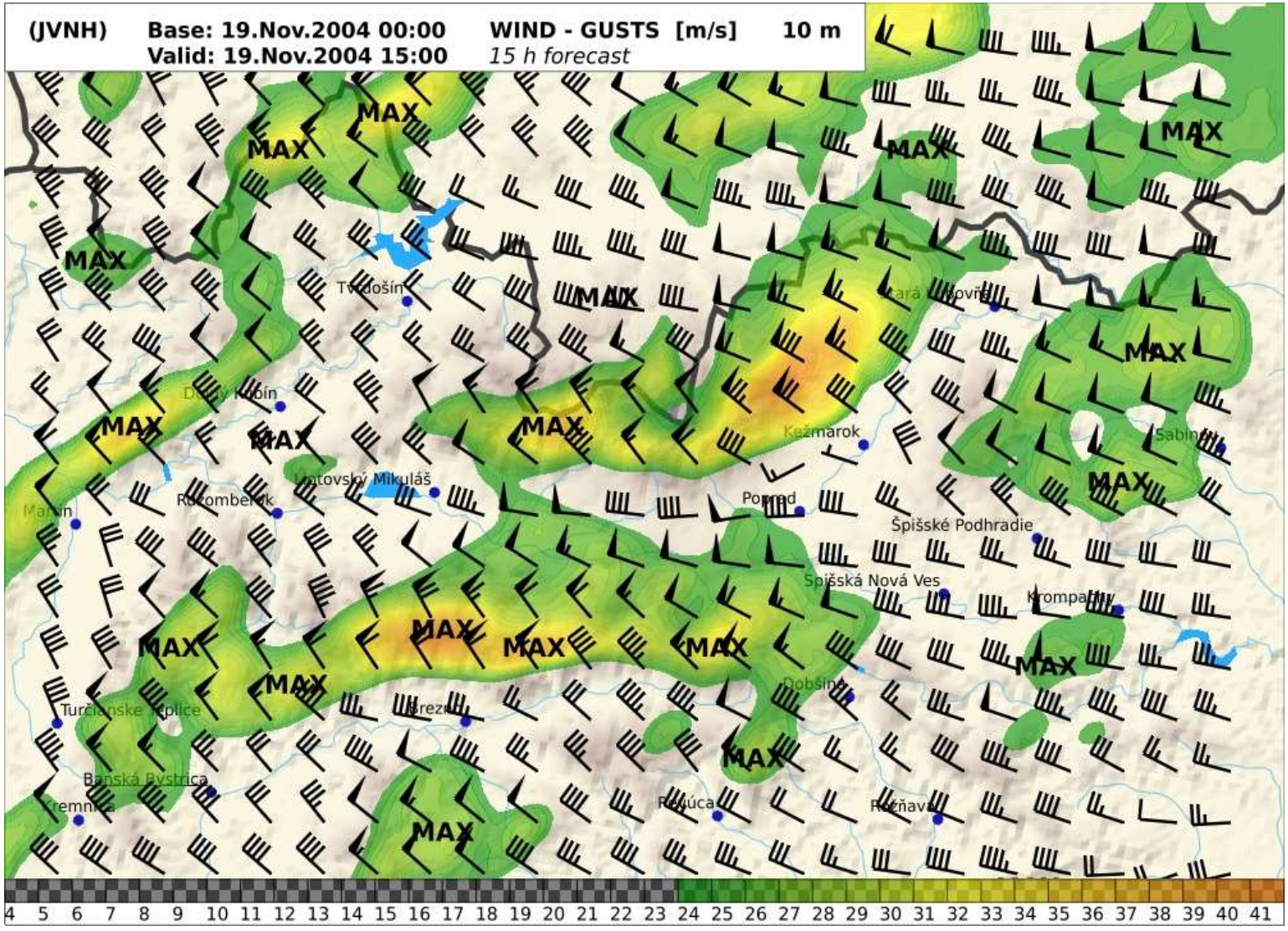
non-hydrostatic, 2.5 km



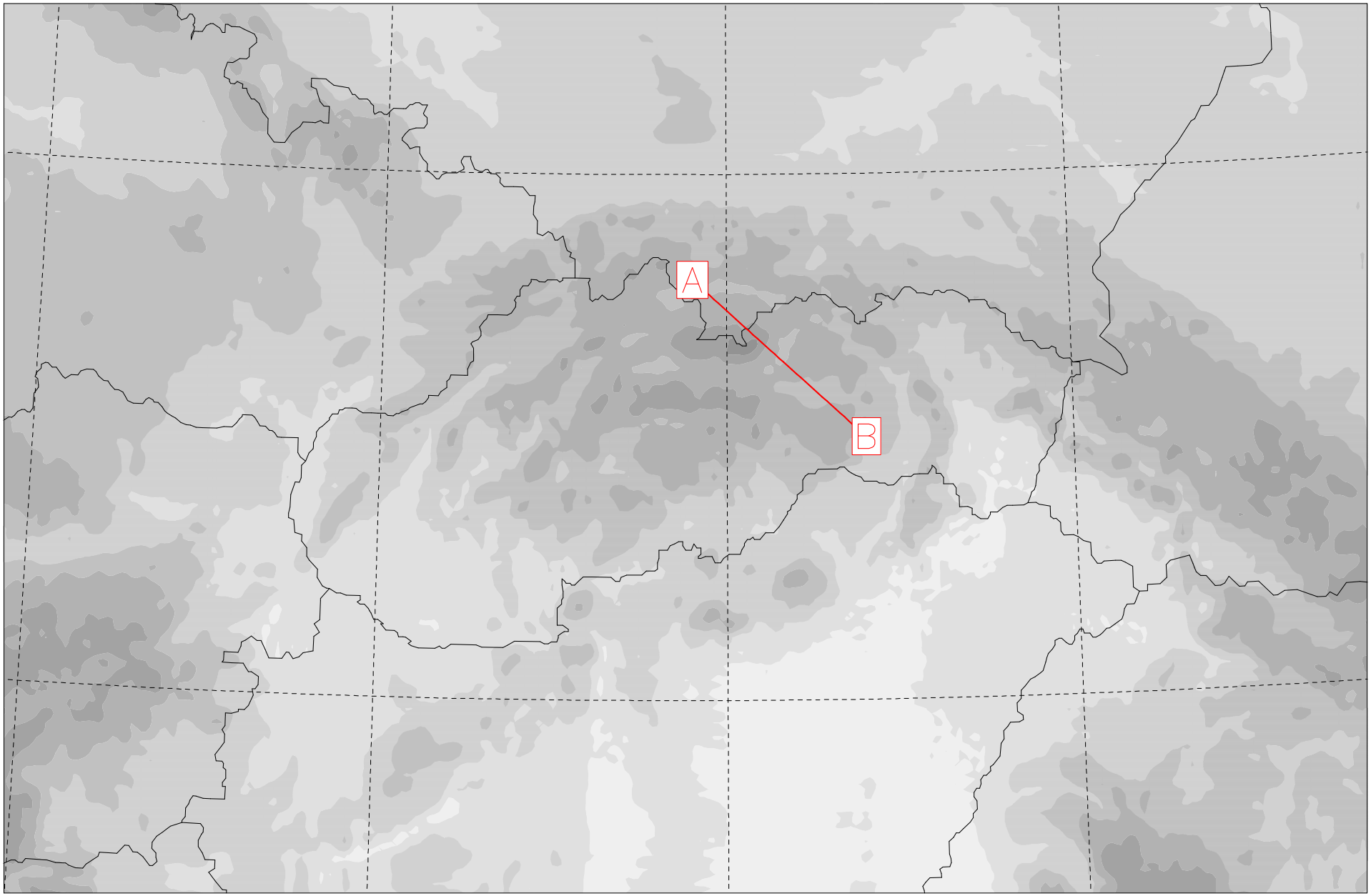
10 m wind gusts − H run for +15 h at 2.5 km



10 m wind gusts – NH run for +15 h at 2.5 km



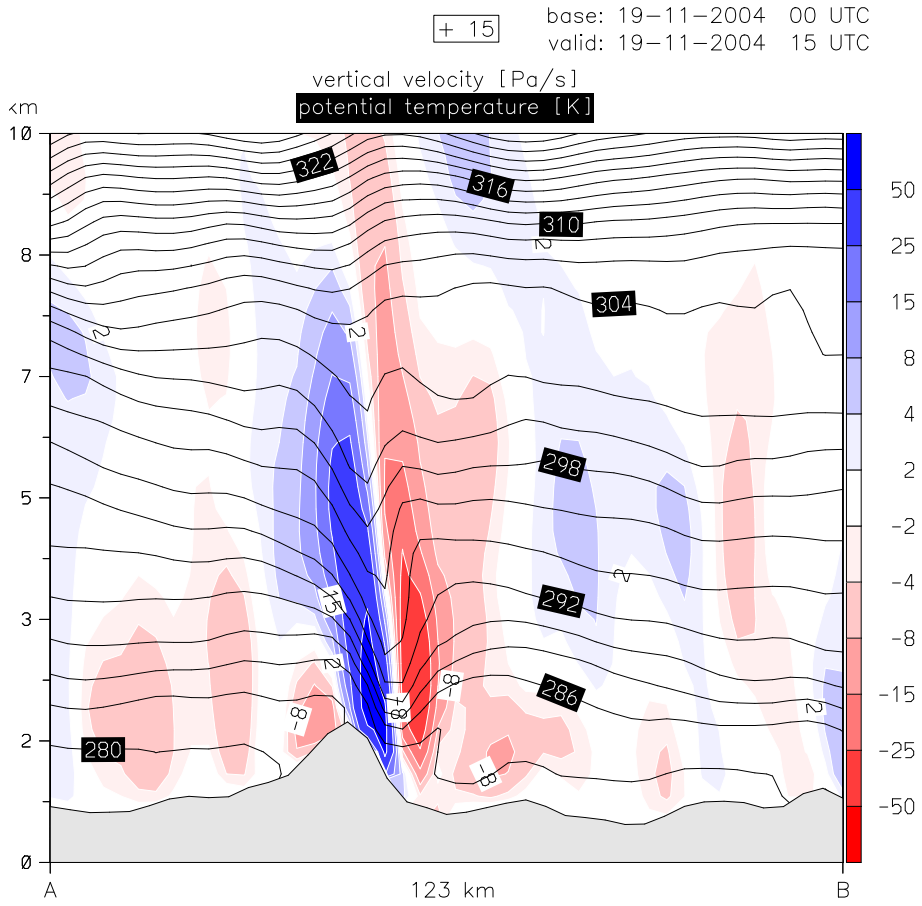
2.5 km orography + position of cross section line



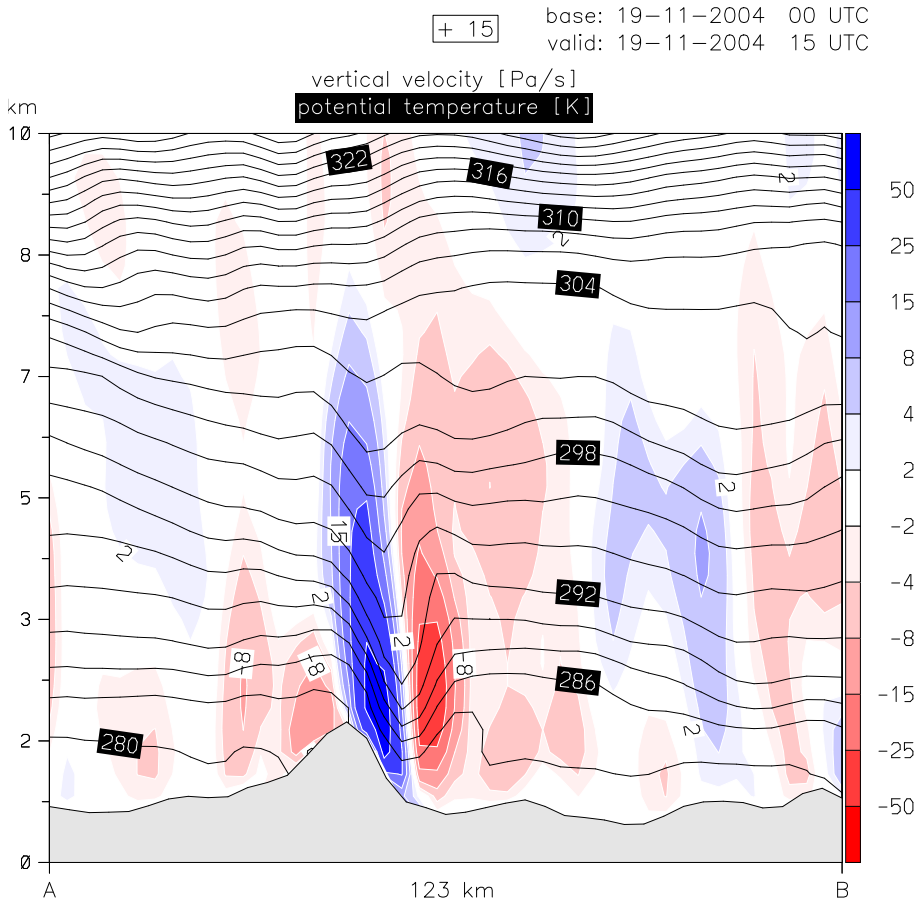
Space cross section – H versus NH at 2.5 km

ω and θ, +15 h forecast

hydrostatic



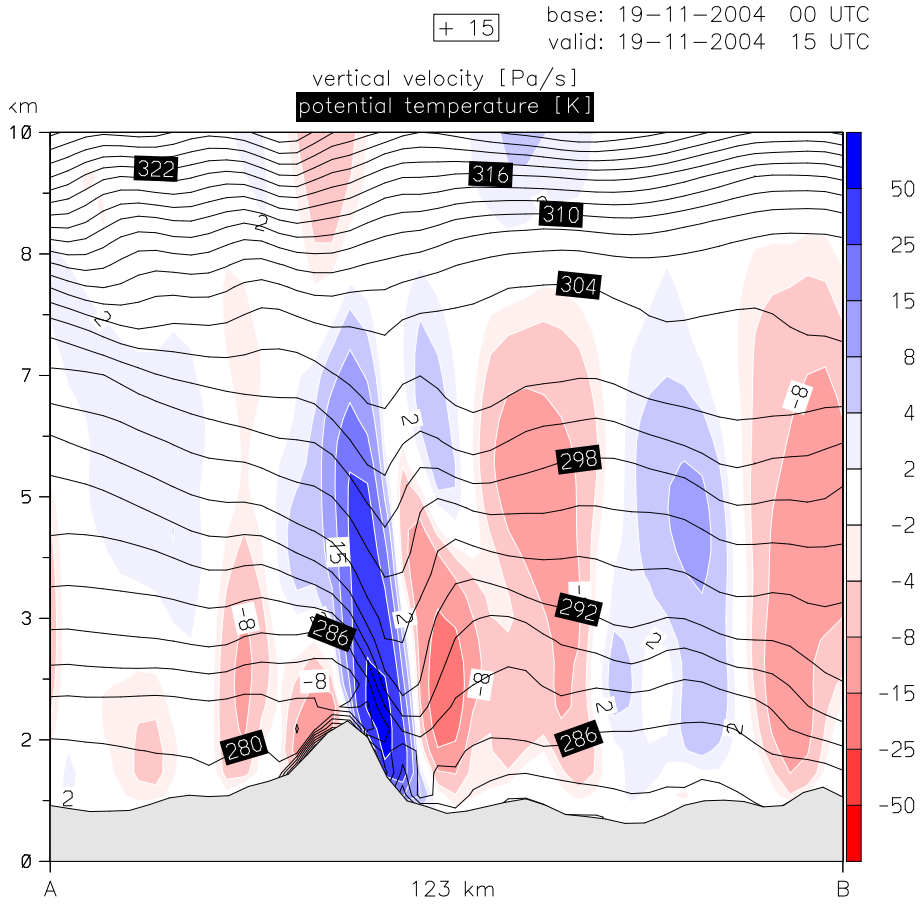
non-hydrostatic, d_4



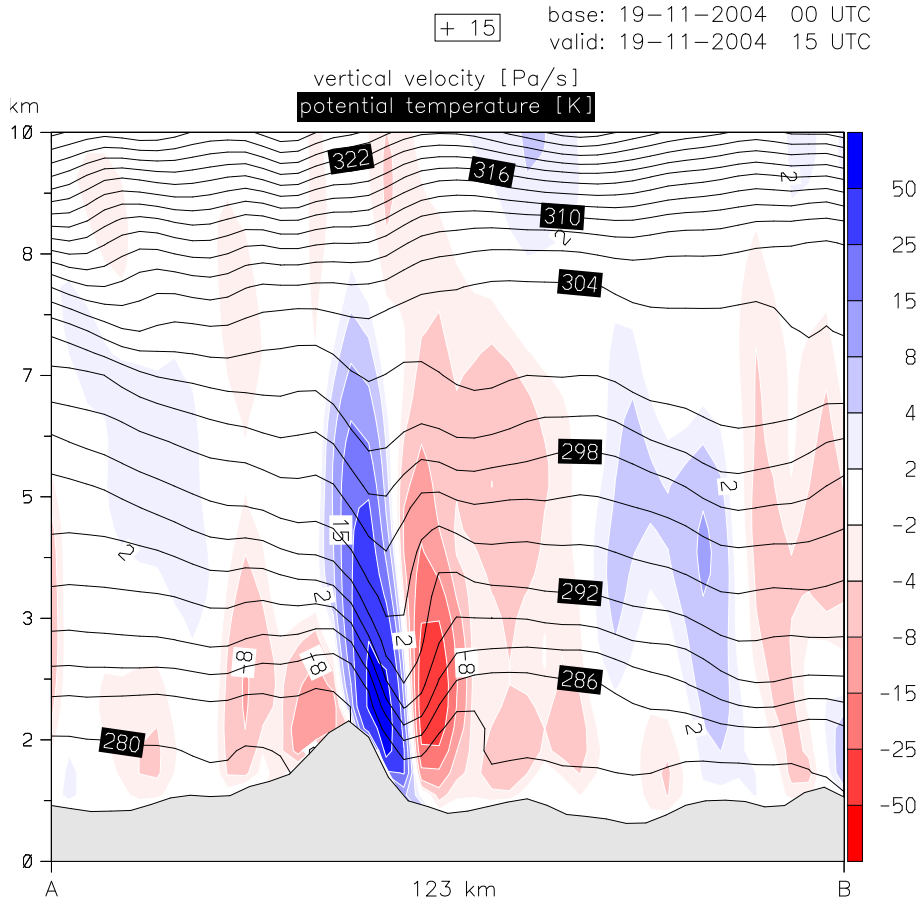
Space cross section – d_3 versus d_4 at 2.5 km

ω and θ, +15 h forecast

non-hydrostatic, d_3



non-hydrostatic, d_4



(!) blows up after 33 hours

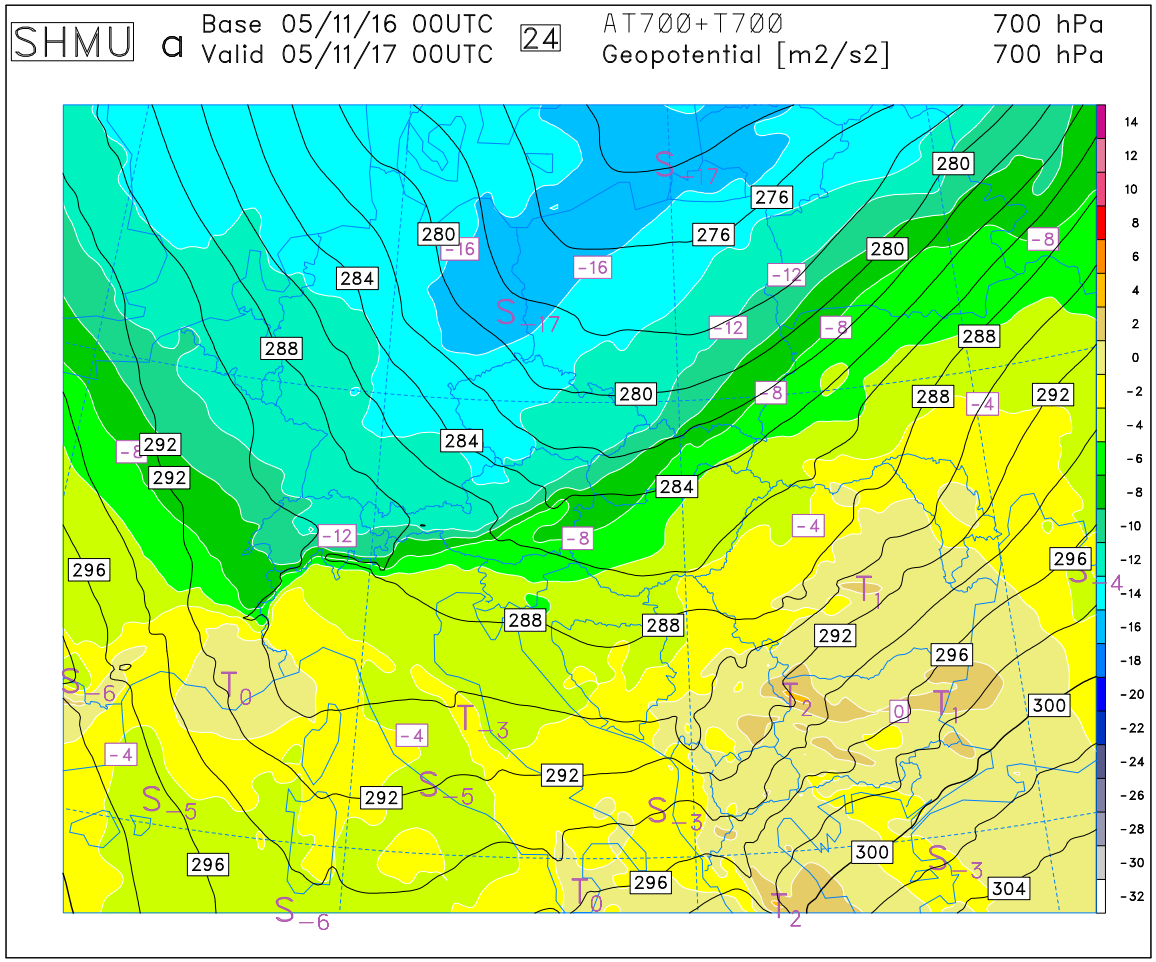
Ordinary cold front passage through Central Europe (16.11.2005)

- this case was taken only to illustrate differences between H and NH models in common meteorological situation

- cold front passing through Central Europe destroys low level temperature inversion which developed in stable anticyclone

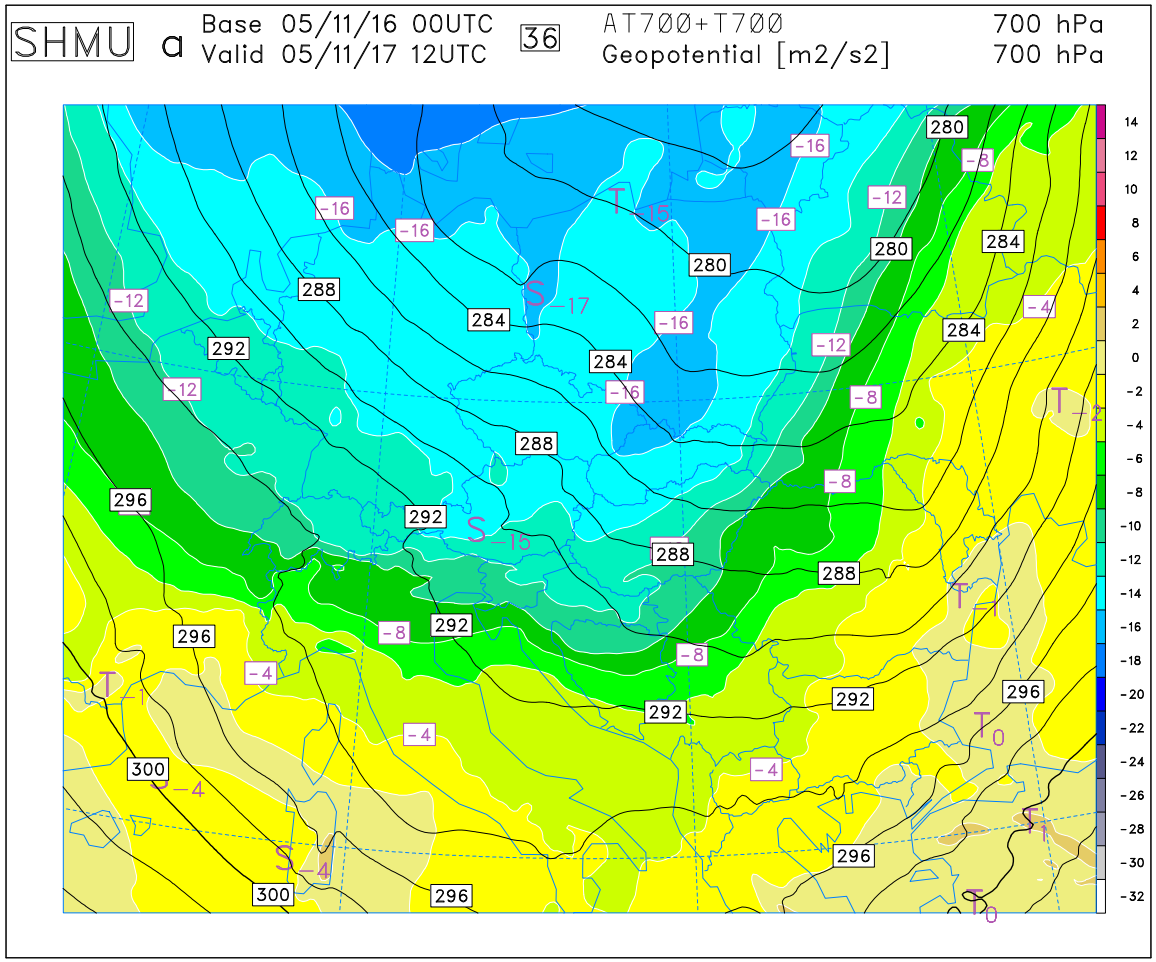
Situation predicted by 9.0 km run

T and ϕ at 700 hPa level, +24 h forecast



Situation predicted by 9.0 km run

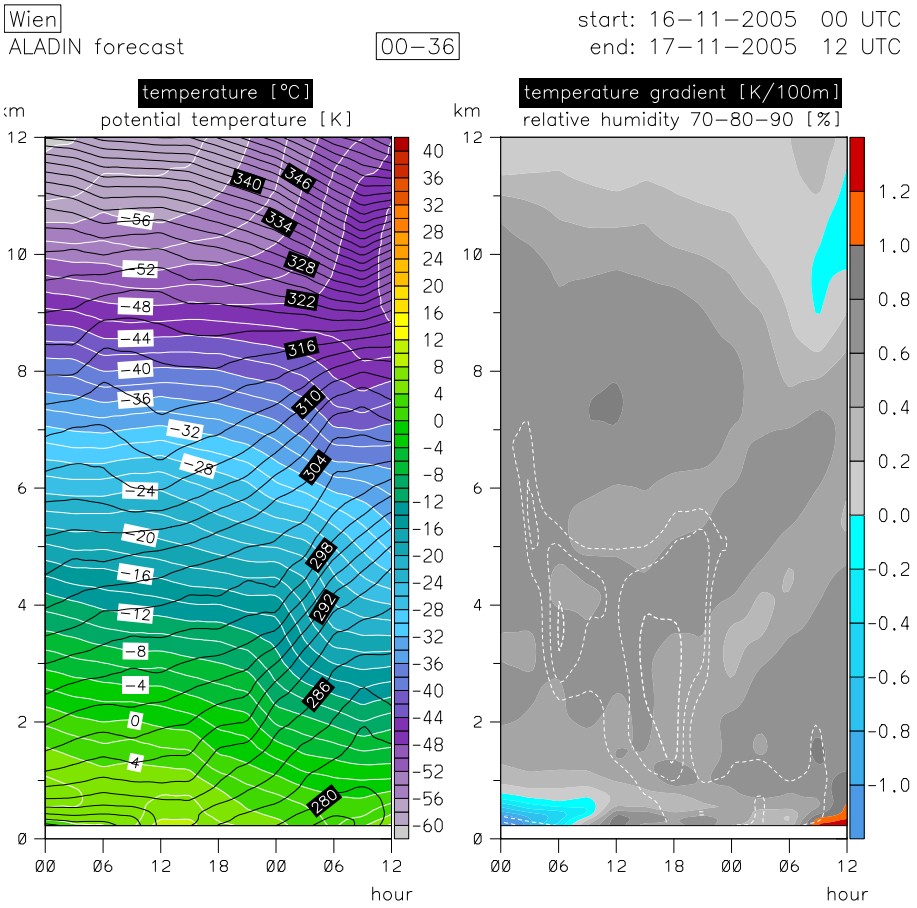
T and ϕ at 700 hPa level, +36 h forecast



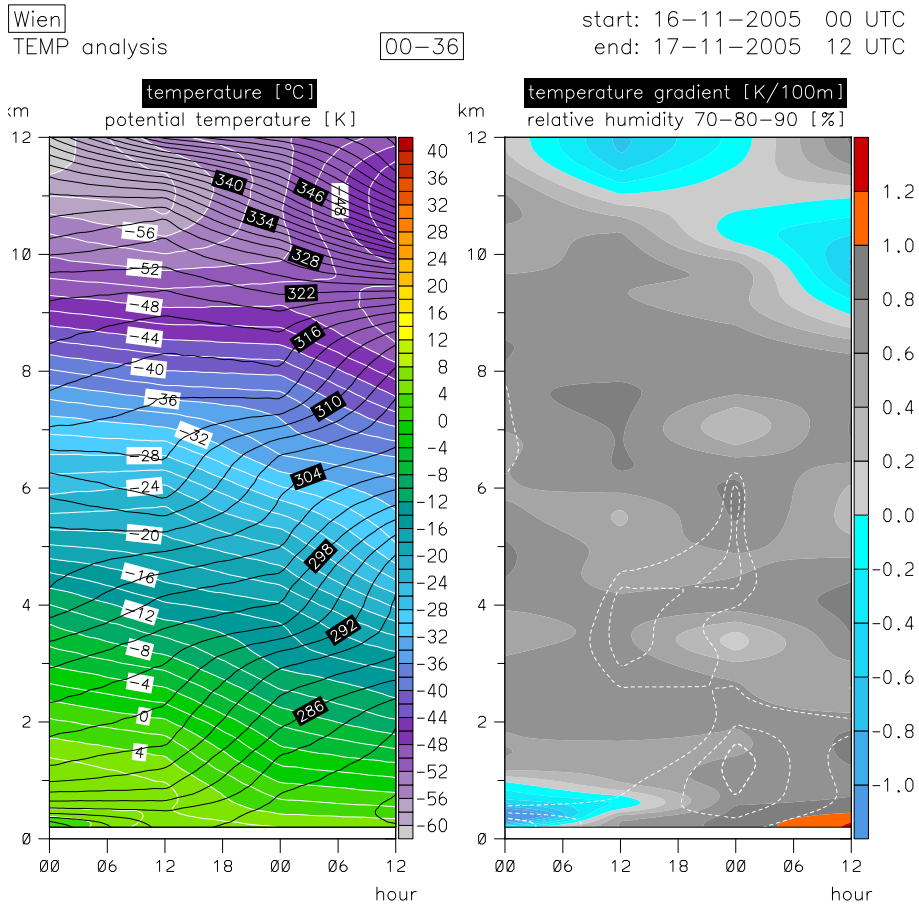
Time cross sections – 9.0 km run versus TEMP

(T, θ) and (Γ, r), station Wien

hydrostatic, 9.0 km



TEMP analysis



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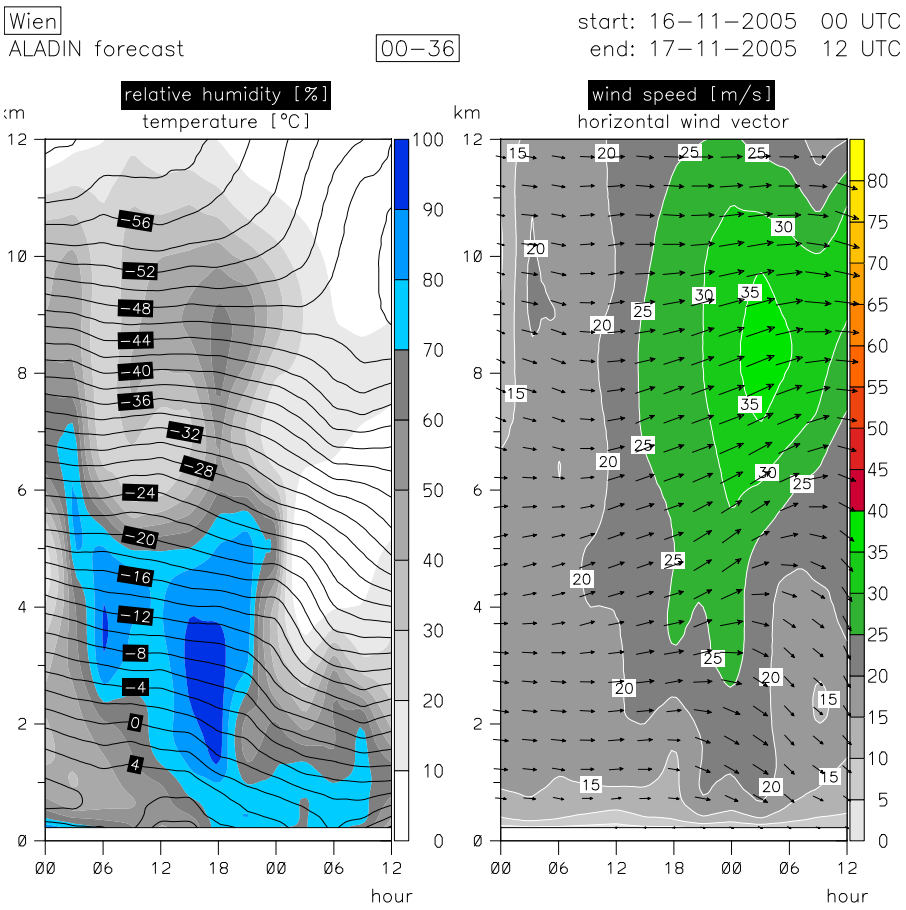

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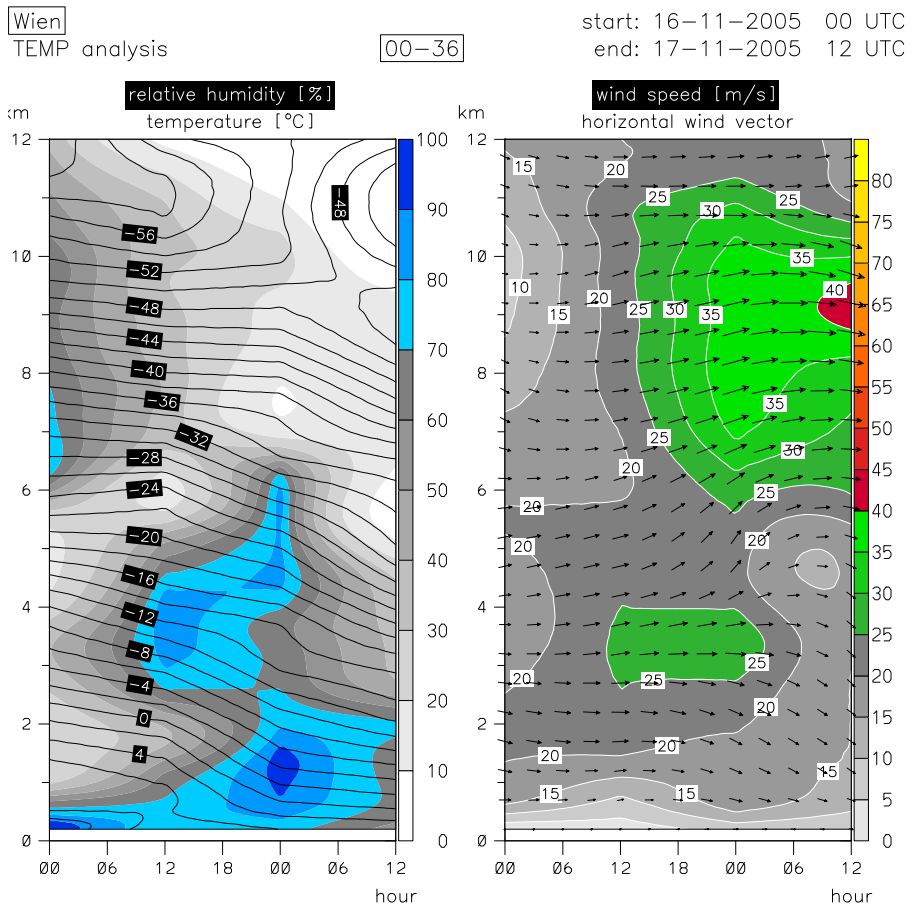
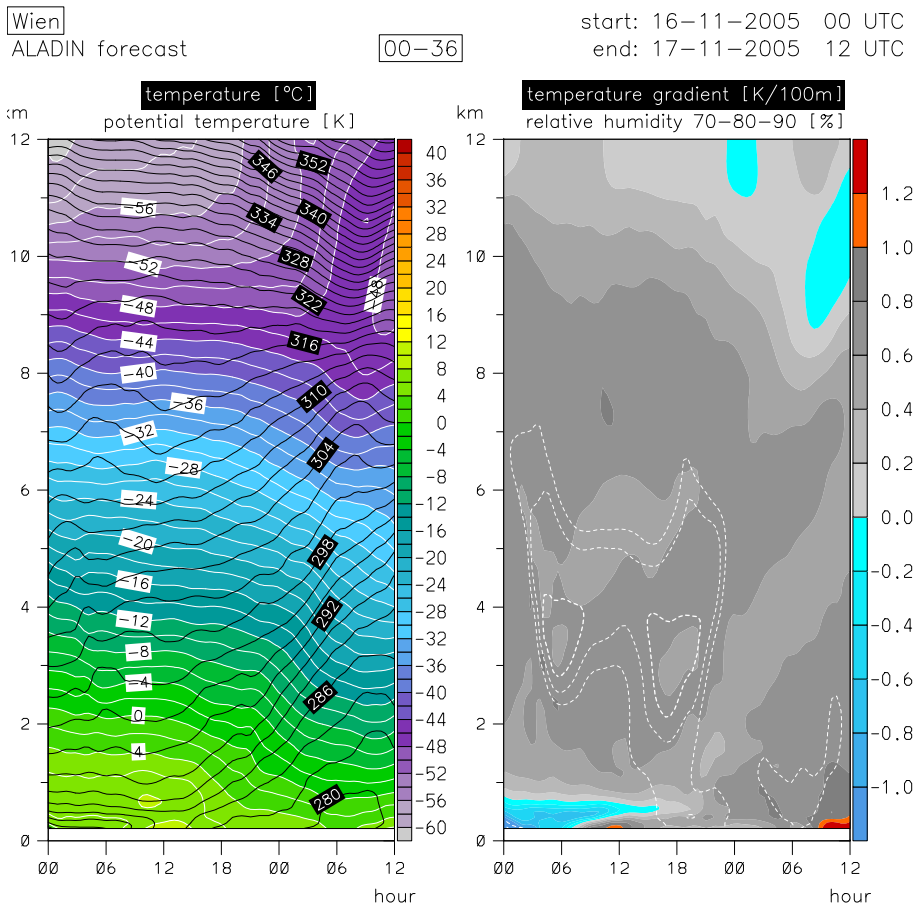


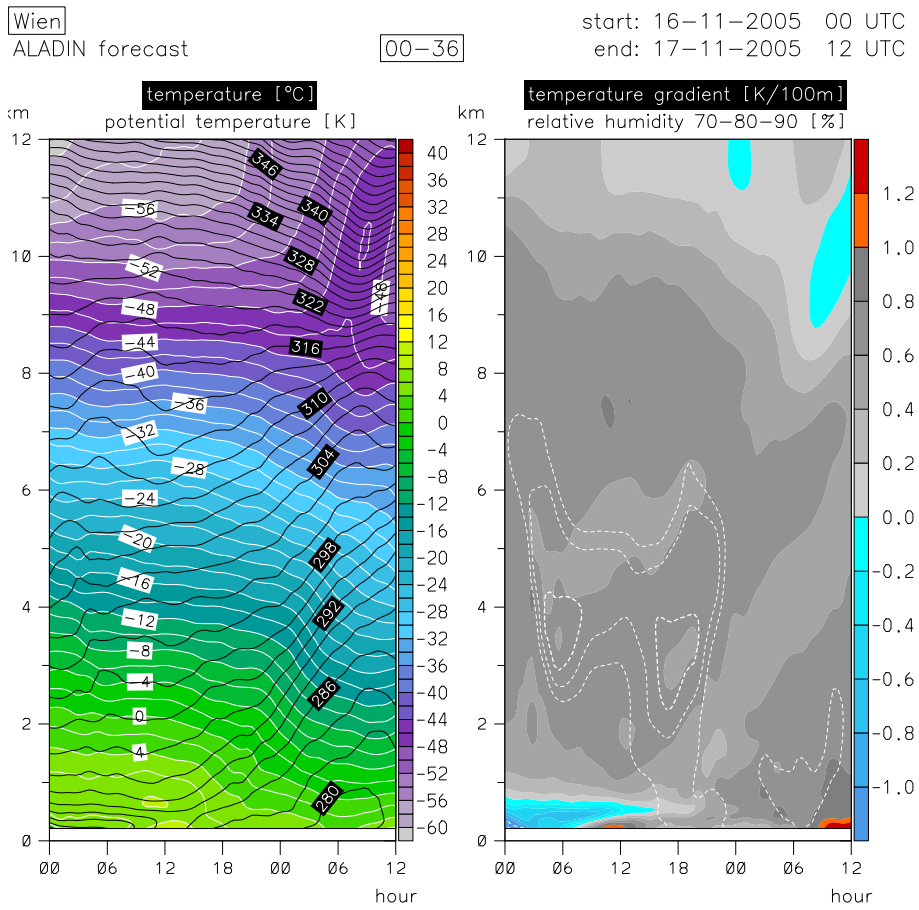
Time cross sections – H versus NH at 2.5 km

(T, θ) and (Γ, r), station Wien

hydrostatic, 2.5 km



non-hydrostatic, 2.5 km



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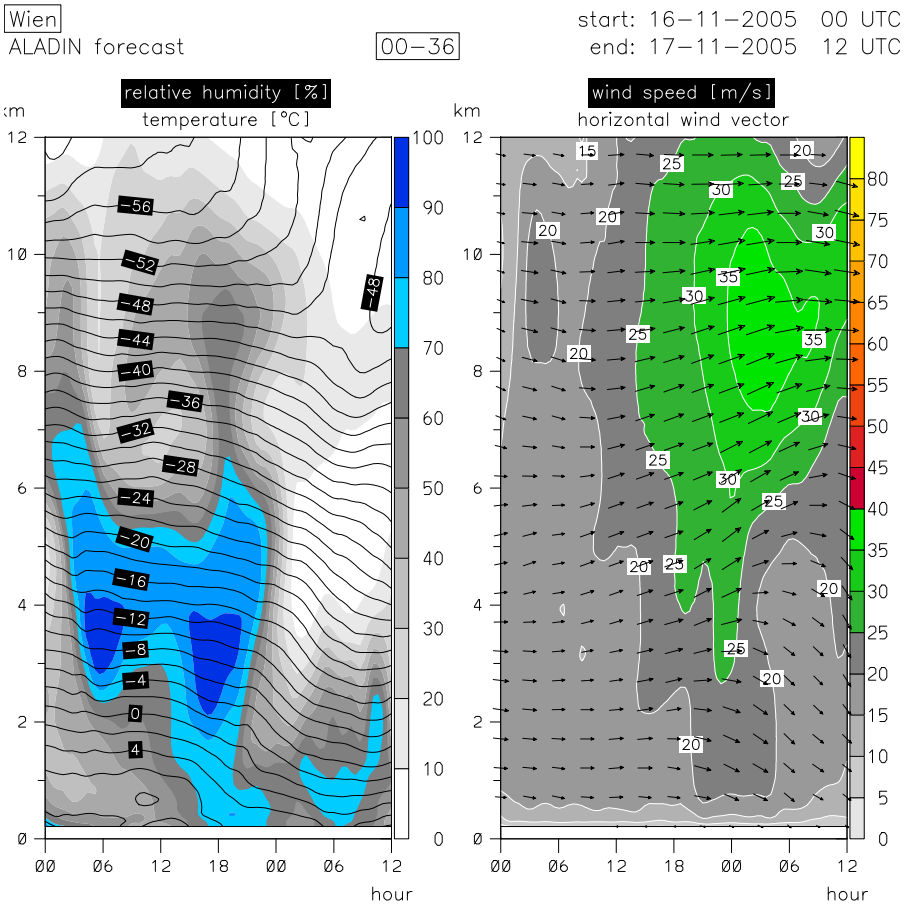
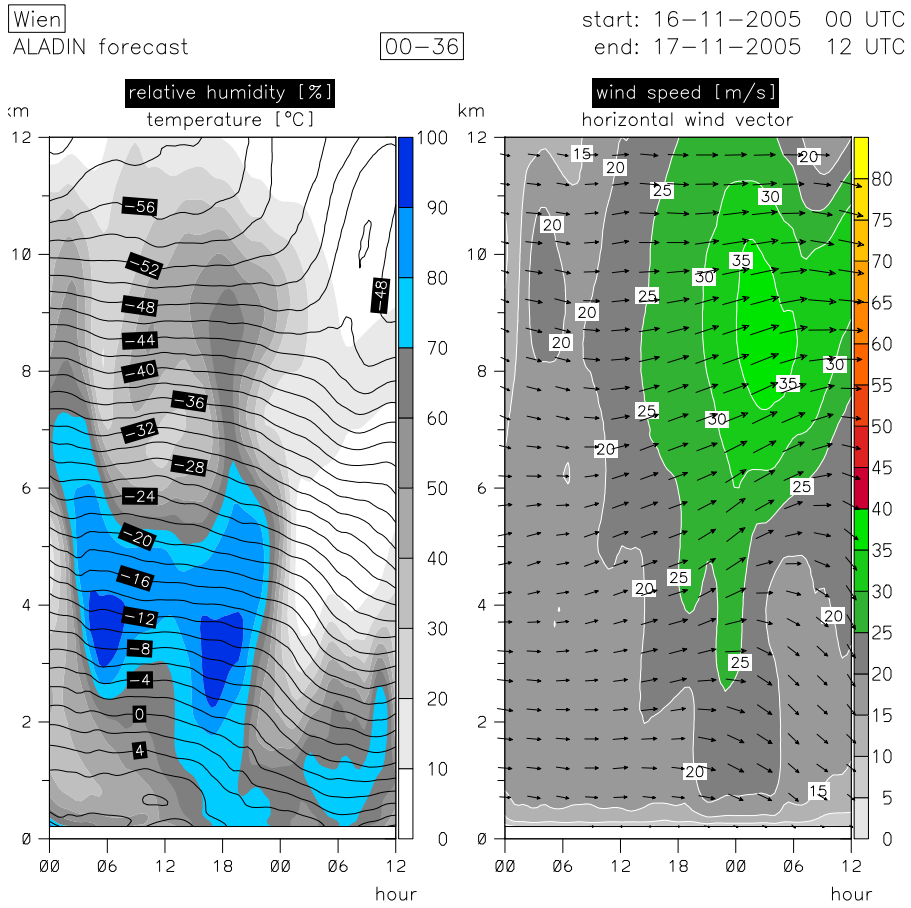
hydrostatic, 2.5 km



non-hydrostatic, 2.5 km



Conclusions for 2.5 km resolution

- in extreme cases, there are detectable differences between H and NH runs
- performance of H model is still satisfactory, but the slight tendency to overestimate vertical velocities can be seen
- in common meteorological situations, differences between H and NH runs are unimportant
- for the time being we do not have a case which would show necessity of NH model at 2.5 km resolution, but it does not mean that there is no such case

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question whether we need NH model at 2.5 km resolution remains opened