The role of surface evaporation in the triggering of mountain convection in ALADIN

(master thesis)

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1. Introduction

Introduction (1)

The experiment:

- High-resolution version of ALADIN-Vienna (Δx = 4.0 km)
- 24-hour model run with evaporation set equal to zero
- Technically speaking: PDIFTQ(KLEV) = 0 in subroutine ACDIFUS
- That means: Water leaves the soil, but does <u>not</u> enter the atmosphere
- This model run is further referred to as „experimental run“ (EXP) and is compared to the standard model run, hence referred to as „reference run“ (REF)

Motivation:

- To isolate the effect of surface evaporation on convection

Introduction (2)

Criteria for the selection of the case study:

- Weather situation: a series of days with deep convection triggered locally by orographic effects in the absence of large-scale forcing
- Area: a valley that is well covered by weather stations enabling a verification of the model output by observational data

⇒ August 10th – 12th, 2000

⇒ Drau valley in Carinthia, Austria‘s southernmost province

real topography

ALADIN topography

2. Background

Background (1)

Necessary conditions for convection:

- Potential instability ($\Gamma > \gamma_f = 6.5$ K/km)
- Enough moisture
- A release mechanism („trigger“) for upward vertical velocity

„(…) one can define three roles that large-scale forcing can have in regulating thunderstorm occurrence: suppression, permission or direct and active forcing. (…) In its permissive role, the large-scale atmosphere is passive, ‚allowing‘ deep convection to occur if the other necessary factors are supplied by smaller scales. (…)“

Source:

Banta, R.M., 1990: The role of mountain flow in making clouds. In: Blumen (ed.), Atmospheric processes over complex terrain. Meteor. Monogr., **23**, p 229 – 283.

Background (2)

- Potential instability ($\Gamma > \gamma_f = 6.5$ K/km)
- Enough moisture
- A release mechanism („trigger“) for upward vertical velocity

How can these conditions be delivered on the mesoscale?

ad 3. differential diabatic heating => diurnal wind systems => convergence acts as trigger for upward vertical velocity

ad 2. evapotranspiration => moisture enrichment over humid valleys and plains => moisture is fed into diurnal wind systems

ad 1. can be created or augmented by the elevated heating surfaces of mountaineous terrain

=> Mountains with their differential evaporation and solar heating regimes create mesoscale baroclinic circulations and may establish an environment locally favourable for deep convection

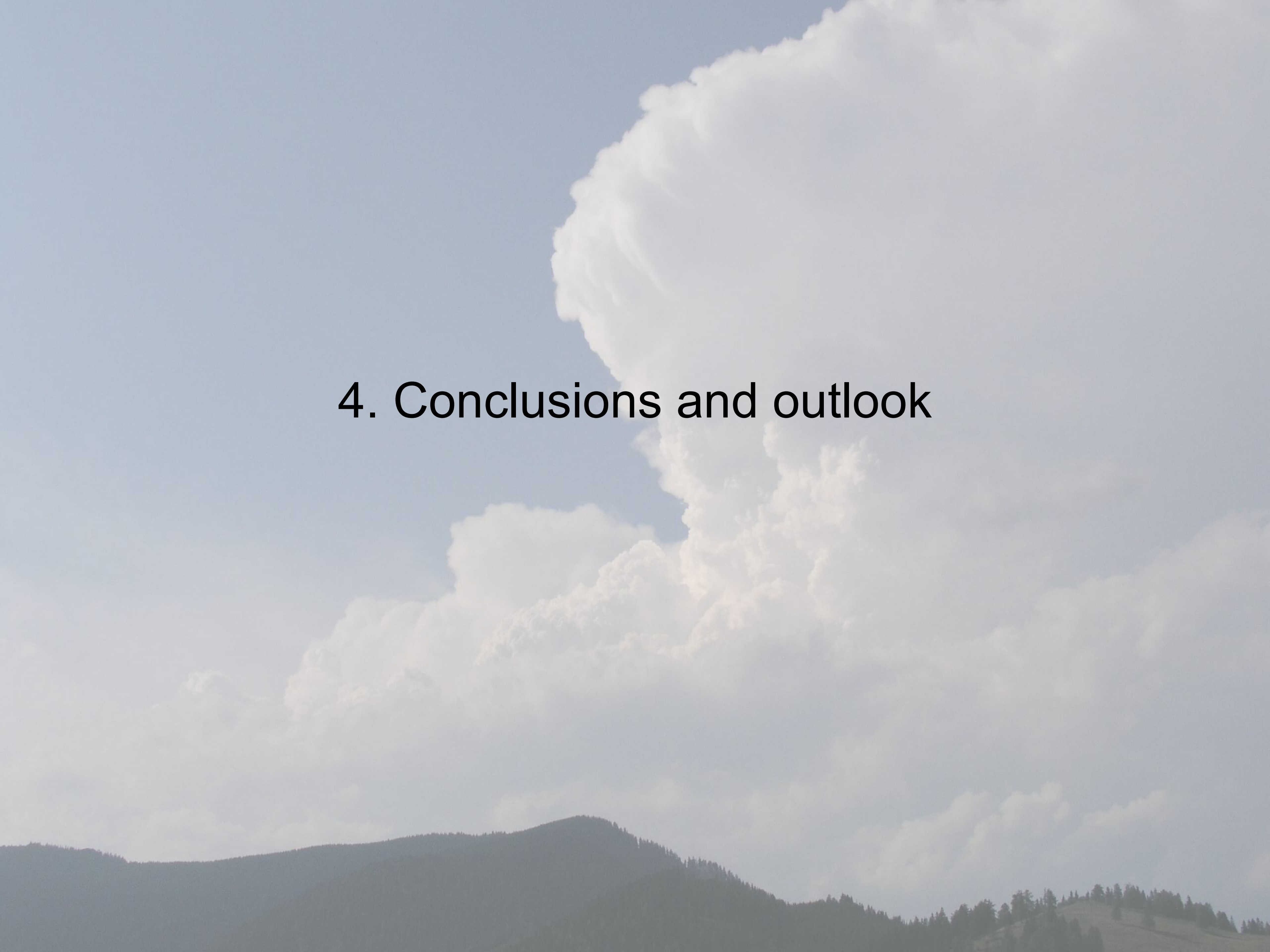
3. The August 2000 case study

The case study (August 2000)

- description of the weather situation
- an example for the observed daily course of humidity and valley wind

Comparison between reference run and experimental run:

- August 10th
- August 11th
- August 12th


4. Conclusions and outlook

Conclusions and outlook (1)

Results of the experimental run (as compared to the reference run):

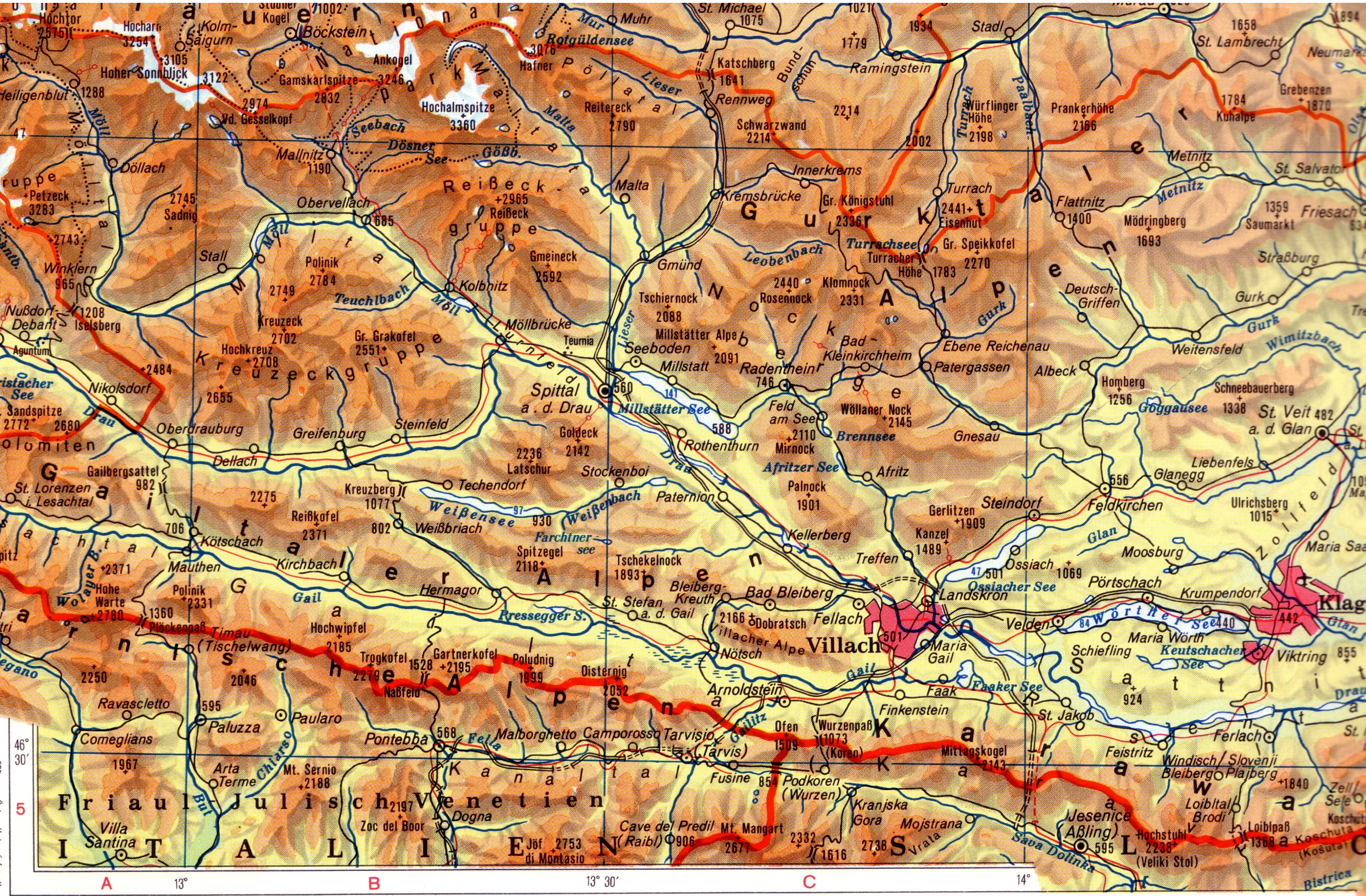
- The fine structures of the 2m humidity field vanish and give way to a smooth pattern
- Essentially only <u>one</u> well-marked air mass boundary remains, which separates dry, well-mixed intra-alpine atmosphere from the more humid air mass in the Klagenfurt basin (generally: in the foreland), where low-level moisture is caught by compensatory subsidence
- The propagation of this air mass boundary depends on the progress of convective mixing and on the superimposed wind field
- Near-surface humidity convergence over the mountain chains reduces by around 30% to the north („dry“) side of the boundary, but by only 10 – 20% to the south („humid“) side
- Convective precipitation decreases significantly; remaining convection concentrates on the mountains along and to the south („humid“) side of the air mass boundary, where it can still obtain enough moisture

Conclusions and outlook (2)

Suggestions for future work:

- To „export“ this case study to other alpine areas
- To have a closer look at the 3D humidity differences between REF and EXP
- To carry out some temporary high-resolution measurements to obtain humidity observations also at mountain sites
- Hypothesis: The switching-off of the evaporation has a smaller effect in situations with stronger instability and / or strong large-scale forcing
- To increase the knowledge about the evaporation field!

Thank you for your attention!



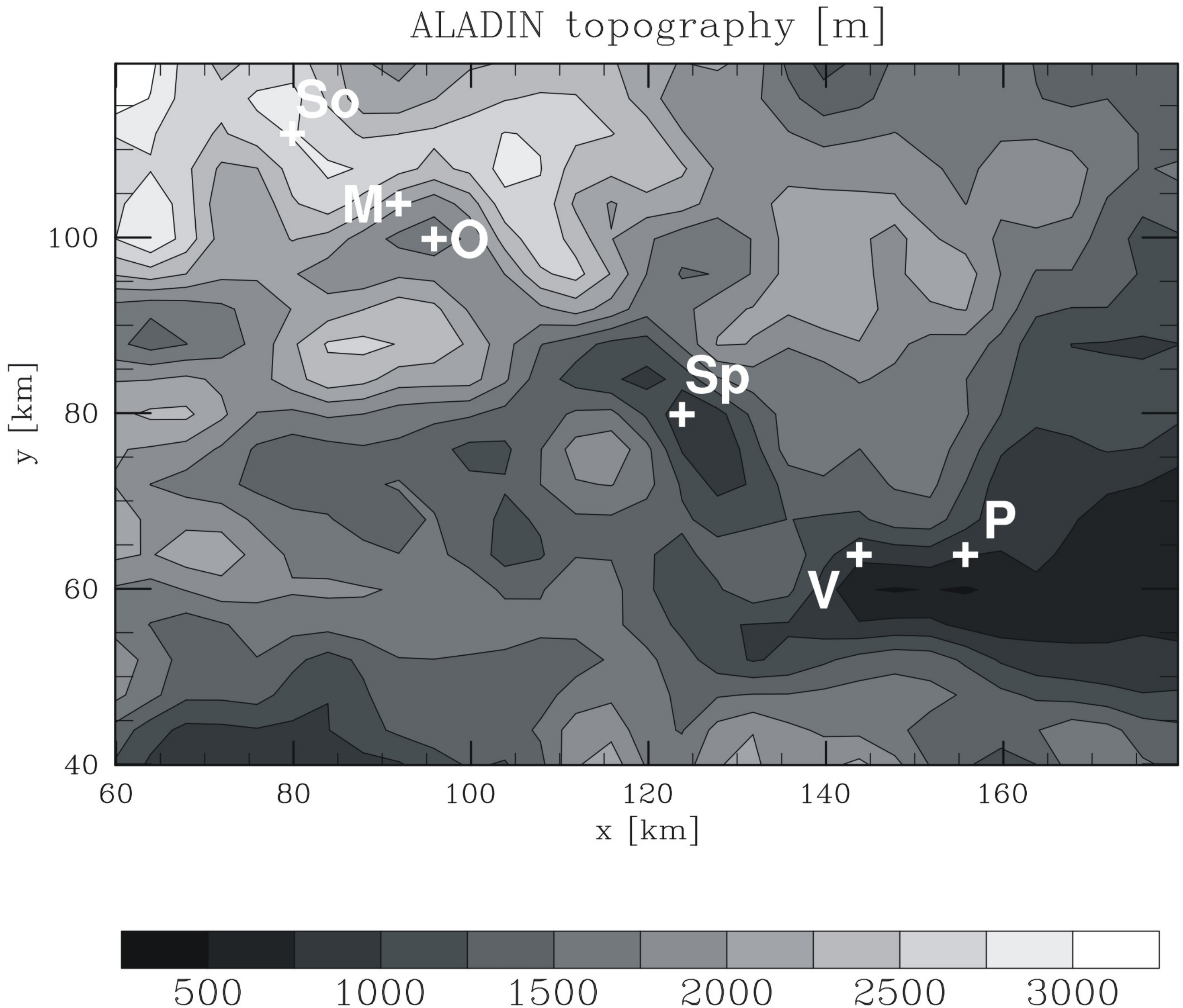
Maßstab 1 : 750 000

10 5 0 10 20 30 km

- über 20 000 Einwohner
- über 10 000 Einwohner
- über 2 000 Einwohner
- unter 2 000 Einwohner

- Hauptbahn
- Nebenbahn
- Zahnradbahn
- Seilbahn
- Tunnel

- Autobahn
- Autobahn in Bau
- Straße



ALADIN topography [m]
So
M
O
Sp
V
P
100
80
60
40
60
80
100
120
140
160
y [km]
x [km]
500
1000
1500
2000
2500
3000

Weather situation:

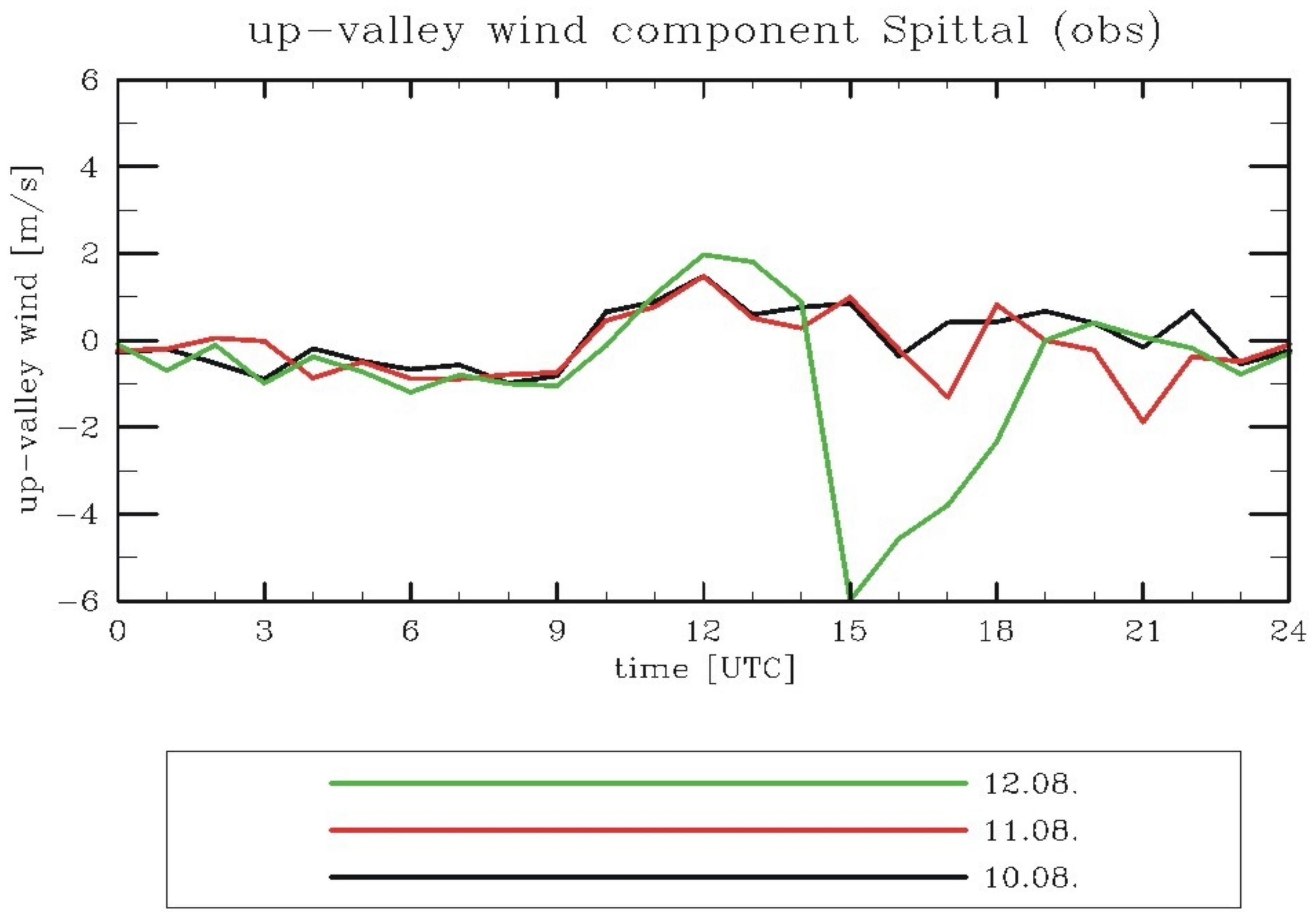
- „quiet“ midsummer pattern with weak pressure gradients and little synoptic forcing for convection
- Deep convection is initiated only locally at orographically favoured spots
- The meteorological parameters show similar daily courses (at least until noon)

=> The days of this case study can be considered as representative for a large number of days each summer!

Day-to-day differences:

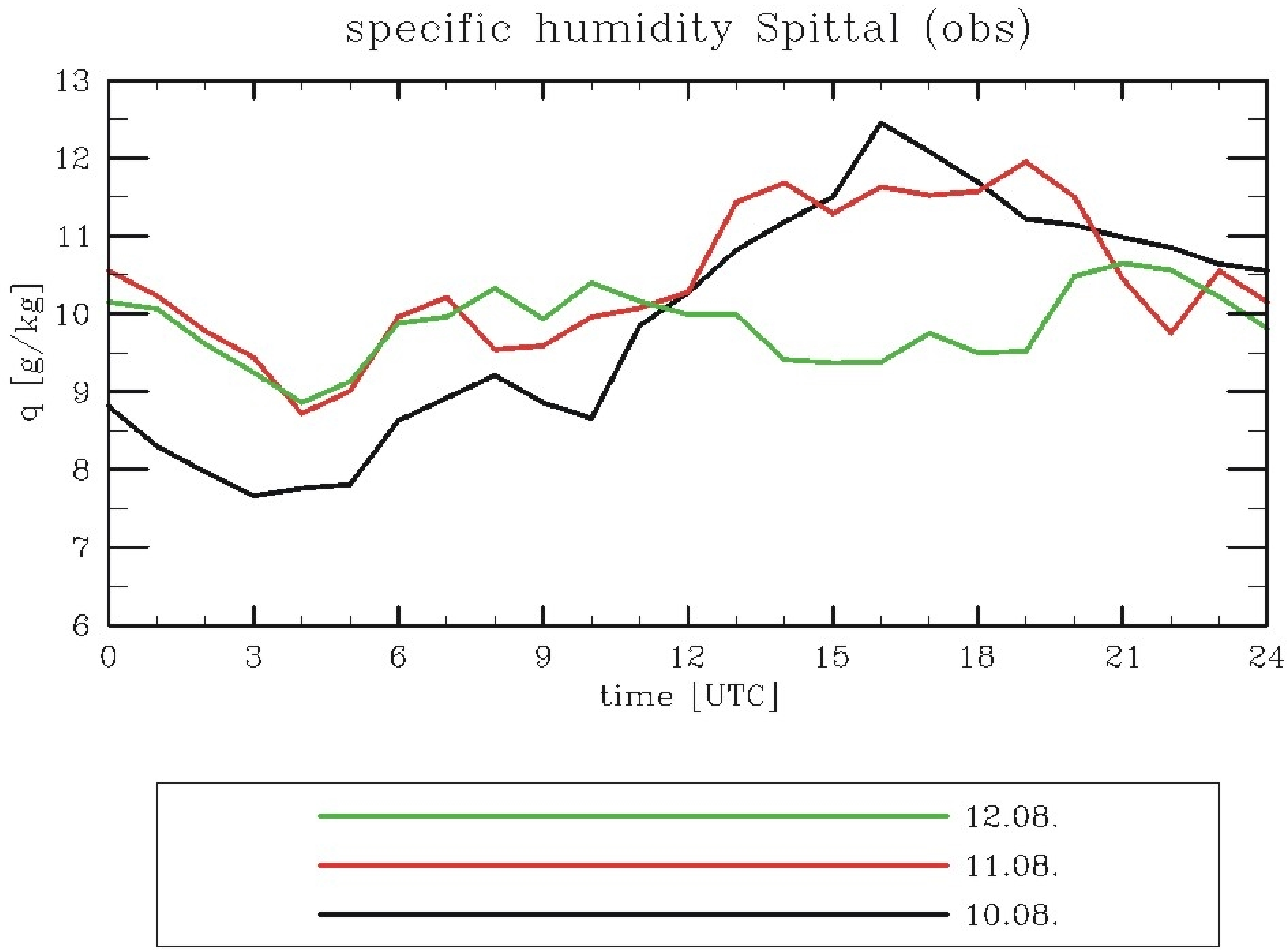
- The large-scale flow regime slowly changes from NW to SW
- Rising temperature level and increasing instability

back



up-valley wind component Spittal (obs)
up-valley wind [m/s]
6
4
2
0
−2
−4
−6
0
3
6
9
12
15
18
21
24
time [UTC]
12.08.
11.08.
10.08.

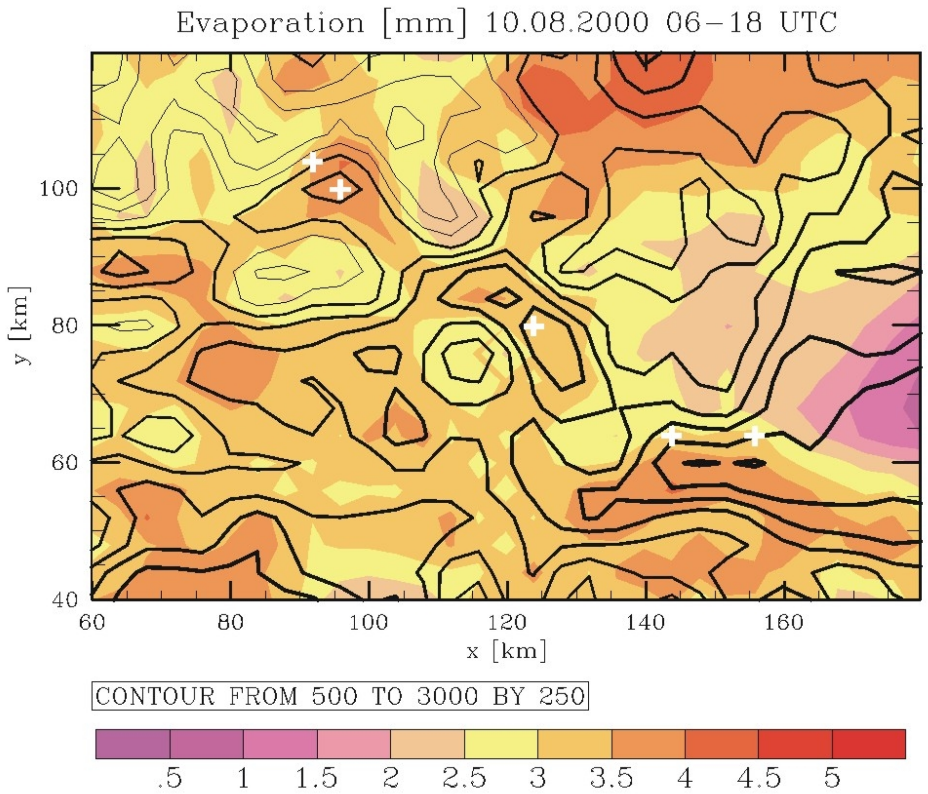
back



specific humidity Spittal (obs)
q [g/kg]
13
12
11
10
9
8
7
6
0
3
6
9
12
15
18
21
24
time [UTC]
12.08.
11.08.
10.08.

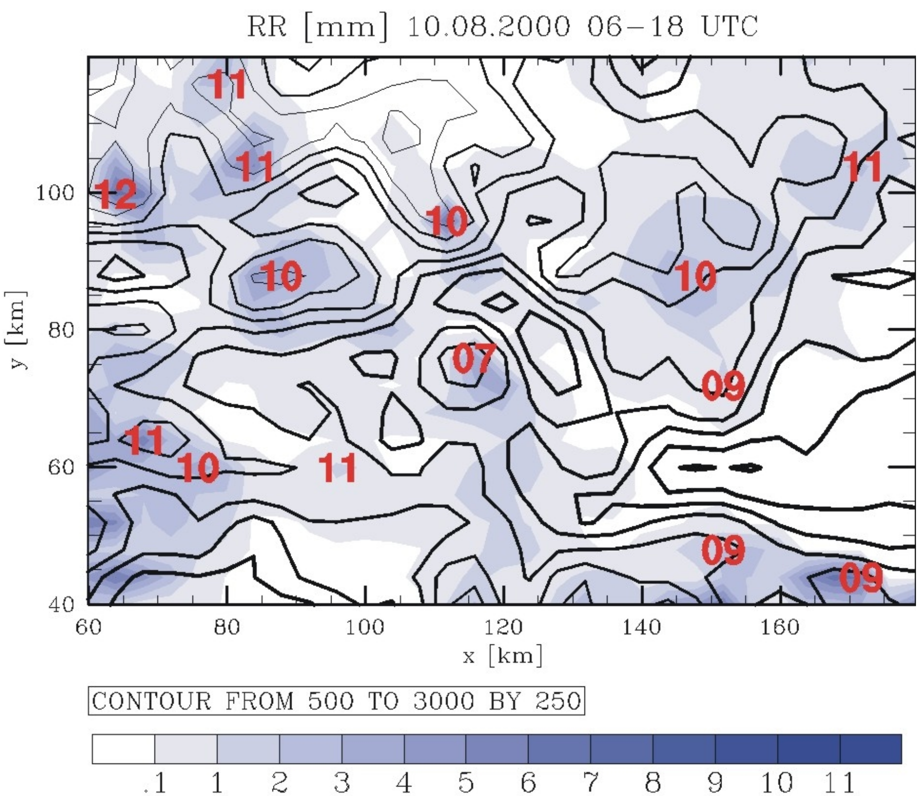
back

Evapotranspiration (06 – 18 UTC):



REF

Precipitation (06 – 18 UTC):



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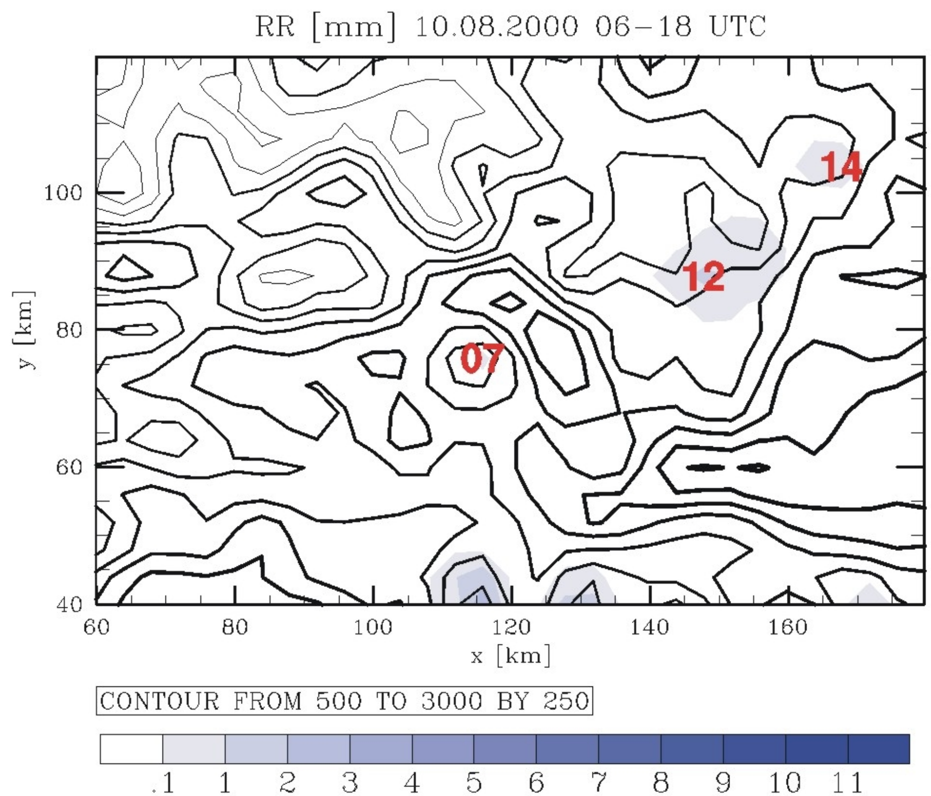
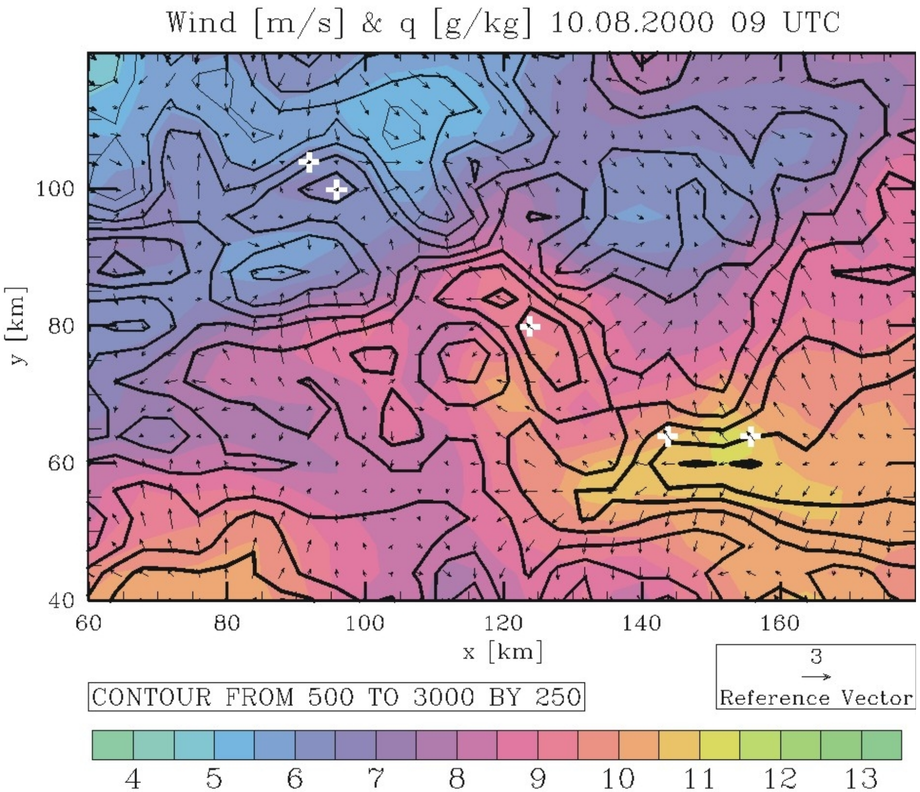


EXP

red numbers: first precipitation at .. UTC

2m specific humidity (09 UTC):



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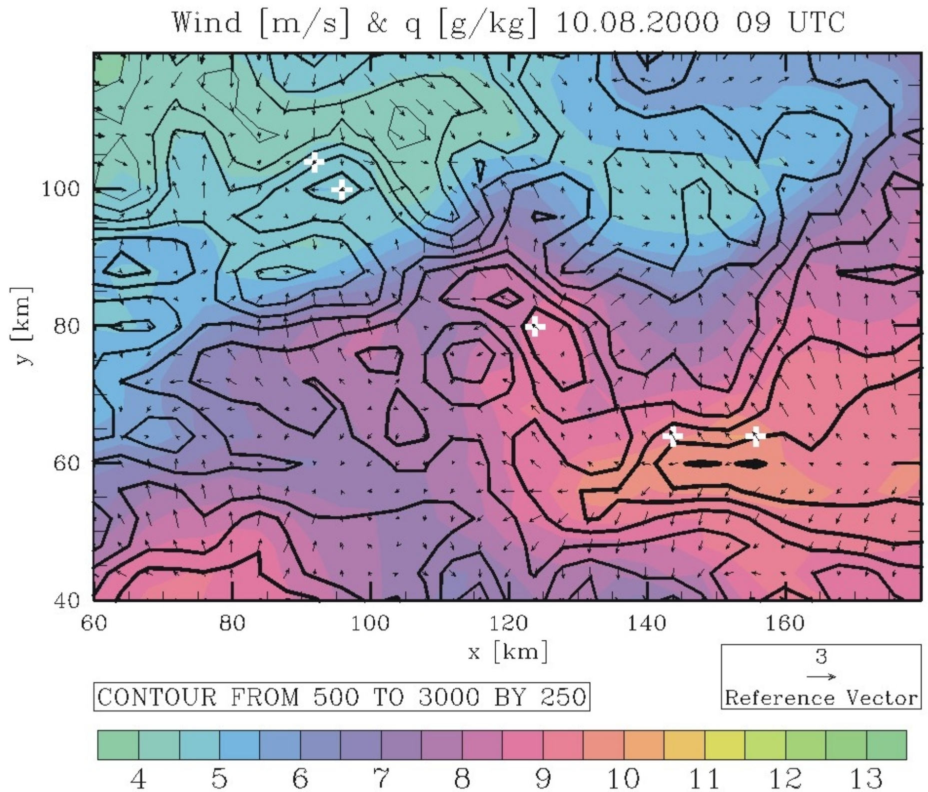
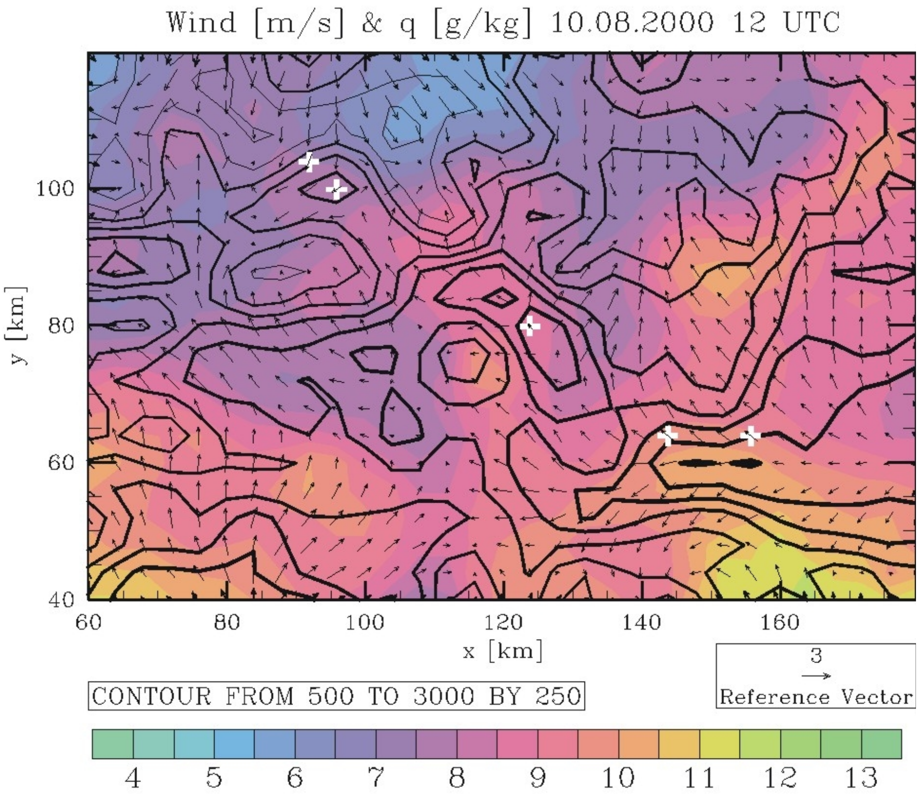


EXP

2m specific humidity (12 UTC):



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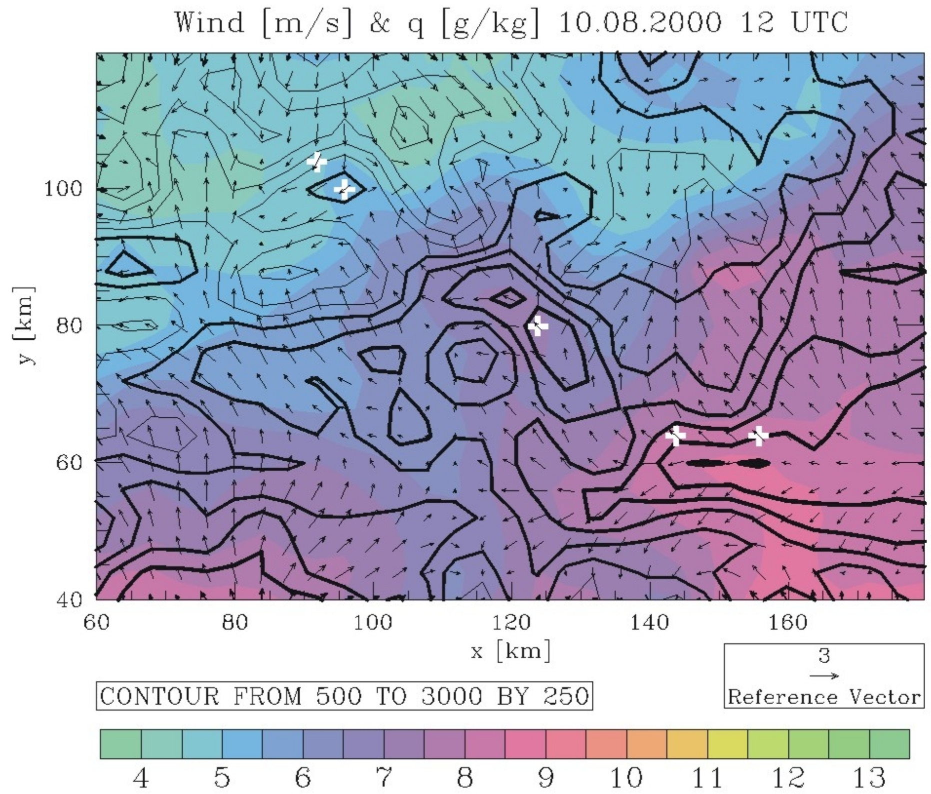
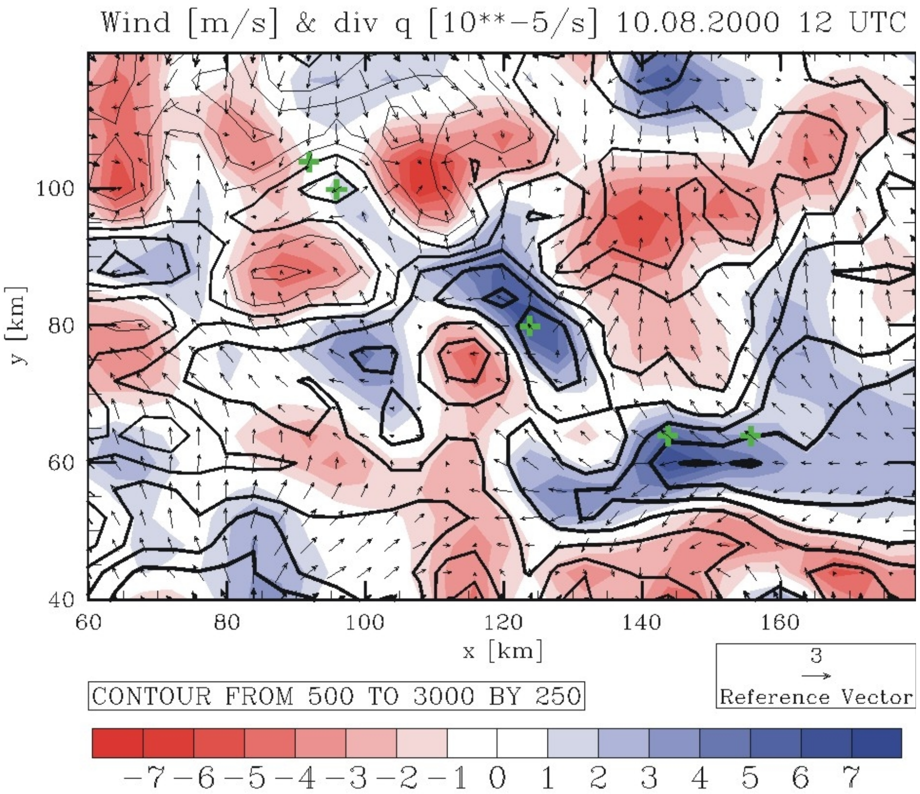


EXP

2m humidity divergence (12 UTC):



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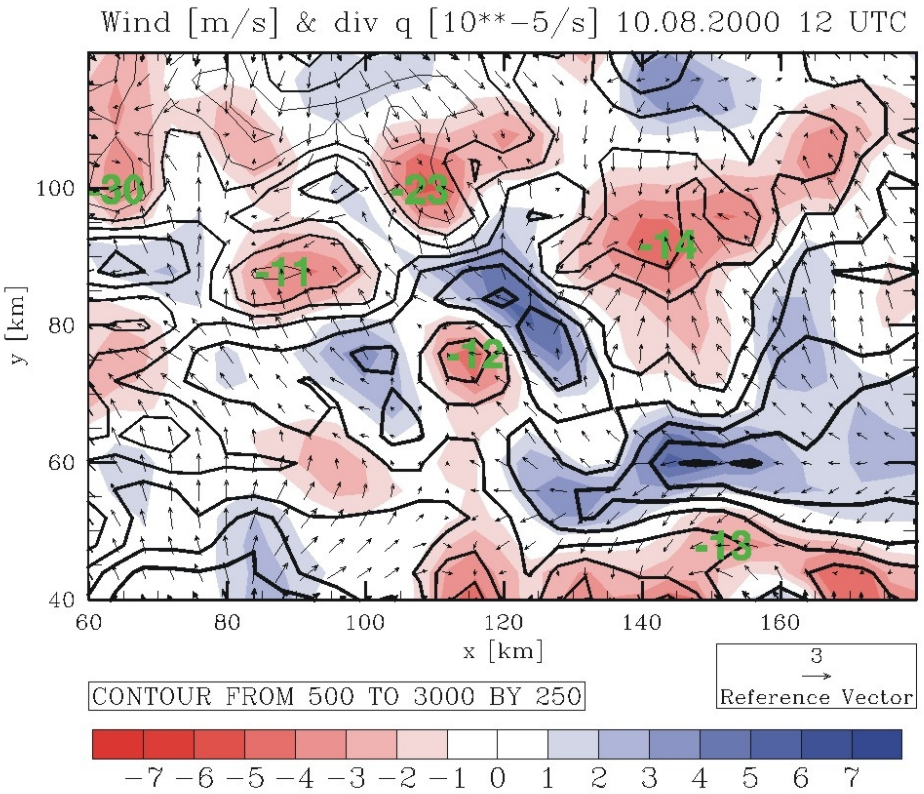
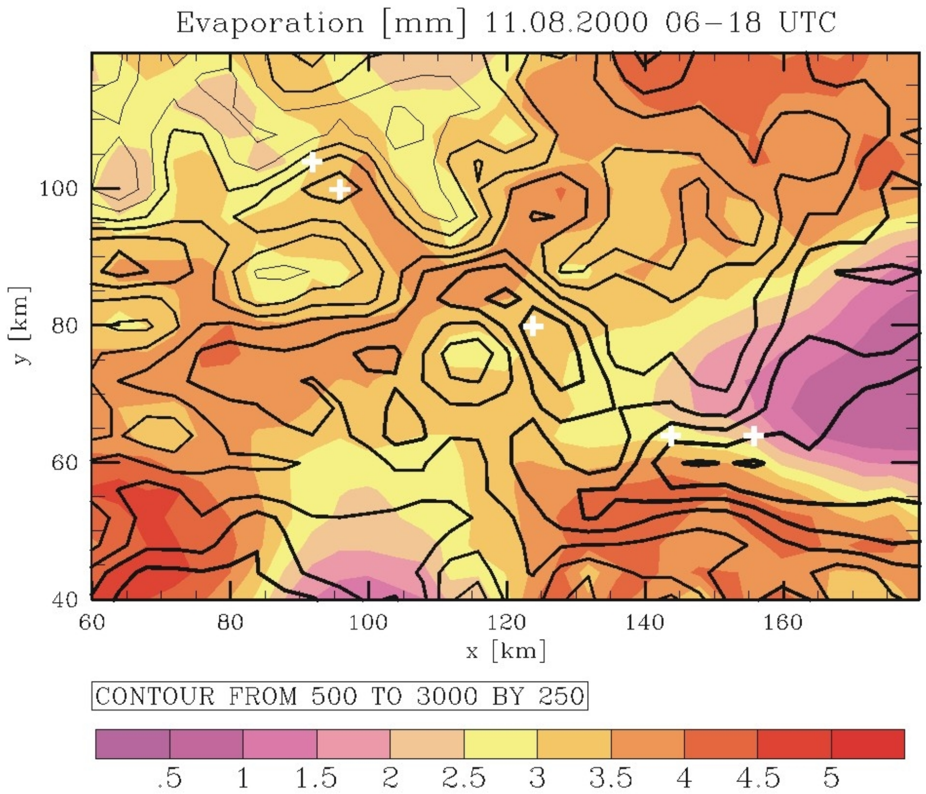


EXP

back

Green numbers: relative decrease of humidity convergence [%] compared to REF

Evapotranspiration (06 – 18 UTC):



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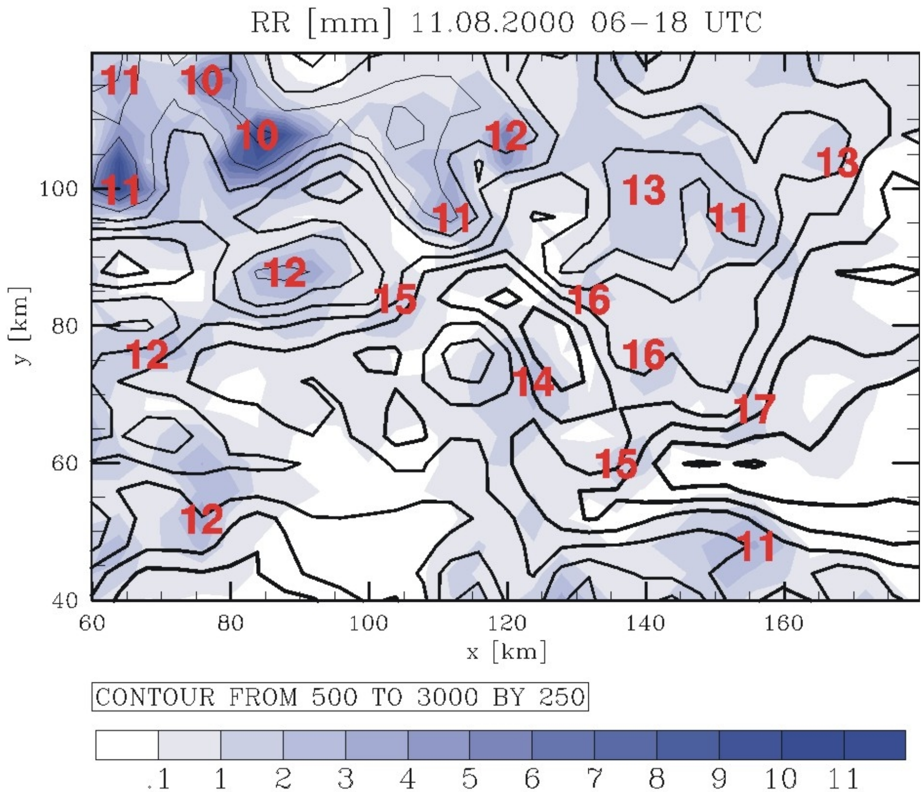

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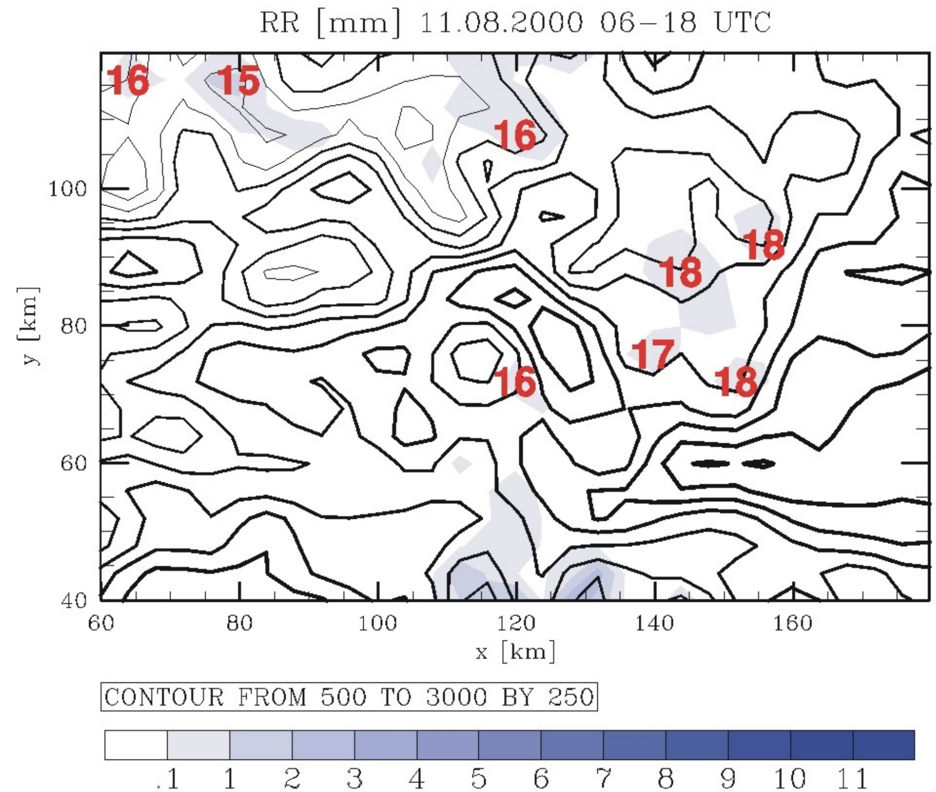
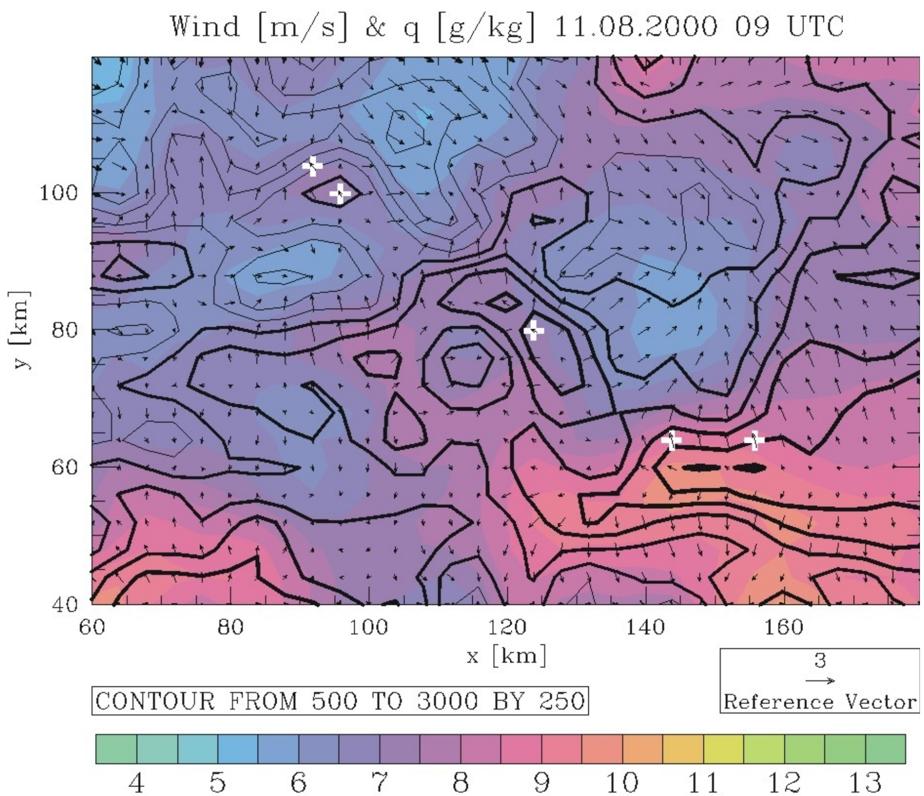


EXP

red numbers: first precipitation at .. UTC

2m specific humidity (09 UTC):



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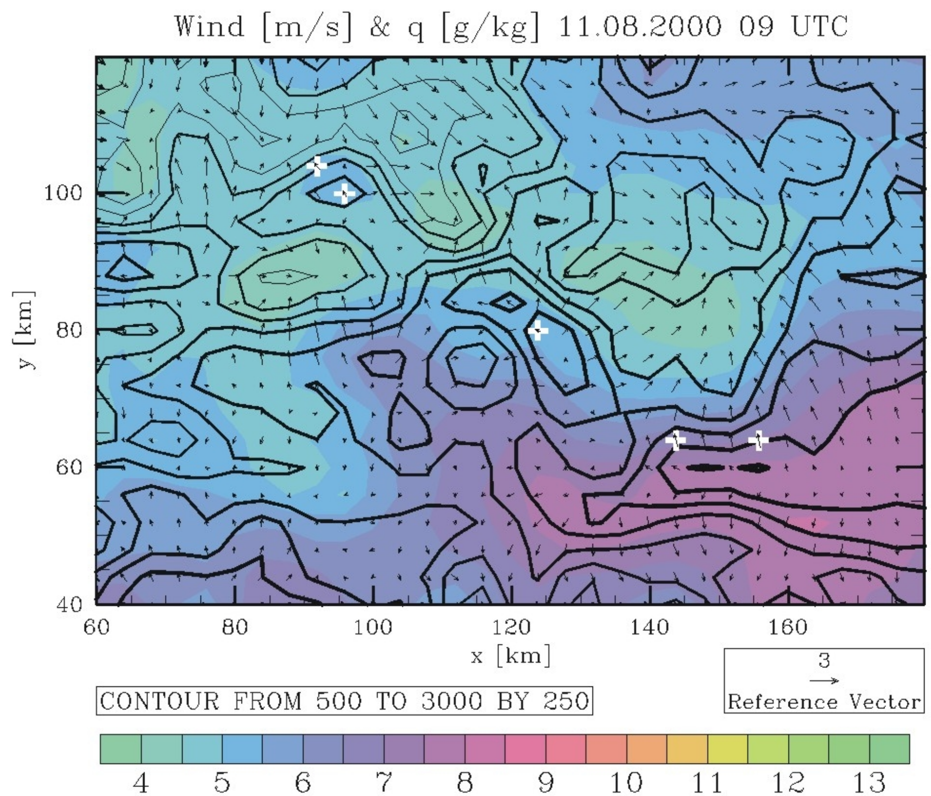

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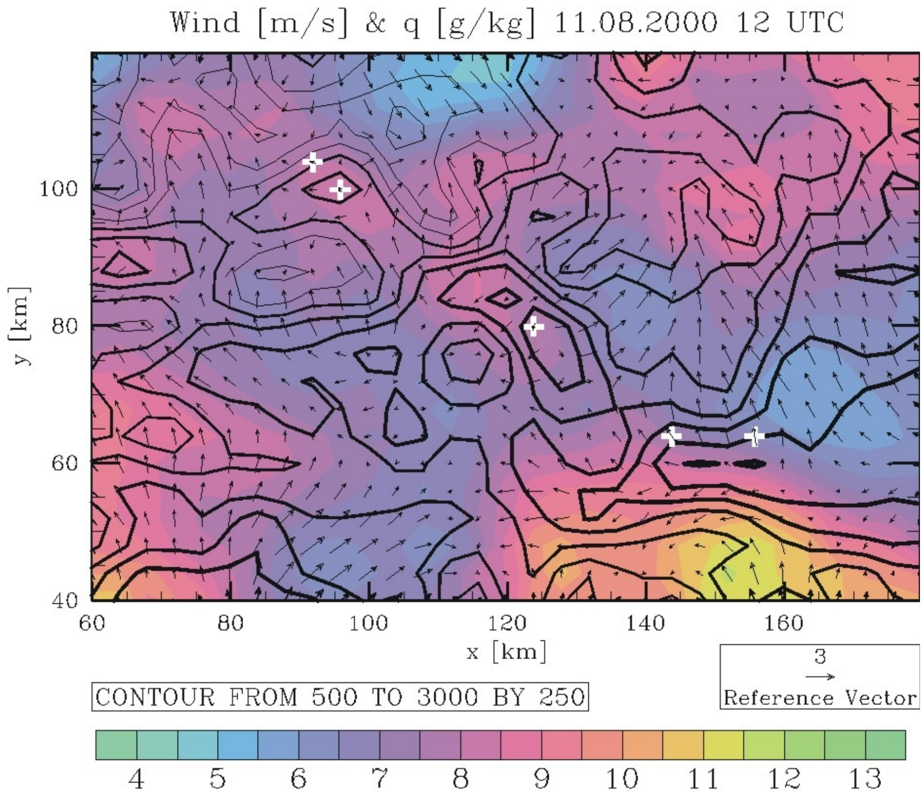

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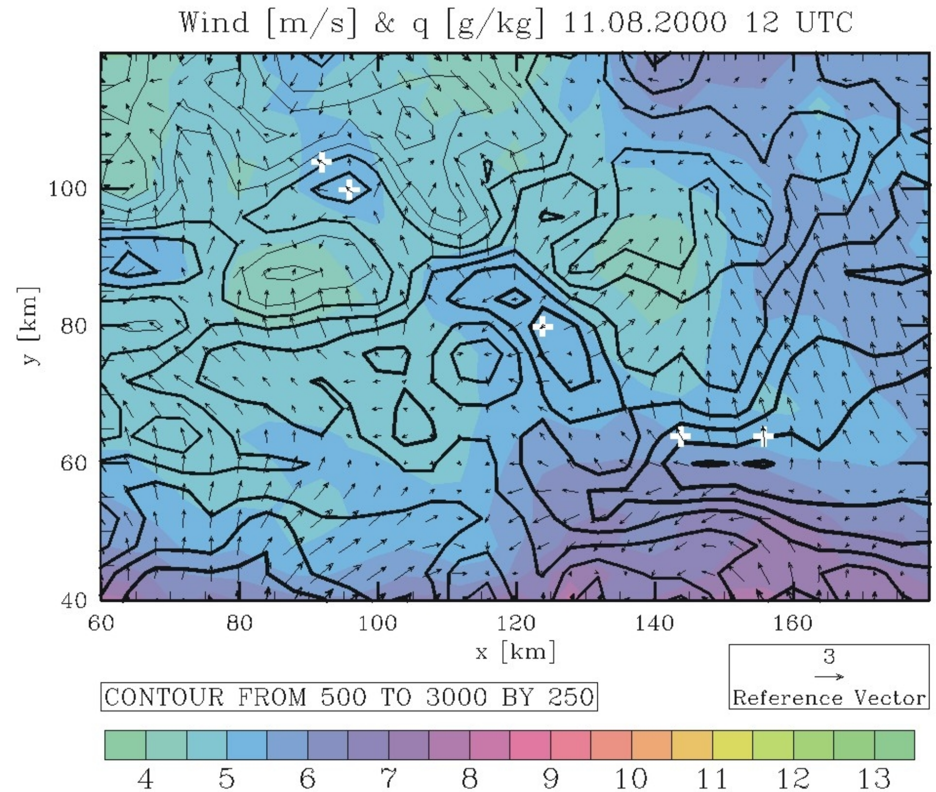

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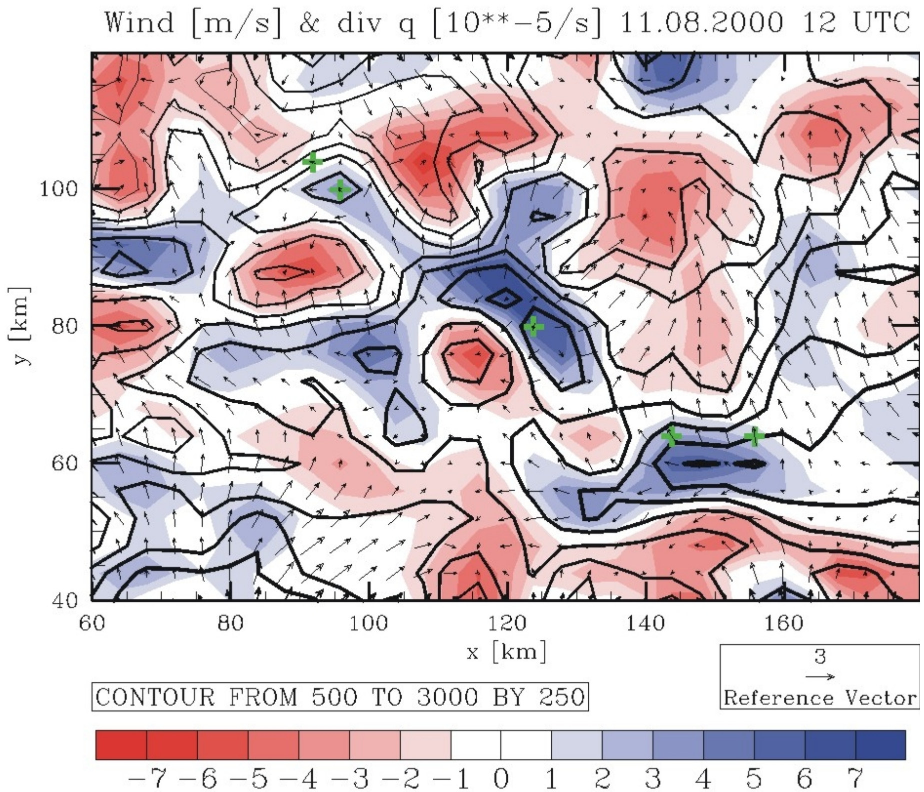
2m humidity divergence (12 UTC):



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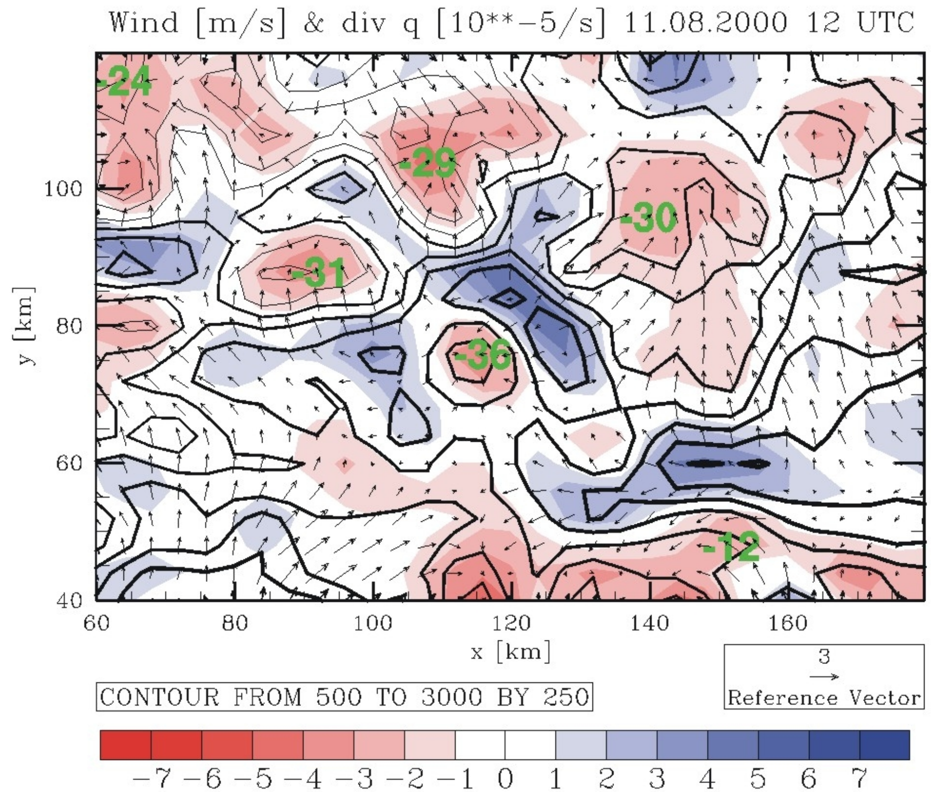

EXP

back

Green numbers: relative decrease of humidity convergence [%] compared to REF

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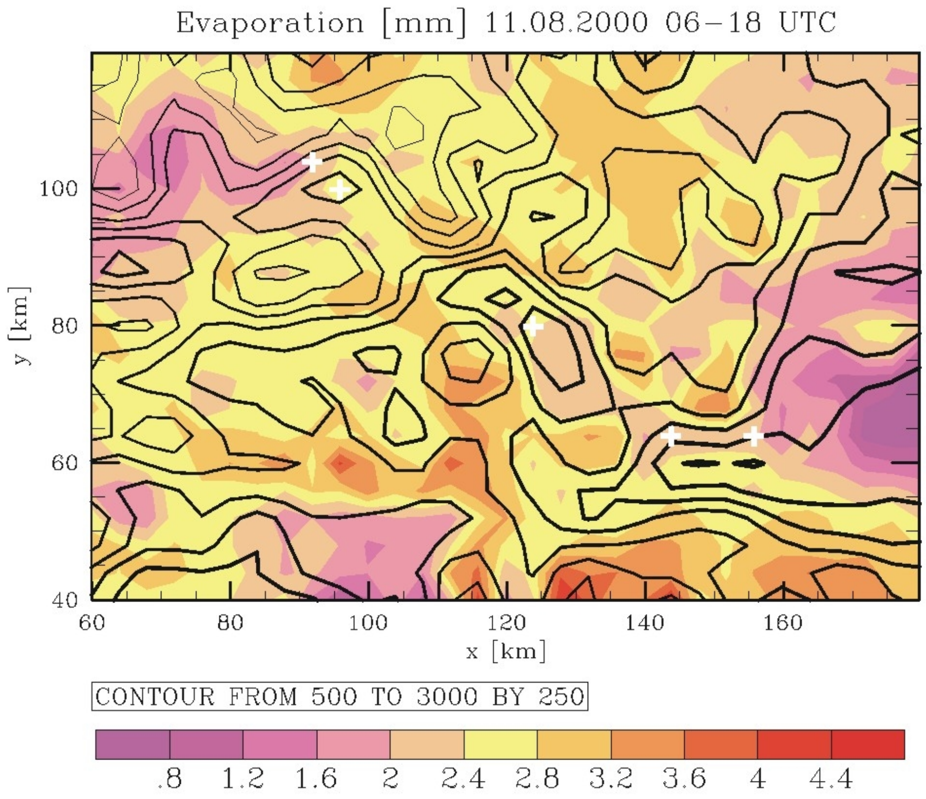

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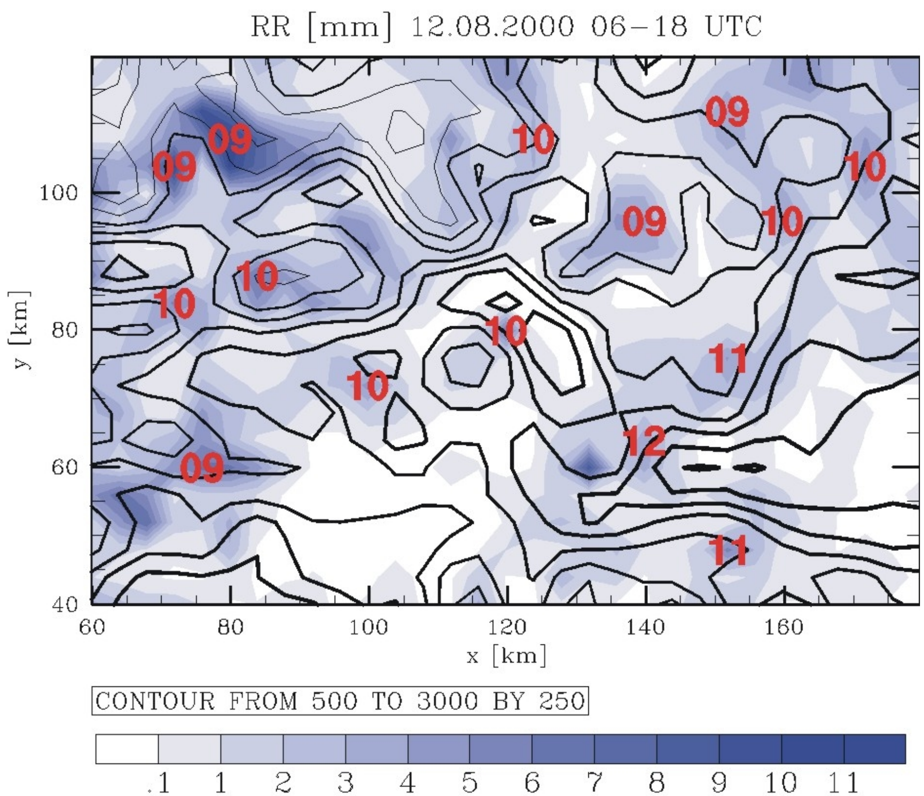

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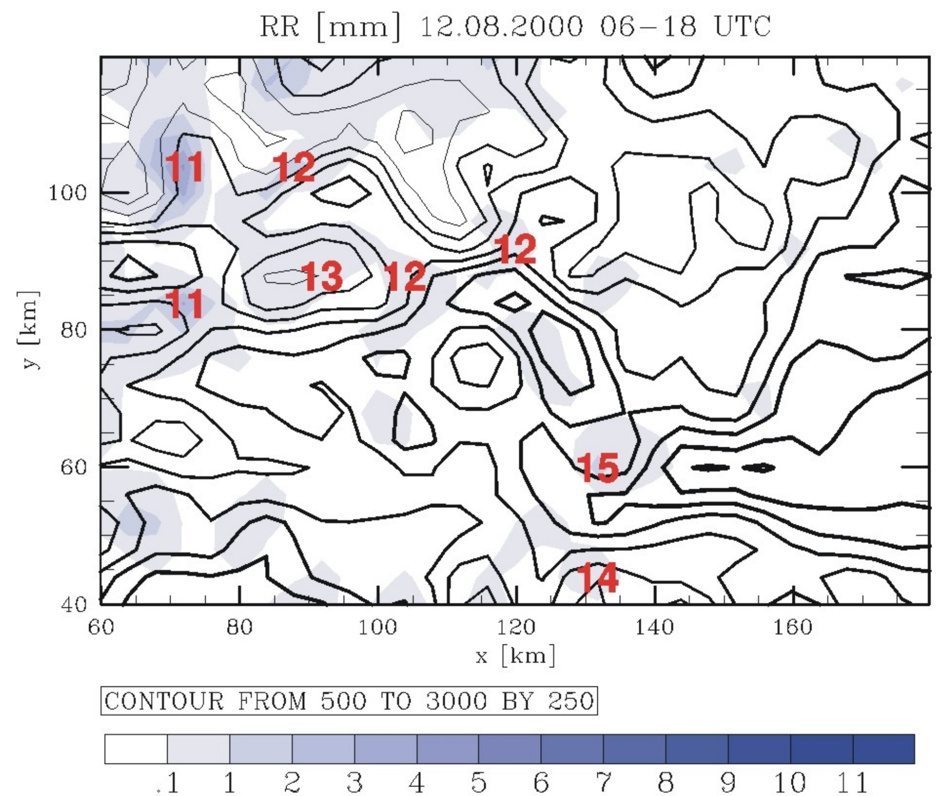

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red numbers: first precipitation at .. UTC

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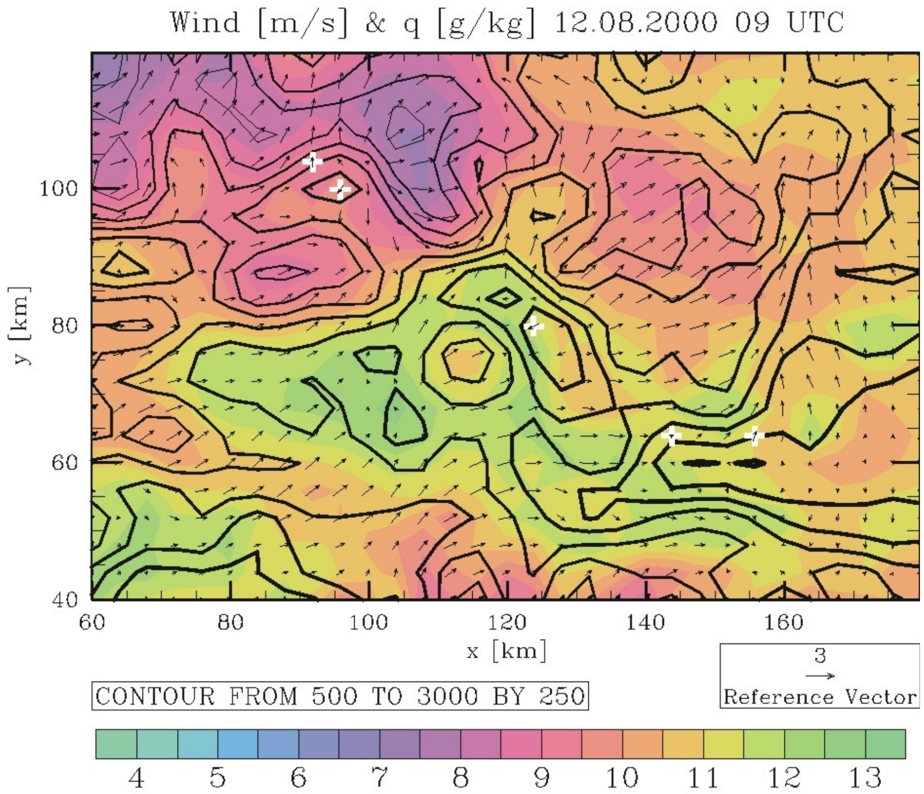

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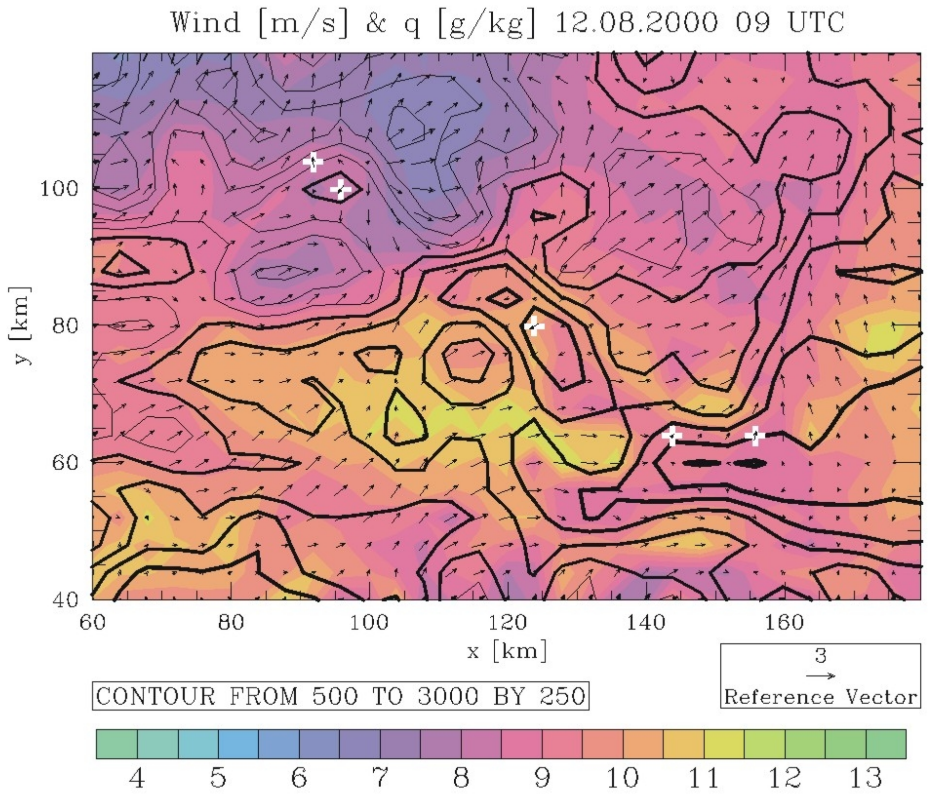

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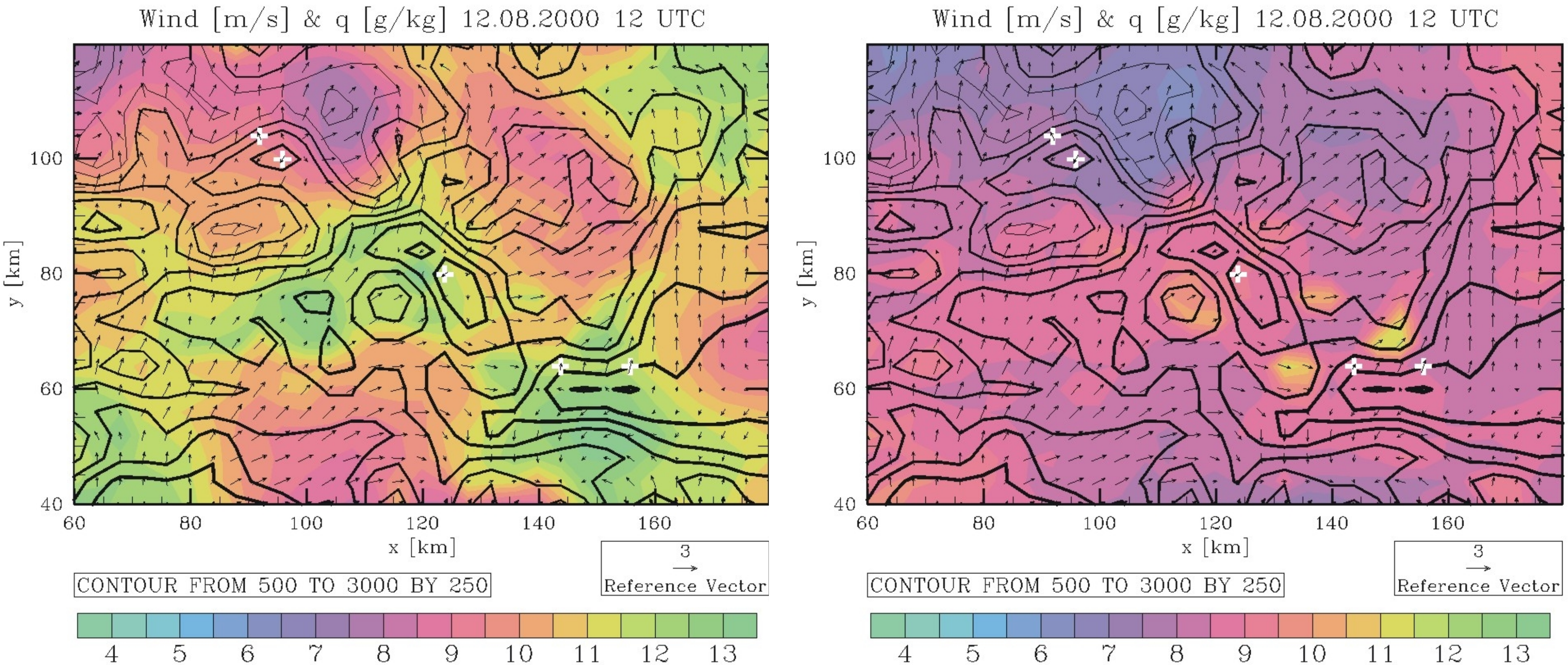

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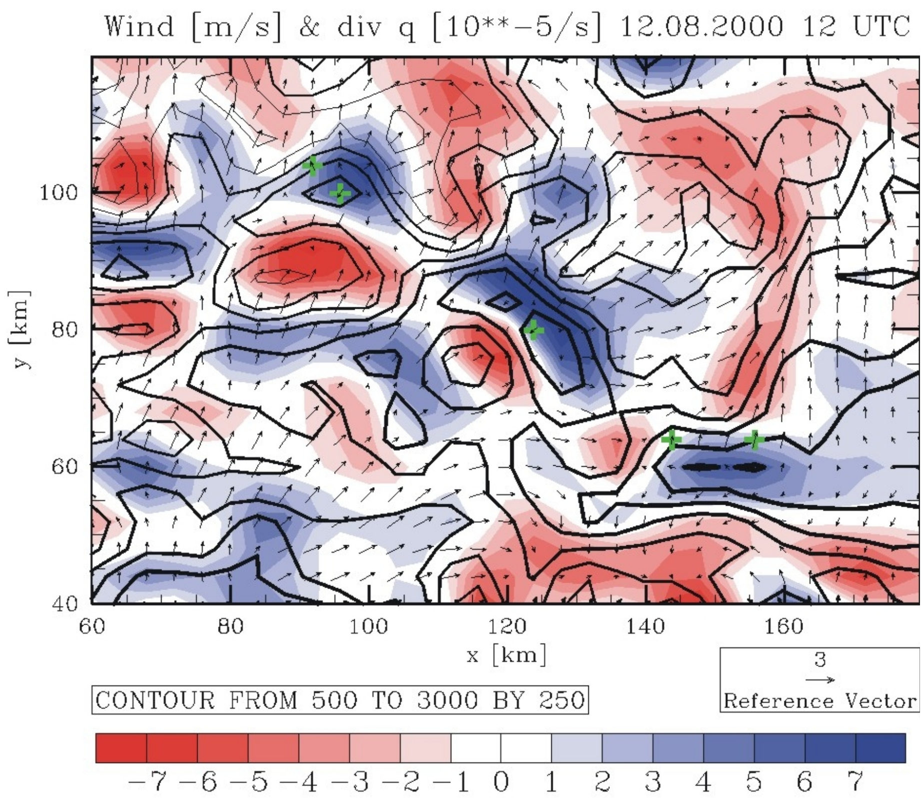
2m humidity divergence (12 UTC):



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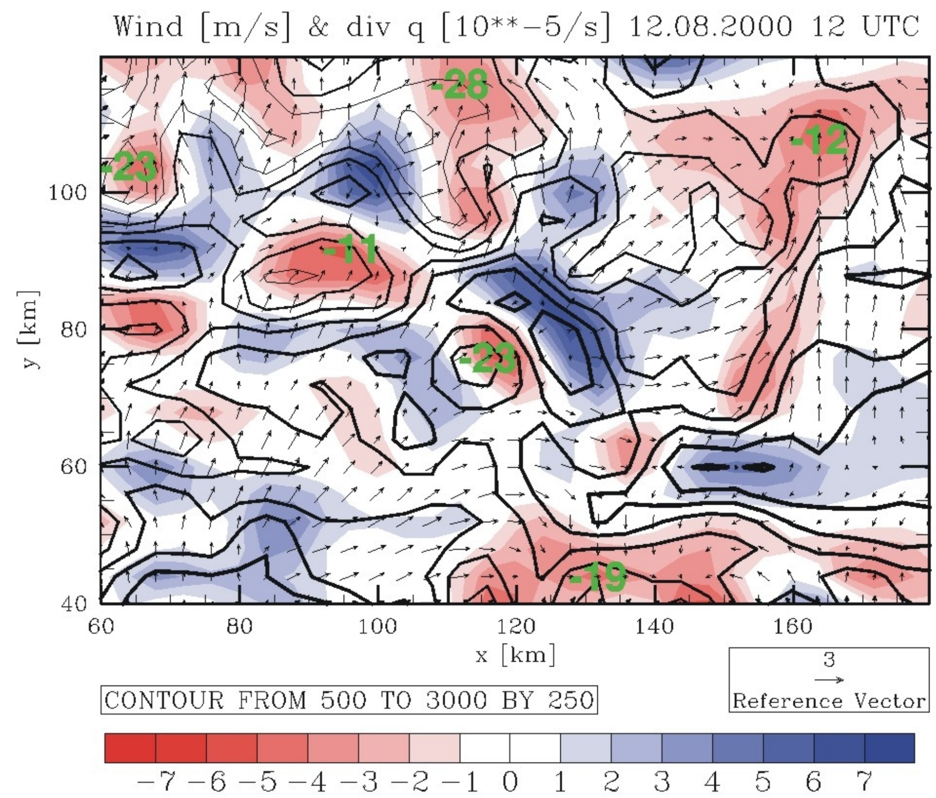

EXP

Green numbers: relative decrease of humidity convergence [%] compared to REF

back