Convective Activity in Aladin-Vienna

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1. Introduction

A significant part of precipitation, especially during the warm season, is convective in nature. Since operational numerical models currently do not explicitly resolve and predict convection at the space and time scales where they occur, the effects of convection on the resolvable scales of the model must be parameterized. In order to be convectively active a layer has to provide some convective instability as for instance CAPE, which is dependent on humidity and temperature in the lower atmosphere and a vertical temperature gradient. In Aladin convective precipitation is related to CAPE and moisture convergence. Little variations in dewpoint and temperature can cause considerable modifications in CAPE and consequently in the precipitation output. Convective activity is frequently overestimated in the alpine regions of western and southern Austria. Aladin-Vienna tends to produce precipitation too early and too widespread. What is more there are regions, above all in the western part of Austria, that receive precipitation preferentially. A comparison between observed and simulated temperature, dewpoint and CAPE shall help to explain the systematic error.

2. Method

In mountainous or hilly terrain, the valley floors of adjacent valleys are generally found at similar heights. Thus we may define a hypothetical surface that is smooth compared to the actual topography and that connects major valley floors. This valley floor surface is calculated by an algorithm which identifies the minimum elevation within a given radius for every gridpoint and arithmetically smoothes the resulting field over the same area.
Parallel to the valley floor surface a z-grid is set, which both observed data as well as the p-gridded temperature and dewpoint prediction of Aladin-Vienna are interpolated to. The overheating during the day, which is included in the predicted 2m-temperature is not taken into account in this temperature interpolation. A 3-d temperature and dewpoint correction is computed at a station if the following conditions are fulfilled:

- the station lies on a crest (at night shallow cold air drains off, during the day overheating is weak).
- the observed temperature and dewpoint during the day are below the Aladin prediction.
- the observed temperature and dewpoint at night are higher than the Aladin prediction.
- the difference between the observed and the simulated temperature during the day is greater than 2 K (usual overheating).

The sense of the distinction of cases is a physically meaningful separation of the correction in a 2d and a 3d-proportion. A 2d- and 3d interpolation provides a corrected temperature and dewpoint field, which accord with reality near a station.

3. Analyses of Results:

In May and June 2003 nine days without precipitation have been recorded in Austria. On the other days precipitation occurred due to front passage, prefrontal convection

or convection tied to topographic features. In Aladin-Vienna there was no day that was completely free of precipitation. Especially in Tyrol, Carinthia and Styria convective activity was quite high in the model.
In order to find out why Aladin-Vienna tends to overestimate the production of convective precipitation we have to examine in the first place the days which stayed dry in reality. If we look at CAPE simulated by Aladin-Vienna it is apparent that in each of the nine days there was at least some instability with positive values of CAPE (see Figure 1). In most cases already small CAPE involved some precipitation in the model, usually the amount was in the order of magnitude of tenth of millimetres. (see Figure 2).

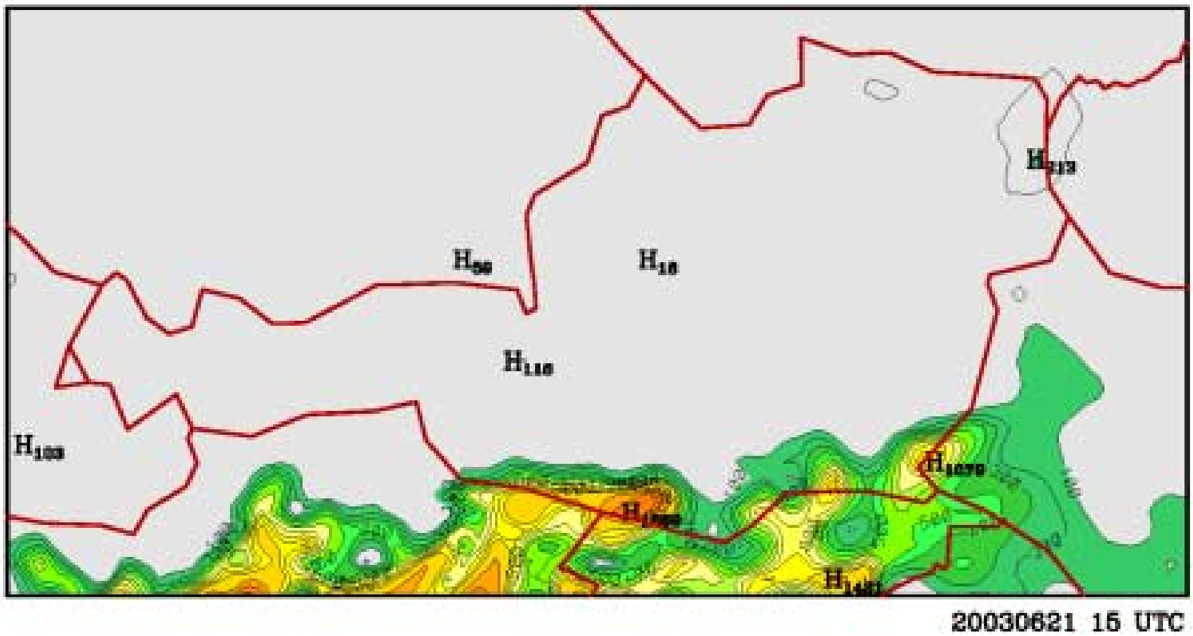

Figure 1: Cape [J/kg] simulated by Aladin-Vienna

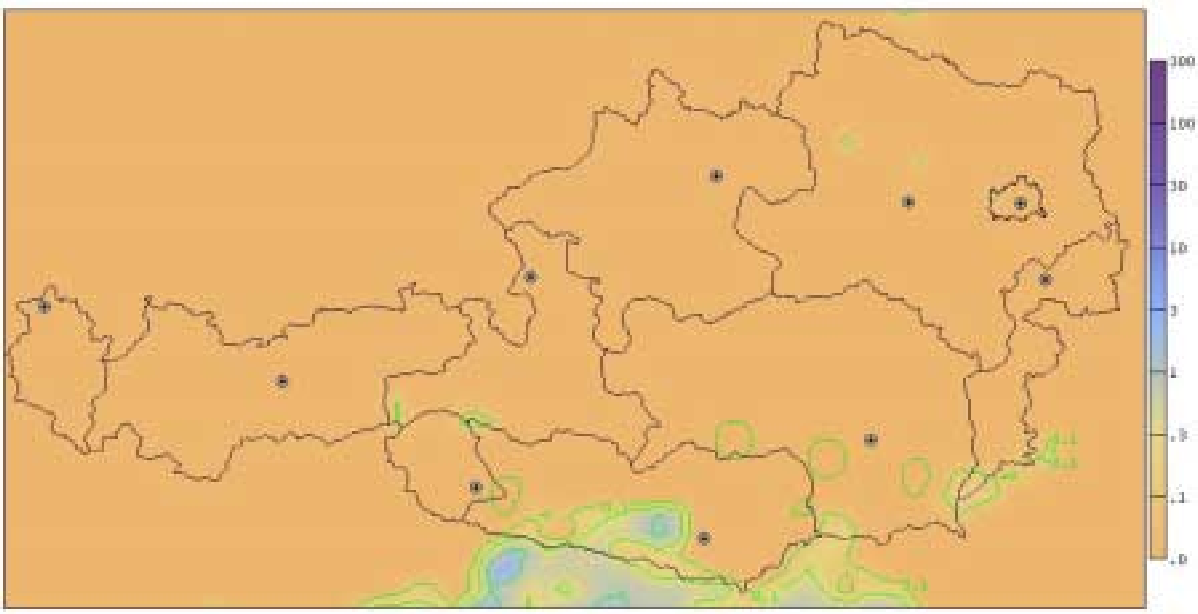

Figure 2: precipitation rate [mm/h] simulated by Aladin Vienna, 2003 06 21 15 UTC

A typical precipitation forecast of Aladin-Vienna for a day which is characterized by stable atmospheric conditions in reality is shown in Figure 3. It shows some convective precipitation from the Ötztaler Alps to the Lechtaler Alps and over the Hohe Tauern and the Dolomites. The pattern with some precipitation over the Ötztaler Alps and the Hohe Tauern is particularly characteristic for a Aladin-Vienna precipitation forecast at days with undisturbed weather conditions. These regions represent the highest parts of the model topography and the production of this precipitation is linked to moisture convergence, which becomes obvious if we look at the 10 m-wind prediction.

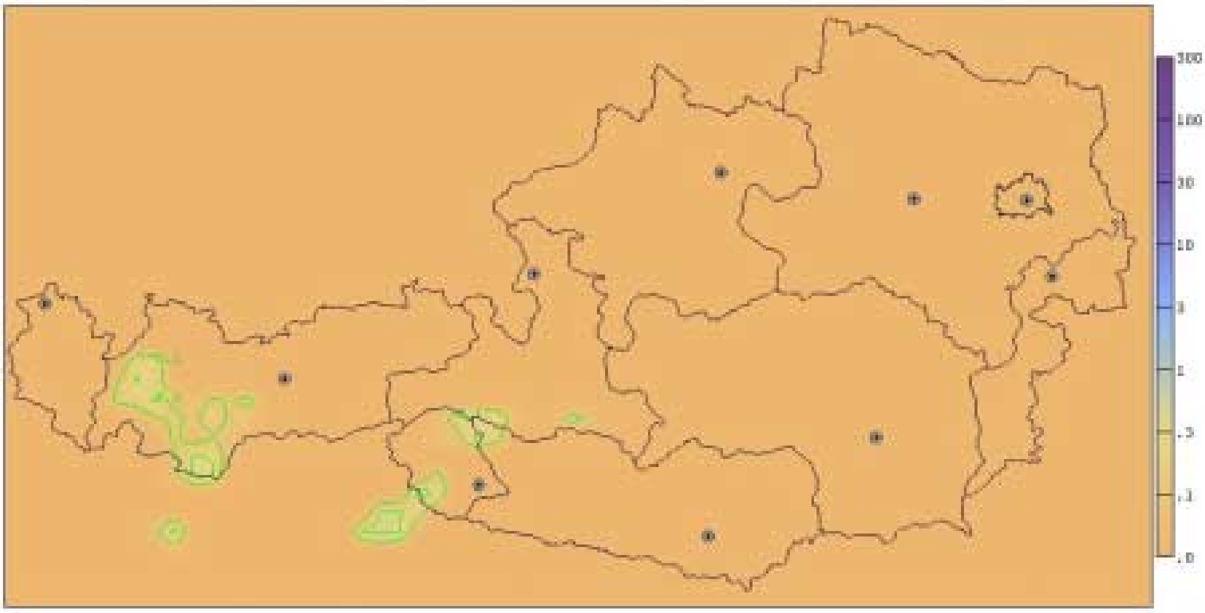

Figure 3: precipitation rate [mm/h] simulated by Aladin Vienna, 04.05.2003 15 UTC

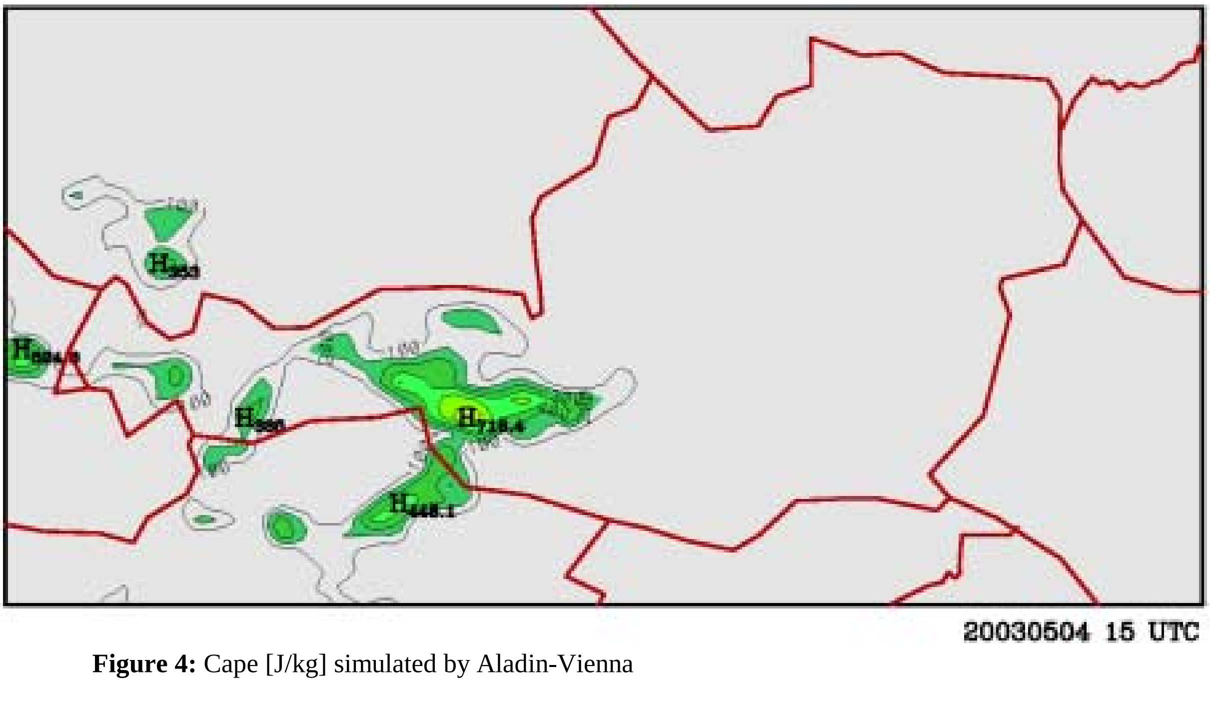

Figure 4: Cape [J/kg] simulated by Aladin-Vienna

There is a strong correlation between convective precipitation and CAPE in the model. A comparison of figure 3 and figure 4 demonstrates that the fields of precipitation and CAPE are nearly congruent. Again, already low values of CAPE cause some convective precipitation.
In order to find out about the actual instablity CAPE was computed from the corrected temperature and dewpoint fields. That implied that CAPE was partly too low, partly too high in the model compared to reality, but above all in close vicinity to simulated precipitation the simulated CAPE was rather too high. Hence it seemed that the overestimation of convective precipitation was due to this error in the CAPE simulation. But after a more precise inspection it turned out that there were always some regions where CAPE fit well to reality and nevertheless there was some precipitation in the model. The existence of CAPE is not enough in reality to produce convective precipitation, there must also be a trigger.
Therefore it seems as if the threshold value for triggering convective precipitation is foremost responsible for the overestimation of convective precipitation. The threshold value seems to be too low. But as mentioned above there were also some regions where CAPE has been overestimated by the model. It is of interest whether the temperature or the dewpoint or even both have been responsible for the overestimation of CAPE.
Figure 5 shows the difference of simulated and observed CAPE for June, 30th. It is obvious that in some regions CAPE is too high in Aladin-Vienna.

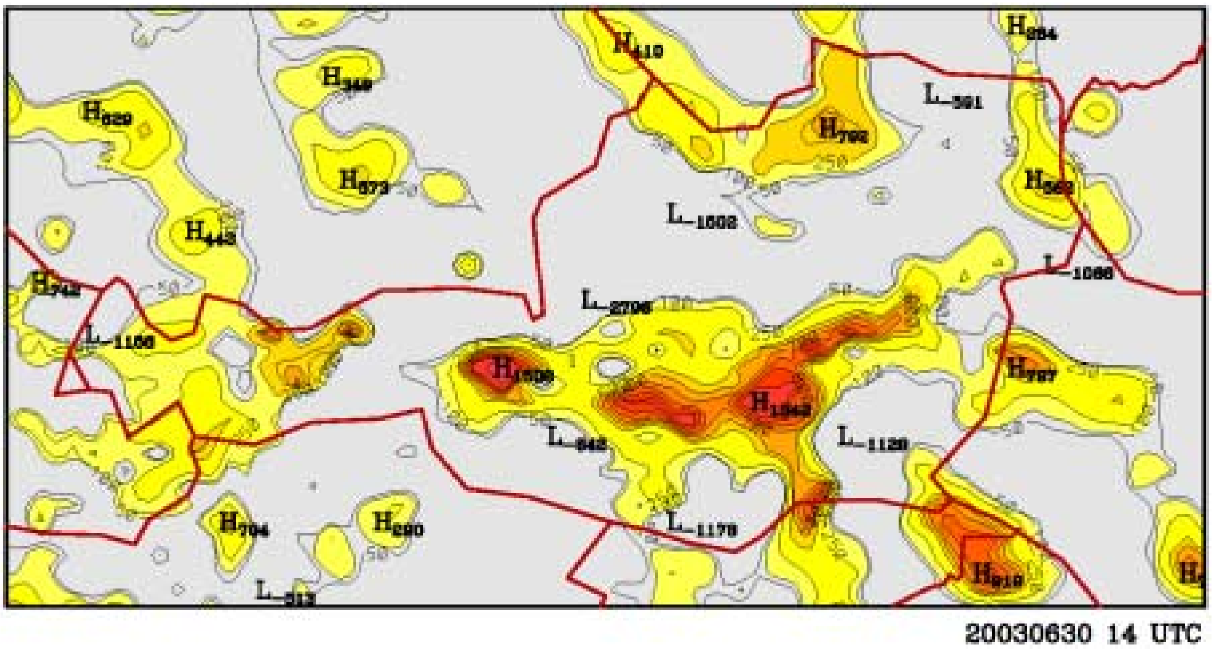

Figure 5: Difference between CAPE, simulated by Aladin-Vienna and Cape observed

Above all in Styria the overestimation of CAPE corresponds to some convective precipitation. If we look at Figure 7 we can recognize that the dewpoint prediction overestimates the actual humidity conditions mostly over mountainous terrain. In many cases the dewpoint was too high over Salzburg, Styria and Carinthia but also over some regions of Tyrol (see Figure 8) and over the Wald- und Mühlviertel. The difference between the Aladin-Vienna dewpoint and the actual one has it's greatest values in the afternoon. In this context we have to consider that in the afternoon over some regions precipitation is produced and a comparison to reality is difficult. In the morning the dewpoint fits either well to reality or is even significantly lower than in reality (above all in western Austria).
As far as the temperature is concerned the model simulates too high temperatures over the Alps above all in the forenoon. During the day the difference between the simulated and the

observed temperature decreases and in the late afternoon the observed temperature is mostly in nearly whole Austria above the Aladin-Vienna forecast (see Figure 8). Only in western Austria there are some regions where the model temperature is above the observed one.
The exaggerated dewpoint over the mountainous regions of Austria is probably owing to moisture flux and convergence. The usually too low temperatures of Aladin-Vienna in the afternoon are mostly caused by too much convective cloudiness.
To sum up, there are two problems that we have to cope with. First of all, there is convective precipitation whenever there is positive CAPE. A threshold for triggering convection or additional conditions are needed in order to get rid of this problem or at least to reduce it. And secondly there is too much moisture over certain regions of the Alps. Thermally-induced upslope flows carry moisture to higher levels and thereby favors cumulus formation and even convective precipitation over peaks. The second problem should be reduced in higher resolution. Simulations which capture a more realistic topography are going to be fulfilled shortly.

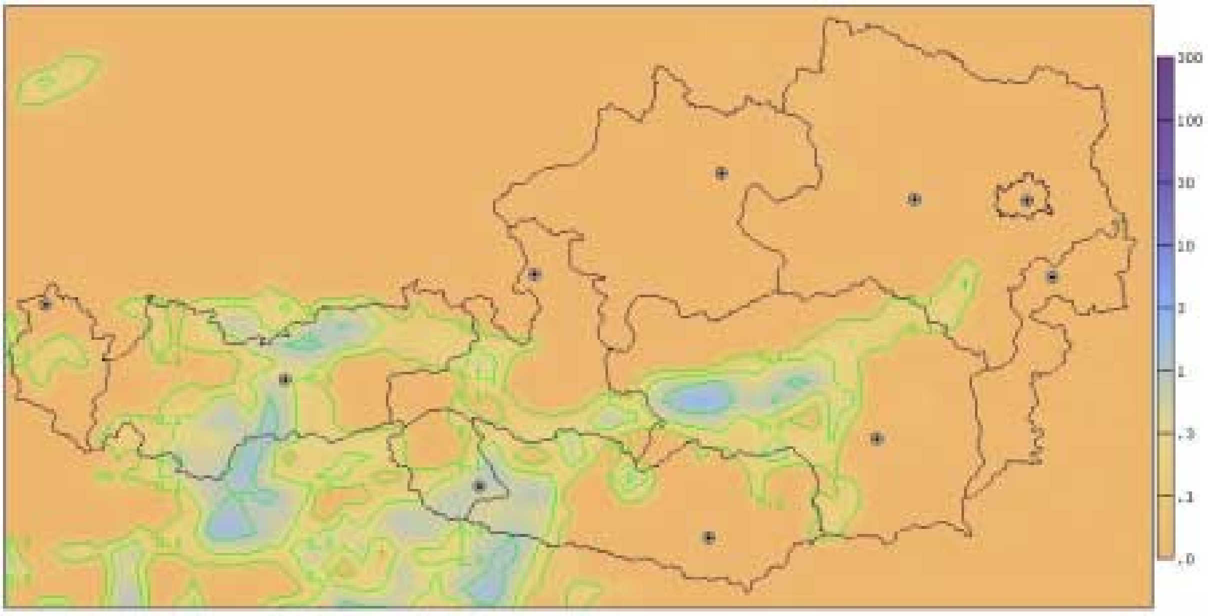

Figure 6: precipitation rate [mm/h] simulated by Aladin Vienna, 30.06.2003 14 UTC

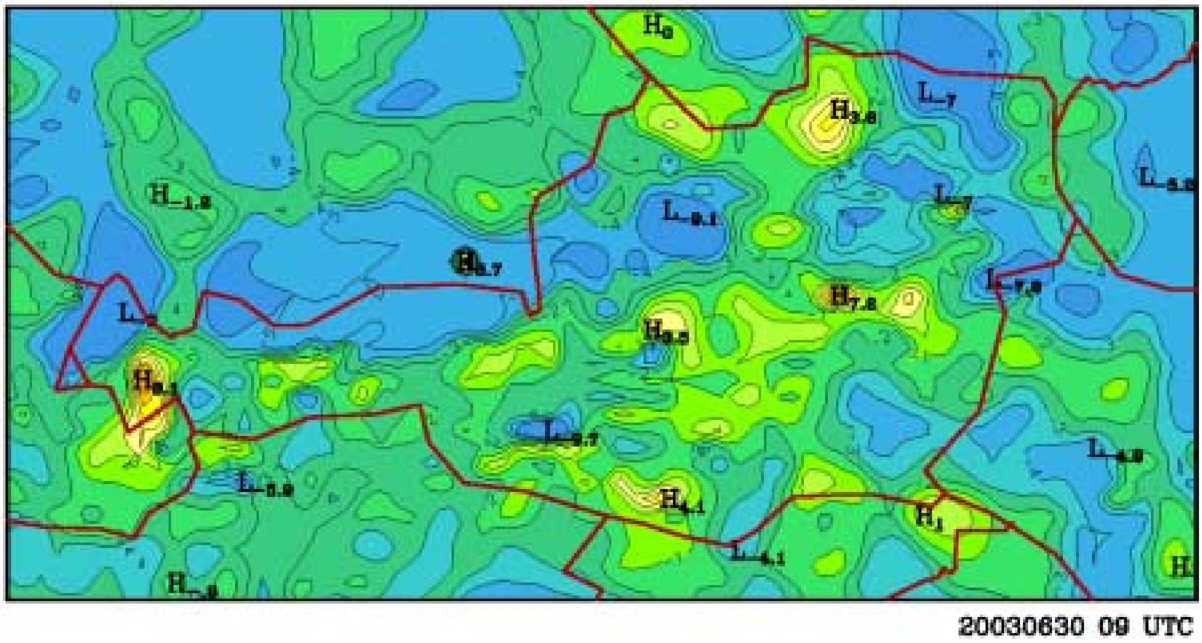

Figure 7: difference between the Aladin-Vienna output and the corrected dewpoint-field

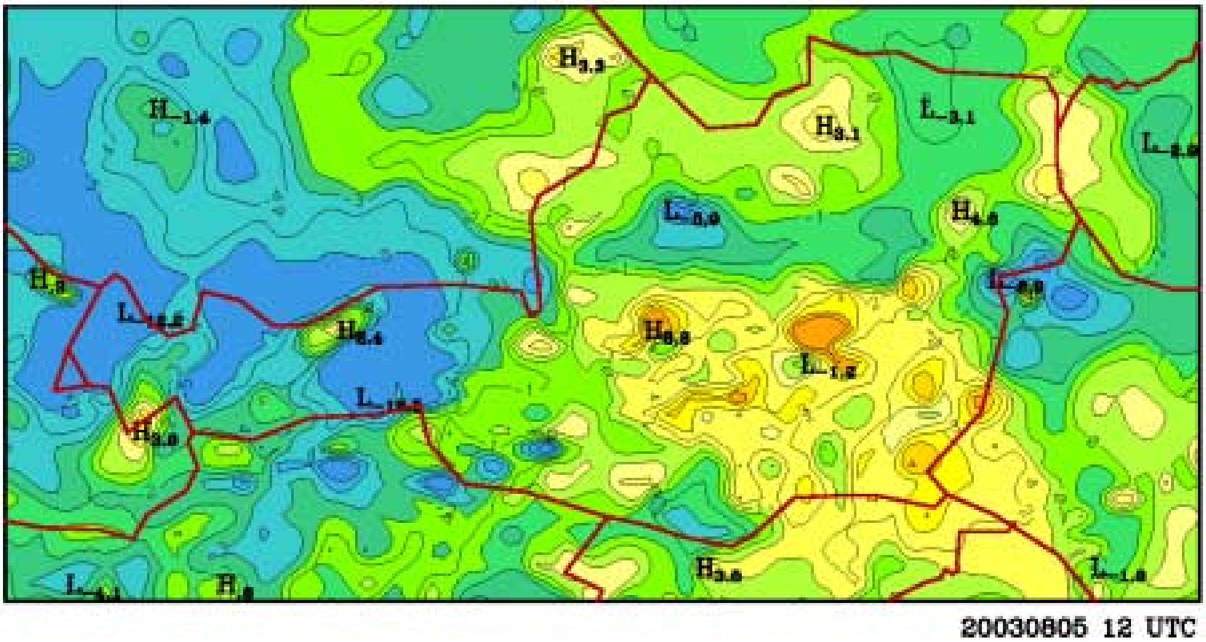

Figure 7: difference between the Aladin-Vienna dewpoint output and the corrected dewpoint-field

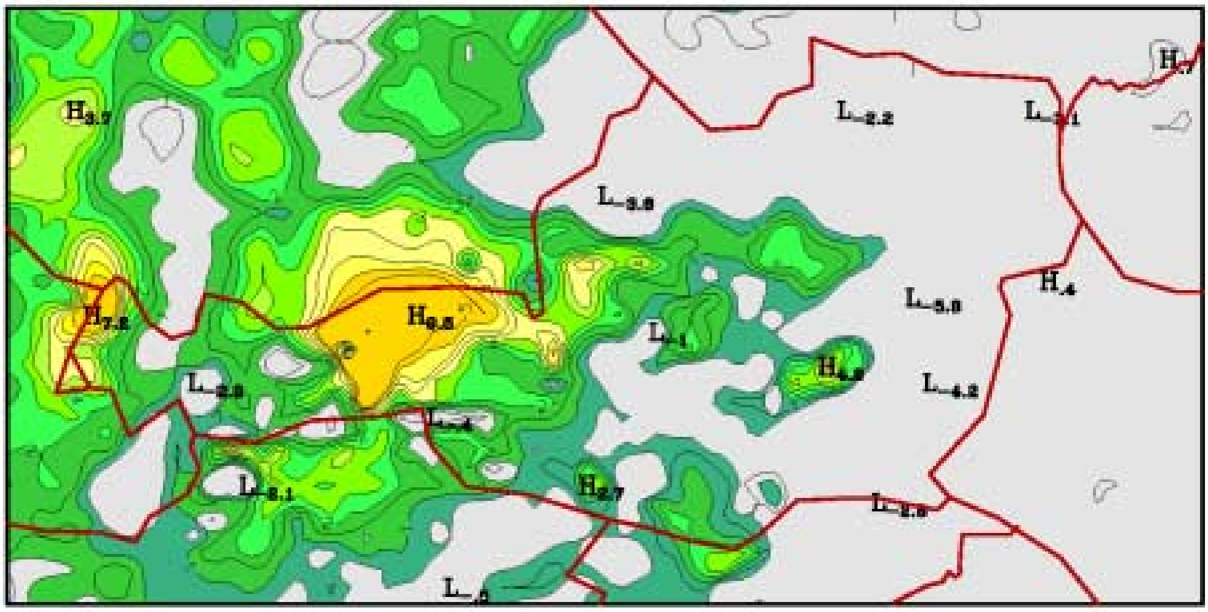

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Figure 8: difference between the Aladin-Vienna temperature output and the corrected temperature-field