One month parallel run of the Seidl-Kann cloudiness scheme

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1. Introduction

Observing spatial and temporal evolution of temperature and moisture in the ALADIN model, deficiencies can be identified during typical wintertime periods. Although large areas are covered by a widespread low stratus layer, the model underestimates cloudiness in the lowest model levels. One source of errors is due to the treatment of observed strong inversions, which are smoothed unrealistically by the current operational data assimilation scheme if the model background is too far away from reality. Consequently, further development of the inversion strength is reduced and PBL - cloudiness cannot form.

An approach to improve the diagnosis within the cloudiness scheme is to establish a formulation that aims at typical sub-inversion cloudiness.

2. Design of Seidl - Kann stratus cloudiness scheme

A detailed description of the scheme was given in ALADIN Newsletter 22. Basically four additional criteria are introduced in subroutine *acnebn.F90* to identify low cloudiness which is connected to an inversion :

a) Quasi-saturation has to be fulfilled (currently set to 90%).

b) Coherent levels that are quasi-saturated must define a layer thicker than a critical value (currently set to 150 m).

c) Coherent inversion of critical strength must exceed a predefined value (currently 2K).

d) Distance between the lower boundary of the inversion and the upper boundary of the quasi-saturated layer must not exceed a critical value (set to 500 m).

If these four criteria are fulfilled, low cloudiness and the cloudiness of the quasi-saturated layers are set equal to one.

Comparison with the standard *acnebn.F90* and "Xu-Randall" *acnebn.F90* shows that the Seidl-Kann scheme gives results much closer to the latter with regard to inversion cloudiness.

3. One month of parallel model run

Before the modified *acnebn.F90* routine became operational in ALADIN-Vienna, a parallel run was installed and afterwards verified for the location Vienna.

From 20.12.2002 to 20.01.2003 several high-pressure systems with stratus coverage affected Central Europe, leading to differences in model output between the original *acnebn.F90* and the modified one.

Figure 1 shows an ALADIN-Vienna meteogram for the station Vienna with the original cloudiness scheme (initial time: 20.01.2003 00 UTC run). Although relative humidity often exceeds 90% in lowest model levels, only little cloud fraction is generated by the model. On the other hand, the parallel run with the modified *acnebn.F90* routine increases the cloud coverage up to 100%, which is maintained during most of the integration time (Fig. 2). The improvement of cloudiness forecasts has also positive side effects on 2 m-temperature forecasts : diurnal amplitudes are reduced due to reduced sensible heat fluxes.

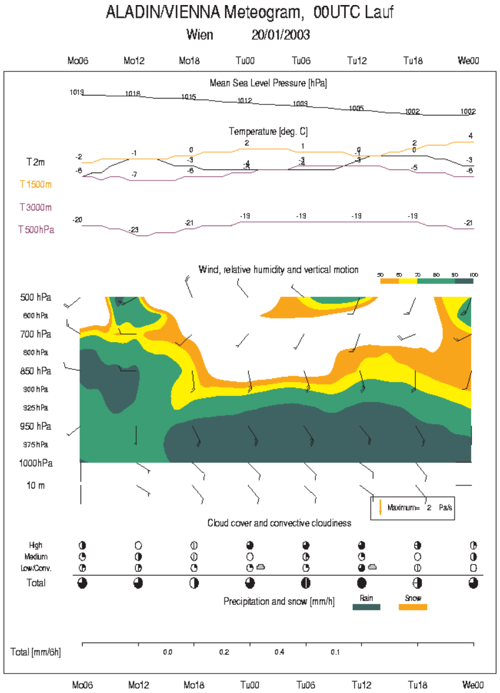


Fig. 1: ALADIN-Vienna forecast meteogram from 20.1.2003 00 UTC with original acnebn.F90

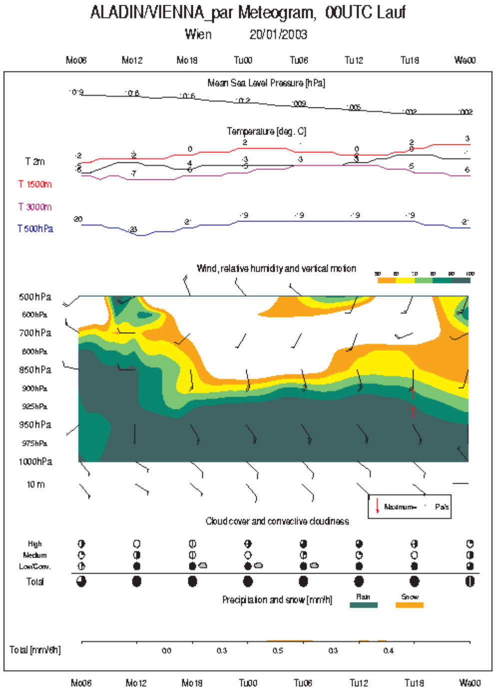


Fig. 2: ALADIN-Vienna forecast meteogram from 20.1.2003 00 UTC with modified acnebn.F90

Figure 2 points out an intensification of the vertical gradient of moisture between 850 hPa and 925 hPa as well. This is mainly based on the temporal evolution of the inversion, which becomes more pronounced in presence of low cloudiness (mainly due to cloud-top cooling).

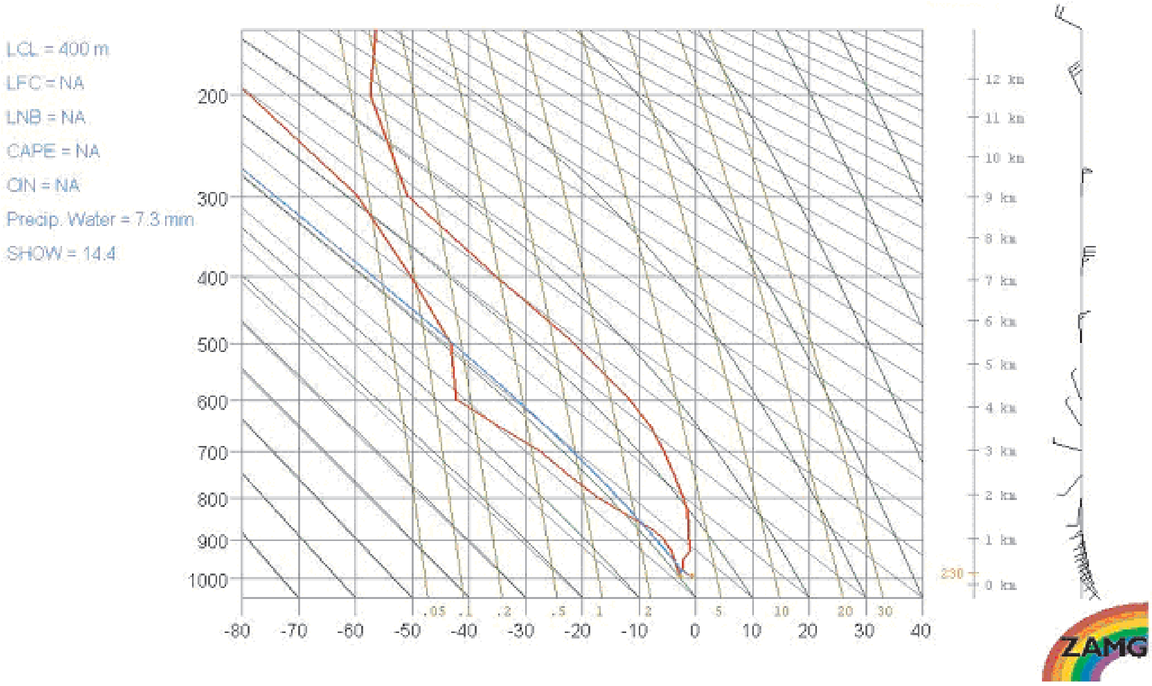


Fig. 3: ALADIN-Vienna operational model run
Date: 19.01.2003 00 UTC +12 hours forecast, location Vienna

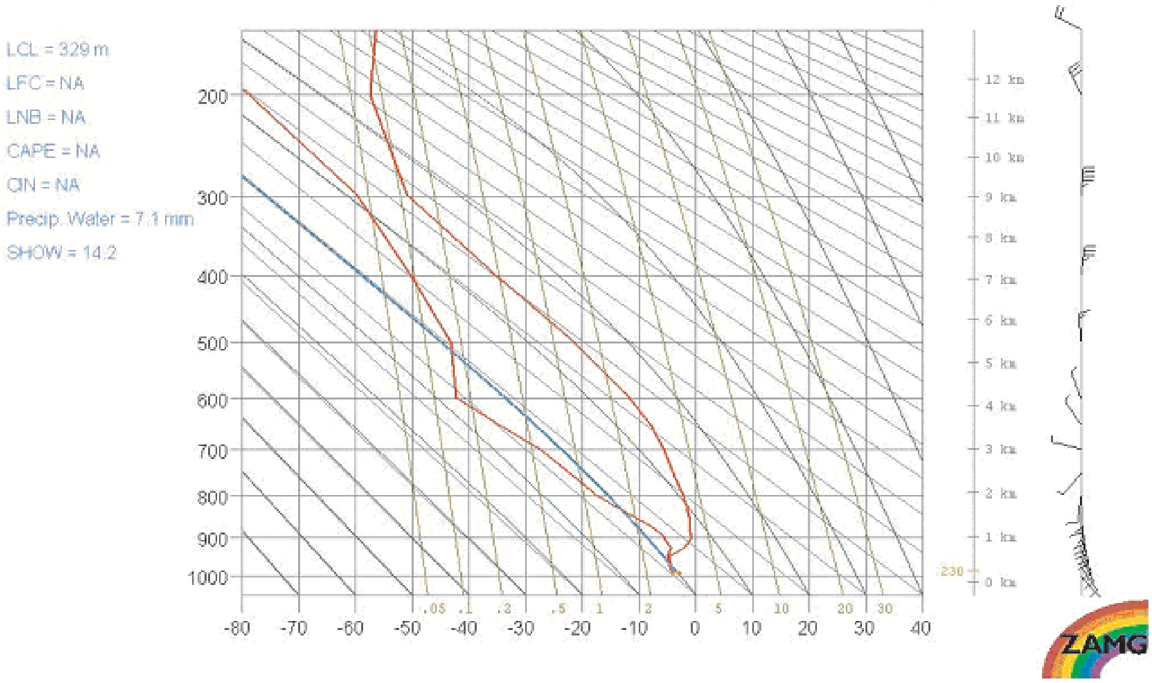


Fig. 4: ALADIN-Vienna parallel model run with "*acnebn.F90* + Seidl–Kann"
Date: 19.01.2003 00 UTC +12 hours forecast, location Vienna

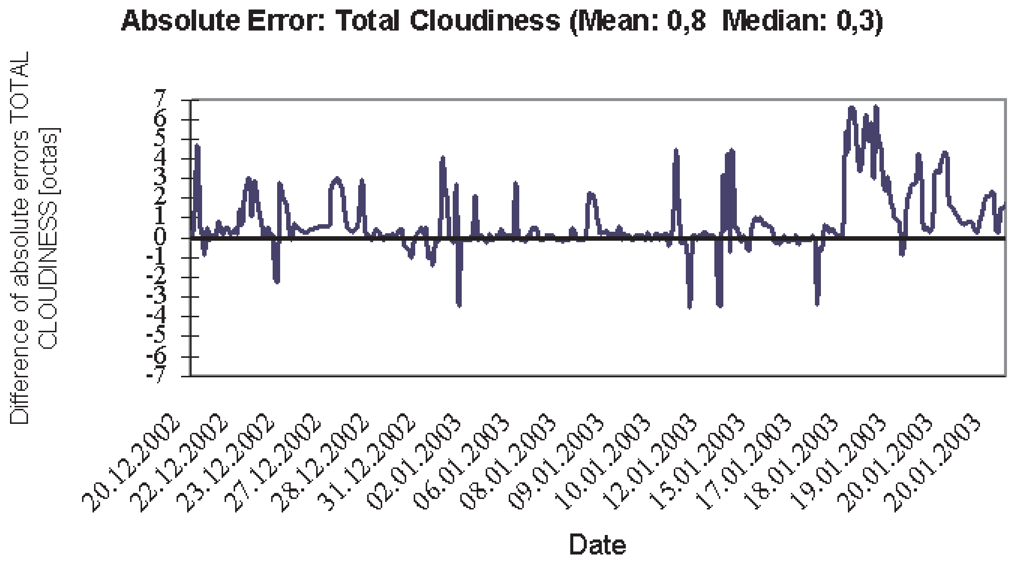
This fact is confirmed in Fig. 3 (operational run, vertical profile at Vienna, 19.01.2003 00 UTC +12 hours forecast) and Fig. 4 (parallel run with modified *acnebn.F90*, vertical profile at Vienna, 19.01.2003 00 UTC +12 hours forecast) which demonstrate the formation of a more realistic stratus-type temperature and moisture profile in presence of a stratus layer.

This development was found in an other experiment as well, where low cloudiness was set equal to one regardless of the inversion strength. Cloud-top cooling and subsidence lead to a more realistic temperature and moisture profile with respect to sharpness and strength, that allows to maintain cloud coverage. Thus, a more realistic development of the vertical PBL structure seems to require the presence of a stratus-like cloudiness in the model.

The verification of one month parallel run of ALADIN-Vienna includes the parameters total cloudiness (Fig. 5) and 2 m-temperature.

Many cases in Fig. 5 show only slight changes of model output concerning total cloudiness. The vertical structure of temperature and moisture is too far away from reality, thus the four criteria (discussed in section 2) are not fulfilled. Positive values indicate an improvement using the modified cloudiness routine. The reduction of absolute errors may reach values up to 7 octa, especially during the last stratus episode, from 18.01.2003 to 20.01.2003. An overestimation of low clouds was rarely produced by the modified diagnosis within one month of parallel run. About 25% of all cases with different model output concerning total cloudiness show a slight decrease of the forecast performance, whereas 75% indicate an increased forecast quality. The mean absolute error (MAE) of total cloudiness diagnosed with the standard *acnebn.F90* is 2.0, this MAE could be reduced to 1.2 with the modification set. Note that by definition only cases with different model output of low cloudiness form the basis of MAE.

The verification of 2 m-temperature shows similar results. The mean absolute error of operational model run is about 1.8 K, the modifications in *acnebn.F90* cause a reduction to 1.5 K. 65% of all cases (= hourly observations) show improvements if forecasted with modifications, about 35% of them lead to worse forecasts.



<u>*Fig. 5*</u>: Total cloudiness in octa : Absolute error of operational model output minus absolute error of parallel (=*acnebn.F90* + Seidl-Kann scheme) model run (location Vienna, interpolated). Chronological cases are chosen hourly from 20.12.2002 – 20.01.2003, and for daily 00 UTC runs (+48 hours), but only if total cloudiness at station 11035 is observed.

4. Final Remarks

The parallel run during the chosen month suggests an improved stratus forecast for the next wintertime period. Nevertheless, it should be mentioned that physical approaches with respect to a better simulation of the PBL structure are still necessary to forecast more realistic stratus-like temperature and moisture vertical profiles (improvements in the model's ability of cloud top cooling, synoptic subsidence above the PBL and tests with different cloudiness schemes, e.g. Lopez, Xu-Randall, Meso-NH schemes).