New Approaches to Stratus Diagnosis in ALADIN

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Observing ALADIN vertical profiles of temperature and moisture for the latest winter periods, some severe model deficiencies were discovered in 3D and 1D forecasts. One type of error is associated with weak gradient cases, where vertical turbulent fluxes of heat and moisture tend to zero (Fig.1). This leads to unrealistically strong inversions too much confined to the ground (Fig.2). Inclusion of an additional model level in the Single Column Model, at 2m, did not really improve fluxes and profiles. Implementing an additional laminar layer on top of the soil, on the other hand, is not straightforward to code in the model. It will need cooperation among the ALADIN community.

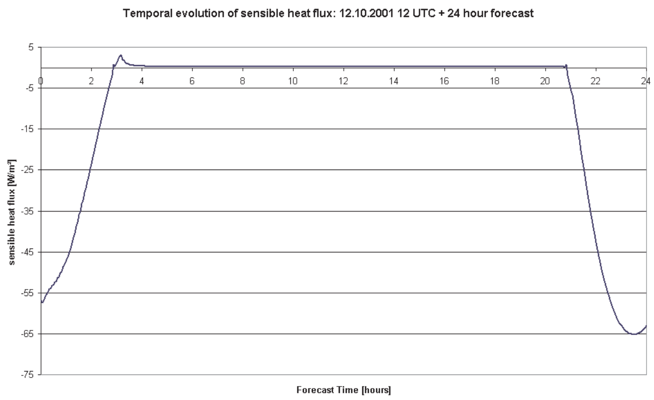


Fig.1: 12.10.2001 24 hour forecast of sensible heat flux in [W/m²] predicted by SCM (CY22T1_OP8) for lon=16.36 and lat=48.22

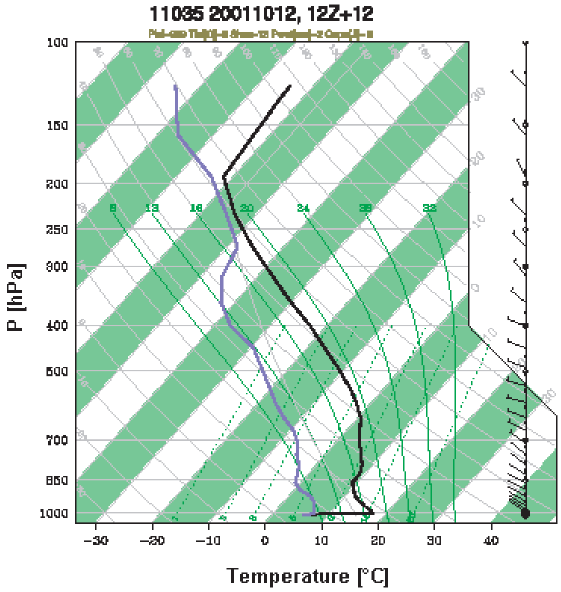


Fig.2: 12.10.2001 12 hour prediction by SCM for lon=16.36 and lat=48.22

The second type of error is related to the diagnosis of low stratus, which leads to an unrealistic evolution of the whole PBL. This may happen right from the initial time of model runs. In order to check for possible ways to improve the boundary-layer cloud representation, some empirical modifications were carried out in the subroutine *acnebn.F90,*. The levels belonging to the Low Cloud Etage were "re-scanned" and 4 new critical parameters introduced :

- Quasi-saturation (currently = 10 %), computed from Q(JLEV) and QSAT(JLEV) which enter the routine, has to be reached.
- Coherent Levels of Quasi-Saturation must define a LAYER thicker than a critical value (currently set to about 200 m).
- Coherent Inversion of critical strength (currently set to only 2K) must exist as well.
- The distance between the lower boundary of this inversion and the upper boundary of quasi-saturation layer must not exceed another critical value (currently set to about 500 m). This seems reasonable because the inversion layer and quasi-saturation layer must not become too much decoupled from each other in order to gain a "stratus signal".

If all 4 criteria are fulfilled, cloudiness for all quasi-saturated levels is set to 1. . Cloud fraction for all other levels within the low cloud etage is set to 0. . As mentioned above, medium and high-level cloudiness are not modified at all. However response from radiation schemes can be expected to be significant and in return may keep temperature and moisture profiles in a realistic "lifted fog shape".

The new scheme was tested both in 3D and 1D with Stratus case 15-16 January 2002. A high pressure system affected Central Europe for a couple of days and led to extensive areas with fog and low stratus conditions (Fig. 3). In contrast to the operational version of *acnebn.F90,* (Fig. 4), the modification improved low cloudiness for large areas but not for the whole domain (Fig. 5). In SCM, the vertical profiles of temperature and humidity better correspond to the radiosounding (Fig.6) than the original stratus diagnosis. So there is a positive impact of our scheme on radiative transfer during the integration time (Fig. 7 & Fig. 8).

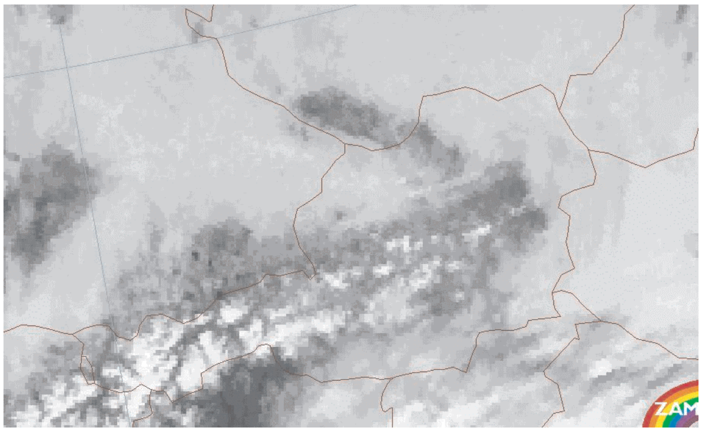
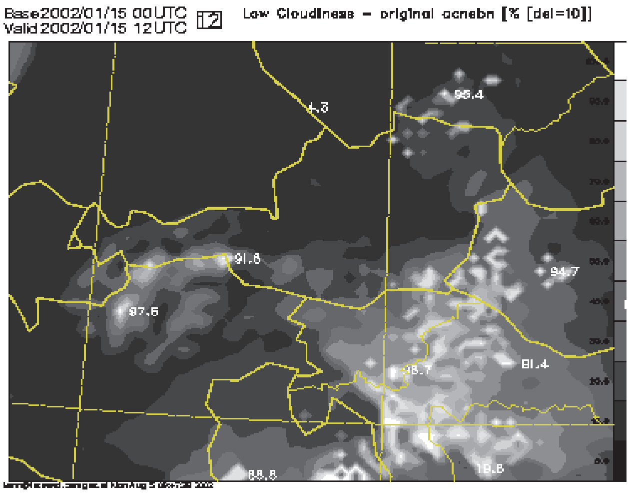


Fig.3: Satellite image (visible) at 15.01.2002 12 UTC



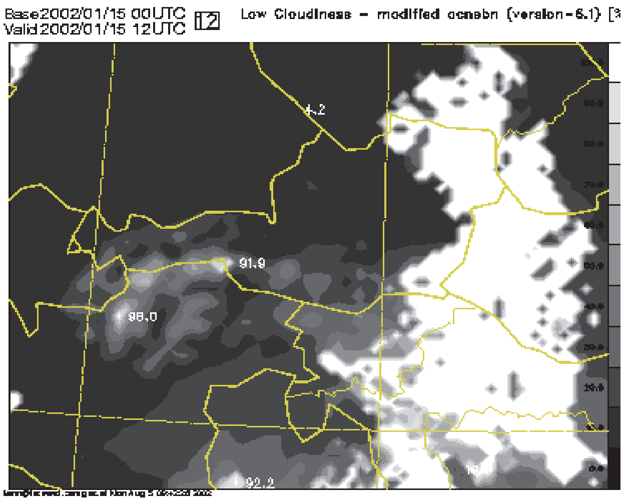


Fig.4: Low Level Cloudiness with original   *Fig.5: Low Level Cloudiness with modified*
acnebn.F90, predicted by ALADIN-Vienna (export version al12op03).
Base: 15.01.2002, 12-hour forecast

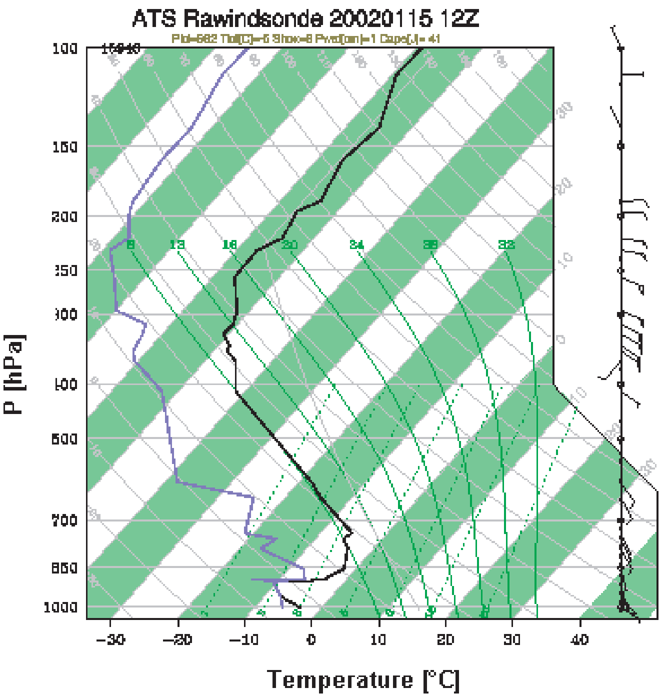
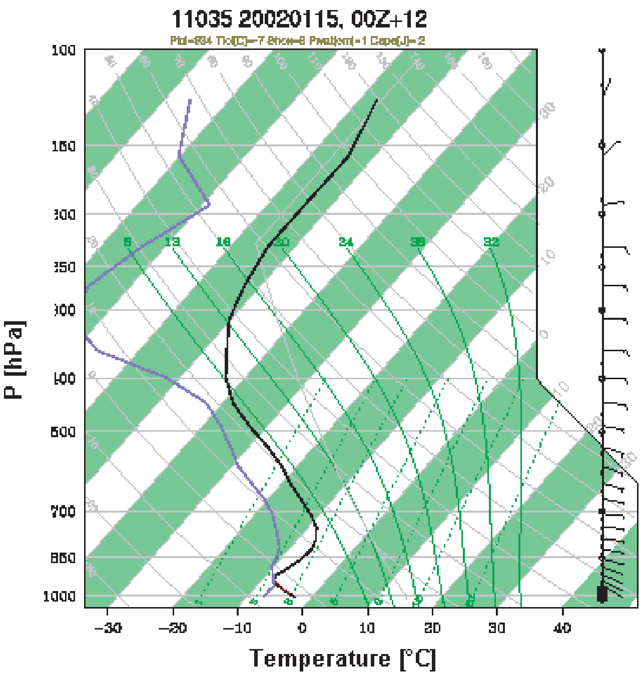


Fig. 6: Sounding of Vienna/Hohe Warte, date: 15.01.2002 12 UTC



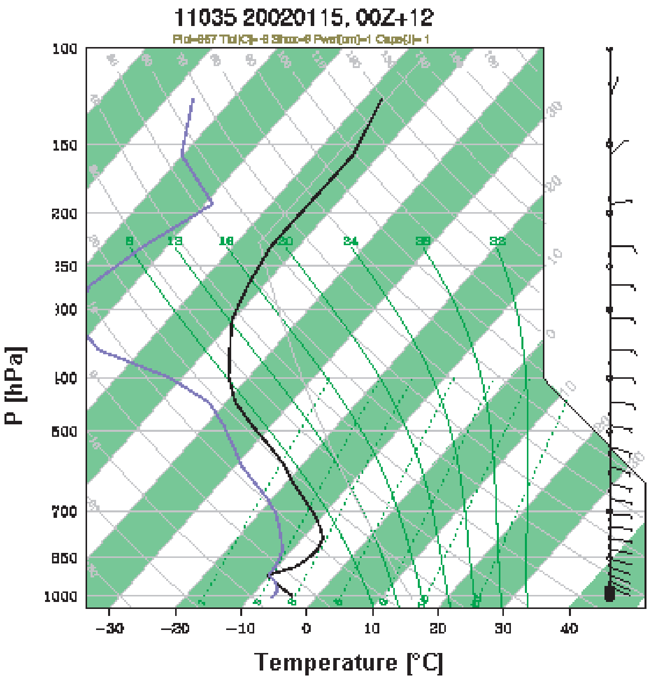


Fig.7: 12-hour prediction by SCM with original *Fig.8: 12-hour prediction by SCM with modified acnebn.F90, Base: 15.01.2002 00 UTC, valid for 15.01.2002 12 UTC.*

It is of course necessary that the scheme handles not just one but many cases successfully before any actual operational implementation can be recommended. For example, it will be most crucial to make sure that this Stratus Diagnosis scheme also allows for fog clearing whenever frontal or different type of synoptic-scale forcing reach certain degrees of intensity. Such kind of generalization will be part of our future work. Apart from that method, testing of Xu-Randall cloud parameterization scheme in SCM did not improve low cloud fraction in the case of the 15th January 2002 significantly. The problem is very probably due to a wrong forecast of the inversion layer, rather than to the parameterization of cloudiness. Work will go on in close cooperation with other ALADIN teams.