Representation of low cloudiness in Aladin

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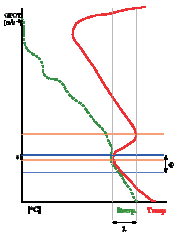
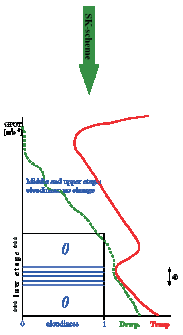
Introduction

In Austria low Stratus and fog are common phenomena especially during the cold season. Since the original parameterization did not capture lifted inversions properly and initial state turned out too smooth as well we decided to implement a simple but reasonable diagnostic enhancement scheme for Stratus - and this approach turned out to be quite successful.





SK-Scheme

It is implemented in Aladin/AUSTRIA as an extension to subroutine ACNEBN without Xu-Randall scheme, which computes low cloudiness level by level and also total low cloudiness.

SK-scheme rescans only the levels belonging to LOW CLOUD ETAGE (downwards from NTSML+1 to KLEV=lowest model level).

Saturation deficit ρ is computed for each level from specific humidities Q and QSAT and levels with $\rho < \rho_c$ are declared quasi-saturated.

SK-1) Coherent levels of quasi-saturation must define a layer of thickness Φ exceeding a critical thickness value Φ_c.

SK-2) Coherent inversion of critical strength in terms of temperature difference $\lambda > \lambda_c$ must also exist in order to trigger Stratus diagnosis.

SK-3) Final necessary condition for SK-scheme to act is the so-called shift criterion which states that quasi-saturation zone may not arbitrarily penetrate into inversion layer: Penetration depth δ may not exceed another critical value: $\delta < \delta_c$.

Current settings are: ρ_c**=0.1,** Φ_c**=2000 (m²/s²),** λ_c**=1.5K, and** δ_c**=2000 (m²/s²).** (Φ_c and δ_c are in terms of geopotential)

If all three criteria are fulfilled at a gridpoint SK-scheme acts in the following way:

Cloudiness for each level within LOW CLOUD ETAGE is re-initialized to zero, and each quasi-saturated level as well as total low cloudiness is set to 1.0.

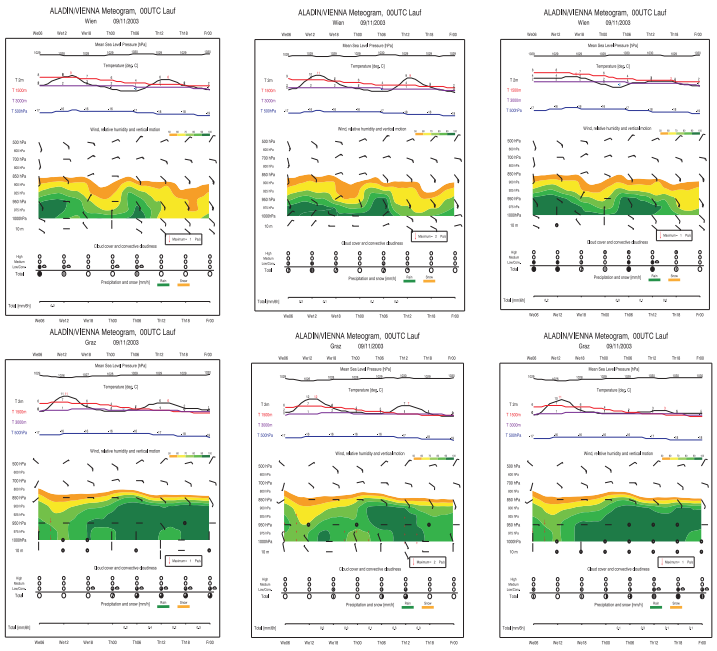
This will in return trigger a strong response from radiation routine ACRANEB tending to intensify or at least keep the pre-existing inversions through infrared flux divergence inducing cloud-top cooling.

Experiments with different parameterization

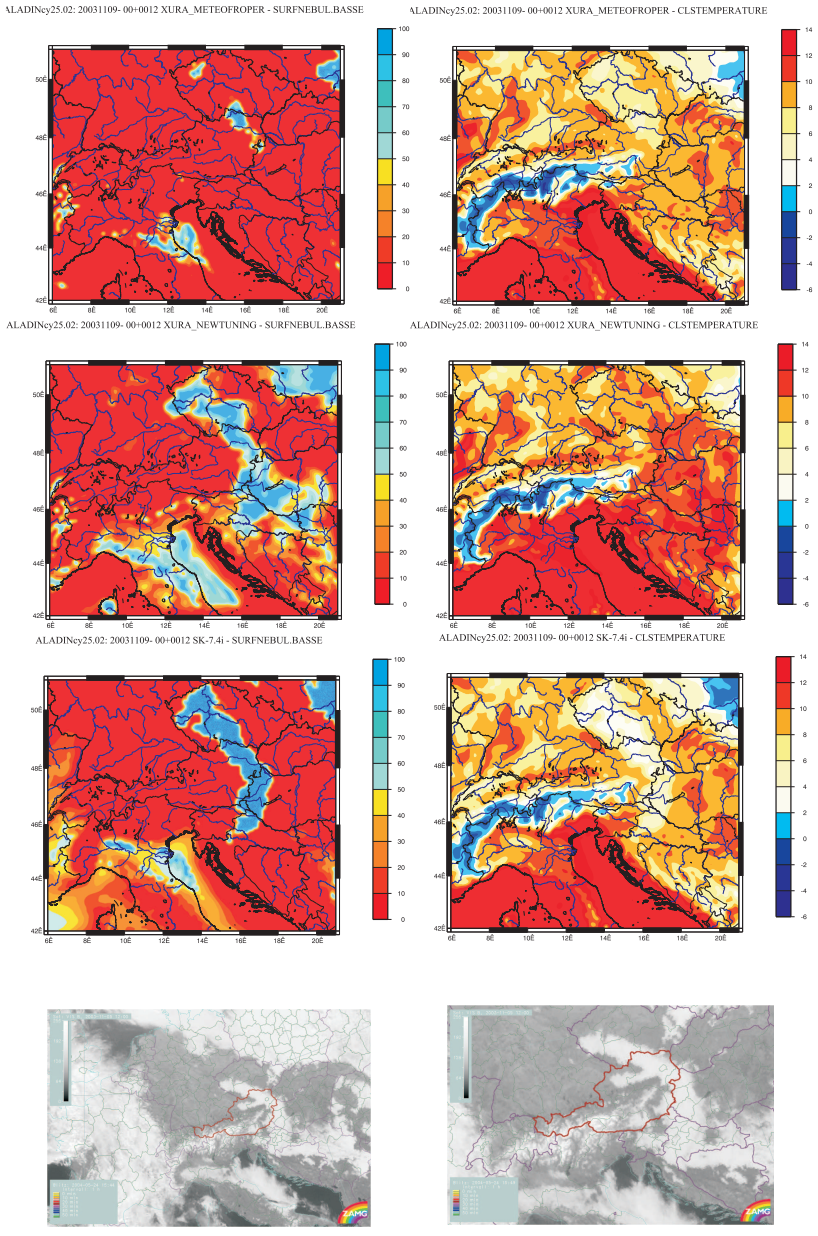
Forecasts based on November 09, 2003, 00 UTC were re-run.

A) Meteograms

Figures in the first row are for VIENNA, those in the second row are for GRAZ. **Left column** result from simulations with **METEO FRANCE** scheme with **Xu-Randall** cloudiness parameterization, **operational setting**. **Second column** stem from similar experiment but with **new setting of Xu-Randall**. **Third column** meteograms belong to **traditional ACNEBN** parameterization but with **SK-scheme added**.



For the whole period lifted fog was persisting at both locations. (compare also with satellite images) However only runs with SK-scheme are able to re-produce stratus close to reality. Not only 2m-temperatures, also several levels inside PBL are influenced in a consistant way.



Experiments with different parameterization

B) Low Cloudiness and 2m temperature charts

Series of charts on the left hand side show results after 12 hours integration, series of charts on the right hand side after 36 hours integration.

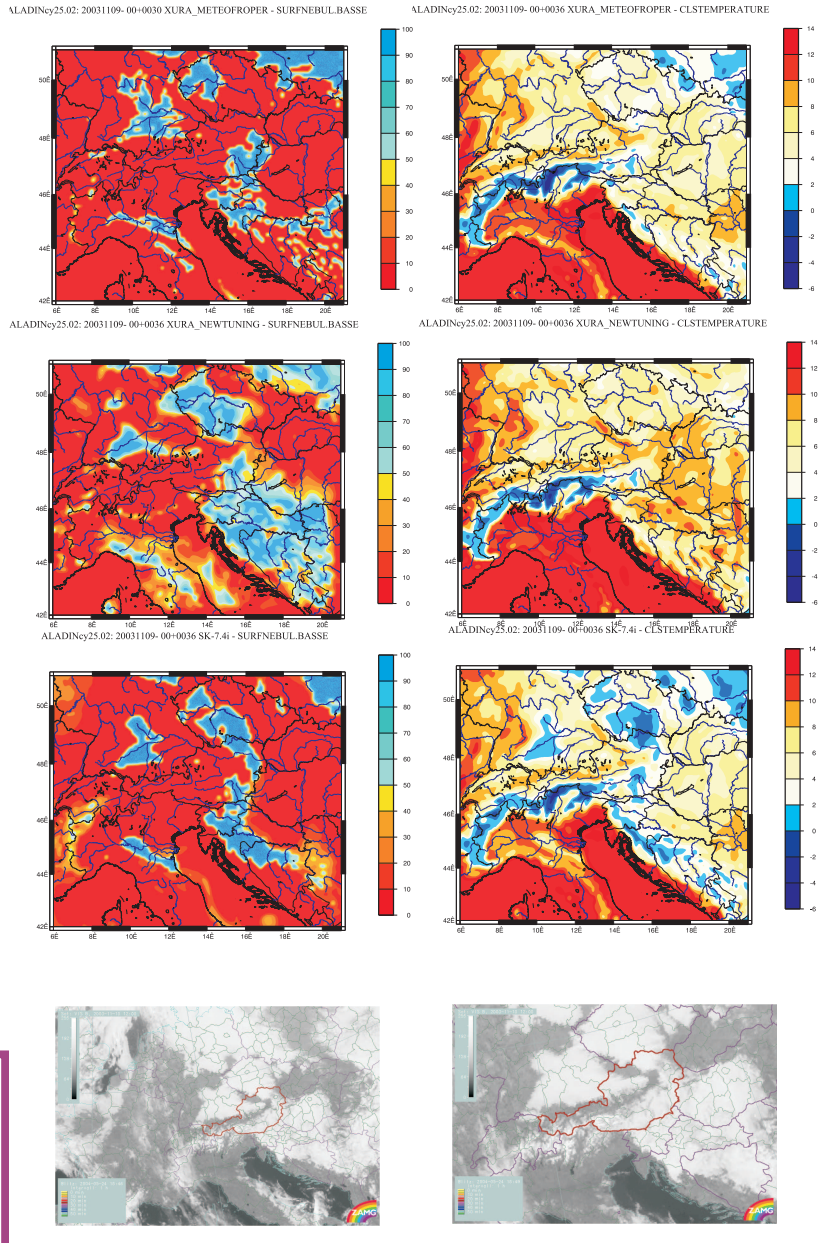
First row is for MeteoFrance, operational setting, second for MeteoFrance new tuning experiment and **third row for traditional ACNEBN + SK-scheme.**

Again, the positive effect of SK-stratus diagnosis scheme is quite obvious. It captures wide spread lifted fog area North, East and Southeast of the Alps rather well in comparison with Meteo France Xu-Randall settings. 2m-temperatures are responding consequently.

Still, not all of the lifted fog area is forecast with simulations.

Experiments with horizontal diffusion lead to further improvement of Stratus coverage. (Not part of this presentation)

NOTE: New tuning set results (second row of model charts) may look promising at first sight, but cloudiness hardly ever exceeds 80 per cent, so day-time 2m-temperatures remain much too high.



Conclusion & Outlook

With traditional cloudiness schemes Aladin was not able to simulate/develop a realistic vertical structure of temperature and humidity for typical winter type lifted inversions. The idea to enhance an already existing signal (quasi-saturation layer below an inversion) by means of SK-type schemes leads to a positive feedback loop reacting on radiative fluxes and thus also temperature. Future work should/will aim at a more realistic development of vertical profiles, where horizontal (T-)diffusion, but also vertical diffusion play an important role. As PBL cloudiness is not explicitly treated in schemes used by the Aladin community (e.g. Xu-Randall), they have similar deficiencies in low stratus diagnosis at this stage of physical parameterization. Prognostic liquid water could lead to improvements of cloudiness diagnosis, but, probably, a revision of physical parameterization AND changes of the cloudiness schemes (e.g. through re-tuning of vertical structure of critical humidity based on Central European observations, study of Thomas Haiden) are inevitable to increase the model performance concerning low stratus significantly.

References

Seidl H., Kann, A.: New approaches to stratus diagnosis in Aladin. Aladin Newsletter 22, July 2002.

Kann A.: One month parallel run of the Seidl-Kann cloudiness scheme. Aladin Newsletter 24, October 2003.

Xu K. M., Randall D. A., 1996b: A Semi-empirical Cloudiness Parameterization for Use in Climate Models. J. Atmos. Sci., **53**, 3084 - 3102.