ALADIN/HR: TESTING THE NEW RADIATION AND CLOUDINESS PARAMETRIZATION

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Abstract: Unsatisfactory model forecasts of 2m temperature and cloudiness in inversion cases with fog and low stratus clouds have encouraged research of alternative parametrization for these processes that could be used in the operational version of the Aladin model. Few computationally cheap modifications are introduced and tested. Different cloud schemes and cloud overlap assumptions play more important role than the modifications in the radiation scheme.

Keywords *Radiation, Cloudiness, Parametrization, Xu-Randall Scheme*

1. INTRODUCTION

For the cases of stable atmosphere with low-level inversion, low cloudiness and fog, the operational ALADIN/HR model does not predict the diurnal pattern of the surface temperature nor the low cloudiness well. Although the model initially recognizes the existence of the temperature inversion and an almost saturated state of the atmosphere adjacent to the ground, the cloudiness scheme is usually not able to diagnose neither low level cloudiness nor fog. Consequently, radiation scheme heats the ground and breaks the inversion, making the situation even worse.

There are several radiation schemes available in Aladin, the operational one (Geleyn and Hollingsworth, 1979), FMR (Morcrette 1989) and RRTM (Mlawer et al. 1997). The first one is very simple and computationally cheap and may be used at every time step. The other two are computationally expensive, so they could be called only every few hours. This is why the first scheme is used in the operational forecast and will be explored more in this study.

Alternative versions of cloudiness and radiation schemes have been introduced and tested on a synoptic case marked by a strong temperature inversion, low cloudiness and fog in inland part of Croatia, that lasted for several days. The results show significant improvement in the low cloudiness and the surface temperature (2m AGL) diurnal pattern for certain configurations.

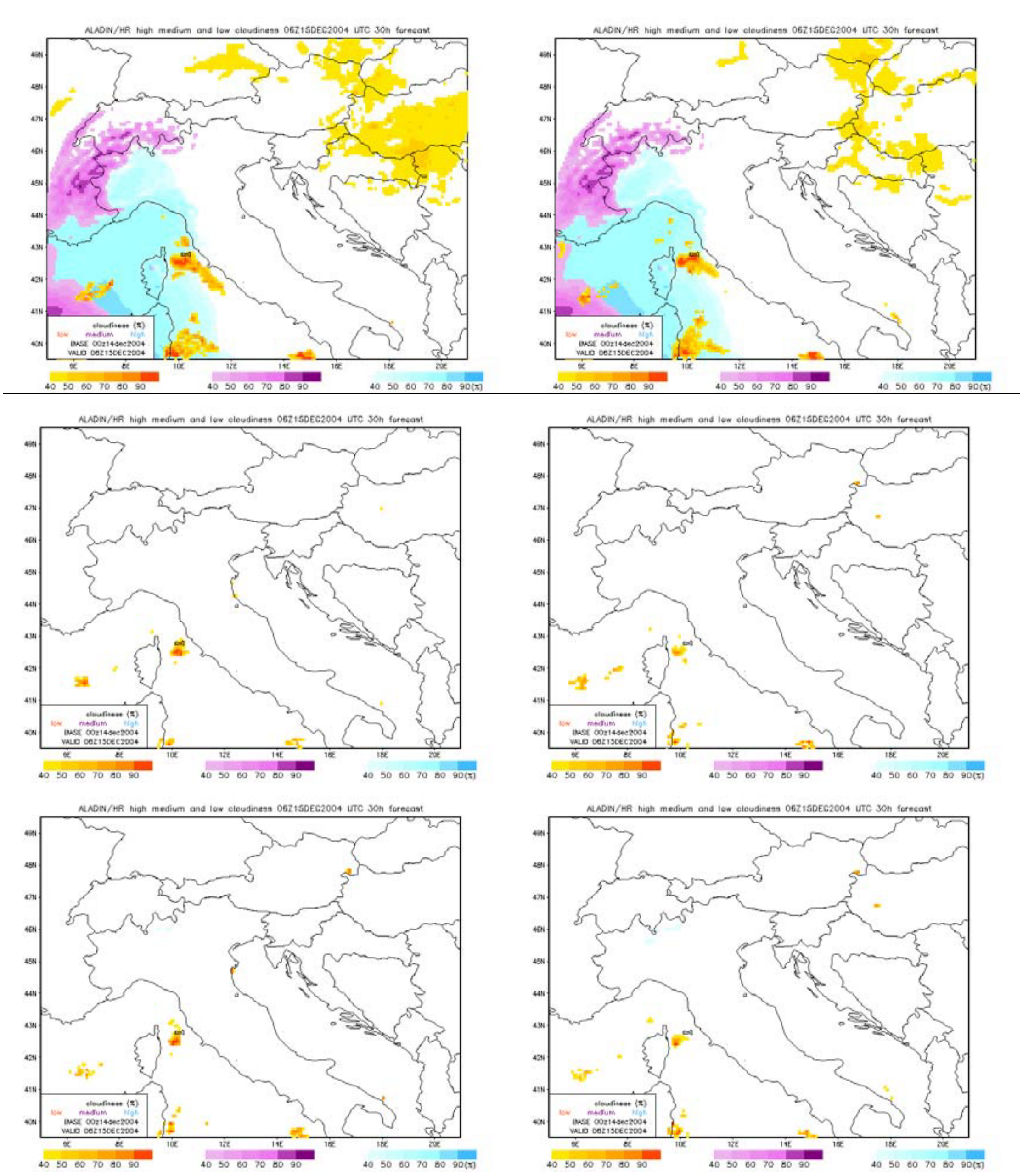
2. METHODS

The reference model version is described in Ivatek-Šahdan and Tudor (2004). The operational cloudiness parametrization results have been compared to the results from the scheme adapted from Xu and Randall (1996). Secondly, the operational radiation scheme has been enhanced (Bouyssel et al. 2003, Geleyn 2004) and the results have been compared to the one without the enhancements. In addition, the effect of different cloud overlap assumptions and modified vertical profile of critical minimum mesh averaged relative humidity producing a cloud has been tested.

The operational cloudiness scheme diagnoses cloudiness in such a way that if a parcel is oversaturated the amount of diagnosed cloudiness depends on oversaturation (cloudiness ranges from 0.7 to 1.0). Therefore e.g. a 0.7 cloudiness allows part of the radiation through. Therefore, the surface cools more during the night and warms more during the day giving pronounced diurnal pattern in surface temperature. In the morning this leads to the temperature rise due to heating, inversion breaking and eventual loss of cloudiness.

In the scheme adapted from Xu and Randall (1996) the oversaturated parcel has cloudiness equal to one. Therefore shortwave radiation is more efficiently reflected and longwave radiation is more efficiently absorbed. This helps in preserving the temperature inversion, fog and low stratus clouds.

If there are several layers of clouds with cloudiness less than one, the maximum overlap will vertically align these clouds in a way that they will be on top of each other, leaving a part of the column without clouds permiting radiation transfer. On the other hand, randomly overlapped clouds produce more total cloudiness and reduce the cloud free area in the grid cell.



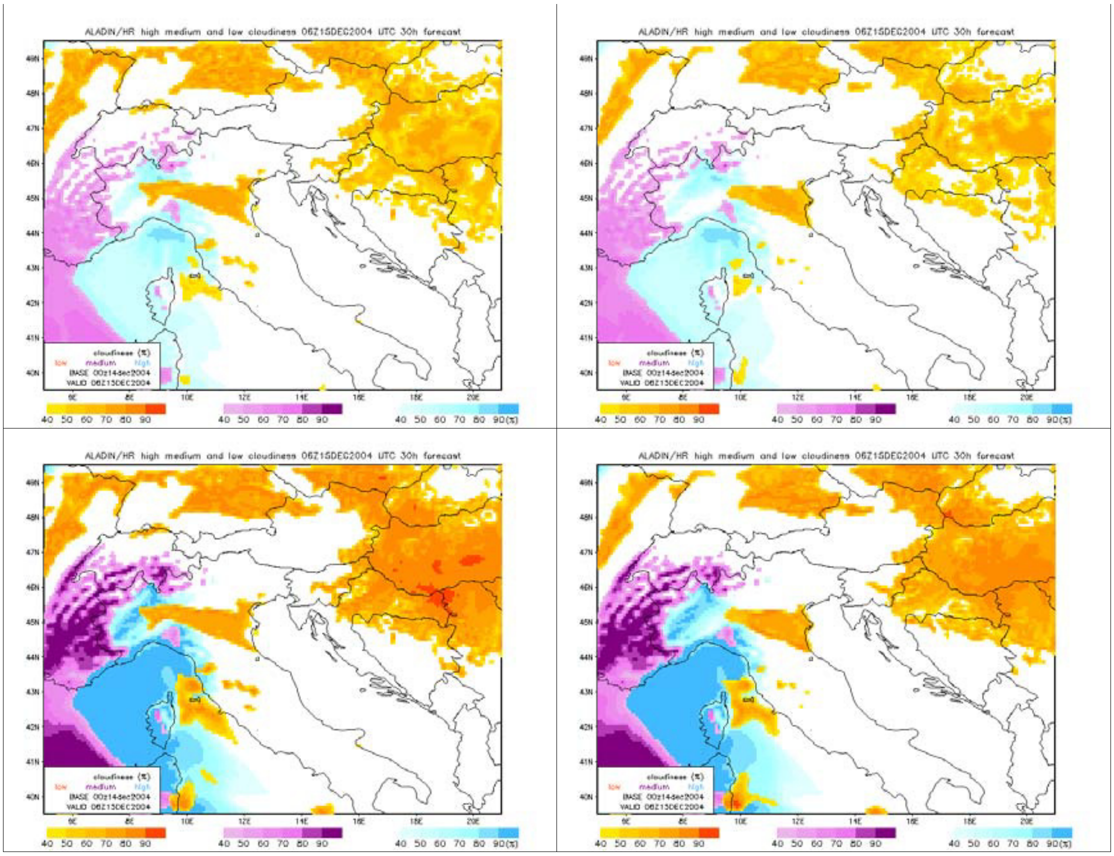


Figure 1. Low, medium and high cloudiness, with the operational (left) and enhanced (right) radiation scheme, operational critical relative humidity profile, cloudiness parametrization and random overlap (top row), random maximum overlap (second row), new critical relative humidity profile (third row), Xu-Randall cloudiness scheme (fourth row) and with random overlap (bottom row), (only the modifications to the setup of the previous row are listed).

3. RESULTS AND DISCUSSION

December 2004 has been characterized by long lasting fog in valleys inland. Results are shown for one run covering 2 days during that period. The 2m temperature varied very little during that period and showed no diurnal pattern. The reference forecast (most like the operational one) is the experiment 1 (exp1). It is shown that the new critical relative humidity profile has little impact. The use of random maximum overlap assumption when computing cloudiness significantly reduces the amount of clouds and even amplifies the diurnal variation of temperature. However, the introduction of the Xu-Randall cloudiness scheme gives more clouds and improves the 2m temperature forecast. Finally, the random overlap assumption produces even more clouds. Thus, the scheme with most clouds forecasts surface temperature that is closest to the measured data.

The operational radiation scheme with Xu-Randall cloudiness parametrization and random overlap assumption produces the thickest low cloud layer that reduces the night cooling and heating during the day. It still shows signs of diurnal variation but is closest to the measured data. Enhanced radiation increases the amplitude of the diurnal variation of temperature, which gives worse forecast in this case. It seems that the modification in the critical relative humidity profile does not play a significant role.

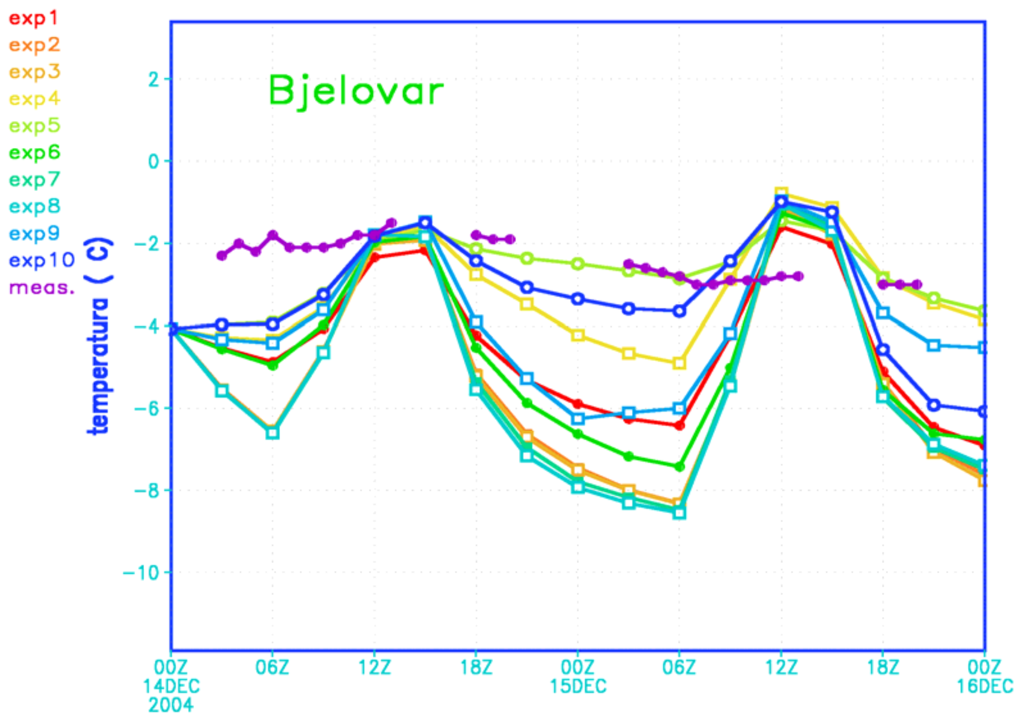


Figure 2. Comparison of the modelled 2m temperature evolution with measured data, exp1 to exp5 are obtained with the operational and exp6 to exp10 with enhanced radiation scheme, circles are with random maximum overlap and squares with random overlap, open marks are with operational and full marks with new critical relative humidity profile.

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