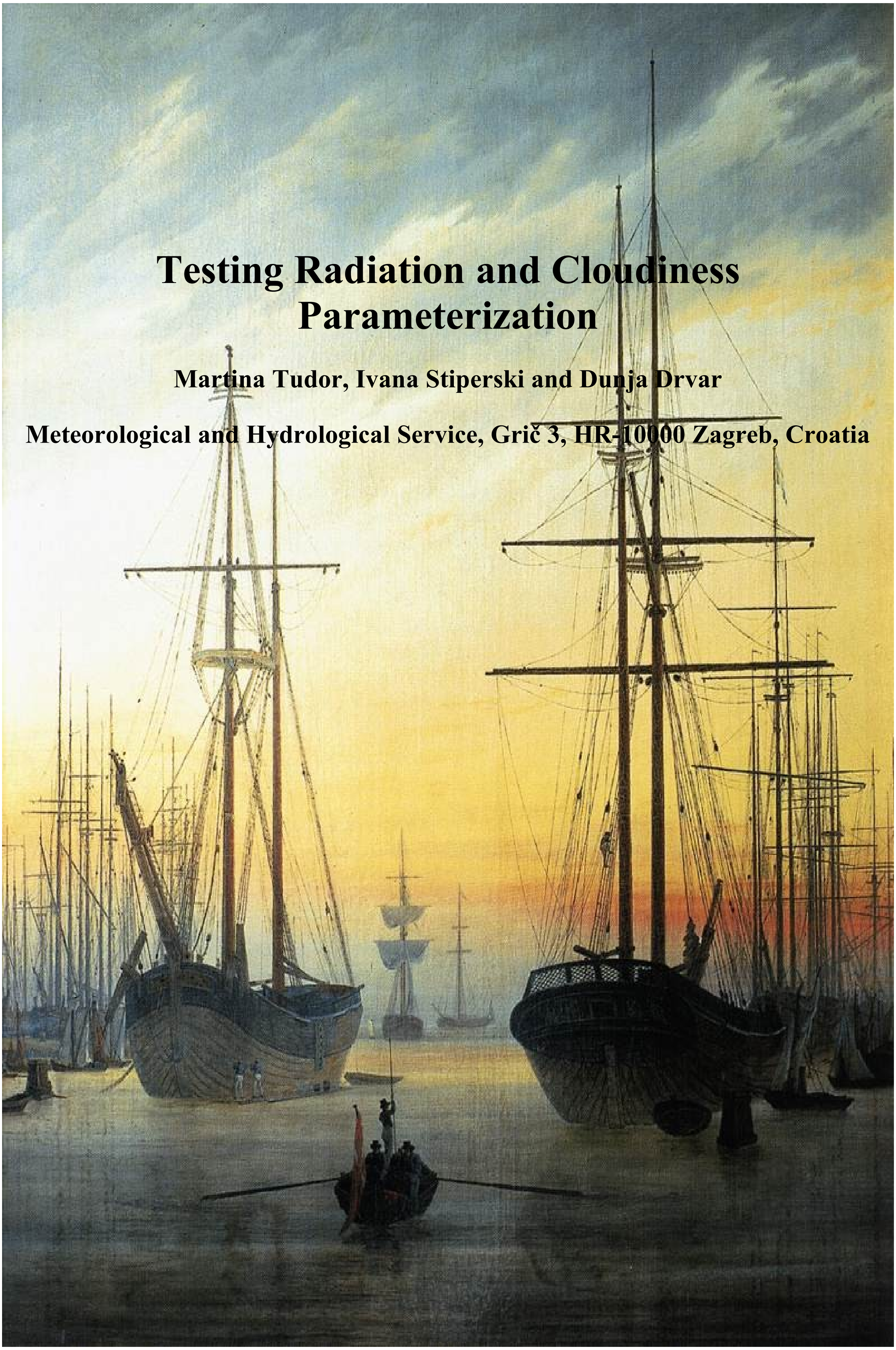
Testing Radiation and Cloudiness Parameterization

Martina Tudor, Ivana Stiperski and Dunja Drvar

Meteorological and Hydrological Service, Grič 3, HR-10000 Zagreb, Croatia



1. Summary

In cases of stable atmosphere with low-level inversion and low cloudiness or fog, the operational version of the ALADIN model does not predict enough low cloudiness and consequently the diurnal cycle of the 2m temperature is too pronounced. Different cloud schemes and cloud-overlap assumptions play a more important role in the 2m temperature prediction than the modifications in the radiation scheme.

2. Introduction

For the cases of stable atmosphere with low-level inversion, low cloudiness and fog, the operational ALADIN 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 unable to diagnose either low-level cloudiness or fog. Consequently, radiation scheme heats the ground and breaks the inversion, making the situation even worse.

3. Methods

There are several radiation schemes available in ALADIN, the currently 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.

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 have been tested.

The operational cloudiness scheme diagnoses cloudiness in such a way that if a parcel is over-saturated the amount of diagnosed cloudiness depends on over-saturation (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 over-saturated parcel has cloudiness equal to one. Therefore short-wave radiation is more efficiently reflected and longwave radiation is more efficiently absorbed. This helps to preserve 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 such a way that they will be on top of each other, leaving a part of the column without clouds permitting radiation transfer. On the other hand, randomly overlapped clouds produce more total cloudiness and reduce the cloud free area in the grid cell.

Random maximum is an intermediate method when maximum overlap is used for continuous cloud levels and random overlap when clouds are not continuous in the vertical.

4. 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 similar to the operational one) is the experiment 1 (exp1). 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 a 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.

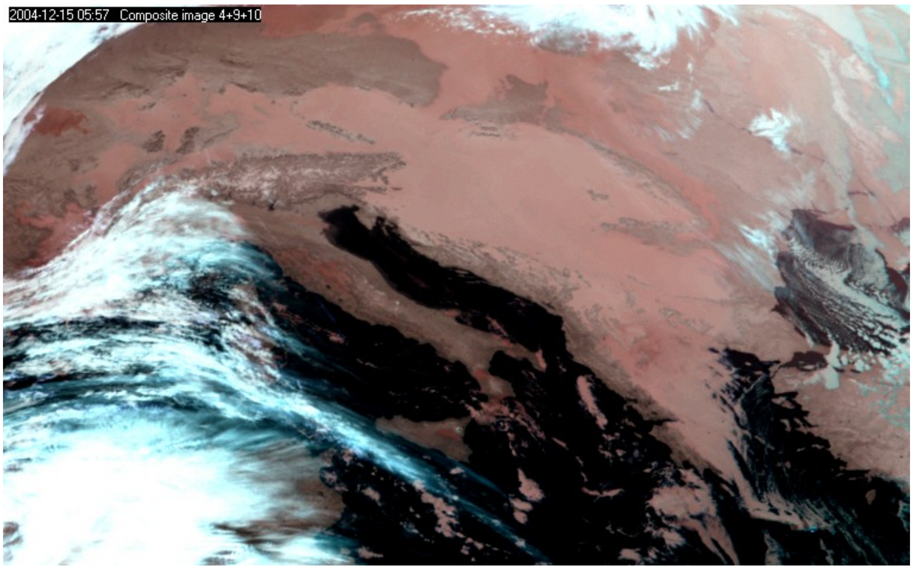


Figure 1. Meteosat-8 RBG composite of channels 3.9, 10.8 and 12.0 µm for December 15th 2004, 06 UTC. Fog or low clouds over Southeastern Europe are clearly visible.

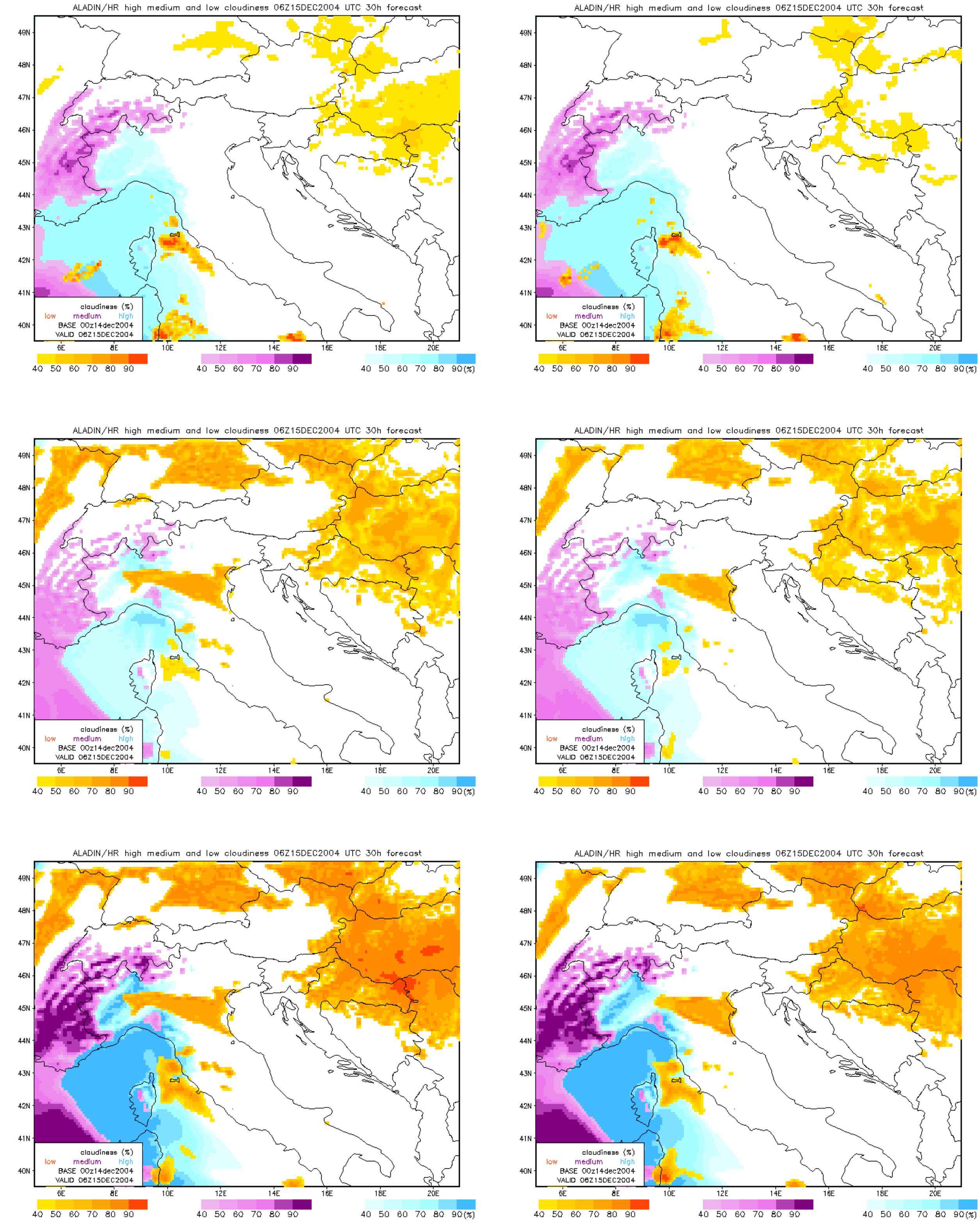


Figure 2. Low, medium and high cloudiness, with the operational (left) and NER (right) radiation scheme, operational critical relative humidity profile, cloudiness parametrization and random overlap (top row), random maximum overlap (second row), Xu-Randall cloudiness scheme and random overlap (bottom row), (only the modifications to the setup of the previous row are listed).

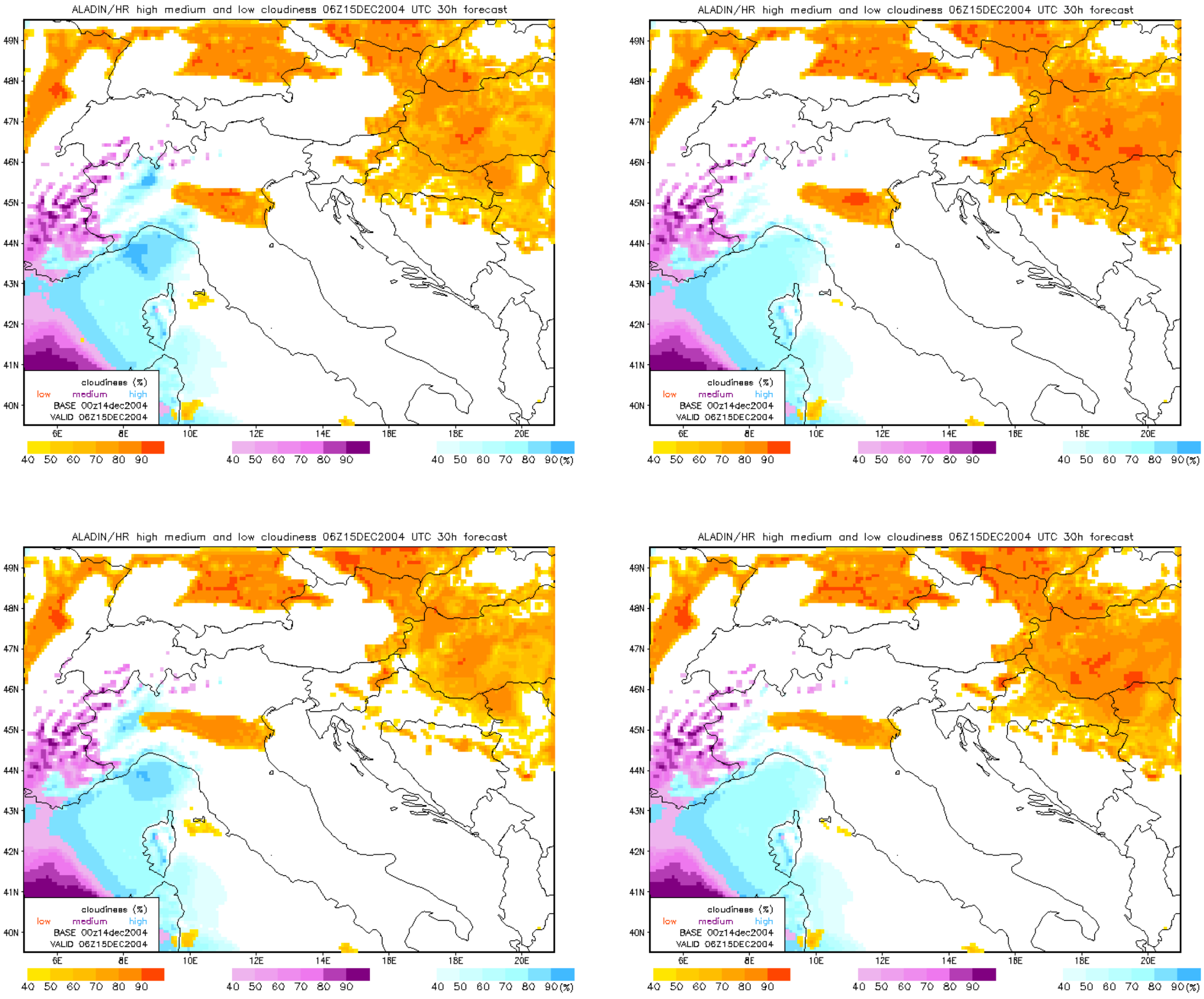


Figure 3. Low, medium and high cloudiness, with FMR radiation scheme called with 1 hr (top row) and 3 hr interval (bottom row), with maximum (left) and random overlap (right) and Xu-Randall cloudiness scheme, 30 hour forecast starting 00 UTC 14th December 2004.

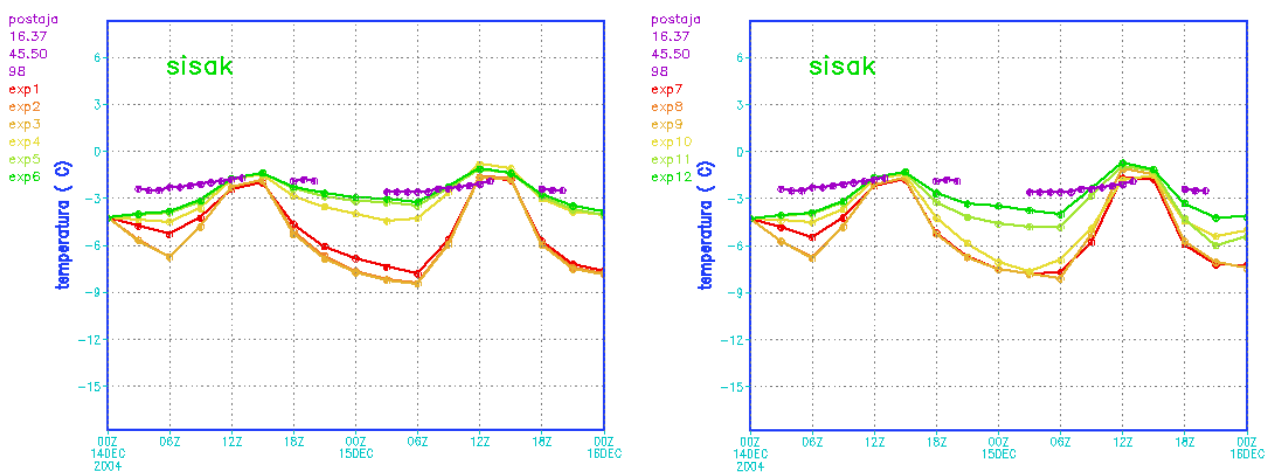


Figure 4. Comparison of the modelled 2m temperature evolution for 00 UTC run on 14th December 2004 with measured data from synoptic station with operational radiation scheme (left) and including NER (right),

reference, rand max, rm+new RH, XR cloud, random, old RH .

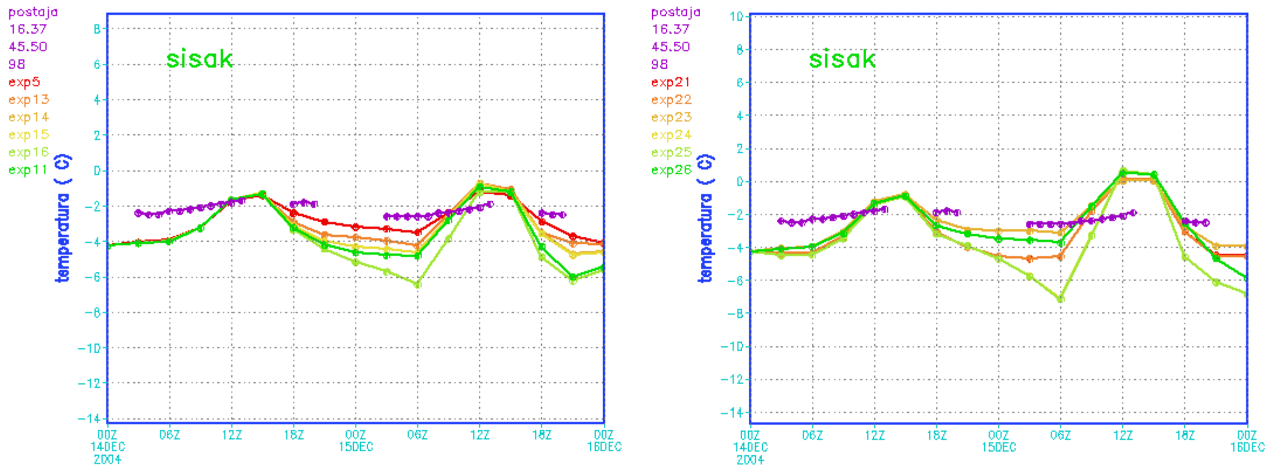


Figure 5. Comparison of the modelled 2m temperature evolution for 00 UTC run on 14th December 2004 with measured data from synoptic station with only parts of NER (left, **reference**, **LRMIX, LRPROX, LRSTAB, LRTDL, NER**) and FMR (right, **max, 1hr, r-max, 1hr, rand, 1hr, max, 3hr, r-max, 3hr, rand, 3hr**).

5. Conclusion

Alternative versions of cloudiness and radiation schemes have been 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.

New relative humidity profile only slightly increases low cloudiness. Random maximum overlap significantly reduces the amount of clouds and amplified the diurnal variation of temperature when compared to the random overlap results. Xu-Randall cloudiness scheme gives more clouds and improves 2m temperature forecast. More sophisticated radiation schemes did not improve results.

Unsatisfactory model fog forecast has encouraged a study of alternative radiation and cloudiness schemes combined with different cloud overlap assumptions. The parameterization of cloudiness seems more important than the radiation parameterization for better forecast of 2m temperature.

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