Near Maximum Overlap Version for ACNPART

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1 Introduction

Diagnostics of total and partial cloud cover (low, medium, high and convective) is computed in subroutine *ACNPART* out of 2D radiative cloudiness fraction array $PNEB$ (and $PNEBC$). In *ACNPART* there are two possibilities implemented for the computation of total and partial cloud coverage: LRNUMX=.FALSE. for random overlap of adjacent clouds assumption and LRNUMX=.TRUE. for maximum overlap of adjacent clouds. When using the maximum overlap assumption (within ALARO-0 environment) a significant underestimation of cloud cover can be observed. Figure 1 shows the relative frequencies for total cloud covers (for 9 stations

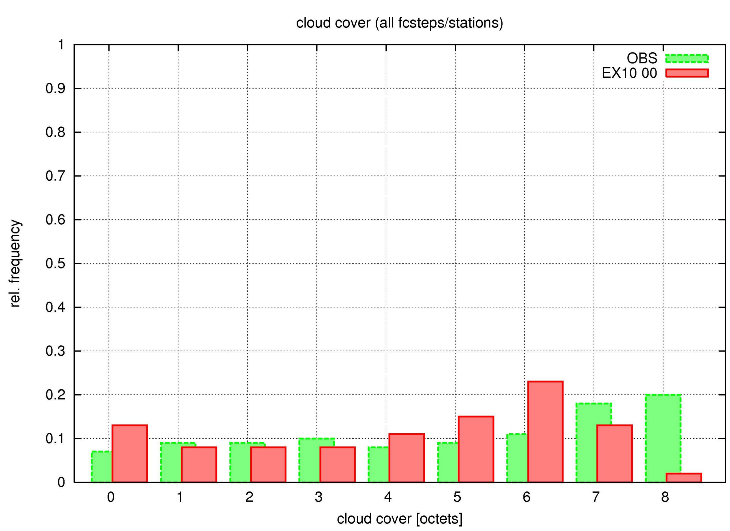

Figure 1: Relative frequencies for total cloud cover; green/OBS: observation, red/EX10: ALARO-0 (with 3MT) using maximum overlap assumption for cloud diagnostics.

in Austria including all forecast steps) for ALARO-0 (with 3MT and LRNUMX=.TRUE.), the considered period is June 2008. The histogram shows that the occurrence of cloud covers near 100% is cleary underestimated with respect to the observed frequencies. Figure 2 shows the relative frequencies coming from current operational ALADIN-AUSTRIA model (using ALARO-0 without 3MT and LRNUMX=.FALSE.). Cloud covers near 100% are represented much better. In order to increase the quality of total and partial cloud cover diagnostics when using the maximum overlap assumption within the 3MT environment the routine $ACNPART$ was modifed by introducing a "near" maximum overlap solution. The modifications are described in chapter

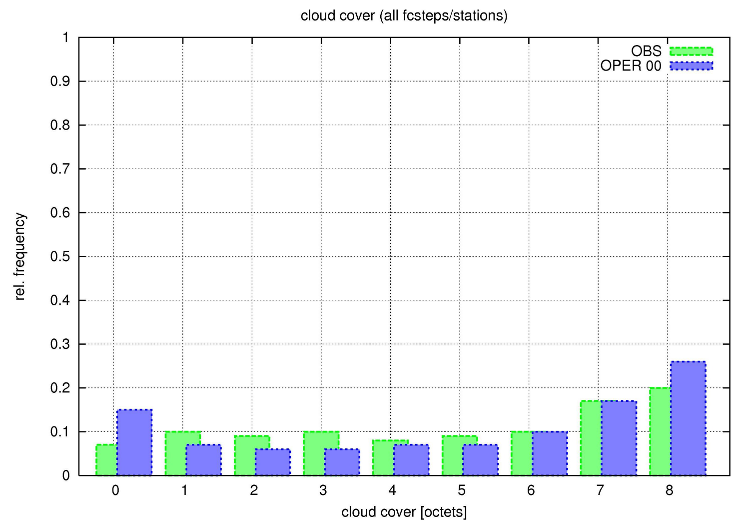

Figure 2: Relative frequencies for total cloud cover; green/OBS: observation, blue/OPER: ALARO-0 (without 3MT) using random overlap assumption.

2, the results are finally shown in chaper 3. It is important to underline that the modification shown in the next section does not affect any other model fields except the 1D fields for total and partial cloud cover, being without any importance for the model itself (but having great value for any downstream applications).

2 Modification of $ACNPART$

Using LRNUMX (maximum overlap of adjacent clouds), cloud cover $PFPLC[X]$ (with $[X] = T$ for total, $[X] = L$ for low, $[X] = M$ for medium, $[X] = H$ for high and $[X] = C$ for convective cloudiness) is diagnosed in routine $ACNPART$ following

$$PFPLC[X] = 1 - \prod_{l=n_{[X]}}^{m_{[X]}} \frac{1 - max(n^l, n^{l-1})}{1 - n^{l-1}} \tag{1}$$

with n being the 2D array for radiative cloud fraction $PNEB$. For convective cloudiness, n has to be replaced by n_c (being $PNEBC$ in the code).
For random overlap (LRNUMX=.FALSE.) the formulation is

$$PFPLC[X] = 1 - \prod_{l=n_{[X]}}^{m_{[X]}} (1 - n^l). \tag{2}$$

The intention for the modification was to find some intermediate solution between random (slight overestimation of cloudiness) and maximum overlap formulation (significant underestimation of cloudiness) for total and partial cloud cover computation, as this should lead to a realistic representation of cloud cover frequencies. This intermediate solution can be found the following way:
The term $\frac{1-max(n^l,n^{l-1})}{1-n^{l-1}}$ in equation (1) can also be expressed through $\frac{min(1-n^l,1-n^{l-1})}{1-n^{l-1}}$. The formal transition between maximum overlap and random overlap formulation can be then expressed through

$$(1 - n^l) = \lim_{\epsilon \to 0} \frac{min(1 - n^l, 1 - \epsilon n^{l-1})}{1 - \epsilon n^{l-1}}. \tag{3}$$

For $\epsilon = 0$, the expression for maximum overlap reduces to the one for the random overlap case. Routine $ACNPART$ was finally modified by introducing a new logical switch named LACPANMX activating a modified computation for total, low, medium, high and convective cloud cover

$$PFPLC[X] = 1 - \prod_{l=n_{[X]}}^{m_{[X]}} \frac{min(1 - n^l, 1 - \epsilon n^{l-1})}{1 - \epsilon n^{l-1}} \tag{4}$$

with ϵ being $WMXOV$ (weight for maximum overlap) in the code. Tests showed that $WMXOV = 0.8$ is a suitable value, being somehow a "near maximum overlap" solution.

3 Results with LACPANMX

The new formulation for total and partial cloud cover activated via switch LACPANMX was finally tested for June 2008. Figure 3 shows the relative frequencies for total cloud cover. It can be clearly seen that the modification yields a more realistic representation of the observed cloud cover "climatology" than the ones shown in Figure 1. There is even a small improvment with respect to the current operational version shown in figure 2. To verify the benefit of the

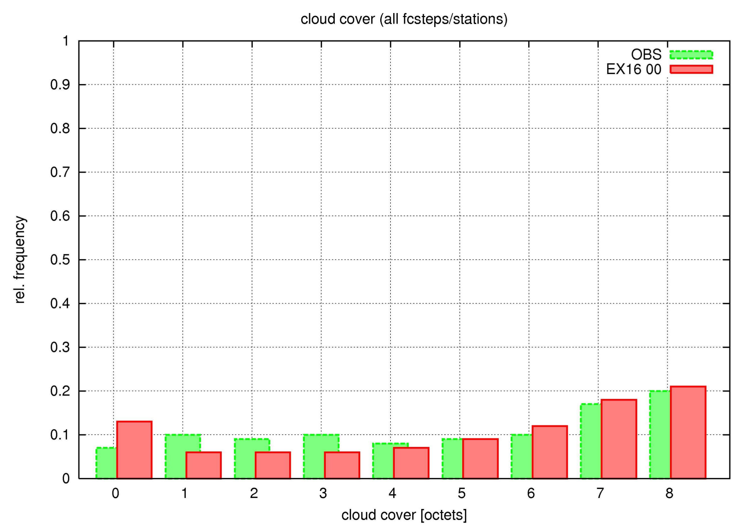

Figure 3: Relative frequencies for total cloud cover; green/OBS: observation, red/EX16: ALARO-0 (with 3MT) using "near" maximum overlap solution.

new formulation for a period in winter, the three versions were also compared for January 2009. Figures 4, 5 and 6 show the total cloud cover frequencies for the winter period. All three versions tend to underestimated the occurence of cloud covers near 100%. The reason is that all versions missed a significant number of low stratus situations. Anyway, the cloud cover "climatology" of the near maximum overlap formulation in figure 4 comes closer to observed frequencies than the original formulation (figure 6). The reason for all three versions yielding cloud cover frequencies being more similar than during the summer period shown above, is that all three versions are using the Seidl-Kann sub-inversions scheme increasing the occurence of cases with cloud covers near 100% significantly.

4 Short summary and Acknowledgement

The present report shows that a small modification in the subroutine $ACNPART$ brings improvements of the total and partial cloud cover diagnostics within the ALARO-0 environment while keeping all the benefits resulting from the introduction of 3MT and further LRNUMX. The modifications just affect 1D model fields being not used in the model itself for any further purpose. But the value for downstream applications is big, as total and partial cloud covers are of great importance for customers and forecasters.

Finally i would like to thank Thomas Haiden for the fruitful and inspiring discussions on this topic which finally led to the implementation of the the near maximum overlap formulation.

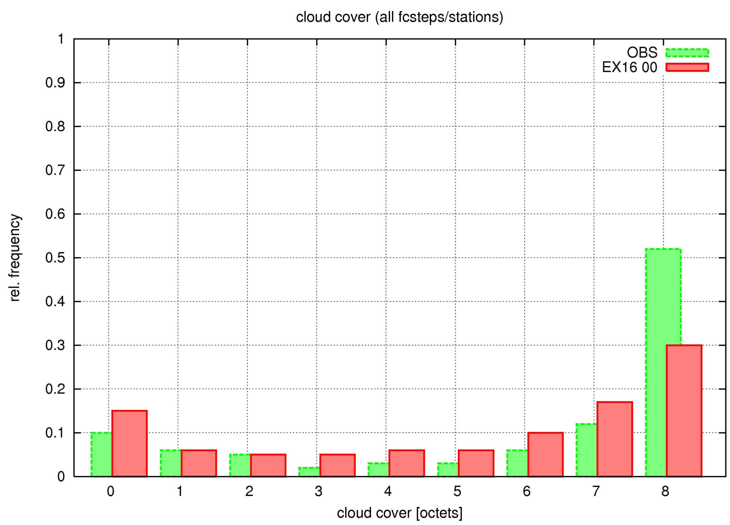

Figure 4: Relative frequencies for total cloud cover; green/OBS: observation, red/EX16: ALARO-0 (with 3MT) using ”near” maximum overlap solution.

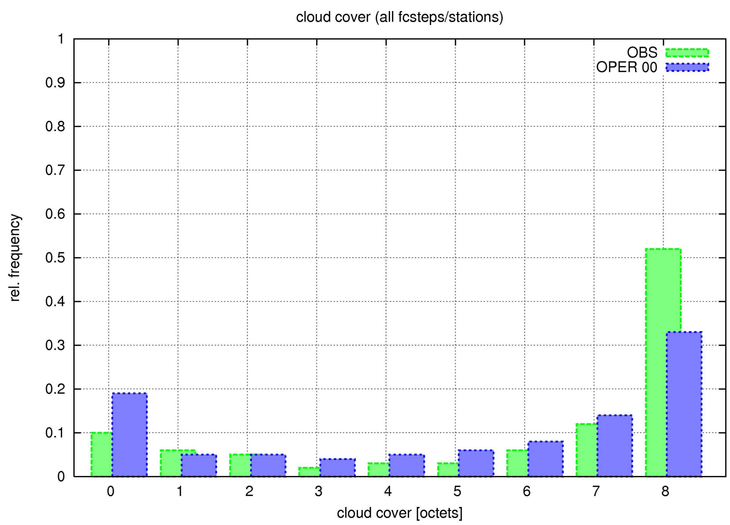

Figure 5: Relative frequencies for total cloud cover; green/OBS: observation, blue/EX16: ALARO-0 (without 3MT) using random overlap solution.

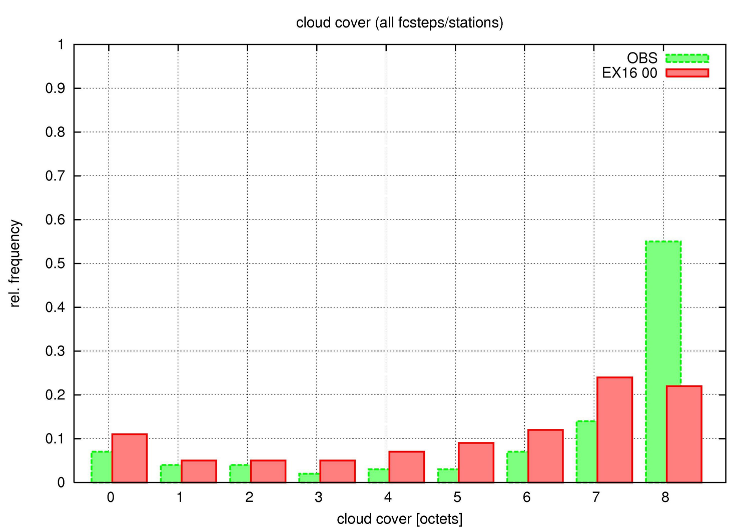

Figure 6: Relative frequencies for total cloud cover; green/OBS: observation, EX16: red/ALARO-0 (with 3MT) using maximum overlap solution.