Evaluation of different AROME shallow cumulus convection schemes on the convective situation 4 of June of 2005

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1. Introduction

The objective of this work is to evaluate different AROME shallow cumulus convection schemes in particular the current version of AROME and the experimental versions EDMF OLDN (Soares et *al*., 2004), EDKF OLD and EDKF NEWN.

2. Data and methodology

In order to make this evaluation, simulations with the above mentioned versions of AROME were made for the convective situation occurred in the southwest of France on 4 of June of 2005. These simulations were made on OLIVE for the coupling part and the forecast part. However, due to some problems with the fullpos part the historical files were converted in MesoNH files and after plotted as gmeta files.

On the next sections, some comparisons between Cloud Fraction forecasts, Cloud Water forecasts, Zonal Wind Component forecasts and Meridional Wind Component forecasts obtained from each one of the AROME versions will be done.

3. Comparison of the fields derived from the different versions of AROME

3.1 Cloud fraction forecasts for 12h

Heights 1000 /1500 m

The current version of AROME (REF version) forecasts larger areas of Cloud Fraction (CF) with high values of this parameter (fields at 1000m on Figures 1-4). This result was already expected and is derived from its cloud shallow convection scheme.

Contrary to the other versions, REF version does not forecast CF in the northern border of the domain what can be considered unrealistic being account the detected low clouds on the visible satellite image at 12:30UTC (Figure 5).

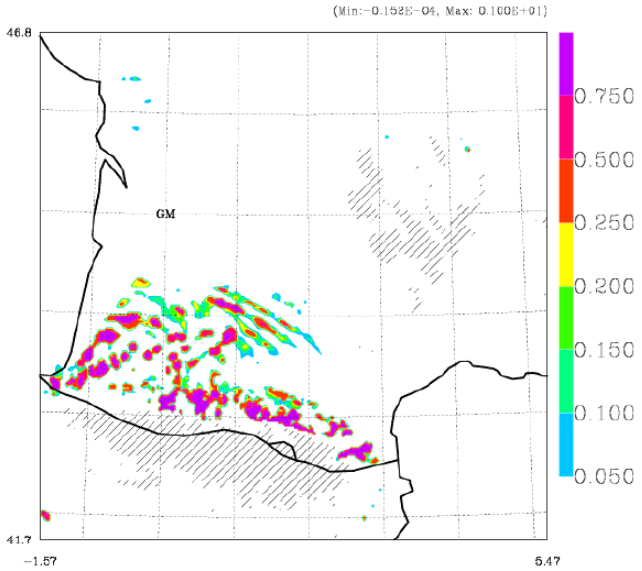

Figure 1. REF version (AROME), run 00UTC: Cloud Fraction at 1000m for 12h.

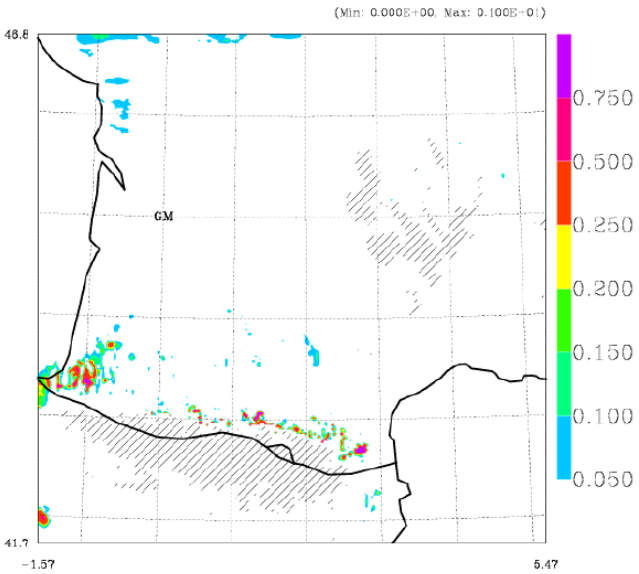

Figure 2. As Figure 1, but using EDMF OLD version.

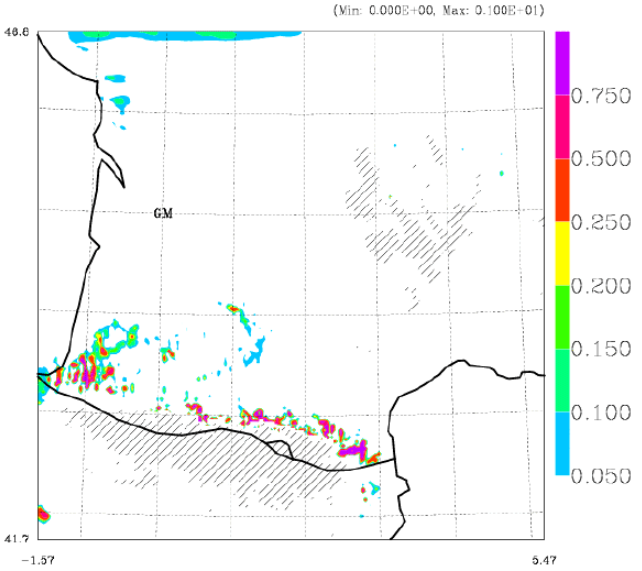

Figure 3. As Figure 1, but using EDKF OLDN version.

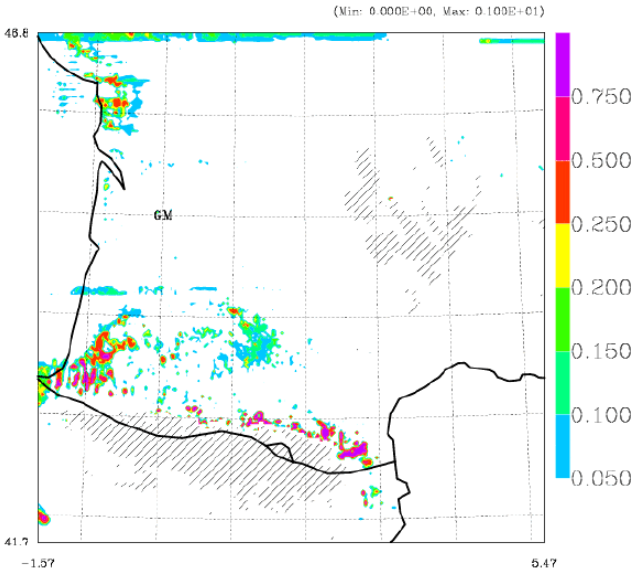

Figure 4. As Figure 1, but using EDKF NEWN version.

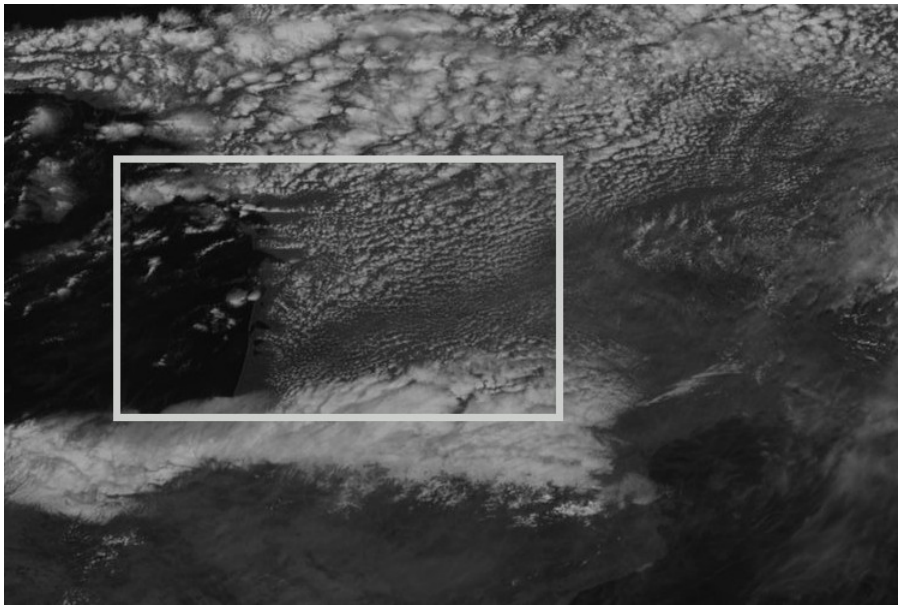

Figure 5. Visible MSG high resolution satellite image at 12:30UTC (extracted from H. Gwen, 2006)

At 1500m the region of CF increases in all the models (Figures 6-9), showing EDKF NEWN version a larger zone of CF constituted by broken up areas of the field.

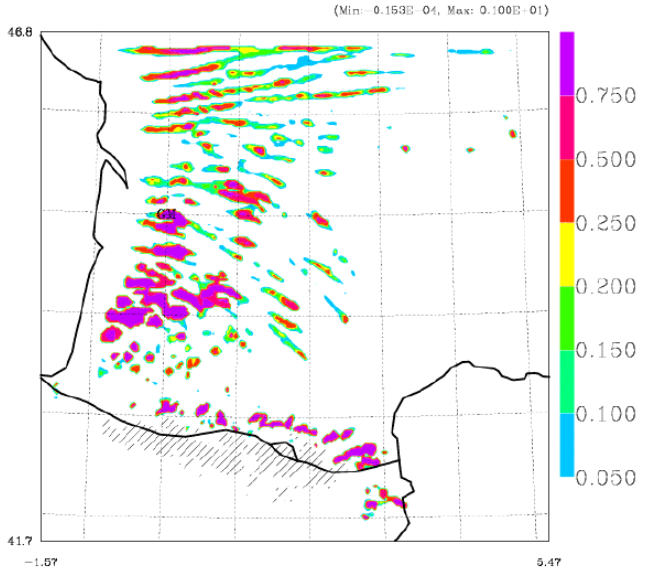

Figure 6. REF version (AROME), run 00UTC: Cloud Fraction at 1500 m for 12h.

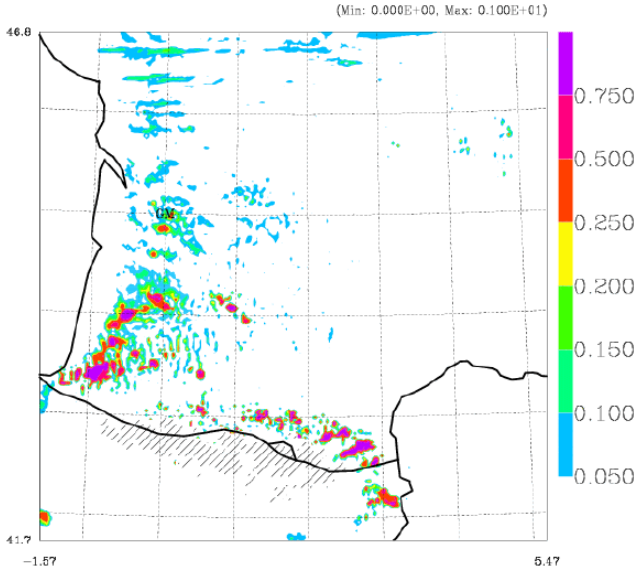

Figure 7. As Figure 6, but using EDMF OLD version.

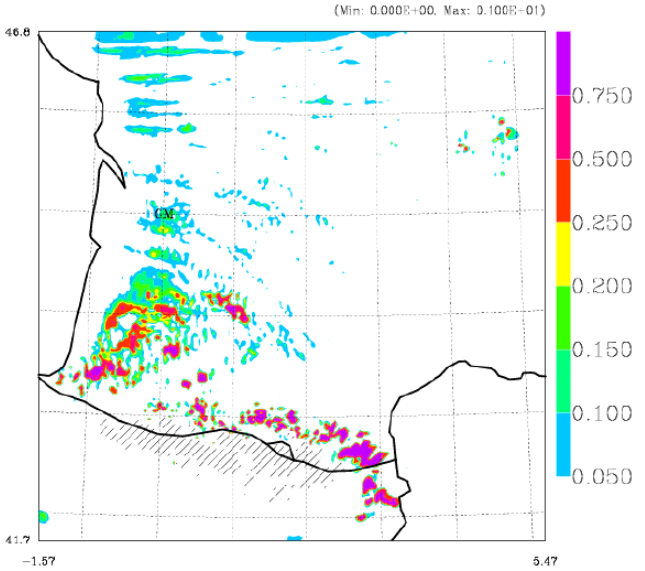

Figure 8. As Figure 6, but using EDKF OLDN version

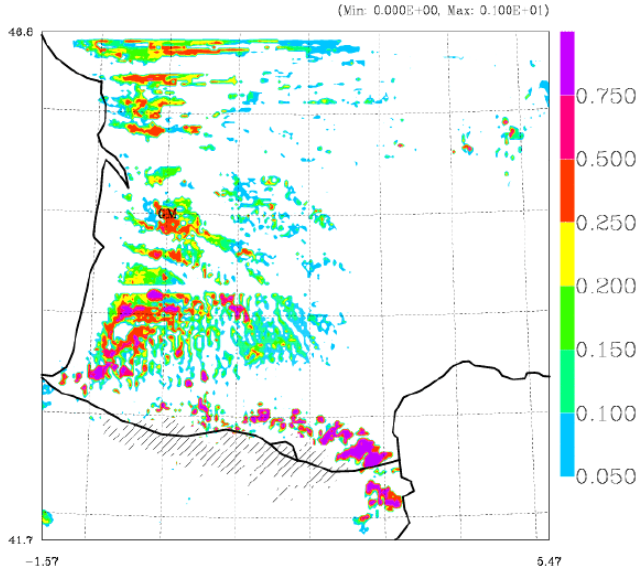

Figure 9. As Figure 6, but using EDKF NEWN version

Height 2000 m

At this height EDKF NEWN version is similar to EDKF OLDN version close to the Pyrenees (Figures 10-13). However, EDKF NEWN version produces a larger region of CF than the other versions, special on the northern part of the domain.

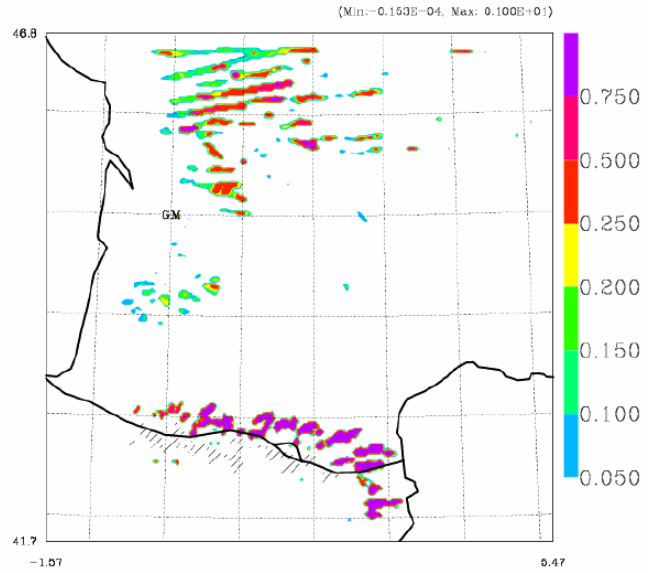

Figure 10. REF version (AROME), run 00UTC: Cloud Fraction at 2000 m for 12h.

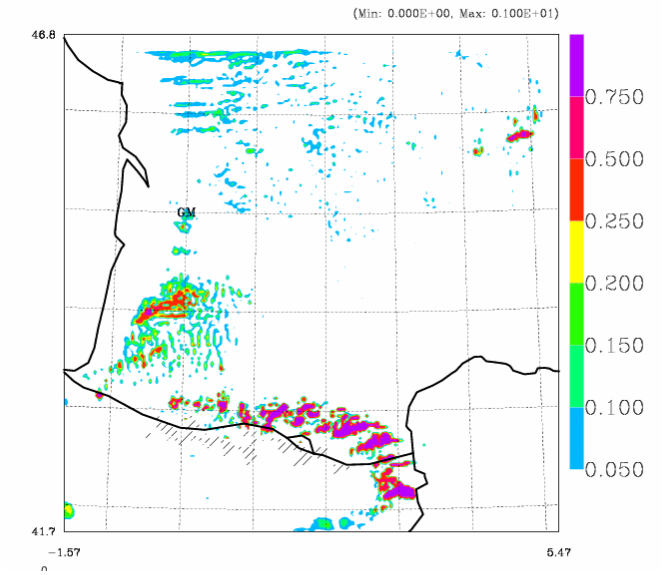

Figure 11. As Figure 10, but using EDMF OLD version.

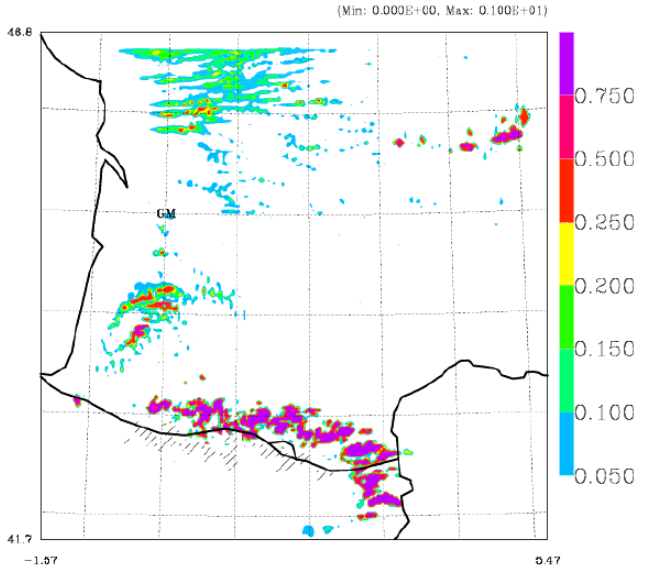

Figure 12. As Figure 10, but using EDKF OLDN version.

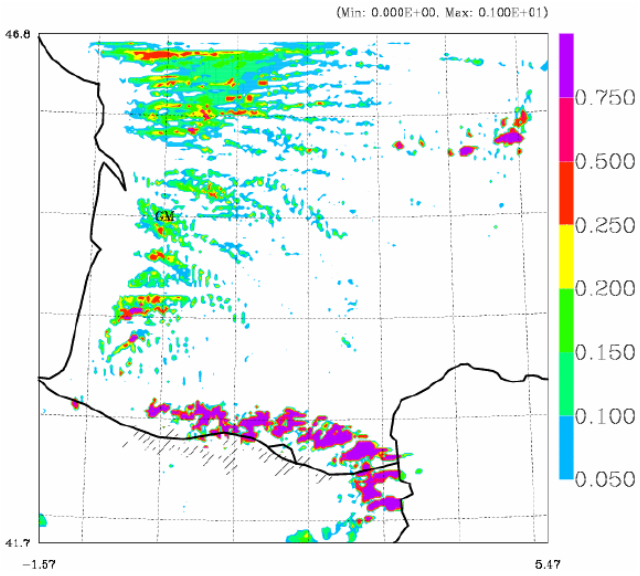

Figure 13. As Figure 10, but using EDKF NEWN version.

Heights 2500 /3000 m

At these heights the REF version presents smaller areas of CF than the other versions (fields at 3000m on Figures 14-17).

Contrarily to the other versions, the current version does not forecasts CF over the Mediterranean sea. This may be considered a more realistic result taking account the inexistence of clouds at these levels (Figure 1).

The EDKF OLDN, EDKF NEWN and EDKF OLDN versions have very similar forecasts.

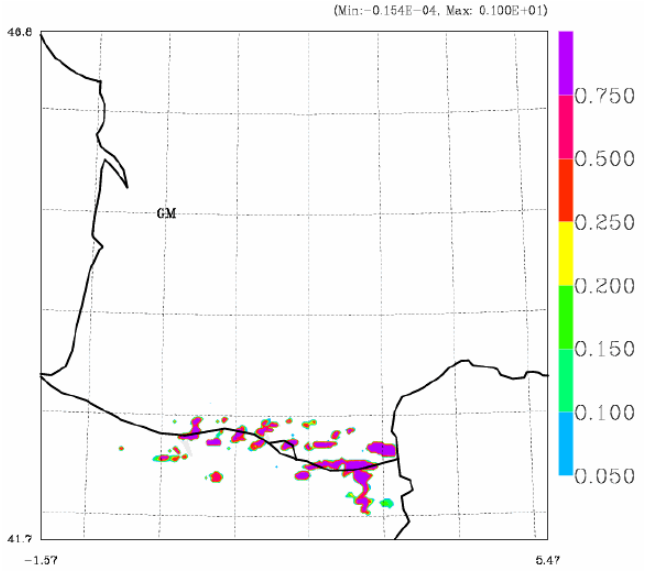

Figure 14. REF version (AROME), run 00UTC: Cloud Fraction at 3000m for 12h.

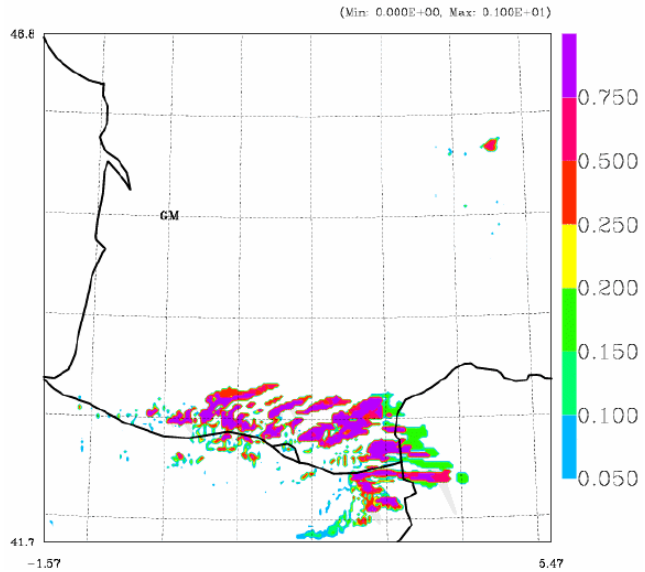

Figure 15. As Figure 14, but using EDMF OLD version.

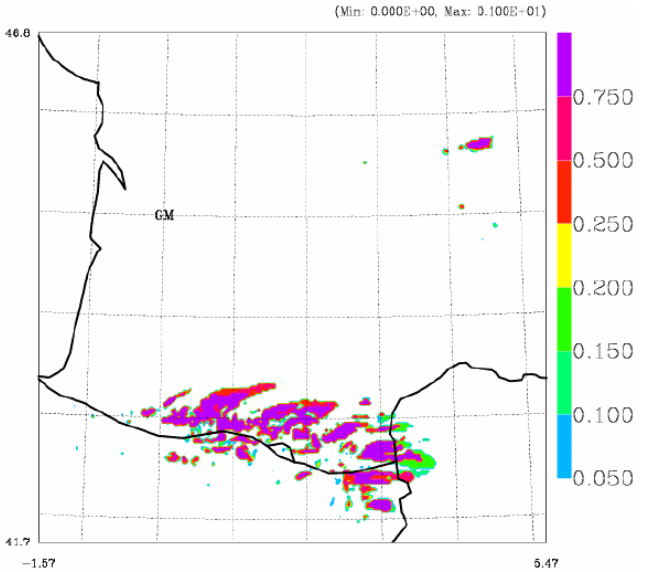

Figure 16. As Figure 14, but using EDKF OLDN version.

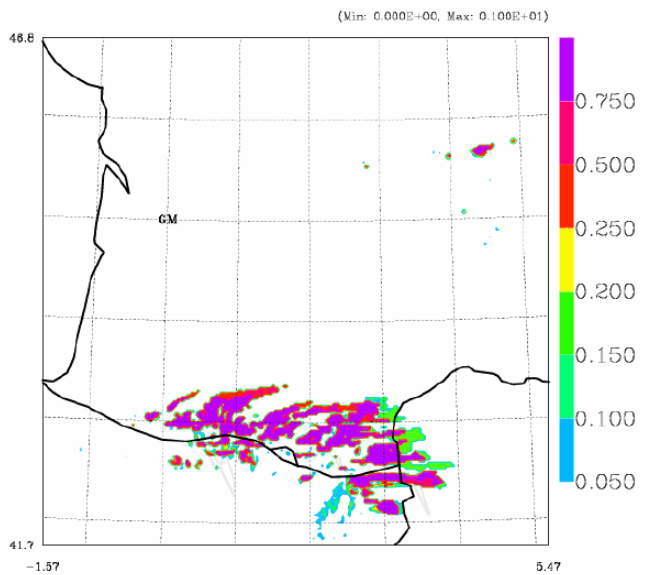

Figure 17. As Figure 14, but using EDKF NEWN version.

3.2 Cloud Water forecasts for 12h

Heights 1000/1500 m

As for Cloud Fraction, the current version of AROME forecasts larger areas of Cloud Water (CW) with high values of this parameter what represents a worth result derived from its cloud shallow convection scheme.

At 1500m the region of CW increases in all the models (Figures 18-21) consistent with the CF field.

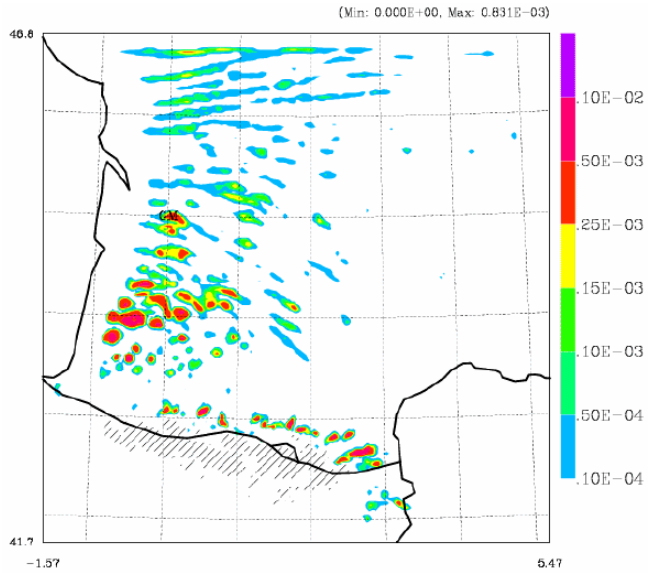

Figure 18. REF version (AROME), run 00UTC: Cloud Water at 1500m for 12h.

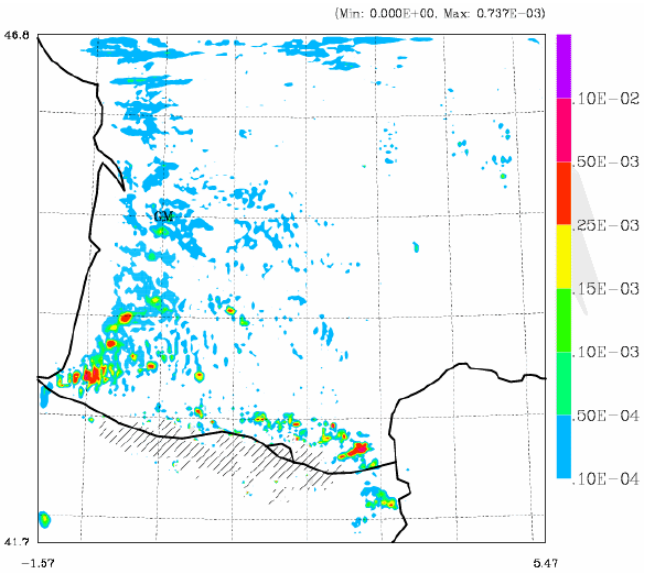

Figure 19. As Figure 18, but using EDMF OLD version.

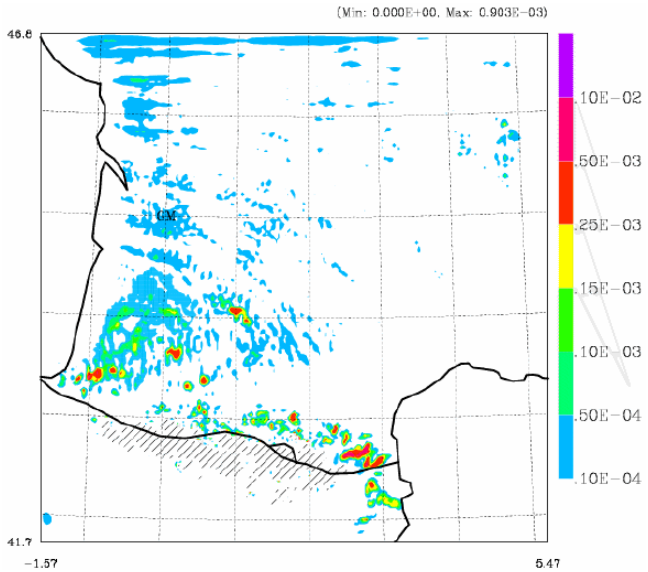

Figure 20. As Figure 18, but using EDKF OLDN version.

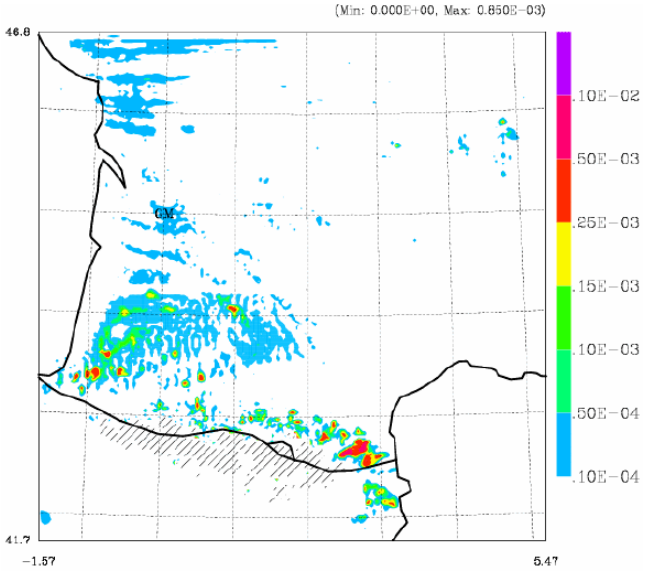

Figure 21. As Figure 18, but using EDKF NEWN version.

Heights 2000/2500/3000 m

At these levels REF version presents a smaller zone of CF than the other versions (fields at 3000m on Figures 22-25).

Contrarily to the other versions, REF version does not forecasts CW over Mediterranean sea at 2500m and 3000 m.

The EDKF OLDN, EDKF NEWN and EDKF OLDN versions have very similar forecasts.

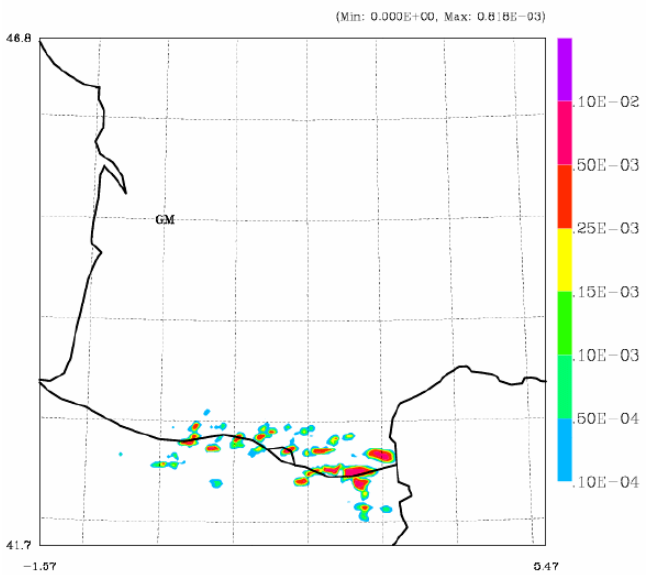

Figure 22. REF version (AROME), run 00UTC: Cloud Water at 3000m for 15h.

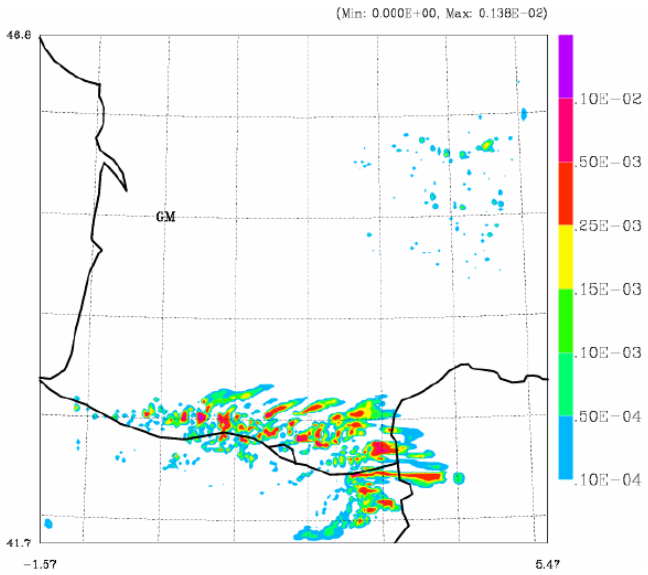

Figure 23. As Figure 22, but using EDMF OLD version.

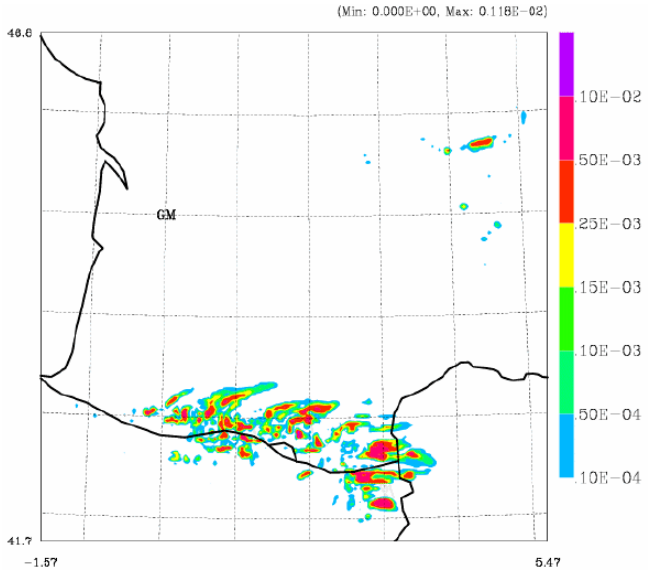

Figure 24. As Figure 22, but using EDKF OLDN version.

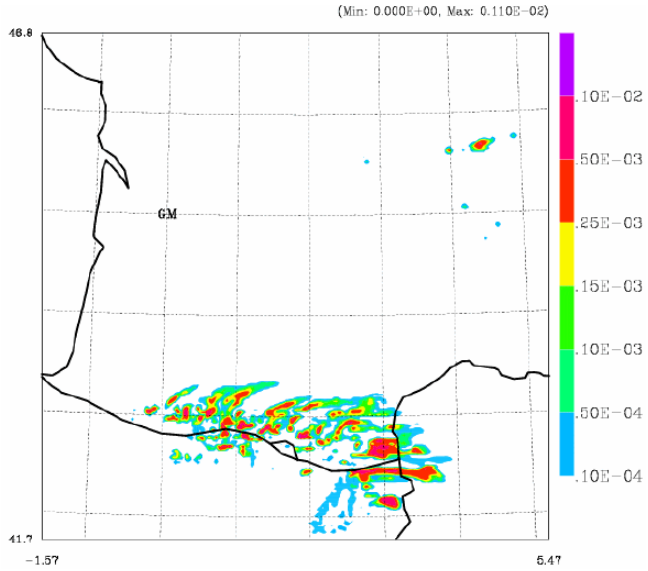

Figure 25. As Figure 22, but using EDKF NEWN version.

3.3 Zonal component and meridional component of horizontal wind forecasts for 12h

By the comparison of the zonal vertical wind profiles at the point 43.2N 0.5W forecasted for 12h it can be conclude that the ones derived from the experimental versions are very similar to the one derived from the REF version (Figures 26-29).

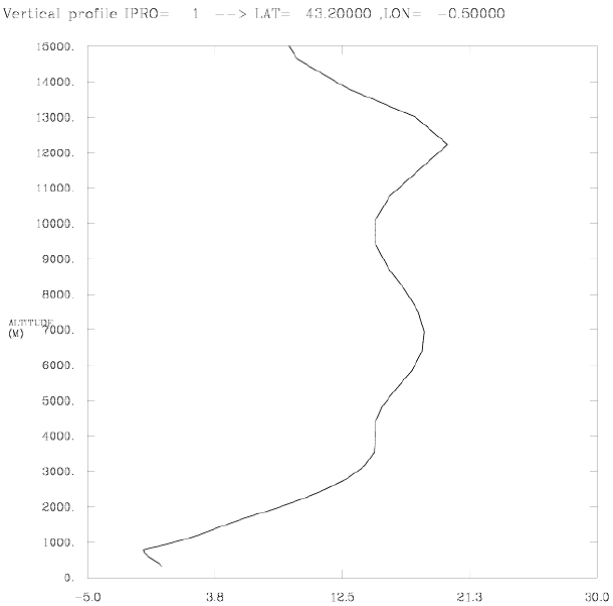

Figure 26. REF version (AROME), run 00UTC: vertical profile of u-component for 12h.

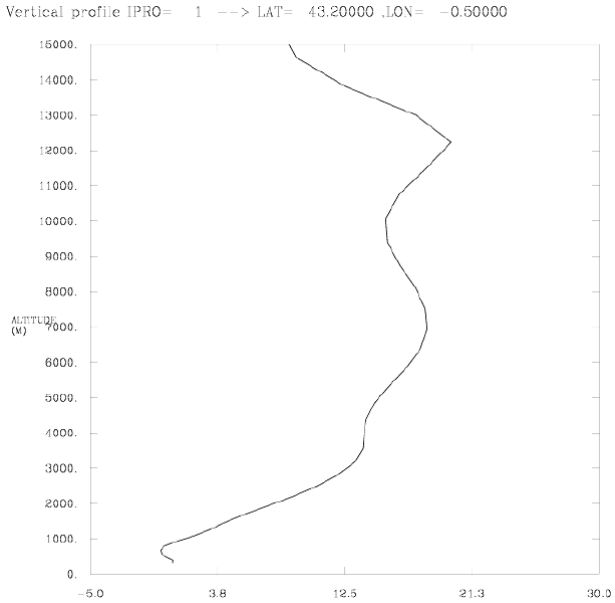

Figure 27. As Figure 26, but using EDMF OLD version

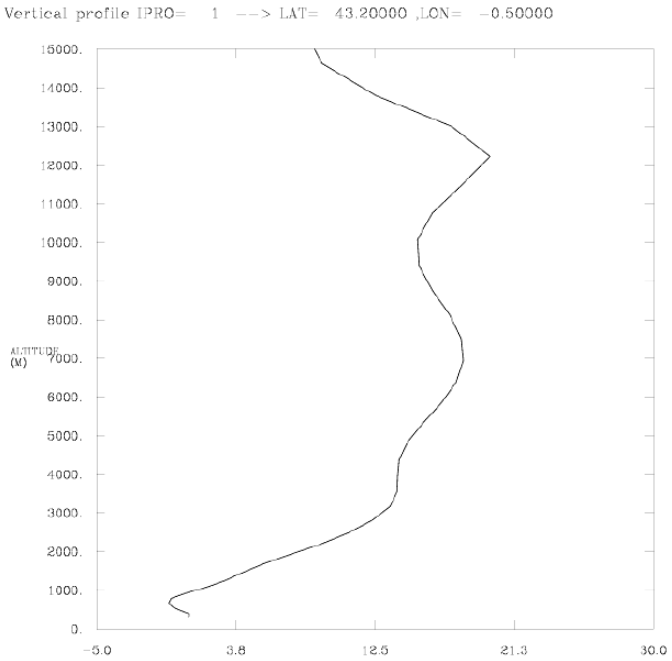

Figure 28. As Figure 26, but using EDKF OLDN version.

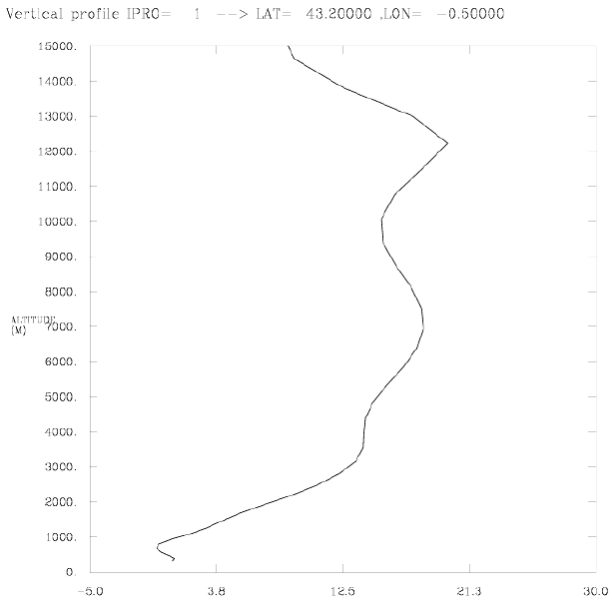

Figure 29. As Figure 26, but using EDKF NEWN version.

Likewise, the meridional vertical wind profiles provided by the experimental versions are very similar to the one derived from the current version (Figures 30-33).

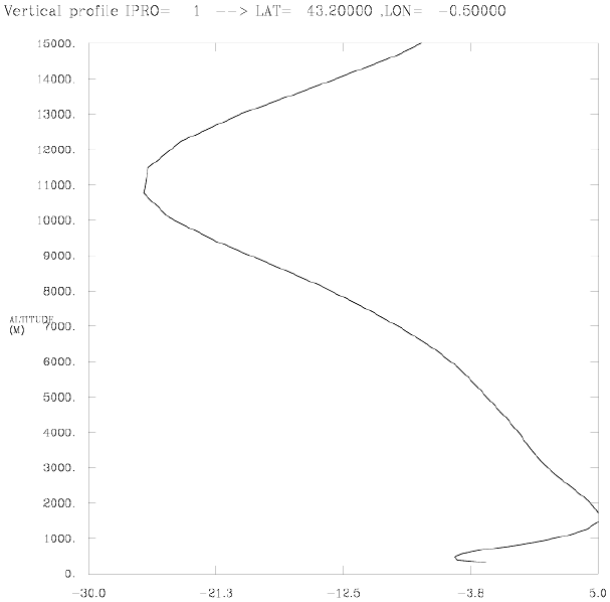

Figure 30. REF version (AROME), run 00UTC: vertical profile of v-component for 12h.

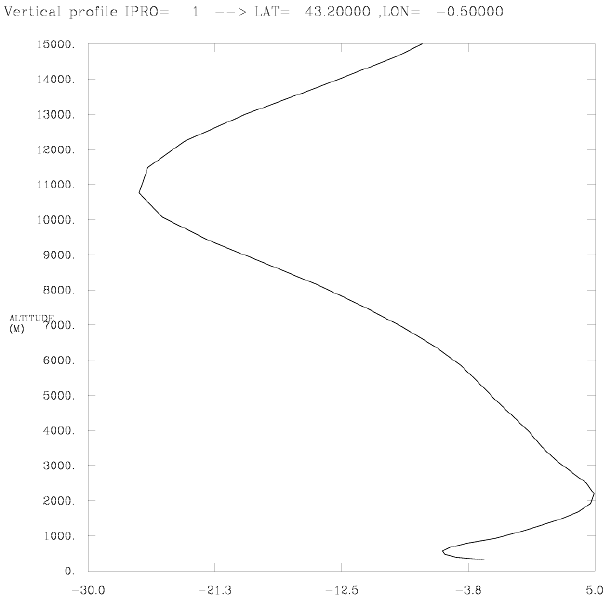

Figure 31. As Figure 30, but using EDMF OLD version

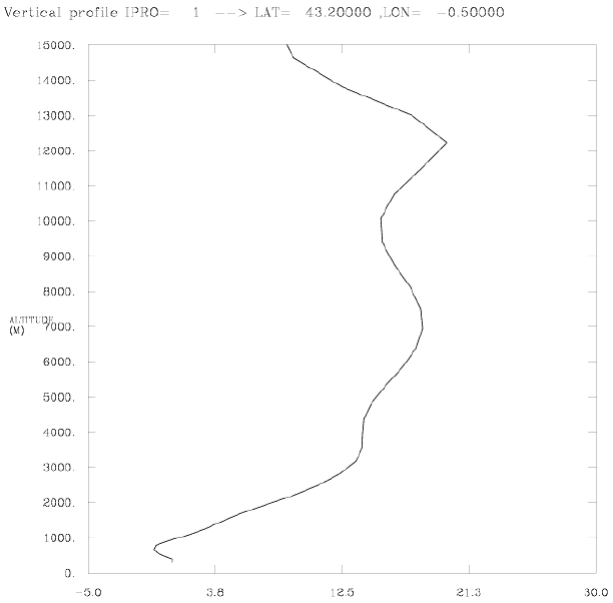

Figure 32. As Figure 30, but using EDKF OLDN version.

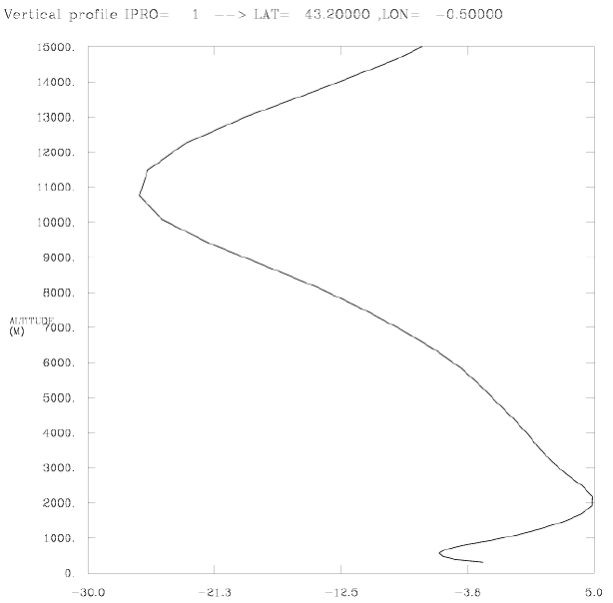

Figure 33. As Figure 30, but using EDKF NEWN version.

3.4 Cloud Fraction forecasts for 15h

Heights 1000/1500 m

As in 12h forecast, REF version of AROME shows larger areas of CF with high values of this parameter in the northern side of the Pyrenees (fields at 1000m on Figures 34-37).

Also in this forecast, EDKF OLDN and EDKF NEWN versions produce very similar results for CF at 1000m with broken up areas of this parameter on the northern side of the Pyrenees. However, contrarily to the other versions, EDKF NEWN forecasts areas with CF in the north-western part of the domain what seems to be a more realistic result being account the existence of low clouds at this time (Figure 38). Furthermore, EDKF OLDN and EDKF NEWN versions show more significant values of CF in a small zone southwest of the Pyrenees.

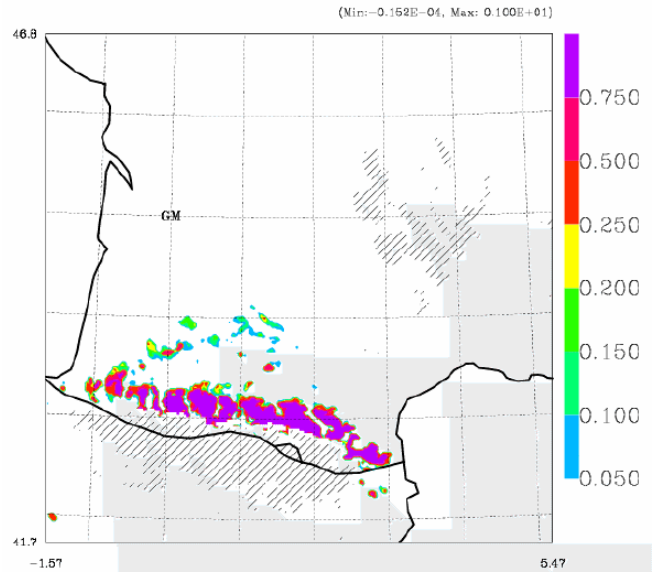

Figure 34. REF version (AROME), run 00UTC: Cloud Fraction at 1000m for 15h.

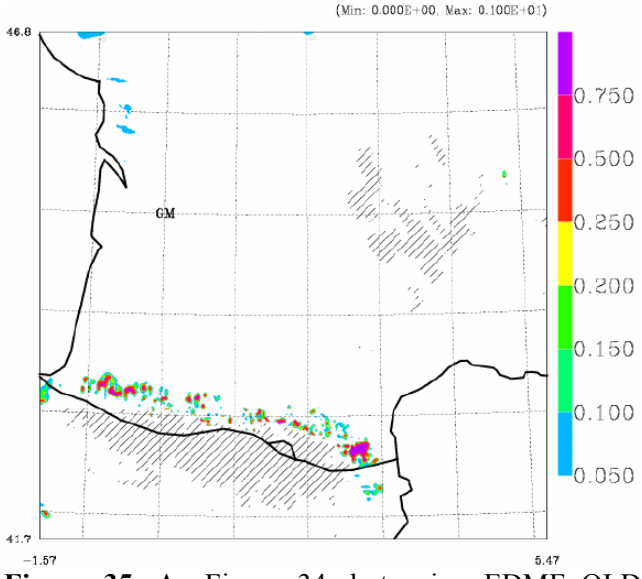

Figure 35. As Figure 34, but using EDMF OLD version.

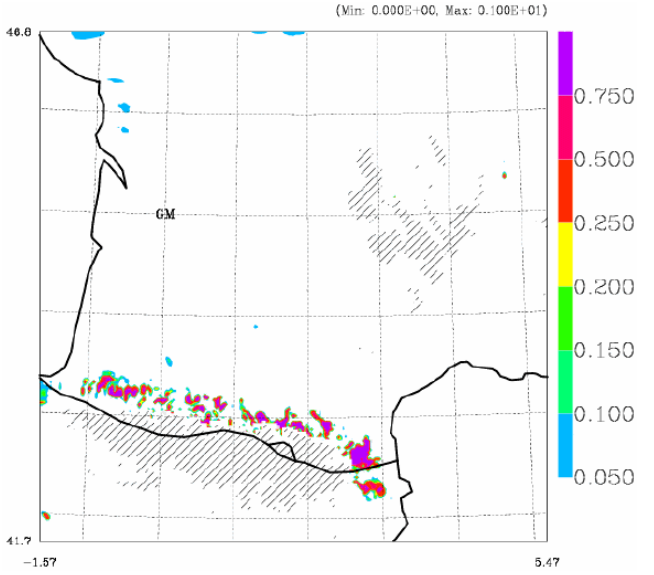

Figure 36. As Figure 34, but using EDKF OLDN version.

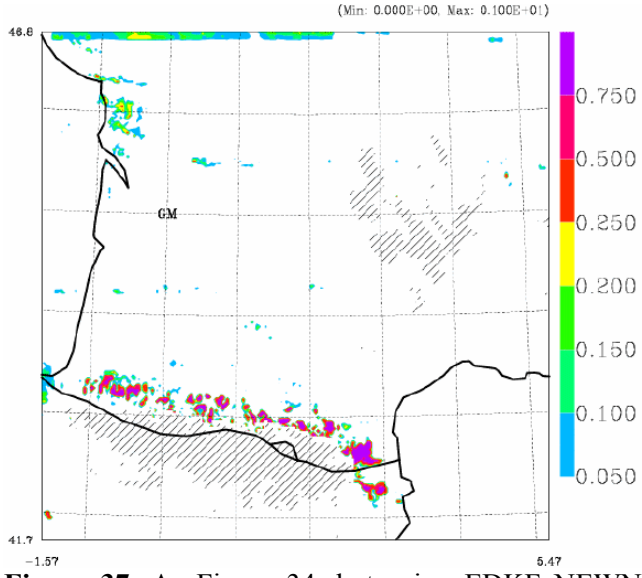

Figure 37. As Figure 34, but using EDKF NEWN version.

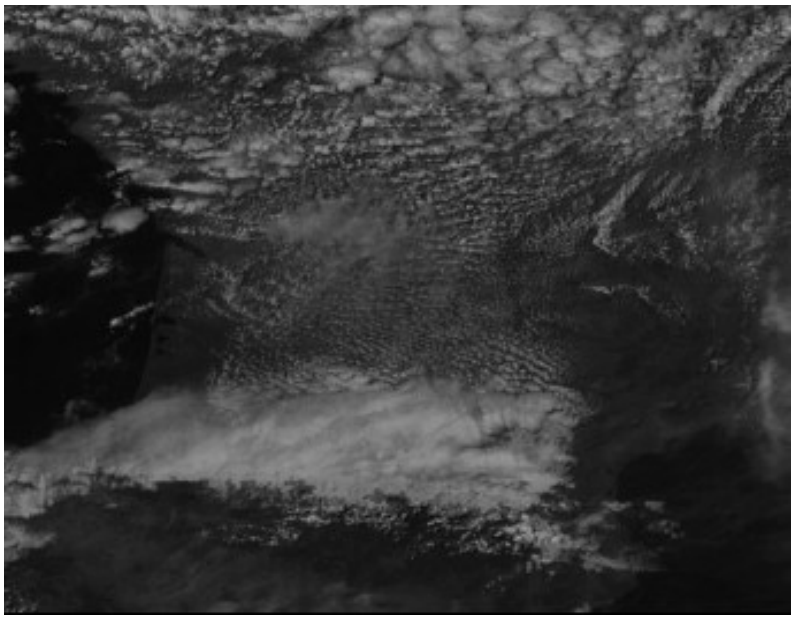

Figure 38. Visible MSG high resolution satellite image at 15UTC (extracted from H. Gwen, 2006).

Height 2000 m

At this height, the region of CF increases on the western part of the domain (Figures 39-42).

Furthermore, the REF version shows smaller areas of CF below parallel 44°N, approximately.

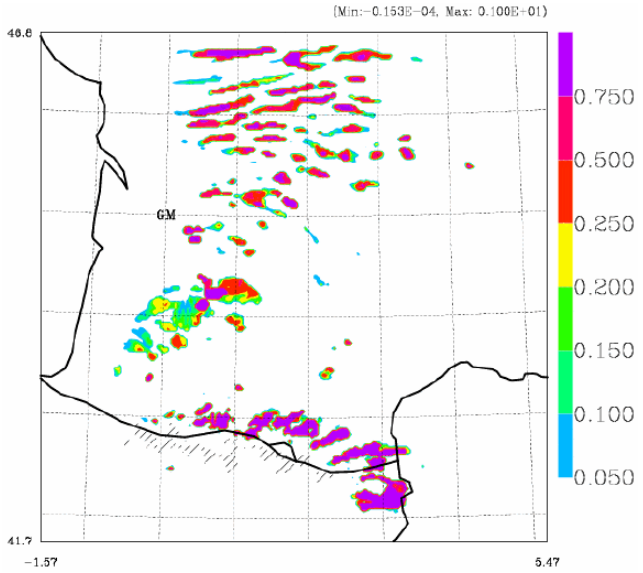

Figure 39. REF version (AROME), run 00UTC: Cloud Fraction at 2000m for 15h.

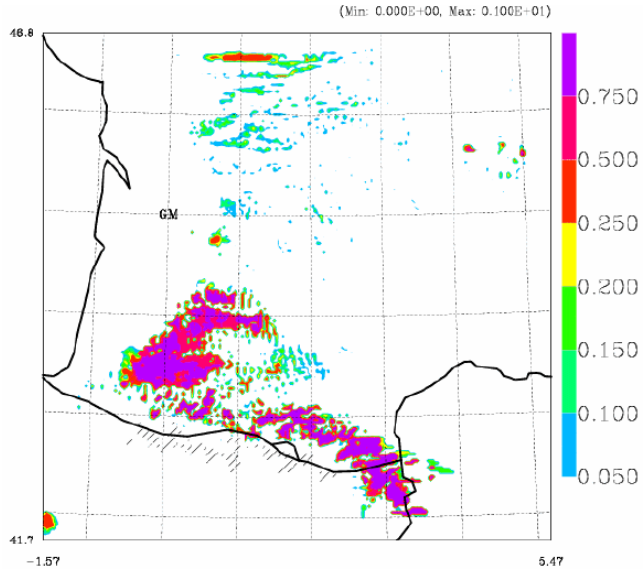

Figure 40. As Figure 39, but using EDMF OLD version.

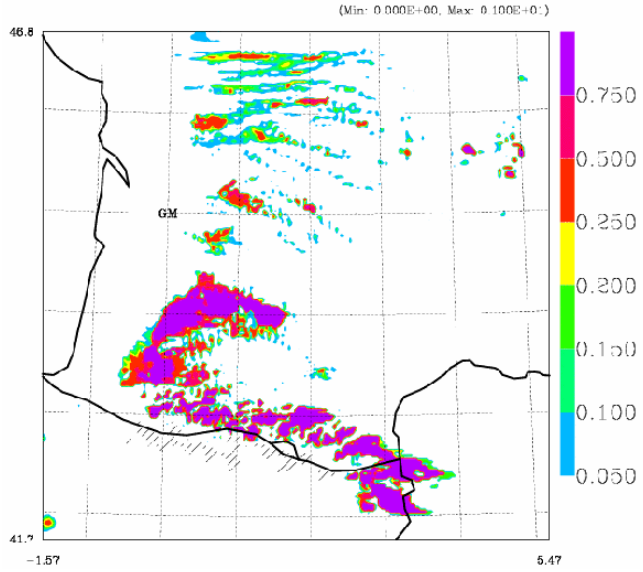

Figure 41. As Figure 39, but using EDKF OLDN version.

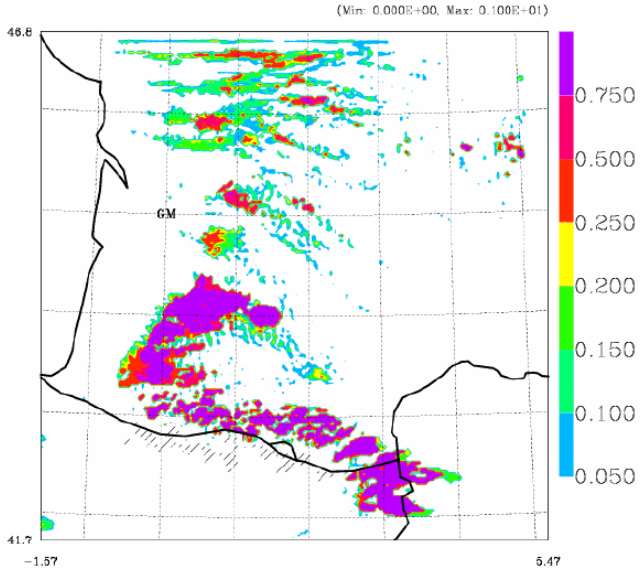

Figure 42. As Figure 39, but using EDKF NEWN version.

Heights 2500 / 3000 m

Likewise on the 12h forecast, the REF version shows smaller areas of CF than the other versions and EDKF OLDN, EDKF NEWN and EDKF OLDN versions present very similar forecasts.

Height 11000 m

At this height all the versions present extensive zones of CF associated to cirrus clouds. However, comparing the forecasts with the satellite image at 15UTC (Figure 38) it can be concluded that all the forecasts overestimate these clouds.

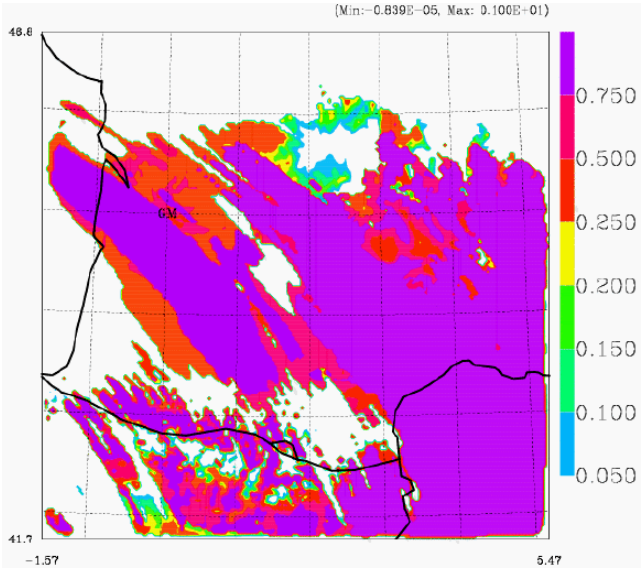

Figure 43. REF version (AROME), run 00UTC: Cloud Water at 11000m for 15h.

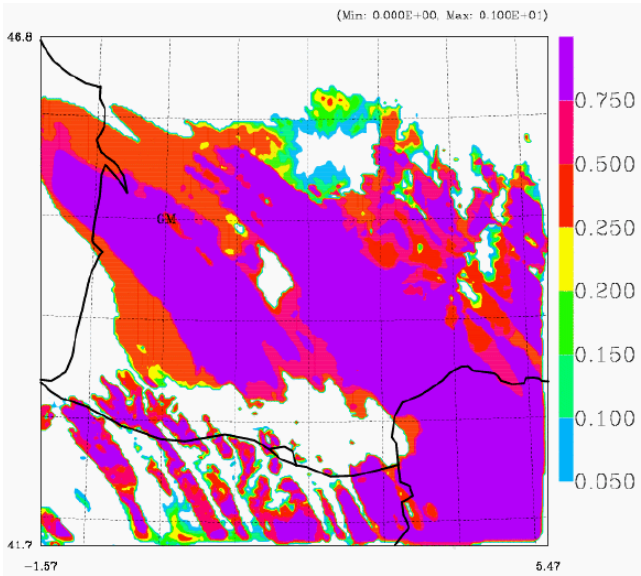

Figure 44. As Figure 43, but using EDMF OLD version.

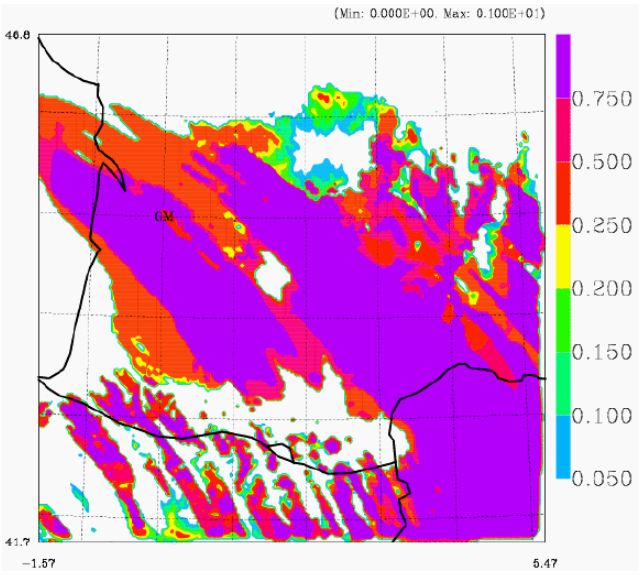

Figure 45. As Figure 43, but using EDKF OLDN version.

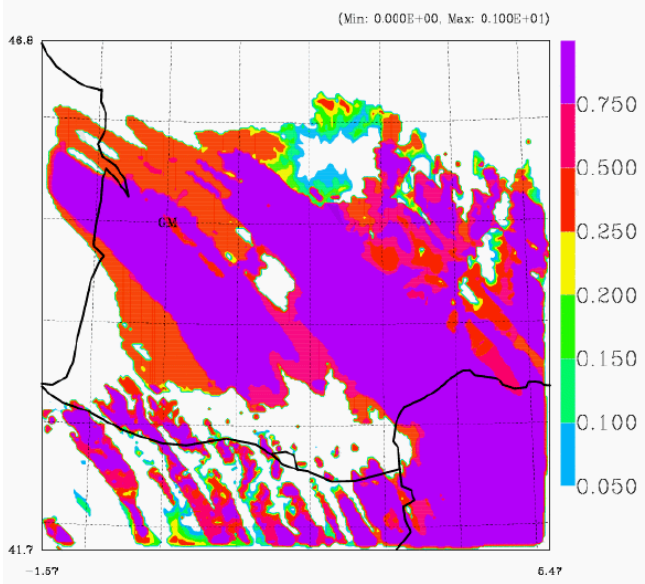

Figure 46. As Figure 43, but using EDKF NEWN version.

In order to investigate the vertical structure of CF in the region affected by the convection, a vertical cross section was plotted between the points 43.2N 0.5W and 44.4N 1.0E (Figure 47).

With the analysis of the vertical cross sections of CF (Figures 48-51) it is evident the similarity between the results of the different versions. At higher levels, all the models forecast a very thick layer of cloud fraction (between 9000 and 13500m, approximately). Likewise at level 11000 m, these results are quite unrealistic and reveal a problem already known related with the overestimation of the cirrus clouds by the different schemes.

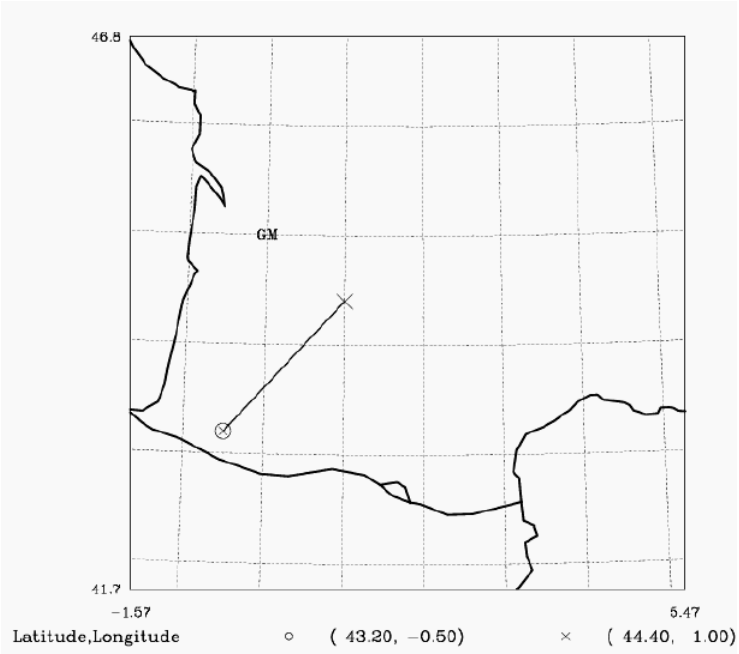

Figure 47. Vertical Cross Section.

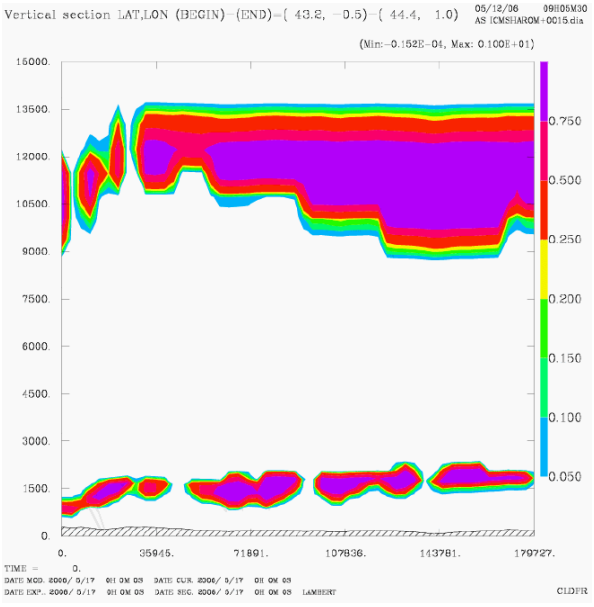

Figure 48. REF version (AROME), run 00UTC: Vertical Cross Section of Cloud Fraction for 15h.

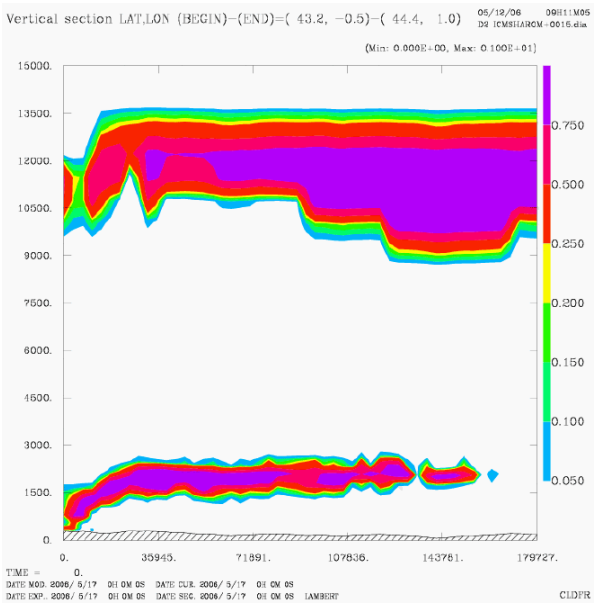

Figure 49. As Figure 48, but using EDMF OLD version.

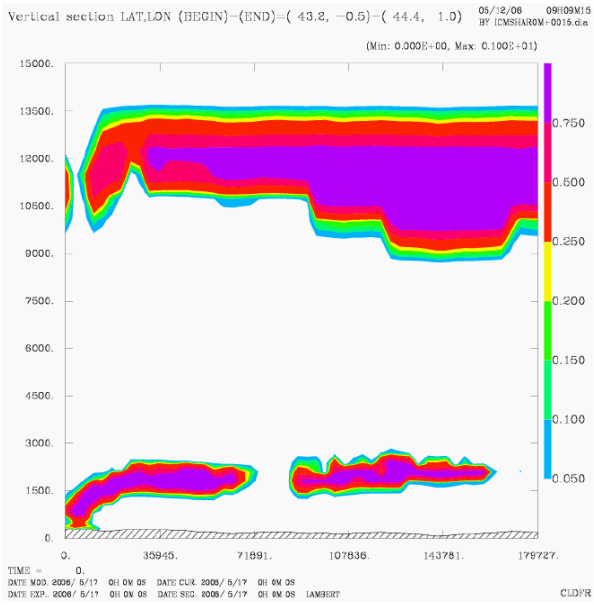

Figure 50. As Figure 48, but using EDKF OLDN version.

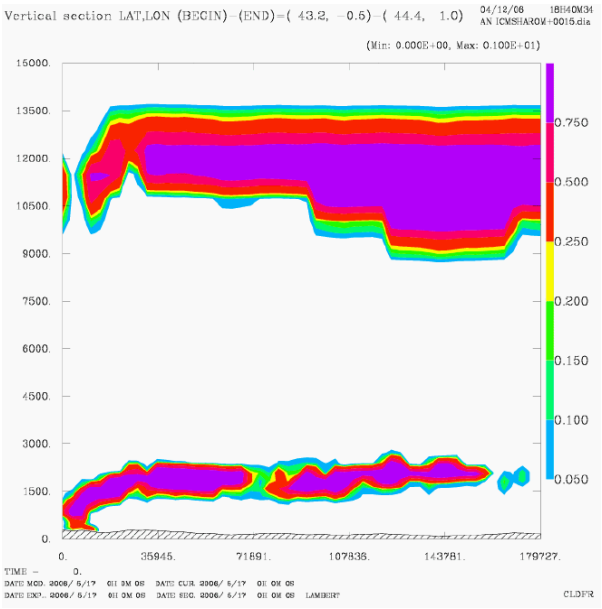

Figure 51. As Figure 48, but using EDKF NEWN version.

3.5 Cloud Water forecasts for 15h

Cloud Water fields (not shown) presented consistent results to the Cloud Fraction fields on the above mentioned levels.

3.6 Zonal component and meridional component of horizontal wind forecasts for 15h

The wind fields (not shown) had very similar results to the ones derived from the 12h forecasts.

4 Some final considerations

The comparison between the cloud fields and between the wind fields of the different versions of AROME highlight some results:

- As would be expected, the current version of AROME produces in general lower clouds than the other versions and also patterns of CF and CW with larger areas of high values. These constitute worth results of the current version derived from its shallow convection scheme.

- EDKF NEWN version forecasts a larger area of CF than the other versions over low lands what can be considered a better result of this version.

- As would be expected, the zonal and the meridional wind profiles produced by the experimental versions of the model are very similar to those produced by the current version.

- At height levels all the versions overestimate CF what can be associated to an overestimation of the cirrus clouds. These results are quite unrealistic and reveal an problem not yet solved by the different schemes.

References

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