COMPARATIVE EVALUATION OF WEATHER FORECASTS FROM THE COSMO, ALARO AND ECMWF NUMERICAL MODELS FOR ROMANIAN TERRITORY

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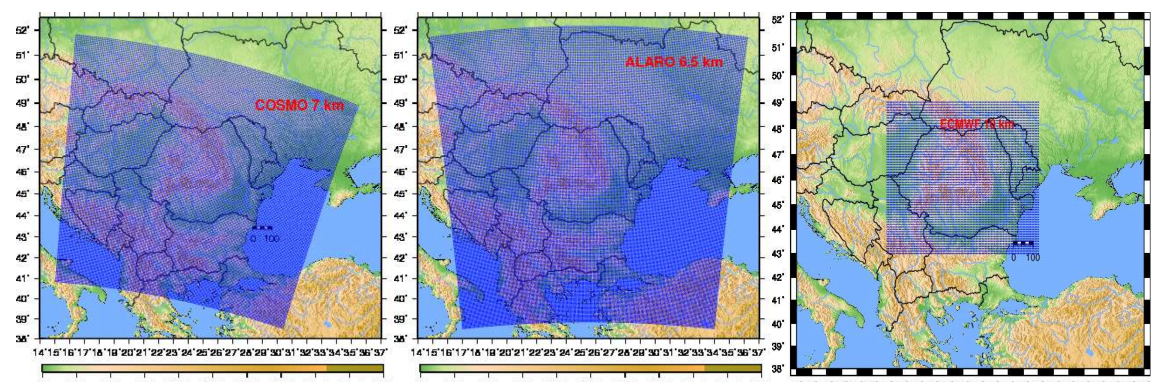
1 Introduction

The aim of this study is to assess the performance of the COSMO and ALARO limited are models and the ECMWF global model for Romanian territory.

For this purpose, we use the numerical forecasts of the COSMO model integrated for the operational domain covering the entire Romanian territory (figure 1) at 7 km horizontal resolution (201x177 grid points), with 40 vertical levels. The initial and lateral boundary conditions for the COSMO model are given by the ICON global model.

The ALARO limited area model is also integrated operationally for a domain covering the entire Romanian territory (figure 1) at 6.5 km horizontal resolution (240x240 grid points), with 60 vertical levels. The initial and lateral boundary conditions for the COSMO model are taken from the ARPEGE global model.

For the present comparative evaluation we also take into account the numerical weather forecasts of the ECMWF model available for the Romanian territory (interpolated at roughly 10 km horizontal resolution).



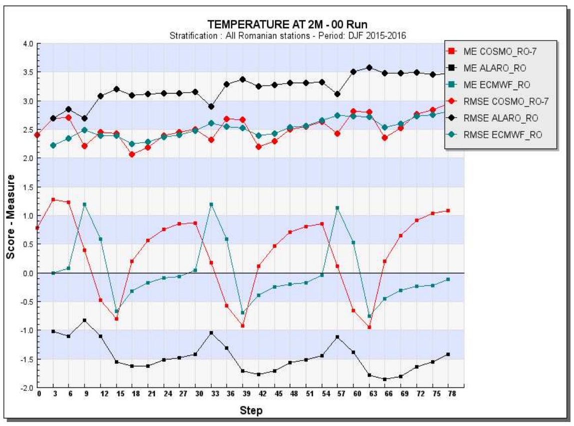
(a) (b) (c)

Figure 1: Integration domains and associated topography height of COSMO (a), ALARO (b) and ECMWF (c) for Romanian territory.

2 Case Study

The performance of the 00UTC runs from the three models for Romanian territory was analyzed for three consecutive seasons: DJF (December 2015 – February 2016), MAM (March 2016 – May 2016) and JJA (June 2016 – August 2016). The verification of the models was performed taking into account all SYNOP observations available for Romanian territory (160 stations). All available SYNOP observations (in BUFR format), as well as numerical weather forecasts and corresponding topography files for each of the three models (in GRIB1 format) were uploaded into the VERSUS system, which was used for this comparative evaluation. Statistical scores were computed for 2 meter temperature, pressure reduced to mean sea level, 10 meter wind speed and 6-hour cumulated precipitation.

2 meter temperature, pressure reduced to mean sea level and 10 meter wind speed were ingested into the VERSUS system using the nearest grid point optimized method (1), while mean values on a 15 km radius method (6) was used to ingest cumulated precipitation. ME (mean error) and RMSE (root mean squared error) were computed for continuous parameters, along with scatter plots. Dichotomic scores POD (probability of detection), FAR (false alarm rate), PC and ETS (equitable threat score) were used to evaluate hours precipitation for different thresholds, along with performance diagrams.



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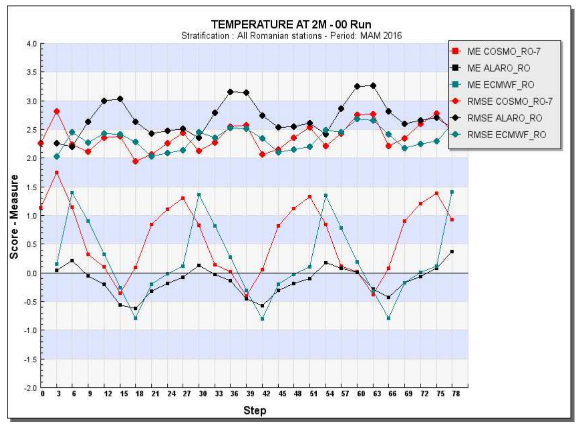

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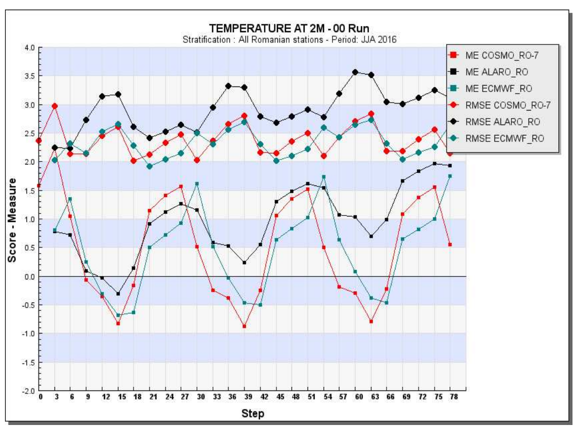
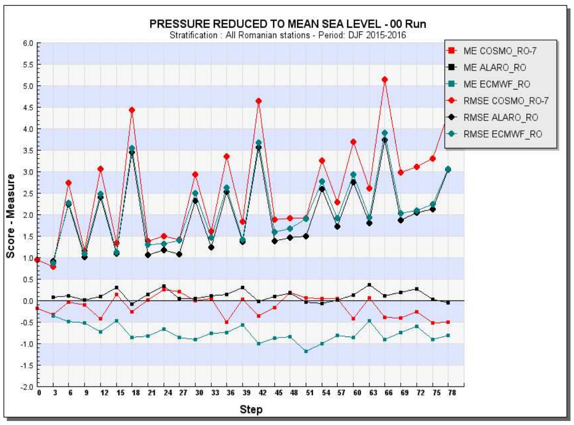


(c)

Figure 2: 2 meter air temperature, ME and RMSE - COSMO-7km (red); ALARO (black) and ECMWF (blue): DJF (a), MAM (b) and JJA (c)

For 2 meter temperature (figure 2), both the COSMO and the ECMWF models display the same sistematic behaviour for all three analyzed seasons. The general tendency of the two models is to underestimate forecasted values during the day, while overestimating during night time, comparred to observations. While ME values for COSMO and ECMWF (for Romanian territory) are comparable, lower RMSE values from the COSMO model for the entire period of interest suggest a better performance than the ECMWF model in forecasting this parameter.

The ALARO model integrated for Romanian territory strongly underestimates this parameter during winter and overestimates its values during summer. Although the ALARO model displays the smallest ME values from the MAM season, higher RMSE values suggest a larger amplitude of errors compared to the other two models.



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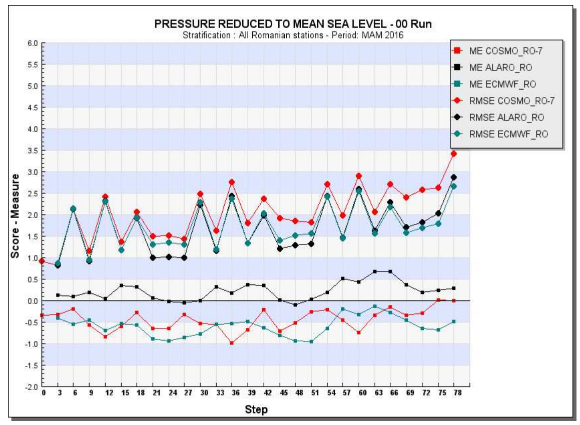

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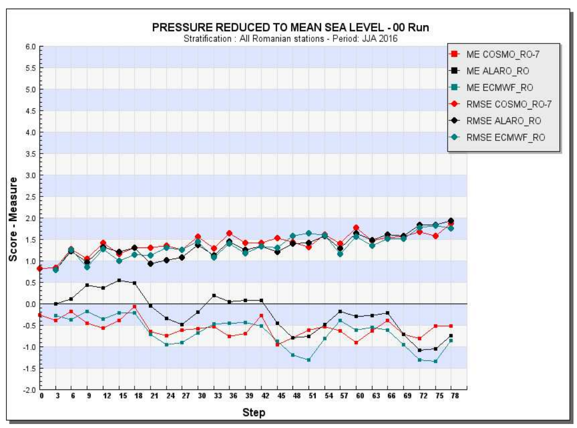
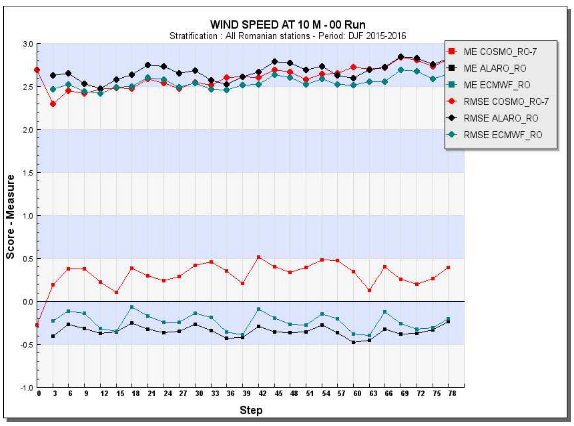


(c)

Figure 3: Pressure reduced to mean sea level, ME and RMSE - COSMO-7km (red); ALARO (black) and ECMWF (blue): DJF (a), MAM (b) and JJA (c)

ME values for mean sea level pressure from the COSMO model show again a sistematic behaviour for all three seasons (figure 3). The general tendency of the model is to underestimate the values for this parameter with up to 1 hPa compared to the synoptic observations, especially for the MAM and JJA seaons. Slightly reduced errors can be observed for the DJF season. However, for most of the DJF and MAM seasons, the COSMO model integrated for Romanian territory displays the highest amplitude of errors, quantifiable by the larger RMSE values, compared to the other two numerical models.

The genral tendency of the ALARO model integrated for Romanian territory is to slightly overestimate the forecasted values for mean sea level pressure during winter (DJF) and spring (MAM), while for the summer period (JJA), the tendency of the model is to underestimate this parameter after the first day, compared to the observations. RMSE values for the DJF, MAM and JJA seasons suggest that the ALARO model has a smaller amplitude of errors compared to the COSMO and ECMWF models. Finally, the ECMWF model displays the overall tendency of underestimating the values for pressure reduced to mean sea level, and has the largest mean errors from the three models.



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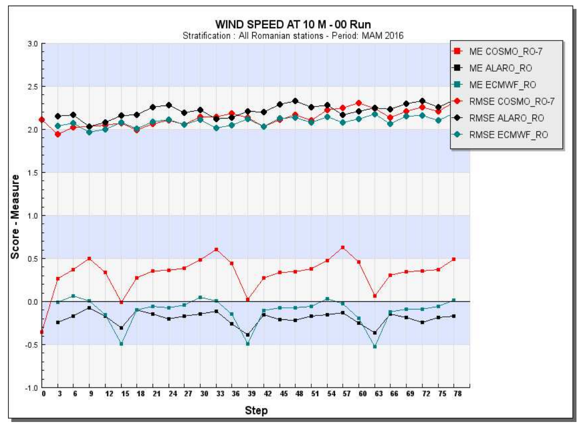

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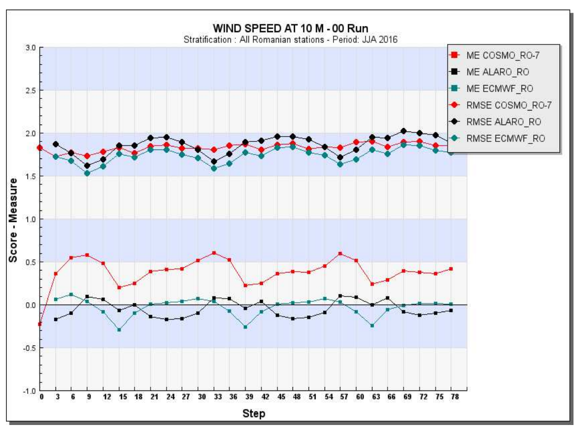
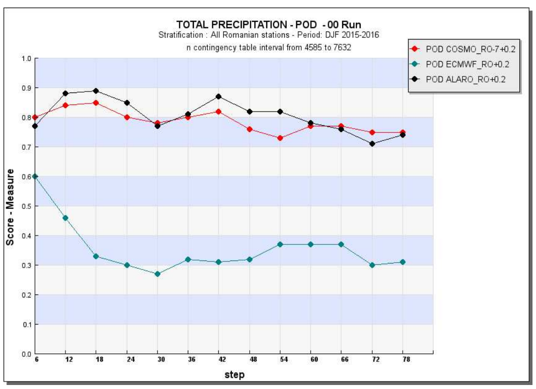


(c)

Figure 4: 10 meter wind speed, ME and RMSE - COSMO-7km (red); ALARO (black) and ECMWF (blue): DJF (a), MAM (b) and JJA (c)

All three models display high accuracy in forecasting 10 meter wind speed, with mean errors between -0.5 m/s and 0.5 m/s and a reduced amplitude of errors, especially for the summer period (figure 4). Comparable values for ME and RMSE are obtained for the entire forecast period, suggesting that the models offer a good estimation of this parameter even with up to 78 hours anticipation. Similar to the forecast for 2 meter temperatures and pressure reduced to mean sea level, the COSMO model displays a sistematic behaviour for all seasons; except for the first step (+0), 10 meter wind speed values are always slightly overestimated compared to the observations (with up to 0.5 m/s), for the entire period of interest. Although ME values for the ALARO and ECMWF models seem slightly lower, especially for the JJA season, these two models do no exhibit the same sistematic behaviour for all the seasons, as is the case of the COSMO model.

The limited area models COSMO and ALARO integrated for Romanian territory display a higher accuracy in forecasting 6-hour cumulated precipitation than the global ECMWF model. The scores presented in figures 5-7 were computed for 6-hour cumulated precipitation over 0.2 mm. The highest probability of detection for the two limited area models are obtained for the winter season (up to 0.8 - 0.9), while the lowest results for POD are obtained during the convective season (JJA). This suggests that roughly 3/4 of the observed rain events are estimated correctly for the winter season (figure 5), while the ratio can drop up to 2/4 for the summer, with a slight worsening during the last hours of forecast, for all three seasons. For the spring season and especially for the summer season, it can be noticed that the COSMO and ALARO models integrated for Romanian territory display a better ability in capturing the rain events during the day, while POD drops during night time (figures 6 and 7). This behaviour is also noticeable for the ECMWF model, during the convective season (JJA).



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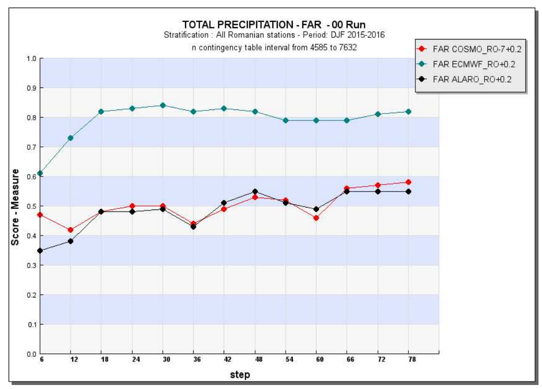

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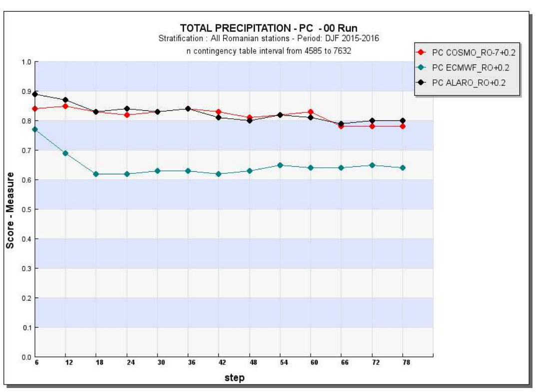

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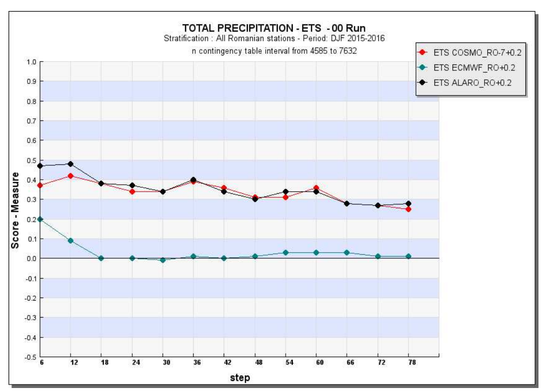
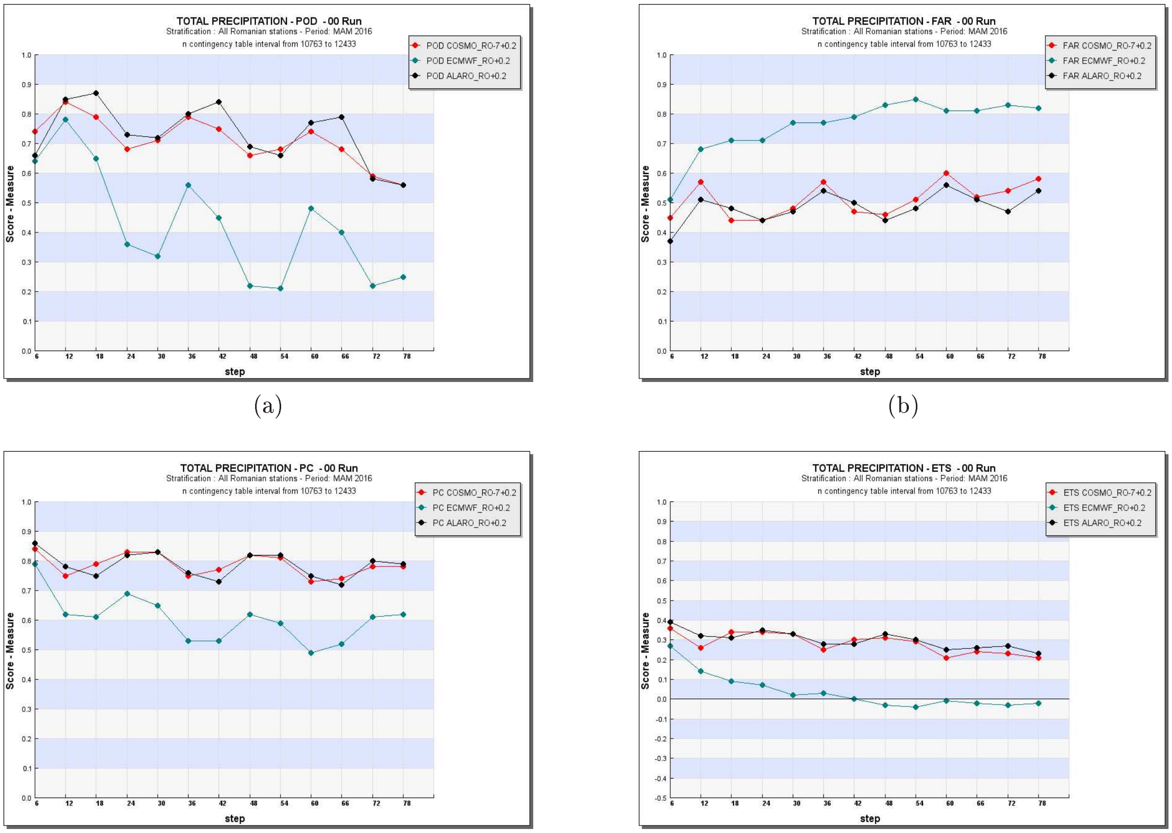


(d)

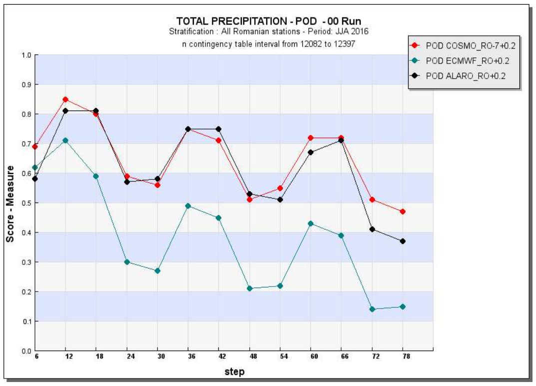
Figure 5: 6-hour cumulated precipitation for DJF - COSMO-7km (red); ALARO (black) and ECMWF (blue): POD (a), FAR (b), PC (c) and ETS (d)

The FAR results computed for ECMWF forecasts suggest that the model tends to overpredict the occurence of rain for all three seasons, while for the COSMO and ALARO models in roughly up to 1/3 – 1/2 of the of the forecast rain events, rain was not observed. Similar to the case of POD, the FAR score also shows a slight worsening in the forecast of this parameter for the last anticipations. Finally, the ETS values for the COSMO and ALARO models suggest that roughly half of the observed rain events were forecasted correctly.



(a) (b) (c) (d)

Figure 6: 6-hour cumulated precipitation for MAM - COSMO-7km (red); ALARO (black) and ECMWF (blue): POD (a), FAR (b), PC (c) and ETS (d)



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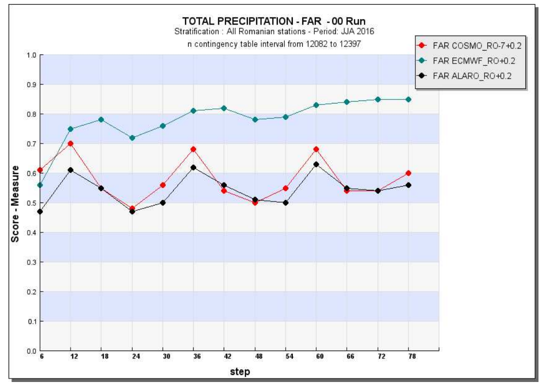

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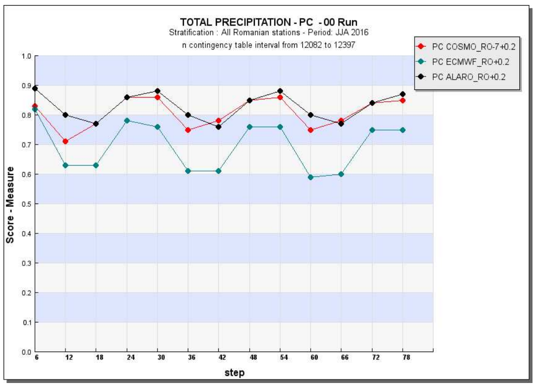

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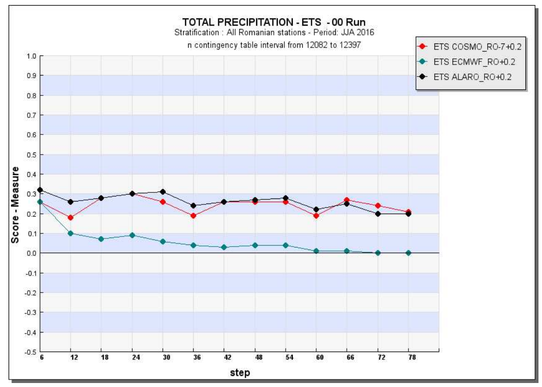

(d)

Figure 7: 6-hour cumulated precipitation for JJA - COSMO-7km (red); ALARO (black) and ECMWF (blue): POD (a), FAR (b), PC (c) and ETS (d)

References

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