Seasonal and monthly verification of COSMO_PL

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1 Introduction

At the beginning of the paper the results of seasonal verification of COSMO_Pl model are presented. The period from September 2009 to August 2010 was taken into account. The second part of the article presents the results of monthly verification of the 24h accumulated precipitation in May 2010, distinguished by very high rainfall throughout the country. The model data were verified with SYNOP stations.

2 The verification method

For continuous parameters the mean error (ME) and the root mean square error (RMSE) were calculated. To verify the diurnal behavior of the model, the couples forecast-observation were stratified according to the hour of the day (frequency of 3 hours) and the season of the year. The model started at 00 UTC with the forecast range 72h. The verification was performed for the following parameters:

- Temperature at 2 m above ground level;
- Dew point temperature at 2m above ground level;
- Mean sea level pressure;
- Wind speed at 10m above ground level;
- Total cloud cover.

Calculations were performed for four seasons, SON 2009, DJF 2009/2010, MAM, 2010, JJA 2010.

For the 24 accumulated precipitation indices FBI, ETS from contingency table were calculated. The following precipitation thresholds were taken into account: 0.2, 2, 5, 10, 20, 25, 30, 35, 40, 45, 50 mm. The time series plots for total precipitation are also presented. The 24h accumulated precipitation in May 2010 was selected. As the month was extremely wet, the amount of long-term average precipitation throughout the country was exceeded. The results were calculated for all stations and separately for four different geographical terrains: coast, flat region, low mountains, and mountains.

3 Results of seasonal verification

3.1 The 2m temperature

Figure 1 presents the results of verification of the air temperature for all Polish stations for each season. Daily and seasonal cycles of ME and RMSE are observed. The largest diurnal amplitude of errors occurred in autumn (SON). The temperature at this season was underpredicted during daytime (09UTC-18 UTC) with minimum at 12UTC-15UTC and overpredicted at nighttime (21UTC-06UTC) with maximum at 00UTC-03UTC. Two maxima of RMSE (00UTC-03UTC and 12UTC-15UTC) and two minima (06UTC-09UTC and 18UTC-21UTC) were observed. The smallest errors were observed in spring (MAM). ME range from -0.8 to 0.6. Predicted values are lower than those observed in the morning (06UTC-09UTC). For the remaining hours of a day the model calculates the value only slightly higher than those observed. Error RMSE reaches a maximum at 12 UTC and minimum during the night (18UTC-06UTC). In winter the mean error was negative for the whole forecast range. The difference between maximum of RMSE at 12 UTC and minimum at night (21UTC-03UTC) was only about one degree .In summer (JJA), the predicted values are higher than those observed during the night (21UTC-03UTC), while during the day (apart from the first forecast day) are lower than those observed. RMSE reaches a maximum at 12 UTC and a minimum generally about 21 UTC.

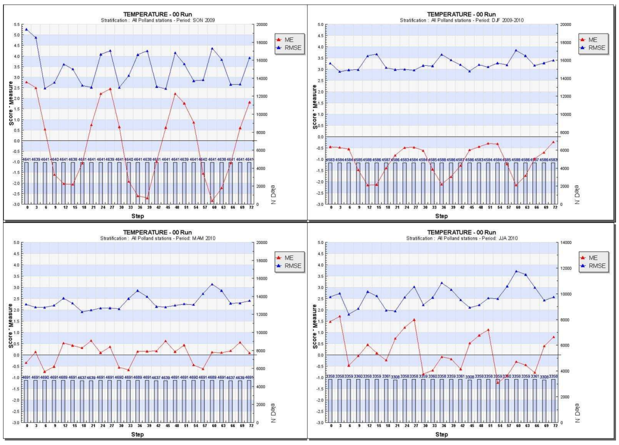

Figure 1: ME,RMSE, Temperature 2m, SON 2009-JJA 2010, Poland

3.2 Dew point temperature 2m

The large differences of diurnal cycle of errors for the seasons were observed. For all forecast range, model values of the dew point temperature were higher than observed during the spring and the summer, while in the winter the forecasted values were smaller than observed. However, in autumn ME was negative during the daytime (09UTC-18UTC) and positive during night-time (21UTC-06UTC) with a maximum at 03 UTC. For RMSE clear diurnal cycle occurs in the summer with a maximum at 15 UTC and a minimum at 06UTC. For the other seasons, the error performance is rather smooth.

3.3 Mean sea level pressure

MAE and RMSE of atmospheric pressure for all seasons (except the summer) clearly increase with forecast time. The values of RMSE during the summer are smaller for the first day (1) and bigger for the two others (1.5-1.8). ME is positive and increases with the forecast range for autumn (SON). For other seasons, in general ME is negative except the first 9 hours of the forecast (winter, spring) and the last few hours of the forecast range (summer).

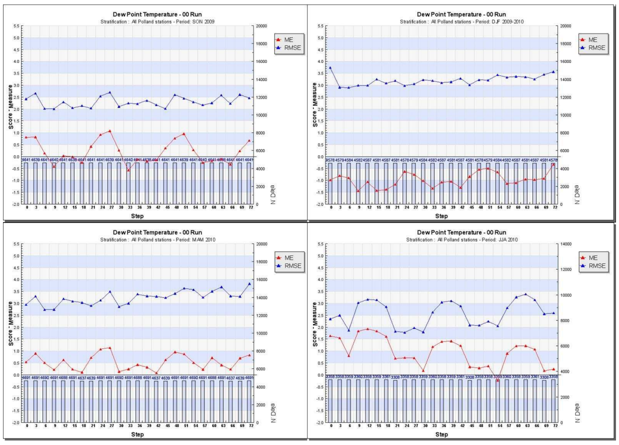

Figure 2: ME,RMSE , Dew point temperature 2m, SON 2009 JJA 2010, Poland

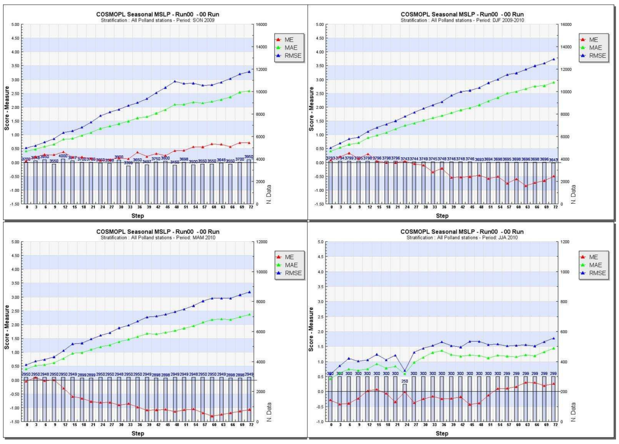

Figure 3: ME, MAE, RMSE, Mean sea level pressure, SON 2009 JJA 2010, Poland

3.4 The 10m wind speed

Seasonal RMSE of the wind speed increases with the forecast range for all seasons. The amplitude of RMSE is small (from 1.5 to 2). The ME performance is marked by diurnal distribution, larger errors occurring at night and the lowest in the morning (09UTC-12UTC).

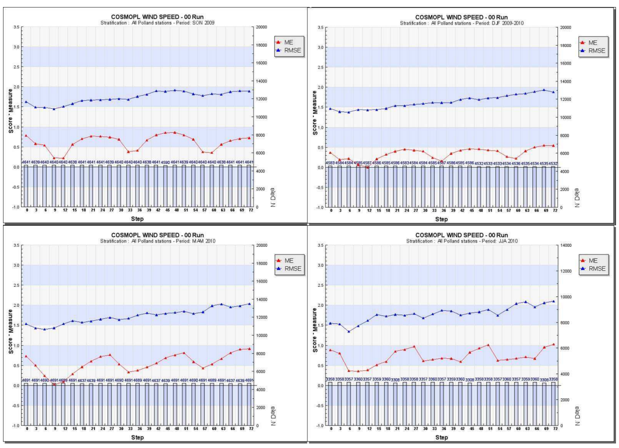

Figure 4: ME, RMSE, 10m wind speed, SON 2009 - JJA 2010, Poland

3.5 The total cloud cover

The smallest cloud cover forecast errors occur during winter (DJF).This season RMSE amplitude is small. In winter ME oscillates around zero. In autumn (SON) ME is positive for all forecast steps. In spring (MAM), ME is also positive for most steps in the forecast (except for the first day). In summer, ME is above zero during nighttime (21UTC-06UTC) and below zero during daytime (09UTC-18UTC). Clear diurnal cycle of error is observed in autumn (SON) and spring (MAM) with a minimum error around noon and a maximum around midnight.

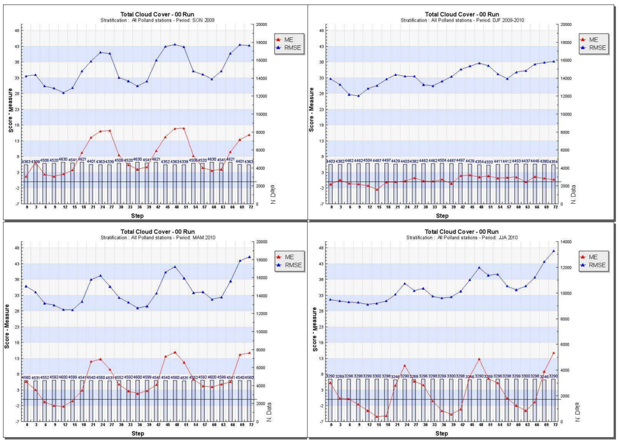

Figure 5: ME, RMSE, Total cloud cover, SON 2009 JJA 2010, Poland

4 Monthly precipitation May 2010

In May 2010, a very high rainfall throughout the country occurred. The highest rainfall was recorded between the 16th and the 18th. Comparing the time series plots for the whole country in the first and second day of heavy rainfall on the 16th and the 17th, the model predicts lower amount of accumulated precipitation than was observed. For the next two days of the 18th and the 19th the model provides more accumulated precipitation than actually occurred. On a mountain terrain the model predicts the highest rainfall a day later, i.e. on the 17th than actually occurred on the 16th. Also on a low-mountain and flat areas a one day delay of the highest rainfall occurred. Time displacement between the forecast and observation is also seen the other days of the month.

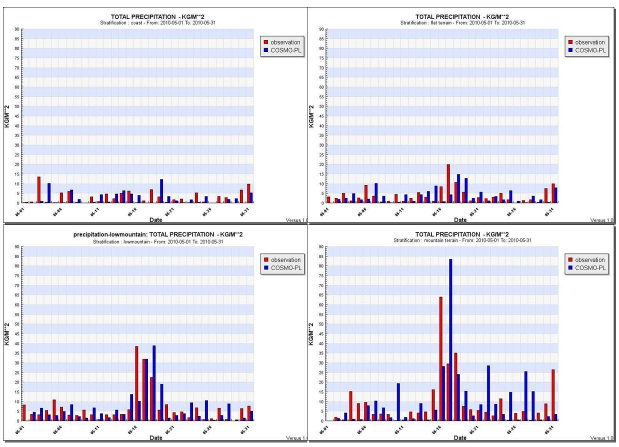

Figure 6: Time series plot, total 24h accumulated precipitation, May 2010, Poland, coast terrain, flat terrain, low mountain terrain, mountain terrain

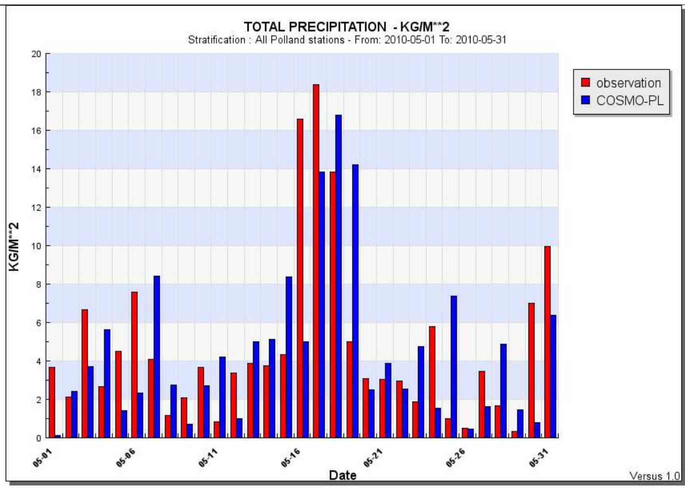

Figure 7: Time series plot, total 24h accumulated precipitation, May 2010, all Poland stations

On a mountain terrain, for small precipitation thresholds the first and second day of forecast, a bit more rainfall is predicted than observed ($FBI > 0$). For bigger thresholds the model underestimates the precipitation ($FBI < 0$). 72-hour forecast seems to be better than 48 hours one. For low- mountain areas FBI is above zero for lower thresholds on the second day of the forecast. FBI is positive for all thresholds on the third day of the forecast (72 hours). For the highest precipitation thresholds forecasts for 24 and 48h rainfall are underestimated. The value of FBI on the first forecast day oscillates around zero. For flat and coastal terrains on the first forecast day and the lowest thresholds the positive FBI was observed. The negative FBI rises with precipitation thresholds on the first 24 hours forecast. On the second and third day of the forecast FBI is positive for all precipitation thresholds.

When analyzing the performance of FBI for all stations, rainfall on the second and third forecast days are overestimated ($FBI > 0$). FBI fluctuates around zero on the first forecast day. May 2010 had a large number of days with heavy rain. FBI is reliable even on the threshold of 50 mm.

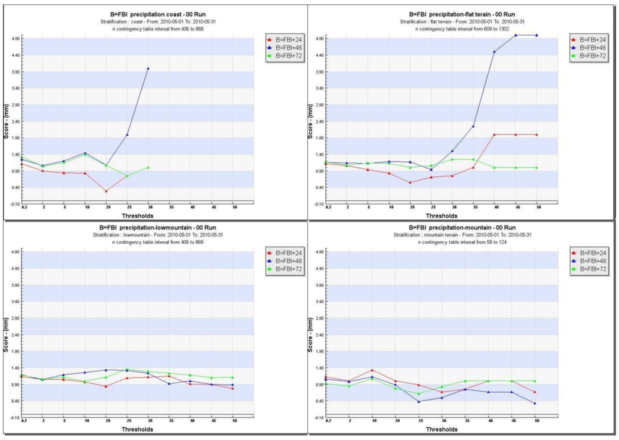

Figure 8: FBI, 24h accumulated precipitation, May 2010, Poland, coast terrain, flat terrain, low mountain terrain, mountain terrain

The accumulated precipitation in the mountains is well predicted for high thresholds, while rainfall forecast for flat and coastal terrains is better for small precipitation thresholds. On a flat terrain the number of cases with heavy rain is small. Analysing the value of ETS the best forecast is on the first forecast day and the worst for the second one. On the flat terrain and coastal areas for small precipitation thresholds the value of ETS decreases with forecast step. It means an increase of forecast errors.

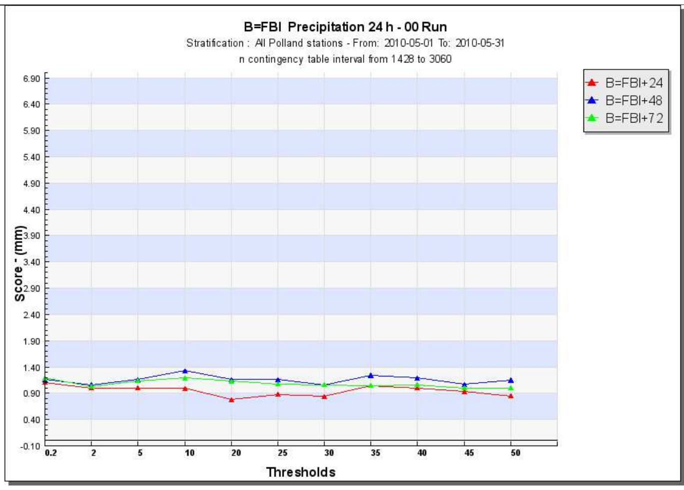

Figure 9: FBI, 24h accumulated precipitation, May 2010, all Poland stations

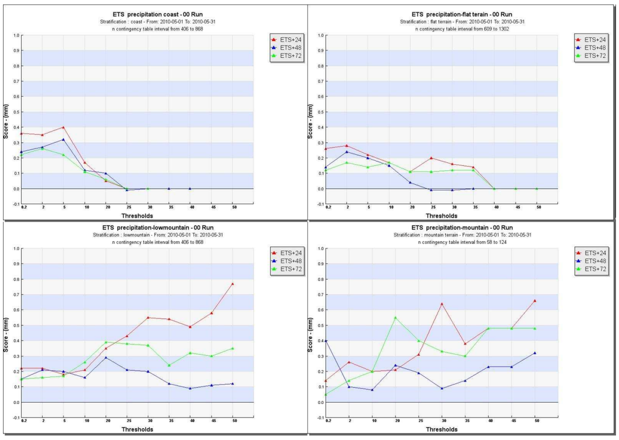

Figure 10: ETS, 24h accumulated precipitation, May 2010, Poland, coast terrain, flat terrain, low mountain terrain, mountain terrain

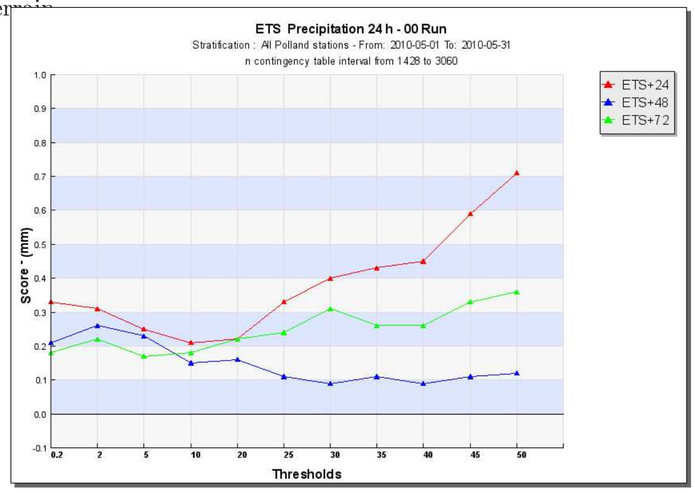

Figure 11: ETS, 24h accumulated precipitation, May 2010, all Poland stations

5 Conclusions

Seasonal (SON 2009, DJF 2009/2010, MAM 2010, JJA 2010) verification results of continuous parameters and monthly (May 2010) 24h accumulated precipitation were shown in this paper. Diurnal, seasonal cycles of ME for almost all considered continuous parameters (T2m, dew point, total cloud cover, wind speed) were observed for all seasons. RMSE and MAE of the mean sea level pressure increase with forecast range for all seasons. The best accumulated precipitation forecast was observed on low mountain area considering all precipitation thresholds as well as forecast range.