Application and verification of ECMWF products 2011

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1. Summary of major highlights

At MeteoSwiss, the model setups COSMO-7 and COSMO-2 are used for operational numerical weather prediction at a regional and local scale, respectively. In addition, both the results of the ECMWF Ensemble Prediction System (EPS) and the products of deterministic models are used for short- and medium-range forecasts. In particular CDF plots, provided by the web application ecCharts, are new helpful tools which help to assess meteorological parameters (e.g. precipitation amounts and gusts) during extreme weather events. The operational SYNOP verification, which was introduced in 2010 at MeteoSwiss, comprises the comparison of the performances of the IFS and COSMO-7 forecasts. COSMO-7 reflects a more detailed orography and a higher spatial resolution than IFS and therefore provides slightly more accurate forecasts for several near surface parameters in the short term.

2. Use and application of products

2.1 Post-processing of model output

2.1.1 Physical adaptation

MeteoSwiss produces operational numerical weather predictions with two different model setups called COSMO-7 and COSMO-2. The former is the 6.6 km version covering large parts of Europe and a forecast-range of +72 h. The latter is the 2.2 km version covering the Alpine region and a forecast-range of +24 h. The lateral boundary fields for COSMO-7 are provided by the global model IFS from the European Centre for Medium-Range Weather Forecasts (ECMWF). For COSMO-2 they are taken from COSMO-7. This model chain and the operational domains of COSMO-7 and COSMO-2 are shown in Figure 1.

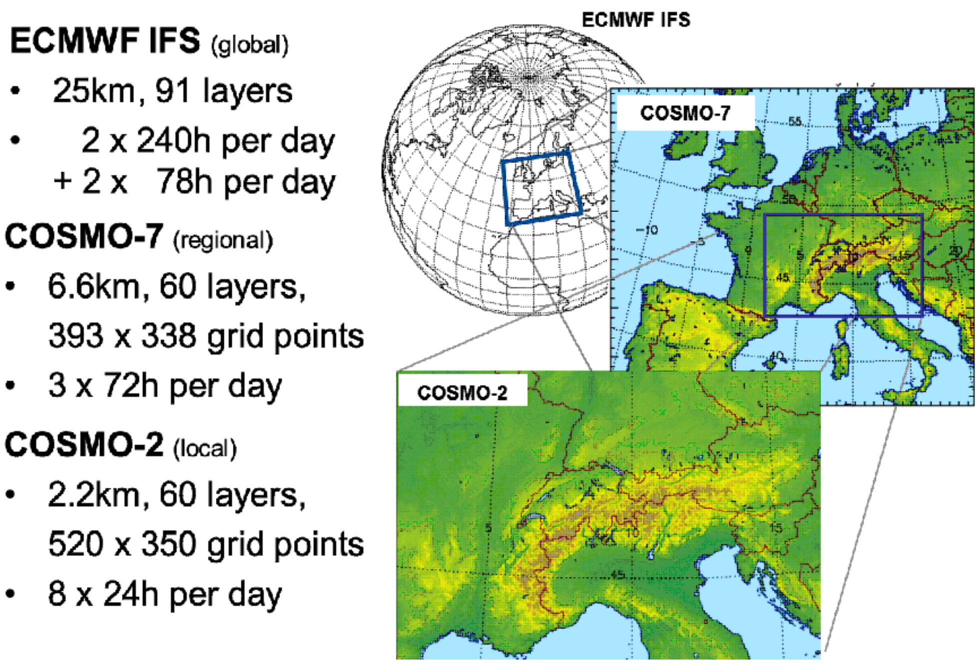


Figure 1 Model chain of the MeteoSwiss operational forecast suite.

Besides these two deterministic forecasting systems, MeteoSwiss supports the COSMO-LEPS time-critical application running at ECMWF. These ensemble data are used to derive probabilistic products for the early medium-range which complement the deterministic ones.

At MeteoSwiss, the dispersion model FLEXPART is run operationally with IFS deterministic forecast fields. Forecasts can be made up to +135 hrs for the whole globe.

The hydrological forecast suites are produced by the Federal Office for the Environment (FOEN). Several suites are run by COSMO-2, COSMO-7, COSMO-LEPS and IFS forecast data.

2.2 Use of products

Both the products of the deterministic models and the results of EPS are used for short- und medium-range forecasts. Visualization of the forecasts is mainly achieved by using the software "Ninjo" which enables comparisons of ECMWF products with alternative data (e.g. satellite and radar data) and numerical models.

For daily and extreme weather situations, new helpful tools have recently been launched. Using the web application ecCharts, for example, EFI and CDF plots can be produced which are used in the operational forecast section at MeteoSwiss.

CDF plots, which can be chosen for every grid point, turned out to be valuable in extreme weather situations. Based on CDF plots, the spatial distribution of the expected precipitation amounts and gusts can be assessed. The steepness of the curves provides information about the forecast uncertainty. Moreover, the results of the deterministic model can be compared with the EPS values. To facilitate these comparisons, we propose to display the deterministic values for precipitation, gusts and mean temperatures as a thin coloured line in the CDF plots.

In particular for synoptic- and mesoscale events, accurate forecasts for warning-relevant parameters could be obtained. For smaller scale meteorological situations, however, orographical influences (e.g. Swiss Alps) may reduce the resolution of the EPS. For most of these events, the deterministic model shows more accurate results (e.g. for the spatial precipitation distribution). Another problem is that the CDF time interval is fixed for 24 hours from 00 to 00 UTC of the following day. Because extreme events can last from one day to the following day (e.g. 18 to 06 UTC), less restrictions for choosing the time intervals are desirable.

Figures 2 to 6 illustrate the use of ecChart and CDF plots for the forecast of an extreme heavy precipitation event from July 13th 2011 in Switzerland.

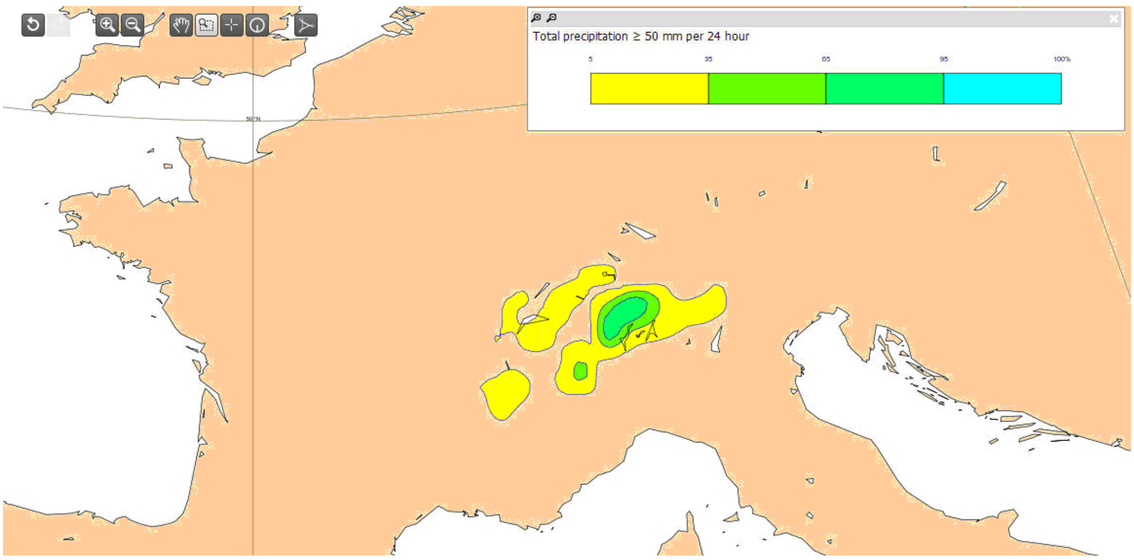


Figure 2 Heavy precipitation event in Switzerland on 13th July 2011: EPS probabilities for precipitation ≥ 50 mm/24 h, 14th July 2011 00 (+48 h forecast), calculated by ecChart.

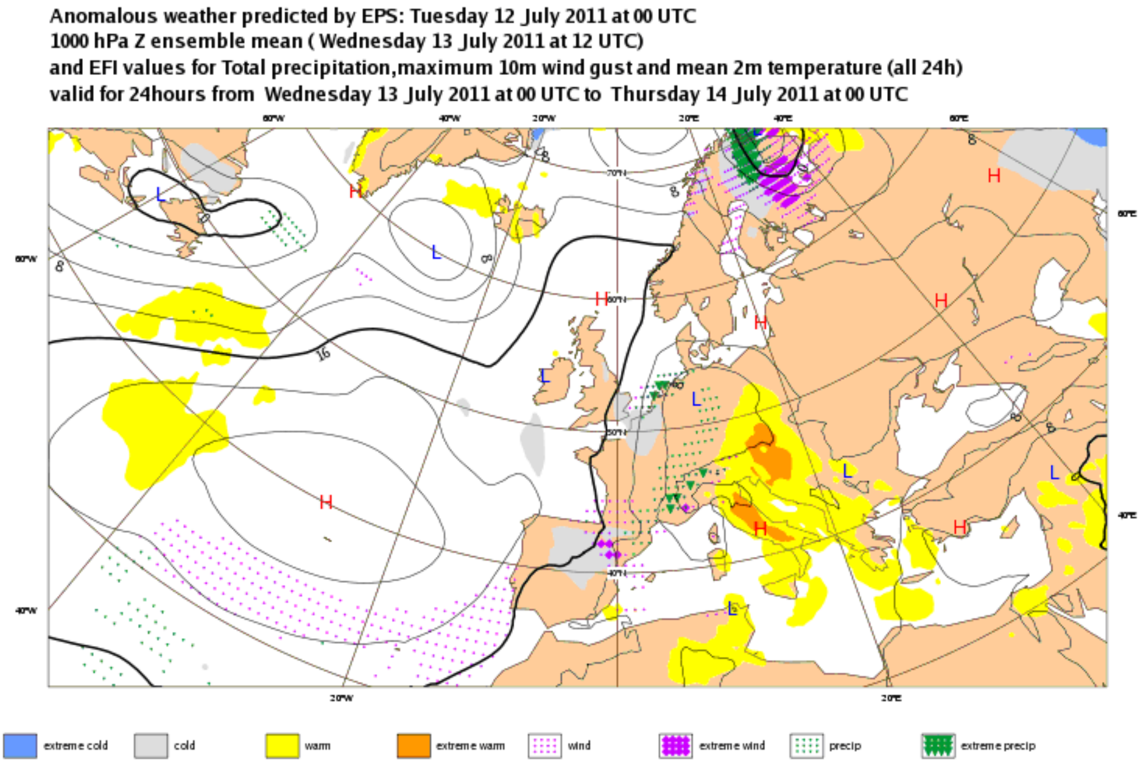


Figure 3 Interactive EFI-chart showing a moderate to high precipitation risk over Switzerland, especially in the southern part of Switzerland (Ticino area, green triangles).

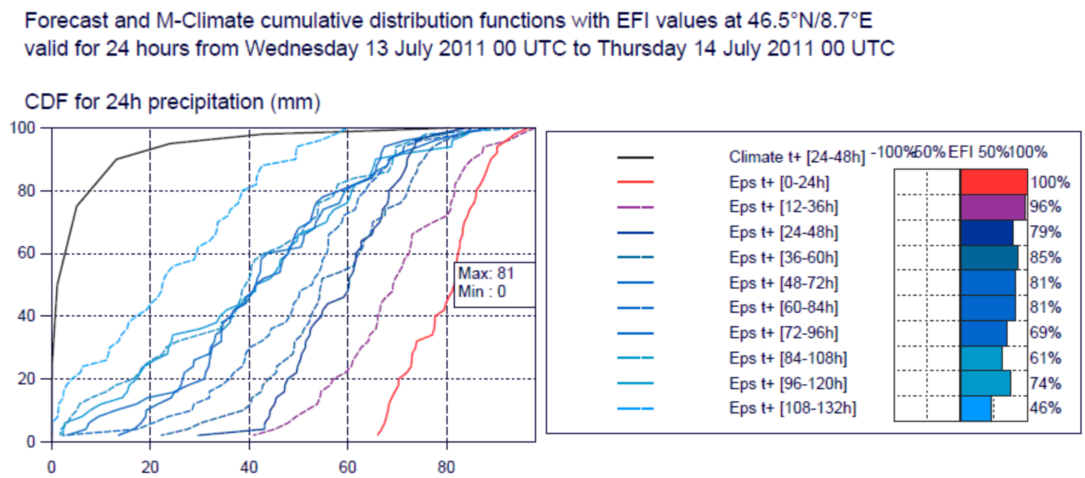


Figure 4 CDF-plot and EFI for Piotta in the northern part of the Ticino area. From run to run, the precipitation amount and the steepness of the curves increased. The last run (12th July 2011 00 UTC, red curve) best represented the measured precipitation (see Fig.5).

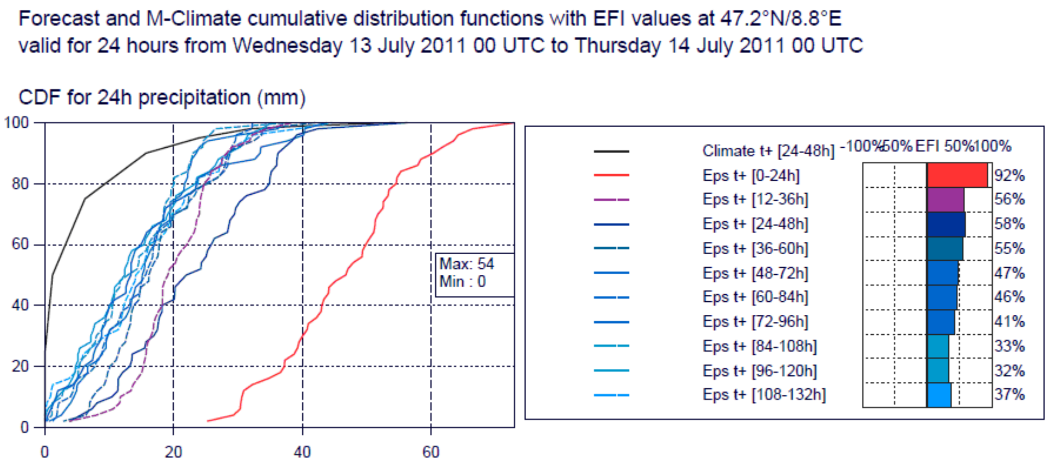


Figure 5 CDF-plot and EFI for Wèdenswil situated north of the Alps near Zurich. Most model runs significantly underestimated the precipitation amounts. Only the last run (12th July 2011 00 UTC, red curve) captured the heavy precipitation event, which brought 30 to 50 mm in this region (see Fig.6).

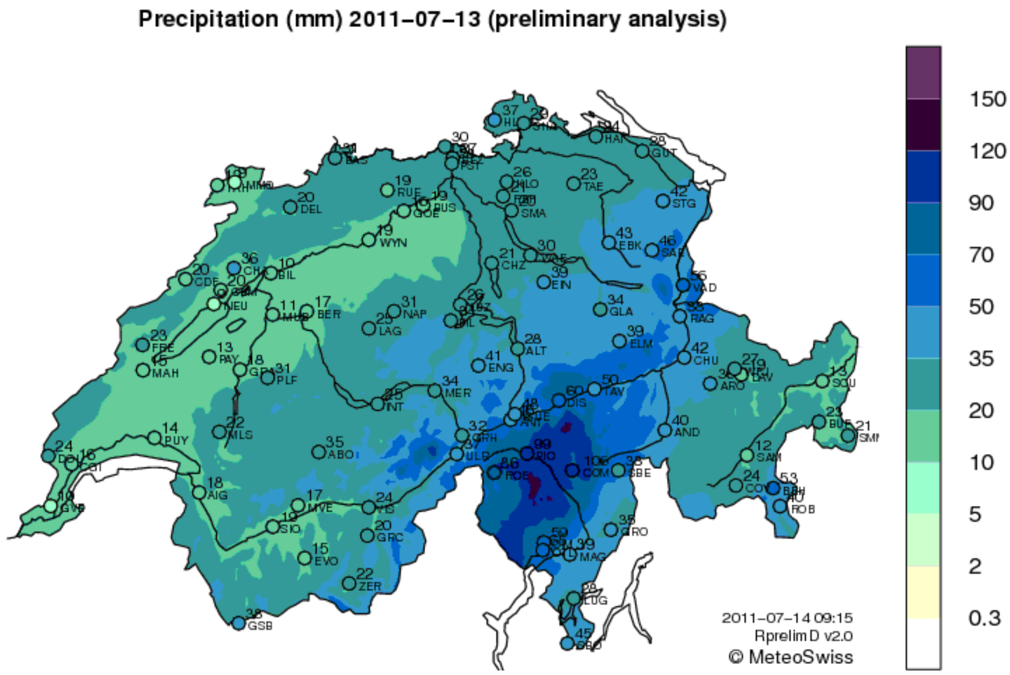


Figure 6 Total precipitation over Switzerland measured on 13th July 2011. The maximum amounts in the northern Ticino area are between 90 and 115 mm. The spatial distribution was forecasted quite accurately.

EcChart is intuitive and easy to use. The response time of the application is in an acceptable range but could possibly be improved. Specific products can be built instantly and called up at a later moment in time. The possibility to choose thresholds and lengths of time intervals in EPS probability charts (e.g. for precipitation) is highly appreciated. Furthermore, probabilities over one or several days can be calculated. These probabilities often seem to be too low. However, this assumption should be verified by MeteoSwiss. In addition, the functionality to build model vertical soundings for any grid point is desired.

3. Verification of products

3.1 Objective verification

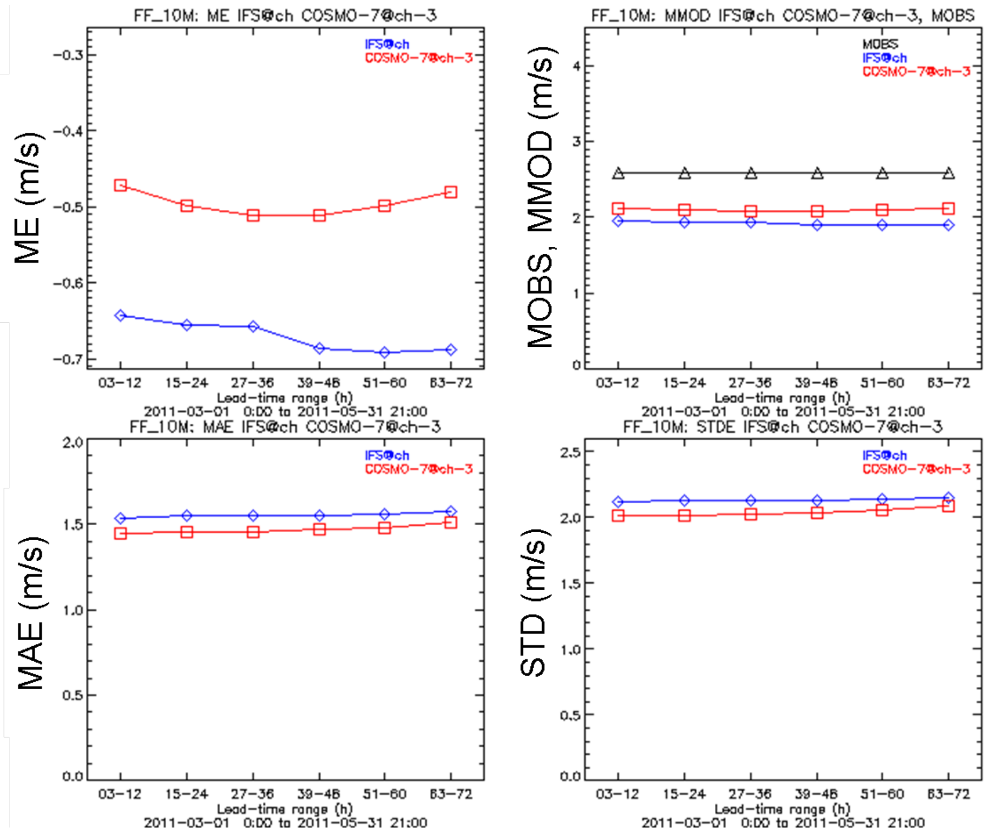
3.1.1 ECMWF model output compared to other NWP models

Since spring 2010, the operational SYNOP verification at MeteoSwiss comprises the comparison of the performances of IFS forecasts and COSMO-7 forecasts for the entire COSMO-7 domain (most of Europe) and for the Swiss stations only. The following typical near surface parameters are verified: 12 h precipitation sums (06–18UTC, 18–06UTC), total cloud cover, surface pressure and pressure reduced to sea level, 2 m temperature, 2 m dew point temperature, 10 m wind speed, direction and wind gusts. For the 2 m temperature forecasts, a height correction with a constant lapse rate of 0.006 K/m is applied in order to account for in parts significant height differences between the measurement location and the associated grid point. For the precipitation forecasts, the nine nearest neighbour grid points are aggregated for COSMO-7, the one nearest neighbour grid point is taken for IFS. Frankly, this comparison is somewhat unfair as IFS is more subject to double penalty. For an entirely fair comparison, a neighbourhood approach (*Weusthoff et al*. 2010) is applied to radar observations and forecast fields, but this is not shown here.

In general, the added value of the higher resolution of COSMO-7 manifests itself in a smaller standard deviation of the forecast error (Fig. 7a and b as examples for 10 m wind speed and 2 m temperature). The spatial distribution of the wind speed bias also reflects the more detailed orography in COSMO-7 compared to IFS (Fig. 8). The systematically overestimated amplitude of the daily temperature cycle of IFS is damped in the COSMO-7 forecasts resulting in a smaller bias particularly during night-time (Fig. 9).

For precipitation, several thresholds are verified with typical scores derived from the contingency table. Largest differences between IFS and COSMO-7 precipitation forecasts can be observed in the smallest threshold of 0.1mm/12h, revealing the systematic overestimation of the occurrence of these events by IFS ("drizzle problem") which is reduced in the COSMO-7 forecasts (Fig. 10). Figure 11 shows the relationship between the hit rate against the false alarm rate ("pseudo ROC") for all considered thresholds. It exhibits the consequences of this overestimation of IFS in a higher hit rate but much more so in the false alarm rate. The scores for medium precipitation events are very similar for the two models but show a lead time dependency. In summary, the comparison of the performance of IFS and COSMO-7 for precipitation does not result in a clear advantage of one model.

a)



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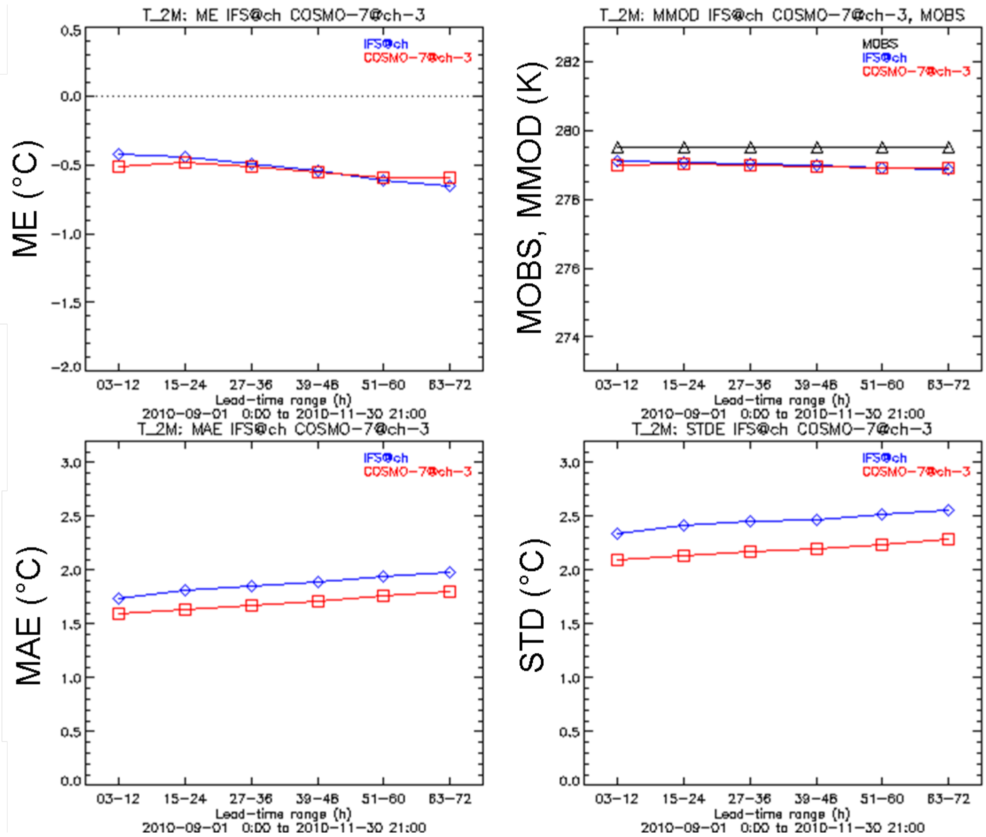

Figure 7 Summary verification for 10 m wind speed forecasts for spring 2011 (a) and 2 m temperature forecasts for autumn 2010 (b) at all Swiss stations. Scores are plotted as a function of lead time, summarising two runs (00UTC, 12UTC) per day. IFS scores are plotted in blue, COSMO-7 scores are plotted in red. COSMO-7 shows a smaller standard deviation of the error compared to IFS.

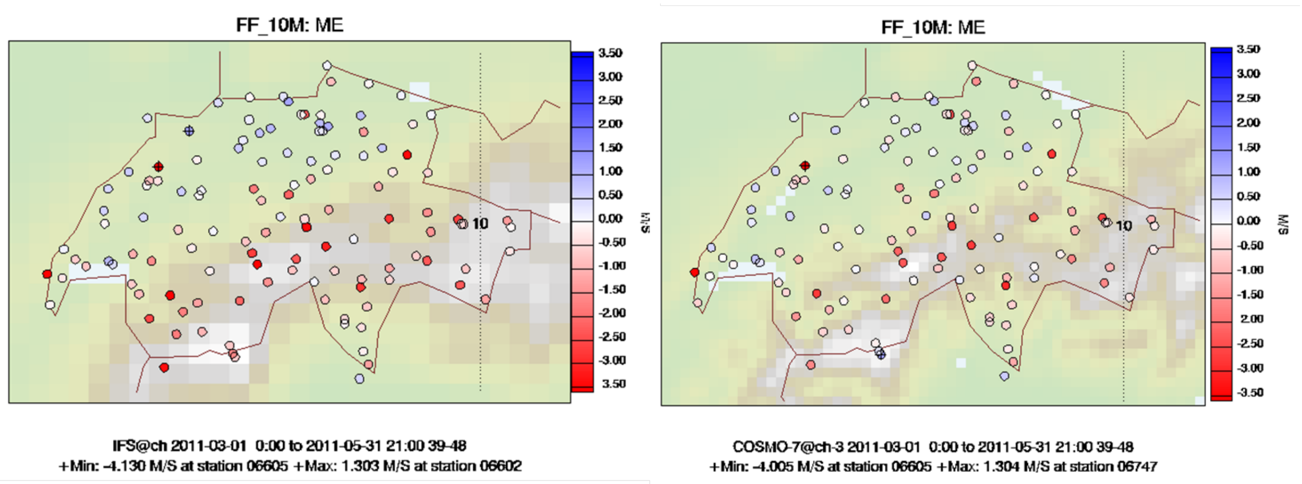

Figure 8 Spatial distribution of the mean error of IFS 10 m wind speed forecasts (left panel) compared to COSMO-7 forecasts for the Swiss stations for the lead times 39–48 h. The advantage of the higher resolution of COSMO-7 is particularly observable for Alpine stations.

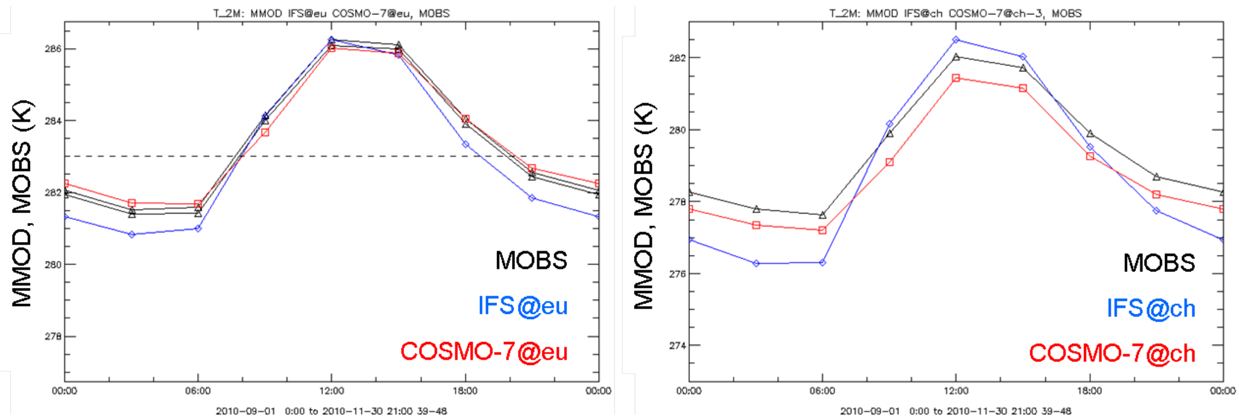

Figure 9 Daily cycle of the 2 m temperature for all European stations (left panel) and all Swiss stations (right panel) for autumn 2010 and lead time 39–48 h. IFS forecasts are characterised with an overestimation of the amplitude in the daily cycle, COSMO-7 forecasts do not exhibit this property. (Note: the dashed line in the left panel only indicates a deviation from the operationally set plotting range)

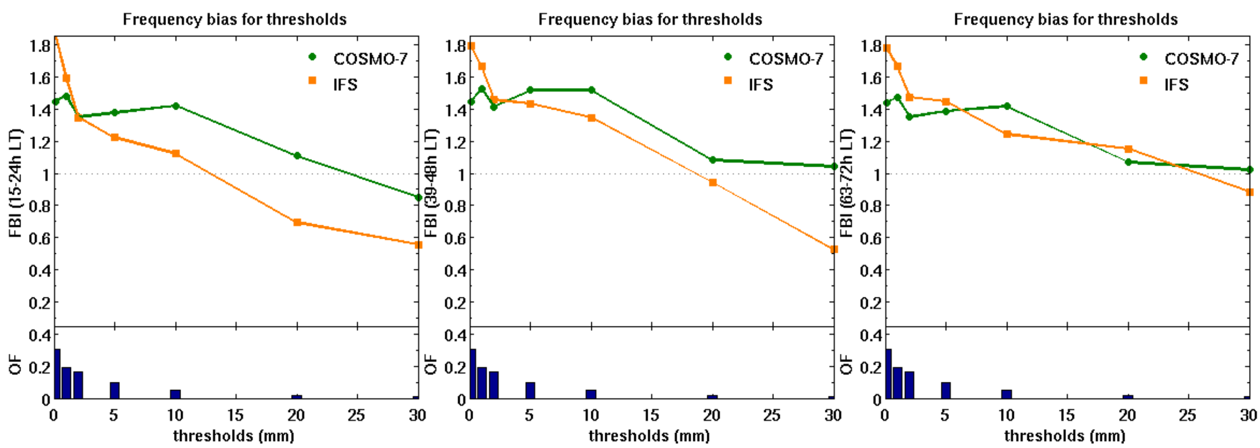

Figure 10 Frequency bias of precipitation events as a function of threshold for three different lead times (15–24 h on the left, 39–48 h in the middle, 63–72 h on the right) for all Swiss stations in autumn 2010. IFS scores are shown in orange, COSMO-7 forecasts are shown in green. The observed frequency of the events of each considered threshold is plotted at the bottom of each figure. The overestimation of the frequency of events with low precipitation amounts of IFS is reduced in the COSMO-7 forecasts. The overestimation in the FBI of COSMO-7 persists also for higher thresholds.

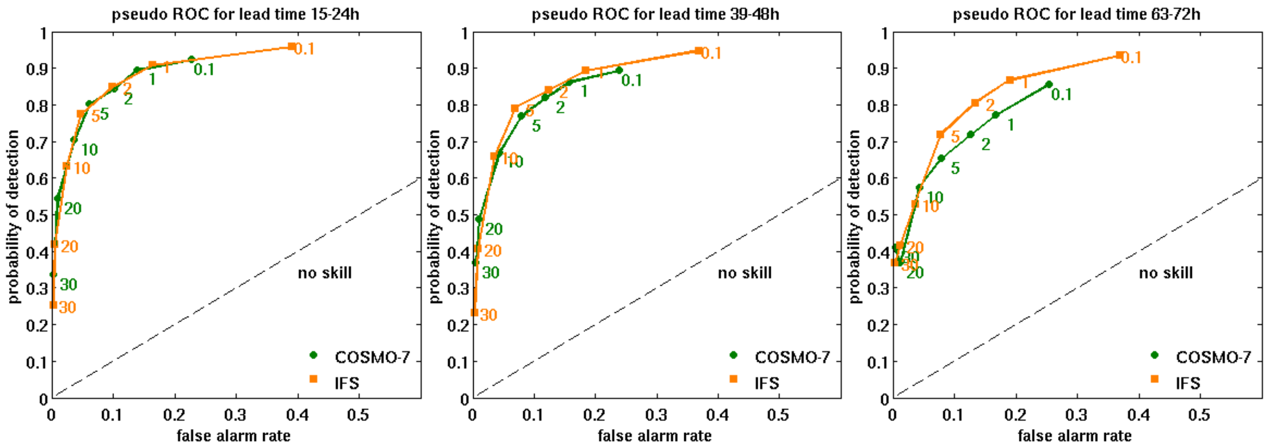

Figure 11 "Pseudo-ROC" plotting the false alarm rate for each threshold (as indicated by the numbers in the plots) against the hit rate for IFS in orange and COSMO-7 in green for all Swiss stations and autumn 2010 for the same lead time ranges as in Figure 10. The overestimation of small precipitation events by IFS is reflected in a higher false alarm rate compared to COSMO-7. The scores for medium precipitation events are fairly similar for IFS and COSMO-7 except for the longest lead time range (right panel) where IFS shows clearly better results (confirmed in other seasons). For high precipitation events (20mm/12h), COSMO-7 has a higher hit rate than IFS for earlier lead times, with increasing lead time, this advantage of COSMO-7 diminishes.

4. References

Weusthoff, T., Ament, F., Arpagaus, M. and **Rotach, M.W**., 2010: Assessing the Benefits of Convection-Permitting Models by Neighborhood Verification: Examples from MAP D-PHASE. *Mon. Wea. Rev.,* **138 (9)**, 3418–3433.