Application and verification of ECMWF products 2015

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1. Summary of major highlights

2. Use and application of products

2.1 Post-processing of ECMWF model output

2.1.1 Statistical adaptation

Extended and long-range forecasts

Post-processing methods and strategies are extensively analysed at MeteoSwiss to improve the usability of extended-range and long-range forecasts. In particular, post-processing is used to improve forecasts of application-relevant climate indices and to combine medium-range and extended-range forecasts with monitoring products. Furthermore, MeteoSwiss issues recalibrated seasonal temperature forecasts using the climate-conserving recalibration proposed by Weigel *et al.* (2009).

Issuing forecasts for application-relevant climate indices requires the use of forecast information and post-processing at daily resolution. In particular, daily bias correction is essential for indices defined with respect to an absolute threshold (e.g. heating degree days, frost days). In a recent publication, we have shown that temporal smoothing can substantially improve the estimates of bias correction parameters (Mahlstein *et al.,* 2015). The same publication also describes the importance of the temporal smoothing for an accurate estimate of percentile-based index. Figure 1 illustrates the difference between the conventional 5-day window approach to guess the percentile and the newly introduced LOESS-fit. Figure 1a shows the absolute difference in the number of warm nights a year between the two methods and Figure 1b illustrates the difference in the anomaly correlation between the two. Figure 1c depicts the actual skill of System 4 to forecast the number of warm nights based on a LOESS-fitted percentile estimate. Figure 1d shows the same as Figure 1b but for wet days.

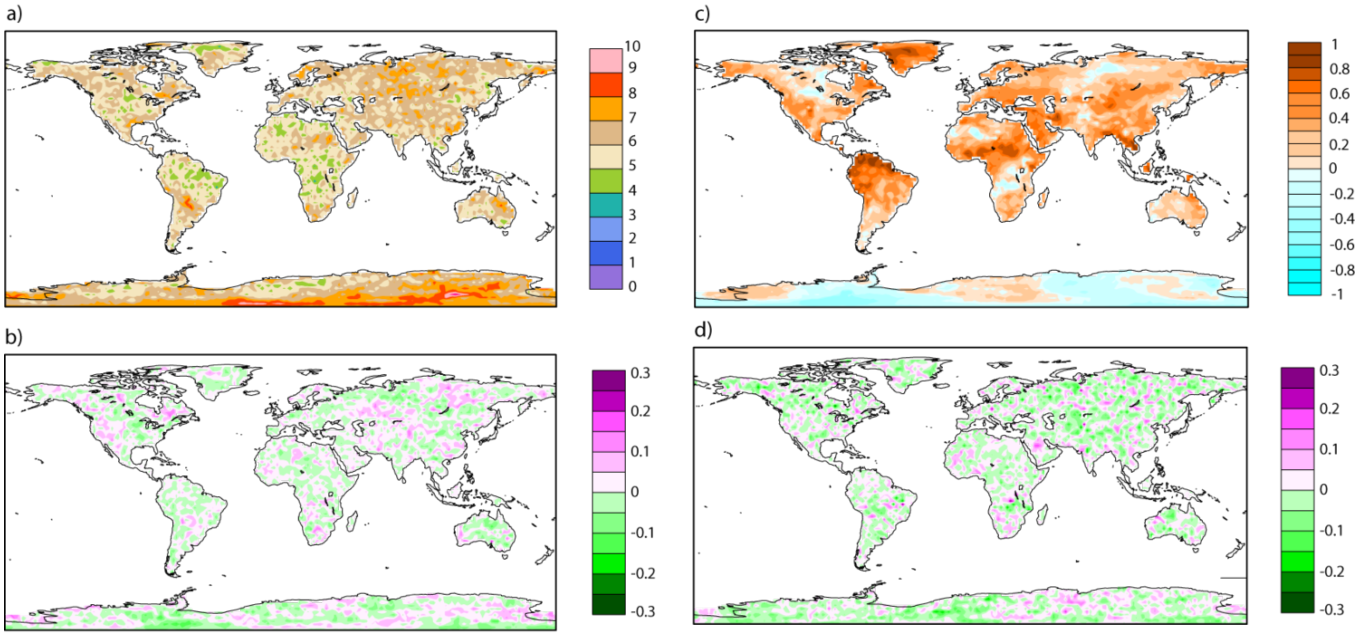

Fig. 1 a) Mean absolute difference in number of warm nights a year between the 5d-fit and the LOESS-fit averaged over the time period 1981-2010 of the ERA-Interim data set. b) Difference in skill (anomaly correlation) averaged over a 30-year hindcast period (1981-2010) between the two approaches for JJA. Positive values indicate an improvement in skill by the use of the LOESS-fit compared to the 5d-fit, negative a decline in skill. c) Anomaly correlation between System4 and LOESS-fitted ERA-Interim data for warm nights over the hindcast period 1981-2010 for JJA. d) Difference in skill (anomaly correlation) averaged over a 30-year hindcast period (1981-2010) between the two approaches for JJA for the number of wet days. Positive values indicate an improvement in skill by the use of the LOESS-fit compared to the 5d-fit, negative a decline in skill.

In addition, daily bias correction methods of varying complexity have been compared and the effect of bias correction on the skill of forecasts of climate indices has been analysed as part of the EUPORIAS project. We find that while some form of bias correction is important, the specific choice of bias correction method has little effect on the skill of seasonal forecasts of climate indices. In addition, we currently explore the effect of spatial aggregation of forecasts of climate indices on forecast skill (Figure 2).

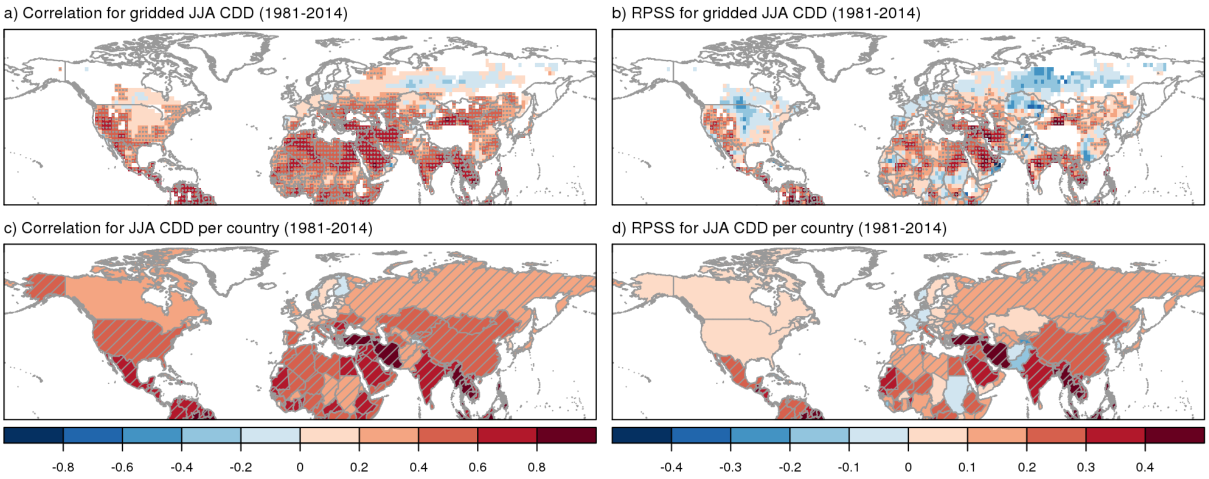

Fig.2 Correlation (a, c) and ranked probability skill score (b, d) of cooling degree days in summer (JJA) derived from bias corrected seasonal forecasts with ECMWF System4 for the period 1981-2014. The cooling degree day forecasts in c and d are aggregated nationally with weighting by population density as a proxy for national energy demand for cooling. Stippling and hatching denotes significance at the 10% level.

2.1.2 Physical adaptation

MeteoSwiss runs its own short-range forecasting system. The core of this system is the non-hydrostatic model COSMO (www.cosmo-model.org). It is running operationally at two spatial scales: The regional model COSMO-7 with a horizontal resolution of about 6.6 km is driven by the ECMWF global model IFS. The local model COSMO-2, having a horizontal grid spacing of about 2.2 km, is nested in COSMO-7. The nesting of NWP models is illustrated in Fig. 3.

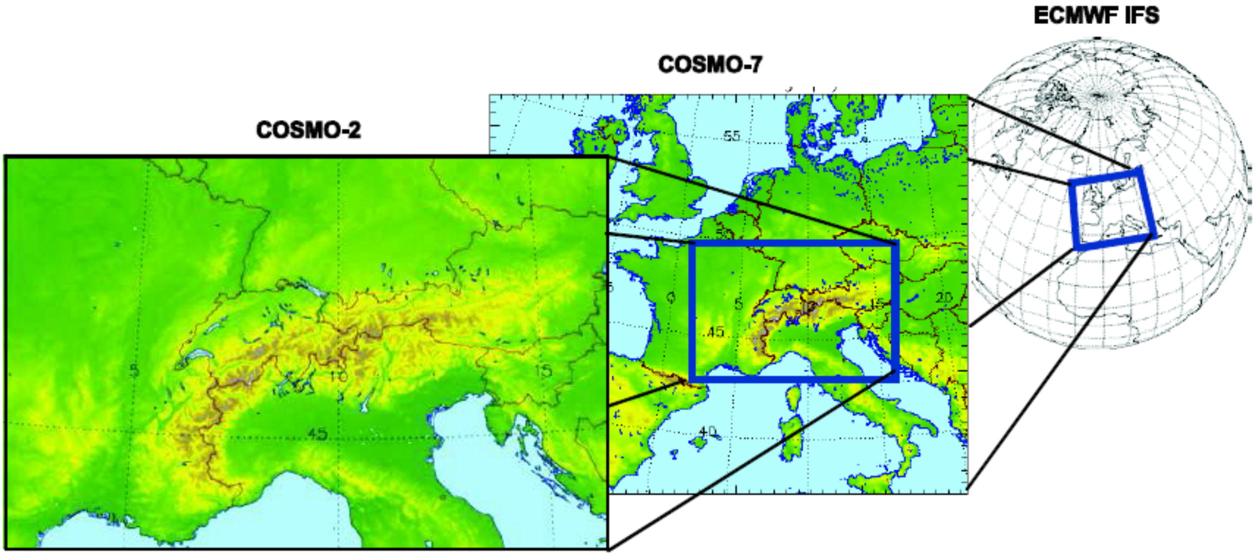

Fig. 3 NWP System of MeteoSwiss

Both COSMO-7 and COSMO-2 have their own assimilation cycle, which is updated in intervals of 3 hours. Three daily 72 hours COSMO-7 forecasts are calculated, based on the 00, 06 and the 12 UTC IFS (main or boundary conditions) runs. One COSMO-2 forecast is computed every 3 hours just after the computation of the necessary COSMO-7 boundary conditions. The lead time of the COSMO-2 forecast starting at 03 UTC is 45 hours, and 33 hours otherwise. The cut-off time for all forecasts is 45 minutes.

An on-demand mode can be activated, e.g. in case of an incident in nuclear power plants. COSMO-2 is then computed hourly with at least 4 hours assimilation and 6 hours forecast.

A sophisticated set of scripts controls the whole operational suite, and allows for a very high reliability of the system, with less than 2% of the forecasts requiring manual intervention. This same environment is also used to run parallel suites to validate proposed modifications to the system and to facilitate experimentation by the modelling group.

The computing resources and expertise are provided by the Swiss National Supercomputing Centre (CSCS, www.cscs.ch). COSMO-2 and COSMO-7 are calculated in parallel on a Cray XE6 equipped with 12-cores Opteron Magny-Cours with 1728 computational cores and achieve a sustained performance of 280 GFlops on 1079 computational Cores for COSMO-2. Pre- and post-processing run on the service nodes of the machine. A similar machine with 4032 computational Cores is available as fail-over and used for research and development. A large multi-terabytes long-term storage is used for archiving purposes and a 1 GBit/s link connects the MeteoSwiss main building with the CSCS (on the other side of the Alps!).

2.1.3 Derived fields

2.2 Use of ECMWF products

3. Verification of products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS)

3.1.2 ECMWF model output compared to other NWP models

Compare the performance of ECMWF models with other NWP models used by your service

As part of the operational seasonal verification with SYNOP observations, IFS forecasts are regularly compared to the COSMO models operated at MeteoSwiss. For this, parameters such as pressure, 2 m temperature, 2 m dewpoint, 10 m wind speed, cloud cover, 12-hourly precipitation, and 10 m wind gusts are compared to associated observations. For precipitation as one of the most important parameters, an example of a verification summary is shown in Fig. 4. Compared to COSMO-2 and COSMO-7, IFS shows a stronger overestimation of low precipitation amounts and also a stronger underestimation of high amounts. For thresholds of 10 mm/12 hours the values of all three models are quite similar.

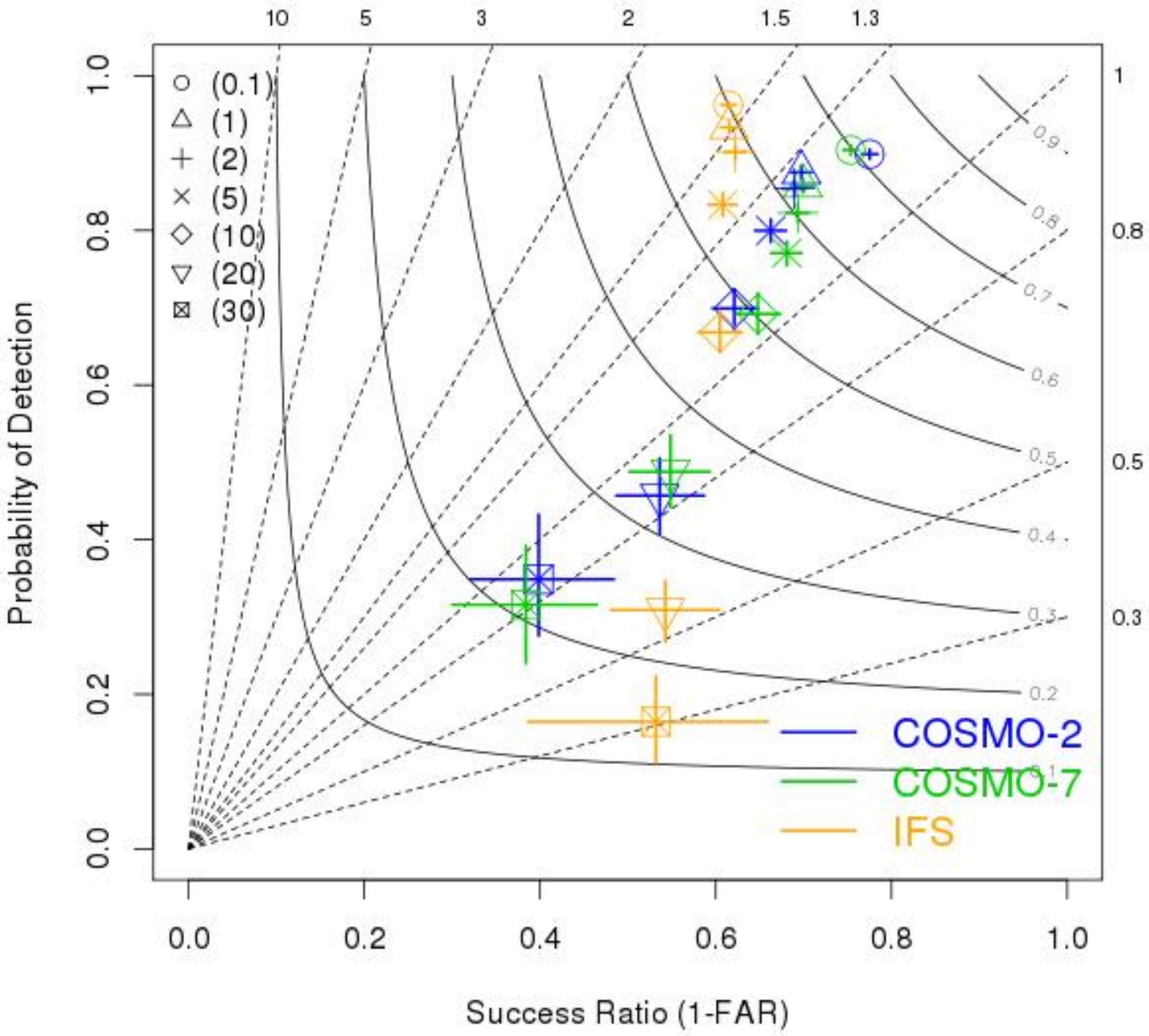

Fig. 4: Comparison of the performance in Spring 2015 of COSMO-2, COSMO-7 and IFS 12 for 12 hour accumulated precipitation forecasts with the lead time +6 to +18 hours

For Fig. 4, forecasts data from all 00 and 12 UTC base times and observational data from the 117 Swiss stations are used. Shown are the results for 7 different thresholds in a performance diagram derived from the geometrical relationship between several scores based on the contingency table (Roebber, 2009). Plotted is the success ratio (1-false alarm ratio) against the probability of detection. The dotted auxiliary lines indicate the frequency bias with the values at the marginal axes of the plot and the solid black contours are isolines of the critical success index with the respective values at the right end within the plot area. The perfect forecast lies at the upper right corner of the plot. The different thresholds are visualized with different symbols, the results of the different models have different colours. The cross on each symbol depicts the 95th quantile of the sampling uncertainty derived from bootstrapping (with N=1000 random draws) giving an indication about the confidence in the result.

3.1.3 Post-processed products

Extended-range and long-range forecasts

Post-processed products such as seasonal forecasts of application-relevant climate indices are extensively verified using both deterministic and probabilistic scores (see also Fig. 2). Verification of long-range forecasts uses scores independent of ensemble size developed in the SPECS project and implemented for use with the statistics software R by MeteoSwiss (see https://github.com/MeteoSwiss/easyVerification).

3.1.4 End products delivered to users

3.2 Subjective verification

3.2.1 Subjective scores (including evaluation of confidence indices when available)

3.2.2 Case studies

4. References to relevant publications

Mahlstein, I., **C. Spirig, M.A. Liniger,** and **C. Appenzeller**, 2015: Estimating daily climatologies for climate indices derived from climate model data and observations. *J Geophys Res-Atmos*, **120**, 2808-2818

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