Application and verification of ECMWF products 2018

Federal Office of Meteorology and Climatology MeteoSwiss

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1. Summary of major highlights

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2. Use and application of products

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2.1 Post-processing of ECMWF model output

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2.1.1 Statistical adaptation

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2.1.2 Physical adaptation

No changes have been made last year to the suite of limited-area models. The IFS forecasts serve as boundary conditions for the deterministic model COSMO-1 with 1.1 km grid spacing, driven by HRES, and the ensemble system COSMO-E with 2.2 km grid spacing, driven by ENS. COSMO-1 has 80 levels and runs 8 times per day out to 33 hours (base time 03:00 UTC to 45 hours). COSMO-E is a 20 member ensemble with 80 levels, with a maximum forecast range of 120 hours. The regional model COSMO-7 with a grid spacing of 6.6 km, covering a larger domain, is planned to phase-out next year. Currently work is ongoing to replace the COSMO-7 products by HRES products with maximum grid resolution. All models are directly one-way nested into IFS with no intermediate step. The domains of the COSMO models and their topography are illustrated in Figure 1.

Figure 1 Domains of COSMO models at MeteoSwiss. Left: COSMO-1, middle: COSMO-E, right: COSMO-7

All COSMO models have their own assimilation cycle, which is updated in intervals of 3 hours. COSMO-E uses an Ensemble Kalman Filter analysis, COSMO-1 and COSMO-7 use Nudging.

The Lagrangian trajectory calculation tool Lagranto (Sprenger and Wernli 2015) is used to produce routine and on-demand trajectory plots based on global HRES fields with 0.25° resolution. Currently the use of 0.1° HRES fields over Europe is tested to replace the COSMO-7 trajectory products.

The Lagrangian particle dispersion model Flexpart (Stohl et al. 1998) is used for on-demand calculation of the dispersion of radioactive nuclides based on HRES fields with a resolution of 1° worldwide and 0.25° over Europe. As for Lagranto, the use of hourly 0.1° HRES fields is currently being tested.

2.1.3 Derived fields

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2.2 ECMWF products

2.2.1 Use of Products

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2.2.2 Product requests

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3. Verification of products

3.1 Objective verification

3.1.1 *Direct ECMWF model output (both HRES and ENS)*

The routine seasonal model verification at MeteoSwiss includes both HRES and ENS. The surface parameters verified on an hourly basis are precipitation (also 12-hourly and 6-hourly), total cloud cover, global radiation, sunshine duration (also 12-hourly), 2 m temperature, dewpoint temperature, and relative humidity, 10 m wind speed, gusts (also 6-hourly), and direction, station pressure and pressure reduced to sea level. These parameters are available at 160 SwissMetNet stations in Switzerland. Some are not available on the larger verification domains of COSMO-7 (encompassing approximately 1400 SYNOP stations) and COSMO-1/COSMO-E (encompassing more than 560 SYNOP stations).

As the averaging of grid points has proven to be detrimental to HRES precipitation forecasts, the averaging is no longer applied to HRES. Nevertheless, there is still a considerable positive bias for weak and even moderate precipitation in HRES (Figure 2 left). The dew point temperature (Figure 2, middle) and relative humidity (not shown) at 2 m are underestimated by HRES. These two findings occur all year round. The total cloud cover (Figure 2, right) has been well estimated by HRES last winter. More often, there is a positive bias in HRES, but as the measured cloud cover is derived from long wave radiation, it is less sensitive to high clouds and might in fact have a slight negative bias.

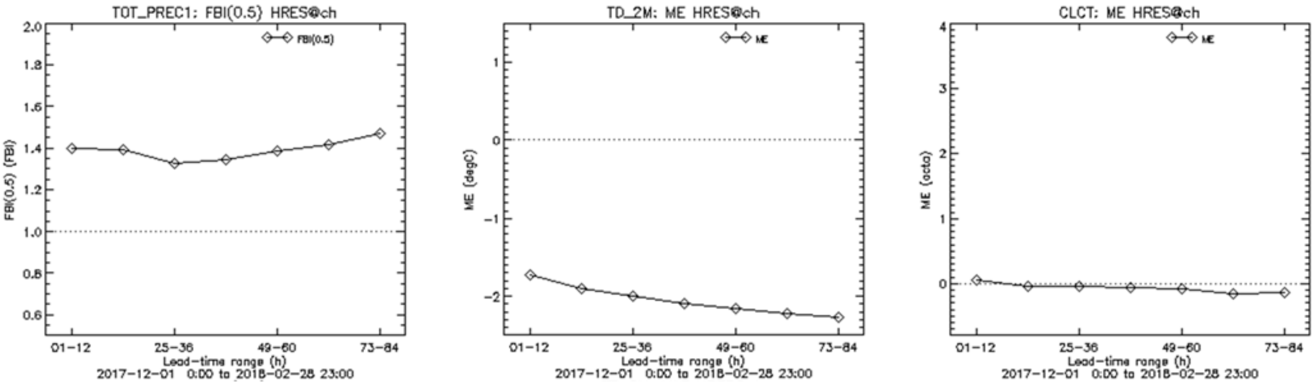
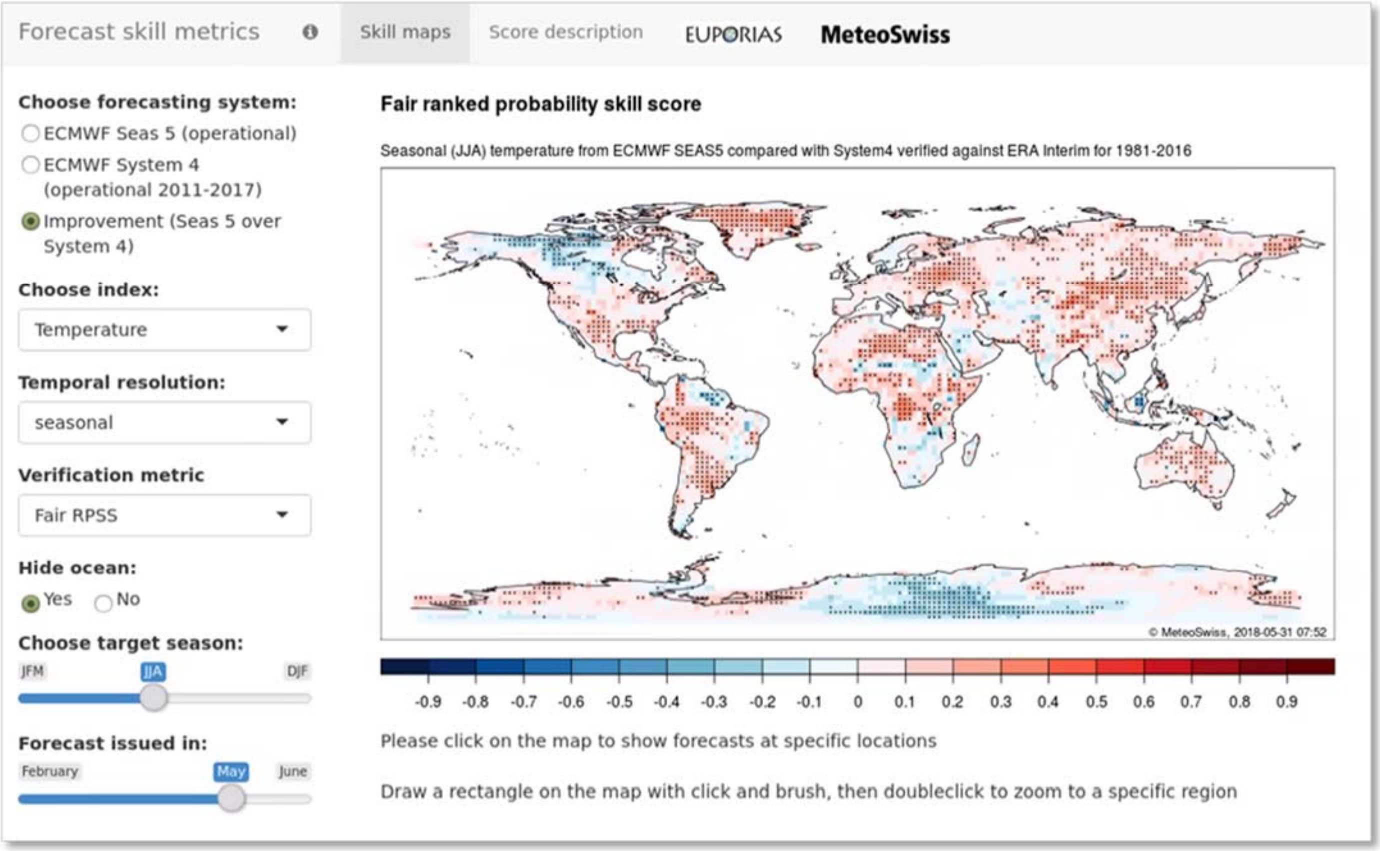


Figure 2 Frequency bias of HRES hourly precipitation above 0.5 mm (left), dew point temperature bias (middle) and total cloud cover bias (right), in function of 7 lead time ranges, for Winter 2017/2018, at Swiss stations.

Seasonal Forecasts

The public web platform (https://meteoswiss-climate.shinyapps.io/skill_metrics) with verification of seasonal temperature and rainfall forecasts has been updated to include results from the new operational seasonal forecasting system ECMWF SEAS5. In addition, comparative verification illustrating the improvement in predictive accuracy and association between ECMWF System4 and SEAS5 has been included (Figure 3). Overall, ECMWF SEAS5 outperforms System 4 in accordance with the verification results made available by ECMWF. The web platform keeps being regularly used by a number of users and feedback on the content and functionality has been overwhelmingly positive.



Choose forecasting system:
○ ECMWF Seas 5 (operational)
○ ECMWF System 4 (operational 2011-2017)
● Improvement (Seas 5 over System 4)

Choose index: Temperature

Temporal resolution: seasonal

Verification metric Fair RPSS

Hide ocean: ● Yes ○ No

Choose target season: JJA

Forecast issued in: May

Fair ranked probability skill score

Seasonal (JJA) temperature from ECMWF SEAS5 compared with System4 verified against ERA Interim for 1981-2016

Please click on the map to show forecasts at specific locations

Draw a rectangle on the map with click and brush, then doubleclick to zoom to a specific region

Figure 3 Improvement in forecast quality as measured using the fair ranked probability skill score for ECMWF SEAS5 summer (JJA) temperature forecasts issued in May over forecasts with the previously used system, ECMWF System 4. In red areas where SEAS5 outperforms System4 are shown. Stippling denotes significant differences in scores at the 5% level.

ENS forecasts of integrated vapor transport (IVT)

In several places around the world atmospheric rivers or extreme integrated vapor transport (IVT) are causally related to flood events. Also in Switzerland, extreme IVT (threshold is the 99th percentile) oriented perpendicular to the main orography heralds extreme flood events. This relationship is exploited for an operational flood alert system on the medium-range time scale. We verify probabilistic medium-range forecasts of IVT and precipitation by the IFS-ENS and we develop compact visualizations for operational use by hydrologists. The study was done in three regions in Switzerland for all four seasons. The regions are the East of Switzerland, the Jura representing the West and the Tessin in the South of Switzerland. In the course of the study quite a large number of different verification analysis were performed. Here, we show two of the lesser known skill scores:

1. Flux direction weighted CRPSS

The direction of the flood as well as the magnitude of IVT is central for flood triggering in this example. Therefore, we developed a verification skill that consists of the combined product. In order to analyze the combined product of IVT amplitude and flux direction we proceed as following: Depending on the direction of the flux the IVT was weighted. For IVT values coming from within the relevant sector, the weight is one. With decreasing distance from the border of the sector up to a distance of 90°, the weight was linearly decreased to 0. Then, the CRPSS of this combined product was calculated as shown in Figure 4. Figure 4 shows that in June-July-August (JJA), the skill remains positive for at least 9 days in all three regions.

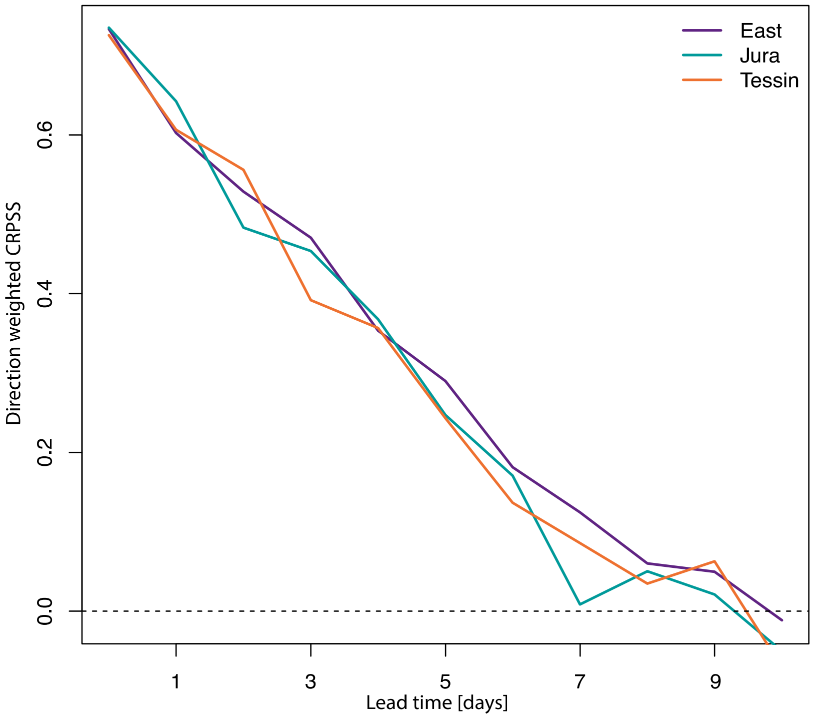


Figure 4 CRPSS of combined product of direction-weighted IVT in JJA for the three relevant regions (climatological distribution is used as a reference forecast).

2. The weighted CRPS

As extreme events are the main focus of this study, it was inevitable to verify the forecasts on their ability to forecast such events. Lerch (2017) describe in their work a possibility to verify extreme events in a probabilistic forecast. The score is based on the CRPS and can be described as following: The method uses all possible events but attaches a weight around a threshold. In our case, IVT events slightly smaller than the 99th percentile are given a small but increasing weight until the threshold is met. All events greater than the threshold are fully taken into account, hence are given weight one.

Only results for the East and Jura are shown for the following reason: As the flux direction is not included in this skill score, hence all events larger than the threshold are considered independent of their direction. For the two regions analyzed the number of high IVT events is enough as the threshold is defined as a direction-dependent threshold, there are still a number of events greater than the threshold, yet coming from a different direction. However, in the Tessin there is only a handful of events above the threshold, which will not be enough to generate any meaningful statistics, especially when calculating the skill score. Figure 5 shows that extreme events can skillfully be forecasted up to about six days ahead in the East of Switzerland and Jura during JJA.

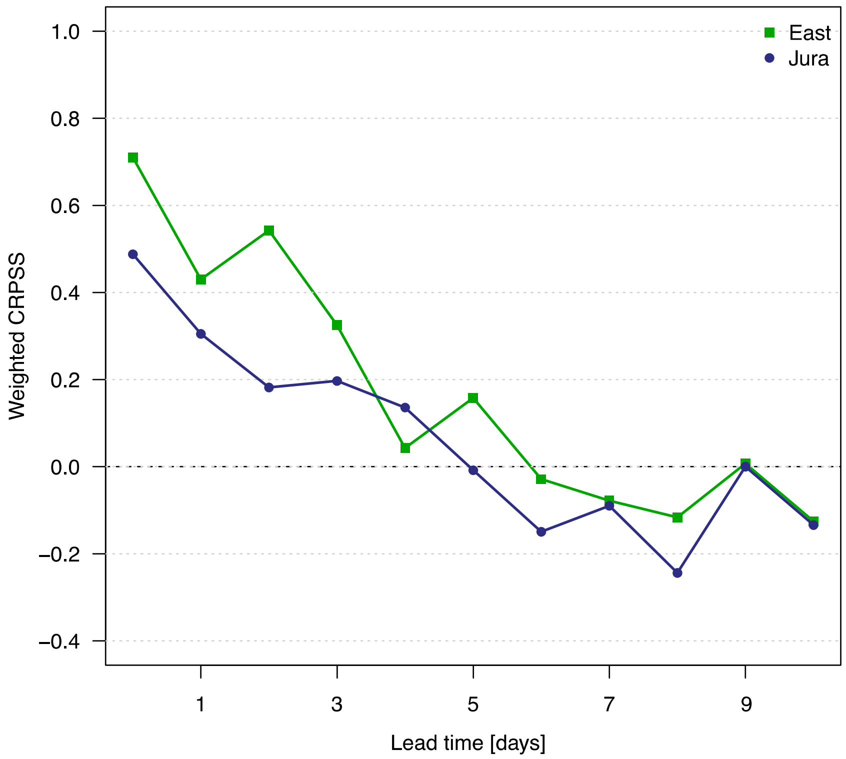


Figure 5 The weighted CRPSS of the IVT forecast for the East and Jura for JJA.

3.1.2 *ECMWF model output compared to other NWP models*

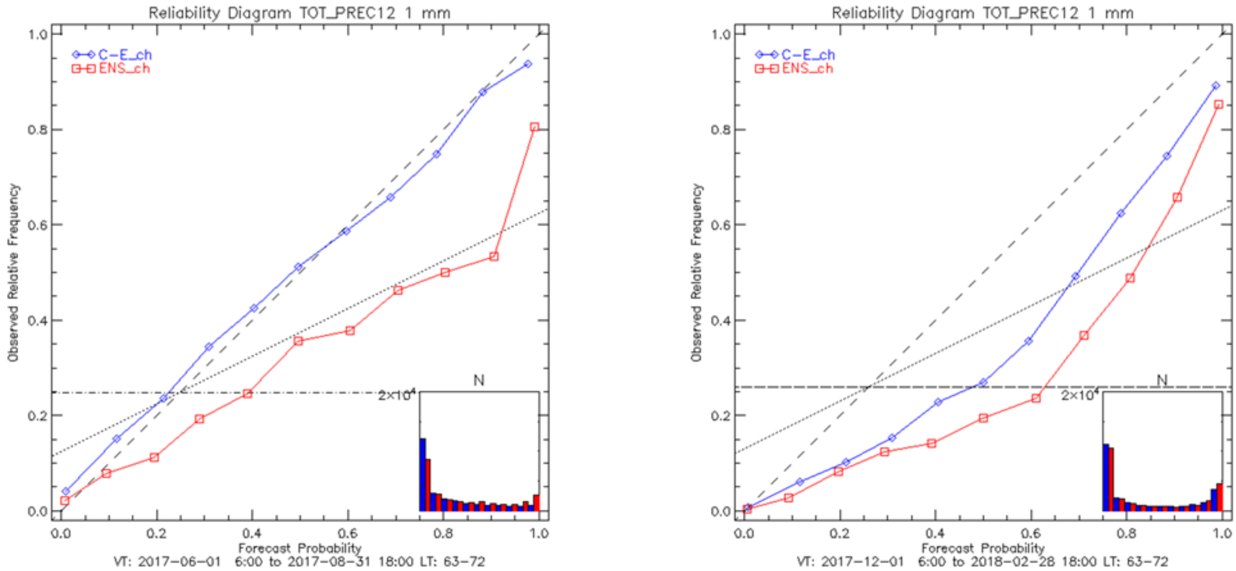


Figure 6 Reliability diagram for Summer 2017 (left) and Winter 2017/2018 (right). Comparison of COSMO-E (blue) and ENS (red). Threshold 1 mm/12 h, lead times +60 h to +72 h of all 00 and 12 UTC forecasts, at Swiss stations.

Figure 6 compares the reliabilities of the ensemble systems COSMO-E and ENS. The forecast event is precipitation larger than 1 mm/12 h. The COSMO-E probabilities are quite accurate for Summer 2017 (left). ENS on the other hand is over-confident and overestimates the probabilities considerably. In Winter 2017/2018 (right), both ensemble systems are over-confident and overestimate the probabilities. For probabilities of 30% and larger however, COSMO-E has an increasing advantage over ENS.

3.1.3 *Post-processed products*

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3.1.4 End products delivered to users

3.2 Subjective verification

3.2.1 Subjective scores

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3.2.2 Case studies

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4. Feedback on ECMWF "forecast user" initiatives

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5. References to relevant publications

Lerch, S., T. L. Thorarinsdottir, F. Ravazzolo and **T. Gneiting,** 2017**:** Forecaster's Dilemma: Extreme Events and Forecast Evaluation. Statistical Science**, 32,** 1, 106–127

Sprenger, M. and **H. Wernli**, 2015: *Geosc. Model Dev*., **8**, 2569–2586, DOI: 10.5194/gmd-8-2569-2015

Stohl, A., M. Hittenberger, and **G. Wotawa**, 1998: Validation of the Lagrangian particle dispersion model FLEXPART against large scale tracer experiments. *Atmos. Environ*., **32**, 4245–4264