Application and Verification of ECMWF Products 2021

Deutscher Wetterdienst (DWD)
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1. Summary of major highlights

The usage of a combined ICON-MOS (MOS=model output statistics) and ECMWF-MOS at DWD continues to form the basis for the production of local short and medium range forecasts (known as MOSMIX dataset). ECMWF high resolution forecasts (HRES) in conjunction with ICON forecasts are also being used for the production of a probabilistic warning guidance based on the MOS technology. Both, MOSMIX and the warning guidance are visualised and frequently used via DWD's Weather Warning App (for the use on mobile phones). The use of ECMWF Ensemble data within DWD's visualisation software NinJo continues, too, and has been extended over the past years.

2. Use and application of products

2.1 Direct Use of ECMWF Products

The operational forecasting division at DWD uses ECMWF products via DWD's visualization system NinJo and also via direct access to the website of ECMWF. In the context of extreme weather events especially outside of Europe, ecCharts is often used. Within the last two years, an extreme weather index (EWI) has been developed and is highly excepted also by customers using ensemble data for the forecast of high impact weather on the global scale with focus on heavy rain and strong wind events.
Obviously, the quality of monthly forecasts could be increased (useful signals in temperature forecasts up to week 3, up to week 2 for signals in precipitation forecasts). Up to now, the recommended "Open Charts" is not well known in the forecaster's community at DWD.

2.2 Other uses of ECMWF output

2.2.1 Post-processing

At DWD, a range of operational products is derived by statistical post-processing. In most of these MOS systems, the standard ECMWF HRES is among the input data. The training data sets span impressively long time periods of up to 20 years (2001-2020). Besides the long training period, the uniqueness of the DWD MOS systems lies in the large number of predictors (>300). Many of the predictors are directly taken from the NWP model output. In addition, DWD MOS systems use so-called "empirical predictors" and they also use observation-based predictors including remote sensing. Some DWD MOS systems use so-called advection predictors. This results in a seamless transition from nowcasting to forecasting up to the medium range. The ECMWF HRES output contributes to more than 50 predictors. A subsequent blending approach (based on linear regression) merges the ECMWF MOS forecasts with the ICON MOS forecasts.

Depending on the specific post-processing method, the resulting products serve various applications (Fig. 1). In addition to the operational post-processing of HRES output, also ensemble output is post-processed on a daily experimental basis (Hess, 2020). Further research looks into a blending approach for ensemble forecasts, using neural networks (Schaumann et al., 2021).

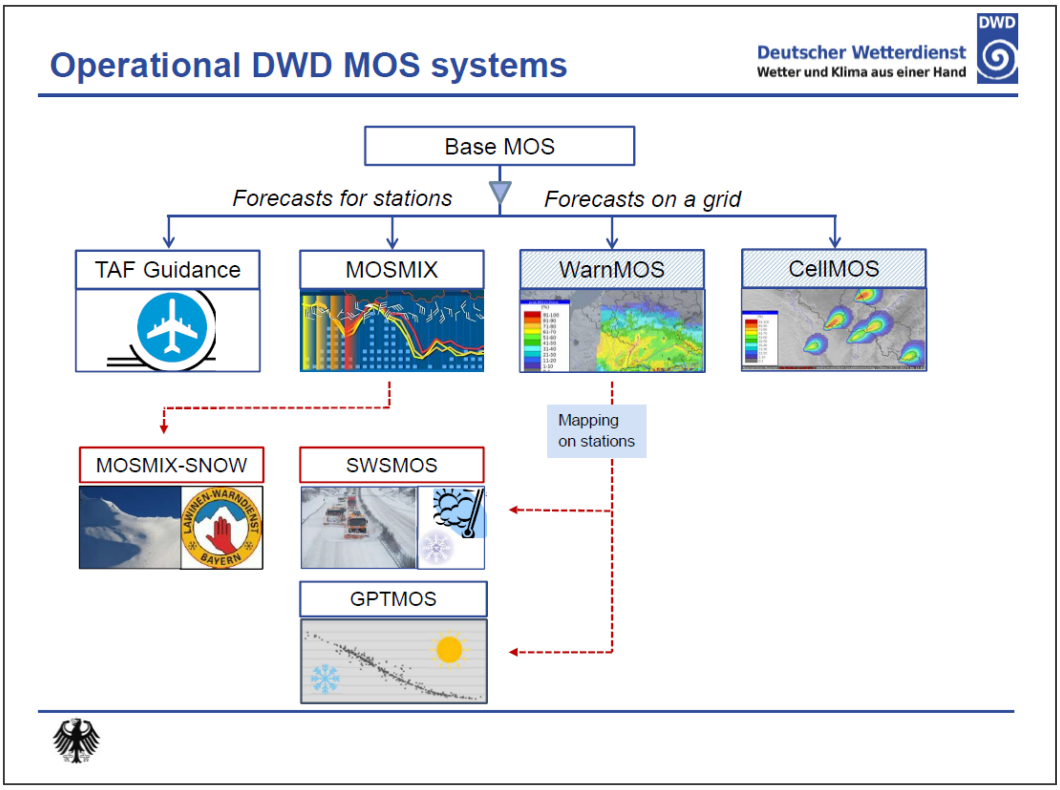

Figure 1: At DWD, operational post-processing serves a range of aims and applications, such as terminal aerodrome forecast (TAF) guidance, localised forecasts (MOSMIX), avalanche guidance (MOSMIX-SNOW), road maintenance (SWSMOS), energy consumption (GPTMOS) and warning guidance (WarnMOS, CellMOS).

2.2.2 Derived fields

A weather type classification is carried out on the 15-day ensemble output, based on the 29 "Grosswetterlagen" (GWL) synoptic types over Europe. The results are summarized in an html-based matrix showing GWL clusters as a function of forecast time and frequency across the ensemble members (Fig. 2). The user can also examine specific composites for each GWL cluster, to assess its impact in terms of potential weather conditions across the European regions. Specific ensemble members with the highest (lowest) mean temperatures and rainfall over Germany for the day 6 to 15 period are also highlighted. This product is produced every 12 hours and is used frequently in DWD to aid assessments of the current medium-range forecast scenarios (Fig. 2).

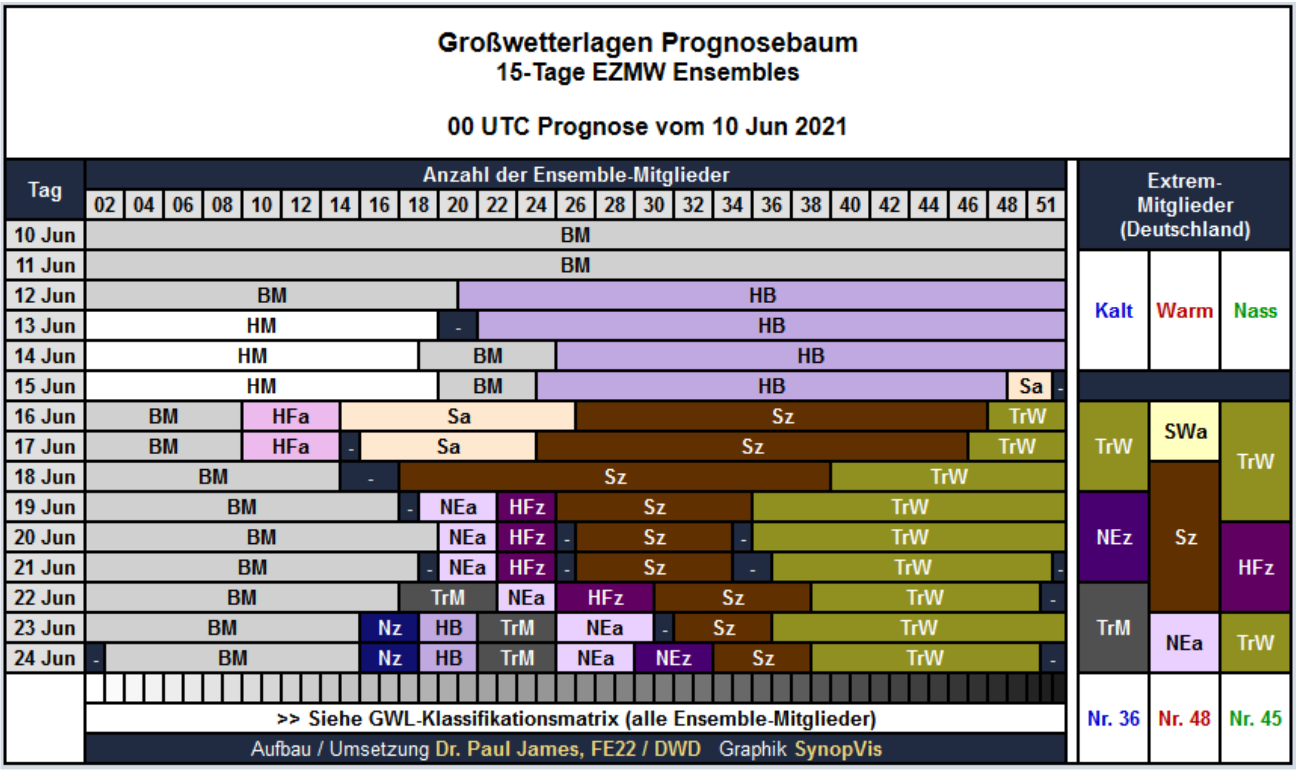

*Fig. **2**. GWL forecast matrix based on the 00 UTC ECMWF ensemble on 10th June 2021, showing increasing uncertainty with forecast time.*

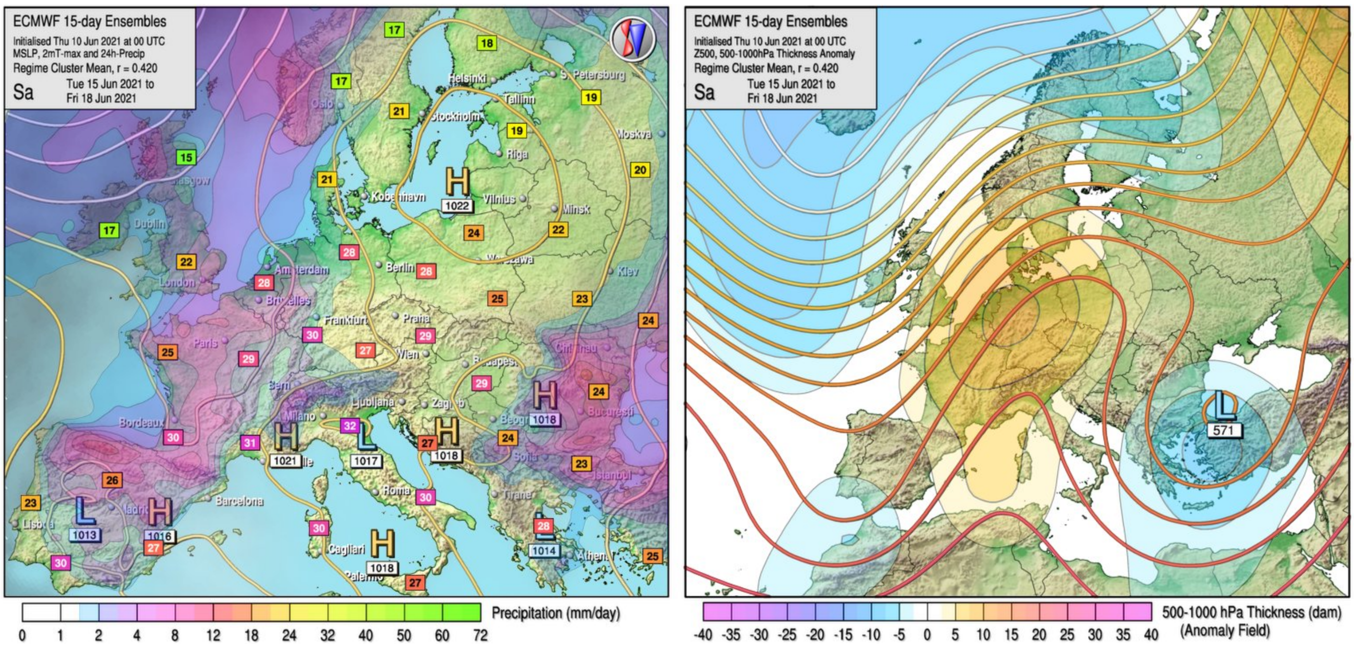

Fig. 3. GWL composite for the Sa cluster from the above matrix (Fig 2), showing (left) MSLP, Max. 2m-temperature, precipitation and cloud cover and (right) 500 hPa geopotential height and 500-1000 hPa thickness, highlighting the potential for hot conditions across Central Europe about a week into the forecast.

<u>2.2.3 Modelling</u>

none

3. Verification of ECMWF products

3.1 Objective verification

3.1.1 Direct ECMWF model output (both HRES and ENS), and other NWP models

Following the results of former editions, upper air forecasts from ECMWF continued to exhibit smaller errors than DWD ICON forecasts while the gap between both has been clearly decreased.

3.1.2 Post-processed products and end products delivered to users

The comparison of ICON DMO point forecasts with MOSMIX (combined product of ICON-MOS and ECMWF-MOS) point forecasts shows clear advantages of post-processed and combined products (including ECMWF data). This can be clearly shown for continuous parameters like temperature whereas it is not that significant for categorical parameters and longer lead times (e.g. precipitation and wind gusts).

3.1.3 Monthly and Seasonal forecasts

DWD uses the friday sub-seasonal forecasts up to week 4 to produce a newsletter for Germany of weekly mean anomalies for temperature, precipitation and wind. The newsletter is not publicly available but distributed internally and to special customers. An objective verification is not carried out.
DWD also uses lead month 1 of the seasonal forecasts of SYS5 for an outlook one month ahead in a climate monitoring bulletin (https://www.dwd.de/DE/leistungen/pbfb_verlag_monat_klimastatus/monat_klimastatus.html). A visual evaluation of the forecast being reasonable or not is discussed in the bulletin as well.
Currently, a testing of sub-seasonal ECMWF forecasts is implemented within a development for monthly soil-moisture forecasts. Further, DWD is testing an empirical statistical method to downscal sub-seasonal ECMWF forecasts for internal and special customers.

3.2 Subjective verification

3.2.1 Subjective scores

none

3.2.2 Case studies

none

4. Requests for additional output

Currently, there are no bigger requests known at DWD

5. References to relevant publications

R. Hess, 2020: Statistical postprocessing of ensemble forecasts for severe weather at Deutscher Wetterdienst. *Nonlin. Processes Geophys.*, **27**, 473-487, https://doi.org/10.5194/npg-27-473-2020

Schaumann, P., Hess, R., Rempel, M., Blahak, U. and **V. Schmidt**, 2021: A calibrated and consistent combination of probabilistic forecasts for the exceedance of several precipitation thresholds using neural networks, *Weather and Forecasting*, **36**, 1079-1096