Verification of ECMWF products at the Deutscher Wetterdienst (DWD)

DWD – Dr. Marcus Paulat, Dr. Ulrich Damrath, Gabriele Schweigert

1 Summary of major highlights

The usage of a combined GME-MOS and ECMWF-MOS at DWD continues to form the basis for the production of local short and medium range forecasts. It has been augmented in the short range by forecasts from the regional model COSMO-EU in the best available guidance called Objectively Optimised Guidance (OOG, available up to +168 h). Current discussions challenge the benefit of COSMO-EU (direct model output) concerning forecasts at certain locations. ECMWF high resolution forecasts in conjunction with GME forecasts are also being used for the production of a probabilistic warning guidance based on the MOS technology. The use of ECMWF Ensemble data within DWD's visualisation software NinJo continues, too.
Also, the high resolution ECMWF model is one of four driving models for the high resolution COSMO-DE-EPS which is operational since May 2012 and well accepted in forecasting deep convection fairly good especially compared to deterministic information.

2 Use and application of products

2.1 Post-processing of model output

2.1.1 Statistical adaptation

The high resolution ECMWF model (both 00 and 12 UTC run) and DWD's model GME are statistically interpreted up to 10 days in terms of near surface weather elements by MOS and subsequent weighted averaging of the two interpretations to form "MOS/MIX". The MOS technique is also used to produce "MOSGEB" as a forecast product for certain areas (in operations since October 2012).
Since 2008 ECMWF high resolution forecasts in conjunction with GME forecasts have been used for the production of a probabilistic warning guidance based on the MOS technology which will form the basis to produce automated warn status proposals.

2.1.2 Physical adaptation

2.1.3 Derived fields

2.2 Use of products

The high resolution ECMWF model forms together with DWD's model GME the general operational data base. ECMWF's high resolution model is always used together with other models in short- and medium-range forecasting. For medium range forecasting the ECMWF-EPS is used additionally; in the short range COSMO-LEPS (Local model nested into ECMWF-EPS clusters) provides ensemble information. EPS products are used intensively in order to create a daily simple confidence number and describe alternative solutions. Furthermore, they are used to estimate the prospect for extreme weather events. Here, use of the Extreme Forecast Index (EFI) is made. There is high usage of the products as presented on the ECWMF website. To make some of these products more easily usable in the context of DWD environment (layer technique for comparison to other meteorological data), ECMWF-EPS, LEPS and COSMO-DE-EPS products are displayed within NinJo since three years now.

3 Verification of products

3.1. Objective verification

3.1.1 Direct ECMWF model output (both deterministic and EPS)

3.1.2 ECMWF model output compared to other NWP models

Following the results of former editions, upper air forecasts from ECMWF continued to exhibit smaller errors than DWD-GME forecasts (Fig. 1). The RMSE of the ECMWF model for 500 hPa geopotential height has not significantly improved in the short range since 2009. ECMWF MSLP error growth with forecast range remains about one day better than for DWD-GME (Fig. 1, right).
Note that since 20[th] of January 2015, DWD is running the new global model ICON in operational mode. It will be part of the next year ECMWF report to compare ECMWF forecasts against ICON.

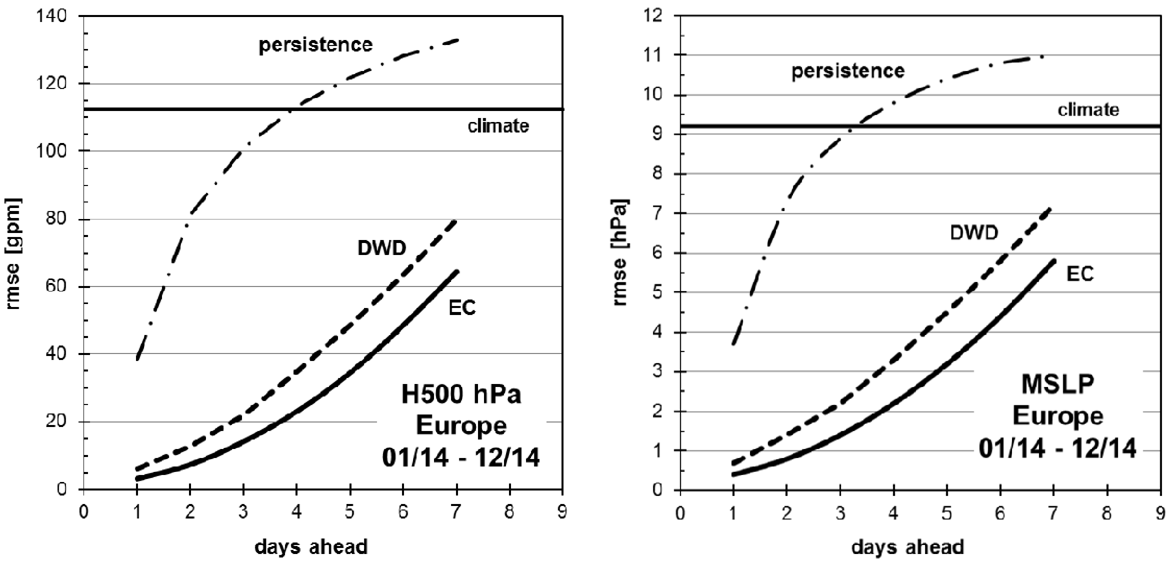

Figure 1: RMSE of 500hPa geopotential (left) and mean sea level preasure (right) over Europe: DWD (Numerical Weather Prediction model GME), EC (ECMWF high resolution model), persistence (analysis from the initial state is used as a forecast for all following days) and climate (long term mean of the predictand serves as a constant forecast).

3.1.3 Post-processed products

Here, various statistically post-processed model forecasts are compared for the following:

Predictands

MIN	=	daily minimum temperature (°C)
MAX	=	daily maximum temperature (°C)
SD	=	daily relative sunshine duration (%)
dd	=	surface wind direction (°) 12 UTC. Only verified, if ff(obs) ≥3 m/s
ff	=	surface wind speed (m/s) 12 UTC
PoP	=	Probability of Precipitation >0 mm/d
PET	=	potential evapotranspiration (mm/d)
RR	=	a binary predictand: precipitation amount >0 mm/d: Yes/No;

Forecast Types

MOS/MIX	=	post processed product, a weighted average of Model Output Statistics of MOS/GME and MOS/EC, verified at 6 stations
MOSGEB	=	Area forecasts calculated by averaging selected point forecasts of MOS/MIX output, verified at 6 stations.

Verification measures

RMSE	=	Root Mean Square Error
RV	=	Reduction of Variance against reference, $1-(RMSE/RMSE^{*})^2$
		here: mean value for day 2-7
RMSE*	=	smoothed climate as the best reference forecast to evaluate forecast skill
HSS	=	Heidke Skill Score, only for binary predictands
<u>HSS</u>	=	mean value for day 2-7

Table 1: Verification of operational medium range forecasts for 6 stations in Germany (Hamburg, Potsdam, Düsseldorf, Leipzig, Frankfurt/Main, München); 01/2014 - 12/2014; RMSE and HSS, respectively. Day of issue = day +0 = today at noon. [1)] Here, persistence is used as a 'reference forecast'.

RMSE		**day**								**RMSE***	**RV [%]**
		+2	**+3**	**+4**	**+5**	**+6**	**+7**	**+8**	**+9**	**(climate)**	
MIN	MOSGEB	1,63	1,83	2,04	2,32	2,61	2,91	3,10	3,30	4,20	74
	MOS/MIX	1,49	1,69	1,94	2,20	2,52					77
MAX	MOSGEB	1,89	2,15	2,52	2,89	3,25	3,53	3,80	4,05	4,70	70
	MOS/MIX	1,76	2,04	2,42	2,81	3,19					72
SD	MOSGEB	20,2	22,3	24,4	26,0	27,8	28,4	29,3		29,3	28
dd[1)]	MOSGEB	35,9	41,2	48,1	56,1	63,6	72,5	75,7	81,9	86,5	68
	MOS/MIX	33,7	38,9	45,9	55,3	61,8					70
ff	MOSGEB	1,43	1,56	1,72	1,82	1,91	1,99	2,09	2,14	2,20	40
	MOS/MIX	1,34	1,48	1,65	1,77	1,86					45
PoP	MOSGEB	38,3	41,3	43,2	45,4	47,0	48,1	49,0	48,8	48,0	23
	MOS/MIX	36,7	39,0	41,1	43,5						30
PET	MOSGEB	0,93	1,07	1,06	1,09	1,12				0,878	-45
HSS [%]											**<u>HSS</u> [%]**
RR	MOSGEB	56	48	42	34	25	19	14	12		45
	MOS/MIX	58	51	45	31						46

Table 1 shows verification results of MOS/MIX and MOSGEB for different elements and forecast days. The elements SD and PET are only available within MOSGEB. The nearly unrealistic RV results for PET can be explained by different algorithms used for MOSGEB and observations (PET is not measured directly). Of course it is planned to unify both algorithms again.
A comparison between MOS/MIX point forecasts of 2014 with results of 2013 shows no clear tendency of increasing or decreasing quality. While RV of MIN has been increased MAX has been slightly decreased. Especially RV of ff has been clearly improved whereas RR has been decreased of some degree (perhaps because of a summer season 2014 with a high number of rain events).

In comparison to 2013, the reliability diagram (Fig. 2) shows again an “underforecasting” of probability of precipitation >0 mm/day (both forecast types) with lower quality for area forecasts than for point forecasts.

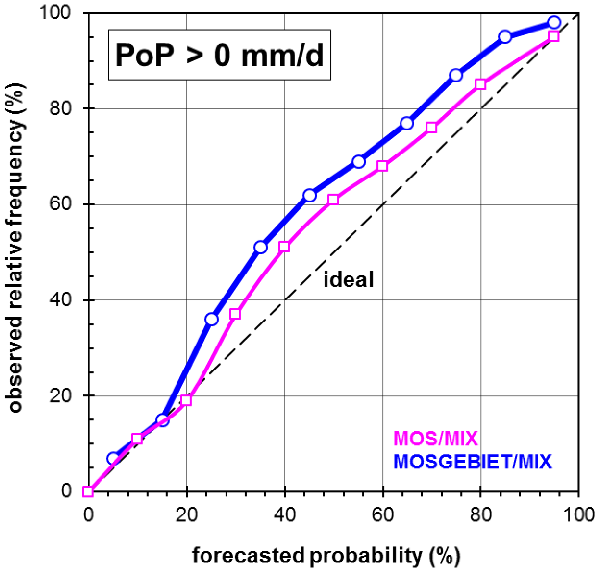

Figure 2: Reliability diagram for precipitation >0 mm/day (6 stations, 01/14 – 12/14, day+2 ... day+7; only up to day+5 for MOS/MIX)

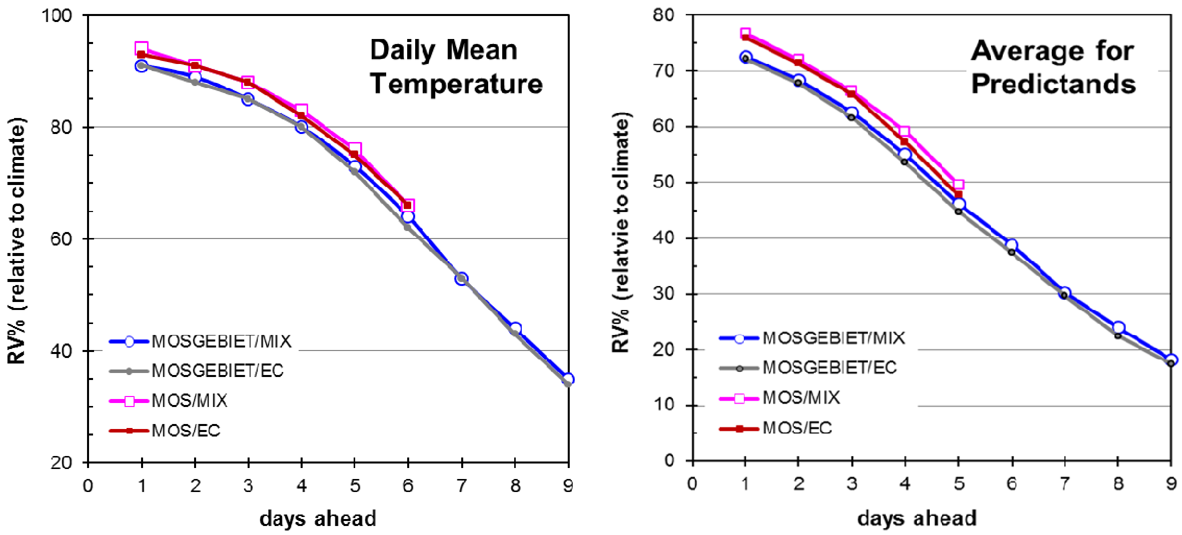

Figure 3: Forecast skill RV as a function of lead time (days ahead). Left: Daily Mean Temperature (6 stations, 01/14 – 12/14), right: average for predictands MIN, MAX, dd, ff and PoP (Tab. 1).

Figure 3 compares not only area against point forecasts but also the MIX approach against a pure EC-MOS. Looking at results for daily mean temperature and the average for predictands MIN, MAX, dd, ff and PoP (Tab. 1), a mixed product slightly improves the forecast quality. It is an open question to answer whether the new operational DWD global model ICON can further improve the MIX quality again.

To summarize, the quality of mixed post-processed forecasts reaches a satisfying level. The differences between 2014 and 2013 show no clear tendency.