The global ICON Ensemble

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The ICOsahedral Non-hydrostatic general circulation modelling framework (ICON) has been jointly developed by the Max Planck Institute for Meteorology in Hamburg and the German Weather Service (Zaengl et al., 2014). It is based on a triangular grid with nearly uniform resolution on the globe which enables local refinements by two-way grid nesting. The global ICON forecast suite at DWD became operational in January 2015. The deterministic configuration has 90 vertical layers and a global horizontal resolution of 13km including a two-way nested 6.5km (60 layers) refinement over Europe.

Based on the ICON modelling framework DWD runs an ICON ensemble suite with 40 members. In contrast to the deterministic system the horizontal resolution is approx. 40km on the global scale and 20km over Europe. Since 17th January 2018 the ICON-EPS runs 8 times a day in operational mode. At 03/09/15/21UTC the maximum lead time is limited to +30h. Otherwise, the European nest is integrated together with the global system up to +120h. For the 00/12 UTC runs the forecasts of the global system extend to +180h.

Perturbations in the ICON-EPS

The spread-skill properties of the ICON ensemble are mainly determined by the initial perturbations which are set by the global ensemble data assimilation system (EDA) running at DWD, because the ICON-EPS members are initialized directly from the EDA analysis states. The EDA is based on a Local Ensemble Transform Kalman filter (LETKF) implementation following Hunt et al. (2007) with a 3-hourly assimilation cycle. The algorithm solves the underlying equations in ensemble space spanned by a background ensemble of 40 members. The “Kalman gain” from adding observations may reduce the spread of the analysis ensemble and it must be re-inflated at each assimilation step. We use multiplicative inflation following Houtekamer et al. (2005) with a factor ranging from 0.9 to 1.5 and relaxation to prior perturbations (RTPP, Zhang et al., 2004) with a rate of 0.75. In addition, random perturbations are added to the analysis ensemble members, where the vertical correlations are estimated from the climatological background error co-variances determined by the NMC Method. Horizontal correlations are prescribed with a length scale of 400 km for geopotential, velocity potential and stream function and 200km for relative humidity. In addition, SST’s are perturbed by 1° K random perturbations with spatial correlations of 100km/1000km and correlations in time of one day. The flow-dependent error co-variances of the LETKF EDA are used in a further hybrid-variational analysis step (En-Var) to generate the high resolution analysis for the operational deterministic system (13km/6.5 km).

To simulate model error a simple methodology for perturbing various physics tuning parameters has been implemented. At the beginning of each forecast the actual values of a predefined set of tuning parameters are calculated using a random number generator depending on the ensemble member ID. The user can specify a range within each parameter may vary. For most parameters, the perturbation is applied in an additive symmetric way by setting pert_param = ref _param + 2*(rand_num - 0.5)*range, where rand_num = [0; 1]. The perturbations remain constant during the forecast. A list of perturbed tuning parameters can be found in the “ICON Database Reference Manual” at www.dwd.de.

Evaluation

A subjective evaluation (see Figure 1) during summer 2017 by the forecasters at DWD shows that in the majority of relevant wind gust events (upper panels) the ICON-EPS adds value to the existing warning process. For precipitation (lower panels) this effect is less pronounced but still noticeable. In general, the added value is larger for the short range (0-48h) than for the early medium range (60-108h). Because the latter time period is somewhat longer than the former, we observe more cases in the latter period (e.g. 479 vs. 604 cases for the wind gusts). An objective verification with more recent data is in preparation (Denhard et. al. 2018).

wind gust (6h)

0-48h

		479 cases	%
added value	Yes	285	59,5
	some	121	25,3
	No	73	15,2

60-108h

		604 cases	%
added value	Yes	297	49,2
	some	175	29
	No	132	21,8

precipitation (12h)

0-48h

		61 cases	%
added value	Yes	23	37,7
	some	15	24,6
	No	23	37,7

60-108h

		91 cases	%
added value	Yes	20	22,0
	some	17	18,7
	No	54	59,3

Fig. 1: *Subjective verification of 6-hourly wind gusts (upper panel) and 12-hourly precipitation events which exceed the different warning thresholds used at DWD. The forecasters ranked the ICON-EPS forecast in three categories according to their added value for the alert generation process: yes, some or no added value. All cases are considered, where either an event was observed or forecasted by the ensemble with a likelihood of at least 10%. The evaluation has been done separately for the short (0-48h) and early medium (60-108) range in summer 2017.*

References

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