Author Response to RC#1

Thank you for a very positive feedback on our article. We appreciate the valuable comments that are helpful in order to improve the manuscript.

We would like to apology for the missing references. The error emerged when we specified the HESS format, and un-intentionally deleted many references from the reference list. The main author should nonetheless have detected this flaw prior to posting.

Replies and corrections are done as follows: the Author response (AR) is marked with red text, while the author's suggestions to corrections (AC) are marked with blue text. All Referee comments are kept in a black; we use page and line number when needed to specify the appropriate location.

Interactive comment on "Streamflow forecast sensitivity to air temperature forecast calibration for 139 Norwegian catchments" by Trine J. Hegdahl et al.

Anonymous Referee #1
Received and published: 6 November 2018

General comments:
This is a well written paper. It investigates the impact of temperature forecasts on streamflow forecast skill, especially considering the effect of pre-processing of temperature ensemble forecasts. The study is based on forecasts for a large number of catchments in Norway, thus providing a very comprehensive and systematic analysis. The paper provides an important contribution to the research and practical application of ensemble meteorological forecasts for streamflow forecasting.

Detailed comments:
1. Page 2, line 16-17. There are different ways of producing meteorological ensemble forecasts. Typically, also model physics are perturbed.
AR: You are right. The ECMWF ensemble prediction system includes stochastic perturbation to the model physics. We will add to the sentence to address this aspect.
AC: Suggestion "… are created by perturbing both the initial states of the original deterministic forecast and the physics tendencies of the …."

2. Page 5, line 18-19. Not clear here how catchment average precipitation and temperature are estimated. Are they based on the SeNorge data sets? If so, is it then necessary to apply elevation corrections for the model calibration, since elevation corrections have been applied for producing the SE Norge data sets?
AR: We agree that the description of how temperature is used in the hydrological model is ambiguous and this will be clarified in the text. You are right that elevation correction is applied to the SeNorge dataset. Our set-up for the HBV models uses catchment average temperature as input, calculated from the SeNorge data. The elevation correction mentioned in l18-19 refers to the internal correction in the HBV model. These are used to adjust catchment average temperature and precipitation, representing the catchment mean elevation, to each elevation zone in the HBV model. A linear elevation adjustment is applied to temperature, whereas an exponential adjustment is applied to the precipitation.
AC: We reformulate line 18-19 as follows:
"The model uses catchment average temperature and precipitation as input. Each catchment is divided into 10 elevation zones, each covering 10% of the total catchment area. The catchment average precipitation and temperature are elevation adjusted to each elevation zone using catchment specific laps rates.

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3. Page 6, line 17-20. Why use a daily time step for the streamflow forecasts? Meteorological forecasts with a 6-hour time step are available.
AR: The operational HBV model used for flood forecasting runs on a daily time step. In addition, the SeNorge data that is used for model calibration and updating, provides only daily values.
AC: We make no modifications to the manuscript

4. Page 7, line 4-6. For the quantile mapping, a critical issue is the mapping of forecasts outside the range of observed data. How is this done?
AR: MetNorway use parametric quantile mapping based on the hourly first 24h. When a forecast is outside the observation range, a 1:1 extrapolation is used. Therefore, if a forecast is 2°C higher than the highest percentile of forecasts used for calibration, then the calibrated forecast is 2°C higher than the same percentile for the reference.
AC: Suggestion p7, line 12: "The same coefficients, based on the first 24h mapped, are applied to all lead times and ensemble members individually. For forecasts outside the observation range, a 1:1 extrapolation is used. I.e. if a forecast is 2°C higher than the highest mapped percentile, then the calibrated forecast is 2°C higher than the same percentile for the reference. "

5. Page 8, line 12-13. Alternatively, you could use persistent forecast as benchmark. This would be more appropriate for evaluating short-term forecast skill.
AR: A persistent forecast will have some predictive skill in the short-range, but less for longer lead times. Engeland and Steinsland (2014; Fig. 4) show that the persistence did not add value after two days for selected Norwegian catchments. Pappenberger et al (2015) suggest using persistence as benchmark, based on a study of catchments larger than 6000km^2. However, given our selection of catchments, which are relatively small, quick responding, and with rapid changes in weather, combined with an aim to evaluate at longer lead times, we choice not to use persistence as benchmark. Rather, we used climatology as a benchmark since: (1) it is straightforward to get climatology as an ensemble, and (2) the focus of study is a lead time of five days. The daily climatology represented as daily ensemble (not an average value) gives a good representation of seasonal variations. Moreover, for this lead time persistent forecast has small predictive power due to the relatively short memory of our catchments (e.g. the streamflow autocorrelation for a time lag 5 days is less than 0.6 for about 80% of our catchments for the 25% highest flows).
AC: We make no modifications.

6. Page 12, section 5.3. There are a lot of repetitions in this section. I suggest including discussion on spatial patterns in sections 5.1 and 5.2.
AR: We will carefully read and revise Section 5.3 to avoid repetitions, and consider rewriting 5.1 and 5.2, to include the discussion from 5.3.
AC: We will revise and rewrite section 5.1 and 5.2 for the new version of the manuscript

Technical corrections:
1. Page 2, line 30. Evensen (2003) not in reference list.
AR: Thanks; will be added
AC: "Evensen, G.: The Ensemble Kalman Filter: theoretical formulation and practical implementation. Ocean Dynamics, 53(4), p343-367, 2003."

2. Page 4, line 27. "og" -> "and"
AR: This will be corrected.
AC: Changed

3. Page 11, line 20 and 24. Delete "Ivar".

AR: OK
AC: We will write: “Seierstad et al. (2016) documented the relatively low skill and cold bias for sub-zero ECMWF temperature forecasts for the Norwegian coastal areas in cold seasons.”

References

Engeland, K. and Steinsland, I.: Probabilistic postprocessing models for flow forecasts for a system of catchments and several lead times. Water Resources Research 50(1), p182-197, doi:10.1002/2012WR012757, 2014.

Pappenberg, F., et al.: How do I know if my forecasts are better? Using benchmarks in hydrological ensemble prediction. Journal of Hydrology, 522, 697-713. 2015