ANSWERS TO THE REFEREES FOR THE ARTICLE ENTITLED
"HYDROMETEOROLOGICAL EVALUATION OF TWO NOWCASTING SYSTEMS FOR MEDITERRANEAN HEAVY PRECIPITATION EVENTS WITH OPERATIONAL CONSIDERATIONS."
SUBMITTED TO HYDROLOGY AND EARTH SYSTEM SCIENCES

POINT BY POINT ANSWERS TO REFEREE 2

⇨ We would like to thank Referee2 for the time she/he spent on our manuscript and for the useful and constructive comments that will help to improve the quality of the manuscript. In the following, we will answer each comment and indicate how the suggestions have been taken into account in the new version of the manuscript.

hess-2020-629 review: Hydrometeorological evaluation of two nowcasting systems for Mediterranean heavy precipitation events with operational considerations

The purpose of this article is to compare two different meteorological nowcasting products AROME-NWC and PIAF in South-eastern France. The study is conducted both from a meteorological point of view (comparison of cumulated rainfall on the whole domain) and from a hydrological point of view (comparison of cumulated rainfall at the catchment scale and corresponding discharges simulated with the hydrological model ISBA-TOP).

The topic is of great interest in the field of hydrology and the article clearly shows the potential of these nowcasting products for Mediterranean events. However, the present article lacks a global view on two main points:

- The added value of these nowcasting systems with respect to traditional forecasting systems for Mediterranean heavy precipitation events: only nowcasting systems have been tested without any comparison or analysis of other existing systems,

⇨ In this study nowcasting systems have been tested without any comparison or analysis of other existing systems for several reasons:

- Precipitation forecasts were evaluated here at a 15 min time resolution whereas most of traditional forecasting systems are run with longer time steps (usually one hour).
- The availability times of rainfall forecasts are taken into account in this study to consider the operational real time constraints. Traditional forecasts are not necessarily quickly delivered. For instance, the effective availability time of the forecasts of AROME-France (which is the convective-scale numerical weather prediction system running operationally at Météo-France) varies from 2h45 to 5h05 depending on the starting time of the forecast. At the nowcasting ranges (few minutes to 6h), this delay is not negligible.
- Nowcasting systems bridge the gap with the "classical" forecasting lead times. They should be used in addition to traditional forecasting systems.

- The forecasted discharges are compared to reference discharges, simulated with observation of precipitations: this makes it possible not to take into account the uncertainties in the model structure and parametrization but adds the uncertainties related to precipitation observations. It would have been interesting to extend the analysis also to observed discharges and see to what extent the current conclusions are still valid.

⇨ Comparing forecasted discharges with reference discharges is a common practice to assess rainfall forecasts quality. A new sentence with three references will be added in the revised manuscript:

"...The reference is the discharge simulation obtained using the radar rainfall estimates ANTILOPE as input to the distributed hydrological model. This approach allows to dissociate the error made by the hydrological model from that made by the rainfall forecasts (Borga, 2002, Berenguer et al., 2005, Poletti et al. 2019)."

Borga, M. (2002). Accuracy of radar rainfall estimates for streamflow simulation. *Journal of Hydrology*, *267*(1-2), 26-39.

Berenguer, M., Corral, C., Sánchez-Diezma, R., & Sempere-Torres, D. (2005). Hydrological validation of a radar-based nowcasting technique. *Journal of Hydrometeorology*, *6*(4), 532-549.

Poletti, M. L., Silvestro, F., Davolio, S., Pignone, F., & Rebora, N. (2019). Using nowcasting technique and data assimilation in a meteorological model to improve very short range hydrological forecasts. *Hydrology and Earth System Sciences*, *23*(9), 3823-3841.

From the results and analysis, it also seems to me that AROME-NWC is more promising than PIAF for flash-flood forecasting, at least on the tested events and catchments, yet it is not clearly stated either on the abstract, or in the conclusions. Am I missing something on the added value of PIAF on that point?

⇨ We would say that both provide valuable information but on different lead times. AROME-NWC forecasts are appropriate for lead times greater than two hours and PIAF forecasts for very first lead times. The availability time of the PIAF rainfall forecasts and their frequency might be very useful for planning the intervention of emergency services in crisis time.

1. P4 L119: what is the "regret"? A more detailed description of PIAF will be interesting for a better understanding of the results and analysis, without the need to read several other publications.

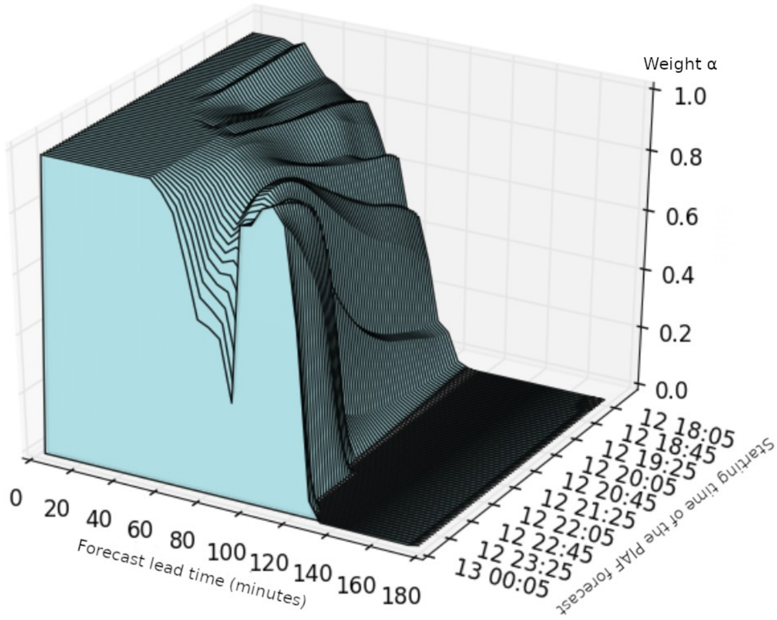
⇨ In the revised manuscript, we will expand section 2.2.2 by including more details about PIAF. The second paragraph will be modified and an additional figure will be added as follows:

"PIAF is based on a sequential aggregation of these two predictors (radar extrapolation and numerical prediction) and the results of blending is a linear compound of both of the form: PIAF $=\alpha$ * Extrapolation + $(1-\alpha)$ * AROME-NWC. Its aim is to perform better than the best predictor. The accuracy of a prediction proposed by the experts (radar extrapolation and AROME-NWC) or by PIAF is measured through a loss function. The Gerrity score (Gerrity Jr, 1992) described in Appendix A is here used to estimate the loss of each product with respect to the radar quantitative precipitation estimates. The difference between the forecaster's accumulated loss and that of an expert is called regret, as it measures how much the forecaster regrets, in hindsight, of not having followed the advice of this particular expert (Cesa-Bianchi and Lugosi 2006). As the forecaster's goal is to minimize the regret, the weights given to each predictor in PIAF are adjusted according to their deviation from the previous 6 hours observations, this results in weighting more the expert whose cumulative loss is small. The polynomially weighted average forecaster with multiple learning rates (ML-Poly, Cesa-Bianchi and Lugosi 2006, Gaillard and Goude, 2015) is the aggregation rule used in PIAF to assign weights to each predictor. This method provides a real choice of predictor rather than a mixture. The weights depend also on the forecast range (additional

Figure) and on the geographical area, according to a division of France into six sub-areas. PIAF is run every 5 minutes with a 3 hours lead time and a time step of 5 minutes. Forecasts are available within 2 minutes."

Cesa-Bianchi, N., & Lugosi, G. (2006). *Prediction, learning, and games*. Cambridge university press.

Gaillard, P., & Goude, Y. (2015). Forecasting electricity consumption by aggregating experts; how to design a good set of experts. In *Modeling and stochastic learning for forecasting in high dimensions* (pp. 95-115). Springer, Cham.



Additional figure : 3-D representation of the weight α given to radar extrapolation in PIAF. It shows the PIAF forecast lead time (interval [0, 180 minutes]) dependency on α (interval [0, 1]) for PIAF forecasts starting from 12 October 2016 18:05UTC to 13 October 2016 00:05UTC.

2. P5 L123: the Gerrity score is detailed in Appendix A, you should add a crossreference here for clarification.

⇨ A crossreference will be added in the revised manuscript.

3. P5 §2.3: how is handled the different spatial resolution between ISBA (300m) and TOPODYN (50m)?

⇨ To answer this question and to make it clearer in the revised manuscript, the ISBA-TOP section (2.3) will be modified as follows: (P5 L129)

"This coupling consists in introducing into ISBA a lateral distribution of soil water following TOPODYN concept. ISBA deals with the water and energy budgets within the soil column and between the vegetation and the atmosphere above. Fluxes are computed for all grid meshes of its domain. From the resulting volumetric water content over a ISBA grid cell, water-storage deficit as well as the hill slope recharge are determined on the corresponding TOPODYN watershed pixels of 50-m x 50-m resolution. TOPODYN manages the computation of the lateral redistribution of water within the catchment by using topographical indexes and the spatial variability of the rainfall. The new saturated areas and new soil moisture fields obtained by TOPODYN are then aggregated on the ISBA mesh to update water contents in ISBA. From them, ISBA computes sub-surface runoff and deep drainage which are dispached on each 50m-sided pixel and then routed up to the river and total discharges are then produced at catchment outlets."

4. P6 L171: how is ISBA-TOP calibrated? Using ANTILOPE rainfall estimates and observed discharges at the catchment outlet? With continuous or event-based simulations? On which time period?

⇨ In ISBA-TOP, most of the soil hydrodynamic parameters can be derived from soil data through PedoTransfer Function approaches. Other parameters such as speeds of transfer on the hillslopes and in the river can be calibrated. In this study, default values fitting Mediterranean watersheds discharge simulations are used. An example of the calibration of ISBA-TOP parameters for the simulation of flash-flood events can be found in Bouilloud et al. (2010) on three watersheds located in the French Cévennes–Vivarais region. Ten events that have occurred between 2000 and 2005 were used for the calibration and the independent evaluation. The calibration is based on the comparison of observed discharges time series at the catchment outlet with discharge time series simulated by ISBA-TOP driven by 1-h accumulated rainfall fields from rain gauges spatially interpolated with a kriging method.

The sentence P6 line 171 will be modified as follows:

"ISBA-TOP, which needs calibration for its routing parameters, was calibrated as described by Bouilloud et al., 2010 for hourly rainfall estimates, thus only hourly discharges were simulated."

5. P7 L186: AROME-NWC shows a trend to predict too frequently high rainfall accumulation but at the same time precipitations are underestimated by the model on average (see mean error figure 3). I'm not sure I correctly get this point: does it indicate a questionable representation of the dynamic of precipitation (high peaks forecasted instead of continuous precipitation of lower intensity)?

⇨ It is true that considering AROME-NWC forecasts at a 15 min time resolution high rainfall accumulation are predicted too frequently and precipitations are underestimated on average according to the point-to-point comparisons of the forecasts and observations. This verification based on short time steps gives significant weight to even small timing errors, especially in the case of convective situations. That's why it seems difficult to really conclude on the representation of the dynamic of precipitation with AROME-NWC. Furthermore, these results need to be considered with caution because the sample of events and catchments was limited.

6. Table 2, second column: maximum cumulative rainfall estimate (mm): where does this estimation come from? ANTILOPE radar product?

⇨ You are right the second column was filled in using the quantitative precipitation estimates from ANTILOPE.