Interactive comment on "A study on weather radar data assimilation for numerical rainfall prediction" by J. Liu et al.

Many thanks for the deep and constructive concerns from Referee #2. Our replies to all these concerns are as follows:

General observations:

G1. The title as well as the content of the paper are mostly concerned with a traditionally typical problem in Meteorological community where data assimilation + weather radar have been widely discussed and documented. Although it is intended by the author to focus on the "hydrological' aspect, it is hardly so apart from using a catchment areal rainfall for testing the performance. In fact, most of the content, in my opinion, is superseded by a number of publications already appeared in different meteorological journals. for a recent example, Sugimoto et al (2009).

Reference: Soichiro Sugimoto, N Andrew Crook, Juanzhen Sun, Qingnong Xiao, and Dale M Barker (2009): An Examination of WRF 3DVAR Radar Data Assimilation on Its Capability in Retrieving Unobserved Variables and Forecasting Precipitation through Observing System Simulation Experiments. Monthly Weather Review, 137(11),pp. 4011-4029.

Reply: Although the meteorological community has discussed and reported data assimilation (inc the weather radar lately) for many years, studies on their efficacies for hydrological applications are rare. For example, the paper recommended by the reviewer (Sugimoto et al. (2009)) used the simulated field from WRF as the 'truth field', not the measured rainfall field by rain gauge networks. It is well known that the simulated rainfall field from NWP models usually have significant errors and hydrologists would not be convinced by such an approach. Only rainfall fields measured by rain gauges are considered as the 'ground truth' by hydrologists. In addition, the assimilated radar data in Sugimoto et al.'s paper were derived from the simulated the 'truth field' instead of the actual radar measurements. Those two 'flaws' may sound reasonable to meteorologists, but they are not convincible to hydrologists. Therefore, not being superseded by those publications in the meteorological community, the study reported in this manuscript provides more useful and relevant information to the hydrological community.

G2. The content of the paper does not fit well the current title in terms of its scientific contribution - it is merely a case study using existing technics/models. Even for a case study paper, it still lacks of deeper insight into the problems presented in the paper, e.g., the reasons discussed in the paper needs to be consolidated by further experiments rather than staying as speculations.

Reply: We agree that the paper title may mislead meteorologists into believing that it is to deal with data assimilation mechanisms in meteorology with ‘deeper insight’. As mentioned above, the audience of this paper is the hydrological community who are eager to use ‘the existing technics/models’ in real life flood forecasting, and they are keen to know the performance of the ‘existing technics/models’ in catchment rainfall estimation, instead of ‘deeper insight’ in the data assimilation mechanisms embedded in NWP models. Nevertheless, we believe meteorologists could also benefit from the results in this paper so as to reflect the successes/failures of the ‘the existing technics/models’ in order to improve them further. The paper title will be changed to ‘WRF weather radar data assimilation for hydrological rainfall prediction’ to avoid the potential confusion mentioned above.

G3. The fact that the study uses an outdated NWP dataset (1999 ECMWF deterministic forecast), although to some extent is unavoidable (data availability issues), it inevitably has a detrimental impact on its scientific value since the model has progressed by several generations since then.

Reply: Although progresses have been made to various NWP models since 1999, they are mainly incremental instead of revolutionary, especially in precipitation estimation. Therefore, the results and conclusions in this study should still be relevant to the hydrological community.

Technical concerns:

T1. Eq. 2 is one of the key equations for the entire experiment. The equation is taken as it is from the current 3DVAR WRF system without showing its limitation/assumptions as well as its applicability in the area (SW England). If the equation does need to be modified, what the consequence will be, in terms of sensitivity.

Reply: Further details on Eq. 2 will be added from the reference Sun and Crook (1997). However, since Eq. 2 is beyond the control of hydrological users, the consequences and sensitivities in modifying the equation are not relevant to hydrologists. We have contacted Dr. Hans Huang (WRFDA programme manager in UCAR) to explore ways of improving the formulation by his team in the future.

Reference: Sun, J. and Crook, N. A. (1997): Dynamical and microphysical retrieval from Doppler radar observations using a cloud model and its adjoint, Part I: Model development and simulated data experiments, Journal of the Atmospheric Sciences, 54, 1642–1661.

T2. Eq. 3 is used as the original form of the Marshall-Palmer equation. There is no discussion as to why this form is used, e.g., any calibration, documentation, references etc?

Reply: The Z-R relation is still an unsolved problem in weather radar due to the complexities involved, which is why the Marshall-Palmer equation is still widely used. We have accumulated over 8 years of disdrometer data in the study catchment and will tackle the Z-R relation in the future with more relevant rain drop size distributions. However, this paper aims for hydrologists to use the standard weather radar products without the access to distrometer data, hence the standard Marshall-Palmer equation is the most practical formula to be used in this study. We will add some text in the manuscript to clarify the concerns raised on this formula.

T3. What is the point of configuring the WRF model to a 10 km resolution whereas the radar dataset is on a 2km grid. Back to the point of Hydrological use, I doubt whether the 10km resolution (even with an ideal 3DVAR improvement) can actually make sense for a catchment of 135 km2.

Reply: Higher resolution WRF runs take longer time to process which are not ideal in real time flood forecasting. Therefore, coarse resolutions should be adopted whenever possible. The reason for using the 10km resolution WRF model in this study is to match the catchment size as close as possible (135 sq km). Since lumped hydrological models are usually used in flood forecasting, finer WRF outputs need to be averaged into coarse resolutions anyway. It is possible that the information for 2km radar grid might be underused for the 10km WRF setting and we will explore this further in the future. Some text will be added to address the point raised here.

T4. While the catchment rainfall can be used to measure the performance, other methods like showing the prognosis of the rainfall system with snapshots would give more details (and possibly reasoning) as to deciding a forecast is good or not.

Reply: For hydrologists, the catchment rainfall is the only relevant input to hydrological forecasting models. This is in contrast to the measures used in the meteorological community.