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# ***Interactive comment on “The effect of flow and orography on the spatial distribution of the very short-term predictability of rainfall” by L. Foresti and A. Seed***

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We thank Evan Ruzanski for the constructive comments and for the extended discussion on the predictability of precipitation.

Answers to the review comments:

1. We will try to specify in the title that we are using composite radar observations.
2. There is no particular physical motivation for using rainfall rates in decibel scale (dB $R$ ) instead of the original reflectivity (dB $Z$ ). From a statistical viewpoint it is important that the field is lognormally distributed before applying the cascade decomposition.

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In our experience the decibel scale of rainfall rates is slightly closer to a lognormal distribution than the decibel scale of reflectivity measurements (as it was done in the original version of the Short Term Ensemble Prediction System). We do not expect the predictability estimates to be strongly affected by such choice since we do not use rain gauge measurements in the verification process. Decomposed fields of dBR are advected forward by 10 minutes and compared with decomposed fields of dBR. Similar results are expected if comparing decomposed fields of reflectivity (dBZ) if compared with decomposed fields of dBZ. Unfortunately there are no operational radars in Australia that use the dual-polarization technology and we have to rely on the accuracy that can be obtained with single-polarization radars together with a well calibrated operational quantitative precipitation estimation system.

3. The analysis of the spatial distribution of the precipitation predictability also reveals the issue of edge effects, with lifetimes getting shorter when moving away from the center of the domain. The goal of the paper was exactly to analyze such spatial heterogeneities, which can be due to atmospheric processes, radar uncertainties and edge effects. The interesting exercise is to understand where these patterns carry a clean atmospheric signal. All studies based on radar observations have to deal with these issues when drawing interpretations and conclusions.

4. We will rephrase the sentence to account for the study cited and only focus on the fact that the lifetimes and spatial scales cannot be directly compared. Please refer to the answer of question 1 in the Discussion comments.

5. We are not questioning X-band radars in terms of Quantitative Precipitation Estimation or Very-Short Term Forecasting, but only the ability to measure the Lagrangian auto-correlation at such small scales. We will rewrite the paragraph and specify that "Given that the extrapolated lifetimes are shorter than the typical temporal resolution of X-band radars, it would be interesting to know whether they have sufficient temporal resolution to accurately estimate the Lagrangian auto-correlation of such small scale features." We agree with the reviewer that the conclusions were a bit pessimistic.

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## Answers to the discussion comments:

1. Indeed, the predictability is dependent upon a forecasting model and dataset used. In the paper we study the predictability by Lagrangian persistence (forecasting model) of composite radar images (dataset). All predictability studies will be relative to a given forecasting model and affected by the type of data assimilated within the model and/or used for verification. We will try to rephrase the comparison of lifetimes with the study of Ruzanski and Chandrasekar (2012). The difference relies in the definition of scale. In our approach the rainfall features of a given scales are isolated in Fourier domain by a Gaussian filter centered on that scale (which removes the contribution of all scales above and below it). In our understanding, Ruzanski and Chandrasekar (2012) use a different definition of scale. In fact, the scale-dependence is studied by upscaling the rainfall fields into coarser resolutions. This is what we meant when we stated that the values are not directly comparable.

2. In section 2 of the manuscript we provided a summary of the quantitative precipitation estimation system that is operationally used at the Australian Bureau of Meteorology. This should give enough details and references to the techniques that are used to reduce the uncertainty in radar rainfall measurement. The accurate characterization of each source of uncertainty goes beyond the topic of this paper. As already mentioned, all predictability studies are relative to a forecasting method and dataset used, which includes the various model and observation uncertainties that may affect the interpretations.

3. Of course, the predictability study presented in our paper can be generalized further by using other data sources which optimally combine radar, satellite and rain gauges. However, different data sources will have different error structures, which will lead to a very complex error structure of the combined product. It could be very hard to understand the origin of the spatial heterogeneity of the predictability of precipitation of such

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combined product, in particular when trying to separate the contribution of the different data sources. In Section 4.1 we mentioned the possibility to use precipitation fields calculated by NWP models to eliminate the heterogeneities introduced by the inhomogeneous quality of radar measurements. This could be a good starting point for further research.

4. In Section 4.2 we compared the predictability estimates of the Fourier-based decomposition approach proposed in our paper with the wavelet-based decomposition of Germann et al. (2006) at similar spatial scales. Both methods gave comparable results although using different ways to decompose the rainfall field. When interpreting the spatial distribution of predictability we tried to carefully analyse the possible sources of uncertainty to avoid giving misleading statements. We are currently working on the quantification of radar measurement uncertainty, which may help in the comparison of predicted and observed fields.

5. The definition of predictability you give is interesting and it should also depend on the particular verification score used. Other predictability estimates than the lifetime derived from the correlation pixel-by-pixel can be employed to account for phase and/or timing errors in precipitation forecasts, e. g. the neighborhood verification approaches (fractions skill score, etc). This is particularly important for medium range NWP forecasts, which are known to suffer from timing and location errors. In the nowcasting range it is probably less of an issue since the model is only an extrapolation which is not designed to initiate, grow and dissipate rain in a dynamical way.

## References:

- Germann U, Zawadzki I, and Turner B (2006) Scale-dependence of the predictability of precipitation from continental radar images, Part IV: Limits to prediction, *J. Atmos. Sci.*, 63, 2092–2108.
- Ruzanski E, and Chandrasekar V. (2012) An investigation of the short-term predictability of precipitation using high-resolution composite radar observations. *J. Appl.*

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