Response to the reviewers by Frech and Steinert:

First we thank for the helpful and constructive comments by the reviewers. We first of all have a general statement to the editor recommendations.

- as requested the analysis of the event is extented and better related to the synoptic situation and the thermodynmic environment.

- a radar-radar HMC cannot be done, since the polarimetric measurements at 90° elevation do not provide any meteorological information from which a HM classification can be deduced (e.g. ZDR is always 0 dB, and should be, even if there is drizzle, or snow). A comparison of the reflectivity factors is included now.

- with the current version of the paper, the discussion of the hydrometeor classification results are considered as an illustrative information in the context of this synoptic situation. A full description of Hymec does not fit into the scope of this work and should be in an extra paper. It would put the paper out of "balance".

But what is more important in our opinion: the explanation and interpretation of the what we call mesoscale event (related to warm front) relies not on the Hymec results. Here the Hymec discussion part raises or better illustrates some general issues that all HM algorithms have when it comes to relating a large pulse volume classification to the surface observation (see eg. the Schuur presentation at ERAD 2014). Nevertheless the basic and essential steps of the algorithm are written up, and the references to the relevant references describing a fuzzy logic approach and to the employed MBF are given in the references.

In our initial responce we mentioned the following that is still valid:
Since the birdbath scan is part of the operational scanning this scan opens the opportunity to provide high-resolution information on the precipitation process to the (end-) user that has not been available before. Furthermore the combination of operational high resolution profile measurements (birdbath scan), surface measurements and visual observations is in our opinion a unique combination to investigate radar products based on volume scans. To our knowledge there aren't that many studies published where this operational set-up is available. So in the first part we demonstrate what can be seen in birdbath scan, focusing on an observation above the melting layer that is not often revealed, but which has a direct link to surface rain rate, especially if the orography plays a crucial role.

Response to reviewer 1:

The verification of the hydrometeor classification (Hymec) is overemphasized by the inclusion into the title. Here, we suggest to rename the title to avoid the misleading focus on the hydrometeor classification.

1. orographic precipitation (caused by the Alps as a natural barrier for the synoptic flow and special synoptic patterns; the flow is forced to ascend which further enhances the precipitation intensity) is a common feature. We include a synoptic map showing predominant Northerly flow towards Alps responsible for sometimes long-lasting precipitation events along the Alpine ridge. We can refer to the work of Houze and Medina (2005)

Furthermore we include sounding information showing the synoptic warm air advection alof associated with substantial vertical wind shear, inorder to convince the reviewer 1 that this a precipitation event that is intensified by the presence of the Alps.

2. (a) we provide a possible mechanismn explaining the variability in the radar data. The suggested lifting and the associated microphysical mechanisms can and will be substantiated using radiosounding information from Munich in relation to results from Houze and Medina (2005), who study common features of orographic predicipation effects based on the MAP and IMPROVE2 experiment. Some aspects of the analysis in Houze and Medina (2005) fit very well to our observations (the also find pockets of enhanced reflectivity upwind ahead of the Alpine barrier). The combination of sounding information and the synoptic analysis shows that the event is related to a warmfront.

A COSMO model analysis of this event (which would in itself require a thorough discussion on the validation of the microphysical scheme for such a precipitation event) is beyond the scope of this work.

2. (b) Hymec is in an evaluation phase. This is a crucial task for a hydrometeor classification scheme : to properly guide the forecaster when and where precipitation phases change. As such this has to be considered as a case study and not as a thorough verification of the hydrometeor classification. In particular in areas, where there is no ground instrumentation is available, the forcaster relies on radar data.
We are talking about the performance of the scheme for a particular scenario (so the analysis confined to the hydrometeors that expected for this type of moment and time of season. This fits well in the results and aspects shown by Schuur et al., 2014 at the ERAD 2014. So The Hymec results illustrate general aspects one has when a pulse volume information has to be related to surface data.

Response to the specific comments. (ok means we will work on the text to make the paper more concise).

1. We can include some references of flooding events related to orographic forcing. And we can sharpen the main points we intend to cover in this work (see also the general comments above).

2. LDR mode is possible, but not used operationally.

3. ok

4. ok

5. The additional marking of the melting layer (ML) class is related to a user request. Because of this, the wet snow class, which shall reside in this regions, is suppressed by highlighting the ML class. Furthermore a post processing is applied on the ML detection and lead to combined ML segments. In addition single wet snow classified range bins retained by using this ML detection technique.

6. ok

7. ok

8. The attenuation correction is applied to all meteorological classes by using the proposal of Testud et al. (2000) together with an adaptive adjustment of the model parameter alpha, which is exemplarily reported in the book of Bringi et al. (2001). For every ray the radar data is separated in clutter-free segments with an equal hydrometeor class. After that the adaption of alpha is done on the individual range segments.

9. as discussed in the cited reference, the mixture of HM is also of relevance explaining the rhohv minimum Matrosov et al

10. ok, included.

11. agreed, but the the cavaets of an optical disdrometer apply to an Parsival and a Thies instrument.

12. ok

13. ok

Response to reviewer 2:

A radar - radar HMC comparison cannot be done but has its limitations discussed in the initial statements

We have included a more detailed discussion on the synoptics using sounding in order add explanations about the observations (see comments above)

Response to the specific comments. (ok means we have worked on the text to make the paper more concise).

1. (P.8847 L.17) a thourough description is not relevant here as we use only the lowest elevation. We refer to the reference

2. (P.8848 L.1006) ok, we can detail the orography (included a plot).

3. (P.8848 L.27) ok?

4. (P.8849 L.2) Straka et al. (2000) summarise in their paper the different polarimetric measurement variables as base for a hydrometeor classification. So, the hydrometeor types give more or less unique signatures in the radar data and the inclusion of polarimetric measurements results in a higher degree of freedom for the hydrometeor classification.

5. (P.8850 L.13) The attenuation path correction is applied all along the ray of clutter-free segments with constant hydrometeor class. Furthermore all hydrometeor types and not only the liquid ones are considered. More information can be found in the response to comment 8 of the first reviewer.

6. () Details of the membership functions are beyond the scope of the paper. A complete description of the hydrometeor classification algorithm including the membership functions will be published later after the completion of verification and testing.

7. (P.8852 L.17) see line 16: no clutter filter applied.

8. (P.8853) will be stated.

Memmingen radar:

the focus of this study is to compare a high resolution column (birdbath + surface observations) against classication results obtained from an operational radar.

in the revised version we have considered the suggestions with respect to the figures.

Response to reviewer 3:

with respect to the comment relating to unusal observations:

this is exactly why we present this case, as it is not what we would expected - it is simply not a text book example. There is no reason and indication to question the measurements here. The suggestion, that this might be downdraft is in our opinion not plausible considering that this is not a convective situation (where one could expect strong downdrafts).
Aside from this, if it would be a downdraft associated to a synoptic front for example.
Also the time scale associated with this event is too large to argue with a strong downdraft. The synoptic situation and together with the sounding informatioin suggest that the event related to the passage of a warm front.

regarding the comment about the configuration of the membership functions (MBF) and the usage of S-band thresholds:

Though the implemented hydrometeor classification follows the algorithm of Park et al. (2009) with the related S-band MBF the used thresholds have just an initial status for the usage with C-band measurements. Especially for hydrometeor types consisting of small hydrometeors below the resonance effect (with dimension less than a tenth of the wavelength) this first guess is considered appropriate. For other hydrometeor types based on

larger hydrometeors like the big drops or the hail class, which aren't in the focus of this weather case study, a nearly frequency independence isn't fulfilled. To handle the mentioned relation of the reflectivity intensity to the polarimetric measurements for the rain classes, 2-dimensional MBF as function of the reflectivity are used for ZDR and KDP, cf. the method in Park et al. (2009).
Furthermore, for every additional input parameter as HZEROCL, SNOWLMT and the ML history trapezoidal MBF are used for each hydrometeor class. An adaptation of the MBF parameters is envisaged in the course of the testing and verification phase of the hydrometeor classification scheme (if necessary).

Specific comments by the reviewer:

comments related to p8847 line 13: to p 8853 line 2:

we will consider those editorial remarks

p 8853 l 21: will be reformulated

p 8853 l 22: will formulated to be more precise.

p 8853 l 27: melting layer thickness: This is based on the observation in the earlymorning hours, where the melting layer was above the radar site (see Figure 5)

p 8854 l 5: agreed; this will be included as an explanation

p 8857 l 11: will be reformulated.

References:

[Bringi et al. (2001)]
Bringi, V. N., Chandrasekar, V.: Polarimetric Doppler Weather Radar. Cambridge University Press, 2001.

[Park et al. (2009)]
Park, Hyang Suk, et al. "The hydrometeor classification algorithm for the polarimetric WSR-88D: Description and application to an MCS." Weather and Forecasting 24.3 (2009): 730-748.

[Straka et al. (2000)]
Straka, Jerry M., Dusan S. Zrnic, and Alexander V. Ryzhkov. "Bulk hydrometeor classification and quantification using polarimetric radar data: Synthesis of relations." Journal of Applied Meteorology 39.8 (2000): 1341-1372.

[Testud et al. (2000)]
Testud, J., Bouar E. L., Obligis, E., and Ali-Mehenni, M.: The rain profiling algorithm

applied to polarimetric weather radar. J. Atmos. Oceanic, Vol. 17., pp. 322–356, 2000.

Houze and Medina (2005), Turbulence as a Mechanism for Orographic Precipitation Enhancement. Journal of Atmospheric Sciences Vol. 62., pp. 3599–3623.

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http://www.pa.op.dlr.de/erad2014/programme/ExtendedAbstracts/134_Schuur.pdf