Interactive comment on "Cloud classification of ground-based infrared images combining manifold and texture features" by Qixiang Luo et al.

We thank R. Clay for the insightful comments, which have allowed us to produce a stronger manuscript. Our responses to the comments are given below.

General comments:

The machine classification of cloud types found in automatically recorded images is an aim of considerable importance. However, it has proved difficult to develop suitable algorithms for this task. This paper combines two approaches, a texture analysis, such as one might expect based on statistical examination of the image structure, plus a manifold analysis such as is found effective, for instance, in facial recognition. The paper demonstrates that this combined process represents an improvement on previous analyses. The paper is interesting, well presented, and should be publishable.

The progress represented by this paper is incremental and the ultimate aim of classifying any cloud image is still distant. The paper demonstrates an ability to analyse images of "high visual quality" and avoids "a complex mixture of cloud types" in its dataset, which is used both for training and analysis when manually analysed and then split into various groups. We are NOT addressing images with clouds of mixed types at various formation levels, which is a not-uncommon occurrence (noted as a next step in the Conclusions). However, the difficult issue of examining clouds away from the zenith, where the aspect of the cloud changes, is addressed with reasonable success.

Specific comments:

1. Comment: The images under study are recorded in the long-wave infra-red. In these cases, the clear sky background brightness (temperature) varies with time and zenith angle (clear in figures 3 b, e). There is no discussion of whether those variations affect the image analysis, particularly the textural features which may have baseline issues.

Response: Many thanks for the thoughtful commenting. It is true that the clear sky background radiance in 8-14 μm varies with time and zenith angle. The images of the datasets have been preprocessed in the consideration of this important factor. The clear sky radiance threshold in each image is calculated using the radiation transfer model (Liu et al., 2013). The real radiance R at each pixel in each image is converted to the grey value G_{pixel} between [0,255] with $G_{pixel} = \frac{R}{R_{temp} - R_{clear}} * 255$, where R_{clear} is the corresponding clear sky radiance threshold and R_{temp} is the radiance corresponding to the real-time environment temperature. As a result, the effects of the clear sky background brightness temperature can be ignored, which means that this factor has little influence on the feature extraction of the images. In the revised manuscript, a further description of the cloud image preprocessing will be added in Section 2.1.

Reference

Liu, L., Sun, X., Gao, T., and Zhao, S.: Comparison of Cloud Properties from Ground-Based Infrared Cloud Measurement and Visual Observations, J. Atmos. Ocean. Tech., 30, 1171-1179, doi:10.1175/JTECH-D-12-00157.1, 2013.

2. Comment: In the same sense, the camera (if radiometric) provides real information on the apparent temperature of the cloud, and this is unused.

Response: Thanks for your constructive comments of the manuscript. The real information on the apparent temperature of the cloud is useful for analysing the images. The radiance value at each pixel in the image corresponds to a bright temperature. How to utilize the information of the brightness temperature effectively is worth further studying. At present, we mainly use the texture and manifold features to identify the cloud type. The addition of the brightness temperature of the physical information, or the combination of the height information obtained from the laser ceilometer might be helpful for the improvement of the cloud type recognition accuracy. We will carry out the research in the following work. Thanks again for the reviewer's advice. We will add this point to the section of Conclusions in the revised manuscript.

3. Comment: So far as presentation is concerned, the paper is clearly written. Tables 4 and 5 should include some explanation of the fractions 1/10, 1 /2, 9/10 even though their meaning is clear from a reading of the text (minor revision).

Response: Many thanks for your careful reading of our manuscript. We are sorry for our negligence. We will add some explanation of the fractions 1/10, 1 /2, 9/10 in Tables 4 and 5 in the revised manuscript to make it clear: 1/10, 1/2 and 9/10 are the certain proportions of the training set selected randomly from each category, and the rest part forms the testing set correspondingly.