Met Office

Erroneous deletion of precipitation echoes over Jersey

January 17, 2018

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Contents

1 Introduction

Following ongoing concerns with the quality control scheme erroneously flagging rainfall/drizzle as non-meteorological echoes, we were sent the following case study.

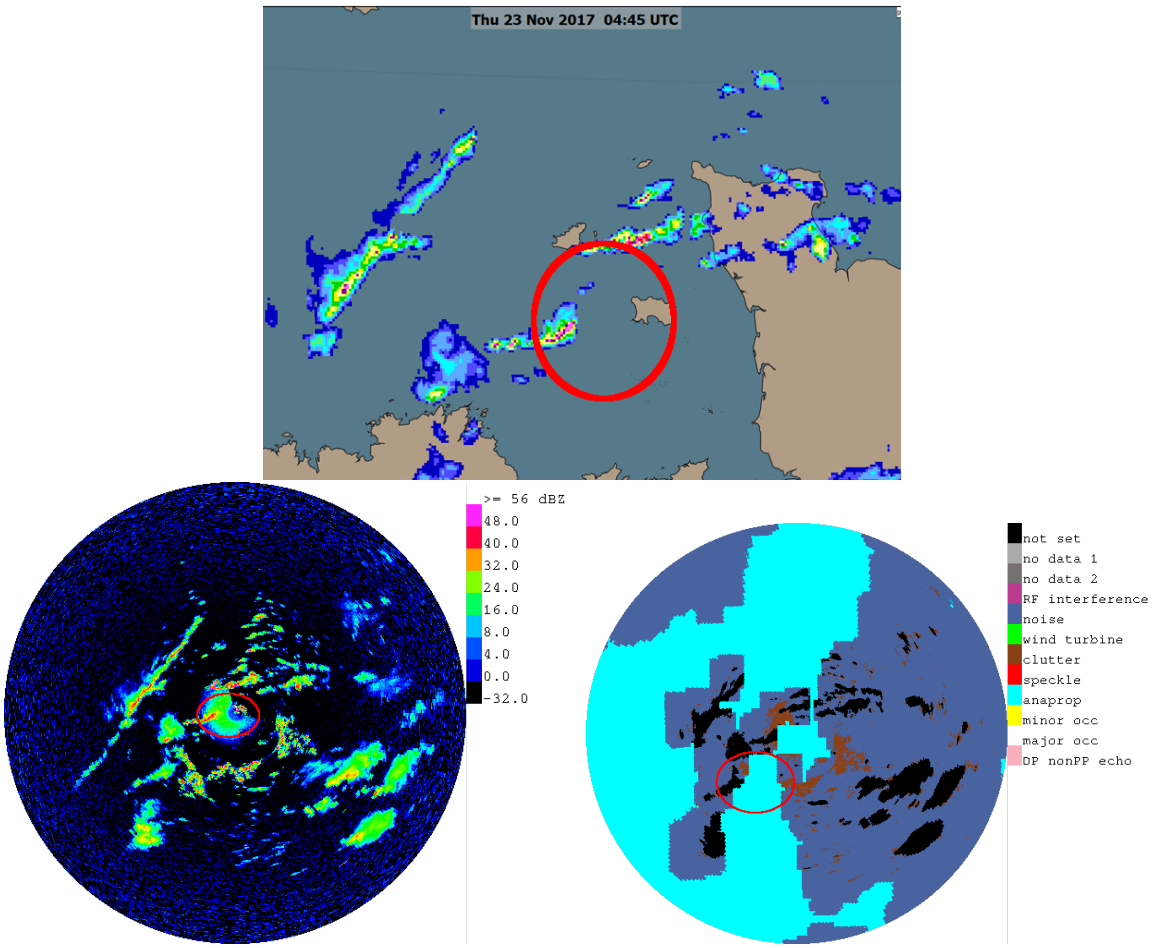

Figure 1: **Top:** rainfall rates, with a sharp discontinuity where the rainfall (over sea clutter) disappears into nothing. **Bottom left:** Reflectivity (the rainfall is clearly detected in the "empty" region). **Bottom right:** The cyan colouring is the "anaprop" filter flagging the rainfall erroneously, using satellite alphas (see rest of this note).

2 Input data

Dual polarisation radar data

We obtain dualpol data from the Channel Island radar on the same timescale as the other radars (5min cycles) - Reflectivity, phidp, rhohv, zdr. The example shows light drizzle over the Channel Islands, and contains non-meteorological echoes (i.e. no quality control applied yet).

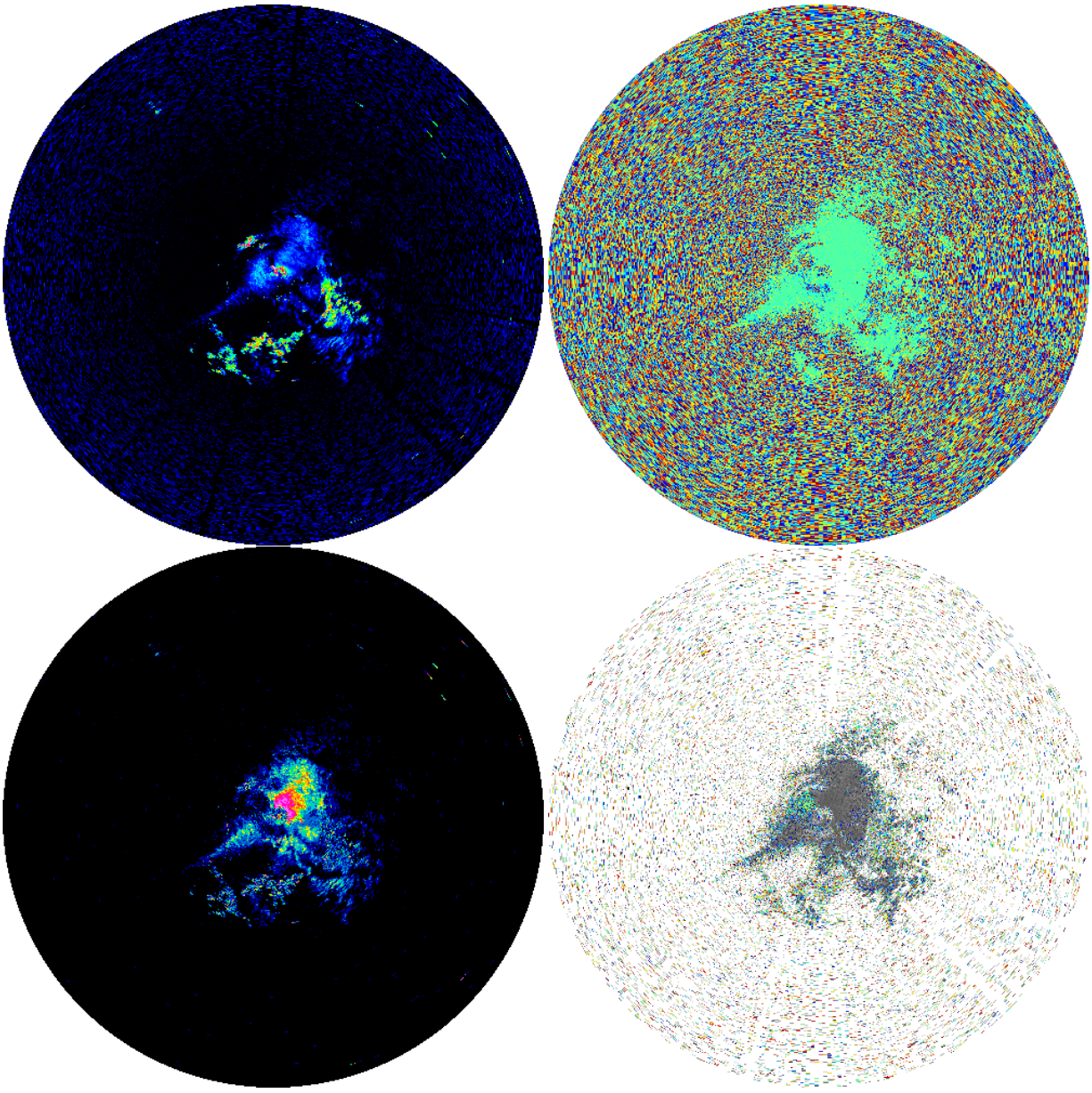

Figure 2: Dual pol data. **Top left:** reflectivity. **Top right:** differential phase. **Bottom left:** correlation coefficient. **Bottom right:** differential reflectivity.

Satellite data

We obtain a “satellite alphas” field from the satellite team every 15mins, HH:00, HH:15, HH:30, HH:45 (bright = cloudy, plotted log10(alpha) below). These alpha values vary from 0 to tens of thousands, with below 100 being “clear sky” and above being “cloudy”.

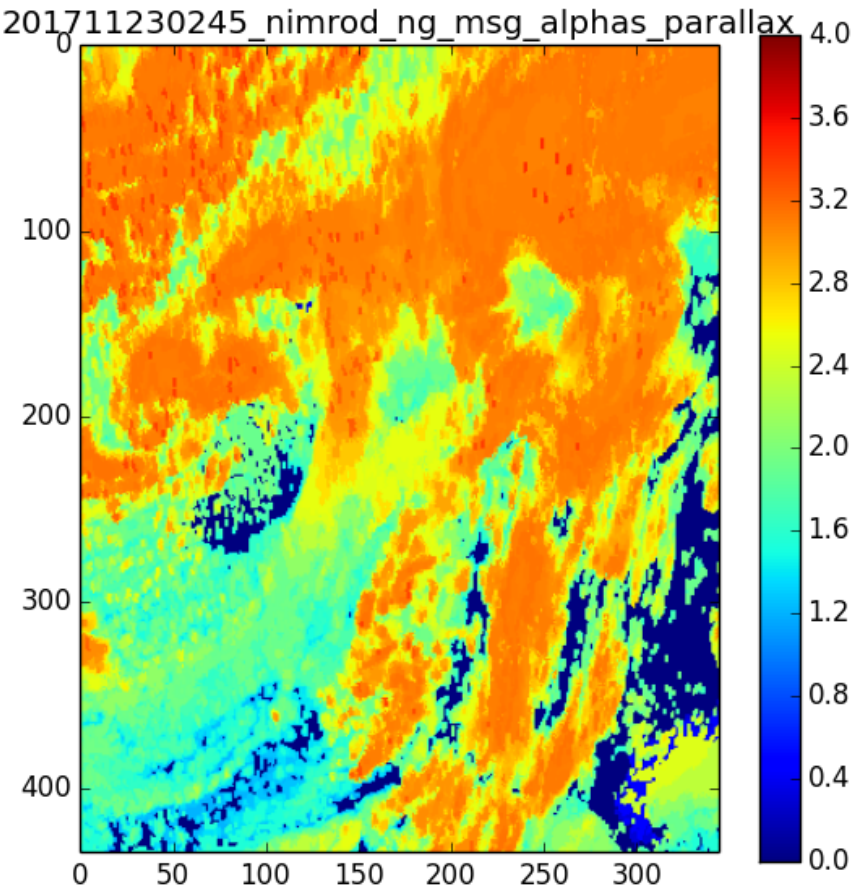

Figure 3: Example alphas field. The bright areas represent “cloudy” regions, and the dark areas represent “cloud-free” regions.

The “satellite alphas” field is computed from infrared satellite images, using the 0.8 μm, 1.6μm, 3.9μm and 10.8μm channels when the sun is high in the sky, and the 10.8μm and 12μm channels during the night. At twilight, the scheme is further modified to include some correction factors for biases. The resulting value is an estimate of the ratio of the probability of the given pixel is wet (i.e. some sort of hydrometeor present) to the probability that the given pixel is dry.

3 Quality control

We run a dual polarisation quality control step to flag data that is not precipitation based on the dual pol data in a scan alone - black represents rainfall from the dualpol classifier. We apply a threshold of 100 to the satellite alphas, which are an odds ratio (something like $P(x)/P(\bar{x})$) - (cyan=no clouds).

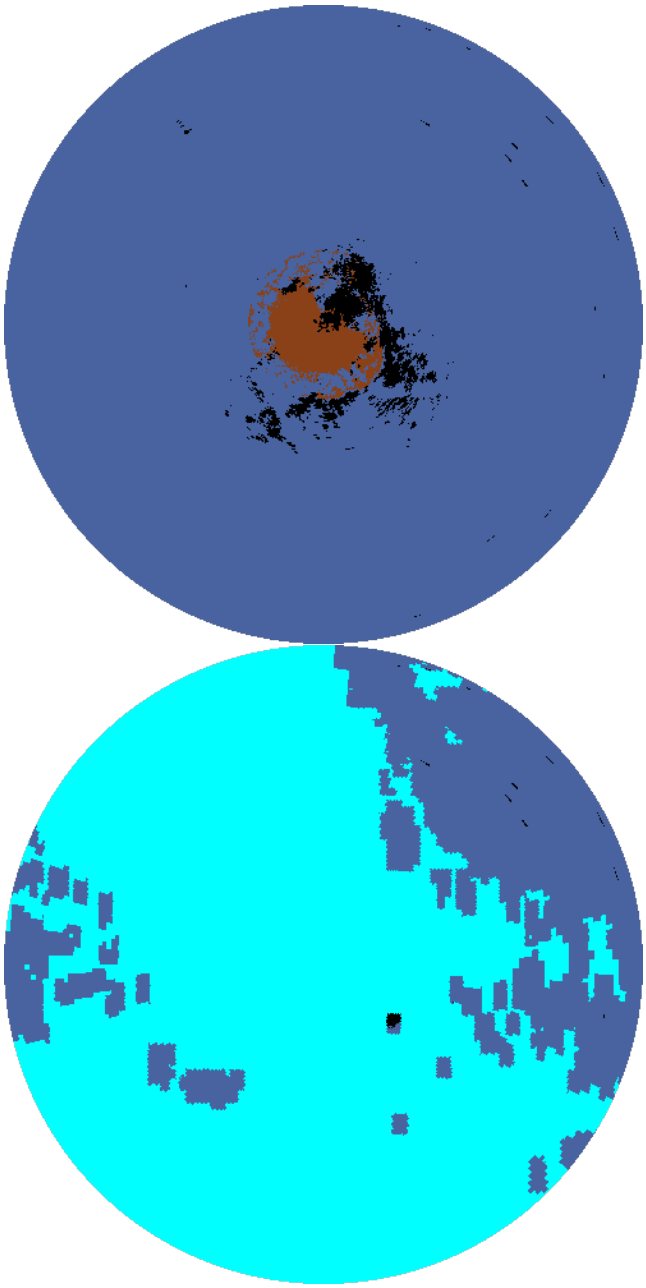

Figure 4: Quality control “flags”. **Top:** no alphas applied, red is clutter, black is precipitation. **Bottom:** Cyan is the anaprop flag set from the alphas field.

If we change the threshold to be 80, we allow more data (alphas 80-100) to be considered "cloudy" rather than "clear sky", and hence improve the pass-through of drizzle slightly. In the following figure, we apply the threshold at 70, 50, 30 and 10 respectively:

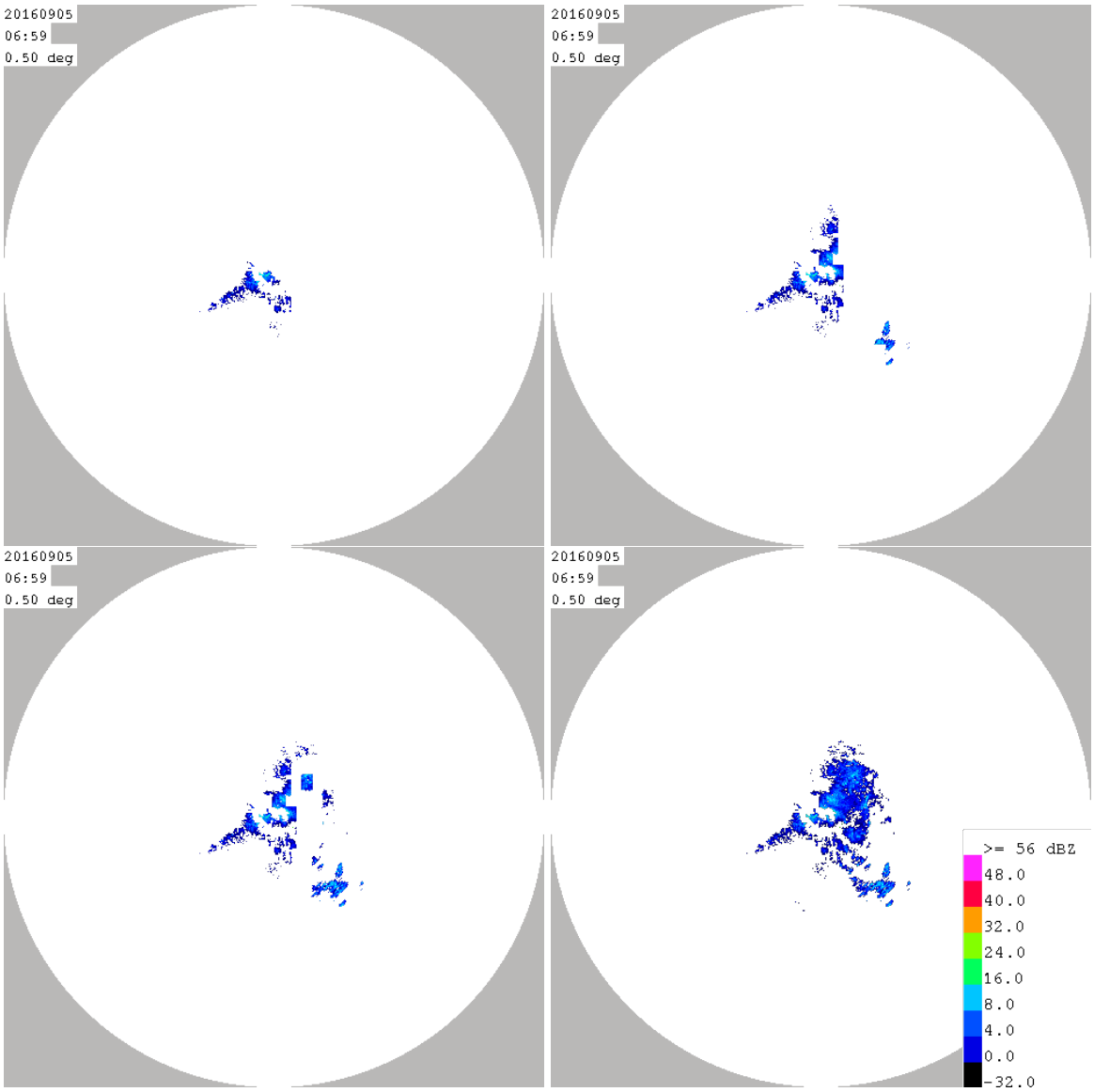

Figure 5: Single reflectivity scan, with the alphas threshold at 70 (top left), 50 (top right), 30 (bottom left) and 10 (bottom right).

We have to drop the threshold to nearer 20 to see all the drizzle coming through.

At this point, unfortunately, the non precipitation echoes start to appear and cause a lot of artefacts in an accumulation. In the following, we use the same thresholds as before, and show the difference in accumulation from threshold=100, for the first 30km from the radar, for September 2016:

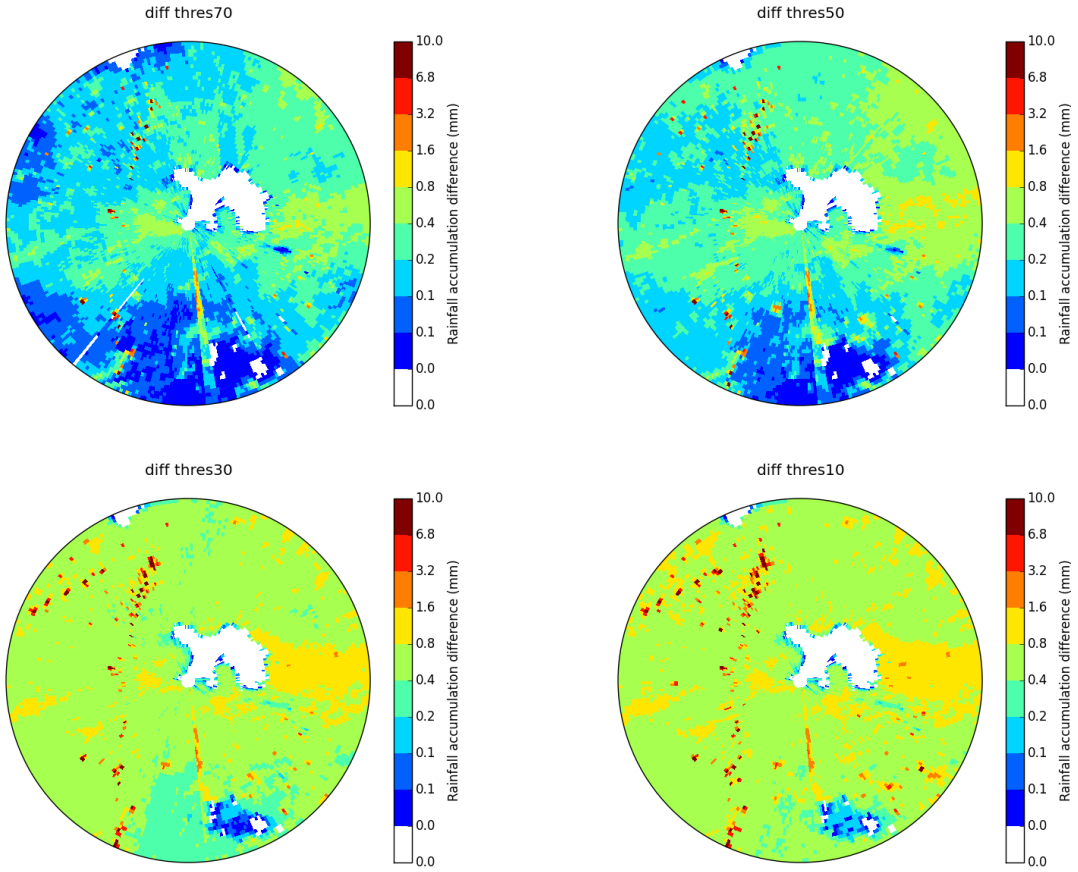

Figure 6: Difference between accumulations over 1 month (with threshold of alphas at 70, 50, 30 and 10) as compared to the same accumulation with threshold at 100.

4 Multimodal distribution of alphas in drizzle

We looked at the distribution of alphas in the presense of drizzle: we selected the pixels near Jersey with $Z < 10$dBZ where the dualpol quality control reported “rainfall” (to catch the drizzle). We then read the corresponding alphas values for the pixel. This is plotted below for 23rd November 2017:

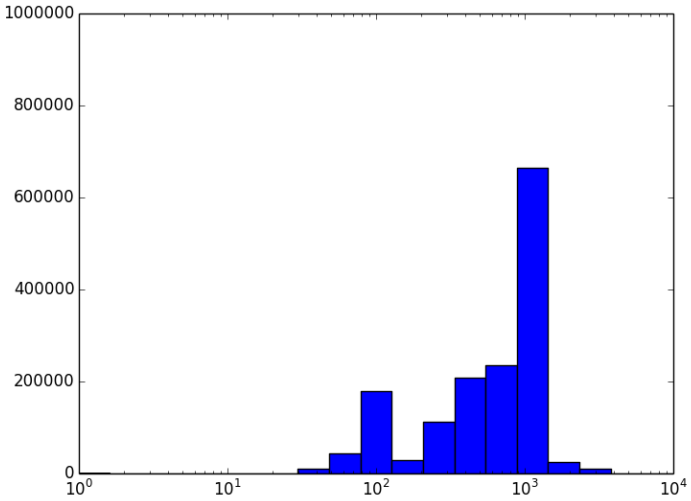

Figure 7: Histograms of values of alphas in drizzle over 24h (dualpol qc claims “rainfall” and reflectivity $<$ 10dBZ).

If we look at two individual alphas fields, 2017/11/23 02:45 and 06:30, we see the two peaks:

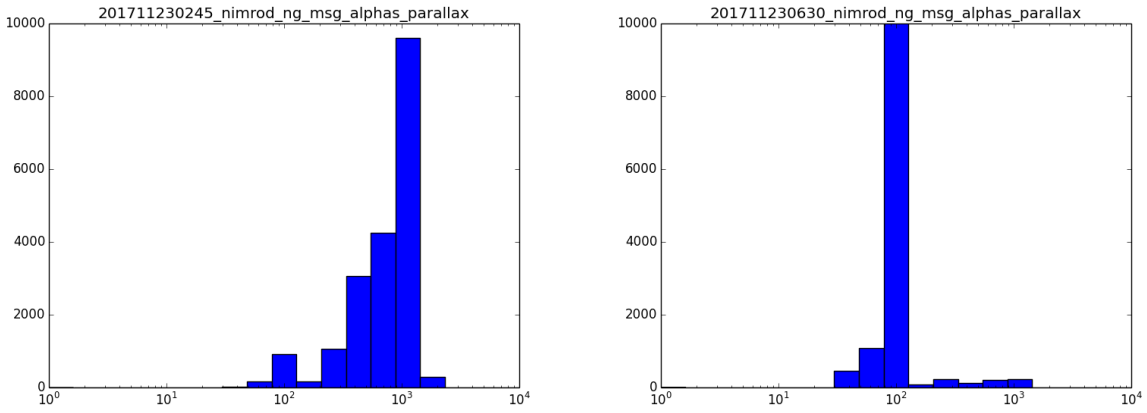

Figure 8: Histograms of alphas in drizzle at specific times. **Left:** 02:25. **Right:** 06:30.

These two peaks, at 10^3 for night time and 10^2 for twilight, indicate the alphas field is not consistent for a given meteorological condition, but instead changes with the time of day.

5 Outlook

Discussions with the satellite team have indicated that there are six schemes used to generate the alphas, based on the time of day and the actual values in the channels, a different number of satellite channels is being used in the alternative schemes. This can be seen as a discontinuity in the alphas field:

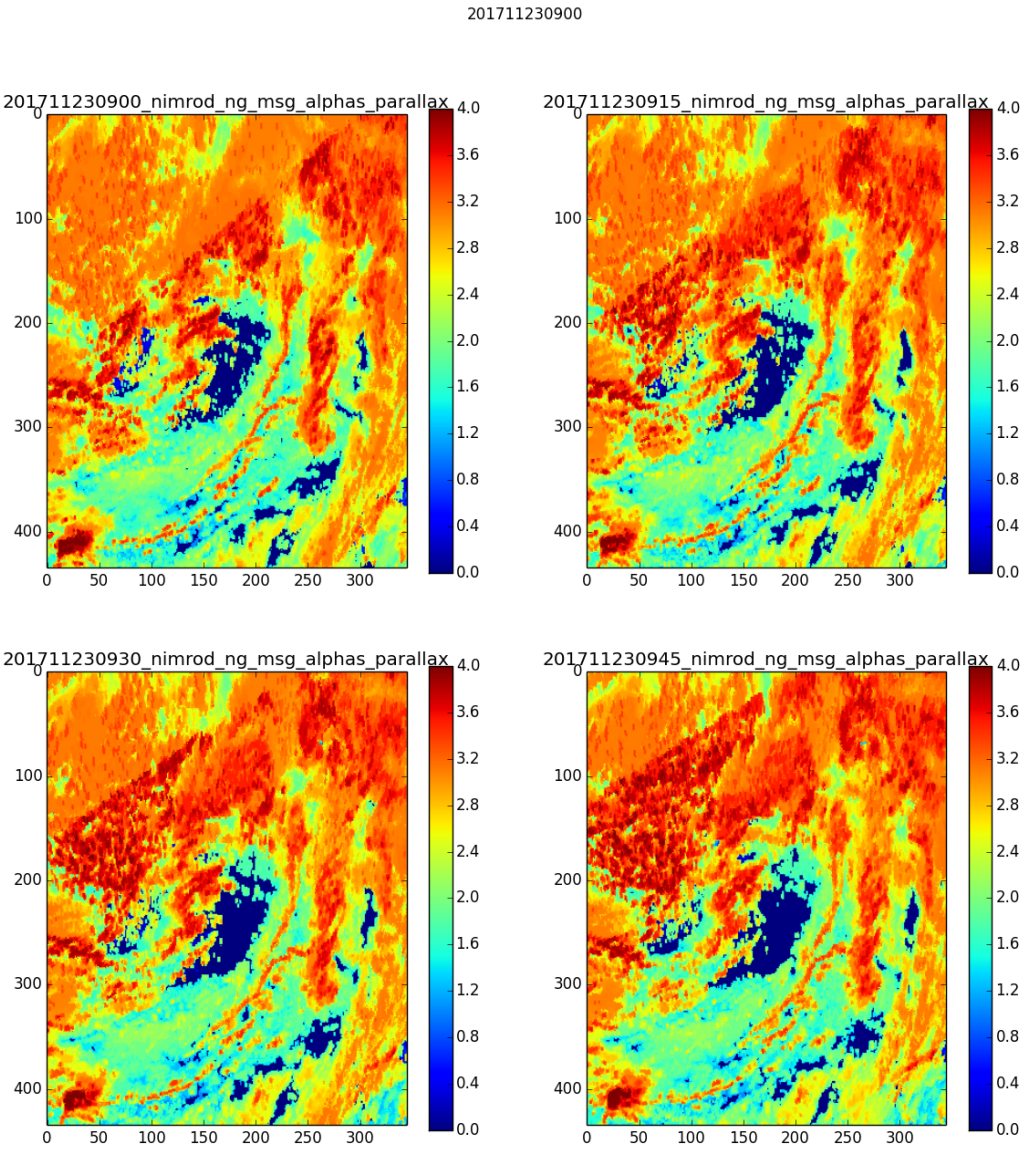

Figure 9: Alphas over a transition at twilight. Note the discontinuity in the top left of each image.

- We have asked the satellite team to provide a field of "which scheme is being used" so we can look at the different histograms separately, and we will see if we can transform the data using a simple mathematical transform, which we will ask them to implement.

- If we consider the fact that the alphas do a generally good job most of the time, we can see that the twilight case of alphas within drizzle being near 100 is the problem. Thus, we aim to transform the probability distribution towards that of the day/night scheme if possible.
- This will mean the alphas value will only depend on the meteorological condition, instead of the number of channels used. This is a data consistency issue with the satellite product, but we (the radar team) are putting some effort into understanding and mitigating the issue with the hope of a fix sooner rather than later.
- Once the values of the alphas field are consistent with meteorological conditions, this will mean the current problem will be reduced.
- If the problem persists (or in parallel with testing of the proposed solution), we will implement a probabilistic use of the alphas, in the same way we use the dual polarisation parameters in the quality control stage. This means that instead of using a blanket threshold on the image based on the alphas, the alphas will yield a $P(\mathrm{rain}|\mathrm{alphas})$, $P(\mathrm{notrain}|\mathrm{alphas})$, which will be included in the existing classifier to give a value of $P(\mathrm{rain}|\mathrm{alphas}, \mathrm{dualpolparameters}, \mathrm{CPA}, \mathrm{etc})$.
- The practical step for this will involve using the dualpol qc to generate a batch of training data, checking it by human-eye-brain to ascertain the training data is adequate, then generating a histogram of the corresponding alphas field (with the suitably amended values for consistency with meteorological conditions). This histogram is the “lessons learned” of the classifier.
- The latter change would be a major change to the quality control scheme since 2014, and will thus require some significant testing with multiple sites over multiple weather conditions to ensure there is no degradation to the product.

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