Data quality overview

This report describes issues that should be considered when further processing any of the 2008 ARSF datasets. The document will be updated over the course of the year, with the latest version available at:

http://www.npm.ac.uk/rsg/projects/arsf/trac/wiki/Reports

Issues affecting all sensors

Geo-referencing accuracy

ARSF currently deliver data at level 1 (calibrated sensor data) rather than level 3 (geo-referenced). This allows users to generate level 2 products (e.g. atmospherically corrected radiances) if they wish, and/or map to any projection or datum that suits.

Since ARSF does not currently process data to level 3 except for quality control purposes, instructions for applying precise geometric adjustments to align imagery to other data sets (such as vector overlays) are given to users with delivered datasets. Where a vector overlay or other ground truth information is available, ARSF provide an indication of the average error prior to any such adjustments.

Timing errors

Correction of the timing offsets between navigation and imagery has been necessary to correct errors in some flight lines. These are primarily present in the Eagle/Hawk system but occasionally occur in ATM data. Timing errors manifest as "wobbles" in the imagery correlated to but out of sync with movements of the aircraft. An example is shown in Figure 1 below.

In Eagle and Hawk, the issue is presently attributed to some part of the system losing scan lines of data without recording the loss. Consequently the image scans become out of sync with the GPS data. This is under investigation at various levels and has been raised with Specim.

We endeavour to correct all timing errors prior to delivery. As this is a manual process and relies on finding suitable visible features in the imagery, some errors may still remain. If any are found, please contact us at arsf-processing@pml.ac.uk.

Figure 1a: timing error in an Eagle line

Figure 1b: corrected version of above (0.13 seconds difference)

Specific sensor issues

Specim Eagle and Hawk

Radiometric calibration

The NERC Field Spectroscopy Facility (FSF) were unable to do a complete calibration for 2007 (attempted in December) due to the failure of the lamp in their NPL calibrated uniform sphere source. By examining spectral response to various other known light sources, FSF were able to partially validate the February 2007 factory calibration as spectrally correct and suitable for 2007 data. Comparisons of concurrent Eagle and CASI spectra, and of Eagle/Hawk data versus modelled (SMARTS) results support this.

The timing of the calibration cycle at NPL and ongoing FSF equipment problems have prevented acquisition of a 2008 calibration (as of the end of May 2008) of the Eagle and Hawk instruments. Consequently, early 2008 data have been processed and delivered with the February 2007 factory calibration as the best available option (so as not to delay data deliveries further).

When a true 2008 calibration is available, we will make a comparison with the 2007 calibration and if there are significant differences, PIs will be notified and data will be reprocessed as appropriate.

Quality of 2007 radiometric calibration

The data quality appears to degrade at the low and high wavelength limits of both Eagle and Hawk. For example, a comparison of pixels near the Eagle/Hawk spectral overlap over dark targets such as water reveals a mismatch (see Figure 2). Caution is advised when examining spectral responses at the edges of the usable range.

Issue tracked at: http://www.npm.ac.uk/rsg/projects/arsf/trac/ticket/113

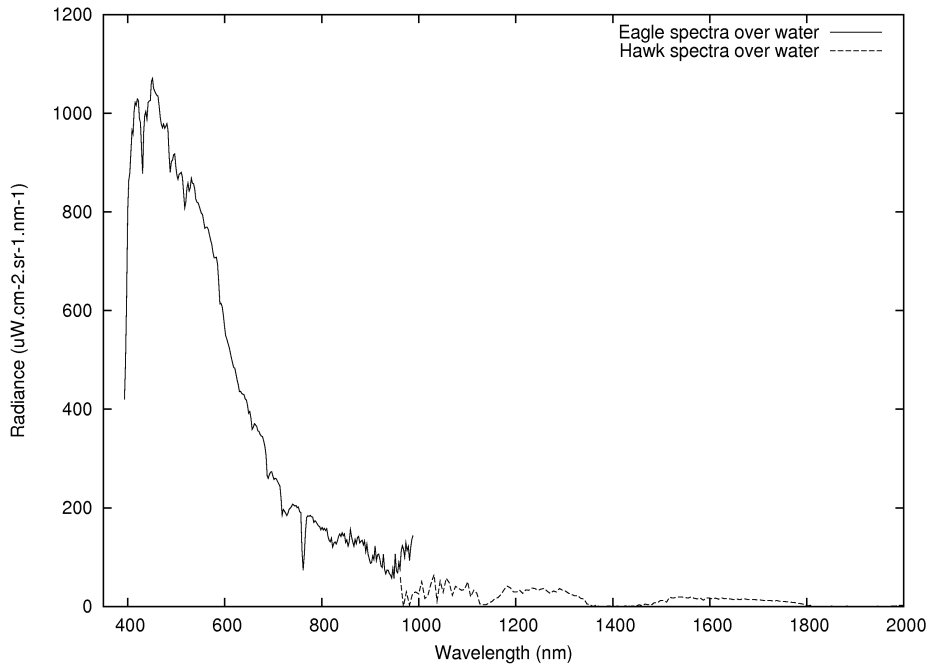

Figure 2a: Eagle vs. Hawk spectra over water (dark target), showing mismatch at the overlap point

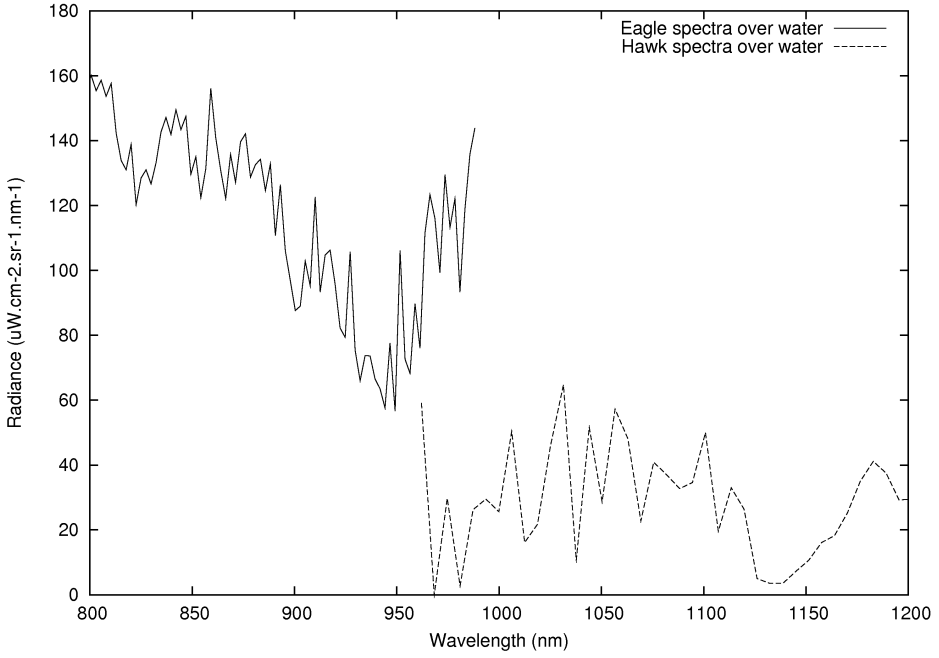

Figure 2b: zoomed up version of Figure 2a

Overflowed pixels

The instruments have a limited dynamic range and must be set to capture data over the appropriate range of signal strength. For example, if the area of interest is dark, then the instrument will be configured to capture as much low light detail as possible. This configuration is set based on operator experience, the principal investigator's indication of the areas of importance and the prevailing conditions. Inevitably, some pixels are unexpectedly bright – e.g. sunglint over water or part of a cloud. These pixels may exceed the maximum capture level and overflow. Overflowed pixels are marked with an invalid value (65535) in delivered level 1 data. Typically they are not in areas of interest, but should be accounted for.

In Hawk, overflows are marked for just the pixel/band in question. However, Eagle uses a frame transfer CCD, where data are read out in rows. Incoming light continues to accumulate in unread rows during the transfer and is removed by "smear correction" software, which relies on data from one row to correct the next. If a pixel overflows, information is lost and all subsequent pixels in that column cannot be fully corrected. In Eagle, the net effect is that an overflow at 600nm will cause all bluer bands (600nm -> ~400nm) to be undercorrected for that spatial pixel.

When Eagle data with overflows are delivered, we mark as bad all bands following an overflow as they will incorporates some unknown additional light. If your Eagle data contains overflows, the spectrum for that pixel will look like the masked Eagle (solid line) in Figure 3. The dashed line in Figure 3 shows what data were captured, although some are undercorrected – if you wish your data delivered unmasked, please contact us.

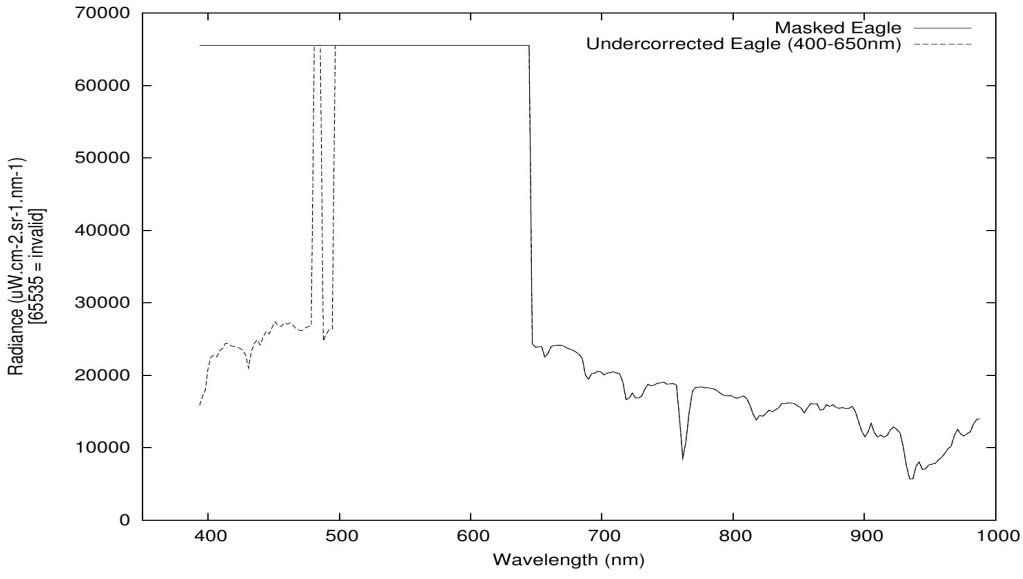

Figure 3: Sample spectra for an overflowed pixel (overflow at ~650nm), showing the masked data (normally delivered) and the undercorrected (400-650nm) capture data.

Bad pixels

The Hawk instrument has a number of bad pixels that give inaccurate values. There are different types of error (e.g. constant pixel values, uncorrected offset, duplicating neighbouring pixels, etc), and ~1% of bad pixels are to be expected on the type of CCD used in the Hawk instrument. Specim has provided a list of known bad pixels and these are filled with zero values in delivered data.

While the majority of bad pixels are corrected or blanked out, some have not been detected and may appear in delivered data. These appear in level 1 datasets as straight lines along the direction of flight and as undulating lines in level 3 following the motion of the aircraft (e.g. Figure 4). Typically, they will only affect a single band and are difficult to detect. A complete solution for detecting and removing these will be pursued in 2008.

Issue tracked at: http://www.npm.ac.uk/rsg/projects/arsf/trac/ticket/111

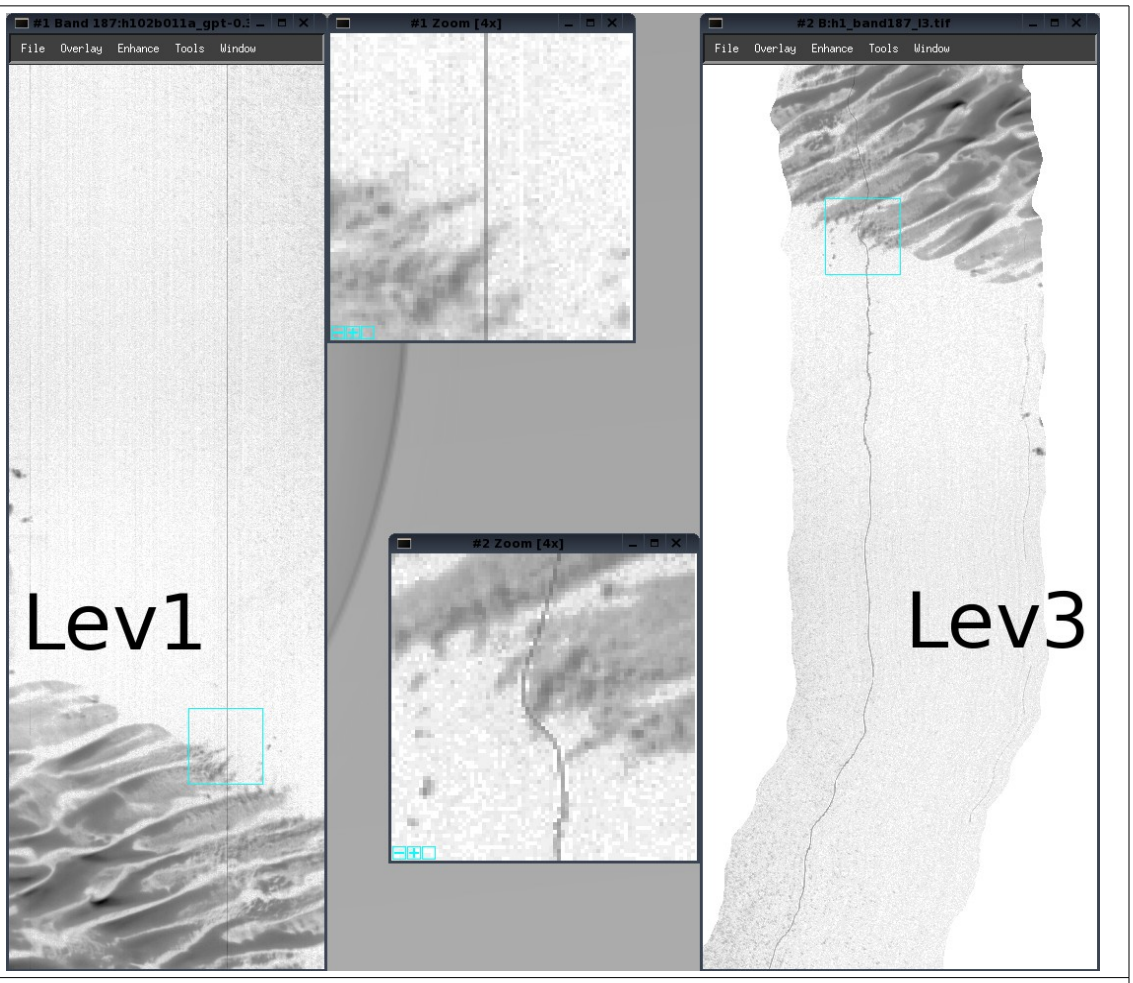

Figure 4: A bad pixel on Hawk band 187, in a scene over water (images inverted to improve contrast on paper)

ATM

Radiometric calibration

The ATM radiometric calibration undertaken at the beginning of 2007 has been found to differ markedly from the 2007 post-season and the subsequent 2008 pre-season calibrations. Furthermore, ATM suffered a serious failure at the beginning of the 2008 Ethiopia campaign, and this may partly explain the poor quality of the two calibrations prior to this.

Through comparison against CASI and/or Eagle data collected simultaneously, the 2007 pre-season calibration was judged as the more accurate representation for the whole of 2007 and was used for 2007 data deliveries. See Figure 5 for a single sample over land.

With no proper calibration for Eagle and Hawk in 2008 and with the CASI removed from service, we do not have a good basis for repeating this comparison. Rather than wait for the next ATM calibration (scheduled for late summer/autumn), we have continued to use the 2007 pre-season calibration for 2008 data deliveries, including any accompanying this report. As with Eagle and Hawk, when a valid 2008 calibration is available, we will evaluate the differences and redeliver if there are significant ones.

For more information, see:
http://www.npm.ac.uk/rsg/projects/arsf/trac/ticket/75 (2008) and
http://www.npm.ac.uk/rsg/projects/arsf/trac/ticket/39 (2007)

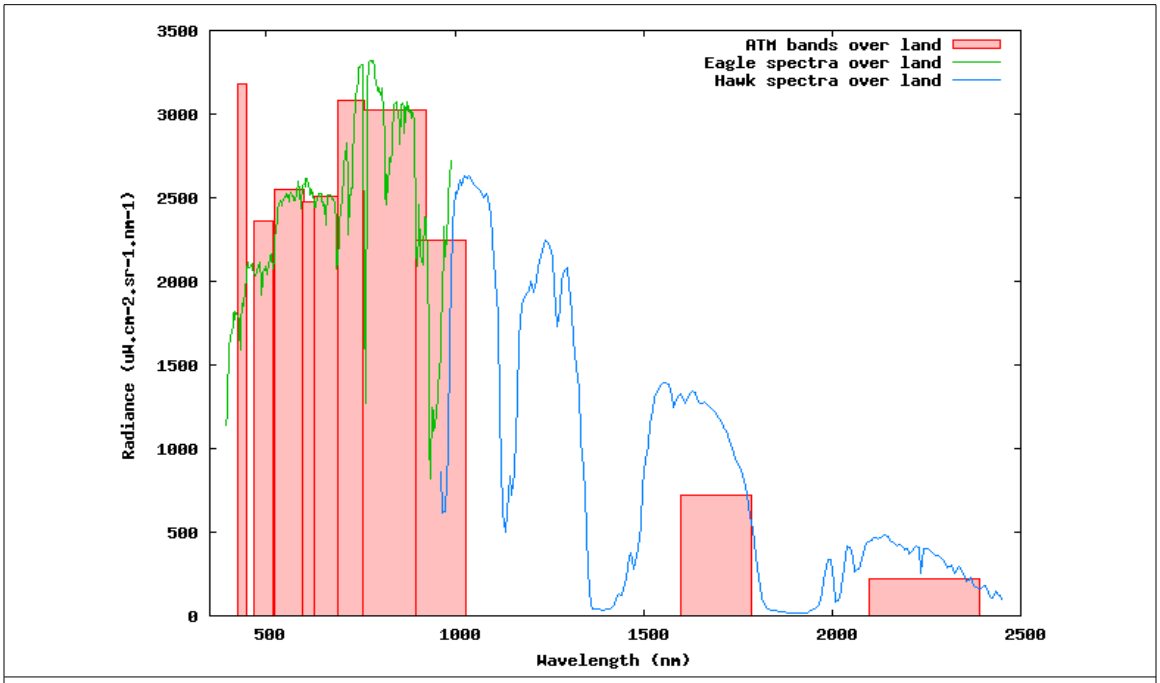

Figure 5a: ATM bands 1-10 plotted with Eagle and Hawk spectra

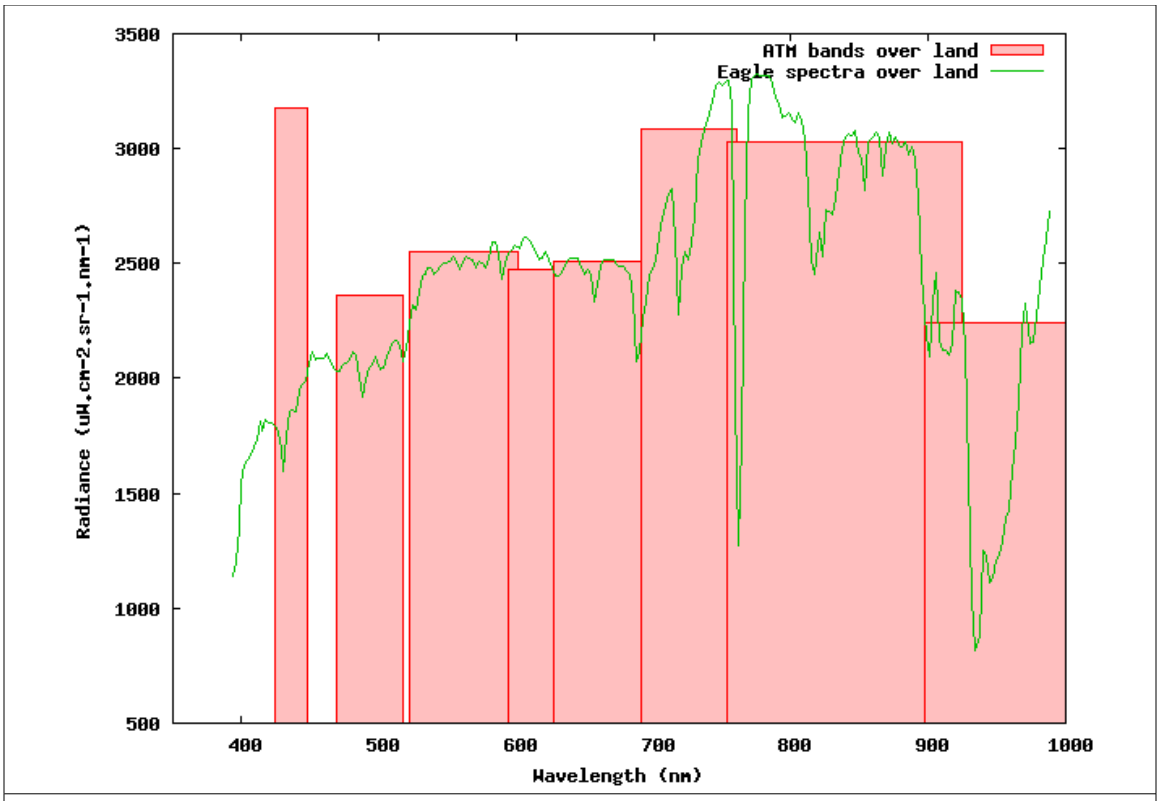

Figure 5b: ATM bands 1-8 plotted with Eagle spectra

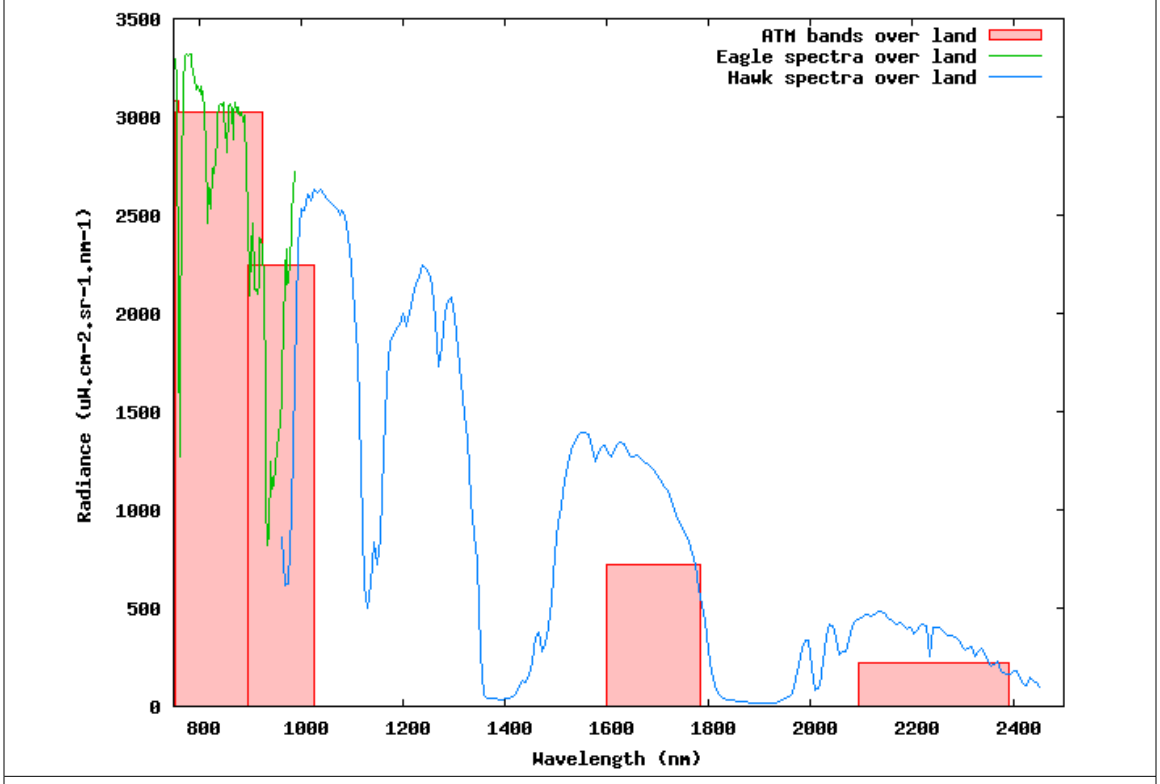

Figure 5c: ATM bands 7-10 plotted with partial Eagle and complete Hawk spectra

Noise

Some ATM data exhibit small black and white speckles, particularly in band 11 (thermal infra-red), which is believed to be due to electrical interference (see Figure 6).

Figure 6a: band 2 of ATM showing suspected electrical interference (dark speckles)

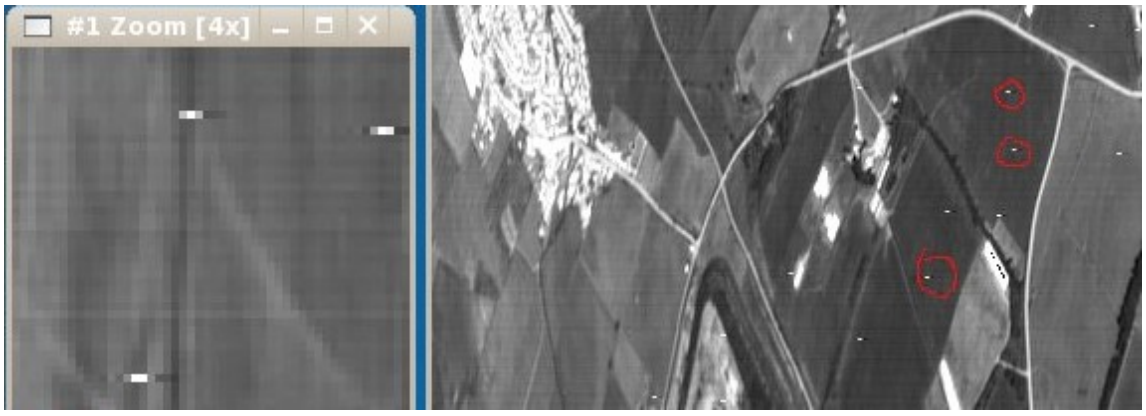

Figure 6b: band 11 of ATM showing suspected electrical interference (white speckles)