Data Quality Report - 2015

Thermal Hyperspectral

ARSF - Data Analysis Node

Updated on: November 1, 2016

Contents

1 Introduction

The Airborne Research and Survey Facility (ARSF) collect thermal data with a Specim AISA Owl instrument, operated since 2014. The Owl instrument covers wavelengths from 7.6 – 12.3 μm. A pair of black bodies, which are mechanically moved in front of the sensor lens one by one, are used for calibration. This data quality report describes issues for thermal data acquired with the Owl instrument that should be considered when further processing any ARSF datasets acquired in 2015.

This document may be updated over the course of the year, the latest version is available at: http://arsf-dan.nerc.ac.uk/trac/wiki/Reports

2 Geo-referencing accuracy

ARSF currently delivers level 1b (calibrated at-sensor radiance) and level 3 data (mapped level 1b data). This offers users quick access to georeferenced data whilst maintaining the capability to operate on the original pre-gridded data and use a coordinate projection or datum of choice.

The quality of the geocorrection for each project is described in the documentation supplied with the delivery. Typically the geocorrection is of the order of 2 – 3 metres, equating to approximately 1 pixel depending on flight altitude. Higher accuracy relies on an accurate Digital Surface Model (DSM). The freely available global ASTER digital elevation data is used and supplied with the delivered mapped files. Accuracy may be improved by using a DSM derived from higher resolution data such as LiDAR. An indication of the average error between vector overlays is included in the delivery documentation where vector overlays or other ground truth information is available.

It may be possible to tune specific flight lines for higher accuracy and instructions can be provided on how to make your own alignments. If a higher accuracy is required, please contact us at: arsf-processing@pml.ac.uk

3 Timing Errors

Small timing errors occur due to a fault in synchronisation between the navigation system and the Specim sensors. The result of these timing offsets is incorrect scan line positioning manifesting as distortions in the imagery correlating to, but out of sync with, movements of the aircraft. An example is shown in Figure 1.

This issue has been extensively investigated and demonstrated to be a fault in the Specim systems. ARSF are working with Specim to resolve this issue.

We endeavour to correct all timing errors prior to delivery. As this is a manual process reliant 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.

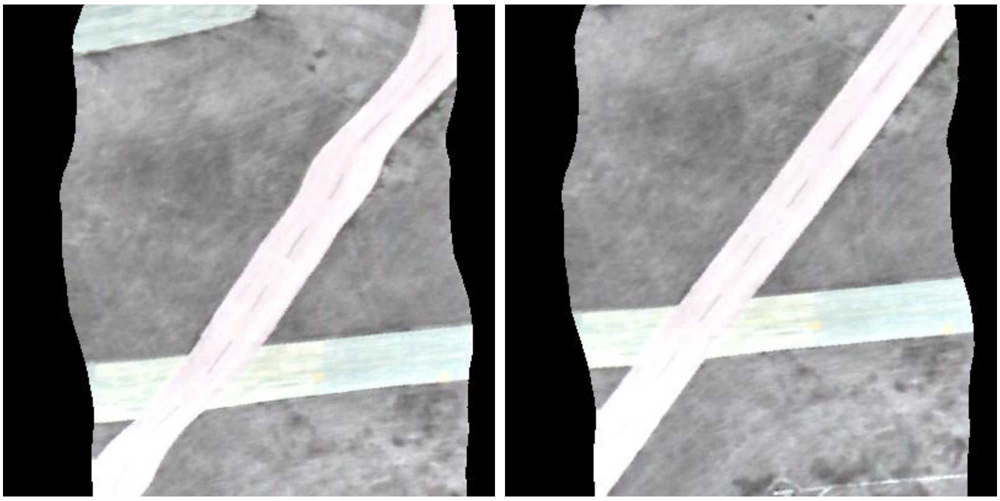

Figure 1: *Left: timing error in an Owl line. Right: corrected version without timing error (0.6 seconds difference).*

4 Sensor calibration

Calibration data is collected for each flight line using the Owl's internal black bodies set to temperatures bracketing the temperature range of interest. The raw data is calibrated to level 1b at-sensor radiance with Specim's "Proctool_owl_v2.6.1" using a proprietary method.

4.1 Detector Stability

Each time the sensor is turned on the detector response is completely different, so must be calibrated for each flight. The detector response is usually fairly stable over short time periods and Specim have advised a calibration after approximately every 30 mins. An internal test shows less than 0.02% variation for a single pixel across all bands over a 3 hour period, as can be seen in figure 2. Note that this will result in a greater error in the calibrated data. The larger spikes are due to the pixel blinking during acquisition of the internal black body data used for calibration. Figure 3 shows the actual calibration data for each of the data acquisitions. In both plots greater variation is observed in the higher bands. Thus calibration data may be used for multiple flight lines without a substantial decrease in performance. Where lines are not processed using the corresponding calibration file, a reason will be noted in the readme.

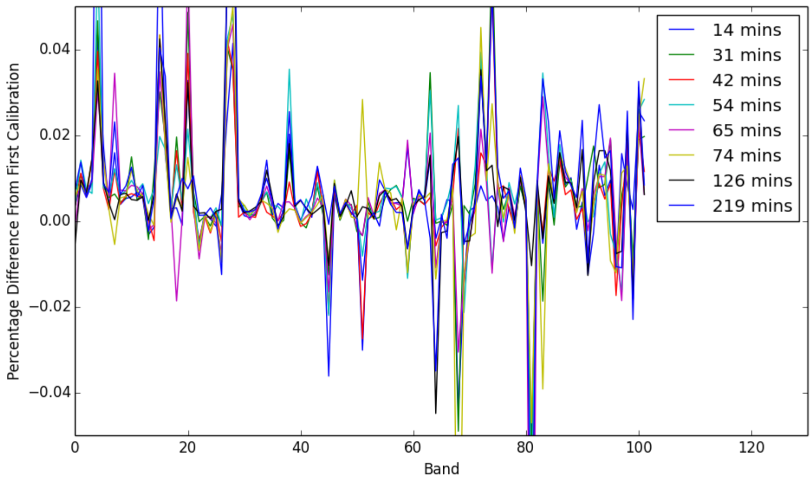

Figure 2: *Percentage difference in each of the calibration files from the first calibration file for a single spatial pixel.*

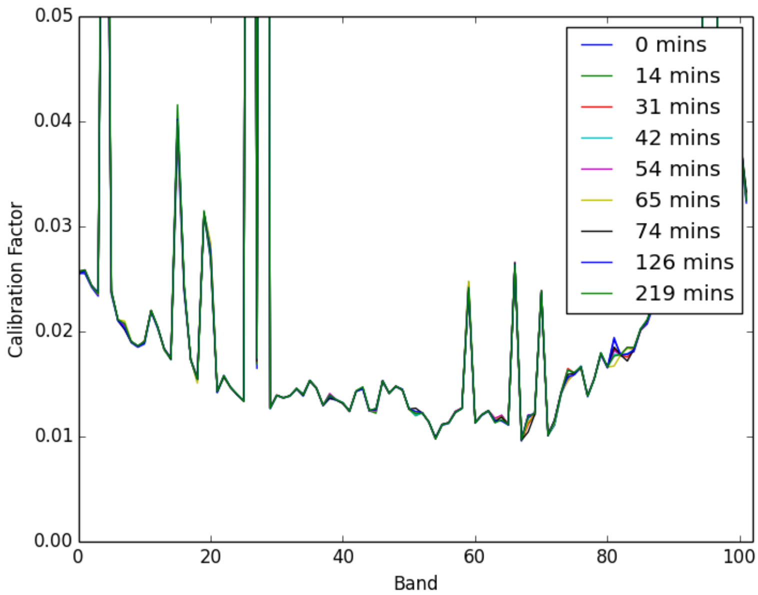

Figure 3: *Calibration data for a single spatial pixel after various time delays.*

4.2 Absolute Temperature Accuracy

During the July 2014 calibration event, data were collected of a black body at various temperatures to test the Owl's accuracy at measuring absolute temperature. Whilst the Owl is stated to have a temperature resolution in the 10 – 100 mK range, the absolute temperature accuracy of thermal imagers in general is much poorer. Figure 4 shows the spectral error at different temperatures during the calibration test compared to the theoretical black body spectra. Inaccuracies in the target black body temperature also contribute to this data, so the values should not be taken as absolute error of the Owl. The data do show a general trend in increasing error with increasing temperature, which is not uniform across the spectrum. Bands between 8 – 9 μm generally show a reduced error, which is more noticeable at the higher temperatures. The error below 8 μm is likely to be due to absorption by moisture in the air.

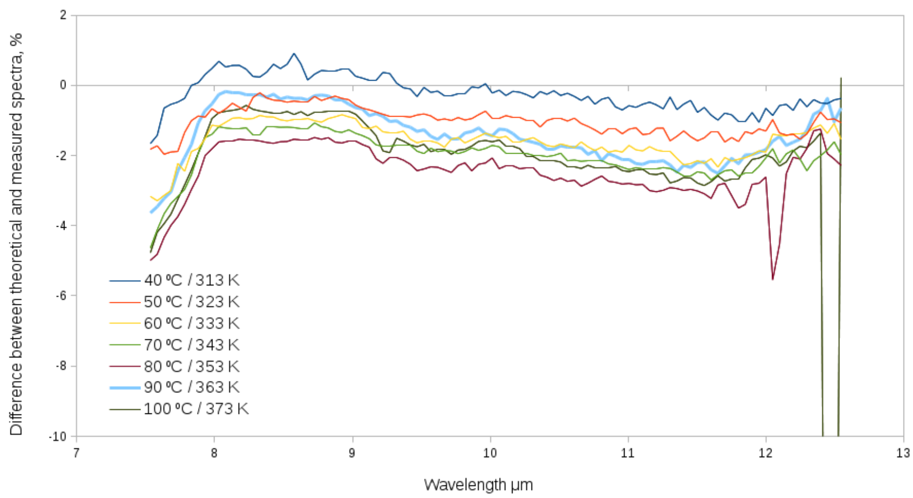

Figure 4: *Percentage spectral error at different target temperatures. Some of the error may be due to inaccuracy in the target black body temperature.*

5 Pixel Overflows

Hyperspectral instruments have a finite dynamic range and must be configured to capture data such that the received signal strength falls within this range. For example, if the area of interest is dark, then the instrument will be configured to capture as much low light as possible. Configuration of the Owl instrument is set based on operator experience, prevailing conditions and the requested principal investigator's areas of importance. Inevitably some pixels may be unexpectedly bright due to high responses recorded on the instrument. These pixels may exceed the maximum capture level and 'overflow'. These pixels are not typically in areas of interest and do not appear to be as common for the Owl as for the Fenix, but should be accounted for when examining files. The accompanying mask file will contain an overflow flag value in the level 1b equivalent pixel. If you would prefer your actual level 1b files to be masked rather than use the separate mask file, please contact arsf-processing@pml.ac.uk.

6 Bad and Blinking Pixels

The Owl uses a Mercury Cadmium Telluride detector array as this is the most sensitive commercial LWIR detector technology available to Specim. However, this technology suffers both from bad pixels and blinking pixels. Bad pixels are those that do not react properly to light, so stay dark or bright. Blinking pixels do react properly to light, but have randomly varying dark current causing variable behaviour throughout a data collection. Whilst bad pixels typically constitute 1 % of all pixels, 5 – 9 % of the pixels may be blinkers.

Detection of blinking pixels is much more difficult than bad pixels due to their random nature. On each power-up of the detector different pixels will exhibit blinking behaviour, ruling out the use of a fixed blinking pixel map like that used for the Fenix bad pixels. The blinking frequency also varies from one pixel to another, in the range of approximately 50 Hz to 0.01 Hz.

Blinking and bad pixels are currently dealt with during the calibration step using v2.6.2 of Specim's processing tool. This looks at the dark frames collected at the end of the flight line and labels any pixel with a standard deviation in its radiance signal greater than a set threshold as a blinker. The blinking pixels are then replaced by data from a neighbouring pixel, preferentially in the spectral domain.

6.1 Known Issues with Blinker Removal

Examination of both test and flight data suggests that the blinker detection algorithm currently implemented is not optimal and requires further development. Undetected blinkers appear in the level 1b data as intermittent bright and dark vertical stripes and as undulating lines in the level 3 data following the motion of the aircraft. It is possible to alter the threshold in Specim's calibration tool for blinker detection, but this also removes more data, particularly from the higher bands, so is not normally adjusted by ARSF-DAN. Figure 5 shows the effects of decreasing the threshold on example imagery of a region of farmland. Although decreasing the threshold finds more blinkers and thus removes some striping from the second and third image, data is lost from the spectra, particularly in the high and low bands.

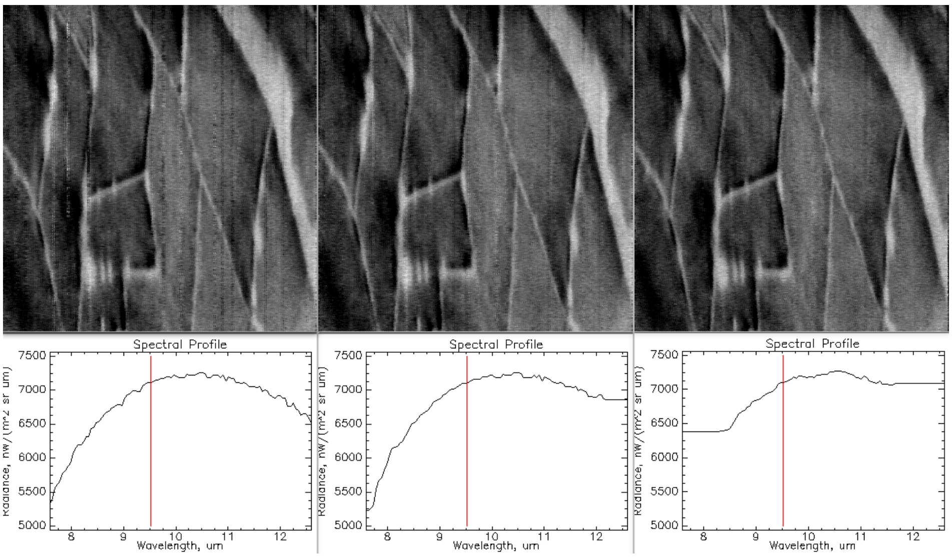

Figure 5: *Example image processed with decreasing blinker threshold. The red vertical lines on the spectra indicate the band displayed in the images above.*

It is anticipated that in the future ARSF-DAN will develop an improved blinker detection algorithm. If you would like further information about reprocessing using improved techniques please contact us at arsf-processing@pml.ac.uk.