Data Quality Report - 2017

Hyperspectral

NERC-ARF - Data Analysis Node

Updated on: August 23, 2017

Contents

1 Introduction

The NERC Airborne Research Facility (NERC-ARF) have collected hyperspectral data with a Specim AISA Fenix instrument since 2014. Due to a fault with the system prior to the 2017 season, a similar instrument was loaned from Specim for all 2017 campaigns. This has an extra band, but otherwise there should be no difference in the data acquired.

The Fenix instrument comprises two detectors covering the Visible to Near Infra-Red (VNIR) and Short Wave Infra-Red (SWIR) regions, giving a total spectral range of 380–2500 nm. It replaced the Eagle (400–970 nm) and Hawk (970–2500 nm) hyperspectral instruments previously operated by NERC-ARF. This data quality report describes issues for hyperspectral data acquired with the Fenix instrument that should be considered when further processing any NERC-ARF datasets acquired from 1^{st} January 2017 until the start date listed in the succeeding data quality report.

This document may be updated over the course of the year; the latest version is available at:

https://nerc-arf-dan.pml.ac.uk/trac/wiki/Reports

2 Geo-referencing accuracy

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

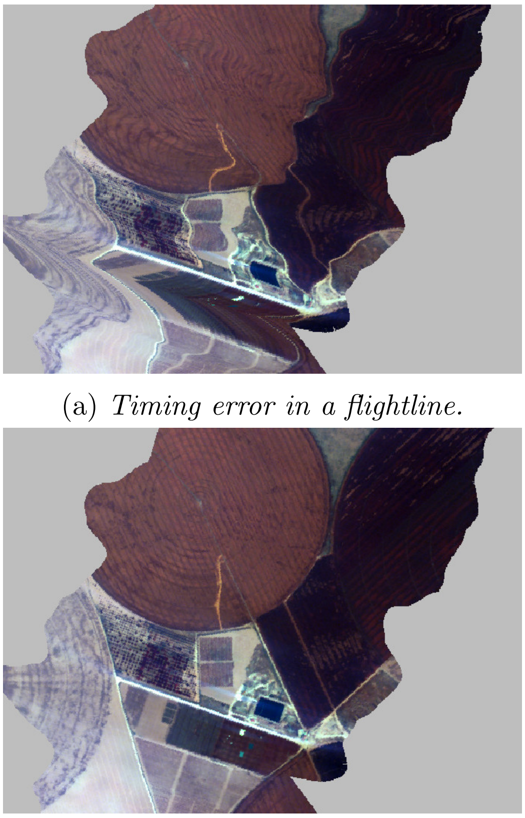
The quality of the geocorrection for each project is described in the documentation supplied with the delivery. Typically the geocorrection is of the order of a couple of metres, equating to approximately 1 pixel depending on flight altitude. High accuracy relies on an accurate Digital Surface Model (DSM). The freely available global ASTER digital elevation data are used during quality checks and an elevation model is 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: nerc-arf-processing@pml.ac.uk

3 Timing Errors

If the navigation data and scanline imagery are misaligned then it will manifest itself as a distortion in the geocorrected image. This misalignment is most often caused by an error in the timing, which means that the scanlines get syncronised to incorrect navigation (position and attitude). A timing error can range from a fraction of a second to tens or hundreds of seconds if the system crashes. An example is shown in Figure 1.

This issue was extensively investigated and fixed in 2016 for the NERC-ARF Fenix instrument. This fix also appears to apply to the loan instrument used in 2017. If any distortions are found in your data then please contact us at nerc-arf-processing@pml.ac.uk and we will investigate and correct (where possible).



(a) *Timing error in a flightline.*

(b) *Corrected version of the above image (0.5 s timing difference).*

Figure 1: *Illustration of timing offset present in geo-referenced Fenix data.*

4 Sensor calibration

Normally, Fenix sensor calibration is undertaken annually in collaboration with the NERC Field Spectroscopy Facility to ensure spectral (wavelength) and radiometric accuracy. However, during the 2017 calibration there was a SWIR integration time error with the loan system which meant that the data acquired were not suitable for use. Therefore, the Specim calibration has been used to calibrate all data this year. The fault with the SWIR integration time has not been observed in any of the flight data.

4.1 Wavelength calibration accuracy

Specim wavelength calibration is performed in a similar manner to NERC-ARF using spectral calibration lamps. These lamps provide spectral emission features at known wavelengths that can be detected with the Fenix sensor. This procedure allows specific pixel numbers to be checked against known wavelengths. The lamps included in the Specim calibration were: Mercury (Hg), Argon (Ar) and Xeon (Xe). Differences from known spectral features versus their values measured by the Fenix can be found in Table 1 (VNIR) and Table 2 (SWIR).

The Full Width at Half Maximum (FWHM) values have been measured separately for each wavelength. For a copy of these data, please contact nerc-arf-processing@pml.ac.uk. Please note that the FWHM as labelled in the data header (.hdr) files is the bandwidth of each band, not the FWHM.

4.2 Radiometric calibration accuracy

Radiometric calibration was undertaken by Specim using a similar method to NERC-ARF and calibration files were provided for each spectral binning mode.

Peak (nm)	**Deviation (nm)**
404.66	-0.04
435.83	0.05
546.08	0.03
696.54	0.04
706.72	0.02
738.40	0.01
763.51	-0.13
772.39	-0.06
826.45	0.03
852.14	0.04
866.79	0.07
912.30	0.02
922.45	0.01
965.78	-0.08

Table 1: *VNIR Wavelength calibration offsets for the February 2017 calibration of the Fenix.*

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 Fenix instrument is set based on operator experience, prevailing conditions and the requested principal investigator's areas of importance. Inevitably some pixels are unexpectedly bright due to high responses recorded on the instrument, such as sunglint over water or reflected light from part of a cloud. These pixels may exceed the maximum capture level and 'overflow'. These pixels are not typically in areas of interest but should be accounted for when examining files. The accompanying mask file will contain an overflow flag value in the level 1 equivalent pixel. If you would prefer your actual level 1 files to be masked rather than use the separate mask file, please contact nerc-arf-processing@pml.ac.uk.

Peak (nm)	**Deviation (nm)**
1013.98	0.00
1083.80	0.18
1128.71	-0.02
1262.30	-0.09
1365.70	-0.26
1473.30	-0.17
1529.58	0.02
1541.80	0.15
1672.80	0.13
1878.99	0.20
2026.20	0.00
2319.80	-0.44
2319.80	0.24

Table 2: *SWIR Wavelength calibration offsets for the February 2017 calibration of the Fenix.*

6 Bad CCD Pixels

Typically a Fenix instrument has a varying number of pixels that provide inaccurate values. Based on the type of Charge-Coupled Device camera used in the Fenix instrument ∼1 % of pixels (about 600) are expected to be bad. Bad pixels manifest in level 1 datasets as straight lines along the direction of flight and appear as undulating lines following the motion of the aircraft in level 3 data. An example is shown in Figure 2. Typically bad pixels will only affect a single wavelength band making detection difficult.

A complete solution for identification and removal of bad pixels from the Fenix instrument was finalised in 2014 and is updated every year. Due to a fault with the SWIR integration time settings during the internal calibration there are not sufficient data to examine the bad CCD pixels using this solution. Thus these values will not be included in the provided mask. If you require bad pixels to be masked please contact nerc-arf-processing@pml.ac.uk, since some of these can be manually identified on a flight by flight basis.

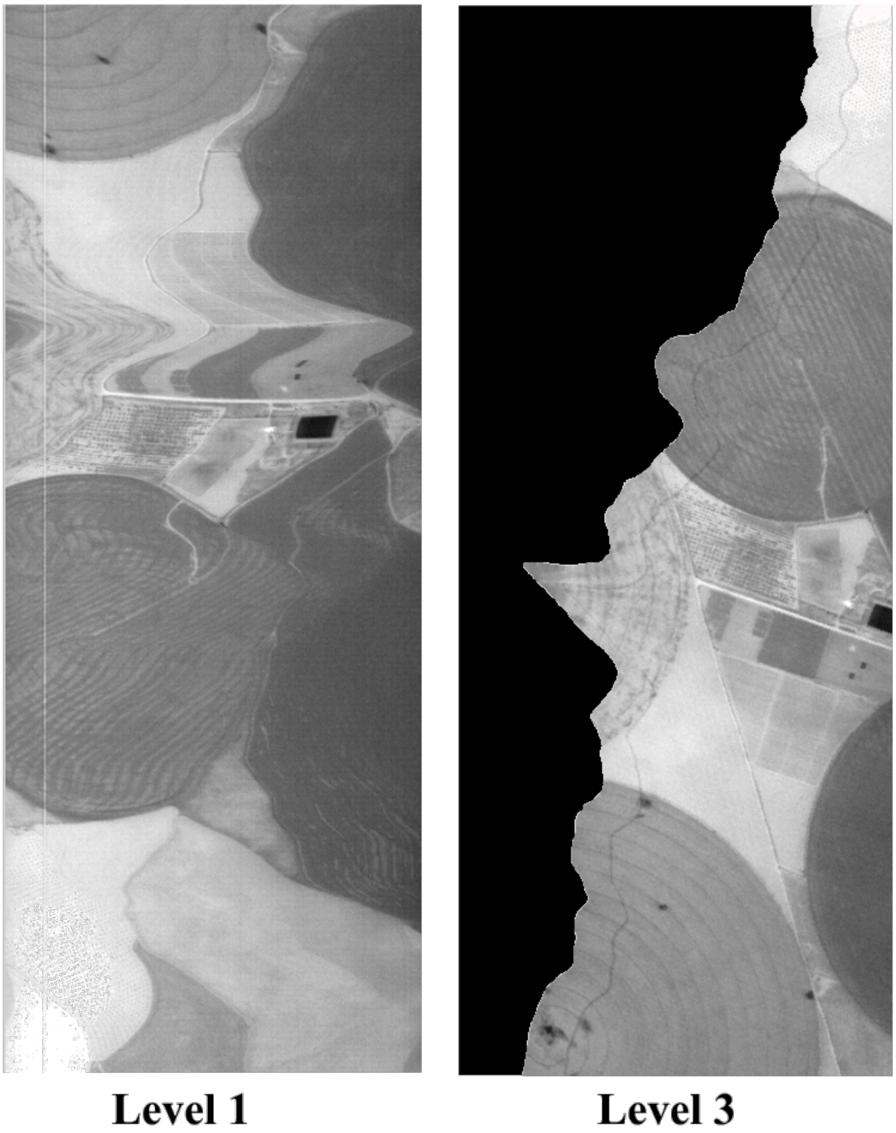


Figure 2: *Bad pixel on one Fenix band. On the left, bad pixel appears as a straight line in level 1 data; on the right, the same one is visible in level 3 as an undulating line.*