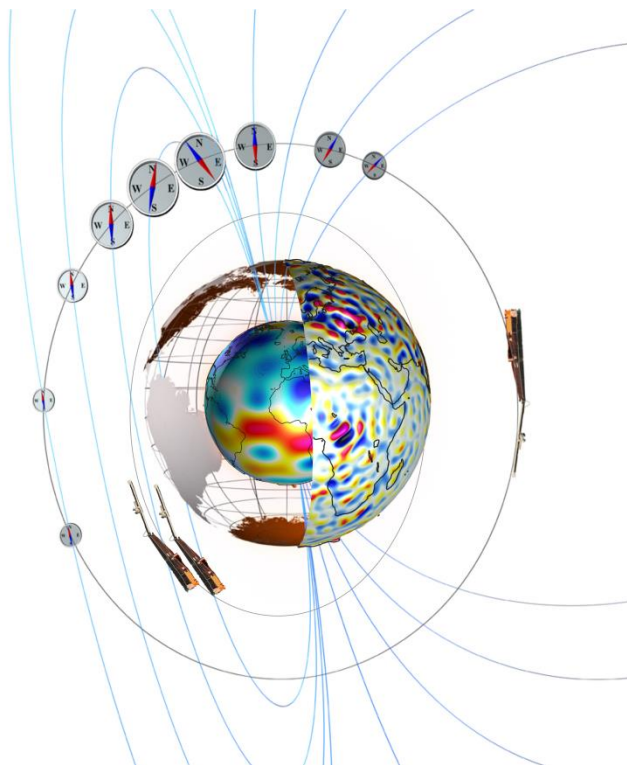




Optical Bench Heater Test on Swarm Alpha Scalar Calibration Analysis



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1 Introduction

1.1 Scope and applicability

This document describes the scalar calibration analysis performed by Lars Tøffner-Clausen (DTU Space) of the magnetic vector data acquired during the test of the heaters around the optical bench on Swarm Alpha conducted from 30 May through 3 June 2016.

2 Applicable and Reference Documentation

2.1 Applicable Documents

None.

2.2 Reference Documents

The following documents contain supporting and background information to be taken into account during the activities specified within this document.

[RD-1] ASM –VFM residual investigation: Heater test proposal, by Riccardo Mecozzi dated 18/05/2016.

2.3 Abbreviations

Acronym or abbreviation	Description
ASM	Absolute Scalar Magnetometer
DISC	(Swarm) Data, Science, and Innovation Cluster
DTU	Technical University of Denmark, DK
ESA	European Space Agency
L1b	Level 1b (satellite data)
OB	Optical Bench
Swarm	Constellation of 3 ESA satellites, http://www.esa.int/Our Activities/Observing the Earth/Swarm/Introducing Swarm
STR	Star Tracker
VFM	Vector Field Magnetometer

3 Introduction

For the further investigation of the observed residuals between the magnetometers of the Swarm mission a thermal test has been conducted on Swarm Alpha in the period from 30 May through 3 June 2016; see [RD-1]. Two heaters located around the optical bench (OB) have been used for this test; an operational heater (id 21) mounted on the radiator plate of the OB, and a powerful survival heater (id 01) located on the OB interface bracket. The heaters were activated by setting the temperature control points as listed in Table 3-1 below.

Table 3-1 Heater Test Timeline

Time	Heater	Set-point [°C]	Comment
2016-05-30 07:21:28	21	-15	Heater predominantly on.
2016-05-31 13:03:20	21	-10	Heater not powerful enough to reach the set-point, i.e. heater constantly on
2016-06-01 12:24:48	21	-33	Nominal setting
2016-06-02 13:17:52	01	-9/-7	Set-point temperature quickly reached (less than 10 minutes), i.e. heater only on occasionally
2016-06-03 06:22:02	01	-4/-2	
2016-06-03 14:12:23	01	-30/-28	Nominal setting

4 Scalar Calibration Analysis

4.1 Input Data

The input data for the analysis consist of the operational Level 1b Mag-C data from Swarm Alpha (version 0408) covering the period from 25 May through 5 June 2016. These data are calibrated and corrected using parameters estimated from data until mid-2015, hence some deviations between the ASM and VFM readings are to be expected as observed in Figure A-1.

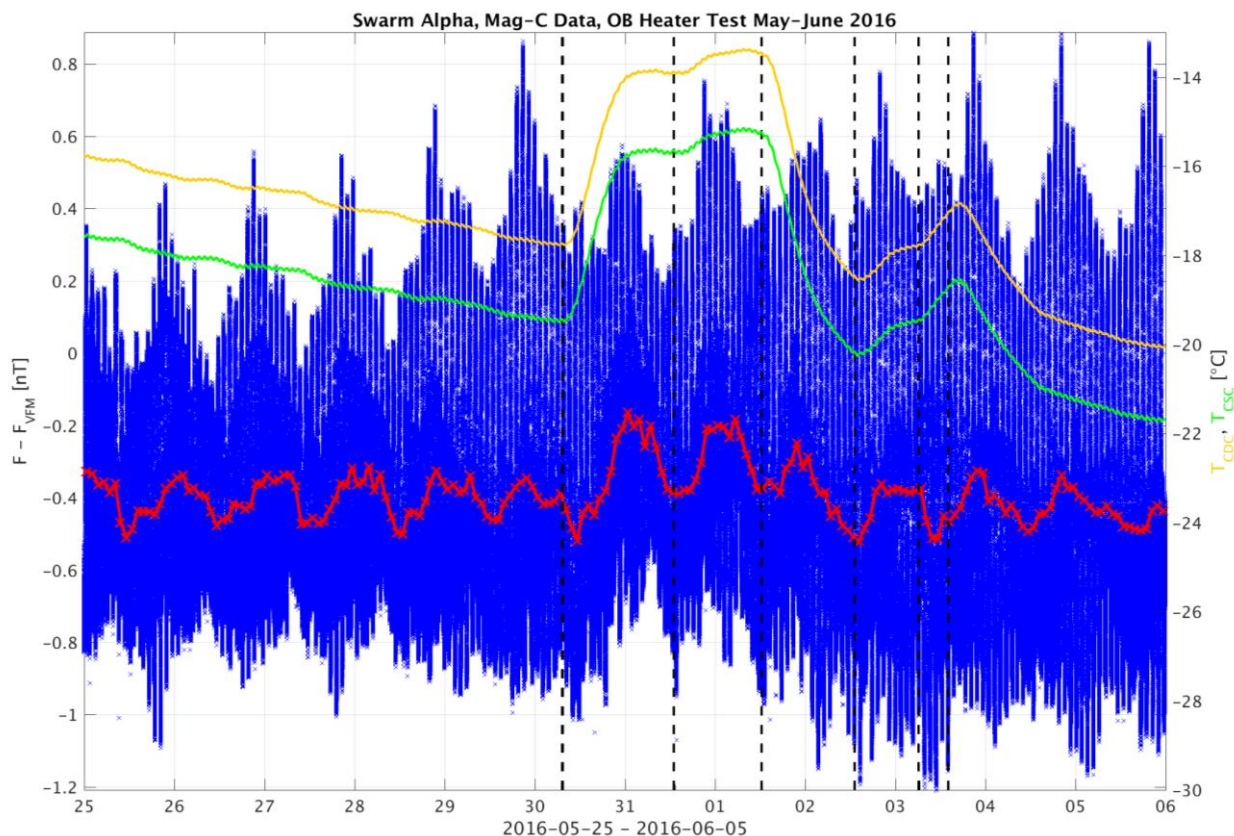


Figure A-1 Scalar Residuals, Mag-C Data

The scalar residuals are shown in blue and the orbital averages of these are shown in red. The yellow and green curves show the VFM sensor temperatures (detector coils, “CDC”, and spherical sensor, “CSC”, respectively) on the axis to the right. The vertical dashed lines indicate the test timeline events, cf. Table 3-1.

4.2 Recalibration 1

The first step in the analysis was a recalibration of the VFM scaling and offset using data prior to and following the test period; specifically, data between 2016-05-30 7:00 and 2016-06-04 16:00 were disregarded in this first recalibration. Initially, a recalibration using static scales and offsets was performed; Figure A-1 below shows the scalar residuals hereof as a function of the Sun incident angle α , and reveals systematic deviations, i.e. reveals the imperfect correction of the Sun induced magnetic disturbance. Consequently, the final recalibration using data outside the test period use static scales and α dependent offsets; the residuals after this recalibration are shown in Figure A-2 below. From this figure, the effect of the first part of the test (using heater id 21, period 30/5 – 1/6) is clearly visible whereas only minor effects of the second part of the test (2/6 – 3/6) are seen.

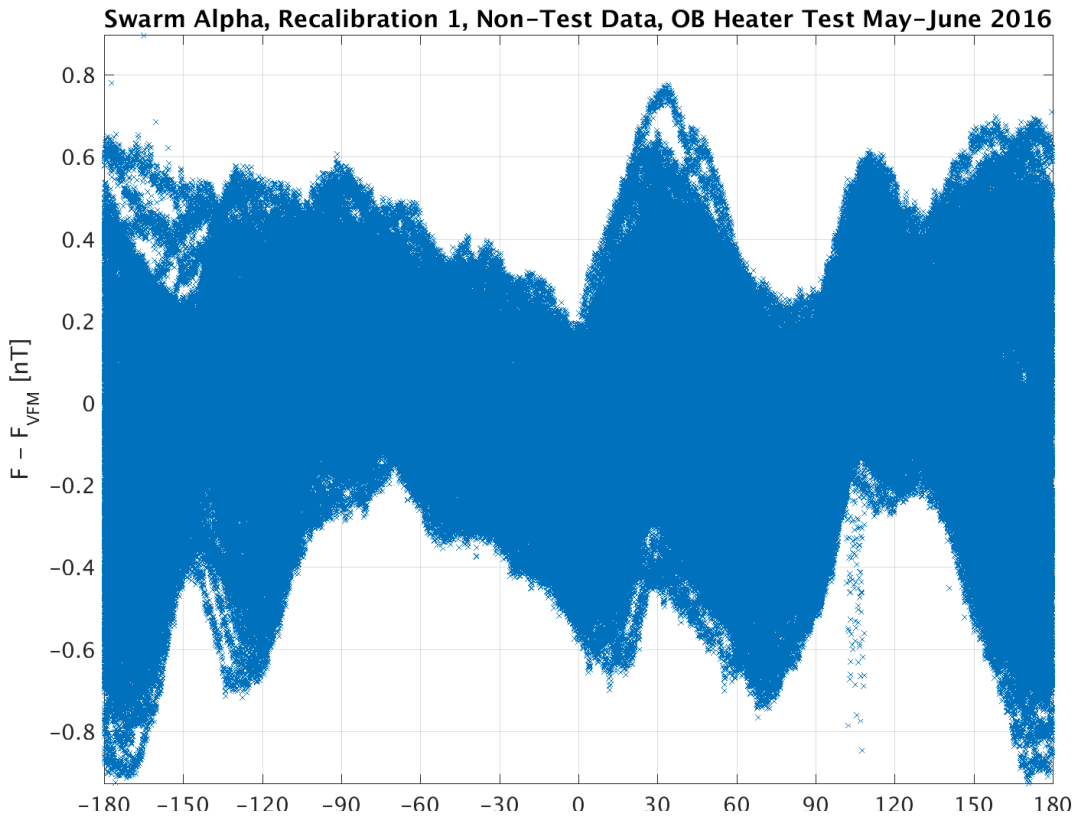


Figure A-1 Scalar Residuals vs Sun Angle Alpha, Recalibration 1

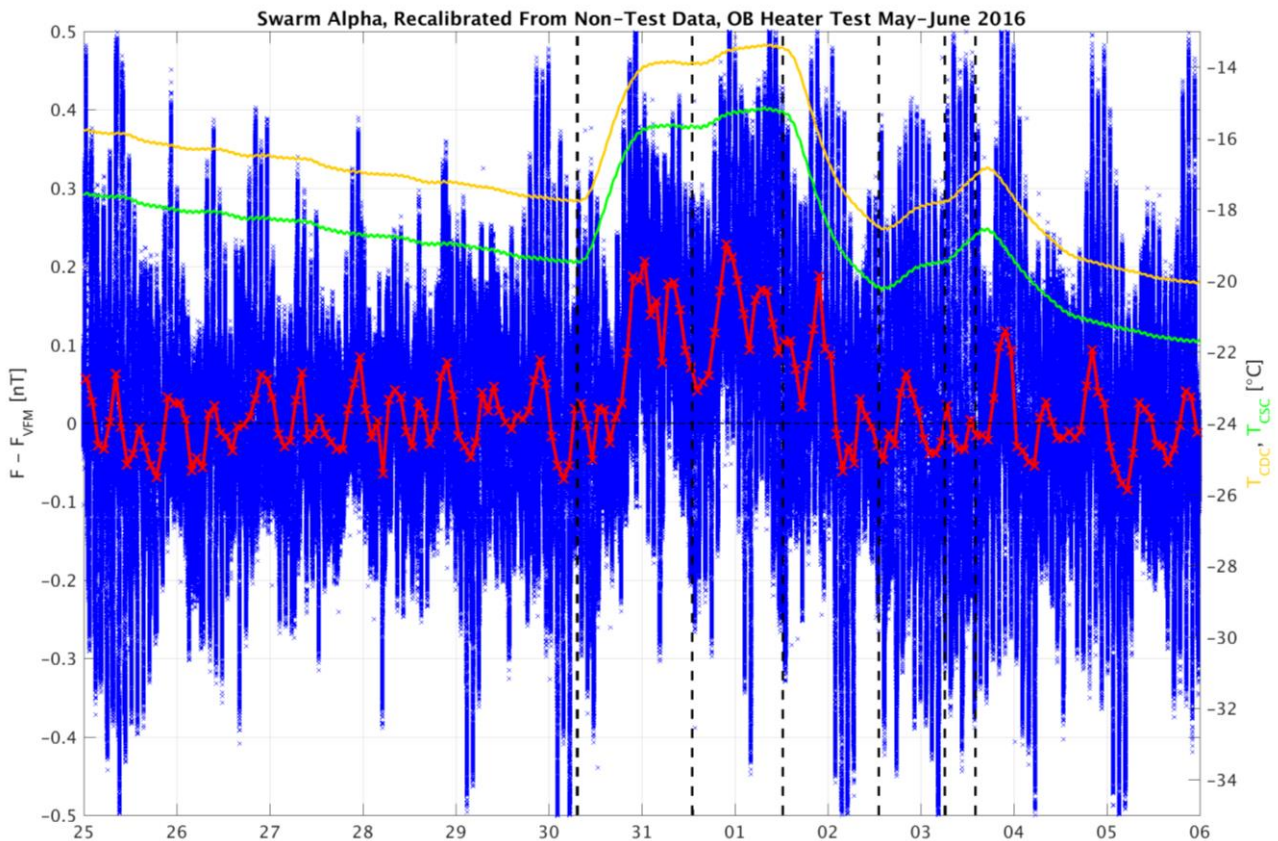


Figure A-2 Scalar Residuals after Recalibration of Non-Test Data

4.3 Recalibration 2

The next step in the analysis was a recalibration of the full data-set depicted in Figure A-2 above, i.e. the full data set after applying the static scale and α -dependent offset corrections estimated as described in Section 4.2. This second re-calibration uses parabolic B-splines (in time) to model a scale common to all three VFM sensor axes (to compensate for the possible non-uniform temperature of the VFM sensor during the heater test) and stepwise 3-axes offsets with slight damping of the y-component offset; the estimated scale and offsets as a function of time are plotted in Figure A-1 below (together with VFM sensor temperatures and heater test timeline markings).

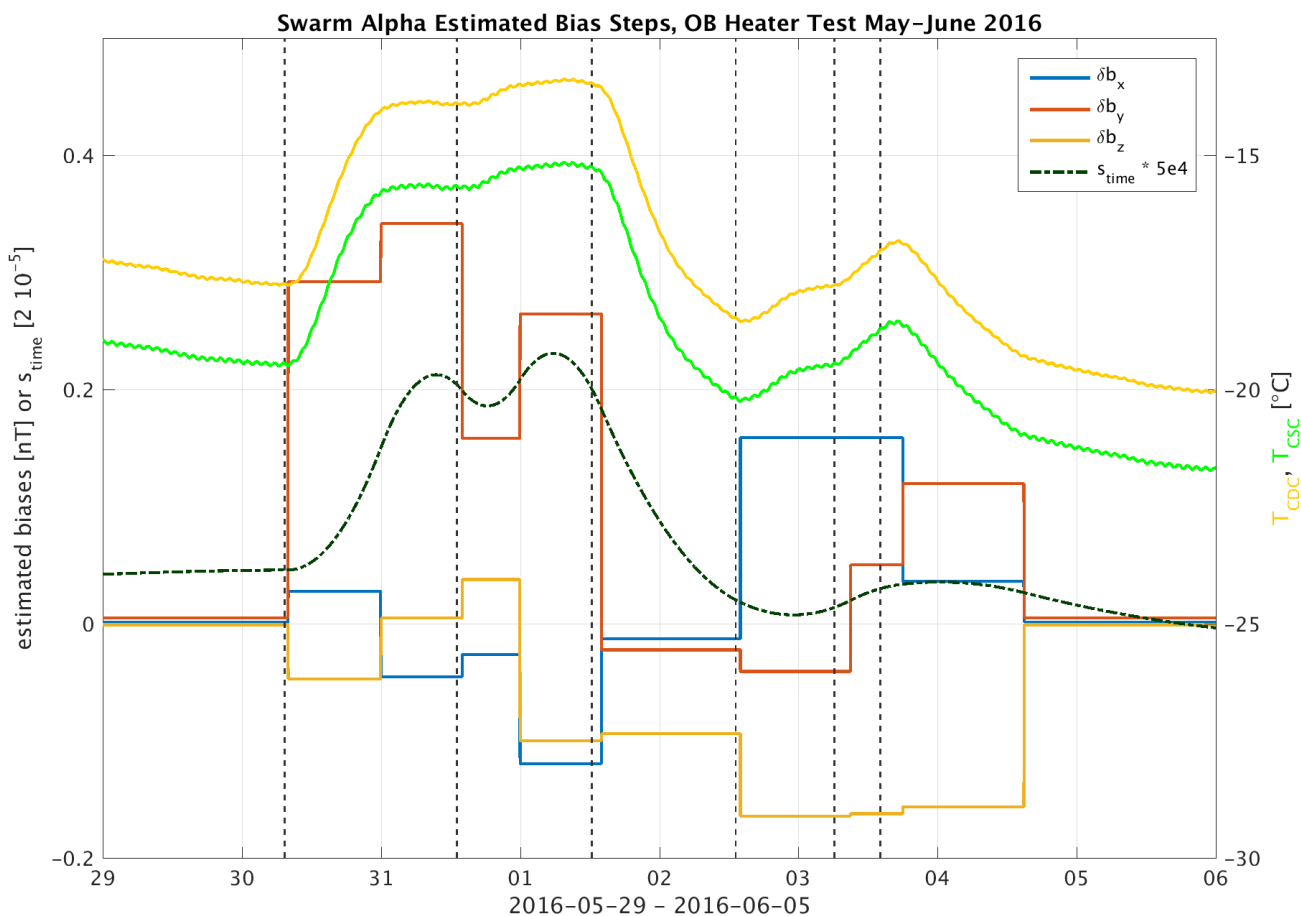


Figure A-1 Estimated Biases and Scale

The scalar residuals following this second re-calibration are shown in Figure A-2 on the next page.

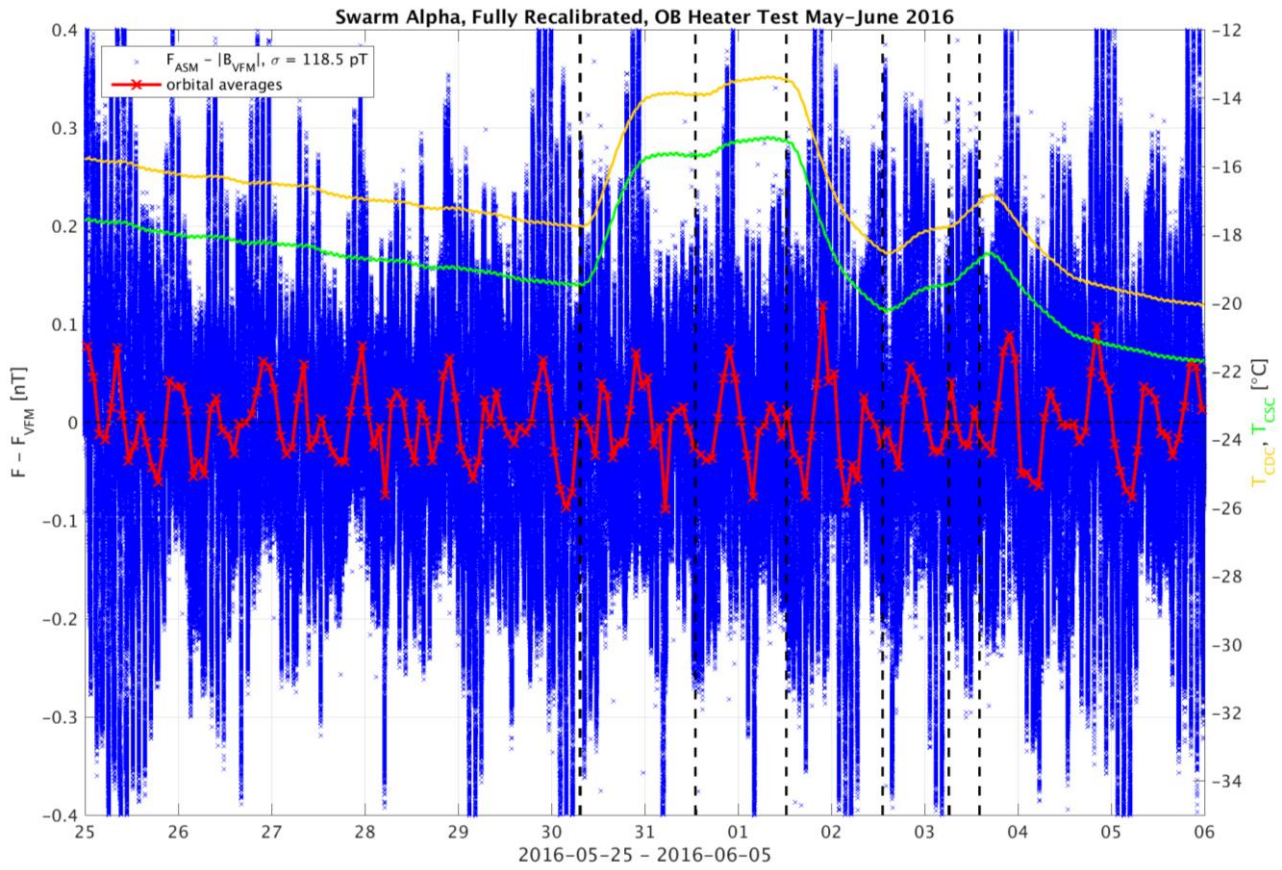


Figure A-2: Scalar Residuals after 2nd Recalibration

A Magnetic Stray Field of Survival Heater 01

The direct, electrically induced magnetic stray field from the *survival* heater on the optical bench as seen by the VFM sensor has been investigated by looking at 50 Hz VFM samples from the MAGA_HR_1B products. Below are two plots showing 50 Hz VFM vector data surrounding the time-instants of heater turn on and off, one second of data on either side, degree one polynomials subtracted (“detrrend”). Vertical lines indicate a possible time-offset of activation (100 – 150 ms). From these plots, the magnetic stray field from the survival heater is estimated to be below 50 pT per component.

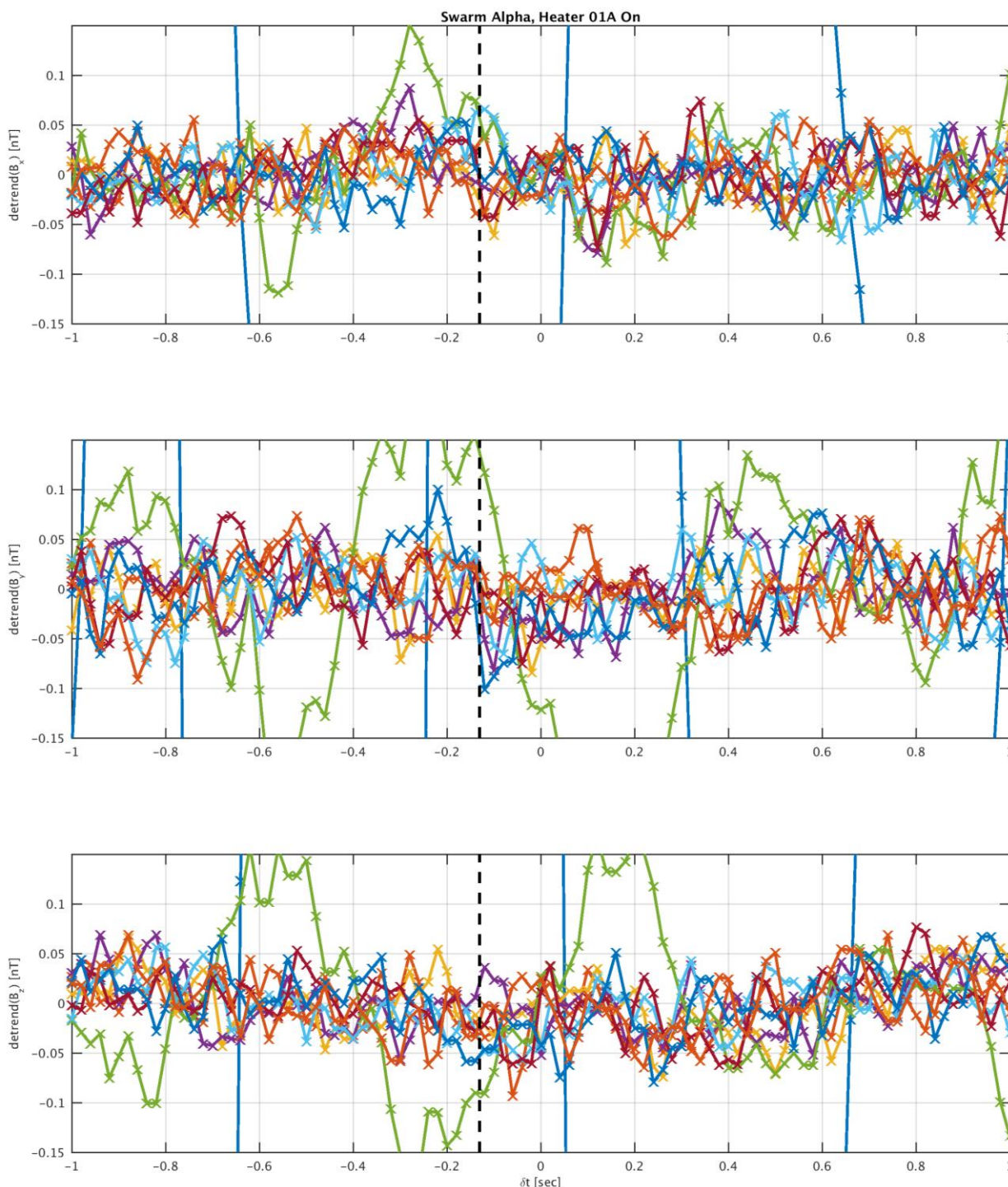


Figure A-1 VFM Vector Data at Survival Heater 01 On

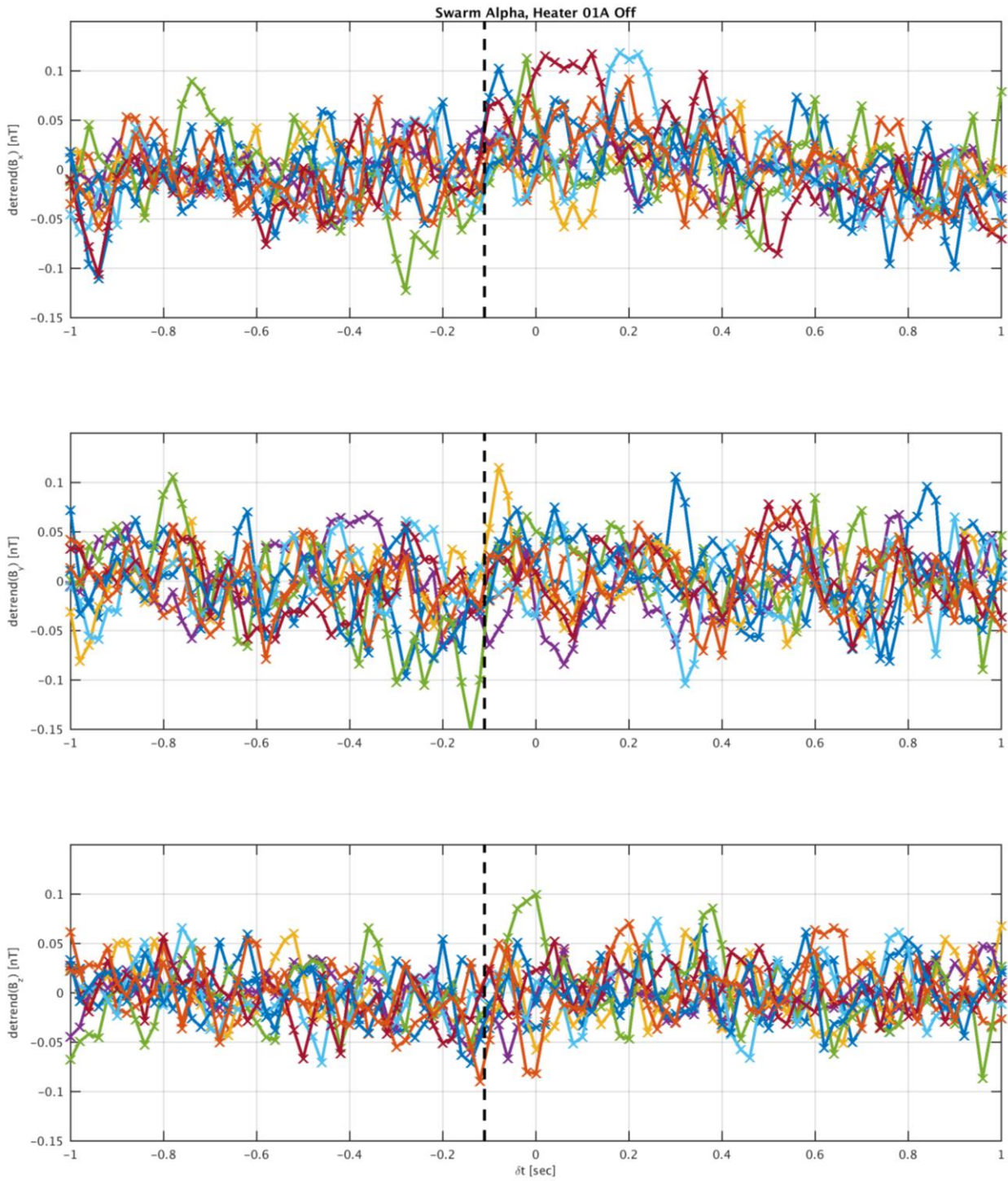


Figure A-2 VFM Vector Data at Survival Heater 01 Off