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OVERVIEW OF AVAILABLE RPCMAG DATA AND DATA QUALITY ASSESSMENT

Mission Phases: LUTETIA
Time Period: July 2010 - September 2010

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1 Introduction

. This document contains information about all available data and its quality for the time period between July 2010 until September 2010.
This covers this Mission Phase LUTETIA.

The only time where RPCMAG was switched on was

- July 2010 for the LUTETIA Flyby.

For every day where measurement data are available overview plots have been created. The data availability plots show all data calibration levels being available. For RESAMPLED data the average interval is listed as well. An overview table of available data completes the data overview.

Additionally for each measurement day two plots of calibrated LEVEL_F data (s/c coordinates) are available. These plots show

- the OB and IB data and
- the differences of OB-IB

In these plots the phases where the sensors are not in thermal equilibrium have been marked as red areas. The assessment indicator I of these "BAD INTERVALS" has been derived from the first derivative of the difference of the sensor temperatures

$$I = \frac{\partial(T_{\mathrm{OB}} - T_{\mathrm{IB}})}{\partial t}$$

Areas are marked red if I exceeds a certain threshold level. Details about further data quality assessment can be found in section 2.

The science modes of the data are distinguished by different colors in the plots.

This document shall give a quick overview of all data available.

2 Data Quality Assessment & Quality Flag System

Magnetic field data measured onboard a s/c can be disturbed and influenced by various entities, leading to a decreased level of data quality. In order to get an idea about the data quality a qualitative and – where possible – a quantitative assessment criterion has to be established. For the RPCMAG data this is achieved by a system of data quality flags which are set at the end of the data processing chain. As the data quality is a time dependent entity, each magnetic field vector needs to be flagged individually. Therefore, each magnetic field vector in the CALIBRATED and RESAMPLED data files gets a flag-string (to be found at the end of each row in the *.TAB files). These flags strings have a length of 8 characters. Each character/position of the string represents a specific property of quality diminishment. Each of these 8 variables is enciphered by an alphanumerical code with the general meaning:

VALUE:	MEANING:
x	Property described by flag is unknown, no assessment has been made
0	No disturbance, good quality
1 . . . 9	Specific disturbance/problems, specific codes: see section 2.1, The higher the number the more severe the quality diminishment

The flag definition as given in section 2.1 is an open and expandable scheme. For the actual situation all known problems are covered, however, more details i.e. subitems can be added if necessary. Therefore, some TBDs are intentionally placed in the table.

2.1 Quality Flags Description

FLAG-STRING POSITION 8 7 6 5 4 3 2 1	FLAG 1	DESCRIPTION
– – – – – – – 1	1	IMPACT OF REACTION WHEELS:
– – – – – – – 1	1	x = impact not assessed
– – – – – – – 1	1	0 = no disturbance
– – – – – – – 1	1	1 = disturbance eliminated during data analysis
– – – – – – – 1	1	2 = disturbance elimination failed
– – – – – – – 1	1	3 = data disturbed
– – – – – – 2 –	2	IMPACT OF LANDER HEATER CURRENTS:
– – – – – – 2 –	2	x = impact not assessed
– – – – – – 2 –	2	0 = no disturbance
– – – – – – 2 –	2	1 = disturbance eliminated during data analysis
– – – – – – 2 –	2	2 = disturbance elimination failed
– – – – – – 2 –	2	3 = data disturbed
– – – – – 3 – –	3	BOOM DEPLOYMENT:
– – – – – 3 – –	3	0 = boom deployed
– – – – – 3 – –	3	1 = boom stowed
– – – – – 3 – –	3	2 = boom deployment ongoing. Data only valid
– – – – – 3 – –	3	in instrument coordinates
– – – – – 3 – –	3	3 = pyros fired for boom release
– – – – 4 – – –	4	OFFSET/RESIDUAL-FIELD RELATED EFFECTS:
– – – – 4 – – –	4	x = offset/residual-field issues not assessed
– – – – 4 – – –	4	0 = no offset/residual-field problems
– – – – 4 – – –	4	1 = offset/residual-field behavior not clear
– – – – 4 – – –	4	2 = offset drifts, sensor not in thermal
– – – – 4 – – –	4	equilibrium thus temperature model N/A
– – – – 4 – – –	4	3 = offset/residual-field drifts, reason unknown
– – – – 4 – – –	4	4 = residual-field jump detected, reason unknown
– – – 5 – – – –	5	CORRELATION BETWEEN IB AND OB SENSOR:
– – – 5 – – – –	5	x = correlation not assessed
– – – 5 – – – –	5	0 = perfect correlation
– – – 5 – – – –	5	1 = good correlation
– – – 5 – – – –	5	2 = poor correlation
– – – 5 – – – –	5	3 = IB and OB show different long term behavior
– – 6 – – – – –	6	OTHER IMPACTS DECREASING THE QUALITY:
– – 6 – – – – –	6	x = no assessment
– – 6 – – – – –	6	0 = no other problems detected
– – 6 – – – – –	6	1 = TBD
– – 6 – – – – –	6	2 = TBD
– – 6 – – – – –	6	3 = TBD
– – 6 – – – – –	6	4 = data disturbed by pulses originated in s/c
– – 6 – – – – –	6	5 = data disturbed by AC signal originated in s/c
– – 6 – – – – –	6	6 = data noisy due to power on failure
– – 6 – – – – –	6	7 = data not calculatable due to thermistor failure
– – 6 – – – – –	6	8 = sensor saturated due to huge external field
– – 6 – – – – –	6	9 = sensor saturated, instrument power on sequence failed
– 7 – – – – – –	7	TBD
– 7 – – – – – –	7	x = no assessment
8 – – – – – – –	8	TBD
8 – – – – – – –	8	x = no assessment

2.2 Quality decreasing Entities

- Reaction Wheels (RW)
  The 4 reaction wheels of the ROSETTA s/c generate varying magnetic fields due to the rotating magnetic material. The changing frequency is known; if burst mode data are present, the disturbance can in general be eliminated by transformation of the data into the frequency domain and damping the affected frequencies down to background noise. The AC disturbance caused by the RWs is in the order of nT. Due to the nature of the occurring frequencies data measured in normal mode are in general not disturbed. In case of disturbance, however, elimination is hardly possible due to the bandwidth of the disturbance and the relation to the background signal.

- Lander Heater Currents
  During mission phases where the ROSETTA Lander PHILAE was operated, disturbances caused by various heaters of PHILAE P/L instruments were detected. Those heaters were operated continuously or pulsed with periods in the order of a few seconds. The flowing currents caused magnetic signatures in the order of nT. For certain mission phases these disturbances could semi-manually be eliminated.

- Boom Deployment
  During the commissioning phase in March 2004 the magnetometer boom was deployed, changing its orientation from the stowed position to the final deployed orientation. The whole procedure took about 2 hours. During this time interval the residual magnetic field of the s/c measured by the moving RPCMAG sensors changed dramatically, as the distance to the disturbing sources located on the s/c changed. In the deployed boom orientation, which is stable since that time, the residual-field and the disturbance/noise level caused by the s/c is much less than in the stowed boom orientation (Therefore the sensors are mounted on the boom ...!).

- Offset/residual-field related Effects
  It's a known fact that the quality of magnetic field measurements is inter alia strongly dependent on the

  - sensor offset
  - s/c residual-field

  The sensor offset is a temperature dependent entity, which has been calibrated on ground in a limited temperature range. Using inflight data it was possible to create an improved temperature offset-model for an extended temperature range. Thus, the sensor offset can be calibrated if the sensor is in thermal equilibrium. In phases of fast changing temperatures (e.g. a flyby with a fast varying pointing) the actual offset might not be computed correctly. Therefore data might drift during such phases.

  Additionally the s/c residual field affects the magnetic field measurements strongly. Changes in the s/c residual field (either drifts or jumps) occur quite often due to

varying payload or s/c-subsystem activities. Reasons are varying currents, moving magnetic parts or temperature effects acting on spacecraft parts and causing magnetic properties to be changed.
The magnetic cleanliness requirements for the ROSETTA s/c were far from the requirements applied to e.g. the CLUSTER spacecrafts. Therefore, a very limited magnetic cleanliness program yielded a relatively unstable and "magnetically dirty" ROSETTA satellite which generates the disturbances seen in the magnetic field data during flight.

- Correlation between Inboard (IB) and Outboard (OB) Sensor
  Under ideal conditions the IB and OB sensor measure the same field. This perfect situation can, however, be declined by different effects:

  – different temperature dynamics (e.g. due to different shadowing and different solar irradiation) cause different offset behavior of both sensors.
  – due to different locations the sensors measure the disturbing sources of the s/c in different ways. Therefore changing s/c fields produce different changes at the locations of the sensors and cause the correlation between the sensor data to be decreased.
  – often the real offset of the sensors is not as important as a good common AC-behavior. Thus, the short term "high frequent" behavior can be acceptable where as the long term behavior is poor due to offset or s/c residual-field drifts. This possible characteristics can be reflected by the flagging system.

  The different thermal behavior of the sensors is characterized using the indicator I defined in section 1:

  $$I = \frac{\partial(T_{\mathrm{OB}} - T_{\mathrm{IB}})}{\partial t}$$

  It is used do obtain a quantitative measure of the thermal behavior. If this indicator exceeds the threshold level of $\frac{0.07\mathrm{K}}{10\mathrm{min}}$ (empirically chosen) the data in the overview plots will be marked red, indicating that the thermal equilibrium is not reached, and that the time series of both sensors can show different trends. In this case the quality flag 4 will be set to 2.

- Other Impacts
  Various effects are imaginable causing the magnetic field data quality to be not optimal. Using data collected during the past years of the ROSETTA mission lots of disturbers could be identified. However, often the situation on the s/c was so complex, especially at the "high activity" times during the flybys, that neither the disturbers could be identified individually nor the disturbing signals were very clear. In these case the disturbance is obvious, a flag indicating that the data are not clean is necessary, but the real polluter can not be named. Currently defined categories for such case are:

– data disturbed by pulses originated in s/c

– data disturbed by AC signals originated in s/c

A second set of problems relates to the RPCMAG instrument itself:

– data noisy due to ”power on” failure
– data not calculatable due to thermistor failure
– sensor saturated due to huge external field
– sensor saturated, instrument power on sequence failed

It happened once in the mission that the ”power on” command was received by PIU but not executed by MAG. A reboot of the system solved the problem. Such a behavior can occur very sporadically (it is very unlikely) due to critical link timing issues; in this case, PIU sends TM data, which are just random noise.

It might happen that a sensor thermistor breaks (extremely unlikely). Then temperature data is not available and the temperature offset-model cannot by applied, i.e. calibrated data cannot be produced in the standard way.

The sensor is designed for a field limit of about ±16000 nT. Therefore, the instrument got saturated for some minutes during the Earth flybys due to the high external field. These circumstances can be indicated by the flag system as well.

It might also happen (already once in the mission) that the instrument suffers a latch up during the ”power on” sequence causing the ADCs to send 0xFFFFF (pretending saturation). This can be indicated by a flag as well. The solution for these cases is also rebooting the MAG instrument.

All the effects discussed above can diminish the data quality. If this happens in any way, an appropriate flag (described in the table above) will be set.

2.3 WARNING for Data User

All effects described above lead to disturbed data which can only partly be improved by sophisticated software. Thus the quality flags of the magnetic field vectors should be observed carefully to avoid misinterpretation of contaminated data.

All data have been processed on best effort base, nevertheless mistakes might slip in always. The data processing is done mostly automatically whereas the quality assessment can only be performed semi-automatically or manually. If a quality flag of a value $\neq 0$ is set, it does not automatically mean that the data are not usable for scientific purposes. One just should be careful and use these data with keen mind.

3 2010

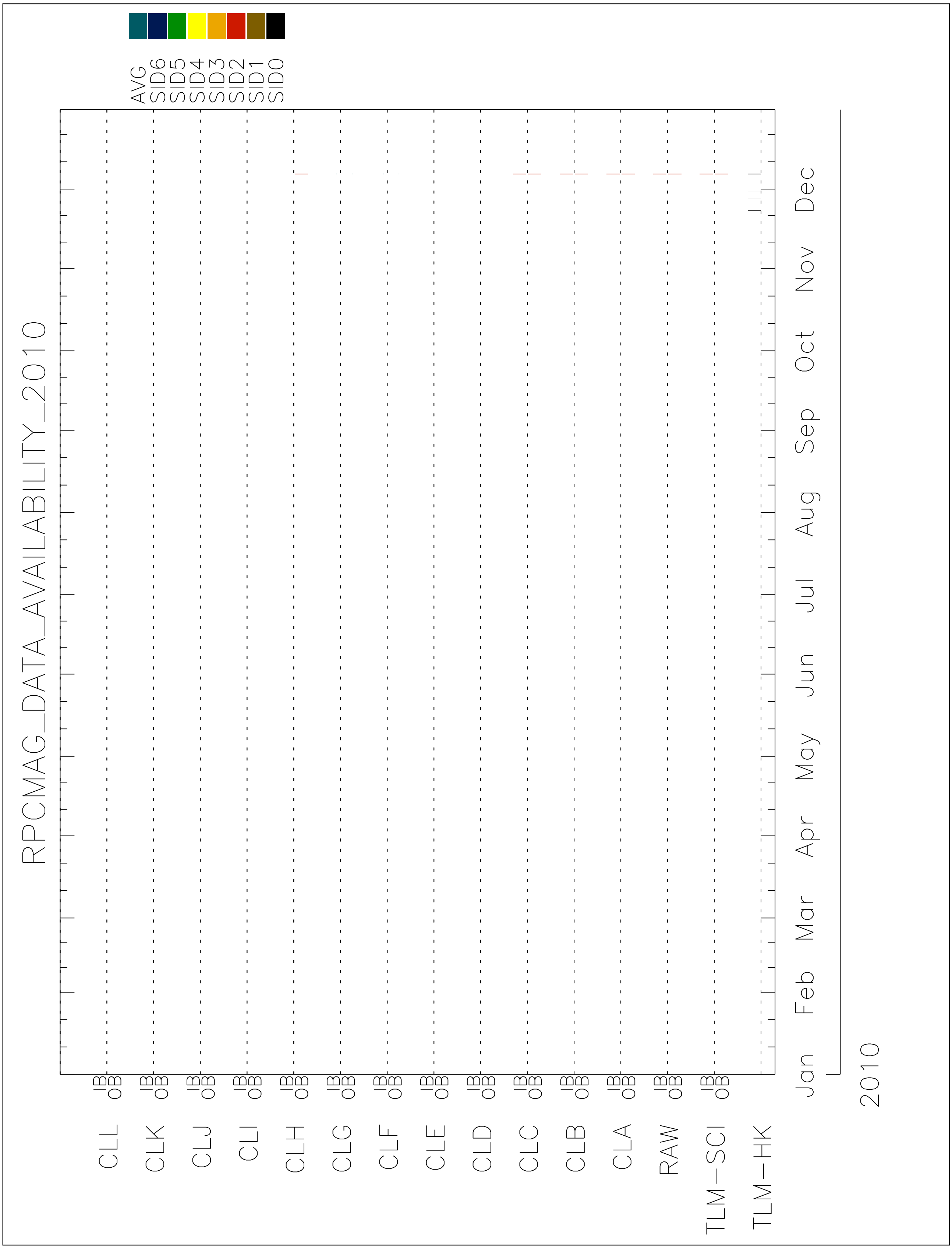


Figure 1: Overview 2010

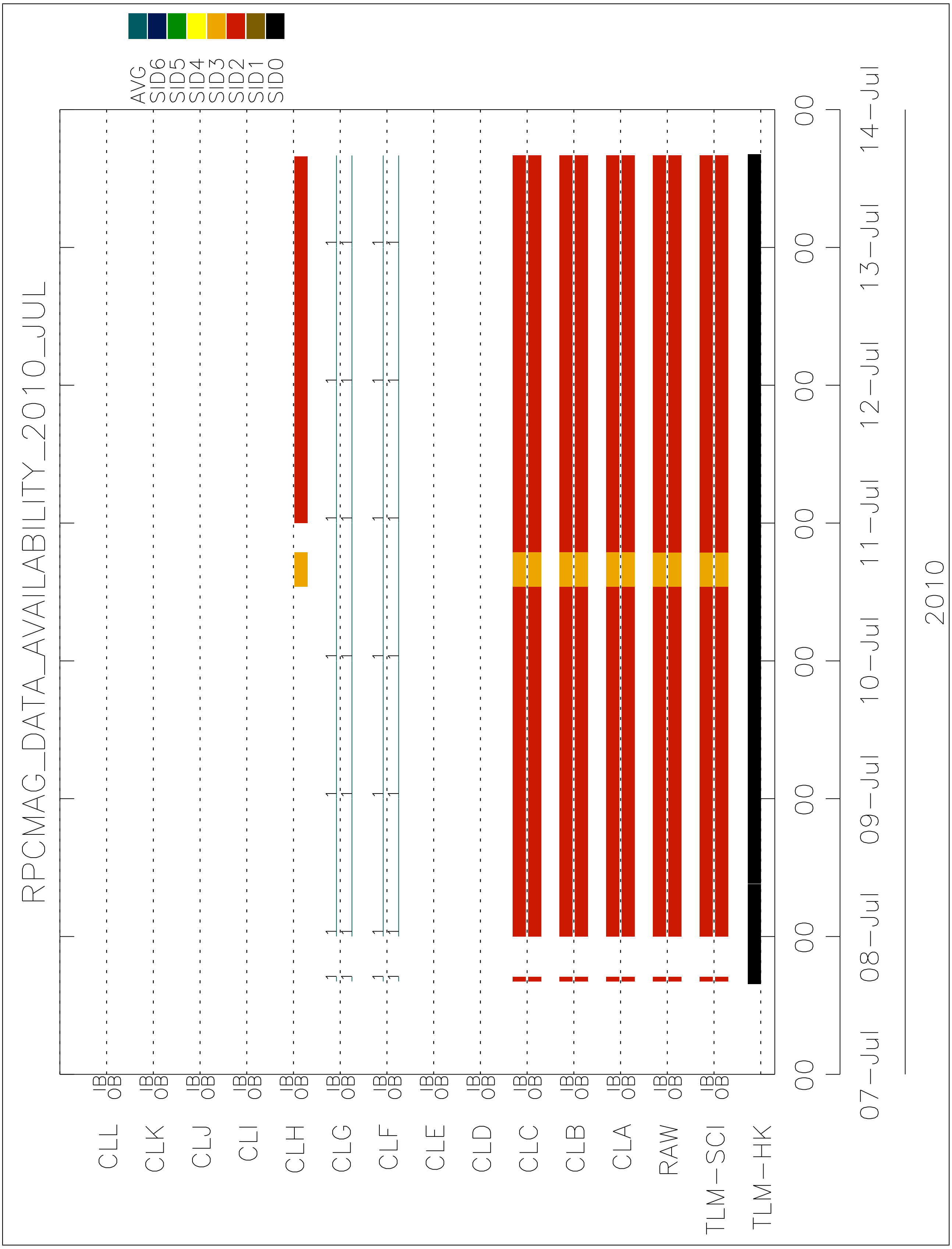
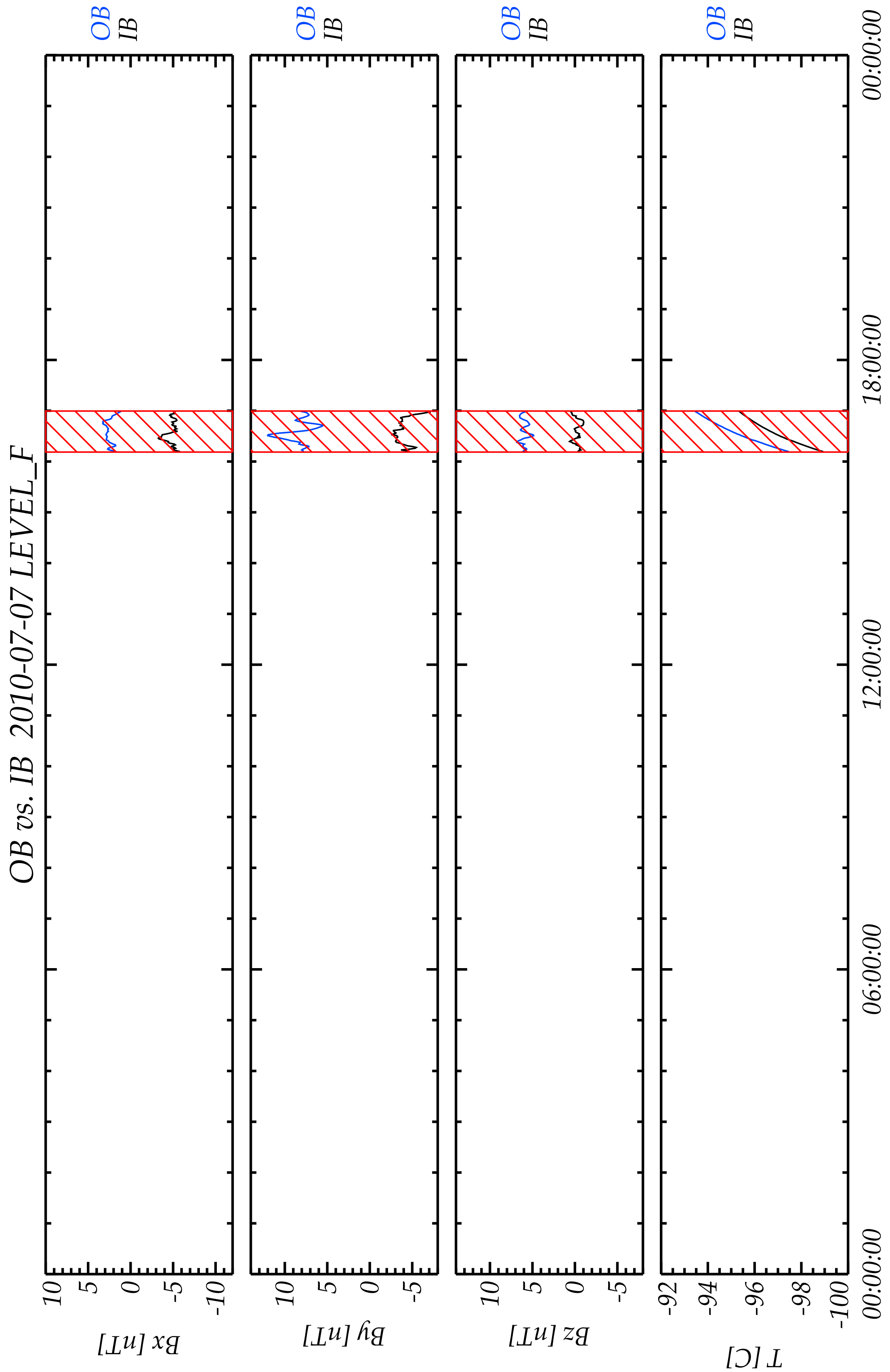
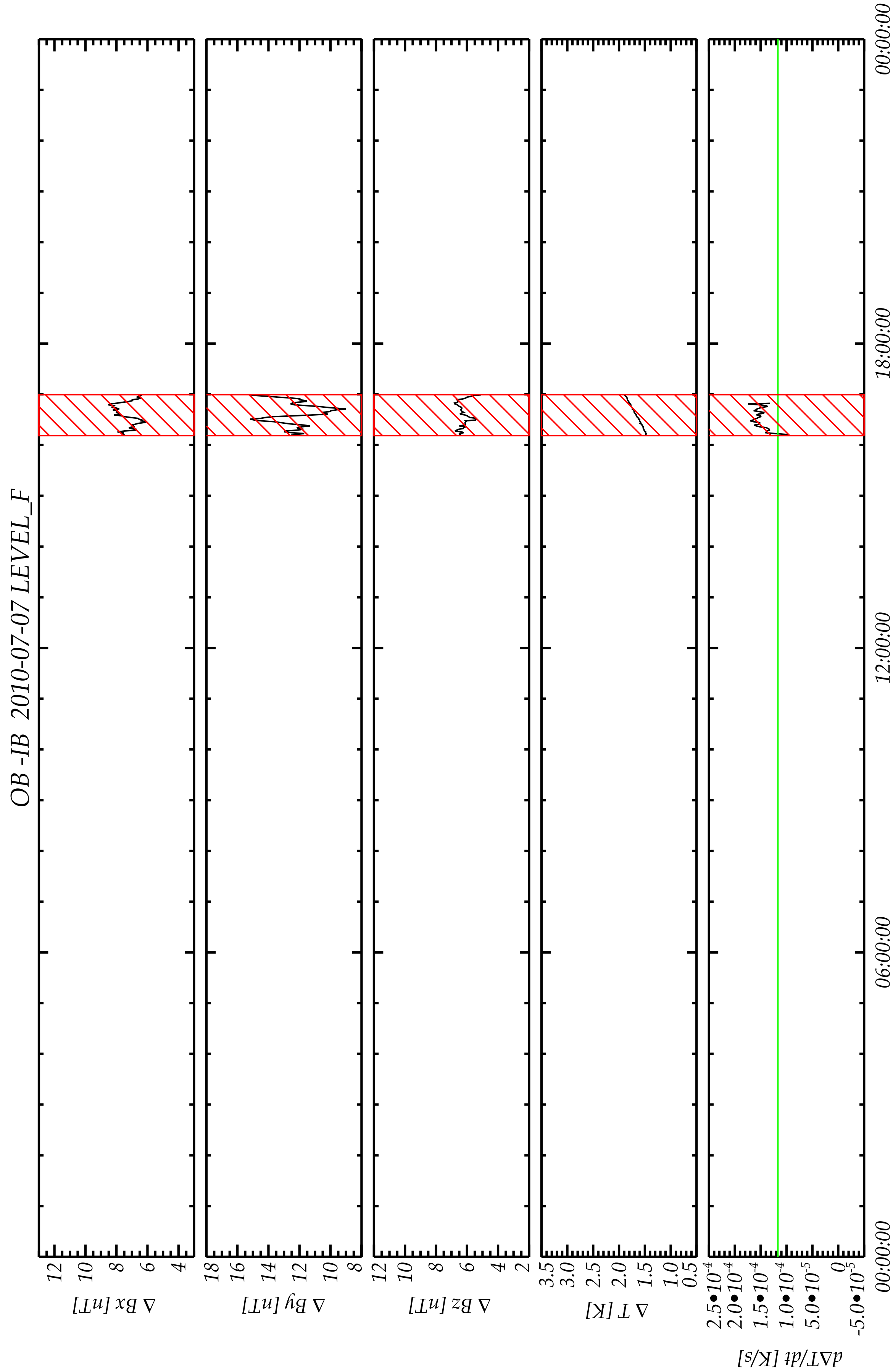


Figure 2: Overview February 2010

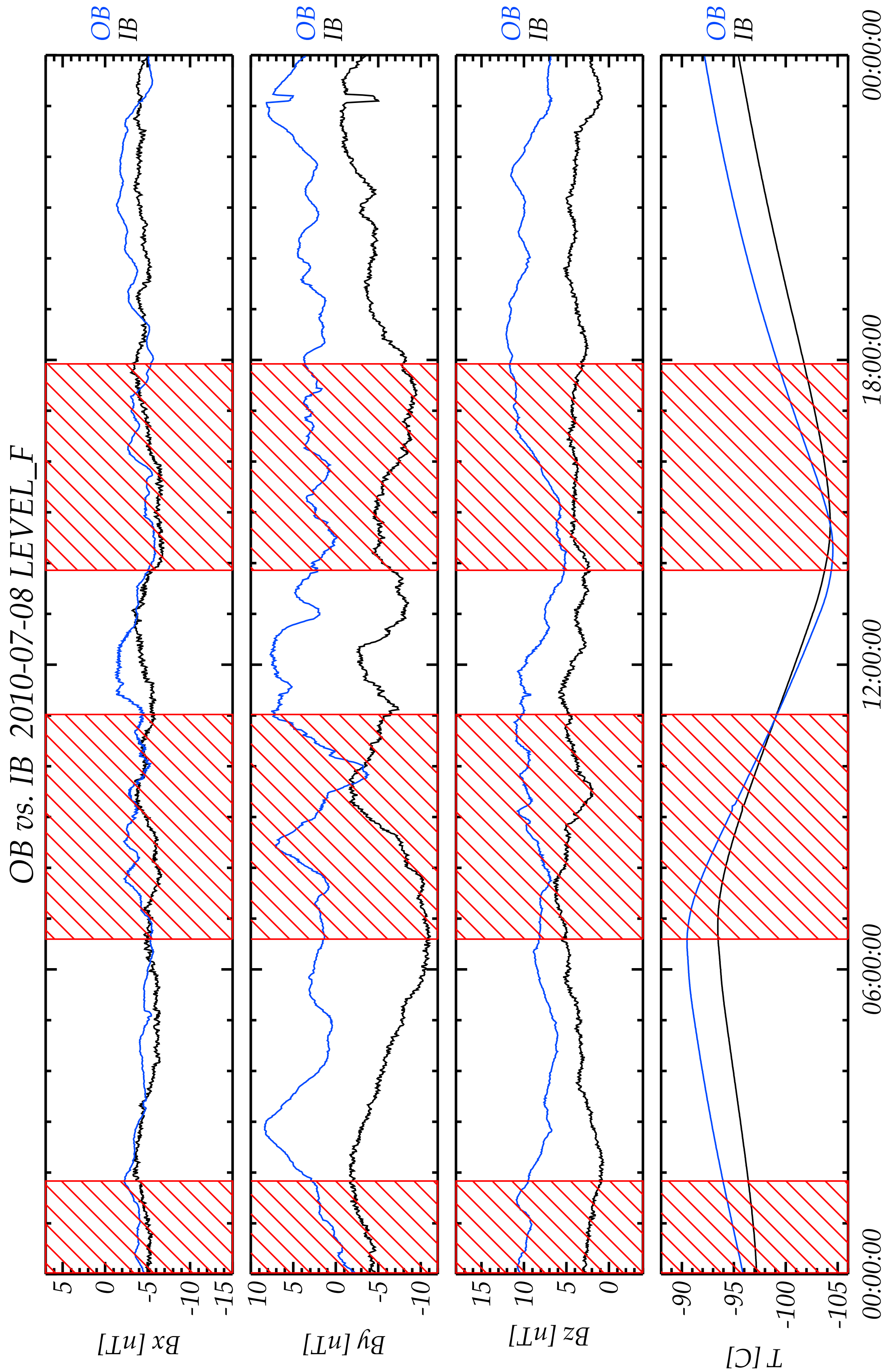
DATE	LEVEL	AVERAGE [s]	SENSOR
2010-07-07	CLG	1	OB
2010-07-07	CLF	1	OB
2010-07-07	CLG	1	IB
2010-07-07	CLF	1	IB
2010-07-08	CLF	1	OB
2010-07-08	CLG	1	OB
2010-07-08	CLG	1	IB
2010-07-08	CLF	1	IB
2010-07-09	CLF	1	OB
2010-07-09	CLG	1	OB
2010-07-09	CLG	1	IB
2010-07-09	CLF	1	IB
2010-07-10	CLF	1	OB
2010-07-10	CLG	1	OB
2010-07-10	CLG	1	IB
2010-07-10	CLF	1	IB
2010-07-11	CLG	1	OB
2010-07-11	CLF	1	OB
2010-07-11	CLG	1	IB
2010-07-11	CLF	1	IB
2010-07-12	CLG	1	OB
2010-07-12	CLF	1	OB
2010-07-12	CLF	1	IB
2010-07-12	CLG	1	IB
2010-07-13	CLG	1	OB
2010-07-13	CLF	1	OB
2010-07-13	CLG	1	IB
2010-07-13	CLF	1	IB



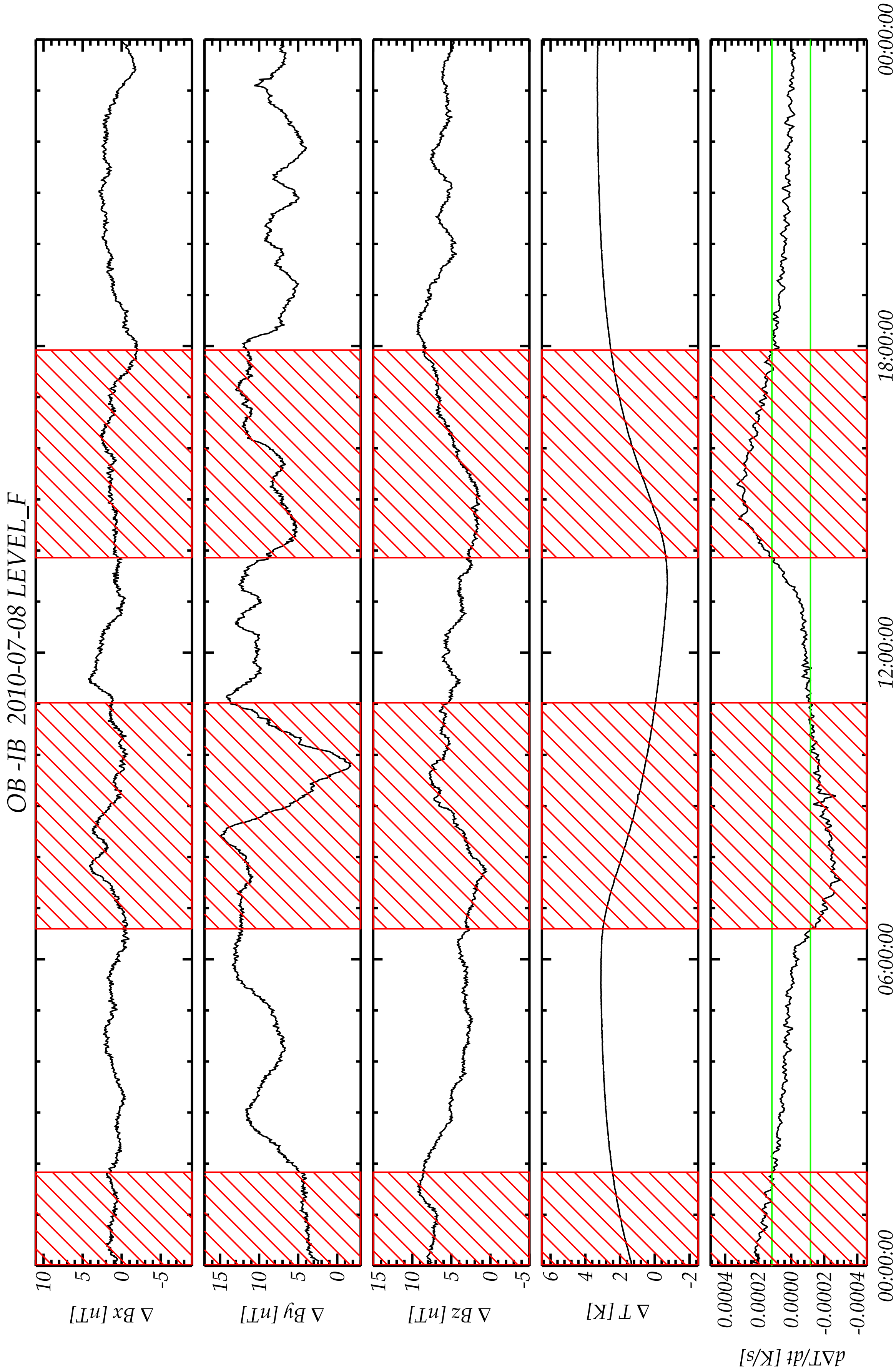
OB vs. IB 2010-07-07 LEVEL_F
OB
IB
Bx [nT]
By [nT]
Bz [nT]
T [C]
10 5 0 -5 -10
10 5 0 -5
10 5 0 -5
-92 -94 -96 -98 -100
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00



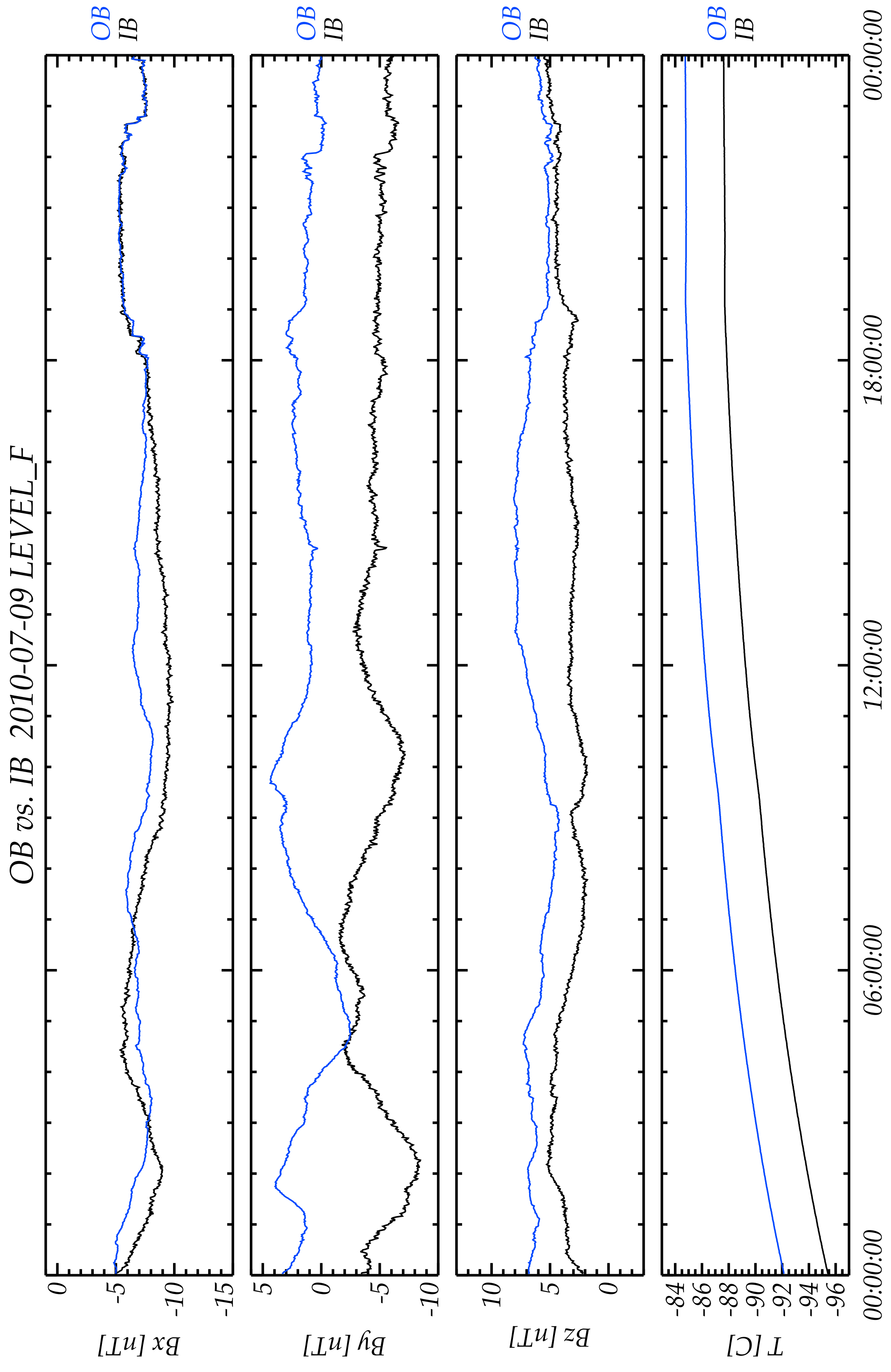
OB -IB 2010-07-07 LEVEL_F
Δ Bx [nT]
Δ By [nT]
Δ Bz [nT]
Δ T [K]
dΔT/dt [K/s]
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00



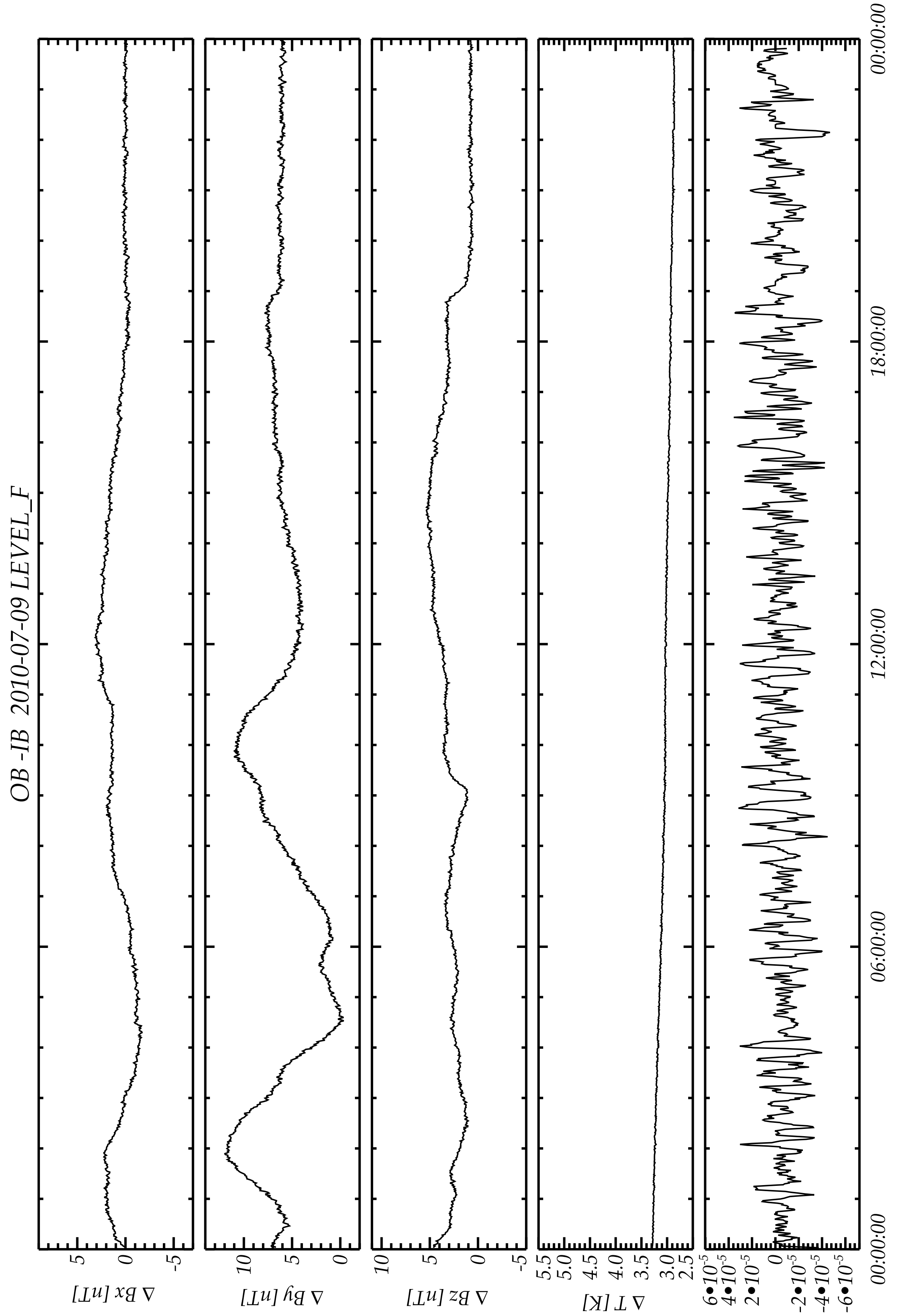
OB vs. IB 2010-07-08 LEVEL_F
OB
IB
Bx [nT]
By [nT]
Bz [nT]
T [C]
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00



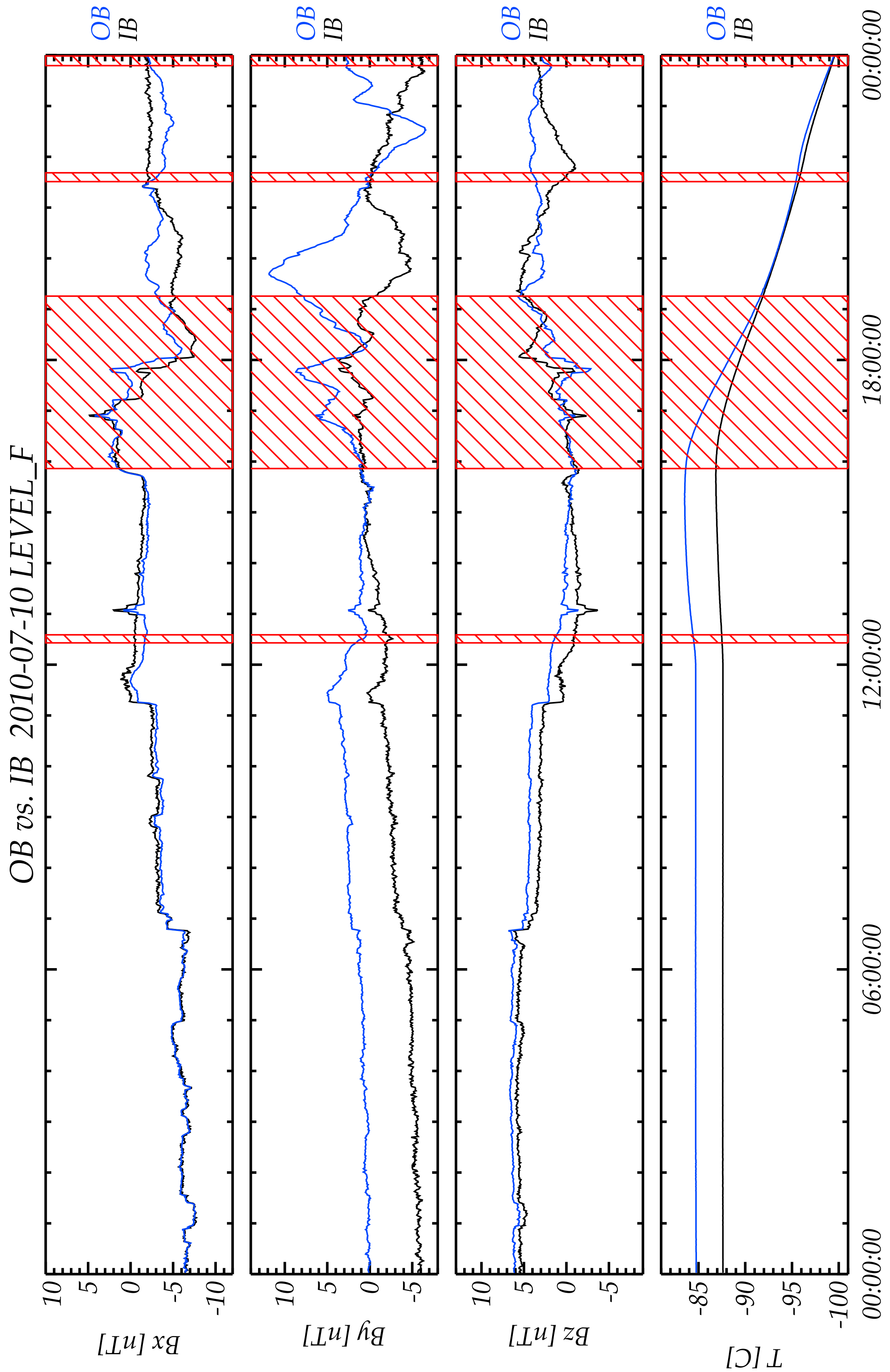
OB -IB 2010-07-08 LEVEL_F
Δ Bx [nT]
Δ By [nT]
Δ Bz [nT]
Δ T [K]
dΔT/dt [K/s]
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00



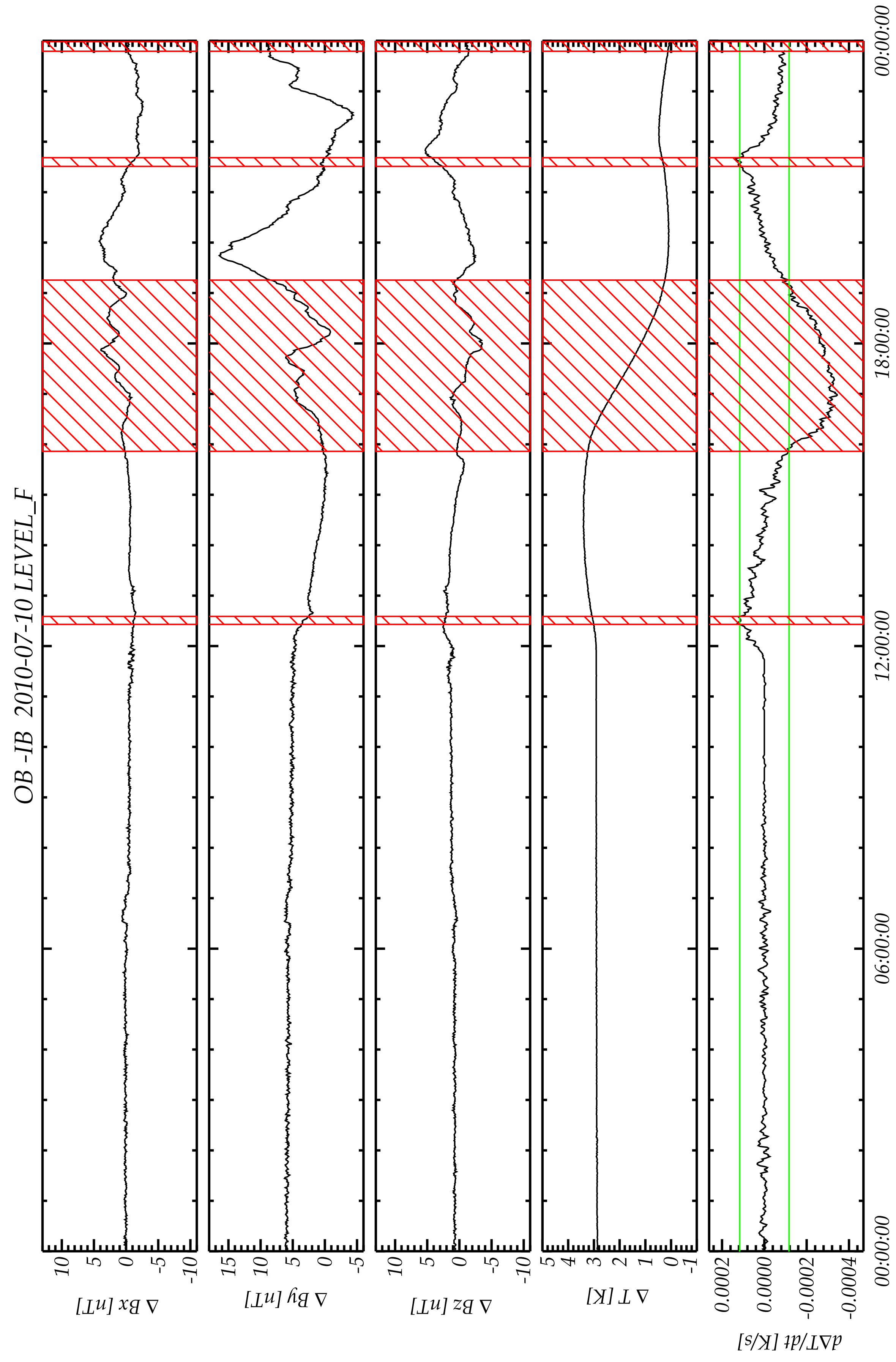
OB vs. IB 2010-07-09 LEVEL_F
OB
IB
Bx [nT]
0
-5
-10
-15
By [nT]
5
0
-5
-10
Bz [nT]
10
5
0
T [C]
-84
-86
-88
-90
-92
-94
-96
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00

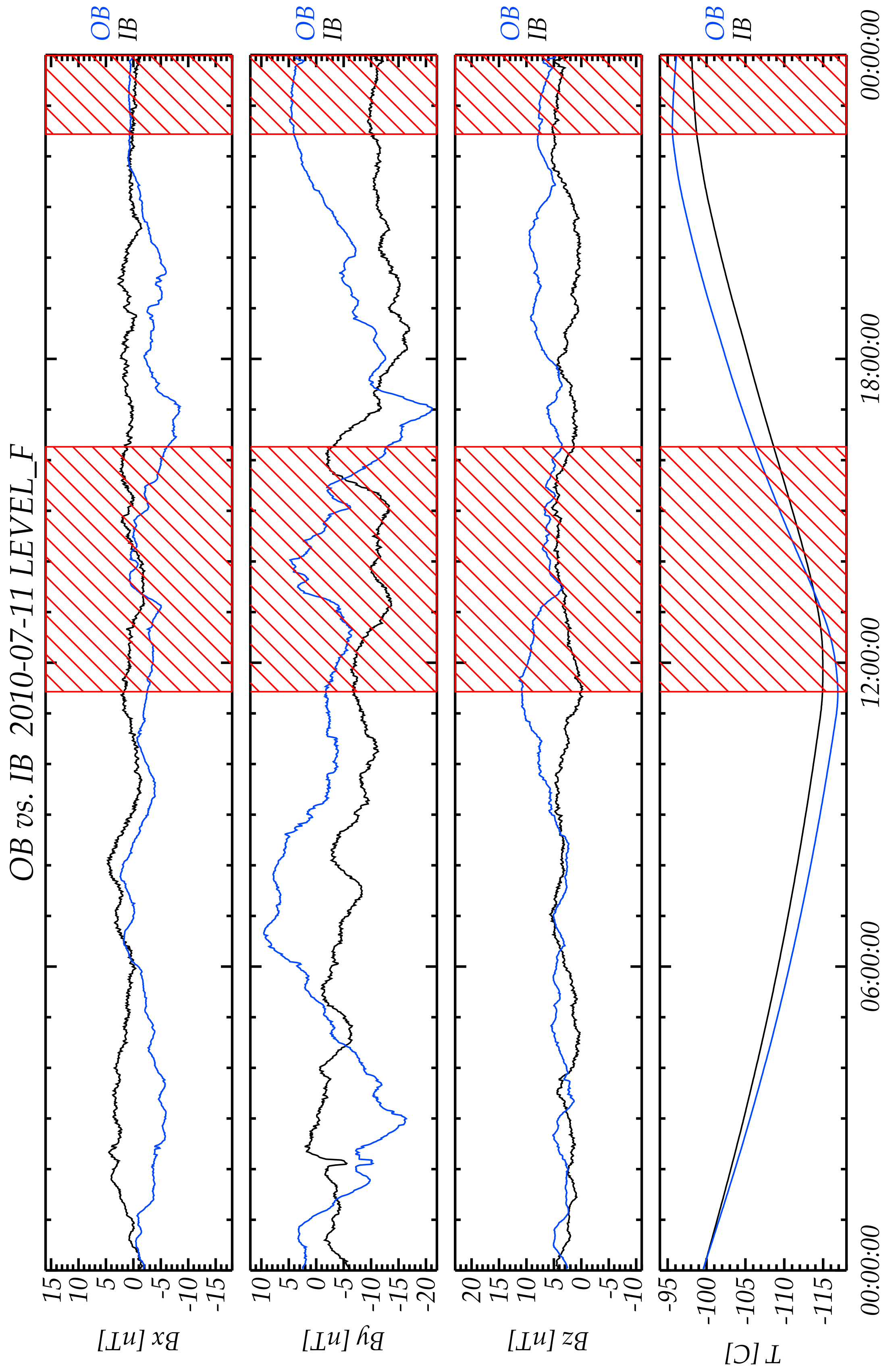


OB -IB 2010-07-09 LEVEL_F
∆ Bx [nT]
∆ By [nT]
∆ Bz [nT]
∆ T [K]
d∆T/dt [K/s]
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00

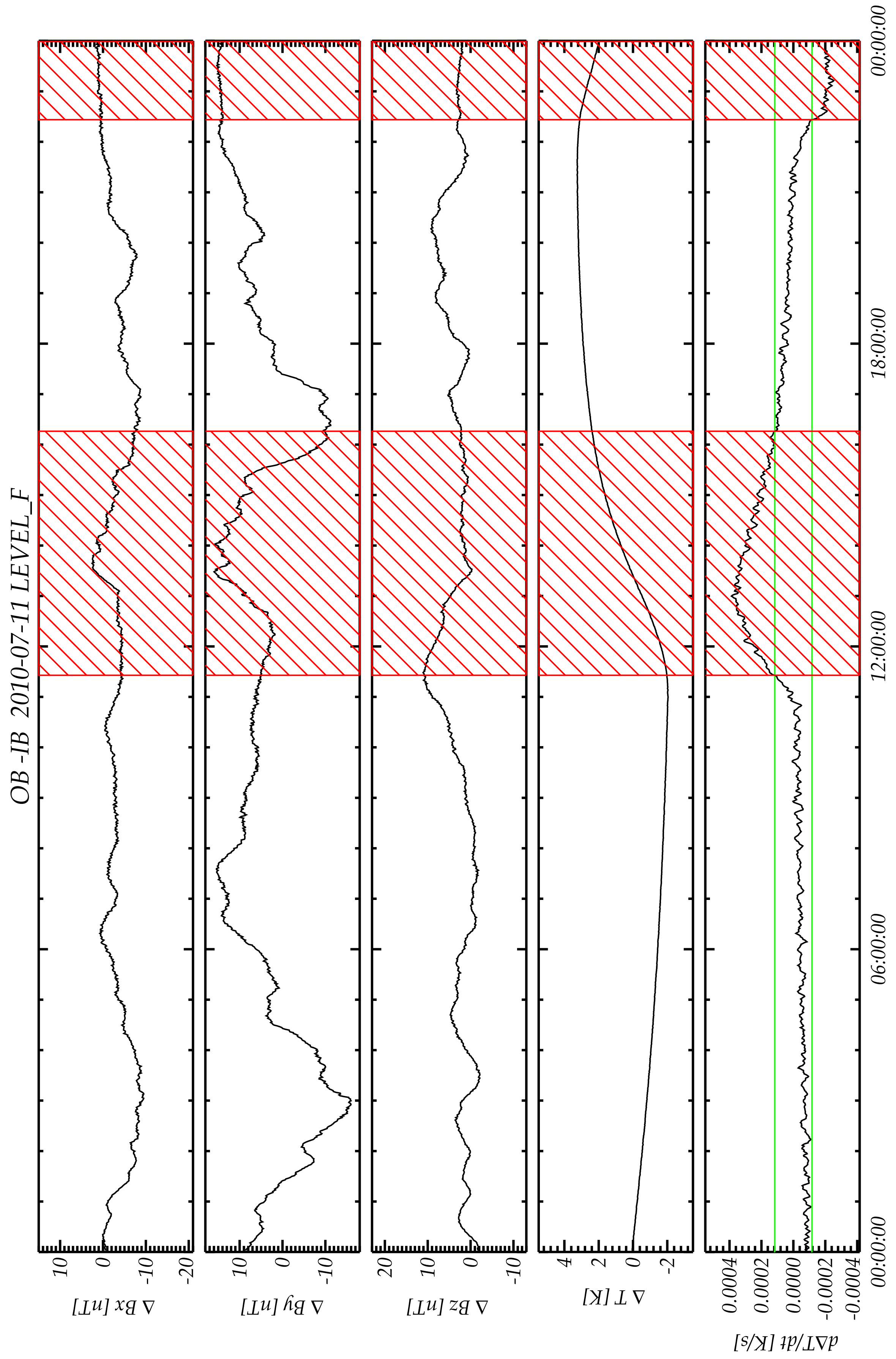


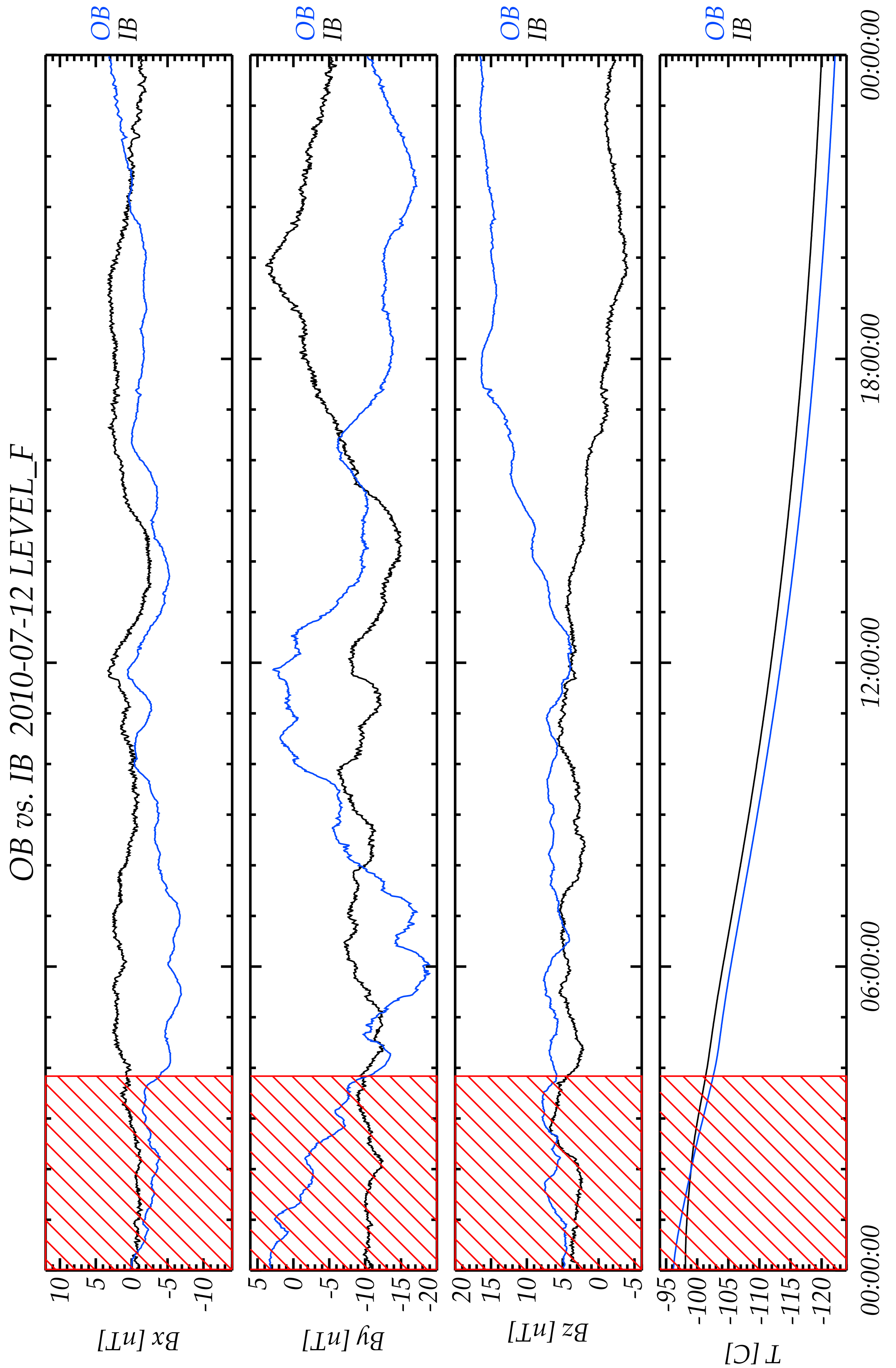
OB vs. IB 2010-07-10 LEVEL_F
OB
IB
Bx [nT]
By [nT]
Bz [nT]
T [C]
10
5
0
-5
-10
-85
-90
-95
-100
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00


OB -IB 2010-07-10 LEVEL_F
Δ Bx [nT]
Δ By [nT]
Δ Bz [nT]
Δ T [K]
dΔT/dt [K/s]
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00

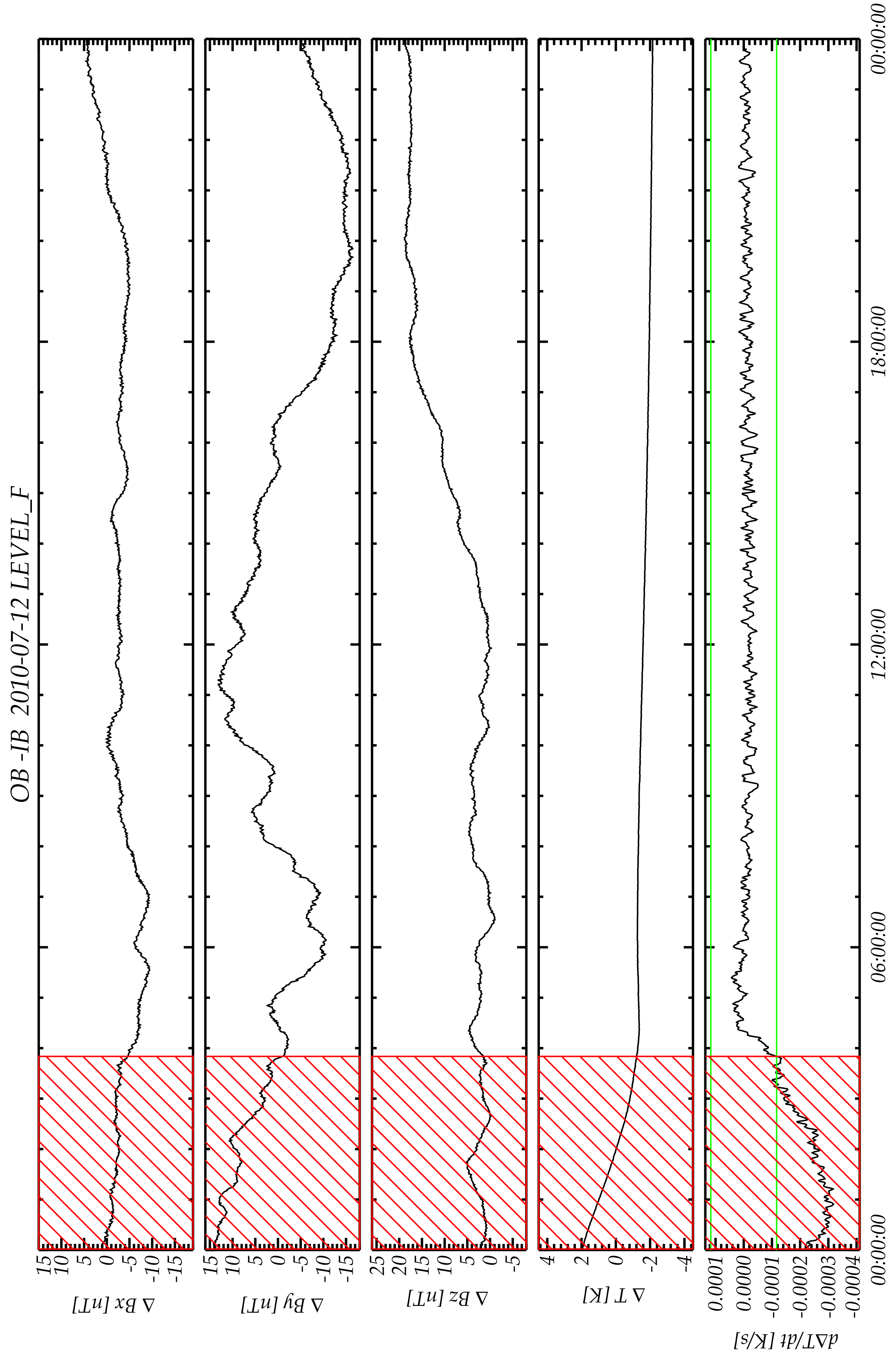


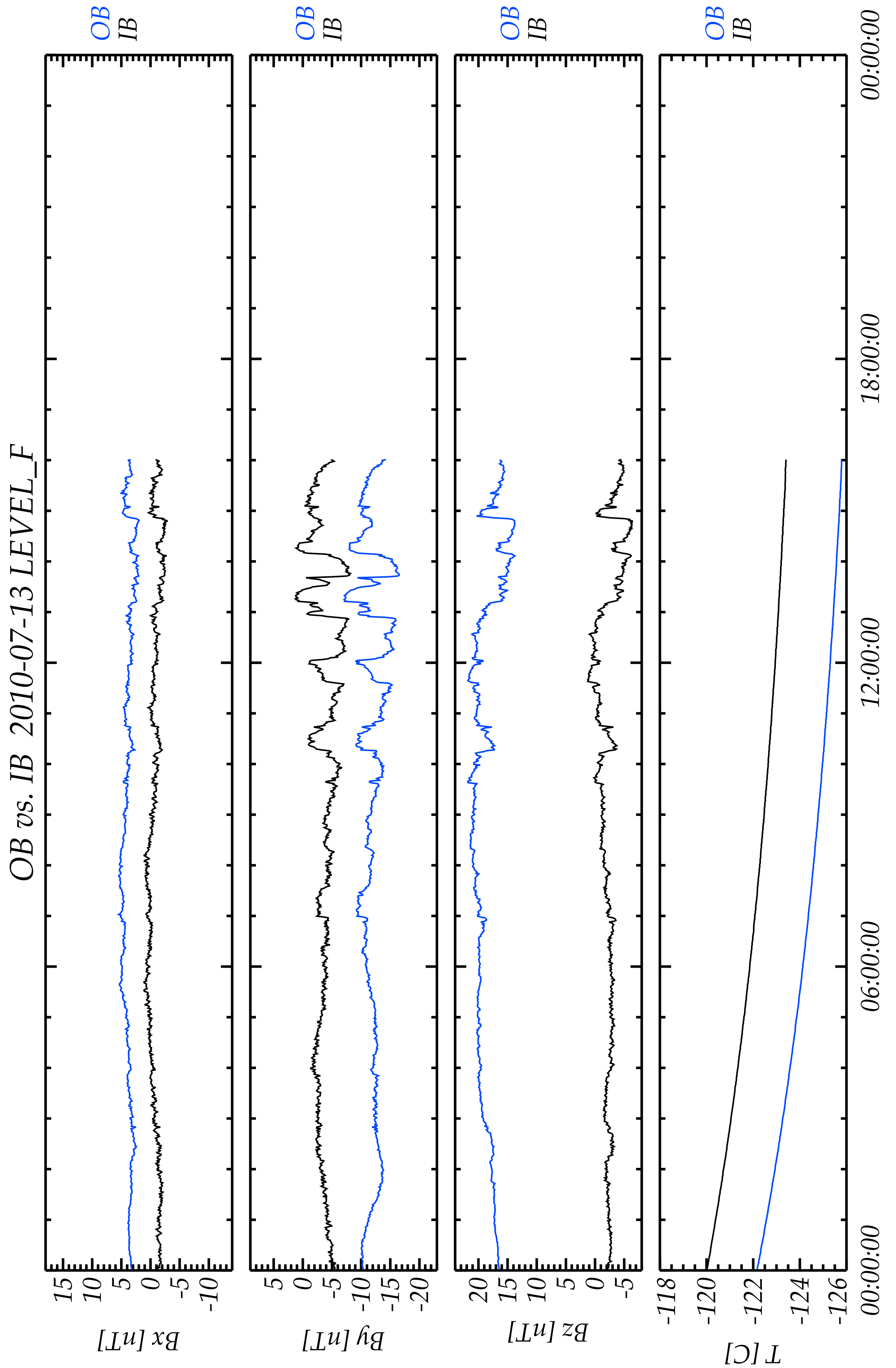
OB vs. IB 2010-07-11 LEVEL_F
OB
IB
Bx [nT]
By [nT]
Bz [nT]
T [C]
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00


OB -IB 2010-07-11 LEVEL_F
Δ Bx [nT]
Δ By [nT]
Δ Bz [nT]
Δ T [K]
dΔT/dt [K/s]
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00

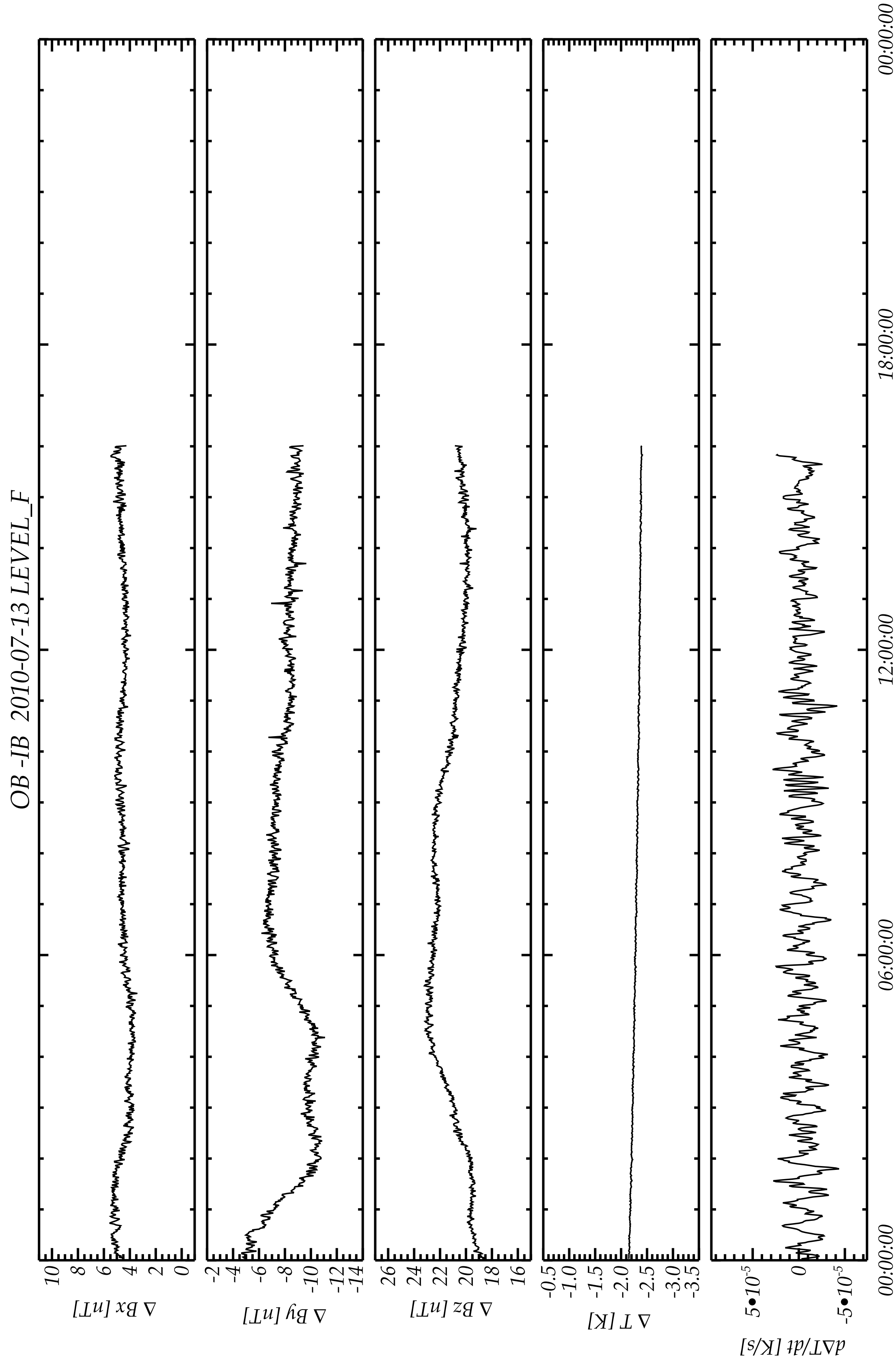


OB vs. IB 2010-07-12 LEVEL_F
OB
IB
Bx [nT]
10 5 0 -5 -10
By [nT]
5 0 -5 -10 -15 -20
Bz [nT]
20 15 10 5 0 -5
T [C]
-95 -100 -105 -110 -115 -120
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00


OB -IB 2010-07-12 LEVEL_F
Δ Bx [nT]
Δ By [nT]
Δ Bz [nT]
Δ T [K]
dΔT/dt [K/s]
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00



OB vs. IB 2010-07-13 LEVEL_F
OB
IB
Bx [nT]
By [nT]
Bz [nT]
T [C]
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00



OB -IB 2010-07-13 LEVEL_F
10 8 6 4 2 0
Δ Bx [nT]
-2 -4 -6 -8 -10 -12 -14
Δ By [nT]
26 24 22 20 18 16
Δ Bz [nT]
-0.5 -1.0 -1.5 -2.0 -2.5 -3.0 -3.5
Δ T [K]
5•10⁻⁵ 0 -5•10⁻⁵
dΔT/dt [K/s]
00:00:00
06:00:00
12:00:00
18:00:00
00:00:00