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Impact of Orbit Correction Maneuvers (OCM) on Magnetic Field Data

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1 Orbital Correction Maneuver OCM

The Rosetta Magnetometer RPCMAG is very sensitive and therefore frail to magnetic field disturbances caused by the spacecraft itself. One of the more noticeable disturbances are the Orbital Correction Maneuvers (OCMs) where the spacecraft changes its attitude. Signatures related to the OCM can be identified within the telemetry data log under the command *ZAC20116*. Within the MAG-data, the disturbance detectability is depending on the MAG-sampling rate and the surrounding magnetic field variations. We will flag the OCMs depending on the grade of perceptibility and therefore the grade of disturbance of the MAG-data

We show three cases as examples of varying degrees of perceptibility.

1.1 Clear Visibility in Magnetic Field Data or Derivatives

When the magnetometer is in its Burst mode with 20Hz sampling rate, the OCMs are easy to detect within the MAG data. For example, we show the appearance of an OCM on 17th August 2014 beginning at 9:00 am UTC in figure 1. The magnetic field components of the OB and IB-magnetometer, their time derivatives and the magnetic field magnitude are shown in nT and nT/s respectively. A vertical black line shows the start time of the command *ZAC20116*. The distinctive influence on the MAG data is visible about 12 seconds after the command initiation. The first order disturbances in the x-, y-, and z-component are about -2 nT, -1.5 nT and $+2.5$ nT respectively. When checking within an OCM in figure 2, a second order disturbance in form of periodic spikes that we will call "comb disturbance" appears in the x- and z- component with a frequency of 625 mHz. The spikes have a 200 ms width and their amplitude is between $4 - 6$ nT. The derivatives of the x- and z-component show a heartbeat-pattern with a maximum slew rate of 400 nT/s. The total magnetic field jumps about 3nT. The end time of the OCM can not be retrieved from the telemetry history log, as the OCM duration is controlled autonomously. Therefore, the end of an OCM must be seen from the data itself. In figure 1 the disturbances in the x- and z-component are visible in the data until 09:06:20, yet the y-component takes about 20 seconds longer to reach pre-OCM values. Therefore, every OCM-incident has to be checked manually for its ending.

1.2 Weak Visibility in Magnetic Field Data or Derivatives

Not all OCMs are on a timespan of 6 minutes as the previous example, most are much shorter, which are even more difficult to detect when the magnetometer is working at a

sampling rate of 1Hz in its normal-mode as in figure 3. Here, the magnetic field fluctuations of about 4nT in the x- and z-component before the issuing *ZAC20116* command are of the same magnitude as the s/c disturbances observed in the previous case. Also no 625 mHz signal can be observed from neither the observed MAG-data nor the calculated derivatives.

1.3 No Visibility in Magnetic Field Data or Derivatives

While Rosetta was in disturbed regions around the comet, the field fluctuations might exceed the OCM-disturbances so that pinpointing the disturbance time span becomes close to impossible as shown in the example in figure 4.

2 OCM Flagging Method

Pinpointing start and end of OCMs proved to be difficult in most cases. Furthermore, the longest lasting visible OCM was about 18 minutes. We flag the start of the OCMs according to the *ZAC20116* command's full minute, i.e. if the command is at 08:59:50, the start flag is set at 08:59:00. With a clear visible end of the OCM while in burst- or normal-mode in the MAG-data or its derivative, the end will be rounded to the second full minute after, i.e. the signal stops at 09:13:40, the ending flag will be set to 09:15:00. For the uncertain cases as in figure 3 and 4, we set a fixed 20 minutes time-interval from the start flag to the end flag. Each OCM is given a flag value depending on their perceptability. The flag values and their respective meaning are shown in table 1.

Table 1: Flagvalues and their meanings.

Flagvalue	Description
0	No OCM active
1	OCM active, no disturbance visible
2	Jump visible in B and/or δB/δt
3	Comb-disturbance visible in B and/or δB
4	Jump and Comb-disturbance visible
5	No data during OCM

All OCMs within the PRL-Phase are attached in section 5. They display field measurements and field derivatives of the OB and IB magnetometer.

3 OCM Examples

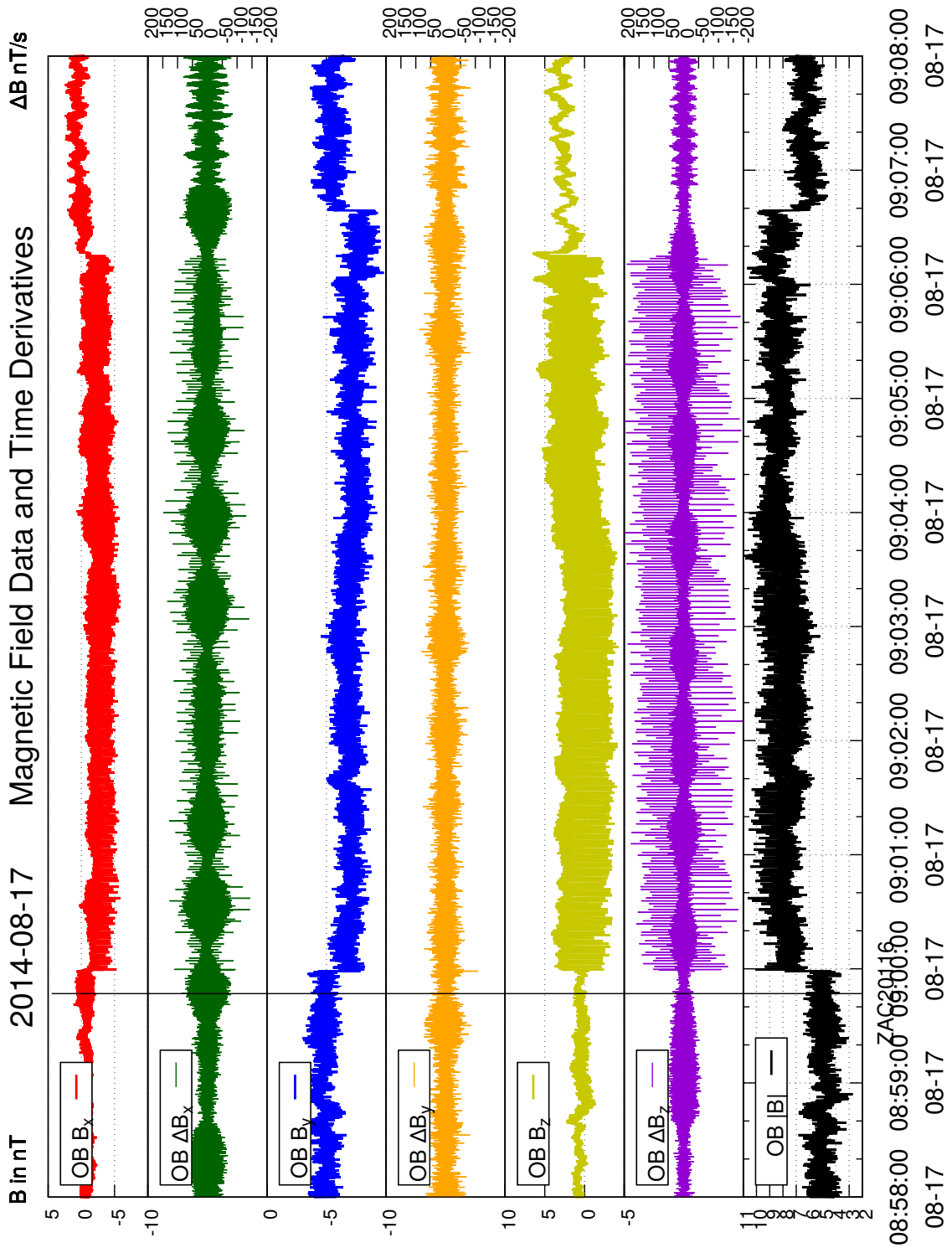


Figure 1: Clear Visible OCM at a sampling rate of 20Hz in burst-mode

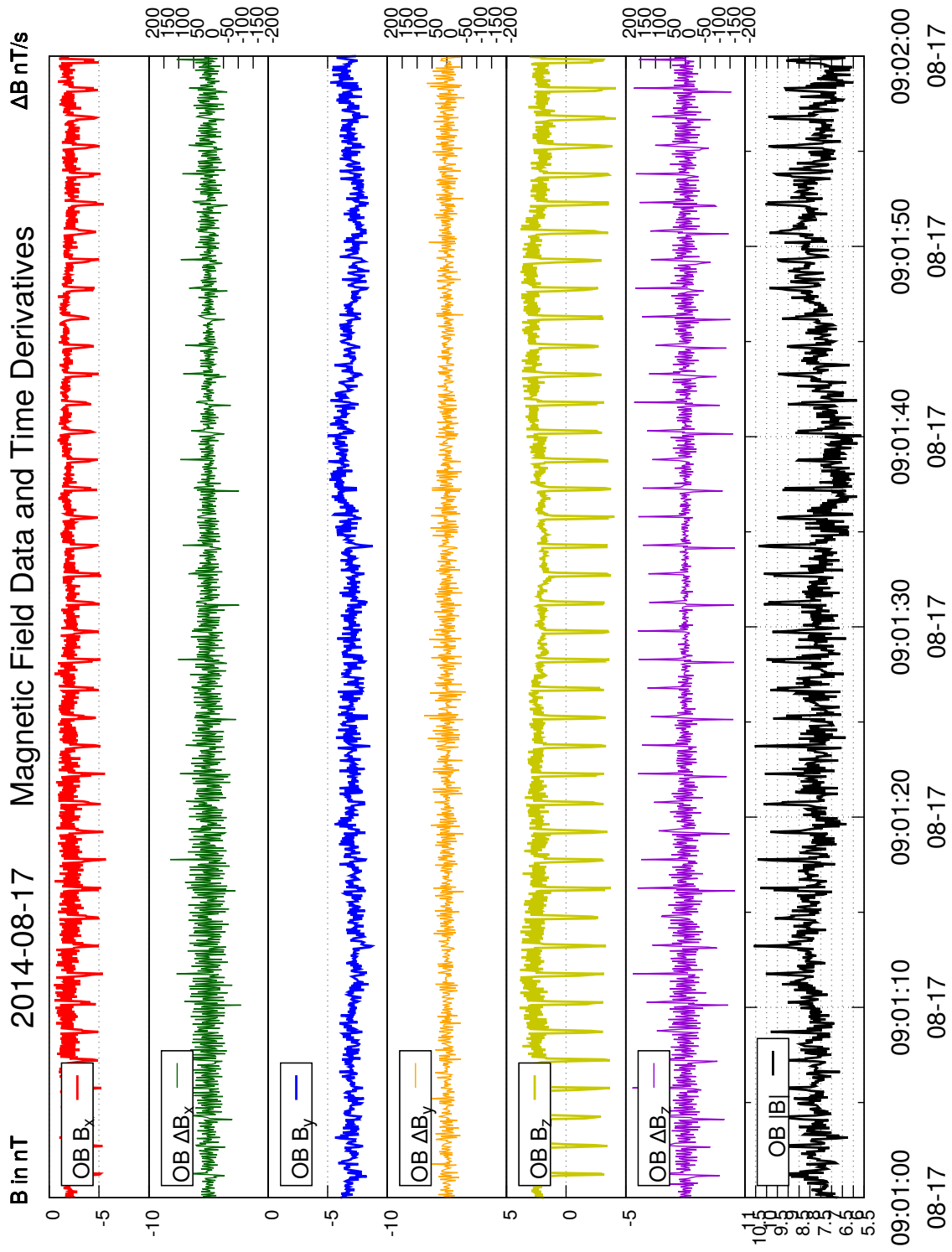


Figure 2: Same as figure 1, but a closeup.

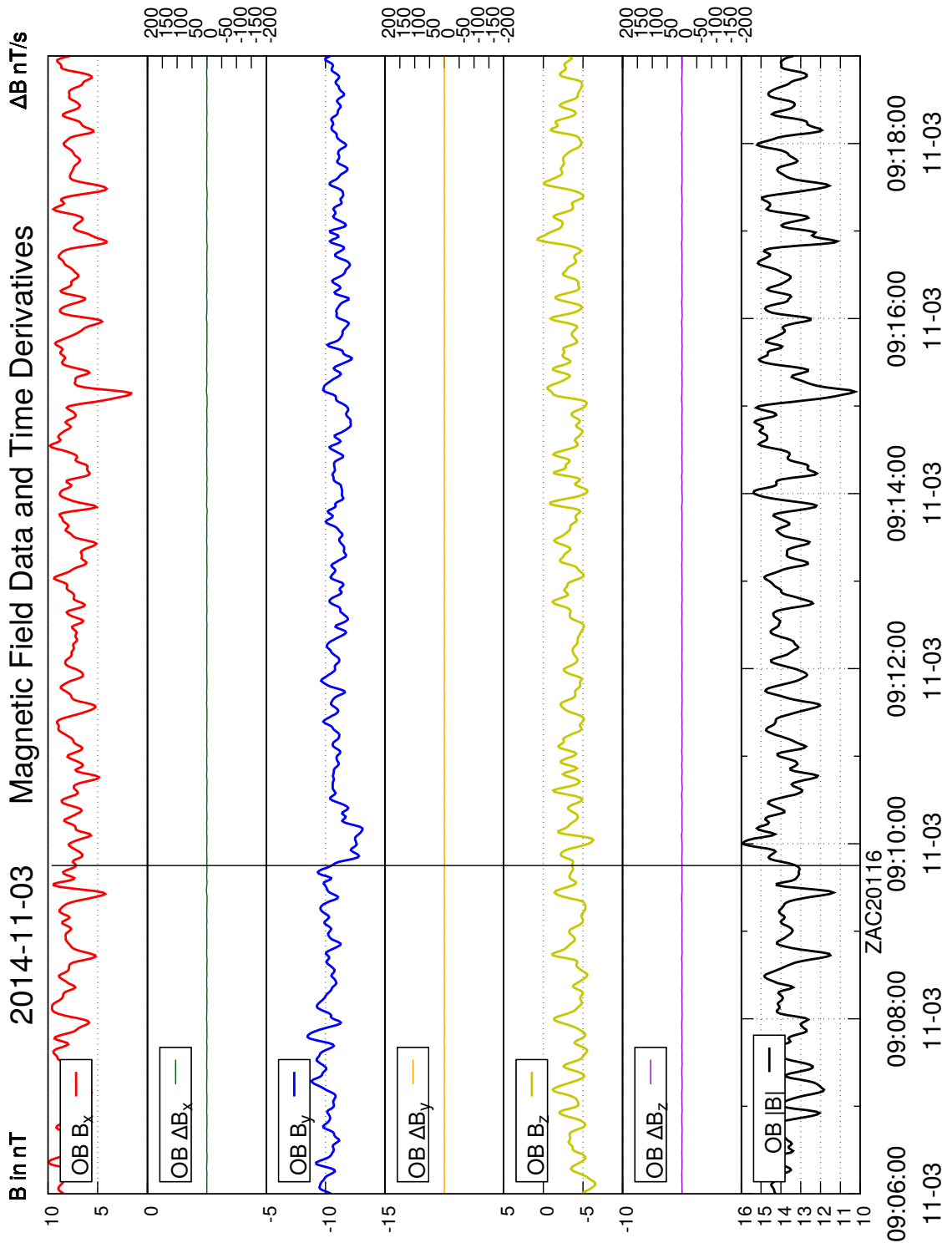


Figure 3: Very short OCM. Disturbance and variations are of similar magnitudes.

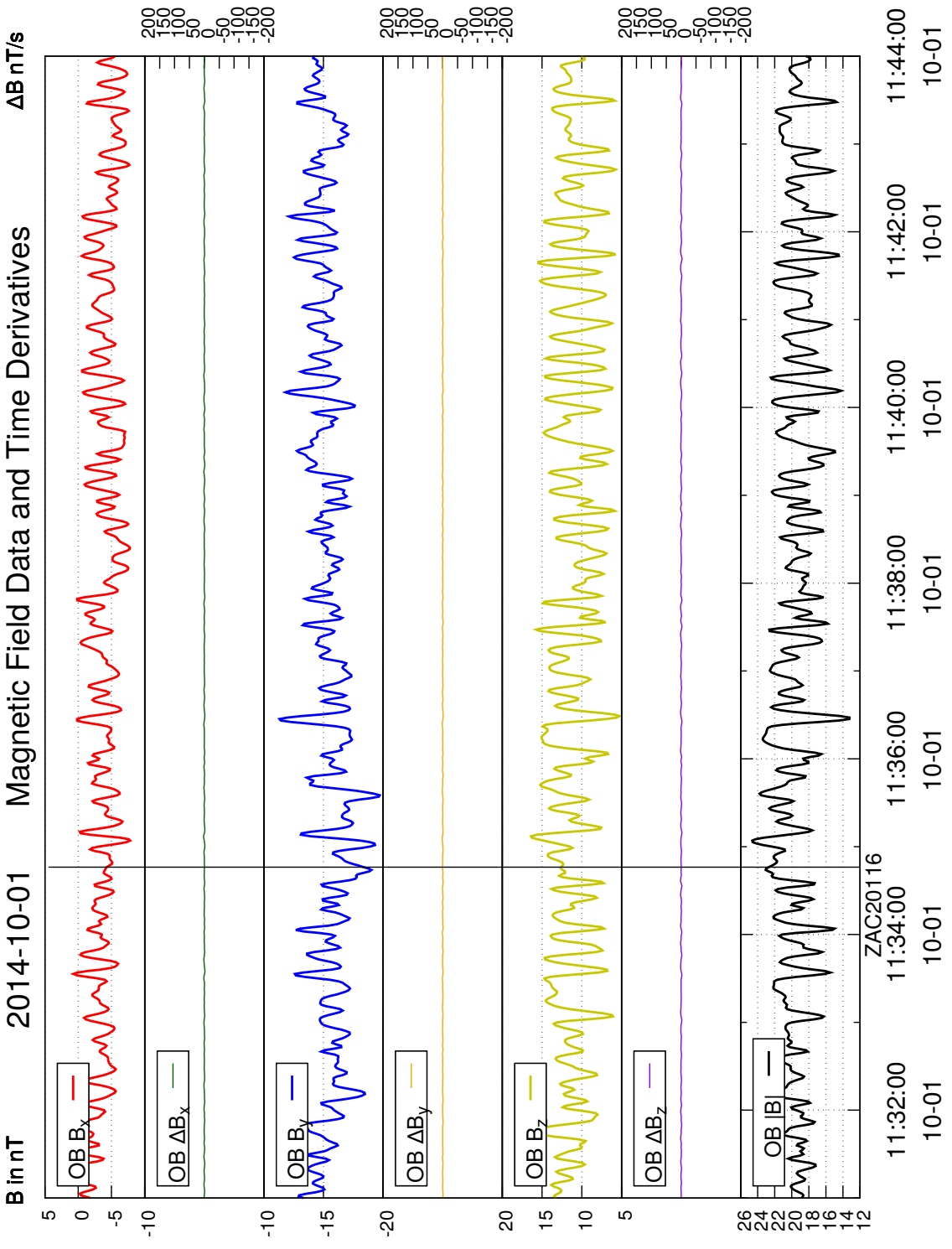


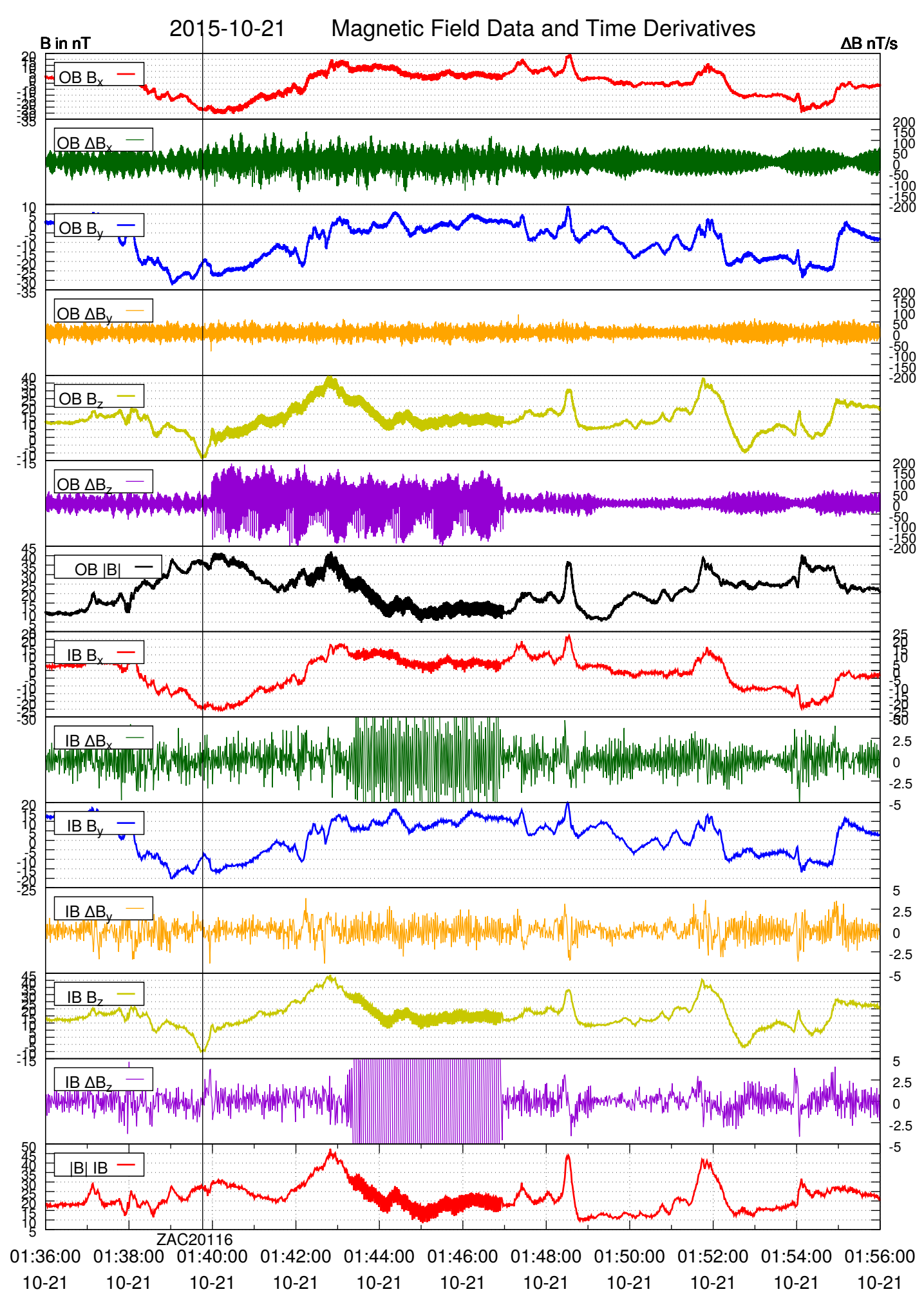
Figure 4: Unnoticeable OCM. Data fluctuation is stronger than disturbance.

4 List of OCMs

ZAC20116_OCM_List

#Order	#ExecutionTime	#Starttime	#Endtime	#QualityFlag
ZAC20116	21.10.15 01:39	21.10.15 01:39	21.10.15 01:48	4
ZAC20116	24.10.15 01:49	24.10.15 01:49	24.10.15 01:59	4
ZAC20116	28.10.15 01:39	28.10.15 01:39	28.10.15 01:47	3
ZAC20116	31.10.15 01:39	31.10.15 01:39	31.10.15 01:48	3
ZAC20116	04.11.15 01:39	04.11.15 01:39	04.11.15 01:47	4
ZAC20116	07.11.15 01:39	07.11.15 01:39	07.11.15 01:47	4
ZAC20116	11.11.15 01:49	11.11.15 01:49	11.11.15 01:56	4
ZAC20116	14.11.15 01:49	14.11.15 01:49	14.11.15 01:56	4
ZAC20116	18.11.15 01:49	18.11.15 01:49	18.11.15 01:55	4
ZAC20116	21.11.15 01:39	21.11.15 01:39	21.11.15 01:56	4
ZAC20116	25.11.15 01:39	25.11.15 01:39	25.11.15 01:45	4
ZAC20116	28.11.15 01:39	28.11.15 01:39	28.11.15 01:45	4
ZAC20116	02.12.15 01:39	02.12.15 01:39	02.12.15 01:44	4
ZAC20116	05.12.15 01:49	05.12.15 01:49	05.12.15 01:54	4
ZAC20116	09.12.15 01:49	09.12.15 01:49	09.12.15 01:55	4
ZAC20116	12.12.15 01:39	12.12.15 01:39	12.12.15 01:44	4
ZAC20116	16.12.15 01:39	16.12.15 01:39	16.12.15 01:45	4
ZAC20116	19.12.15 01:39	19.12.15 01:39	19.12.15 01:44	4
ZAC20116	23.12.15 01:39	23.12.15 01:39	23.12.15 01:44	4
ZAC20116	26.12.15 01:49	26.12.15 01:49	26.12.15 01:53	4
ZAC20116	30.12.15 01:49	30.12.15 01:49	30.12.15 01:54	4
ZAC20116	02.01.16 01:39	02.01.16 01:39	02.01.16 01:44	4
ZAC20116	06.01.16 01:39	06.01.16 01:39	06.01.16 01:44	4
ZAC20116	09.01.16 01:39	09.01.16 01:39	09.01.16 01:43	4

5 Plots of all OCMs in ESC4-Phase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B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 10-21
01:38:00 10-21
01:40:00 10-21
01:42:00 10-21
01:44:00 10-21
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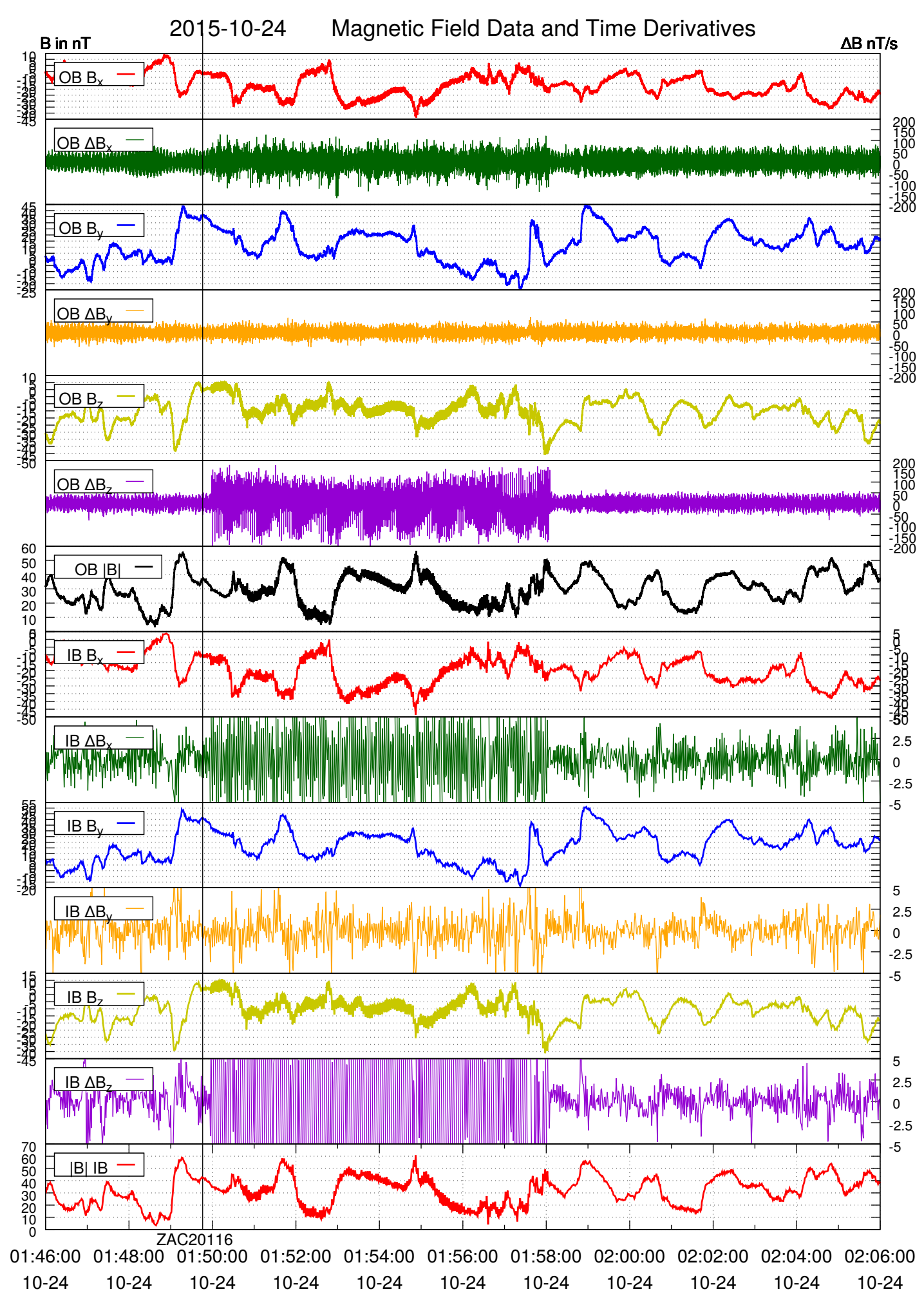
01:52:00 10-21
01:54:00 10-21
01:56:00 10-21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ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:46:00 01:48:00 01:50:00 01:52:00 01:54:00 01:56:00 01:58:00 02:00:00 02:02:00 02:04:00 02:06:00
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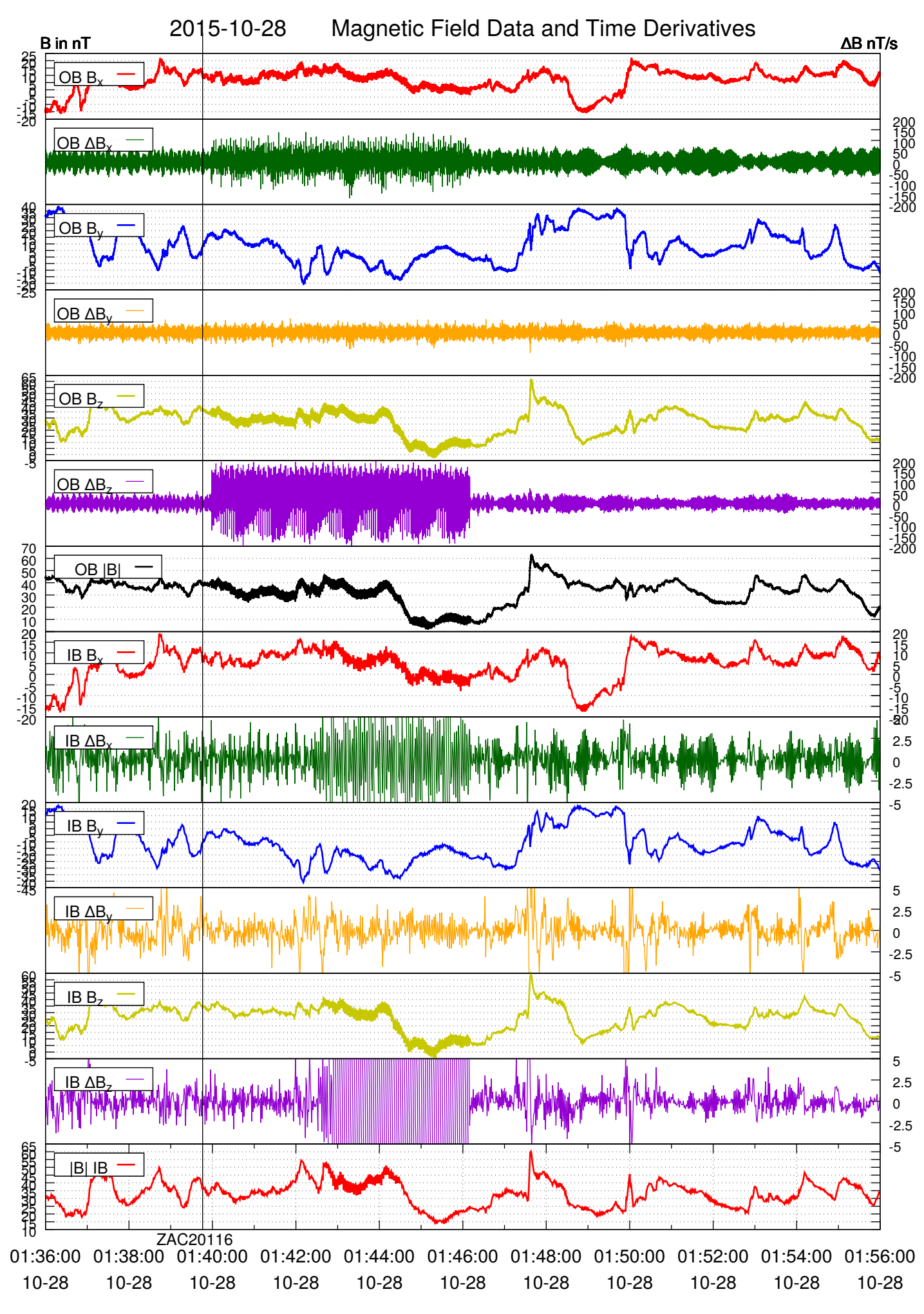
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ΔB nT/s
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OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 01:38:00 01:40:00 01:42:00 01:44:00 01:46:00 01:48:00 01:50:00 01:52:00 01:54:00 01:56:00
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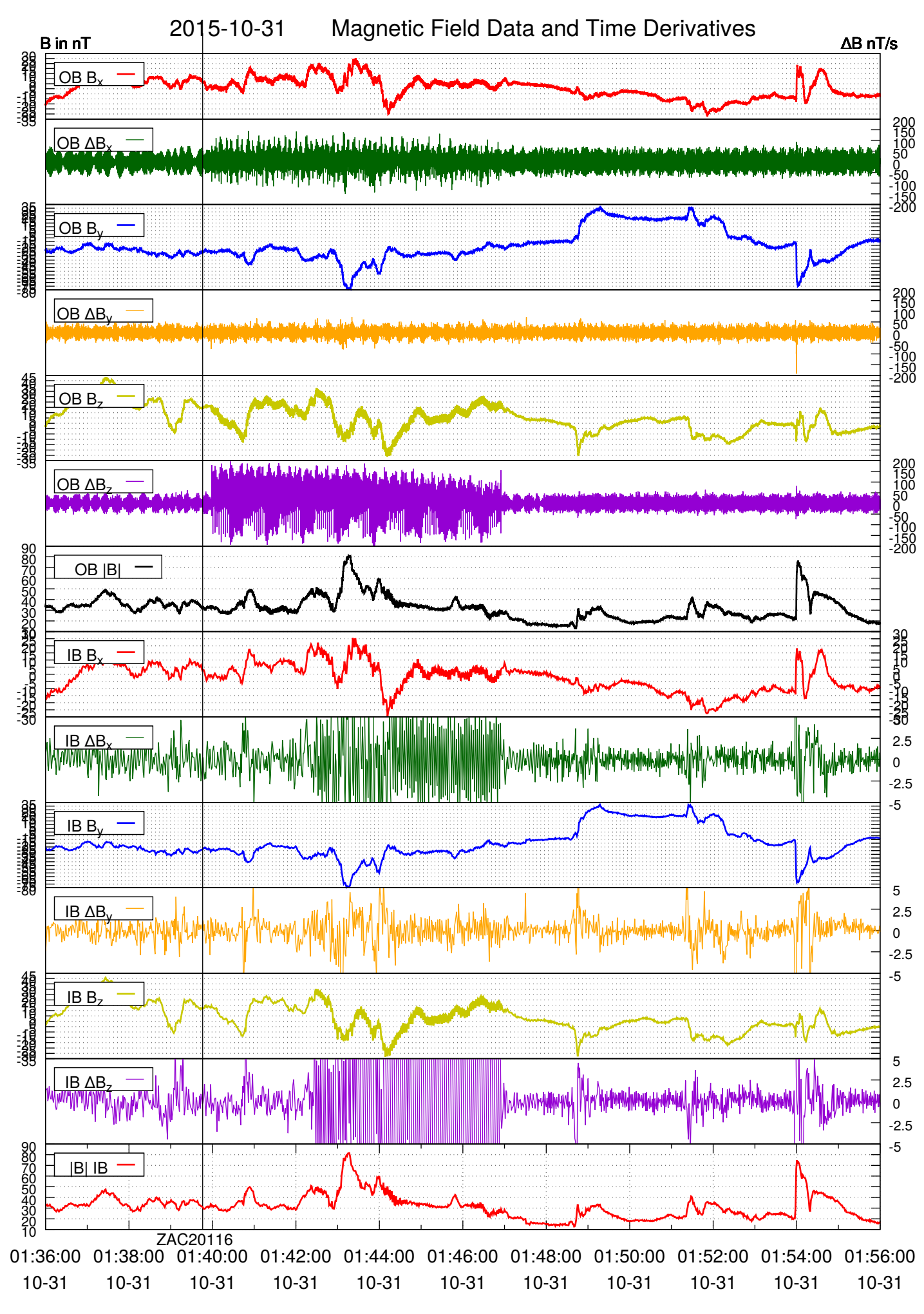
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OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 10-31
01:38:00 10-31
01:40:00 10-31
01:42:00 10-31
01:44:00 10-31
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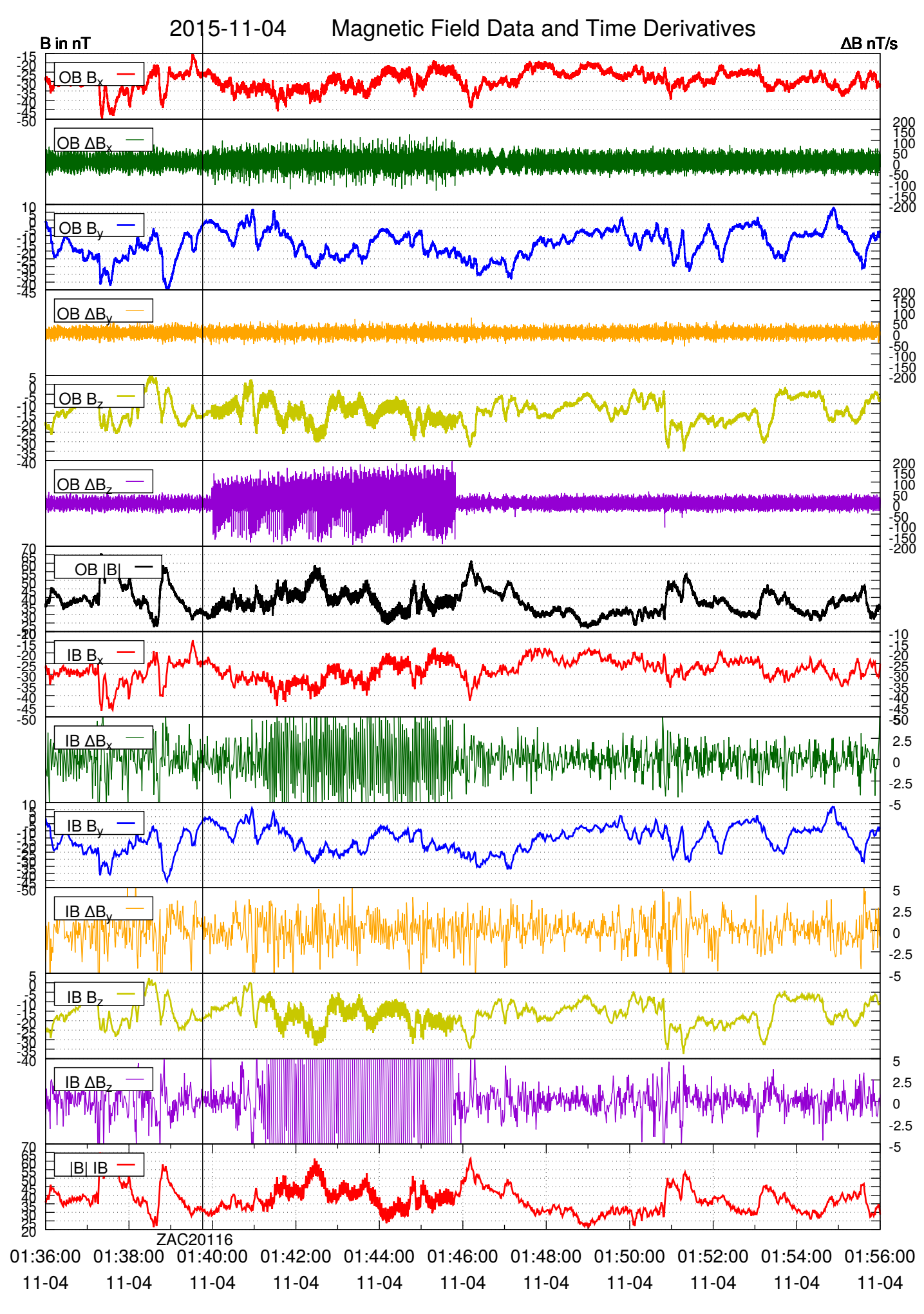
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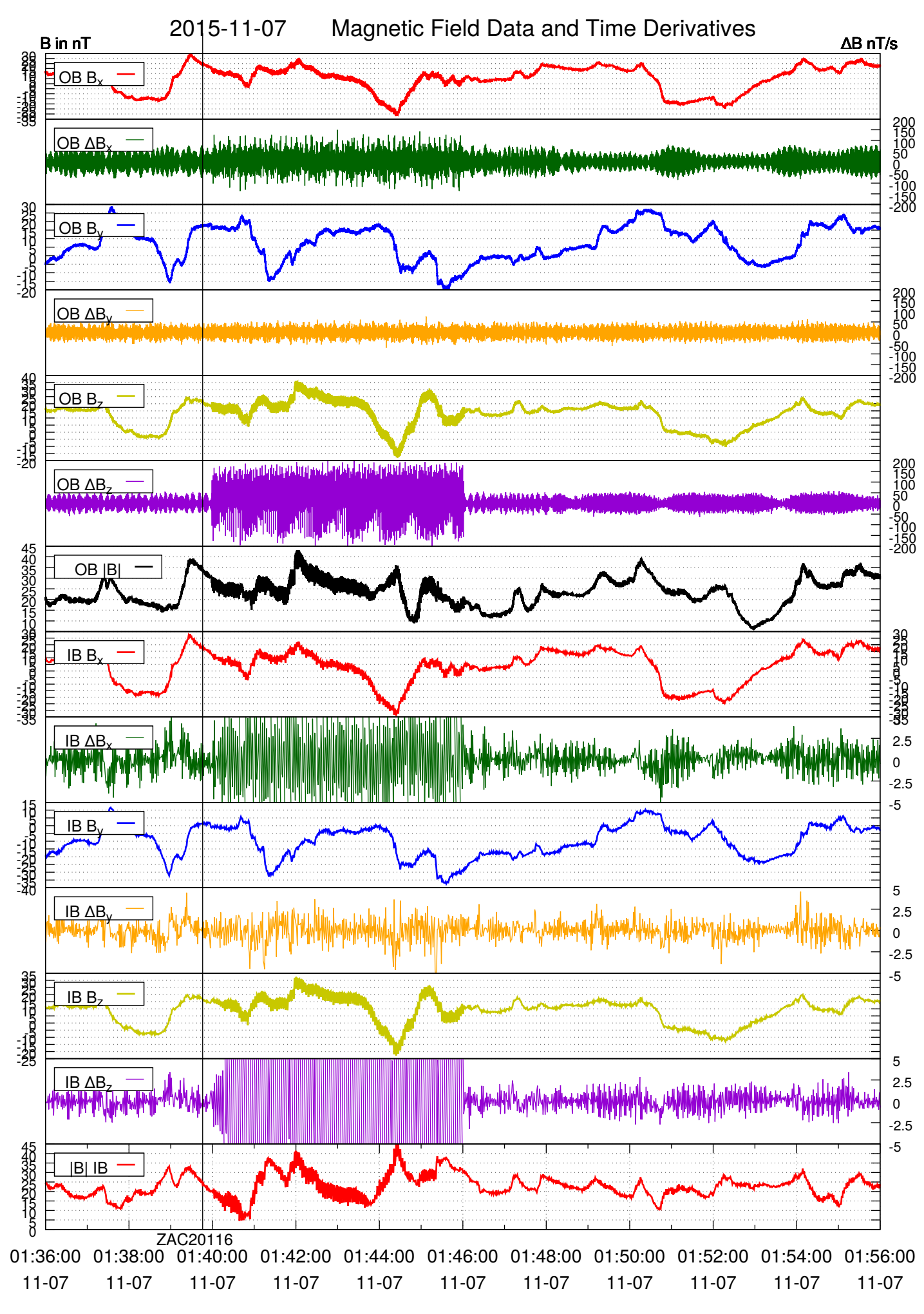
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 01:38:00 01:40:00 01:42:00 01:44:00 01:46:00 01:48:00 01:50:00 01:52:00 01:54:00 01:56:00
11-04 11-04 11-04 11-04 11-04 11-04 11-04 11-04 11-04 11-04 11-04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ΔB nT/s
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OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 11-07
01:38:00 11-07
01:40:00 11-07
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01:44:00 11-07
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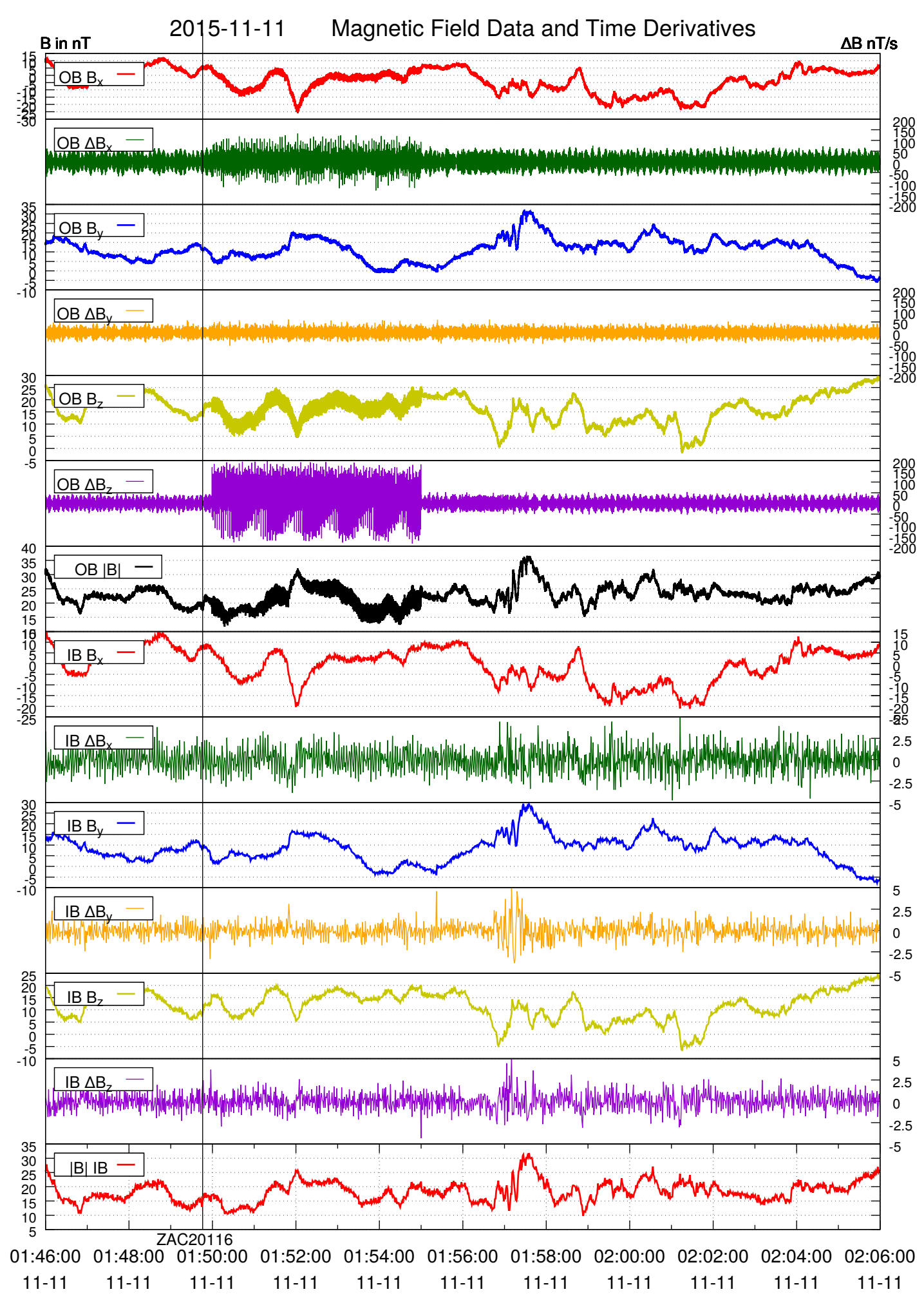
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ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:46:00 11-11
01:48:00 11-11
01:50:00 11-11
01:52:00 11-11
01:54:00 11-11
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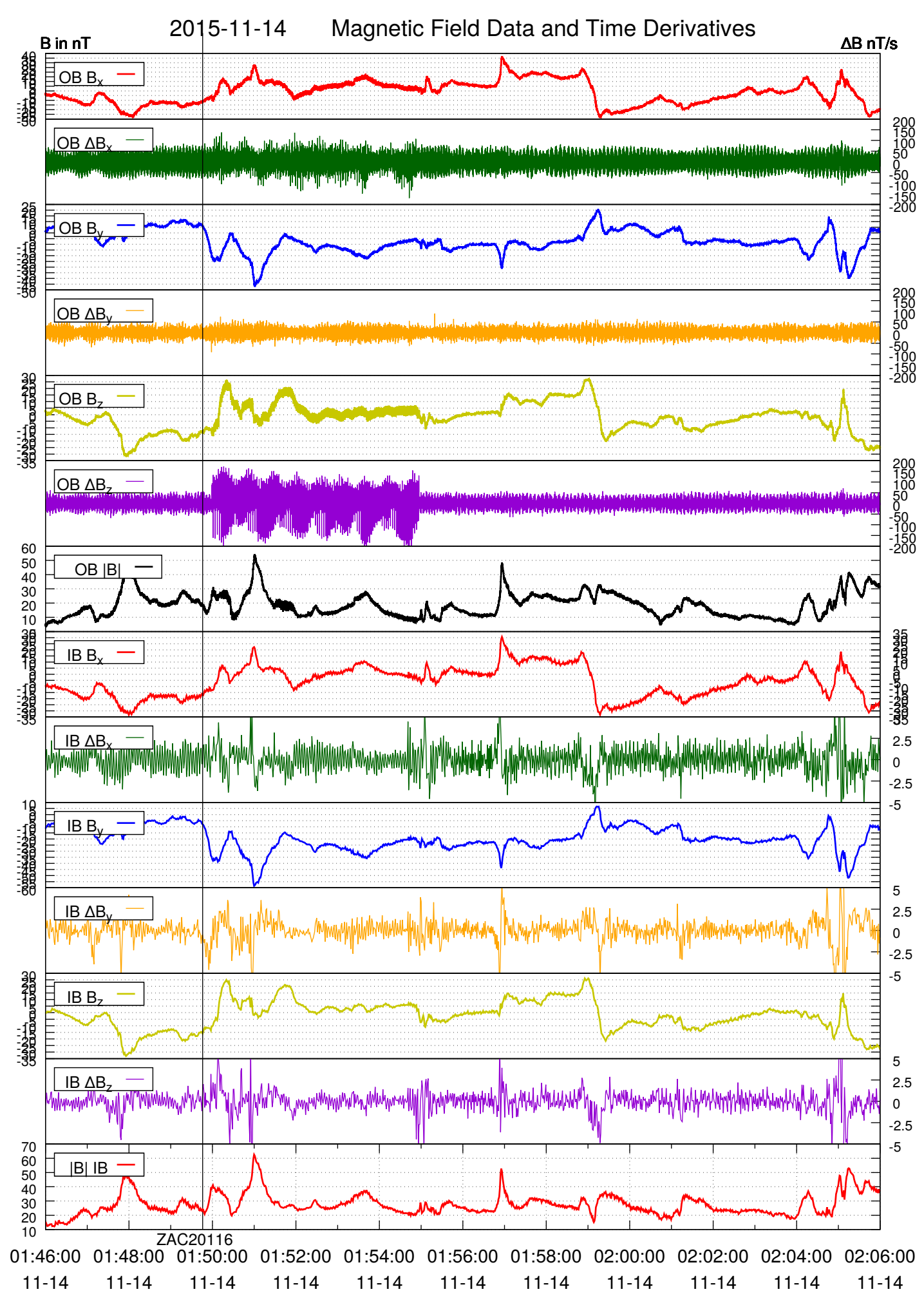
02:06:00 11-11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ΔB nT/s
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OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:46:00 01:48:00 01:50:00 01:52:00 01:54:00 01:56:00 01:58:00 02:00:00 02:02:00 02:04:00 02:06:00
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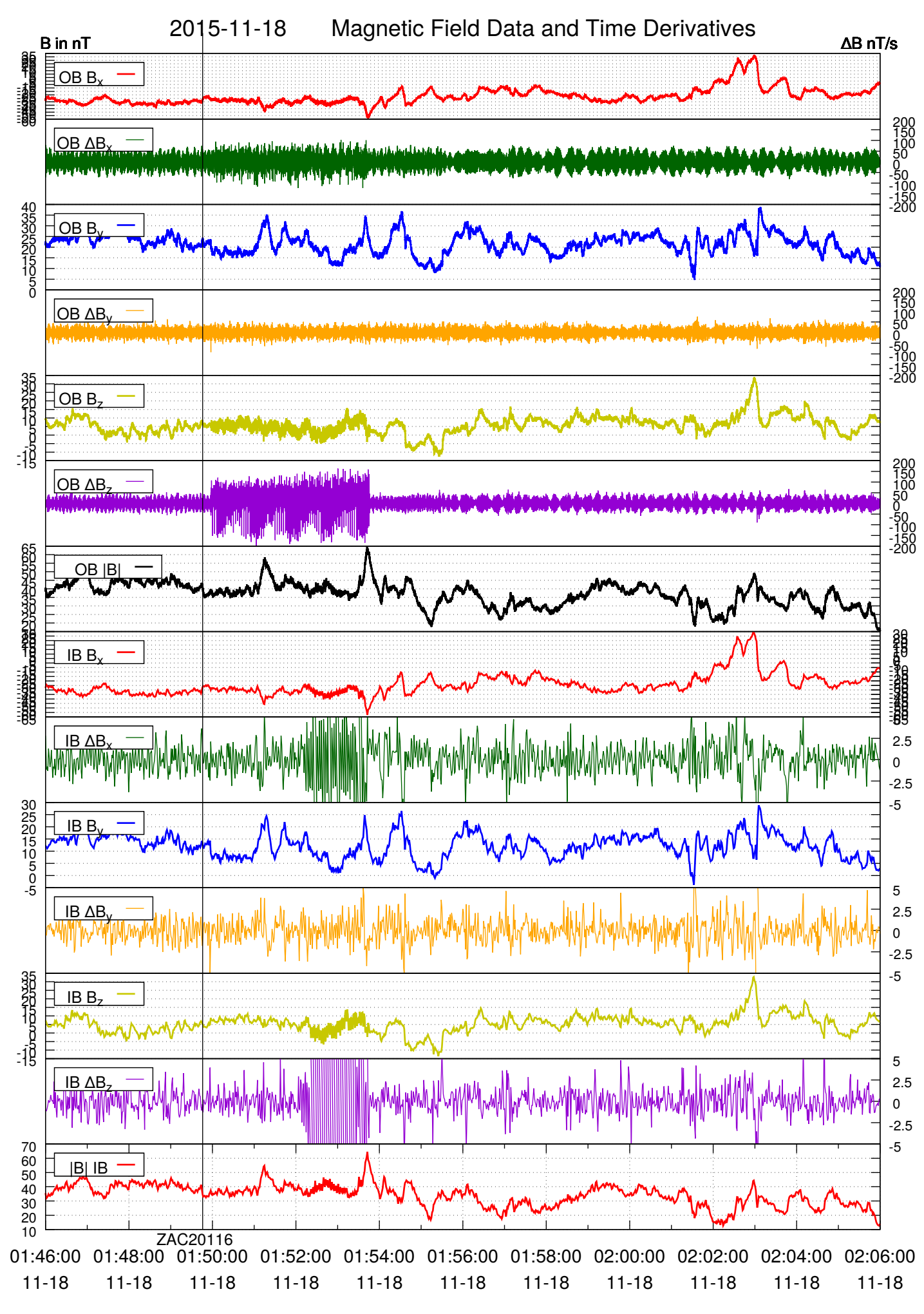
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ΔB nT/s
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OB ΔB_x
OB B_y
OB ΔB_y
OB B_z
OB ΔB_z
OB |B|
IB B_x
IB ΔB_x
IB B_y
IB ΔB_y
IB B_z
IB ΔB_z
|B| IB
ZAC20116
01:46:00 11-18
01:48:00 11-18
01:50:00 11-18
01:52:00 11-18
01:54:00 11-18
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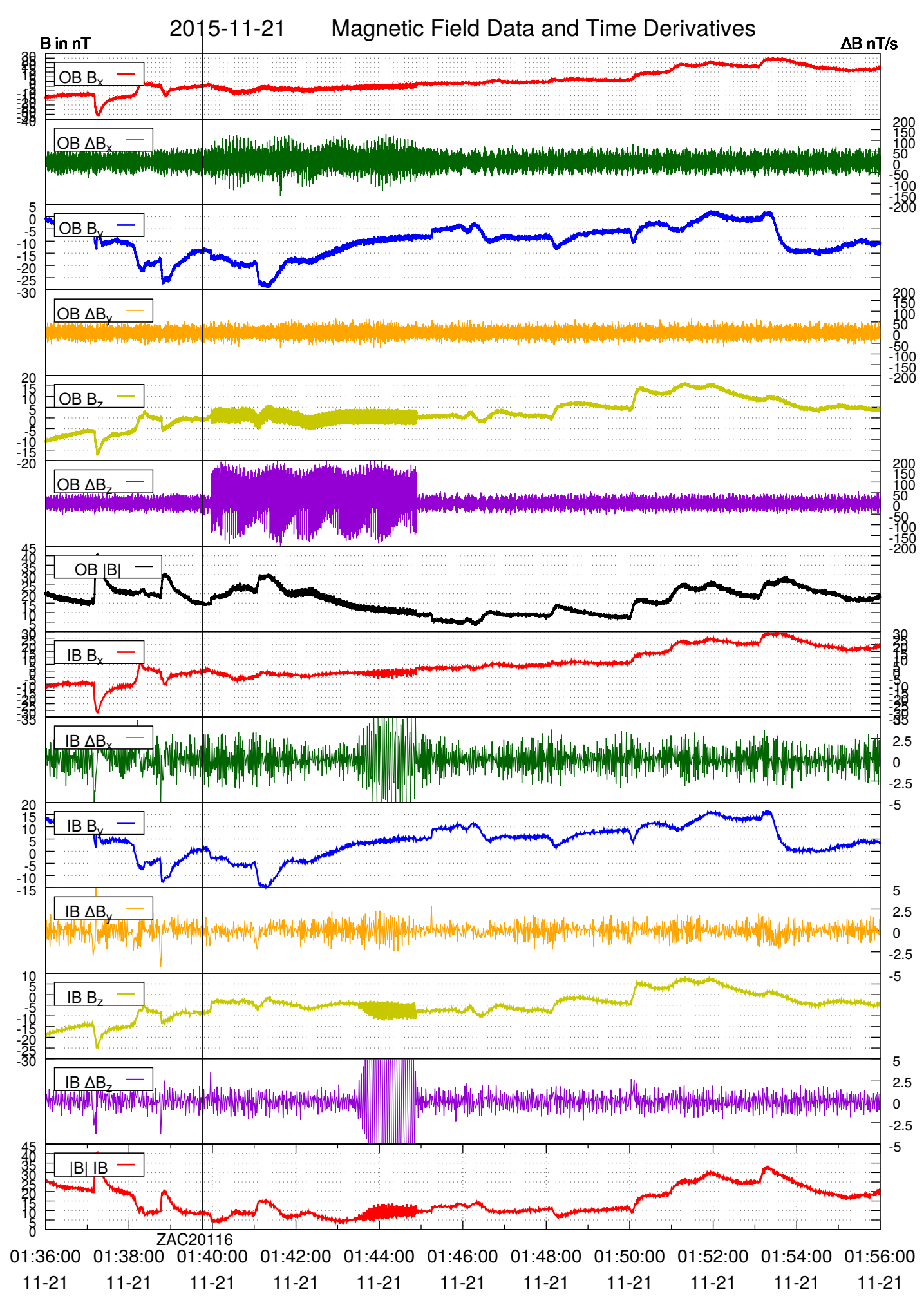
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ΔB nT/s
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OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 11-21
01:38:00 11-21
01:40:00 11-21
01:42:00 11-21
01:44:00 11-21
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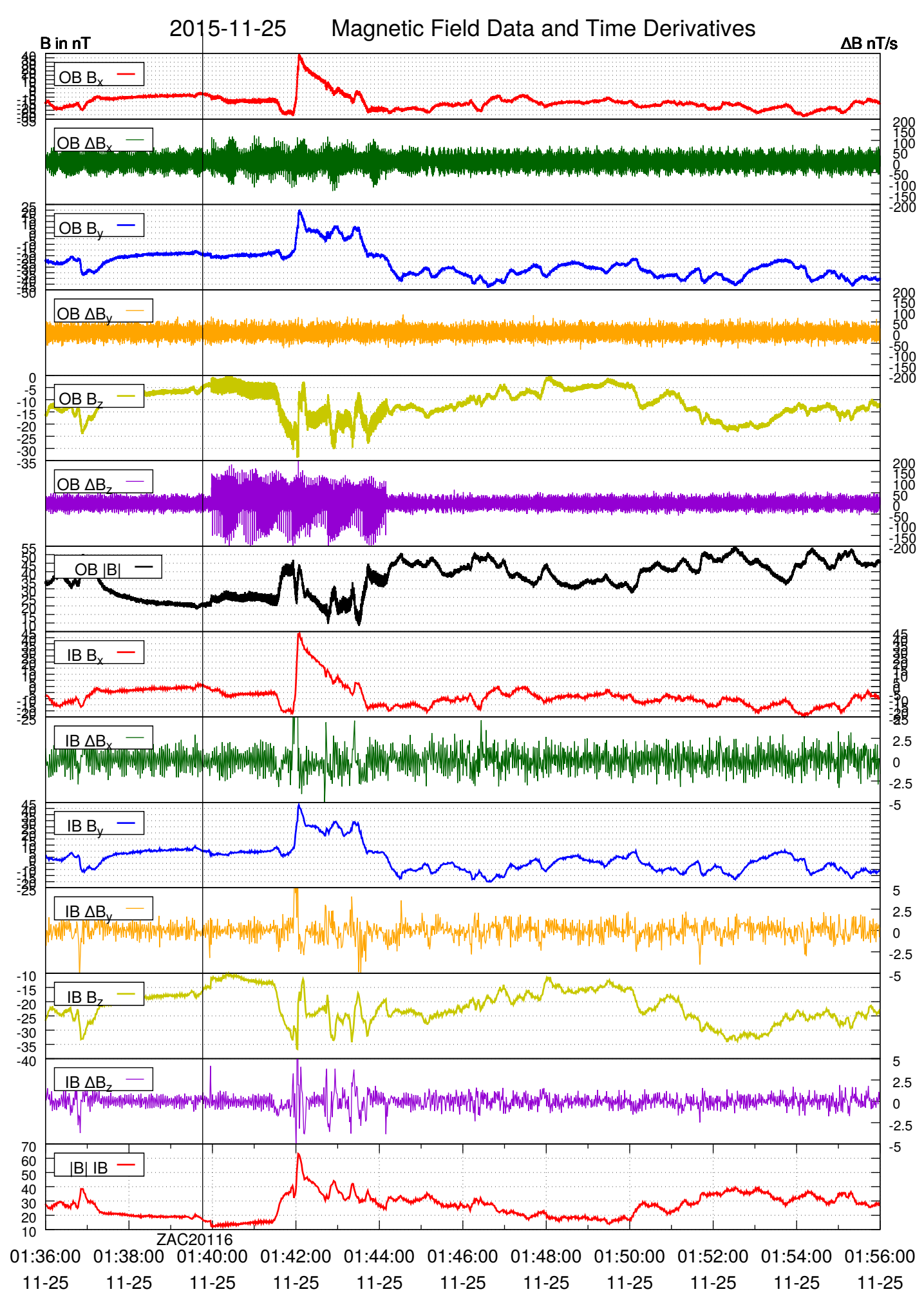
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ΔB nT/s
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OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 01:38:00 01:40:00 01:42:00 01:44:00 01:46:00 01:48:00 01:50:00 01:52:00 01:54:00 01:56:00
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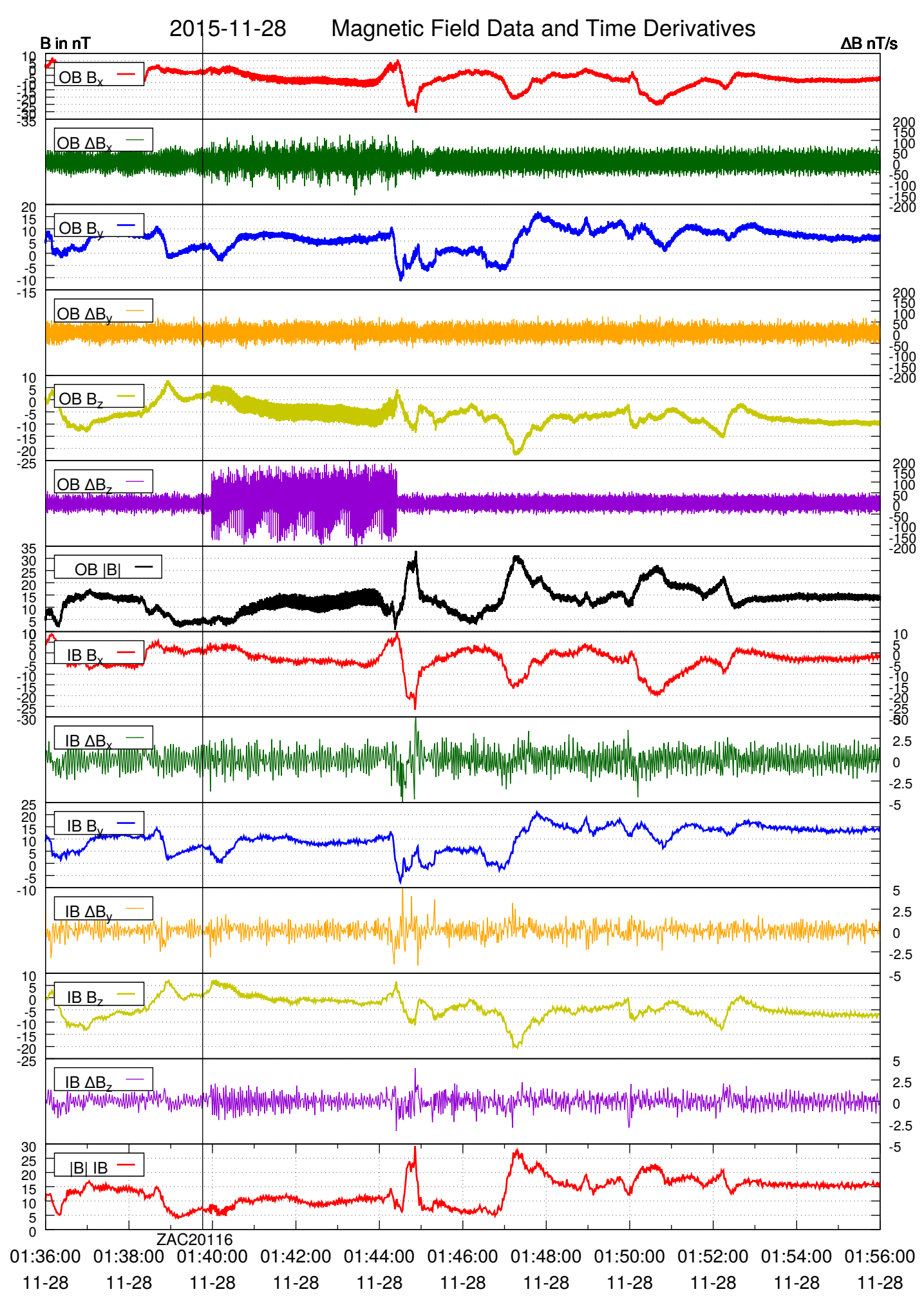
2015-11-28 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 11-28
01:38:00 11-28
01:40:00 11-28
01:42:00 11-28
01:44:00 11-28
01:46:00 11-28
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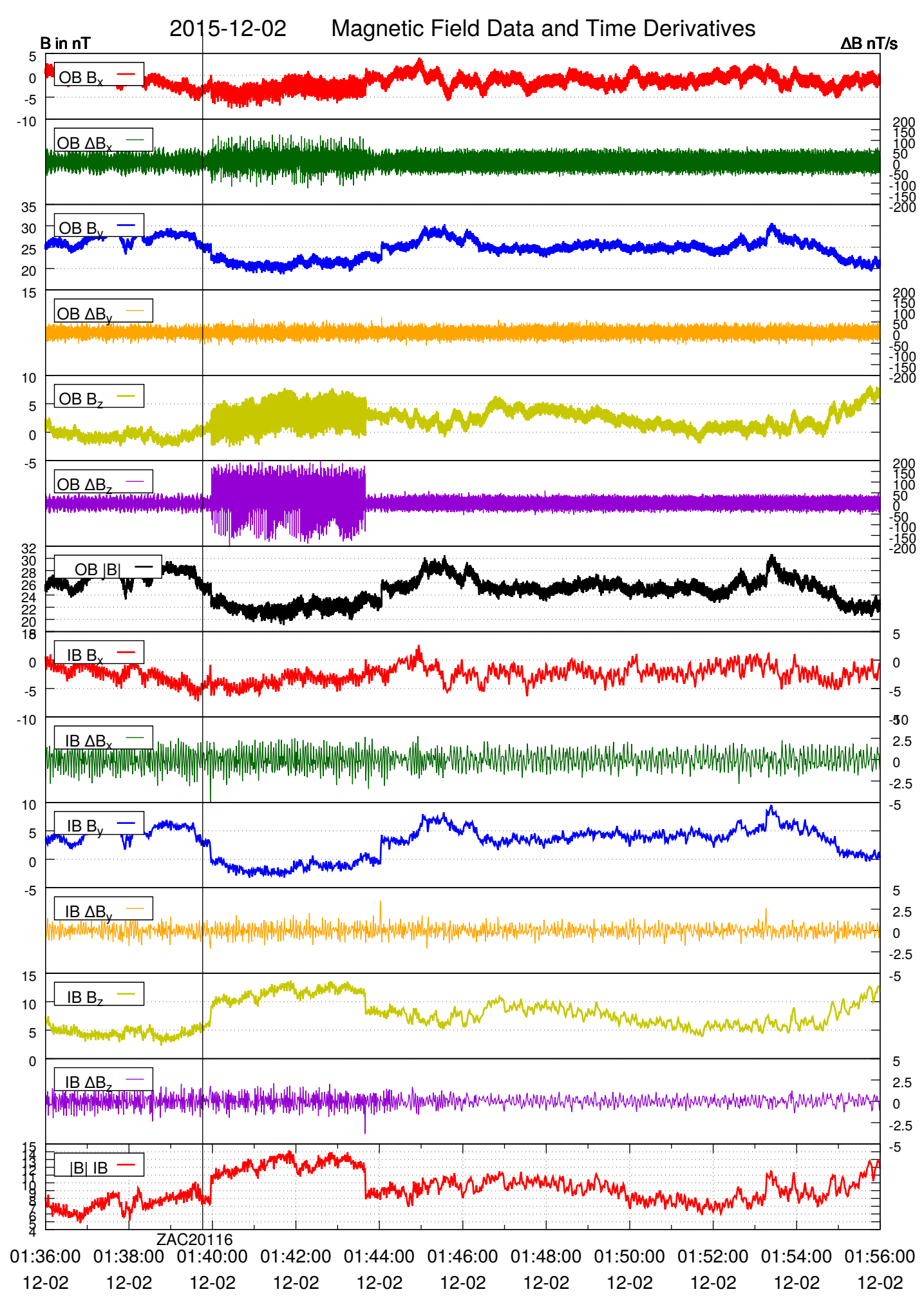
2015-12-02 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 12-02
01:38:00 12-02
01:40:00 12-02
01:42:00 12-02
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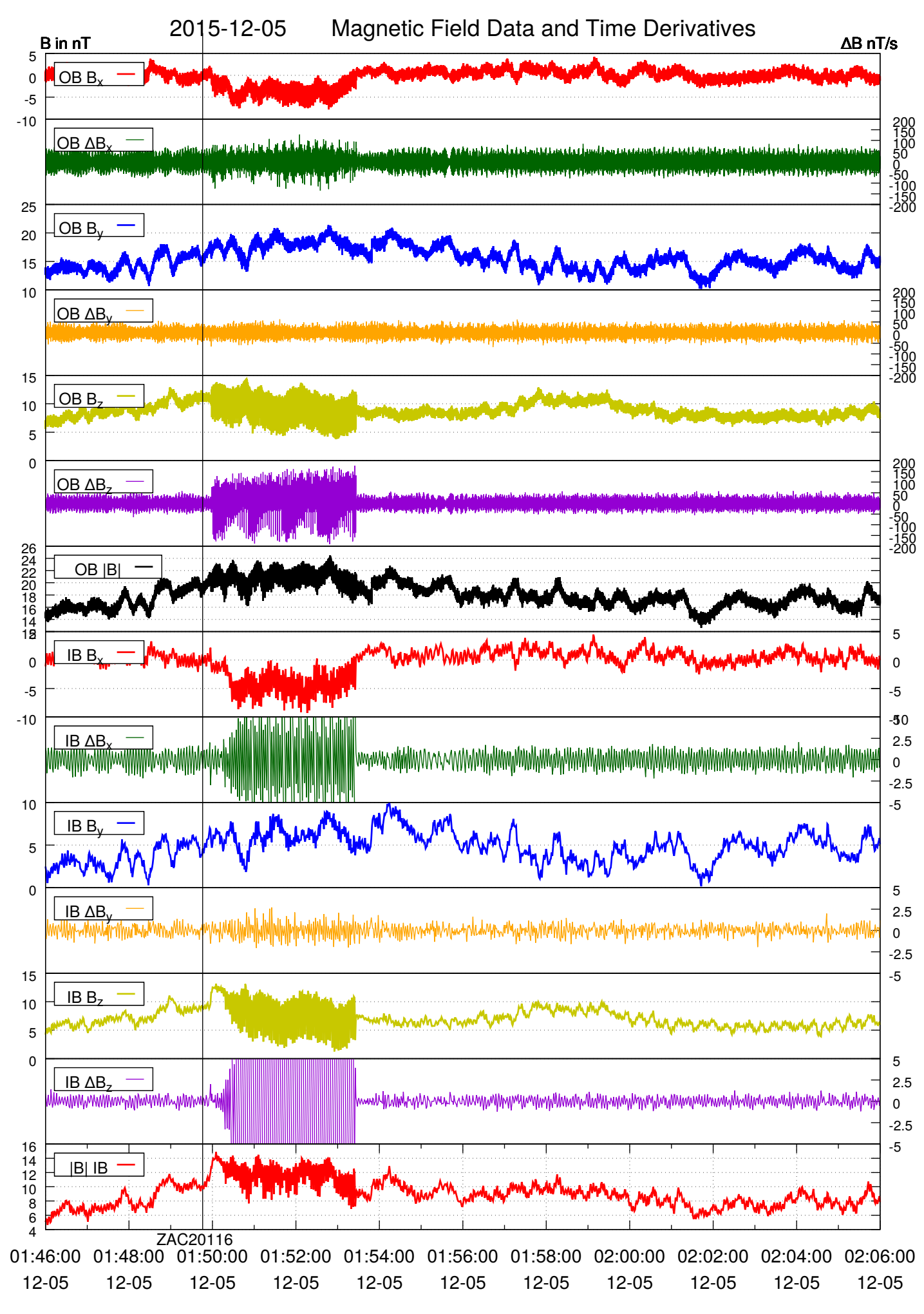
01:56:00 12-02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ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:46:00 12-05
01:48:00 12-05
01:50:00 12-05
01:52:00 12-05
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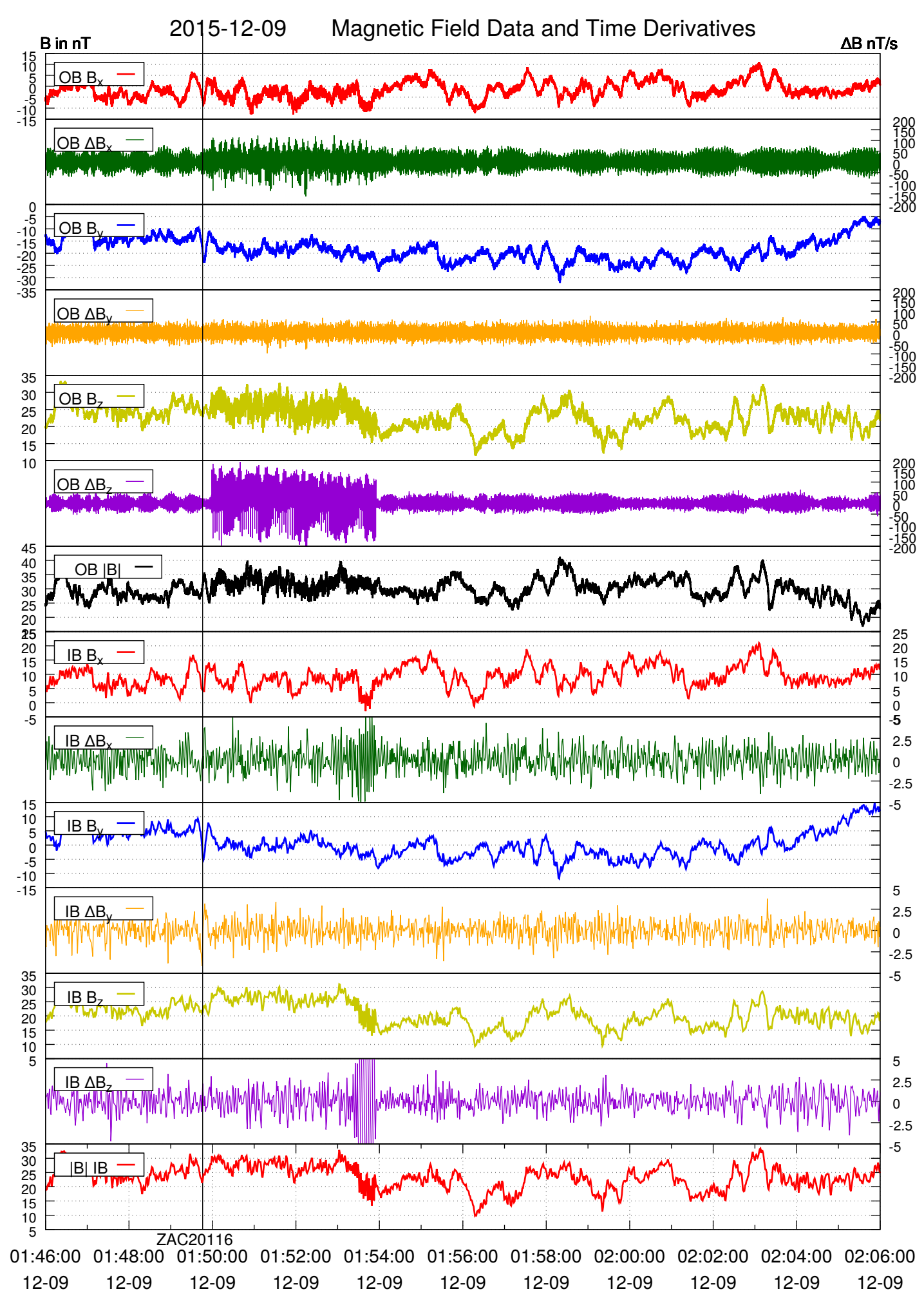
2015-12-09 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:46:00 12-09
01:48:00 12-09
01:50:00 12-09
01:52:00 12-09
01:54:00 12-09
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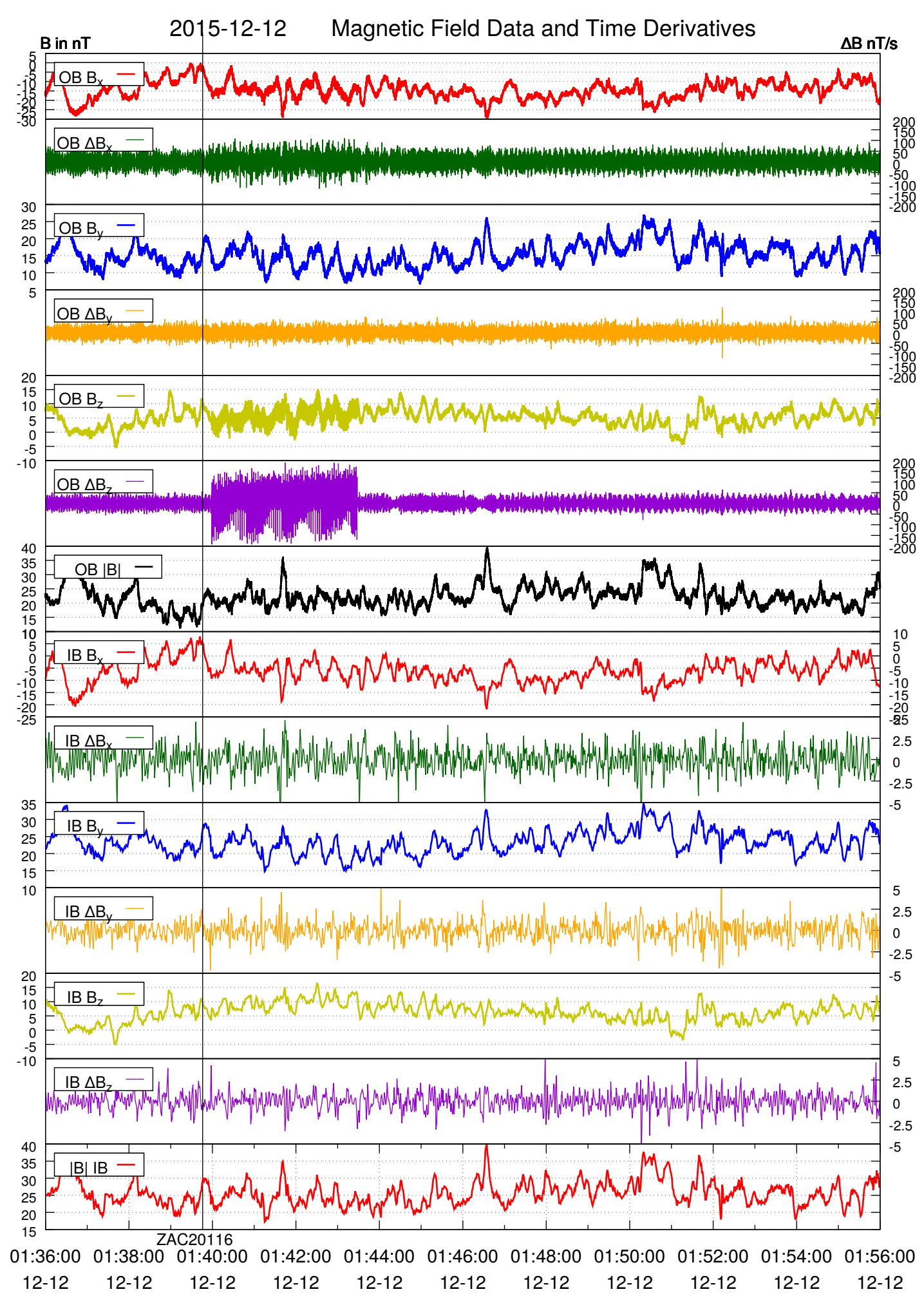
02:04:00 12-09
02:06:00 12-09


2015-12-12 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 12-12
01:38:00 12-12
01:40:00 12-12
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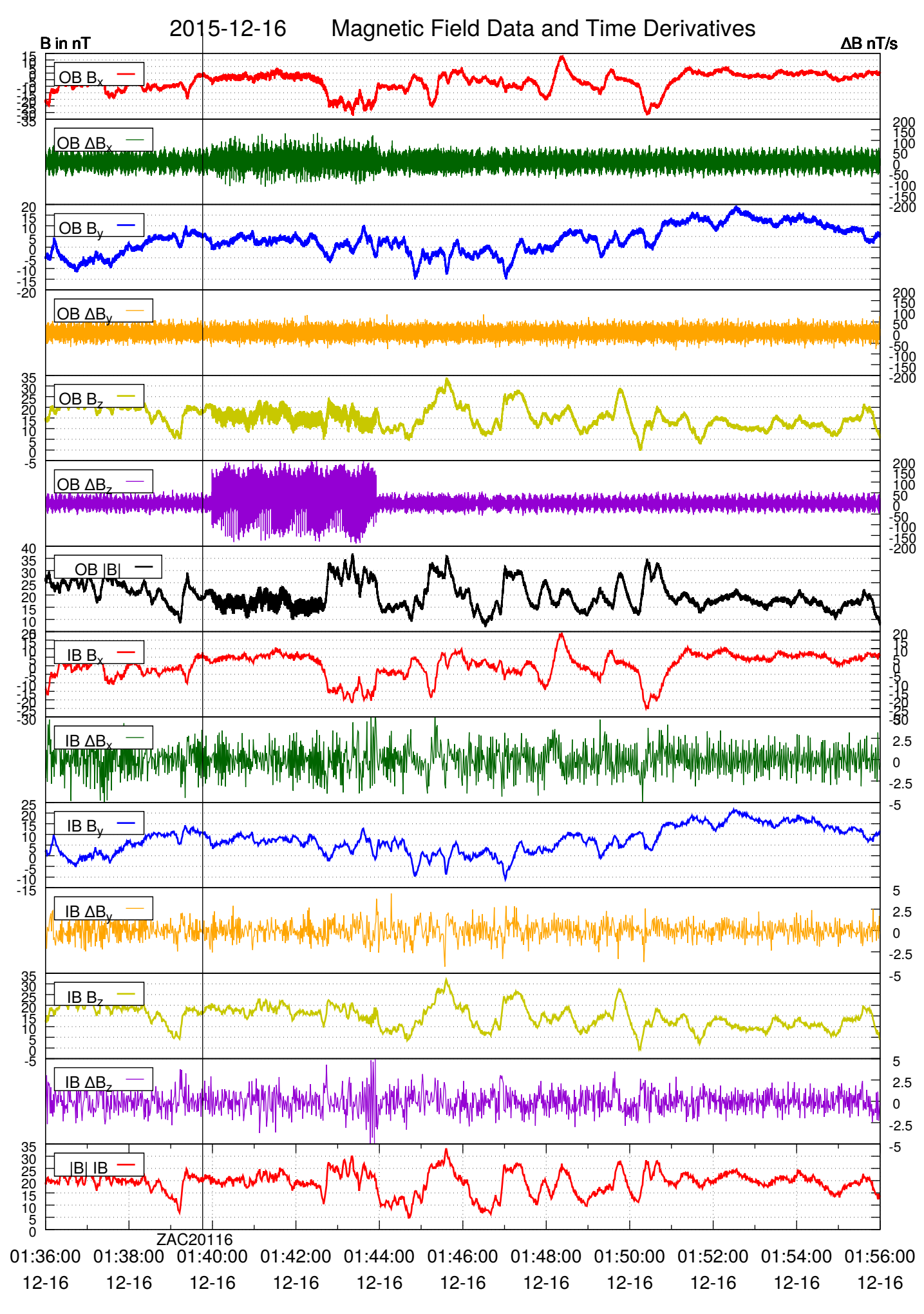
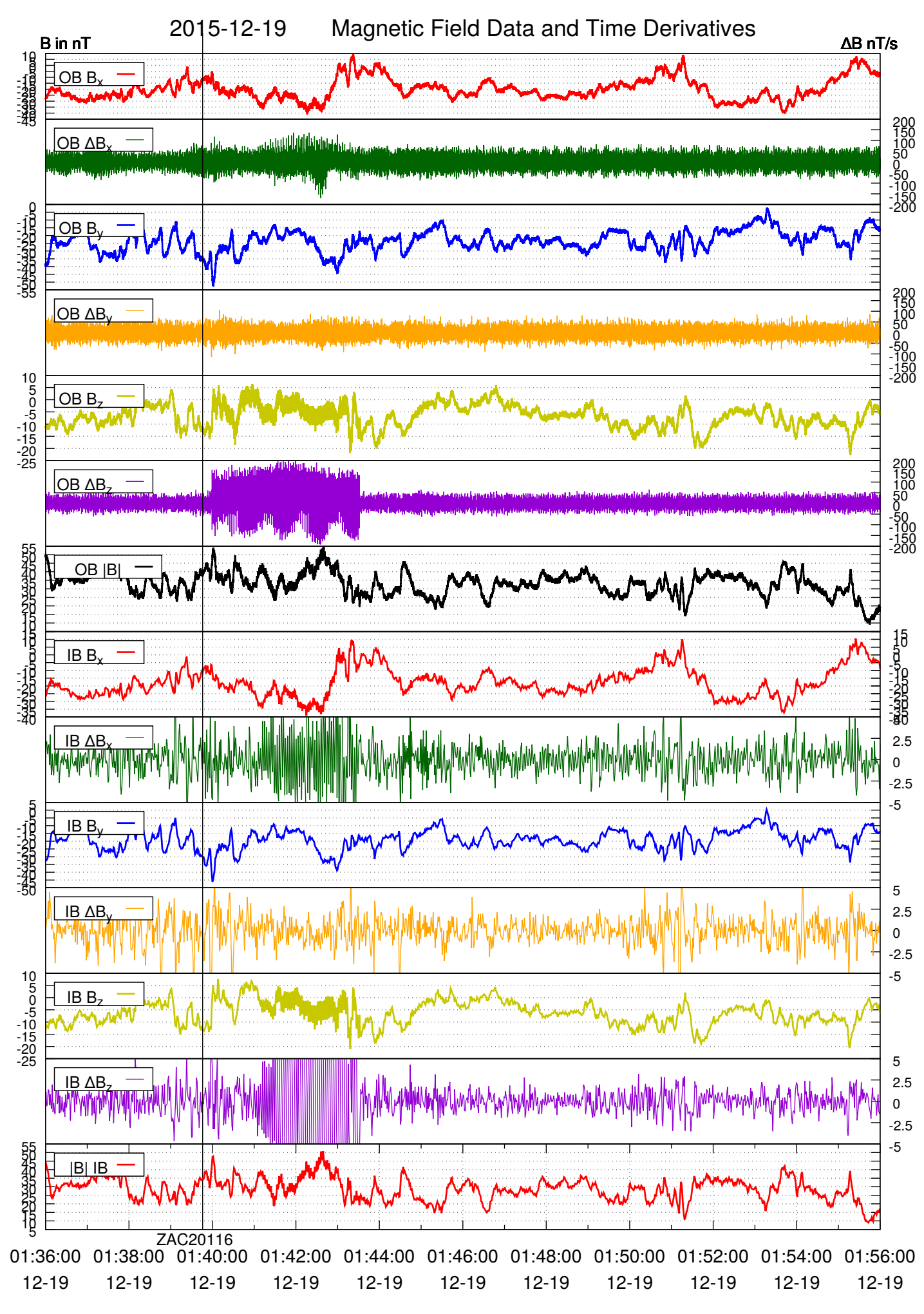
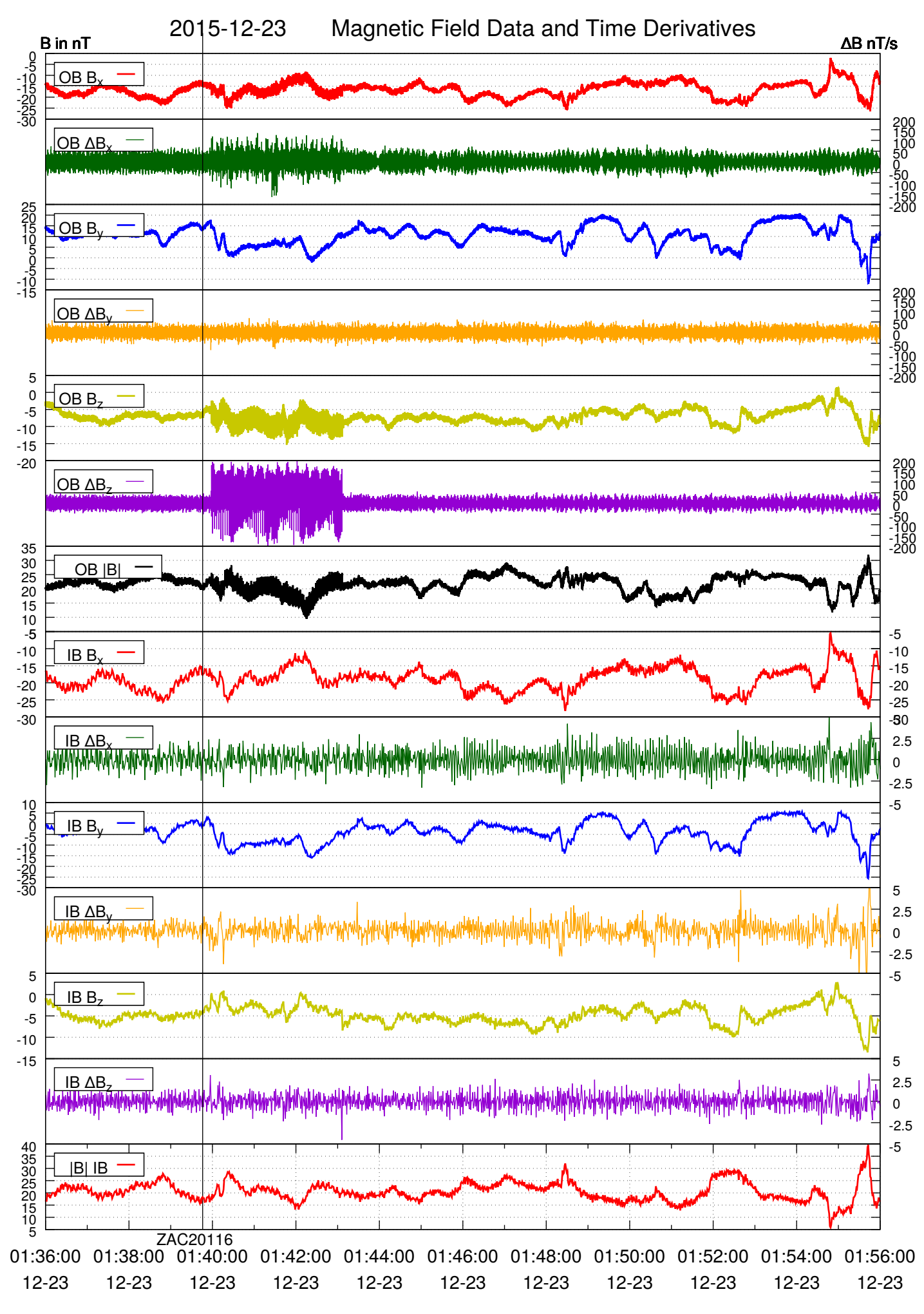
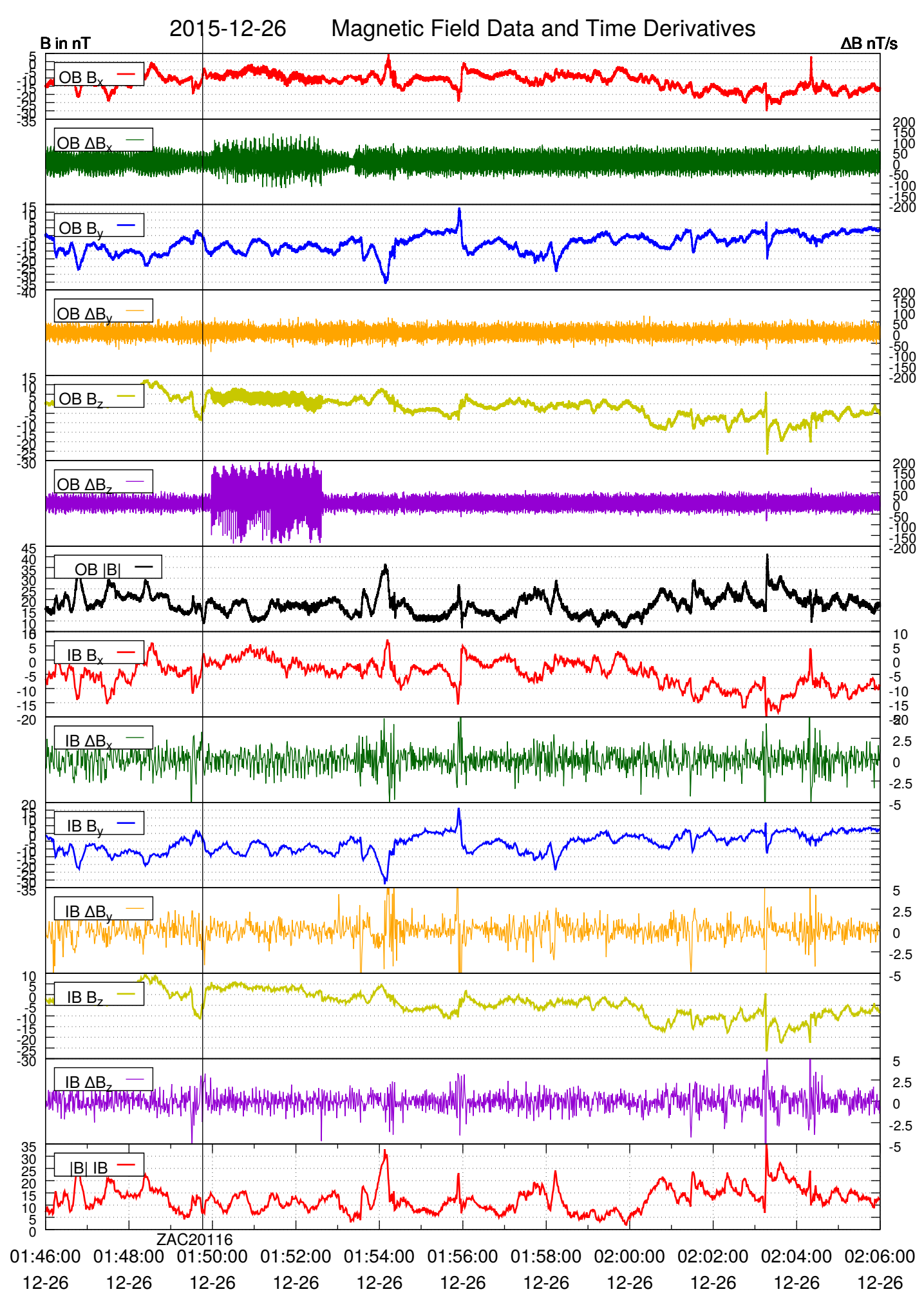
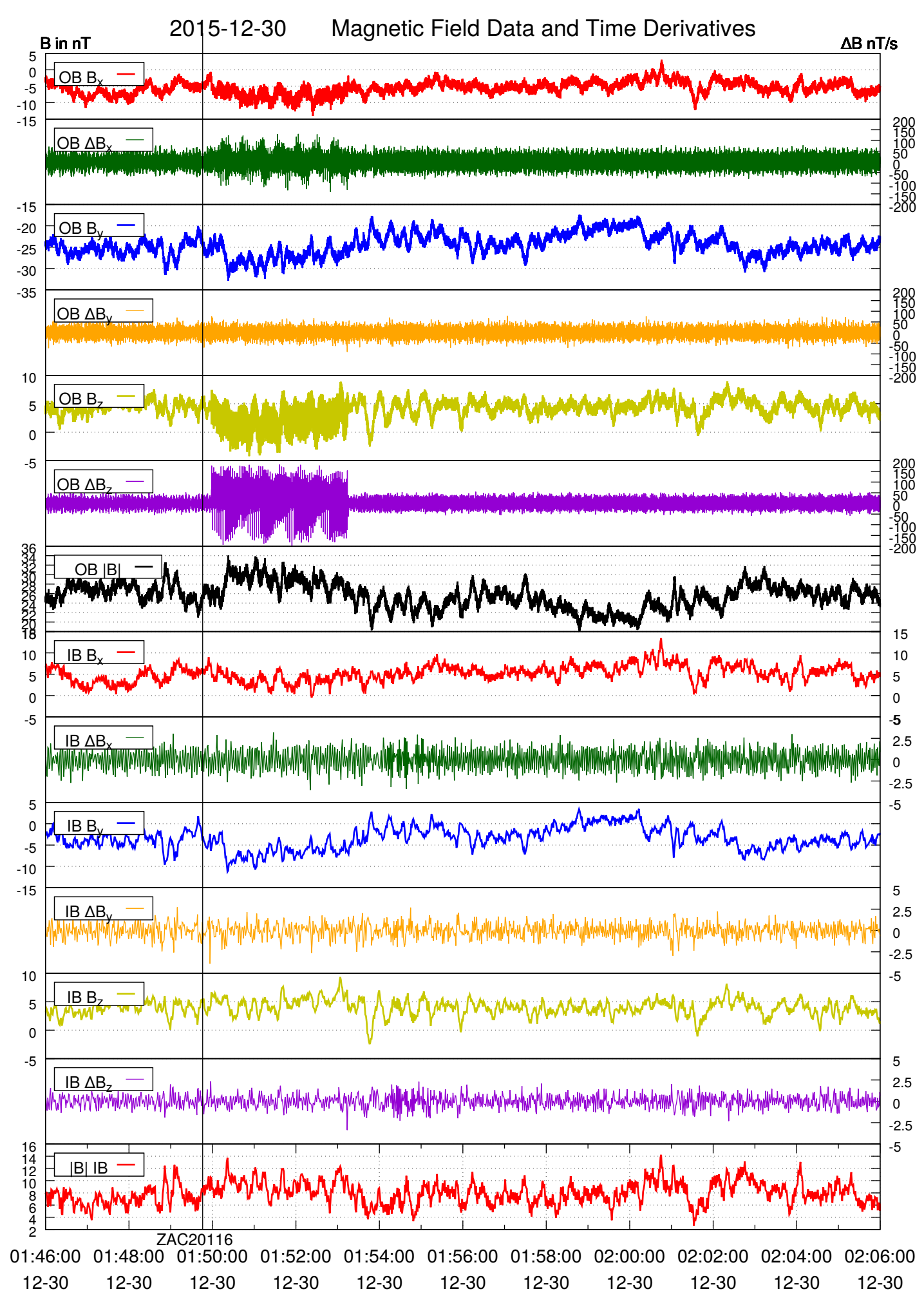
01:44:00 12-12
01:46:00 12-12
01:48:00 12-12
01:50:00 12-12
01:52:00 12-12
01:54:00 12-12
01:56:00 12-12

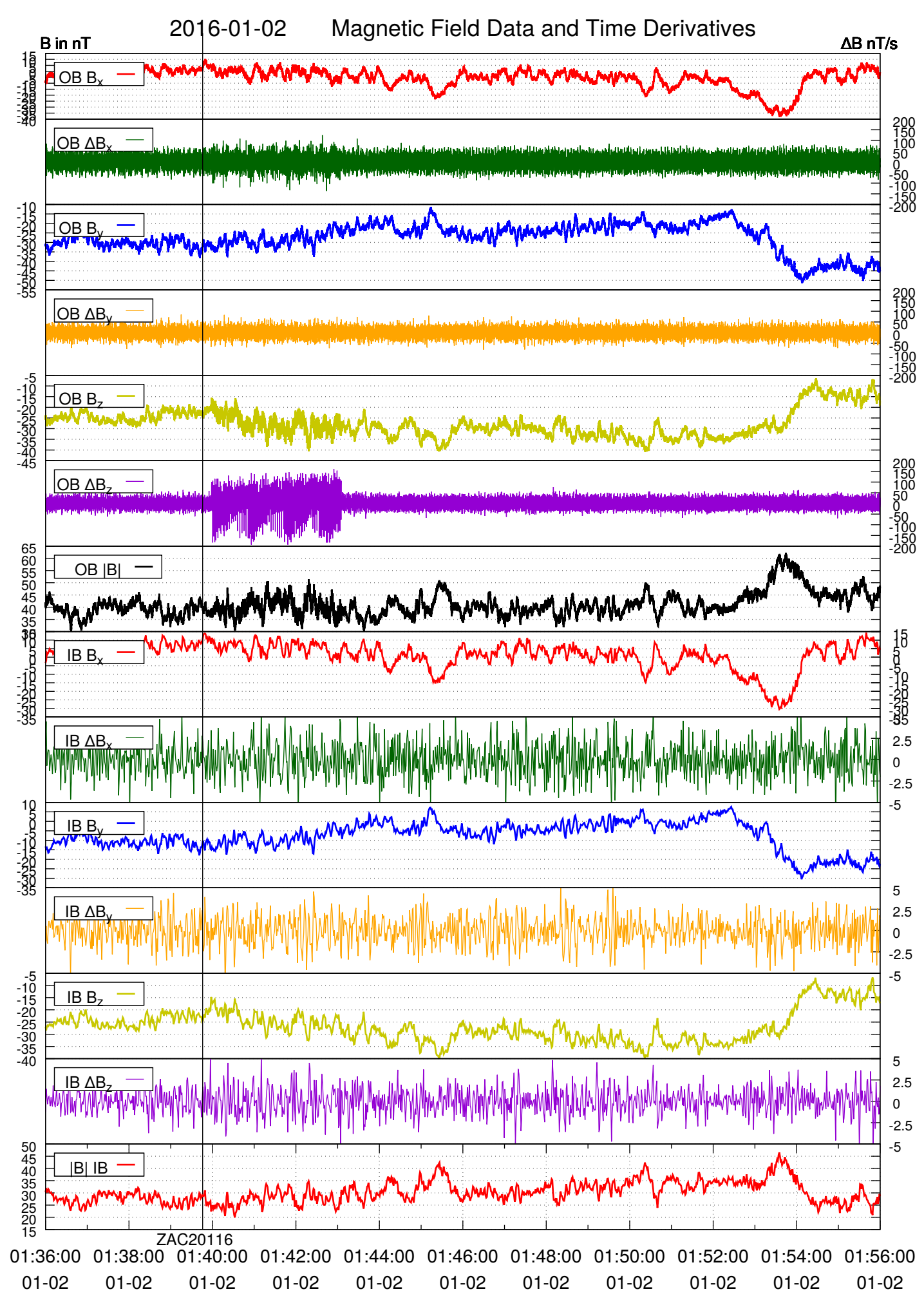

2015-12-16 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 12-16
01:38:00 12-16
01:40:00 12-16
01:42:00 12-16
01:44:00 12-16
01:46:00 12-16
01:48:00 12-16
01:50:00 12-16
01:52:00 12-16
01:54:00 12-16
01:56:00 12-16

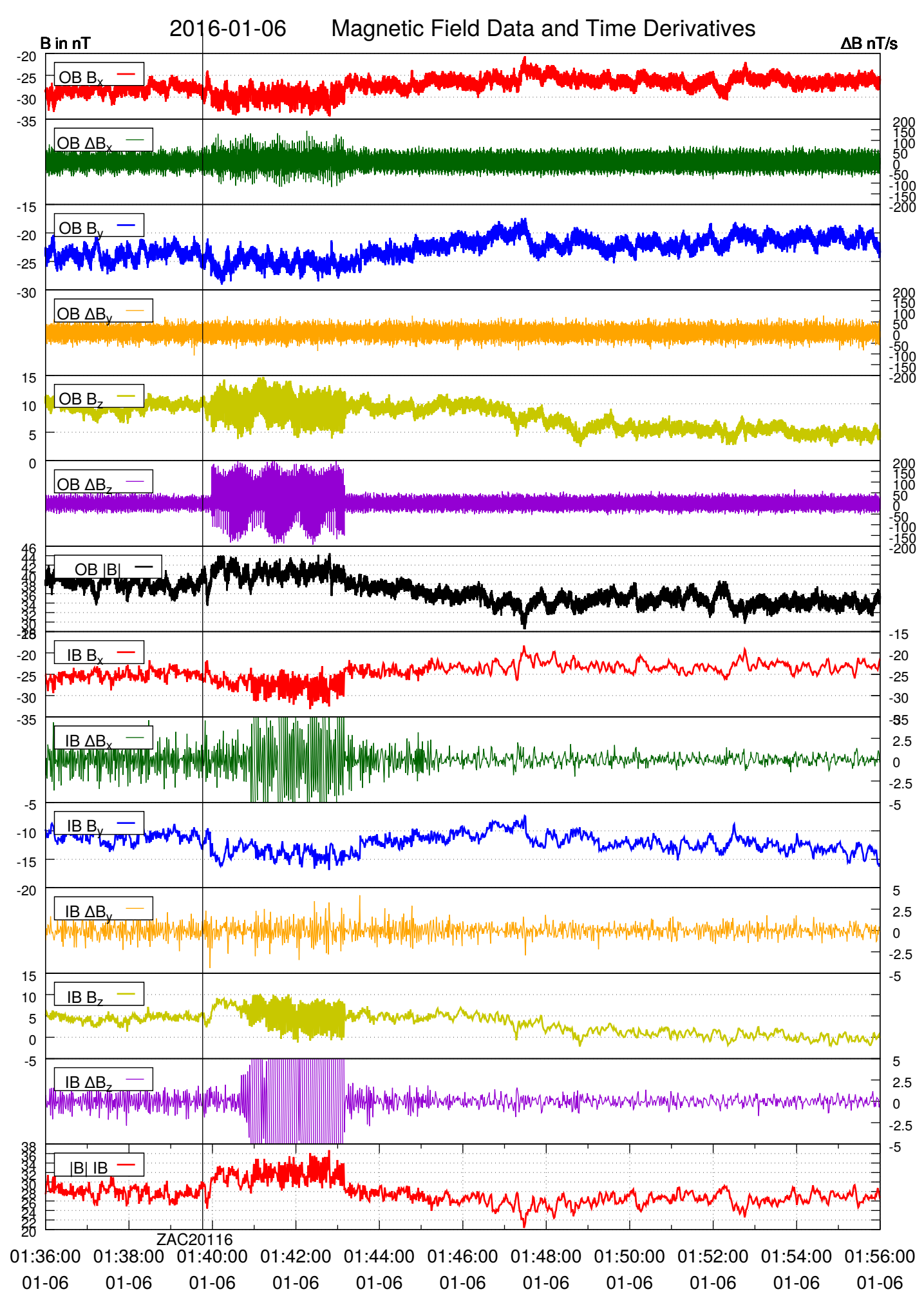

2015-12-19 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 12-19
01:38:00 12-19
01:40:00 12-19
01:42:00 12-19
01:44:00 12-19
01:46:00 12-19
01:48:00 12-19
01:50:00 12-19
01:52:00 12-19
01:54:00 12-19
01:56:00 12-19

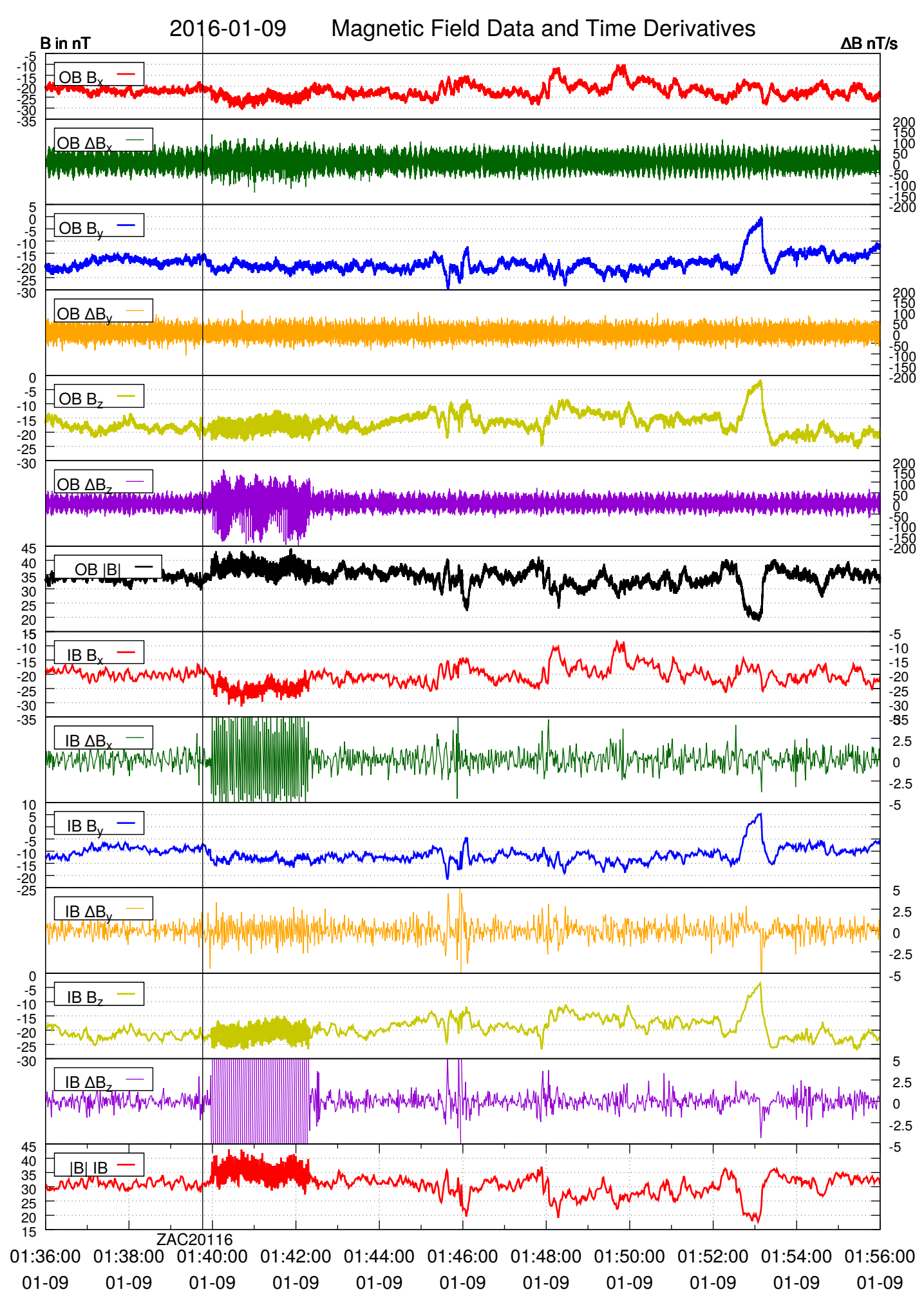

2015-12-23 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 12-23
01:38:00 12-23
01:40:00 12-23
01:42:00 12-23
01:44:00 12-23
01:46:00 12-23
01:48:00 12-23
01:50:00 12-23
01:52:00 12-23
01:54:00 12-23
01:56:00 12-23


2015-12-26 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:46:00 12-26
01:48:00 12-26
01:50:00 12-26
01:52:00 12-26
01:54:00 12-26
01:56:00 12-26
01:58:00 12-26
02:00:00 12-26
02:02:00 12-26
02:04:00 12-26
02:06:00 12-26


2015-12-30 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:46:00 12-30
01:48:00 12-30
01:50:00 12-30
01:52:00 12-30
01:54:00 12-30
01:56:00 12-30
01:58:00 12-30
02:00:00 12-30
02:02:00 12-30
02:04:00 12-30
02:06:00 12-30


2016-01-02 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB B_x
OB ΔB_x
OB B_y
OB ΔB_y
OB B_z
OB ΔB_z
OB |B|
IB B_x
IB ΔB_x
IB B_y
IB ΔB_y
IB B_z
IB ΔB_z
|B| IB
ZAC20116
01:36:00 01:38:00 01:40:00 01:42:00 01:44:00 01:46:00 01:48:00 01:50:00 01:52:00 01:54:00 01:56:00
01-02 01-02 01-02 01-02 01-02 01-02 01-02 01-02 01-02 01-02 01-02


2016-01-06 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 01-06
01:38:00 01-06
01:40:00 01-06
01:42:00 01-06
01:44:00 01-06
01:46:00 01-06
01:48:00 01-06
01:50:00 01-06
01:52:00 01-06
01:54:00 01-06
01:56:00 01-06


2016-01-09 Magnetic Field Data and Time Derivatives
B in nT
ΔB nT/s
OB Bx
OB ΔBx
OB By
OB ΔBy
OB Bz
OB ΔBz
OB |B|
IB Bx
IB ΔBx
IB By
IB ΔBy
IB Bz
IB ΔBz
|B| IB
ZAC20116
01:36:00 01:38:00 01:40:00 01:42:00 01:44:00 01:46:00 01:48:00 01:50:00 01:52:00 01:54:00 01:56:00
01-09 01-09 01-09 01-09 01-09 01-09 01-09 01-09 01-09 01-09 01-09