Joint Center for Satellite Data Assimilation

Office Note

CRTM: GOES-14 and -15 Sounder Spectral Response Functions

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1 Introduction

This document examines the spectral response functions (SRFs) of the GOES-O(14) and -P(15) sounder instrument. These SRFs are used to generate instrument resolution transmittances and, from those, transmittance model coefficients for use in the CRTM.

The original SRF data was obtained from the CIMSS GOES Calibration website in September 2008 and some anomalous features were identified. Revised SRF data from ITT was received in April 2010 (GOES-14) and June 2010 (GOES-15). This document has been updated to determine if the anomalies in the original SRF data have been removed.

2 GOES-O(14) Sounder SRFs

2.1 Nominal SRF plots

Plots of the revised SRF data for each channel detector, along with the detector average, are shown in appendix A. SRF plots for channels 1-6 are shown in figure A.1, channels 7-12 in figure A.2, and channels 13-18 in figure A.3.

2.2 Old Anomalous Features

Inspection of the original GOES-0(14) sounder SRFs showed both ambiguous and clear anomalies for several channels. Comparisons of the original and revised SRF data for the suspect channels are shown in figures 2.1 to 2.6.

2.2.1 Channel 5

Original SRF: The begin point of this channel was unlike any others in that it starts at a relatively large value.

Revised SRF: The anomaly is no longer present. See figure 2.1.

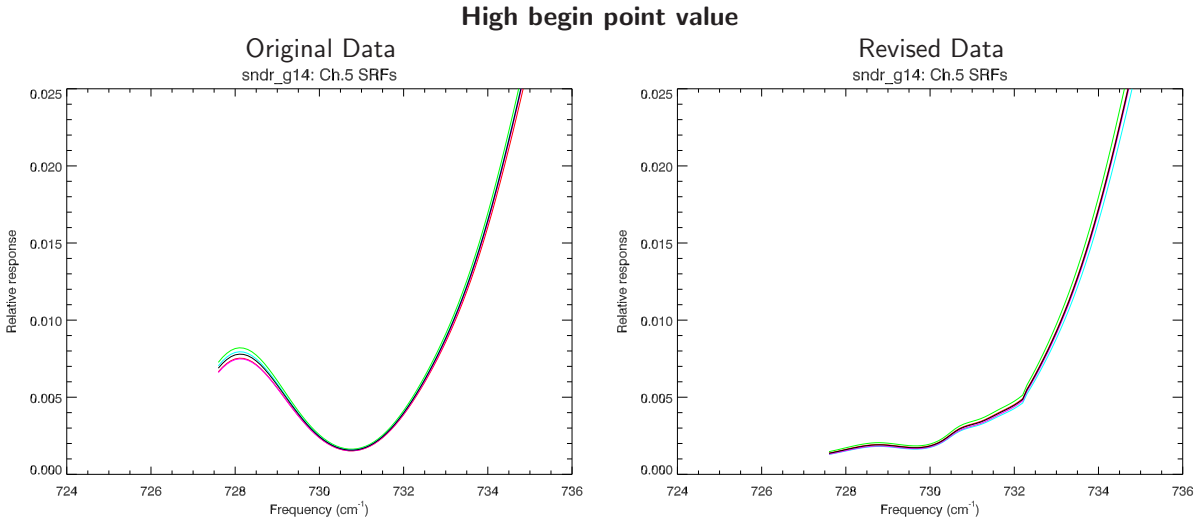

Figure 2.1: Magnification of GOES-O(14) Sounder individual detector and average SRFs for channel 5. The detector average SRF is plotted in black. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data with no anomaly.

2.2.2 Channel 6

Original SRF: The negative values for the low-frequency beginning portions of this SRF have been truncated. The shape of the remaining positive data begged the question: are these data real or an artifact of the fitting algorithm (high order polynomial or spline)?

Revised SRF: The anomaly is no longer present. See figure 2.2.

2.2.3 Channel 9

Original SRF: There are clear, and for 1030cm^{-1} quite large, discontinuities in the data.

Revised SRF: The anomaly is no longer present. See figure 2.3.

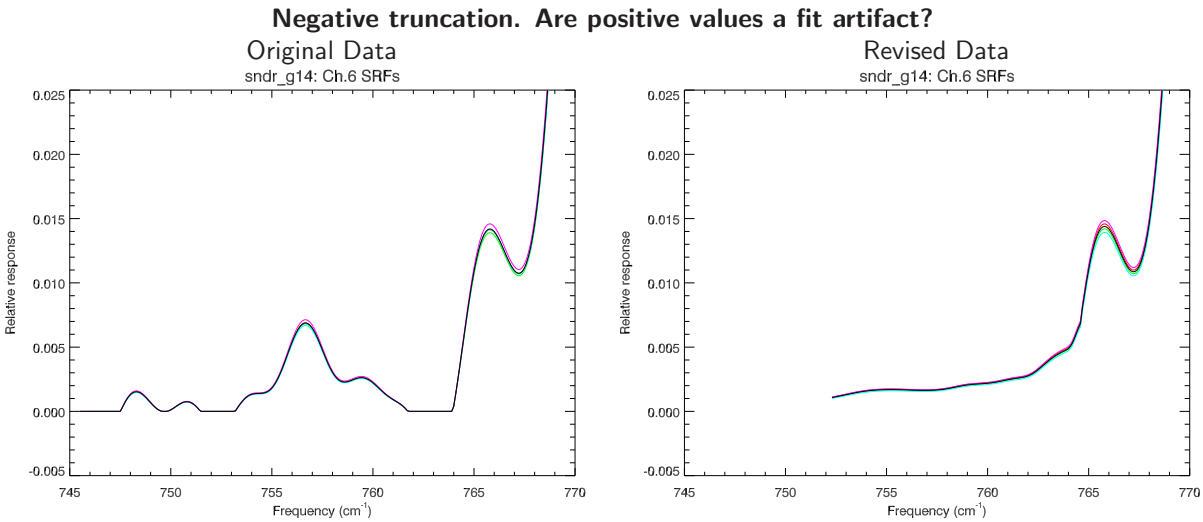

Figure 2.2: Magnification of GOES-O(14) Sounder individual detector and average SRFs for channel 6. The detector average SRF is plotted in black. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data with no anomaly.

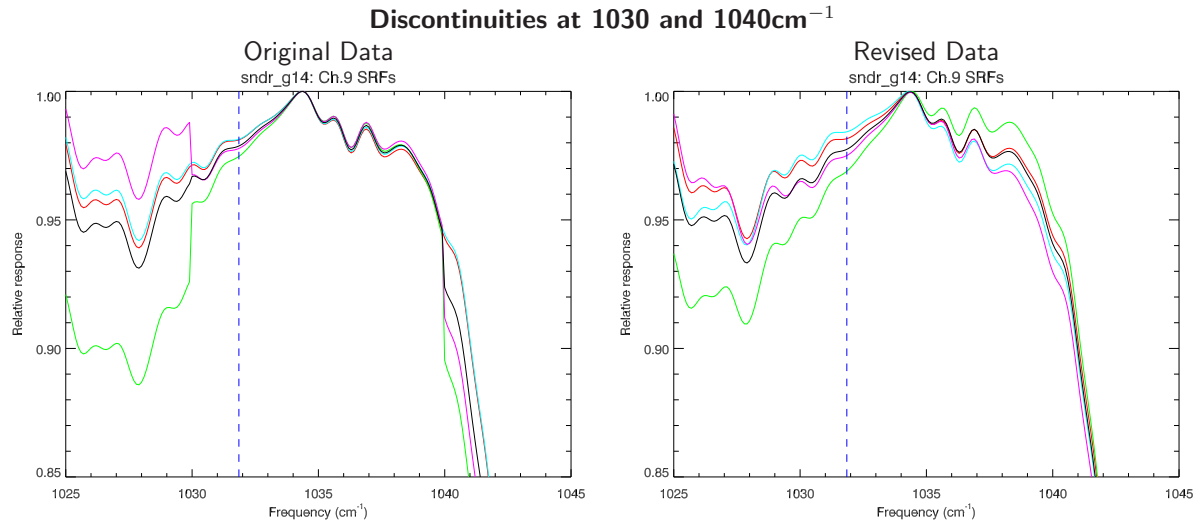

Figure 2.3: Magnification of GOES-O(14) Sounder individual detector and average SRFs for channel 9. The detector average SRF is plotted in black. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data with no anomaly.

2.2.4 Channel 10

Original SRF: Discontinuities in the SRFs are evident, occuring every 10cm^{-1}.

Revised SRF: The anomaly is no longer present. See figure 2.4.

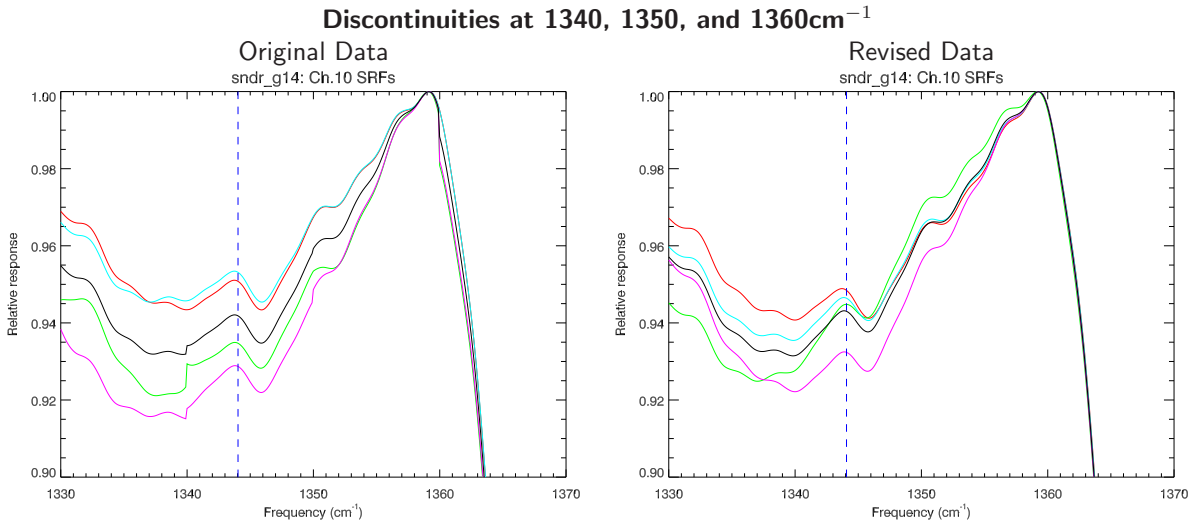

Figure 2.4: Magnification of GOES-O(14) Sounder individual detector and average SRFs for channel 10. The detector average SRF is plotted in black. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data with no anomaly.

2.2.5 Channel 11

Original SRF: Discontinuities at 10cm^{-1} intervals.

Revised SRF: The anomaly is no longer present. See figure 2.5.

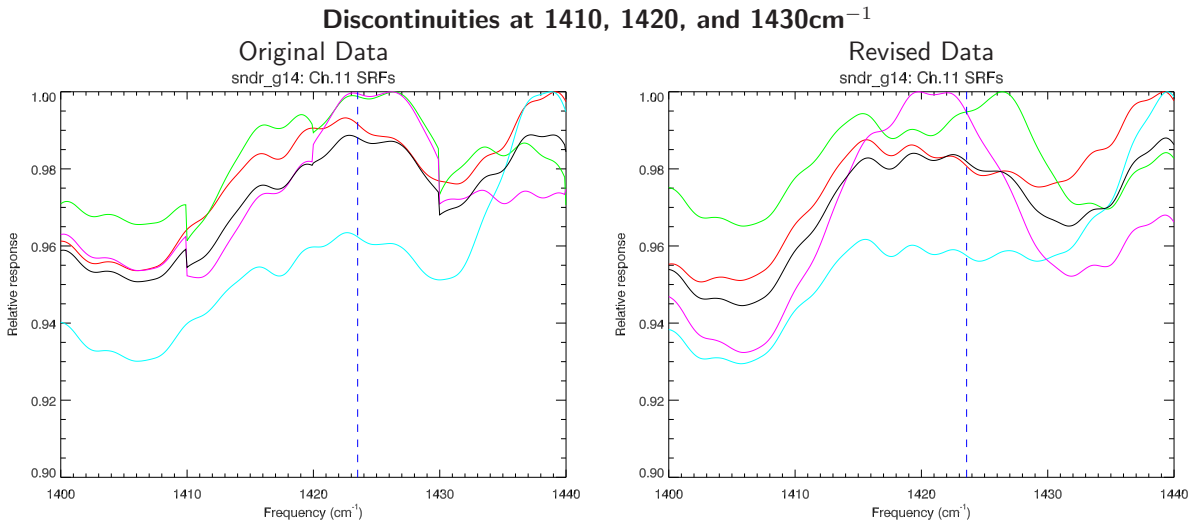

Figure 2.5: Magnification of GOES-O(14) Sounder individual detector and average SRFs for channel 11. The detector average SRF is plotted in black. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data with no anomaly.

2.2.6 Channel 12

Original SRF: Discontinuities at 10cm^{-1} intervals.

Revised SRF: The anomaly is no longer present. See figure 2.6.

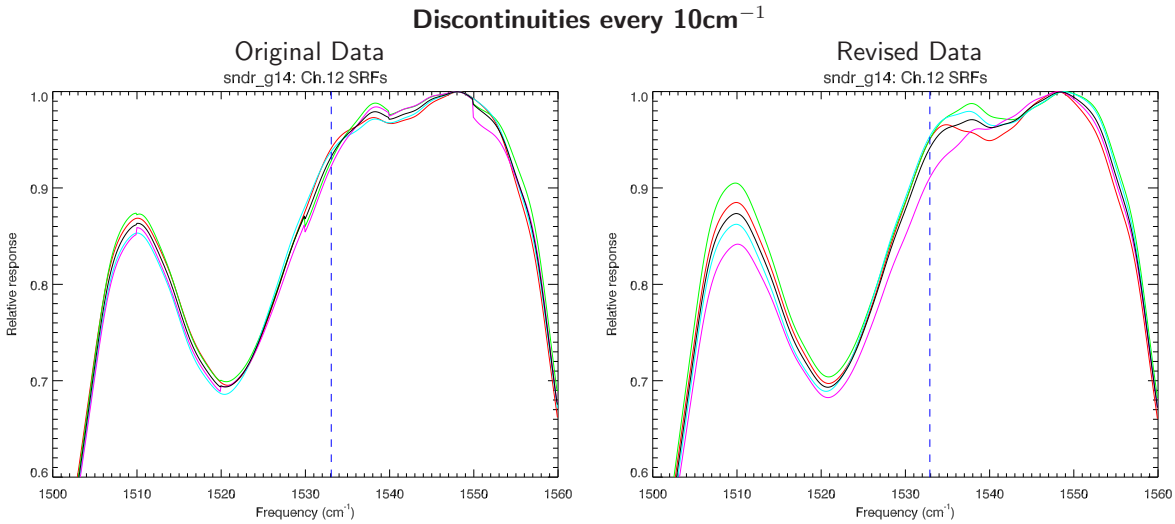

Figure 2.6: Magnification of GOES-O(14) Sounder individual detector and average SRFs for channel 12. The detector average SRF is plotted in black. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data with no anomaly.

2.3 InSb Detector Differences in Revised SRFs

Close inspection of the shortwave sounder channels that use InSb detectors, ch.13 to ch.18, shows that differences in the individual detector responses were *introduced* with the revised SRF data. Comparisons of the original and revised SRF data, shown as a difference from the average SRF for channels 13 to 18 are shown in figures 2.7 to 2.12. It appears that the detector #4 response is behaving differently from the others for channels 13 to 18.

2.3.1 Channel 13

Original SRF: No differences observed between detector SRFs.

Revised SRF: Detector differences are now present. See figure 2.7.

2.3.2 Channel 14

Original SRF: No differences observed between detector SRFs.

Revised SRF: Detector differences are now present. See figure 2.8.

2.3.3 Channel 15

Original SRF: No differences observed between detector SRFs.

Revised SRF: Detector differences are now present. See figure 2.9.

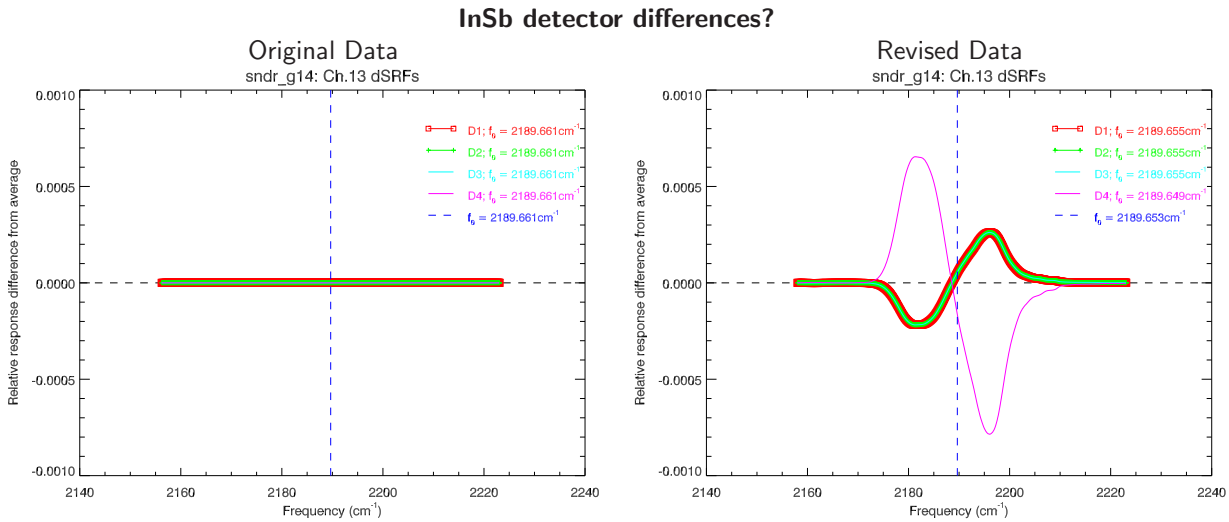

Figure 2.7: Difference of the GOES-O(14) Sounder individual detector SRFs from the average SRF for channel 13. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing no differences between detectors. **(Right Panel)** Revised SRF data now showing differences between detectors.

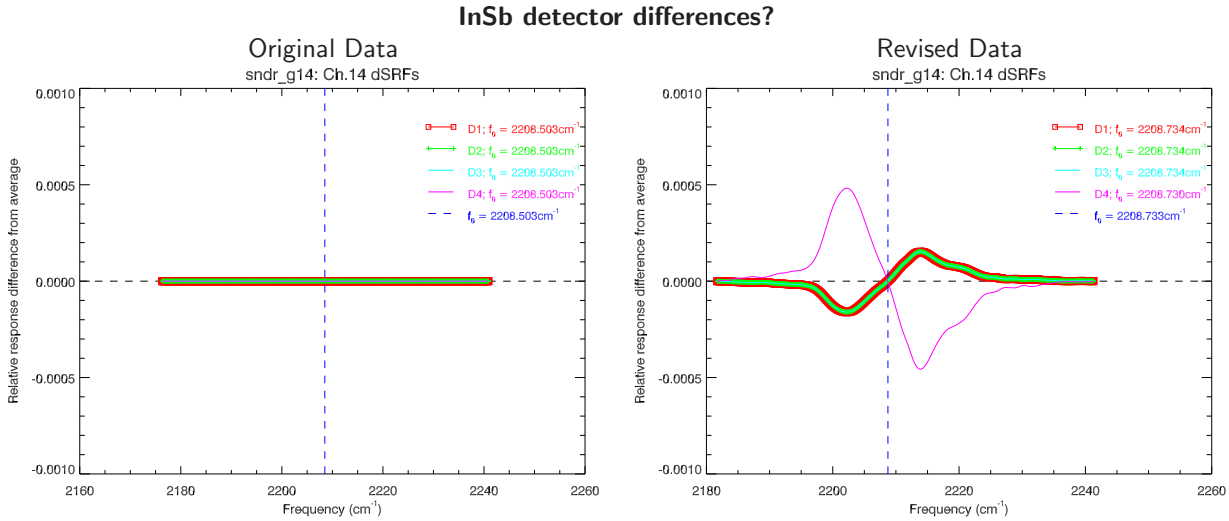

Figure 2.8: Difference of the GOES-O(14) Sounder individual detector SRFs from the average SRF for channel 14. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing no differences between detectors. **(Right Panel)** Revised SRF data now showing differences between detectors.

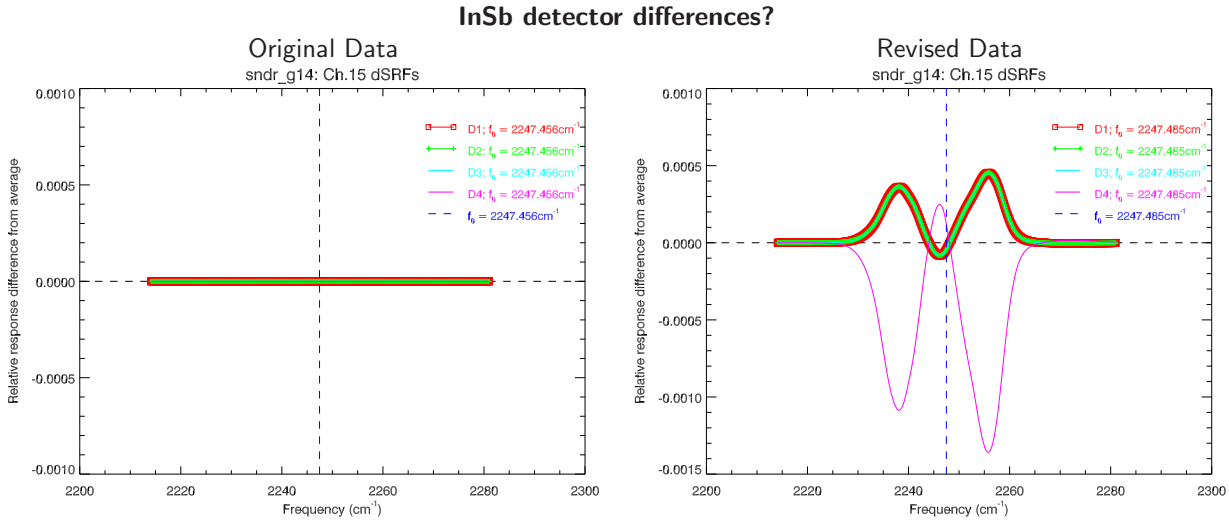

Figure 2.9: Difference of the GOES-O(14) Sounder individual detector SRFs from the average SRF for channel 15. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing no differences between detectors. **(Right Panel)** Revised SRF data now showing differences between detectors.

2.3.4 Channel 16

Original SRF: No differences observed between detector SRFs.

Revised SRF: Detector differences are now present. See figure 2.10.

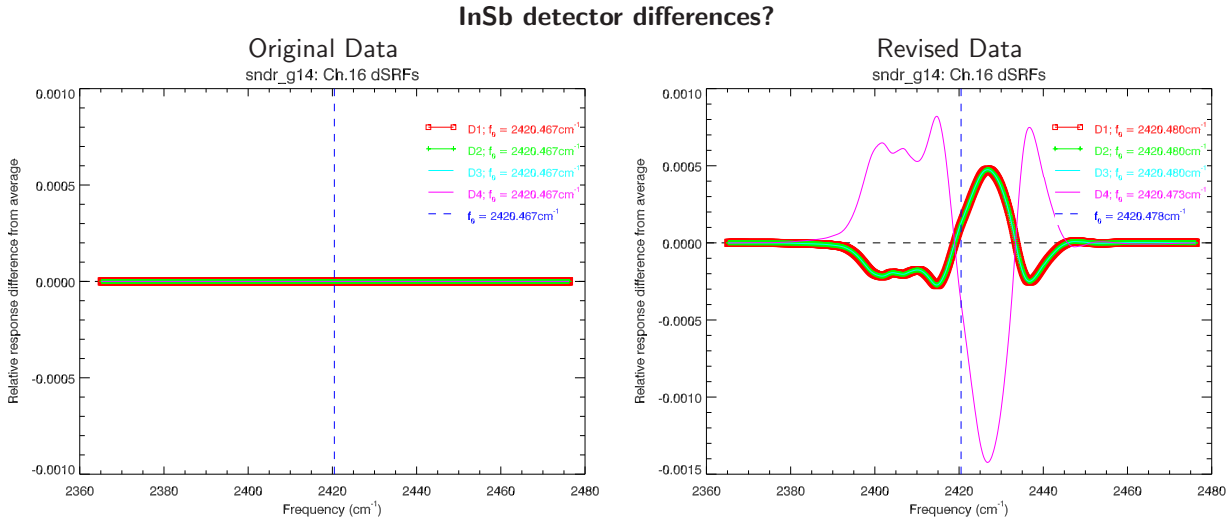

Figure 2.10: Difference of the GOES-O(14) Sounder individual detector SRFs from the average SRF for channel 16. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing no differences between detectors. **(Right Panel)** Revised SRF data now showing differences between detectors.

2.3.5 Channel 17

Original SRF: No differences observed between detector SRFs.

Revised SRF: Detector differences are now present. See figure 2.11.

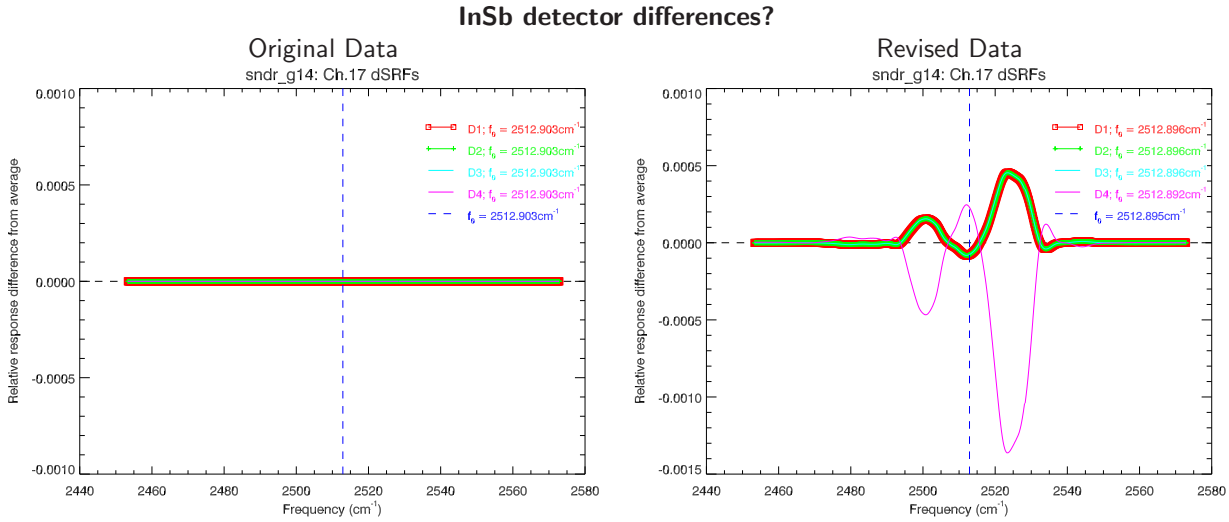

Figure 2.11: Difference of the GOES-O(14) Sounder individual detector SRFs from the average SRF for channel 17. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing no differences between detectors. **(Right Panel)** Revised SRF data now showing differences between detectors.

2.3.6 Channel 18

Original SRF: No differences observed between detector SRFs.

Revised SRF: Detector differences are now present. See figure 2.12.

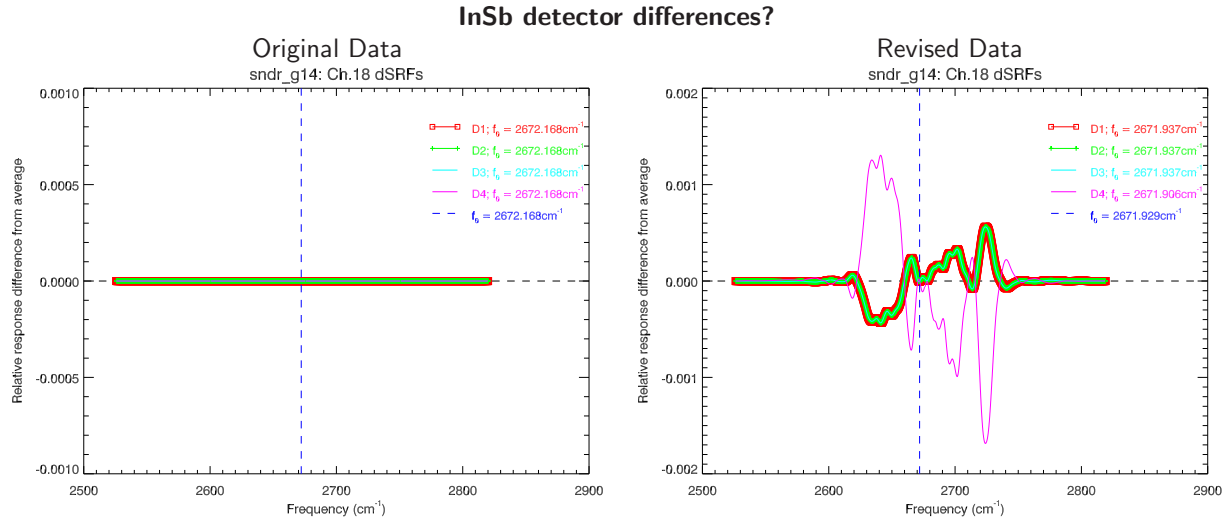

Figure 2.12: Difference of the GOES-O(14) Sounder individual detector SRFs from the average SRF for channel 18. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing no differences between detectors. **(Right Panel)** Revised SRF data now showing differences between detectors.

2.4 Central Frequency Changes

Comparisons of the original and revised GOES-14 Sounder SRF data show that the relative differences between the detector SRFs have changed. A clear example of this is shown in the channel 12 comparison of figure 2.6. The impact of these SRF changes on the central frequencies, f_0, are shown in table 2.1. The change in the average SRF central frequencies are small. Looking at the detector central frequencies, their changes are also small with the possible exception of channel 8 detector #2 where the central frequency shift is $\sim$ -2.5cm^{-1}.

Channel	Original f_0 (cm^{-1})	Revised f_0 (cm^{-1})	Δf_0 (cm^{-1})	D1 Δf_0	D2 Δf_0	D3 Δf_0	D4 Δf_0
				(cm^{-1})			
1	680.3388	680.2358	-0.1030	-0.2675	0.3276	-0.4209	-0.0529
2	695.7302	695.5755	-0.1547	-0.0211	0.0339	-0.2884	-0.3475
3	710.4557	710.3755	-0.0802	0.0034	-0.0104	-0.0999	-0.2092
4	733.3058	733.2341	-0.0718	-0.1769	-0.1228	0.0362	-0.0248
5	747.7370	747.6685	-0.0685	-0.0728	-0.1266	0.0258	-0.1010
6	787.2929	787.0771	-0.2157	-0.1592	-0.3857	-0.1190	-0.2019
7	831.2375	831.1985	-0.0390	0.2290	0.8678	-0.8686	-0.3860
8	910.4850	909.9050	-0.5800	-0.4458	-2.4180	0.9216	-0.3941
9	1031.8518	1031.8502	-0.0016	0.1105	0.1011	-0.1082	-0.1150
10	1344.0341	1344.0710	0.0368	-0.1153	0.2065	-0.0356	0.0907
11	1423.5037	1423.5789	0.0751	0.2837	-0.3656	0.4840	-0.0971
12	1533.0697	1532.9034	-0.1663	-0.4956	-0.4039	-0.0556	0.2610
13	2189.6611	2189.6534	-0.0077	-0.0063	-0.0063	-0.0063	-0.0118
14	2208.5027	2208.7334	0.2307	0.2317	0.2317	0.2317	0.2278
15	2247.4560	2247.4846	0.0286	0.0286	0.0286	0.0286	0.0288
16	2420.4666	2420.4781	0.0115	0.0132	0.0132	0.0132	0.0063
17	2512.9033	2512.8948	-0.0086	-0.0075	-0.0075	-0.0075	-0.0117
18	2672.1685	2671.9288	-0.2397	-0.2319	-0.2319	-0.2319	-0.2626

Table 2.1: Channel central frequencies for the GOES-14 Sounder derived from the original and revised average SRF, along with the change in f_0, and those for each detector's SRF.

3 GOES-P(15) Sounder SRFs

3.1 Nominal SRF plots

Plots of the revised SRF data for each channel detector, along with the detector average, are shown in appendix B. SRF plots for channels 1-6 are shown in figure B.1, channels 7-12 in figure B.2, and channels 13-18 in figure B.3.

3.2 Anomalous Features

Inspection of the original GOES-P(15) sounder SRFs showed some possible anomalies for several channels. Comparisons of the original and revised SRF data for the suspect channels are shown in figures 3.1 to 3.8. Note in particular that the InSb detector differences seen in the shortwave channels SRFs still exist, but their magnitude and character have changed. The new detector-to-detector differences are very like those now seen in the GOES-O(14) sounder shortwave channel detector SRFs.

3.2.1 Channel 9

Original SRF: This is not so much an anomaly as an apparent overfit to noisy data using a spline (or high order polynomial). Are the high frequency undulations a fitting artifact?

Revised SRF: Similar behaviour is still present. See figure 3.1.

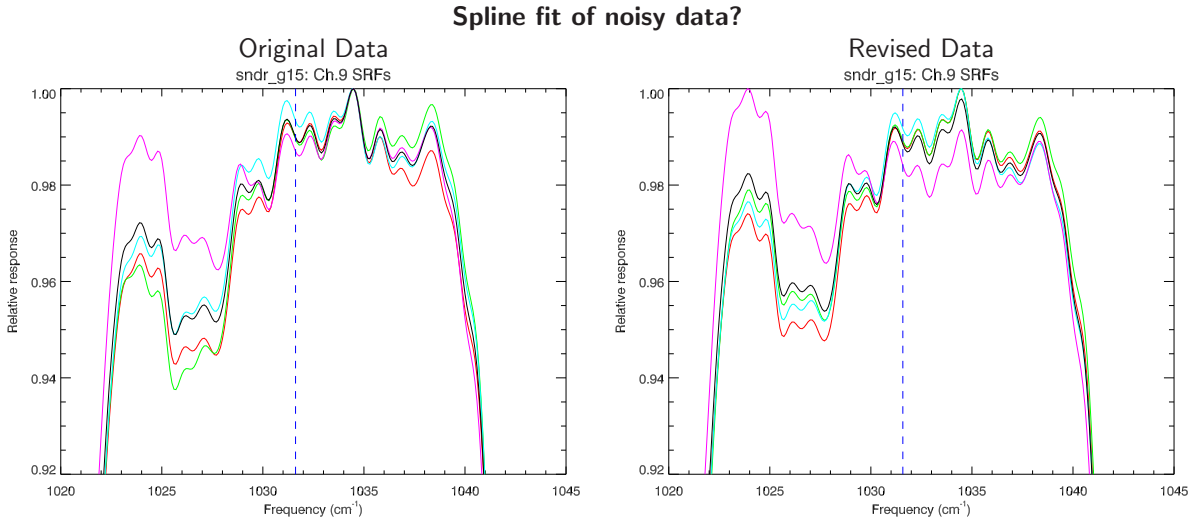

Figure 3.1: Magnification of GOES-P(15) Sounder individual detector and average SRFs for channel 9. The detector average SRF is plotted in black. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data showing similar behaviour.

3.2.2 Channel 11

Original SRF: Similarly to channel 9, there appear to be fit artifacts in the data.

Revised SRF: Similar behaviour is still present. See figure 3.2.

3.2.3 Channel 13

Original SRF: The detector plots are different. Previously the InSb detector channels showed no difference between detectors.

Revised SRF: Differences between detector SRFs are reduced, but still present. See figures 3.3 and 3.4.

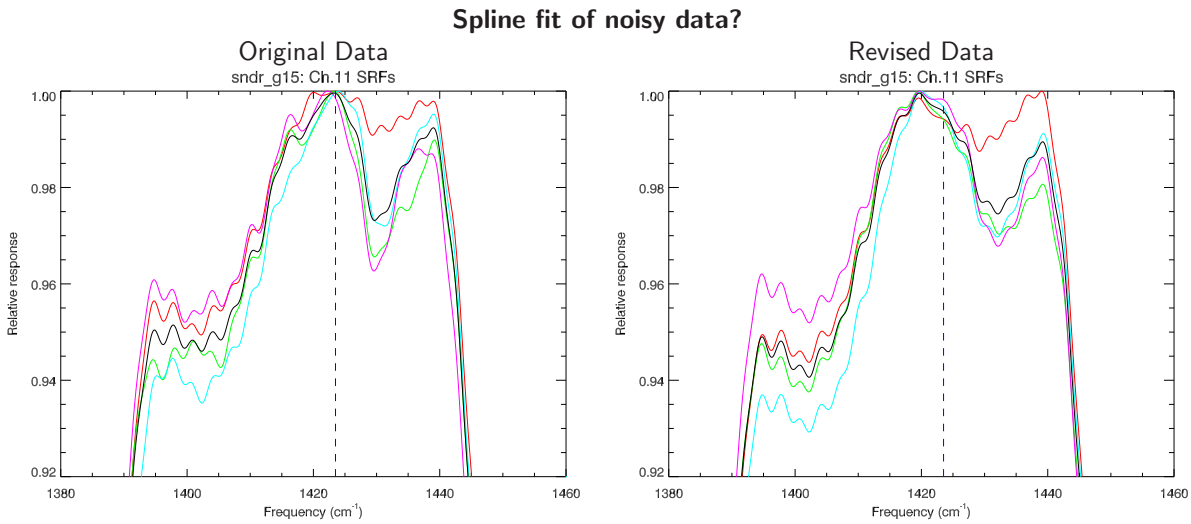

Figure 3.2: Magnification of GOES-P(15) Sounder individual detector and average SRFs for channel 11. The detector average SRF is plotted in black. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data showing similar behaviour.

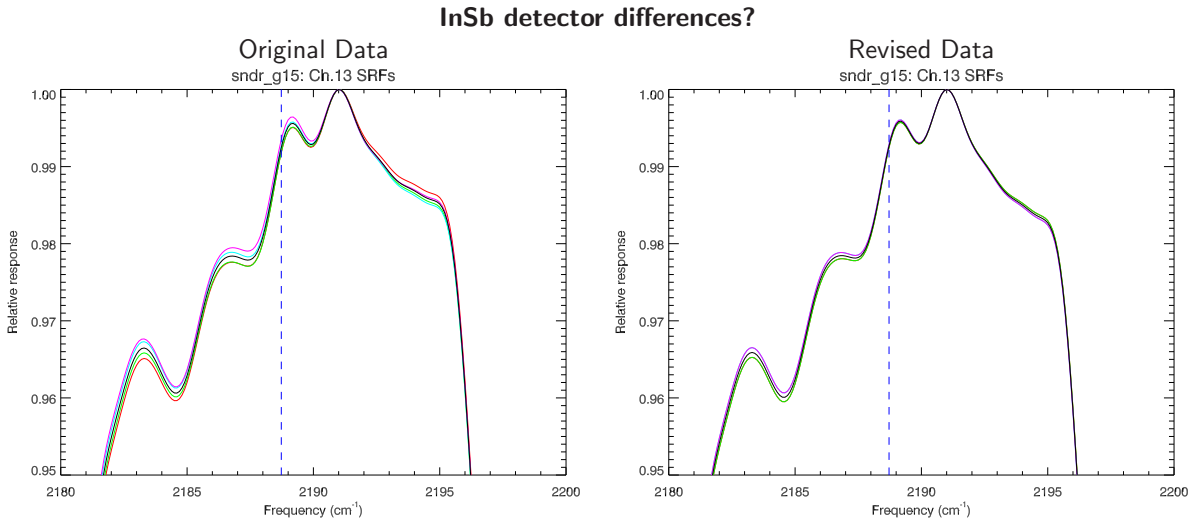

Figure 3.3: Magnification of GOES-P(15) Sounder individual detector and average SRFs for channel 13. The detector average SRF is plotted in black. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data still showing differences between detectors.

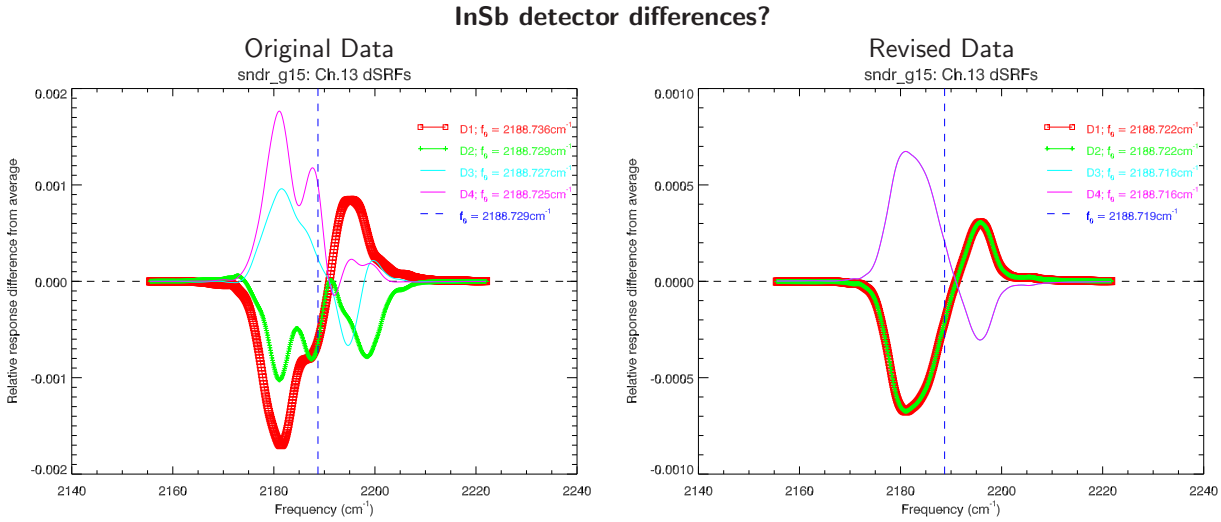

Figure 3.4: Difference of the GOES-P(15) Sounder individual detector SRFs from the average SRF for channel 13. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the differences between detectors. **(Right Panel)** Revised SRF data still showing differences.

3.2.4 Channel 17

Original SRF: Similarly to channel 13, we see significant differences between detector SRFs for InSb detectors.

Revised SRF: Differences between detector SRFs are reduced, but still present. See figures 3.5 and 3.6.

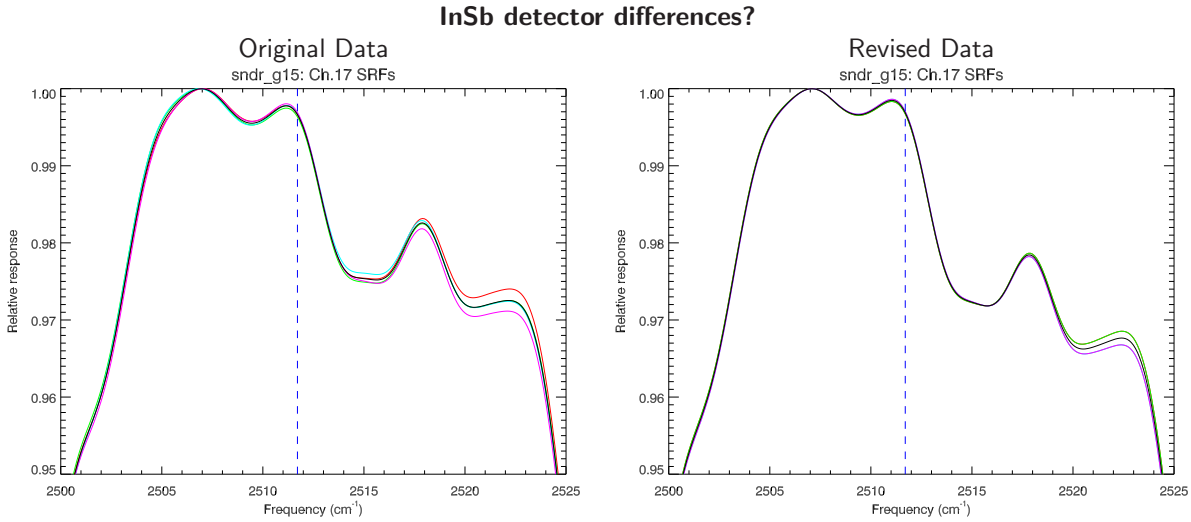

Figure 3.5: Magnification of GOES-P(15) Sounder individual detector and average SRFs for channel 17. The detector average SRF is plotted in black. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data still showing differences between detectors.

3.2.5 Channel 18

Original SRF: Again, we see significant differences between detector SRFs for InSb detectors.

Revised SRF: Differences between detector SRFs are reduced, but still present. See figures 3.7 and 3.8.

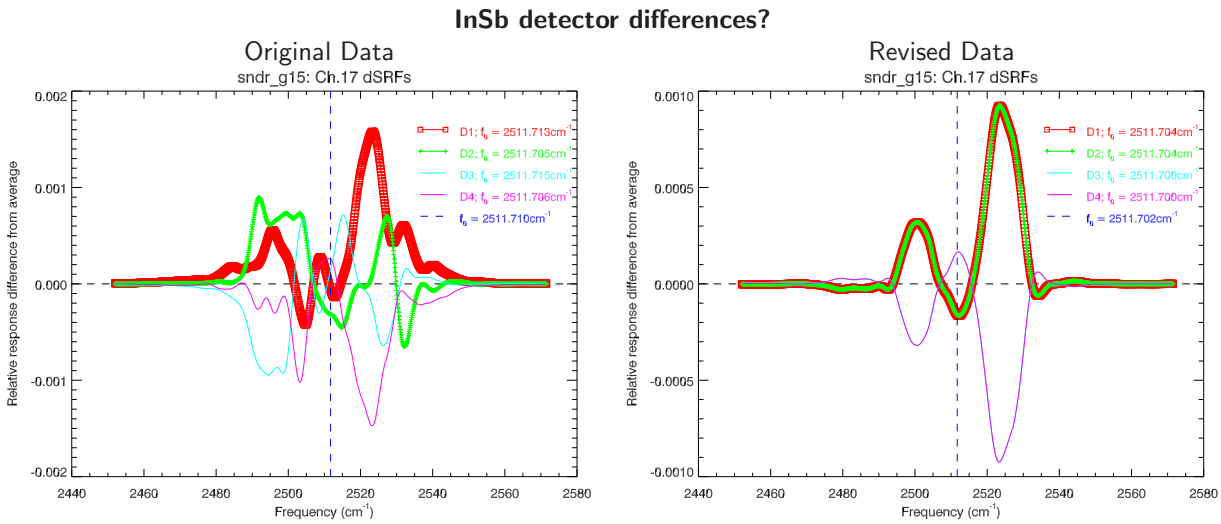

Figure 3.6: Difference of the GOES-P(15) Sounder individual detector SRFs from the average SRF for channel 17. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the differences between detectors. **(Right Panel)** Revised SRF data still showing differences.

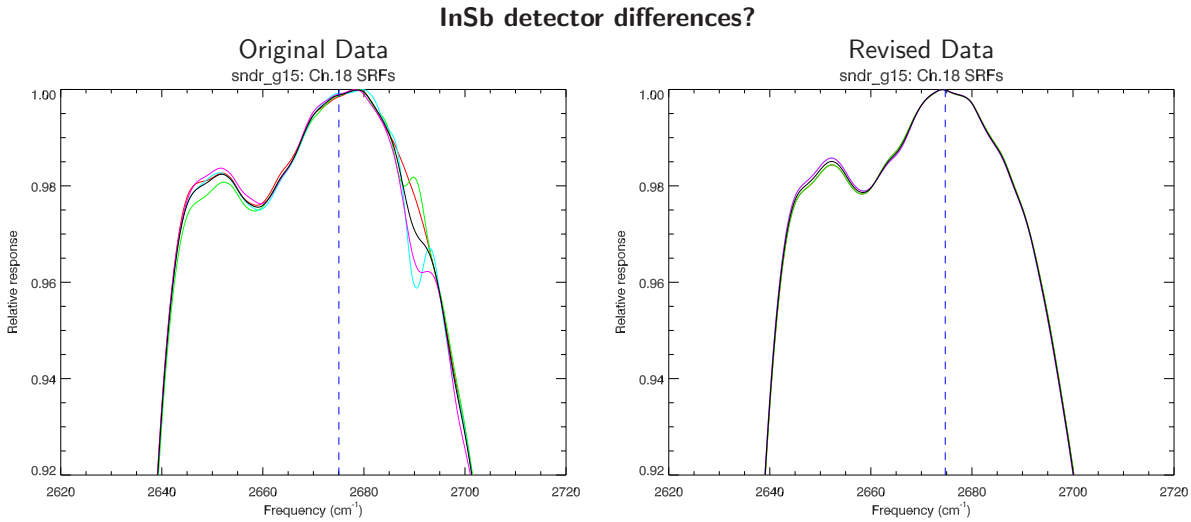

Figure 3.7: Magnification of GOES-P(15) Sounder individual detector and average SRFs for channel 18. The detector average SRF is plotted in black. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the anomaly. **(Right Panel)** Revised SRF data still showing differences between detectors.

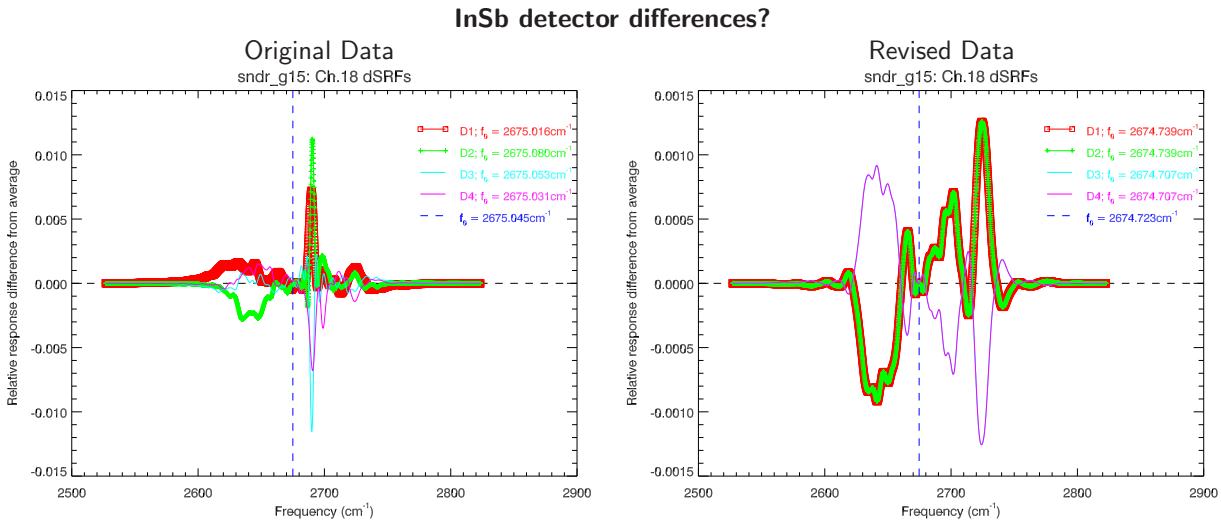

Figure 3.8: Difference of the GOES-P(15) Sounder individual detector SRFs from the average SRF for channel 18. The vertical dashed line indicates f_0. **(Left Panel)** Original SRF data showing the differences between detectors. **(Right Panel)** Revised SRF data still showing differences.

3.3 Central Frequency Changes

As with the GOES-14 revised SRF data, comparisons of the original and revised GOES-15 Sounder SRF data show that the relative differences between the detector SRFs have changed. The impact of these SRF changes on the central frequencies, f_0, are shown in table 3.1. The change in the average SRF and individual detector SRF central frequencies are small.

Channel	Original f_0 (cm^{-1})	Revised f_0 (cm^{-1})	Δf_0 (cm^{-1})	D1 Δf_0	D2 Δf_0	D3 Δf_0	D4 Δf_0
				(cm^{-1})			
1	679.3221	679.2003	-0.1217	-0.1636	-0.1428	-0.1284	-0.0484
2	695.3404	695.2252	-0.1152	-0.1283	-0.1423	-0.1126	-0.0790
3	710.3196	710.1526	-0.1671	-0.1924	-0.1768	-0.1563	-0.1434
4	732.7820	732.6983	-0.0837	-0.1097	-0.0916	-0.0656	-0.0655
5	747.9184	747.8539	-0.0645	-0.0888	-0.0641	-0.0547	-0.0525
6	788.2954	788.2432	-0.0522	-0.0767	-0.0481	-0.0281	-0.0388
7	830.3244	830.2655	-0.0589	-0.0577	-0.0576	-0.0443	-0.0757
8	911.0735	910.6205	-0.4529	-0.3930	-0.3864	-0.5521	-0.5089
9	1031.6160	1031.5810	-0.0350	-0.0311	-0.0310	-0.0278	-0.0504
10	1343.4975	1343.5432	0.0457	0.0629	0.0547	0.0165	0.0481
11	1423.5296	1423.5079	-0.0217	0.0484	-0.0024	0.0053	-0.0217
12	1531.3271	1531.1962	-0.1309	-0.0820	-0.0878	-0.1723	-0.1815
13	2188.7294	2188.7188	-0.0106	-0.0149	-0.0073	-0.0106	-0.0094
14	2208.5915	2208.6053	0.0138	0.0117	0.0149	0.0146	0.0142
15	2247.3589	2247.3869	0.0280	0.0285	0.0273	0.0273	0.0288
16	2423.8983	2423.9059	0.0075	0.0212	0.0018	-0.0000	0.0072
17	2511.7100	2511.7020	-0.0079	-0.0089	-0.0007	-0.0149	-0.0065
18	2675.0451	2674.7226	-0.3225	-0.2773	-0.3418	-0.3463	-0.3241

Table 3.1: Channel central frequencies for the GOES-15 Sounder derived from the original and revised average SRF, along with the change in f_0, and those for each detector's SRF.

4 Conclusions

4.1 GOES-14 Sounder SRFs

The previosuly indicated anomalies in the original SRF data appear to have been addressed. However, differences in the shortwave InSb channel detector SRFs are now present in the revised SRF data.

Apart from channel 8 detector #2, the revised SRF data does not appear to significantly affect the computed central frequencies.

4.2 GOES-15 Sounder SRFs

Previously, two types of SRF anomalies were discussed: high frequency undulations attributed to data fitting, and InSb detector differences. The apparent "over-fitting" is still present in the revised SRF data but it is not clear what more can be done to eliminate this anomaly, or if it should be done.

The shortwave InSb channel detector SRF differences are still present, but their magnitudes are reduced. More of an issue is the change in the character of the differences, which mirror those now seen in the GOES-14 shortwave InSb channel data. It would appear the new processing somehow treated detector #4 for these channels differently.

The revised SRF data does not appear to significantly affect the computed central frequencies.

A GOES-O(14) Sounder SRF plots

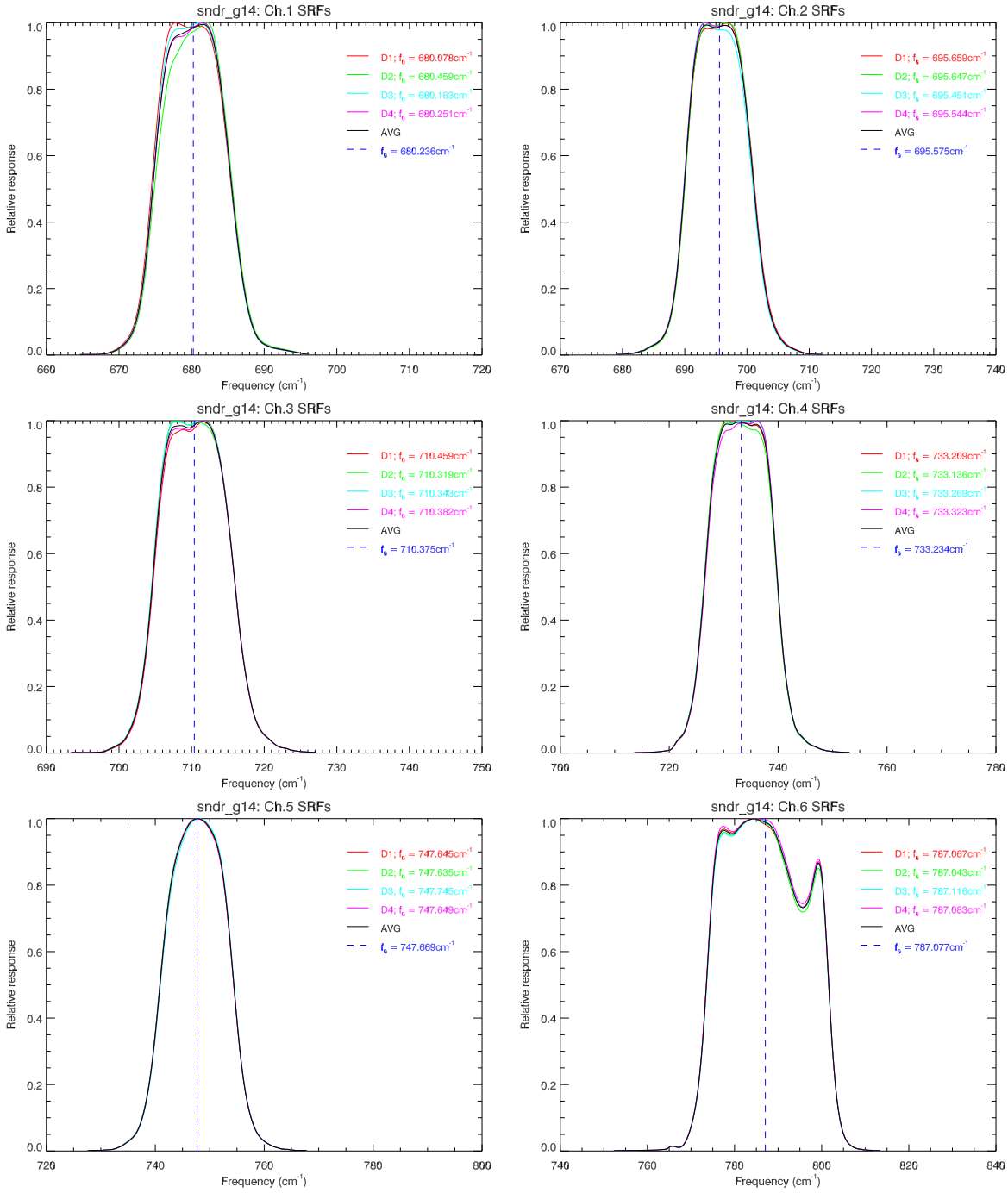

Figure A.1: GOES-O(14) Sounder SRF for channels 1 to 6.

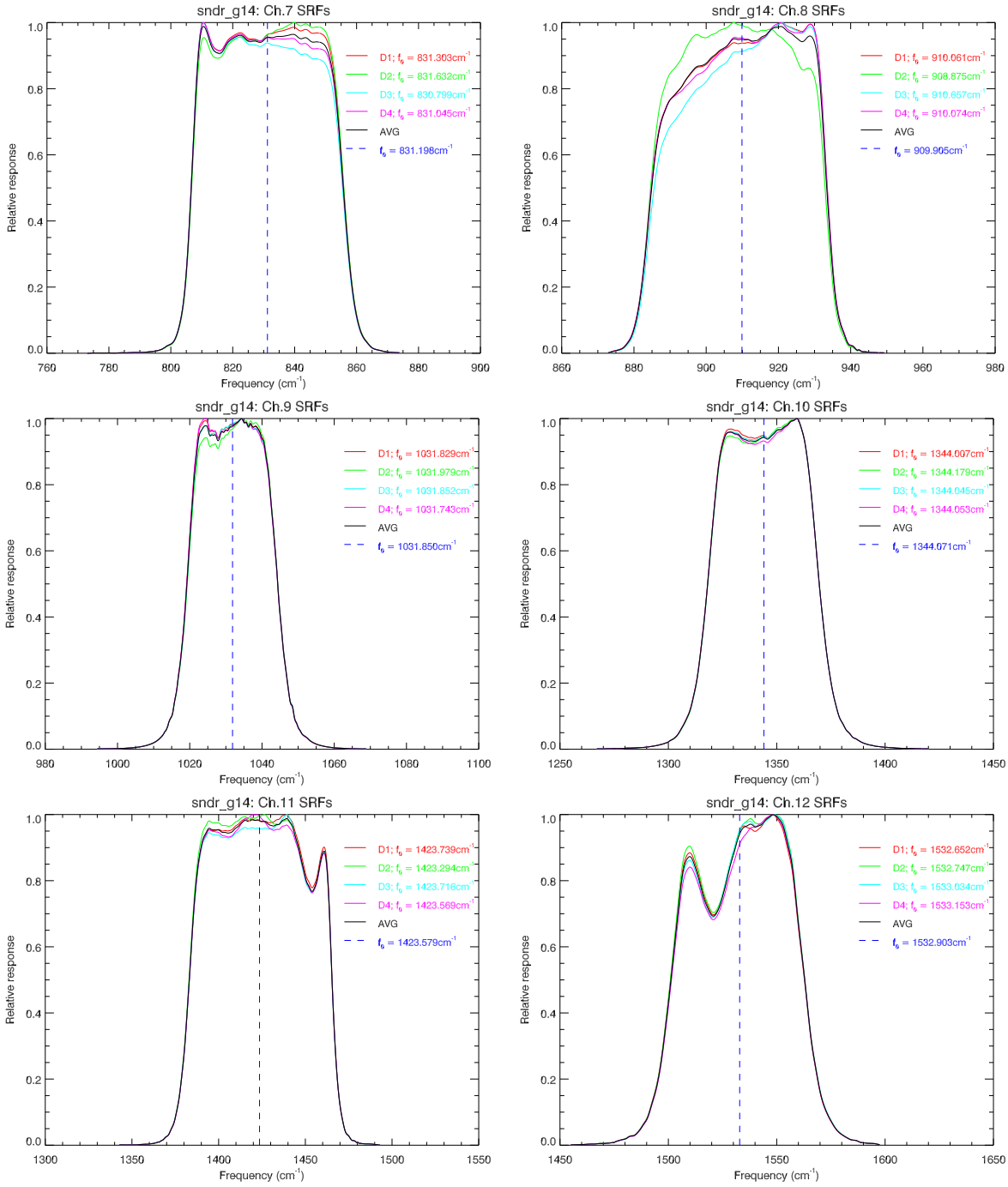

Figure A.2: GOES-O(14) Sounder SRF for channels 7 to 12.

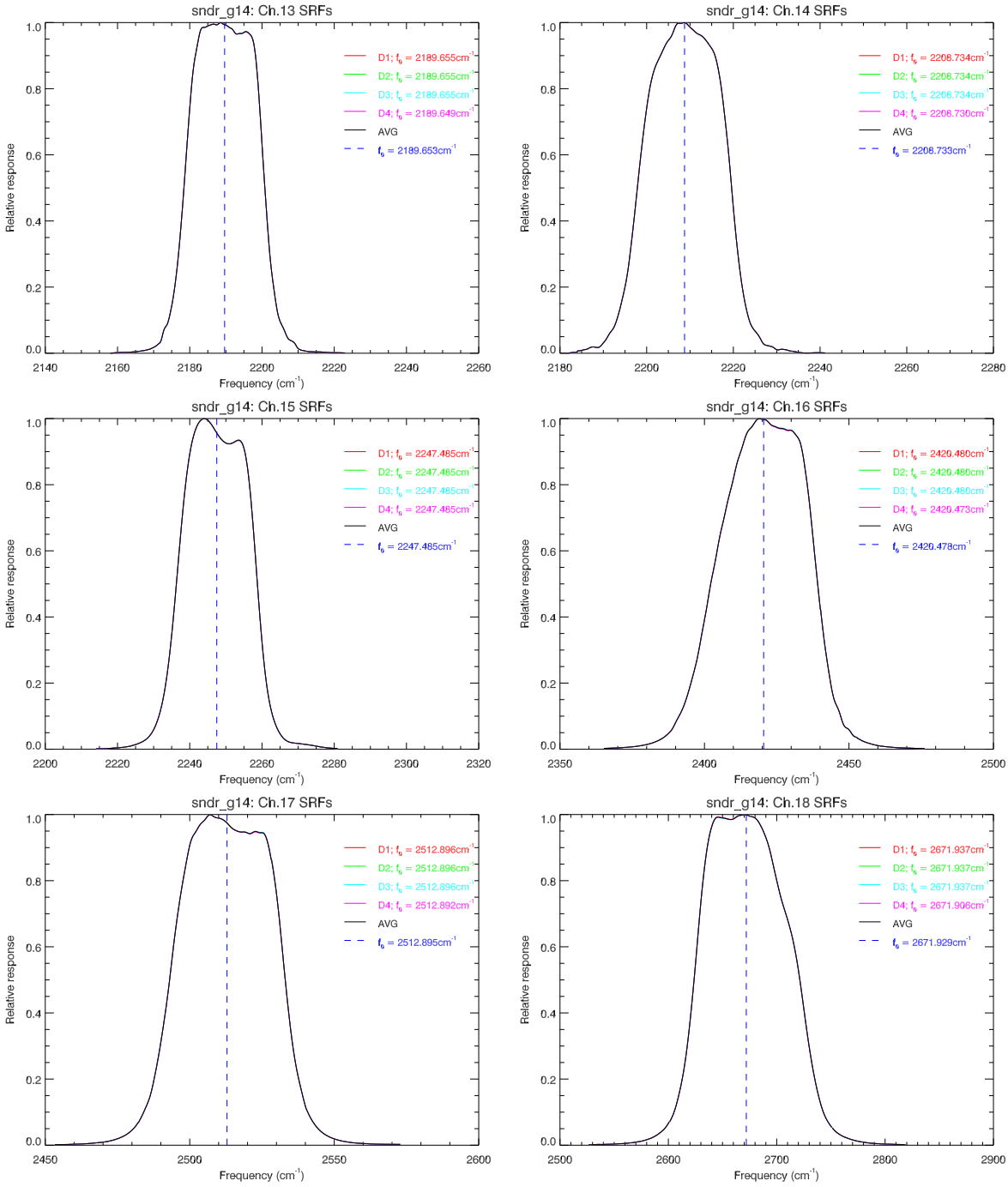

Figure A.3: GOES-O(14) Sounder SRF for channels 13 to 18.

B GOES-P(15) Sounder SRF plots

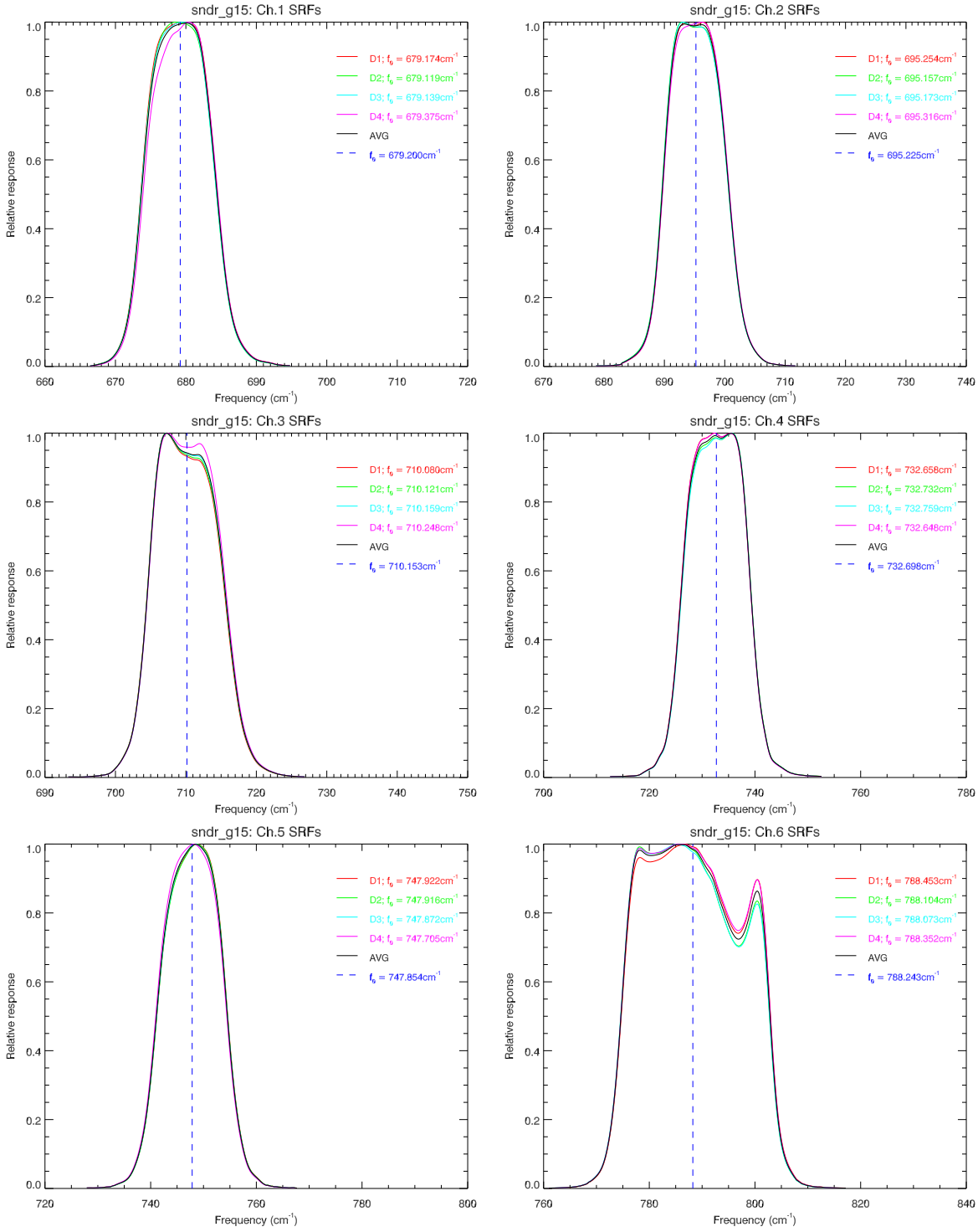

Figure B.1: GOES-P(15) Sounder SRF for channels 1 to 6.

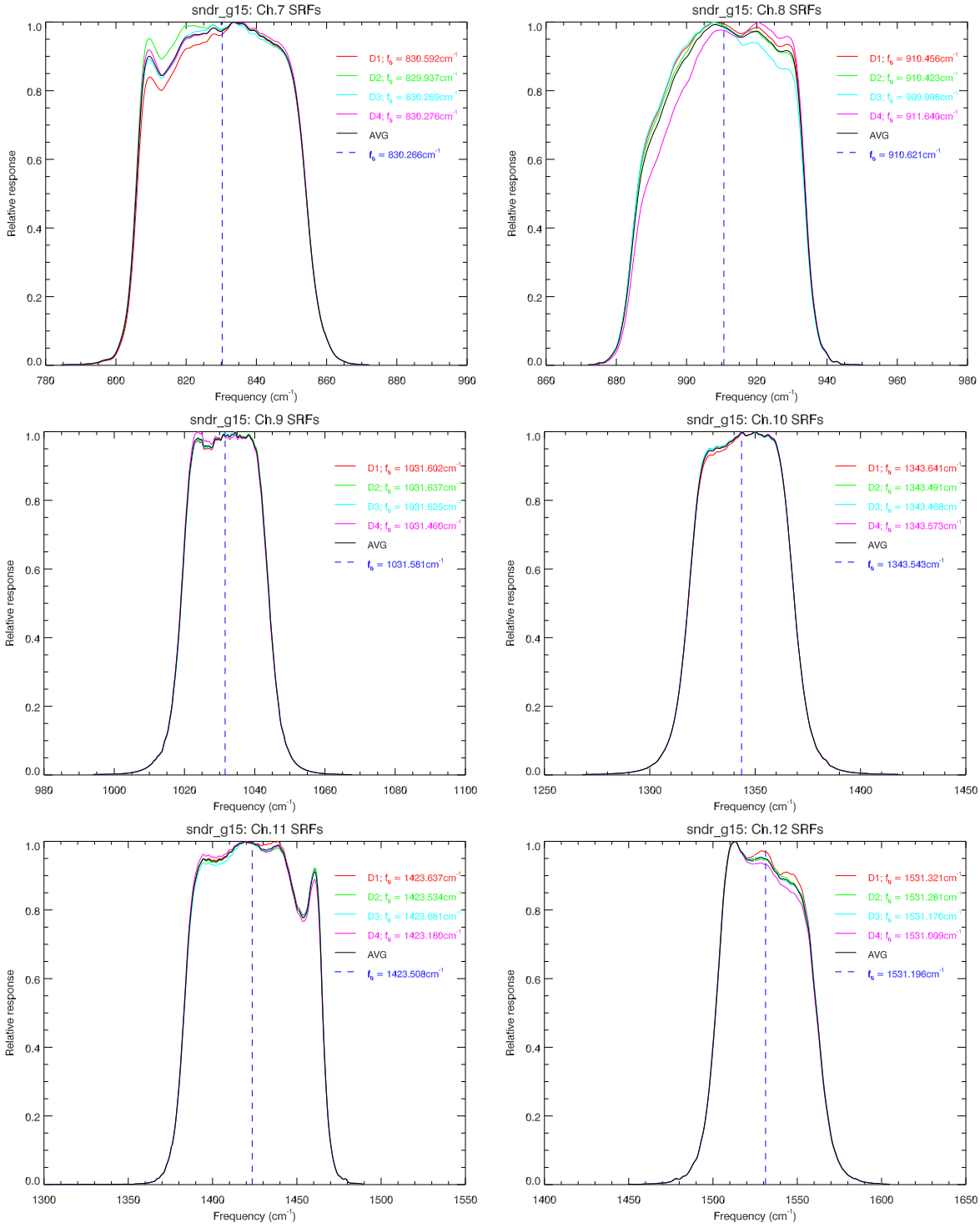

Figure B.2: GOES-P(15) Sounder SRF for channels 7 to 12.

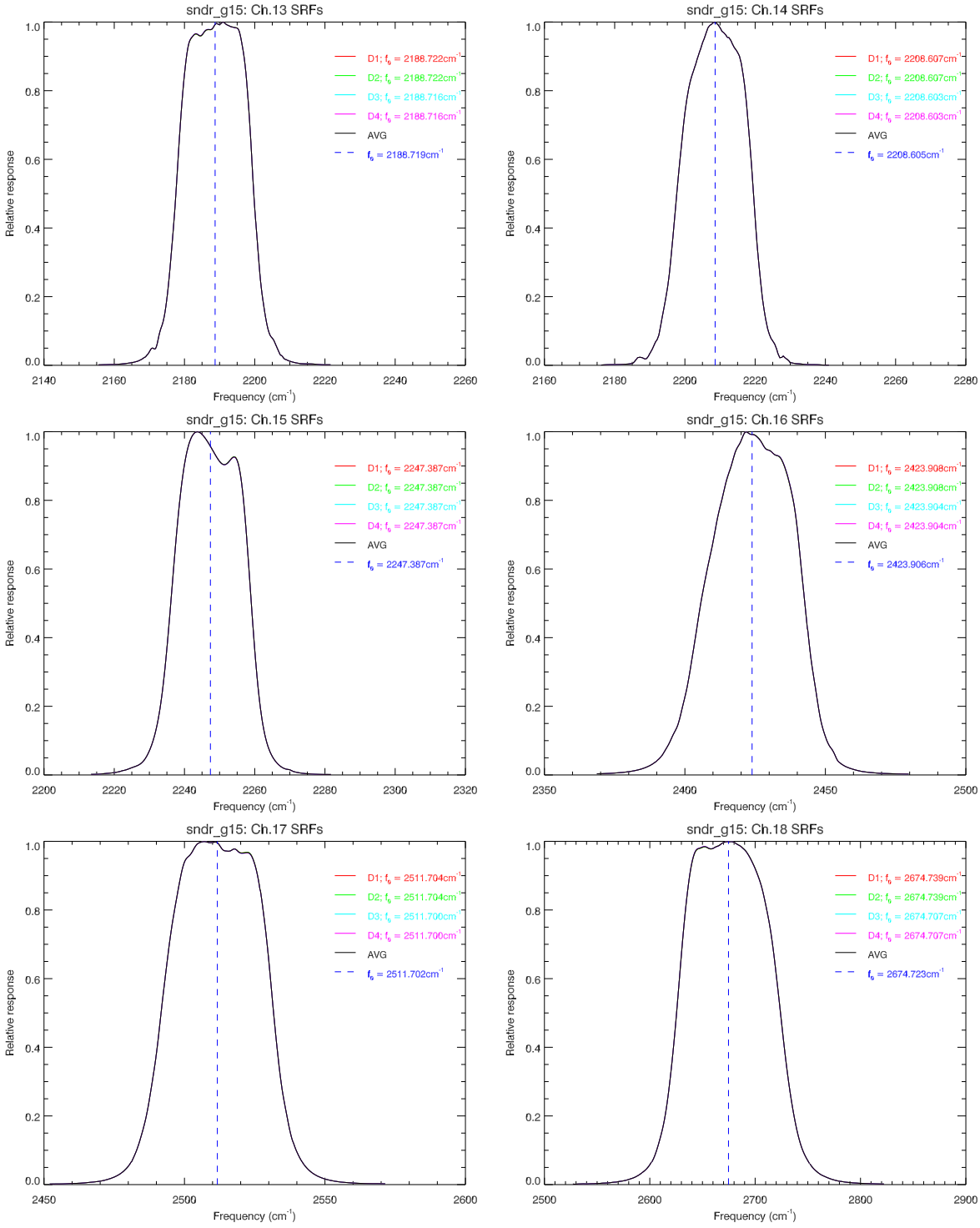

Figure B.3: GOES-P(15) Sounder SRF for channels 13 to 18.