Global-scale Observations of the Limb and Disk (GOLD)

Release Notes

Revision 3.5 – September 22, 2020

Changes

Revision	Date	Changes
1.0	2/28/2019	Initial release
1.1	5/14/2019	Added "Incorrect Radiance values for the Night observations" to Known Issues
2.0	6/3/2019	Fixed issue with L1C NI1 data product and updated L1C NI1 and L1D NI1 to version 02.
		Initial limited release of Level 2 data products.
3.0	9/16/2019	New version of all L1C products with flatfield correction applied. Improved background subtraction algorithm for L1C OCC product.
		Release of additional L2 data products: TDISK, ON2, TLIMB and O2DEN through Aug 13, 2019 (with some exceptions, as noted below). QEUV through Jan 31, 2019.
3.1	12/6/2019	Added L1C and L1D Channel B NI1 data products to released products. See updated section 3.1.5 for more details.
		Added additional sections to Level 1 known issues: 3.1.12 No High Particle Background Flag 3.1.13 Incorrect Background Subtraction in Day and Night Scans 3.1.14 Incorrect variable names and units in L1C occultation files 3.1.15 Irradiance values in L1C occultation files are too large
3.2	4/8/2020	Added L2 NMAX data product to released products. Updated L2 TLIMB product to version 03.
		Added additional sections to Level 2 known issues: 3.2.4.5 Look up table constraints (ON2) 3.2.4.7 Flat Field correction artifacts (ON2)

		3.2.5.5 Flat Field correction artifacts (QEUV) 3.2.6 Issues with NMAX data
3.3	4/16/2020	Updated section 3.2.6 Issues with NMAX data
3.4	8/28/2020	Added additional sections to Level 1 known issues: 3.1.16 Field emission type events 3.1.17 Effect of stars on the brightness Added additional section to Level 2 known issues: 3.2.6.1 Model uncertainty (NMAX)
3.5	9/22/2020	Added additional image to Figure 3-10 Added additional gaps in data for TDISK (3.2.3.7), ON2 (3.2.4.6), and NMAX (3.2.6.1).

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1 Data Products:

This release includes a new version of all Level 1C products. It also adds the Level 2 QEUV data product and extends the released dates of TDISK, TLIMB, ON2 and O2DEN data products. Table 1-1 below provides the list of Version and Revision numbers associated with each data product for this release. The released dates of current GOLD data products can be found at https://gold.cs.ucf.edu/data/current-data-product-versions/

Update – 12/6/2019: L1C and L1D Channel B NI1 products have been added to the released products. See updated section 3.1.5 for additional details.

Update – 4/8/2020: Level 2 NMAX data have been added to the released products. Level 2 TLIMB updated to version 03.

We refer users of these data products to the "***GOLD Public Data Product Guide***", available at https://gold.cs.ucf.edu/documentation/ for details about how these were obtained, about their file format and content.

Data Product	Version Number	Revision Number
L1C: DAY	02	01
L1C: LIM	02	01
L1C: OCC	02	01
L1C: NI1	03	01
L1D: DAY	02	01
L1D: LIM	02	01
L1D: OCC	02	01
L1D: NI1	03	01
L2: NMAX	01	01
L2: O2DEN	02	01
L2: ON2	02	01
L2: QEUV	01	01
L2: TDISK	02	01
L2: TLIMB	03	01
L3: TLIMB AVG	N/A	N/A
L3: QEUV AVG	N/A	N/A

Table 1-1 Version/Revision Numbers by Data Product for this Release

2 Updates with This Release:

This release combines a full reprocess of all Level 1C data products with an extended release of Level 2 data products. The Level 1 updates include a flatfield correction affecting all Level 1C data products as well as an improved occultation background subtraction algorithm and an improved wavelength assignment algorithm. All Level 2 data products were reprocessed using this new version of L1C data, and additional data has been released beyond the time frame of the previous release.

2.1 Level 1

2.1.1 Flatfield Correction

The flatfield data is used to measure and correct relative drop in detector sensitivity since the start of the mission. A flatfield image is taken once per day. Seven days of flatfield data is then combined to generate a daily calibration file. The daily flatfield calibration file is then applied to the current day's data.

2.1.2 Occasional Incorrect Stellar Occultation Background Subtraction

Previously the background subtraction encountered problems when counts were very low. This is shown in Figure 2-1 for 152nm.

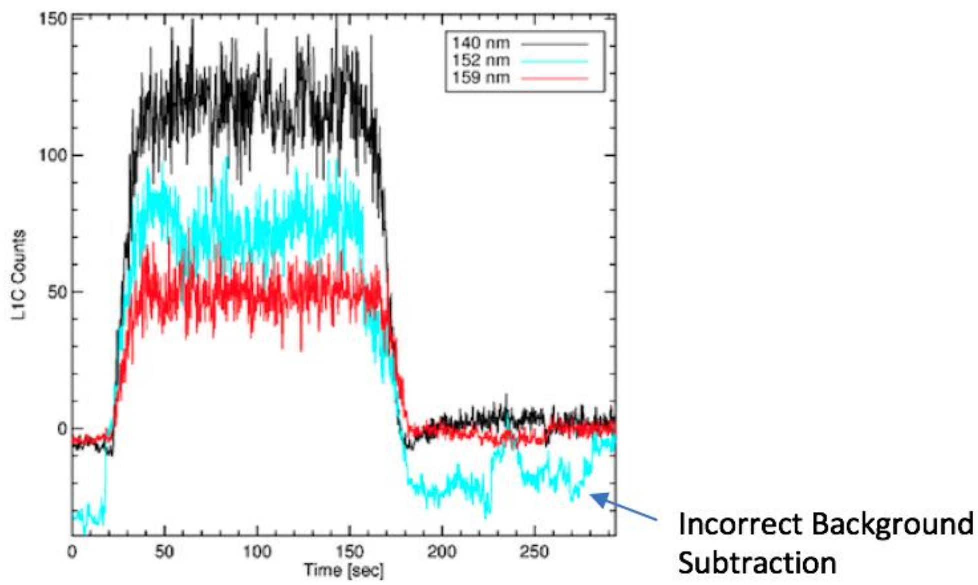

Figure 2-1 Incorrect Occultation Background Subtraction

This has been fixed by adjusting the background subtraction routine based on the solar zenith angle. If the solar zenith angle is greater than 110 degrees, then the night background subtraction is used. The night background subtraction uses a linear fit for the background/wavelength dependence. The day side background subtraction is the same, using the actual airglow measurement to subtract the background. Figure 2-2 shows the same scan after the fix.

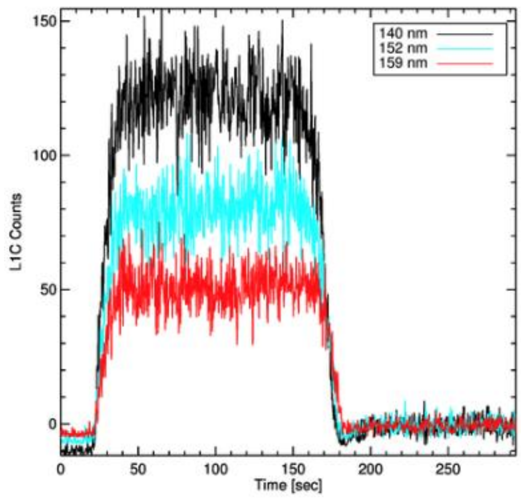

Figure 2-2 Fixed Background subtraction during night occultations

2.1.3 Improved Wavelength Assignment Algorithm

It was found that in a few cases, the wavelength assigned to the Level 1C data product was incorrect. The wavelength assignment algorithm was adjusted such that in such cases it will now fall back to the default wavelength assignment rather than return an incorrect wavelength assignment.

2.1.4 Release of Channel B L1C and L1D NI1 data products (12/6/2019)

The Channel B L1C and L1D NI1 data products have been added to the released data. See updated section 3.1.5 for more details.

2.2 Level 2

The Level 2 release includes the GOLD neutral temperature (TDISK), O/N_2 (ON2), and solar irradiance proxy (QEUV) from dayside disk measurements, exospheric temperature (TLIMB) from limb scans, and O_2 density (O2DEN) from stellar occultations, as well as the initial release of QEUV data.

Update – 4/8/2020: Initial release of the peak electron density (NMAX) from nightside disk measurements. All TLIMB data has been reprocessed to version 03 due to a minor correction in the algorithm to properly handle filtering of solar zenith angle.

3 Known issues:

There are a number of known issues with the data provided in this and previous releases. This section provides a description of these issues and guidance to the user community on the use and interpretation of GOLD data products. This documentation is cumulative so that descriptions of known issues will remain until they are resolved in future releases. For the current release, Section 3.1 describes known issues with Level 1 data while Section 3.2 describes known issues and potential problems in the Level 2 data.

3.1 Level 1

3.1.1 Gradient in sensitivity from top to bottom of detector is not included in the calibration

In this release, we are not correcting for a change in the instrument responsivity along the slit. This is a ~10% effect from top to bottom of the slit. The top panel of Figure 3-1 shows that Near the equator, values extracted from the southern hemisphere scan (red) are ~10% larger than those from the northern hemisphere scan (black). The magnitude of the difference decreases with increasing wavelength as illustrated for LBH radiances shown in the lower panel. We plan on adding this correction in future data releases.

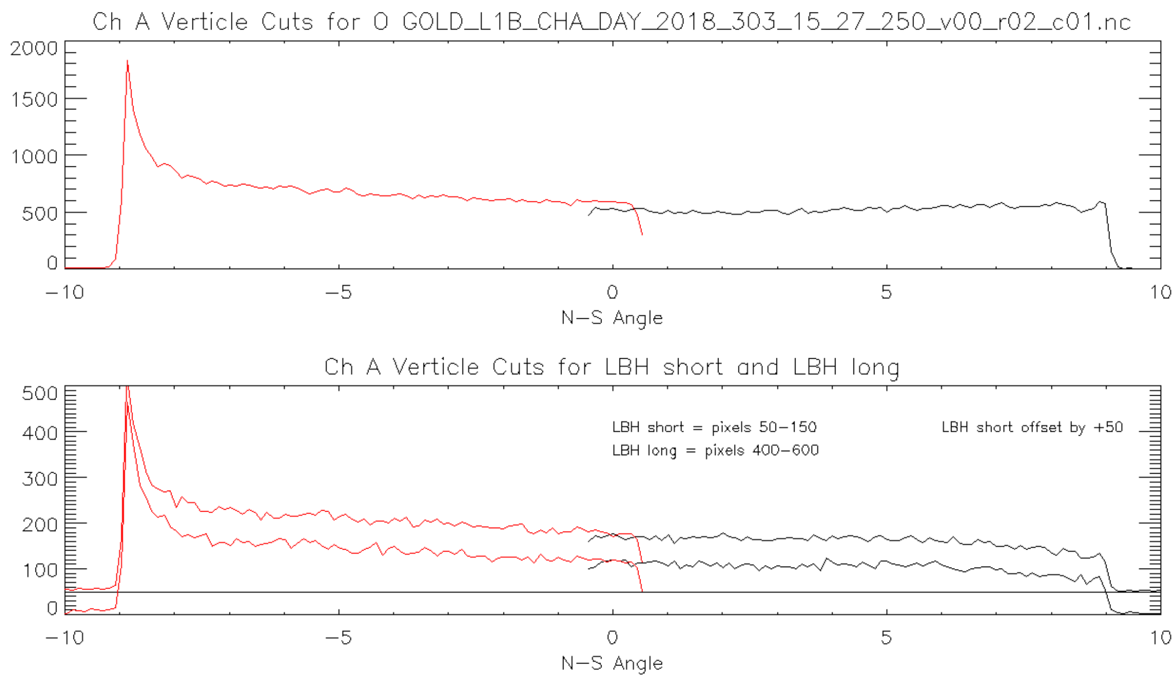

Figure 3-1 Uncorrected Vertical Sensitivity Variation

3.1.2 Time Delay of Reconstructed Full Disk Images

The projected height of the slit covers more than half the Earth, with an overlap around the equator when scanning the northern and the southern hemispheres. Full disk images made by combining northern hemisphere radiance images with those from the adjacent (in time) southern hemisphere image, will show ‘banding’ where the images overlap at the equator. This occurs because incidence and emission angles change throughout the 30 minutes during which the images are obtained. The effect is more pronounced early and late in the day. Figure 3-2 shows this effect on a sample DAY scan.

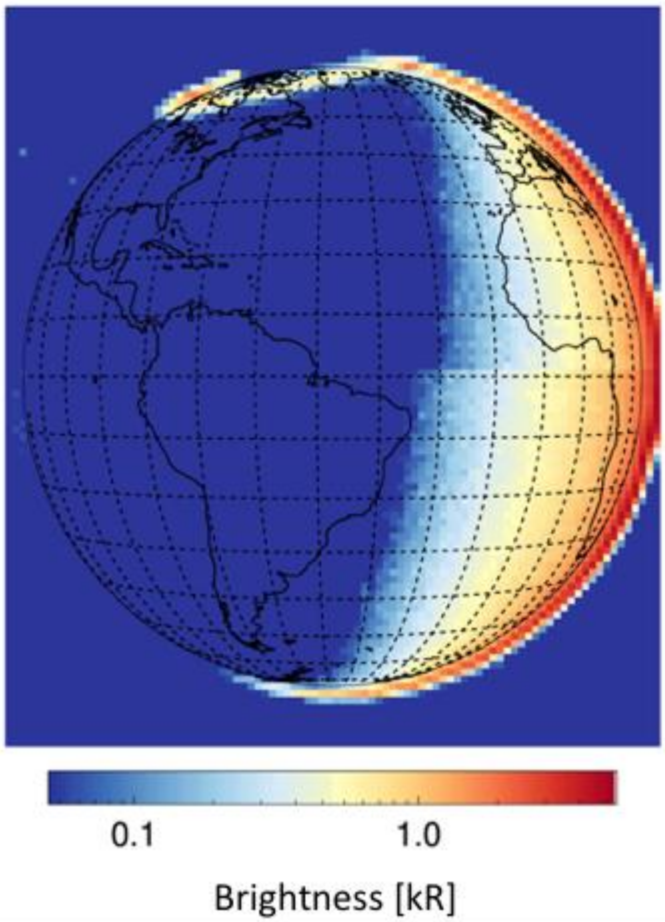

Figure 3-2 Combined scans of north and south latitudes from L1C data

3.1.3 Incomplete Scattered Light Correction

Due to the signal to noise, the first version of the background and scattered light removal algorithm assumes that there is no wavelength dependence. Though small, this is not exact and will be accounted for in later releases. Figure 3-3 below shows that there does appear to be a small slope when looking at the regions of the spectrum where we believe there should be no radiance.

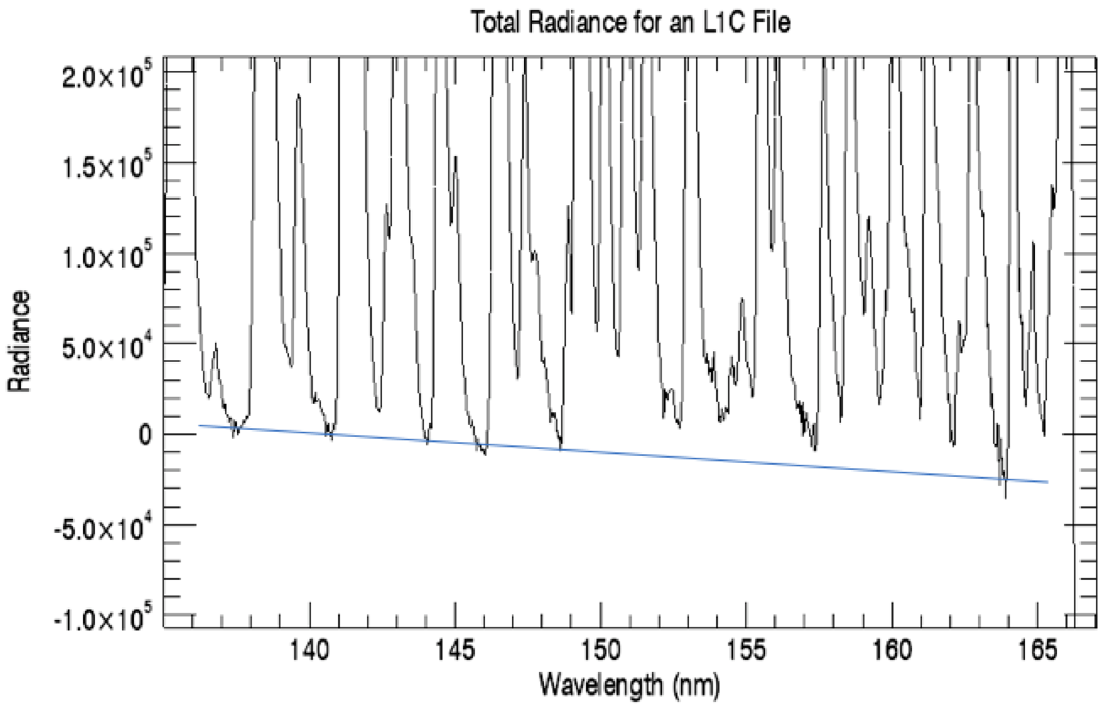

Figure 3-3 Wavelength Dependence Scattered Light

3.1.4 Flatfield Correction

The flatfield correction attempts to correct for a relative drop in detector sensitivity due to line burn-in. See section 3.1.6.2 in the Public Science Data Products Guide. The flatfield correction has some limitations that users should be aware of. It is not able to account for variations in detector gain that are caused by diurnal temperature variations in the instrument. The result is that the flatfield correction can under- or over-correct data depending on the detector gain. The error in the flatfield correction is largest in the 1356 band when a large correction is needed. In the Version 2 L1C data, errors in the flatfield correction are largest for the month of April 2019 and are most prominent in the 1356 emission line. On April 27, 2019 the channel-A grating was rotated to move the spectrum to portions of the detector with little degradation. This change effectively reduced the amount of flat field correction applied which also reduces the error in the correction. Figure 3-4 shows the approximate effect of the flatfield correction on the brightness of several emission bands for Channel-A.

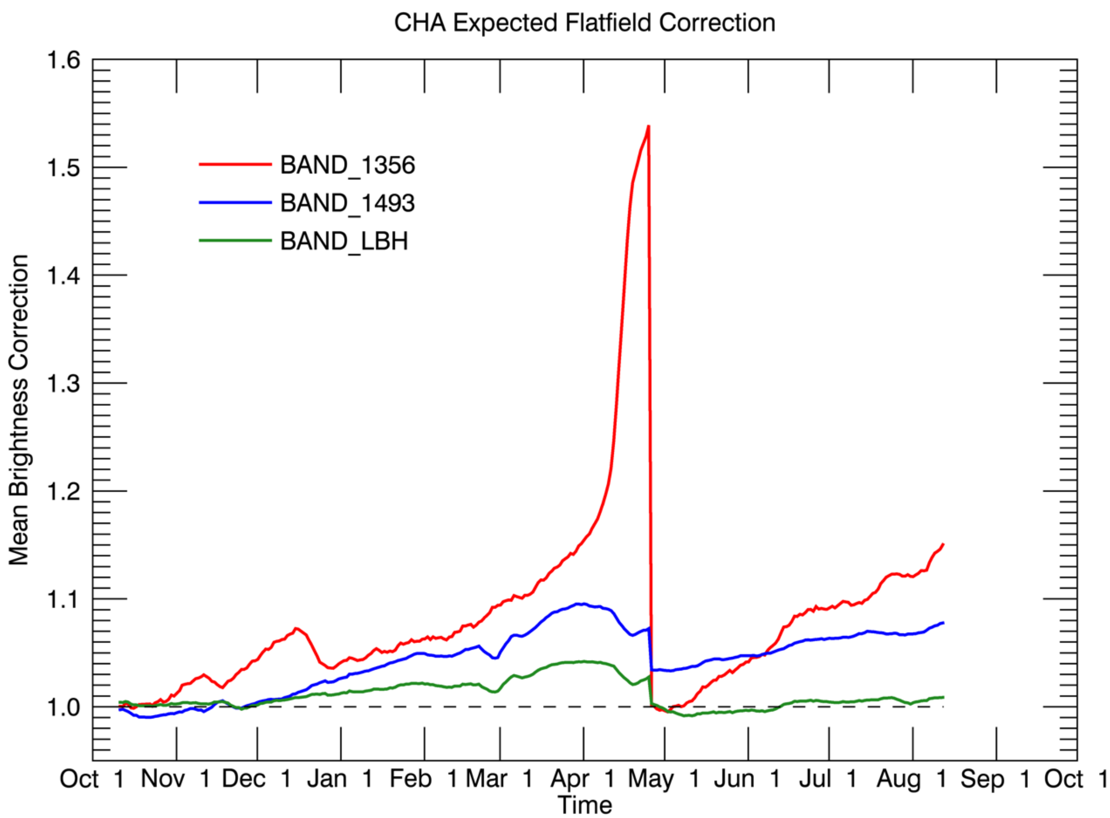

Figure 3-4 Channel A Expected Flatfield Correction

3.1.5 Limited Channel B Data

GOLD detectors show a loss of sensitivity with prolonged exposure to bright emissions. Such losses are most significant for the brightest emission, the 135.6 nm oxygen doublet. The N_2 LBH emissions are five to twenty times less bright during daytime observations. To accommodate sensitivity loss in the 135.6 nm line, a Grating Yaw Mechanism (GYM) is included in each channel to shift the 135.6 nm line, by rotating the grating, to an undegraded portion of the detector where the 'burn in' process begins anew. While a correction, using a standard 'flat-fielding' procedure is performed, this correction can become unreliable with excessive degradation.

During the first three months of operations, the Channel B degradation (also referred to as 'burn-in') proceeded faster than expected. As a result, the 135.6 nm data became unreliable about December 15, 2018, but the GYM was not activated until March 15, 2019. Since then the use of Channel B has been largely restricted to nighttime observations when the 135.6 nm emissions are an order of magnitude less than daytime emissions. As a result, the Channel B 135.6 nm radiance values reported after March 15, 2019 are reliable. Initial analysis of GOLD data from Channel B during December 15 of 2018 to March 15 of 2019 indicates that the current version of the data from that period are useful for qualitative analysis but not for quantitative analyses. To avoid unintentional inclusion of the unreliable radiances in quantitative analyses, the nighttime data for that period are not included in the .tar files generated in searches for data on the GOLD website. However, the data for that period is available by request through a link on the GOLD data download page (https://gold.cs.ucf.edu/search).

Since Channel B has made most of GOLD's nighttime observations, preparation for release of these data have been given first priority over the daytime observations for which Channel A provides the most comprehensive coverage.

3.1.6 Slit Movement due to Thermal Changes

The projected image of the slit on the detector moves slightly with changing temperature. We are currently using the "nominal" slit position on the detector to assign a latitude to every corresponding Y-pixel along the slit and are not correcting for any movement of the image of the slit. This effectively adds additional uncertainties in the assigned latitude. Figure 3-5 shows that for a 26°C change, we see a maximum shift of about 3 L1B pixels which corresponds to ±20 km at nadir. This instrument effect will be corrected in a future release.

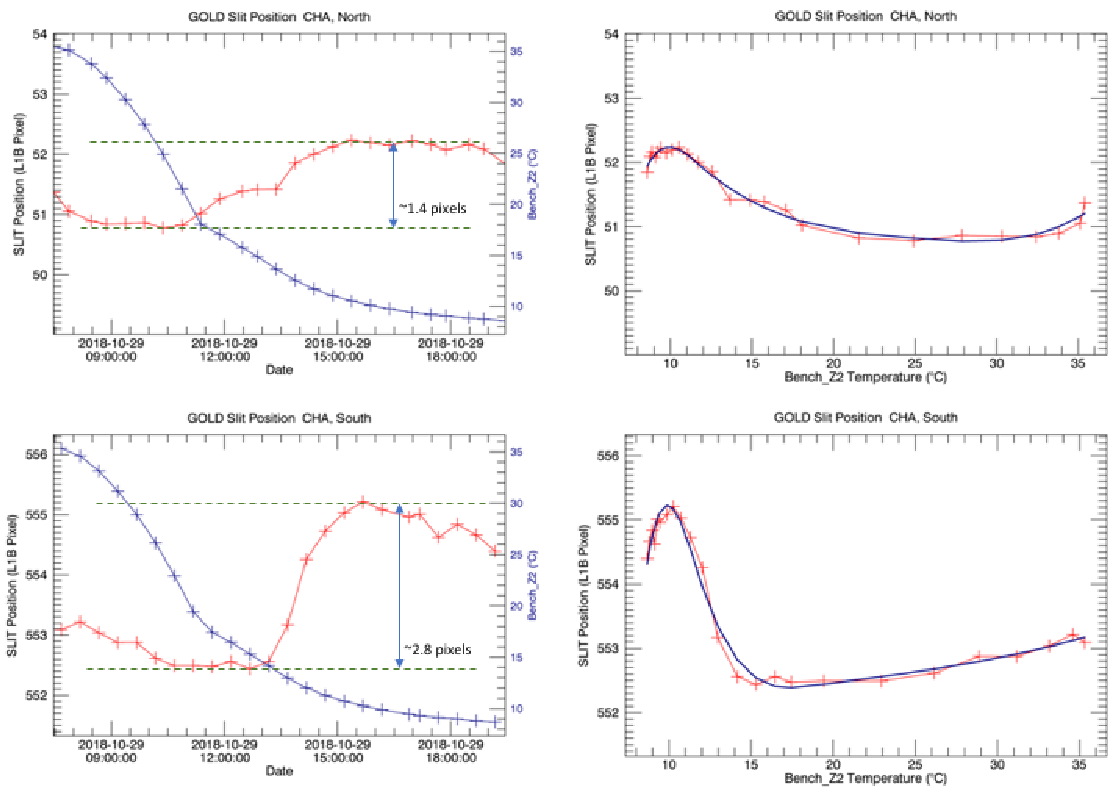

Figure 3-5 Vertical Slit Motion With Temperature

3.1.7 Stellar Occultation Wavelength Feature

The wavelength returned is purely a function of the star and so the solution is not applicable when the star is outside the view of the occultation slit. For the time steps outside of the occultation slit, the default high resolution slit wavelength solution is used. This can add an unrealistic discontinuity in the wavelength data. This is intentional until a better approach is agreed on.

3.1.8 Incorrect Background Subtraction at Limb in Day Scans

The sharp transition in the background between On and Off Limb is not accurately captured, so the background is over corrected as seen in Figure 3-6. This will be addressed in future releases.

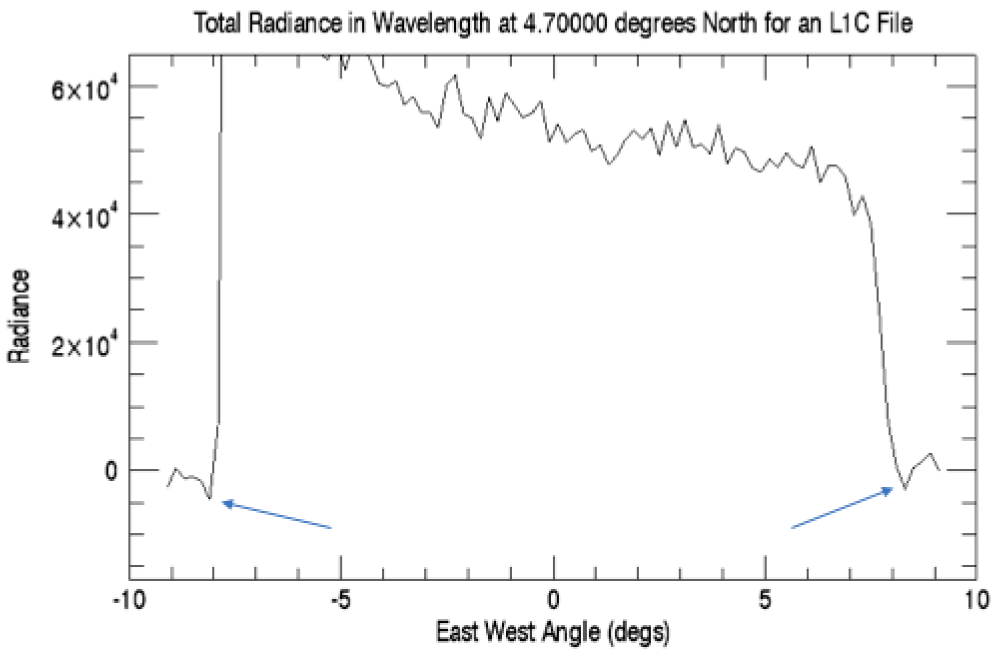

Figure 3-6 Over Corrected Background Subtraction at Limb

3.1.9 No local dead-time Correction for Occultations

Local dead-time correction, which affects the Occultations, has not been applied. The magnitude of the effect varies with the brightness of the star. A sample correction is shown in Figure 3-7.

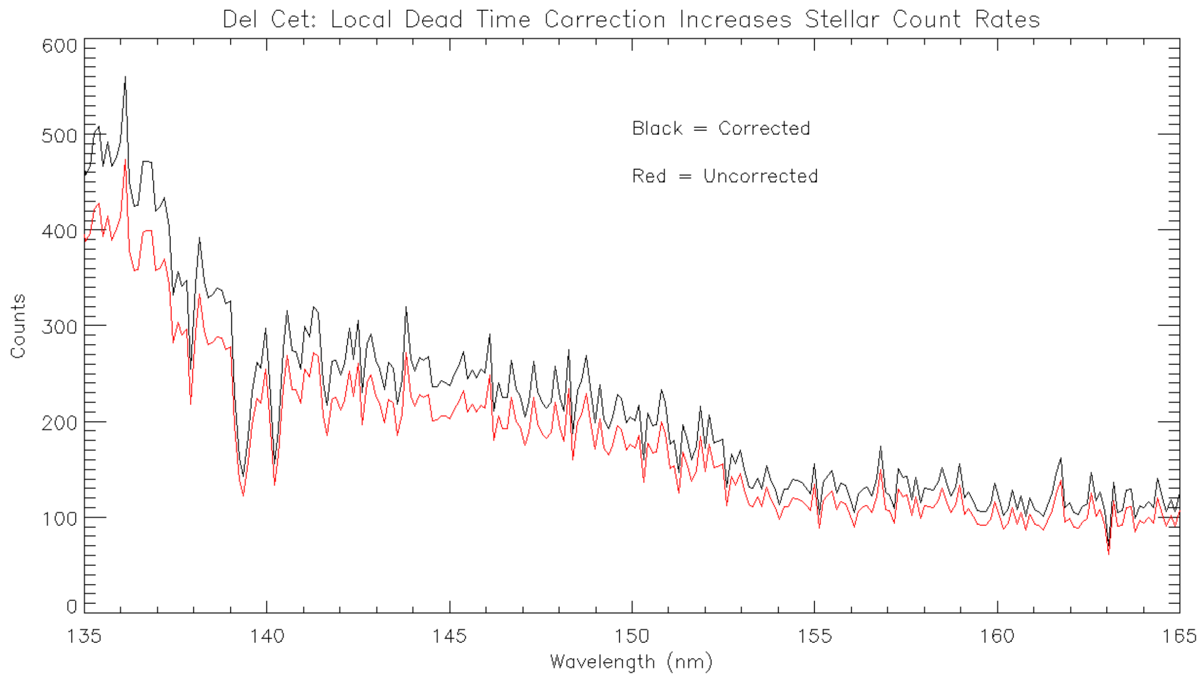

Figure 3-7 Counts Comparison with Dead-Time Correction

3.1.10 No Moon Flag

The presence of the Moon in the field of view is currently not being flagged during processing. This could affect the Limb and Occultation measurements. This issue will be addressed in future releases.

3.1.11 No Xenon Emission Flag

The SES-14 spacecraft that hosts the GOLD instrument uses ion propulsion for spacecraft station-keeping maneuvers. Its thrusters use xenon gas as a propellent and it has been found that the GOLD instrument sees a xenon emission line at 146.96nm during these maneuvers. A quality flag that indicates the presence of this spectral feature will be added in a future release.

3.1.12 No High Particle Background Flag

Particles from the radiation belt(s) produce counts in the detectors of GOLD and can appear as vertical or horizontal stripes of noisy pixels. These images are not flagged in the released data. Some of the examples are shown below in Figure 3-8, Figure 3-9, and Figure 3-10.

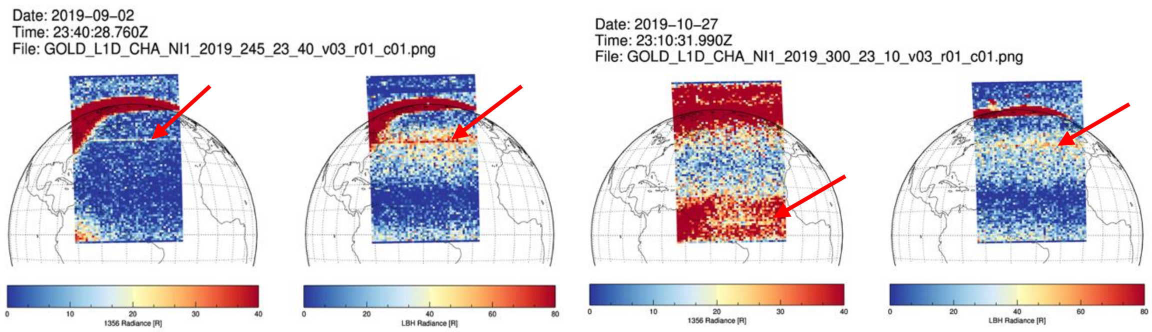

Figure 3-8 Examples of background noise appearing as horizontal stripes in night time images

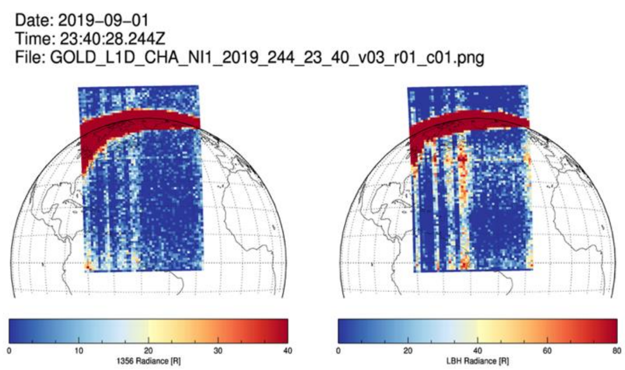

Figure 3-9 Examples of time varying background noise appearing as vertical stripes in night time images

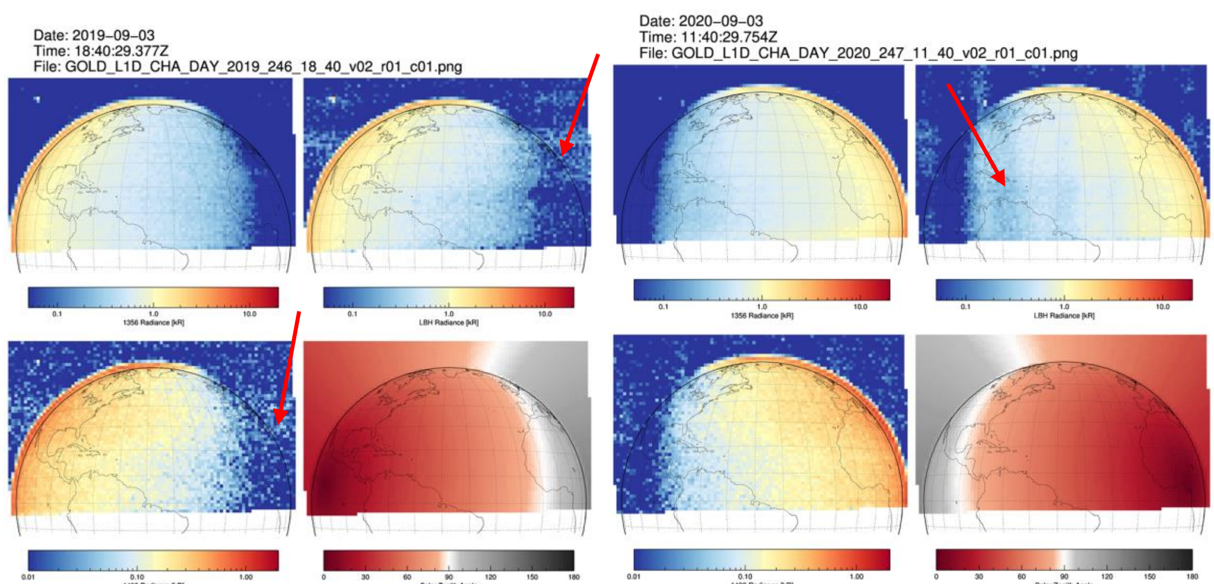

Figure 3-10 Noisy stripes in day time images; more prominent in the LBH emissions due to lower B(R) per pixel but higher background

3.1.13 Incorrect Background Subtraction in Day and Night Scans

On some of the high particle background days, the current pulse height filtering, flat-field correction and background subtraction may introduce artifacts in the north and south disk scans as well as in limb scans at southern latitudes. These appear as a horizontal stripe of brighter OI 135.6 nm emission in the disk scans or a step in the limb scans. These are not flagged in the released data. Some examples are shown in Figure 3-11 below. The limb scans in only the southern hemisphere are known to be affected. There may also be concurrent artifacts in the N2 LBH emissions (disk and limb) at latitudes near those where artifacts are seen in OI 135.6 nm.

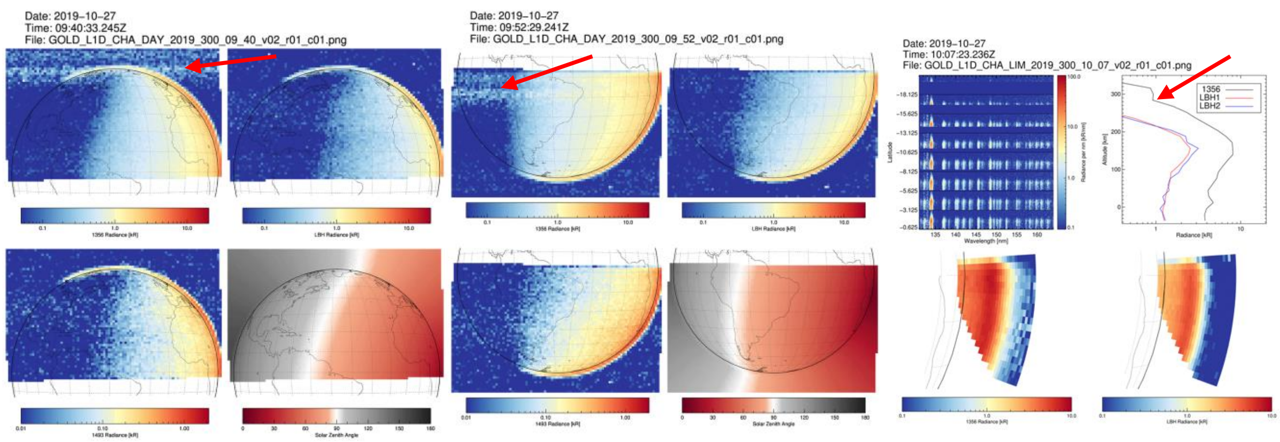

Figure 3-11 Horizontal stripes in observations with high particle background due to current limitations in the pulse height filtering, flat-field correction and background subtraction; more prominent in the OI 135.6 nm emission.

The limitations shown above for Channel A are also seen in Channel B, the horizontal stripes (as shown below) appear in the OI 135.6 nm emission observations. These are not flagged in the released data. Some of the examples are shown in Figure 3-12 below.

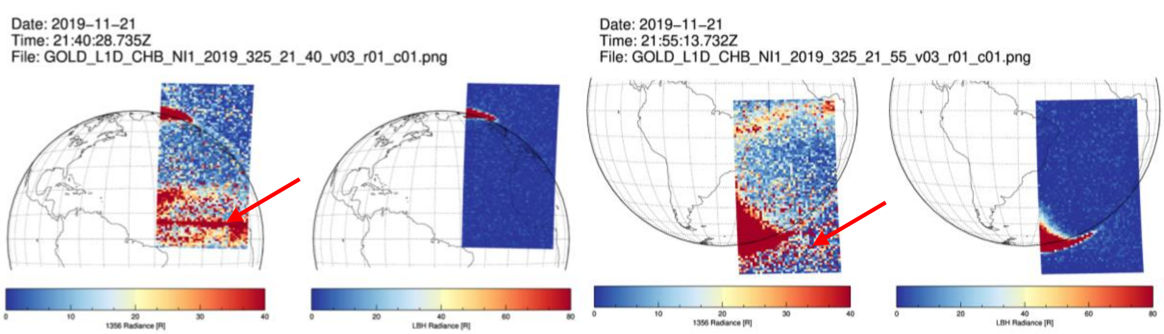

Figure 3-12 Horizontal stripes in Channel B night time scans due to incorrect current limitations in the pulse height filtering, flat-field correction and background subtraction; also seen in Channel A night time scans.

3.1.14 Incorrect variable names and units in L1C occultation files

The L1C OCC netCDF files and Table 3.5.6.1 in the GOLD Science Data Products Guide include the incorrect variable names and units listed in the table below:

Variable Name	Units	Type/Dim	Description
Radiance	Rayleighs/nm	Float/980x266	The Radiance data in Rayleighs/nm.
Radiance_Systematic_Unc	Rayleighs/nm	Float/980x266	The Radiance systematic uncertainties in Rayleighs/nm.
Radiance_Random_Unc	Rayleighs/nm	Float/980x266	The Radiance random uncertainties in Rayleighs/nm.

The correct variable names and units should be:

Variable Name	Units	Type/Dim	Description
Irradiance	Photons/cm^2/nm/sec	Float/980x266	The Irradiance data in photons/cm^2/nm/sec
Irradiance_Systematic_Unc	Photons/cm^2/nm/sec	Float/980x266	The Irradiance systematic uncertainties in photons/cm^2/nm/sec
Irradiance_Random_Unc	Photons/cm^2/nm/sec	Float/980x266	The Irradiance random uncertainties in photons/cm^2/nm/sec

3.1.15 Irradiance values in L1C occultation files are too large

The values for irradiance reported in the L1C OCC netCDF files are too large by a factor of 1.88, Divide the irradiance values by 1.88 in order to obtain irradiance in units of photons/cm^2/nm/sec.

3.1.16 Field emission type events

Some anomalous events occur on the GOLD CHA detector that are most apparent in the night (NI1) images at LBH wavelengths (see Figure 3-13). They appear at mid latitudes between 15^o to 60^o. These may be due to field emission events. Their position on the detector corresponds to midlatitudes (vertically) and within the wavelength range of the LBH band emissions (horizontally). Such events are not flagged in the released data.

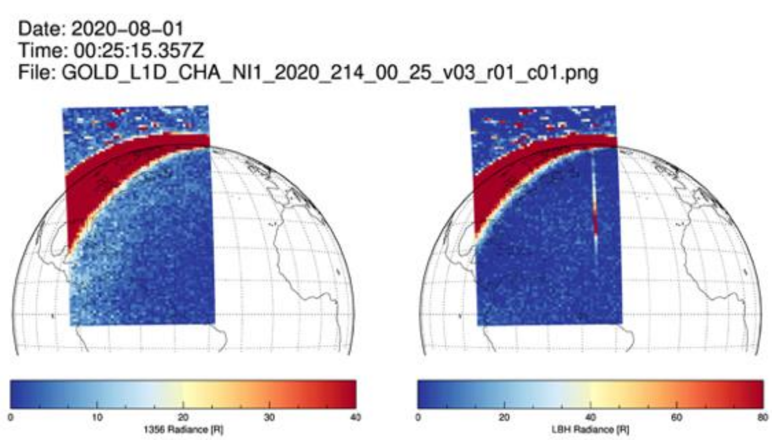

Figure 3-13 Example of field emission type events

3.1.17 Effect of stars on the brightness

When a star comes into the limb of the Earth, it appears as a bright spot in the image as shown in Figure 3-14. The starlight can scatter to pixels along the slit and can form a bright vertical band in the image. These events are not flagged in the released data.

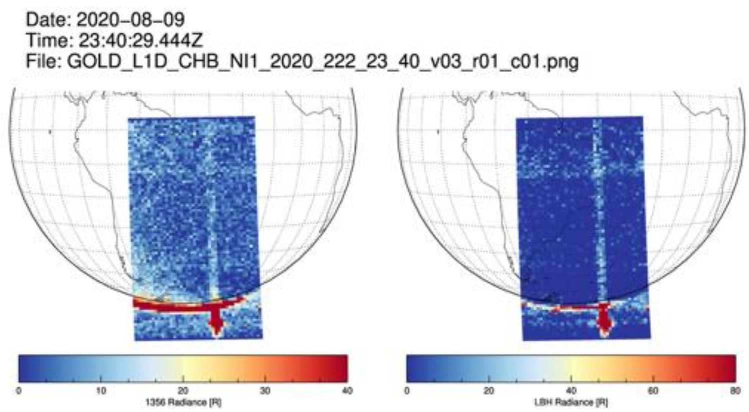

Figure 3-14 Scattering of starlight to pixels along the instrument slit

3.2 Level 2

This release contains data from an expanded portion of the GOLD mission for the GOLD Level 2 data products described in Section 2. Level 2 TLIMB has been updated to version 03 due to a minor correction in the algorithm to properly handle filtering of solar zenith angle. Level 2 NMAX data are being released for the first time. They correspond to previously released Level 1C NI1 observations, which are primarily from Channel B, supplemented by Channel A scans. The dates of currently released Level 2 data products are available here: [https://gold.cs.ucf.edu/data/current-data-product-versions/.](https://gold.cs.ucf.edu/data/current-data-product-versions/) Data that have been withheld from public release are addressed in the sections that follow.

All GOLD Level 2 files contain arrays for three separate components of the total error in retrieved geophysical parameters – random, systematic and model errors. In general, the error characterization for the Level 2 data products in this release is preliminary. Specifics for each data product are described in the sections that follow.

Each Level 2 data product file contains a list of data quality indices (DQI) specific to that data product. These DQI are defined at both the file and individual pixel level and are described in detail in the "***GOLD Public Data Product Guide.***" That document also contains a description of each Level 2 data product, including a summary of the algorithm theoretical basis and a complete description of the contents of each Level 2 daily NetCDF file.

3.2.1 Issues with O2DEN data

3.2.1.1 Preliminary error analysis

A comprehensive error analysis and retrieval characterization for the O2DEN product is in progress but has not yet been implemented in this release. Currently only the random error array is populated in the O2DEN files. These errors should be considered preliminary until the detailed error analysis is implemented.

3.2.1.2 Valid altitude range in retrieved O_2 profile

The O2DEN data product – density profile of molecular oxygen (O_2) retrieved from stellar occultation (OCC) measurements – is retrieved on a fixed geometric altitude grid. However, the altitude range of the retrieved profile varies for each event (altitudes above and below the valid retrieval range for each event are populated by fill values). This is because the algorithm truncates the input measured atmospheric slant path transmission profiles to a fixed transmission range before input to the optimal estimation routine. A given transmission value will correspond to different tangent altitude levels as the absolute O_2 number density varies with geophysical conditions.

Pending a more complete retrieval characterization analysis to accompany the error analysis in a future release, a preliminary sensitivity study has been performed to characterize the degree of *a priori* bias in the O_2 retrievals. Figure 3-15 summarizes the results of this analysis. It shows the relative difference, in %, between the retrieved O_2 profile and the *a priori* profile for a random sample of ~500 occultations over 60 days. Difference profiles for the individual occultation events are shown in the left panel and daily averages are on the right. These plots clearly illustrate the behavior described above, with the retrieved O_2 converging to the *a priori* at both high and low altitudes. Based on this analysis it is recommended that users assign the highest confidence to the altitude region between 130 and 190 km, which contains the most independent information on the absolute O_2 density profile. This range is denoted by the dashed horizontal lines in Figure 3-15. Currently the error bars and DQI reported in the O2DEN data files do not capture this data quality metric.

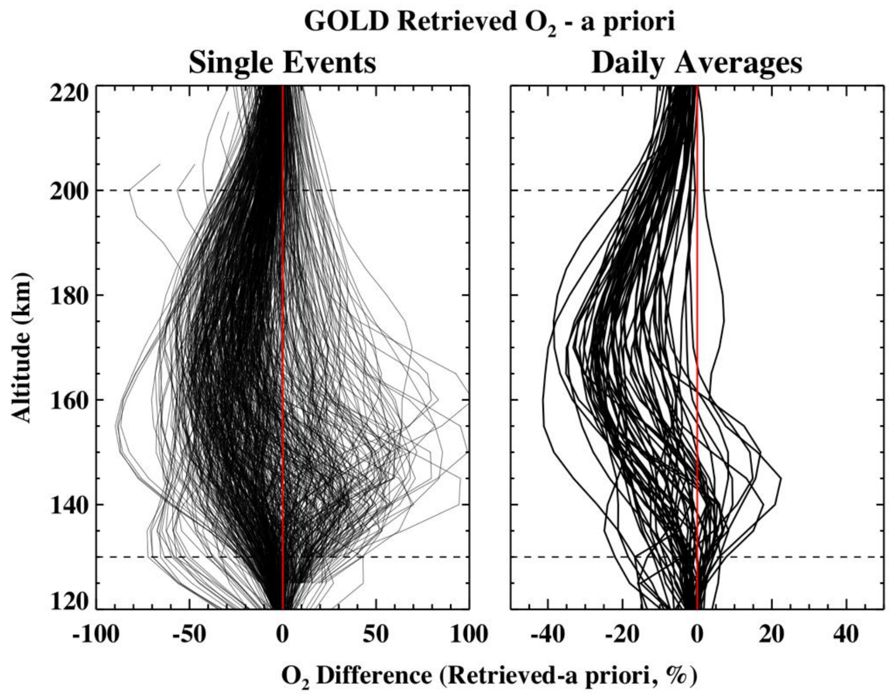

Figure 3-15 Variance between retrieved O2 profile and retrieval a priori.

3.2.1.3 Possible residual background bias in dayside O2DEN data

GOLD performs occultation measurements on both limbs at all times during the day. Therefore, on average approximately half of the O2DEN retrievals are obtained on the sunlit limb. Under these conditions it is particularly important that the atmospheric airglow background be accurately removed from the data in the L1C processing (see Section 2.1.2 above). Small residual errors in the background removal can in principal cause increased noise or systematic bias in the O_2 profile, particularly for events using the dimmer stars in the GOLD target star list. Both dayside and nightside data (Channel A only) are contained in this release. While users are not discouraged from using the dayside retrievals, for a more conservative screening of the data users can easily identify these events using the “dayside” flag in the event level DQI array, or by simply paying attention to the measurement solar zenith angle (an approximate flag for dayside events is SZA < 100 degrees).

3.2.1.4 Data gaps

There is a gap of approximately one month in the O2DEN data set, from December 17, 2018 to January 13, 2019. During this time period there was a glitch in the GOLD operational planning that caused errors in the instrument pointing and timing, resulting in missed occultations. This data will not be recoverable in the future since no underlying L1C data were obtained.

3.2.2 Issues with TLIMB data

The primary issues with TLIMB data are degraded performance at large SZA and failure of the algorithm to converge to a physical solution.

3.2.2.1 Preliminary error analysis

A comprehensive error analysis and retrieval characterization for the TLIMB product is in progress but has not yet been implemented in this data release. Currently only the random error array is populated with non-fill values in the Level 2 files. These errors should be considered preliminary until a more detailed error analysis is performed.

3.2.2.2 Stars in the field of view

It is common for stars to be observed within the field-of-view of the detector during limb scans. An example showing multiple stars within the field-of-view can be seen in Figure 3-16. When a star appears in the field-of-view it can alter the shape of the N_2 LBH limb profile producing systematic biases in retrieved exospheric temperatures. Therefore, the TLIMB algorithm code implements a star detection algorithm that utilizes the difference between stellar and airglow spectra. When a star is detected in the field-of-view the TLIMB algorithm is not run and the corresponding DQI is set to a non-zero value. Note that the star detection algorithm is not 100% reliable, thus false positive and negative detections may occur. Users are advised to independently review the Level 1C data for stars in the field-of-view when working with the TLIMB data

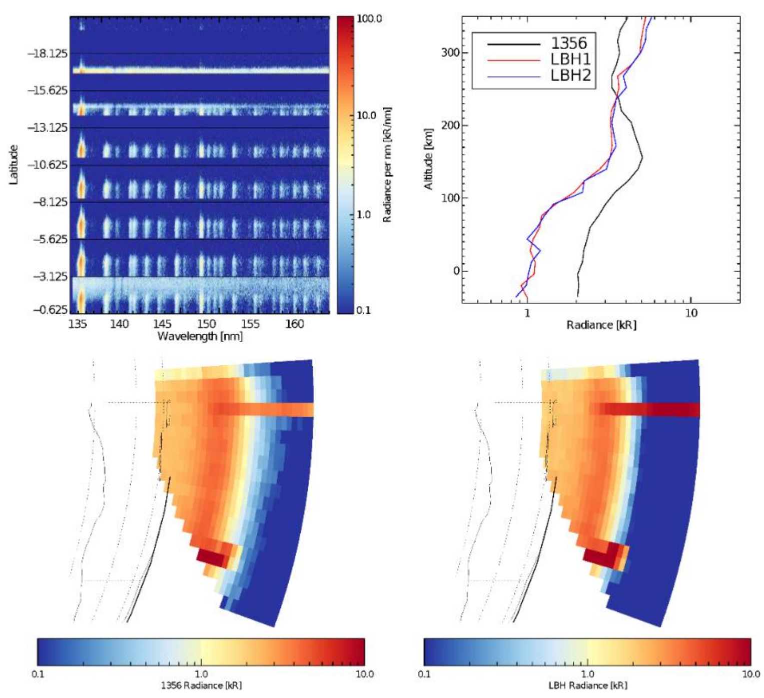

Figure 3-16 Level 1D plot showing observation of multiple stars in the field-of-view during a limb scan.

3.2.2.3 Latitude constraints

The signal-to-noise ratio at the edge of the detector is typically low during southern hemisphere scans, which can produce systematic biases in retrieved temperatures. Therefore, the TLIMB algorithm is not run (TLIMB is set to fill value and DQI set to non-zero value) when the latitude of southern hemisphere limb scan data is greater than 2.5 degrees. Note that northern hemisphere scans may also be affected by low signal-to-noise at the edge of the detector, though no latitude constraint is currently imposed for northern scans (i.e. the TLIMB algorithm is run in this case). Users are advised to use caution when working with TLIMB data derived from the edges of the detector.

3.2.2.4 Tangent altitude constraints

The TLIMB algorithm is only run if the tangent altitudes span the range from 250 km (or higher) to 160 km (or lower) and there are no NaNs in the corresponding Level 1C LIM brightnesses or uncertainties. If this condition is not met, the TLIMB value is set to a fill value and the corresponding DQI is set to a non-zero value.

3.2.2.5 Degraded performance at large SZA

When the SZA is between 60 and 90 degrees the TLIMB algorithm is run but a corresponding DQI is set to a non-zero value indicating degraded algorithm performance. The algorithm is not run when the SZA > 90 degrees. Users should apply extra caution when working with TLIMB data products when algorithm performance is degraded.

3.2.2.6 Algorithm failure

Occasionally the TLIMB algorithm will fail to converge when fitting an observed N_2 LBH limb profile. If the algorithm fails to retrieve an exospheric temperature the TLIMB value is set to a fill value and the corresponding DQI is set to a non-zero value.

3.2.2.7 Possible residual background bias

As noted above there are unresolved issues with the removal of background in Level 1C data. Residual background in the LIM L1C data can produce an apparent increase in the slope of the N_2 LBH limb profile. This is most likely to occur during periods of enhanced particle background. These Level 1C artifacts can subsequently propagate into the TLIMB temperature retrievals. The most noticeable effect is an apparent (but false) increase in the exospheric temperature. At present, there is no check for residual background in the TLIMB algorithm code, thus users are advised to monitor environmental conditions at the spacecraft and to apply extra caution when working with TLIMB data products during periods of enhanced particle background. In particular, users should be cautious when using TLIMB data from the periods October 9, 2018 to January 14, 2019 and October 26, 2019 to December 1, 2019.

3.2.2.8 Data gaps

There is a gap of one day in the TLIMB data for October 9, 2018. During this time period, the particle background was extremely high and resulted in anomalous exospheric temperatures. It is not known at this time if this data will be recoverable in the future. The TLIMB data for this day was inadvertently included in the first Level 2 data release, thus users are cautioned not to use version 1 of TLIMB data on this date.

3.2.3 Issues with TDISK data

The primary issue with TDISK data is marginal signal-to-noise.

3.2.3.1 Preliminary error analysis

A comprehensive error analysis and retrieval characterization for the TDISK product is in progress but has not yet been implemented in this data release. Currently only the random error array is populated with non-fill values in the Level 2 files. These errors should be considered preliminary until a more detailed error analysis is performed.

3.2.3.2 Signal-to-noise ratio

The TDISK algorithm uses the shape of measured spectra to infer the effective temperature of the neutral atmosphere (for each Level 1C DAY pixel). Thus, high signal-to-noise ratio data are necessary for retrieving statistically significant temperatures. Due to the high spatial resolution of current Level 1C DAY data, the corresponding spectral signal-to-noise is low, resulting in relatively large uncertainties in retrieved TDISK temperatures. Improvements in the signal-to-noise of Level 1C DAY data through spatial binning and/or improvements in the TDISK algorithm code are planned for future releases.

3.2.3.3 SZA and EMA constraints

The TDISK algorithm code is not run when the SZA > 80 degrees and/or the EMA > 75 degrees.

3.2.3.4 Effective altitude.

GOLD day disk observations sample a height range of approximately 150 to 200 km, but observed temperatures are weighted by the peak volume emission rate at altitudes where there is a significant temperature gradient. Since the GOLD disk observations represent a column integration of the weighting function (i.e. there is no altitude information), the effective height of derived temperatures must be determined with the aid of forward modeling. This work has not yet been completed; thus we report a fixed altitude of 150 km for the effective disk temperature in the present release.

3.2.3.5 Algorithm failure

Occasionally the TDISK algorithm will fail to converge when fitting an observed spectrum. If the algorithm fails to retrieve an effective neutral temperature the TDISK value is set to a fill value and the corresponding DQI is set to a non-zero value.

3.2.3.6 Sources of contamination

The two primary sources of contamination that may produce artifacts in the TDISK retrieved temperatures are residual background and energetic particles. The former is not expected to produce significant artifacts; however, users are advised to monitor environmental conditions at the spacecraft and to apply extra caution when working with TDISK data products during periods of enhanced particle background. Energetic particles, particularly in the polar regions, are more likely to result in TDISK artifacts. At present, there is no auroral boundary detection algorithm implemented in the Level 2 operational pipeline, therefore users are advised to use caution when working with TDISK data when the geomagnetic latitude > 60 degrees.

3.2.3.7 Data Gaps

There is a gap of one day in the TDISK data for September 3, 2020. During this time period, the particle background was extremely high resulting in artifacts in the retrieved temperatures. It is not known at this time if this data will be recoverable in the future.

3.2.4 Issues with ON2 data

The primary issue with ON2 data is marginal signal to noise, particularly with N_2 LBH intensities, as well as degradation of O I 135.6 nm emission from detector burn in.

3.2.4.1 Preliminary error analysis

A comprehensive review of errors associated with ON2 is in progress. Uncertainty values in ON2 files should be considered preliminary.

3.2.4.2 Contamination of ON2

The O/N_2 algorithm is only valid when the source of O I 135.6 nm and N_2 LBH emission is photoelectrons generated by solar EUV flux. Other sources of these emissions are considered contaminants and will result in erroneous derived O/N_2 values. The main sources of the contaminant emissions for the O/N_2 algorithm are energetic particle precipitation in the polar regions (affecting both 135.6 nm and LBH) and radiative recombination of O^+ in the equatorial ionization anomalies (affecting only 135.6 nm). At present, there is no auroral boundary detection algorithm implemented in the Level 2 operational pipeline, therefore users are advised to use caution when working with ON2 data where the geomagnetic latitude > 60 degrees. Similarly, users are advised to use caution when working with ON2 data during geomagnetically active periods that may produce enhanced radiative recombination emission in the equatorial ionization anomalies.

3.2.4.3 Limits of the algorithm

The O/N_2 values are not derived where the solar zenith angle is greater than 80 or emission angles greater than 75. Also note that DQI flags not set bitwise.

3.2.4.4 Hemispherical bias

Subsequent to the move of the channel A GYM position on April 26, 2019 there is a bias in ON2 between north and south scans that increases with time for several months. The cause of this bias is presently unknown and is under investigation. Users are advised to use caution when working with ON2 data after April 26, 2019 until the cause of the bias is identified and corrected.

3.2.4.5 Look up table constraints

The look up table used by the ON2 algorithm has an upper limit of ~1.65, which can be exceeded under certain circumstances. Users are advised to use caution when working with the data during periods of elevated O/N_2 near or at the upper limit of the look up table. The upper limit of the look up table will be extended in a future release.

3.2.4.6 Data gaps

There are three gaps in the ON2 data set covering the periods March 3 – 5, 2019; April 7 – 25, 2019; and September 1-3, 2020. During the March 2019 and September 2020 periods, the particle background was extremely high resulting in artifacts in ON2. It is unknown at this time if withheld data will be included in a future release. Data from the April 2019 period are being withheld due to sensitivity in ON2 from the effects of instrument degradation and flat field gradients in the short wavelength region of the GOLD detectors (specifically the oxygen 135.6 nm emission). It is unknown at this time if withheld data will be included in a future release.

3.2.4.7 Flat Field correction artifacts

The flatfield correction has some limitations that affect ON2. The flatfield correction can under- or over-correct data depending on the detector gain. Errors in the flatfield correction are largest in the 135.6 nm band when a significant correction is needed. These errors can appear as enhanced scatter in the ON2 data product. Periods of enhanced scatter include: 12/1/18 - 3/7/19, 3/15/19 - 4/6/19, and 8/30/19 - 10/9/19. There is also a small discontinuity in ON2 following the Channel A GYM position change on 3/19/20. Users are advised to use caution when working with data from these specific time periods.

3.2.5 Issues with QEUV data

The primary issue with QEUV data is sensitivity to instrument degradation, flat field corrections, and other effects, particularly with oxygen 135.6 nm intensities.

3.2.5.1 Preliminary error analysis

A comprehensive review of errors associated with QEUV is in progress. Uncertainty values in QEUV files should be considered preliminary.

3.2.5.2 Contamination of QEUV

As with O/N_2, the QEUV algorithm is only valid when the source of O I 135.6 nm and N_2 LBH emission is photoelectrons generated by solar EUV flux. Other sources of these emissions are considered contaminants and will result in erroneous derived QEUV values. The main source of the contaminant emissions for the QEUV algorithm is radiative recombination of O^+ in the equatorial ionization anomalies (affecting only 135.6 nm). Users are advised to use caution when working with QEUV data during geomagnetically active periods that may produce enhanced radiative recombination emission in the equatorial ionization anomalies.

3.2.5.3 Limits of the algorithm

The QEUV values are not derived where the solar zenith angle is greater than 80 degrees, emission angle is greater than 75 degrees, or 10 > UT > 20. Also note that DQI flags are not set bitwise.

3.2.5.4 Data gaps

QEUV data for the following dates are being withheld due to excessive scatter in the data: May 20, 2019, July 2, 2019, and October 29, 2019. It is unknown at this time if withheld data will be included in a future release. Users should also be cautious when working with data from the period December 12, 2018 to February 19, 2019 due to excessive scatter in the data. The source of the scatter is currently under investigation.

3.2.5.5 Flat Field correction artifacts

The flatfield correction has some limitations that affect QEUV. The flatfield correction can under- or over-correct data depending on the detector gain. Errors in the flatfield correction are largest in the 135.6 nm band when a significant correction is needed. These errors can appear as enhanced scatter in the QEUV data product. Periods of enhanced scatter include: 12/1/18 - 3/7/19. There is also a small discontinuity in QEUV following the Channel A GYM position change on 3/19/20. Users are advised to use caution when working with data from these specific time periods.

3.2.6 Issues with NMAX data

3.2.6.1 Data Gaps

A large data gap in the Channel B data between Dec 15, 2018 and Mar 15, 2019 is due to a detector burn in problem, which renders the Channel B NI1 data taken during that time useless for quantitative analysis, such as estimating NMAX. The Channel A data for this period is quite useable.

There is a gap in the NMAX for both channels during the period September 1-3, 2020. The particle background was extremely high during this period, resulting in artifacts in the data.

There is also a small discontinuity in NMAX before and after the Channel A GYM position change on 3/19/2020. This data is not being withheld, however users are advised to use caution when working with data from this time period.

3.2.6.2 Model uncertainty

Because the current NMAX algorithm neglects two sources of 135.6 nm photons (ion-ion mutual neutralization: $O^+ + O^- \rightarrow O + O + h\nu$ and resonant scattering of 135.6 nm photons by atomic oxygen), it tends to overestimate the value of NMAX. We estimate that the model error due to the omission of these two sources is approximately 15% (that is +15% and −0%) depending on several variables mainly having to do with atmospheric composition and variability in the electron density profile shape.

4 Upcoming Work / Plan for Upcoming Releases

4.1 Level 1

Updated sensitivity

Updated scattered light correction

Updated geolocation correction (slit image movement)

Release of additional CHB data products

Quality flags for stars and moon in field of view

Quality flag for presence of xenon emission feature

4.2 Level 2

Routine release of additional TDISK, TLIMB, ON2, QEUV, NMAX and O2DEN (expected except when anomalies are observed in the data).

Release of data held back in the current release due to artifacts or unresolved issues.

Release of additional Channel B data.

Better characterization of error components on retrieved geophysical parameters.

Improve signal to noise for dayside disk products – TDISK and ON2. For TDISK, possible ways to stabilize the retrieval include fixing the vibrational populations. For TDISK and/or ON2, we will explore increased spatial binning (e.g. 2x2 Level 1C binning) – this will result in decreased spatial resolution.

More complete retrieval characterization and error analysis for O2DEN data.

Auroral boundary detection algorithm.

4.3 Level 3

N/A for this release