

Community Satellite Processing Package for Geostationary Data (CSPP Geo) GRB Software Users' Guide

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Section 1: Introduction

1.1 Overview

This document contains instructions for installation and operation of the CSPP Geo GRB software package. The software is intended for use at direct broadcast sites that are receiving GOES-16, GOES-17 or GOES-18 satellite data via the GOES Rebroadcast (GRB) stream. The main functionality offered is to process the GRB data stream, generating products from all GOES-R series instruments locally and in real-time. All products are in mission-standard NetCDF-4 format.

The software was developed at the University of Wisconsin with funding from the NOAA GOES-R Program.

The following products can be generated:

- Advanced Baseline Imager (ABI) Level 1b
- Geostationary Lightning Mapper (GLM) Level 2+
- Space Environment In-Situ Suite (SEISS) Level 1b
- Magnetometer (MAG) Level 1b
- Solar Ultraviolet Imager (SUVI) Level 1b
- Extreme Ultraviolet and X-ray Irradiance Sensors (EXIS) Level 1b

Additional capabilities include generation of quicklook images from ABI products, and conversion of SUVI products to Flexible Image Transport System (FITS) format.

A separate software package called the CSPP Geo AIT Framework is available to further process the ABI Level 1B radiance product to generate Level 2 geophysical products.

This package contains a mix of original software, third-party software libraries, and a modified version of RT-STPS, which is developed and maintained by the NASA Direct Readout Laboratory.

All required third-party software libraries are bundled with the GRB package and automatically linked at runtime, apart from standard Linux system libraries. The user is not required to install any software as a prerequisite to running GRB as long as the minimum system requirements are met.

Visit the CSPP Geo website (<https://cimss.ssec.wisc.edu/csppgeo/>) to obtain the GRB software, test data, and documentation, as well as other software packages and general information on the project.

This software was developed according to the GRB specifications described in the GOES-R Series Product Definition and User's Guide (PUG), Vol. 4, Rev. 2.0, as well as a draft version of the GOES-R PUG (Rev. G.1) that describes recent and planned future changes to the GRB stream. The most recent released version of the GOES-R PUG is

available from the GOES-R project website (<https://www.goes-r.gov/resources/docs.html>).

Please submit any questions or comments about CSPP Geo to csppgeo.issues@ssec.wisc.edu.

1.2 What's New in the Version 1.0 Series Releases

For a full list of changes in each release, refer to the RELEASE_NOTES file that is included in the program tarball.

Note that changes were made to the user interface for Version 1.0, including script names, environment variables, and the output directory structure. Users who are upgrading from a 0.4 series release may want to refer to Appendix A for guidance on migration.

1.2.1 What's New in Version 1.0.27

CSPP Geo GRB Version 1.0.27 includes the following changes, relative to Version 1.0.26:

- Update to continue generating valid SUVI data quality flags (DQF) after the upcoming DO 11.02 update to the ground system. This patch can be applied in advance of the DO update going live in the ground system.
- Adds a GOES-R-Series.xml configuration file that may be used to ingest data from all planned GOES-R series satellites. Users can switch to this configuration in advance of the planned transition to GOES-18 as the operational GOES-West satellite, thereby avoiding having to make a configuration change in sync with the transition (see Section 8.2.1).
- Correctly labels GOES-18 ABI quicklooks.
- Adds CSPP Geo GRB specific attributes to SUVI FITS files.

1.2.2 What's New in Version 1.0.26

CSPP Geo GRB Version 1.0.26 includes the following changes, relative to Version 1.0.25:

- Update to handle GRB data after the DO.09.05.01 update to the ground system. This patch is needed to continue generating valid SEISS SGPS products, and adds helium data to that product. Other products are not affected.

1.2.3 What's New in Version 1.0.25

CSPP Geo GRB Version 1.0.25 includes the following changes, relative to Version 1.0.24:

- Fixes incorrectly typed quality variables in the EXIS EUV and SUVI products, which in the case of EXIS resulted in loss of quality information. The EXIS EUV "qualityFlags" variable changes from uint32 to uint64, and the SUVI "DQF" variable changes from int8 to uint8.

1.2.4 What's New in Version 1.0.24

CSPP Geo GRB Version 1.0.24 includes the following changes, relative to Version 1.0.23:

- Modifies the default delay to wait for data after metadata to 0.5 seconds, as recommended by the GOES-R Series Product Definition and Users' Guide (PUG), improving product latency by about 9.5 seconds.
- Allows the 0.5 second delay described above to be site configurable (e.g. increased or decreased slightly, if desired). Refer to Section 8.8 for instructions.
- Closes socket that was opened by underlying RT-STPS software, but never used.
- Fixes extraneous error messages in EXIS EUV product reconstruction logs that were caused by variables being removed from that dataset upstream.

1.2.5 What's New in Version 1.0.23

CSPP Geo GRB Version 1.0.23 includes the following changes, relative to Version 1.0.21 (note that Version 1.0.22 was not publicly released):

- Updates to handle GRB data after the DO.08.01.00 update to the ground system. This patch is needed to continue generating valid MAG and SEIS EHIS products, and to convert SUVI products to FITS format. Other products are not affected.
- Additional SUVI FITS converter changes: better FITS formatting, and improved error handling.

1.2.6 What's New in Version 1.0.21

CSPP Geo GRB Version 1.0.21 includes the following changes, relative to Version 1.0.19 (note that Version 1.0.20 was not publicly released):

- Updates to the reconstructor to improve product yield when upstream data frames are lost, for example due to local RFI.
- Includes a new experimental GOES-16-Or-17.xml configuration file, which can process either satellite without requiring a restart of the ingestor. See Section 8.2.2 for more information.

1.2.7 What's New in Version 1.0.19

CSPP Geo GRB Version 1.0.19 includes the following changes, relative to Version 1.0.18:

- Updates to handle GRB data after the DO.07.01 update to the ground system. This patch is needed to continue generating EXIS EUV products; other products are not affected.

1.2.8 What's New in Version 1.0.18

CSPP Geo GRB Version 1.0.18 includes the following changes, relative to Version 1.0.15 (note that Versions 1.0.16 and 1.0.17 were not publicly released):

- Bug fix to correctly handle a GRB stream error condition involving out-of-order data packets. The error condition was only observed rarely, but previously resulted in an ingestor restart and an exception in the log.
- Bug fix to minimize the effect of lost packets on in-progress products. The ingestor now recovers the remainder of a product if possible after a missing packet is encountered, instead of closing off the product.
- Minor bug fix for an issue that caused the ingestor to try to purge non-existent temporary files, resulting in an error message in the logs
- All generated files other than products are now automatically purged. Refer to Section 8.6 for more information.
- Workaround for a compression issue affecting SUVI data distributed via GRB; resolves incorrect values in the SUVI RAD variable.
- Fixes for various issues in FITS files created from SUVI NetCDF-4 products.
- Bug fix affecting the EXIS X-RAY product: resolves incorrect size specification for two variables that resulted in incorrect values in subsequent variables.

1.2.9 What's New in Version 1.0.15

CSPP Geo GRB Version 1.0.15 includes the following changes, relative to Version 1.0.14:

- Changes to allow continued GLM and EXIS EUV product generation after the DO.07 update to the ground system. The changes are backward compatible with the current data format, so users can upgrade to 1.0.15 at any point before the change goes live. Users who do not use GLM or EXIS EUV products will not need to update to v1.0.15.

1.2.10 What's New in Version 1.0.14

CSPP Geo GRB Version 1.0.14 includes the following changes, relative to Version 0.4.7:

- Various stability improvements and minor bug fixes.
- Performance improvements to reduce overall product latency and CPU load.
- Improved handling of error conditions and edge cases.

- New configuration settings controlling program execution and product generation.
- Migrated to new quicklooks codebase; various quicklooks issues resolved and overall performance improved; new command-line options are available.
- Added support for multicast UDP ingest.
- Added GOES-17 GRB provisional processing capability.
- Interface changes: new installation procedure and environment setup; user-callable scripts have been renamed; package layout and default output directory structure have been reorganized.
- Added provisional support for ABI Mode 6.
- Logging improvements including: monitoring hooks for CADU reception rate by channel, correct log message levels now tagged in ingestor log, logging level is now configurable.
- Added CSPP Geo specific attributes to product files.
- Added a user-callable diagnostics script.
- The CentOS 7 platform is now explicitly supported in addition to CentOS 6
- Changes to program behavior in command-line mode. Note that command-line mode is now deprecated; only streaming mode will be supported in future Version 2.0.

1.3 System Requirements

The minimum system requirements for the CSPP Geo GRB software are:

- 12 core, 2.4 GHz CPU with 64-bit instruction support,
- 32 GB RAM,
- CentOS 6 or CentOS 7 64-bit Linux (or other compatible 64-bit Linux distribution),
- 100 GB free disk space.

1.4 Test Data

The test dataset was acquired from the antenna at the UW-Madison Space Science and Engineering Center and contains GOES-16 data from all instruments. It is provided solely for purposes of testing the CSPP Geo GRB software, and is not intended to be used for product evaluation or verification.

1.5 License and Disclaimer

Original source code, scripts and automation included as part of this package are distributed under the GNU General Public License agreement version 3. Binary executable files and third-party source code included as part of this software package are copyrighted and licensed by their respective organizations, and distributed consistent with their licensing terms.

The University of Wisconsin-Madison Space Science and Engineering Center (SSEC) makes no warranty of any kind with regard to the CSPP software or any accompanying

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There is no expressed or implied warranty made to anyone as to the suitability of this software for any purpose. All risk of use is assumed by the user. Users agree not to hold SSEC, the University of Wisconsin-Madison, or any of its employees or assigns liable for any consequences resulting from the use of the CSPP software.

Section 2: CSPP Geo GRB Software

A basic GRB receiving system consists of an antenna and receiver / demodulator, connected to a Linux-based computer for GRB data processing. The CSPP Geo GRB software runs on the computer and performs the primary functions of ingesting packets from the baseband (digital) GRB data stream, decompressing and recovering the payloads, reconstructing datasets, and writing output to files.

It is recommended that any further processing such as Level 2+ product generation be performed on a separate machine, to avoid resource contention.

2.1 Processing Modes

The GRB software can be run in either of two processing modes: “streaming mode”, in which the software runs as a server and continuously processes a data stream, or “command-line mode” in which the software is called directly and processes data from files. In both modes, output is written to NetCDF-4 files in the format described in the GOES-R PUG.

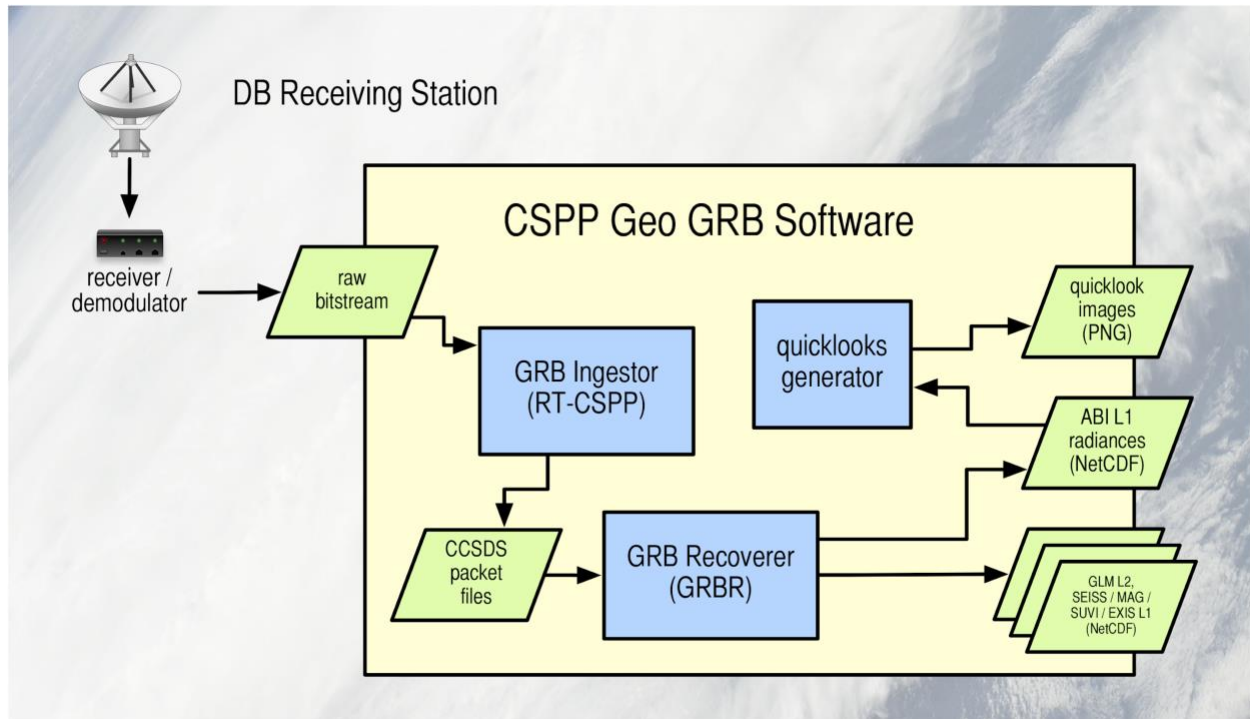
Note that as of the Version 1.0 release, command-line mode has been deprecated. Support for running in command-line mode is scheduled to be dropped in Version 2.0. However, please contact the CSPP Geo team (csppgeo.issues@ssec.wisc.edu) if you are currently running the software in command-line mode and wish to continue to do so.

2.2 CSPP Geo GRB in Streaming Mode

In streaming mode, the GRB software runs as a daemon, reading a GRB data stream and writing output to NetCDF-4 files. Data is read from two sockets to simultaneously process right-hand and left-hand polarization streams. Multi-processing is handled transparently; in other words the GRB software spawns multiple processes which run on compute cores as they become available.

The software consists of two primary components: the “GRB ingestor”, which runs as a server and reads the data stream, and the “GRB recoverer”, which processes the packets and reconstructs product files.

Figure 1. CSPP Geo GRB software running in streaming mode.



The main script for controlling the ingestor is `cspp-geo-grb.sh`. This script uses the Java Service Wrapper to start a GRB ingestor. The service wrapper will monitor the ingestor and restart in the event of any failure.

The GRB ingestor will watch for UDP traffic simultaneously on two network ports. It extracts Channel Access Data Unit (CADU) frames, performs CRC checks, assembles the CADUs into Consultative Committee for Space Data Systems (CCSDS) packets, filters unwanted (e.g., idle) packets, and bundles desired packets in intermediate output files. Each file bundle includes all CCSDS packets required to reassemble one data product. These bundles will be written by default to the location `$CSPP_GEO_GRB_OUT/tmp/RT-CSPP`.

After each packet bundle is written, the GRB recoverer software component is automatically executed to process the GRB space packets, assembling the data payloads into NetCDF-4 files. These files will be written by default to the location `$CSPP_GEO_GRB_OUT/product`. SUVI Flexible Image Transport System (FITS) files can be created manually. See Section 8.7 for more information.

2.3 Input Data Requirements for Streaming Mode

The software processes the GRB data stream as received from a demodulator via UDP. Each UDP datagram must contain CCSDS space packet fragments encapsulated in an

AOS transfer frame and a CADU, as shown in the GOES-R PUG, Vol. 4, Rev. 1.2, Figure 4.4.1. There can be no other network communication artifacts in the input data stream, such as DVB-S2 frames or IPDU headers. The CCSDS packets must be provided in the order received from the spacecraft.

The software is configured to receive via UDP unicast by default, but can also be configured to receive UDP multicast (refer to Section 8.4).

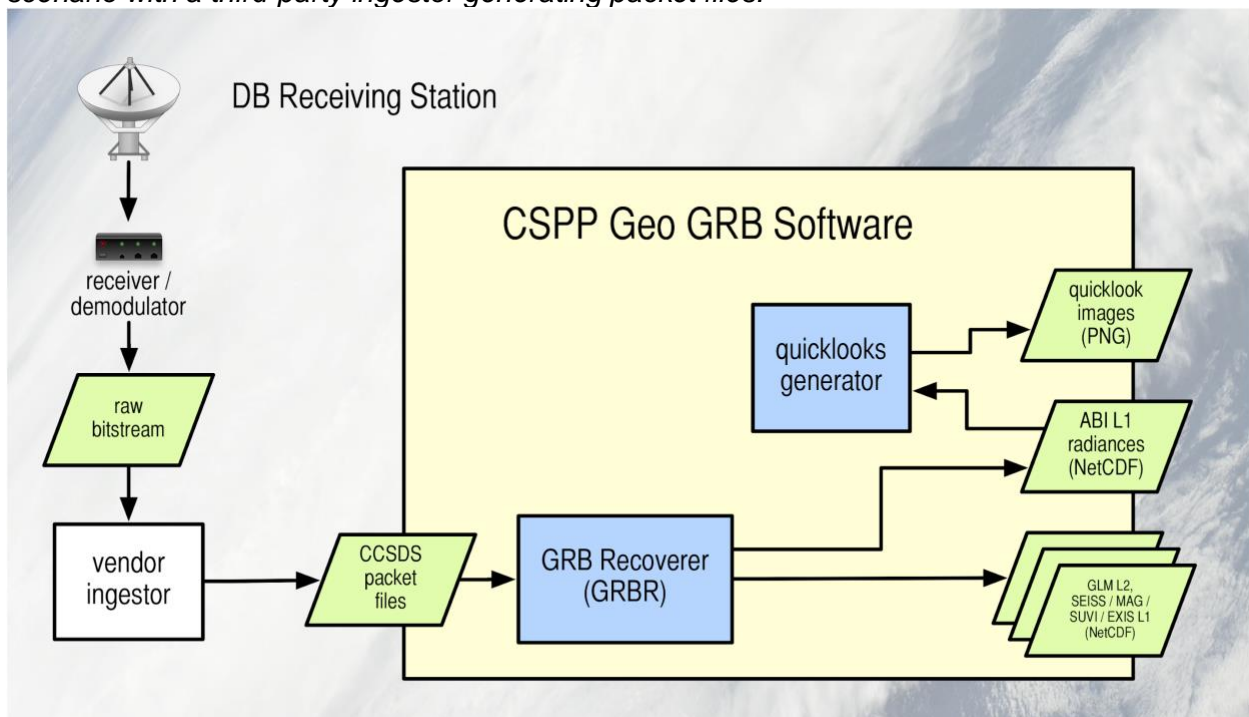
Dynamic ancillary data is not required by the GRB software.

2.4 CSPP Geo GRB in Command-Line Mode

As noted above, command-line mode is deprecated and is planned to be discontinued as of the Version 2.0 release.

In command-line mode, the software is explicitly called by the user at the command line. It reads in data files containing CCSDS packets, equivalent to the intermediate files written by the ingestor as described in Section 2.2, and writes out reconstructed L1 and L2+ data files. This mode is intended for users who want to run their own software to parse the raw data stream, or who want a greater degree of control over program invocation and job scheduling. The assumption here is that the user has already run software to process the raw GRB stream and write out packet bundles, as described in the previous section.

Figure 2. CSPP Geo GRB software running in command-line mode, showing a possible scenario with a third-party ingestor generating packet files.



Multiple simultaneous instances of the GRB software can be run on different files if desired. Expect that each instance may spin off multiple sub-processes.

For more information on command-line mode, refer to Appendix B.

2.5 Quicklook Images

Quicklooks are medium-resolution images that can optionally be generated after processing to give the user an idea of what is happening in a scene, and to quickly see whether there were any obvious processing or data problems. Generation of images from ABI L1B data in PNG format is supported in this version. By default, the quicklooks are generated as projected images with coastlines and geographic boundaries. Various options are available to control the appearance of the images.

Section 3: Installation

3.1 System Configuration

Given the high data rate for the GRB signal, it is recommended the maximum network send and receive buffer sizes be increased from their default settings if the software will be run in streaming mode. This will provide more flexibility to keep up with the data rate in the event of short-lived fluctuations in demands on system resources. To check the values of the buffer sizes, in bytes:

```
cat /proc/sys/net/core/rmem_max
cat /proc/sys/net/core/wmem_max
```

The recommended value for both of these buffers is at least 16777216 (16 MiB). CSPP Geo GRB will still run if the values are less than the recommended value, but will print a warning, and the user may observe missing data in products due to packet loss. Our suggested settings are below; you will likely need root access on your machine to make these changes.

```
sysctl -w net.core.rmem_max=16777216
sysctl -w net.core.wmem_max=16777216
```

In order to retain these settings between system reboots, these lines can be added to the end of `/etc/rc.local` as one way to configure kernel parameters in Linux. The system will need to be rebooted before anything added to `/etc/rc.local` will take effect.

3.2 Installing the GRB software

Version 1.0.27 is distributed as a cumulative patch that can be applied to any previous software version in the v1.0 series. Users may install from scratch and apply the patch, or upgrade an existing v1.0 series installation.

3.2.1 Installing from Scratch

Download the following files from the CSPP Geo website:

<https://cimss.ssec.wisc.edu/csppgeo/>

```
cspp-geo-grb-1.0.14.tar.gz
cspp-geo-grb-1.0.27-patch.tar.gz
```

Install the software as shown below (a new directory named `cspp-geo-grb-1.0` will be created). You can install the software wherever you like, but the rest of this document assumes you have installed it in `$HOME` as shown below.

```
cd $HOME
tar xzf cspp-geo-grb-1.0.14.tar.gz
tar xzf cspp-geo-grb-1.0.27-patch.tar.gz
```

Set the `CSPP_GEO_GRB_OUT` environment variable to indicate the location where program output will be written. This variable must be set for the GRB software to run, and it must indicate a pre-existing directory that is writable. It is advised that the directory should be on a disk that is mounted to the server where the software will run, rather than a network drive.

For example:

```
export CSPP_GEO_GRB_OUT=/data/grb_output
```

Various program defaults can optionally be overridden, including specifying separate locations for different types of output, by setting additional environment variables or editing a configuration file. For more information, refer to Sections 7 and 8.

User-callable executables are located in the main program directory. For convenience, that directory can optionally be added to your path.

```
export PATH=$PATH:$HOME/cspp-geo-grb-1.0
```

If you plan to run the GRB software again, the above lines can be added to your shell login script.

For the rest of this document, we assume you have set up your environment as shown above.

3.2.2 Upgrading an Existing v1.0 Series Installation

Download the v1.0.27 patch from the CSPP Geo website:

```
cspp-geo-grb-1.0.27-patch.tar.gz
```

Next, check the current software version. These instructions assume that you have installed the software in `$HOME`.

```
cd $HOME
grep VERSION ./cspp-geo-grb-1.0/GRB-R/grbr/config.py
```

You should see one of the following version numbers:

```
VERSION = "1.0.14"
```

or

```
VERSION = "1.0.15"
```

or

```
VERSION = "1.0.18"
```

or

```
VERSION = "1.0.19"
```

or

```
VERSION = "1.0.21"
```

or

```
VERSION = "1.0.23"
```

or

```
VERSION = "1.0.24"
```

or

```
VERSION = "1.0.25"
```

or

```
VERSION = "1.0.26"
```

If the current version is not one of those shown above, you cannot apply the patch. You must install from scratch, as described in the previous section.

If the ingestor is running, stop it. This is required because this patch includes updates to ingestor files:

```
cspp-geo-grb.sh stop
```

Next, apply the patch:

```
tar xzf cspp-geo-grb-1.0.27-patch.tar.gz
```

Confirm that the patch was successfully applied by checking the version number.

```
cd $HOME
```


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```
grep VERSION ./cspp-geo-grb-1.0/GRB-R/grbr/config.py
```

You should see the following:

```
VERSION = "1.0.27"
```

Assuming you set the environment variables `CSPP_GEO_GRB_OUT` and `PATH` when you configured the previous version, there is no need to change these settings. However, if you wish to do so, refer to the previous section.

This patch does not affect any user-configurable files, so it should not be necessary to restore any configuration settings that were previously modified.

You can now restart the ingestor if desired ("`cspp-geo-grb.sh start`").

Section 4: Testing Your Installation

4.1 Running the GRB Test Case

If you want to run the test case, download the following file:

```
cspp-geo-grb-test-data-20191026.tar.gz
```

Note that this is a test case that was initially created for the 1.0.23 release. The tarball contains GRB test data in the form of CCSDS packets, as well as a data feeder test script. The test script frames the packets into CADUs, then sends the data as UDP datagrams to the ports monitored by the CSPP Geo GRB software, simulating a GRB data stream as delivered by a demodulator.

The test data should be unpacked in a directory separate from the CSPP Geo GRB installation, e.g.:

```
cd $HOME
tar xzf cspp-geo-grb-test-data-20191026.tar.gz
```

First, edit the ingestor configuration file to receive data from the data-feeder test script running locally. The file is:

```
$HOME/cspp-geo-grb-1.0/RT-CSPP/jsw/conf/grb-ingestor.conf
```

The configuration file contains several preset interface configurations, which you can choose from by commenting and uncommenting lines. Make a backup copy of the file (if desired), and then uncomment the following lines:

```
wrapper.java.additional.6=-DsourceIpAddress=localhost
wrapper.java.additional.7=-DleftPort=5530
wrapper.java.additional.8=-DrightPort=5531
```

Be sure to comment out the equivalent as-shipped settings just below these lines.

Next, start the GRB ingestor (or if the ingestor is already running, you must stop it and restart it for the settings to take effect):

```
cspp-geo-grb.sh start
```

This command starts up a daemon process, which runs in the background, listening for GRB data on ports 5530 and 5531. To verify correct startup and data processing, you can tail the log file:

```
tail -n 15 -f $CSPP_GEO_GRB_OUT/log/ingest/grb.log
```

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In the log, you should see information similar to:

```
jvm 1| 2022/10/13 18:38:51.281 | WrapperManager: Initializing...
jvm 1| 2022/10/13 18:38:51.881 | [INFO ] (AbstractServer) RT-CSPP,
an SSEC Extension of NASA's RT-STPS
jvm 1| 2022/10/13 18:38:51.881 | [INFO ] (AbstractServer) Version
1.0.27 compiled October 12, 2022
jvm 1| 2022/10/13 18:38:52.281 | [INFO ] (Builder) Adding GRB as a
node in the processing pipeline...
jvm 1| 2022/10/13 18:38:52.582 | [INFO ] (GRBIngestor) Left Channel
bound to IP: localhost, Port: 5530
jvm 1| 2022/10/13 18:38:52.582 | [INFO ] (GRBIngestor) Right
Channel bound to IP: localhost, Port: 5531
jvm 1| 2022/10/13 18:38:52.682 | [INFO ] (GRBIngestor) The UDP
input buffer size has been set to 16777216
jvm 1| 2022/10/13 18:38:52.682 | [INFO ] (GRBIngestor) The GRB
ingestor has been successfully initialized.
jvm 1| 2022/10/13 18:38:52.682 | [INFO ] (GRBIngestor) Loading
configuration from file: GOES-16.xml
jvm 1| 2022/10/13 18:38:53.082 | [INFO ] (GRBReceiver) Using bundle
tie-off delay latency of: 0.5s
jvm 1| 2022/10/13 18:38:53.082 | [INFO ] (GRBReceiver) Finishing
setup, preparing shutdown-hook
```

These messages indicate that the ingestor has been successfully started, but that data has not yet started flowing.

If you see any messages marked “ERROR” or “WARN” in the log after the initial message shown above, refer to Appendix C to help identify and resolve the issue. Likely causes of issues at this stage include misconfigured / insufficient maximum network buffer sizes, or that the ports required by the GRB ingestor are not available.

The GRB ingestor is now up and waiting for data.

Now change to the testing directory:

```
cd $HOME/cspp-geo-grb-test-data-20191026
```

Run the data-feeder test script.

```
$HOME/cspp-geo-grb-1.0/runtime/ShellB3/bin/python \
cadu_sender.py -d --left-port 5530 --right-port 5531 cadus
```

You should see screen output similar to:

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```
VCID 5 start at: 2021-08-06 20:25:19.648648
Sending to 127.0.0.1:5531 (1 of 11): cadus/CADU_5_11fXXXX
VCID 6 start at: 2021-08-06 20:25:19.649025
Sending to 127.0.0.1:5530 (1 of 12): cadus/CADU_6_848XXXX
```

The test should take around 14 minutes to run. When the test is complete, you should see some screen output similar to:

```
VCID 5 done at: 2021-08-06 20:38:27.059463
Effective bytes per second: 1874999.65695
```

```
VCID 6 done at: 2021-08-06 20:39:38.642588
Effective bytes per second: 1874999.77343
```

When the test is complete, stop the GRB ingestor:

```
cspp-geo-grb.sh stop
```

Note that NetCDF-4 reconstructor processes will continue running for about fifteen minutes after the test script has stopped sending data. You can ignore these processes.

If the test ran successfully, you should find reassembled NetCDF-4 product files in `$CSPP_GEO_GRB_OUT/product`, with filenames similar to:

```
OR_ABI-L1b-RadC-M6C01_G16_s20192991801340_e20192991804113_c20192991804208.nc
OR_EXIS-L1b-SFEU_G16_s20192991801000_e20192991801300_c20192991801357.nc
OR_SEIS-L1b-EHIS_G16_s20192991810590_e20192991815580_c20192991816001.nc
OR_SUVI-L1b-Fe093_G16_s20192991820001_e20192991820001_c20192991820216.nc
```

To confirm the test ran successfully, count the number of NetCDF-4 data products generated, by running this command:

```
ls -lt $CSPP_GEO_GRB_OUT/product/*.nc | wc -l
```

You should have a total of 1,366 NetCDF-4 files.

To ensure no errors were encountered during data ingest, check for any log messages at ERROR level by running this command:

```
grep ERROR $CSPP_GEO_GRB_OUT/log/ingest/grb.log
```

You should see no output, indicating that there were no error messages.

If you need to re-run the test case for any reason, you may want to change `$CSPP_GEO_GRB_OUT` to indicate a new location, in order to get a clean set of output files.

4.2 Creating Quicklook Images from the Test Case

After the GRB test case has been successfully run, you may generate quicklook images in PNG format from the ABI NetCDF-4 files that were created, by running the script `cspp-geo-grb-ql.sh`. PNG is a standard image format that can be opened with commonly available image viewing software.

Run the invocation below to generate quicklook PNGs for all CONUS NetCDF-4 files, using the Linux “xargs” utility to run in parallel on 8 cores. The images should be created within a couple of minutes, and will be located in the current directory.

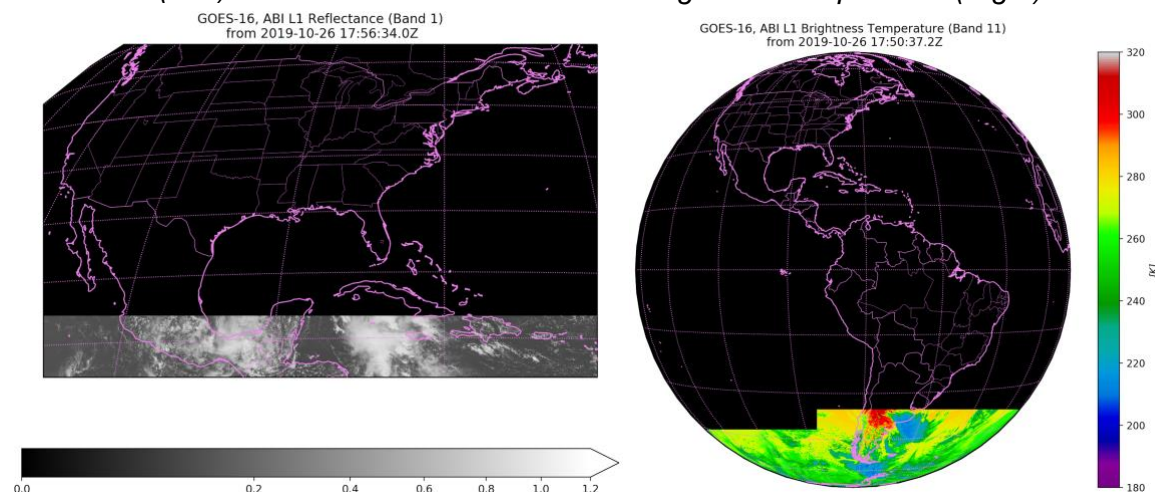
```
ls $CSPP_GEO_GRB_OUT/product/OR_ABI*RadC*.nc | \
xargs -t -n1 -P8 cspp-geo-grb-ql.sh
```

Note that while the quicklooks script is running, you will see various warning messages from supporting Python libraries that can safely be ignored.

You can create quicklook images from the Full Disk and Mesoscale products by varying the file pattern (“*RadF*” and “*RadM*”, respectively).

Because the test case was extracted directly from the GRB stream, you can expect to see some partial images where the test started in the middle of an image. For some bands and sectors, the top part of the first image will contain missing data, like the examples shown on the next page. In addition, the time of the first image will vary across bands due to the timing of when the corresponding packets were sent in the GRB stream.

Figure 3. CSPP Geo GRB quicklooks for partial images of GOES-16 CONUS ABI L1B Band 1 reflectance (Left) and Full Disk ABI L1B Band 11 brightness temperature (Right).

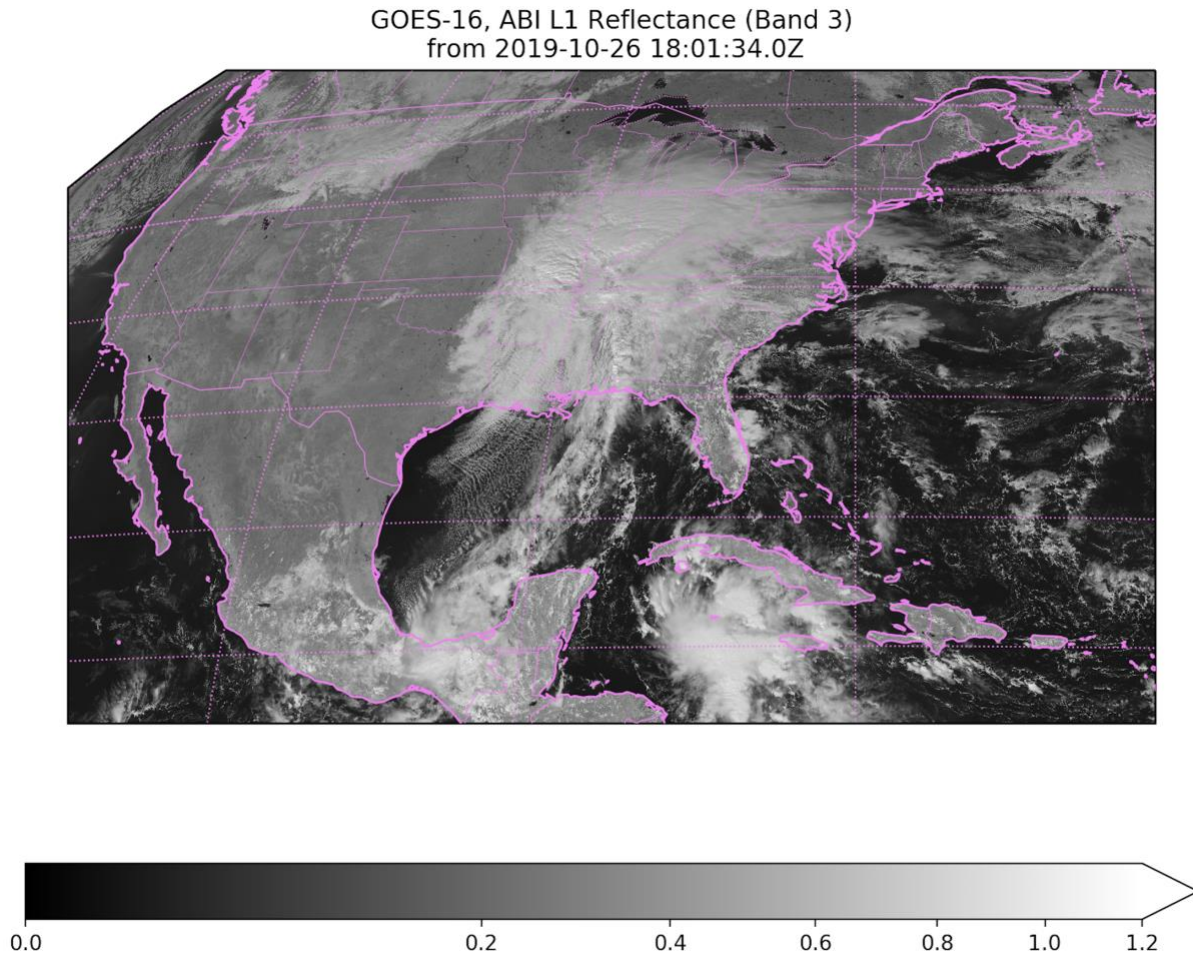


Aside from these partial images at the start of the test case, if rectangular areas of missing data are visible in quicklooks, it is an indication that one or more ABI image packets were

dropped during the test. Typically, dropped packets will result in isolated blocks of missing data in ABI products. If you see these, check that the system meets the minimum hardware requirements, that the system memory buffers were configured as previously described in this document, and that there are no other jobs consuming significant resources or other performance issues with the test machine when the test case is run.

An example quicklook image of the derived ABI CONUS L1b Reflectance is shown below.

Figure 4. A CSPP Geo GRB quicklook example.



Section 5: Basic Usage

User callable scripts can be found in the main program directory.

5.1 Ingestor Script

The GRB ingestor can be started and stopped by calling the script `cspp-geo-grb.sh`. In addition, the script can perform a few other operations related to the ingestor.

The usage of the script is:

```
cspp-geo-grb.sh command
```

The available commands are shown in the table below.

Command	Description
<code>start</code>	Start the ingestor
<code>stop</code>	Stop the ingestor
<code>restart</code>	Restart the ingestor (equivalent to <code>stop</code> followed by <code>start</code>)
<code>status</code>	Check the status of the ingestor (running or not running) and print a message.
<code>console</code>	Start the ingestor running in a console instead of spawning off as a daemon. Log output will be printed to screen, and the ingestor will be shut down when the console is killed (Ctl+C). This may be useful for testing purposes.

5.2 Quicklooks Script

Quicklook images can be created in PNG format from ABI product files, by calling the script `cspp-geo-grb-ql.sh` at the command line.

Some examples of quicklook images are shown in Section 4.2.

Note that the published minimum hardware specifications for the GRB package do not account for routine quicklook image generation. Users who wish to routinely generate quicklook images of products should test that image generation does not negatively impact GRB processing by causing dropped packets. Alternatively, quicklook images can be generated on separate hardware.

The general form of the quicklooks script invocation is:

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```
cspp-geo-grb-ql.sh file_or_directory_name(s)
```

One or more ABI Level 1B files in NetCDF-4 format can be specified, as well as directories containing those files.

Output will be written to the current directory by default, or to the location specified with option “-o”.

For bands 1 through 6 (visible and near IR), the radiance values in L1B files are converted to reflectance, and plotted on a grey scale using square root scaling. For bands 7 through 16 (mid-wave and long-wave IR), radiances are converted to brightness temperature, and plotted on a color scale. For all bands, colorbars are set to a fixed range specific to that band. Options are available to force plotting of the raw radiances, and to override the default colorbar ranges.

To see the full list of available options available for quicklooks generation, run the command `cspp-geo-grb-ql.sh -h`. The list of options is shown below:

```
usage: airtf_ql.py [-h] [-d DPI] [--image_size WIDTH HEIGHT] [-o OUTPUT_DIR]
                  [-O OUTPUTFILEPREFIX] [-S STRIDE]
                  [--customrange USECUSTOMDATARANGE] [--rawrange]
                  [--fileloade drange] [--no-convert] [--onlyvar ONLYVAR]
                  [--unnavigated] [-v] [-V]
                  input_files [input_files ...]
```

Create quicklooks plots from CSPP Geo NetCDF product file.

positional arguments:

input_files

Paths to one or more CSPP Geo NetCDF product files. If a directory is given, the program will examine all files in that directory to see if they are appropriate. This argument will also expand meta-characters understood by python's glob module (including *, ?, and +, among others). Please see the documentation for glob for specific syntax.

optional arguments:

-h, --help

show this help message and exit

-d DPI, --dpi DPI

The resolution in dots per inch of the output png file. [default: 200.0]

--image_size WIDTH HEIGHT

The size of the output image [*width*, *height*] in inches. To determine the expected output size in pixels, multiply these numbers by the DPI. [default: '[10.0, 8.0]']

-o OUTPUT_DIR, --output_dir OUTPUT_DIR

The directory where the generated quicklooks images will be put.

-O OUTPUTFILEPREFIX, --output_file_prefix OUTPUTFILEPREFIX

String to prepend to the automatically generated png names. [default:]

-S STRIDE, --stride STRIDE

Sample every STRIDE rows and columns in the data. If you prefer plot all the data, pass in 1 for the stride. Please keep in mind that this can cause slow plotting and high memory usage for large data sets. By default or if you pass in a negative number the software will generate a stride automatically and attempt to decrease your data size to near the output image size (in pixels). [default: -1]

--customrange USECUSTOMDATARANGE

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	Use a custom range for plotting quicklooks. The range should be defined using the syntax min:max and will be applied to all quicklooks generated during this run. By default the quicklooks will be plotted with a colorbar using custom range limits for some variables and the valid_range attributes for other variables. If --customrange and --rawrange are both present, the custom range will be used. If --customrange and --fileloaddrange are both present, the custom range will be used.
--rawrange	Do not pay attention to the valid range or any flag information, just display the colormap using the raw data range. By default the quicklooks will be plotted with a colorbar using custom range limits for some variables and the valid_range attributes for other variables. If --rawrange and --customrange are both present, the custom range will be used. If --rawrange and --fileloaddrange are both present, the raw range will be used.
--fileloaddrange	Use the range data in the valid_range attribute given in the attributes in the data file for plotting quicklooks. By default the quicklooks will be plotted with a colorbar using custom range limits for some variables and the valid_range attributes for other variables. If --customrange and --fileloaddrange are both present, the custom range will be used. if --rawrange and --fileloaddrange are both included in the command line call, the raw range will be used.
--no-convert	Do not convert level one radiance data to reflectances or brightness temperatures.
--onlyvar ONLYVAR	Process only the variable name given. No other variables from the input files will be used to make quicklooks. If your variable name has spaces use single quotes around it.
--unnavigated	Do not navigate the data on a map, just display it as an image.
-v, --verbosity	each occurrence increases verbosity 1 level from ERROR: -v=WARNING -vv=INFO -vvv=DEBUG
-V, --version	Print the CSPP FW Quicklooks package version

As an example, the following command would generate quicklook images from all Full Disk image products:

```
cspp-geo-grb-ql.sh $CSPP_GEO_GRB_OUT/product/OR_ABI-L1b-RadF*.nc
```

Quicklooks can be generated much more quickly by running multiple jobs in parallel, using the Linux “xargs” command (see the example in Section 4.2). However, as previously mentioned, care should be taken that CPU and memory resource contention does not interfere with GRB processing.

Quicklook images for instruments other than ABI are not supported in this release.

5.3 Diagnostics Script

The diagnostics script `cspp-geo-grb-diag.sh` calls standard Linux utilities to gather information about your system and runtime environment, and prints the output to screen. This information may be requested by the CSPP Geo team to help with troubleshooting if you submit a support request.

Section 6: Processing Live GRB Data

6.1 Configuring to Process Live GRB Data

Before you can process GRB data, you must activate an interface on the GRB processing machine to act as the target for data from a demodulator. The details of demodulator and network configuration are site-specific and beyond the scope of this document, but in general, to set up a network interface on the GRB processing machine you would run the following command:

```
ifconfig <interface> <Demodulator Target IP Address>
```

Refer to the Linux `ifconfig` documentation for more information on setting up an interface.

If you are configuring the software to receive GRB data via UDP unicast (the default method), no configuration changes should be needed. The applicable configuration file is:

```
$HOME/cspp-geo-grb-1.0/RT-CSPP/jsw/conf/grb-ingestor.conf
```

The default settings in that file are as follows:

```
wrapper.java.additional.6=-DsourceIpAddress=192.168.123.105
wrapper.java.additional.7=-DleftPort=50010
wrapper.java.additional.8=-DrightPort=50020
```

The value “192.168.123.105” is the default “target” IP address demodulators such as those provided by Quorum Communications send to. This should only be changed in the case a site utilizes a configuration which is not a direct connection to a demodulator. One scenario is leveraging a UDP multicast switch (see section 8.4). Another scenario is leveraging a “fanout” server such as the system developed by the University of Wisconsin Space Science and Engineering Center’s Data Center.

The values “50010” and “50020” are the default target ports to receive data on the GRB processing machine, and should only be changed in a rare situation such as sites running multiple ingestors on a single machine.

GOES-16 processing is enabled by default. To enable GOES-17 or GOES-18 processing, edit `grb-ingestor.conf` as described in Section 8.2 and continue with this section.

If any changes were made to `grb-ingestor.conf`, save them and then start the ingestor (or if it is already running, stop and restart it):

```
cspp-geo-grb.sh start
```

6.2 Verifying Successful Processing

If the GRB software is successfully processing the GRB data stream, products should start appearing in `$CSPP_GEO_GRB_OUT/product` almost immediately after starting the ingestor. You should see products from all GOES-R Series instruments, matching the following file patterns:

```
OR_ABI-L1b*.nc
OR_EXIS-L1b*.nc
OR_GLM-L2*.nc
OR_MAG-L1b*.nc
OR_SEIS-L1b*.nc
OR_SUVI-L1b*.nc
OR_GRB-INFO*.xml
```

These products should match exactly with products generated by the operational ground system, as available from CLASS, except for some file attributes that are added by CSPP Geo software. For more information on these products, refer to the GOES-R PUG.

6.3 Troubleshooting Problems

The problems that most commonly occur in GRB processing and product generation are described in this section. These problems are:

1) The CSPP Geo GRB ingestor cannot be started.

This problem is most often due to the system not being properly configured for the ingestor to run, or that another program or ingestor instance is already using the required ports. Review the information on system configuration, software installation and software configuration in Sections 3.1, 3.2 and 6.1.

Another possible cause is incompatibility between the software and the hardware or operating system. Refer to the system requirements in Section 1.3.

2) The CSPP Geo GRB ingestor is running, but no output is being generated

This problem may indicate that GRB data is not reaching the ingestor, or it may indicate a software, configuration or hardware problem.

Check the ingestor log for messages like the following, which indicate that the ingestor is running but no data is being received:

```
[INFO ] (CaduService) VCID5 (Right) CADUs per minute: 0
[INFO ] (CaduService) VCID6 (Left) CADUs per minute: 0
[INFO ] (CaduService) VCID63 (Idle) CADUs per minute: 0
```

If you see messages like this, the problem is most likely upstream of the GRB software. The cause could be any of the following:

- Products are currently not being distributed via the GRB data stream due to an outage or a planned interruption. This happens occasionally. Information on GRB stream issues and planned interruptions is distributed via ESPC (contact ESPCOperations@noaa.gov).
- Your receiving system is currently not receiving GRB data, or is failing to provide CADUs via UDP as required by CSPP Geo software. Check with your receiving station vendor or documentation to ensure that the system is functioning properly, and refer to Section 2.3 for information on input data requirements of CSPP Geo software.
- Your local network or the network interface on the GRB processing machine are not properly configured.
- The CSPP Geo software is not properly configured to receive GRB data, as described in Section 6.1.

If you do not see messages like the one shown above, the problem may be due to a processing issue, like a full disk. Check the ingestor log for error or exception messages, as described in Section 7.3.1 and Appendix C.

Finally, note that while all products that are distributed via GRB are reconstructed and written out by default, generation of individual products can be turned on and off, as described in Section 8.1.

3) Output is being generated, but some products are missing or partial (i.e., contain some missing data)

When this problem occurs, it is likely that entire frames or sequences of frames have not been received by the ingestor. Check the ingestor log for “Frame Error” messages occurring around the time of the data problem.

```
grep "Frame Error" $CSPP_GEO_GRB_OUT/log/ingest/grb.log*
```

Since each virtual channel (Left or Right for GRB) has a sequentially incrementing frame counter, frames lost for any reason can be easily detected, and will show up as messages similar to:

```
[ERROR] (CaduService) Frame Error, VCID: 6, prev VCFC: 9472682,  
this VCFC: 9472684
```

In this log message, the difference between the current Virtual Channel Frame Counter (VCFC) value and the previous VCFC value will indicate how many data frames were not received.

These messages indicate that a frame error has occurred, but do not indicate the cause.

Note that if you do **not** see any frame errors in the ingestor log that are associated with the data issues, it is possible that the data was missing on the ground system before the CADUs were framed and sent over GRB. In this case there is nothing to be done at the receiving station since the data was never transmitted.

The root causes of this problem may be:

- Missing data in the GRB stream. Information on GRB stream issues and planned interruptions is distributed via ESPC. It may be useful to check for similar problems at other receiving stations to determine if the issue is universal or local.
- Local issues upstream of the GRB software, such as RF interference, antenna issues or network issues. Check with your antenna vendor and documentation for proper configuration. Check for patterns in the occurrences of problems that might indicate a particular cause, such as time of day, correlation with electrical storms, or impact on specific products or RHCP vs LHCP channels. Your network administrator may be able to determine if all packets sent by the demodulator are reaching the processing machine in the proper order.
- Failure of the GRB ingestor to keep up with the data stream due to under-spec or underperforming hardware, or due to contention for system resources with other processes running on the same machine. Monitor CPU load, I/O load and memory usage on the processing machine, and check whether limits were exceeded when GRB processing problems occurred. Check for hardware issues, and consider rebooting the machine.

Again, note that generation of individual products can be turned on and off, as described in Section 8.1.

Section 7: Output

While processing GRB data, the software writes output in the form of product files, program logs, event logs, tracking files and temporary files.

7.1 Output Locations

By default, output is written to the location `$CSPP_GEO_GRB_OUT`, with different types of output landing in different subdirectories as described in the table below. However, the default output location can be overridden for each type of product if desired, by setting the corresponding environment variable as listed in the table.

Default sub-directory	Description	Overriding environment variable
product	Product files	CSPP_GEO_GRB_PRODUCT
log/ingest	Ingestor logs	CSPP_GEO_GRB_LOG
log/product	Product reconstruction logs	CSPP_GEO_GRB_LOG
log/event	Event logs	CSPP_GEO_GRB_LOG
track	Tracking files	CSPP_GEO_GRB_TRACK
tmp	Intermediate and temporary files	CSPP_GEO_GRB_TMP

For information on cleaning up output, including purging old product files and changing the automatic purging behavior related to logs and temporary files, refer to Section 8.6.

7.2 Product Files

Product files are created in mission-standard NetCDF-4 format. The file format and contents are the same as the products that were created on the ground system (assuming no data was lost in GRB transmission, reception or processing), apart from the attributes shown in the table on the next page, which are added by the CSPP Geo software.

Attribute name	Description	Example
cspp_geo_grb_version	Software name and version number	"CSPP Geo GRB v1.0.27"
cspp_geo_grb_product ion_host	Name of the GRB processing machine	"chai.ssec.wisc.edu"

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cspp_geo_grb_reconstruction_end_time	Date and time the product was finalized on the GRB processing machine	"2018-07-18 20:27:51.839666"
history	per CF standard, audit trail containing date and time of reconstructor program execution, as well as full invocation	"2018-07-18, 20:27:04, graemem, /data/users/graemem/cspp-geo-grb-1.0.12-20180718.163420/GRB-R/grbr/reconstructor.py -b -vv /home/graemem/output/tmp/RT-CSPP/GRB_250_0x120_2018-07-04T15:47:22.162Z.ccsds"

The following products are created by default, in `$CSPP_GEO_GRB_OUT/product`.

Product key	Description	Observed files per hour
ABI-L1b-RadC	ABI Level 1B Radiance, CONUS	Mode 3: 192* Mode 4: 0 Mode 6 (default): 192
ABI-L1b-RadF	ABI Level 1B Radiance, Full Disk	Mode 3: 64* Mode 4: 192 Mode 6 (default): 96
ABI-L1b-RadM1	ABI Level 1B Radiance, Mesoscale Sector 1	Mode 3: 960* Mode 4: 0 Mode 6 (default): 960
ABI-L1b-RadM2	ABI Level 1B Radiance, Mesoscale Sector 2	Mode 3: 960* Mode 4: 0 Mode 6 (default): 960
EXIS-L1b-SFEU	EXIS Solar Flux EUV	120
EXIS-L1b-SFXR	EXIS Solar Flux X-Ray	120
GLM-L2-LCFA	GLM Level 2+ Lightning Detection	180
MAG-L1b-GEOF	MAG Product	60
SEIS-L1b-EHIS	SEISS Energetic Heavy Ions	12
SEIS-L1b-MPSH	SEISS Magnetospheric Electrons and Protons: Medium and High Energy	120
SEIS-L1b-MPSL	SEISS Magnetospheric Electrons and Protons: Low Energy	120

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SEIS-L1b-SGPS	SEISS Solar and Galactic Protons	60
SUVI-L1b-Fe093	SUVI Solar Imagery: X-Ray Band Fe093	90
SUVI-L1b-Fe131	SUVI Solar Imagery: X-Ray Band Fe131	45
SUVI-L1b-Fe171	SUVI Solar Imagery: X-Ray Band Fe171	30
SUVI-L1b-Fe195	SUVI Solar Imagery: X-Ray Band Fe195	105
SUVI-L1b-Fe284	SUVI Solar Imagery: X-Ray Band Fe284	30
SUVI-L1b-He303	SUVI Solar Imagery: X-Ray Band He303	58 or 60

*Different counts may be observed for GOES-17 Mode 3 due to implementation of the cooling timeline beginning in August 2020. For more information, refer to the GOES-R Program's informational page: <https://www.goes-r.gov/users/GOES-17-ABI-Performance.html>.

The product keys in the table above appear in the filenames, and can be used to identify product files. For example, the following command will list all ABI L1B CONUS product files.

```
ls $CSPP_GEO_GRB_OUT/product/*ABI-L1b-RadC*
```

Note that the “observed files per hour” column in the table above is based on product frequencies observed on a GRB system located at the University of Wisconsin. These values may change over time.

The observed product file volume at the University of Wisconsin site has averaged about 170 GB / day while ABI was in Mode 3. Of that total, the breakdown by instrument is about 150 GB for ABI, 1 GB for GLM, and 19 GB for all space weather instruments (SUVI, EXIS, SEISS, and MAG).

Each ABI and SUVI product file contains data related to a single band and scene. GLM, SEISS, MAG, and EXIS product files contain a series of aggregated observations.

Missing data in image datasets is represented by a fill value.

Generation of different types of products can be toggled on and off, as described in Section 8.1.

SUVI data products can optionally be converted to Flexible Image Transport System (FITS) file format. For more information, refer to Section 8.7.

For more information on products, refer to the GOES-R PUG.

7.3 Log Files

While the GRB software is running, informational messages, warnings and error messages are written to the ingestor log file, and to per-product reconstruction log files. Information on data start and end times is written to an event log. Each of these logs is described in this section.

7.3.1 Ingestor Log

The ingestor software component writes messages to the ingestor log file, with a default location of `$CSPP_GEO_GRB_OUT/log/ingest/grb.log`. This log is the primary source of information about program health and any issue encountered processing the GRB data stream, for example due to data dropouts at the antenna.

The ingestor log level is configurable, as described in Section 8.3. At the default logging level, each message is tagged with “INFO”, “WARNING” or “ERROR”, indicating what kind of message it is. Each message has a timestamp indicating the time that it was logged.

To see a list of all errors encountered by the ingestor, you can type:

```
grep ERROR $CSPP_GEO_GRB_OUT/log/ingest/grb.log
```

In some rare situations, the ingestor may be forced to exit without logging an error. In this case, there will be an exception message in the log file, and the ingestor will be automatically restarted by the Java Service Wrapper. This condition should not happen during normal processing, and would generally indicate a system problem, a software configuration problem, or an internal software issue.

To check for exceptions:

```
grep Exception $CSPP_GEO_GRB_OUT/log/ingest/grb.log
```

A count of Java Virtual Machine (JVM) restarts is logged, and this is the easiest way to detect cases when the ingestor has been automatically restarted. For example, if there have not been any restarts since the last time the server was started by the user, the JVM count will always be 1, as seen in this log file message:

```
jvm 1      | 2021/02/03 21:27:22.023 | [INFO ] (AbstractServer) 1.0.27 compiled  
October 12, 2022
```

If the ingestor has been automatically restarted due to the Java Service Wrapper catching an exception, the JVM count will be higher than 1, as seen in this log file message:

```
jvm 2      | 2019/01/01 17:54:33.584 | WrapperSimpleApp:  
java.lang.NumberFormatException: For input string: "config-err"
```

In this example, the ingestor was unable to start because a string was accidentally used for a configuration parameter meant to be an integer value.

If the ingestor cannot be restarted, for example due to a full disk, the Java Service Wrapper will periodically attempt to restart it. In this case you may see a very large JVM count.

Refer to Appendix C for a list of error and exception messages and their possible meanings.

7.3.2 Product Reconstruction Logs

Information on product reconstruction is written to log files located in `$CSPP_GEO_GRB_OUT/log/product`. Generally these files contain less information of interest to the user than the ingestor logs.

Each log file describes a single product. The file name contains the Application Identifier (APID) associated with the product's metadata (as described in the GOES-R PUG, Vol. 4, Rev. 2.1, Section A.1), as well as the start time of the product. An example filename is:

```
GRB_250_0x16f_2018-07-04T15:13:00.082Z.log
```

Messages are timestamped and tagged with "INFO", "WARNING" or "ERROR".

As an example, the following error message was caused by the program reaching a timeout due to missing metadata for a particular product.

```
2018-07-18 20:46:42,810 - ERROR - Timeout occurred after 900  
seconds.
```

7.3.3 Event Log

The GRB software creates an event log, meant to convey important information about when a new dataset starts, when a dataset ends, and if any critical errors were encountered while reconstructing a dataset. It is meant to be human readable, though it can pass by very quickly given the number of datasets in the GRB stream. It is located at `$CSPP_GEO_GRB_OUT/log/event/grb-events.log` and rotates automatically.

An example message looks like:

```
[2016-10-27 07:56:01.802552] : Dataset End : EXIS Solar Flux: X-  
Ray : 2016-10-03 15:54:55.000020 : /home/nickb/dev/grb/dev/cspp-
```

```
geo-grb-dev/output/GRB-R/OR_EXIS-L1b-  
SFXR_G16_s20162771554550_e20162771555219_c20162771601098.nc
```

7.4 ABI Tracking Files

As an ABI image is being received and processed, the software writes data to a temporary NetCDF-4 file, and writes information to a separate “tracking” file describing which data fragments have been processed and written to disk. This is intended to allow use of ABI data in downstream applications before the full image has arrived and been processed.

This capability is experimental, and the interface may change in a future release. If you have feedback about this interface, please contact us!

A complication of any type of GRB streaming interface is that the GRB stream transmits each dataset’s metadata as the final packet. This means that information needed to interpret the data (such as navigation, scale factors and offsets) is not known until after the full image has arrived. A workaround is to use metadata from the previous image, under the assumption that the information is stable across images. For example, navigation information is not expected to change often for Full Disk and CONUS images. However, this assumption will not hold for mesoscale images, which often change the target location.

Tracking files are written to `$CSPP_GEO_GRB_OUT/track` while the image is being received, and end with a `‘.track’` extension.

As each ABI image fragment is written to the corresponding NetCDF-4 file, a single line is added to the tracking file with 0-based indices for that fragment:

```
<west bounds> <north bounds> <east bounds> <south bounds>
```

Also described as:

```
<upper left x> <upper left y> <bottom right x> <bottom right y>
```

User processes can watch this file to see when regions of interest are written, and then read the region of interest from the corresponding NetCDF-4 file (same root name with `.nc` extension). Note that these NetCDF-4 files are temporary files that will be renamed when the final metadata is received and the final filename is known. The temporary files contain radiances and data quality information, but they do not contain metadata, since (as previously mentioned) it has not been received yet.

7.5 Temporary Files

The program writes temporary and intermediate files to the location specified by the user. These files can generally be ignored, but for reference, the naming convention of the

intermediate files used to pass data between the ingestor and recoverer program modules can be found in Appendix D.

Section 8: Advanced Usage and Configuration

Note that the GRB ingestor must be stopped and restarted before any changes made to configuration files will take effect (see Section 5.1).

8.1 Configuring Which Data to Process by Application Identifier (APID)

Which GRB products are created is controlled by XML configuration files, located in the following directory:

```
$HOME/cspp-geo-grb-1.0/RT-CSPP/config/
```

Example configurations are provided for each instrument and each satellite in the GOES-R series. For example, this configuration would process only the GLM instrument for GOES-17, ignoring all other data in the GRB stream:

```
$HOME/cspp-geo-grb-1.0/RT-CSPP/config/GOES-17-GLM-Only.xml
```

By default, the system comes pre-configured to use the following file, which will process all instruments, and all data, for GOES-16:

```
$HOME/cspp-geo-grb-1.0/RT-CSPP/config/GOES-16.xml
```

There are similar configuration files for GOES-17, GOES-18, and GOES-19 (not yet launched). As of Version 1.0.27, there is also a GOES-R-Series.xml file, which will process any of the four satellites in the GOES-R Series (see section 8.2.1 for details).

When using comprehensive configurations like these (GOES-16.xml, GOES-17.xml, GOES-18.xml, GOES-19.xml, or GOES-R-Series.xml), all standard APIDs defined in the GOES-R PUG are processed (refer to GOES-R PUG, Vol. 4, Rev. 1.2, Table A.1). If your site wishes to change the default settings, edit the XML file and comment out all occurrences of XML elements for the APIDs you wish to remove. The standard html comment tag of “<!-- ... -->” can be used. For example, to filter out data for the SEISS Solar and Galactic Protons, search for that term, and comment out each XML element for the metadata and data APIDs so it looks like:

```
<!-- 0x430 1072 SEISS Solar and Galactic Protons Metadata -->
<!-- <pklink apid="1072" label="apid1072" /> -->
<!-- 0x431 1073 SEISS Solar and Galactic Protons Data -->
<!-- <pklink apid="1073" label="apid1073" /> -->
```

Note, there are currently four references in GOES-16.xml, GOES-17.xml, GOES-18.xml, and GOES-19.xml for each APID (one for each node in the ingestor processing pipeline). For each APID you want to stop processing, all four XML elements should be commented out. In GOES-R-Series.xml, there will be seven references, which all should be commented out. This may be simplified in a future release. For each APID, both the

hexadecimal and decimal values are provided in the XML descriptions (in the above example hexadecimal 0x430, decimal 1072 for the metadata and 0x431, decimal 1073 for the data).

8.2 Processing other GOES-R series data

As previously mentioned, the software is configured to process data received from GOES-16 by default. This section describes how to configure the software to process data received from other GOES-R series satellites.

Apart from the changes described below, configuration for other GOES-R series processing is as described in Section 6.1, Configuring to Process Live GRB Data. All other processing steps (starting and stopping data ingest, etc.) remain the same.

8.2.1 Processing GRB data from any satellite in the GOES-R Series

New to Version 1.0.27, a configuration file has been added to allow users to process data received from any GOES-R Series satellite (GOES-16, GOES-17, GOES-18, or GOES-19). This configuration will be enabled by default in a future software release, and is recommended to allow processing of data received from different satellites without a configuration change or ingestor restart. Examples of situations where this would be useful include the transition from GOES-17 to GOES-18 as the operational GOES-West satellite, or an antenna re-point.

To configure the system, edit `grb-ingestor.conf`, as follows:

```
wrapper.java.additional.3=-Dconfig=GOES-R-Series.xml
```

After this change has been made and the ingestor has been restarted, the ingestor can process data from any GOES-R Series GRB feed.

Note: This configuration file is NOT intended for processing data from multiple satellites simultaneously on the same system.

8.2.2 Processing data from a selected satellite in the GOES-R Series

For users running Version 1.0.27, it is recommended that the method described in the previous section should be used to allow processing of data received from any GOES-R Series satellite. However, users who are running an earlier version, or who wish to restrict processing to a single satellite can follow the instructions in this section.

To configure the system to process GRB data received from a single GOES-R series satellite, edit the following line in `grb-ingestor.conf` (note the default value is shown below):

```
wrapper.java.additional.3=-Dconfig=GOES-16.xml
```

Allowed values are "GOES-16.xml", "GOES-17.xml", "GOES-18.xml" and "GOES-19.xml". For example, to process data received from GOES-17, change the line to the following:

```
wrapper.java.additional.3=-Dconfig=GOES-17.xml
```

After editing the file and restarting the ingestor, only data received from the specified satellite will be processed.

8.3 Configuring the GRB Ingestor Logging Level

The GRB ingest software logging level is configurable, with supported levels:

- TRACE : Finest detail, very verbose, used in rare troubleshooting cases
- DEBUG : Fine detail, used to debug anomalous behavior
- INFO : Modest amount of detail, appropriate for tracking normal operations
- WARN : Warnings or errors only
- ERROR : Critical errors only

By default the logging level of the GRB ingest software is set to the INFO level, which provides enough detail to track product creation in real time. To change the logging level, edit the file:

```
$HOME/cspp-geo-grb-1.0/RT-CSPP/config/log4j.conf
```

Modify the statement:

```
log4j.rootLogger=INFO, A
```

Change INFO to the desired logging level. Also, note there is a potential for fine logging levels (DEBUG and TRACE) to affect performance, resulting in data loss. They should only be used temporarily to diagnose anomalies.

8.4 Configuring UDP Multicast Ingest

Ingest of GRB data received via UDP multicast is supported. UDP multicast allows the same packet stream be sent from a source to multiple destination addresses simultaneously. This allows a system configuration where a single demodulator feeds GRB data to multiple processing systems, which are running in parallel. However, note that the UDP datagrams must be received by the GRB software in the same order that they were transmitted by the demodulator. Any re-ordering of datagrams or packet loss over the network will likely result in incomplete or missing data products.

The demodulator must first be configured to send via UDP multicast. Check the documentation of your demodulator or contact the manufacturer to determine if UDP multicast is supported.

To configure CSPP Geo GRB for multicast, the only modification required is two edits to `grb-ingestor.conf`, as follows:

```
wrapper.java.additional.6=-DsourceIpAddress=192.168.123.105
```

The value “192.168.123.105” should be replaced with the IP address of the network interface configured for data reception on the GRB processing machine.

Also uncomment and set this line appropriately:

```
# wrapper.java.additional.16=-DMULTICAST=239.255.123.105
```

The value “239.255.123.105” should be replaced with the IP address of the broadcast group configured at your location.

Note that the “`wrapper.java.additional.X`” parameters must be listed in increasing numerical order, with no gaps in the numerical sequence.

If configured correctly, `grb.log` will show messages at startup similar to:

```
jvm 1      | 2022/10/14 19:41:56.399 | [INFO ] (AbstractServer)
RT-CSPP, an SSEC Extension of NASA's RT-STPS
jvm 1      | 2022/10/14 19:41:56.399 | [INFO ] (AbstractServer)
Version 1.0.27 compiled October 12, 2022
jvm 1      | 2022/10/14 19:41:56.399 | [INFO ] (Builder) Adding
GRB as a node in the processing pipeline...
jvm 1      | 2022/10/14 19:41:56.499 | [INFO ] (GRBIngestor)
jvm 1      | 2022/10/14 19:41:56.499 | [INFO ] (GRBIngestor)
Configuring multicast ingest
jvm 1      | 2022/10/14 19:41:56.499 | [INFO ] (GRBIngestor)
Multicast group address: 239.255.123.105
```


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```
jvm 1      | 2022/10/14 19:41:56.499 | [INFO ] (GRBIngestor) Data
reception interface: 192.168.123.107
jvm 1      | 2022/10/14 19:41:56.499 | [INFO ] (GRBIngestor)
jvm 1      | 2022/10/14 19:41:56.499 | [INFO ] (GRBIngestor) Left
Channel bound to Group: 239.255.123.105, IP: 192.168.123.107,
Port: 50010
jvm 1      | 2022/10/14 19:41:56.499 | [INFO ] (GRBIngestor) Right
Channel bound to Group: 239.255.123.105, IP: 192.168.123.107,
Port: 50020
jvm 1      | 2022/10/14 19:41:56.499 | [INFO ] (GRBIngestor) The
UDP input buffer size has been set to 16777216
jvm 1      | 2022/10/14 19:41:56.499 | [INFO ] (GRBIngestor) The
GRB ingestor has been successfully initialized.
```

8.5 Additional Environment Settings

The following additional environment settings can be specified by the user to control program behavior related to product generation.

Environment variable	Description
CSPP_GEO_GRBR_ENABLE_TRACKING	Enable or disable writing to the tracking file. 1=on (default), 0 = off
CSPP_GEO_GRBR_ENABLE_EVENT_LOG	Enable or disable writing to the event log. 1 = on (default), 0 = off
CSPP_GEO_GRBR_DEFAULT_COMPRESSION	Set the compression level for all products. 0-9 are valid, 1 = default (low), 9 = high (cpu intensive), 0 = off
CSPP_GEO_GRBR_IMAGE_COMPRESSION	Set the default compression level for image products only (ABI & SUVI); uses the same values as default compression above and takes precedence if set

Note that increased compression levels will result in smaller products at the cost of higher CPU and memory utilization, and higher product latencies. If the compression level is increased beyond the default values, check that hardware capabilities have not been exceeded, resulting in data loss (refer to Section 6.3 Troubleshooting).

8.6 Cleaning Up Output

There is no built-in mechanism in the CSPP Geo GRB software for managing product retention and dissemination. These functions are the responsibility of each processing site.

One simple mechanism to set a retention time period and purge old products is to utilize `tmpwatch` and `cron`. For example, this crontab entry will run every 5 minutes, and will retain two days worth of products and purge anything older:

```
* /5 * * * * /usr/bin/tmpwatch --all 2d /data/cspp-geo-grb-1.0/output/product
```

It should not be necessary for users to purge or monitor any output directories other than the “product” directory. Files other than products are considered to be transient, and are automatically cleaned up while the ingestor is running. (Note that auto-cleanup of tracking files and all temporary files was added in Version 1.0.17.)

The table below indicates the default file retention behavior for each type of program output, as well as the recommended clean-up action for users, if any.

Default sub-directory	Description	File retention	Suggested user clean-up action
product	Product files	User is responsible for purging old product files	Set tmpwatch, as described above.
log/ingest	Ingestor logs	Automatically rotated (maximum of 10 files, 100MB each)	User clean-up not required.
log/product	Product reconstruction logs	Automatically purged after 15 minutes by default while program is running	User clean-up not required.
log/event	Event logs	Automatically rotated (maximum of 5 files, 0.5 MB each)	User clean-up not required.
track	Tracking files	Automatically purged after 15 minutes by default while program is running	User clean-up not required.
tmp	Intermediate and temporary files	Automatically purged after 15 minutes by default while program is running	User clean-up not required.

Note that the purge interval for product logs, tracking files and temporary files is determined by the “purgeDelay” parameter in grb-ingestor.conf. Please read the comments in grb-ingestor.conf when considering changing this value, to be certain you are aware of potential ramifications.

Note also when data flow is interrupted or stopped and the ingestor is left running, purging of some files may take up to two hours as internal timeouts are reached.

8.7 Creating SUVI FITS Files

A utility is included to convert SUVI NetCDF-4 files to FITS format. To use it, run:

```
$HOME/cspp-geo-grb-1.0/runtime/ShellB3/bin/python \  
$HOME/cspp-geo-grb-1.0/GRB-R/grbr/tools/suvi-nc2fits.py input.nc
```

A .fits file will be created in the same directory as the input. The CSPP Geo team would like to solicit feedback from FITS users to help us ensure that these files work with their downstream software. Please submit any feedback to csppgeo.issues@ssec.wisc.edu.

8.8 Configuring the GRB Space Packet Bundle Tie-Off Delay

In the GRB data stream, the arrival of product metadata normally signals that a complete dataset has arrived. However, in some cases data packets continue to be received after the product metadata has arrived. The GRB software includes a built-in “bundle tie-off” delay to wait for late data packets before closing out a product, in order to avoid data loss. This delay results in an added latency for all products generated on the GRB receiving system.

In software versions prior to Version 1.0.24, the delay was set to 10 seconds. This value was chosen as a reasonable trade-off between capturing late packets and avoiding adding excessive latency, based on analysis of GRB data spanning several months. However, a more recent analysis found that the situation has improved significantly, due to changes made on the GOES-R Ground System. As a result, the default bundle tie-off delay was reduced to 0.5 seconds in Version 1.0.24, consistent with the recommended delay in the GOES-R Product Users' Guide, Vol. 4, Section 5.0. This change results in a reduction in latency of approximately 9.5 seconds for all products.

The new default delay of 0.5 seconds automatically takes effect after installing Version 1.0.24; no configuration change is needed by the user. However, a mechanism is provided for the user to override the default bundle tie-off delay if needed. Please be aware that setting the value lower than 0.5 seconds will likely result in data loss for some products, and setting it higher will result in added product latency.

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To override the default bundle tie-off delay, the parameter `CSPP_GEO_RTCSPC_CCSDS_DELAY` can be added to the ingestor configuration file:

```
$HOME/cspp-geo-grb-1.0/RT-CSPP/jsr/conf/grb-ingestor.conf
```

For example, to set the bundle tie-off delay to the pre-v1.0.24 value of 10 seconds, the following line would be added.

```
wrapper.java.additional.16=-DCSPC_GEO_RTCSPC_CCSDS_DELAY=10
```

Note that the “`wrapper.java.additional.X`” parameters must be listed in increasing numerical order, with no gaps in the numerical sequence. Therefore this line should be inserted in the file after the line starting with “`wrapper.java.additional.15`”, unless other settings have been added.

The ingestor must be restarted after editing the configuration file.

Section 9: Caveats and Known Issues

1. In this version, some temporary output is written to `/tmp` (or to the location specified by `$TMPDIR`, if set). This behavior will likely be changed in a future release, so all output is written to the user-specified output location(s). The workaround for this version for users who don't want any output written to `/tmp` is to set `$TMPDIR`, in addition to the usual `CSPP_GEO*` environment variables that specify output locations.
2. The quicklooks script typically generates multiple warning messages during normal operation. These messages can safely be ignored, and will likely be eliminated or redirected in a future release.
3. The rounding and precision of numerical attributes in SUVI FITS files will be reviewed and improved in a future version.
4. Certain INFO XML files that are sent via GRB are not created in the products directory: `OR_GRB-INFO-STATIC*.xml` and `OR_GRB-INFO-GLMP*.xml`. This will be fixed in a future version.
5. There are some scenarios where the ingest process (RT-CSPP) is unable to route valid GRB Space Packets to a valid product. For example, if the ingestor is restarted, currently active products are first closed out. Upon restart, any remaining packets that would have been routed to those previously active products are discarded. In these scenarios, there is a log message in `grb.log` that may appear somewhat alarming, reading `"[ERROR] (GRBReceiver) Should never happen, invalid time portion of product key"`. This message is benign and will be removed in a future release. The logger is trying to extract a time field on packets that do not contain one.

Appendix A: Migrating from v0.4 to v1.0

Several changes were made in the Version 1.0 software that affect the user interface, compared to earlier software releases in the Version 0.4.x series. This appendix is intended to help users who are currently running Version 0.4.x software packages to migrate to Version 1.0.

Installation: Users are no longer required to set the environment variable `CSPP_GEO_GRB_HOME`, or to source the environment script `grb_env.sh`. Users are now required to set the environment variable `CSPP_GEO_GRB_OUT` to indicate the location where program output should be written. Users can optionally add the main program directory to their `PATH`, to avoid having to type the full path when calling CSPP Geo scripts. There are several additional environment variables that can optionally be set, as described in Section 7.1 and Section 8.5.

User-callable scripts: The main user-callable scripts have been moved from the “scripts” directory to the main program directory. In addition, the scripts have been renamed as described below. Note that the quicklooks script calling syntax and capabilities have changed significantly.

Version 0.4.x script name	Version 1.0 script name	Description
<code>cspp-rt-grb.sh</code>	<code>cspp-geo-grb.sh</code>	Main script to start, stop or check the status of the GRB ingestor.
<code>cspp-grbr.sh</code>	<code>cspp-geo-grb-recov.sh</code>	Transform intermediate CCSDS packet bundles to products (this script is not called by the user during normal operation).
<code>cspp-ql-grb.sh</code>	<code>cspp-geo-grb-ql.sh</code>	Generate quicklook images.

Output locations: The default output location has been changed from the “output” directory in the main program directory, to the location specified by the environment variable `CSPP_GEO_GRB_OUT`. The directory structure within the output directory has also been changed, as described below.

The v0.4.x directory structure was:

```

.
├── GRB-R          (final product files)
│   └── tmp        (temporary product files, NCML, track files)
├── RT-CSPP        (intermediate CCSDS and product logs)
└── var
    ├── log        (ingestor logs, grb-events logs, lock file)
    └── tmp        (grb-ingestor.pid file)
```

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The v1.0 output directory structure is:

```
.
├── product      (final product files)
├── log
│   ├── product (product logs)
│   ├── event   (events logs, events log lock file)
│   └── ingest  (ingestor logs)
├── tmp
│   ├── GRB-R   (temporary product files, ncml)
│   └── RT-CSPP (intermediate ccsds, grb-ingestor.pid file)
└── track       (track files)
```

A new set of optional environment variables is available to specify the locations of different types of output. Refer to Section 7.1 for more information. Note that the optional environment variables used in Version 0.4.x for a similar purpose (CSPP_GEO_RTCSP_OUT, CSPP_GEO_GRBR_OUT, CSPP_GEO_GRBR_LOG and CSPP_GEO_GRBR_TMP) are obsolete and will have no effect on Version 1.0 software.

Attributes in product files: The Version 0.4.x GRB software added an attribute called “created_by” to NetCDF product files. In Version 1.0, that attribute has been renamed, and other attributes have been added, as indicated below.

Version 0.4.x attribute name	Version 1.0 attribute name	Description
created_by	cspp_geo_grb_version	GRB software name and version
(not applicable)	cspp_geo_grb_production_host	name of processing machine
(not applicable)	cspp_geo_grb_reconstruction_end_time	date and time the product was finalized on the processing machine
(not applicable)	history	per CF standard, audit trail containing date and time of reconstructor program execution, as well as full invocation

Appendix B: Deprecated Command-Line Mode Interface

Input: Each input file must contain only unframed CCSDS space packets with no CADU metadata, UDP headers, or other transport artifacts. The file must not contain duplicate packets, and each packet must appear in only one file. Each packet must be complete and intact. All packets in a single file must belong to the same dataset. The metadata packet must be provided last.

The program can be called before all packets have been written to a file (i.e., as packets for the dataset are still being received). In this case, the program will process new packets until it encounters the metadata packet that indicates the end of the dataset. If the metadata packet is not written 15 minutes after the last data packet, the software will time out and the final product will not be written. Similarly if the software is called on a static file with no metadata packet, the software will wait for 15 minutes after processing the last data packet before timing out.

A file must contain only unsegmented packets and/or complete, in-order sequences of packets.

As described in the GOES-R PUG, Vol. 4, a sequence of packets has all of the following characteristics:

- All packets in the sequence have the same APID.
- The sequence begins with a packet containing primary header sequence flag 0b01.
- The sequence ends with a packet containing primary header sequence flag 0b10.
- All other packets in the sequence have primary header sequence flag 0b00.
- The sequence count increments with each packet in the sequence, rolling over modulo 16384.
- The sequence has no missing sequence counts.

As described in the GOES-R PUG, Vol. 4, an unsegmented packet has a primary header sequence flag value of 0b11.

Output: When running in command-line mode, product files are written as described in Section 7. However, log info is written to standard out and standard error (by default printed to screen).

Return value: When called from the command line, the GRB software returns a value of 0 to indicate that no problems were encountered by the main (i.e., parent) process, or a non-zero value to indicate that a problem occurred.

Example: To see an example of input files, run the GRB software in streaming mode, and have a look at the intermediate files left in the location `$CSPP_GEO_GRB_OUT/tmp/RT-CSPP` (note these will be automatically cleaned up by the software after a period of time).

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To run in command-line mode, provide any number of CCSDS packet bundles to the GRB reconstruction script:

```
cspp-geo-grb-recov.sh filename
```

Output can be found in the location `$CSPP_GEO_GRB_OUT/product`.

Appendix C: Interpreting Error Messages and Warnings

The following error messages and warnings may be found in the ingestor log file `$CSPP_GEO_GRB_OUT/log/ingest/grb.log`, and indicate problems with data or processing as described.

No Space Left on Device

Example:

```
[ERROR] (GRBReceiver) java.io.IOException: No space left on
device
```

This error indicates the partition the ingestor is writing intermediate or log files to is at 100% capacity.

CRC Check Failed

Example:

```
[ERROR] (CrcDecoder) CRC check failed on data (non-Idle)
frame
```

This error indicates that the data transmitted in the current frame may be corrupt. It may be caused by temporary signal noise from solar or radio frequency interference.

Frame Error

Example:

```
[ERROR] (CaduService) Frame Error, VCID: 5, prev VCFC:
9416720, this VCFC: 9416726
```

This error indicates at least one data frame was lost (never received). In this case, the missing frame(s) were from the RHCP Channel (VCID 5), and 5 consecutive frames were lost (the difference between the counter for the current frame and the last frame seen, minus one).

Sequence Error

Example:

```
[ERROR] (GRBReceiver) APID: 0x11d sequence error, counter:
9421
```

This error indicates a missing Space Packet for a particular product, defined by the Application Identifier (APID). In this case, APID 0x11d is ABI Full Disk Band 14, as described in the GOES-R PUG, Vol. 4. A missing packet for a product can negatively affect the product, ranging from loss of a small portion of data to complete loss of the product. This error is typically seen in conjunction with Frame

Errors and CRC check failures, since the root cause is often a lost frame. There have been instances where the root cause was errors in the transmitted data originating from the ground station.

Ports Reserved or In Use

Example:

```
[ERROR] (GRBIngestor) ERROR: Attempting to bind to ports
that are either reserved
[ERROR] (GRBIngestor) or already in use:
192.168.123.105:50010, 192.168.123.105:50020
```

This error occurs when the ingestor starts up and cannot bind to the ports that are specified in the `grb-ingestor.conf` file. Check that these are the correct port numbers configured to receive GRB data, and that there is not another ingestor instance running on the GRB processing machine.

For example, to check the availability of ports 5530 and 5531, run the following commands (root access required):

```
sudo lsof -i -n | grep 5530
sudo lsof -i -n | grep 5531
```

If the ports are free, the command should not return any output. If you encounter output, you can resolve the problem by shutting down or reconfiguring the program that is using the ports. Then start the ingestor as described above.

Resource Temporarily Unavailable

Example:

```
[ERROR] (GRBReceiver) java.io.IOException: Cannot run
program "nice": error=11, Resource temporarily unavailable
```

The GRB software uses a large number of processes. This message likely indicates that the user process limit on your system has been reached, which could cause the software to miss packets. Many environments set this limit at 1024 processes but will allow a user to increase their own limit for a session via: “`ulimit -u 3000`”, where 3000 is a limit that we’ve found sufficient.

Insufficient Network Input Buffer Size

Example:

```
[WARN ] (GRBIngestor) WARNING: The UDP input buffer size is
currently 212992 bytes.
```

The current UDP input buffer size is less than our recommended value. A larger receive buffer will provide more flexibility to keep up with the data rate in the event of short-lived fluctuations in demands on system resources. See Section 3.1 for instructions on configuring to the recommended value.

Data Arrived After Metadata

Example:

```
[WARN ] (GRBReceiver) For 0x0e3_2020-09-17T14:31:56.680,  
data arrived after metadata, latency in milliseconds: 457
```

As described in Section 8.8, the groundstation error scenario where some product data arrives after the final metadata has occurred. Because this data was received before the user-configurable bundle tie-off delay elapsed, a warning has been logged and the data will be included in the product. However, note that any data received after the bundle tie-off delay will not be logged and will not be included in the product.

Appendix D: Intermediate CCSDS File Naming Convention

This appendix describes the naming convention of the intermediate CCSDS files that are written by the ingestor when running in streaming mode. Note that this is simply the convention used by the ingestor, and is not a requirement for processing in command-line mode.

The file naming pattern is:

```
GRB_SID_0xAPD_YYYY-MM-DDThh:mm:ss.sssZ.ccsds
```

This file naming pattern represents:

GRB: Data source, always “GRB”

SID: Spacecraft ID, one of the following hexadecimal values: 250 (GOES-16), 282 (GOES-17), 2E4 (GOES-18), or 2B6 (GOES-19)

APD: The hexadecimal APID this data bundle contains (reference GOES-R

PUG, Vol. 4, Rev. 1.2, Table A.1)

YYYY-MM-DD: Year, Month, and Day this packet bundle was written, e.g., 2013-07-16

T: Delimiter between date and time, <date>T<time>, as per ISO-8601 specification

hh:mm:ss.sss: Hours, minutes, seconds, and milliseconds

Z: Time zone designator, always “Z” indicating UTC, per ISO-8601 specification

ccsds: suffix, always “ccsds”

A sample packet bundle filename might be:

```
GRB_250_0x303_2015-03-25T07:32:03.722Z.ccsds
```