GOES Surface & Insolation Products (GSIP), version 3.3

System Description Document

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TABLE OF CONTENTS

This system description document contains a description of the GOES Surface and Insolation Products (GSIP) data processing system. A system overview contains information on the GSIP application, GSIP input and output products, and an operational scenario of how the GSIP system runs. Subsequent sections describe the system operating environment, system processes, and system programs.

Additional information on GSIP input and output products may be found in the GSIP Interface Control Document (ICD). Information on servers from which inputs are downloaded is contained in the ICD.

Information on installing and compiling the GSIP system, along with system monitoring, recovery of processing failures, and long-term maintenance, may be found in the GSIP System Maintenance Manual.

This SDD is based on SDD for GSIP version 3.2 by V. Kondratovich, NOAA 2012.

1.0 SYSTEM OVERVIEW

1.1 Application Overview

The GOES Surface & Insolation Products (GSIP) processing system is a near real-time operational system for generating products related to Earth radiation budget and associated products. Data from the GOES-EAST and GOES-WEST Imager instrument, MSG SEVIRI imager, and MTSAT-1R/2R imager are the primary inputs. Output parameters include (among others) radiative fluxes for the shortwave, longwave, and visible portions of the electromagnetic spectrum; surface temperature; and cloud properties. Radiative fluxes are calculated for downward and upward directions at the Earth surface and the top-of-atmosphere. The primary output products are the insolation (shortwave downward surface radiative flux) and photosynthetically available radiation or PAR (visible downward surface radiative flux), which are used in predictive models of coral reef health (coral bleaching prediction) and hydrological models (e.g., solar influence on evapotranspiration).

GSIP products are processed for 6 domains: GOES-East and GOES-West Full Disk and Extended Northern Hemisphere, MSG Full Disk, and MTSAT Full Disk. Processing occurs on an hourly basis except 3-hourly basis for the GOES-EAST/WEST Full Disk domain. GSIP also produces Global Daily Average (GDA) of its main products – Insolation and PAR.

This version 3 of the GSIP system is an enhancement to the GSIP version 2 system. The coverage is extended from four GOES scenes to six scenes providing an overlapping global coverage (except polar regions) and two global level 3 products -= daily average insolation and PAR. In addition,

spatial resolution is increased in this version to a pixel-size grid (4 km at nadir).

1.2 System Inputs and Outputs

This section provides a brief listing of the GSIP system inputs and outputs. For a more thorough description, see the GSIP Interface Control Document.

1.2.1 Inputs

- GOES Imager data, 5 channels (each Imager channel is in a separate file)
  - GOES-East Northern Hemisphere Extended (GENHEM), hourly
  - GOES-West Northern Hemisphere Extended (GWNHEM), hourly
  - GOES-East Full Disk (GEDISK), 3-hourly
  - GOES-West Full Disk (GWDISK), 3-hourly
- MSG-3 (METEOSAT-10) SEVIRI Imager data, 11 channels (each Imager channel is in a separate file)
  - Full Disk (MSGFD), hourly
- MTSAT-1R or MTSAT-2R Imager data, 5 channels (each Imager channel is in a separate file)
  - Full Disk (MTSFD), hourly
- NCEP Global Forecast System (GFS) 12-hour forecast, 6-hourly
- Interactive Multisensor Snow & Ice Mapping System (IMS) snow and ice coverage (IMS Snow), daily

1.2.2 Outputs

- 49 GSIP parameters on a pixel-size grid (Level 2 products)
  - For each domain and hour
    - GENHEM, hourly
    - GWNHEM, hourly
    - GEDISK, 3-hourly
    - GWDISK, 3-hourly
    - MSGFD, hourly
    - MTSFD, hourly
  - For each output format:
    - HDF, binary, netCDF
  - All 49 parameters are contained in each file.
- Images showing each GSIP output parameter for each domain and hour, in PNG format

- Global Daily Average (GDA) of Insolation and PAR on externally-defined equal-angle SST grid with step of 0.05^{o} (Level 3 products), in netCDF format
- Images showing each GSIP GDA output parameter, in PNG format

1.3 Operational Scenario

The GSIP system is fully automated, requiring no regular operator intervention. System features fully-parallel processing of its six scenes (GEDISK, GENHEM, GWDISK, GWNHEM, MSGFD, and MTSFD). Each hour, the system downloads GOES-East and GOES-West Imager Northern Hemisphere Extended domains, MSG Full Disk, and MTSAT Full Disk (using McIDAS). In addition, every third hour, the system downloads GOES-East and GOES-West Imager Full Disk domains (using McIDAS). The downloading of the Full Disk is staggered so that only one Full Disk domain (East or West) is downloaded in a given hour. Additional inputs of NCEP Global Forecast System (GFS) forecast fields and IMS Snow coverage are downloaded every 6 hours and daily, respectively.

Pre-processing of the GFS forecast fields and IMS Snow is performed upon download of these files. GFS pre-processing consists of format conversion from GRIB2 format to HDF format. IMS Snow pre-processing consists of a remapping of the IMS Snow polar stereographic grid to GSIP's pixel-level latitude-longitude grid.

The GSIP main processing generates a composite of visible (Channel-1) data (for each domain) from the previous 28 days by selecting the darkest Channel-1 pixel within the 28 days. Through the process of selecting the darkest pixel, clouds are removed. (This composite is referred to as the clear composite, but is also sometimes referred to as the 28-day composite, or dark composite). GSIP processing calculates cloud properties, radiative fluxes and surface temperature from the inputs. The main processing utilizes the GSIP software, provided by University of Wisconsin. In all, there are 49 parameters written to the output file. Outputs are generated for each domain and hour in three output data formats (HDF, binary, netCDF) and gzip-compressed. Images are also generated for most of the 49 output parameters for routine production monitoring and science monitoring.

Every day, at specific hour, global daily average processing starts. It uses 6-domain GSIP V3 output kept for this purpose on the system disk for 72

consecutive hours. The process ingests 24 hour-worth GSIP output for four best-viewing zones of four GSIP GEO satellites. Each zone data set is taken starting from different hour in order to fully cover daytime of the zone. 24-hour data are averaged for each pixel with gaps filled by interpolation and adjustment of momentary cosine of the solar zenith angle to the hourly-averaged one. The technique was used before by the authors for calculation of daily averages for the needs of the solar energy industry [?]. Geolocation subsystem determines correction for pixel coordinates for every zone on the day of interest by georeferencing of GSIP image to a set of targets for several hours and statistical processing of results. Pixel data with corrected coordinates are remapped onto the equal-angle grid and results are output in a netCDF file.

Processing is scheduled through the shell scripts. Processing failures are reported automatically to operations personnel through email warning messages. Recovery of failures requires the manual use of recovery scripts and drivers. There is one recovery script for each stage of download and processing. Driver scripts combine the recovery scripts to recover any type of failure, including processing failures, delayed inputs, and disk crashes (lost outputs). All failures are recoverable as long as the inputs are available. Recovery can be made over any time range (e.g. outputs lost for X days). Recovery processing runs simultaneously with the current near-real-time processing, i.e. recovery processing does not interfere with current GSIP processing.

Also the operations personnel may routinely browse through the GSIP monitoring web site. The HTML code for displaying the images (generated during GSIP production) has been provided to OSDPD. Routine monitoring will ensure the system is running normally.

More detail on system monitoring, recovery, and system maintenance is available in the GSIP System Maintenance Manual.

Information on compiling and running GSIP is available in the GSIP System Maintenance Manual.

2.0 OPERATING ENVIRONMENT

2.1 Hardware Environment

GSIP process for each of the six scenes was tested on a 32-bit Linux machine with a 4-core XEON CPU and 4GB of memory. Up to the full amount of memory and one core are used during the run time of less than three hours. Running the system in full extent (all six scenes in parallel)

was performed on computer with 8 64-bit Xeon 4-core processors at 3.2 MHz, 48GB of memory and 2.8 TB disk space. Full-size GSIP system took up to three processors (a function of time overlap between individual processes) and less than 12 GB of memory. The longest process (MSGFD domain) was performed under 20 minutes. Full-size GSIP process consumed about 100 GB of disk space a day for all outputs (gzipped) and system inputs remaining on the disk. The break-up of daily disk use on test machine (about 110 GB) is as follows: (i) Channel 1 data for all six scenes must be stored for 28 days – 86 GB; (ii) other channel data must be stored at least for the processing hour – 30 channels total – 0.6 GB; (iii) hourly system compressed output is up to 7 GB; (iv) ancillary data for a day - 13.5 GB. Robust configuration would add 5-day storage for all inputs to enable reprocessing, and at least 5-day storage for outputs. This calls for assignment of about *600 GB of disk space* for GSIP run.

The system time should be set to UTC.

2.2 Software Environment

2.2.1 Operating System

The GSIP system runs on the Linux operating system. STAR uses Red Hat Enterprise 5.8. The GSIP processing scripts are written in C shell.

2.2.2 Programming Languages and Compilers

The g95 FORTRAN compiler version 0.93 or higher is required. Other required programming languages include C and IDL (for image product generation). For C, STAR uses the gcc compiler.

2.2.3 Libraries

The software libraries for Hierarchical Data Format (HDF-4) and Network Common Data Format (netCDF-3) are required.

2.2.4 Additional Software

Additional software packages needed are McIDAS and wgrib2. Community-standard HDFView and Panoply netCDF readers are useful for control of the output files format.

2.3 Directory Description

The GSIP system includes the following subdirectories under the GSIP main directory:

ancil_data/

Static data files containing algorithm look-up tables and other data needed for GSIP processing.

area_files/

Location where GOES Imager data are downloaded. Upon download, the GOES data are stored in subdirectories GENHEM, GEDISK, GWNHEM, GWDISK, MSGFD, and MTSFD. Also, McIDAS configuration files are here.

bin/

Program executables.

cronjobs_logs/

FORTRAN log output (see files *log file*).
C-shell error logs (see files *err log*).

gfs_files/

GFS files downloaded from NCEP (in subdirectory /gfs_ftp) and converted to HDF (in subdirectory /gfs_hdf).

image_generator/

IDL program files for image generation. In addition, image generation temporary files are created (and deleted) here.

Images/

Images of all GSIP output products: includes both full images (*LG2.png) and thumbnail images (*SM2.png). Each domain is in a separate subdirectory: GENHEM, GEDISK, GWNHEM, GWDISK, MSGFD, MTSFD, and DAGLOB.

Results/

GSIP main processing result files. Each domain is in a separate subdirectory: GENHEM, GEDISK, GWNHEM, GWDISK, MSGFD, MTSFD, and DAGLOB.

script_files/

Location of GSIP processing scripts, symbolic links needed for FORTRAN execution, and channel-1 listings for clear composite processing (text files). In addition, the GSIP main processing temporary directories and created (and deleted) here.

snow_files/

IMS Snow files downloaded from OSDPD and converted to the GSIP grid. In addition, the file, imstemp.dat, is the template file for establishing the GSIP grid during grid conversion.

src/

Source code for each program that is part of the GSIP processing. Object and include directories are present if applicable.

gda/

Post-processing (Global Daily Average) code

grib2hdf/

GRIB-to-HDF converter

gsip_v3/

GSIP processing code

snowims/

IMS Snow grid conversion code

utilities/

Location of scripts for compiling GSIP, scripts for recovering GSIP processing if failures are detected, and scripts for copying GSIP results to other network locations. In addition, recovery processing occurs here, requiring the needed symbolic links. (Also, temporary directories for recovery processing are created and deleted here.)

3.0 PROCESS DESCRIPTION

The GSIP processing system consists of four jobs: GFS download and pre-processing, IMS Snow download and pre-processing, GSIP processing, and GDA post-processing. The GFS download and pre-processing occurs 4 times daily. The IMS Snow download and pre-processing occurs once daily. The GSIP processing occurs hourly, which consists of an hourly download of the Imager area files, hourly generation of GSIP results (i.e. main processing), and hourly generation of images. GDA post-processing occurs daily.

The above processes are carried out through a group of C-Shell scripts located in the /script_files directory. These processing scripts are described below.

3.1 GFS Download and Pre-processing (gfs_pre_proc_start.scr)

3.1.1 Scripts and Programs Called

Start script:
gfs_pre_proc_start.scr

Main script:
gfs_pre_proc.scr

Programs called:
convert_grib_hdf.exe

3.1.2 Description

The start script that starts the GFS download and pre-processing is gfs_pre_proc_start.scr. The purpose of the start script is to generate the logs of the main script, both Fortran log output (log file) and system error logs (err log).

The main GFS download and pre-processing script is gfs_pre_proc.scr. This main script downloads the GFS 12-hour forecast files four times per day from the NCEP FTP server, performs the pre-processing on the GFS files (i.e. converts the GRIB2

formatted data to HDF format), and deletes all GFS inputs, outputs and logs after a specified number of days

The Fortran executable, convert_grib_hdf.exe, is run by the main script, gfs_pre_proc.scr. This executable converts the GFS files in GRIB2 format to HDF format.

3.2 IMS Snow Download and Pre-processing (snow_pre_proc_start.scr)

3.2.1 Scripts and Programs Called

Start script:
snow_pre_proc_start.scr

Main script:
snow_pre_proc.scr

Programs called:
snowims.exe

3.2.2 Description

The start script that starts the IMS Snow download and pre-processing is snow_pre_proc_start.scr. The purpose of the start script is to generate the logs of the main script, both Fortran log output (log file) and system error logs (err log).

The main IMS Snow download and pre-processing script is snow_pre_proc.scr. This main script downloads the IMS Snow ASCII files once per day from the OSDPD FTP server, performs the pre-processing on the IMS Snow files (i.e. converts the IMS grid to the GSIP grid), and deletes all IMS Snow inputs, outputs and logs after a specified number of days

The Fortran executable, snowims.exe, is run by the main script, snow_pre_proc.scr. This executable converts the IMS Snow grid (polar stereographic) to the GSIP grid (pixel grid of the Imager).

3.3 GSIP Processing (hourly_proc_start_<domain>.scr)

3.3.1 Scripts and Programs Called

Start script:
hourly_proc_start_xxxxx.scr
where domain name xxxxx=gedisk, genhem, gwdisk, gwnhem, msgfd, mtsfd

Main script:

hourly_proc_xxxxx.scr

Sub scripts:

dark_comp_28day.scr
image_gen2_xxxx.scr (xxxx=gsip, msg, mts)

Programs called:

gsip_v3.exe

3.3.2 Description

The start script that starts the GSIP hourly processing of domain xxxxx is hourly_proc_start_xxxxx.scr. The purpose of the start script is to generate the logs of the main script, both Fortran log output (log file) and system error logs (err log).

The main GSIP processing script is hourly_proc_xxxxx.scr. This main script downloads the GOES Imager area files using McIDAS from the ADDE server, calls the script dark_comp_28day.scr to create the file list for clear composite processing, starts the GSIP main processing gsip_v3.exe (cloud and insolation algorithms), starts the image generation for all GSIP output products with the script image_gen2_xxxx.scr, and compresses GSIP results with gzip. Also, the file listing of GSIP results files to be imaged is created by this script.

The script dark_comp_28day.scr creates the list of files with current processing time and domain for last 28 days for clear composite processing in gsip_v3.exe. It also cleans old area files, result files, and log files (the number of days to keep on the server is set in this file).

The script image_gen2_xxxx.scr starts the IDL code that generates images for each hour of GSIP processing of the COES domains (xxxx=gsip) or MSGFD domain (xxxx=msg) or MTSFD domain (xxxx=mts). First, this script creates an IDL “include” file for IDL batch execution. Then, this script starts IDL in batch mode using the “include” file. At the end, the include files are deleted, the file listing of GSIP results files to be imaged is deleted, and images are copied to the web server.

The executable gsip_v3.exe performs the GSIP main processing, which includes generation of clear-composite image and running of the cloud, surface temperature, longwave flux, and insolation algorithms. Forty-nine output parameters are written to output files in HDF, netCDF, and binary format.

3.3.3 Process Flow

The call order of each processing script and executable is as follows:

hourly_proc_start_xxxxx.scr
    hourly_proc_xxxxx.scr
        dark_comp_28day.scr
        gsip_v3.exe
        gzip
        image_gen2_xxxx.scr
            /usr/local/bin/idl image_gen_gsip.inc
            (i.e., include file runs image_gen_gsip.pro)

The order by which hourly_proc_xxxxx.scr processes a domain is as follows:

1. Imager data download using McIDAS
2. GSIP domain processing (clear-composite, cloud & insolation)
3. Domain image generation

3.4 Post-Processing (proc_start_gda.scr)

3.4.1 Scripts and Programs Called

Start script:
    proc_start_gda.scr

Main script:
    proc_gda.scr

Sub scripts:
    image_gen3_gda.scr

Programs called:
    gda.exe

3.4.2 Description

The start script that starts the GSIP post- processing is proc_start_gda.scr. The purpose of the start script is to generate the logs of the main script, both Fortran log output (log file) and system error logs (err log).

The main GSIP post-processing script is proc_gda.scr. This main script starts the code executable gda.exe and supplies its command-line arguments – date of processing, input/output paths and MODIS

database path. Then it starts the image generation for all GDA output products, and compresses GDA output file.

The script image_gen3_gda.scr starts the IDL code that generates images for GDA insolation and PAR. First, this script creates an IDL "include" file for IDL batch execution. Then, this script starts IDL in batch mode using the "include" file. At the end, the include files are deleted, and images are copied to the web server.

The executable gsip_par.exe performs the GDA main processing, which includes geolocation for all four satellite best-viewing zones for several hours around sub-satellite noon, performing statistics of geolocation, finding average daily residuals, correcting pixel coordinates. Then it performs daily average of pixel data with shifting the time interval to fully cover the zone daytime. It fills the gaps in time sequence of data and substitutes the momentary values of the cosine of solar zenith angle to its hourly average. Processing ends with remapping pixel averages onto the global equal-angle grid with step of 0.05 degree. Gridded average insolation and PAR are written to output netCDF file.

3.4.3 Process Flow

The call order of each processing script and executable is as follows:

proc_start_gda.scr
- proc_gda.scr
  - gda.exe
  - gzip
  - image_gen3_gda.scr
    - /usr/local/bin/idl image_gen_gsip.inc
    - (i.e., include file runs image_gen_gda.pro)

The order by which proc_gda.scr processes data is as follows. For each of the four GSIP satellites:

1. Read 24-hour sequence of GSIP output netCDF files (both DISK and NHEM for GOES-EAST and GOES-WEST)
2. Perform geolocation for several hours around sub-satellite noon on the day of interest
3. Performs statistical analysis of geolocation results, finds the average residuals for the day, and applies them to pixel coordinates
4. Calculates daily average pixel wise, filling the gaps in time sequence, and substituting momentary values of the cosine of solar zenith angle by its hourly average

5. Remaps daily pixel averages onto the equal-angle grid with the step of 0.05 degree.

3.5 Other Supporting Scripts

3.5.1 Utility Scripts

The utility scripts are located in the /utilities directory and include scripts for compiling GSIP, setting up the system symbolic links, and recovery of failures.

Table 1: Utility scripts

Script	**Brief Description**
compile_gsip.scr	Compiles the entire GSIP processing system, including pre-processing codes, main processing code and post-processing. Runs all makefiles. Copies executables to the /bin directory. Copies object files and mod files to the appropriate /obj directories.
setup_links.scr	Creates symbolic links needed by the Fortran codes (in order to avoid hard coding pathnames into the Fortran code directly). These links are created in the /script_files directory.
setup_links_utildir.scr	Creates symbolic links for running GSIP recovery processing (same links as setup_link.scr but in the /utilities directory instead of the /script_files directory).
recover_domain.scr	Recovery script for downloading Imager area files for a domain whenever area files were not initially available or were lost after downloading
recover_gfs.scr	Recovery script for downloading and pre-processing GFS files whenever GFS files were not initially available or were lost after downloading
recover_snow.scr	Recovery script for downloading and pre-processing IMS Snow files whenever IMS Snow files were not initially available or were lost after downloading
recover_gsip.scr	Recovery script for regenerating GSIP outputs whenever the initial processing failed or GSIP outputs were lost after initial processing.
recover_all.scr	Driver script for running any combination of the other recovery scripts, depending on the nature of the recovery task. This script can be modified (or other drivers written) to perform any needed recovery task.

3.5.2 IDL Procedures for GSIP Image Generation

The IDL procedures for images generation are located in the /image_generator directory

Table 2: IDL procedures

image_gen2_xxx.pro	xxx=gsip for GOES domains, msg for MSG domain, and mts for MTS domain. Main IDL image generation driver. Reads the file listing of GSIP results files for each hourly run. Controls which GSIP output parameters are plotted.
read_gsipv2_hdf.pro	Reads HDF-formatted GSIP output files. One GSIP parameter is read at a time.
plot_xxx_L2.pro	xxx=gsip for GOES domains, msg for MSG domain, and mts for MTS domain. Plotting code. Makes the images for each GSIP parameter.
load_color_table.pro	Loads IDL color table.
cbar.pro	Draws color bar on image for all parameters except cloud type.
colorbar.pro	Draws color bar on image for cloud type.
cbarr.pro	Draws color bar on image for quality flag.
sds_list2.txt	Control file that controls plotting information of each Level 2 parameter: max value, min value, missing value, and range between tick marks, text to write onto image (parameter name and units). Images can easily be modified by simply changing the plotting information in this control file.
sds_list3.txt	Control file that controls plotting information of each Level 3 parameter: max value, min value, missing value, and range between tick marks, text to write onto image (parameter name and units). Images can easily be modified by simply changing the plotting information in this control file.
image_gen_xxx_template12.inc	Template for IDL batch execution. Domain xxx= GEDISK, GENHEM, GWDISK, GWNHEM, MSGFD, MTSFD. This template is copied and modified by the corresponding script image_gen2_xxxx.scr to create the IDL batch execution “include” file.
filelist_images_*.txt	List of GSIP output files (HDF format) from each hourly GSIP run for which images will be made. This file is created by the script hourly_proc_xxxxx.scr. These files are temporary and are deleted after each hourly GSIP run by the script image_gen2_xxxx.scr.

4.0 PROGRAM DESCRIPTION

The GSIP system consists of the number of Fortran programs that carry out most of the GSIP data processing tasks. These programs include the GSIP_v3 main processing (i.e. algorithm package for calculating cloud and radiation budget outputs from the GOES satellite data), the snow regridding program, and the GRIB-to-HDF converter program.

4.1 GSIP_v3 Main Processing Program

The Fortran program **gsip_v3.exe** conducts the main GSIP algorithm processing. The generation of clear composite image, calculation of radiances, brightness temperatures, cloud mask, cloud properties, surface temperature, and outgoing longwave radiation occurs at the pixel level (i.e. processing level 1 and 2). A configurable number of lines of satellite data, known as a 'segment', are processed at the same time. The insolation algorithm is run at the pixel level.

4.1.1 Make File

src/gsip_v3/code/Makefile

4.1.2 Main Program

gsip_v3.f90

4.1.3 Program Flow

GSIP_v3 runs as follows:

1. Read the command line information (passed to gsip_v3.exe from the script hourly_proc_xxxx.scr)
2. Load satellite information
3. Load algorithm information structure (necessary for cloud mask and other algorithms)
4. Get the domain name from satellite file name
5. Get header data from primary Area file
6. Parse date, McIDAS satellite id (necessary to get coefficients)
7. Make base output file name
8. Reads the list of Channel-1 data files for the hour for last 28 days (prepared by the script dark_comp_28day.scr).
9. Generates the clear-composite image by selecting the darkest pixel of GOES Imager channel-1 data over a period of 28 days. Through the selection of the darkest pixel, clouds are removed from the composite (clouds are bright whereas cloud-free land or water is dark). Because the data are cloud free, this composite is

referred to as the clear composite. Alternate names are dark composite or 28-day composite.

10. Read in ancillary data
    a. Read in the GFS data
    b. Read in entire file of clear composite
    c. Read in cloud property LUTs
11. Open up each Area file for each channel used in processing
12. Populate Planck tables
13. Define HDF structures for Level 2 data
14. Do processing for each segment
    a. Clear all arrays
    b. Perform geolocation and angle calculations for each pixel
    c. Calculate radiances, brightness temperatures
    d. Create a bad pixel mask
    e. Read in specific ancillary data for each segment
    f. Get GFS and RTM data for each segment
    g. Get dark 0.64 micron data, if necessary, from PATMOS-x static dataset
    h. Do cloud mask, cloud type, LST, OLR, CTT, cloud layer, cloud top properties
    i. Calculate insolation
15. Save results in binary, HDF, and netCDF formats
16. Deallocate pixel level arrays
17. Fill meta data and close Level 2 files
18. Close ancillary data
19. Deallocate GFS and RTM data, if necessary

4.1.4 Running gsip_v3.exe

The program, gsip_v3.exe, is run in the script hourly_proc_xxxxx.scr.

GSIP_v3 runs by accepting input from a start file or by reading command-line options. To see all GSIP_v3 command-line options, type:

```
./gsip_v3.exe –help
```

For operational GSIP_v3 processing in the GSIP processing system, start files are not used. Instead, the following command-line options for gsip_v3.exe are provided by the script hourly_proc_xxxxx.scr.

```
./gsip_v3.exe
    -nostart                #do not use start file
    -f $CH1_FILENAME  #Imager Area chan-1 filename
    -iskip 0                #skip 0 pixels in x direction
    -nscans 50              #process 50 scans per segment
```

```
-gfs                    #use GFS data
-dark                   #use Area chan-1 clear composite
-cc_flag 0                  #do not use clear climatology
-area_dir $AREADIR          #GOES Area file directory
-out_dir $RESULTSDIR        #Output directory
-ancil_dir $ANCIL           #ancillary file directory
-nwp_dir $GFS_FILES         #GFS file directory
-ims                        #use IMS Snow data
-ims_dir $IMSNOW_DIR        #IMS Snow directory
```

4.2 Snow Regridding Program

The Fortran program **snowims.exe** regrids the IMS Snow data from its native polar stereographic grid to the GSIP pixel latitude-longitude grid. This regridding is performed during the GSIP system's IMS Snow pre-processing.

4.2.1 Make File

There is no makefile. See the compile steps in the GSIP compile script:

utilities/compile_gsip.scr

4.2.2 Main Program

snowims.f90

4.2.3 Sub Programs

There are no subprograms.

4.2.4 Running snowims.exe

The snowims.exe program is run by the GSIP pre-processing script, snow_pre_proc.scr, by piping the needed parameters into the executable:

```
echo "$YYYY $JDATE" | $BIN/snowims.exe
```

where $YYYY and $JDATE are the year and day-of-year of the IMS Snow file, respectively.

4.3 GRIB-to-HDF Converter Program

The Fortran program **convert_grib_hdf.exe** converts data in GRIB or GRIB2 format to HDF format. This conversion is performed during the GSIP system's GFS pre-processing to convert GFS 12-hour forecast inputs in GRIB2 format to HDF format.

4.3.1 Make File

There is no makefile. See the compile steps in the GSIP compile script:

utilities/compile_gsip.scr

4.3.2 Main Program

convert_grib_hdf.f90

4.3.3 Sub Programs

constant.f90
: Module for declaring Fortran data type kinds and various constants.

f2kcli.f90
: "Fortran 2000 Command-line Interface". Module that provides a shell command-line interface to a Fortran executable.

hdf.f90
: Module for declaring HDF error codes, access codes, etc.

4.3.4 Running convert_grib_hdf.exe

The program, convert_grib_hdf.exe, is run in the script gfs_pre_proc.scr.

The program's command line options are as follows:
First option is the grib type: 1 = grib, 2 = grib2, 6 = 1deg grib2
Second option is array dimension order, i.e. XYZ or ZXY
Third option is the name of the grib file, e.g. gblav.08090812_F012
Fourth option is the path to wgrib or wgrib2, i.e. /bin
Fifth option is the path to input grib file, i.e. /gfs_files/gfs_ftp
Sixth option is the path to output hdf file, i.e. /gfs_files/gfs_hdf

Example of how convert_grib_hdf.exe is run by the script, gfs_pre_proc.scr:
./convert_grib_hdf.exe 2 ZXY $GFS_FILE $BIN/ $GRIB/ $HDF/

The command, convert_grib_hdf –help, prints all available command-line options

4.4 GSIP Post-Processing Program

The Fortran program **gda.exe** conducts the GSIP post-processing. The satellite image renavigation, navigation correction, and calculation of daily

average fluxes occurs at the pixel level. Then the best-viewed parts of the images are remapped onto the equal-angle externally-defined global SST grid with the step of 0.05 degree, which is comparable with the pixel-level resolution.

4.4.1 Make File

src/gda/code/Makefile

4.4.2 Main Program

daily_average.f90

4.4.3 Program Flow

Post-Processing runs as follows:

1. Read the command line information (passed to gda.exe from the script proc_gda.scr)
2. Start zone-by-zone processing
3. Read in geolocation target information for the zone
4. Start hourly loop for preset number of hours around sub satellite noon for the zone
5. For each hour, perform satellite image georeferencing on all zone targets and remember longitude and latitude residuals
6. Transfer the residual array for the zone (for all targets and all hours) to the main process
7. Perform statistical analysis of zone residuals and determine the average daily residuals for the zone.
8. Start daily averaging. Ingest GSIP output data for every hour of 24 past the start hour of the zone (every third hour for GEDISK and GWDISK domains). Ingest pixel coordinates, solar zenith angle (SZA), and processing parameter (insolation).
9. At every pixel, compare GSIP SZA with calculated one for the hour (because pixel coordinates are slightly varying with time, and we take coordinates of the first recorded hour). In the case of difference, recalculate GSIP flux with calculated SZA.
10. At every pixel, analyze time sequence of fluxes for the gaps.
11. If number of daily observations is greater than threshold, fill gaps by interpolation of SZA-independent values of nearest neighbors. Otherwise, assign missing value to the pixel value of the flux.
12. Calculate hourly average cosine of SZA for the pixel and use it to substitute momentary value of the cosine in the flux
13. At every pixel, calculate daily average of interpolated and transformed hourly values.

14. Interpolate pixel averages to the equal-angle global SST grid. For GOES-EAST and GOES-WEST take care to not overwrite grid points filled with NHEM data by DISK data. We consider the latter as less reliable because of less-frequent measurements (3-hour interval instead of hourly NHEM data).
15. Repeat the above for all GDA parameters (currently, Insolation and PAR)
16. Output the daily averages in netCDF file
17. Start plotting GDA parameters.
18. Close log files

4.4.4 Running gda.exe

The program, gda.exe is run by the script proc_gda.scr.

To see all post-processing command-line options, type:

```
./gda.exe –help
```

For operational post-processing in the GSIP V3 processing system, start files are not used. Instead, the following command-line options for gda.exe are provided by the script proc_gda.scr.

```
./gda.exe
    -gsip $GSIPDIR        #GOES output directory
    -modis $MODISDIR      #MODIS database directory
    -yyyy “2013”          #processing year
    -doy “108”            #processing day of year
```