THEMIS and REGO All Sky Imager Data - Worksheet

The following worksheet is designed to give the user experience with the THEMIS White Light and REGO All Sky Imager (ASI) data. The worksheet covers topics including; (1) opening the REGO and THEMIS-ASI raw data files, (2) reading metadata contained in the files, (3) plotting images and values from inside the files, and (4) plotting images on maps. It is intended that the following set of tasks is to be done in IDL, supplemented by code provided on the ftp site.

THEMIS and REGO both record data in PGM format. The data files are not single images, but instead contain multiple "stacked" frames with embedded metadata in the file. For THEMIS and REGO, we stack frames into one minute files; so there are 20 frames in each file (3second cadence images).

A file is written to include metadata for the file AND for each frame, so the contents of a single PGM file look like this (in order);

- First frame metadata (which includes file metadata)
- First frame (an image)
- Second frame metadata
- Second frame
- Third frame metadata
- Third frame
- Etc.

Metadata is included in the files as "comments". Each field begins with a name, which may either be a single word or multiple words, inside double quotes followed by a space. The actual metadata is contained in all remaining characters up to the end of line.

Below is an example of metadata included in a THEMIS file. Note: REGO contains much of the same information but also additional things that are detector/system specific. For UCalgary imagers, this is a common format that will be used for future instruments.

First frame Header (i.e. file header information)

#"Revised" 2006-05-18
#"Project unique ID" themis-gbo
#"Site unique ID" pina
#"Imager unique ID" themis18
#"Imager model" starlight Xpress MX716 with THEMIS all-sky optics
#"Imager comment" site unassigned
#"Ccd type" Sony ICX249AL
#"Ccd xsize" 752 pixels
#"Ccd ysize" 290 pixels
#"Ccd background" 3400
#"Pixel depth" 16 bits
#"Pixel aspect ratio" 0.5181

#"Optical type" THEMIS all-sky
#"Optical projection" a1=1.5,a3=0.0,b2=0.0,b4=0.0
#"Optical center" x0=384,y0=139
#"Computer name" pina i686
#"Operating system" Linux 2.4.26 #2 Tue Jun 29 00:51:07 PDT 2004
#"Project unique ID" THEMIS
#"Site unique ID" pina
#"Site name" Pinawa
#"Geodetic latitude" 50.163320
#"Geodetic Longitude" -96.06613
#"Geodetic altitude" 247
#"Mode unique ID" full
#"Mode sequence number" 1773422
#"CCD device" /dev/ccdA
#"Exposure options" WIDTH=512 HEIGHT=256 XBIN=2 YBIN=1 XOFFSET=128 YOFFSET=11 MSEC=999
#"Image request start" 2007-02-08 06:08:03.134282 UTC
#"Image readout start" 2007-02-08 06:08:04.124045 UTC
#"Exposure plus initial readout"   989.76 ms

Additional frames: Note – there is no reason to duplicate most of the information in the file header
#"Mode unique ID" full
#"Mode sequence number" 1773422
#"CCD device" /dev/ccdA
#"Exposure options" WIDTH=512 HEIGHT=256 XBIN=2 YBIN=1 XOFFSET=128 YOFFSET=11 MSEC=999
#"Image request start" 2007-02-08 06:08:03.134282 UTC
#"Image readout start" 2007-02-08 06:08:04.124045 UTC
#"Exposure plus initial readout"   989.76 ms

By building files with similar structures and naming conventions, we make it easier on the end user to access the data. If you learn to use THEMIS data, you can use REGO data… and so on.

We have built a "generic" readfile for our file structure that runs in IDL. The readfile looks for key metadata flags (things like sites and times) and pull those into IDL structures. Additional items are lumped into a comments section and need to be pulled out by parsing the strings. The idea is to allow flexibility of the metadata structure, while maintaining the format of the critical pieces of information (site, device and time). Scientists won't, in general, look at the other metadata but it serves as a record of what the instrument "thought" it was doing – and so will often need to be pulled out for instrument trouble shooting purposes.

To complete this worksheet you'll need themis_imager_readfile.pro and pam_readfile.pro (the two programs required to read the data), once you have those two pieces of code compiled and some data, you're ready to go. ☺

## Task 1. Open and plot a single image from each of REGO and THEMIS

- Images from the University of Calgary various project/cameras are available from our anonymous FTP site (data.phys.ucalgary.ca). You should be able to find ALL our data by looking there (if you can't see any data here then something is wrong!! please contact either Eric Donovan (edonovan@ucalgary.ca) or Emma Spanswick (elspansw@ucalgary.ca)). You'll need to download some of the data and be able to point the readfile to the data files.
  HINT: It will be easier if you maintain our directory tree structure on your local machine, but there is no requirements to do so – the code just needs to be able to see the files.

- Once you've navigated to the FTP site, pick any THEMIS or REGO date, location, and try to open the image in IDL and make a plot of one of the images. The readfile provided on the ftp site for this type of data is called themis_imager_readfile.pro (and yes, this will also open the REGO data). You'll need to download that file as well as pam_readfile.pro. Compile both of these programs within IDL before starting.

- THEMIS_imager_readfile.pro is the main readfile. Please look at the comments in the program for how to properly use it.

HINT: You're going to need to (1) be able to find a file on your computer and open it inside IDL (look up the command "file_search"), (2) read the image into local memory (command "themis_imager_readfile"). You may also need to look up "structures" in IDL, since the metadata is retuned into a structure. (3) plot the image on the screen (commands "window", "tvscl", and "bytscl"), and (4) write the image you plotted out to a file (commands "tvrd" and "write_png").

Output should look something like this (depending on the location and time you chose) – this is for THEMIS Fort Simpson on 2014-01-01 08:30UT
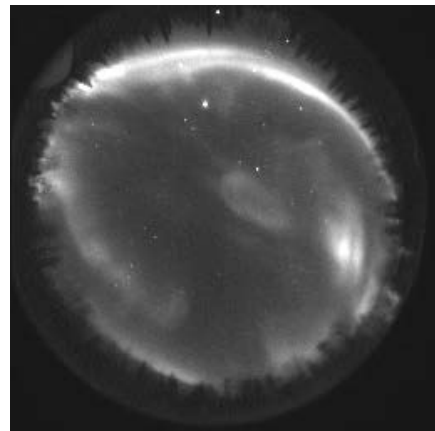
Now look at one file from REGO and one file from THEMIS.

- What's the first thing you notice about the two different imagers?
- Look into the metadata for THEMIS and REGO, pick out a few tags that you think show some key differences between the two detectors.

Task 2. Make a movie

a. Simple movie using the images (play inside a window)
- Write a program that loops through and opens successive images and plots them. Make the program generic, so that you can enter a date, location and it will; (1) find the images, (2) plot them at varying speeds. Remember there are multiple frames inside each file!!

HINT: This does not require that you save each image, just make it loop in the window. Look up "for loops" and "wait". Also try to make your program robust against missing data – it shouldn't crash when you ask for REGO images from Resolute Bay in the middle of June.

b. Add timestamps to the images
- Modify your program from above to use the returned metadata structure and pull out the timestamp and write it over the image.

*HINT: Look up "strsplit" and "xyouts"*

Task 3. Plot the dark and zenith counts for an entire night

We use the unexposed portion of the CCD to estimate the dark counts, which are essentially a measure of total noise sources internal to the system (they are what would happen if the instrument took a picture of nothing). Typically we take the average of the bottom 5x5 array of the pixels in the image. If the instrument is operating normally, the dark counts will be very stable across the night.

Using a single night of data plot the dark counts. Below is an example from our multispectral cameras (557.8,630.0, and 427.8nm). Your plot should look something like this, but with only one channel.
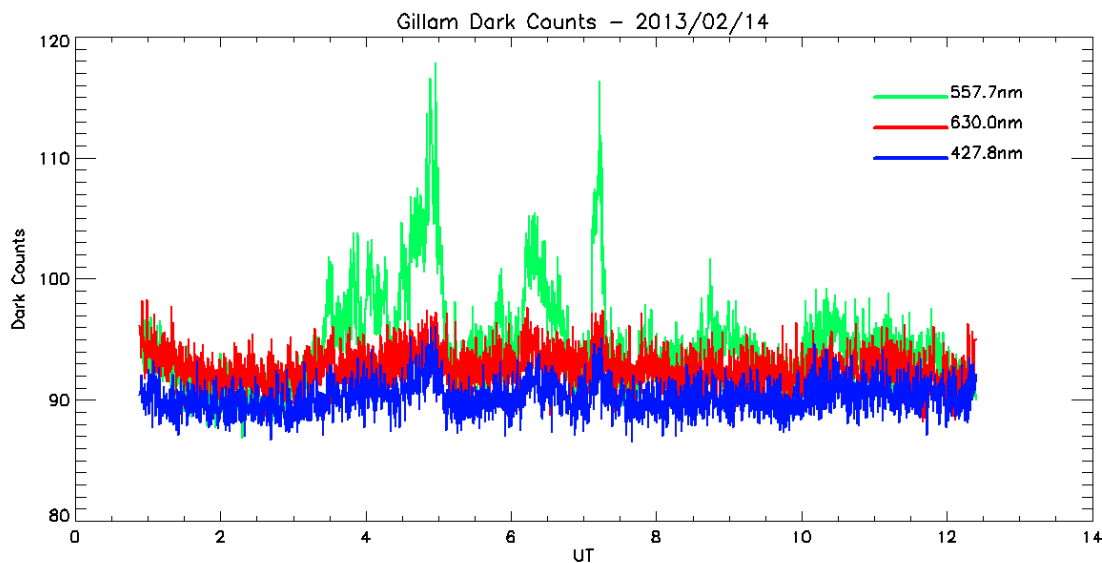
Now, for a SINGLE CAMERA plot the dark counts (same as above), but also over plot the average of the centre 5x5 pixels (which is an estimate of the luminosity straight overhead). Watch out for the image size – you may want to check to make sure you grab the "centre" of the image". It should look something like this.


Gillam Dark/Zenith Counts – 557.7nm – 2013/02/14
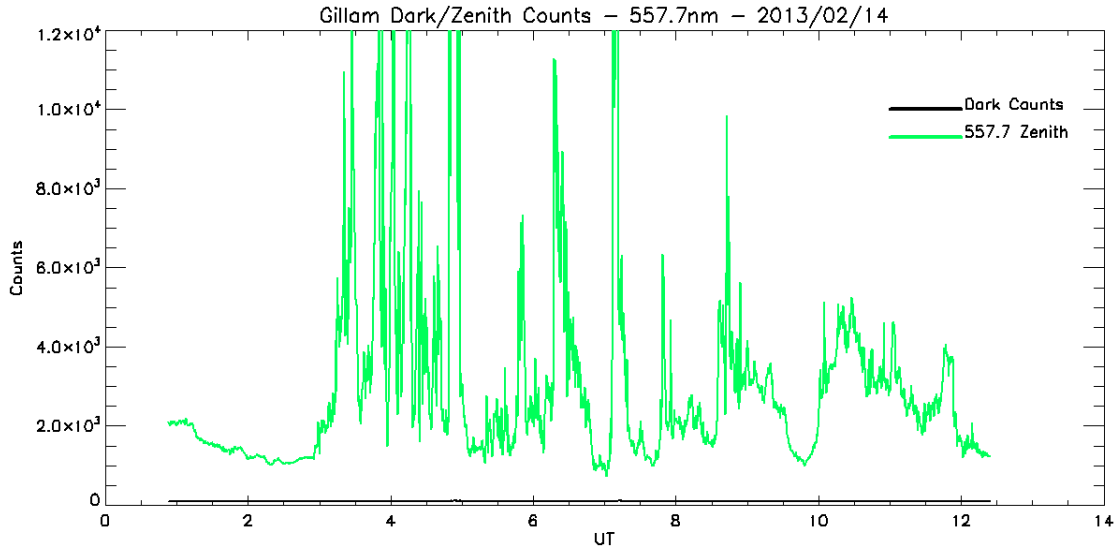
Task 4. For a single image, plot the intensity as a function of CCD pixel location along a N-S cut through the image.

2013-02-14 09:13:45 Gillam NASCAM - 557.7nm
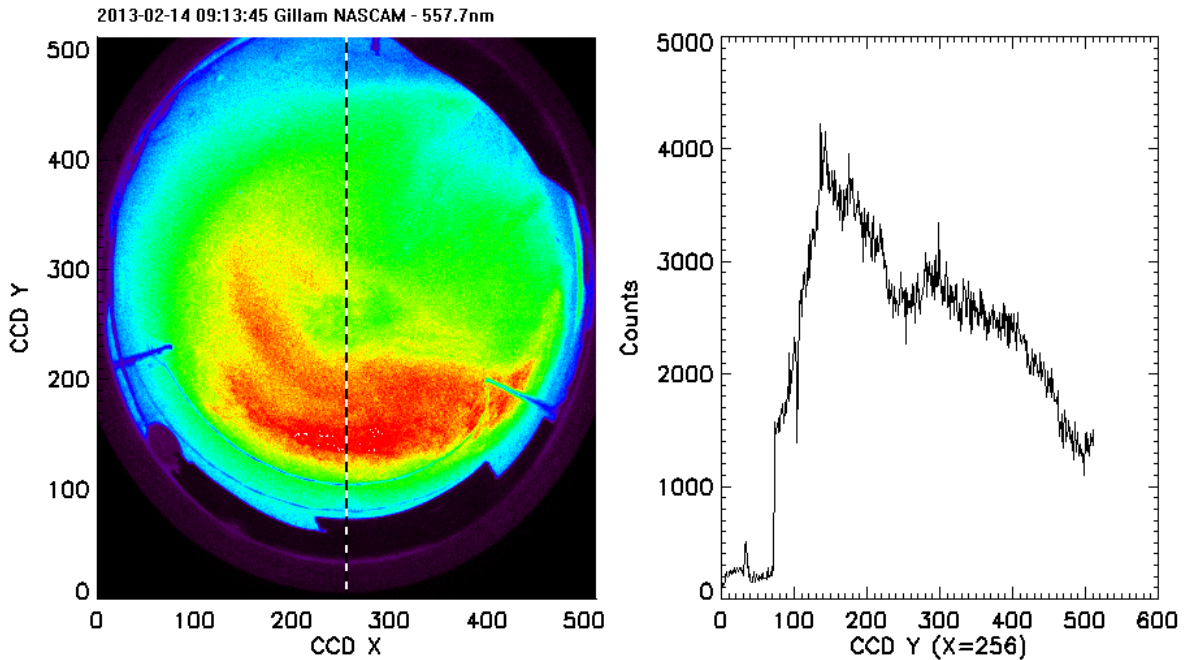
Task 5. Make a keogram

A keogram will use the same type of information you found in Task 4. Remember that slice down the middle? Now just stack them in time.

Your keogram should look something like this (Whitehorse 2008-02-11).


11:00UT   11:30UT   12:00UT
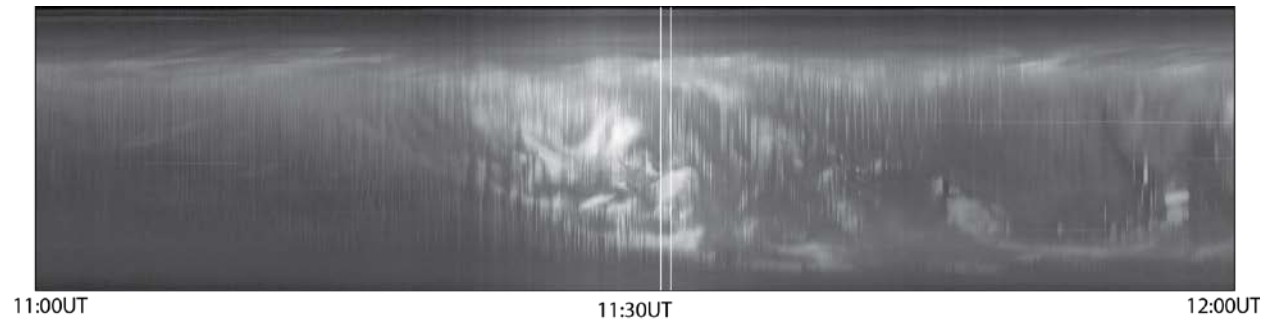
If you're feeling energetic, make a keogram from same site, same date for both REGO and THEMIS.

Task 6. Put an image on a map.

We store pointing information for the cameras in "skymap" files. The files contain the geographic coordinates of all the pixel corners at three heights. Typically, we generate the skymap files once for each imaging season (since the building will move with the freeze-thaw cycle). You can find the skymap files on our ftp site (data.phys.ucalgary.ca)

Find a good day of aurora and plot an image on a map. Hint – use the values of the lat/lon pixel corners to "fill" in a pixel on the map.
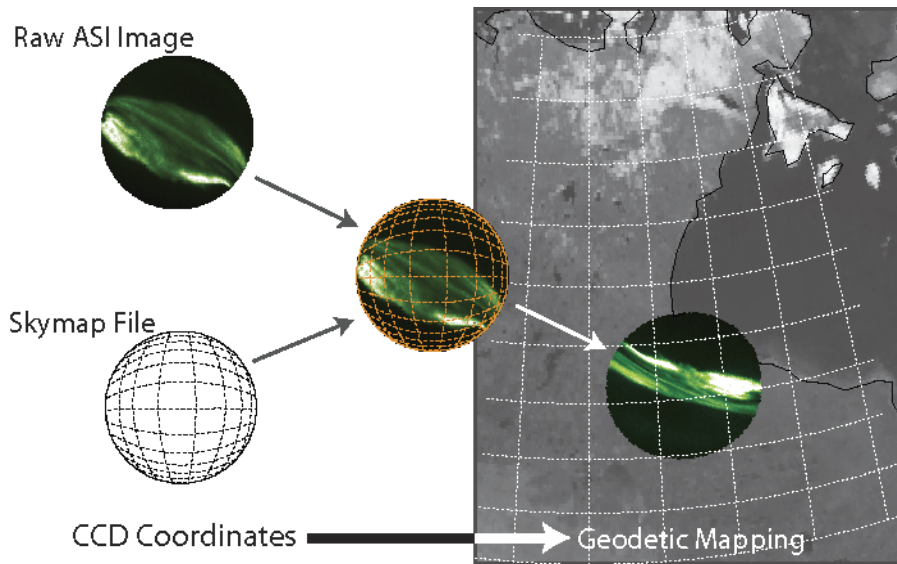
Once you've got one image on a map. Try to put two images (from two different cameras) from the same time, on the same map. It gets tricky fast. If you'd rather use our code to do the projections, look on the ftp site for the code (we have examples for both THEMIS and REGO). Note that you'll need to look inside the file and change the pointers to the skymap and the data (this is why it's easier if you maintain our directory tree structure☺).

NORSTAR NASCAM
20090126 - 11:00:00UT
557.7nm +6sec