# THEMIS Technical Information

## ASI and GMAG Data

The details of the ground stations are given in the following table:

Table 1: THEMIS ground stations equipped with ASI cameras and magnetometers.

| Station Code | Geog Lat (deg) | Geog Long (deg) | Name | Geom Lat (deg) | Geom Long (deg) | Mid night (hh:mm) |
|---|---|---|---|---|---|---|
| **ATHA** | 54.714 | 246.686 | Athabasca,AB | 61.98 | 306.76 | 8:07 |
| **CHBG** | 49.814 | 285.581 | Chibougamau,QC | 59.57 | 3.62 | 4:49 |
| **EKAT** | 64.717 | 250.667 | Ekati,NT | 72.28 | 307.66 | 8:02 |
| **FSIM** | 61.762 | 238.779 | Fort Simpson,NT | 67.3 | 293.85 | 8:57 |
| **FSMI** | 59.984 | 248.158 | Fort Smith,NT | 67.38 | 306.64 | 8:06 |
| **FYKN** | 66.560 | 214.786 | Fort Yukon,AK | 67.24 | 266.14 | 11:00 |
| **GAKO** | 62.407 | 214.842 | Gakona, AK | 63.06 | 269.02 | 10:48 |
| **GBAY** | 53.316 | 299.540 | Goose Bay,NL | 60.73 | 23.08 | 3:37 |
| **GILL** | 56.354 | 265.344 | Gillam,MB | 66.18 | 332.78 | 6:34 |
| **INUV** | 68.413 | 226.230 | Inuvik,NT | 71.23 | 275.09 | 10:17 |
| **KAPU** | 49.392 | 277.680 | Kapuskasing,ON | 59.76 | 351.95 | 5:29 |
| **KIAN** | 66.971 | 199.562 | Kiana,AK | 65.13 | 253.47 | 12:02 |
| **KUUJ** | 58.155 | 291.468 | Kuujjuaq,QC | 66.89 | 13.23 | 4:15 |
| **MCGR** | 62.953 | 204.404 | Mcgrath,AK | 61.72 | 259.84 | 11:32 |
| **NRSQ** | 61.162 | 314.558 | Narsarsuaq,DK | 65.53 | 41.39 | 2:14 |
| **PGEO** | 53.815 | 237.172 | Prince George,BC | 59.13 | 295.67 | 8:52 |
| **PINA** | 50.163 | 263.934 | Pinawa,MB | 60.08 | 331.46 | 6:38 |
| **RANK** | 62.828 | 267.887 | Rankin Inlet,NU | 72.41 | 335.74 | 6:24 |
| **SNAP** | 63.580 | 249.130 | Snap Lake,NT | 70.92 | 305.71 | 8:07 |
| **SNKQ** | 56.536 | 280.769 | Sanikiluaq,NU | 66.45 | 356.99 | 5:12 |
| **TALO** | 69.541 | 266.446 | Taloyoak, NT | 78.39 | 330.01 | 6:41 |
| **TPAS** | 53.994 | 259.059 | The Pas,MB | 63.27 | 323.8 | 7:05 |
| **WHIT** | 61.010 | 224.777 | Whitehorse,YT | 63.66 | 278.14 | 10:01 |
| **YKNF** | 62.520 | 245.687 | Yellowknife,NT | 69.36 | 301.65 | 8:24 |

(Table obtained from THEMIS, University of California, Berkeley)

The ASI data can be found on the Government of Canada's OpenData FTP (ftp.asc-csa.gc.ca) in the directory */users/OpenData_DonneesOuvertes/pub/THEMIS/asi/* with the files organized according to the dates, locations and hour the data was gathered. For example, */users/OpenData_DonneesOuvertes/pub/THEMIS/asi/montage/2015/03/17/ut9* corresponds to the ASI data collected on the 17th of March, 2015 at the Whitehorse ground station in Yukon at 9:00 AM UTC.

Inside this directory, there are .gz files which once unzipped contain .pgm images of montages comprising the array of thumbnail images spanning the given hour with 1 minute intervals. The ASI's capture full-resolution 256x256 pixel images each with RGB channels with their fisheye lenses with f-number 0.95 (ratio between focal length and diameter of the pupil) deforming the images so the horizon is all around the image circle and Nadir is at the center. This distortion is the result of non-rectilinear mapping meaning that the lenses bend straight lines; lines are only truly straight if they appear straight in the image and pass through the center. Furthermore, the images are oriented so the geographic North is Up, South is Down, East is Left and West is right since the image is flipped from the perspective of looking upwards at the sky. An example is given below:

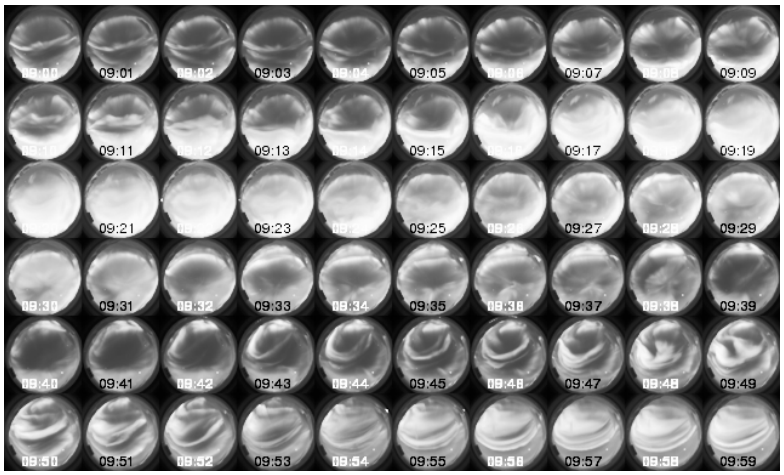


Figure 2: Montage of ASI images taken in Whitehorse, Yukon on March 17th, 2015 between 9:00 and 9:59 AM UTC.

The GMAG data is archived in a similar fashion under the directory */users/OpenData_DonneesOuvertes/pub/THEMIS/magnetometer/* using the same naming convention as for the ASI data. The data files are of the .hkd text type and have for columns the date, time, temperatures in degrees Celsius of the electronics, the sensors and the GPS. Most importantly, the last columns hold the magnetic field components $b_1$, $b_2$, $b_3$ in nanoteslas (nT). The $b_1$ component points to local geographic north; $b_2$ to local geographic west and $b_3$ to the local nadir (into the ground). Each coordinate system is unique to its corresponding ground station, however they are all related by their dependence on the location of the magnetic poles. Note that at the poles the $b_1$, $b_2$ are weakest whereas the $b_3$ is strongest.

The THEMIS satellite mission has pushed our understanding of substorms and their influence on auroras further. However, analysing more than a decade's worth of images and extracting meaningful information on the behaviour of auroras can be a challenge.

Examples of model images follow:

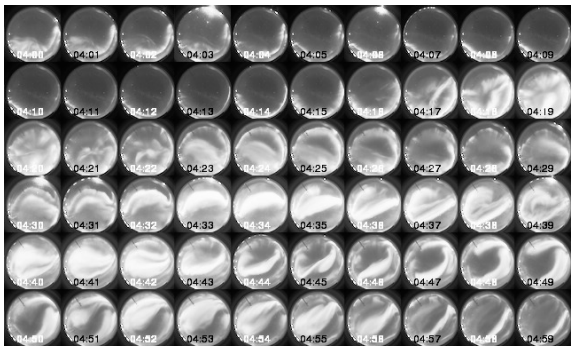

Figure 3: Excellent conditions – No moon, clear sky, bright auroras (28/09/2017, Rankin Inlet).

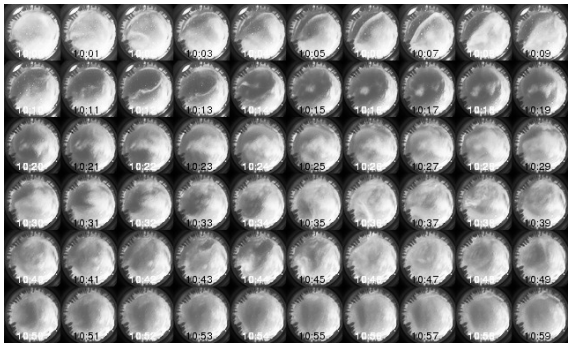

Figure 4: Average conditions – Foggy, some clouds, trees along perimeter, possible auroras (26/08/2018, Whitehorse).

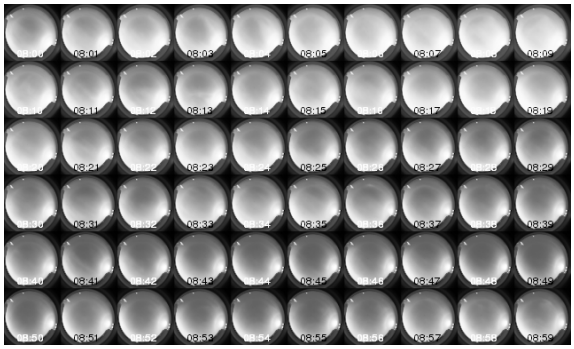

Figure 5: Difficult conditions – Cloudy, bright Moon (09/03/2012, Kuujjuaq).

## PGM format:

Files with the .pgm extension correspond to images in portable graymap format (PGM). They can be either 8-bit or 16-bit and can be encoded in ASCII or in binary depending on their "magic number" set to P2 or P5 respectively. The first line of code is the said magic number, the second line contains the X and Y dimensions of the resulting image and the third line is the maximum value of the greyscale used. There is a newline character at the end of each line An example is given below:

```
P2
# Shows the word "FEEP" (example from Netpbm man page on PGM)
24 7
15
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
0  3  3  3  3  0  0  7  7  7  7  0  0 11 11 11 11  0  0 15 15 15 15  0
0  3  0  0  0  0  0  7  0  0  0  0  0 11  0  0  0  0  0 15  0  0 15  0
0  3  3  3  0  0  0  7  7  7  0  0  0 11 11 11  0  0  0 15 15 15 15  0
0  3  0  0  0  0  0  7  0  0  0  0  0 11  0  0  0  0  0 15  0  0  0  0
0  3  0  0  0  0  0  7  7  7  7  0  0 11 11 11 11  0  0 15  0  0  0  0
0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0  0
```


Figure 1: Example of the .pgm file format. (https://en.wikipedia.org/wiki/Netpbm_format)

## HKD format:

These are basic text files with the following format used for the THEMIS ground-based magnetometer (GMAG) data:

Headings:

| DATE | TIME | ETemp | STemp | GTemp | CH1 | CH2 | CH3 | GPS |
|---|---|---|---|---|---|---|---|---|
| Date (mmddyyyy) | Time (hh:mm) | Electronics temperature (°C) | Sensors temperature (°C) | GPS temperature (°C) | $B_1$ component (nT) | $B_2$ component (nT) | $B_3$ component (nT) | GPS number |

Example (THEMIS Data):

```
   DATE      TIME     ETemp    STemp    GTemp     CH1        CH2        CH3     GPS
  03282008    0:00    45.61    -0.17   -49.41   16674.83    238.03   51458.86 13
  03282008    0:01    45.60    -0.16   -49.41   16674.39    232.48   51459.47 13
  03282008    0:02    45.61    -0.14   -49.41   16676.33    228.71   51464.19 13
  03282008    0:03    45.60    -0.16   -49.41   16684.43    231.35   51473.46 13
  03282008    0:04    45.59    -0.16   -49.41   16690.71    238.40   51482.48 13
```