The THEMIS All Sky Imager (ASI) array.

The THEMIS GBO team*.

The THEMIS mission requirement for the Ground Based Observatories is to determine the time and location of the initial auroral intensification due to substorms in magnetic local time (MLT) and latitude. This will be accomplished partly by using an array of all-sky imagers (ASI-) with at least two ASI per MLT hour, which operate with time resolution equivalent to <10s and spatial resolution <1° degree of latitude. 20 stations are being deployed in the North American arctic region and the station locations are listed in Table 1 and illustrated in Figure 1. The circles represent the fields of view of the all sky cameras when taking a 160 degree total field projected to 110 km altitude. The radius of these circles is about 4.5 latitude degrees. The station array provides complete coverage with the exception of a small gap between stations GILL - FSMI, GILL - KAPU and SNKQ - GBAY.

The THEMIS cameras are relatively simple white light CCD imagers with tele-centric optical system of an equivalent F-number of 0.95. Using white light provides a number of major advantages, simplifications and corresponding cost savings.

The coverage of a single ASI is approximately circular in geographic coordinates (radius of about 4.5 degrees). At high latitudes (60 and above) this distance is equal to about twice as many longitude degrees and each station providing between 16 and 20 degrees of longitude ~ 1 hour local time coverage.

The technique of observing the global aurora from each single ground based stations is limited by the inherent distortion of the observing geometry and the optics. Depending on the zenith angle, different regions of the sky take up different areas on the image plane. We took advantage of this fact and utilized a special data compression scheme for the quasi-real-time retrieval of the data. The scheme limits the resolution over the central (zenith) region of the image while preserving higher resolution towards the horizon. The compression permits the fast electronic retrieval of the data over the internet and still satisfies the major requirements relevant to the major THEMIS objectives.

* The THEMIS ASI-s are part of the Ground Based Observatory (GBO) component of the NASA Time History of Events and Macroscale Interactions during Substorms (THEMIS) project . The Principal investigator of the THEMIS program is Vassilis Angelopoulos of the University of California, Berkeley. The GBO-s are directed by Stephen B. Mende also of the University of California of Berkeley who is assisted by the following key persons: Harald Frey and Stewart Harris. 16 of the 20 GBO-s are located in Canada and were fielded and are serviced by the University of Calgary team under the direction of Eric Donovan. His team includes Brian Jackel and Mike Greffen as the key persons. The GBO-s also contain magnetometer instruments and those data and the associated key individuals are presented elsewhere.

Table 1. GBO stations. Column 1 to 6 are self explanatory, column 7 is the UT time at local magnetic midnight at the station, column 8 shows the serial number of the imager, 9 the serial number of the GBO electronics, 10 the type of magnetometer and 11 the station installation date.

1 No.	2 Site	3 Abbrev.	4 Location	5 Latitude	6 Longitude	7 Magn. Midnight	8 ASI #	9 GBO#	10 GMAG type	11 Deploy
20	Goose Bay	GBAY	Canada	53.316N	299.540E	3:36	13	GBO-14	GMAG-6 (10532/5009)	Feb-06
18	Nain	NAIN	Canada	56.5	298.3	3:40	05	GBO-21	GMAG-8 (10547/5011)	TBD
19	Chibougamau	CHBG	Canada	49.814N	285.581E	4:16	16	GBO-17	GMAG-9 (10546/5013)	Sep-06
16	Sanikiluaq	SNKQ	Canada	56.536N	280.769E	5:05	09	GBO-22	NRCan w/ GPS-9	Oct-06
17	Kapuskasing	KAPU	Canada	49.392N	277.680E	5:29	17	GBO-15	GMAG-7 (10545/5012)	May-06
10	Rankin Inlet	RANK	Canada	62.828N	267.887E	6:25	12	GBO-09	CGSM w/ GPS-4 (10528)	Sep-05
13	Gillam	GILL	Canada	56.354N	265.344E	6:34	19	GBO-19	CGSM w/ GPS-7 (10516)	May-06
15	Pinawa	PINA	Canada	50.163N	263.934E	6:39	18	GBO-16	CGSM w/ GPS-8	May-06
14	The Pas	TPAS	Canada	53.994N	259.059E	7:05	06	GBO-06	GMAG-1 (10505/4001)	May-05
11	Fort Smith	FSMI	Canada	59.984N	248.158E	8:08	10	GBO-10	CGSM w/ GPS-3 (10527)	Jul-05
12	Athabasca	ATHA	Canada	54.714N	246.686E	8:08	02	GBO-02	NRCan w/ GPS-0	Aug-04
7	Ekati	EKAT	Canada	64.733N	249.330E	8:11	04	GBO-04	GMAG-3 (10503/4003)	Dec-04
9	Prince George	PGEO	Canada	53.815N	237.172E	8:53	03	GBO-03	GMAG-2 (10501/4002)	Sep-04
8	Fort Simpson	FSMP	Canada	61.8	238.8	8:58	15	GBO-13	CGSM w/ GPS-6 (10539)	TBD
6	White Horse	WHIT	Canada	61.010N	224.777E	10:02	07	GBO-07	GMAG-4 (10533/4015)	Jul-05
5	Inuvik	INUV	Canada	68.413N	226.230E	10:19	08	GBO-08	CGSM ('06) w/ GPS-2 (10526)	Jun-05
1	Gakona	GAKO	USA	62.407N	214.842E	10:49	20	GBO-18	GI w/ GPS-10	Aug-06
2	Fort Yukon	FYKN	USA	66.560N	214.786E	11:02	14	GBO-12	GI w/ GPS-5 (10529)	Oct-05
3	Mcgrath	MCGR	USA	62.953N	204.404E	11:33	11	GBO-11	GMAG-5 (10525/4016)	Aug-05
4	Kiana	KIAN	USA	66.971N	199.562E	12:04	22	GBO-20	GMAG-10 (10554/4009)	Sep-06
Spare	Berkeley	BERK	USA	37.881N	237.756E		21	GBO-05	GMAG-0 (proto s/n 1)	Mar-05

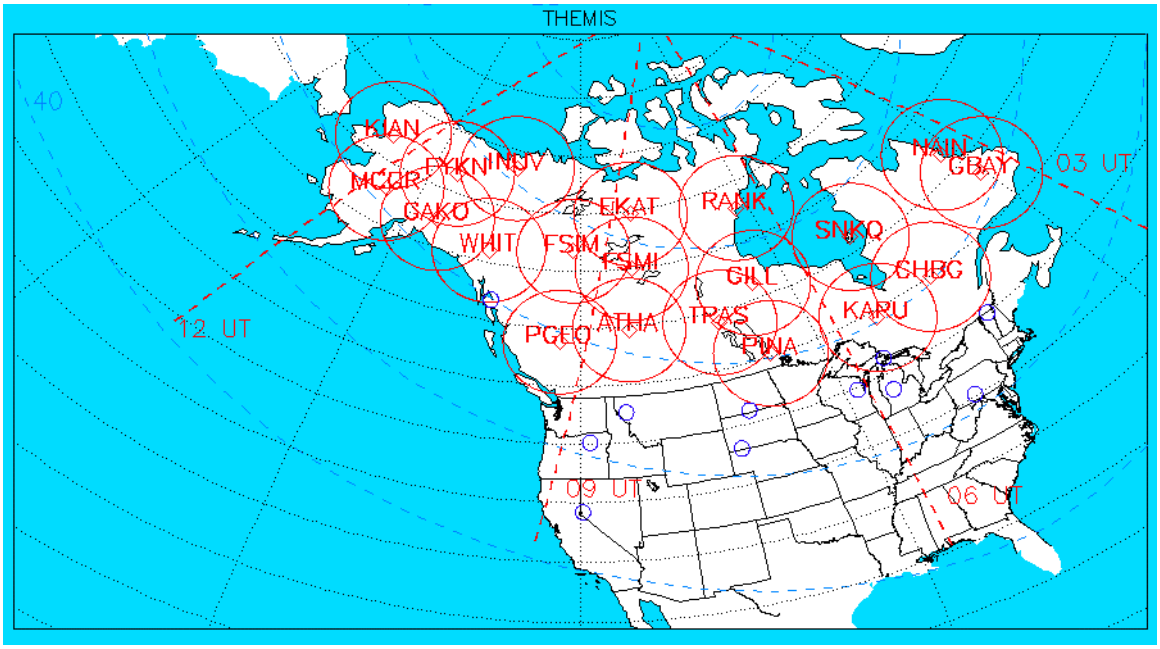

Figure 1. *Map of North America with the GBO station names and their approximate fields of view of the all-sky cameras. Magnetic latitudes are shown and labeled in blue. The red lines represent the meridians of local magnetic midnight at 03, 06, 09, and 12 UT.*

The compressed data produces a separate data stream that is received at the central storage sites (in Calgary and Berkeley) in near real time (approximately one day delay). From this data "thumb nail" images are made that are denoted with T in the browse products. A thumbnail image represents a 1024 pixel vector. This data set retains the spatial and temporal resolution necessary to locate and time the substorm onsets. The thumbnail images also permit the construction of the equivalent of a satellite viewed quasi-global set of auroral oval images, the so-called mosaics. The production of these mosaics proceeds as soon as the NRT data is picked up through the internet usually with less than one day delay. During a year with 100 nights of operation averaging 8 hours per night for 20 stations this set is about 20 Gbytes/year.

We retrieve the full data from the sites by sending the hard-drives back from each station and their receipt therefore is delayed for several months. The full resolution data set is intended to preserve the full raw images for the study of auroral forms. The high time resolution (three seconds cadence), 256 x 256 pixel images and combining with the recording of the full dynamic range (12 to 14 bits of intensity resolution) produces an immense amount of data. The data collected by the 20 stations network with a full image every 3 seconds represents a ~2.6 Mbytes/min continuous data stream per station. During a year with 100 nights of operation averaging 8 hours per night and 20 stations this is 2.5 Tbytes/year.

The data is available freely to use in scientific studies*. They are available from this websites in two forms, (1) browse products where the data is available in ready made gif images in Keograms, image collages and geographically projected mosaic formats, and alternately (2) the data is available in formats where the images had been converted into CDF data files for more detailed analysis. On the browse products the letter "T" on the right shows that the data are from the NRT compressed "Thumbnail-s" and not from the full resolution images. Any work resulting from THEMIS GBO-s should acknowledge NASA contract NAS5-02099, which supports the THEMIS program.

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