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Installation of a MAGDAS-9 magnetometer in Sri Lanka to measure magnetic field variations near the dip equator

A D M P Ranasinghe[1] ,K P S C Jayaratne[1] and A. Yoshikawa[2]

[1]Department of Physics, University of Colombo, Colombo-03, Sri Lanka

[2]International Center for Space Weather Science and Education (ICSWSE), Kyushu University, Fukuoka, Japan

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ABSTRACT

Due to the secular variation of the geomagnetic field, for the past few decades, the dip equator is showing a southward migration and in the Indian subcontinent it is currently crossing Sri Lanka. The main purpose of this proposed project is to establish a data gathering point in this part of the world close to dip equator to fill the vacuum. Preliminary studies on the selection of a site was made in February, 2016. One hour measurements were taken using a MAGDAS-9 magnetometer in several locations close to the places in dip equator till a place with field variations less than 400 nanotesla is found. A site in Dompe area (36 km away from Colombo) was finally selected (6.97^{o}N, 80.07^{o}E). The installation of the magnetometer required a metal free construction. Two brick and cement enclosures each of 1.2 x 1.2 x 0.5 m size pit, one for the magnetometer, and other for the amplifier (about 5 m away from the magnetometer), in the selected area was constructed under the ground and the magnetometer was installed. Magnetometer was aligned to get minimum errors on X, Y and Z components of the magnetic field. A 200 m long cable from the amplifier was connected to a data logger inside a safe place in a nearby shelter with electricity supply. A 4G router was connected to the data logger for continuous uploading of data to MAGDAS world network. A GPS instrument too was connected to the data logger. A 12V car battery was fixed to run the data logger in dc power while the battery is charging from AC mains to avoid interruptions due to power possible power failures. It was found that the magnetometer installed was functioning perfectly. Geomagnetic latitude and longitude of the observatory and the dip latitude are -1.65, 152.90 and -0.34, respectively. Link to real time status graph of Colombo station is http://magdas2.serc.kyushu-u.ac.jp/realtime/fig/mag9_CMB.png.

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INTRODUCTION

MAGDAS (MAGnetic Data Acquisition System) is a global network of ground-based magnetometers in different locations of the world. Using the MAGDAS data, geomagnetic variation can be measured and plasma environment and global electromagnetic change can be monitored in geospace[1]. Studying of plasma environment and global electromagnetic change is used in Solar Terrestrial Physics and space weather researches to understand the complex Sun-Earth system[2]. Geomagnetic dip-equator is currently crossing above Sri Lanka and Sri Lanka is an important place to measure the geomagnetic variation due to different phenomena can be expected close to dip-equator. A MAGDAS-9 observatory has been installed in Dompe, Sri Lanka (6.97^{o}N, 80.07^{o}E) in February, 2016 and the station code of the observatory is CMB and the station has been named as Colombo. The instrument has a Three-Component Ring-Core Flux Gate type magnetometer which can measure the magnetic field in ±70,000 nT range. The noise level of the MAGDAS magnetometers estimated to be 0.02 nTp-p. The instrument measures the magnetic field as three components in three axes horizontal (H), declination (D) and downward(Z).

METHODOLOGY

Dip equator area selection

First we checked the location of dip equator around Sri Lanka longitude by IGRF model for last 5 years.

We found following two things

1. The dip equator is moving to southward at the speed of 0.06 degree per year.
2. Dip equator in Sri Lanka currently exists between 7.4 and 7.5 degree of geographic latitude.

How this area selection was done theoretically.

- The dip angle and Z comp. of magnetic field was checked for 5 years based on IGRF model **at Dambulla(DAM), Kurunegala(KUR), Rambukkana(RAM), Kandy(KAN) and Colombo(COL)**
- A linear fitting was done for geographic latitude and dip angle(the Z comp)
- It was selected approximately 6.9 to 7.5 degree of GG latitude as the location of magnetometer site, where is roughly between Kurunegala city and Colombo city.
- Avoided places near main traffic road because cars can seriously affect our data, and more than 100~200 m distance from the road is needed.
- One hour measurements were taken using a MAGDAS-9 magnetometer in several locations close to the places in dip equator till a place with field variations less than 400 nT is found.

METHODOLOGY

Dip equator area selection

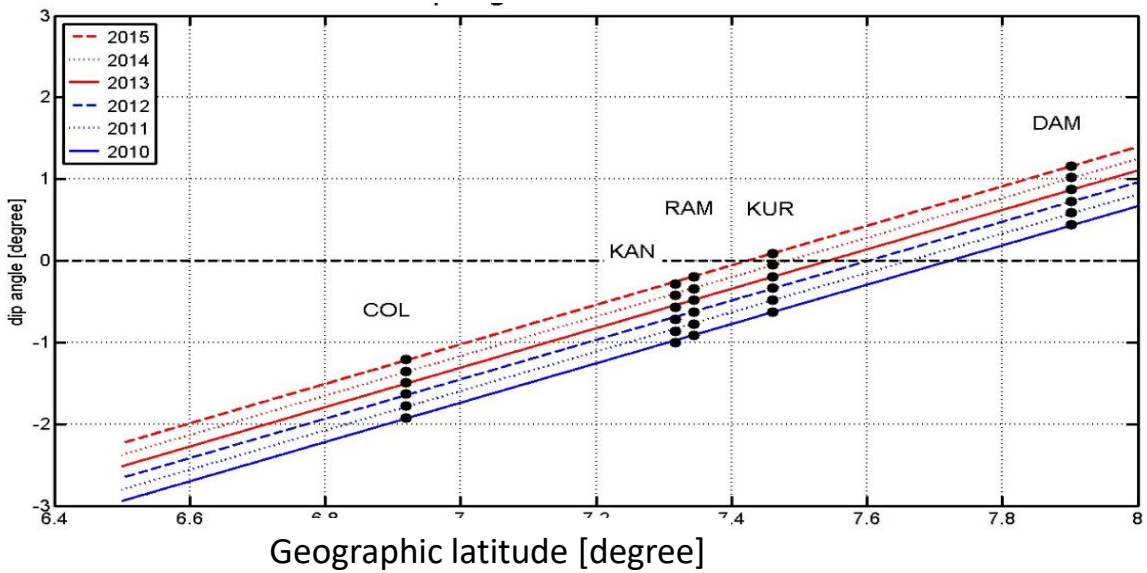


Figure 02 : Change in dip angle of locations tested for the station site

Figure 03 : Locations tested for the station site

DAM-Dambulla, KUR-Kurunegala, RAM-Rambukkana, KAN-Kandy, COL-Colombo

METHODOLOGY

Installation design

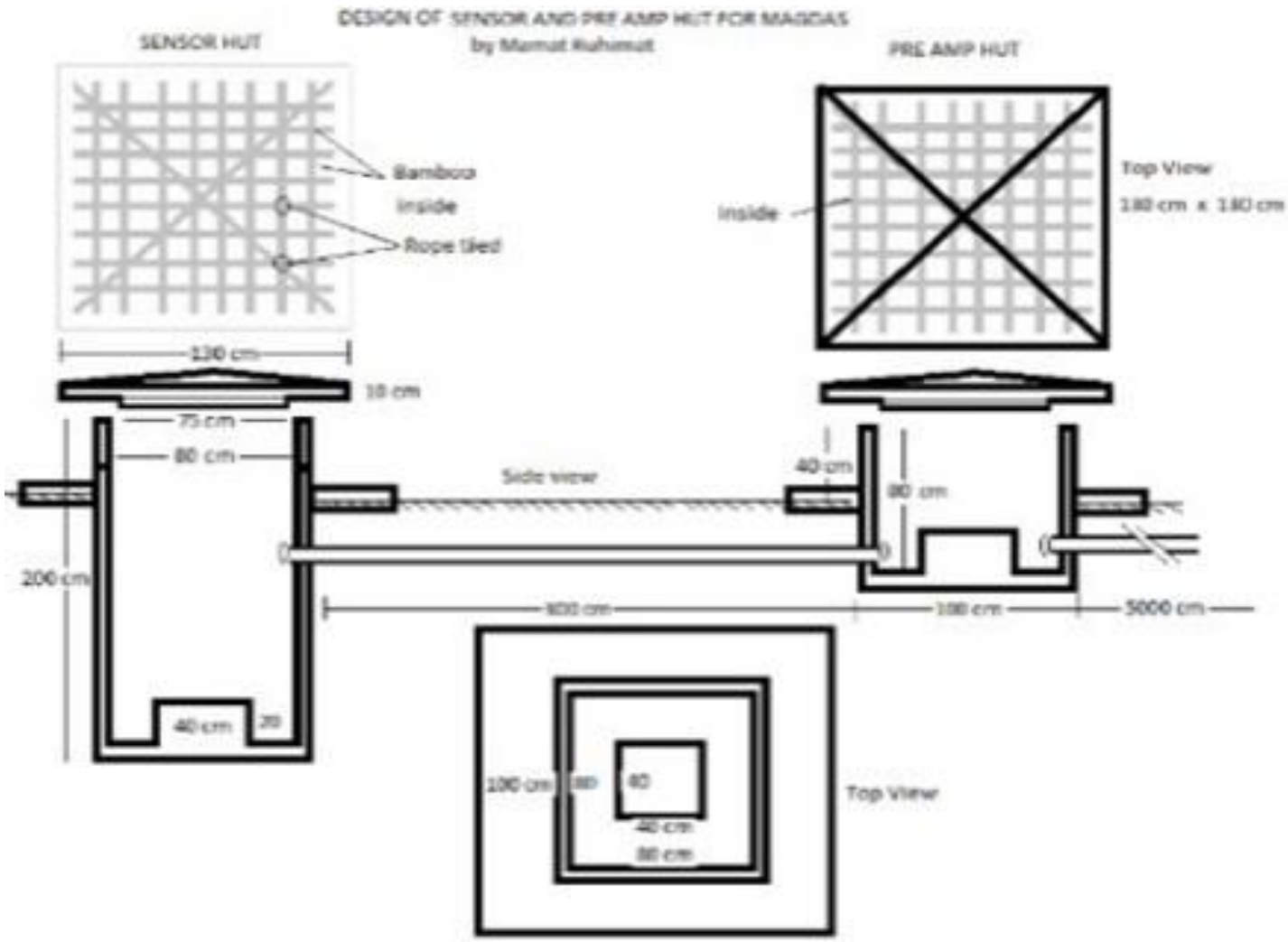


Figure 04-a : Design plan of construction of Sensor hut and Pre-amp hut

METHODOLOGY

Installation design

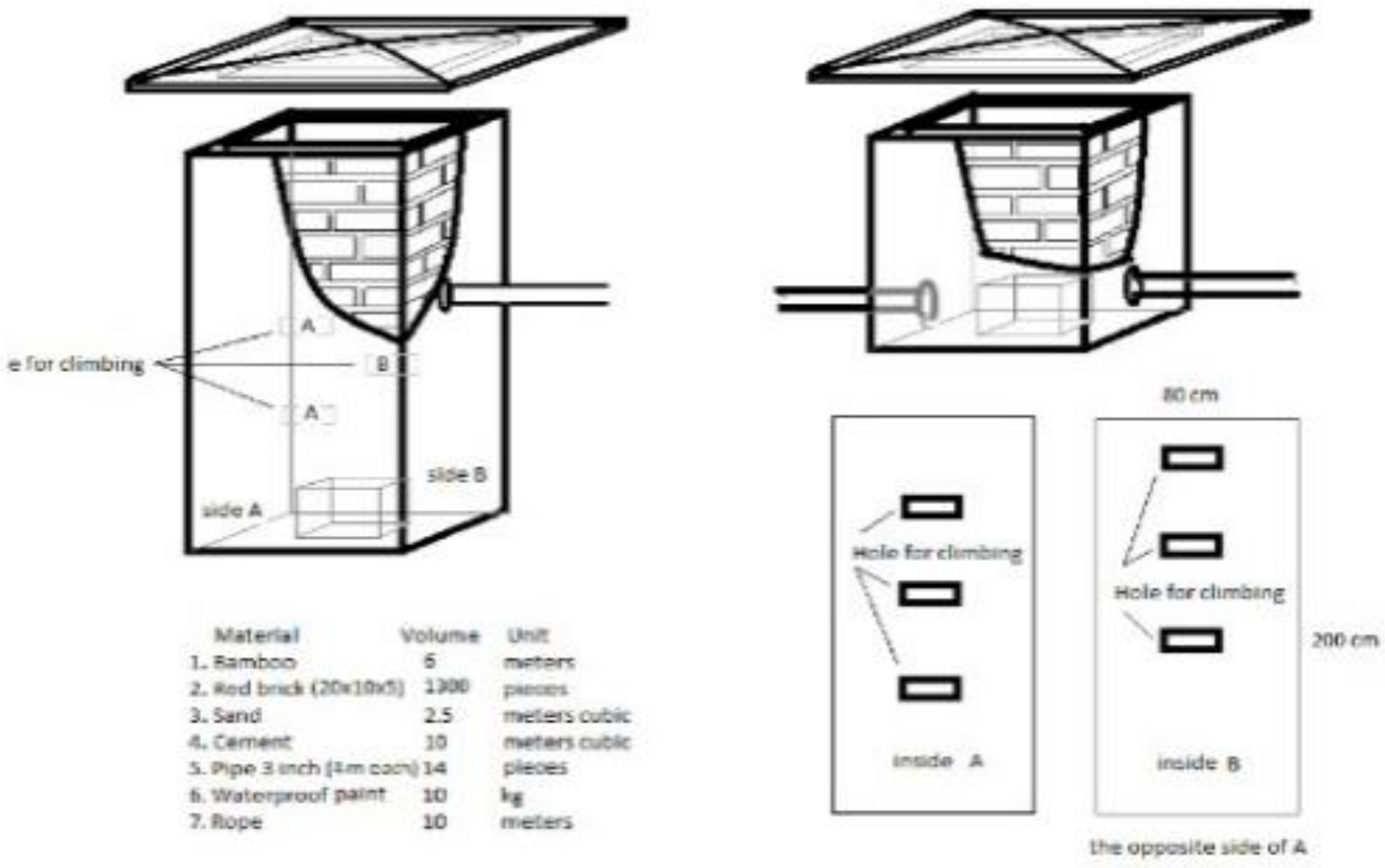


Figure 04-b : Design plan of construction of Sensor hut and Pre-amp hut

METHODOLOGY

Components of the instrument

Figure 05-a : Components of the MAGDAS device

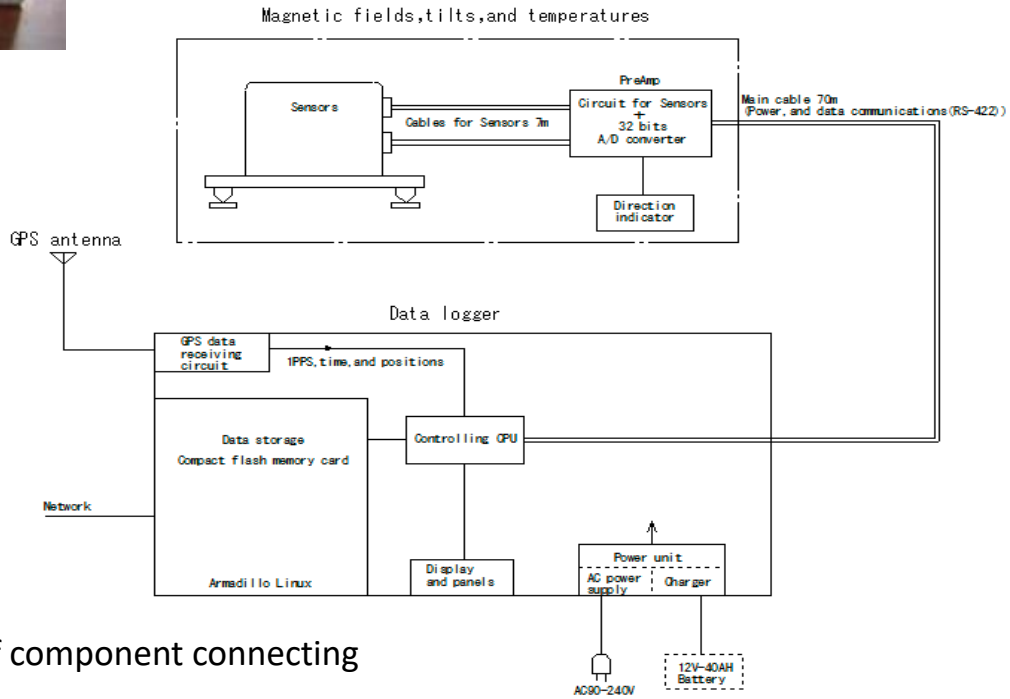
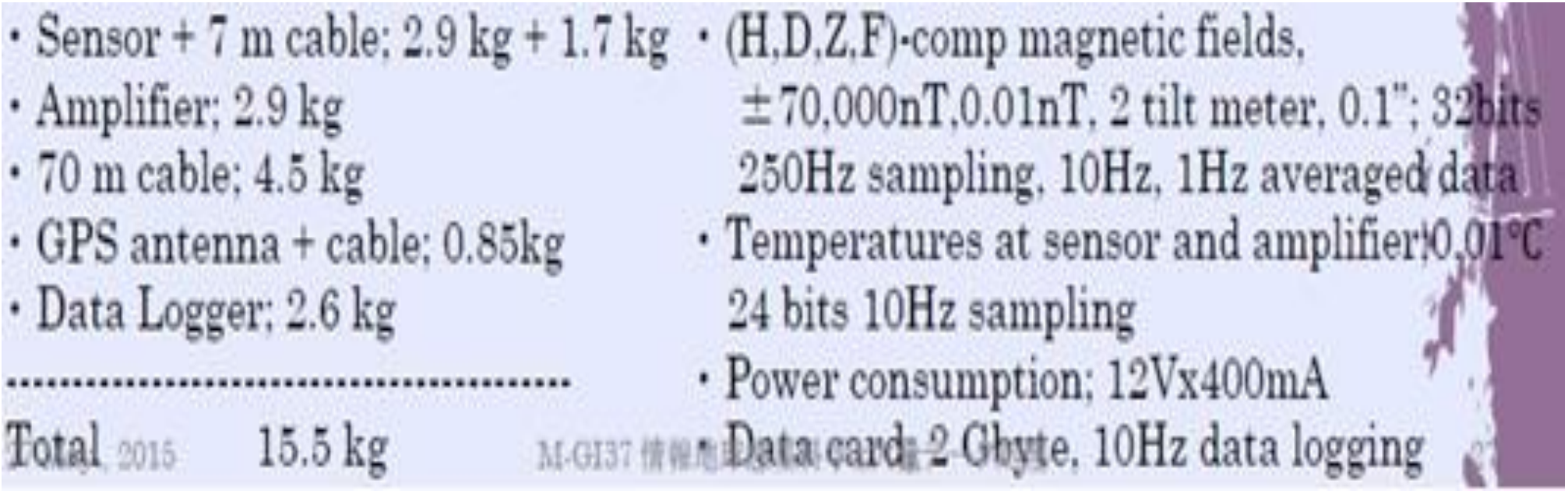


Figure 05-b : Block diagram of component connecting

METHODOLOGY

Specification of the instrument



- Sensor + 7 m cable; 2.9 kg + 1.7 kg
- Amplifier; 2.9 kg
- 70 m cable; 4.5 kg
- GPS antenna + cable; 0.85kg
- Data Logger; 2.6 kg

Total 15.5 kg

- (H,D,Z,F)-comp magnetic fields, ±70,000nT,0.01nT, 2 tilt meter, 0.1"; 32bits 250Hz sampling, 10Hz, 1Hz averaged data
- Temperatures at sensor and amplifier;0.01°C 24 bits 10Hz sampling
- Power consumption; 12Vx400mA
- Data card; 2 Gbyte, 10Hz data logging

METHODOLOGY

Device installation – construction and setting-up



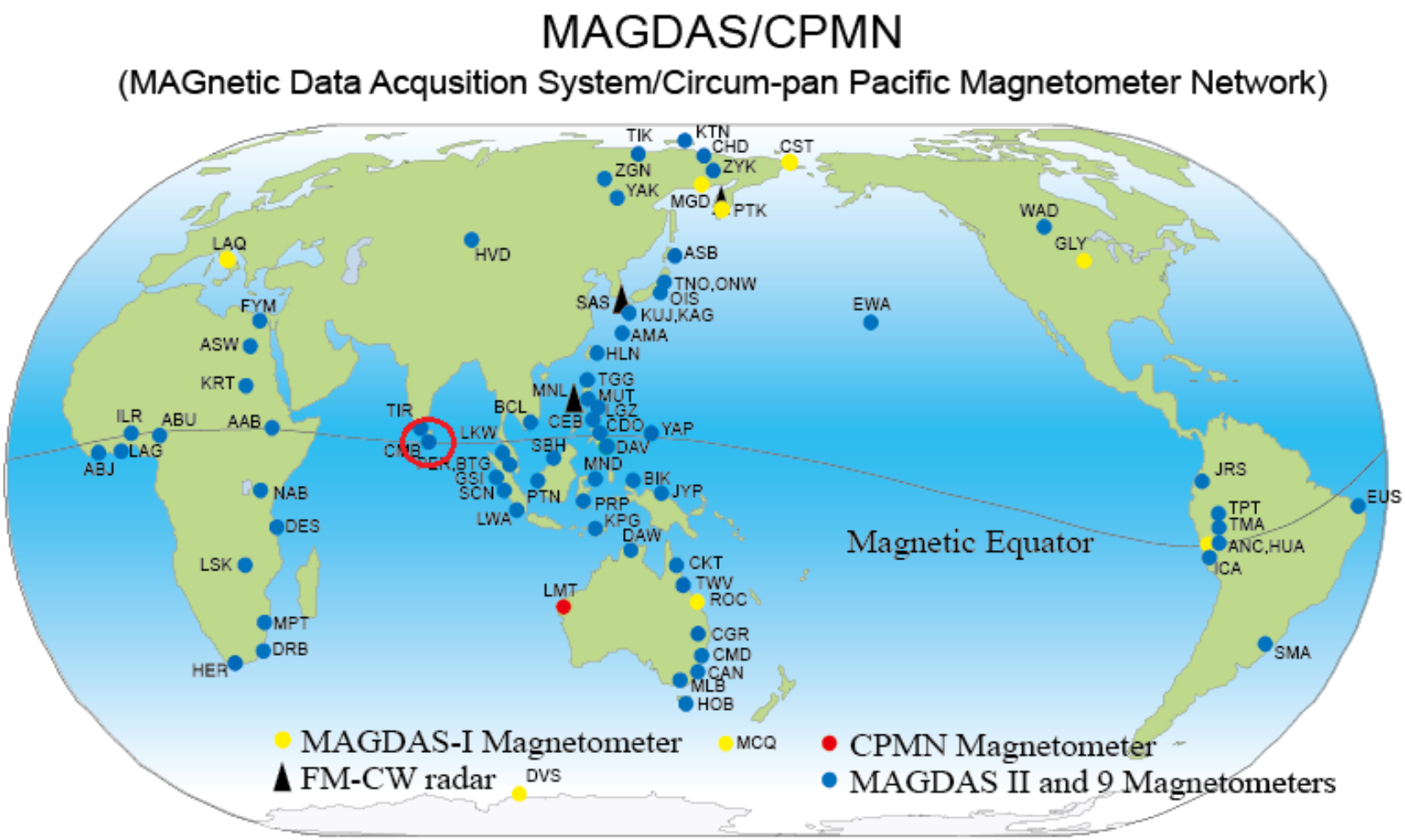






METHODOLOGY

MAGDAS station map



Sri Lanka MAGDAS station is in Dompe area (6.97°N, 80.07°E) and the latitude from geomagnetic dip equator is -0.34°

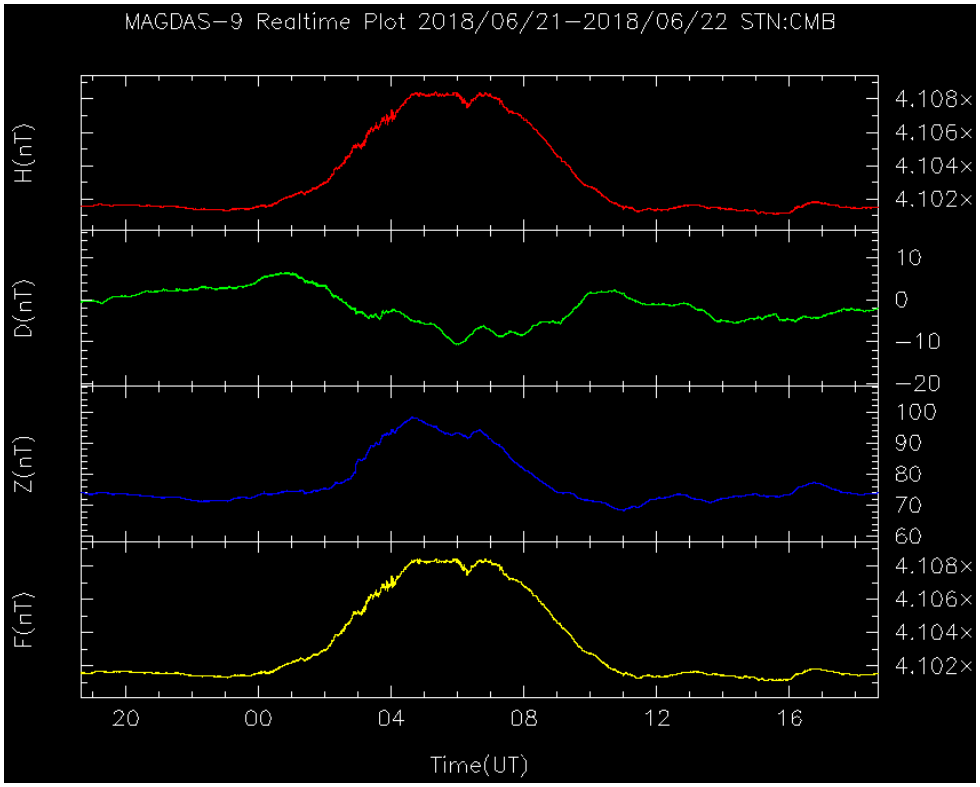
METHODOLOGY

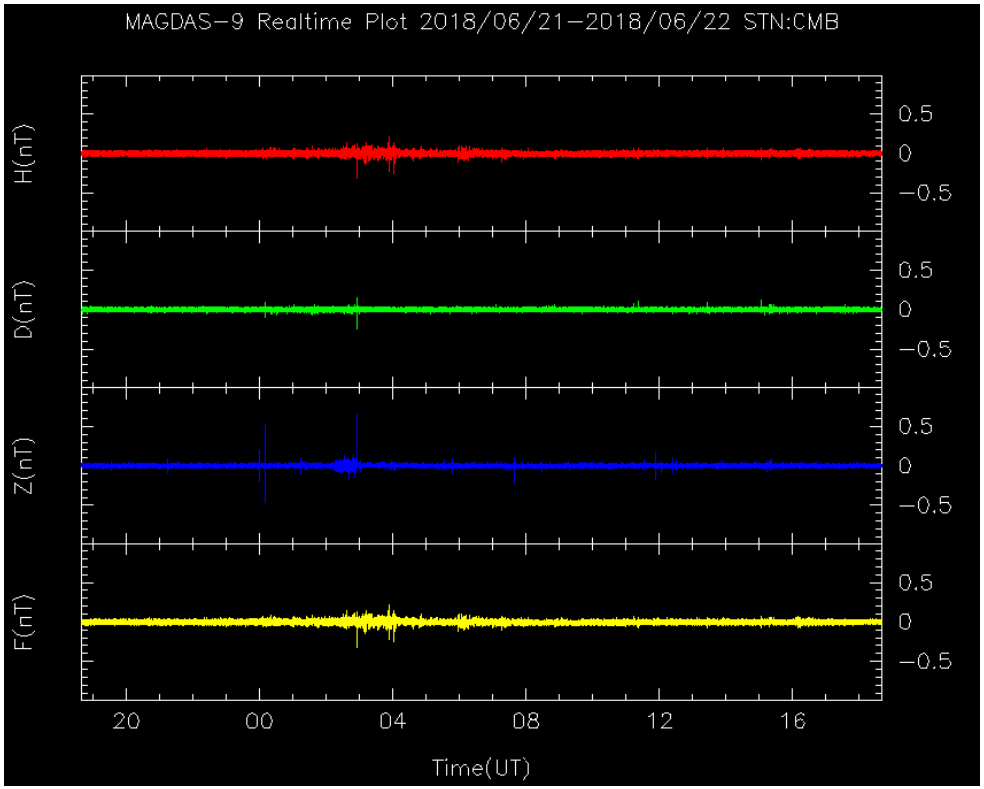
Measurements taken by MAGDAS device

Data	Content	# of bytes	Offset
Geomagnetic HX	0.01 nT unit ±70,000 nT	3	0
Geomagnetic HY	0.01 nT unit ±70,000 nT	3	3
Geomagnetic HZ	0.01 nT unit ±70,000 nT	3	6
Tilt NS IX	0.1 second unit ±900.0"	2	9
Tilt EW IY	0.1 second unit ±900.0"	2	11
Temp. of Sensors TF	0.01 ℃ unit ±60.00 ℃	2	13
Temp. of Preamp TP	0.01 ℃ unit ±60.00 ℃	2	15

RESULTS

MAGDAS device is continuously taking geomagnetic measurements and uploading to world network of MAGDAS geomagnetic database. Link to the real time status graph of Colombo station is http://magdas2.serc.kyushu-u.ac.jp/realtime/fig/mag9_CMB.png





RESULTS

Sample daily variations of H-Component

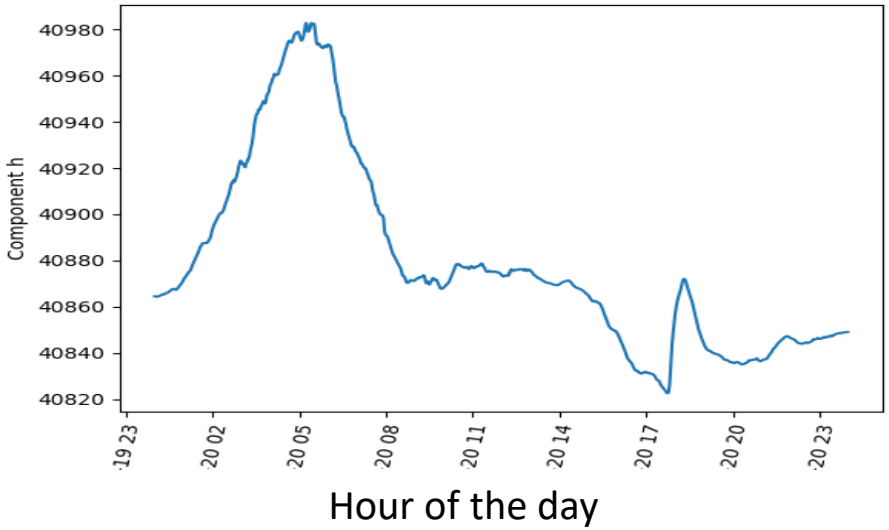


Figure 08 : Daily variation of H-Component on 2016-03-20

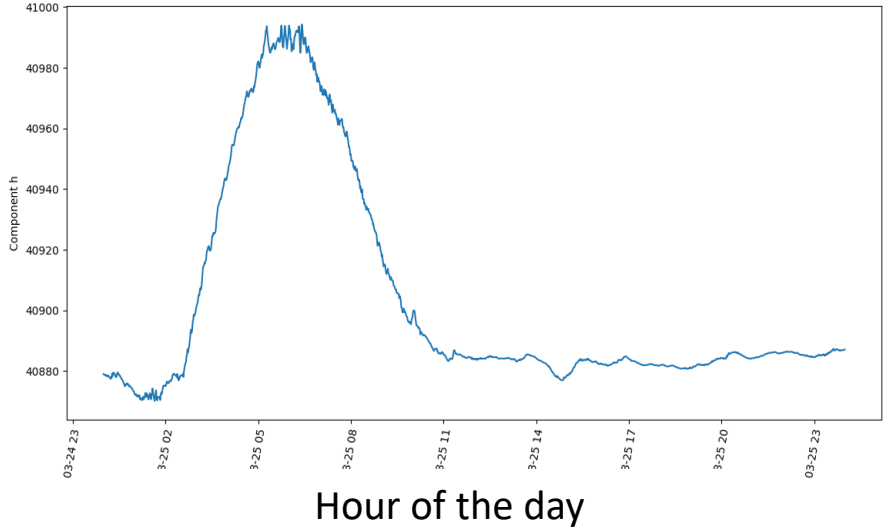


Figure 09 : Daily variation of H-Component on 2016-03-25

RESULTS

Sample monthly variations of H-Component

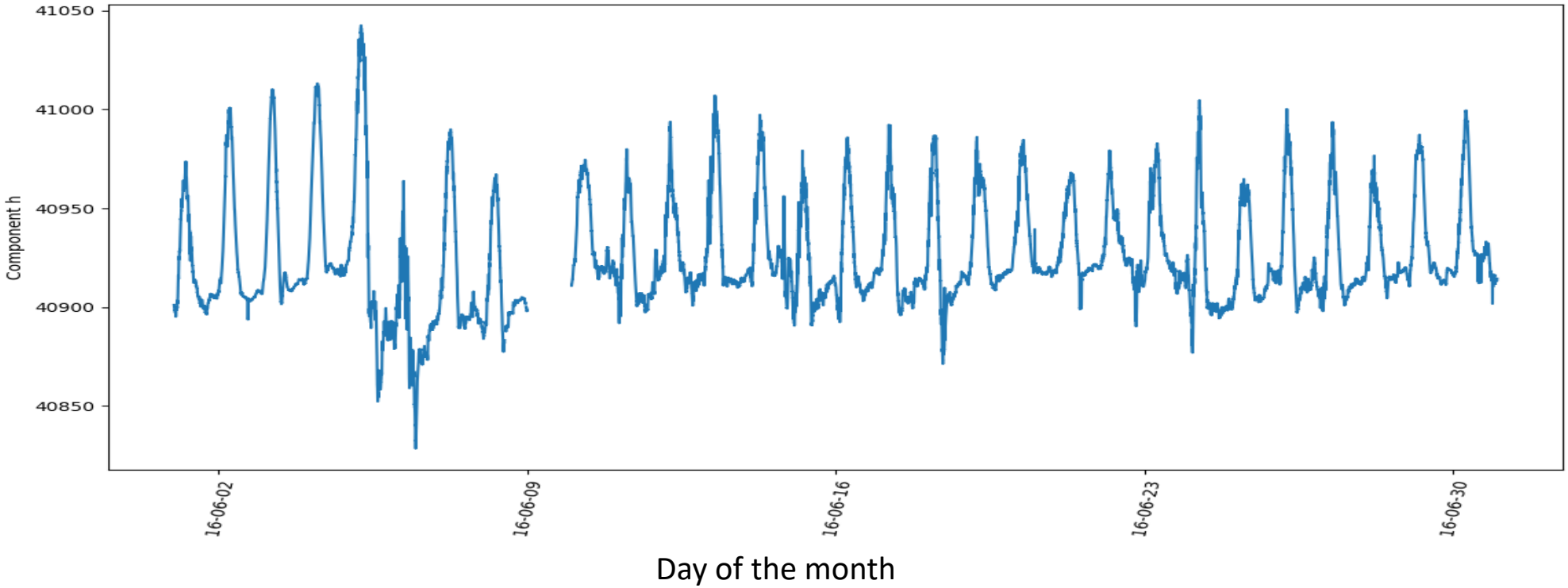


Figure 10 : Monthly variation of H-Component of geomagnetic field in 2016 June

DISCUSSIONS

Sri Lanka MAGDAS station is very close to the geomagnetic dip equator and the dip angle of the station from the dip equator is -0.34. It's expected a high variation in H-Component of the geomagnetic field around dip equator mainly due to Sq current and Equatorial Electrojet (EEJ) phenomena[3]. By looking at daily variations of geo magnetic field around Sri Lanka, we can clearly see a peak around local noon time. As expected, the peak is generated due to Sq current system and EEJ current system. There are other factors like changes in solar wind speed, changes in particle density of the solar wind, changes in interplanetary magnetic field those are causing changes in geomagnetic field.

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3. Akpaneno A.F. and Adimula I.A.,(2015), *Variability of H-Component of the Geomagnetic Field from Some Equatorial Electrojet Stations, Sun and Geosphere*, **vol 10**, no.1, p. 13-16