# THE FIRST MAGNETIC OBSERVATORY OF HONDURAS


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# COLLABORATORS

## FROM THE NATIONAL AUTONOMOUS UNIVERSITY OF HONDURAS

**Department of Astronomy and Astrophysics**
**Department of Arqueoastronomy and Cultural Astronomy**
**(Space Sciences College, FACES)**
**Department of Earth Sciences (College of Sciences)**
**Regional University Center of the Pacific Coast (CURLP)**
**Civil Engineering Laboratory (Engineering College)**

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# COLLABORATORS

## NATIONALS AND INTERNATIONALS

British Geological Survey (BGS) – ÍNDIGO team
Geoforschungszentrum (GFZ), Postdam, Germany
Reservoir International Team II – German Cooperation and Honduras National Electric Power Company (ENEE)
Centre for Earth and Space Research of the University of Coimbra
National Observatory of Brazil
UNAM Geophysical Institute
Costa Rican Electricity Institute (ICE)
Santa Helena Observatory, Costa Rica

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# WHAT DO WE WANT?

- Capture the sources of the natural magnetic field vector at the earth's surface, free of artificial interference.
- Record a continuous, broadband, absolute, long-term time series (Turbitt, 2018).
- Publish the results FOR USE IN ACADEMIC AND COMMERCIAL ENVIRONMENTS.

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# WHAT DO WE WANT?

- **The records will be published in the open database of the World Data Centre for Geomagnetism Edinburgh and in INTERMAGNET, the world's largest network of magnetic observatories, giving worldwide visibility to the science of the region.**
- **We are looking for the data to be integrated into the International Geomagnetic Reference Field Model (IGRF).**

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# WHY IS A MAGNETIC OBSERVATORY IMPORTANT?

- The data from observatories is very important to Geomagnetic research worldwide.
- As in south west Africa,... in Central America there are very few observatories providing data.
- An observatory in Honduras would greatly improve this situation and would be of great interest to the Geomagnetic Community worldwide.

# APPLICATIONS

- Determine the angle between magnetic North and geographic North for surveying, soil boring and other engineering applications.

- Evaluate the impact of geomagnetic induced currents on ENEE's main grid generators and transformers, telecommunication antennas and other technologies.

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# APPLICATIONS

- The data can also be used for a wide range of research work in geophysics, seismic risk prevention and space weather hazards.

- Elaboration of magnetic maps of a country where the magnetic zero meridian passes through.

# APPLICATIONS

- This type of research would involve UNAH in co-operating with INTERMAGNET and other internationally based geomagnetic institutes into Main-field or Space Weather investigations which will generate papers/results which would be published in prestigious research documents.

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# POSTER PREPARED WITH THE STUDENTS OF THE RESEARCH SEMINAR OF THE BACHELOR'S DEGREE IN ASTRONOMY AND ASTROPHYSICS, FOR THE FALL MEETING OF THE AMERICAN GEOPHYSICAL UNION 2021.

AGU FALL MEETING
New Orleans, LA & Online Everywhere
13–17 December 2021

## Local Geomagnetic Model for the First Magnetic Observatory of Honduras

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### Abstract

As a preliminary step to install the First Magnetic Observatory of Honduras, the local geomagnetic components were computed in Tegucigalpa, Honduras, for the temporal interval 2010 – 2013, using the Tsyganenko and Sitnov 2005 (*J. Geophys. Res.* **110**, A03208, 2005: TS05) semi-empirical magnetospheric model. Using the Chiripa Observatory (Costa Rica) $H$-component, the Sq component was obtained both using the International Quiet Days and the Normal Orthogonal Component Analysis. Pearson's correlation coefficients were calculated between the $H$-component computed with the TS05 model in the Tegucigalpa coordinates and the $H$-component of the Chiripa Observatory (CRP). The better correlations were obtained in days with Kp $< 4$, when the Sq and the quiet daily variation were removed from the CRP-$H$ data and the TSY-$H$-component respectively. Seven TS05 magnetospheric currents were obtained in order to evaluate their contribution in the Sq. The Chapman-Ferraro current is the one that fits better in the 0.00 – 12.00 local time interval, and the Birkeland currents fits better in the 12.00 – 24.00 local time interval.


### 1. Introduction

Space Weather (SWE) is about the electromagnetic perturbations and energetic particle events driven by changes in the Sun's magnetic field and solar wind (SW) and by their effects on Earth's magnetic field and upper atmosphere, that affects the Earth's space, atmosphere and surface environments (Thomson, 2012; Schrijver, 2015). SWE affects our modern way of life, some times in very dramatic ways, and its potential to impact is growing.
Geomagnetic storms consist of disturbances of the magnetic field of our planet, having a minimum duration of several hours and a maximum duration of several days. The amplitudes with which storms are observed in different locations are greater the higher the latitudes and mainly affect electrical systems, satellites, high-altitude aircraft and radio communications.
Magnetic observatories provide local measurements of space weather conditions and free data centres provide near-real-time magnetic data from many observatories (i.e., INTERMAGNET, World Data Centres for Geomagnetism of Kyoto and Edinburgh), valuable for analysis of global and regional space weather activity. Different products offered by them are helpful to use with models that simulate or predict impact on the environment and technologies (Thomson, 2012). We consider that since there is no magnetic observatory in Honduras and therefore data for ionospheric, magnetospheric and terrestrial core currents in Tegucigalpa, the TS05 model is suitable because it includes fundamental processes in the magnetosphere (terrestrial and satellite data) such as charge exchange, energy inputs and outputs of geomagnetic storms and thus compared with reference data from the closest magnetic observatory of the region, Chiripa.
The computing of TEG-$H_{TSY}$-component is the basis for the design and creation of a magnetic observatory in Honduras, to introduce and carry out future work in the fields of space weather and geophysical research and implementation.


### 2. Computing the TEG-$H_{TSY}$-component


### 5. Pearson's Cross-correlations

CRP-$H$ time series were compared with the corresponding TEG-$H_{TSY}$ using the Pearson correlation coefficients $r$ with p-values $\leq 0.05$.

$$r(A,B) = \frac{cov(A,B)}{\sigma_A \sigma_B}$$

Where cov(A,B) is the covariance between CRP-$H$ and TEG-$H_{TSY}$, $\sigma_A$ and $\sigma_B$ are the corresponding standard deviations.
As can be seen in Figure 5, better correlations were obtained when both the Sq in CRP-$H$ and the QDV in TEG-$H_{TSY}$ were removed (right panel).

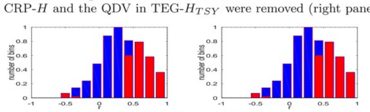



*Figure 5: Left: r between CRP-H and TEG-$H_{TSY}$. Right: r between CRP-H-wo-Sq and TEG-$H_{TSY}$-wo-QD. In both, blue bars are the counts with p-value $> 0.05$. Red bars are the counts for p-value $\leq 0.05$.*

### 6. t-Welch test

The Levenberg-Marquardt algorithm was used to fit correlations to Gaussians (z-Fisher transformation). In the t-Welch test, the correlations of raw data are compared with the corrected correlations. Figure 6 shows the resulting values of the t-Welch test comparing CRP-$H$ vs. TEG-$H_{TSY}$ with CRP-$H$-wo-Sq (removing Sq signal) vs. TEG-$H_{TSY}$-wo-QD (removing quietest days signal) in days with Kp $< 4$ (z-Fisher mean $= 0.56$). For active days, when the diurnal variation is subtracted, there is not a significant change when we compare the same correlations (see Figure 7), because these are large values and just a small value of diurnal variation is subtracted (z-Fisher mean $=$ 0.55).

### 2. Computing the TEG-$H_{TSY}$-component

The $X$-, $Y$- and $Z$-components of the International Geomagnetic Reference Field (IGRF) were computed using the Geopack-2008 code from Nicolai Tsyganenko. The same Cartesian components were computed for the magnetosphere, using the Tsyganenko and Sitnov's TS04 code. From these components we obtained the sum of IGRF's $H$-component plus magnetosphere's $H$-component, formally named TEG-$H_{TSY}$. Figure 1 shows these series versus Chiripa Observatory data (CRP-$H$) for the time interval 2010 – 2013.

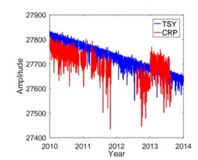



*Figure 1: TEG-$H_{TSY}$ values (blue) versus CRP-H data (red) obtained from World Data Centre for Geomagnetism, Edinburgh.*

### 3. Sq Variation

The Sq variations that are measured on the Earth's surface contain both ionospheric currents and secondary currents induced inside the Earth. Several studies have shown that these Sq variations could be contaminated by the effect of various magnetospheric currents (see Yamazaki and Maute, 2017).

The Sq-$H$ was computed in two ways: a) using the International Quietest Days (IQD) data of the CRP observatory for the 2010 – 2013 interval; b) applying the Singular Value Decomposition Analysis to the CRP-IQD data and selecting a model with 2 modes (Castillo et al, 2017):

$$\mathbf{Q} = \mathbf{USV^T}, \text{ where :}$$

$\mathbf{Q}$ is the data matrix of quietest days, with size 240 x 24; $\mathbf{U}$ is a matrix 240 x 240, with the normalized eigenvectors of the matrix $\mathbf{QxQ^T}$; $\mathbf{V}$ is a matrix 24 x 24, with the normalized eigenvectors of the matrix $\mathbf{Q^TxQ}$; $\mathbf{S}$ is a matrix 240 x 24 matrix, with 24 singular values of $\mathbf{Q}$.

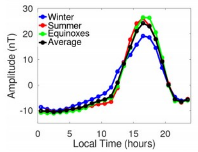



*Figure 2: Lloyd's seasons plots represent the mean of the quietest days data of Chiripa in Winter (blue), Summer (red), and equinoxes (green). Black plot is the annual average.*

### 4. Magnetospheric Currents

Seven magnetospheric currents were computed with the TS05 model, in order to measure their contribution to the Sq daily variation. Using the IQD, the corresponding quiet daily variation (QDV) were calculated for each current.

These quiet-days currents were projected into the NOC-Sq model of Chiripa (CRP-NOC-Sq-$H$). The Chapman-Ferraro current is the one that fits better with the midnight-noon QDV (Figure 3). The Birkeland currents QDV fits with the noon-midnight Sq (Figure 4).

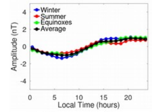



*Figure 3: Chapman-Ferraro Lloyd's plot.*

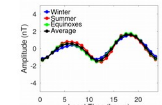



*Figure 4: Birkeland Lloyd's plot.*

compare the same correlations (see Figure 7), because these are large values and just a small value of diurnal variation is subtracted (z-Fisher mean $=$ 0.55).

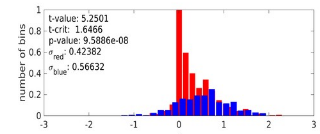
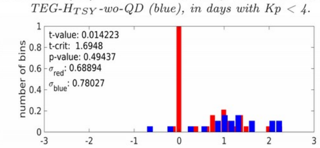



*Figure 6 : t-test results between the Fisher's distribution of CRP-H versus TEG-$H_{TSY}$ (red) and the corresponding CRP-H-wo-Sq versus TEG-$H_{TSY}$-wo-QD (blue), in days with Kp $< 4$.*




*t-test results between the Fisher's distribution of CRP-H versus TEG-$H_{TSY}$ (red) and the corresponding CRP-H-wo-Sq versus TEG-$H_{TSY}$-wo-QD (blue), in days with Kp $\geq 4$.*

### 8. Conclusions

- In days with Kp $< 4$ the correlations improve when the Sq and the QDV are removed from data and the model respectively. We consider that this is because TEG-$H_{TSY}$ do not include the ionospheric neither the crustal field.
- In days with Kp $\geq 4$, the correlations do not improve when we remove the Sq neither the QDV. We conclude that this is because both the Sq and the QDV are small compared with the storm-time values.
- The projection of magnetospheric currents into the NOC-Sq model shows that Birkeland currents are the ones that fit better in the noon-midnight time interval. Similarly, the Chapman-Ferraro currents are the ones that fit better in the midnight-noon interval (see Figures 3 and 4).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*poster layout adapted from* **www.microwave.fr**

# Aquaculture and fisheries research center
# Regional University Center of the Pacific Coast


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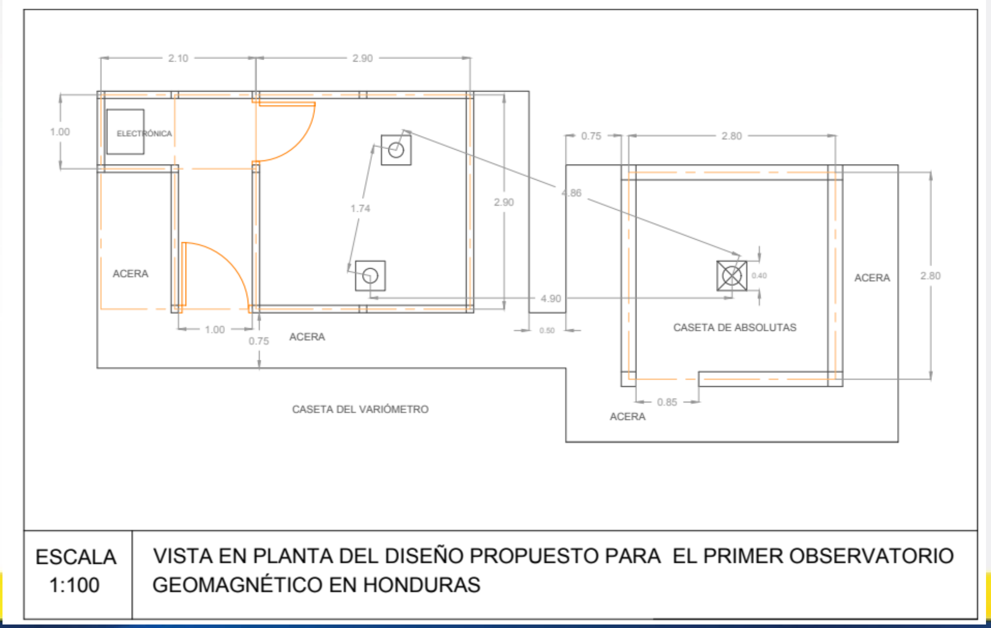
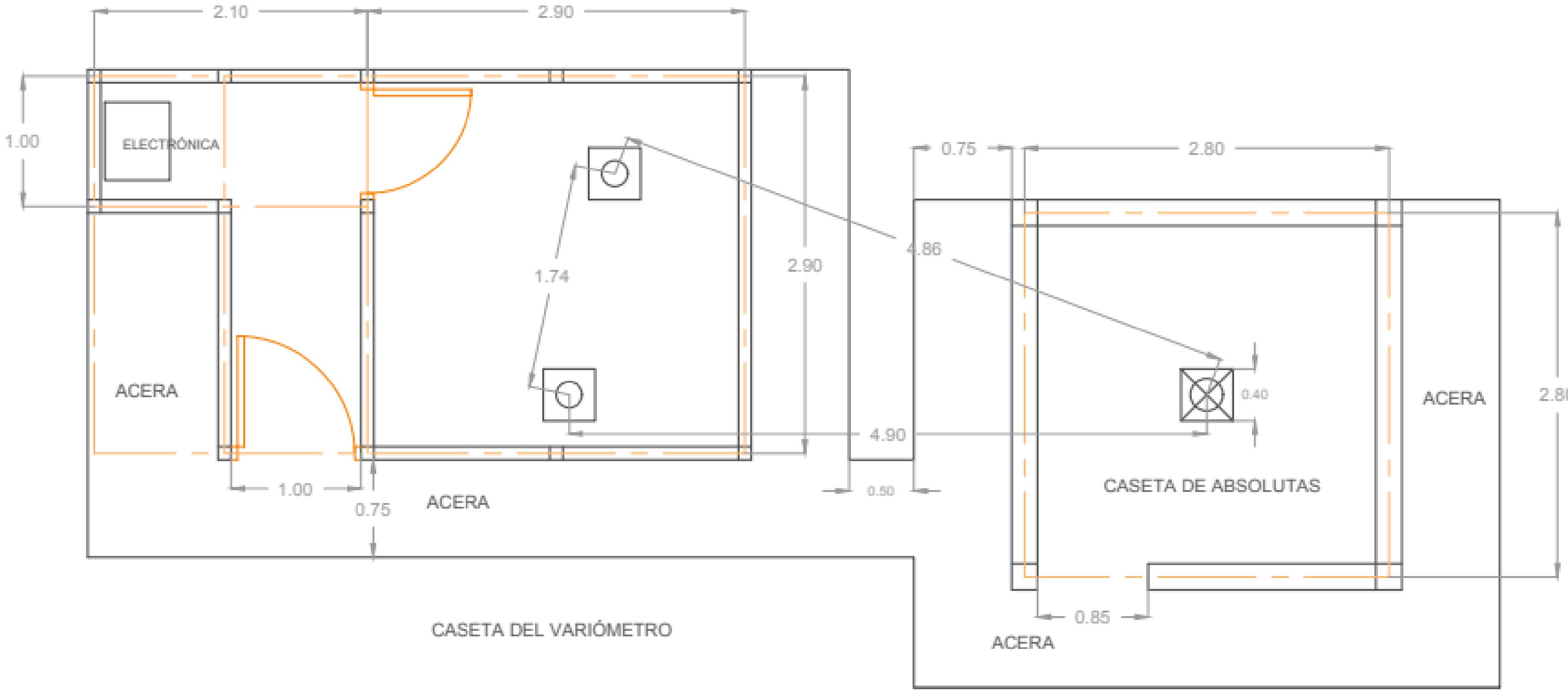
**The equipment to be donated by the British Geological Survey has a market value of**

# US$ 200,000.

**What we need is the funding to build two huts to house the equipment.**

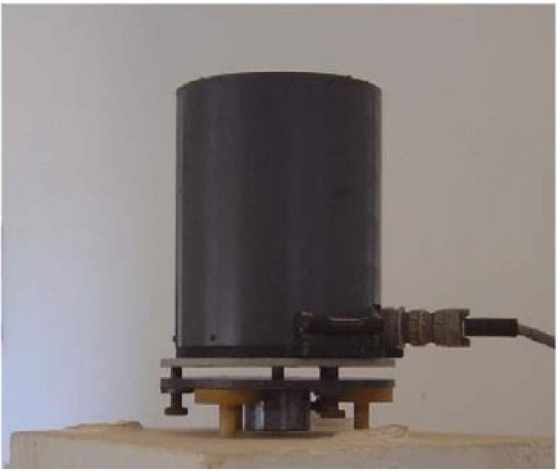





| SCALE 1:100 | PLAN VIEW OF THE PROPOSED DESIGN FOR THE FIRST MAGNETIC OBSERVATORY OF HONDURAS |
|---|---|

# EQUIPMENT INSIDE THE 4 x 3 m HUT

- Proton magnetometer.
- Triaxial fluxgate magnetometer.
- Server.
- Raspberri Pi.

# EQUIPMENT INSIDE THE 3 x 3 m HUT

Theodolite with magnetometer. Fluxgate magnetometer and theodolite on concrete pillar, isolated from the ground.

# THE INDIGO PROJECT

- INDIGO project (Riddick et al., 2009) aims to provide the means for achieving observatories goals where there are gaps in the observatories world map, directing its efforts to Asia, Africa and Latin-America.
- Equipment, software, training, and data processing, when missing on site, are given to collaborators worldwide so that they might improve or start their own geomagnetic observations (Borodin et al., 2011).

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# THE INDIGO PROJECT

- If necessary, local staff are trained in observatory operations and observing skills (we are currently hosting a tutorial with Christopher Turbitt).

- With the help of the INDIGO project, most common problems can be overcome.

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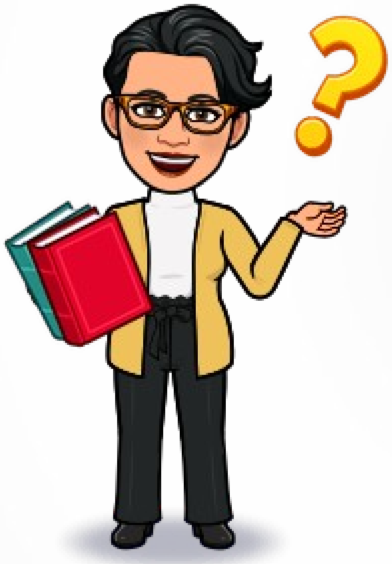
- Turbitt, C., 2018. Data Processing. IAGA-Workshop 2018 Summer School. Conrad Observatory, Austria.

¿Alguna pregunta?



¡GRACIAS!

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