Astronomical site testing and characterization of the Guadalupe Island, Mexico

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Abstract. We present an ongoing campaign for astronomical site testing and characterization at the Guadalupe Island at the Northern Pacific Coast of Mexico. Characterization at optical and radio wavelengths are been carried out at the site to evaluate its potential for astronomical observatories at these wavelengths.

1. Introduction

Guadalupe Island is a Mexican biosphere reserve located in the Pacific Ocean (lat: 28° 58' 24" N, long: 118° 18' 4" W) at a distance of 241 kilometers West of the Baja California peninsula between a latitude of 28° 50' and 29° 12' N and a longitude between 118° 13' and 118° 22' W. Figure 1 shows the location of the island. Its length in the North-South direction is about 35 kilometers, and its maximum width is about 12 kilometers with a total surface of 244 km² [1].

The island has a volcanic origen. Two collapsed craters form the island: at the South, the highest point is Monte Picacho (975 m) and the other one at the North named Monte Augusta with 1,297 m. Guadalupe Island has two different kinds of climate: (1) between 0 and 800 meters it has a semi-warm to very arid climate with annual median temperature of 16°C and (2) over the 800 meters the wheatear is templated during the coldest month of Winter with temperatures between 3 and 18°C and hot and dry during the Summer with an average temperature of 22°C. Frequently, the marine layer rises up to a maximum high of 800 meters over the sea level.

The ecology of the island was severally damage by the introduction of non native animals brought by the first people to arrive to the island during the XVII and XVIII centuries. Cats, dogs and goats brought a lot of destruction to native plants and birds. Starting in 2002, the Grupo de Ecología y Conservación de las Islas (GECI) and other government agencies, started the first actions to preserve the ecology of the island. On April 2006, Guadalupe Island was declared a Biosphere Reserve by the Mexican Government to promote is preservation [2][5].

There has been several reports that Monte Augusta may be an excellent site for astronomical observations. During the 1960s Guadalupe Island was visited by Dr. Eugenio Mendoza from the Institute of Astronomy of National Autonomous University of Mexico (UNAM), in his search to find a new place for the Mexican Optical Astronomical Observatory at that time located in central Mexico and being very affected by light pollution and poor astronomical weather.
This was the search that ended locating the Observatory at the San Pedro Martir sierra at the Baja California peninsula. The GECI has a biological station near Monte August since twelve years ago and its personnel have collected meteorological data and qualitative observations of astronomical quality of the site. It is claimed that the island has a very high quality, dark & transparent sky with about 240 clear nights per year (65.8 % of the nights) [3].

Since the last year a group of astronomers from Mexico and other countries started a program to quantify the astronomical quality of the site near Monte August at the Guadalupe Island at optical and radio wavelengths. In this paper we present the site survey planned and carried out at the island.

2. Optical Testing
Technical staff at the Institute of Astronomy UNAM has developed and tested a robotic site testing system to assert the astronomical quality of the site near the summit Monte August at the Guadalupe Island. The heart of the system is a robotic Double Image Movement Monitor (DIMM) [4]. Figure 2 shows an schematic of the system developed, it consists of:

- Robotic DIMM and protection dome
- All-sky camera
- Weather station
- Web cameras.

The site survey equipment will located close to the biological station of the GECI near the summit of Monte August. In that way it will be possible to the personnel from GECI to made
some easy tasks. Data from all the periferical equipment will SE collected at a central computer and it will be sent thru a satellite Internet connection. Power the whole system will be provide by a set of batteries that will be charged by solar panels. The whole system was proved at the San Pedro Martir National Observatory with excellent results.

3. Radio frequency testing

As a part of the experiment “Sonda Cosmológica de las Islas para la Detección de Hidrogeno Neurto” (SCI-HI) to measure the all–sky–averaged 21 cm brightness temperature in the redshift range of $14.8 < z < 22.7$ the radio noise in the band from 0–250 MHz at the Guadalupe Island was measured in 2013 using a single antenna and a sampling receiver [6].

The antenna, called HIlbiscus, is shown at Figure 3 deployed at the Guadalupe Island. The antenna is fixed an points to the zenith. It has a 55° beam at 70 MHz with roughly frequency independent shape on an octave of frequency [6]. Detail description will be found in J.M. Jáuregui García et al. [7].

A block diagram of the instrument is shown in Figure 4. Signal from the antenna passes through a series of amplifiers and filters to remove radio frequency interference (RFI) below 30 MHz and aliasing signals above 200 MHz. Besides the signal from the antenna, a multi-port electro–mechanical switch controlled by a computer allows collection of calibration spectra from terminators of 50Ω, 100Ω, and a short of known temperature. The signal is sampled at 500 MSamples s$^{-1}$ with 12 bits resolution by a GE PCIe digitizer board (ICS1650) and a PC with software for power spectrum generation from 0–250 MHz. The system is placed inside a
Faraday cage about 50 m away from the antenna. The entire system is designed to run off 12 VDC batteries, allowing the system to be portable and easy to set up in remote locations [6].

The major noise contribution in the 40–130 MHz frequency band is RFI by TV and FM radio broadcasting. Even at NRAO quiet zone in Green Bank, West Virginia, the FM radio signals exceed the sky signal by 10 dB over the entire band of 88–108 MHz. At Guadalupe Island, it is still detected some RFI from mainland although the residual FM radio signal is only about 0.1 dB above the Galactic foreground and there are no other strong RFI signals in the used band [6].

Preliminary radio frequency testing at 1.4 GHz at Guadalupe Island were completed in 2013 June. The data was cleaned to excise channels contaminated by radio frequency interference, and the system response was calibrated by comparing the measured brightness temperature to the Global Sky Model of the Galaxy and by independent measurements of Johnson noise from a calibration terminators.

**Figure 3.** Hibiscus antenna deployed at Guadalupe Island, Mexico [6].

**Figure 4.** System block diagram [6].

4. Conclusions
An ongoing site survey campaign to assert the astronomical quality of Monte Augusta, at Guadalupe Island, Mexico, is being carried at optical and radio wavelengths. Since 1960 its as been known that this is a potential site for optical astronomy. A quantitative evaluation of the site has been asserted by the personnel of a biological station located at the site. A quantitative evaluation of the optical characteristic will be carried out by astronomers of UNAM. At radio wavelengths, Guadalupe Island has proven to be one of radio quiets sites a frequencies 40–130 MHz making it one a potential site for the radio survey of neutral hydrogen whit redshift range of $14.8 < z < 22.7$.

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