3rd School on Cosmic Rays and Astrophysics
August 25 - September 05, Arequipa – Perú.

Preliminary SEEING Measurements on Sasahuine Mountain

Erick Meza[1,2], Patricio Becerra[1], Jorge Samanes[1,3] and Gabriel Ferrero[1,4].

(1) Comisión Nacional de Investigación y Desarrollo Aeroespacial – CONIDA, Lima – Perú.

(2) Universidad Nacional de Ingeniería, Lima – Perú.

(3) Universidad Nacional del Callao, Lima – Perú.

(4) Universidad Nacional de la Plata, Buenos Aires – Argentina.

Abstract

We present and discuss the results of the first measurements of SEEING at Sasahuine Mountain, in the Southern Peruvian Andes. This data has been obtained from several observation missions that took place between 2006 and 2008. The objective of these missions was to characterize the sky at Sasahuine Mountain and develop a statistical analysis of seeing conditions here, in order for the site to be considered as a potential candidate for the construction of an astronomical observatory. The observations were made using an SBIG ST-7MX CCD camera with a UBVRI filter wheel, attached to a MEADE LX200 35mm telescope. The data reduction was done using IRAF.

Introduction

"Seeing" is the astronomical term for the extent of resolution degradation of an image caused by the Earth's atmospheric turbulence. This degradation in image quality results from fluctuations in the refractive index of air as a function of position above the site.

"Seeing" is often the limiting factor in the quality of astronomical observations at a given site. For this reason CONIDA conducted a search for sites that might be good candidates for astronomical observation, based on meteorological information from 40 years of data from the International Satellite Land-Surface Climatology Project (ISLCP)(fig. 1). It was found that the Andes of Moquegua, in Southern Peru, had the best conditions within the country.

Based on this initial search, CONIDA decided to send astronomical observation missions to the site, to evaluate the quality of the sky there. The first missions used modest 6' telescopes and photographic film. However, in 2006, the astronomy activity at CONIDA acquired a CCD camera and a 35mm telescope. This new equipment has since been used to measure the quality of the sky (especially seeing conditions) at one of the highest points at the site.

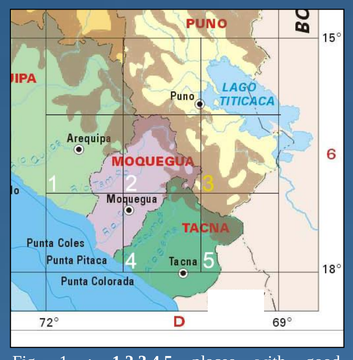

Fig. 1 : **1,2,3,4,5** places with good meteorological conditions for potential astronomical observatory.

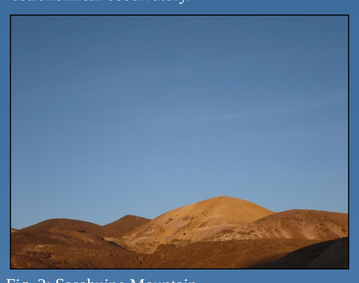

Fig. 2: Sasahuine Mountain

The Site

Sasahuine mountain (fig. 2) is located in the Andes of Moquegua, in Southern Peru, at an altitude between 4300 and 4600 meters above sea level. Due to the difficulty of access and the lack of roads to the top of the mountain we used four different observing points in the various observation missions:

Point 1 : Located 200 meters from Sasahuine mountain, at 4300 m.a.s.l. The first extinction coefficient measurements using photographic plates were done here.

Point 2 : Located at an altitude of 4341 m.a.s.l. on Sasahuine mountain. The first seeing measurements using a CCD camera and the 14' telescope were done here.

Point 3 : Located at 4336 m.a.s.l. on the west/east/south/north skirt of Sasahuine. This point was used due to the flat terrain found here from an abandoned construction camp. It also had the benefit of a road that led directly to the point.

Point 4 : Located at an altitude of 4551 m.a.s.l. The last few seeing measurements were performed here. The point was reached using provisional access. It has the advantage of higher altitude.

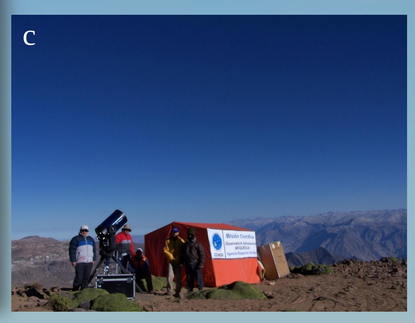

Fig. 3 : **a) Points in Sasahuine Mountain**
b) Point 4
c) Equipment and observers at point 4

Equipment and Observations

All observations were made at or around Sasahuine Mountain at one of the points mentioned above. An ST7-MX SBIG CCD camera was used, with a UBVRI filter wheel. This system was attached to a Meade 35 mm/ 14 inch LX200 telescope with Ritchey-Chretien optical design. The CCD chip was refrigerated to approximately -20C.

Images were taken for either a single star or a star cluster during one or two nights of observation per mission. Seeing measurements were made at 2 to 3 hour intervals, provided that cloud coverage and moonlight allowed imaging.

An observation hour was assessed as photometric if the following conditions were fulfilled:

-Relative humidity less than 60%.

-Average wind speed less than 5m/s.

The wind was sometimes a problem, as we did not have a proper shelter to observe under. Also, the fact that the Alt/Azimuth mount on our telescope does not permit observations at zenith distances under 30deg, prohibited us from obtaining measurements at higher air masses.

Data Processing

The processing and analysis of the images was done in both Unix and Linux operating systems using the IRAF environment.

The first steps were the mandatory image corrections from bias, dark frames and flat fields. Next, aperture photometry was performed on each of the stars imaged (single stars such as Achernar or open clusters such as the Jewel Box cluster), using the IRAF phot task. The output from this task provided us with instrumental magnitudes and FWHM values for each star, in each image, of each filter.

In order to obtain the final seeing measurements in seconds of arc, the air mass for each star in each image in each filter was needed. To find it, the IRAF task astcalc was used, with a script whose job was to read an input table containing the necessary parameters (image name, star coordinates, date and time of observation and exposure time), and calculate the air mass based on these parameters. Once the airmass was calculated, the final seeing value for each star was calculated according to the following formula, which accounts for air mass correction and pixel resolution:

$$SEEING=[FWHM/(airmass^{0.6})]*0.49$$

Where FWHM is the full width at half maximum value obtained from radprof, and there is 0.49 seconds of arc per pixel.

Seeing Results

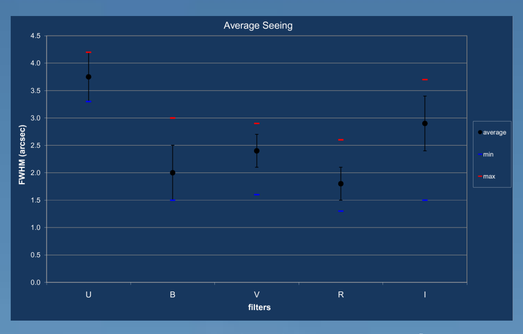

Fig. 4 : **Average seeing in august 22th - 2006**

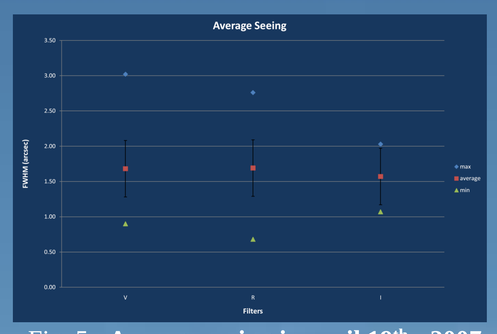

Fig. 5 : **Average seeing in april 19th - 2007**

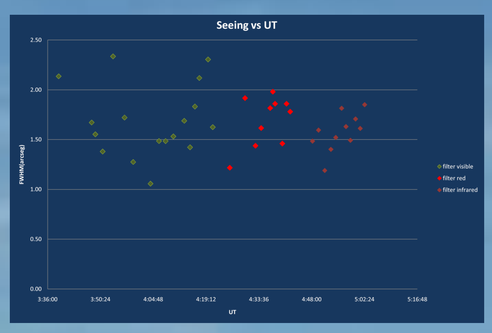

Fig. 5 : **Seeing during the night in april 19th - 2007**

The measurements of FWHM that characterize each radial profile for each star in each image in each filter were found to have mean values of 2.3" for the night of august 22nd, 2006 and of 1.68" for the night of april 19th, 2007. These values are affected at exposure times higher than one second by the slight loss of focus on the images due to tracking errors.

Due to the fact that seeing is a random value that depends on many meteorological factors, more and more continuous measurements are needed, under photometric skies, to better characterize the seeing conditions at the site.

Despite the various errors present, the seeing values for the last few observation missions were around 1" to 2". This indicates that with equipment less sensitive to tracking errors and with proper infrastructure, excellent seeing values are possible at this site.

* Observational data from two missions in this year are in process.

Next Steps

- Observe at more air masses in order to obtain complete characterization of observing conditions at the site.
- Thanks to the construction of new facilities at the site by CONIDA, we can hope for more continuous observation, and in turn, better seeing statistics.
- Install a permanent weather station at the site, to develop a statistical chart of parameters like humidity, temperature, wind speed, etc.

References

[1] G. Ferrero, 2007, Búsqueda de Sitios Astronómicos en Perú. Conferencia en la Universidad Nacional de la Plata – Aregentina.

[2] A. Pereyra and N. Baella, 2003, Medidas de SEEING en el Observatorio de Huancayo, REVCIUNI Volumen 7, numero 1 , pag 103 – 114.

Background Image: Baúl Mountain (Moquegua – Perú)

Comisión Nacional de Investigación y Desarrollo Aeroespacial