

Scientific Potential for Astronomy and Astrophysics of the Southern Andean Peruvian Regions

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The construction of new astrophysical observatories in South America are envisaged for the following years, for example, CTA and SWGO. In this context, we introduce the southern Andean region of Peru, known as the Altiplano (high ground). In this region there are high-altitude plateaus and lagoons with the potential to harbor an observatory dedicated to study high-energy gamma rays from the ground. In this paper we present some candidate sites located near the Peruvian Astronomical Observatory of Moquegua (IAU MPC Code W73). We report their relevant characteristics such as accessibility, internet availability and general weather conditions. We will also discuss the availability of the Peruvian Astronomical Observatory to contribute with local multi-wavelength follow-up campaigns in connection with future astronomical/astrophysical facilities.

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1. Introduction

A new Astrophysical observatory should be built on the best available site, in order to obtain the maximum use of its science potential. Site selection must be based on technical aspects, like site accessibility, communication and access to an adequate supply chain. The election of a suitable site is a very challenging task [1]. Currently operating major high observatories for gamma astrophysics are: HAWC, at an altitude of 4,100 m.a.s.l. in Mexico [2] and LHAASO, located at an altitude of 4,410 m.a.s.l. in China [3]. At the moment, the SWGO collaboration and LHAASO are looking for a site in the southern hemisphere in order to have more complete observation of the sky [4]. In that context, we introduce three sites with the potential to allocate an astrophysical observatory in the southern Andean Peruvian region. A new approach for the construction of this type of observatory is the use of an existing body of water (lagoons or reservoirs) to locate Cherenkov water detectors within them, reducing construction costs. Here we present sites that can serve this purpose.

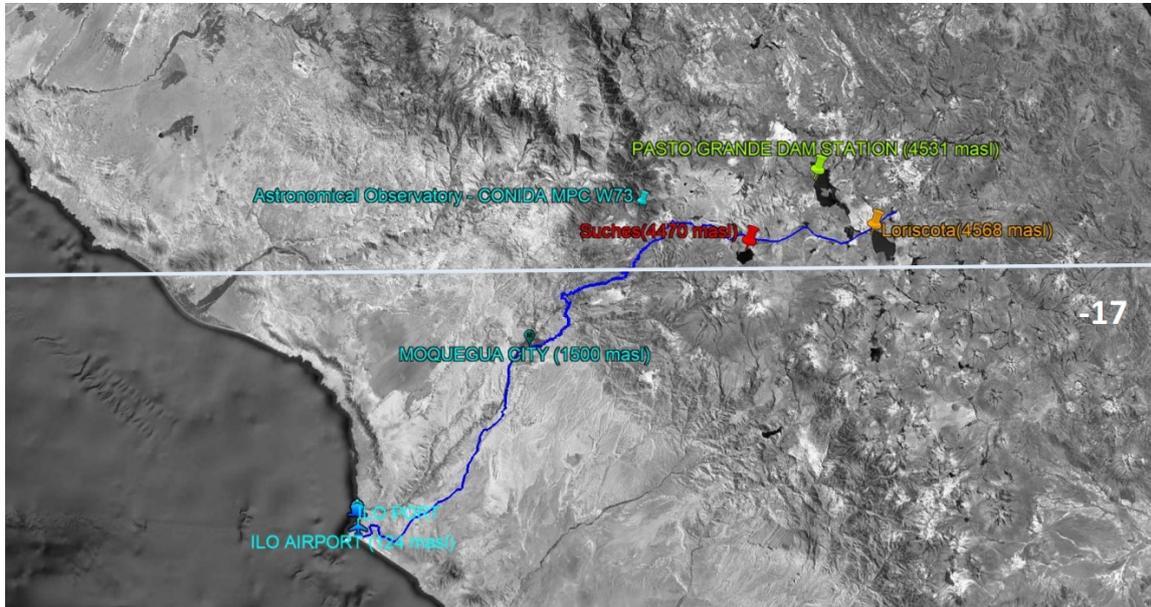


Figure 1: Geographical map of the potential sites: Pasto Grande Dam, Suches and Loriscota, with near flat areas available. The map also shows Moquegua, the nearest big city, Moquegua Astronomical Observatory and the good road (36A) which connect Ilo port and airport with the three potential sites.

2. Potential sites

Two potential sites are being studied near at the Astronomical Observatory of Moquegua. One sites is Pasto Grande dam, which is located in the Moquegua region, and the other one is Suches lagoon. The nearby Loriscota lagoon is the third option, but it has a biological richness, and it could be very difficult to build some facilities around there. The Fig.1 show location of these sites, the Binational Road (36A), the Moquegua Astronomical Observatory (IAU MPC Code: W73) and the nearest airport and seaport in Ilo. The Moquegua Astronomical Observatory is located in the Moquegua Region, at latitude $16^{\circ}49'41.36''S$, longitude $70^{\circ}40'42.43''O$ and altitude 3308 m.a.s.l.

The research carried out at this facility focuses on small bodies of the solar system [5], but the Observatory may well become a complementary optical observational node in a network of other possible and future observatories.

Pasto Grande dam This first site is located at latitude $16^{\circ}43'22.4''S$, longitude $70^{\circ}13'46.9''O$ and altitude 4531 m.a.s.l., in the Moquegua Region (Fig. 1). The Pasto Grande dam is part of a large-scale and long-term project that seeks to satisfy the urgent water needs of the local population, properly managing its use for irrigation or future electricity generation.

Suches Lagoon This site is in the Tacna Region, at latitude $16^{\circ}54'51.81''S$, longitude $70^{\circ}23'39.20''O$, and altitude 4470 m.a.s.l.. The water from this lagoon is used for the mining activities of Toquepala (Tacna) and Cuajone (Moquegua) mines.

3. Sites Features

3.1 Accessibility

As indicated earlier, the proposed sites briefly described above are located near to the Binational Road (blue line in Fig. 2). For example, the distance to the Pasto Grande Dam is about 5 km (red line in Fig. 2) and the Suches Lagoon is about 17 km (green line in Fig. 2). The Binational Road, which links Peru with Bolivia, can certainly facilitate logistical operations of any kind project. In Peru it crosses Panamericana road giving access to the nearby Ilo port and Callao, Peru’s principal port. The Road even goes as far as Brazil, so a connection to the Atlantic Ocean can be established as well. The Road is very well preserved and receives continuously maintenance.

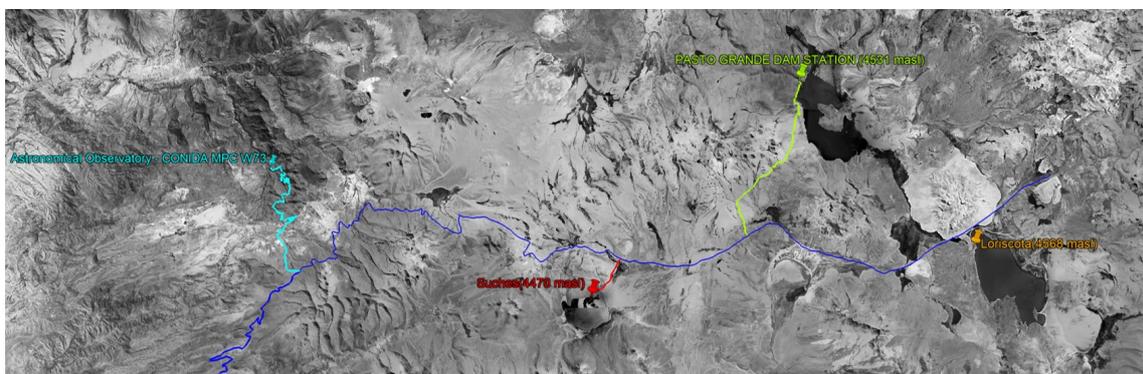


Figure 2: The sites are located very near of the main road(blue), just by the side of the Binational Road (Peru-Bolivia). There are for example 5 km (red) and 17 km (green) from the main road to the Pasto Grande Dam and Suches lagoon, respectively.

3.2 Physical Characteristics

For this paper Pasto Grande Special Regional Project has provide us with bathymetric data (Fig.3) and meteorological data (Fig.4). All of these graphs (Fig.4) utilize meteorological information from the 2017-2021 timeframe, which has been condensed into a single year, taking into account the inherent annual climatic patterns. As a result, we are able to observe monthly fluctuations aligned with the progression of seasons in this southern hemisphere region., as an example.



Figure 3: We have bathymetric as well as meteorological data. Adjacent to the sites, there exist expanses of level terrain.

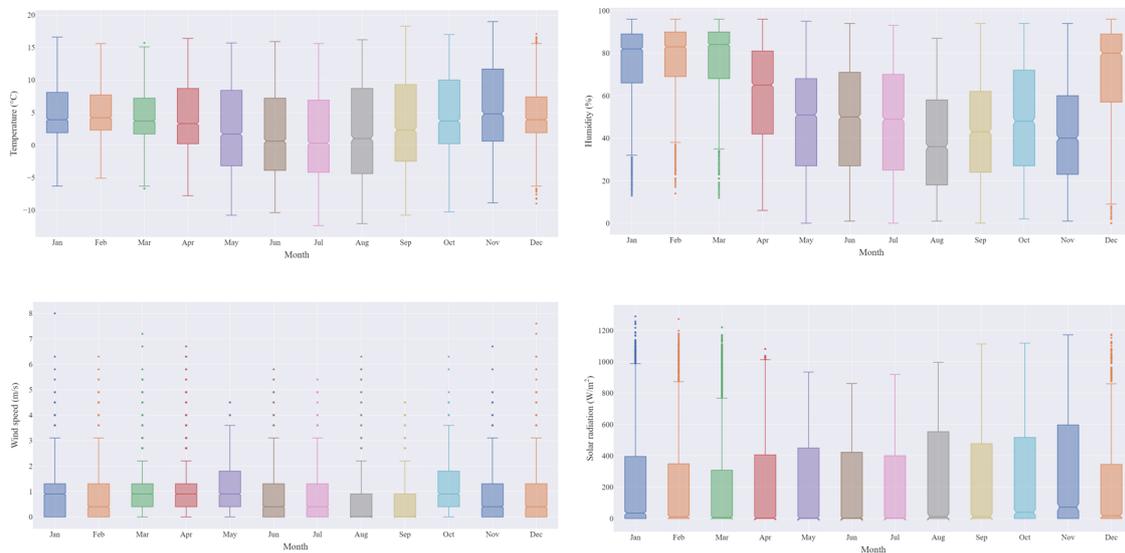


Figure 4: An example of the meteorological data thanks to agreement with Pasto Grande.

3.3 Water

Pasto Grande dam has a spillway to discharge an excess of rain water. Water available is used for local people's agricultural purposes. That will be available for the case of ground-tanks, ponds or mixed technologies.

3.4 Power and Internet

Currently, neither electrical power nor internet is available. However, there is a power transmission line (blue line in Fig. 2) at 20 km and optical fiber lines are available on the Binational Road.

3.5 Local Support and Environment

An important aspect is that all these potential sites are outside both regional and national protected natural regions. Also through Peruvian Laws local universities, such as near Moquegua National University can finance projects with budget that comes from direct mining taxes, also the have importation taxes release for science projects. There is also good relationship with local communities living near of these sites. Huaytire´s town, for example, provides navigation training on the Suches lagoon.

4. Outreach

The Peruvian Moquegua Astronomical Observatory (IAU MPC Code W73) is Peruvian Space Agency's hub for coordinating its public outreach activities around Peruvians regions. One of the missions of the Observatory is to engage the public in astronomy and astrophysics through access to family-oriented educational activities with high levels of satisfaction. Fig.5 shows some of the outreach activities made in the Moquegua region. The Moquegua Regional Government has demonstrated significant enthusiasm for promoting the growth of astronomical tourism within the region. As an example, they have formalized a cooperative agreement with CONIDA and emphasized the paramount significance of the Moquegua Astronomical Observatory in these initiatives.



Figure 5: The 2022 International Day of Astronomy was celebrated in Moquegua, and the regional government declared astro tourism as a regional interest.

5. Outlook

We possess bathymetric and meteorological data for the Pasto Grande dam. However, it might be necessary to acquire more precise data, encompassing associated studies in this context. Nevertheless, with respect to Suches lagoon, no accessible information is currently available. Hence, in this case, it would be essential to undertake primary efforts to establish such data.

6. Conclusion

There is good potential for the development of high-energy cosmic gamma astronomy in the Andean region of Peru. It could promote international collaboration for the development of astrophysics and astronomy and improve the quality of life of people in this region.

7. Acknowledgments

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