Site characterization studies for the Iranian National Observatory

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ABSTRACT

We report on the Iranian National Observatory (INO) ongoing site characterization studies for INO 3.4m optical telescope under development. Iran benefits from high altitude mountains and a relatively dry climate, thus offer many suitable sites for optical observations. The site selection (2001-2007) studies resulted in two promising sites in central Iran, one of which will host the 3.4m telescope. The studies between 2008 and 2010 aimed at detail characterization of the two sites. This involved measurements of a number of parameters including the wind speed and wind direction, astronomical seeing, sky brightness and microthermal variations.

1. INTRODUCTION

The present research and training capabilities in observational astronomy in Iran can, by no mean, respond to the growing demand due to the rapid growth in higher education over the past decade. The existing observational facilities consists of a number of small telescopes in various university campus observatories generally used for undergraduate and graduate training. A medium size optical telescope is thought to be a step to facilitate research in astronomy and observational cosmology. The geographic location of Iran, 32N 53E, relative dry climate and high altitude mountains, offer suitable locations for optical telescopes.

Site selection study for a proposed 2-4 meter class telescope started few years before the INO project received administrative approval. The study led by S. Nasiri (report in preparation) began by collecting and analysis of weather data, seismic hazard data, accessibility and shiny day statistics over central dry regions of the country. A large number of sites were identified and inspected. When the number of potential sites, mostly scattered around the central desert, was reduced to a manageable number, long term seeing monitoring has also started and continued for two years on 4 different sites with altitudes between 2500m and 3000m.

2. SITE CHARACTERIZATION

It has been shown that the atmospheric turbulence has a strong connection to astronomical seeing. In particular the Fried parameter, \( r_0 \), which represents the telescope aperture diameter, for which the diffraction-limited image resolution is equal to the FWHM of the seeing-limited image is shown to be determined by refractive index structure constant (Fried 1966) which itself depends on the temperature structure of the atmosphere (e.g. Marks et al 1996).

Site characterization involved measurement of a number of key site parameters such as the wind speed and direction, sky brightness, seeing and microthermal variation profile at the two sites, known as Dinava (3000m) and Gargash (3600m). These two sites are 70km apart. The key objective of the monitoring was to find the best of the two sites for the installation of the 3.4m telescope.

2.1 Wind speed and direction

Typical weather stations were installed in both sites on 12m masts by the end of 2008. They allowed the measurement of temperature, wind speed and direction, barometric pressure and humidity. Wind data recording was performed every 10 minutes at an 8m height above the peak. Two years of measurement indicates that both sites shows a peak wind speed of 4.0-8.0 m/s but despite a 600m higher altitude, the wind speed in Gargash is generally lower than in Dinava. The west and south-west are generally the dominant wind directions in both sites. This is shown in Fig 1.
2.2 Humidity, clear sky and temperature

Statistically there is about 230 shiny days available for the region. Monitoring the cloud coverage over two years indicates that around 45% clear sky is available annually. This increases to above 70% between June-Oct.

In about 55% of the nights the relative humidity remains below 60%. This increases to over 80% between May-Oct. There is no measurable difference between the two sites in relative humidity.

Temperature variation ($T_{\text{max}} - T_{\text{min}}$) during the night (between twilights) is generally 3 degrees. The temperature changes at a rate of about 0.15 ($\pm 0.3$) degree celsius per hour between sunset and midnight. Dinava site is generally about 5 degrees celsius warmer than the Gargash site.

2.3 Seeing measurement

Seeing is one of the most important parameters describing the atmospheric turbulence. Seeing measurement was carried out using DIMM systems (eg. Sarazin & Roddier 1990, Vernin & Munoz 1995, Tokovinin 2002) which comprised of Orion Ritchey-chretien 8 inches telescopes, 44 mm apertures with a 122 mm separation, installed on metal pillar located on a lifted concrete platform providing an altitude of 3.5m above the ground for the telescopes in both sites. The two DIMM systems installed in Gargash and Dinava were cross calibrated at Dinava site using the same configuration. This configuration was kept unchanged for the period of observations June-Oct 2010. A similar method was adopted by the site selection team (2004-2006) using 11-inch telescopes, but on conventional telescope tripod. A comparison of the measured seeing in Dinava and Gargash is shown in Fig 2.

2.4 Microthermal variation measurement and CFD modeling

The main aim of the microthermal measurements is to determine the height of ground layer turbulence which allows an optimization of the cost-height, driven by desire to located the primary mirror above the turbulent layer. In case of complex peak topography, multiple measurements further helps to better constrain the location of the telescope/enclosure.
As the time-scale of the temperature variation is of the order of 10-100Hz and the amplitude of the variation is of the order of 0.01 of a degree, the sensitivity of the sensors and the data recording system as well as their response time should be adequately set.

We therefore designed a system to deliver ∼1 kHz recording frequency with a few × 0.001 degree sensitivity using Platinum wire with high purity and 20 micron diameter.

The microthermal variation measurements were performed in 6 locations (given the complexity of the peak topography) in Gargash site and 2 locations in Dinava site simultaneously in September-October 2010. The sensors were placed at 8 levels with a separation of 1.5m vertically. The horizontal separation of the sensors is 2 meters. A quick analysis of the results show that first mast in the direction of the dominant wind direction (shown in Fig 3) provides a textbook example of the thermal variation profile. There is a clear difference in the recorded variance between the levels which is observed in day and night time. More detailed analysis of the microthermal measurements is in progress.

We have obtained the topographic map of the peak with resolutions of 1 meter and 5 meters for the upper (~30 meter from the peak) and lower (~100 meters of the peak) regions of the peak to be able to perform a Computational Fluid Dynamics (CFD) modeling of the peak under various wind flow and turbulence conditions. Our initial findings indicate that the boundary layer is about 15-20 meters from the ground.

2.5 Sky brightness

Sky background was measured under photometric conditions in Dinava and Gargash. We find that Gargash site is about 0.4 magnitude darker than the Dinava site owing to a larger distance from major cities. The V-band sky brightness in Dinava and Gargash are 21.6 and 22.0 mag, respectively. A light pollution control project is being planned to preserve the sites for astronomical observations.
Figure 3. An example microthermal variation profile for one of the masts in Gargash. The median of the variance in each level is obtained for 6 consecutive days in Sept 2010. The lower levels show larger variance during the day and night relative to the upper levels.

3. CONCLUDING REMARKS

Our studies indicate a relative advantage of the Gargash site in comparison to Dinava site. Gargash site is found to be darker, benefitting from a better astronomical seeing and also higher altitude and therefore less affected by dust.

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