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Seeing Test at Samorkraeng Mountain

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ABSTRACT

Seeing test based on DIMM method was employed to investigate the atmospheric turbulence at Samorkraeng Mountain, Wangtong district, Phitsanulok province. The latitude and the longitude of the selected site for an observatory are $16^{\circ}50'.59\,\mathrm{N}$ and $100^{\circ}24'.08\,\mathrm{E}$, respectively; the altitude is about 180 meters above the sea level; and the distance is about 15 kilometers north east from the downtown of Phitsanulok.

The statistics of the seeing in FWHM, temperature, and humidity which measured and calculated for 20 nights during December 8, 2004 to January 4, 2006 are as follows: maximum FWHM, minimum FWHM, and average FWHM are 3.6, 0.8, and 1.7 arc seconds, respectively; maximum temperature, minimum temperature, and average temperature are 29.2, 17.4, and 22.8 °C, respectively; and maximum humidity, minimum humidity, average humidity are 80, 55, and 68.8 percent, respectively. The average seeing value at Samorkraeng Mountain is not much different from the average values at Siding Springs in Australia, Kitt Peak in the United States of America, Devasthal in India, and South Pole in Antarctica which are the famous observatories in the world.

Keywords: Site testing-seeing, Astronomical seeing, Atmospheric effects, Seeing disk, DIMM

INTRODUCTION

Phitsanulok province is the center of education in the lower northern part of Thailand where universities and academic institutions are located. One of the most important functions of the universities and institutions is to provide academic service to students and people in that part and also in all parts of Thailand. A project of an optical telescope observatory installing in Phitsanulok by the Faculty of Science, Naresuan University will support this important function. A location of an observatory needs to have a site survey describing about number of clear sky night, temperature, humidity, wind speed, and astronomical seeing. These parameters will be important for considering whether an observatory would be installed. Samorkraeng Mountain, which locates at the distance of 15 kilometers from downtown Phitsanulok with latitude $16^{\circ}50'.59\,\mathrm{N}$ and longitude $100^{\circ}24'.08\,\mathrm{E}$, is the selected site for this project and would, possibly, be considered a location for Naresuan University's observatory.

METERIALS AND METHODS

Astronomical seeing

Although the theoretical resolution of a telescope is proportional to W/D (W is the wave length of the radiation from an observed object and D is the diameter of the telescope's mirror or lens), the atmosphere turbulence at the observing site limits the telescope's resolution. When the light from a star or an object on the sky comes through several turbulence atmospheric layers and air layer near the ground, it results distortion in the image of the star or the object. Ground-based astronomy is severely limits by the atmospheric turbulence, called seeing (Young, 1974; Tokovinin, 2002). Image degradation from the atmosphere is accepted in the framework of the Kolomogorov turbulence model (Tatarskii, 1961; Tokovinin, 2002). The common way to characterize image degradation is to measure the Full Width at Half Maximum (FWHM) intensity of a star in arc second (Boumis *et al*., 2001). The method which becomes the standard instrument for seeing measurement is called Differential Image Motion Monitor (DIMM) (Neimeier *et al*., 2002).

Differential Image Motion Monitor (DIMM)

The DIMM concept was introduced by Stock and Keller and implemented by Sarazin and Roddier (Tokovinin, 2002). The DIMM method is to measure the differential motion of two images of the same star and based on this motion at the focus of a small telescope (Benkhaldoun *et al*., 2005). The advantage of this method is that eliminates erratic motion of the telescope, since it measures the angular differences between the two images and it is not affected by any other motion (Boumis *et al*., 2001). For producing two images of a same star, a mask of a telescope is punched into two apertures with diameter d and separation r; the light from a star passes through the two apertures, which travels through slightly different atmospheric layers producing a tilt in wave front of one compared to the other; it results in a slight variation in the separation of the two images (Boumis *et al*., 2001).

STV

The STV is a versatile instrument (Santa Barbara Instrument Group, 2000); it is a highly sensitive, cooled, and digital video camera. It can take high quality images with image modes: continuous, mosaics, snap shots, track and accumulate, and auto grab. It can measure critical seeing parameters with the monitor modes and measure atmospheric seeing. The seeing monitor mode uses a Differential Image Motion Monitor (DIMM) technique to measure the seeing conditions independent of a system's optical quality and drive errors. The using of seeing monitor mode, a telescope must be covered by a cardboard mask with two circular holes; the separation of the two holes is about 80 percent of the diameter of the telescope and the diameter of each hole is about 20 percent of the diameter of the diameter of the telescope. To do the measurement, find a bright star and image it with the STV; place the mask over the aperture of a telescope and defocus the telescope until two spots can be seen separately. Enter the seeing monitor mode of STV; the software will automatically find the stars, adjust the exposure, and start collecting data. The software will report the seeing as the Full Width Half Maximum (FWHM) in arc seconds of a long exposure stellar image, about 5 to 10 seconds. It uses the root mean square (rms) relative motion of 32 images to calculate the result. The exposure FWHM in arc seconds is given by:

$$\text{FWMH} = 0.98\ \text{Lambda} / (4.85*10^{-6}*R_0)$$

where Lambda = wavelength in centimeter (0.00006)
R_0 = Atmospheric Cell Size in centimeter

R_0 is the transverse phase coherence length (the Fried parameter); it is on the order of 7.5 centimeter to 10 centimeter; it is related to the rms differential image motion by:

$$R_0 = \{rms^2 / [2 * \text{Lambda}^2 * (0.179\ d^{\frac{-1}{3}} - 0.0968\ r)^{\frac{-1}{3}}]\}^{\frac{-3}{5}}$$

where d = diameter of individual hole in centimeter
r = separation of the two holes in centimeter
rms = standard deviation of spot separation in centimeter

The DIMM method is used for seeing test at Samorkraeng Mountain; the equipments which used to collect the data are shown in the figure 1; and the specifications of the equipments presented in the Table 1.

Figure 1 The equipments of the DIMM method for seeing test at Samorkraeng Mountain

Table 1 Specifications of the equipments in the seeing test

equipment	specification
14 Inchs Celestron Telescope	
Diameter	35 centimeter or 14 inchs
Focal length	391 centimeters
F- ratio	11
Optical Design	Schmidt Cassegrain
STV CCD	
Monitor Mode	-measure atmospheric seeing -measure telescope drive periodic
CCD	-Texas Instruments TC-237 -high Sensitivity Frame Transfer (electronic shutter)CCD
Image bit depth	-656 X 480 pixels:@7.4 microns square -10 bit for 1X1 binning mode -up to 16 bits for other binning mode and trace and Accommodate
Cooling	-single stage thermoelectric -25 degrees Celsius from ambient

OBSERVATION AND RESULTS

The seeing test at Samorkraeng Mountain started in December 8, 2004 to January 4, 2006; number of observing nights is 20. Due to the selected site for an observatory on the top of the mountain surrounded by trees which cannot cut down, then the location for collecting data takes place in Wat Khao Samorkraeng where is the basement of Samorkraeng Mountain; its latitude is $16^{\circ}50'.59$ N, longitude is $100^{\circ}24'.08$ E, and the altitude is about 54 meters above the sea level. Because the testing site had no permanent building for data collecting, the equipments (telescope and STV CCD) were transported from the Department of Physics, Naresuan University to the site every observing night. Neither the telescope can set properly nor track accurately, the Polaris which moves less in diurnal motion is selected to be the target. It still is in the monitor of STV CCD although it is taken for a long time of the seeing FWHM exposure. Temperature and humidity were recorded in the night of the observation. The data were analyzed and shown in the Table 2 and figure 2.

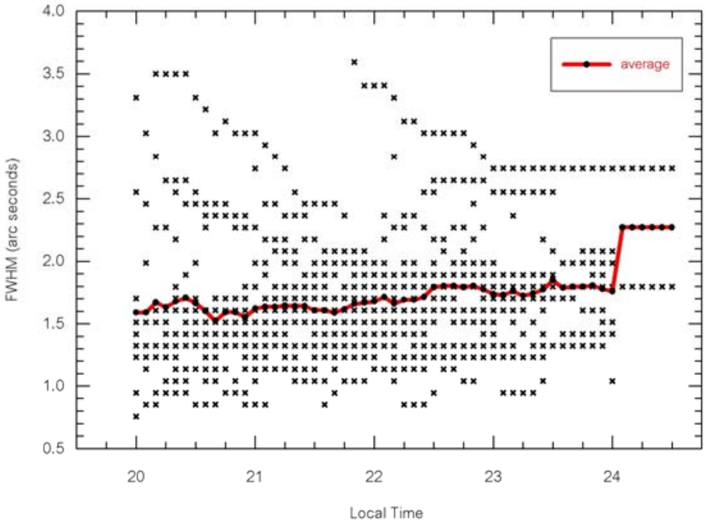

Figure 2 The seeing in FWHM versus local time From December 8, 2004 to January 4, 2006

Table 2 Averages of seeing in FWHM, temperature, and humidity from December 8, 2004 to January 4, 2006

Date Month Year	FWHM (arc second)	Temperature (°C)	Humidity (percent)
8 December 2004	1.4	19.6	71.8
20 December 2004	2.9	21.1	68.9
30 December 2004	2.0	21.4	71.8
28 January 2005	2.1	25.6	67.9
11 March 2005	2.1	28.0	62.6
21 November 2005	1.3	22.2	69.9
23 November 2005	1.3	21.2	75.3
24 November 2005	1.5	22.5	73.9
27 November 2005	1.5	24.2	77.7
30 November 2005	1.7	24.0	77.9
9 December 2005	2.0	23.4	74.2
11 December 2005	1.6	25.4	72.9
13 December 2005	1.9	23.7	66.1
14 December 2005	1.5	22.9	65.5
16 December 2005	1.6	22.0	67.7
17 December 2005	1.1	21.8	61.6
19 December 2005	1.6	18.8	65.7
21 December 2005	1.6	24.4	62.5
23 December 2005	1.1	20.4	57.5
4 January 2006	1.5	24.7	65.3

The statistics of the seeing in FWHM, temperature, and humidity which observed during December 8, 2004 to January 4, 2006 are shown in the Table 3.

Table 3 The statistics of seeing in FWHM, Temperature, and humidity during December 8, 2004 to January 4, 2006

Measurements	Results
The seeing in FWHM	
Maximum FWHM	3.6 arc second
Minimum FWHM	0.8 arc second
Median FWHM	1.6 arc second
Mean FWHM	1.7 arc second
Temperature	
Maximum temperature	29.2 degrees Celsius
Minimum temperature	17.4 degrees Celsius
Average temperature	22.8 degrees Celsius
Humidity	
Maximum Humidity	80 percent
Minimum Humidity	55 percent
Average Humidity	68.8 percent

The counts and FWHM of seeing during December 8, 2004 to January 4, 2006 are presented in a histogram as the figure 3.

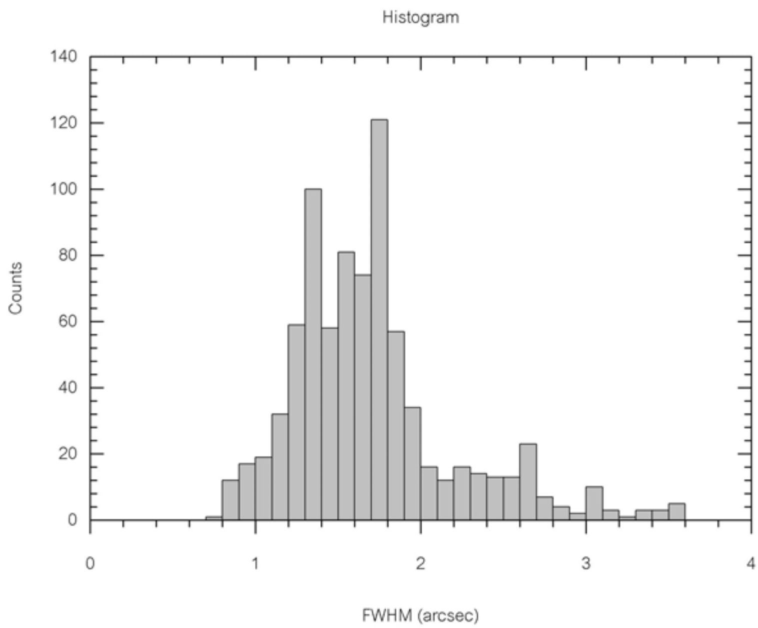

Figure 3 Histogram of counts and FWHM of seeing during December 8, 2004 to January 4, 2006

CONCLUSION AND DISCUSSION

The statistics of the seeing in FWHM, temperature, and humidity which measured and calculated for 20 nights during December 8, 2004 to January 4, 2004 at Samorkraeng Mountain are as follows: maximum FWHM, minimum FWHM, and average FWHM are 3.6, 0.8, and 1.7 arc seconds, respectively; maximum temperature, minimum temperature, and average temperature are 29.2, 17.4, and 22.8 °C, respectively; and maximum humidity, minimum humidity, average humidity are 80, 55, and 68.8 percent, respectively.

The average value of FWHM at Samorkraeng Mountain is quite high which indicates a rather poor value of seeing condition. This poor value may be due to some observational limitations. Firstly, the target star selected, Polaris which its altitude is about 16°, is too low. Secondly, the altitude of the observing site is only 54 meters above the sea level which is quite low and the telescope is affected by heat turbulence from the ground. However, the average seeing value (1.7) at the basement of Samorkraeng Mountain is compared with the average seeing values from various observatories in Table 4, it is not much different from the values at the famous observatories in the world as follows: Siding Springs (1.25), Kitt Peak (1.67), Devasthal (1.51), and South Pole (1.74).

Table 4 Average astronomical seeing in some astronomical observatories

Site	Average FWHM (arc second)	References
Mauna Kea, Hawaii	0.88	Chun et al. (2002)
Karoo Plateau, S. Africa	0.92	Erasmus (2000)
Kunming, China	1.02	Qian et al. (2001)
Gaomeigu, Lijiang, China	0.67	Zizhong et al. (1995)
Mt.Fowlkes, USA	1.03	Barker et al. (2003)
Cerro Tololo, Chile	0.73	Vernin et al. (2000)
La Silla, Chile	0.96	Tokovinin et al. (2003)
La Palma, Spain	0.69	Wilson et al. (1999)
Cananea, Mexico	0.91	INAOE (2002)
Oukaimeden, Moroccan	1.05	Benkhaldoun et al. (2005)
South Pole, Antarctica	1.74	Travouillon et al. (2003)
Devasthal, India	1.07	Sagar et al. (2000)
	1.51	Pant et al. (1999)
Kitt Peak, USA	0.83	LSST (2004) (WYIN)
	1.67	Abt (1980)
Samorkraeng Mt.,Phitsanulok, Thailand	1.7	Boonyarak et al.[a]
Siding Spring, Australia	1.25	Wood et al. (1995)

[a] present paper

For improving the better seeing value and getting the complete data, some bright stars at higher altitude should be selected as target stars and observations should be done consecutively all through the year. The telescope should be at least 3-4 meters above the ground to avoid heat turbulence. Meteorological data should be recorded every night; these data would be very useful for making the decision in selecting the best site for an observatory.

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