A collaborative site survey for astronomical observations in west China (Tibet)

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ABSTRACT

The high plateaus in west China (Tibet) may provide good candidate sites possibly for ELT projects. According to satellite weather data, we found that a certain area in Tibet shows potentiality for good astronomical observations with less cloud coverage. We have explored through west Tibet to watch its topography in summer, 2004. We reanalyze meteorological data collected by GAME-Tibet project. We have started weather monitor in two candidate sites in west China; **Oma** in western area of Tibet and **Karasu** near the western boundary of China. Monitoring observations using modern astronomical site-testing techniques such as a DIMM and an IR cloud monitor camera will be started to catch up continuous monitoring of seeing and cloud coverage.

Keywords: Site survey, Astronomical Observation, ELT, Tibet, China, GAME-Tibet

1. INTRODUCTION

Astronomical site selection is a crucial issue for constructing observatories and effectively operating telescopes. While both Chinese and Japanese astronomical societies have proposed the plans of next generation extremely large telescopes (ELTs such as CFGT and JELT), the sites for the schemes are pendent and become imperative to be devoted. It could be a keystone in our developing strategy to make collaborative site survey in west China both for our ELTs and mid-sized telescopes of the Eastern-Asian astronomy union.

Methodology and guide lines for site survey are well described for ELTs[1]. Site surveys are now carrying on intensively by TMT, OWL and other ELT projects in several sites in Hawaii, Chile, Mexico, and US main land. There are possibly high quality sites remaining to be fully evaluated. Antarctica is recently revealed to be a good site for astronomical observations with extremely small seeing and stable atmosphere[2]. As shown of a global weather map presented at SPIE at Kona[3], we noticed that a part of Tibet area is characterized as cloudless in some degree and may be suitable for astronomical observations[4]. A site survey workshop was held in summer 2004 at Lhasa, focusing areas in west China[5]. Candidate sites in west China were proposed based on remote-sensing data and/or local meteorological observations. Potentiality of candidate sites was confirmed through a topographical survey in Tibet and Xinjiang following the workshop.

We investigate meteorological conditions using available weather data taken from remote-sensing satellites. Another meteorological project on monsoon mechanism has been observing climatic conditions including areas close to our candidate sites from 1997 on. We reanalyze meteorological data at one site and compare them with data measured at our candidate site since Chinese astronomers has settled recently weather stations at two sites[6,7].

2. WEATHER EVALUATION USING SATELLITE DATA

Global weather data are open to public at the web site for Surface Meteorology and Solar Energy (SSE, http://eosweb.larc.nasa.gov/sse/[†]). Looking for area having less cloud cover on time-series cloud distribution maps, an

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area around 32 N and 83 E, north to Oma village, looks possibly a good site (Fig. 1). Monthly cloud cover variations are shown in Fig.2, compared with other astronomical observatory sites. Oma area seems characterized as one of the lowest cloud cover except a monsoon season. Diurnal variation of cloud cover shows that cloud cover is low in nighttime though high in daytime.

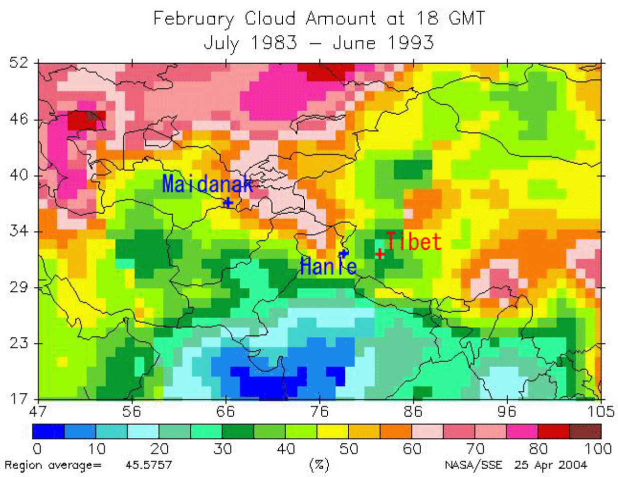

Fig.1. Cloud amount around Tibetan area in February, which is an average between 1983 and 1993 with spatial mesh of 1 deg taken from SSE data archives. A relatively cloudless area around Oma is marked with *Tibet* and other two observatory sites with *Hanle* (India) and *Maidanak* (Uzbekistan).

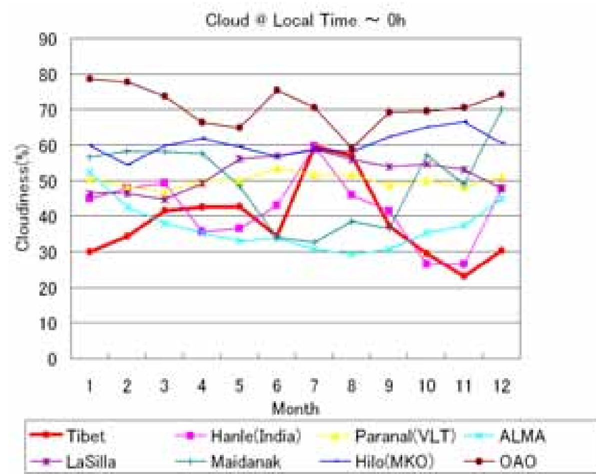

Fig. 2. Monthly variation of cloud cover at local time of 0 h at Oma (Tibet) and astronomical observatory sites. Data are taken from SSE data archives.

3. GROUND –BASED WEATHER MONITOR

Based on satellite weather data and ground-based weather data observed by local meteorological stations, two candidate sites are selected to settle a weather station at Oma in Tibet and at Karasu in Pamir. The coordinate and altitude of Oma is 32:32:39.8 N, 83:03:22.0 E and 5032m, and of Karasu is 38:10:29.3 N, 74:48:08.7 E and 4495 m, which locations are shown in Fig. 3. Both sites are selected to have enough relative height (>4000m) on the plateau, and are wide, flat, and accessible by vehicles. To the west of Karasu site (in the wind direction) there is a large valley in Tajikistan, and the tower is set up hill-top on the borderline. To the west of Oma site (again in the wind direction) there is a long wide valley. We started to take meteorological data intermittently from July 2005. A detailed description and preliminary results are presented in this volume[7].

Another ground-based weather monitor has been conducted since 1997 by a meteorological group to clarify and investigate a mechanism of Asian monsoon, named GAME-Tibet (GEWEX Asian Monsoon Experiment) project under Global Energy and Water Cycle Experiment (GEWEX) and World Climate Research Program (WCRP). Several sites have been monitoring on climatic conditions using automated weather stations (AWS), Radiosonde, SODAR etc. Close to our candidate site at Oma are two stations at Gaize (Gerze, 32:18 N, 84:03 E, Alt. 4420m) and Shiquanhe (Gar, 32:30 N, 80:05 E, Alt. 4279m). We reanalyze meteorological data during 1997 and 2005 supplied by GAME-Tibet project.

As ELTs have a huge telescope structure with a primary resonance frequency closer to the maximum of the wind power spectrum, ELTs will be more sensitive to wind-buffeting than present large telescopes. Wind speed is one of key factors to characterize candidate sites. Fig.4 shows a histogram of wind speeds averaged for 10 min before every hour at 4.6 m

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† "Global/Regional Plots" in "Meteorology and Solar Energy" session in the SSE web page.

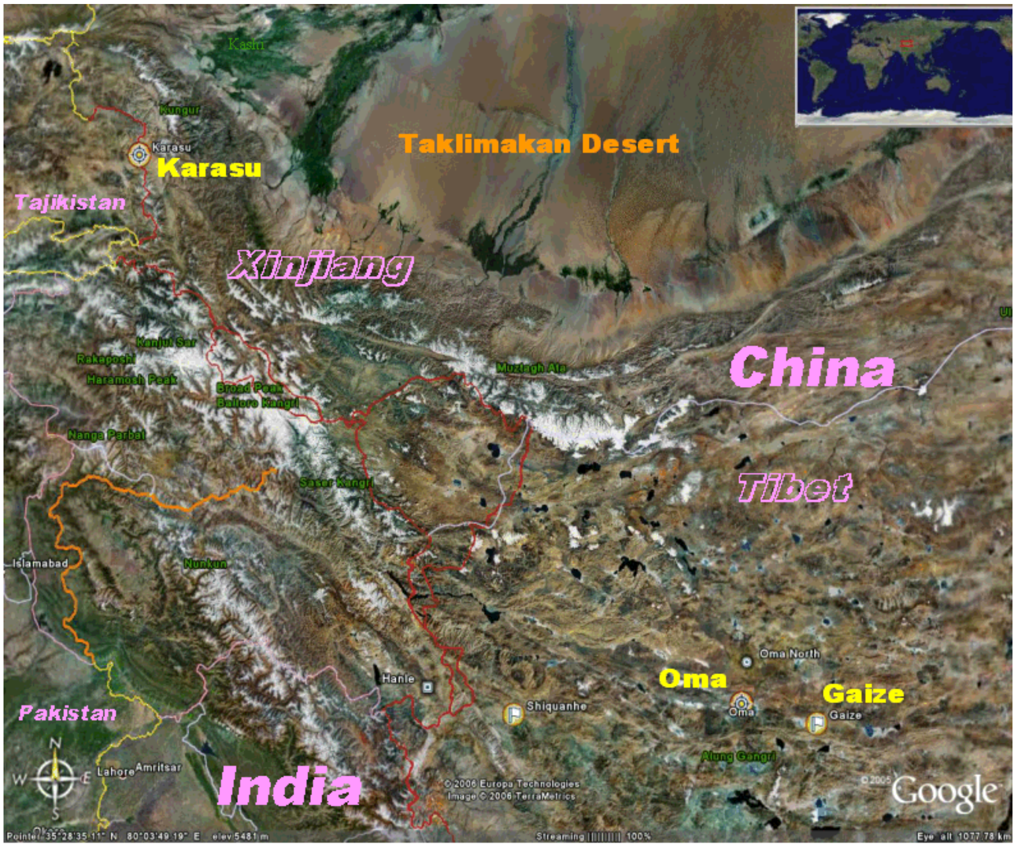

Fig. 3. Locations of candidate sites at Oma and Karasu with meteorological monitor stations at Gaize and Shiquanhe(Gar). Close to Shiquanhe is located Indian Astronomical Observatory with 2m telescope at Hanle. The geographic map is obtained with Google-Earth.

level above ground at Gaize and maximum wind speeds in 60 min interval. An average wind speed is around 2.7 m/sec with a maximum of hourly maximum wind speeds of 15.7 m/sec. Wind speed varies gradually through year and diurnal variation is clear in Fig.5 as wind is developed in daytime due to strong sunshine and deceases in nighttime. Although our weather station is settled at Oma apart from Gaize, comparison with our meteorological data at Oma recently obtained in August 2005 and September 2005 to those at Gaize shows that wind speed distributions at Oma coincident with those at Gaize, which is reasonably expected as Oma and Gaize locate close about 100 km apart and along the same valley between two chains of mountains of 5000 m or higher. The average wind speed at Gaize and Oma seems one of the lowest wind speeds among astronomical sites including Dome C at Antarctica [8].

Precipitable water vapor (PWV) has been observed during summer seasons since observations were difficult due to low temperature in winter. PWV is shown in Fig. 6 with winter data supplemented from a local meteorological station.

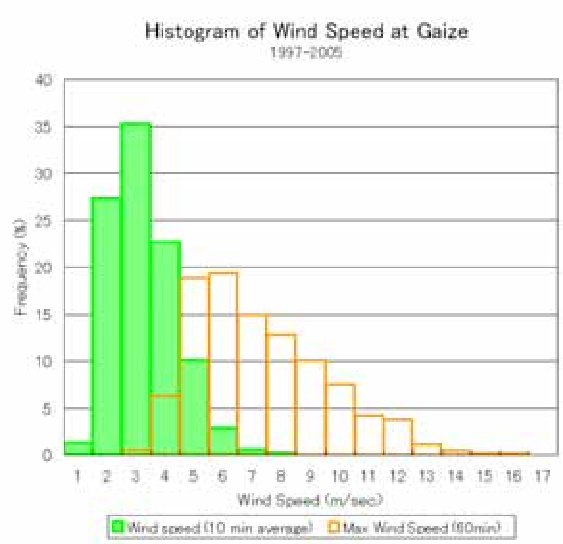

Fig. 4. Histogram of average wind speeds and maximum of maximum wind speeds at 4.6m above ground at Gaize. An average wind speed through year is about 2.7m/sec.

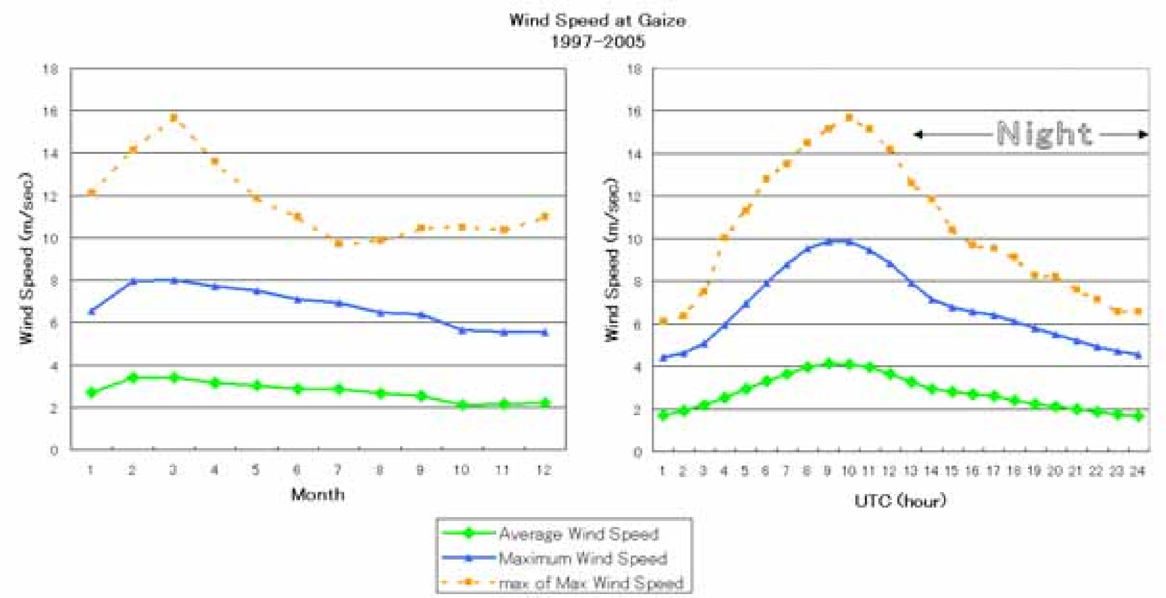

Fig. 5. (**left**) Monthly wind speeds at 4.6m above ground at Gaize. (**right**) Hourly wind speeds at Gaize. Three lines show average wind speed for 10 min before every hour, maximum wind speed for 60 min interval, and maximum of maximum wind speeds for each month or hour.

PWV is concentrated in the monsoon season between June to September and other seasons are so dry.

Monthly and hourly distributions of temperature and relative humidity at 3.6 m level above ground are shown in Figures 7 and 8. Relative humidity is low in daytime at Gaize and high in nighttime. AWS at Gaize is located in valley. A diurnal variation of PWV has been recognized in valley-mountain topographic system over Tibetan plateau[9]. As PWV may be possibly changed in mountain sites or valley sites, multiple-site surveys are mandatory to obtain good sites over the Tibetan area.

It is noted that seismic activity around Oma area in Tibet is infrequent according to an earthquake catalog available at USGS[10].

4. MEASUREMENT USING REMOTELY-CONTROLLED AIRPLANE

It is difficult to measure atmosphere conditions at heights above weather towers about 30 m and below sensitive heights with site-testing instruments about 100m, though atmospheric conditions at these heights are important to obtain an exact height of surface turbulent layer in order to decide a telescope base. We used a remote-controlled model airplane with a temperature sensor and a barometric altimeter aboard on the way through west Tibet, 2004. We detected inversion layers during dawn time at a mountain pass near Shiquanhe. The inversion layer laid at low height before sunrise and gradually went up higher, then disappeared after sunrise (Fig.9). It is convenient

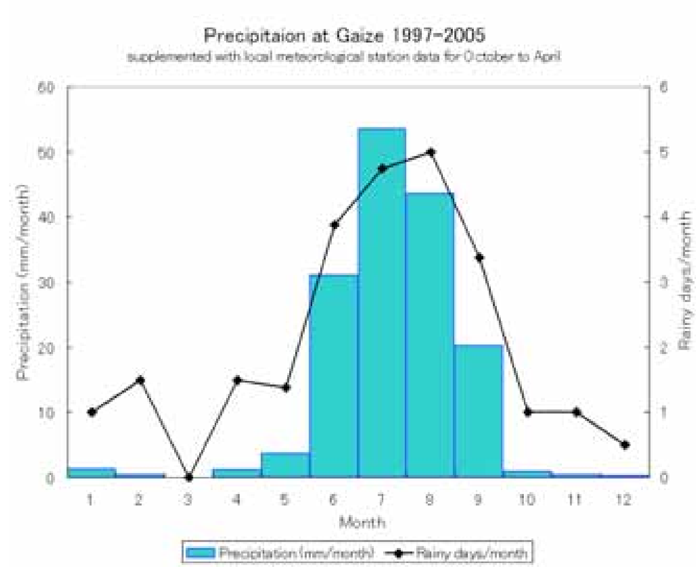

Fig. 6. Precipitaion at Gaize supplemented for October-April data by a local meteorological station. Monsoon season is clearly shown with much rain relatively to other seasons.

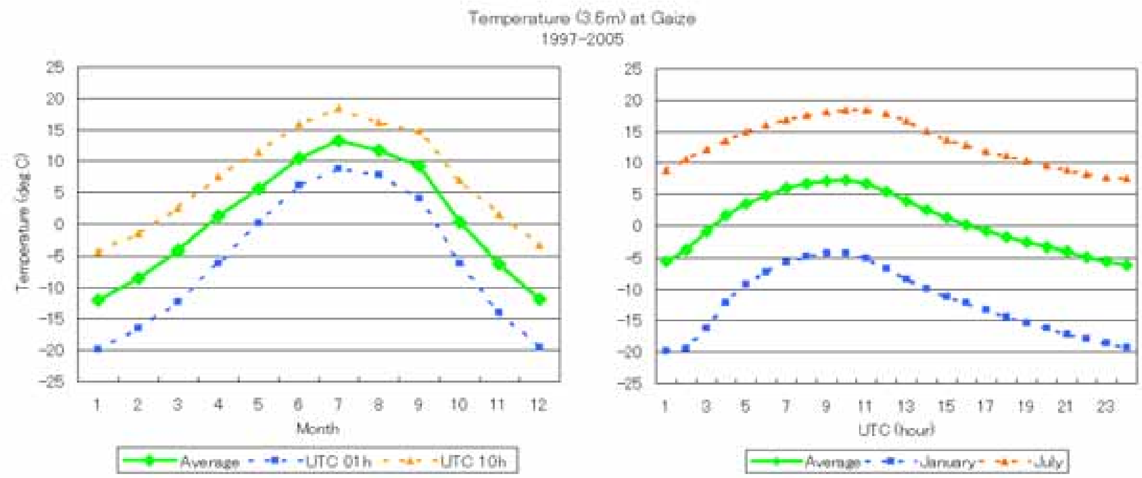

Fig. 7. Monthly and hourly distributions of temperature at 3.6m level above ground at Gaize. Nighttime is between 12 h UTC and 24 h UTC.

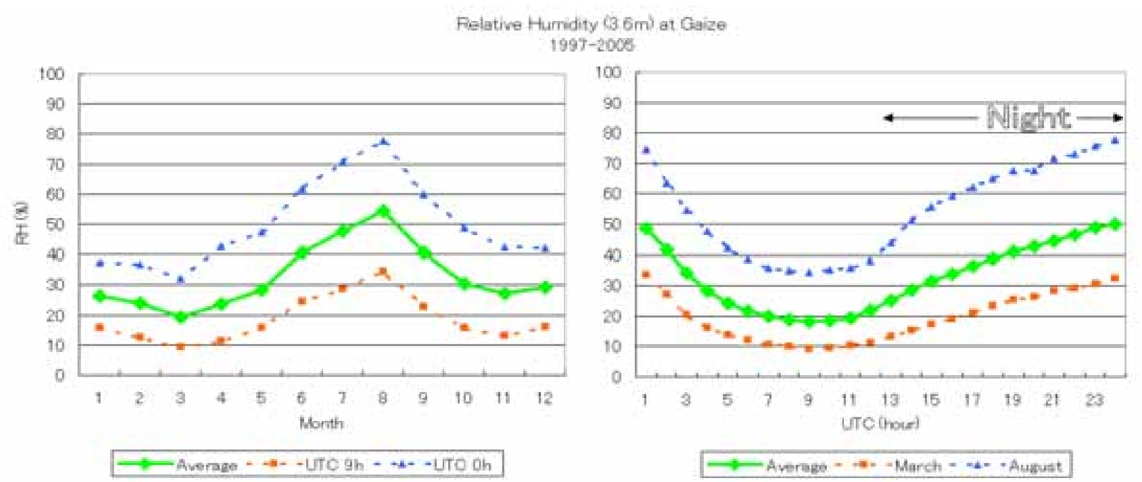

Fig. 8. Monthly and hourly distributions of relative humidity at 3.6 m level above ground at Gaize. Nighttime is between 12 h UTC and 24 h UTC.

with a model airplane to look for good sites over a candidate area as model airplane is portable and easy to use for measurements on atmospheric conditions for multiple site surveys.

5. PROGRESS PLAN FOR SITE SURVEY

As two weather stations have been settled with desperate efforts by Chinese astronomers, we started to conduct site surveys to continue for several years to characterize the candidate sites. In the same time we emphasize necessity of multiple site surveys to look for the locally best site since site characteristics may be affected largely due to the valley-mountain topographic system and diurnal variations. We will set mid-IR cloud monitor cameras[11] at two sites this year to reveal cloud coverage through day and night. As Tibet area is dry almost through year and relatively close to the desert area to north-western China, atmospheric dust contents should be monitored. Other site-testing instruments, DIMM/MASS and SODAR, are also expected to be put at the sites as a part of our collaborative site survey.

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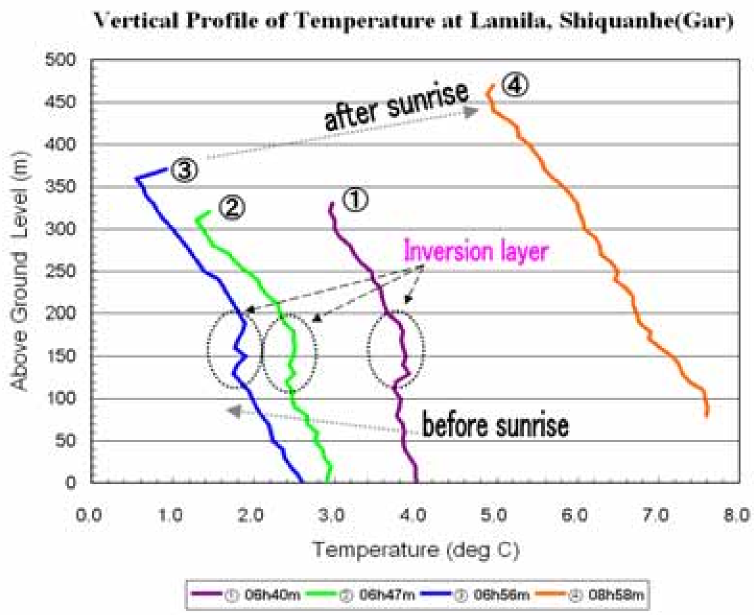

Fig. 9. Vertical profiles of temperature measured with a remote-controlled model airplane near Shiquanhe before and after sunrise. Inversion layers are shown with broken circles. Heights of inversion layers about 150 m are close to mountain heights surrounding the pass.

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