Atmospheric monitoring strategy for the Ali site, Tibet

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Abstract. The astronomical site survey in China has been carried out since 2003. Remote studies and local surveys are performed over the high plateaus, and candidate sites have been selected and performed site testing measurements. The monitoring results show that Ali area in western Tibet can be the best choice for astronomical observations over East Asian regions. Ali site, near the central town of Ali area, has been further identified for small telescope projects and simultaneously for detailed site characterization, and begun construction in 2010. This paper presents the site monitoring strategy and site development plan of the new Ali observatory.

1. Introduction
The site survey in western China has been carried out since 2003, in order to identify appropriate sites for constructing medium-size and large telescopes for East Asian communities. Remote studies and local surveys are performed over the vast land of plateau in the western part of China[1]. Two candidate sites, called Karasu, on Pamirs, and Oma, on Ali plateau in Tibet, are selected in 2005 to make the first phase site testing measurements. Both the sites keep away from cold snap in winter, warm current in summer, and seasonal dust storm, and possess good conditions of low temperature, dry air, less cloudy, less population and delayed development in industry. The topography of the sites shows wide flat summit with enough relative height and good accessibility.

Figure 1. The site testing stations at Karasu on Pamirs and at Oma on Ali plateau in Tibet.
The first phase site testing observations have been deployed in the period of 2005-2006. Cloud cover, seeing, precipitable water vapor, and wind speed are taken as the most important parameters to evaluate the sites, and other meteorological parameters and sky brightness are also measured. The monitoring results for the 1.5 years have shown that Oma site appears to be better than Karasu, and can be really superior and worth proceeding with further facilities for more reliable evaluation. The second phase site testing has concentrated on Oma site with improved facilities in the period of 2008-2010. The cloud monitoring with SBIG A340 at Oma site shows 60.7% photometric nights and 71.5% spectroscopic nights. The seeing measurements with DIMM and SBIG Polaris seeing monitors indicate a rather good seeing at Oma site of median 0.75”-0.8” [2]. Figure 1 shows the site testing stations at Karasu in Oct. 2007 and Oma in Nov. 2008.

In the period of 2008-2010, more candidate sites are explored and inspected following the remote studies to further examine potentially better sites. Several existing observatories and good candidate sites over China are selected for more than one year monitoring to further identify the qualities of Ali area. This site comparison research, together with the remote studies, proves that Ali area in west Tibet can be the best selection for constructing astronomical bases in wide wavelength bands.

2. The Ali observatory

For the requirements of detailed site characterization and small telescope projects, a new site in Ali area has been identified at the end of 2009 and begun construction in Aug. 2010. One of the key advantages of this site is near the central town, Shiquanhe, so that the observatory can be easily sustained. Shiquanhe town, the capital of Ali area, is the political, economic and cultural center in west Tibet, and also the intersection of main lines from Xinjiang, Qinghai, and from Lhasa.

![Image of Ali site in Dec. 2013.]

The Ali site is located at N32°19′ & E80°01′, with an altitude of 5100m. The altitude of vast flat land nearby is around 4300m. The whole course from Lhasa to Ali is 1500km, with all-the-way paved road. The Ali airport is open in 2010, making it possible to fly from Ali to Beijing within one day, or from Beijing to Ali by two days, affording one day acclimation in Lhasa.

The Ali site comes into site testing work in 2011. There are two domes constructed in Oct. 2010, and 25KW solar power supply and satellite communication antenna are completed in May 2011. There is also electrical power and fiber network lines from Shiquanhe passing the way on summit to the Ali airport. In Sept. 2011, the site construction has pass through the tests of electric power and communication, and the site testing instruments have been installed on...
site, including meteorological station, cloud monitor, and DIMM seeing monitor. A SCIDAR system for turbulence profile has made the first on-site run during the campaign in Nov. 2011. Following the site testing strategy, the site construction has continued to make progress in 2012-2013. Figure 2 presents the site layout by the end of 2013.

The construction of Ali site has attracted a lot of attention and support. In April 2012, the East Asian Core Observatories Association (EACOA) has organized a review committee to evaluate the site survey activities and results. The committee recognizes that the site survey team has made great efforts for the past years and agrees that the team has localized the candidate area qualitatively. The Ali site is very promising, although longer time monitoring and more international comparisons with standard instruments are required. The west Tibet is unique for astronomy because of longitudinal location and of high altitude, and the current results imply it is one of the world best infrared and sub-mm sites. The Science journal has reported the Ali site in Sept. 2012 as a world-class observatory rising on 'Roof of the World' [3]. Norio Kaifu, the IAU president, has visited Ali site with a team in June 2013, providing very good comments and instructions for the site development. Jun Yan, the general director of NAOC, has visited Ali site in June 2014, signing cooperation agreement with the local government and promoting to formally establish the Ali observatory.

**Table 1.** The site testing instruments for Ali site.

| Item                        | Instrument                                      |
|-----------------------------|-------------------------------------------------|
| weather condition           | Vaisala: WXT510, Huantron: CAWS620               |
| sky condition               | All-sky camera, MIR cloud monitor               |
| dust counter                | TSI: DustTrak 8520                              |
| water vapor                 | Sun photometer, RPG: TAU 225-340                |
| turbulence in atmosphere    | DIMM, MASS                                      |
| turbulence profiling        | Singe Star SCIDAR                               |
| turbulence in surface layer | $C_T^2$ sensors on tower                        |
| turbulence in upper layer   | UNSW: SNODAR                                    |
| opacity and background      | 50cm scope and instruments                      |
3. The monitoring strategy

Following the EACOA recommendations in 2012, the atmospheric monitoring strategy has been made and implemented. More site testing instruments have been and will be installed at Ali site, with emphasis on complete turbulence measurements and with some facilities in the infrared and sub-mm wavelengths. Table 1 shows a list of site testing instruments for Ali site.

The first sets of site testing instruments have been installed in 2011 on the 10m tower. A 30m tower for microthermal $C_T^2$ sensors has been set up, and three new domes constructed with observing rooms in 2012; one 4.5m dome for SCIDAR telescope to measure turbulence profile, one 6m dome for a 50cm telescope to make observations and to provide some qualified data for the site, and one 8m dome for a newly planned wide field 1.2m telescope of Beijing Planetarium. The real observations will be much helpful to verify the site conditions, including practical operation, and provide with more parameters for practical application, such as sky background and transparency. Additional three 3m domes for the DIMM, MASS instruments, and for a 30cm monitoring telescope have been completed in 2013. The joint effort has been made to complete the connection of local electric power and network, and we can finally make remote observations in Beijing office.

![Figure 4](image-url)

**Figure 4.** The DIMM seeing measured at Ali site in 2013-2014 (top left) and the statistical distribution (top right). The comparison of seeing distributions measured in June 2013 by SCIDAR and by DIMM (bottom left). The monthly averaged seeing in 2010 calculated with WRF model for the Ali site (bottom right).

The recent cloud monitoring at Ali site shows percentages of 72.3% clear nights and 80.4% usable nights. The statistics of DIMM seeing measurements shows a median seeing of 0.82″, and the quartile seeing of 0.72″, as shown in Figure 4. The seeing measured by the single star SCIDAR is consistent in variations with the DIMM seeing, but tends to be lower in values than the latter. Figure 4 presents statistical distributions of the two instrument seeing during the measurements in June 2013; the median SCIDAR seeing is 0.1″ lower than the median.
DIMM seeing, and the seeing <0.6” measurements by SCIDAR seem to be undetectable for DIMM devices. It is probably understandable that the current DIMM seeing monitor with a sub-aperture separation of 20cm could not detect the better seeing conditions. Figure 4 further presents the monthly averaged seeing calculated with WRF model, which are also generally lower than the measured DIMM seeing of each month, with a difference of 0.15”-0.18”.

Figure 5. The 50cm telescope at Ali site equipped with large format CCD (top left) and optical-NIR spectrometer (top right). The setup of MIR imager for cloudiness and sky background emission (bottom left). The Fourier Transform Spectrometer measuring atmospheric opacity in the sub-mm bands(bottom right).

Figure 5 presents the configuration of various instruments at Ali site in 2014, including the 50cm telescope with optical image and spectrometer, the mid-infrared imager, and the Fourier Transform Spectrometer in the sub-mm bands, to show the effort to make real observations involving infrared and sub-mm wavebands. All the instruments have passed the test observations in the period of Jan.-March 2014.

4. The site development
The new Ali observatory is under construction for both detailed site characterization and the proposed small telescopes. The space of the current site seems not enough for an international level observing site. There are good possible sites on higher ridges located south and south-east directions, as shown in Figure 6. The higher ridge B seems to have good topographical location and much wider area. Also the peak C could be a good site for future large telescope. There is already a funded plan to construct the road to ridge B in 2015.

The best site, such as Ali area to reach a consensus, can be very helpful for general purpose astronomy and for cooperation in East Asia. A Site Committee will be organized internationally to decide individual telescope location plans, and to review and advise the site development.
Figure 6. A topographical map of the Ali site, with marks A1, B1, C1 etc. for possible sites for large observing facilities, and the current site operated in point A1.

Acknowledgements
This work is supported by the National Natural Science Foundation of China (NSFC Grants 10903014, 11373043, 11103042, 11203044, 11303055 and 11473041).

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