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NEAR-GROUND OPTICAL TURBULENCE MEASUREMENTS AT CERRO LAS CAMPANAS

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RESUMEN

Se reportan los resultados preliminares de mediciones de turbulencia óptica cerca de superficie llevadas a cabo en Cerro las Campanas, el sitio para la futura instalación del Telescopio Gigante Magallanes (GMT), usando los instrumentos MooSci (Moon Scintillomenter), DIMM (Differential Image Motion Monitor) y MASS (Multiple Aperture Scintillation Sensor), con énfasis en los efectos sobre el domo del GMT. Esta campaña continuará con futuras observaciones de la turbulencia superficial de forma de modelar mejor el desempeño de la óptica adaptativa (OA) y ayudar en el diseño de instrumentación de OA para GMT.

ABSTRACT

We report preliminary results from Near-Ground optical turbulence measurements carried out at Cerro Las Campanas, the future site of the Giant Magellan Telescope (GMT), using MooSci (Moon Scintillomenter), DIMM (Differential Image Motion Monitor) and MASS (Multiple Aperture Scintillation Sensor), focusing on the effects above the future GMT enclosure. This campaign will continue with future observations of the NGL turbulence in order to better model the adaptive optics performance and aid in the design of the GMT AO instrumentation

Key Words: atmospheric effects — site testing — turbulence

1. INTRODUCTION

The understanding of the behavior of turbulence in the atmosphere is one of the most important topics in astronomical site testing. Moreover, the specifics of the ground layer (GL) are of the utmost importance, as they are almost completely tied to the local topography, so that selecting a proper site will reflect on the seeing quality as a whole.

Specifically, GMT will rely on Ground Layer Adaptive Optics (GLAO) for a fraction of its observations, so after the selection of Cerro Las Campanas as the build site of the project (Thomas-Osip et al. 2010) it was decided that the GL should be characterized, but the MASS-DIMM instrument on site was only capable of measuring the 0–500 m layer as a whole, so other options were studied (see Thomas-Osip et al. 2008) and a new instrument was commissioned based on LuSci (Tokovinin et al. 2010).

2. MOOSCI

Built by Texas A&M (Villanueva et al. 2010), MooSci shares the same 6 sensor array design of LuSci, but mirrored so that it has 11 sensors along its baseline (1 sensor is shared). The instrument outputs data at a rate of 500 Hz (raw voltages), and a pipeline was built in Python to process it so that it can be fed to the same profile restoration code used by LuSci (Tokovinin & Berdja 2009). At the end of the process MooSci delivers turbulence profiles with a 2 minute sampling rate, with an altitude scale that can be adjusted between 3 meters (the minimum altitude where sensors beams are correlated) and 500 meters (the maximum altitude at which the profiles are reliable, see Tokovinin et al. 2010).

The instrument was positioned at the South-West of Cerro Las Campanas summit, so that the FOV of the sensors look at the Moon integrating over the area where GMT will be installed, as to gather turbulence profiles that are relevant to what the telescope should see at the ground layer. A future clone of MooSci will be positioned to the North-East, to characterize the difference between the turbulence seen by GMT and the GL to the North of the summit (approximately in the direction of the prevailing winds).

3. OTHER INSTRUMENTS ON SITE

There were also on Cerro Las Campanas summit other instruments as part of the site testing done for the past 5 years, which were added to the GL characterization survey.

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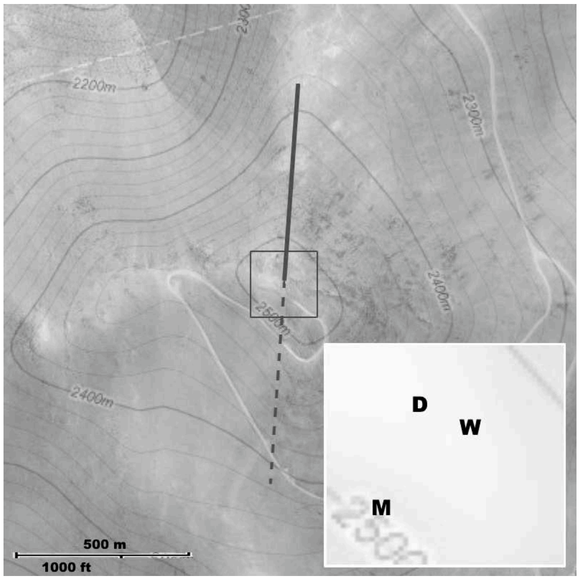

Fig. 1. Map of Cerro Las Campanas: North is up, the lower right square is a blow up of the center region. MooSci, DIMM and the Weather station are represented by the M, D and W letters. The dashed line represents the general direction where the Dimm tower looks, and the complete line represents the general direction where MooSci looks. Prevailing wind direction is from the NE. © 2009 Google Maps.

To the North-East of the summit a tower housed one of the DIMM (Sarazin & Roddier 1990), which was replaced with the MASS-DIMM (Kornilov et al. 2003) previously located at Cerro Manqui. This setup allows for measuring the integration of turbulence from 0–500 m, as to compare with that observed by the scintillometer.

Also to the North-East, overlooking most of the summit, a Vantage Pro weather station was installed. This station was preferred over the existing one, as it sits at ground level, where results from wind speed are used to feed MooSci's model. All 3 instruments are represented in Figure 1.

4. FIRST RESULTS

The campaign began with the August lunation. Data can be acquired around full moon for 10 nights, allowing for 30 hours of data per lunation in ideal weather conditions. We ran the instruments from August to October, but got only 13 full nights of data at the end due to wind and other weather issues. Figure 2 shows an ideal example of the integration of the GL as measured by MooSci and MASS-DIMM. The correlation between the instruments is clear, showing that most of the turbulence happens near the ground.

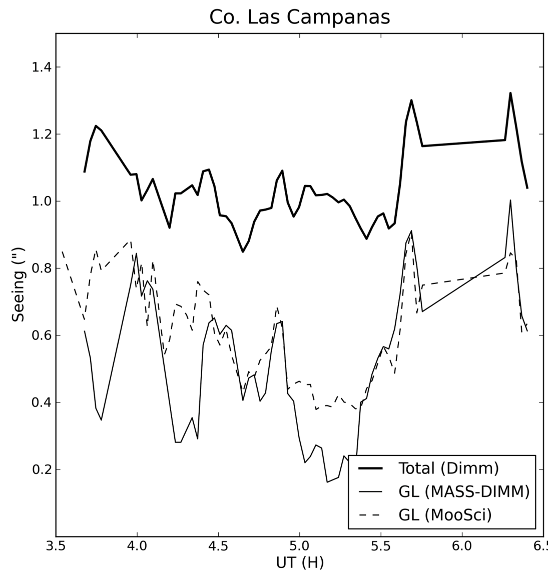

Fig. 2. GL seeing as seen by MASS-DIMM and MooSci on September 25, 2010. The total seeing as observed by DIMM is also shown for comparison.

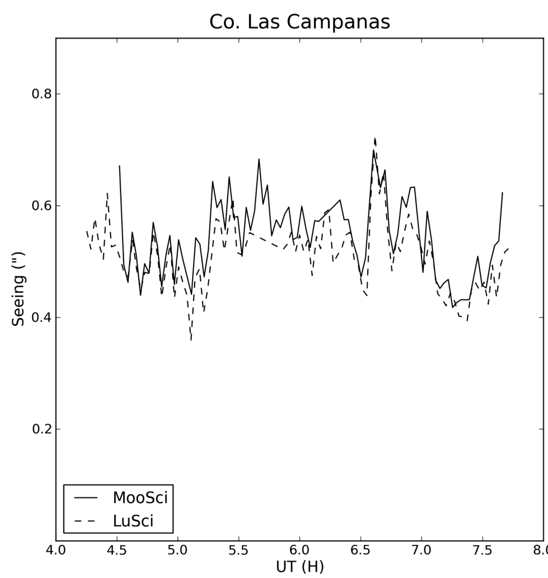

Fig. 3. GL seeing as seen by MooSci and LuSci on October 25, 2010. Both instruments were at the same location on the site.

We also ran MooSci alongside LuSci (borrowed from Cerro Tololo International Observatory), to see how reliable the instrument actually is, since the electronics between the two scintillometers are quite different. Figure 3 shows one particular night of data, with a very good correlation between the two signals.

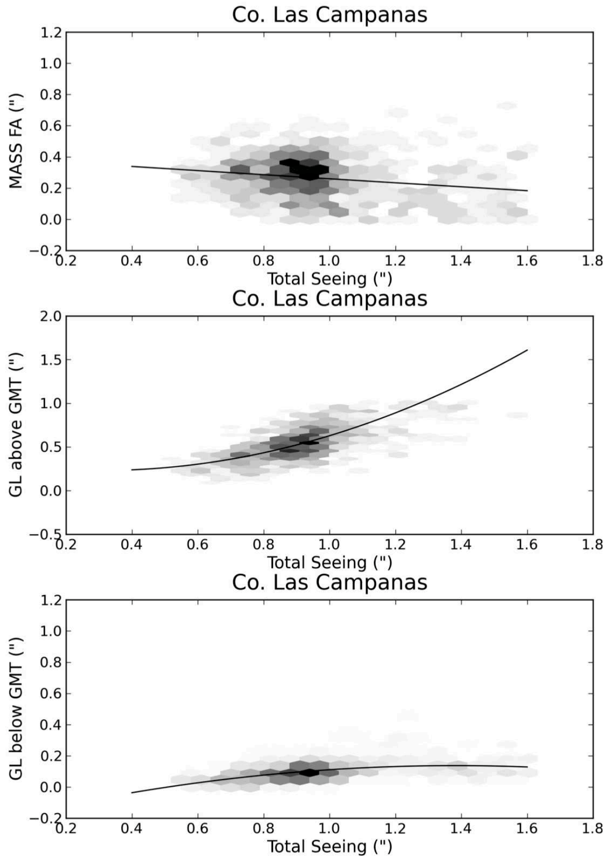

Fig. 4. GL as measured by MooSci and MASS for the whole August lunation, showing the portion of ground layer turbulence that GMT will not see, the free atmosphere (500 m – upper atm.) and the GMT expected GL seeing effects. A 2 degree polynomial fit is also displayed.

The exact nature of the GL can be seen in Figure 4, as the turbulence below GMT (the fraction up to 60 m, the height of the telescope enclosure) accounts to a tenth of the whole seeing for most of the time, and the free atmosphere turbulence accounts to less than half of the whole effect.

This means that even without GLAO, on a typical night with DIMM seeing of 0.63 arcseconds (based on results from Thomas-Osip et al. 2010), GMT will be subject to only 0.60 arcseconds of seeing (since the GL up to 60 m will not be observed by the telescope), 53 percent of it (0.32 arcseconds) belonging to the GL (see Table 1).

TABLE 1

TOTAL AND FRACTIONAL SEEING[a]

Campaign	Total	FA	GMT GL	0–60 m
MooSci	0.932	0.273	0.559	0.091
Site testing	0.630	0.308	0.318	0.035

[a]Total and fractional seeing (0–60 m from MooSci, Free Atmosphere from MASS-DIMM, and GMT GL from all 3 instruments) from the median values of our dataset (August–October 2010), and from the expected values at median seeing for Cerro Las Campanas in general, based on the results of the site testing campaign (April 2005–September 2008, see Thomas-Osip et al. 2010) as inferred from the polynomial fit shown in Figure 4.

5. CONCLUSIONS

Even after only 3 months of regular operations, MooSci has proven to be a reliable tool to measure the ground layer at Cerro Las Campanas. With the addition of MASS and DIMM we aim to do a complete evaluation of Cerro Las Campanas and measure the seasonal stability of the turbulence at ground level. Two other publications are already in the works, with results from our full dataset up to date (Berdja et al. 2011), and more in depth description of the pipeline and profile restoration process (Thomas-Osip, J., et al. 2011, in preparation).

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