# Results from the CA Seeing Monitor

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The CA seeing monitor is a two-element interferometer observing a geostationary satellite. Phase variations are measured and converted into a path length rms in units of microns. This document describes analysis of the data taken with the monitor in the period 5 May 2004 to 11 January 2005. I conclude that summer nights are as good as, or better than, winter days, and hence that scheduling of observations at mm wavelengths outside winter is feasible.

## 1 Data analysis

The data from the seeing monitor are available as two-column text. The first column is the time in hexadecimal format, in units of microseconds of Modified Julian Date (i.e., microseconds since 17 November 1858, 0:00 GMT). The second column is the rms of the atmospheric path length fluctuations, measured over 10 min. The data are processed using a Python script which carries out the following steps:

1. The data are read into memory line by line. The time stamp of each data point is converted to AEST, and the sun's elevation is calculated for this time at the Narrabri Observatory with an accuracy of better than $30'$ (the error is dominated by refraction which has not been taken into account). rms measurements of less than $10\,\mu$m are most likely instrumental failures and are discarded.

2. A list is generated with 12 data sets, one for each month, and each of which is subdivided by AEST into bins of 3 h width. Hence each bin accounts for data taken in one month during a particular eighth of the day (00:00 h to 03:00 h, 03:00 h to 06:00 h, and so on).

3. Similarly, a second list is generated with 12 data sets, one for each month, but the data are sub-divided by elevation of the sun. These bins are $10^\circ$ wide ($0^\circ$ to $10^\circ$, $10^\circ$ to $20^\circ$, and so on). Furthermore, the data sets are sub-divided by AEST to separate data taken before and after noon.

4. The average, rms, median and the first and third quartile are calculated for each bin of each list, yielding a measure of the most likely path length variations at a particular time of day in a particular month, or at a particular elevation of the sun in a particular month. The median is deemed

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to be more significant than the average, because it is less affected by outliers, and because the distribution of path length variations was found to be non-Gaussian.

5. The statistics from all bins are written to text files which can be used for plotting the data.

# 2 Plots and results

At the time of writing, data existed only for the nine months of May 2004 to January 2005. The data taken in January and July are affected by poorer statistics, compared to the other months. Only 11 days and 7 days of data exist for January and July, respectively, compared to almost full coverage during the other months. The rms plotted as a function of time is shown in Figure 1, and the rms as a function of elevation of the sun is shown in Figure 2.

## 2.1 Rms as a function of AEST

Figure 1 clearly shows the diurnal and annual variations of the path length fluctuations. However, it is surprising that the rms in the first two eighths during November to January is comparable to or lower than the rms during the day (eighths four to six) in the months of May to September. This is the period during which mm observations are scheduled in the April 2005 semester. Summer nights appear to be better than winter days. The very low rms measured in July and the comparatively low rms measured in January are probably caused by poorer statistics.

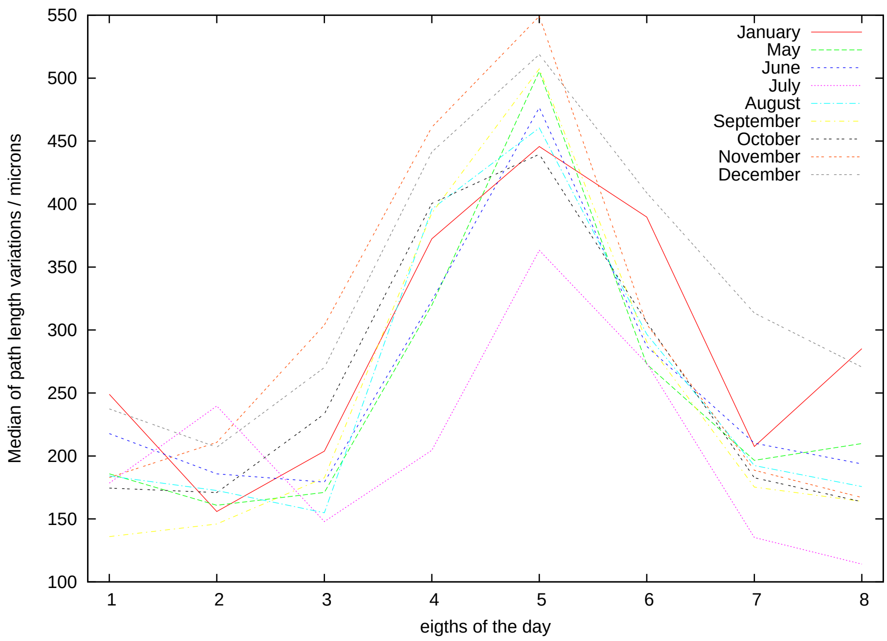


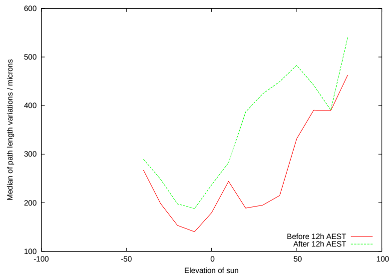

Figure 1: Rms of the path length variations as a function of eighth of the day.

### 2.2 Rms as a function of elevation of the sun

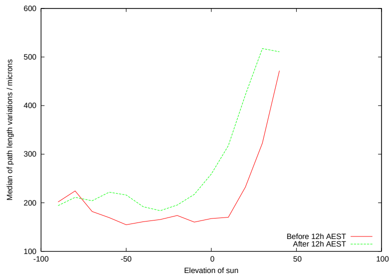
The graphs in Figure 2 reveal that throughout most of the year, the rms sharply increases when the sun has reached an elevation of around 10°. Even in the time of October to January the first half of the day until briefly after sunrise is comparable to winter nights and certainly better than winter days. Furthermore, in any month, the rms in the morning is clearly better than in the afternoon at the same elevation of the sun. The atmosphere and the ground are cool in the morning, and it takes a few hours before the sun has heated the ground enough for warm air to start to bubble up and mix with the cooler air at higher altitudes. In the afternoon, this process is already ongoing, and it takes a few hours before the atmosphere and the ground have cooled and the mixing stops. Note that the measurements in January and July are affected by poor statistics.

## 3 Conclusion

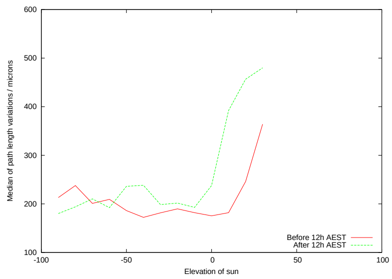
Scheduling of mm observations appears to be feasible at night throughout almost all of the year.



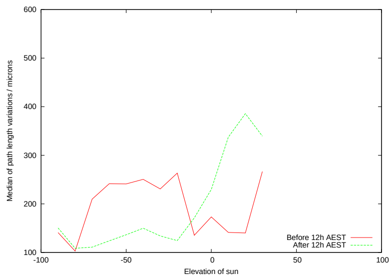

(a) January



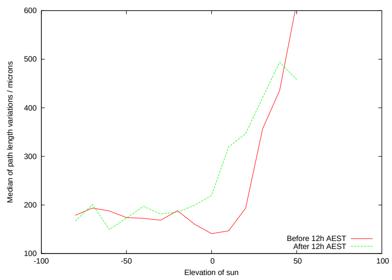

(b) May



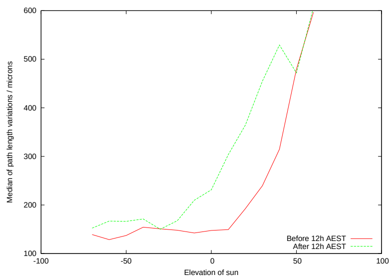

(c) June




(d) July

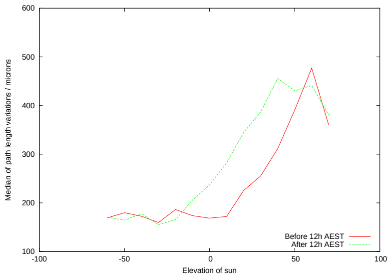



(e) August

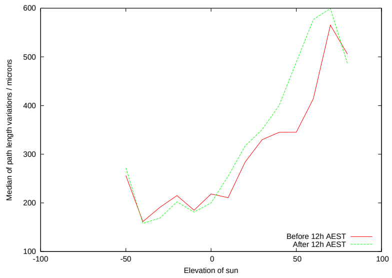



(f) September

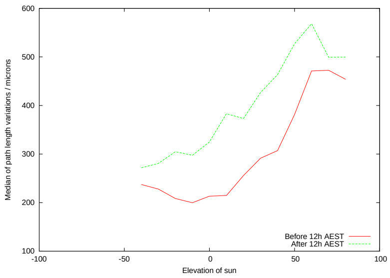
Figure 2: Rms of the path length variation as a function of solar elevation. Red lines show the first half of the day and green lines the second half.




(g) October




(h) November




(i) December

(Fig. 2 continued)