Meteorological Records for Magdalena Ridge Observatory

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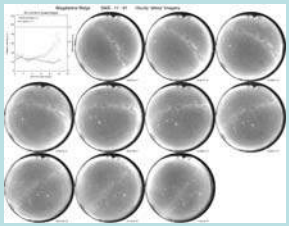
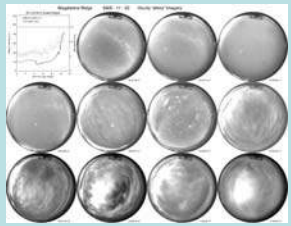
2.4-meter Telescope site, MROST

Introduction:
The Magdalena Ridge has been the site of astronomical research since the early 1970s. We are currently in the process of developing two modern astronomical research facilities on this broad, high ridge. One facility will be a fast tracking 2.4-meter telescope, MROST, with a focus on solar system based research and the other will be a multi-element optical/infrared interferometer, MROI, with base lines up to 400 meters. An analysis of the recent digital information will show that this site, located in the desert southwest at an elevation of 10,600 feet, is an excellent site for astronomical research. We will present analysis of weather data, allsky camera imagery and initial seeing measurements to support this conclusion.

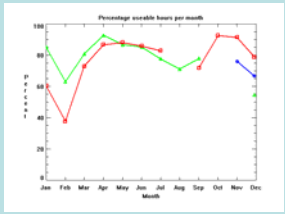
ALLSKY Camera





In order to determine the amount of clear night skies we installed a SBIG ALLSKY camera at a location near MROST. This location allowed us to see the horizon in all directions except in the north where South Baldy peak slightly blocked the horizon. Sixty second exposures are taken every 11 minutes. The "allsky" mosaic shown above has the first image from each hour. Using these images we have estimated the useable observing nights per month as shown below.

This "ALLSKY" mosaic for the night of November 23, 2005 shows a night that started out fairly clear but deteriorated as clouds moved in. The graph at the upper left corner shows wind speed as dots and relative humidity as a line. Both the wind speed and the RH increased as the clouds moved in.



A useable night was defined as when at least 50% of the images showed clear skies. We have data from November 2003 through December 2005. February is the worst month and the monsoon season in July and August is clearly visible.

Month	RH high	percent cloudy					useable hours
		100%	75%	50%	25%	00%	
Nov-03	3.09	18.92	1.93	2.70	4.63	68.73	76.06
Dec-03	16.67	11.95	4.72	2.83	4.72	59.12	66.67
Jan-04	8.96	1.49	4.48	2.99	1.49	80.60	85.07
Feb-04	24.31	9.39	3.31	1.10	3.31	58.56	62.98
Mar-04	1.28	17.31	0.64	1.28	3.85	75.64	80.77
Apr-04	0.00	5.69	1.63	1.63	3.25	87.80	92.68
May-04	0.00	8.76	4.64	2.06	8.25	76.29	86.60
Jun-04	0.00	9.15	5.63	2.11	8.45	74.65	85.21
Jul-04	0.66	15.13	6.58	3.95	17.11	56.58	77.63
Aug-04	8.00	15.50	5.50	4.50	6.50	60.00	71.00
Sep-04	12.21	7.56	2.33	2.91	1.74	73.26	77.91
Oct-04							
Nov-04							
Dec-04	13.86	25.74	5.94	24.75	4.95	24.75	54.46
Jan-05	22.11	16.08	1.51	1.01	0.00	59.30	60.30
Feb-05	17.39	40.58	4.35	2.90	4.35	30.43	37.68
Mar-05	16.31	10.64	0.00	2.13	2.13	68.79	73.05
Apr-05	6.25	4.69	2.34	1.56	6.25	78.91	86.72
May-05	0.00	11.01	0.00	9.17	0.00	78.90	88.07
Jun-05	0.00	13.16	0.88	2.63	7.02	76.32	85.96
Jul-05	1.32	10.53	5.26	1.32	11.84	69.74	82.89
Aug-05							
Sep-05	4.69	10.42	2.08	3.13	7.29	61.46	71.88
Oct-05	0.00	4.21	3.16	3.16	9.47	80.00	92.63
Nov-05	3.08	4.45	1.03	2.40	7.53	81.51	91.44
Dec-05	0.00	19.19	2.02	1.01	4.04	73.74	78.79

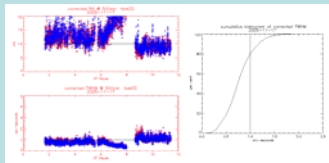
The table above lists the observed nightly hours that had a given percentage of hours clear. The "RH high" column lists the precentage of time that the RH was above 90% and hence would most likely be unusable. The "useable hours" column is a sum of the 50%, 25% and 0% columns.

DIMMWIT Seeing Results

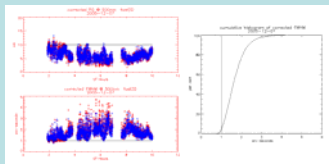
DIMMWIT stands for Differential Image Motion Monitor Which is Transportable (ref 1 and 2). The DIMMWIT has been used in conjunction with a Celestron C-14 telescope mounted on a Software Bisque Paramount ME mount. The CCD used is a Starlight Express MX516 with control software that allows exposure times as short as 1 millisecond and sub frame readout rates as high as 450 per second.

Measurements have been made at both the MROST (30 nights) and MROI (33 nights) sites over a period of 2 years. The FWHM has been measured to be better than 1 arc-second at 500nm 25% and 21% (respectively) for the two sites.

The charts shown below are examples of a good night and a poor night. For each night, the chart in the upper left hand portion shows the calculated value of the Fried parameter "r_0" (ref 4). The horizontal line is drawn at 10 cm which is equivalent to a FWHM of 1 arc-second at 500nm. The lower left hand graph shows the FWHM and the horizontal line is drawn at 1 arc-second. The cumulate histogram of the FWHM measurements is shown on the right side. The vertical line is drawn at 1 arc second for this night.

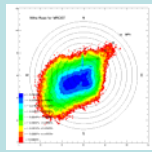


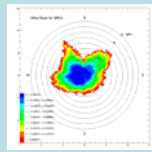
For the night of 2005-11-17 UT, the seeing was better than 1 arc-second ~ 80% of the time.



For the night of 2005-12-07 UT, the seeing was better than 1arc-second only 5% of the time.

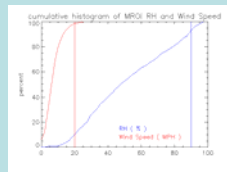
Weather Station Comparisons



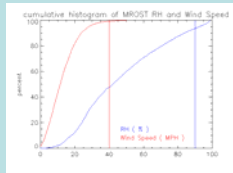


These wind roses show the frequency of the wind speeds and directions for the 2.4-meter telescope, MROST and the interferometer, MROI. The color contours increase by a factor of 2. The circles indicate wind speed in MPH from 5 to 50 MPH. The wind speeds at MROST are approximately 1.5 times as strong as the winds at MROI. The prevailing wind direction for MROST is from the Southwest while for MROI wind appears to come from the West through Northwest. The lack of wind from the North at MROI is due to the fact that MROI is in a saddle with a 100 -150 foot hill blocking the wind from North. The data included in these plots are from February 2005 through December 2005

The interferometer has a wind speed Operational design limit of 20 MPH



These cumulative histograms show what percentage of the night time a given parameter (RH or wind speed) is less than a given amount. The x-axis units are in % for the RH and in MPH for the wind speeds. Based on The operational design limits neither facility will be affected by high winds more than a few percent of the time.



The 2.4-m telescope has a wind Speed operational design limit of 40 MPH.

Conclusions:
If we define a useable night as one that is clear at least half of night, we have at least 70% useable nights except for February and the monsoon season of July and August.

While the winds can be high, they are usually below 10 -15 MPH at the MROI site and below 20 – 25 MPH at the MROST site. And with the design limits for each instrument, the winds will not be a limiting factor in observing time.

The seeing as determined by DIMMWIT measurements over the course of two years indicates that we have better than 1 arc-second seeing for at least 50% of a night on between 20 and 25 percent of the useable nights.

All of which will make the Magdalena Ridge Observatory a fine astronomical location.

Acknowledgements:
The DIMMWIT camera system used for the seeing measurements is on loan from Cambridge University.

The panoramas of the MROST and MROI sites were taken by Dr. Mark Vincent of the MROST project.

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References:
1. B. O'Donovan, J. S. Young, P. J. Warner, D. F. Buscher, D. M. A. Wilson, R. C. Boysen, E. B. Seneta, and J. W. Keen. Comparing atmospheric seeing values measured by a Differential Image Motion Monitor, Which Is Transportable and COAST. In *Interferometry for Optical Astronomy II*, volume 4838 of *Proc. SPIE*, page 794. 22-28 August 2002, Kona, Hawai, SPIE Press, 2003.

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4. Fried, D., 1965, J. Opt. Soc. Am., 55, 1427.

Interferometer site, MROI