Radiometrics
Ahead of the Weather

Optical Seeing based on Microwave Radiometry

Atmospheric turbulence can significantly degrade the performance of optical communication systems. Fortunately, atmospheric turbulence can be independently determined to both characterize operational sites and optimize use of such a system. Atmospheric conditions relevant to turbulence are characterized by the Fried parameter[1] (r_0). This parameter can calculated from differential image motion monitor (DIMM) measurements. Alternatively, r_0 can be calculated from numerical weather models, or from combined model and microwave radiometer profiler observations. This application note discusses optical seeing calculation from combined model and radiometer data.

Differential Image Motion Monitors

Optical seeing can be obtained from DIMM measurements[2]. This technique uses a two hole mask over a Schmidt-Cassegrain telescope aperture, measuring fluctuation of two spots seen when a bright star is imaged out of focus with a fast camera. It detects atmospheric turbulence while rejecting poor tracking and wind vibration noise identified by two spot aggregate motion. However, the resulting system is complicated, requiring an automated weatherproof enclosure, significantly increasing the total cost.

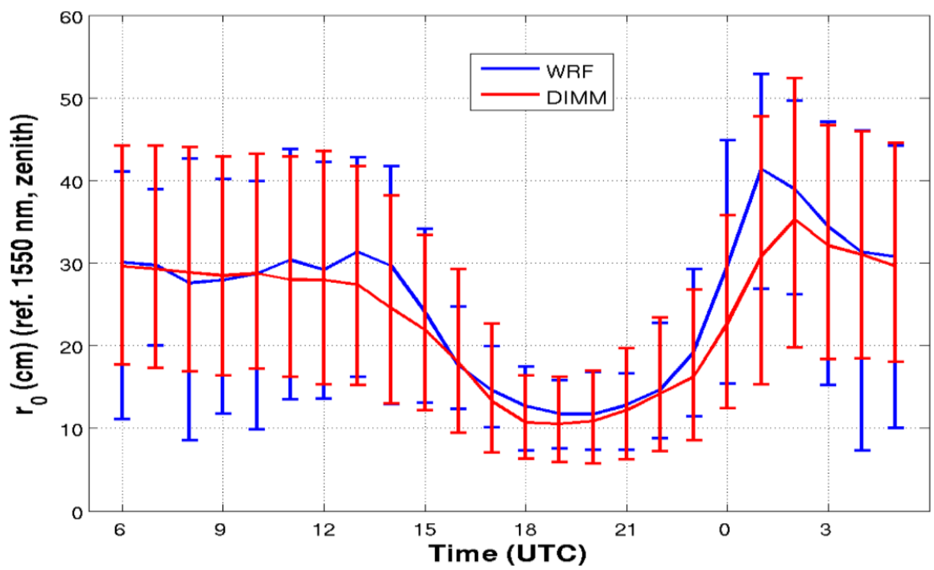

Figure 1. Optical seeing (Fried parameter) estimates based on DIMM and WRF.

Numerical Weather Models

Numerical weather models can be used to estimate and predict optical seeing[1]. Optical seeing is closely related to optical wavefront phase distortion quantified by the Fried parameter[3]. DIMM can be used to measure r_0, and it can also be estimated using

[1] Fried, 1965.
[2] Aristide et al, 2014; Pedersen et al, 1988.
[3] Fried, 1965.

numerical weather analysis and prediction. Smaller r_0 values indicate more severe turbulence and increasingly degraded atmospheric optical seeing conditions. Turbulence determination based on DIMM and the Weather Research and Forecast (WRF) numerical weather model are essentially equal, as shown in Figure 1. Details of optical seeing estimation from numerical weather model analysis and prediction are provided by Kemp et al, 2008.

Improved Optical Seeing Monitoring

Numerical weather model analysis and prediction accuracy can be significantly improved by inclusion of high temporal and spatial resolution microwave radiometer profiler boundary layer temperature and humidity information[4]. Specifically, one-dimensional variational (1DVAR) microwave profiler retrievals can be used to improve model accuracy[5]. Radiometrics has been providing automatic real time 1DVAR soundings combining model and radiometer data from multiple sites for the past several years[6]. The 1DVAR soundings provide higher accuracy temperature and humidity information than the model alone due to radiometer data inclusion, in addition to model winds. As a result, improved optical seeing accuracy monitoring and prediction is expected using 1DVAR compared to WRF soundings.

References

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[4] NRC, 2008;

[5] Illingworth et al, 2015.

[6] www.radiometrics.com/live-data (Sigma Soundings)