Optical Extinction Measurements of Laser Side-Scatter During Tropical Storm Colin

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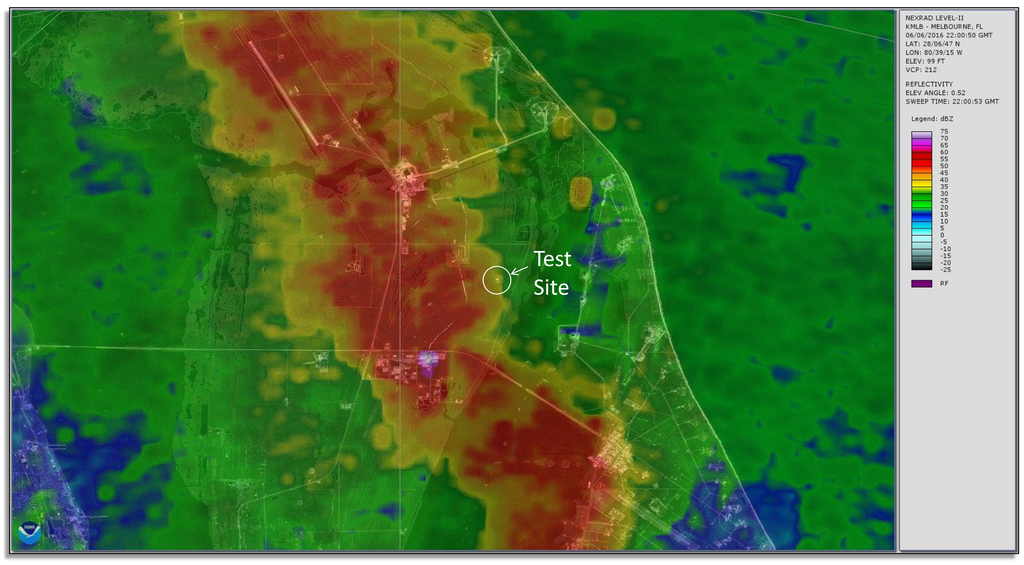
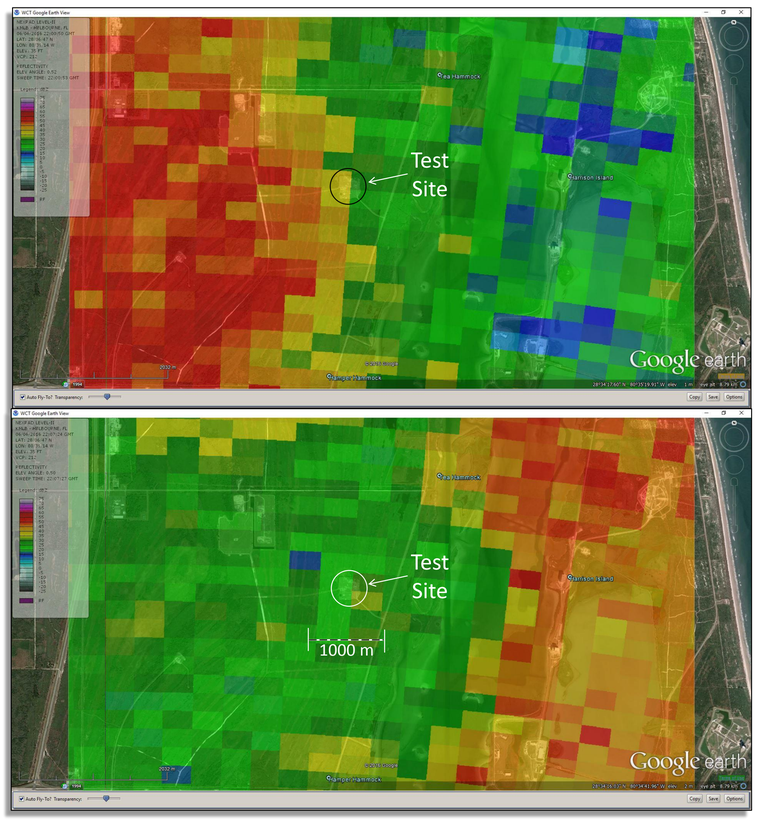
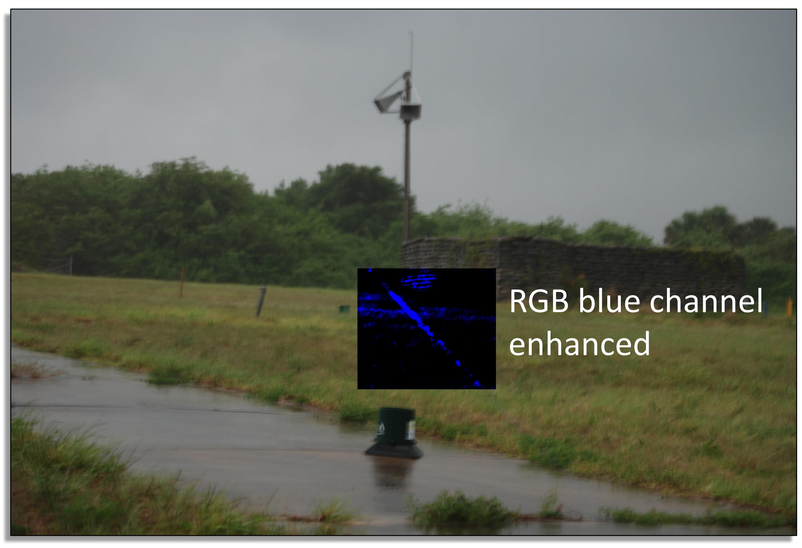


22:00:53 GMT scan of Melbourne dual pole radar.

A side-scatter imaging (SSI) technique using a 447 nm, 500 mW laser and a Nikon D80 camera was tested at Kennedy Space Center, Florida during the passing of a rain band associated with Tropical Storm Colin. The June 6, 2016, 22:00 GMT rain event was intense but short-lived owing to the strong west-to-east advection of the rain band. An effort to validate the optical extinction measurement was conducted by setting up a line of three tipping rain gauges along an 80 m east-west path and below the laser beam. Differences between tipping bucket measurements were correlated to the extinction coefficient profile along the laser's path, as determined by the SSI measurement. In order to compare the tipping bucket to the optical extinction data, a Marshall-Palmer DSD model was assumed. Since this was a daytime event, the laser beam was difficult to detect in the camera images, pointing out an important limitation of SSI measurements: the practical limit of DSD density that can be effectively detected and analyzed under daylight conditions using this laser and camera, corresponds to a fairly moderate rainfall rate on the order of 20 mm/h (night measurements achieve a much improved sensitivity). The SSI analysis model under test produced promising results, but in order to use the SSI method for routine meteorological studies, improvements to the math model will be required.

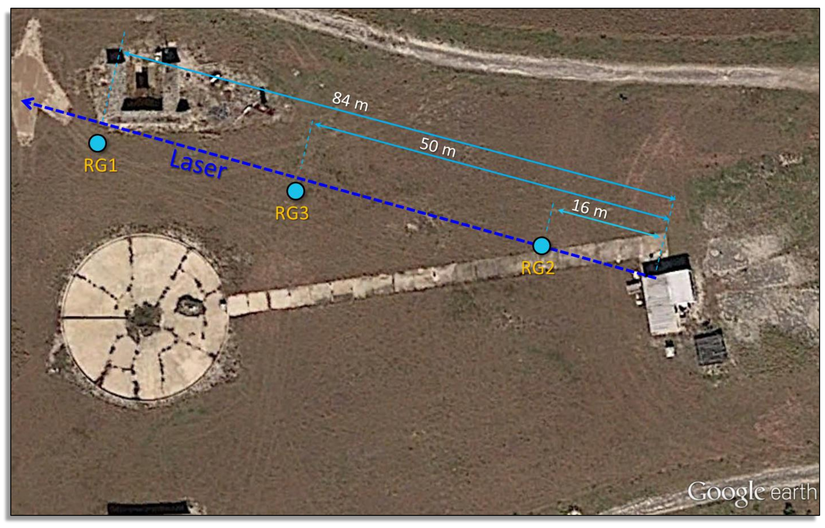


Passing of rain band at 22:00:53 GMT (top) and 22:07:27 GMT (bottom) over test site.

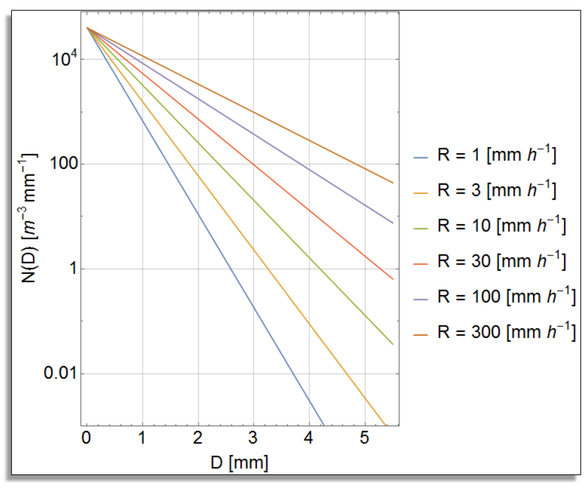


Laser SSI at: (top) 18.0853 h (22:05:07 GMT); (bottom) 18.1047 h (22:06:17 GMT).

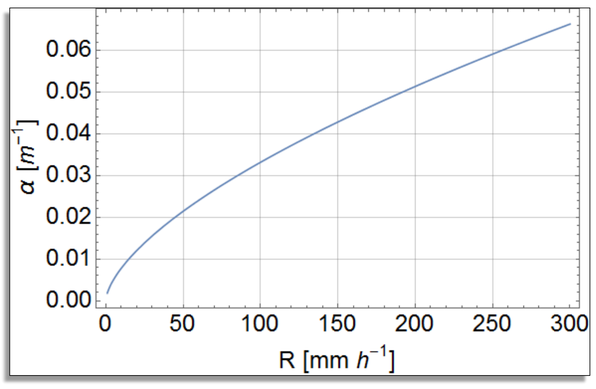
Prototype laser-camera SSI system.



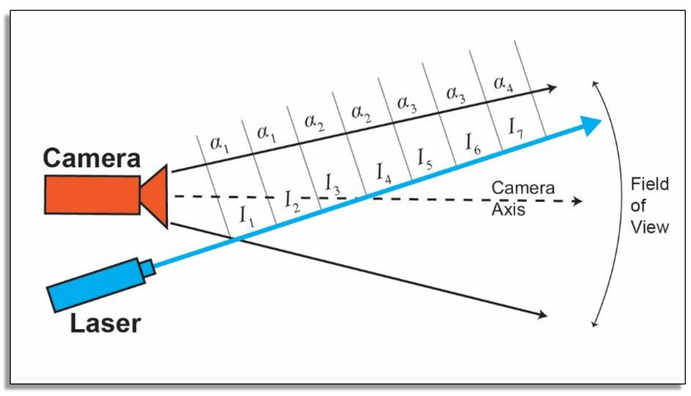
Laser and tipping bucket rain gauges at laser test site.



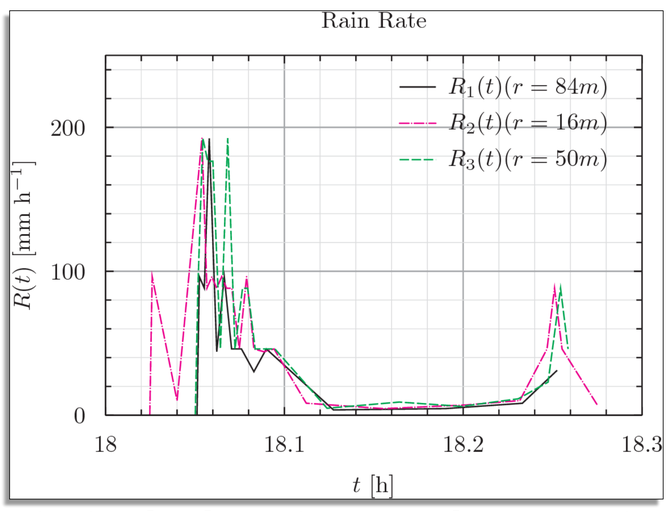
Marshall-Palmer DSD.



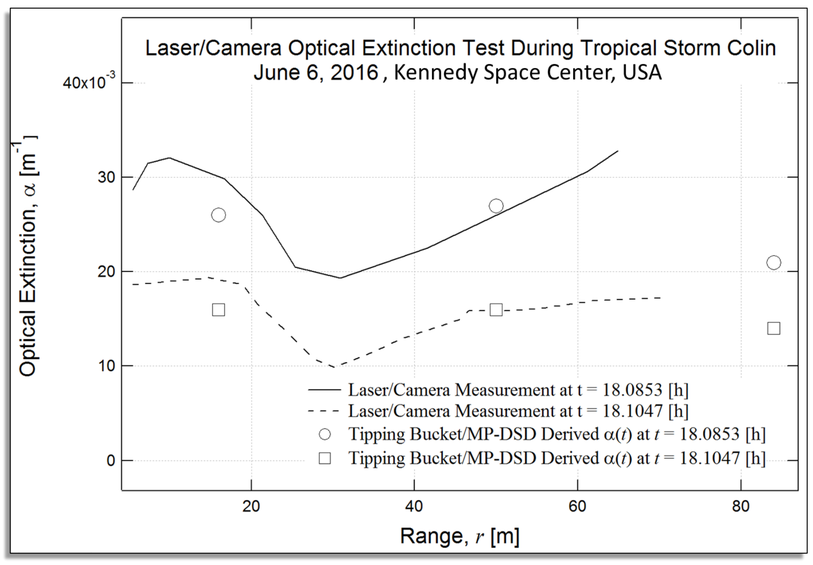
Extinction coefficient as a function of rainfall rate using MP-DSD.



Discrete path and volume segments used by math model approximation.



Tipping bucket rain rate at laser test site.



SSI extinction coefficient profile versus tipping bucket.

$$\hat{I}_k = \frac{\beta}{x_k^{\gamma}}\left(1 - e^{-\alpha_k \lambda}\right)\prod_{j=1}^{k}\exp\left(-2\alpha_j \Delta x_j\right)$$

SSI math model.