Characteristics of Optically-Thin Coastal Florida Cumuli derived from surface-Based Micropulse Lidar measurements

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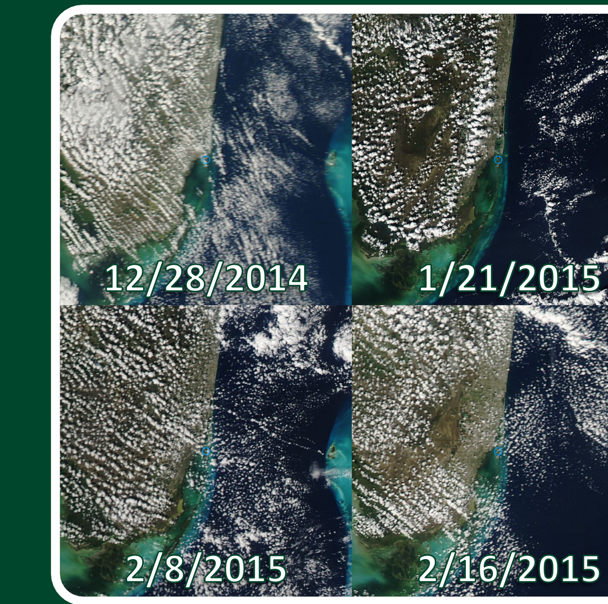


Introduction

- Clouds play an important role in Earth's climate and energy budget.
- Clouds of low optical depth are underrepresented in climate models, with their response to a warmer climate poorly understood, including changes in their vertical distribution.
- Over South Florida, the small cumuli that are iconic of trade wind regions are common year-round. This makes our study site, located 3 km east of mainland Miami, Florida, a good location for studying such clouds.
- We characterize the optical depth and sizes of shallow cumuli with a micropulse lidar during a 10 week period.

Aim

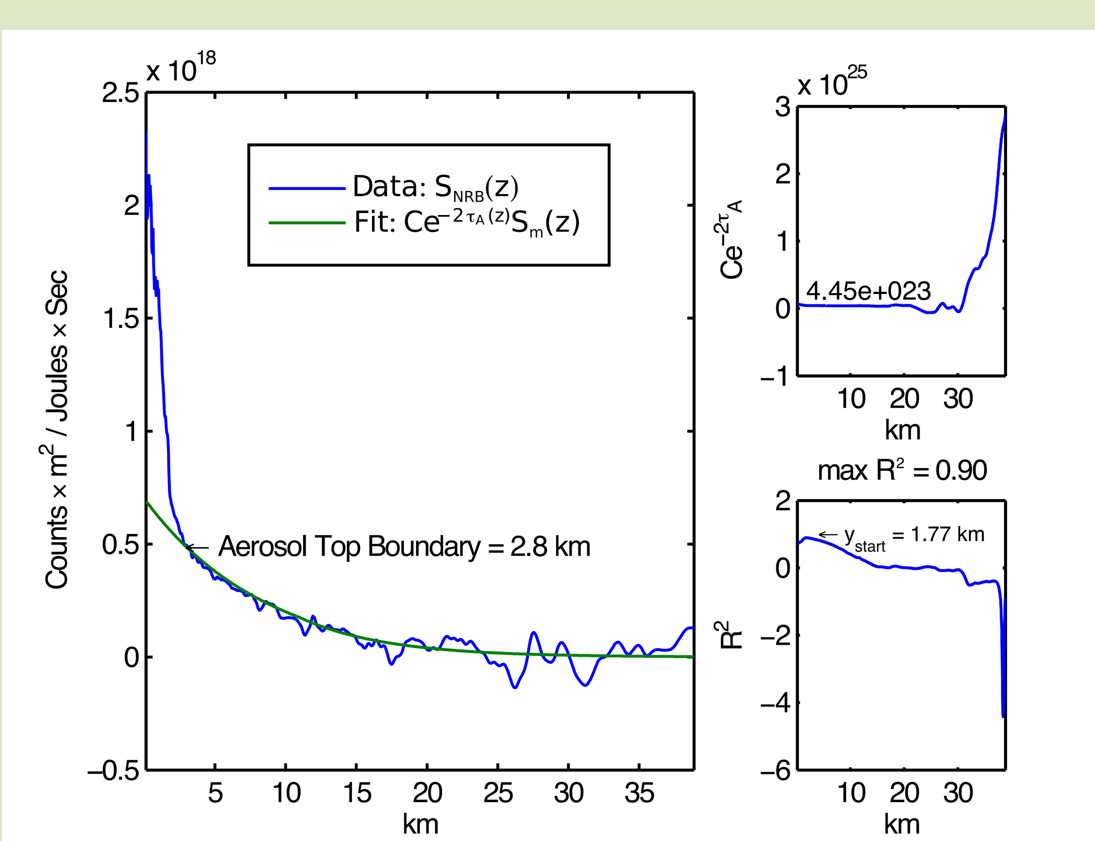
- Characterize radiatively-important small shallow cumuli clouds that are too small for robust characterization from space-based remote sensing.
- Refine a lidar extinction algorithm to depict the optical depth and sizes of small passive shallow clouds.

Finding the Lidar Constant (Inversion with AOD)

- The raw lidar signal is converted to normalized relative backscatter (NRB) after applying the overlap, afterpulse, deadtime, and range corrections:

$$S_{NRB}(z) = C(\beta_a(z) + \beta_m(z))e^{-2(\tau_a(z)+\tau_m(z))}$$

- The molecular portions (m) of S_{NRB} are characterized using a US Standard Atmosphere Model, which agrees well with local sounding measurements.
- The lidar constant (C) is found using a molecular fitting algorithm developed at the University of Miami to find the statistically best top of the aerosol layer and is constrained to on-site Aeronet AOD measurement.

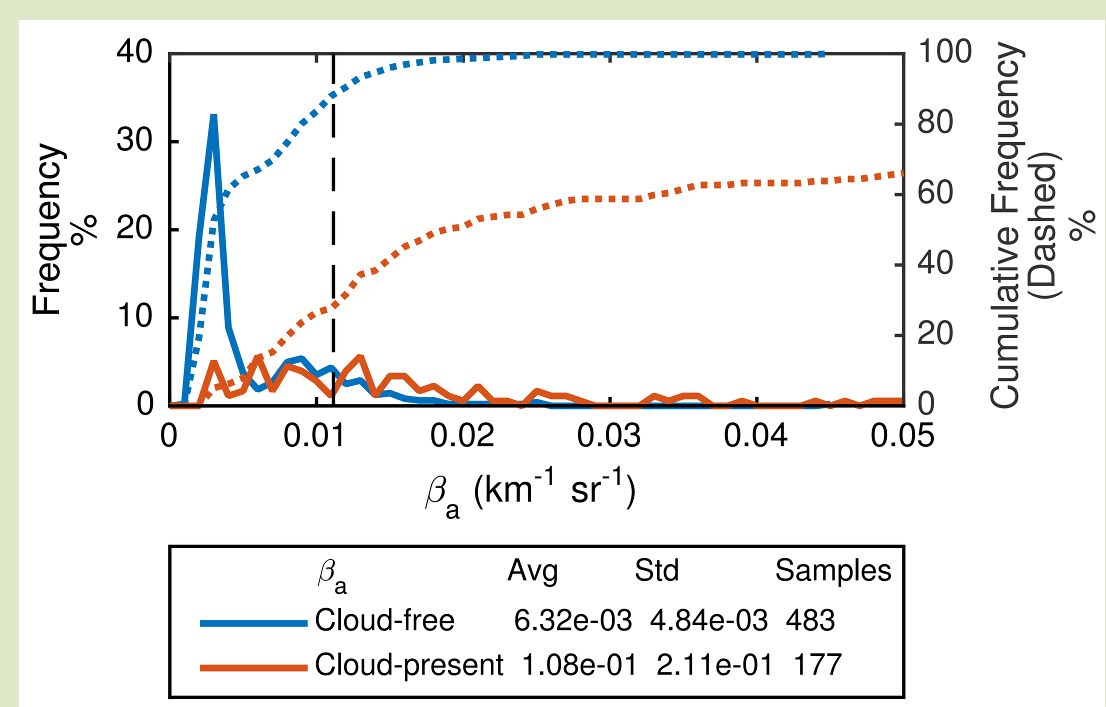


Finding Extinction (Inversion with C)

- A molecular fitting algorithm is applied similar to that which finds the lidar constant method, but begins with the previously-derived lookup table of C values.
- The new profile's molecular fitting constant is combined with the look-up C value to solve for the total optical depth.
- The aerosol/cloud backscatter coefficient (β_a), extinction (σ_a), integrated optical length (τ_a) are obtained using the Fernald algorithm.
- Aerosol and cloud are discriminated and separately characterized

Identifying the Cloud Threshold

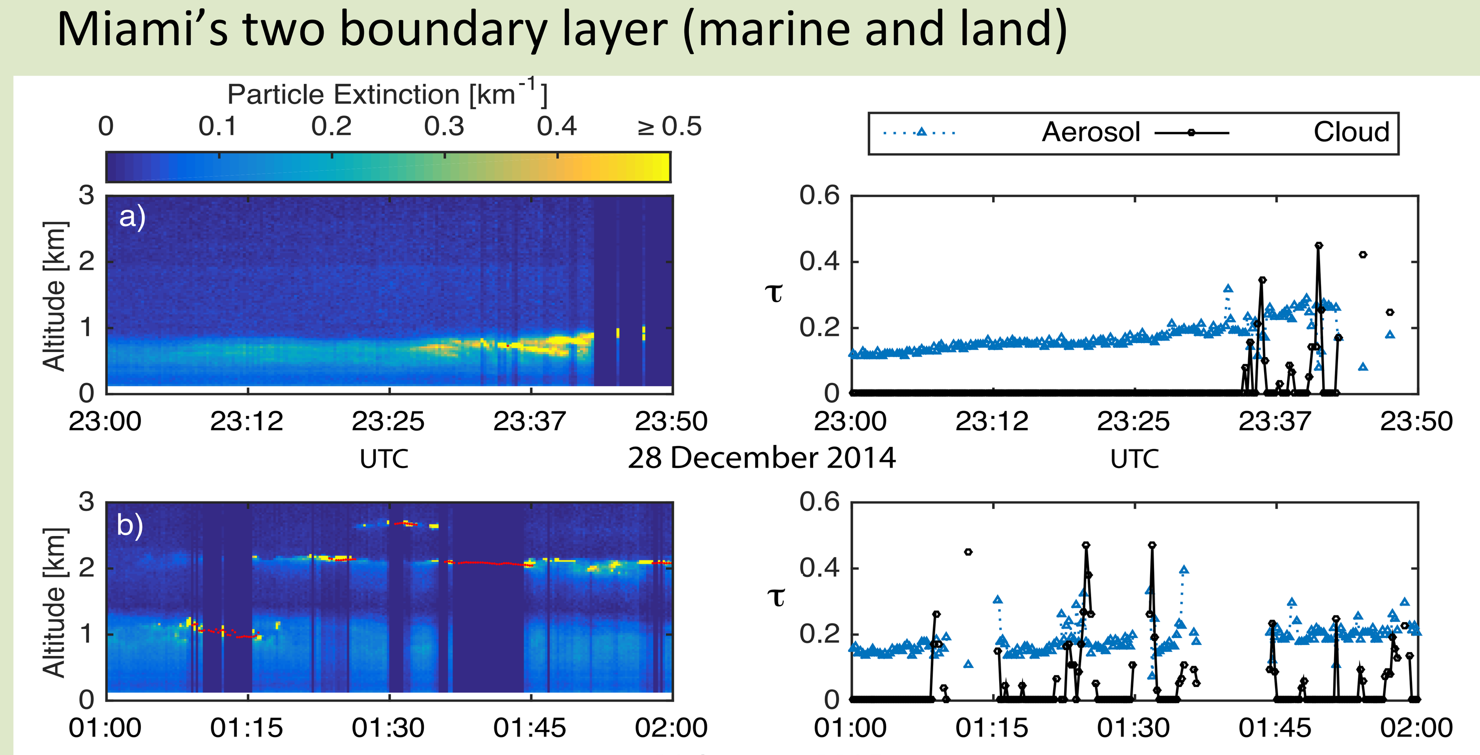
- Clouds are identified using an empirically-derived particle backscatter coefficient threshold based on visual identification of clouds from sky camera imagery.



- Comparison to ceilometer cloud base height indicates a similar distribution to lidar

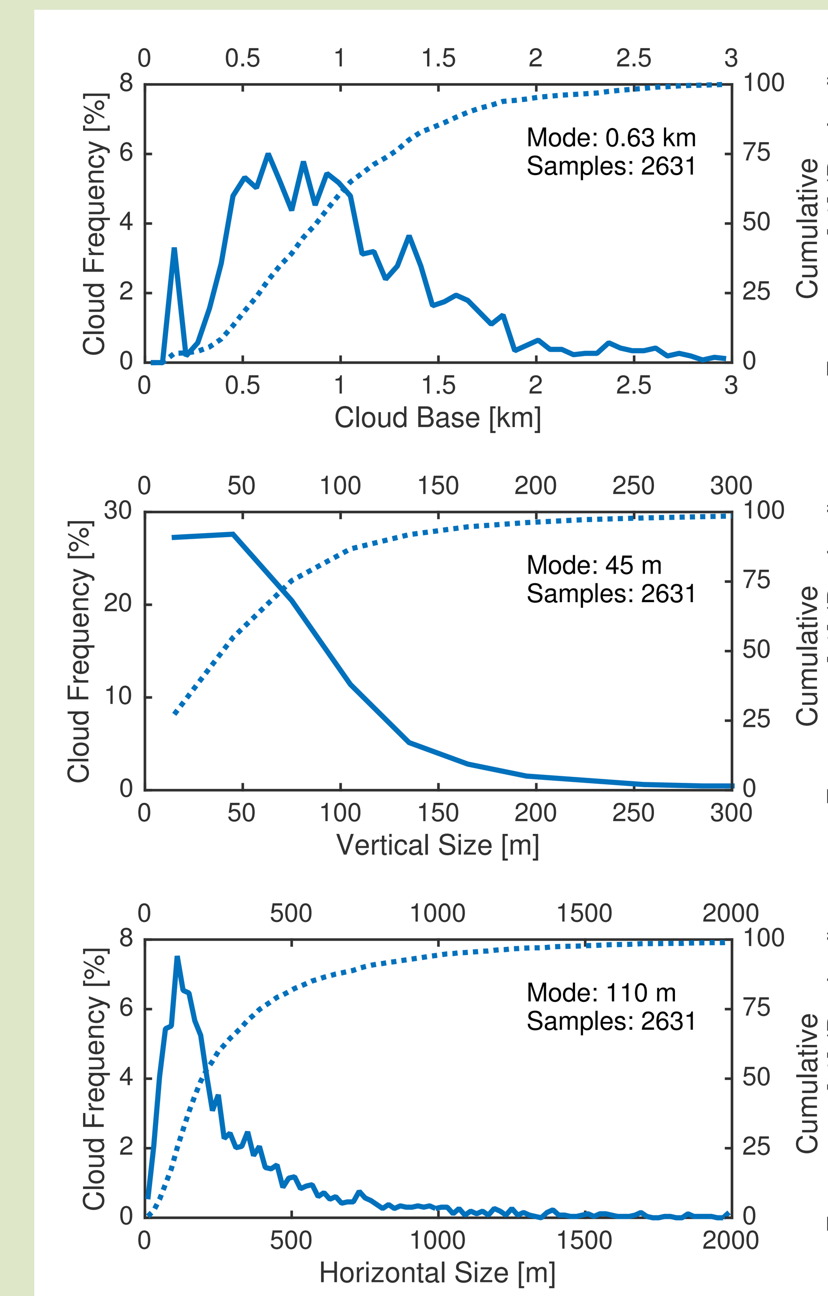
Examples of lidar extinctions and optical depths

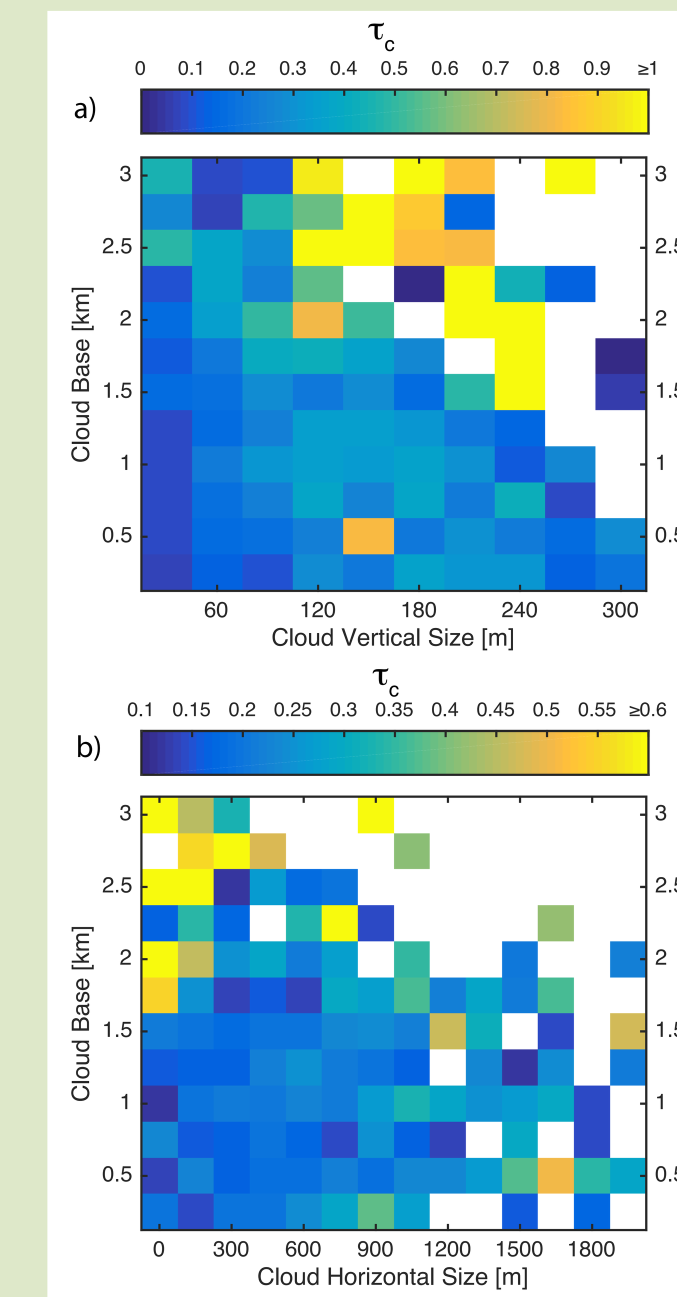
- Indicate a) aerosol hygroscopic swelling barely becoming a cloud before dissipating again (latter not shown) and b) multi-layer clouds, at edges of ceilometer-detected clouds, indicative of Miami's two boundary layer (marine and land)



Cloud Size and Optical Depth

- Lidar-derived frequency (solid) and cumulative frequency (dashed) distributions for cloud base height, cloud thickness, and cloud horizontal extent:





Conclusion

- Clouds with optical depths less than one constitute 12% of the sampled dataset, indicating they are ubiquitous in this synoptically-suppressed environment.
- Such clouds, at this location, occur most frequently at the top of the surface-based mixed layer, are less than 50 m thick and extend horizontally for less than 200 m, most frequently for 110 m and occasionally up to 2 km
- These clouds are too small to be detected by space-based lidar

Acknowledgements

More detail will be available in Delgadillo, R., K. Voss and P. Zuidema, 2018: Characteristics of optically-thin coastal Florida cumuli derived from surface-based lidar measurements. J. Geophys. Res., currently under review.

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