

Comparing remote-sensing observations of aerosols and clouds

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SCIENCE



OVERVIEW

The interaction of clouds and aerosols is one of the least well-understood phenomena affecting climate change, atmospheric dynamics and weather.

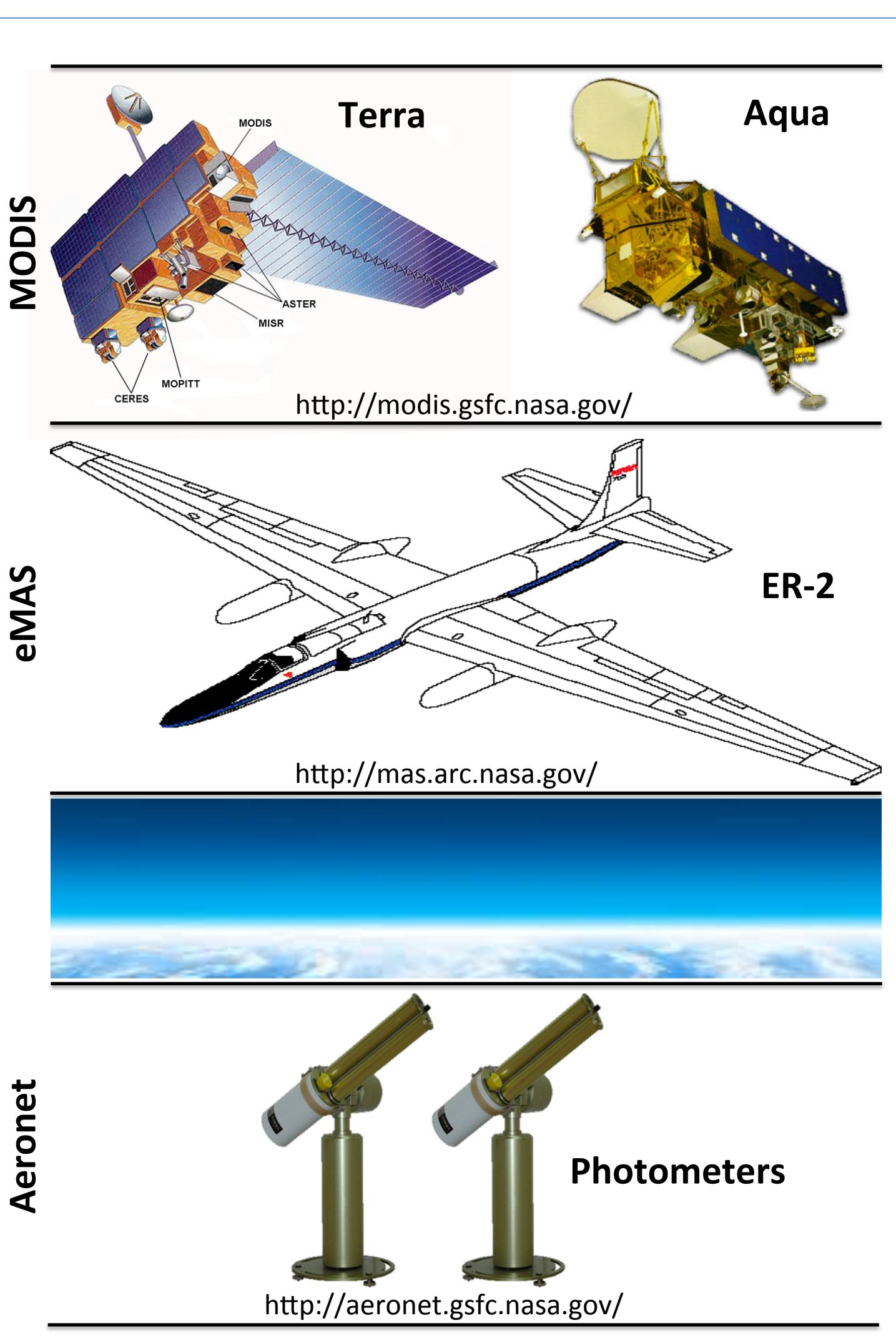
Motivation

The Dark Target (**DT**) satellite retrieval algorithm is responsible for the global distribution of **aerosol optical depth (AOD)** products from the Moderate Resolution Imaging Spectroradiometer (**MODIS**) instrument on the **Terra** and **Aqua** EOS.

This coarse resolution product leaves us with **significant uncertainty in quantifying aerosol cloud interactions**. We want to improve our knowledge using higher resolution data.

Evaluation of High Resolution eMAS data

The DT algorithm was applied to high resolution enhanced-MODIS Airborne Simulator (**eMAS**) data obtained during the "Studies of Emissions, Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (**SEAC4RS**) campaign over the U.S. in 2013. The instrument was deployed in the ER-2 high-altitude aircraft. Aligned with eMAS, the Cloud Physics Lidar (**CPL**) takes centerline profiles at nadir. Additionally, the Aerosol Robotic Network (**AERONET**) provides ground-based AOD measurements for validation of remote-sensed retrievals.



Methods

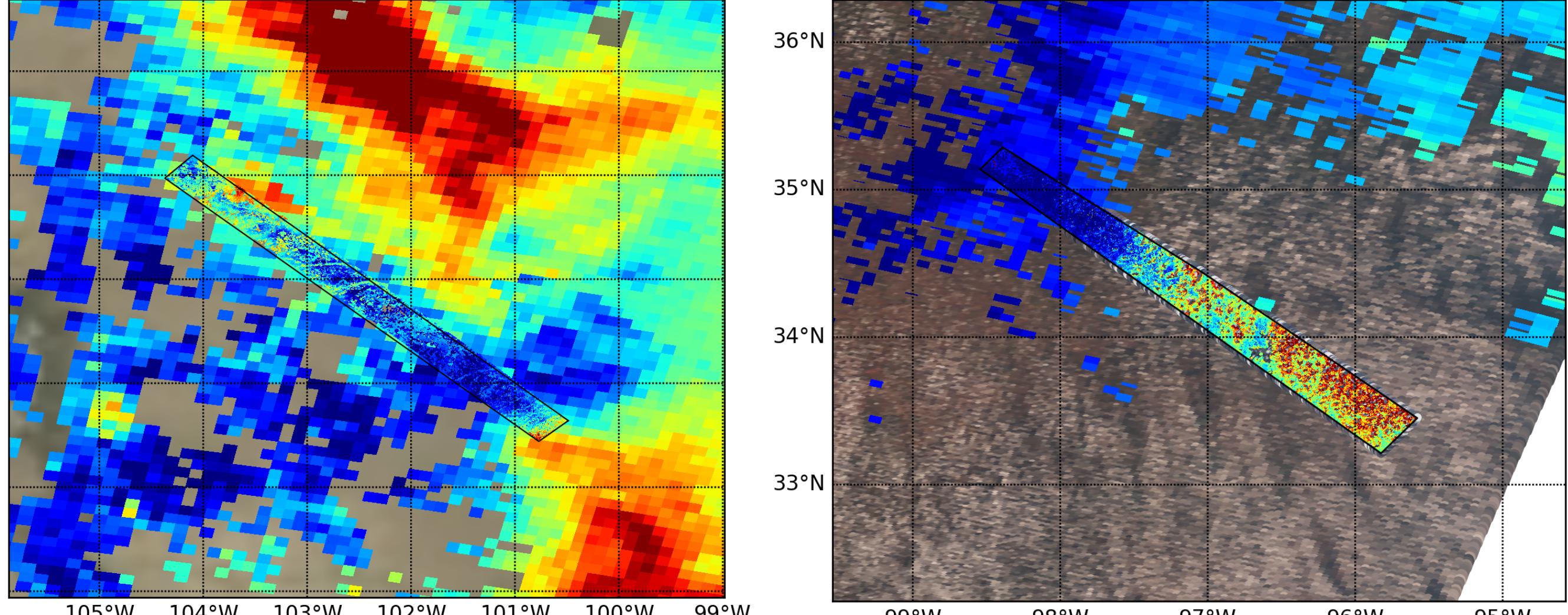
- eMAS was **collocated** with Aeronet and MODIS overpasses.
- The **distance and direction to the nearest cloud** was calculated for every pixel based on the cloud product cloud masks for analysis.

Evaluation of eMAS vs. MODIS DT Products

68 Collocations within +/- 30 min

Resolution: MODIS @ 10 km , eMAS @ 500 m

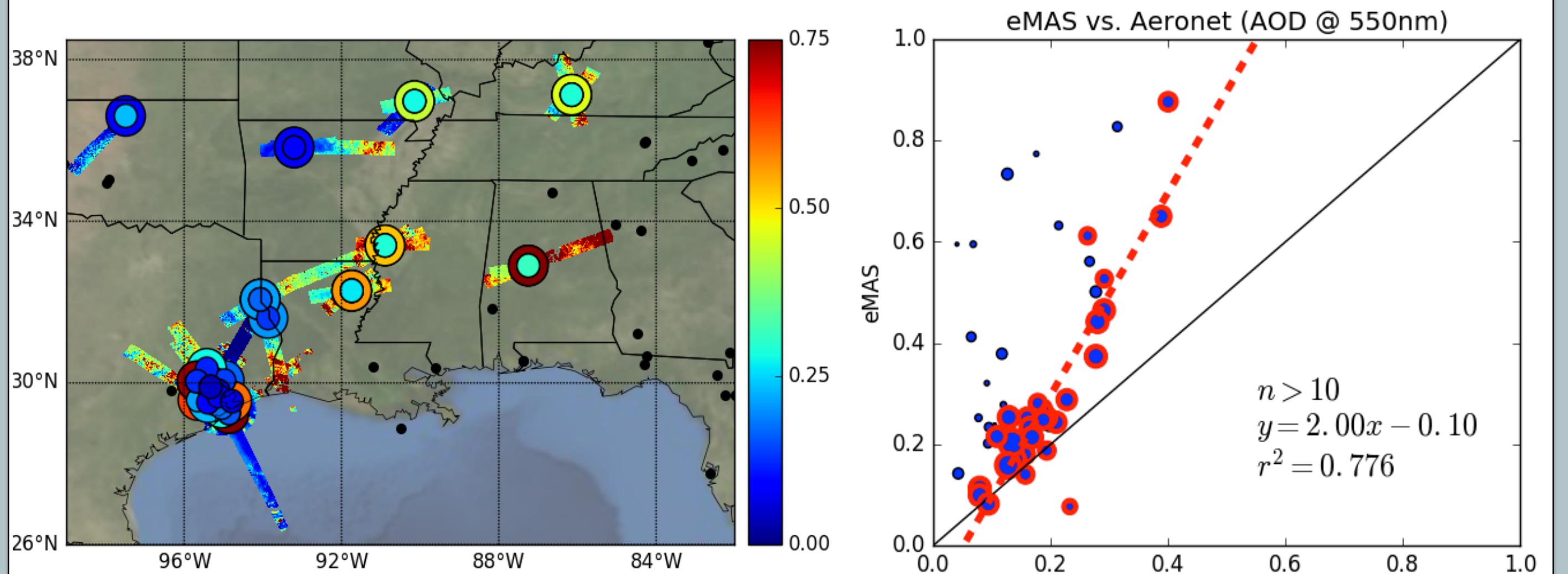
August 19th @ 1714



- eMAS and MODIS retrievals agree in 'clear' sky conditions (left)
- eMAS retrieves elevated AOD within cloud fields (right)

Evaluation of eMAS using Aeronet

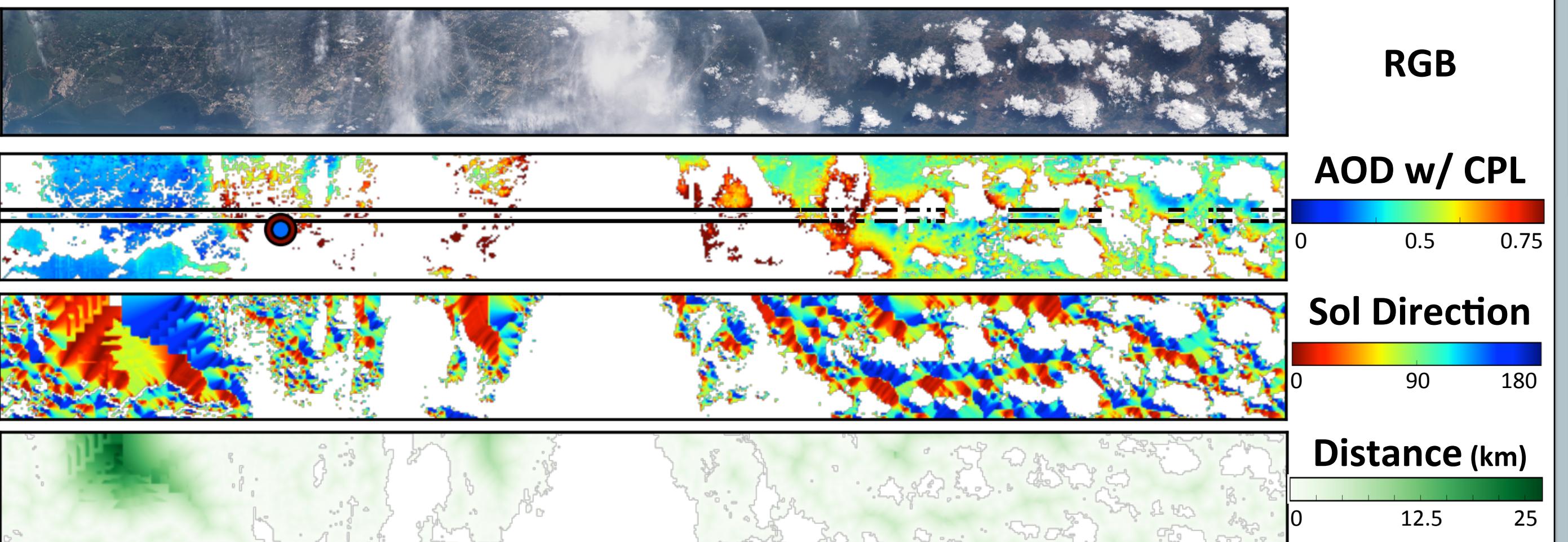
53 Collocations within +/- 3 km and +/- 30 min



- Inner circles specify the Aeronet temporally-collocated samples
- Outer circles specify the eMAS spatially-collocated samples
- Enhanced aerosol bias at higher resolution by a factor of 2**

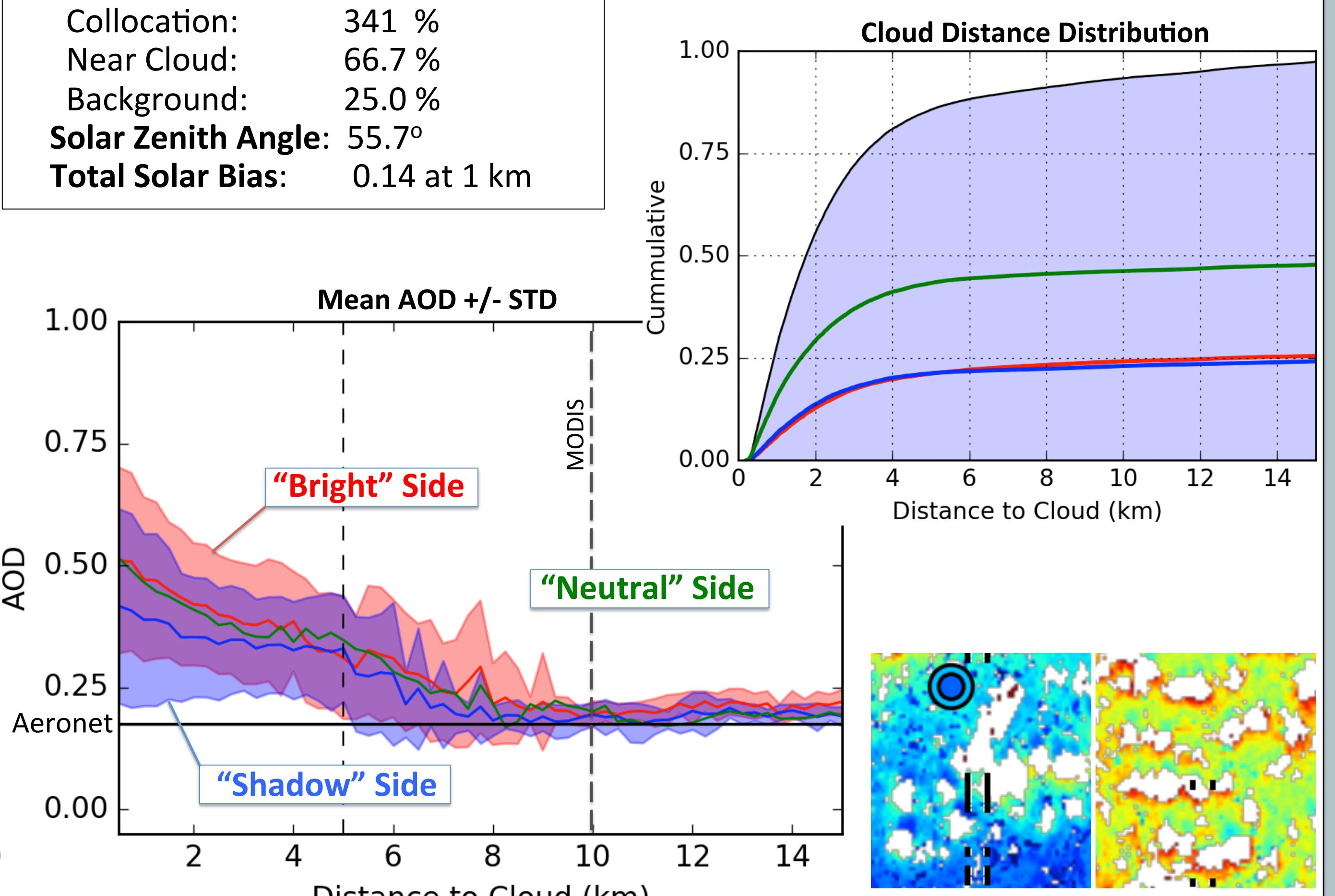
eMAS AOD near Cloud Fields (Direction & Distance)

August 19th @ 2205



AOD Difference from Aeronet:

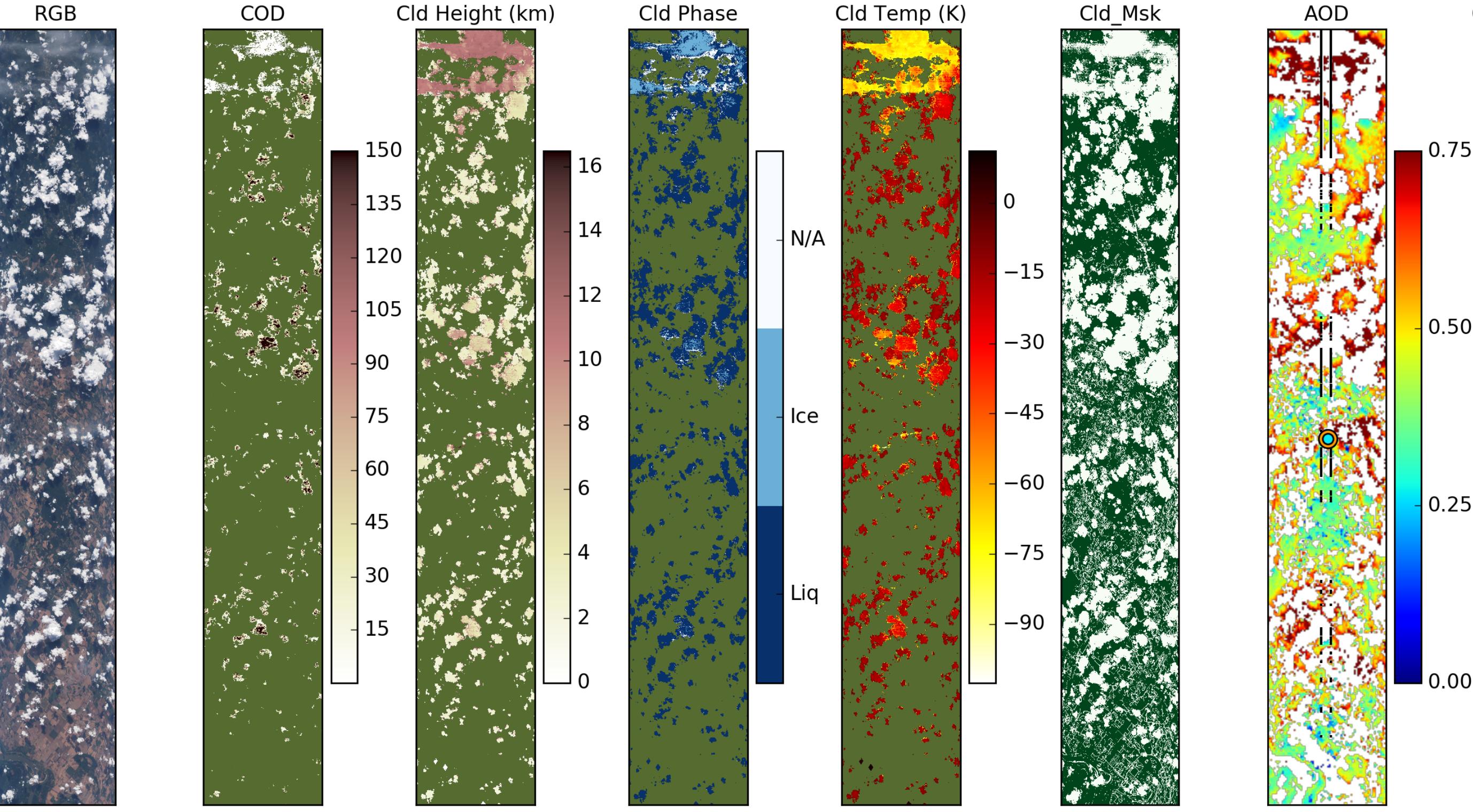
Collocation: 341 %
Near Cloud: 66.7 %
Background: 25.0 %
Solar Zenith Angle: 55.7°
Total Solar Bias: 0.14 at 1 km



- AOD measurements tended to converge to a "clear sky" value with increasing distance from cloud (closer to Aeronet value)
- Within 5 km of clouds, there is generally a high bias of AOD on the sunward facing side of a cloud and a low bias on the "shadow" side.
- 50 % of the "clear" sky pixels are within 2 km of a cloud.

eMAS & CPL Observations of Clouds and Aerosol

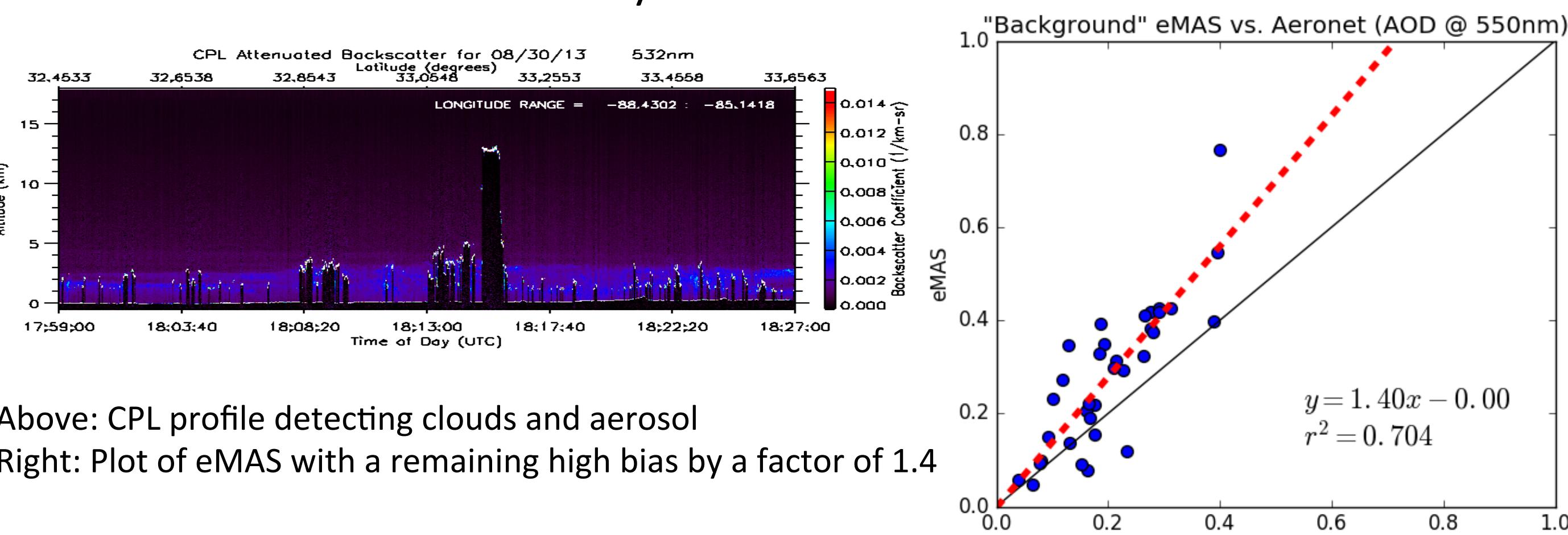
September 18th @ 2032



- eMAS retrieved **rings of enhanced AOD** around some but not all of the identified clouds.
- DT **cloud mask is overly conservative** (picks up surface artifacts)
- CPL registers clouds even when eMAS does not (high cirrus?)

CONCLUSION & FUTURE WORK

- Our study confirms that clouds are not defined by simple boundaries, but as gradients, making a universal cloud mask difficult to delineate.
- Additional work is needed to quantify the presence of the enhanced AOD, such as collocating AOD retrievals with the full CPL profiles.
- Continued analysis is needed to explain the remaining bias and further characterize the gradient behavior of aerosols near-cloud and the conditions under which they occur.



Above: CPL profile detecting clouds and aerosol
Right: Plot of eMAS with a remaining high bias by a factor of 1.4

ACKNOWLEDGEMENTS

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