

NASA Langley’s Airborne Multiwavelength High Spectral Resolution Lidar: Status and Measurement Examples

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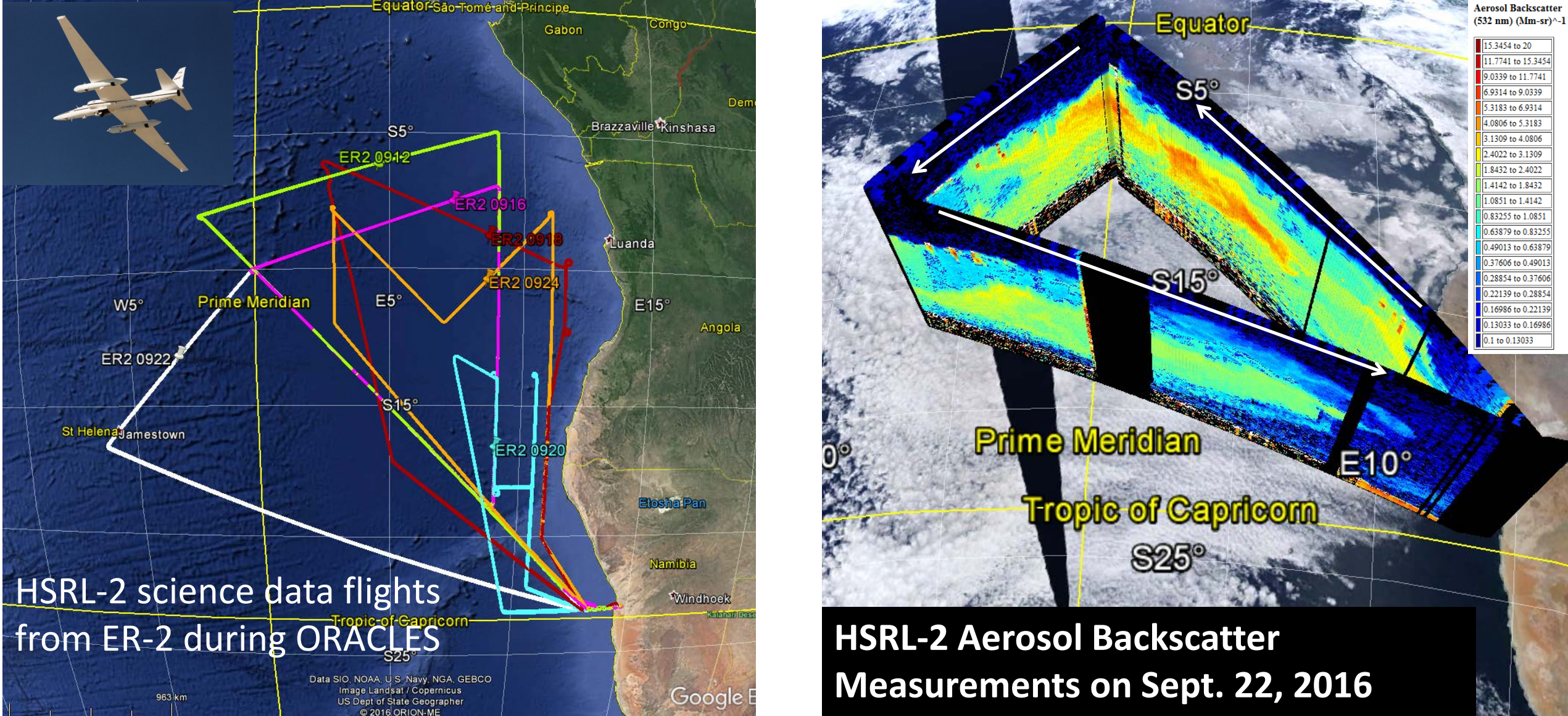
Introduction

The NASA Langley Research Center airborne High Spectral Resolution Lidar (HSRL-2) provided extensive measurements of smoke above shallow marine clouds while deployed from the NASA ER-2 aircraft during the NASA EV-5 Observations of Aerosols above Clouds and their Interactions (ORACLES) mission. During the first ORACLES field campaign in September 2016, the ER-2 was deployed from Walvis Bay, Namibia and conducted flights over the southeastern Atlantic Ocean. HSRL-2 measured profiles of aerosol backscattering, depolarization, extinction and aerosol optical depth (AOD) at 355 and 532 nm and aerosol backscattering and depolarization at 1064 nm and so provided an excellent characterization of the wide-spread smoke layers above shallow marine clouds. We present profiles of aerosol microphysical properties such as concentration and effective radius that are derived from the HSRL-2 multiwavelength measurements of backscatter and extinction.

HSRL-2 Data/Measurements/Retrievals:

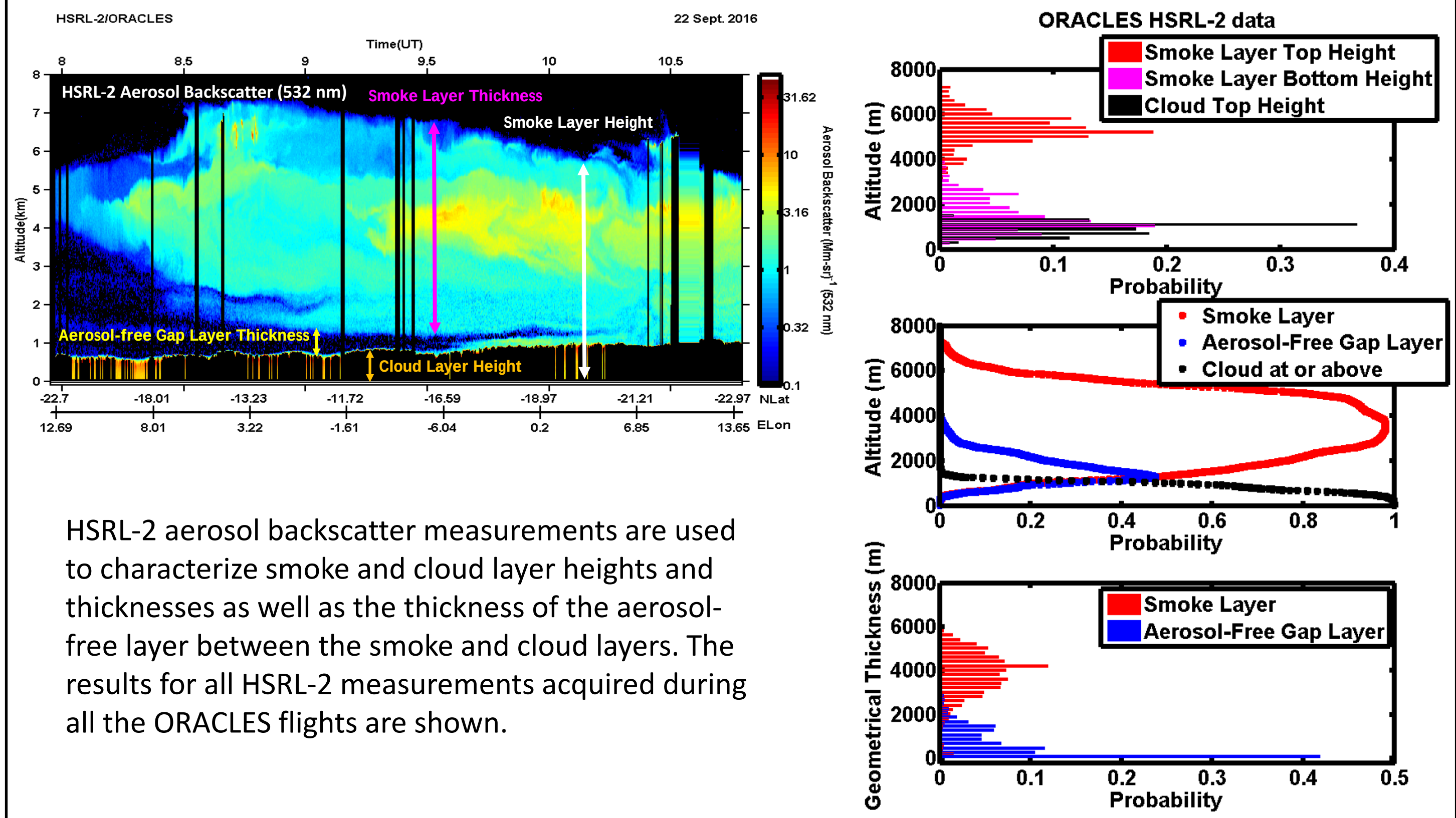
- Aerosol backscatter, depolarization (355, 532, 1064 nm)
- Aerosol extinction and AOD profiles (355, 532 nm)
- Qualitative aerosol classification
- Mixed layer height
- Multiwavelength aerosol retrievals of particle properties (e.g. effective radius, concentration)

NASA ORACLES Mission



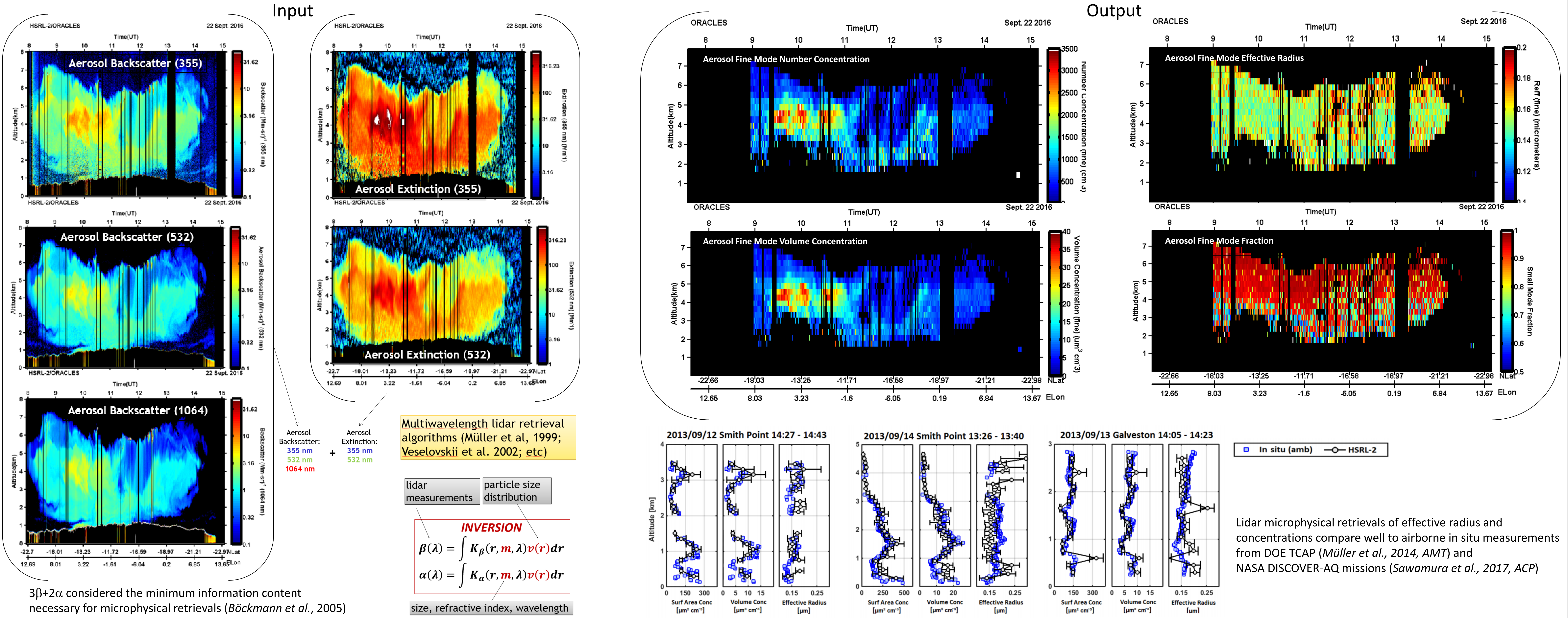
The NASA EV-5 ORACLES mission is being conducted to study the climate impacts of African biomass burning aerosols. Smoke produced over Africa is transported over the southeastern Atlantic Ocean and above the subtropical stratocumulus cloud deck. The direct radiative effects of the smoke depend on the optical properties of the smoke as well as the reflectance and coverage of the clouds below. Depending on the relative vertical location of the smoke aerosols and low level clouds, the smoke can change the cloud condensate, thickness, and lifetime. The airborne HSRL-2 provides an important suite of measurements to characterize the smoke and cloud heights and thicknesses as well as the smoke layer optical properties.

Example of smoke and cloud layers measured on September 22, 2016



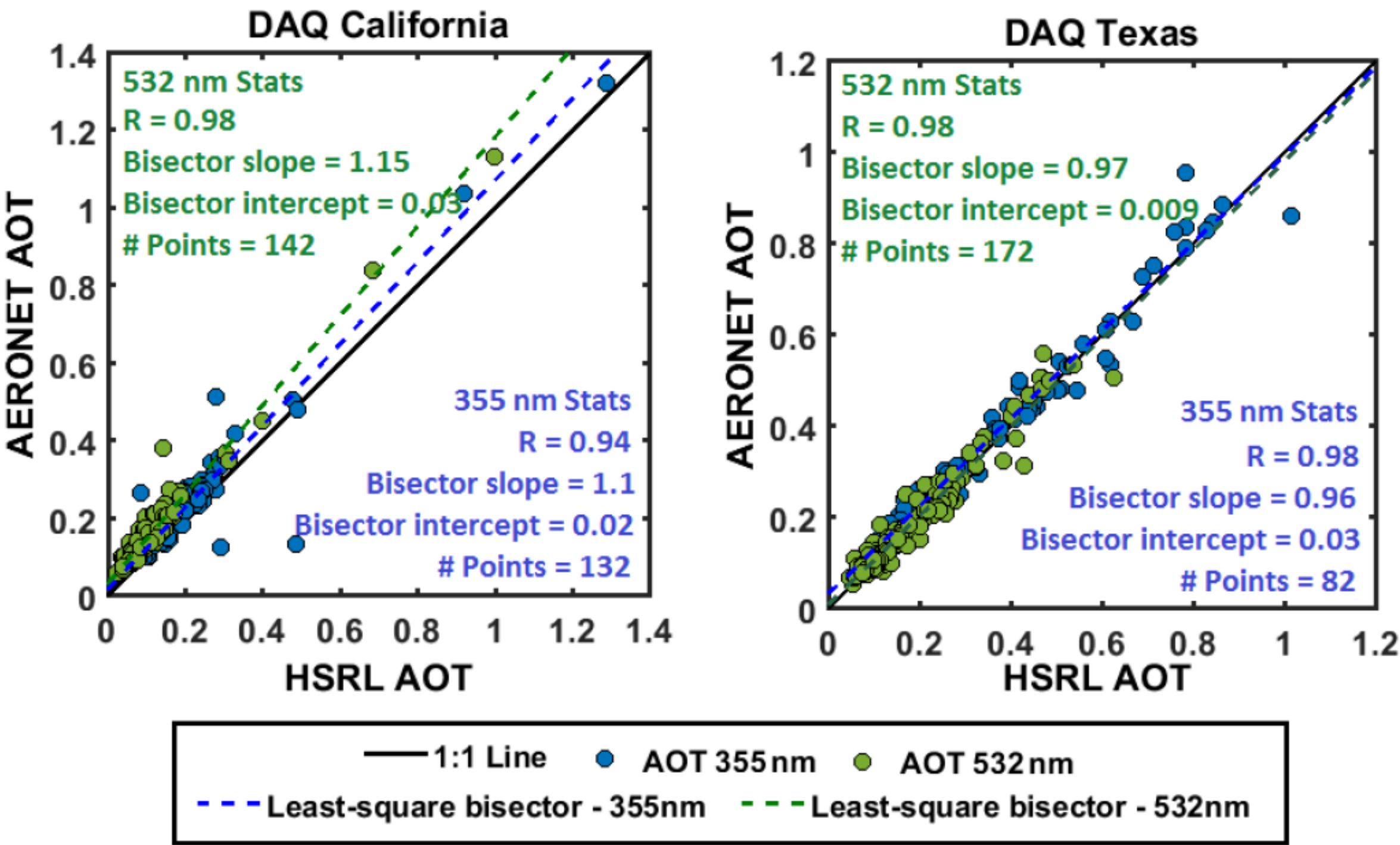
HSRL-2 aerosol backscatter measurements are used to characterize smoke and cloud layer heights and thicknesses as well as the thickness of the aerosol-free layer between the smoke and cloud layers. The results for all HSRL-2 measurements acquired during all the ORACLES flights are shown.

Multiwavelength “3β + 2α” aerosol microphysical retrievals using HSRL-2 data from September 22, 2016



HSRL-2 AOD comparisons with AERONET

HSRL-2 measurements of aerosol optical depth (AOD) are routinely compared with those from AERONET. Here are examples from the DISCOVER-AQ campaigns over California and Houston in 2013 (*Sawamura et al., 2017, ACP*)



Summary

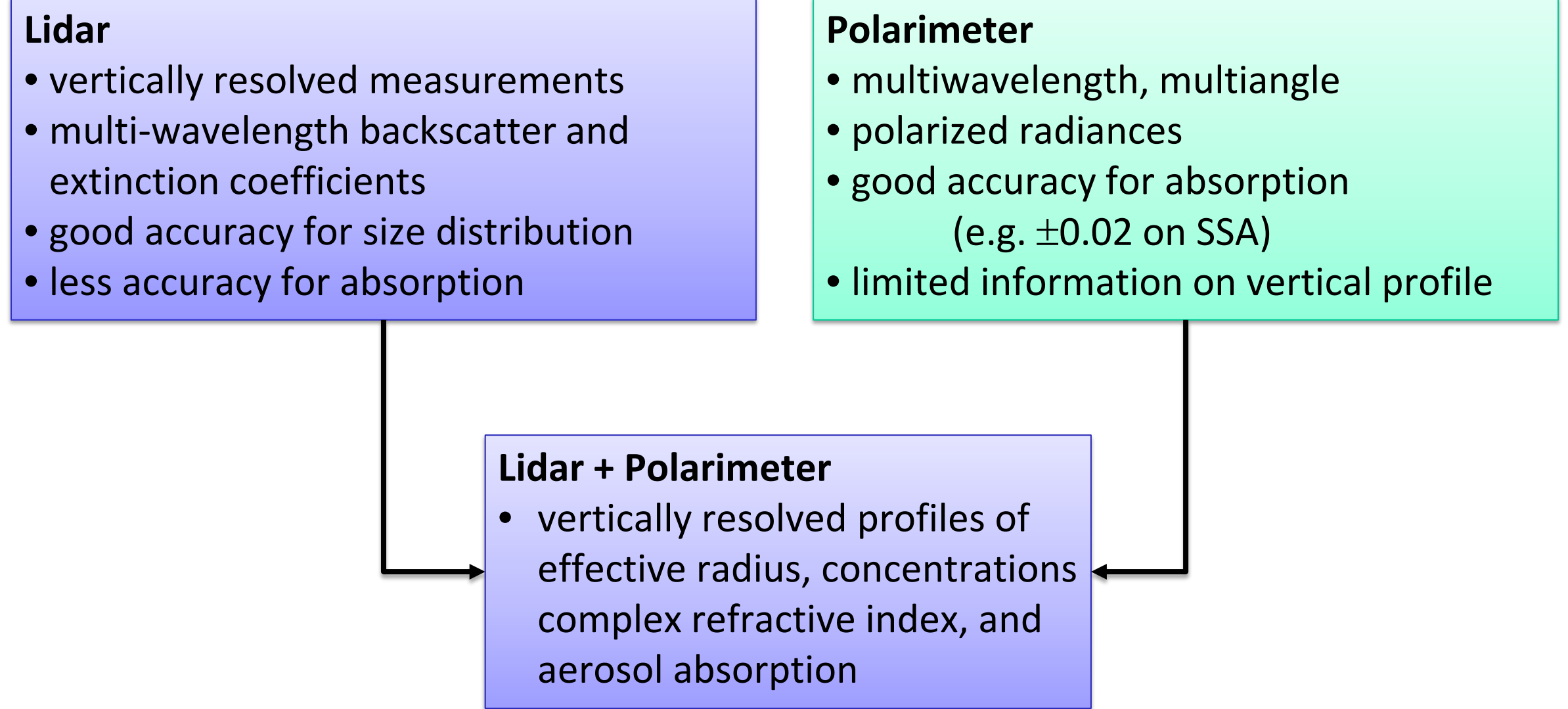
- NASA LaRC airborne HSRL-2, deployed on the NASA ER-2, characterized smoke layer properties over the Southeastern Atlantic Ocean during the first ORACLES mission
- The smoke layer was generally confined to altitudes between 1 and 6 km
- Low level clouds were ubiquitous and were generally confined to altitudes below 1 to 1.5 km
- The smoke layer was in contact with low level clouds over 40% of the time
- The aerosol-free gap layer was less than 1 km thick over 70% of the time
- Ongoing/future studies include:
 - Aircraft instrument intercomparisons
 - Satellite intercomparisons
 - Smoke, gap, cloud layer characterizations
 - Multiwavelength lidar aerosol retrievals
 - Combined lidar+polarimeter aerosol retrievals
 - Relating HSRL-2 above cloud aerosol measurements/retrievals to RSP cloud retrievals
 - ORACLES direct, indirect, semi-direct, etc. studies

Acknowledgements

We thank the ER-2 pilots, ground crew, and managers for their excellent support during ORACLES. We also thank the ORACLES team for their hard work in conducting and supporting the mission.

Outlook. Pursuing combined lidar+polarimeter retrievals

- Limits in information content for lidar-only microphysical retrieval means absorption is retrieved less well than size distribution parameters
- Synergistic combination of active (lidar) and passive (polarimeter) measurements will optimize information content on vertical profile of absorption properties



- Ongoing project by Xu Liu et al (NASA Langley) to combine HSRL-2 (lidar) and RSP (polarimeter) measurements in advanced Optimal Estimation retrieval