

## Airborne High Spectral Resolution Lidar

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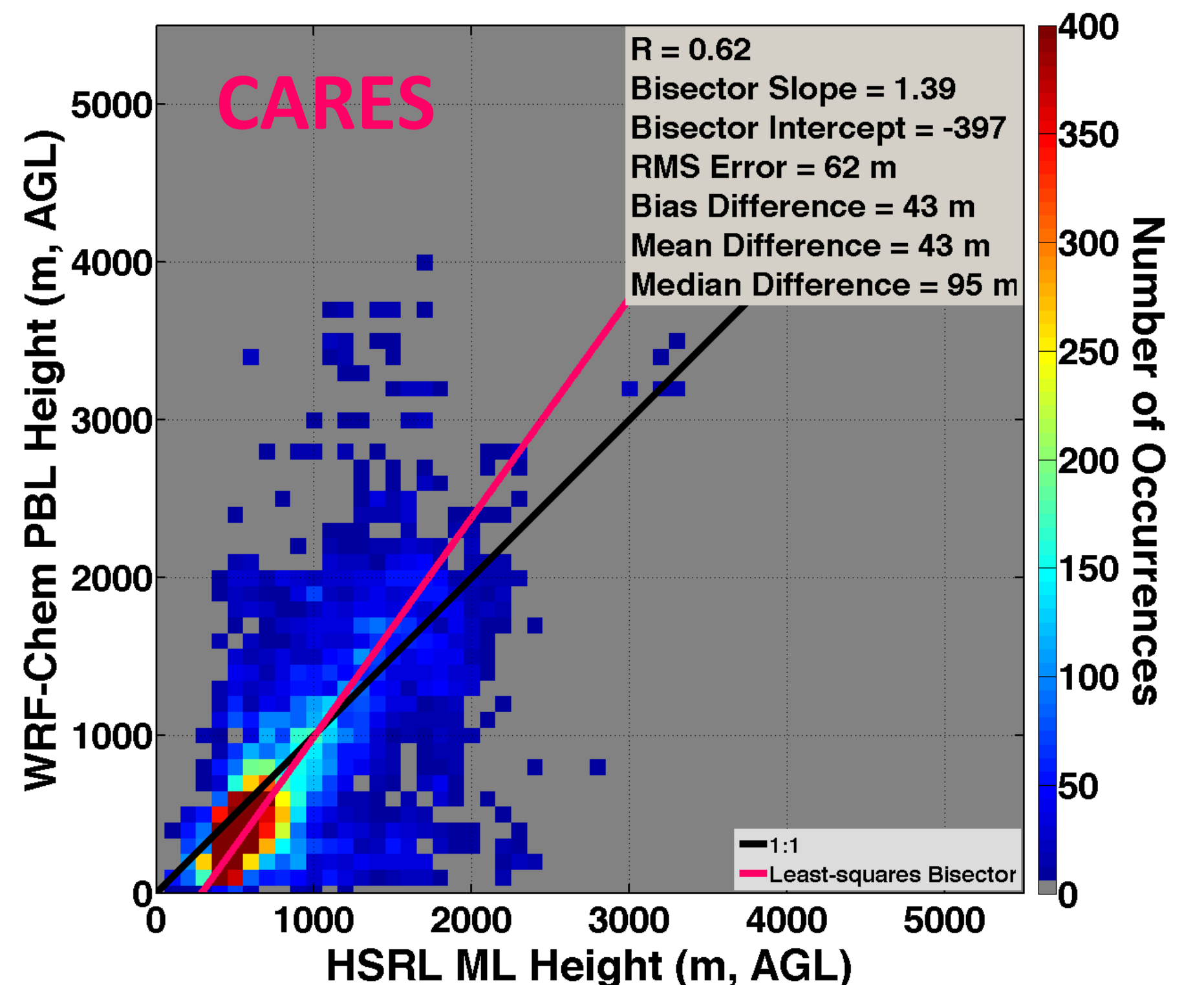
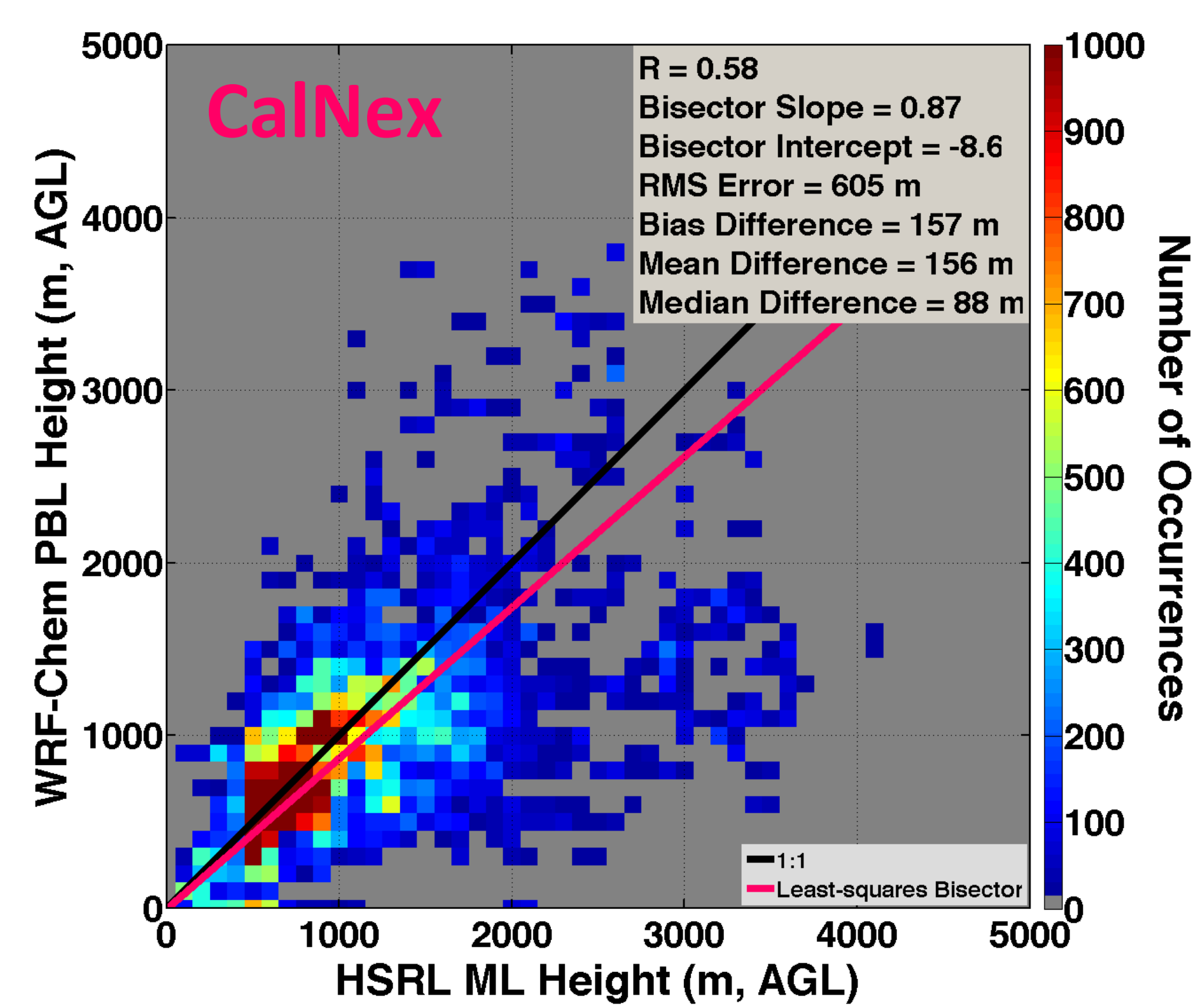
### Background

Measurements from the first-generation NASA airborne High Spectral Resolution Lidar (HSRL-1), onboard the NASA Langley Research Center (LaRC) B-200 aircraft, provide a diverse dataset for use in characterizing the spatial and temporal distribution of aerosols, as well as location and variability of the Mixed Layer (ML) height. The HSRL-1 data collected during these missions are used for computing ML heights and for determining the fraction of aerosol optical thickness within and above the ML, both of which are important for air quality assessments. ML heights derived from HSRL-1 have been used to assess Planetary Boundary Layer (PBL) simulations produced using three models, including Weather Research and Forecasting - Chemistry (WRF-Chem), NASA Goddard Earth Observing System - version 5 (GEOS-5), and European Centre for Medium-Range Weather Forecasts - Monitoring Atmospheric Composition and Climate (ECMWF-MACC).

### WRF-Chem PBL Heights

#### CalNex and CARES 2010

- WRF-Chem is a regional transport model that, in this case, has been processed along the HSRL-1 flight tracks
- WRF-Chem PBL heights are derived from a thermodynamic profile where the potential temperature reaches a critical point (Fast *et al.*, ACP, 2012)
- Settings for the model during CalNex and CARES used the Mellor-Yamada-Janjić (MYJ) parameterization (Janjić, 2002) scheme



- Comparisons from CalNex and CARES show little bias, with some outliers
- Potential reasons for the discrepancies are likely associated with the differences in the method PBL is calculated

### HSRL-1 Information

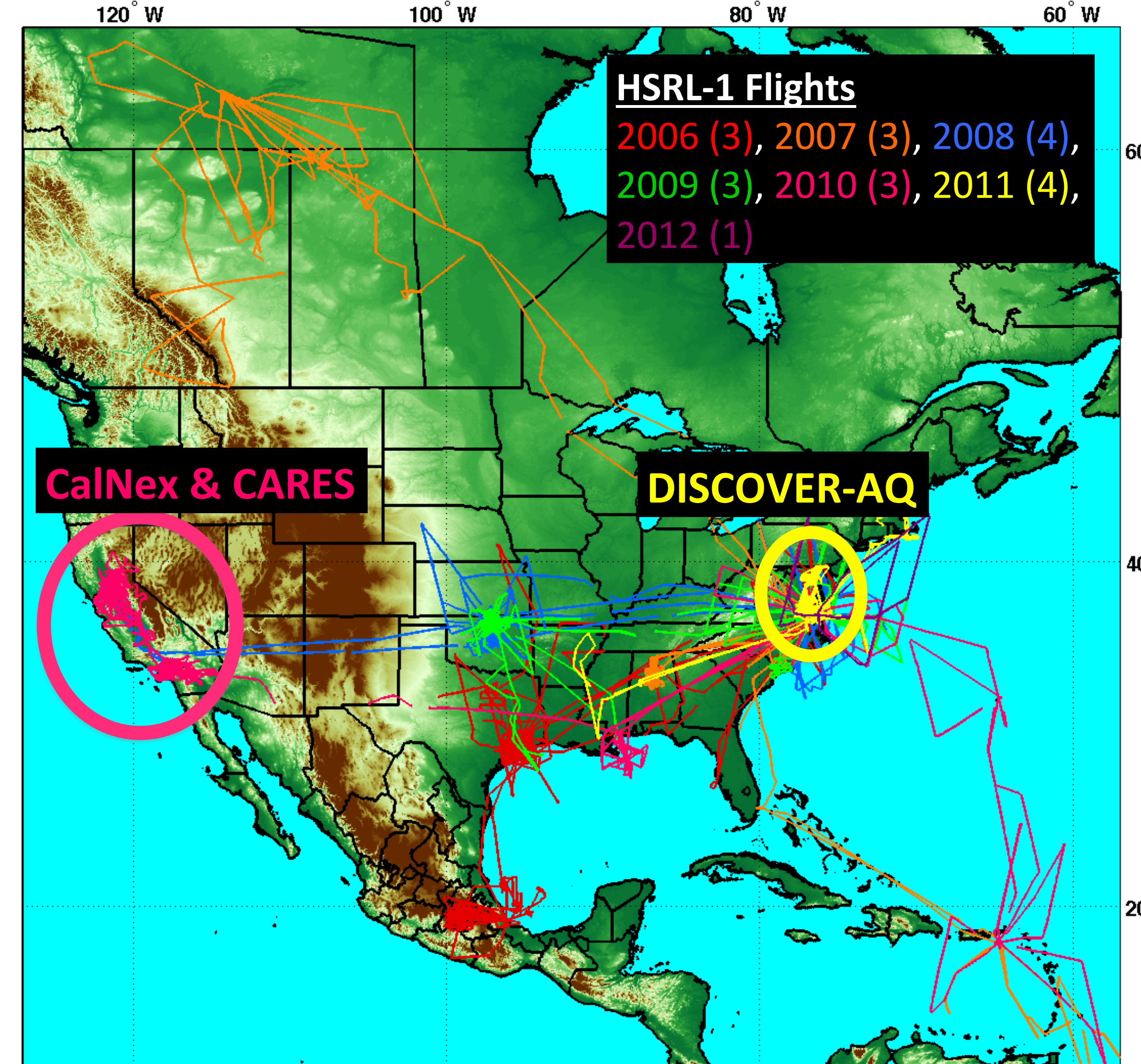
- Deployed on NASA/LaRC B-200/UC-12 aircraft
- Flight altitude  $\approx$  9 km
- Nadir pointing lidar
- 21 Field missions in North America from 2006-2012
  - ML height work focuses on 15 missions
- 349 Science Flights

#### HSRL Technique

- Independently measures aerosol backscatter, extinction, and optical thickness

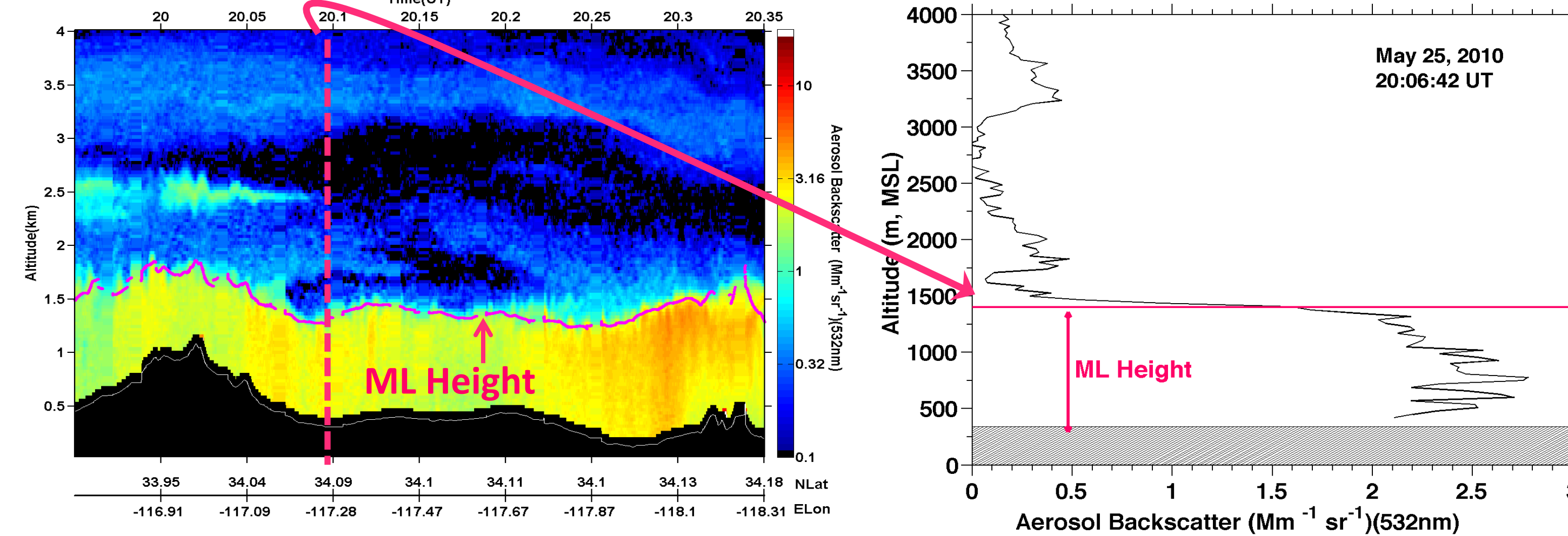
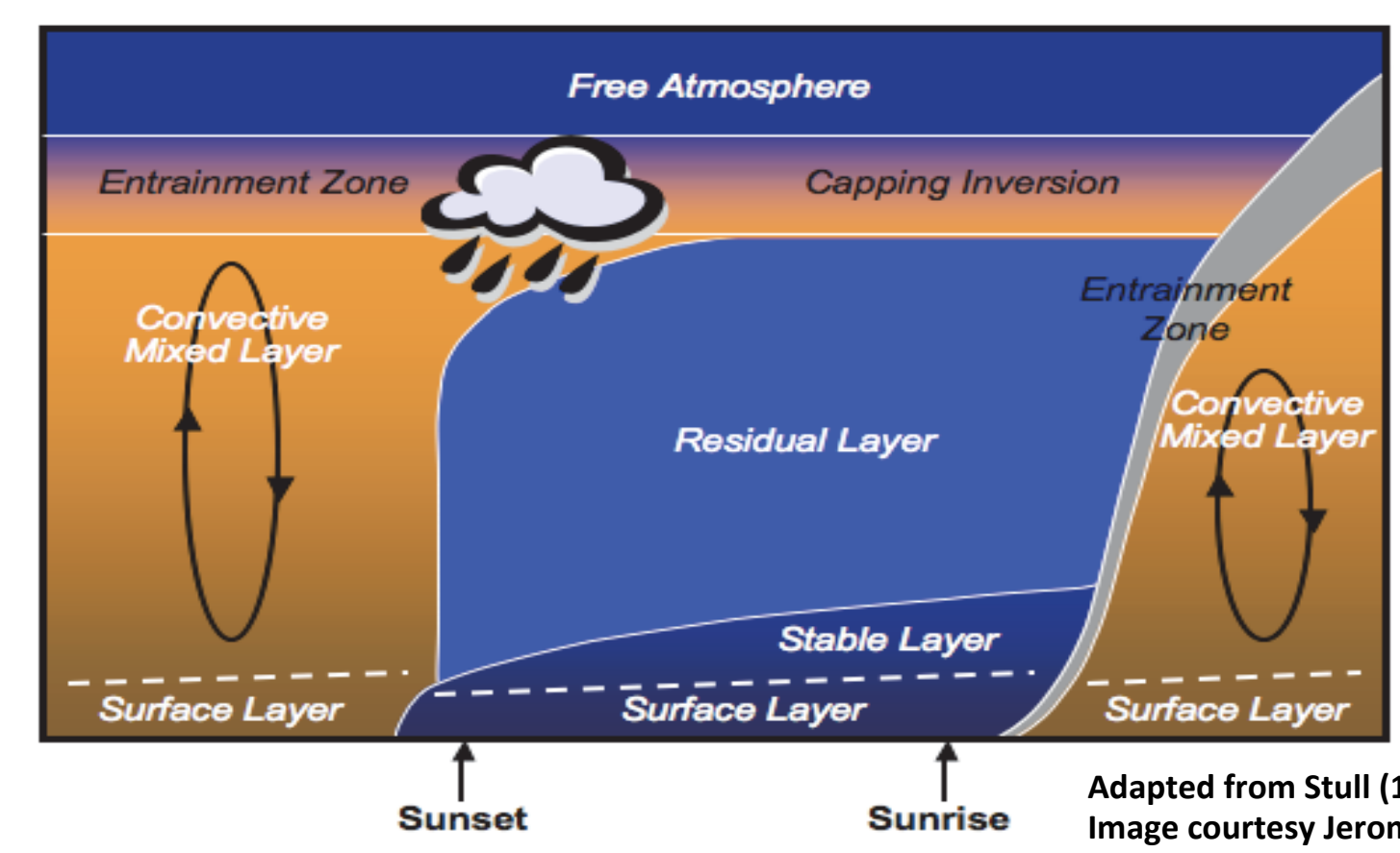
#### HSRL Aerosol Data Products

- Backscatter coefficient (532, 1064 nm)
- Depolarization (532, 1064 nm)
- Extinction coefficient (532 nm)
- Optical Thickness (AOT) (532 nm)
- Mixed Layer (ML) Heights
- Aerosol type



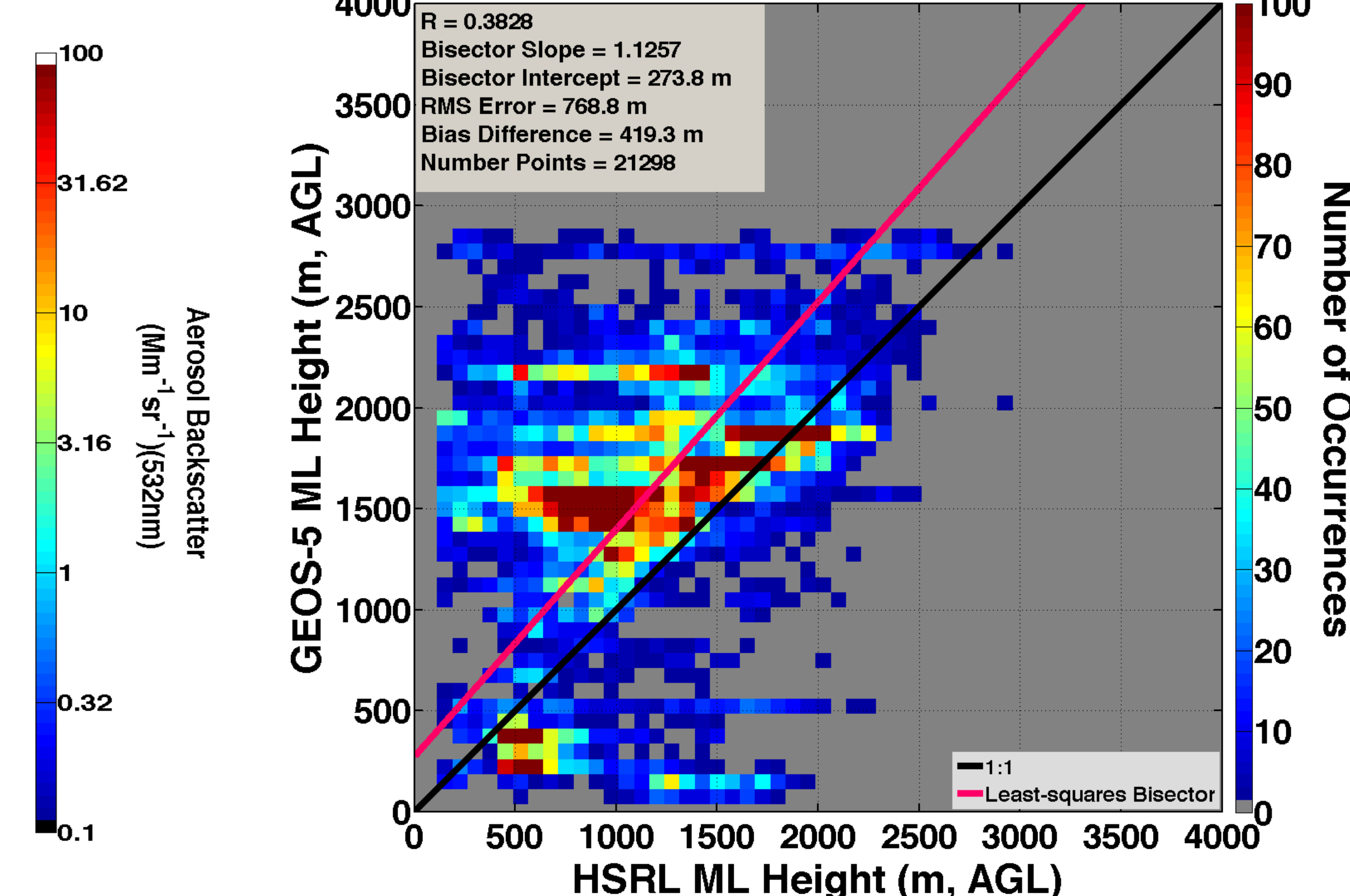
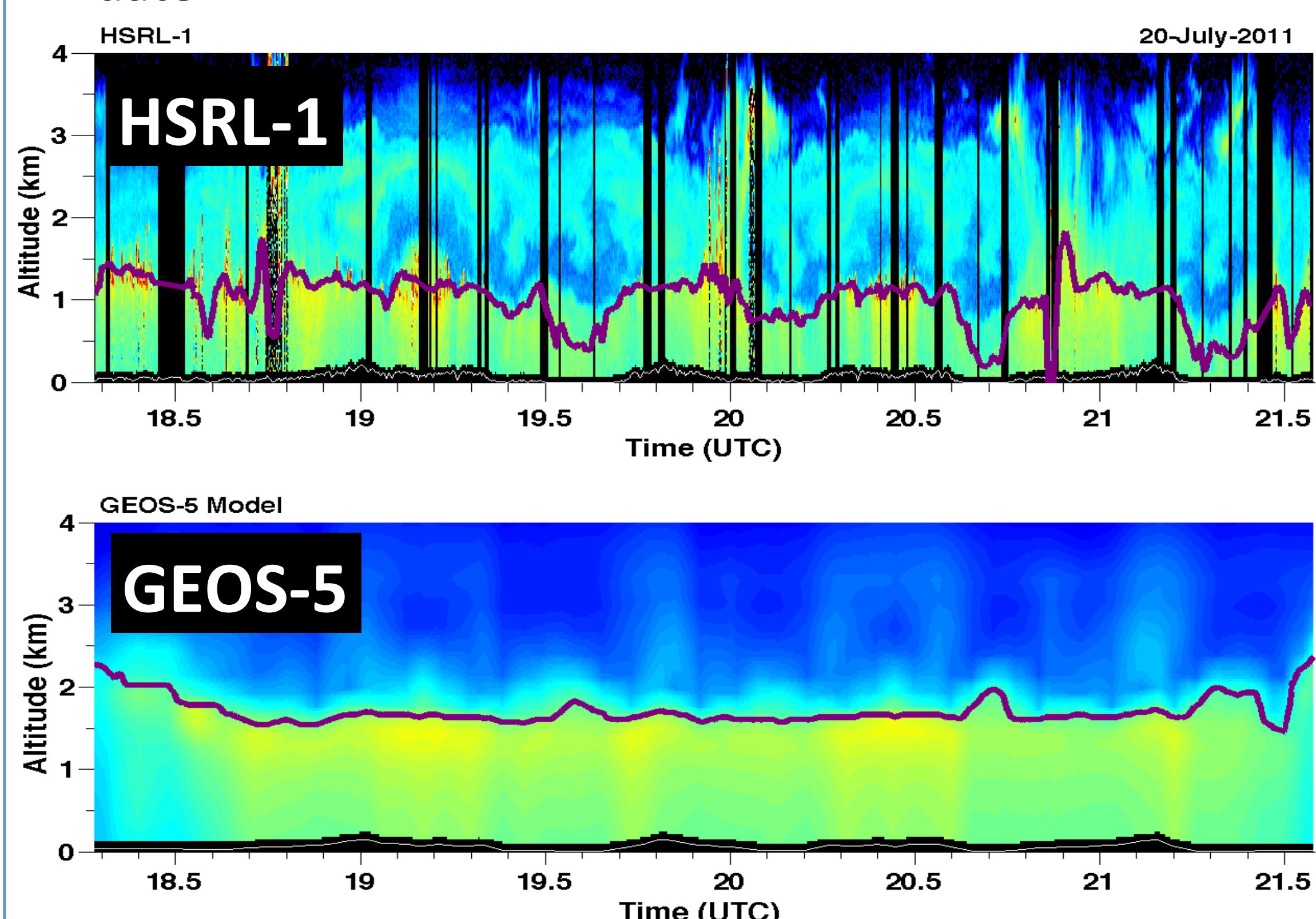
### Mixed Layer Heights Methodology

- ML heights derived from daytime-only cloud-screened aerosol backscatter profiles measured by the airborne HSRL; ML heights are a good proxy for PBL heights during the daytime
- Automated technique uses a Haar wavelet covariance transform with multiple wavelet dilations to identify sharp gradients in aerosol backscatter at the top of the PBL (Brooks, JAOT, 2003)
- Algorithm was modified to reduce erroneous PBL heights caused by elevated aerosol layers and by large variability in PBL height over land-water interfaces
- "Best-Estimate" HSRL PBL heights combine results from automated algorithm as well as results from manual inspection of HSRL backscatter profiles



### GEOS-5 ML Heights during DISCOVER-AQ 2011

- Simulated aerosol backscatter from the GEOS-5 model along the HSRL flight tracks was processed through the wavelet covariance transform algorithm to produce ML heights using the same methodology as used for the HSRL-1 ML heights
- On average, the GEOS-5 ML heights are about 300-500 m higher than the HSRL ML heights, as demonstrated by the afternoon flight on July 20<sup>th</sup> and also in the scatter density plot that compares ML heights across all flights during the mission
- More work is currently being done in the comparison of GEOS-5 and HSRL ML heights and will be presented at a future date

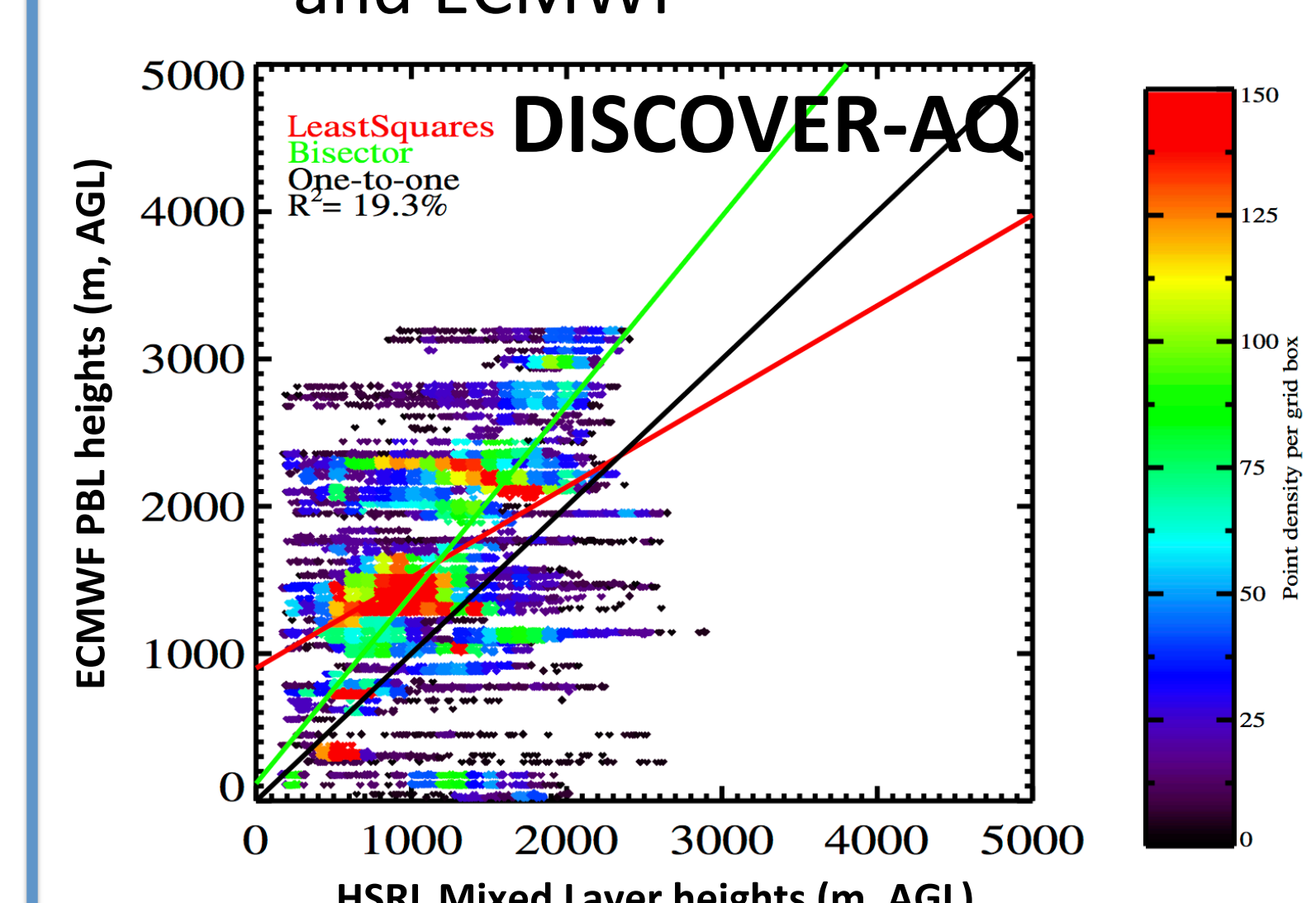
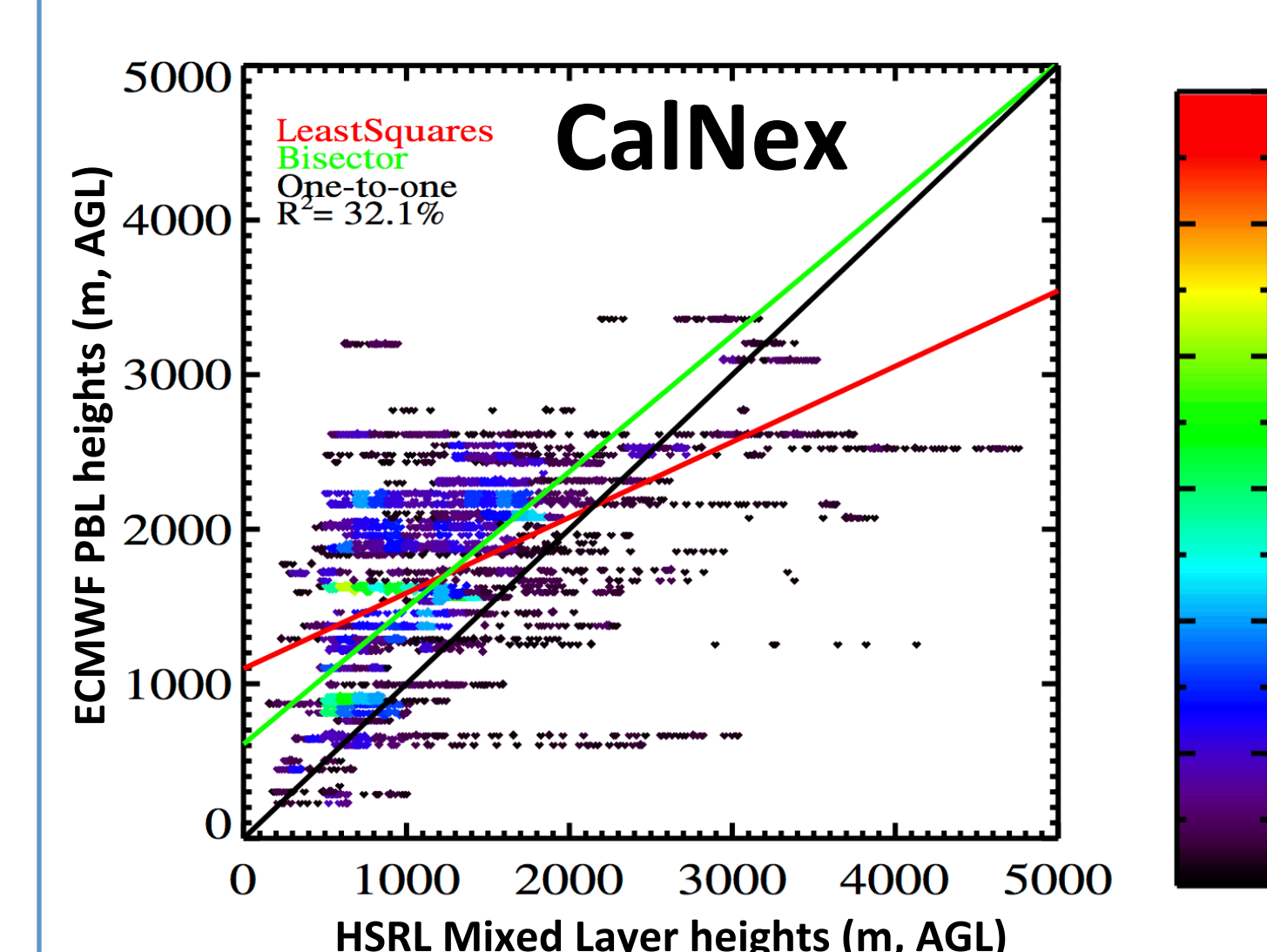
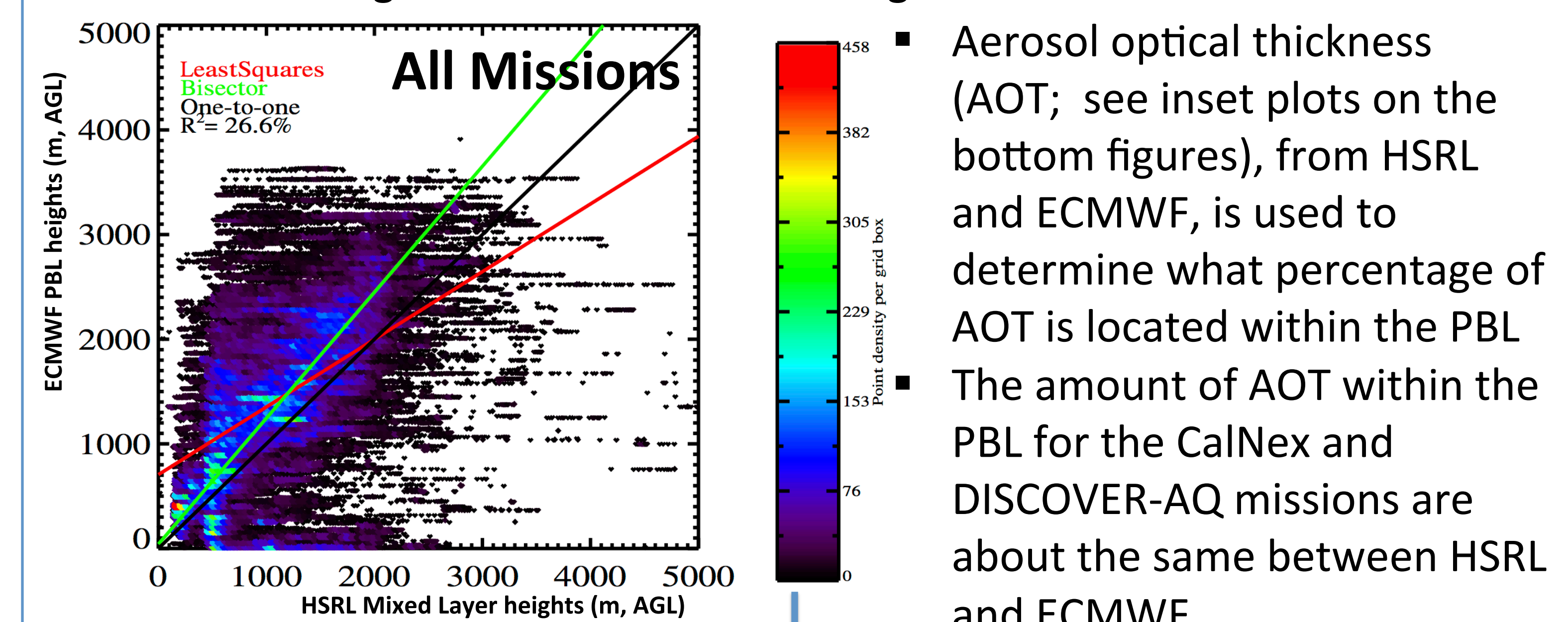


### Summary

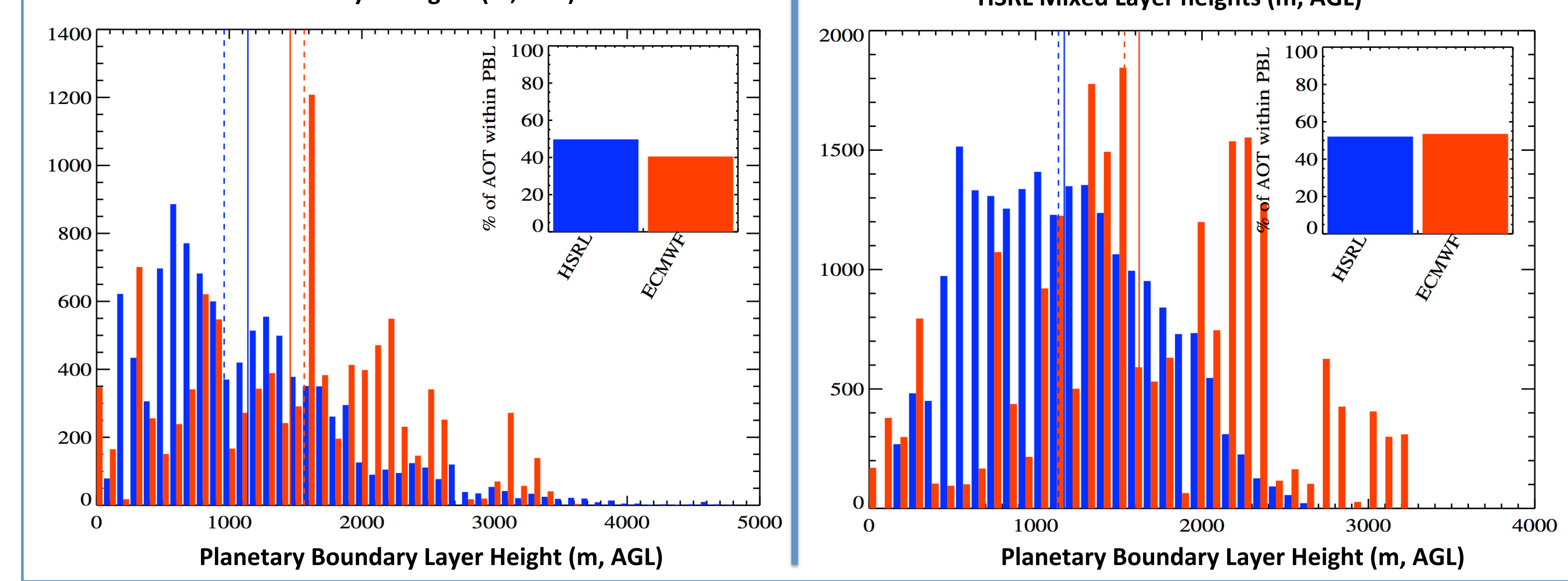
- PBL height is a key parameter for simulating climate processes and assessing model simulation of aerosol pollutant concentrations and transport
- ML heights from airborne lidar are a good proxy for the daytime PBL heights and are useful for evaluating PBL heights from numerical weather and air quality models
- Across all field missions, the ECMWF PBL heights are generally about 100-200 m higher than the HSRL ML heights
- The GEOS-5 ML heights during the 2011 DISCOVER-AQ mission are about 300 - 500 m higher than the HSRL ML heights
- During 2010, the WRF-Chem model PBL heights from the CalNex and CARES field missions show little bias, with some outliers
- Differences in modeled PBL heights are due to model parameterizations and differences in definition, with exception of the GEOS-5 model

### ECMWF-MACC PBL Heights during all HSRL Missions

- ECMWF model results and HSRL measurements were compared along the King Air flight tracks for 14 field missions conducted over North America since 2006
- PBL heights for ECMWF are derived using the parcel lifting method until a critical Richardson Number is reached
- Across all field missions, the ECMWF PBL heights are generally about 100-200 m higher than the HSRL ML heights



- Aerosol optical thickness (AOT; see inset plots on the bottom figures), from HSRL and ECMWF, is used to determine what percentage of AOT is located within the PBL
- The amount of AOT within the PBL for the CalNex and DISCOVER-AQ missions are about the same between HSRL and ECMWF



### Acknowledgements

The authors thank the NASA Langley B-200 King Air flight crew for their outstanding work supporting these flights and measurements. Financial support for the King Air flights and HSRL measurements and analyses was provided by the NASA CALIPSO project, NASA Science Mission Directorate, Office of Science (BER) - Department of Energy, and the Environmental Protection Agency (EPA).