

Airborne High Spectral Resolution Lidar Aerosol Measurements During CalNex and CARES



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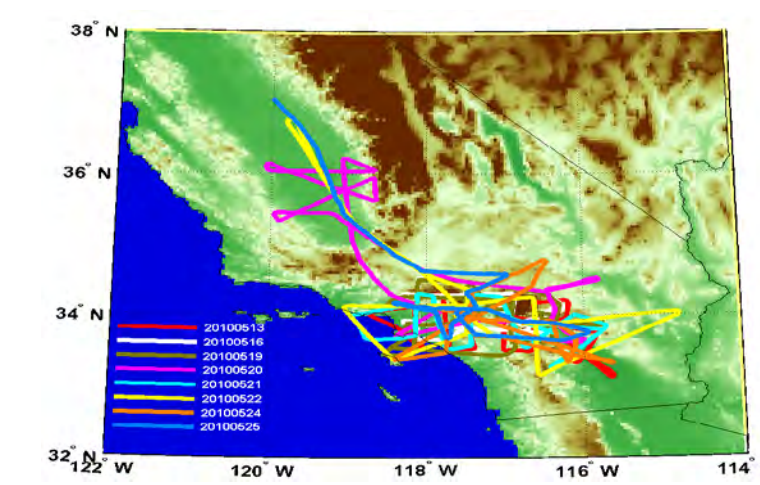


Background

The NASA Langley Research Center (LaRC) airborne High Spectral Resolution Lidar (HSRL) on board the NASA B200 aircraft measured aerosol extinction (532 nm), aerosol optical thickness (AOT), backscatter (532 and 1064 nm) and depolarization (532 and 1064 nm) profiles during the 2010 CalNex and CARES field missions. The HSRL data were acquired to characterize the vertical and horizontal distribution of aerosols during these missions. The B200 flights were conducted so that the NOAA WP-3, NOAA Twin Otter, CIRPAS Twin Otter, and DOE G-1 aircraft often collected coincident data within the HSRL "curtains" such that the HSRL could provide the vertical context for the airborne in situ measurements acquired from these other aircraft. HSRL data have been used to infer aerosol types and mixtures of those types, and apportion aerosol optical thickness to these types. HSRL measurements are also used to determine Planetary Boundary Layer (PBL) height and investigate the variability of PBL height.

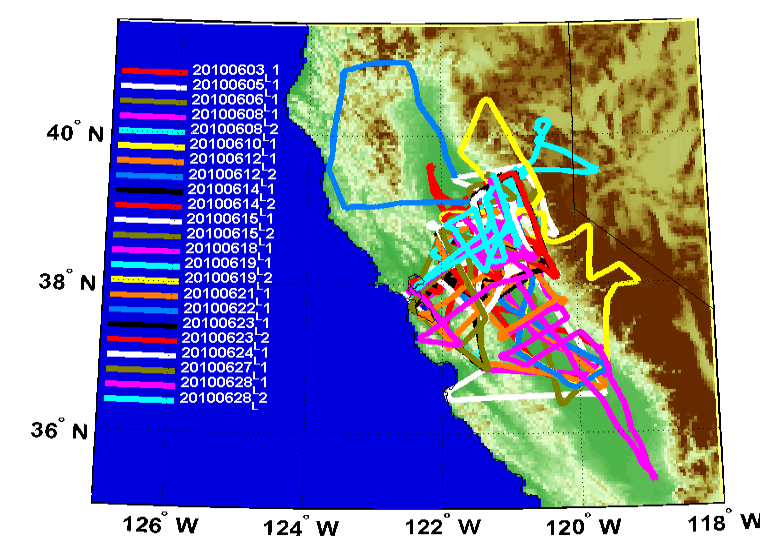
CalNex Deployment May 2010

- Ontario, California
- May 13-25
- 8 science flights (~29.5 hours)
 - 6 with CIRPAS Twin Otter
 - 2 with NOAA P-3
 - 6 with MODIS and/or MISR



CARES Deployment June 2010

- Sacramento, California
- June 3-28
- 23 science flights (~68 hours)
 - 19 with DOE G1
 - 1 with NOAA R/V Atlantis
 - 2 with NOAA P3
 - 6 with NOAA Twin Otter
 - 11 with MODIS and/or MISR
- Instruments deployed for CALNEX and CARES
 - High Spectral Resolution Lidar (HSRL) (NASA/LaRC)
 - Research Scanning Polarimeter (RSP) (NASA/GISS)



NASA Langley Airborne High Spectral Resolution Lidar (HSRL)

HSRL Technique:

- Relies on spectral separation of aerosol and molecular backscatter in lidar receiver
- Independently measures aerosol backscatter, extinction, and optical thickness
- Internally calibrated
- Provides **intensive** aerosol parameter to help determine aerosol type

HSRL Aerosol Data Products:

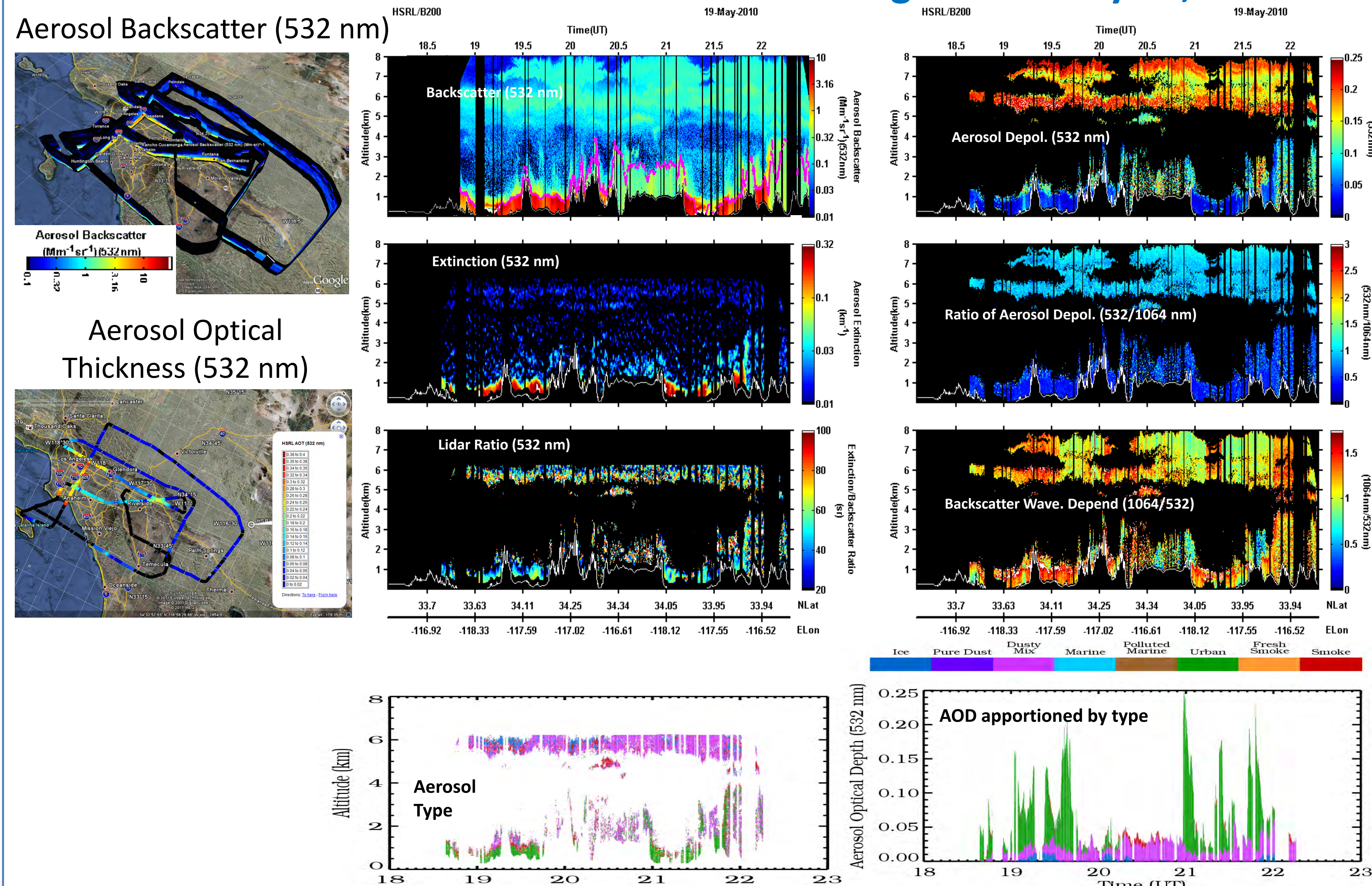
- Scattering ratio (532 nm)
- Backscatter coefficient (532, 1064 nm)
- Extinction Coefficient (532 nm)
- Optical Thickness (532 nm)
- Backscatter Wavelength Dependence (532/1064 nm)
- Extinction/Backscatter Ratio ("lidar ratio") (532 nm)
- Depolarization (532, 1064 nm)



Summary

- Airborne HSRL data acquired during about 100 hours of science flights during CALNEX and CARES
- Initial analyses of preliminary HSRL data acquired during these missions show:
 - Low (usually < 0.1) AOT (532 nm) over Sacramento during CARES
 - Larger and wider range of AOT found over Los Angeles during CALNEX
 - Large spatial and temporal variabilities of PBL height
 - Much of AOT remains above the PBL
 - Variations in aerosol types between Sacramento and areas downwind
 - Relatively good agreement between HSRL and AERONET and MFRSR measurements of AOT
 - Airborne in situ measurements of aerosol extinction are lower than HSRL measurements, possibly due to under sampling of coarse mode by airborne instruments

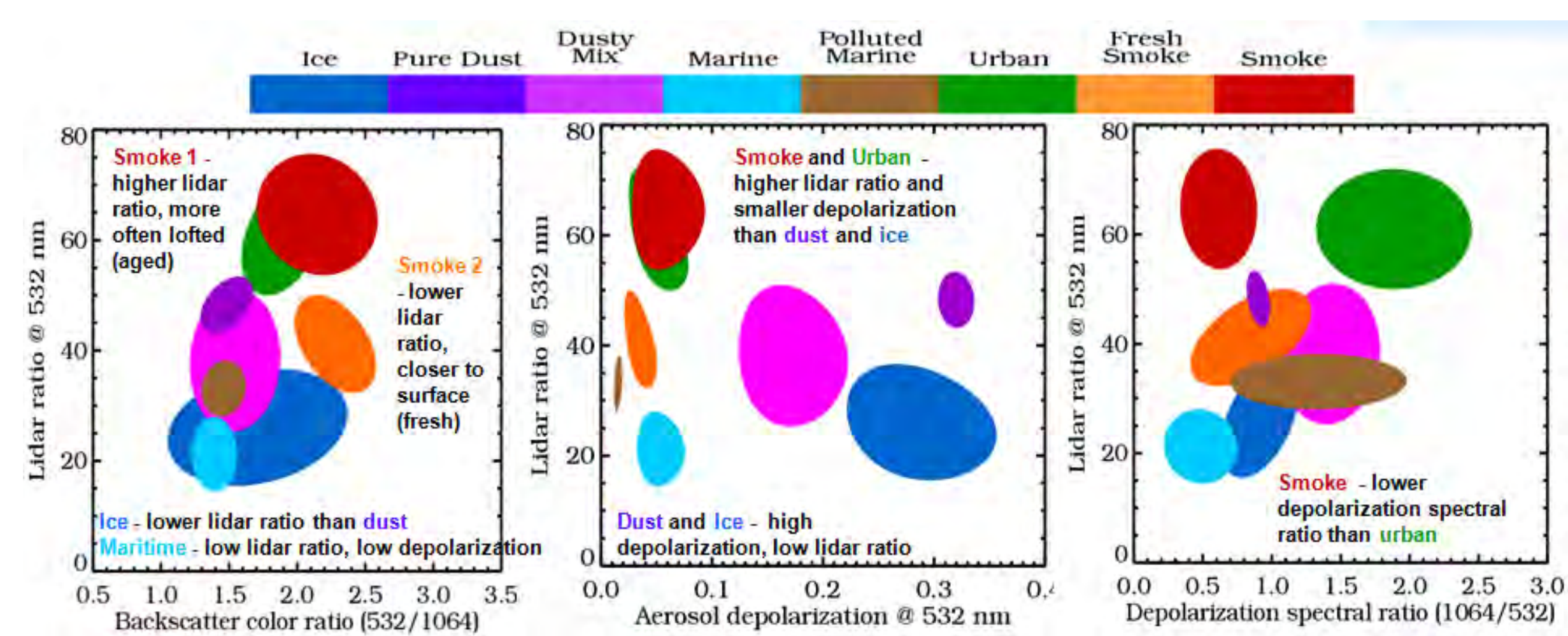
CalNex - HSRL Measurements over Los Angeles on May 19, 2010



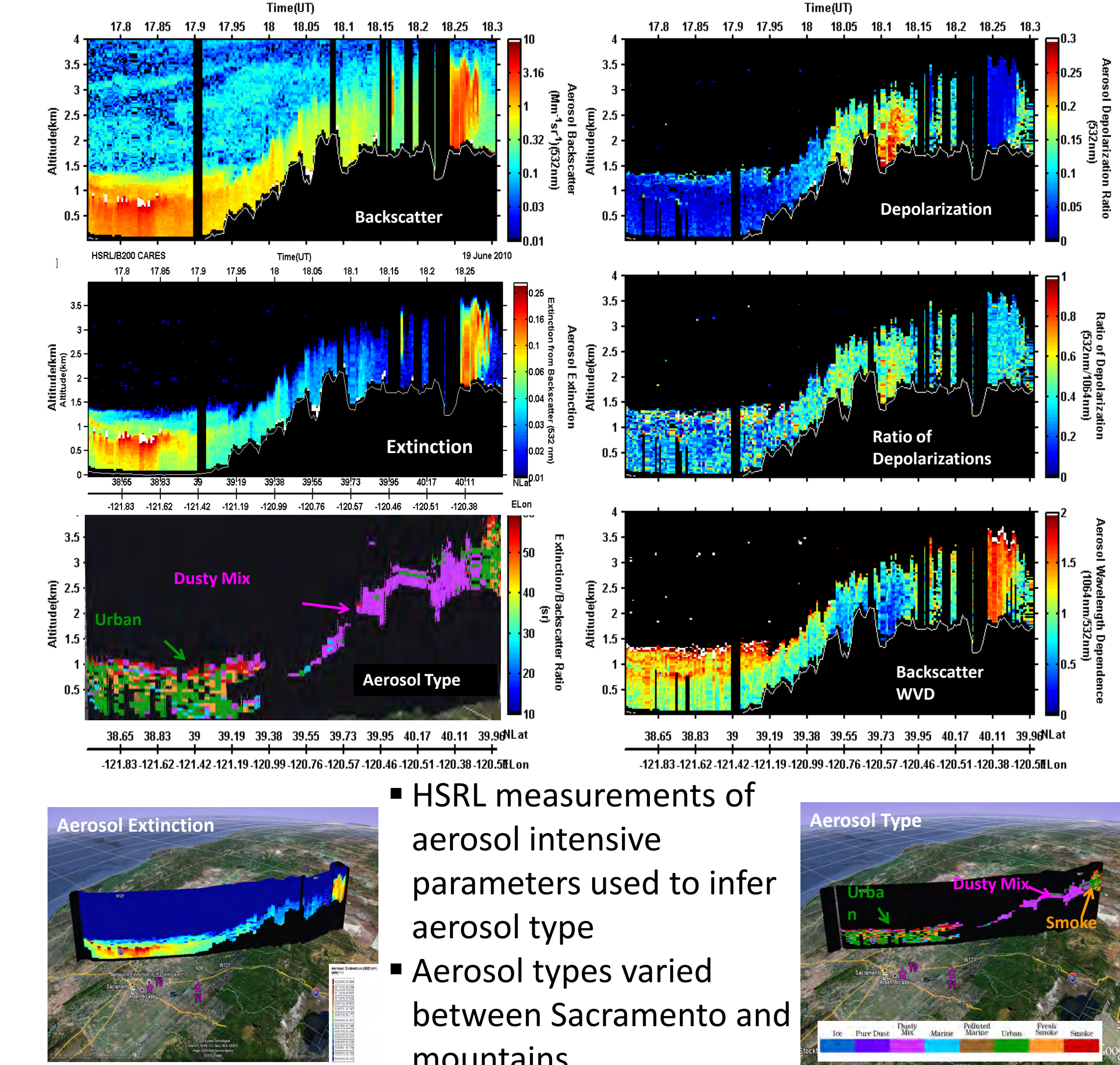
Inference of Aerosol Type and Apportionment of Aerosol Optical Thickness to Aerosol Type

Aerosol Classification using HSRL measurements

- Uses four aerosol intensive parameters to classify aerosols
- Computes Mahalanobis distance to sort points into classes
- Employs a training set of known types comprised of 29 labeled samples (over 26000 points, about 0.3% of all data)
- Estimates the 4-D normal distributions of classes from labeled data, then calculates Mahalanobis distance from each point to each class
- HSRL data acquired from 2006-2010 are classified

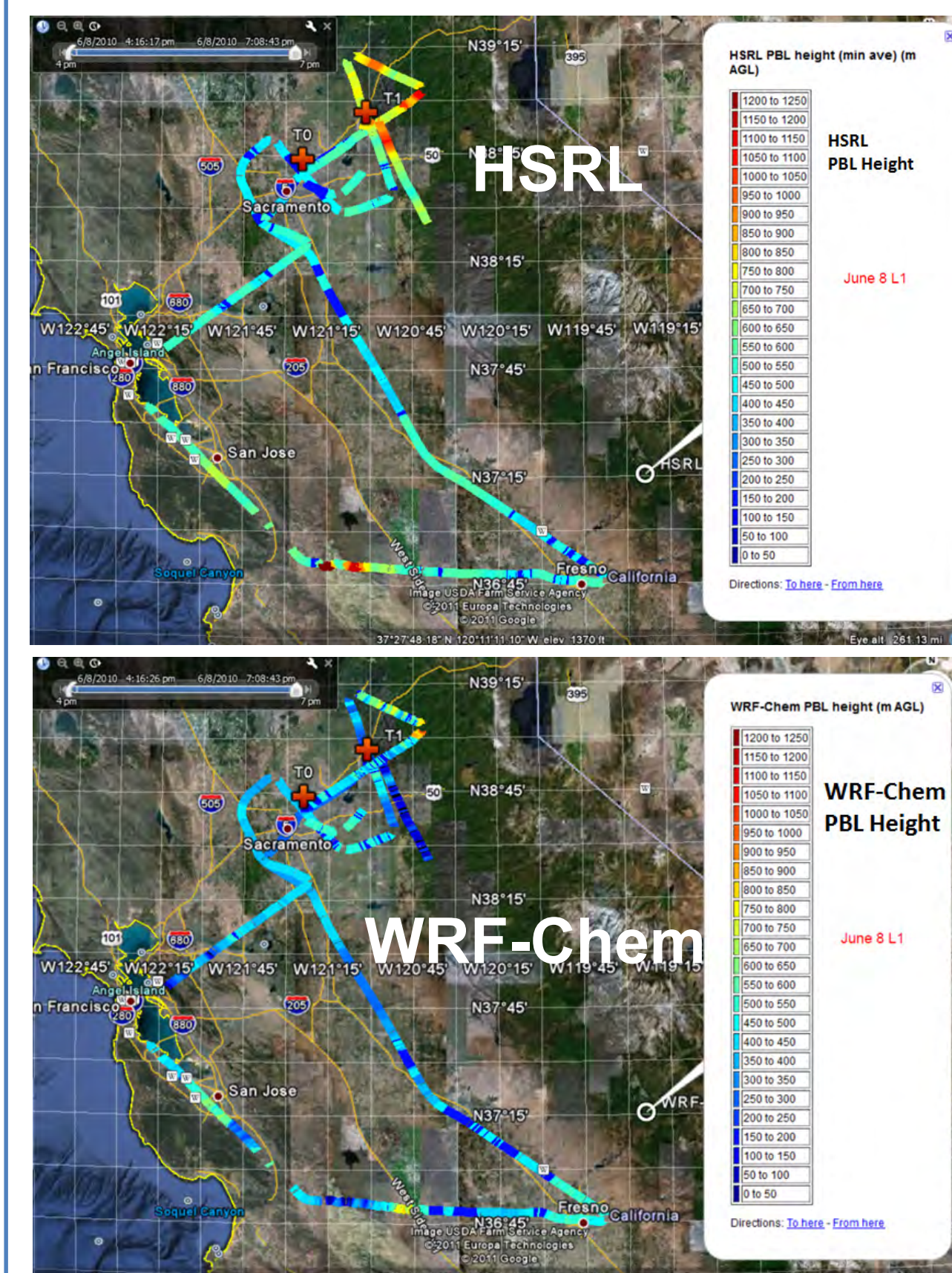


Aerosol Types Inferred from HSRL data June 19th

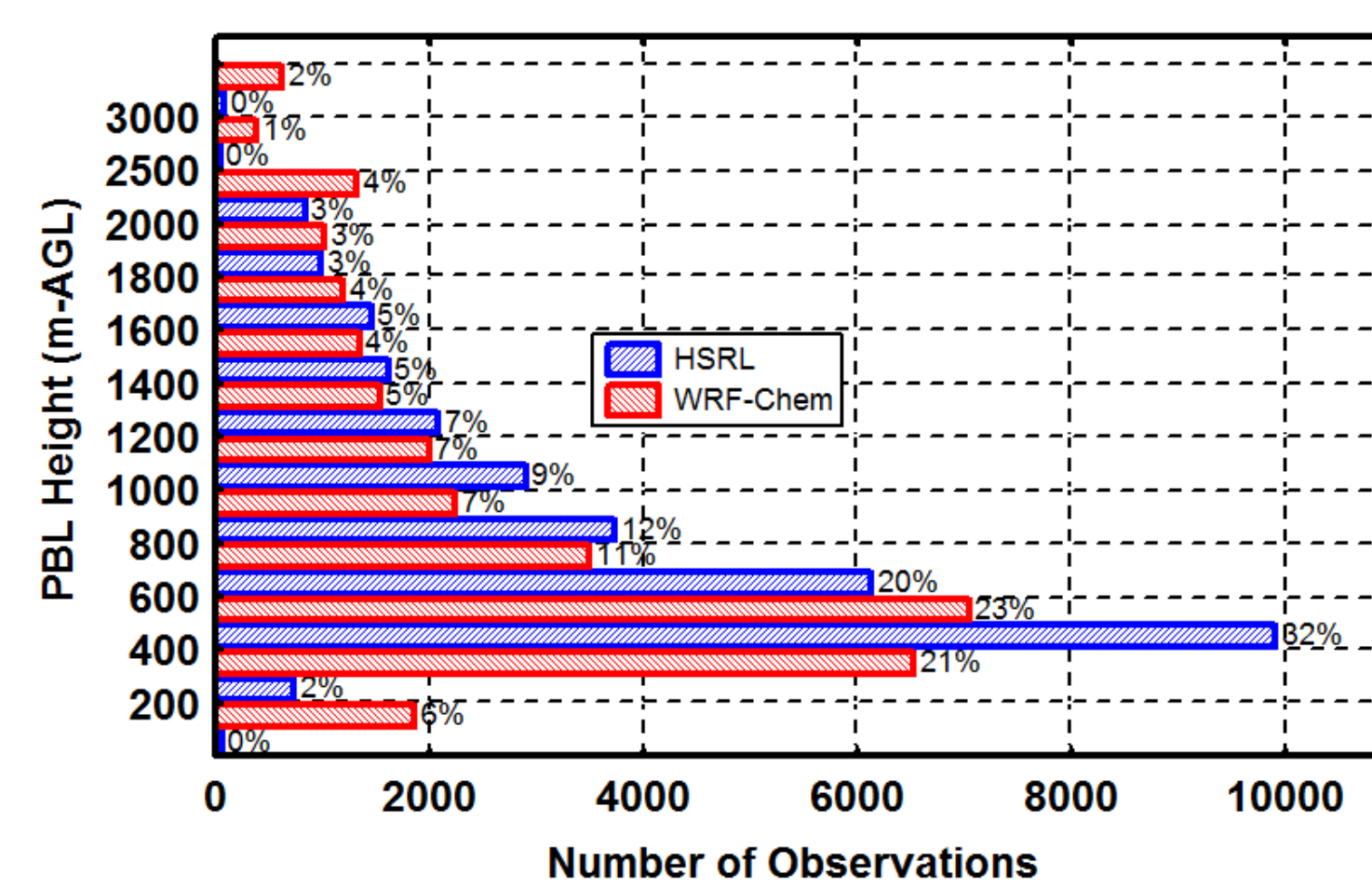


Planetary Boundary Layer (PBL) Height Retrievals – HSRL Retrievals and WRF-Chem Model

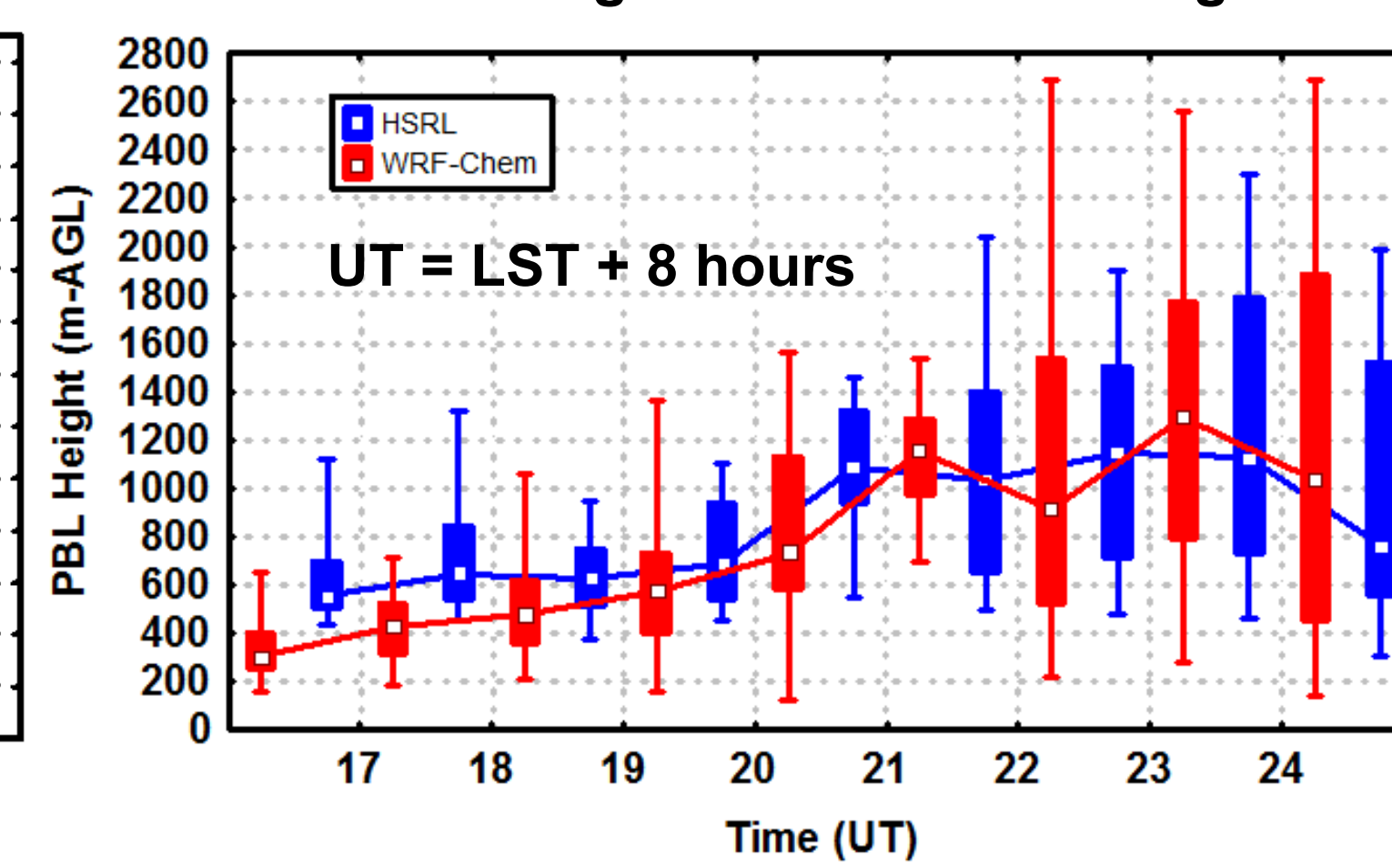
June 8, 2010 Flight #1



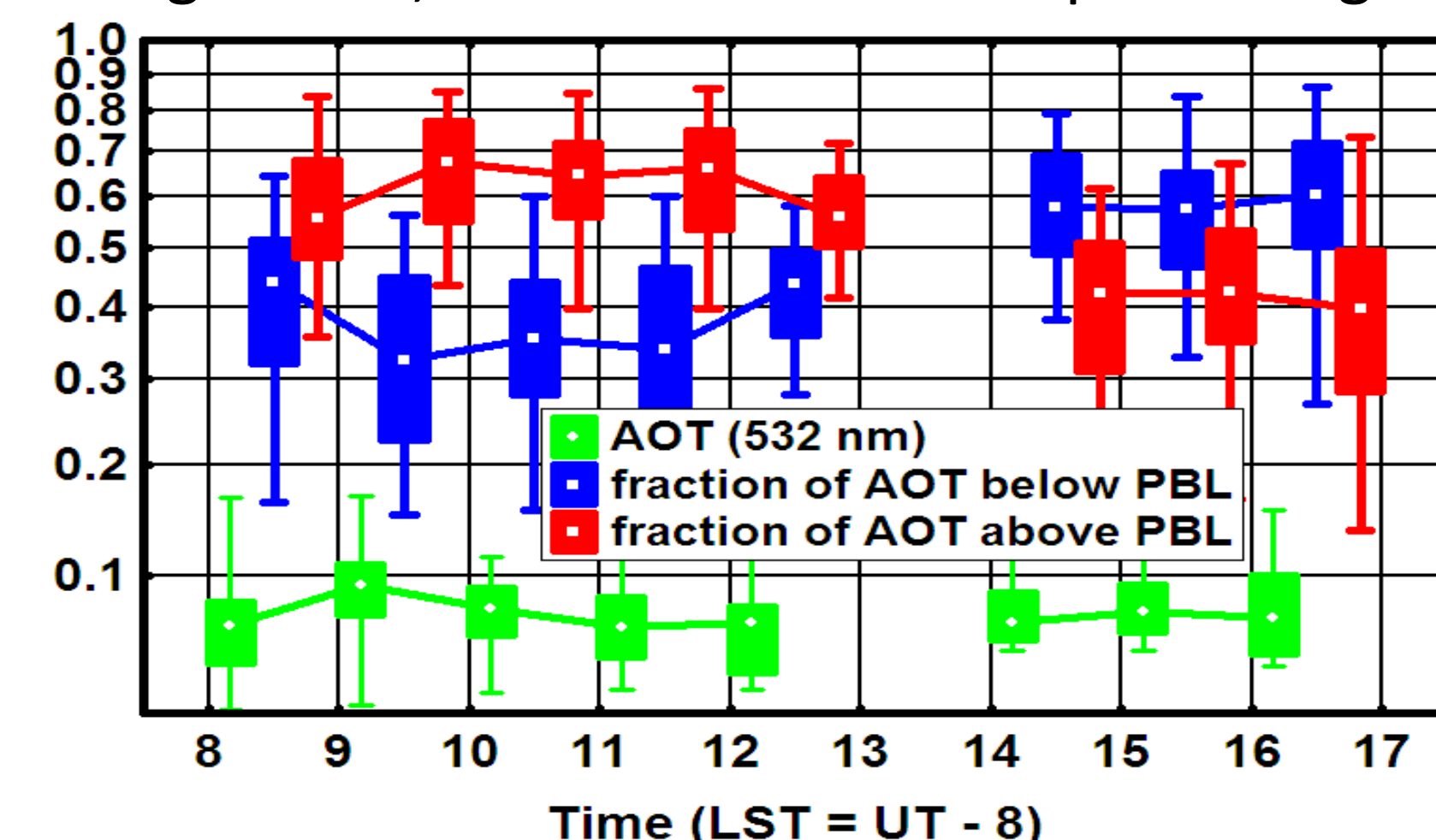
PBL Heights for all CARES Flights



PBL Heights for all CARES Flights

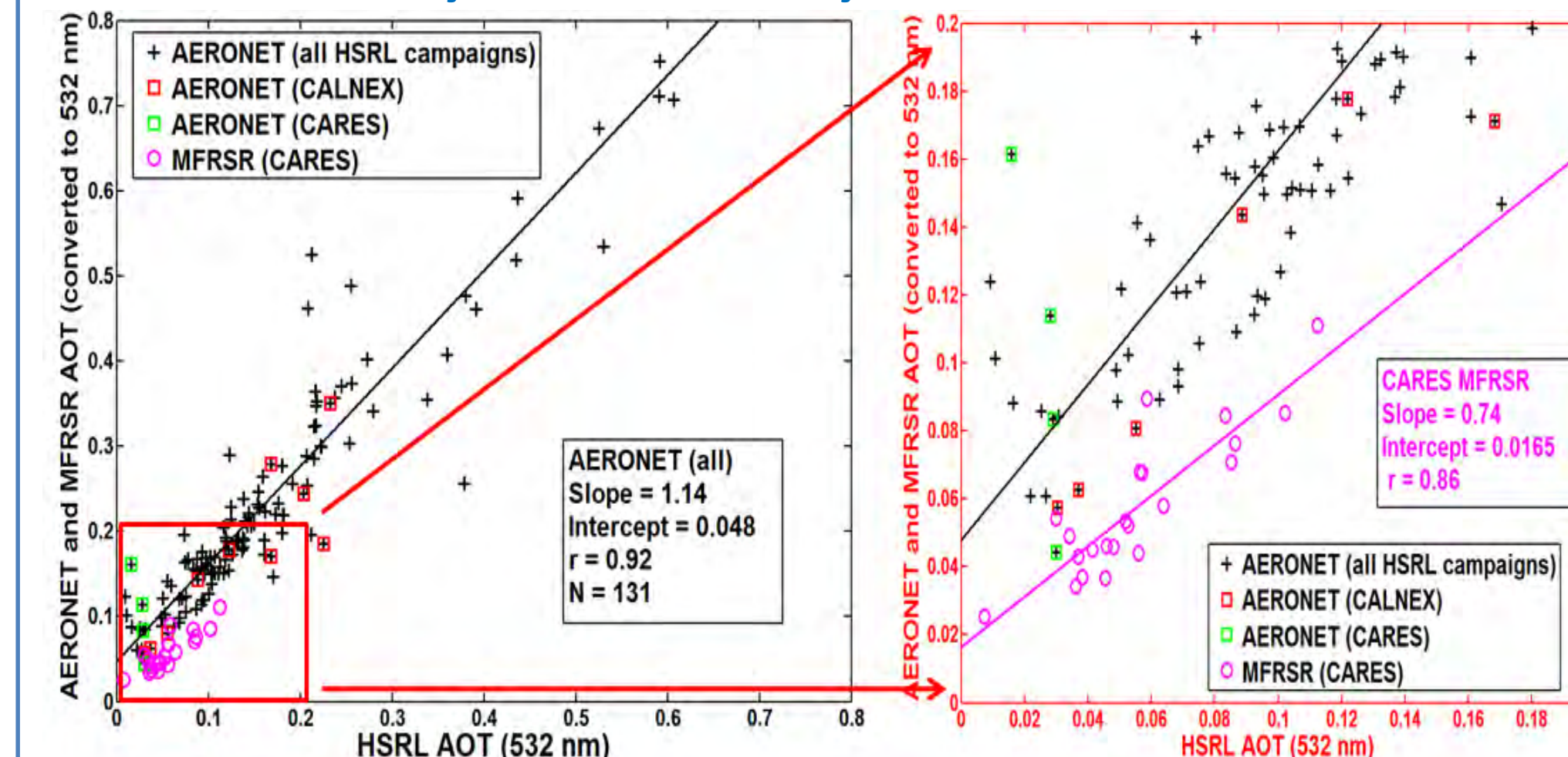


HSRL and WRF-Chem PBL heights are in reasonably good agreement (within ~ 50 m) during the local afternoon. HSRL PBL heights were generally larger by 100-200 m during the morning which may be due to limitations of the HSRL wavelet based analysis for low PBL heights and also to the difference in how the PBL height is determined (HSRL uses aerosol gradient, WRF-Chem uses temperature gradient)



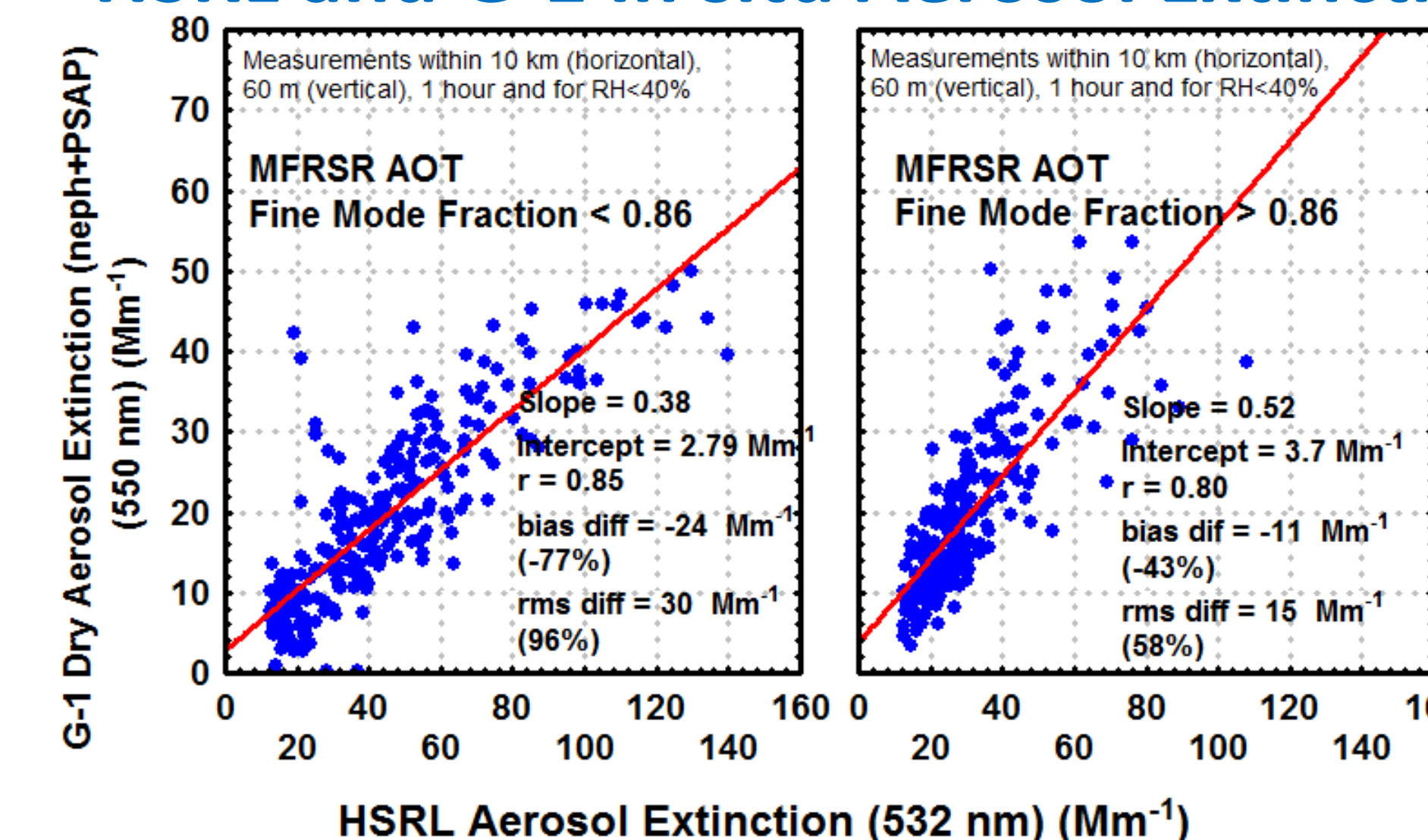
HSRL measurements show much of AOT remains above PBL

HSRL, AERONET, and MFRSR AOT



HSRL, AERONET, and MFRSR AOT retrievals are generally in good agreement (rms and bias differences < 0.02, <30%)

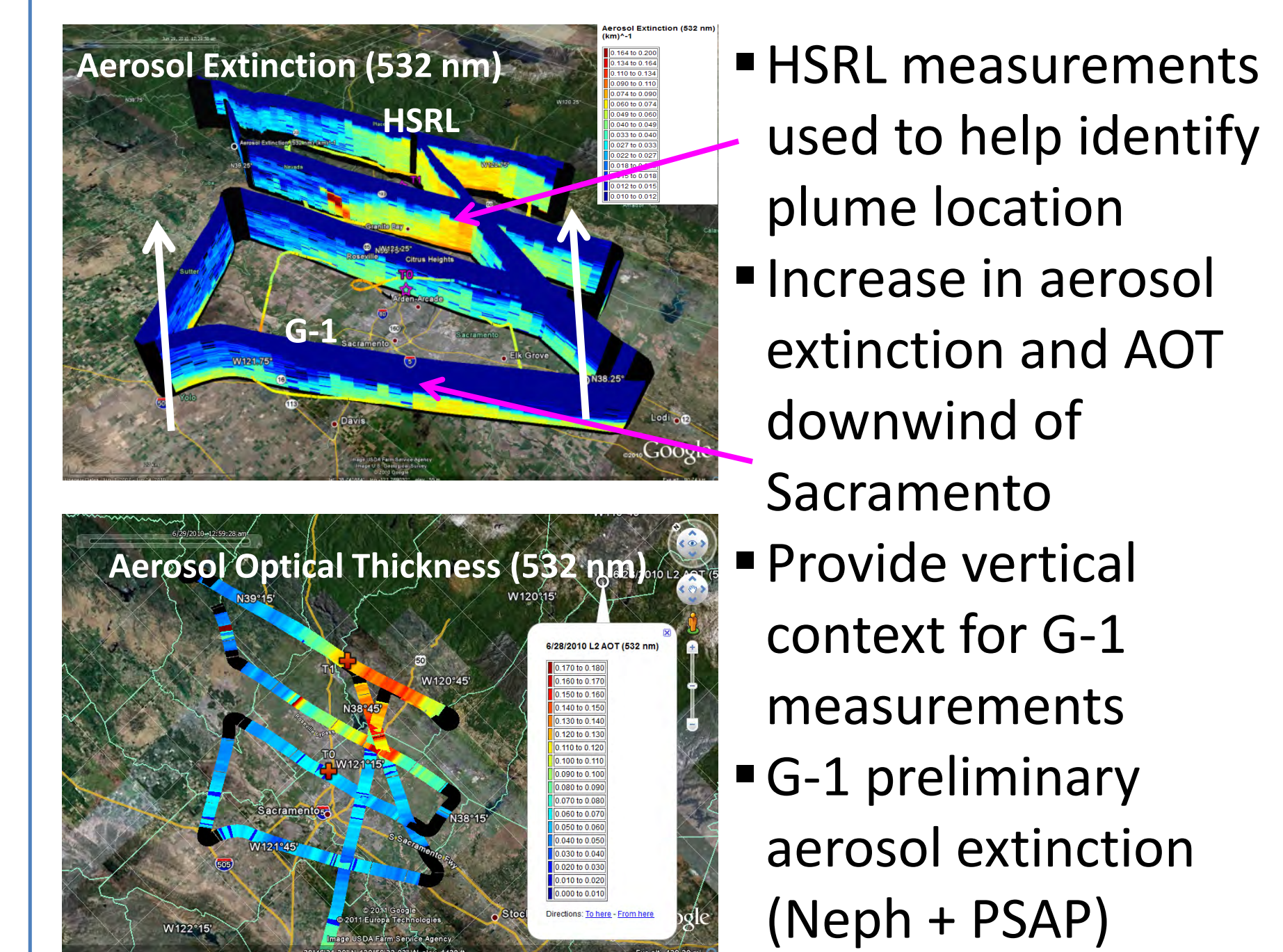
HSRL and G-1 In situ Aerosol Extinction



HSRL aerosol extinction measurements are about 10-25 Mm⁻¹ (40-80%) higher than aerosol extinction derived from G-1 in situ measurements. Differences are smaller during days with larger fine mode AOT fraction.

CARES – June 28, 2010

Airborne HSRL and G-1 Measurements of Aerosol Extinction in Sacramento Plume



- HSRL measurements used to help identify plume location
- Increase in aerosol extinction and AOT downwind of Sacramento
- Provide vertical context for G-1 measurements
- G-1 preliminary aerosol extinction (Neph + PSAP)

Acknowledgements

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