Representativeness of Aggregate Vertical Profiles and Influencing Factors from NASA DISCOVER-AQ

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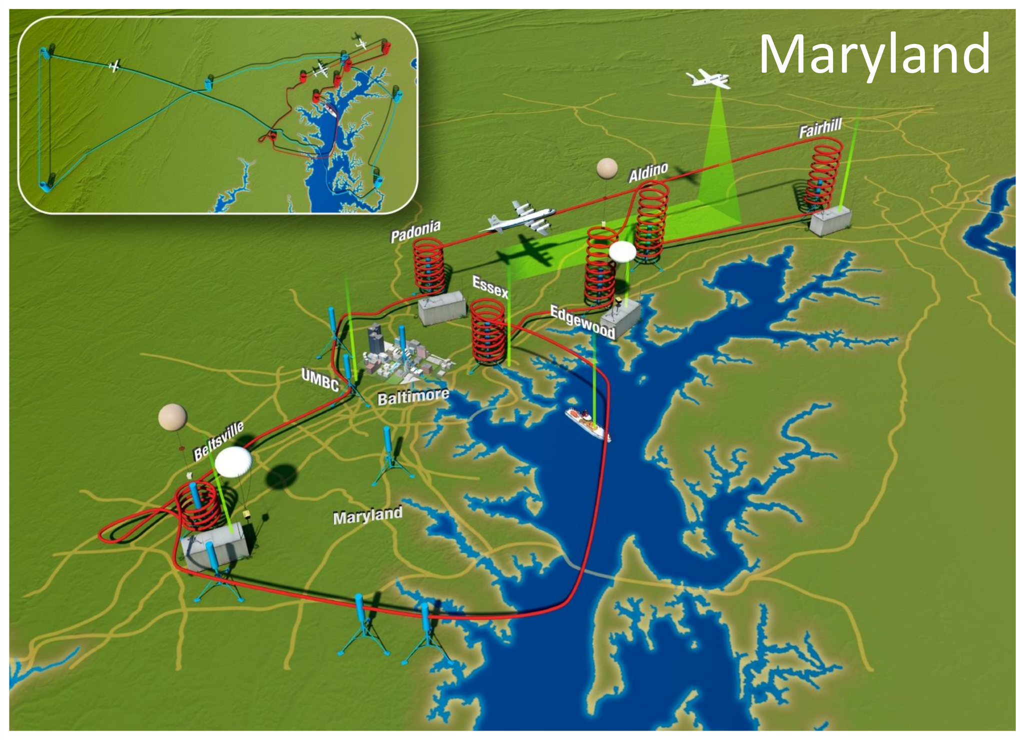
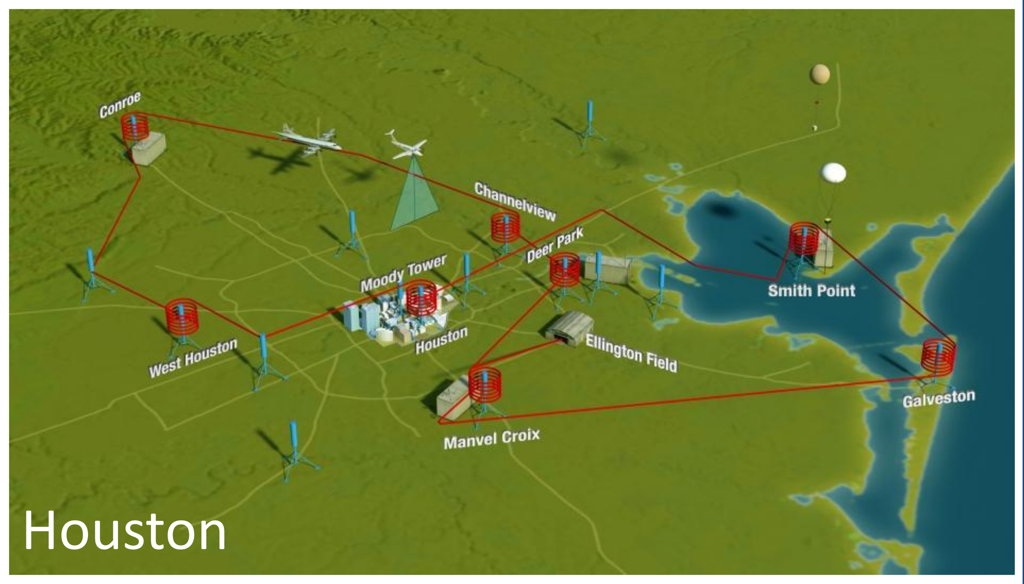
Introduction

- Vertical distribution of aerosols is critical to surface air quality, direct radiative forcing, and remote sensing
- Aerosol loading can be highly variable due to variations in emission/deposition, transport, boundary layer (BL) structure and mixing, and local meteorology
- The NASA DISCOVER-AQ airborne field campaign collected air quality measurements and generated more than 400 vertical profiles from the surface to about 4 km over Maryland and Houston



- These vertical profiles provide a unique opportunity to evaluate variability of vertical profiles in space and time
- From each deployment, three sites were chosen to represent a variety of air quality conditions and local meteorological influences, as well as to allow for comparisons between the deployments for similar sites



- For DISCOVER-AQ Maryland (left), the selected sites are Padonia (inland, polluted), Fairhill (inland, rural), and Essex (coastal, polluted)
- For DISCOVER-AQ Houston (above), the selected sites are Galveston (coastal, polluted), Moody Tower (inland, polluted), and West Houston (inland, rural)

Conclusions

- Variability between comparable sites for Maryland and Houston was not as similar as expected; higher variability in atmospheric conditions appears to contribute to higher air quality variability
- Within a region, atmospheric variability was less important; the coastal sites in both regions had the lowest theta variability but still had relatively high air quality variability
- Two types of temporal variability were observed in Houston
  - Diurnal variability due to BL height evolution, with little change to column loading
  - Day-to-day variability from an aerosol transport event which was clearly decoupled from the BL
- Although AOD measurements can be correlated to surface $PM_{2.5}$ values for Maryland (e.g. *Crumeyrolle et al., 2013*), the observed changes to column density without affecting surface concentrations (or vice versa) indicates that this technique will be more challenging for the Houston area

Future Direction and Acknowledgements

Future Direction

- Continue analysis for remaining sites in Maryland and Houston to identify locations with and causes of unusually high or low variability
- Evaluate the variability of DISCOVER-AQ's two other deployments: California San Joaquin Valley (high aerosol loading with low BL heights) and Denver (low aerosol loading)
- Compare aerosol profiles with HSRL retrievals to better understand the regional extent and variability of aerosol loading
- Identify transport events and their sources using back trajectories

Acknowledgements

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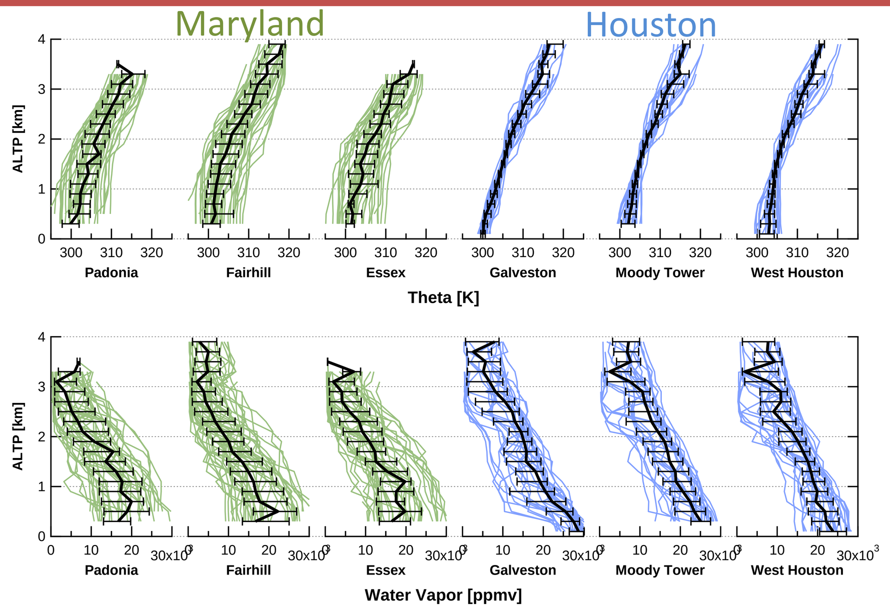
Data for this campaign is available from the NASA LaRC website for Airborne Science Data for Atmospheric Composition: www-air.larc.nasa.gov

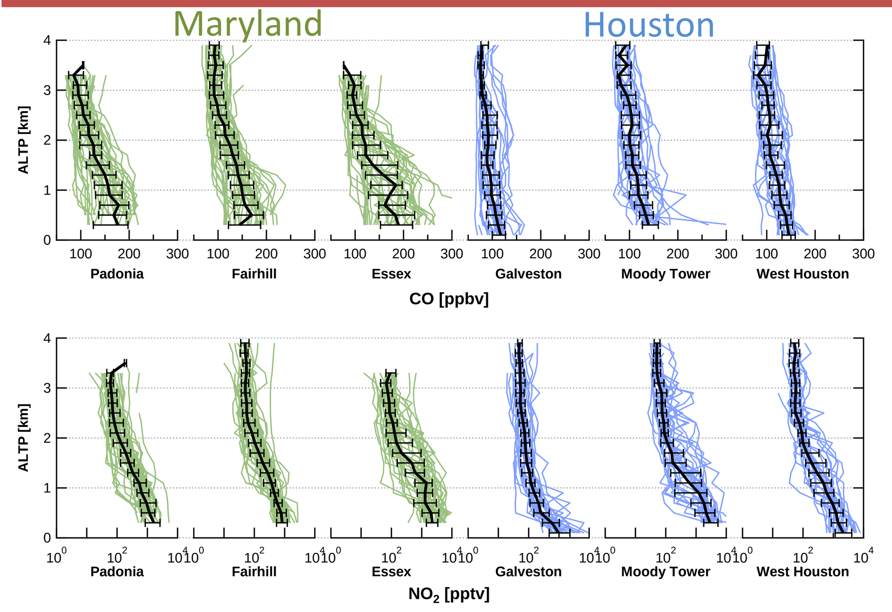
Site Variability of Selected Parameters

Meteorology Parameter Profiles



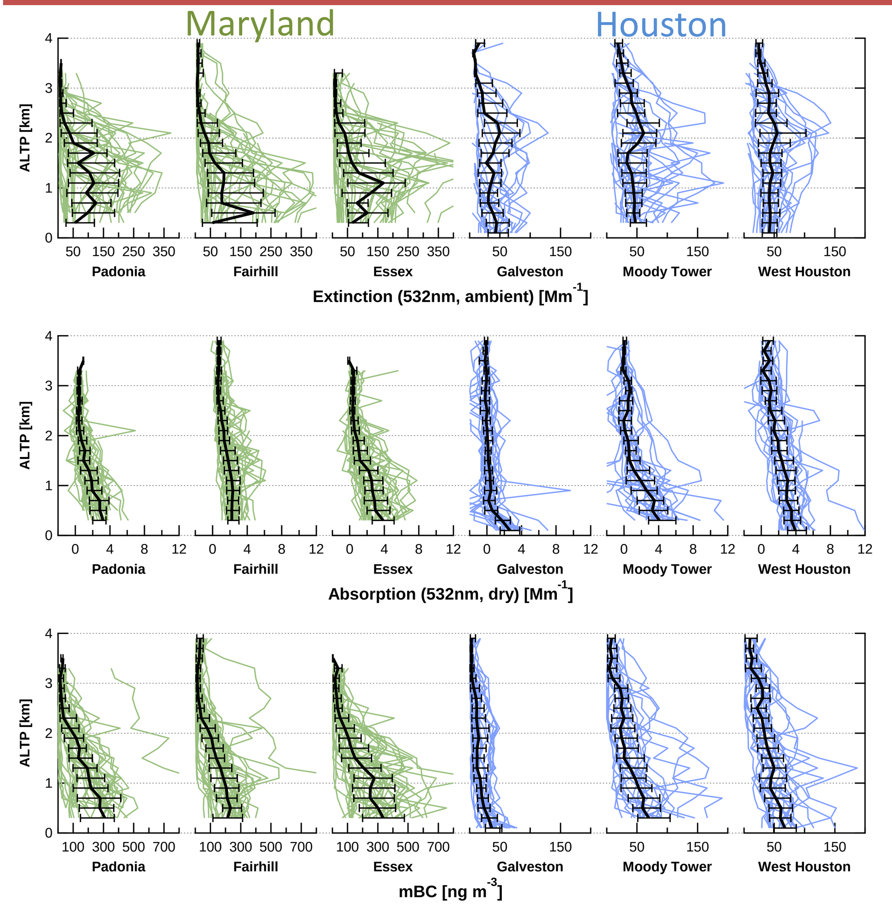
- We expect sites with the same type to have similar variability. However, atmospheric conditions in Maryland were more variable than in Houston, which appears to be driving higher variability for nearly all air quality measurements (see table below)

Gas Tracer Profiles



- NO_2 variability was higher for polluted sites, particularly in the middle of the profile due to BL height changes throughout the day

Aerosol Parameter Profiles



- Aerosol loading in Maryland is much higher than in Houston (note the scale changes from Maryland to Houston sites)
- Extinction variability continues above the BL (i.e. from 1.5-3 km) for Houston sites and is attributable to aerosol transport rather than BL height changes (see "Day-to-day Variability"). In Maryland, extinction variability is confined to the BL and transport is much less pronounced
- BL heights seem lowest and most consistent for Galveston (see absorption and NO_2 profiles)

Site Average Variability (IQR/Median)

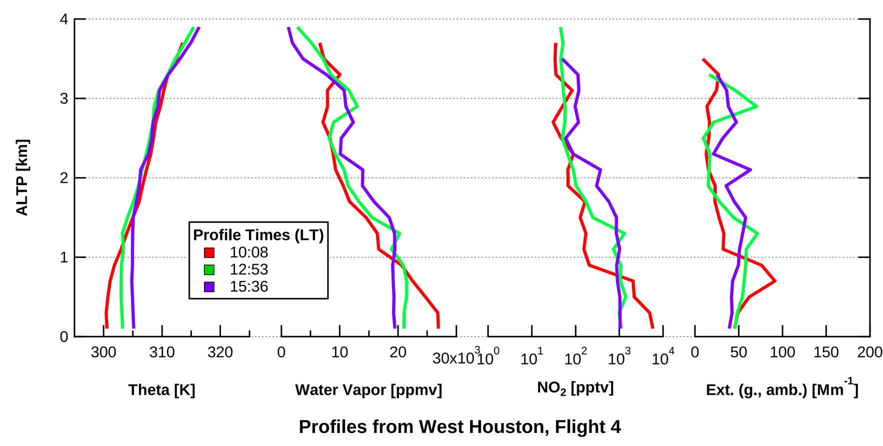
Site	Padonia	Fairhill	Essex	Galveston	Moody Tower	West Houston
Location/Type	MD, Urban, Inland	MD, Rural, Inland	MD, Urban, Coastal	TX, Urban, Coastal	TX, Urban, Inland	TX, Rural, Inland
Theta	0.0161	0.0171	0.0141	0.0057	0.0064	0.0065
Water Vapor	1.1209	1.1079	0.9480	0.7556	0.6598	0.7432
Extinction	1.0231	1.8756	1.8232	0.8560	0.8487	0.7231
Scattering	1.6548	1.6137	1.6037	0.8830	0.8680	0.7525
Absorption	1.0231	0.7698	1.2845	1.2251	4.8778	1.4807
mBC	1.3395	1.2718	1.3179	1.3960	1.4552	1.0360
f(RH)	0.2141	0.2198	0.2084	0.1867	0.1516	0.1523
SAE	0.1597	0.1894	0.2175	0.1237	0.1104	0.0941
CO	0.3024	0.3032	0.3535	0.2509	0.3052	0.2845
NO_2	0.8947	0.7718	1.4721	0.9223	1.2145	1.0764

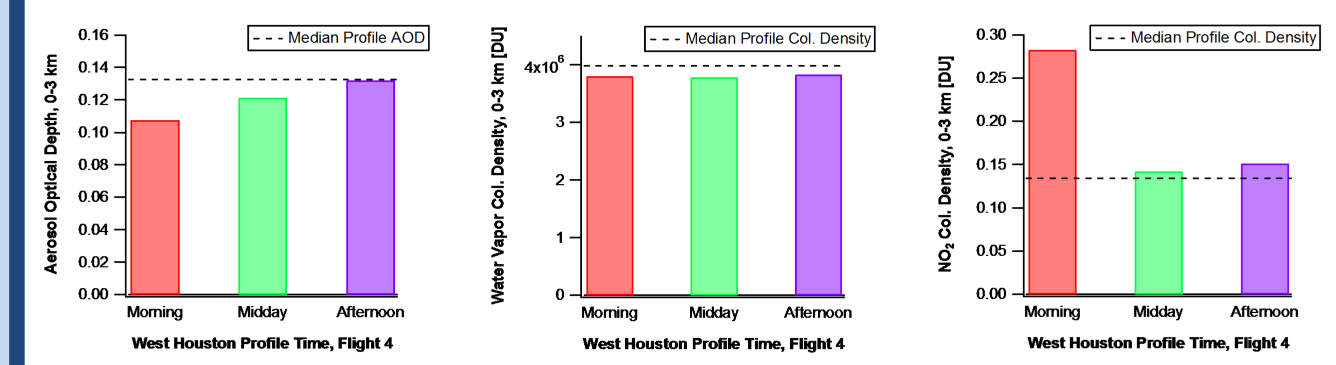
Variability Metric and Observations

- Site average variability metric for a given parameter $= \frac{\sum_{i=1}^{nbins}\left(\frac{IQR_i}{Median_i}\right)}{nbins}$
- Allows comparison of relative variability among sites with different concentrations (e.g. rural vs. urban variability or extinction variability at Maryland sites vs. Houston sites)
- This metric works well for most parameters, but fails for absorption at Moody Tower because the median absorption is low
- Variability of air quality constituents is high at Galveston despite having a consistent BL height (see profiles of NO_2 and absorption) and low theta variability
- Among Maryland sites, Essex had the lowest environmental variability, but high air quality variability
- Fairhill had the lowest air quality concentrations of the three Maryland sites (see profile graphs), but air quality variability lower than or comparable to the other two sites (see table)

Temporal Variability

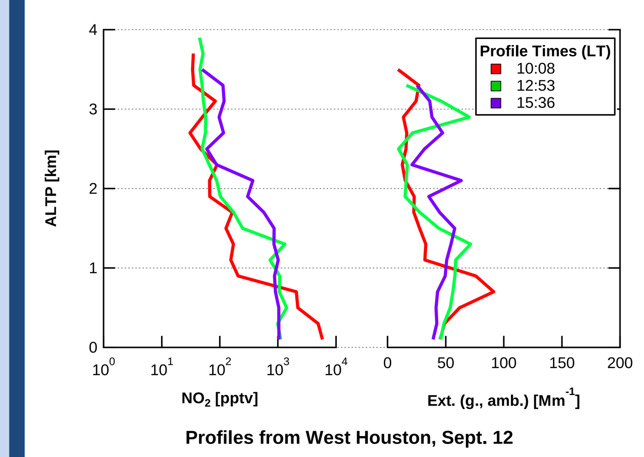
Diurnal Variability

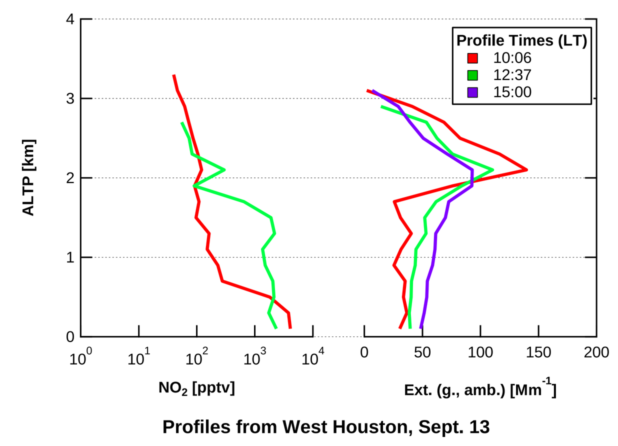


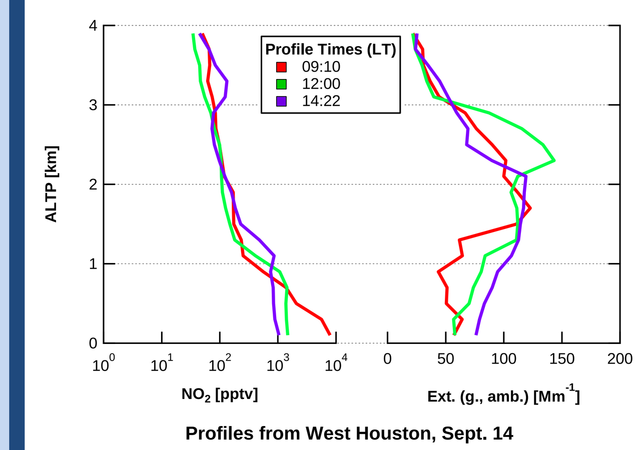


- BL height increased throughout the day with little change in total column loading
- Surface concentration trends can differ from column density trends (e.g. AOD increases as BL extinction decreases)

Day-to-day Variability







- Profiles from three consecutive days of flights over West Houston show significant increase in extinction between 1-3 km
- Enhancement is clearly above the top of the BL (as indicated by the NO_2 profiles)
- No associated increase in NO_2, so increase is likely due to transport rather than local emissions
- BL response is delayed and diminished as the aerosol layer mixes down to surface