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

• 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)

Site Variability of Selected Parameters

Meteorology Parameter Profiles

Galveston

Moody Tower

West Houston

Gas Tracer Profiles

Maryland

Houston

Aerosol Parameter Profiles

Maryland

Houston

• 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)

• NO2 variability was higher for polluted sites, particularly in the middle of the profile due to BL height changes throughout the day

• 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 NO2 profiles)

• 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)

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 PM2.5 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

Variability Metric and Observations

• Site average variability metric for a given parameter = 

• 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 NO2 and absorption) and low theta variability

• Site Average Variability (IQR/Median)

<table>
<thead>
<tr>
<th>Site</th>
<th>Padonia</th>
<th>Fairhill</th>
<th>Essex</th>
<th>Galveston</th>
<th>Moody Tower</th>
<th>West Houston</th>
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</thead>
<tbody>
<tr>
<td>Location/Type</td>
<td>MD, Urban, Inland</td>
<td>MD, Rural, Inland</td>
<td>MD, Urban, Coastal</td>
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<td>TX, Urban, Inland</td>
<td>TX, Rural, Inland</td>
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<td>Theta</td>
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<td>1.4721</td>
<td>0.9223</td>
<td>1.2145</td>
<td>1.0764</td>
</tr>
</tbody>
</table>

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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 NO2 profiles)

• No associated increase in NO2 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