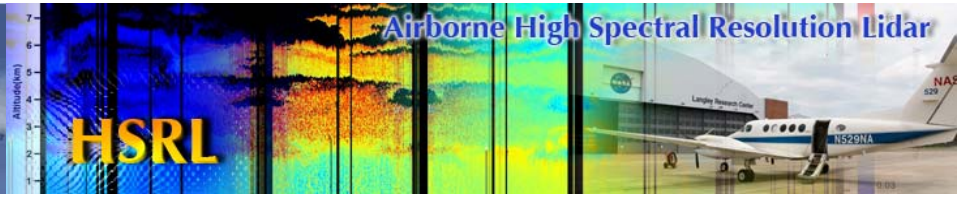
DISCOVER-AQ

Spatial Distribution of Aerosols in Four U.S. Regions: Impacts on Satellite Measurements

Andreas Beyersdorf – NASA Langley Research Center



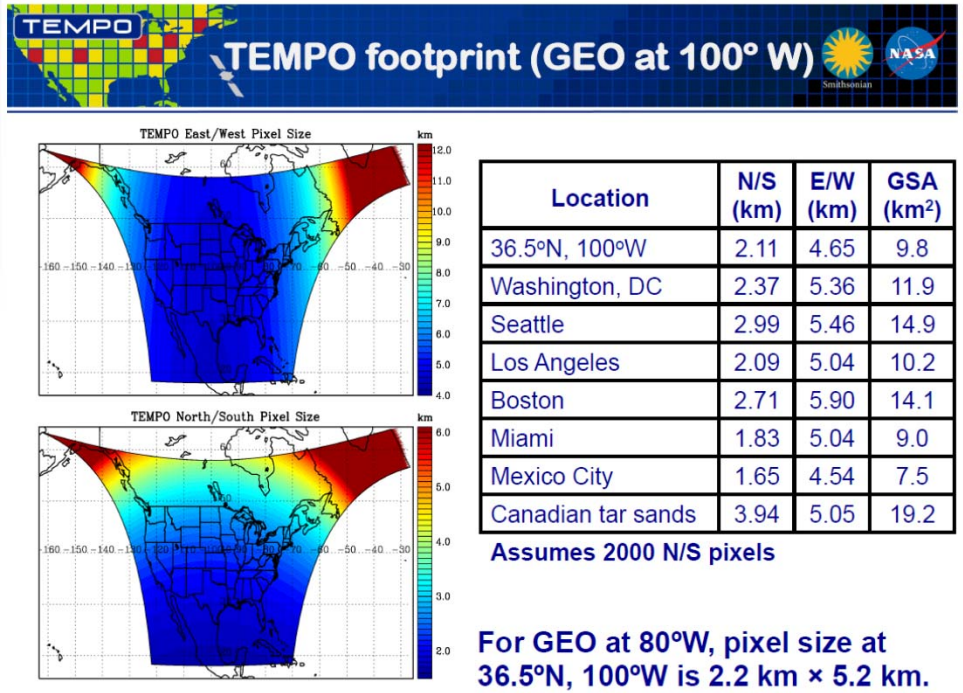
Bruce Anderson, Gao Chen, Chelsea Corr, Robert Martin, Rich Moore, Michael Shook, Lee Thornhill, Eddie Winstead & Luke Ziemba
Suzanne Crumeyrolle (Université de Lille)
Jack Lin (Georgia Tech)

Rich Ferrare, Chris Hostetler, Tim Berkoff, Sharon Burton, Jim Collins, Tony Cook, Marta Fenn, John Hair, David Harper, Patricia Sawamura, Amy Jo Scarino & Shane Seaman
Ray Rogers (Lord Fairfax Community College)

Spatial Variability Analysis

TEMPO

- Footprint in US: 9-15 km^2
- Data product spatial resolution at 8 × 4.5 km = **36 km^2**



Location	N/S (km)	E/W (km)	GSA (km^2)
36.5°N, 100°W	2.11	4.65	9.8
Washington, DC	2.37	5.36	11.9
Seattle	2.99	5.46	14.9
Los Angeles	2.09	5.04	10.2
Boston	2.71	5.90	14.1
Miami	1.83	5.04	9.0
Mexico City	1.65	4.54	7.5
Canadian tar sands	3.94	5.05	19.2

Assumes 2000 N/S pixels

For GEO at 80°W, pixel size at 36.5°N, 100°W is 2.2 km × 5.2 km.

Kelly Chance, TEMPO Stats, AQAST 7
https://www.cfa.harvard.edu/atmosphere/publications/KChance-AQAST-17jun2014.pdf

DISCOVER-AQ

Airborne In Situ Aerosol Measurements

Multitude of Members

All Campaigns: Bruce Anderson, Gao Chen, Lee Thornhill, Eddie Winstead & Luke Ziemba

1-3 Campaigns: Matt Brown, Chelsea Corr, Suzanne Crumeyrolle, Carolyn Jordan, Bobby Martin, Rich Moore & Michael Shook

Georgia Tech: Thanos Nenes, James Hite & Jack Lin

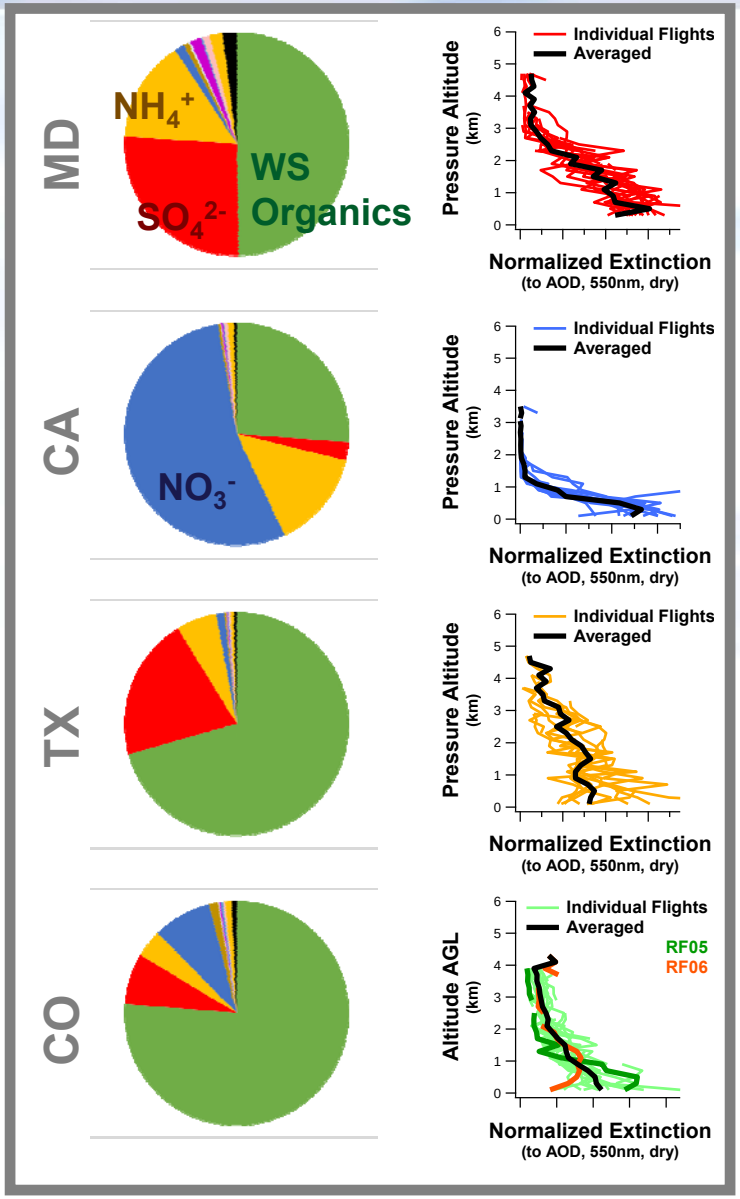
Multitude of Measurements

Aerosol Concentrations

Aerosol Sizes (10 nm - 5 μm)

Composition (PILS & SP2)

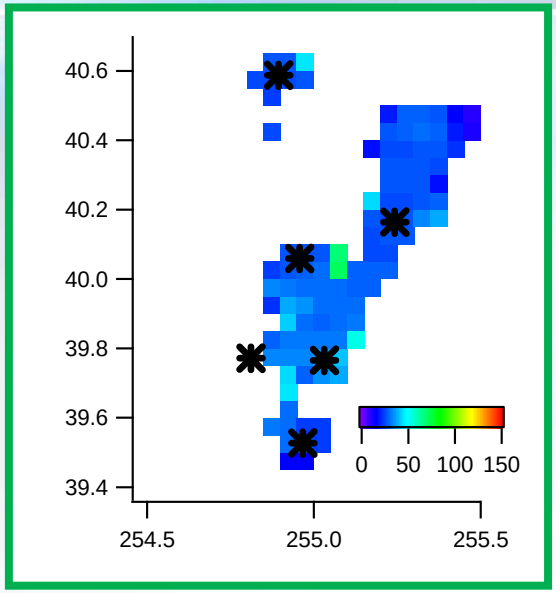
Optical Properties



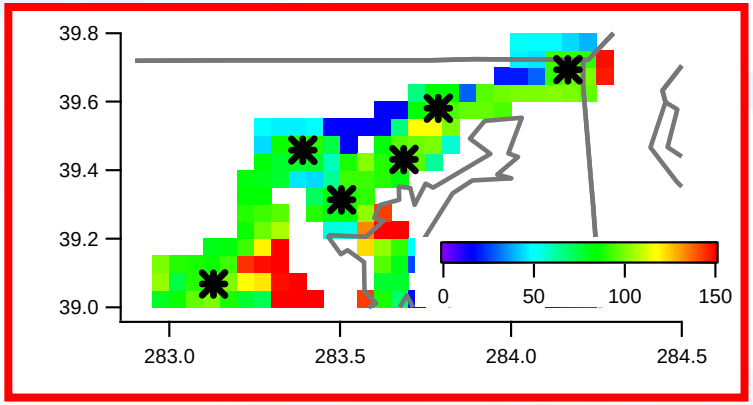
Dry Aerosol Extinction (550nm)

Campaign Averages for 0.05° × 0.05° (25 km^2)

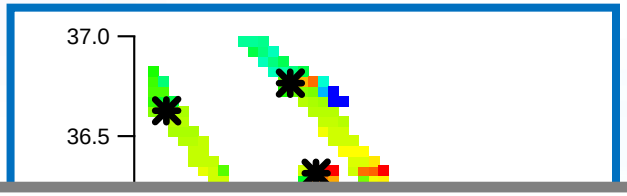
Colorado
(below 1.7-2.2 km)



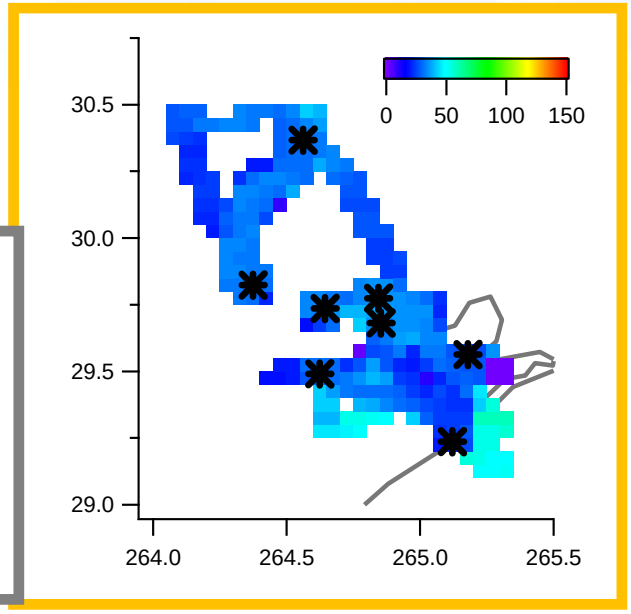
Maryland
(below 1 km)



California
(below 0.5 km)



Texas
(below 1 km)



What can DISCOVER-AQ tell us about the spatial variability of aerosols?

- Sub-pixel Variability
- Aerosol maximums
- Dependence on region
- Dependence on time-of-day

Spatial Variability Analysis

TEMPO

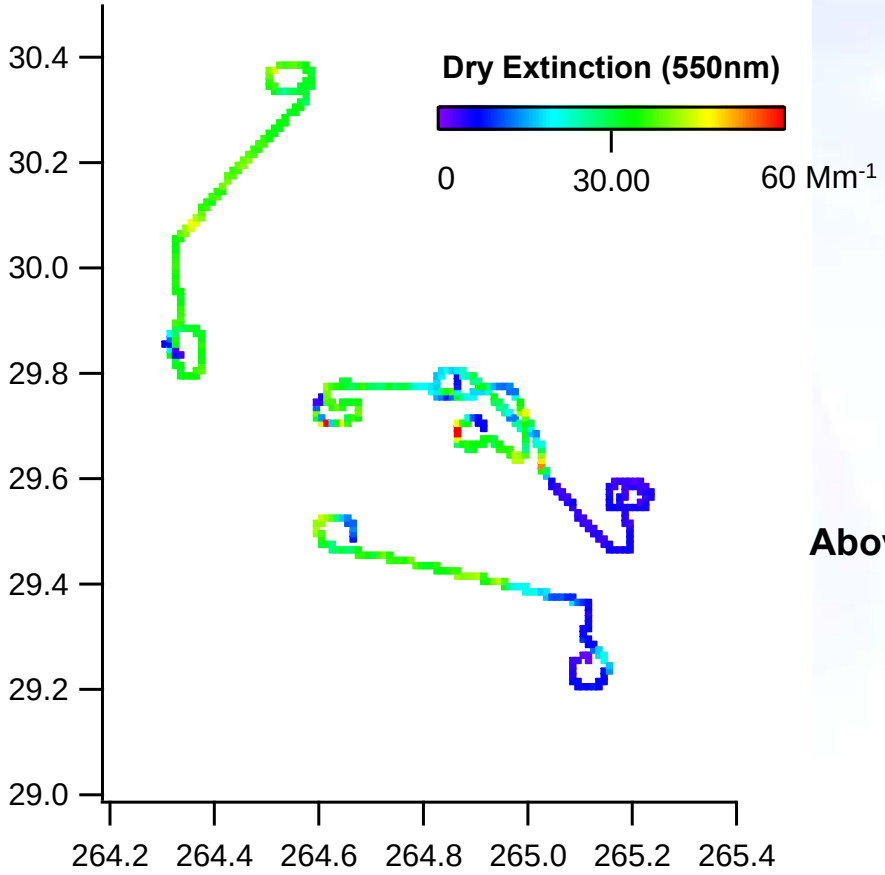
- Footprint in US: 9-15 km^2
- Data product spatial resolution at 8 × 4.5 km = **36 km^2**

Each circuit is taken as a snapshot of the region

- LARGE aerosol extinction in 'boundary layer' at 532 nm
  - At 20% RH → to relate to ground-based $PM_{2.5}$
  - 'boundary layer' defined as <1 km for Maryland &Texas
    <0.5 km for California
    <1.7-2.2 km for Colorado
- Aerosol Optical Depth (AOD) from the HSRL at 532 nm
  - At ambient relative humidity

Texas RF7, Circuit 1

1 km²

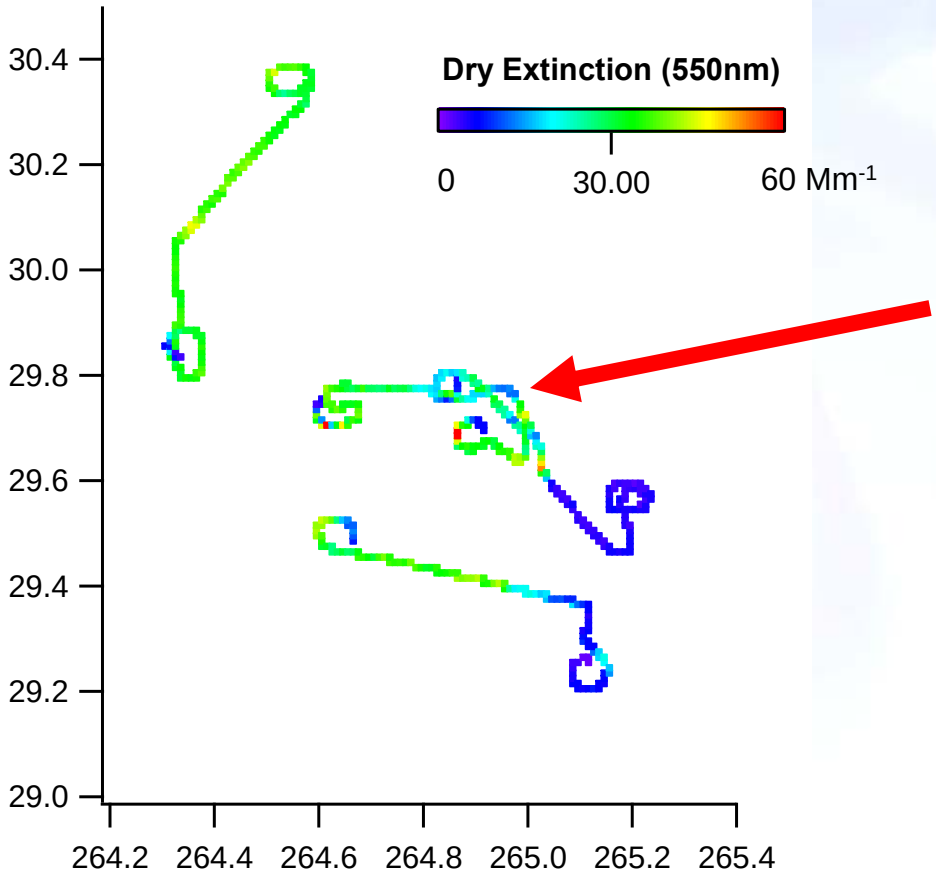


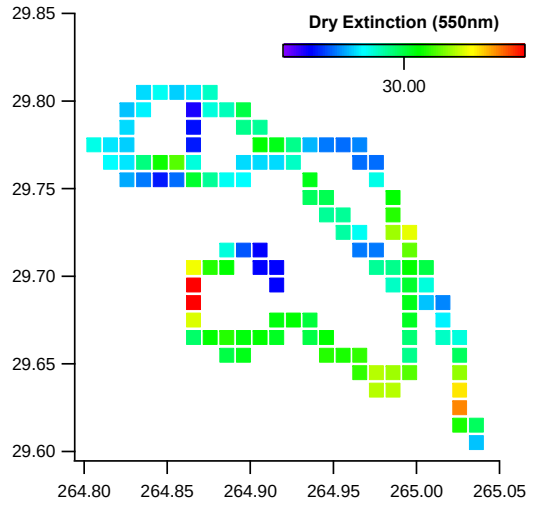
Above 60 Mm^{-1} →

$PM_{2.5}$ (µg/m^3)	AQI
C_{low}- C_{high} (avg)	Category
0.0-12.0 (24-hr)	Good
12.1-35.4 (24-hr)	Moderate
35.5-55.4 (24-hr)	Unhealthy for Sensitive Groups
55.5-150.4 (24-hr)	Unhealthy
150.5-250.4 (24-hr)	Very Unhealthy
250.5-350.4 (24-hr)	Hazardous
350.5-500.4 (24-hr)	Hazardous

Texas RF7, Circuit 1

1 km²

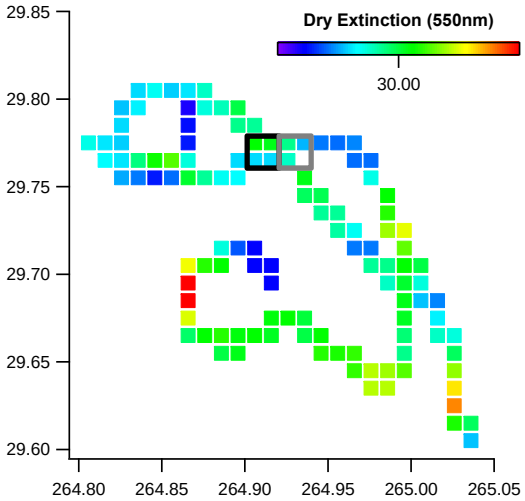




Max = 102 Mm^{-1} **Average = 25 Mm^{-1}**

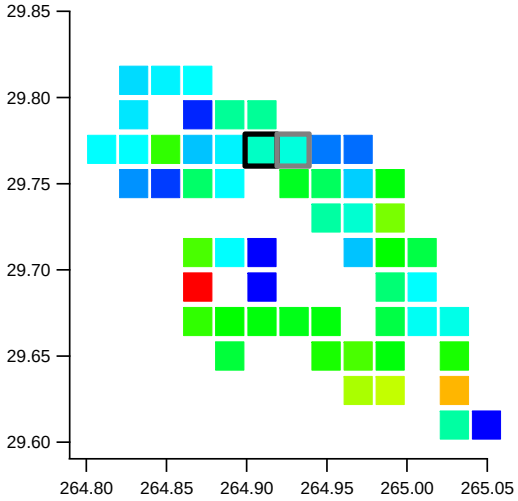
Texas RF7, Circuit 1

1 km^2



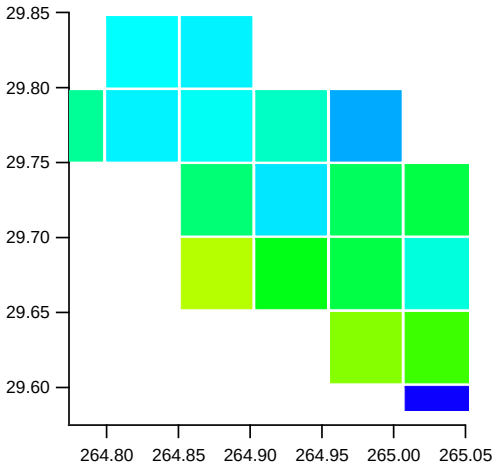
Max = 102 Mm^{-1} Avg = 25 Mm^{-1}

4 km^2



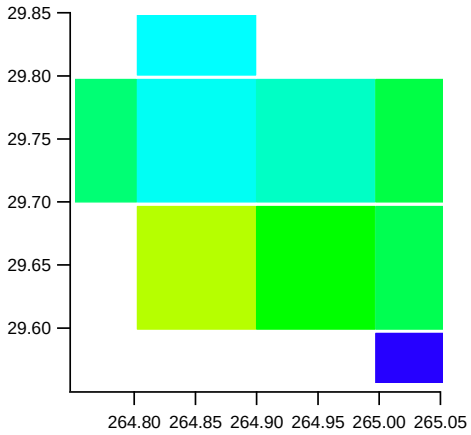
Max = 76 Mm^{-1} Avg = 25 Mm^{-1}

25 km^2



Max = 44 Mm^{-1} Avg = 26 Mm^{-1}

100 km^2

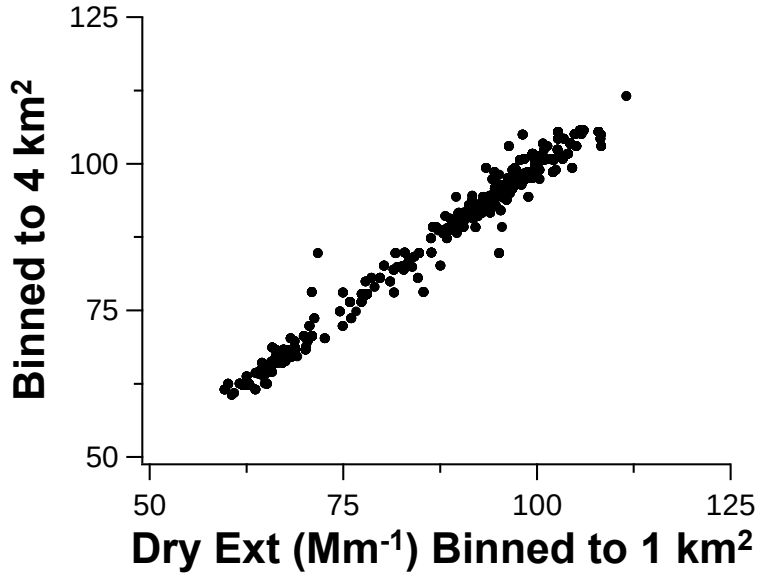


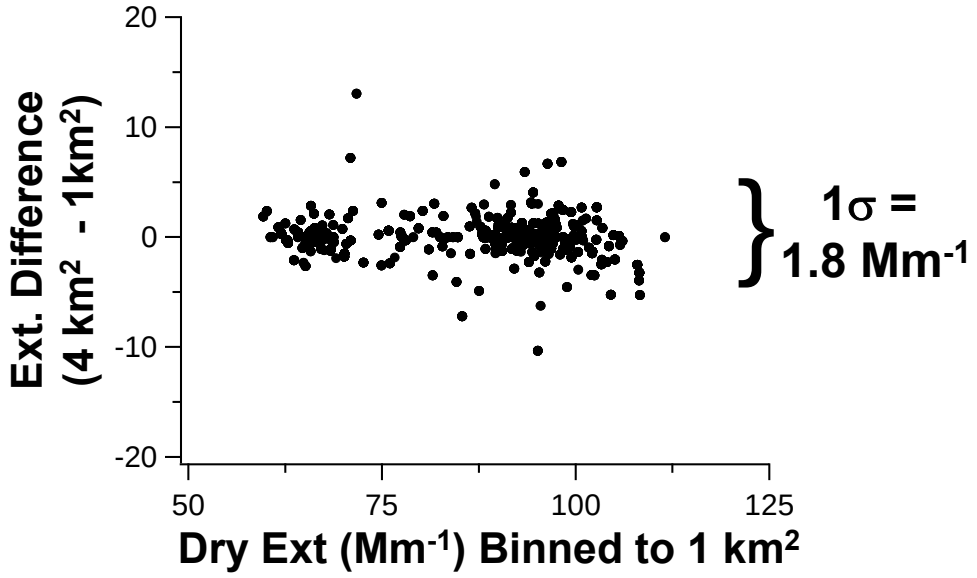
Max = 43 Mm^{-1} Avg = 26 Mm^{-1}

Sub-Pixel Variability

Maryland - RF04, Circuit 2

- Compare data binned to 4 km^2 to data binned to 1 km^2

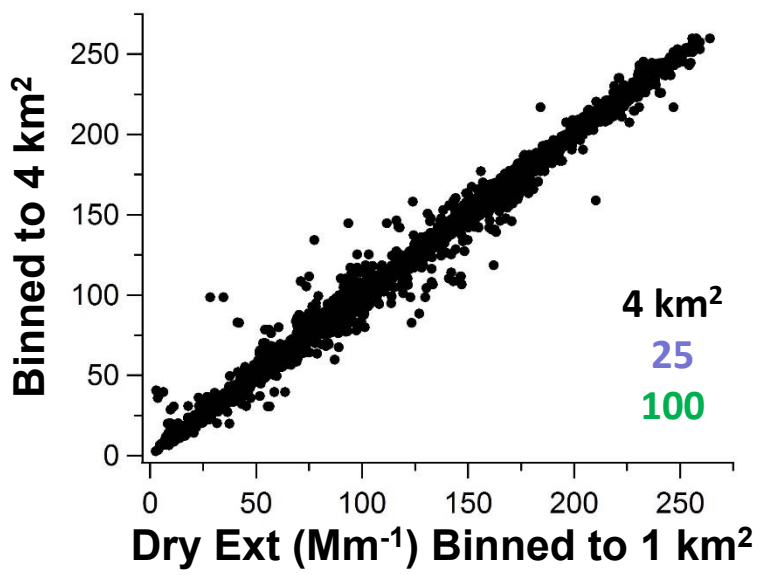


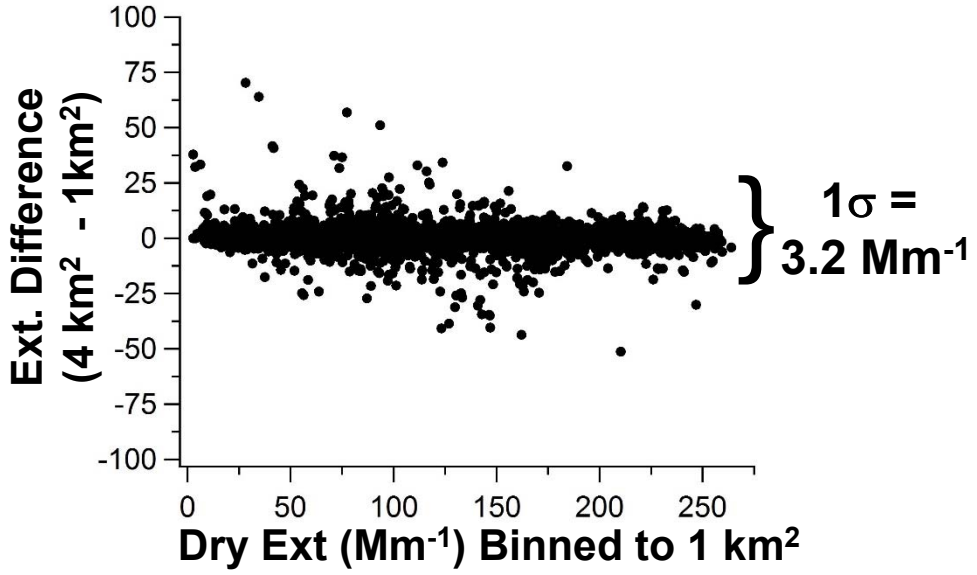


Sub-Pixel Variability

Maryland - All Circuits

- Compare data binned to 4 km^2 to data binned to 1 km^2

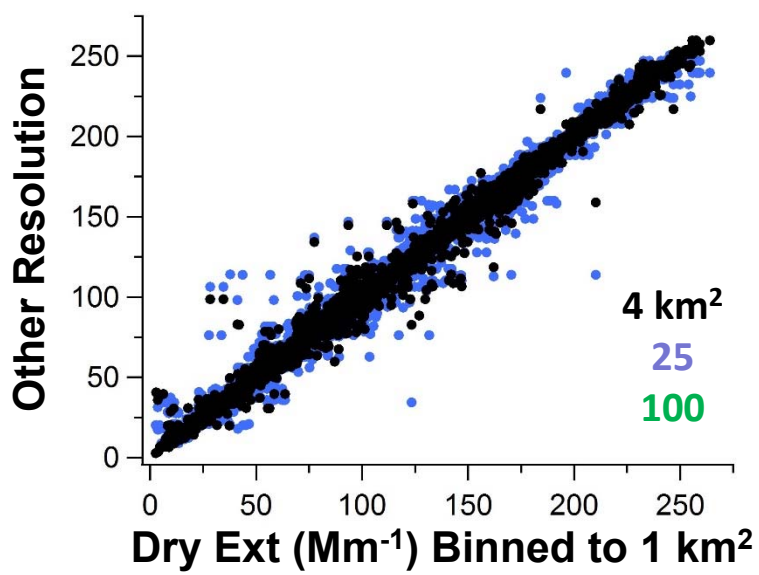


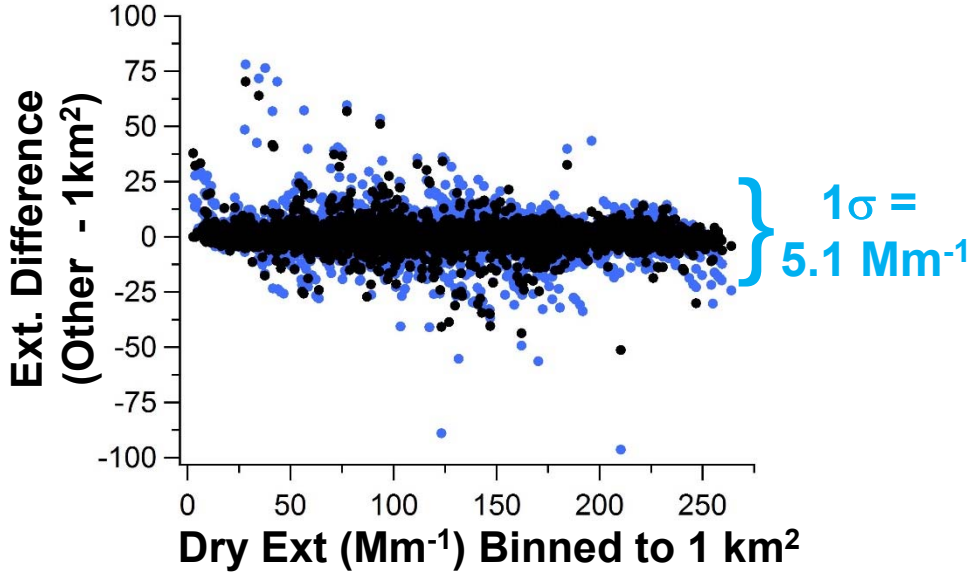


Sub-Pixel Variability

Maryland - All Circuits

- Compare data binned to 25 km^2 to data binned to 1 km^2

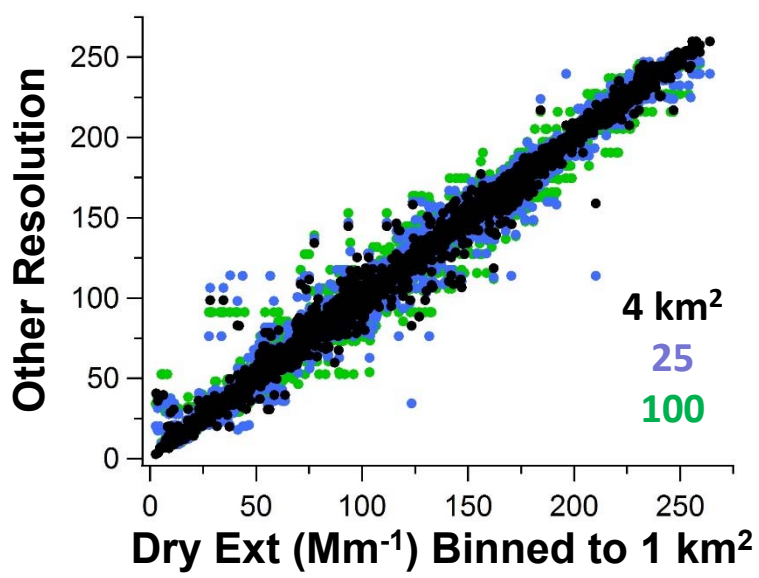


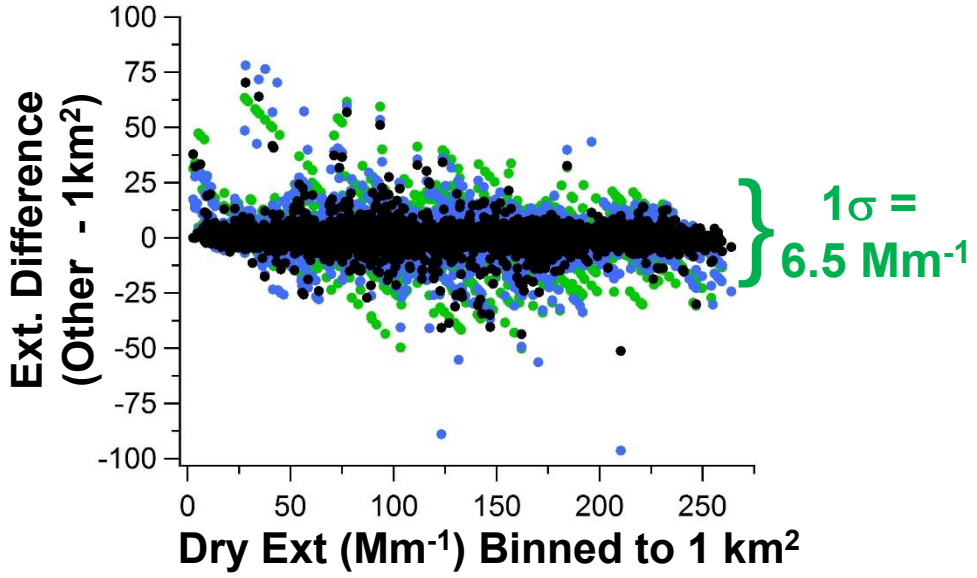


Sub-Pixel Variability

Maryland - All Circuits

- Compare data binned to 100 km^2 to data binned to 1 km^2

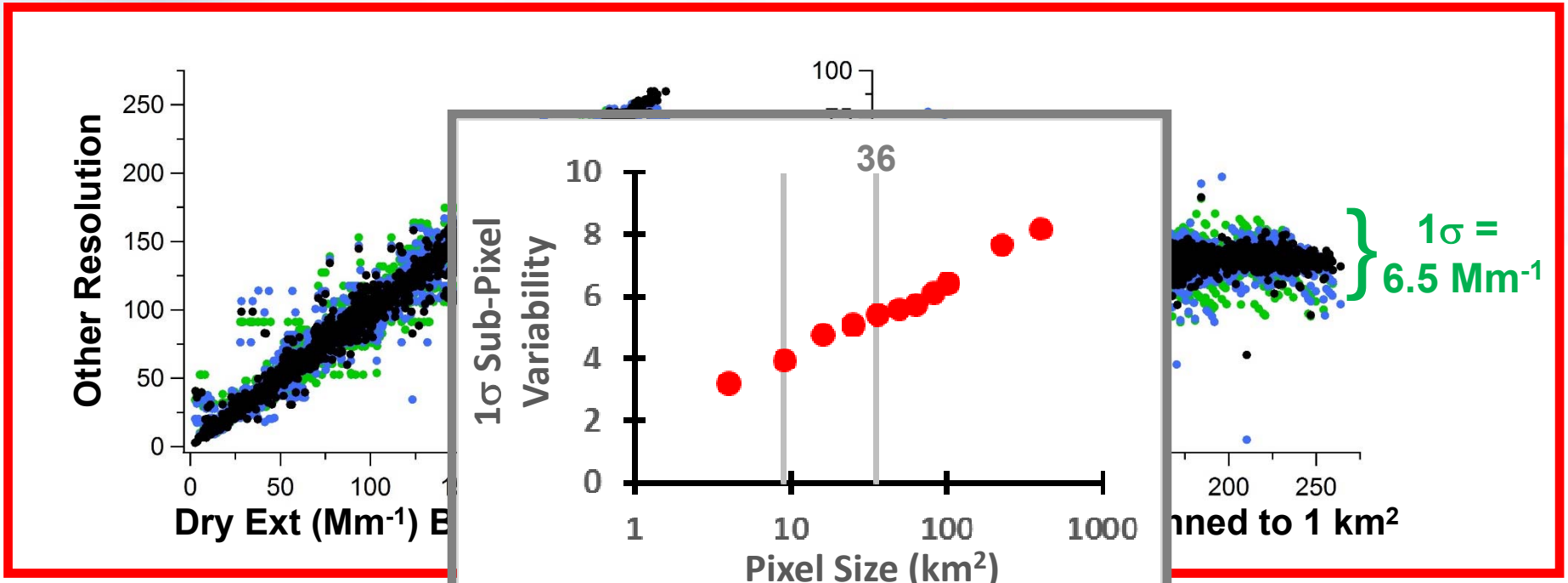




Maryland Sub-Pixel Variability

Maryland - All Circuits

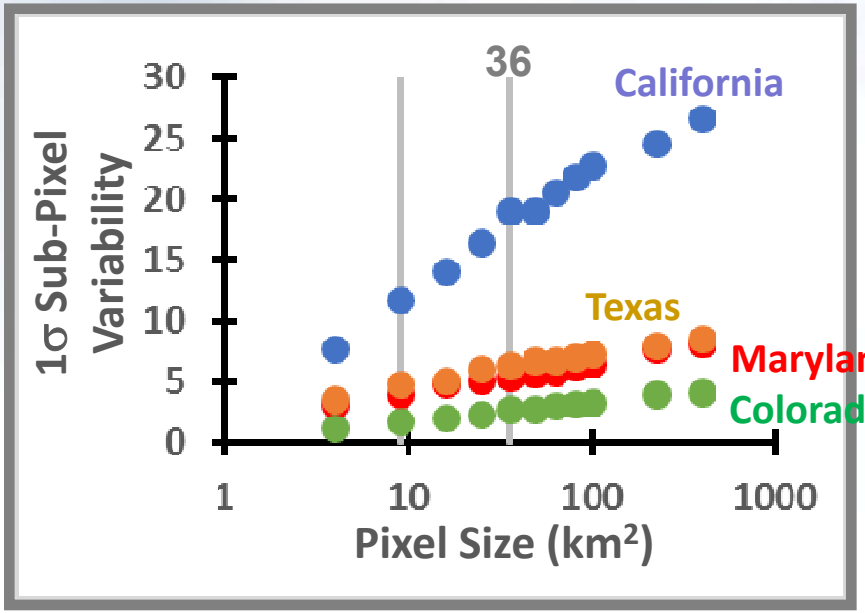
- Varying Resolution
  - As pixel size increases the sub-grid variability increases



Extinction Sub-Pixel Variability

All Campaigns

- Highest in California - shallow boundary layer
- Lowest in Colorado - low aerosol loadings



1σ Variability for 36 km² Pixel Size	Extinction (Mm^{-1})	Mass* ($\mu g\ m^{-3}$)	
Maryland	5.4	1.1	
California	19	3.8	
Texas	6.3	1.3	
Colorado	2.8	0.6	

*Using a Mass Extinction Efficiency of 5

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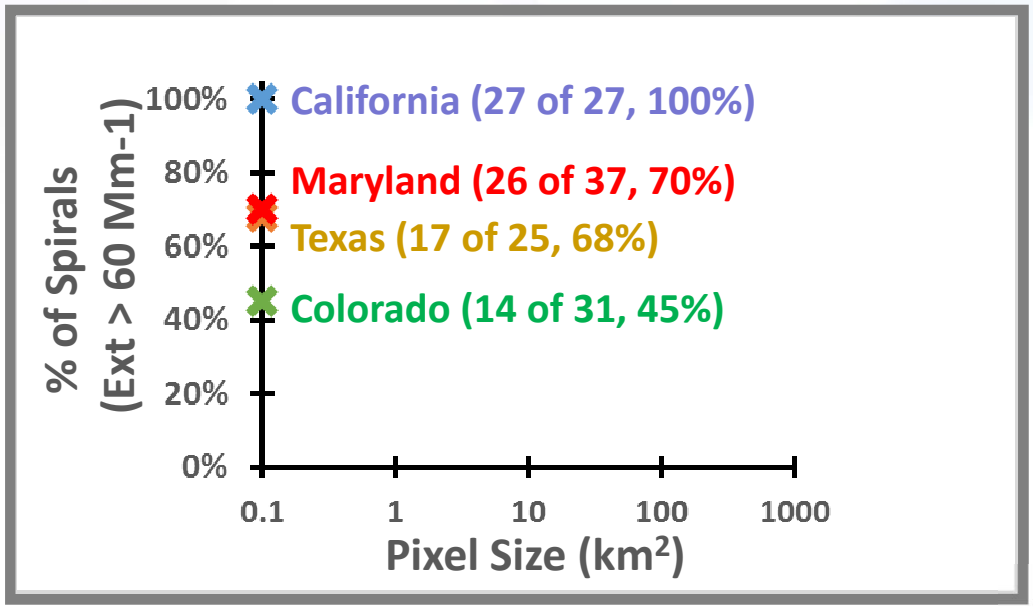
High Aerosol Loadings

What Effects Does Pixel Size have on High Aerosol Loading Periods?

- How many circuits have a ext. >60 Mm^{-1} (~moderate AQI)?
- **120** Total Circuits
  - **84** circuits have at least one 1-sec data point with extinction > 60 Mm^{-1} (70%)



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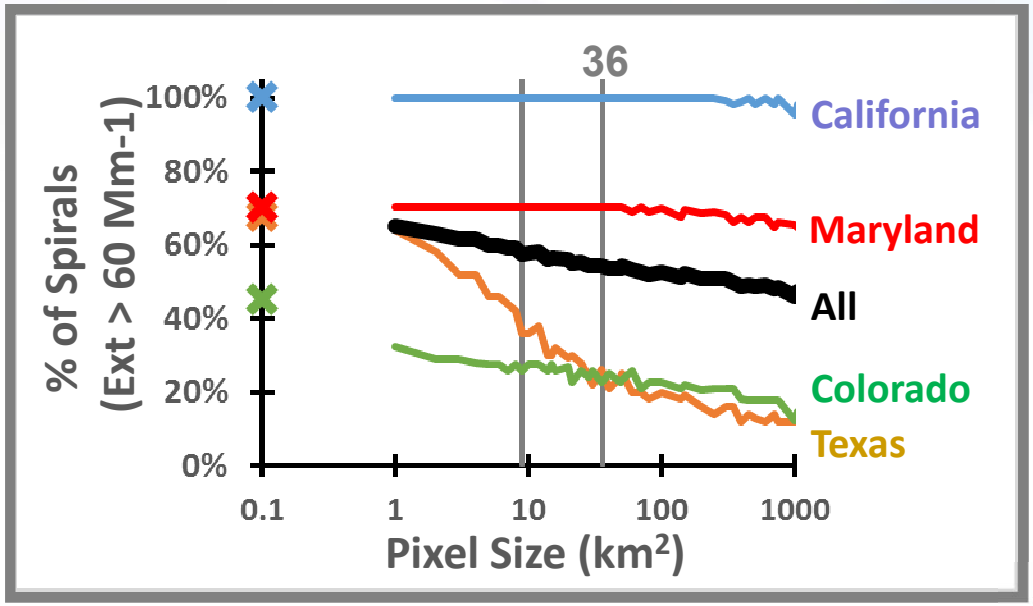
High Aerosol Loadings

What Effects Does Pixel Size have on High Aerosol Loading Periods?

- **36 km^{-2}**
  - CA & MD – same # of circuits with at least one pixel >60 Mm^{-1}
  - CO & TX – 7 circuits each with at least one pixel >60 Mm^{-1}



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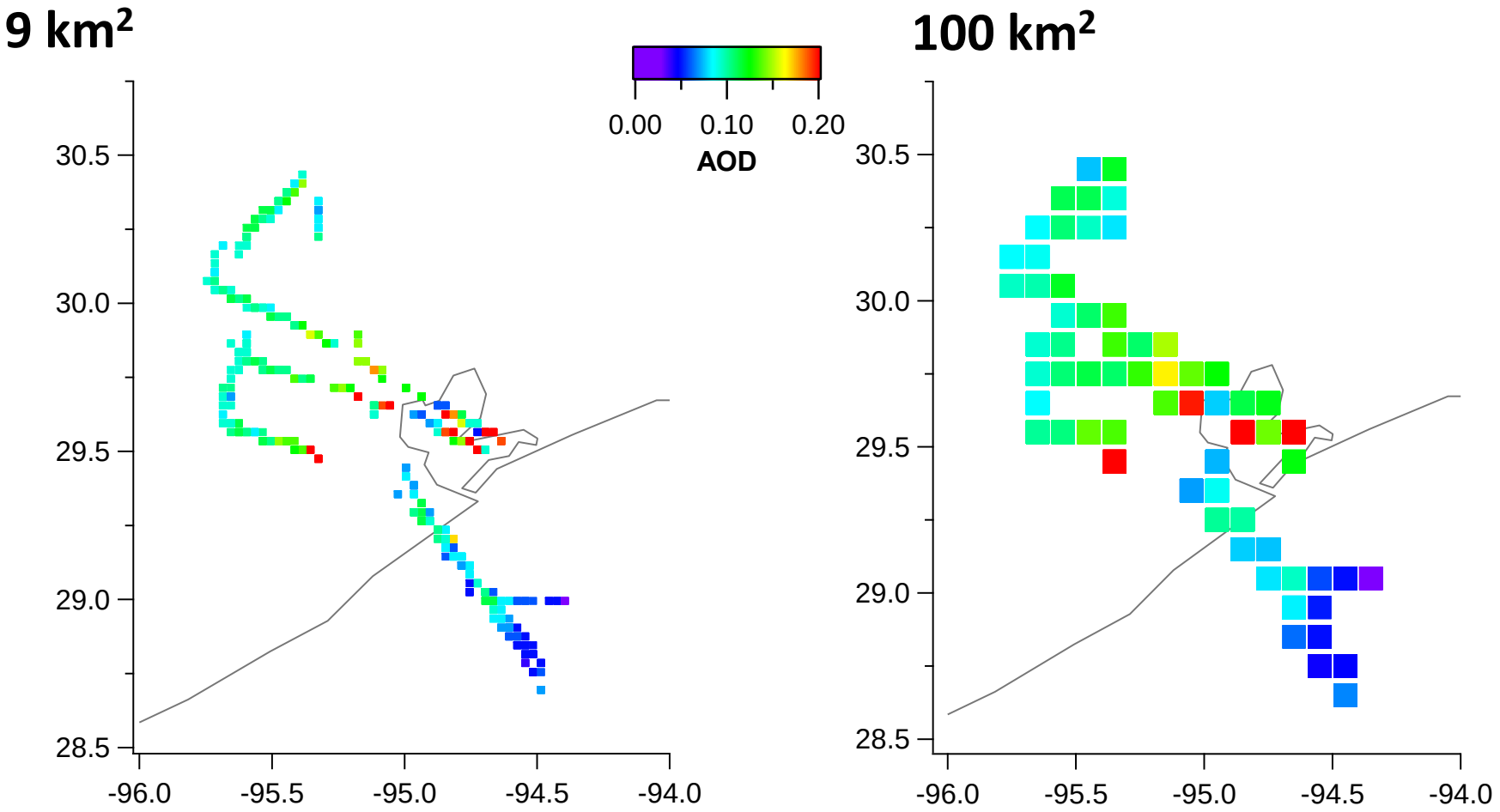
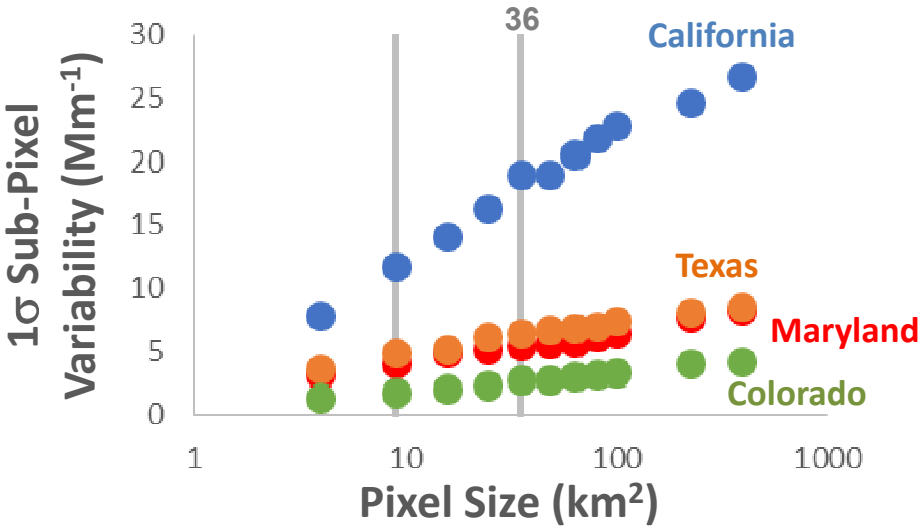
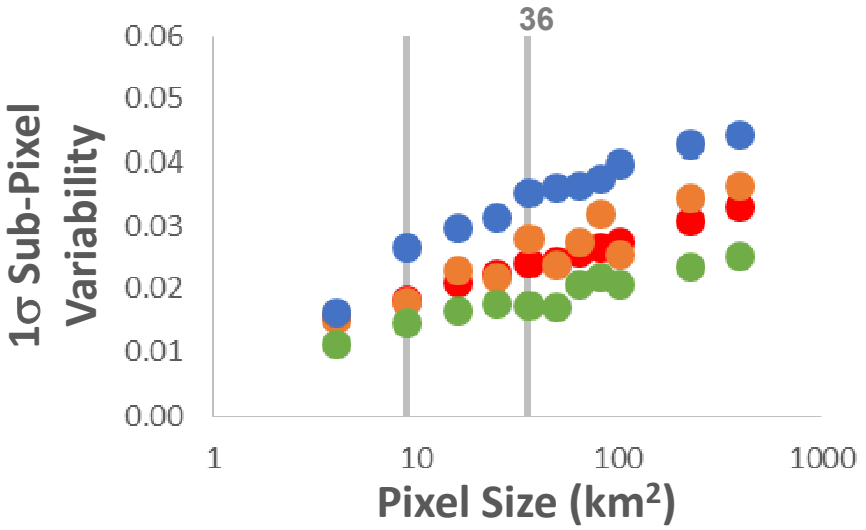
HSRL AODs – Texas, RF7, Circuit 1



High Aerosol Loadings



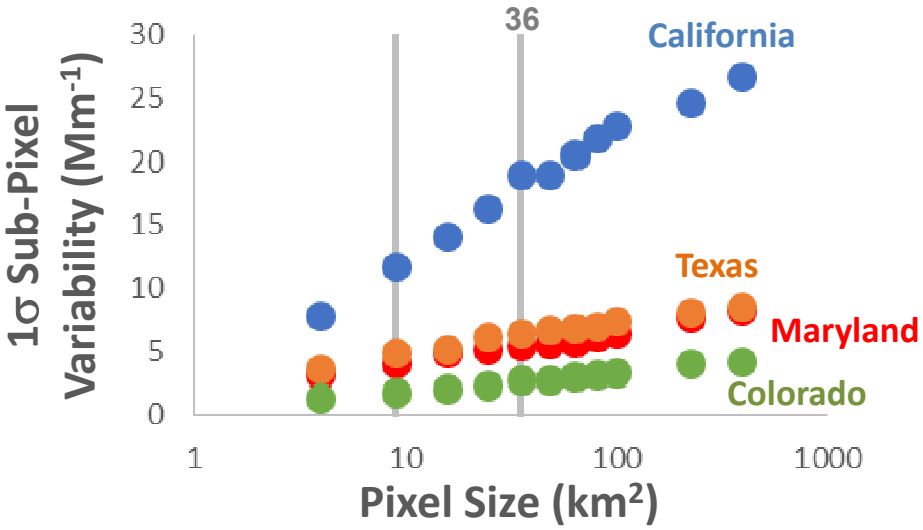


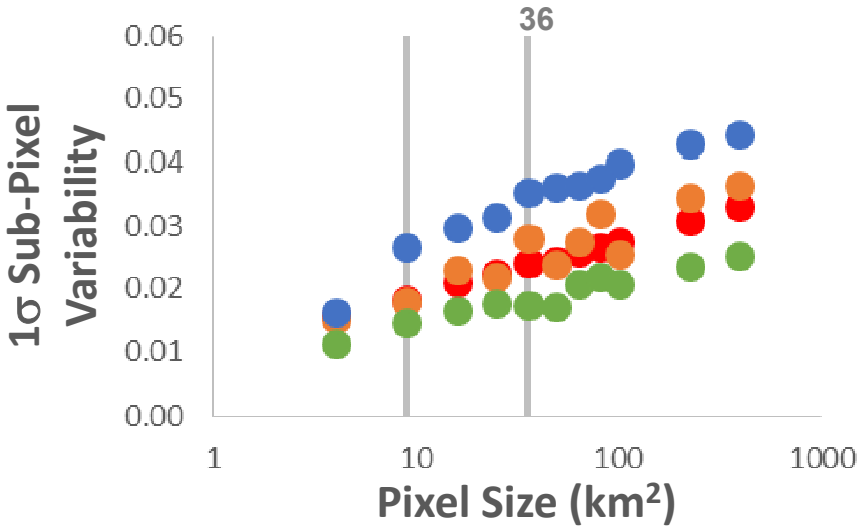
1σ Variability for 36 km² Pixel Size			
	Extinction (Mm^{-1})	Mass* ($\mu g\ m^{-3}$)	AOD
Maryland	5.4	1.1	0.024
California	19	3.8	0.035
Texas	6.3	1.3	0.028
Colorado	2.8	0.6	0.017

*Using a Mass Extinction Efficiency of 5

DISCOVER-AQ

High Aerosol Loadings





1σ Variability for 36 km² Pixel Size	Extinction (Mm^{-1})	Mass* ($\mu g\ m^{-3}$)	AOD	Average AOD
Maryland	5.4	1.1	0.024	0.27
California	19	3.8	0.035	0.11
Texas	6.3	1.3	0.028	0.18
Colorado	2.8	0.6	0.017	0.10

*Using a Mass Extinction Efficiency of 5

Conclusions

Aerosol properties were variable amongst the 4 regions

Maryland – mixture of ammonium sulfate and organics, deep mixing layers

California – ammonium nitrate dominates, shallow mixing layers

Texas – organics dominate, variable vertical profiles

Colorado – organics dominate, high percentage of aerosol above the boundary layer

Variable aerosol absorption properties (Ziemba talk)

Boundary Layer Extinction Sub-Pixel Variability

- Highest in California due to low boundary layer
- Lowest in Colorado

Extinction Above 60 Mm^{-1}

- Measured in all California & most of Maryland
  - Independent of pixel size
- Texas: the number of circuits exceeding 60

1σ Variability for 36 km^2 Pixel Size

	Extinction (Mm^{-1})	Mass* ($\mu g\ m^{-3}$)	AOD
Maryland	5.4	1.1	0.024
California	19	3.8	0.035
Texas	6.3	1.3	0.028
Colorado	2.8	0.6	0.017

*Using a Mass Extinction Efficiency of 5

Future Work

- Further connection with HSRL Measurements
- Effects of other factors on variability: time of day
- Possible analysis of gas-phase tracers
  - At 36 km^2, ozone variability of 2-3 ppbv
    NO_2 variability of 0.6-2 ppbv