Comparison of Sugar Composition in Fine and Coarse Particulate Matter at Four Sites in Eastern Texas and Central Arizona

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RICE

Sugars in Ambient PM

- Summary of 1999 National Emission Inventory by major source category (US EPA, 2001) (millions of tons / year)

Source	$PM_{2.5}$	PM_{10}
Fuel Combustion for Electric Utility	0.13	0.23
On-road Vehicles	0.41	0.46
Agriculture & Forestry	0.95	4.89
Agricultural burning & Forest fires	0.87	1.01

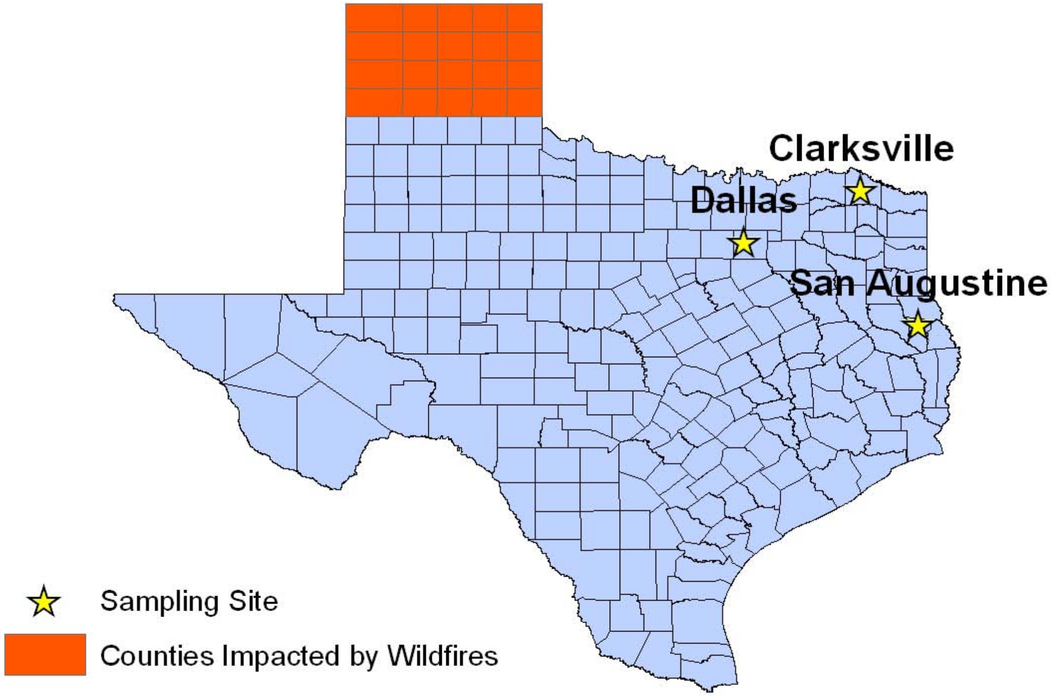
- Sugars as primary markers for biogenic carbon associated with biomass burning and atmospheric entrainment of soil

Sugars and Main Sources

Main Source	Compound	Sugar Category	Formation and Description
Biomass Burning	Levoglucosan	Anhydrosaccharide	Cellulose decomposition; Established marker
Soil Organic Matter	Glucose	Monosaccharide	Cellulose pyrolysis
	Sucrose	Disaccharide	Storage for fixed CO_2
	Trehalose	Disaccharide	Fungal metabolite; storage and transport carbohydrates and cell protectants against environmental stress (e.g., desiccation, frost and heat)
	Mannitol	Sugar Polyol	
	Sorbitol		
	Arabitol		
	Ribitol		
	Iso-erythritol		
	Glycerol		

Sampling in Texas (Nov.2005 – Jul.2006)

- ***24-hr PM2.5 Samples:***
  - Every 3rd day using High-Vol air samplers at a flow rate of 1.13 m^3/min, 174 samples in total
  - Wildfire series in Texas: Nov. 2005 – Apr. 2006

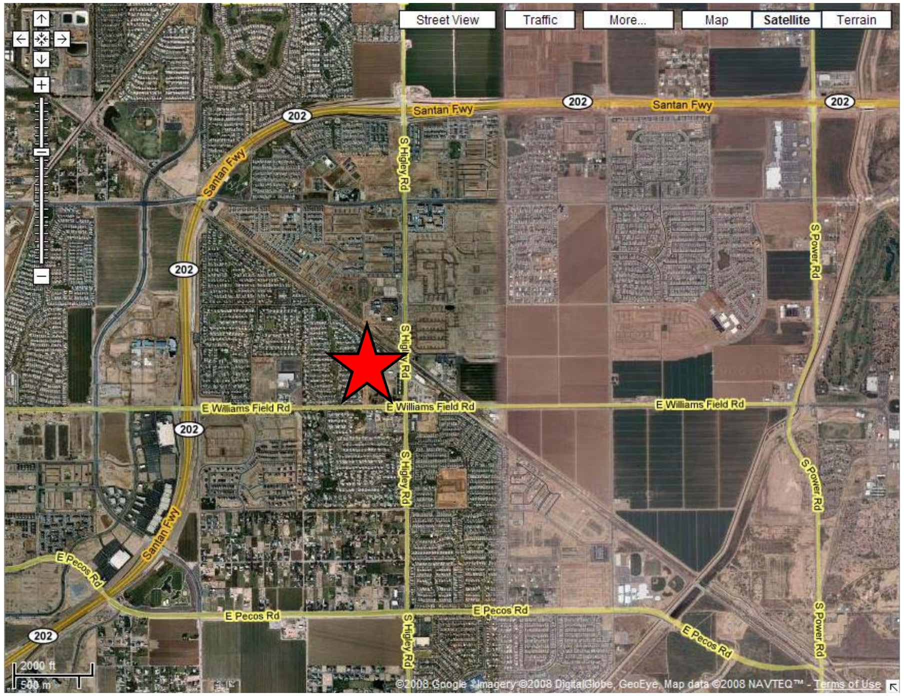


Clarksville	Rural
San Augustine	Rural
Dallas	Urban

Sampling in Arizona (Jan – Apri. 2008)

- ***24-hr PM2.5 and PM10 Samples:***

  - Every other day using a High-Vol air sampler at 1.13 m^3/min
  - A total of 45 PM2.5 and 46 PM10 samples in parallel

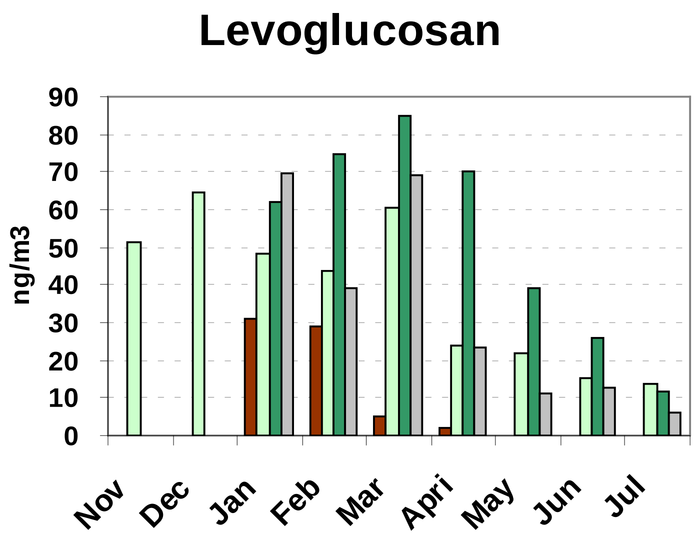


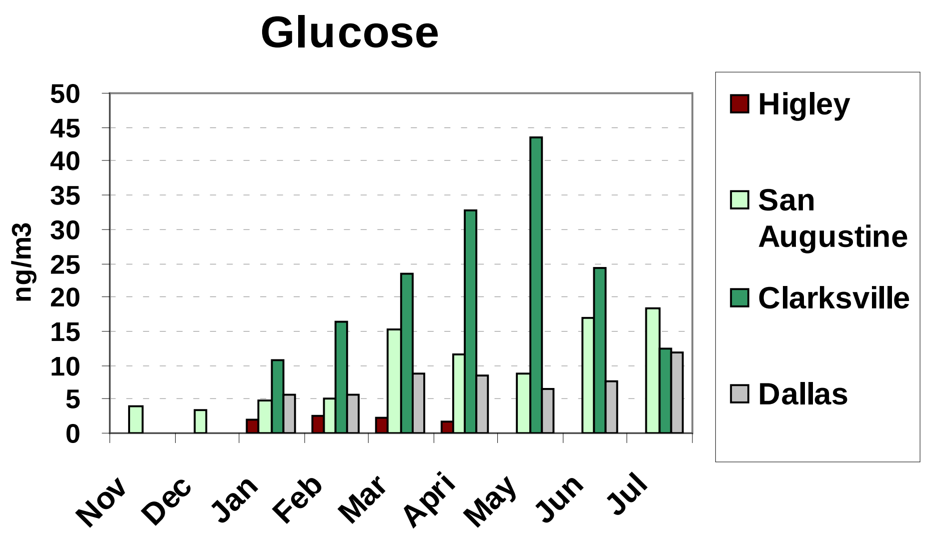
- ***Soil Samples:***

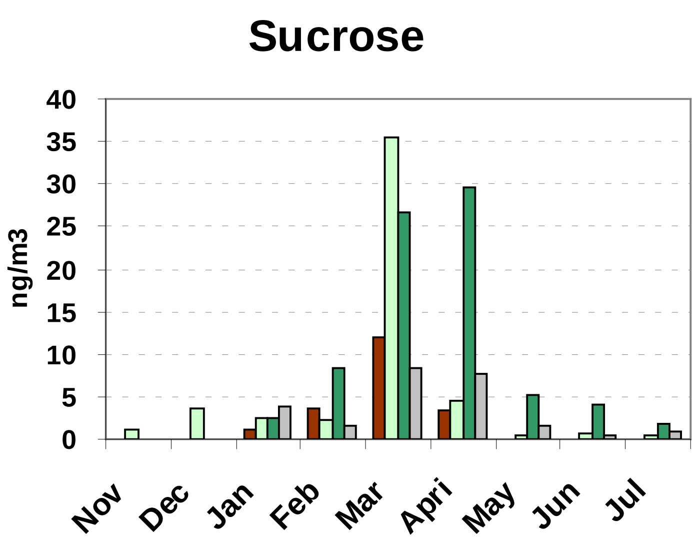
  - 18 agricultural soil samples, 6 native soil samples, 8 road dust samples taken in the vicinity of Higley sampling site in Jan and Apri 2008 for source study

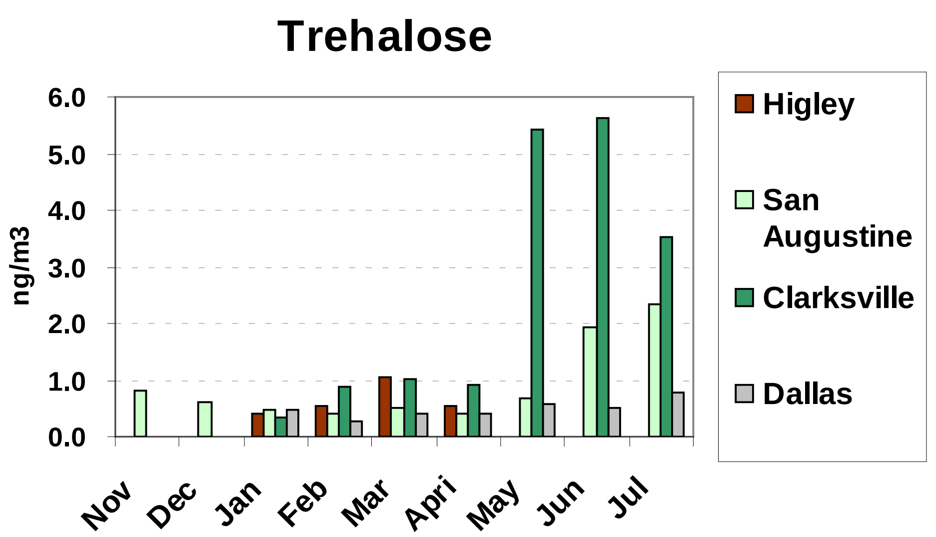
Results and Discussion

Ambient Sugars in PM2.5

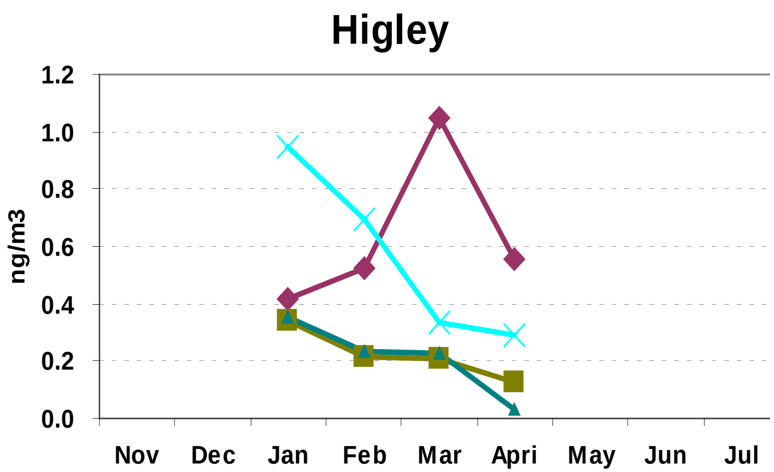


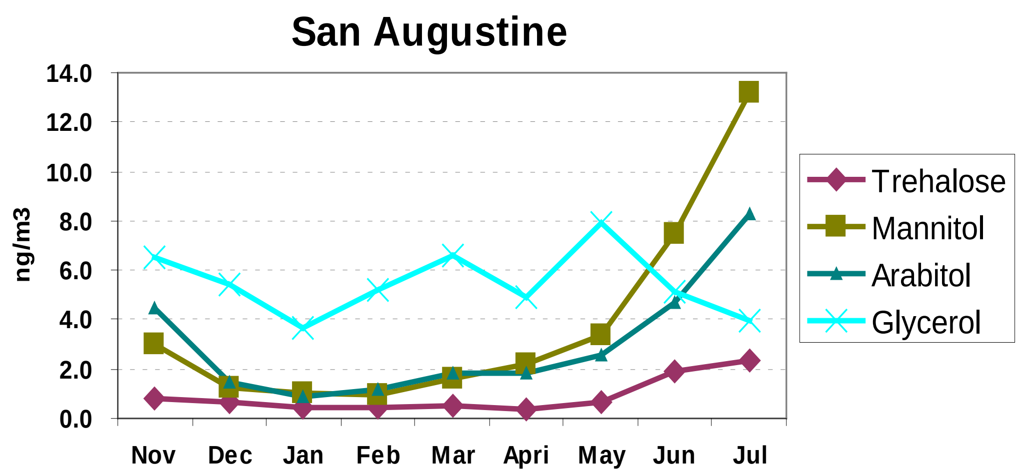


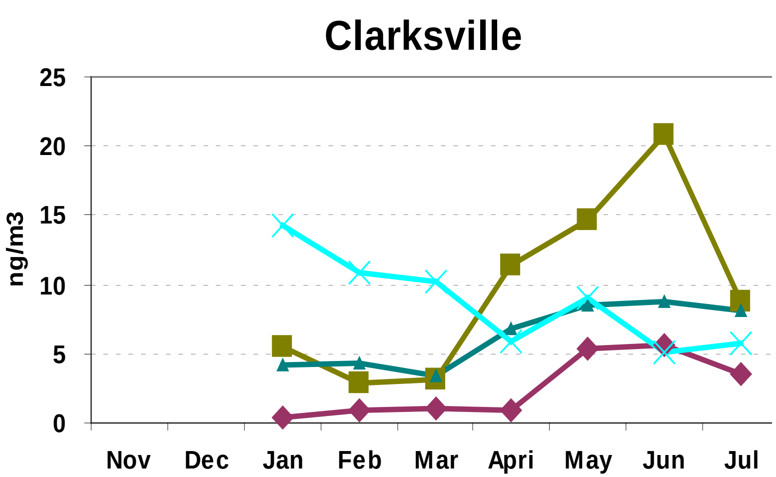


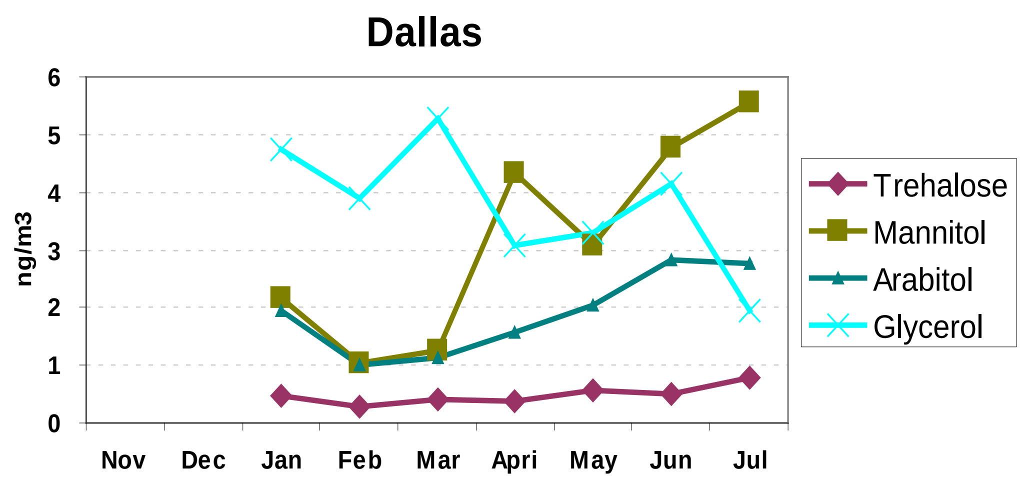


Ambient Sugar Polyols in PM2.5







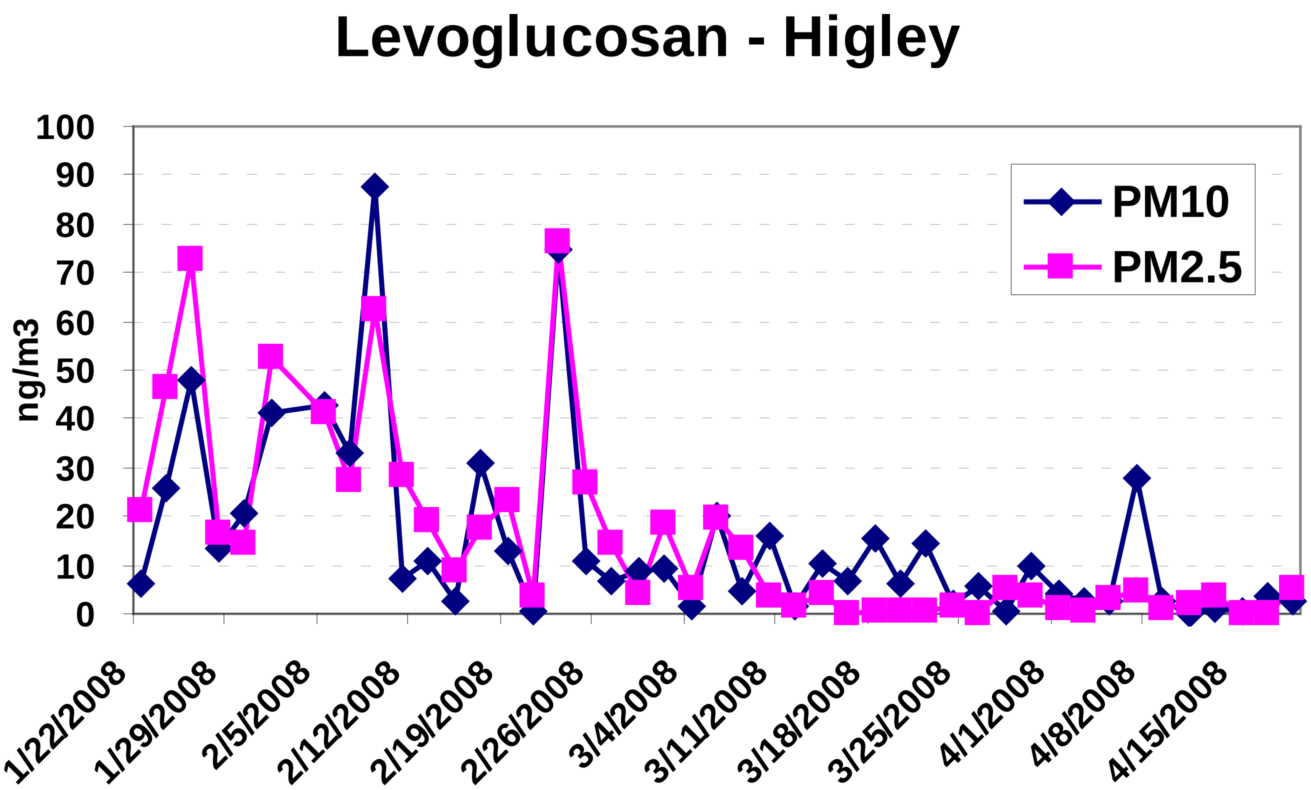


Correlation Analysis

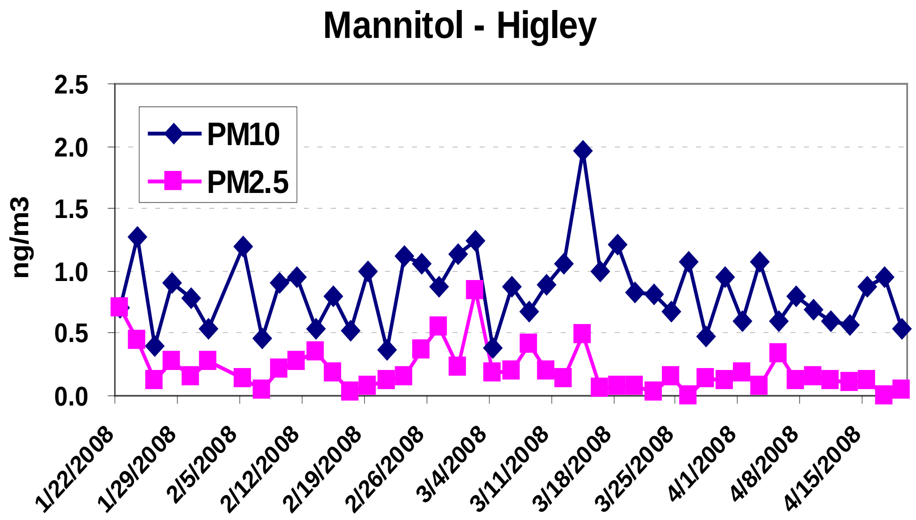
- Strong correlation among trehalose and major sugar polyols (mannitol and arabitol);
- Weaker correlation between glycerol and trehalose, and glycerol with other major polyols – other potential source for glycerol;
- Stronger correlations for samples at the two rural sites – local biogenic sources have less influence on sugars in aerosols at the urban site than at the rural sites

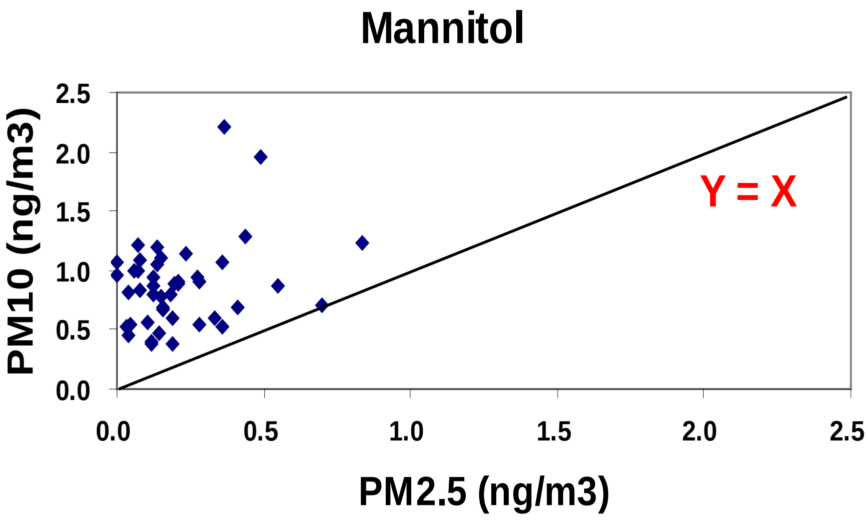
	Higley					San Augustine				
	Trehalose	Mannitol	Arabitol	Glycerol	Levoglucosa	Trehalose	Mannitol	Arabitol	Glycerol	Levoglucosa
Trehalose	1					1				
Mannitol	0.73	1				0.82	1			
Arabitol	0.62	0.84	1			0.71	0.88	1		
Glycerol	0.12	0.49	0.45	1		-0.06	-0.04	0.04	1	
Levoglucosan	-0.15	0.18	0.19	0.54	1	-0.08	-0.24	0.07	0.29	1
	Clarksville					Dallas				
	Trehalose	Mannitol	Arabitol	Glycerol	Levoglucosa	Trehalose	Mannitol	Arabitol	Glycerol	Levoglucosa
Trehalose	1					1				
Mannitol	0.78	1				0.35	1			
Arabitol	0.64	0.85	1			0.49	0.64	1		
Glycerol	-0.02	0.06	0.23	1		0.04	-0.23	-0.11	1	
Levoglucosan	-0.06	-0.03	0.03	0.26	1	0.07	-0.31	-0.21	0.53	1

Higley Sample – PM10 vs. PM2.5



Higley Sample – PM10 vs. PM2.5





Estimated compound ratio in Higley PM_{10} and $PM_{2.5}$ samples using least square linear relationship:

	Levoglucosan	Glycerol	Glucose	Sucrose	Trehalose	Mannitol	Arabitol
PM_{10}/ $PM_{2.5}$	0.89	1.04	2.72	2.57	2.48	4.27	1.93

Higley Sample - Correlation Analysis

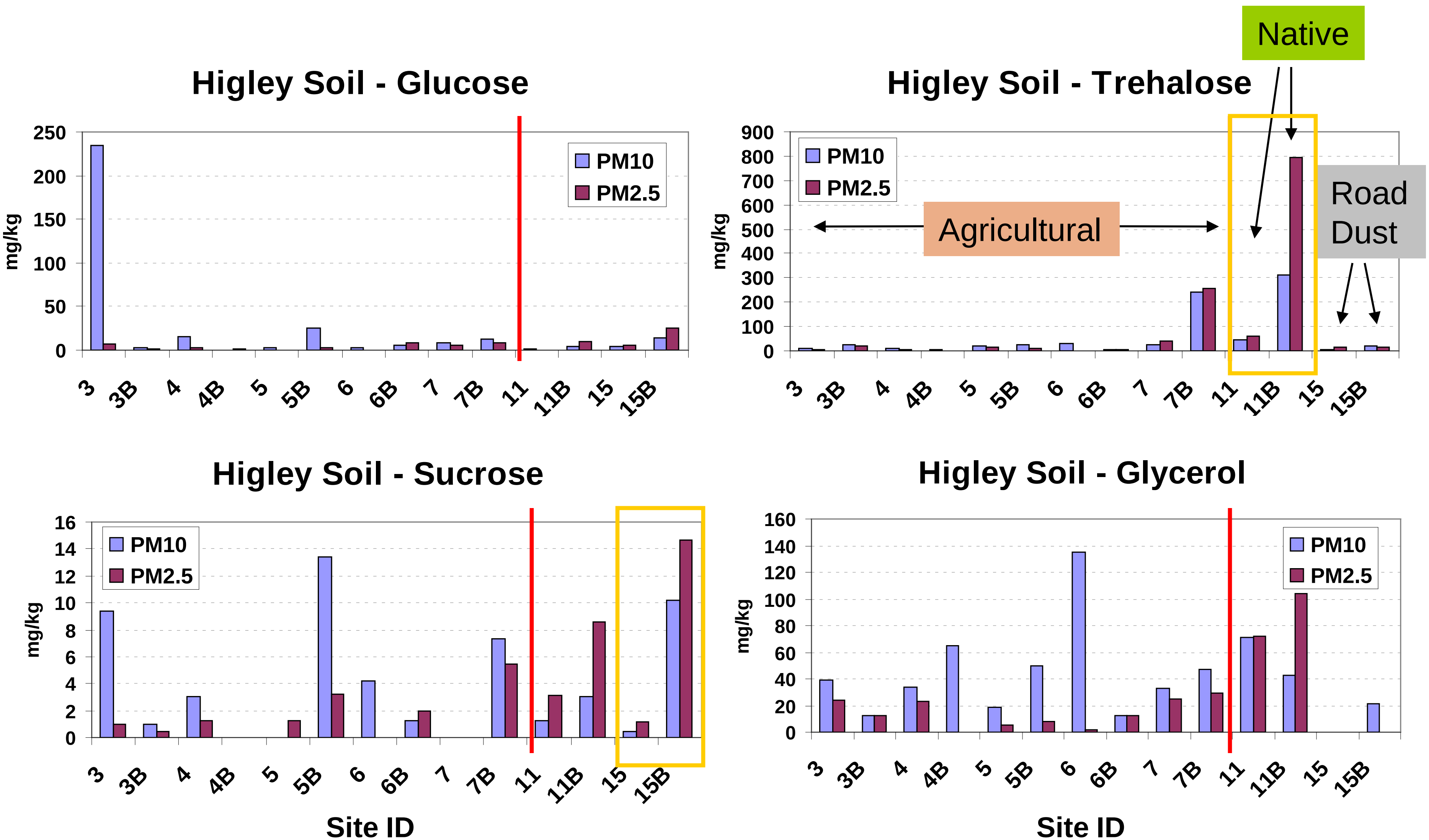
Pearson's Correlation Coefficients (PM2.5, Higley)

	Levoglucosan	Glucose	Sucrose	Trehalose	Glycerol	Erythritol	Arabitol	Mannitol
Levoglucosan	1.00							
Glucose	0.17	1.00						
Sucrose	-0.23	0.63	1.00					
Trehalose	-0.15	0.72	0.84	1.00				
Glycerol	0.54	0.46	-0.06	0.12	1.00			
Erythritol	0.12	0.62	0.60	0.77	0.32	1.00		
Arabitol	0.19	0.64	0.44	0.62	0.45	0.75	1.00	
Mannitol	0.18	0.73	0.51	0.73	0.49	0.83	0.84	1.00

Pearson's Correlation Coefficients (PM10, Higley)

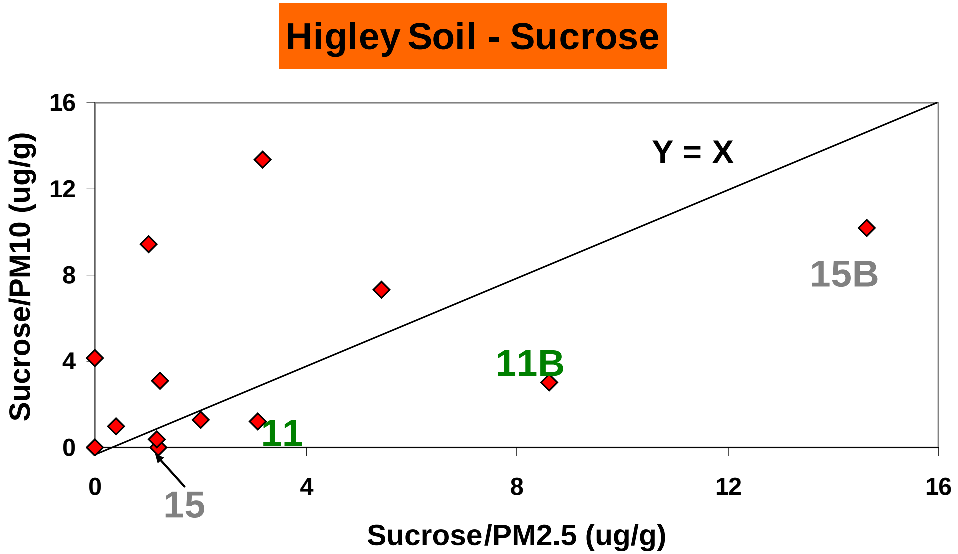
	Levoglucosan	Glucose	Sucrose	Trehalose	Glycerol	Erythritol	Arabitol	Mannitol
Levoglucosan	1.00							
Glucose	0.10	1.00						
Sucrose	-0.33	0.42	1.00					
Trehalose	-0.33	0.38	0.82	1.00				
Glycerol	0.20	0.20	0.14	0.15	1.00			
Erythritol	0.09	0.08	-0.14	-0.07	0.53	1.00		
Arabitol	0.14	0.21	0.16	0.36	0.53	0.39	1.00	
Mannitol	0.01	0.25	0.30	0.44	0.25	0.03	0.77	1.00

Higley Soil Resuspension Samples



Site # with a B suffix refers to samples taken in April, others were taken in Jan

Higley Soil Resuspension Samples



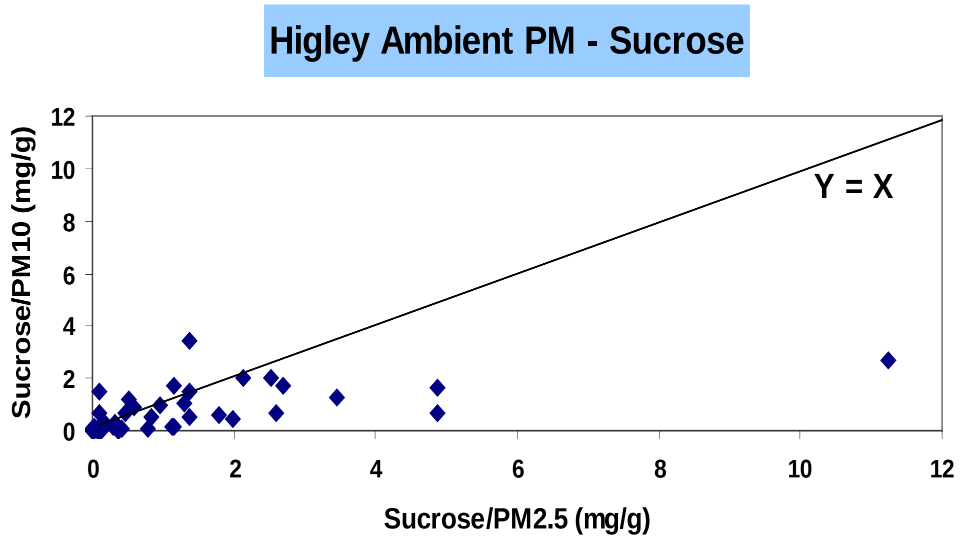
11 – Native Soil

15 – Road Dust

Others – Agricultural Soil

Soil Samples:

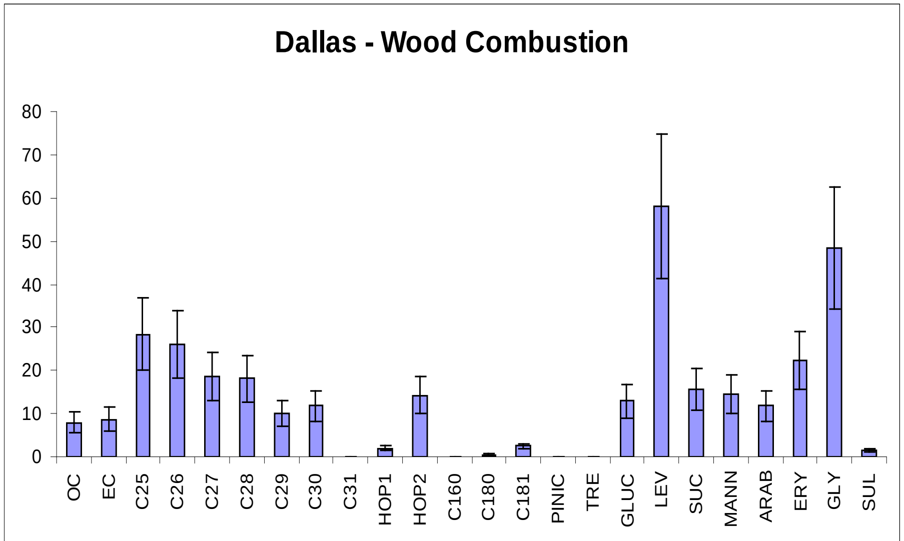
Difference between agricultural soils vs. native



Ambient PM:

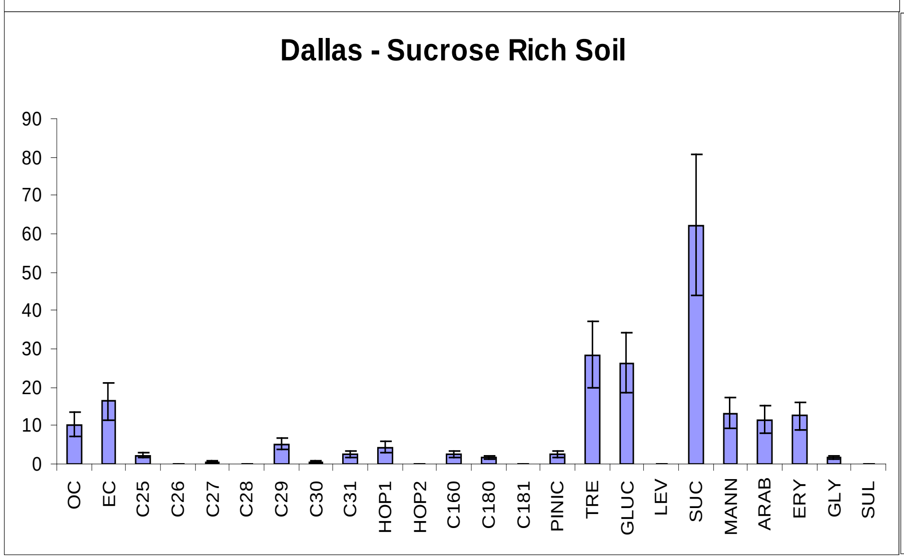
Data shows an enrichment of sugars in ambient PM2.5 relative to PM10

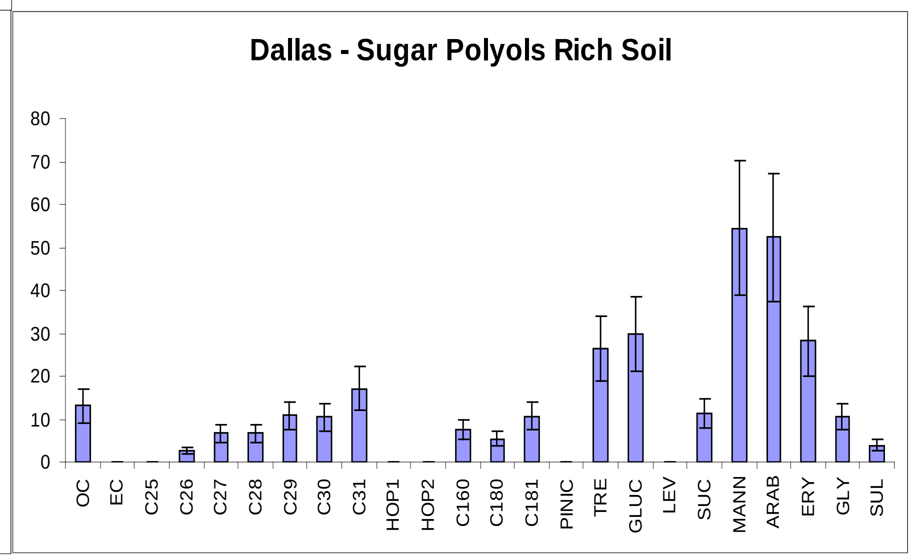
PMF Modeling Using Sugars As Molecular Markers - Texas



- 8 sugar compounds were used along with other particulate molecular markers;

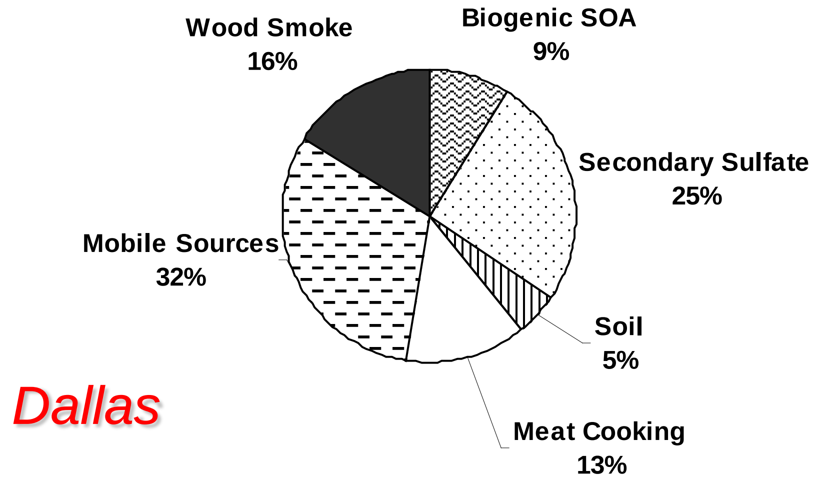
- 3 factors enriched in sugar compounds were resolved to represent the contribution of wood smoke, entrainment of soil to $PM_{2.5}$

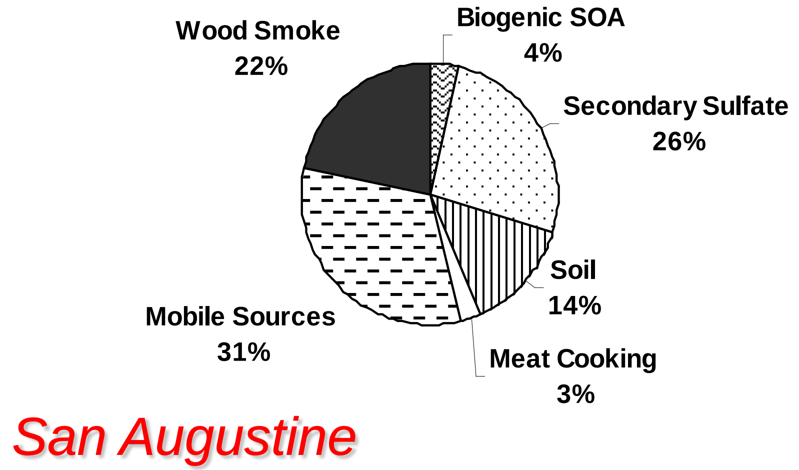




PMF Modeling Using Sugars As Molecular Markers - Texas

Relative Source Contribution to PM2.5





	Dallas	San Augustine
Wood Smoke	16%	22%
Soil Entrainment	5%	14%

- A baseline for the further expansion of sugars as tracers for soil sources in receptor modeling

Conclusions

- Much lower sugar concentrations in ambient PM2.5 in AZ than in TX;
- Biomass burning and entrainment of soils – two major sources of aerosol sugars;
- Different degree of source impact in different seasons and geographic locations;
- Smaller influence of local soil entrainment to the atmosphere at the urban/suburban sites than rural sites.
- Levoglucosan is similar in ambient PM2.5 and PM10, glucose, sucrose, trehalose and sugar polyols are more abundant in ambient PM10;

Conclusions (continued)

- Lower sugar levels in agricultural soil may indicate an alteration of soil microbial activity;

- Higher sugar contents were measured in the coarse fraction of agricultural soil particles. For native and road dusts, the fine faction contained greater sugar contents;

- Although PM2.5 soil samples have higher sugar content, ambient PM10 levels of sugars are greater than PM2.5;

- The contribution of agricultural soil entrainment and biomass burning to ambient PM2.5 can be isolated and quantified using source apportionment models with sugars as molecular markers.

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