Analysis of Atmospheric Particles Deposited onto Mesquite Leaves in the Central Arizona - Phoenix LTER Area

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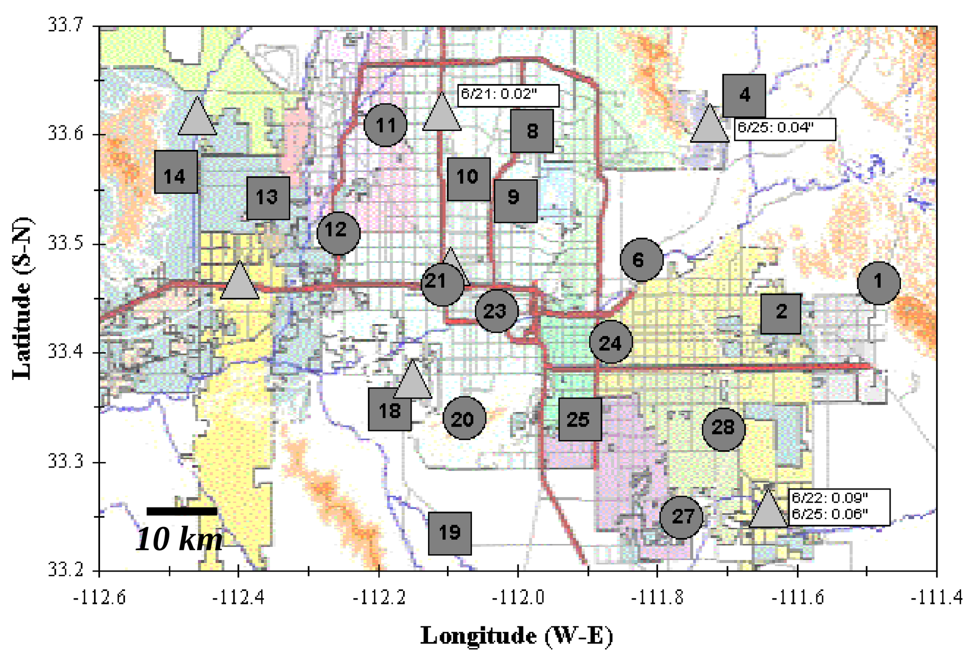
Purposes of Work

- ❑ Characterize the deposition of individual atmospheric particles on Mesquite leaves. This information is useful for:
  - ❖ Identifying particle sources.
  - ❖ Determining deposition parameters.
- ❑ Measure the spatial deposition patterns of particle types throughout the Phoenix area. This information is useful for:
  - ❖ Identifying source locations of deposition.
  - ❖ Observing regional deposition and directions of dispersion.

Methodology

- ❑ Mesquite leaves were collected on June 19 and 29, 2001, from 20 sites.
- ❑ Filters were placed in 10 of the trees from October 29 to November 4, 2002.

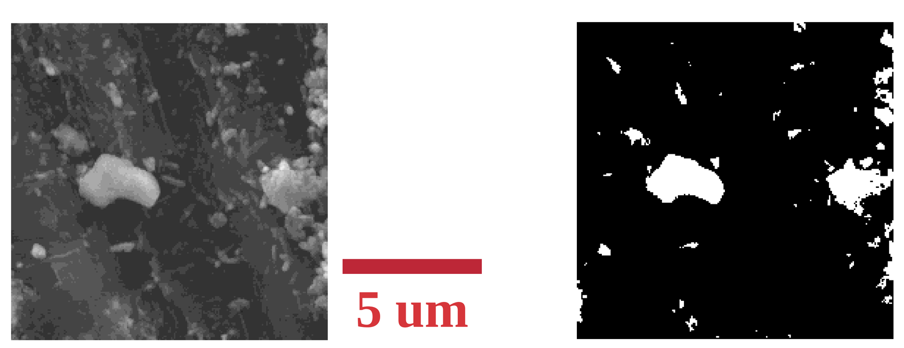


Leaf sample locations

Leaf and filter sample locations

AZMET sites

- ❑ Individual particles on the leaf and filter surfaces were analyzed with an electron microprobe.
- ❑ The particles were distinguished from the leaf surface by segmenting the back-scattered electron image into a binary image.



- ❑ Individual-particle compositions were determined with Energy-dispersive X-ray Spectrometry (EDS).
- ❑ The particles were assigned by composition into pre-defined clusters and principal components with the statistical routine EXPLOR [1].

Results

Table 1: Leaf Samples: Percent abundances, elements within clusters and average sizes (square root of particle areas) for individual-particle types.

X-rich	%	Na	Mg	Al	Si	S	Cl	K	Ca	Fe	Cr	Size (µm)
Si-rich (19)	**58**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**1.18**
with Al (9)	*37*	*X*	*X*	*X*	*X*			*X*	*X*	*X*		*1.35*
Si only (1)	*6*				*X*							*0.97*
with Ca (3)	*5*		*X*	*X*	*X*			*X*	*X*	*X*		*0.98*
with K (2)	*4*			*X*	*X*			*X*	*X*			*0.80*
with Fe (2)	*3*		*X*	*X*	*X*			*X*	*X*	*X*		*1.31*
with Cl (2)	*2*				*X*	*X*	*X*	*X*	*X*			*0.33*
Ca-Si (3)	**10**		**X**	**X**	**X**				**X**			**1.08**
no Cl (2)	*9*		*X*	*X*	*X*				*X*			*1.16*
with Cl (1)	*1*				*X*	*X*	*X*	*X*	*X*			*0.34*
Cl-rich (7)	**6**				**X**	**X**	**X**	**X**	**X**			**0.29**
with S (4)	*3*				*X*	*X*	*X*	*X*	*X*			*0.28*
no S (3)	*3*				*X*		*X*		*X*			*0.30*
Sulfates (4)	**4**	**X**		**X**	**X**	**X**		**X**	**X**			**0.56**
with Ca (2)	*2*	*X*		*X*	*X*	*X*		*X*	*X*			*0.69*
with Si (2)	*2*				*X*	*X*		*X*	*X*			*0.42*
Fe-rich (3)	**3**		**X**	**X**	**X**				**X**	**X**	**X**	**1.95**
K-rich (1)	**1**					**X**	**X**	**X**				**0.60**
Leaf			**X**			**X**	**X**	**X**	**X**			

Table 2: Filter Samples: Percent abundances, elements within clusters and average sizes (square root of particle areas) for individual-particle types.

X-rich	%	Na	Mg	Al	Si	S	Cl	K	Ca	Fe	Cr	Cu	Size (µm)
Si-rich (10)	**54**	**X**	**X**	**X**	**X**			**X**	**X**	**X**			**2.73**
with Al (6)	*37*	*X*	*X*	*X*	*X*			*X*	*X*	*X*			*3.05*
Si only (1)	*12*			*X*	*X*								*1.62*
with Ca (1)	*3*		*X*	*X*	*X*				*X*	*X*			*3.75*
with Fe (1)	*2*		*X*	*X*	*X*			*X*		*X*			*3.16*
with Mg (1)	*1*		*X*		*X*								*0.69*
Ca-Si (2)	**7**		**X**	**X**	**X**				**X**	**X**			**2.70**
Sulfates (6)	**5**	**X**	**X**		**X**	**X**	**X**	**X**	**X**				**0.50**
with Na (4)	*3*	*X*	*X*		*X*	*X*	*X*	*X*	*X*				*0.55*
S only (1)	*1*					*X*							*0.23*
with Ca (1)	*1*	*X*				*X*			*X*				*0.64*
Fe-rich (2)	**3**		**X**	**X**	**X**				**X**	**X**			**1.68**
Na & K-rich (3)	**3**	**X**				**X**	**X**	**X**					**0.73**
Misc Metals													
Cr-rich (1)	*2*				*X*	*X*					*X*		*0.92*
Cu-rich (1)	*1*				*X*							*X*	*0.23*

Results

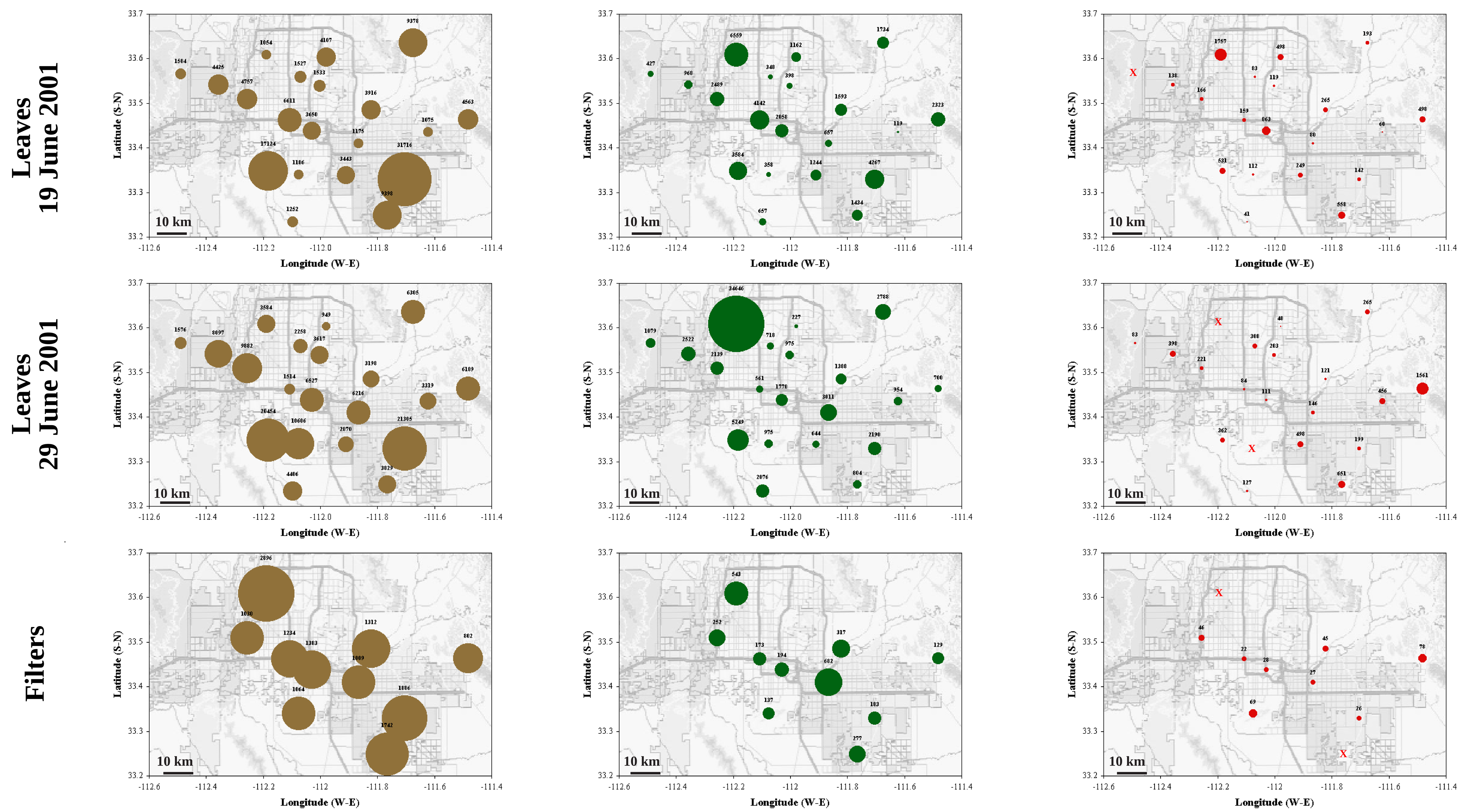


Figure 1: Bubble plots showing the spatial deposition patterns of three particle types on leaves for June 19 and 29, 2001, and filters. The bubble sizes represent the relative particle number concentration (number of particles/mm²).

Discussion

- ❑ Si-rich, Ca-Si, and Fe-rich particle groups are observed on both leaf and filter samples (Tables 1 and 2).
- ❑ Cl-rich, K-rich, and small (< 0.5 micron) Cl-containing particles are observed on the leaves but not the filter samples. Particles in these groups are likely small particles, with which leaf substrate under the particle was included in the EDS chemical analysis.
- ❑ The spatial deposition patterns are similar for both analysis days and between leaf and filter samples for each particle group.
- ❑ Si-rich particles
  - Deposition mostly by sedimentation
  - Most abundant in the southern part of the sampling domain in agricultural areas
  - Observed at every sampling location
  - Dispersed by construction, traffic on surface streets and freeways, and wind
- ❑ Ca-Si particles
  - Deposition mostly by sedimentation
  - Most abundant in the northwest: Nearby source(s) possibly construction involving cement or cement processing
  - Observed at all sampling locations but in lower concentrations than Si-rich particles
  - Dispersed by construction, traffic on concrete roads
- ❑ Sulfates
  - Smaller concentrations than Si-rich and Ca-Si particles
  - Not observed at all sampling sites, likely as a result of low concentrations
  - Deposition mostly by impaction, which depends on highly variable, small-scale, local winds
  - Local sources include motor vehicle emissions
  - Distant sources are coal-burning power plants located about 120km northeast of the Phoenix area [2].

Conclusions

- ❑ Leaves can be used as sampling substrates to characterize deposition of atmospheric particles with an electron microprobe.
  - ❖ Large (> 1 micron) mineral dust and clay particles easily identified on leaf surfaces with this technique.
  - ❖ With small (< 1 micron) particles, usually sulfates, elements from leaf, Cl and K, interfere with analysis.
- ❑ Particles on leaves can be used to measure the spatial deposition patterns of particle types, patterns determined by the regional distribution of particle sources, of both local and distant origins.
  - ❖ Local sources: agriculture, traffic, cement processing, construction, and motor vehicles
  - ❖ Distant sources: coal-burning power plants

References

[1] Shattuck, T. W.; Germani, M. S.; Buseck, P. R. (1991) Multivariate statistics for large data sets: Applications to individual aerosol particles. Anal. Chem., 63, 2646-2656.

[2] Fernando, H.J.S., Lee, S.M., Anderson, J.R., Princevac, M., Pardyjak, E., and Grossman-Clarke, S. (2001) Urban fluid mechanics: Air circulation and contaminant dispersion in cities. Environmental Fluid Mechanics, 1, 107-164.