# Comparative polarization study of light scattering by aerosol particles and particulate surfaces

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# Collaborators

- Prof. Olga Muñoz, Instituto de Astrofisica de Andalucia (IAA), Spain
- Dr. Maria Gritsevich, Finnish Geospatial Research Institute, Finland
- Dr. Jouni Peltoniemi, University of Helsinki, Finland
- Dr. Evgenij Zubko, V.N. Karazin Kharkiv National University, Ukraine
- Dr. Matthew J. Berg, Mississippi State University, USA

# Objectives

Polarization of the scattered sunlight is an important source of information on physical and chemical properties of scatterers.

**Analysis of the light-scattering response from an unknown target**

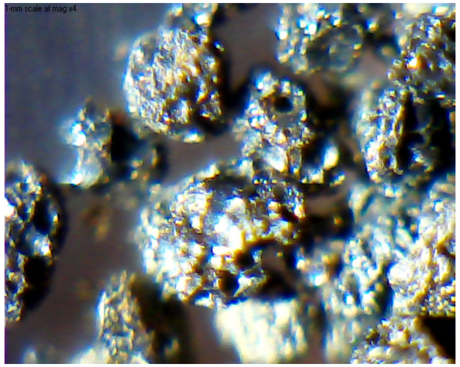
**require**

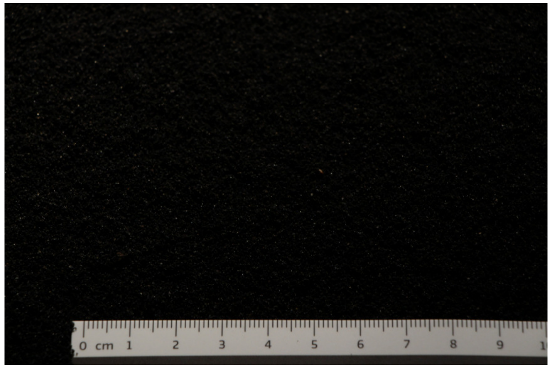
**Comparison with well-characterized reference samples**

**Laboratory measurements are essential for validation of the retrievals**

# Objectives

- Comprehensive comparative investigation of polarization of the scattered light by particles suspended in the air and the same particles deposited on surface.
- Establishment of the interrelation between light-scattering responses from particles suspended in the air and deposited on a surface



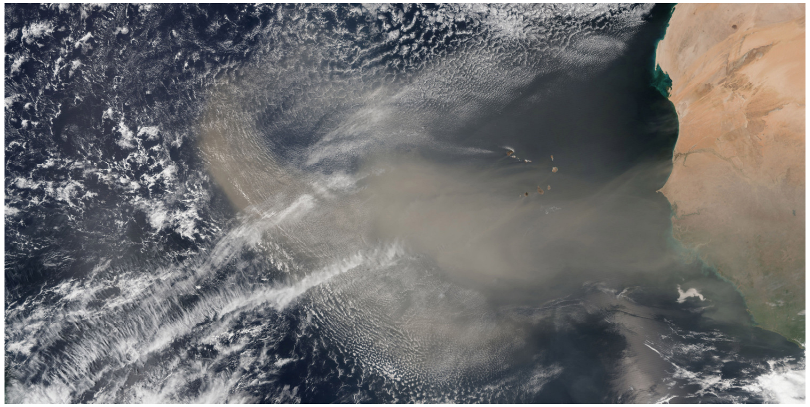


Examples of volcanic sand particles on the left and particulate surface on the right.

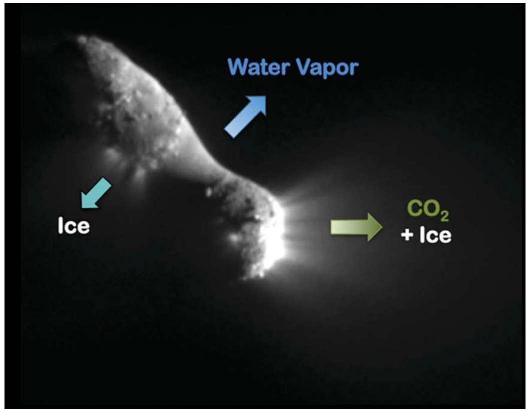
# Applications

By measuring and compare polarization of atmospheric aerosols and particulate surfaces can we find place of origin of the dust clouds?

Can we use polarization to estimate density of thin clouds?

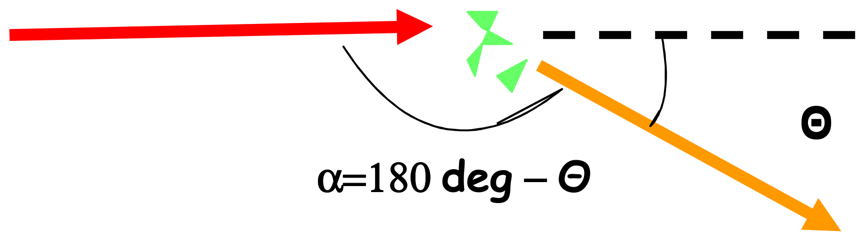


Dust accross the Atlantic
http://earthobservatory.nasa.gov/IOTD/view.php?id=81864&src=eoa-iotd




Comet Hartley 2
M .F. A'Hearn et al., Science, 2011

# Observation geometry




Phase function

– $F_{21}/F_{11}$ Deg. Lin. Pol.

$$
\begin{array}{l}
\text{Intensity} \\
\text{Lin. Pol.} \\
 \\
\text{Circular Pol.}
\end{array}
\begin{pmatrix} I_{sc} \\ Q_{sc} \\ U_{sc} \\ V_{sc} \end{pmatrix} \propto
\begin{pmatrix} F_{11} & F_{12} & F_{13} & F_{14} \\ F_{21} & F_{22} & F_{23} & F_{24} \\ F_{31} & F_{32} & F_{33} & F_{34} \\ F_{41} & F_{42} & F_{43} & F_{44} \end{pmatrix} \cdot
\begin{pmatrix} I_{in} \\ Q_{in} \\ U_{in} \\ V_{in} \end{pmatrix}
$$

*Stokes vector* *Scattering Matrix* *Stokes Vector*

Depends on:
shape
size
refractive index
orientation
wavelength

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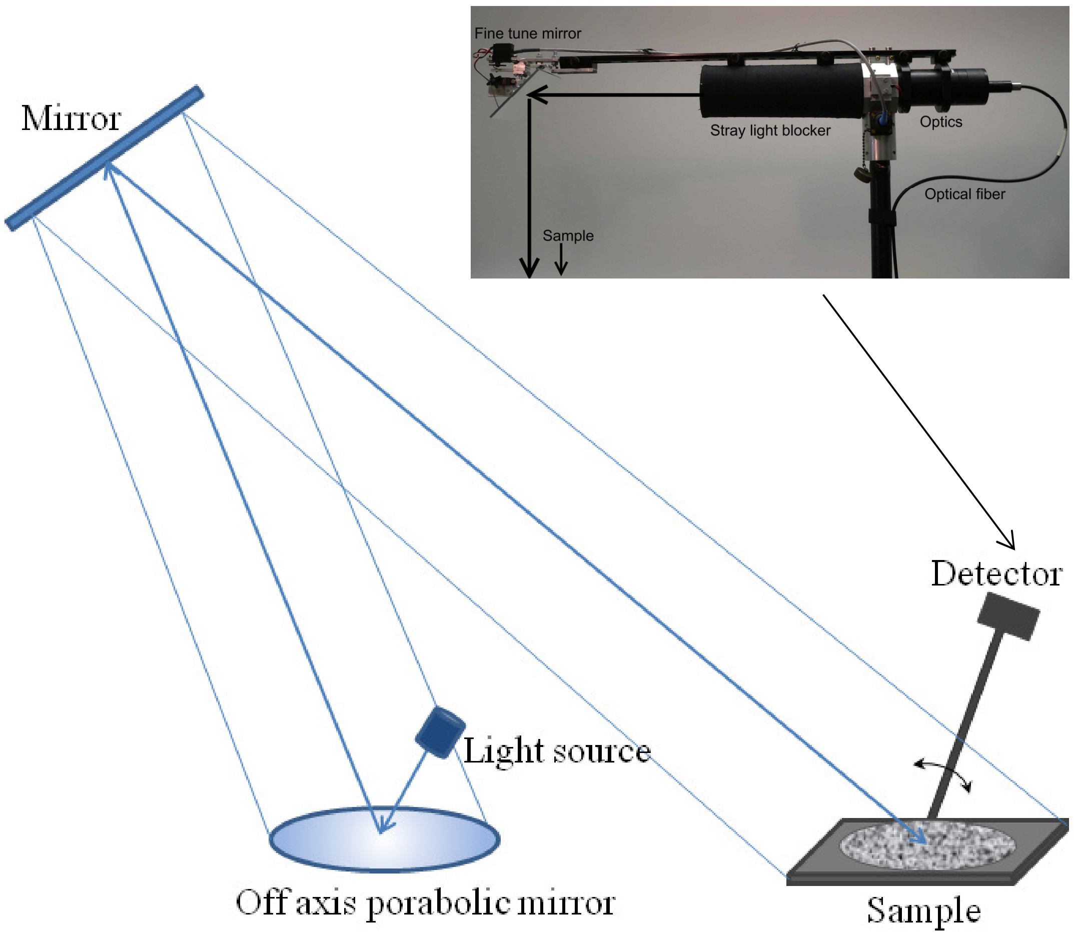
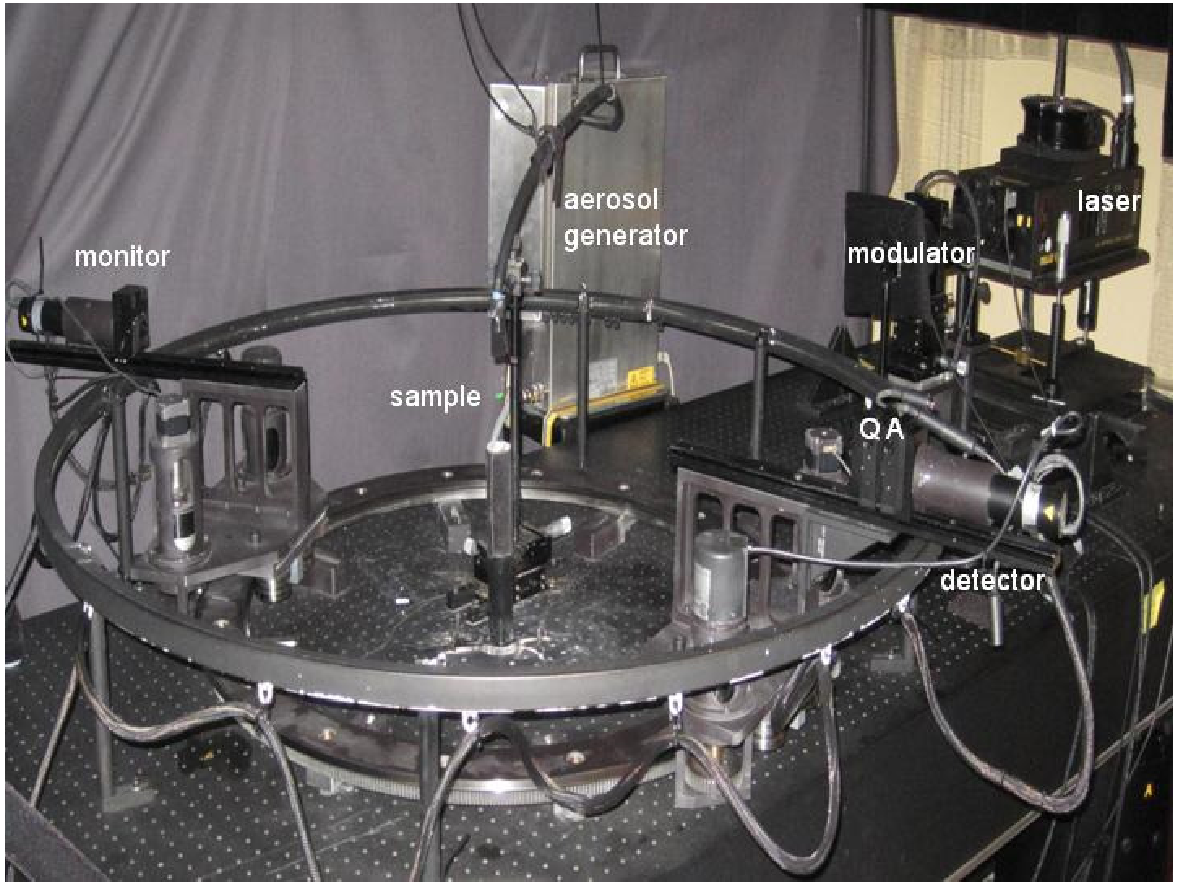
# FGI experimental setup
## particulate surface measurements

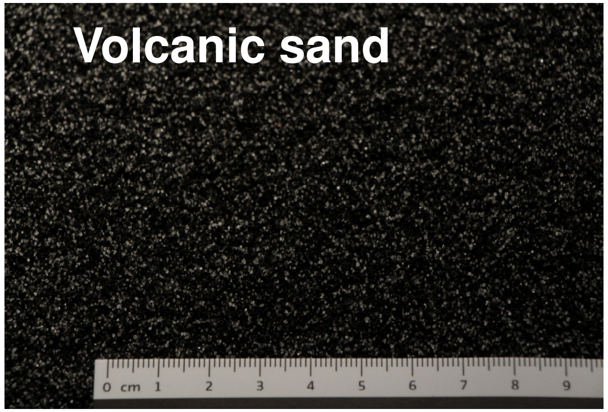



# IAA experimental setup
## aerosole measurements

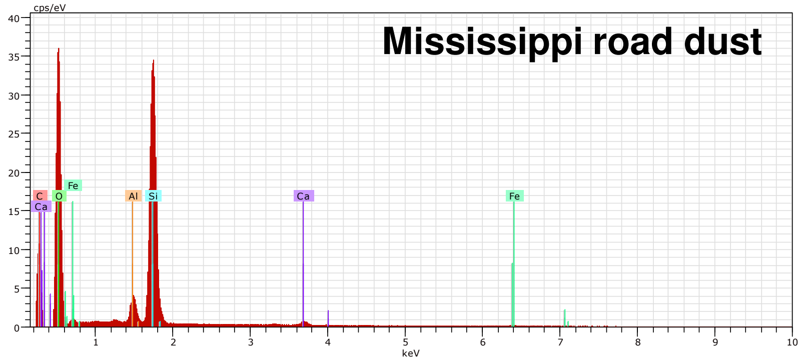


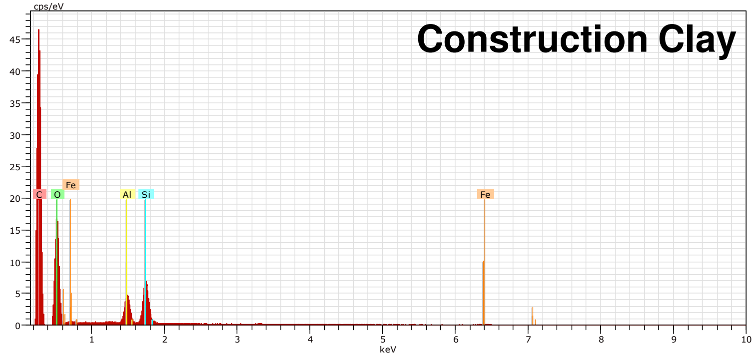
# Measured samples

- Structural particle's analogues

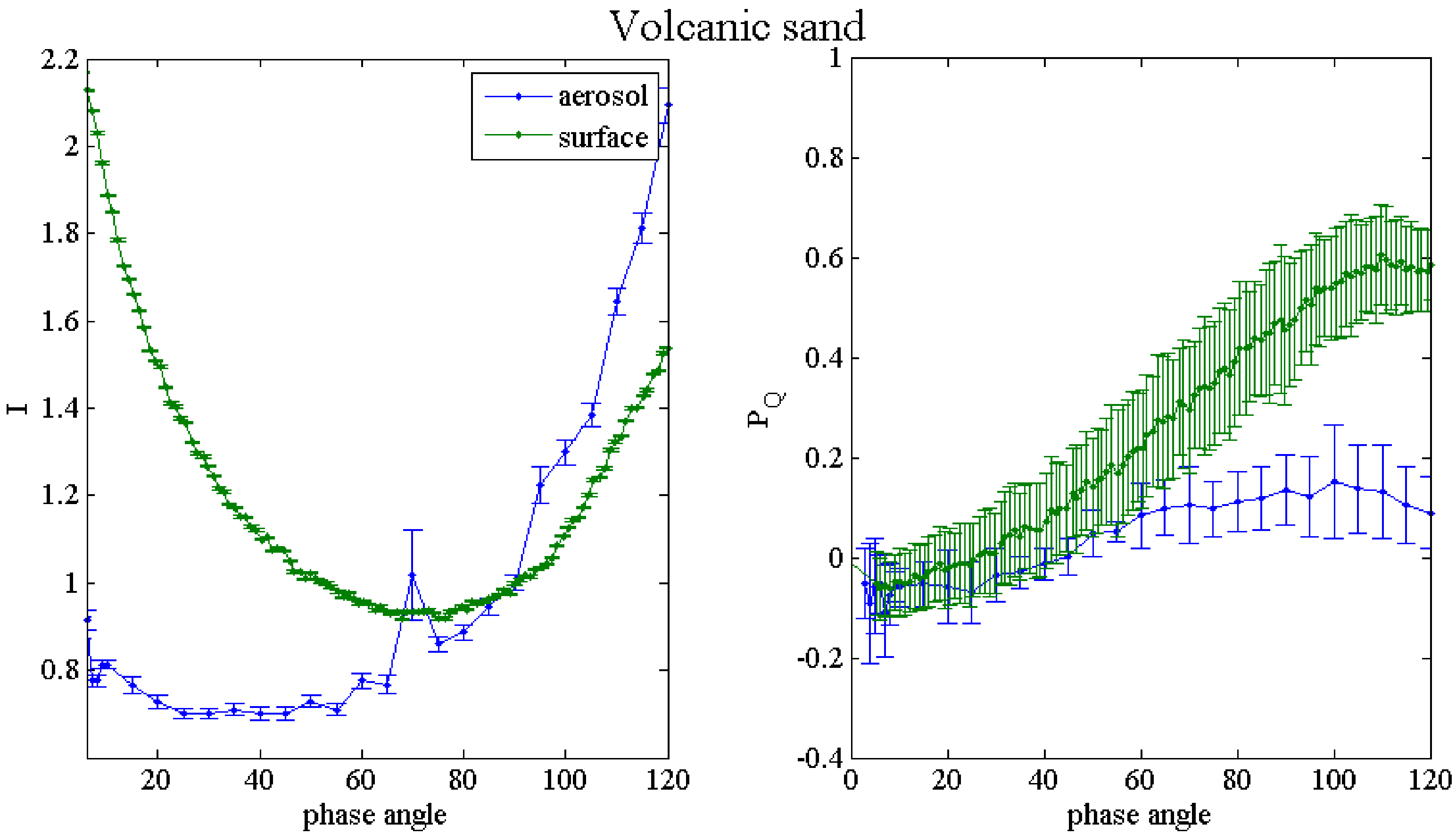





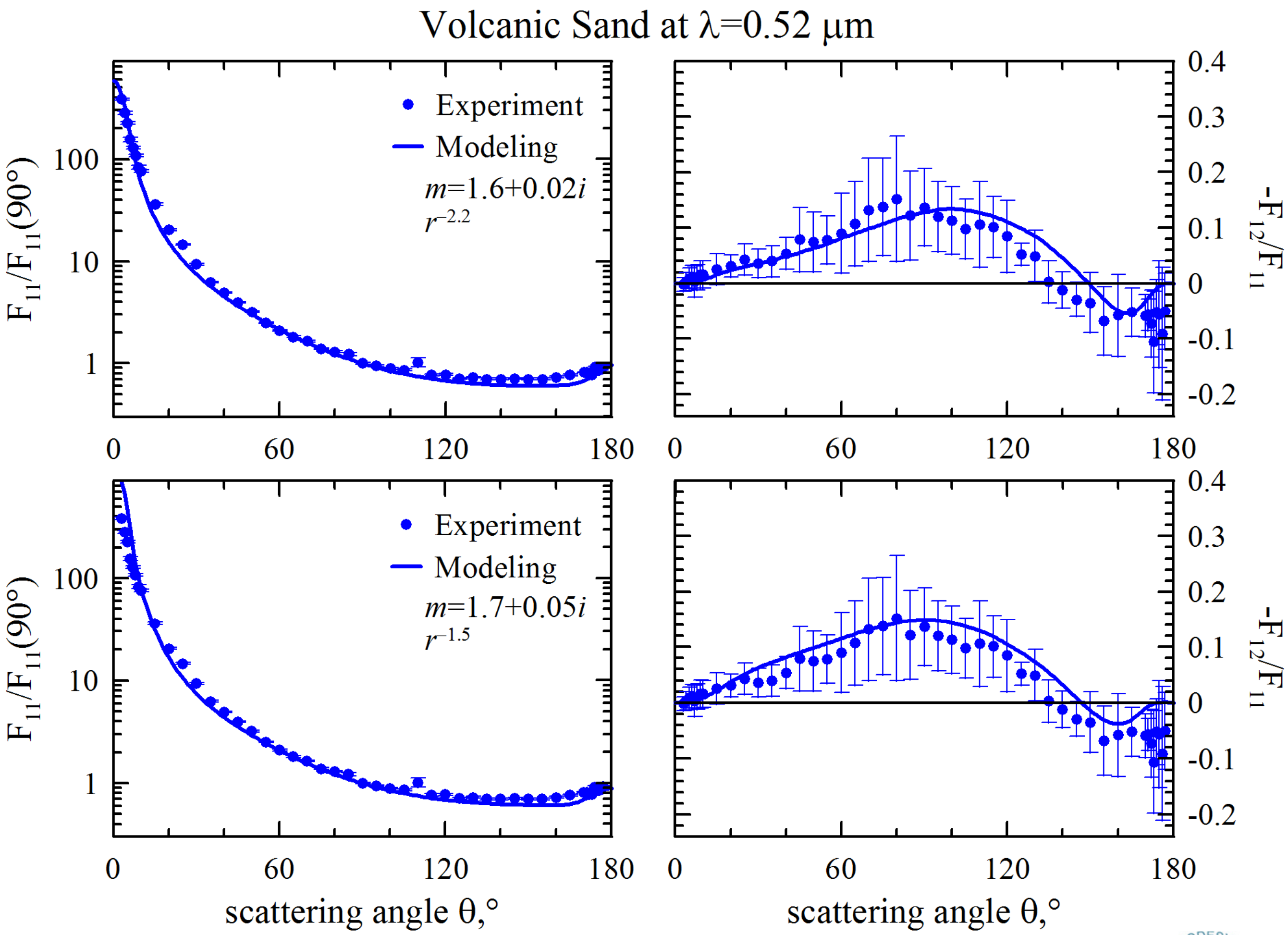


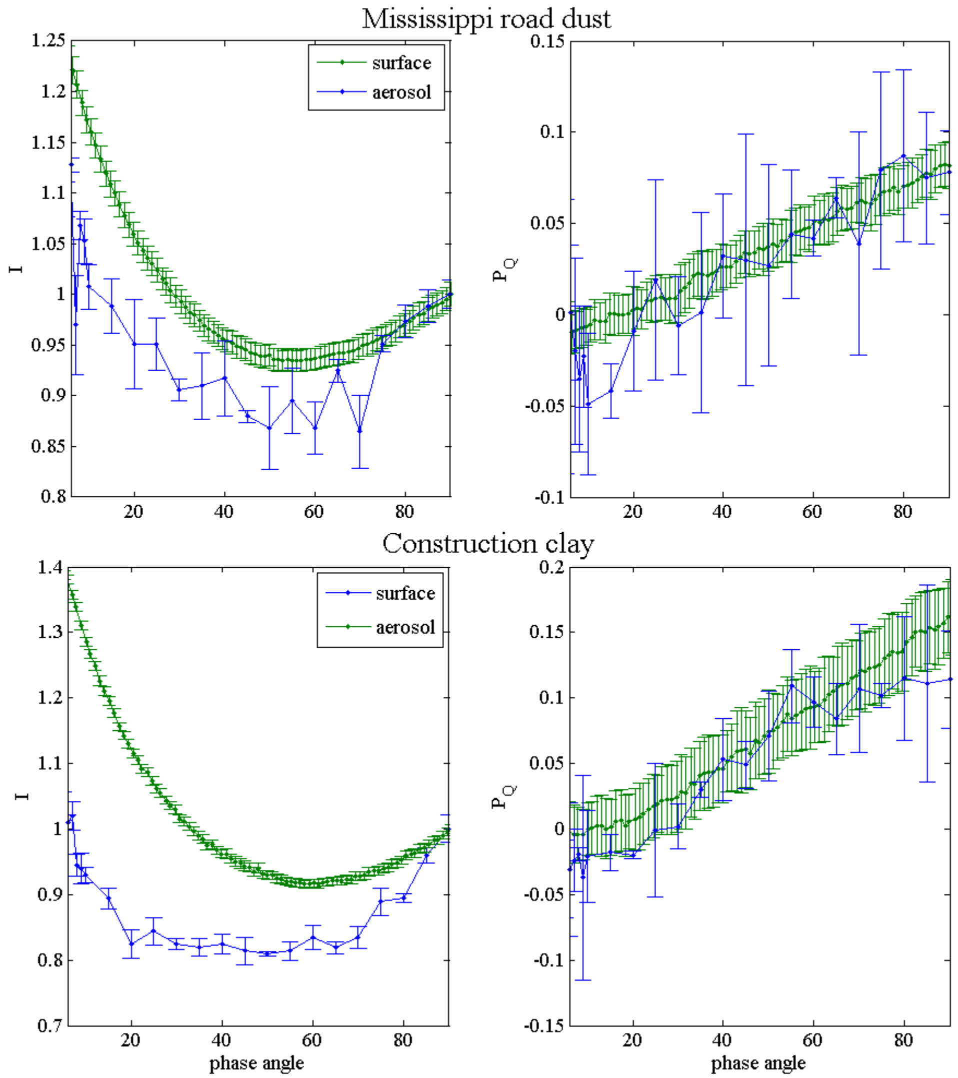
# Polarization properties of aerosols and particulate surfaces.



# Polarization properties of aerosols obtained with experiment and modeling. Refractive index estimation



# Polarization properties of aerosols and particulate surfaces.



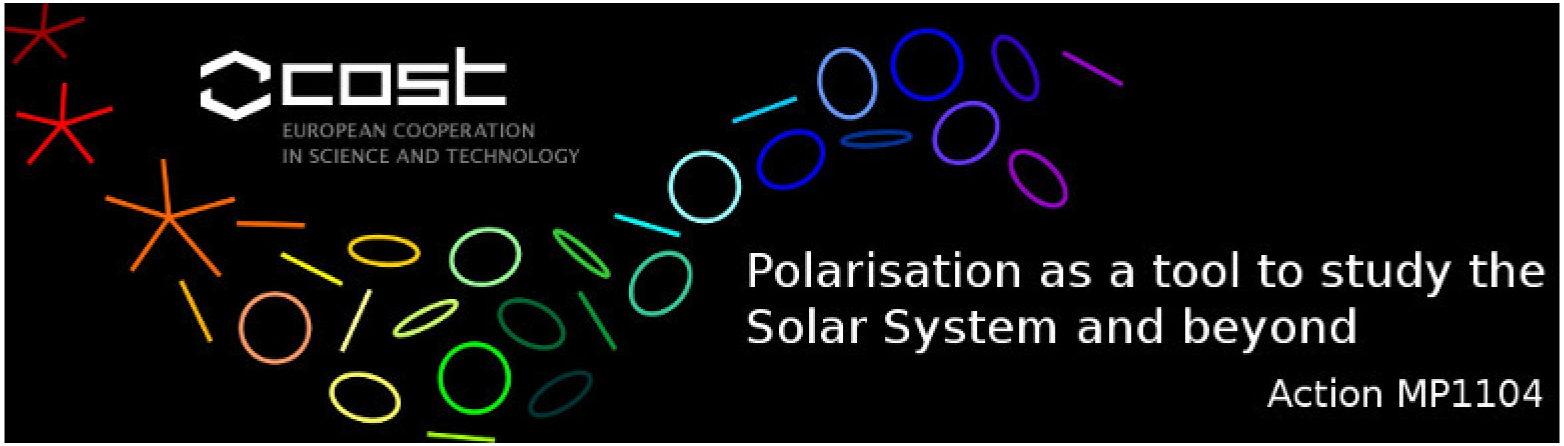
# Conclusions

- Set of samples have been measured with two experimental setups.
- The comparative polarization analysis of light scattering by aerosol particles and particulate surfaces has been performed.
- We estimate refractive index of volcanic sand sample to be Re(m)=1.6-1.7 Im(m)=0.02-0.05.

**Future plans:**

- Measuring polarization of light scattering by aerosol particles at 483, 568, 647 nm.
- Comparative analysis of circular polarization of light scattered by particulate surfaces.
- Establishment of the interrelation between light-scattering responses from particles suspended in the air and deposited on a surface.

# Thank you!

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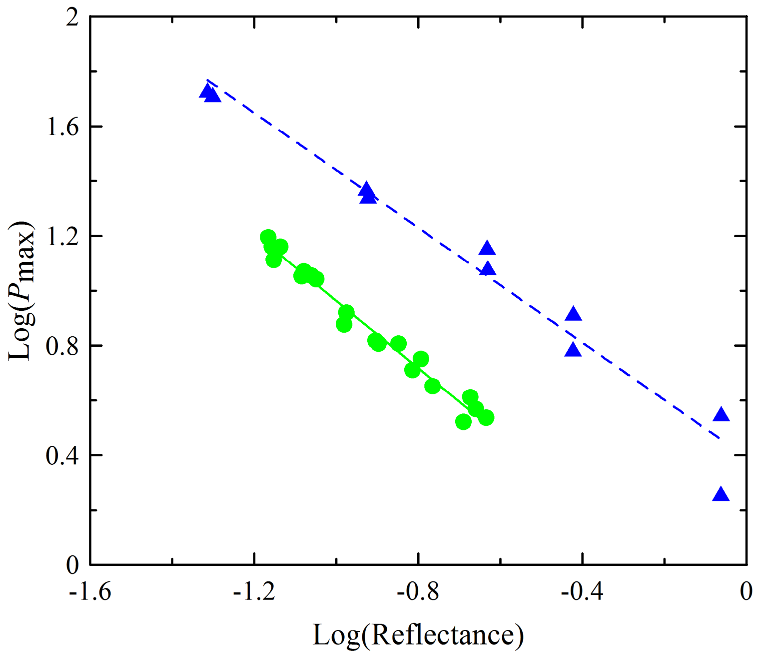
# Umov law

Polarization *P* is inversaly correlated with albedo *α*

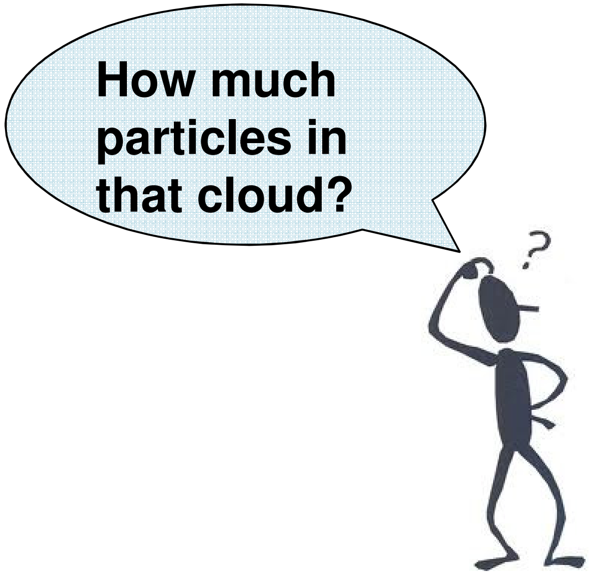
$$P \propto \frac{1}{\alpha}$$

Umov effect has linear trend in log scale




The Umov effect measured for 22 sites on the Moon at wavelength 650 nm (circles), and in different mixtures of the volcanic sand and salt (NaCl) at wavelength 633 nm and 750 nm (triangles).

# Application of Umov law




$$\text{Density} \propto \frac{\text{Flux}}{\text{Reflectance}}$$

Can we estimate the density of thin dust cloud?

- By measuring max degree of linier polarization we can estimate the reflectance in single scattering dust particles.
- Using this information we can discover number density of particles in optically thin clouds.

# Observation geometry

$$P = \frac{I_\perp - I_\parallel}{I_\perp + I_\parallel}$$

$$P > 0 \text{ if } I_\perp > I_\parallel$$
$$P < 0 \text{ if } I_\perp < I_\parallel$$