Name of research institute or organization:

Earth Science Institute, Hebrew University of Jerusalem

Title of project:

Interactions between aerosols and rain clouds as a function of aerosol types and sources

Part of this programme:

ACTRIS

Project leader and team:

Mr. Assaf Zipori, project leader
Prof. Daniel Rosenfeld
Prof. Yigal Erel

Project description:

We collected snow and cloud samples at the High Altitude Research Station Jungfraujoch during CLACE 2014. The samples were taken for chemical analysis of metal concentrations using ICP-MS (Agilent 7500cx). In addition, the Strontium isotopic ratio ($^{87}Sr/^{86}Sr$) was examined in the cloud samples using NEPTON plus high-resolution multi-collector ICP-MS system. The isotopic analysis was done in order to identify the aerosol's source and composition in the cloud, since different sources have different Sr isotopic ratios (Table 1). Air mass back trajectories using the HYSPLIT model were used to verify these findings.

The isotopic ratio found in the cloud samples from Jungfraujoch showed several aerosol sources (Figure 1). Samples 1, 2, 3, 4, 6 & 7 fall on the same mixing line, with two end members: the first end member is sample 3 which is recognized as Saharan Dust because of its high Sr isotopic ratio, high Al concentration and very low Na/Al ratio. In addition, the back trajectories for these samples support this finding. It is important to mention that no Saharan Dust Event notification (SDE; Collaud et al., 2014) was published during the time this sample was collected, because the event was too short (less than three hours).

The second end member is sample 7 which is harder to identify from Figure 1, but from back trajectories it seems to be local dust from Spain and France (Negrel and Roy, 1998 and reference within). Sample 5 falls outside of the mixing line, i.e. the source is not a mix of dust with basalt. This is also supported by back trajectories since this sample was the only one with back trajectories originating from the east of the station.

In order to investigate aerosols-cloud interaction, we combined the Sr isotopic ratio with data from the Portable Ice Nuclei Counter (PINC) operated by Yvonne Boose from ETH Zürich. We also defined the following parameter:

$$ABS(\delta 87) = \left| \left(\frac{\left({}^{87}Sr/{}^{86}Sr \right)_{Sampale}}{\left({}^{87}Sr/{}^{86}Sr \right)_{Marine}} - 1 \right) \times 10^3 \right|; \quad \left({}^{87}Sr/{}^{86}Sr \right)_{Marine} = 0.7092$$

This parameter describes the difference of a given sample from marine air mass. When PINC was operated in sub-saturated conditions in respect to water (RH_w<100%; deposition freezing), the IN concentration and activation factor (AF=IN/CN) increased with increasing ABS (δ87) values (Figure 2).

An opposite trend is seen when a PINC was operated in above saturation conditions in respect to water (RH_w>100%; condensation mode). In such a case, the IN concentration and AF decreased with increasing ABS (δ87) values (Figure 3). This means that marine aerosols are more soluble, so a large fraction of them serves as a condensation freezing IN. For the condensation mode, no connection is seen between CN and IN concentrations.

Several studies were done on IN in marine air mass and the main result is that marine IN are biological aerosols (Bigg 1973; Schnell and Vali, 1976; Saxena, 1983). While all of the mentioned studies were done in remote marine environment, Creamean et al. (2014) showed that marine aerosols can travel for a long way on dust particles or sea salt. This might be the case in sample 1, where marine aerosols presented high IN in the condensation mode.

Table 1. Sr ratios of different sources (Burk et al., 1982; Faure 1986).

Source	$^{87}Sr/^{86}Sr$
Sea Water	0.7092
Granitoid	>0.71
Basalt rocks	<0.706
Mesozoic Limestone	0.707-0.7075

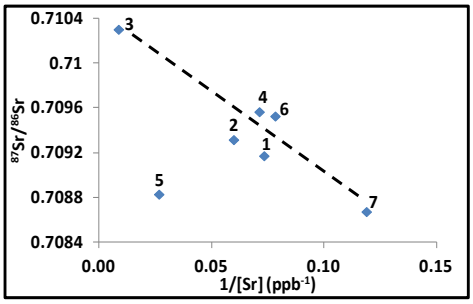

Figure 1. Mixing diagram of Sr concentrations and isotopic ratio. Numbers next to the Lozenge are the sample numbers.

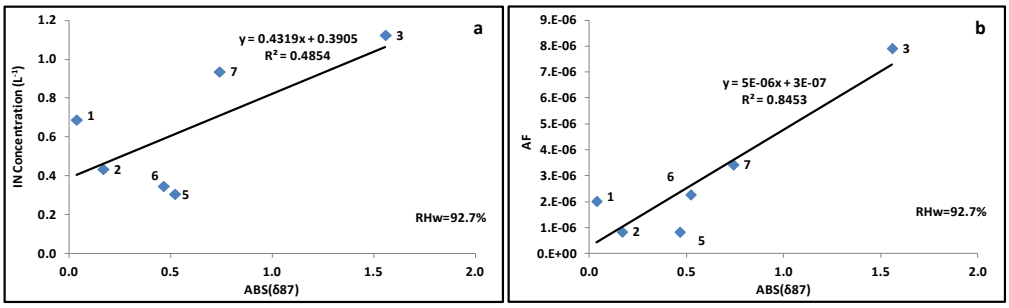

Figure 2. IN concentration (a) and activation factor (AF=CN/IN) as a function of ABS (δ87) in the deposition mode.

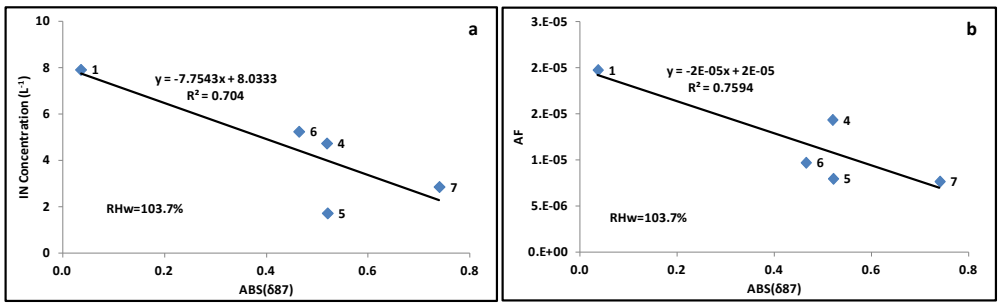

Figure 3. IN concentration (a) and activation factor (AF=CN/IN) as a function of ABS (δ87) in the condensation mode.

References:

Bigg, E.K., 1973. Ice nucleus concentrations in remote areas, *Journal of the Atmospheric Sciences,* 30**,** 1153-1157.

Burke, W.H., Denison, R.E., Hetherington, E.A., Koepnick, R.B., Nelson, H.F. & J.B., O., 1982. ariation of seawater 87Sr/86Sr throughout Phanerozoic time, *Geology,* 10**,** 516-519.

Coen, M.C., Weingartner, E., Schaub, D., Hueglin, C., Corrigan, C., Henning, S., Schwikowski, M. & Baltensperger, U., 2004. Saharan dust events at the Jungfraujoch: detection by wavelength dependence of the single scattering albedo and first climatology analysis, *Atmospheric Chemistry and Physics,* 4**,** 2465-2480.

Creamean, J.M., Suski, K.J., Rosenfeld, D., Cazorla, A., DeMott, P.J., Sullivan, R.C., White, A.B., Ralph, F.M., Minnis, P., Comstock, J.M., Tomlinson, J.M. & Prather, K.A., 2013. Dust and biological aerosols from the Sahara and Asia influence precipitation in the Western U.S, *Science,* 339**,** 1572-1578.

Faure, G., 1986. *Principles of isotope geology,* second edn, Vol. 589, pp. Pages, Wily New York, New York.

Negrel, P. & Roy, S., 1998. Chemistry of rainwater in the Massif Central (France): a strontium isotope and major element study, *Applied Geochemistry,* 13**,** 941-952.

Saxena, V.K., 1983. Evidence of the biogenic nuclei involvement in Antarctic coastal clouds, *Journal of Physical Chemistry,* 87**,** 4130-4134.

Schnell, R.C. & Vali, G., 1976. Biogenic ice nuclei part 1: Terrestrial and marine sources, *Journal of the Atmospheric Sciences,* 33**,** 1554-1564.

Key words:

Aerosol-cloud interactions, aerosol chemical composition, IN concentrations, marine IN

Collaborating partners/networks:

Yvonne Boose, Institute for Atmospheric and Climate Science, ETH Zürich
Paul Scherrer Institute, Switzerland

Address:

Earth Science Institute
Hebrew University of Jerusalem
Edmond J. Safra, Campus Givat-Ram
Jerusalem, 91904
Israel

Contacts:

Assaf Zipori
Tel.: +972 2 616 5018
Fax: +972 2 566 2581
e-mail: assaf.zipori@mail.huji.ac.il