Name of research institute or organization:

Departement Umweltwissenschaften, Universität Basel

Title of project:

Biological ice nucleators at tropospheric cloud height

Project leader and team:

Dr. Franz Conen, project leader
Mr. Emiliano Stopelli
Mr. Lukas Zimmermann

Project description:

In this project we investigate the abundance of atmospheric ice nuclei (IN) at cloud height and try to identify what drives its variation. We concentrate on IN active in the immersion freezing mode at moderate supercooling (-12 °C or warmer). In 2013, our approach has included the analysis of precipitation (mostly snow) samples and of dust collected on PM_{10} filters. Sections of PM_{10} filters were generously provided by the National Air Pollution Monitoring Network (NABEL) at Empa.

Eleven campaigns of precipitation collection and analysis at Jungfraujoch were carried out from October 2012 to September 2013. There appears to be an annual cycle with smallest numbers of IN during late winter and largest numbers during early summer (Fig. 1). Data obtained so far is the starting point for further analyses, where IN abundance will be related to meteorological parameters, physico-chemical (incl. stable isotope ratios) and biological descriptors (microbial abundance). The objective is to understand which processes can explain the observed distribution of IN. These results are the first field data in the SNF-funded PhD project, which Emiliano Stopelli started in September 2012 and that will continue at least until 2015.

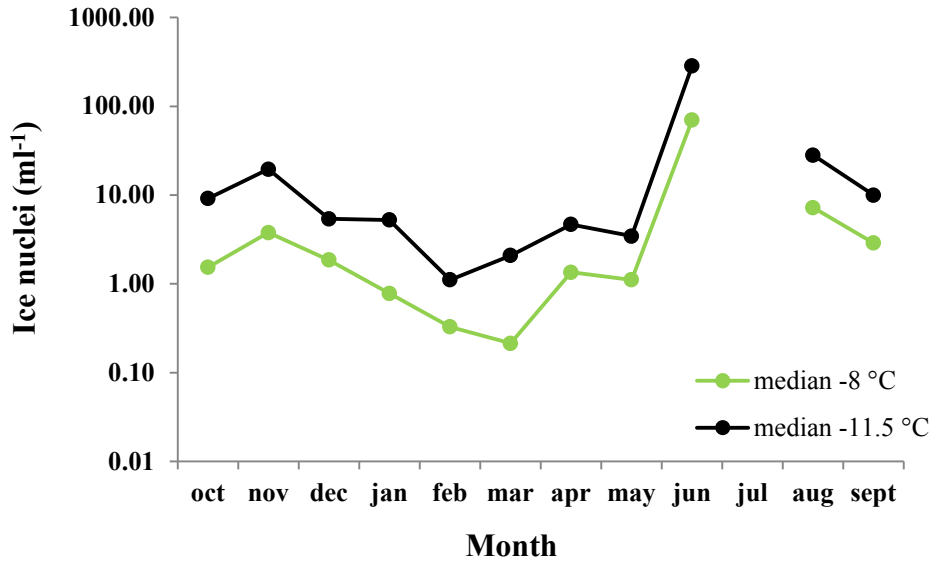

Figure 1. Ice nucleator abundance in snow water collected at Jungfraujoch from October 2012 to September 2013, active at -8, respectively -11.5 °C in immersion freezing mode.

Analysis of PM_{10} filters has provided a similar pattern with largest numbers in summer and small ones during winter (Fig. 2). To learn more about the vertical distribution of IN in the lower troposphere, we are also analyzing filters from Chaumont (1136 m altitude), a small mountain at the northern fringe of the Jura mountains, near Neuchâtel. Filters analyzed so far (5 of 12 months) from this lower location show larger numbers of IN and large numbers even during winter.

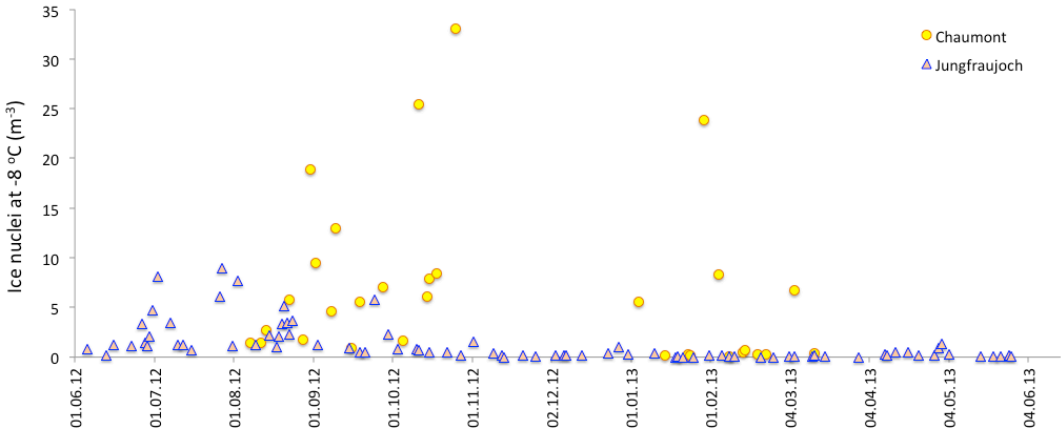

Figure 2. Time course of ice nuclei active at -10 °C at Jungfraujoch (3580 m) and at Chaumont (1136 m).

When pooled together, data from Jungfraujoch and from Chaumont show interesting features (Fig. 3):

a) IN numbers (active > -10°C) are not related to PM_{10}
b) There may be a similar maximum for IN across the full PM_{10} range
c) IN values are split in two groups around $T_{max} = 0$; <u>at both stations</u>!
(T difference between stations is around 16 °C (2.4 km x 6.5 °C/km))

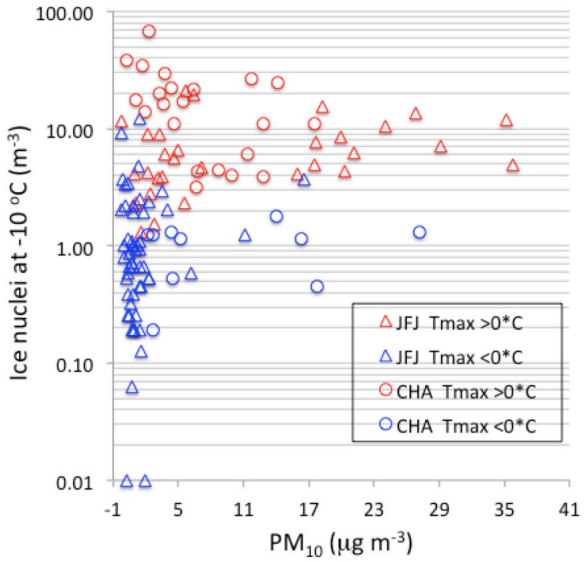

Figure 3. Number of ice nuclei observed at Jungfraujoch and at Chaumont at different PM_{10} concentrations on days with maximum temperatures above and below 0 °C, respectively.

Finding *a* could be explained by large differences in emitted PM_{10} regarding their IN activity. If there would be two groups of PM_{10}, one IN-active, the other not, it would also explain observation *b*: concentrations of IN-active PM_{10} determine IN number concentrations, various admixtures of inactive PM_{10} modify PM_{10} concentrations. Candidates for inactive PM_{10} are Saharan dust and combustion products (Chaumont). But, this would not explain finding *c*.

How could IN values at both stations be split around the same T_{max} although one station is on average so much colder than the other? If IN numbers were controlled by IN emission, the split of IN values at Jungfraujoch should be either side of a T_{max} 16 ^{o}C colder than at Chaumont. Consequently, IN number concentrations at either station are more likely controlled by deposition of IN.

Filter samples integrate over 24 hours. They sample dust from air masses throughout the full diurnal cycle of temperature and relative humidity. Air masses on days when $T_{max} < 0\ ^{o}$C will have seen temperatures at which some (or all) IN are active. Coincidence of lowest temperature with highest relative humidity provides a good chance for such IN to grow ice particles on days when $T_{max} < 0\ ^{o}$C and to be deposited, which does not necessarily mean it has to rain or snow visibly (descent of a few tens of ice particles per m^3 does the job). Other, not IN-active particles in the PM_{10} population will not be deposited by this mechanism, hence the apparent un-relatedness of IN and PM_{10} (observation *a*).

Conclusions could be that:

a) IN number concentrations in the atmosphere cannot be derived from particle numbers of properties other than IN activity itself *(because of observation* a*, but also because of* c*, suggesting a selective deposition of IN-active particles, and these are always only a very small fraction of otherwise very similar (not distinguishable) groups of particles (i.e. perhaps only 10^{-5} of all airborne bacteria are IN active))*

b) The number of IN in an air parcel largely depends on its temperature history (<24h) *(... and its relative humidity (supersaturation) history; to be investigated ...)*

Key words:

Ice nucleation, biological, snow, PM_{10}

Internet data bases:

http://umweltgeo.unibas.ch/
http://azug.minpet.unibas.ch/~lukas/FNA/index.html

Collaborating partners/networks:

Dr. Ernest Weingartner, Aerosol Physics Group, PSI, Villigen
Group for Climate Gases, Empa, Dübendorf
NABEL, Empa, Dübendorf
Dr. Cindy Morris, Plant pathology research unit, INRA, Avignon, France

Scientific publications and public outreach 2013:

Refereed journal articles and their internet access

Xia, Y., F. Conen, C. Alewell, Total bacterial number concentration in free tropospheric air above the Alps, Aerobiologia, **29**, 153-159, doi: 10.1007/s10453-012-9259-x, 2013.
http://link.springer.com/article/10.1007%2Fs10453-012-9259-x#page-1

Conference papers

Conen, F., Aérosol: interaction des poussières du sol avec l'atmosphère au delà de leur composition minérale, Proc. Colloque National 'Microbiologie des Aérosols', La Bourboule, France, 07.-09. octobre 2013, Institut de Chimie de Clermont-Ferrand (ICCF, UMR6296 CNRS-UBP-ENSCCF), 13, 2013.

Stopelli, E., F. Conen, C. Alewell, C.E. Morris, Abundance of biological ice nuclei at tropospheric cloud heights: results and perspectives from one year of observations, Proc. Colloque National 'Microbiologie des Aérosols', La Bourboule, France, 07.-09. octobre 2013, Institut de Chimie de Clermont-Ferrand (ICCF, UMR6296 CNRS-UBP-ENSCCF), 47, 2013.

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