Name of research institute or organization:

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Title of project:

The Global Atmosphere Watch Aerosol Program at the Jungfraujoch

Project leader and team:

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Project description:

Airborne aerosols affect our climate primarily by influencing the atmospheric energy budget through direct and indirect effects. Direct effects refer to the scattering and absorption of radiation and their influence on the planetary albedo and the climate system. Indirect effects refer to the increase in available cloud condensation nuclei (CCN) due to an increase in anthropogenic aerosol concentration. This leads to an increase in cloud droplet number concentration and a decrease in cloud droplet effective radius, when the cloud liquid water content (LWC) remains constant. The resulting cloud droplet spectrum leads to reduced precipitation and increased cloud lifetime. The overall result in the global atmosphere would be an increase in cloud albedo which cools the Earth's climate. Despite the uncertainty it is believed that in regions with high anthropogenic aerosol concentrations, aerosol forcing may be of the same magnitude but opposite in sign compared to the combined effect of all greenhouse gases.

The Global Atmosphere Watch (GAW) program is an activity overseen by the World Meteorological Organization (WMO). It is the goal of GAW to ensure long-term measurements in order to detect trends and to develop an understanding of these trends. With respect to aerosols the objective of GAW is to determine the spatio-temporal distribution of aerosol properties related to climate forcing and air quality up to multi-decadal time scales. Since the atmospheric residence time of aerosol particles is relatively short, a large number of measuring stations are needed. The GAW monitoring network consists of 27 global (including the Jungfraujoch) and about 300 regional stations. While global stations are expected to measure as many of the key variables as possible, the regional stations generally carry out a smaller set of observations.

The Jungfraujoch aerosol program is among the most complete ones worldwide. By the end of 2011 it has reached 17 years of continuous measurements. Table 1 shows the current GAW instrumentation that is continuously running at the Jungfraujoch. For these measurements, ambient air is sampled via a heated inlet (25°C), designed to prevent ice build-up and to evaporate cloud particles at an early stage, ensuring that the cloud condensation nuclei and/or ice nuclei are also sampled. This inlet is called the *total* inlet.

Hourly and daily averages are calculated and the data is visualized in real-time for different time periods in the internet, see
http://aerosolforschung.web.psi.ch/onlinedata or
http://gawrtl.psi.ch

Table 1. *Current GAW aerosol instrumentation*

Instrument	Measured parameter
CPC (TSI 3010 or 3772)	Particle number density (particle diameter D_p>10 nm)
Nephelometer (TSI 3563)	Scattering coefficient at three wavelengths
Aethalometer (AE-31)	Absorption coefficient at seven wavelengths; black carbon (BC) concentration
MAAP	Absorption coefficient at one wavelength; black carbon (BC) concentration
Filter packs	Aerosol major ionic composition (PM1 and TSP)
Betameter and HiVol$^{1)}$	Aerosol mass, PM1 and TSP$^{1)}$

$^{1)}$ measured by EMPA

Since 2008, additional aerosol parameters have been continuously measured at the Jungfraujoch (see Table 2). These measurements were conducted as part of the “GAW plus” program and two EU Projects (EUSAAR and EUCAARI).

Table 2. *Additional aerosol instrumentation operated in 2011.*

Instrument	Measured parameter	Measurement period
SMPS, OPC	Particle number size distribution, D_p = 20 - 22’500 nm	10.1.2008 - ongoing
CCNC	Number concentration of cloud condensation nuclei	10.1.2008 - ongoing

The number size distribution of aerosol particles plays a key role for direct and indirect aerosol climate interactions. A scanning particle mobility sizer (SMPS) and an optical particle counter (OPC) were installed at the JFJ in January 2008. These instruments have been fully operational since then and provide a complete size distribution from 20 nm to 20 μm.

The cloud condensation nuclei counter (CCNC) exposes ambient aerosol particles to a defined water supersaturation (SS, in the range between SS = 0.12-1.18%) and measures the concentration of cloud droplets that were activated at this SS. This instrument was installed in January 2008 and has been running since then. It provides valuable information on the variation, absolute value and SS dependence of the CCN concentration (Jurányi et al., 2011). Figure 1 shows the temporal variation of the measured CCN concentration from 2008 to 2011.

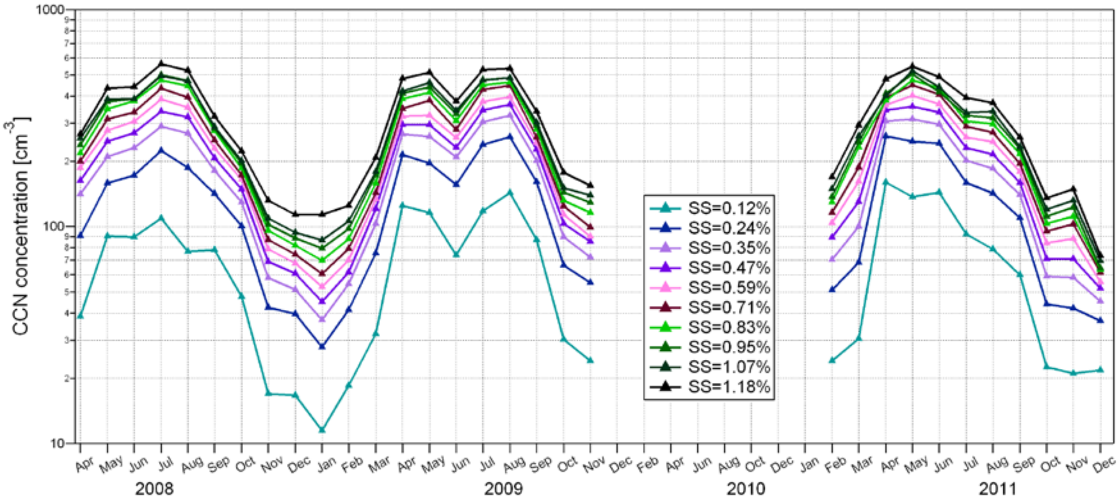

Figure 1. *Time series of CCN concentrations from April 2008 to December 2011 at 10 different supersaturations. The gap in the time series from December 2009 to January 2011 is due to the commitment of the CCNC in another campaign (MEGAPOLI in Paris) and due to a servicing of the instrument at the manufacturer.*

The CLACE 2011 field campaign: Investigation of effective peak supersaturations in liquid-phase clouds

An important aerosol parameter for climate models is the critical supersaturation (described by Köhler theory), at which a particle forms a cloud droplet. This parameter depends on the particle's dry size and chemical composition. At ambient air conditions, the prevailing supersaturation determines the activation diameter of the aerosol particles (i.e. the diameter at which size a particle forms a cloud droplet). The highest supersaturation that a particle experiences in an ambient cloud, leading to a cloud droplet forming from that particle, is the so-called effective peak supersaturation (SS_{peak}).

In summer 2011, the Cloud and Aerosol Characterization Experiment (CLACE2011) was conducted at the high alpine research station Jungfraujoch (3580 m asl, Switzerland). In order to determine SS_{peak} in ambient clouds, the ambient activation diameter (diameter where 50% of the particles are scavenged by water; D_{50}) was retrieved from particle number size distribution measurements of the total and the interstitial (non-activated) aerosol. Two different inlet systems were used to retrieve the aerosol number concentration of (1) the total aerosol including the nuclei of the hydrometeors (N_{tot}) and (2) the non-activated (interstitial aerosols; N_{int}) ones. The difference of these two numbers leads to the number of cloud condensation nuclei (CCN) that were activated at the prevailing ambient air conditions. To retrieve the ambient D_{50}, the activated fraction ($(N_{tot}-N_{int})/N_{tot}$) was calculated. The Köhler theory consists of two different laws: Raoult's law and Kelvin's law. The former is relying on the hygroscopic properties of the aerosol particles. To summarize Raoult's law with one parameter, Petters and Kreidenweis (2007) introduced the hygroscopicity parameter κ. To retrieve the prevailing ambient κ parameter, the activation diameter was compared to those retrieved from a cloud condensation nuclei (CCN) counter measuring at various controlled supersaturations. Therewith, the effective peak supersaturation can be calculated depending on the following parameters: D_{50}, κ and the temperature where the activation of an aerosol to a cloud droplet occurs.

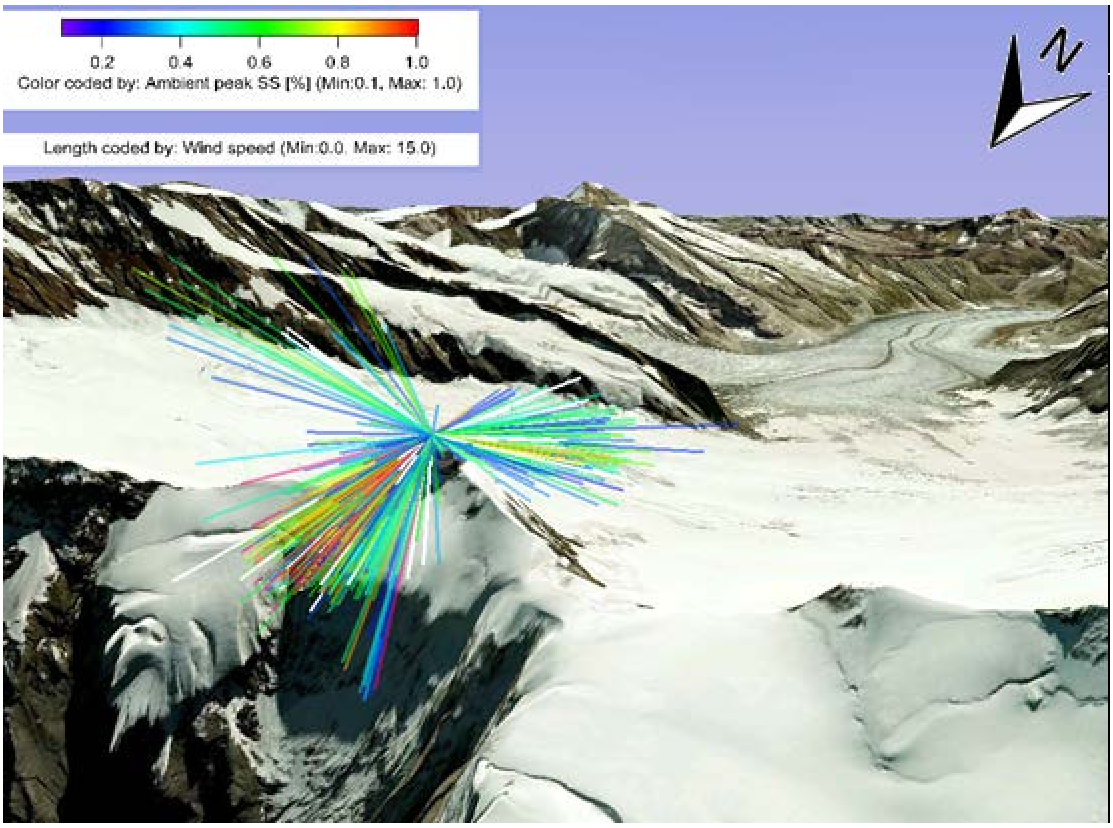

Figure 2. *Effective peak supersaturations are shown (color code) in a 3-dimensional wind field measured with a sonic anemometer representing the wind field around the Sphinx. The length of the lines shows the wind velocity of the air masses reaching the Jungfraujoch. Topography: Google Maps, 2011.*

Figure 2 shows the results of SS_{peak} in a satellite picture provided by GoogleEarth. The different colors of the lines indicate the SS_{peak} values, while the spatial alignment of the lines shows the direction (in a 3-dimension wind field) of the origin of the air masses reaching the Jungfraujoch. The length of the lines indicates the wind velocity. A range of SS_{peak} values between 0.04% and 1.62% has been observed during CLACE2011. While air masses coming from the North showed a wide range of values, SS_{peak} values for air masses coming from the South were more constant at around 0.2%. This can most likely be explained by different topography from south and north of the Jungfraujoch causing different updraft velocities. While the south side of the Jungfraujoch has a rather smooth topography (Aletsch glacier) resulting in relatively low orographically induced updraft velocities, the north side is characterized by steep rock walls, with more turbulent wind conditions and high updraft velocities.

Currently, the influence of particle number concentration and size distribution on the SS_{peak} as a function of updraft velocity is being investigated in detail with a cloud box model.

Planetary boundary layer detected by remote sensing instruments at the Kleine Scheidegg

The knowledge of the planetary boundary layer (PBL) over mountainous terrain is rather incomplete and most studies are based on highly simplified and idealized mountains or undulating areas. The two most important research fields in this domain are the PBL development in mountainous terrain as well as the improvement of algorithms to derive PBL from remote sensing instruments as lidars, ceilometers or wind profilers. In mountains less solar radiation is needed to heat up the same air volume as over lowlands. This fact causes temperature differences between both areas, resulting in pressure differences and local wind systems.

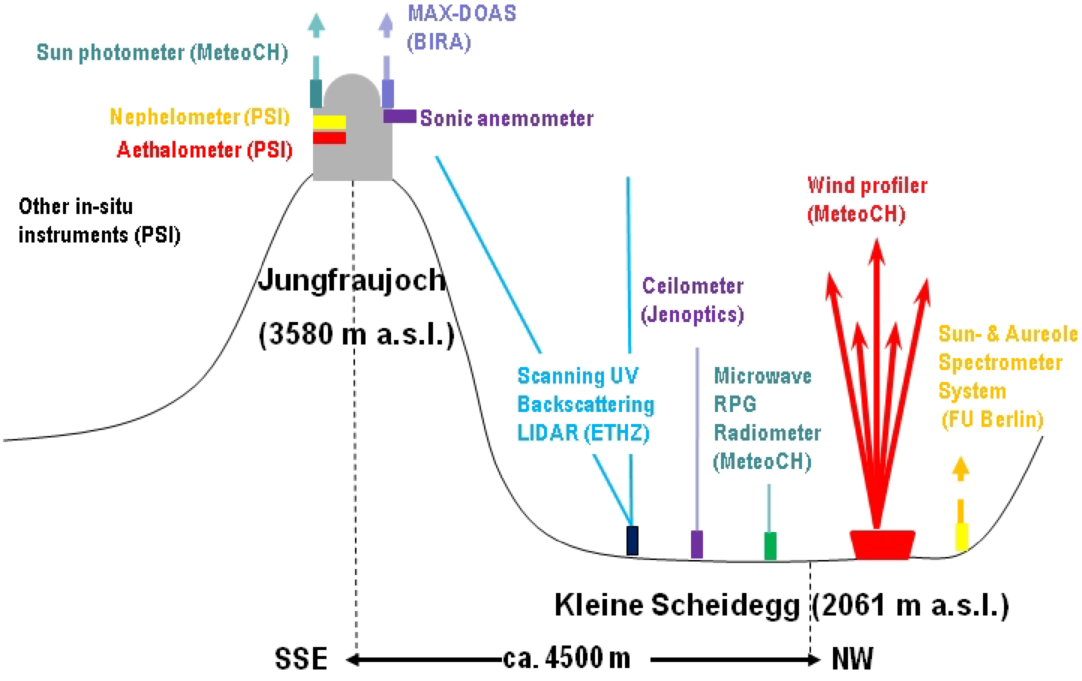

Figure 3. *Outline of CLACE 2010.*

During CLACE 2010, the PBL was estimated by both the ceilometer and the wind profiler at the Kleine Scheidegg for all fair-weather days. Both instruments use gradients in the aerosol backscatter or refractive index, respectively. For the wind profiler, the range-corrected signal to noise ratio (SNR_{corr}) and the resulting PBL estimates are shown in Figure 4 for 8 July 2010. The development of a convective boundary layer (CBL) is clearly observed with a maximum of SNR_{corr}. A growing CBL can be detected by both the ceilometer and the wind profiler with a maximum height around 2 PM, followed by a decay of two successive layers. An incursion of the wind direction from N to W corresponds to the strongest decrease of these layers. During night the ceilometer observes two residual layers, which decrease in height before sunrise. PBL air is therefore transported with updrafts to the JFJ where it can be observed in in-situ measurements (for example in absorption and scattering coefficients).

The diurnal variations of the PBL are therefore well estimated by the Jenoptic ceilometer in case of fair-weather days. The algorithm written for the Vaisala wind profiler data agrees well over daytime with Ceilometer PBL. Using wind profiler data it is more difficult to analyze residual layer or stable boundary layer, because the strongest SNR_{corr} is in the majority of cases observed on the lowest measurement level. For periods with clouds, the ceilometer performs less well in discriminating between cloud base and PBL height.

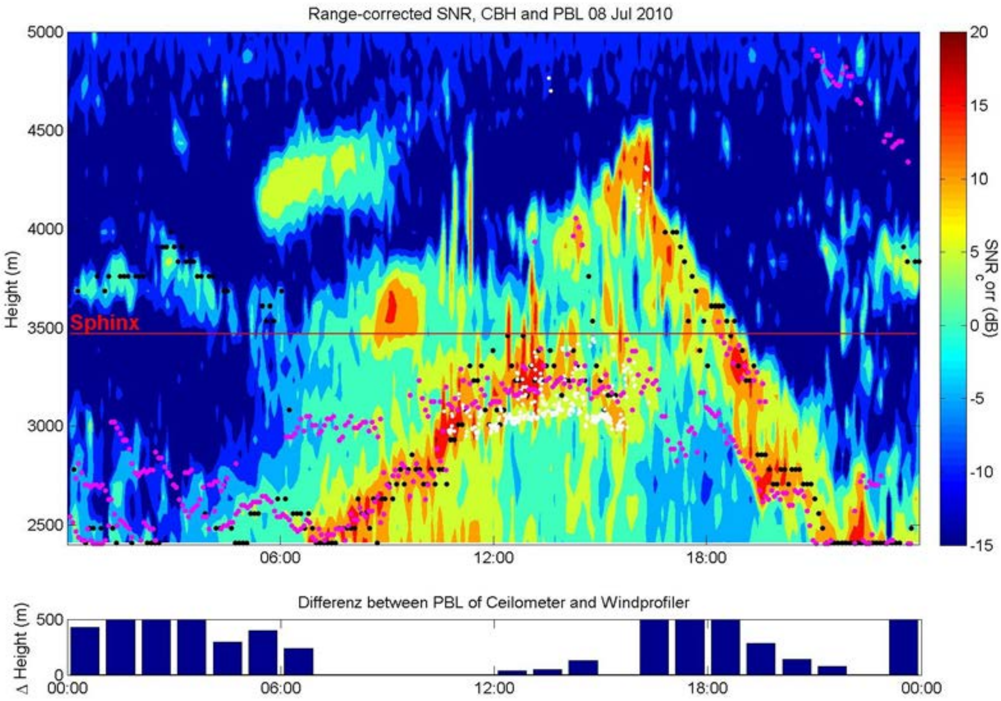

Figure 4. *Range-corrected SNR derived from wind profiler and wind profiler PBL (black dots), ceilometer PBL (purple dots) and clouds (white) as well as the difference between hourly averaged PBL of both measurement devices for 8th July 2010.*

Key words:

Atmospheric aerosol particles, aerosol climatic effects, radiative forcing, light scattering, cloud condensation nuclei, hygroscopic growth, CCN concentration, aerosol size distribution, , remote sensing of aerosol optical properties

Internet data bases:

http://www.psi.ch/lac
http://aerosolforschung.web.psi.ch
http://www.meteoschweiz.admin.ch/web/en/climate/climate_international/gaw-ch.html

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Scientific publications and public outreach 2011:

Refereed journal articles and their internet access

E. Andrews, J.A. Ogren, P. Bonasoni, A. Marinoni, E. Cuevas, Rodríguez, J.Y. Sun, D.A. Jaffe, E.V. Fischer, U. Baltensperger, E. Weingartner, M. Collaud, S. Sharma, A.M. Macdonald, W.R. Leaitch, N.-H. Lin, P. Laj, T. Arsov, I. Kalapov, A. Jefferson, P. Sheridan: Climatology of aerosol radiative properties in the free troposphere, doi:10.1016/j.atmosres.2011.08.017, Atmos. Res. **102**, 365–393 (2011).
http://dx.doi.org/10.1016/j.atmosres.2011.08.017

A. Asmi, A. Wiedensohler, P. Laj, A.-M. Fjaeraa, K. Sellegri, W. Birmili, E. Weingartner, U. Baltensperger, V. Zdimal, N. Zikova, J.-P. Putaud, A. Marinoni, P. Tunved, H.-C. Hansson, M. Fiebig, N. Kivekäs, H. Lihavainen, E. Asmi, V. Ulevicius, P.P. Aalto, E. Swietlicki, A. Kristensson, N. Mihalopoulos, N. Kalivitis, I. Kalapov, G. Kiss, G.d. Leeuw, B. Henzing, R.M. Harrison, D. Beddows, C. O'Dowd, S.G. Jennings, H. Flentje, K. Weinhold, F. Meinhardt, L. Ries, M. Kulmala: Number size distributions and seasonality of submicron particles in Europe 2008–2009, Atmos. Chem. Phys. **11**, 5505-5538 (2011).
http://dx.doi.org/10.5194/acp-11-5505-2011

N. Bukowiecki, P. Zieger, E. Weingartner, Z. Jurányi, M. Gysel, B. Neininger, B. Schneider, C. Hueglin, A. Ulrich, A. Wichser, S. Henne, D. Brunner, R. Kaegi, M. Schwikowski, L. Tobler, F.G. Wienhold, I. Engel, B. Buchmann, T. Peter, U. Baltensperger: Ground-based and airborne in-situ measurements of the Eyjafjallajökull volcanic aerosol plume in Switzerland in spring 2010, Atmos. Chem. Phys. **11**, 10011-10030 (2011).
http://dx.doi.org/10.5194/acp-11-10011-2011

C. Chou, O. Stetzer, E. Weingartner, Z. Juranyi, Z.A. Kanji, U. Lohmann: Ice nuclei properties within a Saharan dust event at the Jungfraujoch in the Swiss Alps, Atmos. Chem. Phys. **11**, 4725-4738 (2011).
http://dx.doi.org/10.5194/acp-11-4725-2011

M. Collaud Coen, E. Weingartner, M. Furger, S. Nyeki, A.S.H. Prévôt, M. Steinbacher, U. Baltensperger: Aerosol climatology and planetary boundary influence at the Jungfraujoch analyzed by synoptic weather types, Atmos. Chem. Phys. 11, 5931–5944 (2011).
http://dx.doi.org/10.5194/acp-11-5931-2011

M. Ebert, A. Worringen, N. Benker, S. Mertes, E. Weingartner, and S. Weinbruch, Chemical composition and mixing-state of ice residuals sampled within mixed phase clouds, Atmos. Chem. Phys., **11**, 2805-2816 (2011).
http://dx.doi.org/10.5194/acp-11-2805-2011

J. Duplissy, P. F. DeCarlo, J. Dommen, M. R. Alfarra, A. Metzger, I. Barmpadimos, A. S. H. Prevot, E. Weingartner, T. Tritscher, M. Gysel, A. C. Aiken, J. L. Jimenez, M. R. Canagaratna, D. R. Worsnop, D. R. Collins, J. Tomlinson, and U. Baltensperger, Relating hygroscopicity and composition of organic aerosol particulate matter, Atmos. Chem. Phys., **11**, 1155-1165 (2011).
http://dx.doi.org/10.5194/acp-11-1155-2011

Z. Jurányi, M. Gysel, E. Weingartner, N. Bukowiecki, L. Kammermann, U. Baltensperger: A 17-month climatology of the cloud condensation nuclei number concentration at the high alpine site Jungfraujoch, J. Geophys. Res. **116**, doi:10.1029/2010JD015199, D10204, (2011).
http://dx.doi.org/10.1029/2010JD015199

C. Reddington, K. S. Carslaw, D. V. Spracklen, M. G. Frontoso, L. Collins, J. Merikanto, A. Minikin, T. Hamburger, H. Coe, M. Kulmala, P. Aalto, H. Flentje, C. Plass-Dülmer, W. Birmili, A. Wiedensohler, B. Wehner, T. Tuch, A. Sonntag, C. D. O'Dowd, S. G. Jennings, R. Dupuy, U. Baltensperger, E. Weingartner, H.-C. Hansson, P. Tunved, P. Laj, K. Sellegri, J. Boulon, J.-P. Putaud, C. Gruening, E. Swietlicki, P. Roldin, J. S. Henzing, M. Moerman, N. Mihalopoulos, G. Kouvarakis, V. Ždímal, N. Zíková, A. Marinoni, P. Bonasoni, and R. Duchi, Primary versus secondary contributions to particle number concentrations in the European boundary layer, Atmos. Chem. Phys., **11**, 12007-12036 (2011).
http://dx.doi.org/10.5194/acp-11-12007-2011

Book sections

E. Weingartner, H. Burtscher, C. Hüglin, K. Ehara, Semi-continuous mass measurement, in P.S. Kulkarni, P.A. Baron, K. Willeke (eds.), *Aerosol Measurement: Principles, Techniques, and Applications*, John Wiley & Sons, Inc., 255-268, 2011.

Conference papers

U. Baltensperger, Why do we measure aerosols at the Jungfraujoch?, GAW-CH Conference, ETH Zürich, January 18-19, 2011.
http://www.meteosuisse.admin.ch/web/en/climate/climate_international/gaw-ch/gaw_ch_conference.html

U. Baltensperger, Z. Jurányi, E. Hammer, M. Gysel, N. Bukowiecki, E. Weingartner, Cloud condensation nuclei concentrations and actual supersaturations in real clouds, Goldschmidt Conference, Prague, Hungary, August 14 -19, 2011.
http://www.goldschmidt2011.org/

N. Bukowiecki, E. Andrews: Climatology of Aerosol Radiative Properties in the Free Troposphere, International Symposium Climate Change in High Mountain Regions, Zentralanstalt für Meteorologie und Geodynamik, Salzburg, August 28 - September 1 (2011).
http://www.zamg.ac.at/veranstaltungen/125jahresonnblick/

N. Bukowiecki, M. Gysel, Z. Jurányi, G. Wehrle, P. Zieger, M. Laborde, E. Hammer, E. Weingartner, U. Baltensperger: Long-term aerosol measurements at the high altitude research station Jungfraujoch (Switzerland), International Symposium Climate Change in High Mountain Regions, Zentralanstalt für Meteorologie und Geodynamik, Salzburg, August 28 – September 1 (2011).
http://www.zamg.ac.at/veranstaltungen/125jahresonnblick/

N. Bukowiecki, P. Zieger, E. Weingartner, Z. Jurányi, M. Gysel, B. Neininger, B. Schneider, C. Hueglin, A. Ulrich, A. Wichser, S. Henne, D. Brunner, R. Kaegi, M. Schwikowski, L. Tobler, F.G. Wienhold, I. Engel, B. Buchmann, T. Peter, U. Baltensperger: Ground-based and airborne in-situ measurements of the Eyjafjallajökull volcanic aerosol plume in Switzerland in April and May 2010, EGU General Assembly 2011, Vienna, Geophysical Research Abstracts **13**, EGU2011-2420, (2011).
http://meetingorganizer.copernicus.org/EGU2011/EGU2011-2420.pdf

N. Bukowiecki, P. Zieger, E. Hammer, Z. Jurányi, M. Gysel, M. Laborde, E. Weingartner, U. Baltensperger, M. Collaud Coen, C. Ketterer, O. Maier, D. Ruffieux, J. Spiegel, W. Eugster, C. Chou, J. Henneberger, U. Lohmann, E. Kienast, F.G. Wienhold, T. Peter, J. von Bismarck, M. Starace, T. Ruhtz, K. Clemer, M. van Roozendael: In-situ investigation of cloud microphysics and aerosol optical properties during the CLACE 2010 campaign at Jungfraujoch, Switzerland (3580 m asl): An Overview, EAC 2011, Manchester, U.K., September 4-9, 2011.
http://www.eac2011.com/

N. Bukowiecki, P. Zieger, E. Hammer, Z. Jurányi, M. Gysel, E. Weingartner, J. Spiegel, W. Eugster, U. Baltensperger: On the activation and ambient peak supersaturation of CCNs at Jungfraujoch, Switzerland (3580 m asl): Results from the CLACE 2010 campaign, European Aerosol Conference 2011, Manchester, UK, September 4-9 (2011).
http://www.eac2011.com/

M. Collaud Coen, E. Weingartner, C. Ketterer, O. Maier, S. Frey, P. Zieger, N. Bukowiecki, U. Baltensperger: Planetary boundary layer influence at the Jungfraujoch: In-situ and remote sensing measurements, EAC, Manchester, UK, September 4-9 (2011).
http://www.eac2011.com/

M. Gysel, M. Laborde, N. Bukowiecki, Z. Jurányi, E. Hammer, P. Zieger, U. Baltensperger, E. Weingartner: In situ measurement of cloud droplet activation behaviour of black carbon particles, European Aerosol Conference, Manchester, United Kingdom, September 5, 2011.
http://www.eac2011.com/

M. Gysel, M. Laborde, N. Bukowiecki, Z. Jurányi, E. Hammer, P. Zieger, U. Baltensperger, E. Weingartner: Influence of mixing state of atmospheric black carbon particles on their cloud droplet activation behaviour in real clouds, 10th International Conference on Carbonaceous Particles in the Atmosphere, Vienna, Austria, June 27, 2011.
http://iccpa.serverkit.de/index_10thICCPA.html

E. Hammer, Z. Jurányi, N. Bukowiecki, E. Weingartner, M. Gysel, J. Spiegel1, W. Eugster1, U. Baltensperger: Calculation and interpretation of cloud peak supersaturations at the High Alpine site Jungfraujoch, 15th ETH-Conference on Combustion Generated Nanoparticles, June 26-29, 2011.
http://www.lav.ethz.ch/nanoparticle_conf/index

E. Weingartner, J. Cozic, B. Verheggen, S. Mertes, N. Bukowiecki, Z. Jurányi, M. Gysel, M. Laborde, E. Hammer, U. Baltensperger: Measurements of aerosol activation behavior in mixed phase clouds at the high alpine site Jungfraujoch (3580 m asl, Switzerland), The XXV IUGG General Assembly, Melbourne, Australia June 28 – July 7, 2011.
http://www.iugg2011.com/

E. Weingartner, Z. Jurányi, M. Gysel, N. Bukowiecki, U. Baltensperger: Climatology of the CCN number concentration at the High Alpine site Jungfraujoch (3580 m asl, Switzerland) , XXV IUGG General Assembly, Melbourne, Australia, 28 June - 7 July, 2011.
http://www.iugg2011.com/

E. Weingartner, Z. Jurányi, E. Hammer, M. Laborde, J. Cozic, N. Bukowiecki, M. Gysel, B. Verheggen, U. Baltensperger: Aerosol-cloud interactions, GAW-CH Conference ETH Zürich, 18.-19.1.2011, 2011.
http://www.meteosuisse.admin.ch/web/en/climate/climate_international/gaw-ch/gaw_ch_conference.html

P. Zieger, N. Bukowiecki, U. Baltensperger, C. Ketterer, M. Collaud Coen, O. Maier, E. Kienast, F. Wienhold, T. Peter, J. Von Bismarck, M. Starace, T. Ruhtz, K. Clemer, M. Van Roozendael, S. Frey, H. Wille, E. Weingartner: Closure study of aerosol optical properties using in-situ and remote sensing techniques, EAC 2011, Manchester, U.K., 2011.
http://www.eac2011.com/

P. Zieger, R. Fierz-Schmidhauser, E. Weingartner, U. Baltensperger, Effects of relative humidity on aerosol light scattering: Results from different European sites, EAC 2011, Manchester, U.K., September 4-9, 2011.
http://www.eac2011.com/

Theses

P. Zieger, Effects of relative humidity on aerosol light scattering, Doctoral thesis, Diss. ETH No. 19659, April 2011.
http://dx.doi.org/10.3929/ethz-a-006668068

E. Hammer, Calculation and interpretation of cloud peak supersaturations at the Jungfraujoch, Master Thesis, Faculty of Science, University of Bern, 2011.
www.climatestudies.unibe.ch/students/theses/msc/52.pdf

C. Ketterer, Investigation of the planetary boundary layer at the Kleine Scheidegg and at the Jungfraujoch using remote sensing and in-situ measurements, Master Thesis, Faculty of Science, University of Bern, 2011.

Magazine and Newspapers articles

"Vulkanasche über der Schweiz“, N. Bukowiecki, Geosciences actuel, 3/2011, 34-46, October 1, 2011.
http://www.geosciences.scnat.ch/downloads/geoforumactuel/GSActuel_2011_3.pdf

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