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Title of project:

The Global Atmosphere Watch Aerosol Program at Jungfraujoch

Part of this programme:

GAW, ACTRIS

Project leader and team:

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Project description:

Aerosols affect Earth's climate primarily by influencing the atmospheric energy budget through direct and indirect effects. Direct effects (aerosol – radiation interactions, ARI) refer to the scattering and absorption of radiation by aerosol particles. Indirect effects (aerosol – cloud interactions, ACI) refer to the role of particles as cloud condensation nuclei (CCN) and ice-nucleating particles (INP). The number of CCN available under certain conditions affects droplet size in a cloud and thus cloud brightness and cloud life-time. The latter is also impacted by INPs which play a key role in initiating precipitation. The climate relevance of both direct and indirect effects results from their effect on the planetary albedo. The IPCC report states that almost all uncertainty with respect to anthropogenic forcing is caused by our limited understanding of these aerosol effects. According to some estimates, however, aerosol forcing may be of the same magnitude (but opposite in sign) as the combined effect of all greenhouse gases. Aerosols thus have a significant cooling effect.

The Global Atmosphere Watch (GAW) programme is an activity overseen by the World Meteorological Organization (WMO). The goal of GAW is 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 31 global (including the Jungfraujoch site) and about 400 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. From April 2011 to March 2014, the aerosol programme at Jungfraujoch was also part of the European infrastructure project ACTRIS I3 FP3 (Aerosols, Clouds, and Trace gases Research Infra Structure), followed by the currently running project phase ACTRIS-2 IA H2020 (May 2015 to April 2019).

The Jungfraujoch aerosol observations are among the most complete worldwide. By the end of 2016 they have reached 21 years of continuous measurements for part of the observables (see Figure 1). In celebration of this anniversary, a review article was compiled summarizing two decades of aerosol research at Jungfraujoch (Bukowiecki et al., 2016). Data from the CCNC (cloud condensation nuclei counter for the measurement of the number of particles that are able to form a cloud droplet at specified supersaturations) are part of an ongoing effort to characterize CCN variability world-wide. While the initial step in the form of a synthesis of measurements within the FP6 project EUCAARI was completed in 2015

(Paramonov et al., 2015), a new study in the ACTRIS framework is being finalized that puts special focus on long-term observations (Schmale et al, Scientific Data, in press). The Jungfraujoch GAW monitoring data also substantially contributed to aerosol nucleation studies (Bianchi et al., 2016, Tröstl et al. 2016, Frege et al., 2016, see separate contribution to the 2016 HFSJG Activity Report).

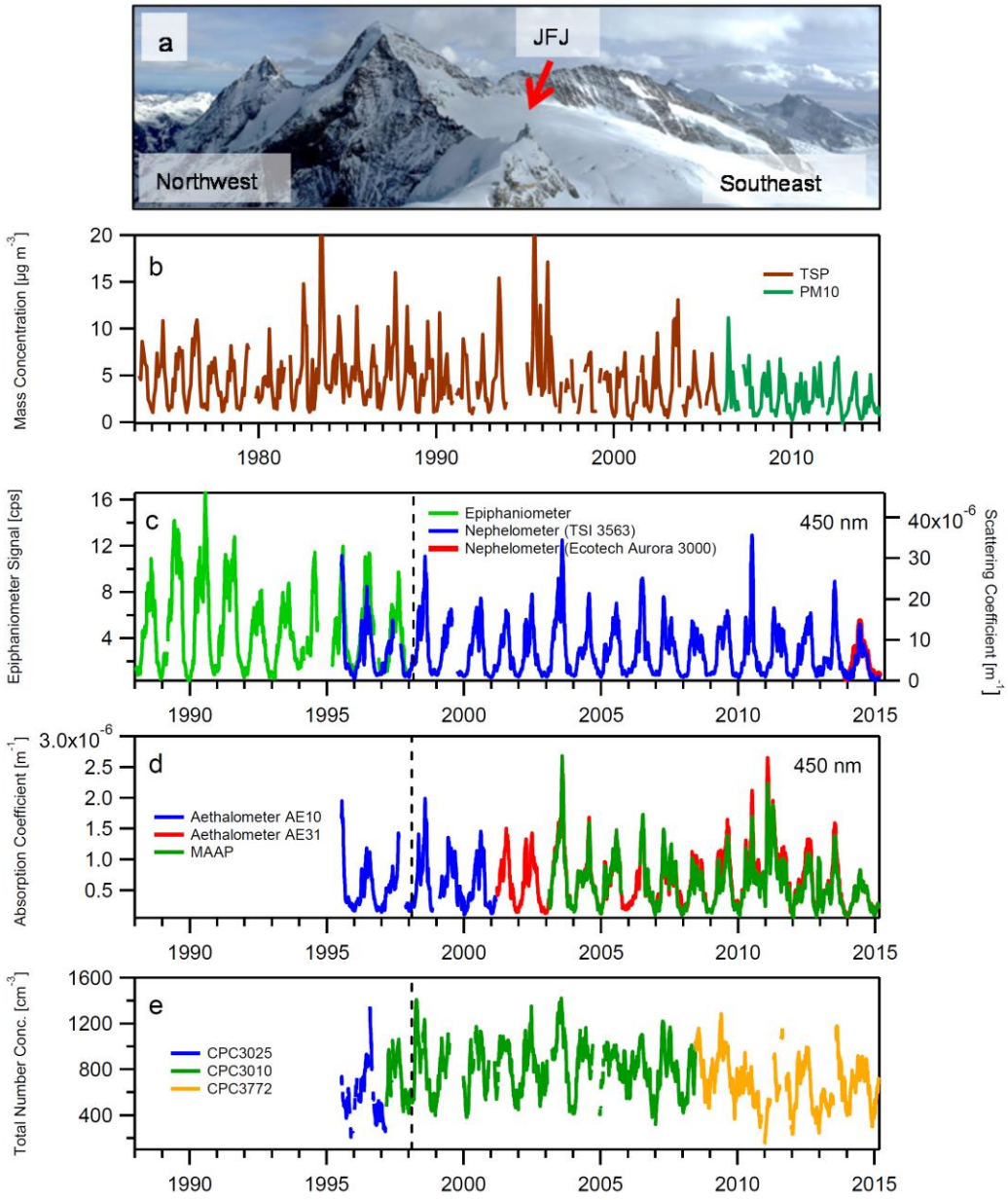

Figure 1 (from Bukowiecki et al., 2016). Panel a: View of the station at Jungfraujoch (JFJ). Panels b–e: Temporal evolution of the continuously measured aerosol parameters at the Jungfraujoch. For TSP and PM10 monthly average values are shown, for the rest of the parameter the 30-day running average of the daily average values. The dashed vertical lines (Panels c–e) indicate that in January 1998, the entire aerosol laboratory was moved from the old JFJ research station (3454 m asl) to the JFJ Sphinx research station (3580 m asl) and a new inlet was employed. Gravimetric TSP and PM10 is sampled separately.

Table 1 shows the current GAW instrumentation that is continuously running at 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. The

sampling is in accordance with GAW recommendations, and the operation and data handling of the individual instruments follows the most recent ACTRIS recommendations. Data delivery to EBAS occurs both hourly in near-realtime (selected instruments, raw data) and annually (quality controlled and flagged data).

Table 1. Current GAW aerosol instrumentation at Jungfraujoch

Instrument	Measured parameter
CPC (TSI 3010 or 3772)	Particle number density (particle diameter D_p>10 nm)
Nephelometers (TSI 3563 & Ecotech Aurora 3000)	Scattering coefficient at three wavelengths
Aethalometers (AE-31 & AE-33)	Absorption coefficient at seven wavelengths; equivalent black carbon (BC) concentration
MAAP	Absorption coefficient at one wavelength; equivalent black carbon (BC) concentration
Filter packs	Aerosol major ionic composition (PM1 and TSP)
Fidas and HiVol[1)]	Aerosol mass, PM1 and TSP[1)]
SMPS, OPC	Particle number size distribution, D_p = 20 - 22'500 nm
CCNC	Number concentration of cloud condensation nuclei at different supersaturations

[1)] measured by EMPA (Fidas replaced Betameter in November 2016)

Observations at Jungfraujoch East Ridge

In October 2014, an aethalometer (AE-33) and a condensation particle counter (TSI 3775) were installed at the Jungfrau East Ridge station (3705 m a.s.l., former Swisscom station), to measure aerosol microphysical properties. These measurements will be compared to those performed at the Sphinx laboratory with a similar setup, to determine the impact of local pollution at Jungfraujoch and to investigate the small-scale spatial variability of aerosol parameters. Figure 2 shows a comparison of the total number concentration at both sites for a couple of days in autumn 2014. While concentrations are nearly identical during night-time, data from the Sphinx show large spikes during the day which indicate tourism-related local pollution (Fröhlich et al., 2015). By the use of appropriate statistical filters, the baseline at the Sphinx can be sufficiently well recovered from the raw data series influenced by spikes. Figure 3 furthermore shows that the spikes occurrence at the Sphinx is rather correlated by the touristic activities than by transported air masses. A detailed analysis is currently ongoing and foreseen for publication in 2017.

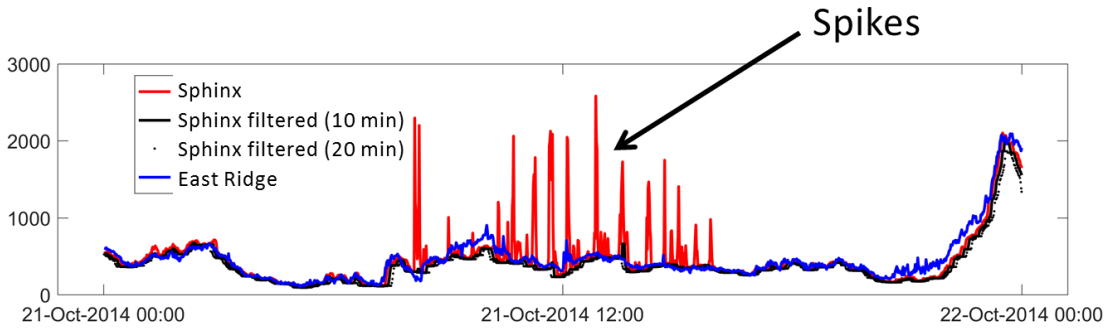

Figure 2. Total number concentrations at Sphinx and East Ridge.

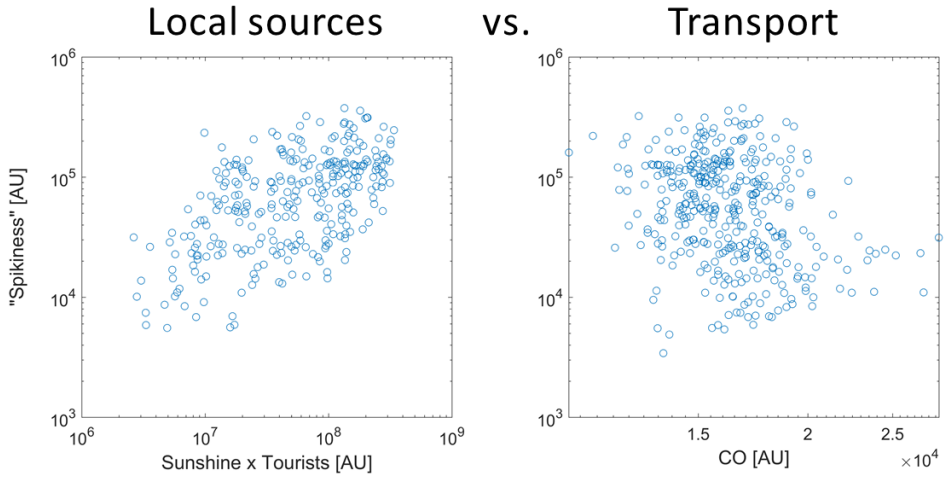

Figure 3. Correlation of spikes with tourist frequencies, sunshine duration and CO as proxy for transported air masses.

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, nucleation

Internet data bases:

http://www.psi.ch/lac
http://www.psi.ch/lac/gaw-monitoring-nrt-data
http://sites.google.com/site/jfjnrt/
http://www.meteoschweiz.admin.ch/web/en/meteoswiss/international_affairs/GAW.html
http://ebas.nilu.no
http://www.actris.net

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Scientific publications and public outreach 2016:

Refereed journal articles and their internet access

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Collaud Coen, M. and E. Andrews, On the role of topography on the planetary boundary layer influence at high altitude sites, GAW Landesausschuss, Zürich, Switzerland, April 6, 2016.

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