Name of research institute or organization:

Laboratory of Atmospheric Chemistry, Paul Scherrer Institute, CH-5232 Villigen PSI, Switzerland

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 the droplet number and size in a cloud and thus cloud brightness and cloud life-time. Both characteristics are also impacted by INPs which, with regard to life-time, 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 a major part of the uncertainty with respect to anthropogenic radiative forcing is caused by our limited understanding of these aerosol effects.

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 FP7 infrastructure project ACTRIS (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 2017 they have reached 22 years of continuous measurements for part of the observables (see Figure 1). 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 goes one step ahead and provides a set of co-located particle number size distribution, CCN and aerosol composition data from

long-term observations all over the globe (Schmale et al. 2017). This harmonized data set will serve as a benchmark for global model simulations.

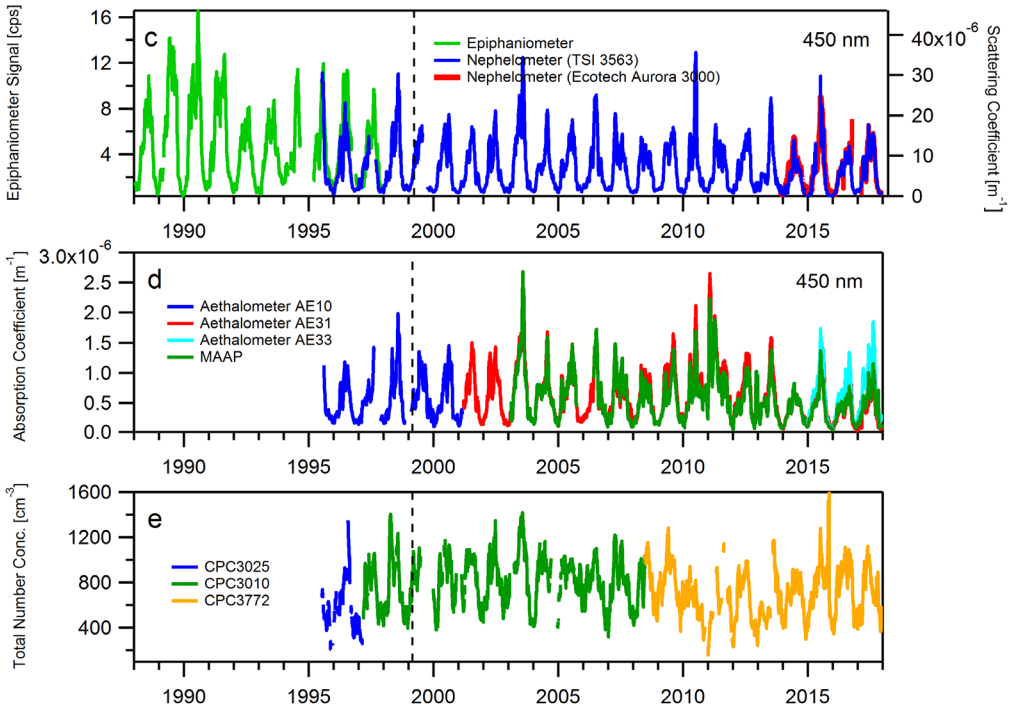

Figure 1 (updated from Bukowiecki et al., 2016). Panels d–e: Temporal evolution of the continuously measured aerosol parameters at the Jungfraujoch (30-day running average of the daily average values). The dashed vertical lines indicate that in January 1998, the entire aerosol laboratory was moved from the old JFJ research station (3454 m asl) to the JFJ Sphinx research station (3580 m asl) and a new inlet was employed.

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. 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 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, OPS	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 the occurrence of high pollution days at the Jungfraujoch, which are defined as days with more than 8 strong peaks at the Jungfraujoch and less than 2 strong peaks at the East Ridge site. In the 3 years of parallel measurements (Oct 2014 to Oct 2017), the percentage of high local pollution days was 9%. During these days, the daily CPC averages including the spikes are 25% percent higher compared to the daily baseline values. During normal days, this value is only 10%. In the median the influence of the spikes is not seen. The invitation to refrain from smoking on the public Sphinx terrace in March 2017 leads to less days with high local pollution.

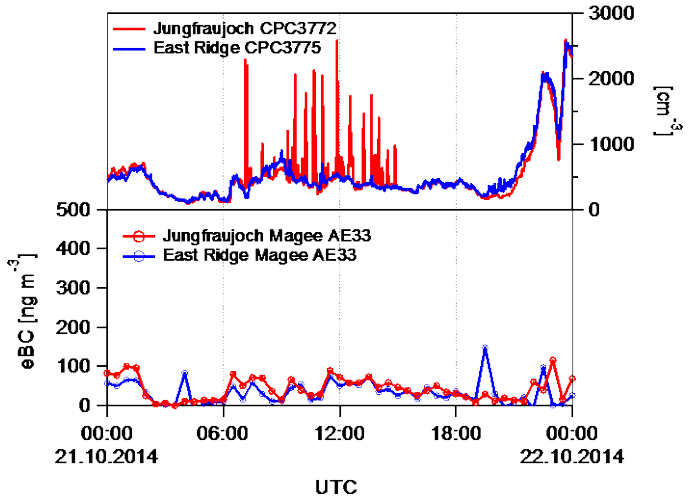

Figure 2. Total particle number concentrations (top panel) and equivalent black carbon concentrations (bottom panel) during a high local pollution day at Sphinx and East Ridge.

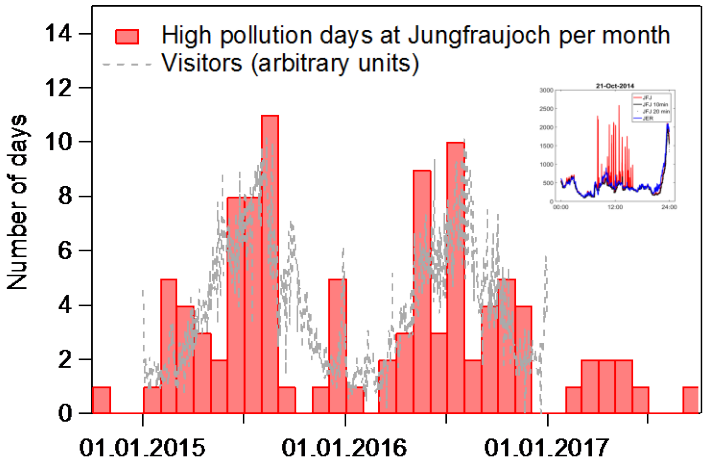

Figure 3. Number of high pollution days at the Jungfraujoch, derived from the CPC time series at the Jungfraujoch and Jungfrau East Ridge. A high pollution day is defined as day with more than 8 strong peaks at the Jungfraujoch and less than 2 strong peaks at the East Ridge site.

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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
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http://www.meteoswiss.admin.ch/home/climate/past/aerosol-monitoring.html
http://www.meteoswiss.admin.ch/home/climate/past/saharan-dust-events.html

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Scientific publications and public outreach 2017:

Refereed journal articles and their internet access

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