Name of research institute or organization:

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Title of project:

Aerosol Chemical Speciation Monitor (ACSM) measurements on the Jungfraujoch within the frame of the EU project ACTRIS (Aerosols, Clouds, and Trace gases Research Infrastructure Network)

Project leader and team:

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Project description:

The project is comprised of two main goals: Firstly, the augmentation of knowledge about the aerosol present in the high-alpine atmosphere by monitoring its chemical composition over a period of at least one full year. Embedded in the framework of the ACTRIS (Aerosols, Clouds, and Trace Gases Research InfraStructure Network) network which encompasses about a dozen similar measurement stations all over Europe, these measurements are to contribute to a unique, chemically resolved dataset of the European aerosol. The second goal is the validation of a prototype of a new time of flight instrument (ToF-ACSM, see Fig. 1) suitable to monitor the chemical composition of the non-refractory, sub-micron aerosol with lower detection limits than the current quadrupole version (Q-ACSM). The specific conditions on the Jungfraujoch in terms of aerosol concentrations which are mostly very low but can still be highly variable in summer provide an ideal proving ground for both detection limits and temporal resolution of the instrument. Additionally, the infrastructure and the large number of complementary measurements at the Sphinx Research Station allow for sanity tests of the recorded data and the testing of the prototype's remote control capability.

Fig. 1. Sketch of ToF-ACSM.

Work on the project was started in late June 2012. From the beginning of August until mid-November 2012 the ToF-ACSM prototype was operated in parallel with the current Q-ACSM version, which has already been validated and available on the market for about three years. The inter-comparison of the time series of the individual chemical species (organics, sulfate, nitrate, ammonium and chloride) recorded with the two instruments (see Fig. 2a and 2b) showed very good agreement in absolute concentrations (±15%) as well as in capturing the variability (R^2 = 0.97 (total mass)). Furthermore, an inter-comparison of the ToF-ACSM to a co-located instrument employing an optical method to estimate aerosol mass (nephelometer, see Fig. 2c) also showed a very good qualitative agreement (R^2 = 0.94). These results are a very important step towards proving the validity of the ToF-ACSM data and therefore suitability for the market. A further comparison to the high-end aerosol mass spectrometer (AMS) during the CLACE campaign in the first quarter of 2013 will complete the validation and will be published soon.

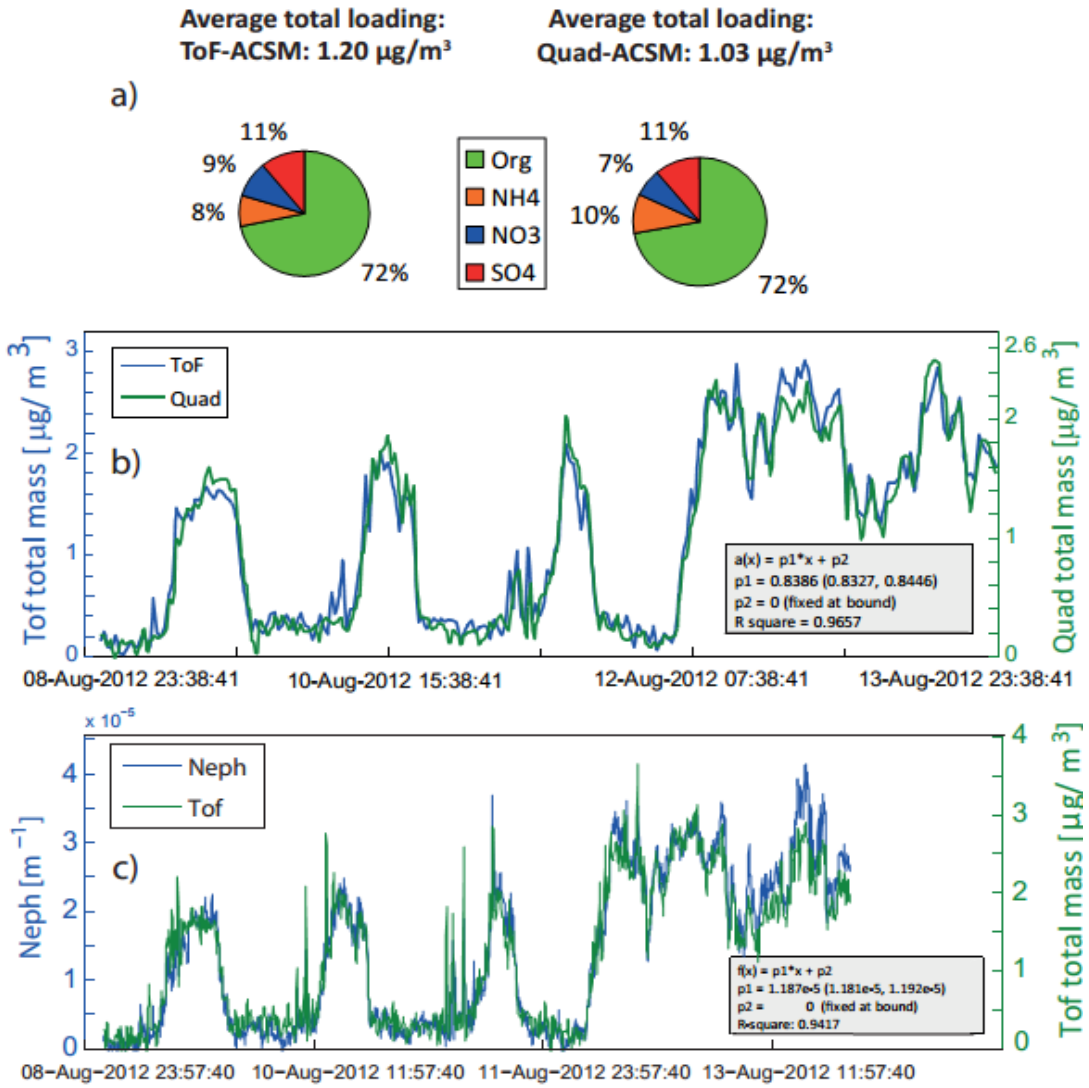

Fig. 2. a) Contribution of individual species to total mass loading of the ToF-ACSM (left) and the Q-ACSM (right) in the displayed period. b) Time series of the total mass concentration (µg/m³) recorded with the ToF-ACSM (blue) and the Q-ACSM (green) during five days in August 2012. c) Time series of the nephelometer at λ = 450nm in m^{-1} (blue) and time series of the total mass concentration measured with the ToF-ACSM in µg/m³ (green) during five days in August 2012. Results of a fit to scatter plot of same data are given in right corner for b) and c).

The aerosol concentrations at the Jungfraujoch typically go down to very low levels in winter. They are well below the detection limit of the Q-ACSM and therefore from mid-November on it was brought to another measurement station and only the ToF-ACSM remained on the Jungfraujoch. Because of these low concentrations this season is very well suited to test and explore the detection limits of the new instrument.

Fig. 3 shows most of the times-series recorded so far. The summer data was recorded with the Q-ACSM and the winter data with the ToF-ACSM. The aerosol concentration in summer follows the typical pattern of vertical exchange processes causing injections of planetary boundary layer air in the valleys or the Swiss Plateau into higher altitudes during the afternoon. This results in increasing aerosol concentrations starting around noon at Jungfraujoch and which decrease again at night. The peak concentrations in summer are usually around 5-8 µg/m³ and occur around 5 pm. There were two days with extraordinarily high concentrations, the 30th of June and the 9th of September with peak concentrations of 21 µg/m³ and 29 µg/m³ respectively. The largest mass fraction of the non-refractory, submicron

aerosol in summer consists of organic compounds (58%) and sulfate (25%), additionally there is some ammonium (10%) and nitrate (7%). In winter the Jungfraujoch resides in the free troposphere, i.e. it is no longer under the influence of the planetary boundary layer and therefore the concentrations are much lower (generally below 0.5 µg/m³). The chemical composition is also different, dominated by sulfate (54%). The other species contribute fractions of 30% (organics), 9% (ammonium) and 6% (nitrate) respectively.

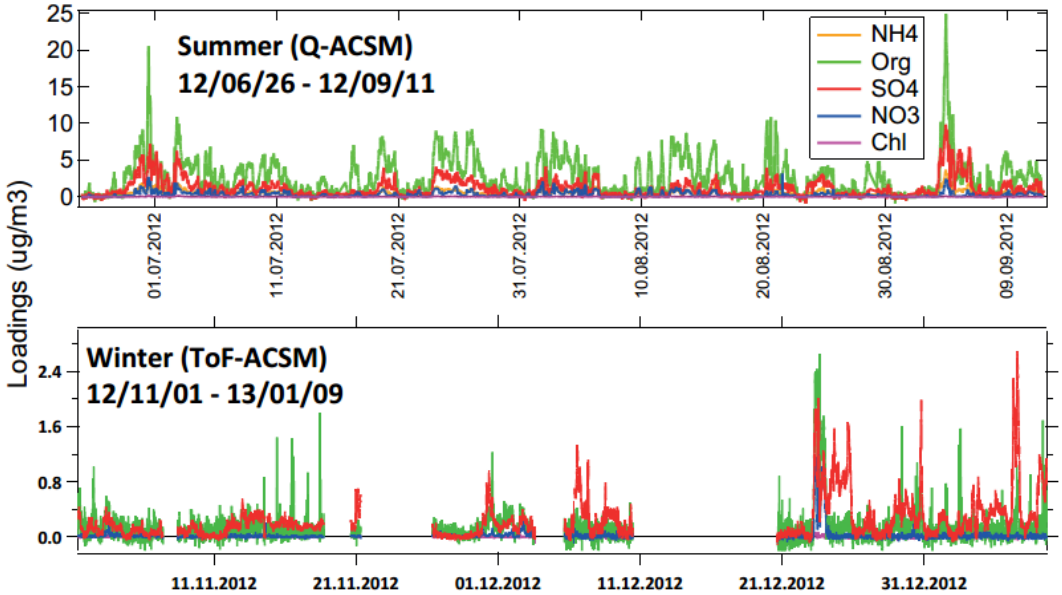

Fig. 3. Aerosol time series recorded at the Jungfraujoch. Top: 2.5 months in summer measured with the Q-ACSM. Bottom: 2 months in winter measured with the ToF-ACSM. Note the different scaling of the y-axis. (green: organics, red: sulfate, blue: nitrate, orange: ammonium, pink: chloride).

A more thorough analysis of the obtained data with inclusion of meteorology, back trajectories, data from additional measurements, etc. will be performed in 2013.

Key words:

Atmospheric aerosol particles, ACSM, Aerosol Chemical Speciation Monitor, Aerosol Mass Spectroscopy, Intercomparison, Prototype, ToF, Aerosol Chemical Composition, ACTRIS, Online Measurement, Aerosol Mass, Aerodyne, Tofwerk

Internet data bases:

http://www.psi.ch/lac/
http://www.psi.ch/acsm-stations/
http://www.actris.net/

Collaborating partners/networks:

Tofwerk AG, CH-3600 Thun, Switzerland
European FP7 project ACTRIS (**A**erosols, **C**louds, and **T**race gases **R**esearch **I**nfra**S**tructure Network)
Aerodyne Research, Inc., Billerica, MA-01821, United States

Scientific publications and public outreach 2012:

Conference papers

Fröhlich R., M. Cubison, J. Slowik, A. Prévôt, U. Baltensperger, U. Rohner, M. Gonin, J. Kimmel, D. Worsnop and J. Jayne, A novel compact aerosol mass spectrometer - the ToF-ACSM: Instrument performance and first field deployment, European Aerosol Conference (EAC), Granada, Spain, September 02-07, 2012.

Cubison M., R. Fröhlich, J. Slowik, A. Prévôt, U. Baltensperger, U. Rohner, M. Gonin, J. Kimmel, D. Worsnop and J. Jayne, A novel compact aerosol mass spectrometer - the ToF-ACSM: Instrument performance and first field deployment, AAAR 31st Annual Conference, Minneapolis, Minnesota, USA, October 08-12, 2012.

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