Local pollution sources and local vertical transport effects at the Jungfraujoch, Switzerland (3580 m asl) and Jungfrau East Ridge (3700 m asl)
As an international organization, the Foundation is dedicated to providing the infrastructure and support for scientific research of international significance that must be carried out at an altitude of 3000-3500 meters above sea level or for which a high alpine climate and environment are necessary.

Scientists from universities, schools of technology, and research institutes of the member countries, and exceptionally from other countries, can carry out research in the laboratories and observatories provided by the Foundation. Administrative assistance and information are provided by the Foundation’s offices that are integrated in the University of Bern, Switzerland.
The Jungfraujoch in Swiss and International Atmospheric Networks

ACTRIS is the European Research Infrastructure for the observation of Aerosol, Clouds, and Trace gases. ACTRIS is composed of observing stations, exploratory platforms, instruments calibration centres, and a data centre. ACTRIS serves a vast community working on models and forecast systems by offering high quality data for atmospheric gases, clouds, and trace gases.

Current ACTRIS2 Phase: May 2015 to April 2019

GAW Global station since 2005

Swiss Air Quality Monitoring Network (NABEL)

http://www.empa.ch/nabel
http://www.bafu.admin.ch/luft/
### Continuous aerosol measurements at the Jungfraujoch

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Employed method or instrument</th>
<th>Responsible institute</th>
<th>Measuring period</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Multiwavelength optical depth</strong></td>
<td>Sunphotometers</td>
<td>MeteoSwiss</td>
<td>3.1999 – ongoing</td>
</tr>
<tr>
<td><strong>Mass in three size fractions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM1</td>
<td>Betagauge</td>
<td>PSI</td>
<td>2.2004 – 1.2015</td>
</tr>
<tr>
<td>PM10</td>
<td>HiVol, Gravimetry</td>
<td>Empa</td>
<td>1.2006 – ongoing</td>
</tr>
<tr>
<td>PM10</td>
<td>Optical Particle Counter</td>
<td>Empa</td>
<td>12.2016 - ongoing</td>
</tr>
<tr>
<td><strong>Major chemical components in two size fractions (PM1 and TSP)</strong></td>
<td>Inorganic fraction: Ion chromatography sampling every 6th day</td>
<td>PSI</td>
<td>7.1999 – ongoing</td>
</tr>
<tr>
<td><strong>Light absorption coefficients at</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- various defined wavelengths</td>
<td>Aethalometer (AE31, AE33)</td>
<td>PSI</td>
<td>3.2001 – ongoing</td>
</tr>
<tr>
<td>- 630 nm (with a higher precision)</td>
<td>MAAP</td>
<td>PSI</td>
<td>3.2003 – ongoing</td>
</tr>
<tr>
<td><strong>Light scattering and backscattering coefficient at various wavelengths</strong></td>
<td>Nephelometer (TSI, Ecotech)</td>
<td>PSI</td>
<td>7.1995 – ongoing</td>
</tr>
<tr>
<td><strong>Number concentration (CN)</strong></td>
<td>Cond. particle counter</td>
<td>PSI</td>
<td>7.1995 – ongoing</td>
</tr>
<tr>
<td><strong>Aerosol size distribution</strong></td>
<td>Mobility analyzer optical particle counters</td>
<td>PSI</td>
<td>1997/98 div. campaigns; 1.2008 - ongoing</td>
</tr>
<tr>
<td><strong>CCN number concentration (at various supersaturations)</strong></td>
<td>Cloud condensation nuclei counter (CCNC)</td>
<td>PSI</td>
<td>div. campaigns; 4.2008 – ongoing</td>
</tr>
</tbody>
</table>
We have reached 22 years of continuous aerosol data.
Local Pollution

Particle Number Concentration $N_{>10\text{nm}}$ [cm$^{-3}$]

UTC

16.07.2014

17.07.2014
Additional measurements at the Jungfrau East Ridge
The measurements at JER are ongoing since 2014. Beside scientific interest, a major goal of the measurements is to assess the degree of local pollution at the Sphinx.

At the JFJ, the aerosol number concentration (N>10 nm) is sensitive to:

- PBL influenced air masses (“moderate” concentrations)
- New particle formation (bursts/”bananas” up to 20’000 cm-3)
- Helicopter exhaust (spikes up to 10’000 cm-3)
- Cigarettes (spikes up to 10’000 cm-3)

The equivalent black carbon mass concentration is sensitive to:

- PBL influenced air masses (“moderate” concentrations)
- Local combustion processes in general (e.g. diesel generators)
- Snow cat emissions
- What’s the quantitative influence of these spikes on daily average of CPC and other data?
- Can the parallel measurements at East Ridge help to quantify this effect?
• Clear correlation with touristic activities
• In 2017 less spikes, likely due to a (voluntary) smoking ban on tourist terrace in March 2017
• Clearly less spikes, no regular pattern seen
High Local Pollution Days

High local pollution day: More than 8 strong peaks at JFJ and less than 2 strong peaks at JER

- In the 3 years of parallel measurements (Oct 2014 to Oct 2017), the percentage of high local pollution days was 9%
- Filtering pollution spikes possible for those instruments with high time resolution
- Particle number concentration 25% increased during high pollution days compared to filtered baseline
During strong Foehn wind conditions from the Southeast, clear baseline differences between Jungfraujoch and East Ridge are regularly observed. In these cases, a spatially narrow air mass layer is advected to the Jungfraujoch, sometimes also accompanied by a visually observable cloud cap engulfing the site. In the 3 years of parallel measurements (Oct 2014 to Oct 2017), the percentage of typical Foehn days with different baselines was 2%. While these conditions likely are statistically irrelevant for the long-term measurement, further case studies can provide valuable insight into the small-scale air mass dynamics around the site.
New particle formation

- New particle formation is frequently observed at the Jungfraujoch (15-20% of days) and has been thoroughly described in literature
  - In a recent publication, the site played an important role in the mechanistic examination of atmospheric nucleation (Bianchi et al., 2016)
- The CPC measurements at the East Ridge will help for an additional assessment of the spatial variation of the nucleation events detected at the Jungfraujoch
  - A typical case of new particle formation during sunny days, with no significant PBL influence at the Jungfraujoch
  - The JER CPC 3775 has a lower size cutoff than the JFJ CPC 3772 and thus counts more of the freshly nucleated particles
  - Nucleation likely takes place simultaneously at both sites
• A case of new particle formation during sunny days, including significant PBL influence at the Jungfraujoch
• The lower CPC count at JER suggests that nucleation is spatially inhomogenous
• The additional measurements at Jungfrau East Ridge are extremely helpful to quantitatively assess the influence of local pollution at JFJ.

• They also helped to develop statistical tools to filter out the peak cases of local emissions from the long-term data series.

• After intense construction work at JFJ between 2010 and 2013, the local emissions have decreased again, and the invitation to the tourists to refrain from smoking on the Sphinx outdoor platform in March 2017 additionally improved the situation.

• In addition to the focus on local emissions, we are currently working on the connection of the aerosol measurements at both sites to nearby ceilometer measurements, to assess the effect of local vertical transport on baseline differences between JFJ and JER.
Thank you for your attention!

• Calculate baseline (running 10-min 5th-percentile)
• Subtract baseline to have the isolated «spike series»
• Apply automated spike algorithm to define JFJ and JER spikes (running 60-min 80th-percentile smaller than original value → spike)
• Analyze the spike frequency and quantitatively define the «JFJ high local pollution days» (more than 8 strong peaks at JFJ and less than 2 strong peaks at JER)