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An aerosol climatology for the Jungfraujoch, Part 1: Criteria for cloud presence and boundary layer influence

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The high alpine research station at the Jungfraujoch in Switzerland is located at 3580 m asl. Depending on meteorological conditions, the station is in the planetary boundary layer or in the free troposphere; and often it is inside clouds. In one location, it is thus possible to study aerosols under very different conditions. These possibilities have been recognized early on, with aerosol measurements starting in 1995. Over the years, the instrumentation has been extended significantly, today including various measurements of aerosol optical properties (nephelometer, aethalometer, MAAP) as well as aerosol size distribution (SMPS, OPC, APS). Additionally, the station regularly hosts campaigns (e.g. CLACE) with a multitude of additional devices, mostly focusing on new particle formation, cloud condensation nuclei, and ice nuclei. However, there are no continuously operated direct measurements to determine whether the station is in the clouds or not, whether it is in the PBL or the free troposphere. As these are essential parameters to describe the aerosol observed at the station, we present approaches to describe them based on the observations available to us.

The intuitive choices to look at in terms of clouds are relative humidity and dew point. When comparing dew point and ambient temperature, a clear criterion to identify clouds can be easily deducted. However, the determination of "no clouds" is more ambiguous.

Based on longwave radiation measurements performed routinely at the site, it is possible to calculate the sky temperature, i.e. the temperature at the point of origin of the radiation. When within a cloud, the sky temperature should be identical or at least close to ambient temperature. The comparison of sky and ambient temperature shows two clear clusters which can be interpreted as "cloud" and "no cloud". One has to note that in case of inversion or clouds shortly above the research station, this approach will produce false positives. However, combining this method and the dew point criterion for clouds should allow for a clear distinction between "cloud" and "no cloud" conditions.

To determine in which atmospheric layer the research station is Conen et al. (2011) have developed a method based on radon concentration measurements. Comparing radon concentrations at the Jungfraujoch with concentrations in Bern, one finds that the probability distribution of the difference is the sum of two log-normal modes. Essentially, one mode means that both sites are in the same layer, the second means the sites are in different layers. With this approach it is possible to determine a lower limit for the radon concentration difference: When the difference is larger than this limit, the JFJ site can be considered to be in the free troposphere.

Based on these new and various traditional parameters (synoptic weather, meteorological conditions, etc) we have analyzed size distributions collected at the JFJ in the years 2008-2013, mainly focusing on SMPS data but including additional measurements when called for. The objective is to determine which factors shape the aerosol observed at the Jungfraujoch.

References

Conen, F., Zahorowski, W., & Zimmermann, L.: Defining a criterion for free tropospheric air at Jungfraujoch. From "International Foundation HFSJG Activity Report 2011". Bern, Switzerland, 2011.