Visualization of surface heat transfer around the Jungfraujoch using thermal imaging

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1 Project description

The characterization of local wind fields, turbulence and eddies around the High Altitude Research Station Jungfraujoch, located in the Swiss Alps, is of large interest for the atmospheric research performed at the site, because some of the atmospheric in-situ measurements are strongly influenced by these local phenomena. In a series of experiments in 2022 and 2024, movies of visualized surface eddies and surface heat transfer around the Jungfraujoch were recorded with help of a high-resolution thermal camera (Figure 1). Time series of thermal images were decomposed by subtracting the average images and the trend deviation of the image average from the total average (Hilland et al. 2022; Vogt 2008). This decomposition delivers temperature fluctuations at the surface, caused by the sensible heat flux in the uppermost layer of the surface. These fluctuations are a function of the thermal admittance and the roughness of the surface, and of the surface wind speed. The time sequence of the decomposed images thus delivers a proxy for the surface wind movements and provide a tool to visualize local turbulence and wind fields at the surface (Figure 2).

A collection of time lapse movies that visualize the surface winds around the Jungfraujoch can be accessed via the link given in the Outreach Section of this report. The movies illustrate the extremely complex surface wind structures that are typical for mountainous terrain. Strong turbulence across the ridge dominated most of the time. Additionally, local upwind movement along south-oriented mountain slopes during daytime was observed (anabatic winds), as well as night-time valley wind movements along slopes and above glaciers (catabatic winds).

Figure 1: Thermal camera on the Aletsch glacier.

2 Link to aerosol measurements

Besides the visualization of wind for illustration purposes, one goal of this project is to put these results in context with other measurements performed at the Jungfraujoch in collaboration with other research groups doing research at the site, and to extend these measurements in upcoming field campaigns related to mountain meteorology. For several decades, in-situ aerosol parameters have been monitored at the Jungfraujoch (Bukowiecki et al. 2016). Since some years, additional aerosol measurements are performed at Jungfrau East Ridge (JER), an adjacent mountain ridge at 3705 m asl in 1000 m air-line distance to the main site (Bukowiecki et al. 2021). The diurnal variation of the aerosol number concentration is mainly driven by the free tropospheric aerosol background, by injections of planetary boundary layer air parcels (mainly in summer), as well as by local sources (especially during daytime). While an advanced understanding of these effects has been established by numerous previously performed studies, one open question that remains is how local wind fields may influence the fine structure of the observed aerosol diurnal variations.

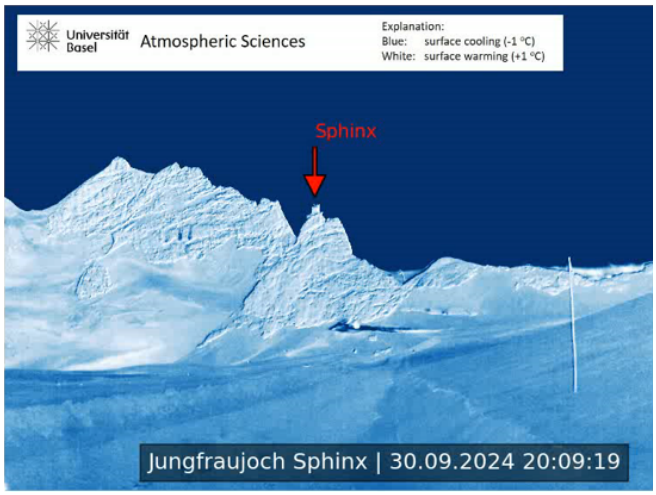

Figure 2: Decomposed IR image. The animated time series of these decomposed images visualize local turbulence and wind fields at the surface.

In our experiments performed in 2024, a Partector (Naneos GmbH, Switzerland) was run simultaneously to the thermal camera, measuring the aerosol lung deposited surface area (LDSA) with a time resolution of 1 second. Days with significant local emissions (e.g. by diesel snowcats etc.) were selected for the experiments, and the experimental hypothesis was to see a correlation between the Partector signal and the wind movements from the emission source towards the Partector. However, the wind speed was too high and too turbulent on the days of the experiments to establish this link. Therefore, experiments in calmer, non-alpine environments with lower wind speeds were initiated (Müller 2024). In these additional experiments, a correlation between the two measurements was found, and the gained experimental knowledge will help to repeat the experiments at the Jungfraujoch in future campaigns.

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Collaborating partners / networks

Paul Scherrer Institute (PSI), Laboratory of Atmospheric Chemistry. Dr. B. Brem and Dr. M. Gysel-Beer. Villigen, Switzerland.

Conference papers

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Theses

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Public outreach

Bukowiecki, N. and P. Müller. *Visualization of surface heat transfer around the Jungfraujoch using thermal imaging.* News article. Nov. 25, 2024. URL: `https://www.hfsjg.ch/en/publications/news/2024-11-25/`.

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