

Monitoring the Earth Meteor Environment with optical meteor cameras in Switzerland

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1. Project description

There is a continuous flux of extra-terrestrial particles into the Earth's atmosphere. These particles originate mostly from the primordial dust cloud that was formed during an early phase in the genesis of our solar system. These particles are characterized by their size. Objects above with a diameter above 1 m are called Asteroids and smaller particles are referred to as meteoroids. Meteoroids entering the Earth's atmosphere are decelerated by the impinging atmospheric atoms and molecules, heated, and eventually reach the meteoric vaporization temperature and start to ablate forming a visible plasma trail that is often called meteor. Monitoring the meteor Earth environment has become an important task for meteoroid sizes that can pose a threat to human space travel.

The ALLSky7 meteor camera network is an open-source science project to monitor some part of the meteoroid size distribution. The network aims to observe bright meteor fireballs that are caused by meteoroids that are in the size range of centimetre or decimetre. The University Bern has joined the network and operates two cameras installed at the Zimmerwald (AMS202) and Jungfrauoch – Sphinx observatory (AMS201) (see Figure 1).

ALLSKY7 Meteor Observations

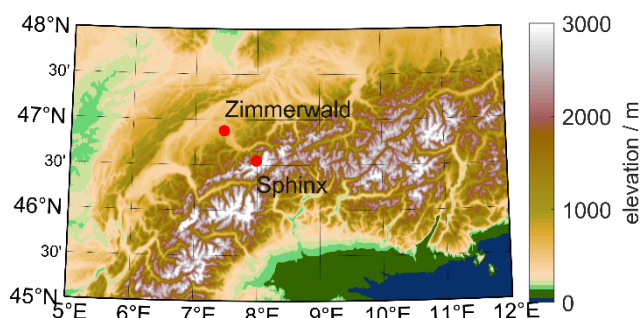


Figure 1. Lambert projection of the Swiss Alpine region with colour coded elevation levels indicating the location and altitude of the Zimmerwald and Sphinx observatory.

Each ALLSky7 camera site consists of a dome that houses inside 7 Sony consumer cameras, which are controlled and connected to a minicomputer. Figure 2 presents scenic views of both ALLSky7 cameras at both observatories. Although there are meanwhile about 200 ALLSky7 cameras deployed across Europe from the Arctic circle down to Greece and Spain, the Swiss network is unique due to the higher altitude of both stations. There are two other ALLSky7 cameras available in Switzerland, which are in Monteggio (AMS73) and Wangen (AMS64).



Figure 2. Images of the ALLSky7 camera installations at Zimmerwald (left) and Sphinx observatory (right).

The ALLSky7 camera that was installed at the Sphinx observatory received a special lightning protection of the power over ethernet connection to avoid damage to the computer in the case of a lightning strike.

Since 8th August 2022 both cameras became operational and started the data collection as bi-static system. The Zimmerwald camera was already installed in February 2022. The ALLSky7 camera comes with a software that provides an automatic recording of potential meteor observations and some initial data reduction. However, there is still a lot of manual data cleaning required to remove detections of aircraft, clouds, or cars from the data.

The camera at the Sphinx observatory also is very sensitive to snow, which leads to many unwanted detections. Occasionally mountain daws are also recorded. Apparently, these birds enjoy sitting on the dome during the day. However, the cold temperatures and winds did not cause substantial technical challenges for this camera.

During a clear night the AMS201 at Sphinx observes between 60-200 meteors. AMS0202 at Zimmerwald records on average 30% less events due to more light pollution caused by the city of Bern. We also conducted a first meteor shower campaign during the Perseids meteor shower in August. The campaign started on 10th August and was concluded on 15th August 2022. We detected about 750 meteors at Zimmerwald and more than 1100 meteors from the Sphinx observatory during the peak of the Perseid shower. Figure 3 shows an example of a very bright meteor fireball that was recorded during the Perseids meteor shower campaign.



Figure 3. Bright meteor fireball recorded on 15th of August 2022 at 03:33 UTC in the morning hours. The upper images show the

stacked images recorded from Zimmerwald; the lower image shows the same event as seen from the Sphinx observatory.

The next step in the data analysis is the astrometric calibration and lens characterization. This is done via a machine learning approach. The camera takes 1-2 calibration images per night to detect and track the position of known stars. Figure 4 shows an example of a reduced meteor event recorded at Zimmerwald. In the background of the image several stars are detected. Furthermore, the position of the meteoroid is color-coded for each frame (red -first detection -bluish end of trajectory). Considering the known position of the stars, it is possible to assign for each pixel an elevation and azimuth angle, which can be converted into celestial coordinates of right ascension and declination. However, this procedure also requires removing dome distortions and lens effects. Therefore, we collect thousands of calibration images (with or without meteor) and estimate the lens and dome characteristics. An initial calibration is available for Zimmerwald AMS202, but we are still collecting calibration data for the AMS201 camera. Once both cameras are fully astrometric calibrated, we can reduce the bi-static data to obtain the source radiant, velocity and brightness curves for the events. The main goal is to use both cameras to characterize the sporadic meteor background and some selected meteor showers in the future.



Figure 4. Example of a detected meteor at the Zimmerwald station with calibration information of detected stars in the background and colour coded trajectory information.

Internet data bases

<https://www.allsky7.net/>

Collaborating partners / networks

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