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Looking for Meteors and Fireballs in the atmosphere of Mars from the Visual Monitoring Camera (VMC) on Mars Express

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Meteors and fireballs, often as part of meteor showers, are commonly observed in the atmosphere of Earth. The same phenomena is expected to take place in other planets (Christou, 2005). Observations are rare, as no suitable instruments have been launched in interplanetary missions, however, these observations can push forward our understanding of interplanetary dust (Christou et al., 2019). In recent years, a number of impacts on Jupiter have been reported based on ground based amateur observations (Hueso et al., 2018) and Juno observations (Giles et al., 2021). On Mars, the Panoramic Camera on Mars Exploration Rover Spirit tried to observe meteors, with no conclusive detections (Domokos et al., 2007), however a meteor was possibly imaged by a navigation camera (Selsis et al., 2005).

The Visual Monitoring Camera (VMC) onboard Mars Express is a wide field camera initially designed as an engineering camera (Ormston et al., 2011). VMC was recently upgraded to a science instrument, and in recent years different works have shown the scientific capabilities of this camera (e.g. Sánchez-Lavega 2018; Hernández-Bernal et al., 2021a;2021b).

As part of the VMC science program, we performed a few campaigns to try to find meteors or fireballs. To maximize probabilities, we programmed observations coincident with theoretically predicted meteor showers on Mars. While the sensibility of the VMC sensor is low, which reduces the probability to find meteors, its field of view is very wide compared to other instruments, which enhances the probabilities. So far, we have not captured any clear meteor or fireball.

Methodology

We planned our campaigns based on predictions published by Christou (2010). Hardware limitations require all other instruments to be switched off when VMC is observing, this is an important limitation to this work, as only a few observations could be performed, and VMC observations cannot be very long. VMC accepts exposures of up to ~90 s, however observations longer than ~30 s are highly affected by the thermal noise of the sensor, additionally there is a gap of around 48 s between VMC images. As a result, less than 40% of the time VMC is switched on can be effectively used for monitoring.

Exposures of a few seconds by VMC are usually noisy, and they require processing to extract the presence of dim objects, such as stars, planets (e.g. https://twitter.com/esaoperations/status/1247096203550101504), or in this case, meteors. In the case of meteors, we expect them to appear as dim lines in only one image, then the best way to extract the noise from an image is by making a synthetic dark from images obtained close in time. Considering the sensibility of VMC as revealed by observations of stars, we expect it to be able to capture only very bright meteors, around absolute magnitudes of -6 to -10. Figure 1 shows an example of the simulations performed to analyze observability.

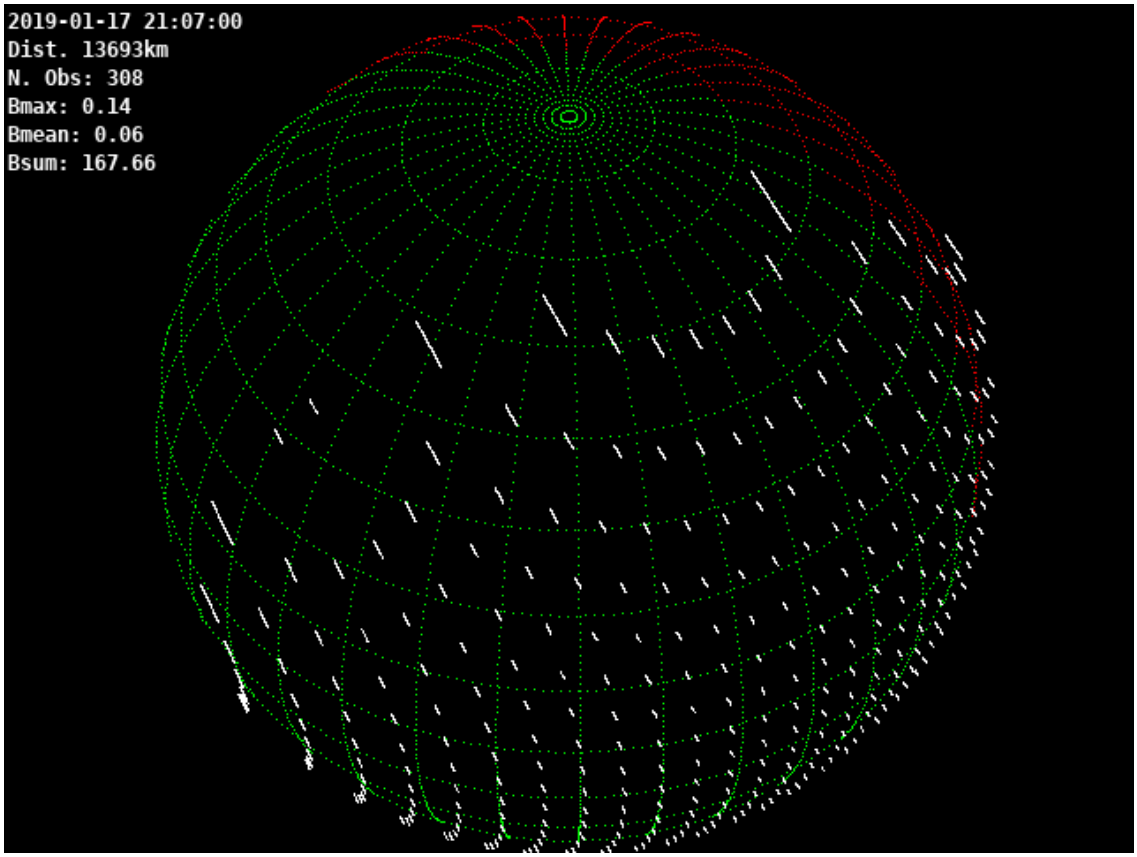

Figure 1.

Results

We performed two campaigns to try to find meteors or fireballs, table 1 summarizes these campaigns.

Parent Comet	**Ls**	**Velocity**	**SZA**	**Observations**	**Accumulated time**
5335 Damocles	47.8	29.9 km/s	98.4º	2019-07-03_23.54-01.13	25 minutes
1P Halley	325.9	53.8 km/s	121.4º	2020-12-04_01.35-02.04 2020-12-15_02.53-03.21 2020-12-20_01.42-02.05	21 minutes

Table 1. Meteor shower details from Table 2 in Christou (2010).

Once processed, images did not show any significant trace potentially related to a meteor burning in the atmosphere. The total effective observation time was 46 minutes, part of this time elapsed out of the expected area for the meteor shower.

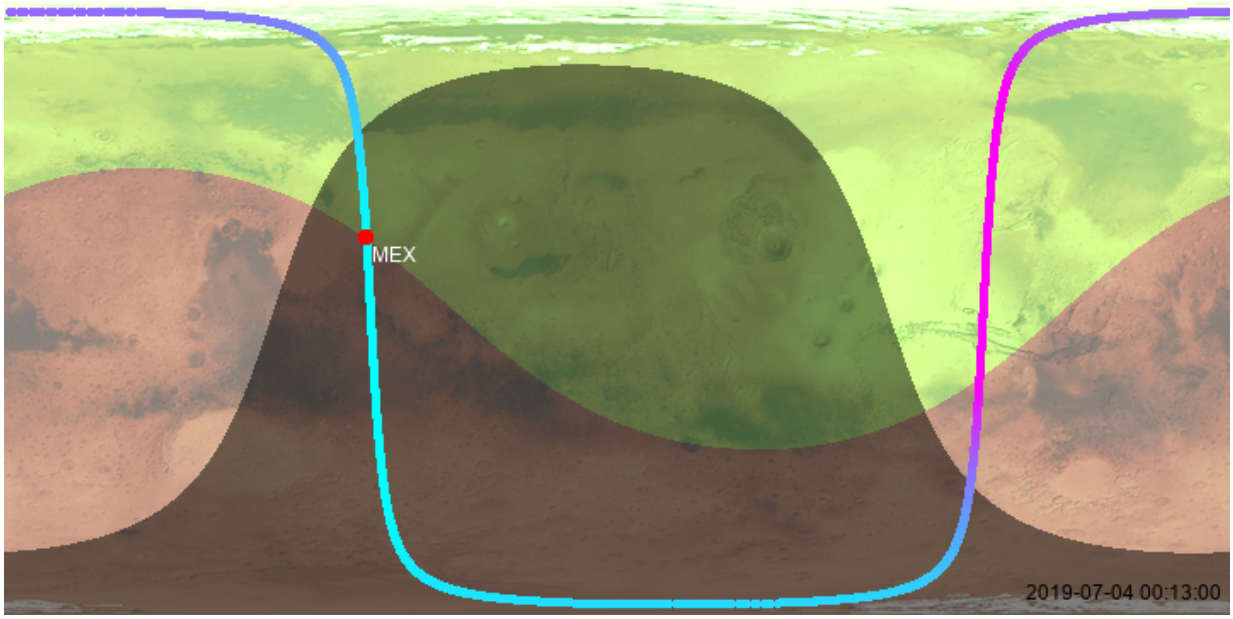

Figure 2. Scheme of an observation. The area expected for the meteor shower is green shaded. Dark shaded area is the night.

Conclusions

We did not achieve positive results. The main reason is probably the low sensibility of the VMC sensor. While VMC is a low quality engineering camera designed in the 90s, modern commercial cameras can achieve very high sensibilities. The technical planning of these campaigns shows that VMC-like cameras could be a tool suitable to monitor meteor activity on Mars and other planets from space in the future, as already pointed by Christou et al. (2012). The wide field of view of VMC, when exploited from a moderate distance to the planet, provides full-disk images covering wide areas, and thus potentially enabling the large-scale monitoring of meteor activity.

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