

Stellarium Gornergrat

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1. Project description

The Stellarium Gornergrat is a long-term project carried out by an on-going collaboration between the Center for Space and Habitability (CSH), the Astronomical Institute (AIUB), the University of Geneva (UoG), and the International Foundation High Altitude Research Stations Jungfrauoch and Gornergrat (HFSJG). Its major focus lies with public outreach and education. The project's main goals are:

- To build bridges between science and society.
- To spark and foster the public's interest in space, space sciences, and astronomy.
- Attract young people to the field and illustrate potential careers in astronomy and space sciences.
- Help people recognize and understand different observable phenomena in the day and night sky and let them appreciate the beauty and delicacy of nature.

To achieve these goals, the partners installed and operate an observatory at the Kulmhotel Gornergrat with different instruments and hardware (see Figure 2). The instrumentation in the south dome has to survive challenging meteorological conditions and is under constant maintenance. Our instrument park currently consists of these 5 different instruments:

1. The Allsky Camera (OMEA 8M) takes around the clock exposures of the day and night sky. This instrument replaces the previous Allsky Camera that was destroyed in the lightning incident. The camera is currently being commissioned in Bern.
2. The RiFast 600mm telescope with a huge Field of View (FOV) is ideal for deep sky objects.
3. The Planet Camera (Takahashi Mewlon-250) is ideal for planetary objects and small targets that require a smaller FOV.
4. The Constellation Camera is ideal to depict complete constellations, asterisms, and group of constellations. It has a customized housing that was developed and built in Bern.

5. The Look-through Telescope (Takahashi TAO-150) for local guests and guided tours at the observatory.

A major way to use the Stellarium Gornergrat is by scheduling observations remotely through a web portal that triggers robotic observing. Teachers, students, and the broad public can browse and pick among different astronomical activities and schedule observations. The Stellarium automatically works through the different scheduled observations and allows a registered user to access the obtained data or status information upon completion of an observation task.



Figure 1. The Owl nebula (M97) obtained in a total of 1.6h of exposure time in the filters R, G, B, Clear, H α . The planetary nebula is estimated to be over 800 pc away. Image: Jesse Weder.

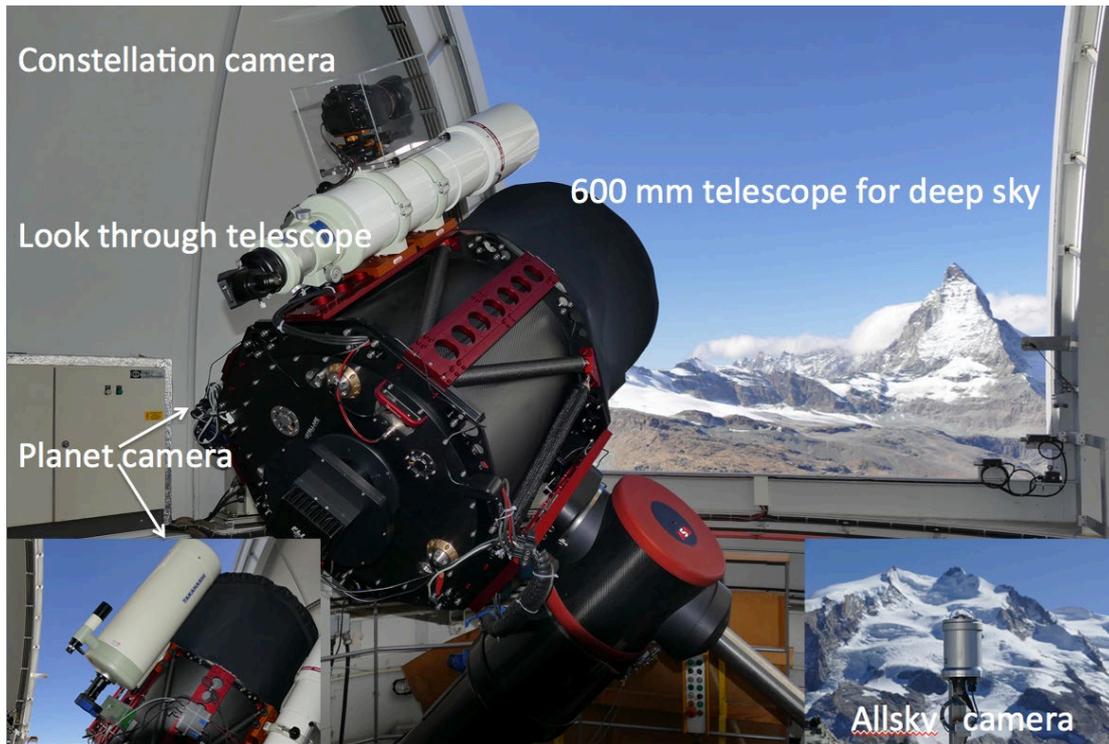


Figure 2. Available instruments at the Stellarium Gornergrat: On the ASA DDM 160 mount (with absolute encoders) inside the south dome are the Officina Stellare RiFast 600mm “Deep sky telescope”, the Canon 60Da “Constellation camera”, the Takahashi TAO-150 “Look-through telescope”, and the Takahashi Mewlon-250 “Planet Camera” (see image inset in the lower left). Mounted on a boom outside the north dome is the Alcor systems “Allsky camera” with a DMK51AG02.AS CCD sensor (see image inset in the lower right).

2. Status of hardware and instruments

Table 1. Instrument/hardware status and performance

Instrument	Status / Performance
Officina Stellare RiFast 60cm (DeepSky telescope)	The telescope performs very well and shows constant quality over the whole range of instrument attitude in both equatorial orientations.
FLI Proline PL16803 (Main CCD detector)	The CCD is in good health and performed as expected.
Takahashi Mewlon 250 (Planet camera)	The instrument worked as expected.
Takahashi TOA 150 (Looking through telescope)	Telescope and eyepieces are in very good condition.
Canon 60Da (Constellation camera)	The camera is in very good condition and working as expected. We are still exploring options to produce images in an easier format, i.e. debayered and compressed.
ALCOR OMEA 8M (Allsky camera)	This instrument was impaired by lightning and is currently being repaired. Work is in progress to improve the overall resilience to lightning.

SAIA and weather sensors	Cloud and rain sensors, and SAIA itself worked as expected. The Lambrecht weather sensor was dismantled at the end of 2019 for maintenance and repairs.
ASA DDM160 (Equatorial mount)	The new mount, now with absolute encoders performed very well in the winter season of 2019. It was the first time where the mount was not affected in a bad way by temperatures below -20 deg.
EATON USV (Large UPS in the cellar)	Life Cycle of the batteries was necessary, due to early degradation. The shortened lifetime was expected due to altitude (3100m) and temperature higher than 25 deg. °C (close to hotel heating system)
USB hubs, and actives repeaters	All electronic components worked as expected.

Table 1 summarizes the instrument status throughout the reporting period. We are happy to report that 2019 has been a good year for the Stellarium project. The main instruments worked very reliably and we had regular observations almost every usable night. An

exception once more is the Allsky-Camera, that was once more damaged by lightning. The particular setting outside the North dome is very challenging. Interior and exterior anti-lightning measures seem not yet to be able to fully prevent damage. Possible improvements are currently under consideration.

3. Milestones & Achievements regarding robotic abilities and software on site

The automated observing procedure requires constant monitoring and generated error reporting output needs to be reviewed regularly. In addition to these recurring tasks, our collaborators in Fribourg also worked on significant improvements summarized below.

Recover from bad weather: So far, bad weather had cancelled a complete night with no chance of resuming operations in case of a weather improvement. In 2019, the automated observing system has been updated to provide the possibility to pause operations after the detection of unsafe weather and resume them on safe weather. The system can resume up to three times before completely aborting the operations for the night. The developed code has been validated in simulated conditions and is currently being tested in real observing conditions.

Focusing operations: Significant improvements have been applied to the automated process regarding the focus of the deep sky telescope.

- The numeric value of the focus is now stored in the FITS header of the generated images during automatic observations.
- An Autofocusing procedure using AutoFocusMax is triggered for each observing plan involving the DeepSkyCam.
- Focus frames are stored separately for later analysis.
- The automated system was hardened to recover from errors in the 3rd party software AutoFocusMax.

Further improvements:

- Dynamic dome opening time according to local sunset time in order to optimize dome seeing and noise (hotel).
- A software has been developed to parse the weather information collected by our sensors and loggers in order to generate statistics and plots automatically with information about the quality of the nights on the Gornergrat.
- Possibility to by-pass and simulate the data provided by our different weather stations. This allows us to remove selected units for maintenance without disabling the sensory network used to determine whether it is safe to observe or not.
- The way the system updates and works with comet orbits was improved.
- Code responsible for creating email alerts in case of problems with the relaybox was updated and improved.
- Improving the web portal itself created side effects, that required hours of analysing file exchange between Bern and Gornergrat. The problems were located and solved, and further monitoring and alerting was implemented.

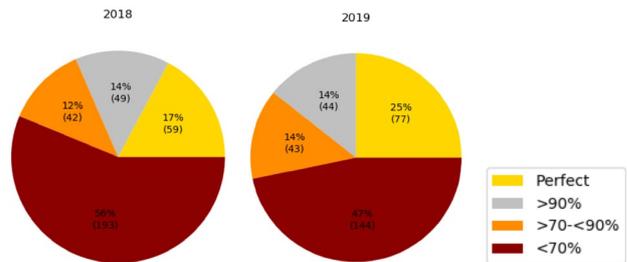


Figure 3. Statistics of the night quality due to weather in 2018 (left) and 2019 (middle) and the legend explaining the colors (right). The percentages in the legend refer to the proportional amount of time of a night, where weather was considered bad for observations, i.e. when the system would close the dome, or refuses to open.

Figure 3 shows, that roughly half the nights per year are considered for 30% of the time or more non observable as bad weather is being detected during that particular night. The other nights are mostly usable, requiring a detection of good weather for 70% of the time or more during a particular night (orange, silver, gold). Roughly a quarter of all nights in 2019 was considered perfect (gold). According to our long term statistics (omitted here), 2019 is very close to the 4-year average of 25.5% perfect nights per year, where the 17% seen in 2018 were significantly below.

4. Local formats and Remote Observations and User Statistics

Local: In 2019, a total of 776 people (previous year: 722) visited the Stellarium and got a tour of the facility and/or night time observing on site. Further key numbers: Total days with crew on site: 36. Total nights with crew on site: 32.

Remote: Remote usage significantly ramped up in 2019 compared to the previous year. The amount of submitted observing plans increased by a factor of 6 from 502 to 2964. The vast majority of the plans (2794) were request for images from instruments sitting on the DDM 160 mount, the remainder were requests for the Allsky camera. Figure 4 further itemizes the use of the exact instrument on the DDM 160 mount.

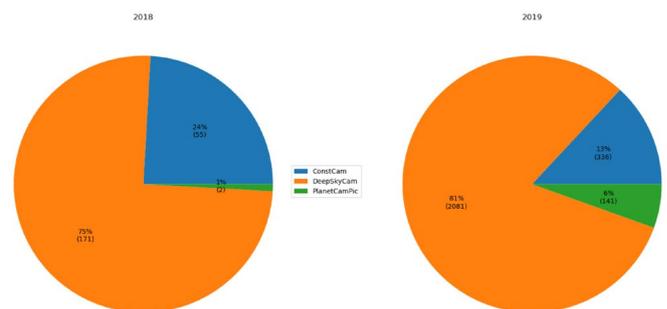


Figure 4. Break down of instrument use in the last two years. Only instruments in the South dome are considered here (i.e. not the AllSky camera). Of biggest interest to the users is clearly the RiFast 60cm main telescope (orange) followed by the Canon 60da (blue) and by the Meowlon 250 (green).

From the submitted 2964 plans, 1425 were successful in the technical sense. The failures were almost completely due to bad weather and the fact that so far a night was lost after bad weather was detected. We are excited to see, how the newly implemented recovery mechanism will alter these statistics in the years to come.

5. Pedagogical Activities

The Stellarium Gornegrat supported 9 matura theses in the reporting period, with still 5 being underway. Some more will probably come soon as some students must choose their topic for the matura thesis in the next few weeks. In 2019 many activities for classes were booked. Furthermore, the web portal was improved and several activities were finished or revised. Figure 5 depicts a recent screenshot of the web portal, showing some of the activities that can be booked.

In the last months, three additional activities were uploaded to the web portal and are ready to be booked in German (see table 2). The Module “LUNAR MOUNTAIN HEIGHT” will be finished soon. Development of a module on “EXOPLANETS” was started, with the basic concept and ideas already available. There are some mostly technical questions that have to be answered first before, using the experience of a matura thesis and input by a new post-doctoral collaborator (see below). When it is finished, it will cover a new aspect of astrophysics at the Stellarium Gornegrat, strongly connected to the research in Geneva and the Nobel Prize in physics in 2019. A new post-doctoral collaborator with a fellowship by a physics education foundation is providing substantial input for these and further activities at all stages of development: from review of now finished activities through realization of existing basic ideas (e.g. a new module CEPHEIDS, to be ready in the next months) to the development of new ideas (EXOPLANETS).

For the finished activities, the translation process can be started, using Scientix.

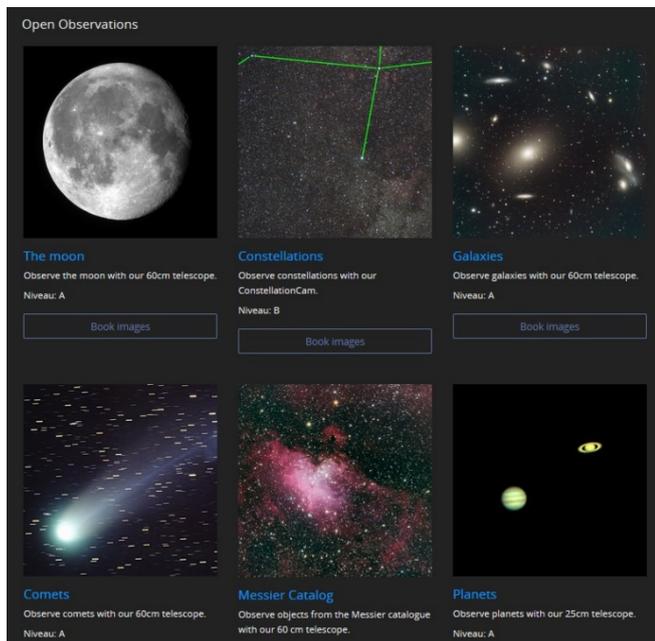


Figure 5. Screenshot showing the improved web portal with several available activities.

The project was presented at different opportunities (see table 3). Several talks, professional education courses etc. are scheduled in 2020 in order to further increase the reach of the Stellarium Gornegrat (see table 4).

Finally, the reader will find below some statements from students having used the Stellarium as testimonials.

Remerciements

Je tiens particulièrement à remercier deux personnes qui m’ont aidé dans la réalisation de mon travail de maturité.
 Le premier est mon maître accompagnant M. Picon, qui a été très disponible et dont ses réponses m’ont été très utiles.
 Le second est M. Gschwind, enseignant à Genève et surtout un membre du « Stellarium Gornegrat », qui m’a permis de réaliser ce travail de maturité de par sa disponibilité et son implication dans mon travail.

And here another message we received from a matura thesis student:

> Dear Mr. Riesen,
 >
 > Hello! I hope you are doing well and that you are having a good start
 > to 2019. I would just like to inform you that I got full marks on my
 > thesis. It would definitely not have been possible without your help!
 > Thank you so much! I have become very interested in the field of
 > astronomy and hope to maybe study it in the near future. This was
 > really good experience for me and for that I am very grateful. I wish
 > you all the best and hope to meet you one day.
 >
 > Sincerely,

That’s exactly what we aim for!

Looking at the results and satisfactions we got with our proposals of matura thesis, we must be on a right direction and therefore we will gladly follow the new “batch” of matura thesis and proposing some new ideas of themes in order to improve the development of this important aspect of our project. We have also planned to further increase promotion of our matura thesis, based on the positive experience gathered so far.

Table 2. New activities of the last months (levels: A: general public, primary school; B: lower secondary school, C: higher secondary school).

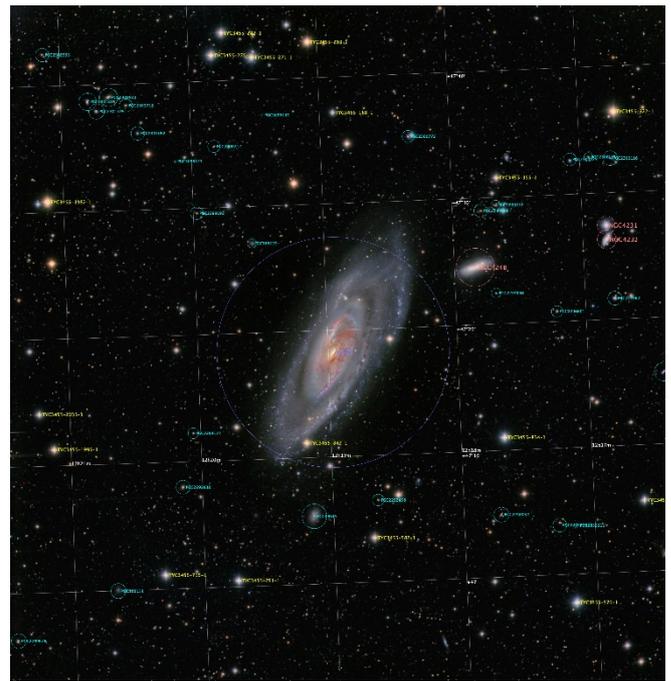
Name	Level	Status	Comment
Das Einmaleins des Nachthimmels	B	Finished	New version uploaded, translations in progress
Phases of the moon	A	Finished	New version uploaded, translations in progress
Earth’s Rotation	A	Finished	New version uploaded
Lunar Mountain Height	C	Finishing working sheets	Ready for upload in some weeks, revised concept
Constellations	A	Finishing documents	Ready for upload in some weeks
Parallax method	C	Finishing documents	Started to collect data
Exoplanets	C?	Basis concept existing, working on mostly technical questions	New activity related to the Nobel Prize 2010

Table 3. Presentations.

Name	Type	Place	Date	Activity
R@mène ta science	Science Festival	CO Vuillonex, Geneva	12.4.2019	Talk, Flyer distribution
Matura thesis Mail	Mail	Physics Education, Geneva	16.9.2019	Flyer distribution
RD Physics	Physics Head-teacher meeting from Geneva	CO Montbrillant, Geneva	24.09.2019	Talk
Matura thesis presentation	Presentation	College Calvin, Geneva	19.9.2019	Presentation, Q&R

Table 4. Planned national and international talks and teacher education courses in 2020.

Name	Type	Place	Date	Activity
DiNAT 11 th Forum	Forum of the Swiss Science Education Association	Geneva	23.-24.1.2020	Live commented Powerpoint/Poster
Teacher training GE 2020	Teacher Training	Geneva	4.3.2020	Half-day teacher training
DPG-Spring Meeting	Conference of the German Physical Society	Bonn	29.03-03.04.2020	Talk
3 rd World Conference on Physics Education	Conference	Hanoi (Vietnam)	20.-24.07.2020	Talk
Bundesweite Lehrerfortbildung Astronomie	Teacher Training	Heidelberg	6.11.2020	Talk with livestream from the Stellarium



Figures 6 & 7: Galaxy Messier 106 (Fig. 7 with annotations of visible objects), obtained with the RiFast 60cm telescope at the Stellarium Gornergrat. The image is a result of a matura thesis with the topic of Astrophotography and data reduction. The overall exposure time was over 12 hours. The student covered image planning, retrieval, reduction (bias, dark, flats, lights), filters, pre- and postprocessing as well as the theory of galaxies, hubble classification, star forming regions and color indices (B-V), among other things. The 47p long thesis received excellent grades. Image Credit: Stellarium Gornergrat, Lars M. Wüthrich.



Internet links

<https://www.stellarium-gornergrat.ch>
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