Synoptic observations in Ondřejov and the cloud detection

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WP8 – SPRING Meeting, Freiburg 29. – 30. 4. 2019

Full-disc synoptic observations in Ondřejov:
test data sets for calibration and merging

White light

Telescope 50/500 mm, Baader foil

Camera 1: Imaging Source DMK 51AG02

CCD 1600 x 1200, pixel 4.4 µm, 8 bit
exp. < 1 ms, cadence 1 fps, max. 12 fps
D_{SUN} = 1062 pix, 1.8”/pix

Camera 2: Thorlabs Quantalux CS2100M

CMOS 1920 x 1080, pixel 5.04 µm, 16 bit
exp. 1 ms, cadence 50 fps (rolling shutter)
D_{SUN} = 957 pix, 2.04”/pix

H-alpha

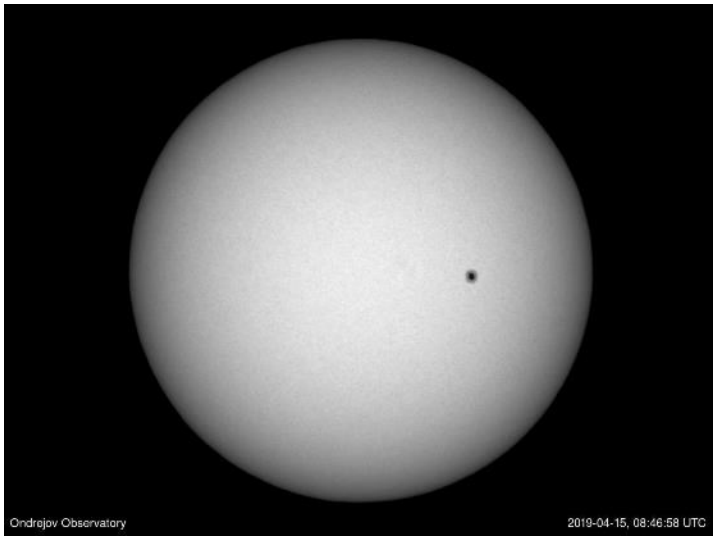
Telescope 60/750 mm, Daystar 0.7 Å

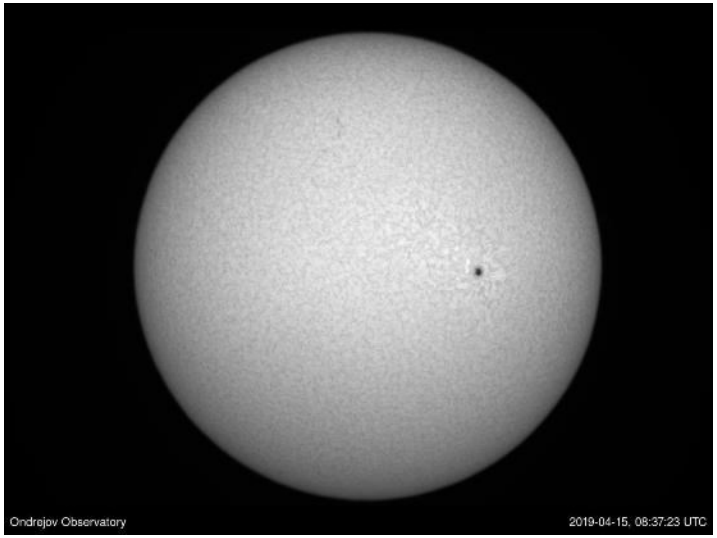
Camera: ZWO ASI174mm

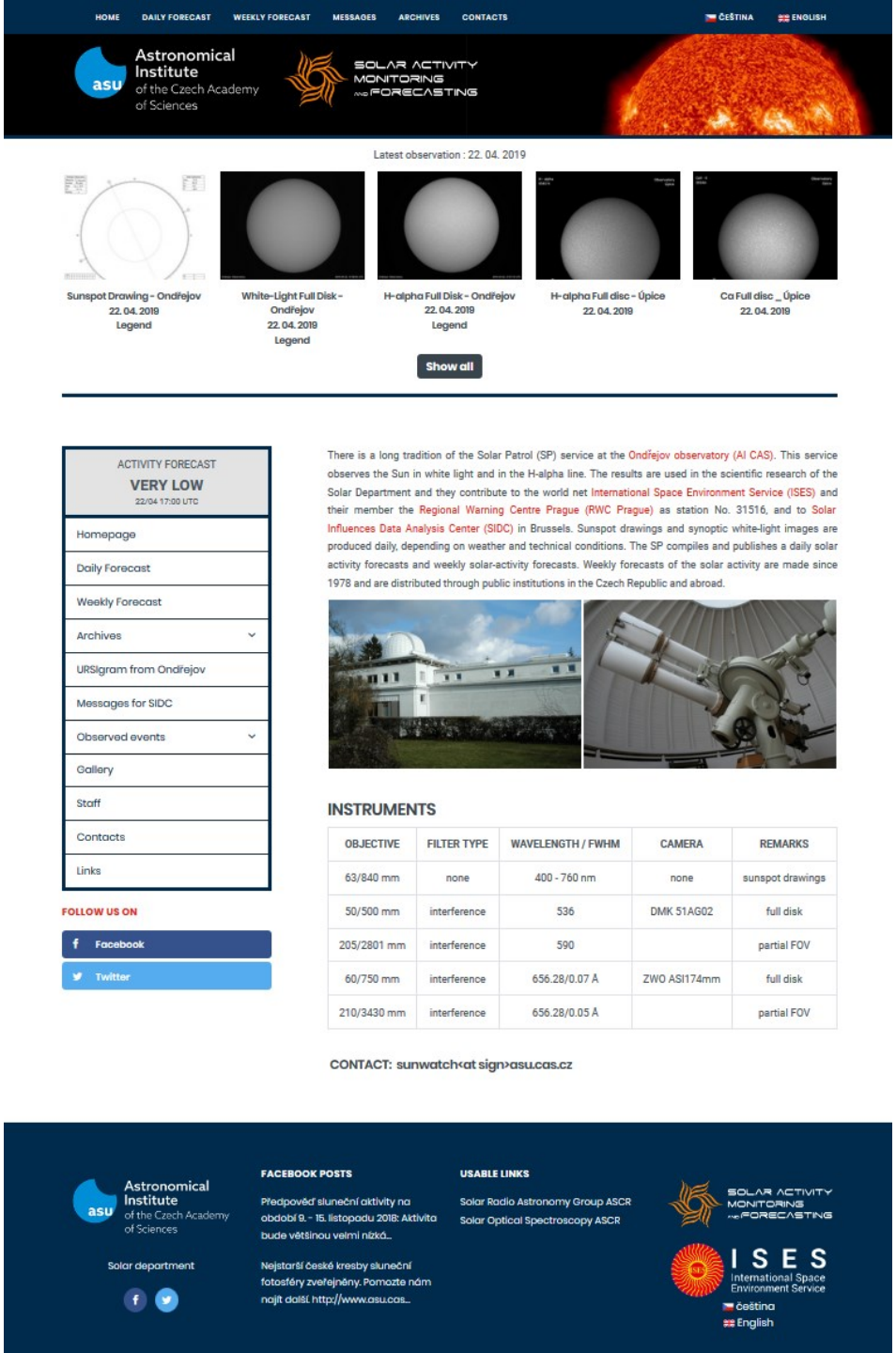
CMOS 1936 x 1216, pixel 5.85 µm, 12 bit
exp. 50 ms, cadence 12 fps (global shutter)
D_{SUN} = 1195 pix, 1.6”/pix

Web page:

www.asu.cas.cz/~sunwatch/







Online cloud detection

For automated full-disc synoptic observations, there is a need to detect the presence of cloud shadows and to evaluate their effect on data degradation.

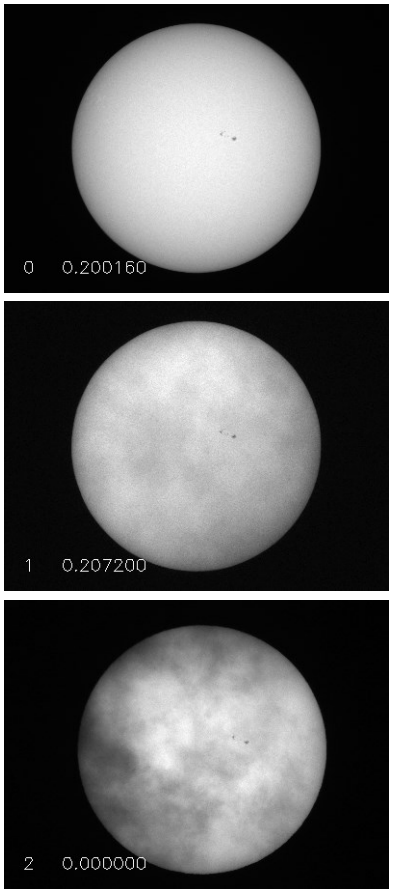
Cloud score:

0 – Clean Sun, no clouds; the images can be used for automatic solar activity detection.

1 – Weak clouds; the images cannot be used for automatic detection but they are still useful.

2 – Strong clouds; the images are severely affected and it is not worth to store them.

3 – No Sun; the solar disc is completely obscured by clouds.



Feng et al. (2014, *New Astronomy*, 32, 24) published a method of automatic detection of cloud shadows in full-disc images, based on a comparison of observed images with a reference one. The method requires a centering of solar disc in the image and it is intended mostly for a post-processing.

We present a method that analyses each observed image individually and does not need a reference frame or a cross-comparison between the images. This makes it possible to determine the cloud score immediately after taking the image. Our IDL code CLOUD_TEST, running on an ordinary PC, is capable to analyze of about 35 frames per second.

Data used to develop the code:
White-light images obtained by the Ondřejov full-disc telescope (D = 5 cm, f = 50 cm), 8 bit, 1600 x 1200 pixels, 1.83”/pix, 10 series of 10–2500 images, cadence 1 s.

Criteria of evaluation:

Crit. 0: Minimum brightness – the signal must be large enough for further evaluation. If not, the Sun is considered to be completely obscured.

Crit. 1: A ratio of average intensities of the solar disc and of the rest of frame; *crit1* = mean (I_{disc}) / mean ($I_{non\text{-}disc}$) – A signature of weak clouds.

Crit. 2: A ratio of observed and calculated disc areas;

crit2 = $N_{pix\_obs} / N_{pix\_calc}$, where $N_{pix\_calc} = \pi(r \odot / scale)^2$ is calculated for a given time by an ephemeris routine. – A signature of strong clouds.

Crit. 3: A normalized standard deviation of the full-disc intensity. After a smoothing to diminish the effect of sunspots and plages, its value depends on the center-to-limb variation and the perturbation by clouds (weak or strong).

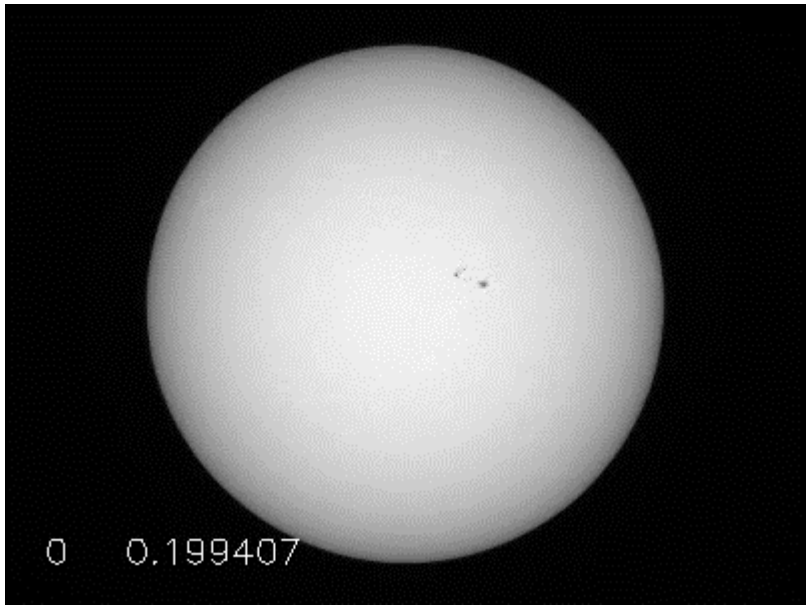
Parameters defining the criteria limits must be determined experimentally for a given instrument.

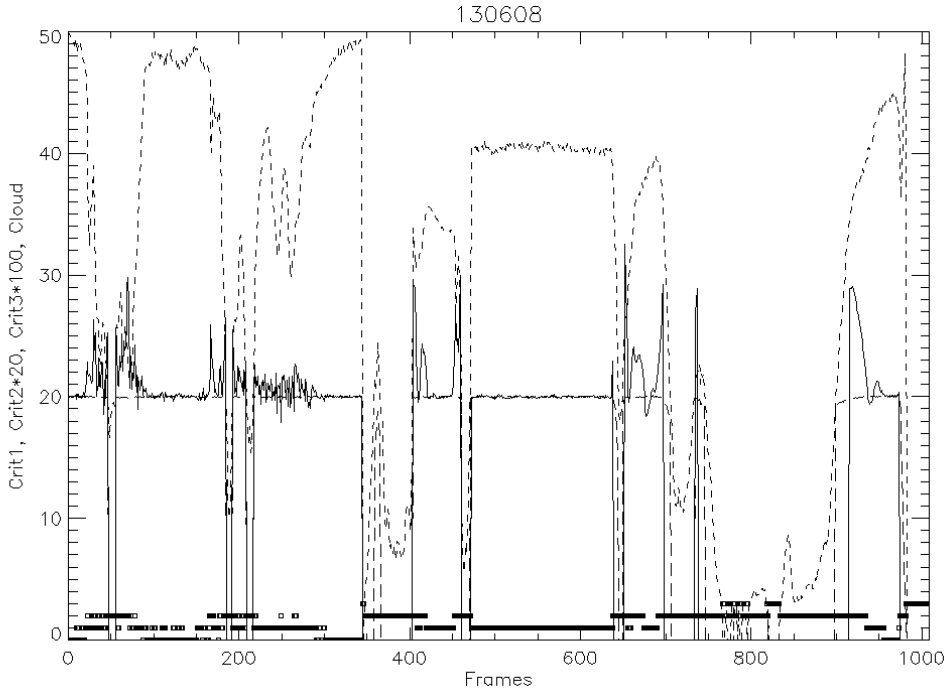
The cloud score is obtained from a combination of these criteria.

Cloud score	*cr0*	*cr1*	*cr2*	*cr31*	*cr32*
0 – clean Sun	1	1	1	1	1
1 – weak clouds	1	**0**	1	1	1
1 – weak clouds	1	0 or 1	1	**0**	1
2 – strong clouds	1	0 or 1	1	0	**0**
2 – strong clouds	1	0 or 1	**0**	n/a	n/a
3 – no Sun	**0**	n/a	n/a	n/a	n/a

Table 1 – Cloud score and the corresponding combination of conditions. Filled cells show the decisive conditions for cloud scores 1–3.

Results





Score, Crit. 3

Crit. 1 - dashed, Crit. 2 - long dash, Crit. 3 - solid

Compared to the visual assessment, the success rate of the code is 97 %.

What to do

Testing, tuning, and verification of the cloud-detection algorithm on extended data sets:

- Collecting more WL full-disc images with clouds in Ondřejov,
- using also the 16-bit camera Quantalux CS2100M.
- Collecting WL full-disc images with clouds from other sites, instruments, cameras… we need your help.

Thanks for your attention

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