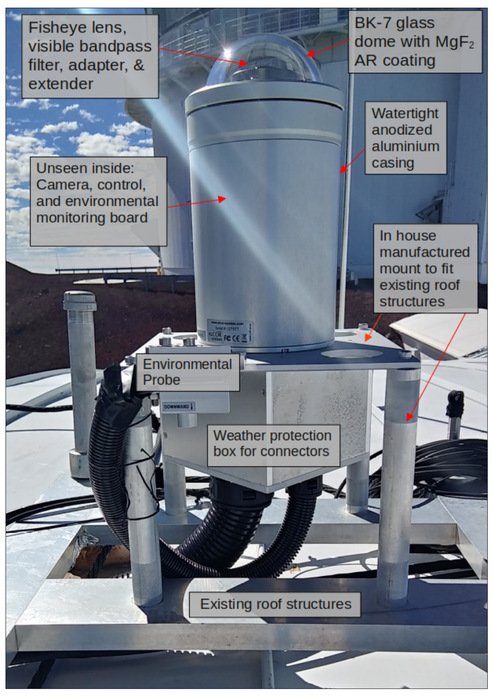
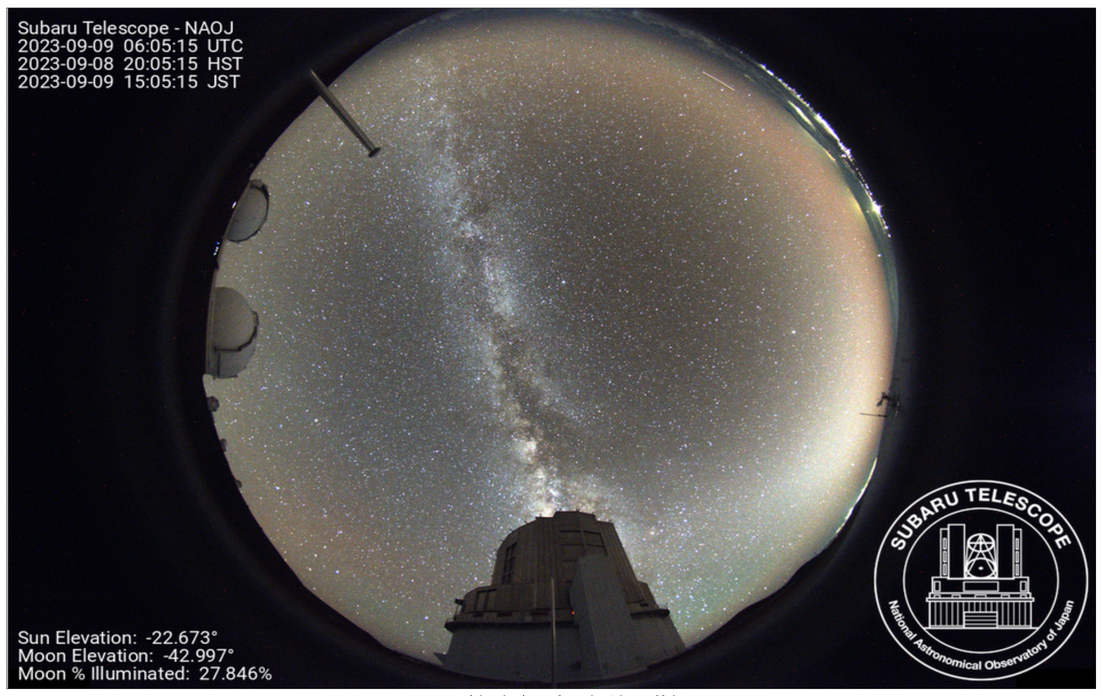
Subaru Telescope Optical Allsky Camera

Andrew Neugarten[1], Ichi Tanaka[1], Larissa Schumacher[1]
with special thanks to Matt Wahl[2], Rita Morris[2], and Mike Lemmen[1]



The allsky camera installed on the roof of the Subaru control building on Maunakea, with parts labelled.

Subaru's Allsky camera, an Omea-5C purchased from Alcor-System[3] in late 2020, and installed in 2021, is designed to observe 360^0 in color in the optical wavelengths.
It is used for environmental monitoring during current onsite observations, and is intended to do so for future remote observations as well. Additionally, it is incorporated into public outreach.
The camera, cables, and camera software are part of the Alcor-System package.
The camera mount, control computer, and the internal and external websites are provided and maintained in house by operations, scientific, and engineering staff.



A night sky image from the Subaru allsky camera

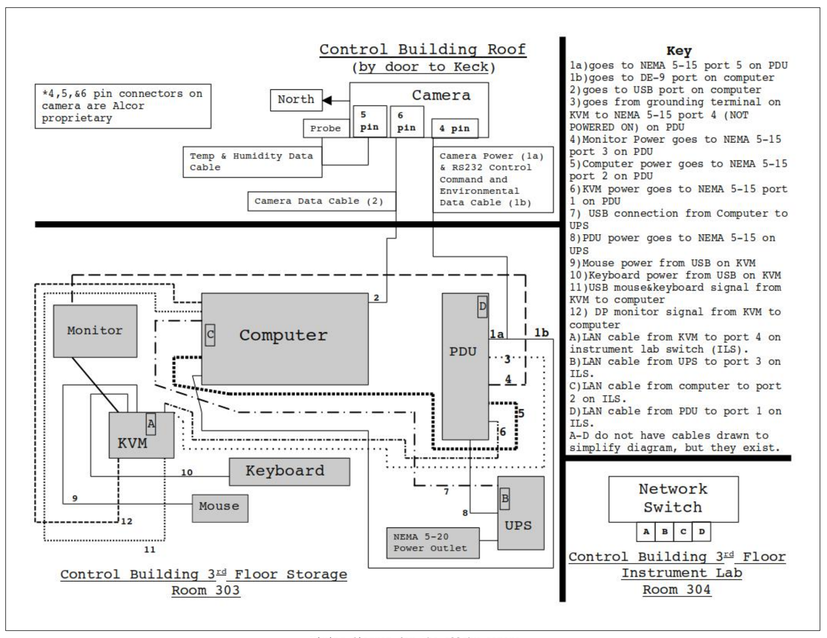
Parameter	Value
Camera Model	ZWO ASI83MC Pro
CMOS Detector	Sony IMX183CQJ-J
Field of View	180° × 180°
Detector resolution	5500 × 3650 pixels
"Illuminated" pixels (inside fisheye circle)	10 Million pixels
Pixel Scale	3.0 arcmin/pix
Pixel Size	2.4µm
Wavelength Range	420nm to 680nm
ADC resolution	12 bits
Max Frame Rate	2.5 fps (via USB 2.0)
Exposure time	32µs to 1hr
Gain	Variable, Logarithmic mode from 30x to 10000x
Download time	400ms Max
Readout Noise	1.6e to 3.0e
Full Well Depth	Up to 15000e
Sensor Cooling	45c ebelow ambient
Dome Dew Heater	Automatic, tunable power from 18W - 36W
Operating Range	-35˚C to +45˚C
Power supply	24V / 3A
Body	Watertight anodized aluminum casing
Dome	BK 7 Glass
AR Coating	MgF_2 , inside only
Watertight	IP67
Dimensions	Diameter: 130mm, Height: 270 mm
Mass	3.5 kg

Specifications for the Omea-5C by Alcor-System

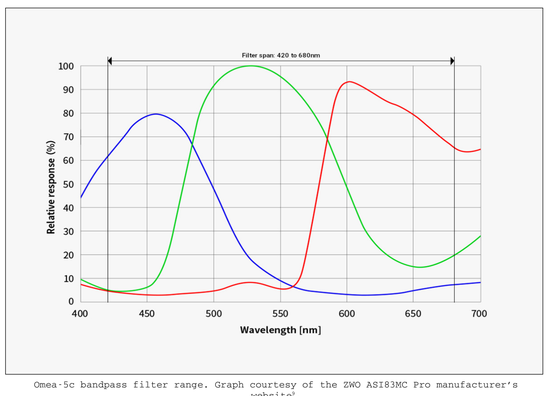
The Omea-5C fisheye lens, filter (λ: 420nm - 680nm), camera (5k Sony CMOS sensor with $1.6e^-$ to $3.0e^-$ readout noise) and related components are contained in a watertight anodized aluminium casing with a BK-7 glass dome that has a MgF_2 AR coating on the inside.
It is attached to a mount designed and created in-house to fit existing roof structures and be north aligned. An in-house designed weather protection box and cable tubing were added to the underside of the mount due to the extreme weather conditions on Maunakea (below freezing temperatures and winds up to 70 m/s). The camera is mounted on the east roof of the Subaru Control Building, while the control computer and related equipment are installed inside the control building.

Due to the camera's cooling capacity, we loose less than 1 hot pixel per frame and therefore the usage of dark frames is not required.

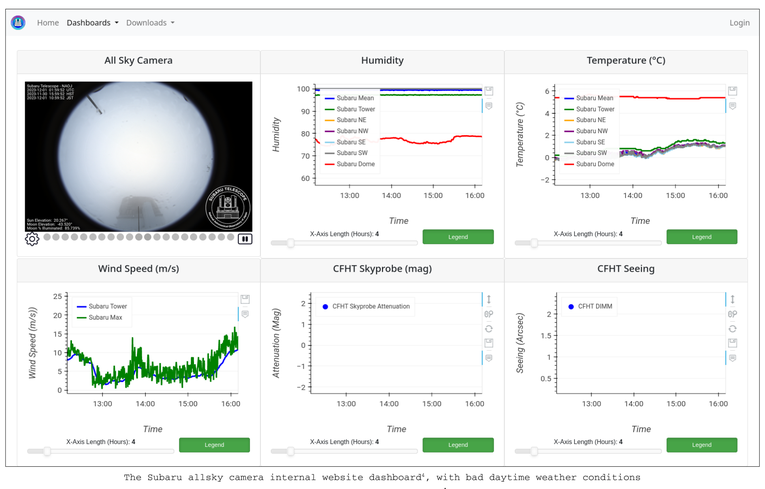
Currently the Alcor-System Skywatch software is used for image acquisition. The development of in-house software is planned to provide greater flexibility in acquisition and compatibility with Unix-like systems.



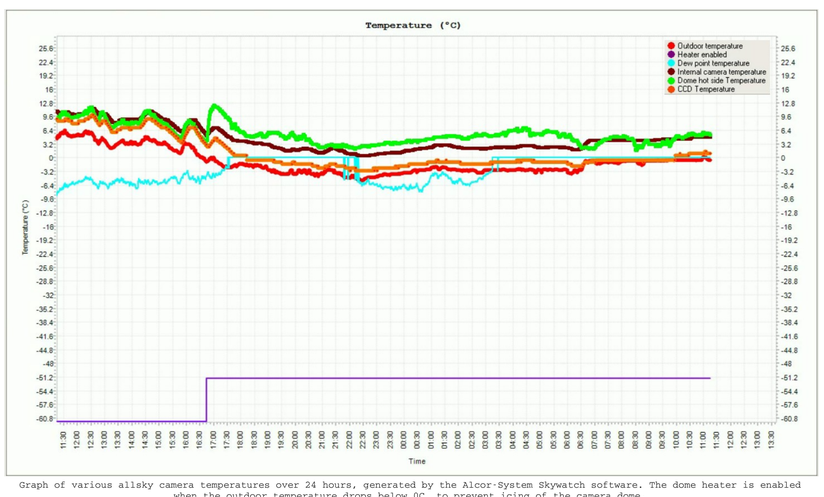
Wiring diagram for the allsky camera



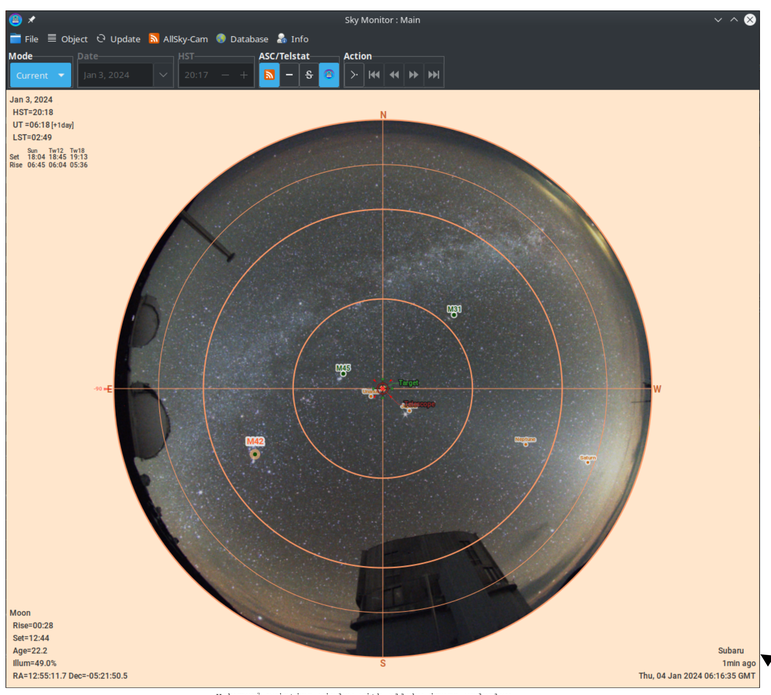
Omea-5c bandpass filter range. Graph courtesy of the ZWO ASI83MC Pro manufacturer's website[3].



The Subaru allsky camera internal website dashboard[4], with bad daytime weather conditions



Graph of various allsky camera temperatures over 24 hours, generated by the Alcor-System Skywatch software. The dome heater is enabled when the outdoor temperature drops below 0C, to prevent icing of the camera dome.



Hskymon[7] pointing window with allsky image underlay

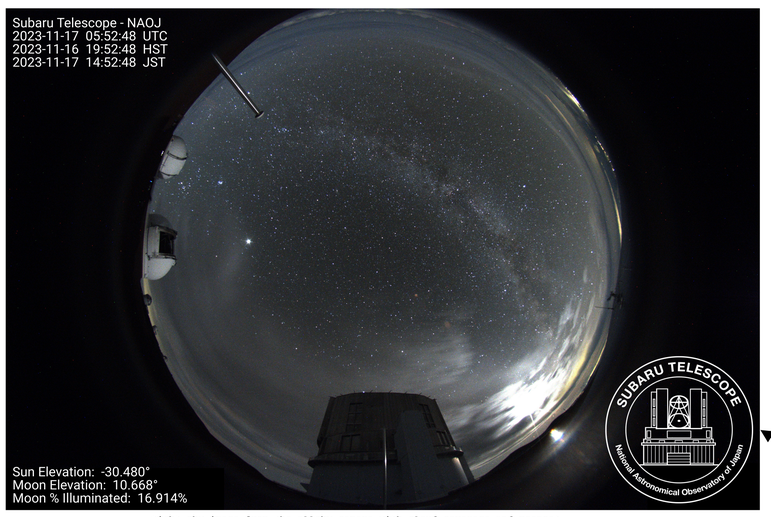
The Allsky website was written and is maintained in-house. It contains a loop of the most recent images (adjustable from 1 to 24 frames), as well as plots for the humidity, temperature, and wind speed at Subaru and the sky attenuation and seeing from the CFHT weather tower[5]. This allows for compact real-time monitoring of environmental conditions. The dashboard is currently internal only, but a simplified external version will be provided to the public in the future.

Subaru also transfers the latest Allsky image to the Maunakea Weather Center Web Cams page, to be accessed as a single frame or time-lapse. This allows the greater Maunakea astronomy community, safety staff, and the public to monitor weather conditions.

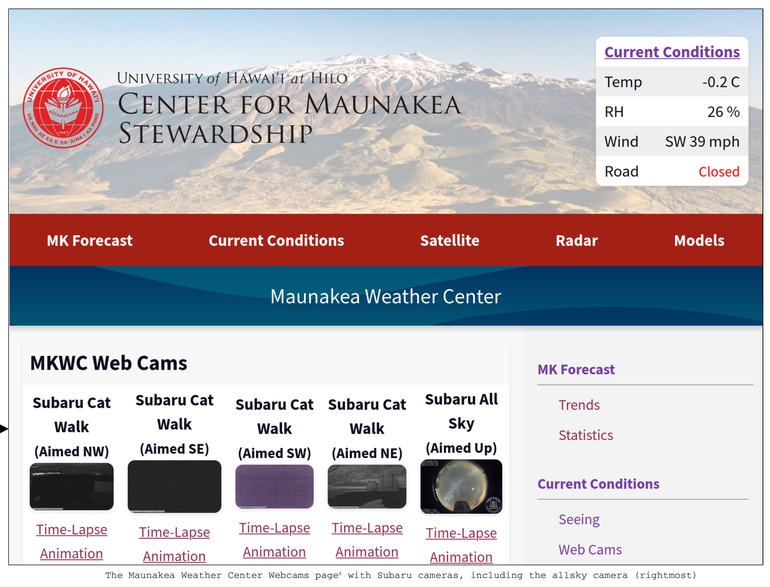
Hskymon is the Subaru Telescope sky monitor for celestial objects and program targets. It has been configured to use our allsky image as the background for the overlay. This allows for better sky condition monitoring than the previous CFHT mid-IR allsky image due to location differences.

The Alcor-System software provides a 24 hour noon-to-noon time-lapse, which is currently manually shortened to an evening to morning time-lapse and uploaded to the ' 管理人 _SubaruTel_StarCamAdmin' YouTube account. There are plans to make both these steps automated, in combination with our in-house software.

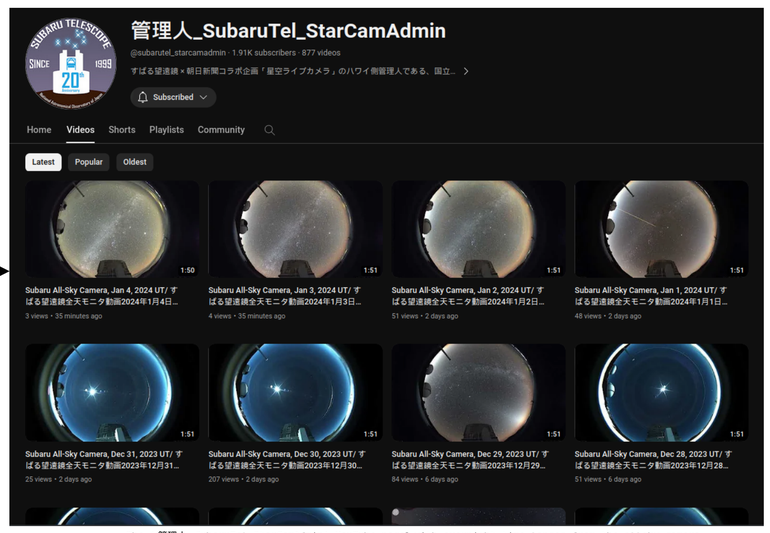
During the night, the Allsky camera is used predominantly to monitor cloud cover and sky conditions. It is also used during the day to evaluate conditions if the weather is forecasted to worsen.



Night sky image from the allsky camera with cloud coverage and moonset



The Maunakea Weather Center Webcams page[6] with Subaru cameras, including the allsky camera (rightmost)



The '管理人_SubaruTel_StarCamAdmin' YouTube page[8] with overnight time-lapses from the allsky camera

Affiliations: [1]Subaru Telescope; [2]Keck Telescope

To contact the Subaru Telescope Allsky project members, please email allsky@naoj.org

Resources: [3]https://www.alcor-system.com/new/AllSky/Omea_camera.html; [4]https://allsky.subaru.nao.ac.jp/allsky/db; [5]https://www.cfht.hawaii.edu/Instruments/Elixir/skyprobe/home.html; [6]http://mkwc.ifa.hawaii.edu/current/cams/; [7]https://subarutelescope.org/Observing/tools/hskymon/index.html; [8]https://www.youtube.com/@subarutel_starcamadmin/videos; [9]https://astronomy-imaging-camera.com/product/asi183mc-pro-color/