Observing conditions at the Skinakas Observatory

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This report describes the quality of the Skinakas observatory as a site to perform astronomical observations. The site quality is characterized by the following indicators: weather, seeing, extinction, and sky brightness.

1. Executive Summary

- **Weather –** on average ~60% of the nights are clear. However this percentage increases to more than ~70% during the summer months.

- **Seeing** - mode seeing is 0.69 arcsec (July 2001), 0.65 arcsec (2015).

- **Extinction**

U mag	B mag	V mag	R mag	I mag
0.56 ± 0.13	0.29 ± 0.06	0.18 ± 0.05	0.14 ± 0.05	0.09 ± 0.05

- **Sky brightness** (in mag/arcsec^2)

Year	B Mag		V mag		R mag	
	Zenith	All-sky	Zenith	All-sky	Zenith	All-sky
2008	22.51±0.05	22.36±0.16	21.74±0.06	21.60±0.14	21.18±0.07	21.07±0.14
2016	22.80±0.10	22.35±0.03	21.92±0.09	21.50±0.02	21.39±0.07	20.98±0.04

2. Seeing

[Observations and data analysis performed by Dr. M. Palaiologou (University of Crete)]

Using a two-aperture Differential Image Motion Monitor (DIMM), it was shown that the Skinakas Summit is indeed an excellent site – in fact one of the best known in the Mediterranean area and comparable to major sites worldwide. The seeing observations were made in two different campaigns, each one spanning over two years. The first one took place from the beginning to the end of randomly chosen astronomical nights from June to September 2000 and from May to June 2001 (43 nights in total). The second campaign were made in 2014 (August: 18-23) and 2015 (June: 20-21; July; 10-12, 14,18-20; August: 12,15-18; September: 12,15; November: 11-12). Examples of two such nights of the Skinakas DIMM measurements are shown in the figures below.

2000-2001 campaign: The diagrams show that the seeing does not change rapidly at Skinakas during the observing night, staying within 0.3". Extremely good seeing values have been measured often (0.4"), with the best measured ~0.23". Two histograms with the seeing measurements for the year 2000 and 2001 are shown below. The median seeing for the two periods was 0.64" and 0.69" respectively.
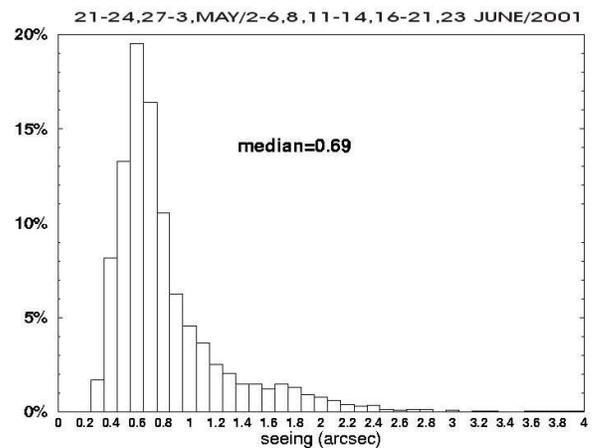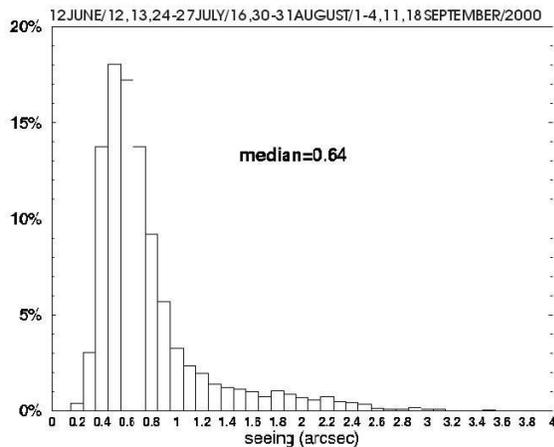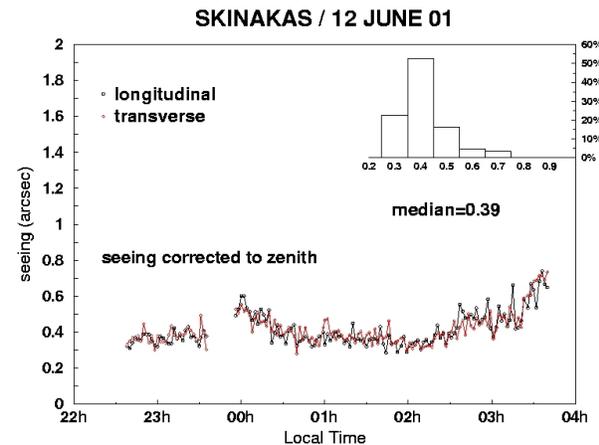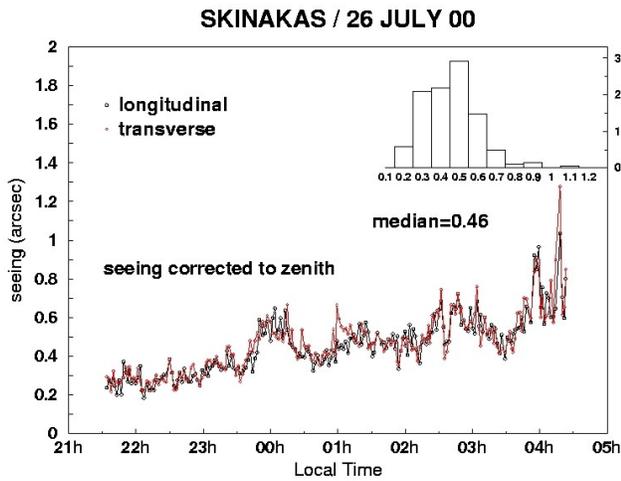
2014-2015 campaign: Note the secondary peak at ~0.2-0.3" , indicating the presence of extraordinarily good nights and in agreement with data from the 2000-2001 campaign.
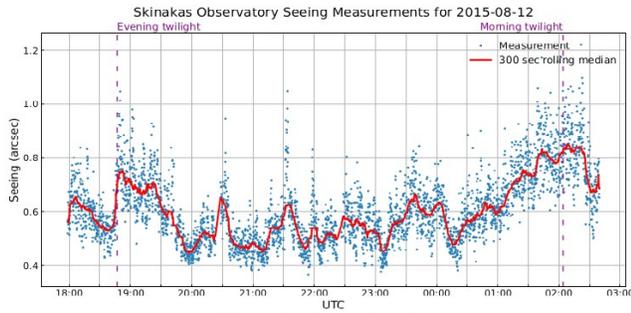

Figure 2. A **Typical** night
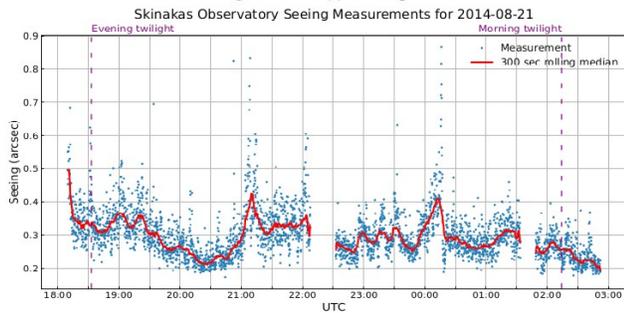
Figure 3. A **Good** night
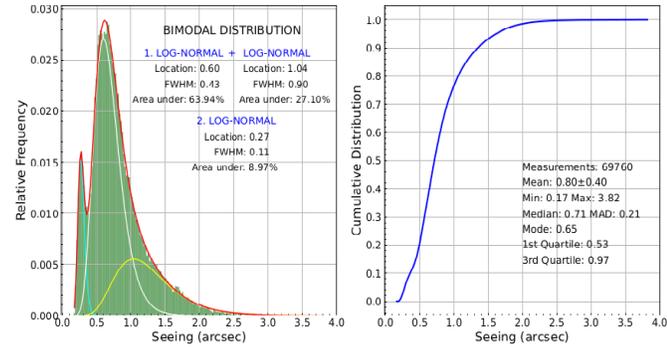
Figure 7. Seeing statistics of the entire campaign

Seeing measurements were obtained from other observatories' archives, corresponding exactly to the same observing nights as in this campaign.
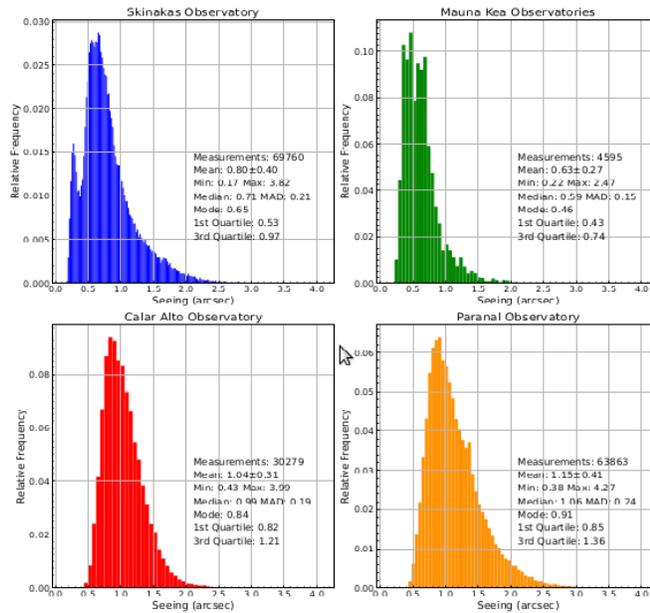
Figure 8. Seeing histograms between observatories
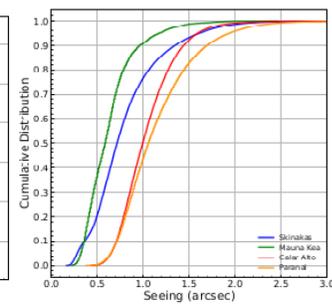
Figure 9. Cumulative seeing distributions

3. Extinction

[Observations and data analysis performed by Dr. P. Reig (Institute of Astrophysics/FORTH)]

Atmosphere extinction is the astronomical parameter that evaluates sky transparency. Sources of sky transparency degradation are clouds (water vapor) and aerosols (dust particles included). Extinction values and their stability throughout the night are essential for determining the accuracy of astronomical measurements. The nights with low and constant extinction are classified as photometric.

The mean extinction at the Skinakas Observatory in the Johnson-Coussins photometric system is given in the table below. The values were obtained *during photometric nights* and are given in mag/airmass.

	U mag N=3	B mag N=35	V mag N=35	R mag N=35	I mag N=35
Mean	0.56 ± 0.13	0.29 ± 0.06	0.18 ± 0.05	0.14 ± 0.05	0.09 ± 0.05
Weighted mean	0.52 ± 0.02	0.285±0.002	0.185±0.001	0.139±0.001	0.081±0.002

Extinction Coefficient - Photometric Nights Only
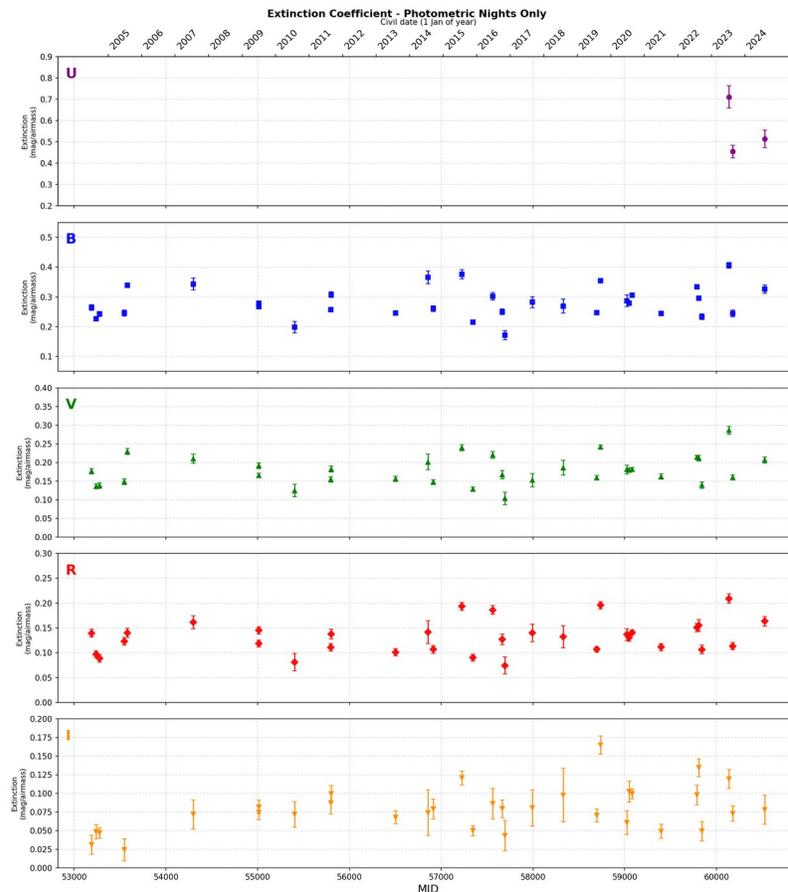
4. Night Sky Brightness and Spectrum

[Observations and data analysis performed by Dr. M. Palaiologou (University of Crete)]

We have performed two different campaigns to study the brightness of the sky over the Skinakas observatory during moonless nights. The first one took place in August 2008 and the second one over a five month period from June to October 2016. These campaigns revealed that Skinakas Observatory is a dark site, with the exception of the direction towards the city of Heraklion (North East).

	B Mag		V mag		R mag	
Year	Zenith	All-sky	Zenith	All-sky	Zenith	All-sky
2008	22.51±0.05	22.36±0.16	21.74±0.06	21.60±0.14	21.18±0.07	21.07±0.14
2016	22.80±0.10	22.35±0.03	21.92±0.09	21.50±0.02	21.39±0.07	20.98±0.04

All sky maps

Figure 5. Zenith-corrected night sky surface brightness maps in the passband of B, V and R filters, expressed in magnitudes arcsecond^{-2}. The polar grid indicates the local horizontal coordinate system, with constant zenith-distance circles corresponding to the lower boundary of the 4 Zones considered.
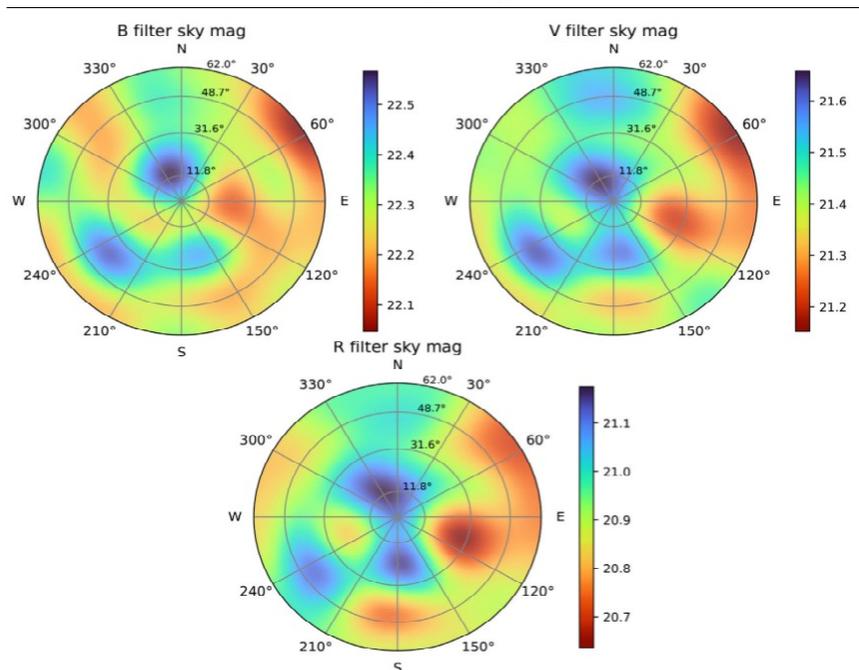
6. Weather & Operations

[Data analysis performed by Dr. P. Reig (Institute of Astrophysics/FORTH)]

This section presents a statistical analysis on the efficiency of the observing time at the Skinakas Observatory. It gives the average fraction of observing time lost to bad weather and the parameters involved as the main cause of the bad weather.

The period analyzed is 2015 to 2025.

A typical observing season covers the period May to October. Although observations during April and November are not rare, the available data are scarce. Thus we distinguish two date sets:

- Data set 1: includes all available nights: 1984 nights

- Data set 2: includes data from 1st May to 31 October of each year. We will call this the "summer data set": 1888 nights

Source of data

There are two sources of data that serve for different purposes:

- Source 1 – **Observations log**: This source of data is based on the feedback of the observers. The observer fills in a log each night, reporting on the observing conditions during the night (both technical and weather related) as well as information about the purpose of the observations

- Source 2 – **Weather station**: The weather station outputs the values of the following parameters: humidity, air temperature, sky temperature, wind speed, and wind direction

The information from Source 1 is used to estimate the amount of "Equivalent Open Nights" per year/month and the reason for lost time due to weather conditions. The information from Source 2 is used to estimate the number of "Operational Nights", defined as those in which the weather parameter are within the allowed limits.

Naturally, the "Equivalent Open Nights" and "Operational Nights" provide similar information and should not differ too much one from the other. Note, however, that source 2 does not gather data on the concentration of dust, which is an important parameter during certain months (May typically, but not only). Section 8 provides a comparative study of the two methods.

Observations log

The options given to the observer to quantify the amount of the observing time are the following:

- **Closed all night (CAN):** The dome was closed during the entire night regardless of the reason.

- **Open all night (OAL):** The dome was open during the entire night, hence observation took place normally.

- **Open 1/2 of the night (OHN):** The dome was opened during at least half of the night.

- **Open 1/4 of the night (OOQ):** The dome was opened for about one fourth of the night.

- **Open 3/4 of the night OTQ):** The dome was opened for about three fourth of the night.

From this, we computed the following two metrics:

- **'Equivalent Open Nights (EON):** It is calculated as

  EON=OAN+1/4*OOQ+1/2*OHN+3/4*OTQ

- **'Equivalent Closed Nights (ELN):** It is calculated as

  ELN=CAN+1/4*OTQ+1/2*OHN+3/4*OOQ

The lost nights refer to the total time that the telescope was not operational. This can be due to technical reasons or due to bad weather. The amount of time lost due to technical issues is less than 3% of the total available time and includes both technical problems during the night and scheduled maintenance works. There have been two major disruptions of the observations schedule due to the mechanical/optical problems with RoboPol (August 2022, October 2025). This reports will focus on the lost time due to bad weather conditions.

Lost time due to weather are divided into the following categories:

- **High humidity:** It refers to the number of nights during which the dome was closed because the humidity level was higher than the allowed limit of 80%.

- **Clouds:** These are nights when the clouds prevented normal operation but the humidity was in the allowed range.

- **Thunderstorms:** implies electrical phenomena. The protocol demands to shut down all electric devices at the observatory and the transfer of the observers down to Heraklion. It also included rainfall.

- **Strong wind:** It refers to the number of nights during which the dome was closed because the wind velocity was higher than the operational limit of 70 km/h (or > 55 km/h if pointed directly into the wind).

- **High dust content:** When the dust level was higher than 800 particles per cubic feet.

One extra limit was applied to the weather station data:

- "**Cloudiness**": The night was assumed to be cloudy, hence not operational, if the difference between the sky temperature and the ambient temperature was greater than -15ºC.

Weather analysis

The overall picture (2015-2025)

Top Weather Phenomena (Equivalent Nights Lost)

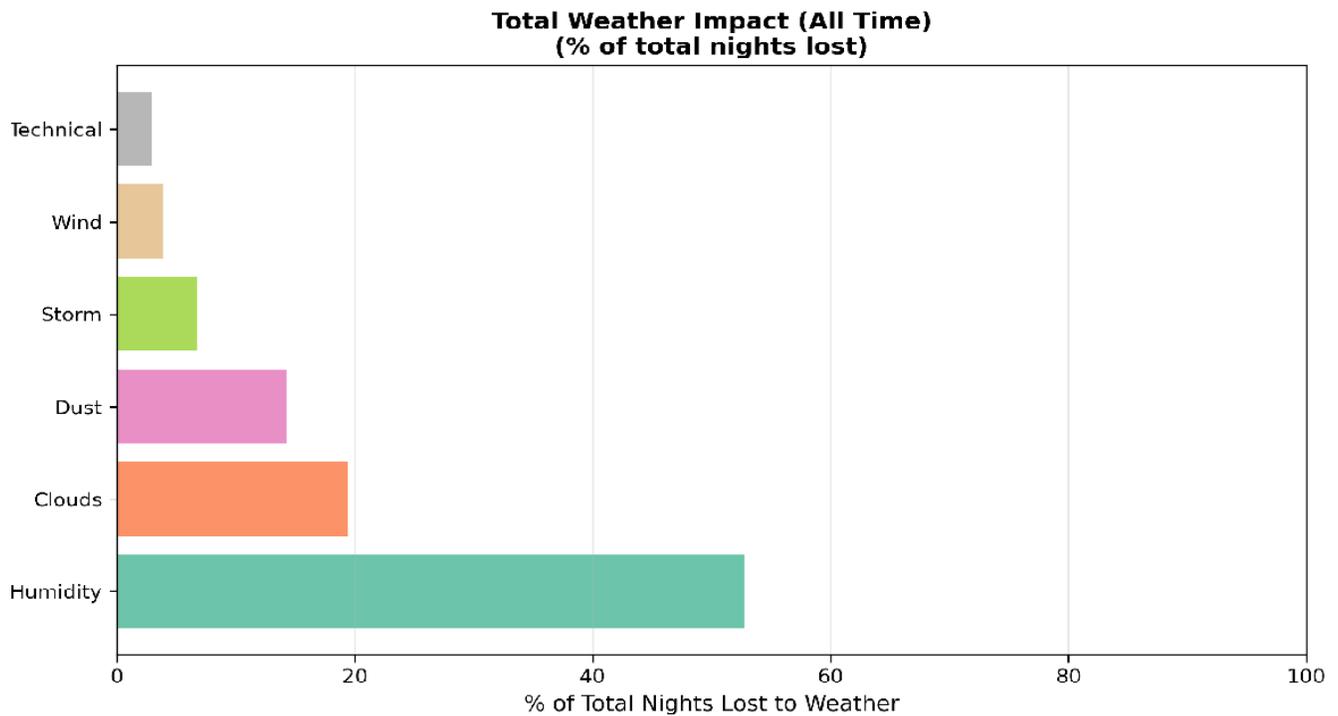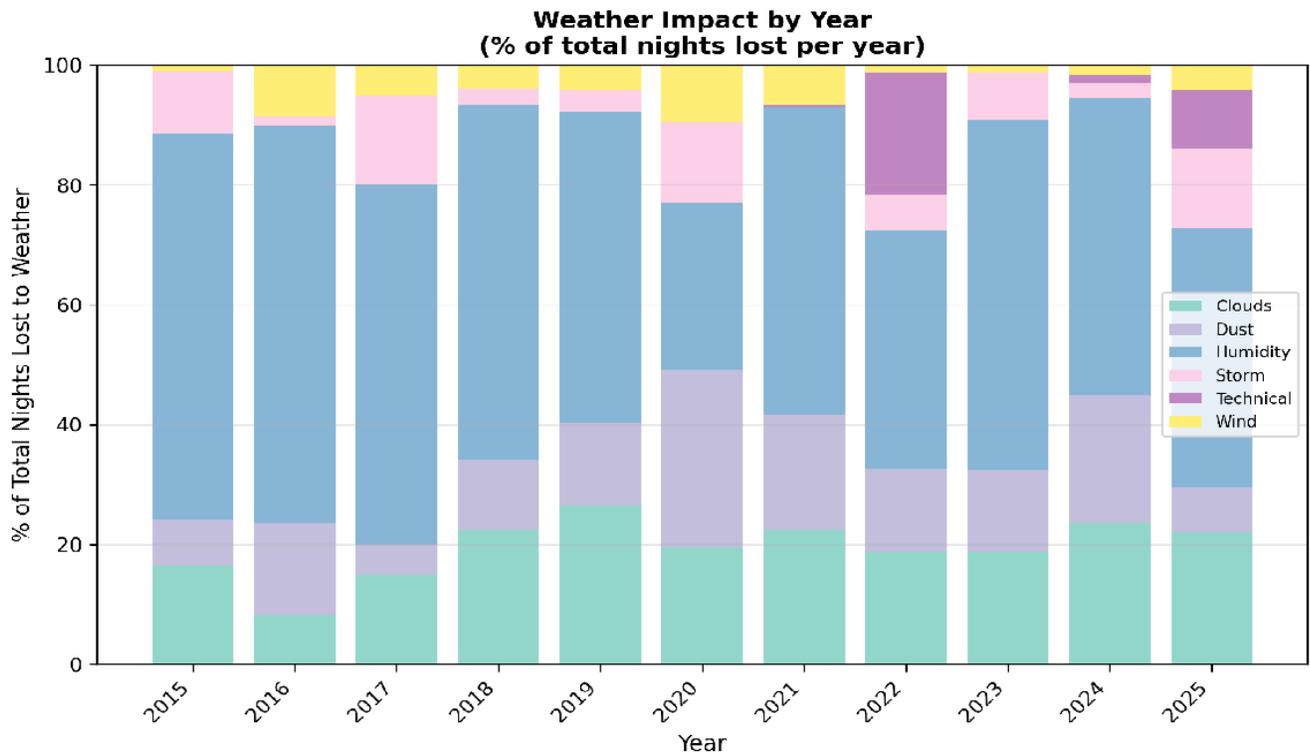|	*All data set*		*Summer data set*	
Total Recorded Nights	1984		1888	
Humidity	424.25	52.7%	393.75	52.3%
Clouds	156.50	19.5%	141.25	18.8%
Dust	114.75	14.3%	113.75	15.1%
Storm	54.00	6.7%	51.00	6.8%
Wind	31.25	3.9%	30.25	4.0%
Technical*	23.75	3.0%	23.00	3.1%

*It includes technical issues during the night and scheduled maintenance works.
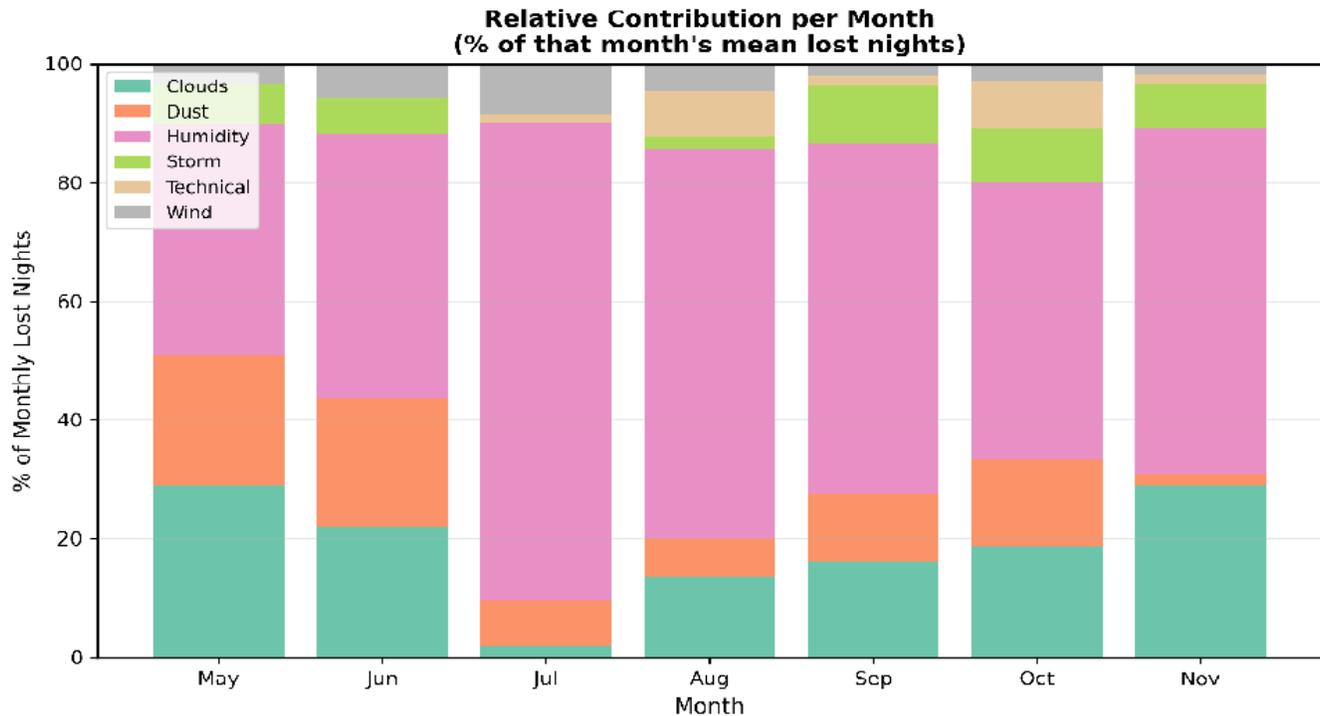
Weather impact by year (all data)

Year	Clouds	Dust	Humidity	Storm	Wind	Total Lost
2015	17.25 (16.4%)	8.25 (7.9%)	67.50 (64.3%)	11.00 (10.5%)	1.00 (1.0%)	105.00 (100.0%)
2016	5.00 (8.1%)	9.50 (15.4%)	40.75 (66.3%)	1.00 (1.6%)	5.25 (8.5%)	61.50 (100.0%)
2017	8.00 (14.9%)	2.75 (5.1%)	32.25 (60.0%)	8.00 (14.9%)	2.75 (5.1%)	53.75 (100.0%)
2018	19.25 (22.4%)	10.00 (11.7%)	51.00 (59.5%)	2.00 (2.3%)	3.50 (4.1%)	85.75 (100.0%)
2019	15.50 (26.4%)	8.25 (14.0%)	30.50 (51.9%)	2.00 (3.4%)	2.50 (4.3%)	58.75 (100.0%)
2020	11.75 (19.6%)	17.75 (29.6%)	16.75 (27.9%)	8.00 (13.3%)	5.75 (9.6%)	60.00 (100.0%)
2021	16.00 (22.4%)	13.75 (19.2%)	36.75 (51.4%)	0.00 (0.0%)	4.75 (6.6%)	71.50 (100.0%)
2022	15.25 (18.8%)	11.25 (13.8%)	32.25 (39.7%)	5.00 (6.2%)	1.00 (1.2%)	81.25 (100.0%)
2023	16.75 (19.0%)	12.00 (13.6%)	51.50 (58.4%)	7.00 (7.9%)	1.00 (1.1%)	88.25 (100.0%)
2024	18.25 (23.5%)	16.75 (21.5%)	38.50 (49.5%)	2.00 (2.6%)	1.25 (1.6%)	77.75 (100.0%)
2025	13.50 (22.1%)	4.50 (7.4%)	32.50 (53.3%)	8.00 (13.1%)	2.50 (4.1%)	61.00 (100.0%)

Weather Impact by Year
(% of total nights lost per year)

Legend: Clouds, Dust, Humidity, Storm, Technical, Wind

Total Weather Impact (All Time)
(% of total nights lost)

Average Weather Impact by Calendar Month (all years combined)

Month	Clouds	Dust	Humidity	Storm	Wind
May	4.53 (29.0%)	3.42 (22.0%)	6.05 (38.8%)	1.10 (7.1%)	0.50 (3.2%)
June	2.68 (22.0%)	2.64 (21.6%)	5.43 (44.6%)	0.73 (6.0%)	0.70 (5.8%)
July	0.11 (1.8%)	0.50 (7.9%)	5.11 (80.4%)	0.00 (0.0%)	0.55 (8.6%)
August	1.14 (13.6%)	0.55 (6.5%)	5.45 (65.4%)	0.18 (2.2%)	0.39 (4.6%)
September	2.05 (16.2%)	1.41 (11.2%)	7.45 (59.1%)	1.27 (10.1%)	0.25 (2.0%)
October	2.75 (18.7%)	2.14 (14.6%)	6.84 (46.6%)	1.36 (9.3%)	0.41 (2.8%)
November	1.91 (29.0%)	0.12 (1.9%)	3.81 (58.1%)	0.50 (7.6%)	0.12 (1.9%)

Relative Contribution per Month
(% of that month's mean lost nights)

Operation analysis

|	*All data set*	*Summer data set*
Total Recorded Nights	1984	1888
Equivalent Open Nights	1172 (**59.1%**)	1129 (**59.8%**)
Equivalent Closed Nights	812 (**40.9%**)	759 (**40.2%**)
Open all night	958 nights (48.3%)	927 nights (49.1%)
Open 3/4 of the night	171 nights (8.6%)	164 nights (8.7%)
Open 1/2 of the night	119 nights (6.0%)	109 nights (5.8%)
Open 1/4 of the night	106 nights (5.3%)	97 nights (5.1%)
Closed all night	630 nights (31.8%)	591 nights (31.3%)

Statistics by year (all data)

Year	Total	Open All	Open 3/4	Open 1/2	Open 1/4	Closed	Equiv.Open	Open %
2015	207	77	18	16	10	86	101.00	48.8%
2016	182	104	12	6	14	46	119.50	65.7%
2017	158	88	12	9	11	38	104.25	66.0%
2018	171	66	14	11	13	67	85.25	49.9%
2019	173	94	15	14	7	43	114.00	65.9%
2020	156	75	15	8	15	43	94.00	60.3%
2021	178	87	18	9	6	58	106.50	59.8%
2022	181	75	21	12	8	65	98.75	54.6%
2023	190	80	15	16	10	69	101.75	53.6%
2024	200	101	19	10	8	62	122.25	61.1%
2025	188	111	12	8	4	53	125.00	66.5%

Average per calendar month (all years combined)

| Month	Total	OpenAll	Open3/4	Open1/2	Open1/4	Closed	Eq.Open	Eq.Closed	Open%
May	26.40	8.30	2.40	0.90	1.00	13.80	10.80	15.60	**40.9%**
June	29.73	14.27	2.64	1.91	1.36	9.55	17.55	12.18	**59.0%**
July	30.36	21.45	1.82	1.73	1.27	4.09	24.00	6.36	**79.0%**
August	30.55	18.82	2.45	1.36	2.36	5.55	21.93	8.61	**71.8%**
September	30.09	13.18	3.00	2.64	1.82	9.45	17.20	12.89	**57.2%**
October	26.55	8.73	2.82	1.45	1.09	12.45	11.84	14.70	**44.6%**
November	11.75	3.50	0.88	1.25	1.12	5.00	5.06	6.69	**43.1%**

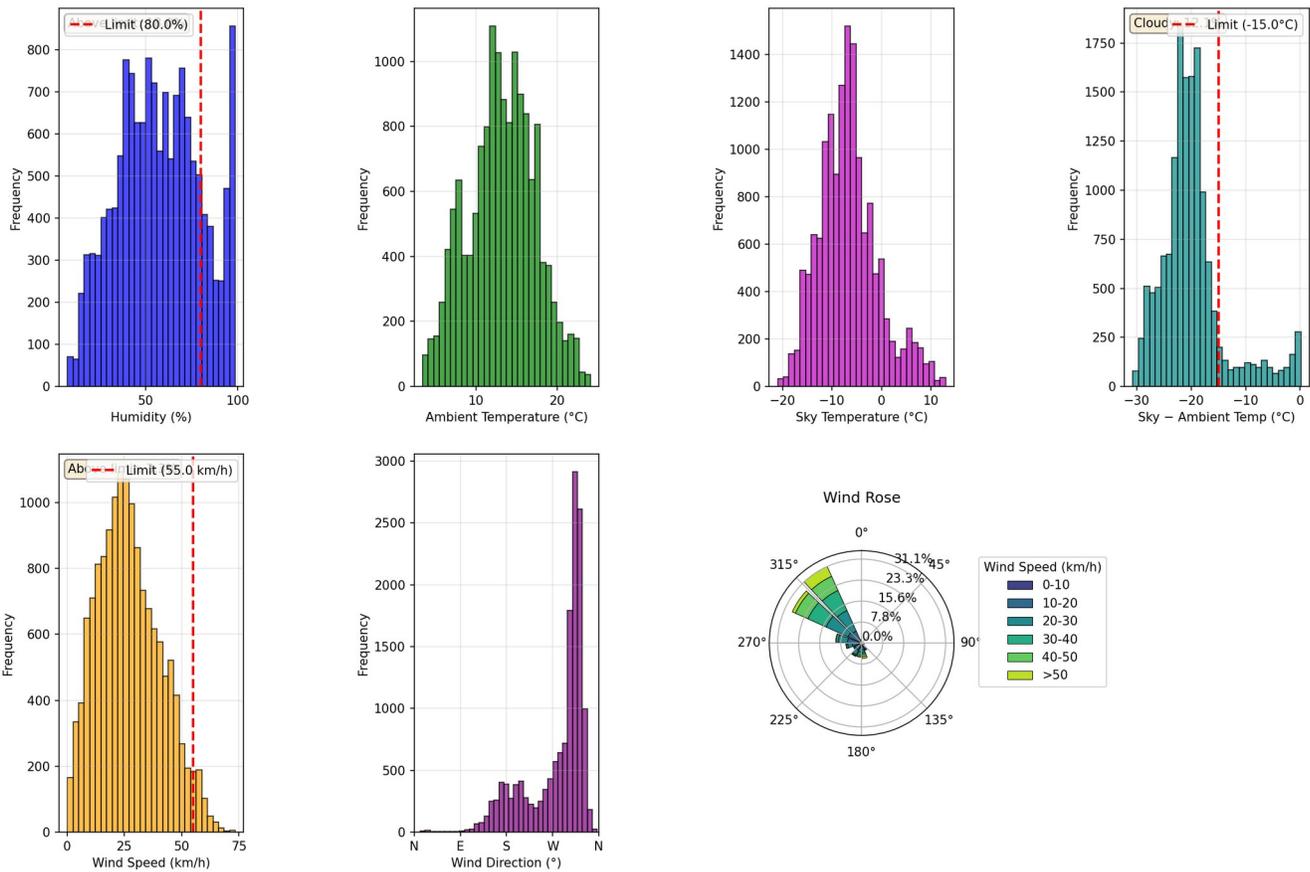Dome Status Distribution by Year
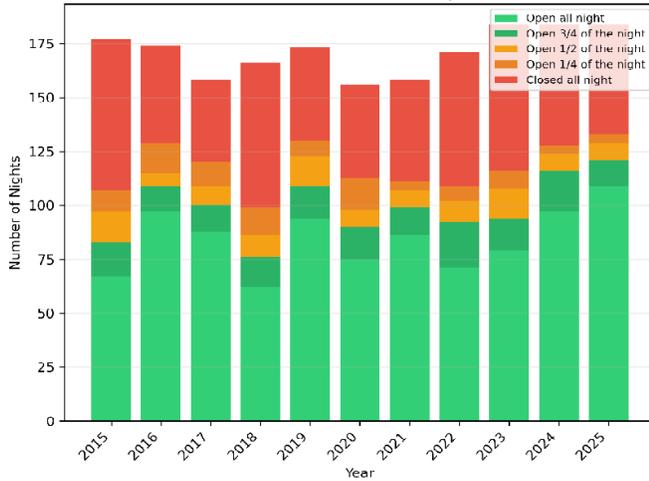
Open vs Closed Nights by Year
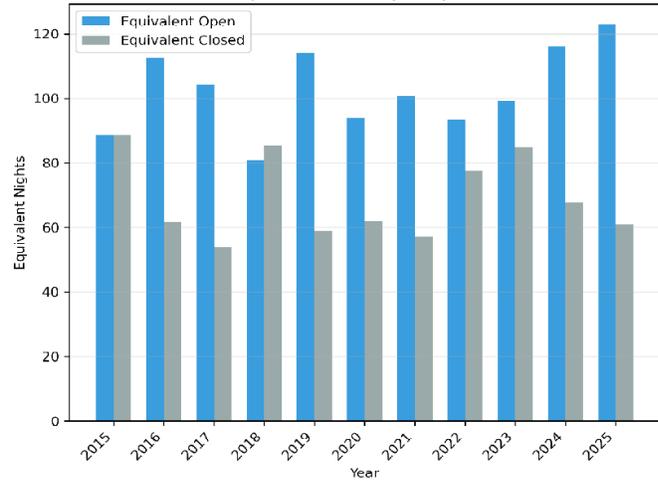
Opening Percentage by Year
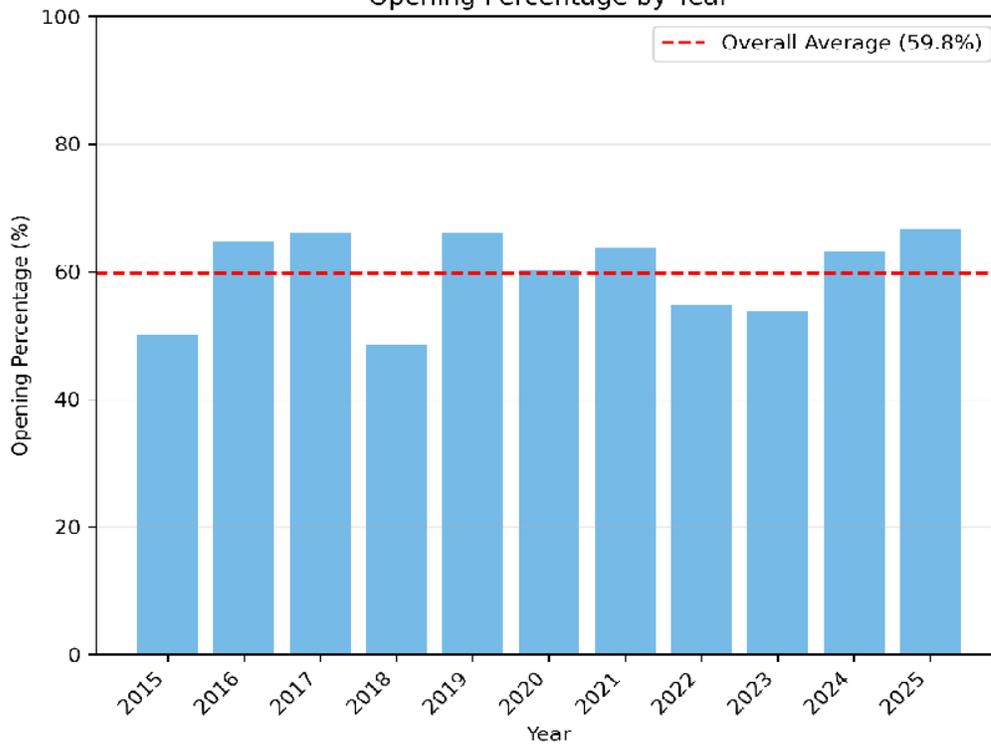
7. Weather charts

Data extracted from the weather station log file. Reported results correspond to data covering the time interval from evening twilight to the morning twilight of the following day.

Year 2025

The "Operational hours" correspond to the time when all the weather parameters were within the permitted limits (excluding dust concentration for which no data are available), while "Possible hours" is the sum of daily (or rather "nightly") hours from twilight to twilight. [1]

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1   There is a data gap for May. Data started on the 13th.

Month	Fraction Operational	Operational Hours	Possible Hours	Humidity Mean	Wind Speed Mean	Ambient Temp Mean	Sky Temp Mean
2025-05	71.1%	86.7h	121.9h	53.7%	27.0 km/h	11.0°C	-6.4°C
2025-06	82.5%	147.2h	178.3h	46.9%	31.8 km/h	14.0°C	-11.2°C
2025-07	95.8%	187.8h	196.1h	45.6%	28.0 km/h	17.3°C	-6.5°C
2025-08	77.5%	179.9h	232.1h	58.3%	27.7 km/h	15.8°C	-2.7°C
2025-09	71.0%	186.8h	263.2h	62.1%	31.2 km/h	12.2°C	-5.4°C
2025-10	62.5%	191.9h	307.2h	67.7%	20.4 km/h	9.5°C	-8.4°C
2025-11	55.8%	180.1h	322.9h	70.0%	21.7 km/h	7.1°C	-43.6°C
2025-12	24.0%	82.8h	345.8h	83.2%	24.1 km/h	3.2°C	-50.0°C

8. Comparative study: human vs machine

As pointed out above, there are two sources of data on which this study is based: the observations log, where observers must provide the information (human factor) and the data from the weather station (machine factor). The "Equivalent Open Nights" derived from the observations log and the "Operational Nights" computed from the data provided by the weather station correspond to the total number of nights when the weather conditions were within the limits, hence observations could or indeed took place. However, they are computed in a very different way. The "Operational Nights" are computed as the fraction between the time (in hours) when the weather limits were within operation values over the total time (in hours) from evening twilight until morning twilight. The input data set has a time resolution of 5 minutes. The "Equivalent Open Nights" are obtained by adding the fraction of the night (1,3/4,1/2,1/4) the observers decided was adequate for observations. The weather station data do not include information about the dust concentration, nor about technical issues. These two events are indeed accounted for in the "Equivalent Open Nights".

The figure below shows a comparison between the effective "good" nights computed by the two methods. The red line is the one-to-one relation (it is not a fit to the data).

Year 2025