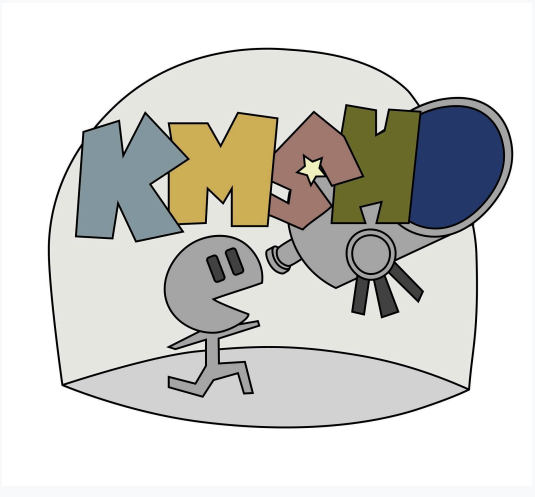
Topic:

The Relationship Between Cloud Height and the Reflection Position of the Kinmen Bridge.



Instructor

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Author

楊甯鈞 YANG NING-JUN
楊沛宸 YANG PEI-CHEN

Abstract

During our astronomical observations at the school's observatory, we discovered that clouds reflect the light spots from the Kinmen Bridge. We considered whether we could deduce the cloud height from the reflection position. Combining this with weather data, we found that the light spot position changes with cloud height. Based on our observations, most light spots appear closer to the western horizon, indicating lower cloud positions.

Motivation

During our astronomical observations on the school rooftop, we noticed reflections appearing above the Kinmen Bridge. Based on the position of these reflections, we can roughly estimate cloud types based on altitude. Our cloud observations are often conducted during the day, as effective night observations are frequently hindered. This led us to consider a physical method using the reflection of light from clouds, making nighttime cloud observations feasible. Our school has equipment in collaboration with the Taipei Astronomical Museum: a fisheye camera for all-sky observations. Combined with weather data and landscape photos, we were inspired to explore whether the reflections on the Kinmen Bridge can indicate cloud height, or if there is a correlation between the reflection height and weather conditions.

Research Methods

During astronomical observations from October to December, we noticed reflections appearing in the clouds above the lit Kinmen Bridge at night. Through images from the fisheye camera, we can observe whether cloud reflections occur on a given day. In mid-February, we compared ground-level cloud photos with images from the fisheye camera (equipment in collaboration with the Taipei Astronomical Museum). By also analyzing meteorological data, we aim to identify correlations between weather conditions and cloud height.

Here are the primary methods for measuring cloud height:

1. Visual Estimation: Observers estimate cloud height based on cloud type, shape, and size, as well as their understanding of local terrain and climate.
2. Ceilometer: The instrument emits a laser or light beam towards the sky. When the beam encounters the cloud base, it is reflected back. By measuring the round-trip time of the beam, the cloud height can be calculated. This method is widely used in airports and meteorological stations.
3. Weather Balloons: Carrying detection instruments aloft, they can measure data such as temperature, humidity, and atmospheric pressure.
4. Meteorological Satellites: Through infrared or visible light sensors, they can observe cloud top temperature and height.

This work is visual estimation. It is a relatively fast and necessary way to roughly judge the cloud height through the reflection position of the clouds in the fisheye camera.

Observation Equipments:

Fisheye Camera: Fisheye lenses possess an ultra-wide-angle field of view approaching or equaling 180°. They were initially designed for ground-based observation of celestial dome phenomenon, making their broad perspective ideal for recording large-scale astronomical events. In addition to capturing stars in the celestial sphere, they can also produce all-sky star trail images. As shown in the image, the Kinmen Bridge is located to the west of the camera. The bridge lights are turned on from 6 PM to 10 PM nightly, during which time cloud reflections are more easily observed (circled area).

The automatic weather station on the rooftop (left), the Skyline Surveillance Camera (middle), and the Kinmen Bridge (right).

Climatic Characteristics During the Observation Period

Kinmen in February is in winter, and the climate characteristics are as follows:

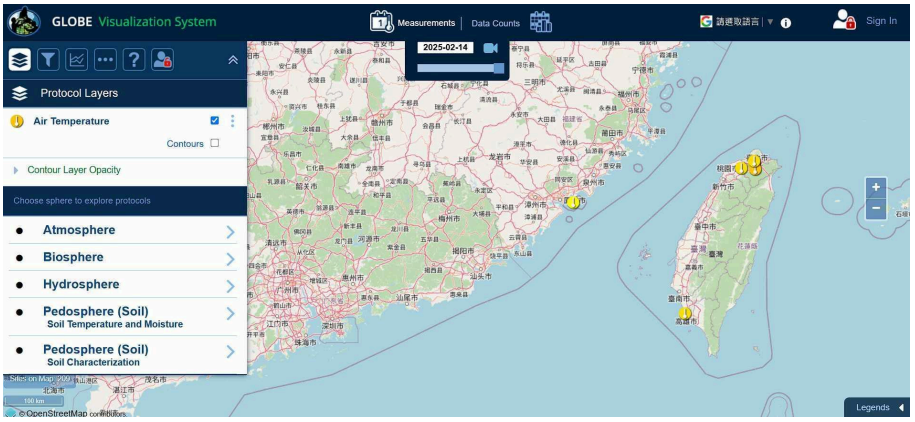
- Lower temperatures: The average temperature ranges from 10°C to 17°C.
- Strong winds: The northeast monsoon prevails, with stronger sea winds.
- Less rainfall: It is drier compared to most areas in Taiwan.
- Large temperature difference between day and night: The temperature can differ by up to 5°C within a day.

Characteristics of the Kinmen Bridge

The Kinmen Bridge, connecting Greater Kinmen and Lesser Kinmen, is 5.4 kilometers long. A unique feature of the Kinmen Bridge is that it is illuminated every evening from 6 PM onwards. This illumination is essential for us to conduct research on cloud reflection phenomenon.

Geographic Location Brief

Kinmen, surrounded by the sea on all sides, is located in the Taiwan Strait, adjacent to the southeastern coast of mainland China, and is a county of Taiwan. Kinmen faces Xiamen City across the sea and is only 1.8 kilometers away from Jiaoyu in Xiang'an District, People's Republic of China, and 210 kilometers away from the main island of Taiwan. The Kinmen Islands include 12 islands of various sizes, such as Kinmen Main Island, Little Kinmen (Lieyu), Dadan, and Erdan. The total area is 151.656 square kilometers. The island is narrow in the middle, only 3 kilometers wide; the east and west ends are wider, about 20 kilometers wide, resembling a dumbbell in shape. Kinmen's latitude is similar to that of Taichung in Taiwan, and it has a subtropical maritime climate. Kinmen is surrounded by the sea on all sides, without high mountains to block it, so the wind is strong. In summer, there are southwest sea breezes, and thick fog often occurs in March and April.



	press						Temperature					Dew Point	
觀測時間 (day)	測站氣壓 (hPa)	海平面氣壓 (hPa)	測站最高氣壓 (hPa)	測站最高氣壓時間 (LST)	測站最低氣壓 (hPa)	測站最低氣壓時間 (LST)	氣溫 (℃)	最高氣溫 (℃)	最高氣溫時間 (LST)	最低氣溫 (℃)	最低氣溫時間 (LST)	露點溫度 (℃)	相對濕度 (%)
ObsTime	StnPres	SeaPres	StnPresMax	StnPresMaxTime	StnPresMin	StnPresMinTime	Temperature	T Max	T Max Time	T Min	T Min Time	Td dew point	RH
01	1011.4	1015.7	1013.9	2025/02/01 00:15:00	1008.8	2025/02/01 15:33:00	15.7	22.4	2025/02/01 11:26:00	12.9	2025/02/01 04:19:00	13.2	86
02	1013.1	1017.5	1014.9	2025/02/02 22:18:00	1010.8	2025/02/02 15:15:00	14.5	19.9	2025/02/02 14:00:00	11.9	2025/02/02 03:44:00	10.7	79
03	1018.1	1022.5	1022.7	2025/02/03 23:56:00	1014.9	2025/02/03 00:01:00	11.7	14.4	2025/02/03 13:29:00	9.9	2025/02/03 22:28:00	7.9	78
04	1020.5	1024.9	1022.8	2025/02/04 07:58:00	1017.6	2025/02/04 16:09:00	11.3	17.7	2025/02/04 13:48:00	8.6	2025/02/04 06:32:00	3.0	58
05	1018.2	1022.6	1020.5	2025/02/05 00:50:00	1015.2	2025/02/05 15:19:00	12.9	19.6	2025/02/05 14:35:00	6.9	2025/02/05 07:06:00	3.5	55
06	1017.1	1021.5	1018.8	2025/02/06 09:09:00	1014.7	2025/02/06 14:53:00	14.4	17.7	2025/02/06 14:12:00	12.2	2025/02/06 23:52:00	6.3	59
07	1020.6	1025.0	1024.3	2025/02/07 23:48:00	1018.1	2025/02/07 02:13:00	12.1	16.2	2025/02/07 12:14:00	10.6	2025/02/07 23:56:00	8.1	77
08	1023.9	1028.3	1025.8	2025/02/08 09:50:00	1021.1	2025/02/08 15:36:00	9.8	14.3	2025/02/08 13:07:00	6.2	2025/02/08 23:20:00	1.8	58
09	1023.3	1027.7	1025.7	2025/02/09 00:57:00	1019.4	2025/02/09 15:25:00	9.4	16.1	2025/02/09 13:32:00	5.2	2025/02/09 06:08:00	-0.6	51
10	1020.9	1025.3	1023.5	2025/02/10 00:01:00	1017.5	2025/02/10 15:53:00	12.1	19.0	2025/02/10 13:43:00	7.0	2025/02/10 06:52:00	4.1	59
11	1017.8	1022.2	1020.4	2025/02/11 00:01:00	1014.6	2025/02/11 15:00:00	15.4	22.8	2025/02/11 13:40:00	11.1	2025/02/11 01:30:00	10.6	74
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13	1018.5	1022.9	1020.9	2025/02/13 10:01:00	1016.6	2025/02/13 01:48:00	12.4	16.2	2025/02/13 00:47:00	10.4	2025/02/13 23:08:00	9.3	82
14	1016.4	1020.8	1019.4	2025/02/14 00:07:00	1013.5	2025/02/14 15:55:00	14.4	21.0	2025/02/14 13:49:00	10.7	2025/02/14 00:01:00	9.5	73
15	1012.9	1017.3	1015.6	2025/02/15 00:01:00	1009.8	2025/02/15 16:14:00	14.6	19.4	2025/02/15 14:21:00	11.9	2025/02/15 04:29:00	12.5	88
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18	1021.0	1025.4	1022.9	2025/02/18 09:15:00	1019.2	2025/02/18 15:41:00	13.5	17.1	2025/02/18 11:51:00	11.9	2025/02/18 06:42:00	5.1	57
19	1021.1	1025.4	1022.5	2025/02/19 07:20:00	1019.0	2025/02/19 15:35:00	14.9	20.3	2025/02/19 13:25:00	11.9	2025/02/19 00:01:00	8.2	65
20	1020.5	1024.9	1022.0	2025/02/20 09:10:00	1018.0	2025/02/20 15:57:00	14.5	17.3	2025/02/20 13:29:00	12.4	2025/02/20 23:59:00	9.7	73
21	1022.3	1026.7	1024.6	2025/02/21 23:18:00	1020.5	2025/02/21 14:38:00	12.9	16.7	2025/02/21 14:21:00	11.4	2025/02/21 22:14:00	7.8	71
22	1022.7	1027.1	1024.5	2025/02/22 23:49:00	1020.4	2025/02/22 14:51:00	13.7	18.7	2025/02/22 12:22:00	11.6	2025/02/22 01:06:00	8.2	70
23	1025.2	1029.6	1028.1	2025/02/23 22:37:00	1023.0	2025/02/23 04:24:00	12.6	16.9	2025/02/23 12:55:00	10.3	2025/02/23 23:04:00	9.0	79
24	1027.4	1031.9	1030.1	2025/02/24 09:41:00	1024.9	2025/02/24 14:53:00	11.9	16.9	2025/02/24 13:39:00	9.6	2025/02/24 23:56:00	4.2	60
25	1024.5	1028.9	1027.6	2025/02/25 00:12:00	1021.7	2025/02/25 16:39:00	13.3	19.8	2025/02/25 13:02:00	9.2	2025/02/25 00:21:00	7.2	68
26	1021.5	1025.8	1023.9	2025/02/26 00:01:00	1018.9	2025/02/26 15:34:00	13.6	16.5	2025/02/26 12:53:00	11.5	2025/02/26 00:11:00	10.8	84
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28	1015.2	1019.5	1017.6	2025/02/28 09:14:00	1013.3	2025/02/28 16:14:00	15.9	22.7	2025/02/28 14:27:00	11.7	2025/02/28 05:09:00	13.4	86

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01	1013.0	1017.3	1015.8	2025/03/01 09:32:00	1010.9	2025/03/01 16:39:00	18.5	24.9	2025/03/01 12:38:00	14.9	2025/03/01 00:02:00	15.6	84
02	1010.3	1014.5	1012.3	2025/03/02 09:01:00	1008.2	2025/03/02 15:42:00	20.4	26.1	2025/03/02 12:26:00	16.7	2025/03/02 00:52:00	18.6	90

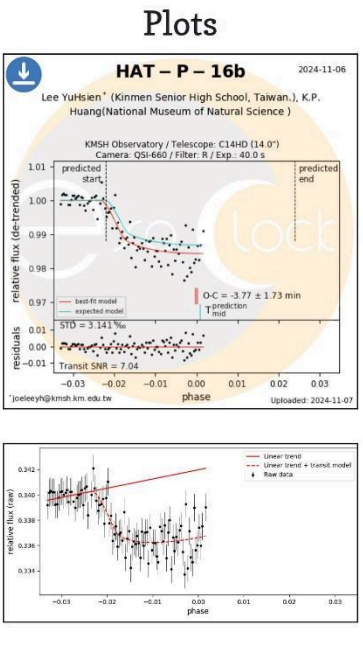
Our Astronomical Observation Highlights Log

From October to December, in addition to photographing my research targets, our teacher sometimes also captures exoplanets when the weather is good. By combining the exoplanet images with cloud charts and explanations, we aim to share the meteorological data we observe during our astronomical research.

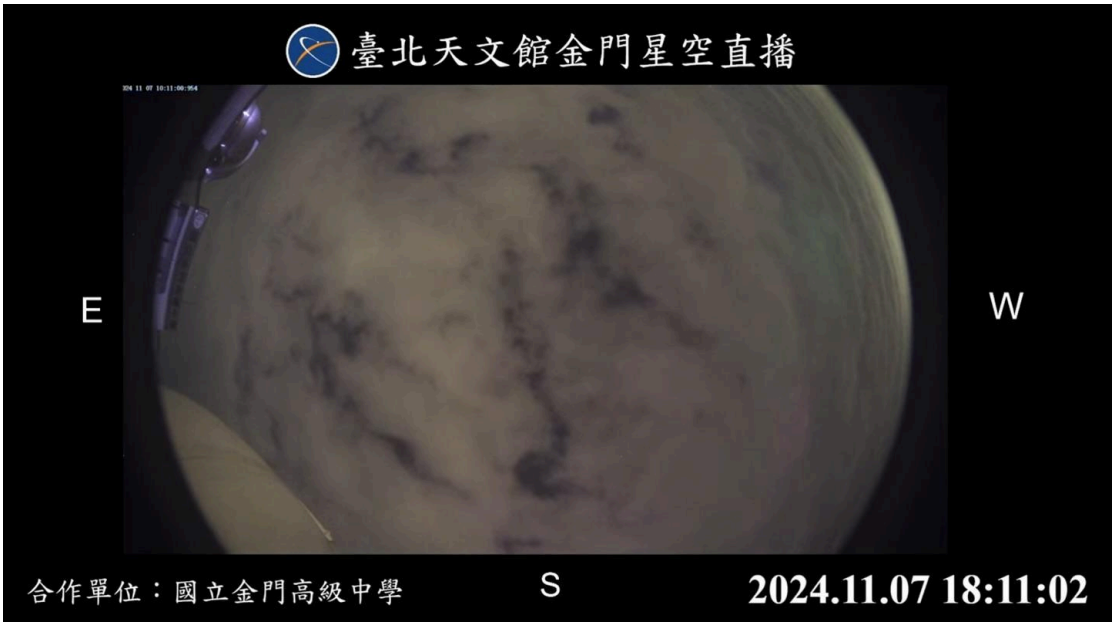
Oct 15: While observing on the rooftop, we accidentally captured a rocket from China (Kinmen is very close to China.) The clear exhaust trail is visible in the photo. In the lower right corner of the image, the city reflections from the Xiamen area are also clearly visible, suggesting that the cloud cover was low that day.

Oct 25: On this day, a lecturer came to give a talk about comets. After researching the data, we found that the cloud height on that day was about 4,900 feet, indicating low cloud cover. The clouds were thin, allowing the laser pointer to penetrate through easily.

Nov 06: After nightfall, our teacher observed an exoplanet. Due to strong winds after midnight, only the first half of the night was observed, but the observation was successful! This indicates that the cloud cover at our school can sometimes appear just in time.

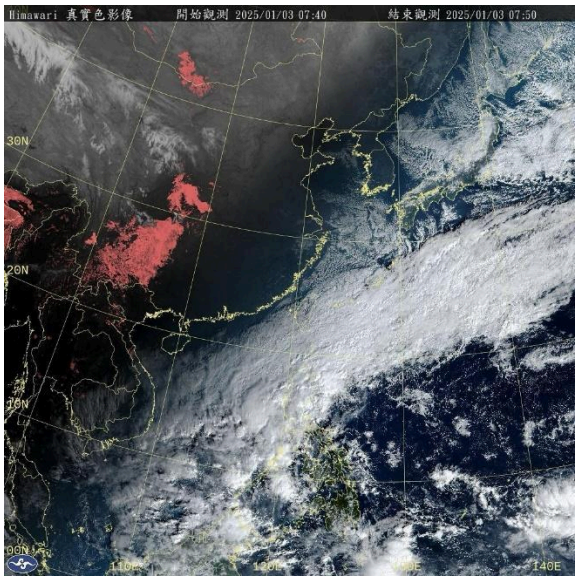


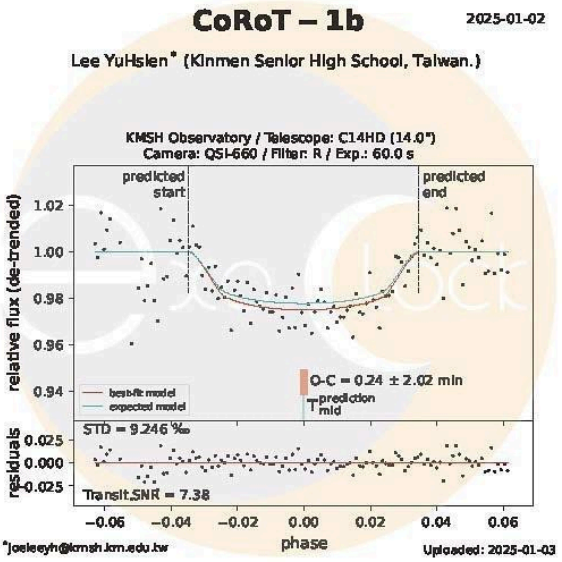
Nov 07: Today, we checked the fisheye camera's footage and noticed a reflection on the clouds. It turns out that the cloud cover was also low on this day. After checking the data, we found that the cloud height was about 5,300 feet.



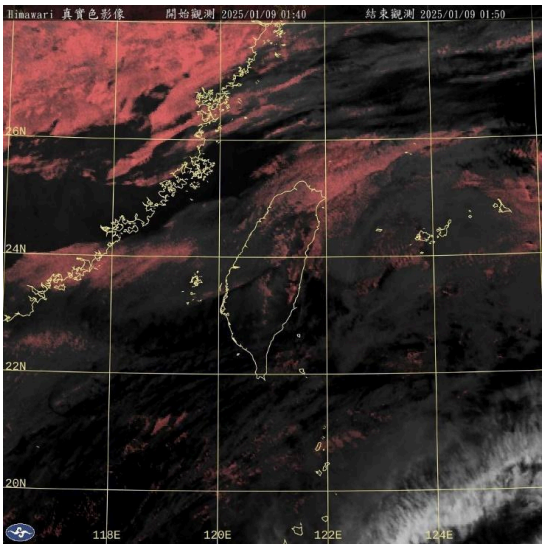
Nov 29: Today was the observatory's open day. The sky was clear and cloudless in the evening, and our teacher took everyone to the rooftop to watch the stars.

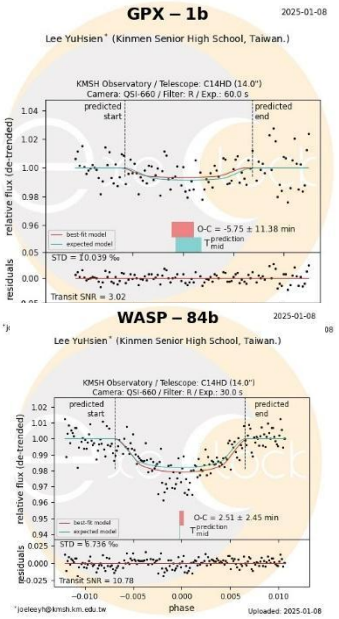
Jan 2: While observing our research targets, our teacher selected an exoplanet for observation. Kinmen was fortunate to remain on the edge of a cold high-pressure system, maintaining good sky conditions, which are expected to last until the peak of the Quadrantids meteor shower, giving us the opportunity to see at least one meteor.



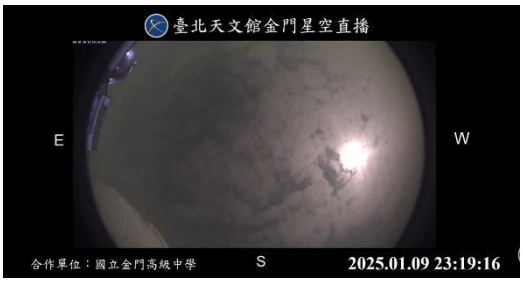


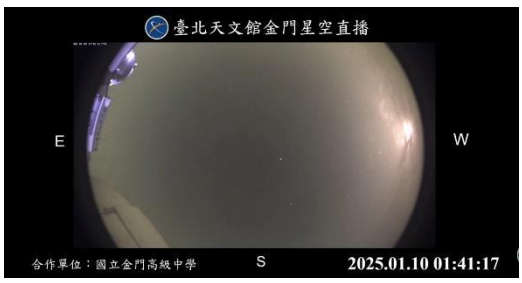
Jan 8: After observing an exoplanet in the first half of the night, we noticed that the weather remained clear, so we successfully switched targets and observed a second exoplanet. Except for Kinmen, all other areas were covered with clouds, indicating that our school has more opportunities to observe the sky through cloud gaps compared to other regions in Taiwan.

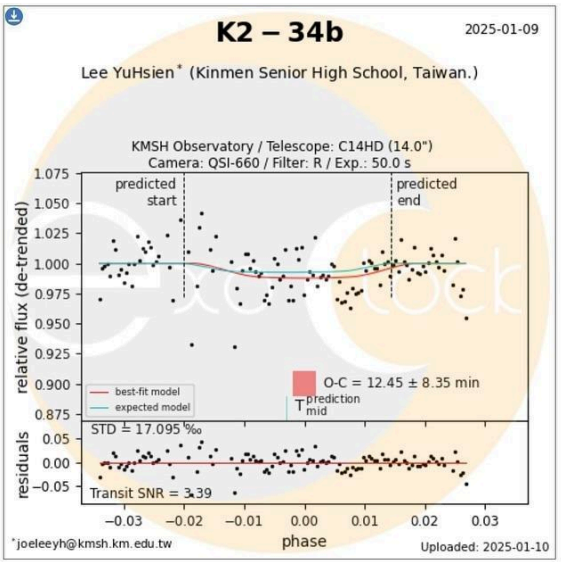




Jan 09: In the second half of the night, Kinmen was between cloud gaps. We selected a target to challenge the poor observation conditions of moonlight, air pollution, and thin clouds. The initial analysis results were not ideal. However, after spending some time making multiple adjustments, we finally found usable observation data. Additionally, it was observed that the reflection of the Kinmen Bridge was not very noticeable on this day.

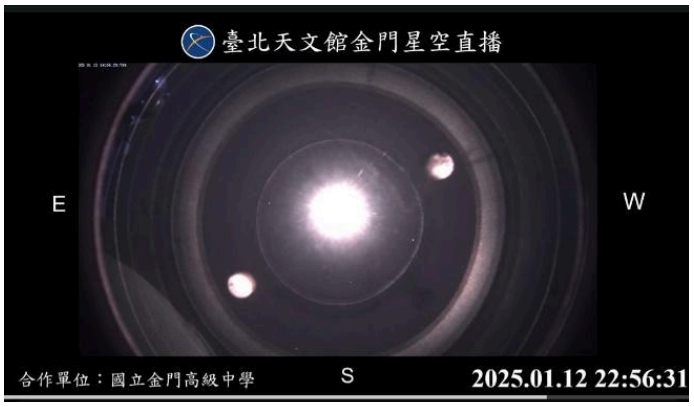


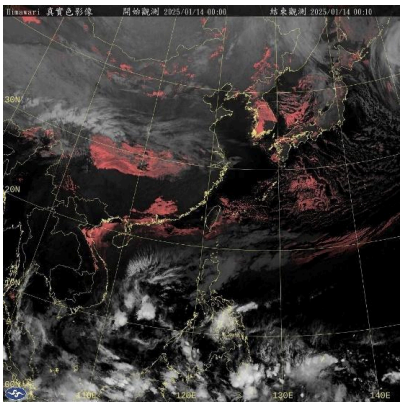




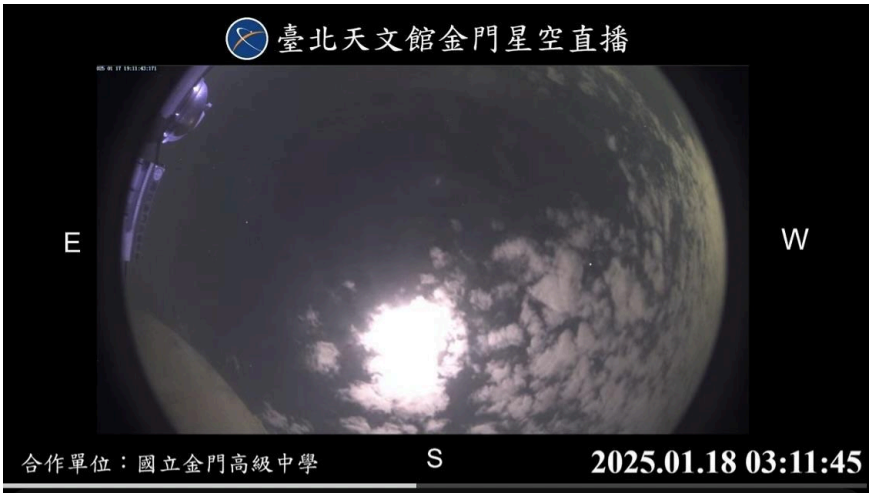
Jan 12: Under the influence of a cold high-pressure system, the sky conditions were ideal.

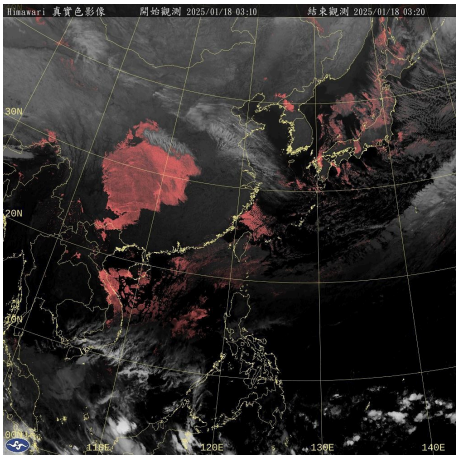
However, during the full moon, when the moon was at the zenith, the surveillance footage displayed some interesting visuals.

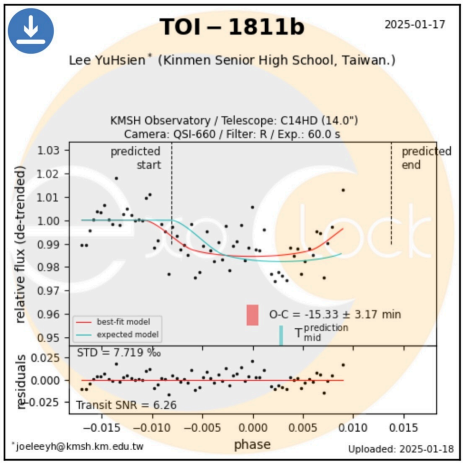




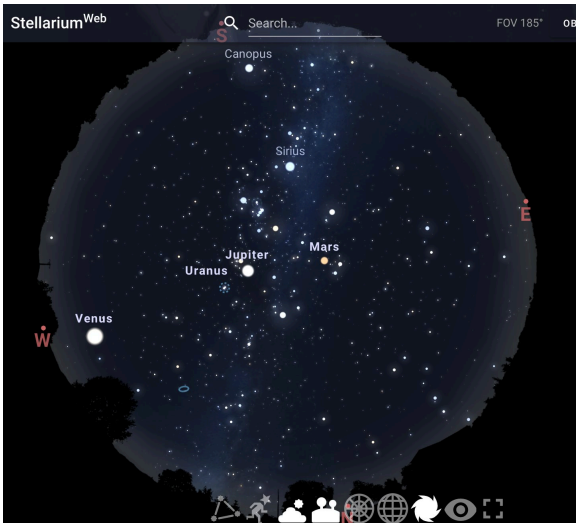
Jan 18: The sky was clear, but the clouds appeared very quickly, interrupting the observation of the selected target. However, after multiple analyses by the teacher, the observation results were still deemed acceptable for use in the database.





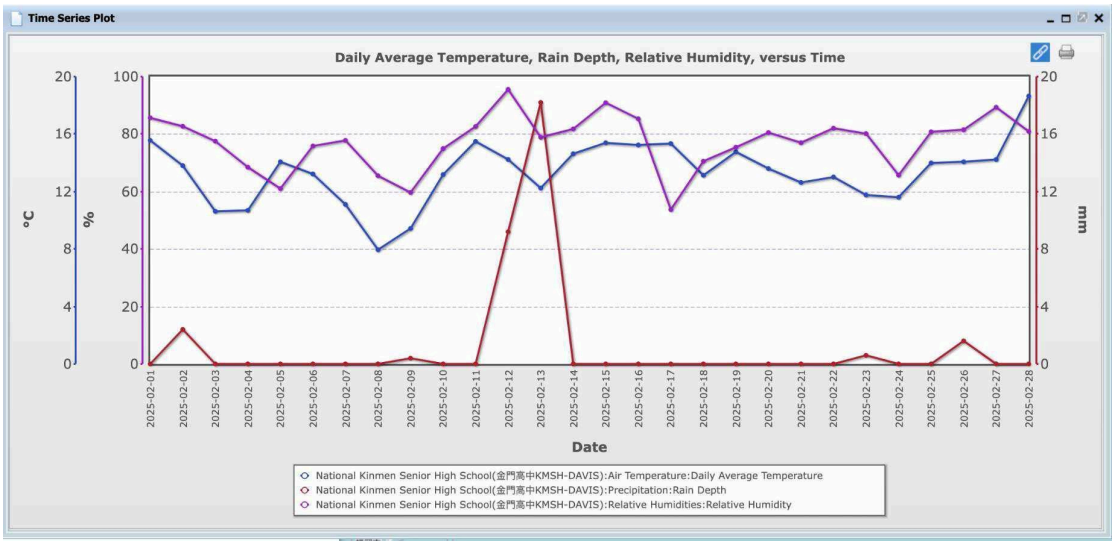


Feb 28: A rare astronomical event occurred, where seven planets from the solar system appeared simultaneously in the sky. The planets formed an arc when connected. Venus, Jupiter, and Mars were clearly visible in the photo, while Uranus and Neptune were farther away. Mercury and Saturn, at low angles, were difficult to see due to the thick atmosphere.



Weather Data from Our School's Automatic Weather Station

The following is the average temperature, humidity, and rainfall for Kinmen in February.

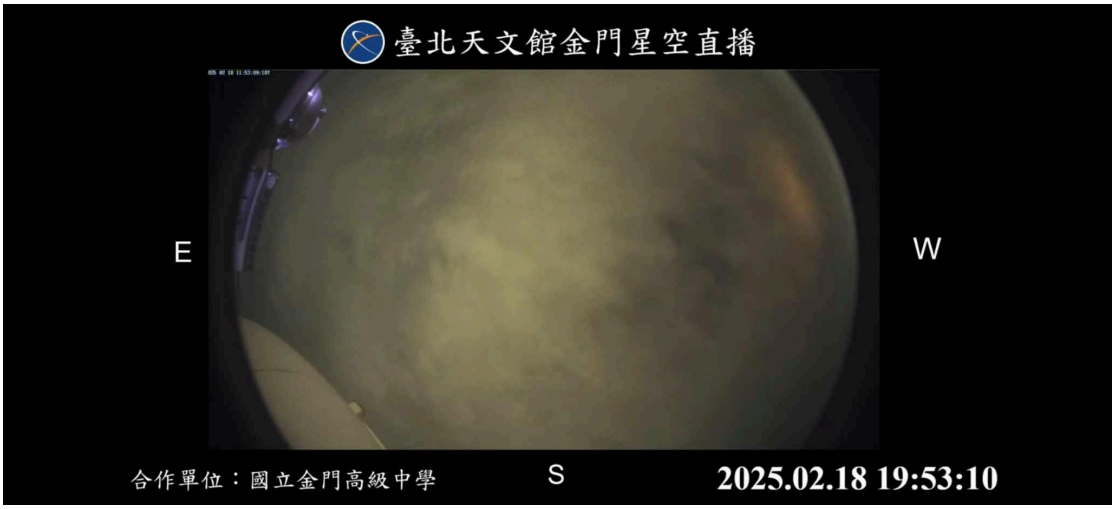


The above graph displays the weather data from Kinmen High School's weather station. According to the line graph, the temperature and humidity in late February were relatively stable, with no significant fluctuations. Apart from sporadic rainfall from February 11th to 14th, there was virtually no rain on the other days

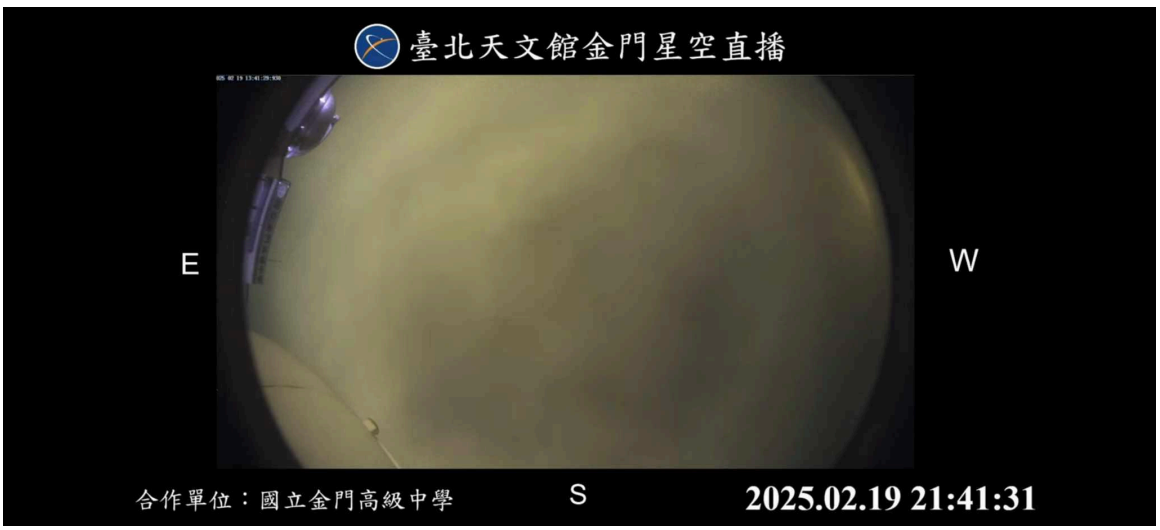
Research Process

During the observation period in late February, we selected screenshots from the fisheye camera when the weather was better and recorded the weather data for that day. We attempted to identify the correlation between the position of cloud reflections and the weather conditions. The reflection positions are roughly divided into three categories based on their distance from the western side: low, medium, and high positions.

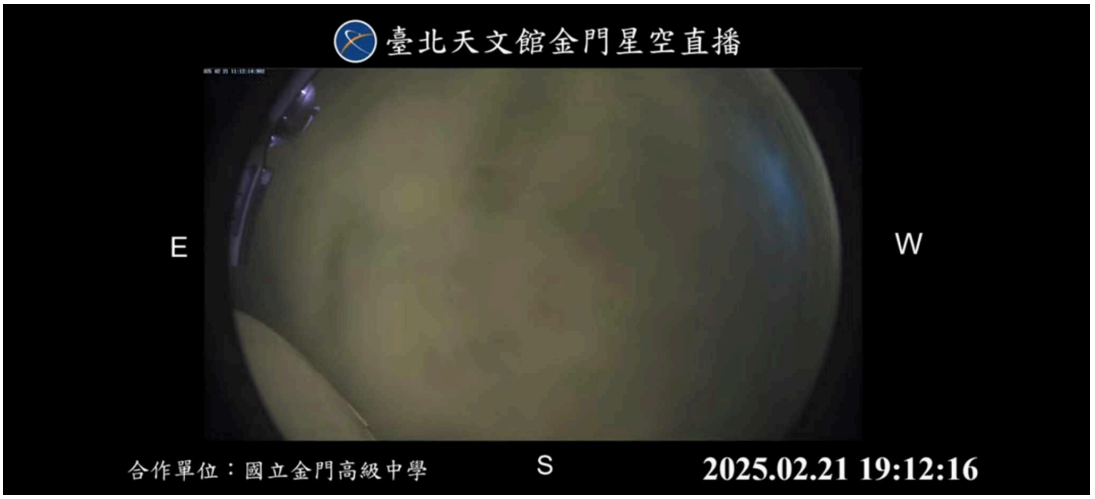
Feb 18
Temperature: 13.3°C
Humidity: 72%
Reflection Position: Medium



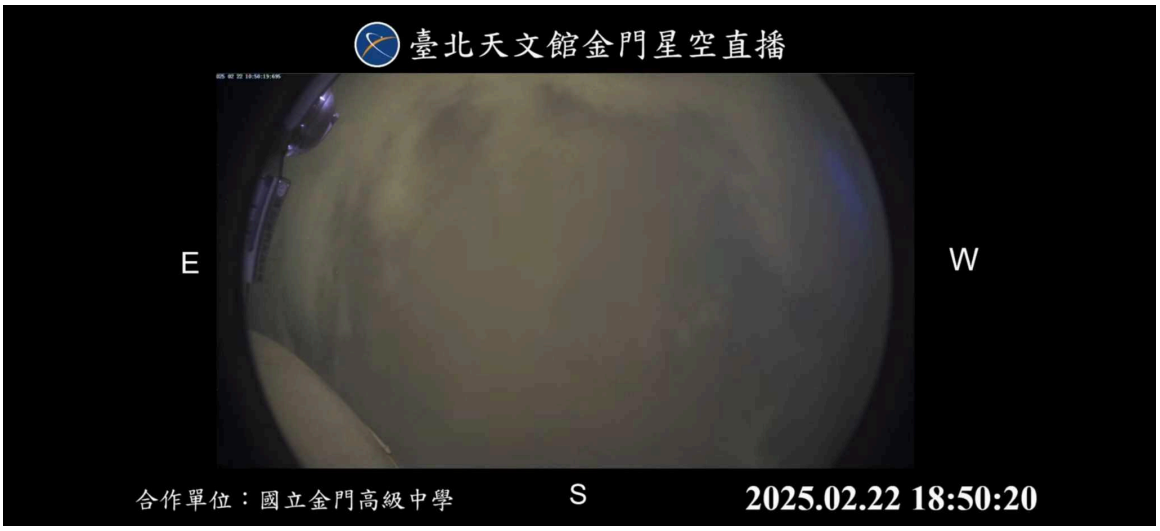
Feb 19
Temperature: 15.4°C
Humidity: 77%
Reflection Position: Low



Feb 21
Temperature: 12.8°C
Humidity: 79%
Reflection Position: High

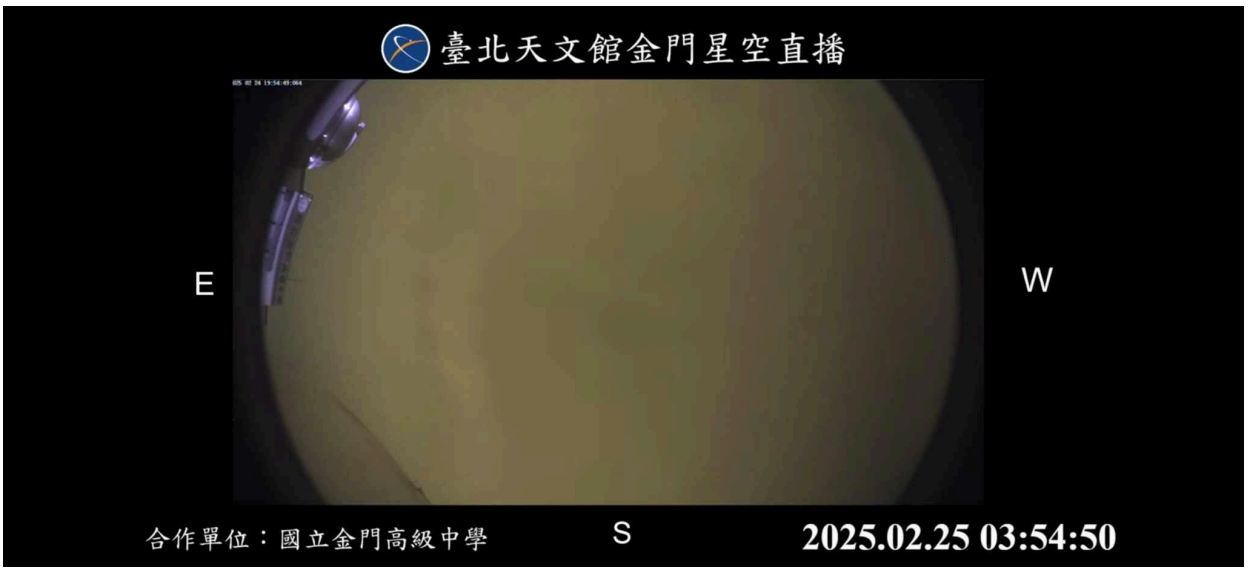


Feb 22
Temperature: 13.1°C
Humidity: 82%
Reflection Position: Medium

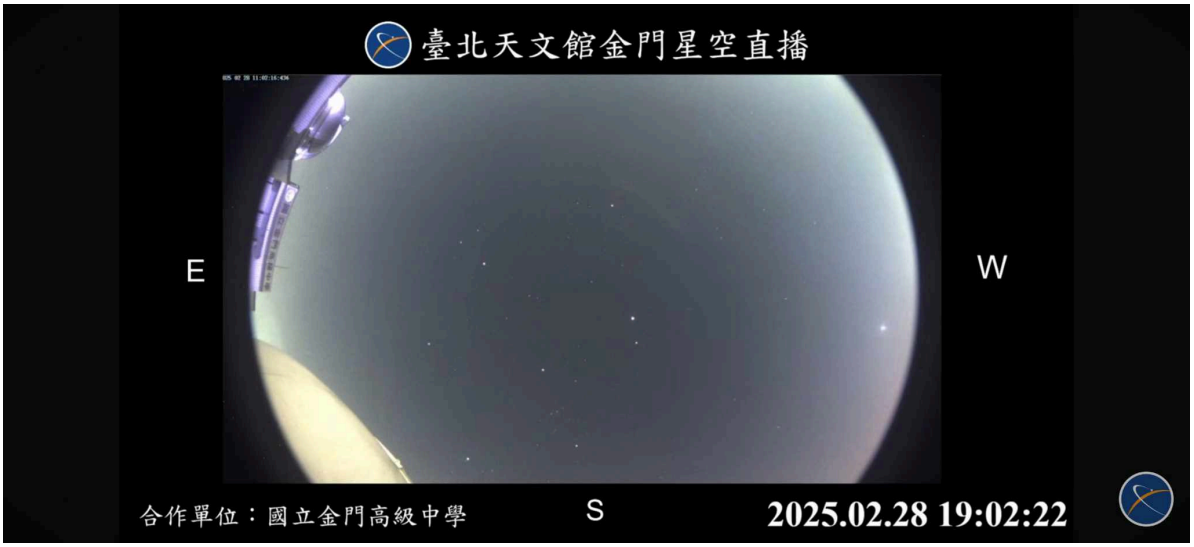


Feb 24
Temperature: 13.1°C
Humidity: 59%
Reflection Position: No clouds

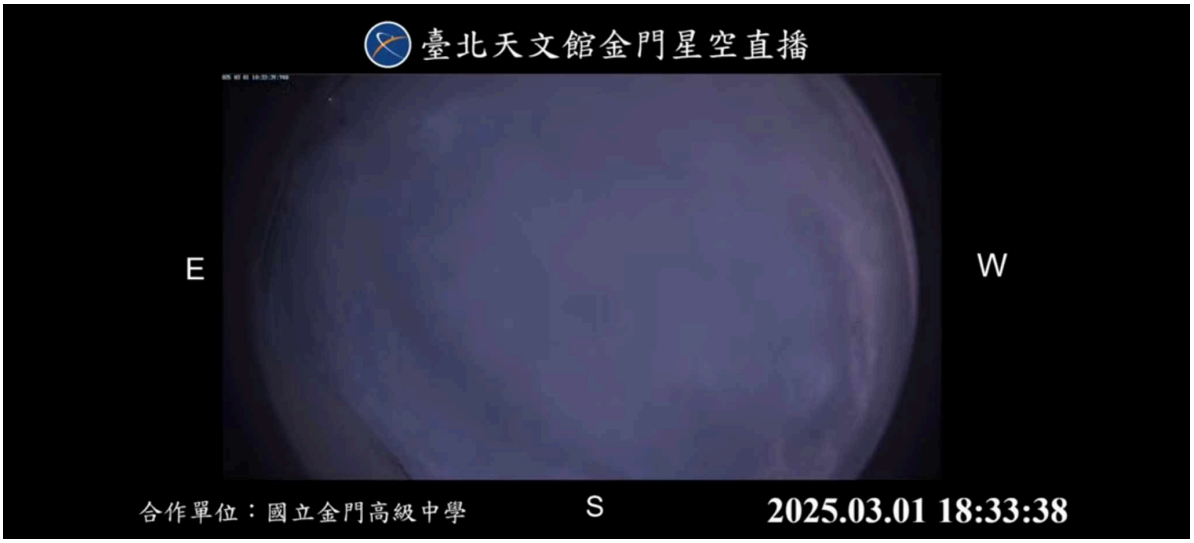
Feb 25
Temperature: 14.1°C
Humidity: 80%
The sky was foggy, and no reflection was visible.



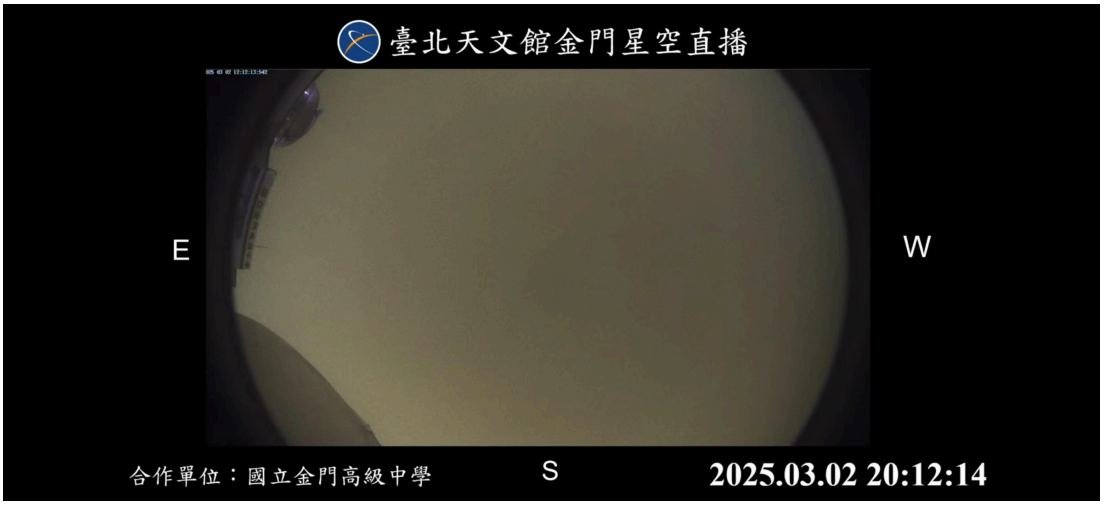
Feb 28
Temperature: 18.8°C
Humidity: 80%
Reflection Position: No clouds



Mar 1
Temperature: 17.2°C
Humidity: 75%
Reflection Position: Low (foggy)

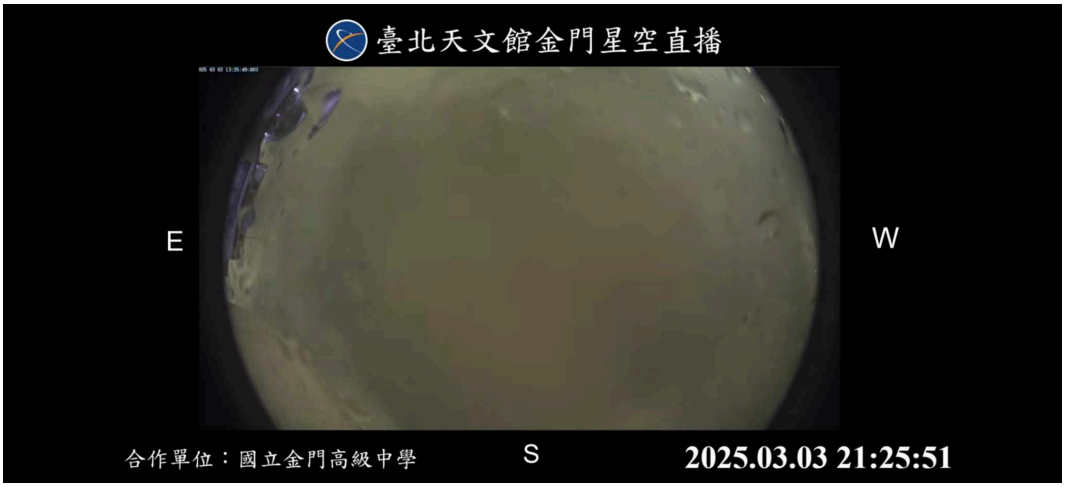


Mar 2
Temperature: 17.8°C
Humidity: 88%
The sky was foggy, and no reflection was visible.



Mar 3

Temperature: 18.2°C
Humidity: 100%
Due to the humid weather and rare rainfall, cloud reflections are not visible.



Discussion

If the weather is good, the cloud height is related to the position of the reflection. The higher the cloud layer, the further the light spot is from the western horizon. By observing the reflection positions in the fisheye camera images, it is apparent that the reflection is relatively low. Combining this with the weather data, it can be inferred that Kinmen, due to local weather conditions and terrain, typically experiences low-level clouds. However, the reflection from the Kinmen Bridge only provides a rough indication of the cloud height. In the future, if opportunities arise, we hope to find a more accurate method of observation.

When the lower atmosphere is very humid, on rainy or foggy days, the air near the ground contains a large amount of moisture, which makes it easier for stratus clouds (low-level clouds) to form. If the ground temperature drops and the humidity in the air increases, stratus clouds may thicken downward. In more stable atmospheric conditions, low-level clouds can also develop over cold seas. When the cloud base reaches the ground or sea level, it transforms into fog. Conversely, when the ground is heated by sunlight and the humidity in the air decreases, dense fog will thin and rise, forming low-level clouds.

When warm, moist air flows over a cooler surface, the air temperature near the ground drops, and the water vapor becomes saturated, which makes "advection fog" more likely to form. In the northwest part of the Taiwan Strait, during winter, the cold air from the northern Chinese coast lowers the sea temperature. When the weather briefly warms in winter and spring, warm air flows into the cooler northern part of the Taiwan Strait, causing frequent fog in Kinmen. Kinmen enters its fog season in February, and the light is unable to penetrate the cloud layers, which is why no reflection is visible.

Conclusion

From this work, it can be preliminarily concluded that under favorable weather conditions, the position of the reflection can be used to roughly determine the altitude of the clouds.

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