Journal of Astronomical History and Heritage, 26(2), 353–366 (2023).

COMETARY RECORDS IN THE VIETNAMESE OFFICIAL HISTORY *ĐẠI NAM THỰC LỤC [CHÍNH BIÊN]*

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Abstract: This paper presents ten cometary records found in the *Đại Nam Thực Lục [Chính Biên]* (大南寔録 [正編]), which is the main volume of the official history of Vietnam's Nguyễn Dynasty. The paper provides the original classical Chinese texts and their English translations, along with the designated names of the comets mentioned in these records. The study primarily focuses on four of these records, which are analysed by comparing their descriptions with the results obtained using astronomical simulation software. The four comets examined are C/1811 F1 (The Great Comet of 1811), C/1825 N1 (Pons), C/1843 D1 (The Great March Comet of 1843), and C/1861 J1 (Tebbutt, or The Great Comet of 1861). This paper discusses the descriptions from some perspectives, such as the reliability of these descriptions and the effect of Vietnam's low-latitude position on observations.

Keywords: Historical records, comets, Vietnam. *Đại Nam Thực Lục*, astronomical simulation

1 INTRODUCTION

Historical documents from ancient, medieval, and pre-modern periods in China, Korea, and Japan are well-known for containing numerous astronomical records. Similarly, some Vietnamese historical sources also include a considerable number of records of astronomical phenomena. For instance, Ho (1964) and Okazaki and Yokoo (1983) found astronomical records in Vietnamese sources. A few studies have been published so far examining these records by comparing them with the results obtained using modern astronomical computations: Okazaki and Tanokura (2011) examined lunar occultation and planetary phenomena records, and Okazaki (2021) examined solar and lunar eclipse records. However, only a few studies have been published examining cometary records in Vietnamese historical sources.

This study focuses on cometary records contained in the *Main Volumes [Chính Biên* (正編)*]* of the *Đại Nam Thực Lục* (大南寔録, the *Veritable Record of the Great South*, hereafter *ĐNTL-CB*). The *ĐNTL* is the official history of the Nguyễn Dynasty, which ruled Vietnam from 1802 onwards. In the nineteenth century, the Dynasty continued to adopt traditional astronomical observation systems, which were largely modelled on those of China, as did Korea and Japan (the latter until the late nineteenth century). On the other hand, in the Western world, many comets were observed more accurately with modern astronomical instruments during the same century, providing reliable orbital elements for these comets. This enables us to examine the descriptions of cometary records in the *ĐNTL-CB* in detail by comparing them with the results of astronomical simulations based on these elements.

During the times when China, Vietnam, Korea and Japan adopted very similar traditional astronomical observation systems, official documents of these countries were written in classical Chinese. This means that the same technical terms were used to describe astronomical phenomena among these four countries. Hence, it is interesting to compare the descriptions of records of the same comet between Vietnam and the other three countries from the viewpoint that Vietnam is located in the most Southern and advantageous position for observing the Southern sky among these countries. It is noted that, in the nineteenth century, the Nguyễn Dynasty introduced a new calendar system from China and constructed a new Royal Observatory to advance astronomy in Vietnam (see Phạm and Lê, 2020).

In Section 2, we present the cometary records compiled in our investigation. In Section 3, we compare the depictions of some of these records with the results of astronomical simulations and discuss these descriptions from various perspectives. Lastly, we provide our Concluding Remarks in Section 4.

2 COMETARY RECORDS FOUND IN THE *ĐNTL-CB*

As far as we know, no comprehensive survey results have been reported on astronomical phenomena in the *ĐNTL-CB*, aside from solar and lunar eclipses (Okazaki, 2021). Therefore, we conducted a survey to identify cometary records by using a facsimile edition of an original block print of the *ĐNTL* up to 1888 (up to Annals No.6) titled *Dainanjitsuroku (大南寔録* or *Chronicle of Nguyen Dynasty)*, which was published by the Institute of Cultural and Linguistic Studies at Keio University (1961–1981) in Tokyo, Japan.

Table 1: Basic information described in the cometary records found in the *ĐNTL-CB*.

No.	Appearance Date	Visibility Period	Corresponding Comet
1	18 September–16 October 1811	---	C/1811 F1 (Great Comet of 1811)
2	1 October 1825	70–80 days	C/1825 N1 (Pons)
3	19 March 1843	10 days	C/1843 D1 (Great March Comet)
4	19 June–17July 1860	–-	C/1860 M1 (Great Comet of 1860)
5	28 Jun 1861	56 days	C/1861 J1 (Tebbutt, Great Comet of 1861)
6	26 June–25 July 1881	6 + 7 days	C/1881 K1 (Great Comet of 1881)
7	26 July–25 August 1881	23 days	C/1881 N1 (Schaeberle)
8	12 September–11 October 1882	3–4 months	C/1882 R1 (Great September Comet)
9	9 January–7 February 1883	3 days	C/1883 D1 (Brooks-Swift Comet)
10	6 December 1885–4 January 1886	---	C/1885 X2 (Barnard)

Our inquiry yielded ten cometary records in the *ĐNTL-CB*, all of which are presented in the Appendix (at the end of this paper), along with their original texts and their English translations. Table 1 contains information on the appearance dates and visibility periods described in these records, as well as the designations of the corresponding comets. To convert Vietnamese calendar dates into Gregorian calendar dates, we employed Lê's (2020) table. We determined the designations of the comets that are mentioned in the records by comparing the described visibility period of the comets in the *ĐNTL-CB* records with those in Kronk's (2003) *Cometography*. Additionally, if necessary, we compared the described sky positions and visibility period of the comets with those obtained by the simulation mentioned later.

3 EXAMINATION OF SOME OF THE COLLECTED RECORDS

In this Section, we will examine the descriptions of records Nos. 1–3, and 5 in the subsequent Subsections. To assess how each comet was observed from the capital, Huế (16.5° N, 107.6° E), on the date(s) described in each record, we utilized the astronomical simulation software program *StellaNavigator 12* (AstroArts) with the orbital element values provided in the *SBDB*.[1]

The cometary total magnitude, m, was calculated using the formula introduced by Vsekhsvyatskii (1964), which has three parameters: the cometary absolute magnitude (H_{10}) and the heliocentric (r) and geocentric distances (Δ) of the comet. Thus,

$$H_{10} = m - 5\log\Delta - 10\log r \qquad (1)$$

Values for H_{10} were obtained from a table by Vsekhsvyatskii et al. (1999) with an uncertainty of 0.1 to 1.0 magnitude. It should be noted that the actual magnitudes of comets do not always conform exactly to equation (1) and can sometimes exhibit significant discrepancies. Therefore, the computed magnitude presented in this study should be considered a very rough estimation, and we have rounded these values to the nearest 0.5 magnitude. Furthermore, regarding the observed magnitudes of comets in the nineteenth century, J.E. Bortle (1998) states:

> Since meaningful cometary photometry did not begin until shortly after 1900, magnitudes cited prior to that time must be considered rather approximate.

Therefore, we will keep in mind such uncertainty of both the computed and the observed magnitudes when we discuss cometary brightness in this study.

During this time period, several Chinese characters were commonly used to represent comets. In the *ĐNTL-CB,* we found two cases: 彗星 (*hui* star) and 長星 (*zhang* star), which we translated to 'broom star' and 'long star', respectively. Record No.3 describes an appearance of 'white vapour (白氣),' which often represents a comet as well. In fact, the white vapour in this record is interpreted as a comet, as will be discussed in Subsection 3.3. Some of the collected records describe the length of comets using Chinese units. According to some studies (e.g., Wu and Liu, 1990), 1 *chi* (尺), which is equal to 0.1 *zhang* (丈), corresponds to 0.93–1.5°.

3.1 C/1811 F1 (The Great Comet of 1811)

Record No.1 says:

> 10th year of the Gia Long reign period, 8th month (18 Sep–16 Oct 1811), a broom star appeared in the west.

The brief description in this record provides little information. However, considering that no other comets visible to the naked eye during the aforementioned period were listed in the *SBDB*, it is highly probable that the "broom star" mentioned in the record refers to Comet C/1811 F1, also known as The Great Comet of 1811. Our simulation results indicate that the comet was visible in the northwest (rather than the west) in the evening sky over Huế during the above period when the solar altitude was –8°, as shown in Figure 1. The sky brightness at a solar altitude of –8° corresponds approximate-

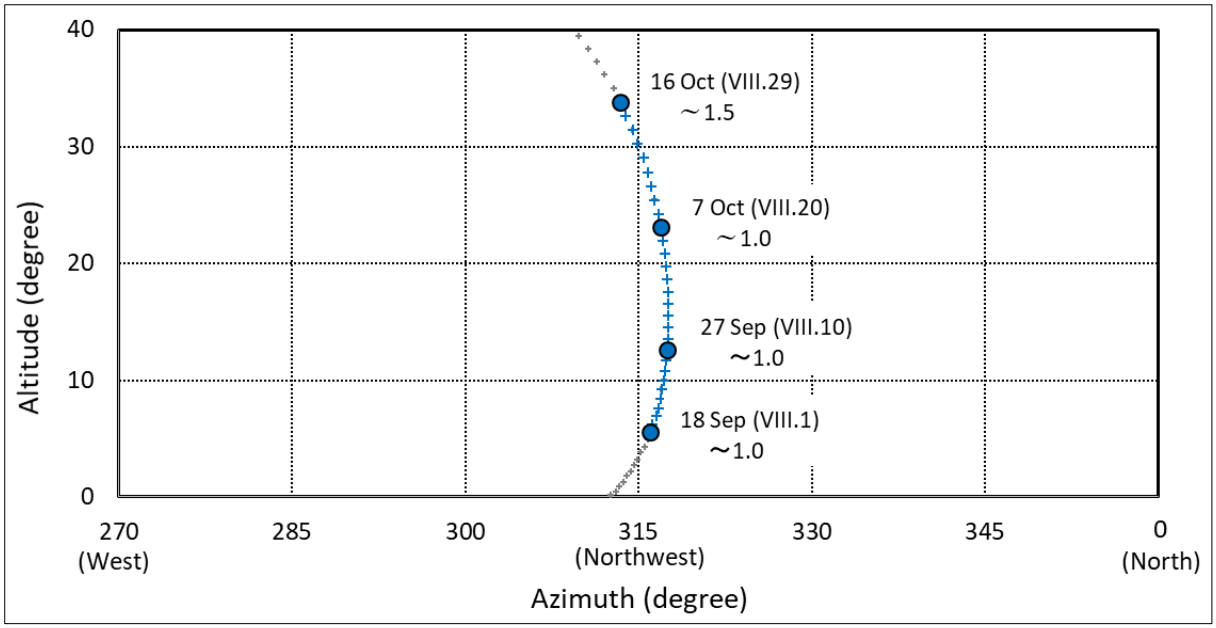

Figure 1: The daily positions of Comet C/1811 F1 in the evening sky over Huế, Blue symbols represent the positions from 18 September to 16 October 1811, when the solar altitude was −8°. The notation with a Roman numeral (e.g., VIII/20) in parentheses indicates the date (e.g., the 20th day of the 8th month) in the Vietnamese calendar. Circles indicate the 1st, 10th, 20th, and last day of the lunar month. A computed magnitude is shown, with a step of 0.5 mag, below each date. See text for details on the magnitude (diagram: Akira Okazaki).

ly to the visibility of 4th magnitude stars (e.g., Bolokrylov et al., 2011).

Bortle (1998) wrote about the appearance of the comet during this period as follows:

> In mid-September, of magnitude 1–2; tail a dozen degrees long. In the beginning of October, visible throughout the night from mid-northern latitudes as a spectacular object situated below the handle of the Big Dipper. Comet's head about first magnitude with a tail spanning up to 25 degrees.

It can be said that the computed magnitudes roughly match those he reported.

3.2 C/1825 N1 (Pons)

Record No.2 describes:

> 6th year of the Minh Mệnh reign period, 8th month, day *jiaxu* (20th day of the month, 1 Oct 1825), a broom star appeared in the southeast in *Mao* lunar mansion, with pointing the northwest.
>
> The broom star persisted for a long time without fading.
>
> However, the broom star gradually became fainter. During the first ten days of the 11th month (10–19 Dec 1825), it disappeared.

Based on the comet list provided the *SBDB*, it is highly likely that the mentioned comet is Comet C/1825 N1 (Pons), as there were no other naked-eye comets visible during the given time frame. Our simulation results suggest that the comet was visible in the sky over Huế towards the east at evening twilight, and in the southeast around midnight on 1 October.

According to Kronk (2003: 72),

> The comet was brightest and best observed during October. Pons said the comet was visible to the naked eye, despite moonlight, on the 1st [of October].

Bortle (1998) wrote about the magnitude of the comet during this period as follows:

> In mid-September, about fourth magnitude … In mid-October, visible most of the night while in Sculptor, at magnitude 2–3 … In early November, apparently an object of magnitude 2–3 in Indus in the southern evening sky. Lost in the evening twilight toward the end of December, when probably still at magnitude 3–4 and located in Sagittarius to the southeast of the sun.

It appears that the calculated magnitudes are systematically approximately 1–1.5 magnitude fainter than those reported.

Our simulation results show that the comet was located in *Wei* lunar mansion instead of *Mao*, which is adjacent to *Wei*, on 1 October, as

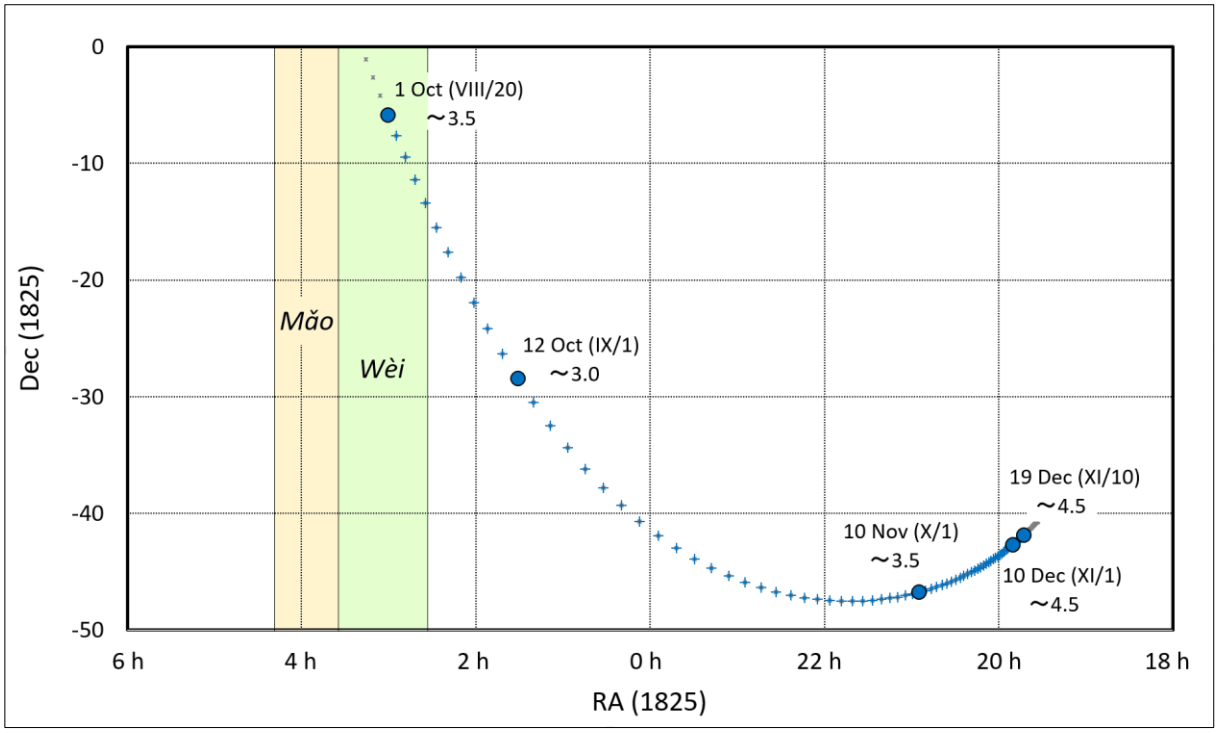

Figure 2: The daily positions of Comet C/1825 N1 in equatorial coordinates at LT = 0h. Blue symbols represent the positions from 1 October to 19 December 1825. Circles indicate the 20th day of the 8th month, the 10th day of the 11th month, and the 1st day of the 9th and 10th months. Zones in yellow and light green indicate the *Mao* and *Wei* lunar mansions, respectively. The date notation and computed magnitudes are the same as those in Figure 1 (diagram: Akira Okazaki).

depicted in Figure 2. The comet moved westward (decreasing in right ascension) during October, with its declination decreasing. On 1 November, the comet reached its most southerly declination (epoch: 1825) of –47.7°, after which its declination slightly increased. However, its declination remained less than –42.8° until 19 December 1825.

While the record states "During the first ten days of the 11th month (10–19 December 1825), it [the comet] disappeared …" Chinese and Japanese records indicate that the comet vanished in the 10th month (10/11 November–9/10 December 1825 for China/Japan), or even earlier in Japan; this comet is not included in the list of Korean historical cometary records compiled by Sekiguchi (1917). While we cannot rule out the possibility that the difference in visible horizons due to the surrounding terrain had an effect, Vietnam's favourable position (Huế is at a latitude of $\phi \sim 16.5°\mathrm{N}$) for observing the Southern sky may account for the difference in the month of disappearance compared to China and Japan, which also employed similar traditional astronomical observation systems. Assuming that the difference in visible horizon can be neglected, we will examine this possibility in more detail below.

According to the *Zhongguo Gudai Tianxiang Jilu Zongji (A Compilation of Chinese Records for Ancient Celestial Phenomena)* compiled by Beijing Astronomical Observatory (1988), three Chinese local gazetteers state that the comet disappeared in the 10th month. The locations were situated in the southern region of China, with $\phi \lesssim 25°\mathrm{N}$. Of these, Xiangshan county is the most southerly located, at $\phi \sim 22.5°\mathrm{N}$. Japanese records show that a diary entry by an individual living in Hirado, situated at $\phi \sim 33.4°\mathrm{N}$, mentions that the comet was visible on the 28th day of the 9th month but later became obscured due to bad weather conditions. When the sky cleared in the mid-10th month, the comet was no longer visible as it had passed below the horizon (Ōsaki, 1994).

Figure 3 shows the positions of Comet C/1825 N1 in the evening sky over Huế and Xiangshan, on 10 November (X/1) and 10 December (XI/1), 1825 during astronomical twilight, i.e., the period from the solar altitude of –12° to –18°. The right vertical axis displays the air mass at sea level, which leads to atmospheric extinction that causes a reduction in the apparent brightness of celestial objects as their light passes through the Earth's atmosphere. We concentrate on the comet's apparent magnitudes affected by atmospheric extinction during astronomical twilight on 10 December (XI/1).

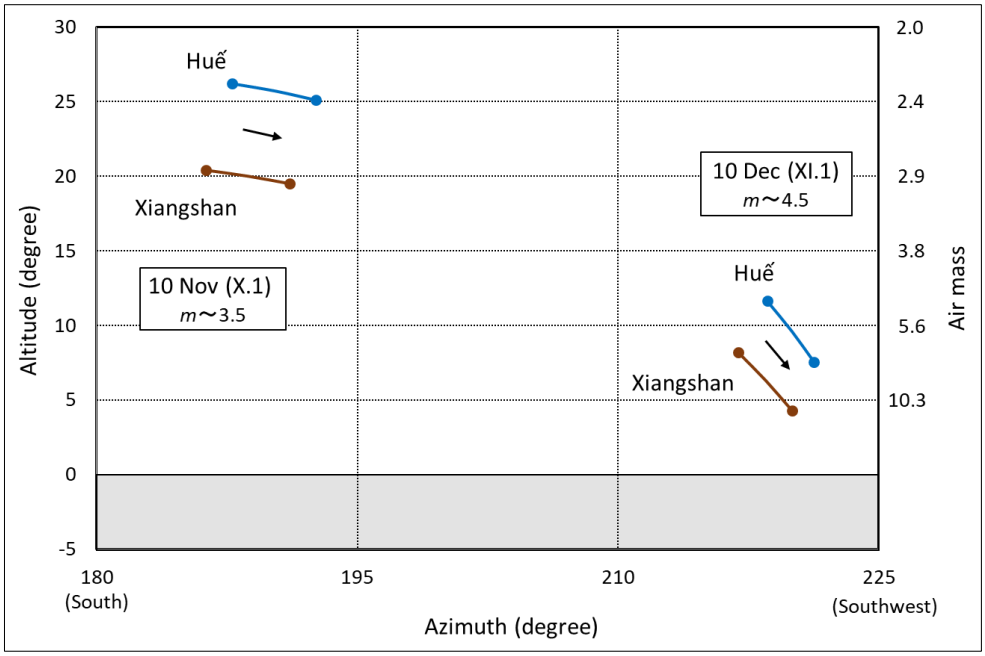

Figure 3: The positions of Comet C/1825 N1 in the evening sky over Huế and Xiangshan during astronomical twilight, i.e., from the solar altitude of –12° to –18° on 10 November (X/1) and 10 December (XI/1) 1825. The right vertical axis displays air mass at sea level. See text for the air mass (diagram: Akira Okazaki).

At the beginning of twilight, when the sky was still slightly bright, the comet's altitude in Huế and Xiangshan were 11.6° and 8.2°, corresponding to air masses of 4.9 and 6.7, respectively. At the end of twilight, when the sky was completely dark in the absence of the Moon, the altitudes in Huế and Xiangshan were 7.5° and 4.3°, corresponding to air masses of 7.3 and 11.7, respectively.

We assume that the comet's magnitude was likely between 3.0 and 4.5, based on Bortle's (1998) estimation of 3–4 mag and the computed magnitude of ∼4.5 mag around 10 December. Assuming a typical atmospheric extinction coefficient of k = 0.2 in the visual light, we estimate the comet's apparent magnitudes affected by the extinction at the beginning and end of astronomical twilight in Huế and Xiangshan. The results of the estimation are as follows: 4.0–5.5 and 4.5–6.0 mag in Huế and 4.3–5.8 and 5.3–6.8 mag in Xiangshan. These magnitudes, particularly towards the end of astronomical twilight, are close to the limiting magnitude visible to the naked eye.

It should be noted that the observed brightness of celestial objects at such low altitudes decreases dramatically towards its setting due to atmospheric extinction. For example, 10 minutes after the end of astronomical twilight, the apparent magnitudes of the comet were 4.6–6.1 mag in Huế and 6.2–7.7 mag in Xiangshan. Although the assumed values used here have some uncertainty, we can conclude that the visibility of faint objects at such low altitudes is significantly affected by a few-degrees difference in altitude. Therefore, we suggest that atmospheric extinction is likely one of the primary factors that could explain the differences in the recorded month of the comet's disappearance between Vietnam and China.

The *ĐNTL-CB* (Annals No. 2, Chapter 34) provides an account of Emperor Minh Mệnh's (Figure 4) response to the appearance of this comet, which can be summarized as follows:

> Upon sighting the comet, the Emperor summoned his officials to the palace and warned them that a disaster had descended from the heavens. He urged them to report everything they had seen and heard, without hiding anything, to enable him to consider aspects he may have overlooked. One of the Royal Astronomers submitted a report stating that, according to ancient books, comets signify either disaster when appearing in the *Mao* and *Wei* lunar mansions, or a good harvest in the country when appearing in the southeast and pointing to the north-west, and since these statements were contradictory, they should not be entirely trusted.
>
> Taking the comet as a warning sign, the Emperor decided to reduce food intake and cease playing music. He in-

> structed his officials to contemplate how to improve themselves to avoid any potential misfortune. He gave the Royal Astronomical Bureau three telescopes and ordered the astronomers to record all observations of celestial phenomena, whether inauspicious or auspicious, truthfully based on what is seen and heard, and reported immediately. Anyone who continues to be cowardly and does not make any discoveries will be punished severely.

This episode highlights three crucial points: Firstly, astrological interpretations of celestial phenomena based on ancient literature significantly influenced the beliefs and actions of the

Figure 4: The second Emperor of the Nguyễn Dynasty of Vietnam Minh Mệnh (or Minh Mạng), r. 1820–1839 (after Crawfurd, 1828: 508/509).

Emperor and his officials. Secondly, in some cases, astronomical reports by the Royal Astronomical Bureau could be affected by astrological considerations. Thirdly, the Emperor recognized the significance of observing celestial phenomena and having accurate information about them immediately.

3.3 C/1843 D1 (The Great March Comet)

Record No. 3 states:

> 3rd year of the Thiệu Trị reign period, 2nd month, day *renchen* (19th day of the month, 19 Mar 1843), a long white vapour stretched across the sky from the northwest to the southeast.
>
> Day *xinchou* (28th day of the month, 28 Mar 1843), the white vapour disappeared. The Astronomical Bureau reported that this white vapour gradually dissipated over the course of two or three nights after its initial appearance, and completely vanished after twelve days. It was never visible again.

Based on the information provided, it is highly plausible that the "white vapour" referred to in this record was Comet C/1843 D1, commonly referred to as The Great March Comet of 1843. Indeed, our simulation results demonstrate that on 19 March, this comet was observable in the western evening sky over Huế, as displayed in Figure 5. No other comets recorded in the *SBDB* were visible to the naked eye throughout March of 1843.

Kronk (2003: 134) provided an account of the appearance of the comet on 19 March when the *ĐNTL-CB* recorded the white vapour, stating:

> On the 19th, Haile said the tail was extending 41.8° and Maclean noted, 'the outline of the comet [was] very plainly marked. The bright spot or condensation in its head was distinctly perceptible to the naked eye'.

Concerning the comet around 28 March when the comet disappeared according to the *ĐNTL-CB*,

> Kay noted the tail was 'much fainter in appearance' on the 27th. F. de Vico (Rome, Italy) said the nucleus was seen to scintillate on the 29th. (ibid.).

On the other hand, Bortle (1998) wrote

> On March 20, the head had faded to about magnitude 4, but the long, straight tail could be traced about 65 degrees. At the end of March, the tail was still nearly 40 degrees long. Comet's head last detected with the naked eye on April 3, but a good portion of the tail was still apparent.

Based on the aforementioned descriptions, it can be deduced that when the *ĐNTL-CB* described the white vapour phenomenon, the magnitude of the cometary head was approximately 4 mag, and the length of the cometary tail was around 40–65°, which is consistent with the computed magnitude. Figure 6, depicting a lithograph that portrays this comet above Paris on 19 March (for the date, see Stoyan 2015, for example), confirms that the comet had

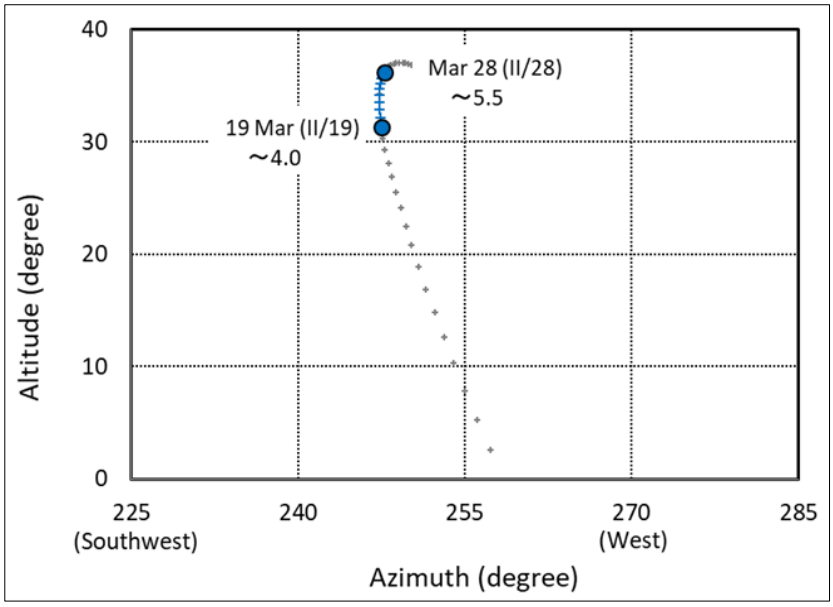

Figure 5: The daily positions of Comet C/1843 D1 in the evening sky over Huế. Blue symbols represent the positions from 19 to 28 March 1843, when the solar altitude was –8°. Circles indicate the appearance and disappearance dates mentioned in the record. The date notation and computed magnitudes are the same as those in Figure 1 (diagram: Akira Okazaki).

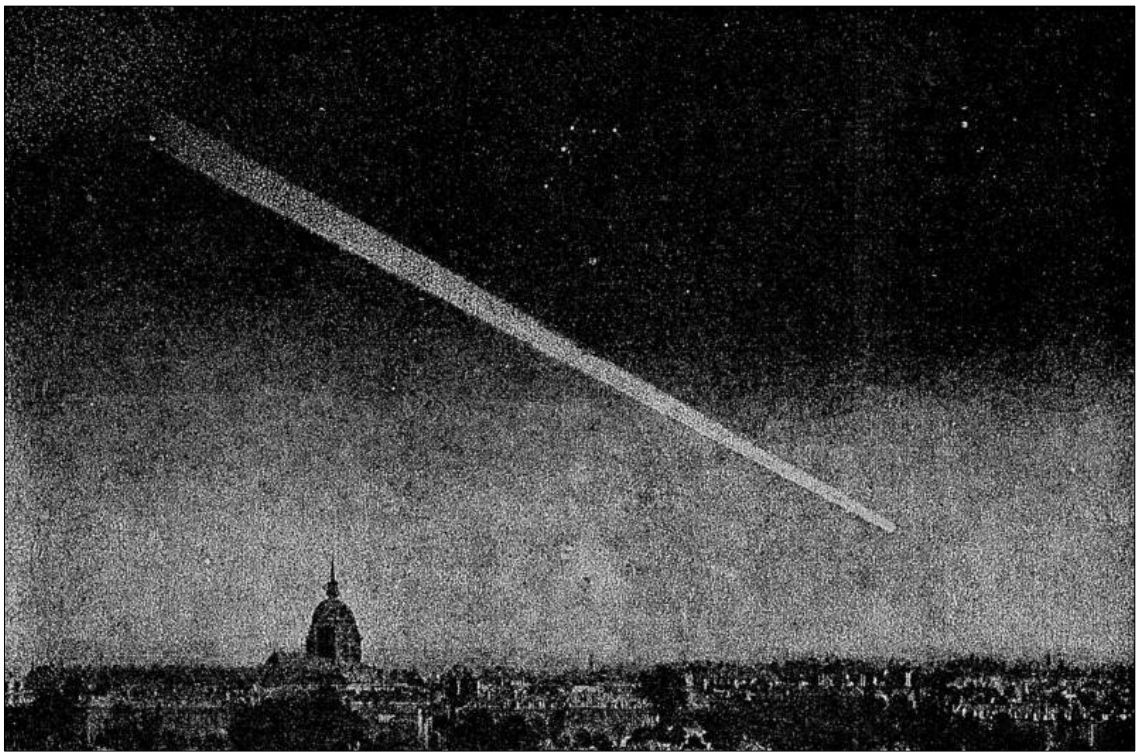

Figure 6: Comet C/1843 D1 above Paris (after Valentiner, 1884: Wikimedia Commons).

a tail that was notably longer than 40°. In fact, the Great March Comet is renowned for having one of the longest tails. Thus, it is not surprising that the *ĐNTL-CB* referred to the comet as "white vapour". Many records of this comet in China and Japan also used the term "white vapour".

3.4 C/1861 J1 (Tebbutt, or The Great Comet of 1861)

Record No. 5 mentions:

> 14th year of the Tự Đức reign period, 5th month (8 Jun–7 Jul 1861), a white vapour appeared. The Astronomical


大南實錄正編第四紀 卷二十四 三十九

其清化寧平士人聽與河內場合試一次

長星見是月二十一日酉牌見西北方在內階旁狀如粉絮體似噴雲燄長二丈餘指于紫微垣西藩每夜進一度至二十八夜行抵斗魁之天樞其芒傍斗杓直指于七公星至六月初二夜抵太乙旁氣燄漸漸微薄及七月十七夜滅

六月戊午朝日食監臣以不先推奏得罰

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Figure 7: A part of the block print page of the *ĐNTL-CB* containing the second part of the record describing the 'long star', i.e., Comet C/1861 J1 (Tebbutt). This part is highlighted in yellow (courtesy: The Keio Institute of Cultural and Linguistic Studies, Tokyo).

Bureau reported that the vapour was from *Ziweiyuan* enclosure (circumpolar area) and passed through the regions of *Han* and *Wei* stars (35 and 33 Cap), and the remaining vapour reached the northern bank of the Milky Way.

A long star appeared. 21st day of the month (28 Jun 1861), in the hour of *you* (17:00–19:00), it appeared in the northwest near asterism *Neijie* (o UMa, 23 UMa, and four other stars), looking like purple powder and emitting flames like clouds. It was over two *zhang* (about 19–30°) long, pointing to asterism *Ziweiyuan-xifan* (α Dra, α Cam, and five other stars). It moved forward one *du* (1°) every night, and on the 28th day's (5 Jul) night, it arrived near *Tianshu* star (α UMa) of *Dou* (the Big Dipper). Its light near the handle of the Dipper pointed directly at asterism *Qigongxing* (42 Her, δ Boo, and five other stars). On the night of the 2nd day of the 6th month (9 Jul 1861), it arrived near *Taiyi* star, and its flames gradually became fainter. On the night of the 17th day of the 7th month (22 Aug 1861), it disappeared.

This record is the most informative among the cometary records found in the *ĐNTL-CB*. Figure 7 shows the block print page of the *ĐNTL-CB* that contains this record. The "long star" mentioned in the record is most likely to be Comet C/1861 J1, also referred to as Comet Tebbutt or The Great Comet of 1861. Besides this comet, there were no comets visible to the naked eye in June and July 1861 in the *SBDB*. The "white vapour" mentioned in the first part of the record indicates the cometary tail instead of the comet itself, as explained below.

Before we explore the first part of the record that describes the "white vapour", let us first examine the second part that explains the "long star", which is Comet C/1861 J1 itself. Figure 8 depicts the daily positions of Comet C/1861 J1 in the evening sky over Huế when

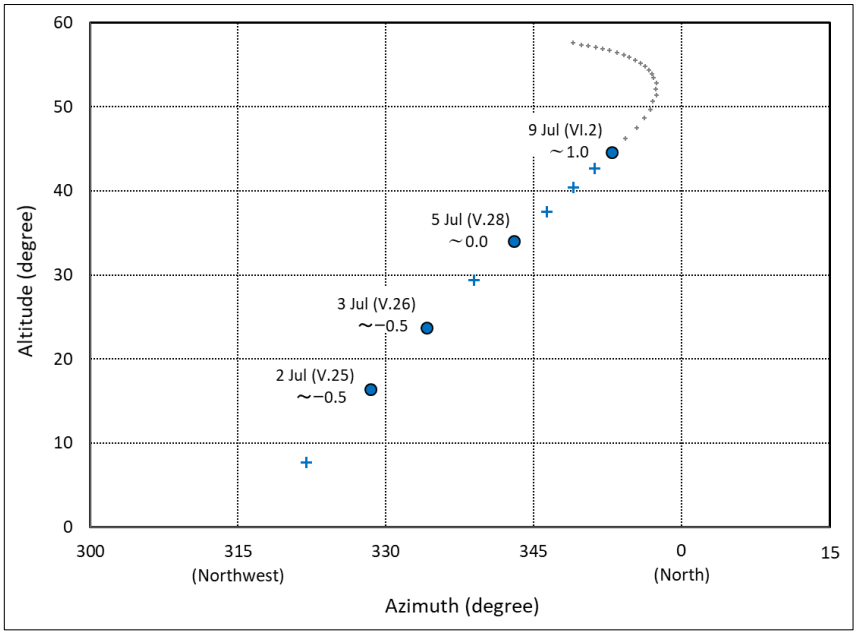

Figure 8: The daily positions of Comet C/1861 J1 in the evening sky over Huế, when the solar altitude was −6°. Blue symbols represent the positions from 1 to 9 July. Blue circles indicate the dates that are discussed in the text. The comet was below the horizon before 1 July in the evening sky. The date notation and computed magnitudes are the same as those in Figure 1 (diagram: Akira Okazaki).

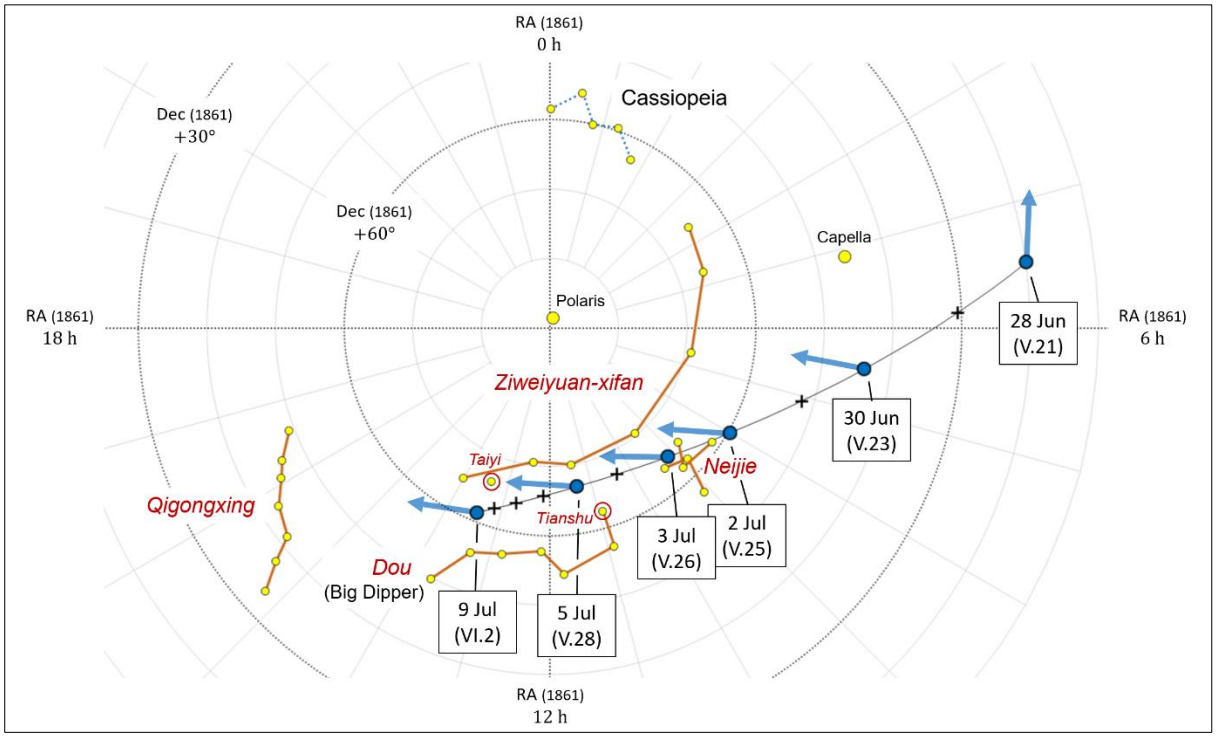

Figure 9: The daily positions of Comet C/1861 J1 in equatorial coordinates at LT=19h from 28 June to 9 July, 1861, except for LT = 24h on 30 June. The blue circles correspond to the dates that are discussed in the text. The arrows from these symbols indicate the anti-solar direction, which corresponds to the direction of the ordinary single (plasma) tail of the comet. Note that the length of these arrows does not mean the length of the tail. Several asterisms and stars are also displayed. The date notation is the same as that in Figure 1 (diagram: Akira Okazaki).

the Sun is at an altitude of −6° or at the end of civil twilight, which are based on our simulation results. The figure shows that the comet was seen in the northwest, as described in the record, in the first few days of July. In Huế, from late June to early July, the solar altitude of −6° corresponds nearly to LT = 19h, which is the end of the hour of *you* (17:00–19:00). Therefore, the comet should have been bright enough to be visible in civil twilight on the day of its appearance.

Although the record mentions that the comet appeared on 28 June, our simulation results demonstrate that Comet C/1861 J1 was below the horizon in the evening sky until 30 June. Hence, the day of its appearance described in the record must be after 30 June. Figure 9 illustrates the daily positions of Comet C/1861 J1 in equatorial coordinates at LT = 19h from 28 June to 9 July, 1861 (except for 30 June), revealing that the comet's position on 28 June was far from asterism *Neijie*. Since the comet was near asterism *Neijie* on 2 and 3 July, we should consider either of the two dates as the appearance date.

With regard to the comet during this period, Bortle (1998) wrote, "On the following night [2 July], the head had a magnitude of zero, and the tail was 97 degrees long." However, his subsequent mention of the comet is on 8 July. According to Kronk (2003), the nucleus' magnitude was reported as first magnitude by two observers on 2 July and by one observer on 4 July, although there was no mention of the magnitude on 3 July. Additionally, tail lengths of 70–107° and 60–100° were reported by several observers on 2 and 3 July, respectively. Hence, it seems that the comet displayed no significant changes during these two dates, leading us to the conclusion that the entire comet became visible in the sky over Huế on 2 July, provided the sky conditions were not poor; otherwise, on 3 July. Therefore, the record's description of the appearance date of 28 June (the 20th day of the 5th month) should be replaced by 2 or 3 July (the 25th or 26th day). The length of the tail described in the record as "… over two zhang (about 19–30°) …" is considerably smaller than the reported values mentioned above. This difference can be attributed to the effect of a relatively bright sky during twilight.

Subsequently, we examine the speed of the comet's movement in the sky. The record states: "It [the comet] moved forward one *du* (1°) every night." Nevertheless, Figure 9 illu-strates that the comet travelled nearly 10° dur-ing the 24-hour period between 2 July and 3

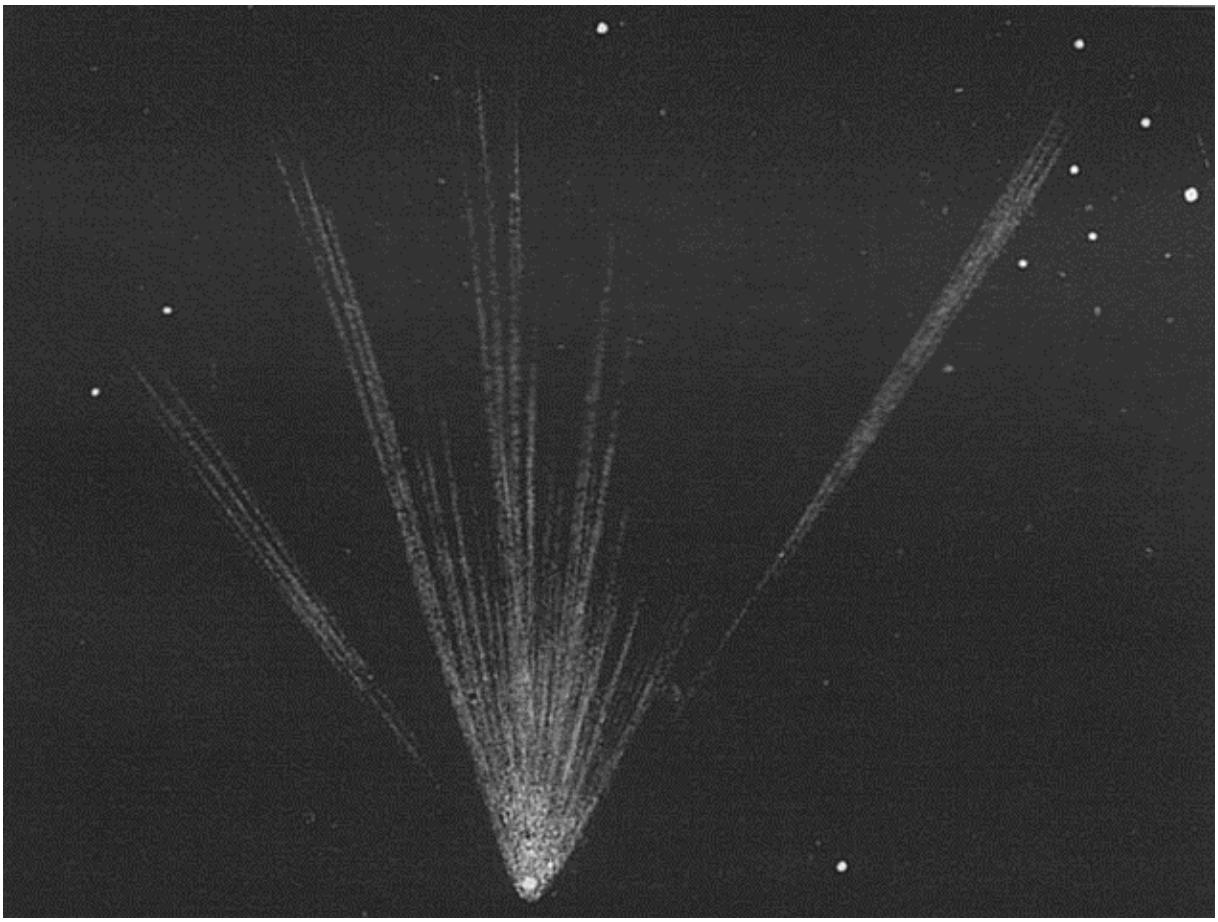

Figure 10: Comet C/1861 J1 drawn by G. Williams on 30 June 1861 (After Guillemin, 1877: 213).

July. Therefore, the expression “one *du*” in the record should be replaced with “ten *du*”. Such a large speed of the comet’s movement was attributed to its closest approach to the Earth a few days earlier. We will discuss the “white vapour” concerning the closest approach subsequently. The portrayals of the comet after this sentence in the record appear to be reasonably in agreement with the simulation results, as seen in Figure 9.

We shall now turn to the initial part of the record that pertains to the “white vapour”. It is inferred that the “white vapour” appeared on the evening preceding 2 July because its depiction precedes that of the long star. According to the account, the vapour originated from the circumpolar region and traversed the area where the stars 33 and 35 Cap are located.

Let us suppose that the “white vapour” was actually the tail of Comet C/1861 J1 on the night of 30 June when it was closest to the Earth (geocentric distance approximately 0.133 au) and the Earth was inside its tail. On that night, the right ascensions of the comet and the Sun coincided at LT ≈ 29h (or LT ≈ 5h on 1 July), which implies that the cometary (plasma) tail roughly passed through the circumpolar area during the night. Owing to the low latitude of Huế, *Ziweiyuan* enclosure (the circumpolar area) is partly (but mostly) visible, with its low-ermost region below the horizon; at Huế’s north-ern horizon, the declination is +73.5° (epoch: 1861) in equatorial coordinates (see Figure 9). Thus, the tail would have been seen as if a “white vapour” had emerged from *Ziweiyuan* enclosure on the northern horizon that night, particularly around midnight when the tail was pointing almost directly upwards.

Figure 10 portrays Comet C/1861 J1 on 30 June, sketched by the British astronomer G. Williams. Judging from the positions of the comet and stars shown in the illustration, it is believed to represent the comet several hours after the time when it was midnight in Huế. The drawing reveals that the comet had a fan-shaped tail containing several rays, with Polaris' direction almost along the central axis (The anti-solar direction on 30 June in Figure 9 is considered to correspond approximately to the central axis). Another drawing of the comet on the same night was made by the British astron-omer Richard Proctor (see Weiss, 1888). This drawing is similar to that of Williams, although slight yet

noticeable differences can be observ-ed in the rays.[2] Orchiston (2017) provides a detailed discussion of the fan-shaped tail of Comet C/1861 J1.

The direction of 33 and 35 Cap lies within the fan-like tail depicted in the drawing. The angular distance between the cometary nucleus and these two stars was approximately 140° at midnight in Huế, indicating that the length of the cometary tail described in the account was at least this angular distance value. This exceeds 122°, which is the largest known value reported so far on that night in Europe (Kronk, 2003: 294). It is noted, however, that 33 and 35 Cap were seen at a rather high altitude in Huế, making it somewhat easier for the Royal Astronomers to observe faint, nebulous objects such as a cometary tail. Considering that the rays in the tail may have varied over several hours during the closest approach of the comet to Earth, it can be inferred that the longest ray in the cometary tail could have measured 140° or more when observed by Vietnamese Royal Astronomers. The other rays would have been perceived as the "remaining vapour" by them, as written in the *ĐNTL-CB*. In conclusion, we propose that the "white vapour" described in this record was actually the tail of Comet C/1861 J1 on the night of 30 June, when it was closest to the Earth.

4 CONCLUDING REMARKS

In our study, we have identified ten cometary records in the *ĐNTL-CB*. All comets associated with these records were bright. However, several other noteworthy comets were not included in the *ĐNTL-CB*. For instance, Bortle (1998) reported that twenty bright comets, which reached a magnitude of m $\lesssim$ 0 at their brightest, appeared between 1801 and 1888. Only seven of these comets, or 35%, were recorded in the *ĐNTL-CB*. Conversely, Okazaki (2021) reported that the *ĐNTL-CB* documented 78% of observable solar eclipses in Huế between 1812 and 1888. It is worth noting that a lack of records for specific astronomical events does not necessarily indicate that they were not observed by the Royal Astronomers. The compilers of the *ĐNTL-CB* would have included only those records they considered significant. It should be remembered that predicting and observing solar eclipses were crucial for calendar-making, which played a significant role in the Dynasty's governance of the country.

With the exception of a few errors, the majority of descriptions found in the four records examined were found to be consistent with the outcomes of the simulations. Let us consider the most significant error among them, concerning the observation date and the velocity of cometary motion in the sky (see Subsection 3.4). It is improbable that the Royal Astronomers would have made errors while recording such critical observational data. Moreover, it is unlikely that such data, particularly the speed of cometary motion, would have been influenced by astrological biases as mentioned in Subsection 3.2. One possibility is that a transcription error occurred during the compilation process of the *ĐNTL-CB*. In reality, instances of confusion between the similar kanji '日' and '月', which are employed for 'solar eclipses' and 'lunar eclipses', respectively, are occasionally encountered in the *ĐNTL-CB*. Concerning the motion speed, the difference between the kanji '一' and '十', which are used for 'one *du*' and 'ten *du*', respectively, is determined by the existence or lack of a vertical stroke in the kanji. We have no definitive evidence, but it is possible that a lack or indistinctness of the stroke in the documents at some stage of the process may have led to confusion.

Finally, we would like to draw attention to two distinctive phenomena related to Vietnam's low latitude that we have found in two of the records. One example is the description of a comet that was visible only at low altitudes when it moved to the Southern Hemisphere skies but could be observed for a longer period compared to in China and Japan (Subsection 3.2). This case suggests that Vietnam was the most advantageous country for observing the Southern sky among the ones that adopted similar traditional observation systems. The other example involves the description of a comet in the Northern sky, where only its tail was visible, appearing as a 'white vapour' (Subsection 3.4). This phenomenon occurred because the comet's head was below the horizon during the night in Vietnam. In mid-latitude regions of the Northern Hemisphere, the comet was observed even at midnight as a circumpolar object on the same night. Although this circumstance was unfavourable for observing the entire comet, Vietnamese Royal Astronomers recorded this phenomenon as a significant noteworthy event, not identifying it as a cometary tail on that night.

5 NOTES

1. Information regarding *StellaNavigator 12* software can be found at the web site: https://www.astroarts.co.jp/products/stlnav12/index-j.shtml (Japanese only). The sky positions obtained using *StellaNavigator 12* were found to be in agreement with those obtained from the *Horizons System* of the JPL (https://ssd.jpl.nasa.gov/horizons/)

with a difference of $\lesssim 0.1'$ for the comets examined in this study, except for C/1843 D1, which had a difference of $\lesssim 1'$. The orbital elements used in our study can be found in the Small-Body Data Base (*SBDB*) of the Jet Propulsion Laboratory at https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/.

2. For those interested in comparing Williams' drawing with Proctor's, the latter can be found on websites such as Wikimedia Commons. These drawings can also be cross-referenced with Figure 9, which has been rotated approximately 80 degrees counter-clockwise in comparison to the drawings.

6 ACKNOWLEDGEMENTS

I would like to express my gratitude to Professor Wayne Orchiston for his valuable comments and for providing me with useful materials. I extend my heartfelt gratitude to the late Professor Lê Thành Lân for providing valuable information. His published calendar conversion tables have significantly enhanced the study of historical astronomical records in Vietnam, including this paper. I am also thankful to Mr Phạm Vũ Lộc for sharing valuable resources.

Additionally, I would like to acknowledge the Keio Institute of Cultural and Linguistic Studies for granting me permission to partially reproduce their publication.

7 REFERENCES

Beijing Astronomical Observatory, 1988. *Zhongguo Gudai Tianxiang Jilu Zongji (A Compilation of Chinese Records for Ancient Celestial phenomena)*. Nanjing, Jiangsu Science and Technology Press.

Belokrylov, R.O., Belokrylov, S.V., and Nickiforov, M.G., 2011. Model of the stellar visibility during twilight. *Bulgarian Astronomical Journal,* 16, 50–72.

Bortle, J.E., 1998. The bright-comet chronicles. *International Comet Quarterly*. (http://www.icq.eps.harvard.edu/bortle.html).

Crawfurd, J., 1828. *Journal of an Embassy to the Courts of Siam and Cochin-China, Exhibiting a View of the Actual State of these Kingdoms.* London, Henry Colburn.

Guillemin, A. (translated and edited by James Glaisher, F.R.S.), 1877. *The World of Comets*. London, Sampson, Low, Marston, Searle, & Rivington.

Dainanjitsuroku (大南寔録, Chronicle of Nguyen Dynasty), Tokyo, The Institute of Cultural and Linguistic Studies, Keio University (1961–1981, Preface in Japanese).

Ho, P.-Y., 1964. Natural phenomena recorded in the Đại Việt Sử Ký Toan Thư, an early Annamese historical source. *Journal of the American Oriental Society*, 84, 127–149.

Kronk, G.W., 2003. *Cometography. A Catalog of Comets*. *Volume. 2: 1800–1899*. Cambridge, Cambridge University Press.

Lê, T.L., 2020. *Lịch Hai Mươi Mốt Thế Kỷ - Năm 0001–Năm 2100*, Hanoi, NXB Khoa Học Kỹ Thuật.

Okazaki, A., and Yokoo, H., 1983. Astronomical records (1040–1225) in the medieval Vietnamese source Việt Sử Lược. *Journal of Oriental Studies*, 21, 40–44.

Okazaki, A., and Tanokura, M., 2011. An examination of astronomical records in Vietnamese historical sources. In Nakamura, T., Orchiston, W., Sôma, M, and Strom, R. (eds.), *Mapping the Oriental Sky: Proceedings of the ICOA-7 Conference*. Tokyo, National Astronomical Observatory of Japan. Pp. 77–81.

Okazaki, A., 2021. Solar and lunar eclipse records in Vietnam from ancient times through to the nineteenth century. In Orchiston, W., and Vahia, M. (eds.), *Exploring the History of Southeast Asian Astronomy: A Review of Current Projects and Future Prospects and Possibilities*. Cham (Switzerland), Springer. Pp.163–224.

Orchiston, W., 2017. The Great Comet of 1861: a magnificent career catalyst. In Orchiston, W., *John Tebbutt: Rebuilding and Strengthening the Foundations of Australian Astronomy.* Cham (Switzerland), Springer. Pp.139–171.

Ōsaki, S., 1994. *Kinsei Nihon Tenmon Shiryō*, Tokyo, Hara Shobō.

Phạm, V.L., and Lê, T.L., 2020. A brief history of Vietnamese astronomy and calendars during the reign of the Royal Dynasties. In Orchiston, W., and Vahia, M. (eds.), *Exploring the History of Southeast Asian Astronomy: A Review of Current Projects and Future Prospects and Possibilities*, Cham (Switzerland), Springer. Pp.119–162.

Sekiguchi, R., 1917. Comets in ancient Korean records. *Astronomical Herald*, 10, 99–103 (in Japanese).

Stoyan, R., 2015. *Atlas of Great Comets*. Cambridge, Cambridge University Press.

Valentiner, W., 1884. *Das Wissen der Gegenwart, 27. Band: Kometen und Meteore*, Leipzig, Freytag.

Vsekhsvyatskii, S.K., 1964. *Physical Characteristics of Comets*. Jerusalem, Israel Program for Scientific Translations.

Vsekhsvyatskii, S.K., Raugh, A.C., and A'Hearn, M., 1999. *Physical Characteristics of Comets*, EAR-C-5-DDR-PCCV1.0, NASA Planetary Data System (https://pdssbn.astro.umd.edu/holdings/ear-c-5-ddr-pcc-v1.0/dataset.shtml).

Weiss, E., 1888. *Bilder-Atlas der Sternenwelt : eine Astronomie für Jedermann*. Stuttgart, J.F. Schreiber.

Wu, S.X., and Liu, C.Y., 1990. Ancient Chinese astronomical observations related to the stellar background in the sky. In Lieske, J.H., and Abalakin, V.K. (eds.), *Inertial Coordinate System on the Sky.* Dordrecht, Kluwer Academic Publishers (Proceedings of IAU Symposium No. 141). Pp. 195–196.

8 APPENDIX

In this appendix, we present the English translations of the cometary records collected from the *Đại Nam Thực Lục [Chính Biên]* (*ĐNTL-CB*), along with their original classical Chinese texts and the Annals and Chapter numbers in the *ĐNTL-CB* where each record can be found. For astronomical and related terms of Chinese origin, such as star/asterism names, unit of angle, and the sexagenary cycle used for day and time, we provide their Chinese names instead of Vietnamese equivalents. If necessary, we add their modern terms in parentheses. The Annals and Chapter numbers in the *ĐNTL-CB* are indicated as follows: ĐNTL-CB-IV.24, for instance, represents the *ĐNTL-CB*, Annals No.4 (第四紀), Chapter 24 (卷二十四).

In some cases, one record consists of multiple paragraphs. This indicates the existence of additional (non-cometary) descriptions between them in the original text of the *ĐNTL-CB*, which have been omitted here. They are for the same lunar month, unless otherwise noted.

(1) 10th year of the Gia Long reign period, 8th month (18 Sep–16 Oct 1811), a broom star appeared in the west.

嘉隆十年八月，彗星見西方。

ĐNTL-CB-I.43

(2) 6th year of the Minh Mệnh reign period, 8th month, day *jiaxu* (20th day of the month, 1 Oct 1825), a broom star appeared in the southeast in *Mao* lunar mansion, with pointing the northwest.

The broom star persisted for a long time without fading.

However, the broom star gradually became fainter. During the first ten days of the 11th month (10–19 Dec 1825), it disappeared.

明命六年八月，甲戌，彗星見于東南昴分，指西北。
彗星久未滅。
而彗色漸微。十一月初旬乃滅。

ĐNTL-CB-II.34

(3) 3rd year of the Thiệu Trị reign period, 2nd month, day *renchen* (19th day of the month, 19 Mar 1843), a long white vapour stretched across the sky from the northwest to the southeast.

Day *xinchou* (28th day of the month, 28 Mar 1843), the white vapour disappeared. The Astronomical Bureau reported that this white vapour gradually dissipated over the course of two or three nights after its initial appearance, and completely vanished after twelve days. It was never visible again.

紹治三年二月，壬辰，白氣經天一條自西北孛指東南。
辛丑，白氣消。欽天監奉言，此白氣一條自初見後二三夜漸漸淡散，浹辰後没。不復見。

ĐNTL-CB-III.28

(4) 13th year of the Tự Đức reign period, 5th month (19 Jun–17 Jul 1860), a broom star appeared in the northwest, with its light pointing straight. Its length was five to six *chi* (5–8° to 6–9°). It rose slightly higher each night.

嗣德十三年五月，彗星見西北方。光芒直指，長五六尺。每夜稍高。

ĐNTL-CB-IV.22

(5) 14th year of the Tự Đức reign period, 5th month (8 Jun–7 Jul 1861), a white vapour appeared. The Astronomical Bureau reported that the vapour was from *Ziweiyuan* enclosure (circumpolar area) and passed through the regions of *Hán* and *Wei* stars (35 and 33 Cap), and the remaining vapour reached the northern bank of the Milky Way.

A long star appeared. 21st day of the month (28 Jun 1861), in the hour of *you* (17:00–19:00), it appeared in the northwest near asterism *Neijie* (o UMa, 23 UMa, and four other stars), looking like purple powder and emitting flames like clouds. It was over two *zhang* (about 19–30°) long, pointing to asterism *Ziweiyuan-xifan* (α Dra, α Cam, and five other stars). It moved forward one *du* (1°) every night, and on the 28th day's (5 Jul) night, it arrived near *Tianshu* star (α UMa) of *Dou* (the Big Dipper). Its

light near the handle of the Dipper pointed directly at asterism *Qigongxing* (42 Her, δ Boo, and five other stars). On the night of the 2nd day of the 6th month (9 Jul 1861), it arrived near *Taiyi* star, and its flames gradually became fainter. On the night of the 17th day of the 7th month (22 Aug 1861), it disappeared.

嗣德十四年五月，白氣見。欽天監奏，自紫微垣過韓魏星垣分。其餘氣至天漢北畔。
長星見。其月二十一日，酉牌見西北方在內階旁。狀粉如紫體似噴雲燄。長二丈餘。指于紫微垣西藩。每夜進一度，至二十八夜行抵斗魁之天樞。其芒傍斗杓直指于七公星。至六月初二夜抵太乙旁。氣燄漸漸微薄。及七月十七日夜滅。

ĐNTL-CB-IV.24

(6) 34th year of the Tự Đức reign period, 6th month (26 Jun–25 Jul 1881), there appeared a broom star in the east outside *Ziweiyuan* enclosure. It was three *chi* (3–5°) long and disappeared after six days.

The comet appeared again in the north of *Ziweiyuan* enclosure. It was five *chi* (5–8°) long, and disappeared after seven days.

嗣德三十四年六月，彗星見在紫微垣外東。長三尺。六日滅。
彗星復見出紫微垣北。長五尺。七日滅。

ĐNTL-CB-IV.65

(7) [The same year,] 7th month (26 Jul–25 Aug, 1881), the comet appeared again in the west at the bowl of the Big Dipper, more than three *chi* (3–5°) long, and disappeared after twenty three days.

［同年］七月，彗星復見。出北斗魁西。長三尺零。二十三日滅。

ĐNTL-CB-IV.65

(8) 35th year of the Tự Đức reign period, 8th month (12 Sep–11 Oct 1882), a long star appeared in the east. At the 5th watch and a half (~04:30), it was seen in *Zhen* lunar mansion. It appeared from bottom to top, red below and white above, and was as long as silk. During more than four months, it gradually decreased in size and continued to move until it reached the star *Tianlang* (Sirius). It disappeared in the last ten days of the 12th month (9–18 Jan 1883).

嗣德三十五年八月，長星見東方。五更半，見軫分。自下而上下赤上白長如絹。四月餘，漸減短行至天狼星。而滅十二月下旬。

ĐNTL-CB-IV.68

(9) 35th year of the Tự Đức reign period, 12th month (9 Jan–7 Feb 1883), a broom star appeared in *Shi* lunar mansion. Its length gradually grew from over one *chi* (1–1.5°) to over two *chi* (2–3°). It disappeared after three days.

嗣德三十五年十二月，彗星見出室宿分。一尺餘漸長至二尺餘。三日而滅。

ĐNTL-CB-IV.68

(10) Đồng Khánh Ất Dậu year, 11th month (6 Dec 1885–4 Jan 1886), a broom star appeared in the southeast. Its tail pointed the northwest and was approximately seven to eight *chi* (6–11° to 7–12°) long.

同慶乙酉年、十一月、彗星出東南方。尾指西北。長約七八尺。

ĐNTL-CB-VI.2

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