Meteoroids 2013, Proceedings of the Astronomical Conference,
held at A.M. University, Poznań, Poland, Aug. 26-30, 2013,
eds Jopek T.J., Rietmeijer F.J.M., Watanabe J., Williams I.P.,
pp 110–116

Meteor Showers in the Ancient Maya Hieroglyphic Codices

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Abstract. Researchers of the ancient Maya culture have long been fascinated with the Maya obsession concerning cyclical calendars and precise visual observations of astronomical bodies and phenomena, in particular the Sun, Moon, visible planets, and solar and lunar eclipses. Although considered possible, heretofore no record of specific sightings of comets or meteor showers in the Maya inscriptions has been firmly established by scholars. Besides difficulties with decipherment of the hieroglyphic script, investigators have had to grapple with an ancient Maya calendar that has not been accurately correlated to the European calendar. Recent examination by this researcher has found that it may be possible to recognize written accounts of meteor showers embedded in the hieroglyphic corpus, especially the codices, the screen-fold books that were the tools of the astronomer-priests of that day. By proposing an alternative decipherment of an astronomical sign and using the accompanying hieroglyphic texts and illustrations with appropriate dates, this researcher believes it is possible to demonstrate that the Maya may have recorded meteor showers occurring in the seventh through the tenth centuries AD.

Keywords: Maya codices, meteor showers, meteor(s), Perseids, Orionids, Dresden codex, Madrid codex.

1. Introduction

The Dresden and Madrid codices and some Classic inscriptions† may provide evidence that the Maya observed and tracked certain specific meteor showers including the Perseids, Orionids, Eta Aquariids and a few of the numbered showers (Jenniskens 2006:598-611, Table 1). By comparing dates recorded in the corpus of Maya hieroglyphic inscriptions, including the codices, to known historical dates of observed meteor showers from the same time period, the author could then examine the text and iconography associated with appropriate solar longitudes to decide if a particular inscription applied to a meteor shower outburst.

The word codices is the plural form of the singular "codex" meaning "an ancient manuscript text in book form," (`www.oxforddictionaries.com`). The codex itself

† The Classic period is usually defined from AD 250 to 900, divided into the Early Classic (AD 250-600) and Late Classic (AD 600-900) periods. Classic inscriptions included carvings on stone monuments, panels, doorway lintels and jambs, wooden lintels, paintings on walls, and carvings and paintings on portable objects such as ceramic vessels, seashells, jade objects, turtle shells and the like. The codices were believed to have been painted during the Late Postclassic period (c. AD 1200-1521)(Vail and Hernandez 2013).

Figure 1. Facsimile of the Dresden Codex (Cholsamaj edition, 1998)(Photograph by author).

was a divination tool of the priests, a handbook containing almanacs and tables‡ that pictorially and hieroglyphically displayed astronomical and religious information, including rituals and daily activities (Vail and Hernandez, 2013). Many of the almanacs and tables had been copied from previous codices and thus may contain some historical information. Currently scholars are not clear on which information is historical fact and which is prophecy, however it appears to this author that many of the possible meteor shower events are actual observations.

The Maya codices are accordion style books made with paper from the inner bark of the fig tree. There are four such surviving screen fold books as they are sometimes called; three, the Dresden, the Madrid (also known as Codex Tro-Cortesianus), and the Paris are known by the names of the European cities where they are now housed. Figure 1 shows a facsimile of the Dresden codex, 74 pages long; the Paris Codex is 22 pages long and the Madrid codex is folded into 56 leaves painted on both sides, giving a total of 112 pages.

Given that precise astronomical information recorded in the codices seemed to include all but comets or meteor showers, *was it possible that previously unrecognized astronomical information concerning meteor showers was embedded in the known tables and almanacs?* China, Japan, Korea and Europe also using naked eye astronomy had observed and recorded comets since the 11th century BC (Ho (2) referenced in Yeomans, 1991:362) and meteors since 687 BC (Imoto and Hasegawa, 1958:134). Embodying the physical aspect of visual astronomy, a prominent structure known as the Caracol at the Maya site of Chichen Itza was known to have been used for astronomical purposes (Aveni 2001:92, 272-282).

‡ Almanacs were normally composed of a continuous 260 day cycle while tables were usually anchored in the Maya Long Count, similar to the Julian Day Number system.

2. History

Although the last 20 years have seen great strides in the decipherment of the Mayan hieroglyphics, students of the Maya culture have been hampered by various problems. Following the arrival of the Spanish in 1521, Bishop Diego de Landa burned a great number of hieroglyphic rolls in 1562 (Gates 1937:iii). These destroyed documents themselves may have contained records of astronomical observations.

The exact correlation of the Christian calendar to that of the Maya is still being debated. The problem covers about a 3 day variance. The so-called correlation constants, 584283, 584285, and 584286 refer to the Julian Day Number for the beginning of the current Maya calendar Long Count. Recent literature seems to favor 584286 (Kennet et al. 2013:1-5; Martin and Skidmore 2012:3-16); naturally even a one day difference is critical when talking about a long period meteor shower.

Physical evidence of the knowledge of meteors seems to appear in the Maya area in the AD 300s. It was thought that heavenly gods hurled flaming arrows or darts at each other. A fourth century ball court marker from Tikal depicts a figure holding a star-studded atlatl interpreted as a meteor; a stone relief of the founding king of the city of Copan, AD 426, is carved on a structure known as Altar Q, holding a flaming dart, also interpreted as a meteor (Taube 2000:298,274, 295, 296) (figure 2). In Maya mythology, the scarlet macaw is related to meteors by the brilliant red feathers being metaphorically substituted for flaming torches (Christenson, 2007:131). Another metaphor used for meteors was fire-drilling, or the sparks resulting from the friction of the spinning shaft: the fire-drilling scene shown in figure 2 is from the Madrid codex; meteors were also represented by twisted cords, ropes that were used to transfer powerful rotational energy to the spinning shaft (Taube, 2000:294). Caterpillars and worms were also thought to represent meteors because of their drilling capabilities (Taube 2000:290-291; Lenkersdorf 2010:505, 506; Barrera, 1980:188). Meteors and obsidian were both thought of as star excrement; obsidian was thought of as both the meteor and the meteorite (Laughlin 1975:93; Lenkersdorf 2010:333, 571).

Physical seizures and illnesses were thought to result from meteor showers. The term for seizure was "tancas," a contraction of "tamacas" which was also the word for Milky Way [galaxy] (Roys 1965:xviii; Barrera et al. 1980:767, 768). In the Mayan language of Tzotzil, *poslom* means both "sickness in leg" and "falling star seen at dusk," (Laughlin 1975:284). Seizures were treated by shamans, persons who would interact with the spirit world through dance, hallucinogens or incantations. A series of these incantations are translated by Ralph Roys in the volume "Ritual of the Bacabs," (Roys 1965:3-70). The incantations took the form of chants and repeated phrases in an almost hypnotic rendition, sometimes conjuring or invoking deities known as *Bacabs*. The incantation was sometimes directed toward a heavenly realm called the fifth celestial place or *Na Ho' Chan*, "First Five Sky", where fires and some meteors may have originated (Roys 1965:7-9). These meteors that caused the seizures were the offspring of rattlesnake rattles, also known as the Pleiades constellation, close to the Perseus constellation and the apparent orig-

Figure 2. Left: drawing of stone carving of Yax K'uk' Mo', Altar Q, founding king of Copan holding flaming arrow, possibly interpreted as meteor (Taube 2000:274, 295, 296)(Drawing by Linda Schele (shading by author)). Right: two god M figures engage in fire-drilling scene from page 51a, Madrid codex (courtesy Akademische Druck-u. Verlagsanstalt-Graz, electronic document online at famsi.org).

ination (radiant) of the Perseid meteor shower; the scarlet macaw was responsible for seizures in the incantations (Roys 1965:7-9, xix).

3. Discussion

One important notation used by the Maya was the sky band. The sky band consists of several signs in a horizontal band used in both the Classic inscriptions and the codices to indicate the heavens and celestial activity. Signs such as the sun, moon, a star or Venus, night and the proposed sign for meteor showers make up the sky band (see Figure 3).

This author bases his hypothesis in part on a proposed reading of what is considered a variant of the k'in, "day, sun" sign found in the sky band that is included in many of the pages of the codices. Specifically that sign is a dotted X conflated within the k'in sign, the dotted X containing small circles at the center and at the end of each leg of the X. The conflated k'in sign is known as a k'in variant T544v (Thompson 1962:155-160) or XQ3 (Macri and Looper 2003:197), but neither catalog distinguishes the k'in sign with or without the dotted X contained within the sign itself. The dotted X variant is found occasionally throughout texts in the Classic inscriptions, and whether or not the meteor shower meaning can be attached in those contexts is beyond the scope of this paper. In the codices the dotted X k'in sign seems to be found only in the sky band and not in the glyphic texts themselves. In the sky band of the throne inscription at Uxmal as interpreted by Bricker and Bricker (1996:210), the author interprets the sign shown in figure 3 and a similar sign as the Perseids and Orionids. Meteor shower dates may be associated with and without texts with the k'in variant, therefore the k'in variant may not be an exclusive indicator of showers.

Having a variant of the day or sun sign representing a mostly night-time event may seem contradictory, but there may be a reasonable explanation. First, as noted above, the scarlet macaw was responsible for the meteors from the area of the Pleiades, and the radiants for both the Perseid and Orionids meteor showers are

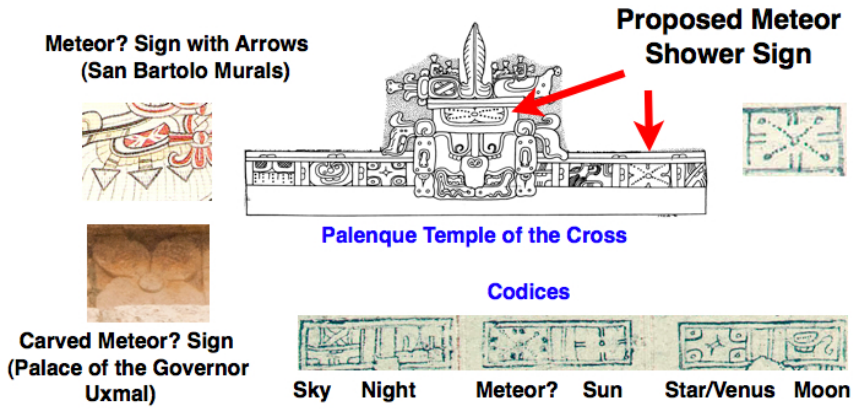

Figure 3. Examples of the k'in sign variant T544v that may signify a meteor shower outburst: Top left: sign with arrows painted on underside of wing of Principal Bird Deity, San Bartolo Murals, circa 100 BC (rendered by Heather Hurst). Bottom left: carving on Uxmal throne inscription, Palace of the Governor, Uxmal, circa AD 900 (photograph by Mauricio Metri Ojeda). Top right: sign carved on Tablet of the Cross, Palenque, on deity G1 forehead and sky band, Classic period (drawing by L. Schele). Bottom right: k'in sign variant contrasted with simple k'in, "sun/day" sign, Dresden codex, late Post-Classic period.

in that vicinity. The macaw, in the form of *Kin-ich-kak-mo* ("sun-eye-fire-macaw"), was also the idol of sun worship at Izamal, where a great number of citizens would bring offerings in times of pestilence (Lizana, Historia de Yucatan. f.4v referenced in Roys 1965:137). The fire of the meteor may have been equated to the fire of the sun, hence the combination.

4. Methodology

The author chose 16 of 34 historically observed showers from China, Korea, Japan and Europe (Jenniskens 2006:598-611, Table 1) for comparison to candidate shower dates in the Maya inscriptions. Since most dates in the Classic Maya inscriptions occur between AD 400 and 900, and many dates recorded in the codices appear to be events that have already occurred from about 700 to 1000, 15 of the 16 historical showers chosen for comparison were observed prior to AD 1000. Shower 15 was an exception as discussed later.

Figure 4 depicts meteor showers that the Maya may have observed arranged according to solar longitudes about a circle. The circular diagram shows the Earth's anti-clockwise direction around the Sun (plan view of the ecliptic plane). Solar longitudes measure from the Earth to the Sun using the J2000 reference for the vernal equinox.

Solar longitudes were calculated for known dates in the codices associated with and without the dotted X kin sign to see if a correlation could be found to historically observed meteor storms. The number of days that showers or outbursts from

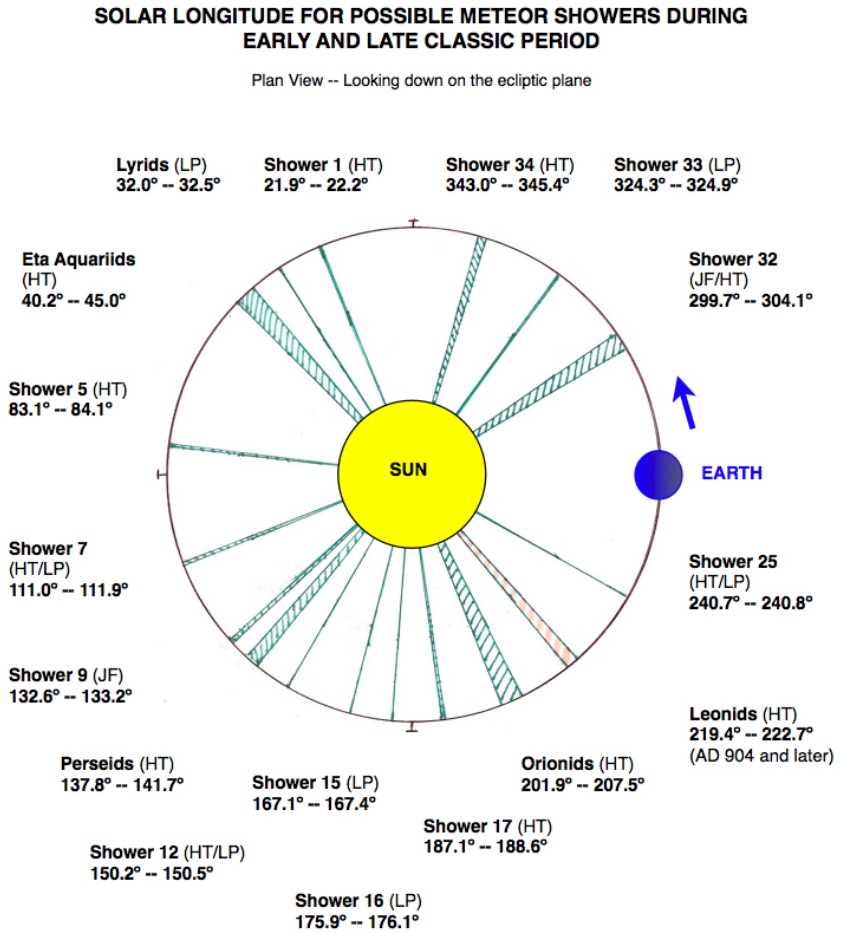

Figure 4. Depiction of solar longitudes of 16 meteor showers that possibly may have been observed by the Maya before AD 1000 (diagram by author)(data from Jenniskens 2006:598-611, Table 1). The Leonids would have only been observed in AD 904 and later (Jenniskens 2006:619, Table 4a).

16 individual showers could be observed amounts to about 36 days, or about 10 percent of the days of a year. Candidate showers fell within the solar longitude and chronological limits with an accompanying text descriptive of a possible meteor event (all dates Julian Calendar, UT, unless otherwise noted).

5. Results

Besides the positive results listed in Table One, several groups of data not included in this analysis had little or no correlation. One group concerned the so-called "star wars" glyph, a glyph indicating a war event. Scholars have suggested that it was related to meteor showers because of droplets that appeared to fall from

a "star" glyph (Aldana 2005:313, 314). The author however found zero correlation to any of those 27 dates and near zero in reference to a set of 27 dates involving fire rituals (Grube, 2000:103-104). In a third set of 94 dates at Yaxchilan (Tate 1992:271-274), the author found only 4 definite possibilities and 9 dates that had some possibility, i.e. greater than 0.5 degrees and less than 1.0 degree outside of the range of a long-period shower, and greater than 1.0 degree and less than 2.0 degrees outside the range of a Halley-type or Jupiter-family comet.

Table One shows candidate showers considered in this study, both from Classic inscriptions and the codices. All of the codical examples contain text that could be considered descriptive of a meteor storm or its perceived potential for damage. Table One notes are found below.†

6. Analysis: Does the K'in Variant in the Sky Band Indicate a Meteor Shower?

The first set of data is analyzed from Table 2 in terms of the dotted *X* k'in sign found in the sky band, although not all candidates contain a sky band nor the sign itself.

In an original sample size of 15 possible candidate showers, 3 samples (nos. 16, 22 and 23) were discarded due to uncertainties in dating and the meteor sign leaving n = 12. First, considering only the sky bands that contained the possible meteor sign, n = 8 (nos. 2, 7, 8, 15, 20, 18, 14 and 21), four (nos. 7, 8, 20 and 18) out of the 8 were acceptable. Two samples were associated with Shower 25, which hasn't yet been determined to be Halley-type or long-period. If Shower 25 is long-period, the solar longitude for each sample is deemed either one degree too high or too low. If Shower 25 is a Halley-type, the two samples are acceptable, yielding 6 out of 8. Sample number 21, Dresden 39a1 is considered unacceptable because a shower does not correlate until the table reaches row 20. Four samples (37a2, 36a3, 39a1 and 68a3) come from the spliced table Dresden 32a-39a, considered somewhat ambiguous

† a. The date of 736 July 24 (Maya Long Count 9.15.5.0.0) is also recorded on Bench XXI at Palenque; all Ahkal Mo' Nahb III events in Table 1 occur on Temple XIX. b. dates for candidates taken from other than the first row of the table: no. 8, Dresden 45b1, row 6; no. 21, Dresden 39a1, row 20. c. The author translates *y-a-ek'* "of the cosmological throne" as "rain-stars" or "meteors" of the cosmological throne," whereas MacLeod translates the same phrase as "crocodile throne" (personal communication, 2013). d. The author translates *ch'o[j]* as "pierce, perforate, be pierced" from the Mayan language Tzotzil (Laughlin, 1975:137) and Ch'ol, *ch'ojch'on*, "to peck something," (Hopkins and Josserand, 2011:53). e. Both paintings depict what has been suggested as hanging textiles; in the historical record, 19 of the shower descriptions use the term "weaving" and one "fabrics of silk" (Jenniskens, 2006:598-611, Table 1). f. The author discards these two showers due to uncertainty in dating, i.e. almanac 33c-39c has no Maya Long Count anchor (as found in tables in the codices) and the fact that the almanac most likely refers to the 16th century, out of the scope of the author's analysis. g. Two k'in sign variants are located in the sky band on the top of the Sarcophagus lid; dates of deaths (or apotheoses) of several kings are carved on the edges of the lid. h. The k'in sign variant is recorded in the sky band and forehead of GI on the Tablet of the Cross. i. The author considered the possible k'in variant found in the sky band too dissimilar to be included in the data analysis.

Table 1. Meteor shower candidates (correlation constant 584286) found in the codices with and without k'in sign variant, including Classic inscription dates. Shower 1 was not recorded in the historical record after AD 581 and the Shower 25 type is uncertain (long-period or Halley-type). Shower 15 was not noted in the historical record before AD 1037, but its possible occurrence in 731 would be (28)(11.86yr) prior to observed 1063; Jenniskens states that this shower is periodic with the 11.86 year period of Jupiter (Jenniskens 2006:603). Showers marked with "x" may have uncertain dates after AD1500. λ = solar longitude in degrees. Explanations for notes found in footnotes.

No	λ	Date	Meteor Shower	Event	Location	Sign?	Notes
1	22.6	959 Mar 24.3	Shower 1?	"Fire from the sky of Rain god (Chahk). It is chopped."[Chahk with shield and holding torches]	Dresden 36a3	No	
2	43.1	959 Apr 14.3	Eta Aquariids	[Deity (Pawahtun?) with axeand bag standing in rain]	Dresden 37a2	Yes	
3	137.7	156 July 16.3	Perseids	Undeciphered (non-Maya)	La Mojarra St 1	No	
4	141.4	570 July 23.3	Perseids	Apotheosis of Ahkal Mo' Nahb II	Palenque	Yes	g
5	139.7	690 July 22.3	Perseids	Burning of heavenly location?	Palenque	Yes	h
6	141.7	736 July 24.3	Perseids	Ahkal Mo' Nahb III, last event; in the presence of GI Triad Deity	Palenque	No	a
7	139.9	775 July 23.3	Perseids	"(It is) his fire from the sky (of) four macaw place... [macaw holding torches]	Dresden 40b2	Yes	
8	140.5	819 July 24.3	Perseids	"Beast" is chopped. Injury to Lord Fire Macaw-? ?? Death to Maize deity	Dresden 45b1	Yes	b
9	141.3	933 July 25.3	Perseids	[macaw holding torches]	Madrid 12a3	No	
10	167.2	731 Aug 20.3	Shower 15?	Ahkal Mo' Nahb III, event involving G1	Palenque	No	
11	203.3	724 Sep 25.3	Orionids	Ahkal Mo' Nahb III, receives "rain-stars"? of cosmological throne in presence of GI, GII, GIII	Palenque	No	c
12	208.3	775 Oct 1.3	Orionids	Unknown event caused by meteor storm? [Moon goddess hangs by neck under sky band]	Dresden 53b Picture 6	No	
13	204.9	874 Sep 28.3	Orionids	Event: K'awiil combined with GI with Heron headdress	Seibal Stela 3	No	
14	239.3	764 Oct 31.3	Shower 25?	Red/great water/rain over Earth/caves	Dresden 56a Picture 3	Yes	
15	241.9	949 Nov 4.3	Shower 25?	Step/foot? of Rain god Chahk?. Earth/sky is pierced?	Dresden 66a2	Yes	d
16	291.7	949 Dec 23.3	none	Bolon K'uhul Yok Te'..,?	Dresden 68a3	?	i
17	302.4	722 Jan 01.3	Shower 32	Ahkal Mo' Nahb III accession to kingship	Palenque	No	
18	302.3	762 Jan 01.3	Shower 32	Meteor storm? sky, Earth Damage to Man, Earth, caves, sky	Dresden 55a Picture 2	Yes	e
19	324.1	779 Jan 23.3	Shower 33	Damage to sky, earth. Governed by Lady Moon. [Textile? hangs from sky band]	Dresden 54b Picture 7	No	e
20	345.4	950 Feb 14.3	Shower 34	(same event as number 15	Dresden 66a2	Yes	
21	344.8	964 Feb 14.3	Shower 34	(eroded) Rain god (Chahk) fire at? cave place. [Dog/oppossum? holds flaming torches]	Dresden 39a1	Yes	b
22	x	1517?	x	Vulture in text [Rain god Chahk in rain with axe and fish]	Dresden 37c2	Yes	f
23	x	1517?	x	Vulture head in text [Rain god Chahk in rain with axe]	Dresden 39c1	Yes	f

Table 2. Meteor shower candidates from the codices. "Success?" refers to positive candidate.

No	Codex	Sign?	Shower	Valid?	Sky Band?	Comment	Year	Type	Success?
2	Dresden 37a2	Yes	Eta Aq.	?	Yes	storm in 964?	959	HT	
7	Dresden 40b2	Yes	Perseids	Yes	Yes	related to no. 9	775	HT	Yes
8	Dresden 45b1	Yes	Perseids	Yes	Yes	row 6	819	HT	Yes
9	Madrid 12a3	No	Perseids	Yes	No	China 933	933	HT	
15	Dresden 66a2	Yes	25?	?	Yes	2 dates for 66a2	949	HT/LP	
20	Dresden 66a2	Yes	34	Yes	Yes	2 dates for 66a2	950	HT	Yes
18	Dresden 55a	Yes	32	Yes	Yes	Picture 2	762	JF/HT	Yes
14	Dresden 56a	Yes	25?	?	Yes	Picture 3	764	HT/LP	
12	Dresden 53b	No	Orionids	Yes	Yes	Picture 6	775	HT	
19	Dresden 54b	No	33	Yes	Yes	Picture 7	779	LP	
1	Dresden 36a3	No	1?	?	No	not seen after 581	959	HT	
21	Dresden 39a1	Yes	34	No	Yes	row 20	964	HT	
16	Dresden 68a3	?	none	No	Yes	meteor sign??	949		
22	Dresden 37c2	Yes	?	No	Yes	Uncertain	1517?		
23	Dresden 39c1	Yes	?	No	Yes	Uncertain	1517?		

since the two spliced sections overlap in dates (Bricker and Bricker, 2011:647). Sample 37a2 correlates to the Eta Aquariids but the translation is unreliable. An additional sample (37a3, not shown nor considered) correlates to the Perseids date but the drawing, sky band, or text seem unrelated to a shower. Sample 8, Dresden 45b1, a Perseid which correlates at row 6 is considered acceptable as explained later. In summary, the success rate is 4 out of 8, or about 50 percent. Therefore, if one finds a dotted X k'in variant in a sky band with a descriptive drawing and text possibly relating to a meteor shower or storm, one could expect to have a date that would coincide with a meteor shower about half of the time. If in the future Shower 25 is found to be a Halley-type, the success rate jumps to 6 out of 8, or about 75 percent. Further, if it is determined in the future that Shower 34 is valid for row 20 for page 39a1 of the Dresden table, the number increases to 87 percent.

7. Analysis: Four Candidates in the Pictures of the Dresden Eclipse Table, Pages 51-58

Scholars agree that the table on pages 51 through 58 is an eclipse table, but whether mostly solar (Bricker and Bricker, 2011:249-342) or lunar (Aveni, 2001:173-184) or undecided (Love, 1994:91) is still under debate. Ten "pictures" or drawings are spread throughout the table as an expansion of certain columns, though not part of the counting sequence itself, and seem to record events already completed. The author bases this interpretation in part on the grammatically "perfect" statements *u-kabijiiy/chabijiiy*, "he/she has caused/governed it," (MacLeod, 2004:291-325) that appear in the text of four of these pictures. Dates associated with four of the pictures, 2, 3 (with a caveat for Shower 25 as discussed above), 6 and 7 coincide with historical meteor shower solar longitudes, well above the one out of ten statistical average. Pictures 2 and 3 have sky bands while pictures 6 and 7 do not, although all four have text and iconography that indicate death, disease and

destruction that are consistent with beliefs about meteors mentioned earlier in this paper.

The possibility that the Maya recorded Shower 32 (Picture 2) seems more than coincidental since both Showers 32 (Table 1) fall within the less than 100 year historical record between AD 685 and 764. The showers of January 685, 743, 745 and December 764 combined with the Maya candidates of January 722 and 762 seem to indicate a shower with about a 20 year period. If Kresáková (1987:935-936) is correct that this shower may have been caused by a comet that appeared in December 684/January 685 (observed in Japan and Europe), that might preclude a prediction by the Maya, especially in 722. Picture 3 concerns Shower 25 which is discussed above, although the table seems to allow an adjustment of a day either way. The plausibility that this shower is described as "red or great rain" is credible since one third (118 of 357) of the historical records use the word "rain" in describing falling stars. Picture 6 depicts a deceased female deity hanging from a sky band. The author translates the first line of the text *ch'a?pahal* as "sickness, disease, possibly contagious," (Barrera, 1980:126), possibly caused by meteors as indicated in the last line of text. This shower would have been Orionids, recorded in AD 288, 585, 903 and 930 prior to AD 1000 (Jenniskens, 2006:604). Picture 7, correlating to long-period Shower 33, seems to record damage to the earth and sky although the cause is not clear due to poor understanding of the text. The shower may be indicated by what has been called a textile suspended beneath the sky band. Moonlight would not have been a factor under a new Moon. In summary, the author believes it plausible that Pictures 2, 6, 7 and possibly 3 are records of meteor storms.

8. Analysis: The Perseids, including events at Palenque

The ruler of Palenque Ahkal Mo' Nahb III recorded his last event on the stone platform in Temple XIX on AD July 23, 736 (local), 9.15.5.0.0, 10 Ahau 8 Ch'en, a date that precisely coordinated with the "road-entering" (death or apotheosis) of Ahkal Mo' Nahb II on 9.6.16.10.7, July 22, 570 (local), exactly 166 sidereal Earth years earlier (365.259 days per year, 365.256 actual). The difference between these two dates, 60,633 days, also equals 14 sidereal cycles of Jupiter (4330.929 days, 4332.589 actual) and 152 synodic cycles of Jupiter (398.901 days, 398.88 actual). These two dates in 570 and 736 also correlate to Perseid solar longitudes of 141.4 and 141.7 degrees respectively when Jupiter was positioned in the constellation Virgo. Grofe (2011:85) demonstrates that the Maya knew the length of the sidereal Earth year and may have tried to keep track of it by adding 23 whole days to 90 Haabs of 365 days to reach 90 sidereal years: (90 x 365) + 23 = (90 x 365.2555556). Similarly, in the case of 166 years between 570 and 736, the sidereal year can also be calculated by adding 43 days to 166 Haab's (one Haab' = 365 days):

60,633 days = (166 Haab's)(365 days/Haab') + 43 days = (2)(83)(365) + 43 = 60,590 days + 43 days = 8.8.5.10 + 2.3 = 8.8.7.13 = (166 sidereal years)(365.259)

The equation is interesting for a couple of reasons. The event immediately prior to 9.15.5.0.0 occurred 43 days earlier inscribed as 6 Kaban 5 Yaxk'in (9.15.4.15.17), a "fire-entering" event. Remarkably, then, counting forward from 9.6.16.10.7, the "road-entering" of Ahkal Mo' Nahb' II in 570, exactly 166 Haab's, or 60,590 days = 8.8.5.10, one arrives at 9.15.4.15.17, the exact date of the "fire-entering" event. Adding another 43 days leads to 9.15.5.0.0, just as in the above formula. The translation of this fire-entering passage is problematic, although Stuart suggests (2005:104-106) it may involve the *o'* bird mentioned in the Ritual of the Bacabs. The *o'* bird is noted in traveler-seizure as being the offspring of the Pleiades (Roys, 1965:9), perhaps a direct reference to the Perseids. First recorded by China in AD 36, the Maya undoubtedly observed the strong annual Perseids regularly (Jenniskens, personal communication 2013). At a normal Zenith Hourly Rate of about 100 meteors and twice that during an outburst (Jenniskens, 2006:649, Table 5c), the Maya would have been interested in predicting future outbursts. In their discussion of the heliocentric sidereal period of Mars and the Upper Water Table of the Dresden codex, the authors state that they know of no reason why the Maya would be interested in such a period [sidereal] (Aveni, et al, 2003:158), yet in the above scenario, the Maya may have been demonstrating the relationship between the sidereal cycle of Jupiter and the Perseid storms and thought that the position of Jupiter was connected to outbursts of the Perseids. Jupiter, in fact, does steer the dust trails [Perseids] of the parent comet 109P/Swift-Tuttle [Jenniskens, 2005:272]).

Continuing with half of the above values, one arrives at a formula using 83 Haab's + 21.5 days that tracks 83 sidereal Earth years and 7 sidereal and 76 synodic cycles of Jupiter:

(83 Haab's)(365 days per Haab') + 21.5 = (83)(365.259) = (7)(4,330.929)
= (76)(398.901) = 30295 + 21.5 = 4.4.2.15 + 1.1 (and a half) = 30316.5

Aveni actually derives nearly the same number, 30,316 in a hypothetical exercise deriving the sidereal cycle of Jupiter (2001:87-89). Projecting forward from AD 736, the Maya may have been able to forecast another outburst of the Perseids:

(83 Haab's)(365 days per Haab') = 30,295 days = 4.4.2.15 days;
Long Count 9.15.5.0.0 + 4.4.2.15 days = Long Count 9.19.9.2.15

Interestingly, the date 9.19.9.2.16 is found in column one, row six of the "Mars" table, Dresden pages 44b and 45b. A 19 day interval follows in column two, leaving only 1.5 days short that the Maya would have needed to arrive at 7 sidereal Jupiter cycles and 83 sidereal Earth years. That date in column 2 corresponds to 9.19.9.3.15, July 23, 819 (local), another possible Perseid storm date at a solar longitude of 140.5 degrees. Although the question of whether the Maya Long Count changed at sunset or sunrise is beyond the scope of this paper, they may have changed over 9.19.9.2.15 to 9.19.9.2.16 at sunset because the event occurred at night and accepted that the Long Count was about a day short in the following column. Only two dates out of 40 total in the Mars table coincide with solar lon-

gitudes of actual historical showers, and the text reads in part, "it is destruction to Fire Macaw and death of the Maize deity." The 83 year pattern in the Perseids is also evidenced by China observations in AD 841 and 924 and Japan in 1007 (Jenniskens, 2006:601).

There is another interesting relationship between two Perseid candidates in cognate eclipse almanacs, Dresden 38b-41b and Madrid M10a-13a. In his discussion of these two instruments, Tony Aveni raises the questions of why the intervallic sequences might be different between the two and "can astronomical knowledge incorporated in one almanac be used to date its cognate?" (2004:152). In fact, the adjusted intervallic count in each almanac produces the Perseids date in frame 8 (H) in each almanac, July 23, 775 in the Dresden and July 25, 933 in the Madrid. In the historical tables China recorded the Perseids only hours later on July 25, 933. Drawings in both almanacs depict an anthropomorphic macaw holding a torch in each hand and the text states "it is fire from the sky of four macaw place" (figure 5).

Another Perseid event may have been recorded at Palenque on Maya date "2 Kib 14 Mol," July 22, 690. Highly important but problematic (but see Stuart, 2006:96-98), this "burning" event of possibly a heavenly location involved the Triad Deities GI, GII and GIII followed by "three-times conjuring" the next day. GI or all the Triad Deities are connected to all four major events of Ahkal Mo' Nahb' III's reign with possible connections to meteor showers. Given the "road-entering" of Ahkal Mo' Nahb' II on a Perseid date in 570, it seems the Maya would have been well aware of the Perseids in 690 and "burning and conjuring" are terms associated with meteors in the incantations.

Ahkal Mo' Nahb' III acceded into kingship over 30 years later on a date corresponding with Shower 32. In fact, four of the major events during his reign occurred on dates of possible meteor showers: Shower 32, the Orionids, Shower 15 and the Perseids, statistically a very unusual occurrence. One wonders whether his name itself wasn't related to meteor showers, as the Orionids radiant is near Orion the turtle *Ahkal* and the Perseid radiant is near the Pleiades connected to *Mo'*, "macaw" as discussed earlier. Indeed "Nahb'" may be a homophonic reading for *naab'*, "rain" in a few of the Mayan languages (Kaufman with Justeson, 2003:482).

9. Conclusions

The author believes the Maya recorded at least three Perseid meteor showers: Dresden 40b2 (AD 775), Madrid 12a3 (AD 933, quite possibly the same event recorded by the Chinese only hours later), and the "2 Kib 14 Mol" event in AD 690 recorded at the Classic site of Palenque. A strong probability exists that the AD 819 date recorded in the Dresden Mars table in row 6, page 45b1 is a prognostication for a Perseid storm derived from a formula for the sidereal Earth year and sidereal cycle of Jupiter from possible Perseid outbursts in AD 570 and AD 736 recorded at Palenque. In the codices there is about a 50 percent (4 out of 8 candidates) chance of

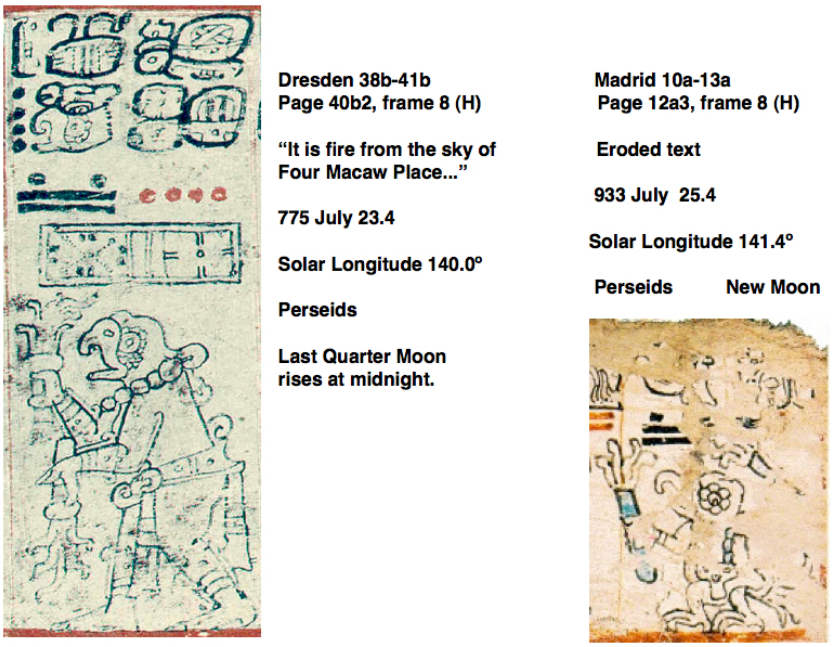

Figure 5. Frames 8 (H) from each of cognate almanacs Dresden 38b-41b and Madrid 10a-13a displaying anthropomorphic macaws holding torches on possible Perseid meteor shower dates.

a meteor storm indicated by the k'in variant in the sky band, somewhat low due to Shower 25 type uncertainty. There is some likelihood of 3 or 4 occurrences of meteor storms recorded in the group of 10 pictures in the Dresden eclipse table (D.51-D.58), although better translations are needed in the accompanying texts; the verification of a strong Orionids meteoroid stream in AD 775 (Picture 6) might increase this likelihood. The possibility of meteor storms being recorded during Ahkal Mo' Nahb' III's reign remains high, though increased understanding of the associated texts and again a verification of a stronger Orionids meteoroid stream in AD 724 would raise this probability. The resultant solar longitudes for the Perseids (see Table 1) very close to the peak solar longitude of 140.19 degrees may serve to verify the correlation constant of 584286, though this may not discount 584285 due to the meteor showers being a night event; however the use of a 584283 constant may be sufficiently low to render the results of this study questionable.

Acknowledgements

I would like to thank Dr. Tony Aveni and Dr. Harvey M. Bricker for reviewing an earlier draft of the paper, Dr. Barbara MacLeod, Dr. Carl Callaway, Dr. Michael Grofe and Dr. Peter Jenniskens for valuable comments and acknowledge the kind invitation extended by Dr. Jenniskens and Dr. Tadeusz Jopek to present at the 2013 Meteoroids Conference.

References

Aldana G., 2005, Agency and the "Star War" Glyph: A Historical Reassessment of Classic Maya Astrology and Warfare, Ancient Mesoamerica, 16 (2005), 305, Cambridge U. Press

Aveni A. F., 2001, Skywatchers: A Revised and Updated Version of Skywatchers of Ancient Mexico, University of Texas Press, Austin

Aveni A.F., 2004, Intervallic Structure and Cognate Almanacs in the Madrid and Dresden Codices, in *The Madrid Codex: New Approaches to Understanding an Ancient Maya Manuscript*, Eds. Vail, G. and Aveni, A., University Press of Colorado, 2009

Aveni A.F., Bricker H.M., Bricker V.R., 2003, Seeking the Sidereal: Observable Planetary Stations and the Ancient Maya Record. *Journal for the History of Astronomy* 34:145-161.

Barrera Vásquez A., Vermont S.R., Dzul G.D., Dzul P.D., 1980, Diccionario Maya Cordemex, Merida, Yucatán

Bricker H.M. and Bricker V.R., 1996, Astronomical References in the Throne Inscription of the Palace of the Governor at Uxmal, Cambridge Archaeological Journal, 6, pp 191-229 doi:10.1017/S0959774300001712

Bricker H.M. and Bricker V.R., 2011, Astronomy in the Maya Codices, Amer. Phil. Society

Christenson A. J., 2007, *Popol Vuh: Literal Translation.* Electronic version of original 2004 publication. Mesoweb: `www.mesoweb.com/publications/Christenson/PV-Literal.pdf`

Gates W., 1937, Yucatan Before and After the Conquest by Friar Diego de Landa (1566), with other related documents, maps and illustrations, translated with notes by William Gates, Dover Publications (1978)

Grofe M. J., 2011, The Sidereal Year and the Celestial Caiman: Measuring Deep Time in Maya Inscriptions, Archaeoastronomy, Vol XXIV

Grube N., 2000, Fire Rituals in the Context of Classic Maya Initial Series, in *The Sacred and the Profane: Architecture and Identity in the Maya Lowlands*, eds Colas P.R., Delvendahl K., Kuhnert M., and Schubart A., Acta Mesamericana, Vol. 10, pp. 93-110, Berlin.

Hopkins N.A. and Josserand K.J., 2011, A Historical Dictionary of Chol (Mayan), Electronic document at `www.famsi.org/mayawriting/dictionary.htm`

Imoto S. and Hasegawa I., 1958, Historical Records of Meteor Showers in China, Korea and Japan, *Smiths. Contra. Astrophys.*, 2, 131 (updated in 1993)

Jenniskens P., 2006, Meteor Showers and their Parent Comets, Cambridge University Press

Kaufman T. with Justeson, J., 2003, A Preliminary Mayan Etymological Dictionary, Electronic document at `www.famsi.org/mayawriting/dictionary.htm`

Kennett D.J., Hajdas I., Culleton B. J., Belmecheri S. et al., 2013, Correlating the Ancient Maya and Modern European Calendars with High-Precision AMS 14C Dating, Scientific Reports, 3:1597, DOI:101038/srep01597

Kresáková M., 1987, Associations between Ancient Comets and Meteor Showers, A&A, 187

Laughlin R. M., 1975, The Great Tzotzil Dictionary of San Lorenzo Zinacantan, Smithsonian Institution Press

Lenkersdorf C., 2010, Diccionario tojolabal-español 1: idioma mayense de Chiapas, Electronic document, `www.webislam.com/media/2011/10/45269`

Love B., 1994, The Paris Codex: Handbook for a Maya Priest, University of Texas Press, Austin

MacLeod B., 2004, A World in a Grain of Sand: Transitive Perfect Verbs in the Classic Maya Script, in *Linguistics of Maya Writing*, Ed. Wichmann S., University of Utah Press, Salt Lake City

Macri M. J. and Looper M. G., 2003, The New Catalog of Maya Hieroglyphs, Volume One: The Classic Period Inscriptions, University of Oklahoma Press, Norman

Martin S. and Skidmore J., 2012, Exploring the 584286 Correlation between the Maya and European Calendars, The PARI Journal 13(2), 2012, p. 3

Roys R. L., 1965, Ritual of the Bacabs: A Book of Maya Incantations, (translator and editor), University of Oklahoma Press, Norman

Stuart, D., 2005, The Inscriptions from Temple XIX at Palenque: a Commentary, The Pre-Columbian Art Research Institute

Stuart D., 2006, Sourcebook for the 30th Maya Meetings, UT Austin

Tate C., 1992, Yaxchilan: The Design of a Maya Ceremonial City, University of Texas Press, Austin

Taube, K., 2000, The Turquoise Hearth: Fire, Self-Sacrifice, and the Central Mexican Cult of War, in *Mesoamerica's Classic Heritage: from Teotihuacan to the Aztecs*, Eds. Carrasco, D., Jones, L., and Sessions, S., University of Press Colorado

Thompson J. E. S., 1962, A Catalog of Maya Hieroglyphs, University of Oklahoma Press, 1991

Vail G. and Hernandez, C., 2013, *The Maya Codices Database, Version 4.1.* A website and database available at `http://www.mayacodices.org/`

Yeomans D. K., 1991, Comets: A Chronological History of Observation, Science, Myth, and Folklore, John Wiley and Sons, Inc., New York