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Weather Prediction in Babylonia

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Abstract: This paper addresses developments in the prediction of weather phenomena in Late Babylonian scholarly texts. Previously published and unpublished texts are analyzed and the underlying methods are compared with omen-based weather prognostication, developments in Babylonian astronomical prediction and reporting practices in the astronomical diaries. It is found that some texts combine long-term astronomical prediction with inferential methods for predicting weather phenomena. It is argued that these new methods for predicting weather phenomena are part of a larger Babylonian effort to predict and explain non-astronomical phenomena by relating them to predictable astronomical phenomena.

Keywords: astronomical diaries, Babylonian astral science, celestial divination, weather prediction

1 Mesopotamian Approaches to Weather

Human existence is continuously controlled by weather. Its effects are especially consequential in pre-modern agricultural societies such as ancient Mesopotamia. The daily experience of securing an existence under changing weather conditions unavoidably shaped how weather was conceptualized in religion and scholarship. According to the cuneiform sources, divine agency in the realm of weather is personified in the deity Adad. He is presented as an ambivalent character, on the one hand credited with sustaining life by providing water and favorable weather, on the other hand with endangering or destroying it through floods, storms, drought, heat, cold and lightning (Schwemer 2001, 2008a, 2008b). This is famously exemplified in the Old Babylonian myth Atraḫasis, which relates how Adad brought about the flood that nearly exterminated all life.[1] Mesopotamian religion not only provided a

1 On the role of Adad in Atraḫasis see Schwemer 2001: 422 and Schwemer 2008a: 151.

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framework for identifying the cause of weather in divine agency, it also offered the tools of divination for interpreting and predicting weather in order to better cope with its phenomena in past and future. Tablets 36–49 of the divination series *Enūma Anu Enlil* (EAE), "When Anu and Enlil", which is attested since the Neo Assyrian era,[2] contain omens for interpreting weather phenomena. The large number of these omens and their grouping together in a central place after the lunar and solar omens (Tablets 1–35) and before the planetary and stellar omens (Tablets 50–ca. 70) imply that weather phenomena were viewed as an important and distinct category of celestial signs. Weather predictions inferred from celestial signs are spread across the entire series EAE and other divinatory compositions such as the astral compendium Mul.Apin, "Plow Star", and the hemerological series *Iqqur īpuš*, "He tore down, he built up". From the 7th century BCE onward Babylonian scholars systematically reported weather phenomena in astronomical diaries and related texts. After the introduction of the zodiac in the 5th century BCE they developed new methods for predicting weather by combining astronomical and divinatory approaches. This paper analyzes the Late Babylonian weather compositions in the light of the divinatory tradition and the astronomical diaries and associated predictive methods. The aim is to understand these compositions as reflections of broader trends in Babylonian scholarship and to set the stage for future investigations of Late Babylonian "astrometeorology". The paper is structured as follows. In §2 the sources are introduced and the predictive statements are divided into long-term rules and short-term inferential statements, which are analyzed in §3 and §4, respectively. §5 addresses the question of how they were combined to produce long-term weather predictions. §6 investigates their relationship with the astronomical diaries and related texts. §7 contains the conclusions.

2 Late Babylonian Compositions about Weather Prediction

Eight Late Babylonian compositions with weather predictions are at the center of this investigation (Table 1). They originate from unscientific excavations in Uruk and, most likely, Babylon. For three tablets the name of a scribe or owner is

2 For an overview see Gehlken 2005 and Koch 2015: 163–82. For editions of EAE T. 42–49 see Gehlken 2008 and Gehlken 2012. For Adad in omen apodoses see Schwemer 2001: 416–19, 687–94.

preserved in the colophon. BM 47494 was written by Iprāya, descendant of Ēṭiru, who was a productive and original scholar, judging from his commentaries and compilations.[3] He was active during the reign of a king Artaxerxes, which implies a date between 464 and 337 BCE. The collection 1881-11-3 to which the tablet belongs includes 12 astronomical diaries written between 392 and 133 BCE and numerous other scholarly tablets probably originating from a library of the Esagila temple in Babylon.[4] Perhaps BM 47494 was also kept in that library. AO 6449 and AO 6455 were written during the Seleucid era by scholars connected to the Rēš temple in Uruk.[5] The former was owned by Anu-aḫa-ušabši, son of Kidin-Anu, descendant of Ekur-zākir, diviner of Anu and Antu, scribe of Enūma Anu Enlil (i.e. astronomer) and high priest of the Rēš temple, and written in SE 84 (228 BCE) by his son Ina-qibīt-Anu, diviner of Anu and Antu. Both were active in the astral sciences and divination.[6] AO 6455, a compendium of astrological and Goal-Year procedures, was owned by Nidinti-Anu, son of Ina-qibīt-Anu, descendant of Ḫunzû, diviner of Anu and Antu, and written by his son Anu-uballiṭ, diviner of Anu and Antu. The tablet is undated, but Anu-uballiṭ is known to have been active during the years SE 97–98.[7] Other tablets owned or written by these two scholars cover topics from celestial divination, mathematics and rituals. The other two tablets from Uruk may originate from the same context and can be assumed to have a similar date.

3 For a list of tablets mentioning this scribe and his relatives see Finkel 1988; see also Jiménez 2016: 218, and Ossendrijver 2019a: 66, footnote 49. For the reading of his name see Schwemer 2009: 57–58.

4 For the scholarly libraries of the Esagila see Clancier 2009: 168–214. For the diaries in the 1881-11-3 collection see Pirngruber 2019: 190; for other scholarly tablets in that collection see Clancier 2009: 445 and Leichty, Finkel & Walker 2019: 656–706. The collection comprises finds from Babylon, Birs Nimrud (Borsippa) and Tell Dailem (Dilbat). For some of Iprāya's tablets an origin from Babylon is documented (Leichty, Finkel & Walker 2019: 656). An origin from the Esagila is certain for BM 47461 (1881-11-3, 166), a copy of Enūma Anu Enlil Tablet 68, which mentions in its colophon that the scribe, who was not Iprāya, "placed it in the Esagila" (*i-na* ^{é}E.SAG.IL$_2$.A *u$_2$-ki-in*) "for his well-being" (*ana* DIN-*šu$_2$*).

5 For the scholarly library of the Rēš temple during the Seleucid era see Clancier 2009: 99–103, 406–409; Proust & Steele 2019: 34–49; Ossendrijver 2019b.

6 Anu-aḫa-ušabši is attested as the owner of seven other scholarly tablets dating from SE 61–77. Four deal with celestial divination (AO 6486 + VAT 7850, K 3753, UCP 9, VAT 7830), two with cultic topics (BRM 4 7; W 18828), and one is a chronicle (*SpTU* 1 2). Ina-qibīt-Anu is attested on four other scholarly tablets, all dealing with astral science (AO 6483 + VAT 7850, MLC 1866 = Beaulieu et al. 2018 Text D, VAT 7809 = *ACT* No. 101, and VAT 7830).

7 For a list of tablets mentioning Anu-uballiṭ see Ossendrijver 2011.

Table 1: Late Babylonian compositions with weather predictions.

AO 6488 (*TU* 20)	Hunger (1976b)	Uruk, ca. 230–190 BCE	Weather predictions
AO 6449 (*TU* 19)	Hunger (1976b)	Uruk, 228 BCE	Weather predictions
BM 36647	Schreiber (2018)	Babylon (?)	Weather predictions and other astrological predictions
AO 6455 (*TU* 11)	Hunger & Brack-Bernsen (2002)	Uruk, ca. 230–190 BCE	Astronomical, weather and other astrological predictions
A 3451	Unpublished	Uruk, ca. 230–190 BCE	Weather and market predictions
BM 35325 (*LBAT* 1600)	Side X: Hunger (2019)	Babylon (?), after ca. 450 BCE	Astrological predictions
BM 41485	Unpublished	Babylon (?)	Weather predictions
BM 47494	Hunger (2004)	Babylon (?), ca. 464–337 BCE	Market and weather predictions

The remaining three tablets from Babylon belong to collections with large numbers of astronomical diaries and other scholarly tablets from the Esagila library.[8]

The zodiac of 12 signs of equal length was introduced in the 5th century BCE, which constitutes a terminus post quem for compositions that use zodiacal signs. Since their names are a subset of the names of the zodiacal constellations, the distinction between zodiacal signs and constellations is not always clear, except if more than 12 zodiacal constellations are mentioned. Six tablets (AO 6449, AO 6455, BM 35325, BM 36647, BM 41485, BM 47494) contain weather predictions that (probably) operate with zodiacal constellations. BM 35325 also contains an astrological section that uses a zodiac of 12 signs,[9] proving that the tablet was written after ca. 450 BCE. Two tablets (AO 6488, A 3451) contain weather predictions involving zodiacal signs. As will be argued, the weather predictions are closely connected to the astronomical diaries and related texts. Since diaries were mainly produced in Babylon, they were probably developed by scholars from that city.

8 BM 35325, BM 36647 and BM 41485 belong to the collections Sp 2, 1880-6-17, and 1881-6-25, respectively. For the astronomical diaries and other scholarly tablets in these collections see Clancier 2009: 409–70; Pirngruber 2019; Leichty, Finkel & Walker 2019.

9 For an edition of BM 35325 side X and its two duplicates from Uruk, *SpTU* 2 43, 20–28 and AO 6483 (*TU* 14) 22–25, see Hunger 2019. *SpTU* 2 43 belongs to the library of the diviner Iqīšâ (ca. 340–300 BCE); AO 6483 was probably written by a scholar of the Rēš temple ca. 230–190 BCE.

The most important compositions are AO 6488, AO 6449 and BM 36647, which are mainly concerned with weather prediction. For full translations and commentaries the reader is referred to the editions (Table 1). As explained by Hunger, AO 6488 and AO 6449 are consecutive tablets of a series comprising at least three tablets.[10] The colophon of AO 6488 mentions the catchline of AO 6449, "In the beginning of the winter, in month VI or in month VII, Mercury or Venus appears in the East: there will be rain this year". The colophon of the latter tablet preserves the catchline of a next one, "Aries, area of the market rate of the merchant", which remains unidentified. The rarity of these texts and the fact that the colophons do not mention a tablet number suggest that they did not enjoy a wide circulation. AO 6449 is now partly duplicated in BM 36647, which shares five procedures in the same order.[11] It follows that the new methods for predicting weather circulated between Babylon and Uruk, though apparently not in a standardized series of tablets. Of the remaining tablets A 3451 and BM 41485 are also mainly concerned with weather.

The eight compositions are not the only ones about weather prediction that were available at the time. Late Babylonian astrometeorology is characterized by a multiplicity of methods, as has been argued for other areas of Babylonian astral science.[12] Weather is also predicted in earlier, pre-zodiacal compositions such as Mul.Apin, EAE and *Iqqur īpuš*, which continued to be copied, excerpted, interpreted and commented by Late Babylonian scholars. As will become apparent, the new compositions share many elements with these earlier ones.

From the fact that several tablets deal almost exclusively with weather phenomena we can infer that the Babylonian scholars continued to conceive them as a more or less distinct category of celestial phenomena, but an emic Babylonian term for weather is not attested. The predicted weather phenomena cover water levels, precipitation, clouds, wind, lightning and temperature, but also comets and earthquakes (Table 2). The most commonly mentioned one is "rain and high water", *zunnu*($ŠEG_3$) *u mīlu*(ILLU), which appears to be a generic term for rain-related phenomena, river levels and ground water. Most of the predicted weather phenomena are attested both in astronomical diaries and in omen texts, but the rain-related terms UTAḪ, DUL-*ḫat*, "loosening of the sandal" and PISAN, whose precise meaning remains unclear, are not or barely attested outside the diaries (*ADRT* 1: 27–34).

10 See also Hunger 2019: 182–83.

11 An additional fragment of this tablet, BM 36353, will be published by M. Schreiber.

12 Steele 2013; Rochberg 2016: 228, 252.

Table 2: Predicted weather phenomena.

Weather phenomenon		Attestations	Diaries	Omens
zunnu(ŠEG$_3$); AN (= *šamû?*)	Rain	Numerous	Yes	Yes
mīlu(ILLU)	Water level ("flood")	Numerous	Yes	Yes
erpetu(DIRI)	Cloud	AO 6488 rev. 6; AO 6449 obv. 22	Yes	Yes
UTAḪ (= *natāku*?)	(Rain related phenomenon)	AO 6488 rev. 6[a]	Yes	No
DUL	(Rain related phenomenon)	AO 6488 rev. 7	Yes	No
paṭār(DU$_8$) *šēni*	"Loosening of the sandal" (rain related phenomenon)	AO 6488 rev. 7	Yes	No
PISAN	(Rain related phenomenon)	AO 6488 rev. 8	Yes	No
rādu	Downpour	AO 6488 rev. 8	Yes	?
riḫiṣti(RA) *Adad*(^{d}IM)	Destruction by Adad	AO 6488 rev. 9	Rare[b]	Yes
kuṣṣu(ŠED$_7$, EN.TE.NA)	Cold	AO 6488 rev. 16; AO 6449 §12; BM 41485 rev. 12′	Yes	Yes
abnu(NA$_4$)	Hailstone	BM 36647 §§5′–7′	Yes	Yes
rigim(GU$_3$) *Adad*(^{d}IM, U)	Thunder ("cry of Adad")	AO 6449 §12, BM 36647 §§5′–7′; A 3451 side X 2′	Yes	Yes
birqu(NIM.GIR$_2$, GIR$_2$)	Lightning	AO 6449 §12, BM 36647 §§5′–7′	Yes	Yes
miqitti išâti (IZI.ŠUB)	Lightning strike ("fall of fire")	AO 6449 §12; BM 41485 rev. 12'; A 3451 side X 8′; AO 6455 §3	Yes	Yes
šāru(IM) ŠAR$_2$	Gusty(?) wind	AO 6455 rev. 29	Yes	Yes
tīb(ZI) *šāri*(IM)	Rising of wind	BM 47494 obv. 29; A 3451 side X 6′	No	Yes
^{d}*ṣallummû*	Comet	AO 6455 §1, §24	Yes	Yes
rību	Earthquake; quaking	AO 6455 §24[c]	Yes[d]	Yes

[a]UTAḪ is also attested in an unclear context in the Late Babylonian astrological compendium BM 32339+ rev. 19' (Ossendrijver 2018).

[b]Destruction by Adad, written *riḫiṣtu*(RA-*tu$_2$*) ^{d}IM, is attested in two diaries, *ADRT* 3 -136 rev. 11' ("destruction among the date palms") and *ADRT* 3 -125 obv. 13.

[c]Earthquakes and quaking of the sky, *ri-i-bi ša$_2$* AN-*e*, are also mentioned in the Late Babylonian astrological text BM 34275 (*LBAT* 1604) rev. 3′–11'. This unedited tablet probably originates from Babylon. According to its colophon, it was copied in SE 62 from a wooden board from Borsippa (*BAK* 152).

[d]Earthquakes are attested three times in the phrase KI-*ti$_3$ i-nu-uš*, "the earth quaked" (*ADRT* 2 -251 rev. 11'; *ADRT* 2 -170E rev. 3'; *ADRT* 3 -93A obv. 1). A "quaking of the sky", ⌜*ri*⌝-*i-bu* AN-*e*, is attested in *ADRT* 3 -119C obv. 16'.

3 Long-term Weather Prediction

Two tablets, AO 6488 and AO 6455, include rules for long-term weather prediction. They can be divided into procedures in which the user is addressed in the second person of the present tense and recurrence statements.

3.1 Procedures Involving Planetary and Lunar Periods

The following two examples belong to a group of procedures for long-term weather prediction based on planetary and lunar periods:[13].

> [If] you (want to) cast a prediction [for … rain and] high water: […] *month II*. For the Large Star (Jupiter) 1,12 (= 72), 24, 12 years, [for Dilbat (Venus)] 16, 8 years, for Šiḫṭu (Mercury) 46, 21, 13 years, [for Kayyāmānu (Saturn)…, for Ṣalbatānu (Mars)] 47 years, for Šamaš (sun) 36, 54 years, for Sin (moon) 18 years (AO 6488 rev. 1–4).

> In order for you to compute ("make") rain and high water: 1,12 for Sagmegar (Jupiter), 64, secondly 16 for Dilbat, 46, secondly 13 for Šiḫṭu, 59 for Kayyāmānu, 1,19 (= 79), secondly 47 for Ṣalbatānu (AO 6455 rev. 23).

No comparable procedures for predicting weather are attested in earlier sources, but their formulation is familiar from other procedure texts. The phrase "you cast a prediction", *qība*(ME.A) *tašakkan*(GAR-*an*), is attested in Mul.Apin and in Late Babylonian procedures for predicting market prices and astronomical phenomena,[14] and the expression "in order for you to compute", *ana epēši*(DU_3)-*ka*, is widely used in mathematical astronomy (Ossendrijver 2012: 35–36).

A most innovative aspect of these procedures is their use of planetary and lunar periods, resulting in weather predictions across intervals of unprecedented length (Table 3). The planets are listed from benefic to malefic as usual in Late

13 Translation slightly modified from Hunger 1976b. The phrase "[…] month II" is without parallel and its meaning remains unclear. Other long-term weather procedures mentioning planetary or lunar periods: AO 6488 rev. 13–14, 17–19; AO 6455 rev. 24–28, 34 (see below).

14 Intercalation rules: Mul.Apin II ii 9–10 (Hunger & Steele 2019: 214); market prices: *SpTU* 1 94 (Hunger 1976a); planetary phenomena: BM 76488 (Ossendrijver 2017). With one exception (Ossendrijver 2012 No. 99 X ii' 1) this phrase is not used in mathematical astronomy, perhaps because its procedures yield sequences of predictions rather than single predictions.

Table 3: Planetary periods for weather prediction and Goal Year periods measured in years. In brackets: valid Goal Year periods that are not attested in Goal Year texts.

Planet	Periods for weather prediction	Attestations	Goal Year periods
Jupiter	12, 24, 72, 83	AO 6455 rev. 23, 26, AO 6488 rev. 2	(12), 71, 83
Venus	8, 16, 64	AO 6455 rev. 23, AO 6488 rev. 3, 14	8
Mercury	6, 7, 13, 14, 21, 30, 46	AO 6455 rev. 23, 25; AO 6488 rev. 3, 14	(1, 6), 46
Saturn	30, 41, 59	AO 6455 rev. 23, 26	(30), 59
Mars	47, 79	AO 6455 rev. 23; AO 6488 rev. 4	47, 79
Sun	36, 54	AO 6488 rev. 4	18
Moon	18	AO 6488 rev. 4	18

Babylonian astral science (Rochberg-Halton 1988b). Being expressed in whole years, the periods are unsuitable for short-term weather predictions. Many are identifiable as Goal Year periods, which were used for predicting planetary and lunar phenomena in Goal Year texts (see below). The other periods are not attested in Goal Year texts, but some of them are valid alternative periods, being multiples or sums of known Goal Year periods.[15] It may be noted that the weather data in the astronomical diaries vary on times scales of up to centuries, consistent with physical indicators of the Mesopotamian climate.[16] The periods are therefore in principle appropriate for modeling Babylonian weather variations, even though long-term weather prediction is extremely challenging from a modern perspective. In earlier compositions such as EAE, Mul.Apin and *Iqqur īpuš* only short-term weather predictions are inferred from planetary, lunar and stellar phenomena and no reference is made to their long-term predictability. Even though some planetary periods such as 8 years for Venus were probably known during the Neo Assyrian era,[17] there is no evidence that they were combined with omen statements to produce long-term weather predictions [18].

15 For a derivation of some of these periods see Ossendrijver 2017: Table 1. As pointed out by Hunger 1976b, multiples of Goal Year periods are less accurate than single periods. The 72-year period for Jupiter, the 30-year period for Mercury and the 41-year period for Saturn are not valid Goal Year periods.

16 For monthly variations and long-term trends of Babylonian weather phenomena and river levels inferred from the astronomical diaries and from physical data see Hecker & Kamminga 1989; Slotsky 1997; Müller 1999/2000; Graßhoff 2011: 41–42, and Figures 4–6; Huijs, Pirngruber & van Leeuwen 2015: Figures 7.3 and 7.6.

17 The 8-year period for Venus phenomena is implied in EAE T. 63 (Reiner & Pingree 1975). See also Brown 2000: 113–22, 193–95. Mul.Apin II i 44–67 mentions schematic intervals of visibility and invisibility for all five planets, but no periods (Hunger & Steele 2019: 204–208).

18 See Brown 2000: 3, 193–207.

In order to determine how the periods were meant to be used for predicting weather it is instructive to recall how planetary and lunar phenomena were predicted with Goal Year periods. Several Late Babylonian procedure texts deal with this topic.[19] Although Goal Year periods were expressed in years they actually correspond to fixed numbers of months. For instance, the 8-year Venus period denotes an interval of 99 months, which connects two identical months or two shifted months separated by eight calendar years, depending on the number of intercalary months. After one Goal Year period, conceived as a fixed number of months, the planetary or lunar phenomena repeat at nearly the same celestial position and calendar date, apart from a possible shift of one month. Each reported phenomenon for which a Goal Year period is known can therefore be repurposed as a prediction. This principle is implemented in Goal Year texts,[20] which contain planetary and lunar phenomena excerpted from different diaries and arranged by planet, each preceding the Goal Year by the appropriate period. The included phenomena are Normal Star passages and synodic phenomena of the planets, lunar and solar eclipses and Lunar Six intervals.[21] On their turn Goal Year texts were the main source for Almanacs and Normal Star Almanacs (Hunger 2014), which contain predictions for one calendar year arranged by month.[22] Other phenomena that were reported in diaries such as Normal Star passages of the moon, the appearance of comets and meteors, planetary brightness, weather phenomena, river levels and events in the city, are not predicted in these texts. For some excluded phenomena such as comets and earthquakes periods are attested in AO 6455, but there is no evidence that they were used for predictive purposes. It is striking that the excluded phenomena are, by modern criteria, more difficult to predict with Goal Year methods than the included ones. This suggests that phenomena were selected for inclusion in Goal Year texts after an evaluation of their predictability. Even though this resulted in the exclusion of

19 For the planets see BM 41004 rev. (Brack-Bernsen & Hunger 2005/6) and BM 45728 (Britton 2002: 59–61). For the moon see AO 6455 (Brack-Bernsen & Hunger 2002) and BM 42282 + 42294 (Brack-Bernsen & Hunger 2008).

20 For editions of the Goal Year texts see Hunger 2006. For the planetary Goal Year methods see Gray & Steele 2009 and Steele 2011. For the lunar Goal Year methods see Brack-Bernsen & Hunger 2002.

21 The Lunar Six are six intervals between the rising or setting of the moon and that of the sun, two of which were measured near New Moon and four near Full Moon. For their definition see *ADRT* 1, 20–22.

22 Almanacs and Normal Star Almanacs also predict the dates of solstices, equinoxes and Sirius phenomena, which were computed with the so-called Uruk scheme. For the relationship between Goal-Year texts, Almanacs and Normal Star Almanacs see Gray & Steele 2008; Steele 2011.

weather phenomena,[23] the weather procedures prove that they were, nevertheless, considered to be predictable at some level.

Before turning our attention to the recurrence statements it should be pointed out that some other long-term procedures on AO 6455 are more difficult to interpret than the ones discussed above. AO 6455 §24 (rev. 24–28) is noteworthy because it appears to mention a very long period expressed in traditional absolute numerals, perhaps representing $9 \times 60 + 9 \times 3600 = 32940$ years,[24] for predicting rain and high water, as well as periods of 72 and 36 years for comets "that appear in the Tails (= Pisces)" and a 21-year period for earthquakes and high water. Since none of these periods is attributed to a planet within the procedure, they appear to be conceived as intrinsic periods. The origin of these periods and they way in which they were meant to be used are unclear.[25] Since the scribe copied this procedure from a damaged original, as indicated by several glosses *ḫe-pi*$_2$, "broken", and no parallels are known, he may also have had difficulty in understanding them.

3.2 Recurrence Statements

Further clues about the predictive method are provided by a second class of long-term statements to be referred to as recurrence statements, which link past and future occurrences of weather phenomena (AO 6488 rev. 5–13, 15–16). Nine of these statements (rev. 5–9) use the template "As much as previously (*ma-la* SUMUN) W, now (*en-na*) W", where all W are weather phenomena (Table 3), except in the first two statements (rev. 5). Their placement after the list of planetary periods (rev. 1–4) suggests that the intervals between "previously" and "now" are determined by these periods. It follows that the associations between astronomical phenomena and weather phenomena are also implied. This is confirmed by further recurrence statements that explicitly mention such associations (rev. 10–13, 15–16):

> [If] the planets appear and there is rain and high water, now rain and high water. If on the 2nd day after its "appearance" (*tāmartu*) rain and high water then now on the 2nd day after its "appearance" rain and high water. [If on the 3]rd rain and high water then now the same. If on the 4th rain and high water then now the same. [If on the 5th(?)] rain and high water then now

23 Except those that obstruct the observation of predictable astronomical phenomena (see below).

24 The number 32940 is a tentative interpretation of 9 UŠ ŠAR$_2$ ŠAR$_2$ ŠAR$_2$ ŠAR$_2$ ŠAR$_2$ ŠAR$_2$ ŠAR$_2$ ŠAR$_2$ ŠAR$_2$, which assumes that 9 UŠ stands for 9×60 and that each instance of ŠAR$_2$ stands for 3600. However, this traditional number notation is rarely used in Late Babylonian scholarly texts and one would expect 9 UŠ to follow the nine instances of ŠAR$_2$.

25 AO 6455 §28 (rev. 34) is another weather procedure mentioning planetary periods that defies interpretation.

> the same. If in 1 month, if in 2 months, if in 3 months (after its "appearance" …) then (this is) now by which […]. [If …], (this is) now by which rain, high water, heat, cold.

Here "appearance" (*tāmartu*) is probably a general term for synodic phenomena (first appearances, stations, acronychal risings, last appearances),[26] as will be argued in §5. It is plausible that the passage exemplifies a general rule, namely that the time delay between the signifying phenomenon and the associated weather phenomenon is the same for past and future instances of the signifying phenomenon. Recurrence statements are therefore second order predictions, because they are concerned with the recurrent nature of inferential statements.[27] The first two recurrence statements (rev. 5) which were set aside from a special case: "As much as it was previously early it will now be early. As much as it was previously late it will now be late". It is proposed here that they are also concerned with time differences between weather phenomena and the associated astronomical phenomena.[28] This would reveal another innovative aspect of the predictive method, because associations between astronomical phenomena and weather phenomena that precede them are unknown in the earlier omen tradition. Apparently due to the long-term predictability of astronomical phenomena, weather phenomena could now, in principle, also be predicted through correlations with subsequent astronomical phenomena. AO 6488 ends with the intercalation rules (rev. 18–19) needed for determining the "new month" when the Goal Year period is added to the "old month" (Hunger 1976b: 246).[29] Their place after the recurrence statements confirms that the weather predictions are obtained with Goal Year periods.

4 Inferential Statements

The remaining weather predictions are inferential statements. Their general structure can be represented as

signifying configuration (protasis) → weather phenomenon (apodosis).

They include traditional omen clauses, "if (*šumma*) P (then) Q", variants with *aššа*, "as soon as", *enūma*, "when", or *kī*, "when", clauses without a conjunction and

26 For the meaning of these phenomena see Ossendrijver 2012: 55–58.

27 On the notion of first and second order weather predictions see Lehoux 2007: 65–69, and Graßhoff 2011: 40–42.

28 This interpretation is alternative to the suggestion by Hunger 1976b: 244, that early and late refer to the timing of the harvest in the year. It remains tentative, because statements that explicitly link specific weather phenomena to subsequent astronomical phenomena are not attested.

29 In AO 6449 this is exemplified for Mercury. Similar rules are attested in the Goal Year procedure texts mentioned in footnote 16.

Table 4: Inferential statements: typology.

Signifying configuration	Inferential statements
Zodiacal signs or constellations	BM 47494 obv. 28–31, A 3451 side X 1′–10’; zodiacal signs or constellations unspecified or broken: BM 41485 obv. 1′–17’; AO 6449 §6 obv. 21, 30, §10 rev. 9–10.
Single planets, moon (+ dates, zodiacal signs, weather)	AO 6449 §§1–4, §6, §10, §12 rev. 20–21, 24; moon: AO 6455 §25; lunar eclipse: BM 35325 side Y 1′–3′
Two planets (+ dates, zodiacal signs, weather)	AO 6449 §1 obv. 3–4, §§7–9 = BM 36647 §§1′–3’ (obv. i 1–22); AO 6449 §§11–13; BM 36647 §§5′–7’ (obv. ii 3′–21′)

clauses involving the preposition *ina*, “in, at, during”, followed by a noun. The aim of this section is to explore their structure, the underlying reasoning and their dependence on earlier compositions such as EAE, and Mul.Apin. Three groups of inferential statements can be distinguished on the basis of their signifying configurations, which include zodiacal signs, dates, and planetary, lunar and weather phenomena (Table 4).[30]

4.1 Predictions from Zodiacal Signs or Constellations

Zodiacal signs or constellations appear in all three kinds of signifying configurations. The need to take into account the zodiacal sign or constellation in which the planet is located is explicitly referred in the instruction “the positions (*qaqqarī*) you evaluate (*tuštabbal*)”, which appears four times in AO 6449.[31] Some statements associate zodiacal signs or constellations with weather phenomena without mentioning planets. In BM 47494 weather phenomena are assigned to zodiacal constellations (obv. 28–31):

> For rain and high water: within the Fish, the Great One (Aquarius), and the Stars (Taurus). For the rising of wind: within the Twins, Pabilsag (Sagittarius), the Crab, the Lion, the Swallow (western Pisces), Anunītu (part of Pisces), the Stars, [and] the Hired Man (Aries).

30 The following inferential statements are not included here, because they are damaged or corrupted and therefore difficult to classify and interpret: AO 6455 §§26, 28; AO 6488 obv. 1′–28’; BM 36647 obv. ii’ 22′–28′, iii’, rev. 1′–15’; BM 41485 obv. 18′–27′, rev. 1′–20’.

31 For a discussion of this phrase see Hunger 1976b: 256. To the four attestations in AO 6449 one in BM 36647 obv. i 5′ can be added. For *šutābulu*($ŠAR_2$.$ŠAR_2$), “to evaluate; to calculate”, in mathematical astronomy see Ossendrijver 2012: 599.

> For the rising of a storm (*me-ḫe-*[*e*]), [destr]uction by Adad, destruction (*ri-iḫ-ṣu*): within the Stars and the Hired Man.

Since the Fish is distinguished from the Swallow this text probably predates the introduction of the zodiac. Further weather associations may have been mentioned in obv. 32–38, but they are damaged. In the preceding lines zodiacal constellations are associated with geographical regions (obv. 1–16)[32] and topics of public interest familiar from EAE such as enemy attacks, plagues, harvest, cattle, and market rates (obv. 17–27). A partly overlapping sequence of associations is found on A 3451:

> The Stars (Taurus): for Šiḫṭu (Mercury), large destruction, thunder. […] region of large destructions and thunder (?) ("cry"), rising of wind […]
> The Twins (Gemini): region of the price of grain, earthquake […] … strong earthquake, strong …
> The Crab (Cancer): region of rains and high waters, rising of wind […] … in … Larsa […]
> The Lion (Leo): region of the coming forth of lightning strike ("fall of fire") and rising of […]

There were presumably 12 such statements on the tablet, one for every zodiacal sign. A similar list of weather phenomena including "rain and high water" is offered by BM 41485, but the zodiacal signs are broken away. A "region of rain and high water" is also mentioned in weather predictions inferred from planets as in AO 6449 obv. 21: "If a planet becomes visible in the region of rain: that day it will rain" and obv. 30: "It (the prediction) is the same in the (other) regions of rain and high water". Predictions from planetary oppositions and conjunctions confirm that the Great One (Aquarius) is connected to rain and high water (see below).

For some associations there are precursors in earlier compositions. On EAE Tablet 50 several statements associate weather phenomena with stars and constellations,[33] including "The False Star is for the rising of wind". This is explained as follows in K 4292, a Neo Assyrian commentary from Niniveh: "The False Star (LUL.LA) is the Crab (AL.LUL)."[34] The Crab's association with rising winds (A 3451) can therefore be traced back to the Neo Assyrian era. The same is true for its association with high water, which is mentioned in EAE Tablet 51:[35]

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32 For Mesopotamian astrological geography see Steele 2015.

33 EAE T. 50 I–III (Reiner & Pingree 1981). See also Lehoux 2007: 107–108.

34 EAE T. 50 III 7–7c (Reiner & Pingree 1981: 110–11). For K 4292 see also Frahm 2011: 148–49, and Horowitz 2014.

35 EAE T. 51 XV 11–13 (Reiner & Pingree 1981: 72–73).

> If the Crab's stars scintillate: high water [will come]. If the Crab's stars are faint: the high water will not come. If the Crab's front stars scintillate and […]: high water will come but will not irrigate the field of the commons

An association between the Crab and water levels can also be identified in several entries from the Great Star List (Koch-Westenholz 1995: 187–205), a composition attested since the Neo Assyrian period: "The Crab: the Tigris (…) The front stars of the Crab: the Tigris. The rear ones: the Euphrates."[36] Several omens in EAE Tablet 51 establish a connection between the Field constellation and high water: [37]

> If the stars of the Field scintillate: high water [will come]. If the Field's stars are faint: high water will not [come]. If the Field's front stars scintillate, and ditto […]: high water will come but will not irrigate the field of the commons.

Since the Field is located north of the Fish and is sometimes used in Late Babylonian astrology as an alternative name for the zodiacal sign Pisces, these are potential precursors for the association between the Fish and rain and high water. A connection between the Scorpion and rain and high water is attested in EAE Tablet 56: "If a planet stands within the Scorpion: that year rains and high waters will persist. If a planet stands before the Scorpion that year rains and high waters will persist. If a planet approaches the Scorpion that year rains and high waters will persist."[38]. For the Fish, the Great One, a deity connected to Ea, and the Field, which are intrinsically connected to water, the associations with rain and high water are evidently based on analogical reasoning.

4.2 Predictions from Single Planets

The second group in Table 4 comprises inferences from single planets or the moon. Mercury features most often, followed by Venus, Jupiter, Mars, Saturn and the moon. The frequent use of Mercury contrasts with the weather predictions in earlier compositions such as EAE, which are predominantly inferred from Venus,[39]

36 Great Star List 145–149 (Koch-Westenholz 1995: 192–93).

37 EAE T. 51 XV 20–22 (Reiner & Pingree 1981: 72–73). XVII 9–11 contains analogous rules for the Raven, which is located south of the Furrow (Virgo): "If the Raven, in its position, its head looks heavenward: in that year there will be rain. If the Raven, in its position, its head looks earthward: in that year rain will come. If the Raven's stars are very bright: Adad will bring copious rains."

38 EAE T. 56 omens 77, 78, 79a (Largement 1957). In omen 107–108 the interruption of rain and high water is inferred from Mars approaching Šugi (Perseus). For this tablet see also Fincke 2015.

39 Especially EAE T. 59–60 (Reiner & Pingree 1998). The rarity of weather predictions from Mercury in EAE is confirmed by the Assyrian astrological reports (Hunger 1992) which usually quote omens concerning a "planet" to support their inferences from Mercury phenomena.

perhaps a reflection of Ištar's connection to fertility (Koch-Westenholz 1995: 126). The involved planetary and lunar phenomena and attributes are first appearances, acronychal risings, stations, last appearances, dates (time of year, month, day), brightness, zodiacal signs, and eclipses. An explicit instruction to investigate first appearances and stations is partly preserved in AO 6488 obv. 16': "Pay attention to […] the (first) appearance and the station of Venus and Mercury." In AO 6449 §§1–5 rain or high water is inferred from configurations involving Mercury or Venus, months and rainfall at the beginning of the month. The following examples from AO 6449 contain elements that can be traced back to earlier compositions:

> (§1) At the beginning of the winter in month VI or in month VII Šiḫṭu (Mercury) or Dilbat (Venus) appears in the East: there will be rain that year. At the beginning of the summer in month XII or in month I Šiḫṭu or Dilbat appears in the West: there will be high water that year. They appear together in the East: there will be no rain. They appear together in the West: there will be no high water. It is bright, then abundant rain and high water. It is faint: little.

> (§3 obv. 12) If Šiḫṭu appears in a winter month at the beginning of the month and it rains: day 3 it will rain or every day 4 it will rain. If day 10: from day 10 for 3 days and 1/3 of a day.

> (§4) Šiḫṭu: when it rains on day 1 it will rain (on day) 7, 14, 21.

The first passage is closely related to an omen from EAE Tablets 59–60,[40] "If Dilbat in winter rises in the West, in summer in the East: enemy kings will make peace, rains from the sky will be scarce." The predictions involving Mercury are related to Mul.Apin II i 54–59:[41]

> Šiḫṭu (Mercury), whose name is Ninurta, becomes visible either in the East or in the West and stands in the sky 7 days, secondly 14 days, thirdly 21 days, fourthly a month, fifthly a month and 15 days, and when it disappears it remains invisible as many days as it stood in the sky, and rises and becomes visible either in the East or in the West in the path of Šamaš (sun). This star becomes visible in the winter: rain and high water.

As in AO 6449, Mercury's first appearance in the winter signifies rain. Furthermore, the rainy days predicted in AO 6449 §4 mirror the intervals of Mercury's invisibility mentioned in Mul.Apin. AO 6449 §6 contains predictions inferred from the five planets in specific locations:[42]

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40 Reiner & Pingree 1998: 50–51 (A 95); 156–57.

41 Hunger & Steele 2019. A duplicate is EAE T. 56, omen 99–104 (Largement 1957). Both tablets are preserved in Late Babylonian copies.

42 The translation of obv. 19–20 differs from that of Hunger 1976b, who interpreted "standing" as being stationary and "approaching" as being in conjunction with another planet.

(§6) When Šiḫṭu (Mercury) or Dilbat (Venus) or Kayyāmānu (Saturn) or the White Star (Jupiter) or Ṣalbatānu (Mars) stands in or approaches the Goat-Fish (Capricorn), the Swallow (western Pisces), the Scorpion: there will be a cold. When a planet appears in the region of rain: it will rain that day; until it emerges from it, the clouds will not be cut off: it is because clouds and rain correspond.

One might conclude from this that Capricorn, Pisces and Scorpio define a "region of the cold", but such a region is not attested elsewhere. The explanatory gloss equating clouds with rain is of interest because it appears to justify the prediction with an empirical argument. In AO 6449 §10 "rain and high water" of different intensities are inferred from various Jupiter phenomena and the zodiacal constellations or signs in which they occur:

(§10) At the risings (to) daylight (= acronychal rising) of Sagmegar (Jupiter): abundant rain and high water. You evaluate the positions. At the second station of Sagmegar: strong rain and high water. The Great One (Aquarius), the Tails (Pisces), the Twins (Gemini), the Crab (Cancer), the Lion, the Furrow (Virgo), the Scales (Libra) and Lisi (Scorpio): it produces a lot (*ma-diš u_2-ban-ni*). Sagmegar when it rises and sets in the Crab, the Stars (Taurus), the Scales, the Great One, and the Tails: it produces (*u_2-ban-ni*) rain and high water.

For some predictions in §6 and §10 there are precursors in earlier compositions. In Mul.Apin Jupiter is also associated with rain and high water[43] and several omens on EAE Tablet 64 infer the absence of rain from Jupiter's position in the Fish:[44] "[If Sagmegar (Jupiter)] leaps in the middle of the Fish and stands: there will be no rain for one month. [If Sagmegar leaps in the middle of the Fish to the right and stands: there will be no rain for two months. [If Sagmegar] leaps in the middle of the Fish to the left and stands: there will be no rain for three months." Further associations between planets and weather are mentioned in K 4292, a Neo Assyrian commentary on EAE Tablet 50.[45]

The Star of Elam is for cold. The Star of Elam is Ṣalbatānu (Mars), the Anzû-bird. If the Anzû-bird's star is very red: there will be cold. (…) The stars at sunrise are for rain. If the stars are visible at sunrise: in that year rain and high water will persist. If planets, either three or four, stand at sunrise one after the other: ditto. (…) Bright stars are for the rising of wind.

43 Mul.Apin II iii 33: "If Engišgalanna is bright: high water and rain". In a Neo Assyrian astrological report (Hunger 1992: No. 254) this omen is quoted with the comment "Engišgalanna is Sagmegar (Jupiter)". In Mul.Apin II iii 22, "If the U.RI.RI star becomes visible: rain and high water", U.RI.RI may also be a planet (Hunger & Steele 2019: 223).

44 EAE T. 64 Group A: BM 35045 + 46236 rev. 1′–3′ (Reiner & Pingree 2005: 42–43) and LKU 109 obv. 1 (Reiner & Pingree 2005: 59). The former tablet is a Parthian-era copy from Babylon; the latter one a Neo Babylonian copy from the Eanna temple in Uruk.

45 EAE T. 50 III 4–18a; IV 8–13a (Reiner & Pingree 1981); see also Frahm 2011: 148–49. For the statement concerning Mars see also EAE T. 56, omen 76 (Largement 1957).

> Scintillating stars are for the rising of wind. The planets are brilliant. (…) Veiled stars are for the abating? of wind. The planets are faint.

These associations were generated from statements in EAE Tablet 50 by equating stars and constellations to planets. The association between Mars and cold weather can be seen at work in AO 6449 §6. In AO 6449 §12 lightning strikes are inferred from the first appearance of Mars, Mercury or Saturn in the Lion, consistent with the association with the "fall of fire" mentioned in A 3451 side X 8'. Only two weather predictions from the moon alone are attested in the Late Babylonian weather compositions. In AO 6455 §25 (rev. 29) "gusty wind", a phenomenon often reported in the astronomical diaries, and an unidentified weather phenomenon are inferred from the moon standing in the signs from Leo to Pisces and being surrounded by a halo. BM 35325 includes the following prediction from a lunar eclipse: "If the eclipse is little: a little high water" (side Y 2′–3′). Neither of these predictions has close parallels among the lunar eclipse omens in EAE Tablets 15–22, but the astronomical diaries confirm that Babylonian scholars assumed a connection between eclipses and river levels (see below).

In some predictions an underlying principle of reasoning can be identified. The prediction of abundant or little rain and high water in AO 6449 §1, depending on whether Mercury is bright or faint, is an example of analogical reasoning familiar from earlier divination. The phrase "it produces (*u_2-ban-ni*) rain and high water", which occurs twice in AO 6449 §10, is of interest because it appears to express a notion of agency of the planets in causing weather phenomena. However, grammatical difficulties (see Hunger 1976b: 259) and a lack of parallels prevent a conclusive interpretation of the nature of this agency.[46]

4.3 Predictions from Two Planets

Numerous weather predictions (Table 4) are inferred from two planets – conjunctions, oppositions, near oppositions and simultaneous synodic phenomena. The first three examples to be discussed here (AO 6449 §§7–9 = BM 36647 §§1′–3′) deal with conjunctions and oppositions of Jupiter with Mercury, Saturn and Mars, the fourth one (BM 36647 §6′) with (near) oppositions of Saturn and Venus:[47]

46 Two more instances of this expression occur in BM 36647 (Schreiber 2018) and the unpublished join BM 36353.

47 The translations of AO 6449 §§7–9 are based on those of Hunger (1976b). That of BM 36647 §6' (obv. ii' 8′–13′) is based on Schreiber (2018) with additions and modifications resulting from the unpublished join BM 36353.

(AO 6449 §7) Passings (= conjunctions), which Sagmegar (Jupiter) and Šiḫṭu (Mercury) perform together: heavy rain and high water. Right and left you evaluate the positions. At the *nipṣu* (= opposition): heavy rain and high water. When Sagmegar appears or sets in the Lion (Leo) and Šiḫṭu in the Great One (Aquarius) (or) in the (other) regions of rain and high water: the same. In order to compute ("construct") (by how much) rain and high water of the *nipṣu* extend beyond those of the passing you evaluate the positions.

(AO 6449 §8) Passings, which Sagmegar (Jupiter) and Kayyāmānu (Saturn) perform together: for 2 days, 3 days abundant rain and high water. At the *nipṣu*, when Sagmegar stands in the Lion and Kayyāmānu in the Great One, rain and high water for the lands you predict, a rise of the market rate, prospering of Nisaba you predict. When they stand together in the Great One or the Lion, rain and high water, a rise of the market rate you predict. When Sagmegar and Kayyāmānu are standing steady in their positions[48] (and) Sin or Šamaš produces an eclipse with them: a heavy famine will occur, mankind will be strongly depleted.

(AO 6449 §9) At the *nipṣu* of Sagmegar (Jupiter) in the Lion, Ṣalbatānu (Mars) in the Great One: heavy rain. In the Tails (Pisces) and the Furrow (Virgo): the same. Sagmegar stationary in the Stars (Taurus), Ṣalbatānu in the Scorpion: heavy high water. Sagmegar stands in Šugi (Perseus) or the Twins (Gemini) and Ṣalbatānu in Pabilsag (Sagittarius): that month you predict rain and high water for the lands. In month IX Ṣalbatānu appears in Pabilsag then rain and high water.

(BM 36647 §6′) At the *nipṣu* of Kayyāmānu in Pabilsag (Sagittarius) and Dilbat (Venus) in Šugi (Perseus): abundant rain, hail stone, lightning, thunder, high water. Kayyāmānu (Saturn) stands in Šugi, Dilbat in Pabilsag, then abundant rain, hail stone, lightning, thunder, high water. Kayyāmānu stands in the Lion, Dilbat in Pabilsag: you predict ("construct") rain and high water.

Other sections not quoted here deal with oppositions of Jupiter and Mercury (AO 6449 §11), Saturn and Venus (BM 36647 §7′), conjunctions of Mercury and Mars or Saturn (AO 6449 §12) and of Venus and Mercury (AO 6449 §13, BM 36647 §5′). The problematic term *nipṣu*, literally "beating; smashing", is rarely attested outside these compositions. Most instances concern two planets standing in opposite zodiacal signs (Hunger 1976b: 256–57). This is confirmed by a hitherto overlooked parallel in AO 6455 obv. 18–19: "the Scales (Libra), the opposite (*mi-ḫir*) of the Hired Man (Aries), its tautening of the straight string (GU SI.SA$_2$ DUB$_2$-*šu$_2$*)", where DUB$_2$ probably represents the infinitive *napāṣu*, "to tauten".[49] However, in BM 36647 §6′ *nipṣu* denotes a configuration where Saturn is in Pabilsag (Sagittarius)

48 The exact meaning of *ina manzāzī*(KI.GUB)-*šu$_2$-nu ka-a-a-nu-ma* GUB.MEŠ is unclear. *Manzāzu* is not the usual term for position and *kayyānu izuzzu* is not the usual expression for planetary stations.

49 For attestations of GU SI.SA$_2$ *napṣu*(DUB$_2$.BA), "taut straight string", in an astronomical context see the Dalbanna Text (Hunger & Pingree 1995: 100–11). In AO 6455 the reading *napṣu* is probably ruled out by the suffix -*šu$_2$*.

and Venus in Šugi (Perseus),[50] which is north of the Stars (Taurus) and therefore about one sign or constellation away from opposition with Saturn. The exact meaning of the term *nipṣu* therefore remains to be determined.

The weather predictions from two planets reflect a methodological shift with respect to EAE, which predominantly uses single planets for predicting weather. The only known parallels from EAE are several omens in Tablets 59–60 that infer weather phenomena from conjunctions of Venus and Jupiter.[51] Pairs of planets also feature prominently in O 176 (*TU* 13), a badly understood astrological tablet from Seleucid Uruk (Rochberg-Halton 1987). It therefore appears that the predominant use of conjunctions and oppositions for predicting weather is a Late Babylonian innovation. A complete understanding of the reasoning underlying the quoted sections remains out of reach, but several features can be pointed out. The predictions are often inferred from one benefic planet (Jupiter, Venus) and one malefic planet (Saturn, Mars). Some also depend on the zodiacal signs of the planets or on whether they are visible in the West or in the East (AO 6449 §12). For instance, Pabilsag (Aquarius) and the Fish (Pisces), which belong to the region of "rain and high water" according to BM 47494, and their opposite signs Leo and Virgo usually signify rain and high water. Planets in Šugi (Perseus), the Stars (Taurus) and the Goat-Fish (Capricorn) often signify unfavorable phenomena such as lightning, hailstone, thunder, or cold. AO 6449 §1, which was discussed above in §4.2, is of special interest, because it reveals how inferences from two single planets interact to yield a single inference from two planets. While first appearances of Mercury and Venus individually indicate rain and high water, the effect of their simultaneous first appearance is to cancel both predictions of rain or high water: "They appear together in the East: there will be no rain (…) They appear together in the West: there will be no high water". A similar principle of cancellation is not attested elsewhere, as far as known.

All three groups of inferential statements operate with hermeneutical techniques and forms of analogical reasoning that are familiar from earlier omen compositions and commentaries.[52] This is evident from how the predictions are aligned with the

50 For the approximate correspondence between Šugi, "the Old Man", and Perseus see Hunger & Pingree 1999: 71, 274.

51 EAE T. 59–60, Group A, VAT 10218, omens 51–53 (Reiner & Pingree 1998: 44–45): "If Venus reaches Sulpae (Jupiter), variant: comes near Sulpae and stops: high water will carry off the land, high water will come. If Venus reaches Sulpae and they follow upon each other: high water will carry off he land. If Venus reaches ditto and passes it: a mighty high water will come." Some of these omens are quoted in the Neo Assyrian astrological report Hunger 1992: No. 212.

52 For the hermeneutical principles underlying EAE see Brown 2000: 126–53. For hermeneutical techniques in Late Babylonian commentaries see Frahm 2011; Frahm 2018. For analogical reasoning in Babylonian scholarship see Rochberg 2016: 149–63 and Rochberg 2018.

benefic and malefic nature of the planets, their brightness or faintness, and their presence in zodiacal signs associated with specific weather phenomena. Several predictions inferred from planets contain hints of causal reasoning.

5 Combining Long-term Rules and Inferential Statements

The previous sections have prepared the ground for analyzing the functional relationship between long-term rules and inferential statements. Inferential statements are short-term predictions which presumably set in as soon as the signifying configuration is valid and terminate when it no longer is. Sometimes a delay is specified, which is typically measured in days and always less than one year.[53] Two kinds of long-term rules were identified: general instructions that mention planetary and lunar periods and recurrence statements. The latter are concerned with the recurrent nature of inferential statements, with the planetary and lunar periods serving as intervals of recurrence. The predictive method that emerges from the texts therefore comprises two stages: long-term prediction of astronomical phenomena using Goal-Year-type periods and short-term inference of weather phenomena from the astronomical phenomena thus predicted. Each stage corresponds to a different approach to prediction: a mathematical, period-based approach for planetary and lunar phenomena and an inferential approach rooted in celestial divination for the weather phenomena.[54] The planetary and lunar phenomena in question are synodic phenomena, conjunctions, oppositions, brightness, zodiacal positions, dates and eclipses. A very similar scenario also underlies the Babylonian market predictions (Ossendrijver 2019a). According to *SpTU* 1 94 (Hunger 1976a), a Seleucid tablet from Uruk, they are obtained with the following procedure:

> If you want to make a prediction for the region of the market rate of barley: — broken — you investigate the course of the planets and you observe the (first) appearance, the last appearance, the station, the "balancing", the approaching, the faintness and brightness of the planets, and the zodiacal sign in which they begin to ascend and descend, and then you cast a prediction for your year, and it will be correct. (obv. 1–4)

53 The same appears to be true for the predictions in AO 6488 obv. 7′–28′, which are strongly damaged. In obv. 18′–28′ rain "begins" (*ušarri*), "proceeds" (*illak*) or is "cut off" (*ipparras*) on days 1, 15 or 30 of certain months, but the month names and the signifying configurations are broken away.

54 Rochberg 2016: 232–33. See Lehoux 2007: 67–69 for a similar reconstruction of Greco-Roman astro-meteorological predictive methods.

Here market rates are inferred from first appearances, last appearances, stations, "balancing", which probably denotes oppositions, Normal Star passages ("approaching"), brightness, and latitudinal motion ("ascending and descending") of the planets. Except for latitudinal motion, the same phenomena are used for predicting weather phenomena.[55] The method involves "investigating" and "observing" the planetary phenomena and "casting a prediction for your year". Although *SpTU* 1 94 lacks a list of periods, the formulation is consistent with the Goal Year methods alluded to in AO 6488, which suggests that weather and market rates were predicted with very similar methods.

For the new approach to work, the prescribed periods ought to be valid for the astronomical phenomena in question. However, several discrepancies are apparent. First, no methods for predicting planetary brightness appear to have been available. As far as known, inferences of weather phenomena from planetary brightness could therefore not be used for long-term weather prediction. Secondly, the periods that are mentioned in the long-term procedures pertain to single planets or the moon but not to conjunctions and oppositions, the phenomena that feature most prominently in the inferential statements. Periods for planetary conjunctions are attested in a single procedure text (Ossendrijver 2017), but the relevant passages are difficult to interpret and there is no evidence for the use of these periods. This apparent discrepancy vanishes if conjunctions and oppositions are conceived in terms of whole zodiacal signs, as is done in the weather predictions. In that case it is sufficient to predict the zodiacal signs of the individual planets, because this also reveals their conjunctions and oppositions, as can be illustrated with the following passage from an Almanac for the year SE 92 (*ADRT* 7 No. 153 obv. 6–7):[56]

> Month III, (the first of which will be identical with) the 30th (of the preceding month),… The first, (first) appearance of Šiḫṭu (Mercury) in the West in the Crab (Cancer). The White Star (Jupiter) [in] the Hired Man (Aries), Dilbat (Venus) in the Twins (Gemini). The 4th, Dilbat will [reach] the Crab. The 7th, "rising to daylight" (= acronychal rising) of Kayyāmānu (Saturn) in Pabilsag (Sagittarius), Ṣalbatānu (Mars) in the Crab. The 9th, Ṣalbatānu will reach the Lion (Leo). The 13th, NA (= first moonset after sunrise). The 14th, solstice. The 18th, Dilbat's (first) appearance in the West in the Crab. The 27th, KUR (= last visibility of the moon before sunrise). The 28th, Dilbat will reach the Lion.

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55 In AO 6488 rev. 11–16 the different phenomena are subsumed under the general term *tāmartu*(IGI.DU$_8$.A), literally "appearance". A comparable usage of this term is attested in EAE T. 1–8, which form a subseries titled "The appearances of the Moon."

56 Translation based on *ADRT* 7 No. 153. Note that obv. 7, GENNA *ina* PA *ana* ME E, "Saturn rises to daylight (= acronychal rising) in Sagittarius", was mistakenly translated with "station" instead of "rises to daylight".

In month III of SE 92 Venus and Saturn will be in opposition until day 3 (Venus in Gemini, Saturn in Sagittarius) and Mercury, Venus and Mars[57] will be in conjunction in Cancer from day 4 onward. These data were almost certainly predicted with Goal-Year methods for individual planets. The Almanacs are a promising source for most of the astronomical data that are needed for predicting weather, but they are not attested before SE 92 (220/219 BCE). Normal Star Almanacs, which are available from SE 12 onward, could also have provided most of the astronomical data including conjunctions and oppositions, although this would require more work, because Normal Stars positions would have to be converted to zodiacal signs. Alternatively the positions, dates and synodic phenomena needed for predicting weather could have been computed with mathematical astronomy, which was available after ca. 400–350 BCE.

6 Weather Prediction and the Astronomical Diaries

The Goal-Year periods constitute one link between the weather procedures and the astronomical diaries and related texts. Another indication for a connection with the diaries is the weather terminology (Table 4), which largely overlaps with that of the diaries. In fact, the rain-related terms UTAḪ, DUL-*ḫat*, "loosening of the sandal"[58] and PISAN belong to the technical vocabulary of the diaries and are virtually unknown outside that corpus. One may add that the four tablets from the British Museum (Table 1) belong to the same collections as the astronomical diaries and related texts, which suggests a provenance from the same archival contexts. These indications make it very likely that the methods for long-term weather prediction were developed by scholars connected to the diary program. It is therefore worthwhile to explore the diaries and related texts for further indications that weather phenomena were assumed to be predictable.[59] Some basic features of the diaries must be recalled.[60] Most diaries cover half a calendar year of six or seven months, depending on whether the year is intercalary or not. In each

57 According to the preceding sections for months I and II Mars will be in Cancer from month I day 17 onward.

58 See also Hunger 2019: 182–83.

59 This investigation has benefited greatly from the searchable editions of the diaries in the digital repository http://oracc.museum.upenn.edu/adsd/ which was created by Reinhard Pirngruber and Maya Rinderer.

60 For editions of the diaries see Sachs & Hunger 1988; 1989; 1996. For the onset and early development of the astronomical diaries and related texts see Steele 2019.

monthly section weather phenomena are reported almost daily in the same paragraph as the astronomical phenomena, while market rates, the river level and political events occupy separate paragraphs. The systematic and persistent nature of these parallel records of non-astronomical and astronomical phenomena suggests an underlying assumption that they are connected in some fashion and that this renders the non-astronomical phenomena predictable. As argued above, this is precisely what the weather procedures achieve by combining period-based methods for predicting astronomical phenomena with inferential statements for predicting weather phenomena from astronomical phenomena. Several weather phenomena were indeed always reported simultaneously with and in close spatial proximity to astronomical phenomena and never independently from them; this applies to halos, the "crown", and the "garment of the sky". Wind directions were reported during eclipses, but also on countless other days. Intermittent weather phenomena such as rain, lightning, fog and clouds were occasionally reported together with astronomical phenomena. The underlying reason may differ from case to case. An astronomical phenomenon may have been taken to signify a weather phenomenon or they may together form a signifying configuration. Weather phenomena that were reported for predictive purposes must be distinguished from weather expressions such as "clouds, (therefore) I did not observe" (DIRI NU PAP) and "clouds/mist (but nevertheless) measured" (DIRI/*a-kam muš*)[61] which served to document the adverse conditions under which predictable astronomical phenomena were observed or could not be observed.[62]

61 For *muš* as an abbreviation of *muš-šuḫ*$_2$ = *muššuḫ*, "measured", see Walker 1999. Hunger has pointed out that it must have a more specific meaning, because many Lunar Six values are neither marked with NU PAP nor with *muš* (*ADRT* 6, xii; Huber & De Meis 2004: 12). This is also suggested by the fact that *muš* is, for unclear reasons, not attested in reports of the planetary intervals NA. For the first appearances of Mars, Jupiter and Saturn and morning first of Mercury and Venus NA is the time between the rising of the planet and sunrise; for the evening first of Mercury and Venus it is the time between sunset and the setting of the planet. For example (*ADRT* 1 -273B rev. 23′): "The 2[1st, Saturn's] first appearance in Pisces; it was bright and high, NA (was) 17 (UŠ), around the 19th (ideal) first appearance."

62 Since the obstructed phenomena were replaced by predictions, these statements enabled the users of the diaries to distinguish reported phenomena from predicted ones and, perhaps, to assess the reliability of the reports. This may explain why they are the only weather reports that were copied from diaries to Goal Year texts, along with the astronomical phenomena which they accompany.

6.1 Level of the River Euphrates

The level of the river Euphrates, referred to as "high water" (*mīlu*) in the diaries, is the only weather-related phenomenon for which quantitative measures were reported. From 568 BCE onward the increase or decrease of the river level was reported in cubits and fingers, where 1 cubit = 24 fingers. After ca. 300 BCE the quantity NA which represents the absolute river level measured downward from a reference height was additionally reported at the end of each month.[63] One might expect the scholars to have developed methods for predicting these values, but none are attested in the Late Babylonian weather compositions. As was shown above, they only contain qualitative predictions of the "high water". But the river level reports may contain further clues of predictive practices. The frequency of reporting could reflect an assumption about how it correlates with astronomical phenomena. Until ca. 350 BCE the river level change was reported among the celestial phenomena whenever it stopped rising, falling or being constant, which typically happened several times per month. In later diaries it was reported in a separate paragraph after the market rates and before the historical section, usually once per month but occasionally more often. A frequency of one per month reveals seasonal variations that reflect the annual course of the sun, while a higher frequency also reveals variations within the month. In principle this could reflect an assumption that the river level is correlated with solar and lunar motion, but there is no other evidence to support this. A more convincing indication that a connection was assumed between the river level and astronomical phenomena concerns eclipses, which sometimes triggered almost daily reporting of the river level. This is attested for observed eclipses as well as predicted eclipses that did not materialize. A similar phenomenon has been noted for market rates (Ossendrijver 2019a). The frequent reporting usually sets in at least several days before the eclipse and continues for several days after it. The earliest known example occurs

63 The river level NA is expressed in an unnamed unit corresponding to 4 fingers = 1/6 cubit (Sachs & Hunger 1989: 276).

in a diary for month X of Artaxerxes III year 12, which reports a lunar eclipse on day 13 and an omitted solar eclipse on day 28 (*ADRT* 1 -346 obv. 28–33):

> The 28th, eclip[se of Šamaš which passed by. Night] of the 29th, last part of the night, lightning, much thunder,… rain PISAN DIB (= rain-related phenomenon). The 29th, in the morning, lightning, much thunder, rain a little PISAN DIB. Above Babylon and below Baby [lon] much […] rained down. (…) [That month from the … to] the 14th, the river level rose 8 fingers; from the 15th to the 19th the river level receded 8 fingers; the 22nd the river level rose 4 fingers; from the 23rd t[o the 26th? the river level receded? …;] the 27th, 28th, (and) 29th the river level rose 1/2 cubit.

Around a dozen further examples are attested between 322 and 88 BCE.[64] The possible context of this practice are predictions of the river level from lunar eclipses.[65] One such prediction is attested in the Late Babylonian composition BM 35325 (see above). Numerous predictions in EAE Tablets 15–22 also infer "high water" or "flood" (*abūbu*) from lunar eclipses. Depending on the date and other circumstances of the eclipse the prediction is favorable or unfavorable, e.g. "If in month VII on day 14 an eclipse occurs and begins and clears in the east: rains and high waters will be regular" or "If (in month IV) on day 15 an eclipse occurs: rains in the sky, high waters in the source will be cut off."[66] The frequent reporting of the river level may well be motivated by such predictions, but the exact purpose remains unclear. Was the aim to verify the predictions or to improve on them by establishing more accurate regularities between eclipses and the river level?

64 Lunar eclipses: *ADRT* 1 -321 (Ph. Arrh. 2 month I), *ADRT* 1 -304 (SE 7 II), *ADRT* 3 -134 (SE 177 XII), *ADRT* 3 -123A (SE 188 V), *ADRT* 3 -118 (SE 193 VII), *ADRT* 3 -87C (SE 224 XII). Solar eclipses: *ADRT* 2 -232 (SE 79 VIII), *ADRT* 3 -137 (SE 174 II), *ADRT* 3 -136B (SE 175 XII_2), *ADRT* 3 -124 (SE 187 X), *ADRT* 3 -119 (SE 192 I), *ADRT* 3 -118 (SE 193 I). However, the river level was not always reported more frequently during eclipses and the frequent reporting was not always triggered by an eclipse.

65 Omens inferred from eclipses and the river level, as they exist for eclipses and wind directions, could provide an alternative explanation for the frequent reporting of the river level during eclipses, but they are not attested for lunar eclipses (Rochberg-Halton 1988a: 27–29). For solar eclipses this remains to be investigated.

66 EAE T. 16 IV 3; T. 21 IV 2 (Rochberg-Halton 1988a: 94, 238). There are numerous further examples in EAE T. 15–22 (Rochberg-Halton 1988a).

6.2 Lightning Strikes, Halos, the "Crown", Wind Directions and the "Garment of the Sky"

Other weather phenomena that were probably reported because of their divinatory significance are halos, wind directions, the "garment of the sky", and the "crown". Except for wind directions they were always reported together with the moon or the sun. This investigation follows the example of Pirngruber (2013), who demonstrated that several phenomena reported in the historical sections of the diaries signify future events according to the omen series. They include the weather phenomenon lightning strike ("fall of fire"), which is usually reported in the phrase "lighting strike in the city quarter so-and-so."[67] Predictions inferred from lightning strike are contained in Tablet 50 of the terrestrial omen series *Šumma ālu*, which has the incipit "If fire falls in a city".[68] This probably explains why they are reported in the historical section and not in the main section along with the other weather phenomena. The phenomenon of halo, literally "cattle pen" (TUR_3 = *tarbaṣu*), is often attested in diaries, always in the expression "Sin/Šamaš was surrounded by a halo" (*ADRT* 1, 33). In some reports the halo is said to "billow" (literally "smoke") "greatly" (*ma-diš iq-tur*$_7$). Sometimes the halo was "not closed" or "its gate was opened towards the N/S/E/W". In rare cases two halos are reported or a planet or star is said to stand within the halo.[69] Except for the "billowing", all of these phenomena are attested in omen protases. Halos around the moon are dealt with in EAE Tablets 8–10, as indicated by their incipits:[70]

> If on the first day of month VII Sin in his (first) appearance is surrounded by a halo. (EAE T. 8)
> If Sin in his (first) appearance is surrounded by a halo and it is thick (*ka-bar*) and spread out (*šu-par-ru-ur*). (EAE T. 9)

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67 For an analysis of the locations of the lightning strikes reported in diaries see Stevens 2019: 225–31.

68 See also Stevens 2019: 226. For an overview of the series see Koch 2015: 239–62. *Šumma ālu* T. 51 has the incipit "If fire is visible in the land" (Freedman 1998: 336) and may also deal with lightning strikes. For editions of Tablets 50 and 51 see Freedman 2017.

69 Examples: *ADRT* 1 -651 i 2: *šamaš*$_2$ TUR_3 $NIGIN_2$, "Šamaš was surrounded by a halo"; *ADRT* 1 -342 obv. 7: *Sin* TUR_3 $NIGIN_2$ *ma-diš iq-tur*$_7$, "Sin was surrounded by a halo, it billowed greatly"; *ADRT* 1 -342 rev. 6': [*sin*] TUR_3 NU KAD_2 $NIGIN_2$, "[Sin] was surrounded by a halo that was not closed"; *ADRT* 3 -163B rev. 26': […] TUR_3 $NIGIN_2$ KA_2-*šu*$_2$ *ana* ULU_3 BAD, "[…] was surrounded by a halo, its gate opened towards the South"; *ADRT* 3 -164C obv. 18': *šamaš*$_2$ 2 TUR_3.MEŠ $NIGIN_2$, "Šamaš was surrounded by two halos".

70 EAE T. 9–11 are fragmentarily preserved and not available in a modern edition. For an overview see Weidner 1941–44: 314–17; for the incipits see also Rochberg 2019: 132–35.

If in month I Sin is surrounded by a halo and it does not have a gate. (EAE T. 10)

Similar protases involving halos around the sun are attested in EAE Tablets 23(24)–29(30).[71] The close agreement between these protases and the descriptions of halos in diaries strongly suggests that they were reported at least partly because of their divinatory relevance. Reports of the first crescent often include the phrase "he (Sin) wears a crown", *agâ*(AGA) *a-pir*.[72] Modern translators interpret this as earthshine (*ADRT* 1, 22). Unlike halos, reports of the "crown" were copied to Goal Year texts. This may suggest that the "crown" was viewed as an attribute of the moon, predictable with the same method as the first crescent. However, Almanacs and Normal Star Almanacs do not contain any predictions of the "crown". It therefore remains unclear why it was included in Goal Year texts. The divinatory significance of the "crown" is amply documented in EAE Tablet 3, which has the catchline "If Sin at his appearance wears a crown".[73] The "garment of the sky", TUG_2 *šamê*(AN), is often mentioned in reports of lunar eclipses. All attestations are of the form "his (= Sin's) eclipse was provided with the garment of the sky".[74] The underlying empirical phenomenon has not been identified. The "garment of the sky" was not copied to Goal Year texts, which suggests that it was not considered to be predictable with the same method as eclipses. It may have been reported for its divinatory significance (Rochberg 2016: 226), but the only evidence for this is a lunar omen from EAE Tablet 1 mentioning the "garment of the sky" in its protasis.[75]

During eclipses the wind direction was nearly always reported, sometimes also the strength of the wind (*ADRT* 1: 23–24). Typical examples are "In his (Sin's) eclipse the north wind blew" and "During onset, the north wind blew, during clearing, the west wind" (*ADRT* 5 No. 4). Wind data were only reported for actual eclipses and not for predicted eclipses that failed to materialize. Like the "garment of the sky" the wind data were omitted from Goal Year texts. This is not surprising,

71 EAE T. 23 IVa 1; T. 24 III 65; T. 25 III 31, 32, 52, 64, 68a; T. 26 IV 8; T. 27 II 4, 5; T. 28 79, 84, 89, 94, 99, 104; T. 29 III 62–66 (van Soldt 1995; Fincke 2014).

72 Attested ca. 22 times in astronomical diaries (*ADRT* 1–3), ca. seven times in lunar reports (*ADRT* 5) and ca. 37 times in Goal Year texts (*ADRT* 6).

73 Akkadian: DIŠ *sîn ina* IGI.LA_2-$šu_2$ AGA *a-pir* (Verderame 2002: 59–100). The omens probably cover more phenomena than only earthshine (Verderame 2002: 60–62).

74 Akkadian: AN.MI-$šu_2$ TUG_2 AN-*e* GAR-*in*. Examples: *ADRT* 1 85; *ADRT* 2 15, 72; *ADRT* 5 3, 4, 9, 27, 30. The intended Akkadian reading of TUG_2, "garment", is unclear (*nalbašu, lubuštu, or lubāru*). For *šakin*, "provided with" see *CAD* Vol. Š1: 133–34, *šakānu* 3c. Since the "garment of the sky" is only attested during lunar eclipses it cannot refer to cloudiness as suggested in *ADRT* 1 and Huber & De Meis 2004: 15.

75 EAE T. 1 §58 (Verderame 2002: 12, 17, 206–207), but note that instead of TUG_2 AN the logogram AN.MA is used; see *CAD* Vol. N1, 200, *nalbašu* 3.

because the wind direction was often reported without eclipses and therefore clearly not predictable with the same method as eclipses. Their omission from Goal Year texts can be illustrated for the lunar eclipse of 15 XII_2 SE 148 (30 March 163 BCE), which is reported as follows in a diary:[76]

> (When the point) 3 UŠ behind the (star) Rear Harness culminated: [eclipse of Sin …; his eclipse] was provided with [the "gar]ment of the sky"; in his eclipse the north wind which was set to the west side blew; in his eclipse […].

In a Goal Year text for SE 166 the same eclipse is reported as follows (*ADRT* 6 No. 47 rev. 3′–9′):

> (When the point) 3 UŠ behind the [(star) Rear] Har[ness] culminated: eclipse of Sin; when it began, on the south side, in 10 UŠ of night it made 3 fingers. At 1,25 (UŠ) before sunrise.

Since this passage is complete and followed by another report there is no doubt that the wind direction and the "garment of the sky" are absent.[77] Inspection of the Goal Year texts reveals that whenever an eclipse report was copied to a Goal Year text only those weather phenomena that affect the visibility of the eclipse were retained. This can be illustrated with the following report of a lunar eclipse on 13 I SE 100 (30 April 212 BCE) in a Goal Year text for SE 118 (*ADRT* 6 No. 20, rev. I 14–19):

> Year 1,40 (= 100), king An(tiochus), month I, night of the 13th, ME (= moonrise to sunset) was 9;20 (UŠ), "measured". Eclipse of Sin, when it began on the south side, I did not watch onset and maximal phase (due to) clouds. He set eclipsed. At 20 (UŠ) before sunrise.

The importance of wind directions for inferring the meaning of eclipses is amply documented in EAE Tablets 15, 16, 19–21, which contain numerous instances of the following protases:[78]

> If an eclipse begins in the N/S/E/W and the N/S/E/W wind blows. (EAE T. 15)
> If an eclipse occurs in month M on day 15 and the N/S/E/W wind blows. (EAE T. 16)
> If an eclipse occurs during watch 1/2/3, it completes the watch and the N/S/E/W wind blows. (EAE T. 19)

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76 *ADRT* 3 -163B rev. 20′–22′. A partly overlapping report of this eclipse is preserved in *ADRT* 3 -163C_1 rev. 12′: "[…] cleared from south to west; 20 UŠ onset and clearing. (In) his eclipse the "garment of the sky" [was present; …]". For the circumstances of this eclipse see Huber & De Meis 2004: 130–31, 200.

77 Only very few reports of observed eclipses are preserved both in a diary and in a Goal Year text. Two other examples are the lunar and solar eclipse of SE 175 XII_2 (diary: *ADRT* 3 -136B rev. 6′–8′, Goal Year text: *ADRT* 6 No. 69 rev. I 14–25).

78 Examples: EAE T. 15 §§6′–9 (Fincke 2016; Rochberg-Halton 1988a); EAE T. 16 §I 12–15, §III 11–14, §IV E 13–16, §VII 13–16, §VIII 10–13, §§IX–XII_2; EAE T. 19 §II (Fincke 2016: 105–108).

EAE Tablets 20 and 21 even include explicit instructions to pay attention to winds, e.g.:[79]

> The god (Sin), who in his eclipse became dark on the side east above and cleared on the side south below: observe his darkening and keep the north wind in mind (IM.SI.SA$_2$ *ina* ŠU-*ka tu-kal*) by means of which (*ina libbi*) a decision is given for Ur. (EAE T. 20 IV A 6–7)

In *SpTU* 4 162 (al-Rawi & George 2006), a commentary on EAE Tablet 20 from the library of the scholar Iqīšâ in Uruk dating to 322 BCE, these instructions are explained as follows (obv. 7–9): "the wind that you keep in mind (means) the wind that blows on the lands, thereby you pronounce the interpretation (*pišru*)". EAE Tablets 15–21 and this commentary leave no doubt that wind directions were reported during eclipses because they affect the ominous significance of the eclipse. Other weather phenomena that were occasionally reported during eclipses include lightning and thunder, clouds and mist, rain, cold, and meteors.[80] Most of these phenomena are mentioned in the protases of EAE Tablets 16–22 (Rochberg-Halton 1988a: 57–61), which is probably why they were reported. Like wind directions they were omitted from Goal Year texts, which indicates that they were not considered to be predictable with the same methods as eclipses.

7 Conclusions

A major innovation of the Late Babylonian weather compositions is that they explicitly combine period-based methods for long-term prediction of astronomical phenomena with inferential methods for predicting weather phenomena. The integration of these different approaches within a single predictive framework is expressed in recurrence statements, which have no parallels in earlier compositions. A comprehensive understanding of all predictive rules remains out of reach, because of the small number of texts and their often fragmentary state of preservation. Two further innovations are evident in the signifying configurations. First, the incorporation of the zodiac as a new spatial framework for describing planetary and lunar configurations and inferring predictions from them. Secondly, instead of single planets which predominate in earlier omen compositions, the Late Babylonian weather predictions mainly operate with conjunctions, (near) oppositions

79 EAE T. 20 §§IV–XII (Rochberg-Halton 1988a: 192–214). See also EAE T. 21 §I (Rochberg-Halton 1988a: 231, 233).

80 Lightning and thunder: *ADRT* 1 -369 rev. 9′, *ADRT* 2 -238 rev. 1, *ADRT* 5 No. 2 rev. II 13′, No. 5 rev. II 7, No. 14 edge 5'; clouds (DIRI): *ADRT* 5 No. 9 obv. 10′, No. 10 II′ 12′, No. 21 obv. 10; clouds (DIRI AN ZA): *ADRT* 3 -160 rev. 4'; mist: *ADRT* 5 No. 12 rev. II 11; rain (AN): *ADRT* 1 -369 rev. 9'; rain (AN UTAḪ): *ADRT* 3 -165B obv. 7'; cold: *ADRT* 2 -214 rev. 3; meteors: *ADRT* 5 No. 12 rev. II 8.

and other simultaneous phenomena of two planets. It was shown that they can be predicted with the Goal Year periods for single planets which are listed in several procedures on AO 6488 and AO 6455. It may be noted that planetary conjunctions and oppositions are also used for predicting weather phenomena in some Greco-Roman astro-meteorological works (Tolsa 2020). This raises the possibility of a transfer of knowledge regarding weather prediction between Babylonia and the Greco-Roman world, which remains to be investigated. Some weather predictions appear to go beyond a signifying function of the planets and may be interpreted as evidence for a notion of planetary agency in causing weather phenomena. Prayers and rituals from Seleucid Uruk addressed at the planets rather than at the deities connected with them (Krul 2018: 185–90) may support the idea that some Late Babylonian scholars assumed the planets to have a direct effect on terrestrial events, but more evidence is required to confirm this.

Nevertheless, the overwhelming impression raised by the new compositions is one of continuity with earlier omen traditions. It is sometimes argued that predictable phenomena could no longer count as signs produced by gods, but this tension is not apparent in the sources.[81] The weather predictions operate with similar strategies of analogical reasoning to infer predictions from astronomical phenomena. This is evident from correspondences between the predicted phenomena and the benefic or malefic nature of the planets, their brightness and presence in zodiacal regions associated with specific weather phenomena. Furthermore, many inferential statements can be traced back to omens from EAE, Mul.Apin and other pre-zodiacal compositions. It was also found that some weather reports in the astronomical diaries reflect divinatory practices that are well known from omen series such as EAE but barely represented in the new compositions. This concerns the reporting of wind directions and other phenomena during eclipses, the daily reporting of river levels near eclipses, and the reporting of halos, lightning, and earthshine ("the crown"). Another point of agreement with earlier celestial omens is that quantitative weather predictions are notably absent from the new compositions, even though a vast amount of quantitative data about weather regularities was available in the astronomical diaries, in particular the river level data. Although it cannot be completely excluded that there were tablets with quantitative weather predictions that have escaped our attention, all extant predictive rules are of a qualitative nature, as in earlier divination. Furthermore, no tablets are extant with weather predictions for concrete future dates as they exist for astronomical phenomena in the form of Almanacs, Normal Star Almanacs and tables computed with mathematical astronomy. The same discrepancy applies to Late Babylonian market predictions (Ossendrijver 2019a). In other words,

81 Lehoux 2007: 444; Rochberg 2016: 247–48.

long-term predictive methods were developed for two important groups of non-astronomical phenomena reported in the astronomical diaries, but there is no evidence that they were used for predicting these phenomena for future dates. Such predictions might have escaped our attention, but a more plausible explanation is that the weather compositions served a different purpose.

Although Babylonian scholarship often appears to be mainly concerned with prediction, explanation was also an important purpose. The various modes of explanation that can be identified in Babylonian scholarly texts were discussed by Rochberg (2016).[82] According to Pingree (1992: 559–60), omen divination can be said to explain phenomena because it construes them as signified by other phenomena. On that account weather phenomena are explained by the astronomical configurations from which they are inferred according to predictive texts. This mode of explanation is in some sense complementary to the hermeneutical, exegetical mode which operates in the other direction by interpreting signs as if they are a form of writing (Frahm 2011: 20–22; Frahm 2018). But how can inferential statements that reflect analogical reasoning serve as explanations without being falsified all the time? A possible answer that underscores the rational nature of Mesopotamian divination was suggested by Graßhoff (2011: 43–44), who argues that omens are to be understood as *ceteris paribus* statements and not as material conditionals. In that account "if P then Q" can be true even if P is true and Q is false, because in addition to P there may be hidden factors P′ that must be satisfied for Q to occur. If we accept Pingree's definition of what it means to explain phenomena in the Babylonian context then the Late Babylonian weather predictions could have played a role in explaining past weather phenomena. However, the explanatory power of the new compositions is on a deeper level than that of the traditional omens, because they explicitly link weather phenomena to sequences of periodically repeating astronomical phenomena that stretch both into the past and into the future.[83]

Abbreviations

ADRT Astronomical Diaries and Related Texts (Hunger 2001, 2006, 2014; Sachs & Hunger 1988, 1989, 1996)

82 Rochberg 2016: Ch. 8 "Prediction and Explanation in Cuneiform Scholarship", 231–73.

83 In this connection recall that AO 6455 §24 may mention a period of 32940 years for rain and high water, but its relation to planetary periods is unclear.

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