




Geographic longitude in Latin Europe during the twelfth and thirteenth centuries

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Abstract

This article surveys surviving evidence for the determination of geographic longitude in Latin Europe in the period between 1100 and 1300. Special consideration is given to the different types of sources that preserve longitude estimates as well as to the techniques that were used in establishing them. While the method of inferring longitude differences from eclipse times was evidently in use as early as the mid-twelfth century, it remains doubtful that it can account for most of the preserved longitudes. An analysis of 89 different estimates for 30 European cities indicates a high degree of accuracy among the longitudes of English cities and a conspicuous displacement eastward (by 5° – 7° ; 30°) shared by most longitudes of cities in Italy and France. In both cases, the data suggest a high level of interdependence between estimates for different cities in the same geographic region, although the means by which these estimates were arrived at remain insufficiently known.

1 Introduction

One of the many scientific concepts that began to spread in Latin Europe in the twelfth century as a consequence of Arabic-to-Latin translations was that of geographic longitude, understood as the angle of separation between two meridians. This concept played a key role in Graeco-Arabic mathematical astronomy insofar as calculations of planetary positions had to be made for specific meridians, which necessitated frequent adjustments or even the wholesale recasting of astronomical tables for a new longitude. The importance of astronomical tables as storehouses of information on medieval measurements of terrestrial longitudes and latitudes was highlighted one hundred years

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ago in an important article by John Kirtland Wright (“Notes on the Knowledge of Latitudes and Longitudes in the Middle Ages”), who also made a pioneering attempt to reconstruct the steps by which Latin astronomers of the twelfth to fourteenth centuries established the longitudes of cities in their region of the world.¹ Since then, however, the scholarly attention paid to geographic coordinates in medieval Latin sources has been rather sporadic.² This state of neglect becomes especially noticeable when compared with the available work on Islamic science, which includes E. S. and M. H. Kennedy’s substantial catalogue of *Geographical Coordinates of Localities from Islamic Sources*, published in 1987.³

The most significant technical contribution on the subject of medieval European longitudes to have appeared since Wright is a 1998 study by Kremer and Dobrzycki, who inter alia analyzed manuscript glosses to the mean-motion radices of the Alfonsine Tables (fourteenth to sixteenth centuries) and their implicit values for longitude differences relative to Toledo. Kremer and Dobrzycki’s findings reveal a relatively high degree of accuracy, “especially at places where large numbers of glossed radices indicate sustained interest,” and support the general conclusion that “Alfonsine users [...] employed somewhat more accurate longitudes relative to Toledo than those available in the cartographic sources.” Mindful of the limitations of the astronomical methods then available, they tried to account for this accuracy by arguing that “the Alfonsine glossators or their predecessors must have combined topographic distance estimates with repeated lunar observations.” At the same time, they urged “more detailed studies of the *tabulae regionum* [i.e., tabular lists of geographic coordinates] accompanying later copies of the [pre-Alfonsine] Toledan Tables” to answer questions concerning the origins of certain values.⁴

The present article aims to complement Kremer and Dobrzycki’s study in the suggested manner, by focusing on longitude values that were first established during the pre-Alfonsine period of Latin astronomy, or more specifically between 1100 and 1300. Its basic purpose is to document such values on a comprehensive scale as well as to undertake an analysis of the data in question. As a preliminary step, Part 2 of this article surveys the different types of sources from the two relevant centuries in which longitude estimates are transmitted in either explicit or implicit form. Part 3 discusses contemporary historical evidence regarding the ‘eclipse method’ (i.e., the practice of inferring longitude differences from the time differences between observed/computed eclipses), which is the only method of longitude determination whose use is clearly attested for this period. A comprehensive tabular overview of recorded estimates is presented in Part 4, while Part 5 provides the corresponding analysis. Included in this last part is a brief consideration of the geographic and chronological distribution of surviving longitude estimates as well as a discussion of the patterns of error that can be

¹ Wright (1923).

² Contributions of note include Zinner (1939: 71–73), Dobrzycki (1985), Mercier (1985), Kremer and Dobrzycki (1998), Gautier Dalché (1998: 198–202, 2000: 410–424, 2009: 118–142, 2011, 2013: 222–241) and North (2002). Certain other publications on this subject must be used with considerable caution: Chabanier (1932), Durand (1952) and Sezgin (2000: 205–267).

³ Kennedy and Kennedy (1987). See also Comes (1992–1994, 2000), Weber (2020), Mercier (2020, 2020–2021) and van Dalen (2021).

⁴ Kremer and Dobrzycki (1998: 191).

discerned among them. As will be shown in more detail below, medieval astronomers were evidently capable of determining the longitude distances between European cities to a surprisingly high degree of accuracy, although the methods by which this success was achieved remain, for the most part, difficult to reconstruct.

2 Sources

As was already highlighted by Wright in 1923,⁵ the richest available source type for European longitudes established between 1100 and 1300 are the tabular lists of geographic coordinates that were routinely included in sets of astronomical tables. In the vast majority of cases, we are dealing with descendants of an Islamic list covering 62 places that was translated from Arabic into Latin in the second quarter of the twelfth century as part of the so-called Toledan Tables.⁶ In what follows, I shall refer to this list simply as the ‘Toledan coordinate table’ or TCT. Nearly all of the localities listed in the original TCT belong to regions under Islamic dominion in Iberia, North Africa, the Levant, and the Middle East. Among the handful of exceptions are the city of Rome and the elusively titled “seat of the kingdom of the Franks” (*sedes regni Francorum*). Thirteenth-century copies of the TCT in Latin manuscripts frequently augment this original list with one or more entries for other European cities. Common examples are Cremona, Marseilles, Novara, Paris, and Toulouse (see Part 4).

To the extent that the TCT can be assumed to employ a uniform zero meridian, it locates this meridian 11° to the west of Toledo. This placement reflects the influence of Ptolemy’s *Geography* and *Handy Tables*, which reckoned longitudes from the western extremity of the Fortunate Islands, placing Toledo at 10° .⁷ Despite this Ptolemaic legacy in the TCT, the surviving Latin canons to the Toledan Tables assign to Toledo a longitude of $4;6\text{ h} = 61;30^\circ$ west of the Indian city of Arim (Ujjain), which was hypothetically located on the equator and on a zero meridian in the middle of the inhabited world.⁸ A corollary of this longitude difference is the commonly attested placement of Toledo $28;30^\circ$ to the east of the meridian located 90° west of Arim, which notionally corresponds to the westernmost edge of the inhabited world.⁹ In Latin astronomical texts of the twelfth and thirteenth centuries, the location of this meridian is sometimes referred to as the *Gades Herculis* (i.e., the Cadiz of Hercules), while the one 90° to the east of Arim received the label *Gades Alexandri* (i.e., the Cadiz of Alexander [the Great]).¹⁰

⁵ Wright (1923: 88, 91–96).

⁶ See the critical edition of the TCT with discussion of some of its offshoots and variants in Pedersen (2002: iv. 1509–1518 (MA11–13)). It makes its earliest datable appearance in Latin in Raymond of Marseilles, *Liber cursuum planetarum* (ed. and trans. Alverny et al. 2009: 198–199). For other discussions and reproductions, see Wright (1923: 86–88), Chabanier (1932) (unreliable), Toomer (1968: 134–139), Laguarda Trías (1990: 64–73) (with Tables 1 and 2), Gautier Dalché (2009: 101–103) and Huth (2013: 221–228, 473–475) (unreliable).

⁷ Defaux (2017: 43–44).

⁸ Toledan canons Ca82, 90; Cb133 (ed. and trans. Pedersen 2002: i. 250–251, 254–255; ii. 430–431).

⁹ On the background, see Comes (1992–1994, 2000) and Samsó (2020: 703–708).

¹⁰ For references to these meridians, see *Investigantibus astronomiam primo sciendum...*, Jn28–29 (ed. Pedersen 1990: 229); *Diversi astrologi secundum diversos annos...* (MS Oxford, Bodleian Library, Savile

When working with longitudes in medieval Latin sources it accordingly becomes necessary to distinguish between two different zero meridians, whose respective locations were 11° and $28;30^\circ$ west of Toledo. Some contemporary readers were certainly cognizant of this fact, as can be seen from the remarks in a letter written soon after 1246 by the astronomer John of London.¹¹ A contrasting case is the set of astronomical tables for Ferrara in MS Paris, Bibliothèque de l'Arsenal, 1128, fol. 28v (s. XIII^{2/2}), where the TCT is expanded with an additional column of data taken from some unknown external source. This source used as its references point the *Gades Herculis* and accordingly increased the longitudes of cities also found in the TCT by $17;30^\circ$. The scribe who put these columns together did not realize that the discrepancy was caused merely by diverging reference points and instead assumed that the longitudes shown in the additional column were more accurate than those in the TCT.¹²

Before the year 1300, there seem to be few surviving instances of Latin coordinate lists that are not variants of the TCT. An independent list of 23 localities was included in the second part of the *Liber canonum* written by Robert of Chester c. 1150.¹³ It includes degrees of longitude and latitude for Palermo, Messina, Rome, Pisa, England (*Anglia*) as well as a number of cities in Iberia and in the wider Islamic world. Robert's list seems to be distantly related to a list of 18 localities in MS Cambridge, University Library, Hh.6.8, fol. 38v (s. XIIIⁱⁿ), where it is placed ahead of a variant of the TCT (fols. 38v–39r).¹⁴ Relative to Robert, this list adds the coordinates of Toulouse (long. 33° , lat. 43°), which resonates with the fact that the two coordinate lists in the Cambridge manuscript belong to a set of astronomical tables for Toulouse starting in 1110. These tables were composed or otherwise influenced by the Iberian Jewish scholar Abraham bar Ḥiyya,¹⁵ which makes it likely that the independent list is derived from an Andalusī source. The same may be said for the coordinate list in the work by Robert of Chester, who was active in Spain as a translator of Arabic texts.¹⁶

Footnote 10 continued

21, fol. 43r); *Notandum quod VII sunt puncta...* (MS Cambridge, University Library, Kk.1.1, fol. 141r–v); *Circulus solis dicitur esse eccentricus...* (ibid., fols. 193r, 194r); *Theorica planetarum Gerardi*, c. 8 (ed. Carmody 1942: 45); *Motuum Solis alius est medius...* (MS Toledo, Archivo y Biblioteca Capitulares, 98–22, fol. 1va); *Quelibet ars suum habet artificem...* (MS Erfurt, Universitätsbibliothek, Dep. Erf. CA 4° 352, fol. 112va); Roger Bacon, *Opus maius*, pt. 4 (ed. Bridges 1897–1900: i. 298–300); Roger of Cotum, *Canones*, tr. II (MS Oxford, Bodleian Library, Laud. Misc. 644, fol. 217ra); commentary *Sicut dicit Hermes...* on Toledan canons 'Cb', Ap484 (ed. Pedersen 2001–2002, pt. 2: 137); William of Saint-Cloud, *Kalendarium regine*, c. 13 (ed. Harper 1966: 137–138). See Gautier Dalché (2000: 422–424); gloss *Cum Iulius Cesar universum orbem volens describere...* in bottom margin of MS Oxford, Bodleian Library, Savile 21, fol. 4r (s. XIII). The claim that the *Gades Herculis* are near Lisbon is made in Petrus Gallecus, *Summa de astronomia*, l. 349 (ed. Martínez Gázquez 2000: 50), but here Arim's role as the center of the world is assigned to Jerusalem.

¹¹ John of London, *Letter to R. de Guedingue*, §§26–27 (ed. Nothaft 2021a: 14).

¹² Nothaft (2021a: 29).

¹³ Robert of Chester, *Liber canonum: pars altera*, Lc5 (ed. and trans. Nothaft 2023b: 246–249).

¹⁴ See MA13 in Pedersen (2002: iv. 1517–1518).

¹⁵ Mercier (1987: 103–104, 2014: 185–203).

¹⁶ On Robert's identity and known works, see Nothaft (2023b: 193–195).

A Latin coordinate list that appears to have been wholly derived from Ptolemy's *Handy Tables* has recently been identified in MS Florence, Biblioteca Medicea Laurenziana, Ashburnham 211, fol. 251r (s. XIII^{2/2}).¹⁷ Its 46 entries predominantly cover the Mediterranean region, with a particular focus on Sicily and Italy. Several of these Italian longitudes are also attested in an eclectic table of coordinates in Gerard of Feltre's *Summa de astris* (bk. 1, ch. 8), which dates from c.1264. Aside from entries that are traceable back to Ptolemy or the TCT, Gerard's table contains a handful of coordinates that must have reached him through additional channels. For Table 1 in Part 4 below, I have selected his longitudes for Cremona, Feltre, London, Piacenza, and Paris, assuming that they are reckoned from the meridian 11° west of Toledo.¹⁸

One of the original purposes of the TCT and other coordinate lists of this kind was to assist users in adapting the tables for mean motions included in the Toledan Tables for other meridians. Rather than recasting these tables wholesale, many astronomers simply made the necessary adjustments while working with the original version, by subtracting or adding a certain amount to the radices listed in the table for 'collected years'. In some copies of the Toledan Tables, these adjustments are explicitly indicated in the margins of individual mean-motion tables. Known examples from the thirteenth century reflect the following estimates for the longitude distance from Toledo:

Cremona: 1;20 h = 20°. ¹⁹

Lodi: c.1;18.40 h = c.19;30,10°²⁰

Milan: 1;18 h = 19;30°. ²¹

Rome: 1;36 h = 24°. ²²

The same principle can be observed in the sole surviving manuscript of Robert of Chester's recension of Adelard of Bath's twelfth-century translation of the astronomical tables of al-Khwārizmī. Its mean-motion tables record corrections for the meridian of London that amount to a westward shift of 3;40 h = 55° with respect to Arim (the reference meridian of al-Khwārizmī's tables).²³ Accepting that Toledo lies 61;30° west of Arim, this implies a longitude difference Toledo–London of 6;30°.

The contrasting practice of recasting mean-motion tables entirely for a new meridian (as well as for a Christian calendrical format) is again attested most frequently for

¹⁷ See Nothaft (2022).

¹⁸ MS Milan, Biblioteca Ambrosiana, C 245 inf., fol. 7r (s. XIII^{ex}).

¹⁹ MSS Erfurt, Universitätsbibliothek, Dep. Erf. CA 8° 81, fols. 25r–v, 29r–v (s. XIII^{ex}); Florence, Biblioteca Nazionale Centrale, Conv. soppr. J.V.5, fols. 13v, 17r, 23r, 24v, 29r, 33v, 38r, 42v (s. XIII^{2/2}); Paris, Bibliothèque de l'Arsenal, 1128, fols. 8v (s. XIII^{2/2}); Paris, Bibliothèque nationale de France, lat. 7409, fols. 11r, 13r, 15v, 16v, 18v, 20v, 23v, 25v (s. XIII^{4/4}). See CF11 in Pedersen (2002: iii. 1213–1214); Chabás (2019: 104).

²⁰ MS Florence, Biblioteca Nazionale Centrale, Conv. soppr. J.V.5, fol. 17r (s. XIII^{2/2}). See CF40 in Pedersen (2002: iii. 1215).

²¹ MS Florence, Biblioteca Nazionale Centrale, Conv. soppr. J.V.5, fols. 13v, 17r, 18r (s. XIII^{2/2}). See CF35 in Pedersen (2002: iii. 1215).

²² MS New York, Columbia University, Rare Book & Manuscript Library, Smith Western Add. 06, fols. 85r, 87v, 93r, 94r, 98r, 102r, 106r, 110r (s. XIII^{ex}). See CF50 in Pedersen (2002: iii. 1215–1216).

²³ MS Madrid, Biblioteca nacional de España, 10016, fols. 14v, 18v, 23v, 24v, 28v (s. XIII). See Neugebauer (1962: 94), Mercier (1987: 96–97) and Nothaft (2023b: 198–199).

the Toledan Tables.²⁴ A full survey of these adaptations, of which several remain unstudied, cannot be offered here. The following listing is restricted to instances where the longitude of the intended meridian of reference is either clearly stated (e.g., in table headings) or where it can be inferred straightforwardly from the radices contained in the tables for ‘collected years’.

- The Tables of Marseilles by Raymond of Marseilles (c. 1141) place the eponymous city 3 h = 45° to the west of Arim and 1;6 h = 16;30° to the east of Toledo.²⁵ The same longitude difference is apparent in a different set of Tables of Marseilles, composed by William the Englishman (fl. 1219/30).²⁶
- The Tables of Hereford by Roger of Hereford (1178) adapt Raymond’s Tables of Marseilles to a meridian 21° further west, which implicitly puts Hereford 4;30° west of Toledo.²⁷
- The Tables of Toulouse (s. XIII^{1/2} [before 1239]) give the longitude of Toulouse as 40° from the west, while the radices differ from the Toledan Tables by 0;48 h = 12°. This may imply an assumed longitude of Toledo at 28° rather than 28;30°. ²⁸
- The Tables of Ferrara by a certain Johannes (fl. 1244) give the longitude of Ferrara as 2;48 h = 42° east of the ‘middle of the world’. This would imply a distance of 3;12 h = 48° from the western zero meridian and of 1;18 h = 19;30° from Toledo. The mean-motion radices in these tables appear to differ from the Toledan Tables by the equivalent of 1;20 h = 20° rather than 19;30°. ²⁹
- The Tables of Novara by Campanus of Novara (s. XIII^{med}, before 1261) give the longitude of Novara as 30;15° and reduce the Toledan radices by 1;17 h = 19;15°. ³⁰ This is consistent with a placement of Toledo at 11°.
- According to a canon (*Composui hanc tabulam ad inveniendum diem...*) that accompanies stand-alone copies of Campanus of Novara’s tables for mean syzygy, Paris lies 0;25 h = 6;15° west of Novara,³¹ which would imply that Paris lies 19;15° – 6;15° = 13° east of Toledo. This information may have been used to compute

²⁴ A few of these adaptations are discussed in Chabás (2019: 104–108). Contrary to what is claimed in Miolo (2020: 394, 404–405), there are no tables for the meridian of Le Mans.

²⁵ Raymond of Marseilles, *Liber cursum planetarum* II.1d, 3a (ed. Alverny et al. 2009: 200, 204). See Mercier (1987: 107).

²⁶ MS Edinburgh, Royal Observatory, Crawford, Cr. 2.5, fols. 92r–96v (s. XIII^{med}). Besides the usual tables for the Sun, Moon (mean longitude, anomaly, ascending node), and five planets, there is also a table for the ‘access and recess’ of the eighth sphere, of which a second copy (covering collected and expanded years) survives in MS Leiden, Universiteitsbibliotheek, Scaliger 64, fol. 131r (s. XIII/XIV). See CE35, PA40 in Pedersen (2002: iii. 1210, iv. 1548–1549).

²⁷ See Table 1 and n. 68.

²⁸ See Poulle (1994); Pedersen (1998, 2002: iii. 1197–1205, 1223, iv. 1341–1346, 1546–1547, 1561–1562); Chabás (2019: 108–110).

²⁹ MS Paris, Bibliothèque de l’Arsenal, 1128, fols. 1r–6r (s. XIII/XIV). Johannes’s *floruit* seems to follow from the solar almanac on fols. 29r–32v, which covers the 4-year period from March 1244 to February 1248.

³⁰ On these tables, see Benjamin and Toomer (1971: 3–5, 15–16); Pedersen (2002: iii. 1205–1207, 1221, iv. 1347, 1548, 1562–1563); Chabás (2019: 110–113).

³¹ MS London, British Library, Royal 12.C.IX, fol. 60v: “Item debes scire quod meridies Navarie ad quam facte sunt hee tabule preceedit meridiem Parisius per 25 minuta unius hore.” See Benjamin and Toomer (1971: 16 n. 58).

the Tables of Paris in MS Bernkastel-Kues, Cusanusstiftsbibliothek, 215, fols. 103r–127r (s. XIV^{1/2}), which use the French (Picard-Waloon) vernacular and originally date from c.1271. Their mean-motion radices reflect an approximate shift of 0;25 h relative to Campanus's tables.³² According to Pedersen, the same time difference Paris–Novara was used by Peter Nightingale when calculating the syzygy tables for Paris included in his *Tractatus instrumenti eclipsium* (1292/1300).³³

- The Toledan mean-motion tables in MS Paris, Bibliothèque nationale de France, lat. 16658, fols. 115r–131v (s. XIII^{med}) were augmented with additional radices (571 to 691 collected years of the Hijra era) valid for Paris. In the case of the Sun (fol. 115r), Moon (fol. 116r), and lunar anomaly (fol. 117r), the difference between the Toledan and Parisian radices amounts to 0;34 h = 8;30°, which is confirmed by a note on fol. 115r (*Parisius distat a Toleto in oriente VIII gradus et XXX minuta*).³⁴

Other sets of tables that circulated in Latin during the twelfth and thirteenth centuries were related not to the Toledan Tables, but to the tenth-century *zīj* of al-Šūfī. In c.1143, al-Šūfī's mean-motion tables were adapted for the Christian calendar and the meridian of Lucca/Pisa by the prominent Jewish astrologer Abraham Ibn Ezra.³⁵ According to Ibn Ezra's Latin *Liber de rationibus tabularum* (1154), in which these tables are discussed, Pisa has a longitude of 33°. ³⁶ While this is close to the Ptolemaic value of 33;30°, ³⁷ Ibn Ezra appears to have reckoned Pisa's longitude from a different zero meridian. Elsewhere in the same work, he assigns to Córdoba a longitude of 27° in opposition to the Ptolemaic 9°, which strongly suggests that his own preferred reference point was the meridian 90° west of Arim.³⁸ Indeed, he follows this convention in a text mentioning a lost adaptation of his tables for Winchester, to which he assigns a longitude of 19° = 71° west of Arim.³⁹

A longitude of 19° was also retained for the Tables of London, created around 1150, whose mean-motion radices were for the most part derived from the Tables of Pisa via a shift corresponding to 0;56 h or 14° (= 33°–19°).⁴⁰ In one copy of the Tables of London, a further adjustment is proposed to adapt the radices for Mars to the meridian of Toledo. The subtraction in this case would imply that Toledo can be found 10;30°

³² Boudet and Husson (2012) and Chabás (2019: 112).

³³ Pedersen (1983–1984: i. 63).

³⁴ The Parisian radices of the remaining mean-motion tables are not consistent with this difference or have been partially erased. See also Pedersen (1983–1984: i. 60, 2002: iii. 1212 [CE50]).

³⁵ Nothaft (2023b: 9–20).

³⁶ Abraham Ibn Ezra, *Liber de rationibus tabularum* (ed. Millás Vallicrosa 1947: 87, ll. 20–21). The same value reappears in Gerard of Feltre, *Summa de astris* 1.8 (MS Milan, Biblioteca Ambrosiana, C 245 inf., fol. 7r) and in various additions to the TCT. See, e.g., *Me*, fol. 16v; *Ny*, fol. 116v.

³⁷ Raymond Mercier has argued that the creation of the Tables of Pisa involved a reduction of mean-motion radices from a meridian of 80° (Baghdad) to one of 33;30° (Pisa). See Mercier (1991/2004: 5–12). Attested placements of Pisa in Islamic coordinate lists include 33;30° and 33;40°. See Kennedy and Kennedy (1987: 255). The variant 33;20° appears in the coordinate list in MS Cambridge, University Library, Hh.6.8, fol. 38v (s. XIIIⁱⁿ).

³⁸ Abraham Ibn Ezra, *Liber de rationibus tabularum* (ed. Millás Vallicrosa 1947: 79, ll. 3–5; 86, ll. 4–10).

³⁹ Abraham Ibn Ezra, *De revolutionibus annorum mundi* §7.1:4 (ed. Steel in Sela et al. 2020: 252). See the analysis by Nothaft in Sela et al. (2020: 209–222).

⁴⁰ Nothaft (2023b: 210–212).

east of London or merely $14^{\circ}-10;30^{\circ} = 3;30^{\circ}$ west of Pisa.⁴¹ It is possible that this grossly mistaken placement was inspired by the aforementioned list of coordinates in Robert of Chester's *Liber canonum* (written for the Tables of London), which records longitudes of 18° for England, $28;30^{\circ}$ ($= 18^{\circ} + 10;30^{\circ}$) for Toledo, and 33° for Pisa.⁴²

Finally, one may mention the example of the astrologer Henry Bate, who computed a set of tables for his hometown Mechelen in Brabant no later than 1280. In structural terms, these Tables of Mechelen were clearly influenced by the Tables of Pisa, although Bate can be shown to have used a distinct set of parameters. From the preserved table headings, it appears that Bate assigned to Mechelen a longitude $47;45^{\circ}$ west of Arim, or $42;15^{\circ}$ from the western zero meridian. This implicitly puts Mechelen $42;15^{\circ}-28;30^{\circ} = 13;45^{\circ}$ east of Toledo.⁴³

3 The eclipse method

Records of longitudes in medieval sources are almost never accompanied by information on how they were derived. One method that was nevertheless clearly involved in generating some of the estimates known from this period was that of comparing the times of eclipses at two different meridians.⁴⁴ The basic insight that eclipses are capable of revealing time differences between localities had, in fact, been available to Latin audiences long before the scientific translations of the twelfth century. The Venerable Bede reports on it in his eighth-century treatise *De natura rerum*, by reproducing relevant passages from Pliny's *Natural History* (2.280–281).⁴⁵ Walcher of Malvern, who was active in England in the decades around 1100, concluded from this that the conjunction tables he had drawn up for the years 1036–1111 were not universally valid, but required adjustments for one's local meridian.⁴⁶ The treatise that accompanies Walcher's tables also contains his famous remark concerning the large time difference between Italy and England, which he deduced after comparing the lunar eclipse he had observed on a journey in Italy in 1091 with a report on the same eclipse he later received in England.⁴⁷

It is only in the twelfth century, however, that Latin texts begin to address the possibility of converting the difference between eclipse times into degrees of longitudes, called *longitudo*. Perhaps the first to do so is Petrus Alfonsi's *Dialogus contra Iudaeos* (c.1110), which brings up the hypothetical example of an eclipse being observed two

⁴¹ Nothaft (2023b: 309).

⁴² See above, n. 13.

⁴³ Nothaft (2018a: 284–285).

⁴⁴ On the use of this method in antiquity, see Stückelberger and Mittenhuber (2009: 235–237).

⁴⁵ Bede, *De natura rerum*, c. 23 (ed. Jones 1975: 215). See also Martianus Capella, *De nuptiis* 6.594 (ed. Willis 1983: 208).

⁴⁶ Walcher of Malvern, *De lunationibus* 3.6, 4.3 (ed. and trans. Nothaft 2017: 112–113, 118–119).

⁴⁷ Walcher of Malvern, *De lunationibus* 4.1 (ed. Nothaft 2017: 114–115). The relevant passage is also reproduced, translated, and discussed in Gautier Dalché (2013: 235, 237, 239). It was already noted by Wright (1923: 81) and Gautier Dalché (1998: 198, 2000: 412).

hours earlier in one city than in another, thus revealing a longitude difference of 30° .⁴⁸ A source that gave wider exposure to this general approach in the first half of the twelfth century was the treatise on astrolabe use by Ibn al-Šaffār, which was translated into Latin on at least three different occasions.⁴⁹ The earliest Latin Christian author to pen a full account of the ‘eclipse method’ appears to have been Raymond of Marseilles in the *Liber cursuum planetarum* that accompanied his astronomical tables for Marseilles (c.1141). To those who desired to adapt these tables to their own location and for this purpose needed to know the distance in longitude from Marseilles, Raymond recommended the following series of steps:

- (a) use the Tables of Marseilles to compute the time of either the beginning or the end of an upcoming lunar eclipse
- (b) convert the computed time from equinoctial into seasonal (or ‘artificial’) hours
- (c) observe the beginning or end of the eclipse with a reliable time-keeping instrument and compare the time thus found with the time previously computed
- (d) convert the difference between the observed and computed time from seasonal hours (and their parts) into equinoctial hours (and their parts)
- (e) if the eclipse was observed later [*sic*] than the computed time, the observer is located west of Marseilles and the amount of mean motion corresponding to the time difference must be added to the radices in the table; if it is observed earlier [*sic*], the location is east of Marseilles and the same amount must be subtracted.⁵⁰

This account is not without its flaws, especially insofar as it claims that on a meridian to the west of Marseilles, the same eclipse will be seen later rather than earlier in terms of local time, as well as the reverse. Another difficulty lies in the way Raymond describes the necessary comparison between computed and observed eclipse times. In his series of steps, the time computed for Marseilles must first be converted into seasonal hours before it can be compared with the time observed at another location, which is likewise measured in seasonal hours. Unless both cities happen to be on the exact same latitude, this method tacitly presupposes using the latitude of the observer’s city when converting Marseilles’s eclipse time from equinoctial into seasonal hours. A simpler recommendation would have been to convert the *observed* eclipse time from seasonal into equinoctial hours, as was already done by Walcher of Malvern in c.1092 when he computed the aforementioned conjunction tables for 1036–1111.⁵¹

Most Latin authors subsequent to Raymond managed to avoid these shortcomings in their discussions of the eclipse method. Relatively detailed accounts of how to proceed

⁴⁸ Petrus Alfonsi, *Dialogus*, tit. 1.64 (ed. and trans. Cardelle de Hartmann et al. 2018: 36). See Wright (1923: 82–83), Gautier Dalché (1998: 198–199, 2000: 412–413).

⁴⁹ Ibn al-Šaffār, *On the Uses of the Astrolabe*, trans. John of Seville, c. 26 (ed. Millás Vallicrosa 1942: 275); Ibn al-Šaffār, *On the Uses of the Astrolabe*, trans. Plato of Tivoli, c. 28 (ed. Lorch et al. 1994: 160); Ibn al-Šaffār, *On the Uses of the Astrolabe*, trans. anon., c. 19 (ed. Nothaft 2023a: 98). A similar chapter appears in pseudo-Māshā’ allāh, *Practica astrolabii*, c. 26 (ed. Thomson 2022: iv. 260–265). The connection between eclipse times and differences in longitude is also drawn in al-Farghānī, *Book on the Summaries of the Science of the Stars and the Principles of the Celestial Movements*, c. 3 (trans. John of Seville ed. Carmody 1943: 6–7; trans. Gerard of Cremona ed. Campani 1910: 67).

⁵⁰ Raymond of Marseilles, *Liber cursuum planetarum* II.3b–f (ed. Alvernay et al. 2009: 204).

⁵¹ Walcher of Malvern, *De lunationibus* 4.1 (ed. Nothaft 2017: 114–117).

appear in two texts by Robert of Chester written in the years around 1150,⁵² in Adelard of Bath's *Libellus de opere astrolapsus* (c. 1149/50),⁵³ and in various anonymous texts on instruments and astronomical tables, such as *Investigantibus astronomiam primo sciendum* from the final quarter of the twelfth century.⁵⁴ As one would expect, a common element in most of these descriptions of the eclipse method is the equivalence $1^\circ = 0;4$ h that will be required to convert time differences into degrees of longitude difference, and vice versa.⁵⁵ What is generally ignored, by contrast, is the necessity of converting the observed time of an eclipse into mean solar time, which is the time standard required for obtaining a precise correlation between the hour angle of the (mean) Sun and the degree of geographic longitude.⁵⁶ This conversion would have required factoring in the equation of time, which was, in principle, available through astronomical tables.⁵⁷ While some texts emphasize the importance of this term in navigating between tables and observation,⁵⁸ this point is almost never made in the specific context of longitude determination. An exception in this regard is Peter of Saint-Omer's *Tractatus de semissis* (c. 1294), in which readers are reminded to subtract the equation of time from any observed eclipse before comparing it with the time predicted by a set of tables.⁵⁹

Rather than comparing an observed eclipse time with a computed one, it was at least theoretically possible to use observations of the same eclipse in different locations. This is how the eclipse method is described in the aforementioned astrolabe treatise by Ibn al-Šaffār, even though the difficulty of coordinating such a dual observation would

⁵² Robert of Chester, *Liber canonum: pars altera*, Lc5 (ed. and trans. Nothaft 2023b: 244–247); Robert of Chester, *Liber de officio astrolabii*, c. 25 (MS Oxford, Bodleian Library, Canon. misc. 61, fol. 18v).

⁵³ Adelard of Bath, *Libellus de opere astrolapsus* (ed. Dickey 1982: 191, 193–194).

⁵⁴ *Investigantibus astronomiam primo sciendum...*, Jn379–388 (ed. Pedersen 1990: 300–302); *Quomodo opus tabularum istarum...* (MS Copenhagen, Det Kongelige Bibliotek, GkS 277 2°, fol. 191va); *Circulus solis dicitur esse eccentricus...* (MS Cambridge, University Library, Kk.1.1, fol. 194v); *Motuum Solis alius est medius...* (MS Toledo, Archivo y Biblioteca Capitulares, 98–22, fol. 1va); *Quelibet ars suum habet artificem...* (MS Erfurt, Universitätsbibliothek, Dep. Erf. CA 4° 352, fol. 112va). See also Toledan Tables canon CbA.C13 (ed. Pedersen 2002: ii. 514; from MS Erfurt, Universitätsbibliothek, Dep. Erf. CA 4° 352, fols. 116v; s. XIII^{1/2}); Giles of Lessines, *De crepusculis*, pt. 2, c. 1 (MS Bologna, Biblioteca Universitaria, 1845, fols. 94vb–95ra); Robert the Englishman, *Commentary on John of Sacrobosco's Tractatus de spera*, lectio XV (ed. Thorndike 1949: 196).

⁵⁵ See also *Ezich Elkaurezmi*, trans. Adelard of Bath, c. 7 (ed. Suter 1914: 8); Abraham Ibn Ezra, *Liber de rationibus tabularum* (ed. Millás Vallicrosa 1947: 88, ll. 2–4); *Tractatus magistri Habrahe de tabulis planetarum* (MS London, British Library, Arundel 377, fol. 56v); Robert of Northampton(?), *Diversi astrologi secundum diversos annos...* (MS Oxford, Bodleian Library, Savile 21, fol. 43r); Roger of Cotum, *Canones*, tr. II (MS Oxford, Bodleian Library, Laud. Misc. 644, fol. 217r); commentary *Sicut dicit Hermes...* on Toledan canons 'Cb', Ap257, 484 (ed. Pedersen 2001–2002, pt. 1: 260; pt. 2: 137); John of Sicily, *Scriptum super canones Azarchelis*, J298c (ed. Pedersen 1986: 142).

⁵⁶ A related problem was that the radices of the available astronomical tables typically referred to true noon on a particular date, which effectively prevented a consistent standard of mean solar time from being used. See on this point Mercier (1985: 23–25).

⁵⁷ BB in Pedersen (2002: iii. 968–987); Chabás and Goldstein (2012: 27–28, 37–41).

⁵⁸ Abraham Ibn Ezra, *Liber de rationibus tabularum* (ed. Millás Vallicrosa 1947: 88, ll. 17–30); Robert of Northampton(?), *Diversi astrologi secundum diversos annos...* (MS Oxford, Bodleian Library, Savile 21, fol. 53r–v); John of Sicily, *Scriptum super canones Azarchelis*, J409–411 (ed. Pedersen 1986: 198–199).

⁵⁹ Peter of Saint-Omer, *Tractatus de semissis* §4.13 (ed. Pedersen 1983–1984: ii. 704).

have been considerable.⁶⁰ The scenario also receives some consideration in the letter written soon after 1246 by John of London, who surmised that Ibn al-Zarqālluh, the putative author of the Toledan Tables, would have found the longitude of Toledo from the west by comparing an observed eclipse with a computed time for Arim. As John explains to his letter's addressee (a certain *R. de Guedingue*), Ibn al-Zarqālluh might have found a different result had he sent an assistant to the western zero meridian (the *Gades Herculis*) to observe the eclipse at this longitude with his own eyes.⁶¹ That this sort of approach was not entirely out of reach for medieval Europeans is indicated by the introduction to a calendar by the astronomer Alard of Diest, whose conjunction times cover the years 1301–1376. Alard calculated these times for the meridian of his hometown Diest in Brabant, which according to his own testimony differs from that of Paris by one half-hour (i.e., 7;30°). He seems to claim that this result was suggested to him by individuals who observed the same eclipse in both places (*sicut per eclipses ibidem et Parisius observantes inveni*).⁶²

Not all discussions of the eclipse method in twelfth- and thirteenth-century sources restrict this procedure to eclipses of the Moon, which had the particular advantage of maintaining the same appearance across different latitudes.⁶³ Many of them leave the type of eclipse unspecified, while some expressly mention lunar and solar eclipses.⁶⁴ An unusual case is Petrus Alfonsi's aforementioned *Dialogus*, whose hypothetical example of an eclipse observed in two different places concerns a solar eclipse rather than a lunar one.⁶⁵ What is even more striking, however, is that the two applications of the eclipse method that are directly attested from the twelfth century both involved solar eclipses, despite their rarity and sensitivity to lunar parallax. The earlier of these is Abraham Ibn Ezra, who used an unspecified solar eclipse he 'examined' (*probavi*) in Bordeaux to infer a time difference of 0;36 h or 9° between Angers and Pisa, presumably by comparing the observed time with the time predicted by the Pisan tables.⁶⁶ The resulting distance of 9° between Angers and Pisa, which put

⁶⁰ See above, n. 49.

⁶¹ John of London, *Letter to R. de Guedingue*, §§29–34 (ed. Nothaft 2021a: 14–15).

⁶² MS Erfurt, Universitätsbibliothek, Dep. Erf. CA 4° 370, fol. 1v (s. XIVⁱⁿ): "Locus autem super cuius meridem hoc kalendarium est factum est Dist in Brancia, cuius latitudo est 50 graduum et 58 minutorum. Meridies autem eius precedit meridiem Parisiensem fere per dimidiam horam, sicut per eclipses ibidem et Parisius observantes inveni."

⁶³ This is the case in Ibn al-Šaffār, *On the Uses of the Astrolabe*, trans. John of Seville, c. 26 (ed. Millás Vallicrosa 1942: 275); Ibn al-Šaffār, *On the Uses of the Astrolabe*, trans. Plato of Tivoli, c. 28 (ed. Lorch et al. 1994: 160); Ibn al-Šaffār, *On the Uses of the Astrolabe*, trans. anon., c. 19 (ed. Nothaft 2023a: 98); pseudo-Māshā'allāh, *Practica astrolabii*, c. 26 (ed. Thomson 2022: iv. 262); Raymond of Marseilles, *Liber cursuum planetarum* II.3b (ed. Alverny et al. 2009: 204); *Circulus solis dicitur esse eccentricus...* (MS Cambridge, University Library, Kk.1.1, fol. 194v).

⁶⁴ Both types of eclipses are mentioned in Adelard of Bath, *Libellus de opere astrolapsus* (ed. Dickey 1982: 193); Abraham Ibn Ezra, *Liber de rationibus tabularum* (ed. Millás Vallicrosa 1947: 79, l. 4; 88, ll. 8–9); Robert of Chester, *Liber de officio astrolabii*, c. 25 (MS Oxford, Bodleian Library, Canon. misc. 61, fol. 18v); *Quomodo opus tabularum istarum...* (MS Copenhagen, Det Kongelige Bibliotek, GkS 277 2°, fol. 191va).

⁶⁵ See above, n. 48.

⁶⁶ Abraham Ibn Ezra, *Liber de rationibus tabularum* (ed. Millás Vallicrosa 1947: 88, ll. 12–14). See Gautier Dalché (2000: 417–418) and Samsó (2012: 188).

Angers at a longitude of $33^\circ - 9^\circ = 24^\circ$,⁶⁷ is less than 2° below the actual distance of $c.10;57^\circ$, making this a relatively successful estimate. The longitude difference between Bordeaux and Pisa is only marginally greater at $c.10;59^\circ$, which goes some way towards vindicating Ibn Ezra's implicit assumption that Angers and Bordeaux share the same meridian.

The other twelfth-century astronomer who is known to have used this type of method is Roger of Hereford, who adapted Raymond of Marseilles's Tables of Marseilles to his local meridian. An abridged copy of the resulting Tables of Hereford is preserved in a manuscript once at Ely Abbey, Cambridgeshire (MS London, British Library, Arundel 377; s. XII/XIII), where a brief text (fol. 86vb) informs the reader that Roger used the solar eclipse of 13 September 1178 to establish the difference in longitude between Hereford and three other locations, namely, Arim (*Aren*), Toledo, and Marseilles. The eclipse times and resulting longitude differences mentioned in this text are as follows⁶⁸:

Arim: 15:54 h.

Marseilles: 12:54 h ($-3 \text{ h} = 45^\circ$).

Toledo: 11:50 h ($-1;4 \text{ h} = 16^\circ$).

Hereford: 11:30 h ($-0;20 \text{ h} = 5^\circ$).

By assuming Arim's customary position in the middle of the world, Roger was also able to assign longitudes from the western zero meridian: Marseilles at 45° , Toledo at 29° , and Hereford at 24° . Although the text does not explicitly say so, it seems very likely that Roger computed the eclipse time for Marseilles using Raymond's original tables.⁶⁹ It would have been possible for him to infer the corresponding eclipse times at Arim and Toledo from the information supplied in Raymond's *Liber cursum planetarum*, which mentions Marseilles as lying $3 \text{ h} = 45^\circ$ west of Arim and $1;6 \text{ h} = 16;30^\circ$ east of Toledo.⁷⁰ Yet, this raises the question why Roger shortened the distance Toledo-Marseilles to $1;4 \text{ h} = 16^\circ$. For his own location in Hereford, the observed time of eclipse revealed a distance from Marseilles of $1;24 \text{ h} = 21^\circ$, which he subtracted from the mean-motion radices in Raymond's tables to generate those in the Tables of Hereford. In terms of accuracy, this determination fell considerably behind Ibn Ezra's result for Bordeaux and Angers, considering that Hereford and Marseilles lie only $c.8;5^\circ$ apart.

Cases such as Roger's and Ibn Ezra's, where longitudes are expressly documented as having been established from eclipse observations, are overall very rare. For the thirteenth century, one can point to a set of canons for the Tables of Pisa (*Quomodo opus tabularum istarum...*), which was apparently written in Paris in the middle of the

⁶⁷ Note that Millás Vallicrosa edition (see above, n. 66) gives the longitude of Angers as 23° , which is inconsistent with the stated time difference of $0;36 \text{ h} (= 9^\circ)$ between Pisa and Angers. The correct reading of 24° is attested in MSS Erfurt, Universitätsbibliothek, Dep. Erf. CA 4° 381, fol. 4v (s. XII^{2/2}); Oxford, Bodleian Library, Digby 40, fol. 58v (s. XII/XIII).

⁶⁸ A part of this text is printed, translated, and discussed in Gautier Dalché (2013: 235, 237, 239–240). See also Gautier Dalché (2000: 418–419).

⁶⁹ Wright (1923: 85) misread the passage to mean that the eclipse times for Hereford, Marseilles, and Toledo were all three observed. See also Mercier (1987: 108), who writes that “[i]t is not clear whether he determined the difference $21;0$ between the meridians of Marseilles and Hereford by a comparison of the observed times of this eclipse.”

⁷⁰ See above, n. 25.

century. The text assigns to Paris an identical longitude to Pisa (33°), claiming that this has been demonstrated via eclipses (*quod per eclipses probatum est*).⁷¹ The same assertion appears in one of the two known copies of an unpublished astrolabe treatise starting *Quelibet ars suum habet artificem...*, which also notes that the longitude of Toledo is 11° . This time the remark about the use of eclipses is made in the first person—*sicut per eclipses probavimus*—, which suggests that it was the source for the Parisian canons.⁷² It also seems worth mentioning that Ristoro d’Arezzo transmits the longitude of his hometown in the context of a detailed account of the total solar eclipse of 3 June 1239, which was very widely reported in sources from Northern Italy and further afield.⁷³ The thought seems at least worth entertaining that some of the European longitudes that are first attested in sources with a *terminus a quo* of 1239 originated as a consequence of this eclipse.

In addition to the widely attested eclipse method, a handful of sources provide alternative astronomical techniques, although none that could be considered practical in a pre-modern context. Adelard of Bath, in his astrolabe treatise of c. 1149/50, suggested that it would be easier to measure the position of the Moon or some other planet at a given moment in time and compare this with the computed position for Arim.⁷⁴ Echoes of the same basic idea appear in the twelfth-century treatise *Investigantibus astronomiam primo sciendum...* and in the very widely copied *Theorica planetarum* sometimes attributed to Gerard of Cremona (s. XIII?).⁷⁵ Given the computational and observational means available at the time, this was not a viable method and one may doubt that it was used to generate any of the longitude estimates to be discussed in what follows.

4 Preserved estimates

The following table is a systematic display of longitudes of European cities established during the period from 1100 to 1300. In drawing data from manuscript sources, I have generally erred on the side of parsimony, meaning that longitudes attested in undated tables, short texts, and marginalia were included only if the scribal hand can with some confidence be assigned to the period before 1300. For augmented versions of the TCT, I have used the following 24 codices containing a total of 26 coordinate lists:

Ba = Basel, Universitätsbibliothek, O.II.7, fol. 162r (s. XIII^{ex}),

Bf = Berlin, Staatsbibliothek, lat. fol. 610, fol. 234r (s. XIII^{ex}),

⁷¹ MS Copenhagen, Det Kongelige Bibliotek, GkS 277 2°, fol. 191vb.

⁷² MS Oxford, Bodleian Library, Ashmole 361, fol. 40vb (s. XIV). This remark is missing from an earlier copy of this treatise in MS Erfurt, Universitätsbibliothek, Dep. Erf. CA 4° 352, fols. 111ra–112vb (s. XIII^{1/2}).

⁷³ Ristoro d’Arezzo, *La composizione del mondo*, bk. 1, ch. 15 (ed. Morino 1997: 37). For reports of the eclipse of 1239, see Celoria (1875: 2–10) and Stephenson (1997: 385, 397–402), Martínez Usó et al. (2016: 63–67) and Martínez Usó and Marco Castillo (2022: 418).

⁷⁴ Adelard of Bath, *Libellus de opere astrolapsus* (ed. Dickey 1982: 194–196). See the remarks on this passage in Pouille (1987: 126–127) and Gautier Dalché (2000: 413–414).

⁷⁵ *Investigantibus astronomiam primo sciendum...*, Jn380–388 (ed. Pedersen 1990: 300–302); *Theorica planetarum Gerardi*, c. 8, §109 (ed. Carmody 1942: 46). See Wright (1923: 83–84).

Ca = Cambridge, University Library, Hh.6.8, fols. 38v–39r (s. XIIIⁱⁿ), 184r (s. XIII^{2/2}),

Ed = Edinburgh, Royal Observatory, Crawford Collection, Cr. 2.5, fol. 73v (s. XIII^{med}),

Eq = Erfurt, Universitätsbibliothek, Dep. Erf. CA 8° 82, fol. 88r (s. XIII^{ex}),

Fj = Florence, Biblioteca Nazionale Centrale, Conv. soppr. J.V.5, fol. 66r (s. XIII^{2/2}),

Fl = Florence, Biblioteca Medicea Laurenziana, San Marco 185, fols. 51r, 83r (s. XIII^{ex}),

Lh = London, British Library, Harley 3734, fol. 40r (s. XIII^{2/2}),

Ma = Madrid, Biblioteca nacional de España, 10016, fol. 70v (s. XIII),

Me = Metz, Bibliothèque municipale, 1223, fols. 16v, 110r (XIII^{ex}),

Ny = New York, Columbia University, Rare Book & Manuscript Library, Smith Western Add. 06, fol. 116v (s. XIII^{ex}),

Ol = Oxford, Bodleian Library, Laud. Misc. 644, fol. 91v (s. XIII^{2/2}),

Ot = Oxford, Bodleian Library, Savile 22, fol. 67r (s. XIII^{med}),

Pa = Paris, Bibliothèque de l'Arsenal, 877, fol. 75r (s. XIII^{2/2}),

Pb = Paris, Bibliothèque de l'Arsenal, 1128, fol. 28v (s. XIII^{2/2}),

Pc = Paris, Bibliothèque nationale de France, lat. 7198, fol. 90r (s. XIII^{ex}),

Pe = Paris, Bibliothèque nationale de France, lat. 7409, fol. 37v (s. XIII^{4/4}),

Pg = Paris, Bibliothèque nationale de France, lat. 7421, fol. 203v (s. XIII^{ex}),

Ph = Paris, Bibliothèque nationale de France, lat. 11249, fol. 79r–v (s. XIII^{1/2}),

Pl = Paris, Bibliothèque nationale de France, lat. 16211, fol. 93v (s. XIII^{ex}),

Pn = Paris, Bibliothèque nationale de France, n.a.l. 3091, fol. 74v (s. XIII^{ex}),

Pr = Princeton (NJ), University Library, Garrett 99, fol. 78v (s. XIII^{ex}),

Vp = Vatican City, Biblioteca Apostolica Vaticana, Pal. lat. 1414, fol. 138v (XIII^{2/2}),

Vi = Vienna, Österreichische Nationalbibliothek, 2385, fol. 36v (s. XIII).⁷⁶

Aside from including such lists, astronomical codices sometimes insert information on geographic longitudes in the form of short notes or glosses, especially ones found in the margins of the Toledan Tables or their various canons. For the purpose of compiling Table 1, I have drawn on relevant examples in *Bf*, *Fl*, *Ny*, and *Vp* as well as the ten following manuscripts:

Bq = Berlin, Staatsbibliothek, lat. qu. 526 (s. XIII/XIV),

Ck = Cambridge, University Library, Kk.1.1 (s. XIII),

Oa = Oxford, Bodleian Library, Auct. F.3.13 (s. XIII),

Oc = Oxford, Corpus Christi College, 283 (s. XIII),⁷⁷

Od = Oxford, Bodleian Library, Digby 20 (s. XIII),

Os = Oxford, Bodleian Library, Savile 21 (s. XIII),

Pd = Paris, Bibliothèque nationale de France, lat. 7406, fol. 10r (s. XIII^{2/2}),

Pk = Paris, Bibliothèque nationale de France, lat. 16208 (s. XII^{2/2}),

Pm = Paris, Bibliothèque nationale de France, lat. 16658 (s. XIII^{med}),

Po = Pommersfelden, Gräfl. Schönbornsche Bibliothek, 66 (2640) (s. XIII).

⁷⁶ In using these copies to compile the data in Table 1, I ignored secondary additions to these lists if there was a strong likelihood that they post-date the year 1300. Several further TCTs were excluded from consideration on the same chronological grounds.

⁷⁷ See Neugebauer (1962: 229–230), North (2002: 15) and Gautier Dalché (2013: 236, 238, 240).

The longitudes in Table 1 are organized alphabetically according to cities. In selecting data for inclusion, I have generally disregarded longitudes that were clearly derived from an earlier Greek or Arabic source. For example, in the TCT of *Ed* (s. XIII^{med}), the city of Lyon is given the same set of coordinates (longitude 23;45°, latitude 45;50°) the TCT normally ascribes to the *sedes regni Francorum*. The same can be observed in the TCT of *Ny* (s. XIII^{ex}), where the name of Paris appears in lieu of the *sedes regni Francorum*. Potential entries were also excluded if it seemed plausible that they trace their ultimate origin to Ptolemy's *Geography* and/or *Handy Tables*. This is true of Ibn Ezra's longitude value for Pisa (see Part 2) and some of the longitudes listed in Gerard of Feltre's *Summa de astris*, although I have retained Gerard's values for Cremona, Feltre, London, Piacenza, and Paris.

For the entries that remain, Table 1 displays the pertinent information in five columns. The first, unnumbered column assigns to each entry an identifying number, which will be used to refer to entries throughout the rest of this study. The following column (i) gives the name of the city or locality in question. Column (ii) shows the longitudinal value (Λ) attested in a given source or group of sources. Where this is a longitude reckoned from the 'Ptolemaic' meridian 11° west of Toledo, it will be accompanied by '(A)'. Longitudes reckoned from the meridian 28;30° west of Toledo are marked with '(B)'. A question mark will occasionally be added to highlight cases where the reference point is unknown or ambiguous. In such cases, I have generally chosen the option that implied the smaller deviation from geographic reality. If no letter appears after the longitude, this means that the value is explicitly transmitted as a distance from Toledo, expressed in either degrees or hours.

Where multiple different estimates are attested for the same city, these are given in an order of increasing longitude towards the east. This approach is hindered to some extent by the parallel use in the sources of (at least) two different zero meridians separated by 17;30°. To circumvent this problem and facilitate comparisons between estimates, I have introduced a uniform standard of showing each city's distance from Toledo.⁷⁸ This use of Toledo as a reference point seems justified in light of the very prominent role played by the Toledan Tables in the computational astronomy of this period, which entails that attempts to establish geographic longitudes via eclipses would have typically involved comparing an observed eclipse time with one calculated for Toledo. Column (iii) accordingly shows for each recorded estimate the corresponding interval in degrees from Toledo (λT). It was derived from the data in column (ii) by converting the relevant time interval into degrees or by reducing degrees by either 11° or 28;30°, depending on whether the original value is marked '(A)' or '(B)'. Where an estimate places a city to the west of Toledo, the value in column (iii) is negative. Some entries in this column are also accompanied by a '[!]', which is meant to signify that the value in question probably arose from scribal corruption or as the result of some misunderstanding. An example of the latter would be the confusion between reference meridians in the work of Abraham Ibn Ezra, which explains why several of the entries

⁷⁸ This approach of reducing longitudes to the distance from Toledo was already adopted (for a much smaller data sample) by Wright (1923: 92–93).

Table 1 Synopsis of longitude estimates for European cities in Latin sources from AD 1100 to 1300

	i	ii	iii	iv	v
#	Place	Λ	λT	δ	Sources
1	Amiens	40;30°(B)	12°	+ 5;41°	Richard de Fournival, <i>Nativitas</i> (before 22 Oct 1239); ^a Richard de Fournival, <i>Biblionomia</i> (c. 1250) ^b
2	—	40;36°(B)	12;6°[!]	+ 5;47°	<i>Po</i> , fol. 65v (s. XIII)
3	Angers	24°(B)	— 4;30°[!]	— 7;58°	<i>Tractatus magistri Habrahe de tabulis planetarum</i> (c. 1150) ^c
4	—	0;50 h	12;30°	+ 9;2°	<i>Ck</i> , fol. 145v (s. XIII)
5	Arezzo	32;20°(A)	21;20°	+ 5;26°	Restoro d'Arezzo, <i>La composizione del mondo</i> (c. 1282) ^d
6	Bordeaux	24°(B)	— 4;30°[!]	— 7;57°	Abraham Ibn Ezra, <i>Liber de rationibus tabularum</i> (1154) ^e
7	—	0;18 h	— [!]	—	<i>Bq</i> , fol. 6r (s. XIII/XIV)
8	Bourges	17°(A)	6°	— 0;25°	TCT: <i>Ca</i> , fol. 38v (s. XIII ^{im})
9	Cremona	31°(B)	2;30°[!]	— 11;33°	Appendix to <i>Liber erarum</i> (1191) ^f
10	—	20°(A)	9°[!]	— 5;3°	TCT: <i>Fj</i> (s. XIII ^{2/2})
11	—	31°(A)	20°	+ 5;57°	John of Sicily, <i>Scriptum super canones Azarchelis</i> (1291/93); ^g TCT: <i>Eq</i> ; <i>Fl</i> , fols. 51r, 83r; <i>Me</i> , fols. 16v, 110r; <i>Lh</i> ; <i>Ny</i> ; <i>Ol</i> ; <i>Or</i> ; <i>Pa</i> ; <i>Pc</i> ; <i>Pe</i> ; <i>Ph</i> (s. XIII ^{2/2})
12	—	48;30°(B)	—	—	<i>Od</i> , fol. 44r (s. XIII); TCT: <i>Ca</i> ; <i>Pb</i> (s. XIII ^{2/2})
13	—	1;20 h	—	—	Canons 'Cb' to Toledan Tables (s. XII ^{2/2}); ^h corrections to Toledan radices ⁱ
14	—	31;30°(A)	20;30°	+ 6;27°	Gerard of Feltre, <i>Summa de astris</i> (1264); ^j TCT: <i>Pl</i> (s. XIII ^{ex})
15	—	31;45°(A)	20;45°	+ 6;42°	TCT: <i>Ba</i> (s. XIII ^{ex})
16	Feltre	33;40°(A)	22;40°	+ 6;44°	Gerard of Feltre, <i>Summa de astris</i> (1264) ^k
17	Ferrara	48°(B)	19;30°	+ 3;52°	Tables of Ferrara (s. XIII ^{med}) ^l
18	—	[1;20 h]	20°	+ 4;22°	Tables of Ferrara (radices) ^m
19	Florence	33;25°(A)	22;25°	+ 7;9°	TCT: <i>Pl</i> (s. XIII ^{ex})

Table 1 (continued)

	i	ii	iii	iv	v
20	–	34°(A)	23°	+ 7;44°	<i>Fl</i> , fols. 51r, 83r (s. XIII ^{ex}); TCT: <i>Fl</i> , fol. 83r (s. XIII ^{ex})
21	–	23°	–	–	<i>Fl</i> , fols. 51r, 83r (s. XIII ^{ex})
22	–	1;32 h	–	–	<i>Fl</i> , fol. 12r (s. XIII ^{ex})
23	Genoa	29°(A)	18°	+ 5;2°	TCT: <i>Eq</i> (s. XIII ^{ex})
24	Hereford	24°(B)	– 4;30°	– 5;48°	Roger of Hereford: Tables of Hereford (1178); ⁿ ascension tables for Hereford ^o ; TCT: <i>Ma</i> (s. XIII)
25	–	30°(B)	1;30°	+ 0;12°	TCT: <i>Ca</i> , fol. 184r (s. XIII ^{2/2})
26	–	38°(B)	9;30°	+ 8;12°	<i>Pd</i> , fol. 10r (s. XIII ^{2/2})
27	–	13;38°	13;38°	+ 12;20°	<i>Bf</i> , fol. 140v (s. XIII ^{ex})
28	Le Mans	0;5 h	1;15°	– 2;59°	<i>Pk</i> , fols. 5r, 100v (s. XII ^{2/2})
29	Lodi	[c. 1;18 h]	c. 19;30°	c. + 5;59°	Correction to Toledan radices ^p
30	London	0;42°	– 10;30°[!]	– 14;24°	Tables of London, correction to radices ^q
31	–	19° (B)	– 9;30°[!]	– 13;24°	Tables of London (c. 1150) ^f
32	–	11°(A)	0°	– 3;54°	Gerard of Feltre, <i>Summa de astris</i> (1264) ^g
33	–	29°(B)	0;30°	– 3;24°	<i>Pk</i> , fol. 5r (s. XII ^{2/2})
34	–	3;4°	3;4°	– 0;50°	<i>Bf</i> , fol. 140v (s. XIII ^{ex})
35	–	3;15°	3;15°	– 0;39°	<i>Bf</i> , fol. 140v (s. XIII ^{ex})
36	–	32;30°(B)	4°	+ 0;6°	Robert of Northampton (?), <i>Diversi astrologi</i> (s. XII/XIII) ^l ; Robert of Cotum, <i>Canones</i> (s. XIII) ^u ; TCT: <i>Ca</i> , fol. 184r (s. XIII ^{2/2})
37	–	[0;26 h]	6;30°	+ 2;36°	Tables of al-Khwārizmī, rev. Robert of Chester (s. XII ^{med}) ^v
38	–	19°(A)	8°	+ 4;6°	TCT: <i>Ed</i> ; <i>Me</i> , fol. 16v; <i>Ny</i> ; <i>Or</i> (s. XIII ^{med})
39	–	19;26°(A)	8;26°	+ 4;32°	<i>Os</i> , fol. 43r (s. XIII)
40	Magdeburg	0;47 h	11;45°	– 3;54°	Friar John of Gu..., <i>Computus philosophicus</i> (1273) ^w
41	Marseilles	42° (B)	13;30°	+ 4;6°	TCT: <i>Ca</i> , fol. 184r (s. XIII ^{2/2})

Table 1 (continued)

	i	ii	iii	iv	v
42	–	27°(A)	16°	+ 6;36°	TCT: <i>Ed; Eq</i> (s. XIII ^{med})
43	–	45° (B)	16;30°	+ 7;6°	Raymond of Marseilles, <i>Liber cursuum planetarum</i> (c.1141); ^x Roger of Hereford (1178) ^y ; <i>Pd</i> , fol. 10r (s. XIII ^{2/2}); TCT: <i>Pb; Pl</i> (s. XIII ^{2/2})
44	–	1;6 h	–	–	Raymond of Marseilles, <i>Liber cursuum planetarum</i> (c.1141); ^z William the Englishman: Tables of Marseilles (s. XIII ^{1/2}) ^{aa}
45	–	27;30° (A)	–	–	TCT: <i>Bf; Me</i> , fol. 110r; <i>Ny</i> (s. XIII ^{ex})
46	–	27;45°(A)	16;45°	+ 7;21°	TCT: <i>Me</i> , fol. 16v (s. XIII ^{ex})
47	–	1;7 h	–	–	<i>Ny</i> , fol. 86r (s. XIII ^{ex})
48	–	37°(A)	26°[!]	+ 16;36°	TCT: <i>Ol; Pc</i> (s. XIII ^{1/2})
49	–	37;30°(A)	26;30°[!]	+ 17;6°	TCT: <i>Ot</i> (s. XIII ^{med})
50	Milan	[1;18 h]	19;30°	+ 6;17°	Correction to Toledan radices (s. XIII ^{2/2}) ^{ab}
51	Montpellier	26°(A)	15°	+ 7;6°	Robert the Englishman, <i>Commentary on John of Sacrobosco's Tractatus de spera</i> (1271) ^{ac}
52	Naples	36;38°(A)	25;38°	+ 7;21°	TCT: <i>Eq; Me</i> , fol. 16v; <i>Ol; Pc</i> (s. XIII ^{2/2})
53	–	41°(A)	30°	+ 11;43°	TCT: <i>Ny</i> (s. XIII ^{ex})
54	Novara	30;15°(A)	19;15°	+ 6;37°	Campanus of Novara, <i>Tables of Novara</i> (before 1261); ^{ad} TCT: <i>Ba; Bf; Me</i> , fol. 110r; <i>Pe; Pg; Pn; Vi</i> (s. XIII ^{4/4})
55	–	[1;17 h]	–	–	Tables of Novara (radices); ^{ae} <i>Ny</i> , fol. 86r (s. XIII ^{ex})
56	–	30;35°(A)	19;35°[!]	+ 6;57°	TCT: <i>Pr</i> (s. XIII ^{ex})
57	–	30;55°(A)	19;55°[!]	+ 7;17°	Peter of Maricourt, <i>Nova compositio astrolabii partiularis</i> (1263/64); ^{af} TCT: <i>Pl</i> (s. XIII ^{ex})
58	Oxford	31;30°(B)	3°	+ 0;14°	TCT: <i>Ca</i> , fol. 184r (s. XIII ^{2/2})
59	–	32;15°(B)	3;45°	+ 0;59°	Oxford calendar of 1292 ^{ag}
60	–	0;15,43 h	3;55,45°	+ 1;10°	<i>Oa</i> , fol. 215r (s. XIII)
61	–	0;16°	4°	+ 1;14°	<i>Os</i> , fol. 38r (s. XIII)

Table 1 (continued)

	i	ii	iii	iv	v
62	Paris	23;30°(B)	– 5°[!]	– 11;22°	Giles of Lessines, <i>Summa de temporibus</i> (c.1264) ^{ah}
63	–	[0;12 h]	4°	– 2;22°	John of Saxony, <i>Computus novus</i> (1297) ^{ai}
64	–	8;6°	8;6°	+ 1,44°	<i>Bf</i> , fol. 140v (s. XIII ^{ex})
65	–	8;30°	8;30°	+ 2;8°	Radices added to Toledan Tables; ^{aj} <i>Bf</i> , fol. 140v (s. XIII ^{ex}); <i>Pm</i> , fol. 115r (s. XIII ^{med})
66	–	37°(B)	–	–	TCT: <i>Pb</i> (s. XIII ^{2/2})
67	–	20°(A)	9°	+ 2;38°	Gerard of Feltre, <i>Summa de astris</i> (1264); ^{ak} TCT: <i>Ed</i> ; <i>Me</i> , fol. 16v (s. XIII ^{med})
68	–	10°	10°	+ 3;38°	<i>Vp</i> , fol. 140r (s. XIII ^{2/2})
69	–	0;44 h	11°	+ 4;38°	<i>Vp</i> , fol. 139v (s. XIII ^{2/2})
70	–	22;30°(A)	11;30°	+ 5;8°	John of Sicily, <i>Scriptum super canones Azarchelis</i> (1291/93) ^{al}
71	–	40°(B)	–	–	Commentary <i>Sicut dicit Hermes...</i> on Toledan canons ‘Cb’ (c.1290); ^{am} TCT: <i>Pl</i> (s. XIII ^{ex})
72	–	0;46 h	–	–	<i>Vp</i> , fol. 139v (s. XIII ^{2/2})
73	–	40;30°(B)	12°	+ 5;38°	TCT: <i>Ba</i> ; <i>Bf</i> ; <i>Pg</i> ; <i>Pn</i> ; <i>Pr</i> (s. XIII ^{ex})
74	–	40;47°(B)	12;17°	+ 5;55	<i>Speculum astronomiae</i> (1260/70?); ^{an} TCT: <i>Vp</i> (s. XIII ^{2/2})
75	–	0;49,8 h	–	–	<i>Vp</i> , fol. 139v (s. XIII ^{2/2})
76	–	12;18°	12;18°[!]	+ 5;56°	Peter of Limoges in <i>Pm</i> , fol. 115r (s. XIII ^{ex})
77	–	41;30°(B)	13°	+ 6;38°	<i>Vp</i> , fol. 140r (s. XIII ^{2/2})
78	–	[0;52 h]	–	–	Campanus of Novara, canon <i>Composui hanc tabulam...</i> on syzygy tables (s. XIII ^{2/2}); ^{ao} Tables of Paris (c.1271) ^{ap}
79	–	44;30°(B)	16°	+ 9;38°	TCT: <i>Eq</i> (s. XIII ^{ex})
80	–	1;15 h	18;45°	+ 12;23°	<i>Od</i> , fol. 44r (s. XIII)
81	–	48;30°(B)	20°[!]	+ 13;38°	<i>Os</i> , fol 2v (s. XIII)
82	–	33°(A)	22°	+ 15;38°	<i>Quelibet ars suum habet artificem...</i> (s. XIII ^{1/2}); ^{aq} <i>Quomodo opus tabularum istarum...</i> (c.1250) ^{ar} TCT: <i>Ca</i> , fol. 184r (s. XIII ^{2/2})

Table 1 (continued)

	i	ii	iii	iv	v
83	Piacenza	20°	20°	+ 6;17°	Canon on Tables of Pisa (s. XII/XIII) ^{as}
84	–	31;20°(A)	20;20°	+ 6;37°	Gerard of Feltre, <i>Summa de astris</i> (1264) ^{at}
85	Reggio	2 h	30°	+ 10;19°	<i>Bq</i> , fol. 6r (s. XIII/XIV); <i>Od</i> , fol. 44r (s. XIII)
86	Rome	1;36 h	24°	+ 7;28°	<i>Ny</i> , fols. 53v, 86r (s. XIII ^{ex}); corrections to Toledan radices ^{au}
87	Roskilde	30°(A)	19°	+ 2;54°	<i>Liber daticus Roskildensis</i> (c. 1274); ^{av} Peter Nightingale, <i>Tractatus</i> <i>instrumenti eclipsium</i> (1292/1300) ^{aw}
88	Sarum	31°(B)	2;30°	+ 0;17°	TCT: <i>Ca</i> , fol. 184r (s. XIII ^{2/2})
89	Stafford	30;40°(B)	2;10°	+ 0;16°	TCT: <i>Ca</i> , fol. 184r (s. XIII ^{2/2})
90	Toulouse	33°(B)	4;30°	+ 0;58°	<i>Ca</i> , fol. 38v (s. XIII ⁱⁿ)
91	–	40°(B)	11;30°	+ 6;2°	Tables of Toulouse (s. XIII ^{1/2}); ^{ax} TCT: <i>Ca</i> , fol. 184r (s. XIII ^{2/2})
92	–	11;45°	11;45°	+ 6;17°	<i>Bf</i> , fol. 140v (s. XIII ^{ex})
93	–	22;48°(A)	11;48°[!]	+ 6;20°	TCT: <i>Ny</i> (s. XIII ^{ex})
94	–	0;48 h	12°	+ 6;32°	Tables of Toulouse (radices); ^{ay} <i>Ny</i> , fol. 86r (s. XIII ^{ex})
95	–	40;47°(B)	12;17°	+ 6;49°	<i>Speculum astronomiae</i> (1260/70?); ^{az} TCT: <i>Ba</i> ; <i>Bf</i> ; <i>Me</i> , fol. 110r; <i>Pg</i> ; <i>Pl</i> ; <i>Pn</i> ; <i>Pr</i> ; <i>Vp</i> (s. XIII ^{2/2})
96	Mechelen	42;15°(B)	13;45°	+ 5;15°	Henry Bate, <i>Tables of</i> <i>Mechelen</i> (before 1280) ^{aaa}
97	Winchester	19°(B)	– 9;30°[!]	– 12;12°	Tables of Winchester (s. XII ^{2/2}) ^{aab}
98	–	– 9;30°	– [!]	–	<i>Od</i> , fol. 44r (s. XIII)
99	–	19;30°(B)	– 9°[!]	– 11;42°	<i>Oc</i> , fol. 145r (s. XIII); <i>Od</i> , fol. 44r (s. XIII); <i>Os</i> , fol. 2v (s. XIII); <i>Po</i> , fol. 65v (s. XIII); commentary <i>Scientie tabularum...</i> on Toledan Tables canons 'Ca' (s. XIII) ^{aac}
100	–	19;36°(B)	– 8;54°[!]	– 11;36°	<i>Oc</i> , fol. 145r (s. XIII)
101	–	24°(B)	– 4;30°[!]	– 7;12°	<i>Tractatus magistri Habrahe</i> <i>de tabulis planetarum</i> (c.1150) ^{aad}

Table 1 (continued)

	i	ii	iii	iv	v
102	–	31;30°(B)	+ 3°	+ 0;18°	TCT: <i>Ca</i> , fol. 184r (s. XIII ^{2/2})

^aMS Vatican City, Biblioteca Apostolica Vaticana, Reg. lat. 1261, fol. 60r

^bEd. Delisle (1874: 520)

^cMS London, British Library, Arundel 377, fol. 56va

^dSee above, n. 73

^eSee above, nn. 66–67

^fEd. Nothaft (2014: 124)

^gEd. Pedersen (1986: 141–142) (J298)

^hEd. Pedersen (2002: ii. 434) (Cb140)

ⁱSee above, n. 19.

^jSee above, n. 18

^kSee above, n. 18

^lSee above, n. 29

^mSee above, n. 29

ⁿMSS London, British Library, Arundel 377, fol. 86vb; Madrid, Biblioteca nacional de España, 10016, fols. 71r (s. XIII)

^oMS Madrid, Biblioteca nacional de España, 10016, fol. 85r (s. XIII)

^pSee above, n. 20

^qSee above, n. 41

^rSee above, n. 40

^sSee above, n. 18

^tMS Oxford, Bodleian Library, Savile 21, fol. 43r

^uMS Oxford, Bodleian Library, Laud. Misc. 644, fol. 217ra–b

^vSee above, n. 23

^wMS Lüneburg, Ratsbücherei, Miscell. D 4° 46, fol. 10v (II.1). See Nothaft (2014: 608)

^xSee above, n. 25

^ySee above, n. 68

^zSee above, n. 25

^{aa}See above, n. 26

^{ab}See above, n. 21

^{ac}Ed. Thorndike (1949: 196–197) (lectio XV)

^{ad}MS Paris, Bibliothèque nationale de France, lat. 7411(B), fol. 1r. See above, n. 30

^{ae}See above, n. 30

^{af}Ed. Thomson in Sturlese and Thomson (1995: 129) (c. 7)

^{ag}MS Oxford, Bodleian Library, Digby 149, fol. 124r–v

^{ah}Ed. Steele (1926: 159, l. 36–p. 160, l. 2 (III.3.4))

^{ai}Nothaft (2014: 608)

^{aj}See above, n. 34

^{ak}See above, n. 18

^{al}Ed. Pedersen (1986: 143) (J300j)

^{am}Ed. Pedersen (2001–2002, pt. 1: 259–260 (Ap257); pt. 2: 137 (Ap484))

^{an}Ed. Caroti, Pereira, Zamponi, and Zambelli in Zambelli (1992: 218, ll. 64–66 (c. 2))

^{ao}See above, n. 31

^{ap}See above, n. 32

^{aq}See above, n. 72

^{ar}See above, n. 71

^{as}MS Vatican City, Biblioteca Apostolica Vaticana, Vat. lat. 3119, fol. 1r

^{at}See above, n. 18

^{au}See above, n. 22

^{av}Pedersen (1983–1984: i. 54–55)

^{aw}MS Florence, Biblioteca Nazionale Centrale, II.III.24, fol. 212ra (s. XIVⁱⁿ), ed. in Pedersen (1978: 35, ll. 1–3 (c. 2.24)). See Pedersen (1983–1984: i. 39, 54, 461–462)

^{ax}See above, n. 28

^{ay}See above, n. 28

^{az}Ed. Caroti, Pereira, Zamponi, and Zambelli in Zambelli (1992: 218, ll. 64–66 (c. 2))

^{aaa}See above, n. 43

^{aab}See above, n. 39

^{aac}MS Madrid, Biblioteca nacional de España, 10112, fol. 93r

^{aad}MS London, British Library, Arundel 377, fol. 56va

for Angers (#3), Bordeaux (#6–7), London (#31), and Winchester (#97, 101) are marked this way.⁷⁹

Column (iv) shows the deviation (δ) from the correct longitude interval according to modern geographical data.⁸⁰ These values, which are all rounded to minutes of arc, must in many cases be taken as rough approximations, owing to the fact that the modern standard coordinates for European cities do not necessarily provide an exact match with the locations of medieval settlements or the places where past astronomers carried out their observations. Finally, column (v) lists twelfth- and thirteenth-century sources attesting to the relevant longitude or time interval. They are placed in an approximate chronological order, with dates shown in brackets. Manuscript notes and glosses are cited according to the two-letter sigla listed above. If a particular longitude appears in one or more copies of the standard list of coordinates in the Toledan Tables, this is indicated by ‘TCT’, followed by the relevant manuscript sigla, followed by a bracket showing the approximate date or time window of its earliest appearance.

5 Analysis

If one counts entries that imply the same λT (as shown in column (iii)) as one unique estimate, the 102 entries recorded in Table 1 reduce to 89 longitude estimates for 30 different cities. A relative plurality of these cities, namely 12, are located in Italy. Of the remaining 18 cities, 9 are found in France, 6 in England, while the Low Countries (Mechelen), Germany (Magdeburg), and Scandinavia (Roskilde) are only represented by one city each. This distribution broadly reflects the fact that the principal centers of astronomical activity in Latin Europe during the twelfth and thirteenth century were in (Northern) Italy, France, and England, while Central and Northern Europe became more prominent only in the late Middle Ages.⁸¹ It also seems noteworthy that 16 of the 30 cities listed have two or more unique estimates associated with them: Amiens (2), Angers (2), Bordeaux (2), Cremona (5), Ferrara (2), Florence (2), Hereford (4), London (10), Marseilles (6), Naples (2), Novara (3), Oxford (4), Paris (16), Piacenza (2), Toulouse (6), and Winchester (5). The exceptionally high number of estimates recorded for Paris (16) can be taken as a clear reflection of that city’s status as the foremost center for astronomical as well as astrological study and practice in thirteenth-century Europe, which created a situation where multiple generations of scholars tried their hand at a longitude determination.⁸²

Some caution seems necessary, however, since not every unique longitude distance on record is necessarily the result of an independent investigation. For example, the attested placements of Novara at 30;35° (#56) and 30;55° (#57) can presumably be explained as corruptions of the very widely attested value of 30;15° (#54, #55), which applies to meridian (A). Misunderstandings could also arise in the interpretation of

⁷⁹ See above, nn. 37–39.

⁸⁰ For modern geographical as well as astronomical data, I have used the open source software *Stellarium* 23.1 (<https://stellarium.org>).

⁸¹ Durand (1952: 103) was right to observe that the “gradual extension” of coordinate lists during the Middle Ages reflects the “establishment of new astronomical centers in Europe”.

⁸² On the importance of Paris in this period, see Juste (2018: 68–80) and Nothaft (2021b: 10–11).

reference meridians, as when a brief text concerning the Sun's entry into (sidereal) Aries in the year 1191 places Cremona 59° west of Arim, which implies a longitude of 31° from meridian (B) (#9). The origin of this 'estimate' is presumably the information that Cremona lies $1;20\text{ h} = 20^\circ$ east of Toledo, as attested in the most common set of canons to the Toledan Tables (#13). Assuming Toledo's location relative to meridian (A), this would put Cremona at 31° , as is reflected in many copies of the TCT (#11). Yet, the author of the note for 1191 interpreted this longitude of 31° in light of meridian (B) and thus ended up placing Cremona $90^\circ - 31^\circ = 59^\circ$ from Arim. Column (iii) of Table 1 flags a total of 21 entries as having probably arisen through such processes of corruption or confusion (#2–3, 6–7, 9–10, 30–31, 48–49, 56–57, 62, 76, 81, 93, 97–101), but it should be borne in mind that the actual number of cases may be significantly higher.

Another difficult question concerns the precise chronological order in which these estimates were first established. The earliest *terminus ad quem* we can assign to any of them is 1141, the year in which Raymond of Marseilles began writing the *Liber cursuum planetarum* accompanying his Tables of Marseilles (#43, #44).⁸³ Further longitudes or time differences were introduced in the middle years of the twelfth century by Robert of Chester for London (#37) and by Abraham Ibn Ezra. The latter determined the longitudes of Bordeaux (#6) and Angers (#3) using an observed solar eclipse (see Part 3). In addition, some of the preserved twelfth-century estimates for London (#31) and Winchester (#97, 101) are connected with his Tables of Pisa. An eclipse-based determination of the longitude of Hereford (#24) was carried out by Roger of Hereford in 1178 (see Part 3), while the placement of Cremona at $+20^\circ$ from Toledo (#11–13) must have been circulating well before 1191. Two other estimates that apparently still originated in the twelfth century are those for Le Mans (#28) and London (#33), which are both mentioned in *Pk* = MS Paris, Bibliothèque nationale de France, lat. 16208, fol. 5r, in the context of glosses that give the present year as AD 1165.

Most of the remaining estimates in Table 1 presumably belong to the thirteenth century, although it is rare that their actual year of origin can be pinpointed with any precision, or that their originator can be identified by name. The longitude of Amiens (#1) is first reported in a horoscope cast by Richard de Fournival for his own birth on 10 October 1201. In his interpretation of the birth chart, Richard makes reference to a future event on 22 October 1239, which provides a *terminus ad quem* for the determination of longitude.⁸⁴ A similar case is the astrological autobiography composed in 1280–81 by Henry Bate, who for this purpose cast the horoscope for his birth in Mechelen on 24 March 1246. Bate made the requisite calculations with a set of mean-motion tables for the meridian of this town, the longitude of which (#96) must have been known to him by 1280.⁸⁵ The only Central European coordinate preserved from this period is that of Magdeburg (#40). It receives a mention in a

⁸³ For the year, see Raymond of Marseilles, *Liber cursuum planetarum* I.10 (ed. Alverny, Burnett, and Poulle 2009: 140).

⁸⁴ See on the background Birkenmajer (1949) and Boudet and Lucken (2018).

⁸⁵ See on the background Steel et al. (2018) and Nothaft (2018a).

Compotus philosophicus composed in 1273 or not much later by a Franciscan friar named John.⁸⁶

If one takes into account the rather crude or error-prone methods that medieval astronomers had at their disposal for measuring geographic longitudes (see Part 3), it can come as no big surprise that the errors in their estimates, as displayed in column (iv) of Table 1, ranged widely and could even exceed $\pm 10^\circ$ (#9, 27, 30–31, 48–49, 53, 62, 80, 82, 85, 97, 99–100). It may, in fact, be considered remarkable that such instances are not more frequent and that a majority of them (#9, 30–31, 48–49, 62, 81, 97, 99–100) concerns values that were affected by evident corruption or confusion. More impressive still is the fact that 11 estimates in Table 1 (#8, 25, 34–36, 58–59, 88–90, 102) exhibit an error of $< 1^\circ$. If we eliminate from further consideration any entries flagged with ‘[!]’ in column (iii), these 11 estimates account for 16% of the remaining total of 68. For errors less than $3;45^\circ$, which is the equivalent of one quarter-hour, the percentage nearly doubles to 31% or 21 out of 68 estimates.

The degree to which the ‘success’ of any of these estimates was due to skilled effort or sheer luck can no longer be assessed with any confidence. What seems worth highlighting, however, is that estimates with a fair degree of accuracy are especially common for cities in England. Among the 19 estimates for the longitudes of Hereford (#24–27), London (#32–39), Oxford (#58–61), Sarum (#88), Stafford (#89), and Winchester (#102), one encounters no fewer than 6 (32%) where the implied distance from Toledo is accurate within $0;25^\circ$ (the equivalent of 0;1 h). Moreover, 9 or nearly half of them (47%) are accurate within $\pm 1^\circ$ and 13 (68%) are still within $\pm 3;45^\circ$. The estimate with the smallest error occurs in a treatise beginning *Diversi astrologi secundum diversos annos...*, which is attributed to Roger of Hereford in most of the extant manuscripts, but to a certain Robert of Northampton in the earliest copy, MS Oxford, Bodleian Library, Savile 21, fols. 40v, 42r–61v.⁸⁷ The relevant part of the latter codex is datable approximately to the first half of the thirteenth century, although the text may potentially be earlier. London is here placed $32;30^\circ$ with respect to meridian (B) (#36) and thus 4° from Toledo.⁸⁸ This is in error by approximately $+ 0;6^\circ$, if we assume modern data for the city centers of Toledo ($4;1,21^\circ$ W) and London ($0;7,33^\circ$ W), or by as little as $+ 0;3^\circ$, if we use a more historically adequate point of reference such as the Tower of London ($0;4,34^\circ$ W).

Remarkably good longitude estimates are also transmitted for Oxford. The four entries for this city (#58–61) show errors ranging from only $0;14^\circ$ to a still very moderate $1;14^\circ$. One of these comes from a gloss in MS Oxford, Bodleian Library, Auct. F.3.13, fol. 215r (s. XIII^{2/2}), which gives the distance between Oxford and Toledo as $0;15,43$ h (#60), with an implied longitude difference (λT) of $3;55,45^\circ$ and an approximate error (δ) of $+ 1;10^\circ$. This inclusion of seconds in an estimated time

⁸⁶ See on the background Nothaft (2014: 573–611, 2018b: 155–159).

⁸⁷ See Nothaft (2021b: 59–60).

⁸⁸ MS Oxford, Bodleian Library, Savile 21, fol. 43r: “Cum igitur sciveris medium cursum Solis ad meridiem Toleti in aliquo die, cuius civitatis longitudo est a Gadibus Herculis in occidente positus 28 graduum et dimidii, ille idem est medius cursus solis apud Londonias, non in meridie illius diei, sed 16 minutis unius horae post meridiem. Quoniam longitudo Londoniarum est 32 graduum et dimidii a Gadibus Herculis et ideo citius est ibi merides quam apud Toletum tanto tempore quanto oriuntur 4 gradus equinoctialis circuli, et est 16 minuta hore.”

difference between two locations is extremely rare in a twelfth- or thirteenth-century context. It could potentially be explained as the artifact of a very precise calculation of an eclipse time for Toledo, which may have been subtracted from an observed time at Oxford to yield the difference.

It should be noted as well that many of the best estimates for English longitudes stem from a single source, which is a copy of the TCT in MS Cambridge, University Library, Hh.6.8, fol. 184r, apparently made in the second half of the thirteenth century. It repeats the aforementioned estimate for London at $32;30^{\circ}$ (#36) and includes further longitude values for Hereford (#25), Oxford (#58), Sarum (#88), Stafford (#89), and Winchester (#102). The errors in these values are astoundingly low, raging between $+0;12^{\circ}$ and $+0;18^{\circ}$.

When it comes to those estimates that are found to deviate more strongly, it is very conspicuous that twelfth- and thirteenth-century sources had a tendency towards overestimating the extent to which a given city lies to the east of Toledo. For the 68 estimates in Table 1 that are not marked as corrupt, column (iv) shows a positive error in 59 cases and a negative error only in the remaining 9. The fact that the errors in medieval longitude estimates are not normally distributed was already noticed by Wright in his 1923 article. Working from a much smaller data sample than is being considered here, he arrived at the overall conclusion that European longitudes attested from the twelfth to fourteenth centuries tend to be misplaced by $5;30^{\circ}$ to 8° towards the east with respect to Toledo. Wright accordingly suspected “a single initial error in the estimation of the number of degrees between the meridian of Toledo and that of some intermediate station (perhaps Marseilles) from which the positions of the remaining stations were then calculated with only slight errors”.⁸⁹

An analysis of the data in column (iv) adds further weight to Wright’s findings. It shows that 28 (47%) of the 59 positive errors just mentioned are clustered within a relatively narrow range of 5° – $7;30^{\circ}$, with an average value of $6;22^{\circ}$. It is conspicuous, moreover, that almost all estimates in this range belong to cities in either Italy or France. Italian cities account for 14 of 28 cases (Arezzo, Cremona (3), Feltre, Florence, Genoa, Lodi, Milan, Naples, Novara, Piacenza (2), and Rome), French ones for 13 of the remaining 14 (Amiens, Marseilles (3), Montpellier, Paris (4), and Toulouse (4)). The fact that the recorded estimates for these cities tend to exhibit a similar positive error naturally implies that medieval sources managed to place them fairly accurately in relation to each other, though not with respect to Toledo. This can hardly be a coincidence, but points, as Wright correctly saw, to some shared reference point or source of error.

One question that arises in this context is whether the systematic overestimation just noted may reveal the footprint of Ptolemy, whose *Geography* famously exaggerated the longitudinal extent of the Mediterranean Sea and accordingly assigned excessive longitude values to most locations in this area.⁹⁰ That a selection of Ptolemy’s European longitudes was available in Italy in the second half of the thirteenth century is evident from MS Florence, Biblioteca Medicea Laurenziana, Ashburnham 211, fol. 251r,

⁸⁹ Wright (1923: 94). Similar findings were made by Mercier (1985: 26–27) and Kremer and Dobrzycki (1998: 191).

⁹⁰ Shcheglov (2016).

which preserves a tabular list of geographic coordinates that were ultimately drawn from the *Κανὼν πόλεων ἐπισήμων* (“Table of important cities”) in Ptolemy’s *Handy Tables* (see Part 2 above). Although this source shares only a single city, Naples, in common with Table 1, it seems possible that the pool of Ptolemaic coordinates available in the twelfth and thirteenth centuries was more extensive than presently known.⁹¹ A case in point is Gerard of Feltre’s placement of Piacenza at a longitude of $31;20^\circ$ from meridian A (#84), which is not attested in the Florentine list, but which happens to be the exact longitude given in Ptolemy’s *Geography*. At the same time, Gerard’s latitude for this location ($44;50^\circ$) exceeds Ptolemy’s ($43;30^\circ$) by a substantial $1;20^\circ$, which casts doubt on the hypothesis of direct dependence.⁹²

The juxtaposition of data in Table 2 is meant to clarify the question of Ptolemy’s influence on the medieval longitude values documented above. It repeats entries from Table 1 for cities whose longitude is also mentioned in the *Geography* and/or the *Handy Tables*. The number of the original entry in Table 1 is cross-referenced in the unnumbered first column. Column (i) mentions the name of the city, while column (ii) is based on column (iii) in Table 1. It adds 11° to the original column’s values for the distance from Toledo, which equates to showing the longitude relative to meridian (A). As a general rule, I have only included entries where this resulting longitude is within $\pm 5^\circ$ of Ptolemy’s value. Entries in Table 1 that were flagged with ‘[!]’ have also been excluded. Ptolemy’s original longitude according to the *Geography* is shown in column (iii).⁹³

As can be seen from this comparison, almost none of the longitudes implicit in Table 1 are exactly identical with Ptolemy’s longitudes, the only exceptions being Gerard of Feltre’s value for Piacenza (#84) and one of the entries for Marseilles (#41), which is attested only in a single copy of the TCT. Neither does there seem to be any revealing pattern in the discrepancies between the Ptolemaic and medieval data, which range between $0;10^\circ$ (Milan) and several degrees. One should also underline that not all cities whose medieval longitudes fall within the aforementioned error range of 5° – $7;30^\circ$ have known Ptolemaic coordinates. For example, the longitude of Feltre (#16), which was recorded by Gerard of Feltre, appears neither in the *Geography* nor in the *Handy Tables*. Taken together, these findings leave open the possibility that the approximate convergence between Ptolemy and many of the medieval longitudes is to a large extent coincidental.

The alternative seems to be that most estimates in Table 2 are close to Ptolemy’s because they were derived from a common reference point, from which they inherited a shared error in their placement relative to Toledo. For the Italian cities, the most plausible such reference point is the information, known since the second half of the twelfth century, that Cremona lies $1;20 \text{ h} = 20^\circ$ east of Toledo, which is in error by approximately $+ 5;57^\circ$. It may be more than a coincidence that the same 20° -difference relative to Toledo was assumed to hold true for Piacenza by the author of

⁹¹ See on this point the remarks in Nothaft (2022: 10–12).

⁹² See Ptolemy, *Geography* 3.1.46 (ed. Stükelberger and Graßhoff 2006: 271); Gerard of Feltre, *Summa de astris* 1.8 (MS Milan, Biblioteca Ambrosiana, C 245 inf., fol. 7r).

⁹³ This column was compiled on the basis of the edition in Stükelberger and Graßhoff (2006). The *Κανὼν* in Ptolemy’s *Handy Tables* shows identical values except in the case of Rome, for which it gives a longitude of $36;20^\circ$ instead of $36;40^\circ$. See Stükelberger and Mittenhuber (2009: 152–215), at p. 163.

Table 2 Comparison between selected entries in Table 1 and the corresponding Ptolemaic longitude

#	i	ii	iii
1	Amiens	23°	22;15°
5	Arezzo	32;20°	34;40°
8	Bourges	17°	20;15°
9	Cremona	31°	32°
14	—	31;30°	
15	—	31;45°	
19	Florence	33;25°	33;50°
20	—	34°	
23	Genoa	29°	30°
36	London	15°	20°
37	—	17;30°	
38	—	19°	
39	—	19;26°	
41	Marseilles	24;30°	24;30°
42	—	27°	
43	—	27;30°	
46	—	27;45°	
50	Milan	30;30°	30;40°
52	Naples	36;38°	40°
53	—	41°	
54	Novara	30;15°	30;30°
64	Paris	19;6°	23;30°
65	—	19;30°	
67	—	20°	
68	—	21°	
69	—	22°	
70	—	22;30°	
73	—	23°	
74	—	23;17°	
77	—	24°	
79	—	27°	
83	Piacenza	31°	31;20°
84	—	31;20°	
85	Reggio di Calabria	41°	39;50°
86	Rome	35°	36;40°
90	Toulouse	22;30°	20;10°
91	—	22;45°	
94	—	23°	
95	—	23;17°	

canons for the Tables of Pisa (#83), or that the Tables of Ferrara seem to operate with the same difference (#18). In both cases, the authors may have chosen this value on the assumption that their cities were roughly on the same meridian as Cremona. Other Italian longitudes that share a similar error may have been derived from Cremona's via similar 'guesstimations', perhaps aided by known directions and distances in miles.

Analogous procedures may have given rise to some of the recorded estimates for cities in France, where suitable reference points similar to Cremona could have been provided by the Tables of Marseilles or the Tables of Toulouse. The latter set of tables appears to have served Richard of Fournival in computing his aforementioned horoscope for the longitude of Amiens. Richard estimated this longitude to be $40;30^\circ$ relative to meridian (B) (#1), which would have required him to subtract a mere $0;2$ h from the radices in the Tables of Toulouse, whose reference meridian was at 40° . The actual distance between the two cities is $c.0;51^\circ$, so Richard's estimate is a rather accurate one with respect to their relative location, though less so when it comes to their respective distance from Toledo.

Even in England, where the attested errors with respect to Toledo tend to be significantly smaller than on the continent, the hypothesis of a derivation of different longitude estimates from a shared local reference point remains plausible. One obvious candidate in this respect is the aforementioned highly accurate placement of London at a longitude of $32;30^\circ$ relative to meridian (B) (#36). It is chronologically early enough to be at the root of other English estimates, such as those recorded in one thirteenth-century TCT (MS Cambridge, University Library, Hh.6.8, fol. 184r) for Hereford (30°), Oxford ($31;30^\circ$), Sarum (31°), Stafford ($30;40^\circ$), and Winchester ($31;30^\circ$) (#25, 58, 88–89, 102).

The accuracy of these placements in relation to each other is too consistently high to be plausibly explained as the result of independent applications of the eclipse method. The same holds true for the concentration of surprisingly many continental estimates within the positive error range of 5° – $7;30^\circ$. That the eclipse method could not guarantee such consistency is obvious even from the small handful of clearly attested cases. As already discussed in Part 3, Ibn Ezra's eclipse observation made him underestimate the distance between Bordeaux and Pisa by roughly 2° , whereas Roger of Hereford overestimated the distance between Hereford and Marseilles by 13° . In another instance, the alleged use of eclipses to derive the position of Paris even led to a result that overstated the distance from Toledo by $15;38^\circ$ (#82).

There is, hence, every reason to suspect that the eclipse method was used only occasionally and that a substantial number, probably the majority, of the European longitudes recorded in twelfth- and thirteenth-century sources was derived by other means. It remains, unfortunately, difficult to arrive at a clear understanding of what these other means consisted in. Previous scholars have tried to account for the patterns in medieval longitude estimates by suggesting the use of topographic distance estimates, such as were obtainable from itineraries or maps, which were only subsequently converted into differences of time and/or longitude.⁹⁴ One of the caveats that must be borne in mind when approaching this hypothesis is that medieval sources do not operate with any uniform standard for the length of a terrestrial mile or for the mile

⁹⁴ Zinner (1931: 351), Durand (1952: 105) and Kremer and Dobrzycki (1998: 191).

length of a degree along the meridian. This lack of uniformity and the corresponding uncertainty create considerable problems for any attempt at ‘reverse engineering’ medieval longitude determinations by converting them back into topographic distance estimates.

Another major problem concerns the fact that the mile length of a degree of longitude is not universal, but will decrease as a function of the cosine of the angle of terrestrial latitude. While the basic fact of this decrease, which was a consequence of the sphericity of the Earth, was certainly known and understood in the period under investigation,⁹⁵ the sources from this period are conspicuously silent about the procedures and trigonometric formulae that would be necessary for a successful conversion of topographic distances into degrees of geographic longitude.⁹⁶ An example that can serve to underscore this general point is the thirteenth-century *Liber daticus* of Roskilde cathedral chapter (c. 1274), which was destroyed by fire in 1728. From one of the surviving extracts, it is known that the book gave Roskilde’s geographic position in relation to Rome and Jerusalem, by providing degree values for the differences in latitude and longitude as well as the corresponding topographic distances in miles and stades. Furthermore, the text states the ‘direct’ or shortest distances (*directa distantia*) that supposedly follow from these values. While the recorded figures for the latter seem to defy explanation, the topographic distances for latitude and longitude were evidently derived, with slight errors, by applying a conversion of $1^\circ = 66 \frac{2}{3}$ miles, with no regard for the crucial difference between distances in longitude and distances in latitude.⁹⁷

The erroneous conversion attempt in the *Liber daticus* was probably inspired by the *Practica astrolabii* of pseudo-Māshā’allāh, a text on astrolabe use that circulated extremely widely in the thirteenth to fifteenth centuries.⁹⁸ One of its chapters teaches how to derive the direct distance in miles between two places of known latitude and longitude, using the Pythagorean theorem. The initial conversion is portrayed as a simple matter of reckoning $1;30^\circ$ for every 100 miles, which amounts to the aforementioned conversion of $1^\circ = 66 \frac{2}{3}$ miles.⁹⁹ The text contains no hint that this conversion applies only to degrees of latitude or degrees of longitude on the equator. Nor does it discuss the reverse case of deriving longitudinal coordinates from known topographic distances. The suggestion of proceeding in this way is made briefly in

⁹⁵ The distance decrease is mentioned in al-Farghānī, *Book on the Summaries of the Science of the Stars and the Principles of the Celestial Movements*, c. 8 (trans. John of Seville ed. Carmody 1943: 14); trans. Gerard of Cremona ed. Campani 1910: 90); Bernard of Verdun, *Tractatus super totam astrologiam* 2.5.5 (ed. Hartmann 1961: 59).

⁹⁶ This changes somewhat in the fourteenth century, as seen from Gautier Dalché (2011). On the required trigonometric procedures, see Mercier (1992: 184–188), Berggren and Jones (2000: 16–17) and Stückelberger and Mittenhuber (2009: 237–239).

⁹⁷ See Pedersen (1983–1984: i. 54–55), who reproduces and discusses the relevant extract.

⁹⁸ See Kunitzsch (1981: 48–56, 1982: 501–502).

⁹⁹ pseudo-Māshā’allāh, *Practica astrolabii*, c. 27 (ed. Thomson 2022: iv. 268–275). Other sources from before 1300 that give the length of a degree of latitude as $66 \frac{2}{3}$ miles include: *Ezich Elkaurezmi*, trans. Adelard of Bath, c. 7 (ed. Suter 1914: 9); *Liber ysagogarum Alchorismi*, bk. 5 (ed. Dickey 1982: 320); Ibn al-Šaffār, *On the Uses of the Astrolabe*, trans. John of Seville, c. 27 (ed. Millás Vallicrosa 1942: 276); Ibn al-Šaffār, *On the Uses of the Astrolabe*, trans. Plato of Tivoli, c. 29 (ed. Lorch et al. 1994: 162, ll. 661–666); Ibn Mu‘ādh, *De crepusculis* (ed. Smith [A. Mark] 1992: 100, ll. 102–103).

Abraham Ibn Ezra's *Liber de rationibus tabularum* (1154), which states that the longitude of one place can be inferred from the known longitude of another by assuming 1° for every 20 miles.¹⁰⁰ Once again, the rule is obviously flawed in the sense that it makes no allowance for the decrease in mile distance as a function of latitude. There is also the problem that 20 miles is an unusually diminutive value for the length of a degree that does not seem to be attested elsewhere. Even if Ibn Ezra had intended the equivalence $1^\circ = 20$ miles to be valid only for a specific latitude such as that of Bordeaux, the corresponding value at the equator would remain significantly below even the smallest commonly cited medieval value for the number of miles in a degree of latitude, which is $1^\circ = 56 \frac{2}{3}$ miles.¹⁰¹

All this goes to indicate that the hypothesis according to which topographic distance estimates underlie the various longitudes that have come down to us from the twelfth and thirteenth centuries must be treated with a degree of skepticism. Further evidence would be required to turn this idea from a mere possibility into an attested aspect of the determination of longitude in this period. As it stands, the problem of the origin of medieval longitude data is yet to be fully solved.

6 Conclusion

For this article, an attempt was made to conduct a comprehensive survey of longitudes of cities in Latin Europe that were established between 1100 and 1300. Besides longitude estimates that are explicitly recorded in coordinate lists and manuscript annotations, it is possible to extract further relevant information from the mean-motion radices of astronomical tables, provided these tables were adjusted or recomputed for a known location. Overall, this approach has made it possible to collect 89 individual longitude estimates for 30 cities, most of them located in Italy, France, and England. While the accuracy of these estimates ranges very widely, one significant finding is that 11 of them are accurate to within $\pm 1^\circ$. Most of these successful estimates concern the longitudes of English cities, which suggests that they were derived from a single reference point, such as a highly successful placement of the longitude of London with respect to Toledo. A similar explanation may account for many of the attested longitudes of cities in Italy and France, which tend to exhibit an eastern displacement in the range of 5° – $7;30^\circ$.

Both the high accuracy of the English longitudes and the shared pattern of displacement among many continental longitudes pose questions that are difficult to answer given the evidence at our disposal. The possibility that Ptolemy's *Geography* influenced the medieval longitudes of continental cities on a large scale has been considered, but found to be insufficiently supported by the data. It has also been shown that the method of deriving longitudes from observed/computed eclipse times was well known

¹⁰⁰ Abraham Ibn Ezra, *Liber de rationibus tabularum* (ed. Millás Vallicrosa 1947: 88, ll. 9–13). See Gautier Dalché (2000: 418), for the suggestion that Ibn Ezra used such a distance estimate to 'control' the astronomically obtained difference for Bordeaux/Angers and Pisa.

¹⁰¹ See al-Farghānī, *Book on the Summaries of the Science of the Stars and the Principles of the Celestial Movements*, c. 8 (trans. John of Seville ed. Carmody 1943: 13–15; trans. Gerard of Cremona ed. Campani 1910: 89–92); Mercier (1992: 178–181).

in this period and that it was put to use at least occasionally. Nevertheless, the inherent limitations of this method make it doubtful whether the sizeable pool of longitude data from this period, and especially the patterns of accuracy just mentioned, can be explained on this basis alone. While it seems *prima facie* plausible that topographic distances were used to derive longitude estimates from shared reference points, the available sources from the twelfth and thirteenth centuries do not offer any positive confirmation that this method was already in successful use in this period.

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