Ptolemaeus Arabus et Latinus

EDITING AND ANALYSING NUMERICAL TABLES

TOWARDS A DIGITAL INFORMATION SYSTEM FOR THE HISTORY OF ASTRAL SCIENCES

Edited by

Matthieu Husson, Clemency Montelle
& Benno van Dalen

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Editing and Analysing Numerical Tables

Ptolemaeus Arabus et Latinus

Studies

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Tackling a Thirteenth-Century Arabic Source with the Aid of a Computer Database

Benno van Dalen

In fond memory of Ted and Mary Helen Kennedy

1. The *Shāmil Zīj*

The *Shāmil Zīj* (i.e., 'Comprehensive *Zīj*') is an Arabic astronomical handbook with tables from the first half of the thirteenth century.[1] It was primarily intended for the practising astronomer or astrologer, since in most of its surviving manuscripts it consists of, on average, 12 folios of very compact instructions for solving the common problems in spherical and planetary astronomy and astrology as well as a standard set of tables covering 60 folios. The title of the work is explicitly mentioned in the introduction of only three of the twelve more or less complete manuscripts that I have consulted, whereas one other, the earliest surviving manuscript, has ornamented title pages stating the title explicitly for both the explanatory text and the tables.[2] The author of the *Shāmil Zīj* is unknown, but judging from similarities between the *Shāmil Zīj* and the two contemporary *zīj*es by the well-known philosopher Athīr al-Dīn al-Mufaḍḍal ibn ʿUmar al-Abharī (fl. in Mosul from *c.* 1230 onwards, d. 1263–1265),[3] it is possible that al-Abharī was also the author of the *Shāmil Zīj*. The fact that the geographical table in the *Shāmil Zīj*, as one of only relatively few Islamic geographical sources, also presents coordinates for the small town Abhar in northwestern Iran, and that the mean motion tables are set up for its meridian, may be further evidence for this attribution.[4]

[1] For Islamic *zīj*es and their contents, and for overviews of the most important *zīj*es that are extant or known from references, see Kennedy, 'A Survey' and King & Samsó, 'Astronomical Handbooks'.

[2] Furthermore, the title page of Tehran, Majlis Library, MS 6445 gives a distorted form of the title. For extensive information on all manuscripts, see Section 2.

[3] For al-Abharī, see the *BEA* article by Hüseyin Sarıoğlu; the *EI*[3] article by Heidrun Eichner; *MAOSIC*, no. 595, pp. 209–10, and Hasse, 'Mosul and Frederick II'.

[4] *GAS*, vol. XIII, p. 381 presents al-Abharī as the author of the *Shāmil Zīj* on the basis of a second entry for the work (with the same incipit) in the Yaltkaya edition of Ḥājjī Khalīfa's *Kashf al-ẓunūn* (see Yaltkaya and Bilge, *Keşf-el-zunun*, vol. II, cols 968–69 and the *EI*[2] article

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The author of the *Shāmil Zīj* states both in the preface and in a later section that he used the planetary mean motion parameters of the important tenth-century mathematician and astronomer Abū l-Wafāʾ al-Būzjānī (Baghdad, 940–997/8).[5] He criticizes the author of the *ʿAlāʾī Zīj* (i.e., al-Fahhād, Shirwan in northwestern Iran, *c.* 1176) for presenting his planetary parameters as having been observed by himself, but instead actually having taken them from Abū l-Wafāʾ.[6] Since the chapters on planetary theory and all tables of Abū l-Wafāʾ's major *zīj*, entitled *al-Majisṭī* after Ptolemy's *Almagest*, are missing from the unique manuscript Paris, Bibliothèque nationale de France, arabe 2494, and planetary mean motion parameters attributed to Abū l-Wafāʾ in the margins of the thirteenth-century Berlin manuscript of a revision of the *zīj* of

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'Kātib Čelebi' by Orhan Şaik Gökyay, esp. vol. IV, p. 761b, no. 12). This second entry is not found in the edition by Flügel (*Kashf al-ẓunūn*, vol. III, p. 565) and in the online Bologna manuscript of the work, which both contain only the attribution to Abū l-Wafāʾ. However, Flora Vafea kindly confirmed for me that the second entry is found in one of the two manuscripts used by Yaltkaya and Bilge, namely Istanbul, Süleymaniye, Carullah 1619, fol. 70v. This is an 'autograph draft' dated AH 1051 (AD 1641) and consists of a main text with numerous marginal additions. The second entry for the *Shāmil Zīj* is written upside down and diagonally in the margin. It does not repeat the title of the work, but is linked to the main entry by a line drawn with the same black ink.

GAS, ibid., also states that the *Shāmil Zīj* was the earliest work to integrate corrections of coordinates in the eastern part of the Islamic world with those from the Maghrib and al-Andalus relative to the meridian of water (cf. footnote 10). However, since the geographical table in the *Shāmil Zīj* associated with al-Abharī does not include any localities west of Constantinople, I suspect that this merit should rather be assigned to the *Shāmil Zīj* by Ibn al-Raqqām, as indicated in Comes, 'The "Meridian of Water"', p. 47.

[5] For Abū l-Wafāʾ, see the *DSB* article by A. P. Youschkevitch, the *BEA* article 'Būzjānī: Abū al-Wafāʾ' by Behnaz Hashemipour, the *EI*[3] article by Ulrich Rebstock, and *MAOSIC*, no. 256, pp. 96–98. On Abū l-Wafāʾ's astronomical work *al-Majisṭī*, see, among others, Carra de Vaux, 'L'Almageste'; van Dalen, *Ancient and Mediaeval Astronomical Tables*, Chapter 4; Moussa, 'Mathematical Methods', and several sections and footnotes in van Dalen, *Ptolemaic Tradition*. The explicit mention of Abū l-Wafāʾ in the preface of the *Shāmil Zīj* misled several cataloguers, and thence also authors of modern biobibliographical works, into naming him as the author of the *zīj*.

[6] This paragraph is transcribed from the manuscript Paris, Bibliothèque nationale de France, arabe 2528 in de Slane, *Catalogue des manuscrits arabes*, p. 451 (with a French translation) and in King, *Fihris al-makhṭūṭāt*, Part II, pp. 107–08. See also Suter, 'Nachträge', no. 167, pp. 166–67. For the *ʿAlāʾī Zīj*, see Pingree, *The Astronomical Works* (containing an edition of the Byzantine version) and van Dalen, 'The *Zīj-i Nāṣirī*'. An incomplete Persian manuscript of the *ʿAlāʾī Zīj* was noted by Sonja Brentjes to be present in the library of the Salar Jung Museum in Hyderabad. Mohammad Mozaffari informs me that the introduction of the *ʿAlāʾī Zīj* makes clear that al-Fahhād did make regular observations and that he compared the results with calculations based on the *Mumtaḥan Zīj* by Yaḥyā ibn Abī Manṣūr (Baghdad/Damascus, *c.* 830), the lost *ʿAḍūdī Zīj* by Ibn al-Aʿlam (Baghdad, *c.* 960) and the *Sanjarī Zīj* by al-Khāzinī (Marw, *c.* 1120).

Ḥabash al-Ḥāsib (Damascus/Samarra, *c.* 870) appear unreliable, it has not yet been possible to verify this claim. In any case, it can be seen that the author of the *Shāmil Zīj* makes use of the same parameters as the *ʿAlāʾī Zīj*, which he lists in a table together with epoch values for the beginning of the year 600 Yazdigird (AD 1231/2).[7] The *Shāmil Zīj* is therefore of interest both for recovering the values of Abū l-Wafāʾ's mean motion parameters and for studying the transmission of the *ʿAlāʾī Zīj* to Byzantium, where it was translated into Greek by Gregory Chioniades around the year 1300.

All extant manuscripts of the *Shāmil Zīj* contain basically the same explanatory text and the same set of accompanying tables.[8] The explanatory text, headed *al-qawl fī muʾāmarat al-aʿmāl* 'Statement on the Restoration of Astronomical Operations', consists of ten numbered chapters (*abwāb*), further divided into unnumbered sections (*fuṣūl*), and an epilogue (*khātima*). The topics of the chapters are as follows:

1. Calendars: year and month lengths in the Arabic, Persian, Byzantine and Maliki calendars; numbers of days since epoch, date conversion, days of the week of month beginnings.
2. Sines and versed sines: finding the sine and versed sine from an arc and vice versa, by means of the sine table.
3. Tangents: finding the tangent and cotangent of an arc and vice versa, by means of the tables of the first and second tangents.
4. Fundamental arcs on the heavenly sphere: first and second declinations, right ascensions, geographical longitudes and latitudes, equation of daylight, and oblique ascensions.
5. True planetary positions: mean motions and epoch positions, apogee longitudes, true longitudes of the sun, the moon, the lunar nodes, and the five planets.
6. Progressive and retrograde motion and planetary latitudes: first and second stations, lunar latitude, latitudes of the superior and the inferior planets, positions of the fixed stars.
7. Preliminaries for the operations on ascendants: distance of a planet or star from the equator, equation of daylight, maximum altitude, half arc

[7] See van Dalen, 'The *Zīj-i Nāṣirī*', pp. 830–36.

[8] Unlike early European sets of astronomical tables, most extant Arabic and Persian *zīj*es appear in a fixed form with a consistent set of instructions and tables. Only occasionally tables were replaced for use at a different geographical latitude; more often additional tables were provided at the end of the manuscript of a *zīj*. The major exceptions among extant manuscripts are the two recensions of the *Mumtaḥan Zīj* by Yaḥyā ibn Abī Manṣūr (cf. footnote 6) and those of the *zīj* by Ḥabash al-Ḥāsib (see above), which were all copied four centuries after the original works were written and also include materials from later centuries.

of daylight, hours of daylight, degree of transit, degree of rising and setting.

8. Ascendants: calculating the ascendant from the altitude of a star and from the time of day or night, ascendant of a year transfer.
9. Conjunctions and eclipses: time of a conjunction or opposition, solar eclipses, lunar eclipses, lunar crescent visibility, lunar conjunctions with planets or stars.
10. Other astronomical operations: equalisation of the houses, projection of the rays, rising amplitude, altitude of the ecliptic pole, proportion and equation of the azimuth, azimuth and its direction, latitude of the incident horizon, prorogations (*tasyīr*s).
11. Epilogue. On the azimuth of the *qibla* (i.e., the direction of prayer towards Mecca).

The standard set of tables provided in the *Shāmil Zīj* includes all tables that are necessary to carry out the basic operations of astronomy and astrology, but nothing further. Various tables have a non-standard arrangement, as indicated in the following overview. Some tables (especially the first and second declination and solar equation) are tabulated not only for integer degrees but for every 6′ of arc, several others (especially the lunar and planetary equations) for every 12′.

1. Sines and versed sines (these are combined into a single table, in which shared additive values for 2, 4, 6, ..., 60′ must be added to the sine and versed sine values for integer degrees given at the top of each column).
2. First tangent, second tangent.
3. First declination, second declination.
4. Right ascension.
5. Longitudes and latitudes of localities.
6. Universal table of the equation of daylight (with values for every 10° of the ecliptic and the range of geographical latitudes 28, 29, 30, ..., 45°).[9]
7. Universal table of oblique ascensions, with tabular differences for carrying out linear interpolation (with the same general set-up as the equation of daylight).
8. Table of planetary mean motion parameters said to be taken from al-Būzjānī.

[9] Tables and instruments are called ‘universal’ if they cannot only be used for specific geographical latitudes, but for all or at least a wide range of latitudes. Cf. King, ‘Universal Solutions’.

9. Table of planetary apogee motion.
10. Mean motion tables: solar centrum; lunar centrum, anomaly and longitude and lunar node; centrum and anomaly for each of the five planets. These display the planetary positions for the beginnings of the Yazdigird years 600, 601, 602, ..., 699 together with the motions in 100, 200, ..., 1400 Persian years and in 1, 2, 3, ..., 365 days (arranged in 13 columns for the months Farwardīn to Isfandār(mudh) plus the five 'stolen days' *al-mustaraqa*). The mean motions are given for a longitude of 84° measured from the Fortunate Isles, i.e., the same as that used by al-Fahhād in the *ʿAlāʾī Zīj*.[10]
11. Equation tables: sun; lunar first and second equation, interpolation minutes and variation (*ikhtilāf*); planetary first and second equation, interpolation minutes and variation (*ikhtilāf*).
12. Equation of time (for an apogee longitude of $2^s\,28°$, with the true solar longitude as the argument).
13. Planetary stations.
14. Lunar latitude and planetary latitudes.
15. Fixed stars.
16. Parallax for the 4th and 5th climates.
17. Eclipse tables: radius of the luminaries and of the shadow, 'general digits' and 'amount of darkness' (for calculating eclipse magnitudes), times of solar eclipses and of lunar eclipses (for calculating eclipse durations).
18. The velocity of the moon and its distance (i.e., the distance traveled by the moon in multiples of half an hour as a function of its true velocity).
19. *Ittiṣālāt* (i.e., conjunctions of the moon and planets).

As in many surviving manuscripts of early *zīj*es, in most of the manuscripts of the *Shāmil Zīj* we find additional tables, in particular of types that are not included in the work itself, for example chronological tables, the equation of

[10] Longitudes in medieval Islamic sources were traditionally measured from the Fortunate Isles (*al-jazāʾir al-khālidāt*), i.e., the Canaries, or from the 'Western Shore (of the encompassing sea)' (*sāḥil al-baḥr al-muḥīṭ al-gharbī*), i.e., a point on the Atlantic coast of Africa that was assumed to be 10° east of the Fortunate Isles. (The actual situation was more complicated and stood in relation to a rescaling of Ptolemy's longitudes, especially by the geographers of the caliph al-Maʾmūn around AD 830, which made the Mediterranean 10° shorter. See *GAS*, vol. X, Chapter 2 for an extensive description of this process, and Robles Macías, 'The Longitude of the Mediterranean' for an analysis based on geographical tables, maps and instruments. In western-Islamic sources the so-called 'meridian of water' became in use due to similar reasons; cf. Comes, 'The "Meridian of Water"', which also explains that in many geographical tables longitudes measured from different meridians would occur together).

daylight and oblique ascensions for specific latitudes between 36 and 39°, and astrological tables (for example, duration of gestation, lots, and lunar mansions).

Only scattered materials from the *Shāmil Zīj* have been treated in the literature.[11] In this article I will turn my attention to one of the only very few non-mathematical tables in the *Shāmil Zīj*, namely the geographical table with longitudes and latitudes of 79 localities, concentrated in and around northwestern Iran. Geographical tables lack the standard features that allow us to analyse and restore many types of mathematically computed tables. Foremost, they cannot be recomputed, and since the individual coordinates tended to be copied uncountable times during many centuries, an unusually large number of scribal errors would creep in, including of types that are almost impossible to correct without multiple copies of a table or the original source at hand. Although many geographical tables were arranged by climate,[12] and within each climate by increasing longitude, in practice this only very rarely allows one to correct coordinates or the order of entries. As a result, we will see that even an exhaustive critical edition incorporating eleven manuscript copies of the table from the *Shāmil Zīj* leaves several cases in which we cannot decide on the correct or original entries on the basis of the evidence in the table alone. Therefore it will be necessary to look at a database of a much wider range of Islamic geographical sources, which will not only allow us to make well-founded decisions for the edition, but will also show us on which earlier sources the author of the geographical table in the *Shāmil Zīj* based himself, and that he included several coordinates that appear to be entirely original.

Such a database of Islamic geographical data can be found in an indispensable secondary source for the study of Islamic geographical tables, namely *Geographical Coordinates of Localities from Islamic Sources* by Edward S. Kennedy

[11] Individual methods and tables were discussed in Kennedy, 'Comets', pp. 47–48; Berggren, 'The Origins', pp. 5–7; and King, 'Some Early Islamic Tables', pp. 217–218. In van Dalen, 'A Statistical Method', pp. 106–13, I used the solar equation table from the *Shāmil Zīj* as an example for the application of various statistical estimators that I had developed. (The result of my estimation of the solar eccentricity was confirmed in Bellhouse, 'An Analysis of Errors', pp. 287–92, by means of a different statistical method making use of integer-valued residuals). In van Dalen, 'The *Zīj-i Nāṣirī*' (with a summary of results on p. 857), I compared the planetary tables in the *Shāmil Zīj* and their underlying parameters with those in several earlier *zīj*es and found that the planetary equations were mostly taken from Kūshyār ibn Labban's *Jāmiʿ Zīj* (Iran, *c.* 1025) and in some cases from al-Khāzinī's *Sanjarī Zīj* (Marw, *c.* 1120), possibly through the intermediary of the *ʿAlāʾī Zīj*.

[12] The climates (or climes) were seven bands of latitude values determined from round numbers for the maximum lengths of daylight. See Honigmann, *Die sieben Klimata*; the *EI*[2] article 'Iḳlīm' by A. Miquel; Dallal, *Al-Bīrūnī on Climates*; and King, *Bringing Astronomical Instruments*, pp. 6–9. For a more general introduction to Islamic mathematical geography, see Kennedy, 'Mathematical Geography' or King, *World-Maps*, Section 1.6, pp. 23–28.

and his wife Mary Helen Kennedy (here further abbreviated as K&K). This book contains lists of place names, longitudes and latitudes as found in about 80 Islamic works, including *zīj*es, instruments and several others. As will be explained in more detail in Section 5, the sources are indicated by a three- or six-letter alphabetical code as well as a chronologically ordered numerical one, with the data arranged in four different ways. The geographical table from the *Shāmil Zīj* is included in K&K as source SML, on the basis of a manuscript that my edition will show to be defective in various respects.[13]

2. The Geographical Table in the *Shāmil Zīj*

The geographical table in the *Shāmil Zīj* is found among the trigonometric and spherical-astronomical tables that immediately follow the explanatory text and precede the planetary tables. It thus facilitates the use of the *zīj* for the computation of arcs on the celestial sphere and planetary positions for any locality covered by the table and, as described in Chapter 4 of the explanatory text, in other localities by means of interpolation between the longitudes of two localities with the same latitude and known distance (the text prescribes to find the latitude of other localities by direct observation of the solar altitude at noon). The table covers a single page in the manuscripts and includes 26 localities in the first and second columns, and originally 27 in the third (some minor deviations are specified in the apparatus to my edition in Section 3). With its total of 79 localities it is one of the smaller geographical tables found in Islamic *zīj*es.

For critically editing the table, I will make use of nearly every single copy that I have been able to get hold of. The *Shāmil Zīj* is extent in more or less complete form in the following twelve manuscripts, eight of which include the geographical table:

- Cairo, Dār al-kutub, *mīqāt* Ṭalʿat 138 (58 fols, only the tables, copied *c.* 900 Hijra; see King, *Fihris al-makhṭūṭāt*, Part I, p. 476 and Part II, pp. 107–09, as well as King, *A Survey*, B100, p. 52 and plate XVIII, p. 238). A fine copy in clear *naskh* with a variety of additional tables. An inlaid sheet misled some scholars in attributing the work in this manuscript to Ibn Yūnus. — This manuscript omits the geographical table and the universal tables for the equation of daylight and oblique ascensions and replaces them by specific tables for latitude 38°.
- **C** = Cairo, Dār al-Kutub, *riyāḍī* Taymūr 296/1 (pp. 1–160 [220 pp. in total], copied in 1123 Hijra = AD 1711/2; see King, *Fihris al-makhṭūṭāt*, Part I, p. 609 and Part II, pp. 107–09, as well as King, *A Survey*, B100,

[13] The description of source SML is found in Kennedy and Kennedy, *Geographical Coordinates*, p. xxxii, and the coordinates from the table, arranged alphabetically by location, on pp. 471–73.

p. 52). Written in a clear *naskh*, with several additional tables. — The geographical table is on fol. 21v. The place names are frequently written with diacritical dots, but occasionally the shapes of the letters are completely wrong. All text is in black; only the frame of the table, somewhat carelessly drawn, is in red. The first column with place names is preceded by a column containing only the word *madīna* 'city' for every entry. **C** has an unusually large number of scribal errors, nearly all of which are shared by manuscript **J** of a *zīj* written in Mosul, likewise in the 18th century (see below). Different from the common form ے for *abjad* 10 found in all other witnesses, **C** and **J** both use the standard form ى used for *yāʾ* in ordinary text. Since the tables in **C** and **J** can be seen to be descendants of the already rather faulty manuscript $\mathbf{T_2}$, to which they add further scribal errors of their own, variants from **C** and **J** are only included in the apparatus of my edition if they differ from $\mathbf{T_2}$ or show very typical or informative deviations.

- $\mathbf{F_1}$ = Florence, Biblioteca Medicea Laurenziana, Or. 95b (previously Palatina 289, 116 fols separately numbered from Or. 95a in the same volume, copied in 747 Hijra = AD 1347; see Assemanus, *Bibliothecae Medicae Laurentianae*, no. 289, p. 394). Written in a clear *naskh* on uneven lines. The explanatory text (up to fol. 18r) is followed by a similar but unrelated text in Persian and some other smaller ones. This manuscript has an unusually large number of additional tables beyond the basic set. — The geographical table is found on fol. 41v. It omits the second column of the original table and distributes the localities from the first and third columns over three shorter columns, adding some further localities at the end. The place names are mostly written without diacritical dots and the definite article *al-* is omitted even from place names for which most other manuscripts include it. As the only witness, this manuscript includes a label *iqlīm awwal* 'first climate' before the first entry and Hindu-Arabic numbers 2 to 7 roughly at the places where the other climates start. These undoubtedly do not stem from the original work, but their exact placement will be mentioned in the general comments to my edition.
- Florence, Biblioteca Medicea Laurenziana, Or. 106/1 (fols 1–71r [170 fols in total], 8th c. Hijra; see Assemanus, *Bibliothecae Medicae Laurentianae*, no. 120, pp. 197–98). Written in a clear *naskh* on uneven lines. The last four pages of the explanatory text were replaced by a copy written on ruled lines within an outer frame in a different hand, apparently that of Or. 106/2. The second half of this manuscript contains one of the two *zīj*es explicitly attributed to al-Abharī with a copy of the geographical table from the *Shāmil Zīj*; see $\mathbf{F_2}$ below. —

The geographical table is missing together with the second half of the right ascension table that would have immediately preceded it, possibly because the sheet concerned was lost or torn out. The two universal tables are included in this manuscript, but the oblique ascensions were never filled in.

- Istanbul, Süleymaniye Kütüphanesi, Carullah 1479 (65 fols, undated; very brief notice in Krause, *Stambuler Handschriften*, p. 466). Written in a clear, slightly cursive *naskh*. The title 'Shāmil Zīj' is explicitly mentioned in the preface. — The geographical table is missing from this manuscript, together with all spherical astronomical tables.
- Meshhed, Holy Shrine Library, MS 12086 (96 fols, copied in 781 Hijra = AD 1379/80; see ʿIrfānian, *Fihrist-i kutub-i khaṭṭī*, no. 536, pp. 60–63). A fine copy in a very clear *naskh*, generally with diacritical dots. The title 'Shāmil Zīj' is explicitly mentioned in the preface. Both text and tables have a large number of well-informed glosses in the margins. The explanatory text is followed by sections on lunar crescent visibility from the *(Il)khānī* and *Shāhī Zīj*es copied by a different hand. The tables are supplemented by an unusually large set of additional tables, including several for latitudes 38° and 39°, a table for the equalisation of the houses and an uncommon double-argument table for the lunar equation covering 35 pages. — The geographical table is missing from this manuscript together with all trigonometrical and spherical-astronomical tables.
- $\mathbf{P_8}$ = Paris, Bibliothèque nationale de France, arabe 2528 (73 fols, manuscript from the 15th/16th c.; see de Slane, *Catalogue des manuscrits arabes*, pp. 451–52 and http://archivesetmanuscrits.bnf.fr/ark:/12148/cc30444x). Written in a clear *naskh* on carefully drawn lines. Numbers that would have been in red are systematically missing from the headings of the tables, probably because the manuscript from which this copy was made already lacked those. — The geographical table appears on fol. 19v. The diacritical dots on the place names are frequently missing. Each of the three columns with place names is preceded by a column containing only the word *madīna* 'city' for every entry. The coordinates from this copy of the geographical table from the *Shāmil Zīj* were included in K&K as source SML (cf. p. 517).
- $\mathbf{P_9}$ = Paris, Bibliothèque nationale de France, arabe 2529 (76 fols, manuscript from the 16th c.; see de Slane, *Catalogue des manuscrits arabes*, p. 452 and http://archivesetmanuscrits.bnf.fr/ark:/12148/cc304455). Written in a clear and careful *naskh*. The title 'Shāmil Zīj' is explicitly mentioned in the preface. — The geographical table is included on fol. 27v (see Plate 16). It omits the entry for Siwas, but gives four

additional localities in the same hand as the 78 original ones. It provides diacritical dots for most place names with some exceptions near the end of the first column, where also the original latitudes of three localities appear to have been corrected to alternative ones. The definite article *al-* is omitted from all place names except al-Raqqa and al-Rayy.

- $\mathbf{P}_0$ = Paris, Bibliothèque nationale de France, arabe 2540 (fols 7v–15 and 29v–99 [99 fols in total], manuscript from the 15$^{\text{th}}$ c.; see de Slane, *Catalogue des manuscrits arabes*, p. 454 and https://archivesetmanuscrits.bnf.fr/ark:/12148/cc30455c). This manuscript was obtained in Aleppo in 1673. The remaining folios contain a rather sloppy copy of the explanatory text and tables of *al-Dustūr al-ʿajīb* by Naṣir al-Dīn ibn ʿĪsā ibn al-Ḥiṣkafī, pointing to a strong relationship to the Vatican manuscript (**V** below), which likewise contains this work together with the *Shāmil Zīj*. The text is written in a somewhat untidy but readable *naskh*. The tables of the *Shāmil Zīj* are nicely laid out as in most of the other manuscripts, but those of *al-Dustūr* are in a small and often unclear script. Numbers in red are systematically missing from the headings of the tables belonging to the *Shāmil Zīj*. In general the calligraphy of the headings of these tables is very similar to $\mathbf{P}_8$. *Abjad* 3 (ج) and 4 (د) look very much alike in this manuscript when written separately. — The geographical table is on fol. 38v. It generally includes the diacritical dots on the place names. Each of the three columns with place names is preceded by a column containing only the word *madīna* ‘city’ for every entry.
- $\mathbf{T}_1$ = Tehran, Majlis Library, MS 6422 (76 fols, copied in 672 Hijra = AD 1273/4; see Ḥusaynī Ashkawarī, *Fihrist-i nuskhahā-yi khaṭṭi*, pp. 15–16 and https://dlib.ical.ir/site/catalogue/835022). This is the oldest surviving copy of the *Shāmil Zīj*. Fol. 1r gives the title with ornaments in gold and blue, fol. 11r the title of the second *maqāla* ‘On the tables of the *Shāmil Zīj*’ in gold. Folios 2–9, and therewith almost the entire explanatory text, are missing from the manuscript. Fol. 10 contains the last part of the epilogue and several additional texts in different hands. The original set of tables is included in its entirety in the correct order. The tables were copied in an elegant *naskh*, possibly different from the explanatory text. Some additional tables and texts are found from fol. 71v onwards, including oblique ascensions for latitudes 38° and 39° (Konya). — The geographical table is on fol. 20v. It generally includes the diacritical dots on place names. Different from all other manuscripts, the place names are here alternately written in black and in red. In the last column, the minutes of four longitude and six latitude values and the degrees for one latitude value have been omitted.

My edition of the table will make clear that these must in each case be taken to be equal to the last written digit above them (all minutes concerned are zero, and the degrees for Aqsaray are 38). These omissions have not been noted in the apparatus.

- **T_2** = Tehran, Majlis Library, MS 6445 (91 fols, copied in AD 1880 according to the catalogue, but this is probably incorrect because the earlier manuscripts **C** and **J** depend on it (cf. below); see Ḥusaynī Ashkawarī, *Fihrist-i nuskhahā-yi khaṭṭi*, p. 29 and https://dlib.ical.ir/site/catalogue/836523). I only became aware of this manuscript after an earlier version of this article had been submitted. The title is given on the title page (fol. 2r) in the distorted form *al-Zāʾirja al-shāmila li-l-maḥāsin al-mukāmila* 'The Comprehensive *zāʾirja* for the Perfect Merits'.[14] A different hand on fol. 1r describes the contents as 'The *zīj* of Abū l-Wafāʾ Būzjānī and the introduction of the *Athīrī Zīj*'. The *Shāmil Zīj* is here mixed with some texts, tables and diagrams from very different sources written on different paper by different hands. Text and tables of the *zīj* are in a *naskh* hand. The introduction starts at fol. 7r and is indeed followed by the opening lines of the *Athīrī Zīj* on fol. 15v; the opening section of the *Shāmil Zīj* is repeated on fol. 16v on different paper. — The geographical table is on fol. 27r. The place names are generally written with diacritical dots. The first two columns with place names (but not the third) are preceded by a column containing only the word *madīna* 'city' for every entry. Since this table is clearly an ancestor of the even faultier copies **C** and **J**, I have included all variants from **T_2** in my edition but those from **C** and **J** only when they differ from **T_2** or provide typical or informative further deviations.
- **V** = Vatican, Biblioteca Apostolica Vaticana, Vat. ar. 1499 (fols 3v–10v and 14r–101v [102 fols in total], 984–87 Hijra = AD 1576–1580; see Levi della Vida, *Secondo elenco*, pp. 2–3). Like in **P_0**, the *Shāmil Zīj* appears here mixed up with a copy of al-Ḥiṣkafī's *al-Dustūr al-ʿajīb*. The *Shāmil* tables are neatly laid out, those from the *Dustūr* in a very small script. — The geographical table is found on fol. 48v. The scribe omitted most of the diacritical dots on place names and used a form for *abjad* zero (٩) that is very close to the letter *ʿayn* ع. Instances in which the manuscript indeed has an actual *ʿayn* rather than a zero are not separately included in the apparatus. Each of the three columns with place names is preceded by a column containing only the word *madīna* 'city' for every entry. The first two longitude values (for Haba-

[14] The *zāʾirja* is a divinatory device involving letter magic, geomancy and astrology; cf. the *EI²* article 'Zāʾirdja' by T. Fahd.

sha and Sanaa, in black) were written over further copies of this word that were mistakenly inserted in red.

Some further fragments of the *Shāmil Zīj* are contained in London, British Library, Add. 7492/3 (fols 51v–67r with only the explanatory text, copied in 912 Hijra = AD 1506/7), and possibly in Mumbai, Cama Oriental Institute, R I.86. The commentary on the *Shāmil Zīj* by al-Qumnāṭī is extant in Paris, Bibliothèque nationale de France, arabe 2530 and Istanbul, Süleymaniye Kütüphanesi, Laleli 2137, and the commentary by Ḥasan Muḥammad Ṭūsī in Isparta, Halil Hamit Paşa İl Halk Kütüphanesi, MS 2252.[15]

The geographical table from the *Shāmil Zīj* is also included in several works that are strongly related to the *zīj*. Of these works I have used the following manuscripts:

- **F_2** = Florence, Biblioteca Medicea Laurenziana, Or. 106/2 (fols 72v–170r, copied in the 8th c. Hijra; see Assemanus, *Bibliothecae Medicae Laurentianae*, no. 120, pp. 197–98) of the *Athīrī Zīj* (described as a shortened version of *al-Zīj al-mulakhkhaṣ ʿalā arṣād al-ʿAlāʾī* in the opening sentences) by Athīr al-Dīn al-Abharī. This work appears to be contemporary and to share several tables and other characteristics with the *Shāmil Zīj*, but it also shows a large number of significant differences. The explanatory text of the *Athīrī Zīj* consists of 15 sections (*fuṣūl*). The planetary mean motions are for geographical longitude 70°, most likely Damascus, and the planetary positions are given for the year 600 Yazdigird. A detailed investigation is necessary in order to establish the exact relationships between the *Shāmil Zīj*, its slight reworking in the manuscript Dublin, Chester Beatty, Arabic 4076, and the two *zīj*es of al-Abharī. This part of the manuscript is written in a clear *naskh*; the first half contains a copy of the *Shāmil Zīj* that is listed above but lacks the geographical table. — The geographical table from the *Shāmil Zīj* is included by al-Abharī on fol. 141v just after a set of spherical astronomical tables for latitude 36°. Different from the *Shāmil Zīj*, the geographical table here comes after the planetary tables. Most of the diacritical dots on place names are omitted and some names are completely miswritten. Every single occurrence of a digit 50 in the coordinates is written as an unambiguous 55, making it plausible that in one of the ancestors of this manuscript the shapes of 50 and 55 were extremely close.
- **J** = Mosul, Pāshā Mosque (*Jāmiʿ al-Bāshā*), MS 323 (90 fols, copied in 1141 Hijra = AD 1728/9; see al-Shantī, *Fihris al-makhṭūṭāt al-muṣaw-*

[15] See *GAS*, vol. V, pp. 324–25 and vol. VI, pp. 223–24 (under Abu l-Wafāʾ). For the commentaries see also *OALT*, vol. I, no. 6, p. 22 and vol. II, pp. 809–10, as well as *MAOSIC*, no. 766, p. 259 and no. 859, p. 290.

wara, no. 319, p. 121) of the *zīj* by ʿAbd al-Qādir ibn Ṣafāʾī al-Mawṣilī. This manuscript might now very well have been lost for eternity if the Cairo Institute of Arabic Manuscripts had not prepared a microfilm of it many decades ago. Professor Edward S. Kennedy was kind enough to lend me a copy of this film. A more extensive description of the *zīj* of al-Mawṣilī will appear in my *A New Survey of Islamic Astronomical Handbooks*. Written in a very clear *naskh*. — The geographical table is on fol. 8v. The place names generally include the diacritical dots, *shadda*s and *hamza*s. However, the tabular frame was drawn in an amateurish way without a ruler and with one column too many and two rows too few. The first column of place names (but not the second and third) is preceded by a column containing only the word *madīna* in every row. The shape of *abjad* zero ([illegible]) is somewhat similar to the Hindu-Arabic numeral 5, but is also repeatedly confused with *abjad* 8 (ح). This table can be seen to be a descendant from manuscript $\mathbf{T_2}$ through the intermediary of manuscript **C**. The three manuscripts share a large number of peculiar errors that do not appear in any of the other eight witnesses. These include grave mistakes in the spelling of place names, the confusion of *abjad* numbers 0 and 8 (especially in **C** and **J**), and the slide of 14 place names towards the end of the third column which made it impossible for Kennedy to recognize that **J** is in fact a copy of the table from the *Shāmil Zīj*. In my critical edition of the geographical table I have only included variants from **C** and **J** if they are different from those in $\mathbf{T_2}$ or show very typical or informative deviations.

- **O** = Oxford, Bodleian Library, Laud Or. 253 (88 fols, autograph; see Nicoll, *Bibliothecae Bodleianae*, no. 274, pp. 242–46) of *al-Durr al-muntakhab* by the Priest Cyriacus (in Arabic: al-Qiss Qiryāqus). The author presumably worked in Mardin, now in southeastern Turkey, toward the end of the 15th century. The introduction of his *zīj* states that it was based on the *Athīrī Zīj* by al-Abharī (cf. $\mathbf{F_2}$ above) and the planetary mean motion parameters of Abū l-Wafāʾ. The highly original lunar and planetary equations with double arguments, displacements and further adjustments, as well as some other individual tables, were studied by Saliba and Kennedy.[16] The author's hand is a clear *naskh*. — The geographical table, basically identical with that in the *Shāmil Zīj*, appears on fol. 84v. As in most of the manuscripts described above, the title is written in suprascript; most of the diacritical dots on the place names are provided.

[16] See Saliba, 'The Double-Argument Lunar Tables'; Saliba, 'The Planetary Tables'; Kennedy, 'Comets'; Kennedy and Agha, 'Planetary Visibility Tables', and Saliba, 'Easter Computation'.

As has already been mentioned in Section 1, K&K includes the geographical table from the *Shāmil Zīj* as source SML on the basis of manuscript $\mathbf{P_8}$. Furthermore, since they appear in different works, K&K separately presents the table from manuscript **J** as source ABD and the table from manuscript **O** as source QIR. Besides these, it includes one further copy of the geographical table from the *Shāmil Zīj*, namely the source that it abbreviates as ULE because it is included on the inside of the back cover of the manuscript Oxford, Bodleian Library, Greaves 5 of the *Zīj* of Ulugh Beg (Samarqand, *c.* 1440).[17] The title and place names in this table were copied in Arabic by a European hand, but most of the numbers are in European numerals rather than in the standard Arabic alphabetical notation. This is most likely a copy by the Savilian professor of astronomy John Greaves himself of a table from another manuscript from his own collection or from the Bodleian Library, or one that he inspected during his travels in the Levant from 1638 to 1640.[18] A direct comparison seems to exclude that the table was copied from the Bodleian manuscript **O** of the *zīj* of the Priest Cyriacus. Whereas seven place names are incorrectly spelled, the tabular values agree almost entirely with those in my edition, with the exception of a possible scribal error for Qum and glitches for Malatiya and Qaysariyya. For Egypt (*Miṣr*, i.e., Cairo), Greaves gives the correct longitude 64;40°, which is further only found as an obvious later correction in manuscript $\mathbf{P_8}$.[19] So in some respects, ULE (or GRV as I will further call it) can be considered the earliest edition of the geographical table from the *Shāmil Zīj*. Because of the uncertainty of its exact sources I will nevertheless omit it from my own edition.

[17] Kennedy and Kennedy, *Geographical Coordinates*, p. xxxv mistakenly states that this table appears after the colophon of the manuscript used for source ULG (the *Zīj* of Ulugh Beg), namely Oxford, Bodleian Library, Marsh 396. The coordinates are listed in ibidem, pp. 564–65.

[18] See Maddison, 'Greaves'; R. Mercier, 'English Orientalists', pp. 261–77, and the further literature mentioned by Maddison. Cf. also Greaves, *Binae tabulae geographicae*. The astronomical sources used by Greaves and the astronomical marginalia in his manuscripts are currently being investigated in detail by Taha Yasin Arslan as part of the pilot project 'The Arabic Books and Astronomy in Seventeenth Century Oxford' led by Julia Bray.

[19] Although most digits in Greaves' copy are written with European numerals, their order remains as in the Arabic. Thus '30 73' stands for the longitude 73;30° of Sanaa. The mistakes in the place names include curious ones such as مكيه for Mecca, اسكنديّه for Alexandria and بادنته for Qadisiyya. The longitude of Qum is given as 82;55°, different from all three values found in the eleven witnesses that I have used for my edition; the latitude of Malatiya is listed as 38;30°, possibly miscopied from the entry for Qaysariyya; and the latitude of Qaysariyya is written in a mixed form in incorrect order as '39 ى'. Seven incorrect digits of coordinates are underlined and were corrected in standard Arabic alphabetical notation above the numbers.

3. Editing the Geographical Table

I present my edition of the entries from the geographical table in the *Shāmil Zīj* in Table 1 on pp. 529–31 and that of the further textual elements such as headings and marginal notes below. For easier reference I have indicated all entries in the original table with a letter (A, B and C for the first to third columns in the manuscripts) and a running number within each column (up to 26 for the first two columns and up to 27 for the third). For the modern equivalents of the place names in the second column of the edition I have used for easier comparison the exact forms as found in Kennedy and Kennedy, *Geographical Coordinates* (K&K) with only very few exceptions.[20] The apparatus to the table is given in the form of notes in the last column of the edition. Here any Arabic form gives a variant to the place names, 'long.' refers to the longitude and 'lat.' to the latitude. In a pair of coordinates separated by a slash the longitude precedes the latitude. The symbols ° and ′ indicate variants in respectively the degrees and the minutes of longitude or latitude.[21] In addition to the sigla for the manuscript sources introduced in Section 2, I use **K** for cases where K&K deviates from my reading of $\mathbf{P_8}$ (in all other cases K&K gives the value that I present for $\mathbf{P_8}$). A question mark indicates a reading that is uncertain or ambiguous.

I have applied the following general editing policies:

- Any variants in the apparatus for place names, longitudes and latitudes are given in the order $\mathbf{T_1P_9F_1F_2OP_8P_0VT_2CJ}$, i.e., as we will see, in the order of general correctness (or smallest number of errors) of the manuscripts. Note that variants from **CJ** are only given explicitly when they differ from $\mathbf{T_2}$ or are otherwise of interest.
- If an entry is unclear but can be read as what I consider to be correct on the basis of the entire manuscript evidence or the correct spelling of place names, I will assume that the correct entry was intended and not mark the unclarity in the apparatus.
- If an entry was corrected in the main hand, I will not include the incorrect original entry in the apparatus unless it appears relevant, for example because other witnesses have the same incorrect entry.

20 Specifically, I write Sanaa for Sana, Madāʾin for Ctesiphon, and Qum instead of Qumm.

21 As most numbers in Islamic astronomical sources, the coordinates in geographical tables are written in the Arabic alphabetical (*abjad*) notation, in which letters *alif* to *ṭāʾ* denote the numbers 1 to 9, letters *yāʾ* to *ṣād* the numbers 10 to 90, and letters *qāf* to *ghayn* the numbers 100 to 1000 (with small variations in a system that was mostly used in the western Arabic world). By combining the letters for one thousand, hundreds, tens and units, any number up to 1999 can be written. For example, *ghayn-shīn-nūn-wāw* غشنو denotes 1356. See Irani, 'Arabic Numeral Forms' and Thomann, 'Scientific and Archaic Arabic Numerals'. For the types of scribal errors that may result from the similarities between certain letters, see Section 4.

- If an entry was corrected in a different hand, I will indicate this whenever the correction is clear.

In editing the place names I have applied the following specific policies:

- In the edition I generally write the place names with correct diacritical dots and *shadda*s, unless all witnesses concerned write them differently (e.g., several manuscripts write زيحان Zayhān with a dotted *yāʾ* for زنجان Zanjān, B17). I write dots on *tāʾ marbūṭa* even though they are almost never written in the manuscripts.
- In the apparatus I will write the variant names exactly as they appear in the manuscripts, i.e., often without diacritical dots. If two or more manuscripts have the same letter shapes for a place name, I will add any diacritical dots that are found in at least one of the witnesses.
- I have not been able to recognize any systematic patterns in the addition or omission of the definite article *al-* before certain place names and have therefore decided generally not to indicate such additions or omissions in the apparatus of the table.

In editing the coordinates, I have used the following general rules:

- All variants caused by the omission or inclusion of diacritical dots are indicated in the apparatus.
- A *fāʾ* or *qāf* without dot is read as 80; thus a reading as 100 requires both dots. Only for the longitudes of Kirman and Khwarizm is the presence of the dots explicitly specified in the apparatus, because the writing in most manuscripts is incorrect.
- Variants in place names or coordinates that are part of a slide in some of the manuscripts (cf. Section 4) are given for the locality for which they were originally intended, i.e., after the errors resulting from the slide itself have been corrected. Whenever a variant is the direct result of a slide, this is explicitly indicated.

Title of the table

جدول أطوال البلدان من الجزائر الخالدات وعروضها عن خطّ الاستواء

jadwal aṭwāl al-buldān min al-jazāʾir al-khālidāt wa-ʿurūḍihā ʿan khaṭṭ al-istiwāʾ

Table of the Longitudes of Cities from the Fortunate Isles and their Latitudes from the Equator

Apparatus. جدول] $\mathbf{P_8P_0VT_2C}$ om., **J** هذا جدول   أطوال] $\mathbf{P_0V}$ لطول   الجزائر] $\mathbf{T_1F_1OP_8T_2CJ}$ جزائر, $\mathbf{P_0V}$ خزاين   الخالدات] $\mathbf{F_2}$ الخالده   وعروضها] $\mathbf{F_2}$ وعرضها   عن] $\mathbf{T_2CJ}$ من   عن خطّ الاستواء] $\mathbf{F_1}$ om. $\mathbf{P_8T_2}$ add عرض لز 'latitude 37°' above البلدان.

Column headers

al-buldān / al-aṭwāl / al-ʿurūḍ البلدان / الأطوال / العروض
Cities / Longitudes / Latitudes

Apparatus. الأطوال] $\mathbf{P_9F_1}$ الطول العروض] $\mathbf{P_9F_1T_2}$ العرض.

Other general characteristics

$\mathbf{P_8P_0V}$ add a column containing only the word *madīna* for every entry before each of the three columns with place names. $\mathbf{T_2}$ adds such a column before the first and second columns of place names, **CJ** only before the first column.

$\mathbf{F_1}$ adds indications of the climates as follows: *iqlīm awwal* above the first column, and Hindu-Arabic numerals '2' before Madina (A5), '3' in the cell of Egypt and Alexandria (A7–A8), '4' before Tarsus (A23), '5' before Khwarizm (C6), '6' before Konya (C26) and '7' before the unidentified *al-ʿzh* (see below) at the end of the table.

Marginal notes

$\mathbf{T_1}$ (right margin in two different hands):

عرض الموصل على ما ذكر العمّالون بها ووجد في حسابهم وتحريرهم له نه مح

*ʿarḍ al-Mawṣil ʿalā mā dhakara al-ʿammālūn bihā wa-wujida fī ḥisābihim wa-taḥrīrihim **lh nh mḥ***

The latitude of Mosul according to what those who work at ⟨the city⟩ stated and to what was found in their calculation and their redaction, is 35;55,48°.[22]

انحراف دمشق شرق وجنوب لا ى / حلب يو م / ترابلس كح ى / حماه كح ل / انطاكية كا مه

inḥirāf dimashq sharq wa-janūb lā y / ḥalab yw m / tarābulus kḥ y / ḥamāh kḥ l / anṭakiya kā mh

The inclination ⟨of the *qibla*⟩ is ⟨for⟩ Damascus south-east 31;10, Aleppo 16;40, Tripoli 28;10, Hama 28;30, Antioch 21;45.[23]

A note in the margin of the table in $\mathbf{P_0}$ computes the longitude and latitude differences between Mecca (rounded coordinates 78° / 21°) and possibly Mardin (74° / 33°, correct latitude 37°), apparently with the purpose of calculating the *qibla*. The numbers are here written with Hindu-Arabic numerals.

[22] This latitude is found in a section on solar eclipses (fols 7v–8r) and in an oblique ascension table for Mosul (fol. 100r–v) in the manuscript Escorial, RBMSL, árabe 927 of a thirteenth-century recension of the *Mumtaḥan Zīj* by Yaḥyā ibn Abī Manṣūr (cf. footnote 6).

[23] These values are in full agreement with the *qibla* values found in the geographical table from al-Khāzinī's *Sanjarī Zīj* (see King, *World-Maps*, pp. 71–75 and Appendix D).

Additional localities

Several of the manuscripts give additional localities and coordinates in the table itself or in the bottom margin. In some cases these were copied into some of the other extant manuscripts as well, in others they appear to be incidental additions by the scribe or a user.[24]

P$_0$V insert entries Mardin ماردين with longitude 74;30° (**V** 37′) and al-Ḥiṣn الحصن with longitude 75;35° after the first and third entries of the second column. **O** adds the same entries in the opposite order with coordinates 75;30° / 38;15° for al-Ḥiṣn and 75;0° / 37;30° for Mardin. In **P$_0$** these additions are clearly in a slightly lighter red and a different hand, in **VO** they are in the main hand. Because of its relative position with respect to Mardin and Harran, al-Ḥiṣn can be assumed to stand for Ḥiṣn Kayfā (now Hasankeyf), which is found in only very few Islamic sources with coordinates 74;35° / 37;35°.

P$_9$ adds an entry لادىں و سركى with coordinates 62;30° / 41;30° at the end of the first column and an entry اياثلوغ with coordinates 61;0° / 41;0° at the end of the second column. These can be recognized as two localities in western Anatolia, namely respectively Laodicea (*Lādhiq*) of Lycos (or Phrygia), whose ruins are just north of present-day Denizli, and Ayathulūg or Ayasulūk, now Selçuk (cf. the *EI²* articles 'Lādhiḳ' and 'Aya Solūk'). I have not been able to interpret the word following *Lādhiq*, but the excellent relative coordinates of the two cities leave little doubt about their identification. Neither locality occurs in K&K.

Both **P$_9$** and **F$_1$** add entries Bulghar بلغار with coordinates 68;0° / 49;30° and Saray with coordinates 72;20° / 46;10° (**F$_1$** 20′) at the end of the third column. The former stands for the Turkic people that founded a state on the Volga in the early Middle Ages, and the latter most probably for one of the two capitals of the Mongol Golden Horde, likewise in modern southern Russia. The coordinates for Bulghar stem from al-Khāzinī, those for Saray are not attested. **F$_1$** furthermore adds العزه *al-ʿzh* with longitude 43;11° and latitude 38;22°, which I have not been able to identify.[25]

F$_2$ adds under the table مدينه باجوج *madīna Bājūj* with longitude 172;30 (for ياجوج *Yājūj* (Gog) or perhaps also ماجوج *Mājūj* (Magog), since 172;30° is the latter's commonly used longitude measured from the Western Shore). **F$_1$** adds مدنه ياجوح *madīna Yājūḥ* (for Gog) with coordinates 65;0° / 21;5° which are unattested and nonsensical.

O writes under the last entry بغير تغيير 'without any change'.

[24] Marginal notes with geographical coordinates that allow the use of, for example, planetary tables at a different locality, may be found in many manuscripts of Islamic astronomical works.

[25] Judging from its coordinates this locality should be near Ammuriya (Amorion) in western Anatolia. Note that Ghazza غزّة is an unlikely candidate both because of the bad agreement of the coordinates (it appears in most sources with longitude 64;50° and latitude 32;0°) and because it is generally written without definite article.

Table 1: Edition of the geographical table from the *Shāmil Zīj*

Column 1

	locality		long.	lat.	apparatus
A1	Habasha	حبشة	51;40	19;30	long. $\mathbf{F}_1$ 11°
A2	Sanaa	صنعا	73;30	14;30	$\mathbf{P}_8\mathbf{P}_0\mathbf{V}$ صنعه
A3	Aden	عدن	75; 0	13; 0	$\mathbf{P}_0\mathbf{V}$ عند, lat. $\mathbf{T}_2$ 8′
A4	Oman	عمان	94;30	19;45	long. $\mathbf{P}_8\mathbf{P}_0\mathbf{VT}_2$ 74°, lat. $\mathbf{F}_1$ 15′
A5	Madina	(ال)مدينة	75;20	25; 0	–
A6	Mecca	مكّة	77;10	21;40	long. **K** 74°, lat. $\mathbf{P}_9$ 30′
A7	Egypt	مصر	54;40	29;45	long. $\mathbf{T}_1$ 14° $\mathbf{P}_8$ 64° (corrected) $\mathbf{P}_9$ 55′, lat. $\mathbf{P}_9$ 55′ (?) **O** 42′ $\mathbf{P}_8\mathbf{P}_0\mathbf{VT}_2$ 47′ (**CJ** 40′)
A8	Alexandria	اسكندريّة	60;30	30;20	long. $\mathbf{P}_8\mathbf{P}_0\mathbf{VT}_2$ 65°
A9	Jerusalem	بيت المقدس	66;30	32; 0	–
A10	Damascus	دمشق	70; 0	33; 0	lat. $\mathbf{P}_9$ 30′
A11	Kufa	(ال)كوفة	79;30	31;50	long. $\mathbf{T}_1\mathbf{F}_2$ 0′, lat. $\mathbf{F}_2$ 55′
A12	Baghdad	بغداد	80; 0	33;25	long. $\mathbf{P}_8\mathbf{P}_0\mathbf{VT}_2$ 10′, lat. $\mathbf{P}_0\mathbf{V}$ 46′ (beginning of slide[+3])
A13	Wasit	واسط	81;30	32;20	lat. $\mathbf{P}_0\mathbf{V}$ 10′ (due to slide)
A14	Basra	(ال)بصرة	84; 0	31; 0	lat. $\mathbf{P}_0\mathbf{V}$ 10′ (due to slide)
A15	Qadisiyya	قادسيّة	79;25	31;46	$\mathbf{P}_0\mathbf{V}$ فادسه, lat. $\mathbf{P}_0\mathbf{V}$ 0′ (due to slide) $\mathbf{T}_2$ 47′
A16	Hilla	الحلّة	79;10	32;10	lat. $\mathbf{P}_0\mathbf{V}$ 0′ (due to slide)
A17	Madāʾin	مدائن	80;20	33;10	lat. $\mathbf{P}_0\mathbf{V}$ 0′ (end of slide[+3], here or at one of the next two entries)
A18	Ahwaz	الاهواز	85; 0	30; 0	$\mathbf{T}_1\mathbf{F}_2$ entry inserted after Shiraz
A19	Shiraz	شيراز	88; 0	32; 0	$\mathbf{P}_0\mathbf{V}$ سبران, lat. $\mathbf{T}_2$ 30°
A20	Sabur	سابور	88;40	30; 0	$\mathbf{T}_1\mathbf{F}_2$ entry inserted before Shiraz, $\mathbf{T}_1\mathbf{F}_1\mathbf{P}_9$ شابور, $\mathbf{P}_0\mathbf{V}$ سانوز, long. $\mathbf{T}_2$ 0′
A21	Kirman	كرمان	100; 0	30; 0	long. $\mathbf{T}_1$ 105°, $\mathbf{F}_1\mathbf{P}_8$ 80° (undotted) $\mathbf{OT}_2$ 80° (dotted)
A22	Kabul	كابل	110; 0	28; 0	$\mathbf{P}_8\mathbf{P}_0\mathbf{V}$ بحابد $\mathbf{T}_2$ عاوند, long. $\mathbf{T}_2$ 61°, lat. $\mathbf{P}_8\mathbf{P}_0\mathbf{VT}_2$ 37;0
A23	Tarsus	طرسوس	67;40	37;15	$\mathbf{P}_9$ طرطوس, long. $\mathbf{F}_2\mathbf{O}$ 60°, lat. $\mathbf{P}_9$ 36° (corrected) $\mathbf{T}_2$ 45′
A24	Aleppo	حلب	71;00	35;50	lat. $\mathbf{F}_2$ 55′, $\mathbf{P}_9$ 36;0 (corrected)
A25	Manbij	منبج	63;45	35;30	$\mathbf{F}_1$ Homs حمص (but the coordinates are correct for Manbij), long. $\mathbf{P}_8\mathbf{P}_0\mathbf{VT}_2$ 15′, lat. $\mathbf{P}_9$ 36;10 (corrected) **O** 34;0
A26	Homs	حمص	71; 0	33;40	$\mathbf{F}_1$ Sarakhs سرحر (but the coordinates are correct for Homs), lat. $\mathbf{F}_2$ 0′

Column 2

	locality		long.	lat.	apparatus
B1	Raqqa	الرقّه	73;15	36; 0	$\mathbf{P_8}$ لرقه $\mathbf{T_2}$ مرقه
B2	Amid	آمد	75;15	38; 0	$\mathbf{P_9}$ امل
B3	Harran	حرّان	77; 0	37; 0	long. **OV** 76;0
B4	Hama	حماه	72;40	36; 0	$\mathbf{P_9P_8P_0VT_2}$ حما
B5	Mosul	(ال)موصل	78; 0	36;30	–
B6	Antioch	انطاكيه	79; 0	35;30	$\mathbf{P_9}$ انطاله
B7	Hulwan	حلوان	81;45	34; 0	$\mathbf{P_8P_0VT_2}$ Shahrazur (beginning of slide[+1] of place names); **K** 87;0 / 35;0 (due to the slide in $\mathbf{P_8}$)
B8	Shahrazur	شهرزور	80;20	37;15	$\mathbf{P_8P_0VT_2}$ Nahawand (due to slide), $\mathbf{F_2T_2C}$ شهرور $\mathbf{OP_8P_0V}$ شهروز **J** شهرروز, long. $\mathbf{F_2J}$ 100°, lat. $\mathbf{T_2}$ 45′; **K** Shahrud, 81;45 / 34;0 (due to the slide in $\mathbf{P_8}$)
B9	Nahawand	نهاوند	82; 0	36;10	$\mathbf{P_8P_0VT_2}$ Hamadan (due to slide); **K** 80;20 / 37;15 (due to the slide in $\mathbf{P_8}$)
B10	Hamadan	همذان	83; 0	36;10	$\mathbf{P_8P_0VT_2}$ Qum (due to slide), lat. $\mathbf{P_8T_2}$ 37;0 $\mathbf{P_0V}$ 0′; **K** long. 82;0 (due to the slide in $\mathbf{P_8}$, lat. correct by coincidence)
B11	Qum	قم	80;15	34; 0	$\mathbf{P_8P_0VT_2}$ Hulwan (end of slide[+1] of place names), long. $\mathbf{P_8T_2}$ 87;0 $\mathbf{P_0V}$ 84;15, lat. $\mathbf{P_8P_0VT_2}$ 35°; **K** 83;0 / 37;0 (due to the slide in $\mathbf{P_8}$)
B12	Sawa	ساوه	87; 0	35; 5	**V** ساده **CJ** ساده, lat. $\mathbf{F_2}$ 34;5, $\mathbf{P_8P_0VT_2}$ 34;0
B13	Isfahan	اصفهان	84;40	32; 0	$\mathbf{OP_8P_0VT_2C}$ اسفهان
B14	Rayy	الريّ	85; 0	35;30	lat. $\mathbf{T_2}$ 0′
B15	Qazwin	قزوين	85; 0	37; 0	–
B16	Abhar	ابهر	85; 0	36; 0	$\mathbf{F_2}$ الهد **O** الهري, long. **K** 84°
B17	Zanjan	زنجان	84; 0	36; 0	$\mathbf{P_9OP_8P_0VT_2C}$ زيحان $\mathbf{F_2}$ ابحان, long. $\mathbf{OP_8T_2}$ 85°
B18	Daylam	الديلم	85; 0	38; 0	$\mathbf{P_8}$ الرسلبه $\mathbf{P_0V}$ الرسبله $\mathbf{T_2}$ الرمله
B19	Ruyan	رويان	86;35	37;10	$\mathbf{P_9}$ رونان **O** روسانه $\mathbf{P_8P_0VT_2}$ روسان, long. **O** 30′, lat. $\mathbf{P_9}$ 0′
B20	Sariya	سارية	87;50	38; 0	long. $\mathbf{F_2}$ 55′
B21	Damghan	دمغان	88;37	37; 0	$\mathbf{T_1P_9}$ دامغان, $\mathbf{F_2}$ دابعان
B22	Bistam	بسطام	89;15	35;40	$\mathbf{F_2}$ بطام $\mathbf{P_8P_0VT_2}$ اسطام, long. **V** 55′
B23	Astarabad	استراباد	89;50	38;45	**O** استارياب $\mathbf{P_8}$ سيراز $\mathbf{P_0V}$ شيراز $\mathbf{T_2}$ سيزاز **CJ** سيرات, long. $\mathbf{F_2}$ 55′, lat. $\mathbf{P_8P_0VT_2}$ 15′
B24	Jurjan	جرجان	90; 0	36;50	$\mathbf{F_2}$ (؟) خرطان $\mathbf{P_8P_0VT_2}$ اباد, long. $\mathbf{P_8T_2}$ 95°, lat. $\mathbf{F_2}$ 55′; **K** Anar/Abad?, 92;0 / 37;0 (coordinates of Tus, due to distortion of entry B23)
B25	Tus	طوس	92; 0	37; 0	$\mathbf{P_8P_0VT_2}$ Jurjan **J** جرحرن; **K** om. entry
B26	Nishabur	نيسابور	92;30	36;21	$\mathbf{T_2}$ نيابور, long. $\mathbf{OP_0V}$ 0′, lat. **O** 37°

Column 3

	locality		long.	lat.	apparatus
C1	Sarakhs	سرخس	93;20	36; 0	$\mathbf{F_1F_2}$ سرحر ($\mathbf{F_1}$ with coordinates for Homs, see above) $\mathbf{P_8}$ حرحسر (?) $\mathbf{P_0V}$ جرجس $\mathbf{T_2}$ حرحر
C2	Marv	مرو	94;20	37;30	**O** مرف $\mathbf{P_8}$ Balkh crossed out $\mathbf{P_0V}$ مرد $\mathbf{T_2}$ بكح
C3	Bukhara	بخارا	97;20	36;50	$\mathbf{OT_2}$ بخاره, long. **O** 96°, lat. $\mathbf{F_2}$ 55′
C4	Balkh	بلخ	98;30	38;40	lat. $\mathbf{P_9F_1}$ 33°; **K** om. entry
C5	Samarqand	سمرقند	99;30	36;30	lat. $\mathbf{T_2}$ 7′ **CJ** 4′
C6	Khwarizm	خوارزم	101;50	42;10	**O** حوار $\mathbf{T_2}$ خورزم, long. $\mathbf{F_1}$ 81° (undotted), $\mathbf{P_9OP_8P_0VT_2}$ 81° (dotted) $\mathbf{F_2}$ 55′ $\mathbf{P_8P_0VT_2}$ 30′
C7	Darband	دربند	83; 0	42;05	–
C8	Tiflis	تفليس	83; 0	43; 0	lat. $\mathbf{T_1F_2}$ 33° **O** 38° $\mathbf{T_2}$ 83° **CJ** 88°
C9	Kanja	كنجه	81;30	41; 0	$\mathbf{P_8T_2}$ طنجه
C10	Baylaqan	بيلقان	82;30	38; 0	**O** سلقان **V** صلقان $\mathbf{T_2}$ تلقان, long. $\mathbf{T_1O}$ 81°, lat. $\mathbf{P_0V}$ 33°
C11	Bardhaah	برد ع	84; 0	43; 0	$\mathbf{P_0V}$ بروح, long. $\mathbf{T_1O}$ 81°, lat. $\mathbf{F_1CJ}$ 48°
C12	Shirwan	شروان	84; 0	35; 0	$\mathbf{F_1}$ شروار $\mathbf{F_2}$ سرفان $\mathbf{P_8P_0V}$ شيروان, long. $\mathbf{P_0V}$ 85°
C13	Tabriz	تبريز	83;10	37;30	$\mathbf{T_2}$ Maragha (beginning of slide[+1] of place names); $\mathbf{P_0}$ place name partially erased (...سرا ?) **V** سرليف, long. $\mathbf{F_1CJ}$ 88°, lat. **K** 10′
C14	Maragha	مراغة	83;20	37;25	$\mathbf{T_2}$ Ardabil (due to slide); lat. $\mathbf{P_9}$ 20′ modified to 24 or 25?
C15	Ardabil	اردبيل	83; 0	38; 0	$\mathbf{T_2}$ Marand (due to slide); $\mathbf{P_0V}$ اردنيل $\mathbf{T_2}$ اردبفد
C16	Marand	مرند	83;10	37;15	$\mathbf{T_2}$ Salmas (due to slide); $\mathbf{T_2}$ مراند, lat. **OJ** 45′
C17	Salmas	سلماس	83;10	38;30	$\mathbf{T_2}$ Khuway (due to slide); $\mathbf{P_8P_0VT_2}$ سلاماس, lat. $\mathbf{P_8P_0V}$ 33° $\mathbf{T_2}$ 7′
C18	Khuway	خوي	82; 0	38;30	$\mathbf{T_2}$ Akhlat (due to slide)
C19	Akhlat	اخلاط	74;50	39;50	$\mathbf{T_2}$ Arzan Rum (due to slide); $\mathbf{T_1F_2}$ خداك **O** حدال $\mathbf{P_8P_0VT_2}$ خلاط, long. $\mathbf{F_2}$ 55′, lat. $\mathbf{P_9}$ 19° $\mathbf{F_2}$ 55′
C20	Arzan Rum	ارزان الروم	76; 0	39; 0	$\mathbf{T_2}$ Arzingan (due to slide); $\mathbf{F_2OP_8P_0VT_2}$ ارز الروم, lat. $\mathbf{P_8P_0VT_2}$ 44′ **K** 45′
C21	Arzingan	ارزنجان	74; 0	38; 0	$\mathbf{T_2}$ Siwas (due to slide); **V** ارزنجانه $\mathbf{T_2}$ ارنجان **CJ** om., long. **V** 75°, lat. $\mathbf{P_8P_0VT_2}$ 37°
C22	Siwas	سيواس	71; 0	39; 0	$\mathbf{T_2}$ Malatiya (due to slide); $\mathbf{P_9}$ om. entry, lat. $\mathbf{P_8P_0V}$ 30° $\mathbf{T_2}$ 37°
C23	Malatiya	ملطية	71; 0	39; 0	$\mathbf{T_2}$ Qaysariyya Rum (due to slide); $\mathbf{P_8T_2}$ ملاطيه
C24	Qaysariyya Rum	قيصريّة	69; 0	38;30	$\mathbf{T_2}$ Konya (end of slide[+1] of place names); **O** قيساريّه $\mathbf{F_1T_2}$ قيسربه, lat. $\mathbf{P_8P_0VT_2C}$ 2′
C25	Aqsaray	اقسرا	68; 0	38; 0	$\mathbf{P_8P_0VT_2}$ om. entry (or mixed up with Konya), $\mathbf{F_2}$ اقصرل (?)
C26	Konya	قونيه	65; 0	38; 0	$\mathbf{P_8T_2}$ قومه $\mathbf{P_0V}$ قوم, $\mathbf{P_8P_0V}$ coordinates for Aqsaray, $\mathbf{T_2}$ coordinates for Qaysariyya (due to slide); **K** reads *Qūma* as *Aqsarā*, presumably due to the correct coordinates.
C27	Constantinople	قسطنطنيّة	59;50	45; 0	$\mathbf{P_0V}$ قسطنطنه **CJ** قسطنطينيّه, long. $\mathbf{F_1}$ 65° (?) (from Konya?) $\mathbf{P_8}$ degrees (؟) فك $\mathbf{P_0V}$ degrees فها $\mathbf{F_2}$ 55′ **O** 0′, lat. $\mathbf{P_9}$ 41;0 (later modification) $\mathbf{F_1}$ 59;50 (from longitude)

4. Classifying the Errors in the Table

Variants in the place names in the geographical table from the *Shāmil Zīj* are rarer than those in the coordinates. It is often quite obvious from the omission of diacritical dots and ambiguous shapes of certain letters when a scribe did not actually know the localities. In some cases we see clear mistakes such as عند for عدن Aden (A3), the various forms for Kabul (A22) given in Table 1, Ṭanja طنجة for Kanja كنجة (C9), سلقان and صلقان for بيلقان Baylaqan (C10), etc. In some other cases we find slightly different but acceptable spellings of well-known place names, such as صنعا and صنعه for Sanaa (A2), حما and حماه for Hama (B4), or اسفهان and اصفهان for Isfahan (B13). These could have been adjusted independently by any scribe, possibly depending on his or her philological background, and therefore coincidence of the way of writing does not need to point to a close relationship of the manuscripts concerned. As mentioned in Section 3, I have not generally indicated additions or omissions of the definite article *al-* in certain place names in the apparatus of the table.

For most of the localities in the table it is relatively easy to decide on the correct values of the coordinates. For these, a clear majority of our ten witnesses are in agreement, and most of the deviating digits are obvious scribal errors. A list of common scribal errors can be found in Table 2. In this table *t* stands for a number of tens (possibly also none) and *u* for a number of units not equal to zero. For example, the scribal error denoted by 1u–5u indicates all confusions 11–51, 12–52, ..., 19–59 and the scribal error t2–t4 includes the confusions 2–4, 12–14, 22–24, ... The somewhat less common and more specific scribal errors such as the confusion of 0 and 8 (especially in sources **CJ**) and 0 and the letter *ʿayn* (in source **V**) are not included in the table. The same holds for the confusion of digits such as 0 with 30 and 30 with 40 and several others that occur again and again in geographical tables. It is less likely that these were the result of a misreading of the correct digit; instead they may be the result of miscopying from a different entry in the table, or, whenever a digit is given as zero or is entirely omitted, from truncation or rounding of values given to a higher precision. Since the possibilities for such mistakes are almost infinite, I have not attempted to explain these unless other sources provide evidence for their likeliness.[26]

[26] The eleven witnesses for the geographical table from the *Shāmil Zīj* that I have used show seven instances in which an original digit 0 was written incorrectly as 4, 5, 8, 10, 30 or 44 (of these errors only the confusion with 5 is a common scribal one). In eleven cases were original digits 10, 15, 30 and 40 minutes written as 0, which in no case can be considered a common scribal error.

scribal errors in units (t ≥ 0)			
t 0 – t 2, mainly:			
ك	20 – 22	كب	
ل	30 – 32	لب	ǀ
	t 0 – t 5 (t≠1)		ǀǀǀǀǀ
ℨ	0 – 5	ه	ǀ
ن	50 – 55	نه	ǀǀǀǀǀ ǀǀǀǀǀ
t 0– t 7, mainly:			
م	40 – 47	مر	
س	60 – 67	سر	ǀ
ف	80 – 87	فر	ǀ
ٮ	t 2 – t 4	ٮد	
ٮ	t 2 – t 7	ٮر	ǀǀ
ٮح	t 3 – t 4	ٮد	
ٮح	t 3 – t 8	ٮح	ǀǀǀǀǀ ǀǀǀǀǀ ǀǀǀǀǀ ǀǀ
ٮد	t 4 – t 5	ٮه	ǀǀǀǀǀ ǀ
ٮد	t 4 – t 6	ٮو	ǀ
ٮد	t 4 – t 7	ٮر	
ٮو	t 6 – t 7	ٮر	ǀǀǀǀǀ ǀǀǀǀ

scribal errors in tens (u > 0)			
ٮد	1u – 3u	لد	ǀǀ
ٮد	1u – 4u	مد	
ٮه	15 – 45	مه	ǀǀǀǀǀ ǀ
ٮد	1u – 5u	ند	ǀǀǀ
كد	2u – 3u	لد	
لد	3u – 5u	ند	
مد	4u – 5u	ند	ǀ
فد	8u – 5u	ند	ǀǀ
صد	9u – 7u	عد	ǀ
فد	8u – 10u	قد	ǀǀǀǀ
other common scribal errors			
ℨ	0 – 31	لا	
د	4 – 20	ك	
د	4 – 30	ل	ǀ
ز	7 – 30	ل	ǀ
ز	7 – 40	م	
ز	7 – 50	ن	
ط	9 – 20	ك	ǀǀ
ط	9 – 21	كا	
ل	30 – 50	ن	ǀ

Table 2: Common scribal errors in Arabic and Persian numerical tables in *abjad* notation. Note that the forms of the letters as printed here in some cases deviate from those written in the manuscripts, and that the probability of certain errors further depends on the particular type of script (cf. Irani, 'Arabic Numeral Forms'). Diacritical dots have been omitted from letters that often do not carry them in the manuscripts, especially: final ٮ = 2, ح = 3, ر = 7, initial or medial ٮ = 10. The examples for errors of the form t2–t4, etc. are given with an initial undotted *yā'*, the examples for errors of the form 1u–3u etc. with a final *dāl*. The ticks after each error indicate the number of occurrences in the geographical table in the Shāmil Zīj. For some general forms particular occurrences that are especially common have been listed and counted separately (for example, 0–5 and 50–55 for t0–t5).

In Section 5, I will briefly discuss the usefulness of a frequency distribution of scribal errors in astronomical tables for judging the likeliness that one table is dependent on another. As an example I have indicated by tally marks after each possible error in Table 2 its number of occurrences in the geographical table from the *Shāmil Zīj*. Because of the clear interdependence of the manuscripts (see further below), the occurrence of the same error in multiple manuscripts is counted only once. The largest frequencies are found for scribal errors that are also known from general experience with numerical tables to be among the most common ones, namely t3–t8 and t6–t7. However, some other errors known to be common do not show up here so clearly due to the special characteristics of the table. In particular, the vast majority of all numbers of minutes in the coordinates are multiples of 10 and/or 15,[27] while the degrees of the longitudes lie overwhelmingly between 60 and 99 (leaving only three values between 50 and 60 and three values above 100) and those of the latitudes exclusively between 13 and 45. As a result, such common confusions as 1u–5u, t2–t4, t3–t4, t4–t7, 40–47 and 7–50 are found only rarely in the geographical table from the *Shāmil Zīj*, whereas 1u–4u only appears in the form 15–45. Also peculiarities of the handwriting of the manuscripts or their (often unknown) precursors will influence the probability of certain scribal errors. Thus all ten errors 50–55 are due to source $\mathbf{F_2}$, whereas the confusion of digits 0 and 3, which is not included in the table, appears very frequently in, for example, Abū l-Fidāʾ's *Taqwīm al-buldān*.[28]

For a significant number of localities in the geographical table from the *Shāmil Zīj*, the errors in some of the manuscripts cannot so easily be recognised as scribal errors. In these cases there are multiple plausible scribal variants or even on first sight inexplicable variants and no clear majority of the sources in favour of any one of them. Examples are the wide variety of longitude and latitude values for Qum (B11), even after correction of the slide that will be discussed below, the differing latitudes for Tiflis (C8), and a range of significant differences on which we will see that the eleven witnesses are divided into two groups of five and six manuscripts.

A type of scribal error that may cause great problems for a reliable transmission of coordinates is what the late Fritz S. Pedersen dubbed a 'slide':[29] while copying a row or column of tabular values or digits, the scribe skipped or repeated one or more items. As a result, all following values or digits in the row or column concerned would 'slide' by a number of columns or rows until the scribe discovered the mistake and continued with the correct values. In most manuscripts of mathematical tables slides allow us to see that scribes generally

[27] The minutes of only five coordinates in the geographical table in the *Shāmil Zīj* are a multiple of 5 which is *not* a multiple of 10 and/or 15. Furthermore, the table contains three 'irregular' numbers of minutes that can nevertheless be confirmed from most of the witnesses, and even on the basis of other sources, namely for Qadisiyya (A15), Damghan (B21) and Nishabur (B26). 74 of the 168 coordinates (i.e., nearly half of the total) have a number of minutes equal to zero.

[28] For the historian, geographer and gouvernor-prince Abū l-Fidāʾ (1273–1331), see the *DSB* article by Juan Vernet, the *EI²* article by H. A. R. Gibb, or the *EI³* article by Daniella Talmon-Heller. His *Taqwīm al-buldān* is particularly important for the history of geography because it systematically compares the information about many hundreds of localities on the basis of four or five earlier sources, of which some very important ones are now lost (see further Section 5). The *Taqwīm al-buldān* was edited in Reinaud and MacGuckin de Slane, *Géographie d'Aboulféda. Texte Arabe* and translated in Reinaud and Guyard, *Géographie d'Aboulféda. Traduite*.

[29] See for example, Pedersen, *The Toledan Tables*, vol. I, pp. 30–32.

	place names	*correct*		**P_0V**		
A12	Baghdad	80;00	33;25	80;10	33;46	
A13	Wasit	81;30	32;20	81;30	32;10	
A14	Basra	84;00	31; 0	84; 0	31;10	
A15	Qadisiyya	79;25	31;46*	79;25	31; 0	* 47′ in **CJO**
A16	Hilla	79;10	32;10	79;10	32; 0	
A17	Madāʾin	80;20	33;10	80;20	33; 0	
A18	Ahwaz	85;00	30; 0	85; 0	30; 0	
A19	Shiraz	88;00	32; 0	88; 0	32; 0	
A20	Sabur	88;40	30; 0	88;40	30; 0	

Table 3: Slide of the minutes of latitude in sources **P_0V** (slid values underlined).

	place names		coordinates	
	$T_1P_9F_2O$	**$P_8P_0VT_2CJ$**		
B7	Hulwan	Shahrazur	81;45	34; 0
B8	Shahrazur	Nahawand	80;20	37;15
B9	Nahawand	Hamadan	82; 0	36;10
B10	Hamadan	Qum	83; 0	36;10
B11	Qum	Hulwan	80;15	34; 0

Table 4: Slide of five place names in sources **$P_8P_0VT_2CJ$** (differences underlined).

copied tables column by column. Especially in tables with slowly increasing tabular values the slides of values in a column would only be discovered close to the end of the column.

Among the manuscripts of the geographical table in the *Shāmil Zīj* we find three examples of slides, in one case of digits, in the two other cases of place names (or, theoretically but much less plausibly, of the longitudes *and* latitudes corresponding to these place names). Table 3 illustrates the upward slide over three rows of the minutes (but not the degrees) of the latitudes of the localities Baghdad (A12) to Madāʾin (A17, Ctesiphon) in sources **P_0V**. This slide is relatively easy to recognize because in these witnesses the highly uncommon number of minutes '46' appears for Baghdad instead of for Qadisiyya. Table 4 illustrates an apparent slide over one row of the place names for Hulwan (B7) to Qum (B11). In this case the sources are more or less equally divided over the two variants and a decision on the correct form cannot be made without further information. We will later see that the scribe of a common ancestor of sources **$P_8P_0VT_2CJ$** must first have skipped Hulwan and when he noticed this mistake four rows further down, apparently 'corrected' it by inserting Hulwan with the coordinates of Qum.[30]

30 In mathematical tables the 'lost' entries at the end of an upward slide were usually filled up with the correct ones, which would thus be repeated from the rows above. Apparently this was not considered an appropriate strategy for a slide in the place names in a geographical

	$\mathbf{T_1P_9F_2O}$				$\mathbf{P_8P_0VT_2CJ}$			
	place names		coordinates		place names		coordinates	
B22	Bistam	بسطام	89;15	35;40	Astam	اسطام	89;15	35;40
B23	Astarabad	استراباد	89;50	38;45	Shiraz*	شیراز	89;50	38;15
B24	Jurjan	جرجان	90;00	36;50	Anar	اباد	95;00**	36;50
B25	Tus	طوس	92;00	37;00	Jurjan	جرجان	92;00	37;00

* سیزاز in $\mathbf{T_2}$, سیزات in **CJ** ** 90;0 in $\mathbf{P_0V}$

Table 5: Two significantly different versions of four rows near the bottom of the 2nd column (deviations in the second version underlined).

A set of remarkable differences extending over four consecutive lines can be found near the bottom of the second column in six of the ten witnesses (see Table 5). Although the coordinates are basically in agreement and contain only two scribal mistakes, witnesses $\mathbf{T_1P_9F_2O}$ on the one hand and $\mathbf{P_8P_0VT_2CJ}$ on the other here partially give entirely different localities (note that the second column of the table is missing from $\mathbf{F_1}$). A plausible explanation for this confusion that requires some imagination, is that in one early manuscript Astarabad (B23) was written with a rather large vertical descent, for example:

ا سر اباد

In the common ancestor manuscript of $\mathbf{P_8P_0VT_2CJ}$, this might have led to the following mistakes: the initial *alif* was prepended to the preceding entry Bistam (B22) in order to produce اسطام Astam; the middle part سر was restored to a well-known locality, namely Shīrāz, although this city already appears in the first column; the final اباد became a separate locality with the coordinates of the next one, Jurjan (B24); Jurjan received the coordinates of Tus (B25), and Tus was discarded. Having only the manuscript $\mathbf{P_8}$ at his disposal, Kennedy could not do any better than identifying Abād with Anār, formerly Abān, in the province of Kirman (mentioned in Le Strange, *The Lands of the Eastern Caliphate*, p. 286), which does not appear in any other of the sources in K&K.

Tables 4 and 5 illustrate only two of a rather large number of cases in which witnesses $\mathbf{T_1P_9F_1F_2O}$ (from here on to be referred to as Group A) differ significantly from manuscripts $\mathbf{P_8P_0VT_2CJ}$ (Group B). Table 6 lists all of these cases. It turns out that only incidentally, especially where the differences concern place names, is it possible to decide which of the two groups provides the better variant on the basis of the geographical table in the *Shāmil Zīj* alone. As for the other non-trivial cases discussed above, also here a comparison with further geographical data from Islamic sources is necessary in order to make

table, although the insertion of the omitted place name four rows further down can hardly be considered a better one.

localities		*Group A*	*Group B*
entire table		—	columns filled only with *madīna*
third column		27 localities	26 localities (Aqsaray omitted)
A4	Oman	long. 94;30	long. 74;30
A7	Egypt	lat. 29;45	lat. 29;47 ($\mathbf{P}_8\mathbf{P}_0\mathbf{VT}_2$) or 29;40 (**CJ**)
A8	Alexandria	long. 60;30	long. 65;30
A12	Baghdad	long. 80;00	long. 80;10
A24	Kabul	كابل	ىحابد or غاوند
		lat. 28;00	lat. 37;00
A27	Manbij	long. 63;45	lat. 63;15
B7	Hulwan to B11 Qum	—	upward slide of place names
B12	Sawa	lat. 35;5*	lat. 34;0
B18	Daylam	الديلم	الرسله ($\mathbf{P}_8\mathbf{P}_0\mathbf{V}$) or الرمله ($\mathbf{T}_2\mathbf{CJ}$)
B22	Bistam to B25 Tus	—	name Astarabad mutilated
B23	Astarabad / Shiraz	lat. 38;45	lat. 38;15
C1	Sarakhs	سرخس*	حرحس or حرحر
C6	Khwarizm	long. 101;50*	long. 81;30
C17	Salmas	سلماس	سلاماس
C20	Arzan Rum	lat. 39;0	lat. 39;44 (**K&K** 39;45)
C21	Arzingan	lat. 38;0	lat. 37;0
C22	Siwas	lat. 39;0	lat. 37;0 or 30;0
C23	Qaysariyya Rum	lat. 38;30	lat. 38;2
C25	Aqsaray	اقسرا	قومه (presumably for Konya)
C26	Konya	65;0 / 38;0	om. (or combined with previous line?)

Table 6: Significant differences in place names and coordinates between Group A (manuscripts $\mathbf{T}_1\mathbf{P}_9\mathbf{F}_1\mathbf{F}_2\mathbf{O}$) and Group B (manuscripts $\mathbf{P}_8\mathbf{P}_0\mathbf{VT}_2\mathbf{CJ}$). The presence of further scribal errors that are not essential for the differences between the two groups is indicated in this table by an asterisk, but these errors are further ignored. They are, of course, included in the apparatus to the edition of the table in Table 1.

plausible judgements about the correctness of the variants. In the next section I will therefore introduce in more detail the Kennedys' *Geographical Coordinates of Localities from Islamic Sources* as well as the computer program that I have written on the basis of its raw data.

5. The Kennedys' Database of Islamic Geographical Coordinates

In 1987, Edward S. Kennedy and his wife Mary Helen Kennedy published their *Geographical Coordinates of Localities from Islamic Sources* (Frankfurt: Institute for the History of Arabic-Islamic Sciences, abbreviated as K&K). This book includes a total of more than 13,000 entries from 74 geographical tables and several other types of Islamic sources covering more than 2500 different localities. Every entry consists of:

- the place name in a standardised modern form;

- the Arabic form of the place name as found in the original Arabic sources (as opposed to translated and Latin sources);
- a numerical code and a three- or six-letter abbreviation for the source;
- a reference to the source usually consisting of the page or folio, column and line number at which the locality is found;
- the longitude and the latitude of the locality in degrees and minutes; and
- a field with brief comments.

The book contains four different listings of the entries, namely:

1. an alphabetical one by place name (pp. 1–386, with entries for each locality ordered by source code, i.e., roughly chronologically);
2. a listing by source (pp. 387–594, with the sources ordered chronologically and the place names for each source alphabetically);
3. a listing by increasing longitude (pp. 595–655, with abbreviated entries for each longitude ordered by increasing latitude); and
4. a listing by increasing latitude (pp. 657–709, with abbreviated entries for each latitude ordered by increasing longitude).

The Kennedys presented a measure for the dependence of a source A on a source B defined as the percentage of latitude values in A that is also found in B for the same localities. They did not include longitudes in this measure because of the different base meridians that these may refer to. They also did not consider the possibility of scribal errors. For example, the latitude value 38;25° for Baghdad in our witness **J** of the geographical table in the *Shāmil Zīj* (source ABD in K&K) is undoubtedly a scribal error for the common 33;25°, but would not contribute to the Kennedys' measure of dependence of **J** on any source with latitude 33;25°.[31]

In the early 1990s I received from Professor Kennedy a complete dump of the DBASE3 database in which the geographical data were stored at the time K&K was published. Since the collection of data was started long before computers became as versatile as they are now, the only characters used in the original data sets and in the book are capital letters, digits, periods and commas. Thus doubtful readings are indicated by a Q, standing for a question mark. Arabic place names (in the book reproduced in Arabic script) are in the database encoded by means of the letters of the alphabet and the 10 digits. For

[31] In fact, K&K gives the latitude of Baghdad in source ABD as 33;25° although it is unambiguously written as 38;25°. However, the value 38;25° is assigned to Baghdad for source GT2 (a manuscript from Gotha). Some further exploratory statistical analysis on the data of K&K were carried out in Regier, 'Kennedy's Geographical Tables'.

example, the letter C stands for *ṣād*, X for *khāʾ*, the letter O or the digit 0 for undotted medial *bāʾ*, *tāʾ*, *thāʾ*, *nūn* or *yāʾ*, 1 for *ghayn*, 4 for *ḍād*, etc.[32]

In 1995, I programmed in Turbo Pascal a first version of an application KaK that displays the data from K&K and allows sorting in the same four ways as in the listings in the book (and in addition by decreasing longitudes and latitudes). In order not to make standard operations such as sorting and searching too time consuming, I made it possible to load into memory only the data from particular groups of sources, e.g., early Islamic ones, late Persian ones, western Islamic ones, or instruments. Consecutive selections of the data in memory could be made by specifying the sources, place names and ranges of longitudes and latitudes to be included or excluded. In this way it became possible, for example, to select all localities from the *zīj*es of al-Battānī, Ibn Yūnus and al-Bīrūnī with longitudes between 75 and 85° and latitudes between 30 and 35°, sorted first by longitude and then by latitude.

At around the same time, Mercè Comes took over the geographical coordinates project from the Kennedys with as main purposes to convert the DBASE3 database into a more modern format, to replace the limited set of characters by a more extensive one and add Arabic transcriptions for the place names, to correct the existing entries for errors that had crept in during the process of reading the sources, and to expand the database with further sources, especially also those from the various western Islamic *zīj*es that her colleagues in Barcelona had explored. Unfortunately, Comes's untimely death in 2010 did not allow her to finish this huge project. The partially corrected data, with a number of additional sources, are now available in Microsoft Access format, but are not yet ready for publication.

Since 2012, I have continued to work on my program KaK on and off. Most importantly, I made it possible to display the longitudes from all sources with respect to the Fortunate Isles by adjusting them for their particular base meridian. Converted longitudes are indicated in a slightly different colour, and comparison with modern longitudes measured from Greenwich is made easier by making it possible to adjust these in such a way that Baghdad receives a longitude of exactly 80;0° (i.e., by adding 35;34°). Making use of these adjustments, I implemented a function for comparing any two sources, displaying the differences either in alphabetical order of place name or in the order in which the localities appear in one of the sources. I have also experimented with a measure for the dependence of geographical sources that compares the degrees and minutes of both latitude and longitude values and furthermore also attaches a weight to corresponding coordinates that differ only by a plausible scribal error. As an example, the above-mentioned pair of latitude values

[32] These conventions, together with the developments in the early stage of the project, are described in Haddad and Kennedy, 'Geographical Tables'.

38;25° and 33;25° for Baghdad might be attached a weight of 0.8 or 0.9 (as compared with 1.0 if the values were equal). I have not yet attempted to apply such weights consistently; they could be based on frequency counts of scribal errors in a large number of sources (cf. Table 2), possibly to be distinguished by certain categories such as western and eastern Islamic manuscripts. Needless to say, a database containing multiple witnesses for a large number of Islamic mathematical, astronomical and geographical tables would enormously facilitate carrying out such frequency counts.

I also added to the program KaK the entries from the original database for the headers and the cross-references from K&K, so that an export to a text file of the whole database, sorted first by numerical source code and then alphabetically by place name, produces exactly the alphabetical listing from the book. The headers and cross-references also make it possible to select, for example, all entries for Constantinople by searching for 'Istanbul', or to add localities to the current selection that appear in displayed headers with the indication 'cf.' or 'see also' by invoking the command 'Follow'. I systematized and cleaned up the references for each source, so that the entries from a particular source cannot only be displayed in alphabetical order of place name (as in the book), but also in the order in which they appear in the source. Finally, I started to make corrections to the coordinates as published in the book, in several cases by using multiple manuscripts of the sources concerned, and added several new geographical tables, such as those from the Leipzig manuscript of the *Mumtaḥan Zīj* (based on al-Battānī), the Salar Jung Museum (Hyderabad) manuscript of the *ʿAlāʾī Zīj*, and the huge Timurid table (TMR) discovered and edited by David A. King.[33] KaK is still a DOS program in a beta version, but thanks to FreePascal can also be compiled to an executable that runs on 32bit versions of Windows 7 and later. This I am happy to make available on request. Obviously, inclusion of the geographical data in a larger database of astronomical data and re-programming of the functionality of KaK in a platform-independent, mouse-driven application that accesses such a database is a desideratum.

Although my more comprehensive measure of dependence between geographical sources explained above sharpens the Kennedys' results (for example, the measure for the basically identical sources SML (*Shāmil Zīj*) and QIR (Qyriacus) increases from K&K's 68% and 71% to around 95%), the basic conclusions about dependences and the identification of the three main families of geographical sources presented on pp. xl–xliii of K&K remain valid. The Kennedys' conclusions that the likelihood of scribal errors in geographical data that were copied over and over again is particularly large, is also confirmed by my edition of the geographical table in the *Shāmil Zīj* (as well as by my edition of the table from the *Jāmiʿ Zīj* by Kūshyār ibn Labbān, recently published in the

[33] King, *World-Maps*, Section 3.3, pp. 149–61 and Appendix A, pp. 456–77.

book series *Ptolemaeus Arabus et Latinus*,[34] and by the experiences described by David A. King in his *World-Maps*). For this reason it is not possible to take the (presumably) earliest source from each of the three main traditions that Kennedy established (to which one may add Ptolemy's *Handy Tables* and *Geography* because of the influence they had on certain traditions of Islamic coordinates for particular regions and localities) and use those as reference points for all other Islamic sources. Rather, it is necessary to look at the entire evidence of coordinates for each locality in order to determine whether the surviving witnesses of the founding source for each tradition do not already include scribal errors, and which scribal errors that occurred in the transmission of the coordinates became accepted and were included in later dependent sources as well. By thus analysing the data for all important localities, one may obtain a reference table of geographical coordinates in the three main Islamic traditions to which the coordinates in all other sources may be compared, and which may hence be used to make reasonable decisions on the correct coordinates in cases where the sources yield multiple possibilities. In the following section, I will attempt the compilation of such a reference table for all localities included in the geographical table in the *Shāmil Zīj*.

6. Creating a Reference Table for the Main Islamic Geographical Traditions

The main purpose of this section is to establish a geographical reference table, presented as Table 8, showing for all localities appearing in the *Shāmil Zīj* the coordinates in the three main Islamic traditions as well as in some smaller ones. For the purpose of convenient comparison, all longitudes are given with respect to the base meridian of the Fortunate Isles. This means that 10° has been added to the longitudes from all sources that have the Western Shore as their base meridian.[35] Most of the abbreviations for the sources used in the table are briefly introduced below in the description of the traditions.[36] Since only less than half of the localities from the *Shāmil Zīj* is found in Ptolemy's *Geography* (PTO) or *Handy Tables* (HTP), and Ptolemy's coordinates were in

[34] See van Dalen, *Ptolemaic Tradition*, Section IV.13, esp. pp. 508–09.

[35] Cf. footnote 10. The possibility of different underlying meridians needs to be borne in mind in particular when it comes to judging the possibility of scribal errors in the coordinates. For example, the frequent confusion of degrees of longitude of the forms 1u and 5u (cf. Section 4) may be visible in the reference table as a confusion of longitudes 2u and 6u if the underlying sources have the Western Shore as their base meridian.

[36] Further information on these sources may be found in Kennedy and Kennedy, *Geographical Coordinates*, pp. xv–xxxvii. Note that, besides seven new sources, I use the following abbreviations different from those in K&K: ATW for ATH FID, BIRF for BIR FID, and SNJ for entries confirmed by SNB, SNH and SNS (all three conventions as in King, *World-Maps*), MAM for entries confirmed by KHU, KHZ, RES and SUH, DIM for QBL, WAB for MUN and MOS for ABD (i.e., witness **J** for the table from the *Shāmil Zīj*).

only very few cases taken over by Islamic geographers, I have here omitted the data from Ptolemy's works. Whenever coordinates in Islamic sources are equal, or close, to Ptolemy's, this will be mentioned in the comments to the reference table.

The three main Islamic traditions of geographical coordinates as they were already established by the Kennedys are the following:

1. The generic abbreviation MAM stands for the results of the geographical survey carried out under the Abbasid caliph al-Maʾmūn (r. 813–833) with the purpose of creating a world map. The largest and presumably earliest set of coordinates from this survey is contained in KHU, the *Kitāb Ṣūrat al-arḍ* by al-Khwārizmī. KHZ is a table found together with treatises attributed to al-Khwārizmī in MS Istanbul, Süleymaniye Kütüphanesi, Ayasofia 4830. RES, the *Kitāb Rasm al-rubʿ al-maʿmūr*, is said by Abū l-Fidāʾ (1273–1331) to have been translated from Greek into Arabic under al-Maʾmūn, but turns out to be another name for KHU or the corresponding world-map. SUH, the *Kitāb ʿAjāʾib al-aqālim al-sabʿa* by Suhrāb or Serapion (*c.* 930) is a reworking of KHU with some significant differences in the coordinates. K&K also includes several dozens of variant readings for MAM as found in Nallino's edition of al-Battānī's *zīj* and his article on al-Khwārizmī's geography, as well as in Honigmann's *Die sieben Klimata*.[37] For many localities the four sources that constitute the tradition of MAM in the reference table agree with each other. But in many other cases they show differences that cannot all be explained as common scribal errors. In deciding on a value for MAM in such cases, I have given preference to KHU, but may have chosen a value from one of the other three sources (or even a mixed one) if the values in later sources that usually borrow from MAM (especially YUN and KUS, for which see below) give reason to do so. In such cases relevant deviating values from KHU, KHZ, RES and SUH are given in the comments. All Maʾmūnic sources measure the longitudes from the Western Shore.
2. BIR indicates the tradition of the geographical table in al-Bīrūnī's major astronomical work, *al-Qānūn al-Masʿūdī* (Ghazna, *c.* 1030). In his *Kitāb Taḥdīd nihāyāt al-amākin*,[38] al-Bīrūnī explained the methods for establishing the longitudes and latitudes of localities by astronomical observation (solar altitude for latitudes, lunar eclipses for longitude differences) and surveying (triangulation of distances between localities).

[37] See Nallino, *al-Battānī sive Albatenii*; Nallino, 'Al-Khuwārizmī e il suo rifacimento', and Honigmann, *Die sieben Klimata*.

[38] See the edition in Bulgakov and Aḥmad, *Kitāb Nihāyāt al-amākin*; the translation in Ali, *The Determination*, and the elucidations in Kennedy, *A Commentary*.

With 604 localities, *al-Qānūn* contains one of the largest Islamic geographical tables, and it provides mostly new coordinates as compared to MAM.[39] Many of the coordinates are cited in Abū l-Fidāʾ's *Taqwīm al-buldān*, which hence provides a second source for al-Bīrūnī; in K&K this source is referred to as BIR FID, in King's *World-Maps* and here as BIRF. BIR, with longitudes measured from the Western Shore, was the basis for the tradition of the geographical table from the *Sanjarī Zīj* by al-Khāzinī (Marw, *c.* 1125), which contains a selection of localities from BIR in a different arrangement by region, to which rather inaccurate *qibla* values were added. Al-Khāzinī's main table is contained in SNB, the manuscript London, British Library, Or. 6669 of the *Sanjarī Zīj*, which lacks one folio of the table. Two somewhat different extracts of the main table are found in SNH (Istanbul, Süleymaniye Library, Hamidiye 859) and SNS (Tehran, Madrasa-yi ʿĀlī-i Shahīd Muṭahharī (previously Sipāhsalār), MS 682), two abridged versions of al-Khāzinī's *zīj*. These contain some, but by far not all localities missing from SNB. Therefore the copy of al-Khāzinī's table in SHA, the *Jadīd Zīj* of Ibn al-Shāṭir (Damascus, *c.* 1365), which in several of the surviving manuscripts even maintains the exact page layout of al-Khāzinī's table, is our main source for the missing part of the table. I will follow King, *World-Maps* in using the abbreviation SNJ for al-Khāzinī's coordinates whenever the three copies of the *Sanjarī Zīj* agree or the original values can be plausibly deduced from the complete set of available sources. Two somewhat different extracts of SHA can be found in NUZ, the *Nuzhat al-nāẓir* by Shihāb al-Dīn al-Ḥalabī (Damascus, *c.* 1435), and in the slightly later HLB, *al-ʿIqd al-yamānī* by the same author. NUZ is generally more faithful to SHA. HLB, already used by King, was obviously based on the table in SHA since it maintains the same arrangement of the localities within regions and includes the same *qibla* values, but while all other sources in this tradition are based on the meridian of the Western Shore, the coordinates in HLB were adjusted to the meridian of the Fortunate Isles and corrected on the basis of al-Bīrūnī's original geographical table. Thus whenever SNJ deviates from BIR, HLB will generally follow BIR rather than SHA.

SNJ was also copied into ASH, the *Ashrafī Zīj* by Sayf-i munajjim Yazdī (Shiraz, *c.* 1303), which, however, has several distortions and in some cases appears to have chosen the coordinates from the tradition of ATW (see below). Occasionally, when the coordinate tradition for

[39] K&K does not make use of the useful edition of this table in Togan, *Bīrūnī's Picture*. For a recent study of al-Bīrūnī's coordinates of localities in Pakistan and India, see Weber, 'Neue Analysen und Identifikationen'.

a given locality is unclear, I may also resort to the evidence from two further sources that appear to have relied upon BIR to some extent, namely TAJ, the *Tāj al-azyāj* by Muḥyi ʾl-Dīn al-Maghribī (Damascus, *c.* 1258), and TUQ, a treatise on the astrolabe by the otherwise unknown al-Ṭūqānī (*GAS*, vol. XIII, pp. 415–16 names him al-Ṭūqātī ('from Tokat' in present-day Turkey) and tentatively dates him to the 14th century).

3. By ATW (in K&K: ATH FID) I refer to the tradition of the anonymous *Kitāb al-Aṭwāl wa l-ʿurūḍ li-l-Furs*, which is itself lost but from which Abū l-Fidāʾ quotes the coordinates of 452 localities. These coordinates are usually different from those in MAM or BIR and are in many cases of a remarkable accuracy. ATW has been dated to the 12th or early 13th century,[40] but this leaves unexplained that the coordinates in the much smaller table (although incomplete in the unique Paris manuscript) in DST, the Ismāʿīlī astronomical handbook *Dustūr al-munajjimīn* (Alamut (?), *c.* 1110) that is almost entirely derivative from earlier works, almost fully coincide with ATW. Besides DST, a whole range of Persian *zīj*es depended heavily on ATW, especially TUS (al-Ṭūsī's *Īlkhānī Zīj*, Maragha, 1271/2), WAB (Shams al-Dīn al-munajjim al-Wābkanawī's *Muḥaqqaq Zīj*, Tabriz, *c.* 1320; MUN in K&K and King, *World-Maps*), KAS (al-Kāshī's *Khāqānī Zīj*, Kashan/Shiraz, 1413/4), ULG (Ulugh Beg's *Sulṭānī Zīj*, Samarqand, *c.* 1440), TMR (a Timurid table from the second half of the 15th century discovered, edited and analysed by David A. King; cf. footnote 33), THF (the *Tuḥfat-i sulaymānī* by Muḥammad Zamān, Meshhed, 1667/8), ZAH (an anonymous collection in a Ẓāhiriyya manuscript, now in the al-Assad National Library in Damascus), and AIN (the Mughal administrative manual *Āʾīn-i Akbarī* by Abū l-Faḍl ʿAllāmī, India, *c.* 1580).[41] All sources in this tradition, except for ATW itself, present the longitudes with respect to the Fortunate Isles. Of course, it is possible that Abu'l-Fidāʾ adjusted the longitudes of the original *Kitāb al-Aṭwāl*, since all longitudes he quotes in the *Taqwīm al-buldān* are with respect to the Western Shore.

Besides the three main traditions, several smaller coordinate traditions can be recognized as well. Some of these, and especially those that are relevant for

[40] A survey of the literature on this source may be found in *GAS*, vol. XIII, pp. 369–75. See also King, *World-Maps*, pp. 42–43.

[41] The geographical tables of al-Ṭūsī and Ulugh Beg were edited in Greaves, *Binae tabulae geographicae*, that of al-Kāshī in Kennedy and Kennedy, *Al-Kāshī's Geographical Table*.

understanding the sources of the *Shāmil Zīj*, are included in the comments for each locality in the reference table. It concerns the following works:

4. BAT⁺ is the small tradition of the *Ṣābiʾ Zīj* by al-Battānī (Raqqa, *c.* 900).[42] This further consists of MUM, the recension of al-Battānī's table in the second known manuscript copy of Yaḥyā ibn Abī Manṣūr's *Mumtaḥan Zīj* (cf. footnote 6) extant in Leipzig, and DIM, al-Dimyāṭī's (Egypt, 12th century) treatise on the determination of the *qibla* (in K&K and King, *World-Maps*: QBL). This is the only tradition in which some coordinates from Ptolemy's *Geography* (PTO) are preserved, especially for the regions around the eastern part of the Mediterranean. In some cases BAG, the *zīj* by Jamāl al-Dīn al-Baghdādī (Baghdad or Wasit, 1286), is helpful in confirming readings from BAT. Note that in his editions of al-Battānī's table Nallino applied corrections based on KHU and FID which produced geographically better coordinates that, however, are in most cases not historically attested or justified. K&K gives these corrected coordinates without further comment, but I have used those from the unique Escorial manuscript of the *Ṣābiʾ Zīj*, which are indicated in the footnotes to Nallino's editions. The longitudes in this tradition are given with respect to the meridian of the Fortunate Isles, as in Ptolemy.
5. YUN, the *Ḥākimī Zīj* by Ibn Yūnus (Cairo, *c.* 1000) stood at the basis of a tradition of several centuries of Egyptian and Yemeni *zīj*es that also included extracts of its geographical table. YUN generally follows MAM, but there are frequent exceptions that cannot all be explained as scribal errors. In almost every single case the derivative works, namely SHR, BNA=FAR, MUH=ZAD and SAN,[43] follow YUN to the letter with incidental scribal errors. Only in very few cases has a subset of these *zīj*es another particular error in common, which is then separately mentioned in the comments to the reference table. All sources in this tradition measure the longitudes from the meridian of the Western Shore.
6. KUS is the *Jāmiʿ Zīj* by Kūshyār ibn Labbān (Iran, *c.* 1025). As mentioned above (cf. footnote 34), I have edited the tables from this work, including the geographical table, from the eight extant manuscripts that contain them. KUS was obviously heavily influenced by MAM, but in

[42] After Lelewel had been the first to investigate al-Battānī's table in *Géographie du moyen âge*, Tome V (Épilogue), pp. 60–108, Nallino edited it in 'Le tabelle geografiche' and *al-Battānī sive Albatenii*, vol. II, pp. 33–54, whereas Honigmann attempted to identify some additional localities in 'Bemerkungen'.

[43] For details of these sources, see Kennedy and Kennedy, *Geographical Coordinates*, pp. xix, xxvii, xxxi–xxxii and xxxvi.

numerous cases shows small differences, often but not always common scribal errors, that were copied into later sources. The table in MUF, the *Mufrad Zīj* by al-Ṭabarī (Amul in northern Iran, *c.* 1100), is clearly based on KUS but has enough modifications to be called a separate source. As we will see, the author of the *Shāmil Zīj* took a large part of his geographical coordinates from KUS. All three tables measure their longitudes from the Fortunate Isles.

7. ALA is the *ʿĀlāʾī Zīj* by al-Fahhād (Shirwan, *c.* 1176; not in K&K), which is extant in a Persian manuscript at the Salar Jung Museum in Hyderabad as well as in a Byzantine Greek translation (the latter does not contain the geographical table). The smaller table in ABH/UTT, the *Mulakhkhaṣ Zīj* by al-Abharī (northern Iraq, *c.* 1240), is clearly dependent on ALA.[44] Since the *Shāmil Zīj* shares with Ibn al-Fahhād the mean motion parameters as well as some of the planetary equations, and because the Florence manuscript of the other *zīj* by al-Abharī includes the geographical table from the *Shāmil Zīj*, it is worth checking possible dependences of the geographical table in the *Shāmil Zīj* on ALA as well. While a separate study is necessary of the rather large number of unique coordinates in ALA and ABH/UTT, occasionally the coordinates from this small tradition will be mentioned in the comments as confirmation of coordinates in other traditions. Whereas ALA has the Fortunate Isles as its base meridian, ABH/UTT is unique in measuring the longitudes with respect to a meridian 84° east of the Fortunate Isles. Of the two longitude differences of 0° in the table, Kennedy chose Basra as the most likely candidate for the base meridian of UTT. Since we now know that the author of this work is Athīr al-Dīn al-Abharī, Abhar may appear to be the more plausible candidate. However, all coordinates concerned were taken from ALA, in which al-Fahhād also assigned the longitude of 84° to the city of Bardhaah and the region of Azerbaijan in which he was active. Since both surviving manuscripts of ABH/UTT omit the indications in red ink of additive values, doubt about the intended longitudes exists in particular for some localities close to the meridian of 84;0°.

In order to establish the coordinates used in each of the above traditions, I omitted twelve small sources from K&K that seemed to fit less into the overall traditions, in particular the two Latin sources and all instruments. On the other hand, I added the seven new sources that have been mentioned above, two of which were already used in King, *World-Maps*. Of the remaining 69

[44] However, as indicated above, the Yemenī *zīj* by al-Fārisī (FAR), which uses al-Fahhād's planetary mean motions and equations, and the reworking of this *zīj* extant in the same Cambridge manuscript (SHR), borrowed their geographical data from Ibn Yūnus.

sources, several more (especially ZAY, SAA, LYD and MAR) turned out not to be particularly suited for systematic inclusion in the comparisons because they often deviate from the most common coordinates, apparently at least to some extent due to serious defects in the transmission of the sources. These works should be investigated independently in order to discover the origin of the deviations and to place their geographical data into their proper historical context. Of course, for no geographical table can it be excluded that the coordinates were more or less arbitrarily assembled from a variety of sources (possibly with different base meridians) available to the author.

Underlying my decisions on the representative coordinates in each tradition is the basic assumption, also applied by Kennedy and King, that the vast majority of coordinates were simply copied from another source of the types included in K&K rather than newly observed or taken from an entirely different kind of source. It follows that most of the deviations between coordinates within the same tradition may be expected to be the result of scribal confusions. In many cases these will be common scribal errors as listed in Table 2, but in others they may be of more complex types as we have seen in Section 4, for example a slide of place names, coordinates or individual digits, or a miscopy from a different column. Using this basic assumption, it is inevitable that some newly introduced coordinates will be overlooked if they are not attested in sources known to us or clearly stand out in a different way. For the time being, I accept this risk and use the following specific criteria for deciding on the coordinates in each tradition.

- If a majority of the sources within a tradition agree on the same coordinates for a given locality, these coordinates are chosen as the representative ones. In the Maʾmūnic tradition I attach a larger weight to the coordinates from KHU and RES and a smaller weight to those from SUH. If the Maʾmūnic sources differ among them in a significant way, I may use YUN (and incidentally some of the other sources generally dependent on MAM such as KUS and ALA) to decide in favour of one of the candidates. In the traditions of al-Bīrūnī and the *Sanjarī Zīj*, I distinguish between the original coordinates as found in BIR/BIRF/HLB (with occasional confirmations by TAJ and TUQ) on the one hand and those from SNJ/ASH/SHA/NUZ on the other. Al-Bīrūnī's coordinates are given in the main table, those from the *Sanjarī* tradition in the comments ('SNJ=BIR' indicating that they are the same). In the tradition of the *Kitāb al-Aṭwāl wa l-ʿurūḍ li-l-Furs* I will consider coordinates not quoted by Abū l-Fidāʾ but included in DST as deriving from ATW.[45] If TUS includes the earliest coordinates for a locality, or

[45] It is almost certain that Abū l-Fidāʾ did not cite all coordinates from ATW. Examples are the important cities Harran and Homs, which are missing from ATW, but for which DST

ones different from ATW/DST, these will be separately mentioned in the comments.

- Incidental deviating coordinates within each of the three main traditions are generally ignored, especially when they seem inexplicable and may, for example, result from a slide or a miscopy that we have no means of identifying. If the deviations can be explained as common scribal errors of the most likely candidates for the coordinates in a tradition, they will be taken to support these candidates.
- If two or more independent sources from one of the three main traditions and that of Ibn Yūnus share coordinates that deviate from the representative ones, these will be mentioned as a sub-tradition, also in the cases that the difference can be explained as a scribal error. The same holds if the deviating sources differ among themselves by a common scribal error but all differ from the representative coordinates of the tradition in a non-trivial way.
- For the tradition of al-Battānī I select the coordinates (possibly the longitude and latitude separately) that are found in a majority of the three sources BAT, MUM and DIM, or are confirmed by BAG. For Kushyār I always use the reliable values that I have established in my edition of KUS, which are often confirmed by MUF and frequently adopted by SML. For the *ʿAlāʾī Zīj* I take the coordinates from ALA if they are confirmed by ABH/UTT, or those from ABH/UTT if they agree among themselves and have more plausible values than ALA.
- In the reference table I use the following notations: A superscript + after a source code indicates this source together with the sources usually dependent on it. Thus SNJ$^+$ (or also SNB$^+$ if the other sources for al-Khāzinī's table do not contain coordinates for the locality concerned) stands for SNJ, ASH, SHA and NUZ, and SHA$^+$ for SHA, NUZ and HLB (whenever HLB differs from SHA, SHA/NUZ will be written out and HLB mentioned separately). ATW$^+$ includes DST, TUS, WAB, KAS, ULG, TMR, AIN, THF and ZAH. The notation TUS$^+$ is used for coordinates that are not yet present in ATW or DST but appear in TUS and the later sources from the tradition of ATW. KAS$^+$ stands for KAS and AIN, since the latter appears to have followed specific variants in the former relatively often. ULG$^+$ indicates the sources that appear to have followed Ulugh Beg's table specifically, namely TMR, THF and ZAH. In the smaller tradition of al-Battānī's table, BAT indicates that the coordinates are found in BAT or MUM,

already presents the coordinates that were also used by TUS and later sources from the ATW tradition.

BAT$^+$ that they are also included in DIM. 'Not in BAT' (as opposed to 'not in BAT$^+$') therefore means that the locality concerned is only contained in DIM. KUS$^+$ stands for KUS and MUF, 'not in KUS' implies that the locality is found in MUF. ALA$^+$ stands for ALA together with ABH/UTT, ABH includes UTT since they are two copies of the same table. To indicate the sources generally dependent on a source XYZ without the source itself I write $\langle$XYZ$\rangle^+$.

- In the comment column, BIR, SNJ and ATW and the four sources incorporated in MAM are written in bold face to indicate that there are deviations in these sources from the coordinates that I established for their tradition. A notation such as SML=BIR means that the *Shāmil Zīj* uses the coordinates from the *tradition* of al-Bīrūnī, rather than the possibly different specific values from BIR mentioned in the comment column. Individual coordinates may be referred to by λ for longitude and ϕ for latitude. Deviations or elucidations of main variants given in the comment column are placed between parentheses and may be given in the form x° or y′ if they involve only individual digits. For example, the entry '**TUS**$^+$ 86;55/30;0 (WAB/ULG λ 15′)' for Sabur indicates that WAB and ULG have for the longitude of this city the common scribal error 86;15° instead of 86;55°.

Please bear in mind that the purpose of the reference table is to establish the particular pairs of coordinates that were most likely generally used in each of the three main and four smaller traditions, not to provide an overview of all variants found in all sources belonging to each tradition. Also note that in most cases I have only considered the coordinates of the localities that the sources have in common, but not the evidence that the layout of the tables, the order in which the entries appear, the absence or presence of certain localities, and other characteristics of the tables may provide concerning the relationships between them. It is possible that the relations that I have noticed are valid only for localities in the Middle East as covered by the *Shāmil Zīj*, whereas further differences within the traditions might be present, for instance, for localities in the Maghrib and al-Andalus.[46]

It turns out that the localities appearing in the geographical table in the *Shāmil Zīj* (and in Islamic geographical tables in general) are of a widely varying character. Certain groups of localities show only very little variation in their coordinates over the entire set of available sources and some appear in only one or two of the three major traditions. These particularly include cities (or regions) that are far away from the central Islamic lands and where no

[46] Further research in this direction and the compilation of reference tables for a much wider range of localities will be necessary to clarify such issues. See already Robles Macías, 'The Longitude of the Mediterranean' and E. Mercier, 'Mathematical Geography'.

Samarqand			Homs		
HTP	112;30	39;45	PTO	69;40	34;00
KHU	99;30	37;30	KHU	71;00	34;00
RES	99;30	37;30	KHUB	71;10	34;00
KHZ	99;30	36;30	KHZ	71;00	33;10
SUH	99;30	36;30	SUH	71;00	34;00
ATW	99;00	40;00	BAT	69;05	34;00
YUN	99;30	36;30	MUM	69;00	34;00
BNY	99;30	37;30	YUN	71;35	33;10
DIM	99;00	36;00	BNY	71;35	33;10
KUS	99;30	36;30	DIM	69;05	34;00
BIR	98;20	40;00	KUS	71;00	33;40
BIRF	98;20	40;00	BIR	71;00	33;40
MUF	99;30	37;30	ZAY	71;00	33;45
SNB	98;20	40;00	MUF	71;00	33;40
SNH	98;20	40;00	DST	70;45	34;00
SNS	98;20	40;00	SNB	71;00	33;40
ALA	99;30	36;30	SML	71;00	33;40
ABH	99;30	36;30	SAA	71;31	34;00
UTT	99;30	36;30	TUQ	71;00	33;40
SML	99;30	36;30	TAJ	71;00	34;00
YAQ	99;30	36;30	FAR	69;00	34;50
SAA	101;52	36;30	TUS	70;45	34;00
TUQ	98;20	40;00	BNA	69;00	34;50
TAJ	98;20	40;00	LYD	71;00	34;00
SHR	99;30	36;30	MAG	70;40	34;30
FAR	99;30	36;30	MAR	69;05	33;40
TUS	99;00	40;00	BAG	71;00	33;00
BNA	99;30	36;30	MUH	71;35	33;10
MAG	98;20	39;00	SAN	69;00	34;50
BAG	97;00	37;00	QYSF	71;00	34;20
MUH	99;30	36;30	ASH	71;00	33;40
SAN	99;30	36;30	WAB	70;40	34;40
ASH	98;20	40;00	MSR	71;13	33;40
WAB	98;20	40;00	SHA	71;00	33;40
SHA	98;20	40;00	MIZ	71;00	34;20
GT1	49;00	37;30	KHL	71;00	34;20
GT2	99;30	39;30	GT1	71;00	33;40
KAS	99;00	40;00	KAS	70;45	34;00
ULG	99;16	39;37	ULG	70;45	34;00
TMR	99;16	39;37	TMR	70;45	34;00
NUZ	98;20	40;00	NUZ	71;00	34;20
HLB	98;20	40;00	HLB	71;00	34;40
QIR	99;30	36;30	QIR	71;00	33;40
ZAD	99;30	36;30	ZAD	71;35	33;10
AIN	99;00	40;00	AIN	70;15	34;20
THF	99;17	39;37	MOS	71;00	33;40
MOS	99;30	36;30			
ZAH	99;16	39;37			

Table 7: Examples of a rather clean (Samarqand, on the left) and a very convoluted coordinate tradition (Homs, on the right). The coordinates were taken from K&K with incidental corrections and additions on the basis of the actual sources.

astronomical activity may be assumed to have taken place (e.g., Ethiopia and Kabul), famous cities from antiquity that were of lesser importance or were even in ruins through much of the Islamic period or not continuously in Muslim hands (e.g., Tarsus or Qaysariyya), and localities of a mythical nature such as Kang (the cupola of the world) or Yājūj wa-Mājūj (Gog and Magog from the Bible). For many of the large and important cities in the Islamic lands the variation of the coordinates is much larger, partially due to a larger number of scribal errors that occurred during a more extensive copying history, but certainly also because of borrowing from additional sources or adoption of newly observed coordinates, especially latitudes. Obviously, localities of the first category are most suitable for establishing the basic relationships between sources and the outline of the larger traditions of coordinates. Once these have been established, localities from the second category can be tackled with a little more prescience. Table 7 shows examples of a very clean coordinate tradition (Samarqand, on the left) and a much more convoluted one (Homs, on the right).[47] For many other localities one would consider such deviating coordinates as 99;16° / 39;37° for Samarqand in ULB and sources dependent on it to be the result of a non-obvious copying error, but in this case these are of course the results of the extensive, highly accurate observations at the observatory of Ulugh Beg himself.

7. Results and Conclusions

By now comparing the uncertain cases in my edition of the *Shāmil Zīj* with the reference table on pp. 552–56, it is possible to resolve most of them.

For Oman (A4), MAM and a clear majority of all other sources have λ = 94;30°, although 74;30° appears not only in half of the witnesses for the *Shāmil Zīj* but also in the *ʿAlāʾī Zīj*. We conclude that 94;30° was the original value and 74;30° a scribal mistake.

For Egypt (A7), the longitude 54;40° that persists through the entire tradition of the *Shāmil Zīj* (and was apparently later corrected only in manuscript **P**$_8$) is obviously a mistake for the value 64;40° from MAM/BIR, most likely due to a forgotten correction for the different meridian that these sources use. Interestingly enough, with longitude 73;0° for Fustat, which in Islamic sources usually receives coordinates very close to the ones assigned to Egypt, KUS errs consistently by around 10° in the other direction. For Alexandria (A8), the longitude 60;30° in the *Shāmil Zīj* is that used by PTO, BAT and KUS and is obviously the one intended, although it places Alexandria way too far west with respect to Egypt/Fustat.

For Baghdad (A12), the longitude value 80;10° does not appear in any other traditions and is hence most likely a copying mistake (possibly also from a nearby

47 As in the reference table, all longitudes are here given with respect to the Fortunate Isles.

Table 8: Reference table for the localities from the *Shāmil Zīj* in the main coordinate traditions.
The column headed # gives the total number of K&K database entries that were considered for each locality

place name	#	al-Ma'mūn = MAM		al-Bīrūnī = BIR		*Kitāb al-aṭwāl* ATW		*Shāmil Zīj* SML	Other traditions / Comments
Habasha/ Jarmi	17 +26	51;40	19;40	= MAM		65;00	09;30	= KUS	Not in BAT$^+$. **YUN**$^+$,KUS$^+$ 51;40/19;30. **BIR**,SNJ$^+$ Jarmi.
Sanaa	50	73;30	14;30	77;00	14;30	= BIR		= MAM/KUS	**KHU**/**RES** 78;30/14;30. **BAT**$^+$,BAG 73;0/14;30. **YUN**$^+$,KUS$^+$=MAM. **BIR** λ also 77;20, **SNJ**$^+$ 77;30/14;30.
Aden	49	75;00	13;00	76;00	11;00	= BIR		= MAM/KUS	**BAT**$^+$ 74;0/13;38 (DIM φ 13;0). **YUN**$^+$,BAG 75;30/13;00. KUS$^+$=MAM. MAG=BIR. **SNJ**$^+$ 76;30/11;00. **ATW** 77;0/11;0.
Oman	31	94;30	19;45	–		–		= MAM/KUS	Not in SNJ$^+$. **BAT**,**YUN**,KUS$^+$=MAM. ⟨YUN⟩$^+$ also 95;30/19;20.
Madina	56	75;20	25;00	77;30	24;00	= MAM		= MAM/KUS	**BAT**,BAG 75;0/25;0. **YUN**$^+$,TAJ,MAG 75;20/24;0. KUS$^+$=MAM. **ATW** 75;20/25;3. **SNJ**$^+$ 77;30/24;45 (**SHA**/NUZ λ 76;30).
Mecca	57	77;00	21;00	77;00	21;20	77;13	21;40	= KUS	**BAT**$^+$ 71;0/21;40 (DIM λ 71;13). **YUN**$^+$=MAM. KUS$^+$,ASH,KAS/ULG$^+$ 77;10/21;40. **SNJ**$^+$=BIR.
Egypt / Fustat	34 +24	64;40	29;55	64;40	29;55	63;00	30;10	54;40 (!) / 29;45	**KHU** Fustat 64;50[55′]/30;0. **BAT** Fustat 63;0/31;0. **YUN**$^+$ 65;0/30;0. KUS Fustat 73;0 (sic!) / 31;0. **BIR** Fustat, **SNJ**$^+$ Fustat 64;50/29;30. **ATW** Fustat, AIN=ATW. **TUS**$^+$ 63;20/30;20 (KAS/AIN λ 63;0).
Alexandria	53	61;20	31;00	62;00	30;58	61;54	30;58	= KUS	**BAT**$^+$ 60;30/30;18 (DIM φ 30;58). **YUN**$^+$=MAM. KUS$^+$ 60;30/30;20. **BIR**$^+$ φ also 30;18, **SNJ**$^+$ 61;50/30;58.
Jerusalem	58	66;00	32;00	66;00	33;00	66;30	31;50	= KUS	**BAT**$^+$=ATW. **YUN**$^+$ 67;50/32;0. KUS 66;30/32;0. MAG/WAB 68;0/31;0. **SNJ**$^+$=BIR (**SHA**$^+$=MAM).
Damascus	53	70;00	33;00	70;00	33;30	–		= MAM/KUS	**BAT**$^+$ 69;0/33;0 (=PTO). **YUN**$^+$,KUS$^+$,**DST**=MAM. **SNS**/ASH 70;0/32;30, **SHA**/NUZ 70;0/33;25. TAJ/MAG/ WAB/KAS 70;0/33;20, **TUS**/AIN=BIR, ULG$^+$ 70;0/33;15.
Kufa	54	79;30	31;50	= MAM		79;30	31;30	= MAM/KUS/BIR	**BAT**$^+$=ATW. **YUN**$^+$,KUS=MAM.
Baghdad	54	80;00	33;09	80;00	33;25	= BIR		= BIR/ATW	**BAT**$^+$=MAM. **YUN**$^+$ 80;0/33;10 (YUN also φ 33;25). KUS 75;0 (sic! corrected to 80;0 in only 2 mss) /33;0. TAJ/MAG 80;0/33;21.
Wasit	53	81;30	32;20	= MAM		= MAM		= MAM/KUS/BIR	**BAT**$^+$,BAG 81;30/32;30 (?). **YUN**$^+$ 81;30/31;30 (φ also 32;0). KUS=MAM. **BIRF**/NUZ 81;30/32;25.
Basra	53	84;00	31;00	= MAM		84;00	30;00	= MAM/KUS/BIR	**BAT**$^+$ 80;10/31;0. **YUN**$^+$,KUS$^+$,TAJ/MAG=MAM/BIR. **ATW** 84;0/30;3. **SNJ**$^+$ 85;0/31;0.
Qadisiyya	16	–		79;25	31;45	79;25	31;10	79;25 / 31;46	Not in BAT$^+$, KUS$^+$. **YUN** om./32;0, not in ⟨YUN⟩$^+$. AIN=BIR. **ATW** om. λ. Not in TUS$^+$.
Hilla[a]	7	–		–		–		79;10 / 32;10	Not in BAT$^+$, YUN$^+$,KUS$^+$. KAS 79;15/32;15. AIN 79;0/32;0.

[a] According to the *EI*^{2} this is a town on the Euphrate between al-Kufa and Baghdad, founded in 496 Hijra = AD 1102. Of the only very few sources including this locality, the *Shāmil Zīj* is the earliest.

place name	#	al-Ma'mūn = MAM		al-Bīrūnī = BIR		*Kitāb al-aṭwāl* ATW		*Shāmil Zīj* SML	Other traditions / Comments
Madā'in	23	80;00	33;00	80;20	33;10	80;00	33;10	= BIR	**BAT**$^+$ 80;0/35;55. Not in YUN$^+$,KUS$^+$. Not in SNJ$^+$. WAB/ULG 79;0/33;10, KAS/AIN 80;20/33;0.
Ahwaz	36	85;00	32;00	= MAM		85;00	31;00	= KUS	Not in BAT. **YUN**$^+$=MAM. KUS,DIM 85;0/30;0. Not in SNJ$^+$. **ATW** 85;0/31;8.
Shiraz[b]	50	88;00	32;00	88;35	29;36	–		= MAM/KUS	**YUN**$^+$,KUS=MAM (KUS (Fatih ms)/MUF 88;0/30;0). TAJ=BIR. **SNJ**$^+$ 85;30/30;0 (HLB φ 29;30). **TUS**$^+$ 88;0/29;36. BAG/ASH/KAS 88;0/29;30.
Sabur	22	88;15	31;00	–		–		= KUS	**YUN**$^+$=MAM. KUS$^+$ 88;40/30;0. **TUS**$^+$ 86;55/30;0 (WAB/ULG λ 86;15).
Kirman	32	100;00	30;00	–		–		= MAM/KUS	Not in BAT$^+$. **YUN**$^+$,KUS$^+$=MAM. KAS/AIN 91;30/30;5.
Kabul	34	110;00	28;00	105;20	33;45	104;40	34;30	= MAM/KUS	**BAT**$^+$,**YUN**$^+$,KUS$^+$=MAM. Not in SNJ$^+$. Not in TUS/ULG.
Tarsus	35	68;00	36;15	= MAM		–		= KUS	**KHU** 68;0/36;55, **KHZ** 68;0/38;0, **SUH** 68;0/37;35. **BAT**$^+$ 67;40/36;55 (≈PTO). **YUN**=MAM. KUS 67;40/37;15. Not in SNJ, ASH/SHA 68;0/36;0. **TUS**$^+$ 68;40/36;42 (KAS/AIN 68;40/36;50).
Aleppo	52	73;00	34;30	= MAM		72;10	35;50	= KUS/ALA	**BAT**$^+$ 71;0/34;50. **YUN**/BNY 73;0/35;30. **KHZ**/⟨YUN⟩$^+$ 73;0/33;30. KUS$^+$/ALA$^+$ 71;0/35;50. **SNH** 73;0/34;50, ASH=BIR, **SHA**/NUZ 73;0/35;50. TUQ/TAJ 72;0/35;50.
Manbij	35	73;45	35;30	= MAM		–		63;45 (!) / 35;30	**BAT**$^+$ 71;15/36;15 (=HTP). **YUN**=MAM, ⟨YUN⟩$^+$ also 71;20/35;40. Not in KUS$^+$. **TUS**$^+$ 72;15/36;15 (KAS/AIN 72;50/36;30). Not in SNJ, ASH 73;0/34;50, **SHA** 73;0/35;50 (NUZ φ 36;0, HLB φ 36;15).
Homs	45	71;00	34;00	71;00	33;40	70;45	34;00	= KUS/BIR	**KHZ** 71;0/33;10. **BAT**$^+$ 69;5/34;0. KUS$^+$=BIR. **YUN**$^+$ 71;35/33;10 (⟨YUN⟩$^+$ also 69;0/34;50). Not in SNJ, ASH/**SHA**$^+$=BIR. Not in **ATW** (but in **DST**/**TUS**$^+$).
Raqqa	50	76;00	36;00	73;15	36;01	73;15	36;00	= BAT/KUS/ATW	**BAT**, KUS$^+$,ALA, TUQ,TAJ/MAG 73;15/36;0 (=ATW). **YUN**=MAM, ⟨YUN⟩$^+$ also 83;15 (sic!) / 36;0.[c] **SNJ**$^+$=BIR.
Amid	39	75;50	37;52	67;30	37;45	77;20	37;00	= BAT/KUS	**BAT**$^+$, KUS 75;15/38;0. **YUN**$^+$ 87;20 (sic!) / 37;45. **SNJ**$^+$=BIR (SNH/SNS φ 45;30). Not in TUS,WAB,ULG. KAS/AIN 77;20/37;52[42′]. TMR/ZAH 73;40/38;0.
Harran	46	77;00	37;00	67;00	37;00	–		= MAM/KUS	**KHU** 75;0/36;40, **SUH** 77;30/36;30. **BAT**$^+$,**DST**/**TUS**$^+$ 73;0/36;40. **YUN**$^+$ 77;0/39;0 (sic!). KUS$^+$=MAM. **SNJ**$^+$ 83;0/37;0 (SNH/SNS φ 32;0).
Hama	23	72;15	36;00	72;40	36;00	–		= BIR	Not in YUN$^+$,KUS$^+$,ALA$^+$. **BAT**$^+$,BAG 69;30/35;20. Not in SNJ$^+$, TUQ/HLB 71;0/35;0.
Mosul / Nineveh	44 + 13	79;00	35;30	–		77;00	36;30	= KUS	**BAT**$^+$,BAG 78;10/36;30. **YUN**,**SNH**/**SNS**=MAM. [YUN]$^+$ also 79;35/35;30. KUS 78;0/36;30. KAS/AIN 77;0/36;50, TMR/THF/ZAH 77;0/34;30. Niniveh: **BIR** 79;0/36;0, **SNB**$^+$ 79;0/35;15.

[b] Note that the modern latitude of Shiraz is 29;36°.

[c] The table in FAR does not specify from which meridian the longitudes are measured, but for nearly all localities this is obviously from the Western Shore. There are, however, some more localities (including such major ones as Madina and Mosul) for which apparently a longitude measured from the Fortunates Isles was adopted without adjustment, in this case most likely from al-Battānī or Kūshyār.

place name	#	al-Ma'mūn = MAM		al-Bīrūnī = BIR		*Kitāb al-aṭwāl* ATW		*Shāmil Zīj* SML	Other traditions / Comments
Antioch	44	71;35	34;10	71;30	34;10	–		= KUS	**KHZ/YUN** 71;35/33;10. ⟨YUN⟩$^+$ 71;35/35;30. **BAT**$^+$ 69;0/35;30 (=PTO). KUS$^+$,BAG 79;0 (sic!) / 35;30. **BIR** 71;35/34;10 (=MAM), **SNJ**$^+$=BIR. **TUS**$^+$ 71;26/35;30 (TUS φ 35;35, KAS/AIN φ 35;40).
Hulwan	45	81;45	34;00	82;15	34;00	= BIR		= MAM/KUS	**BAT**$^+$ 81;0/38;0 (MUM φ 35;0). **YUN**$^+$,KUS$^+$=MAM. **SNJ**$^+$=BIR. **ATW** 82;55/34;0.
Shahrazur	24	80;20	37;45	–		80;20	35;30	= KUS	Not in BAT. **YUN**$^+$=MAM. KUS 80;20/37;15. Not in SNJ$^+$. ULG/TMR 82;20/32;30.
Nahawand	37	82;00	36;00	86;20	35;00	83;15	34;20	= KUS	Not in BAT$^+$. **KHU/SUH** 84;0/36;0. **YUN**$^+$=MAM. KUS$^+$ 82;0/36;10. Not in SNJ$^+$. **ATW**/MAG/KAS 83;45/34;20.
Hamadan	51	83;00	36;00	85;20	34;40	83;00	35;10	= KUS	**BAT** 60;20 (sic!) / 36;0.[d] **YUN**$^+$/AIN=MAM. KUS 83;0/36;10. **SNJ**$^+$=BIR (SNH/SNS 85;20/37;30). **ATW**/MAG 84;0/35;0.
Qum	45	84;15	35;40	87;00	34;10	85;40	34;45	= KUS	**BAT**$^+$ 84;0/36;0 (DIM λ 85;0). **YUN**$^+$ 85;15/35;40. KUS 80;15/34;0. **SNB**$^+$ 87;0/35;10, ASH=BIR.
Sawa	23	–		87;00	35;00	85;00	35;00	= BIR	Not in BAT$^+$, YUN$^+$,KUS$^+$. ALA$^+$ 83;0 or 85;0/32;0.[e] **BIR** φ 35;5, **SNB**$^+$=BIR. **TUS**/KAS 85;0/36;0.
Isfahan	45	84;40	34;30	87;20	33;30	86;40	32;25	= KUS	Not in BAT. **YUN**$^+$=MAM. KUS 84;40/32;0. **SNJ**$^+$ 87;20/32;30 (ASH=ATW). **ATW** 86;40/32;40.
Rayy	51	85;00	35;45	88;00	35;35	86;20	35;35	= KUS	**BAT** 66;0 (sic!) / 36;30 (MUM λ 73;0, DIM λ 96;0). **YUN**=MAM, ⟨YUN⟩$^+$ also 93;53 (sic!) / 35;35. KUS 85;0/35;30 (λ also 81;0, 83;0, 83;15, 84;0). **SNB**$^+$=BIR (SNH/SNS φ 35;40). KAS/ULG/TMR/THF 86;20/35;0.
Qazwin	44	85;00	37;00	= MAM		85;00	36;00	= MAM/KUS	**BAT**$^+$, **YUN**$^+$,KUS=MAM. **SNB**$^+$=BIR/MAM.
Abhar	17	–		84;00	38;00	84;30	36;45	85;0 / 36;0	Not in BAT$^+$, YUN$^+$,KUS$^+$. Not in SNJ$^+$. **ATW**/AIN 84;30/36;55.
Zanjan	21	–		83;00	38;00	83;40	36;30	84;0 / 36;0	Not in BAT$^+$, YUN$^+$,KUS$^+$. **SNB**$^+$ 84;0/38;0. SML λ also 85;0. KAS/AIN 83;0/36;30.
Daylam	19	85;00	38;10	–		–		= KUS	Region. Not in BAT, YUN$^+$. DIM/KUS 85;0/38;0. **SNH/SNS** 87;0/35;0.
Ruyan	21	86;35	36;15	86;00	36;10	85;50	37;03	= KHZ/KUS	**KHZ**, BAT$^+$, KUS 86;35/37;10. **YUN**=MAM, not in ⟨YUN⟩$^+$. **BIRF** λ 87;0. Not in SNJ$^+$. Not in ⟨ATW⟩$^+$.
Sariya	38	87;50	38;00	88;00	36;15	88;00	37;00	= MAM/KUS	**BAT**$^+$, **YUN**,KUS=MAM, not in ⟨YUN⟩$^+$. **BIR**/HLB φ also 36;55, **SNJ**$^+$ 83;0 (sic!) / 36;15.
Damghan	26	–		89;30	36;20	88;55	36;20	= ABH	Not in BAT$^+$, YUN$^+$,KUS. **SNJ**$^+$=BIR. ALA 88;16/37;0, ABH 88;37/37;0.

[d] Because of the Maghribian numerals in the Escorial manuscript of BAT, 60 is denoted by *ṣād* ص, 90 by *ḍād* ض. Nallino corrected this to the more correct, but historically unjustified, 83;20 by comparing with KHU and ATW. The geographical table in the Leipzig manuscript of the *Mumtaḥan Zīj*, heavily based on al-Battānī, has longitude 79;20, al-Dimyāṭī does not give coordinates for Hamadan.

[e] Also for Darband ALA seems to have taken the longitude difference from 84° in the wrong direction, suggesting that the original geographical table from the *ʿAlāʾī Zīj* may have had 84° as its base meridian just as the *Mulakhkhaṣ Zīj* by al-Abharī (ABH/UTT), which is obviously based on it.

place name	#	al-Maʾmūn = MAM		al-Bīrūnī = BIR		*Kitāb al-aṭwāl* ATW		*Shāmil Zīj* SML	Other traditions / Comments
Bistam	25	–		89;15	36;40	89;30	36;10	89;15 / 35;40	Not in BAT$^+$, YUN$^+$,KUS$^+$. ALA$^+$=BIR. **SNB**$^+$=BIR (**BIR**/SNB λ 89;55).
Astarabad	31	89;50	38;45	89;20	37;00	89;35	36;50	= MAM/KUS	Not in BAT. YUN,KUS=MAM. **SNJ**$^+$=BIR (**BIR**/**BIRF**/SNS 89;20/37;5).
Tus	38	92;50	37;00	94;30	36;20	92;30	37;00	= KUS	**KHZ**/**SUH**, **BAT**$^+$, KUS$^+$, WAB 92;0/37;0. **YUN**$^+$ 92;45/37;0. **BIR** 'Ṭābarān, capital of Tus', **SNJ**$^+$=BIR.
Jurjan	50	90;45	38;50	90;10	38;10	90;00	36;50	= KUS/ATW	**BAT** 95;0/40;0. **YUN**$^+$ 90;45/37;45. KUS$^+$=ATW. **SNJ**$^+$ 92;10/38;10, TAJ/HLB=BIR.
Nishabur	42	90;45	37;00	94;00	36;10	92;30	36;21	= ATW	Not in BAT, KUS$^+$. **YUN**$^+$ 90;45/36;0. **BIR** 'Abarshahr, citadel of Nīshāpūr', in K&K under Iranshahr, TAJ=BIR, **SNJ**$^+$ 92;30/36;20 (≈ATW), ASH=ATW.
Sarakhs	40	93;20	37;00	95;00	36;40	94;30	37;00	= KUS	**KHU** 93;20/38;0. **BAT**$^+$, **YUN**=MAM. KUS 93;20/36;0. **SNJ**$^+$=BIR.
Marv	48	94;20	37;35	96;30	37;40	94;00	37;40	= KUS/ALA	Not in BAT. **KHZ**/**YUN**$^+$ 95;27/37;35. KUS$^+$,ALA$^+$ 94;20/37;30. **SNJ**$^+$=BIR. **ATW**/TMR/THF 97;0/37;40, MAG=ATW.
Bukhara	46	97;20	36;50	97;30	39;20	= BIR		= MAM/KUS/ ALA	**KHU**/**RES** 97;20/37;50. Not in BAT. KUS$^+$,ALA$^+$=MAM. **YUN**$^+$ 97;9/38;50. TAJ/MAG/HLB=BIR, **SNJ**$^+$ 96;50/39;0.[f] **ATW** 97;50/39;20, not in **DST**, ULG$^+$ 97;50/39;50.
Balkh	46	98;35	38;40	101;00	36;41	= BIR		= KUS	Not in BAT. **YUN**$^+$ 98;35/37;40. KUS$^+$,ALA$^+$ 98;30/38;40. TAJ/MAG=BIR, **SNJ**$^+$/HLB 101;0/36;40.
Samarqand	48	99;30	36;30	98;20	40;00	99;00	40;00	= MAM/KUS/ ALA	**KHU**/**RES**,MUF 99;30/37;30. Not in BAT. **YUN**$^+$,KUS,ALA$^+$=MAM. **SNJ**$^+$,TAJ,WAB=BIR. ULG$^+$ 99;16/39;37.
Khwarizm/ Gurganj	41 +15	101;50	42;10	94;01	42;17	94;05	42;45	= MAM/KUS	Not in BAT. **YUN**$^+$,KUS$^+$=MAM (⟨YUN⟩$^+$ also 106;0/40;15). TAJ,MAG,HLB=BIR, not in SNJ$^+$. Gurganj: **SNJ**$^+$ 94;0/42;16. **TUS**$^+$ 93;45/42;35 (KAS/AIN 94;0/42;45[15′] ≈ATW).
Darband	6	–		–		–		83;0 / 42;5	Only in ALA$^+$,SML$^+$ (not in BAT$^+$, YUN$^+$,KUS$^+$). ALA 85;0/42;0, ABH 83;0 or 85;0/42;0.[g]
Tiflis	37	–		72;00	42;00	83;00	43;00	= ATW/ALA	Not in YUN,KUS$^+$. **BAT**$^+$ 82;0/43;0. ALA$^+$,MAG=ATW. ⟨YUN⟩$^+$ 83;0 from African shore / 43;0. **SNJ**$^+$=BIR.
Kanja	19	–		–		–		= ABH	Not in MAM, BAT$^+$, YUN,KUS$^+$. ABH 81;30/41;0. ⟨YUN⟩$^+$ 81;30 from African shore (!) / 41;0. **BIRF** 84;0/43;10, not in SNJ$^+$. **TUS**$^+$ 83;0/41;20, not in KAS/AIN.
Baylaqan	16	–		74;00	39;50	–		82;30 / 38;0	Not in BAT$^+$, YUN$^+$,KUS$^+$,ALA. **SNJ**$^+$=BIR. **TUS**$^+$ 83;30/39;50.

[f] Apparently al-Khāzinī (or the scribe of his copy of the *Qānūn*) miscopied the coordinates of Bukhara from those for Baykand, found one line higher up in the table.
[g] cf. note e to this table.

place name	#	al-Ma'mūn = MAM		al-Bīrūnī = BIR		*Kitāb al-aṭwāl* ATW		*Shāmil Zīj* SML	Other traditions / Comments
Bardhaah	44	83;00	43;00	73;00	43;00	83;00	40;30	= KUS	**SUH**/KUS 84;0/43;0. **BAT**, ALA 84;0/42;0. **BIRF**/YUN$^+$ 83;0/48;0. **SNJ**$^+$=BIR.
Shirwan	14	–		77;30	40;50	–		84;0 / 35;0[h]	Not in BAT$^+$, YUN$^+$,KUS$^+$. **SNJ**$^+$=BIR.
Tabriz	23	–		83;10	37;30	–		= BIR/ALA	Not in BAT$^+$, YUN$^+$,KUS$^+$. ALA$^+$=BIR. **SNB**$^+$ 83;10/37;40, ASH=ATW. **TUS**$^+$ 82;0/38;0.
Maragha	25	–		83;20	37;25	81;20	37;40	= BIR	Not in BAT$^+$, YUN$^+$,KUS$^+$. ALA 82;10/37;25 (ABH φ 84;10). Not in DST, **TUS**$^+$ 82;0/37;20. **BIRF** 83;10/37;20, **SNB**$^+$ 83;10/36;25 (ASH=TUS).
Ardabil	24	–		83;00	38;00	82;30	38;00	= BIR	Not in BAT$^+$, YUN$^+$,KUS. **SNJ**$^+$ 83;0/37;50.
Marand	16	–		83;00	37;50	80;45	37;50	83;10 / 37;15	Not in BAT$^+$, YUN$^+$,KUS$^+$. **SNB**$^+$ 83;0/37;15 (SNB φ 37;55). **ATW** 82;45/37;50.[i]
Salmas	16	–		83;10	38;30	79;15	37;40	= BIR	Not in BAT$^+$, YUN$^+$,KUS$^+$. **BIRF** 83;0/38;25, not in SNJ$^+$.
Khuway	20	–		–		79;40	37;40	82;0 / 38;30	**BAT**$^+$ 82;0/41;40. Not in YUN$^+$,KUS$^+$. Not in BIR,SNJ$^+$. **BIR**$^+$/**SNB**$^+$ (Khūnaj *wa-huwa*) Khūna (included under Khuway in K&K) 83;20/38;20 (BIR φ 33;20 and 37;20).
Akhlat	47	74;50	39;50	74;50	39;40	75;50	39;20	= MAM/KUS	**BAT**$^+$ 78;0/39;20. **YUN**$^+$,KUS$^+$=MAM. **SNJ**$^+$=BIR.
Arzan Rum	16	–		–		79;00	41;00	76;0 / 39;0	**RES** 76;0/39;15. Not in BAT$^+$, YUN$^+$,KUS$^+$. Not in SNJ$^+$. **TUS**$^+$ 77;0/39;40 (KAS 79;0/41;15≈ATW).
Arzingan	11	–		–		73;00	39;50	74;0 / 38;0	Not in BAT, YUN,KUS. Not in SNJ$^+$. **TUS**$^+$ 74;0/38;0 (=SML) (KAS/AIN 78;0/39;50≈ATW).
Siwas	18	–		–		71;30	40;10	71;0 / 39;0	Not in BAT$^+$, YUN$^+$,KUS$^+$. Not in SNJ$^+$. **TUS** 71;0/39;0 (=SML). MAG/WAB 71;30/39;30, ULG/TMR 71;40/39;0. KAS/AIN=ATW.
Malatiya	39	71;00	39;00	61;00	39;00	71;00	37;00	= MAM/KUS	**BAT**$^+$, **YUN**,KUS=MAM. **BIRF**/HLB,MAG=MAM. Not in **SNJ**. **SHA**/NUZ,TAJ=BIR.
Qaysariyya Rum	17	–		–		70;00	40;00	69;0 / 38;30	Not in BAT$^+$, YUN$^+$,KUS$^+$. Not in SNJ$^+$. Not in TUS/ULG/TMR. MAG/WAB 69;0/39;30. KAS 67;15/40;40, AIN 60;15/40;0.
Aqsaray	9	–		–		67;08	40;00	68;0 / 38;0	Not in BAT$^+$, YUN$^+$,KUS$^+$. Not in SNJ$^+$. Not in TUS/ULG/TMR. MAG/WAB/HLB=SML. KAS/AIN 67;45/40;15[0′].
Konya	16	–		–		66;30	41;00	65;0 / 38;0	Not in BAT$^+$, YUN$^+$,KUS$^+$. Not in SNJ$^+$. **TUS**/ULG=SML, KAS/AIN 66;30/41;40.
Constan-tinople	53	59;50	45;00	= MAM		= MAM		= MAM/KUS	**BAT**$^+$ 56;40/43;10. **YUN**$^+$,KUS$^+$=MAM. **SNJ**$^+$=MAM. Significantly better values of φ are found in: TUQ 41;15, LYD/NUZ 41;0, BAG 41;20, ZAH 40;58.

[h] The latitude in SML is so far away from a realistic one that we may assume that some kind of mistake has occurred (note that the modern city Shirvan, in the southern part of the historical region, has longitude 48;55° (4;32° east of Baghdad, i.e. virtually at 84;32° from the Fortunate Isles) and latitude 39;55°).

[i] Since the longitude quoted by Abū l-Fidā' from ATW places Marand just east of Ardabil rather than several hundreds of kilometers east of it, it is unlikely that ATW had this value originally.

entry in the table from which it was copied) for the common value 80;0°. The reference table also confirms that the apparent slide of the minutes of latitude in **P_0V** from Baghdad onwards is indeed in these two sources and not in the other eight.

For Kirman (A21), 100;0° is the longitude already found in PTO, MAM and KUS. It places the city (or region) around 8° too far east with respect to Baghdad, but the variants 80° and 105° are neither elsewhere attested nor geographically better. For Kabul (A22), the latitude 28° was the traditional value in MAM, but PTO, ATW and BIR all had values much closer to the actual latitude of 34;30°. So here we can not entirely exclude that a subtradition of SML introduced the improvement 37;0° (possibly a common scribal error for the even better value 34;0°).

For Tarsus (A23), the longitude 67;40° is already found in PTO, BAT and KUS, and the values in ATW and BIR (68;0°) are very near. So 60;40° and 66;40° are undoubtedly scribal confusions. For Manbij (A25), the author of the *Shāmil Zīj* appears to have taken the longitude 63;45° from MAM and omitted to carry out the adjustment for the different meridian. Like for Egypt, he could here not directly rely on KUS. Note that the confusion of 15′ and 45′ found in five of the manuscripts is a very common one.

The coordinates that are found in **$T_1P_9F_2$O** for Hulwan, Shahrazur, Nahawand and Hamadan (B7–B10) are in each case those from Kūshyār's *Jāmiʿ Zīj*, which for Hulwan are the same as MAM and for the other three localities differ minimally from it by what may have been small scribal mistakes. It thus seems certain that the slide of these place names took place in Group B (i.e., sources **$P_8P_0VT_2$CJ**). For Qum (B11) the situation is more complicated. Again **$T_1P_9F_2$O** present the coordinates also found in KUS, whose longitude was certainly distorted. Thus the longitudes 84;15° (=MAM) and 87;0° (=BIR) and the latitude 35;0° found in Group B may in fact have been improvements. Note that the manuscripts **$P_8P_0VT_2$C** also have an incorrect rendering of the name Shahrazur. Since Kennedy made use of **P_8**, the combination of the incorrect spelling and the slid coordinates for Hulwan led him to identify the locality with Shahrud, which in medieval times was a tiny village just south of Bistam and hence does not appear in any other Islamic geographical tables.

For Sawa (B12) the decision is difficult because all latitude values found in the sources for the *Shāmil Zīj* are common scribal errors of each other. I decided for al-Bīrūnī's value 35;5°, also because most other cases show that **$T_1P_9F_2$O** are more reliable than the other witnesses. The value 35;0° does appear in some manuscripts of *al-Qānūn al-Masʿūdī*, in BIRF and in the entire tradition of al-Khāzinī. For Zanjan (B17) the coordinates in the *Shāmil Zīj* are otherwise unattested. I preferred the longitude value of 84;0° because **$T_1P_9F_2$O** are generally the more reliable witnesses and because this value, which is very accurate with respect to Baghdad, was also used in the tradition of al-Khāzinī.

The confusion between the entries for Bistam, Astarabad, Jurjan and Tus has already been explained in Section 4. Again the correct, undistorted entries appear in the sources from Group A (witnesses $\mathbf{T_1P_9F_2O}$). Note that the latitude 38;45° for Astarabad (as compared to 38;15° in Group B) is the value from MAM and the longitude 90;0° for Jurjan (95;0° in three sources from Group B) the value from KUS and ATW. For Khwarizm the intended longitude may be assumed to be the value 101;50° from MAM, from which also the latitude was taken. The 30′ found in Group B can be explained as a scribal error.

For Tiflis it is now clear that the intended latitude is the 43;0° from the tradition of ATW. Only very few Islamic sources give coordinates for Arzan Rum (Erzurum). The more reliable sources from Group A all have latitude 39;0°, but the value 39;44° in Group B is very close to the 39;45° quoted by Abū l-Fidāʾ for the *Kitāb Rasm al-rubʿ al-maʿmūr* (RES). Also for Qaysariyya Rum the *Shāmil Zīj* presents new coordinates. I chose the latitude 38;30° from Group A because of the lesser reliability of Group B in general and the unlikeliness of 2′ in a geographical coordinate in particular (in fact, four of the five manuscripts here have a plain horizontal bar rather than a correctly shaped *bāʾ*). Finally, the manuscripts from Group B omit the entry for Aqsaray but write its coordinates after Konya. For both cities the *Shāmil Zīj* has coordinates not found in the main tradition but in some incidental later sources.

The final version of my edition of the geographical table in the *Shāmil Zīj* as presented in Table 1 (pp. 529–31) allows us to establish a stemma for the eleven witnesses of the table, displayed in Figure 1. It is obvious that Group A ($\mathbf{T_1P_9F_1F_2O}$) and Group B ($\mathbf{P_8P_0VT_2CJ}$) form two independent branches, with Group A being generally more correct and hence closer to the original table.

Group B stands out especially because of the slide of five place names in the middle of the second column and the distorted entries, starting with Astarabad (B23), at the end of the second column. But the group also shares a large number of other peculiarities and errors not found in Group A, ranging from additional columns with only the word *madīna* ‘city’ and deviating spellings of place names to the mix-up of the entries Aqsaray and Konya and numerous mistakes in the coordinates (cf. Table 6). Within Group B some subgroups can be recognized. As was already to be expected on the basis of the description of the entire manuscripts, $\mathbf{P_0}$ and **V** are obviously strongly related. They share a number of deviations that do not appear in other witnesses, namely لطول instead of اطول in the title, the incorrect spelling of Aden (A3) as عند, the slide of the minutes of latitude from Baghdad (A12) to Madāʾin (A17), the addition of interlinear entries for Mardin and al-Ḥiṣn in the first two cells of the second column, the coordinates for Qum (B11), and various other devi-

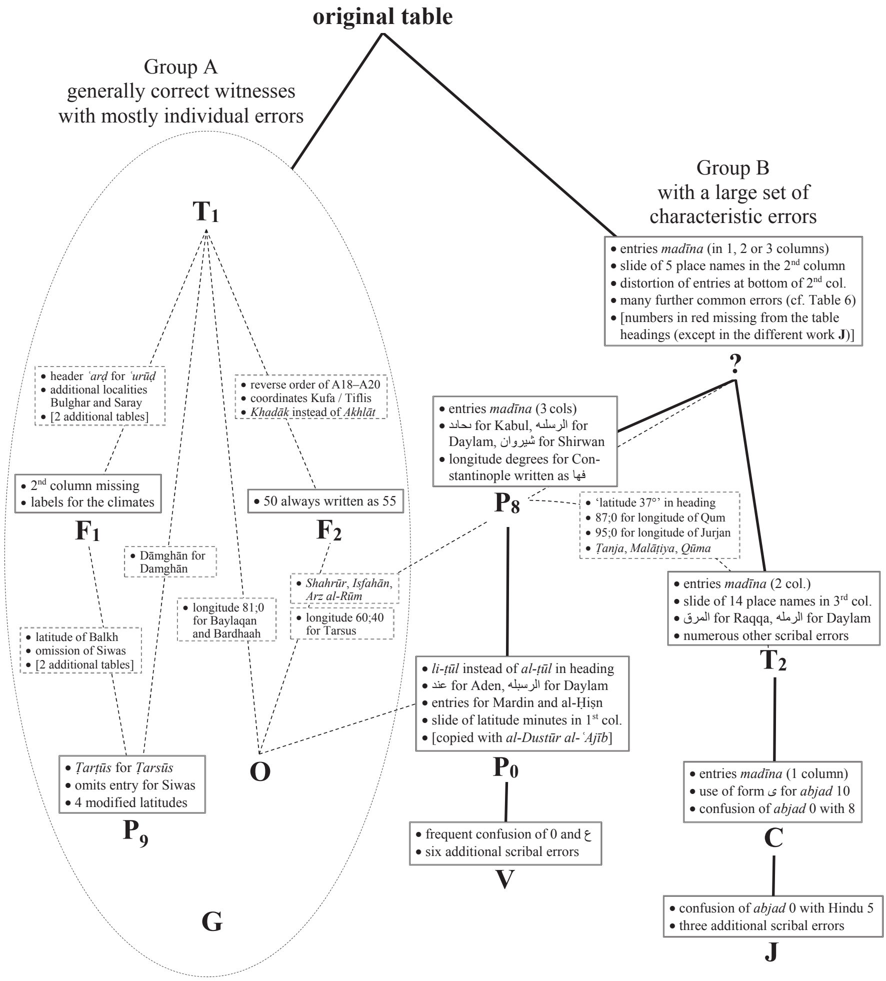

Figure 1: Stemma of the witnesses for the geographical table in the *Shāmil Zīj* on the basis of their errors and other characteristics and some additional information. Solid lines indicate direct dependences; the solid rectangles just above the sigla list the characteristics of the witness concerned that were passed on to its descendants. Dashed lines indicate the presence of shared characteristics, which are listed in dashed rectangles, in addition to individual errors. Characteristics given between square brackets relate to other tables in the manuscripts concerned. In addition to the sigla introduced in Section 2, **G** stands for the transcription of the table by Greaves with its unique errors.

ating longitudes and latitudes. Since **V** has six minor errors not found in $\mathbf{P_0}$ (namely, in the longitudes of Harran (B3), Bistam (B22) and Arzingan (C21) and the spelling of Sawa (B12), Baylaqan (C10) and Arzingan (C21)), but none the other way around, it is almost certain that **V** was copied from $\mathbf{P_0}$, which an investigation of the entire manuscripts should easily be able to confirm. Furthermore, it is likely that $\mathbf{P_0V}$ depend on $\mathbf{P_8}$ (which does not include the slide in the first column), since they follow this witness in the spelling of Sanaa (A2) as صنعه, the defective spellings of the names Kabul (A22) and Daylam (B18), the latitude for Egypt (A7), the incorrect latitude of Siwas (C22), and a peculiar writing of the degrees of longitude (59) of Constantinople (A27) (نط in **P**$_8$, فها in **P**$_0$**V**). As already mentioned, **CJ** include a large number of scribal errors that are otherwise only found in **T**$_2$ and add several further ones of their own. **J** was copied 18 years after **C** and also other parts of the *zīj* contained in it were derived from the *Shāmil Zīj*, so that it is more likely that of these two sources **C** was the original. This is confirmed by three small additional mistakes found in **J** but not in **C**.

Within Group A it is much more difficult to make out patterns, simply because the number of idiosyncratic and shared errors in each of the five witnesses is too small. **T**$_1$**F**$_2$ share the errors in the longitude of Kufa (A11) and the latitude of Tiflis (C8), the reversal of the order of entries A18 to A20, and an incorrect spelling of Akhlat (C19). Additionally, **T**$_1$ has a scribal error in the longitude for Kirman (A21) and inexplicable errors in the longitudes of Baylaqan (C10) and Bardhaah (C11), which are further only found in **O**. **F**$_2$ adds to the common errors the systematic confusion of 50 with 55′ and incorrect spellings of Abhar and several other localities. It thus seems clear that **T**$_1$ and **F** cannot have been copied from each other directly, but must have derived from a common ancestor. **P**$_9$ has seven small deviations in longitudes and latitudes that are not found in any of the other sources and are no common scribal errors. Near the end of the first column several coordinates appear to have been corrected, as was the latitude of Constantinople (C27), which was traditionally much too high in most Islamic sources. Besides the omission of the entire second column and seven deviations in coordinates that are all common scribal errors and only occasionally appear in other witnesses, **F**$_1$ has several distorted place names and some mix-ups at the transition from the first to the third column and for Constantinople. Also **O** has mostly individual errors, most of which are common scribal errors. The inexplicable errors in the longitudes of Baylaqan (C10) and Bardhaah (C11) suggest that **T**$_1$ and **O** had a common ancestor. The addition of interlinear entries for Mardin and al-Ḥiṣn with different longitudes from **P**$_0$**V** and added latitudes, may suggest that the Priest Cyriacus at least consulted a copy of the *Shāmil Zīj* from the family of **P**$_0$**V**.

The reference table also allows us to easily identify the main sources for the geographical table in the *Shāmil Zīj*. The latter has 50 of its 79 localities in common with the table in Kūshyār ibn Labbān's *Jāmiʿ Zīj*, for 49 (!) of which the coordinates are identical (the only exception being Baghdad (A12), for which Kūshyār has the anomalous longitude 75;0°). In 23 of these 49 cases the same coordinates are also found in the Maʾmūnic tradition, in four cases each in al-Bīrūnī and in the *ʿAlāʾī Zīj*. Because we already know that the author of the *Shāmil Zīj* adopted some of Kūshyār's tables for planetary equations, it is thus most probable that KUS was his main source. For seven localities the coordinates given in the *Shāmil Zīj* further only appear in the tradition of al-Bīrūnī's *al-Qānūn*. The geographical table from the *ʿAlāʾī Zīj* is unlikely to have been an important source since it has only 32 localities in common with the *Shāmil Zīj*, and among these the coordinates are identical, or differ merely by a common scribal error, for only 19. For 18 localities, the *Shāmil Zīj* presents coordinates that are not found in any of the seven main and smaller traditions considered in the reference table.

To conclude, we have seen in this article how geographical tables in Islamic sources can be riddled with scribal errors of different types, and how even the availability of multiple copies of the same table may not suffice to establish the original coordinates reliably. We had to make use of the collection of longitudes and latitudes in Kennedy and Kennedy, *Geographical Coordinates* (K&K) in order to be able to decide on the most likely original coordinates for more than a dozen of localities from the geographical table in the *Shāmil Zīj*. For this purpose, the reference table that I have set up of the coordinates in each of the main Islamic traditions turned out to be extremely helpful. The expansion of this table to a larger set of several hundreds of the most important localities, as well as its implementation in the form of a graphical computer database that can conveniently show all traditions and their variations, would be highly desirable. The implementation of a database of geographical coordinates based on K&K, taking into account corrections and additions that Mercè Comes and I have already made and including further ones, will not only facilitate the creation of a more extensive geographical reference table, but also analyses of the probability of scribal errors in numerical values in Arabic and Persian sources.

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جدول اطوال البلدان من جزاير الخالدات وعروضها عن خط الاستوا

البلدان	الطول	العرض	البلدان	الطول	العرض	البلدان	الطول	العرض
حبشه	نا م	لط ل	البروه	عج نه	لو ح	سرخس	صح ك	لو ح
صنعا	عج ل	يد ل	امل	عه نه	لج ح	مرو	صد ك	لد ل
عدن	عه ح	يح ح	حران	عز ح	لد ح	بخارا	صز ك	لو ن
عمان	صد ل	يط مه	حما	عد م	لو ح	بلخ	صح ل	لج م
مدينه	عه ك	كه ح	موصل	عج ح	لو ل	سمرقند	صط ل	لو ل
مكه	عز ى	كا ل	انطاليه	عط ح	له ل	خوارزم	قا ن	مب ى
مصر	ند نه	كط نه	حلوان	نا مه	لد ح	دربند	فح ح	مه ه
اسكندريه	س ل	ل ك	شهرزور	ف ك	لد نه	تفليس	فح ح	مج ح
بيت المقدس	سو ل	لا ح	نهاوند	فب ح	لو ى	كنجه	فا ل	ما ح
دمشق	ع ح	لج ل	همدان	فج ح	لو ى	بيلقان	فد ل	لج ح
كوفه	عط ل	لا ن	قم	ف نه	لد ح	بردع	فد ح	مج ح
بغداد	ف ح	لج كه	ساوه	فر ح	له ه	شروان	فد ح	له ح
واسط	فا ل	لا ك	اصفهان	فد م	لد ح	تبريز	فج ى	لد ل
بصره	فد ح	لا ح	الري	فه ح	له ل	مراغه	فج ك	لد كه
قادسيه	عط كه	لا مو	قزوين	فه ح	لو ح	اردبيل	فج ح	لج ح
حله	عط ى	لا ى	ابهر	فه ح	لو ح	مرند	فج ى	لد نه
مداين	ف ك	لج ى	ريحان	فد ح	لو ح	سلماس	فج ى	لج ل
اهواز	فه ح	ل ح	ديلم	فه ح	لج ح	خوى	فت ح	لج ل
شيراز	فح ح	كط ح	روينان	فو له	لد ح	اخلاط	عد ن	لط ن
شابور	فح م	ل ح	ساريه	فز ن	لج ح	ارزن الروم	عو ح	لط ح
كرمان	ق ح	ل ح	دامغان	فح لز	لد ح	ارزنجان	عد ح	لح ح
كابل	قى ح	لد ح	بسطام	فط نه	له م	ملطيه	عا ح	لط ح
طرطوس	سر م	لو نه	استراباد	فط ن	لح مه	قيصريه	سط ح	لح ل
حلب	عا ح	لو ح	جرجان	صه ح	لو ن	اقسرا	سح ح	لح ح
مسيح	سح مه	لو ى	طوس	صه ح	لد ح	قونيه	سه ح	لح ح
حمص	عا ح	لج م	نيشابور	صه ل	لو كا	قسطنطنيه	نط ن	ما ح
لادق وبركى	سـ ل	ما ل	اياثلوغ	سا ح	ما ح	بلغار	سح ح	مط ل
						سراى	عد ك	مو ى

Plate 16: Geographical table from the *Shāmil Zīj*. Paris, Bibliothèque nationale de France, MS arabe 2529, fol. 20v.

Astronomical tables are a significant yet understudied part of the scientific historical corpus. They circulated among many cultures, and were adopted and transformed by astronomical practitioners for a variety of purposes. The numerical data conveyed in these tables provides rich evidence for pre-modern scientific practices. In the last fifty years, new approaches to the analysis and critical editing of astronomical tables have flourished due to advances in computing power and associated modern mathematical tools. In more recent times, the rapid growth of digital humanities and modern data analysis promises exciting further developments in this area.

The present collection of studies on astronomical tables captures this momentum. It is a result of long-term collaborative work on building a database of astronomical tables and other objects found in manuscripts, released under the name DISHAS (Digital Information System for the History of Astral Sciences). The fourteen contributions in this volume provide a broad coverage of astronomical traditions throughout Eurasia and North Africa, which, with very few exceptions, find their roots in the mathematical astronomy of Ptolemy. The contributions include critical editions of previously unexamined astronomical tables along with insightful mathematical analyses, as well as reflective methodological surveys that open up new perspectives for research on these fundamental sources for the history of mathematics and astronomy.

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