Dmitriy A. Shcheglov

Ptolemy's system of seven climata and Eratosthenes' geography

The *Geographical Directory* by Ptolemy is considered the acme of ancient geography, a work that is far superior to all preceding geographical tracts both in its methods and volume of information. Very little is known about the prehistory of Ptolemy's geography. In the present paper we discuss the problem of the origin of the system of seven climata, which had first appeared in Ptolemy's works and then became one of the basic, canonical elements of late antique, medieval European and Arabic geography[1].

In part 1 the concept of clima is considered: the development of the system of climata and the evolution of meaning of the term κλίμα are discussed. In part 2 the nature of the dependence of Ptolemy's geography on the work by Marinus of Tyre, his immediate predecessor, is examined. Part 3 is devoted to the verification of E. Honigmann's hypothesis that the Ptolemaic system of seven climata goes back to Eratosthenes.

I. Preliminary Remarks on the Concept of Clima and the Evolution of the System of Climata

The system of climata, or key latitudes forming the frame of the geographical map, was one of the fundamental concepts of ancient mathematical geography[2].

The term κλίμα appears first in the *Anaphoricos* by Hypsicles (36 De Falco-Krause-Neugebauer) and in the *Commentary on Aratus* by Hipparchus, and later is widely used by many authors, primarily by Strabo, Geminus and Cleomedes. In most cases, κλίμα can be translated as "latitude". Various questions concerned with the use of this term and the history of the concept of climata have been analysed in a number of works[3]. Detailed analysis of all these

[1] E. Honigmann, *Die sieben Klimata und die πόλεις ἐπίσημοι*, Heidelberg, Winter 1929 (further – Honigmann, *SK*).

[2] The main works on climata: W. Kubitschek, *Klima* 2, in *RE* XI A1, 1921, coll. 838-844; Honigmann, *SK*; A. Diller, *Geographical Latitudes in Eratosthenes, Hipparchus and Posidonius*, «Klio» 27 3, 1934, pp. 258-269; D. R. Dicks, *The ΚΛΙΜΑΤΑ in the Greek Geography*, «Classical Quarterly» V 3-4, 1955, pp. 248-255; Id., *The Geographical Fragments of Hipparchus*, London, Athlon Press 1960 (further – Dicks, *Hipparchus*). On the clima-related trigonometric methods: O. Neugebauer, *A History of Ancient Mathematical Astronomy*, 1-3, Berlin, Heidelberg, New York, Springer Verlag 1975, pp. 43-45, 333-336, 725-733 (further – *HAMA*); A. Szabó, E. Maula, *Les débuts de l'astronomie de la géographie et de la trigonométrie chez les grecs*, Traduit par M. Federspiel, Paris, Vrin 1986. A recent paper adds nothing new: D. Marcotte, *La climatologie d'Ératosthène à Poséidonios: genèse d'une science humaine*, in G. Argoud, J.-Y. Guillaumin (ed.), *Sciences exactes et sciences appliquées à Alexandrie (IIIᵉ siècle av J.-C. – Iᵉʳ ap J.-C.)*, Université de Saint-Étienne 1998, pp. 263-277.

[3] Honigmann, *SK*, pp. 4-7; Dicks, *The ΚΛΙΜΑΤΑ*, pp. 249-250; Id., *Hipparchus*, pp. 154-157; also: G. Aujac, *Lexique grec*, in G. Aujac (ed.), *Strabon. Géographie*, I 2, in CUF, Paris, Les Belles

questions exceeds the limits of the present paper, which is greatly indebted to the works of previous scholars. In part 1 we presume only to state the main facts characterizing the development of the system of climata and try to stress a few points, which were overlooked by previous scholars and are important for the solution of our prime question – the origin of the system of 7 climata.

The development of the system of climata may be divided into three stages, briefly characterized below: 1) the use of the concept of clima to express latitudes of a single place, 2) the creation of the system of climata, 3) the invention of the canonical variant of this system.

The term κλίμα originates from the verb κλίνω and means (in astronomy and geography) the angle of inclination of the celestial sphere with respect to the plane of the local horizon[4] that could be expressed by an exact number, as well as the geographic latitude characterized by this angle[5]. In this meaning, the term κλίμα could refer to any latitude whatsoever.

This definition reveals the fundamental difference originally existing between the notions of κλίμα and παράλληλος. In modern geography, "parallel" is considered an element of the coordinate grid closely related to the notion of "latitude". In antiquity, the term "parallel" appeared long before the grade grid and the term "latitude" (πλάτος). In ancient geography, the coordinate grid was first used by Hipparchus, the terms "latitude" and "longitude" were introduced only by Ptolemy[6]. To define latitude in degrees Hipparchus used the expression "elevation of the pole" (ἐξάρματα τοῦ πόλου; *Comm.* I.3.6-7, 11.8 Manit. 26.15, 18; 28.27, 114). Initially, the term "parallel" did not refer to the measurability of latitude[7]. "Parallel" was characterized by its abstract geometric character: this was a term for a circle parallel to the equator and passing through an arbitrarily chosen point. Even after the introduction of the grade grid, the geographers of Hipparchus' and Strabo's era kept using the term "parallel" as an attribute of certain place rather than an element of the coordinate grid. When our contemporary says: «Rhodes lies on the 36° parallel», an ancient geographer would have said: «The parallel of Rhodes is 36° away from the equator»[8]. The relation between the terms κλίμα and παράλληλος is clearly displayed in Strabo's account of the map projection (II.5.10 C116-117 = Erat. F III A 25)[9], which probably goes back to Hipparchus[10]: the grid of parallels is not used *per se* here, but only as a convenient tool for describing «climata, winds and other differences» (τά τε κλίματα καὶ τοὺς ἀνέμους διασαφοῦμεν καὶ τὰς ἄλλας διαφορὰς) characterizing the latitude.

Until the introduction of the grade grid, it was only the concept of clima that gave a way to define the latitude of the given parallel. Therefore, both terms could be used without further reservations to denote the same object, a locality situated at the given latitude, depending on the requirements of the context: clima – to point out definite, measurable nature of the latitude, parallel – to link the given place to the abstract coordinate grid forming the basis of map. In other words, the literal meaning of the term κλίμα is the angle characterizing the given parallel.

Lettres 1969, p. 186; MARCOTTE, *La climatologie*, pp. 265, 275-276. Besides latitude, in some cases the term could mean a cardinal point, a region of the world, or even a district of the Byzantine Empire.

[4] The only extant definition is «Inclinationes caeli quas Graeci κλίματα dicunt, et aeris et locorum» (Vitruv. I.1.10).

[5] Cf. the definitions by KUBITSCHEK, *Klima*, coll. 838; HONIGMANN, *SK*, 4; DICKS, *The ΚΛΙΜΑΤΑ*, pp. 248-249; ID., *Hipparchus*, p. 154; *HAMA*, pp. 333-334, 725; MARCOTTE, *art. cit.* (in note 2), p. 264.

[6] It was noted by E. H. BUNBURY, *A History of Ancient Geography*, 2nd ed., New York, Dover Publications Inc. 1959, I, p. 626 note 9; II, p. 550; P. TANNERY, *Recherches sur l'histoire de astronomie ancienne*, Paris, Gauthier-Villars 1893 p. 134; HONIGMANN, *SK*, p. 4 note 1; *HAMA*, p. 333; P. JANNI, *La mappa e il periplo. Cartografia antica e spazio odologico*, Roma, Pubblic. Fac. Lettere Filos. XIX, Univ. di Macerata 1984, pp. 68-71.

[7] This circumstance was disregarded by HONIGMANN, *SK*, p. 11: «παράλληλος ist die mathematische Linie, die *in einem bestimmten Abstande* dem Äquator gleichläuft» (my italics).

[8] It was noted by H. BERGER, *Geschichte der wissenschaftlichen Erdkunde der Griechen*, 2. Aufl., Leipzig, von Veit 1903, pp. 420-421; JANNI, *op. cit.* (in note 6), pp. 66-68.

[9] All further references without an author specified are to Strabo: S. RADT (ed.), *Strabons Geographika*, 1, *Prolegomena, Buch I-IV, Text und Übersetzung*, Göttingen, Vandenhoeck & Ruprecht 2002. Hipparchus' fragments are numbered according to H. Berger and D. Dicks, Eratosthenes' fragments – according to H. Berger.

[10] As is shown by BERGER, *Erdkunde*, pp. 476-478.

This is likely to be the very cause why the geographers engaged in charting map (Eratosthenes[11], Hipparchus[12], Strabo, Pliny, Ptolemy) preferred to use the term παράλληλος, even when the latitude they refer to was defined by one of the methods implied by the concept of clima (see below).

Until the introduction of the coordinate grid based on the division of the circle into 360°, only two methods allowed expressing latitude by number: (1) determining the proportion of gnomon to its shadow at the equinox (= $\tan\ \phi$), and (2) determining the length of the longest (*M*) or the shortest day (or night) at the solstice, or their ratio[13]. Any results obtained by one method could be converted *post factum* into the corresponding result expressed by another.

The significance of these methods and their relation to the concept of clima can be well illustrated by two quotes from Hipparchus' geographical treatise cited by Strabo:

Τὸ μὲν οὖν κατὰ Μερόην κλίμα Φίλωνά τε τὸν συγγράψαντα τὸν εἰς Αἰθιοπίαν πλοῦν ἱστορεῖν (FGH 670 F 2) ὅτι πρὸ πέντε καὶ τεσσάρακοντα ἡμερῶν τῆς θερινῆς τροπῆς κατὰ κορυφὴν γίνεται ὁ ἥλιος, λέγειν δὲ καὶ τοὺς λόγους τοῦ γνώμονος πρός τε τὰς τροπικὰς σκιὰς καὶ τὰς ἰσημερινάς, αὐτόν τε Ἐρατοσθένη (F II B 36) συμφωνεῖν ἔγγιστα τῷ Φίλωνι (II.1.19 C77 = F II 4 = F 17).

«Philo, who wrote an account of his voyage to Ethiopia, reports about the clima of Meroe that the sun is in the zenith 45 days before the summer solstice[14], and he also gives the ratios of the gnomon to both the solstitial and equinoctial shadows; and Eratosthenes himself agrees very closely with Philo».

...τὸ ἐπειδὴ οὐκ ἔχομεν λέγειν οὔθ' ἡμέρας μεγίστης πρὸς τὴν βραχυτάτην λόγον οὔτε γνώμονος πρὸς σκιὰν ἐπὶ τῇ παρωρείᾳ ἀπὸ Κιλικίας μέχρι Ἰνδῶν, οὐδ' εἰ ἐπὶ παραλλήλου γραμμῆς ἐστιν ἡ λόξωσις ἔχομεν εἰπεῖν, ἀλλ' ἐὰν ἀδιόρθωτον, λοξὴν φυλάξαντας, ὡς οἱ ἀρχαῖοι πίνακες παρέχουσι (II.1.11 C 71 = F II 2 = F 14)[15].

«Since we can neither tell the ratio of the longest day to the shortest nor of the gnomon to its shadow along the mountainside from Cilicia to India, nor can we say whether the [mountain range] slants along a parallel, we should leave it uncorrected, as the ancient maps show».

The advantage of the former method was its greater easiness in use and precision of results[16]. However, the latter method, more graphic, had a decisive advantage for the introduction of the system of climata: only the measurement of *M* could be a substitute for the (nonexistent) grade grid, allowing one to elaborate a uniform scale for fixing the latitude of any area[17].

Therefore, from the initially broad doctrine of κλίμα one can deduce a narrower definition of the concept of clima that has formed the basis for systems of climata in ancient geography: κλίμα is a geographic latitude expressed in terms of the length of the longest day at this latitude [$\phi = f(M^h)$; ΔM^h = const; h = hour] and constituting a frame of map. The shadow-to-gnomon ratios also form an integral part of every "detailed" system of climata we know, but are used either as a supplement, or to give precise values of some latitudes[18].

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[11] BUNBURY, *History*, II, p. 4 note 2; H. BERGER, *Die geographischen Fragmente des Eratosthenes*, Leipzig, Teubner 1880, pp. 191-192. Anm. 2; ID., *Erdkunde*, pp. 416-417; DICKS, *The ΚΛΙΜΑΤΑ*, p. 253; ID., *Hipparchus*, p. 159.

[12] Relying upon his erroneous definition of clima as a 400st-wide belt, E. Honigmann attempts to prove that Hipparchus has completely rejected climata in favour of parallels, because he considered climata not fitting his exactness requirements in calculations: HONIGMANN, *SK*, pp. 11-17, 19-21; cf. also (independently): G. AUJAC, *Strabon et la science de son temps. Les sciences du monde*, Paris, Les Belles Lettres 1966, p. 169; EAD., *Lexique grec*, p. 186; EAD., *Eratosthène de Cyrène, le pionier de la geographie*, Paris, Édition du CTHS 2001, p. 100. This opinion appears unfounded: DILLER, *Geographical Latitudes*, p. 265; JANNI, *op. cit.* (in note 6), pp. 68-69; SZABÓ, MAULA, *op. cit.* (in note 2), pp. 91-93.

[13] Cf. BUNBURY, *History*, I, pp. 632-633; DILLER, *Geographical Latitudes*, pp. 268-269.

[14] It corresponds to the latitude where the longest day is 13 hours.

[15] Cf. Geminus V. 58: καὶ τὰ μεγέθη τῶν ἡμερῶν καὶ τὸ κλίμα καὶ πάντα τὰ φαινόμενα τὰ αὐτά: G. AUJAC, *Géminos. Introduction aux phénomènes*, in CUF, Paris, Les Belles Lettres 1975, p. 31.

[16] On the history of this method: SZABÓ, MAULA, *op. cit.* (in note 2).

[17] This circumstance has been disregarded by NEUGEBAUER, *HAMA*, pp. 937-938, who was surprised that the system of climata became so widespread in antiquity even though the length of the daylight *M* is much more difficult to measure than the latitude ϕ. However cf. *HAMA*, p. 333: «the mere fact that the length *M* ... appears to be the most popular description of latitudinal positions (the whole concept of "climata" was based on it) suffices to show that one was satisfied, by and large, with the least accurate but practically most important parameter, not surprising at a time when one was not yet able to transform *M* into ϕ or vice versa mathematically correctly».

[18] Cf. TANNERY, *Recherches*, p. 134; *HAMA*, p. 333.

One should remember, however, that this definition is not taken directly from ancient texts, but rather may even contradict the usage of the term κλίμα in many of them. Most authors, even those who describe particular systems of climata, use the term κλίμα in its initial broad meaning: i.e. they often apply it to an arbitrarily chosen latitudes not related to any systems (Strabo, Geminus, Cleomedes) and not meeting the formula $\varphi = f(M)$, while the latitudes of $\varphi = f(M)$ are often referred to as parallels.

The strict link of the term κλίμα to the latitudes of $\varphi = f(M)$ is presented in Ptolemy, in the system of 7 "astrological" climata[19], the table of climata of Martianus Capella (VIII.876–877 Dick 462), and in Strabo's abstract of Hipparchus' table (II.5.34 C131). It is remarkable also that Hypsicles and Hipparchus, referring to Eudoxus (*Comm.* I.2.22 Manit. 23 = F 68 Lasserre), the very first authors to mention the term κλίμα, use it just in the meaning of $\varphi = f(M^h)$. These facts prove that the narrower definition of the term κλίμα as a latitude being $\varphi = f(M^h)$ was really in use in ancient mathematical geography.

In brief, the main development stages of the system of climata in ancient geography are as follows. The introduction of the concept of clima is often attributed to Eudoxus of Cnidus (see note 85). According to the hypothesis of Ernst Honigmann, the system of 7 climata, used by Marinus of Tyre and Ptolemy, has originated with Eratosthenes. Hipparchus has created the first "detailed" table of climata, which is often considered as a prototype of the Ptolemaic Shadow Table (see note 78). Marinus of Tyre and Ptolemy used the system of 39 parallels of the Shadow Table, with the seven of them being picked out and termed climata. On the other hand, Ptolemy has been the first to discard the system of climata and make the grade grid the only universal method of specifying geographical positions.

We know of only three "detailed" tables of climata with latitudes defined as $\varphi = f(M)$ and the data on the gnomon shadow: those by Hipparchus, Pliny and Ptolemy[20].

The Shadow Table from Ptolemy's *Almagest* (II.6 Heib. 101-117) can be considered the gold standard and the most advanced form of the system of climata. The Table consists of 39 parallels from the equator to the pole, first in $\Delta M = \frac{1}{4}^h$ increments, then in $\frac{1}{2}^h$ increments starting from the 18^h (58°) and 1^h-spaced from 20^h (63°). For these parallels, the table states: (1) the longest daylight *M*, (2) the latitude in degrees, (3) the shadow-to-gnomon ratio at the equinox and the solstice, (4) the names of corresponding places for 29 parallels from the equator to Thule (20^h; 63°), and (5) for places to the south of the tropic – the duration of the period of shadows falling southward.

Pliny's table (*N.H.* VI.211-219) is an arbitrary combination of two distinct systems. The table is based upon the system of 7 "astrological" climata (14^h, $14^h\ 24^m$, $14^h\ 32^m$, $14^h\ 40^m$, 15^h, $15^h\ 12^m$, $15^h\ 36^m$) with the list of cities and countries and the shadow-to-gnomon ratios for each of them. Since the system of "astrological" climata only covered the latitudes of the Roman Empire, for more northern and southern areas Pliny gives the parallels taken from some system of "geographical" climata, similar to those quoted by Cleomedes and Martianus Capella. Pliny calls his latitudes *circuli* or *paralleli*, though the sources describing similar tables – Vettius Valens (*Anth.* I.7 Kroll 24, 157), Firmicus Maternus (*Math.* II.11 Kroll-Skutsch I 53-55), P. Michigan 149 (XI.38-47) and Martianus Capella (*De nupt.* VIII.876-877 Dick 462) – refer to them as climata.

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[19] Vettius Valens: Anth. I 7 Kroll 24, 157; Firmicus Maternus: Math. II 11 Kroll-Skutsch I 53–55; the Michigan papyrus 149: XI 38-47. On the "astrological" climata: Honigmann, *SK*, pp. 31-50, more detailed: Id., *Die Anaphorai der Alten Astrologen. Ein Versuch, die Anaphorai und Klimata des Michigan-Papyros 149 zu erklären*, in *Michigan Papyri*, III, *Papyri of the University of Michigan Collection. Miscellaneous Papyri*, Edited by J.G. Winter, Ann Arbor, Univ. of Michigan Press 1936 (= *Univ. of Michigan Studies, Humanistic Series*, XL), pp. 301-321; for more detailed survey with the improvement of some Honigmann's mistakes see: O. Neugebauer, *On Some Astronomical Papyri and Related Problems of Ancient Geography*, «Transactions of American Philosophical Society» 32, 1942, pp. 251-263; *HAMA*, pp. 706-733. A peculiar trait of this system is the interleaving of the increments $\Delta M = 8^m, 16^m, 24^m$ between the latitudes, with the two southern of them being drawn through Alexandria and Babylon.

[20] In his list of scientists involved in sundial issues, Vitruvius mentions a lost treatise by Theodosius, πρὸς πᾶν κλίμα (IX.8.1). It can be inferred from this mention that Theodosius studied the relationship between the length of shadow at the given place and its clima (probably expressed through *M*): R. Fecht, *Theodosii De Habitationibus liber, De diebus et noctibus libri duo*, Berlin, 1927 (= *Abh. Ges. Wiss. Göttingen*, Phil.-hist. Klasse, N.F., XIX,4), pp. 1-3; cf. Honigmann, *SK*, p. 16.

Hipparchus' table is only known from Strabo's synopsis (II.5.34-43 C131-135). Strabo mentions the total of 17 parallels: 14 of them are $\phi = f(M)$, with 12 of them in $\Delta M = 1^h, ½^h, ¼^h$ increments (except Babylon 14 2/5^h[21], and Athens 14 3/5^h; cf. *Comm.* I.3.12; 4.8 Manit. 28 24, 34 14 = F V 11 Berger)[22]; he states shadow-to-gnomon ratios for four parallels (Meroe, Alexandria, Carthage, Massalia), Pytheas' data on solar elevation at equinox – for four northern parallels, information on visible stars – for five parallels (the Land of Cinnamon, Syene, Alexandria, the mid-Pontus, the mouth of the Borysthenes).

Early or late, one variant of the system of climata is accepted as a canonical, which radically changes the meaning of the term κλίμα. The authors who accept the canonical system apply this term only to the latitudes included in it, but not to all latitudes corresponding to the initial meaning of this term, or to $\phi = f(M)$ formula, which sets the basis for the very canonical system.

The canonical system of climata appeares first in Ptolemy. In the *Almagest*, Ptolemy gives two tables of latitudes: the Shadow Table and the table for calculating ἀναφοραί[23]. Essentially, all latitudes in these tables are climata, though Ptolemy invariably refers to them as parallels. Besides these tables, Ptolemy has been the first to use the system of 7 climata, following in $\Delta M = ½^h$ increments: 13^h – Meroe, 13½^h – Syene, 14^h – lower Egypt, 14½^h – Rhodes, 15^h – Hellespont, 15½^h – the mid-Pontus and 16^h – the mouth of the Borysthenes. Only these 7 latitudes are referred to by Ptolemy as climata. This system is used by Ptolemy in the table of zenith distances in the *Almagest* (II.13 Heib. 172-187), in the *Handy Tables* (the tables for calculating the oblique ascendance, ortive amplitudes and parallax of the Sun; cf. *Alm.* VI.4, 5 Heib. 175, 181-182) and in the *Analemma*[24]. This system is also described in the anonymous treatise Διάγνωσις, an adaptation of Ptolemy's geography[25], and depicted on the Ptolemaic maps[26].

Deserving a special mention are two points not taken into account by prior researchers.

Firstly, neither E. Honigmann nor other scholars (F. Gisinger, A. Diller, D. Dicks, O. Neugebauer) have noticed the obvious fact that the appearance of the system of 7 climata in sources and its canonical status are owed solely to Ptolemy. Thus, E. Honigmann makes an obvious mistake by linking the mentions of the 7 climata in Cassiodorus and Achilles Tatius directly to Eratosthenes[27], for he does not even touch on the questions of their origin and of the nature of the relationship between the Ptolemaic system of climata and Eratosthenes' geography. Meanwhile, Achilles Tatius (*Isag.* 19 Maass 47) and Cassiodorus refer directly to Ptolemy before mentioning the 7 climata[28]. Equally unfounded are any other attempts to attribute the canonization of the system of 7 climata to pre-Ptolemaic authors (e.g. F. Gisinger and D. Dicks suggest Hipparchus[29], or K. Reinhardt and W. Theiler suggest Posidonius[30]).

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[21] HONIGMANN, *Die Anaphorai*. This subject should be discussed somewhere else with a special argumentation.

[22] P. F. J. GOSSELLIN, *Recherches sur la Géographie systématique et positive des anciens*, I, Paris, Imprimerie de la République 1798, p. 56; H. BERGER, *Die geographischen Fragmente des Hipparch*, Leipzig, Teubner 1869, pp. 50-52.

[23] I.e. of the rising times of the zodiacal signs. This table is an abbreviated variant of the Shadow Table: 11 parallels follow in $\Delta M = ½^h$ increments from the equator to the mouth of the Tanais (II.8 Heib. 134-141).

[24] Cf. *HAMA*, pp. 38, 50-52, 125-129, 852-853, 978, 990-991.

[25] Edition: A. DILLER, *Agathemerus, Sketch of Geography*, «Greek, Roman and Byzantine Studies» 16, 1975, pp. 59-76.

[26] In MSS: Vaticanus Urbinas 82, Constantinopolitanus Serapliensis 57, Fabricianus Havniensis 23, Venetus Marcianus 516. Cf. P. SCHNABEL, *Text und Karten des Ptolemäus*, Leipzig, K. F. Koehler 1939 (= *Quellen und Forschungen zur Geschichte der Geographie und Völkerkunde*, I), pp. 87-92; A. DILLER, The Parallels on the Ptolemaic Maps, «Isis» 33 1, 1941, pp. 4-7.

[27] HONIGMANN, *SK*, p. 54; against him DICKS, *The ΚΛΙΜΑΤΑ*, p. 252; ID., *Hipparchus*, p. 157.

[28] HONIGMANN, *SK*, pp. 102-103 mentions it, but does not draw a conclusion from it.

[29] F. GISINGER, Rez.: E. Honigmann. Die sieben Klimata, «Gnomon», 1933, p. 97; DICKS, *The ΚΛΙΜΑΤΑ*, pp. 253-254; ID., *Hipparchus*, pp. 157-158; against them W. THEILER, *Poseidonios. Die Fragmente*, II, Berlin, New York, de Gruyter 1982, p. 31.

[30] K. REINHARDT, *Kosmos und Sympathie*, München, C. H. Beck 1926, pp. 398-400; ID., Poseidonios 3, in *RE* 22, 1953, coll. 677-678; THEILER, *Poseidonios*, pp. 29-31, 74-75; against it I. G. KIDD, *Posidonius*, II, *The Commentary*, Cambridge, Univ. Press 1988, pp. 737-738. Arguing that Posidonius did use the system of climata, E. Honigmann brings as the key argument an evidence of Proclus (*Ad Plat. Tim.* III.125.11-14 = F 205 Edelstein-Kidd = F 74 THEILER) about Posidonius' measurement of the Earth, where the expression *the third clima* is used for the latitude of Alexandria: HONIGMANN, *SK*, p. 25; ID., *Marinos* 2, in *RE* XIV, 1930, coll. 1780; REINHARDT, *Poseidonios*, coll. 677. More likely, this expression is merely a reminiscence of the Ptolemaic system of 7 climata. Cleomedes and Geminus (*Isag.* III.15 Aujac 20), as more reliable sources, describing Posidonius' measurement of the Earth mention neither *the third clima* nor *the second*; cf. KIDD, *op. cit.*, p. 737. Proclus was an expert on Ptolemy's works.

I think that the common mistake of all mentioned scholars consists in their inattention to the fact that the appearance of canonical system of climata entails changing in the meaning of the term κλίμα. The Ptolemaic system should be called canonical not because it was accepted by the most of his successors, but as the first system in which a strict distinction was drawn between the seven climata and the infinite number of all other possible latitudes. Ancient authors, most importantly Strabo, Geminus and Cleomedes, give a fairly complete account of the geographical systems of Eratosthenes, Hipparchus and Posidonius, and mention climata frequently. None of these pre-Ptolemaic authors attempts to limit the number of climata to a canonical set[31]. All known tables of climata predating Ptolemy substantially differ by their content from his system of 7 climata (see part 3). It will be shown further that even Marinus, an immediate Ptolemy's precursor, did not associate the term κλίμα only with the 7 canonical latitudes (in II.2). Therefore, there is no reason whatsoever for attributing to any pre-Ptolemaic authors any clear terminological distinction between climata and parallels and the limitation of the number of climata to a canonical set, which is found in the Ptolemaic system.

The second substantial mistake of E. Honigmann (and of many other scholars following him) is his definition κλίμα as a *narrow belt of 400st in width* (as opposed to parallel having no width), within which the naked eye cannot discern variations in the positions of celestial bodies, which determines the allowable uncertainty in measuring the latitude (within these limits, latitude may be rounded off, or two points may be considered equal in latitude). Nowadays, this definition is almost universally accepted[32]. According to E. Honigmann, this is precisely how Eratosthenes defined all the 7 climata, clearly distinguishing them from parallels for this very reason.

E. Honigmann's hypothesis is based on mere two fragments. Strabo quotes Hipparchus (II.1.35 C87 = F V 10a = F 18 = Erat. F III A 15):

καίτοι ἐκεῖνόν γε καὶ παρὰ τετρακοσίους σταδίους αἰσθητὰ ἀποφαίνεσθαι τὰ παραλλάγματα, ὡς ἐπὶ τοῦ δι' Ἀθηνῶν παραλλήλου καὶ τοῦ διὰ Ῥόδου.

«[Eratosthenes claimed] that differences [in latitude] are perceptible even within 400st, as [for example] between the parallel of Athens and that of Rhodes».

Geminus (without reference to Eratosthenes) also points out that the variations of clima, length of day and all celestial phenomena are indiscernible within 400st (V.58-60 Aujac 31).

The link between the passages by Geminus and Strabo is undeniable, but neither these passages nor other sources can support E. Honigmann's opinion that Eratosthenes (or any other ancient author) associated the given margin of uncertainty only with the concept of clima, rather than with the determining of any latitude whatsoever[33]. It is remarkable that in the quoted passage Strabo speaks of the parallels of Rhodes and Athens[34]. Independently of Eratosthenes, other ancient authors quote similar margins (300st to 500st) of the width of a belt where the variations of latitude cannot be discerned[35].

Nothing supports E. Honigmann's view that Eratosthenes associated the given margin of uncertainty with all other parallels in his geography, besides those of Rhodes and Athens[36]. On the

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[31] Cf. DICKS, *The ΚΛΙΜΑΤΑ*, pp. 251, 254 note 2.

[32] It was used already by BUNBURY, *History*, II, p. 4 note 2: BERGER, *Eratosthenes*, pp. 191-192 Anm. 2; J. FISCHER, *Ptolemäus und Agathodämon*, in *Denkschriften der Kaiserliche Akademie der Wissenschaften in Wien*, Phil.-hist. Klasse, 59 4 Anhang II, 1916, p. 90; KUBITSCHEK, *Klima*, 841-842: later, Honigmann's definition was accepted by DILLER, *Geographical Latitudes*, pp. 262, 264; DICKS, *The ΚΛΙΜΑΤΑ*, pp. 250, 253; ID., *Hipparchus*, pp. 154, 156, 160; AUJAC, *Strabon*, p. 168; EAD., *Lexique grec*, pp. 186-187; *HAMA*, p. 726; C. NICOLET, *L'inventaire du monde. Géographie et politique aux origins de l'Empire romain*, Paris, Fayard 1988, p. 77; J. ENGELS, *Die strabonische Kulturgeographie in der Tradition der antiken geographischen Schriften und ihre Bedeutung für die antike Kartographie*, «Orbis Terrarum» 4, 1998, pp. 82-83; K. CLARKE, *Between Geography and History. Hellenistic Construction of the Roman World*, Oxford, Clarendon Press 1999, p. 208 note 35; J. L. BERGGREN, A. JONES, *Ptolemy's Geography: an Annotated Translation of the Theoretical Chapters*, Prin-ceton, Univ. Press 2000, p. 10.

[33] It was suggested by K. MÜLLENHOFF, *Deutsche Altertumskunde*, I, Berlin, Weidmann 1870, p. 288 Anm. *; BERGER, *Eratosthenes*, pp. 137 Anm. 4, 184; ID., *Erdkunde*, pp. 415-416; cf. HONIGMANN, *SK*, p. 20.

[34] It was noted by DICKS, *The ΚΛΙΜΑΤΑ*, pp. 253, 254 note 2: ID., *Hipparchus*, p. 160.

[35] Posid. F 115 Edelstein-Kidd = 290a Theiler = Cleomed. *De motu*. I.7.72-76; II.1.211-215, 270-276 Todd 36, 51, 53; Plin. *N.H.* II.182; Mart. Capella. *De nupt.* VI.595; Macrob. *In somn. Scip.* I.15; *Saturn.* VII.14; Procl. *De sphaera*. 11-12. BERGER, *Eratosthenes*, pp. 137-138 Anm. 4; ID., *Erdkunde*, p. 410.

[36] Cf. the same doubts: REINHARDT, *Poseidonios*, coll. 678; O. A. W. DILKE, *Greek and Roman Maps*, Ithaca, London, Thames and Hudson Ltd. 1985, p. 216 note 40.

contrary, Strabo speaks of the only one particular case where Eratosthenes admits that the difference in latitude between the points being ≈ 400^{st} apart from each other is discernible. However, as E. Honigmann validly emphasized, Strabo in fact uses the expressions *the parallel of Athens* and *the parallel of Rhodes* interchangeably, clearly following Eratosthenes' views[37]. The second example of the 400^{st} uncertainty in Eratosthenes' latitudes is his estimate of the latitude of the Land of Cinnamon: in one case, he claims that this area is 3000^{st} south of Meroe (II.1.12 C71, 17 C74), while in another, when assessing the maximum extent of the oikoumene, he increases this estimate to 3400^{st} (I.4.2 C63 = F II C 2)[38].

Even if we accept that Eratosthenes considered any clima as a belt of 400^{st} wide, this would not imply that the width is an inherent property of clima. The "width" of clima may only be related to the margin of uncertainty accepted by Eratosthenes for measurements of latitude. Strabo repeatedly emphasized that Eratosthenes, as opposed to Hipparchus, considered all distances and geometrical figures forming the *sphragides* as conventional and approximate (II.1.23-24 C78-79 = F III B 25; II.1.34 C86 = F X 4 = F 23; 37 C89 = F III A 16; II.1.39 C91 = F III A 15; II.1.41 C92-93 = F III B 66)[39]. In chime with these Strabo's statements, the most of the distance values used in Eratosthenes' geography are the multiples of the hole thousand of stades. This circumstance allows us to suggest another explanation of the origin of the 400^{st} uncertainty margin, unrelated to the measurements of latitude. Understanding the inaccuracy of all distance estimates at his disposal, Eratosthenes strived to generalize his values as much as possible, and wherever possible rounded them to the whole thousands of stades, which makes sense only within the limits of 400^{st}[40]. In those cases, when figures deviated from the whole thousands by a greater value, they were to be rounded to 500^{st}[41].

II. The System of Climata by Ptolemy and Marinus of Tyre

In this part we shall try to show that the immediate source from which Ptolemy has borrowed the system of 7 climata, the "Shadow Table", as well as all other geographical passages of the *Almagest*, was an early version of the geographical work of Marinus of Tyre.

Ptolemy's Geographical Directory and Marinus of Tyre

In fact, Ptolemy's *Geographical Directory*[42] is a critical rework of the last variant of Marinus' geographical treatise. Let us consider the relation between Ptolemy's and Marinus' works in detail.

It is from Ptolemy's references alone that we know about Marinus. We are told that Marinus was the most competent geographer of his time, who republished his work not once with additions and corrections (I.6.1 Müller 14-15). Ptolemy justifies writing his own treatise in geography

[37] Bunbury, *History*, I, p. 630 note 7; Honigmann, *SK*, pp. 19-20; but: Berger, *Eratosthenes*, p. 187.

[38] Berger, *Eratosthenes*, pp. 152-153; Diller, *Geographical Latitudes*, p. 264.

[39] Berger, *Eratosthenes*, pp. 260, 264; Id., *Erdkunde*, p. 421.

[40] He rounds off the distances between the parallels: the Land of Cinnamon-Meroe – from 3400^{st} to 3000^{st} (see above); Syene-Alexandria – from 5300^{st} to 5000^{st} (XVII.1.2 C785-786 = F III B 51; Berger, *Erdkunde*, pp. 152-153, 304-305); Alexandria-Lysimachia – from 8100^{st} to 8000^{st} (I.4.2 C63 = F II C 2; II 5.42 C135 = F II C 5). Discussing the issue of the latitude of north India, Eratosthenes took the distance between Meroe and Athens to be $15{,}000^{st}$, but other figures he stated give $13{,}750^{st}$ or $14{,}150^{st}$: Berger, *Eratosthenes*, p. 187; Dicks, *Hipparchus*, p. 123. Diller, *Geographical Latitudes*, p. 264 quotes these facts to prove that Eratosthenes understood clima as a belt of 400^{st}; cf. Aujac, *Strabon*, p. 186 note 2. However, Eratosthenes rounded off the distances between meridians as well: from the Caspian Gates to Thapsacus – from $10{,}300^{st}$ to $10{,}000^{st}$.

[41] S. Bianchetti, *Dall'astronomia alla cartografia: Ipparco di Nicea*, in *ΠΟΙΚΙΛΜΑ. Studi in onore di Michelle R. Cataudella in occasione del 60° compleanno*, La Spezia, Agorà Edizioni 2001, p. 152 notes that many figures quoted by Eratosthenes are whole multiples of 500^{st} or 1000^{st}.

[42] Edition: C. Müllerus, *Claudii Ptolemaei Geographia*, I.1. Paris, Didot 1883; the Germane translation of the Book I: H. von Mžik, *Des Klaudios Ptolemaios Einführung in die darstellende Erdkunde*, Wien, Gerold & Co 1938 (= *Klotho*, 5); we use its English translation: Berggren, Jones, *op. cit.* (in note 32); its French translation: G. Aujac, *Claude Ptolémée astronome, astrologue, géographe. Connaissance et représentation du monde habité*, Paris, Édition du CTHS 1993, pp. 305-379.

by the fact that Marinus has not prepared a map for the last edition of his work (I.17.1, 18.3-4 Müller 43-44, 49)[43]. Meanwhile, it is nothing but a map that would allow one to detect and correct mistakes and contradictions in Marinus' data (I.17.1 Müller 43-44). Marinus' work was so diffuse and inconsistent in presenting material as to produce great difficulties for anyone attempting to draw a map according to it (I.6.1, 17.1, 18.4-5 Müller 15, 43, 49-50)[44]. For this very reason, Ptolemy has set himself a task of preparing a mapping manual so easy and convenient as to allow one to compose a map from its text alone, even without a pattern map. Ptolemy emphasizes that he will "preserve [Marinus'] opinions [as expressed] through the whole of his compilation, except for those things that need some correction" (I.19 Müller 50)[45].

Implementing this task, in Book I of the *Directory*, Ptolemy sets out the main principles of his work and criticizes methodological shortcomings and some factual errors in Marinus' treatise. The next six volumes embody the result of Ptolemy's work, a systematic description of the map in the form of lists of coordinates. Since Ptolemaic geography is entirely based upon Marinus' work, which is known to us solely due to Ptolemy, it is often impossible to draw an exact distinction between the elements contributed by Ptolemy and those going back to Marinus.

Those few examples of Marinus' reasoning adduced in the *Directory* demonstrate that Marinus presented his material in a substantially different way than Ptolemy[46]. Unlike Ptolemy, Marinus utilized various methods: (1) latitude and longitude coordinates, (2) the system of climata, (3) measurements of distances, and (4) topographical descriptions. It is difficult to assess the proportions of these four groups of data in Marinus' work[47] for they all have been reworked by Ptolemy into uniform tables of coordinate.

Ptolemy openly states that Marinus gave the coordinates of only few cities (I.18.5 Müller 50)[48], and mentions several parallels which he drew through the following points: Syene (the summer tropic: I.7.1 Müller 16), the Land of Aromas ($\frac{1}{4}^h = 4\frac{1}{4}°$: I.14.4 Müller 37), Meroe (without a direct reference to Marinus: I.10.1 Müller 25), Rhodes, Smyrna, Hellespont, Byzantium (I.11.2, 5; 12.5, 6, 7, 9; 15.8-10; 16 Müller 27, 29, 31, 32, 41, 43), the mid-Pontus (I 16 Müller 43) and Thule (I 7.1; 20.7-8; 22.2 Müller 16, 53, 54). Without reference to Marinus, Ptolemy lists 21 parallels to be specially marked on the map: starting from $4\frac{1}{4}° – \frac{1}{4}^h$-spaced, from $45° – \frac{1}{2}^h$-spaced up to Thule (63°), without stating the corresponding places, except Meroe, Rhodes and Thule (I.23 Müller 56-58)[49]. All these parallels are present in the Shadow Table and thus are climata *per se* [as being $\varphi = f(M^h)$][50]. Many key points of the Ptolemaic map are situated precisely on these parallels; all these data are likely to go back to Marinus. The system of these parallels evidently constituted a basis of Marinus' geography.

Marinus' parallels are closely related to his system of climata. Ptolemy mentions Marinus' climata only three times (I.11.1; 15.6-10, 17.1 Müller 27, 40-44) and gives only two specific examples of their use (I.15.8-9 Müller 41):

...τὴν Ἀμφίπολιν καὶ τὰ περὶ αὐτὴν ὑπὲρ τὸν Ἄθω καὶ τὰς τοῦ Στρυμόνος ἐκβολὰς κείμενα ἐν τῷ τετάρτῳ καὶ ὑπὸ τὸν Ἑλλήσποντον κλίματι τίθησιν...

«He puts Amphipolis and its environs, which lie north of Athos, and the mouth of Strymon in the fourth clima, which is below [the parallel through] Hellespont...».

[43] It was stressed by BERGER, *Erdkunde*, p. 645; HONIGMANN, *Marinos*, coll. 1770-1771, 1773-1774.

[44] Cf. W. KUBITSCHEK, *Karten*, in *RE* X A2, 1919, coll. 2059, 2068-2069.

[45] It was noted by KUBITSCHEK, *Karten*, coll. 2068-2069; J. FISCHER, *Introduction*, in *Geography of Claudius Ptolemy*, Translated and edited by E.L. Stevenson, New York Public Library 1932, pp. 6-7, 9-10; BERGGREN, JONES, *op. cit.* (in note 32), p. 23.

[46] N. G. PHOTINOS, *Marinos von Tyros*, in *RE*, Suppl. XII, 1970, coll. 795-796.

[47] BUNBURY, *History*, II, pp. 542-543; BERGER, *Erdkunde*, pp. 614-615; G. J. TOOMER, *Ptolemy*, in *Dictionary of Scientific Biography* XI, New York, Scribner 1975, p. 198.

[48] HONIGMANN, *Marinos*, coll. 1777-1778.

[49] The names of other places are given in interpolations and marginalia: DILLER, *The Parallels*, p. 7.

[50] The only exception is the Marinus' latitude of Ocelis, 11° 24', based on stellar observations (I 7.4 Müller 17).

This example shows that Marinus used the term κλίμα differently from all other authors: he understood κλίμα not as a parallel, but as a belt between two parallels.

The fact that it is the *fourth* clima that is said to be delimited on the north by the parallel of *Hellespont* can be explained in the most natural way on the assumption that the interval between the parallels demarcating Marinus' climata was ½^h, and the first clima started northwards from the parallel of Meroe. If this is the case, then these demarcating parallels turn out to be no other than the 7 Ptolemaic climata. From this fact scholars draw a reasonable conclusion that Marinus used the same system of 7 climata as Ptolemy, yet treating climata as belts, each delimited on the south by the respective Ptolemaic clima[51].

However, the very next phrase shows that, besides the 7 climata, Marinus could also delimit his climata by ¼^h-spaced latitudes from the Shadow Table:

Ὁμοίως δὲ καὶ τῆς Θρᾴκης σχεδὸν ὅλης ὑπὸ τὸν διὰ Βυζαντίου παράλληλον κειμένης, τὰς μεσογείους αὐτῆς πόλεις ἁπάσας ἐν τῷ ὑπὲρ τοῦτον τὸν παράλληλον κλίματι κατέταξεν.

«Similarly, although almost the whole of Thrace lies below the parallel through Byzantium, he has set all of its inland cities in the clima above this parallel».

Another example of the term κλίμα used in a similar way is given by Ptolemy in the description of Germany (II.11.12-14 Müller 266, 268, 271). Listing the coordinates, Ptolemy divides them among several belts, which he calls κλίματα. The boundaries of these belts are also the ¼^h-spaced parallels from the Shadow Table. Furthermore, Ptolemy twice uses the term κλίμα for the northernmost latitudes of the oikoumene (V.9.16; VII.5.15). Most likely, these examples reflect Marinus' manner of understanding the term κλίμα. This allows us to assume that Marinus, as opposed to Ptolemy, applied the term κλίμα not only to the 7 latitudes but also to other parallels from the Shadow Table, though he also emphasized the 7 major climata among others[52].

Although the 7 climata are never used in the *Directory*, they are shown on many surviving Ptolemaic maps and described in the Διάγνωσις that had a common source with the inscriptions on the maps[53]. It is significant that these maps represent climata not as parallels, but as zones delimited by parallels, in accord with Marinus' approach[54]. Hence, several scholars have supposed that these mentions of climata are merely rudiments of Marinus' geography or even an echo of a separate traditions going back to Eratosthenes and Hipparchus[55]. This assumption was used to prove that the maps were drawn not by Ptolemy, but rather by his successors. However, this conclusion is not sufficiently substantiated: Ptolemy used the 7 climata in the *Almagest* and the *Handy Tables*, therefore it would be wrong to stipulate that the mentions of climata on maps cannot be attributed to Ptolemy just because they are lacking in the *Directory*[56].

Geography in the Almagest and the early version of Marinus' work

Paul Schnabel has shown that the geographical passages in the *Almagest* represent an earlier stage of the Ptolemaic geography than the *Directory*[57]. This is proved by three features in the *Almagest* inherited evidently from Eratosthenes and Hipparchus, but abandoned by Ptolemy in the *Directory*: (1) the equator as a southern limit of the oikoumene, (2) the principal meridian of Erato-

[51] Cf. FISCHER, *Ptolemäus und Agathodämon*, pp. 89-93; HONIGMANN, *SK*, pp. 55-56; ID., *Marinos*, 1780-1781; BERGGREN, JONES, *op. cit.* (in note 32), p. 161; otherwise, but wrong: BERGER, *Erdkunde*, pp. 612-613; K. ABEL, *Zone*, in *RE*, Suppl. XIV, 1974, coll. 1134-1134.

[52] HONIGMANN, *SK*, pp. 55-56; ID., *Marinos*, coll. 1781 assumes that Marinus would not use the term κλίμα for others than the 7 canonical climata and attributes this usage to Ptolemy.

[53] DILLER, *The Parallels*; ID., *The Anonymous Diagnosis of Ptolemaic Geography*, in *Classical Studies in Honour of William Abbott Oldfather*, Urbana, Univ. of Illinois Press 1943, pp. 39-49.

[54] Arabic geographers relying on Ptolemy also interpreted climata as zones: HONIGMANN, *SK*.

[55] FISCHER, *Ptolemäus und Agathodämon*, p. 90; KUBITSCHEK, *Klima*, coll. 841-842; DILLER, *The Parallels*, pp. 6-7.

[56] Cf. SCHNABEL, *Text und Karten*, pp. 85 Anm. 1, 87-88.

[57] P. SCHNABEL, *Die Entstehungsgeschichte des kartographischen Erdbildes des Klaudios Ptolemaios*, in *Sitzungsberichte der Preussischen Akademie der Wissenschaften*, Philol.-hist. Klasse, XIV, 1930, pp. 214-220.

sthenes' geography drawn through Alexandria, Rhodes and Hellespont, (3) the circumference of earth = 252,000st[58].

Five reasons allow us to make a step further along the road indicated by Schnabel and assume that the geography of the *Almagest* is nothing else but an early version of Marinus' work, which Ptolemy has mentioned in the *Directory* (I.17.1 Müller 43-44).

(1) Marinus' system of parallels and the table of 21 parallels from the *Directory* correspond almost exactly to Ptolemy's Shadow Table. Except for a few insignificant differences, their data coincide, even in such details as the latitudes of unimportant places – the Avalitic and Adulitic Gulfs, Napata and Ptolemais[59].

(2) Marinus used the canonical system of 7 climata (see above).

(3) After the tables of shadows, ἀναφοραί and zenith distances, Ptolemy points out that in order to perform astronomical calculations in different countries, one should also state latitudes and longitudes with respect to Alexandria for «every noteworthy city of every region». He promises to devote a special treatise to this subject, which would «follow the most convenient works among the most perfected» (ἀκολουθήσαντης ταῖς τῶν ἐπεξειργασμένων ὡς ἔνι μάλιστα τοῦτο τὸ εἶδος ἱστορίαις: II.13.1 Heib. 188)[60]. This expression is very similar to Ptolemy's statement in the *Directory* (I.6.1 Müller 14-15):

Δοκεῖ δὴ Μαρῖνος ὁ Τύριος ὕστατός τε τῶν καθ' ἡμᾶς καὶ μετὰ πάσης σπουδῆς ἐπιβαλλεῖν τῷ μέρει τούτῳ· φαίνεται γὰρ καὶ πλείοσιν ἱστορίαις περιπεπτωκὼς παρὰ τὰς ἔτι ἄνωθεν εἰς γνῶσιν ἐλθούσας, καὶ τὰς πάντων σχεδὸν τῶν πρὸ αὐτοῦ μετ' ἐπιμελείας διειληφώς.

«Marinus of Tyre seems to be the last [author] in our time to have undertaken this subject, and he has done it with utmost diligence. He has discovered numerous accounts besides those that had come to knowledge still earlier, and treated those of nearly all his predecessors with care...».

Ptolemy fulfilled his promise and included into the *Handy Tables* a table of the "important cities"[61] listing some 360 places in 82 regions, with their latitudes and longitudes specified in degrees with the meridian of Fortunate Islands taken as the origin. The table was later reworked into the eighth volume of the *Directory*, where the degrees of latitudes were converted into *M*, those of longitudes – into time differences with respect to the meridian of Alexandria[62]. The coordinates of the "important cities" coincide almost exactly with the data in the *Directory*, though some insignificant differences prove that the table was an earlier work[63]. Therefore, the table must also have been based upon Marinus' work and probably followed its content more closely than the *Directory*. Thus, Ptolemy's initial promise to compose a table of famous cities relying upon the best works most likely referred to Marinus of Tyre.

(4) Our special attention is attracted by a set of baseline data to be discern on the Ptolemaic map, which most likely reflects an earlier stage of its ordering, based on the scale 1° = 700st and being a mathematical interpretation of Eratosthenes' geography.

In Ptolemaic geography, the map of the Middle East clearly reflects the views of Eratosthenes. The frame of this map is formed by three meridians: 79° – Babylon, 94° – the Caspian Gates and

[58] An additional validation of this conclusion is the fact that Ptolemy drew the clima of 14^h = 30° 22' through Lower Egypt, obviously following Hipparchus. According to Strabo, Hipparchus drew this clima 400st south of Alexandria (II.5.38 C133 = F V 6 = F 48). Ptolemy places Alexandria at the latitude of 31° (or 30°58' in *Alm.* V.12 Heib. 407), i.e. 38' (or 36') to the north of the 14^h clima = 316.(6)st (or 300st) ≈ 300st for 1° = 500st, or = 443.(3)st (or 420st) ≈ 400st for 1° = 700st (cf. BERGER, *Hipparch*, p. 49). Thus, the data by Ptolemy and Hipparchus come into agreement only for 1° = 700st.

[59] BERGER, *Erdkunde*, pp. 595, 612; SCHNABEL, *Entstehungsgeschichte*, pp. 216-217.

[60] On this passage: KUBITSCHEK, *Karten*, coll. 2061-2062; E. POLASCHEK, *Klaudios Ptolemaios. Das geographische Werk*, in *RE*, Suppl. X, 1965, coll. 681-682; BERGER, *Erdkunde*, pp. 681-682; BERGGREN, JONES, *op. cit.* (in note 32), p. 19.

[61] BERGER, *Erdkunde*, pp. 617, 643; POLASCHEK, *Klaudios Ptolemaios*, coll. 682-683.

[62] KUBITSCHEK, *Karten*, coll. 2077; SCHNABEL, *Entstehungsgeschichte*, pp. 70-71.

[63] CUNTZ, *Die Geographie des Ptolemaeus, Galliae Germania Raetia Noricum Pannoniae Illyricum Italiae. Handschriften, Text und Untersuchung*, Berlin, Weidmann 1923, pp. 96-106; W. KUBITSCHEK, *Studien zur Geographie des Ptolemäus*, I, *Die Ländgrenzen*, Wien, Leipzig, Hölder-Pichler-Tempsky 1934, pp. 32-33; SCHNABEL, *Entstehungsgeschichte*, pp. 70-74; E. POLASCHEK, *Ptolemy's Geography in a New Light*, «Imago Mundi» XIV, 1959, pp. 18-19; ID., *Klaudios Ptolemaios*, coll. 684-692.

the border between the second and third Eratosthenes' *sphragides* (in Ptolemy's work – between Parthia/Carmania and Persia/Media), and 119° for the border between the first and second Eratosthenes' *sphragides* (Ariana and India, in Ptolemy's work – between Arachosia/Paropanisades and India: VI.18.1, 20.1, 21.1 Ronca 66, 73). Assuming 1° = 700st, the intervals between Ptolemaic meridians 79°, 94° and 119° converted in stades exactly coincide with the corresponding distances stated by Eratosthenes:

1. The interval between the meridians of the eastern boundary of Persia and that of Babylon is 15° = 9000st at the parallel of Alexandria (31°, where 1° = 600st) and coincides with the length of the southern side of Eratosthenes' third *sphragis*, i.e. the way from Babylon to the eastern end of Persia (more accurately, 9200st: II.1.25, 27 C80, 81 = F III B 25, 26; Hipparchus rounds it off to 9000st: II.1.36 C89 = F X 8 = F 27).

2. The distance from the meridian of 94° to the meridian of the Indian border is 25°, being converted into 14,000st at the latitude of 36° (where 1° of parallel = 560st), coincides exactly with the length of Eratosthenes' second *sphragis* measured along its northern side (I.4.5 C64 = F II C 18; XV.2.8 C723-724 = F III B 20; Amm. Marc. XXIII.6.74)[64].

(5) P. Schnabel's hypothesis on Ptolemy's longitudes of Rome and Babylon in the *Almagest* implies that they were initially expressed in stades and not in degrees. This is exactly the way by which Marinus expressed the length of the Mediterranean Sea and the path of Maes Titianus' agents to China[65]. Most of Marinus' data must evidently have been expressed in conventional measures of distances rather than coordinates[66].

Hence, we are allowed to draw a final conclusion that the system of 7 climata first used by Ptolemy in the *Almagest* and later forming the basis of his map in the *Directory* goes back to the work of Marinus of Tyre, to its early and late versions, respectively.

III. Seven Climata of Ptolemy and the Geography of Eratosthenes

According to E. Honigmann's hypothesis, the system of 7 climata was introduced by Eratosthenes. This hypothesis has acquired both advocates and opponents. Considered below are different interpretations of Eratosthenes' geographical system and the facts allowing us to trace its link to the system of 7 climata; it will be demonstrated that neither E. Honigmann and his following nor their opponents are fully correct.

Three reconstructions of Eratosthenes' geography

There are three different reconstructions of Eratosthenes' system, substantially different in what evidence have been chosen for their bases, and accordingly, in the complexity or simplicity of the resulting images.

The first reconstruction relies solely on the explicit evidences and accordingly suggests the most simplified view of Eratosthenes' system[67].

According to this reconstruction, Eratosthenes' geography was based on two coordinate axes called στοιχεῖα – the basic parallel and meridian crossing at Rhodes (the parallel of Lysimachia is also accepted: II.5.40 C134 = F III A 22). Eratosthenes used these two axes primarily to estimate

[64] Berger, *Eratosthenes*, pp. 243-244, 251, 259.

[65] Berggren, Jones, *op. cit.* (in note 32), pp. 150-154.

[66] Honigmann, *Marinos*, coll. 1777-1778.

[67] K. Mannert, *Einleitung in die Geographie der Alten und Darstellung ihrer vorzüglichen Systeme*, Leipzig, Hahn 1829, pp. 82, 91-92; Bunbury, *History*, I, pp. 638-640; II, p. 4 note 2; Reinhardt, *Kosmos und Sympathie*, p. 399; F. A. Thalamas, *La géographie d'Ératosthène*, Versailles, Ch. Barbier 1921; C. van Paassen, *The Classical Tradition of Geography*, Groningen, J. B. Wolters 1957, pp. 39-42; Dicks, *The ΚΛΙΜΑΤΑ*, pp. 250-255; Id., *Hipparchus*, pp. 128-129, 159; Id., *Eratosthenes*, in *Dictionary of Scientific Biography* IV, New York, Scribner 1971, pp. 389-390.

the length and breadth of the oikoumene by measuring the distances between a succession of key points located on them. Merging these data[68] together gives us the following scale of distances[69]:

	Distance from the preceding point	Distance from the equator
The Land of Cinnamon		8800st
Meroe	3000st	11,800st
Syene	5000st	16,800st
Alexandria	5000st	21,800st
Rhodes	≈ 4000st (3750st)	≈ 25,800st (25,500st)
Hellespont	≈ 4000st (4350st or 4450st)	≈ 29,800st (29,800st or 29,900st)
Borysthenes	5000st	34,800st or 34,900st
The Isle of Thule	11,500st	

The second reconstruction suggested by Hugo Berger implies that Eratosthenes' geography was based, besides the two στοιχεῖα, on a system of auxiliary parallels and meridians[70]. Examining Strabo's abstract of Hipparchus' table, H. Berger attempts to detect foreign elements coinciding with Eratosthenes' data stated above in the table. On this basis, he reconstructs Eratosthenes' system, assuming that Strabo has arbitrarily confused its data with those of Hipparchus. H. Berger attributes to Eratosthenes 7 parallels: the Land of Cinnamon, Meroe, Syene, Alexandria, Rhodes, Lysimachia, Borysthenes and Thule[71]. He considers the mid-Pontus parallel to be Hipparchus' innovation.

H. Berger's view does not contradict the first variant, merely supplementing it. In Eratosthenes' geography, στοιχεῖα had another important function besides measuring the length and breadth of the oikoumene: they play the role of the Cartesian coordinate system for determining locations of all other points of the map. This was the very purpose of auxiliary parallels and meridians, which were to be drawn through the points in questions as perpendiculars to the cardinal axes[72]. Strabo gives a description of this method of mapping (II.5.16 C120 = F III A 24; cf. II.5.34 C131)[73].

The third reconstruction of Eratosthenes' geography was suggested by E. Honigmann and based on the comparison of Eratosthenes' data with the Ptolemaic system of 7 climata[74].

E. Honigmann emphasizes that the weakness of other reconstructions is their failure to explain Eratosthenes' choice of those six points he has situated on the main meridian to measure the distanc-

[68] I.4.2 C62-63 = F II C 2, 7; II.5.42 C135 = F II C 5, 7; II.5.35-42 C133-134 = F III A 17-22; II.1.3 C68 = F III A 2; II.5.7 C114. Cleomed. I.7.53, 108 Todd 35, 37 = F II B 34; Plin. *N.H.* II.183 = F II B 38; II.1.19 C76 = F III A 9; cf. II.2.2 C95, 5.7 C114. II.5.24 C125-126; Plin. *N.H.* V.132 = F II B 28. Cf. BERGER, *Eratosthenes*, 152-153.

[69] BERGER, *Eratosthenes*, pp. 142-155; ID., *Erdkunde*, pp. 408-409, 414-417; cf. DILLER, *Geographical Latitudes*, pp. 261-263; *HAMA*, p. 1313 fig. 291.

[70] This idea was earlier suggested by A. FORBIGER, *Handbuch der alten Geograhie*, 2. Aufl., I, Hamburg, Haendcke & Lehmkuhl 1877, pp. 180-182, 545, though with insufficient argumentation.

[71] BERGER, *Eratosthenes*, pp. 188-198; ID., *Erdkunde*, pp. 421-426, 476-478. His reconstruction was accepted by C. SCHOY, *Die geschichtliche Entwicklung der Polhöhbestimmungen bei den älteren Völkern*, in *Aus dem Archiv der Deutschen Seewarte*, XXXIV 2, Hamburg 1911, pp. 8-9; KUBITSCHEK, *Karten*, coll. 2053; GISINGER, *Geographie*, coll. 611; ABEL, *Zone*, coll. 1045; AUJAC, *Strabon*, pp. 197-198; EAD., *Eratosthène de Cyrène*, pp. 80-81, 85; DILKE, *op. cit.* (in note 36), pp. 33-35; A. STÜCKELBERGER, *Einführung in die antiken Naturwissenschaften*, Darmstadt, Wiss. Buchges. 1988, pp. 6-67; K. GEUS, *Die Welt in antiken Karten und Globen*, «Die Alten Sprachen im Unterricht» 46.4, 1999, p. 17; ID., *Eratosthenes von Kyrene. Studien zur hellenistischen Kultur- und Wissenschaftgeschichte*, München, C. H. Beck 2002, p. 273; ID., *Measuring the earth and the oikumene: zones, meridians, sphragides and some other geographical terms used by Eratosthenes of Kyrene*, in K. BRODERSEN, R. J. A. TALBERT (eds.), *Space in the Roman World. Its Perception and Presentation*, Münster 2004, pp. 9-26; partly by VAN PAASSEN, *op. cit.* (in note 67), pp. 39-42; cf. also W. A. HEIDEL, *The Frame of the Ancient Greek Maps*, New York, Amer. Geogr. Society 1937 (= *Research Series* 20), p. 125.

[72] C. JACOB, *Cartographie et rectification*, in G. MADDOLI (ed.), *Strabone. Contributi allo sudio della personalità e dell'opera*, II, Perugia, Univ. degli Studi 1986, pp. 52-53; F. PRONTERA, *Sulle basi empiriche della cartographia greca*, «Sileno» 23 1-2, 1997, pp. 50-54.

[73] BERGER, *Eratosthenes*, pp. 198-200; ID., *Erdkunde*, pp. 420-428, 432; VAN PAASSEN, *op. cit.* (in note 67), pp. 39-42; BIANCHETTI, *Dall'astronomia* (in note 41), p. 148.

[74] It was accepted by DILLER, *Geographical Latitudes*, pp. 261-263; AUJAC, *Strabon*, pp. 40-48, 168-170; DILKE, *op. cit.* (in note 36), p. 178; MARCOTTE, *La climatologie*, p. 264.

es between them (Meroe, Syene, Alexandria, Rhodes, Hellespont, Borysthenes). It appears inconsequent to follow those scholars who assert that Eratosthenes' estimates of these distances are often based on determining of latitudes (or even of *M*), but deny his familiarity with the concept of clima. E. Honigmann remarks that all six points of Eratosthenes are present in the system of 7 climata[75]. From this striking coincidence E. Honigmann assumes that (1) there is continuity between the Eratosthenian geography and the Ptolemaic system of climata; (2) it is only the system of 7 climata that could have underlaid Eratosthenes' distance measurements along the main meridian[76]; (3) the canonical number of 7 climata and the parallel of mid-Pontus go back to Eratosthenes[77].

A few reasons in favour of Honigmann's hypothesis

Given below are additional arguments to affirm E. Honigmann's hypotheses.

1. The clear distinction drawn by Ptolemy between the 7 climata and the 39 parallels of the Shadow Table implies that these tables reflect two essentially different development stages of the system of climata. The similarity of the system of 7 climata and Eratosthenes' set of parallels is most significantly emphasized by the fact that all the reference points of the climata lie on Eratosthenes' principal meridian. On the other hand, the Shadow Table has a lot in common with Hipparchus' table: (1) $\frac{1}{4}^h$-spaced climata, (2) reference points lies outside of the principal meridian, (3) the table covers the entire area from the equator to the pole and exceeds by far the system of 7 climata in its scope[78]. All the 7 climata are included in both the Shadow Table and Hipparchus' table[79]. These facts prove that the system of 7 climata predates both the Shadow Table and Hipparchus' table, which should be considered as its further developement.

2. A number of facts testify that the parallel of the mid-Pontus goes back to Eratosthenes, rather than to Hipparchus; therefore, the canonical number of 7 originates with Eratosthenes as well. (1) All of Hipparchian parallels pass through definite points, while the position of this parallel is quite vague: it passes through the midpoint of navigation from Hellespont to Borysthenes (II.5.41 C134 = F V 14 = F 56). (2) All of Hipparchian parallels (except that of Byzantium and the six from Eratosthenes) pass through points outside of Eratosthenes' principal meridian, while the mid-Pontus is linked to it. (3) Recounting Hipparchus' table of climata, Strabo estimates the distance from the equator to the parallel of the mid-Pontus at $31{,}700^{st}$, which corresponds to the latitude of 45°10', the 15^h clima at the obliquity of the ecliptic $\varepsilon = 23\frac{2}{3}°$. Analysis of other data from Strabo confirms that Hipparchus' table was based on the value $\varepsilon = 23\frac{2}{3}°$ [80], and other investigations allow one to assume that he used this value in astronomy as well – in the *Commentary* and in his stellar catalogue[81]. Contradicting this, Strabo states that the parallel of the mid-Pontus is equidistant from the equator and the pole, at the latitude of 45°, which is the 15^h clima for $\varepsilon = 24°$ – the value used by Eratosthenes[82]. (4) The system of 7 climata is internally uniform and self-contained – it involves four 1^h-spaced climata with three $\frac{1}{2}^h$ climata in between; an absence of the clima of the mid-Pontus would violate this integrity.

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[75] Eratosthenes' fragments lack only the mid-Pontus; the latitudes of Thule and the Land of Cinnamon are not included in the Ptolemaic system of climata.

[76] It was acknowledged even in *HAMA*, pp. 334 note 8, 928.

[77] HONIGMANN, *SK*, pp. 13-14, 54.

[78] It was noted by MÜLLENHOFF, *op. cit.* (in note 33), pp. 328-349, BERGER, *Erdkunde*, pp. 594, 612; SZABÓ, MAULA, *op. cit.*, pp. 85-90; BIANCHETTI, *Dall'astronomia* (in note 41), pp. 146-147.

[79] HONIGMANN, *SK*, pp. 13-14.

[80] DILLER, *Geographical Latitudes*, p. 265; cf. D. RAWLINS, *Competence Held Hostage #2: The Princeton Institute vs Aubrey Diller*, «Dio» 4.2, 1994, p. 55 (http://www.dioi.org).

[81] R. NADAL, J. P. BRUNET, *Le "Commentaire" d'Hipparque. I. La sphère mobile*, «Archive for History of Exact Sciences» 29, 1984, pp. 201-236; D. RAWLINS, *Ancient Geodesy: Achievement and Corruption*, «Vistas in Astronomy» 28, 1985, pp. 262-253.

[82] BERGER, *Eratosthenes*, pp. 131-132, 137; ID., *Erdkunde*, pp. 411, 414; his opinion was accepted by: T. L. HEATH, *Aristarchus of Samos. The Ancient Copernicus*, Oxford, Clarendon Press 1913, p. 131 note 4; J. O. THOMSON, *History of Ancient Geography*, Cambridge, Univ. Press 1948, p. 163; cf. also: C. M. TAISBAK, *Eleven-Thirties. Ptolemy's Reference to Eratosthenes in Almagest I.12*, «Centaurus» 27.2, 1984, pp. 165-167.

3. The close coincidence between Eratosthenes' data and the 7 Ptolemaic climata becomes especially clear in comparison with three other systems of climata known from Cleomedes (*De motu*. II.1.438-444 Todd 59), Pliny (VI.219) and Martianus Capella (*De nupt*. VIII.876-877 Dick 462).

M =	Ptolemy's 7 climata	Cleomedes	Martianus Capella	Pliny[83]
13^h	Meroe	Meroe	Diameroes	Meroe ($12½^h$)[84]
$13½^h$	Syene		Diasyenes	Syene (13^h)
14^h	south of Alexandria	Alexandria	Dialexandria	
$14½^h$	Rhodes	Rhodes	Diarrhodes	
			Diarrhomes	
15^h	Hellespont	Hellespont	*per Hellespontum*	Hellespont
		Rome (> 15^h)		Rome ($15\ ^1/_9{}^h$)
		Massalia ($15½^h$)		
$15½^h$	Mid-Pontus			
16^h	mouth of Borysthenes	Celts	*Diaborysthenis*	
		Maeotis (17^h)	*ultra Maeotis*	mouth of Tanais (16^h)
		Britain (18^h)	*infra Rhiphos montes*	Hyperboreans and Britain (17^h)
				Rhipaean Mts. and Thule Island (24^h)

Despite a number of differences, these lists have two common features: (1) they all contain the principal elements of the system of 7 climata (Meroe, Syene, Alexandria, Rhodes, Hellespont, Borysthenes or Celtica), (2) they add a number of clearly posterior elements: (a) Rome, (b) elements close to Hipparchus' table, revealing its possible influence (Massalia, Maeotis or the mouth of Tanais, Britain), (c) climata north of 16^h (Maeotis, the mouth of Tanais, Britain, Rhipaean Mountains). These features allow us to draw the following conclusions: (1) the three lists reflect different variants of generally the same table of climata, (2) this table is based on the system of 7 climata, which then must have originated in at earlier times, and (3) the system of 7 climata differs from this table to a much greater degree than from Eratosthenes' set of parallels.

4. Three points of the 7 canonical ones had been known as climata long before Eratosthenes. The clima of Hellespont (15^h) was known to Eudoxus[85], the clima of Alexandria (14^h) – to Berosus (circa 300 B.C.)[86], the clima of Meroe (13^h) was established by Philo (II.1.20 C77 = Erath. F II B 36). Pytheas (2nd half of the IVth century B.C.) could have expressed via M the latitudes of the places of northern Europe he visited[87]. Eratosthenes also mentioned the measurements of gno-

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[83] Pliny only mentions a few parallels from a similar system to supplement his table of 7 "astrological" climata.

[84] In parenthesis are given those values of M, which are absent in the system of 7 climata. It is interesting, that four latitudes in Pliny's table are shifted southwards "on one point" of ΔM^h, as compared with the Ptolemaic geography, where Meroe is linked to M = 13^h, Syene – to $13½^h$, mouth of Tanais – to 17^h, Britain – to 18^h.

[85] Hipp. *Comm*. I.2.22 Manit. 23 = F 68 Lasserre; cf. I.3.5, 7-8 Manit. 26; I.3.9-10 Manit. 28 = F 67 Lasserre. See SCHOY, *art. cit.* (in note 71), p. 7; KUBITSCHEK, *Klima*, coll. 838-839; HEIDEL, *The Frame*, pp. 49, 98-99; THOMSON, *History*, pp. 116-117; AUJAC, *Strabon*, p. 168; *HAMA*, pp. 729, 733 note 28, 737-746; SZABÓ, MAULA, *op. cit.* (in note 2), pp. 154-157; MARCOTTE, *La climatologie*, pp. 263-264; F. PRONTERA, *Karte (Kartographie)*, in *Reallexikon für Antike und Christentum*, XX, 2003, coll. 196. HONIGMANN, *SK*, pp. 10-11 and DICKS, *The KAIMATA*, pp. 248, 254; ID., *Hipparchus*, p. 160 try to argue that Eudoxus was not acquainted with the concept of clima at all, but unconvincing: GISINGER, *Rez.: Honigmann*, p. 96; DILKE, *op. cit.* (in note 36), pp. 26-27, SZABÓ, MAULA, *op. cit.*

[86] Plin. *N.H.* VII.49, 160; Censor. *De die natali* XVII.4. See HONIGMANN, *Die Anaphorai*, pp. 307-312; *HAMA*, p. 721.

[87] AUJAC, *Strabon*, pp. 40-48, 168-170; MARCOTTE, *La climatologie*, p. 264; BERGGREN, JONES, *op. cit.* (in note 32), p. 9 note 7. Pytheas' data are handed down only through Hipparchus' transmission, and we have no direct evidence about the original form Pytheas used to express latitudes. It arouses a certain doubt, whether Pytheas used the system of climata or not: BERGER, *Erdkunde*, pp. 337, 341.

mon's shadow for the latitudes of Syene, Alexandria and Rhodes (II.5.24 C125 = F II B 28; Cleomed. *De motu*. I.7 Todd 35-37 = F II B 34, 35)[88].

5. There is a significant coincidence between the system of 7 climata and Eratosthenes' geography. Eratosthenes makes a clear distinction between the points corresponding to the 1^h-spaced latitudes in the system of 7 climata, those corresponding to the $½^h$-spaced latitudes, and the latitudes of the Land of Cinnamon and Thule (see above). Measuring the breadth of the oikoumene, Eratosthenes mentioned only the points of 1^h-spaced climata: Meroe, Alexandria, Hellespont and Borysthenes. Syene and Rhodes are only mentioned in different context and evidently considered as less important, the mid-Pontus is not mentioned in the fragments at all. The Land of Cinnamon and Thule do not lie on the principal meridian and are distinguished from all other points as marking the two extremities of the oikoumene. Unsurprisingly, these two points were not included in the system of 7 climata[89].

6. Pliny's table of 7 "astrological" climata, probably going back to Nigidius Figulus[90], proves that this number of climata became canonical by the middle of the Ist century B.C. as the latest. Similar variants of the table of "astrological" climata are given by Vettius Valens (I.7 Kroll 24, 157), Firmicus Maternus (*Math.* II.11 Kroll-Skutsch I 53-55) and P. Michigan 149 (XI.38-47). The pattern of all these tables ($\Delta M = 8^m, 16^m, 24^m$) does not necessarily limit the number of climata to 7, unlike the Ptolemaic system (for $\Delta M = ½^h$). This prompts us to assume that it was in a geographical system where the number of climata was initially limited to 7, and then it was transferred to the table of "astrological" climata. Therefore, the canonization of the number 7 must have occurred long before Marinus and Ptolemy.

Pliny's table was apparently derived from a more complex and detailed geographical system of climata. For each latitude Pliny gives the shadow-to-gnomon ratio – which is useless for astrological calculations but is a crucial element of the geographical system of climata. Pliny retains the 15^h clima of Hellespont despite the fact that this value of M is not provided for in the system of "astrological" climata (where $14^h\ 56^m$ is proper). Pliny draws the 7th clima, $15^h\ 36^m$, through the mouth of the Borysthenes, which should be considered as a reminiscence of the system of 7 climata where the northernmost latitude is necessarily linked to Borysthenes.

Unfortunately, the scarcity of available data does not allow one to find clearer and convincing answers to the questions of time and circumstances of introduction of the "astrological" system of climata, the nature of its relation to the "geographical" system, and the cause for devising the "astrological" system on $\Delta M = 8^m, 16^m, 24^m$.

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[88] BUNBURY, *History*, I, pp. 632, 661, 665-666. K. Geus draws attention to a Vitruvian passage listing the issues related to various measurements to be addressed in astronomical treatises, including also the determination of the length of daylight as a function of geographic latitude (*Inst. log.* 12.3; GEUS, *Eratosthenes*, pp. 234-235; cf. HEIDEL, *The Frame*, p. 124). At the beginning of this passage, there is a single reference to Eratosthenes' treatise *About the measurement of the Earth*. K. Geus remarks that all other questions listed by Vitruvius – measurements of distances between tropics and polar circles, between the Earth, the Sun, and the Moon, dimensions of the Sun and the Moon – have also been discussed by Eratosthenes. On this basis, K. Geus assumes that the entire passage was derived from the mentioned treatise and may serve as a principal evidence to reconstruct its content: GEUS, *op. cit.*, pp. 235-250. This conclusion is precarious: (1) there are no reasons to attribute the entire passage to Eratosthenes for the reference only deals with the measurement of the Earth; (2) there is nothing else to imply that the treatise *About the measurement of the Earth* addressed issues of any other measurements.

[89] On the Land of Cinnamon: XVI.4.20 C779; BERGER, *Eratosthenes*, pp. 151, 155, 191, 207-208, 295-297. MÜLLENHOFF, *op. cit.* (in note 33), pp. 378, 392 assumed that Thule would have to lie on the principal meridian; it was supported by BERGER, *Erdkunde*, p. 427 Anm. 3. This opinion, however, lacks support: there were no data at Eratosthenes' disposal to link Thule to the basic meridian. In fact, Eratosthenes mentions Thule along with the points on this meridian for the only purpose of determining the maximum breadth of the oikoumene, since it marks the latitude of its northern border; this does not imply that he did place the island on the meridian.

[90] D. DETLEFSEN, *Ursprung, Entstehung und Bedeutung der Erdkarte Agrippas*, Berlin, 1906 (= *Quellen und Forschungen zur alten Geschichte und Geographie*, 13, Hgg. von W. Sieglin), p. 99; HONIGMANN, *SK*, p. 31. On "astrological" climata see note 19.

Was Eratosthenes the inventor of the seven climata system?

E. Honigmann's opponents reasonably note the principal weakness of his hypothesis: Strabo never calls Eratosthenes' latitudes "climata" and never associates them with *M*. On this basis, many scholars deny Eratosthenes' familiarity with the notion of clima and the relation of his geography to the system of climata[91].

It seems to me quite erroneous to equate the use of the term κλίμα by ancient authors with their knowledge of the concept underlying this term[92]. In fact, ancient authors could use the concept of clima without the term κλίμα, applying the term παράλληλος instead[93], or, conversely, could use the term κλίμα without implying any definite concept. It is indicative that many authors, such as Hipparchus, Geminus, or Vettius Valens, often use the terms κλίμα, ἔγκλιμα, ἔγκλισις interchangeably[94]. Cleomedes, describing his system of climata, uses none of these special terms (*De motu*. II.1.438-444 Todd 59).

So, the lack of the term κλίμα in the most of Eratosthenes' fragments does not imply that he did not use the concept of climata.

The term κλίμα is mentioned in relation to Eratosthenes only twice, and only in a doubtful context. The first mention is contained in pseudo-Scymnus' geographical poem (112-114 = F 6)[95]:

τῷ τὴν γεωγραφίαν γὰρ ἐπιμελέστατα / γεγραφότι, τοῖς τε κλίμασι καὶ τοῖς σχήμασιν, / Ἐρατοσθένει μάλιστα συμπεπεισμένος.

«most of all I follow Eratosthenes, for he was the most diligent in writing on geography [related to] climata and schemes».

This evidence is doubtful since ps.-Scymnus is too unreliable as a source, and the only one directly linking Eratosthenes to climata[96]. However, the investigation of ps.-Scymnus' poem shows that he was indeed familiar with Eratosthenes' tract and used its data[97]. Besides Eratosthenes' treatise, ps.-Scymnus knew no other works in mathematical geography and had no such knowledge of his own. This prompts us to assume that he must have taken the mention of climata from Eratosthenes' treatise.

The second mention is given in the context of Hipparchus' reasoning cited by Strabo. As an example of what does the term κλίμα mean, Hipparchus reports Philo's data on the latitude of Meroe (cited in the part 1) adding that "Eratosthenes closely agrees with Philo" (II.5.20 C77 = F II 4 = F 17). F. Gisinger and W. Theiler consider this passage as a proof that Eratosthenes and Hipparchus understood the term κλίμα in the same way[98]. D. Dicks makes a valid point that this entire passage conveys Hipparchus' reasoning, and therefore it is Hipparchus who is responsible for making use of the term κλίμα[99]. However, even under this assumption, since Eratosthenes examined Philo's data, he was familiar with the concept of clima, though he may not have used the term κλίμα.

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[91] BUNBURY, *History*, II, pp. 4 note 2, 5-11; BERGER, *Eratosthenes*, pp. 191-192 Anm. 2; ID., *Erdkunde*, pp. 416-417; THALAMAS, *Eratosthenes*, pp. 187-251; REINHARDT, *Poseidonios*, coll. 678; DICKS, *The ΚΛΙΜΑΤΑ*, pp. 250-255; ID., *Hipparch*, pp. 156-160; ID., *Eratosthenes*, pp. 389-390; cf. the objections by HONIGMANN, *SK*, pp. 21-22.

[92] Thus, R. Fecht attribute the introduction of the concept of climata to Posidonius on the basis of the mere fact that all sources widely using the term κλίμα (Strabo, Cleomedes, Geminus) postdate Posidonius. E. Honigmann remarks that Hipparchus preferred the term παράλληλος, and assumes on this basis that he abandoned the concept of clima (see note 12).

[93] Many scholars find in sources no substantial distinction between the terms κλίμα and παράλληλος, and admit that they could be used interchangeably, depending on the context: BERGER, *Hipparch*; MÜLLENHOFF, *op. cit.* (in note 33), pp. 328-349; KUBITSCHEK, *Klima*, coll. 842; DICKS, *The ΚΛΙΜΑΤΑ*, pp. 250-251; ID., *Hipparchus*, p. 155; *HAMA*, p. 334; J. ENGELS, *Kulturgeographie*, p. 83; against them: HONIGMANN, *SK*, p. 14 Anm. 2.

[94] Hipp. *Comm*. I.2.21; 3.5, 8, 10; 7.22; II.6.1 Manit. 22, 26, 26, 26, 26, 28, 74, 200; Gemin. *Isag*. V.47, 48, 61; VI.24, 26; XVI.14, 17, 18 AUJAC 29, 37, 38, 78, 79; Vett. Valens. *Anthol*. Kroll 317, 343. These facts were noted in *HAMA*, p. 725.

[95] D. MARCOTTE (ed.), *Les géographes grecs*, I, *Introduction générale. Ps.-Scymnos: Circuit de la Terre*, in CUF, Paris, Les Belles Lettres 2000, p. 108.

[96] HONIGMANN, *SK*, p. 10; cf. DICKS, *The ΚΛΙΜΑΤΑ*, p. 254.

[97] U. HÖFER, *Pseudo-Skymnos und Eratosthenes*, «Philologus» 77, 1928; ID., *Die Periegese des sog. Skymnos*, «Rheinisches Museum für Philologie» 82, 1933.

[98] GISINGER, *Rez. Honigmann*, p. 96; THEILER, *Poseidonios*, p. 30.

[99] DICKS, *The ΚΛΙΜΑΤΑ*, p. 252; ID., *Hipparchus*, pp. 157-160.

It is more difficult to explain the fact that Eratosthenes' passages never associate the latitudes of his key points with the length of day *M*. This fact contradicts the very close coincidence of his set of latitudes with the 7 Ptolemaic climata.

Three explanations can be given for this contradiction: (1) Eratosthenes indeed made no relation between his main latitudes and *M*, and this relation was only established by his successors – however, all the above speaks in favour of Eratosthenes' latitudes initially relying upon the system of 7 climata; (2) Eratosthenes did link his 7 latitudes to *M*, but Strabo omitted this fact – however, such a distrust for Strabo is unfounded; (3) these latitudes were linked to *M* before Eratosthenes, who only applied the already existing system of 7 climata to his own particular task. It is certain indeed that the main problem Eratosthenes was solving was not the determination of the latitude of certain points from *M* (which is the essence of the concept of clima) but rather the measurement of the maximum breadth of the oikoumene from the distances between these points. Therefore the last supposition seems to be the most convincing. We may assume that certain works on mathematical geography had existed even before Eratosthenes.

A small difference between Eratosthenes' and Ptolemy's data elucidates the continuity between the systems of climata by Eratosthenes, Hipparchus and Ptolemy. Ptolemy draws the 14^{h} clima through the Lower Egypt, while Eratosthenes draws it through Alexandria. Evidently, Eratosthenes follows the simplest and traditional view linking the 14^{h} clima to Alexandria proper. This view is stated in the tables of climata by Cleomedes (*De motu*. II.1.442 Todd 59) and Martianus Capella, and in the system of "astrological" climata (Berosus, Epigenes, Hypsicles, Pliny, Vettius Valens, Firmicus Maternus). Hipparchus was the first to amend it and draw the 14^{h} clima 400^{st} south of Alexandria (II.5.38 C133 = F V 6 = F 48). This is reflected in the system of 7 climata: Ptolemy places Alexandria at the latitude of 31°, which is 38'= $443.(3)^{st} \approx 400^{st}$ north of the 14^{h} clima, given 1° = 700^{st}[100]. Thus, the Ptolemaic system of climata, yet descending from Eratosthenes, could not have escaped Hipparchus' influence.

Sum up the main conclusions. The system of 7 climata first used by Ptolemy in the *Almagest* and forming the basis of his geography in the *Directory* goes back to the treatise by Marinus of Tyre – to its early and late versions, respectively. Ptolemy was the first to make the system of 7 climata canonical, starting to apply the term κλίμα only to the elements of this system: all pre-Ptolemaic authors could apply this term to any others latitude. E. Honigmann's assumption that the system of 7 climata forms the basis of Eratosthenes' geography proves valid. However, Eratosthenes is unlikely to be the creator of this system. Most probably, this system was introduced by his predecessors and only used by Eratosthenes for his own purposes.

[100] First it was noted by DILLER, *The Parallels*, p. 6 note 10; cf. DICKS, *Hipparchus*, p. 174.