Cel Nav & RZA

Celestial Navigation

In 1777 by Royal Decree the Globular lat/long coordinate system we're all familar with was imposed on the world.

https://cudl.lib.cam.ac.uk/view/PR-NAO-01776/7 [Pages 6-8]

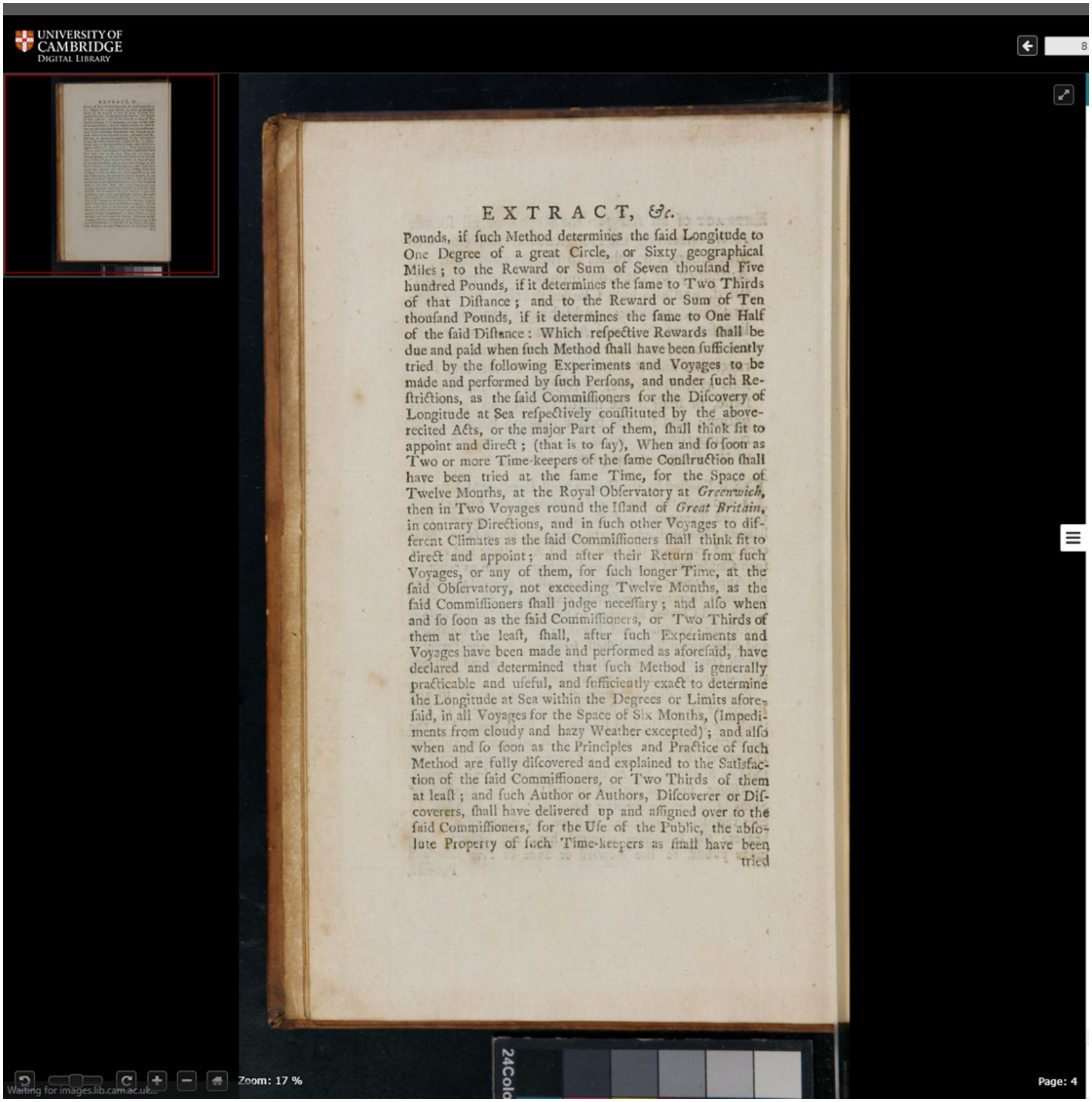
The Nautical Almanac and Astronomical Ephemeris, For the Year 1776. (NAO1776)

EXTRACT of an Act for the Repeal of all former Acts concerning the Longitude at Sea, except ſo much thereof as relates to the Appointment and Authority of the Commiſſioners thereby conſtituted, and alſo ſuch Clauſes as relate to the conſtructing, printing, publiſhing, vending, and licenſing of Nautical Almanacs and other uſeful Tables; and for the more effectual Encouragement and Reward of ſuch Perſon and Perſons as ſhall diſcover a Method for finding the ſame, or ſhall make uſeful Diſcoveries in Navigation; and for the better making Experiments relating thereto: Made in the Fourteenth Year of the Reign of his preſent Majeſty.

BE it Enacted by the KING's Moſt Excellent Majeſty, by and with the Advice and Conſent of the Lords Spiritual and Temporal, and Commons, in this preſent Parliament aſſembled, and by the Authority of the ſame, That each and every of the ſaid recited Acts (ſave and except ſuch Clauſe and Clauſes in each or any of them as relate to the Appointment or Authority of all or any of the Commiſſioners thereby reſpectively conſtituted, and alſo ſuch Clauſe and Clauſes as relate to the conſtructing, printing, publiſhing, vending, and licenſing of Nautical Almanacs, and other uſeful Tables) ſhall, from and after the Twenty-fourth Day of *June* One thouſand Seven hundred and Seventy-four, be, and are hereby repealed.

And, for a due and ſufficient Encouragement to any Perſon of Perſons who ſhall diſcover any Method or Methods for finding the ſaid Longitude, Be it Enacted by the Authority aforeſaid, That the Firſt Author or Authors, Diſcoverer or Diſcoverers, of each and every ſuch Method or Methods, his or their Executors, Adminiſtrators, or Aſſigns, ſhall be intitled to and have the Rewards or Sums of Money herein-after mentioned; that is to ſay, In caſe the Method propoſed ſhall be, by means of a Time-keeper, the Principles whereof have not hitherto been made public, to the Reward or Sum of Five thouſand Pounds,

Royal Decree and $45 penalty [using current money standards for convenience the actual amount is in gold pieces]



EXTRACT, &c.

Pounds, if ſuch Method determines the ſaid Longitude to One Degree of a great Circle, or Sixty geographical Miles; to the Reward or Sum of Seven thouſand Five hundred Pounds, if it determines the ſame to Two Thirds of that Diſtance; and to the Reward or Sum of Ten thouſand Pounds, if it determines the ſame to One Half of the ſaid Diſtance: Which reſpective Rewards ſhall be due and paid when ſuch Method ſhall have been ſufficiently tried by the following Experiments and Voyages to be made and performed by ſuch Perſons, and under ſuch Reſtrictions, as the ſaid Commiſſioners for the Diſcovery of Longitude at Sea reſpectively conſtituted by the above-recited Acts, or the major Part of them, ſhall think fit to appoint and direct; (that is to ſay), When and ſo ſoon as Two or more Time-keepers of the ſame Conſtruction ſhall have been tried at the ſame Time, for the Space of Twelve Months, at the Royal Obſervatory at *Greenwich*, then in Two Voyages round the Iſland of *Great Britain*, in contrary Directions, and in ſuch other Voyages to different Climates as the ſaid Commiſſioners ſhall think fit to direct and appoint; and after their Return from ſuch Voyages, or any of them, for ſuch longer Time, at the ſaid Obſervatory, not exceeding Twelve Months, as the ſaid Commiſſioners ſhall judge neceſſary; and alſo when and ſo ſoon as the ſaid Commiſſioners, or Two Thirds of them at the leaſt, ſhall, after ſuch Experiments and Voyages have been made and performed as aforeſaid, have declared and determined that ſuch Method is generally practicable and uſeful, and ſufficiently exact to determine the Longitude at Sea within the Degrees or Limits aforeſaid, in all Voyages for the Space of Six Months, (Impediments from cloudy and hazy Weather excepted); and alſo when and ſo ſoon as the Principles and Practice of ſuch Method are fully diſcovered and explained to the Satisfaction of the ſaid Commiſſioners, or Two Thirds of them at leaſt; and ſuch Author or Authors, Diſcoverer or Diſcoverers, ſhall have delivered up and aſſigned over to the ſaid Commiſſioners, for the Uſe of the Public, the abſolute Property of ſuch Time-keepers as ſhall have been

tried

Reward tier: $10,500 for providing correction angles using their newly imposed lat/long coordinate system such that two ships can complete a circuit opposite directions to one another around Britain.

Suppose you have two observers A and B. The starting point for both A and B are right next to each other. They look at the stars, take measurements. Their location being the same, they see the stars in the same location. Let's say that A remains stationary and B travels away from A in a straight line until the stars in the sky shift 1 degree from their original position at A.

This is the basis for the purposed imposed coordinate system given to us in 1777.

For a single observer, globe or plane, in the north, correction angles to Polaris would be indistinguishable. The issue now is they need TWO observers to be able to use the sky for triangulation and end up in the correct location using their new lat/long system that's derived from the sky.

They do this via correction tables or traverse tables which enable quick calculations for using the stars to match a 2D map projection of the that same lat/long system. [Note: All modern published maps are required to use the globular lat/long system that stems from labors of 1777.] These correction angles and tables are derived from fulfillment of the successful circumnavigation of Britain

Summary: The globe and map projections thereof are derived from the equivalent of planar correction angles to Polaris. Using selective stars for navigation to make a lat/long coordinate system that's backwards compatible with a two-party reference system isn't mutually exclusive proof of a globe.

While on the subject of correction angles and coordinate system transformations. The correction angles and traverse tables provided to navigate successfully on the globular lat/long map were derived from a 2D planar rectangular coordinate system and through corrections and transformations the celestial sphere model for heliocentrism is derived.

Office, G. B. N. A. and U. S. N. O. N. A. Office (1961). Explanatory Supplement to the Astronomical Ephemeris and the American Ephemeris and Nautical Almanac, H.M. Stationery Office.

2. Symbols for heliocentric and geocentric coordinates

Heliocentric:		
spherical ecliptic	l, b, r	with appropriate subscripts
rectangular equatorial	x, y, z	
rectangular ecliptic, geometric for mean equinox of date	x_c, y_c, z_c	
Geocentric:		
spherical ecliptic	λ, β, Δ	with appropriate subscripts
spherical equatorial	α, δ, Δ	
rectangular equatorial	ξ, η, ζ	
rectangular equatorial (Sun)	X, Y, Z	

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6. Figure of the Earth

ϕ = geographic, or geodetic, latitude—see special note in section 2F

ϕ' = geocentric latitude $\quad \tan \phi' = (1 - e^2) \tan \phi$

ϕ_1 = parametric latitude $\quad \tan \phi_1 = (1 - f) \tan \phi$

e = ellipticity, or eccentricity, of the Earth's meridian

f = flattening $\quad 1 - f = (1 - e^2)^{\frac{1}{2}}$

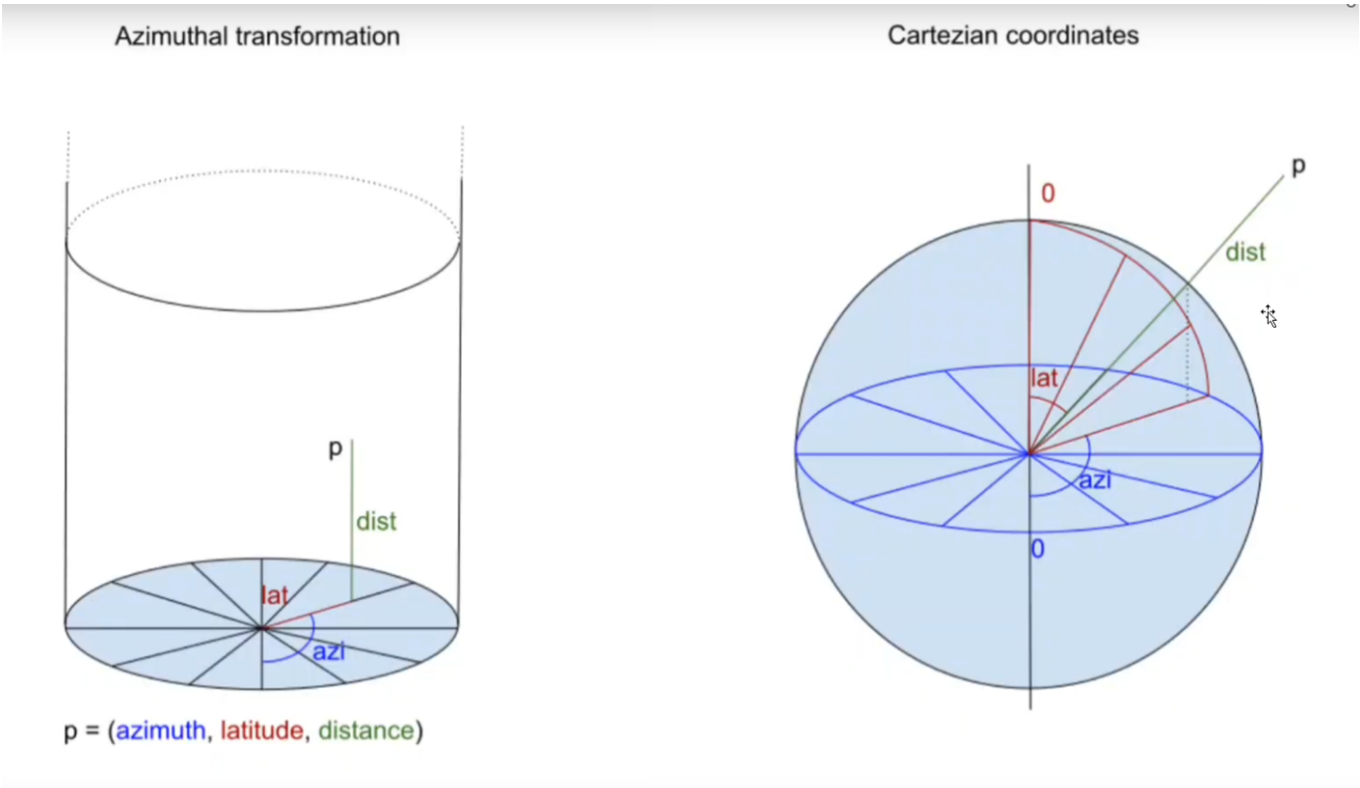
ρ = geocentric distance in units of the Earth's equatorial radius

S, C = auxiliary functions such that $\rho \sin \phi' = S \sin \phi$

$\rho \cos \phi' = C \cos \phi = \cos \phi_1$

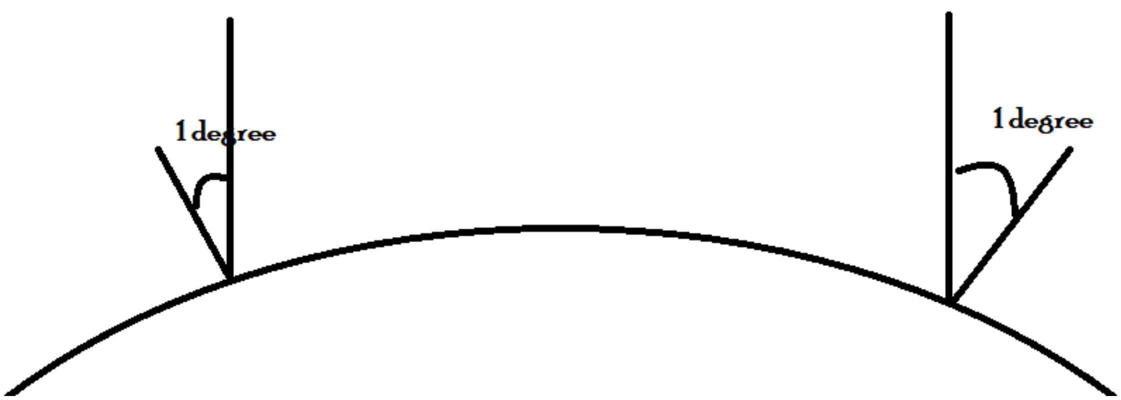
Using these equations, they went out and corrected their 2D planar maps to fit the globular coordinate system by adjusting the ellipticity or flattening of the area. Using that correction to fit the globular lat/long, they build a traverse table for everyone to use as quick reference to their location on the globular coordinate system without having to do actual spherical trig, which is a much lengthier process to use their map with. The reason all 2D projection maps work from their globular projection is because of transformations and supplemental corrections.

The end result of said transformations turns a 2D map into a globe with a radius of 3959 that matches the stars, because it was derived from the stars.



The Globularist argument is that when you are 69 mil away from an originating reference point, you are now tilted away from that original point such that there's a 1 degree deviation from your zeniths.

[Overly simplified and exaggerated for visual clarity]



On a plane, the two zeniths would be parallel, on a globe, at 69mi distance, they're 1 degree of deviation. 138mi = 2 degrees, 201 = 3 degrees, so on and so forth. We're told that the mechanism for this divergence is Earth's curvature. The flat earth explanation is perspective. As you get further away, the objects in the sky are apparent and relative to your location on the plane.

An attempt to measure the summation of this alleged 1 degree deflection of the vertical, the arc parallel is put forward.

Schott, C. A. (1900). Geodesy: The Transcontinental Triangulation and the American Arc of the Parallel, GOP.

Here we're told that by taking line of sight measurements at altitude [usually stations on mountains, etc]. By taking measurements of small triangles all across the country, the summation of these triangles is supposed to tell us there is excesses or not in the measurement.

Measuring spherical exceese is a misnomer. SE is not measured, it COMPUTATED via a process;

Operation of Triangulation Survey

Steps for executing triangulation project

The field work of a triangulation project is carried out in the following well defined operations:

1. Reconnaissance
2. Erection of Signals & Towers
3. Measurement of Horizontal Angles
4. Astronomical Observations Necessary to Determine the True Meridian and the Absolute Positions of the Stations
5. Measurement of Baseline
6. Adjustment of observed Angles
7. Computations of Lengths of each side of each triangle
8. Computations of the Latitude and Longitude of ST

[1] Line of sight measurements taken at altitude that form a triangle

[2] **Reduction of the Horizontal Directions to Seal Level**: A correction are applied for each measurement of the triangle to reduce the altitude of the triangle to make as if it were measured

at sea level. [Page 47]

(D.) REDUCTION OF HORIZONTAL DIRECTIONS TO SEA LEVEL.

The resulting directions at a station, as given in the abstracts, still need a small correction to reduce them to what they would have been had the object observed upon been at the sea level. The altitude of the observing station and the distance between them does not enter into the case; the reduction is due to the circumstance that, in general, the verticals at the two stations are not in the same vertical plane. The correction * is given by $\frac{e^2}{2} \cdot \frac{h}{\rho} \sin 2\alpha \cdot \cos^2\phi$, where $e^2 = \frac{a^2 - b^2}{a^2}$ and h = altitude of the station observed upon. ρ = radius of curvature in the plane normal to the meridian, α = azimuth of the line (counted from south around by west) and ϕ = latitude of place. With $\log e^2 = \bar{7}.8305$ and $\log \rho = 6.8054$ for $\phi = 39°$ and Clarke's spheroid (of 1866), and dividing the expression by $\sin 1''$, we get for the correction in seconds and the height in metres

$$0''.000\ 066 \sin 2\alpha . h$$

[3] Comparing the accuracy of the reduction by using a map derived from the stars that already fits a lat/long coordinate system that was originally derived from a planar correction angles to Polaris, the accuracy of the reductions are compared.

[4] Using coefficients (constants) for lateral refraction, further adjustments are considered. No laps rate required or actual measurements of refraction. Just assumptions. to make the calculations easier. However when we make observations, we must provide a lapse rate every 10 ft.

the one occupied. Persistent lateral refraction also has a share in producing the above result. Following the methods outlined at the beginning of this paper and used in the adjustment of the Yolo Base Net, we have $e_c = \sqrt{(0.28)^2 - (0.09)^2} = \pm 0.27$, which is to be combined with the particular value of e_s; hence the relative weight of an observed direction becomes—

$$p = \frac{1}{e^2} = \frac{1}{e_s^2 + (0.27)^2}$$

In the case of the Salt Lake Base Net, we have in the main figure the *extreme* values of $e_s \pm 0''.06$ and $\pm 0''.15$; hence the extreme weights to directions would be in the proportion of 13 to 11 nearly. The introduction of weights was therefore deemed unnecessary, especially when we consider the strength of the development of the length of the base to that of the primary line.

[5] After a using a weighted means average of the measurements, everything is summed up and get these measurements as a result.

Mean error of an observed *direction* (of unit weight) $m_1 = \sqrt{\frac{[pvv]}{n}} = \sqrt{\frac{4·870}{13}} = \pm 0''·61$ where n = number of conditions.
Mean error of an *angle* $m_> = m_1\sqrt{2} = \pm 0''·87$ and probable error of the same $\pm 0''.59$.

TRIANGLES OF THE KENT ISLAND BASE NET, MARYLAND, 1844 TO 1897.

No.	Stations.	Observed angles.			Corrections.	Spherical angles.	Spherical excess.	Log s.	Distances in metres.
		°	′	″	″	″	″		
1	Taylor	38	36	52·37	−0·59	51·78	0·08	3·938 897 1	8 687·545
	Kent I. N. Base	88	35	36·91	−0·31	36·60	0·08	4·143 529 1	13 916·47
	Kent I. S. Base	52	47	32·01	−0·15	31·86	0·08	4·044 816 9	11 087·07
				01·29			0·24		
2	Marriott	21	56	43·96	+0·09	44·05	0·15	4·044 816 9	11 087·07
	Taylor	119	32	44·32	+0·17	44·49	0·15	4·411 765 6	25 808·67
	Kent I. N. Base	38	30	31·55	+0·36	31·91	0·15	4·266 498 4	18 471·34
		179	59	59·83			0·45		
3	Marriott	40	10	21·28	+0·39	21·67	0·21	4·143 529 1	13 916·47
	Taylor	80	55	51·95	+0·76	52·71	0·22	4·328 444 0	21 303·16
	Kent I. S. Base	58	53	46·24	+0·03	46·27	0·22	4·266 498 5	18 471·34
		179	59	59·47			0·65		
4	Marriott	18	13	37·32	+0·29	37·61	0·14	3·938 897 1	8 687·545
	Kent I. N. Base	50	05	05·36	−0·66	04·70	0·15	4·328 444 1	21 303·16
	Kent I. S. Base	111	41	18·25	−0·12	18·13	0·15	4·411 765 8	25 808·68
				00·93			0.44		
5	Linstid	34	46	24·83	+1·01	25·84	0·09	4·044 816 9	11 087·07
	Kent I. N. Base	32	26	27·42	+0·28	27·70	0·09	4·018 198 2	10 427·93
	Taylor	112	47	[illegible]	+1·02	06·73	0·09	4·253 398 1	17 922·48
		179	59	59.47			0·27		

This rigorous weighted computational method occasionally produces a few arcseconds in spherical excess which is used as proof of a globe.

In short; after begging the question and using a map derived from the stars, spherical excess emerges from the ashes from the measurements.