Reading Schöner's Lines:
Problems of Longitude in the *Tabulae Resolutae* and The *Opusculum Geographicum*

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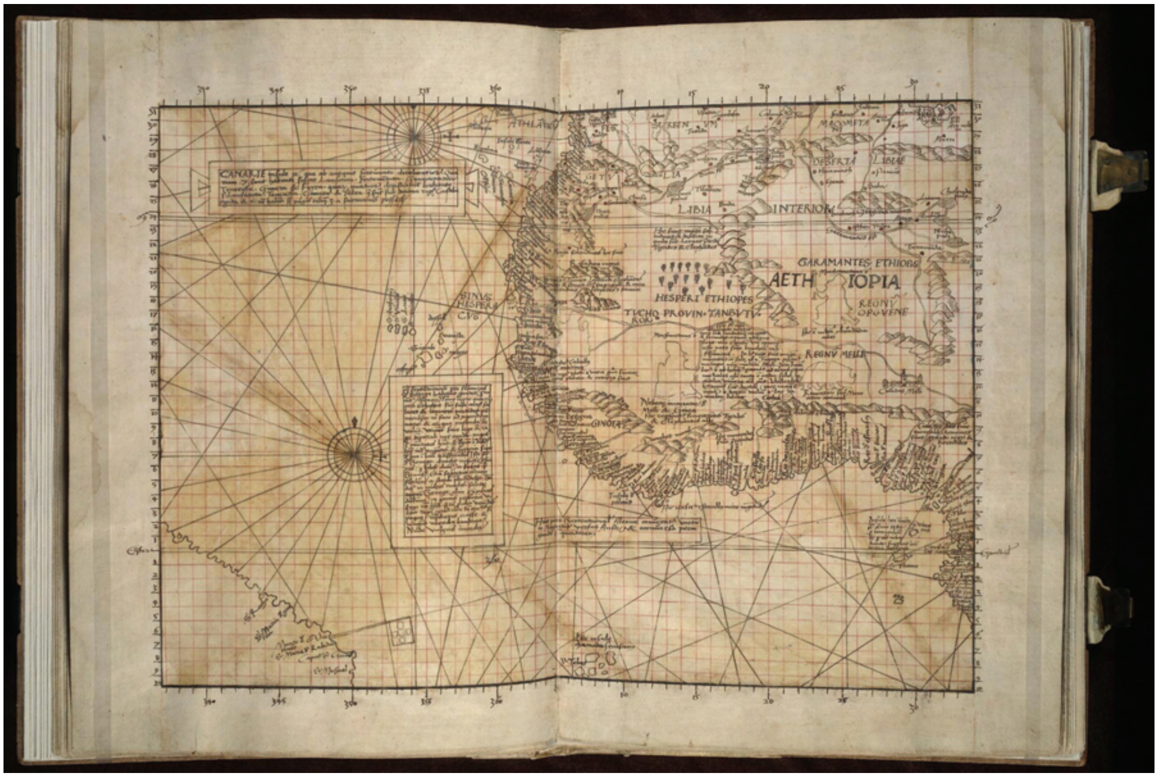
The only surviving copies of the two world maps created in 1507 and 1516 by Martin Waldseemüller and his colleagues at the gymnasium Vosenges in St. Dié France are found in a single bound volume that is now known as the Wolfegg Codex. The codex was discovered by Joseph Fischer in 1901 and now resides in the collections of the Library of Congress. The contents of the volume were brought together sometime after 1516 by the Nuremburg astronomer and mathematician Johann Schöner (1477-1547). Schöner also included in the volume a set of globes of his own design and a copy of a star-chart by Albrecht Dürer. The maps contained in the volume are annotated with a series of red-lines drawn by Schöner that form a grid over their surface the purpose of which has not been seriously considered in the scholarly literature[1]. The grid covers only a small portion of the 1507 map covering parts of Europe, Asia, and the Middle East. The grid on the 1516 map, known as the Carta Marina, covers nearly its entire surface (Figure 1).

The present paper presents a new, and as will become obvious, speculative theory regarding the purpose of these grids based on Schöner's need for correct longitudes in his updating of a catalogue of stellar positions in the *Tabulae Resolutae* (1536), in his *Opusculum Geographicum* (1533), and in his analysis of Copernicus's observations. I will seek to explain Schöner's grids as interpolation lines used to calculated and transcribe longitudes for the

[1] Elizabeth Harris in her seminal study of the typography of the Waldseemüller maps suggest that the grid may have been used to copy portions of the map to be used in the making of Schöner's gores. We suggest that this interpretation may not be correct being the grid lines also appear on the gores themselves. "The Waldseemüller World Map: A Typographic Appraisal" *Imago Mundi* 37 (1985): 30-53.



purpose of reducing astronomical observations. The need to reduce these observations to a convenient meridian comes about when attempting to use astronomical observations from different locations. In this study we shall compare the longitudinal reductions of Schöner and of Copernicus with the values of longitudinal differences found in the 1486 Ulm Ptolemy, the 1507 and 1516 worlds maps of Waldseemüller, and the modern values in an effort to show how and why Schöner made these interpolations.

The idea that Schöner knew of Copernicus's observations and of his new planetary theories well before the publication of the *De Revolutionibus Orbium Caelestium* in March of 1543, and that he participated in the debates surrounding the mathematical and astronomical problems of the early sixteenth century is not difficult to establish. Copernicus wrote and circulated among a small group of astronomers his heliocentric theory in a small manuscript called the *Commentariolis* as early as 1510[2]. Very few copies of this text have survived and Copernicus does not mention it in the *De Revolutionibus* suggesting that it was an early attempt at a theory.

The *Commentariolis* contains many errors when compared to his later mature theory and in essence is a straightforward modification of Arabic models, specifically that of Ibn ash-Shâtir made into a heliocentric from. That Schöner was also interested in these Arabic Marâgha models can be seem from the fact that he produced an edition of Regiomontanius's *Oration* together with al-Farghânî and al-Battânî commentaries on the mathematical sciences printed by Petrieus in Nuremburg in 1537. Schöner also annotated the copy of Dürer's star chart bound in the Wolfegg Codex with the names of Arabic astronomers as shown in Figure 2.

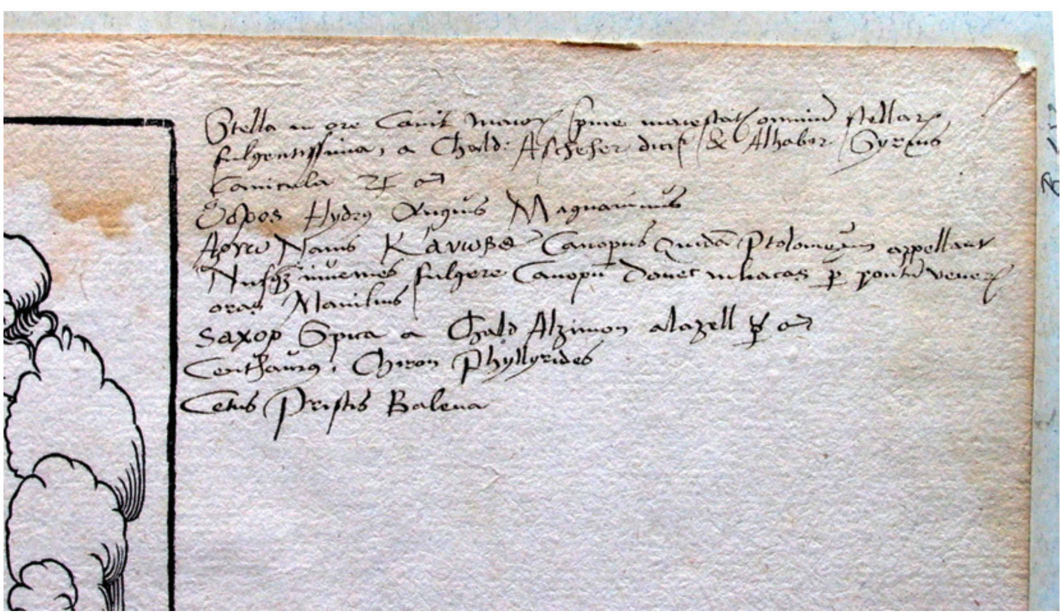


Figure 2: Schöner's Annotation on Dürer's Star-Chart

[2] N.M. Swerdlow and O. Neugebauer *Mathematical Astronomy in Copernicus's De Revolutionibus* (Berlin: Springer-Verlag, 1984) 9.

In the *Commentraiolis* Copernicus presents his heliocentric model without proof as one of the postulates that begin the text. He says in postulate 3, "All the spheres revolve about the sun as their mid-point, and therefore the sun is the center of the universe,"[3] leaving the mathematical details to his later work.

While there is no conclusive evidence that Schöner had a copy of the *Commentariolis* specifically there is a great deal of evidence that he knew of Copernicus's new theories. In 1538 Schöner was visited by a young mathematician named Georg Joachim Rheticus (1514-1574), who had just completed his studies at the University of Wittenberg. After taking a degree Rheticus decided to set out on a journey to visit and work with the most prominent mathematicians he could find. The journey took him over three years to complete. His first stop was in Nuremburg and he stayed and studied with Schöner for several months. Schöner possessed at the time a large collection of geographical and astronomical manuscripts including those of Regiomontanus, Bernhard Walther (1430-1504) and Johann Werner (1468-1532).

Werner's manuscripts are especially interesting in that his commentary of the first book of Ptolemy published in 1514 sets out a modification of Ptolemy's method of map projection that represents the first solution to the problem of mapping the whole of the surface of the earth on a single flat sheet and develops a series of projections that includes the type used on Waldseemüller's 1507 map[4].

During his stay in Nuremburg Rheticus was introduced by Schöner to Johann Petrieus who would eventually print Coperincus' masterpiece. In May 1539, at the urging of

[3] Nicholus Copernicus *Three Copernican Treatises*, translated and edited by Edward Rosen (New York: Columbia University Press, 1939) 58.
[4] John Hessler "Warping Waldseemüller: A Phenomenological and Computational Study of the 1507 World Map" *Cartographica* 41 (2006).

Schöner, Rheticus went to visit Copernicus in Frauenberg, Prussia, carrying a large group of books. The Latin texts in the group were printed by Petrieus and presented to Coperinicus as gifts. These works included:

> Regiomontanus, *De Triangulus omnimodis* (1533), Latin
> Apianus, *Instrumentum primi mobilis* (1534), Latin
> Jabir ibn-Alfah, *De Astronomia* (1534), Latin
> Euclid, *Elements* with commenrtay on the first book by Proclus (1533) Greek
> Ptolemy, *Almagest* with Theon's commentary (1538), Greek

Schöner and Petreius may have been attempting to suggest that Copernicus publish his work in Nuremberg and sent the books as an example of the type of scientific printing being doen in Nuremburg. The books are still extant in Copernicus's library.

Rheticus would spend the next two years and three months with Copernicus learning his theories and his observational methods. In September of 1539 Rheticus wrote a letter to Schöner that has become known as the *Narratio Prima*. The letter is a long and detailed description of Copernicus' work and his observational methods that led to the heliocentric theory. It describes in detail as Rheticus says, "The principal reasons why we must abandon the hypothesis of the ancient astronomers.[5]" The letter was widely read and published in Danzig and Basel in 1540 and 1541.

In the letter Rheticus describes the scope of the new theory,

"We shall have, most learned Schöner, a true system of hypothesis for deducing in its entirety what the moderns call the doctrine of the first motion, which at present is derived form all sorts of motions of the starry sphere; and for determining the causes of the motions and phenomena of the sun and moon, as they have been carefully observed by scholars for the past two-thousand years[6]."

One common problem encountered by both Copernicus in using observations taken over the past two thousand years, and by Schöner in this production of updated star charts

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[5] Copernicus, (1939): 136.
[6] Copernicus, (1939): 149

for the meridian of Nuremberg known as the *Tabulae resolute,* is geographical and not astronomical. The use and comparison of astronomical observations from different locations requires the reduction of those observations to a common meridian. The formal and logical structure of astronomical theory in the early sixteenth century is still that of Ptolemy found in his book the *Almagest*. This work lays out a theory and a method for the calculation of the positions of the sun, the moon, the stars and the planets. In doing so it employs a structure that is progressive, in which each subject is built on what has gone before. One needs a solar theory to calculate lunar positions, a lunar theory to calculate stellar positions and a stellar theory to calculate the motions of the planets, which is the ultimate goal. The emphasis is first placed on empirical observations that allow for the development of geometrical models. The geometrical models are then used to calculate numerical parameters that allow for the prediction of planetary positions.

The importance of observation in the astronomy of the early sixteenth century was no different than in Ptolemy's time and saw the production of updated tables of stellar positions based on more accurate determination of the observing locations on the earth like Schöner's *Tabulae resolutae*. Accurate astronomical theories require observations over long periods of time making it impossible for one observer to do all the necessary work. It was therefore important not only to collect observations from other observers but also to have accurate determinations of the locations at which the observations where made and the differences in longitude and latitude between these locations.

Determining Copernicus' sources for observing locations is difficult. Aside from his own observations down in Frauenberg Copernicus uses observations made in Alexandria, Rhodes, Raqqa (Syria), Bolonga, Rome, and Nuremburg, all of which must be reduce to the meridian of Carcow. No single source has been found that give his values for the reduction to this meridian and the values that he used are shown in Table 1.

	Δt^h	ΔLongitude
Nuremburg	-1;0	-15
Bologna	-;36	-9
Rome	-;20	-5
Rhodes	+;50	+12;30
Alexandria	+1;0	+15
Raqqa	+1;40	+25

Table 1: Copernicus' Reductions to Cracow Meridian

Figure 3 shows a graphical comparison of reduction values for these same locations in the 1482 Ulm Ptolemy, Schöner's *Opusculum geographicum*, on the 1507 and 1516 Waldseemüller maps, and modern values. Several things are immediately apparent from this graph. First, that Copernicus's values represent an average of all the values falling in between two groups, 1507 and the 1482 Ptolemy on the one side, and the 1516 and modern values on the other. Schöner's values oscillate between the two groups. The 1516 map by Waldseemuller displays an error in longitude that is far less than the 1507 map and whose statistical and geometric character is different (Figure 4). The shape of the error curve for the 1516 map does not resemble the shape of a typical Ptolemaic longitudinal error and therefore must derive from a different source. Second, Schöner's values as shown in Figure 3, alternate back and forth between the two groups of error types, suggesting that he probably used a composite of sources for his longitudes in the *Opusculum geographicum*. Could his grids on the 1507 and 1516 maps be the source of his longitudinal interpretations? Could he be using the 1507 and 1516 maps that he bound together to check the observations found in his *De Revolutionibus* and other astronomical texts? There are very few sources in the early sixteenth century for accurate longitudes and any sources more accurate than Ptolemy for such data would have been welcomed additions to the astronomers tool box. While there is no definitive may to prove how he used them that fact that Schöner drew only a partial grid on the 1507 map and only over the areas from which astronomical observations were available, ignoring the more interesting display of the new world, suggests this a strong possibility.

Although it is only speculation it is interesting to imagine Schöner sitting in his study checking his longitudes and reading his Copernicus through Waldseemüller.

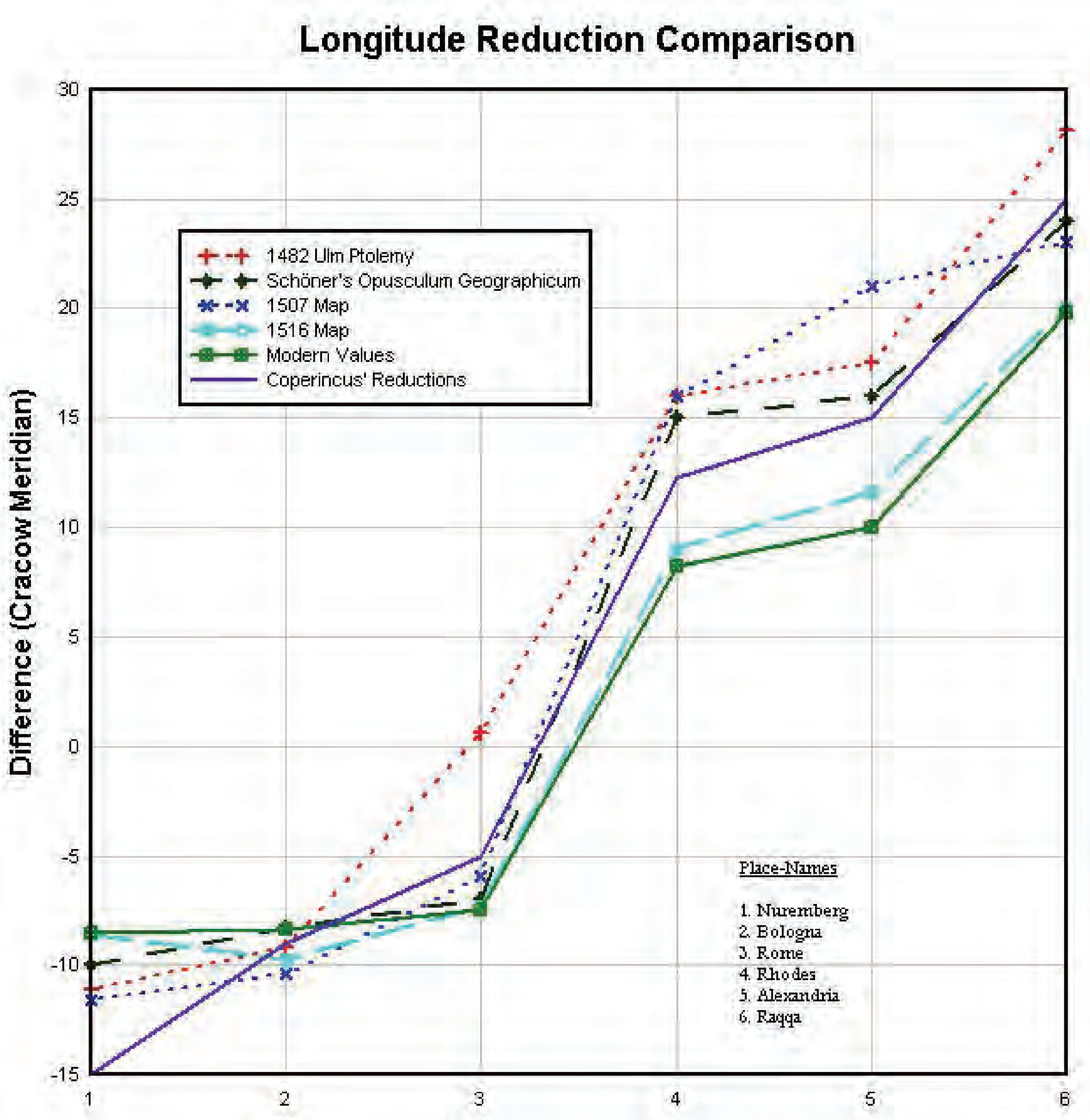

Figure 3: Comparison of Longitudinal Reductions

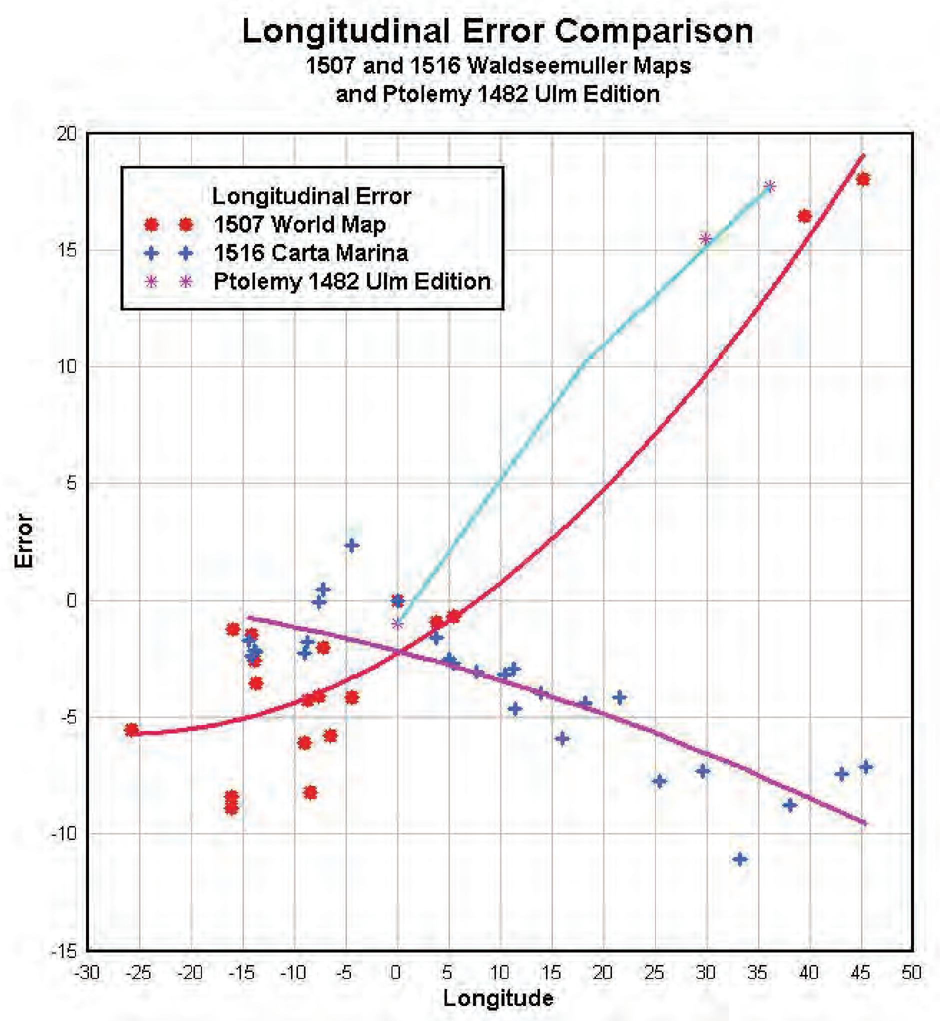

Figure 4: Overall Longitudinal Error on 1507, 1516 and 1482 Ulm Ptolemy