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The Renaissance and the Round Ball:
Spheres, Globes and the Early Modern Spatial Imagination

Importante

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Abstract

The contemporary literature on the Renaissance invention of terrestrial globes is fixated on the images that globemakers drew, expending great energy in determining how "correct" they were. This essay, in contrast, understands the history of globes through the rise of a new ways of projecting space and argues that the application of a homogenous and homocentric spatial aesthetic to the cosmos made the Renaissance's global thought possible. This spatial aesthetic emerged in the course of the fifteenth century, with the return of Claudius Ptolemy's Geography*, and yielded the long-standing practice of globe pairing. From roughly 1450 until 1850 terrestrial globes were regularly paired with celestial ones, as the celestial and the terrestrial were place under one spatially defined rubric. The history of globes is, thus, not about the images that were painted on round balls, but the space in which geographic thought became possible.*

Resumen

La bibliografía contemporánea sobre la invención renacentista de globos terráqueos está obsecionada en las imágenes dibujadas por los constructores de globos terráqueos, invirtiendo gran cantidad de energía en determinar que tan "correctos" eran. En contraste, este ensayo entiende la historia de los globos a través del surgimiento de nuevas formas de proyectar el espacio y argumenta que la aplicación de una estética espacial homogénea y homocéntrica al cosmos hizo posible el pensamiento global renacentista. Esta estética espacial surgió en el transcurso del siglo XV, con el retorno de la Geografía *de Claudio Ptolomeo, dando paso a la larga práctica del emparejamiento de globos. Desde, aproximadamente, 1450 hasta 1850 los globos terráqueos se emparejaban con los celestes, y ambos se colocaban en una categoría espacial definida. Por consiguiente, la historia de los globos no trata sobre las imágenes pintadas en bolas redondas, sino sobre el espacio en el que el pensamiento geográfico se hizo posible.*

Introduction

On a round ball
A workman that has copies by, can lay
An Europe, Afrique, and an Asia,
And quickly make that, which was nothing, All.[1]

John Donne "A Valediction of Weeping" (1633)

The earth was invented in 1477. In that year, Nicolaus Germanus, a German cartographer working in Rome, completed a little-known terrestrial globe.[2] It is difficult to say whether it was the first such globe produced in Europe, but it was the first terrestrial globe to be paired with a celestial one.[3] This innovation marks the start of an epoch, as globe pairing became ever more prominent across the western world, reaching its height in the middle of the seventeenth century, before ending by the middle of the nineteenth.[4] Today, terrestrial globes are sold singly, one sphere being sufficient to establish a global space. It was not always so. For over three centuries after its invention, the terrestrial globe was associated directly and continually with the heavens.

Although heaven and earth were born twins as globe pairs, scholars have largely overlooked the rise and fall of this practice.[5] This is due to two weaknesses. First, they have emphasized the superficial, cataloguing globes' images and chronicling which globemaker got what right (and when).[6] Edward

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[1] Charles M. Coffin, ed., *The Complete Poetry and Selected Prose of John Donne* (New York: The Modern Library, 2001), 30.

[2] Jósef Babicz, "The Celestial and Terrestrial Globes of the Vatican Library, Dating from 1477, and their Maker Donnus Nicolaus Germanus (ca 1420- ca 1490)," *Der Globusfreund: Wissenschaftliche Zeitschrift für Globenkunde* 35/37(1987): 155-166; Jósef Babicz, "Donnus Nicolaus Germanus - Probleme seiner Biographie und sein Platz in der Rezeption der ptolemäischen Geographie," *Wolfenbütteler Forschungen* 7(1980): 9-42.

[3] For informed speculation on potential earlier globes, see Patrick Gautier Dalché, *La Géographie de Ptolémée en Occident (IVe-XVIe siècle)*, Terrarum Orbis (Turnhout, Belgium, 2009), 246; Patrick Gautier Dalché, "Avant Behaim: les globes terrestres au xve siècle," *Médiévales* 58, no. 1 (2010): 43-61.

[4] Elly Dekker and P. C. J. van der Krogt, *Globes from the Western World* (London, 1993).

[5] Catherine Hofmann, *Le globe & son image* (Paris, 1995); Alois Fauser, *Die Welt in Händen: Kurze Kulturgeschichte des Globus* (Stuttgart, 1967); Oswald Muris and Gert Saarmann, *Der Globus im Wandel der Zeiten; eine Geschichte der Globen* (Berlin, 1961); Edward Luther Stevenson, *Terrestrial and Celestial Globes: Their History and Construction, Including a Consideration of Their Value as Aids in the Study of Geography and Astronomy* (New Haven, 1921).

[6] Ute Obhof, "Der Erdglobus, der amerika benannte: Die Überlieferung der Globensegmente von Martin Waldseemüller," *Der Globusfreund: Wissenschaftliche Zeitschrift für Globenkunde* 55/56(2009): 13-22; Thomas Horst, "Der Niederschlag von Entdeckungsreisen auf Globen des frühen 16. Jahrdunderts," *Der Globusfreund: Wissenschaftliche Zeitschrift für Globenkunde* 55/56(2009): 23-38; Edward H. Dahl and Jean-François Gauvin, *Sphaerae mundi: Early Globes at the Stewart Museum* (Sillery, Québec, 2000); Tony Campbell, "A Descriptive Census of Willem Blaeu's Sixty-Eight Centimeter Globes," *Imago Mundi* 28(1976): 21-50; H. M. Wallis, "The Molyneux Globes," *The British Museum Quarterly* 16, no. 4 (1952): 89-90; Alfred Kohler, "Die Entwicklung der Darstellung Afrikas auf Deutschen Globen des 15. und 16. Jahrhunderts," *Der Globusfreund: Wissenschaftliche Zeitschrift für Globenkunde* 18/20(1970): 85-96.

Stevenson's magisterial *Terrestrial and Celestial Globes* (1921) details the drawings on globes of both kinds, but ignores pairing.[7] Subsequent works by Oswald Muris, Alois Fauser and Catherine Hofmann cleave a similar line, with the only exceptions being Elly Dekker and P. C. J. van der Krogt's *Globes from the Western World* (1993) and David Woodward's "The Image of the Spherical Earth" (1989), both of which broach the issue, but without pursuing it.[8] Second, scholars conflate the thought behind globes with the Age of Exploration and limit themselves, thus, to tracing how explorers' reports were transferred onto globes.[9] In pursuing this course, however, they reduce a dense process of imagination to a mere chronicle of Europe's navigatory exploits. The mapping of the New World occurred within traditions of thought that extended back through the medieval and classical worlds.[10] Globemaking was much more than a simple process of transcription.

The literature's weaknesses stem, in part, from a historical accident. The oldest surviving terrestrial globe is not that of Germanus, but the *Erdapfel* of the Nuremberg merchant Martin Behaim.[11] In addition to being pre-Columbian—it was completed in 1492—this globe was constructed singly and, to this day, stands alone. The globe's singularity emerged from Behaim's commercial interests. He lived in Portugal, but built the globe, while on a visit home, in order to encourage investment in maritime ventures. Already in the nineteenth century this globe achieved such prominence that it set the terms of the entire field's discussion. Although much has improved, in this respect, contemporary works that give pride of place to Behaim's globe still lock their gaze on the Americas and detail how these regions and others were added over time.[12]

Behaim's work took form, however, within an older culture of space that had long anchored itself to the celestial realm. The first celestial globes predate terrestrial ones, going back to roughly 1000 AD, while the oldest

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[7] Stevenson, *Terrestrial and Celestial Globes*.

[8] Muris and Saarmann, *Der Globus*; Fauser, *Die Welt in Händen*; Alois Fauser, *Kulturgeschichte des Globus*, Reprint ed. (Vienna, 1967); Dekker and Krogt, *Globes from the Western World*; David Woodward, "The Image of the Spherical Earth," *Perspecta* 25(1989): 3-15.

[9] Horst, "Der Niederschlag."; Kohler, "Die Entwicklung der Darstellung Afrikas auf Deutschen Globen des 15. und 16. Jahrhunderts."

[10] Gautier Dalché, *La Géographie de Ptolémée en Occident (IVe-XVIe siècle)*: 242. On the active nature of German geographic thought, see Christine R. Johnson, *The German Discovery of the World: Renaissance Encounters with the Strange and Marvelous*, Studies in Early Modern German History (Charlottesville, VA, 2008).

[11] Gerhard Bott and Johannes Karl Wilhelm Willers, *Focus Behaim Globus: Germanisches Nationalmuseum, Nürnberg, 2. Dezember 1992 bis 28. Februar 1993*, 2 vols. (Nuremberg, 1992); Oswald Muris, "Der Globus des Martin Behaim," *Mitteilungen der Geographischen Gessellschat Wien* 97(1955): 169-182.

[12] Günther Hamann, "Der Behaim-Globus als Vorbild der Stabius Dürer Karte von 1515," *Der Globusfreund* 25-27(1977-79): 135-147; Arthur H. Robinson, "It Was the Mapmakers Who Really Discovered America," *Cartographica: The International Journal for Geographic Information and Geovisualization* 29, no. 2 (1992): 31-36; Mirjanka Lechthaler, "The World Image in Maps -- From the Old Ages to Mercator," *Cartography and Art* (2009): 1-20.

surviving ones are from the late fourteenth century.[13] The *Erdapfel* was the product of culture that was already comfortable with projections of great spaces, and the continental extent of this practice is apparent in celestial globes' dispersed pattern of production. In 1480, for example, an instrument maker named Hans Dorn completed the oldest surviving celestial globe while working for the royal court in Budapest.[14] And in 1493, the mathematician Johannes Stöffler fashioned the second oldest in Justingen (Württemberg) for the Bishop of Constance.[15] The web of production for all globes extended far and wide, as before 1500 it included Rome, Budapest, Nuremberg, and Justingen—and many other cities would join them. If one wants to understand terrestrial globes as a Renaissance phenomenon, one must begin with the general approach to space in which globes were paired.[16]

This essay understands the invention of terrestrial globes through the emergence of a Renaissance sense of space that defined the relationship between heaven and earth in a new way.[17] It does not separate terrestrial globes from celestial, but considers them jointly and as products of a wide-ranging, Trans-Alpine network of humanists that continually pushed the boundaries of traditional spatial projection. For our first illustration, we turn to a fresco from south of the Alps, "The School of Athens," by Raphael. (Figure 1.) Completed in 1511 in Rome, it is a celebrated work in the history of art, but one aspect offers an important perspective on pairing.[18] In the bottom right-hand corner (see, Figure 2) there is a globe pair, with the celestial globe held by the Hellenic astronomer Hipparchus and the terrestrial one by the Hellenistic astronomer and geographer Claudius Ptolemy.[19] Critically, Raphael has painted the two men so that they face each other.

By juxtaposing Hipparchus and Ptolemy so directly, Raphael captured the chief qualities of the new Renaissance space, homogeneity and

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[13] Olaf Pedersen, "Astronomy," in David C. Lindberg, ed., *Science in the Middle Ages*. (Chicago, IL, 1978), 303-337; Oscar G. Darlington, "Gerbert the Teacher," *American Historial Review* 52(1946/1947); Anna A. Grotans, *Reading in Medieval St. Gall*, Cambridge Studies in Palaeography and Codicology (Cambridge, 2006), 80-81; Werner Bergmann, *Innovationen im Quadrivium des 10. und 11. Jahrhunderts: Studien zur Einführung von Astrolab und Abakus im lateinischen Mittelalter*, Sudhoffs Archiv Beihefte (Stuttgart, 1985); Dekker and Krogt, *Globes from the Western World*: 16.

[14] Dekker and Krogt, *Globes from the Western World*: 16; Ernst Zinner, *Deutsche und niederländische astronomische Instrumente des 11.-18. Jahrhunderts*, 2., erg. Aufl. ed. (München, 1967), 292-297.

[15] Dekker and Krogt, *Globes from the Western World*: 27. See also Elly Dekker, *Illustrating the Phaenomena Celestial Cartography in Antiquity and the Middle Ages*, 1st ed. (Oxford, 2013), 291-301, 401-407.

[16] On the general idea behind this paragraph, see Nicholas Jardine, "The Places of Astronomy in Early-Modern Culture," *Journal for the History of Astronomy* 29(1998): 49-62.

[17] On Renaissance space in general, see Samuel Y. Edgerton, *The Renaissance Rediscovery of Linear Perspective* (New York, 1975); Samuel Y. Edgerton, *The Heritage of Giotto's Geometry: Art and Science on the Eve of the Scientific Revolution* (Ithaca, NY, 1991); John R. Short, *Making Space: Revisioning the World, 1475-1600* (Syracuse, NY, 2004).

[18] Heinrich Wölfflin, *Die klassische Kunst: ein Einführung ind die italienische Renaissance* (Basel, 1948); Luitpold Dussler, *Raphael: kritisches Verzeichnis der Gemälde, Wandbilder und Bildteppiche* (Munich, 1966).

[19] Noel M. Swerdlow, "Essay Review: Ptolemy's Geography, An Annotated Translation of the Theoretical Chapters by J. Lennart Berggren and Alexander Jones," *Annals of Science* 60, no. 3 (2010): 313-320, here 313.

homocentricity.[20] The homogeneity is evident in how heaven and earth are neither hierarchically arranged, as they might have been in a medieval image, nor depicted as differing greatly in size (the celestial sphere is only slightly larger). The homocentricity, meanwhile, is palpable in the privileging of the human imagination, as the image presumes that the mind can project a godlike perspective and, from that vantage point, associate things that are not normally seen together. These two qualities combined to provide the intellectual infrastructure within which heaven and earth were united within the Renaissance mind.

Within the Renaissance sense of space heaven and earth are neither above nor below, but float in a generic realm that justifies a human viewer. With this in mind, it becomes significant that in 1517 the Nuremberg globemaker and mathematician Johannes Schöner completed the first known globe pair with spheres of equal size.[21] It incorporated the three aspects of what became the Renaissance's material culture of globes: a terrestrial globe, a celestial globe, and a combination of a physical and a projected grid pattern that put the spheres into homogeneous and homocentric space.

Schöner's globe pair offers another view of the ferment that was occurring in spatial thought. As a trained mathematician, he was aware of the latest literature on methods of spatial projection. Moreover, he had undoubtedly created other globe pairs as early as 1504, which means his global thought both predated that of Raphael and reflected broader trends in European thought.[22] Schöner's globe pair, in turn, set a standard that endured into the nineteenth century, as paired globes, having been enveloped by homogeneous space, became so similar in structure that their spheres were distinguished by little beyond surface images. The history of the terrestrial globes is, thus, not about the cataloguing of images, but the illumination of the matrix in which spheres that represented radically different areas were produced and used in concert.

In contrast to its ubiquity in the Renaissance, the earth was curiously absent from the medieval world's material culture. The absence is curious, because the ancient Greeks and Romans, from whom medieval thinkers borrowed much, produced and used terrestrial globes. In the first century AD, for instance, the Roman geographer Strabo reported that around 150 BC a Stoic thinker named Crates of Mallos had built a terrestrial globe ten feet in diameter, so that he could trace Odysseus' voyages.[23] Drawings of globes also decorated Roman-era interiors, which suggests that such items enjoyed a

[20] The argument here has been informed by: Edgerton, *Renaissance Rediscovery*; Edgerton, *The Heritage of Giotto's Geometry*; Woodward, "The Image of the Spherical Earth."
[21] Dekker and Krogt, *Globes from the Western World*: 23-31.
[22] ibid., 23.
[23] Woodward, "The Image of the Spherical Earth," 8.

broader cultural currency.[24] This spatial tradition did not, however, survive the dissolution of the Roman Empire. Between 400 and 1400, among Rome's three successors—Islam, Byzantium, and Europe—only the first produced in the thirteenth century a single terrestrial globe, which it shipped it to China and promptly forgot about.[25]

The sustained reinvention of the terrestrial globe took a millennium, because medieval cosmological space was deeply fractured. This held true for all three post-Roman civilizations, but it was especially the case for the one that permanently reinvented the earth, Western Europe. Beginning in the ninth century, Europeans recovered two key doctrines of classical space: the spherical cosmos and spatial hierarchy. They had access to few texts, as only a handful of works by Macrobius, Martianus Capella, Plato and Pliny the Elder were available.[26] After imbibing what they could, early medieval Europeans accepted the sphericity of the cosmos, as well as its hierarchical nature, which meant that they assumed higher regions to be more perfect than lower ones.[27] This approach was, in turn, overlaid with Christian assumptions about Creation, with the result that God and the angels also became fixed in those realms above.

During the twelfth century, with the return of more classical texts the spherical cosmos became even more hierarchical. This was due, above all, to the return of Aristotle's corpus and Claudius Ptolemy's *Almagest*. Aristotle's cosmological works, especially his *Physics*, divided the cosmos into sub-lunar and supra-lunar realms, with each having a different physics and a different space.[28] Ptolemy, in turn, simplified Aristotle's thought and added observational details that made the *Almagest* the definitive astronomical/cosmological work. The Aristotelian-Ptolemaic system that emerged from Ptolemy's work comprised eight nested crystalline spheres, in which the sun, moon, and other planets and stars were embedded, while the earth resided at the center.

The scholarship on medieval and early-modern cosmological doctrines usually concentrates on the rise and fall of geocentrism. This legitimate interest in our how our planet was nudged away from the cosmos' center has, nonetheless, overshadowed the significance for global thought of another discipline that medieval thinkers readily absorbed, geometry. We understand

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[24] Dekker and Krogt, *Globes from the Western World*: 11.

[25] Willy Hartner, "The Astronomical Instruments of Cha-ma-lu-ting, Their Identification, and Their Relations to the Instruments of the Observatory of Marāgha," *Isis* 41, no. 2 (1950): 184-194.

[26] Bruce Eastwood, *Ordering the Heavens: Roman Astronomy and Cosmology in the Carolingian Renaissance*, History of Science and Medicine Library (Leiden 2007); William Harris Stahl, *Roman Science: Origins, Development, and Influence to the Later Middle Ages* (Madison, 1962); Marcia L. Colish, *Medieval Foundations of the Western Intellectual Tradition, 400-1400*, Yale Intellectual History of the West (New Haven, CT, 1997).

[27] Eastwood, *Ordering the Heavens*: 187-217.

[28] Edward Grant, "The Medieval Cosmos: Its Structure and Operation," *Journal for the History of Astronomy* 28(1997): 147-167; W. G. L. Randles, *The Unmaking of the Medieval Christian Cosmos, 1500-1700: From Solid Heavens to Boundless Aether* (Aldershot, 1999).

geometry narrowly, today, as a system of idealized spatial projection. In the classical and medieval periods, however, its spatial thought also had metaphysical resonances. For example, in addition to sphericity and hierarchy, early medieval thinkers accepted the idea that geometry's idealized space could only be applied to the perfect, higher realms of the cosmos. Not all classical thinkers accepted this idea, but those to whom medieval thinkers had access did so—and this had long-term consequences for how global space was imagined.

Against the backdrop of Renaissance global space, it is important to understand how idealized geometric space differed from Aristotelian cosmological space. According to Euclid, although points, lines and planes define geometric objects, none of the former has substance, but all are part of an object's surface. As a result, Euclidian space is independent of the objects that reside in it. This brand of space was never applied fully to medieval cosmology, largely on account of broader metaphysical concerns. Martianus Capella, whose cosmological thought was crucial to the ninth-century reception of classical thought, infused his works with Neo-Platonism, a 3rd century AD extension of Platonism that located perfection at the top of a chain of being. The chain of being distanced the physical world from being's highest realms, where Euclid's perfect idealized space resided, with the result that geometry had no terrestrial place. Aristotle, meanwhile, developed a theory of space that differed sharply from Euclid's, but which produced an effect similar to Neo-Platonism; he defined space as an area that was contained within something else, which when put in cosmological terms meant that each of the heavenly spheres defined a different space.[29] The ultimate consequence for medieval thought was a fractured and hierarchical cosmos.

Fractured space impeded the earth's reinvention. Although the medieval world understood the earth to be a sphere, the broader space in which this sphere rested could not sustain a terrestrial globe. This distinction is best explained via the medieval material culture of space. The medieval world imagined global space primarily through three items: the armillary sphere, the astrolabe, and the celestial globe. (Medieval maps are excluded, because their center was not primarily geometric, but was a reflection of a sacred history that put Jerusalem at the center of the world.[30]) These items all assume a fractured realm, in that they project an inside out perspective on the cosmos, i.e., from beyond the celestial realm, and represent the earth only schematically as a sphere. The astrolabe, for instance, uses a projection

[29] Grant, "The Medieval Cosmos."; Randles, *The Unmaking*; Eastwood, *Ordering the Heavens*.

[30] Evelyn Edson, *The World Map, 1300-1492: the Persistence of Tradition and Transformation* (Baltimore, 2007); P. D. A. Harvey, *The Hereford World Map: Medieval World Maps and their Context* (London, 2006); David Woodward, "Reality, Symbolism, Time, and Space in Medieval World Maps," *Annals of the Association of American Geographers* 75, no. 4 (1985): 510-521.

that assumes the viewer to be below the celestial sphere, at the southern polar axis, and represents our rounded planet as a series of circles and arcs that are arranged around a central point.[31] The earth was, thus, defined as a sphere, but the lines that circumscribed it actually had little to do with terrestrial space.

Among the three instruments, the armillary sphere reveals most clearly how fractured space obscured our planet. It consists of two spheres, a solid one on the inside that represents a generic body and an imagined one that is structured by a network of rings (*armillae* in Latin), which is, in turn, connected to the inner sphere by an axis. The instrument is illustrated in Figure 3, which comes from the frontispiece to Johannes Regiomontanus' *Epitome of Ptolemy's Almagest* (1496), a widely used Renaissance re-translation and digest of the Alexandrian's great work.[32] The most important among the rings are the celestial equator and the ecliptic. The former is a circle that divides the heavenly sphere, while the latter does the same, but is about 23.5 degrees off vertical. This line represents a geocentric average of the sun's perceived motion, which is projected outward as a plane—and where it intersects with the celestial sphere the ecliptic appears. To this circle are affixed the signs of the zodiac, which are crucial to marking time's passage, since constellations move across the night sky, during the year.

The armillary sphere reified the terrestrial globe's absence. On this point we will rely on testimony from another of Raphael's frescoes, the "Astronomia," (Figure 4). Residing in the same room as the "School of Athens," the "Astronomia" includes a female personification of the celestial science who looks down on a milky sphere that is covered with stars and the outlines of some constellations. Yet, in spite of her exalted position, Astronomia does not pierce the celestial veil and can only see the earth as a fuzzy blob—an absence of detail that stands in contrast to the Mediterranean's clear depiction on Ptolemy's globe in the "School of Athens." That the obscuring of the earth is related specifically to medieval space is apparent in a study that Raphael drew in preparation (Figure 5). As the image reveals, in first iteration the celestial discipline looks down not on a celestial sphere, but an armillary sphere.[33] This image probably emerged from contact with a version of Ptolemy's *Almagest,* as the sphere has the same proportions as the one that appears on the title page of Regiomontanus' *Epitome*. Raphael

Jean-Marc Besse, *Les grandeurs de la terre: aspects du savoir géographique à la renaissance*, Collection Sociétés, Espaces, Temps, (Lyon, 2003).

[31] Roderick Webster and Marjorie Webster, *Western Astrolabes*, Historic scientific instruments of the Adler Planetarium & Astronomy Museum (Chicago, 1998), 28-39.

[32] Johannes Regiomontanus, *Epytoma Joannis de monte regio In almagestum Ptolomei* (Venice, 1496). On Regiomontanus in general: Rudolf Mett, *Regiomontanus: Wegbereiter des neuen Weltbildes* (Stuttgart, 1996); Ernst Zinner, *Leben und Wirken des Joh. Müller von Königsberg genannt Regiomontanus*, ed. Helmut Rosenfeld and Otto Zeller, Second ed., Milliaria; 10,1 (Osnabrück, 1968); John D. North, *Cosmos: An Illustrated History of Astronomy and Cosmology* (Chicago, IL, 2008), 207-208.

[33] Edgerton, *The Heritage of Giotto's Geometry*: 202.

likely had access to this book, since it was an important work by a renowned mathematician, and the Pope also kept a copy in the very room where the fresco was painted.[34]

Raphael's "Astronomia" and "School of Athens" highlight how terrestrial globes emerged in the context of homogeneity and homocentricity's application to the cosmos. This is especially clear in one detail from the "School of Athens." Slightly down and to the left of Hipparchus and Ptolemy is an old man, probably Euclid, who has bent down to teach geometry. That Raphael bunched geometry, geography and astronomy so closely is already suggestive. More revealing, however, is that much of Euclid's lower half is between Hipparchus and Ptolemy, so that before the geometer bent down, his two companions could have embraced him. Euclid's physical position is, thus, a sign of how profoundly the underpinnings of spatial thought were changing.[35] Idealized space now touched both the celestial and the terrestrial realms.

Raphael's frescoes lay bare an epochal change in Renaissance spatial thought whose origins lie in yet another reception of classical thought.[36] This is illustrated in an easily overlooked detail. Contrary to long tradition, Raphael depicted the astronomer Claudius Ptolemy as a geographer and extended to him the singular honor of putting the earth in his hands. Raphael's maneuver was not new, as over the course of the fifteenth century, the collective image of Ptolemy had changed dramatically with the return of his great terrestrial text, the *Geography*.[37] This work played a crucial role in the earth's invention. It was not the only one involved—Euclid's *Elements* was important, too—but it occupied a unique position, because unlike other classical works it remained out of reach for so long. From the fifth century AD on, the *Geography* began a slow withdrawal from the Latin-speaking realm. This was due to the disappearance of Greek from the western half of the empire, which meant that Greek-language manuscripts, such as the *Geography*, ceased to be copied and, over time, disappeared. Although it is not true that all knowledge of the text disappeared, manuscript copies did, as

[34] ibid.

[35] Bert Roest, "Rhetoric of Innovation and Recourse to Tradition in Humanist Pedagogical Discourse," in Stephen Gersh and Bert Roest, eds., *Medieval and Renaissance Humanism: Rhetoric, Representation and Reform*. *Brill's Studies in Intellectual History* (Leiden, 2003).

[36] On Renaissance receptions in general, see Anthony Grafton, *Defenders of the Text: The Traditions of Scholarship in an Age of Science, 1450-1800* (Cambridge, 1991); Anthony Grafton, *Commerce with the Classics: Ancient Books and Renaissance Readers*, Jerome lectures (Ann Arbor, MI, 1997).

[37] Jim Bennett, "Practical Geometry and Operative Knowledge," *Configurations* 6, no. 2 (1998): 195-222; Edson, *The World Map, 1300-1492*; J. A. May, "The Geographical Interpretation of Ptolemy in the Renaissance," *Tijdschrift voor Economische en Sociale Geografie* 73, no. 6 (1982): 350-361; Erich Polaschek, "Ptolemy's "Geography" in a New Light," *Imago Mundi* 14(1959): 17-37; Zur Shalev and Charles Burnett, *Ptolemy's Geography in the Renaissance*, Warburg Institute Colloquia (London, 2011); Woodward, "The Image of the Spherical Earth."

there is no known western version, in Greek or Latin, from before the fifteenth century.[38]

Whereas, Aristotle's corpus, the *Almagest*, and the *Elements* all returned by 1200, the *Geography* came back only in 1406. In that year Jacopo Angelo de Scarperi, a Florentine humanist, translated it into Latin from a Byzantine manuscript and multiple versions of the translation soon circulated around Italy.[39] One example, to which we will return, appeared in Florence circa 1470 and includes hand-drawn maps that set a standard for all subsequent editions.[40] The *Geography* then entered into print and an even more rapid diffusion began. In 1475, the first print edition of Scarperi's translation was published in Vicenza, although without maps.[41] Additional versions and new translations were soon published in Bologna (1477), Rome (1478 and 1490), Florence (1482), and Ulm (1482 and 1486). The editions from Ulm reveal the vigor of Trans-Alpine humanism, as versions appeared in Strasbourg (1513, 1520, 1522, 1525), Nuremberg (1514), Vienna (1518), Cracow (1519), Basel (1533, 1540), Louvain (1535), Lyon, (1535), Lisbon (1537), Cologne (1540, 1578, 1597), and Paris (1546). And these came amidst new Italian editions, such as one that appeared twice in Rome (1507 and 1508)—and to which we will also return.

The esteem in which the Renaissance held Ptolemy's *Geography* is reflected in the eminent figures that were involved in its publication. The most striking example is the Dutch humanist Desiderius Erasmus, who provided an introduction for the Basel edition of 1533.[42] Less well known today, but significant at the time, was the Nuremberg publisher Willibald Pirckheimer, who edited the 1525 edition from Strasbourg.[43] Michael Servetus, the Spanish humanist who had the misfortune of running afoul of both the Catholic Church and the Reformation in a violently confessional age, edited the 1535 edition from Lyon.[44] Other important figures are the cosmographer and cartographer Sebastian Münster, who was involved in the Basel edition of 1540, and the cartographer and globemaker Gerard Mercator, who

[38] On the persistance of Ptolemy's geographic thought, see: Gautier Dalché, *La Géographie de Ptolémée en Occident (IVe-XVIe siècle)*.

[39] Bennett, "Practical Geometry."; Germaine Aujac, *Claude Ptolémée, astronome, astrologue, géographe: connaissance et représentation du monde habité* (Paris, 1993), 173.

[40] On this text, see Anthony Grafton, April Shelford, and Nancy G. Siraisi, *New Worlds, Ancient Texts: The Power of Tradition and the Shock of Discovery* (Cambridge, MA, 1992).

[41] For all the editions listed in this paragraph, see Henry N. Stevens, *Ptolemy's Geography. A Brief Account of All the Printed Editions Down to 1730* (London, 1908).

[42] Claudius Ptolemy, *Klaudiou Ptolemaiou Alexandreōs philosophou en tis malisa te paideumenou. Peri tēs geōgraphikēs biblia oktō, meta pasēs akribeias entiptothenta* (Basel, 1533).

[43] Claudius Ptolemy, *Claudii Ptolemaei Geographicae Enarrationis Libri Octo* (Strasbourg, 1525).

[44] Claudius Ptolemy, *Claudii Ptolemaei Alexandrini Geographicae Enarrationis Libri Octo ; Adiecta insuper ab eodem scholia, quibus exoleta urbium nomina ... exponuntur / Ex Bilibaldi Pirckeymheri translationem sed ad Graeca et prisca exemplaria à Michaele Villanovano iam primum recogniti ...* ed. Michael Servetus, trans. Willibald Pirckheimer (Lugduni, 1535).

contributed to the Cologne edition of 1578.[45] For the history of globes, however, the most important person associated with the *Geography* is Nicolaus Germanus. Not much is known about him, beyond his having worked in Rome as a cartographer.[46] It is clear, however, that his maps appeared in the 1470 manuscript from Florence, the Rome editions of 1478 and 1490, and the Ulm editions of 1482 and 1486.[47]

That one of Ptolemy's earliest illustrators also made a globe pair could be coincidental, except for the *Geography*'s other reverberations through space. Martin Behaim, who made the oldest surviving terrestrial globe, had a copy to hand in Nuremberg, as did Martin Waldseemüller, a cosmographer and cartographer in St. Dié (Alsace), who in 1507 published the first map with the name America on it.[48] And when Raphael painted the "School of Athens," at his side was Johannes Ruysch, a Dutch cartographer who drew the maps for the Rome editions of 1507 and 1508.[49] Most significant, perhaps, the globemaker Johannes Schöner owned copies of both Ulm editions and, as is clear from the comments he scribbled in the margins, read these books with care.[50] And then a certain Genoese adventurer had a copy, too.[51]

Ptolemy's fingerprints are all over the Renaissance globe. Why did the return of his *Geography* have such a profound effect? Here, we must recognize that, through its mere presence, the *Geography* demarcated what amounted to a textual space for global thought. Since the twelfth century, Ptolemy and the *Almagest* had defined astronomy for European culture, especially as it related to the production of celestial globes, since the text not only contained all the knowledge required for putting stars into place but also bequeathed to medieval culture an outside in perspective on space.[52] With the *Geography*'s arrival the cosmos was now book-ended in a way that expanded the conceptual realm available to spatial thought, as one text explained the earth

[45] Claudius Ptolemy, *Geographia Vniversalis, Vetvs Et Nova, Complectens Clavdii Ptolemæi Alexandrini Enarrationis Libros VIII. Quorum primus noua translatione Pirckheimeri et accessione commentarioli illustrior quàm hactenus fuerit, redditus est. Reliqui .. castigatiores facti sunt. Addita sunt insuper Scholia ... Succedunt tabulæ Ptolemaic[a]e, opera Sebastiani Munsteri nouo paratæ modo. His adiectæ sunt plurim[a]e nouæ tabulæ, moderna[] orbis faciem .. explicantes ... Vltimo annexum est compendium geographic[a]e descriptionis, in quo uarij gentium & regionum ritus & mores explicantur. Pr[a]efixus est ... index ...* (Basileae, 1540); Claudius Ptolemy, *Tabvlae geographicae Cl: Ptolomei: ad mentem autoris restitutae & emendate* (Cologne, 1578).

[46] Babicz, "Celestial and Terrestrial Globes of the Vatican Library," 219-224; Babicz, "Donnus Nicolaus Germanus."; Gautier Dalché, *La Géographie de Ptolémée en Occident (IVe-XVIe siècle)*.

[47] Stevens, *Ptolemy's Geography.*: 38-42.

[48] Muris and Saarmann, *Der Globus*: 49.

[49] James Sykes, "Der Erdglobus in Raphaels 'Die Schule von Athen'," *Der Globusfreund: Wissenschaftliche Zeitschrift für Globenkunde* 55/56(2009): 53-73.

[50] Chet A. Van Duzer and Johann Schöner, *Johann Schoner's Globe of 1515: Transcription and Study*, Transactions of the American Philosophical Society held at Philadelphia for Promoting Useful Knowledge (Philadelphia, 2010), 202; Bennett, "Practical Geometry."; Margriet Hoogvliet, "The Medieval Texts of the 1486 Ptolemy Edition by Johann Reger of Ulm," *Imago Mundi* 54(2002): 7-18.

[51] Numa Broc, *La géographie de la Renaissance (1420-1620)*, Mémoires de la Section de géographie / Ministère des universités, Comité des travaux historiques et scientifiques (Paris, 1980), 9-11.

[52] Claudius Ptolemy, *Ptolemy's Almagest* (Princeton, 1998).

and the other the heavens. This arrangement had an enormous effect on the intellectual agenda of globemakers, as we will see.[53]

With this textual frame in mind, let us turn to *Geography's* contents. The text comprises eight books, among which three (1, 2, and 7) provide instructions on how to represent terrestrial space in image and object.[54] These are considered to be the theoretical books and, for our purposes here, the most important among them is the first. Comprising twenty-four chapters, this book explains in detail how to project the earth's curved space onto a plane.[55] Ptolemy began it with a distinction that coursed through early-modern geographic thought, the difference between geography and chorography. According to Ptolemy, the former relates to the entire earth, and assumes a position that was inaccessible to humans, while the latter relates to experiences that can be gathered via travel:

> For these reasons, [regional cartography] has no need of mathematical method, but here [in world cartography] this element takes absolute precedence. Thus the first thing that one has to investigate is the earth's shape, size, and position with respect to its surroundings [i.e., the heavens], so that it will be possible to speak of its known part, how large it is and what it is like, and moreover [so that it will be possible to specify] under which parallels of the celestial sphere each of the localities in this [known part] lies.[56]

This is a key distinction within spatial thought, because it limited the value of direct experience.[57] Human beings can report on the information acquired by their senses, but the data they gather are useless, if these are not run through a mathematical filter that is anchored to a larger conception of (unseen) space.

By linking knowledge of the whole earth to the extraterrestrial realm Ptolemy's *Geography* legitimized the terrestrial world as a mathematical counterpart to the stars, with geometry and mathematics providing the homogeneity that lay between. In order to understand the effect that this arrangement had on the Renaissance, one must recall that traditional definitions of the liberal arts had never included geography. Martianus Capella, for instance, counted seven liberal arts: grammar, rhetoric, and dialectic (or, the trivium) and astronomy, geometry, mathematics, and music

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[53] May, "The Geographical Interpretation of Ptolemy in the Renaissance."

[54] J. L. Berggren and Alexander Jones, eds., *Ptolemy's Geography: an annotated translation of the theoretical chapters* (Princeton: Princeton University Press, 2000), Pages, here 57-117.

[55] ibid., 57-93.

[56] ibid., 58.

[57] On the significance of the horizon as an aspect of European thought, see Albrecht Koschorke, *Die Geschichte des Horizonts: Grenze und Grenzüberschreitung in literarischen Landschaftsbildern*, 1. Aufl. ed. (Frankfurt am Main, 1990), 7-10.

(or, the quadrivium).[58] For a culture that had long imbibed Capella, the direct association of heaven and earth was already revolutionary. Ptolemy's work, however, extended the implications of this association by sandwiching the earth between the heavens and a projected center:

> For it has already been mathematically determined that the continuous surface of land and water is (as regards its broad features) spherical and concentric with the celestial sphere [*Almagest* 1.4-5], so that every plane produced through the [common] center makes as its intersections with the aforesaid surfaces [of the terrestrial and celestial spheres] great circles on [the spheres], and angles in [this plane] at the center cut off similar arcs on the [celestial and terrestrial great] circles.[59]

The mixture of idealized space with an image of our planet was legitimized culturally through the allusion to the *Almagest*, which anchored the then-regnant vision of the heavenly sphere. As a result, heaven and earth were thought together in the context of two volumes.

A deeper look into the work reveals more specifically how Ptolemy's understanding of space formed Renaissance global thought. It contained two methods for representing three-dimensional space on a plane, both of which appeared in the final chapter of Book I.[60] The first is a conical projection, in which parallels are represented as concentric arcs and meridians as straight lines, with the viewer assumed to be above the image. This projection works well for spaces north of the equator, with the most significant distortion coming below it, where the meridian lines are, in effect, folded. The second method better represents the earth's curvature. Here both parallels and the meridians are curved, while the viewer is at a greater distance and above the equator. From this perspective the earth's upper hemisphere appears in proportion, but with greater marginal distortion.

Ptolemy's two projections reveal the possibilities inherent within the full application to the cosmos of homogeneity and homocentricity. When Ptolemy moved between his two methods, he put the viewer in an extraterrestrial position without undermining the structure of human knowledge. In the medieval world's fractured, hierarchical realm, in contrast, to leave the earth signified that one was leaving humanity's knowledge-space and entering into the realm of God and the angels.[61] Such an upward journey was possible for medieval thinkers via a conceptual stairwell constructed by reason, but it

[58] David L. Wagner, ed. *The Seven Liberal Arts in the Middle Ages* (Bloomington, IA: Indiana University Press, 1983), Pages; Eastwood, *Ordering the Heavens*; Stephen Gersh and Bert Roest, eds., *Medieval and Renaissance Humanism: Rhetoric, Representation and Reform*, Brill's Studies in Intellectual History (Leiden: Brill, 2003), Pages; Grant, "The Medieval Cosmos."; Colish, *Medieval Foundations of the Western Intellectual Tradition, 400-1400*.

[59] Berggren and Jones, *Ptolemy's Geography*, 31.

[60] Aujac, *Claude Ptolémée*: 165-166.

[61] On knowledge-spaces and science, see David Turnbull, "Cartography and Science in Early Modern Europe: Mapping the Construction of Knowledge Spaces," *Imago Mundi* 48(1996): 5-24.

could not be done with the tools of spatial projection, because the limits on geometry were still in effect. In the thirteenth century, for instance, the Aristotelian thinker St. Thomas Aquinas defined the bounds of human knowledge by beginning with what God and the angels could know; since angels lived "above," a different kind of knowledge necessarily resided with them.[62] Yet, in this homogeneous realm, regardless of how Ptolemy dismantled and reassembled the earth, the human mind never lost contact with either a terrestrial whole or the knowledge that came from the extraterrestrial tour.

The epistemological implications of Ptolemy's spatial thought expose a profound ambiguity at the heart of the Aristotelian-Ptolemaic synthesis.[63] Ptolemy never accepted fractured Aristotelian space, but leaned toward the uniform space of the Stoics. A rival school to the Aristotelians, the Stoics accepted the spherical cosmos, but not the metaphysically defined hierarchy that Aristotle had imposed on it.[64] For the Stoics, in contrast, the cosmos was an organic whole that was permeated by a common substance, the pneuma, and the entire arrangement floated within an infinite vacuum. Stoic cosmology was congenial to Euclid's thought, since heaven and earth formed a unity and, moreover, the infinite vacuum ran parallel to Euclid's endless, idealized realms.[65] Thus, viewed historically, it is no accident that the sixteenth century saw both the rise of paired globes and the resurgence of Stoicism. The Renaissance's global space was, in many ways, a Stoic space—and it should not go unmentioned that a Stoic produced a terrestrial globe in 150 BC. Some vision of a spatial unity was probably a prerequisite for producing a terrestrial globe.

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[62] Stephen Brown, "The Intellectual Context of Later Medieval Philosophy: Universities, Aristotle, Arts, Theology," in John Marenbon, ed., *Medieval Philosophy. Routledge History of Philosophy* (London; New York, 1998), 188-203, here 116-129; John Marenbon, *Later Medieval Philosophy (1150-1350): An Introduction* (London; New York, 1987).

[63] Gautier Dalché, *La Géographie de Ptolémée en Occident (IVe-XVIe siècle)*. On the abiding significance of Stoicism for medieval thought, see C. Stephen Jaeger, "Philosophy, CA. 950-CA. 1050," *Viator* 40, no. 1 (2009): 17-40; Michel Spanneut, *Permanence du Stoïcisme: De Zénon à Malraux* (Gembloux, 1973); Steven K. Strange and Jack Zupko, *Stoicism: Traditions and Transformations* (Cambridge, 2004); Marcia L. Colish, *The Stoic Tradition from Antiquity to the Early Middle Ages*, 2 vols., Studies in the History of Christian Thought (Leiden, 1985); Colish, *Medieval Foundations of the Western Intellectual Tradition, 400-1400*. On Stoicism in the early modern world, see Gerhard Oestreich, *Neostoicism and the Early Modern State*, ed. Brigitta Oestreich and H. G. Koenigsberger (Cambridge, 1982); Anthony Pagden, "Stoicism, Cosmopolitanism, and the Legacy of European Imperialism," *Constellations* 7, no. 1 (2000): 3-22; A. A. Long, "Stoicism in the Philosophical Tradition: Spinoza, Lipsius, Butler," in Brad Inwood, ed., *The Cambridge Companion to the Stoics*. (Cambridge, UK, 2003), 365-392.

[64] On Stoic physics, see Keimpe Algra, "The Early Stoics on the Immobility and Coherence of the Cosmos," *Phronesis* 33, no. 2 (1988): 155-180; Shmuel Sambursky, *Physics of the Stoics* (London, 1959); Alexander Jones, "The Stoics and the Astronomical Sciences," in Brad Inwood, ed., *The Cambridge Companion to the Stoics*. (Cambridge, UK, 2003), 328-344; Michael J. White, "Stoic natural Philosophy (Physics and Cosmology)," in Brad Inwood, ed., *The Cambridge Companion to the Stoics*. (Cambridge, UK, 2003), 124-152; David E. Hahm, *The Origins of Stoic Cosmology* (Columbus, OH, 1977).

[65] There were also medieval precursors to this development. See, Edward Grant, "Medieval and Seventeenth-Century Conceptions of an Infinite Void Space beyond the Cosmos," *Isis* 60, no. 1 (1969): 39-60.

In a Renaissance context the *Geography* put idealized space at humanity's service. We need not delve further into Ptolemy's projections, except to note that Germanus exceeded them through his invention of the "Donis" projection, which yielded a trapezoidal frame, along the borders of which coordinates in latitude and longitude were inscribed.[66] It was not a sophisticated projection, but it did allow cartographers to put any region of the earth into a global context, since the lines assumed that homogeneous space extended beyond (and behind) the image's borders. More significant, however, is how the "Donis" projection highlights the unleashing of the spatial imagination, as cartographers and globemakers who came after Germanus fashioned ever more radical projections. We have no better example of this phenomenon than Gerard Mercator's orange-peel projection, in which the earth's surface is separated from its round ball and is laid flat as a series of lightly attached slices.[67] The terrestrial globe was not a sphere, but was a conceptual veneer produced by the human mind and produced by human hands.

When Renaissance thinkers learned that the world's surface could be peeled, bent, and even rended, they crossed a boundary that had been in place since Charlemagne. Recognizing this moment's significance does not, however, get us to the production of globes themselves. For this final step, we must look to the twenty-second chapter of Book I, where Ptolemy explains how to draw a map onto a sphere:

> Whatever size it may be, we are to take its poles and accurately attach through them a semicircle very slightly separated from the [globe's] surface, so that it only just avoids rubbing against it when it is turned. Let the semicircle be narrow in order not to obstruct many localities; and let one of its edges pass precisely through the points [representing] the poles, so that we can use it to draw the meridians. We divide [this edge] into 180 parts and label them with the [corresponding] numbers, starting from the middle division, which is going to be at the equator. Similarly, we draw the equator and divide one of its semicircles into the same number, 180, of divisions, and inscribe [their] numbers on this [semicircle] too, starting from the endpoint through which we are going to draw the most western meridian.[68]

On the one hand, this paragraph is a practical guide to making a terrestrial globe, the first seen since Rome's dissolution. On the other hand, it is a mental gateway through which homogeneous space passed into Renaissance material culture. By putting a terrestrial globe into the context of an

[67] Turnbull, "Cartography and Science."; Peter van der Krogt, "Gerard Mercator and his Cosmogrpahy: How the *Atlas* became an Atlas," *Archives Internationales d'Histoire des Sciences* 59, no. 163 (2009): 465-483.
[68] Berggren and Jones, *Ptolemy's Geography*, 83-84.

unchanging space Ptolemy justified the pairing of celestial and terrestrial space. Paired globes were only a natural result.

Perhaps the greatest flaw in the contemporary literature on globes is its failure to exploit the many surviving early modern manuals on globes. Known collectively as *De usu globi* ("On the use of globes"), between 1500 and 1850, at least eighty such manuals were published across Europe and North America. The exact number is difficult to establish, since no systematic study has been done and the manuals also bleed into (and out of) other disciplines, such as astronomy, cosmography, and geography.[69] We cannot consider all of the works involved, but must limit ourselves to two volumes that were published as a pair in 1533 under the titles *Celestial Globes* and *Little Work of Geography*.[70] These manuals are critical to the history of global thought. Not only were they among the earliest such works produced, but they were also written by a globemaker mentioned above, Johannes Schöner.

We will begin with Schöner's *Celestial Globes*, because its understanding of celestial space was built with tools fashioned by the medieval world. The techniques Schöner used to project his sphere did not differ significantly from those used in thirteenth-century cosmological works by people such as Johannes Sacrobosco or Robert Grosseteste, both of whom based their cosmology on Aristotle and Ptolemy.[71] Schöner built his globe on a collection of old definitions, opening with spheres in general:

> The sphere we understand as a globe; it is a round, solid body. The ancients, however, who explained better the rotation of the heaven, thus set forth that it was directed and turned around as a wheel on its axle, but a certain distinctive feature of this axle is that it is above and below us, or it lies hidden in each direction. Since the position of the earth is settled so strongly, in this case the highest are called poles.[72]

All the basic concepts that medieval thinkers applied to the heavens are present, including sphere, axis, and pole. Moreover, again without doing anything original, Schöner explained how the lines allow us to organize the zodiacal signs and constellations. If he had not added a second volume, very

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[69] See, for example, Gemma Frisius, *Principiis Astronomiae et Cosmographiae: deque usu Globi ab eodem editi. Item de Orbis divisione, & insulis, rebúsq; nuper inventis. Eiusdem libellus de locorum describendorum ratione. Et de eorum distantiis inveniendi, nunquam antehac visus* (Paris, 1547).

[70] Johannes Schöner, *Globi Stelliferi, Sive Sphaerae Stellarum fixarum usus, & explicationes, quibus quicquid de primo mobili demonstrari solet, id uniuersum prope continetur, Directionum autem ipsarum quas uocant, ratio accuratis, est exposita. Autore Ioanne Schonero Carolostadio, atque haec omnia multò quâm ante emendatiora & copiosiora singulari ac studio in lucem edita fuere Anno Christi M. D. XXXIII* (Norimbergae, 1533); Johannes Schöner, *Opusculum geographicum ex diversorum libris ac cartis summa cura & diligentia collectum, accomodatum ad recenter elaboratum ab eodem globum descriptionis terrenae* (Nürnberg, 1533).

[71] On Sacrobosco, see: Lynn Thorndike, *The Sphere of Sacrobosco and Its Commentators* (Chicago, 1949); Olaf Pedersen, "In Quest of Sacrobosco," *Journal for the History of Astronomy* 16, no. 3 (1985): 175-220, here 9; Woodward, "The Image of the Spherical Earth," 9. On Grosseteste, ibid.; Randles, *The Unmaking*.

[72] Schöner, *Globi Stelliferi*.

little would have separated Schöner's global thought from that of his medieval predecessors.

The second book, the *Little Work of Geography*, lays bare the nature of the Renaissance break with medieval space. Like Ptolemy, Schöner applied to the earth mental tools once thought appropriate only to the heavens. The work is divided into two parts, with the first applying idealized space to the earth's surface and the second describing known regions of our planet. We will discuss only the first part here and will concentrate on its images. Our baseline is Figure 6, which is the second image in the text and displays an armillary sphere with all the accouterments. Like Raphael's "Astronomia," this image presented the reader with pure medieval space, as an earthly blob languishes at the center of the sphere, with a few celestially defined lines drawn in relief across the midsection.

Like Raphael's "School of Athens," the succeeding image in the text reveals what happened when the celestial veil was lifted. (See, Figure 7). In this drawing Schöner scaled back the armillary sphere to a collection of circles, at the center of which rested a detailed image of the terrestrial globe. This globe's location highlights the first step toward the earth's invention, as the surrounding circles bear only the loosest connection to the heavens, with the ecliptic, the zodiac, and any hint of the stars conspicuously absent. This is, moreover, merely a prefatory maneuver, as from a theoretical perspective these lines are completely inadequate to the task of placing images on the terrestrial sphere itself. The conceptual foundation of the final step becomes fully apparent, when we consider the work's first image. Included as Figure 8, it depicts a terrestrial globe that includes all the circles and geographic details from the previous images and has two additional features—a frame and a uniform spatial grid.

The terrestrial globe appeared only after the Renaissance made a conceptual space for it. Schöner folded both heaven and earth into a realm produced by latitudinal and longitudinal lines. He did not invent this way of associating the two realms, of course. Nonetheless, in the early sixteenth century, to put the earth into a generic space remained an inspired act, because it privileged a human perspective on the cosmos. The privileging is rooted in terrestrial longitude. Unlike the equator and its attending horizontal lines, the adscription of any meridian to a sphere is arbitrary, as the up–down orientation of spheres means that an equator is always in a "middle" from which one can measure up or down.[73] A meridian, however, has no *location*, since there is no mid-point between left and right. Instead, any longitudinal line only has a location, in so far as it exists in relation to a prime meridian, whose position is determined by fiat.

[73] Dekker and Krogt, *Globes from the Western World*: 16, 168.

In a terrestrial context, longitude boils down to the problem of where to begin counting. Ptolemy put his prime meridian near the Canary Islands; today, it runs through the middle of the Greenwich Observatory. The arbitrariness of terrestrial longitude stands in contrast, however, to celestial longitude (which is known as right ascension), whose prime meridian is determined by a celestial phenomenon, the vernal equinox.[74] This is one of the two points where the celestial ecliptic and equator cross—the other is the autumnal equinox. (One may use either of the great circles to calculate the celestial equivalent of longitude. Today, only the celestial equator is used.) Unlike on earth, celestial longitude has a starting point that is defined by the regularity of celestial movements. On earth, however, the definition of terrestrial space began with an act of human will. Put another way, by wrapping the earth within a grid whose prime meridian was defined by convention, Schöner joined a revolution that began with Ptolemy's *Geography*.

Considered broadly, the Renaissance rediscovered that the human mind could project global space and in a way that respected its own needs. This discovery's effects effervesced across the continent, entering into art, as we have already seen in the work of Raphael, although one could also add Albrecht Dürer, who knew spatial projection well and applied the latest techniques to his varied oeuvre.[75] In order to establish the sweep of Renaissance global space, however, we will consider an example from someone who was neither a globemaker nor an artist, the German mathematician Peter Apian. A younger contemporary of Schöner, Apian was a professor of mathematics at the University of Ingolstadt, from which point his ideas radiated across the continent in a slew of publications, the most important among which was *Cosmography, or Description of the Universal Orb* (1529).[76]

Apian's work is a prime example of the now-defunct discipline of cosmography, which like globemaking associated heaven and earth within geometric space.[77] The literature on globes has generally not explored the

[74] Ibid., 169.

[75] Thilo Hilpert, *Geometrie der Architekturzeichnung : Einführung in Axonometrie und Perspektive nach Leonardo da Vinci, Gerrit Rietveld, Friedrich Weinbrenner, Albrecht Dürer, Le Corbusier, El Lissitzky* (Braunschweig, 1988); Erwin Panofsky, *Albrecht Dürer*, Third ed. (London, 1948); Jeffrey Chipps Smith and Archer M. Huntington Art Gallery., *New perspectives on the art of Renaissance Nuremberg : five essays* (Austin, 1985).

[76] Petrus Apian, *Libro dela Cosmographia de Pedro Apiano, el qual trata la descripcion del Mundo, y sus partes, por muy claro y lindo artificio, aumentado por el doctissimo varon Gemma Frisio, doctor en Medecina, y Mathematico excellentissimo: con otros dos libros del dicho Gemma, de la materia mesma. Agora nueuamente traduzidos en Romance Castellano* (Basle, 1548).

[77] On cosmography, see Adam Mosley, "The Cosmographer's Role in the Sixteenth Century: A Preliminary Study," *Archives Internationales d'Histoire des Sciences* 59, no. 163 (2009): 423-439. Frédéric Tinguely, "Le Vertige Cosmographique à la Renaissance," *Archives Internationales d'Histoire des Sciences* 59, no. 163 (2009): 441-450. On the connection between cosmography and globes, see Lesley B. Cormack, "The World at Your Fingertips: English Renaissance Globes as Cosmographical, Mathematical and Pedagogical Instruments," *Archives Internationales d'Histoire*

connections between cosmography and globemaking, but these disciplines should be studied together, since they share common intellectual underpinnings. Centered initially on the German-speaking universities of Central Europe, cosmography rose to prominence in the course of the sixteenth century, as leadership passed to the Netherlands and France. The discipline rapidly lost influence, however, after 1600 in the face of natural philosophy's rise—a phenomenon that we call the Scientific Revolution—and by 1650 it was moribund.

We will concentrate on one image from Apian that not only epitomizes the new global space but also calls attention to some broader implications of its rise. Reproduced in Figure 9, it is the first image in the body of the work.[78] The image clearly projects a generic spatial realm in which appear four items that are not inherently related to each other, a celestial sphere, a terrestrial sphere, a terrestrial globe and a disembodied eye. We will begin with Apian's eye. It has neither a location nor a body, but sees the celestial and terrestrial spheres within a generic space that it, in turn, helps to define.[79] Although the two spheres are not equal in size, they are presented in a non-hierarchical manner, with the eye determining the relationship between the two. Meanwhile, the terrestrial globe to the right closes a Renaissance-era hermeneutic circle. Not only does the terrestrial sphere rest within a frame, but its surface also boasts a network of lines that we saw in previous images, including latitude and longitude. Finally, both the celestial sphere and the terrestrial globe are inscribed with the same longitudinal lines, thus effecting a unity. Heaven and earth float within a uniform space—and Apian's eye sees it all.

This image illustrates the totalizing result of the Renaissance's embrace of homogeneity and homocentricity. Heaven and earth appeared together, without a hierarchy, and within a generic space. If we return to the celestial sphere with this context in mind, another detail indicates a final shift. Among the signs that are depicted on the ecliptic is Pisces, which is the last of the twelve signs, and is located to the left of the squiggly lines that represent Aquarius, which is the eleventh sign. In order for this globe to represent the zodiacal progression correctly, it must move from left to right, which is how the human eye perceives the motion of the heavens. This is, in short, and inside-out celestial globe and its left-to-right motion is, thus, the reverse of what the armillary sphere depicted in figure 3 assumed, given that the latter has Pisces to the right of Aquarius.

des Sciences 59, no. 163 (2009): 485-497; Johnson, *The German Discovery of the World*; Frank Lestringant, *L'atelier du cosmographe: ou l'image du monde à la Renaissance*, Bibliothèque de Synthèse (Paris, 1991).

[78] Petrus Apian, *Cosmographiae Introductio: Cum quibusdam Gaeometriae ac Astronomiae principiis ad eam rem necessariis* (Ingolstadt, 1529).

[79] The argument here has been influenced heavily by Hans Blumenberg, *The Genesis of the Copernican World*, trans. Robert M. Wallace (Cambridge, 1987), 37-47.

The Renaissance shift in global space, ultimately, reversed the heavens in the name of Renaissance "Man's" convenience. It is not clear when celestial globes in general shifted to an inside-out perspective, although it seems to have occurred in the course of the sixteenth century.[80] We do not know what perspective Germanus' celestial globe presented, since the entire pair was lost in the sack of Rome in 1527, but both the Dorn and Stöffler spheres mentioned above were outside-in, which suggests that Germanus' was no different.[81] The significance of this second shift to inside-out space lies in the break it made with much of classical culture. The outside-in method dated back to Hipparchus and was, in turn, accepted by Ptolemy, who distributed it to the medieval world through his *Almagest*. That heaven and earth were, now, at humanity's disposal was the ultimate end of homogeneity and homocentricity.

Although early modern globemakers still produced outside in celestial globes, inside out versions became ever more prominent, especially within globe pairs. And the association of an inverted heaven with a terrestrial globe remained a prominent practice among globemakers until the entire Renaissance approach to space dissolved in the nineteenth century. Apian's image highlights, therefore, how spatial thought continued to evolved after the earth's invention, as homogeneity and homocentricity now impelled the Renaissance mind up to the heavens, from which point Ptolemy's legacy garnered a reappraisal. It is worth highlighting, here, that the shift to inside-out celestial globes never occurred in the early modern Muslim world, as its globemakers made outside-in celestial globes into the nineteenth century—by which point the western world was already cast pairing aside.[82] In Renaissance hands global space had become a whole that was altogether foreign to this sophisticated heir of Rome.

[80] Dekker and Krogt, *Globes from the Western World*; Elly Dekker, "Conspicuous Features on Sixteenth Century Celestial Globes," *Der Globusfreund: Wissenschaftliche Zeitschrift für Globenkunde* 43/44(1995): 77-97; Dekker, *Illustrating the Phaenomena Celestial Cartography in Antiquity and the Middle Ages*.

[81] Babicz, "Celestial and Terrestrial Globes of the Vatican Library."

[82] Emilie Savage-Smith and Andrea P. A. Belloli, *Islamicate Celestial Globes, their History, Construction, and Use* (Washington, DC, 1985), 56-60.

Conclusions

Inventing the earth was a subversive act. Supremely comfortable within its sense of global space, the contemporary literature frames the history of globes in essentially progressive terms and has, for that reason overlooked the implications that Renaissance global space had for previous beliefs and traditions. To see subsequent iterations of globes as evidence of progress is to miss, however, the true significance of the earth's invention. Early globes were not halting steps on the path to a "correct" image of the earth, but constituted challenges to assumptions about what could be known and who should do the knowing.

Writ large, Renaissance global thought established a human claim to its own perspective on the cosmos. Humanity no longer raised its mind to God's perspective, but tried actively to replace it. In this respect Apian's eye encapsulates the Renaissance's grandest act of self-fashioning, as every globe pair assumed both a homogeneous space and a human viewer who dominated it.[83] This was heady stuff and it caused some disquiet, much of which has gone unnoticed. The epigram above, taken from "A Valediction of Weeping" by John Donne, is particularly illustrative, especially in its observation that an artisan can "quickly make that, which was nothing, All." Donne's words harbor two criticisms. First, the production of globes had social implications, as the earth could not be fashioned by mere artisans. Second, global space had broader epistemological and theological implications, because the artisan dared to create a world *ex nihilo*—or with a wooden ball, printed globe gores, and some glue. Even more profoundly, all projections of global space began with a geometric tradition that was literally based on nothing, as every edition of Euclid's *Elements* begins with the phrase, "A point is that which has no part."[84]

When Renaissance globemakers applied idealized space to the terrestrial realm, they built a world on top of nothing. One can see why Donne was discomfited—and "Valediction of Weeping" was not his first expression of irritation. In 1611, in "An Anatomy of the World" he lamented:

> We seem ambitious, God's whole work t'undo;
> Of nothing he made us, and we strive too,
> To bring our selves to nothing back; and we
> Do what we can, to do't so soon as he.

[83] Stephen Greenblatt, *Renaissance Self-Fashioning: from More to Shakespeare* (Chicago, 1980).
[84] Euclid, *Euclid's Elements: All Thirteen Books Complete in One Volume*, trans. Thomas L. Heath (Santa Fe, NM, 2002), 1.

And he added, in famous lines:

> T'is all in peeces, all cohaerence gone;
> All just supply, and all Relation:
> Prince, Subject, Father, Son, are things forgot,
> For every man alone thinkes he hath got
> To be a Phoenix, and that then can bee
> None of that kind, of which he is, but hee.[85]

When read with respect to the history of globes, Donne's lament suggests that, far from being a cause for celebration, global space's internal coherence was itself unsettling.

Donne was not alone in expressing doubts either. Around 1590 in Antwerp an anonymous Flemish artist engraved a world map inside a fool's cap. (Figure 10). Covered in deprecatory nostrums from the Bible and the classics, the image implied that humanity should not be quite so proud of the space that it had constructed—nor of itself, for that matter. Moreover, this image was copied from a French version that dated to 1575 (and there may have been an even older one) which pushes the doubts not only back in time but also into another linguistic realm.[86] Just as global space was a continental phenomenon, so too, were the doubts about it.

Renaissance global space disappeared in the second half of the seventeenth century, along with worries that it had once inspired. The long-standing alliance between homocentricity and homogeneity dissolved in the face of two powerful new currents. One was heliocentrism, which traces its origins to the publication in 1543 of Nicolaus Copernicus' *On the Revolutions of the Heavenly Spheres*.[87] By the beginning of the seventeenth century a cadre of thinkers had embraced Copernicus' doctrines and was diffusing them actively. As the new heliocentrism rose in prominence, both the earth and the homocentricity that had undergirded it were ushered from the center of the cosmos' stage. The consequences for Renaissance space were severe, because heliocentrism assumed that the mind had to break free of terrestrial experience in order to understand the truth, rather than to unite heaven and earth under one rubric.[88] The other development was the growing acceptance of the infinite universe. A phenomenon of the late seventeenth century, by the middle of the eighteenth century, few educated people would have

[85] Charles M. Coffin, ed. *The Complete Poetry and Selected Prose of John Donne* (New York: The Modern Library, 2001), Pages, here 192.

[86] Anne S. Chapple, "Robert Burton's Geography of Melancholy," *Studies in English Literature, 1500-1900* 33, no. 1 (1993): 99-130; Rodney W. Shirley, *The Mapping of the World: Early Printed World Maps, 1472-1700*, Holland Press cartographica (London, 1983); ibid.

[87] Nicolaus Copernicus, *De revolutionibus orbium coelestium, libri vi* (Norimbergae, 1543).

[88] Blumenberg, *Genesis*: 45-47.

disputed it.[89] The acceptance of unbounded space obliterated the celestial sphere's remaining epistemological warrants and drained pairing, in turn, of any larger meaning.

The homogeneity of Renaissance global space lived on, but in a changed cultural context. After 1650, globes no longer represented a larger truth, but had become pedagogical tools. This is apparent in the *De usu globi* of the later seventeenth- and eighteenth centuries, which went to great lengths to explain that paired globes represent the structure of the cosmos *as it appears to the eye*, rather than as it truly is. Apian's eye had been demoted. The writers of these manuals usually went on to note, that paired globes remained useful, nonetheless, but only as a means for preparing students to manipulate the more complicated and difficult concepts of natural philosophy.[90] As had already happened once before, a new approach to space flowed around an old one, rendering its predecessor inert through a totalizing embrace.

The production of globe pairs survived for two centuries more, but dissolved by the middle of the nineteenth century. Globes of both kinds are made to this day, but globe pairs no longer occupy the industry's pinnacle. This is because the nineteenth century wrought fundamental changes in how people experienced space. The rise of rapid travel through the railway journey and the industrialization of daily life sparked broader transformations in how art and culture portrayed space, making it discontinuous and less reliable.[91] At a deeper level, the late nineteenth century also robbed paired globes of their most important underpinning, Euclidian space. In the first half of the nineteenth century, doubts about the foundations of Euclidian geometry began to emerge, sparking a critical process that culminated in 1854 with Bernhard Riemann's completion of the first non-Euclidian system.[92] Space could now be projected into higher dimensions, which no eye could actually see. When the cutting edge of geometric thought took leave of Euclid, his *Elements* also dropped to the status of pedagogical tool, and globe pairing became not so much wrong as irrelevant.

Although we can appreciate the beauty of globe pairs, we live in a space so different from that of Johannes Schöner and other globemakers that our earth needs no celestial companion. A round ball, tinted blue is quite enough. In the modern world our terrestrial space exists independently of a once-

[89] Alexandre Koyré, *From the Closed World to the Infinite Universe* (New York, 1957); Randles, *The Unmaking*; Seyyed Hossein Nasr, *Religion & the Order of Nature* (New York, 1994).

[90] See, for example, Johann Wolfgang Müller, *Anweisung zur Kenntnis und dem Gebrauch der künstlichen Himmels- und Erdkugeln besonders in Rücksicht auf die neuesten nürnberger Globen, für die höhern Classen der Schulen und Liebhaber der Sphaerologie*, 2 vols., vol. 1 (Nuremberg, 1791), 7-35.

[91] Wolfgang Schivelbusch, *The Railway Journey: the Industrialization of Time and Space in the 19th century* (Berkeley, Calif., 1986); Stephen Kern, *The Culture of Time and Space, 1880-1918* (Cambridge, MA, 2003).

[92] Howard Whitley Eves, *An Introduction to the History of Mathematics*, 5th ed. (Philadelphia, PA, 1983); Morris Kline, *Mathematical Thought from Ancient to Modern Times*, 3 vols. (New York, 1990); Carl B. Boyer and Uta C. Merzbach, *A History of Mathematics*, 2nd ed. (New York, 1991).

essential celestial backdrop—and this not only highlights an enormous historical change but also offers an opportunity to rethink the contemporary literature's foundations. The current fascination with whether our global predecessors got the earth "right" has overshadowed how, with the demise of paired globes and their accompanying space, the Renaissance's earth has ceased to exist. We understand Renaissance globes when we see them, but actually live on "spaceship" earth rather than within the uniformity that the Renaissance injected into the gap between heaven and earth.

From their beginnings in the classical world, globes have incorporated the totality of each age's spatial thought. In the course of this essay we have seen three consecutive totalities: heaven alone, heaven and earth joined, and heaven and earth separated. Against this backdrop, establishing whether an early-modern globe got the Americas right is less significant than recognizing that the space in which all early modern globes existed is no longer supported by our contemporary age. When the era of paired globes ended, our planet disappeared and had to be quietly reinvented.

Anexos

Figure 1: Raphael, “The School of Athens,” (1510)
(Removed image due to copyright)

Figure 2: Raphael, “The School of Athens” (detail)
(Removed image due to copyright)

Figure 3: Regiomontanus, Epytoma in almagestum ptolemaei (1496)
(Removed image due to copyright)

Figure 4: Raphael, “Astronomia” (1510)
(Removed image due to copyright)

Figure 6: Schöner, Little Work of Geography (1533)
(Removed image due to copyright)

Figure 7: Schöner, Little Work of Geography (1533)
(Removed image due to copyright)

Figure 8: Schöner, Little Work of Geography (1533)
(Removed image due to copyright)

Figure 9: Apian, Cosmography, or Description of the Universal Orb (1524)
(Removed image due to copyright)

Figure 10: “Fool’s Cap World Map” (ca. 1590)
(Removed image due to copyright)

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