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INSTITUTE OF CARTOGRAPHY AND GEOINFORMATICS

# **Analysis and comparison of maps made in the 18<sup>th</sup> century of the Amazon River**

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**Topic of the Thesis:**

*(Upon consulting with your supervisor, give a 150-300-word-long synopsis of your planned thesis. )*

During the 18th century, South America was in colonial times under the rule of European powers like Spain and Portugal. The vast territory had not been fully explored, and without a doubt the Amazon rainforest and the Amazon river were an extensive area that served as a boundary between the two great colonial territories.

The first explorations to this territory were carried out by religious orders to evangelize the natives and turn them into believers of the Catholic Church. With the explorations, the missionaries, who had higher education, could sketch and draw the first maps of the region.

The study will identify a group of maps belonging to the 18th century, after that the analysis will focus on the following aspects:

- General background of the person who made it (biography, studies, activities carried out in America),
- Brief historical description of the time in which the map was developed,
- ¿How was the map developed? ¿How many years did it take to do?,
- Description of the accuracy, symbology, projection, toponomy, among others,

The practical part of the study will consist of the georeferencing, digitization and creation of the geodatabase of each identified map. With the processed information, a comparison will be made at graphic and content level between the different maps and the actual state of the region. This process will be carried out mainly using the MapAnalyst software, which provides the possibility to analyze data against a current reference map.

The conclusions will be formulated according of the results and the comparison between the maps.

Budapest, 2020.12.01.

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## ABSTRACT

The main obstacle to the conquest and colonization of America by European powers was the scarce knowledge of the territory and the hostility of indigenous ethnic groups to its presence. Over the years, remarkable characters played the role of explorers and applying empirical methods began the survey of the territory, using the data collected the first maps were delineated. Nearly two centuries passed and maps with the Amazon River and its hydrographic basin as the central element began to be produced by religious and scientific personalities, the purposes were totally different, but the expected result was a reliable representation of the area. Through the use of geographic information system programs and specialized software in map comparison, a temporal and comparative analysis of five old maps published in the eighteenth century was carried out, with which in a graphical way the reader can visualize the updates of the mapped geographic elements and the accuracy of the work. Likewise, the selected area was digitalized and the basic cartography of each map with its respective database was created.

**Key words:** Amazon River, old maps, eighteenth century, GIS.

## INTRODUCTION

### 1.1. HISTORICAL BACKGROUND

By the arrival of Christopher Columbus to America in 1492, the conquest and colonization of the continent began which lasted about three hundred years. America was invaded and incorporated into the Spanish Empire, except for Brazil, British America, and some small regions in South America and the Caribbean. Civil and religious structures were created to administer this vast territory, the '*mission system*' was implemented in the Spanish colonies as a community that grouped a certain amount of indigenous population in it. This system facilitated the expansion of the empire through religious conversions and pacification of the natives, being evident that the main motivation was the obtaining of profits across minerals resource extraction.

Expeditions were planned with the objective of discovering the territories towards the interior of South America, guided by stories of vast empires with incalculable riches in gold or spices (cinnamon). However, these were not successful in finding such riches, but gave way to discover the Amazon River in 1542 by Francisco de Orellana. Since that episode, a slow process began due to the hostility of the indigenous population, which led to the exploration and colonization of this region. With the beginning of the seventeenth century, the Amazon River was the target of commercial investments by the Spanish, Portuguese, English, Dutch, and French, all of whom perceived it as an important route to the interior. It was decisive to gain territorial control, since navigating the river had three main objectives: to cross from one side of the continent to the other, to exploit the natural resources, and to be the first in contacted indigenous tribes (Dias, 2012).

A Portuguese expedition to highlight was carried out by captain Pedro Teixeira from Grão Pará (now called Belém), at the mouth of the Amazon River, towards to the interior of the continent by river arriving to Quito in 1638. The journey did not generate an armed conflict between the two colonial empires, however, the Spanish authorities sent Father Cristobal Acuña as their emissary on the way back, he was commissioned to accompany them to their starting point and prepare an official report. Some decades later, a map was published by the French cartographer Nicolas Sansón D'Abbeville in 1680, based on the book notes and observations of Father Acuña. Undoubtedly, the expedition of captain Pedro Teixeira began a more intense period to know the territory in detail, the two colonial empires understood that it was necessary



to establish more exact physical limits between their domains than those determined by the Treaty of Tordesillas (1494).

During the beginning of the eighteenth century, a period of greater production of maps began focused on the Amazon River basin, due to the presence of religious orders with excellent knowledge in geography and cartography, and who were the main explorers that documented their surveys. In the subsequent decades, the scientific interest increased and notable figures such as Charles-Marie de la Condamine explored the area as well.

This study seeks to learn more about South American colonial history and how the topic of cartography was approached in its most practical form during the first half of the eighteenth century, a time when the technology used was scarce, so explorers carried out astronomical measurements in order to determine their geographical position. Thus, a search for the most representative maps with a good detail regarding the geographic information of the region will be carried out. With those selected maps, a comparative and temporal analysis will be generated through the use of Geographic Information System software. In addition, a virtual environment will be generated to provide greater rigor in the research, as well as to preserve the information in digital form and facilitate its greater dissemination.

## 1.2. JUSTIFICATION

Multiple arguments could be established to justify the development of this study, approaching the topic from different points of view. However, in relation to the scientific area to which this Master belongs, I must highlight the historical and geographical aspects that motivates me to work in this topic.

The historical aspect is closely related to the stories and chronicles of explorations carried out by mainly religious or scientific characters throughout the eighteenth century along the Amazon River course. These explorations originated due to the power struggles between the two imperial powers to set limits on their domains. This fact started the boom in the creation of maps that emphasized the importance of this disputed area.

At this point, the geographical aspect is introduced since it was necessary for the geographers and cartographers of that time to have a constant source of information to prepare their maps. In fact, the sources were found in books, diaries, or reports that explorers wrote to record events throughout their journeys. It should be noted that there were cases in which the explorer had knowledge in geography or cartography, so he prepared his own maps as was the case of the Jesuit father Samuel Fritz.

Therefore, the relationship between the historical and geographical aspects is evident, being important and beneficial to understand and learn about the change in the cartographic representation of the study area, through the different old maps generated by several authors during the eighteenth century. Thus, a timeline will be established that allows the reader to graphically view the updates of the mapped geographic elements and be able to appreciate the accuracy of the work done three hundred years ago.

### 1.3. MAIN OBJECTIVE

Perform a temporal analysis and comparison of the Amazon River maps prepared throughout the eighteenth-century using Geographic Information System software (QGIS Desktop 3.10.11).

### 1.4. STUDY AREA

The Amazon basin is the part of South America drained by the Amazon River and around ten thousand watercourses with fifteen main tributaries, an extensive water network that flows into the so-called longest and mightiest river in the world. Its extension is greater than 7.000 square kilometers and has 20 million kilometers of navigable waterways.

The total set of the basin and the Amazon rainforest occupies seven percent of the planet's surface and a third part of South America, covering the territories of eight countries (in order according to the percentage occupied): Brazil, Peru, Bolivia, Ecuador, Colombia, Venezuela, Guyana, and Suriname (Figure 1).



**Figure 1.** Location of the Amazon River basin (FAO/USDA).

Certainly, a large study area so it will be limited according to the following geographical points:

- North: Quito, capital of Ecuador.
- South: Lima, capital of Peru.
- East: Mouth of the Amazon River.
- West: Pacific Ocean coastline.

## THEORETICAL FRAMEWORK

### 2.1. CONCEPT OF HISTORICAL MAP

Below there are three definitions of the word *'map'*, presenting a simple and concise concept of it:

- *"A representation or abstraction of geographical reality: a tool for presenting geographical information in a way that is visual, digital, or tactile"* (Board, 1990).
- *"A map is a symbolized representation of geographic reality, representing selected features or characteristics, resulting from the creative effort of its author's execution of choices, and is designed for use when spatial relationships are of primary relevance"* (ICA, 2003).
- *"Graphic representation, drawn to scale and usually on a flat surface, of features - for example, geographical, geological, or geopolitical - of an area of the Earth or of any other celestial body"* (Fuechsel, 2019).

The scientific definition of a map involves research and work to directly convey its meaning, not being a surprise that a historical overview records 321 definitions of it (Andrews, 1996). For the present study, it is not intended to create a debate about which concept is more accurate, it is simply considered to establish that a map represents a particular territory, in a specific time, and its final objective is to make it known to the public.

The definition of the word *'historical'* can be taken from a simple dictionary, which means *"based on people or events of the past"*. In the strictest sense, all maps are historical because history encompasses events of even an instant ago (Post, 1981). In addition, an aid to facilitate the assimilation is to divide the past time, generally into periods, whether these are arbitrary or not. (e.g., pre-1700 maps, nineteenth century maps, among others).

### 2.2. EARLY REPRESENTATIONS OF THE CONTINENT FOCUS ON SOUTH AMERICA

From the first expedition of Christopher Columbus to the Antilles in 1492, the elaboration of schemes or sketches of the new continent began, necessary to guide and organize the conquest activity (Vega, 2010). At the beginning, this activity produces fragmented

information of the territory, among others causes, because European exploration was slow, and the extension or characteristics of the region were also unknown.

In the search to dispel the scarce knowledge of the territory, an attempt was made to fill these empty gaps with images; in this process, the reference to the rivers was central since they allowed the construction of projections of the unknown continental interior, based on the association between mountains and water courses. The certainty that the mountains are the origin of rivers is a geographical opinion shared by classical authors and already widespread in medieval Christian thought (Vega, 2010).

This mountain-river link influences the preconfiguration of the continental interior, so that before the first exploration to the west was carried out, the unknown territory was imagined from the edge or limit constituted by the Atlantic coast of the continent. With this antecedent, either through the observation, assumption, or interpretation of indigenous informants, the first cartographic works were conceived that focus their attention on the new continent (Vega, 2010).

With this approach, three early works of the new continent are highlighted below, which are related to the first news about the new continent and the Amazon River.

### 2.2.1. *“Universalis cosmographia secundum Ptholomaei traditionem et Americi Vespuccii alioru[m]que lustrationes”<sup>1</sup>.*

The world map was made under the direction of the German geographer Martin Waldseemüller at the Vosgense Gymnasium and printed in Saint-Dié, France in 1507 (Figure 2). It consists of twelve sections printed from woodcuts that represented the whole terrestrial globe, a modification of Ptolemy’s conical projection was used, in which the meridians are curved lines, and the parallels form concentric lines.

At the top of the map there is a miniature map inset, on its sides are the portraits of Ptolemy and Amerigo Vespucci. The new continent is visualized fragmented in two pieces of land, although clearly separated from Asia, and extending from north to south. The approximate eastern profile was presented with numerous rivers that flow into the sea. The lack of knowledge in relation to the western coastal profile was solved by means of almost rectilinear lines, in the interior of the continent an irregular mountain chain and the legend *‘Terra Vltra Incognita’* are displayed (Vega, 2010).

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<sup>1</sup> Waldseemüller, M. (1470-1519). (1507). *“Universalis cosmographia secundum Ptholomaei traditionem et Americi Vespuccii aliorumque lustrationes”*. Strasbourg, France. Library of Congress, Geography and Map Division (<https://lccn.loc.gov/2003626426>).



**Figure 2.** “*Universalis cosmographia secundum Ptholomaei traditionem et Americi Vespucii aliorumque lustrationes*” (Waldseemüller, 1507).

The form of representation of the new continent in the map inset in which it is drawn as a single body joined by an isthmus differs from the main map representation, also another ocean is displayed in the western part of the continent unknown at that time (Pacific Ocean). It is considered the first map that called ‘*America*’ to the new continent in homage to the explorations made by Amerigo Vespucci.

### 2.2.2. “*Mappemonde (title)*”<sup>2</sup>.

The Italian cartographer and experienced senior pilot of the Trade House of the Indies, Sebastian Cabot, published a world map in Antwerp dated 1544 (Figure 3), two years after the discovery of the Amazon River by Francisco de Orellana in 1542. The map consists of eight sections and it was engraved on copper.

The winding path of the Amazon River was outlined, which comes from the Atlantic coast towards the interior of the continent, where a small mountain serves as the starting point, indicating its Andean origin. The author drew a mountain range that runs from north to south, parallel to the Pacific coast and that extends to the Strait of Magellan, as well as a semicircle of eastern mountains associated with the River Plate (Vega, 2010). It is known that a second edition of the map, dated London, 1549, circulated in England as the handiwork of Cabot during his last stay in that country.

<sup>2</sup> Cabot, S. (1476-1557). (1544). “*Mappemonde (title)*”. Antwerp, Belgium. National Library of France, GE AA-582 (RES) (<http://catalogue.bnf.fr/ark:/12148/cb406117137>).



Source gallica.bnf.fr / Bibliothèque nationale de France

**Figure 3.** “Mappemonde (title)” (Cabot, 1544).

### 2.2.3. “Atlas nautique portugais”<sup>3</sup>.

Atlas prepared by Diogo Homem (Figure 4), member of a Portuguese family of cartographers, whose skills and knowledge were widely recognized, he developed his profession in Lisbon, London, and Venice. This work was carried out from the beginning of 1554 to the end of 1558, the twelve maps and tables were drawn on a double page.



Source gallica.bnf.fr / Bibliothèque nationale de France

**Figure 4.** “Atlas nautique portugais” (Homem, 1558).

<sup>3</sup> Homem, D. (1520?-1576). (1558). “Atlas nautique portugais”. National Library of France, GE C-5086 (1-8 RES) (<http://catalogue.bnf.fr/ark:/12148/cb40611727x>).

This medieval atlas is considered as a collection of portolan charts, a cartographic aid that, together with other nautical instruments such as a compass, became authentic tools that allowed sailors to move with certain confidence along coasts.

In reference to the discovery of the new continent, more than sixty years passed when this atlas was published, showing a wide number of coastal details. The important fact is the appearance of place names such as: *Mundus Novus* (New World), *Quarta orbis pars* (Fourth Continent), America, Peru, *Tera argentea* (Argentina), *Tera incognita y Mare aque dulcis* (first denomination to the Amazon River).

### 2.3. EIGHTEENTH CENTURY MAPS OF THE AMAZON RIVER

The extensive hydrographic network of this basin offered Europeans the means for their penetration and subsequent colonization. There were two fronts, from the west to the east, the Spanish descended by rivers Napo and Marañón; another '*port*' of incursion into this region was Cartagena city, through the Magdalena River, they could reach Peru or Santa Fé de Bogota, and then move to the Orinoco River. On the other hand, from the east to the west, the Portuguese reached the interior by the Amazon, Mamoré or Madeira rivers (Barcelos, 2006).

During the seventeenth century, cartography had become an important activity for the European kingdoms particularly that relating to colonial territories. The relevance attributed to such maps meant that they were often considered state secrets, although on other occasions they were allowed to be copied, translated, and published in collections (Torres, 2012). Three events marked the beginning of this intense period in the region, which are:

- Two Franciscan missionaries, Domingo de Brieva and Andrés de Toledo, after surviving an attack on the upper Napo, went down this river following a similar route to that of Francisco de Orellana, reaching Grão Pará in February 1637.
- The Portuguese organized an upstream expedition with fourty five canoes, seventy soldiers and nine hundred natives that began in October 1637 and arrived in Quito in June 1638, whose captain was Pedro Teixeira.
- On the return journey, the Spanish authorities sent Father Cristobal de Acuña as their emissary, he was commissioned to accompany the Portuguese group to Grão Pará; then he traveled to Spain and reported all the details of this episode directly to the King of Spain (Philip IV).



In addition, the separation between the Spanish and Portuguese crown in 1640 and its subsequent armed conflict, increased the growing interest and generated greater support for the actions of presence in the Amazon River and its tributaries. One of the main colonial agents were the religious orders, especially the Jesuits who are considered among the first explorers of the region, establishing the so-called '*missions*' that facilitated the expansion of the borders and conversion of the indigenous population to Christianity (Barcelos, 2006).

With this approach, nine eighteenth-century maps that focus on the study area are listed below, classified according to the depicted area (Table 1). A concise outline of the region maps is described in relation to the author and his cartographic work.

### 2.3.1. Guillaume De L'Isle

Guillaume De L'Isle, (born Feb. 28, 1675, Paris, France - died Jan. 25, 1726, Paris, France), was a French cartographer. He studied under the guidance of the astronomer Jean-Dominique Cassini and was admitted into the French Academy of Sciences in 1702. In 1718 he gained a full membership of this institution and was appointed chief royal geographer, so he had access to news of the latest discoveries and issued several maps particularly of France's colonial possessions in America.

By applying his knowledge of astronomy, science, mathematics, and cartography to the vast amount of information that he had access, he created the technique as '*scientific cartography*', essentially an extension of Sanson's '*positive geography*'. This approach improved the accuracy of the continental outlines, in addition his method reduced the error in determining lines of longitude, and it was a considerable improvement over earlier maps.

In 1703 he published a map of the northern part of South America (Figure 5), the map renders the region in extraordinary detail offering both topographical and political information with forest and mountains beautifully rendered in profile. This map, like most early maps, contrasts a detailed mapping of the coast with a speculative discussion of the interior, particularly the Amazon Basin. He credits the mappings and explorations for Antonio de Herrera, Joannes de Laet, Cristobal de Acuña and Manuel Rodriguez.

**Table 1.** Maps published in the eighteenth century.

DEPICTED AREA	
Region map	Continent map
Carte de la Terre Ferme du Perou, du Bresil et du pays des Amazones: Dressée sur les Descriptions de Herrera, de Laet, et des PP. d'Acuna, et M. Rodriguez et sur plusieurs Relations et Observations posterieures (1703) <sup>4</sup> .	L'Amerique meridionale, dressée sur les observations de Mrs. de l'Academie Royale des Sciences & quelques autres, & sur les memoires les plus recens (1708) <sup>5</sup> .
El Gran Río Marañón, o Amazonas con la Misión de la Compañía de Jesús geográficamente delineado por el P. Samuel Fritz misionero continuo en este Río (1707) <sup>6</sup> .	Amerique meridionale qui fait l'autre partie des Indes Occidentales (1711) <sup>7</sup> .
Carte du cours du Maragnon ou de la grande route des Amazones, La Condamine e D'Anville (1745) <sup>8</sup> .	Amérique Méridionale publiée sous les auspices de Monseigneur le Duc d' Orleans Premier Prince du Sang / par le Sr. d'Anville (1748) <sup>9</sup> .
A new and accurate map of Peru and the country of the Amazones drawn from the most authentic French Maps e C. and regulated by astronomical observation (1747) <sup>10</sup> .	South America from the latest discoveries shewing the Spanish & Portuguese Settlements according to Mr. D'Anville (1771) <sup>11</sup> .
Provincia Quitensis Societatis Iesu in America Topographice exhibita (1751) <sup>12</sup> .	

<sup>4</sup> L'Isle, G. (1675-1726). (1703). "*Carte de la Terre Ferme du Perou, du Bresil et du pays des Amazones: Dressée sur les Descriptions de Herrera de Laet, et des PP. d'Acuna, et M. Rodriguez et sur plusieurs Relations et Observations posterieures*". Paris, France. National Library of Brasil ([http://acervo.bn.digital.bn.br/sophia/index.asp?codigo\\_sophia=60674](http://acervo.bn.digital.bn.br/sophia/index.asp?codigo_sophia=60674)).

<sup>5</sup> L'Isle, G. (1675-1726), and Nicholas Guérard. (1708). "*L'Amerique meridionale, dressée sur les observations de Mrs. de l'Academie Royale des Sciences & quelques autres, & sur les memoires les plus recens*". [Paris, France] Library of Congress (<https://www.loc.gov/item/gm71005435>).

<sup>6</sup> Fritz, S. (1656-1725). (1707). "*El gran rio Marañón, o Amazonas, con la mission de la Compañía de Jesus geograficamente delineado / por el P.Samuel Fritz, misionero continuo en este rio*". Quito, Ecuador. National Library of France, GED 7855 (<http://catalogue.bnf.fr/ark:/12148/cb40595397f>).

<sup>7</sup> Ménard, A. (1711). "*Amerique meridionale qui fait l'autre partie des Indes Occidentales*". Paris, France. National Library of France, EST-1504 (<http://catalogue.bnf.fr/ark:/12148/cb45038740w>).

<sup>8</sup> La Condamine, C. (1701-1774). (1743-1744). "*Carte du cours du Maragnon ou de la grande route des Amazones*". National Library of France, GE DD-2987 (9542) (<http://catalogue.bnf.fr/ark:/12148/cb40622019t>).

<sup>9</sup> Anville, J. B. (1697-1782). (1748). "*Amérique Méridionale publiée sous les auspices de Monseigneur le Duc d' Orleans Premier Prince du Sang / par le Sr. d'Anville*". [Paris, France]. National Library of France, GE DD-2987 (9168 B) (<http://catalogue.bnf.fr/ark:/12148/cb40595776k>).

<sup>10</sup> Bowen, E. (1694-1767). (1747). "*A new and accurate map of Peru and the country of the Amazones drawn from the most authentic French Maps e C. and regulated by astronomical observation*". National Library of Brasil ([http://acervo.bn.digital.bn.br/sophia/index.asp?codigo\\_sophia=198](http://acervo.bn.digital.bn.br/sophia/index.asp?codigo_sophia=198)).

<sup>11</sup> Delarochette, L. (1731-1802). (1771). "*South America from the latest discoveries shewing the Spanish & Portuguese Settlements according to Mr. D'Anville*". Digital Library Banco de la República (<https://babel.banrepcultural.org/digital/iiif/p17054coll13/475/full/full/0/default.jpg>).

<sup>12</sup> Brentán, K. (1694-1752). (1751). "*Provincia Quitensis Societatis Iesu in America Topographice exhibita*". National Library of France, GE C-10116 (<http://catalogue.bnf.fr/ark:/12148/cb405958687>).



**Figure 5.** “Carte de la Terre Ferme du Perou, du Bresil et du pays des Amazones: Dressée sur les Descriptions de Herrera de Laet, et des PP. d’Acuna, et M. Rodriguez et sur plusieurs Relations et Observations posterieures” (L’Isle, 1703).

This document was printed and reproduced several times throughout the time (ca. 1720<sup>13</sup>, ca. 1720<sup>14</sup>, ca. 1730<sup>15</sup>, ca. 1741<sup>16</sup>), eventually undergoing small alterations (Figure 6). In addition, was included in a North American publication of 1897 commissioned to investigate the border between Venezuela and Guiana (Venezuela - British Guiana Boundary Commission).

### 2.3.2. Samuel Fritz

Samuel Fritz, (born Apr. 9, 1654, Trautenau, Kingdom of Bohemia - died Mar. 20, 1725 or 1730, Peru), was a Czech Jesuit missionary. He entered the Society of Jesus in 1673 where

<sup>13</sup> L’Isle, G. (1675-1726). (ca. 1720). “Carte de la Terre Ferme, du Perou, du Bresil, et du Pays des Amazones”. Huntington Library, Rare Books Department, Maps (<https://hdl.huntington.org/digital/collection/p15150coll4/id/1430/rec/1>).

<sup>14</sup> L’Isle, G. (1675-1726), and Homann Erben. (ca. 1720). “Tabula Americae specialis geographica regni Peru, Brasiliae, Terrae Firmae & Reg. Amazonum: secundum relationes de Herrera, De Laet, & PP. de Acuna & M. Rodriguez; aliorumque observationes recentiores de signata & edita / par Guiliem de l’Isle, Geogr. Reg. Parisiensem nunc recusa per Homanianos Heredes”. Nuremberg, Germany. Huntington Library, Rare Books Department, Maps (<https://hdl.huntington.org/digital/collection/p15150coll4/id/3274/rec/1>).

<sup>15</sup> L’Isle, G. (1675-1726), and Homann Erben. (ca. 1730). “Tabula Americae specialis geographica regni Peru, Brasiliae, Terrae Firmae & Reg. Amazonum: secundum relationes de Herrera, de Laet, & PP. de Acuña & M. Rodriguez, aliorumque observationes recentiores de signata & edita / per Guiliem. de l’Isle, Geogr. Reg. Parisiensem, nunc recusa”. Nuremberg, Germany. Huntington Library, Rare Books Department, Maps (<https://hdl.huntington.org/digital/collection/p15150coll4/id/3331/rec/2>).

<sup>16</sup> L’Isle, G. (1675-1726). (ca. 1741?). “Carte de la Terre Ferme du Perou, du Bresil et du Pays des Amazones: Dressée sur les descriptions de Herrera, de Laet, et des PP. d’Acuna, et M. Rodriguez, et sur plusieurs Relations et observations posterieures / Par Guillaume del’Isle, Geographe de l’Academie Royale des Sciences”. Amsterdam, Netherlands. National Library of Brasil ([http://acervo.bn.digital.bn.br/sophia/index.asp?codigo\\_sophia=7449](http://acervo.bn.digital.bn.br/sophia/index.asp?codigo_sophia=7449)).

he probably studied Cartography, then in 1683 he decided to go as a missionary to South America.



**Figure 6.** A. “*Carte de la Terre*” (L’Isle, ca. 1720), B. “*Tabula Americae*” (L’Isle & Homann Erben, ca. 1720), C. “*Tabula Americae*” (L’Isle & Homann Erben, ca. 1730), D. “*Carte de la Terre*” (L’Isle, ca. 1741?).

He began his career in 1686 and was assigned the task of incorporating the territory between the Napo River and the Rio Negro, that territory spanned about 700 kilometers along the river and was inhabited by the Omagua nation. In the late 1680s, the Maynas mission had probably included the Omagua Indians, and their neighbors the Yurimagua, Aisure, and Ibanoma because the work done by him.

After three years of work, he felt ill and travel to the Portuguese side for treat his illness. However, this decision was not received in the best way by the Portuguese, who retained him in Grão Pará for a year and a half until 1692. Probably in this lapse of time, he created part of his cartographic work according to his personal diary. Later, there was a change in the way that the Portuguese empire expanded its domain in the territory. Another three orders (Franciscans, Mercedarians and Carmelites) were incorporated into the evangelization process. The removal

of the exclusivity granted to the Jesuits, undoubtedly generated conflicts between the two Iberian empires in the land demarcation of their limits (Dias, 2012).

In this context, he developed his activities, being a turbulent time in the political sphere of the two Iberian empires. The priest's main objective was to obtain military and financial resources to consolidate his missions along the river course and be able to annex the other villages with which he had already established contact. Apart from many letters, reports and a journals which covers the period from 1689 to 1723, he also produced several maps only some of which appear to have survived.

#### 2.3.2.1. “*Tabula Geographica Missionis Omaguae Societatis Iesu*”<sup>17</sup>.

This is perhaps the oldest manuscript map and is probably to have been completed before his arrival in Grão Pará in 1689 (Figure 7). The map does not carry his signature but can be attributed to him because the lettering is identical to that found in his signed map dated 1691. Another reason is that the mapped area corresponds only to a particular section of the Amazon River, the Omagua mission region, where he had been working between 1686 and 1689 (de Almeida, 2003).



**Figure 7.** “*Tabula Geographica Missionis Omaguae Societatis Iesu*” (1689).

Apparently, the purpose of the map was for internal use of the Society of Jesus as an illustration of the territory where he was working, the names of the indigenous groups and toponyms coincide with those found in the following works signed by him. It shows a scale in leagues and a graticule of longitude and latitude, but the degrees are not numbered (de Almeida, 2003).

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<sup>17</sup> [Fritz, S.]. (1689). “*Tabula Geographica Missionis Omaguae Societatis Iesu*”. Negative of the original map in the Archivum Romanum Societatis Iesu. Rome. ARSI, Hist. Soc. I 50, II.

### 2.3.2.2. “*Tabula Geographica del Rio Marañon o Amazonas*”<sup>18</sup>.

This map also does not contain the author’s name (Figure 8), however, among the reasons for which the authorship is attributed to him are the following: the creation date (1690) coincides with the time he was in Grão Pará, the lettering, and the mapped area (covers the Amazon River from the Andes to the Atlantic Ocean). It is made up of four sheets with a little difference in their measurements which do not match perfectly, it seems more a preliminary version than a final result (de Almeida, 2003).

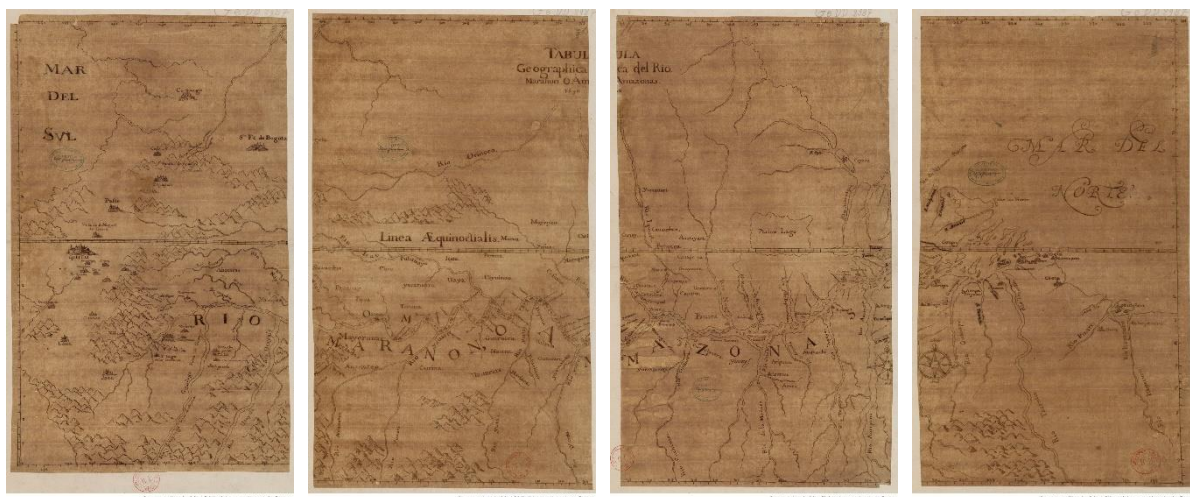


Figure 8. “*Tabula Geographica del Rio Marañon o Amazonas*” (1690).

The data provided for the eastern part of the map, from the Rio Negro to the city of São Luís do Maranhão, seems to be based on Portuguese sources indicating the location of their missions along the Amazon River and its tributaries, as well as towns and forts near to the coast. Regarding the northern part of the Maynas mission, this map covers the territories of the Audience of Quito and part of the Audience of Santa Fé, so many important cities and towns were drawn (de Almeida, 2003).

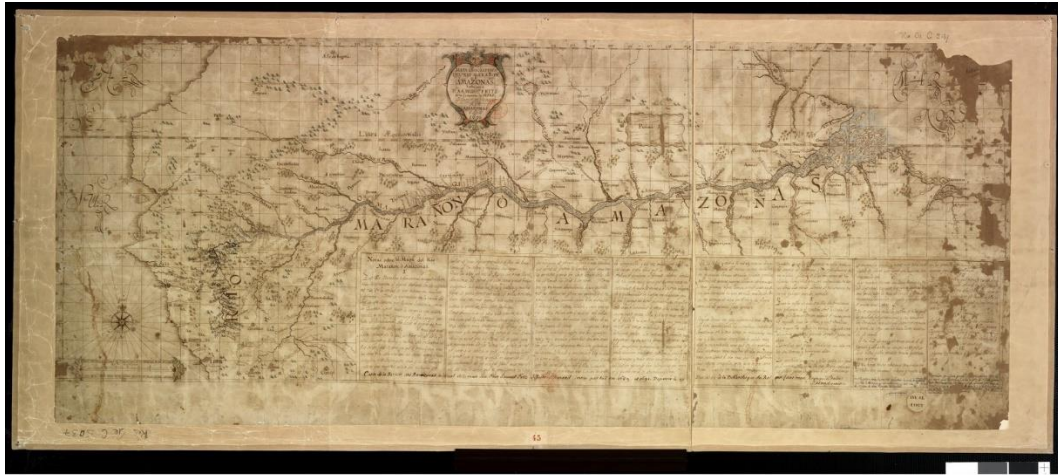
### 2.3.2.3. “*Mapa Geographica del Rio Marañon o Amazonas*”<sup>19</sup>.

It was brought to France by the French explorer Charles-Marie de la Condamine in 1745 (Figure 9), after he was exploring South America for ten years, and deposited in the King’s

<sup>18</sup> [Fritz, S.]. (1690). “*Tabula Geographica del Rio Marañon o Amazonas*”. National Library of France, Ge DD 2987 (9544-9547) (<http://catalogue.bnf.fr/ark:/12148/cb40622021c>).

<sup>19</sup> Fritz, S. (1656-1725). (1691). “*Mapa Geographica del Rio Marañon o Amazonas*”. National Library of France, Ge C 5037 (RES) (<http://catalogue.bnf.fr/ark:/12148/cb40595394d>).

library in 1752. The mapped area is larger than the two previous one using a smaller scale, it covers the whole of the Pacific coast from Callao northward to beyond Cape San Francisco, the territory of the Audiencia de Quito, and part of the Audiencia de Lima (south) and the Audiencia de Santa Fé (north) (de Almeida, 2003).



**Figure 9.** “*Mapa Geographica del Rio Marañon o Amazonas*” (Fritz, 1691).

In the upper part the title, the author’s name and the date of elaboration are shown, a box in the lower right part contains an extensive legend that include a geographical description of the Amazon River, its inhabitants, and its natural resources. An explanation about the signs and letters used on the map is also described in the legend for better understanding.

2.3.2.4. “*El gran rio Marañon, o Amazonas, con la mission de la Compañia de Jesus geograficamente delineado / por el P.Samuel Fritz, misionero continuo en este rio*”.

In 1704, he was named superior of the missions of the Province of Quito and was installed at the Colegio Maximo in 1707. In that year, he engraved this map with the help of the Jesuit Juan de Narvaez whose initials appear on the title, and the support of the colonial authorities of Quito so it was dedicated to Phillip V (Figure 10); by the way in 1692 an unsuccessful attempt to print this map was done in Lima.

This shows the course of the Amazon River from its headwaters close to Quito to its mouth at the Atlantic Ocean, a high level of detail of the hydrography in the region is shown, as well as the names of the towns and the tribes that inhabit them. Regarding to the legend described in the lower right corner, the first part details the river and its geographical characteristics, the main natural resources that can be exploited and the region’s population

density. The second part is a description of the missionary work done by the Society of Jesus (Dias, 2012).



Source: gallica.bnf.fr / Bibliothèque nationale de France

**Figure 10.** “El gran rio Marañon, o Amazonas, con la mision de la Compañia de Jesus geograficamente delineado / por el P. Samuel Fritz, misionero continuo en este rio” (Fritz, 1707).

This map was reprinted with minor changes in the 34-volume of the ‘*Lettres édifiantes et curieuses*’ (1717) with a French translation of an account of the Omagua missions taken from Fritz’s Spanish memoirs under the title “*Cours du fleuve Maragnon, autrement dit des Amazones / par le P. Samuel Fritz, Missionnaire de la Compagnie de Jésus*”<sup>5</sup>. In 1727, another version was included in ‘*Der Neue Welt-Bolt*’, a German edition of the ‘*Lettres*’, along with Fritz’s account (de Almeida, 2003).

### 2.3.3. Charles Marie de La Condamine

Charles-Marie de La Condamine (born Jan. 28, 1701, Paris, France - died February 4, 1774, Paris, France) was a French mathematician and naturalist who achieved the first scientific exploration of the Amazon River. In 1731, he participated in a yearlong sea journey to several ports along the Mediterranean Sea coast; after he presented his scientific results, the members of the French Academy of Sciences invited him to an expedition which purpose was to determine the length of a degree of the meridian near the equator (Encyclopedia Britannica, 2021).

The cause for conducting this research was the contradiction of two theories about the shape of the Earth, on the one hand the English physicist Sir Isaac Newton calculated that the



planet flattened out at the poles and bulged at the equator; on the other hand, the French astronomers Giovanni Domenico Cassini and his son Jacques, established that it was elongated at the poles and drew in at the equator. In order to solve this issue, two expeditions were organized: one to Scandinavia near the North Pole, the second to the northern Peru (now Ecuador) where the equator passes through the Andes Mountains (Suarez, 2021).

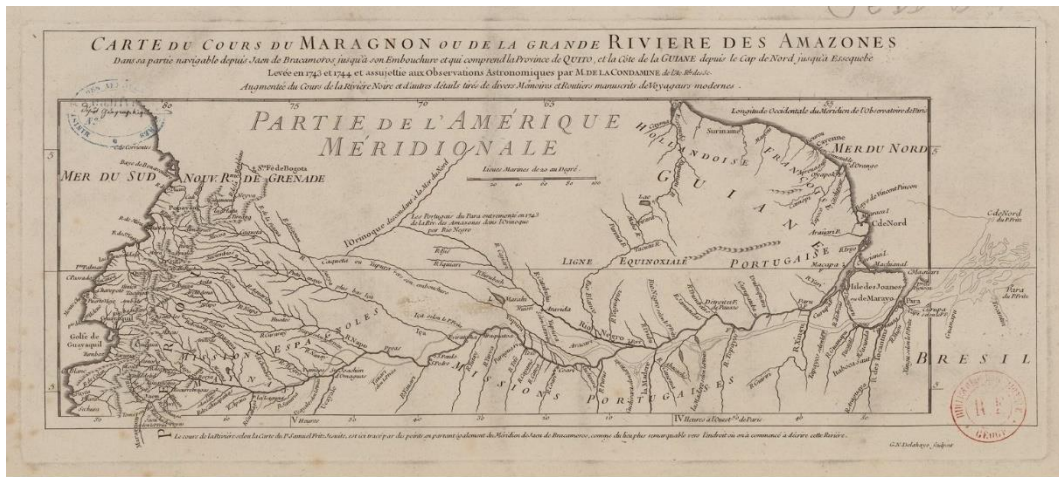
In May 1735, the expedition led by the mathematician Louis Goudin sailed from France to South America where the group spent eight years developing their research until 1743. After that, La Condamine decided to change the way back to Europe taking the Amazon River course as a route to reach the Atlantic Ocean, his primary motivation was to produce a map “*of the course of a river that traverses vast lands nearly unknown to [French] geographers*” according to his account (La Condamine, 1747).

His expedition began in the river port of Jáen (now northern of Peru), then passed throughout the Pongo of Manseriche where the river narrowed to 45 meters. The journey was scheduled to take place in a short time, so four months later he reached the city of Grão Pará on September 19, 1743. From Cayenne, in what is now French Guyana, he took a ship to Europe where he arrived at France in February 1745, almost ten years after he had left.

Don Josef Pardo de Figueroa y Acuña, Marquis of Valleumbroso, a creole born in Lima and the great-nephew of Father Cristobal de Acuña was one of his sources of information. He asked Father Andrés de Zarate of the Jesuit mission in Quito for a compilation of Pablo Maroni’s diaries, as well as a report on the latest news regarding the river. Therefore, La Condamine benefited with useful information that was sent to him a year and a half before the beginning of his journey (Safier, 2009).

Finally, the presentation of his results was in November 1745 under the title of “*Relation Abrégée d’un voyage fait dans l’intérieur de l’Amérique méridionale*”, which was published the same year with a map based on his observations (Figure 11). La Condamine was the person that took the measurements and the French geographer Jean-Baptiste Bourguignon d’Anville (1697-1782) was the responsible to draw it (Cintra, 2011).

The map includes the Pacific and Atlantic coast, it extended from the Spanish province of Quito in the west to the Portuguese city of Grão Pará in the east, including the Guyanas to the north and parts of Brazil and Peru to the south. He had two ways to determine his notes: in certain places he took meticulous astronomical observations for several days; while other times he relied on maps, travel diaries or oral reports from missionaries or natives with insufficient accuracy.



Source gallica.bnf.fr / Bibliothèque nationale de France

**Figure 11.** “Carte du cours du Maragnon ou de la grande route des Amazones” (La Condamine, 1743-1744).

#### 2.3.4. Emanuel Bowen

Emanuel Bowen (born ca. 1694 - died May 08, 1767) was an English engraver, publisher and mapseller in London from 1720 to 1767. His remarkable work earned him the rare distinction of being Royal Mapmaker to both, King George II of Great Britain, and Louis XV of France.

He was highly regarded by his colleagues for producing some of the largest, detailed, and accurate maps of his era, due to his reputation he worked with most of the British cartographic figures of the period including John Owen and Herman Moll. He engraved large numbers of maps for general atlases, geographical textbooks, and periodicals, particularly “*The Complete System of Geography*”, the “*Universal History of the World*”, the small-format periodical “*The General Magazine of Arts and Sciences*” and the “*Complete Atlas*”.

The British Empire wanted to become a power in the chart and map market of the eighteenth century, with Emanuel Bowen being one of its best representatives. The maps that belong to his world atlas “*The Complete System of Geography*” (1744 - 1747) have a distinctive and attractive style, rococo cartouches with vignettes representative of the areas shown, and annotations describing the region. This work is a description of countries, islands, cities, ports, lakes, rivers, mountains, and mines of the known world published in two volumes, it contains seventy maps that were drawn and engraved according to the latest discoveries and surveys of the time; one of which includes the representation of the Amazon River and its tributaries (Figure 12).



**Figure 12.** “A new and accurate map of Peru and the country of the Amazonas drawn from the most authentic French Maps e C. and regulated by astronomical observation” (Bowen, 1747).

He also produced a large number of English county maps, his earliest known publication was a series of road maps of English and Wales, the “*Britannia Depicta*”, with a map of each county, created with John Owen in 1720. Maybe, his most important work was published with Thomas Kitchin, the “*Royal English Atlas*” and the “*Large English Atlas*”, several maps of English counties on large scale and with great number of details.

### 2.3.5. Károly Brentán

Károly Brentán (born Aug. 23, 1694, Komárom, Hungary - died Nov. 19, 1752, near Genoa, Italy), was a Hungarian Jesuit missionary that spent a long time in South America, mainly performing tasks of evangelization and education with the indigenous population in the territories that are now Colombia, Ecuador, and Peru.

He studied at the college of Nagyszombat (today in Slovakia, as Trnava) and joined the Jesuit order in 1714. He applied for a missionary service position, after completing a training in Seville, he went to Quito probably in 1722 or 1724. The Marañón River was the area where he carried out his religious activities, he lived in the Andoa tribe but later visited the Miguiano, Amaono and Parano tribes; with his expeditions and knowledge of the territory he made the first detailed description of the confluence between the Marañón and Ucayali rivers and was the first European to cross the Nanay and Itatay rivers (Lazca, 2000).

His efficient missionary work was rewarded in 1742, and he was nominated for prelate in the province of Quito which includes Ecuador, the southern part of Colombia and the northern part of Peru. He held the position from 1744 to 1747, after his four-year term his superiors sent him to Rome to represent the province there. For his voyage to Rome, he decided to take the river route along the Amazon River, in 1748 together with the Spanish missionary, Nicolás de la Torre, left Quito for the city of Grão Pará. According to several research, his objective was to complete his work with observations of the middle course of the river between the Napo and the Negro estuary, for which he carried out this expedition. During it, he was taken prisoner twice by the Portuguese in the cities of Óbidos and Gurupá, for which it took almost three years until he was able to take a ship and reach Rome in the beginning of 1751 (Lazca, 2000).

In addition to performing his diplomatic function, he also prepared his manuscripts to be published in two volumes, the first on the geographical conditions, flora, and fauna of the Marañón region and the second describing the customs, life, and beliefs of the indigenous tribes. The title of his work was “*Marannonensium S. J. Missionum generalis Historia iconibus illustrata*”, unfortunately on the way to Genoa where he would print it, he suffered a deterioration of his health and died in November 1752 (Lazca, 2000). All his notes disappeared after this event, only a map intended as an appendix remained which was first published in Quito and then in Rome (Figure 13).



**Figure 13.** “*Provincia Quitensis Societatis Iesu in America Topographice exhibita*” (Brentán, 1751).

Long time after his death, the work entitled “*Loyalaei Amazonici Prolusiones*” was published on the history of the Jesuit missions in the Amazon region, however, this was

probably not the one that had been lost in Genoa. Giovanni Petroschi (1715 - 1766), who had been close to the Jesuit order and had published several maps of South America, published the map, the Roman Cigni brothers were in charge of drawing and engraving. A copy of this can be found in the British Museum and another one in the Ecuadorian Library Aurelio Espinosa Pólit. It is composed of four separate pages that were pasted together.

## METHODOLOGY

### 3.1. CINTRA METHOD

The first methodologies designed for the validation of old maps emphasized that the computer could provide a great help in the task of superimposing old and modern maps by verifying their distortions, an example was the methodology developed by John Brian Harley in 1968. From that time to the present, technological resources evolved and Cartography is almost entirely developed in digital form, which facilitates visual analysis and its comparison with modern maps (Cintra, 2009).

In this study, the methodology described in the research entitled “*A Cartografía digital como ferramenta para a Cartografía histórica*” will be used as a reference, elaborated by Jorge Pimentel Cintra, Associate Professor of the Polytechnic School of São Paulo and member of the Historical and Geographical Institute of São Paulo. The research examines the preliminary data of the old maps and using digital tools an analysis is carried out to determine its scale, the meridian of origin, and the projection used.

#### 3.1.1. Preliminary Data

A scan of the map must be obtained in digital format available in an online database, in most cases, there may be the option of accessing an original map or a copy of a museum. The researcher must choose the format in which the file will be stored (TIFF, JPEG, among others) and its resolution (pixels per inch), depending on this parameter the size or digital weight of the file will be established. It is also necessary to investigate data regarding the map, which are used in the following study stages such as the approximate scale, meridian of origin, type of projection used, coordinate system, among others.

#### 3.1.2. Scale

The approximate scale, if a graphical or numerical scale is not identified, can be determined by measuring the distance between two (or more) previously known coordinate points on the map. It should be noted that the scales may be different in the North (N) and East (E) directions, and that the digitized map may not be the original or may even have been reduced or enlarged.

In order to check these data, the map coordinate network can be used, if the coordinates are Geographic (latitude and longitude), the distance between consecutive degrees is measured and compared with the real value, that is, with the distance corresponding to one degree (111,11 km in latitude and the same value multiplied by the cosine of the mean latitude in longitude) (Cintra, 2009).

It should be mentioned that the graphic scales are reduced or enlarged together with the map, therefore, this is a parameter to determine the scale of the copy, but not of the original map, since it is reduced or enlarged together with the rest of the map.

### 3.1.3. Meridian of Origin and Projections

This data can be explicitly included in the analyzed map, however, there are many old maps that do not have this information. Several old maps have taken as reference point the meridians of Ilha do Ferro, Rio de Janeiro (Morro de Castello), Praia (Cape Verde), among others. The longitudes from these meridians are counted from the point of origin to the west and from 0° to 360° (Cintra, 2009). In order to determine the meridian of origin, theoretically the longitude ( $\lambda_a$ ) of a point measured on the map must be compared with the true longitude of that point, obtained from a current map, whose meridian of origin is Greenwich ( $\lambda_G$ ).

$$\text{Equation 1.} \quad \lambda_{\text{orig}} = \lambda_G - (360 - \lambda_a)$$

$\lambda_{\text{orig}}$ : Longitude of the meridian of origin in relation to Greenwich.

$\lambda_G$ : Longitude of the point relative to Greenwich, obtained from a current map.

$\lambda_a$ : Longitude of the measurement point on the map.

For the purpose to not depend on a single measurement, the same calculation can be carried out for the desired number of points, so a mean and its corresponding standard deviation can be calculated. In order to ease the calculations, it is recommended to use the coordinates of the localities in decimal degrees.

The grid or graticule drawn on the map is the parameter to be analyzed, the projection used by the author will be determined using the theoretical concepts and classifications previously mentioned. A bibliographic source to be employed as a complement is the book “*An Album of Map Projections*” (Snyder & Voxland, 1989), which contains graphic examples about the appearance of the grid according to each projection. Additionally, the central meridian with

which the projection was designed must be determined because it will be a parameter to be used in georeferencing of the map.

### 3.2. GEOREFERENCING

The determination of the coordinate system is essential to locate the map in the exact position of the territory it represents, usually the position of the objects were calculated by astronomical measurements and the distances were measured on the ground (Cajthaml, 2011). In this process, it is necessary to determine identical points on the map and on the terrain, called '*ground control points*' that will allow the map to be adjusted according to the current reality. Their distribution should be along the whole image and they must be represented by figures or entities that are as stable and recognizable as possible, a greater number of ground control points can improve the process of georeferencing by reducing the error of the transformation method used.

There are two transformation methods, the global methods use two mathematical equations for the whole image and are non-residual only for the minimal number of ground control points for equation solving. Local methods use other approach where either the image is cut into areas with own equations or any point is transformed with own equations, they are non-residual where ground control points after transformation fit precisely, but the image can be distorted and alter its shape. Based on the number of map sheets, the projection used and the dimensions of the map, specific procedures could be carried out to georeference it correctly (Cajthaml, 2011).

#### 3.2.1. One map sheet, unknown projection, unknown dimensions

A common case in old maps, in which it is proposed to use the 'Lat/Long' projection that matches with Plate Carree projection (equidistant cylindrical with undistorted equator), the ground control points are entered in degrees for the terrain and in pixel coordinates for the image. As the shrinkage of the paper is unknown the used transformation should reduce the distortion, after affine transformation the image can be scaled in both axes and distorted, or after second/third order polynomial transformation the image can be bended locally (Cajthaml, 2011).



### 3.2.2. One map sheet, known projection, unknown dimensions

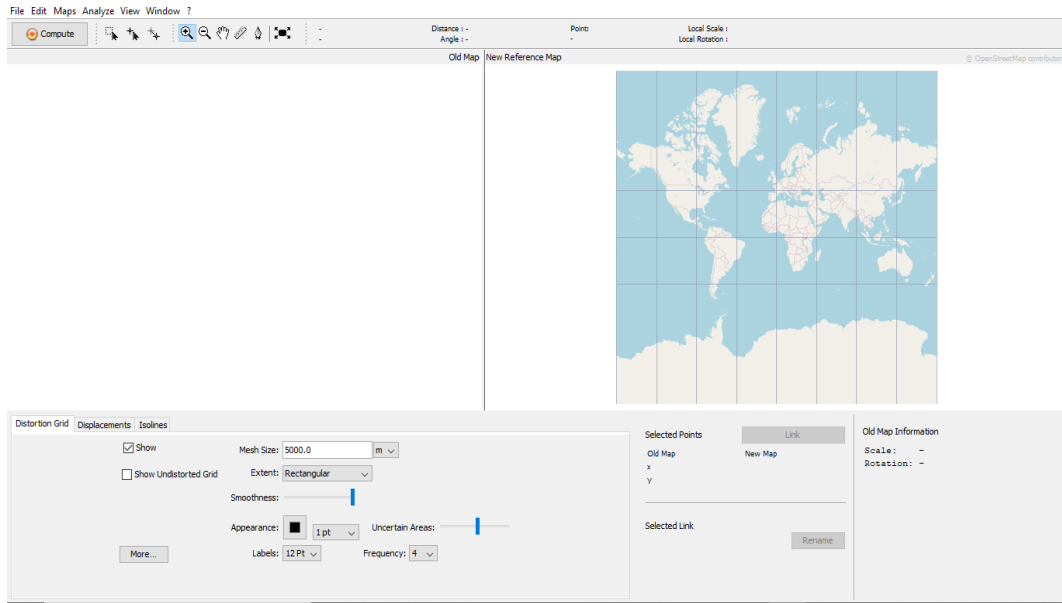
Georeferencing must be done using the original projection of the map, which leads to know the geodetic datum and the cartographic parameters (meridian of origin, central meridian, scale factor, among others). The coordinates of the ground control points must be transformed from the projection in which the data were collected to the original map projection, the affine transformation can be used for the adjustment.

### 3.3. MAP ANALYST

MapAnalyst software is able to perform an automatic comparison between the old map and the reality of that study area. This applications was designed to determine and analyze the precision of the old maps. Its main purpose is to calculate the distortions of the grid and other types of visualizations that illustrate the geometrical accuracy of old maps. The program uses pairs of control points on an old map and on a new reference map like Open Street Map, then with these control points the user can construct distortion grids, vectors of displacement, accuracy circles, and isolines of local scale and rotation. As it is a free access program with open-source code, it can be programmed to carry out additional tasks depending on the requirements.

The program's starting interface contains a menu that displays the main functions and tools available, and two windows are displayed in parallel to show the old map and the current reference (Open Street Map) or a second map. Finally, at the bottom the user can find the three main graphic results and their setting that allow the visualization of the comparison done, such as the distortion grid, displacements (vectors and circles) and isolines (Figure 14). In order to establish the control points there is the option Set New Point with which the same location is marked on the old map as well as on the current reference, if the location and accuracy of the two points is the desired one, the user can use the Link option and name the control point pair. The table of the points created, and their coordinates can be found by clicking on the Edit tab in the option Show List of Linked Points.

Finally, when the control points have been distributed throughout the study area in a homogenous way, the comparison of the work carried out can be started using the Compute tool, according to the user's preferences.



**Figure 14.** Main interface of MapAnalyst.

## DEVELOPMENT OF THE PRACTICAL WORK

A search was carried out for maps published during the eighteenth century in online databases belonging to the National Library of France, Huntington Digital Library, Library of Congress (USA), National Library of Brazil, National Library of Rio de Janeiro, Republic Bank of Colombia, Mariano Moreno National Library, among others. Once the maps were selected, a classification was established based on the depicted area by defining two classes (region or continent), with which the research will be done with the region maps based on their greater level of detail and information (Table 1).

In order to avoid the repetitive use of the maps' titles in the rest of the document, each one will be named with a reference letter followed by the initials of its author

- Carte de la Terre Ferme du Perou, du Bresil et du pays des Amazones: Dressée sur les Descriptions de Herrera, de Laet, et des PP. d'Acuna, et M. Rodriguez et sur plusieurs Relations et Observations posterieures: A\_GI.
- El Gran Río Marañón, o Amazonas con la Misión de la Compañía de Jesús geográficamente delineado por el P. Samuel Fritz misionero continuo en este Río: B\_SF.
- Carte du cours du Maragnon ou de la grande route des Amazones, La Condamine e D'Anville: C\_LC.
- A new and accurate map of Peru and the country of the Amazones drawn from the most authentic French Maps e C. and regulated by astronomical observation: D\_EB.
- Provincia Quitensis Societatis Iesu in America Topographice exhibita: E\_KB.

### 4.1. PRELIMINARY DATA SEARCH

A brief examination of the digital characteristics of the images to be used was done (Table 2), in which its dimensions, resolution and file size are detailed. In relation to the historical data of the maps, these can be reviewed in the footnotes of the present document.

### 4.2. CALCULATION OF THE SCALE

Using the CorelDRAW 2020 program, the images were resized based on the data obtained from consultations with online libraries that have an original or a copy of the maps in

their collection (Table 3). Then, the distance between two consecutive parallels was calculated in order to establish the measurement of a degree of latitude and to compare this with the real distance on the ground. In order not to depend on a single measurement, between four or six measurements were made to have a greater sample of data and determine a more accurate result (Table 4 to 8).

**Table 2.** Digital characteristics of the images.

Map	Height (pixels)	Width (pixels)	Resolution (ppp)	File size (Mb)
A_GI <sup>20</sup>	4248	5465	96	2,69
B_SF <sup>21</sup>	6276	8479	400	9,65
C_LC <sup>22</sup>	2186	4419	300	8,64
D_EB <sup>23</sup>	4241	5837	96	4,32
E_KB <sup>24</sup>	5114	6398	96	7,85

\*The link in which the images can be downloaded without any restriction is detailed in the footnotes.

**Table 3.** Real dimensions of the maps.

Map	Height (cm)	Width (cm)	Source of data
A_GI	48,4	55,5	National Library of Brasil
B_SF	32	42	National Library of France
C_LC	16,2	38	John Carter Brown Library
D_EB	32	42,5	National Library of Brasil
E_KB	63	90	John Carter Brown Library

The origin of the measurements is the equatorial line, for which positive positions are calculated for northern latitudes and negative positions for southern latitudes. For a better visualization of the process, a screenshot of the image and the position of the parallels taken as a reference is included (Figure 15 to 19).

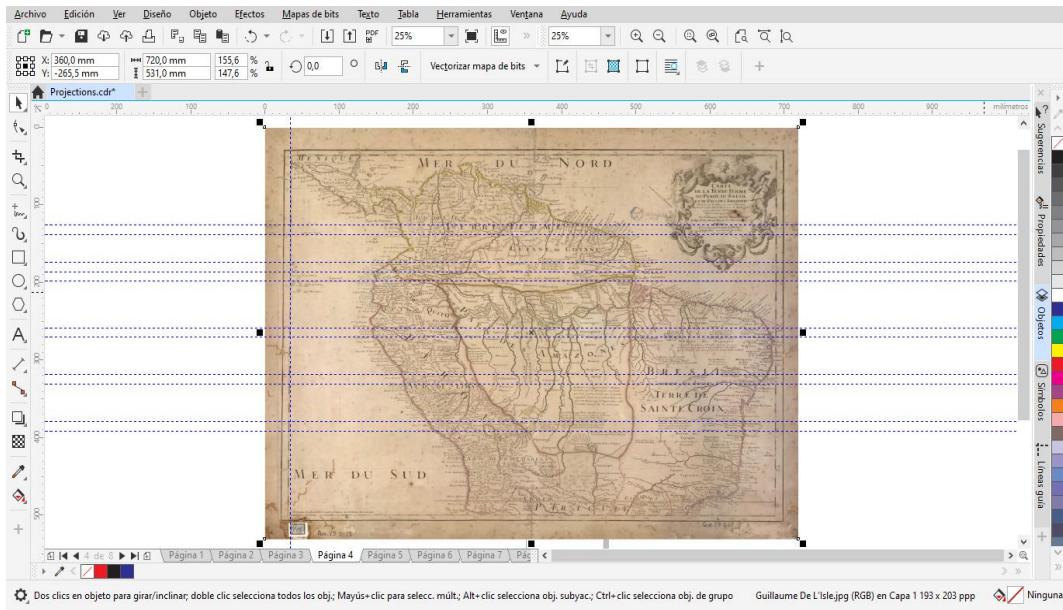
<sup>20</sup> [http://acervo.bndigital.bn.br/sophia/index.asp?codigo\\_sophia=60674](http://acervo.bndigital.bn.br/sophia/index.asp?codigo_sophia=60674)

<sup>21</sup> [https://www.europeana.eu/en/item/9200517/ark\\_12148\\_btv1b8446616z](https://www.europeana.eu/en/item/9200517/ark_12148_btv1b8446616z)

<sup>22</sup> <http://www.manioc.org/gsd/cgi-bin/library?e=q-11000-00---off-0images--00-1---0-10-0---0---0direct-10-DO--4-----0-11--11-fr-Zz-1---20-about-Amazonie--00-3-1-01-0-0-11-0-OutfZz-8-00&a=q&q=La+Condamine%2C+Charles-Marie+de+%281701-1774%29&fqf=DN&t=0>

<sup>23</sup> <https://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~2602~280018>

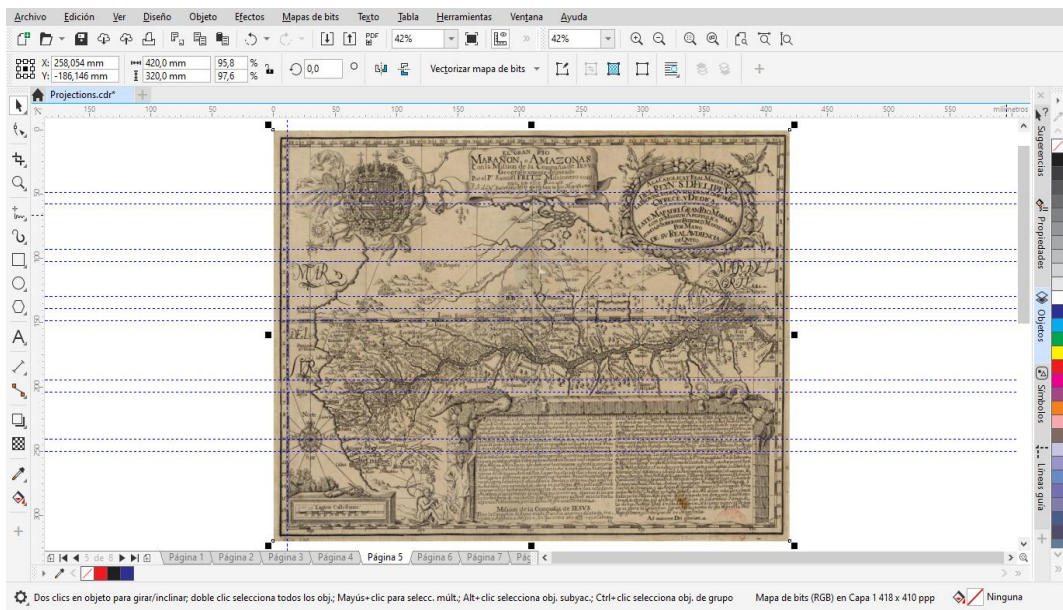
<sup>24</sup> <https://jcb.lunaimaging.com/luna/servlet/detail/JCBMAPS~1~1~4325~102388:Provincia-Quitensis-Societatis-Iesu>



**Figure 15.** Position of the parallels of A\_GI.

**Table 4.** Calculation of the scale of A\_GI.

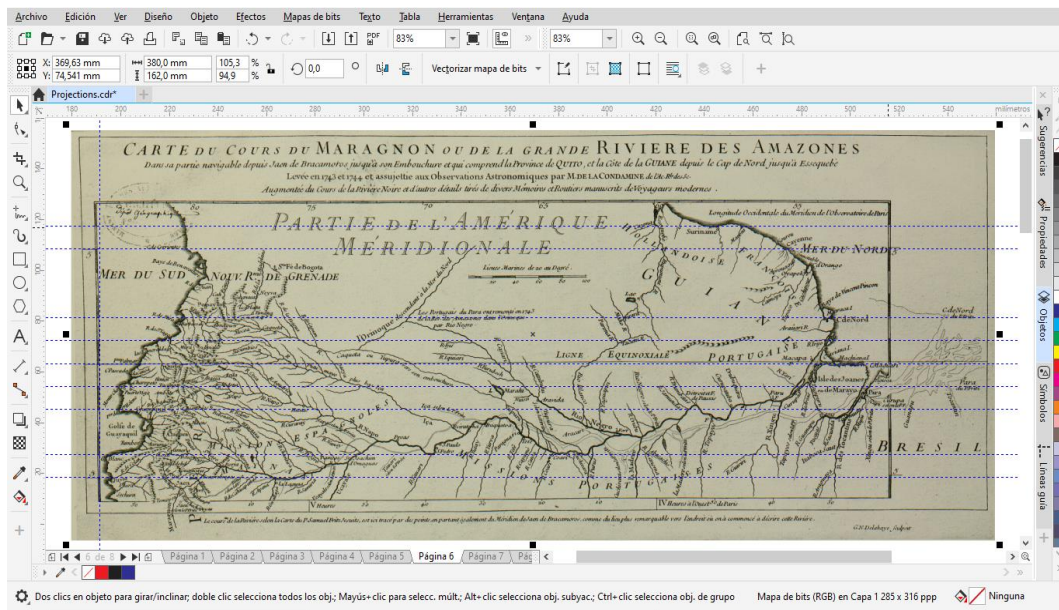
N°	Parallels (°)		Position (mm)		Distance between the parallels (mm)	Calculated scale	Estimated scale
1	6	5	71,818	59,488	12,33	9°011.354	9°000.000
2	2	1	23,482	11,376	12,106	9°178.093	9°100.000
3	-6	-5	-72,586	-60,691	11,895	9°340.899	9°300.000
4	-11	-10	-132,992	-121,121	11,871	9°359.784	9°300.000
5	-16	-15	-193,785	-181,810	11,975	9°278.496	9°200.000



**Figure 16.** Position of the parallels of B\_SF.

**Table 5.** Calculation of the scale of B\_SF.

N°	Parallels (°)		Position (mm)		Distance between the parallels (mm)	Calculated scale	Estimated scale
1	11	10	99,789	90,755	9,034	12'299.092	12'300.000
2	6	5	55,213	46,118	9,095	12'216.602	12'200.000
3	2	1	18,556	9,217	9,339	11'897.419	11'900.000
4	-6	-5	-55,334	-46,333	9,001	12'344.183	12'300.000
5	-11	-10	-101,815	-92,246	9,569	11'611.453	11'600.000



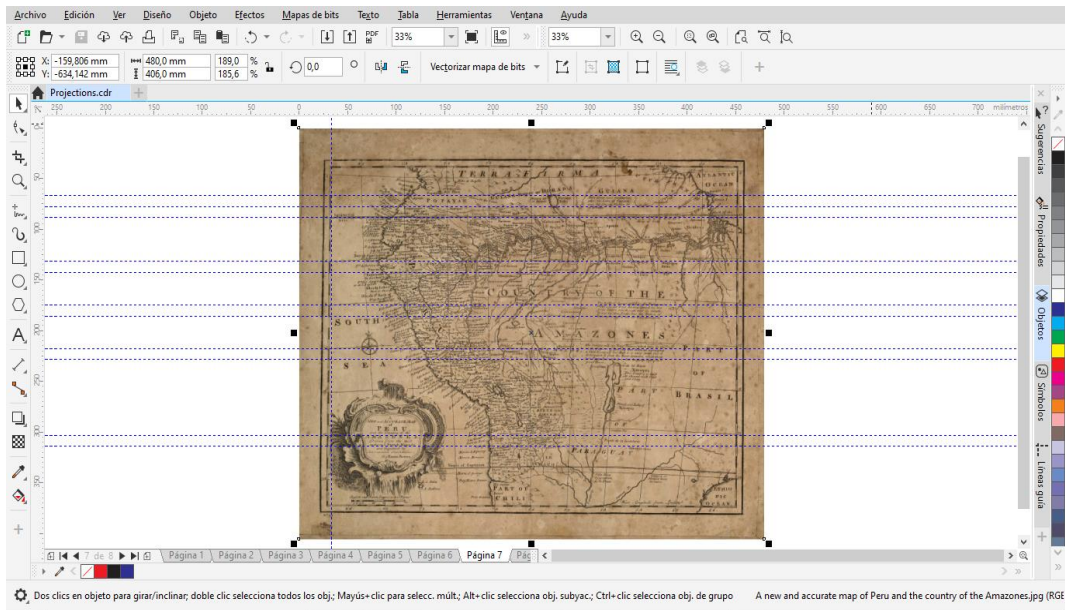
**Figure 17.** Position of the parallels of C\_LC.

**Table 6.** Calculation of the scale of C\_LC.

N°	Parallels (°)		Position (mm)		Distance between the parallels (mm)	Calculated scale	Estimated scale
1	6	5	54,324	45,337	8,987	12'363.413	12'400.000
2	2	1	18,156	9,033	9,123	12'179.107	12'200.000
3	-2	-1	-18,091	-8,948	9,143	12'152.466	12'200.000
4	-5	-4	-44,838	-35,966	8,872	12'523.669	12'500.000

Only in the case of the D\_EB<sup>25</sup> map, a different image from the sources specified in the Table 2 was used to calculate the scale.

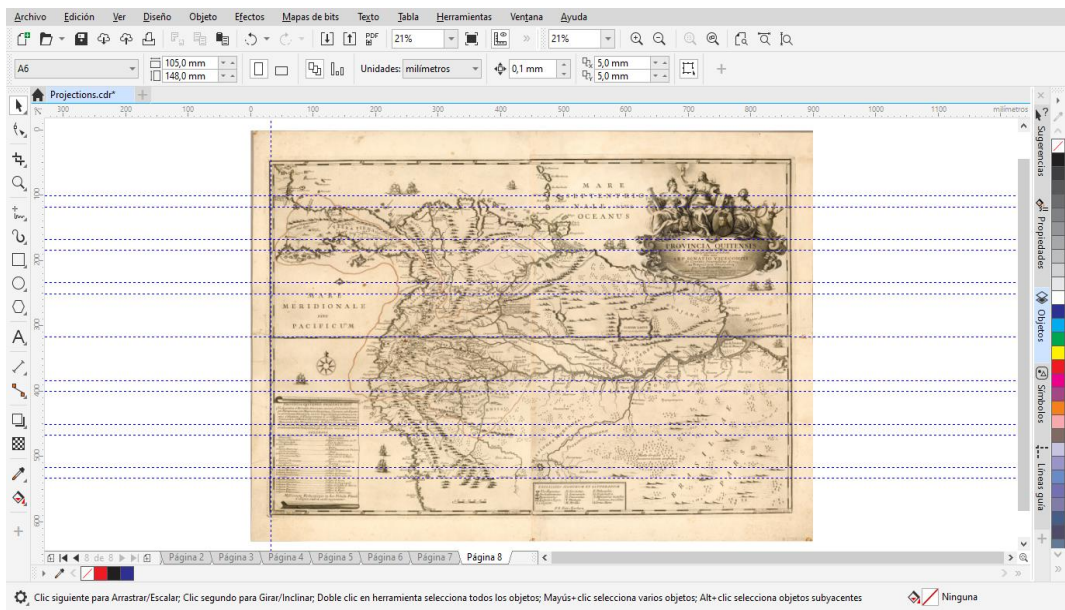
<sup>25</sup> [http://acervo.bndigital.bn.br/sophia/index.asp?codigo\\_sophia=198](http://acervo.bndigital.bn.br/sophia/index.asp?codigo_sophia=198)



**Figure 18.** Position of the parallels of D\_EB.

**Table 7.** Calculation of the scale of D\_EB.

Nº	Parallels (°)		Position (mm)		Distance between the parallels (mm)	Calculated scale	Estimated scale
	2	1					
1	2	1	21,404	10,343	11,061	10'045.203	10'000.000
2	-5	-4	-54,883	-43,7	11,183	9'935.616	9'900.000
3	-9	-8	-97,978	-86,591	11,387	9'757.618	9'800.000
4	-13	-12	-140,385	-129,669	10,716	10'368.607	10'400.000
5	-21	-20	-226,064	-215,183	10,881	10'211.377	10'200.000



**Figure 19.** Position of the parallels of E\_KB.

**Table 8.** Calculation of the scale of E\_KB.

N°	Parallels (°)		Position (mm)		Distance between the parallels (mm)	Calculated scale	Estimated scale
1	13	12	216,315	199,815	16,5	6'733.939	6'700.000
2	9	8	149,969	133,325	16,644	6'675.678	6'700.000
3	5	4	83,620	66,852	16,768	6'626.312	6'600.000
4	-5	-4	-83,257	-66,645	16,612	6'688.538	6'700.000
5	-9	-8	-149,875	-133,268	16,607	6'690.552	6'700.000
6	-13	-12	-215,957	-199,352	16,605	6'691.358	6'700.000

With the estimated data, an average scale can be determined for each map and its corresponding standard deviation, which indicates the margin of error of the process (Table 9). This method is based on the dimensions described in Table 3, if the values change depending on the source, the calculation must be carried out again.

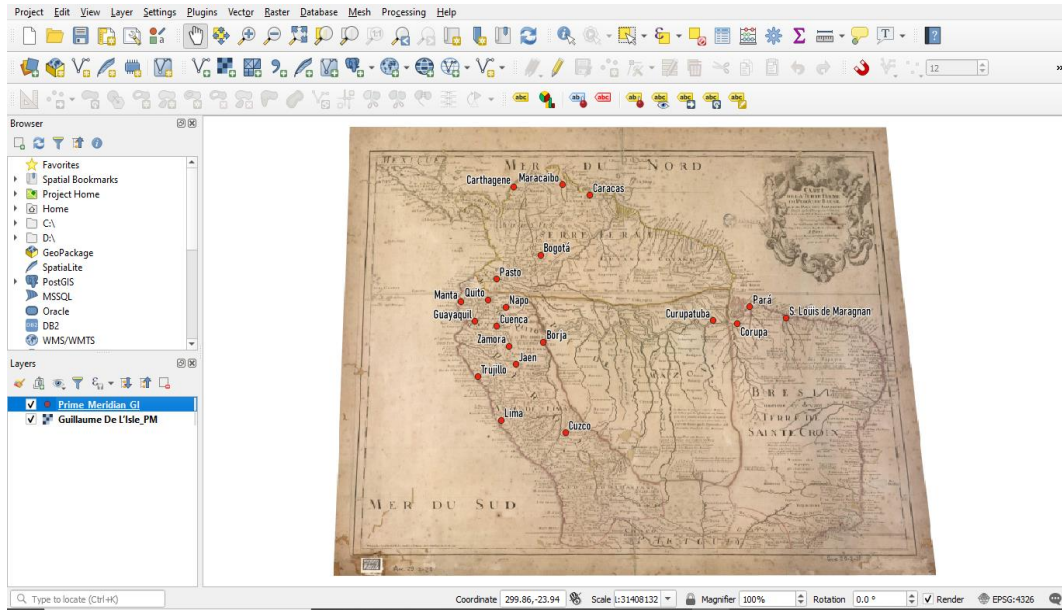
**Table 9.** Mean scale and standard deviation of the maps.

Map	Mean scale	Standard deviation
A_GI	9'200.000	+/- 130.000
B_SF	12'000.000	+/- 300.000
C_LC	12'300.000	+/- 150.000
D_EB	10'000.000	+/- 240.000
E_KB	6'700.000	+/- 50.000

#### 4.3. CALCULATION OF THE MERIDIAN OF ORIGIN

In Global Mapper v20.0 program, images were georeferenced by the Rectify (Georeference) Imagery tool using the meridian and parallel intersections as control points in the drawn grid of each map, the projection was Latitude/Longitude, and the datum was WGS84. The georeferenced images were imported to QGIS Desktop 3.10.11 program, in which the longitude of 15 or 20 locations were determined in the coordinate system of each map, depending on the case; after from these same locations its current longitude were determined taking Greenwich as the meridian of origin. Finally, in a calculation table the Equation 1 was applied with the collected data, thus calculating the meridian of origin in reference to each of the locations (Table 10 to 12). For a better visualization of the process, a screenshot of the georeferenced image and the distribution of the locations taken as a reference for the calculation of the meridian of origin is included (Figure 20 to 22).

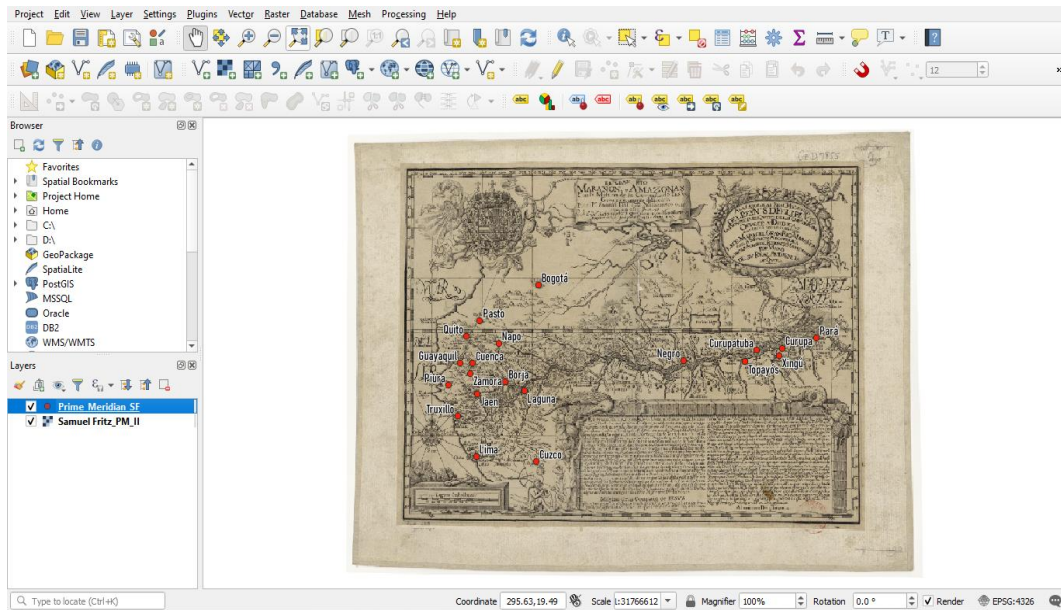




**Figure 20.** Distribution of the locations of A\_GI.

**Table 10.** Calculation of prime meridian of A\_GI.

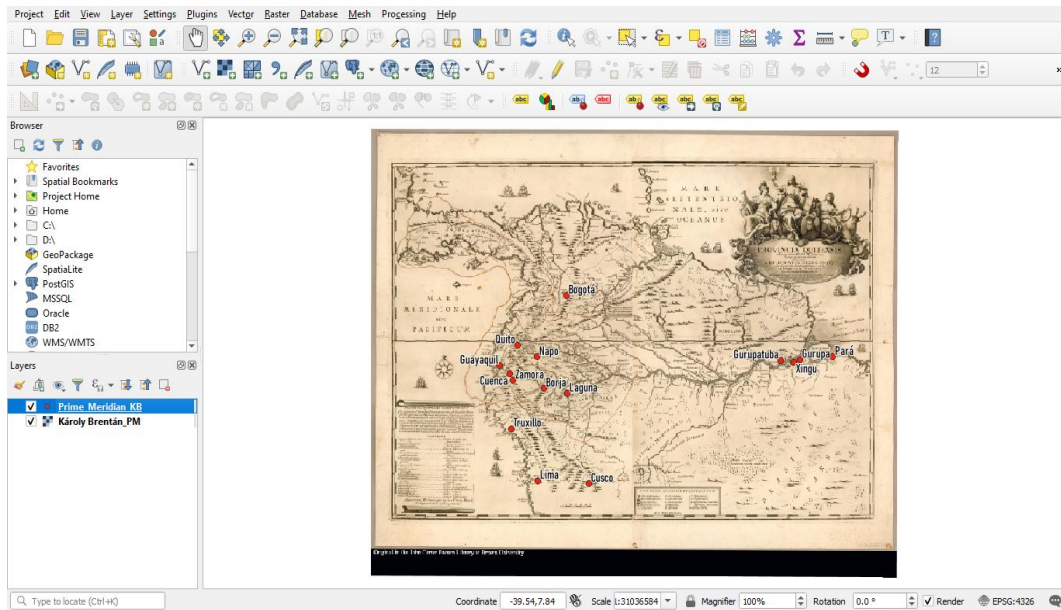
N°	Locations	$\lambda_a$ (°)	$360^\circ - \lambda_a$	$\lambda_G$ (°)	$\lambda_{orig}$ (°)
1	Bogotá	306,80	53,20	-74,07	-20,87
2	Borja	307,11	52,89	-77,55	-24,66
3	Caracas	311,88	48,12	-66,90	-18,78
4	Carthegene	304,04	55,96	-75,48	-19,52
5	Corupa	327,11	32,89	-51,62	-18,73
6	Cuenca	302,28	57,72	-80,00	-22,28
7	Curupatuba	324,62	35,38	-54,06	-18,68
8	Cuzco	309,37	50,63	-71,97	-21,34
9	Guayaquil	299,99	60,01	-79,89	-19,88
10	Jaen	304,24	55,76	-78,80	-23,04
11	Lima	302,75	57,25	-77,04	-19,79
12	Manta	298,55	61,45	-80,70	-19,25
13	Maracaibo	309,04	50,96	-71,61	-20,65
14	Napo	303,27	56,73	-77,81	-21,08
15	Pará	328,42	31,58	-48,49	-16,91
16	Pasto	302,25	57,75	-77,28	-19,53
17	Quito	301,38	58,62	-78,47	-19,85
18	S. Louiis de Maragnan	332,15	27,85	-44,26	-16,41
19	Trujillo	300,34	59,66	-79,03	-19,37
20	Zamora	303,55	56,45	-78,95	-22,50



**Figure 21.** Distribution of the locations of B\_SF.

**Table 11.** Calculation of prime meridian of B\_SF.

Nº	Locations	$\lambda_a$ (°)	$360^\circ - \lambda_a$	$\lambda_G$ (°)	$\lambda_{orig}$ (°)
1	Bogotá	300,61	59,39	-74,07	-14,68
2	Borja	297,30	62,70	-77,55	-14,85
3	Cuenca	294,00	66,00	-80,00	-14,00
4	Curupa	325,07	34,93	-51,62	-16,69
5	Curupatuba	322,50	37,50	-54,06	-16,56
6	Cuzco	300,39	59,61	-71,97	-12,36
7	Guayaquil	292,71	67,29	-79,89	-12,60
8	Jaen	294,44	65,56	-78,80	-13,24
9	Laguna	299,19	60,81	-75,67	-14,86
10	Lima	294,37	65,63	-77,04	-11,41
11	Napo	296,63	63,37	-77,81	-14,44
12	Negro	315,15	44,85	-60,01	-15,16
13	Pará	328,51	31,49	-48,49	-17,00
14	Pasto	294,73	65,27	-77,28	-12,01
15	Piura	291,57	68,43	-80,65	-12,22
16	Quito	293,39	66,61	-78,47	-11,86
17	Topayós	321,35	38,65	-54,94	-16,29
18	Truxillo	292,48	67,52	-79,03	-11,51
19	Xingú	324,74	35,26	-52,25	-16,99
20	Zamora	293,76	66,24	-78,95	-12,71



**Figure 22.** Distribution of the locations of E\_KB.

**Table 12.** Calculation of prime meridian of E\_KB.

N°	Locations	$\lambda_a$ (°)	$\lambda_G$ (°)	$\lambda_{orig}$ (°)
1	Bogotá	-76,45	-74,07	2,38
2	Borja	-78,64	-77,55	1,09
3	Cuenca	-81,93	-80,00	1,93
4	Cuzco	-74,28	-71,97	2,31
5	Guayaquil	-82,89	-79,89	3,00
6	Gurupa	-53,83	-51,62	2,21
7	Gurupatuba	-55,71	-54,06	1,65
8	Laguna	-76,36	-75,67	0,69
9	Lima	-79,21	-77,04	2,17
10	Napo	-79,29	-77,81	1,48
11	Pará	-50,64	-48,49	2,15
12	Quito	-81,20	-78,47	2,73
13	Truxillo	-81,78	-79,03	2,75
14	Xingú	-54,42	-52,25	2,17
15	Zamora	-81,61	-78,95	2,66

It should be added that the name of the locations was taken from each map, so there may be spelling mistakes or not coincidence with which it currently has. With the calculated data, an average  $\lambda_{orig}$  can be determined for each map and its corresponding standard deviation, which indicates the margin of error of the process (Table 13). In relation to the C\_LC and D\_EB maps,

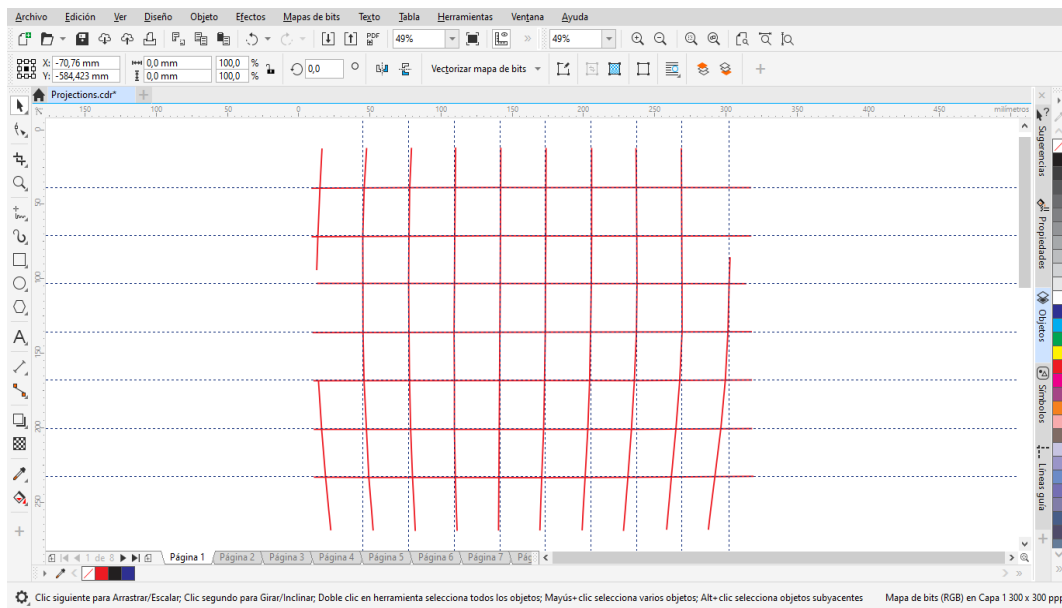
it was not necessary to carry out the previous procedure since each author described the meridian of origin used in their work.

**Table 13.** Meridian of origin of the maps.

Map	Mean $\lambda_{orig}$ (°)	Standard deviation	Meridian of origin
A_GI	-20,16	+/- 1,98	Ferro (-18°)
B_SF	-14,07	+/- 1,94	Tenerife (-16°)
C_LC	-	-	Paris Observatory (2°)
D_EB	-	-	London (0°)
E_KB	2,09	+/- 0,64	Paris Observatory (2°)

#### 4.4. DETERMINATION OF THE PROJECTION

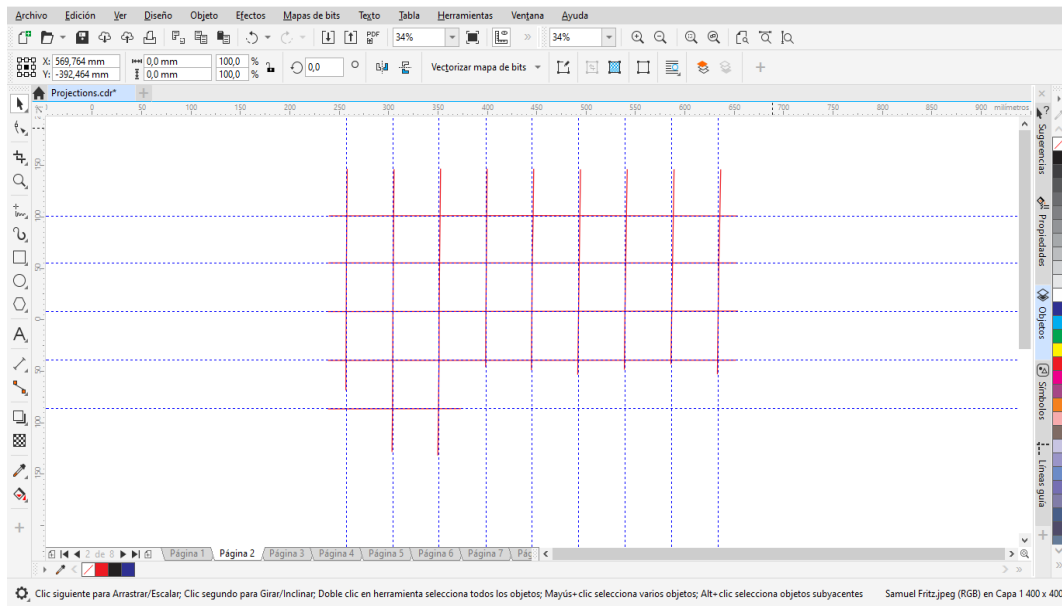
Using CorelDRAW 2020 program, the grid drawn on each map was delineated for a better visualization of its shape and the angles formed between meridians and parallels. Then, the distances between each of the meridians and parallels were calculated, taking the left and upper sides of the map as a reference (Table 14 to 16). The origin of the measurements for the parallels is the equatorial line, for which positive positions are calculated for northern latitudes and negative positions for southern latitudes; in the case of meridians, the origin of the measurements is a random meridian from which the positions to its left are negative and to its right are positive. For a better visualization of the process, a screenshot of how each grid looks like is included (Figure 23 to 25).



**Figure 23.** Drawn grid of A\_GI.

**Table 14.** Distance between each meridian and parallel of A\_GI.

Parallels (°)	Position (mm)	Distance with the previous parallel (mm)	Meridian (°)	Position (mm)	Distance with the previous meridian (mm)
10	64,445	32,376	305	-96,363	32,106
5	32,069	32,069	310	-64,257	32,139
0	0	0	315	-32,118	32,118
-5	-32,310	32,31	320	0	0
-10	-64,678	32,368	325	31,753	31,753
-15	-97,355	32,677	330	63,957	32,204
-20	-129,382	32,027	335	96,049	32,092
			340	127,629	31,58
			345	160,692	33,063

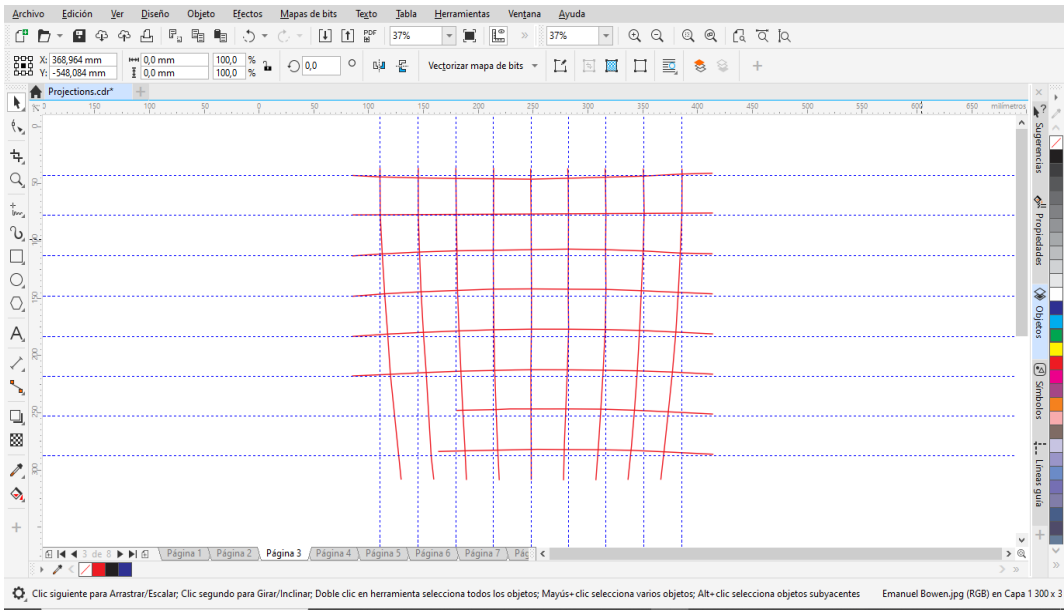


**Figure 24.** Drawn grid of B\_SF.

**Table 15.** Distance between each meridian and parallel of B\_SF.

Parallels (°)	Position (mm)	Distance with the previous parallel (mm)	Meridian (°)	Position (mm)	Distance with the previous meridian (mm)
10	93,068	45,767	200	0	0
5	47,301	47,301	205	47,29	47,29
0	0	0	300	94,06	46,77
-5	-47,466	47,466	305	141,43	47,37
-10	-94,606	47,14	310	187,948	46,518
			315	235,227	47,279
			320	282,192	46,965
			325	329,584	47,392

330	376,545	46,961
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**Figure 25.** Drawn grid of D\_EB.

**Table 16.** Distance between each meridian and parallel of D\_EB.

Parallels (°)	Position (mm)	Distance with the previous parallel (mm)	Meridian (°)	Position (mm)	Distance with the previous meridian (mm)
4	34,5	34,5	82	0	0
0	0	0	78	34,693	34,693
-4	-35,888	35,888	74	69,338	34,645
-8	-71,1	35,212	70	103,354	34,016
-12	-106,213	35,113	66	137,597	34,243
-16	-140,743	34,53	62	171,684	34,087
-20	-175,714	34,971	58	205,829	34,145
-24	-210,617	34,903	54	240,701	34,872
			50	275,145	34,444

With the drawn grid, the type of line with which the meridians and parallels were represented and the distance between each of them, the most probable projection used was determined (Table 17). In relation to the C\_LC and E\_KB maps, it was not possible to carry out the previous procedure since each author did not depicted any grid in their work.

**Table 17.** Projection of the maps.

Map	Analysis of parallels	Analysis of meridians	Projection
A_GI*	Straight lines that keep a uniform distance between each of them.	Concave curves toward the central meridian, which appears to be located near the 320°. They keep a uniform distance between each of them.	Sinusoidal
B_SF	Straight lines that keep a uniform distance between each of them.	Straight lines that keep a uniform distance between each of them.	Plate Carree
D_EB	Equator is a straight line, other parallels are concave curves toward their respective pole and keep a uniform distance between each of them.	Concave curves towards the central meridian, which appears to be located at 66°. They keep a uniform distance between each of them.	Stereographic in equatorial aspect

#### 4.5. PROCESS OF GEOREFERENCING

The data determined in the previous stages allowed to perform a correct georeferencing of the images using the Rectify (Georeference) Imagery tool of the Global Mapper v20.0 program (Table 18). An adjustment was made with 4 control points for each of the maps, with the exception of the B\_SF in which 6 control points were used, for a better visualization of the process, a screenshot of the control points distribution is included (Figure 26 to 30).

**Table 18.** Data to perform the georeferencing.

Map	Projection	Meridian of origin	Central meridian
A_GI	Sinusoidal	Ferro (-18°)	316°
B_SF	Plate Carree	Tenerife (-16°)	-
C_LC	Plate Carree <sup>26</sup>	Paris Observatory (2°)	-
D_EB	Stereographic in equatorial aspect	London (0°)	-66°
E_KB	Plate Carree <sup>27</sup>	Paris Observatory (2°)	-

<sup>26</sup> This projection was assumed according to the historical research "Sailing Down the Amazon River: La Condamine's Map" (Cintra & Freitas; 2011).

<sup>27</sup> This projection was assumed, no previous study was found about this parameter.

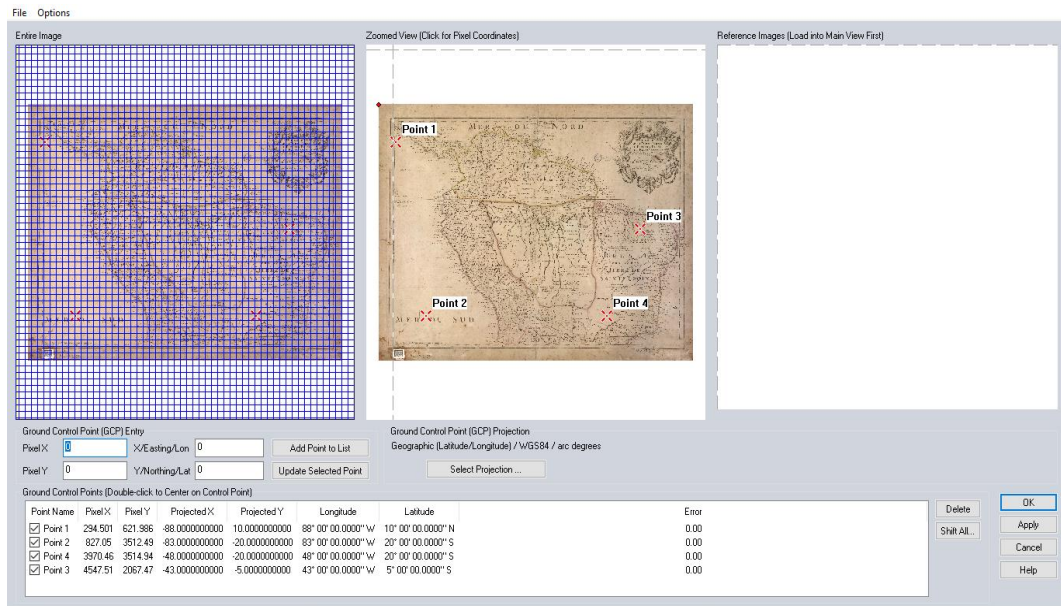


Figure 26. Control points distribution of A\_GI.

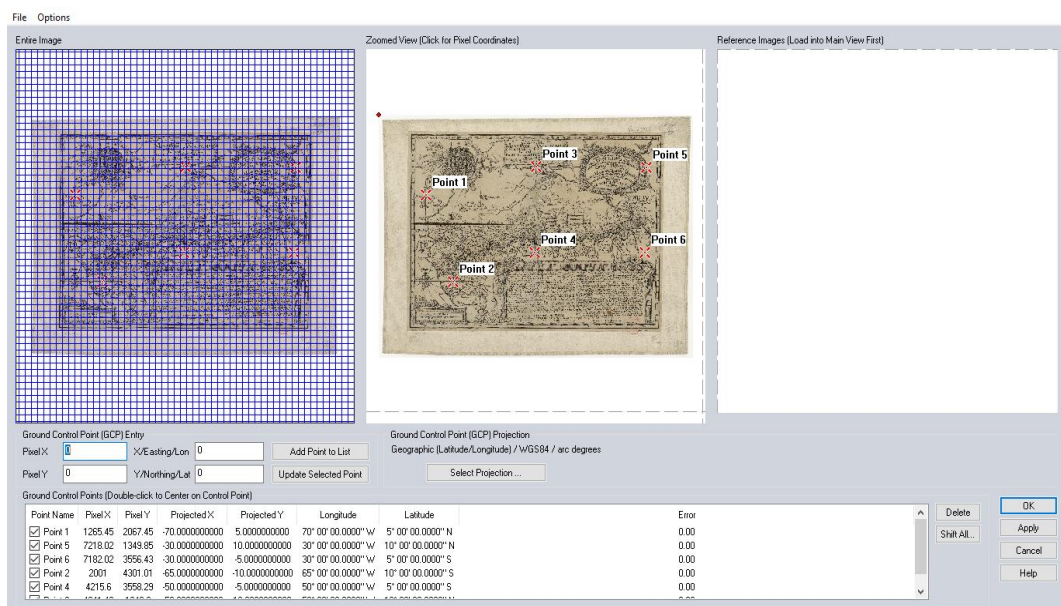


Figure 27. Control points distribution of B\_SF.



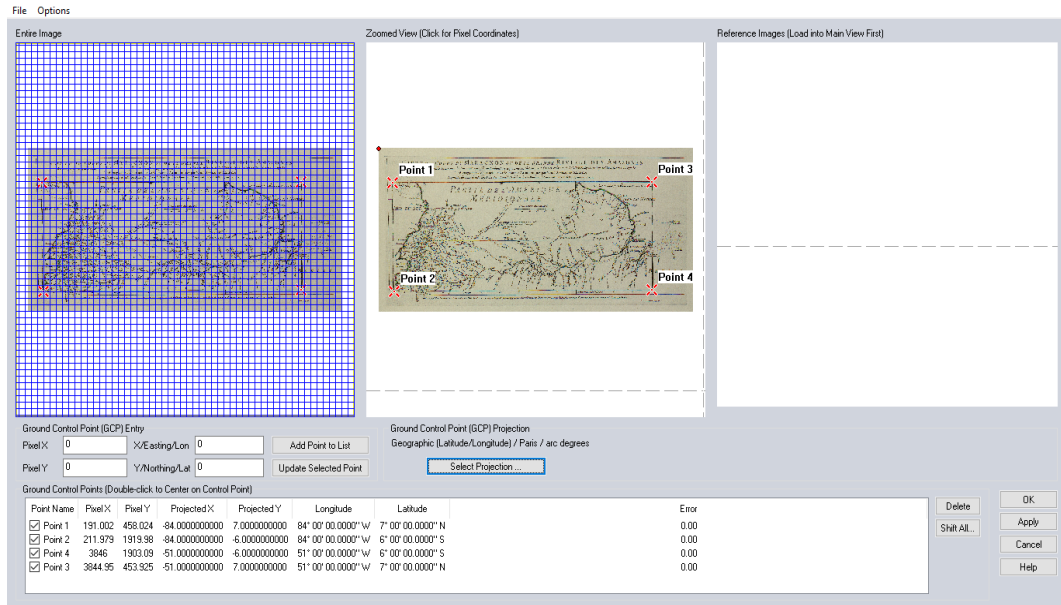


Figure 28. Control points distribution of C\_LC.

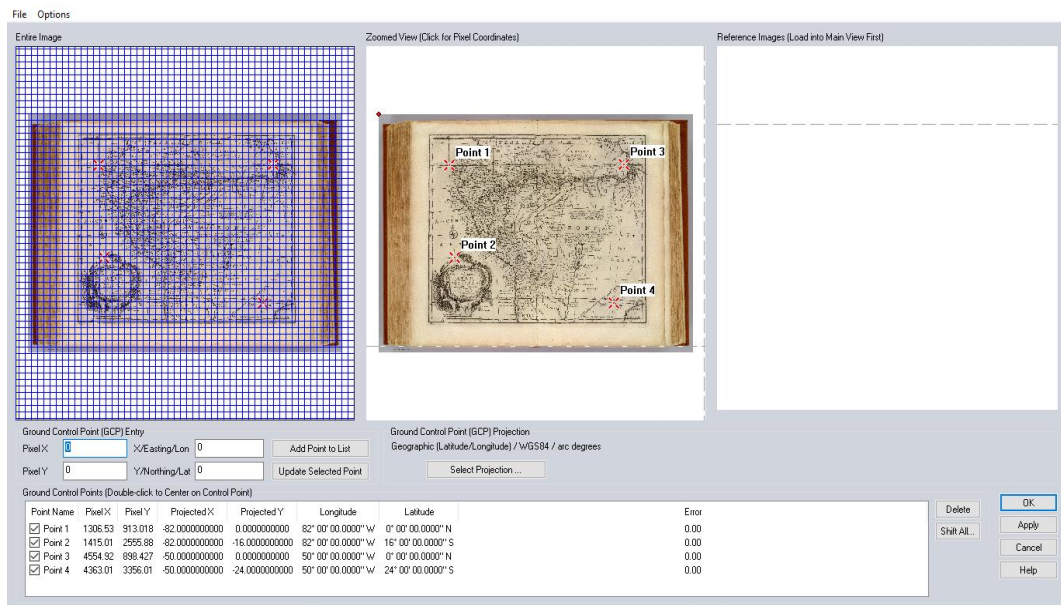
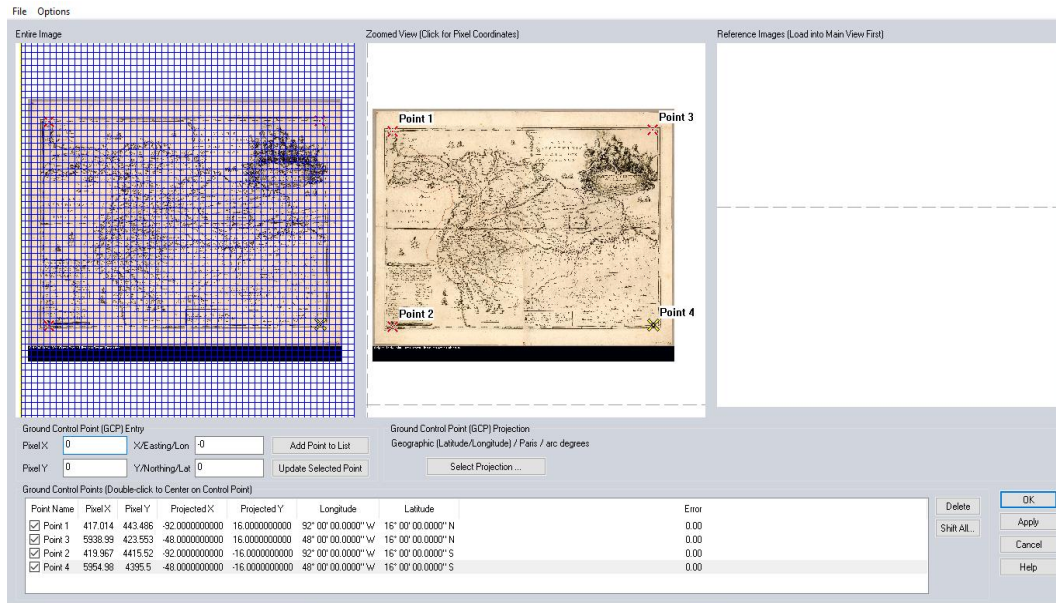


Figure 29. Control points distribution of D\_EB.



**Figure 30.** Control points distribution of E\_KB.

Once each one of the georeferencing process was finished and its correct execution was verified, the images were exported using the Layer - Export option to GeoTIFF (.tif) format together with their corresponding PRJ file (.prj).

#### 4.6. DIGITALIZATION OF THE MAIN FEATURES

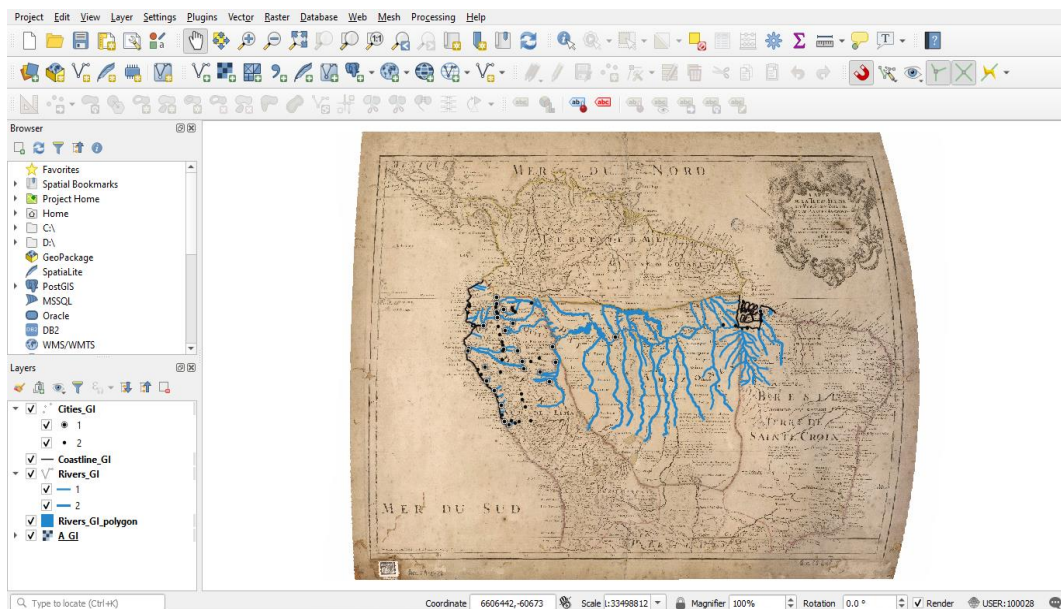
With the georeferenced images, the digitalization of the main features such as cities, rivers and coastlines began using the QGIS Desktop 3.10.11 program. Later, the Project Coordinate Reference System (CRS) was defined with the Custom Coordinate Reference System Definition option in which the required projections were created based on the parameters described in Table 18. Then, a GeoPackage (.gpkg) was created to store the digitalized shapefiles (.shp), the projection for these files is EPSG: 4326 (WGS84) to facilitate their manipulation and later use in other programs.

Using the New GeoPackage Layer option, the necessary shapefiles were created to represent the cities, rivers, and coastlines, setting the geometry type (point, line, or polygon) and the fields of the attribute table (name and level). Then, the digitization process was carried out, in the case of the cities and rivers, these elements were classified according to the symbology represented by each author in the original map, establishing categories in reference to their importance and flow, respectively. Finally, the attribute table was loaded with the map information and a particular style was defined for each shapefile that allows a quick

identification of the entity it represents (Table 19). For a better visualization of the process, a screenshot of the digitalized map is included (Figure 31).

**Table 19.** Information of each shapefile created.

Name	Feature	Geometry type	Attribute information
Cities_GI	City	Points with different symbols	Name and level
Rivers_GI_polygon	Main river	Polygon	Name
Rivers_GI	Secondary rivers and tributaries	Lines with thickness variation	Name and level
Coastline_GI	Coastline	Line	-



**Figure 31.** A\_GI digitalized map.

Once each one of the digitalization process was finished and its correct execution was verified, the shapefiles were exported using the Export option to GeoJSON (.geojson) format.

#### 4.7. COMPARISON OF THE MAPS

The process of comparing the maps was carried out using MapAnalyst version 1.3.35, each image was imported by the Import Old Map Image option and defining its resolution (dpi). Later, each one of the control points between the old map and Open Street Map was determined using the Set New Point option and a name was assigned that allows its identification. In relation to the control points, common locations were selected among the five maps in order to

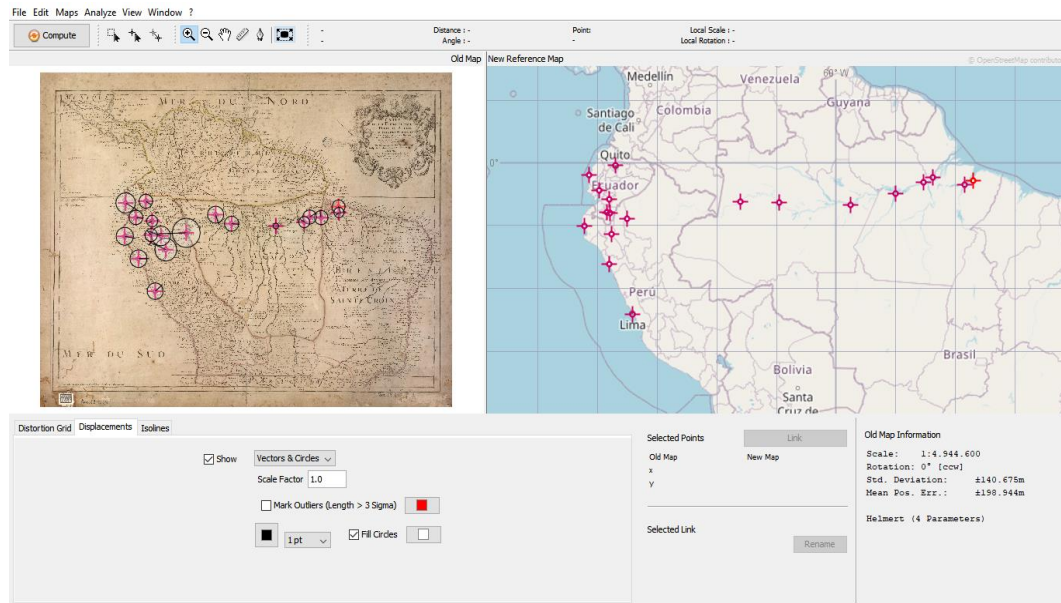
better visualize and interpret the results, these sites were easily identifiable cities and main river mouths that in few exceptions were not represented (Table 20).

**Table 20.** Locations of the control points.

N°	Description	A_GI	B_SF	C_LC	D_EB	E_KB
1	city	Borgia	Borja	Borja	Borja	Borja
2	city	Cuenca	Cuenca	Cuenca	Cuenca	Cuenca
3	city	Guayaquil	Guayaquil	Guayaquil	Guayaquil	Guayaquil
4	city	Jaen	Iaen	Jaen	Jean	Jaen
5	city	-	Laguna	la Laguna	-	Laguna
6	city	Lima	Lima	-	Lima	Lima
7	city	Loxa	Loxa	Loxa	Loxa	Loxa
8	river mouth	Madere	Madera	Madere	Madera	Madera
9	city	Manta	-	-	Manta	-
10	city	-	Napo	Napo	Napo	Napo
11	river mouth	-	Napo	Napo	Napo	Napus
12	river mouth	-	Negro	Negro	Negro	Negro
13	city	Para	Para	Para	Para	Para
14	river mouth	Parou	Parú	Paru	-	-
15	city	Payta	Payta	Payta	Payta	Payta
16	river mouth	Putomayo	Putumayo	Putumayo	Putumayo	Putumayo
17	city	Quito	Quito	Quito	Quito	Quito
18	river mouth	Tapaysos	Topayós	Topayos	Topayos	Topayos
19	river mouth	-	Tefe	Tefe	-	Tefe
20	river mouth	Tocantins	Tocantin	Tocantins	Paranayba	Tocantin
21	city	Truxillo	Truxillo	-	Truxillo	Truxillo
22	river mouth	Yay	-	Yari	-	Yary
23	river mouth	Yurupau	Yurupa	Yupura	Yapura	-
24	city	Zamora	Zamora	Zamora	Zamora	Zamora

Once the control points were correctly determined and distributed, the Compute option was selected, generating the graphical visualization of the comparison. The selected method was Displacements showing the variation of the position using Vectors & Circles at a scale factor of 1 (Figure 32). Additionally, the program generated a statistical report of the process that can be consulted in the Analyze tab, Show Report of Last Computation option, which contains the following sections:

- Description of transformation
- Transformation parameters and standard deviations computed
- Standard deviation and root mean square position error for all points
- Residuals

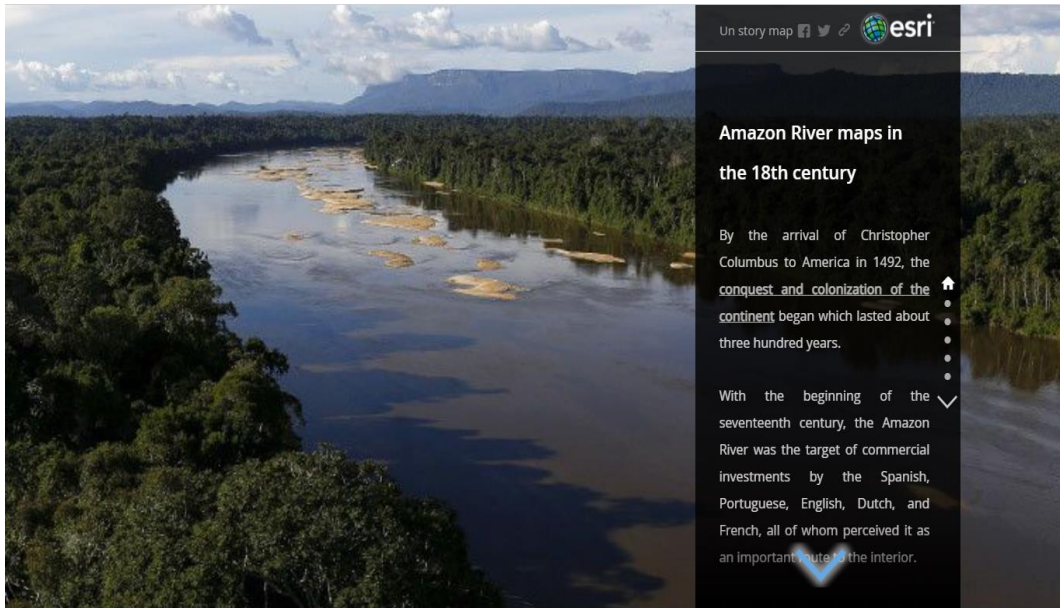


**Figure 32.** Process of comparison of A\_GI using MapAnalyst.

Once each one of the comparison process was finished, the images were exported using the Export Old Maps Graphics to JPEG (.jpg) format.

#### 4.8. STORY MAP IN ARCGIS ONLINE

In order to visualize the information generated through a virtual environment, ArcGIS Online was used, this is a cloud-based mapping and analysis solution. The shapefiles in GeoJSON format (.geojson) were loaded one by one (cities, coastlines, and rivers) with the same style previously defined in QGIS Desktop 3.10.11 program, to have a reference to the current state of the terrain a base map of satellite images was defined. Once the five web maps had been created, it was chosen to make a web mapping application called Story Map Journal, in which the cartography generated and the most outstanding information of each author are shown at the same time (Figure 33). A brief summary is presented about the life of each author, a link to a website with their biography, a description and the bibliographic reference of the map made, and the map compared to the reality carried out in MapAnalyst.



**Figure 33.** Story Map Journal.

## PRESENTATION AND DISCUSSION OF THE RESULTS

The discussion of the results is based on the maps prepared with the digitalized shapefiles viewed through ArcGIS Online and the images produced by the comparison made with MapAnalyst, a concise description and visual analysis of the main characteristics of the maps under study will be presented.

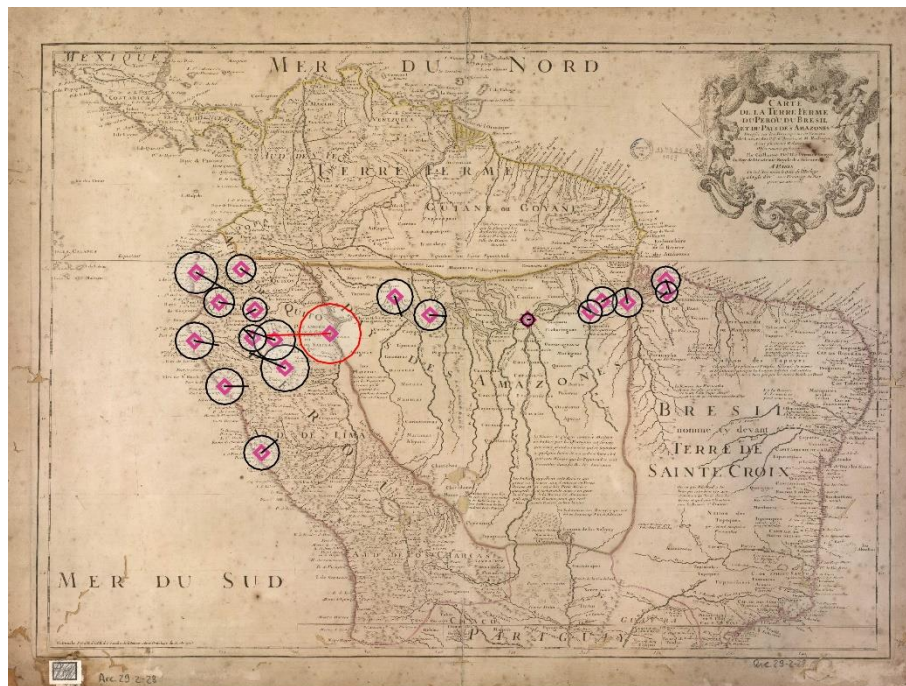
### 5.1. A\_GI MAP

The cities were represented in two different categories according to the symbol used (a type of house and a circle), visibly there was a greater knowledge of the cities in Ecuador and Peru, while in the Amazon and the Brazilian coast there is a reduced number of cities. The hydrographic network is scarce in the west side, in the northwest only the Coca, Napo, d'Ambato, and Curaray rivers can be seen, while to the southwest the Xauxa ou de Maragnon river and later the Moyobamba (Marañón) river mark the beginning of the R. des Amazones. In the middle basin, few secondary rivers are recognized such as Putumayo, Yurupau (Japurá), Madere (Madeira), and Basururu, the last one has a high probability of representing the Rio Negro. Upon reaching the river mouth at the Mer du Nord (Atlantic Ocean), the Tapaysos (Tapajós), des Paranayba (Xingu), Para, des Tocantins, Parou (Parú) and Yay (Jari) rivers are represented, among the main ones to be mentioned.

The coastal profile is detailed, on the Ecuadorian coast the Isla de la Plata and Isla Puna are already displayed. The Peruvian coast has been represented in an irregular way, exaggerating the landforms from Truxillo (Trujillo) to Lima. The opposite case is visualized on the Brazilian coast since the coastal profile and the islands at the river mouth do not match with reality, being represented several fragmented islands of medium extension.

The longitudes on the left side were displaced towards the east, the opposite case happened on the right side which were displaced towards the west, whereby the longitudinal extension of the map is less than the reality. Regarding the positional displacements, it can be observed that it exist to a greater extent in the area of Ecuador and Peru, being the location of S. Francois de Borgia (Borja) an outlier of the control points. Likewise, it is worth noting the precision with respect to the location of the Madere river mouth. This great difference that can be observed in the terms of positional displacement is because the author took different sources of consultation to carry out his work (in the map title the author described the names of his

sources), therefore, at the mouth of the Amazon River a shorter positional displacement is shown (Figure 34).



**Figure 34.** A\_GI compared map.

## 5.2. B\_SF MAP

The map contains considerable information regarding cities, indigenous ethnic groups, rivers, geographical features, relief, symbology, among others, without considering the account of the exploration carried out by the author during his period as missionary. The document can be divided into two for an analysis starting from the central meridian to the west, in the Spanish territory at that time an important level of detail is displayed, the opposite case occurs from the central meridian to the east (Portuguese territory) in which the detail is lower.

The cities were represented in three categories according to the symbol size used. A greater knowledge of the cities in Ecuador and Peru is maintained, the first towns appear in the Amazon such as Laguna, Tarmas, Papateruanas, Topayós, as well as Spanish villages where indigenous groups were concentrated for their evangelization. The hydrographic network shows an adequate knowledge of the area, in the northwest is displayed the appearance of tributaries and secondary rivers such as Napo, Tigre, Paftaca (Pastaza) and Santiago. In the southwest, in addition to showing the possible origin of the Amazon River in Lake Lauricocha, the Guallaga (Huallaga) and Vcayale (Ucayali) rivers are already shown. In the middle basin the



representation of the secondary rivers is numerous: Putumayo, Yupura (Japurá), Negro, de las Trompetas (Trombetas), Yauari (Javary), Yurua (Juruá), Tefe, Madera (Madeira); however, those that flow from the south to the north were represented with a short and schematic course due to the inclusion of an extensive legend. Upon reaching the river mouth at the Mar del Norte (Atlantic Ocean), the least knowledge is evident, just highlighting the representation of the Topayos (Tapajós), Aoripana (Xingu), Tocantin and Paru rivers among the most recognized.

The coastal profile has little accuracy with reality, an almost vertical coastline was represented from Cabo de San Francisco to Punta de Sta. Helena (peninsula of Santa Elena), Punta de Aguja (peninsula of Illescas) in the northern part of Peru looks oversized and the river mouth on the Brazilian coast was represented by countless islands of small and medium size. There is a displacement of the longitudes towards the west on the left side, however, this displacement is corrected along the map until reaching the right side, in which the displacement is towards the east, whereby the longitudinal extension of the map is greater than the reality. The positional displacement shows the lower precision of the control points in Ecuador and Peru, although clearly along the river course it can be presumed that there were adjustments in the determination of the position, that allowed greater precision between the Rio Negro and Paru river until reaching the mouth of the Amazon River (Figure 35).

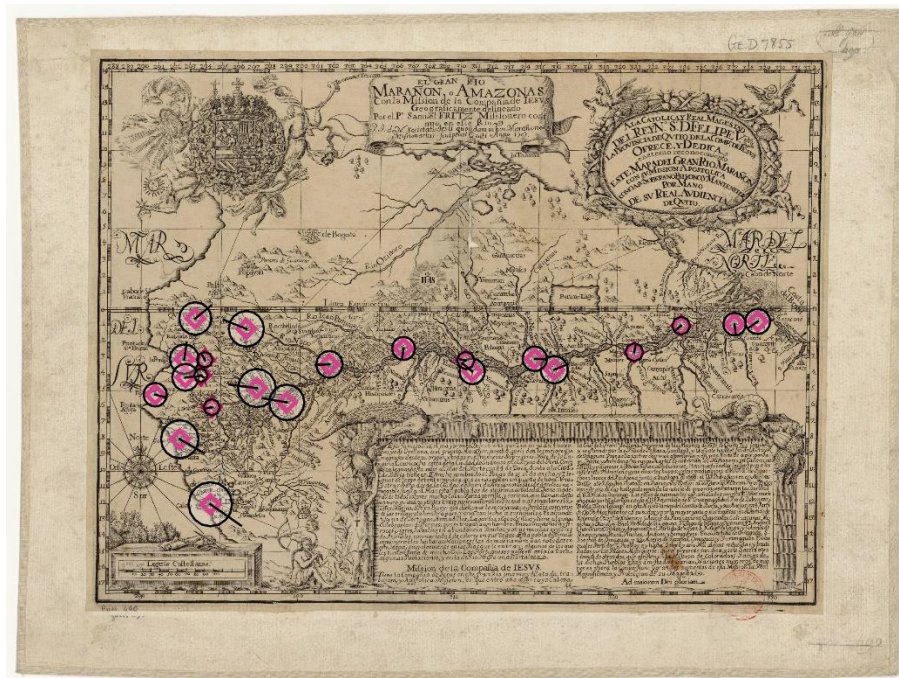


Figure 35. B\_SF compared map.

### 5.3. C\_LC MAP

Being the work of Samuel Fritz earlier, and in order to establish a comparison between it and his map, the author included the Amazon River course and its most important tributaries drawn by Fritz as a background (dotted line) from the meridian that passes through Jaen to the river mouth at the Atlantic Ocean. The cities were represented in two different categories according of the symbols used (a circle with a cross on top and a circle), more cities in the Amazon are included such as Yameos, S. Joachim d’Omaguas, S. Pedro, S. Paulo, Tefe and Coari. Regarding the hydrographic network, its representation is simplified with lines of variable thickness according to the flow of the rivers. The relief was also included in the representation, determining the appearance of mountain ranges in Ecuador and the north of Peru.

The detail increased in the east side of the map with respect to the tributaries of the secondary rivers, the Aguaricu (Aguarico), Bobonaza, Morona, Paute, St. Yago (Santiago) and Chinchipe rivers are displayed. Similarly, that in Fritz map those rivers that flow from the south to the north such as Guallaga, Ucayale, Yauari (Javary), Tefe, Purus, la Madere (Madeira) were represented with a short course. It should be noted the inclusion of the Blanco River (Branco) as a tributary of the Rio Negro and the denomination of the Xingu river with that name.

The coastal profile does not match in the part of the Gulf of Guayaquil, being deformed towards the continent, the Isle des Joanes ou de Marayo (Ilha de Marajó) is represented at the river mouth in the Mer du Nord (Atlantic Ocean) surrounded by few small islands. The longitudes on the left side were displaced towards the east, the opposite case happened on the right side which were displaced towards the west, whereby the longitudinal extension of the map is less than the reality. The positional displacement is variable, in Ecuador and the northern Peru a greater displacement is visualized except for Jaen and Borja compare with the locations near the Brazilian coast, the mouth of the Napo River is the outlier of the control points while the mouths of the Rio Negro and la Madere River show the best positional precision. It can be presumed that in several positions the measurements did not follow the same methodology, or they were not carried out and external data sources were taken as reference (Figure 36).

#### 5.4. D\_EB MAP

The map is part of a world atlas prepared by the author, according to his description the sources of consultation were French maps from which he took the information and represented it according to his criteria. The cities were represented in two different categories according to the symbol used (a type of house and a circle), more cities are included in the eastern part of

Ecuador and Peru. In the Amazon and the Brazilian coast, main cities are consolidated, and secondary cities appear such as Vrubu, Arubaquis, Apamas, Yavacuara and Xingu. There is a wealth of information detailing the indigenous ethnic groups and the coastal landforms.

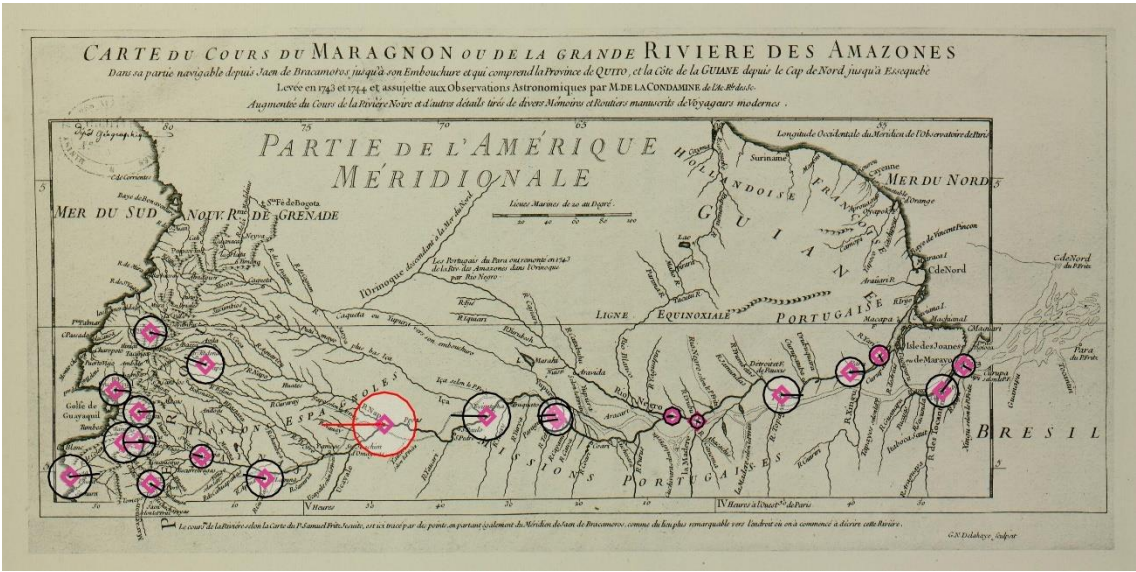


Figure 36. C\_LC compared map.

The hydrographic network is not detailed since the representation only focuses on the main course of the Amazon River and its secondary rivers. Unlike the previous maps, this highlight those rivers that flow from the south to the north in the upper and middle basin. Their long courses stand out, but they have low precision in relation to their real trajectory and the use of previous names to the current ones such as Guanuco (Huallaga), Combos (Uyacali), Cuchivara (Purus), among others. Upon reaching the river mouth at the Atlantic Ocean, the least knowledge is evident, just highlighting the representation of the Topayos (Tapajós), Aoripana (Xingu), Paranaiba (Tocantins) and Para rivers among the most recognized.

The coastal profile in Ecuador and Peru is irregular, the presence of islands such as I. d Plata, I. d Salango and I. de la Puna is visualized. The river mouth in the Atlantic Ocean does not match with reality since it was represented by islands of medium and small extension with a latitudinal displacement of the entire area towards the south. The longitudes on the left side were displaced towards the east while on the right side there is no considerable displacement, whereby the longitudinal extension of the map is less than the reality. The positional displacement is variable, on the Ecuadorian and Peruvian coasts it is greater compared to the central zone of both countries, the city of Napo (Tena) and St. Francois d' Borja (Borja) show the largest displacement while at the Topayos River mouth is the shortest. Finally, on the Brazilian coast a lower positional precision is visualized (Figure 37).

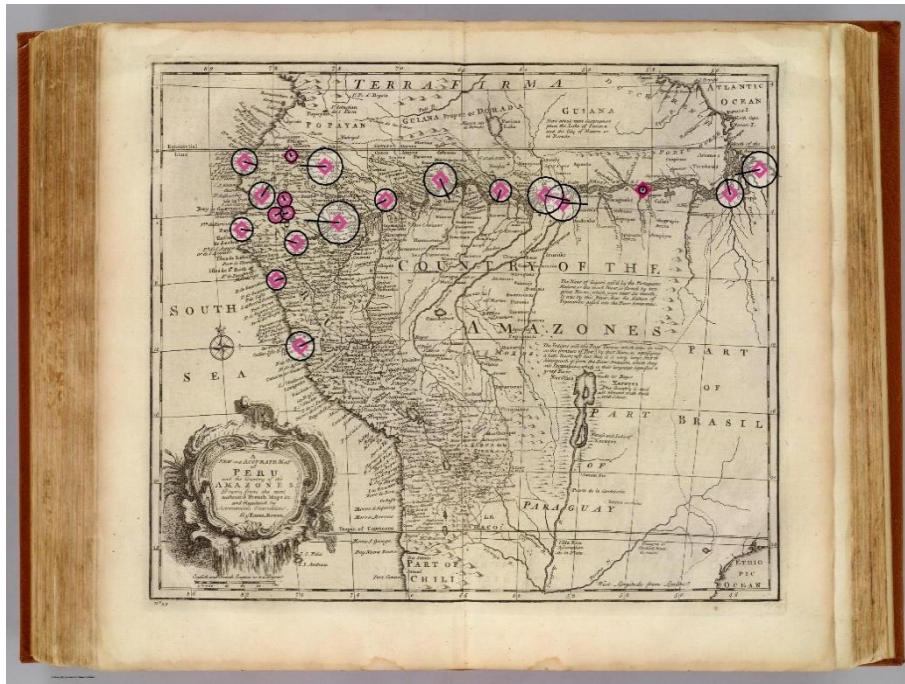


Figure 37. D\_EB compared map.

### 5.5. E\_KB MAP

The cities were represented in three categories according to the symbol size used and information regarding their religious hierarchy is included, a greater presence of cities is displayed on the Brazilian coast as Gurupatuba, Vaugovara, Paru, Gurupa, Araparipudi, Pacayas. The hydrographic network is detailed, the main and secondary rivers were represented by polygons of variable extension according to their flow, while the tributaries were represented with lines of the same thickness. This representation generated difficulty to understand the different categories of the rivers and it is established that the position and course of the tributaries are only schematic. Some information is displayed regarding the coastal landforms, the location of indigenous ethnic groups and elevation names such as Pechincha (Pichincha), Tiupullo, Cotopaxi, Ylinifsa (Illiniza), Chimborafso (Chimborazo), Sangay in the mountain ranges represented.

The author belonged to the same religious mission as Samuel Fritz, so it can be assumed that he had access to its reports and maps, therefore it is observed that basic information remains on the map supplemented with the data obtained from his explorations. In the northwest, the representation of the secondary rivers and the appearance of several tributaries without names are maintained. In the southwest, Lake Lauricocha continues to be the possible origin of the Maragnon River and the courses of Guallaga (Huallaga) and Ucayale (Ucayali) rivers are

complemented by their tributaries. The Yurupa (Japurá) mouth river has been fragmented into several connections with the Amazon River, partially resembling its reality. The rivers courses in the middle and lower basin, with the exception of the Rio Negro and Madera (Madeira) River, are represented with a medium length, possibly due to the scarce knowledge of the area.

The coastal profile in Ecuador and Peru is irregular considering that the river mouths towards the sea are wider and penetrate the continent. The Ins. De Joannes alias de Marayó (Ilha de Marajó) surrounded by few small islands was represented at the river mouth in the Mar Septentrio (Atlantic Ocean). The longitudes on the left side were displaced west while on the right side there is no considerable displacement, whereby the longitudinal extension of the map is greater than the reality. The positional displacement is greater in Ecuador and Peru compare with the control points along the river course and the Brazilian coast, the Napus (Napo) River mouth is an outlier of the control points. From the Tefe River mouth to the Brazilian coast, the positional precision improves so adjustments may have been made in the determination of the position (Figure 38).

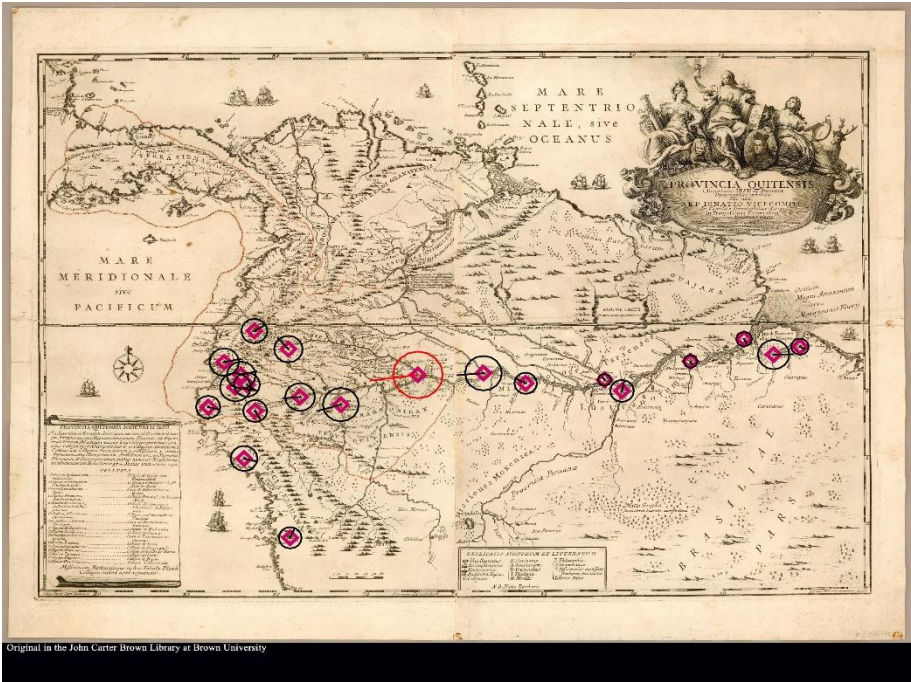


Figure 38. E\_KB compared map.

## CONCLUSIONS

The conclusions that can be formulated after the completion of this study are the following:

- The search for maps published during the eighteenth century was carried out in online databases belonging to the National Library of France, Huntington Digital Library, Library of Congress (USA), National Library of Brazil, National Library of Rio de Janeiro, Republic Bank of Colombia, Mariano Moreno National Library, among others. Once the maps were selected, a classification was established based on the depicted area by defining two classes (region or continent), the research was done with the region maps based on their greater level of detail and information.
- QGIS Desktop is effective to rephrase an old map and have a digital version of its information stored for later use, preserving each of the characteristics such as prime meridian, central meridian, ellipsoid, projection, among others, with which the author prepared his work.
- The comparison of old maps is viable and can be done using specialized software, in this case MapAnalyst is a program that allows the user to carry out this task and through three different visualization methods (distortion grids, vectors of displacement, accuracy circles, and isolines) the correlation between an old map and reality can be established.
- The methodology to carry out this type of studies must be standardized in order to have specific parameters to be compared between the old map and the reality, which would allow an objective and precise analysis to be obtained for the formulation of the results.
- The visual and descriptive process for the comparison of old maps must necessarily be complemented with the inclusion of statistical tables and mathematical analyzes in relation to the position of the objects, with which the accuracy achieved, and its corresponding error will be calculated. This study provides a cartographic base to continue working and mathematically determine which map best fits reality.
- The products obtained at the end of this work are five georeferenced images in Geotiff (.tif) format and their respective PRJ (.prj), one Geopackage (.gpkg) containing twenty two digitalized shapefiles (.shp), one Story Map Journal viewed using ArcGIS Online, and five images in JPG (.jpg) format with the comparison made in MapAnalyst.

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## DECLARATION

I, undersigned *Francisco Manuel Guerrero Narváez* (NEPTUN CODE: F5NJ9B), declare that the present master's thesis is my original intellectual product in full and that I have not submitted any part or the whole of this work to any other institution. Permissions related to the use of copyrighted sources in this work are attached.

I AGREE to the publication of the accepted master's thesis in pdf form on the website of the Department of Cartography and Geoinformatics.

Budapest, 15<sup>th</sup> May 2021.

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*(signature of the student)*

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