

**Eberhard Knobloch \***

***Presidential address on the occasion of the 2<sup>nd</sup> International Conference of the European Society for the History of Science***

## **Alexander von Humboldt: The explorer and the scientist**

### **Abstract**

On June 5, 1799 Alexander von Humboldt, explorer and scientist, left La Coruña in Spain to go to Cumaná, Venezuela. On August 3, 1804 he arrived again in Bordeaux, France. The paper deals with five aspects of this famous journey:

- The itinerary of the American journey;
- Scientific aims: Humboldt's journeys and scientific activities were two sides of the same coin;
- Methodology: Humboldt explained in detail his positivistic scientific methodology in his treatise *On the isothermal lines and the distribution of heat on the earth* (1817);
- Achievements and results: The old Humboldt claimed only three merits: the geography of plants, the theory of isothermal lines and geomagnetism, and the isotherms as a case study;
- In the case of the isotherms, Humboldt spoke at great length about errors, limits, and advantages of the method of mean values.

### **Keywords**

*Interaction of forces, observations, instruments, empirical laws, method of mean values.*

### **(1) Introduction**

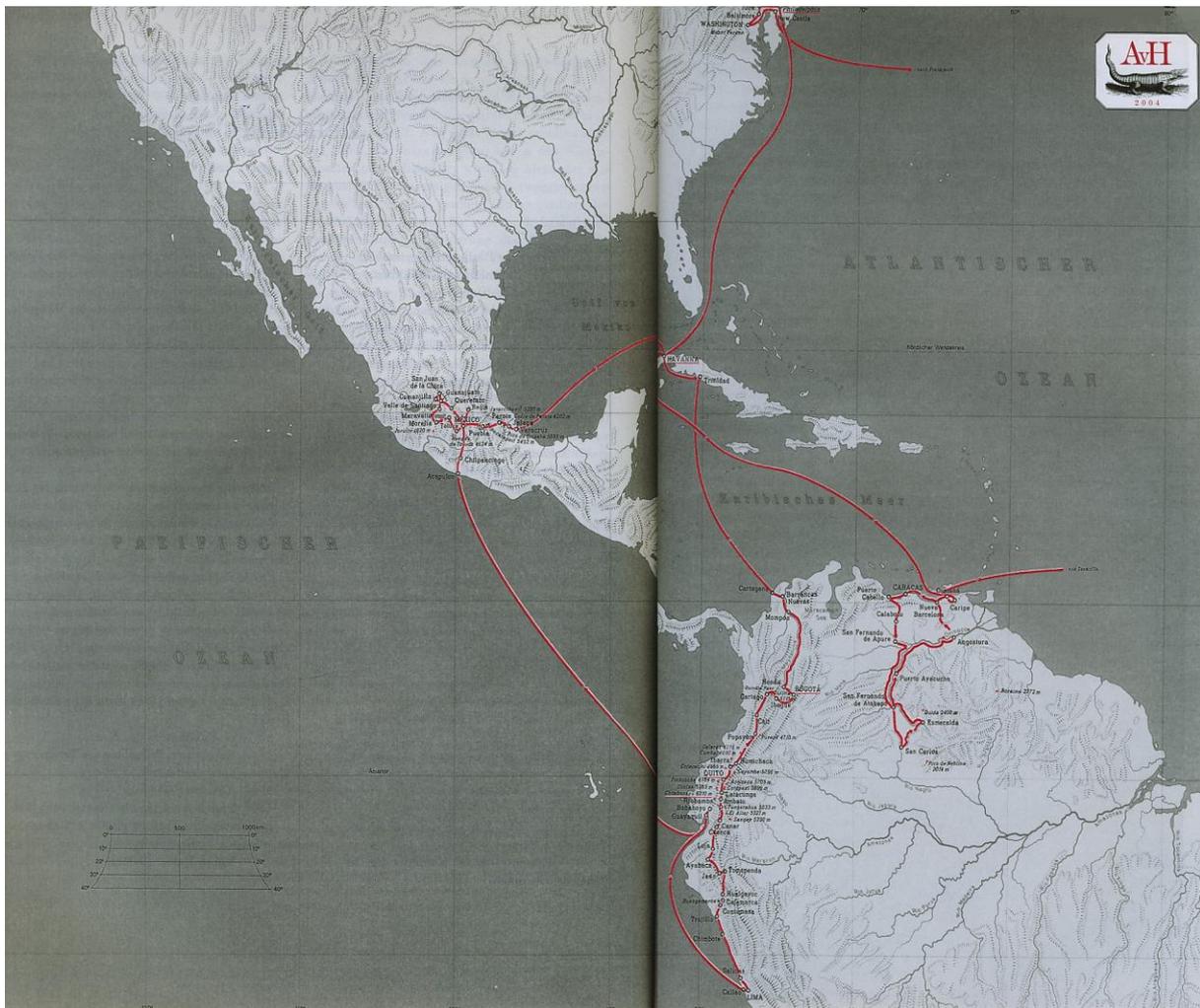
Alexander von Humboldt was, so to speak, a global player who preferred to live in Paris and who in 1827 only reluctantly came back to Berlin where he was born. When he was still very young he wanted to travel, and this desire remained strong up to the end of his life. His Parisian acquaintance Elisabeth de Pommard called it his "maladie centrifuge", his "centrifugal illness".<sup>1</sup> He began his first famous journey through the New World when he was 30 years old. He made his second not so famous journey through Russia, that is, through the Old World when he was 60 years old. He still worked on his book *Kosmos* wherein he described and interpreted his world-wide experiences when he was 90 years old.

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<sup>1</sup> See Moheit (1993), p. 246 and Moheit (1999), p. 182.

## (2) The itinerary of Humboldt's American journey



**Illustration 1**

Humboldt's itinerary was the result of a continuous improvisation. On June 5, 1799 he left La Coruña in Spain to go to Cumaná, Venezuela, where he arrived on July 16, 1799. He was away from Europe for more than five years. During that time he travelled in Cuba, Columbia (in those days called New Granada), Ecuador, Peru, Ecuador (a second time), Mexico (in those days called New Spain), Cuba (a second time), and the USA. On June 30, 1804 he left Newcastle, USA, and arrived in Bordeaux, France, on August 3. Originally, he planned to travel for two or three years: from La Coruña to the Canarian Islands, Havana, Mexico, Ecuador (Quito), Panama, and back to Spain.<sup>2</sup> Neither Venezuela nor Columbia nor Peru were originally included. In Venezuela he left the ship because of an epidemic disease. Only then he decided to explore the region of the Orinoco and Casiquiare.<sup>3</sup> In order to go from Venezuela to Panama he originally had planned to travel by land. His journey on the Rio Magdalena, over the Andes was not planned.

His complete independence from financial helpers enabled him to realize his itinerary according to the respective circumstances. This was a crucial difference between his own journey and that of his predecessors La Condamine, Bouguer, Malaspina, Cook, Bougainville. While he improvised the whole route, his research program was diligently planned and realized. One might take an arbitrary page from his *Journal de route* which enumerates the measuring data of his cruise from Spain to Venezuela:

<sup>2</sup> Humboldt (2003b), p. 176.

<sup>3</sup> Humboldt (1814–1825), vol. I, p. 217.

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ÉPOQUES 1799.	LATITUDE boréale.	LONGITUDE occidentale	OBSERVATIONS PHYSIQUES.																											
Juillet 11	11° 17'	57° 47'	<p>Beau temps; petit vent.</p> <table border="1"> <thead> <tr> <th>Heures.</th> <th>Thermomètre centigrade.</th> <th>Hygromètre de Deluc.</th> </tr> </thead> <tbody> <tr> <td>18<sup>h</sup> .....</td> <td>24°,2 .....</td> <td>60°</td> </tr> <tr> <td>20<sup>h</sup> .....</td> <td>24°,8 .....</td> <td>59°</td> </tr> <tr> <td>21<sup>h</sup> .....</td> <td>25°,2 .....</td> <td>58°,3</td> </tr> <tr> <td>23<sup>h</sup> .....</td> <td>25°,0 .....</td> <td>59°</td> </tr> <tr> <td>0<sup>h</sup> .....</td> <td>25°,2 .....</td> <td>58°,5</td> </tr> <tr> <td>2<sup>h</sup> .....</td> <td>26°,6 .....</td> <td>57°</td> </tr> <tr> <td>8<sup>h</sup> .....</td> <td>25°,0 .....</td> <td>60°</td> </tr> <tr> <td>11<sup>h</sup> .....</td> <td>23°,7 .....</td> <td>58°</td> </tr> </tbody> </table> <p><i>Hygromètre de Saussure</i> constamment entre 89° et 90°,7; sur le méridien de Surinam, à 80 lieues de distance des bouches de l'Orénoque et de la Barbade : pendant la nuit, un peu de pluie et un bel arc-en-ciel lunaire.</p>	Heures.	Thermomètre centigrade.	Hygromètre de Deluc.	18 <sup>h</sup> .....	24°,2 .....	60°	20 <sup>h</sup> .....	24°,8 .....	59°	21 <sup>h</sup> .....	25°,2 .....	58°,3	23 <sup>h</sup> .....	25°,0 .....	59°	0 <sup>h</sup> .....	25°,2 .....	58°,5	2 <sup>h</sup> .....	26°,6 .....	57°	8 <sup>h</sup> .....	25°,0 .....	60°	11 <sup>h</sup> .....	23°,7 .....	58°
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12	10° 46'	60° 54'	<p>Bon frais, surtout la nuit, vent d'est assez fort; mer agitée; ciel très-beau, mais vaporeux.</p> <p><i>Température</i> de l'Océan, 25°,8; temp. de l'air, 25°,3. <i>Cyanomètre</i>, 14°,4.</p> <p><i>Hygromètre de Saussure</i>, tout le jour, de 89°,5 à 90°,2. <i>Inclinaison magnétique</i>, 46°,95; oscillations, 229 (bonne observation).</p>																											
13	11° 16'	62° 45'	<p>Nuageux, grains; vent d'est très-frais; mer très-grosse; un peu de pluie, à une lieue de distance dans l'est-sud-est du cap septentrional de l'île de Tabago.</p> <p><i>Température</i> de l'Océan, 25°,8; temp. de l'air, 25°,1. <i>Hygromètre</i>, de 90° à 91°,8 (division de Saussure).</p>																											
14	11° 1'	64° 51'	<p><i>Température</i> de l'Océan, 25°,6; mais sur le bas-fond qui s'étend depuis l'île de Tabago à celle de la Grenade, 23°,1; temp. de l'air, 25°.</p> <p><i>Hygromètre de Saussure</i>, 91°,5 à 92°,7. <i>Inclinaison magnétique</i>, 47°,5; oscillations, 237; bonne observation. La côte montagneuse de Paria est relevée à 4 lieues de distance; petit frais, temps beau et serein.</p>																											

Illustration 2

Humboldt's data prove that he measured day and night whatever could be measured, the temperature of air and ocean, the moisture of the air, the blue colour of the sky, the magnetic inclination, etc.

## (2) Scientific aims

Humboldt explicitly pursued a double aim: to report on the visited countries and to collect facts in order to improve physical geography.<sup>4</sup> For him to travel and to do research work were two sides of the same coin. Already Johannes Kepler had equated astronomical research with a journey around the world:

<sup>4</sup> Humboldt (1814–1825), vol. I, p. 2f.

Qui vero hebetior est, quam ut Astronomicam scientiam capere possit, vel infirmior, quam ut inoffensa pietate Copernico credat, ei suadeo, ut ab hac peregrinatione mundana desistens, domum ad agellum suum excolendum se recipiat.<sup>5</sup>

Yet, I advise him that is unable to understand the science of astronomy, or is too fainthearted to believe Copernicus without disturbing his piety to desist from this journey around the world and to withdraw home to groom his little estate.

Kepler, however, was a theorist, Humboldt was an empiricist who collected data, facts. What did he aim at? He said it to his correspondents. On June 5, 1799 he wrote to Karl Ehrenbert von Moll:

Ich werde Pflanzen und Fossilien sammeln, mit vortreflichen Sextanten von Ramsden, einen Quadrant von Bird, und einen Chronometer von Louis Berthoud werde ich nützliche astronomische Beobachtungen machen können; ich werde die Luft chemisch zerlegen, — dieß alles ist aber nicht Hauptzwek meiner Reise. Auf das Zusammenwirken der Kräfte, den Einfluß der unbelebten Schöpfung auf die belebte Thier- und Pflanzenwelt, auf diese Harmonie sollen stäts meine Augen gerichtet seyn.<sup>6</sup>

I shall collect plants and fossils, I shall be able to make useful astronomic observations with an excellent sextant by Ramsden, with a quadrant by Bird, and a chronometer by Louis Berthoud; I shall conduct chemical analyses of the air, — but all that is not the main purpose of my expedition. Above all, I will observe the interactions of forces, the influence of the inanimate environment on plant and animal life. My eyes will constantly focus on this harmony.

Regarding the interaction of forces Laplace served as a model:

Tout est lié dans la nature, et ses lois générales enchaînent les uns aux autres, les phénomènes qui semblent les plus disparates.<sup>7</sup>

Laplace based his conviction on Newton's universal law of gravitation. No wonder that Humboldt dedicated his *Relation historique* to the French mathematician. He even transferred this conviction from the natural phenomena to natural science itself:

Les sciences physiques se tiennent par ces mêmes liens qui unissent tous les phénomènes de la nature.<sup>8</sup>

His journey to America was the ideal field of experiments. The aim of the journey, his convictions, methods, research program were mutually conditioned by each other. Mathematization was not his aim, he was well aware of his limited mathematical competence. Thus he wrote to Jean Baptiste Delambre on November 24, 1800:

... les instrumens que j'ai (des sextans de Ramsden et Troughton, un quart de cercle de Bird, un horizon de Caroches), [...] vous savez que je ne suis pas très-savant en mathématiques, et que l'astronomie n'est pas le but de mon voyage; cependant avec du zèle et de l'application, et en maniant journellement les mêmes instrumens, on parvient à faire quelque chose et à le faire moins mal.<sup>9</sup>

On January 27, 1804 Humboldt wrote from Puebla, Mexico, to Juan José Oteyza:

Usted sabe que nadie admira más que yo los profundos conocimientos matemáticos de los cuales usted está adornado y tendré motivos de elogiarlos públicamente.<sup>10</sup>

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<sup>5</sup> Kepler (1609), p. 33.

<sup>6</sup> Jahn, Lange 1973, p. 682.

<sup>7</sup> Laplace (1835), p. 377.

<sup>8</sup> Humboldt 1814–1825 I, p. 3.

<sup>9</sup> Moheit (1993), p. 118; Moheit (1999), p. 82f.

<sup>10</sup> Moheit (1993), p. 267; Moheit (1999), p. 202.

You know that nobody admires your profound mathematical knowledge more than I do, in which you excel and I shall have reason to praise it publicly.

Humboldt wept over his stupidity that prevented him from understanding Laplace's *Celestial Mechanics* though he admired the author and the work as well.<sup>11</sup>

### (3) Methodology

'J'ai la fureur des chiffres exactes', Humboldt wrote to Johann Gotthilf Fischer von Waldheim on March 20, 1837.<sup>12</sup> He measured whatever he could measure. He was especially proud of his instruments. Before he had left Germany he had learned to handle them. The famous painting by Friedrich Georg Weitsch dating from 1810 shows him with an Indian carrying a sextant in the plane of Tapi at the bottom of the Chimborazo.



**Illustration 3**

His methodology can be described as a reduction of phenomena to empirical laws which consisted of three steps: First, he collected observations, that is, measurements. Thus he got numerical elements that could be visualized. In such a way he hoped to discover empirical laws strictly confining himself to factual statements.

Jabbo Oltmanns elaborated the astronomical part of Humboldt's travelling report. They dedicated its German version to Franz baron von Zach and Karl Friedrich Gauss. In front of it they placed a citation taken from Zach's paper 'De vera longitudine et latitudine Erfordiae' (On the true longitude and latitude of Erfurt):

Quantum ad geographiae et astronomiae incrementum intersit, veras locorum positiones geographicas nosse, neminem latere potest nisi eum, qui, quem scientiae illae cum populi et patriae, emolumento nexum habeant, plane ignorat.<sup>13</sup>

How important it is for the advancement of geography and astronomy, to know the true geographical positions of localities, cannot be unknown to anybody except to him who completely ignores the connection those sciences have with the benefit of people and homeland.

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<sup>11</sup> Moheit (1993), p. 205f.; Moheit (1999), p. 148.

<sup>12</sup> Manuscript: Archives of the Russian Academy of Sciences F. 260, op. 2, Nr. 50, l. 11.

<sup>13</sup> Humboldt, Oltmanns (1810), Erster Theil, title page.

Humboldt was impelled by an unappeasable thirst for knowledge, an indescribable, intellectual curiosity as he called it (*curiosité*). It played a crucial role in his behaviour and was not always well understood by his hosts. An obtrusive missionary of San Fernando asked him for the true purpose of his journey which seemed to him to be risky and at least very useless.<sup>14</sup> He preferred good meat from cows, for him the travellers were but deplorable fools.

#### (4) Achievements and results

Some years ago, Fritscher and Urbani provided a survey of Humboldt's major geological concerns<sup>15</sup> — Pieper just published his booklet on Humboldt's geognosy of volcanoes<sup>16</sup> — : volcanic phenomena (volcanoes, thermal springs, geysers, steam and gas exhalations), a comparative geological and mineralogical survey of South America, petroleum geology, paleontology, mineralogy of South America.

Yet, the old, self-critical Humboldt claimed only three merits. On October 31, 1854, he wrote to his publisher Georg von Cotta:

Der wichtigen und eigentümlichsten Arbeiten von mir gibt es nur drei:

- die Geographie der Pflanzen und das damit verbundene Naturgemälde der Tropenwelt,
- die Theorie der isothermen Linien und
- die Beobachtungen über den Geomagnetismus, welche die über den ganzen Planeten auf meine Veranlassung verbreiteten magnetischen Stationen zur Folge gehabt haben.<sup>17</sup>

There are only three important and most characteristic achievements I have contributed:

- the geography of plants and the natural painting of the tropical world connected with it,
- the theory of the isothermal lines and
- the observations concerning geomagnetism, which have resulted, at my suggestion, in the establishment of magnetic stations throughout the whole planet.

Thus his geophysical results were in his eyes his own most important achievements. For that reason I selected his invention of the isotherms as an example in order to illustrate his scientific activities.

Towards the same Cotta he complained about the flawed handling of his journey report in Germany on September 20, 1847:

Das beste, was ich in meiner amerikanischen Reise geliefert, hat nie Leben in Deutschland gehabt, weil ich leider nicht deutsch geschrieben, schlecht übersetzt worden bin und weil die lebendigere Naturbeschreibung nicht von rein wissenschaftlichen und langweilig statistischen Elementen getrennt worden ist.<sup>18</sup>

The best contributions in my American journey were never received in Germany, because regrettably I did not write in German, was badly translated and because the vivid description of nature was not separated from merely scientific and boringly statistical elements.

Whatever Humboldt and Bonpland achieved, they achieved it taking many risks and being continuously tormented by mosquitos. Several times, Humboldt was in mortal danger: Humboldt could not swim when the ship was on the verge of capsizing on the Orinoco, he was threatened by wild animals, once by a native as well.<sup>19</sup> The mosquitos represented the normal situation. Humboldt told a characteristic story in this respect.<sup>20</sup> In 1795, all mosquitos had suddenly disappeared for twenty minutes in Esmeralda at the upper Orinoco. But instead of enjoying this extraordinarily unusual situation the inhabitants feared the end of the world and were convinced that they had to be prepared for the worst case.

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<sup>14</sup> Humboldt (1814-1825), vol. I, p. 374.

<sup>15</sup> Fritscher, Urbani (2000).

<sup>16</sup> Pieper (2006).

<sup>17</sup> Biermann (1971), p. 95.

<sup>18</sup> Leitner (1995), p. 20.

<sup>19</sup> Humboldt (2000), p. 249, 258; Humboldt (1814-1825), vol. I, p. 508f.

<sup>20</sup> Humboldt 1814–1825 I, p. 581f.

In the years 1805–1807, Humboldt published the first part of his travel report in Paris, that is his *Essai sur la géographie des plantes*. The German version appeared in 1807.<sup>21</sup> In February 1803, he wrote down the first sketch of his book in Guayaquil. Various things were added at the bottom of the Chimborazo. His tableau of nature comprehended the main results of the phenomena observed by him in a general picture. It was meant to lay down only general views, certain factual statements that could be expressed by numbers: the optical metaphor is ubiquitous in Humboldt.<sup>22</sup>

His tableau of nature of the tropic countries comprehends all physical phenomena of the surface of the earth and the atmosphere between the 10<sup>th</sup> parallel of northern and southern latitude. It was a section through the Andes from the West to the East.



**Illustration 4**

All phenomena are related to the idea of measurement and height: temperature of the air, atmospheric pressure, chemical nature of the atmosphere, altitude of eternal snow, boiling point of water, geognostical view of the tropic world, weakening of the light rays, horizontal refraction of rays, condition of the soil etc.

### (5) Case study: the isotherms

Humboldt's theory of the isothermal lines was based on the diligently applied method of mean values. Many influences contributed to the measured temperature of the air: winds, causing a mixture of temperatures from different latitudes, the proximity of seas or oceans, the inclination, chemical quality, colour, radiation, and exhalation of the soil, the direction of mountain ranges.

The measurements do not reveal the parts of the different causes. Among the possible different methods of calculating mean values Humboldt favoured that one which makes two observations every day: the minimum and the maximum, supposed to occur at sunrise and at two p.m. In such a way one has to combine 730 thermal observations in the course of one year. Humboldt used the simple arithmetical mean without presupposing any hypothesis about the behaviour of the numerical ratios:

<sup>21</sup> Humboldt (1807).

<sup>22</sup> Knobloch (2004), p. 14; Knobloch (2005), p.13.

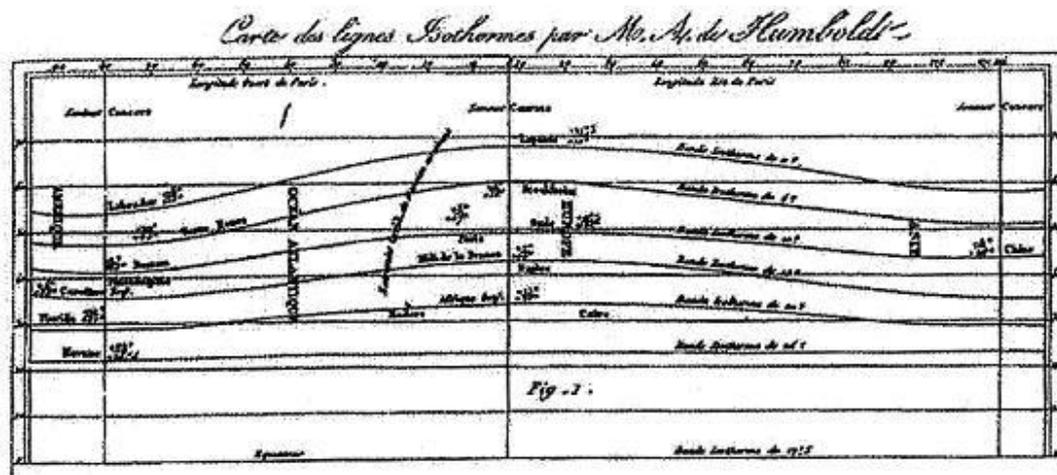


Illustration 5

The map covers the major part of the northern hemisphere reaching from America to China. In his *De distributione geographica plantarum secundum coeli temperiem et altitudinem montium, prolegomena* (Introductory explanations on the geographical distribution of plants according to the weather of the climate and the altitude of the mountains) he commented:

Ita videmus circulos aequalis caloris annui sive, ut novo vocabulo utamur, isothermos, haud aequatori parallelos esse sed, ut lineas magneticas, angulo variabili parallelos geographicos transversim intersecare.<sup>23</sup>

Thus we see that circles of equal annual heat, or — to use a new term — isotherms, are not parallel to the equator but — like the magnetic lines — they cut the geographic parallels under a variable angle slantwise.

Humboldt's smaller second figure related the altitudes of the Cordilleras to the geographic latitudes. The curves represent longitudinal sections through the earth or the atmosphere, and connect points with the same annual mean temperature:

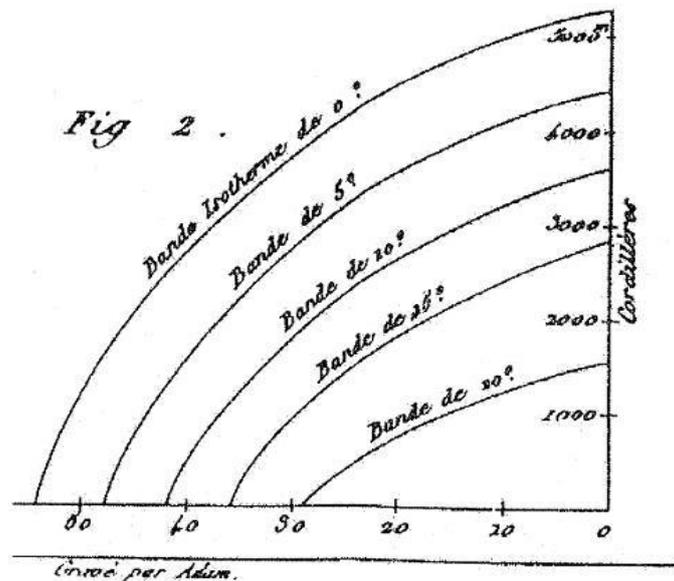


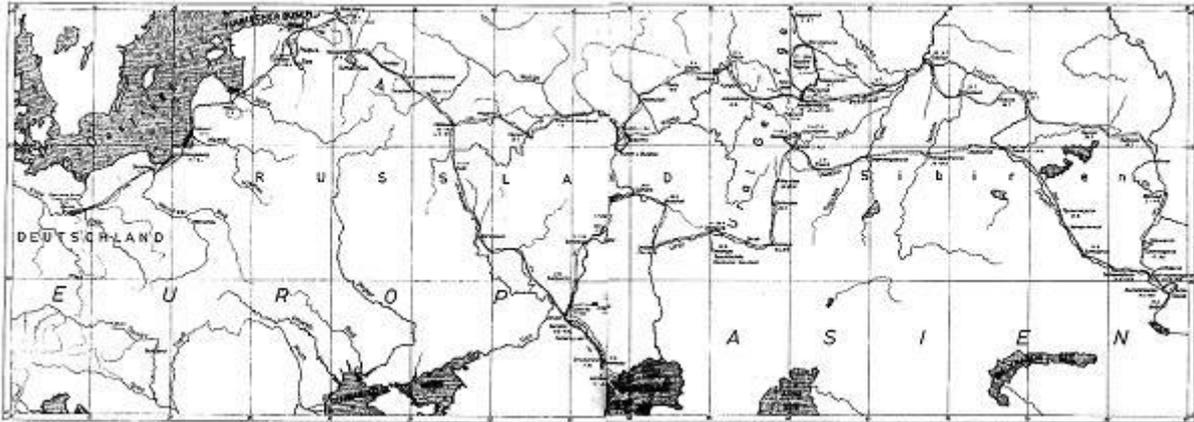
Illustration 6

Given such a particular temperature, the latitude decreases if the altitude increases.

<sup>23</sup> Humboldt (1817b), p. 70.

## (6) Epilogue

In 1829, when Humboldt was sixty, he made his second extensive journey, this time through Russia:



*Die russische Reise 1829*

### Illustration 7

One could believe that there was an element of acceleration in his life. While his lifetime was running out, he travelled in nine months — instead of five years — more than 15000 kilometres through Russia. A friendly cartoon by Herbert König dating from 1853 did not show Humboldt as tall and slim but rather as small and thick-set. This was indeed the case:



A politician in the salon.  
A cosmopolitan, mais de bon ton.  
He numbers among Germany's heros.  
We see him standing fixed at the throne,  
even more fixed on the world's summits,  
as a citizen of both worlds."

### Ein deutscher Bürger beider Welten.

Politiker in dem Salon,  
Kosmopolit, mais de bon ton.  
Zählt er zu Deutschlands Helben.  
Wir seh'n ihn fest am Throne steh'n,  
Noch fester auf des Erdballs Höh'n,  
Als Bürger beider Welten.

### Illustration 8. "A German citizen of both worlds"

Humboldt is standing on the Old World with his left leg and on the New World with his right leg.<sup>24</sup>

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<sup>24</sup> Humboldt (2003), p. 92.

150 years later, on April 28, 1997, the British Library wrote to Alexander von Humboldt:

Dear Alexander von Humboldt,

Thank you for your inquiry received 26/03/97, details of which are listed below etc.<sup>25</sup>

There are two possible conclusions that might be drawn from this letter (it is kept by the Alexander-von-Humboldt-Forschungsstelle of the Berlin-Brandenburg Academy of Sciences and Humanities): Either the confidence in Humboldt's longevity is unlimited or, sic transit gloria mundi, "thus passes the glory of the world".

## Captions

- III. 1 The route of Humboldt's American journey according to A. v. Humboldt, *Kosmos, Entwurf einer physischen Weltbeschreibung*, herausgegeben von Ottmar Ette und Oliver Lubrich, (Frankfurt/Main: Eichborn, 2004), p. 922f.
- III. 2 *Journal de route*, Humboldt (1814–1825), vol. I, p. 274.
- III. 3 Friedrich Georg Weitsch, "Alexander von Humboldt and Aimé Bonpland in the plane of Tapi at the bottom of the Chimborazo" (Ecuador, 1810). Stiftung Preußische Schlösser und Gärten Berlin-Brandenburg. By favour of the Bildarchiv Preußischer Kulturbesitz.
- III. 4 "Tableau des Régions équinoxiales": Humboldt (1807); copy of the Alexander-von-Humboldt-Forschungsstelle Berlin.
- III. 5 "Carte des lignes Isothermes", Humboldt (1817a), p. 19, figure 1.
- III. 6 "Carte des lignes Isothermes", Humboldt (1817a), p. 19, figure 2.
- III. 7 The route of Humboldt's Russian journey according to Hanno Beck, *Alexander von Humboldts Reise durchs Baltikum nach Russland und Sibirien 1829* (Stuttgart/Wien: Erdmann, 1983, p. 278f.)
- III. 8 Herbert König's cartoon of A. v. Humboldt, taken from: *Eine Gallerie von Zeitgenossen* (1853). Mit einem Nachwort neu hrsg. von P. A. Merbach (Berlin: E. Heckendorff, 1930).

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<sup>25</sup> Knobloch (2004), p. 15; Knobloch (2005), p.15.

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