GEODEZIJA IR KARTOGRAFIJA / GEODESY AND CARTOGRAPHY
2010
36(1):35–40

UDK 528.92 doi: 10.3846/gc.2010.06

HOW ARBITRARY LOCATIONS TURN INTO PLACES OF INTEREST

Rainer Mautz

Swiss Federal Institute of Technology, ETH Zurich, Switzerland
E-mail: mautz@geod.baug.ethz.ch

Received 2009 07 28, accepted 2010 01 05

Abstract. This article describes points that have almost become pilgrimage sites for people with geographic enthusiasm. Details are given of three different types of special points where the coordinate values have been the key drivers for the site location. The first type is the well discussed Geographical Centre of Europe, the second type are points chosen by the Russian scientist Friedrich Georg Wilhelm von Struve to measure his legendary geodetic arc. The third kind of points is devoted to the so-called "degree confluences" that are integer valued intersections of WGS84 latitude and longitude lines. A global web-based project to collect and publish information about the points is presented including visitor statistics. Besides the provision of global statistics, special attention is given to those points located in Lithuania.

Keywords: Centre of Europe, Struve Arc, confluence points, integer degree intersections

1. Introduction

Usually special attractions such as famous buildings, beautiful landscapes or extraordinary natural wonders decide weather a place is worthwhile a visit. This article however, is devoted to a different approach. It's about those places that have become meaningful simply through their coordinate values: The Geographical Centre of Europe and Confluences of Integer Degree Lines. As a third category – although not driven by coordinate only – the Struve Arc points are introduced. Figure 1 gives an overview of these special points in Lithuania.

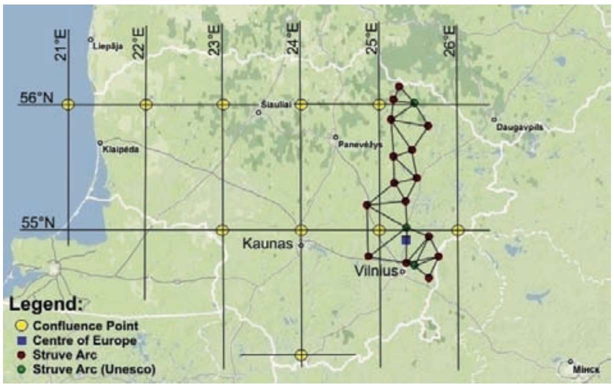

Fig. 1. Location of Various Special Points in Lithuania

One point of each type has been visited as part of the social programme during the "2nd Swiss Geodetic Science Week" held in Lithuania in September 2007. This seminar was carried out as part of the cooperation between the Institute of Geodesy and Photogrammetry at ETH Zurich and the Institute of Geodesy at Vilnius Gediminas Technical University (VGTU).

2. The Geographical Centre of Europe

In 1989 Jean-George Affholder, a scientist at the Institut Géographique National (French National Geographic Institute) determined that the Geographic Centre of Europe is located at 54°54'N and 25°19'E. The method he used for calculating this point was that of the centre of gravity of the geometrical figure of Europe. This point turned out to be located in Lithuania, specifically 26 kilometres north of its capital city, Vilnius, near the village of Purnuškės. A monument (Figure 2), composed by the sculptor Gediminas Jokūbonis and consisting of a column of white granite surmounted by a crown of stars, was erected at the location in 2004.

According to the French scientists, the boundary of the continent runs along the Kara River, the highest crest of the Urals, along the Ural River and the Caspian Sea, along to the Apsheron Peninsula, over the highest crests of the Caucasus mountains, through the Black Sea and the channels of the Dardanelle and the Bosphorus, along the eastern shore of the Aegean – the border between Greece and Turkey – and through the Mediterranean Sea and the Gibraltar channel. The scientists did not take into account the location of Malta in the middle of the Mediterranean; in either case, this would change the location of the geographical centre of Europe by only 100 metres.

Fig. 2. Monument of the Centre of Europe in Lithuania

Lithuania's claim for the Centre of Europe is not unique. There are different opinions on the definition of the boundaries. One disagreement is in the answer to the question whether islands should be included or not? Should the extreme points count or the centre of gravity? Interestingly, many national surveying institutes managed to determine the Centre of Europe to be located in their own country's territory. As a result, about 10 locations far apart from each other are claimed as "The European Centre" – see Figure 3.

Fig. 3. Various Claims for the European Centre

Counties with their 'own' Centre of Europe are Germany, Poland, Slovakia, Ukraine, Estonia and Norway. Most of these centres have their own monument that can be visited.

3. Survey Triangulation Station Points of the Struve Geodetic Arc

The Struve Arc is a chain of survey triangulations, stretching from Hammerfest in Norway to the Black Sea, through 10 countries and over 2820 km. These are points of a survey, carried out between 1816 and 1855, by the astronomer Friedrich Georg Wilhelm Struve. The survey represents the first accurate measurement of a long segment of a meridian and was essential for determining the shape and size of the earth. The accuracy of the Arc measurement was 1/232390 (4 ppm). The original arc consisted of 258 main triangles with 18 station points located in Lithuania. Doubtlessly, the site selection was driven by topographic conditions, but eventually the coordinates follow geometric constraints along the 26th Meridian in form of triangles sides with ca. 25 km in length. The UNESCO World Heritage "Struve Geodetic Arc" nomination includes 34 out of 258 original station points. Three of these stations are located in Lithuania, see Table 1 and Figure 4. The location of the 18 triangulation points in Lithuania are shown in Figure 1. Most of the stations were originally marked with natural stones or wooden logs and remonumented with concrete blocks by Polish surveyors in the 1930s.

Table 1. Station Points of the Struve Geodetic Arc that have become part of the UNESCO world heritage

Original Point Name	Present Name	Location	Nothing	Easting
Karischki	Gireišiai, Panemunėlis	Northern Lithuania	55° 54' N	25° 26' E
Meschkanzi	Meškonys, Nemenčinė	Eastern Lithuania	54° 55' N	25° 19' E
Beresnäki	Paliepiukai, Nemėžis	Eastern Lithuania	55° 38' N	25° 25' E

More details on the Arc can be found in the thesis of Peterhans (2008) that includes an international online forum for the Arc at the website http://struvearc.wikidot.com/. This site gives opportunity for the 10 participating countries to keep records on the Struve points up to date and the world to watch progress in the research.

Fig. 4. Monumentation of Struve Arc Point Meškonys in Lithuania: Natural stones and lime safeguarding. Remonumented with concrete in the 1930s, renovated in 1992. Now surrounded by a 0.5 m high openwork profile

4. Intersections of Integer Degree Lines

How would the world look like if you were standing on an arbitrary point on earth? In order to get an unbiased view of the world the following attempt is being made: each of the latitude and longitude integer degree intersections in the world are visited, pictures are taken at each location, stories about the visits are collected and posted at a website. Altogether there are 64'442 intersections – let us call them "degree confluences" since these are the meeting places of geographical latitude and longitude degree lines, see Figure 5. 21'543 confluences – almost exactly one third (33.4%) are on land. Ignoring those confluences without view of land and after thinning out the poles region which has an impropriate density of degree intersections, still 16'194 confluences are considered as worthwhile visiting – in the following denoted as "primary confluences".

Standing on any point on Earth, there is always one confluence within 79 km radius. Typically, confluences are about 100 km apart. Using the WGS84 system that includes the mathematical GRS80 ellipsoidal model of the Earth we find that the distance between degrees of latitude varies from 110.57 km at the equator to 111.69 km near the poles. The distances between longitude lines continuously decrease from 111.32 km at the equator towards the poles. However, the locations are reasonably well equidistributed for representing the earth, but also creating a huge task for reaching them. This is in particular the case, because the confluence locations go against all human infrastructures.

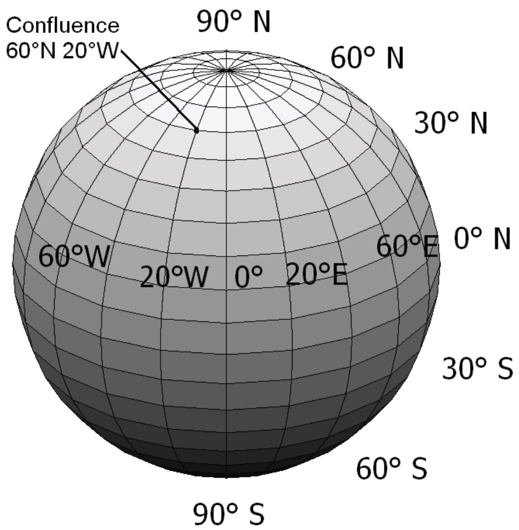

Fig. 5. Grid with Geographical Coordinate Lines

4.1. The Degree Confluence Project

76'681 pictures and 10'461 stories about confluence visits in 179 countries have been collected at the project website with the URL www.confluence.org. One of the project's principles is to keep the confluence points as they are. Any changes made by visitors – e.g. leaving souvenirs, or even placing markers, sign posts, cairns is considered as pollution and visitors are encouraged to follow the policy "take nothing but pictures, leave nothing but footprints".

It all began in February 1996 when the US-American citizen Alex Jarrett used his new hand-held GPS receiver in order to reach the nondescript location 43°00'00"N 72°00'00"W. After bicycling 16 km and a bit of a hike he was able to exactly locate and document the spot. An then he posted his pictures of the confluence to a website that showed some snow covered trees of New Hampshire's winter. From there snowballing began. Alex visited another confluence in May of the same year, in the following year the number of visits doubled to 4. Other people joint the project quadrupling the number of visits each year, so that in 2001 the tremendous number of 1513 postings had been reached. Since then, progress continued at a constant rate between 1000 and 2000 postings each year. Figure 6 shows that the total number of confluence visits each month has been approximately at a constant level over the last 6 years. Clearly, there is an obvious yearly cycle with a summer-peak and a winter low.

Even though the total number of visits hasn't changed, progress towards the project goal has in fact slowed down. After taking revisits out of the statistic in Fig. 6, we find that the actual rate of first conquers has halved within the last 5 years.

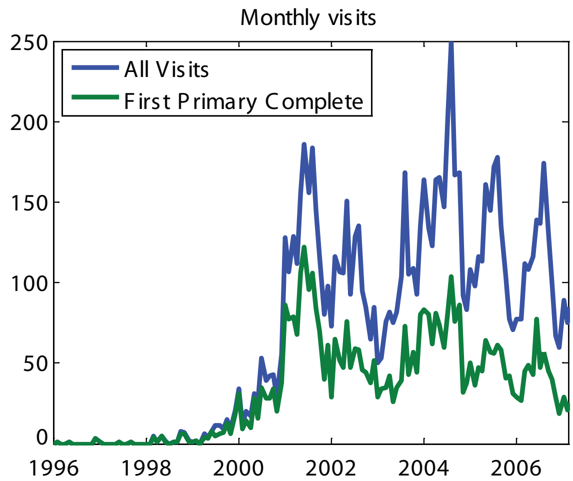

Fig. 6. Total number of degree confluence visits for each month since 1996. The upper curve shows all visits, the lower curve only first successful visits to primary confluences

The project progress differs largely in from country to country. As can be seen from Figure 7 and 8, initially all of the world's first visits had been occurred in the USA. The passion for confluencing reached Europe in 2001 and Russia in summer 2004. From Figure 8 it can be witnessed how quickly Lithuania and Germany (as comparatively small countries) were captured almost totally within one single year. The USA still remains 25% incomplete due to remote Alaska. Densely populated countries such as China find more and more enthusiasts – now being finalised by 40% China has overtaken the world average in terms of reaching completeness. However, huge remote unpopulated areas such as the Himalaya region in China or the Siberian tundra in Russia will prevent completion for quite a while.

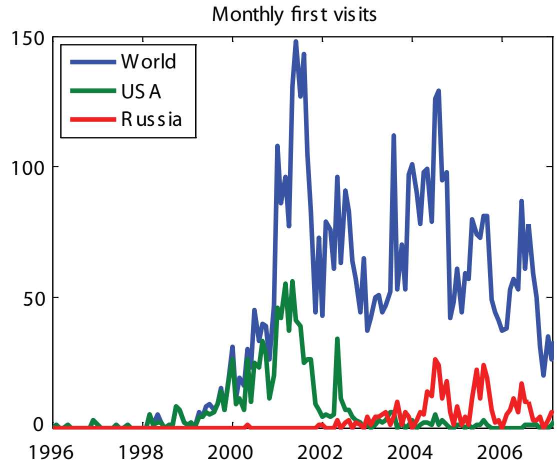

Fig. 7. Number of first visits to confluence points each month in the world, USA and Russia

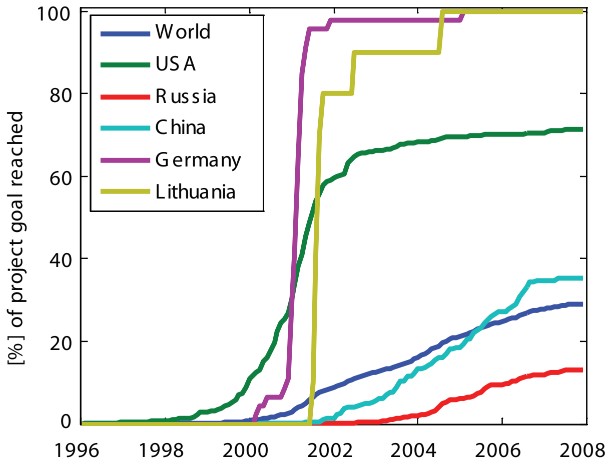

Fig. 8. Fraction of visited confluences in some selected countries

Figure 9 discovers an astonishing correlation: the upper part of the figure shows each of the world's confluence visits as a square. The brightness of each pixel is proportional to the number of revisits. The bottom picture is based on totally different data, showing the earth by night in a composed picture from NASA. Central Europe, the USA and Japan are clearly the brightest regions in both pictures, whereas central Africa, the Brazilian jungle, Greenland and Antarctica both times are represented by dark spots. Only for some touristy regions such as New Zealand and the Western USA confluencing activities are ahead of the emitted light in the region. Apparently, key factors such as Gross National Product (GNP) and population density seem to be the main drivers for both, light emission and confluence visiting.

Figure 10 presents the distribution of confluences by latitude. Antarctica causes all intersections at latitude 78°S or further to the South Pole to fall on land. But almost none of these Antarctic confluences have been visited. At the equator as well as close to the poles, finding integer degree intersections seems to be rather difficult due to remote jungles, swampy tundra and ice. The two

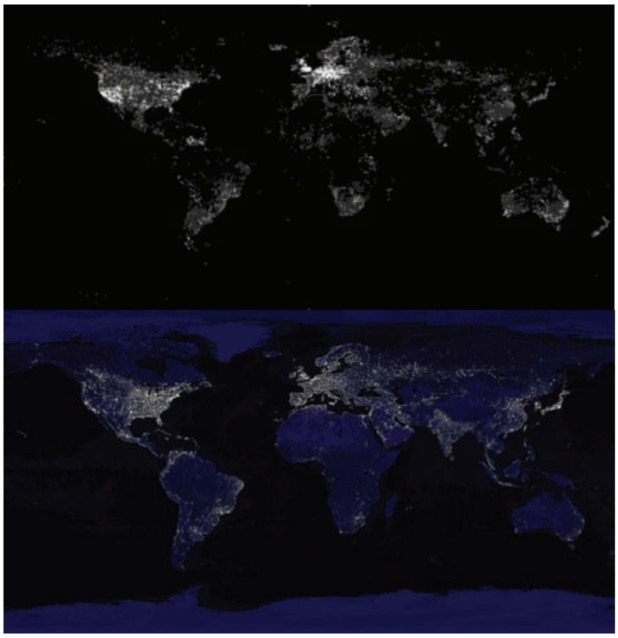

Fig. 9. Visited confluences (top) and light pollution (bottom) created by the U.S. National Oceanic and Atmospheric Administration

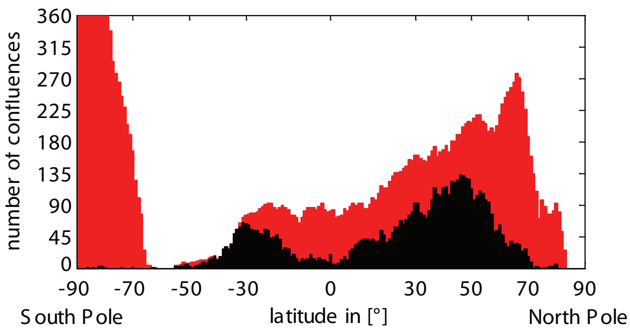

Fig. 10. Land based confluence points by degree latitude. Negative values represent the southern hemisphere. The fraction of visited confluences is drawn in black

peaks in black in Figure 10 indicate that temperate zones are preferable regions for 'confluencing'.

The reported accuracies of locating confluences are driven by two key factors: the minimal distance at the nearest point and the GPS accuracy. Initial positional accuracies had been around 10-30 m, but after removal of selective availability in May 2000 accuracies improved to 5-10m. Nowadays with the help of augmentation systems accuracies of 1-5 m are typical. In the year 2012, assuming availability of 35 Beidou Navigation Satellites (北斗⊠航系⊠), 18 GLONASS satellites, 30 Galileo satellites and an improved GPS, positional accuracies of less than a meter can be expected. With 107 satellites in the sky, positional service will cover deep canyons and forests. Even today a fix position solution is oftentimes possible for confluences that are located in forests or valleys but accuracies are low due to shading of satellites.

Figure 11 shows how close confluence visitors were able to reach their target. The maximum at 5m correlates well with the positional accuracies for current hand held GPS receivers. The other peaks at 10 m, 20 m and 30 m are caused by rounding and imprecise reporting.

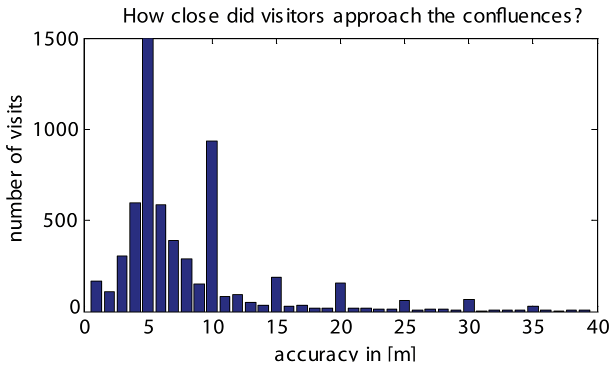

Fig. 11. Reported minimal distances. Distances over 40m are not shown. The median is 7 m, the average is over 635 m due to some outliers

What confluence has most unsuccessful attempts?

36°N 112°W, Arizona, USA has 7 unsuccessful attempts due to its location in the Grand Canyon. This point in the National Park is tempting for many visitors, who then fail 200 m from the goal at almost vertical Coconino Sandstone. The second rank is taken by confluence 41°N 112°W near Salt Lake City with 5 attempts. The salt march of the Great Salt Lake forced five visitors to abandon their mission.

Which confluences had most visits?

1) 52°N 0°, England, 60 km north of London: 21 visits.
2) 37°N 122°W, USA, 75 km from San Francisco: 20 visits.
3) 40°N 105°W, Colorado, 25 km out of Denver: 17 visits.

Expectedly, these frequently visited confluences are located close to megacities and easily accessible.

Which confluence had most visitors?

48°N 9°W Southern Germany – 540 visitors within 14 visits. A teacher managed to bring 470 students of a school.

What are the highest confluences?

1) 30°N 81°E, Nepal, 5870m (not yet visited)
2) 33°N 80°E, Tibet, China 5836m (visited on 29-5-2005)
3) 34°N 82°E, Tibet, China 5805m (not yet visited)

Unfortunately, the most reliable source for altitude data today, the SRTM 90 m survey, does not provide information for this area. Therefore Google Earth – a less reliable elevation data source – was used, introducing an uncertainty about the ranking of these confluences. So the ranking will stay a mystery until these points have actually been reached.

What are the highest successful confluence visits?

1) 33°N 80°E, Tibet, China, 5836m (visited on 29-May-2005, 11-day hitch & hike trip)
2) 30°N 90°E, Tibet, China, 5587m (visited on 20-May-2004, 6-day exhausting hike)
3) 18°S 69°W, La Paz, Bolivia, 5170m (visited on 21-May-2007 3-day drive & hike)

What is the lowest confluence?

30°N 27°E, Matrūh, Egypt, -83m (visited on 04-Dec-2004)

4. 2. Confluence Points in Lithuania

10 confluence points are on Lithuanian land; their details are given Table 2. Most of them are located on fields and can be easily accessed by car. However, three points are located in water such as 55°N 24°E, see Figure 12.

4.3. When will the confluence project get finished?

At the time of writing 10'886 unvisited primary confluences out of 16'194 that belong to the project goal are waiting to be reached. Currently, the rate of first visits to primary confluences is 1-2 a day, or 500 a year. Assuming a linear trend, the last confluence should be visited in 22 years, i.e. in the year 2030. However, when it comes to finish the last 1%, I predict a clear slowdown: as can be seen an asymptotic completion for individual countries from Figure 8 this may well be valid for the whole world. Imagine that the very last unvisited intersections may need special permission due to restricted areas or they are just extremely unattractive for a visit. This fact could postpone project completion beyond the year 2050.

Table 2. Details of the 10 Confluence Points in Lithuania

Point	Region	Visits	Location Description		Transportation
54° N24° E	Alytus	1	Forest	In Dzukia National Park	Car
55° N23° E	Marijampolės	1	Bush	At the shoreline of a pond	Car
55° N24° E	Kaunas	2	Lake	Query pond	Swimming
55° N25° E	Vilnius	3	Field	Near a Farmhouse	Motor-Bike
55° N26° E	Vilnius	1	Creek	River Bank of Santaka River	Hike, Swimming
56° N21° E	Klaipėdos	0	Sea	5 km from the coast	Ship, Boat
56° N22° E	Telšių	1	Swamp	Carrot Field	Hike
56° N23° E	Šiaulių	1	Field	Grain Field	Car
56° N24° E	Šiaulių	1	Field	Irrigation Ditch	Rental Car
56°N25° E	Panevėžio	1	Field	Farmstead of Uzubaliai	Unknown

Fig. 12. Panoramic view of the Confluence Point 55°N 24°E which is in the middle of a lake

5. Conclusions

This article has shown that originally insignificant locations that had neither a meaning nor a specific feature have become meaningful just from their determined coordinate position. Three very different types of such points have given proof that arbitrary locations can turn into well visited attractions not only for geographic enthusiasts but also for tourists and the general public.

References

Confluence Website [online], [last accessed on 8th September 2009]. Available from Internet: <http://www.confluence.org>.

Mautz, R. 2006. Sampling the Earth Surface - What Does Our World Really Look Like? Coordinates – Positioning, Navigation and Beyond 3: 8–11.

Mautz, R. 2008. Sampling the World, Coordinates – Positioning, Navigation and Beyond 3: 22–27.

NASA [online], [last accessed on 8th September 2009]. Available from Internet: <http://earthobservatory.nasa.gov/Features/ BlueMarble/>.

Peterhans, J. 2008. International Forum for the Struve Geodetic Arc., Diploma Thesis at the Institute of Geodesy and Photogrammety, ETH Zurich.

Dr. Rainer Mautz. Senior Research Assistant.

ETH Zurich, Institute of Geodesy and Photogrammetry Phone +41 44 633 78 27, email: *mautz@geod.baug.ethz.ch*

Research interests: positioning in wireless sensor networks; deformation analyses; detection of frequencies in geodetic data; parameter estimation, adjustment computations, engineering geodesy and visiting confluences.