Mosaics of historical atlases of the Russian Empire

Project description:

Harvard has provided Consultant with scanned images of Russian historical atlases, dated in 1745 and 1821, in jpeg2000 and jpeg format respectively.

Initially scanned images were individually georeferenced in their determined source projection and subsequently two mosaics, one for European Russia (west region) and the other for Asian Russia (east region) were compiled for each atlas.

This document contains a description of georeferencing and mosaic procedures, including datum and projection used for images as well as an accuracy assessment for the material.

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Introduction:

18th and 19th century Russian cartographers compiled both Russian atlases with the understanding that each page of the atlases would be handled and viewed as individual and finite entity. Therefore each map was compiled in scale and projection optimal for the paper sheet on which it would be printed and the eventuality that anyone might wish to join together dozens of these paper maps was never taken into account.

Two/three centuries later GIS software has enabled the compilation of mosaic views of these atlases on computer screen but obviously maps are not well suited for this.

At the time the cartographers immediate concern must have been how to fit on a single sheet of paper such a large volume of meaningful topographic information. In the case of the 1821 atlas an even greater challenge must have been finding on the paper sufficient space to handwrite thousands of feature/locality names (names are in duplicate characters: Cyrillic and Latin).

Creative skills were required not only to develop some suitable coordinate systems capable to consistently display information across a huge territory (Delisle appears to have formulated and refined the Equidistant Conical Projection while working on the 1745 atlas) but also to record all names used by different people for a particular locality (at times a locality is identified by two or even three names). In addition relatively little care was used to ensure feature consistency across map sheets.

In general both atlases should be regarded as not well suited for georeferencing and extremely complex for mosaic purpose.

Images of the 1821 Atlas (jpeg 2000 format) were digitized at lower resolution and quality settings than images of the 1745 Atlas (jpg format).

Projection and datum:

As it is generally the case in older maps there is no reference to coordinate system used in the map compilation for either the 1745 and 1821 atlases.

Sheets in the 1745 atlases have degree markings on collar but no graticule on sheets (except for Asian - east- sheets and large scale sheets). Sheets of 1821 atlas have a degree graticule.

Prime Meridian: Ferro was used as meridian of origin for all sheets in both the 1745 and 1821 atlases with the exception of sheet no. 54 (file number 56) "Carte Generale de la Province d'Omsk" where the Paris meridian was used as prime meridian instead.

Ferro, from Canarian island of El Hierro (18° 03' west of the Greenwich meridian, later redefined as 17° 39' 46" W), had been historically the prime meridian in common use since the 2nd century A.D., when Ptolemy considered a definition of the zero meridian based on the western-most position of the known world, giving maps with only positive (eastern) longitudes (http://en.wikipedia.org/wiki/El_Hierro).

In 1634, France decreed that Ferro's meridian should be used as the reference on maps, since this island was not only the most western position of the Old World but also defined as 20 degrees west of Paris. For this reason old maps (outside of Anglo-America) often have a common grid with Paris degrees at the top and Ferro degrees offset by 20 at the bottom (http://en.wikipedia.org/wiki/Paris_Meridian).

Equidistant Conic projection: Literature indicates that the Equidistant Conic projection was chosen in the compilation of the 1745 atlas of Russia and in fact it would appear that the prototype of this projection by Ptolemy, 150 A.D. might have been improved by De l'Isle about 1745 while working on the Russian atlas itself. De l'Isle placed "the two standard parallels at 1/4 and 3/4 of the latitude" (Flattening the earth: two thousand years of map projections" by John Parr Snyder).

Since then the equidistant conic projection has been chosen in Russia as a good compromise since scale is the same along all meridians (parallels are constantly spaced) and distortion is constant along any given parallel (it is free of distortion only along the two standard parallels). In practice this projection is neither conformal nor equal area but it is a compromise in distortion between equal-area and conformal conic projections which suites Russia well due to the east-west extent of its territory.

De l'Isle choice of equidistant conic projection with Ferro central meridian 115E and standard parallels 62.5N and 47.5N for a 1745 large map of Russia fits very well the large map of Russia in the 1821 atlas and is remarkably similar to the equidistant conic derivative proposed V. V. Kavrayskiy in the 1930s (with standard parallels 62°N and 47°N) and later used by the Soviet Union for mapping that nation (Flattening the earth: two thousand years of map projections" by John Parr Snyder).

Although P. Snyder seems to suggest that in the 1745 Atlas "De l'Isle used the trapezoidal projection for the larger-scale maps" this was found to be not correct since maps for Asia were compiled using a modified equidistant conic coordinate system not very different from the one used in the more detailed maps of European Russia.

Georeferencing Methodology:

All sheets were georeferenced in a Equidistant Conic coordinate system with two standard parallels (generally at 1/4 and 3/4 of the sheet latitude but occasionally, when this did not produce acceptable result, more suitable standard parallels were identified) and central meridian estimated according to sheet geometry.

The main guideline in parameter selection was to obtain a georeferenced sheet with a geometry free of distortion which resembled closely the square paper sheet. In addition theoretic graticule and graticule on raster images should closely comply.

All possible graticule intersection points were used for georeferencing; this resulted in over 100 ground control points generally being used for most tiles with extremes of 190 points for some particular sheets. Whenever a degree graticule was not available, as it was the case in western sheets of the 1745 atlas, GCPs position was extrapolated

All georeferencing was done in native Ferro coordinate system: for this purpose a standard datum based on Ferro as prime meridian (Potsdam / DHDN / FERRO) was arbitrarily chosen. However georeferenced output was generated in a WGS84 datum system (with translated equidistant conic values) to ensure user friendliness of the output.

Original equidistant conic parameters (standard parallels and central meridian with reference to Ferro or Paris prime meridian) of individual files are listed in Appendix 1a and 1b.

Rectification by the triangulation method was chosen and bicubic interpolation resampling method was selected to optimize quality of output in 24bit geotiff format.

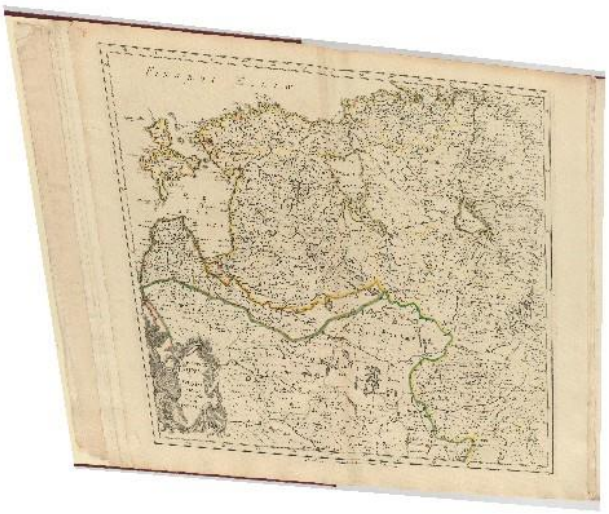
Sheets of the **1821 Atlas** exhibit a well defined graticule. This resulted in a easier assessment (and verification) of the coordinate system originally used in the compilation of each sheet and allowed georeferencing point identification with a high degree of certainty.

The opposite applied to most sheets of the **1745 Atlas**: as result of the lack of a graticule in western sheets, georeferencing ground control points had to be selected in proximity of collar degree markings and their estimated position on the map was first estimated and later refined by trial and error method.

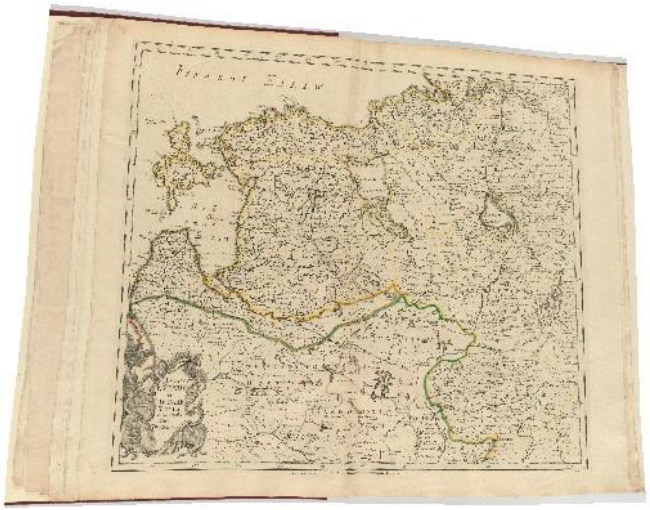
However it was possible to georeference with a good degree of accuracy the large scale map in 1745 atlas (file 003894548_0006, Mappa Generalis Totius Imperii Russici) due to the fact that it contained a graticule as well as coordinates on collar and this served as good reference for understanding the general knowledge of the Russian territory of the time.

Georeferenced tiles were verified against 1821 Atlas western mosaic, Landsat 7 mosaic as well as the 1745 large scale map (file 003894548_0006) of Western Russia and where appropriate adjusted accordingly.

In particular it was established that coordinate markings on east and south collar of tile 003894548_0010 (sheet 3: Ducatum Estoniae et Livoniae) are incorrect as the overall geometry of the map initially suggested:



Overall geometry of tile 003894548_0010 georeferenced against the 1821 western mosaic on the other hand appears more reasonable as well as more compliant with reality:



On the other hand sheets by the Black Sea region and in particular file 003894548_0014 (Crimea - sheet no.7) fall under a different category since although not compliant with satellite imagery and 1821 western mosaic they are fully compliant with large scale map in 1745 atlas (file 003894548_0006 - Mappa Generalis Totius Imperii Russici). Alternative georeferencing against the 1821 western mosaic (in background) produces an output which is not only extremely distorted and almost unreadable ...

but also not compliant with the large scale map of 1745 atlas and incompatible with surrounding 1745 sheets.

In conclusion we have little doubt that at the time the 1745 Atlas was compiled the understanding of the overall geography of the Black Sea region was approximate (with errors in excess of one hundred kilometers). It is very much the case of deciding if such sheets should be used for general reference purposes as they are or simply ignored altogether.

In Eastern tiles the presence of graticule in sheets allowed for more precise georeferencing as well as a more accurate identification of the coordinate system.

Although literature suggested that "De l'Isle used the trapezoidal projection for the larger-scale maps" in the 1745 Atlas " (Flattening the earth: two thousand years of map projections" by John Parr Snyder) and general sheet geometry might have prompted such assessment, parallels were not straight lines as it would be expected in trapezoidal projections.

It is not unlikely that eastern maps originally could have been planned as a single map sheet with common projection parameters (as it is the case for some of the mosaic sheets of the 1821 atlas) but that during compilation decision was taken to rather split this tiled mosaic into six individual sheets maintaining standard parallels common to all sheets but optimizing the central meridian for individual sheets.

Mosaic Methodology:

Mosaic techniques and workflow applicable to modern maps are not well suited to this type of historic cartographic material. In addition characteristics of the 1745 and 1821 atlases differed so greatly that in the mosaic process each mosaic required a different approach.

For each atlas two mosaics (European / Western mosaic and Asian / Eastern mosaic) were generated. The allocation of a particular image tile to each was not necessarily related to its geographic location but rather to its characteristics (scale/resolution and geometry). In general source maps of the eastern mosaics have lower resolution / scale than maps in western mosaics. In the particular case of the 1745 atlas a degree graticule is only present in maps of the eastern mosaic.

The greatest challenge were features (borders, rivers, roads) which did not comply in adjacent sheets: not only feature location are not accurate to the pixel level (in fact they could be offset by many kilometers) as it is the case with modern maps but also feature styles could significantly differ in adjoining sheets.

A recurrent example: in each sheet borders are color coded to facilitate the understanding of adjacency between sheets. However the color coding is not compatible with the generation of a mosaic.

Due to lack of space on paper sheets (as a result of the need to cater for two alphabets and multiple locality names) cartographers had placed many names along edges of sheets (where a sheet should be joined to an adjacent sheet). Furthermore direction in which names had been written (right to left in one sheet, bottom to top in the other - sometime even at some arbitrary angle) very often interfered with features and/or names in neighboring maps.

Typical ***mosaic workflow***:

Step 1: georeference as accurately as possible wrt graticule and degree markings on collar.
Georeferencing and rectification executed with GlobalMapper version 13.
Since numerous reprojection might be required in the mosaic process always use bicubic interpolation to optimize quality preservation.

Step 2: assess adjacent sheets

- a) both compatible: if so join (see Step 3)
- b) not joining correctly although graticule matches?
- Decision making process (scale, details, comparison sheet accuracy):
  - i) can recognize common features?
  - ii) are features drawn differently? (example: border marked following a different river)
  - iii) are features reconcilable?
  - iv) is meridian of origin the same? (Ferro/Paris)
  - v) is coordinate system correct? (important when away from graticule intersection)
- Identify, decide course of action and if possible correct and then repeat Step 1 and 2.

Step 3: draw feathering vector

Step 4: generate output merge (ensuring that best sample spacing is used for merged output).

Step 5: graphic edit (preserving georeferencing information) by U-Lead Photoimpact and/or Photoshop.
Objective: reconcile features without altering geoinformation and improve esthetic appearance.

Step 6: re-encode georeferencing information

Step 7: repeat Steps 1 to 6 with adjacent sheets.

In order to ensure consistency during compilation of the mosaic the following criteria were followed:

Name preservation:

a) preserve names in both Cyrillic and Latin; when not possible
b) if possible give preference to preserve Latin name (as it appears authors did when confronted by lack of space – cmf. sheet 54 (file Atlas 056.jpg).
c) when more than one name for a locality is present but space insufficient: give priority to first (and second) name
d) reposition/resize names if necessary (and possible)
example:

Border discrepancies:

a) use most detailed or best scale sheet.
b) Use more recent sheet (if dated)

example: border Atlas 012.jpg - Atlas 022.jpg

Irreconcilable features: when not possible to immediately reconcile features

a) identify a major common feature on Landsat 7 imagery
Select as base image the sheet where irreconcilable feature is closest to reality (example in Appendix 2a)
b) when above fails: add notice " IRRECONCILABLE ".
(example in Appendix 2b and 2c)

For roads: irreconcilable roads are joined by dotted line or marked (as in above exaple).

An example of workflow and application of criteria is illustrated in Appendix 3: Mosaic of 1821 Atlas of the Russian Empire.

Mosaic outputs were generated in equidistant conic projection (referenced to WGS84 to ensure user friendliness of the output) which was the projection of choice in the Russian Empire as well as in the Soviet Union. Projection parameters were chosen to comply with projection parameters of large scale maps in the Atlas which also appear to be very similar to parameters used during Soviet Union times.

With particular reference to the output mosaics it should be noted:

1. **1745 Atlas**:
   Although source maps are generally remarkably accurate considering that at the time tools to determine locations were not only rudimentary but also limited in number and that their access was restricted to few privileged scholars (literature speculates that such tools could only be accessed by permission from the Tsar) knowledge of the huge territory was inconsistent and sometime superficial. This is apparent from the lack of compliance with present day data particularly in regions at the edges of the Empire.

   a. **1745 western mosaic**: georeferencing accuracy was negatively impacted by lack of degree gridlines. In addition some tiles (see previous comments on file 003894548_0010) had to be adjusted against external sources.

      General accuracy is in the region of 10-20km. However since tiles in the Black Sea / Crimea region are fundamentally lowed in that region inaccuracies of the order of 100km or more can be expected.

      The significant tile overlap permitted to identify reasonable intersection points for features and when features could not be readily connected additional GCPs were used to force intersection.

   b. **1745 eastern mosaic**: the overall geometry of the mosaic appears sound. Good tile overlap allowed good continuity of features across sheets.

      Compliance with satellite imagery is erratic, ranging from 30km in places but degrading to up to 400km in certain Asian regions. It appears that in Asia only certain areas (example: tip of Kamchatka Peninsula - including islands) were mapped with precision better than 50km, while rest was mapped with lower accuracy.

2. **1821 Atlas**:
   Source maps are more detailed in scale but also more accurate. Duplicate names are used (Cyrillic and Latin). The main challenge was luck of overlap between tiles: each sheet only contains features for the particular district. In practice mosaic was compiled by merging along district borders rather than along sheet collar as it is the case in modern maps.
   A number of original image tiles in the Atlas are in fact rudimentary mosaic assemblies of multiple sheets separated by a white gap.

   It was possible to mosaic most georeferenced tiles without need for additional GCPs in order to obtain feature continuity between tiles.

Both western and eastern mosaics have a general accuracy of better than 5km (for various major towns an accuracy of 3.5km or better was actually recorded) although in spots (parts of the Black Sea and Kamchatka Peninsula) accuracy may decrease down to 40km.

The improvement in compliance against satellite imagery is remarkable when compared to the 1745 Atlas demonstrating a great improvement in both cartographic skills and knowledge of the territory.

A point of interest is the presence in the 1821 Eastern mosaic of the territories of Alaska and California.

Appendix 1a: Projection parameters for 1745 Atlas

SOURCE FILENAME	MOSAIC	PROJECTION	1st std Parallel	2nd std Parallel	Central Meridian	Prime Meridian
003894548_0008.jp2	1745 Western	Equidistant Conic	66	69	50	Ferro
003894548_0010.jp2	1745 Western	Equidistant Conic	55.5	58.5	52	Ferro
003894548_0011.jp2	1745 Western	Equidistant Conic	55.5	58.5	56	Ferro
003894548_0012.jp2	1745 Western	Equidistant Conic	51.5	54.5	54	Ferro
003894548_0013.jp2	1745 Western	Equidistant Conic	65.5	68.5	64	Ferro
003894548_0014.jp2	1745 Western	Equidistant Conic	45.5	48.5	54	Ferro
003894548_0015.jp2	1745 Western	Equidistant Conic	60.5	63.5	65	Ferro
003894548_0016.jp2	1745 Western	Equidistant Conic	54.5	57.5	65	Ferro
003894548_0017.jp2	1745 Western	Equidistant Conic	49.5	52.5	62	Ferro
003894548_0018.jp2	1745 Western	Equidistant Conic	44	47	62	Ferro
003894548_0019.jp2	1745 Western	Equidistant Conic	56.5	59.5	84	Ferro
003894548_0020.jp2	1745 Western	Equidistant Conic	50.5	53.5	76	Ferro
003894548_0021.jp2	1745 Eastern	Equidistant Conic	60	60	123.5	Ferro
003894548_0022.jp2	1745 Eastern	Equidistant Conic	60	60	123.5	Ferro
003894548_0023.jp2	1745 Eastern	Equidistant Conic	60	60	125.5	Ferro
003894548_0024.jp2	1745 Eastern	Equidistant Conic	60	60	125.5	Ferro
003894548_0025.jp2	1745 Eastern	Equidistant Conic	60	60	127.5	Ferro
003894548_0026.jp2	1745 Eastern	Equidistant Conic	60	60	127.5	Ferro

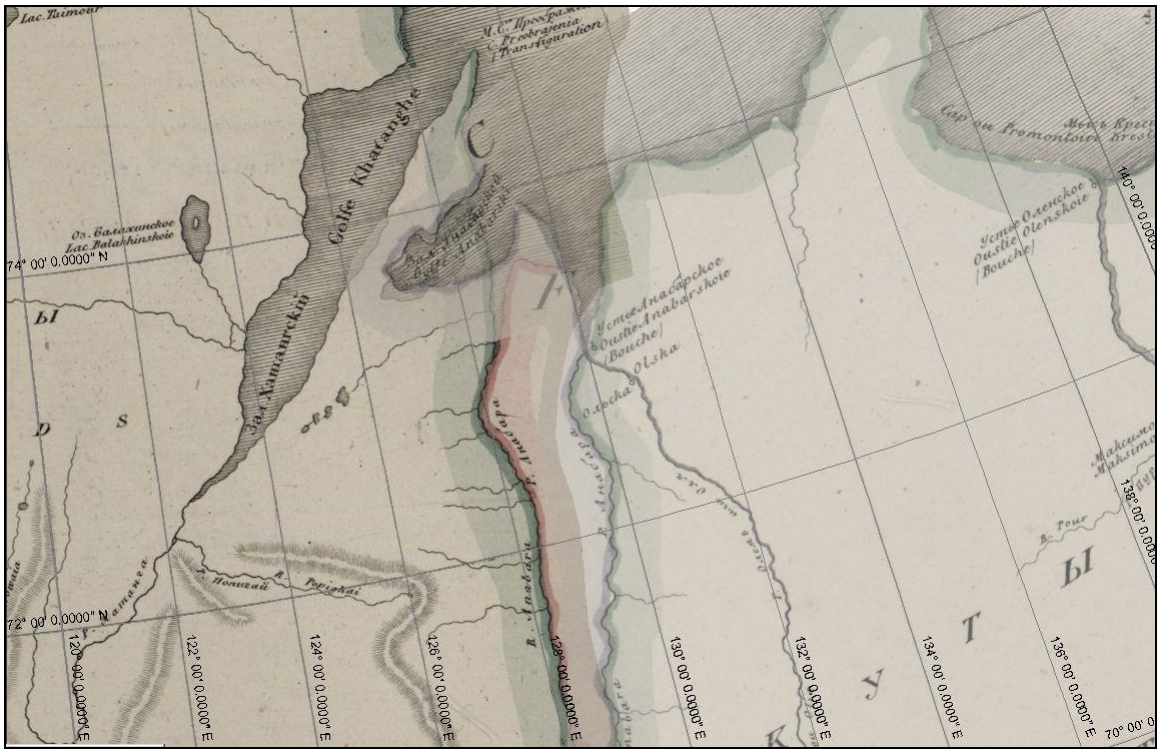
Appendix 1b: Projection parameters for 1821 Atlas

SOURCE FILENAME	SHEET No	MOSAIC	PROJECTION	1st std Parallel	2nd std Parallel	Central Meridian	Prime Meridian
Atlas003.jpg	1	1821 Western	Equidistant Conic	55	50	39	Ferro
Atlas004.jpg	2	1821 Western	Equidistant Conic	50	48	46.5	Ferro
Atlas005.jpg	3	1821 Western	Equidistant Conic	52	49.5	44.5	Ferro
Atlas006.jpg	4	1821 Western	Equidistant Conic	54	52	42	Ferro
Atlas007.jpg	5	1821 Western	Equidistant Conic	56.5	54	42	Ferro
Atlas008.jpg	6	1821 Western	Equidistant Conic	58	56	41	Ferro
Atlas009.jpg	7	1821 Western	Equidistant Conic	59	57	42	Ferro
Atlas010.jpg	8	1821 Western	Equidistant Conic	60	58	43	Ferro
Atlas011.jpg	9	1821 Western	Equidistant Conic	60.5	57.5	49	Ferro
Atlas012.jpg	10	1821 Western	Equidistant Conic	58	56	48	Ferro
Atlas013.jpg	11	1821 Western	Equidistant Conic	57.5	54.5	46	Ferro
Atlas014.jpg	12	1821 Western	Equidistant Conic	57.5	54.5	46	Ferro
Atlas015.jpg	13	1821 Western	Equidistant Conic	55	52	48	Ferro
Atlas016.jpg	14	1821 Western	Equidistant Conic	51.5	48.5	48	Ferro
Atlas017.jpg	15	1821 Western	Equidistant Conic	90	35	46	Ferro
Atlas018.jpg	16	1821 Western	Equidistant Conic	90	35	49.75	Ferro
Atlas019.jpg	17	1821 Western	Equidistant Conic	61	57	53	Ferro
Atlas020.jpg	18	1821 Western	Equidistant Conic	58.5	56	52.25	Ferro
Atlas021.jpg	19	1821 Western	Equidistant Conic	57	55	54.75	Ferro
Atlas022.jpg	20	1821 Western	Equidistant Conic	56.5	53.5	50.75	Ferro
Atlas023.jpg	21	1821 Western	Equidistant Conic	53	50	49.5	Ferro
Atlas024.jpg	22	1821 Western	Equidistant Conic	51.5	48.5	51	Ferro
Atlas025.jpg	23	1821 Western	Equidistant Conic	51.5	48.5	54	Ferro
Atlas026.jpg	24	1821 Western	Equidistant Conic	49.5	46.5	54	Ferro
Atlas027.jpg	25	1821 Western	Equidistant Conic	48	44	52	Ferro
Atlas028.jpg	26	1821 Western	Equidistant Conic	53	50	53.25	Ferro
Atlas029.jpg	27	1821 Western	Equidistant Conic	54	52	54	Ferro
Atlas030.jpg	28	1821 Western	Equidistant Conic	55.5	53.5	53	Ferro
Atlas031.jpg	29	1821 Western	Equidistant Conic	55	53	55	Ferro
Atlas032.jpg	30	1821 Western	Equidistant Conic	59	57	57	Ferro
Atlas033.jpg	31	1821 Western	Equidistant Conic	59	57	62	Ferro
Atlas034.jpg	32	1821 Western	Equidistant Conic	57	55	58	Ferro
Atlas035.jpg	33	1821 Western	Equidistant Conic	55.5	53.5	57.5	Ferro
Atlas036.jpg	34	1821 Western	Equidistant Conic	55	54	59.75	Ferro
Atlas037.jpg	35	1821 Western	Equidistant Conic	52	50	58	Ferro
Atlas038.jpg	36	1821 Western	Equidistant Conic	59	56	68	Ferro
Atlas039.jpg	37	1821 Western	Equidistant Conic	57	52	62	Ferro
Atlas040.jpg	38	1821 Western	Equidistant Conic	55	53	62	Ferro
Atlas041.jpg	39	1821 Western	Equidistant Conic	56.5	54.5	66.5	Ferro
Atlas042.jpg	40	1821 Western	Equidistant Conic	55	53	66	Ferro
Atlas043.jpg	41	1821 Western	Equidistant Conic	53	50	65	Ferro

SOURCE FILENAME	SHEET No	MOSAIC	PROJECTION	1st std Parallel	2nd std Parallel	Central Meridian	Prime Meridian
Atlas044.jpg	42	1821 Western	Equidistant Conic	50	47	59.5	Ferro
Atlas045.jpg	43	1821 Western	Equidistant Conic	49	45	65.5	Ferro
Atlas046.jpg	44	1821 Western	Equidistant Conic	47	41	60	Ferro
Atlas047.jpg	45	1821 Western	Equidistant Conic	44	40	61	Ferro
Atlas048.jpg	46	1821 Western	Equidistant Conic	64	60	54	Ferro
Atlas049.jpg	47a,b	1821 Western	Equidistant Conic	90	55	66.25	Ferro
Atlas050.jpg	48a,b	1821 Western	Equidistant Conic	49	49	64	Ferro
Atlas051.jpg	49	1821 Western	Equidistant Conic	90	55	76.666	Ferro
Atlas052.jpg	50	1821 Western	Equidistant Conic	49	54	75.167	Ferro
Atlas053.jpg	51a,b	1821 Eastern	Equidistant Conic	65	65	88.5	Ferro
Atlas054.jpg	52	1821 Eastern	Equidistant Conic	58	53	100	Ferro
Atlas055.jpg	53a,b	1821 Eastern	Equidistant Conic	62.5	47.5	112	Ferro
Atlas056.jpg	54	1821 Eastern	Equidistant Conic	25	25	**73**	**Paris**
Atlas057.jpg	55	1821 Eastern	Equidistant Conic	62	48	126.5	Ferro
Atlas058.jpg	57	1821 Eastern	Equidistant Conic	62.5	47.5	176	Ferro
Atlas059.jpg	56a,b,c,d	1821 Eastern	Equidistant Conic	55.5	55.5	154	Ferro
Atlas060.jpg	58a,b	1821 Eastern	Equidistant Conic	62.5	47.5	147	Ferro
Atlas061.jpg	59a,b,c,d,e,f	1821 Western	Equidistant Conic	48	64	43	Ferro
Atlas062.jpg	Russia Empire (6)	overview map	Equidistant Conic	62.5	47.5	115	Ferro

Appendix 2a: ***Irreconcilable features*** in Mosaic of 1821 Atlas of the Russian Empire

File 59 (Carte Generale de la Province d'Iakoutska et de Cercle Okhotskoi) and file 55 (Carte Generale du Gouvernement de Yenissey) are generally compliant except in the extreme northern section of Anabara river (border between the two regions) where discrepancy is in excess of 50km.



Although the Anabara river is remarkably compliant across both sheets for more than 1000km it starts to progressively to diverge in last 500km to the north.

Detailed examination against L7 imagery indicates that while in the west the Anabar Gulf is roughly compliant it is not shifted in the eas by some 60km and it is shaped incorrectly when compared with Landsat 7 imagery.

On the other hand river "Olem ou Olia" is well to the west of where it actualy is.

It appear that knowledge of the region at the mouth of the Anabara river was vague.

The course of Anabara river in in Atlas 059 was preferred since closest to L7 imagery

Area comprised between Ferro coordinates 128-130E , 74-68N was extensively edited. Western tributaries to the Anabara river were marked by dotted line when they could not be reconciled.

No feature was actually modified but either obtained from one sheet or the other.
In general features in Atlas 59 were preferred over features in Atlas 55.

Appendix 2b: ***Irreconcilable features*** in Mosaic of 1821 Atlas of the Russian Empire

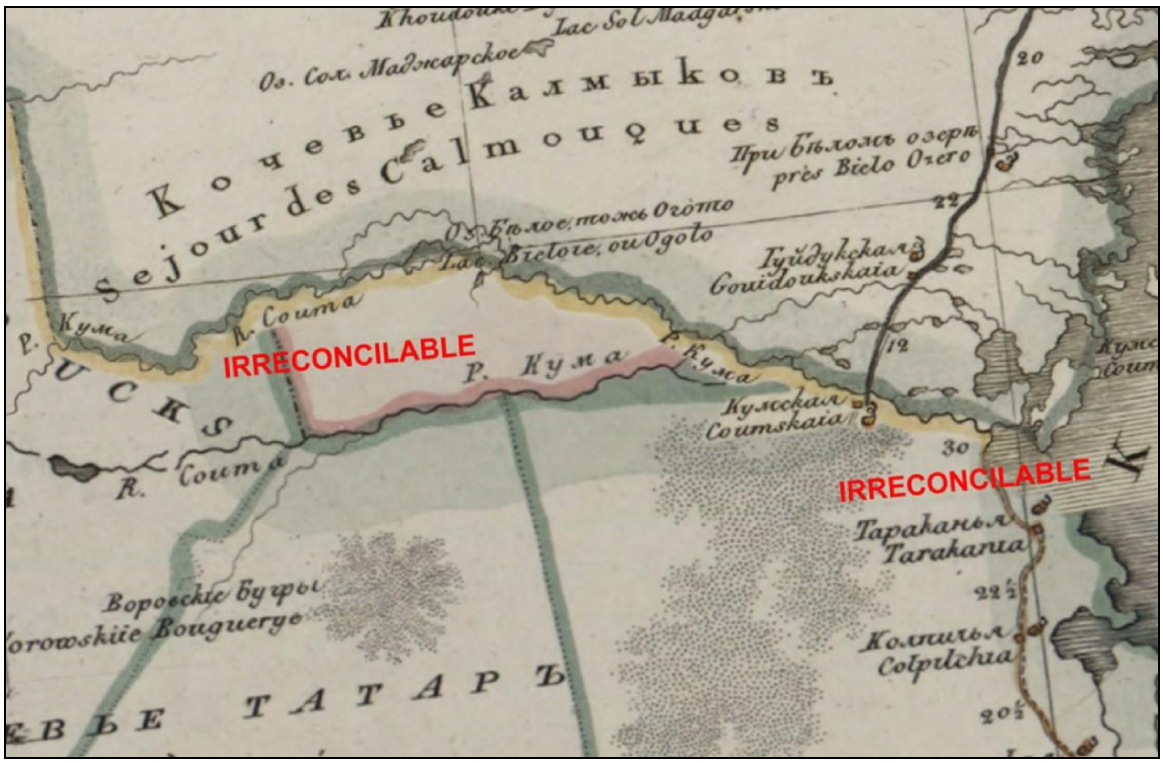
Towns of Proskurow and Woloczysk (Ukraine) in files Atlas 04 and Atlas 05 of the 1821 atlas are located on either sides (west and east respectively) of their actual position:

Although near Proskurow tile Atlas 05 is more correct than tile Atlas 04 (only 3.97 km east vs 16.54km west of actual location) by Woloczysk (a little to the west) offset against actual location is similar (9.375 km east for Atlas 05 and 9.083 km west for Atlas 04).

To the East of Proskurow maps are reconcilable.

Appendix 2c: ***Irreconcilable features*** in Mosaic of 1821 Atlas of the Russian Empire

1821 Atlas tiles Atlas 045 and Atlas 046 (on the Caspian Sea) were also irreconcilable:



In this case the geography of the two sheets is obviously incompatible with the course of the Couma River, which defines the border between the two territories, differing greatly not only in location (up to more than 20km) but also in overall geometry.

Differences are not limited to the Couma river but are applicable to other features such as coastline and roads as well. Also two sheets are quite different in style.

This would indicate some lack in coordination and in quality control during the compilation of the sheets which make up the Atlas.

Appendix 3: Mosaic of 1821 Atlas of the Russian Empire

Mosaic compilation and Graphic editing: this material is far from ideal for mosaic purposes since mosaic is not compiled by joining sheets cropped by a collar but by matching district borders and other features.

Workflow is quite complex and is best illustrated by an example.
Let us consider a particular spot on sheet 12 ...

and on sheet 22 (from 1821 Atlas)

Superimposing 12 on 22 with transparency illustrates the problematic of the project

Please take note that although features are generally compatible district borders do not necessarily match.

When there is no match district border in sheet of most detailed scale is preferred.

The only way to join these two maps is by choosing a "merge shapefile" along which features are reasonably compatible:

In order to eliminate any loss of information vector path must be chosen carefully so that at least one name (Latin or Cyrillic) is preserved.
River names are not generally a problem since names are repeated regularly along a river.

The "merge shapefile" is used to feather one sheet onto the other (with no transparency):

A merged output is then generated:

This output is far from ideal and graphic editing is required to reduce "noise"

After graphic editing: