TECHNISCHE UNIVERSITÄT DRESDEN

Cartography M.Sc.

Historical Spatio-temporal data in current GIS

Case Study: German-Herero war of resistance 1904

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- Research Objectives & Questions
- Research Workflow
- Materials & Methodologies
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Introduction

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History describes geography in the past.

Without time we cannot discuss the past, present nor future.

Spatial data represents features and objects in space at a point in time.

Problem Definition

- Need for temporal GIS applications
- Time is hardly supported in GIS applications
- Historical spatio-temporal data is widely available

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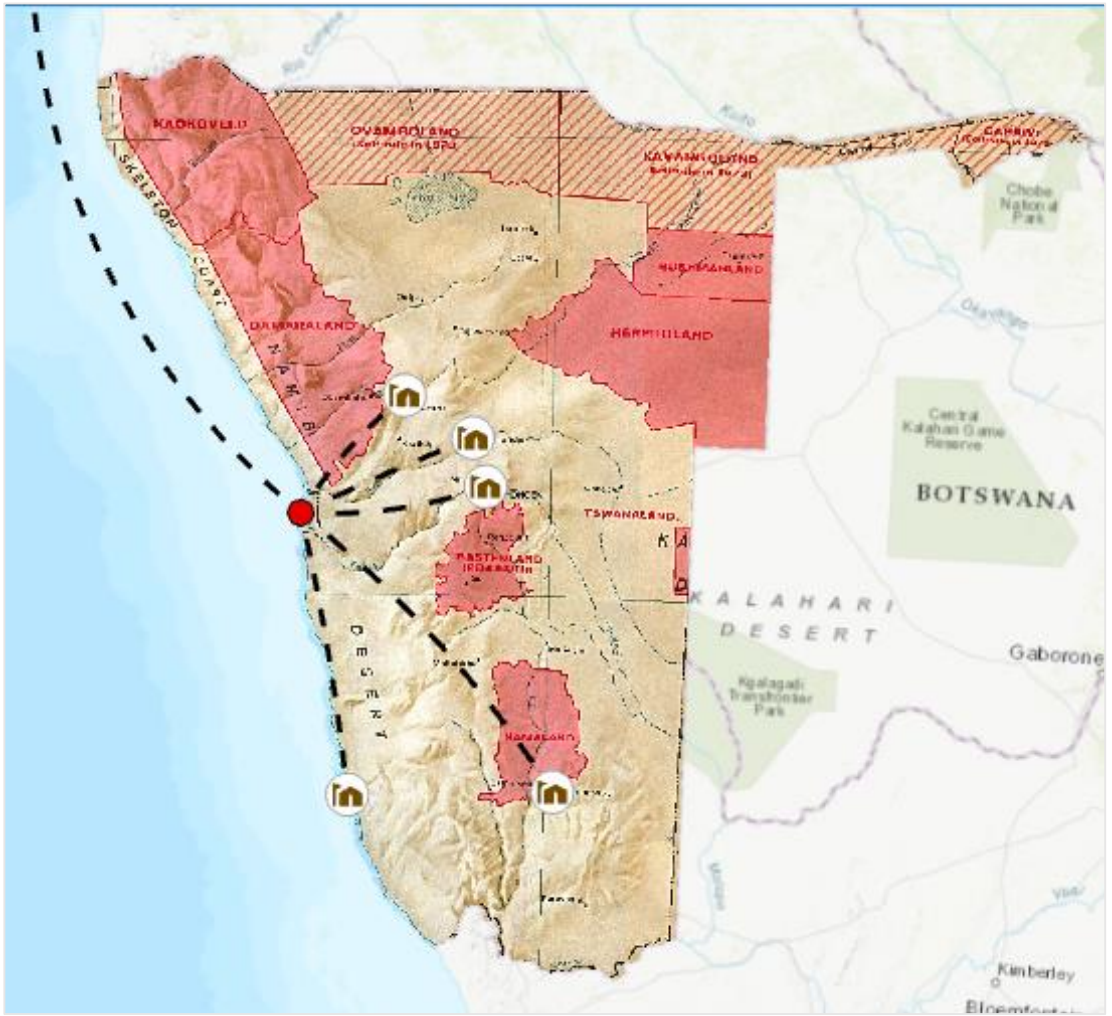
Case Study Background:

- 1880s German Settlers arrived in SWA.
- Spread Across the country
- Early 1900's the resistance struggle began.
- Hereros revolted in 1904.
- Germany responded by sending approx. 15000 troops under General Von Trotha.
- Herero got defeated on the 11th August 1904 in a decisive battle of Hamakari.

Source: Resistance struggle 1904 by Klaus Dierks



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Research Objectives:

- Framework to automatically extract historical spatio-temporal information from text documents.
- Assess ArcGIS capability in handling time.

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Research Questions:

1. What methods are available to recognise and extract spatial and temporal information from text documents?
2. How can we extract location event information and produce trajectories from the extracted references?
3. How can historical data be modelled best in regards to
   - Temporal vs. spatial data
   - Precision vs. accuracy of historical information
4. What analysis methods and functions are available for historical spatio-temporal data?
5. What cartographic visualization techniques are suitable to visualize the case study information?

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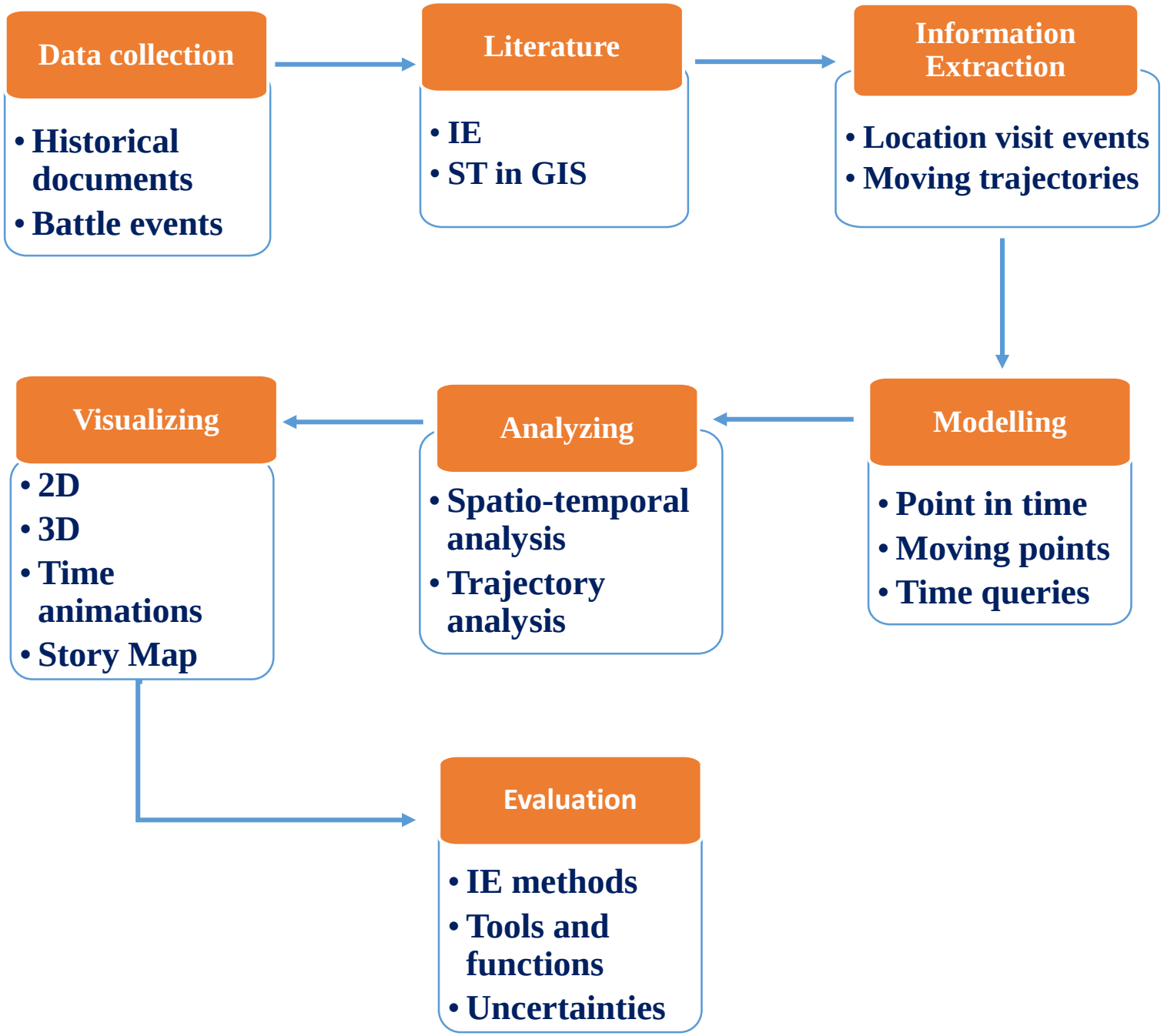

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Materials used:

Historical publications

1. Let us die fighting
2. The revolt of the Hereros
3. Chronology of the Namibian history
4. South West Africa under German rule
5. Herero Uprising – Namibia 1 on 1 – online article
6. Battle events – the-eis system

Tools:

- Notepad ++
- GATE 8.4
- PostgreSQL 1.6
- ArcGIS 10.5
- Esri Story Map Journal

❖ JAPE

❖ Python 3.4

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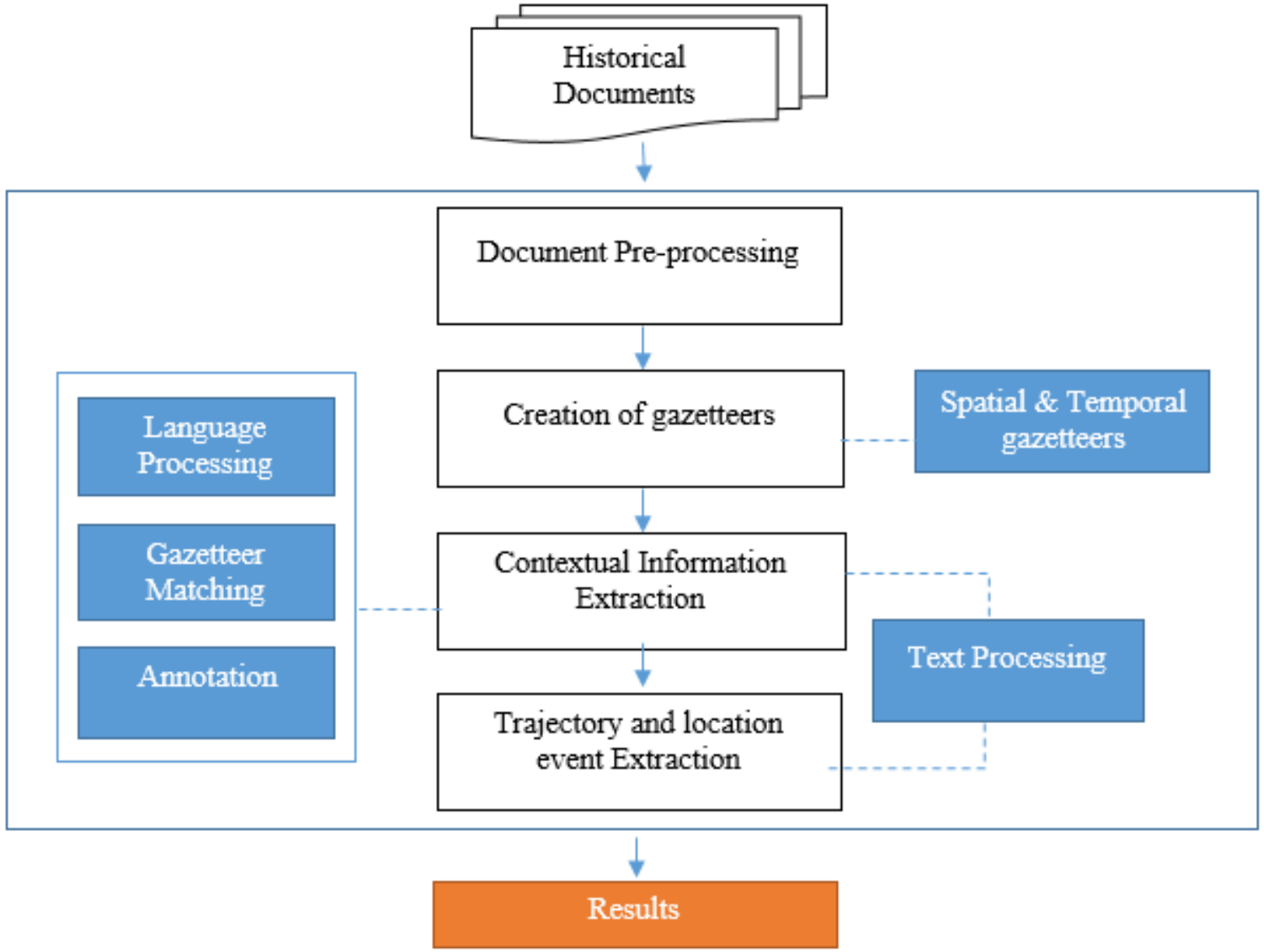
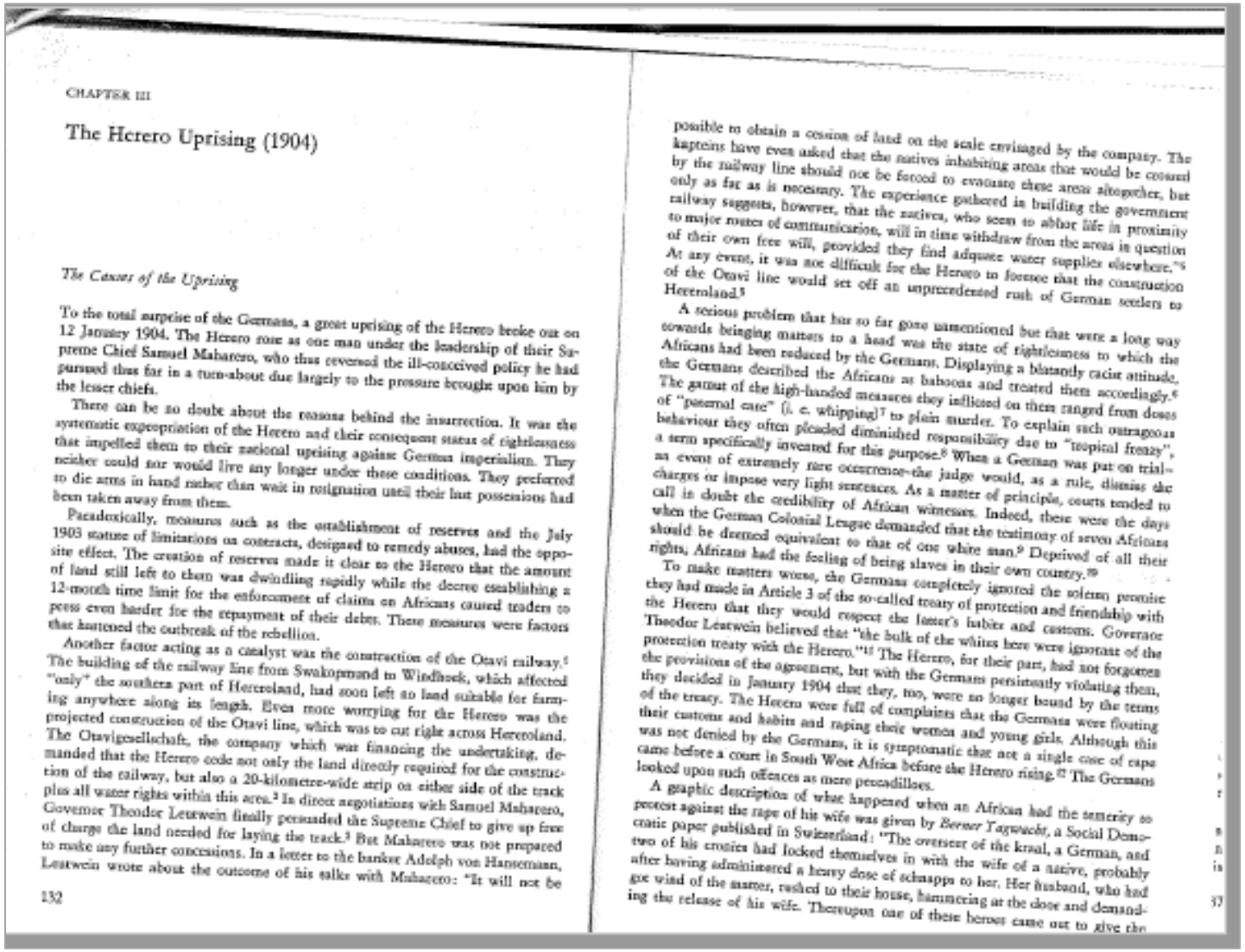
Information Extraction



Document Pre-processing:

- PDF to XML conversion



CHAPTER III

The Herero Uprising (1904)

The Causes of the Uprising

To the total surprise of the Germans, a great uprising of the Herero broke out on 12 January 1904. The Herero rose as one man under the leadership of their Supreme Chief Samuel Maharero, who thus reversed the ill-conceived policy he had pursued thus far in a turn-about due largely to the pressure brought upon him by the lesser chiefs.

There can be no doubt about the reasons behind the insurrection. It was the systematic expropriation of the Herero and their consequent status of righteousness that impelled them to their national uprising against German imperialism. They neither could nor would live any longer under these conditions. They preferred to die arms in hand rather than wait in resignation until their last possessions had been taken away from them.

Paradoxically, measures such as the establishment of reserves and the July 1903 statute of limitations on contracts, designed to remedy abuses, had the opposite effect. The creation of reserves made it clear to the Herero that the amount of land still left to them was dwindling rapidly while the decree establishing a 12-month time limit for the enforcement of claims on Africans caused traders to press even harder for the repayment of their debts. These measures were factors that hastened the outbreak of the rebellion.

Another factor acting as a catalyst was the construction of the Otavi railway.[1] The building of the railway line from Swakopmund to Windhoek, which affected "only" the southern part of Hereroland, had soon left no land suitable for farming anywhere along its length. Even more worrying for the Herero was the projected construction of the Otavi line, which was to cut right across Hereroland. The Otavigesellschaft, the company which was financing the undertaking, demanded that the Herero cede not only the land directly required for the construction of the railway, but also a 20-kilometre-wide strip on either side of the track plus all water rights within this area.[2] In direct negotiations with Samuel Maharero, Governor Theodor Leutwein finally persuaded the Supreme Chief to give up free of charge the land needed for laying the track.[3] But Maharero was not prepared to make any further concessions. In a letter to the banker Adolph von Hansemann, Leutwein wrote about the outcome of his talks with Maharero: "It will not be

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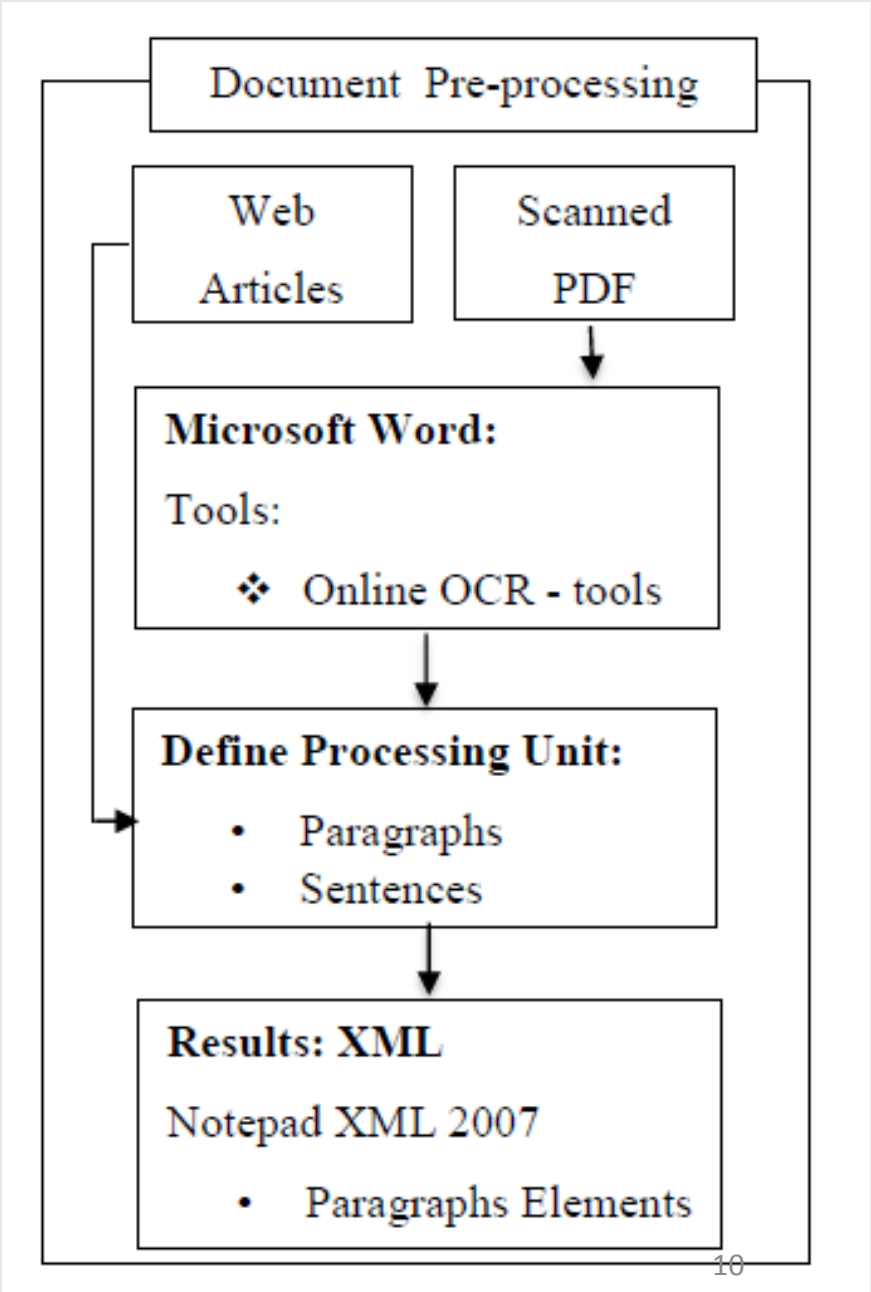
possible to obtain a cession of land on the scale envisaged by the company. The kapteins have even asked that the natives inhabiting areas that would be ceased by the railway line should not be forced to evacuate these areas altogether, but only as far as is necessary. The experience gathered in building the government railway suggests, however, that the natives, who seem to abhor life in proximity to major routes of communication, will in time withdraw from the areas in question of their own free will, provided they find adquate water supplies elsewhere."[4] At any event, it was not difficult for the Herero to foresee that the construction of the Otavi line would set off an unprecedented rush of German settlers to Hereroland.[5]

A serious problem that has so far gone unmentioned but that were a long way towards bringing matters to a head was the state of righteousness to which the Africans had been reduced by the Germans. Displaying a blatantly racist attitude, the Germans described the Africans as baboons and treated them accordingly.[6] The gamut of the high-handed measures they inflicted on them ranged from doses of "paternal care" (i. e. whipping)[7] to plain murder. To explain such outrageous behaviour they often pleaded diminished responsibility due to "tropical frenzy", a term specifically invented for this purpose.[8] When a German was put on trial—an event of extremely rare occurrence—the judge would, as a rule, dismiss the charges or impose very light sentences. As a matter of principle, courts tended to call in doubt the credibility of African witnesses. Indeed, these were the days when the German Colonial League demanded that the testimony of seven Africans should be deemed equivalent to that of one white man.[9] Deprived of all their rights, Africans had the feeling of being slaves in their own country.[10]

To make matters worse, the Germans completely ignored the solemn promise they had made in Article 3 of the so-called treaty of protection and friendship with the Herero that they would respect the latter's habits and customs. Governor Theodor Leutwein believed that "the bulk of the whites here were ignorant of the protection treaty with the Herero."[11] The Herero, for their part, had not forgotten the provisions of the agreement, but with the Germans persistently violating them, they decided in January 1904 that they, too, were no longer bound by the terms of the treaty. The Herero were full of complaints that the Germans were flouting their customs and habits and raping their women and young girls. Although this was not denied by the Germans, it is symptomatic that not a single case of rape came before a court in South West Africa before the Herero rising.[12] The Germans looked upon such offences as mere peccadilloes.

A graphic description of what happened when an African had the temerity to protest against the rape of his wife was given by *Berner Tagwacht*, a Social Democratic paper published in Switzerland: "The overseer of the kraal, a German, and two of his cronies had locked themselves in with the wife of a native, probably after having administered a heavy dose of schnapps to her. Her husband, who had got wind of the matter, rushed to their house, hammering at the door and demanding the release of his wife. Thereupon one of these heroes came out to give the



Document Pre-processing results:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<document title="The Resistance Struggle culminates in genocide: 1904-1906">
    <paragraph id="100" date="11.01">
        <sentence id="101">11.01. Samuel Maharero orders all Ovaherero chiefs to take up arms against the Germans.</sentence>
        <sentence id="102">He orders them to "refrain from touching missionaries, English, Basters, Berg-Damaras, Namas and Boers".</sentence>
        <sentence id="103">There are doubts concerning the date of this order.</sentence>
        <sentence id="104">It is possible that Maharero wrote this letter after the outbreak of the war (around 20.01.), after the first shots were f
        <sentence id="105">Samuel Maharero tries to involve the Basters, under Hermanus van Wyk and Hendrik Witbooi, in the struggle. The two letters
        <sentence id="106">Van Wyk hands over the letters for Witbooi to the Germans. In the second of these letters Samuel writes: "All our obedienc
        <sentence id="107">Hence I appeal to you, my Brother, not to hold aloof from the uprising, but to make your voice heard so that all Africa ma
        <sentence id="108">" These three letters were also written after the outbreak of the war. They can therefore, together with Samuel Maharero's
        <sentence id="109">On the other hand, from the very beginning of the German presence in SWA, substantial numbers of Ovaherero are employed by
        <sentence id="110">After the outbreak of the war a number of Ovaherero continue to serve in the German forces.</sentence>
        <sentence id="111">Some are even killed on the German side.</sentence>
        <sentence id="112">Gustav Duft tries to negotiate with Samuel Maharero at Okahandja, to no avail because Maharero and Assa Riarua are at Oson
    </paragraph>
    <paragraph id="200" date="12.01">
        <sentence id="201">12.01. After the first shots were fired at Okahandja (allegedly by the Germans), the Ovaherero revolt throughout SWA.</sen
        <sentence id="202">In the first couple of days 123 Germans are killed (among them 13 active soldiers, seven Boers and five women), goods and
        <sentence id="203">This uprising takes place due to loss of control and ownership of traditional land (German native reserve" policy), usury
        <sentence id="204">Missionary Carl Wandres reports Gustav Duft saying: "If Zurn had not been in Okahandja, then the issue would not have deve
        <sentence id="205">Zurn is later threatened with a German court martial because he is held responsible for the outbreak of the war.</sentence
        <sentence id="206">A further war cause is the absence of Maharero, Assa Riarua and Leutwein from Okahandja.</sentence>
        <sentence id="207">The many rumours amongst German settlers and soldiers of a possible Ovaherero uprising add to the outbreak of the war, alt
        <sentence id="208">On 06.01. Kurt Streitwolf reports on a meeting with Traugott Tjetjo in the Gobabis district.</sentence>
        <sentence id="209">Streitwolf does not believe that war is imminent.</sentence>
        <sentence id="210">At the Waterberg, Sergeant G Rademacher and missionary Wilhelm Eich react to reports by Else Sonnenberg, whose husband, tr
        <sentence id="211">Rademacher and Eich report that war is unlikely, but that Kambazembi is preparing for a visit of Chief Ouandja at Otjikuru
        <sentence id="212">The Gobabis-Dama support the Ovaherero.</sentence>
        <sentence id="213">The Germans are supported by Hendrik Witbooi, but in October 1904 Witbooi is prompted to revolt against German rule by the
        <sentence id="214">Leutwein later reports that the war came as a complete surprise to all "white" settlers, including the missionaries, due t
        <sentence id="215">The reinforcement of soldiers from Germany is slow.</sentence>
        <sentence id="216">Ultimately 14 000 German soldiers are involved, 1 500 of whom die.</sentence>
        <sentence id="217">This war effort costs Germany 585 million Mark.</sentence>
        <sentence id="218">T  he Ovaherero resistance effort is characterised by disorganisation and a lack of co-ordination. The uprising is trigg
```

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Creation of Gazetteers

Temporal gazetteer

No.	Entity	Pattern
1.	Date	June 1904
2.	Date	June 13
3.	Date	June 13, 1904
4.	Date	13 June
5.	Date	13 June 1904
6.	Date	11.06.
7.	Date	11.06.1904

Spatial gazetteer

- List of place names – **3859** place names
- Declared in list.def

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Creation of Gazetteers

JAPE Transducer

- Text Patterns
- LHS Rule
- RHS Rule
- Annotation Class

- Date Expressions
- Attributive information

```
Phase: datetimefinder
Input: Token Lookup SpaceToken
Options: control = appelt

////////////////////////////////////Macros
//Initialization of regular expressions
Macro: DAY_ONE
({Token.kind == number,Token.category==CD, Token.length == "1"})

Macro: DAY_TWO
({Token.kind == number,Token.category==CD, Token.length == "2"})

Macro: YEAR
({Token.kind == number,Token.category==CD, Token.length == "4"})

Macro: MONTH
({Lookup.minorType=="month"})


////////////////////////////////////////////Rule 6
//For date format 12.08 for 12 August
Rule: numberdate
Priority: 50
(
    (DAY_ONE|DAY_TWO)
    ({Token.string == ","}|{Token.string == "."} |{Token.string == "-"})
    (DAY_ONE|DAY_TWO)
    ({Token.string == ","}|{Token.string == "."} |{Token.string == "-"})?
)
:numberdate
-->
    :numberdate.NumberDate= {rule = "numberdate"}

```

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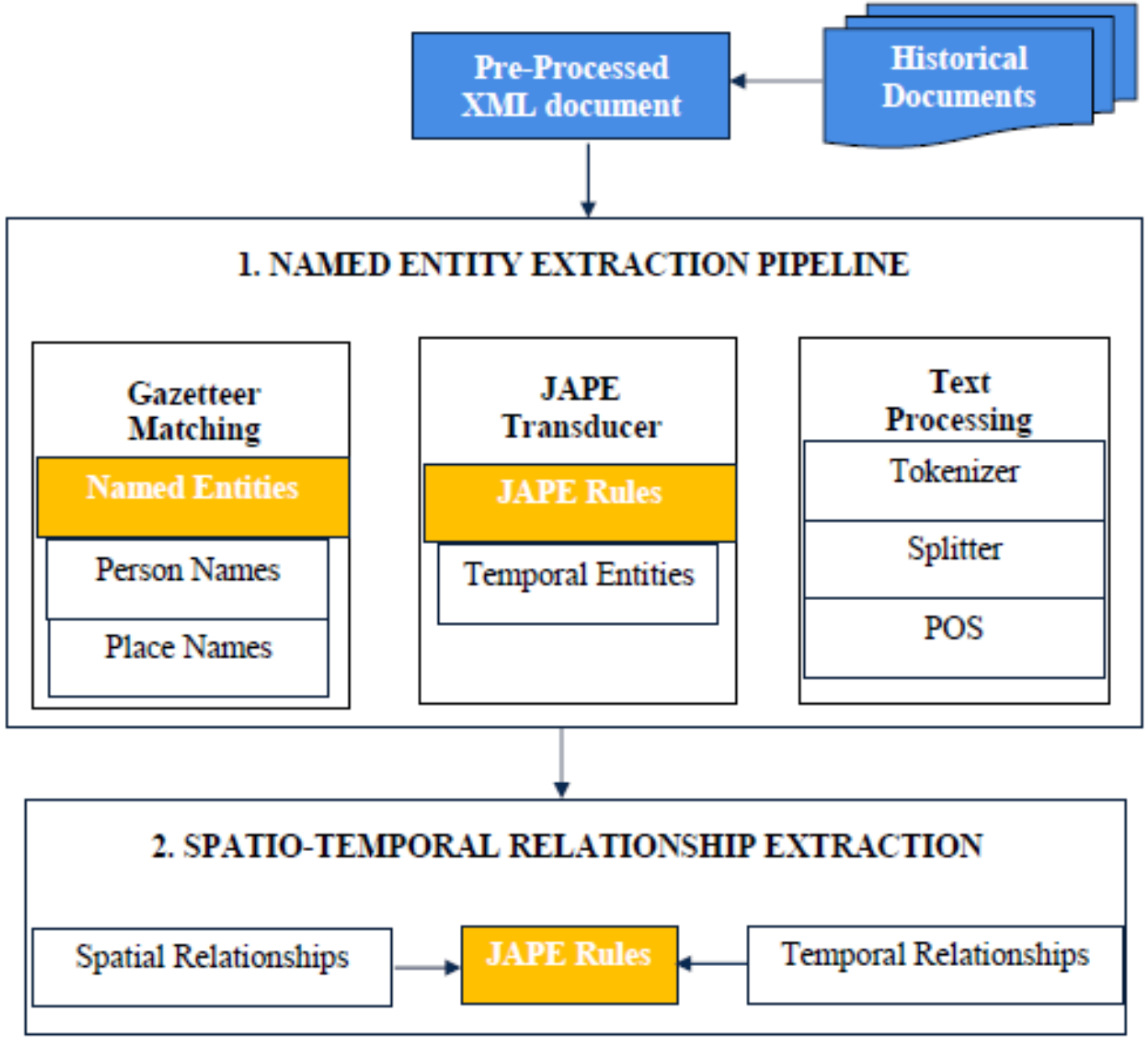
Contextual Information Extraction



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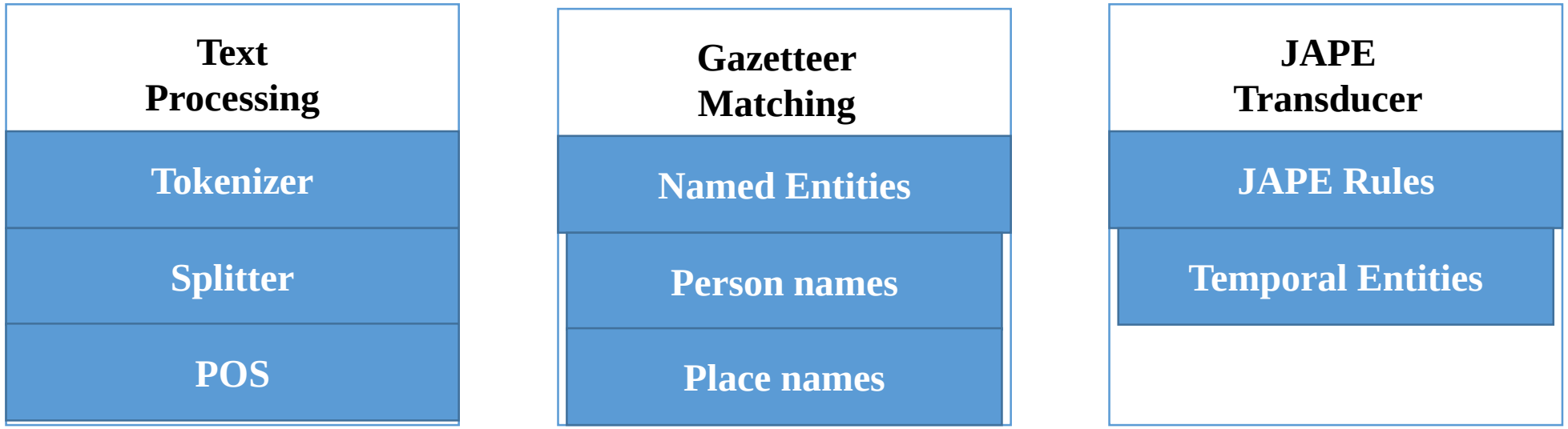
Entity Extraction Pipeline



Date

Person

location

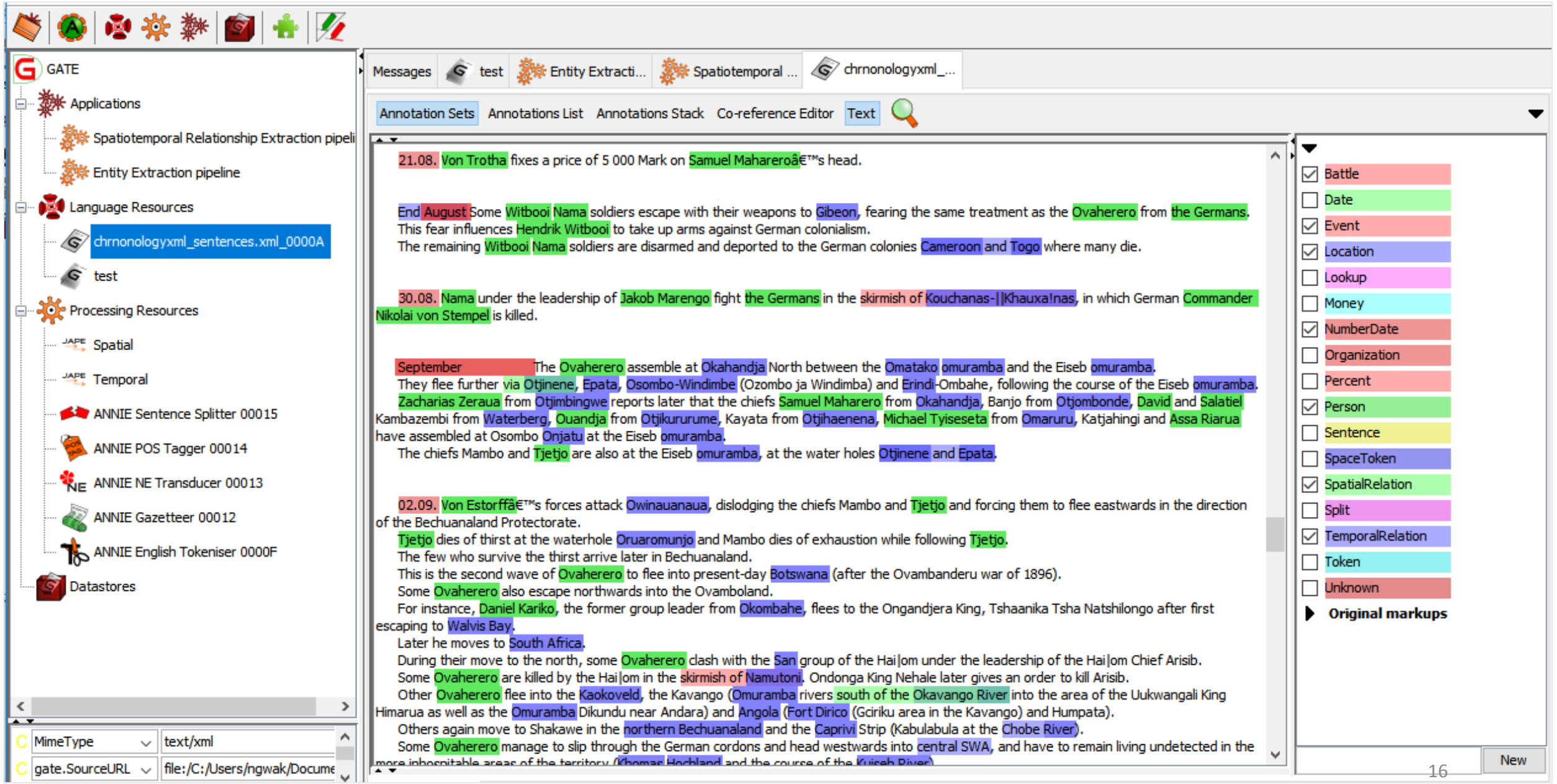
28./29.03. Zeraua leaves the area of Oruware and moves via Teufelsbach to the east.

30.03. Zeraua joins the Otjimbingwe and Omaruru Ovaherero at Samuel's station at Ongandjira in the upper Swakop valley.

01.04. Von Glasenapp's unit proceeds in the direction of Otjikuoko without meeting the Tjetjo community.

03.04. Tjetjo meets the Germans in a battle at a site between Okaharui and Otjikuara, with heavy losses on both sides.

GATE annotation framework:



GATE Annotation Results:

```
1  <?xml version="1.0" encoding="UTF-8"?>
2  <document xmlns:gate="http://www.gate.ac.uk" gate:gateId="0" gate:annotMaxId="28690" title="The Resistance Struggle culminates in genocide: 1904-1906">
3  <paragraph gate:gateId="1" date="11.01" id="100">
4      <sentence gate:gateId="2" id="101">
5          <NumberDate gate:gateId="28273" rule="numberdate">11.01.</NumberDate>
6          <Person gate:gateId="28443" firstName="Samuel" rule="PersonFull" ruleFinal="PersonFinal" gender="male" surname="Maharero" kind="fullName">Samuel Maharero
7          orders all
8          <Person gate:gateId="28444" rule="GazPerson" ruleFinal="PersonFinal" surname="Ovaherero" kind="fullName">Ovaherero</Person>
9          chiefs to take up arms against
10         <Person gate:gateId="28445" firstName="the" rule="GazPerson" ruleFinal="PersonFinal" surname="Germans" kind="fullName">the Germans</Person>
11         .
12     </sentence>
13     <sentence gate:gateId="3" id="102">He orders them to &amp;quot;refrain from touching missionaries, English, Basters, Berg-Damaras, Namas and Boers&amp;quot;
14     <sentence gate:gateId="4" id="103">There are doubts concerning the date of this order.</sentence>
15     <sentence gate:gateId="5" id="104">
16         It is possible that
17         <Person gate:gateId="28446" rule="GazPerson" ruleFinal="PersonFinal" surname="Maharero" kind="fullName">Maharero</Person>
18         wrote this letter after the outbreak of the war (around
19         <NumberDate gate:gateId="28274" rule="numberdate">20.01.</NumberDate>
20         ), after the first shots were fired in
21         <Location gate:gateId="28447" rule="InLoc1" ruleFinal="LocFinal" locType="town" kind="locName">Okahandja</Location>
22         , where it is not clear at all, who actually fired these first shots (Missionary Diehl reports that only
23         <Person gate:gateId="28448" firstName="the" rule="GazPerson" ruleFinal="PersonFinal" surname="Germans" kind="fullName">the Germans</Person>
24         fired on his house, not the
25         <Person gate:gateId="28449" rule="GazPerson" ruleFinal="PersonFinal" surname="Ovaherero" kind="fullName">Ovaherero</Person>
26         ).
27     </sentence>
28     <sentence gate:gateId="6" id="105">
29         <Person gate:gateId="28450" firstName="Samuel" rule="PersonFull" ruleFinal="PersonFinal" gender="male" surname="Maharero" kind="fullName">Samuel Maharero
30         tries to involve the Basters, under
31         <Person gate:gateId="28451" firstName="Hermanus" rule="GazPerson" ruleFinal="PersonFinal" surname="van Wyk" kind="fullName">Hermanus van Wyk</Person>
32         and
33         <Person gate:gateId="28452" firstName="Hendrik" rule="GazPerson" ruleFinal="PersonFinal" surname="Witbooi" kind="fullName">Hendrik Witbooi</Person>
34         , in the struggle. The two letters
35         <Person gate:gateId="28453" rule="GazPersonFirst" firstName="Samuel" ruleFinal="PersonFinal" gender="male" kind="firstName">Samuel</Person>
```

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Information Extraction Algorithm:

Input: *XML Document D, Paragraph P, Sentence E*
Results: *combine[T, S, N]*
where T= Temporal term, S = Spatial term, N = personNames

Begin:
Parse D,
For *each Paragraph P in D do:*
Get paragraph date as Pd
For *each Sentence E in P do:*
If *only S and N* ***then***
assign Pd as T
combine (T, S, N)
If *only one T, one S and N* ***then***
combine(T, S, N)
If *multiple T and one S* ***then***
assign S to each T , combine(T1, S, N), combine(T2, S, N)....
If *multiple S and one T* ***then***
assign T to each S, combine(T, S1, N), combine(T, S2, N).....
If *multiple S and multiple T and one N* ***then****:*
if *S == T* ***then***
combine(T1, S1, N), combine(T2, S2, N)....
If *multiple T, multiple S and multiple N* ***then***
if *T == S == N* ***then***
combine(T1, S1, N1), combine(T2, S2, N2)....
Else
Jump to next sentence
Return combine(T, S, N)
End

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Extracted information in PostgreSQL:

	person text	location text	date text	temporalrelation text	spatialrelation text	sentenceid integer
97	Tjetjo	between Otjiku...	03.04.1904		between Otjikuara	3201
98	the Germans	between Otjiku...	03.04.1904		between Otjikuara	3201
99	Samuel Maharero	Okatumba	10.04.1904			3401
100	Samuel Maharero	Oviumbo	10.04.1904			3401
101	the Germans,Leutwein,Ovaherero	Oviumbo	13.04.1904			3501
102	the Germans,Leutwein,Ovaherero	Otjosazu	13.04.1904			3501
103	Von Glasenappâ	Otjihangwe	24.04.1904			3502
104	Von Glasenappâ	Otjihaenena	24.04.1904			3502
105	Ovaherero	Waterberg	19.04.1904			3601
106	the Germans	Engarawau	19.04.1904			3602
107	Ovaherero	Okangundi	28.04.1904			3701
108	Arthur Koppel	Warmquelle	20.05.1904		near Zesfontein	3901
109	Kutako	Tsumeb	06.08.1904			4803
110	Herero	Waterberg	10.08.1904			5002
111	Von Estorff	Okomiparum	10.08.1904			5003

- ✓ **Cleaning**
- ✓ **Geocoding**
- ✓ **Creating individual trajectories**

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Historical Spatio-temporal data

1. Location visit events
2. Individual trajectories
3. Battle events

We are interested in:

- Space and existence in time
- Change in position
- Spatial relationships in time
- Query attributes of spatial objects in time

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Modelling historical events in ArcGIS

- Point in time
- Duration in time
- Time as attribute

tjetjo

Shape *	date	person	location	latitude	longitude	loc_vistid	group	end_date
Point	06/01/1904	Tjetjo	Gobabis	-22.45	18.9717	1	Herero	11/03/1904
Point	11/03/1904	Tjetjo	Onjati Mountains	-22.19	17.4378	82	Herero	12/03/1904
Point	12/03/1904	Tjetjo	Onjatu	-20.94	16.44	89	Herero	13/03/1904
Point	13/03/1904	Tjetjo	Owikokorero	-21.9832	16.9131	90	Herero	01/04/1904
Point	01/04/1904	Tjetjo	Otjikuoko	-21.69	17.31	99	Herero	03/04/1904
Point	03/04/1904	Tjetjo	Between Okaharui and Otjiku	-21.65269	17.519	100	Herero	15/05/1904
Point	15/05/1904	Tjetjo	Tsumeb	-19.24444	17.7122	117	Herero	01/09/1904
Point	01/09/1904	Tjetjo	Epata	-21.00775	18.8763	189	Herero	01/09/1904
Point	01/09/1904	Tjetjo	Otjinene	-21.13833	18.785	191	Herero	01/09/1904
Point	01/09/1904	Tjetjo	Omuramba - Omatako	-21.15907	16.7186	192	Herero	16/09/1904
Point	16/09/1904	Tjetjo	Oruaromunjo	-20.864	20.784	203	Herero	16/09/1904

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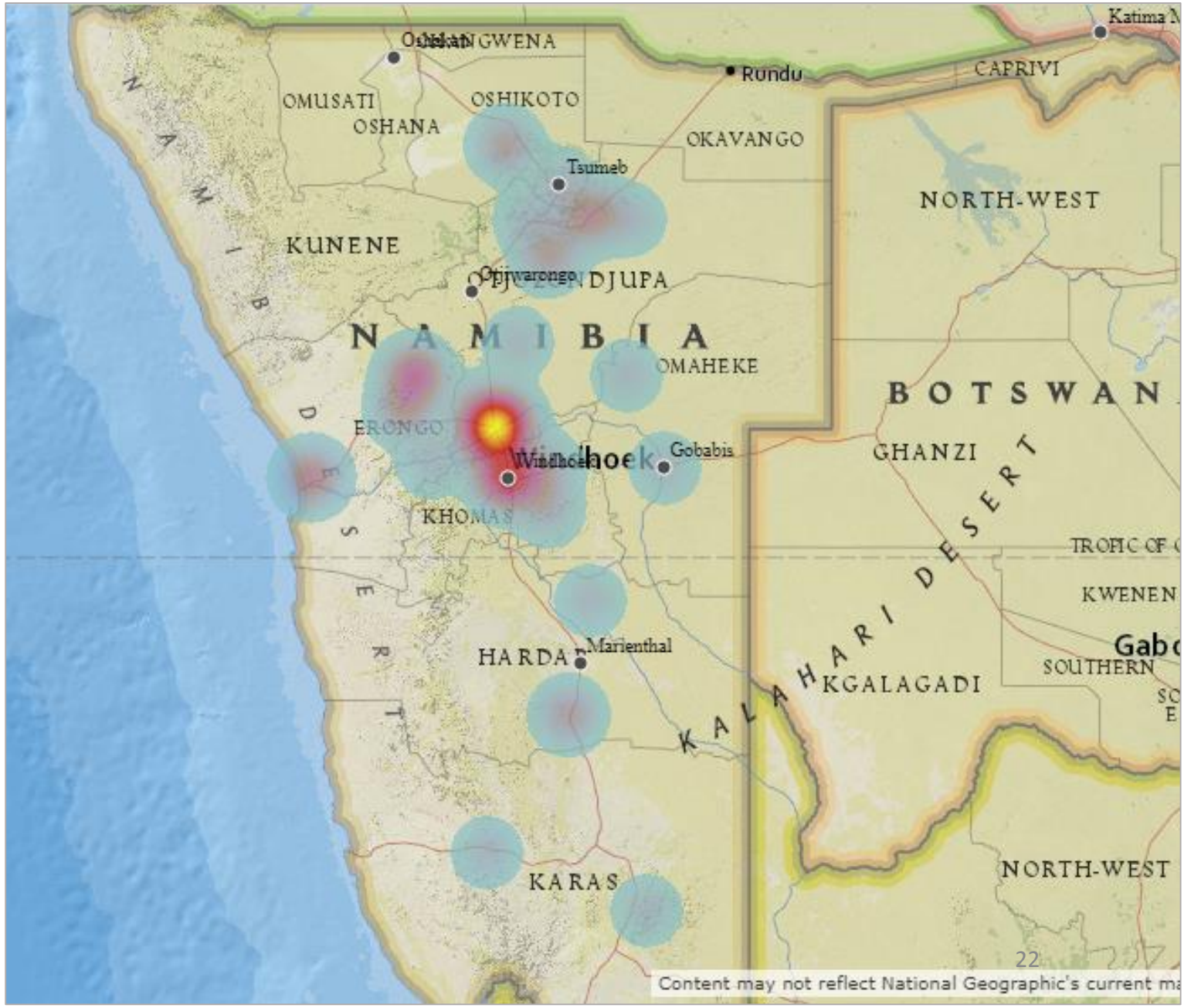
Spatio-temporal Cluster Analysis

- Isarithmic Method
- Answers ***"Where"***
- Animated to detect cluster patterns



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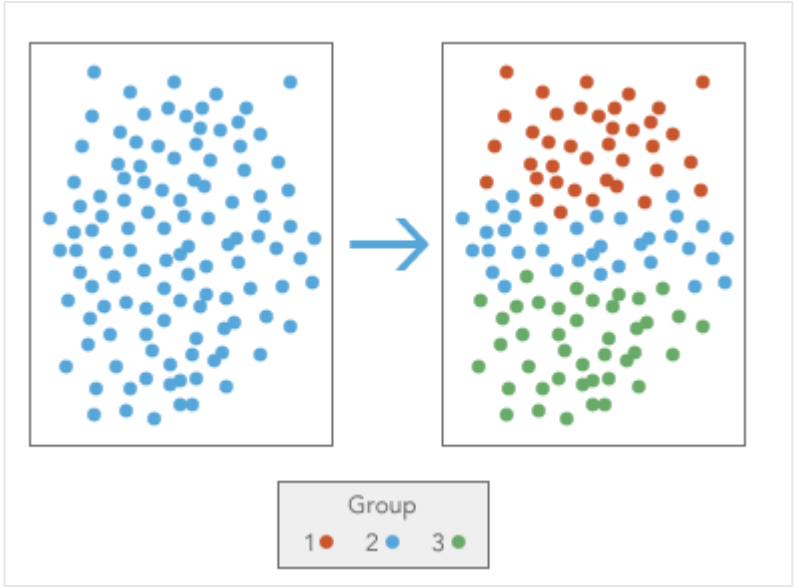
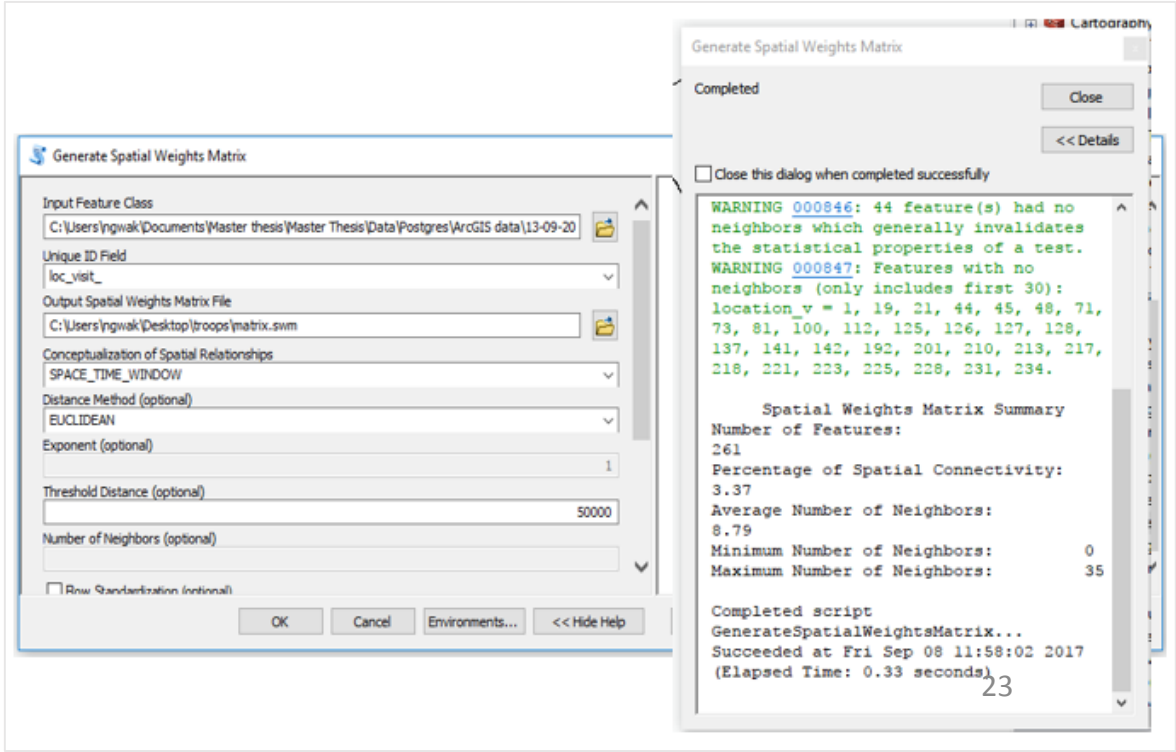
Spatio-temporal Cluster Analysis

- Grouping Analysis Method
- Defines Spatial and temporal neighbours



- Generate Weight matric tool
- Space time window method
- Insufficient data



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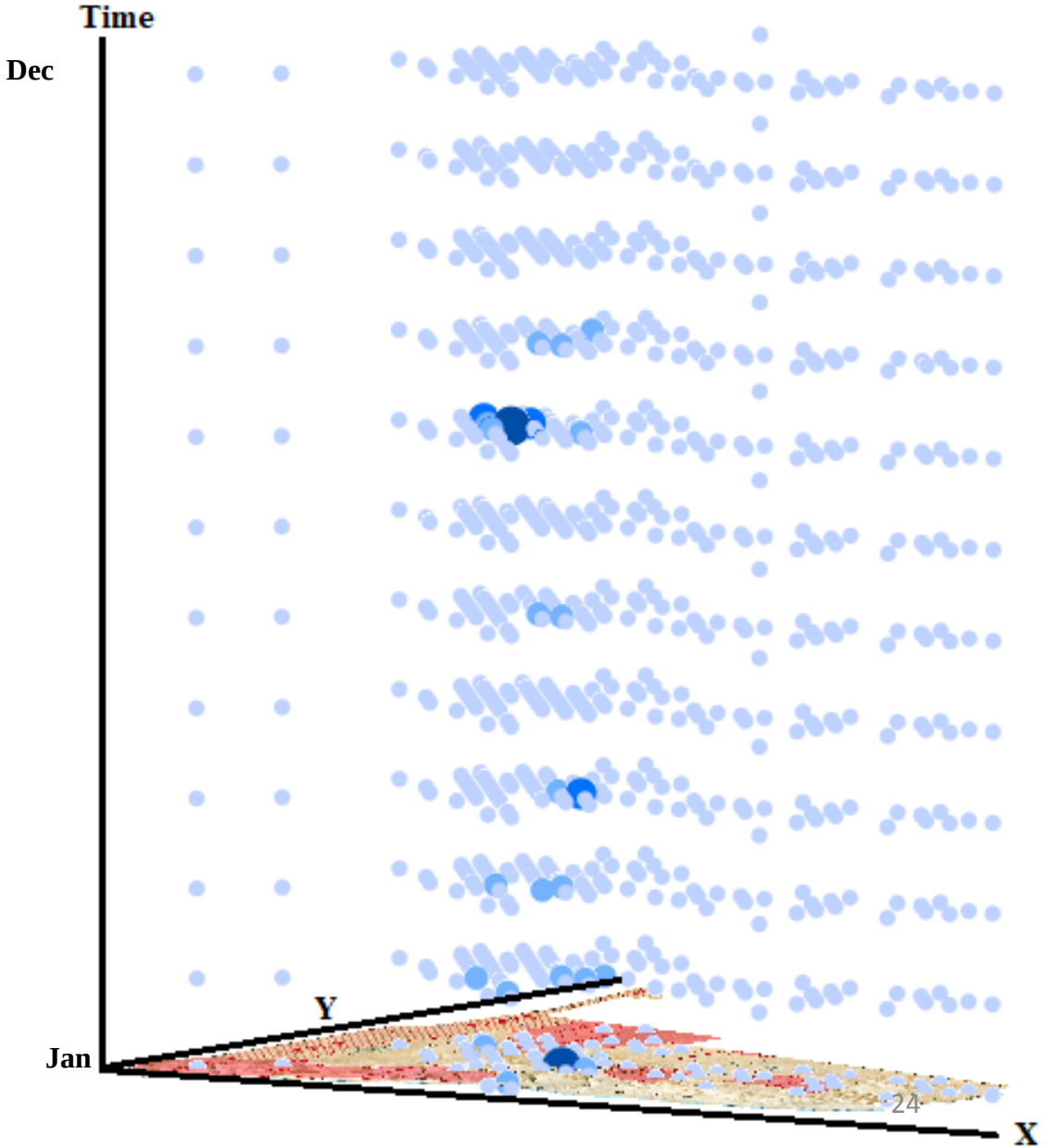
Space – time cube Analysis

- (x, y, time) representation
- Count = Size and colour
- Animated to detect space-time patterns

- Answers:
  - ***"Where"?***
  - ***"When"?***

Monthly location visit events



Trajectory representations & Analysis

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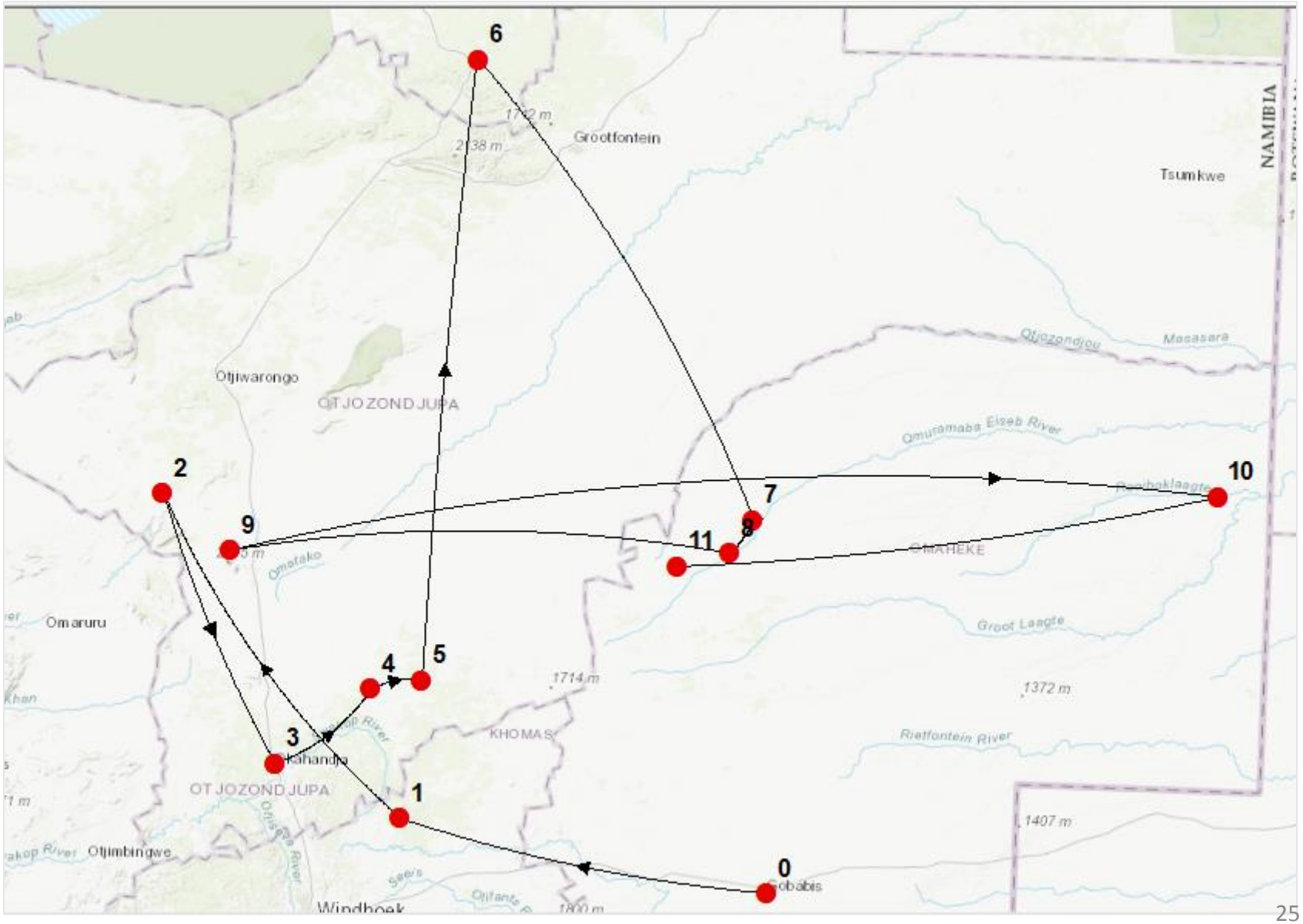

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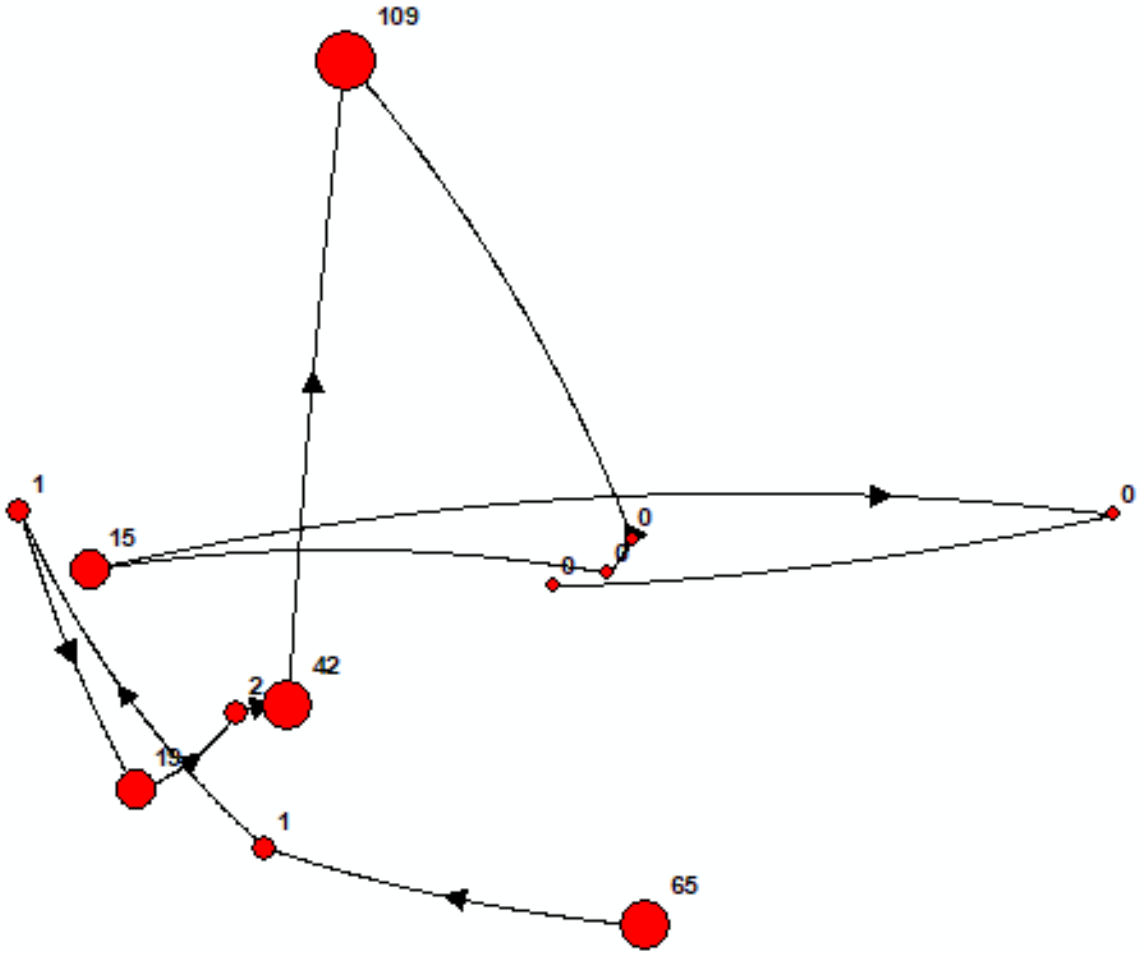
Trajectory representations & Analysis

- ***What space-time analysis?***
- Query trajectory attributes
- Duration between locations



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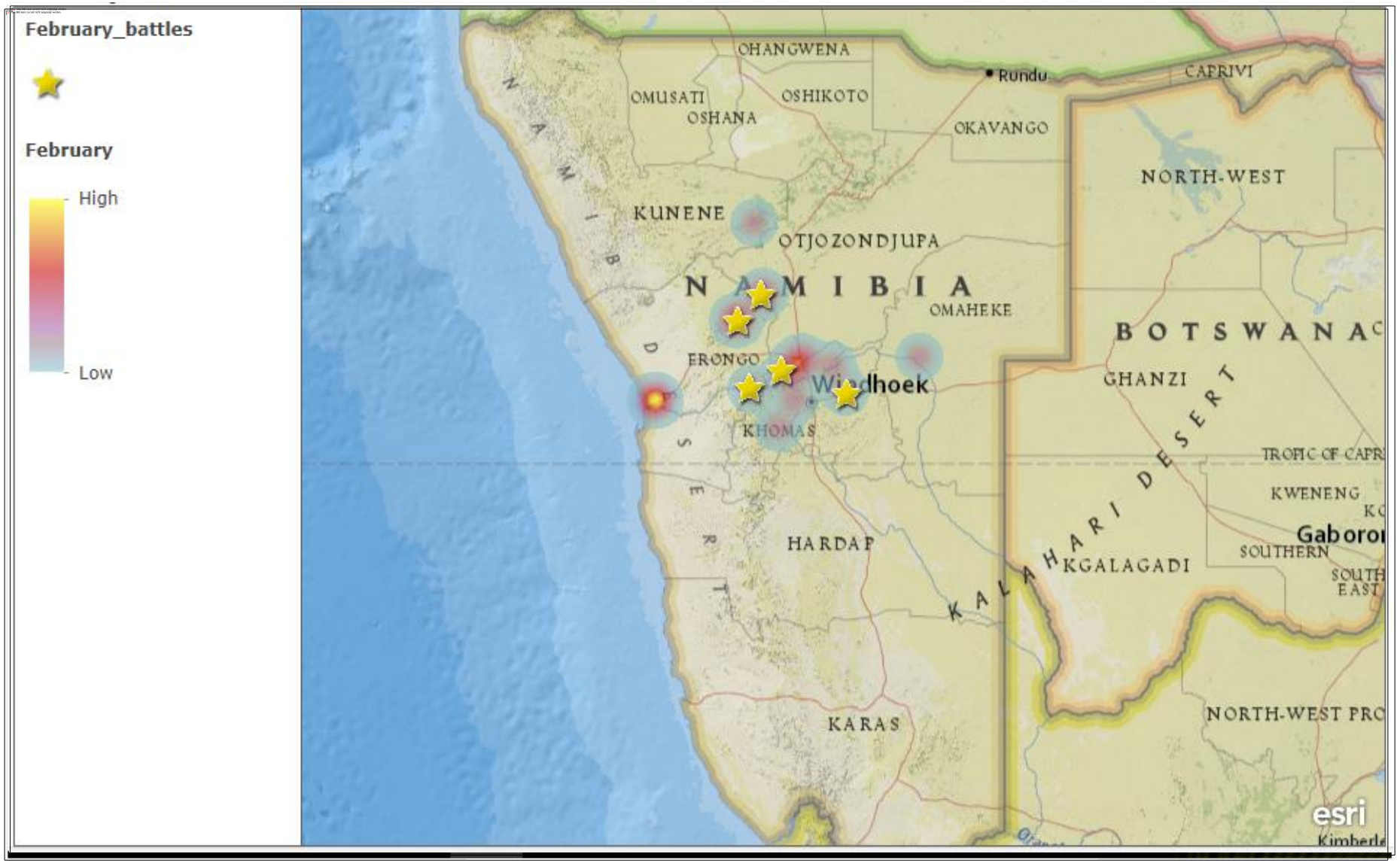
Static and Multiple Static Maps



Monthly historical visit events

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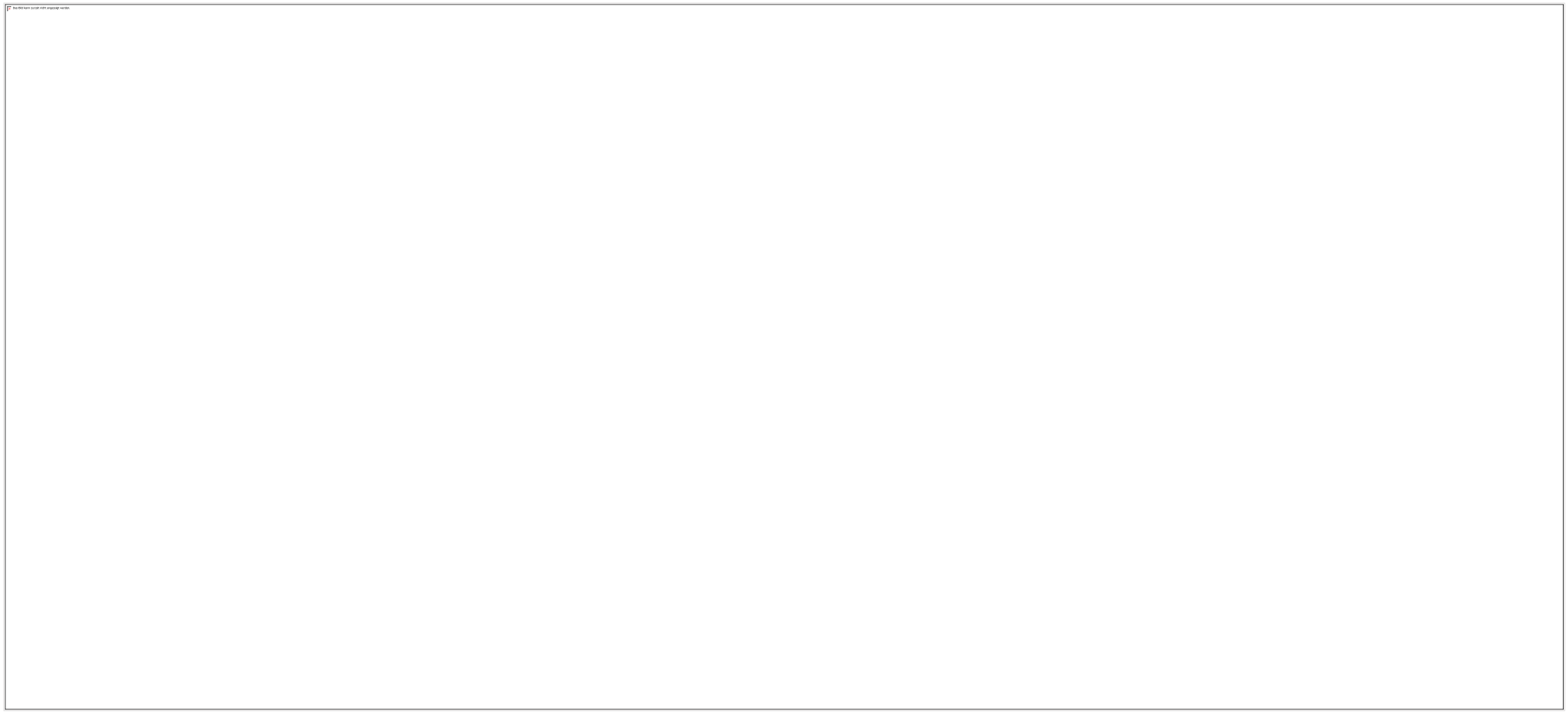
Time Animations

Story Map Journal



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Information Extraction Method

- Approach used successfully extracted Spatial, temporal and attributive
- Spatio-temporal relationship terms
- Support Domain specific extractions
- Results in document structure
- Flexible framework

X Time consuming

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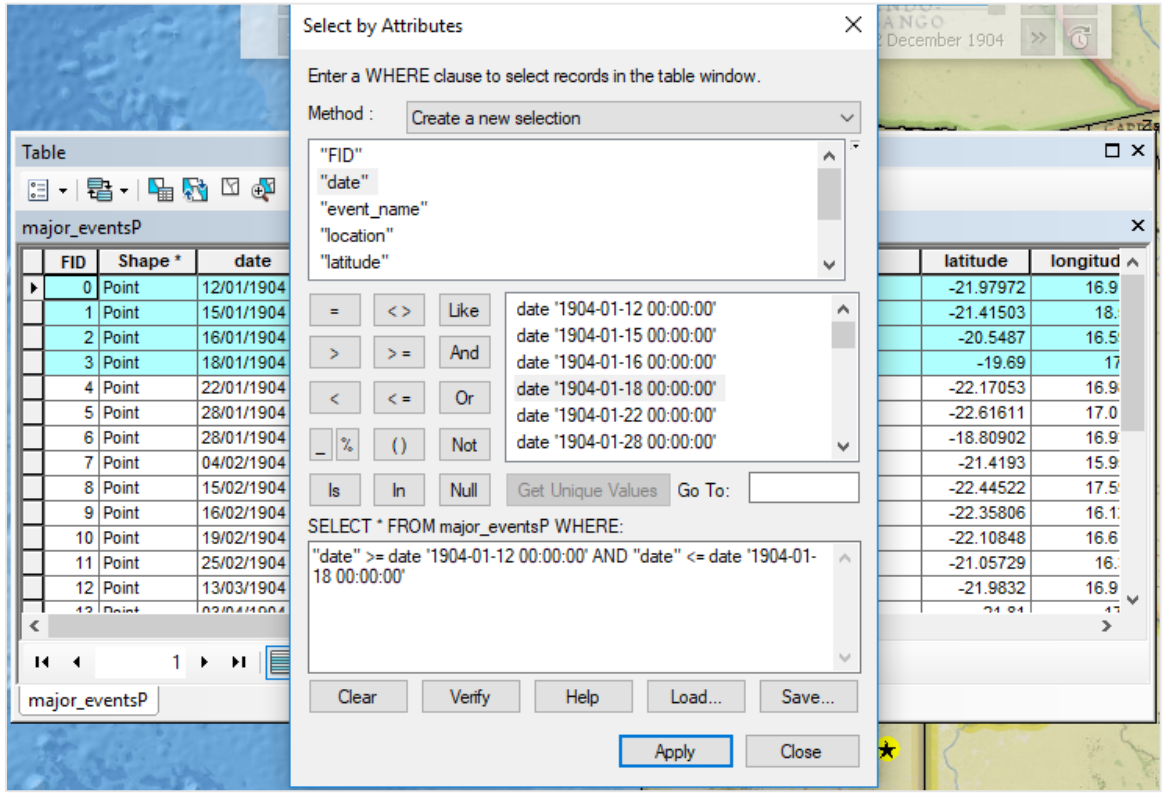
Modelling time

- Time as attribute
- Limited time retrieval functions
- Simple SQL queries

X Topological relationships in time



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Spatio-temporal cluster Analysis

- ✓ Spatio-temporal neighbors
- X Requires substantial amount of data
- X Not suitable for dynamic discrete data

Space time cube analysis

- ✓ 3D representation of space & time
- ✓ “Where & When” answers
- ✓ Interactivity
- X No attributive information
- X Ability of query cube contents

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Trajectory Representation

- ✓ Moving points
- ✓ Moving line – track lines
- ✓ Time animation
- **X** Inability to query trajectories
- **X** Representation on 2D
- **X** Unnatural movement representation

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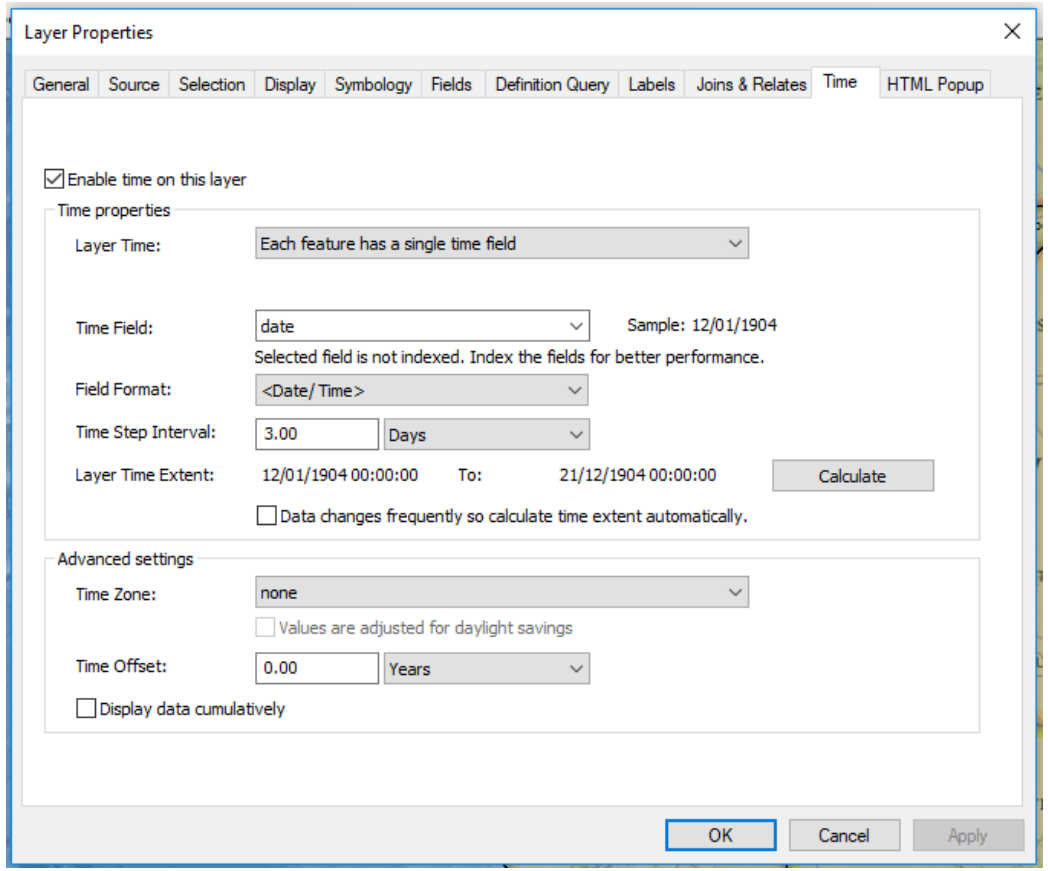
Time animations

- ✓ Time slider functionality
- ✓ Time settings
- ✓ Events at time of existence
- ✓ Emphasize change in time
- X Time step – temporal range
- X Discrete temporal patterns representation



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Uncertainties in historical data

- Positional uncertainties
  - Unknown settlements
  - Approximated locations
  - Uncertain geographic locations
- Temporal uncertainties
  - Specific dates
  - Range of dates

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To what extend are the research questions answered?

1. What methods are available to recognise and extract spatial and temporal information from text documents?
2. How to extract location event information and produce trajectories from the extracted references?
3. How can historical data be modelled best in regards to
   - Temporal vs. spatial data
   - Precision vs. accuracy of historical information
4. What analysis methods and functions are available for historical spatio-temporal data?
5. What cartographic visualization techniques are suitable to visualize the case study information?

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There is limited support for time in ArcGIS for historical spatio-temporal information.

Therefore, **recommend**:

- Development of time query functions.
- Development of trajectory representation functions.
- Use and development of Spatio-temporal data models.

THANK YOU FOR YOUR ATTENTION!