Integration of decision aid tools in a Geographical Information System

Olivier Sobrie

University of Mons
Faculty of engineering

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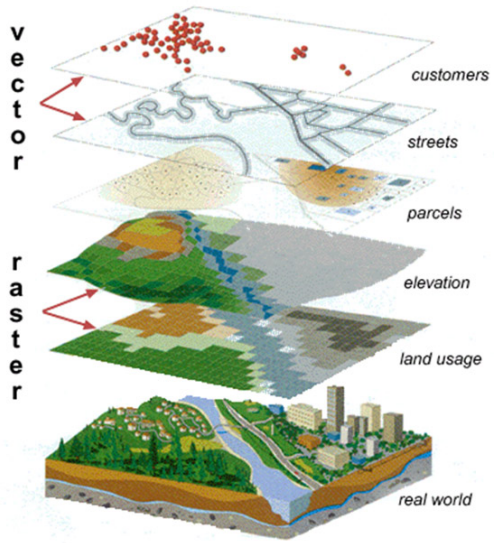
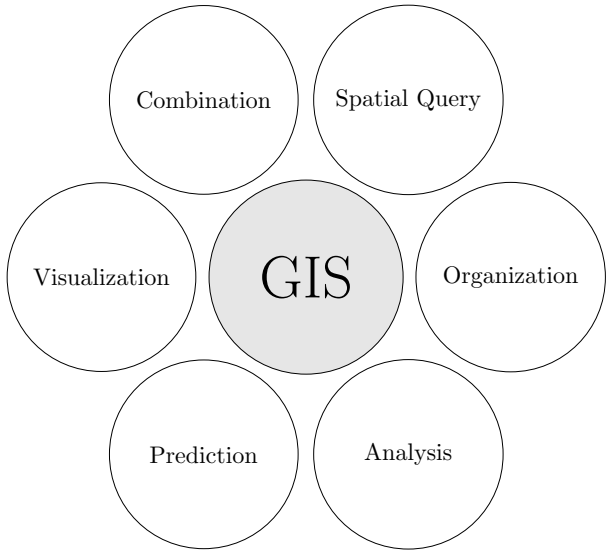
UMONS

GIS and MCDA





- GIS are used in lot of application from land suitability problem to geomarketing
- Since 90's, works about GIS and MCDA
- Not a lot of work based on ELECTRE methods
- ELECTRE methods fit well for ordinal problems

GIS and MCDA

Limitations of GIS-MCDA works according to S. Chakhar :

- Weak coupling
- One MCDA method integrated (Single criterion synthesis)
- Choice of the MCDA method
- User's knowledge of GIS and MCDA

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We add an extra one :

A good number of GIS-MCDA tools were abandoned or never surpassed the stage of prototype. Moreover it has been done in commercial GIS.

Objectives of our GIS-MCDA integration

First objectives

- ELECTRE TRI implementation
- Tight coupling
- User friendly interface
- Open Source GIS (and implementation)

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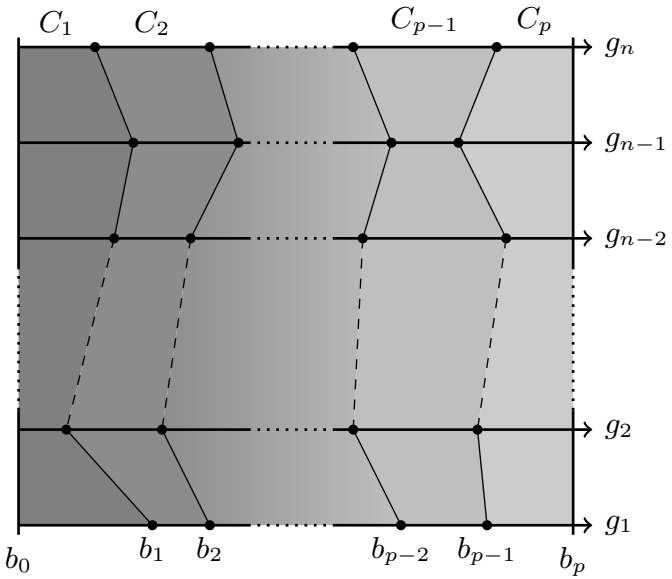
Second objectives

- Learning of parameters
- Implementation of a XMCDA webservice
- Experimentations
- Coupling with the ELECTRE TRI plugin

ELECTRE TRI



Parameters

- weights
- profiles
- credibility threshold
- ...

Approach

- Classical
- Bouyssou-Marchant

Major interests

- Judge an action independently from the others
- Allow to consider more actions than other ELECTRE methods
- Reference values fixed : profiles

Application : Densification of Quebec city

Subject

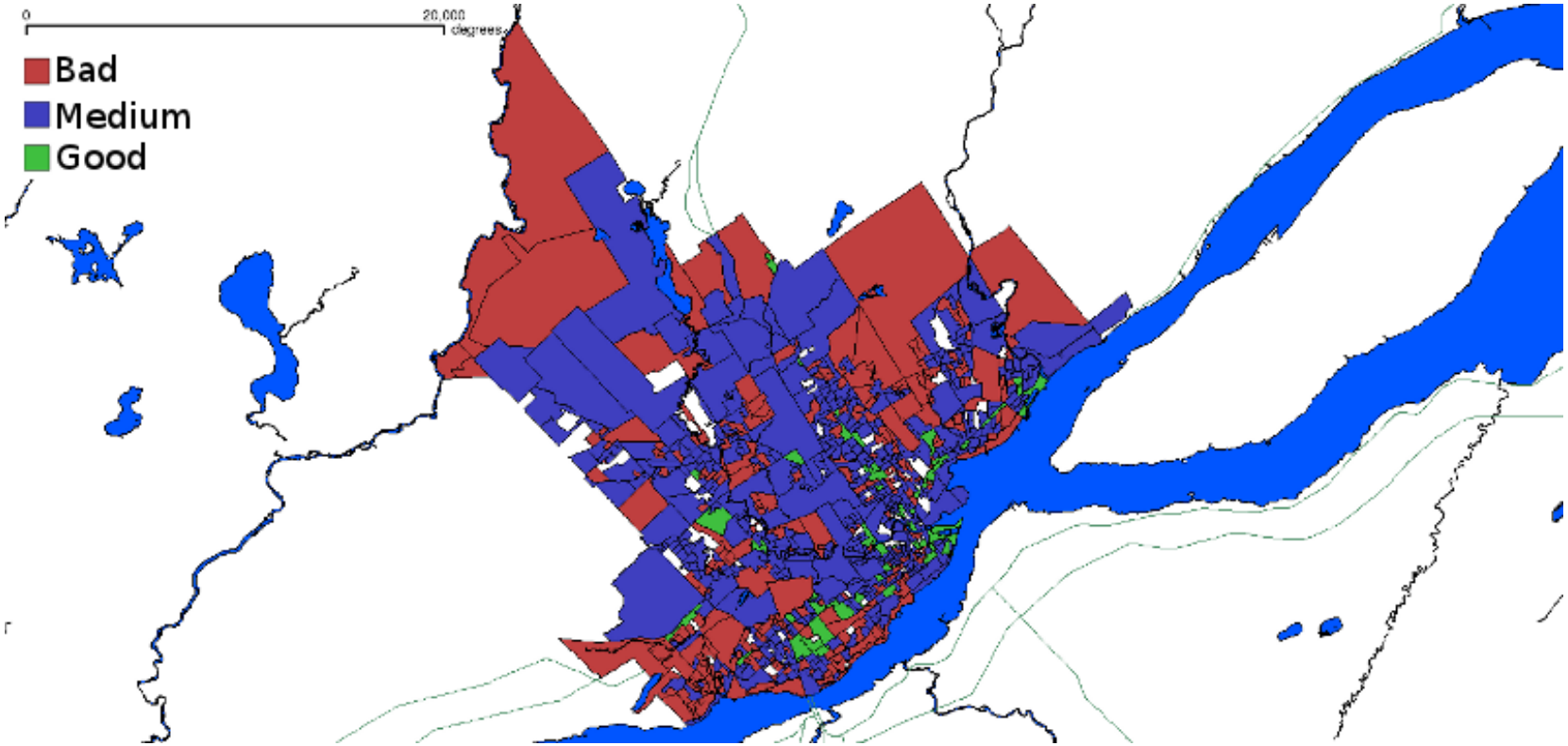
Quebec city wants to create a program to densify its population in the centrum and around the small crown. The program consists to build rental properties at low prices for young families in empty areas.

Objectives

- Densify central sectors where there are more public transports
- Sustain a good social diversity by choosing in priority the sectors where young people and immigrants are not well represented
- Favor sectors with a lot of small shops

Application : Densification of Quebec city

Decision map



Application : Densification of Quebec city

Definition of the problem

Actions

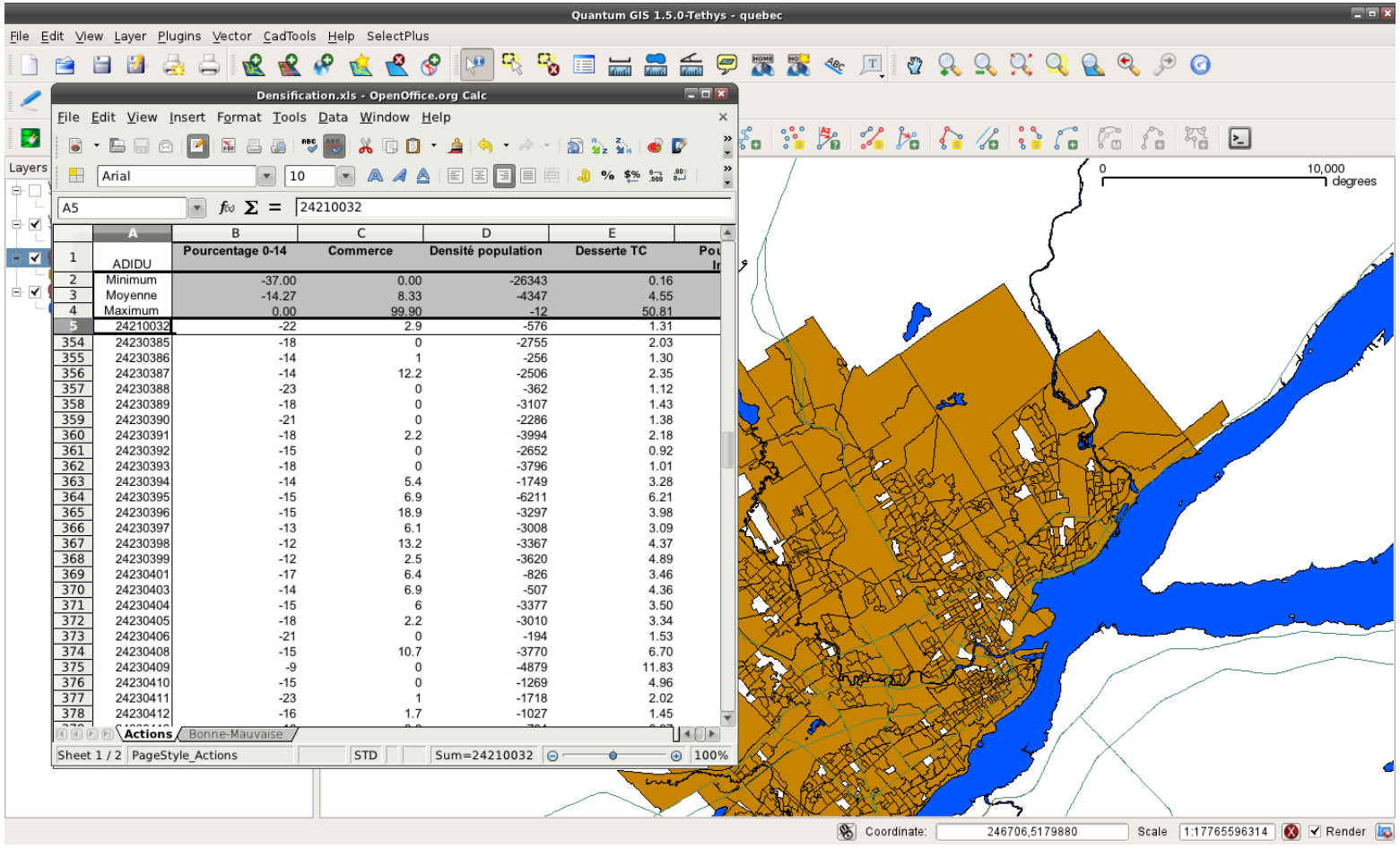
786 districts (polygons)

Criteria

- Density of 0-14 years old [%] (min)
- Density of shops [shops/ha] (max)
- Density of people [residents/ha] (min)
- Level of public transports (average) [bus/hour] (max)
- Ratio of immigrants [%] (min)

Application : Densification of Quebec city

Performance table



	A	B	C	D	E
1	ADIDU	Pourcentage 0-14	Commerce	Densité population	Desserte TC
2	Minimum	-37.00	0.00	-26343	0.16
3	Moyenne	-14.27	8.33	-4347	4.55
4	Maximum	0.00	99.90	-12	50.81
5	24210032	-22	2.9	-576	1.31
354	24230385	-18	0	-2755	2.03
355	24230386	-14	1	-256	1.30
356	24230387	-14	12.2	-2506	2.35
357	24230388	-23	0	-362	1.12
358	24230389	-18	0	-3107	1.43
359	24230390	-21	0	-2286	1.38
360	24230391	-18	2.2	-3994	2.18
361	24230392	-15	0	-2652	0.92
362	24230393	-18	0	-3796	1.01
363	24230394	-14	5.4	-1749	3.28
364	24230395	-15	6.9	-6211	6.21
365	24230396	-15	18.9	-3297	3.98
366	24230397	-13	6.1	-3008	3.09
367	24230398	-12	13.2	-3367	4.37
368	24230399	-12	2.5	-3620	4.89
369	24230401	-17	6.4	-826	3.46
370	24230403	-14	6.9	-507	4.36
371	24230404	-15	6	-3377	3.50
372	24230405	-18	2.2	-3010	3.34
373	24230406	-21	0	-194	1.53
374	24230408	-15	10.7	-3770	6.70
375	24230409	-9	0	-4879	11.83
376	24230410	-15	0	-1269	4.96
377	24230411	-23	1	-1718	2.02
378	24230412	-16	1.7	-1027	1.45

Actions Bonne-Mauvaise
Sheet 1 / 2 PageStyle_Actions STD Sum=24210032 100%

Strategy of integration

Reference

- Chakhar's thesis (2006)

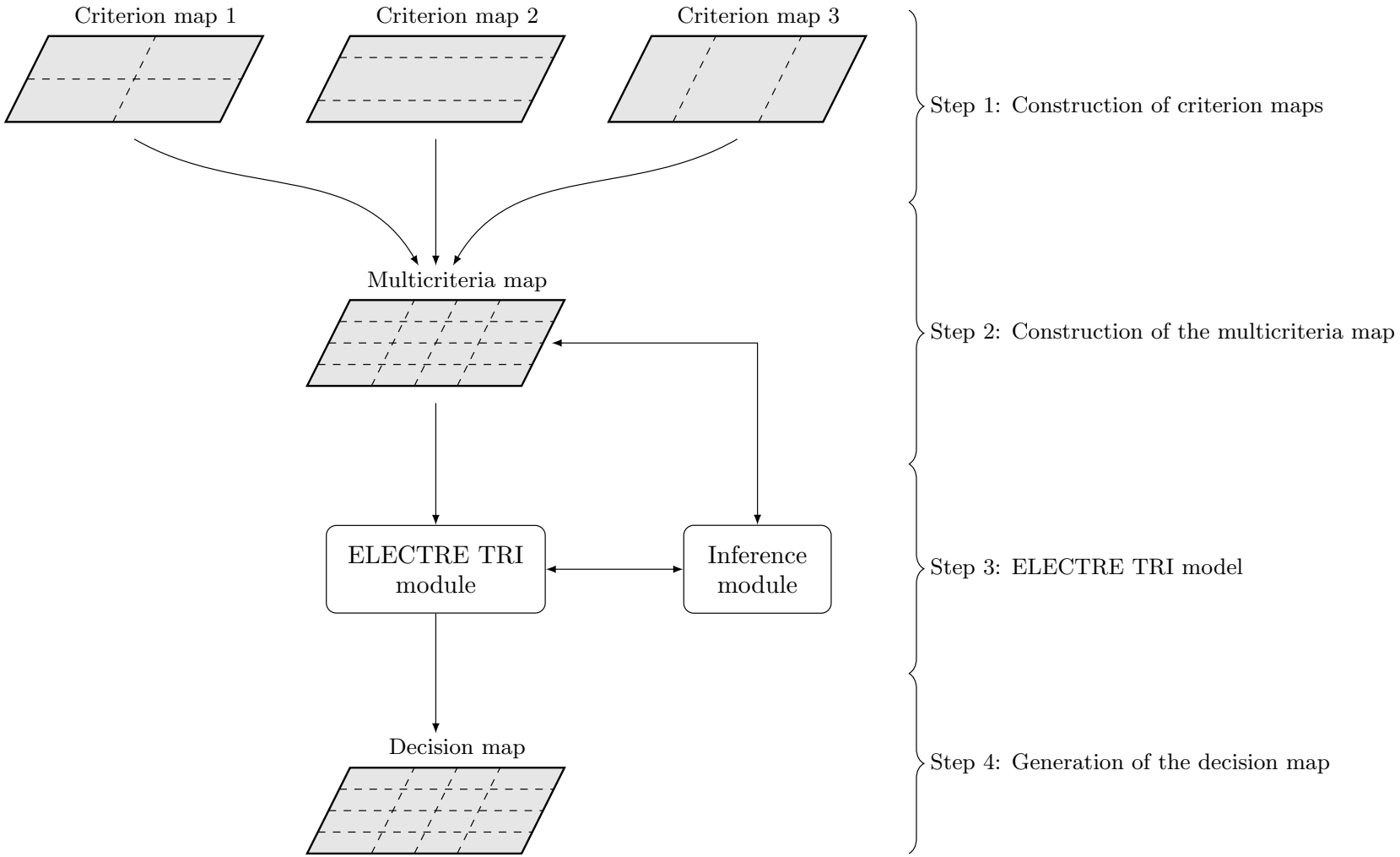
Coupling strategy

- Malczewski (2006) reports only 10 % of works using a strategy of tight coupling of the MCDA method in the GIS
- Tight coupling

Actions and criteria

- Vector layer
- actions = points, lines, polygons
- criteria = attributes

Strategy to build the decision map



Choice of the GIS

Requirements

- Open Source GIS and implementation
- User friendly interface
- Support of vector layer
- With map algebra tools

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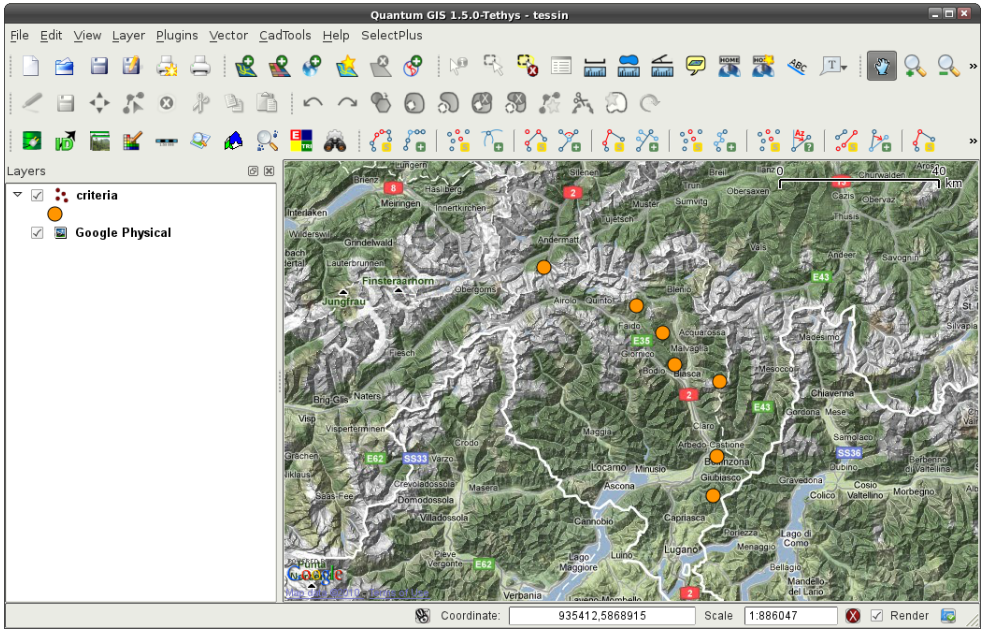
Lot of open source GIS

- GRASS, PostGIS, Quantum GIS
- `http://opensourcegis.org/`

Quantum GIS

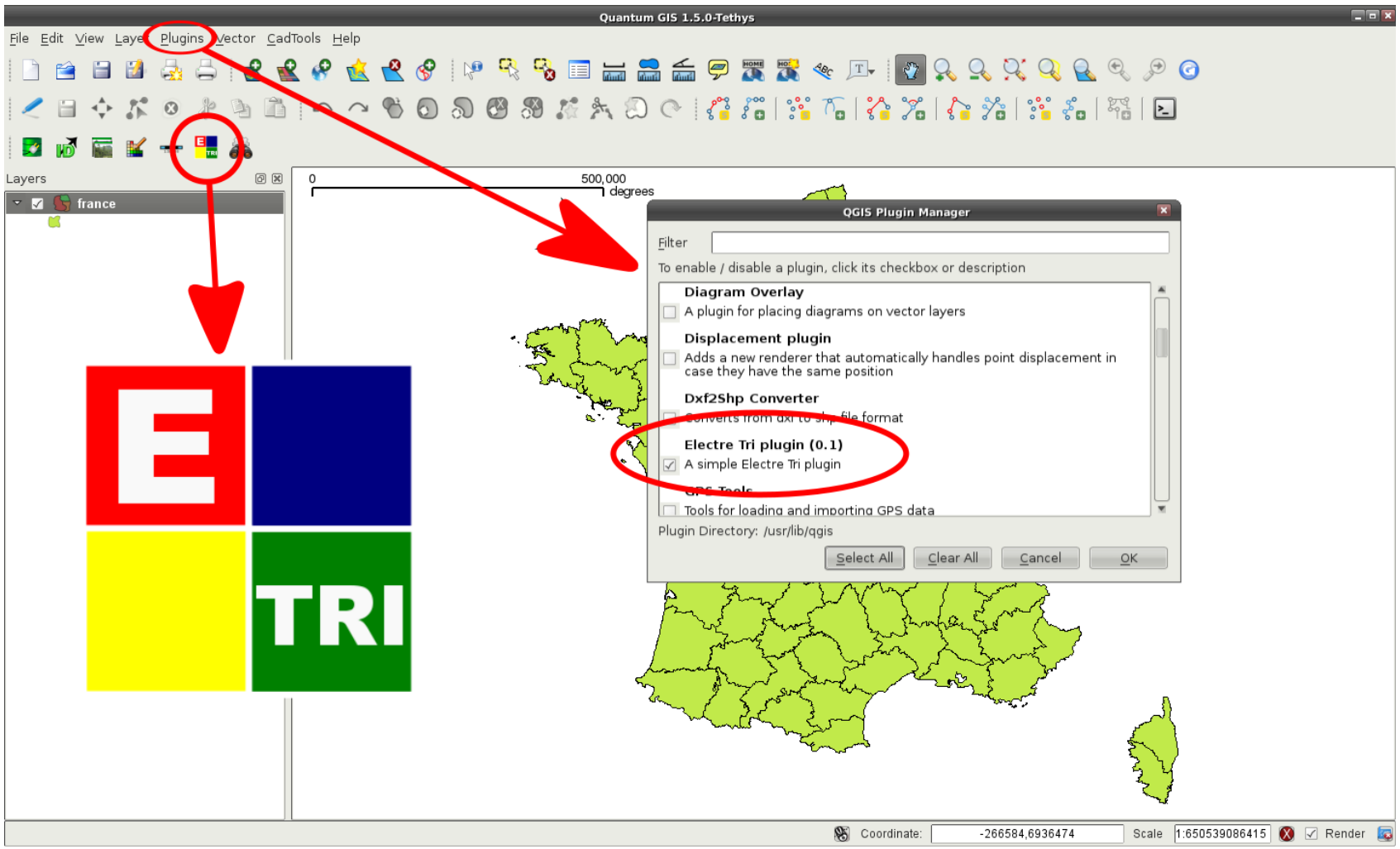


Characteristics

- Great portability (Linux, Windows, Mac OS)
- Plugin mechanism
- Lot of functionnalities (GRASS, map algebra, ...)
- User-friendly interface

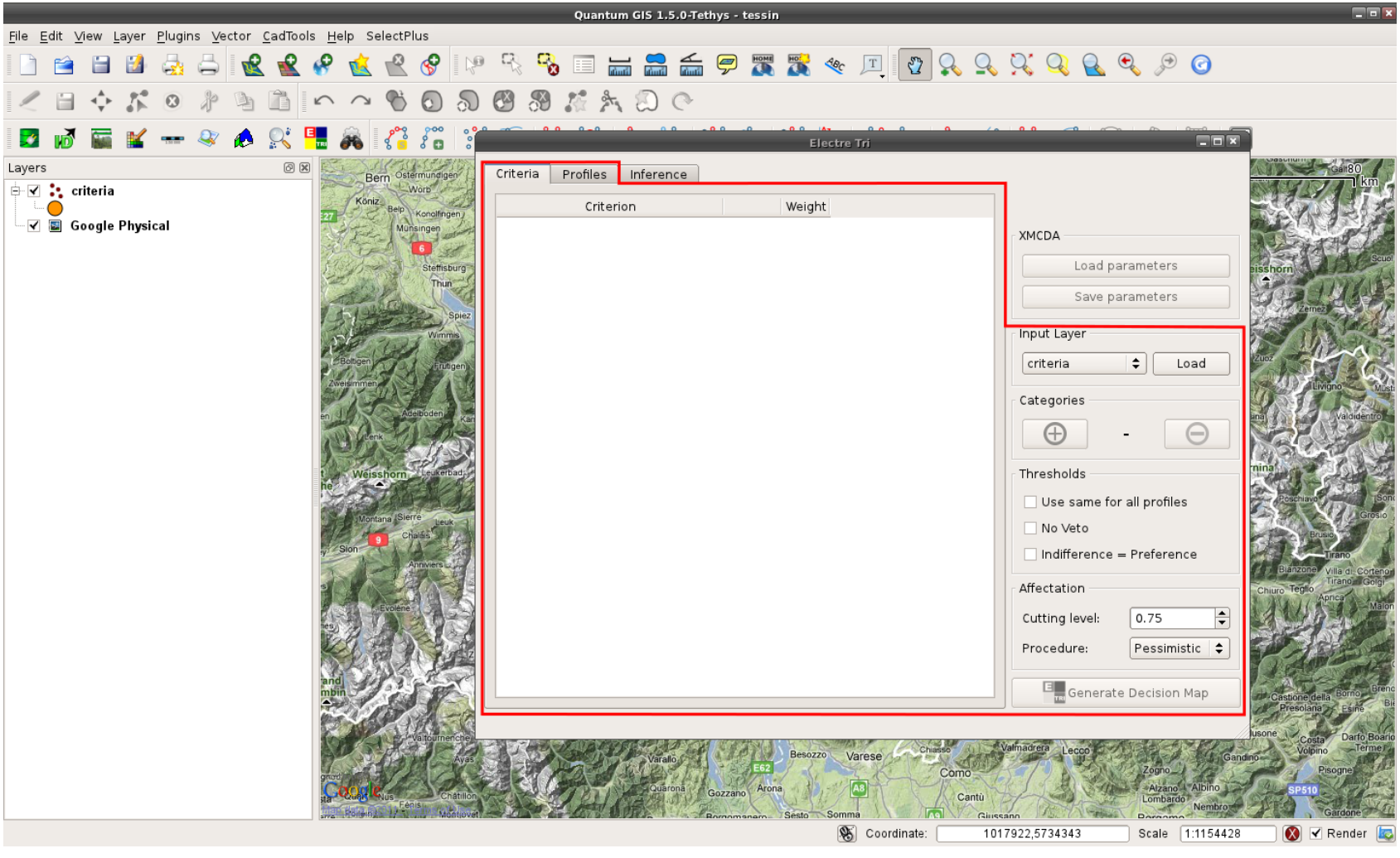
ELECTRE TRI plugin

Tight coupling



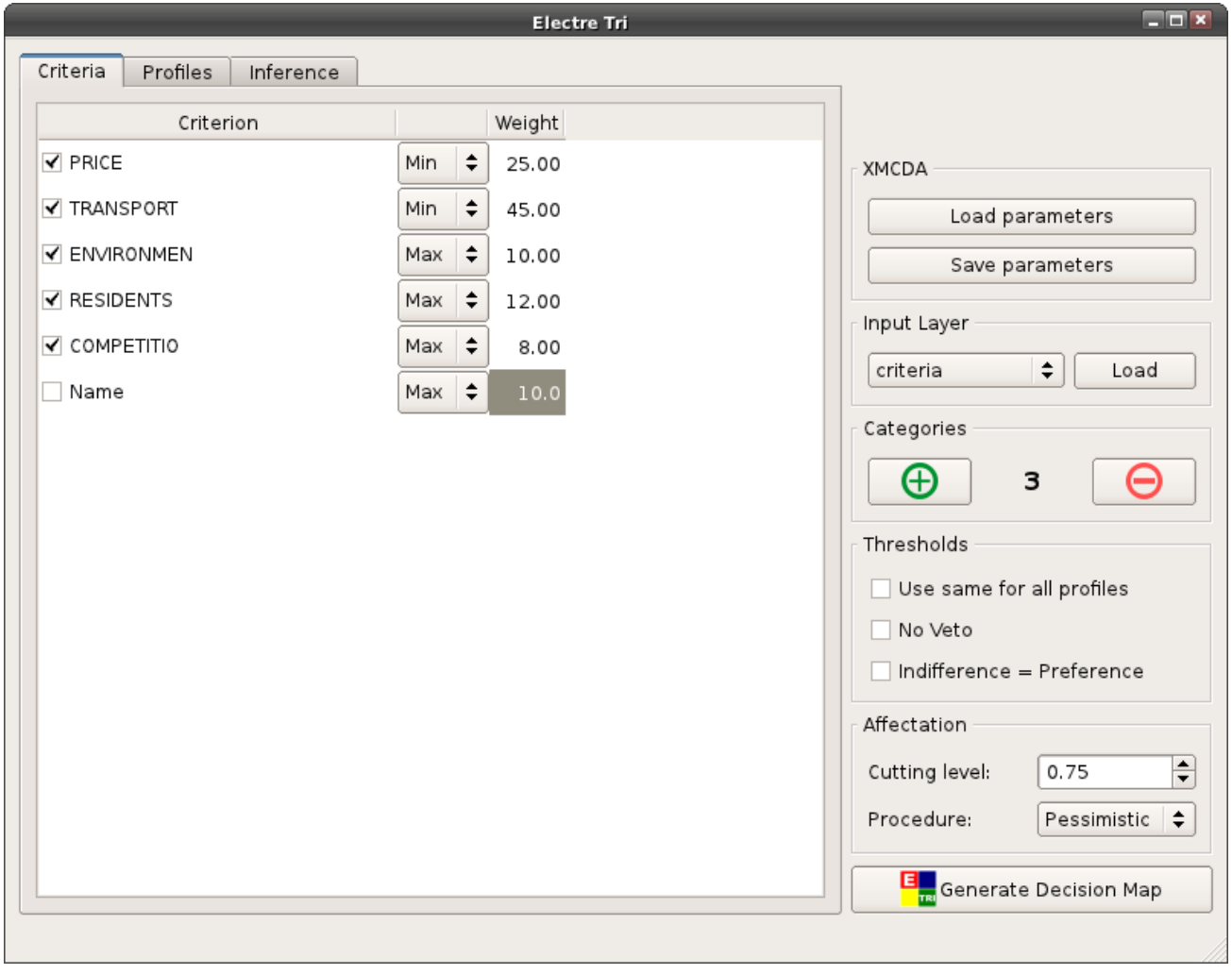
ELECTRE TRI plugin

User interface



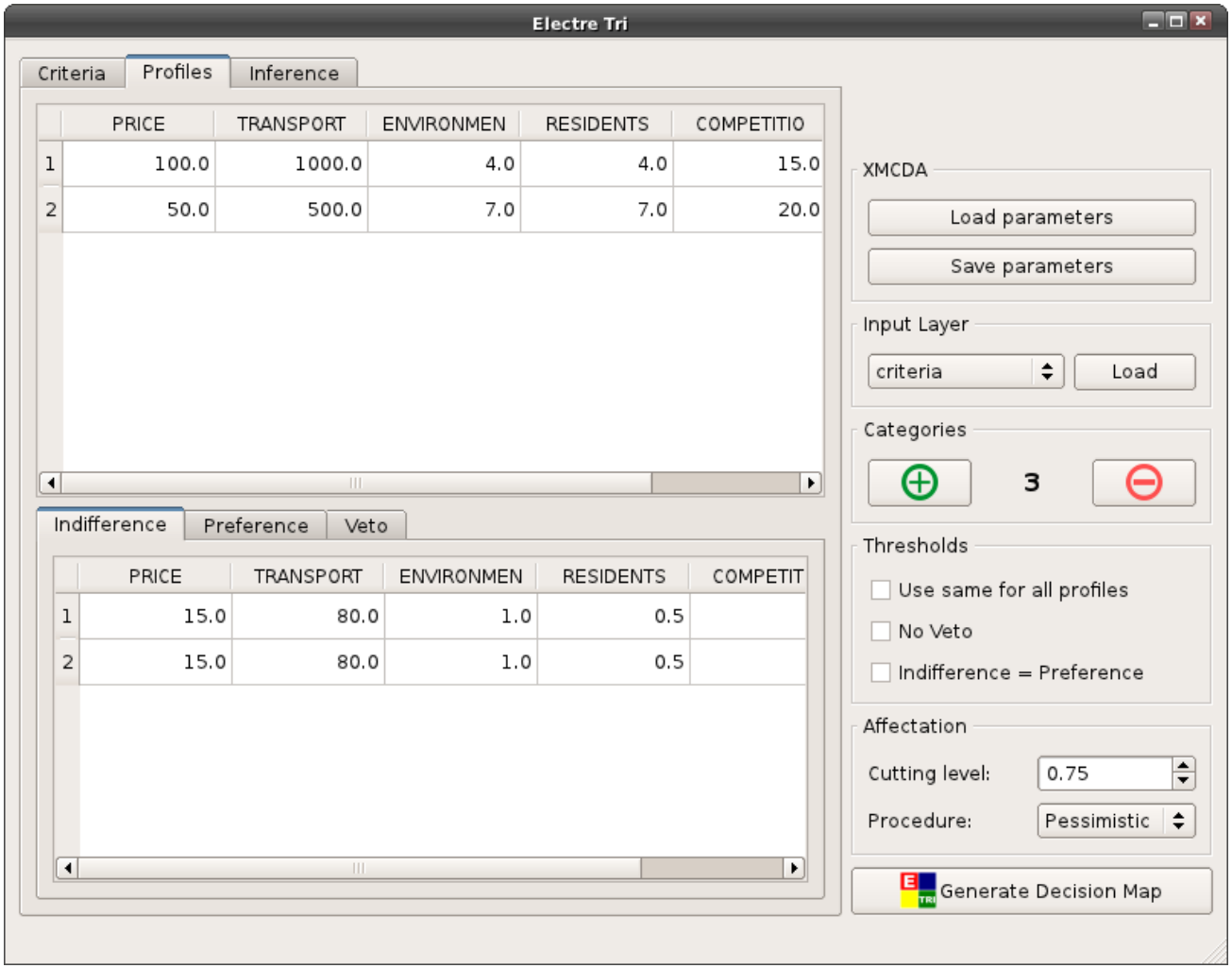
ELECTRE TRI plugin

User interface

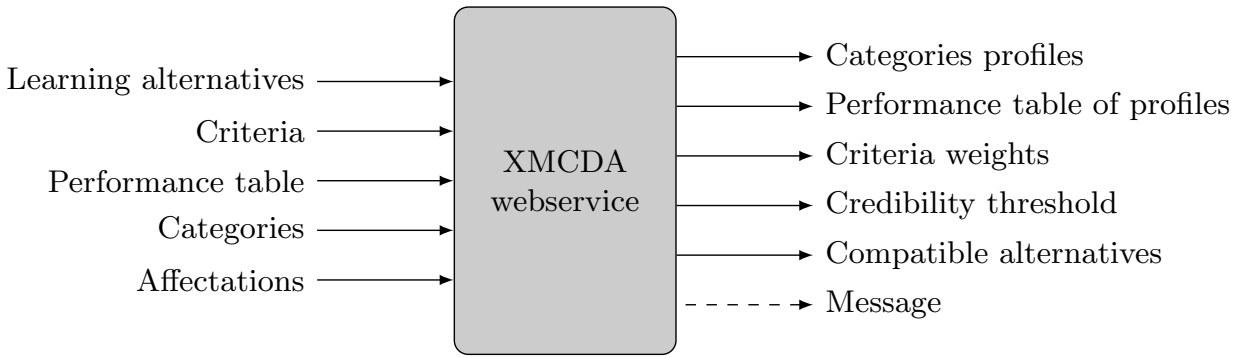


ELECTRE TRI plugin

User interface



XMCDA webservice



Characteristics

- Based on A. Leroy master thesis (2010)
- Learning of ELECTRE TRI Bouyssou-Marchant parameters
- Accept non-admissible set of learning alternatives
- Maximize number of compatible alternatives
- MIP problem
- Use GLPK

ELECTRE TRI BM inference experimentations

First conclusions

- Lot of learning alternatives needed to get good results
- Difficult to get good set of params when learning set not completely compatible with ELECTRE TRI model
- Computing time becomes huge when number of learning alternatives increases

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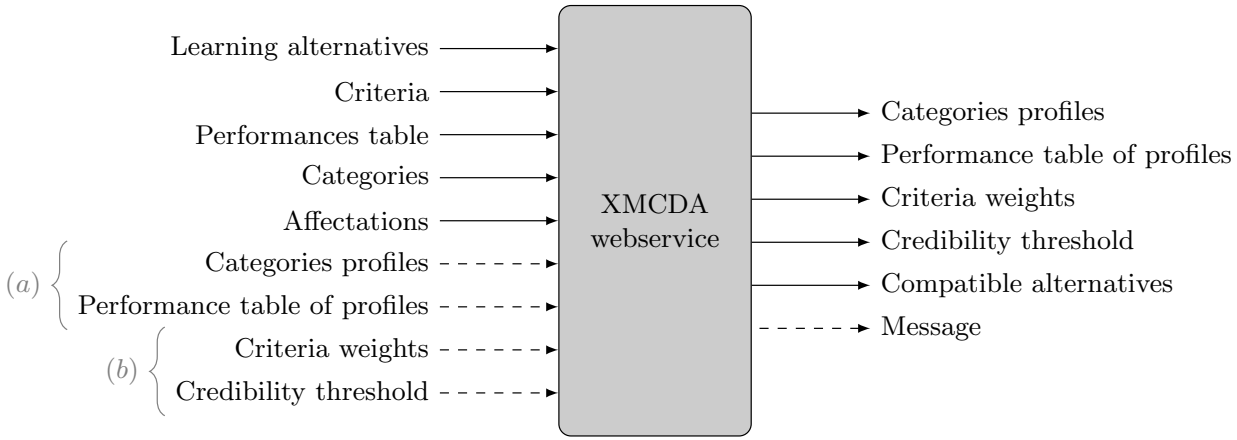
New experimentations

- Two step inference
- Partial inference
- Improve objective of the inference program

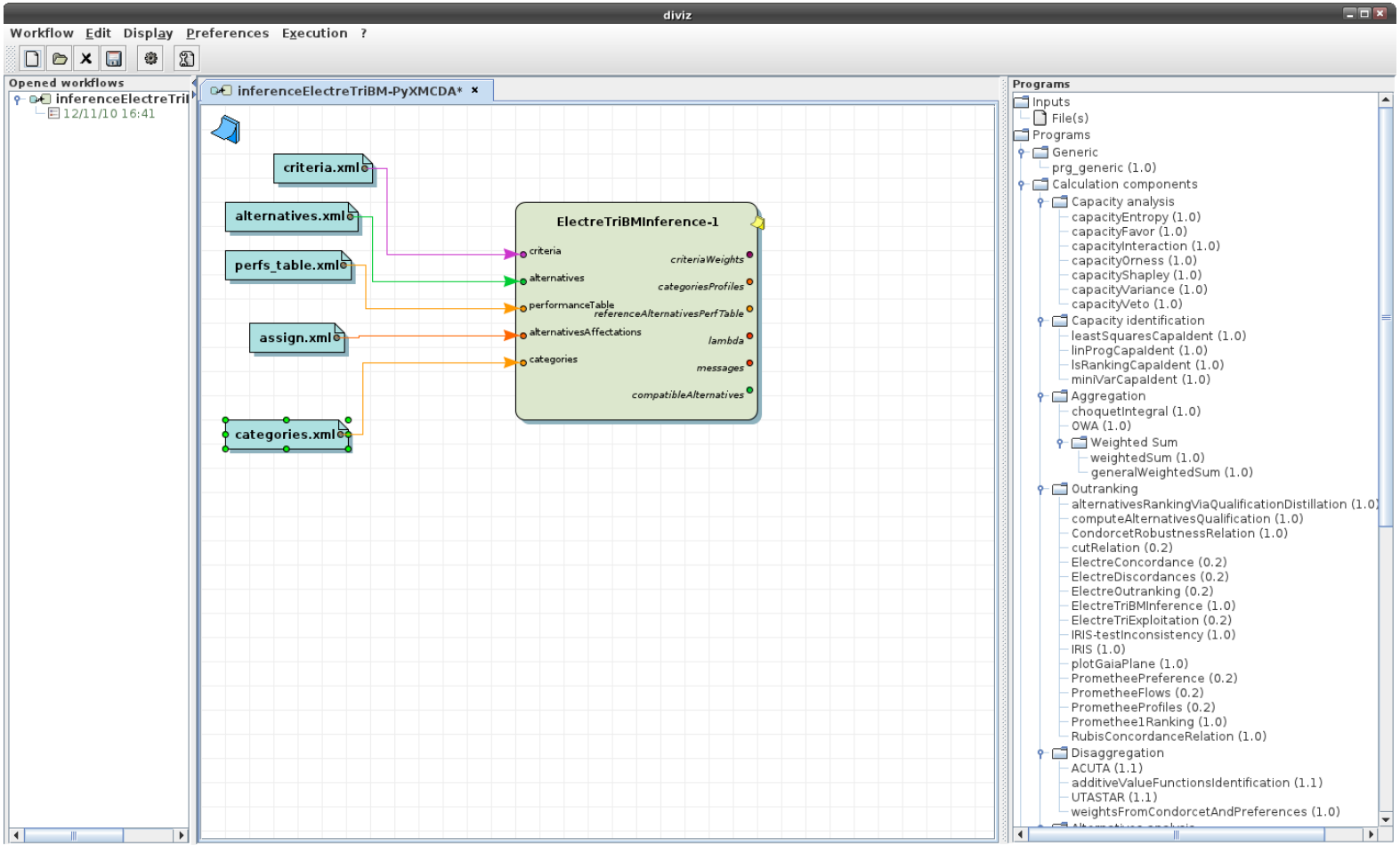
ELECTRE TRI BM inference webservice update



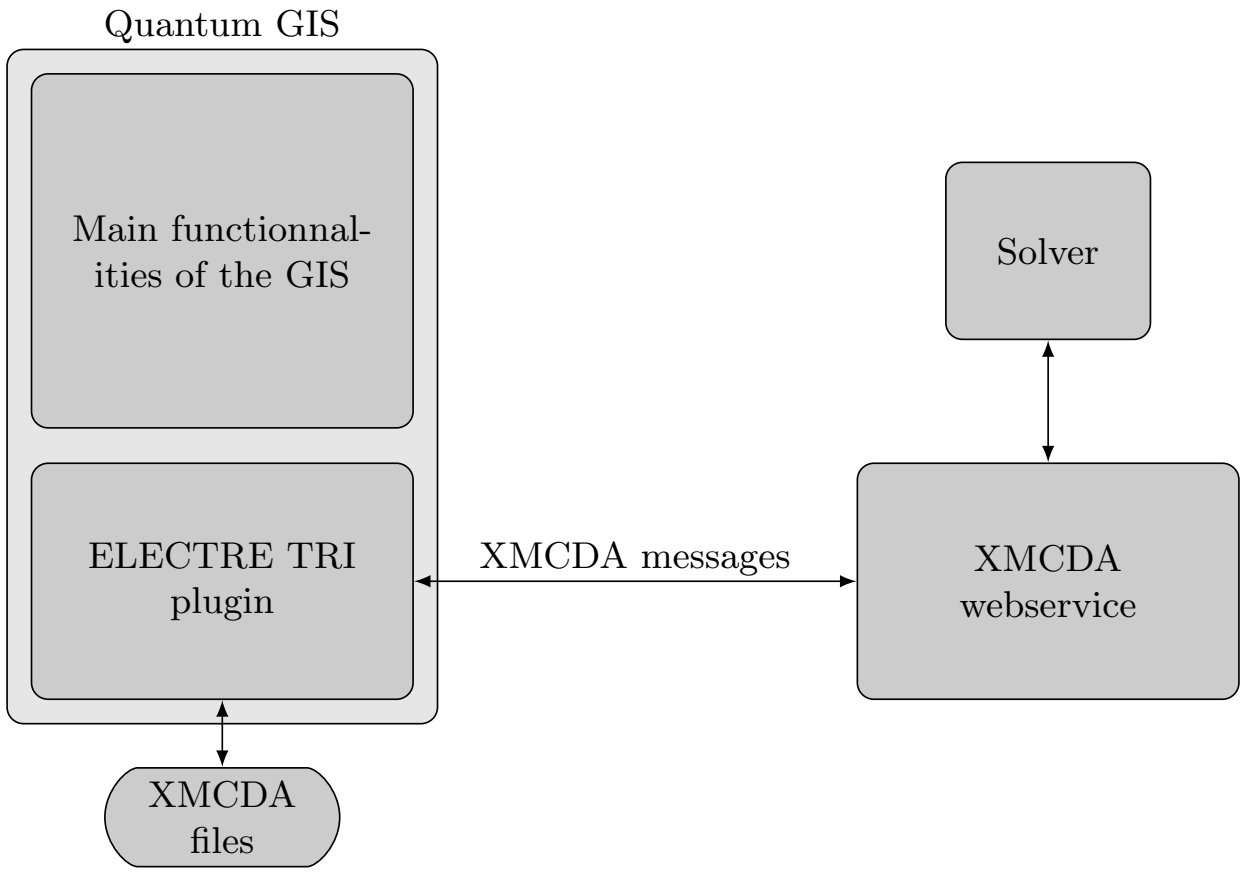
Characteristics

- Two entries added to do partial inference of the weights and lambda threshold
- Two entries added to do partial inference of the profiles

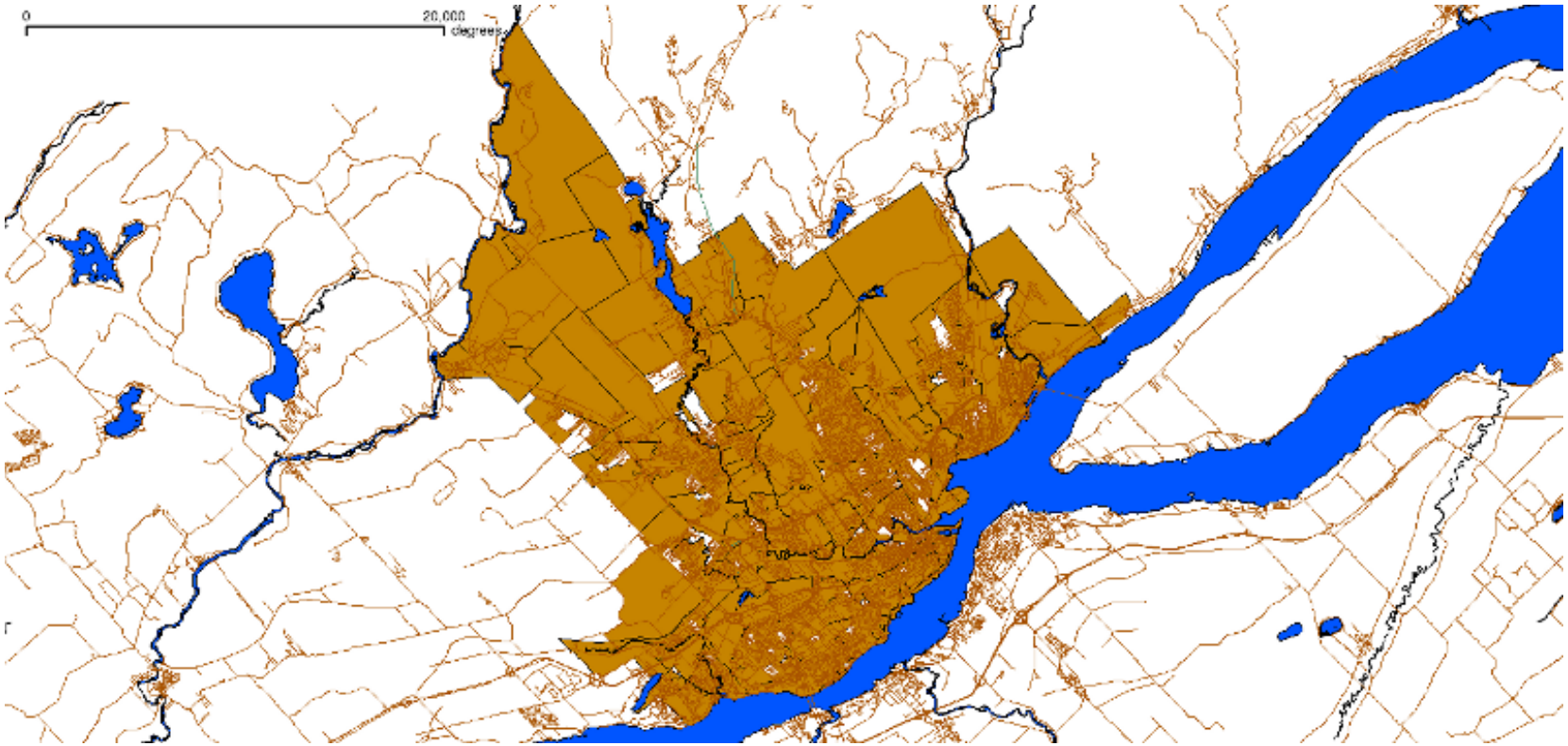
Webservice available in diviz



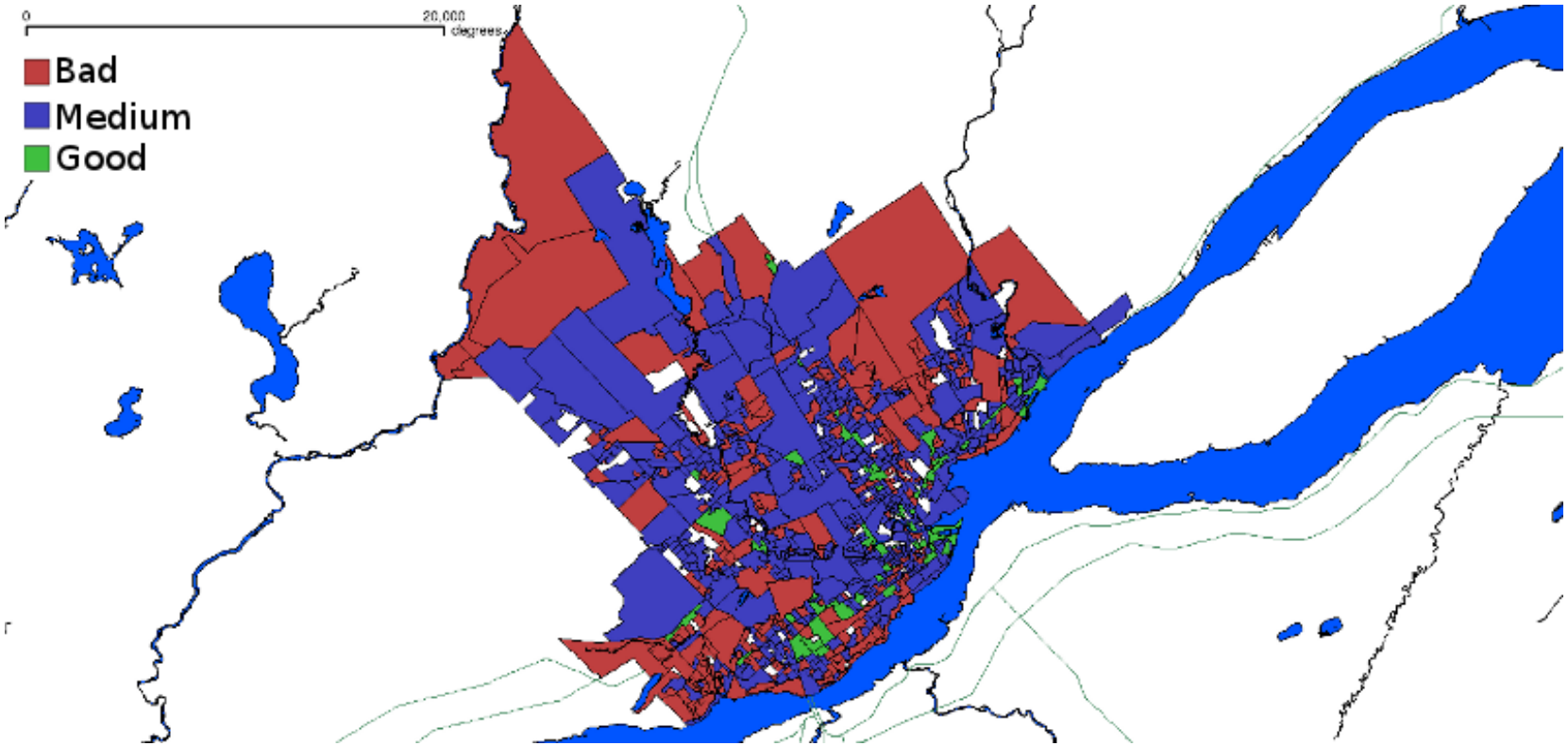
Coupling of XMCDA webservice with Quantum GIS ELECTRE TRI plugin



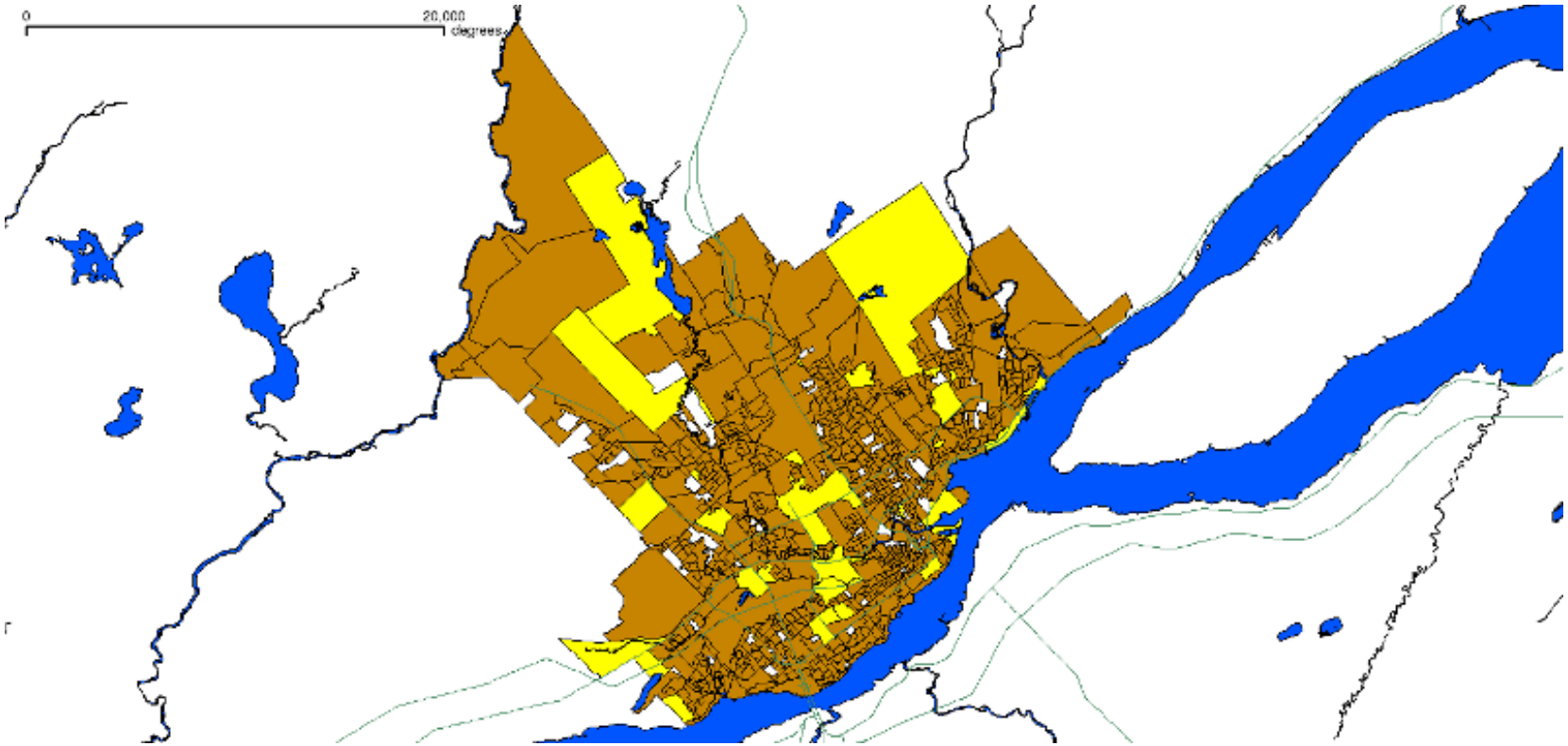
It's time for the demo...



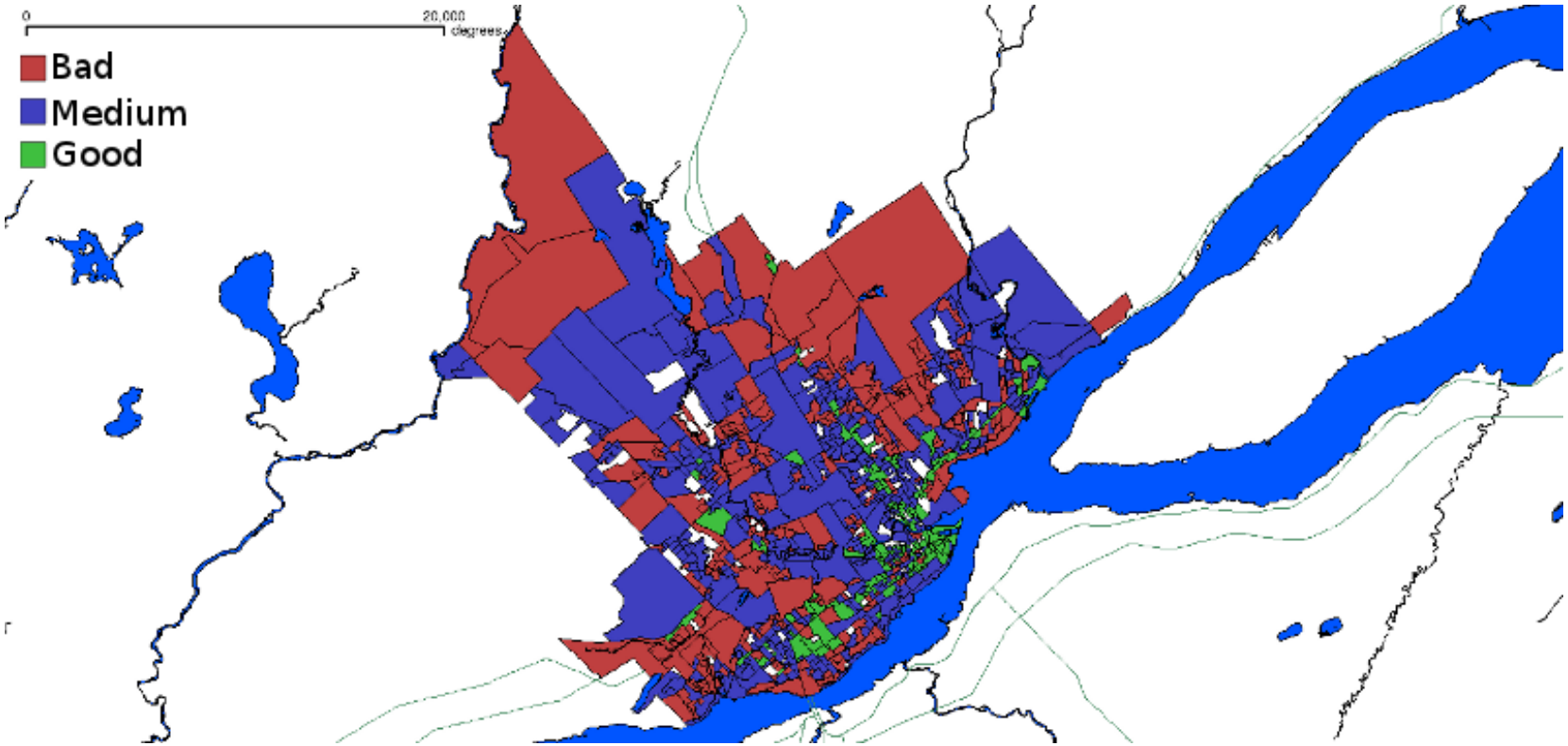
Original model



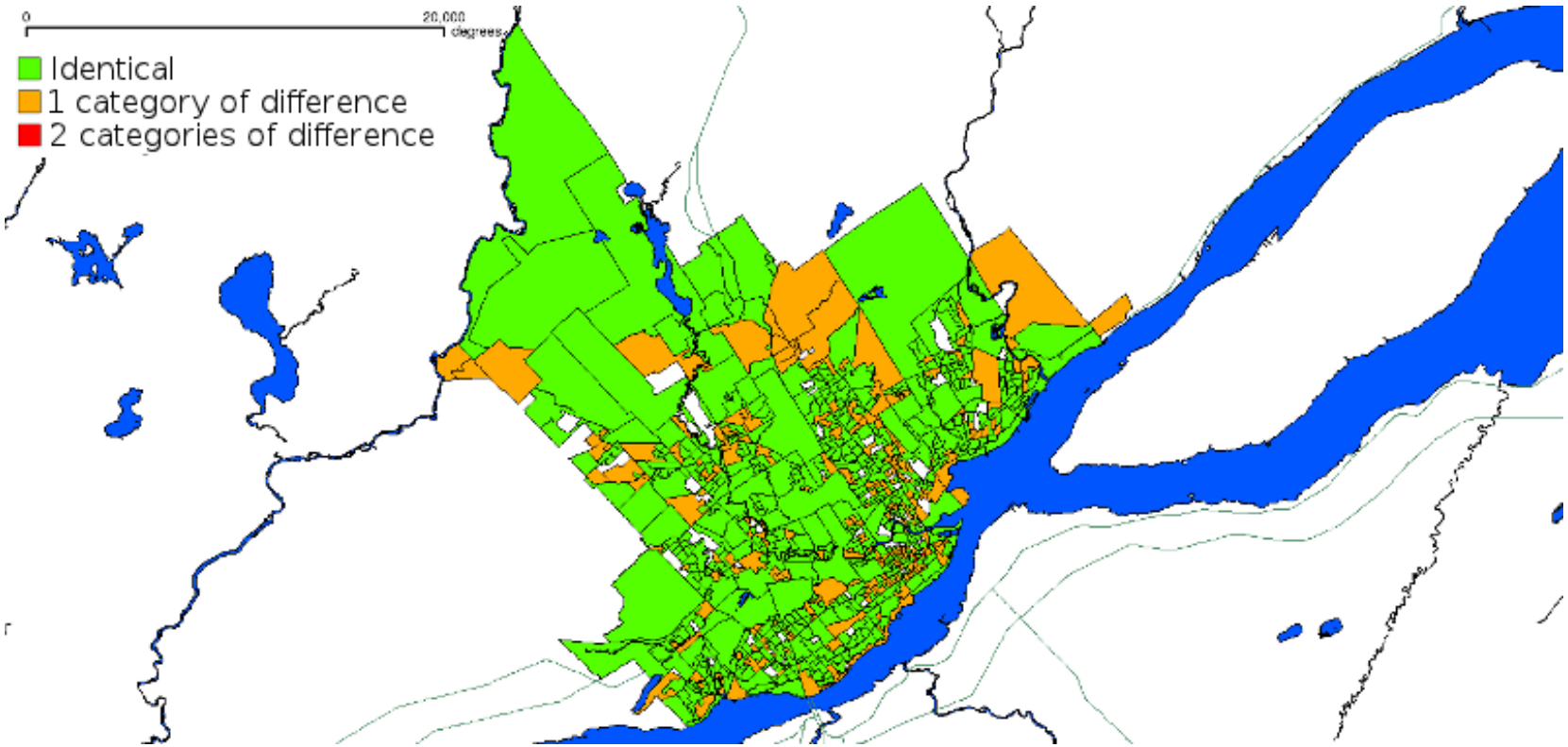
Actions of reference



Global inference

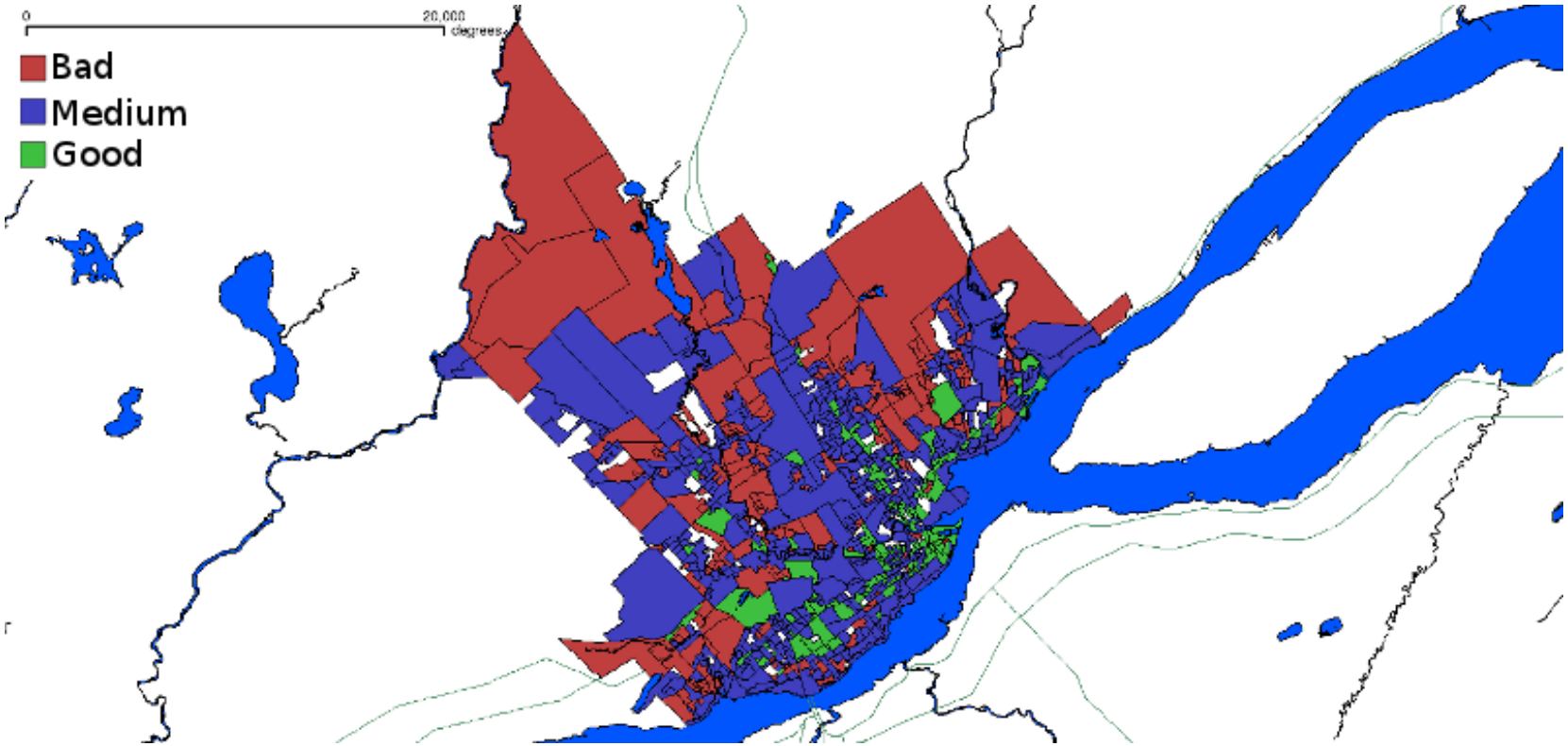


Global inference (difference)

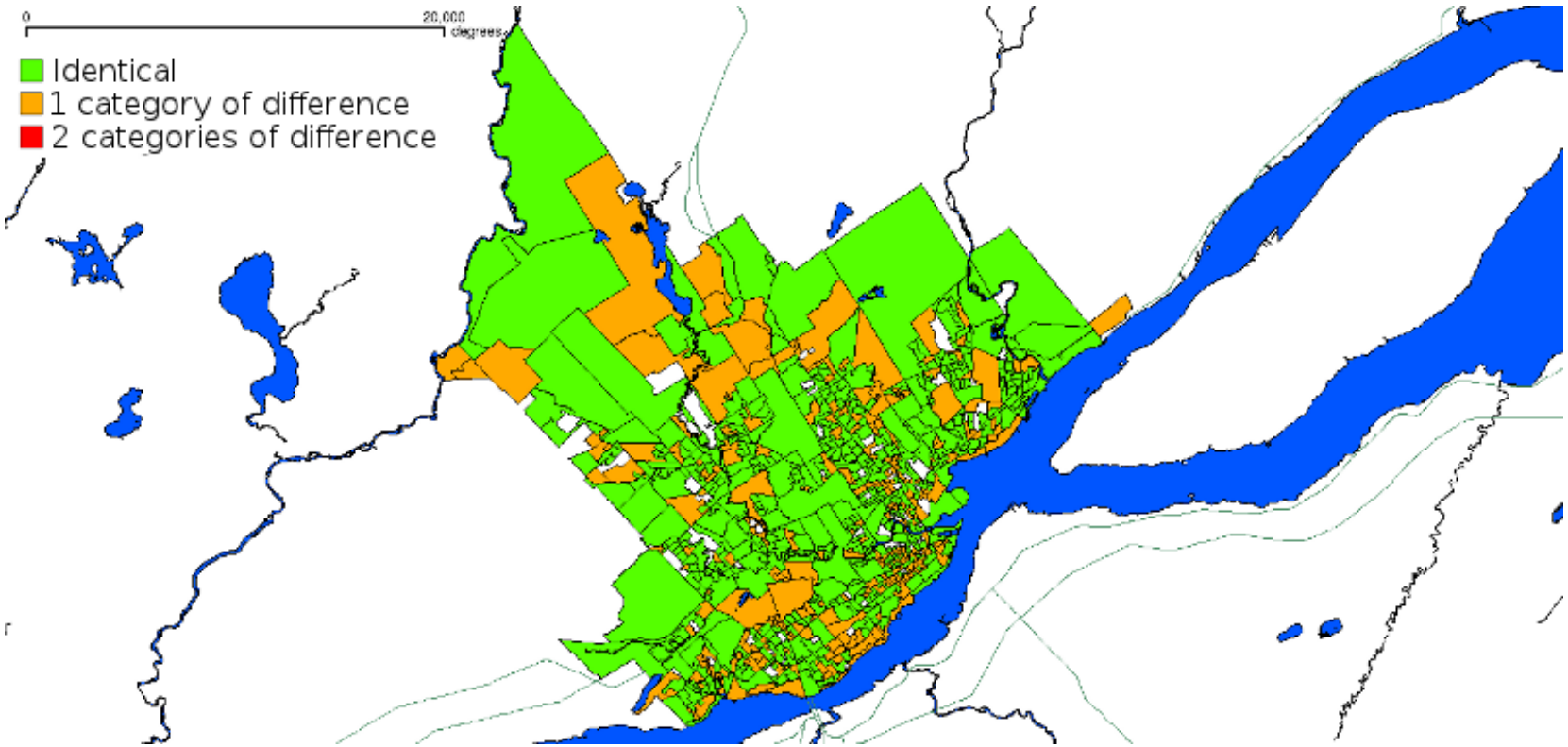


$\pm$ 29% of invalid affectations

Profiles inference

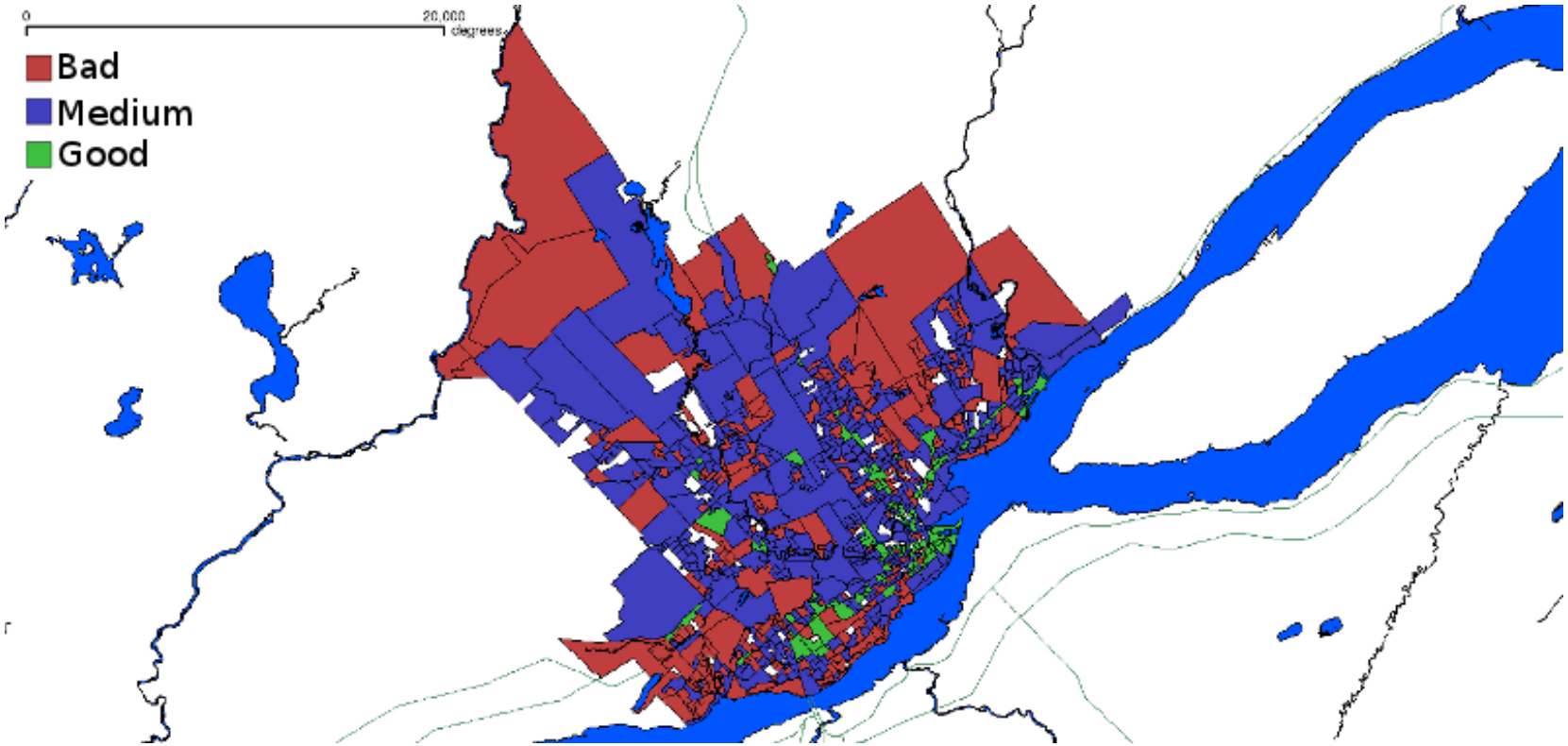


Profiles inference (difference)

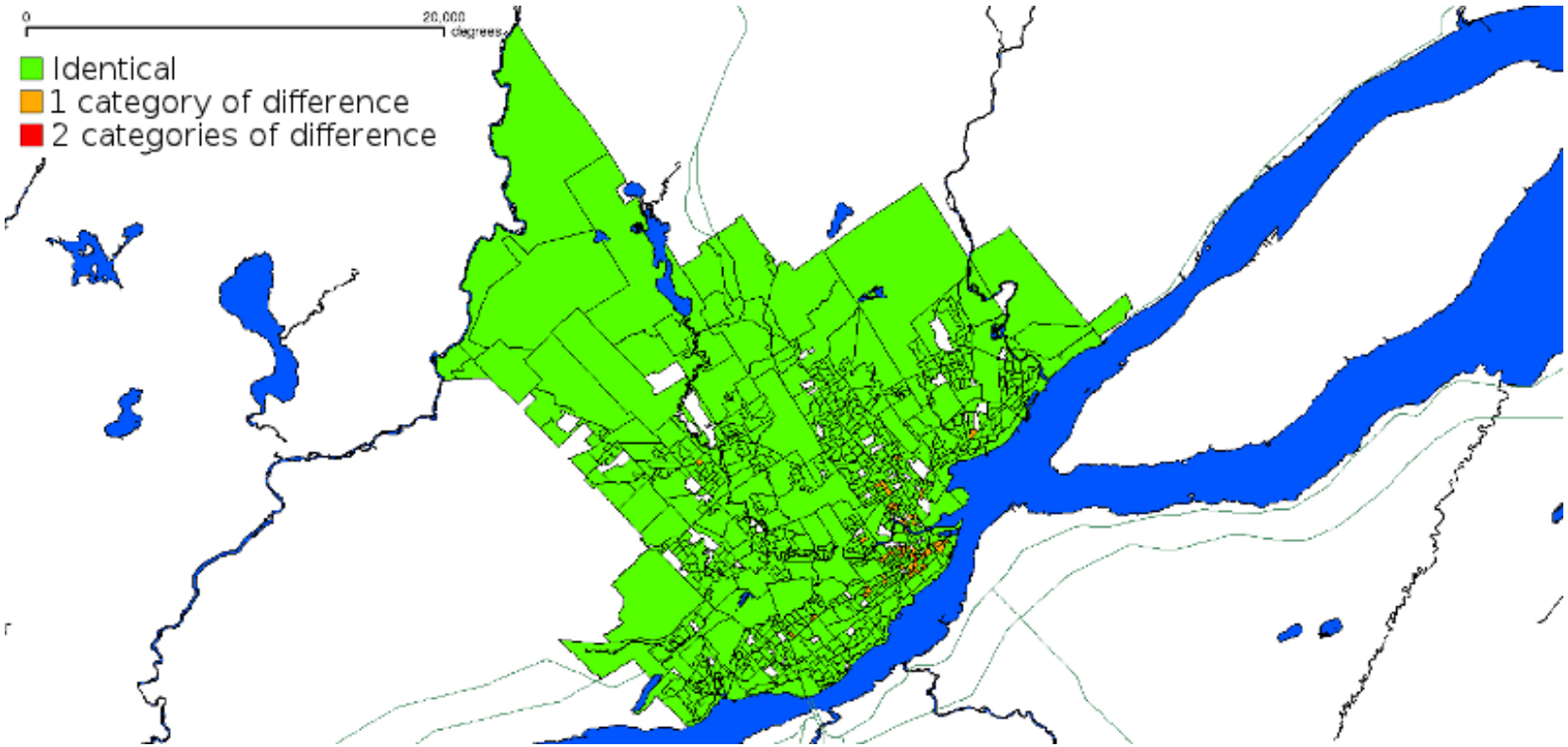


$\pm$ 33% of invalid affectations

Weights and lambda inference



Weights and lambda inference (difference)



$\pm$ 6% of invalid affectations

Conclusion

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- Full open source solution running on several OS
- Good reviews during the two Decision Deck workshops
- Limitations of GIS-MCDA overcome
- Several spatial decision problems treated

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Ideas for improvements

- Plot of the profiles in the plugin
- Add the possibility to choose a spatial entity by clicking on it in the inference module
- Replacement of GLPK by SCIP as solver in webservice
- Metaheuristic to infer parameters
- Algorithm to choose an optimal learning set

Thank you for your attention !