REPUBLIQUE ET CANTON DE GENEVE

POST TENEBRAS LUX

SIG

Construction and usefulness of the solar cadastre of the state of Geneva

Geospatial World Forum, Geneva, Switzerland
05.05.14

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Outline

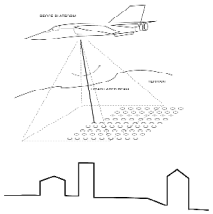
- Aim of the study
- Synoptic view of the process of solar mapping
- Results of the solar cadastre of Geneva
- Some examples of application for energy planning
- Conclusions, questions and perspectives

Goals of Geneva's solar cadastre

- To estimate **solar energy potential** at the urban scale (> building), based on 3D data of building (GIS) and image processing (=> automated process).
- To **communicate** to everyone the solar potential on the top of his/her building
- To give solar potential not only on roofs but also on the **terrain** (to discover other useful objects for solar installation like bike parking)
- To provide useful support in **pre-designing solar collectors**

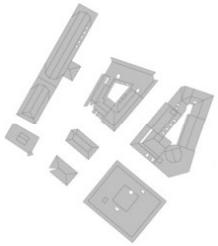
Synoptic view of the process of solar mapping

LIDAR data



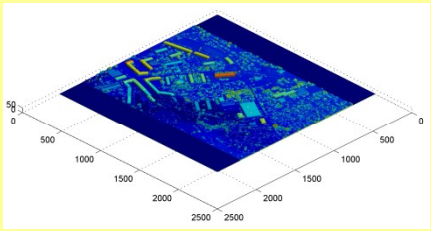
heights

2D&3D-roof/ building footprints



GIS

Building of the 2.5-D DSM of the urban area



Pixel size considered in the studied area:
0.5m X 0.5m

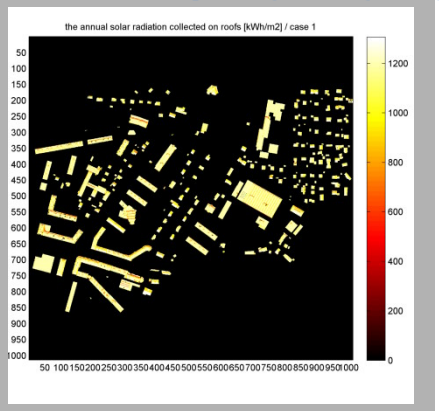
Production raster layers (masks)

1. Heights (2.5D-DSM)
2. Roof slope
3. Roof aspect
4. Building footprints

Meteorological data

Metenorm

Solar irradiation computation on roofs processing raster masks **Scripting language**

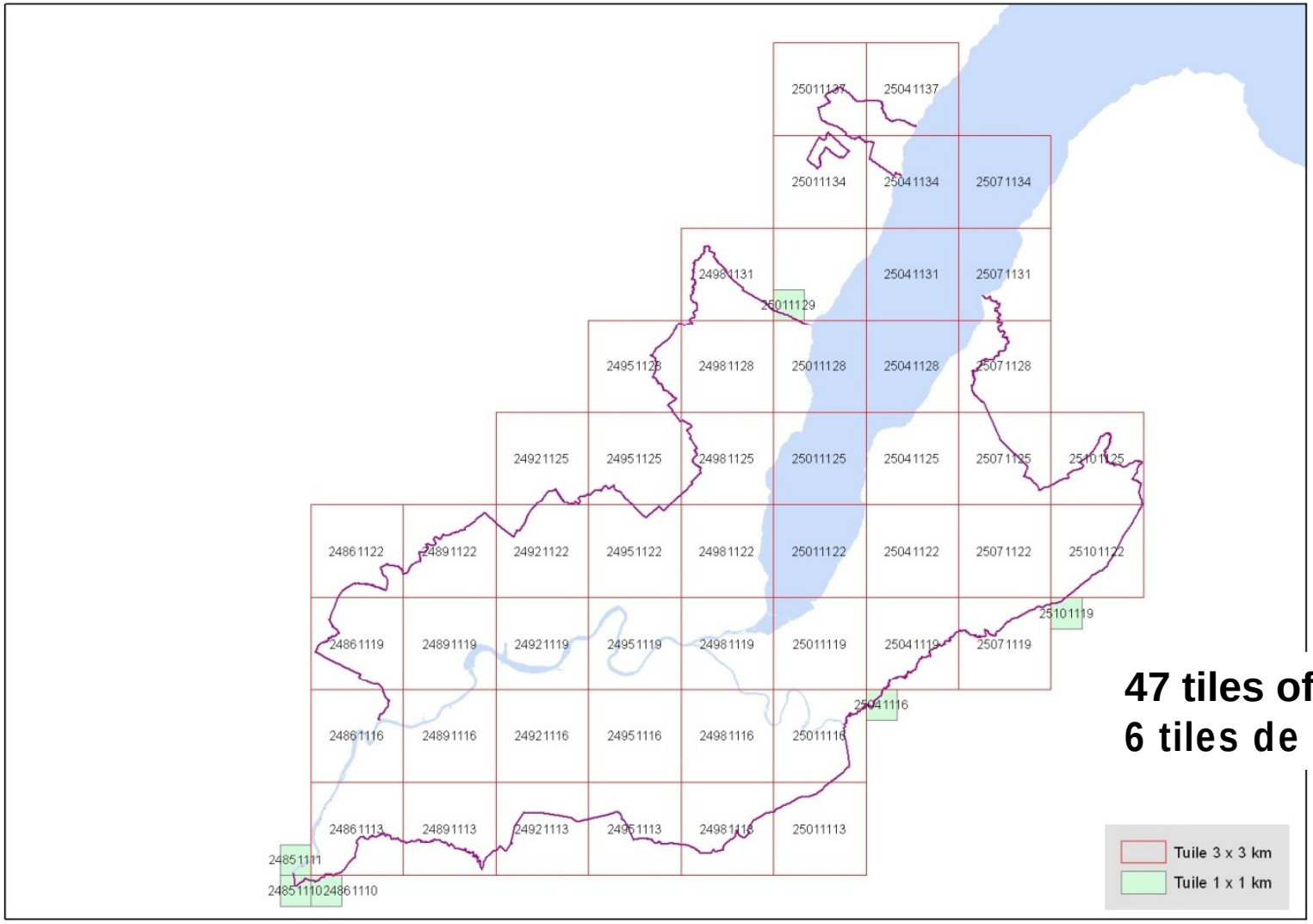


GIS

Visualization/ indicators (2D and 3 D support) and use of outputs for energy urban planning

Integration of 2D / 3D GIS with image processing techniques

Splitting the Geneva State in tiles

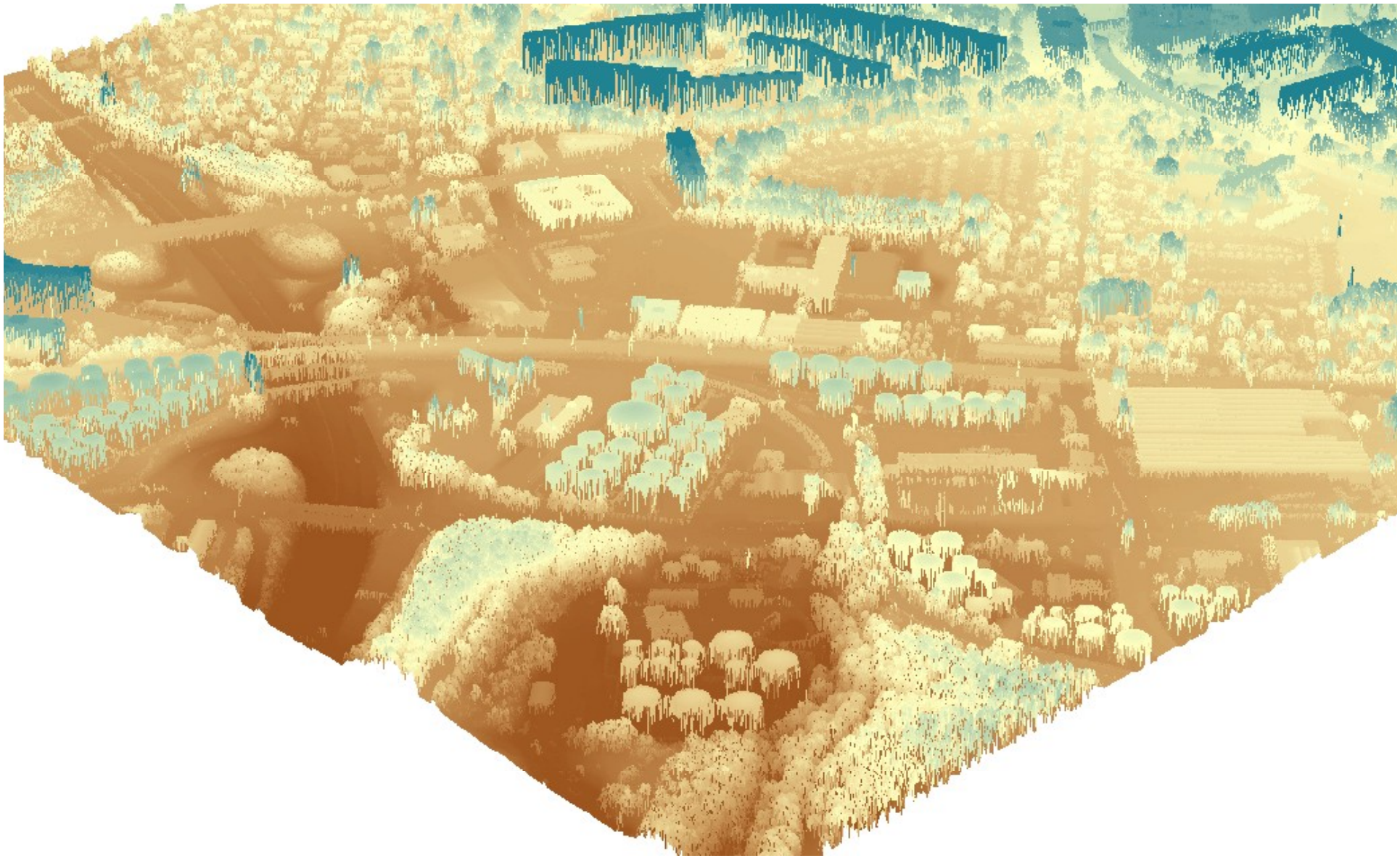


Area of the State:
282 km2

Raster resolution:
50 centimetres

47 tiles of 3 X 3 km
6 tiles de 1 X 1 km

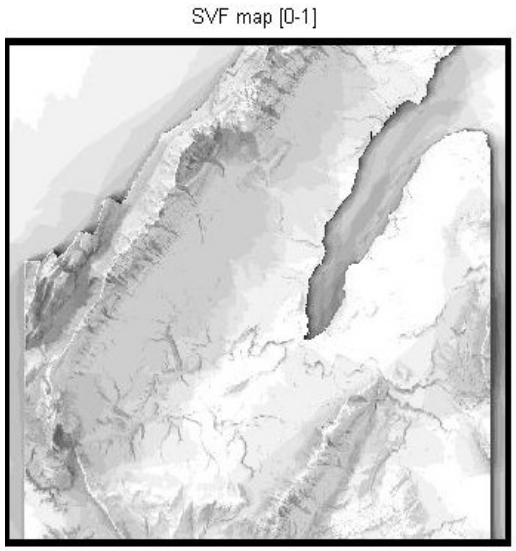
2.5D Digital urban surface model



Shadowing due to relief

Algorithms from Ratti and Richens (2004)

Sky view factor



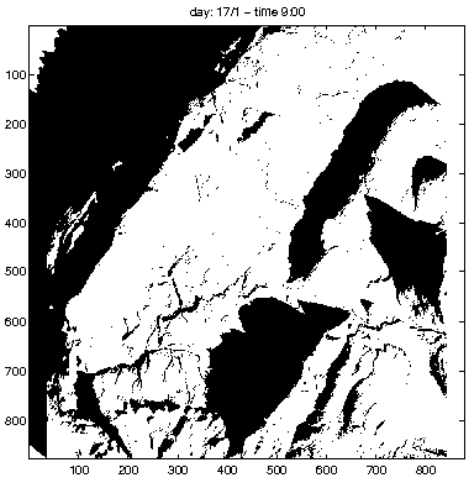
Direct

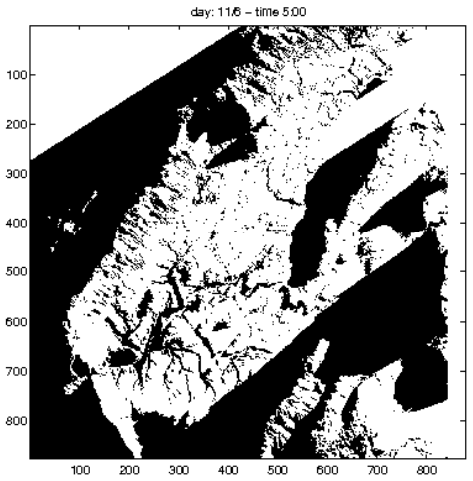
January

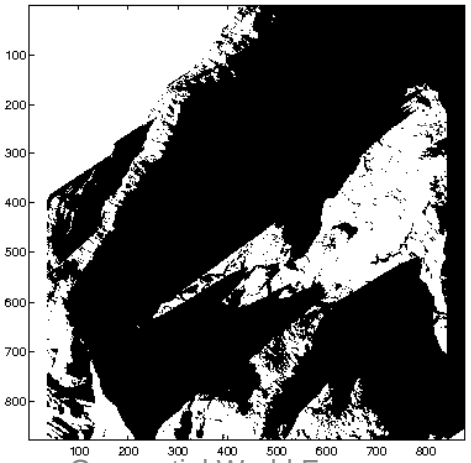
June

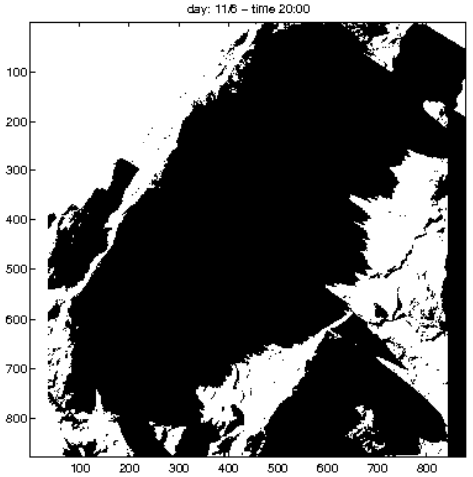
sunrise

sunset



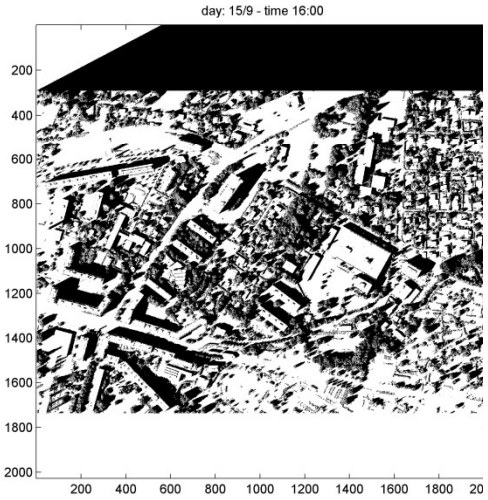


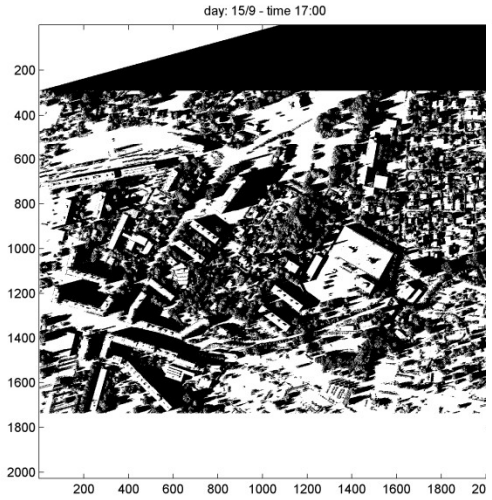


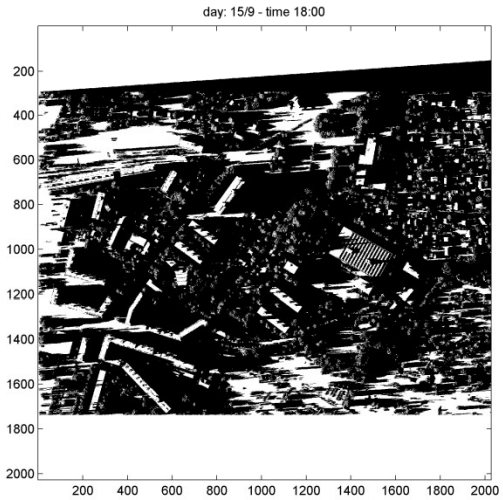


Shadowing in neighborhood (DSM)

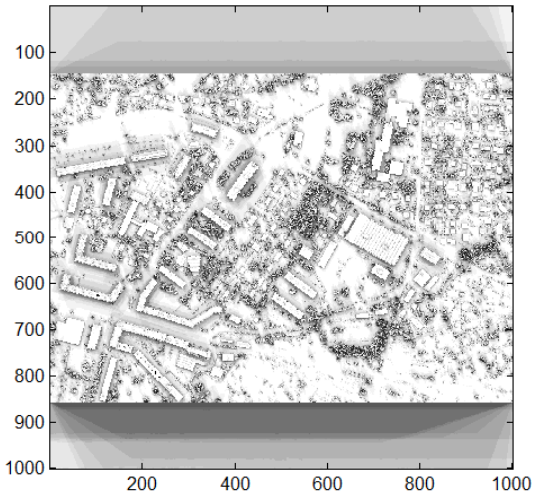
Direct





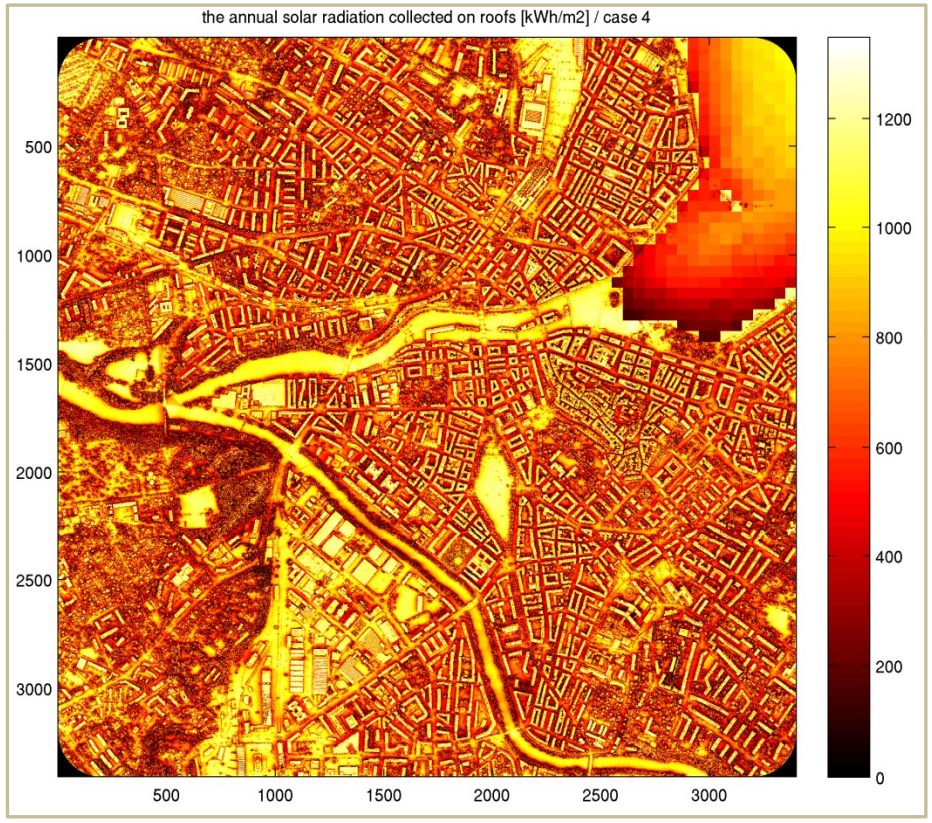


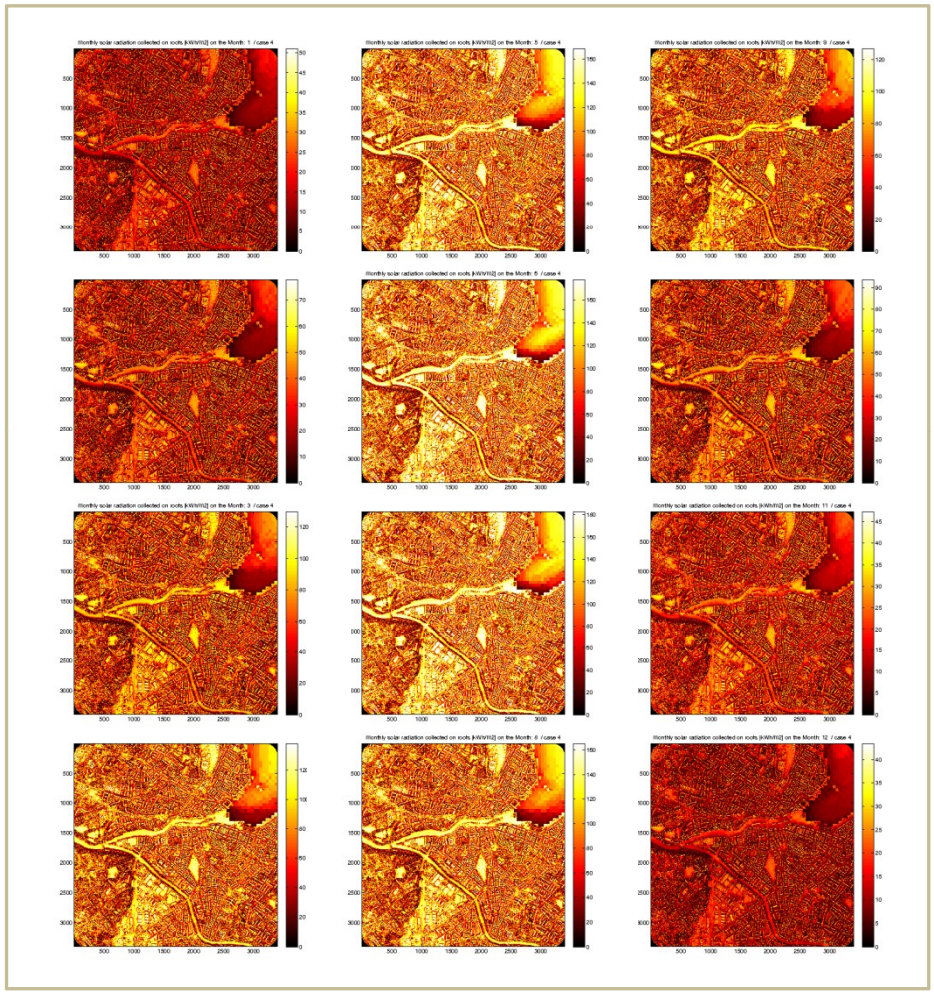
Sky view factor



Algorithms from Ratti and Richens (2004)

Irradiation outputs (raster format ; resolution: 50 centimetres)





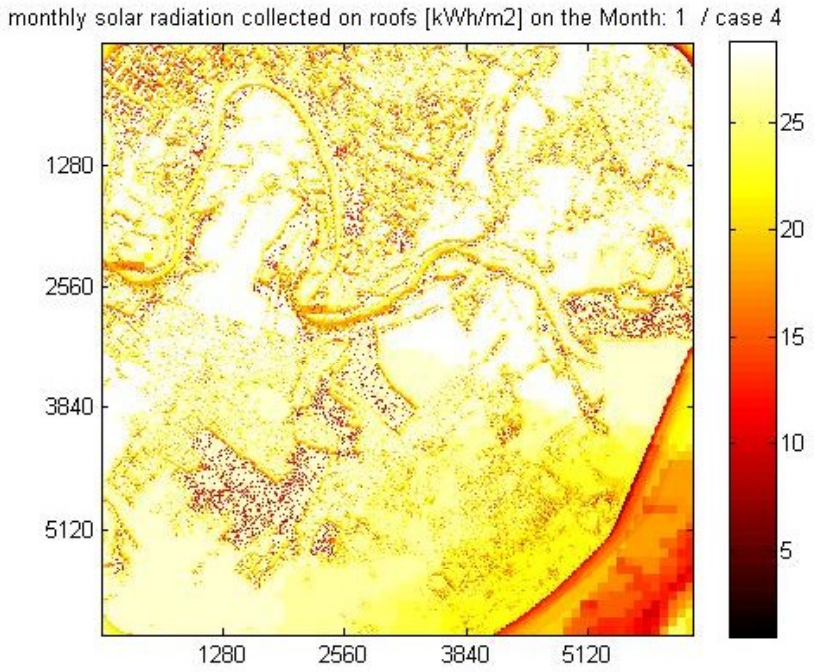
Yearly irradiation

Monthly irradiations

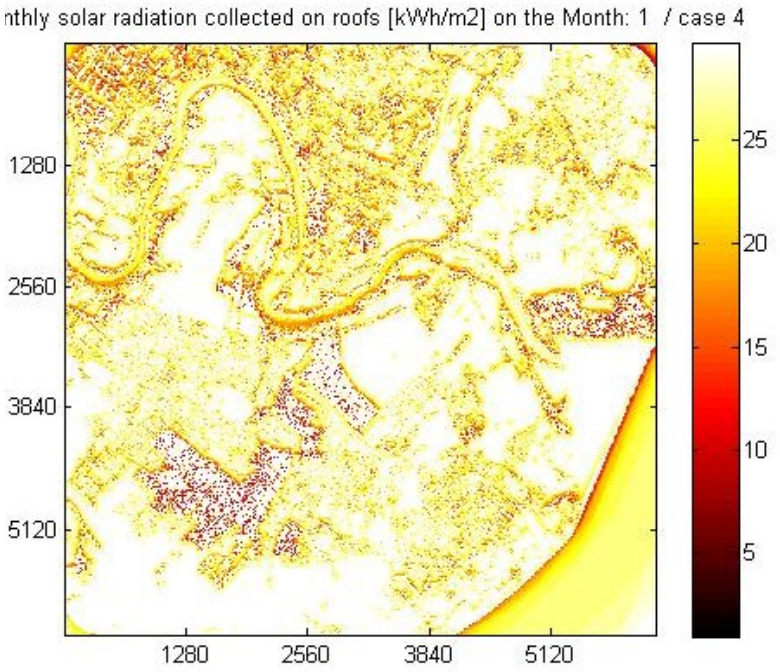
With and without taking into account relief shadowing (raster format ; resolution: 50 centimetres)

Month of January

With



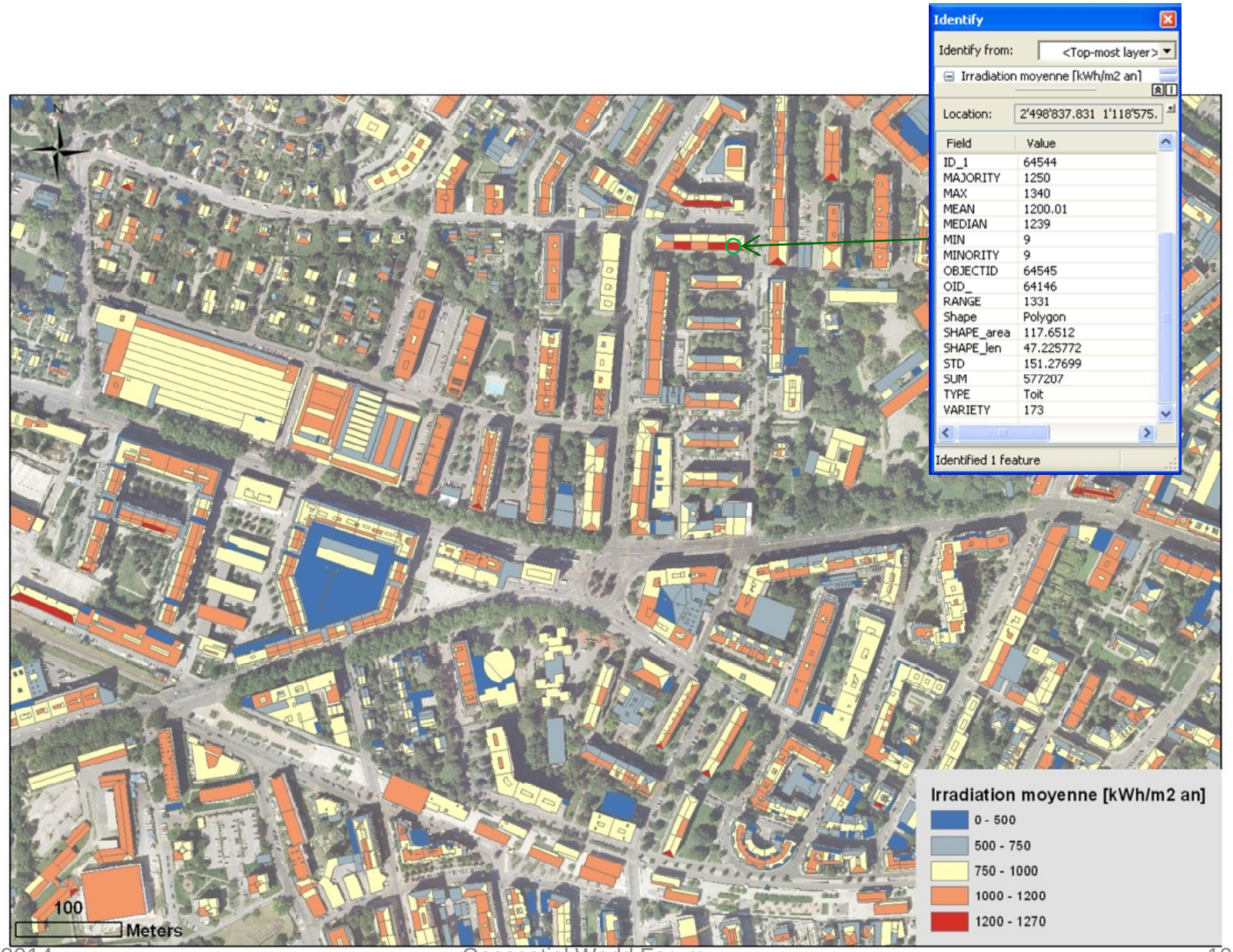
Without



Municipality of Geneva (Veyrier) close to Salève mountain

Importation of the irradiation results (tile by tile, raster format ; resolution: 50 centimetres) into GIS

Irradiation statistics on roofs (vector format) – 2D view

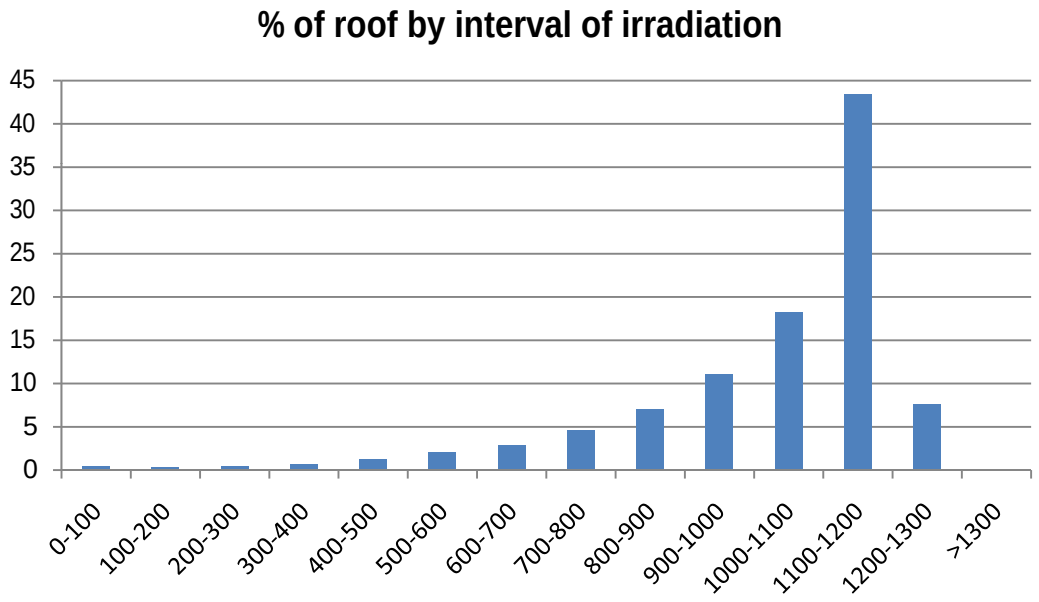


Irradiation statistics on roofs (vector format) – 3D view

Application of solar cadastre: energy planning at district level

Total roof area by interval of irradiation

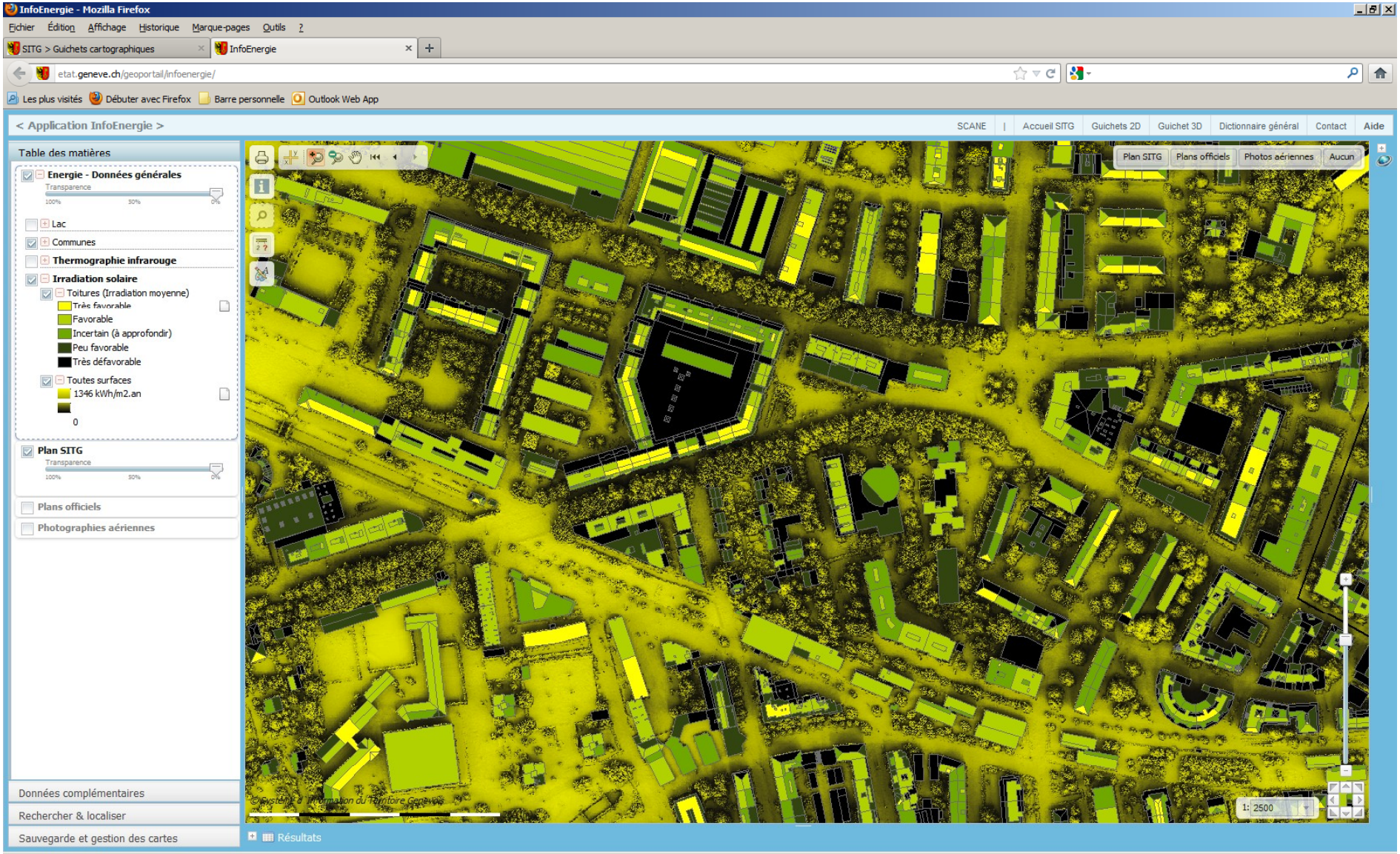
Irradiance en kWh/m² an	Surface toit m2
0-100	404
100-200	321
200-300	438
300-400	663
400-500	1'168
500-600	1'865
600-700	2'635
700-800	4'258
800-900	6'458
900-1000	10'304
1000-1100	16'946
1100-1200	40'314
1200-1300	7'049
>1300	38
SOMME	92'860



Globally the district is well irradiated through 2/3 roofs collecting an irradiation > 1000 kWh/m² yr

Display of the results on the official Geneva geoportal

http://etat.geneve.ch/geoportail/infoenergie/



Some useful examples for energy planning

- Coming integration of **indicators of solar energy production** (technical, financial and environmental indicators)
- **Two kind of target use and actor**:
  - Energy planning at urban scale
  - Preliminary data for specialists (energy companies, energy building consultants, solar panel installers)
- **Specifications**:
  - PV: no link with building features, roofs as a support for a renewable energy grid development
  - Thermal energy: Integration of solar irradiation with energy needs at building level (DHW and heating needs)

Solar PV planning for a building

Technical, financial and environmental indicators for preliminary PV panel installation project.

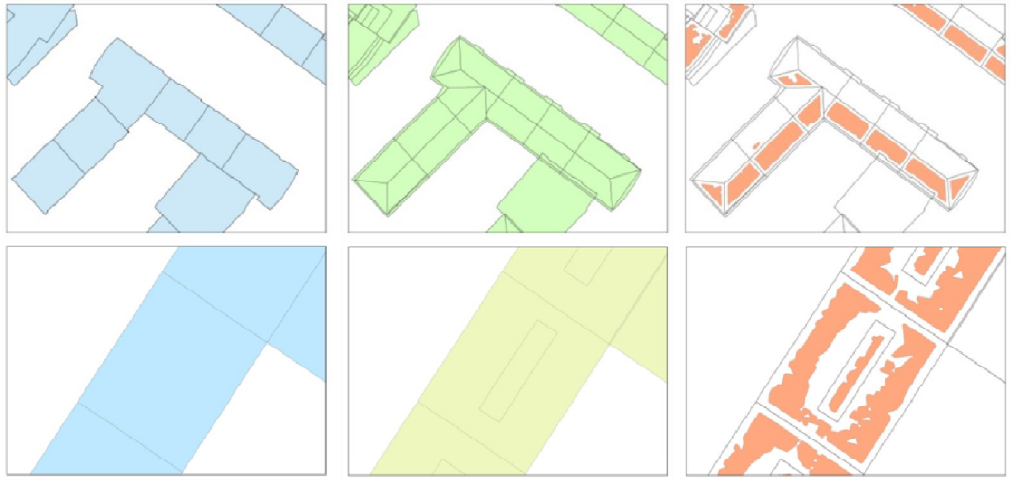
Input data from solar cadastre:

- Area of a given useful roof section
- Mean slope / roof section
- Mean orientation / roof section
- Mean irradiation / roof section

Other useful data:

- PV panels database (technical specifications)
- Swiss incentives (financial aspect)

Vector format: three levels of detail …

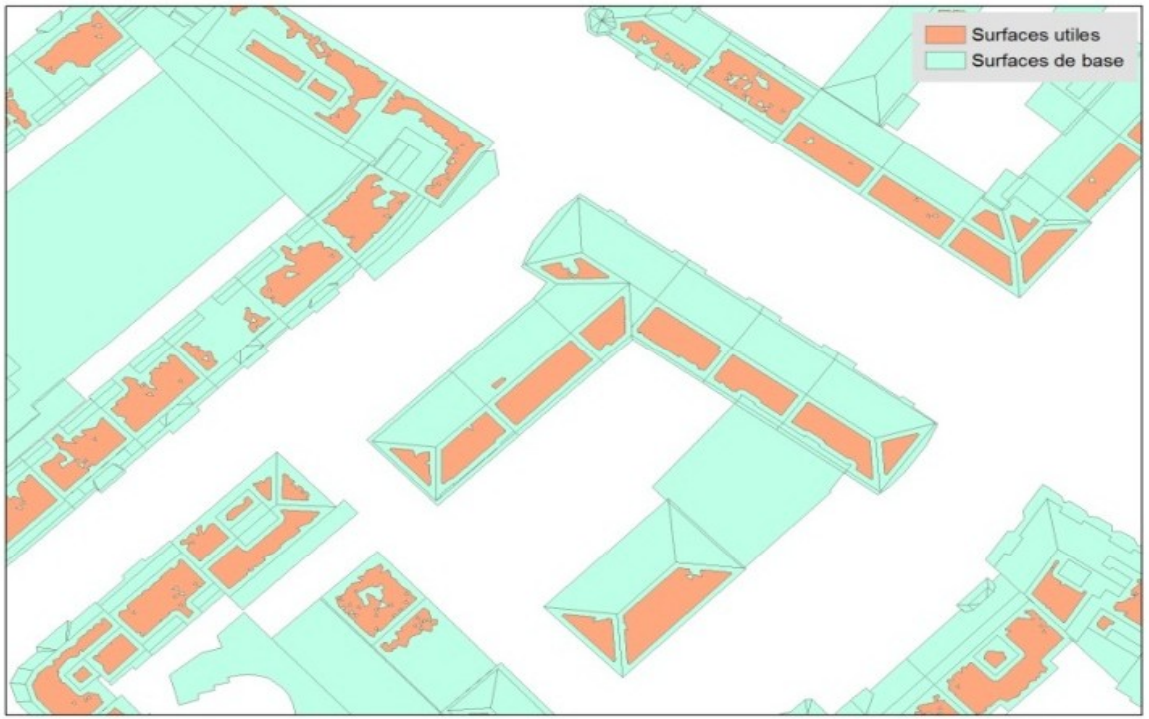


Building | **Roof sections** | **Useful surfaces**

Solar PV planning for a building (useful roof surfaces)

According to specific criteria:

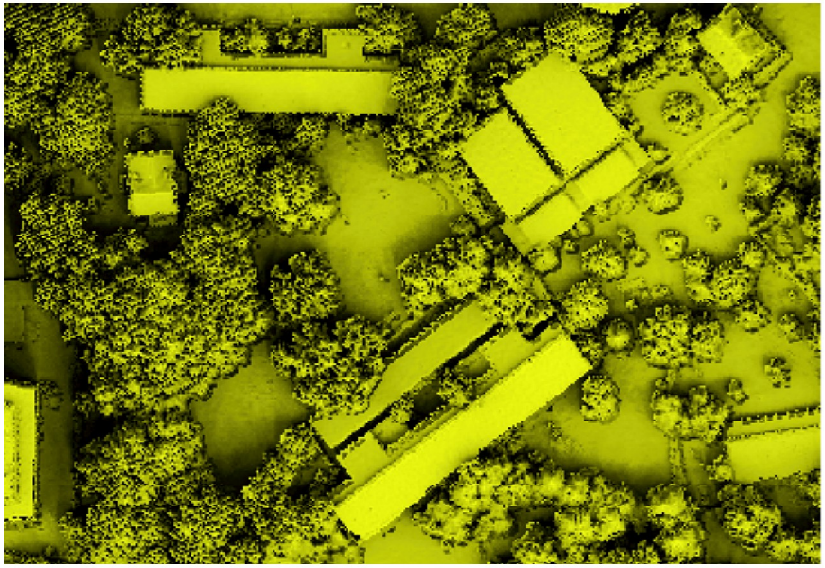
- Minimum irradiation: 1000 kWh/m^2/year
- Borders (1 meter) of roofs are excluded
- Useful areas > 5 m^2



Other useful data:

- Mean slope and orientation
- Real surface
- Length and width

Solar PV planning for a building (useful roof surfaces)



Raw irradiation

Useful roof surfaces

Technologie:	**PV - polycristallin**
Irr. moy. toit:	1'214 [kWh/m2/an]
Pente moy.:	12 [°] *(toiture)*
Orient. moy.:	143 [°] *(toiture)*
Surf. toit. utile :	645 [m2]
Surf. capteur:	645 [m2]
Prod. él. janv:	2.5 [MWh/janv]
Prod. él. juin:	13.9 [MWh/juin]
…	
Prod. él. an:	98.5 [MWh/an]
Sum_Puis:	103.2 [kW]
Invest.:	368'022 [CHF]
Coûts_an:	24'264 [CHF/an]
Recettes_RPC:	23'700 [CHF/an]
Prix_revient:	0.246 [CHF/kWh]

Indicators / roof

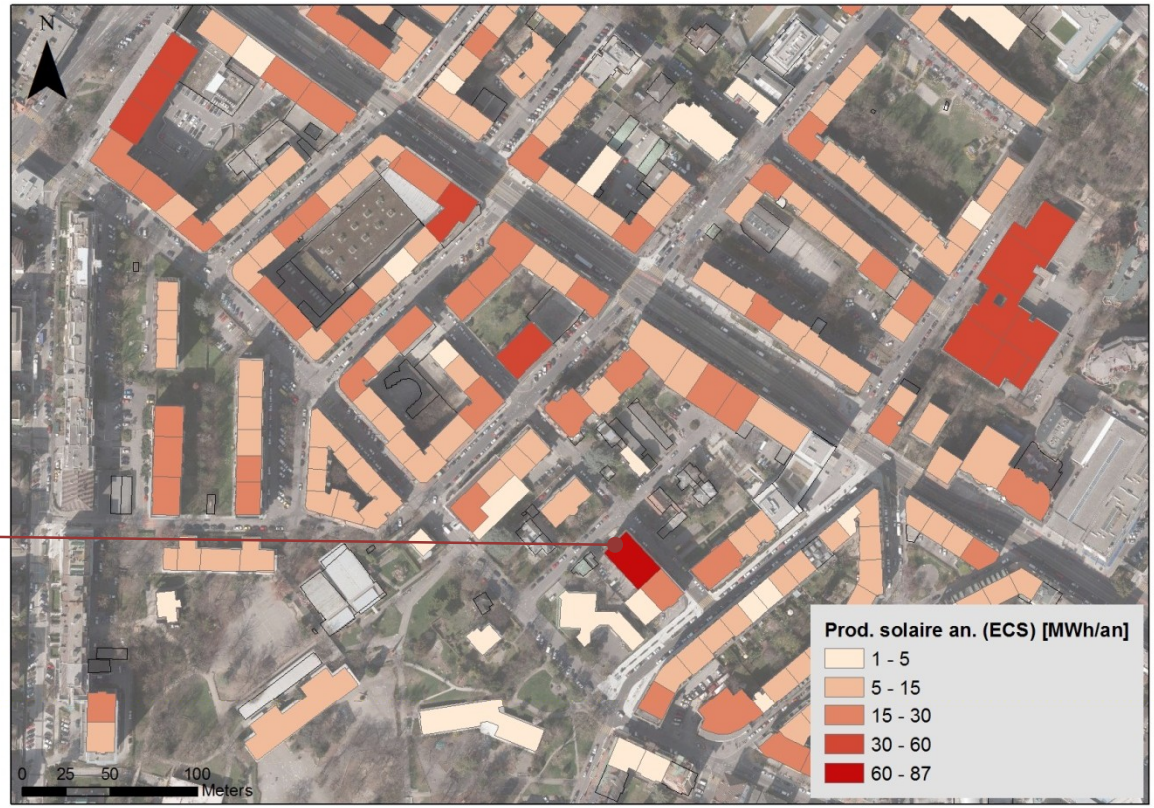
Solar thermal for domestic hot water (DWH) (building)

Thermal solar:

=> *integration with building:*

- **Category of use**
- **Year of building / refurbishment**
- **Nb of occupants (DHW)**
- **Built area**
- **Heat index**
- **Initial energy source**
- **…**

Irr. moy.:	1’163 [kWh/m2/an]
Pente moy.:	12 [°]
Orient. moy.:	182 [°]
Surf. toitures:	135 [m2]
Surf. capteur:	128 [m2]
Prod. an:	60 [MWh/an]
Invest.:	250’000[CHF]
Coûts_an:	18’000 [CHF/an]
Recettes_an:	7’750 [CHF/an]
Prix_revient:	0.30 [CHF/kWh]
CO2_econom:	288 [t]



Solar energy balance for a municipality

VERNIER Une Ville pas Commune AMSTEIN + WALTHERT

City of Vernier (34'000 inhab.)

Useful roof surfaces:

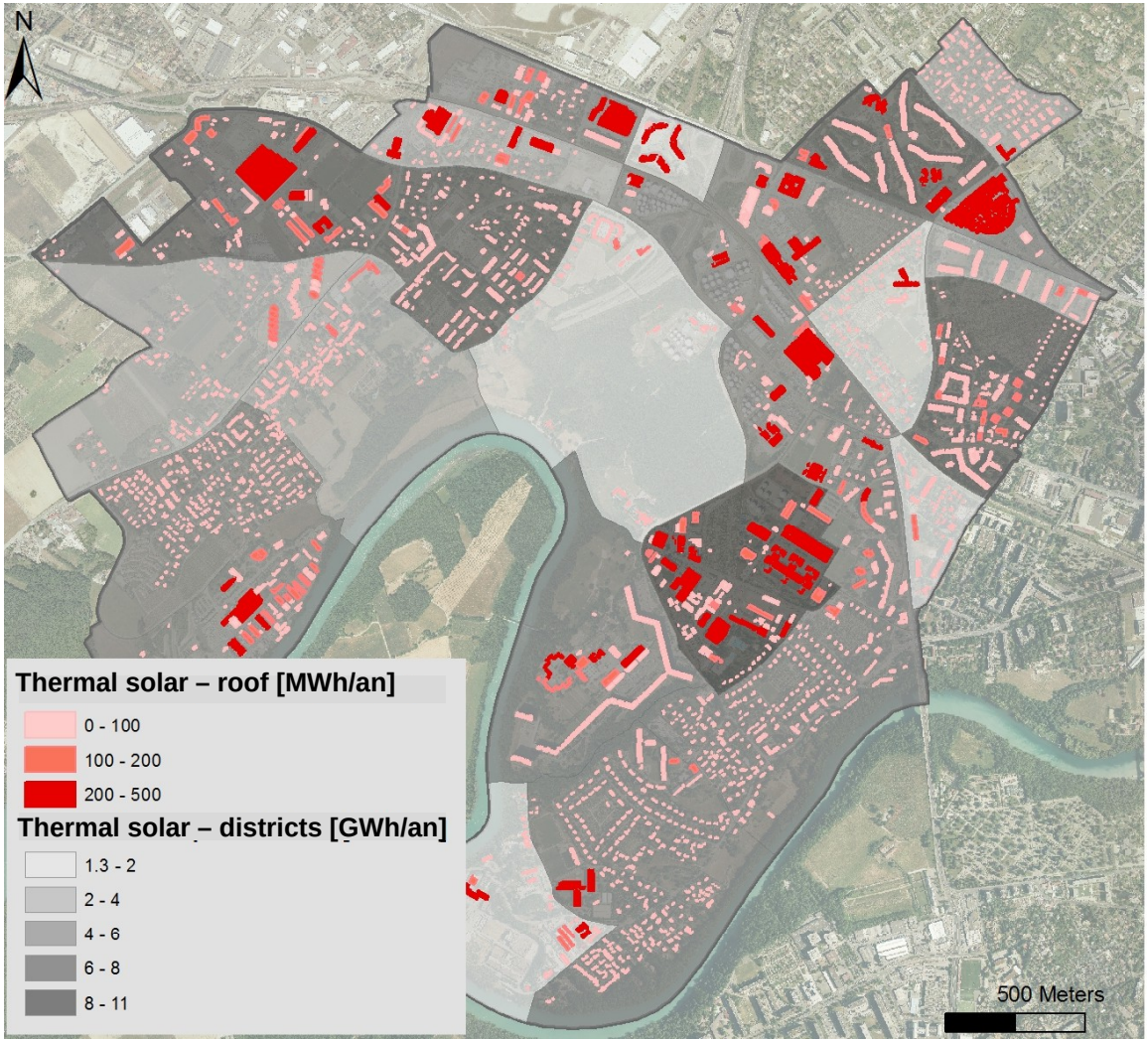
- 550'000 m2 (51% of total roof area)

Thermal potential:

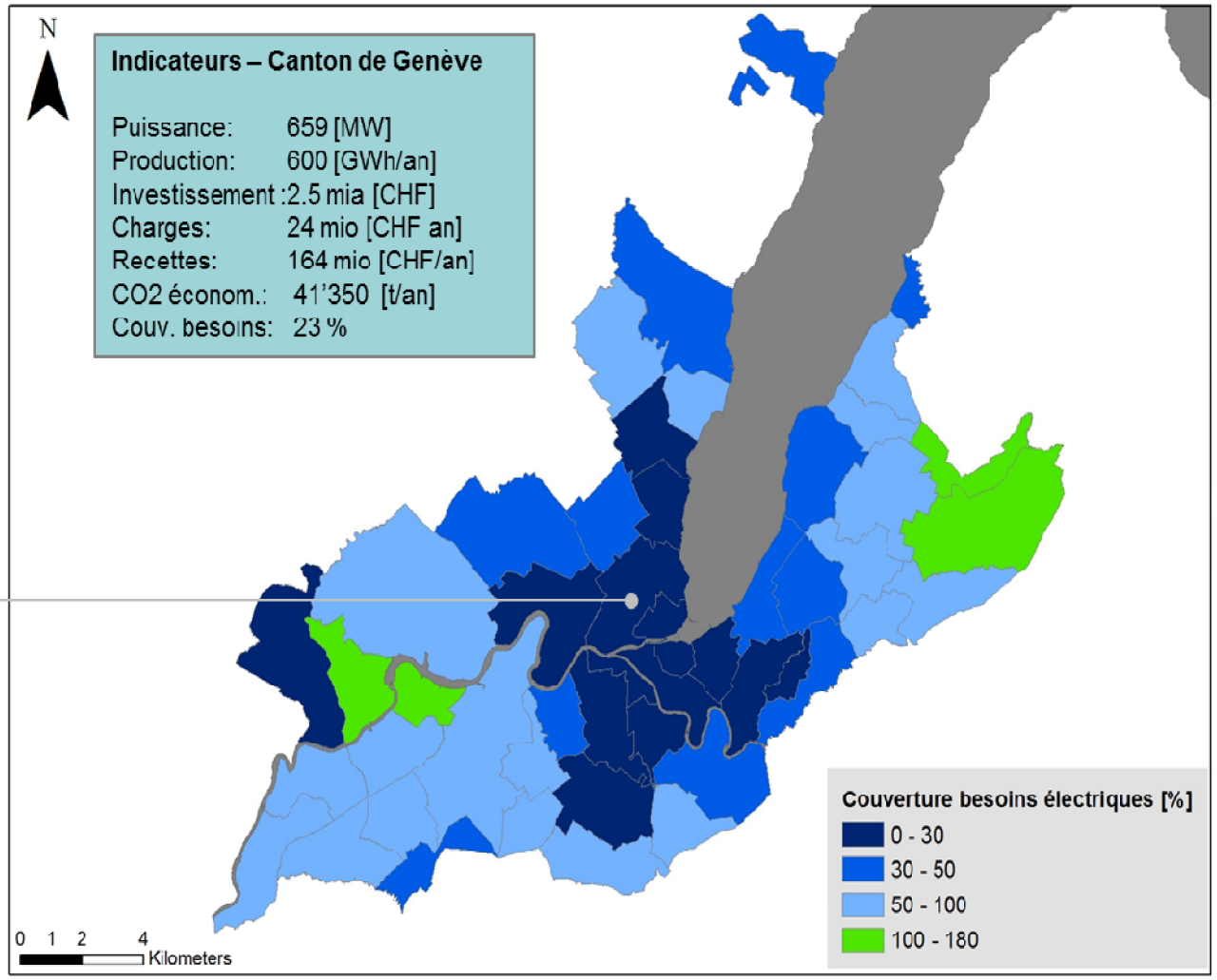
- Tot.: 54 GWh/year
- DHW 60%: 16 GWh/year

Electrical potential:

- Tot.: 47 GWh (26% of needs)



Solar energy balance for the state of Geneva: electrical needs covered



Indicateurs / Petit-Saconnex

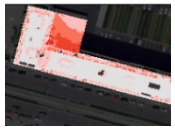
Puissance: 45 [MW]
Production: 41 [GWh/an]
Investissement: 146'000 [CHF]
Charges: 1.6 mio [CHF/an]
Recettes: 11.3 mio CHF /an]
CO2 économ.: 2.8 [t/an]
Couv. besoins: 13 %

Conclusions

Toolbox and indicators for various purposes of roof & building use: data exist but should be reliable, collected (among several owners), centralized, made available and shared (=> issue of privacy)

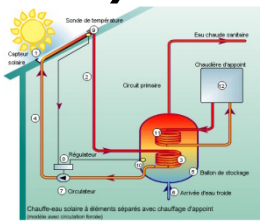
Photovoltaïc

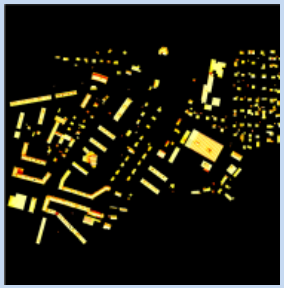
-Orientation
-Min area
-Shadowing



Thermal (hot water)

- Nb of users





Thermal (heating)

- Building features
- Neighborhoods

Green roofs

- Irradiation / shadowing
- Slope

Solar radiation on façades

- Shadowing
- Orientation of façades

Conclusions

Target users for energy cadas

Level of dissemination

Public:
communication, awareness raising

Policy making:
integration

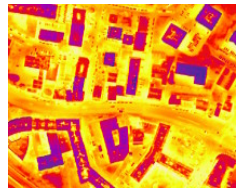
Experts:
urban and building energy concepts

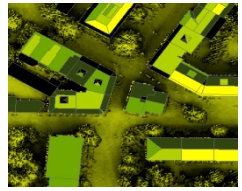
Thermography

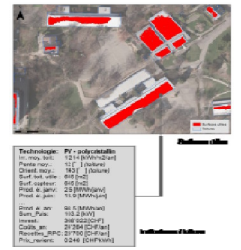
Solar mapping: roof classification

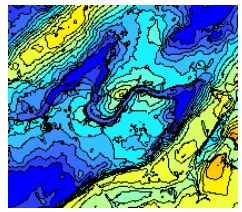
Solar mapping: specific indicators

Geothermal cadastres









Level of expertise

Questions

- The state of Geneva offers a very rich set of data, what about other communities ? How to do when fewer data are available ?
- What about the integration of data and information in decision process, how to move beyond spatial analyses ?

Perspectives

- Extend the proposed method to the analysis of solar radiation on building façades
- To develop a friendly interface for displaying indicators results at building and roof level (as for many solar maps in US, e.g., New York)