



GIS tool to estimate the urban solar radiation

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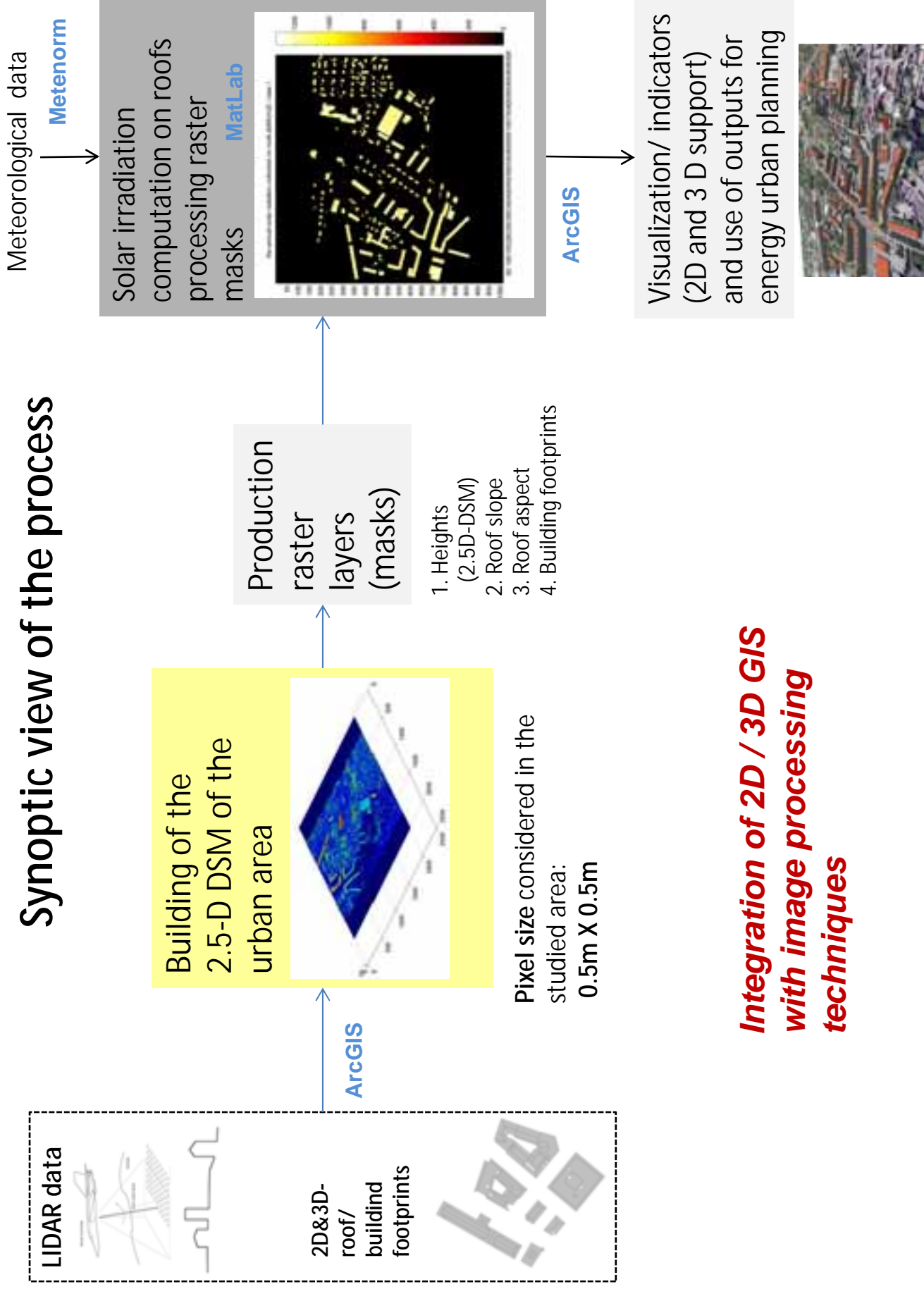
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Switzerland

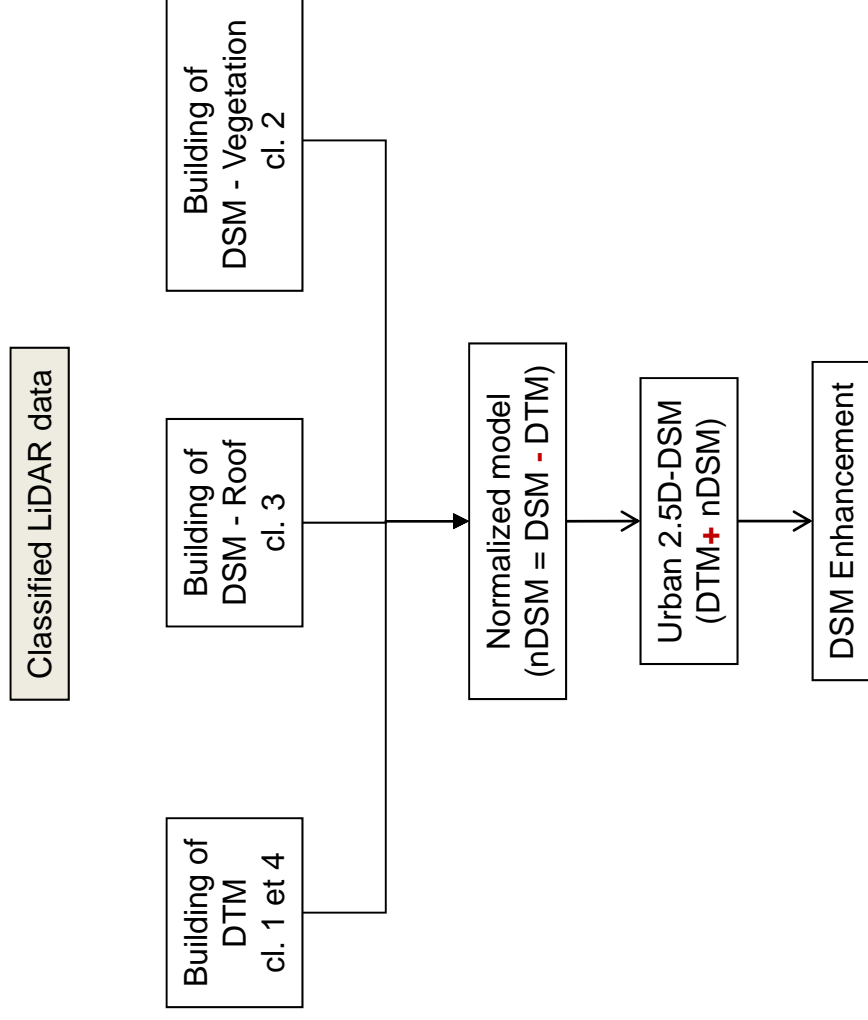
Presentation of the solar mapping process and tools

Synoptic view of the process



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

Building of the urban 2.5D – DSM



Solar calculation: raw data and time scale

- Metenorm (v6): Hourly statistical values of global and diffuse irradiation on horizontal surface, [Wh/m²], for a given location (Geneva)
- **Average hourly irradiation values by month***
 - ⇒ 24h X 12m = 288 time intervals (minus night hours)
- **Day~15 of month** considered for solar geometry
- Possible outputs:
 - hourly **H**
 - daily (day 15) **J** = ΣH
 - monthly **M** = $J^* \{28, 30, 31\}$
 - yearly **A** = $M^* 12$

* In order to reduce time computation

Solar irradiation formulae

- Hourly global irradiation on a titled surface (slope β and orientation γ)

$$I_g = I_{dir} * O_{dir} + I_{diff} * O_{SVF} + I_r$$

SVF: Sky View Factor

source: P. Ineichen (Geneva)





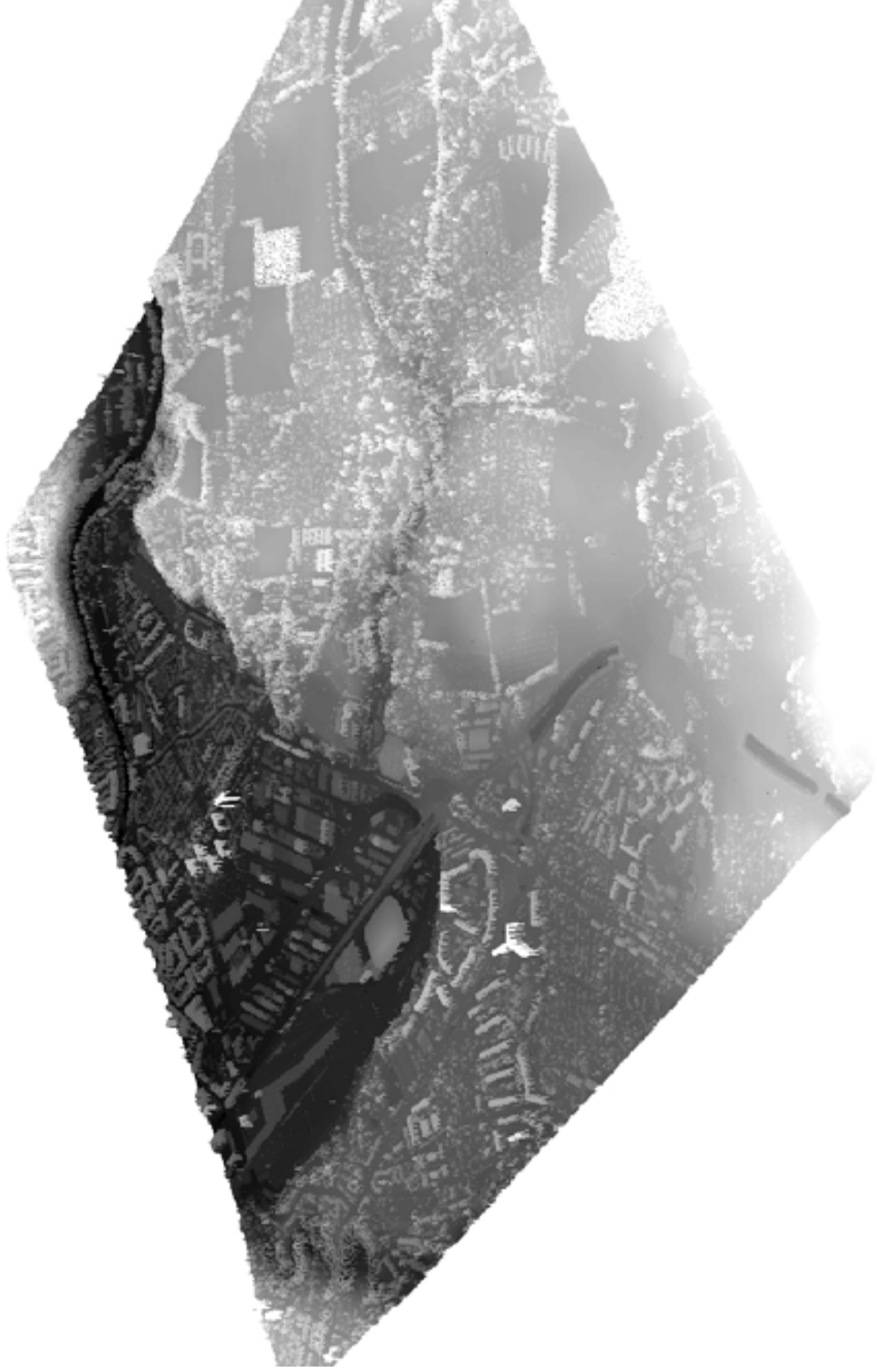
Geneva energy company

Application to the solar mapping (cadaster) of Geneva

Goals of the study

- Solar mapping of Geneva based of 3D data of building, in order to estimate the **local solar energy potential**
- To **communicate** to everyone the solar potential on the top of his/her building
- To provide useful support in **pre-designing solar collectors**
- To give solar potential not only on roofs but also on the **terrain** (to discover other useful objects for solar installation like bike parkings).

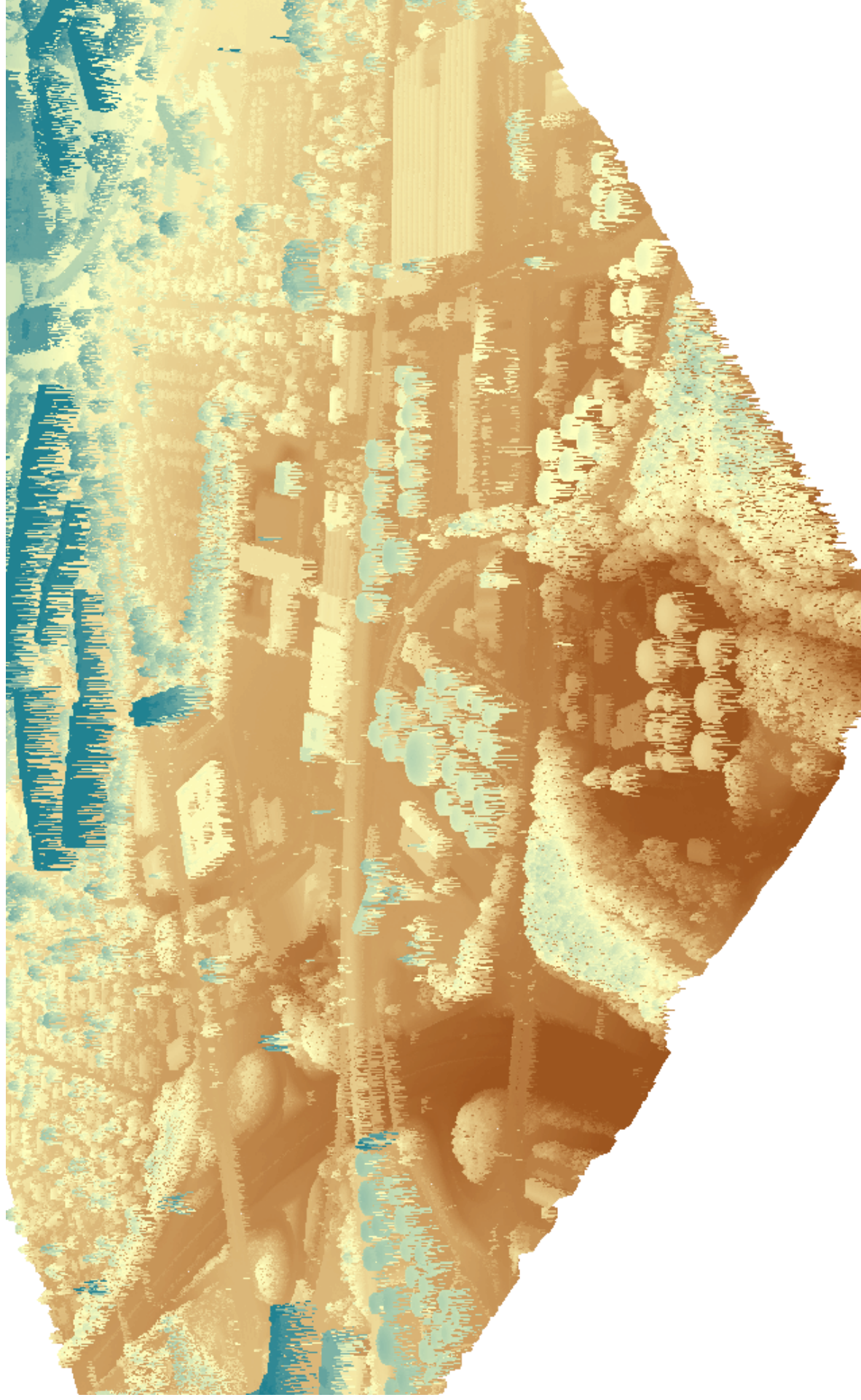
2.5D DSM



2.5D DSM



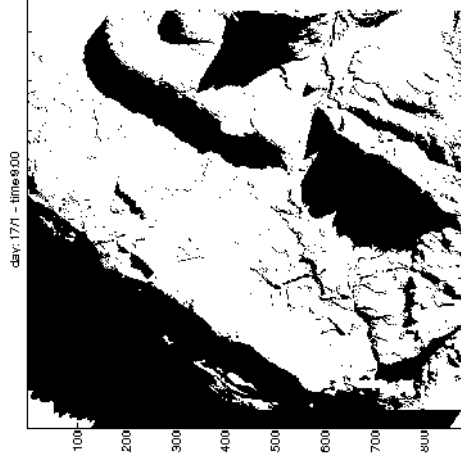
2.5D DSM



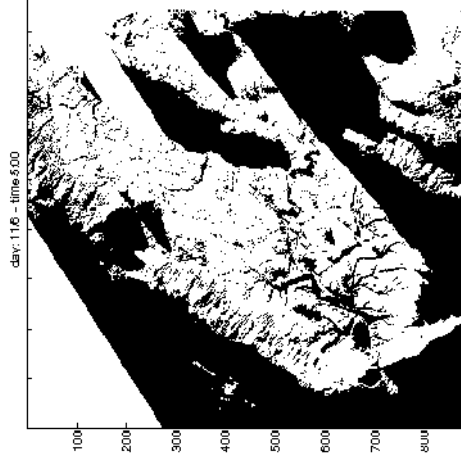
Shadowing due to relief

Direct

January

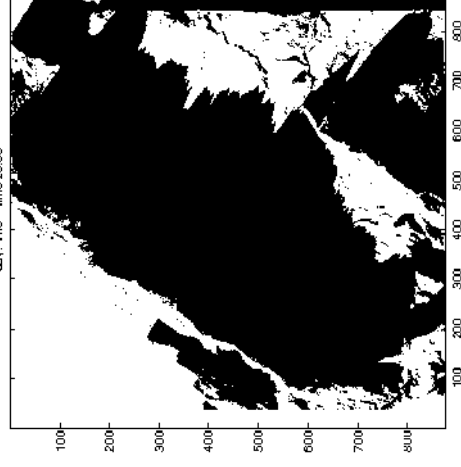
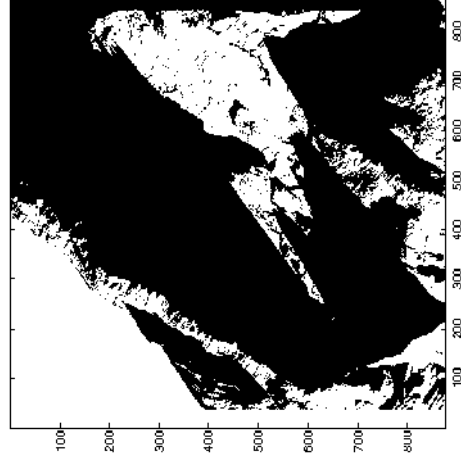
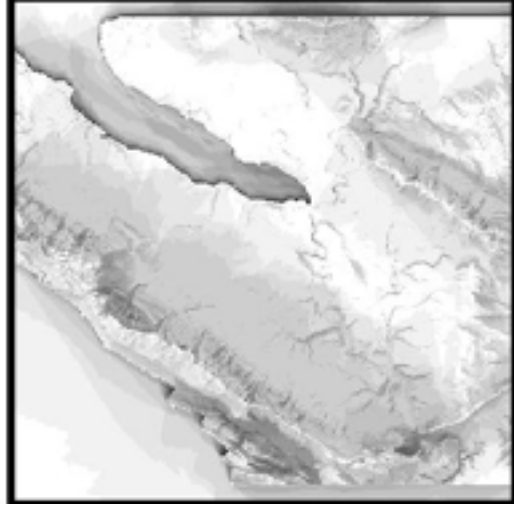


June



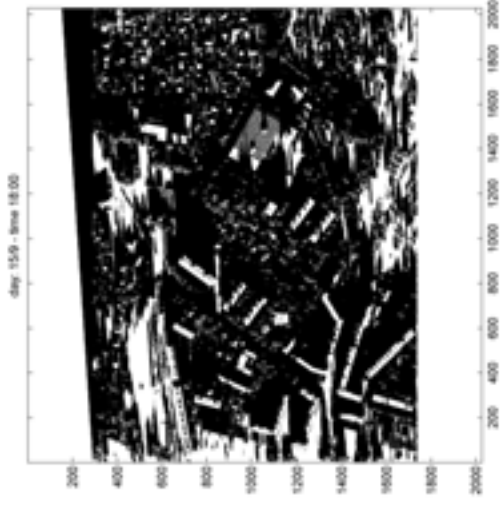
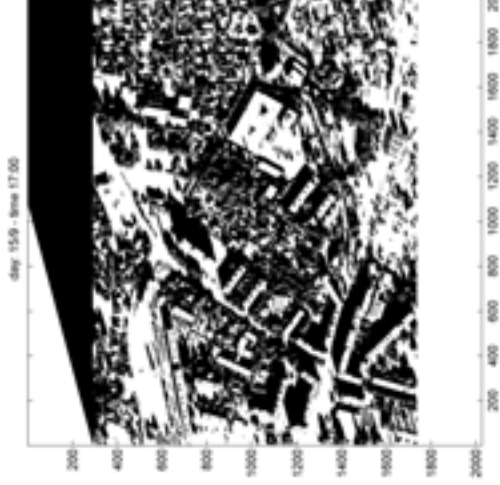
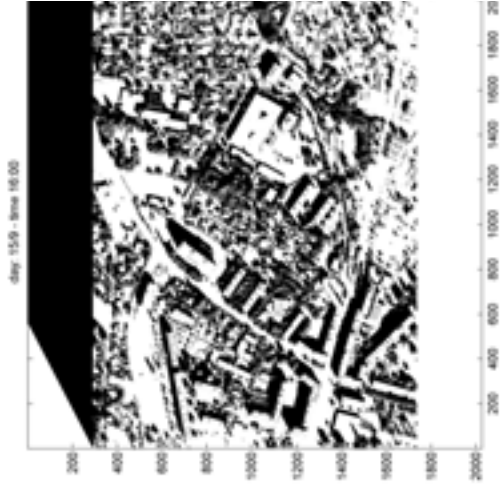
Sky view factor

SVF map [0..1]

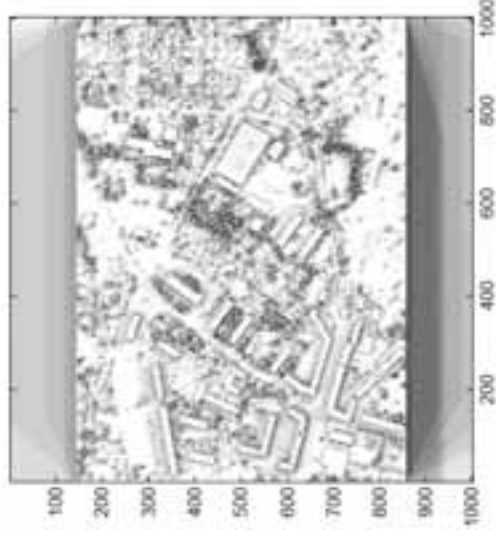


Shadowing in neighborhood (DSM)

Direct

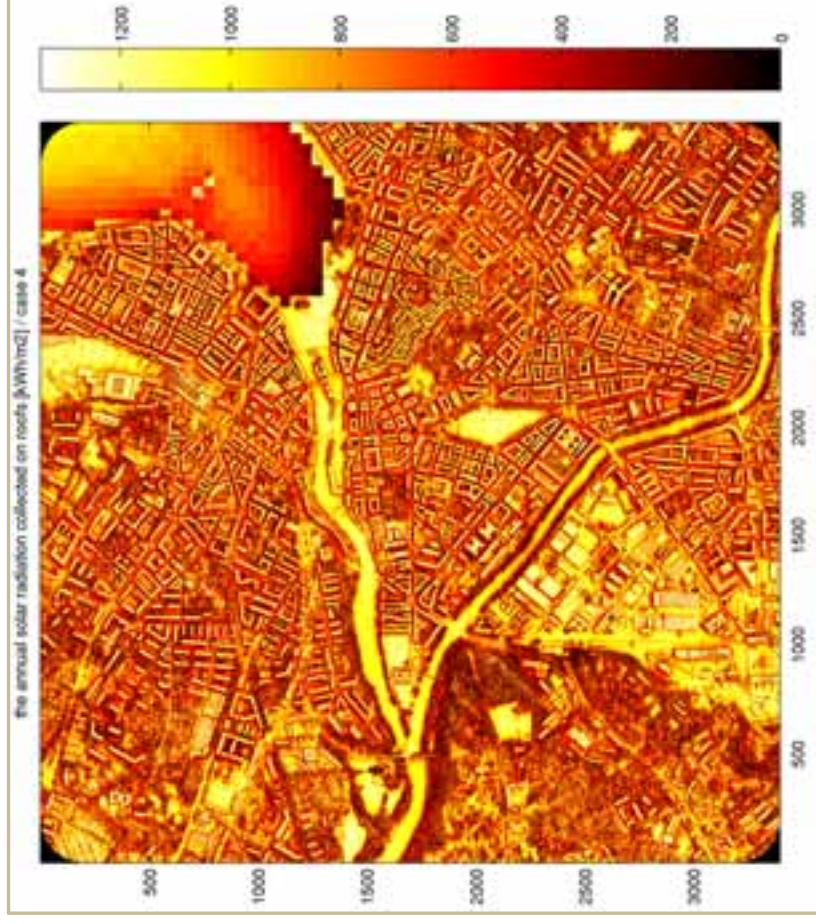


Sky view factor

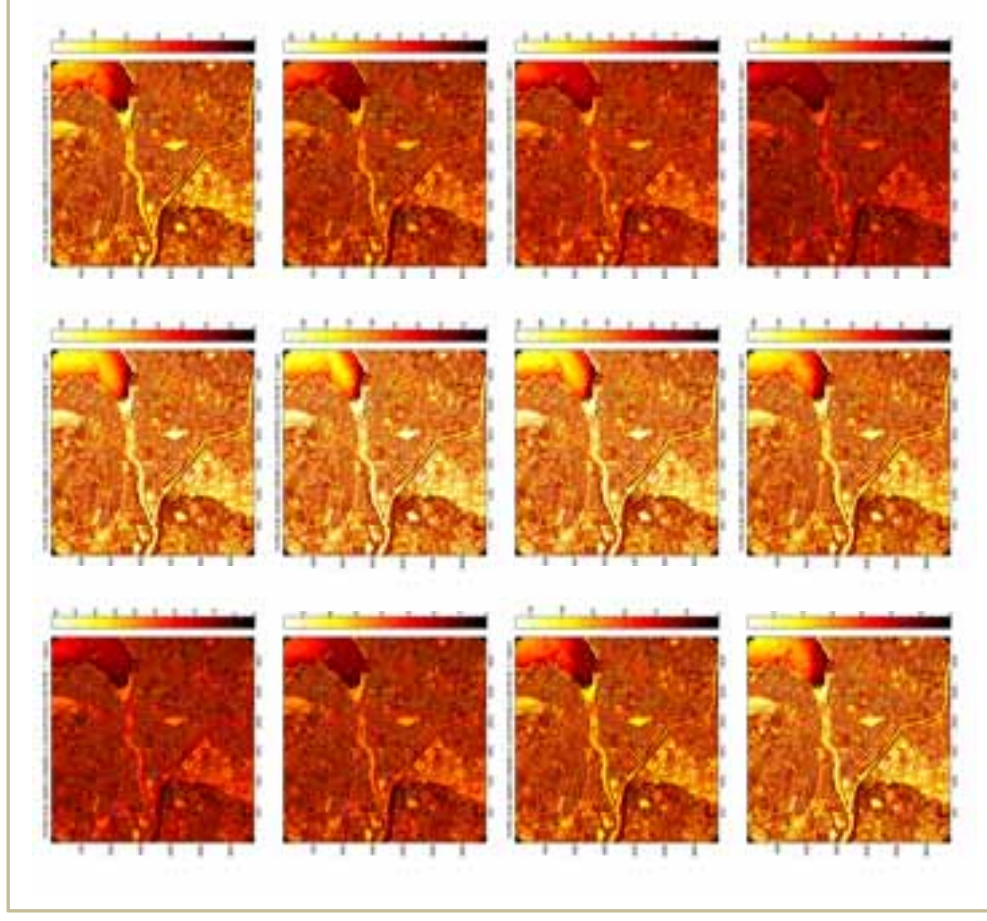


Ratti et Richens (2004)

Irradiation outputs from MatLab



Yearly irradiation

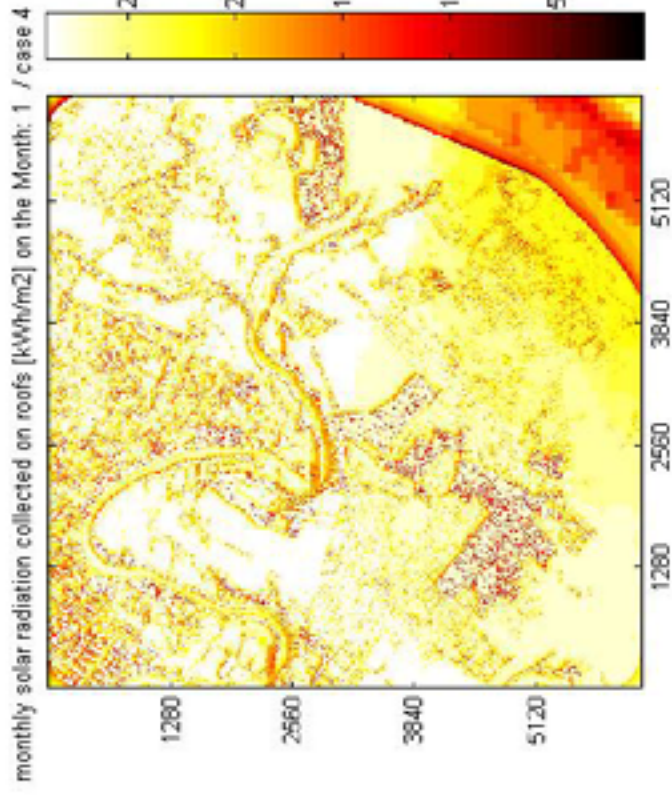


Monthly irradiations

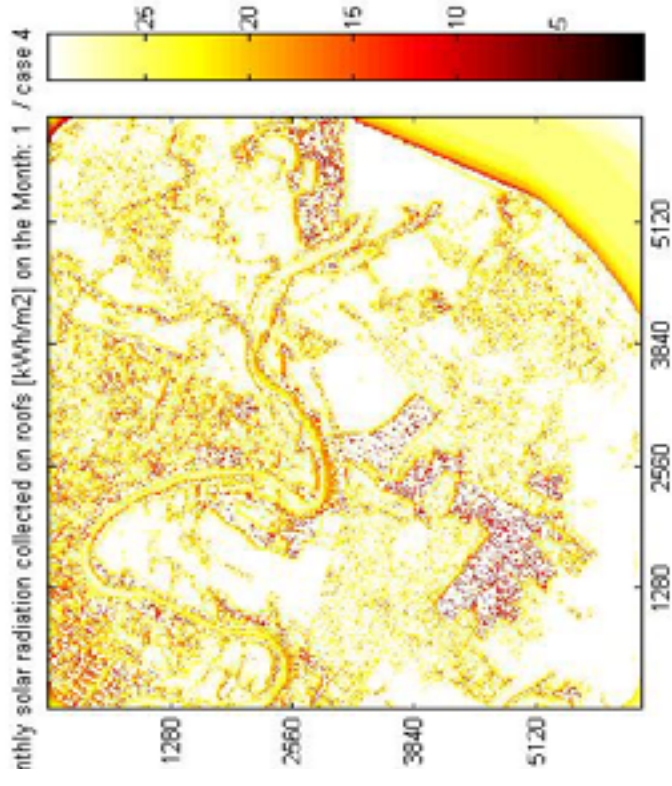
With and without taking into account relief shadowing

January

With

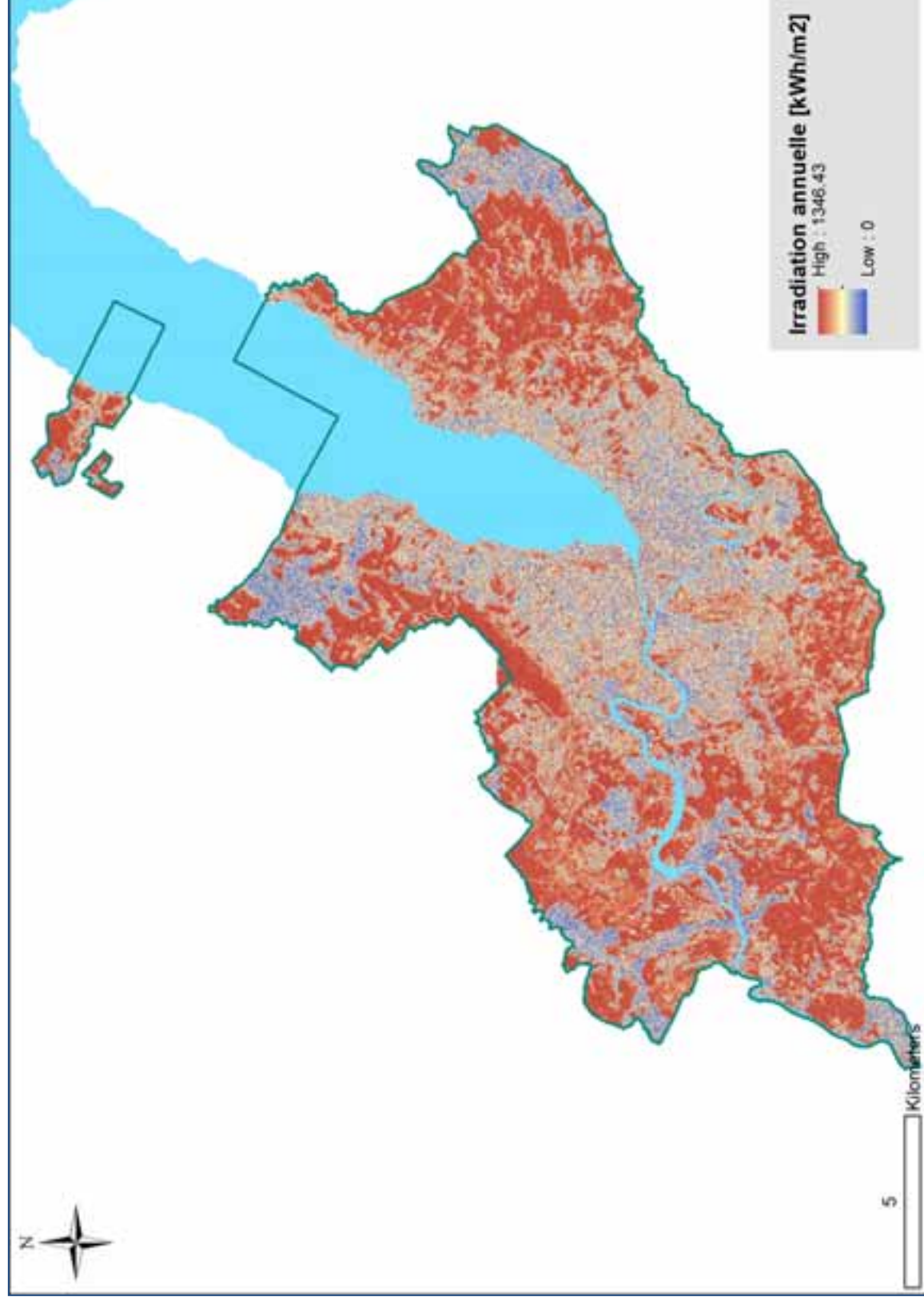


Without



Place of Geneva close to mountain

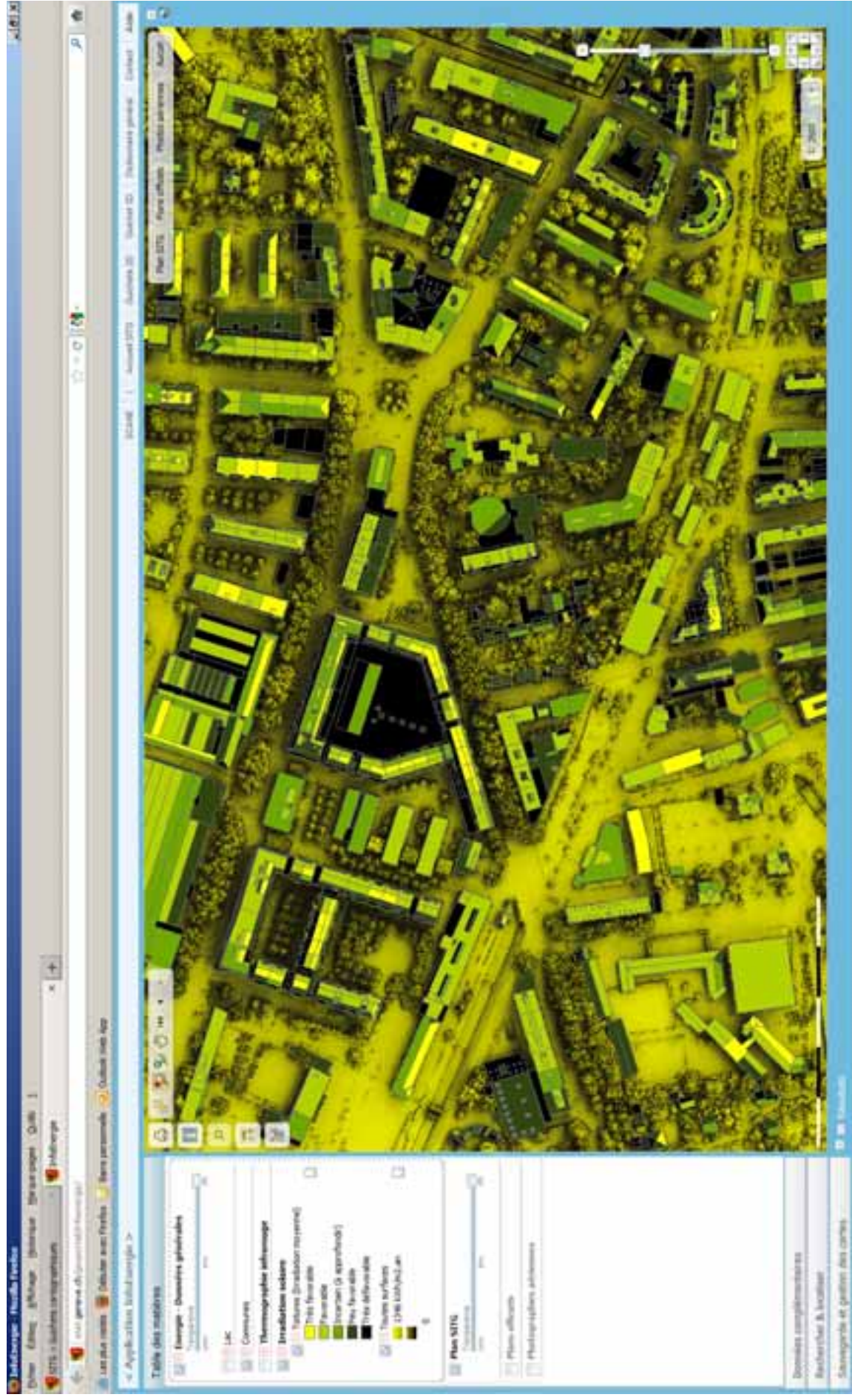
Importation of the irradiation results in ArcGIS



Roof statistics – 2D view



Display of the results on the official Geneva geoportal
<http://etat.geneve.ch/geoportail/infoenergie/>



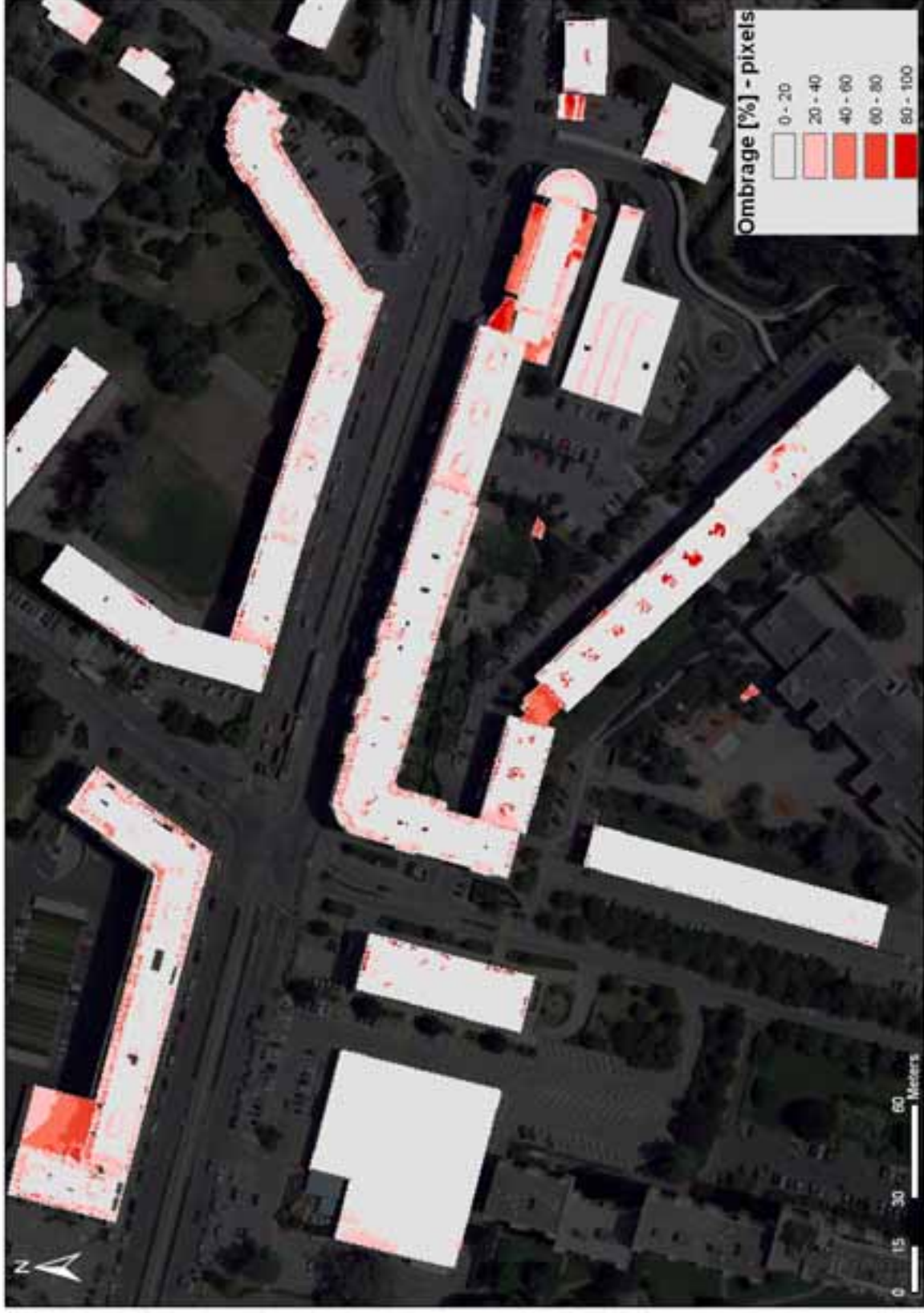
3D View using ArcScene



Perspective of using
solar mapping: useful indicators

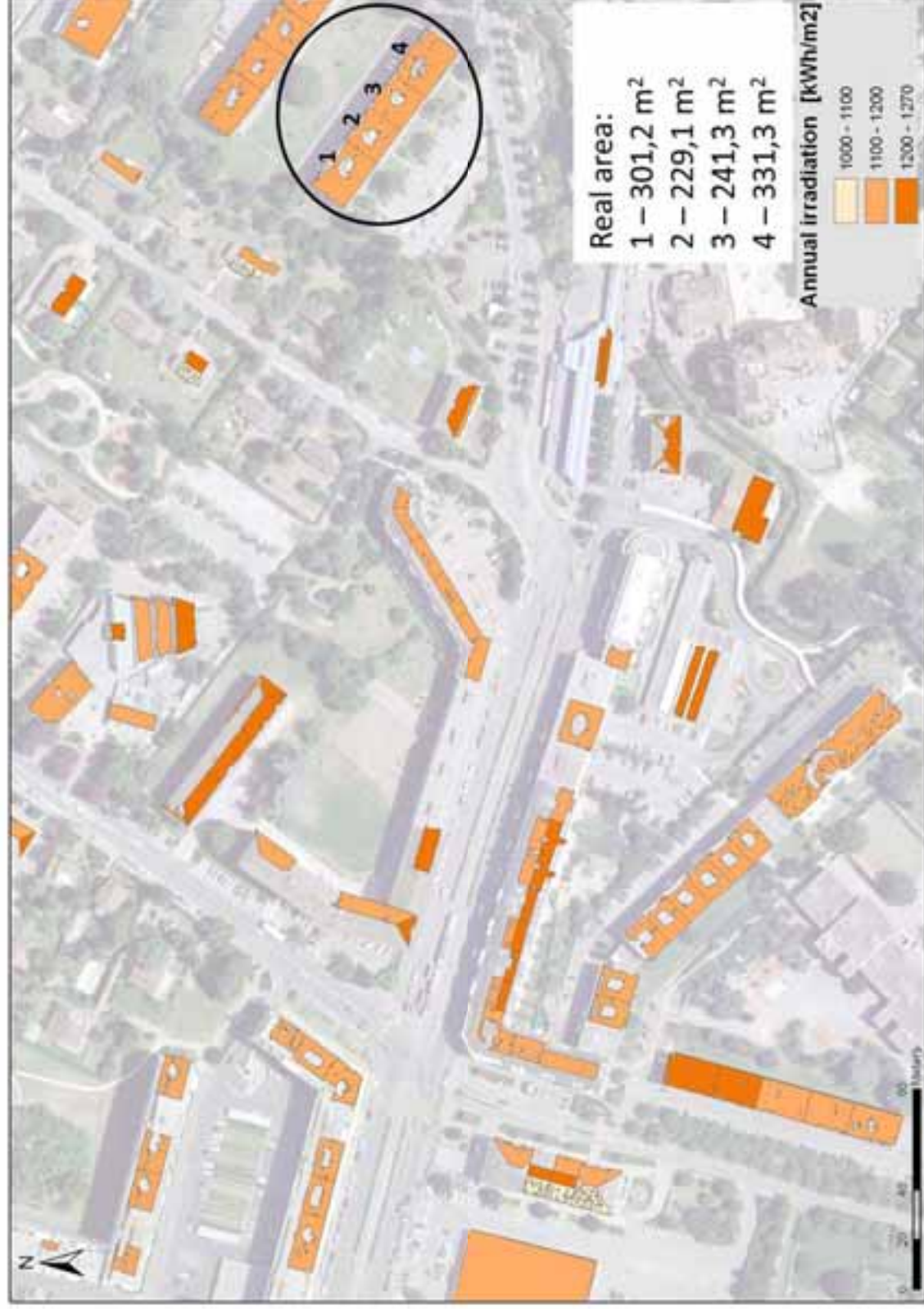
Shadowing ratio (raster)

Irradiation computation with shadowing/ irradiation computation without shadowing

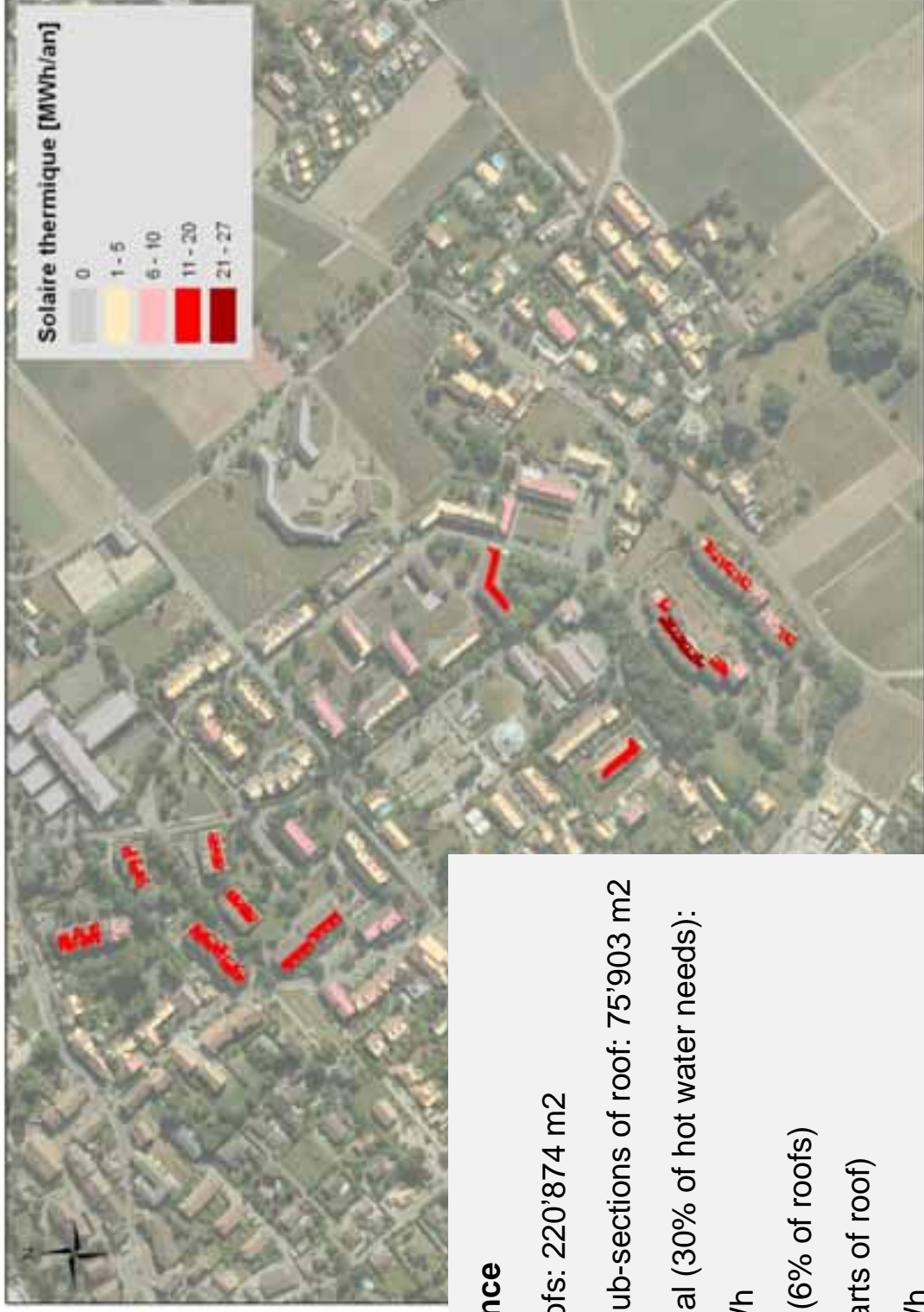


Useful sub-sections of roofs for solar collectors

According to the criterium: irradiation > 1000 kWh/m².yr and minimum shadowing ratio



Solar energy balance for a municipality



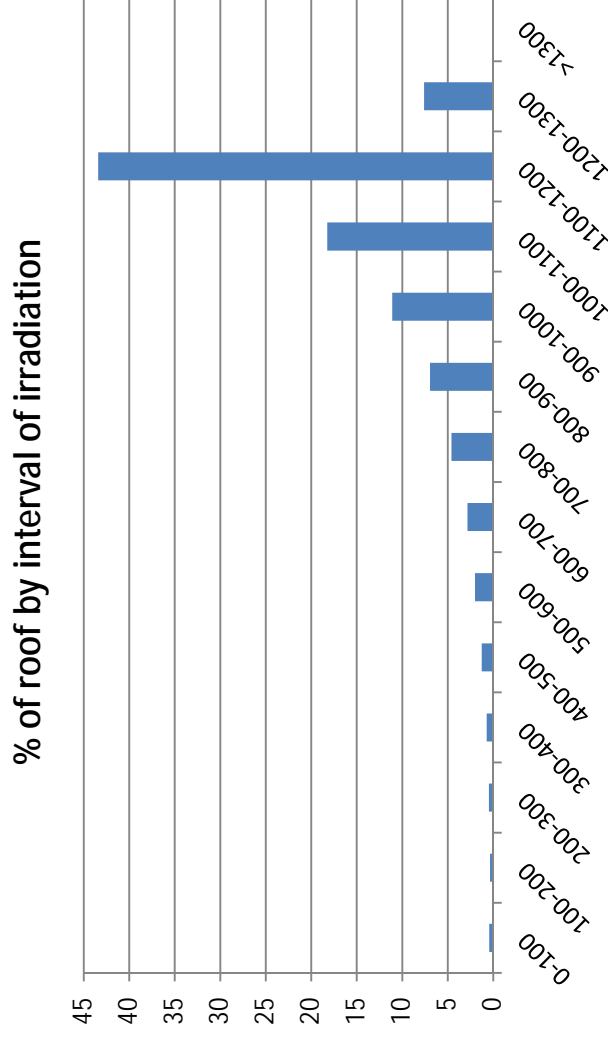
Solar energy balance

- Total area of roofs: 220'874 m²
- Area of useful sub-sections of roof: 75'903 m²
- Thermal potential (30% of hot water needs):
 - 1'675 MWh
 - 4'826 m² (6% of roofs)
- PV (unused parts of roof)
 - 2'758 MWh
 - 27'824 m² (34% of roofs)

Energy planning at district level

Total roof area by interval of irradiation

Irradiance en kWh/m ² an	Surface toit m ²
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

Roofs: vector of multi-uses

Photovoltaic

- Orientation
- Min area
- Shadowing



Thermal (hot water)

- Nb of users
- Neighborhood



Thermal (heating)

- building features
- neighborhoods

Green roofs

- Irradiation / shadowing
- Slope



Solar radiation on façades

- Shadowing
- Orientation of façades



Carneiro et al. (2008)