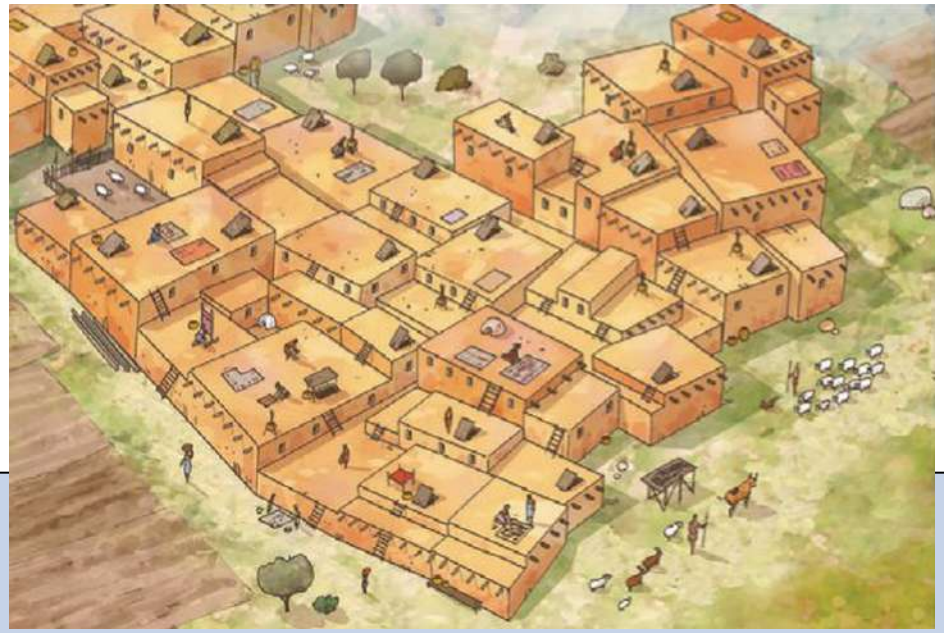
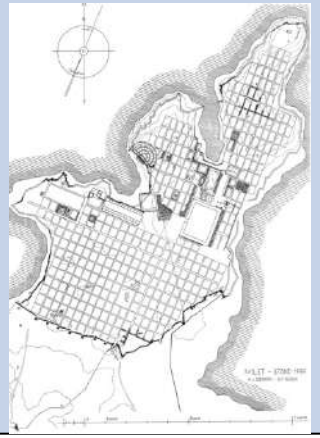
An Introduction to Urban Physics



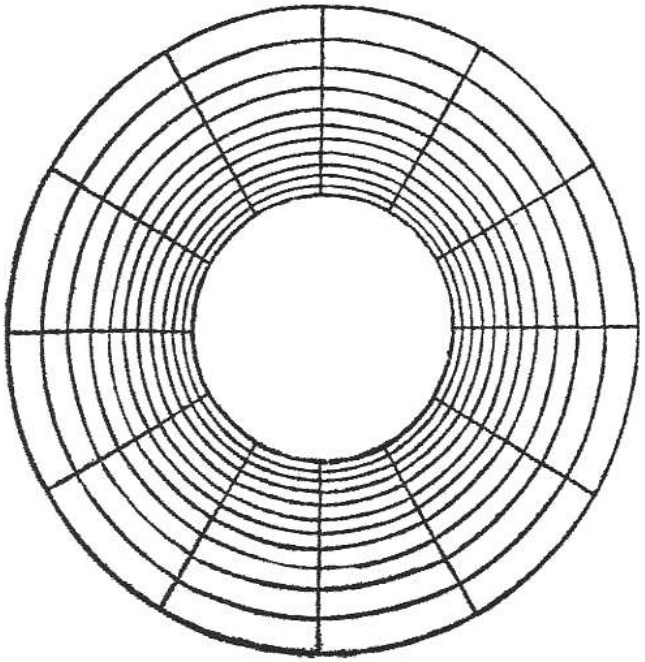


A city has to be Smart, Safe and Sustainable

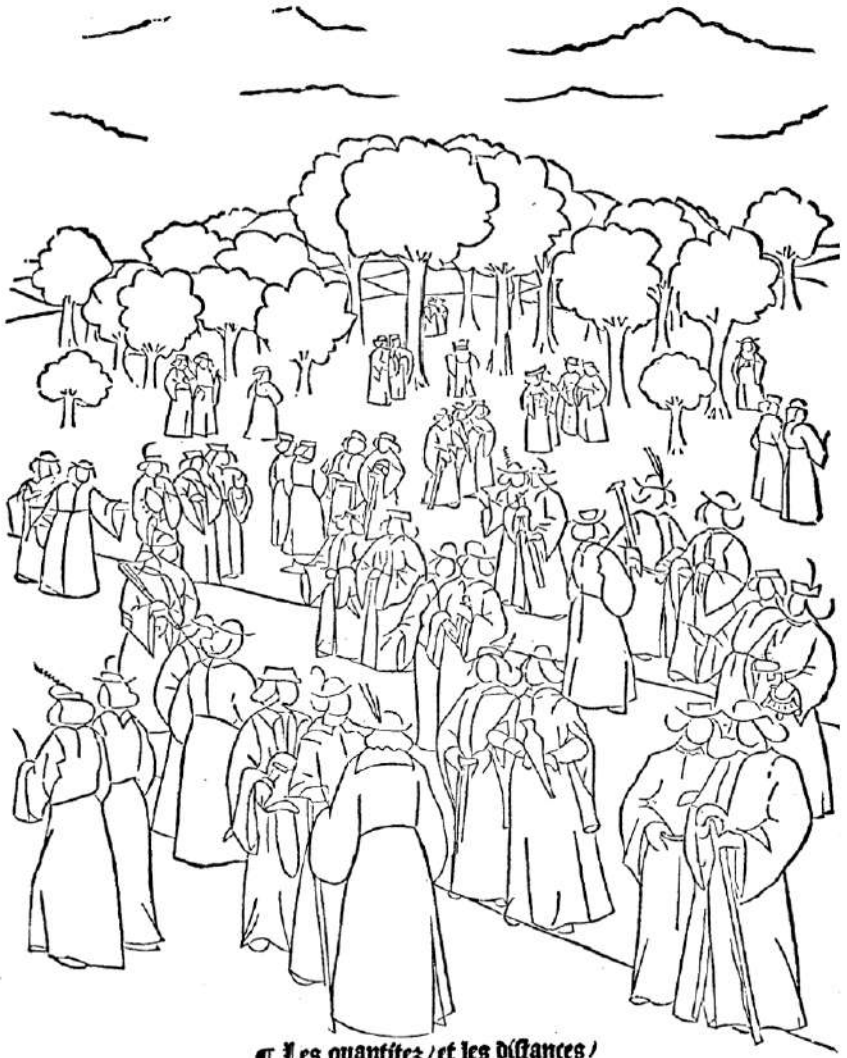
Ἱπποδάμος ὁ Μιλήσιος (c. 498- c. 408 BC)

La Città Ideale (attr. to Francesco Laurana)

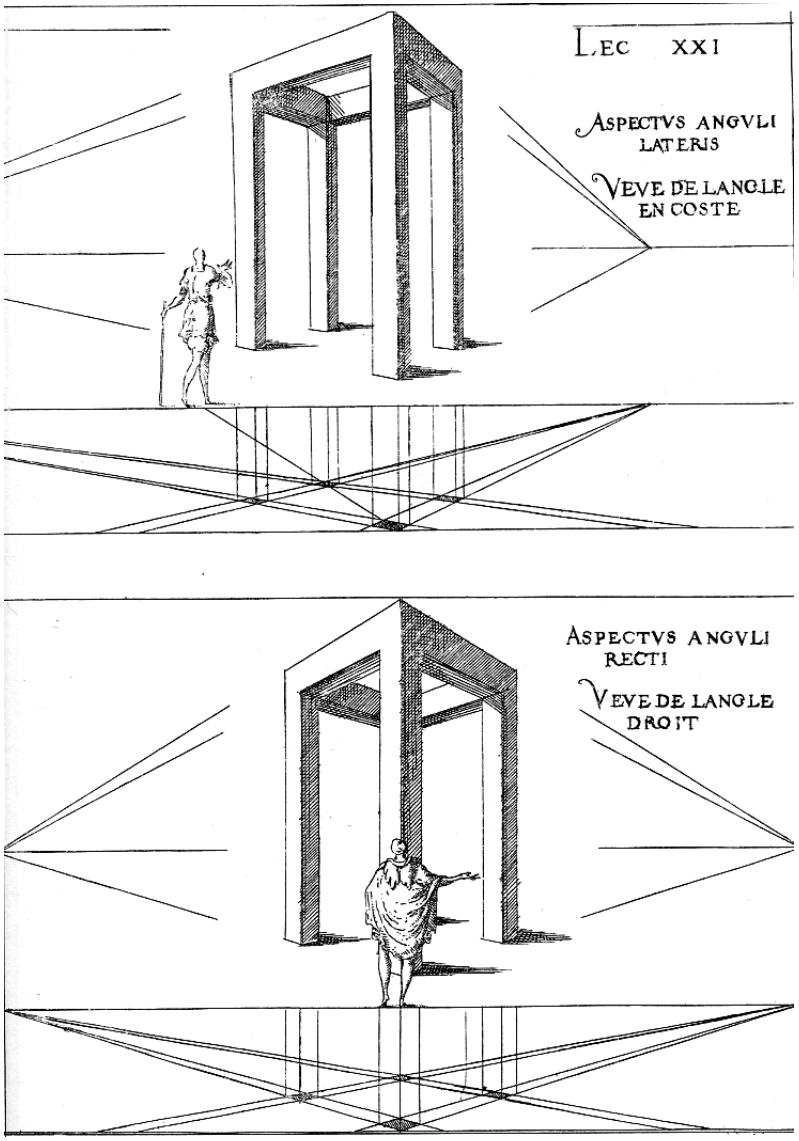
✝ DE·ARTIFICIALI·PSPECTIVA ·

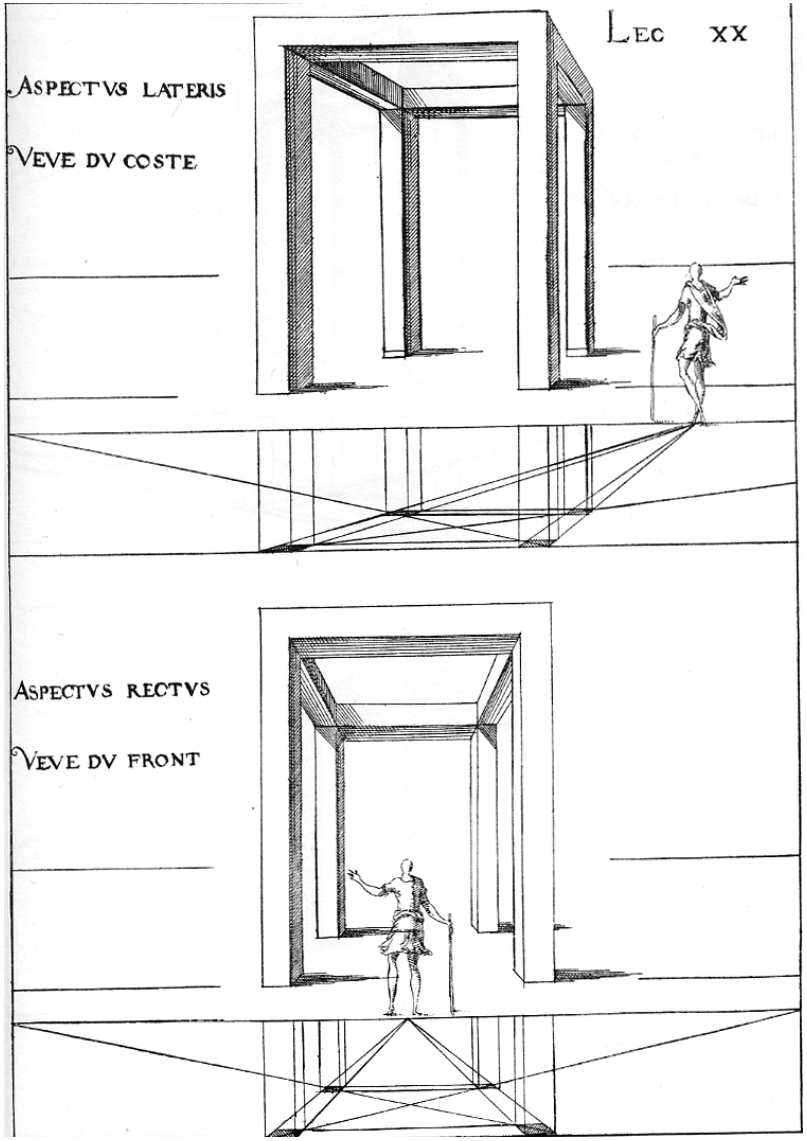


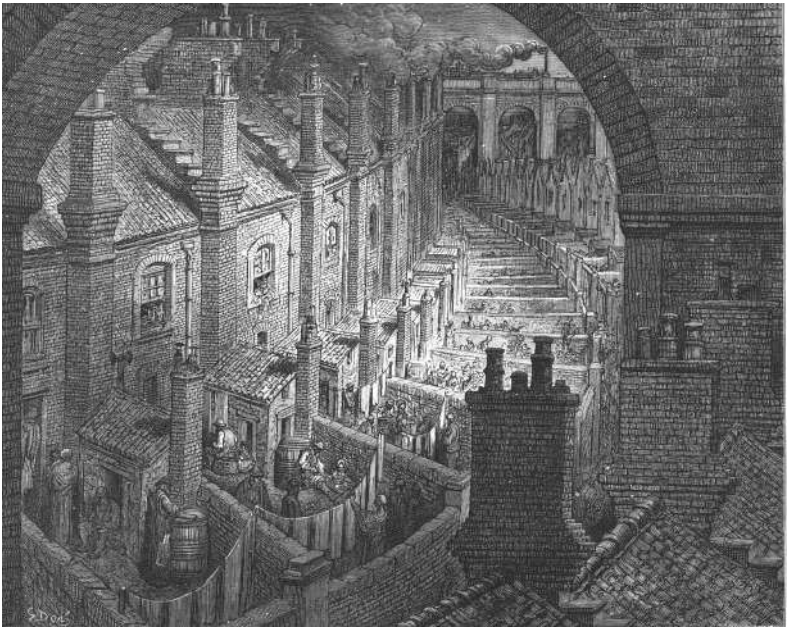
VIATOR ✝



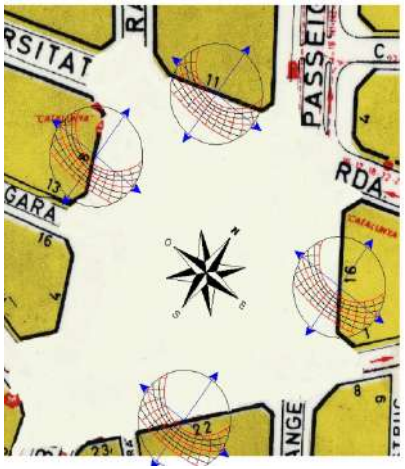
¶ Les quantitez / et les distances /
Ont concordables differences.


LEC XXI
ASPECTVS ANGVLI LATERIS
VEVE DE LANGLE EN COSTE
ASPECTVS ANGVLI RECTI
VEVE DE LANGLE DROIT


LEC XX
ASPECTVS LATERIS
VEVE DV COSTE
ASPECTVS RECTVS
VEVE DV FRONT

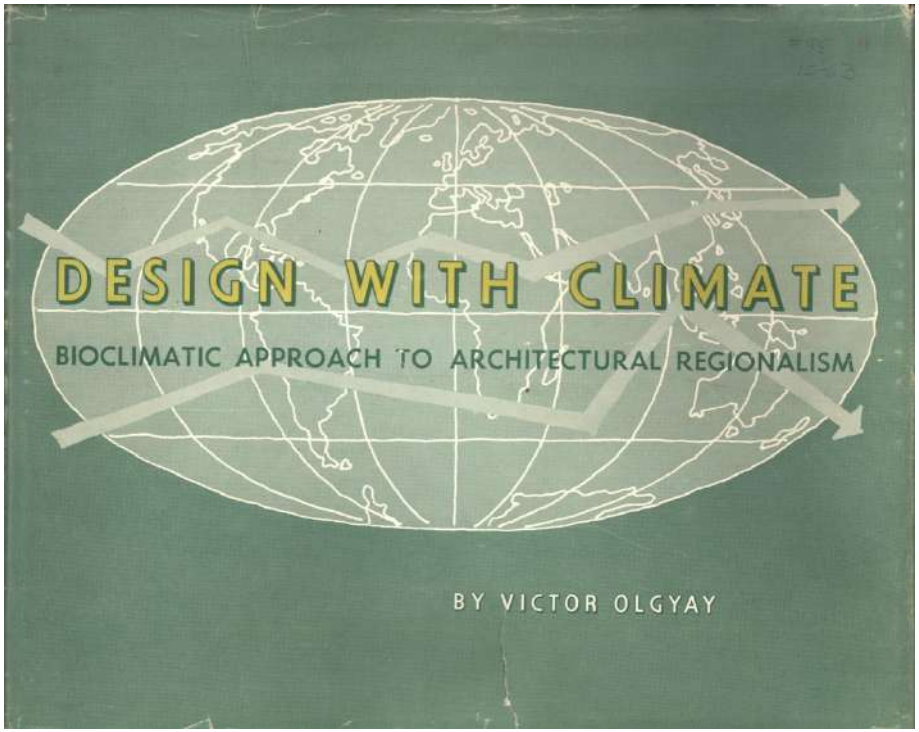


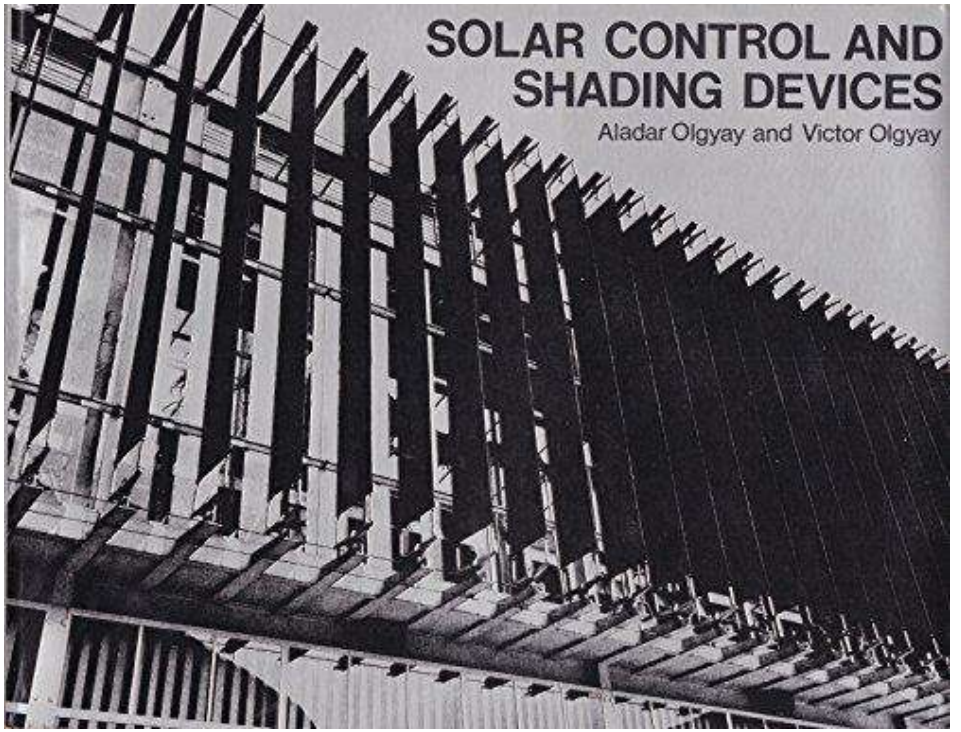
Urbanism, Urban Planning, Design of the city



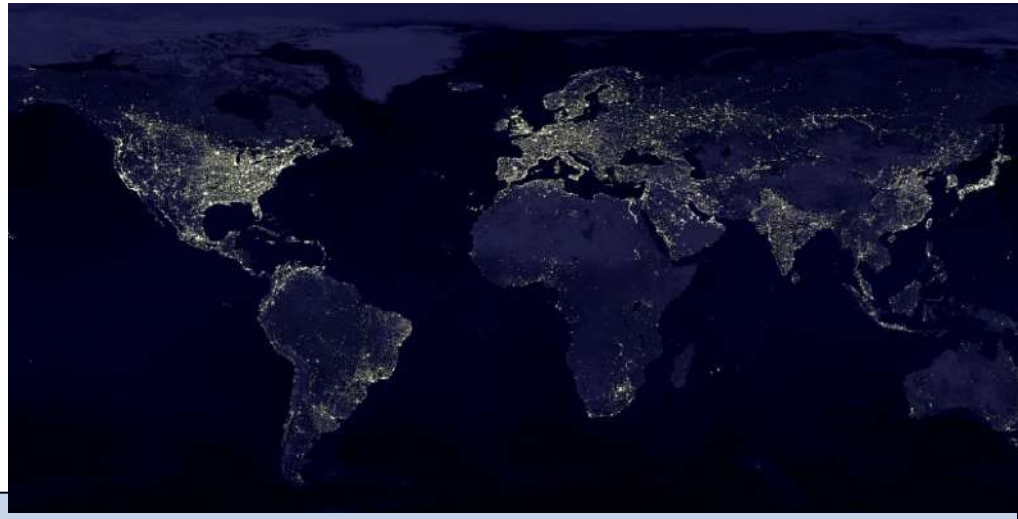
Light, heat, and noise

Composition of the city


DESIGN WITH CLIMATE
BIOCLIMATIC APPROACH TO ARCHITECTURAL REGIONALISM
BY VICTOR OLGYAY


SOLAR CONTROL AND SHADING DEVICES
Aladar Olgyay and Victor Olgyay

Urban sprawl



1970 © NASA GSFC 2000

" … If current trends in population density continue and all areas with high probabilities of urban expansion undergo change, then by 2030, urban land cover will increase by 1.2 million km2, nearly tripling the global urban land area circa 2000."

Seto K. C., Güneralp B. & Hutyra L. R., "Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools", Proceedings of the National Academy of Sciences of USA,2012 October 2; 109(40): 16083–16088.

Urban sprawl

"The combination of an increasing number of human beneficiaries of ecosystem services and increasing competition for the land that provides these services is a worldwide phenomenon for which **the policy implications are only now beginning to be considered**."

Eigenbrod V.F., Bell A., Davies H.N. et al. (2011), "The impact of projected increases in urbanization on ecosystem services", Proceedings of the Royal Society B. 278:3201-3208.

"The heat generated **by everyday activities in metropolitan areas** [of Northern Asia and North America] has a significant enough warming effect to **influence the character of the jet stream** and other major atmospheric systems during winter months."

Guang J. Zhang, Ming Cai & Aixue Hu, Energy consumption and the unexplained winter warming over northern Asia and North America, *Nature Climate Change* (January 27, 2013)

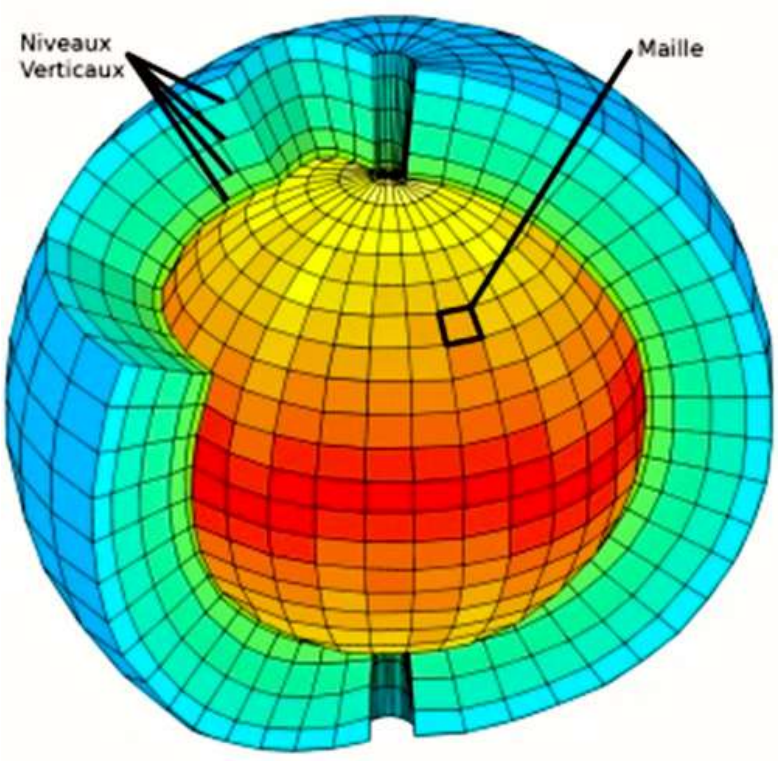
"Urban Physics is a well-established discipline, incorporating relevant branches of physics, environmental chemistry, aero-dynamics, meteorology and statistics. Therefore, **Urban Physics is well positioned to provide key-contributions to the existing urban problems and challenges**."

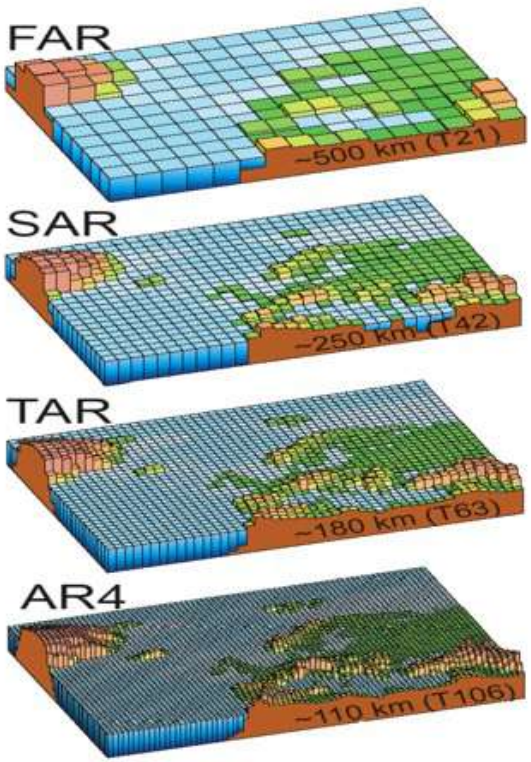
Moonen P., Defraeye T., Dorer V., Blocken B., Carmeliet J., "Urban Physics: Effect of the micro-climate on comfort, health and energy demand", Frontiers of Architectural Research (2012) 1, 197–228

The key challenges for Smart Cities and Communities are to significantly increase the overall energy efficiency of cities, to exploit better the local resource both in terms of energy supply as well as through the demand side measures. This will imply the use of energy efficiency measures optimizing at the level of districts, the use of renewables, the sustainability of urban transport and the needed drastic reduction of greenhouse gas emissions in urban areas - within economically acceptable conditions - while ensuring for citizens better life conditions: lower energy bills, swifter transport, job creation and as a consequence a higher degree of resilience to climate impacts (e.g. urban heat islands effects) etc.

CALL Smart cities and communities

(http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/2148-scc-01-2015.html)





GIEC 2007

FICUP 2016

First International Conference on Urban Physics

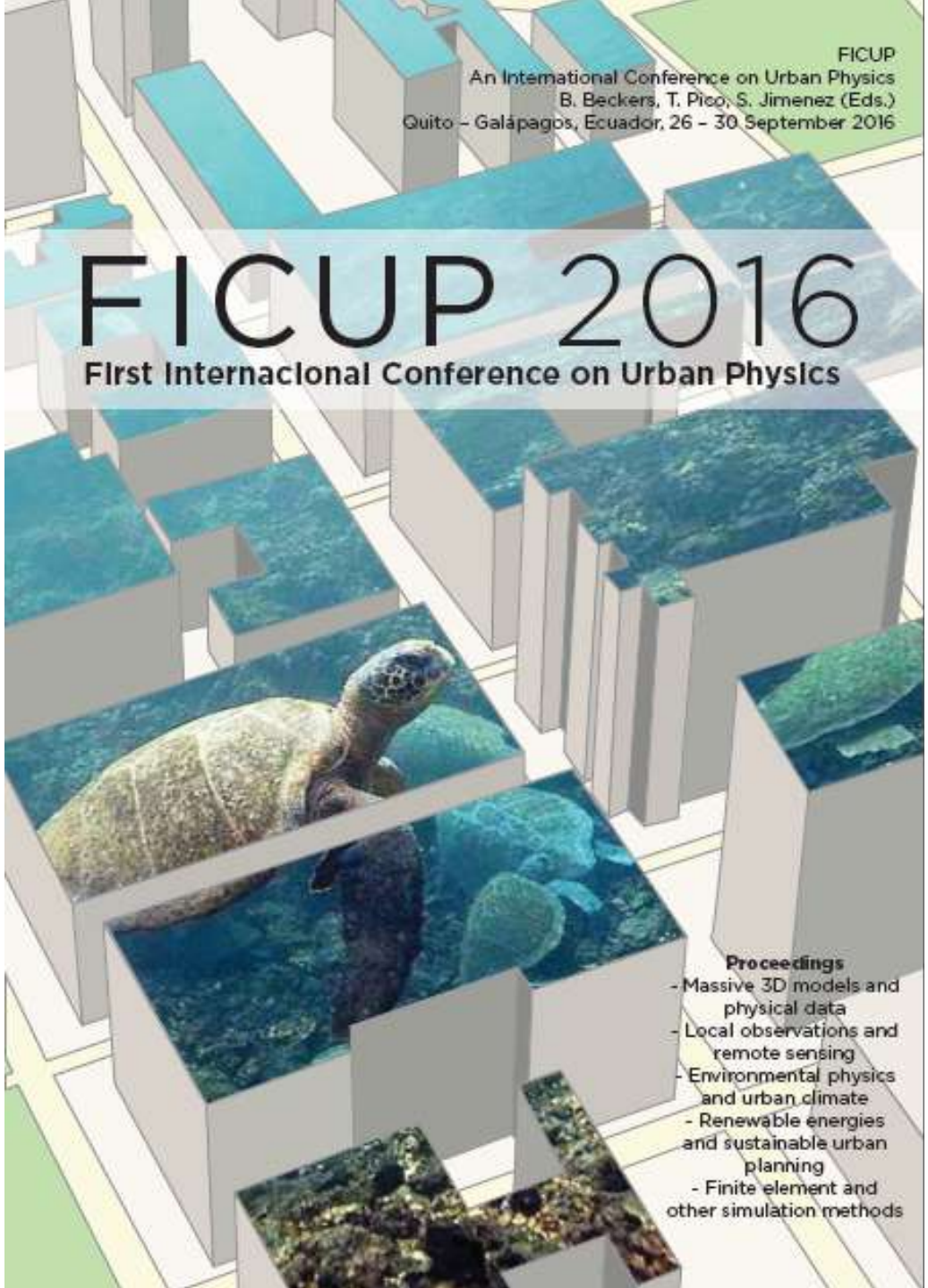
Quito - Galápagos, 25 September - 2 October 2016

The First International Conference on Urban Physics aims to be a founding event for the numerical simulation of cities and megacities, which are facing worldwide critical problems, such as their dual participation - as victims and actors - to the present and upcoming climate changes. The conference will provide an opportunity for scientists from different disciplines (computer graphics, environmental physics, numerical models, renewable energies, urban planning ...) to confront their ideas and methods for the detection and analysis of physical quantities, in order to better manage the development of cities and to meet economic and environmental constraints.

Benoit Beckers

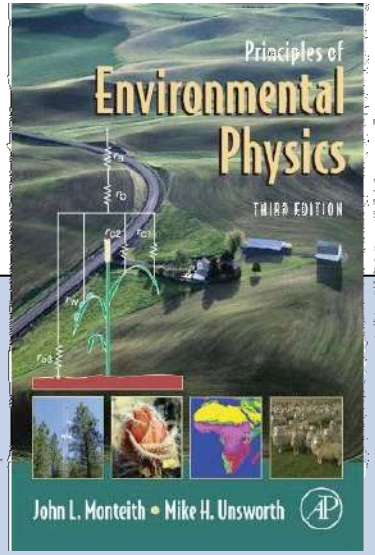
Daniel Aliaga,
Pierre Alliez,
Viorel Badescu,
Pierre Beckers,
Gonzalo Besuievsky,
Philippe Blanc,
Bert Blocken,
Emmanuel Bozonnet,
Piotr Breitkopf,
Wouter Buytaert,
Guedi Capeluto,
Alberto Cardona,
Alain Clappier,
Raphaël Compagnon,
Philippe R B Devloo,
Eduardo Fernández,
Gérard Hégron,
Adnan Ibrahimbegovic,
Jérôme Kämpf,
Vincent Lemort,
John Mardaljevic,
Alberto Martilli,
Valéry Masson,
Edward Ng,
Gustavo Patow,
Marius Paulescu,
Claude Puech,
Luis Quiroz,
Alain Rassineux,
François Sillion,
Marcos Villacis,
James Voogt,

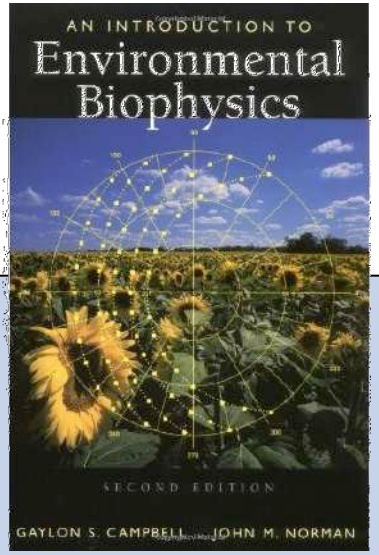
- Massive 3D models and physical data
- Local observations and remote sensing
- Environmental physics and urban climate
- Renewable energies and sustainable urban planning
- Finite element and other simulation methods

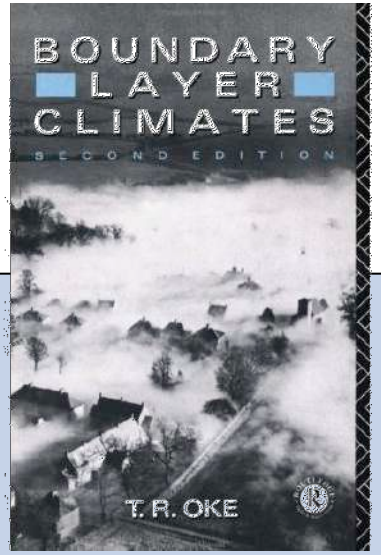

FICUP
An International Conference on Urban Physics
B. Beckers, T. Pico, S. Jimenez (Eds.)
Quito – Galápagos, Ecuador, 26 – 30 September 2016
FICUP 2016
First Internacional Conference on Urban Physics
Proceedings
- Massive 3D models and physical data
- Local observations and remote sensing
- Environmental physics and urban climate
- Renewable energies and sustainable urban planning
- Finite element and other simulation methods

La physique urbaine - références

La **Physique Environnementale** se développe dans les années 1970 (rendement des cultures), 1980 (forêts et pluies acides), 1990 (trou dans la couche d'ozone), 2000 (changement climatique). Parmi ses méthodes : le bilan local des flux d'énergie (conductif, radiatif, sensible et latent).



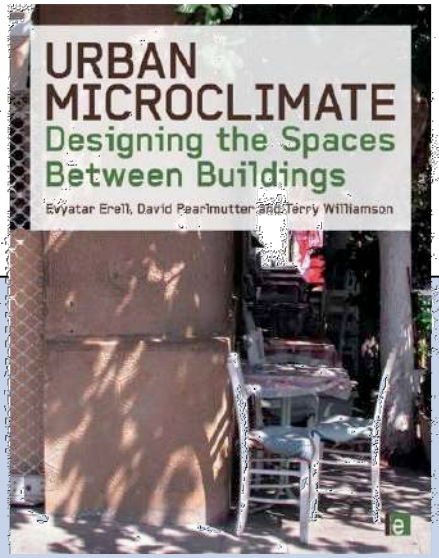


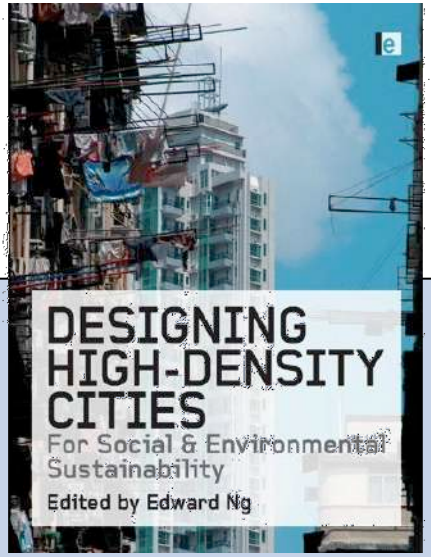


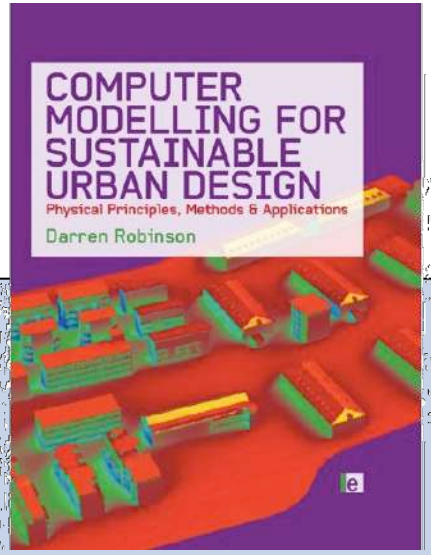
L'application des mêmes méthodes aux structures urbaines est proposée dès les années 1970 par T. R. Oke, autour de la problématique de l'Ilot de Chaleur Urbain. On peut dès lors parler de **Physique Urbaine**.

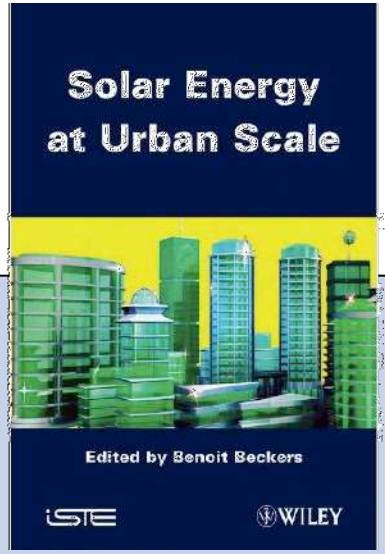
La physique urbaine - références

Ces dernières années, des progrès considérables dans plusieurs domaines annexes: systèmes d'information géographique, standardisation du niveau de détail des modèles 3D (BIM et CIM), mesures terrestres et satellitaires, puissance de calcul des ordinateurs,…





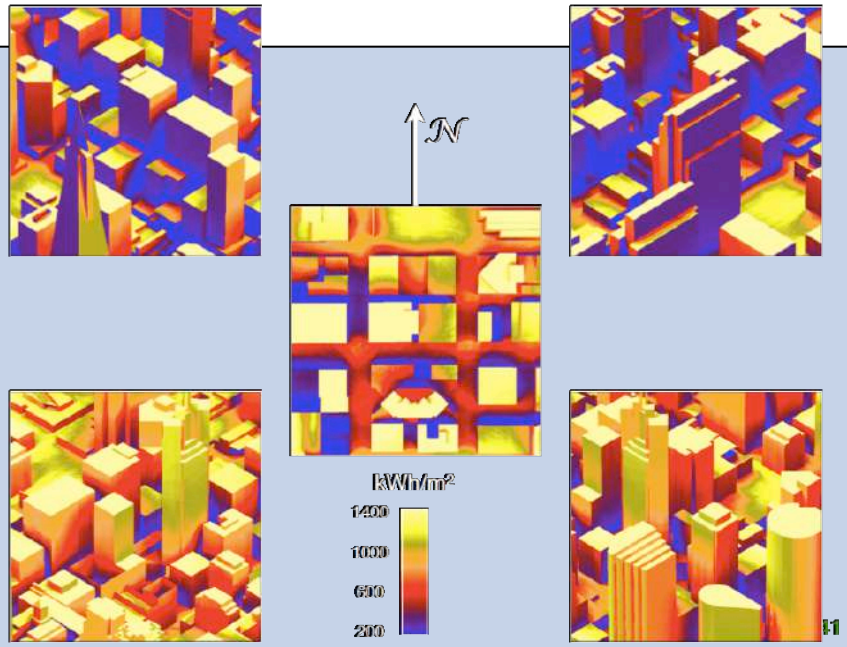


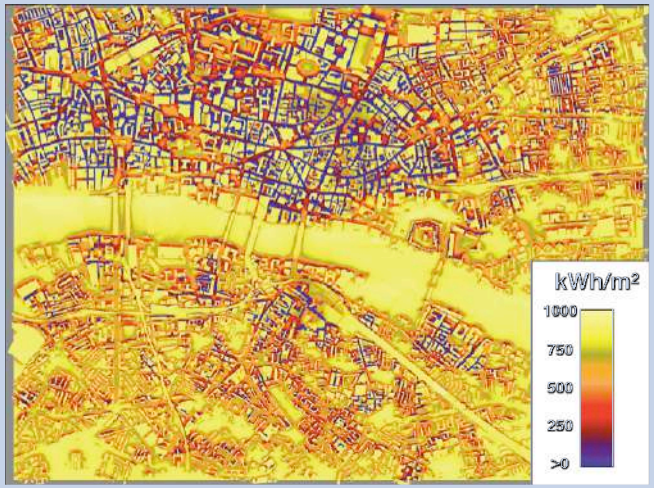


…permettent une première appréhension de la physique urbaine par la simulation numérique.
Cadre: "smart", "safe" and "sustainable" city.
Emergence de la **thermique urbaine** (climat urbain, flux thermiques bâtiment-ville-territoire, efficience énergétique, production locale d'énergie renouvelable).

SOLAR ENERGY AT URBAN SCALE

- **SOLAR ENERGY AT URBAN SCALE**
- **24 /25 may 2010, Compiègne**
- **www.utc.fr/seus**

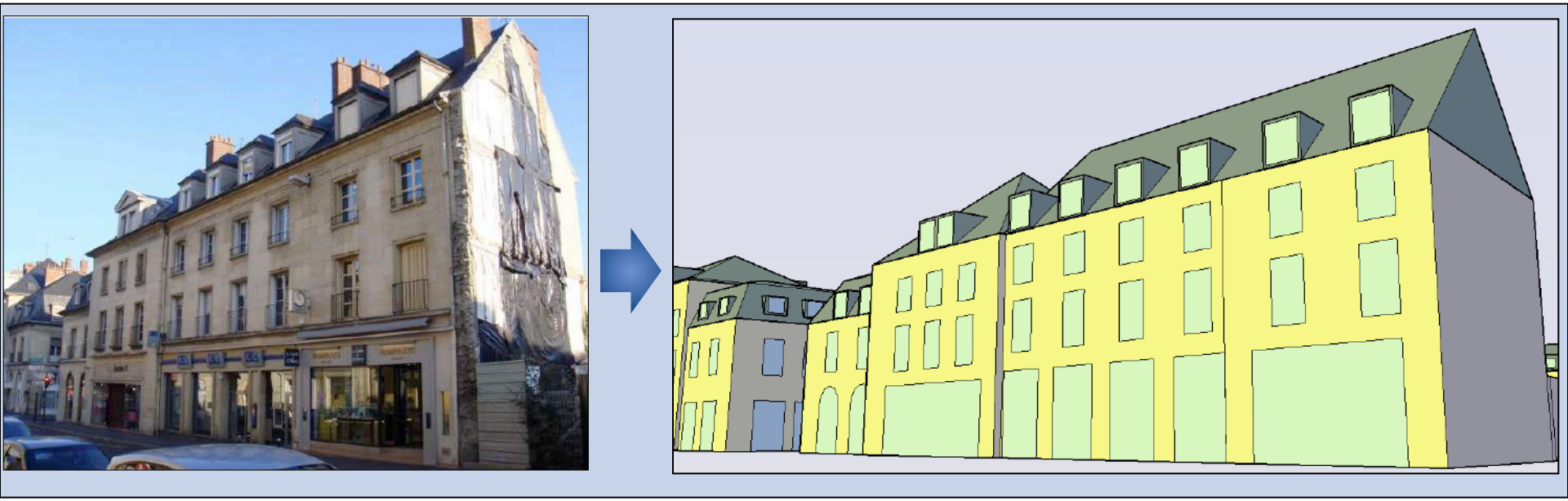




John Mardaljevic
De Beaufort
University

3D URBAN MODEL

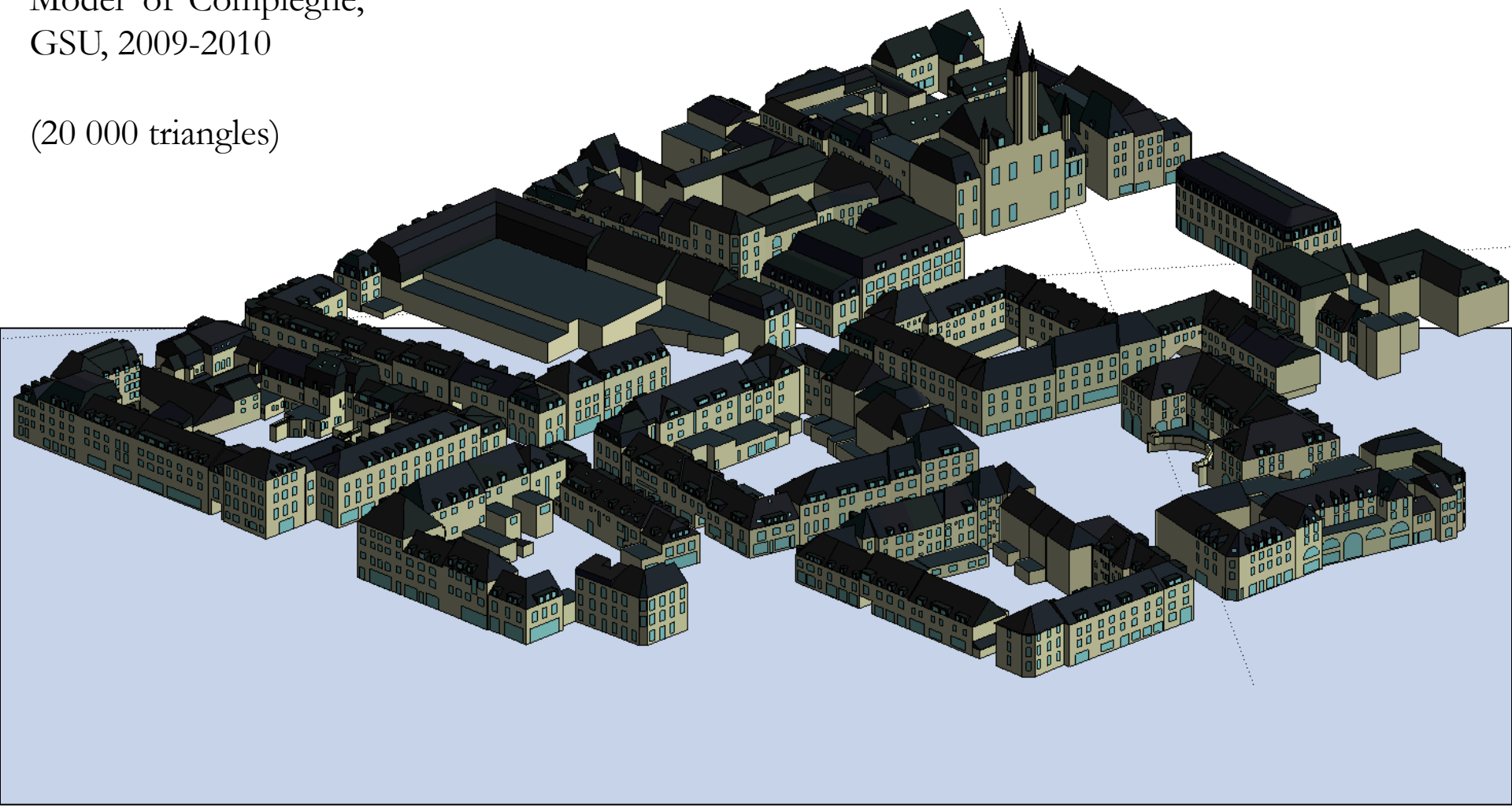
- 3DModel wisely simplified
- Roofs and façades correctly oriented, tilted
- Windows: rectangles shifted from the façades



3D URBAN MODEL

Model of Compiègne,
GSU, 2009-2010

(20 000 triangles)



3D URBAN MODEL

Model of Compiègne,
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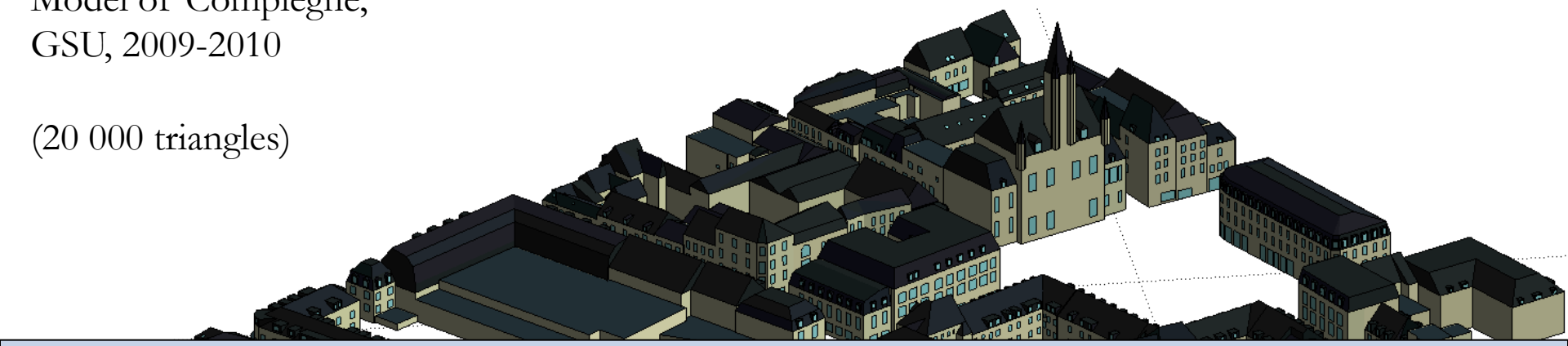
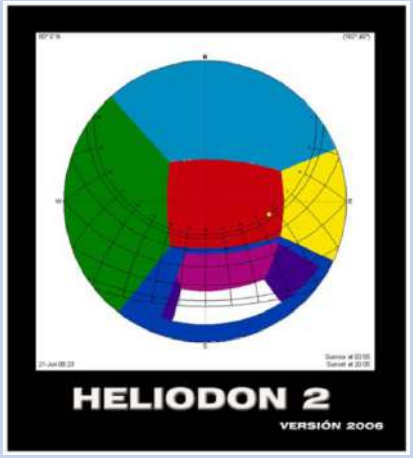
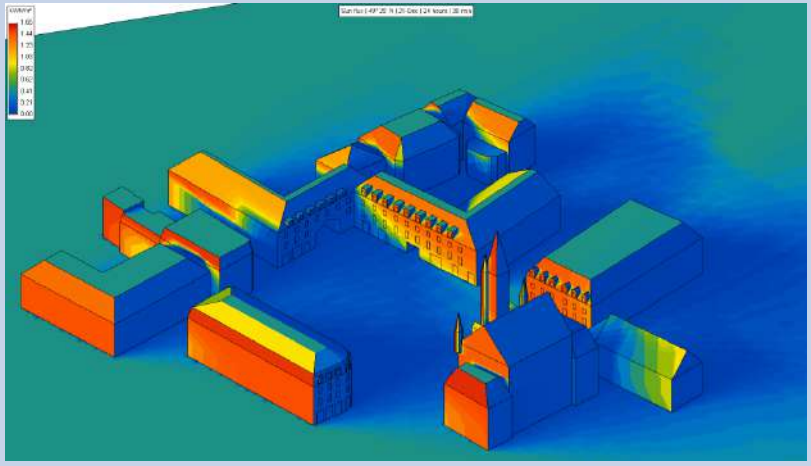
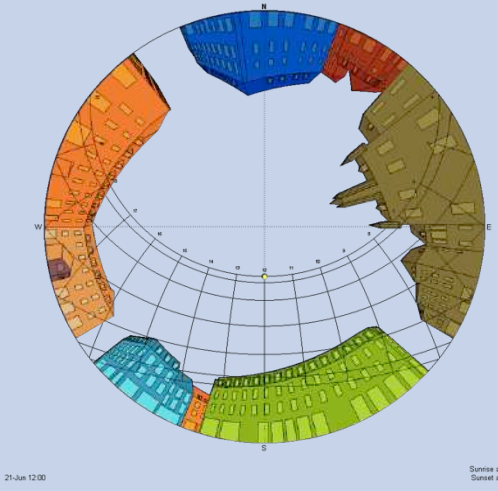




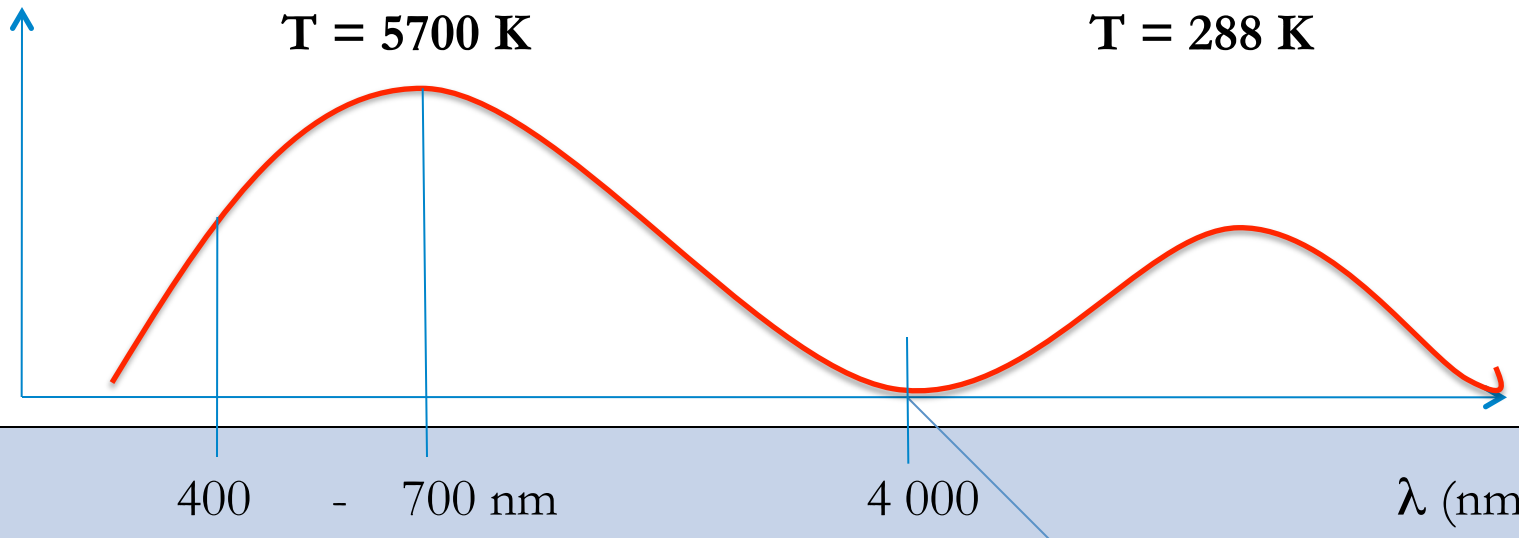


www.heliodon.net



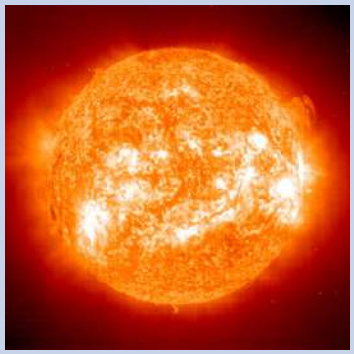
« Heliodon 2 », Benoit Beckers & Luc Masset, 2003-2010

Short and long waves

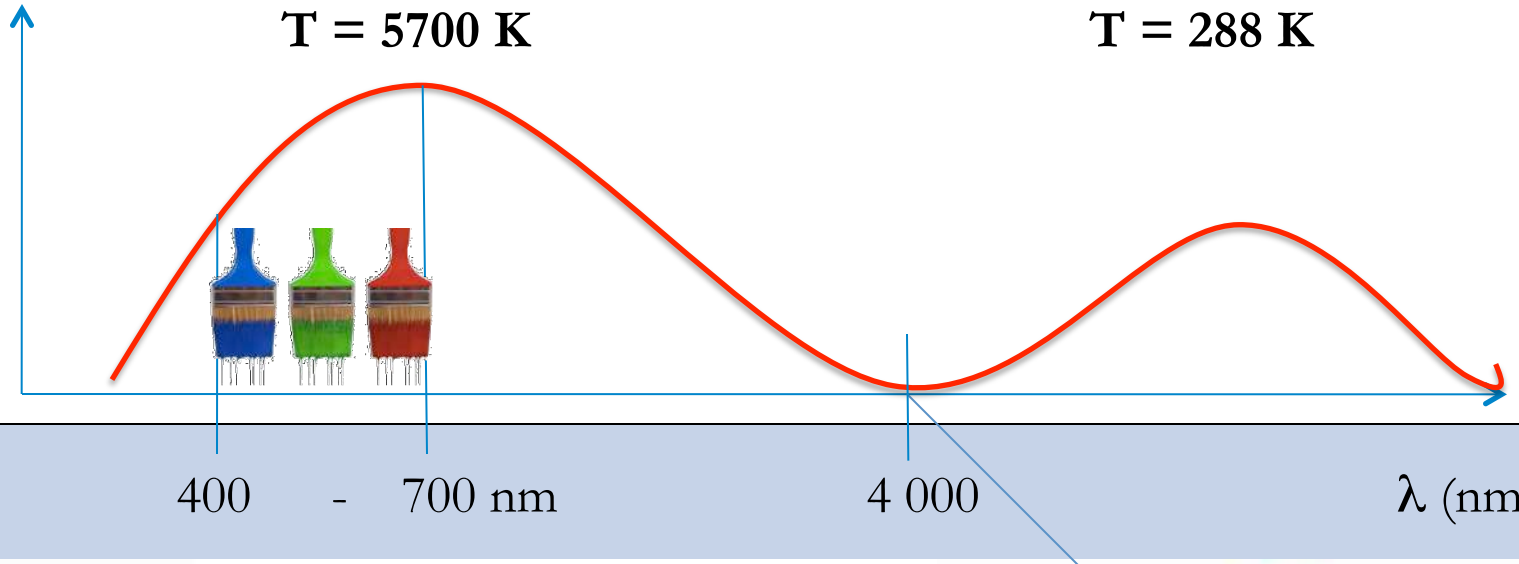


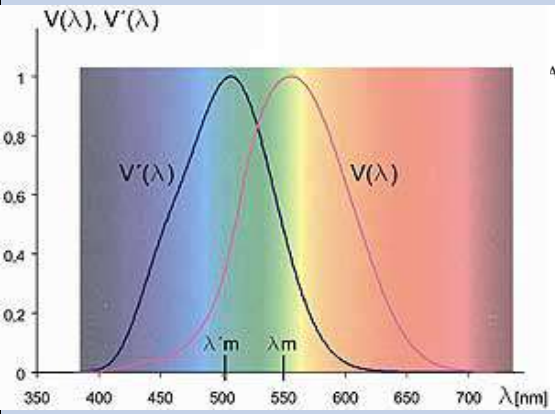
UV visible Near IR

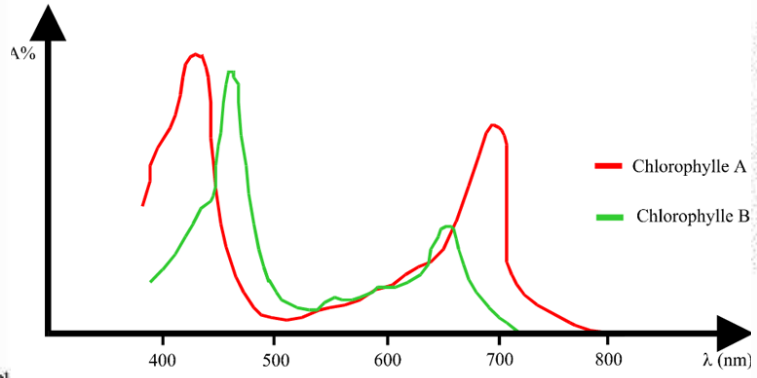
Thermal IR

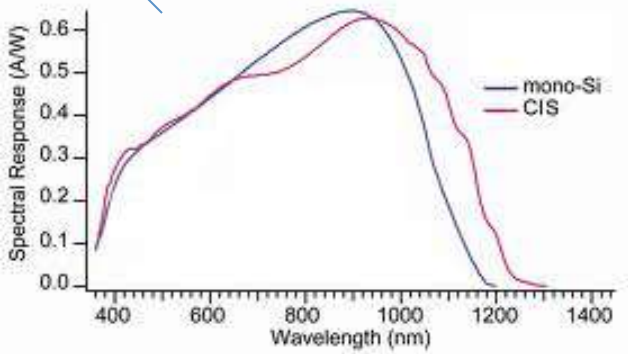


Spectral sensitivity





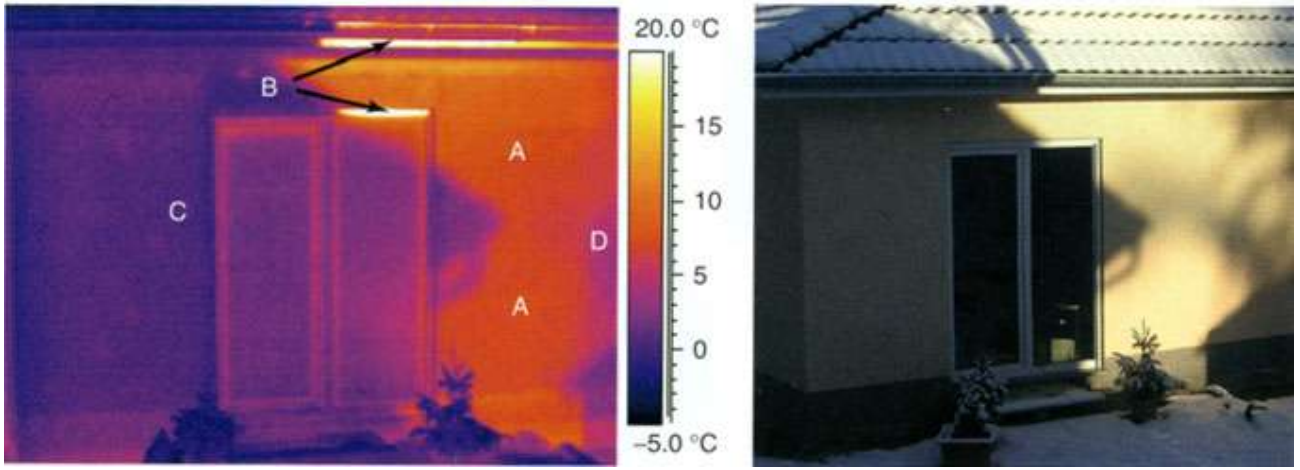


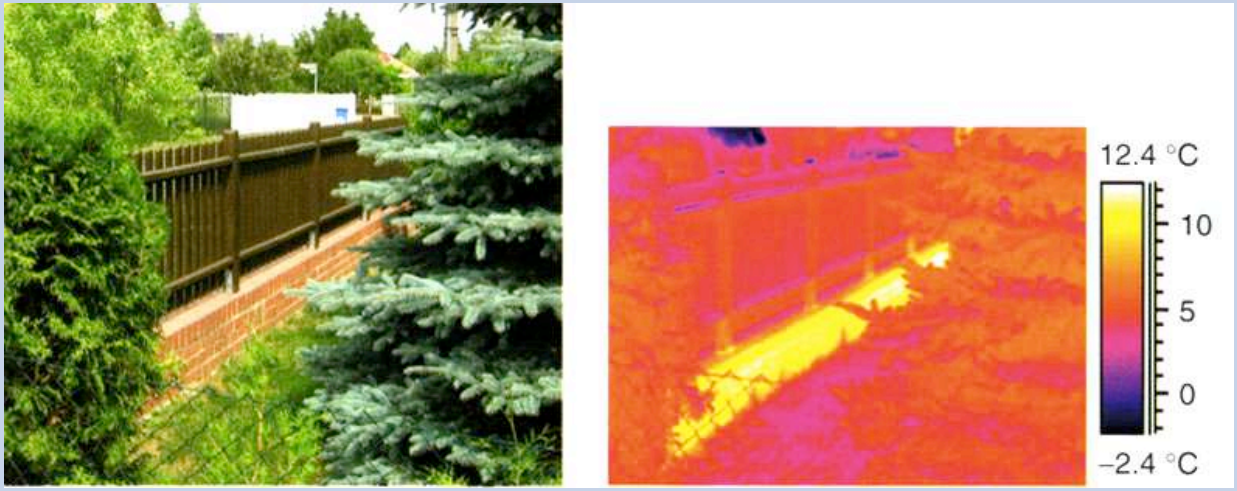


Short waves

Long waves

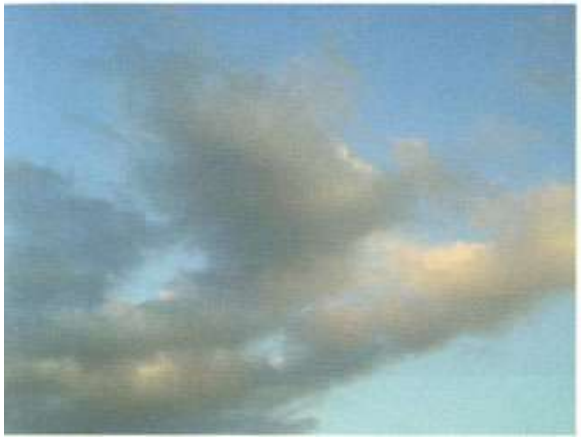
Thermography

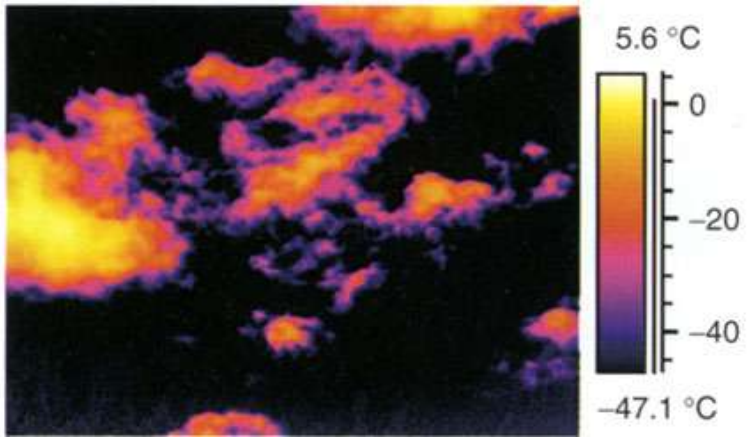


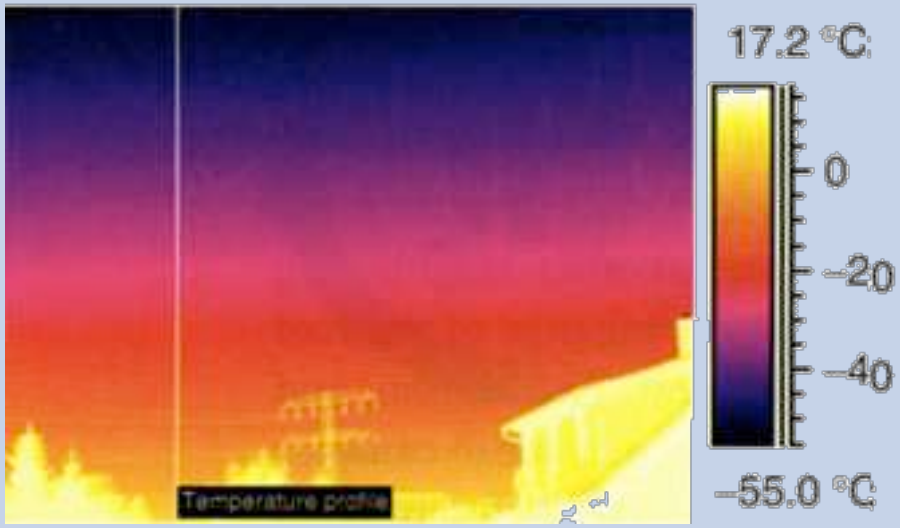


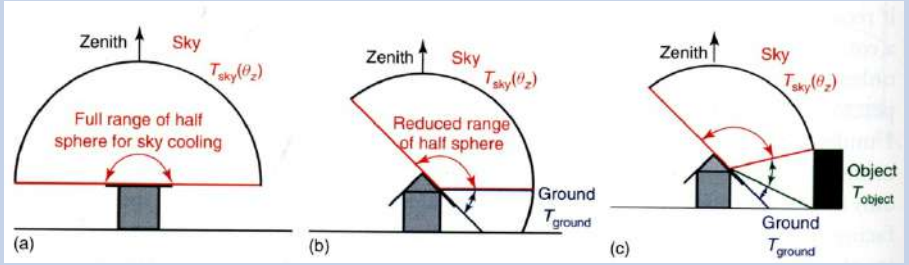
M. Vollmer & K.-P. Möllmann "Infrared Thermal Imaging: Fundamentals, Research and Applications", Wiley-VCH, 612 pages, 2010.

Thermography





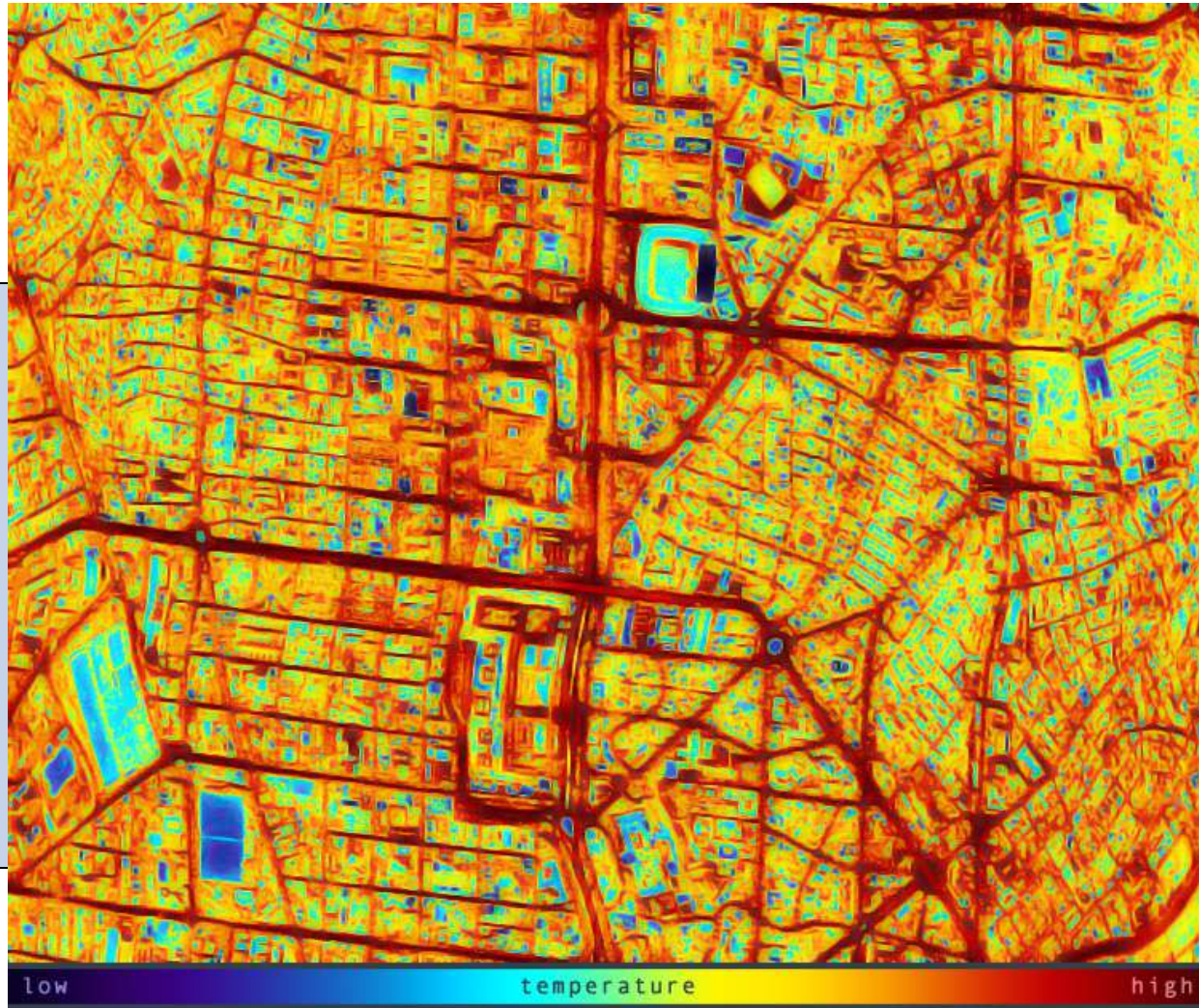




M. Vollmer & K.-P. Möllmann "Infrared Thermal Imaging: Fundamentals, Research and Applications", Wiley-VCH, 612 pages, 2010.

Thermography of the city

Airborne Hyperspectral Scanner (AHS)
Night temperatures in Madrid
Cold zones in dark blue, hot in red
Zone: "Paseo de la Castellana."
Image: July 1, 2008, night
Space resolution : 3 m/ píxel.



"Dual-use European Security IR Experiment 2008"

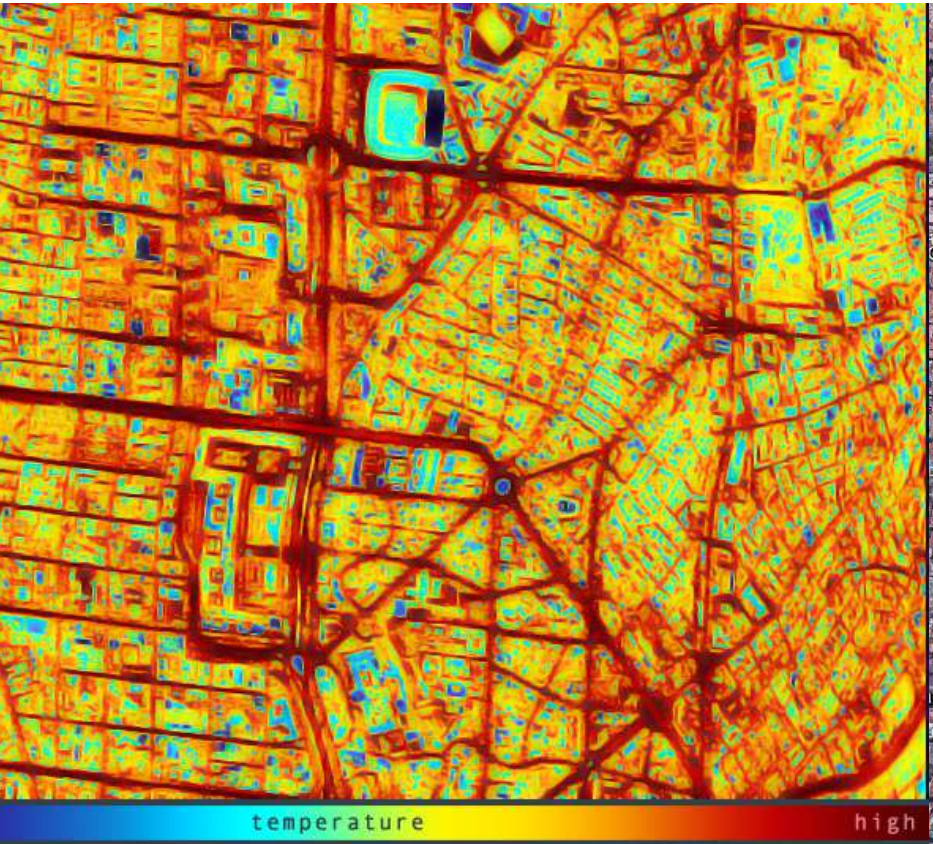
(DESIREX 2008)

Contract No. 21717/08/I-LG

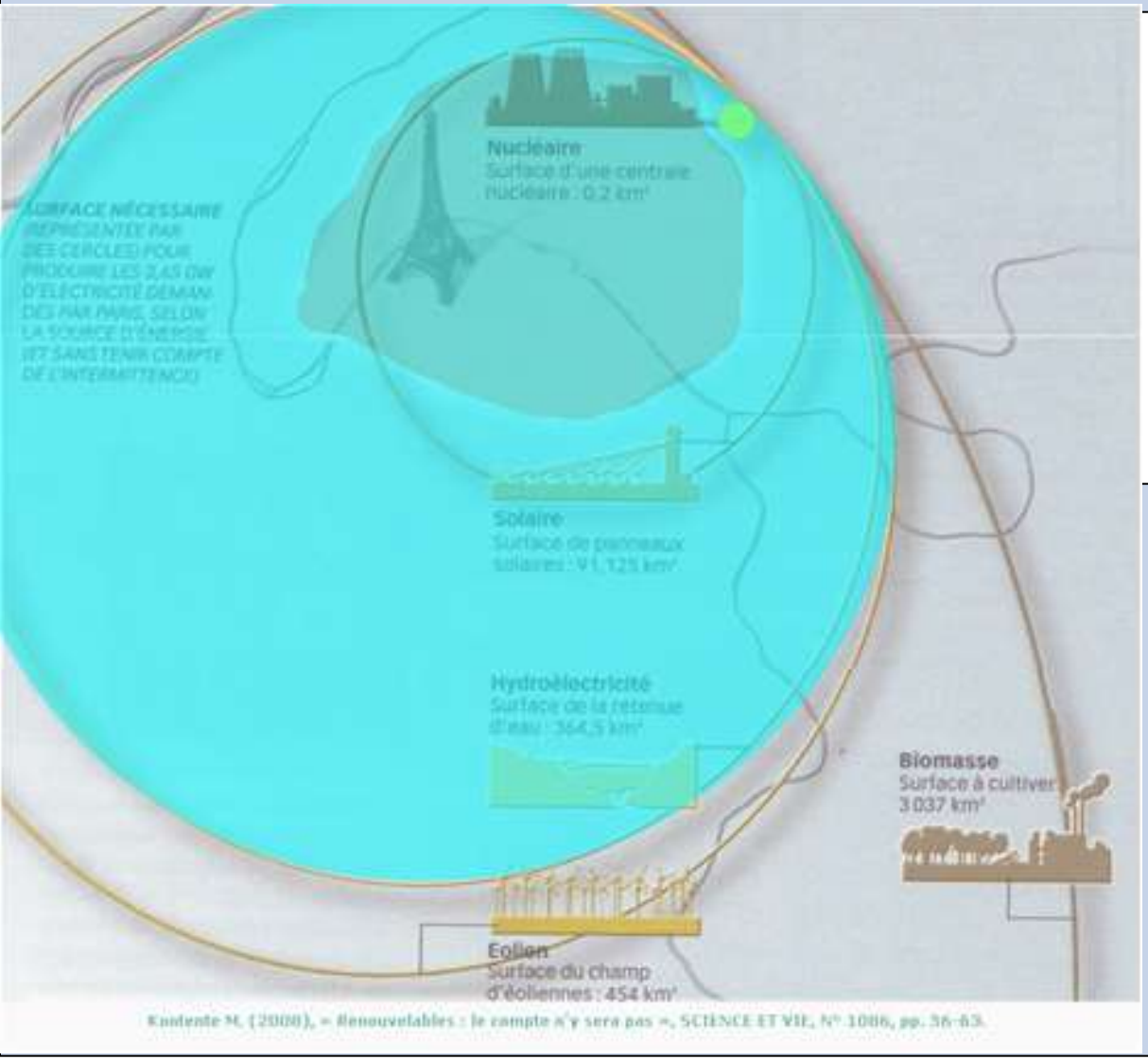
esa

Madrid: Paseo de la Castellana

The challenge:
To model a city zone, compute the heat exchanges & produce a surface temperature map coherent with the results obtained by image processing of thermographies issued from Airborne Hyperspectral Scanner or satellite instruments….



Daylight and Solar Energy Simulation at Urban Scale



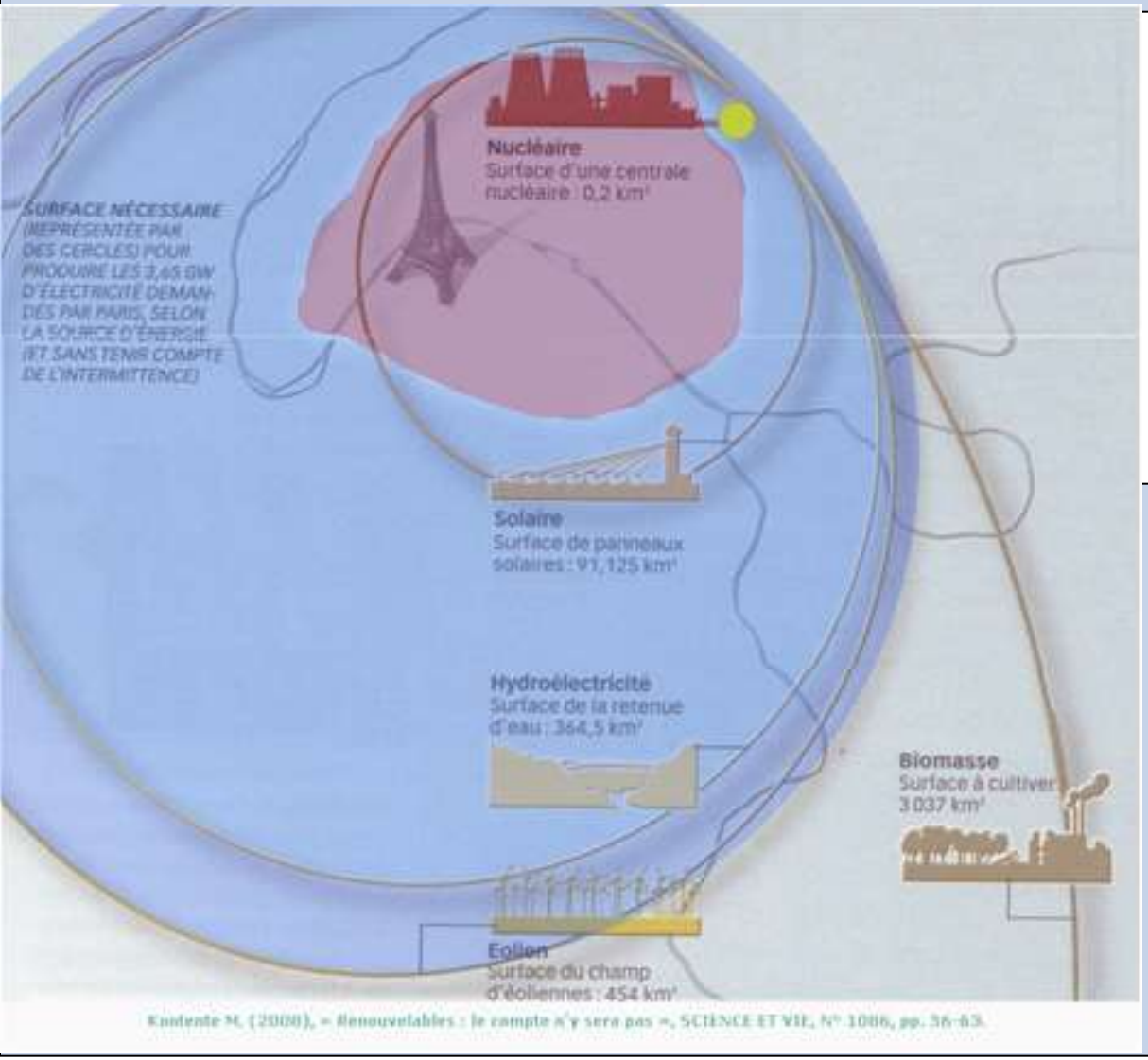
Roudeste M. (2008), « Renouvelables : le compte n'y sera pas », SCIENCE ET VIE, N° 1086, pp. 56-63.

Hydropower

260 km2 to produce 3,65 GW

(water retention)

Daylight and Solar Energy Simulation at Urban Scale



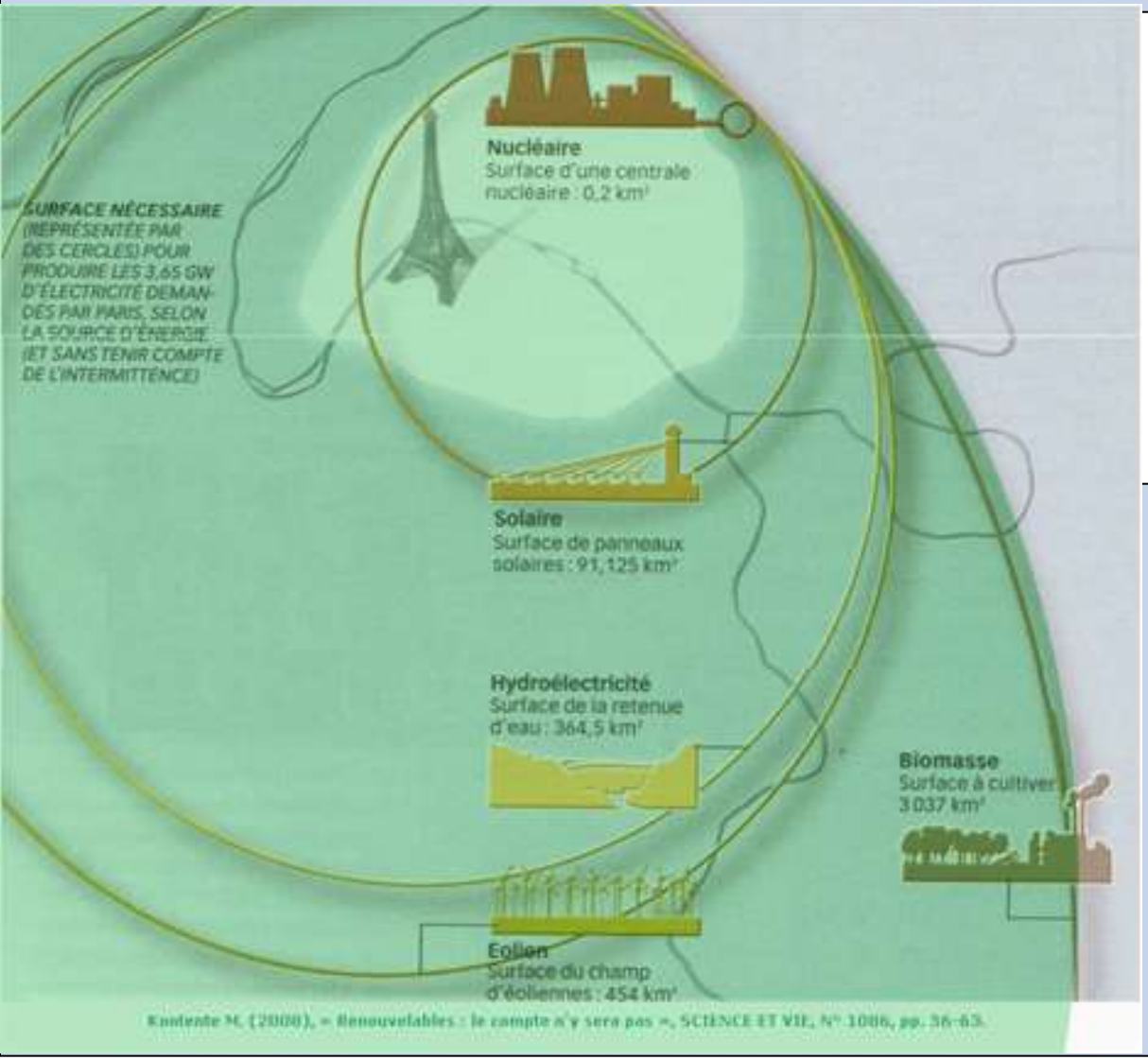
Kandente M. (2008), « Renouvelables : le compte n'y sera pas », SCIENCE ET VIE, N° 1086, pp. 56-63.

Wind energy

450 km2 to produce 3,65 GW

(wind farm)

Daylight and Solar Energy Simulation at Urban Scale



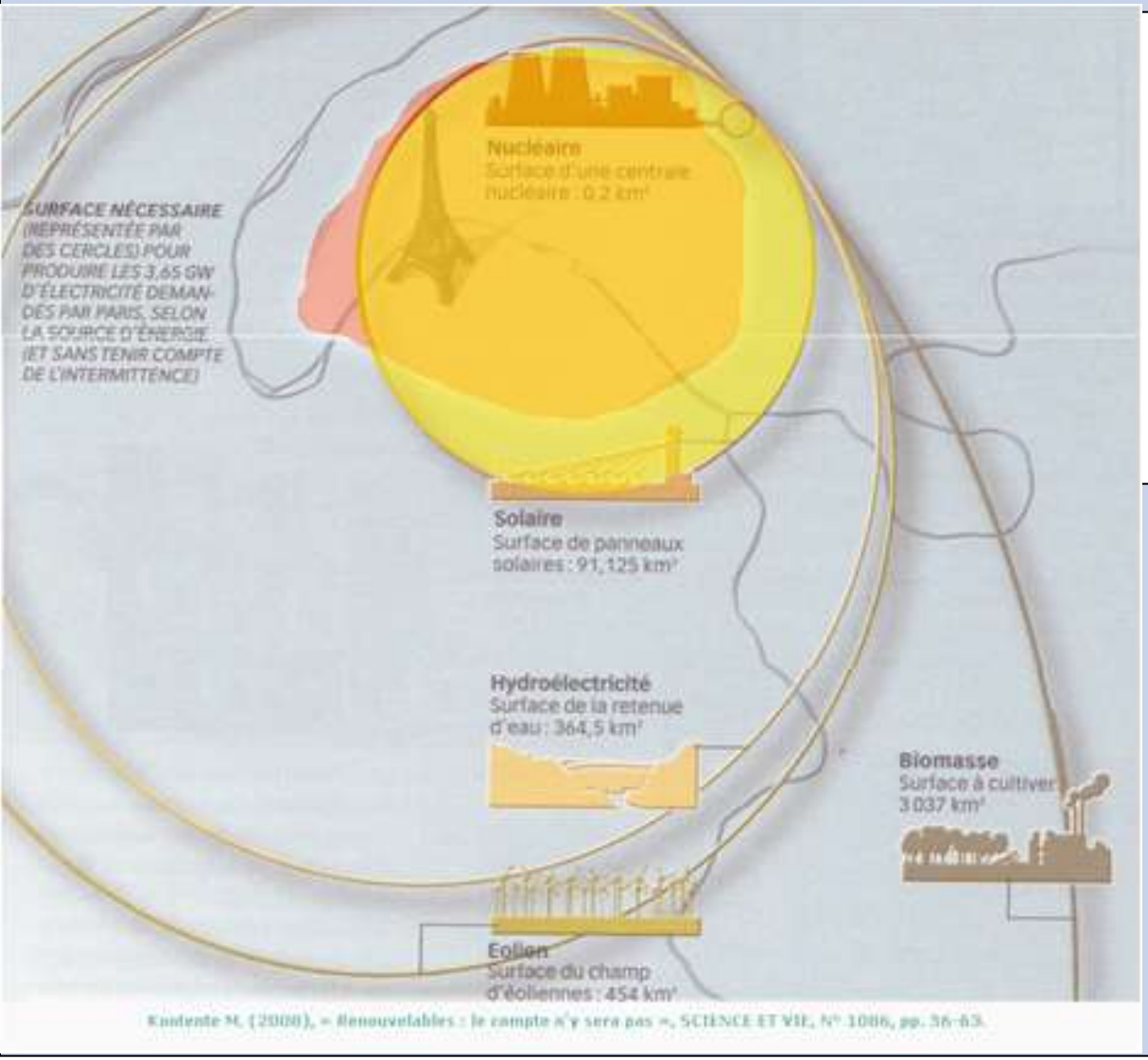
Kandelle M. (2008), « Renouvelables : le compte n'y sera pas », SCIENCE ET VIE, N° 1086, pp. 56-63.

Biomass

3000 km2 to produce 3,65 GW

(surface to cultivate)

Daylight and Solar Energy Simulation at Urban Scale



Roudaut M. (2008), « Renouvelables : le compte n'y sera pas », SCIENCE ET VIE, N° 1086, pp. 56-63.

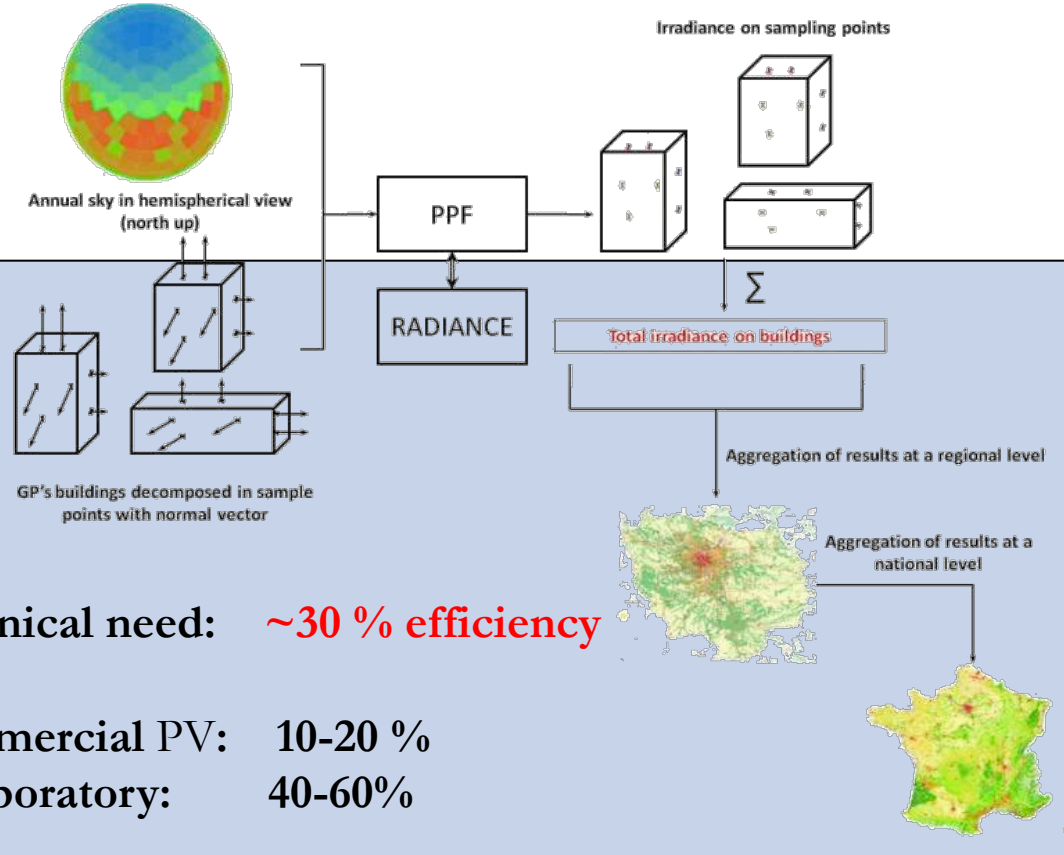
Solar energy

90 km2 to produce 3,65 GW

(solar panels)

General issues

- PhD (2012) : Elie Ghanassia (EDF, dir.: M. Maïzia & B. Beckers)



« The sun will provide 100% of our energy needs in twenty years »

Ray Kurzweil – Le Monde Magazine 26/03/2011

Technical need: **~30 % efficiency**

Commercial PV: **10-20 %**
In laboratory: **40-60%**

- **PhD (2014) : Thibaut Vermeulen (dir.: B. Beckers & P. Villon)**

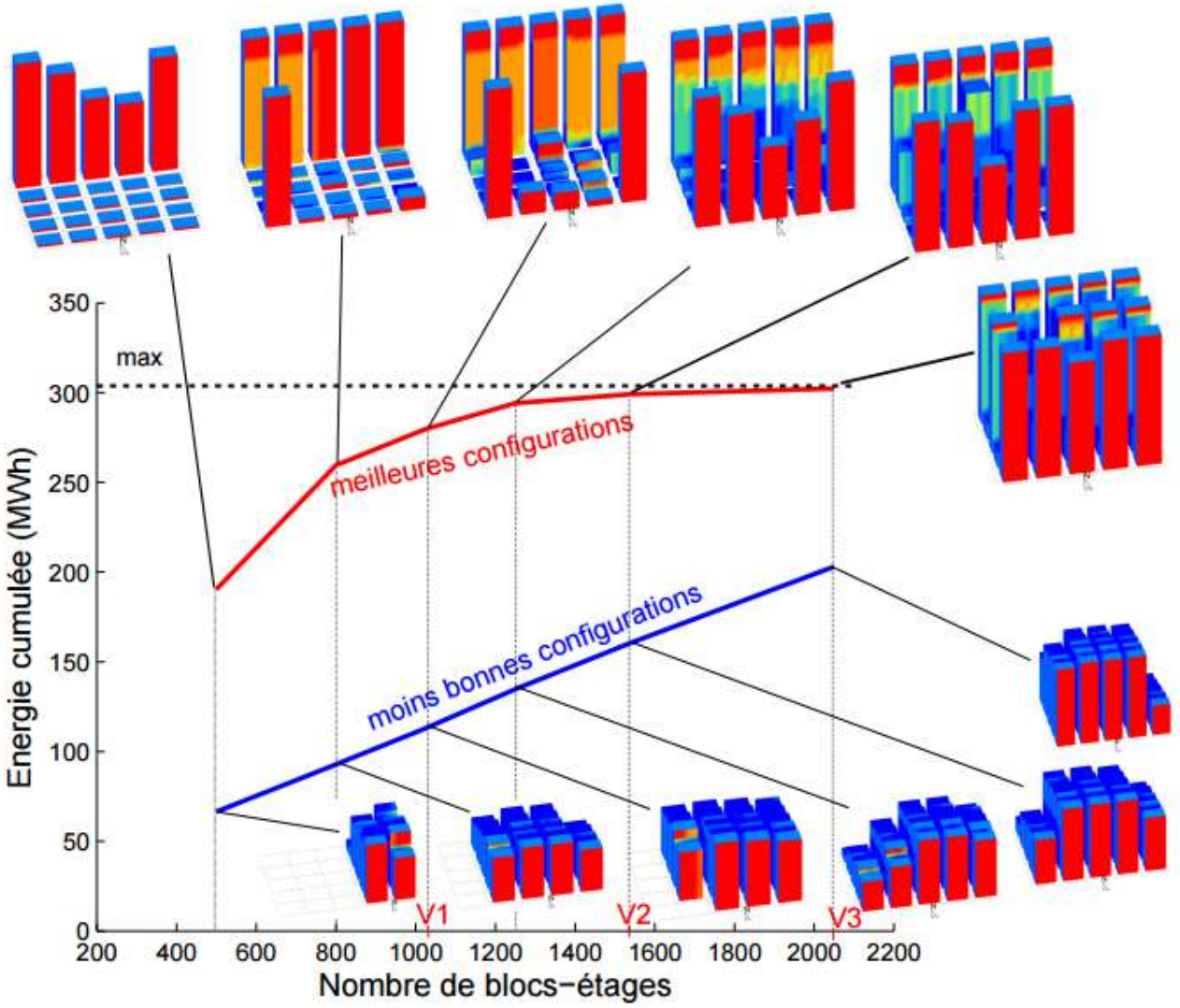


FIGURE 1.10: Evolution de la fonction-objectif avec la densité (21 décembre, 50°N, ciel clair, Liu & Jordan)

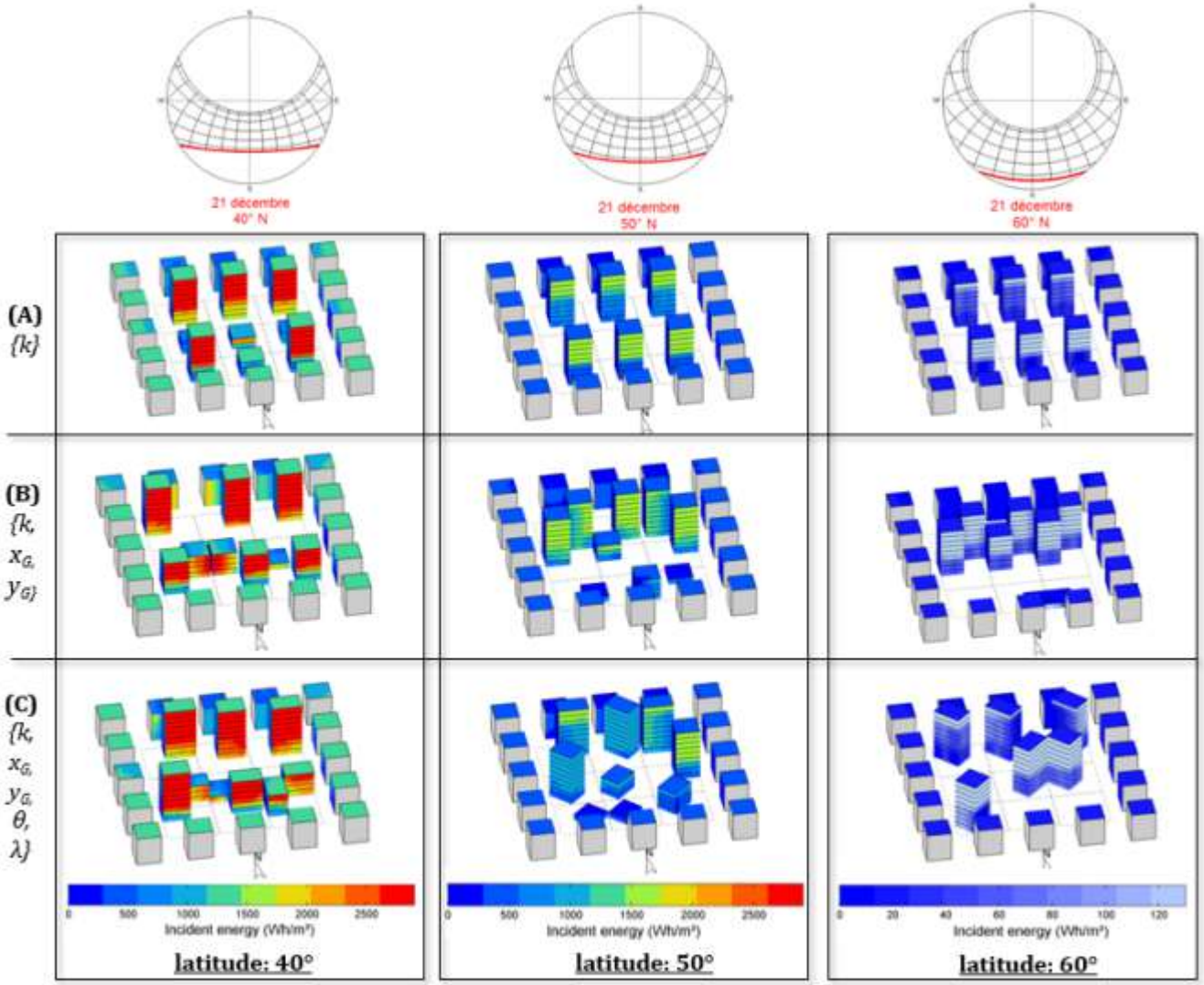


FIGURE 1.17: Formes optimales pour différents ensembles de paramètres et différentes latitudes (21 décembre, ciel clair, Liu & Jordan)

Composition Urbaine