Earth Observation for Urban Climate and Resilience

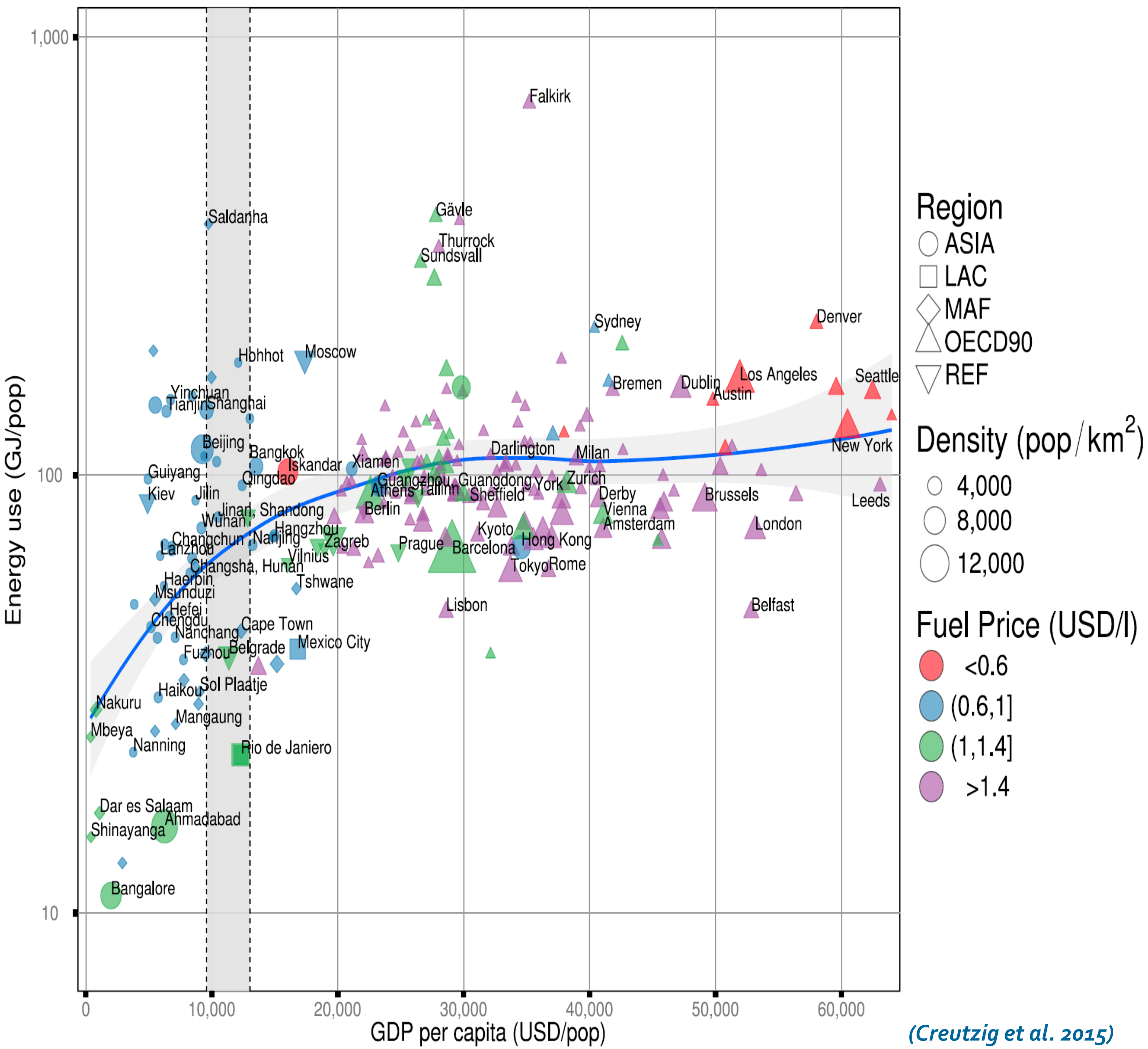
Nektarios Chrysoulakis

Remote Sensing Lab | IACM| FORTH | http://rslab.gr

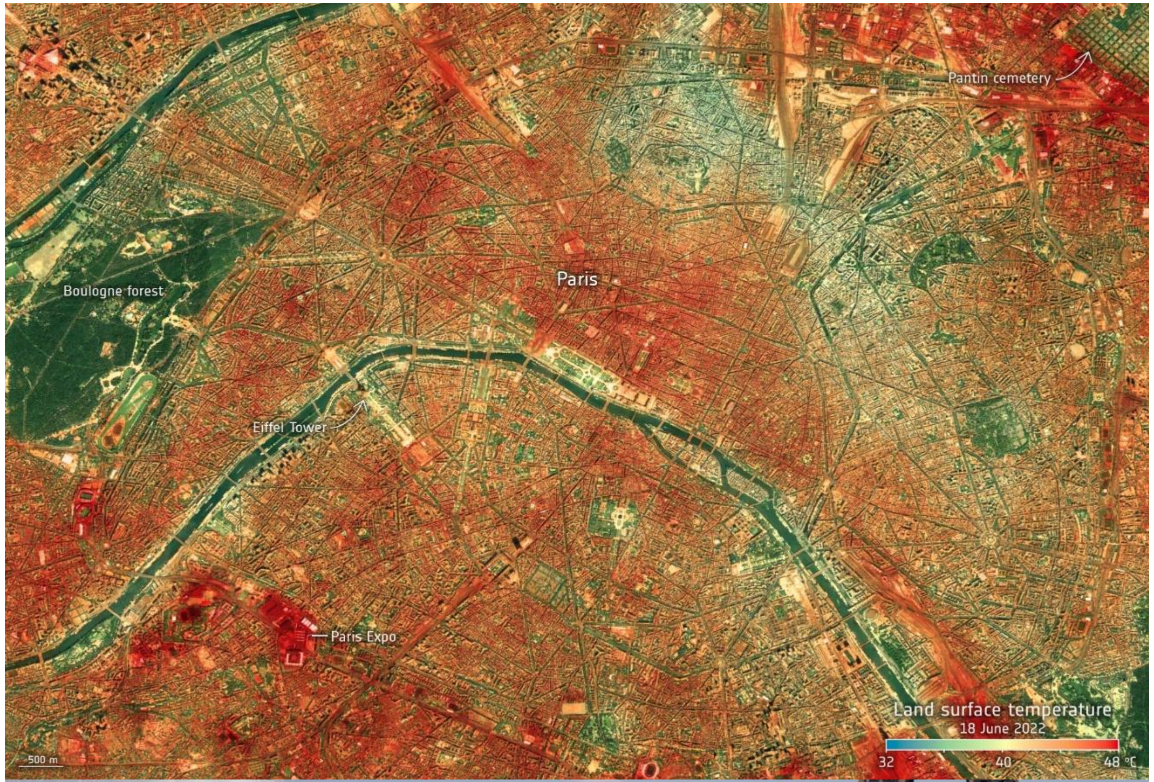
13th FORTH Retreat, Heraklion, 15 July 2022

FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS

(Oke et al. 2017)

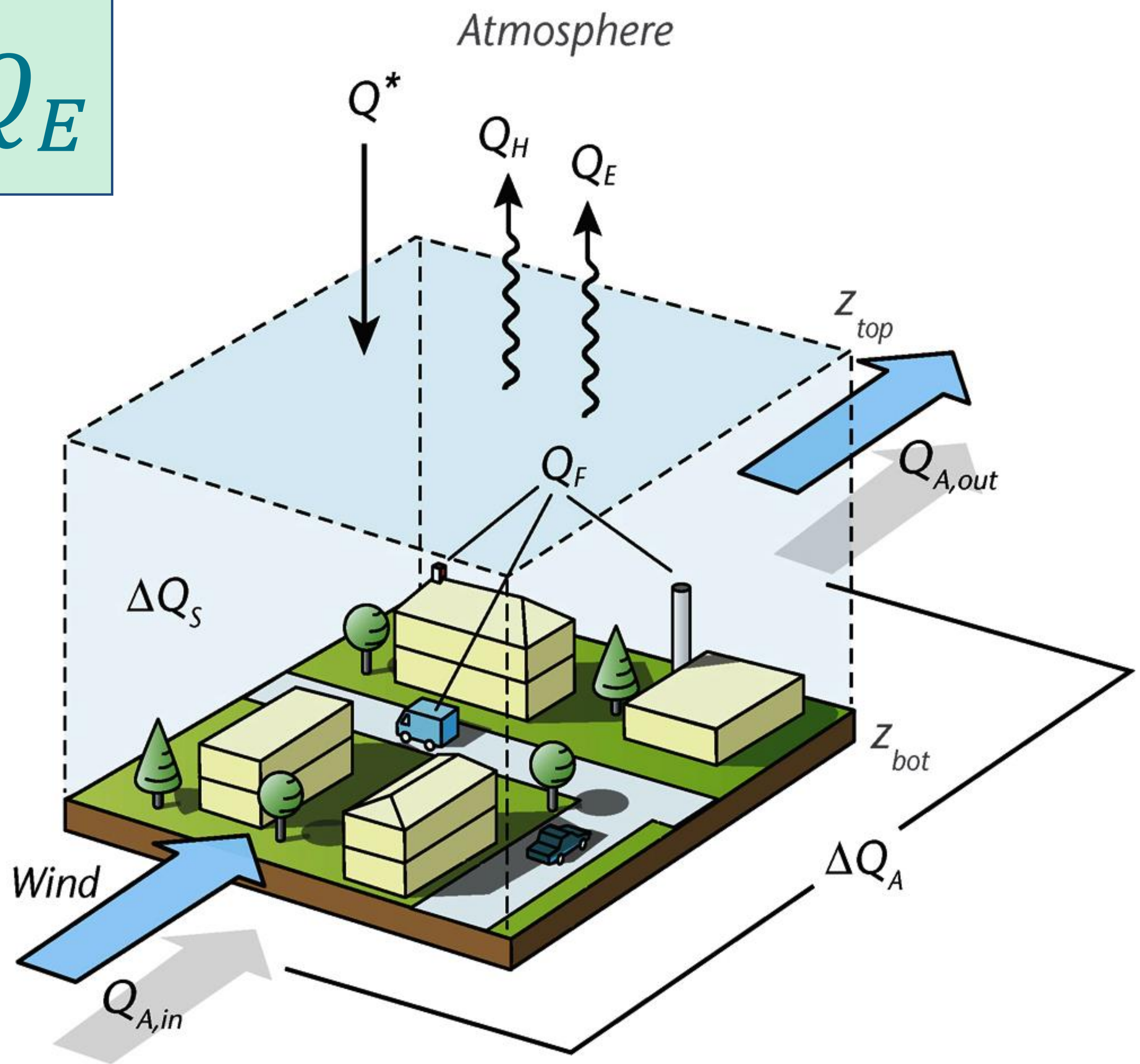


(Creutzig et al. 2015)



$$Q^* + Q_F = \Delta Q_S + Q_H + Q_E$$

- **Q^*:** Net Radiation
- **Q_F :** anthropogenic heat flux
- **ΔQ_S :** net change in heat storage
- **Q_H :** turbulent sensible heat flux
- **Q_E :** turbulent latent heat flux



(Oke et al. 2017)

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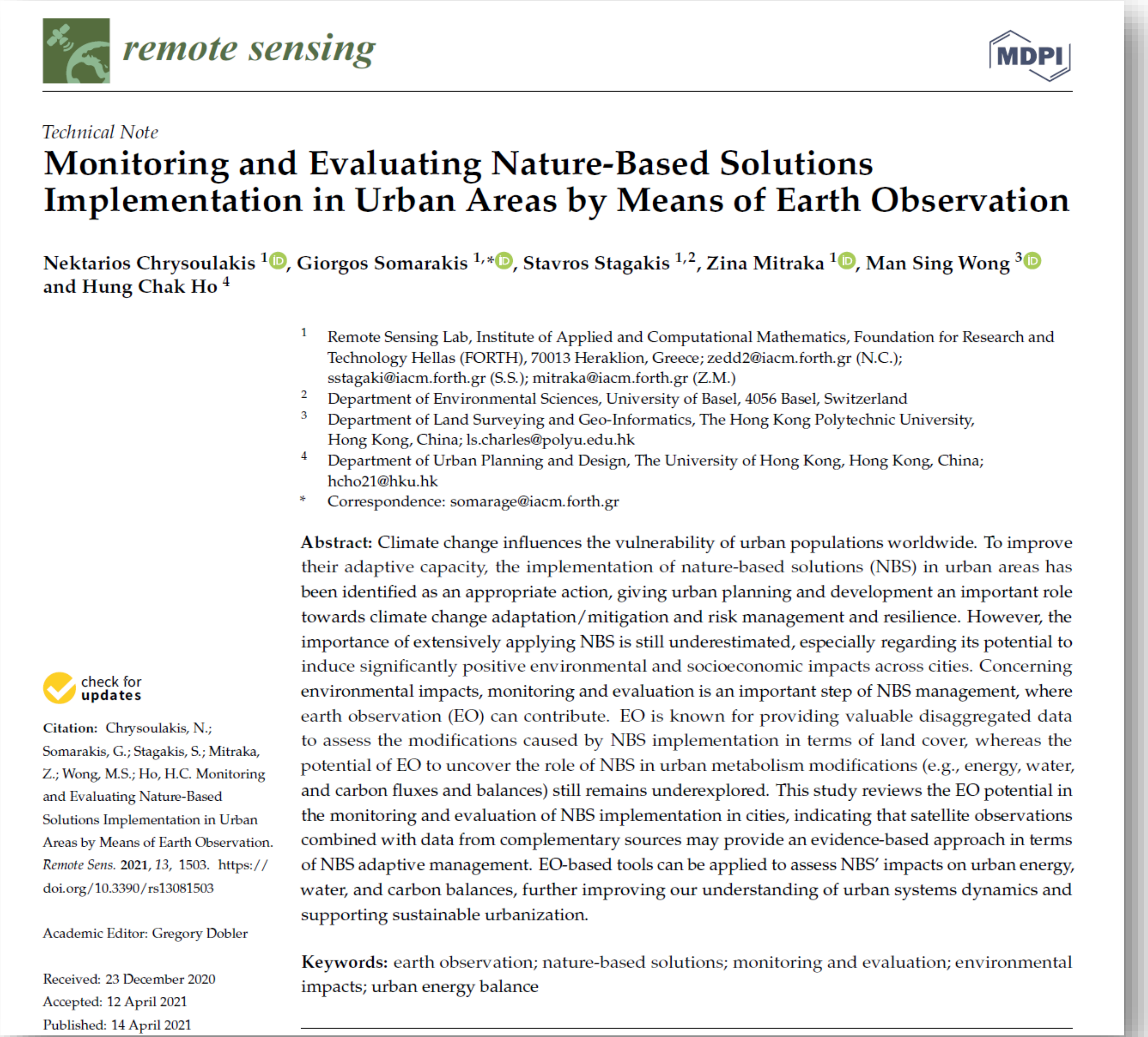
remote sensing

MDPI

Technical Note

Monitoring and Evaluating Nature-Based Solutions Implementation in Urban Areas by Means of Earth Observation

Nektarios Chrysoulakis [1], Giorgos Somarakis [1,*], Stavros Stagakis [1,2], Zina Mitraka [1], Man Sing Wong [3] and Hung Chak Ho [4]

1 Remote Sensing Lab, Institute of Applied and Computational Mathematics, Foundation for Research and Technology Hellas (FORTH), 70013 Heraklion, Greece; zedd2@iacm.forth.gr (N.C.); sstagaki@iacm.forth.gr (S.S.); mitraka@iacm.forth.gr (Z.M.)
2 Department of Environmental Sciences, University of Basel, 4056 Basel, Switzerland
3 Department of Land Surveying and Geo-Informatics, The Hong Kong Polytechnic University, Hong Kong, China; ls.charles@polyu.edu.hk
4 Department of Urban Planning and Design, The University of Hong Kong, Hong Kong, China; hcho21@hku.hk
* Correspondence: somarage@iacm.forth.gr

Abstract: Climate change influences the vulnerability of urban populations worldwide. To improve their adaptive capacity, the implementation of nature-based solutions (NBS) in urban areas has been identified as an appropriate action, giving urban planning and development an important role towards climate change adaptation/mitigation and risk management and resilience. However, the importance of extensively applying NBS is still underestimated, especially regarding its potential to induce significantly positive environmental and socioeconomic impacts across cities. Concerning environmental impacts, monitoring and evaluation is an important step of NBS management, where earth observation (EO) can contribute. EO is known for providing valuable disaggregated data to assess the modifications caused by NBS implementation in terms of land cover, whereas the potential of EO to uncover the role of NBS in urban metabolism modifications (e.g., energy, water, and carbon fluxes and balances) still remains underexplored. This study reviews the EO potential in the monitoring and evaluation of NBS implementation in cities, indicating that satellite observations combined with data from complementary sources may provide an evidence-based approach in terms of NBS adaptive management. EO-based tools can be applied to assess NBS' impacts on urban energy, water, and carbon balances, further improving our understanding of urban systems dynamics and supporting sustainable urbanization.

Keywords: earth observation; nature-based solutions; monitoring and evaluation; environmental impacts; urban energy balance

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(Somarakis et al. 2019)

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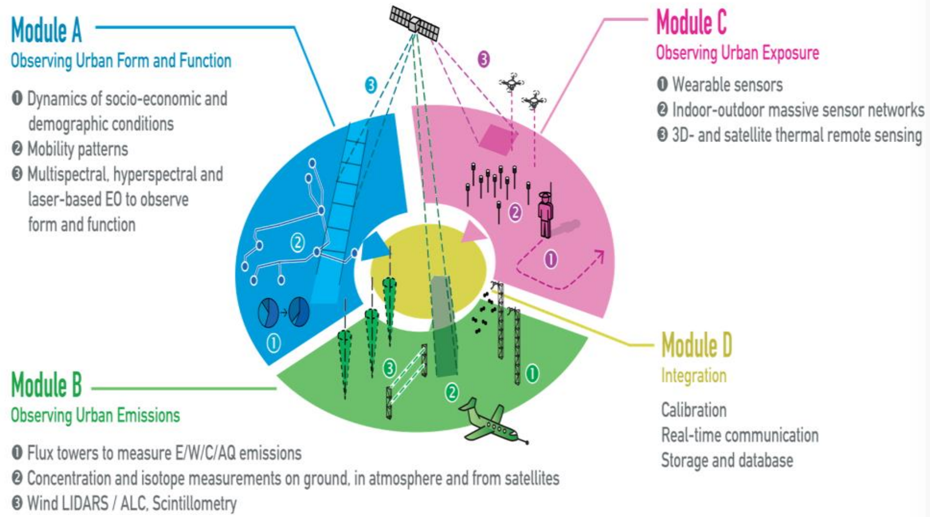
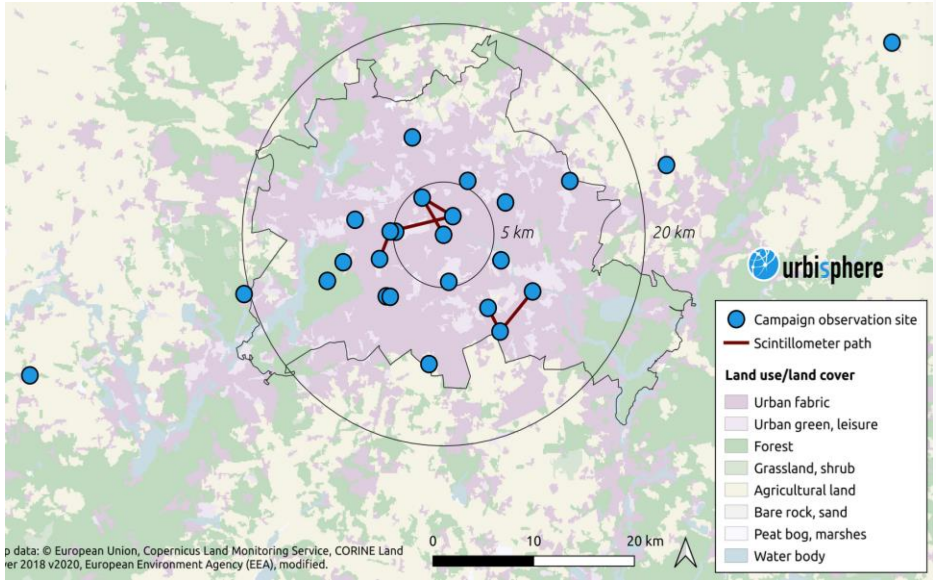

Module A
Observing Urban Form and Function
❶ Dynamics of socio-economic and demographic conditions
❷ Mobility patterns
❸ Multispectral, hyperspectral and laser-based EO to observe form and function
Module C
Observing Urban Exposure
❶ Wearable sensors
❷ Indoor-outdoor massive sensor networks
❸ 3D- and satellite thermal remote sensing
Module D
Integration
Calibration
Real-time communication
Storage and database
Module B
Observing Urban Emissions
❶ Flux towers to measure E/W/C/AQ emissions
❷ Concentration and isotope measurements on ground, in atmosphere and from satellites
❸ Wind LIDARS / ALC, Scintillometry


5 km
20 km
urbisphere
Campaign observation site
Scintillometer path
Land use/land cover
Urban fabric
Urban green, leisure
Forest
Grassland, shrub
Agricultural land
Bare rock, sand
Peat bog, marshes
Water body
0
10
20 km
p data: © European Union, Copernicus Land Monitoring Service, CORINE Land
er 2018 v2020, European Environment Agency (EEA), modified.

Atmospheric Environment 201 (2019) 278–292

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Eddy Covariance measurements and source partitioning of CO_2 emissions in an urban environment: Application for Heraklion, Greece

Stavros Stagakis[a,*], Nektarios Chrysoulakis[a], Nektarios Spyridakis[a], Christian Feigenwinter[b], Roland Vogt[b]

[a] Remote Sensing Lab, Institute of Applied and Computational Mathematics, Foundation for Research and Technology – Hellas (FORTH), Vassilika Vouton, Nikolaou Plastira 100, GR 700 13, Heraklion, Crete, Greece

[b] Department of Environmental Sciences, University of Basel, Klingelbergstrasse 27, 4056, Basel, Switzerland

ARTICLE INFO

ABSTRACT

Keywords:
Eddy covariance
Carbon dioxide emissions
Source area
Earth observation

ICOS INTEGRATED CARBON OBSERVATION SYSTEM

AGU ADVANCING EARTH AND SPACE SCIENCE

Geophysical Research Letters

RESEARCH LETTER
10.1029/2021GL096069

Urban Water Storage Capacity Inferred From Observed Evapotranspiration Recession

H. J. Jongen[1,2], G. J. Steeneveld[2], J. Beringer[3], A. Christen[4], N. Chrysoulakis[5], K. Fortuniak[6], J. Hong[7], J. W. Hong[8], C. M. J. Jacobs[9,10], L. Järvi[11,12], F. Meier[13], W. Pawlak[6], M. Roth[14], N. E. Theeuwes[15,16], E. Velasco[17], R. Vogt[18], and A. J. Teuling[1]

[1]Hydrology and Quantitative Water Management, Wageningen University, Wageningen, The Netherlands, [2]Meteorology and Air Quality, Wageningen University, Wageningen, The Netherlands, [3]School of Agriculture and Environment, University of Western Australia, Crawley, WA, Australia, [4]Chair of Environmental Meteorology, Faculty of Environment and Natural Resources, University of Freiburg, Freiburg, Germany, [5]Foundation for Research and Technology Hellas, Institute of Applied and Computational Mathematics, The Remote Sensing Lab, Heraklion, Greece, [6]Department of Meteorology and Climatology, Faculty of Geographical Sciences, University of Łódź, Łódź, Poland, [7]Department of Atmospheric Sciences, Yonsei University, Seoul, South Korea, [8]Korea Environment Institute, Sejong, South Korea, [9]Wageningen Environmental Research, Wageningen University and Research, Wageningen, The Netherlands, [10]National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands, [11]Institute for Atmospheric and Earth System Research / Physics, University of Helsinki, Helsinki, Finland, [12]Helsinki Institute of Sustainability Science, University of Helsinki, Helsinki, Finland, [13]Chair of Climatology, Technische Universität Berlin, Berlin, Germany, [14]Department of Geography, National University of Singapore, Singapore, Singapore, [15]Department of Meteorology, University of Reading, Reading, UK, [16]Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands, [17]Independent Research Scientist, Singapore, Singapore, [18]Department of Environmental Sciences, University of Basel, Basel, Switzerland

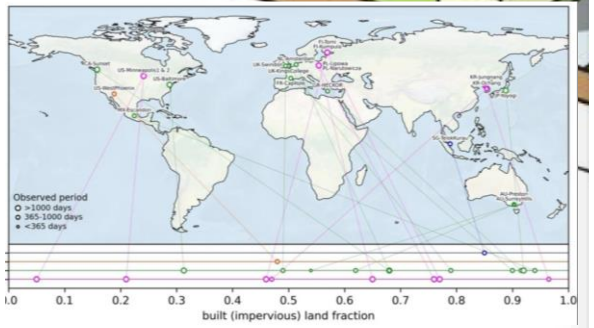
Key Points:
- A new method is applied to infer urban water storage capacity from evapotranspiration recession
- Our analysis of evaporation observations reveals water is limiting within days in cities worldwide
- Water storage capacity in cities is at least five times smaller than in natural systems

Supporting Information:
Supporting Information may be found in the online version of this article.

Correspondence to:
H. J. Jongen,
harro.jongen@wur.nl

Citation:
Jongen, H. J., Steeneveld, G. J., Beringer, J., Christen, A., Chrysoulakis, N.,

Abstract Water storage plays an important role in mitigating heat and flooding in urban areas. Assessment of the water storage capacity of cities remains c…



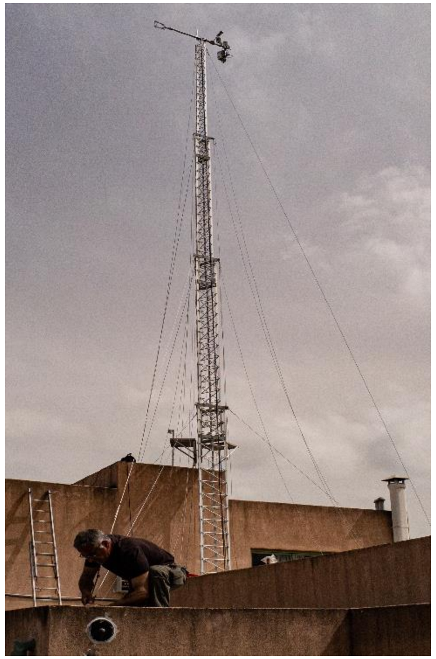
https://doi.org/10.5194/essd-2022-65
Preprint. Discussion started: 3 June 2022

Open Access Earth System Science Data Discussions

Harmonized gap-filled datasets from 20 urban flux tower sites

Mathew Lipson[1,2], Sue Grimmond[2], Martin Best[3], Winston Chow[4], Andreas Christen[5], Nektarios Chrysoulakis[6], Andrew Coutts[7], Ben Crawford[8], Stevan Earl[9], Jonathan Evans[10], Krzysztof Fortuniak[11], Bert G. Heusinkveld[12], Je-Woo Hong[13], Jinkyu Hong[14], Leena Järvi[15], Sungsoo Jo[16], Yeon-Hee Kim[17], Simone Kotthaus[18], Keunmin Lee[19], Valéry Masson[20], Joseph P. McFadden[21], Oliver Michels[22], Wlodzimierz Pawlak[23], Matthias Roth[24], Hirofumi Sugawara[25], Nigel Tapper[26], Erik Velasco[27], Helen Claire Ward[28]

[1]Australian Research Council (ARC) Centre of Excellence for Climate System Science, Climate Change Research Centre, Level 4, Mathews Building, UNSW Sydney, New South Wales, 2052, Australia.
[2]Department of Meteorology, University of Reading, Reading, RG6 6ET, United Kingdom
[3]Met Office, Fitzroy Road, Exeter, Devon, EX1 3PB, United Kingdom.
[4]School of Social Sciences, Singapore Management University, Singapore.
[5]Environmental Meteorology, Institute of Earth and Environmental Sciences, Faculty of Environment and Natural Resources, University of Freiburg, Freiburg, Germany.
[6]Foundation for Research and Technology Hellas, Institute of Applied and Computational Mathematics, Remote Sensing Lab, Heraklion, Greece.



WEATHER CLIMATE WATER

WORLD METEOROLOGICAL ORGANIZATION | GLOBAL ATMOSPHERE WATCH

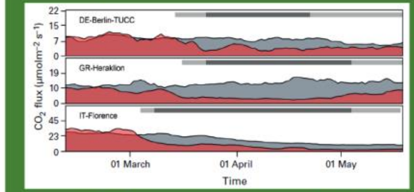
WMO GREENHOUSE GAS BULLETIN

The State of Greenhouse Gases in the Atmosphere Based on Global Observations through 2019

No. 16 | 23 November 2020

ISSN 2078-0796

Can we see the impact of COVID-19 confinement measures on CO_2 levels in the atmosphere?



Average daily CO_2 emissions from 5 February to 6 May 2020 (red area) and average of the previous years during the same period (grey area) for three European cities. The dark grey horizontal bars cover periods of official lockdown, while the light grey bars indicate periods of partial lockdown or general restrictions (for example, school closures, reductions in personal contact, mobility constraints). Source: [6]

Humanity is experiencing a fundamental health and economic crisis related to COVID-19. The confinement measures broadly introduced earlier in 2020 and now reintroduced in many locations have had an impact on anthropogenic emissions of multiple constituents and resulted in changes in the chemical composition of the atmosphere. These changes have been especially pronounced in urban areas and are visible in traditional pollutants as well as in greenhouse gases. However, the reduction in anthropogenic emissions due to confinement measures will not have a discernible effect on global mean atmospheric CO_2 in 2020 as this reduction will be smaller than, or at most, similar in size to the natural year-to-year variability of atmospheric CO_2.

The global atmospheric CO_2 concentration represents the budget between the fluxes of CO_2 in and out of the atmosphere. CO_2 is a gas that is well mixed by turbulent mixing and atmospheric transport; it accumulates in the atmosphere over long timescales, and any non-zero emission leads to an increase in the atmospheric concentration. Anthropogenic emissions of CO_2 have been increasing globally since pre-industrial times (before 1750) and have risen by about 1% per year over the last decade [1]. This has resulted in an annual increase in the atmospheric CO_2 mole fraction(1) of between 2 and 3 ppm(2) over the last ten years. This increase has been documented by the Global Atmosphere Watch (GAW) global network of surface stations, which can detect global changes of atmospheric CO_2 over a year within 0.1 ppm of precision. The year-to-year variability of about 1 ppm in the atmospheric growth rate is almost entirely due to variability in the uptake of CO_2 by ecosystems and oceans (that together take up annually roughly half of human CO_2 emissions [2]). CO_2 originating from fossil fuel sources can be distinguished from CO_2 originating from biogenic sources using isotopic analysis, as was described in the previous Greenhouse Gas Bulletin.

The Global Carbon Project (GCP) [3] estimated that during the most intense period of forced confinement in early 2020, daily global CO_2 emissions may have been reduced by up to 17% compared to the mean level of daily CO_2 emissions in 2019. As the duration and severity of the confinement measures remain unclear, it is very difficult to predict the total annual reduction in CO_2 emissions for 2020; however, preliminary estimates anticipate a reduction of between 4.2% and 7.5% compared to 2019 levels. At the global scale, an emission reduction of this magnitude will not cause atmospheric CO_2 levels to decrease; they will merely increase at a slightly reduced rate, resulting in an anticipated annual atmospheric CO_2 concentration that is 0.08 ppm–0.23 ppm lower than the anticipated CO_2 concentration if no pandemic had occurred. This falls well within the 1 ppm natural inter-annual variability and means that in the short-term, the impact of COVID-19 confinement measures cannot be distinguished from natural year-to-year variability. A similar conclusion was reached by Carbon Brief [4] and the Integrated Carbon Observation System (ICOS) [5].

Determining changes in the fossil fuel signal given the high natural atmospheric variability of CO_2 requires a long time series in order to generate robust statistics, as well as complex data modelling. Several approaches can be used to make this determination. One such approach, the WMO Integrated Global Greenhouse Gas Information System (IG^3IS), utilizes atmospheric observations and modelling. Another approach, adopted by ICOS [6], directly measures CO_2 emissions within cities. A recent study by ICOS detected reductions in CO_2 emissions of up to 75% in the city centres of Basel, Berlin, Florence, Helsinki, Heraklion, London and Pesaro using techniques that directly measure vertical exchange fluxes within a circumference of several kilometres from the measurement point (see the figure).

Only when net fossil fuel emissions of CO_2 approach zero will the net uptake by ecosystems and oceans start to reduce CO_2 levels in the atmosphere. Even then, most of the CO_2 already added to the atmosphere will remain there for several centuries, continuing to warm our climate. In addition, the Earth climate system has a lag time of several decades due to buffering of the excess heat by the oceans, so the sooner we reduce our emissions, the less likely we are to overshoot the warming threshold the world agreed to in the Paris Agreement.

Science of the Total Environment 830 (2022) 154662

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/scitotenv

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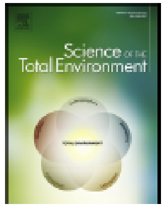

Direct observations of CO_2 emission reductions due to COVID-19 lockdown across European urban districts

Check for updates

Giacomo Nicolini [a,b,*], Gabriele Antoniella [a,b], Federico Carotenuto [c], Andreas Christen [d], Philippe Ciais [e], Christian Feigenwinter [f], Beniamino Gioli [c], Stavros Stagakis [f,g], Erik Velasco [h], Roland Vogt [f], Helen C. Ward [i], Janet Barlow [j], Nektarios Chrysoulakis [g], Pierpaolo Duce [c], Martin Graus [i], Carole Helfter [k], Bert Heusinkveld [l], Leena Järvi [m,n], Thomas Karl [i], Serena Marras [a,o], Valéry Masson [p], Bradley Matthews [q,r], Fred Meier [s], Eiko Nemitz [k], Simone Sabbatini [a,b], Dieter Scherer [s], Helmut Schume [q], Costantino Sirca [a,o], Gert-Jan Steeneveld [l], Carolina Vagnoli [c], Yilong Wang [t], Alessandro Zaldei [c], Bo Zheng [u], Dario Papale [a,b]

[a] Euro-Mediterranean Center on Climate Change, Italy
[b] DIBAF University of Tuscia, Italy
[c] CNR, National Research Council, Italy
[d] Environmental Meteorology, Institute of Earth and Environmental Sciences, University of Freiburg, Germany
[e] Laboratoire des Sciences du Climat et de l' Environnement, CEA CNRS UVSQ, C.E. Orme des Merisiers Gif sur Yvette, France
[f] University of Basel, Switzerland
[g] Institute of Applied and Computational Mathematics, Foundation for Research and Technology Hellas (FORTH), Greece
[h] Independent researcher, Singapore
[i] Dep. of Atmospheric and Cryospheric Sciences, University of Innsbruck, Austria
[j] Dep. of Meteorology, University of Reading, UK
[k] UK Center for Ecology & Hydrology, Penicuik, UK
[l] Wageningen University, Meteorology and Air Quality Section, Wageningen, Netherlands
[m] Institute for Atmospheric and Earth System Research, Helsinki, Finland
[n] Institute of Sustainability Science, Faculty of Science, University of Helsinki, Finland
[o] Dept. of Agricultural Sciences, University of Sassari, Italy
[p] University of Toulouse, Météo-France and CNRS, France
[q] University of Natural Resources and Life Sciences, Department of Forest- and Soil Sciences, Institute of Forest Ecology, Vienna, Austria
[r] Environment Agency Austria, Vienna, Austria
[s] Chair of Climatology, Institute of Ecology, Technische Universität Berlin, Germany
[t] Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China
[u] Tsinghua Shenzhen International Graduate School, Tsinghua University, China

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Time


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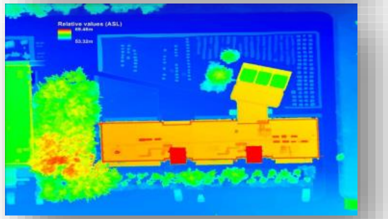
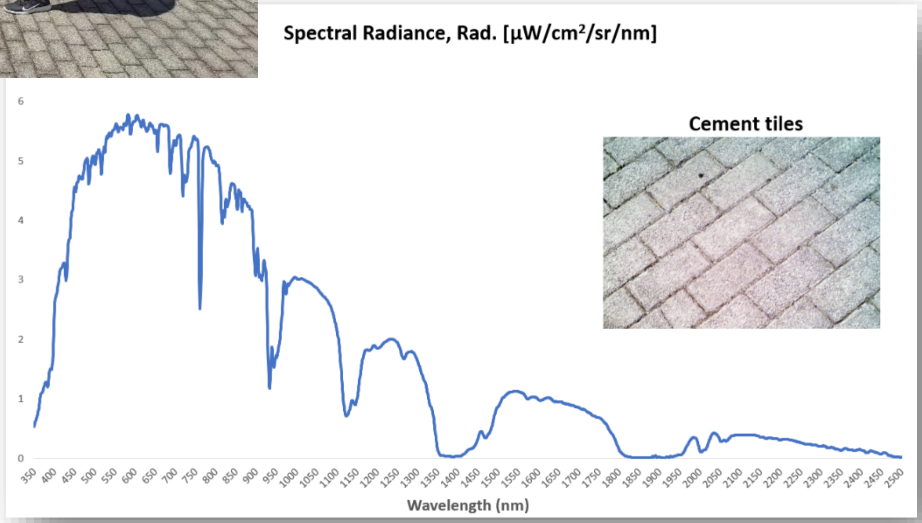



RS-3500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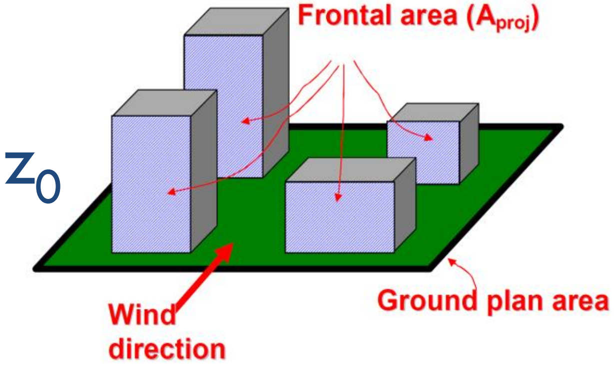
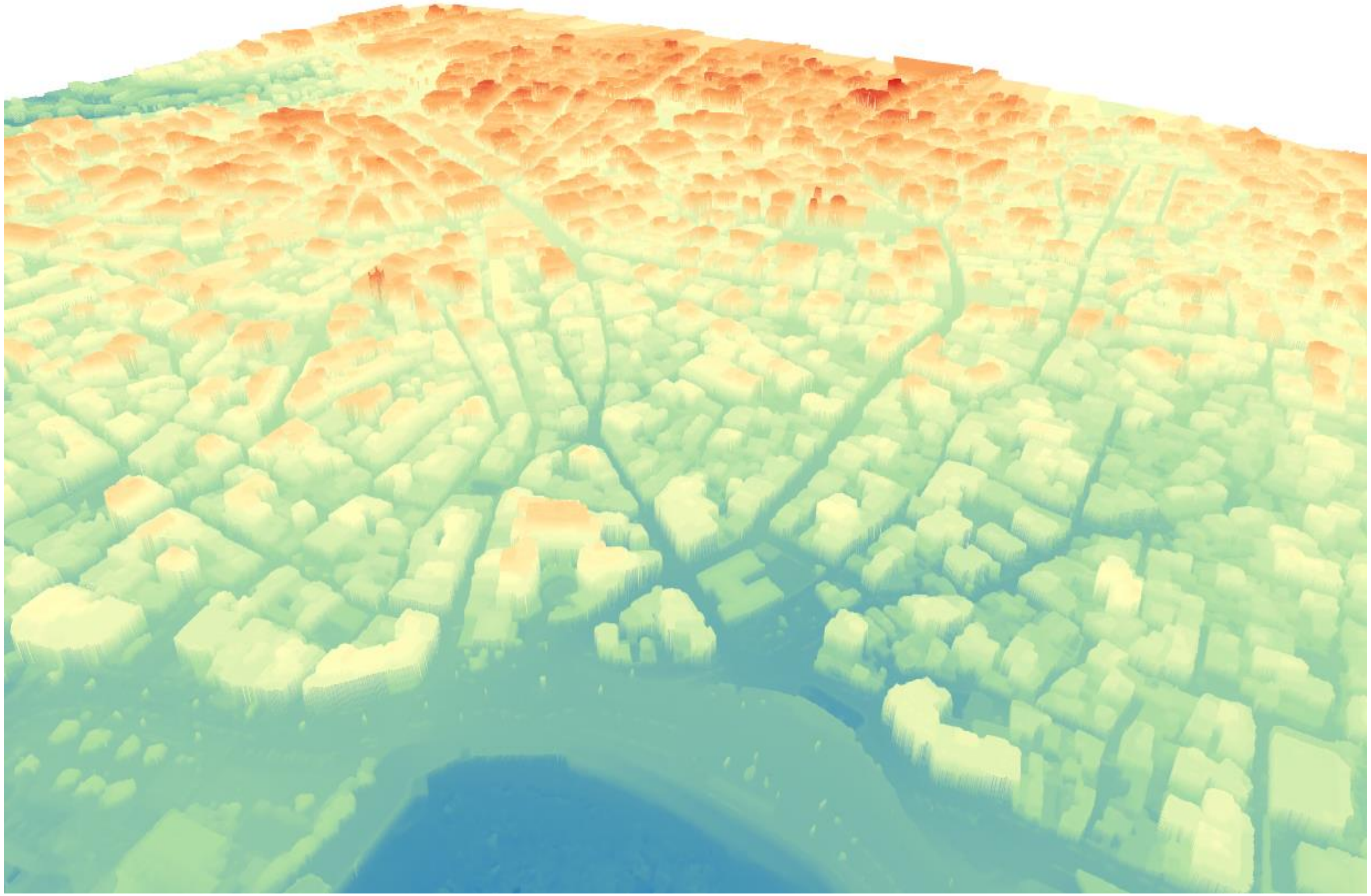
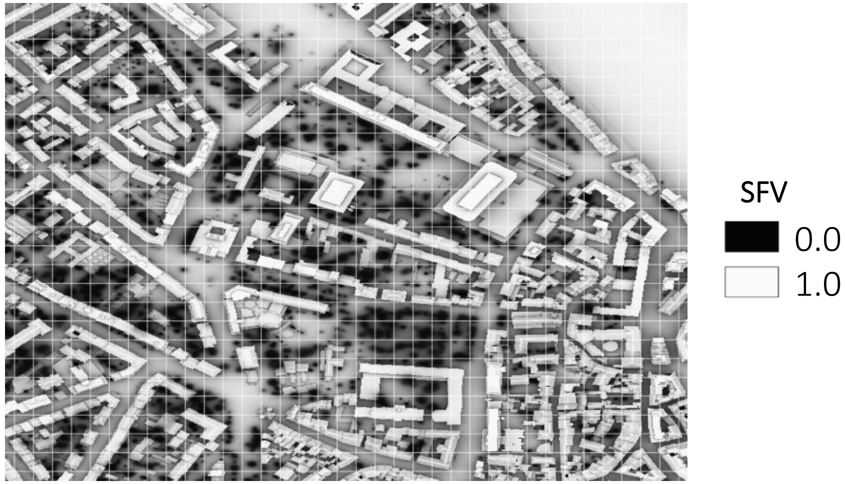
Wavelength (nm)

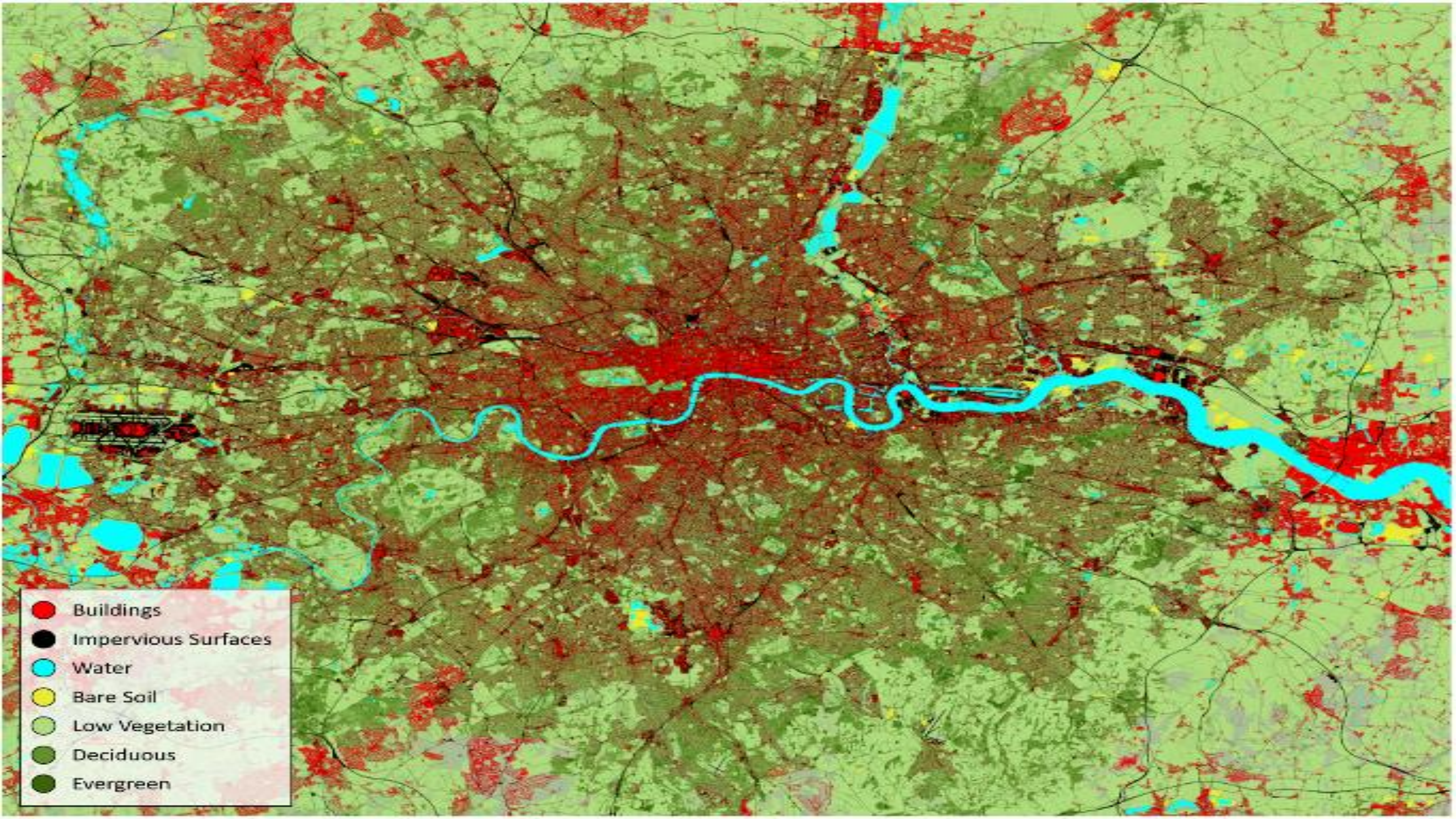
Urban surface structure

Relevant parameters: SVF, λ_P, λ_f, z_d, z_0

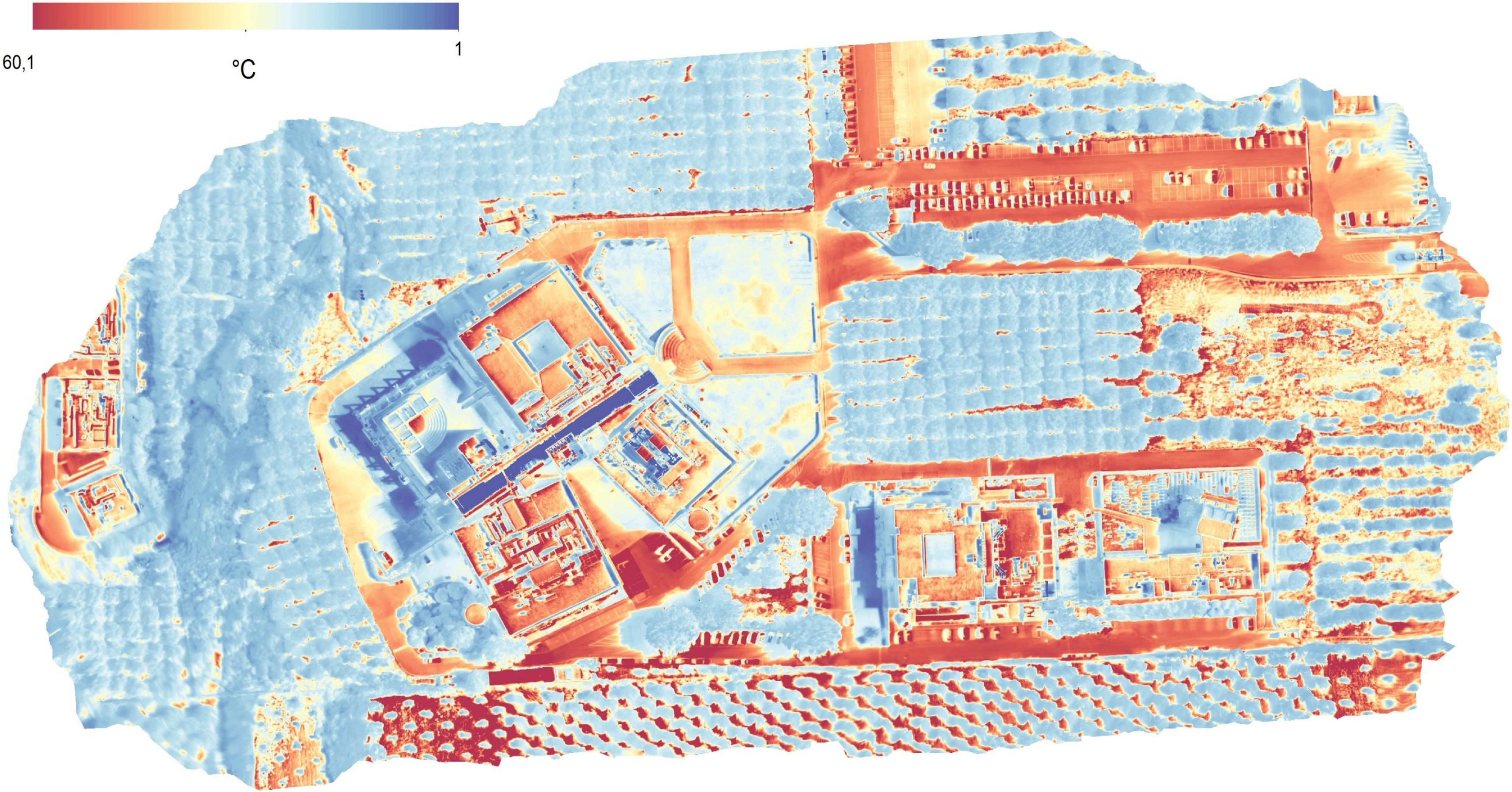








Buildings
Impervious Surfaces
Water
Bare Soil
Low Vegetation
Deciduous
Evergreen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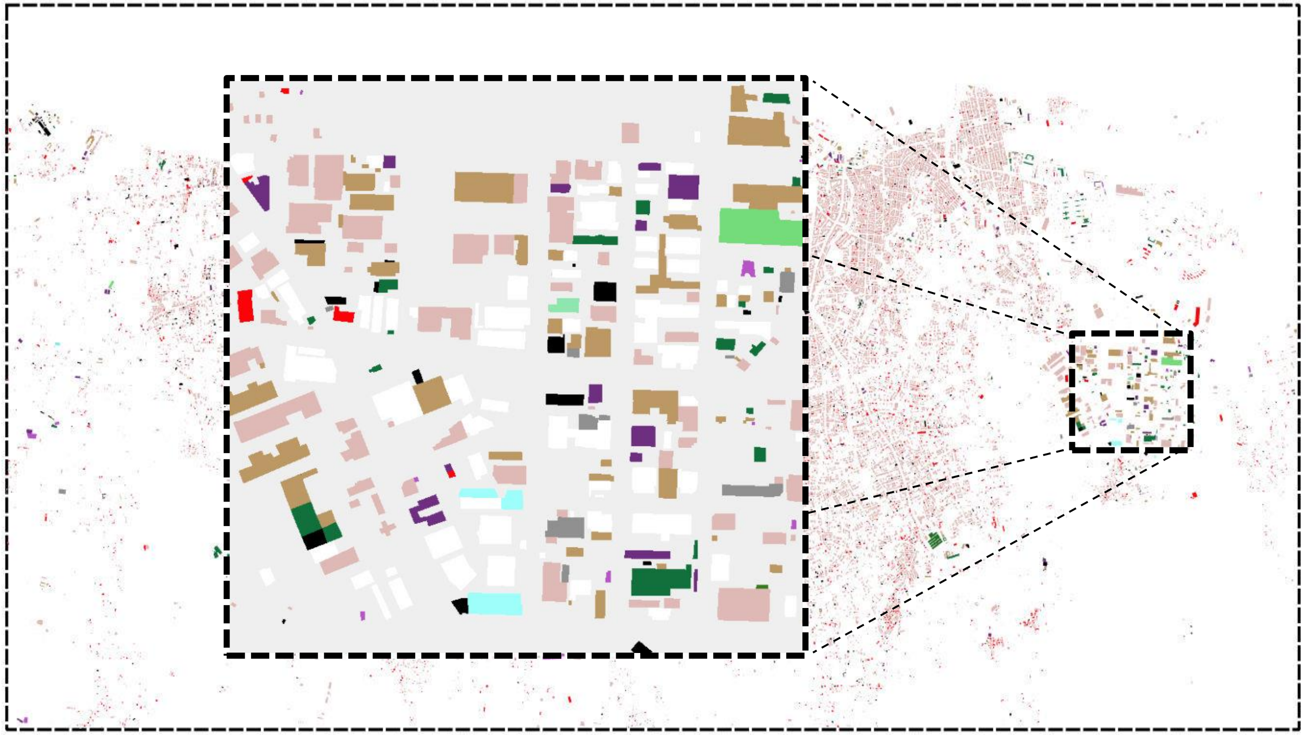

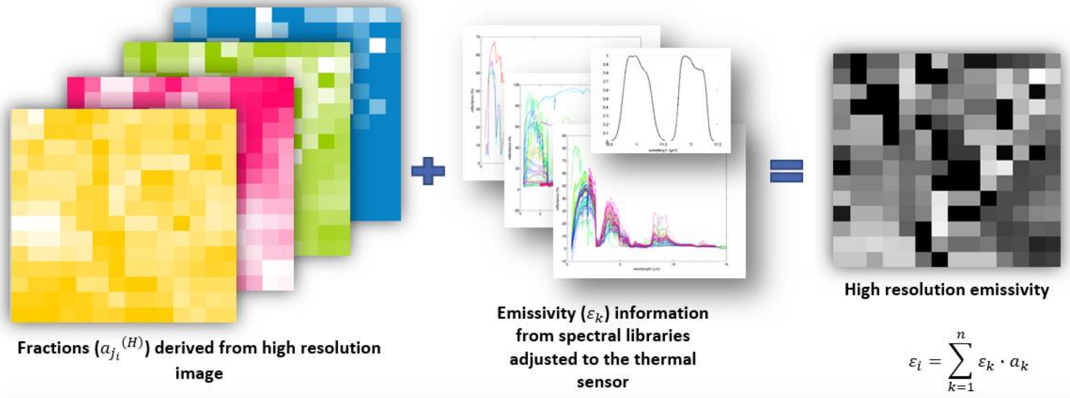

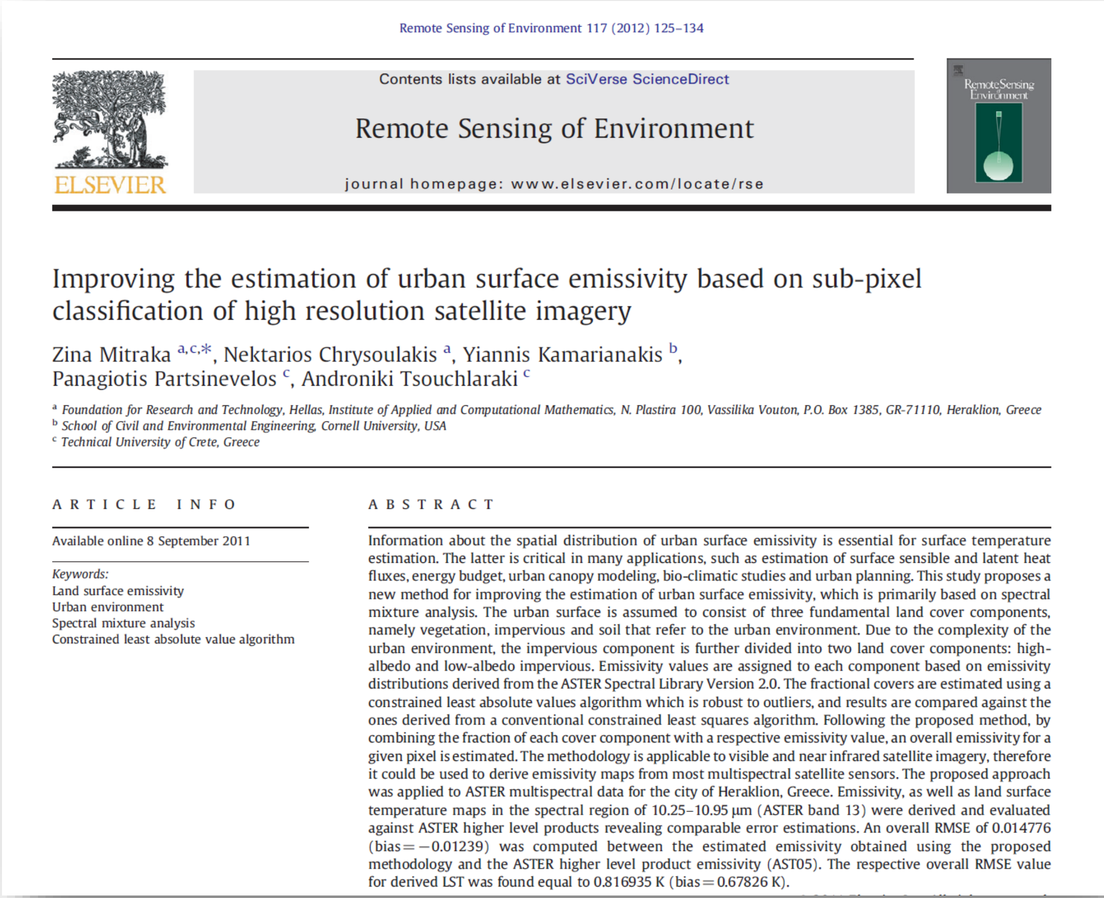

Remote Sensing of Environment 117 (2012) 125–134

Contents lists available at SciVerse ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

ELSEVIER

Improving the estimation of urban surface emissivity based on sub-pixel classification of high resolution satellite imagery

Zina Mitraka [a,c,*], Nektarios Chrysoulakis [a], Yiannis Kamarianakis [b], Panagiotis Partsinevelos [c], Androniki Tsouchlaraki [c]

[a] Foundation for Research and Technology, Hellas, Institute of Applied and Computational Mathematics, N. Plastira 100, Vassilika Vouton, P.O. Box 1385, GR-71110, Heraklion, Greece
[b] School of Civil and Environmental Engineering, Cornell University, USA
[c] Technical University of Crete, Greece

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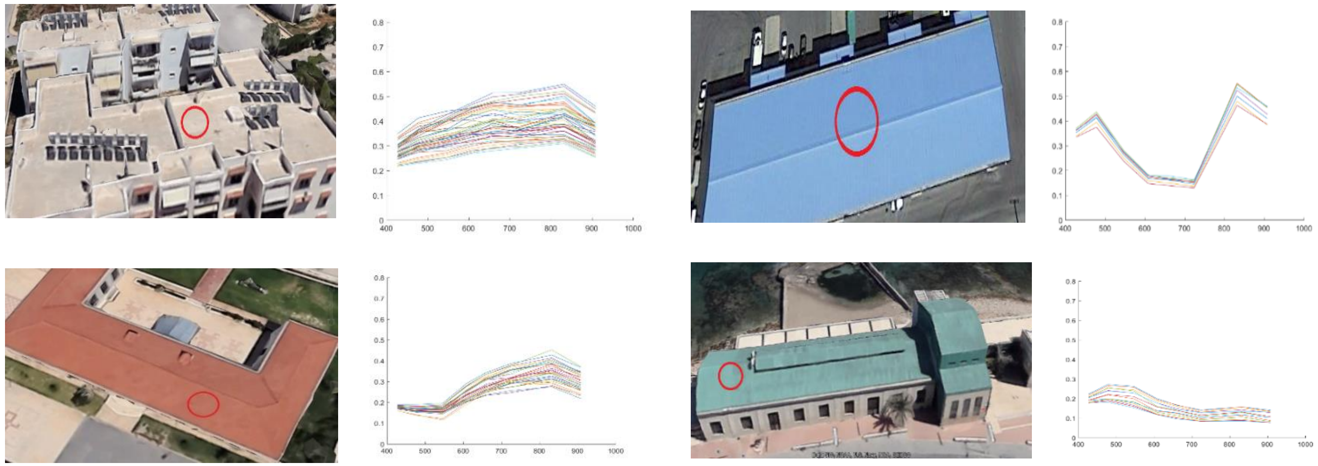
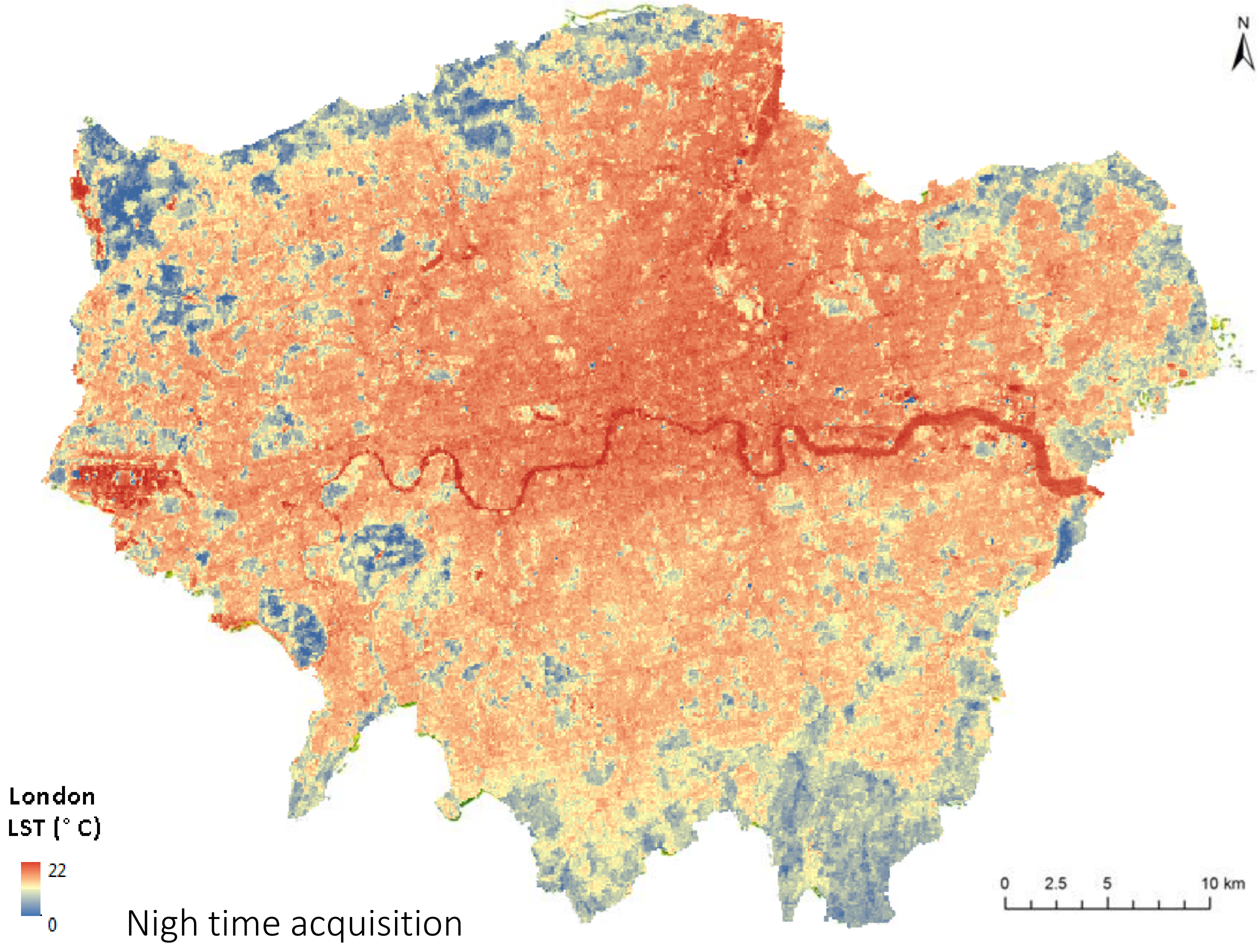
Available online 8 September 2011

Keywords:
Land surface emissivity
Urban environment
Spectral mixture analysis
Constrained least absolute value algorithm

ABSTRACT

Information about the spatial distribution of urban surface emissivity is essential for surface temperature estimation. The latter is critical in many applications, such as estimation of surface sensible and latent heat fluxes, energy budget, urban canopy modeling, bio-climatic studies and urban planning. This study proposes a new method for improving the estimation of urban surface emissivity, which is primarily based on spectral mixture analysis. The urban surface is assumed to consist of three fundamental land cover components, namely vegetation, impervious and soil that refer to the urban environment. Due to the complexity of the urban environment, the impervious component is further divided into two land cover components: high-albedo and low-albedo impervious. Emissivity values are assigned to each component based on emissivity distributions derived from the ASTER Spectral Library Version 2.0. The fractional covers are estimated using a constrained least absolute values algorithm which is robust to outliers, and results are compared against the ones derived from a conventional constrained least squares algorithm. Following the proposed method, by combining the fraction of each cover component with a respective emissivity value, an overall emissivity for a given pixel is estimated. The methodology is applicable to visible and near infrared satellite imagery, therefore it could be used to derive emissivity maps from most multispectral satellite sensors. The proposed approach was applied to ASTER multispectral data for the city of Heraklion, Greece. Emissivity, as well as land surface temperature maps in the spectral region of 10.25–10.95 μm (ASTER band 13) were derived and evaluated against ASTER higher level products revealing comparable error estimations. An overall RMSE of 0.014776 (bias = −0.01239) was computed between the estimated emissivity obtained using the proposed methodology and the ASTER higher level product emissivity (AST05). The respective overall RMSE value for derived LST was found equal to 0.816935 K (bias = 0.67826 K).





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Source: NASA/JPL

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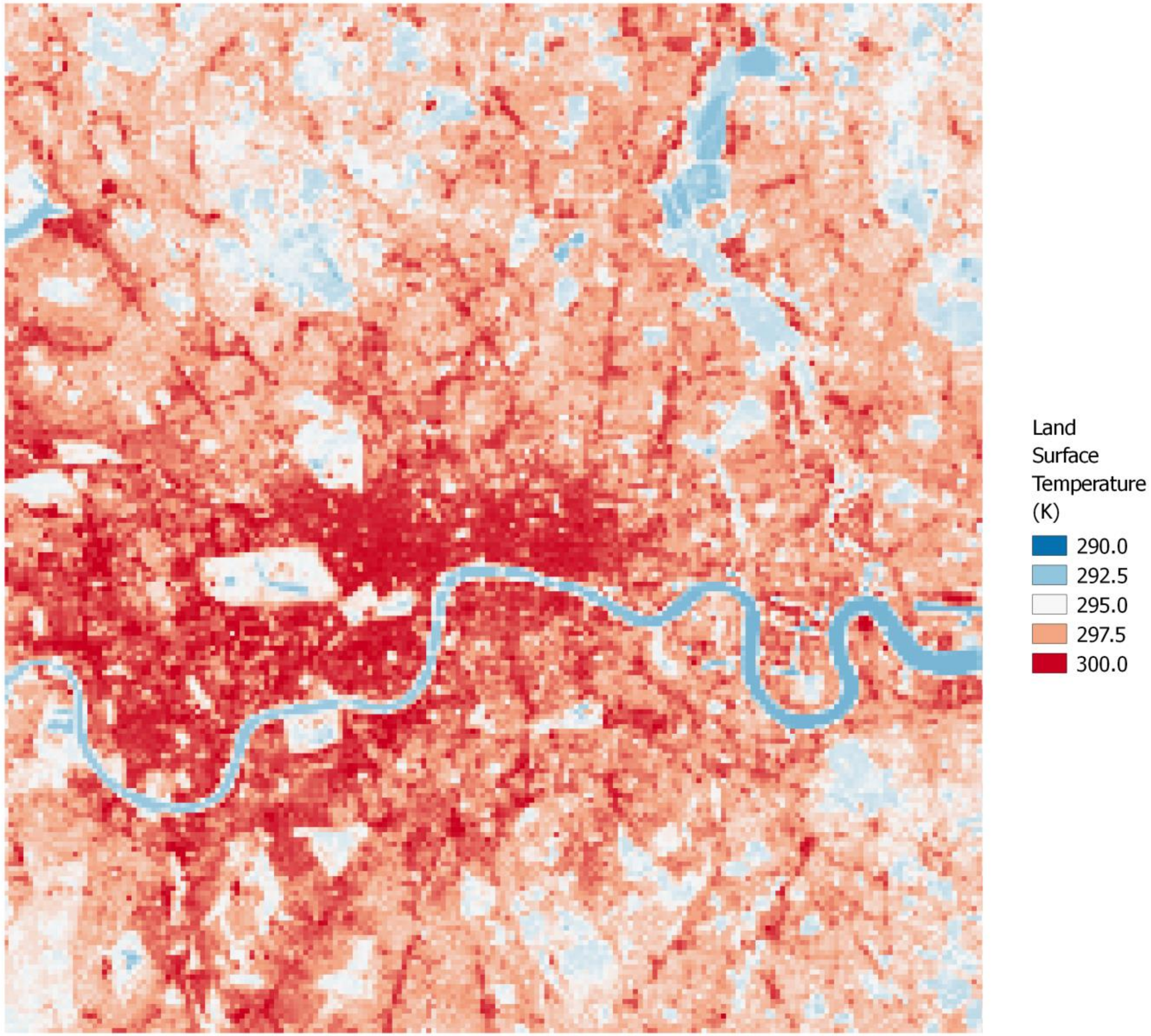

Remote Sens. **2015**, *7*, 4139-4156; doi:10.3390/rs70404139

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remote sensing

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Article

Urban Surface Temperature Time Series Estimation at the Local Scale by Spatial-Spectral Unmixing of Satellite Observations

Zina Mitraka [1,2,*], Nektarios Chrysoulakis [2], Georgia Doxani [3], Fabio Del Frate [1] and Michael Berger [3]

1 DICII, University of Rome Tor Vergata, Via del Politecnico 1, 00133 Rome, Italy; E-Mail: delfrate@disp.uniroma2.it

2 Foundation for Research and Technology Hellas, N.Plastira 100, Vassilika Vouton, 70013 Heraklion, Greece; E-Mail: zedd2@iacm.forth.gr

3 European Space Agency, Via Galileo Galilei, 00044 Frascati, Italy; E-Mails: georgia.doxani@esa.int (G.D.); michael.berger@esa.int (M.B.)

* Author to whom correspondence should be addressed; E-Mail: mitraka@iacm.forth.gr; Tel.: +30-2810-39-1771; Fax: +30-2810-39-1761.

Academic Editors: Zhao-Liang Li, Jose A. Sobrino, Xiaoning Song, Clement Atzberger, Richard Müller and Prasad S. Thenkabail

Received: 31 December 2014 / Accepted: 1 April 2015 / Published: 7 April 2015

Abstract: The study of urban climate requires frequent and accurate monitoring of land surface temperature (LST), at the local scale. Since currently, no space-borne sensor provides frequent thermal infrared imagery at high spatial resolution, the scientific community has focused on synergistic methods for retrieving LST that can be suitable for urban studies. Synergistic methods that combine the spatial structure of visible and near-infrared observations with the more frequent, but low-resolution surface temperature patterns derived

Turbulent sensible heat flux

Satellite-based

Measured in-situ

$$Q_H = \rho c_P \frac{T_S - T_{air}}{r_a}$$

Aerodynamic resistance from morphometric analysis

Theoretical and Applied Climatology (2020) 141:657–672
https://doi.org/10.1007/s00704-020-03230-3

ORIGINAL PAPER

Check for updates

Spatial interpolation of urban air temperatures using satellite-derived predictors

Nikolaos Nikoloudakis[1] · Stavros Stagakis[1] · Zina Mitraka[1] · Yiannis Kamarianakis[1] · Nektarios Chrysoulakis[1]

Received: 3 September 2019 / Accepted: 20 April 2020 / Published online: 9 May 2020

Abstract
Air temperatures in urban environments are usually obtained from sparse weather stations that provide limited information with regard to spatial patterns. Effective methods that predict air temperatures (T_{air}) in urban areas are based on statistical models which utilize remotely sensed and geographic data. This work aims to compute T_{air} predictions for diurnal and nocturnal time intervals using predictive models that do not exploit information on Land Surface Temperatures. The models are developed based on explanatory variables that describe the urban morphology, land cover and terrain, aggregated at 100 m × 100 m resolution, combined with in situ T_{air} measurements from urban meteorological stations. The case study is the urban and per-urban area of Heraklion, Greece, where a dense meteorological station network is available since 2016. Moran's eigenvector filtering and an autoregressive moving average residual specification are implemented to account for spatial and temporal correlations. The

IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING, VOL. 11, NO. 8, AUGUST 2018

URBANFLUXES

Spatial Distribution of Sensible and Latent Heat Flux in the City of Basel (Switzerland)

Christian Feigenwinter, Roland Vogt, Eberhard Parlow, Fredrik Lindberg, Mattia Marconcini, Fabio Del Frate, and Nektarios Chrysoulakis

Abstract—Urban surfaces are a complex mixture of different land covers and surface materials; the relative magnitudes of the surface energy balance components therefore vary widely across a city. Eddy covariance (EC) measurements provide the best estimates of turbulent heat fluxes but are restricted to the source area. Land surface modeling with earth observation (EO) data is beneficial for extrapolation of a larger area since citywide information is possible. Turbulent sensible and latent heat fluxes are calculated by a combination of micrometeorological approaches (the aerodynamic resistance method, ARM), EO data, and GIS techniques. Input data such as land cover fractions and surface temperatures are derived from Landsat 8 OLI and TIRS, urban morphology was calculated from high-resolution digital building models and GIS data layers, and meteorological data were provided by flux tower measurements. Twenty-two Landsat scenes covering all seasons and different meteorological conditions were analyzed. Sensible heat fluxes were highest for industrial areas, railway stations, and areas with high building density, mainly corresponding to the pixels with highest surface-to-air temperature differences. The spatial distribution of latent heat flux is strongly related to the saturation deficit of vapor and the (minimum) stomatal resistance of vegetation types. Seasonal variations are highly dependent on meteorological conditions, i.e., air temperature, water vapor saturation deficit, and wind speed. Comparison of measured fluxes with modeled fluxes in the weighted source area of the flux towers is moderately accurate due to known drawbacks in the modeling approach and uncertainties inherent to EC measurements, particularly in urban areas.

Index Terms—Aerodynamic resistance method, earth observation (EO), eddy covariance (EC), GIS, urban energy budget, URBANFLUXES.

NOMENCLATURE

ρ	Air density (kg·m^{-3}).
ε	Emissivity dimensionless.
ΔQ_A	Net advective heat flux (W·m^{-2}).
ΔQ_S	Net storage heat flux (W·m^{-2}).
u_*, U	Friction velocity and wind velocity (m·s^{-1}).
e_s^*, e_a	Saturation and atmospheric vapor pressure (hPa).
L	Monin–Obukhov length (m).
$L\uparrow\downarrow$	Upwelling/downwelling longwave radiation (W·m^{-2}).
PAR	Photosynthetically active radiation (W·m^{-2}).
$Q_{E,F,H}$	Latent/anthropogenic/sensible heat flux (W·m^{-2}).
r_a	Atmospheric resistance (s·m^{-1}).
Re	Reynolds number (dimensionless).
R_n	Net radiation (W·m^{-2}).
r_{sMIN}, r_s	(Minimum) stomatal resistance (s·m^{-1}).
T_s, T_a, T_{rad}	Surface/air/radiation temperature (K).
z_{0m}, z_{0h}	Roughness lengths for momentum and heat (m).
z_{ref}, z_d	Reference height and zero-plane displacement height (m).

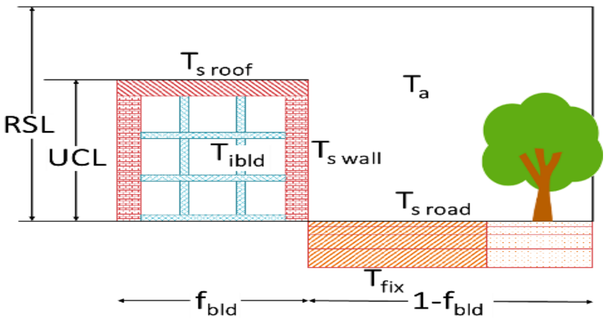
I. INTRODUCTION

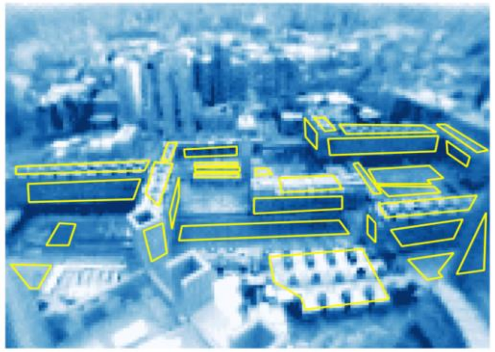
THE URBANFLUXES Horizon 2020 project (http:urbanfluxes.eu) aims to derive the Urban Energy Budget and the anthropogenic heat flux from earth

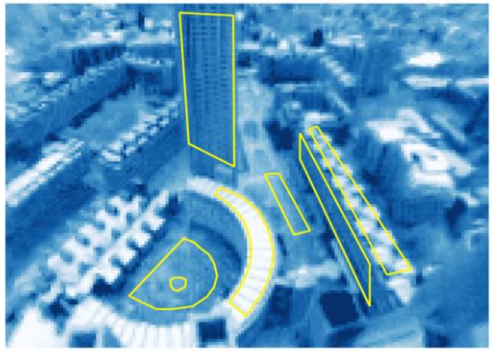
Heat Storage Change

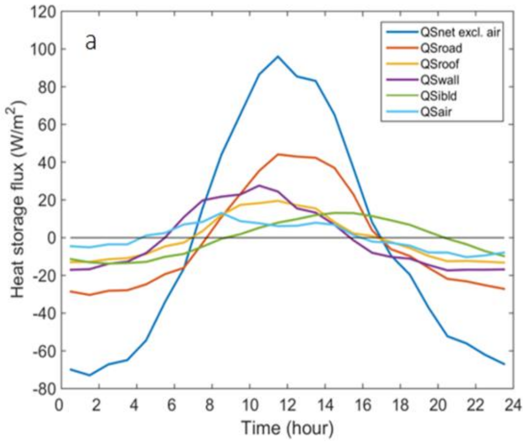
$$\Delta Q_S = \sum_i \frac{\Delta T_i}{\Delta t} \varrho c_i \Delta x_i f_i$$

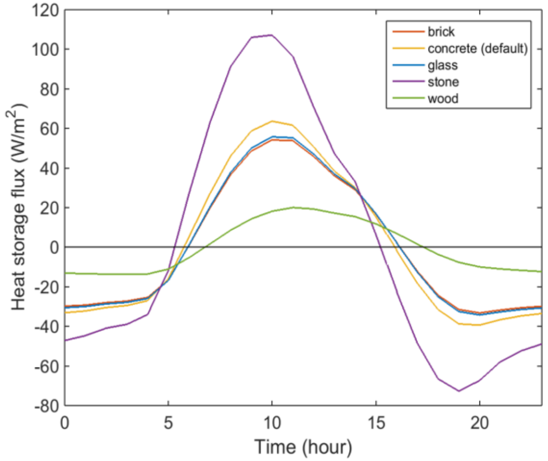
(Offerle et al., 2005)

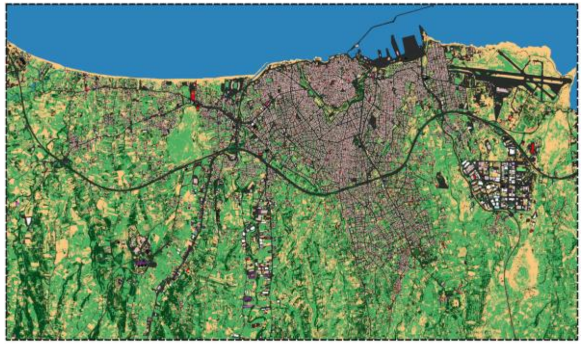


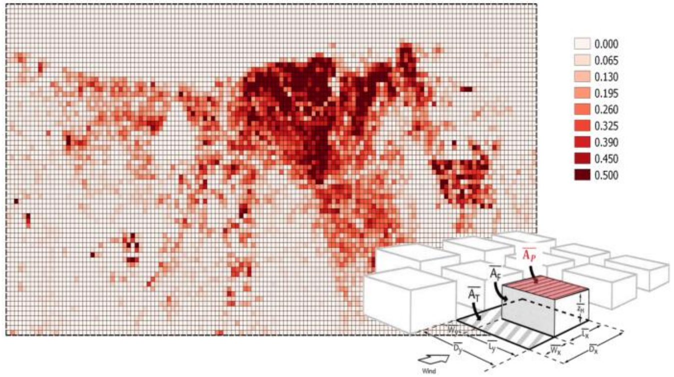


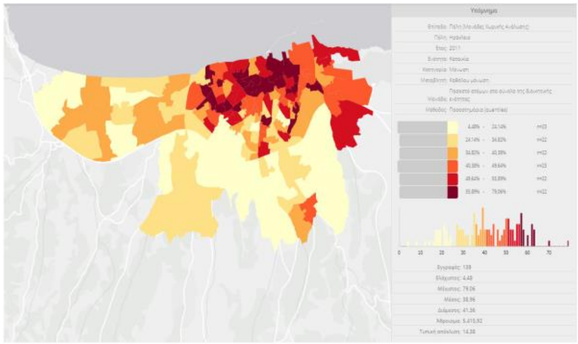


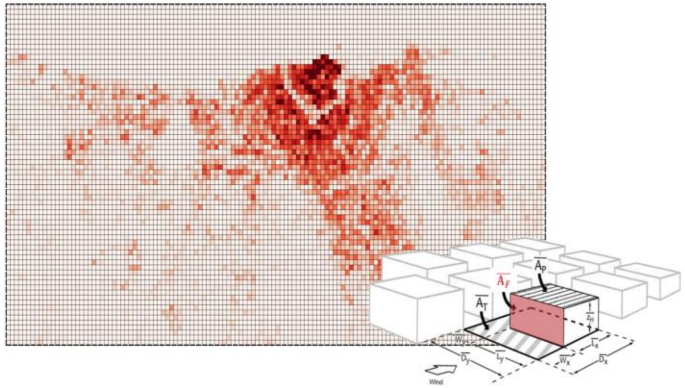


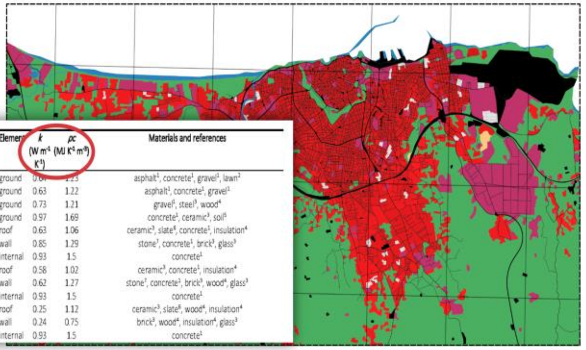




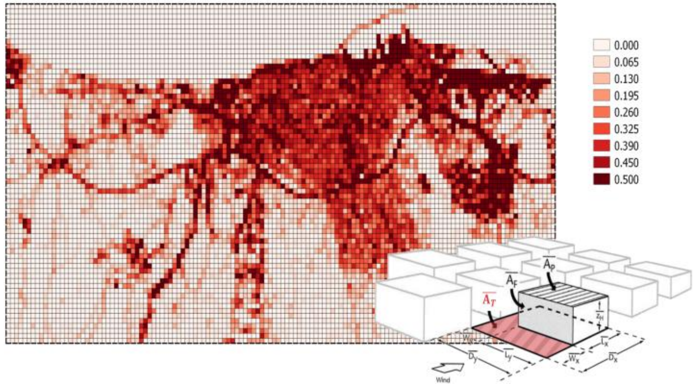




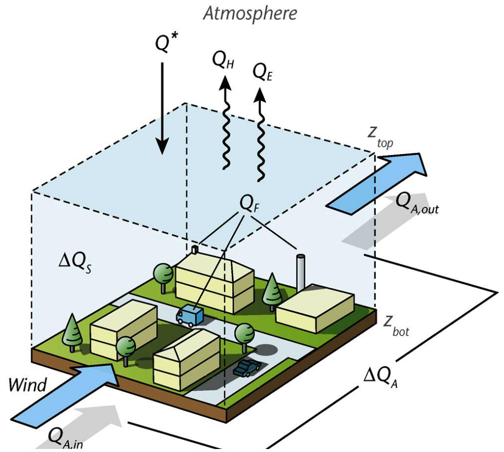


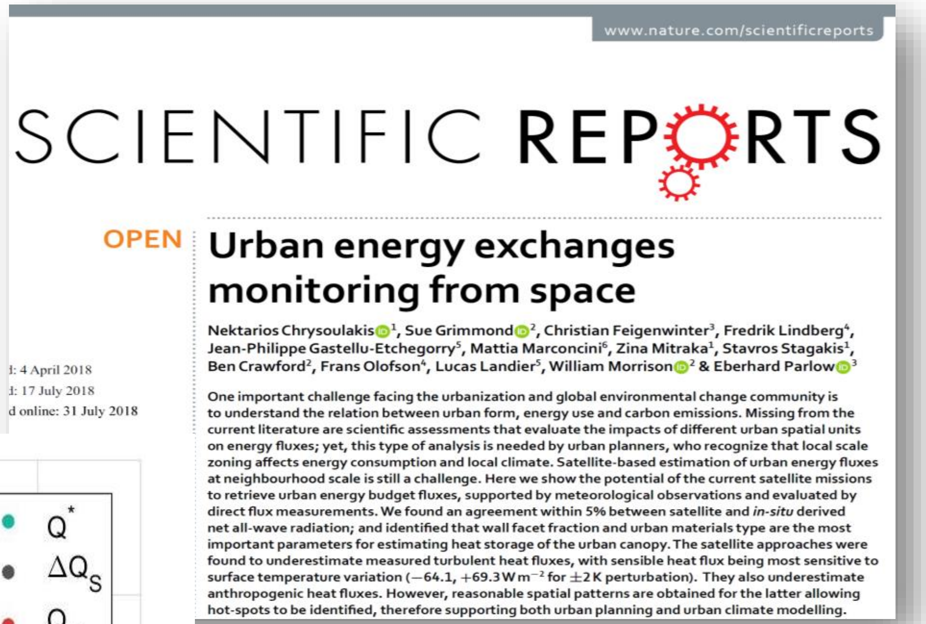


Surface type	Element	k (W m[-1] K[-1])	ρc (MJ K[-1] m[-3])	Materials and references
Paved #1 (L+B)	ground	[illegible]	1.23	asphalt[1], concrete[1], gravel[1], lawn[2]
Paved #2 (L+B)	ground	0.63	1.22	asphalt[1], concrete[1], gravel[1]
Paved #3 (L+B)	ground	0.73	1.21	gravel[1], steel[3], wood[4]
Paved (Barb.)	ground	0.97	1.69	concrete[1], ceramic[3], soil[5]
Building #1 (L)	roof	0.63	1.06	ceramic[3], slate[6], concrete[1], insulation[4]
	wall	0.85	1.29	stone[7], concrete[1], brick[3], glass[3]
	internal	0.93	1.5	concrete[1]
Building #2 (L)	roof	0.58	1.02	ceramic[3], concrete[1], insulation[4]
	wall	0.62	1.27	stone[7], concrete[1], brick[3], wood[4], glass[3]
	internal	0.93	1.5	concrete[1]
Building #3 (L)	roof	0.25	1.12	ceramic[3], slate[6], wood[4], insulation[4]
	wall	0.24	0.75	brick[3], wood[4], insulation[4], glass[3]
	internal	0.93	1.5	concrete[1]



RSLab

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SCIENTIFIC REPORTS

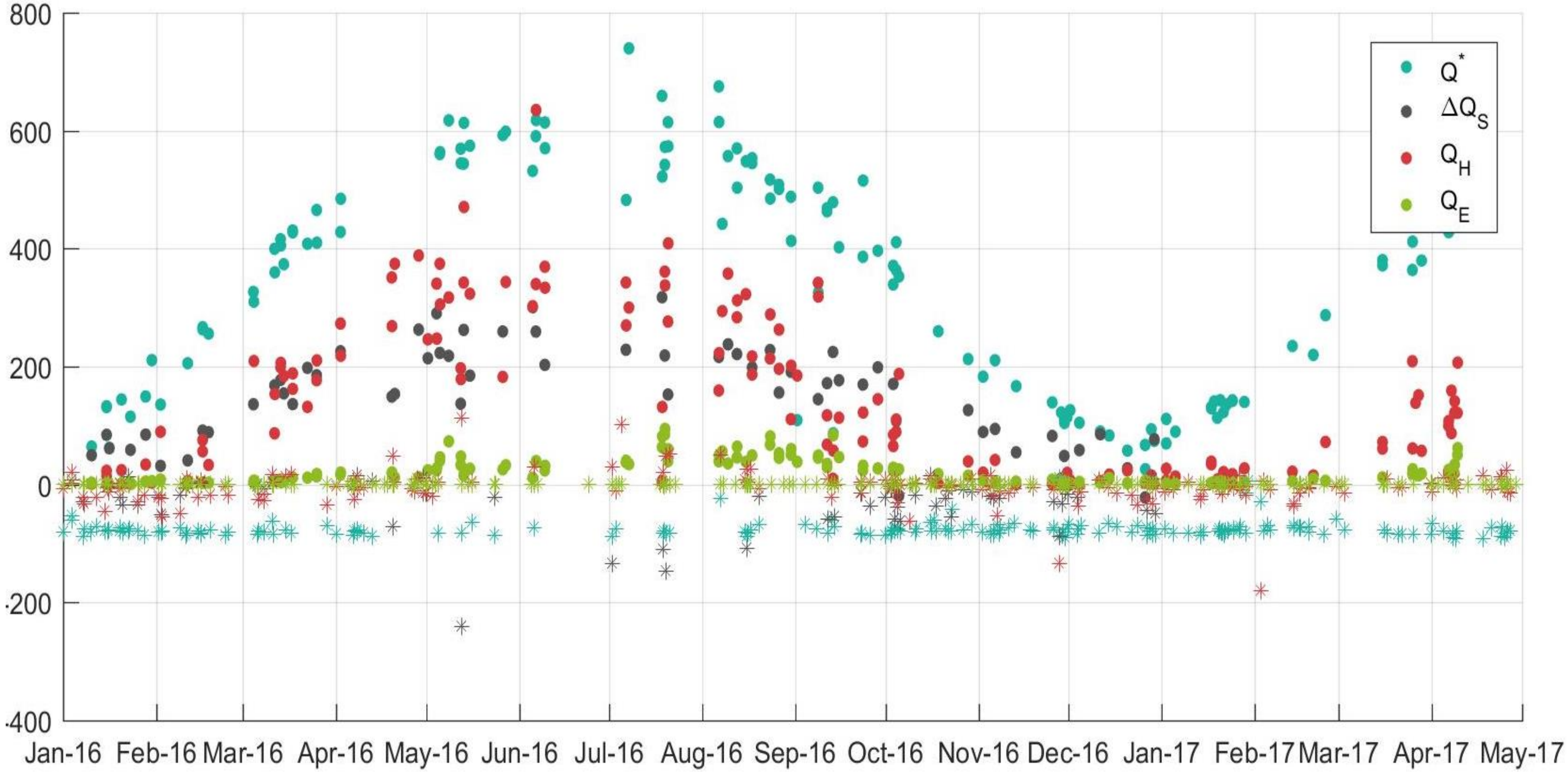
OPEN

Urban energy exchanges monitoring from space

Nektarios Chrysoulakis[1], Sue Grimmond[2], Christian Feigenwinter[3], Fredrik Lindberg[4], Jean-Philippe Gastellu-Etchegorry[5], Mattia Marconcini[6], Zina Mitraka[1], Stavros Stagakis[1], Ben Crawford[2], Frans Olofson[4], Lucas Landier[5], William Morrison[2] & Eberhard Parlow[3]

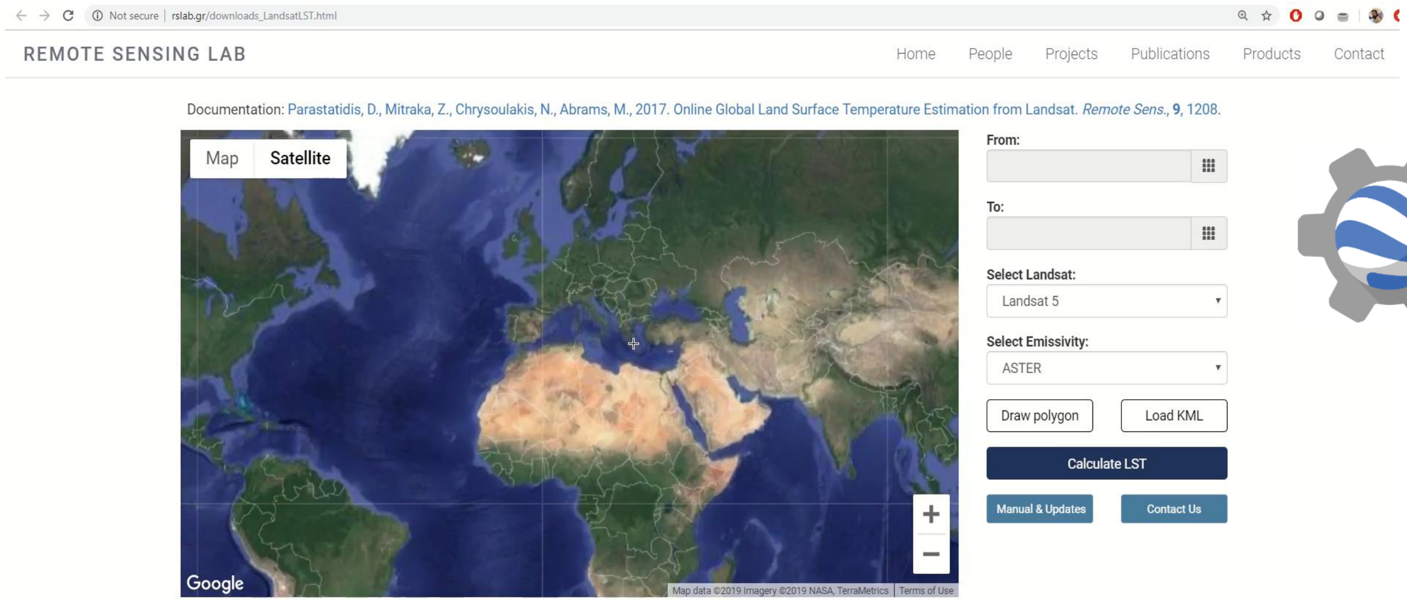
d: 4 April 2018
d: 17 July 2018
d online: 31 July 2018

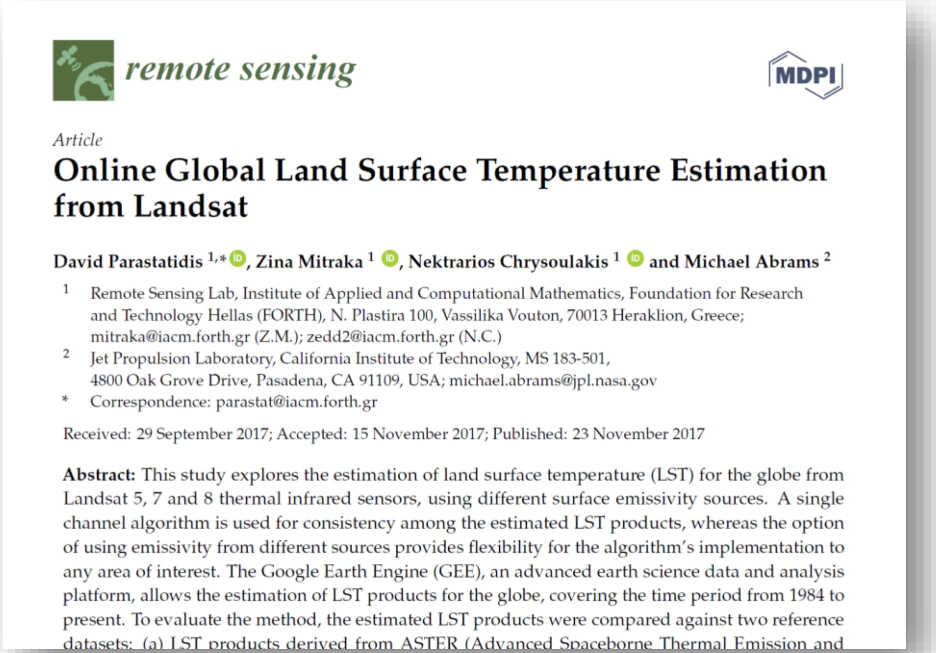
One important challenge facing the urbanization and global environmental change community is to understand the relation between urban form, energy use and carbon emissions. Missing from the current literature are scientific assessments that evaluate the impacts of different urban spatial units on energy fluxes; yet, this type of analysis is needed by urban planners, who recognize that local scale zoning affects energy consumption and local climate. Satellite-based estimation of urban energy fluxes at neighbourhood scale is still a challenge. Here we show the potential of the current satellite missions to retrieve urban energy budget fluxes, supported by meteorological observations and evaluated by direct flux measurements. We found an agreement within 5% between satellite and *in-situ* derived net all-wave radiation; and identified that wall facet fraction and urban materials type are the most important parameters for estimating heat storage of the urban canopy. The satellite approaches were found to underestimate measured turbulent heat fluxes, with sensible heat flux being most sensitive to surface temperature variation (−64.1, +69.3 W m^{-2} for ±2 K perturbation). They also underestimate anthropogenic heat fluxes. However, reasonable spatial patterns are obtained for the latter allowing hot-spots to be identified, therefore supporting both urban planning and urban climate modelling.



URBANFLUXES

http://rslab.gr/downloads_LandsatLST.html




remote sensing

MDPI

Article

Online Global Land Surface Temperature Estimation from Landsat

David Parastatidis [1,*], Zina Mitraka [1], Nektarios Chrysoulakis [1] and Michael Abrams [2]

1 Remote Sensing Lab, Institute of Applied and Computational Mathematics, Foundation for Research and Technology Hellas (FORTH), N. Plastira 100, Vassilika Vouton, 70013 Heraklion, Greece; mitraka@iacm.forth.gr (Z.M.); zedd2@iacm.forth.gr (N.C.)

2 Jet Propulsion Laboratory, California Institute of Technology, MS 183-501, 4800 Oak Grove Drive, Pasadena, CA 91109, USA; michael.abrams@jpl.nasa.gov

* Correspondence: parastat@iacm.forth.gr

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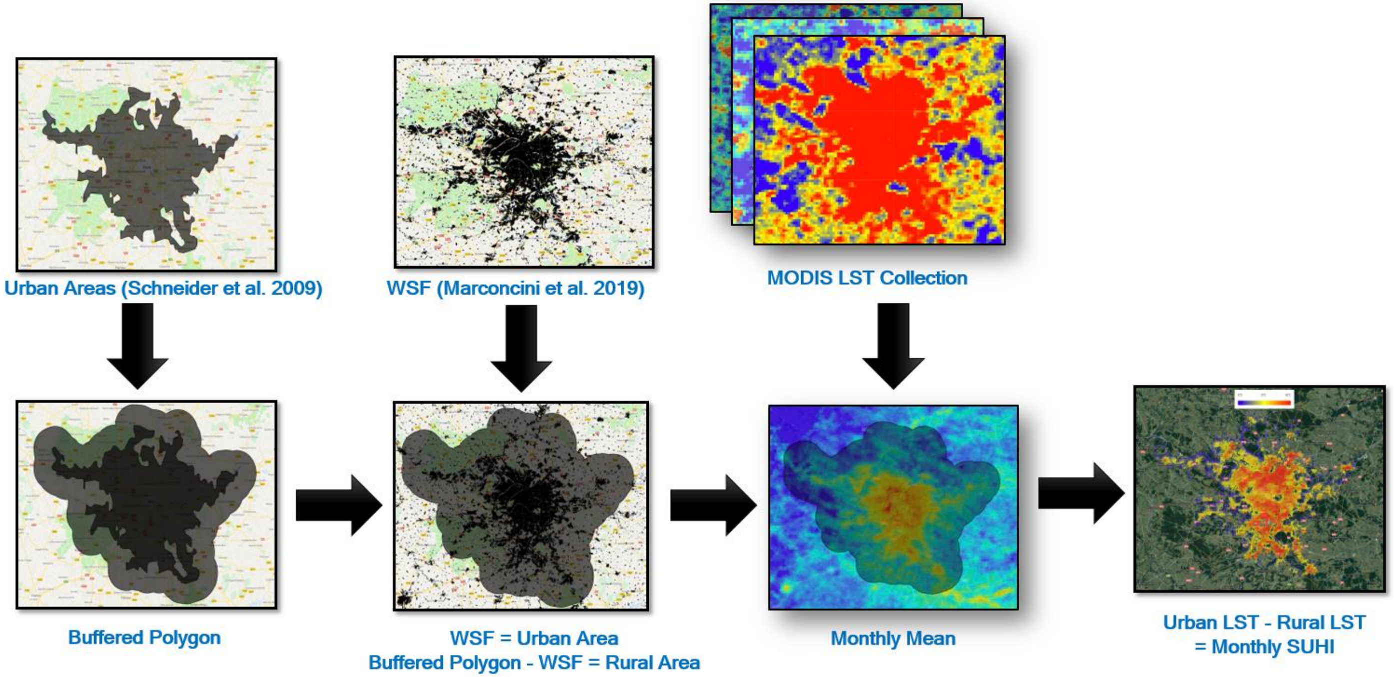
Abstract: This study explores the estimation of land surface temperature (LST) for the globe from Landsat 5, 7 and 8 thermal infrared sensors, using different surface emissivity sources. A single channel algorithm is used for consistency among the estimated LST products, whereas the option of using emissivity from different sources provides flexibility for the algorithm's implementation to any area of interest. The Google Earth Engine (GEE), an advanced earth science data and analysis platform, allows the estimation of LST products for the globe, covering the time period from 1984 to present. To evaluate the method, the estimated LST products were compared against two reference datasets: (a) LST products derived from ASTER (Advanced Spaceborne Thermal Emission and




Sustainable Cities and Society 77 (2022) 103564

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/scs

ELSEVIER

Urban heat island mitigation by green infrastructure in European Functional Urban Areas

Federica Marando [a,*], Mehdi P. Heris [b], Grazia Zulian [a], Angel Udías [a], Lorenzo Mentaschi [c], Nektarios Chrysoulakis [d], David Parastatidis [d], Joachim Maes [a]

[a] European Commission, Joint Research Centre (JRC), Ispra, Italy
[b] Hunter College, Urban Policy & Planning, New York, NY 10065, USA
[c] Department of Physics and Astronomy "Augusto Righi" (DIFA), University of Bologna, Bologna 40127, Italy
[d] Remote Sensing Lab, Institute of Applied and Computational Mathematics, Foundation for Research and Technology Hellas (FORTH), Heraklion 70013, Greece

ARTICLE INFO

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Ecosystem services
Urban green infrastructure

ABSTRACT

The Urban Heat Island (UHI) effect is one of the most harmful environmental hazards for urban dwellers. Climate change is expected to increase the intensity of the UHI effect. In this context, the implementation of Urban Green

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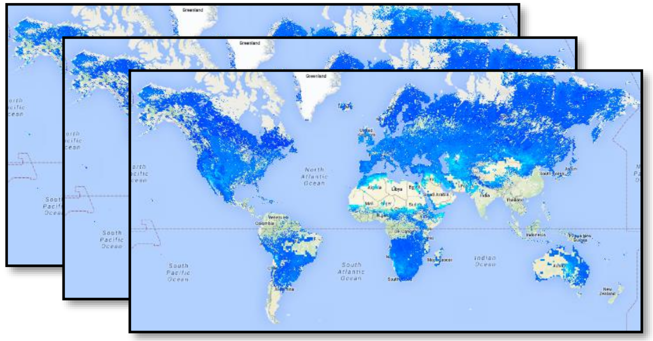
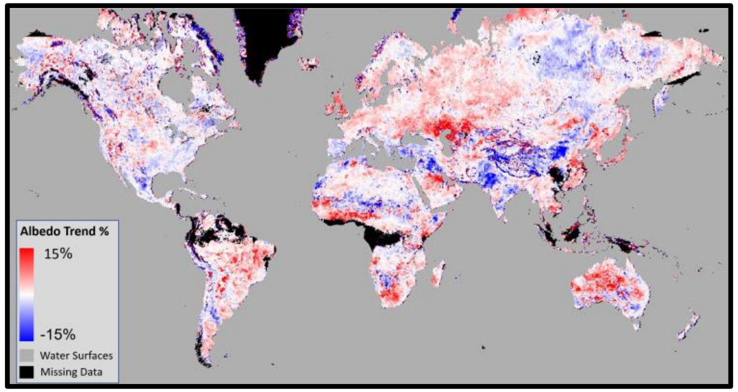
Global 25-years Urban Surface Albedo Trends



Surface Albedo Collection



Surface Albedo Trend

Theoretical and Applied Climatology (2019) 137:1171–1179
https://doi.org/10.1007/s00704-018-2663-6

ORIGINAL PAPER

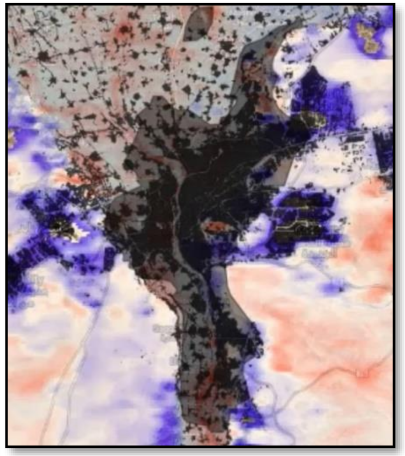
CrossMark

Exploiting satellite observations for global surface albedo trends monitoring

Nektarios Chrysoulakis[1] · Zina Mitraka[1] · Noel Gorelick[2]

Received: 3 January 2018 / Accepted: 8 October 2018 / Published online: 15 October 2018
© Springer-Verlag GmbH Austria, part of Springer Nature 2018

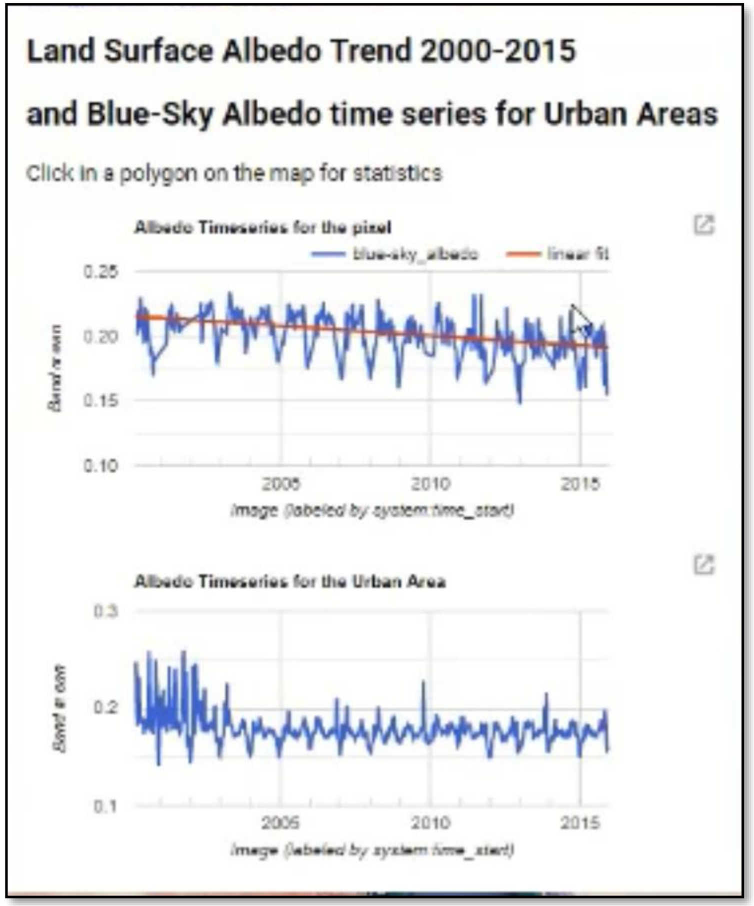
Abstract
Surface albedo is one of the essential climate variables as it influences the radiation budget and the energy balance. Because it is used in a variety of scientific fields, from local to global scale, spatially and temporally disaggregated albedo data are required, which can be derived from satellites. Satellite observations have led to directional-hemispherical (black-sky) and bi-hemispherical (white-sky) albedo products, but time series of high spatial resolution true (blue-sky) albedo estimations at global level are not available. Here, we exploit the capabilities of Google Earth Engine (GEE) for big data analysis to derive global snow-free land surface albedo estimations and trends at a 500-m scale, using satellite observations from 2000 to 2015. Our study reveals negative albedo trends mainly in Mediterranean, India, south-western Africa and Eastern Australia, whereas positive trends mainly in Ukraine, South Russia and Eastern Kazakhstan, Eastern Asia, Brazil, Central and Eastern Africa and Central



Urban areas masking

Urban Areas *(Schneider et al. 2009)*

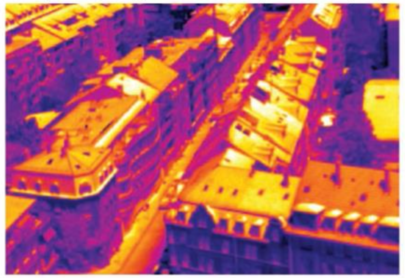
WSF *(Marconcini et al. 2019)*



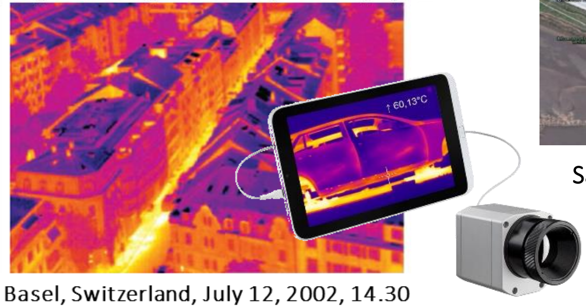
AP	Cross-cutting applications	Berlin	Copenhagen	Sofia	Heraklion	Bristol	Ostrava	Basel	Munich	San Sebastian	Vitoria-Gasteiz
01	Local Scale Surface Temperature Dynamics (FORTH)	•	•	•	•	•	•	•	•	•	•
02	Surface Urban Heat Island Assessment (DLR)	•	•	•	•	•	•	•	•	•	•
03	Urban Heat Emissions Monitoring (UNIBAS)				•			•			
04	Urban CO_2 Emissions Monitoring (UNIBAS)				•			•			
05	Urban Flood Risk (GISAT)				•		•				
06	Urban Subsidence, Movements and Deformation Risk (GISAT)				•		•				
07	Urban Air Quality (VITO)			•		•	•				
08	Urban Thermal Comfort (VITO)		•	•			•			•	
09	Urban Heat Storage Monitoring (FORTH)				•			•			
10	Nature Based Solutions (TECNALIA)			•						•	
11	Health Impacts (socioeconomic perspective) (CWare)		•	•		•					

Map source: European Commission, JRC, GHSL

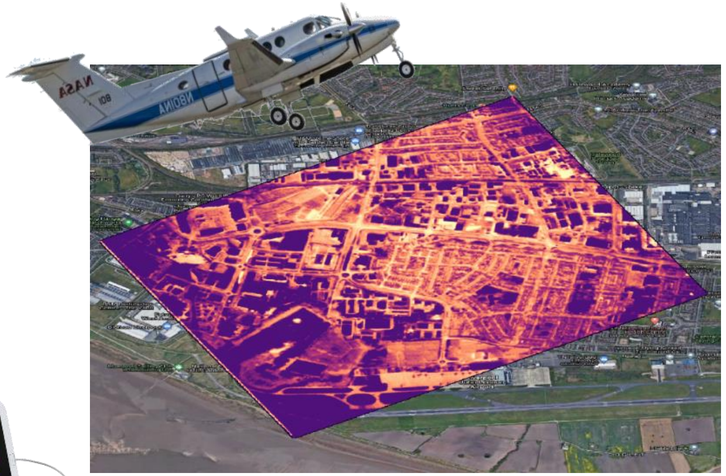
Daytime Brightness Temperature (ºC)



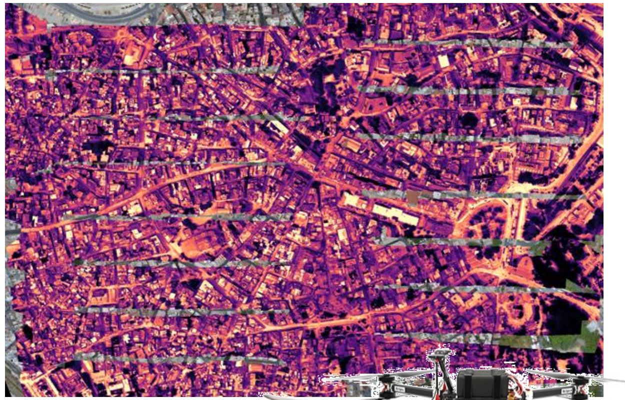
Nighttime Brightness Temperature (ºC)



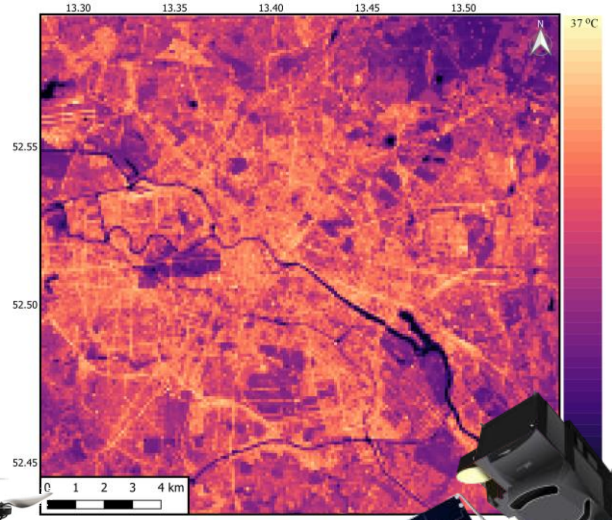
Basel, Switzerland, July 12, 2002, 14.30

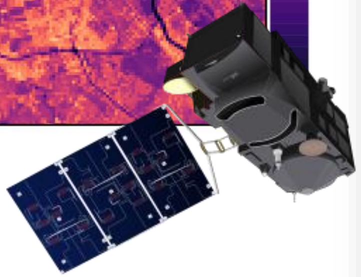


Sample SatVu Simulated Data, Liverpool, 02/03/2021, 21:24

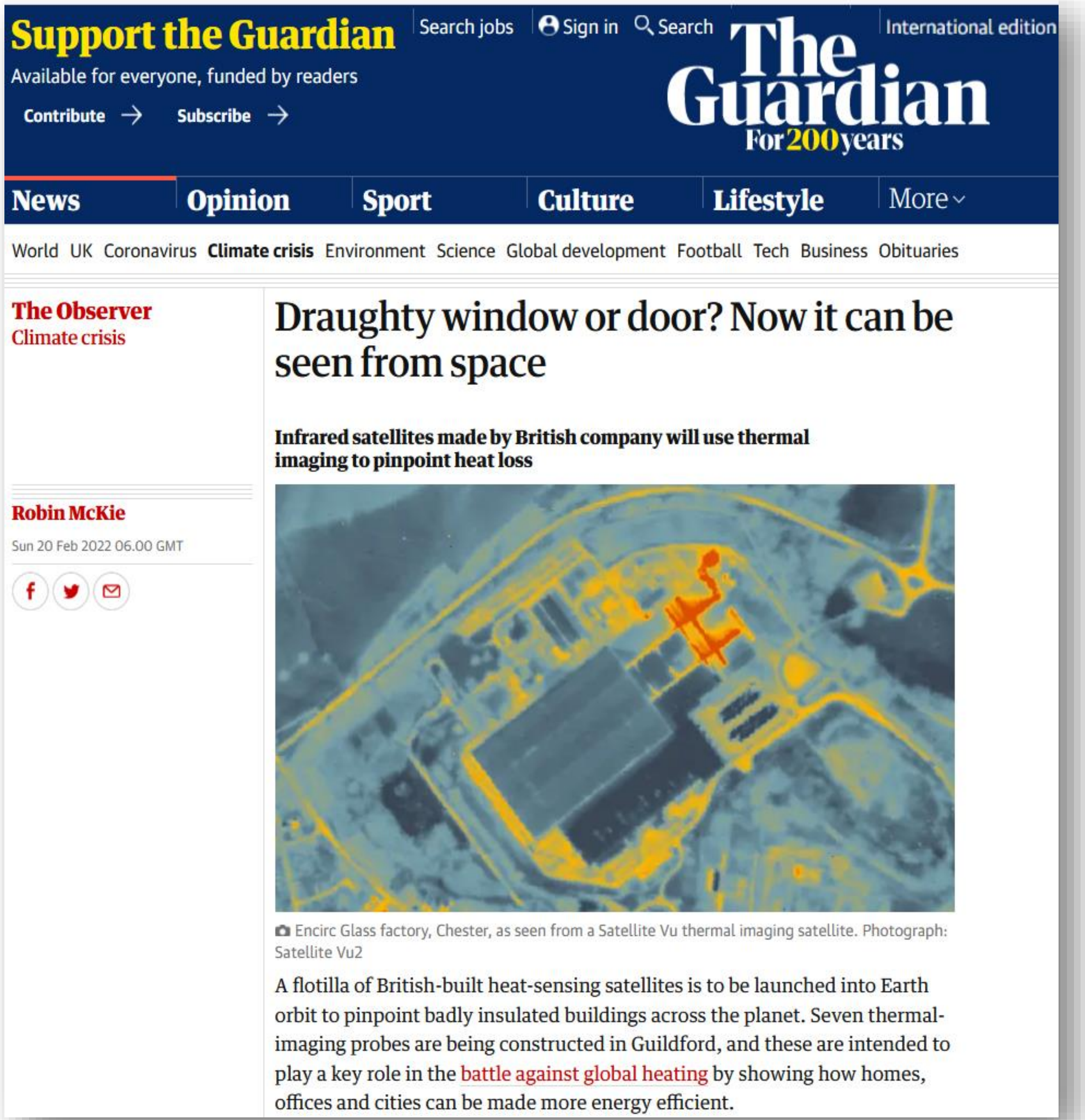


Drone Thermal Campaign, Heraklion, 15/06/2018, 13:2





Downscaled Sentinel-3 Satellite-derived Urban Surface Temperature Berlin - Berlin, 11.26 local time 30/05/2019



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The Observer
Climate crisis

Draughty window or door? Now it can be seen from space

Infrared satellites made by British company will use thermal imaging to pinpoint heat loss

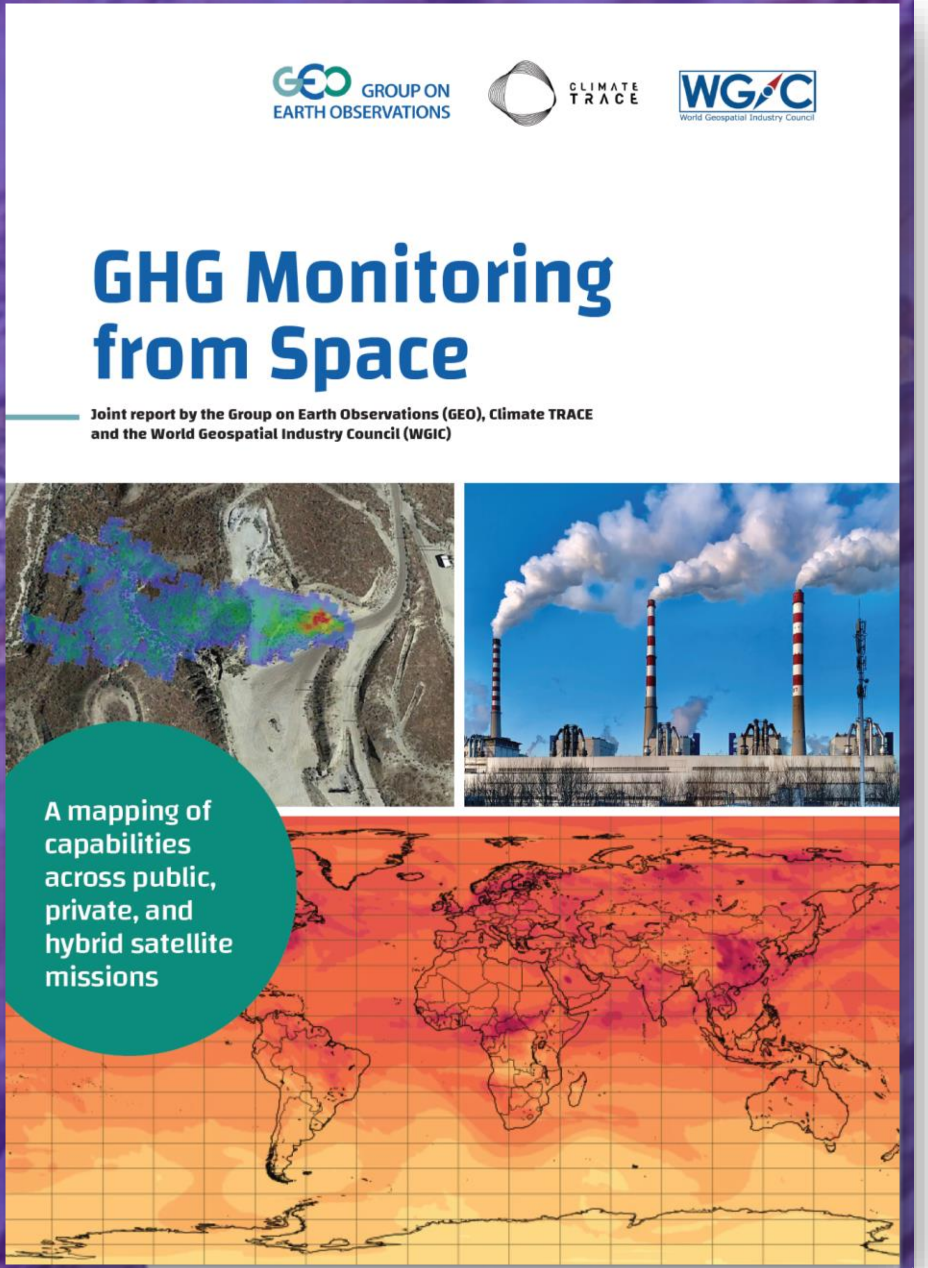
Robin McKie

Sun 20 Feb 2022 06.00 GMT

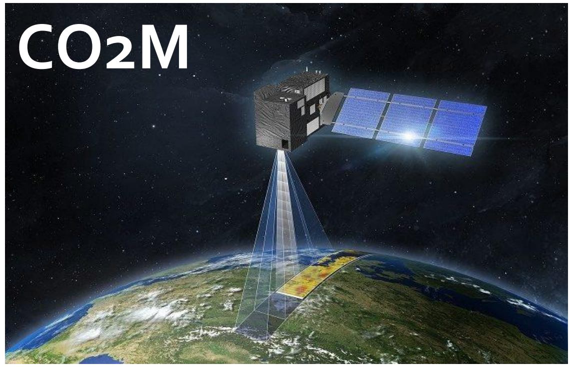
Encirc Glass factory, Chester, as seen from a Satellite Vu thermal imaging satellite. Photograph: Satellite Vu2

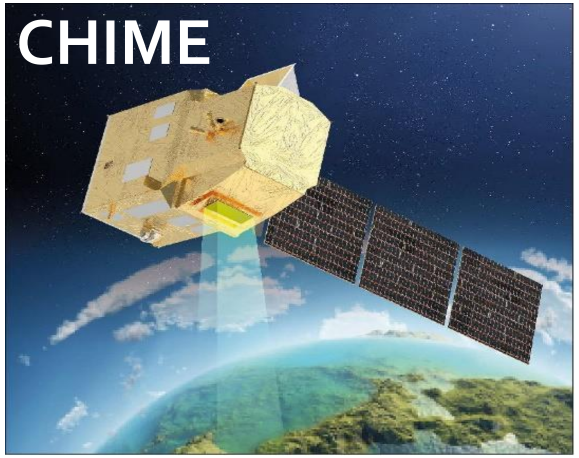
A flotilla of British-built heat-sensing satellites is to be launched into Earth orbit to pinpoint badly insulated buildings across the planet. Seven thermal-imaging probes are being constructed in Guildford, and these are intended to play a key role in the battle against global heating by showing how homes, offices and cities can be made more energy efficient.

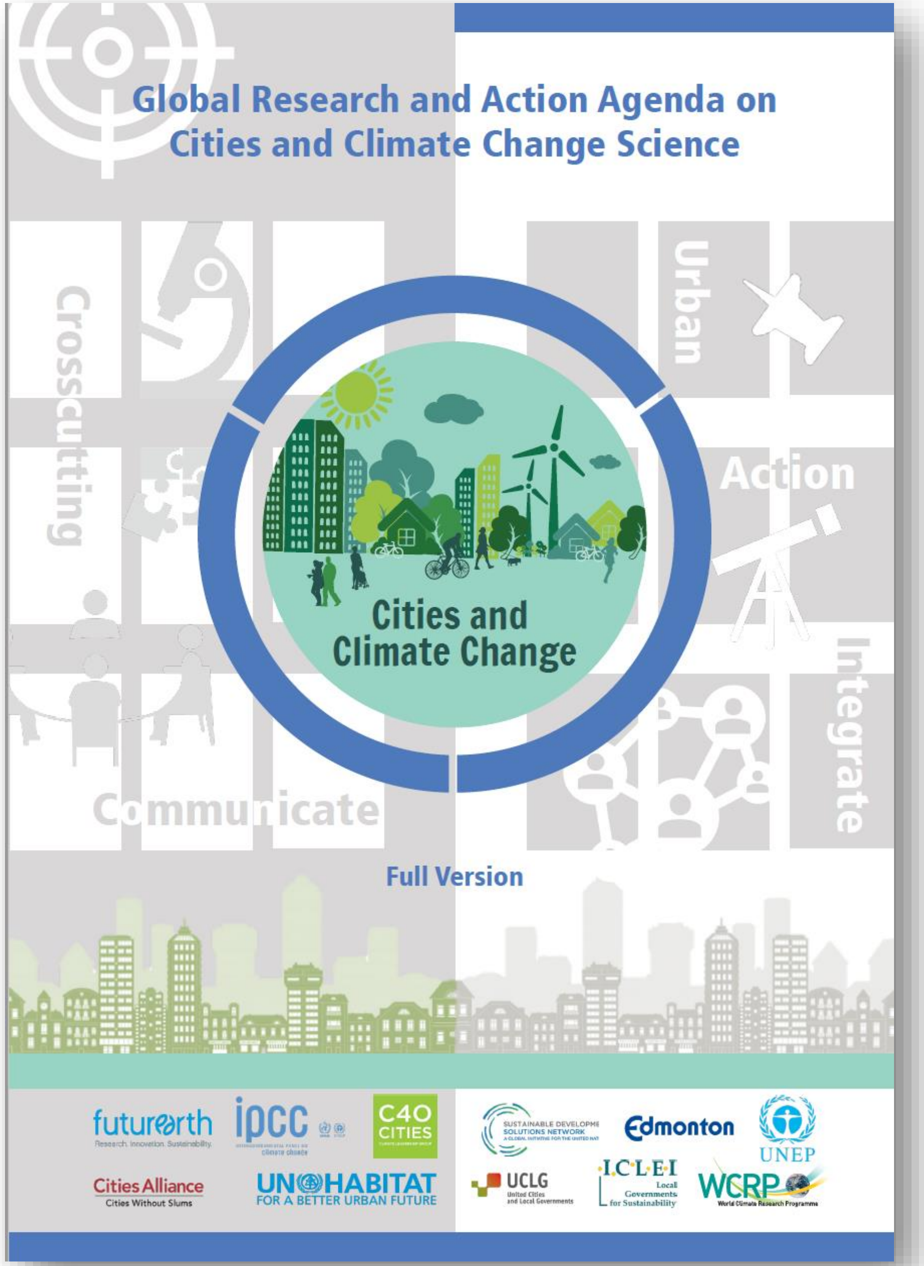

CARBON MAPPER
Google Ear


GROUP ON EARTH OBSERVATIONS
CLIMATE TRACE
WGIC
World Geospatial Industry Council
GHG Monitoring from Space
Joint report by the Group on Earth Observations (GEO), Climate TRACE and the World Geospatial Industry Council (WGIC)
A mapping of capabilities across public, private, and hybrid satellite missions

(NASA 2021)







Polices:

- ✓ SDG 11 and GEO SBAs
- ✓ New Urban Agenda
- ✓ Paris Agreement
- ✓ Covenant of Mayors
- ✓ NBS initiative
- ✓ European Green Deal
- ✓ 2030 Energy Strategy
- ✓ IPCC AR7

Nektarios Chrysoulakis
Director of Research - Head of RSLab

Zina Mitraka
Assistant Researcher
Earth Observation for Urban Climate

Dimitris Poursanidis
Postdoctoral Fellow
Environmental Mapping & Monitoring

Giorgos Somarakis
Postdoctoral Fellow
Urban Sustainability & Resilience Planning

Michael Foumelis
Collaborating Researcher
Imaging Geodesy - Geohazards Monitoring

George Kochilakis
Collaborating Research Assistant
Spatial Data Analysis & Management

Nektarios Spyridakis
Collaborating Technician
Scientific Equipment Management

Giannis Lantzanakis
Research Assistant
Machine Learning - Algorithm Development

David Parastatidis
Research Assistant
Cloud Computing - GIS Analysis & Applications

Manolis Panagiotakis
Research Assistant
Urban Environment & Climate Modelling

Konstantinos Politakos
Research Assistant
Urban CO2 Emissions Monitoring

Maria Gkolemi
Research Assistant
Algorithm Development - Deep Neural Networks

Stavros Stagakis
Urban Environment Monitoring

Dimitris Tsirantonakis
Research Assistant
Urban Environment & Climate Monitoring

Vasileios Geladaris
Research Assistant
Computer Science - Geospatial Applications

Iosif Doundoulakis
Artificial Intelligence - Spatial Planning & Development