Solar energy potential assessment on urban rooftops using digital surface models

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Abstract →
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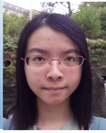


1 Background and Objectives

- Rooftop solar photovoltaic (PV) systems produce electricity
  - without air pollution and greenhouse gas emissions and reduce carbon footprint
- Study objectives:
  - assess physical and geographical levels of solar energy potentials in actual atmospheric conditions (**clouds and aerosols**) on urban rooftops based on digital surface models (DSM)
  - derive economic relevance of rooftop PV systems

2 Study Area

- Very High Resolution (1.1 m x 1.1 m) DSM for 2 neighborhoods in **Athens**, Greece ->
- Allow to calculate **aspect**, **slope** and consequently **shadows** for individual rooftops
- e.g. an area in city-center with 2986 rooftops (0.68 km^2)

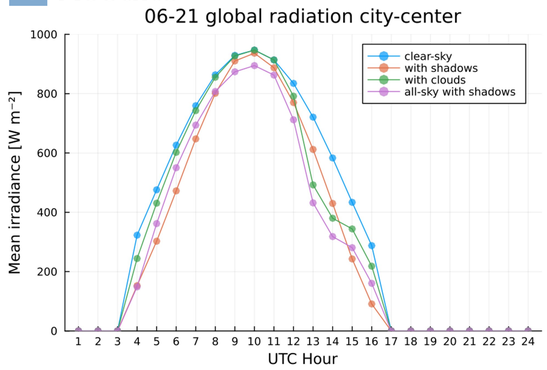
3 Data and Methods

(1) **Dry clean** clear-sky irradiance by QGIS GRASS r.sun
- National Renewable Energy Laboratory sun position algorithm
- input: elevation, aspect, slope and date/time/**shadow** parameters

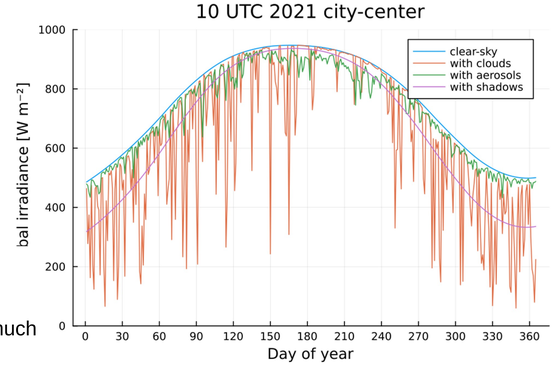
(2) **Clouds and aerosols**
- Global horizontal irradiance (GHI) all-sky / clear-sky (_CS) → Cloud modification factor
- Aerosol optical depth (AOD)

Data	Product	Temporal resolution	Reference
GHI & GHI_CS	CAMS radiation service	every 15 min	Qu et al., 2017
AOD at 550 nm	EAC4	every 3 h	Inness et al., 2019

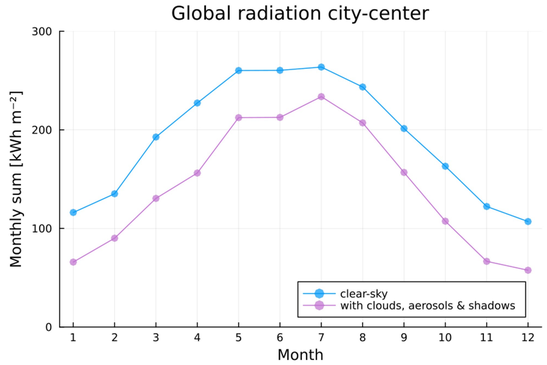
4 Results



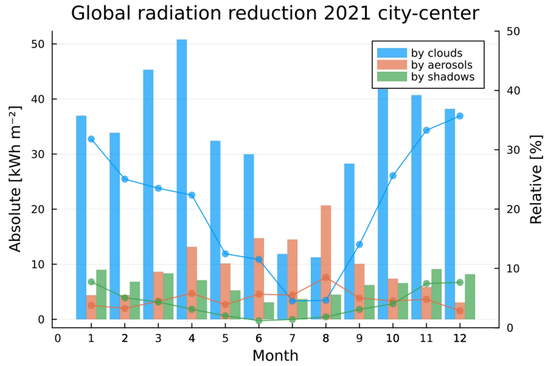
(1) hourly irradiance
- summer sunny day: small difference between clear-sky and when considering clouds
- except a few hours overcast in the afternoon



(2) daily irradiance in a year
- under clear-sky or with shadows has relatively small inter-day variation
- with clouds or with aerosols fluctuates much more from day to day



(3) monthly radiation
- differences between both conditions range from ~30 kWh (Jul.) to > 60 kWh (Mar. and Apr.)



(4) radiation reduction by 3 factors
- clouds account for > 50 kWh m^{-2} of reduction in Apr.
- followed by aerosols: seasonally more significant in spring and summer
- shadowing effect small through the year, though in winter more pronounced than aerosols

5 Conclusions

(1) Digital surface models serve as a helpful tool to assess urban rooftop solar potential.
(2) We demonstrate effects of atmospheric compositions and urban shadows on solar radiation:
- clouds effect up to > 30%
- aerosols and shadows generally < 5% in most months

Acknowledgement
This work is supported by the EU project “Eiffel Revealing the role of GEOSS as the default digital portal for building climate change adaptation & mitigation applications”, Grant agreement ID: 101003518

6 Application

Web map displaying solar potential and economic relevance

Qu, Z. et al., (2017). Fast radiative transfer parameterisation for assessing the surface solar irradiance: The Heliosat-4 method. Meteorol. Z., 26, 33–57.
Inness, A. et al., (2019). The CAMS reanalysis of atmospheric composition, Atmos. Chem. Phys., 19, 3515–3556.

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