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A big data approach to estimate available roof area for solar PV installation at national scale

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The installation of solar photovoltaic (PV) panels on building rooftops, particularly in dense urban areas where space is rare, is a promising solution to reduce greenhouse gas emissions. However, several factors impact the potential roof area for installation of PV panels on buildings. These include (i) the effect of shading from surrounding roofs, trees or objects (shaded area factor), (ii) the impact of roof shape on the number of PV panels that can be placed on its surface (panelled area factor), and (iii) roof superstructures such as dormers, chimneys or windows. Many studies estimate the above factors using statistical methods focusing on city/district scales. Very few studies, however, estimate the above variables using computational methods at national scale. Recent advances in geographic and remote sensing data collection, availability of various building data, as well as enhanced computational resources allow us to estimate the available roof area for solar PV installation at national scale more accurately using a big data framework.

Focusing on Switzerland as a case study, we estimate available roof area for PV installation at national scale. This requires the combination of a large variety of datasets, including (i) a Digital Surface Model (DSM) of the entire country in (2x2)m2 resolution, (ii) roof geometry polygons of 9.7M roof surfaces, representing all 3.7M buildings in Switzerland, and roof superstructure polygons in the Canton of Geneva, (iii) detailed building information for the 1.6M registered residential buildings in the country. To process the high volume of data, we propose a methodology which combines high-performance computing and Machine Learning (ML) techniques. Using highly parallelised GIS workflows, we compute the first two factors mentioned above, namely shaded area factors and panelled area factors for each roof surface. The former is based on viewshed analysis of the DSM over the entire country at hourly scale. The latter is estimated using a geospatial algorithm to place panel-shaped polygons on each roof surface in the study area.

The data to quantify the effects of roof superstructures on available area for PV installation is only available for a subset of the study area. A ML regression model is hence used to infer superstructure effects from building information, and to predict these effects for the rest of Switzerland. We compare five different ML algorithms and show the better performance of our model compared to the standard approach of using a constant scale factor. Furthermore, combining large datasets from various sources requires a careful handling of missing data and the quantification of resulting uncertainties. We discuss the uncertainty arising from discrepancies between datasets created at different times and in different formats as well as the modelling uncertainty, which is introduced during data processing. The latter is computed from the estimations of the best-performing ML algorithm, Random Forests. We hence obtain an estimate for the available area for rooftop PV installation in Switzerland and the related uncertainties. The results show a total available area for rooftop PV installation of 267m2 for the 3.7M buildings in Switzerland.