The Impacts of Solar Resource Variability on Regional Aggregate Photovoltaic Power Time Series

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ICEM 2018, Shanghai, China

22nd May 2018

Introduction

- Estimates of solar PV resource are widely used in energy systems models
- Models often require a single power profile for all PV installations within a very large area
- The output of PV arrays can decorrelate over relatively short distances
- What are the implications of this, particularly with reference to the key parameters for energy system models?

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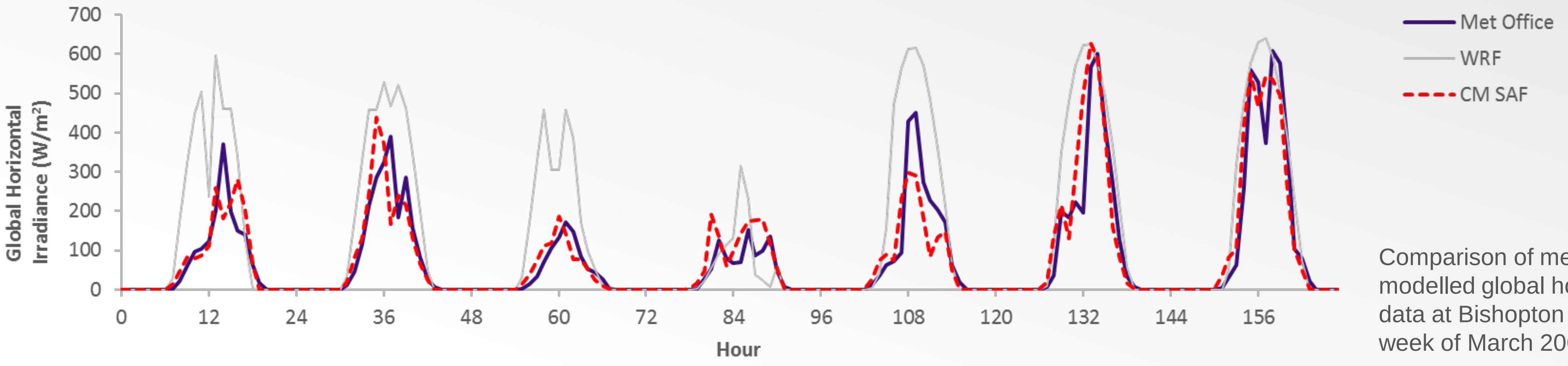
Dataset development



Comparison of measured and modelled global horizontal irradiance data at Bishopton (PA7) for the last week of March 2001 [1-3]

- Analysis based on a solar PV resource dataset developed for use in Scottish energy system models
- Raw satellite weather data from the Meteosat EU meteorological satellite (EUMETSAT) post-processed by the Satellite Application Facility on Climate Monitoring (CM SAF) [3]
- Simple isotropic sky model used to translate data to an inclined surface [4]

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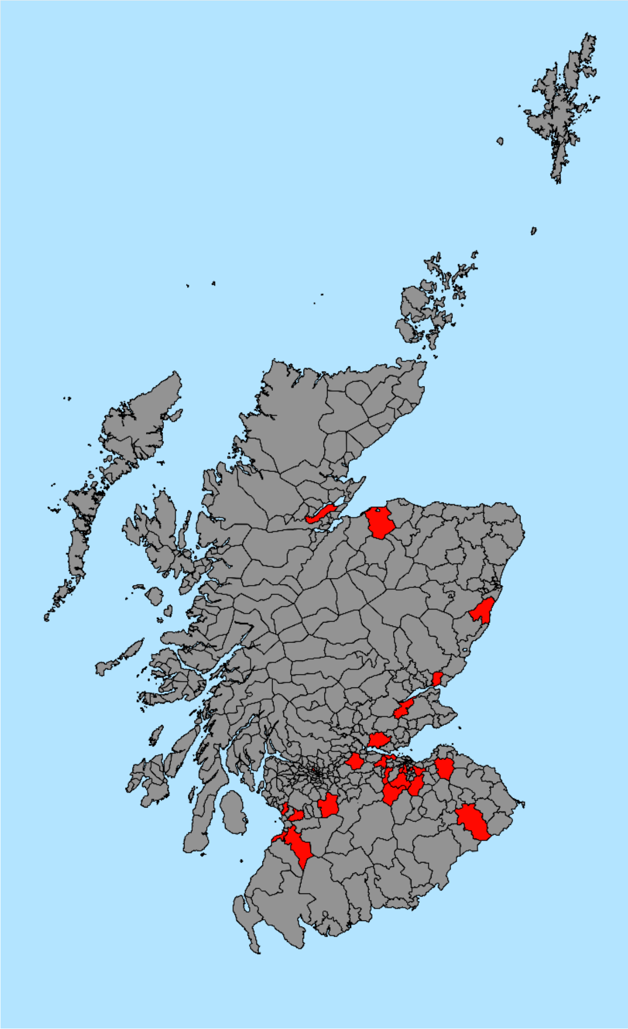
Dataset development

- Validated against reported output of 28 installations in Scotland [5]
- Mean $R^2 = 0.72$
- Mean $\rho = 0.83$

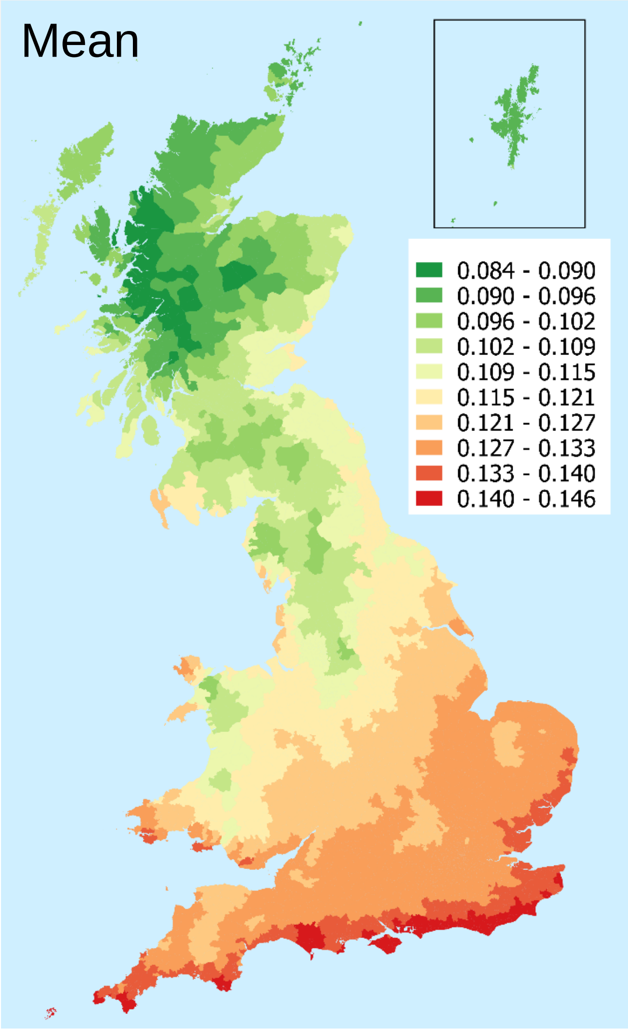
- Three typical installations were defined:

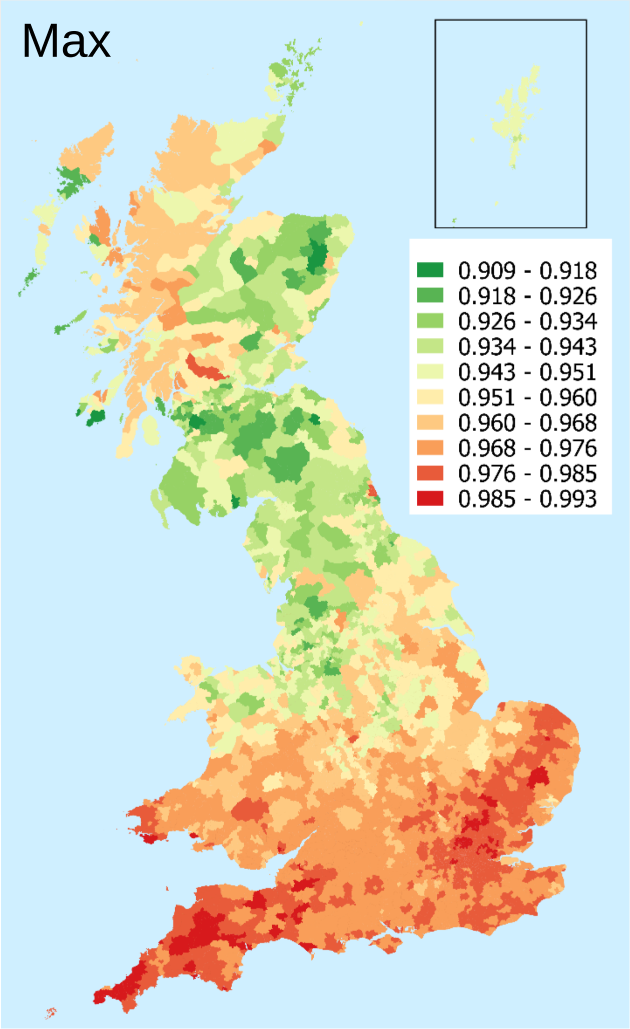
	Installed capacity	*Orientation*	*Tilt*	*Inverter capacity*	*Inverter efficiency*
Domestic (roof-mounted)	4 kW	27% SW, 49% S, 24% SE	35°	3.68 kW	96%
Roof-mounted commercial	10 kW	27% SW, 49% S, 24% SE	35°	2 x 5 kW	96.5%
Ground-mounted commercial	5 MW	S	35°	100 x 50 kW	98.5%



Power output across GB

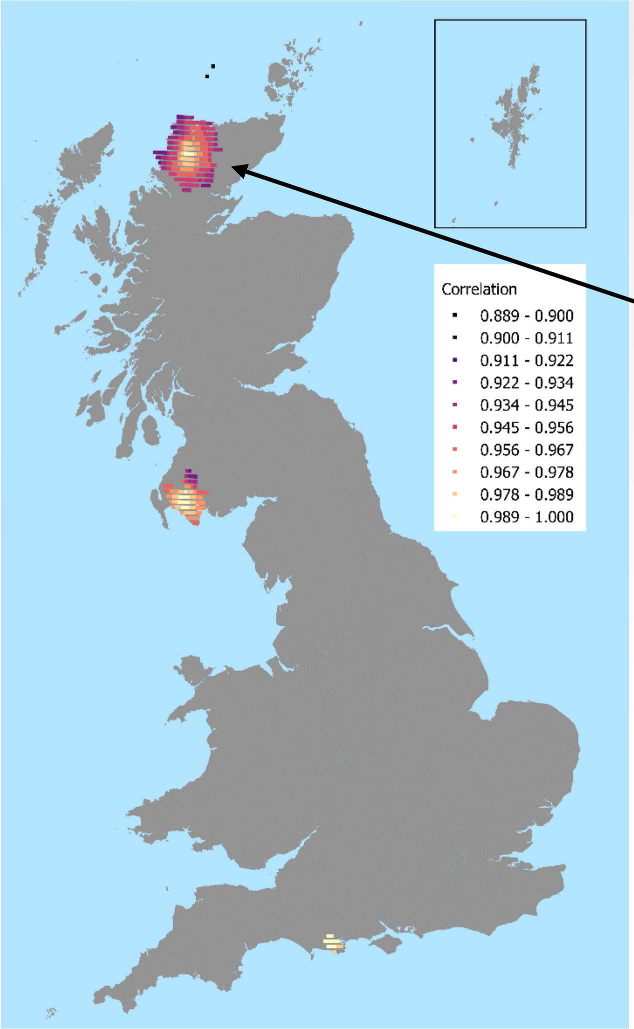
- Hourly power profiles developed for each type of installation across all postcode districts
- Figures show aggregated results from 2000-2015 for a typical roof-mounted array
- Values shown are per unit of installed capacity

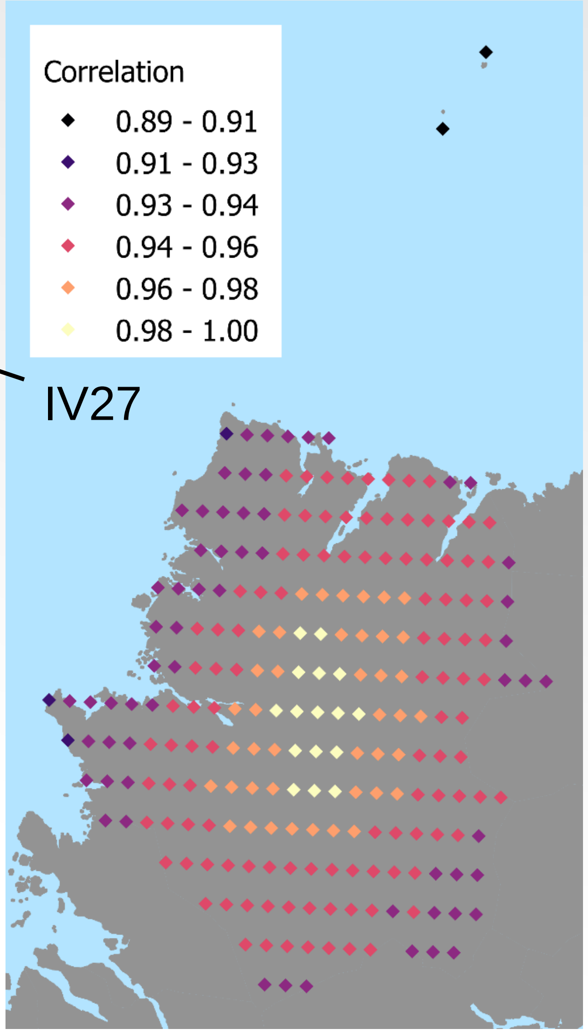




Variation across postcodes

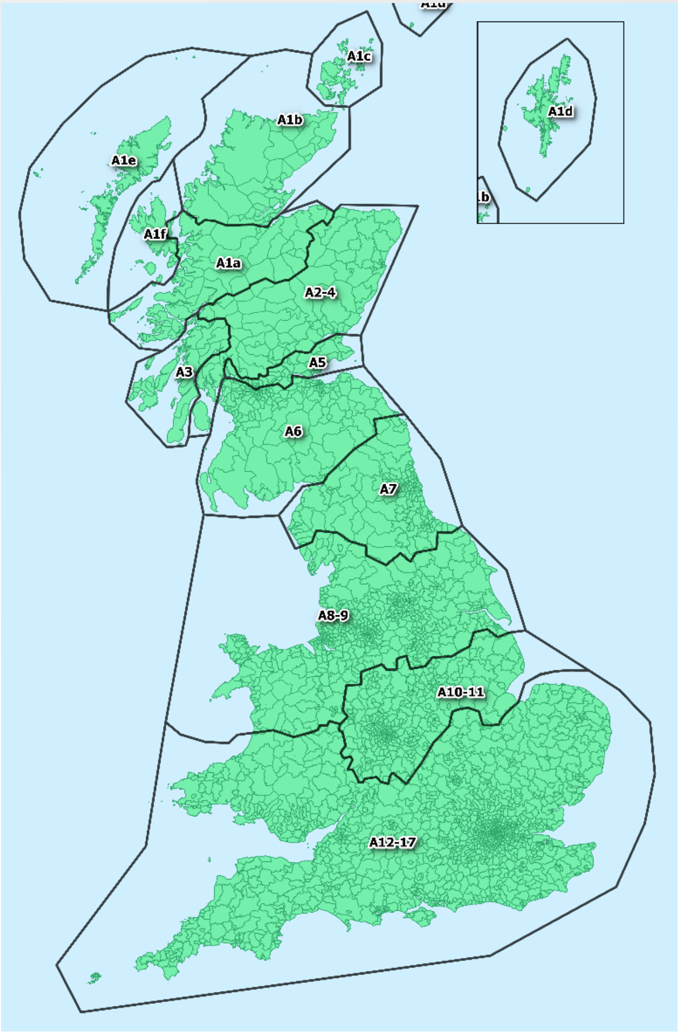
- Analysis of irradiance for 2015
- Correlation of grid points with postcode centroid
- Minimum correlation coefficient 0.89
- Reduces with distance





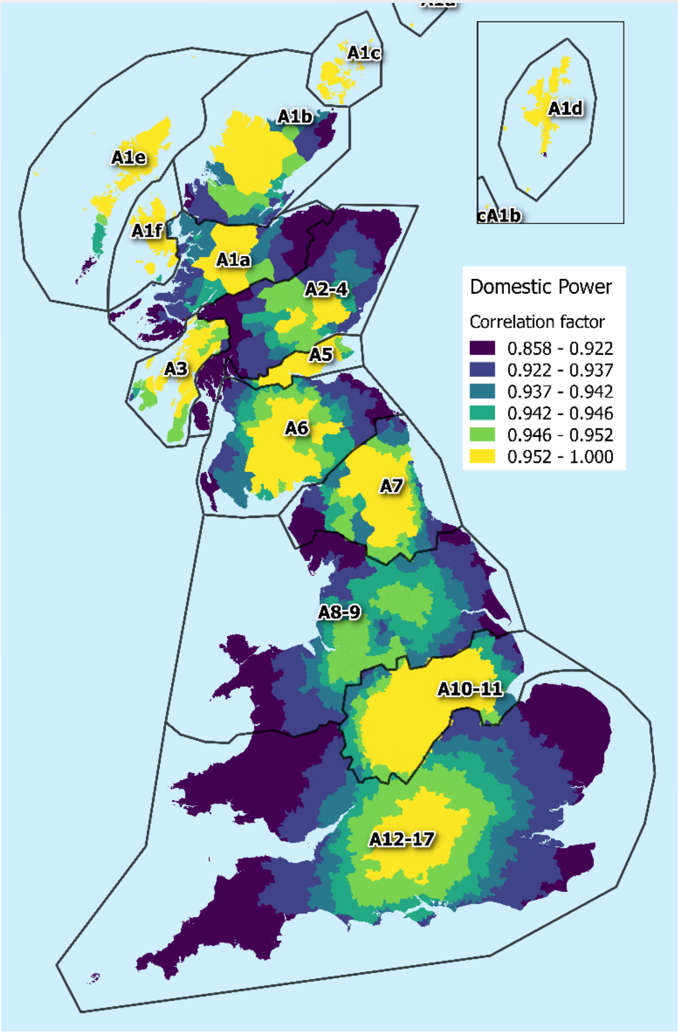
Energy Modelling

- Energy systems models simplify the network into a handful of nodes with corresponding zones [6]
- Impact of aggregating solar data for these zones, with particular reference to:
  - Instantaneous power
  - Ramp rate
  - Daily peak power
  - Time of daily peak

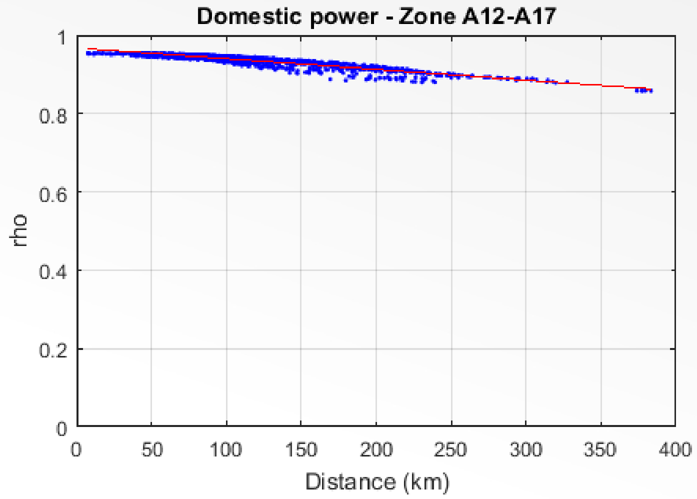


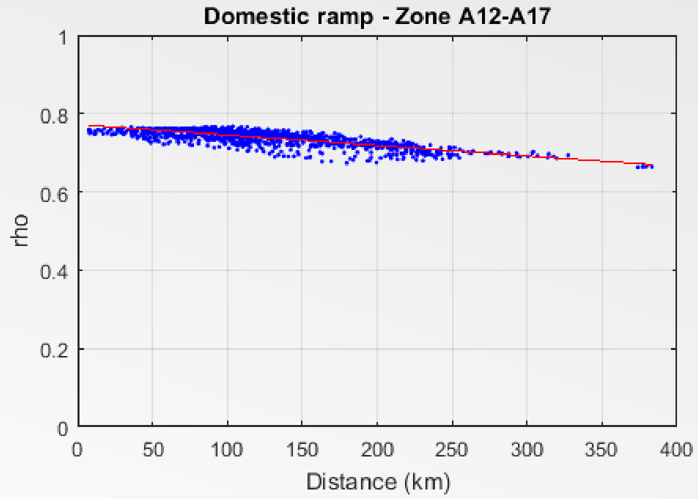
Variation across zones

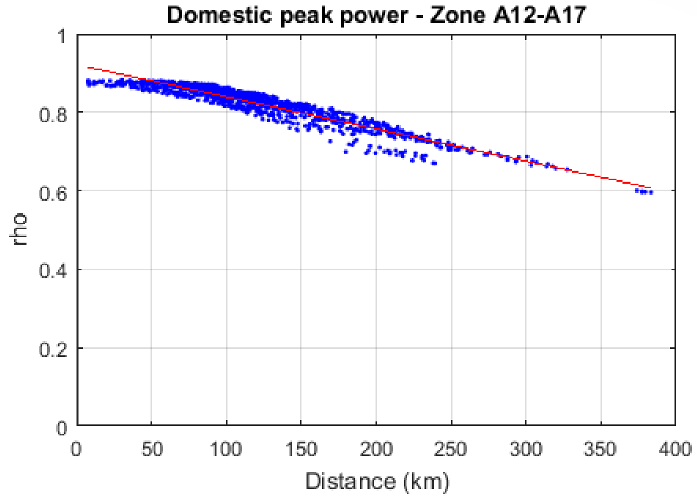
- Correlation of each postcode with the corresponding zonal mean
- Min ρ_{power} = 0.85, Mean = 0.94
- Min ρ_{ramp} = 0.58, Mean = 0.74
- Min ρ_{peak_power} = 0.58, Mean = 0.84
- Min ρ_{peak_time} = 0.03, Mean = 0.38

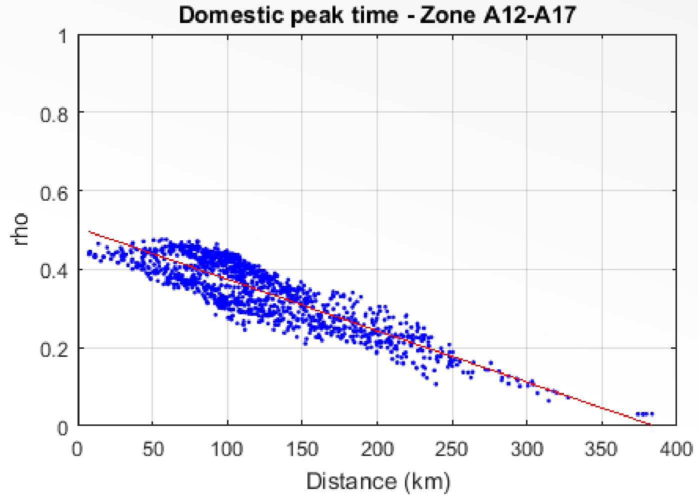


Correlation against distance - Domestic









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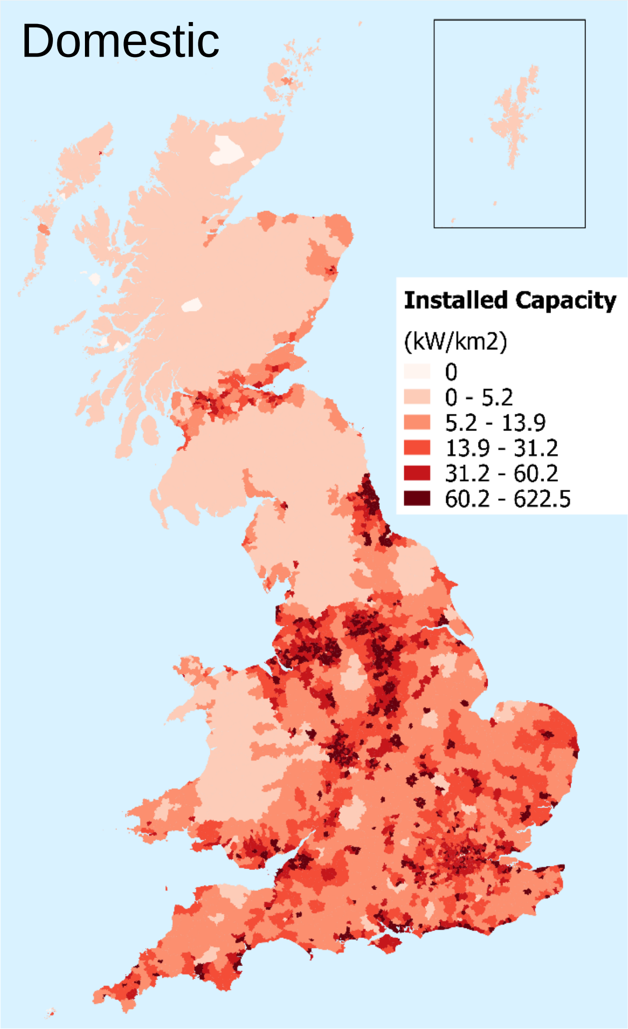
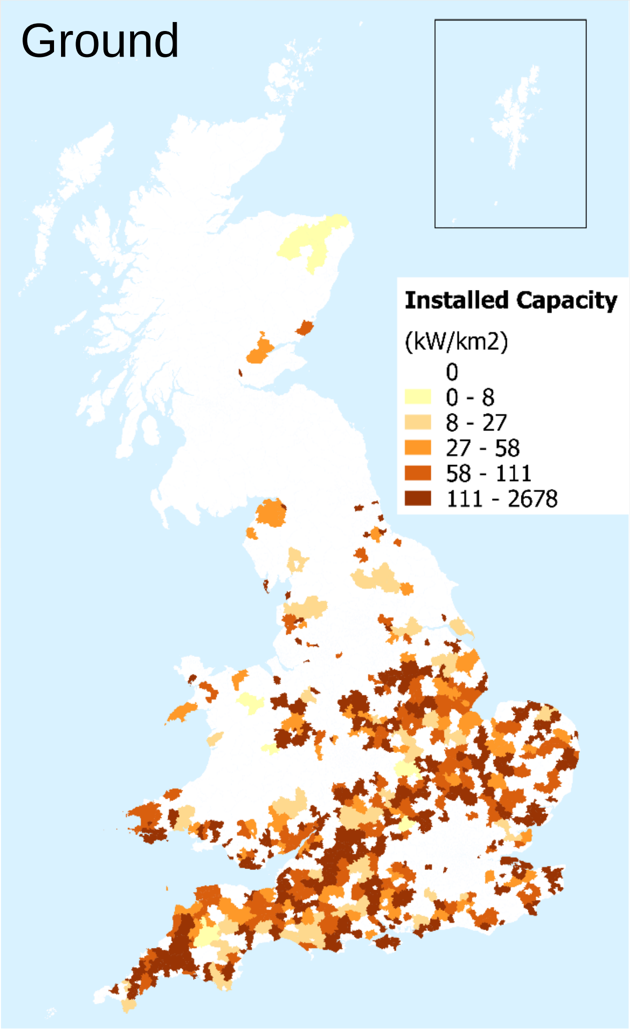
Spatial variation of installed capacity

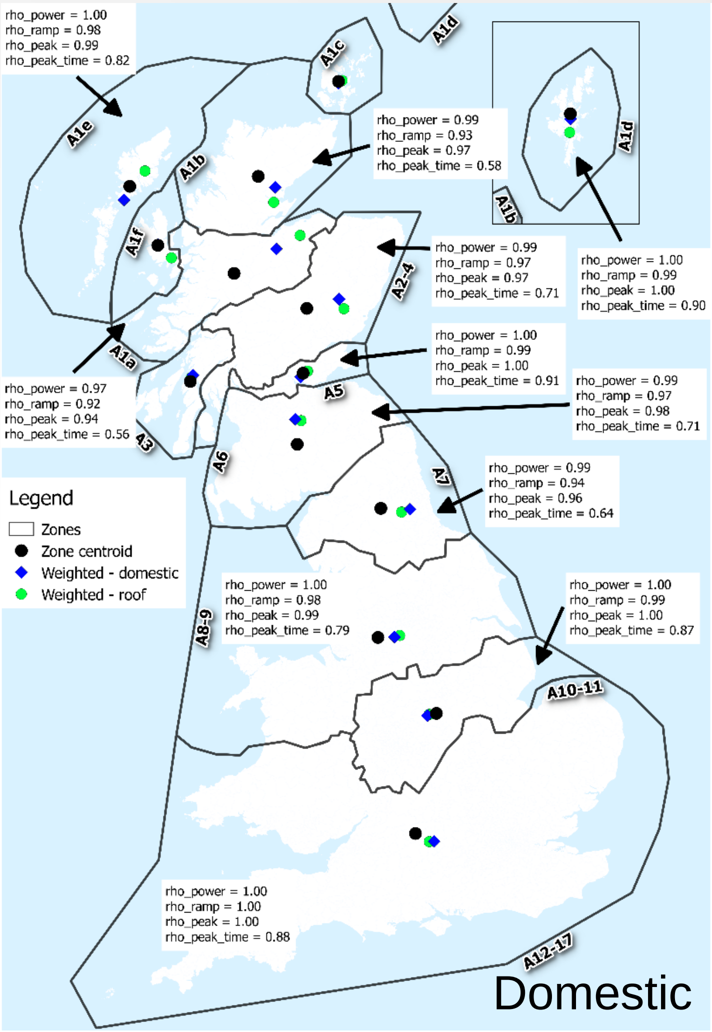
- Current and future installed capacity may not be evenly distributed across zones
- Data on capacity at end of 2016 extracted from UK government information [7,8]

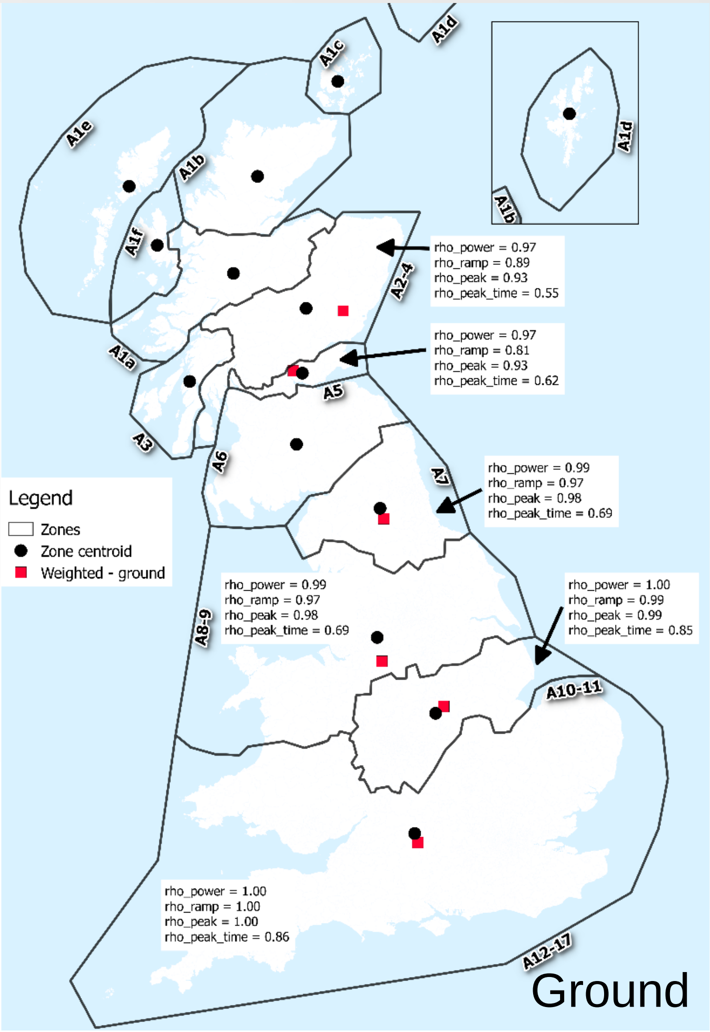




Impact of installation location

- Compare correlation between values estimated with and without consideration of existing installed capacity
- Weighted centroid affected by distribution of urban centres within a zone – particularly in Scotland
- Significant only for the time of daily peak





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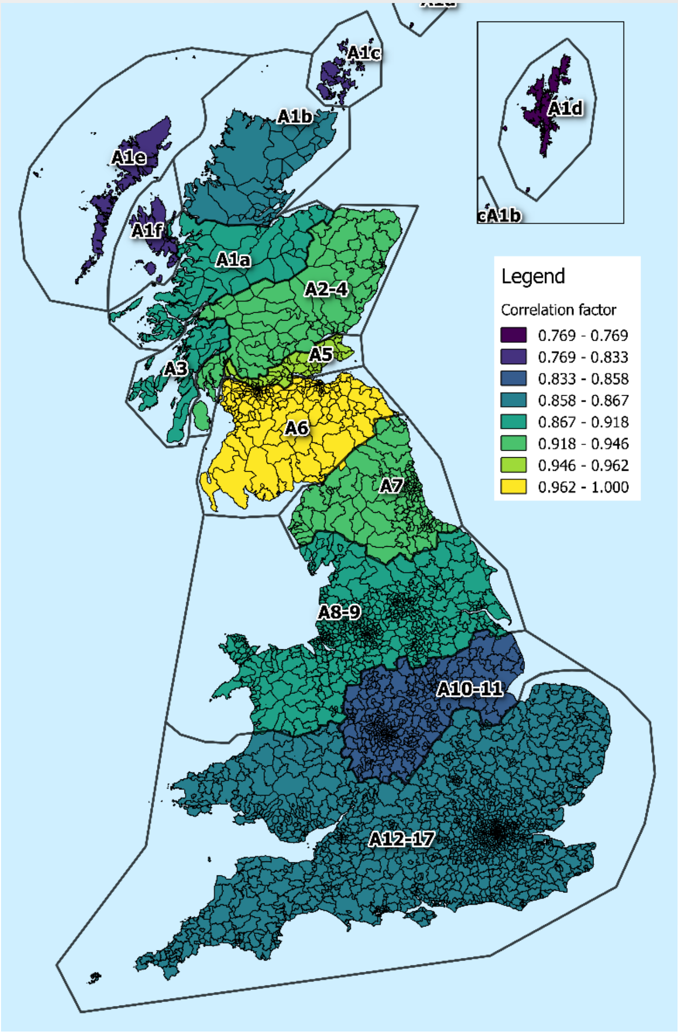
Inter-zonal variation



- Zones do capture variation across the country
- Image shows correlation relative to zone A6

Conclusions

- Aggregation is necessary to provide useful information for energy system modelling
- Techniques used for aggregation should be explicit
- Good correlation of instantaneous power output may miss other important factors for energy systems models, such as ramp rate and daily peaks
- Correlation decreases with increasing distance
- Daily peak information is most affected by the process of aggregation – smoothing effect
- Spatial data should also consider current and likely future locations of installed capacity across a zone

Acknowledgements

The authors are grateful for the financial support of the Scottish Government through the award of a ClimateXChange Fellowship.

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