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Modelling 1-minute directional observations of the global irradiance.

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Direct and diffuse irradiances from the sky has been collected at 1-minute intervals for about a year from the experimental station at the Technical University of Denmark for the IEA project "Solar Resource Assessment and Forecasting". These data were gathered by pyrheliometers tracking the Sun, as well as with apertured pyranometers gathering 1/8th and 1/16th of the light from the sky in 45 degree azimuthal ranges pointed around the compass. The data are gathered in order to develop detailed models of the potentially available solar energy and its variations at high temporal resolution in order to gain a more detailed understanding of the solar resource. This is important for a better understanding of the sub-grid scale cloud variation that cannot be resolved with climate and weather models. It is also important for optimizing the operation of active solar energy systems such as photovoltaic plants and thermal solar collector arrays, and for passive solar energy and lighting to buildings.

We present regression-based modelling of the observed data, and focus, here, on the statistical properties of the model fits. Using models based on the one hand on what is found in the literature and on physical expectations, and on the other hand on purely statistical models, we find solutions that can explain up to 90% of the variance in global radiation. The models leaning on physical insights include terms for the direct solar radiation, a term for the circum-solar radiation, a diffuse term and a term for the horizon brightening/darkening. The purely statistical model is found using data- and formula-validation approaches picking model expressions from a general catalogue of possible formulae. The method allows nesting of expressions, and the results found are dependent on and heavily constrained by the cross-validation carried out on statistically independent testing and training data-sets. Slightly better fits – in terms of variance explained – is found using the purely statistical fitting/searching approach. We describe the methods applied, results found, and discuss the different potentials of the physics- and statistics-only based model-searches.