Excel based tool for global solar radiation forecasting using artificial neural network models

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Introduction

Building reliable solar energy systems regardless of whether the system is a photovoltaic or thermal solar energy system requires information about global solar irradiation (sum of direct and diffuse solar radiation projected on a plane (Wh m–2)) in the region where the system is sited. This can be achieved using various solar irradiation estimation techniques particularly for locations where there are no metrological station. Various studies have shown that artificial neural network techniques predict solar irradiation more accurately than conventional methods.

Objective

A practical method for solar radiation forecasting using Artificial Neural Network (ANN) is presented. An Excel based tool is developed to forecast global solar radiation for a user-specified time and date in a one year prediction horizon. Artificial neural network based nonlinear autoregressive recurrent neural networks with exogenous input (NARX) were used to predict global solar radiation for the location of interest.

Methodology

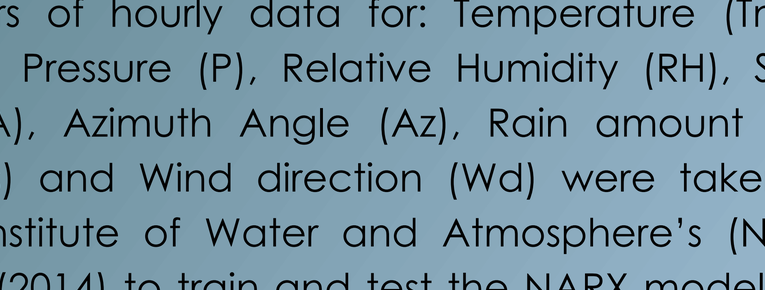
Artificial neural network (ANN) based nonlinear autoregressive recurrent neural network with exogenous input (NARX) approach is used to predict global solar irradiation 24-hours ahead and predicted values are exported to Excel for ease of selection and representation.

Three years of hourly data for: Temperature (Tmax, Tmin), Barometric Pressure (P), Relative Humidity (RH), Solar Zenith Angle (SZA), Azimuth Angle (Az), Rain amount (Ra), Wind speed (Ws) and Wind direction (Wd) were taken from the National Institute of Water and Atmosphere's (NIWA) CliFlo database (2014) to train and test the NARX models. The input weather data was presented as unprocessed data, to study the effect of real input variables on target and predict output.

The equation for the NARX approach is given by

$$y(t) = f\left(y(t-1), y(t-2), \ldots, y(t-n_y), u(t-1), u(t-2), \ldots, u(t-n_u)\right)$$

where the next value of the dependent output signal *y(t)* is regressed on previous values of the output signal and previous values of an independent input signal. The NARX approach is implemented using a feed-forward neural network to approximate the function *f*. Output series *y(t)* is predicted given past values of *y(t)* and another input series x*(t)*.



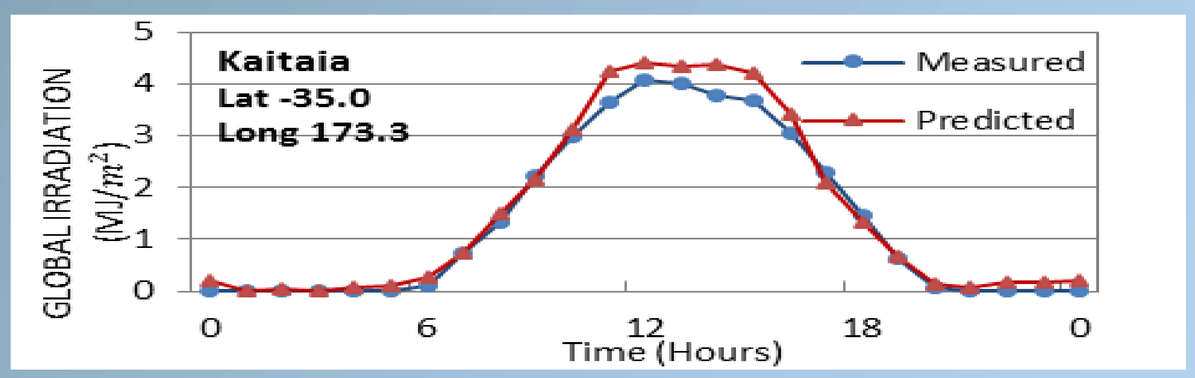
NARX block diagram.

Key findings

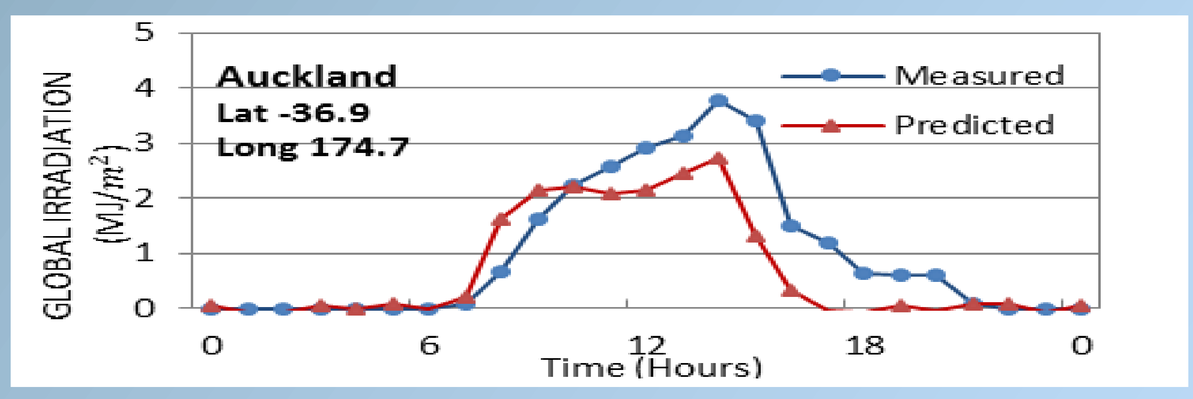
This work has shown the development of an excel based tool for solar irradiation prediction using ANN based NARX approach.

Easy to use solar irradiation prediction template in excel.

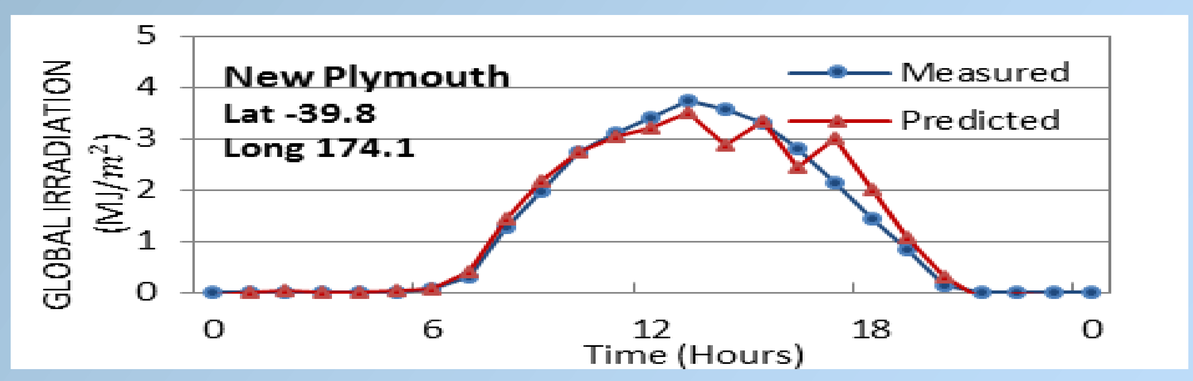
Experimental validation



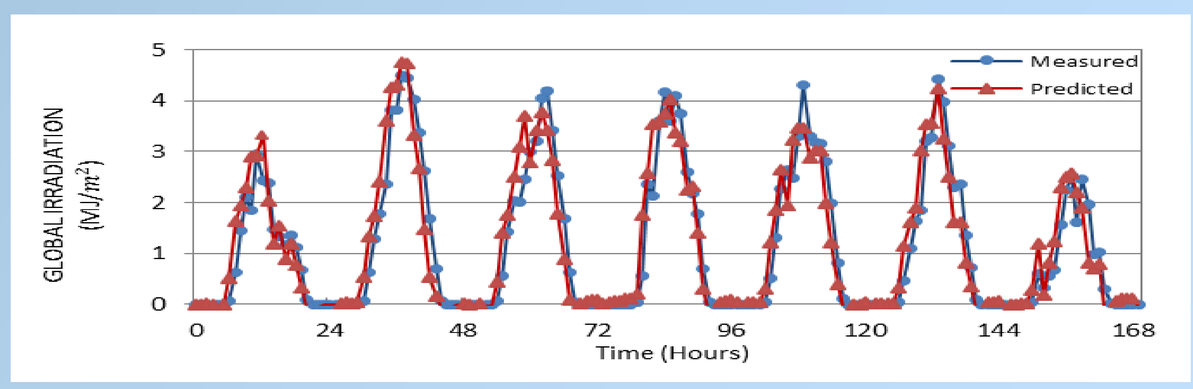
Measured and predicted solar irradiation values for Kaitaia



Measured and predicted solar irradiation values for Auckland



Measured and predicted solar irradiation values for New Plymouth



Measured and predicted solar irradiation values using NARX ANN

$$\mathrm{RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(I_p - I_i)^2}$$

Approach	RMSE (MJ/m²)
NARX	0.243
ARMA	0.315
Persistence	0.514

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