More accurate satellite-based surface solar radiation forecasts in the Swiss Alps

Degree programme: BSc in Industrial Engineering and Management Science | Specialisation: Business Engineering
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Switzerland's quest for sustainable and independent energy supply relies heavily on solar power, necessitating accurate PV production forecasts. However, satellite estimates of surface solar radiation (SSR) needed for forecasts are prone to errors, such as mistaking snow for clouds, leading to biases. To address this, the thesis explores using machine learning models to improve SSR forecasts in the Swiss Alps.

Introduction and Objectives

Swiss energy policy in the coming years aims to make Switzerland's energy supply more sustainable and independent. Solar energy plays a major role in this. Therefore, the Swiss photovoltaic (PV) power capacity is expected to increase in the coming years. An accurate PV production forecast is necessary for balancing the grid and in energy trading. The most important information to calculate PV production forecasts is surface solar radiation (SSR). An efficient but error-prone method is estimating SSR by satellites. For example, errors can be caused by misclassifying snow as clouds. This leads to high negative biases, especially in the Alpine region where many megawatt PV power plants are planned. This thesis aims to improve SSR forecasts in the Swiss Alps by using machine learning models to correct satellite SSR measurements. It compares the effectiveness of different machine learning algorithms for bias correction and examines if the corrected data leads to more accurate SSR forecasts. Additionally, the study investigates how Swiss energy companies utilize satellite-derived SSR products.

Research Design

Machine learning models, including random forest, k-nearest neighbors, and multi-layer perceptron, were used to correct satellite-derived SSR measurements. These corrected measurements were then compared with ground-based measurements. The best-performing models of each algorithm were selected to correct satellite images for both half-hour and one-hour forecasts. In order to gain insights into the usage of satellite-derived SSR products by Swiss energy companies, expert interviews were conducted.

Results

The results showed that forecasts that were created based on satellite images that were corrected by machine learning models are more accurate than those based on uncorrected satellite images. The results can be seen in Figure 1. In total, the best results were achieved by satellite images that were corrected by the multi-layer perceptron model. Compared to the uncorrected images, the RMSE decreased by 13.5% and the MBE decreased by 55.8% in the one-hour forecasts. Similarly, for the half-hour forecast, the RMSE decreased by 12.7% and the MBE decreased by 56.9%. The interviews revealed that satellite-derived SSR products are mainly used by energy companies for historical data analysis to determine optimal PV power plant locations and calculate long-term electricity production forecasts.

Implications and Recommendations

The results have shown that the method leads to an improvement in the forecasts. Further research in this field is recommended to improve accuracy even more. SSR forecasts based on satellite images are likely to gain importance in the future due to an increase in Alpine PV power capacity in Switzerland. Therefore, it would be worthwhile to develop an accurate forecast model for this region.

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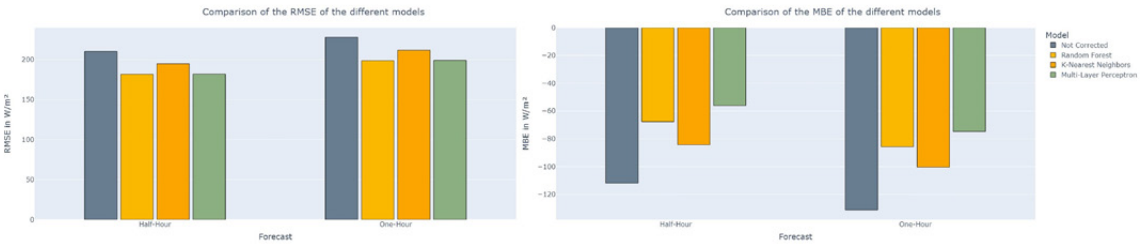

Figure 1: Forecast accuracy of the images corrected by different machine learning models