Mathematical Modelling, Simulations and Machine Learning Techniques for EY Prediction of Solar Cells

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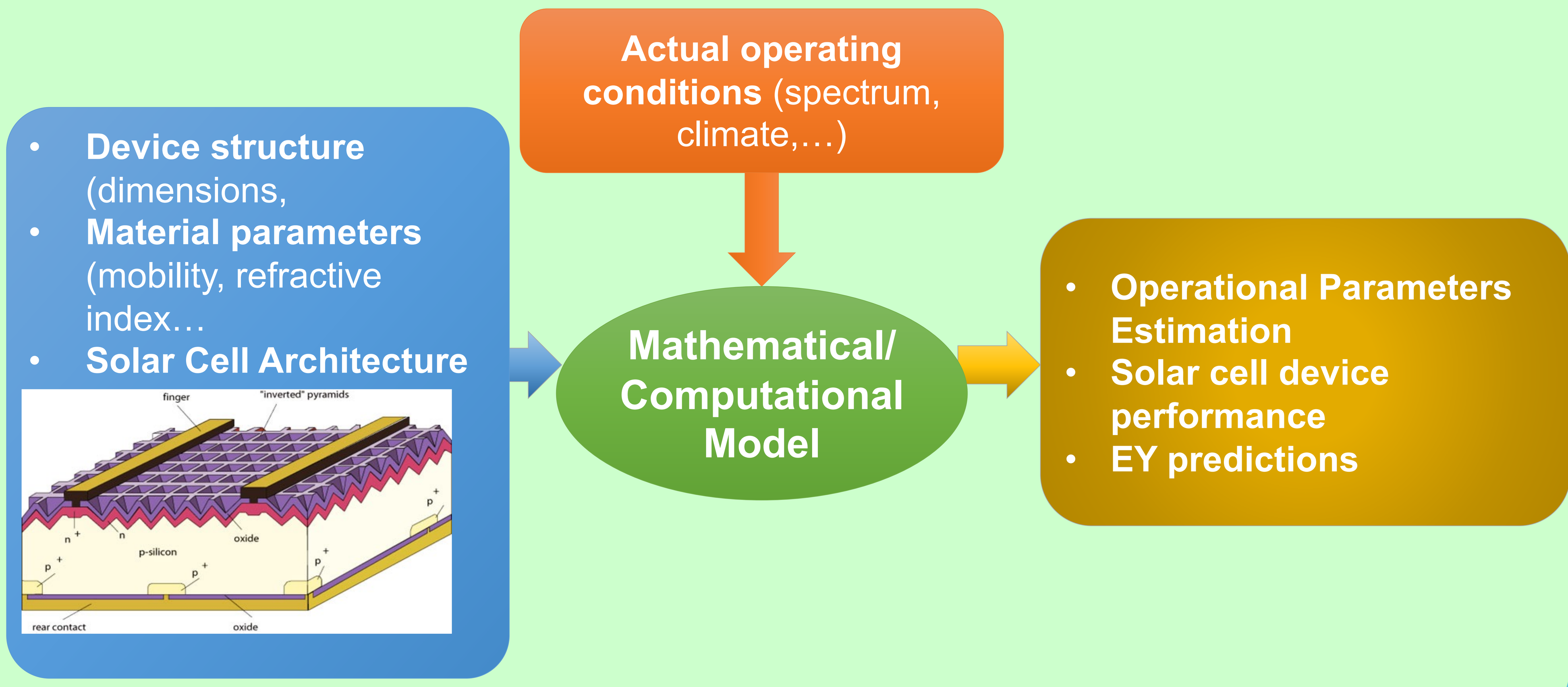
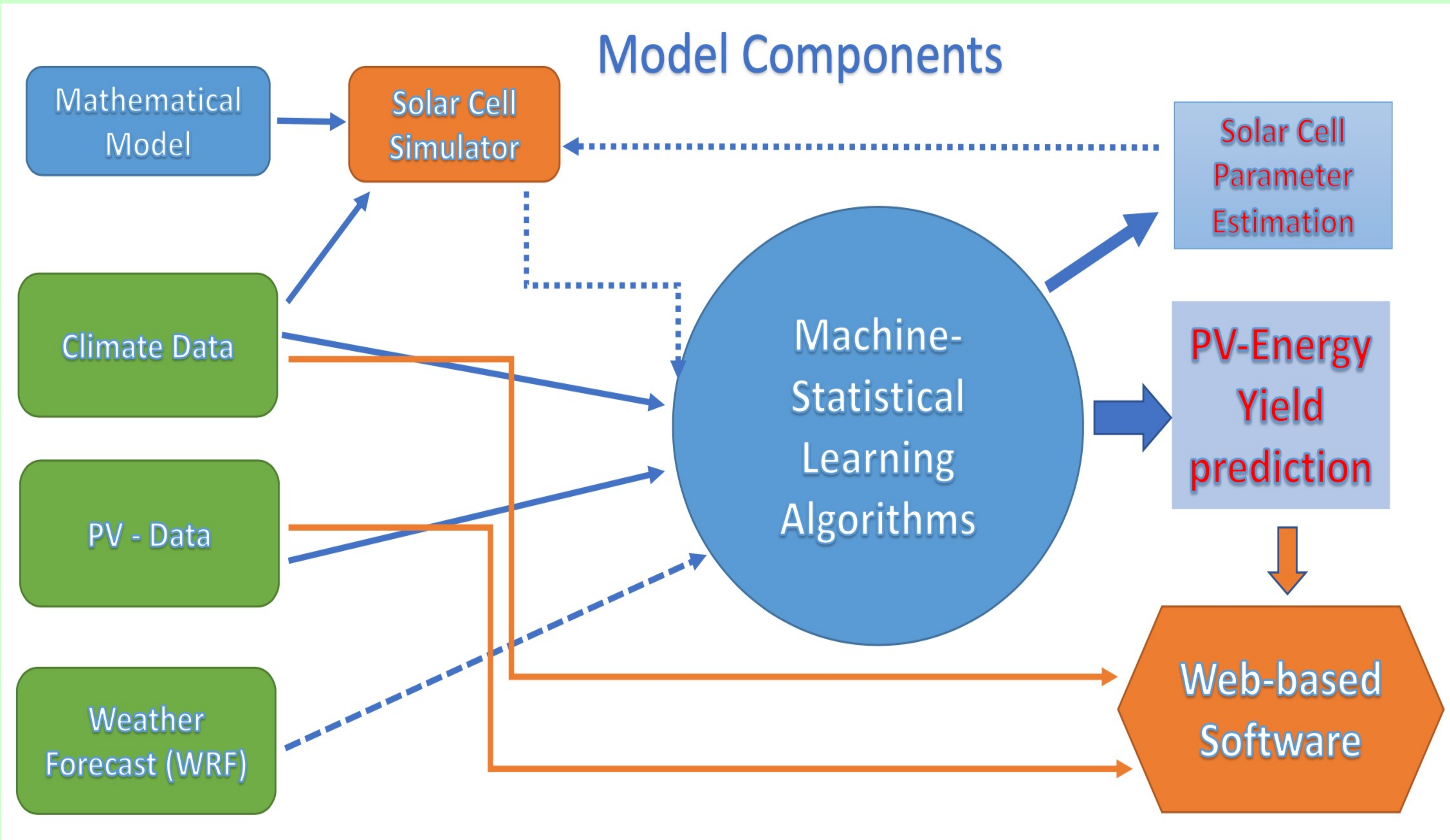
BACKGROUND

The deployment of PV technologies in areas with challenging climate, is expected to increase at rapid pace in the coming years. Although these areas receive a large amount of solar radiation throughout the year, the elevated operational temperature of PV modules leads to energy loss and hence negatively impacts the levelized cost of electricity of utility scale PV systems. The development of high efficiency Silicon solar cells, adapted to such areas, and forecasting their energy yield(EY), requires accurate device modeling in order to find the optimal device parameters under realistic conditions and effective estimation of their power output.

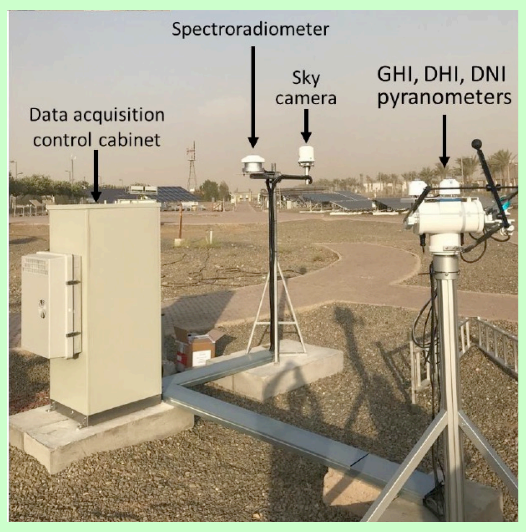
Towards this direction we have developed a mathematical / computational model that address these challenges. The model is a combination of p.d.e modelling and data driven machine-statistical algorithms.



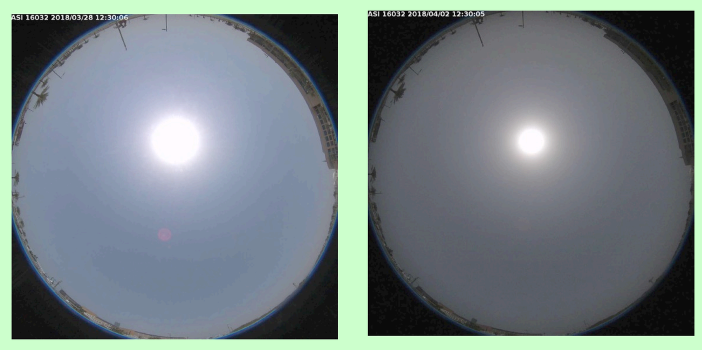
MODEL DEVELOPMENT



EXPERIMENTAL SETUP - DATA ACQUISITION



Solar resource station

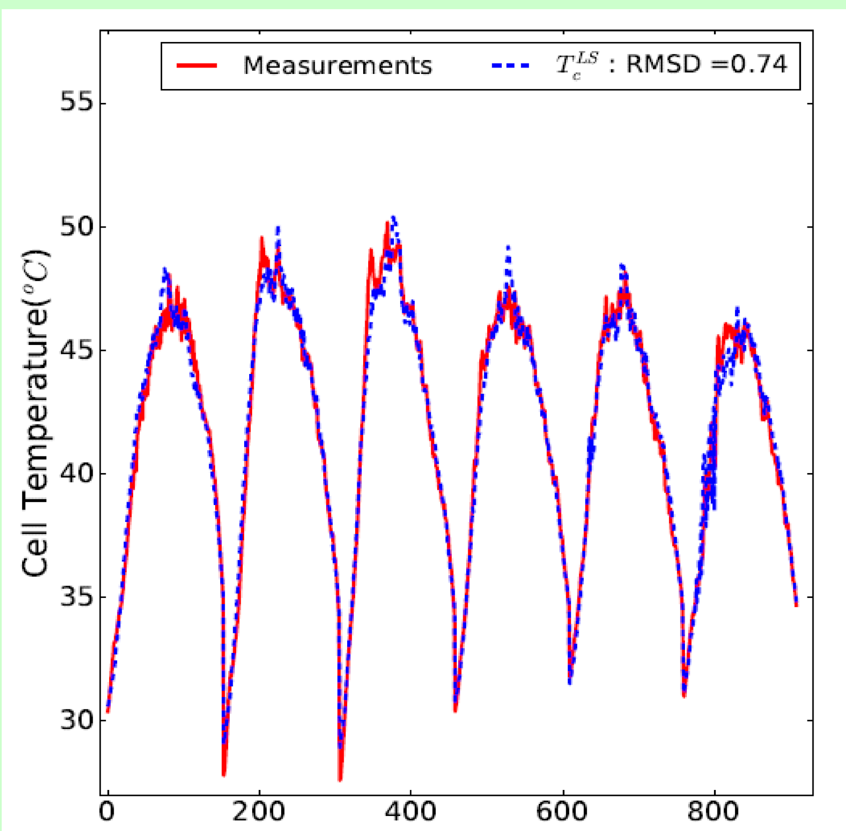


Sky camera of a clear (Left) and dusty day (right)

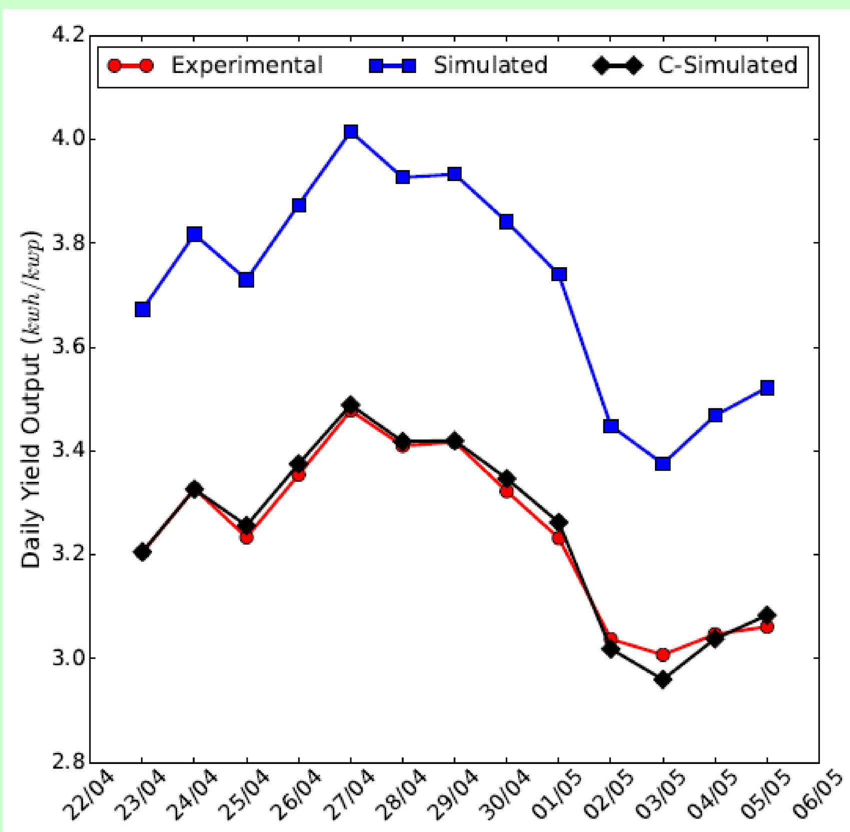
PV module installation at 25 degrees: Monofacial (left) and bifacial (right)

PV curve measuring system

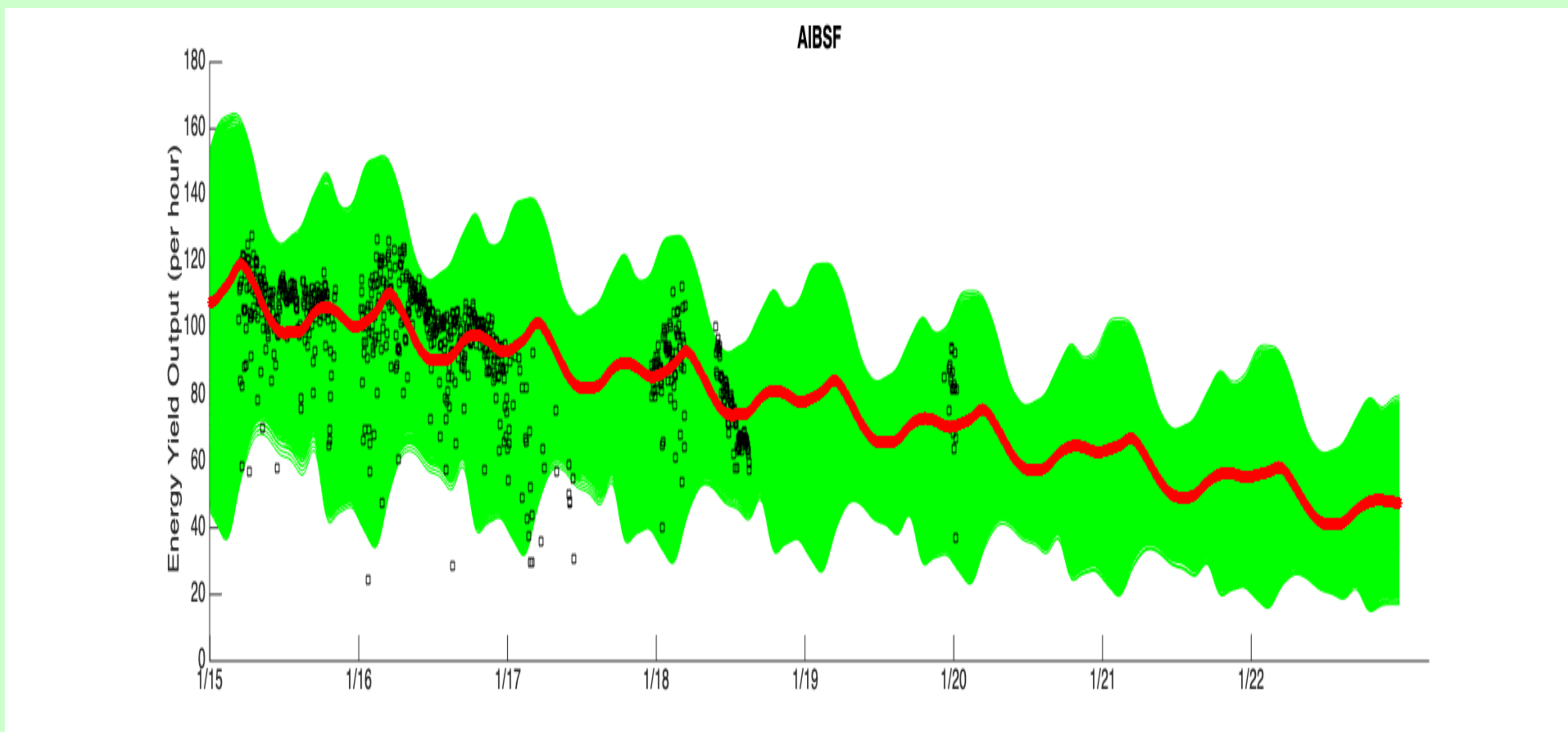
SIMULATION – EXPERIMENTAL COMPARISON RESULTS – EY PREDICTION



PV module temperature measurements (red) and simulated curve(blue) obtain by Deep Neural Networks



Simulated and experimental daily energy yield (kWh/KWp)



EY prediction(forecasting) for AIBSF solar cell architecture using advanced statistical and machine learning algorithms

SUMMARY

- A fully customized model for the simulation of various solar cell structures has been developed
- Local climate characteristics are incorporated
- Machine learning techniques are used to estimate actual solar cell operational parameters
- Highly advanced statistical models have been developed to forecast solar irradiance and EY production
- Very close agreement was observed between simulated and experimental energy yield results
- Web-based software interaction tool has been developed

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