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Validation of a simple and adaptive prediction model for temperature in outdoor microalgae cultivation systems

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Microalgae are unicellular autotrophic organisms that have the potential to be used for various biotechnological applications like biofuel or wastewater treatment in large scale production systems. The dynamics of microalgae growth in outdoor systems are strongly dependent on light and temperature and thus on meteorology. In fact, they are the main drivers of the growth rate of microalgae and further of the process productivity. Based on heat transfer modeling, numerous thermal models have been created for simple reactor geometries (usually for raceway ponds), that deliver accurate temperature predictions. However, these models require a lot of physical constants and a costly setup process. As a consequence, we developed a new generic non-linear model which overcomes these difficulties and is more suitable for control purposes. The novelty of this model is the flexibility to adapt to any cultivation system by using a small data set to identify the parameters of the model.

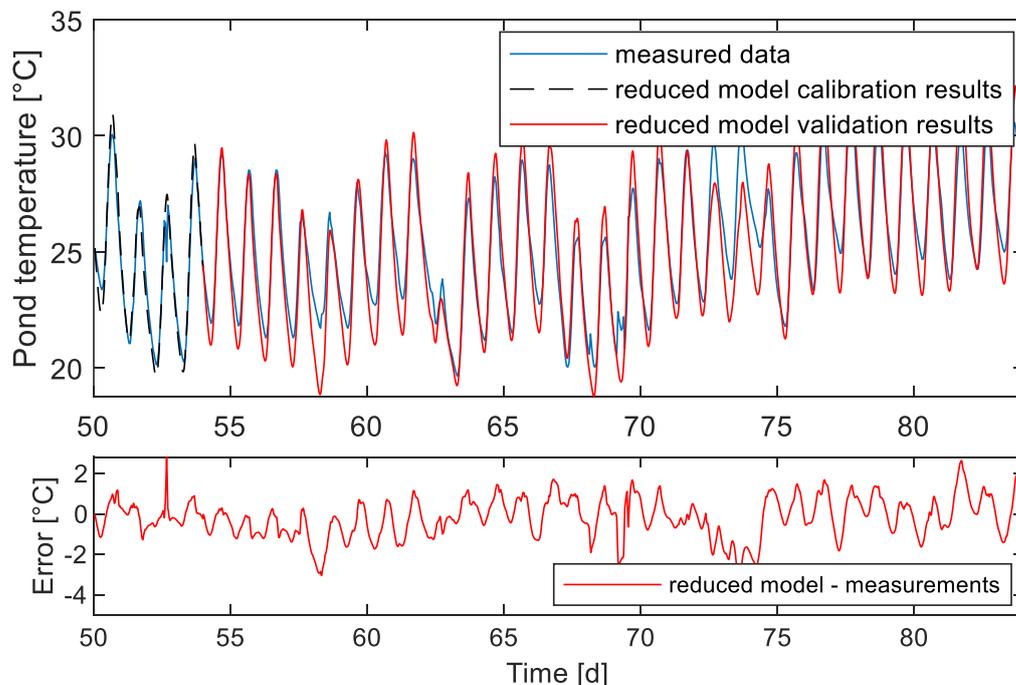


Figure 1: Using a data-set of 4 days (200 points) to fit the reduced-model to measured data from a raceway pond reactor in south of France

The crucial step of this work is the calibration procedure to adapt the model to a new process geometry. Here, we propose a validation of the new model, by using several sets of accessible experimental data. To calibrate the model for precise temperature forecasts over several weeks for the four scenarios, four days of data were needed. The results show, that the model turned out to be accurate for four different cultivation systems. Two raceway ponds, a V-shaped outdoor panel photobioreactor, and a tubular photobioreactor underneath a greenhouse. The next objective is to combine this temperature model to a light model to predict productivity and perform model predictive control.