Turbulent transport model validation at JET using integrated modelling enhanced by Gaussian process regression

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Due to the increasing demand of plasma models to assist in the experimental design process, greater emphasis is being placed on ensuring consistency between model predictions and experimental measurements, called model validation. These validation workflows can be improved by using Gaussian Process Regression (GPR) techniques [1], a regression algorithm based on Bayesian statistical principles which provides both the fit and fit gradients, along with their uncertainties, while maintaining tractability for large-scale data processing. The quick calculation of statistically-consistent fit gradient uncertainties is a novel feature provided by GPR techniques. By applying this to measurement data and using the output uncertainties, validation and sensitivity studies can be performed with increased statistical rigour.

This study outlines the application of GPR techniques to profile fitting for use in tokamak turbulence transport model validation within integrated modelling. With properly tuned optimizers, the developed profile fitting tool can process a single time window in $\sim$2 min., allowing the processing of measurements from an entire discharge in reasonable time. The advantages of this approach are demonstrated through a JETTO integrated modelling simulation [2, 3] of the JET ITER-like-wall discharge #92436 with the QuaLiKiz quasilinear turbulent transport model [4, 5]. Excellent agreement is achieved between the fitted and simulated profiles for n_e, T_e and Ω_{tor} simultaneously, but the simulation predicts a lower T_i than the experimental measurements. The fit envelopes allows for more rigourous error propagation through the model, such as Monte Carlo studies of transport model boundary conditions within the fit uncertainties and the definition of a figure-of-merit to assess the quality of this agreement.

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