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

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Due to increasing complexity and costs of experimental fusion plasma devices, more emphasis is being placed on plasma models to assist in the design process. To have confidence in these model predictions, a self-consistent connection between the predictions and experimental measurements must be ensured via model validation. However, the high sensitivity and non-linear nature of plasma models demand a more rigourous uncertainty treatment in order to determine the significance of any reported agreement between model and experiment. By using Gaussian Process Regression (GPR) techniques [1, 2] on the measurement data, which can provide both fit and fit gradient envelopes while maintaining tractability for large-scale data processing, 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 ∼2 min., allowing the processing of measurements from an entire discharge in reasonable time. The advantages of this approach were demonstrated through a JETTO integrated modelling simulation [3, 4] of the JET ITER-like-wall discharge #92436 with the QuaLiKiz quasilinear turbulent transport model [5, 6]. Excellent agreement was achieved between the fitted and simulated profiles for n_e, T_e and Ω_{tor} simultaneously but the simulation underpredicts T_i for this discharge. This underprediction is suspected to be from known physics which is currently being included in the transport model. The fit envelopes have allowed 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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