Towards multi-machine large-scale integrated modelling validation

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To prepare ITER operation and contribute to DEMO design, a cohesive plan to extend the state-of-the-art in predictive integrated tokamak simulation and associated validation methodologies has been endorsed by E-TASC (*EUROfusion-Theory and Advanced Simulation Coordination*) initiative under the acronym of TSVV11 (*Theory, Simulation, Validation and Verification task on 'Validated frameworks for the Reliable Prediction of Plasma Performance and Operational Limits in Tokamaks'*). The JINTRAC simulation suite, primarily used at the Joint European Torus (JET) facility, was selected as a base to build the required simulation functionality. A sub-task of the project focuses on standardizing and automating the modelling validation and uncertainty quantification pipelines of the JINTRAC simulation suite and its components across multiple experimental regimes and multiple EUROfusion devices. This task also stress tests the existing ITER IMAS architecture, the IDS data structure, and any developed tools for facilitating cross-domain data communication and large-scale data analysis.

The first stages of this validation task are presented here, including developing a rudimentary procedure for configuring the code accounting for current best practices in the modelling community and defining suitable validation metrics. The strict definition and subsequent automation of the simulation setup reduces the undesired impact of human errors and subjectivity on the validation results. Also, the amalgamation of multiple pre-existing 0D metrics (e.g. V_{loop}, l_i, stored energy, radiated power, neutron flux, etc.) allows a comparison to direct experimental measurements for more meaningful validation results.

The upcoming stages in this work intend to incorporate of 1D profiles and 2D line-of-sight information to extend the depth of validation possible. The large-scale study results can also be leveraged to categorize potential model discrepancies by their physical origins, possibly helping to identify or prioritize missing but crucial physics within the simulation suite. Finally, this exercise is currently limited to steady-state plasma conditions but expanding this methodology into time evolution simulations is recommended for future work within this project.