DPP13-2013-000758

Abstract for an Invited Paper
for the DPP13 Meeting of
the American Physical Society

Validation Metrics for Improving Our Understanding of Turbulent Transport – Moving Beyond Proof by Pretty Picture and Loud Assertion[1]

C. HOLLAND, University of California San Diego

Developing validated models of plasma dynamics is essential for confident predictive modeling of current and future fusion devices. This tutorial will present an overview of the key guiding principles and practices for state-of-the-art validation studies, illustrated using examples from investigations of turbulent transport in magnetically confined plasmas. The primary focus of the talk will be the development of quantiatve validation metrics, which are essential for moving beyond qualitative and subjective assessments of model performance and fidelity. Particular emphasis and discussion is given to (i) the need for utilizing synthetic diagnostics to enable quantitatively meaningful comparisons between simulation and experiment, and (ii) the importance of robust uncertainty quantification and its inclusion within the metrics. To illustrate these concepts, we first review the structure and key insights gained from commonly used "global" transport model metrics (e.g. predictions of incremental stored energy or radially-averaged temperature), as well as their limitations. Building upon these results, a new form of turbulent transport metrics is then proposed, which focuses upon comparisons of predicted local gradients and fluctuation characteristics against observation. We demonstrate the utility of these metrics by applying them to simulations and modeling of a newly developed "validation database" derived from the results of a systematic, multi-year turbulent transport validation campaign on the DIII-D tokamak, in which comprehensive profile and fluctuation measurements have been obtained from a wide variety of heating and confinement scenarios. Finally, we discuss extensions of these metrics and their underlying design concepts to other areas of plasma confinement research, including both magnetohydrodynamic stability and integrated scenario modeling.

[1]Supported by the US DOE under DE-FG02-07ER54917 and DE-FC02-08ER54977.