First full-size turbulence simulations of diverted TCV plasmas and comparison with experiments

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The dynamics in the edge region of tokamaks involves a complex, non-linear interplay of turbulent transport, drifts, sources and sinks. To fully understand these processes and predict key quantities for the design of reactors, such as the heat flux width at the divertor plates, simulations require a detailed comparison with existing experiments. Fluid turbulence codes have recently been developed to simulate realistic X-point configurations in devices of increasing size [1, 2, 3, 4]. We will present progress towards predictive capabilities of the boundary dynamics with GBS [5], a 3D code solving drift-reduced Braginskii equations, coupled to a single-species neutral kinetic model. For an in-depth simulation-experiment validation, an extensive, open-source database dubbed "TCV-X21" was built. It includes 45 observables, obtained through time-dependent and time-averaged, 1D and 2D measurements at different poloidal locations in a TCV L-mode scenario, in both field directions.

The validation of GBS full-size TCV simulations, without neutrals and in both field directions, was performed following the rigorous procedure presented in Ricci et al. 2011 [6]. The results show that GBS is capable to reproduce time-averaged profiles and statistical properties of turbulence reasonably well at the midplane, while the time-averaged profiles resulting from GBS are broader than in experiments at the target. The relative effects of turbulent transport and mean-field drifts on divertor transport and profiles will be detailed. We will also present an extension of this work to simulations including kinetic neutrals, which reveal the beneficial impact of the self-consistent description of the density source. This quantitative assessment of the predictive capabilities of GBS gives guidelines on further improvements needed in the modelling of tokamak edge plasmas.

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