Development and validation of a predictive model for the pedestal height

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Abstract. The pressure at the top of the edge transport barrier (or "pedestal height") strongly impacts tokamak fusion performance. Predicting the pedestal height in future devices such as ITER remains an important challenge. While uncertainties remain, MHD stability calculations at intermediate wavelength (the "peeling-ballooning" model), accounting for diamagnetic stabilization, have been largely successful in determining the observed maximum pedestal height, when the edge barrier width is taken as an input. Here, we develop a second relation between the pedestal width in normalized poloidal flux (Δ) and pedestal height ($\Delta = 0.076\beta_{\theta,\mathrm{ped}}^{1/2}$), using an argument based upon kinetic ballooning mode turbulence and observation. Combining this relation with direct calculations of peeling-ballooning stability yields two constraints, which together determine both the height and width of the pedestal. The resulting model, EPED1, allows quantitative prediction of the pedestal height and width in both existing and future experiments. EPED1 is successfully tested both against a dedicated experiment on the DIII-D tokamak, in which predictions were made before the experiment, and against a broader DIII-D dataset, including ITER demonstration discharges. EPED1 is found to quantitatively capture the observed complex dependencies of the pedestal height and width. An initial set of pedestal predictions for the ITER device is presented.

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