Is the relation between the solar wind dynamic pressure and the magnetopause standoff distance so simple?

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The relation between the solar wind dynamic pressure and magnetopause standoff distance is usually supposed to be $R_{\text{SUB}} \sim P_d^{-1/N}$. The simple pressure balance condition gives $N=6$, however $N$ varies in empirical magnetopause models from 4.8 to 7.7. Using several MHD models, we simulate the magnetospheric response to increases in the dynamic pressure by varying separately the solar wind density or the velocity. We obtain different values of $N$ depending on which parameter, density or velocity, has been varied and for which IMF orientation. The changes in the standoff distance are smaller (higher $N$) for a density increase and greater (smaller $N$) for a velocity increase for southward IMF. We explain this result by enhancement of the Region 1 current that moves the magnetopause closer to the Earth for a high solar wind velocity. We suggest for developers of new empirical magnetopause models in the future to replace the simple relation between $R_{\text{SUB}}$ and $P_d$ with a fixed $N$ by a more complicated relation which would separate inputs in the dynamic pressure from the density and velocity taking into account the IMF orientation.