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A predictive universal fractional-order differential model of wall-turbulence[1] FANGYING SONG, GEORGE KARNIADAKIS, Division of Applied Mathematics, Brown University — Fractional calculus has been around for centuries but its use in computational since and engineering has emerged only recently. Here we develop a relatively simple one-dimensional model for fully-developed wall-turbulence that involves a fractional operator with variable fractional order. We use available DNS data bases to "learn" the function that describes the fractional order, which has a high value at the wall and decays monotonically to an asymptotic value at the centerline. We show that this function is universal upon re-scaling and hence it can be used to predict the mean velocity profile at all Reynolds numbers. We demonstrate the accuracy of our universal fractional model for channel flow at high Reynolds number as well as for pipe flow and we obtain good agreement with the Princeton super-pipe data up to Reynolds numbers 35,000,000.

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