

A generalized approach towards a new log law of the wall in Taylor-Couette flows at intermediate Reynolds numbers

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Introduction

- Classical log-law is optimal at high Re N° even in Taylor-Couette system [1].
- However, at intermediate Re N° in the TC system, significant deviations from the classical log-law can be observed near the cylindrical walls [1,2].
- Singh et al [3] presented a new law of the wall, which behaves nonlinearly with the radial distance, based on the turbulent mixing length.

Objective

To create a generalized approach towards the estimation of the two constants of integration: Mixing Length, C_{lm} , and log law, C_u .

Log Law

Simplified RANS equation: $r^2(v + v^t)r \partial(\overline{U_\theta}/r)/\partial r = -r_i^2 U_i^{*2}$

Turbulent viscosity: $v^t(r) = l_m^2(r)r \partial(\overline{U_\theta}/r)/\partial r$

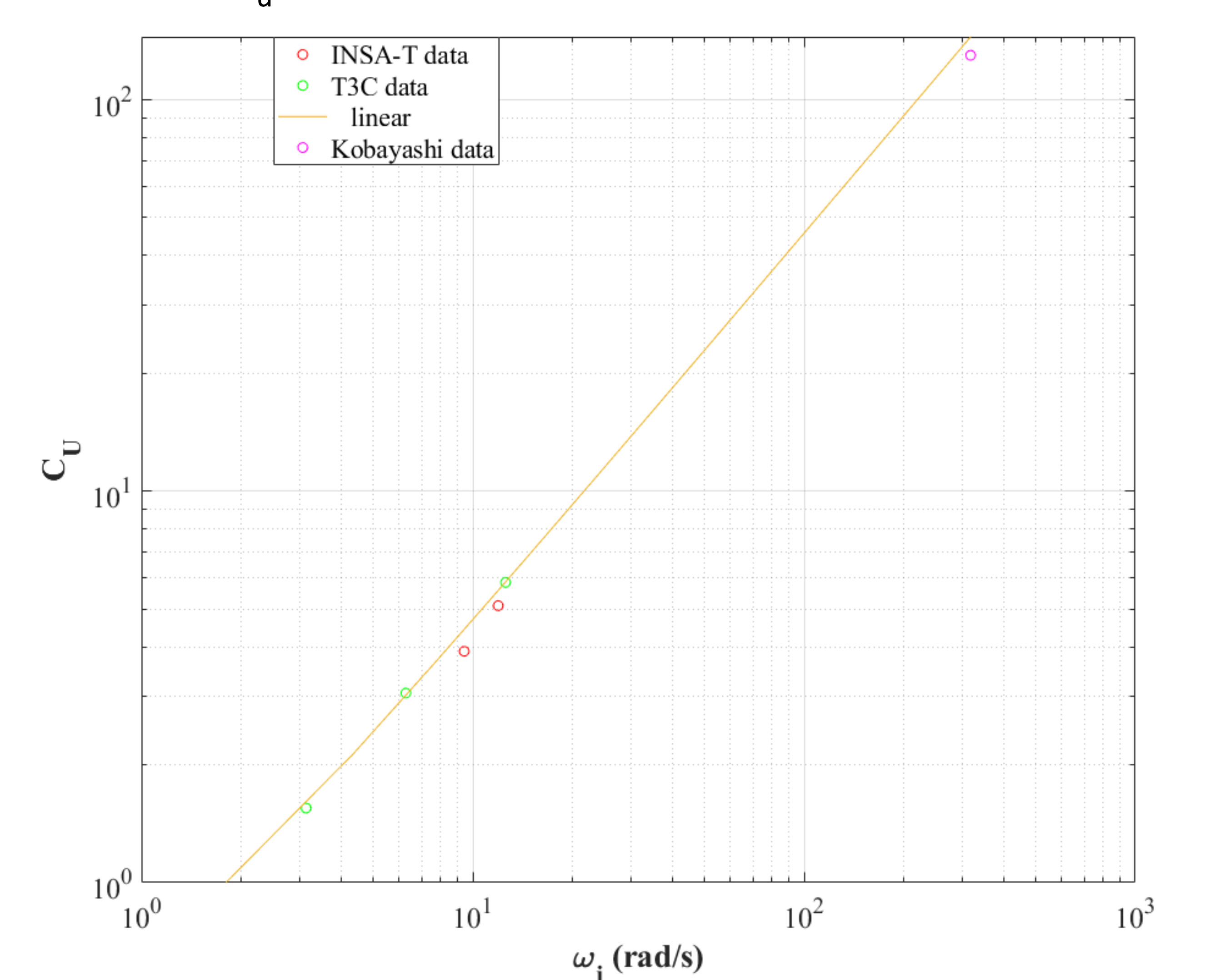
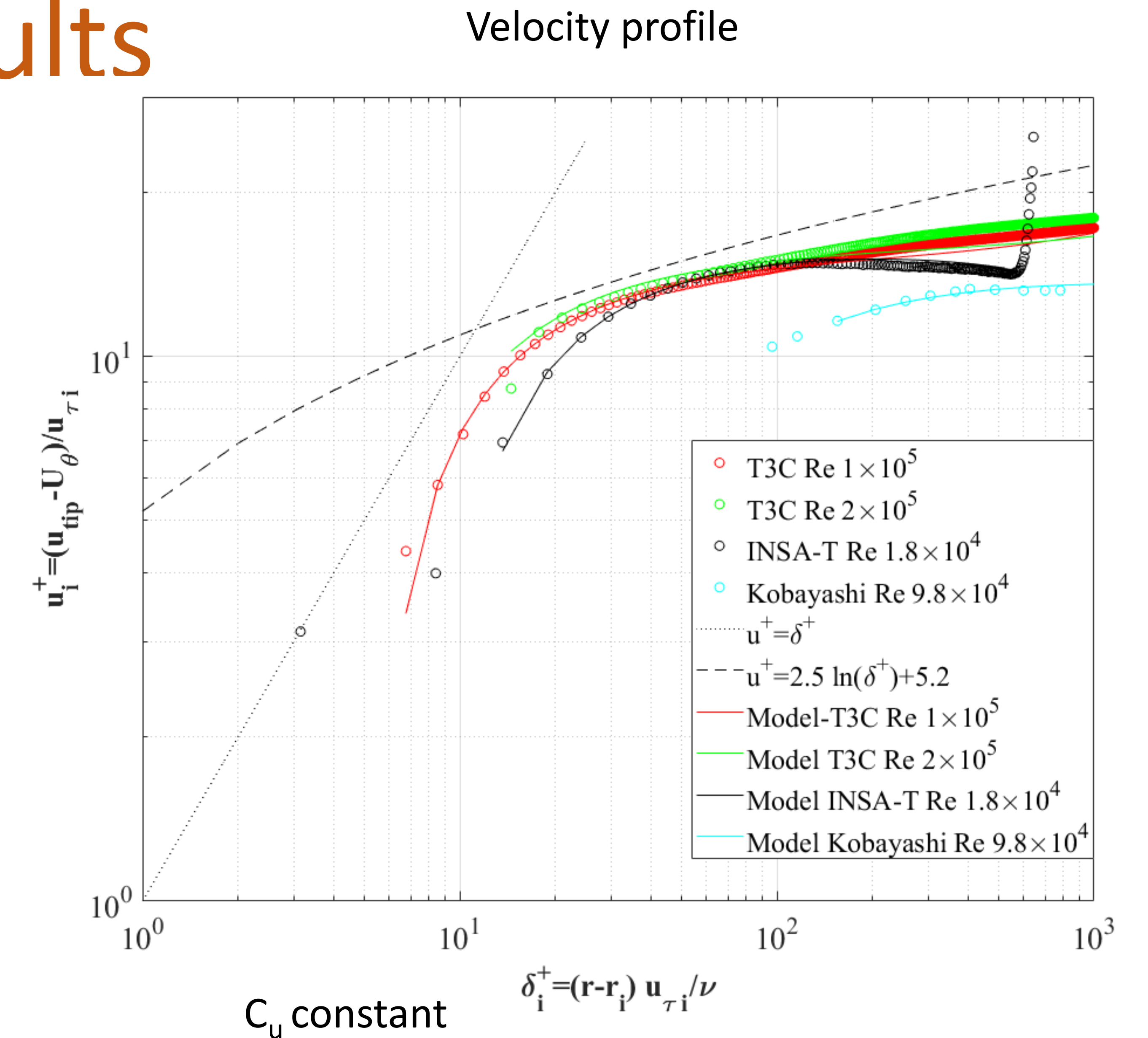
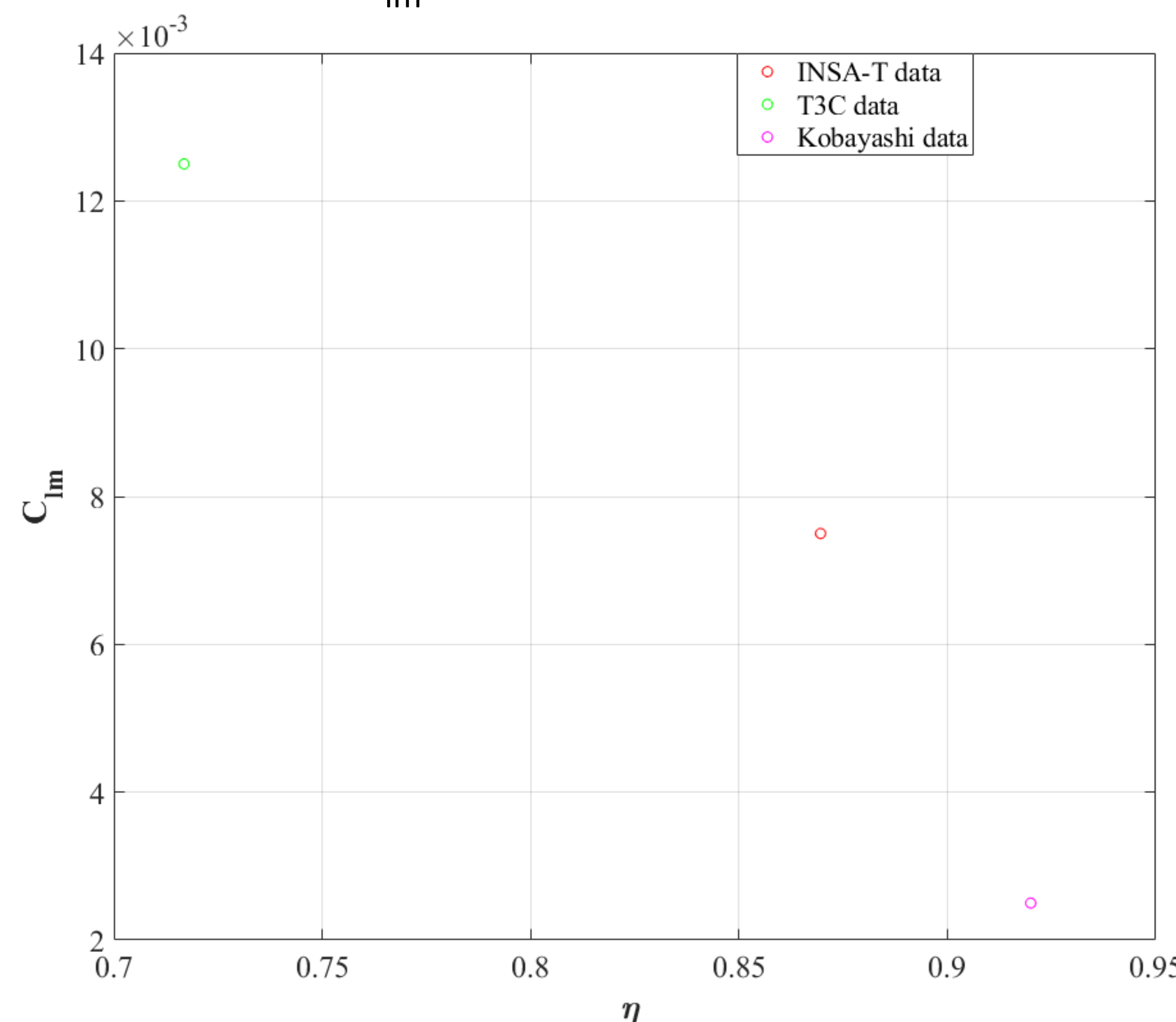
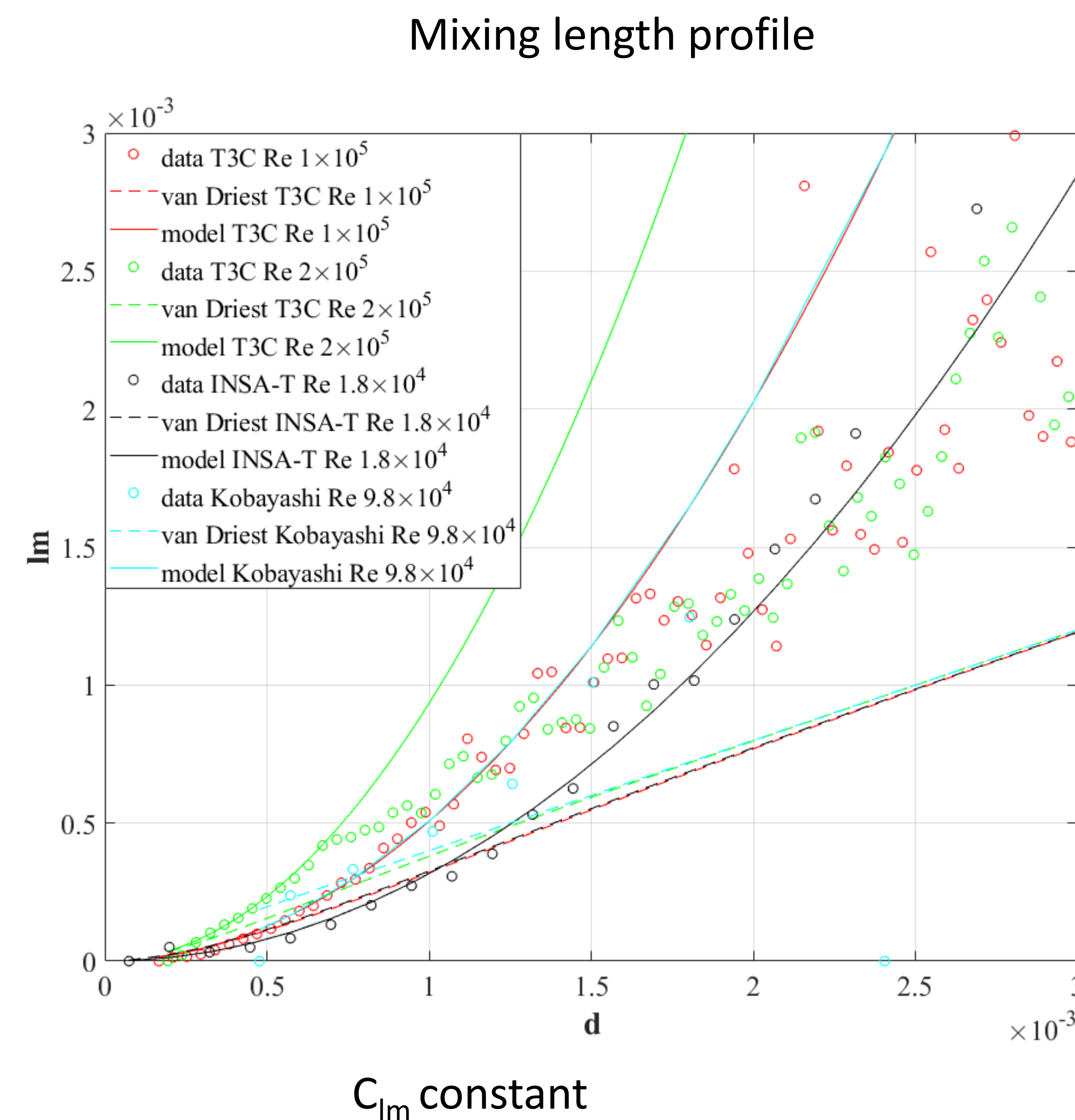
Mixing length as introduced by prandtl: $l_m(r) = r_i/r^2 U_i^*/(\partial(\overline{U_\theta}/r)/\partial r)$

Mixing length profiles near inner and outer cylinder: $l_{mi}(r) = C_{lm}\delta_i^2 U_i^*/\nu$, $l_{me}(r) = C_{lm}\delta_e^2 U_e^*/\nu$

Inserting the mixing length in RANS, we get: $\frac{\partial(\overline{U_\theta}/r)/\partial r}{(-r_i\nu)/(C_{lm}r^2(r-r_i)^2)} =$

Upon integration, we get:
$$\frac{U_{tip} - \overline{U_\theta}(r)}{U_i^*} = -\frac{1}{C_{lm}r_i^+} \frac{r_i - 2r}{\delta_i} + \frac{2}{C_{lm}r_i^+} \frac{r_i + \delta_i}{r_i} \log\left(\frac{\delta_i}{r_i + \delta_i}\right) + \frac{C_u(r_i + \delta_i)}{U_i^*}$$

Results



References

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