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Machine learning for particle-laden viscoelastic flow modelling

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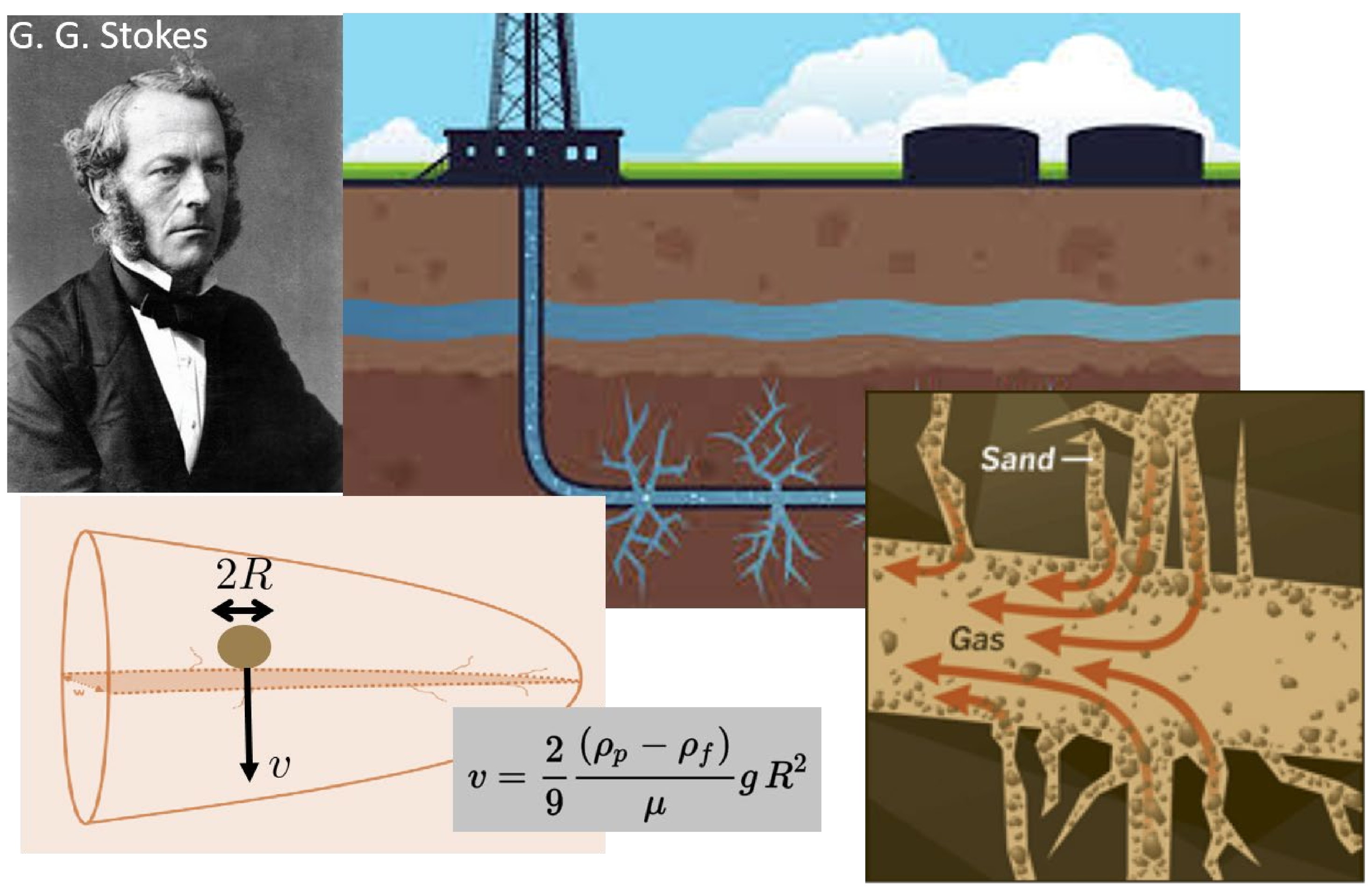
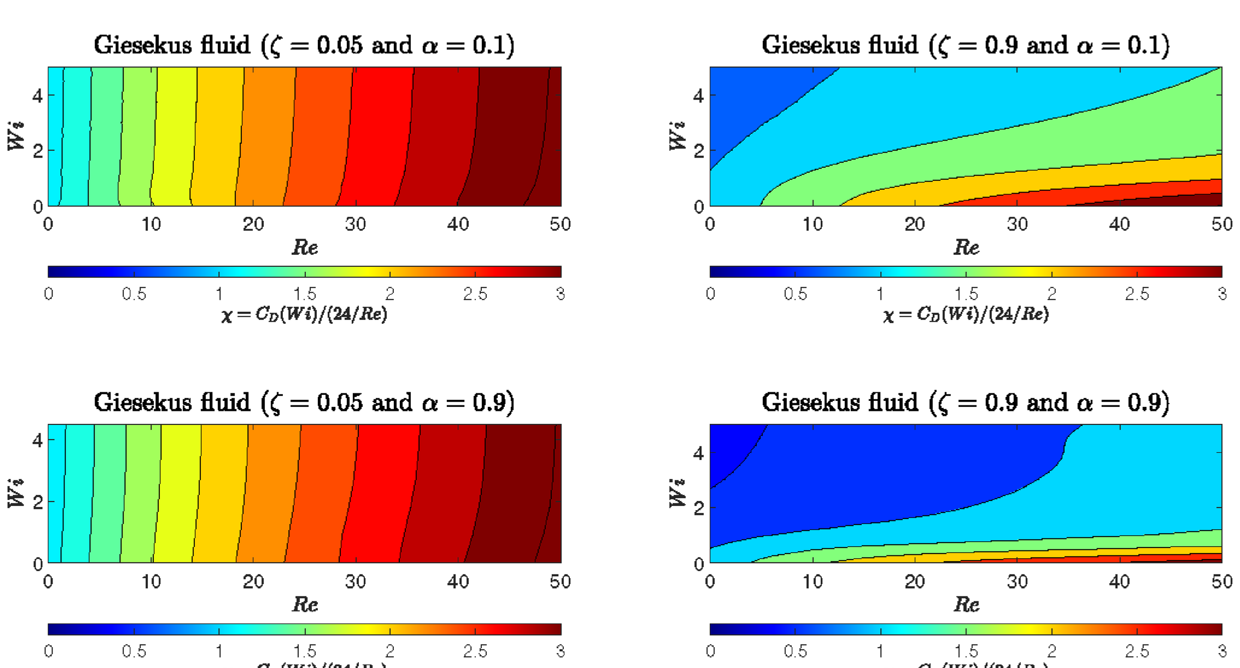
Methodology



- ✓ **Objetives:** explore the possibility of using Machine Learning (ML) techniques to evaluate the drag coefficient of small non-Brownian particles translating and settling in non-linear viscoelastic fluids. The long-term objective is the development of a 3D numerical code for particle-laden viscoelastic flows (PLVF), which will contribute to understanding many advanced manufacturing and industrial operations, specifically the hydraulic fracturing process.
- ✓ **Tasks:** (a) Perform 3D direct numerical simulations (DNS) of PLVF; (b) Develop a general expression for the drag coefficient of rigid particles moving through viscoelastic fluids, using ML techniques; and (c) Implement a CFD-DEM numerical code for fast predictive PLVF.

Results and Discussion

Drag coefficient of *a sphere*[1]



$$Re_a = \frac{2a\rho U}{\eta_0}$$

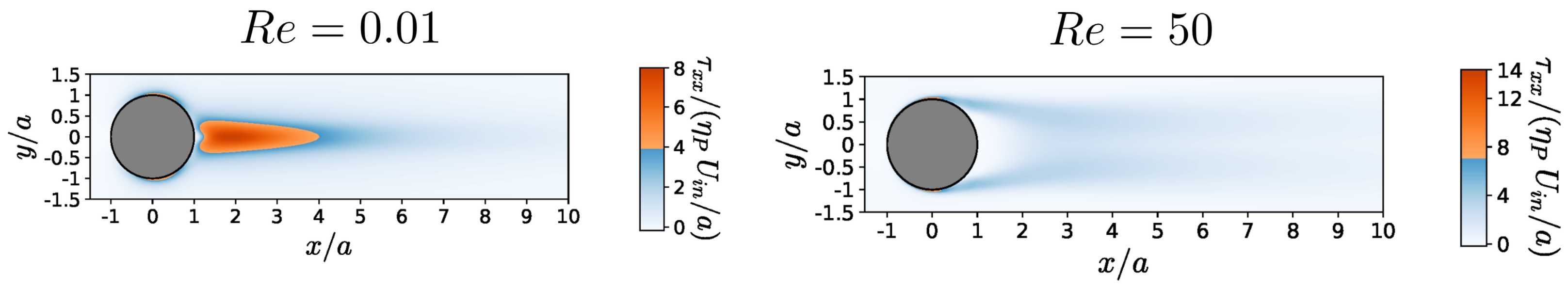
$$Wi = \frac{\lambda U}{a}$$

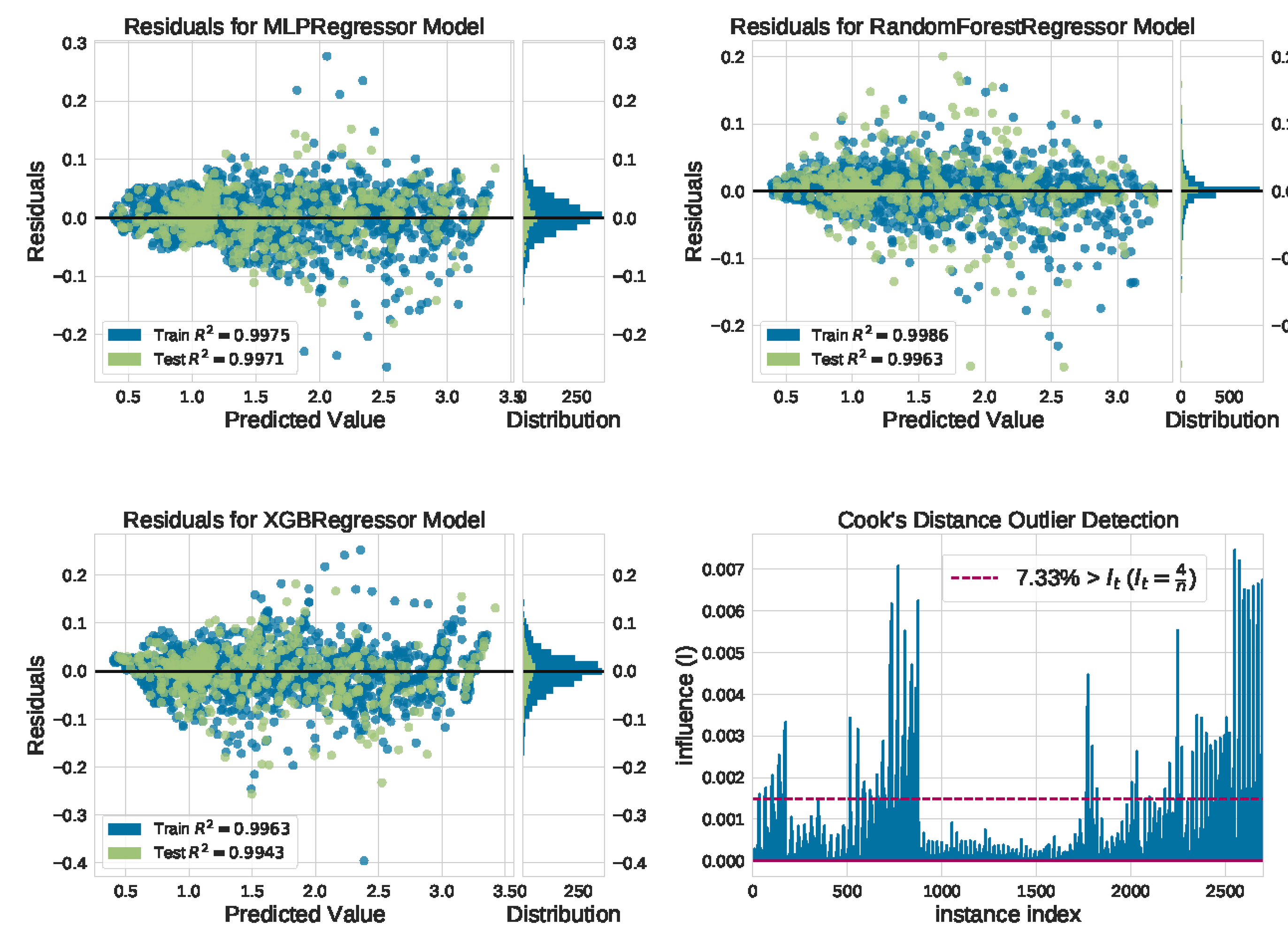
$$\zeta = \frac{\eta_P}{\eta_0}$$

The evolution of the drag correction $\chi = C_D(Wi, \zeta, \alpha)/(24/Re)$ have a different behavior with the increase of Re at higher ζ , due to flow separation.

$$\zeta = 0.9, \ \alpha = 0.9, \ Wi = 5$$

$Re = 0.01$ $\qquad$ $Re = 50$



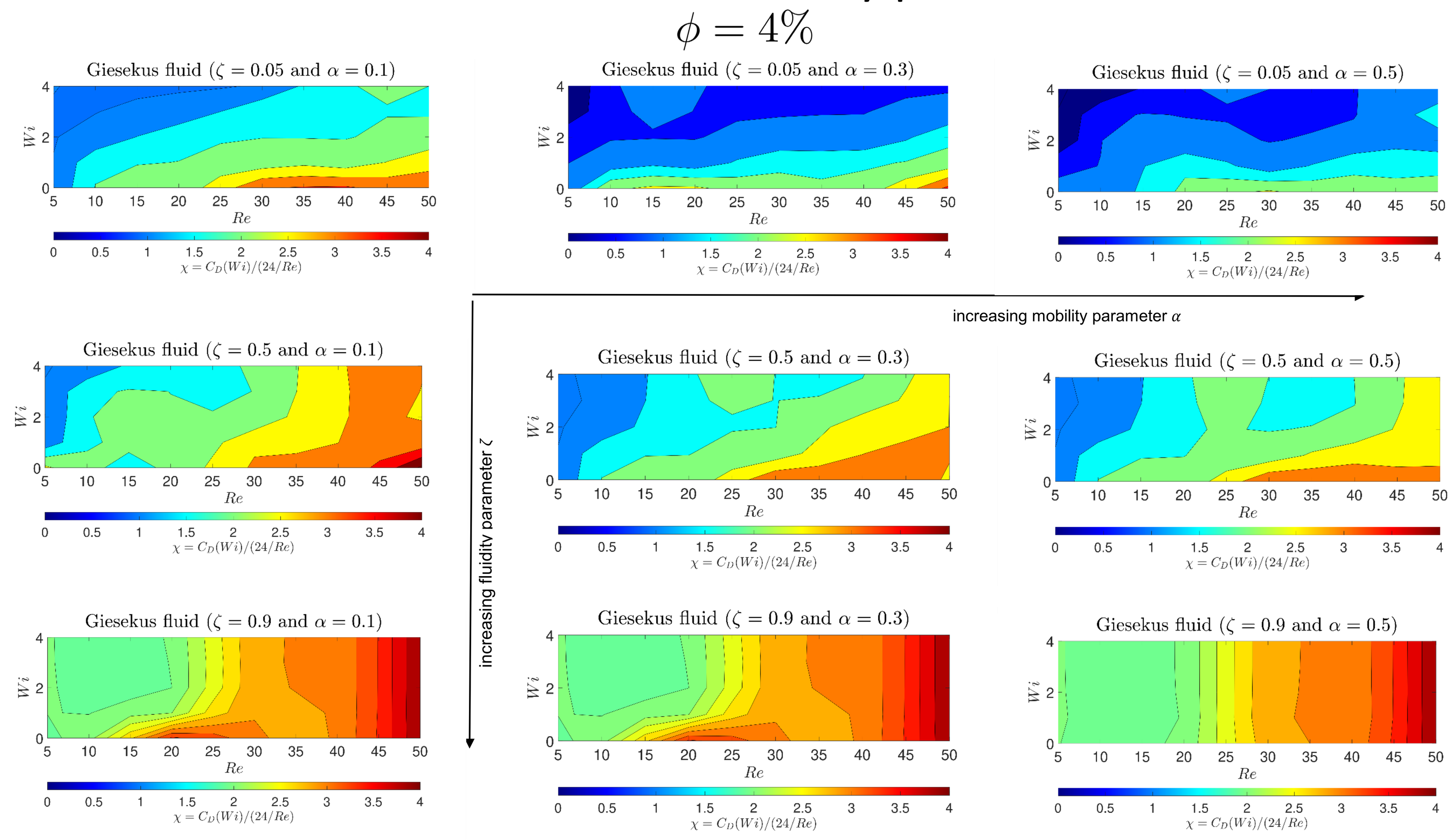


The ML models applied to predict the drag force on a sphere suspended in Giesekus fluids showed good performance results.

Drag coefficient of *random arrays of spheres*[2]

The evolution of the drag correction $\chi = C_D(Wi, \zeta, \alpha, \phi)/(24/Re)$ is obtained for volume fraction of dispersed solids $0 \leq \phi \leq 0.2$, Reynolds number $Re \leq 50$, Weissenberg number $0 \leq Wi \leq 4$, retardation ratio $0 \leq \zeta \leq 1$ and mobility parameter $0 < \alpha \leq 0.5$.

$$\phi = 4\%$$



Conclusions

- ✓ Meta-models to predict the drag coefficient of rigid particles moving through shear-thinning viscoelastic fluids were developed, using ML techniques.

Acknowledgments

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1. S.A. Faroughi, A.I. Roriz, G.H. McKinley, C. Fernandes, *Machine Learning models to predict the drag coefficient of a sphere translating in shear-thinning viscoelastic fluids*, in preparation.
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