Investigation of Stokes Number Effects on Particle-Laden Flows

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Introduction

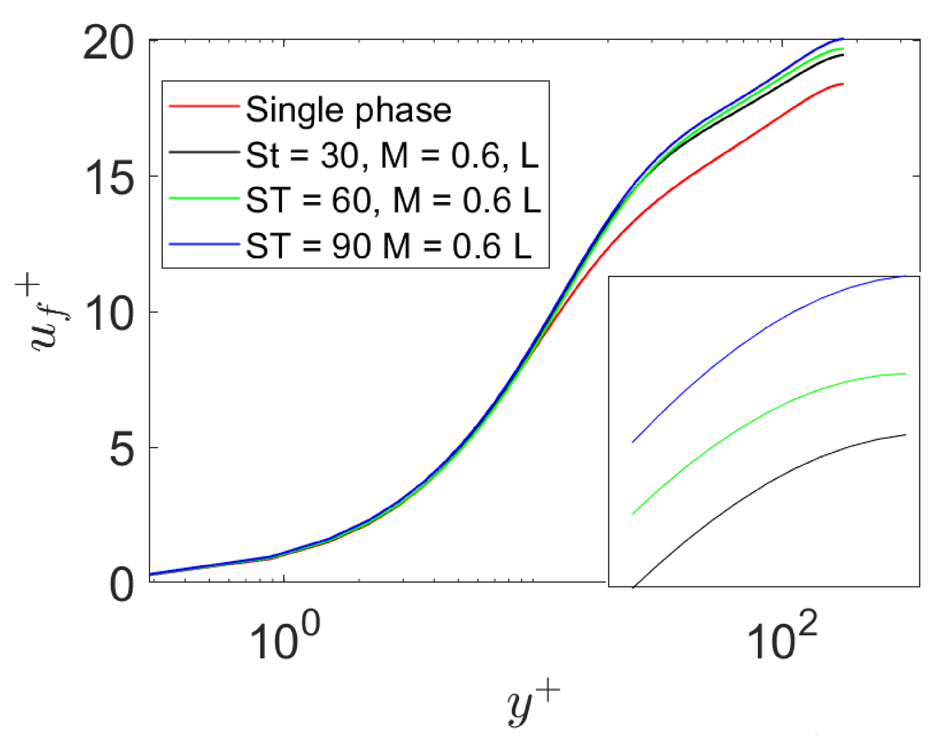
Finding particle characteristics that lead to significant increases in overall mass flow rate is key to reducing energy consumption in turbulent channel flow applications. Many drag reduction techniques have been hypothesized, but introducing inertial particles into a turbulent flow is one of the most promising since it does not require the additional use of energy. This project's focus is on the drag reduction effects particles of Stokes number 30, 60 and 90 had on a turbulent single-phase channel flow.

Methodology and Material Usage

All channel flow simulations were carried out on ASU's research computing cluster Agave. A total of approximately 860,000 core hours were used in this project. Keeping the Reynolds number and volume fraction constant, the Stokes number was the only change by altering the particle's diameter. These particles were then implemented into a turbulent steady-state single phase flow where the drag reduction and mass flow rate were measured.

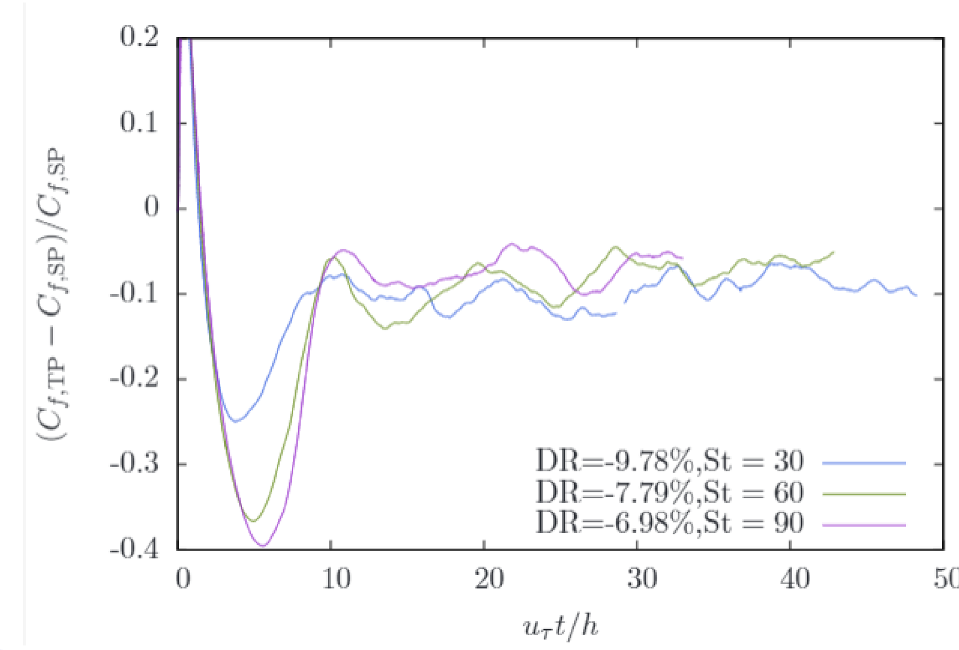
Data and Results

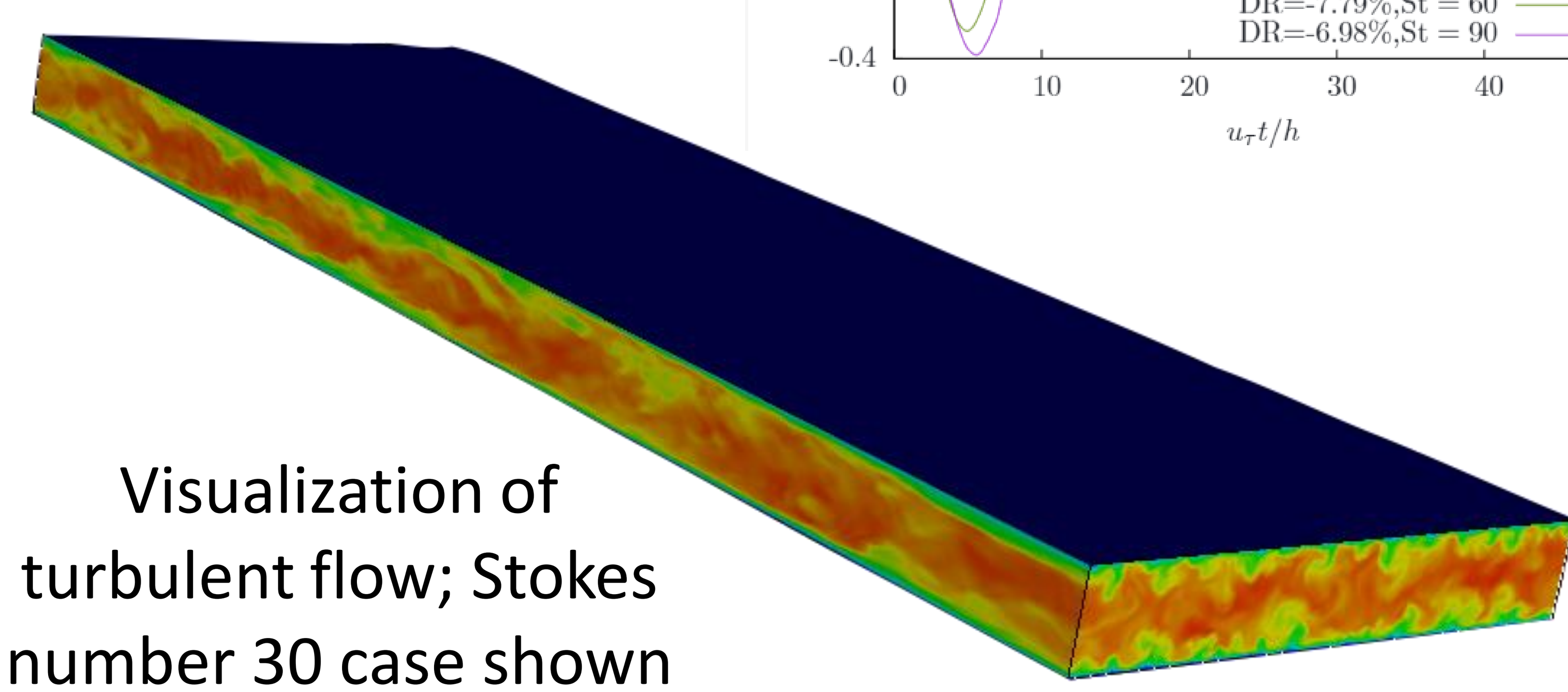
- Each test case ran resulted in a mass flow rate greater than the original single-phase flow
- Greatest mass flow enhancement seen in Stokes number 90 case – 9.12% enhancement



- Stokes number 90 resulted in greatest average streamwise velocity
- Stokes number 30 resulted in greatest overall drag reduction

- Stokes number 30 case most developed out of al simulations





Visualization of turbulent flow; Stokes number 30 case shown

Conclusions and Future Work

The results of this project indicate that the introduction of particles into turbulent channel flow will reduce drag in the system therefore increasing total mass flow rate. A "sweet spot" around Stokes number 90 seems to exist which may be worth investigating to find the ideal Stokes number for drag reduction in this application.

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References

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