A new model for the predication of drag of non-spherical volcanic particles

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Estimation of drag of non-spherical particles is the most important parameter in many multi-phase flow processes in both industry and nature. Although many experimental results on the drag of non-spherical particles exist in the literature, only a few of them are based on measurements in air. We present a new model for the prediction of the drag of non-spherical solid particles of regular and irregular shape that travel in air. Reynolds numbers investigated are between 10 and 10^5 (i.e. laminar to turbulent regimes). The results are obtained from experiments performed on micron size particles in a falling column and on millimetric size particles suspended in a vertical wind tunnel. Both apparatus were designed and built at University of Geneva for the study of sedimentation and aggregation of volcanic particles. Particle shape factors are measured based on various methods existing in the literature and benchmarked against our experimental results. Shape factors are calculated with different instruments depending on the size of particles such as 3D-scanning and image analysis. New easy to measure shape factors are introduced which have the highest correlation with the measured drag coefficient of particles. Performance of the models is benchmarked against well-known spherical and non-spherical models. As an example, we have found that both existing spherical and non-spherical models can estimate settling velocity of volcanic particles with an average error of about 30%. We have also found that the effect of surface roughness on terminal velocity of non-spherical particles of millimetric size is almost negligible. Finally, we observed that secondary motions of particles are considerably higher at high Reynolds numbers. This implies that particles falling in the turbulent regime are better characterized by a range of terminal velocities instead of a single value especially in case of particles with high variation in their projected area. Our experimental benchmarks show that our new model is a reliable and easy to apply model for estimating drag coefficient of non-spherical particles of various shapes in a wide range of Reynolds number.