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

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Introduction

• Estimation of **drag of non-spherical volcnic particles** is the most important parameter to determine particle **velocity** and **atmospheric residence time**.

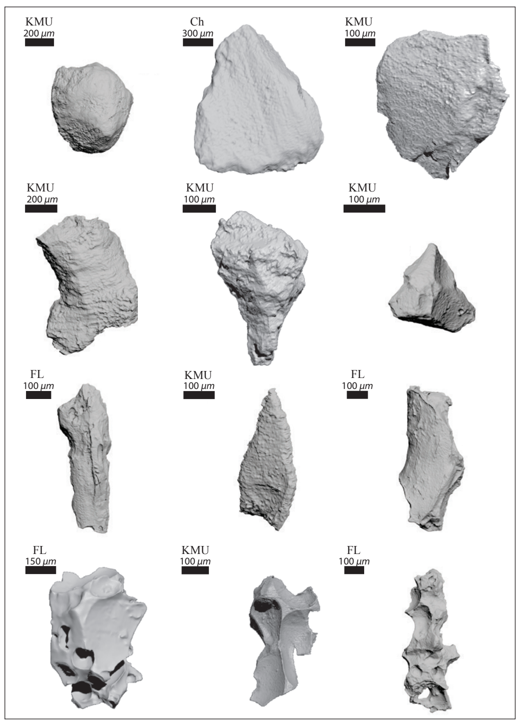
• We present **new models** for measuring **drag coefficients of non-spherical particles** traveling in **air** at **Reynolds numbers between 10 and 10^5**.

• 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**.

Materials

Falling column experiments:

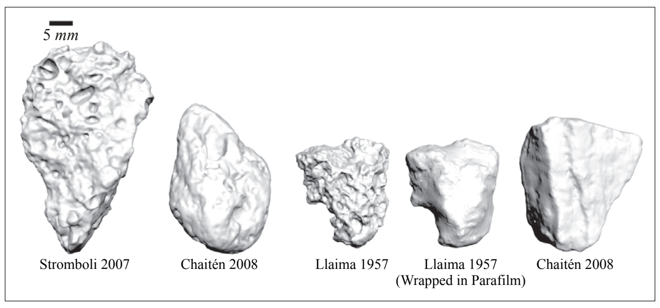
- **130 non-spherical** particles (**114 volcanic clasts**)
- 161 μm < d < 1.5 mm, 10 < Re < 544
- 12 volcanic particles are fully characterized by **SEM micro-CT** and **image analysis**
- The rest are characterized by **multiple-projection**



3D scans of selected ash particles obtained by SEM micro-CT. KMU:Mystery Unit of Keanakakoi formation (Kīlauea), FL: Fontana Lapilli (Masaya), Ch:Chaitén 2008

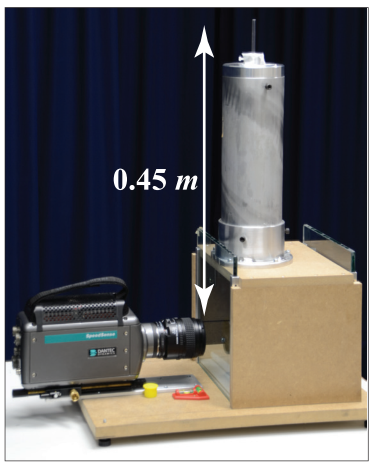
Vertical wind tunnel experiments :

- **178 non-spherical** particles (**116 volcanic clasts**)
- 10 mm < d < 40 mm, 7 × 10^3 < Re < 6 × 10^4
- All particles are fully characterized by **laser scanner** and **image analysis**

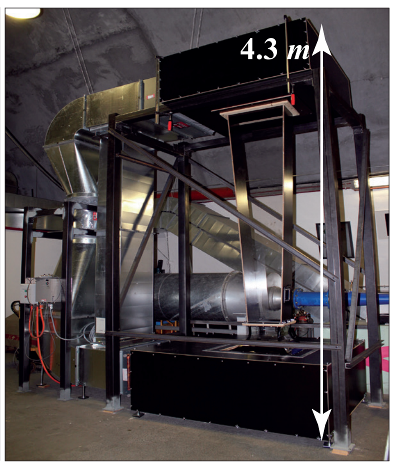


Some examples of 3D scans of lapilli particles obtained by laser scanning

Methods



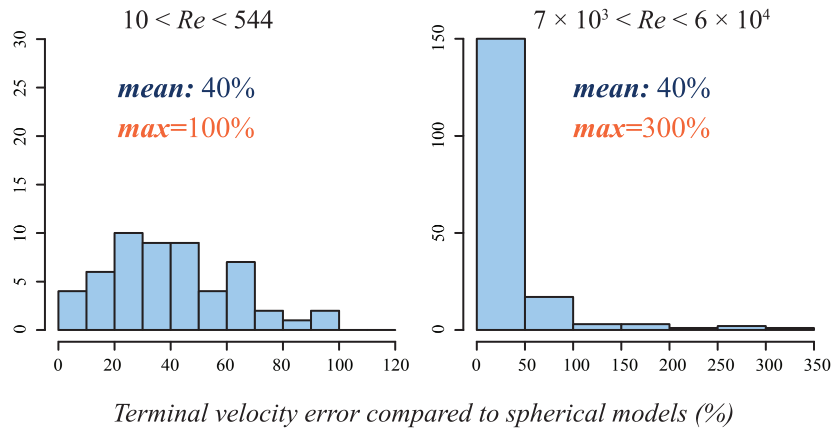
One of the three falling columns of various heights (0.45-3.6 m) used in our experiments



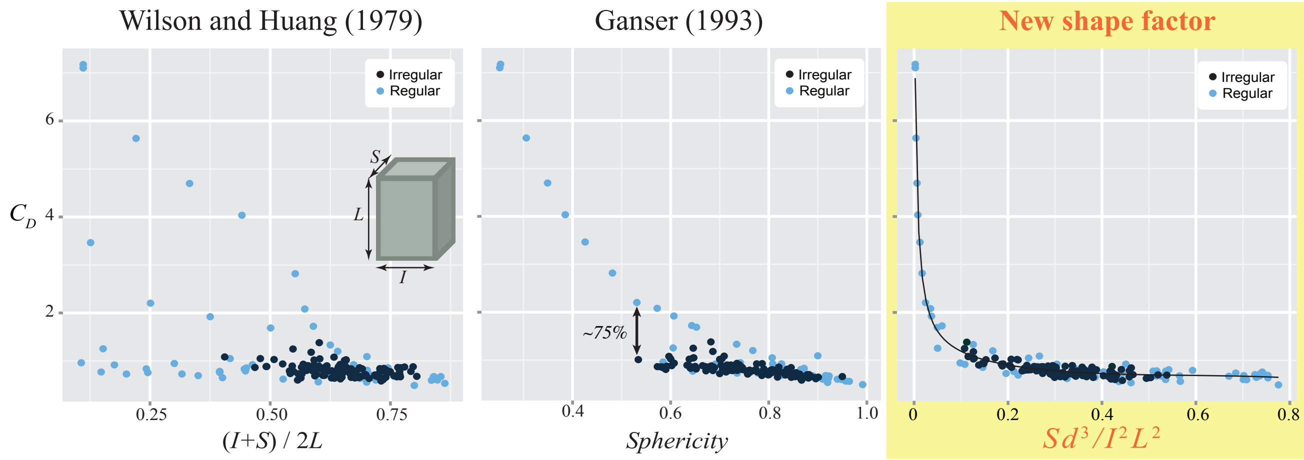
Vertical wind tunnel (Bagheri et al., 2013)

Results

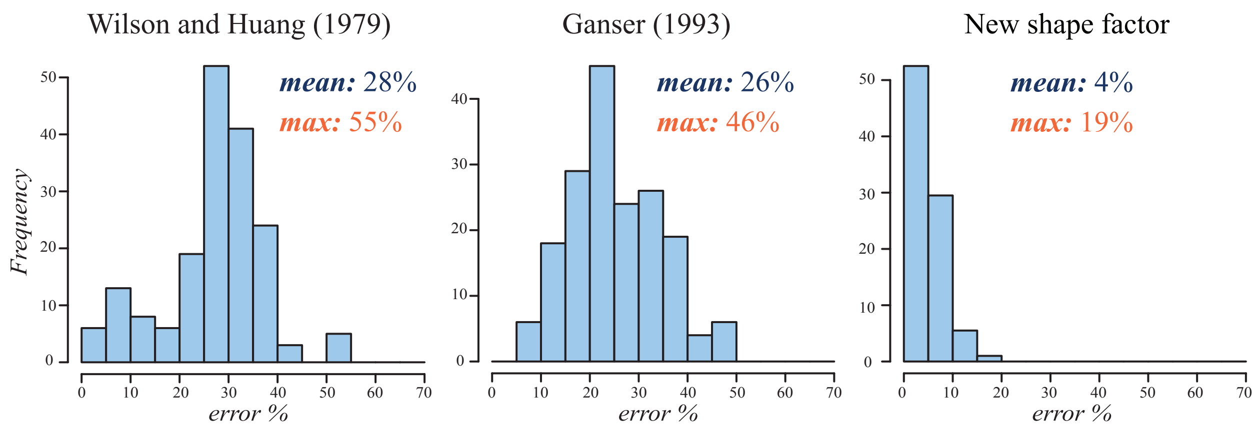
Estimations of spherical models vs. measurements



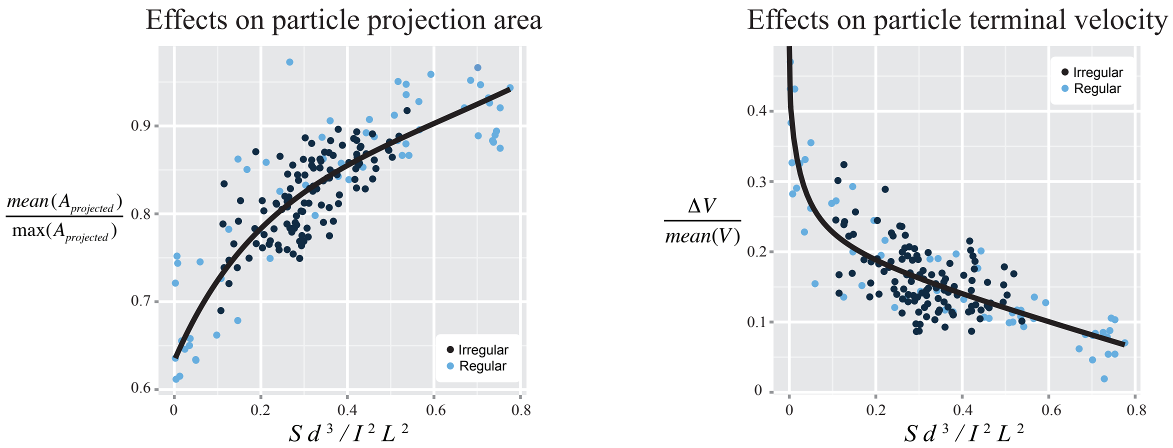
C_D vs. shape parameters



Estimations of non-spherical models vs. measurements



Secondary motions of non-spherical particles suspended in air



Conclusions

- First model of **drag coefficient** for **freely** moving **non-spherical** particles in **air**:
  - ► **Easy-to-measure** shape factor
  - ► Lowest value of estimation error and uncertainty
  - ► Valid in a **wide range of Reynolds numbers** (between 10 and 6 × 10^4) for both **regular** and **irregular** particles (including volcanic clasts)
- First study of **secondary motion** of free falling particles and their **preferred orientation**
- First model describing the **variation** of mean particle **terminal velocity** due to particle secondary motions
  - ► **Terminal velocity of non-spherical particles** is better characterized based on a **range of velocities** rather than a single value

References

Wilson, L. & Huang, T. The influence of shape on the atmospheric settling velocity of volcanic ash particles. Earth Planet. Sci. Lett. 44, 311–324 (1979)

Ganser, G. H. A rational approach to drag prediction of spherical and nonspherical particles. Powder Technol. 77, 143–152 (1993)

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