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# Micro-Physics and Modelling of Martian Dust Storms

Lorenzo Martinuzzo - 40th Cycle

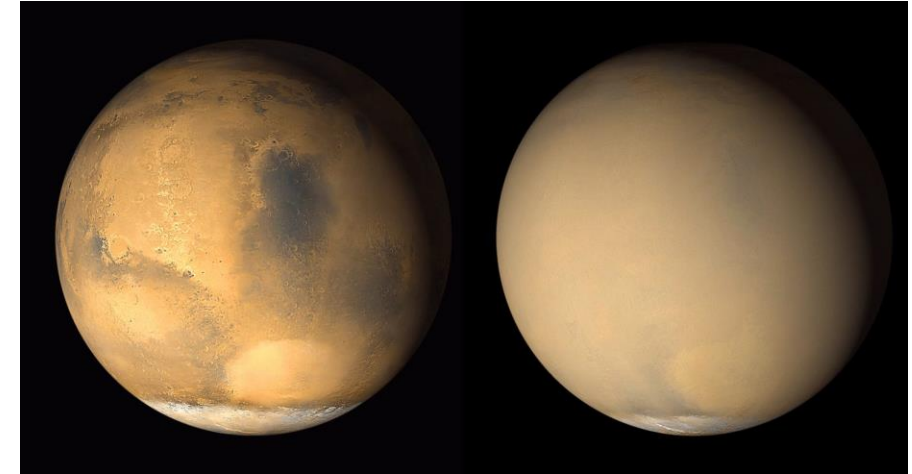
Supervisor: Dr. Federico Dalla Barba

Admission to the first year - 13/11/2024



Dust storms could have a significant impact on both manned and unmanned missions on Mars:

- Huge amount of dust lifts in the atmosphere;
- Wide extent of dust storms.



NASA, Mars Global Surveyor, 2001

These storms lead to several limitations for Mars exploration, e.g.:

- Telecommunication attenuation;
- Solar radiation reduction on solar photovoltaic power systems.

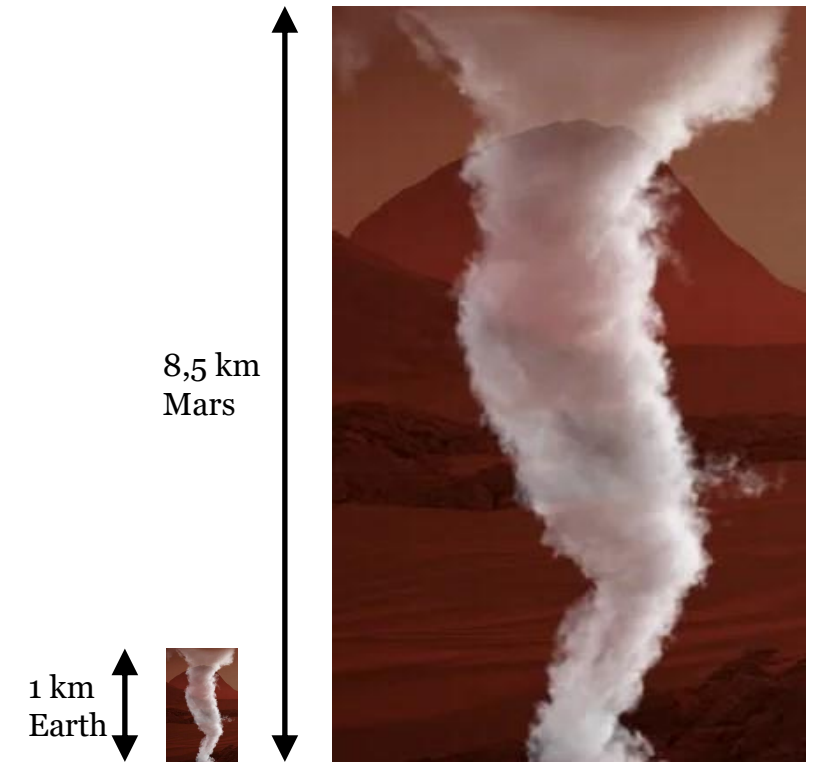


NASA, Opportunity rover

Lift, suspension and sedimentation mechanisms need a deep study of the micro-physics from a computational point of view since wide in situ measurements campaign are not available.

Martian atmosphere has some peculiar characteristics that distinguish it from the Earth atmosphere:

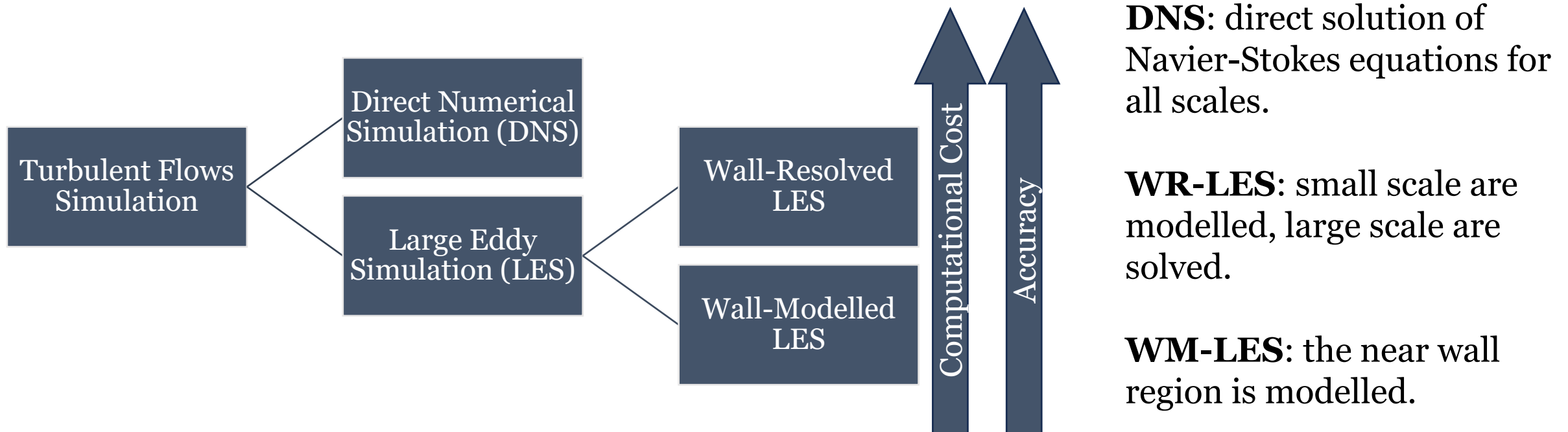
- Larger density ratio between rock particles and the atmosphere;
- Bigger temperature gradients;
- Strong influence of the sublimation/frosting cycle of  $\text{CO}_2$  ices on the atmospheric pressure.



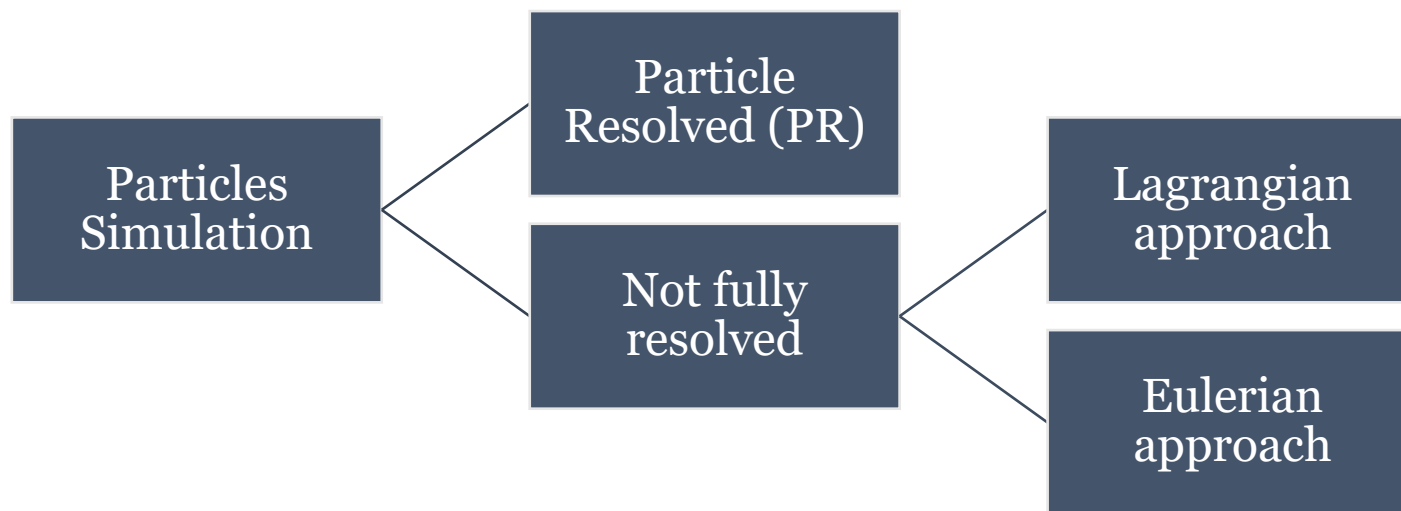
Dust Devils maximum observed height comparison between Earth and Mars

Particles laden flows require to simulate both fluid dynamics and the particles dynamics.

DNS and LES are the state of art for turbulent flow simulations.



Particles simulation can be handled with different methodologies:



- **PR:** fluid-particle boundary conditions are fully resolved;
- **Lagrangian:** Lagrangian equation of motion for particles, fluid interaction is modelled;
- **Eulerian:** fluid and particles are treated as a continuum, models are required.

# Activity 1: PR-DNS

## Purposes:

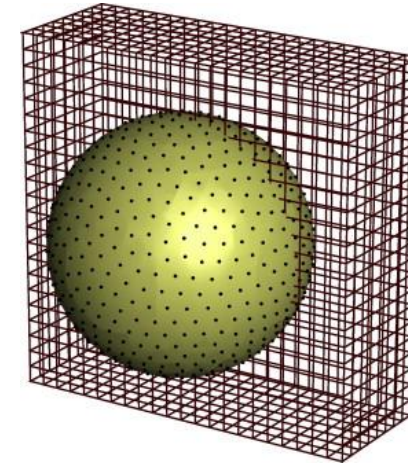
- Understand the physics of particles lift, suspension and sedimentation;
- Create a wide dataset of different flow-particles configurations.

## Adopted methodologies:

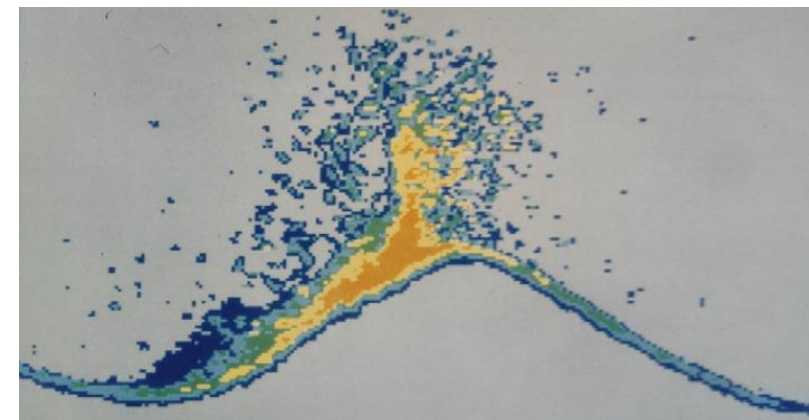
- Particle-Resolved DNS with IBM.

## Activities:

- Integrating an already available numerical code + GPU acceleration;
- Validation of the code and simulations.



W.P. Breugem, 2016



M. Mazzuoli et al., 2024

## Purposes:

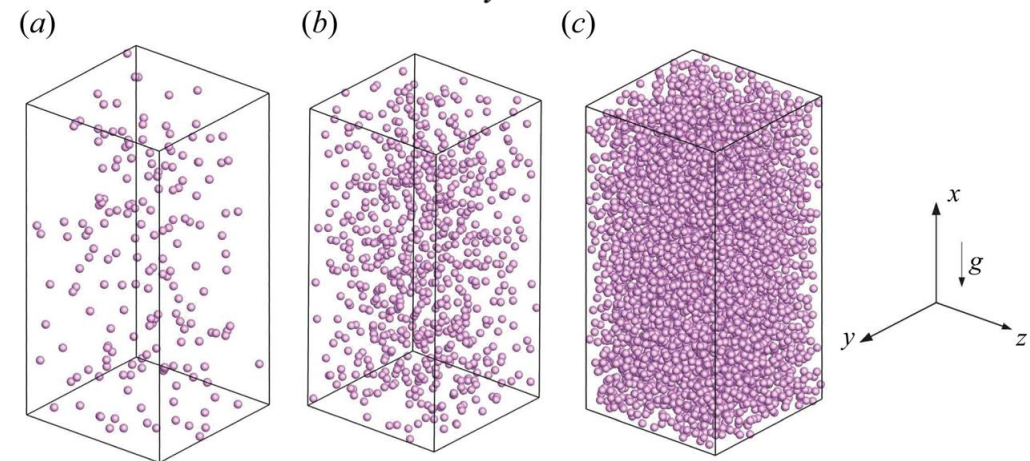
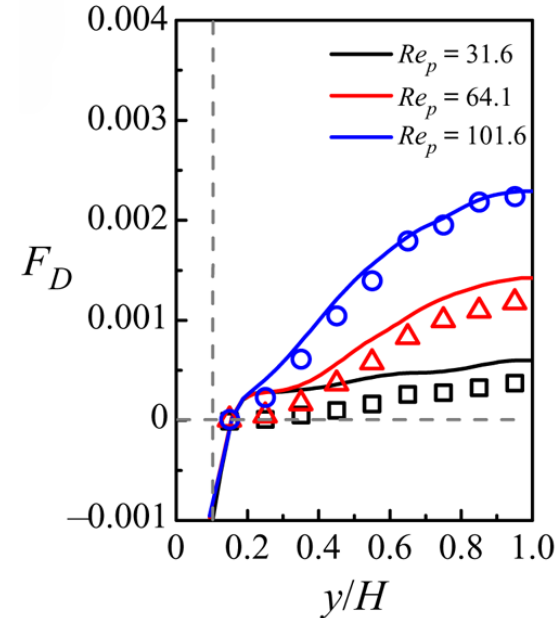
- Identification of fluid-particles interaction models;
- First reduction of computational cost.

## Adopted methodologies:

- Point-Particle DNS.

## Activities:

- Dataset analysis and model extraction;
- Validation of the models and simulation.



Y. Xia et al., 2022



## Purposes:

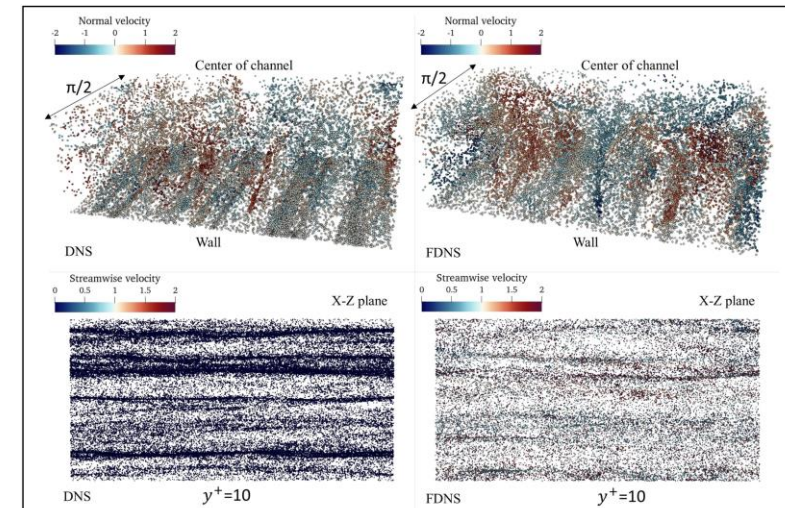
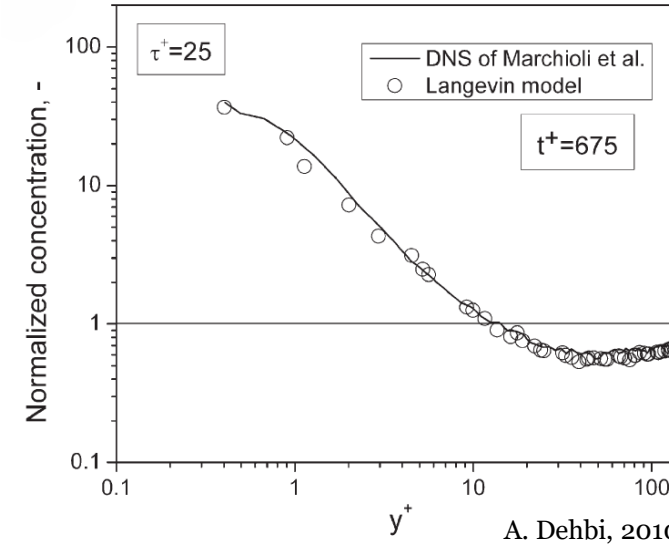
- Verify models for LES;
- Simulate more complex configurations for dust clouds.

## Adopted methodologies:

- WR-LES;
- WM-LES.

## Activities:

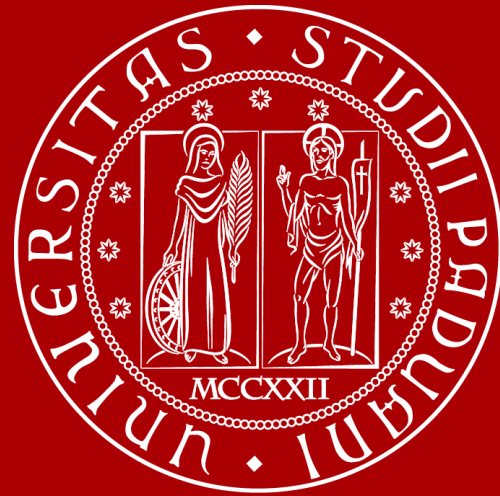
- Apply models to LES and validation;
- Simulation of Martian dust clouds at meso-scale.



F. Rousta et al., 2024



Thanks for the attention



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