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SPIS-DUST Capabilities and Use-Cases

NASA Lunar Science Innovation Center (LSIC) meeting
15/03/2022

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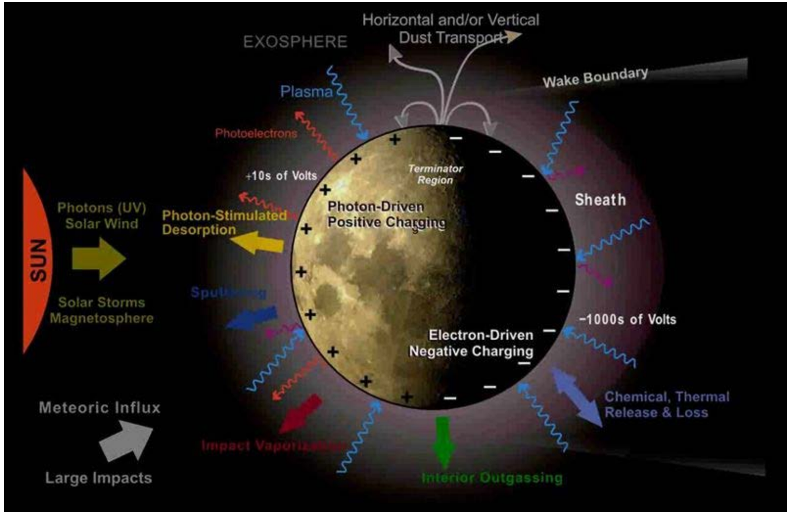
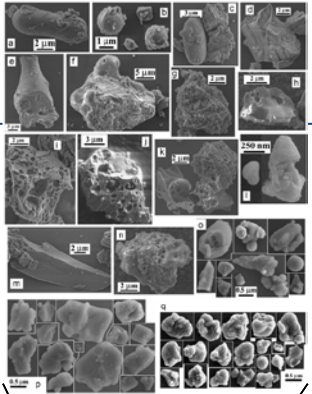
Context

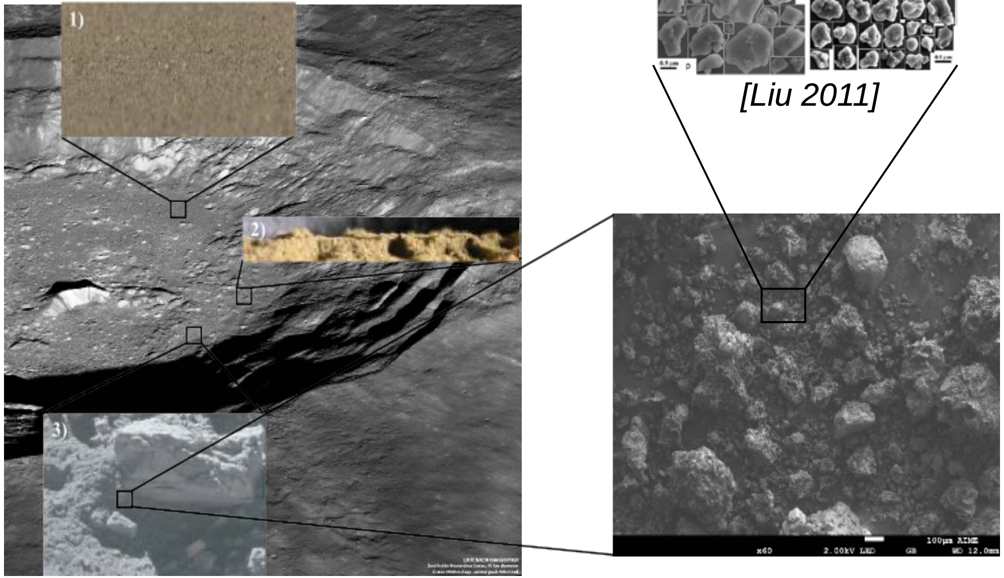
Dust charge & adhesion on airless bodies : multi physics - length - time scales
Evaluation of dust mobilization by numerical modelling is a challenging issues



[Credits : *NASA*]



[Liu 2011]



Content

- SPIS-DUST status
- Overview of Software Capabilities
- Validation and Use-Cases
- Testing Capabilities

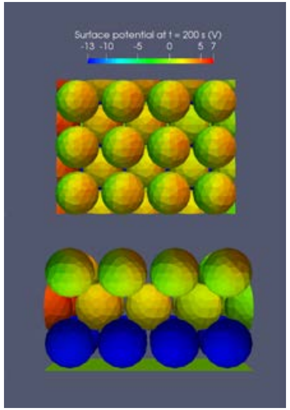
SPIS-DUST status

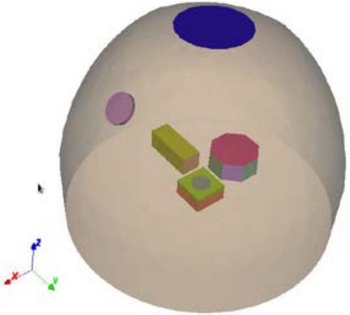
- Free download
  - https://www.spis.org/software/spis/get/

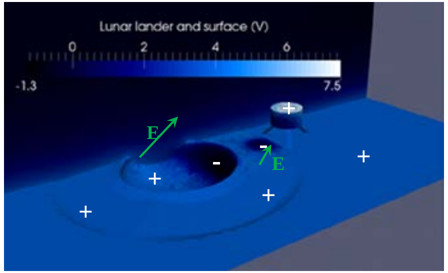
- Developments and test of SPIS-Dust supported by
  - ESA R&D contracts : Dusty env (4000106893/12/NL/CO), SPIS-DUST (40004107327/12/NL/AK),
  - ONERA Research program ONERA : #24471 (Philae), #22804 (PhD), #25660 (Collab. With IKI), #26766 (PhD)

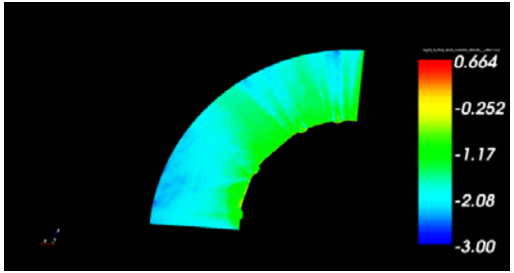
SPIS-DUST Overview

Scale: Microscopic (dust beds & single dusts) → Mesoscopic (sub-system) → Macroscopic (lander and crater) → Astronomic (Bennu asteroid)









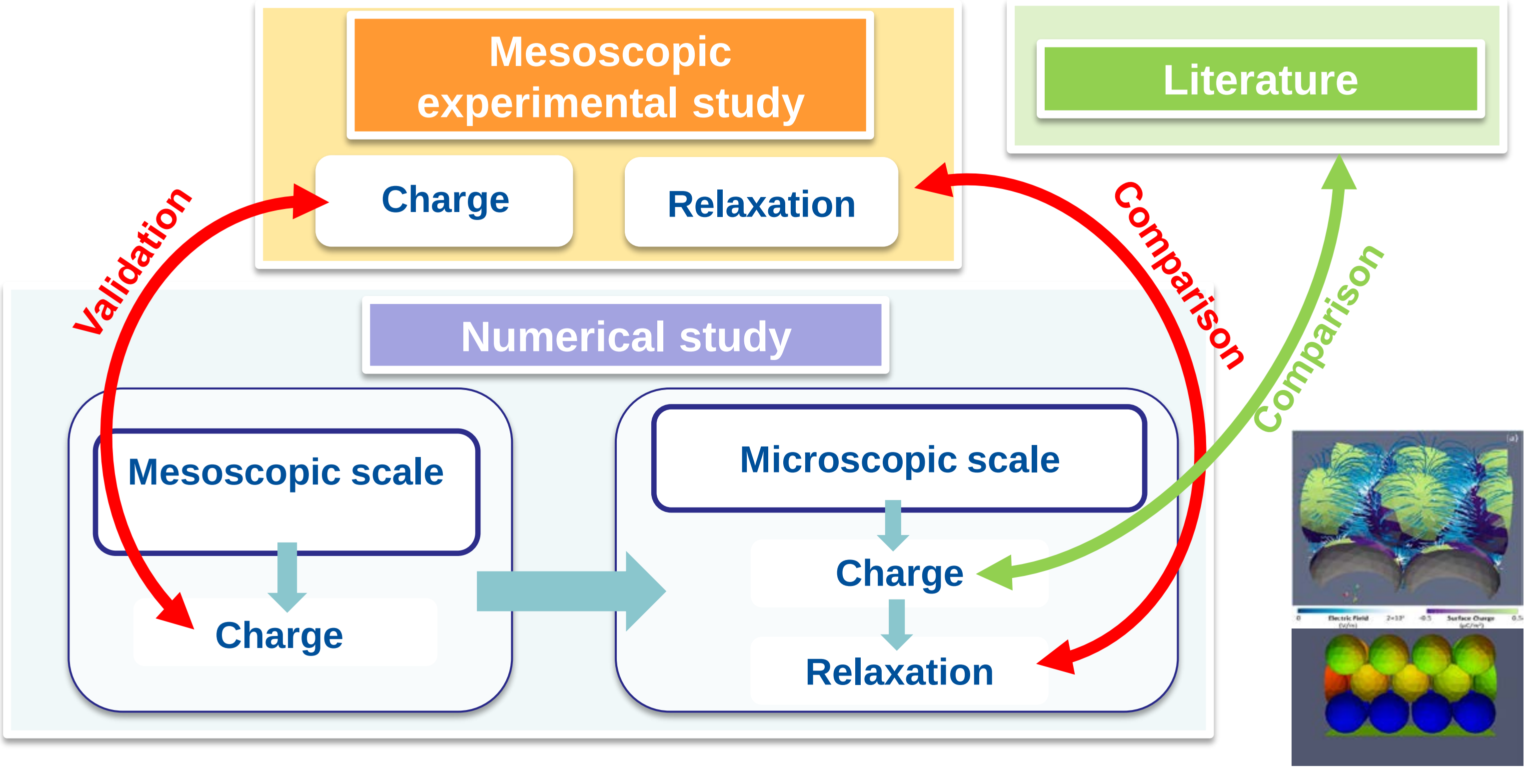
- Charge of individual dust
  deposit, secondaries, photo-e-, internal…
- Charge transport between grains
  through a equivalent resistance

- Charge of dust macroparticles
  reduced charging model
- Forces on grains in regolith
  gravitational, cohesion, electrostatic, inertial, outgassing,…
- Dust emission

- Dust charging in plasma
  collection, secondaries, photo-e$^-$
- Dust transport
  gravitational, electrostatic, pressure, radiation…
- Dust deposit on spacecraft

Experimental / Numerical Validation of Dust Charge

DROP chamber

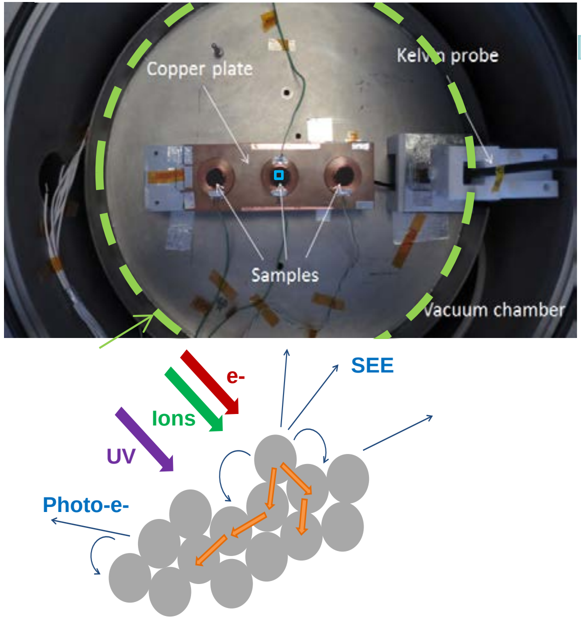


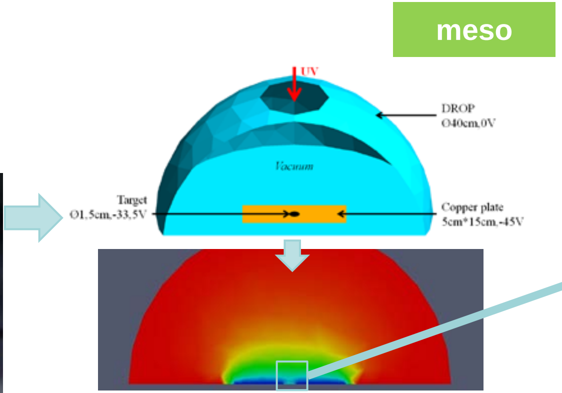
Zimmerman 2016 /Oudayer 2019

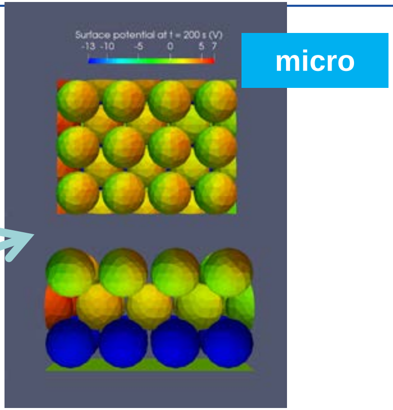
Modelling of Dust Charge Experiments in DROP Chamber

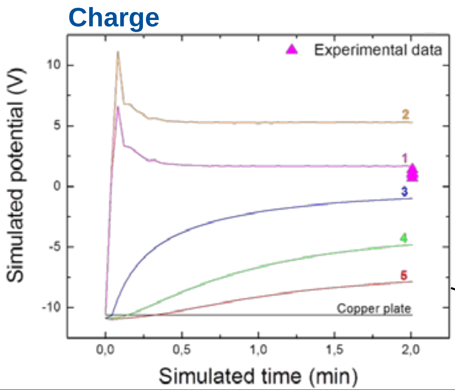
[Oudayer et al, 2019]

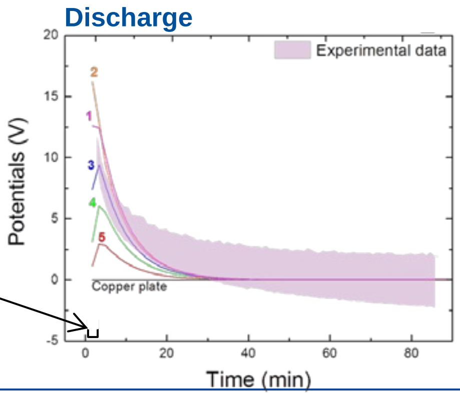
Dust charging
- electron and VUV
- contactless surface potential probe
- electrical conductivity



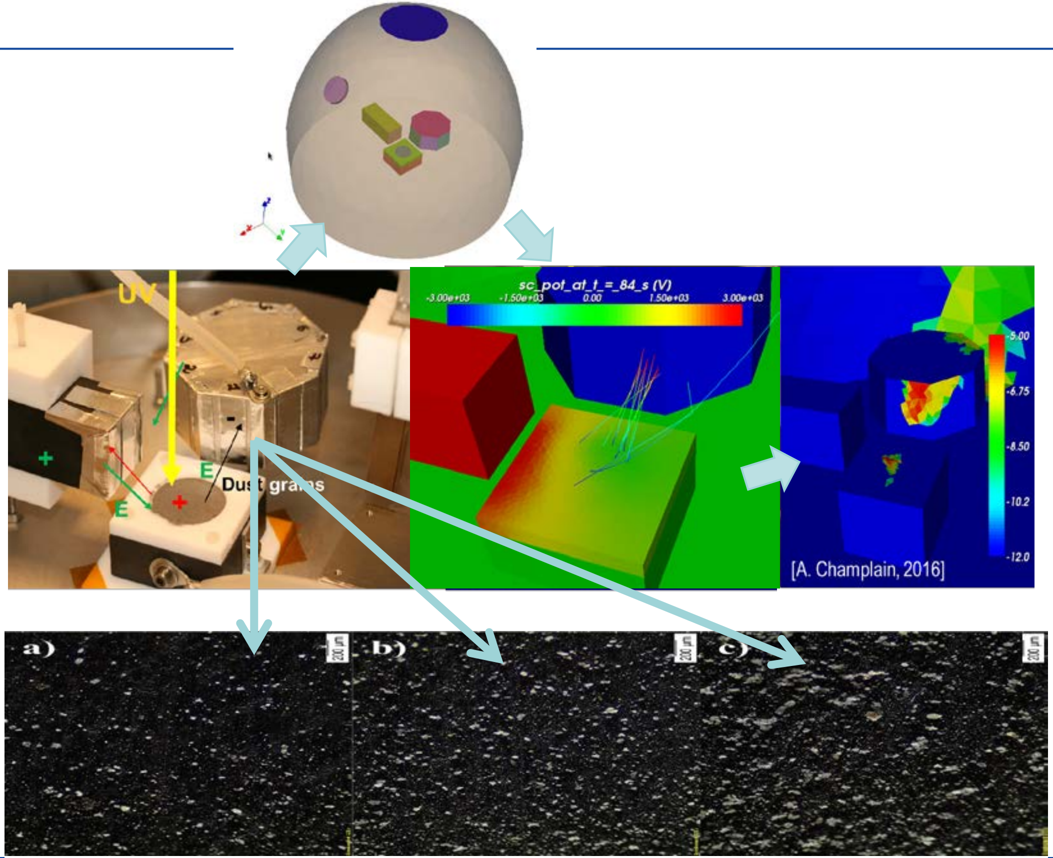








Experimental Investigation of Dust Charge and Transport *[Champlain et al, 2016]*



2000 V
Weighing: 70 µg

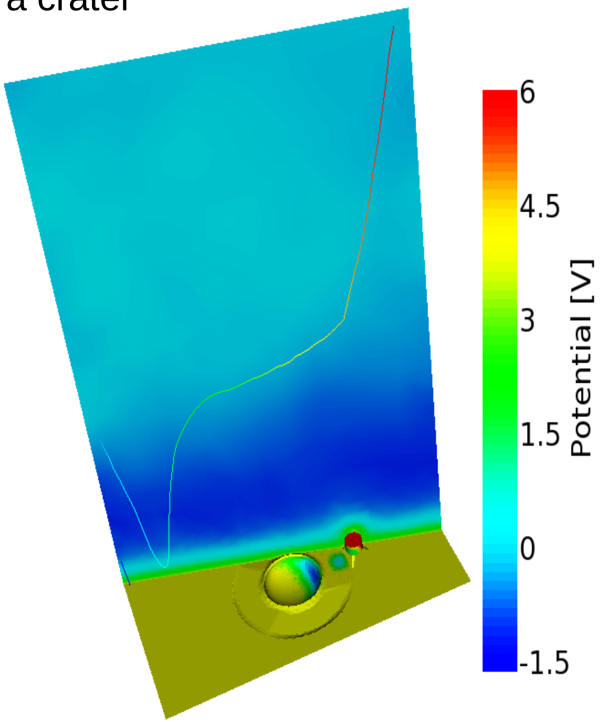
2500 V
Weighing: 140 µg

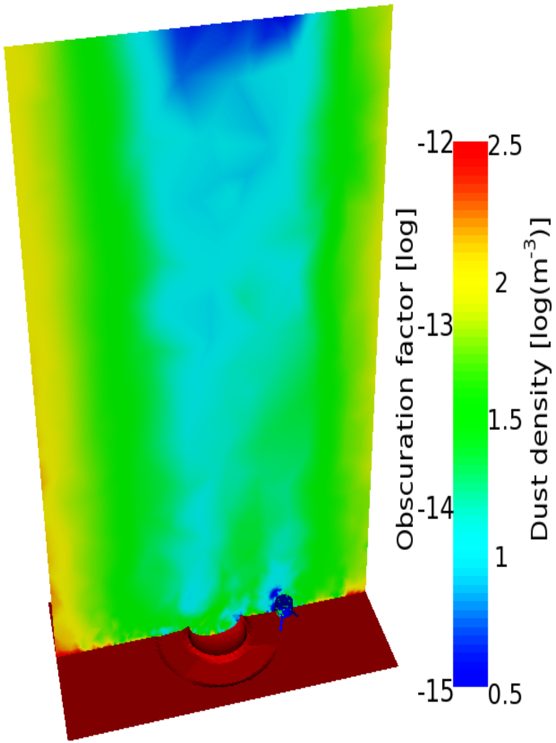
3000 V
Weighing: 200 µg

Use-Case 1 : Crater and Lander

[Hess et al, 2015a]

- Simple lunar geometry: lander close to a crater
- 100m by 50 m by 50 m domain
- Sun Zenith angle =45˚
- Non-monotonic sheath
- Differential potential in the crater
  → enhanced dust emission
- Contamination of lander surfaces





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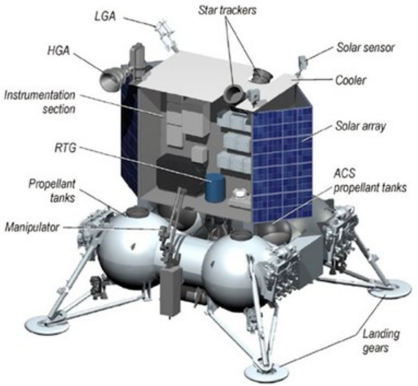
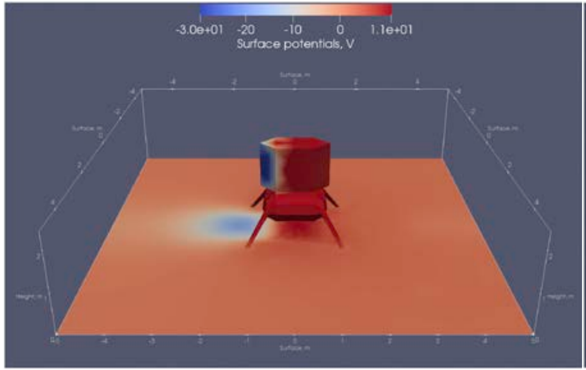
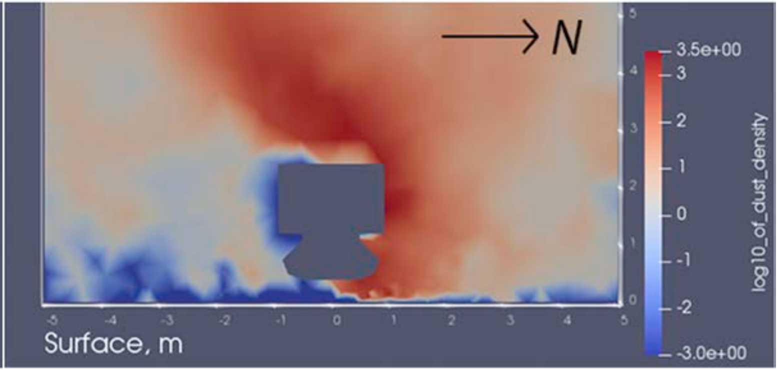
Use-Case 2 : Luna Glob

[Kuznetsov et al, 2018]

- Realistic case: Luna Glob
- Goal: evaluate the dust collection and distribution on the lander and on the dust instrument
- Impact on Langmuir probes and Impact sensor could be estimated, helping to the instrument design

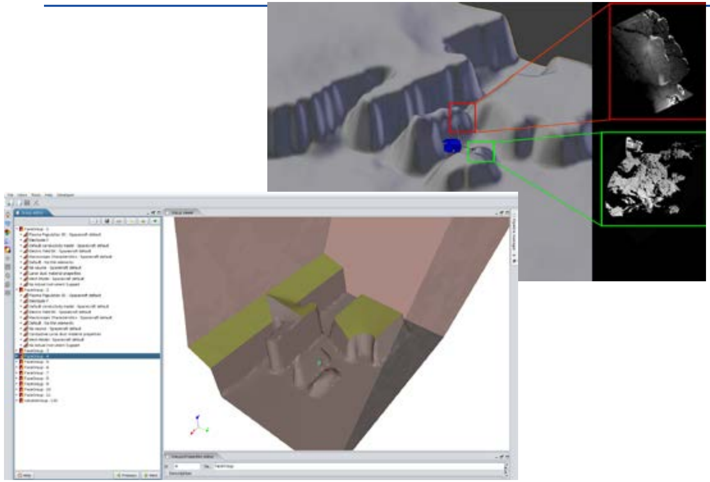






Use-Case 3 : Philae

[Hess et al, 2015b]



Philae on Churyumov-Gerasimenko

CNES DTM reproduced “by hand” for this simulation: 50 m x 50 m x 130 m

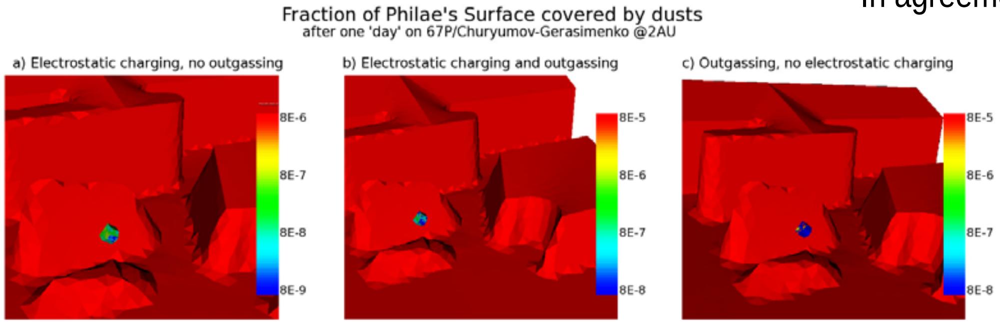
Simulation of one “day” (~12h) on the comet.

Extra package developed by ONERA:

- Computes the surface temperature from the sun flux
- Compute the outgassing flux of H_2O from the temperature
- Compute the dust flux from the H_2O flux

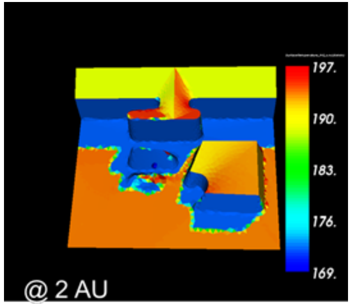
Simple thermal model: $(1-A)\Phi_{\odot}=\varepsilon\sigma T^4+\mathcal{I}\Omega^{-1/2}(T-T_0)+f_{H2O}P_{sat}/(2v_{th})\mathcal{L}$

In agreement with more detailed models [Tenishev et al. 2011,…]

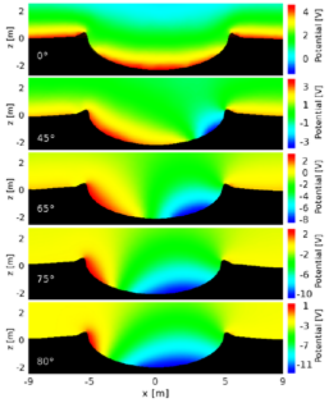


Strong electrostatic effect on dust collection, even with outgassing

Strong collection at dawn.



Use-Case 4 : Bennu



- Simulation of the dust environment of an asteroid (101955 Bennu)
- Full scale ~250 m radius (2D)
- Variety of local times = variety of surface charges and sheath
- Dust density strongly affected by local time and surface topology:
  - More dust at local noon and faster dusts from crater borders
  - At limb, negative surfaces attract positive dusts