Dust electrostatic charging, transport and contamination for Lunar Lander and Human exploration missions

-

SPIS Dust Contract Change Notice

Final presentation days

Jean-Charles Matéo Vélez, Pierre Sarrailh, Sébastien Hess, ONERA
Benjamin Jeanty-Ruard, Nicolas Chabalier, Julien Forest Artenum

ruard@artenum.com

Final presentation Days – 2017/03/06

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Study facts

ESA Contract: 40004107327/12/NL/AK
Funding programme: TRP
Contract Value: 334 970 Euro including CCN1
Start and end dates: December 2012 to September 2016
Technical officers: Fabrice Cipriani and David Rodgers
Study team:

- Prime: ONERA, France
  - Jean-Charles Matéo Vélez
  - Pierre Sarrailh
  - Sébastien Hess
- Partner: Artenum SARL, France
  - Benjamin Jeanty Ruard
  - Julien Forest
- Partner: Lancaster university
  - Steve Marple
  - Honary Farideh

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Introduction

- In the frame of the core contract (already presented in passed FPDs), make SPIS able to model the dust electrostatic charging, transport and contamination especially for lunar lander and human exploration missions
- The current presentation is focused on the new features developed in the CCN context of SPIS Dust

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Outline

Description of features developed

- Geometric edition improvement:
  - Tessellated surface creation from digital terrain model: simplify the control parameter setting
  - Add a new landing feature
  - Merging feature between geometric surfaces:
    - Develop more efficient algorithm to compute faces in contact
    - Simplify the user interface to compute faces in contact
    - Detect and suppress overlaps between faces in contact
- Geometric Shadowing:
  - Add new shadowing visualization feature
- Global parameter editor improvement:
  - Possibility to define the formula of ions from chemical formula
- New monitoring features
- New validation test cases
- Final packaging

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Penelope ray tracer presentation

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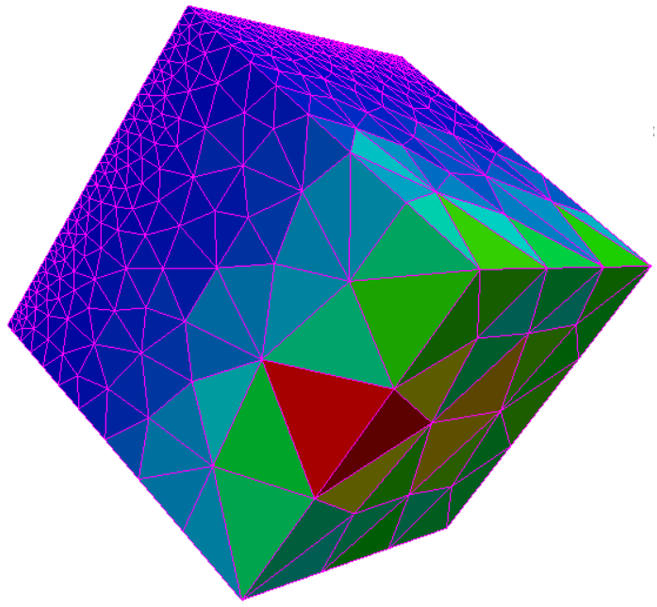
Penelope library presentation



Mesh

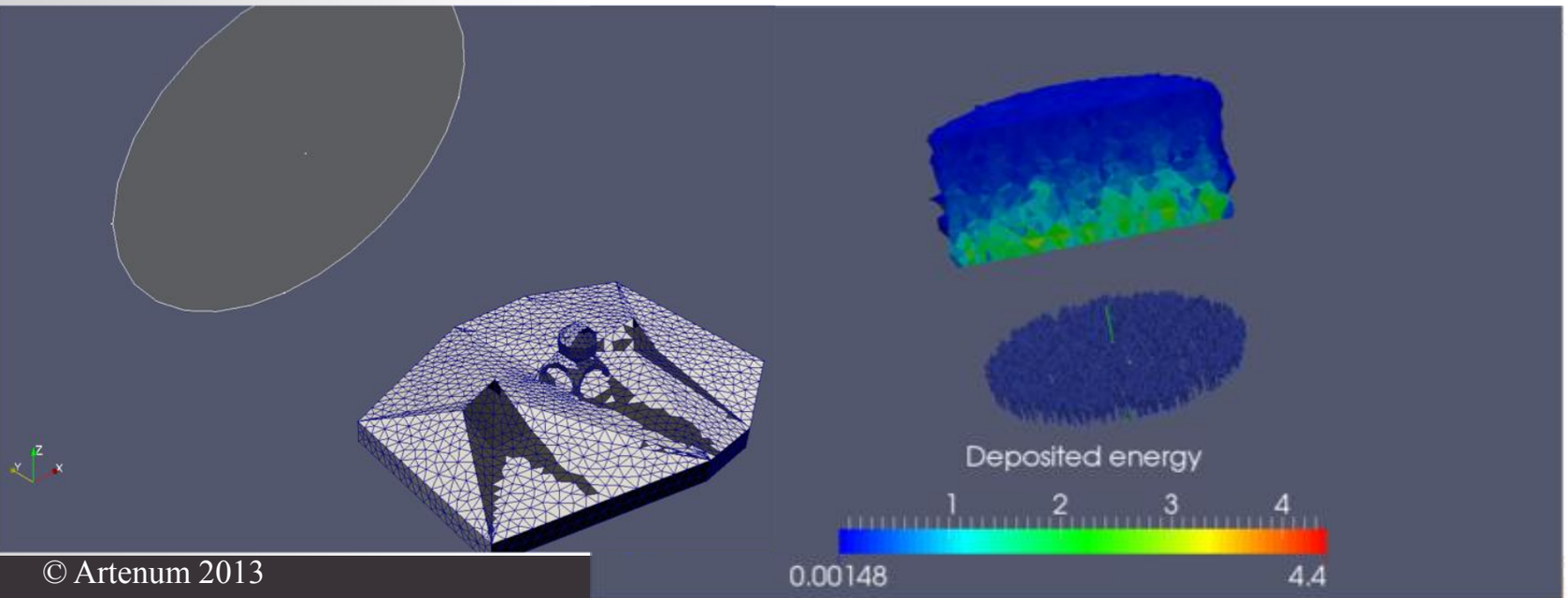
- 3D unstructured
- Low memory foot-print

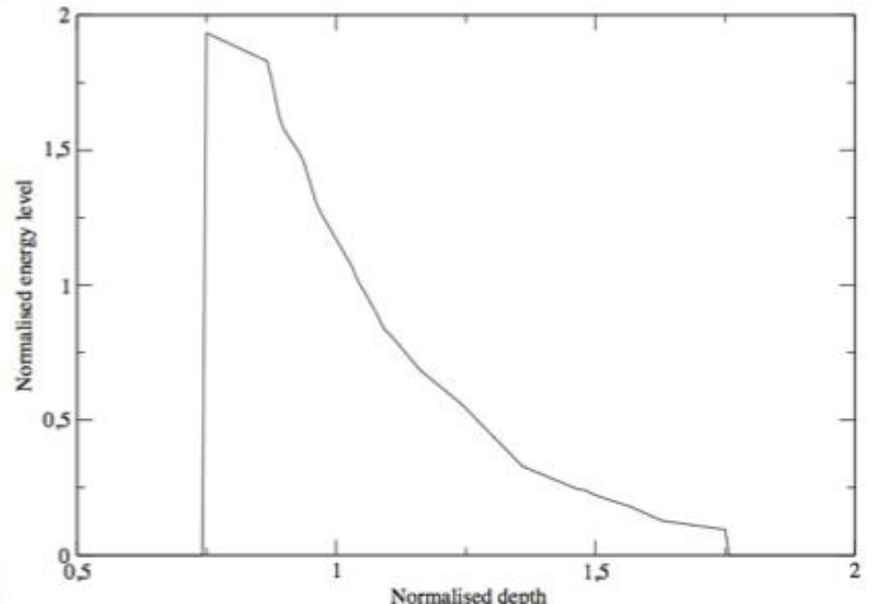
DataFields/MeshMask

- Various types of data (scalars, vectors, objects)
- Various location on elements

Dynamic management of mesh elements allowing lots of mesh operations

- Ray-tracer
- Mesh splitting
- ...





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Geometric edition improvement

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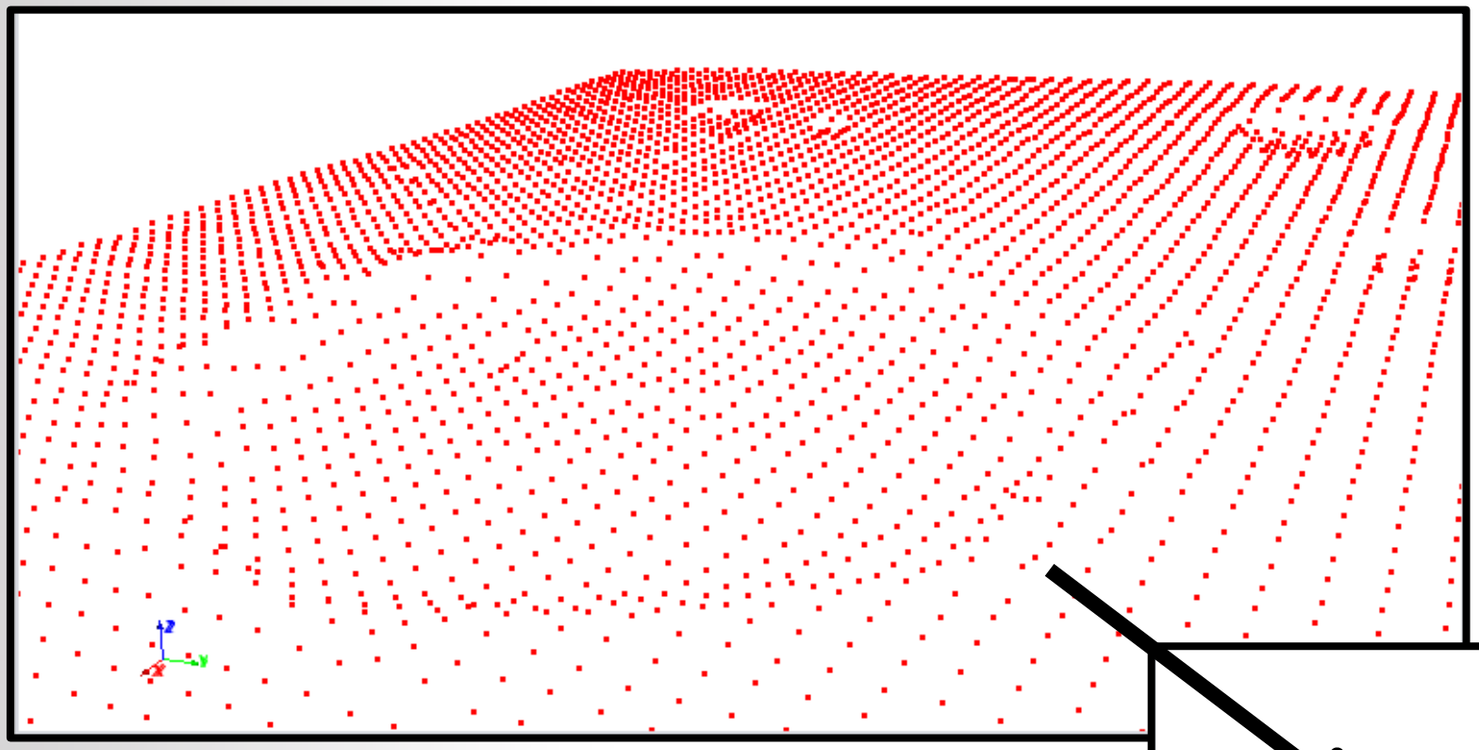
Geometric edition improvement

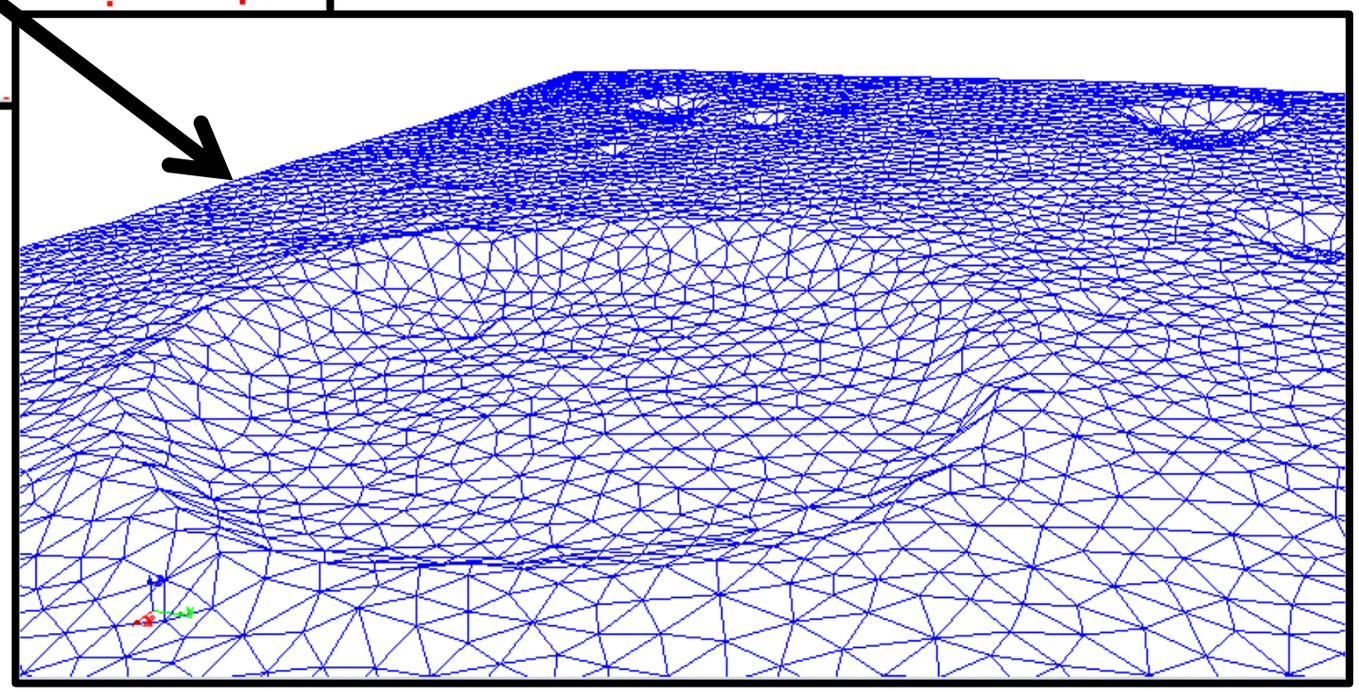
Objective: Create a tessellated surface from digital terrain model

- Perform simulation on realistic lunar surface



Digital terrain model

Tessellated surface to create



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Geometric edition improvement

Simplify the control parameters setting of the tessellated feature

- Add new section called “Show advanced settings”
- How to use:
  - Select a valid digital terrain model
  - A valid set of parameters are automatically computed
  - Click on tessellation button to generate the set of triangles
- Users can adapt the kriging parameters, like before, depending on they wish
  - Generate more or less triangles,
  - increase or decrease the number of neighbors used to compute the altitude of a point,
  - change the value of the mesh refinement to use during the generation of the final computational volume mesh
- Performance: The duration of the tessellation with the automated computed default values used on a standard desktop computer is about 10 seconds

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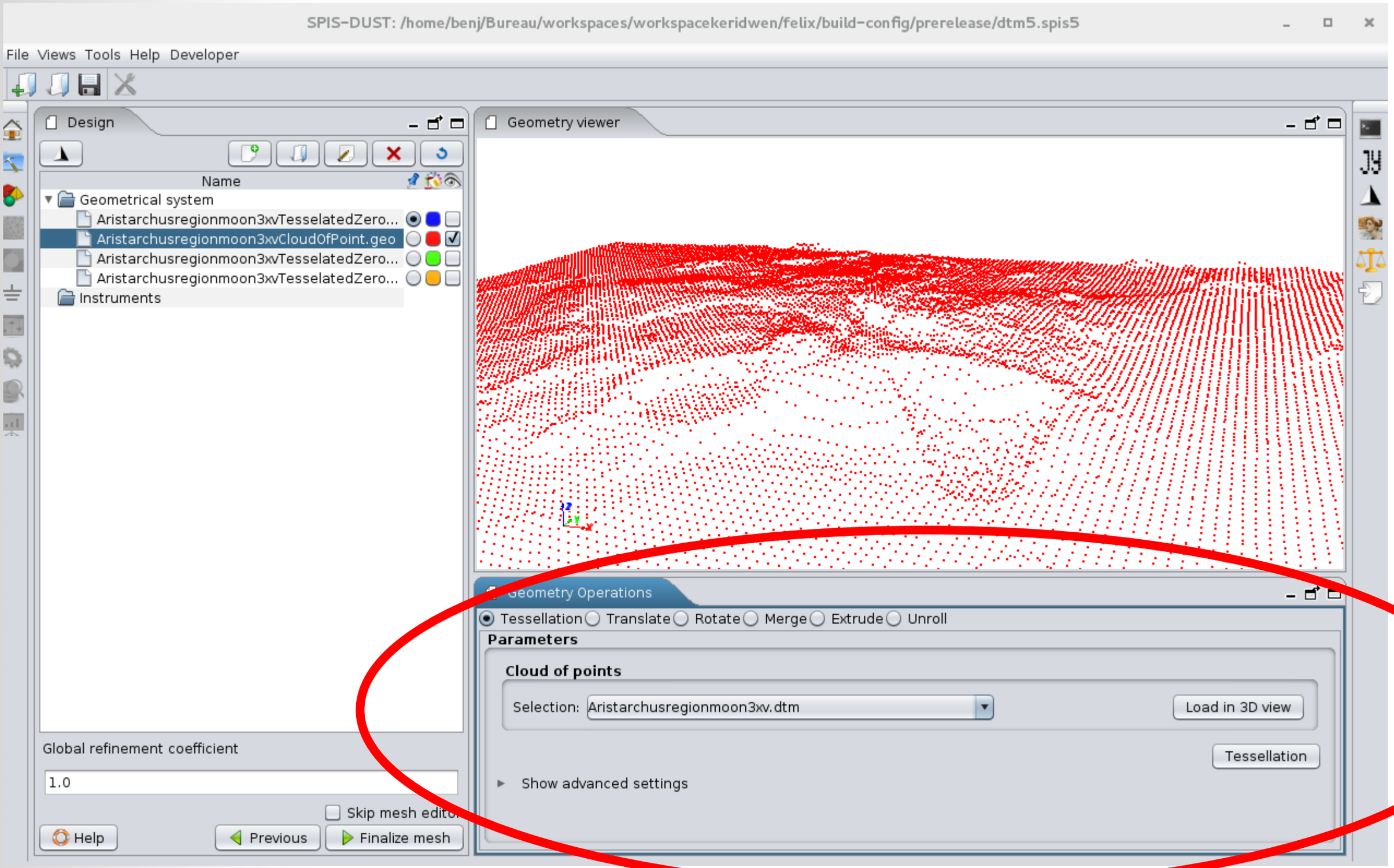
Geometric edition improvement



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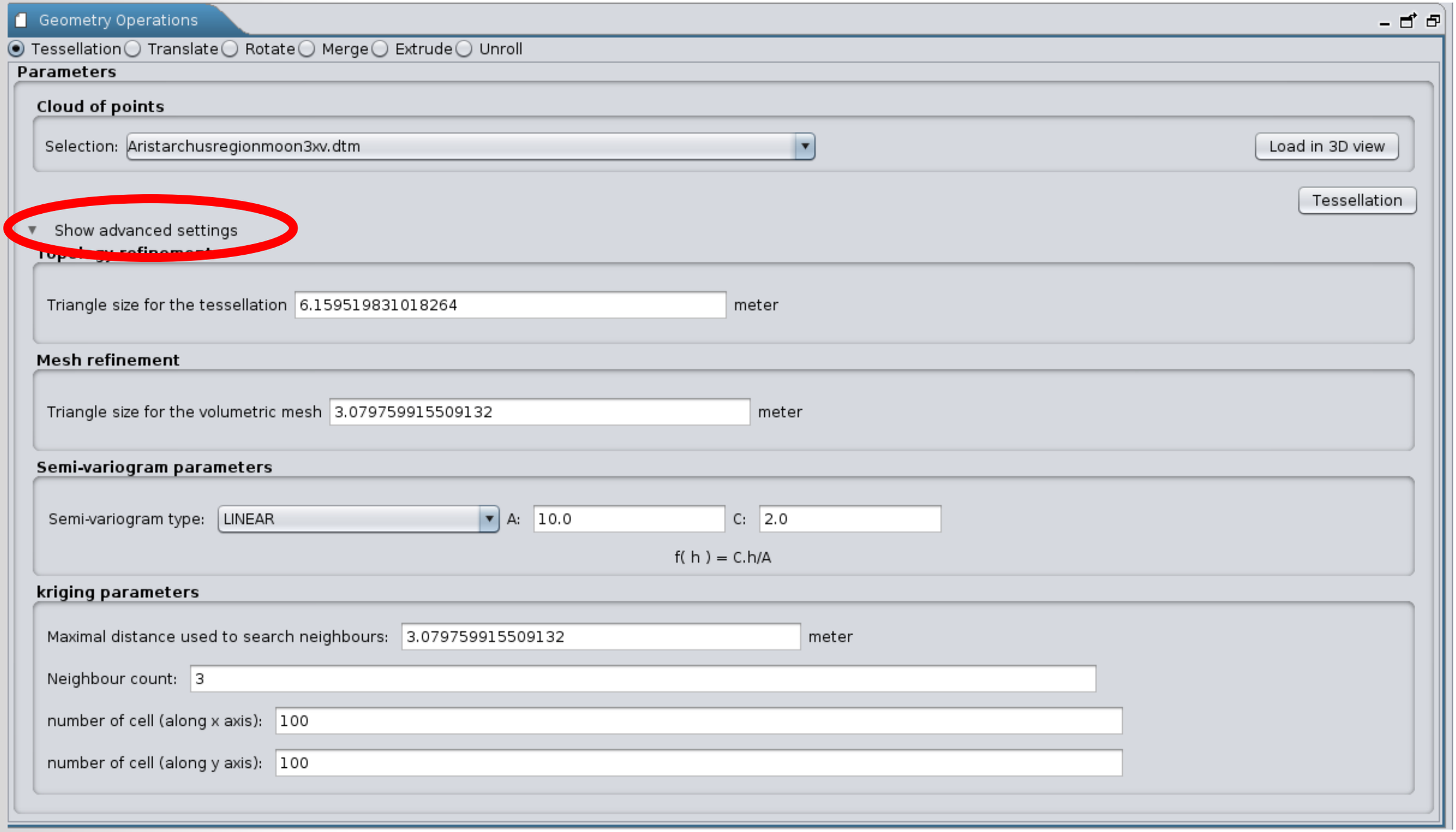
Geometric edition improvement



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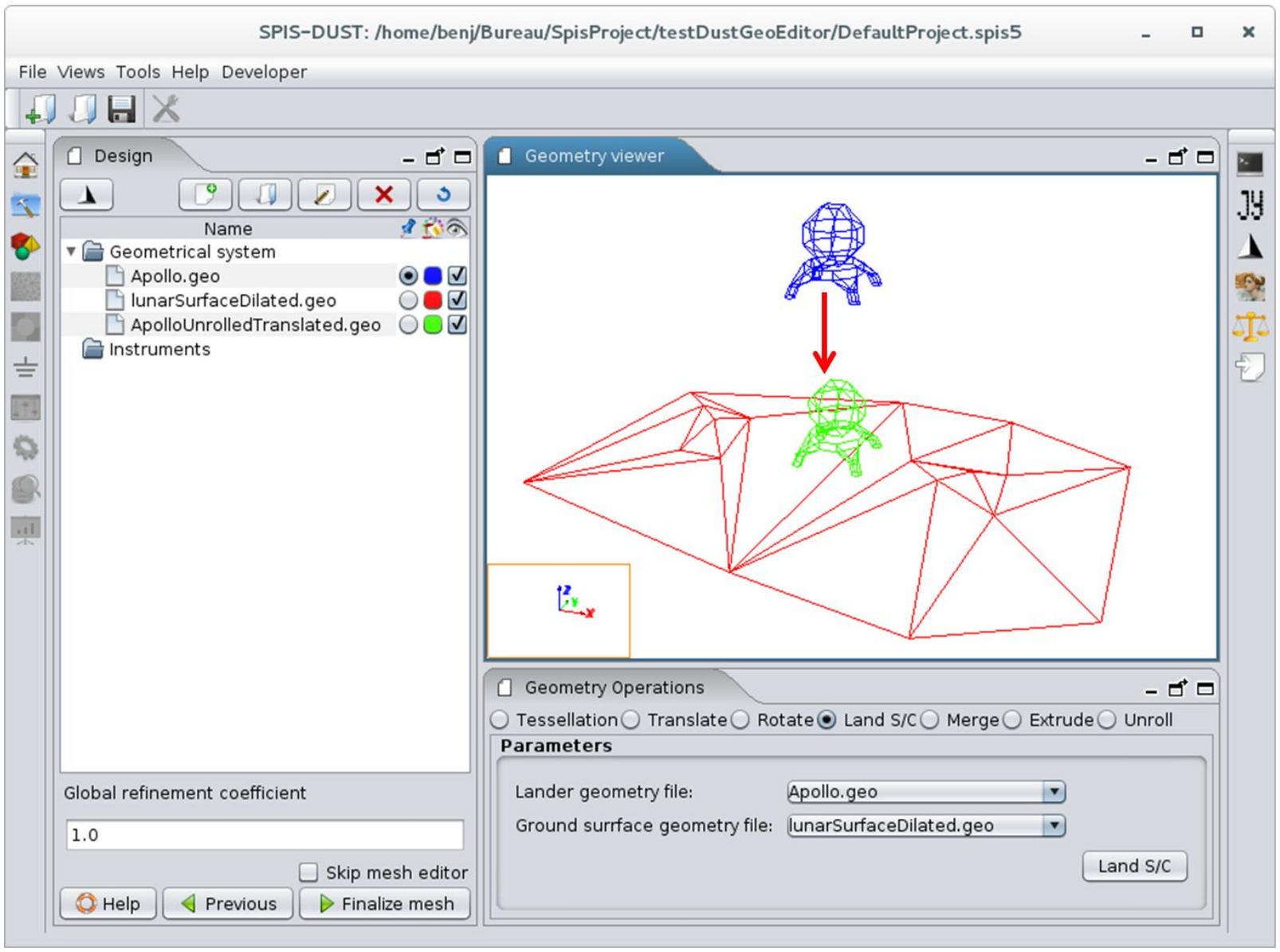
Geometric edition improvement

New automatic landing feature is available

- Allows placing easily the lander if any at the right place in the computational volume.



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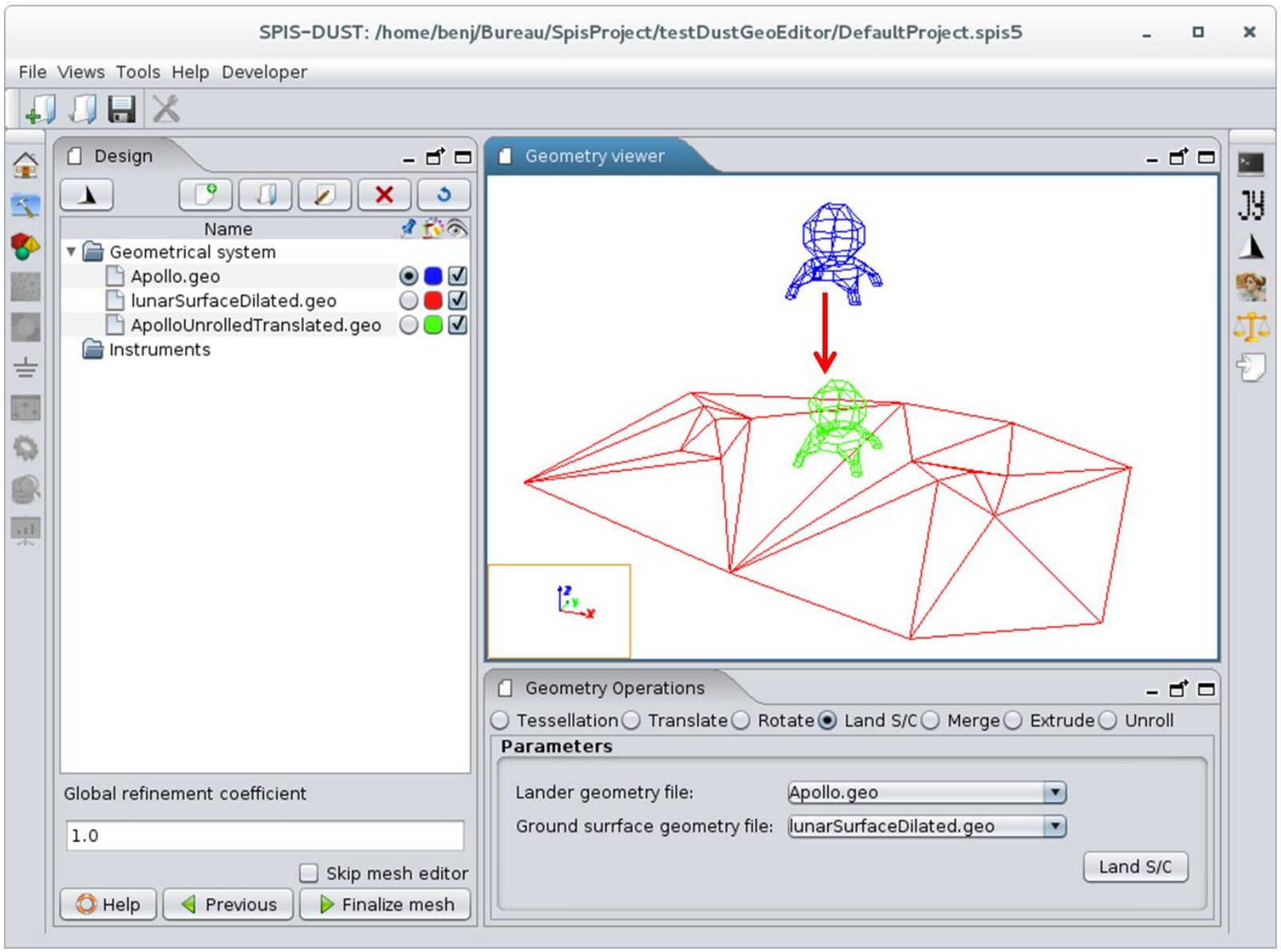
Geometric edition improvement

Algorithm:

- Uses the ray-tracer engine of the Penelope library to compute the minimal distance between the lander and the ground surface.

- After computation of the minimal distance between the two geometrical models, an automated translation along the z-axis is performed.



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Geometric edition improvement

Merging feature between geometric surfaces has been improved

Useful feature:

- When an exploration unit has been landed on the terrain model, the intersection of surfaces of both geometries should be carefully computed.
- In SPIS, the external boundary should be continuous.
- A specific merge operator has been developed
  - Identification facing face-elements thanks to Penelope ray-tracer
  - Try to fuse them in order to build-up a continuous surface
  - Remove existing overlaps between facing face-elements

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Geometric edition improvement

Before

- Algorithm to compute faces in contact
  - not enough efficient
  - Problem with overlaps of faces in contact
- User interface used to compute faces in contact
  - very complex

New developments

- Algorithm to compute faces in contact
  - Based on Penelope ray tracer
  - Efficient
  - New feature to remove automatically overlaps
- User interface used to compute faces in contact
  - Much more simple

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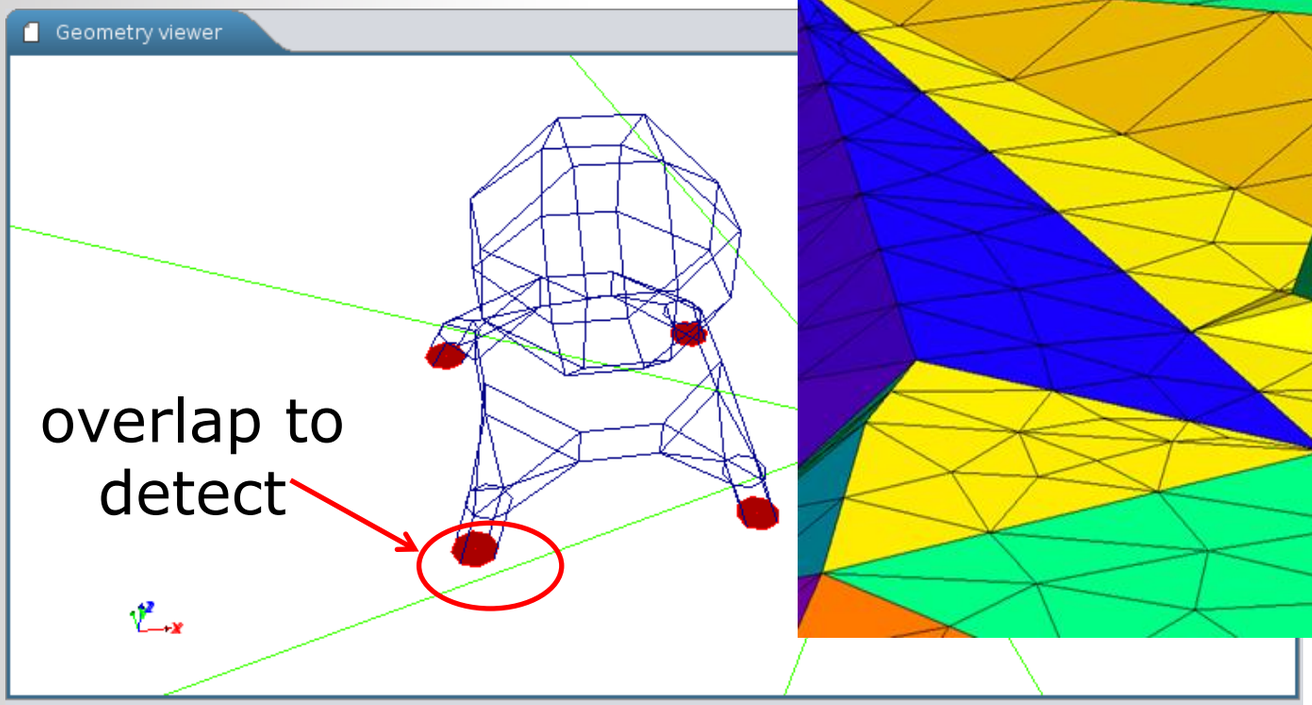
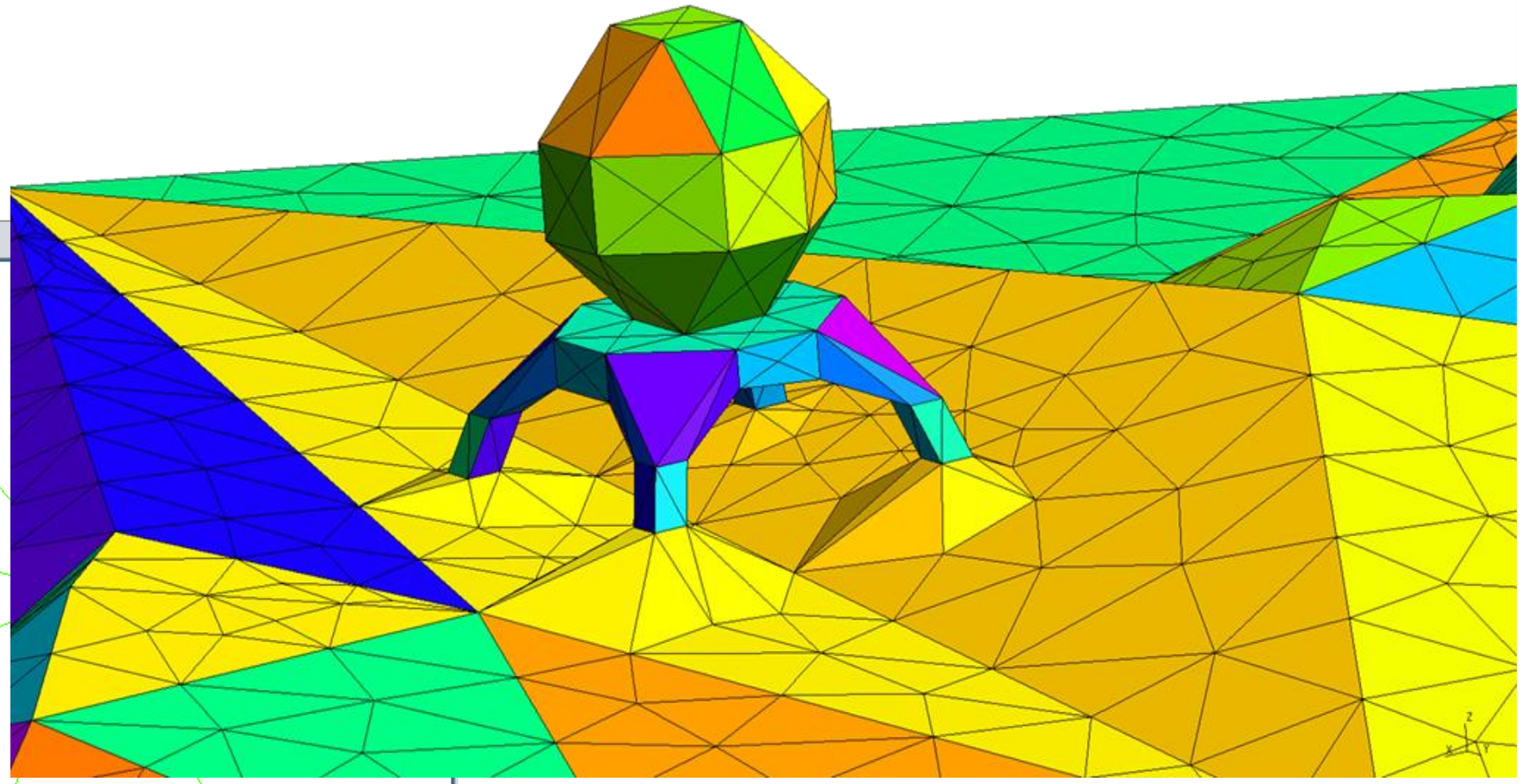
Geometric edition improvement

New features to detect and suppress overlaps

- efficient
- simple user interface





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Geometric shadowing development

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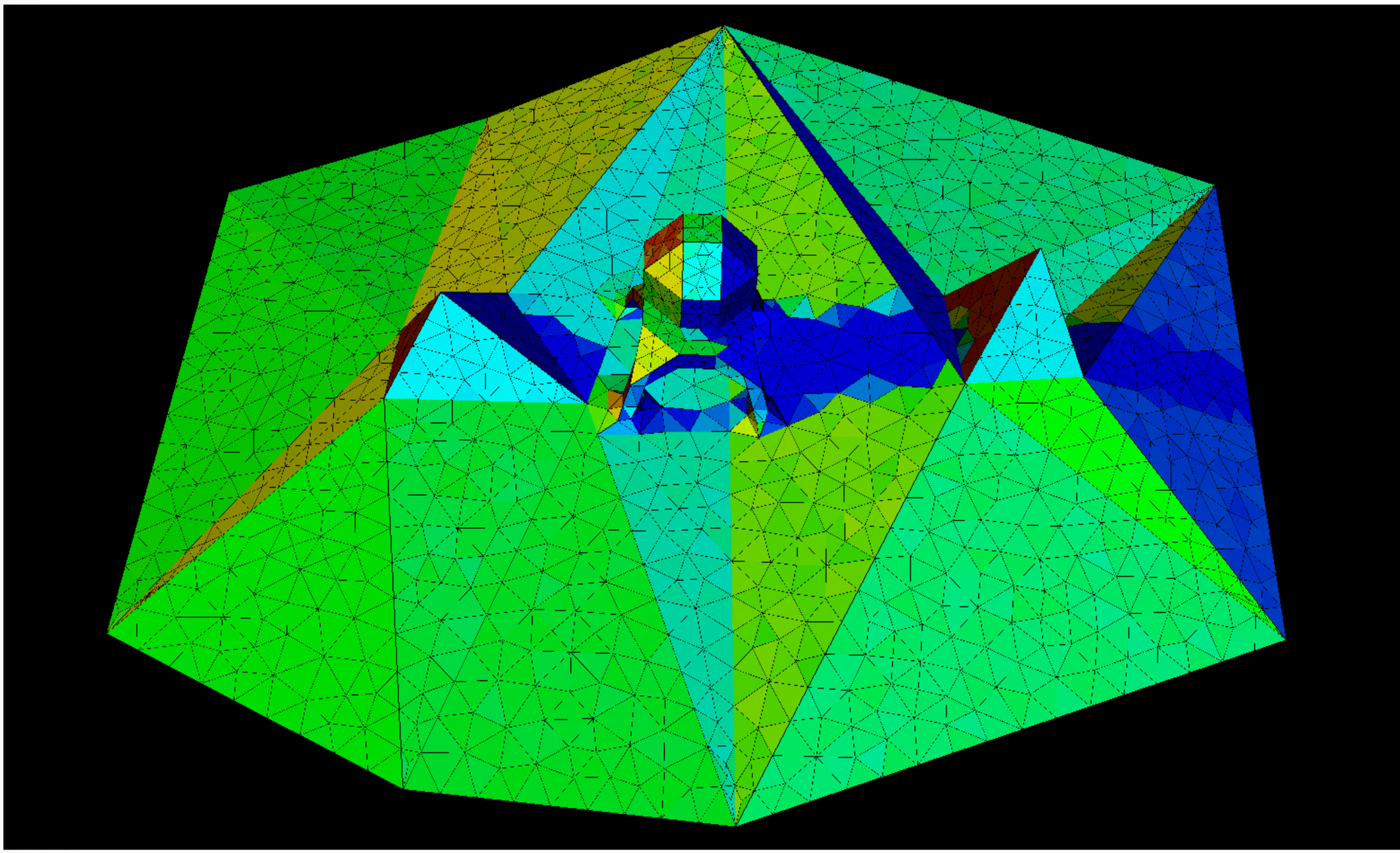
Sun illumination visualization

New feature to visualize the sun illumination and shadowing

- Available in global parameter editor with button
- New shadowing based on Penelope Ray tracer



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Global parameter editor

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Global parameter editor

- Possibility to define the formula of ions with a chemical formula

SPIS-DUST: /home/benj/Bureau/SpisProject/dust_demo/DefaultProject2.spis5

File Views Tools Help

Transitions editor | Global parameters

Predefined parameters: SPIS-DUST_SW_parameters.xml

Expertise level: EXPERT

Poisson equation | Sources | Volume Interactions | B Field | Simulation control | Scenario

MultiZone | Plasma | Surface Interactions | Dusts | Spacecraft | Outputs

Name	Type	Value	Unit	Description	...
ionDuration2	double	0.0	[s]	Maximum integration duration for ion 2nd population (...	...
ionSpeedUp	double	1.0	[-]	Numerical times speed-up factor for ion 1st population	...
ionSpeedUp2	double	1.0	[-]	Numerical times speed-up factor for ion 2nd population	...
ionTemperature	double	1000.0	[eV]	Ion temperature (1st population)	...
ionTemperature2	double	1000.0	[eV]	Ion temperature (2nd population)	...
ionTrajFlag1	int	0	[-]	Plot ambient ion (1st population) trajectory? 0=no, 1=...	...
ionTrajFlag2	int	0	[-]	Plot ambient ion (2nd population) trajectory? 0=no, 1=...	...
ionType	String	CO2+	None	First ion population	...
ionType2	String	H+	None	Second ion population	...
ionVx	double	0.0	[m/s]	Ion drift velocity along x axis (1st population)	...
ionVx2	double	0.0	[m/s]	Ion drift velocity along x axis (2nd population)	...
ionVy	double	0.0	[m/s]	Ion drift velocity along y axis (1st population)	...
ionVy2	double	0.0	[m/s]	Ion drift velocity along y axis (2nd population)	...
ionVz	double	-430000.0	[m/s]	Ion drift velocity along z axis (1st population)	...

ionType String CO2+ None First ion population

Add global parameter | Delete selected global parameter | Sun orientation

Help | Previous | Finalize run configuration and save project

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Monitoring development

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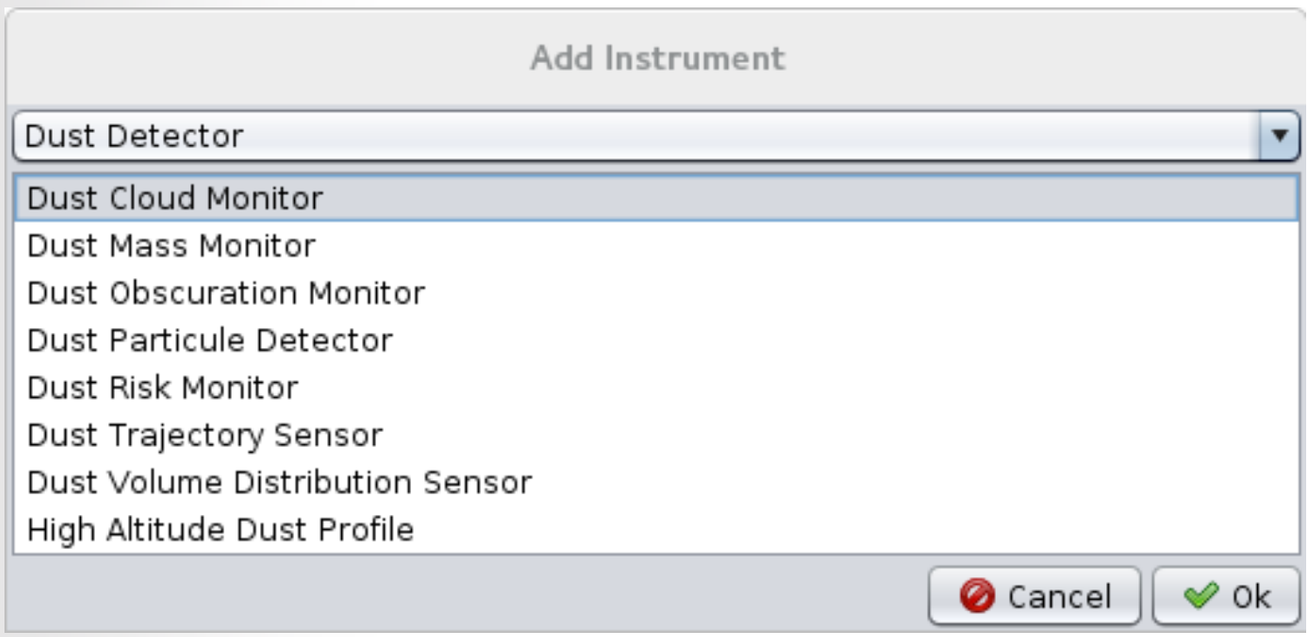
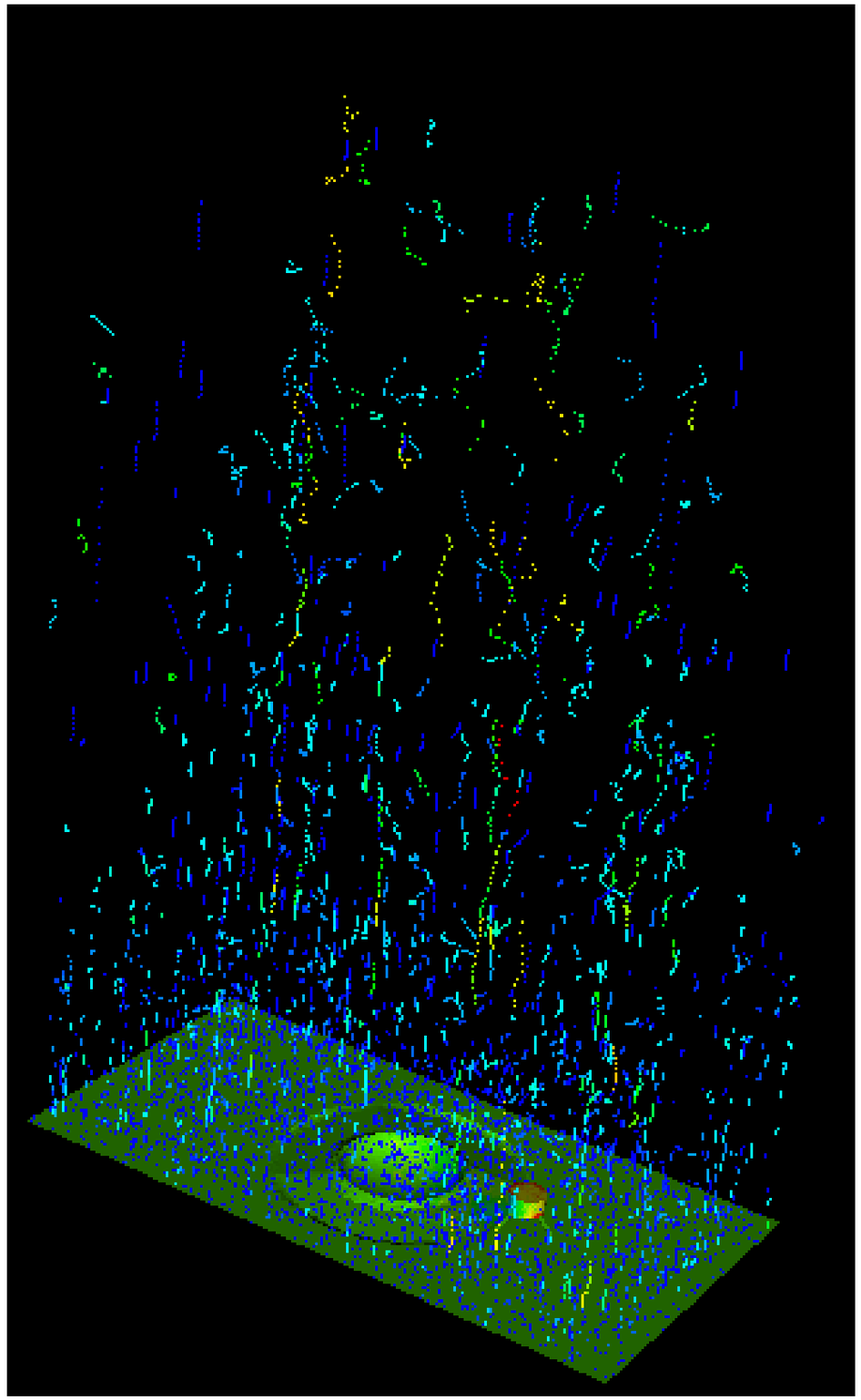
Monitoring

Spis Instruments: set of monitoring and analysis tools

New developed features:

- Rename an existing instrument
- Import instruments from another external SPIS project
- Duplicate an existing instrument
- Add a new instruments type with dust cloud result





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New validation test cases

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Validation test cases

- SPIS validation chain exists since 2011
- Check no regression with the new and future SPIS releases
- Principle:
  - perform simulations with the last SPIS version
  - compare results between results previously validated and the new results performed by the last SPIS version
- New test cases to validate some new SPIS features about dusty plasma model
- These test cases have been added to the SPIS validation chain

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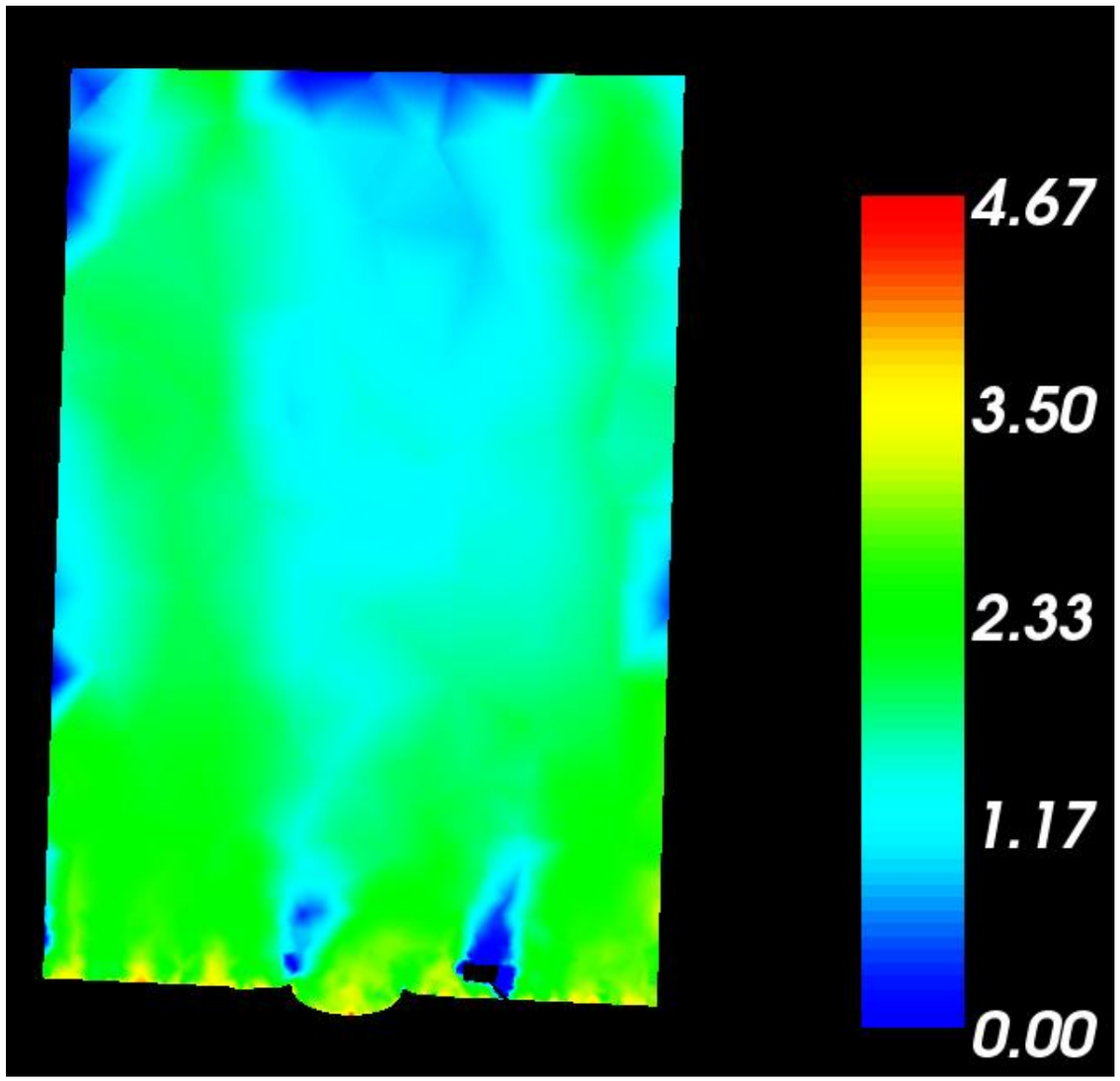
Validation test cases

Dust non regression test

- 3D domain above a cratered lunar surface with a lander
- Comparison with:
  - Poppe et al, 2010
  - SPIS Dust final presentation

Plasma sheath non regression test

- Quasi monodimensional configuration; cratered Moon surface facing dense solar wind conditions
- Comparison with:
  - Poppe et al, 2010
  - Manka, 1973
  - SPIS Dust final presentation



3D domain above a cratered lunar surface with a lander

Several publications from this activity, for example:

P. Sarrailh et al., 2014; J.-C. Matéo-Vélez et al, 2015; S. L. G. Hess et al., 2015; ...

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Packaging

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Packaging

- Merge the developments from this activity with the trunk SPIS
- Package a new release
- Submission of this release to the SPINE community
- SPIS-5.2.4 is available on the following web pages

http://dev.spis.org/projects/spine/home/spisgeo/nightly/Spis-5_2_4-linux64b_zip
http://dev.spis.org/projects/spine/home/spisgeo/nightly/Spis-5_2_4-win7-64b_zip
http://dev.spis.org/projects/spine/home/spisgeo/nightly/Spis-5_2_4-win7-32b_zip

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Conclusion

- All new features scheduled in the CCN activity have been developed
- A new SPIS distribution, called SPIS-5.2.4 has been released with all the new features developed in the ESA contract 40004107327/12/NL/AK
- SPIS-5.2.4 has been submitted to the SPINE community
- Open and possible future improvements from first feedbacks:
  - Introduce GIS cooridnates
  - Tessellation on closed surface (67P/Churyumov–Gerasimenko)
  - Improve shadowing with specular and diffusive effects
  - New environment: rover kinematic and related tribology

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Questions?

ruard@artenum.com

Demo

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