Data intensive electromagnetic scattering simulation for planetary radar data analysis

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MARSIS instrument

Mars **A**dvanced **R**adar for **S**ubsurface and **I**onosphere **S**ounding

To map the distribution of water in the upper portions of the crust of Mars

- Synthetic-aperture orbital sounding radar
- On board the ESA spacecraft *Mars Express*
- Two 20 meters elements nadir-looking dipole antenna
- Centre frequencies: 1.8, 3.0, 4.0, 5.0 MHz (1.0 MHz bandwidth) chirp

- Radar echoes will contain both surface and subsurface reflection components
- Surface backscattering from off-nadir directions is called ”clutter”
- *Clutter can mask, or be mistaken for, subsurface echoes*

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MARSIS clutter simulation

Facet model of rough surface scattering

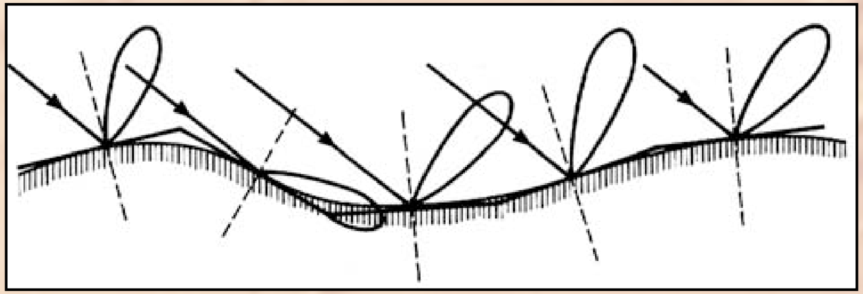
+

500-meter resolution elevation map of Mars

from NASA MOLA instrument (*Mars Global Surveyor)*

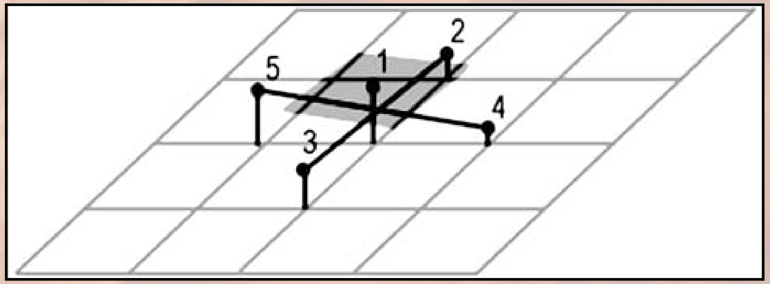
Surface echo simulation

Nouvel et al. (Radio Science vol.39, 2004)



The facet model of rough surface scattering

Rees, W. G. (1990), *Physical Principles of Remote Sensing*



Facet definition

Nouvel et al. (*Radio Science vol.39, 2004*)

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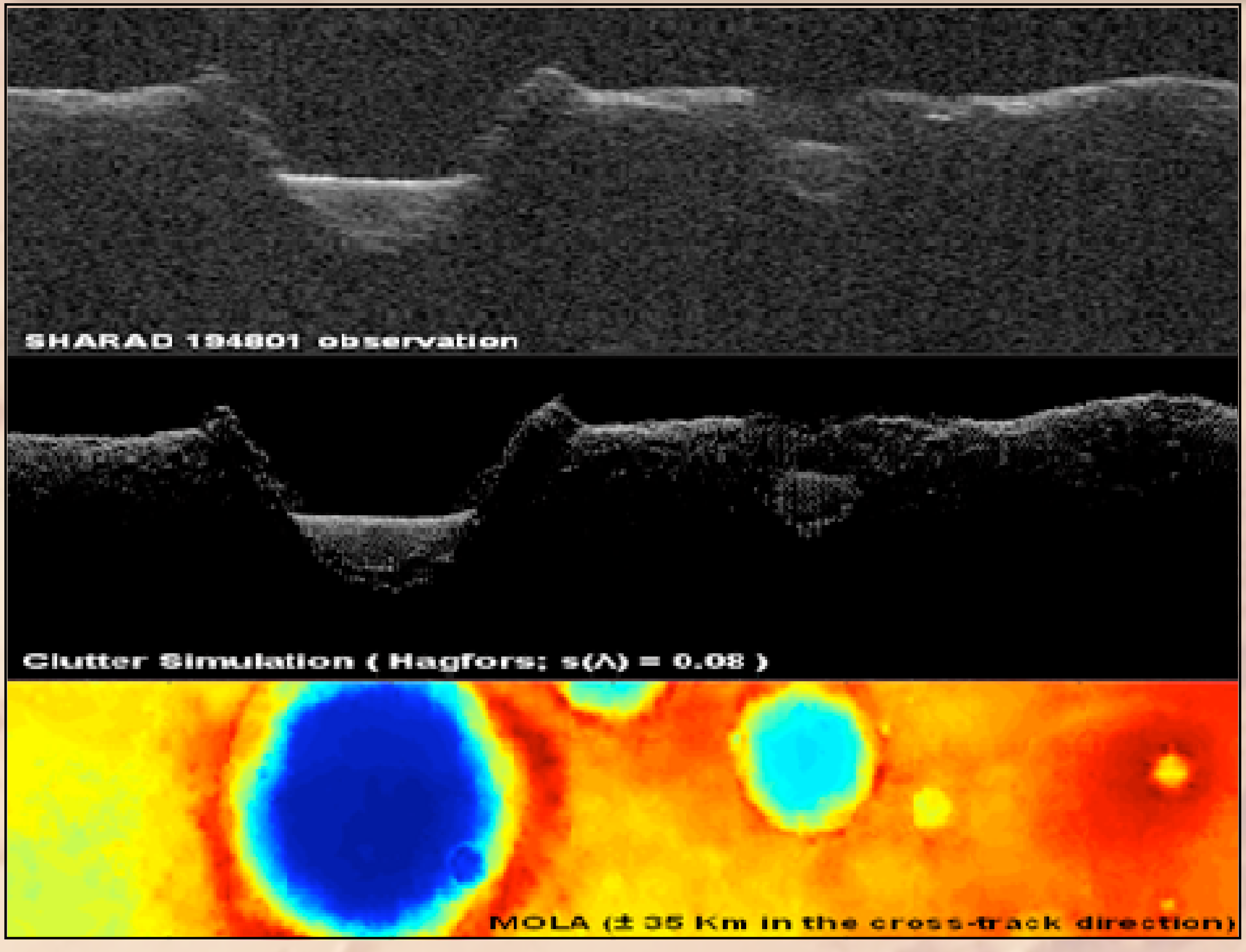
MARSIS clutter simulation



SHARAD observation (orbit 1948)

Clutter simulation

MOLA topography

SHARAD (SHAllow RADar) - carried by NASA Mars Reconnaissance Orbiter

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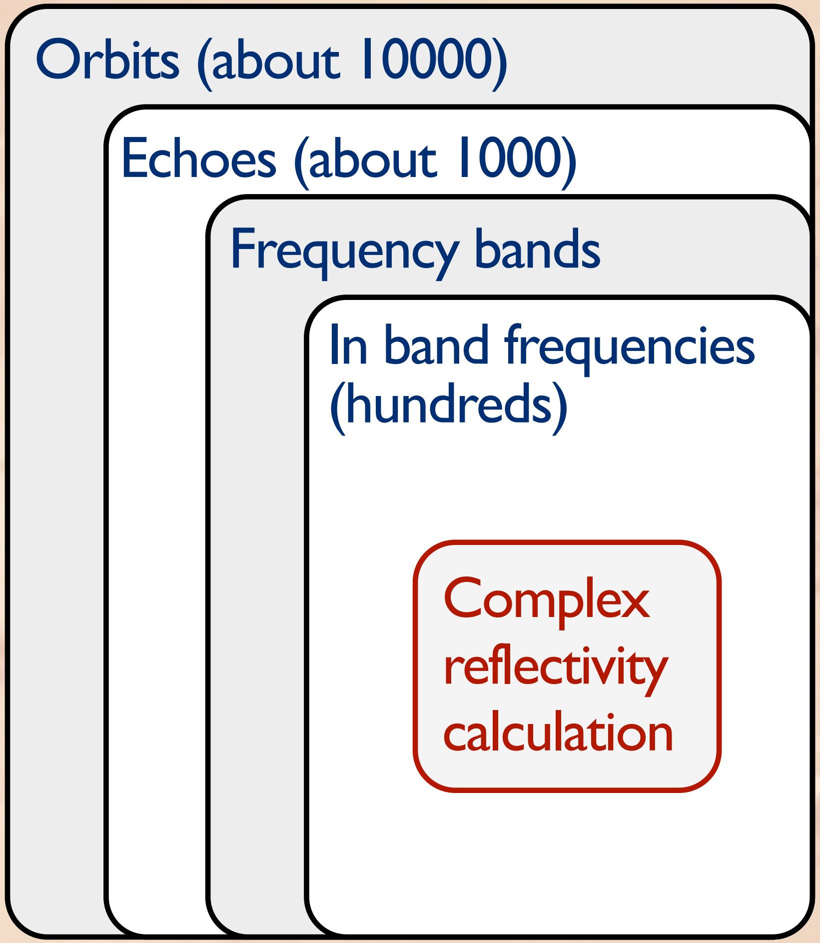
MARSIS clutter simulator



Input: *orbit data, MARSIS parameters, Mars elevation*

Output: *simulated echoes*

MATLAB/OCTAVE version (*R. Orosei*)

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Serial C version

Estimated time required for the calculation of a testing orbit (#2665) on a single core of the CINECA PLX cluster (*Intel Westmere 2.40 GHz*): 25.6 days

All the orbits: > 600 years

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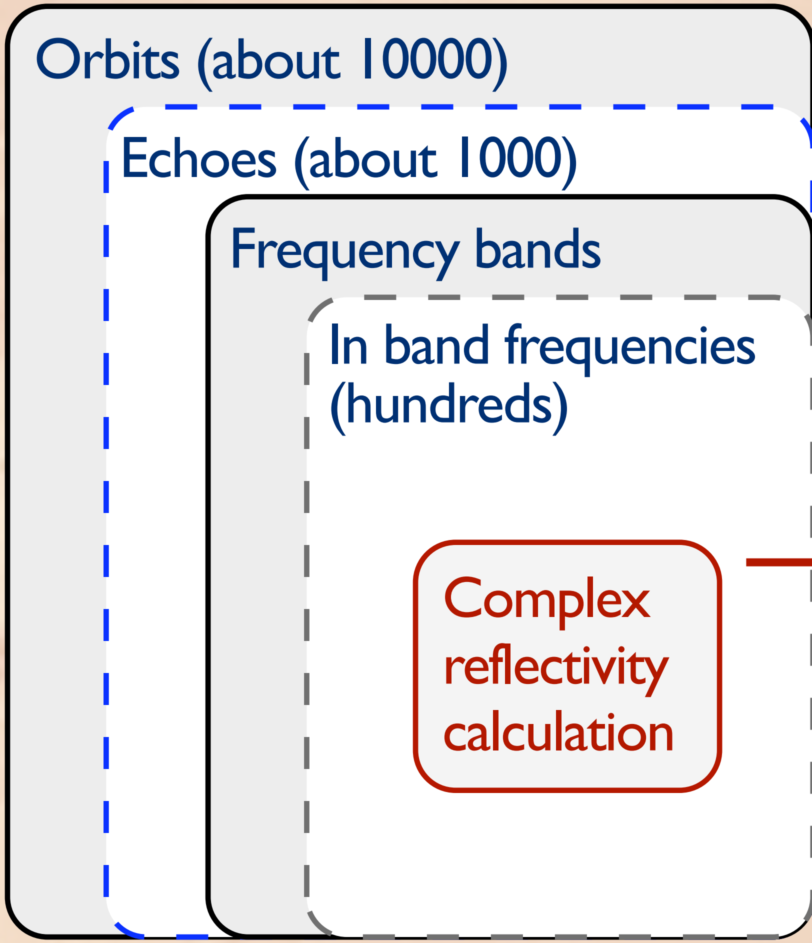
Parallelization



More orbits can run simultaneously

MPI

OpenMP

Further level of parallelization can be introduced whether accelerators are available (GPU, Intel MIC, ...)

No need for communications between MPI processes

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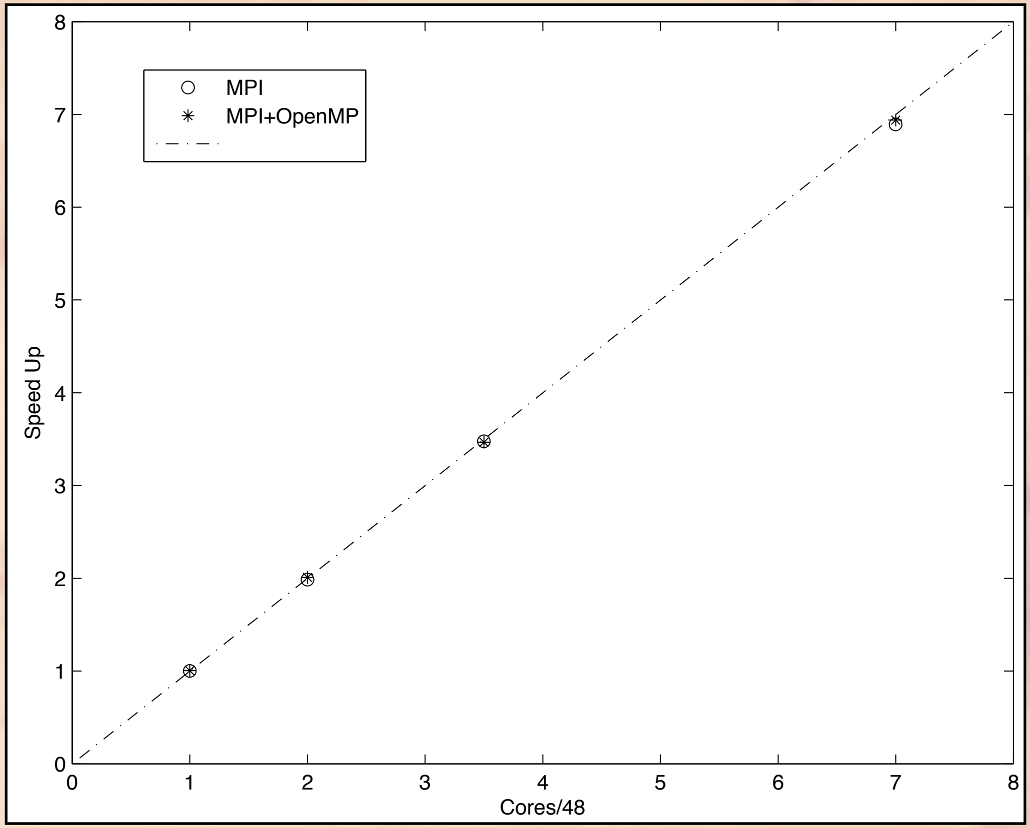
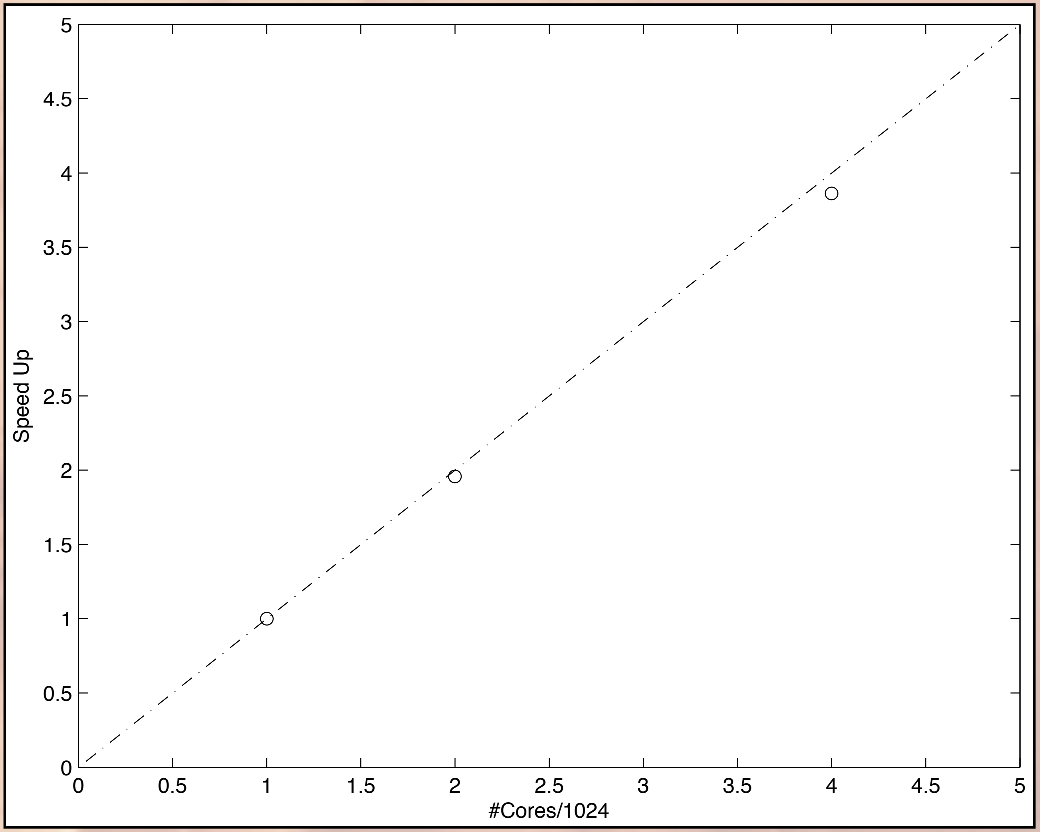
Scalability

Tested on CINECA PLX and Fermi BG/Q clusters



PLX



Fermi

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Required resources

Time required for the calculation of a testing orbit (#2665):

PLX (336 cores, 10%): 1.7 hours

Fermi (4096 cores, 2.5%): 0.43 hours *(all the orbits: 180 days)*

Input *(orbit data, MARSIS parameters, Mars elevation)*: ~ 5GB

Output (*simulated echoes)*: ~ 600GB

Memory allocation: 1.2TB *(per orbit, 4096 cores on Fermi)*

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Conclusions

- Parallelization allows calculation on suitable hardware
- Computing resources allocation requested in 7th PRACE call
- Since the simulations of each echo and each orbit are independent, MPI is not necessary
- Application can be suitable for a Map-Reduce approach

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