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Planetary subsurface investigation by 3D visualization model

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Abstract. Subsurface data analysis and visualization represents one of the main aspect in Planetary Observation (i.e. search for water or geological characterization). The data are collected by subsurface sounding radars as instruments on-board of deep space missions. These data are generally represented as 2D radargrams in the perspective of space track and z axes (perpendicular to the subsurface) but without direct correlation to other data acquisition or knowledge on the planet . In many case there are plenty of data from other sensors of the same mission, or other ones, with high continuity in time and in space and specially around the scientific sites of interest (i.e. candidate landing areas or particular scientific interesting sites). The 2D perspective is good to analyse single acquisitions and to perform detailed analysis on the returned echo but are quite useless to compare very large dataset as now are available on many planets and moons of solar system. The best way is to approach the analysis on 3D visualization model generated from the entire stack of data. First of all this approach allows to navigate the subsurface in all directions and analyses different sections and slices or moreover navigate the iso-surfaces respect to a value (or interval). The last one allows to isolate one or more iso-surfaces and remove, in the visualization mode, other data not interesting for the analysis; finally it helps to individuate the underground 3D bodies. Other aspect is the needs to link the on-ground data, as imaging, to the underground one by geographical and context field of view.

Key words. Planets: 3D radargrams – Subsurface: 3D model – Missions: MRO, MEX

1. Introduction

Planetary exploration by means of radar systems, mainly subsurface sounding Radars is an important role of the Italian scientific community and industry: three important experiments under Italian leadership provided by ASI within a NASA/ESA/ASI joint venture framework, are successfully operating and now are ongoing:

- MARSIS on-board Mars Express
- SHARAD on-board Mars Reconnaissance Orbiter
- CASSINI Radar on-board Cassini spacecraft

SHOC (Sharad Operating Centre), MOC (Marsis Operating Centre) and CASSINI PAD are devoted to a single instrument management and control, data processing and distribution and operate from the starting of the missions to support all the scientific communities, institutional customers and experiment teams operation. The three centers guarantee the products generation and delivery in the standard PDS (Planetary Data Science) format. Although they had been conceived to operate independently one from each other, synergies and overlaps have been envisaged leading to the suggestion of developing a unified SSR processing center, the Planetary Radar Processing Center (PROC), collocated with the above centers at the ASI premises in Matera by successful transfer from TASI Rome premises, that has been recently enhanced again (for the second time) in order to support the mission life extensions.

2. Subsurface 3D model

Generally, subsurface data are represented as 2D radargrams in the perspective of space track and z axes (perpendicular to the subsurface) but as stand-alone pictures and without direct correlation to other data acquisition or knowledge on the planet. In many case there are plenty of data from other sensors of the same mission, or other ones, with high continuity in time and in space and especially around the scientific sites of interest (i.e. candidate landing areas or particular scientific interesting sites).

Thanks to the web facility of the PROC (Catallo et al. 2012) center all the radardgrams for each level of products (from EDR to RDR and MDR) are catalogued, by the extraction of the most important metadata of the acquisition, and prepared for the streaming on the web. The users can search for the products and navigate them via the interactive web tool SpaceGIS which gives the possibility to integrate Mars maps, radargrams and their data ground tracks in a unique vision allowing the use of different on-line analysis tools.

The 2D perspective is good to analyze single acquisitions and to perform detailed analysis on the returned echoes but a better way is to approach the analysis of a 3D visualization model generated from the entire stack of data. This approach allows to navigate the subsurface in all directions and analyse different sections and slices or moreover navigate the iso-surfaces with respect to a value (or interval). The last one allows to isolate one or more iso-surfaces and remove, in the visualization mode, other data not interesting for the analysis; finally it helps to individuate the underground 3D bodies. Another aspect is the need to link the on ground data, as imaging, to the underground one by geographical and context field of view.

The 3D model allows the synoptic analysis of all available data. That visualization models need a pre-processing of the data to re-project all heterogeneous data in a common coordinate system; finally it is necessary to proceed with the volumetric rendering to interpolate and extrapolate the information for the volume area where the data are not acquired or available. The 3D interpolation algorithms are different and based on the final use case, so they need to be developed starting from scientific analysis of the research field.

The 3D results are possible thanks to the integration into a processing chain of mature software technologies and algorithms, used operatively on the Earth science, with adaptation for the planetary context.

3. Conclusions

The 3D analysis could be used as pre-cursor respect to the analysis of single echo to speed-up the screening of huge mole of data or on the contrary to validate different data based on different missions or instruments. The 3D model allows the synoptic analysis of all available data. The base models and tools could be adopted from other science very common in the oil&gas field and for the geophysical investigation by geo-radar and similar on Earth. That visualization models need of pre-processing of data to re-project all heterogeneous data in a common coordinate system; finally it is necessary proceed with the volu-

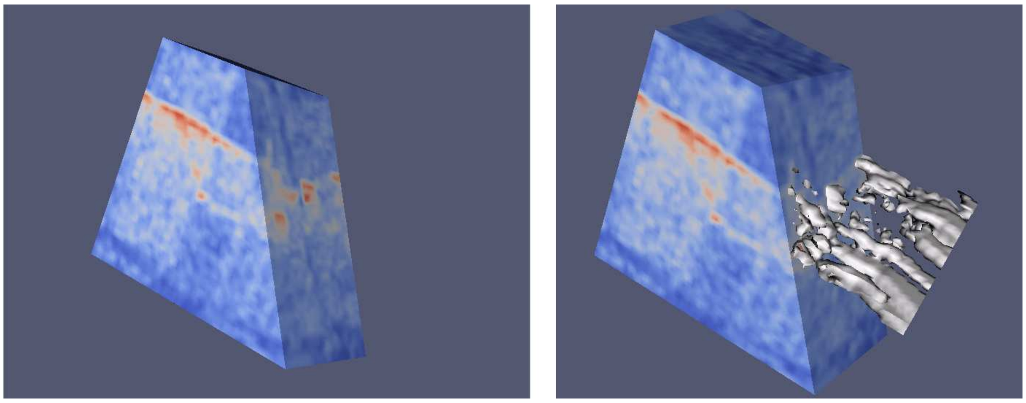

Fig. 1. SHARAD Data 3D-View: Voxel Navigation, Isosurfaces extraction South pole East zone (Lat, Lon) = (-83,160); (-82,166). In this screen shot we show the 3D model of subsurface starting from 5 tracks and data acquired by SHARAD antenna south pole. The image at left shows the volumetric rendering for the subsurface buffered between the terrain level and less deep sounding on the fifth used tracks; a oblique slicing is applied to allow the analysis on that plane. On the right the image shows the same area and slicing with moreover the iso-superface (for interval of science values) belonging to the adjacent volume; in other words the searched surface is extracted by values and rendering in false colour.

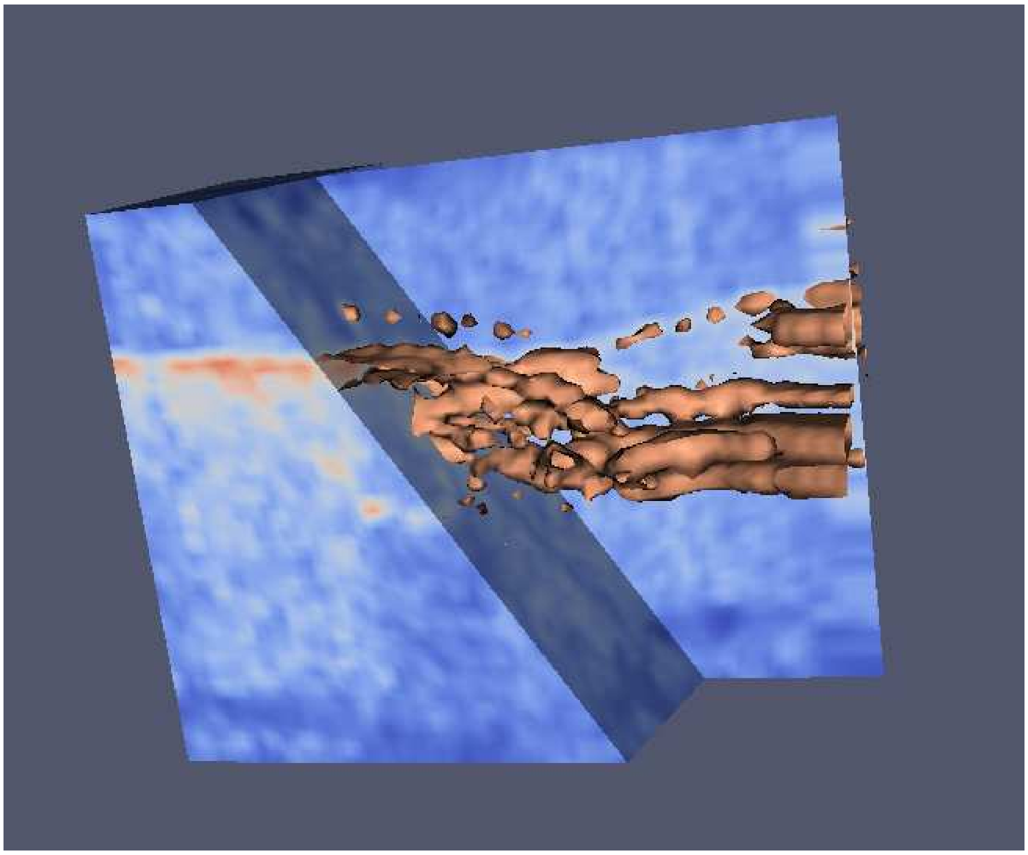

Fig. 2. On the bottom the same as the right one in 1 but for another iso-surface plus a second slicing in the background.

metric rendering to interpolate and extrapolate the information for the volume area where the data are not acquired or available. The 3D interpolation algorithms are different and based on the final use case, they need to be developed starting from scientific analysis of the research field.

This paper presents the integration of mature software technologies and algorithms, used operatively on the Earth science, with adaptation for the planetary context shown unprecedented results in the Planetary data analysis. The study and the demonstrators are based on MRO and MEX missions data, results are shown in the context of two different scientific projects using real data. Finally a processing chain is discussed and proposed as well as with further consideration on the data format and protocol for that applications. The used SW were:

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