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LIRAS mission for lunar exploration by microwave interferometric radiometer: Moon's subsurface characterization, emission model and numerical simulator

Sara Pompili (1,2), Frank Silvio Marzano (3,4), Alessandro Di Carlofelice (1), Mario Montopoli (3,5), Marco Talone (6), Raffaele Crapolicchio (6), Michelangelo L'Abbate (2), Silvio Varchetta (2), and Piero Tognolatti (1)

(1) Department of Industrial and Information Engineering and Economics, University of L'Aquila, 67100 L'Aquila, Italy, (2) Thales Alenia Space, 00131 Rome, Italy, (3) Center of Excellence CETEMPS, University of L'Aquila, 67100 L'Aquila, Italy, (4) Department of Information Engineering, Sapienza University of Rome, 00184 Rome, Italy, (5) Department of Geography, University of Cambridge, Cambridge, CB2 1SB, UK, (6) Serco S.p.A., 00044 Frascati (Rome), Italy

The "Lunar Interferometric Radiometer by Aperture Synthesis" (LIRAS) mission is promoted by the Italian Space Agency and is currently in feasibility phase.
LIRAS' satellite will orbit around the Moon at a height of 100 km, with a revisiting time period lower than 1 lunar month and will be equipped with: a synthetic aperture radiometer for subsurface sounding purposes, working at 1 and 3 GHz, and a real aperture radiometer for near-surface probing, working at 12 and 24 GHz. The L-band payload, representing a novel concept for lunar exploration, is designed as a Y-shaped thinned array with three arms less than 2.5 m long.
The main LIRAS objectives are high-resolution mapping and vertical sounding of the Moon subsurface by applying the advantages of the antenna aperture synthesis technique to a multi-frequency microwave passive payload. The mission is specifically designed to achieve spatial resolutions less than 10 km at surface and to retrieve thermo-morphological properties of the Moon subsurface within 5 m of depth. Among LIRAS products are: lunar near-surface brightness temperature, subsurface brightness temperature gross profile, subsurface regolith thickness, density and average thermal conductivity, detection index of possible subsurface discontinuities (e.g. ice presence).
The following study involves the preliminary design of the LIRAS payload and the electromagnetic and thermal characterization of the lunar subsoil through the implementation of a simulator for reproducing the LIRAS measurements in response to observations of the Moon surface and subsurface layers. Lunar physical data, collected after the Apollo missions, and LIRAS instrument parameters are taken as input for the abovementioned simulator, called "LIRAS End-to-end Performance Simulator" (LEPS) and obtained by adapting the SMOS End-to-end Performance Simulator to the different instrumental, orbital, and geophysical LIRAS characteristics. LEPS completely simulates the behavior of the satellite when it becomes operational providing the extrapolation of lunar brightness temperature maps in both Antenna frame (the cosine domain) and on the Moon surface and allowing an accurate analysis of the instrument performance.

The Moon stratigraphy is reproduced in LEPS environment through three scenarios: a macro-layer of regolith; two subsequent macro-layers of regolith and rock; three subsequent macro-layers of regolith, ice and rock, respectively. These scenarios are studied using an incoherent approach, taking into account the interaction between the upwelling and downwelling radiation contributions from each layer to model the resulting brightness temperature at the surface level. It has been considered that the radiative behavior of the Moon varies over time, depending on solar illumination conditions, and it is also function of the material properties, layer thickness and specific position on the lunar crust; moreover it has been examined its variation with frequency, observation angle, and polarization. Using the proposed emission model it has been possible to derive a digital thermal model in the microwave frequency of the Moon, allowing in-depth analysis of the lunar soil consistency; this collected information could be related with a lunar digital elevation model in order to achieve global coverage information on topological aspects. The main results of the study will be presented at the conference.