PRL News – The Spectrum

October 2019

Physical Research Laboratory
Ahmedabad - 380009
India

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Global Mapping of lunar refractory elements: multivariate regression vs. Machine learning

(M. Bhatt, C. Woehler, A. Grumpe, N. Hasebe, and M. Naito)

Megha Bhatt

The quantitative estimation of elemental concentrations at the spatial resolution of hyperspectral near-infrared (NIR) images of the lunar surface is an important tool for understanding the processes relevant for the origin and evolution of the Moon. We used NIR observations obtained by the instrument Moon Mineralogy Mapper (M3) onboard Chandrayaan-1 for inferring the abundances of the elements Fe, Ti, Ca and Mg on global scales with typical accuracies of about 1 wt.% at a spatial resolution of 20 pixels per degree. The method is based on a set of spectral parameters which are insensitive to the spectral characteristics of mature soils. These parameters were used to construct a multivariate regression model based on the global abundance data of the instruments Lunar Prospector Gamma Ray Spectrometer (LP GRS) and Kaguya GRS (KGRS) as a ground truth. We compared a classical multivariate linear regression (MLR) approach and the machine learning based support vector regression (SVR) technique applied to M3 global observations. The results derived using MLR and SVR are compared to sample-based ground truth data of the Apollo and Luna sample-return sites, where the root-mean-square deviations obtained by the two regression models are similar. A comparison of results obtained in this work with previously published methods of estimating Fe abundance is shown in Figure 1. The region shown in Figure 1a is from crater Lichtenberg and surroundings located in the western part of Oceanus Procellarum. The maturity-independent multivariate regression model is found to be the least sensitive to surface albedo and to topography induced effects that are otherwise prominent. The range and distribution of the Fe variation is similar and the boundary of low-and-high-Ti is detectable using all four algorithms of iron estimation as shown in Figs. 2d–g. Comparison with previous work on local and global scales suggest that the proposed method combines the advantages of previous approaches which were based on Clementine global multispectral image data. The elemental maps of Mg and Ca provide additional information and reveal structures not always visible in the Fe map. The global elemental abundance maps derived for the fully calibrated M3 observations will serve as an important tool for lunar geologic investigations. Our high-resolution elemental maps will be of interest for future lander missions in the context of landing site selection.

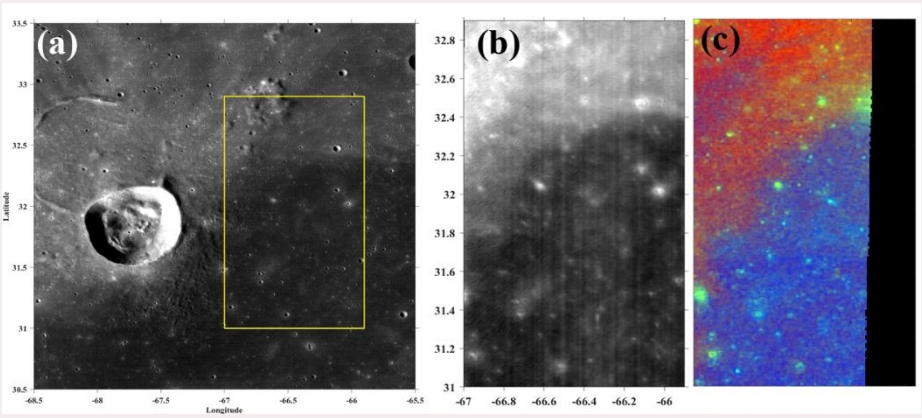

Figure 1: (a) Lunar Reconnaissance Orbiter (LRO) Wide Angle Camera (WAC) mosaic of the crater Lichtenberg and surroundings. The yellow box outlines the region considered for obtaining Fe abundances using different approaches. (b) Full resolution M3 mosaic of the region east of the crater Lichtenberg. (c) Clementine UV/VIS color ratio mosaic (R channel: 750/415 nm, G channel: 750/1000 nm and B channel: 415/750 nm; Pieters et al. 1994) at 200 m/pixel spatial resolution. The low-titanium regions appear in red and yellow and the high-titanium regions appear in blue.

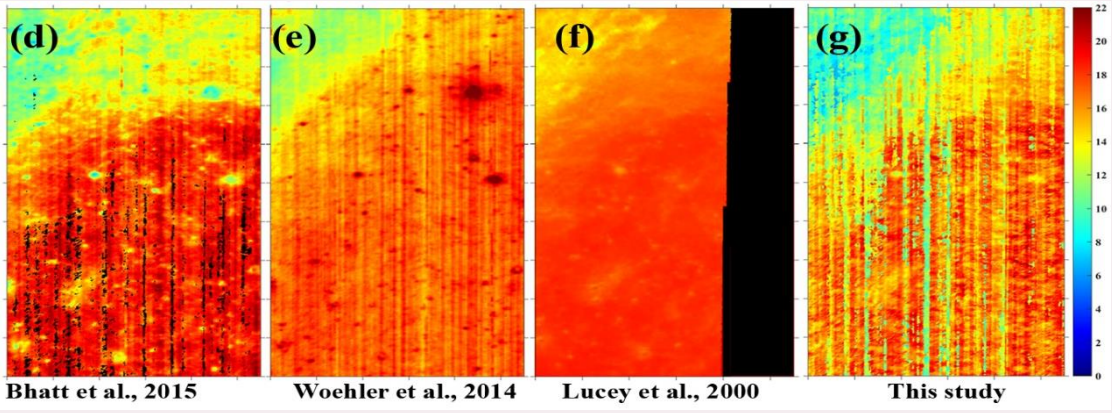

Figure 1: (g) Derived Fe abundance using four different methods. The algorithm of Lucey et al. (2000b) was applied to Clementine UV/VIS data at 100 m/pixel spatial resolution. The dark region is due to a data gap in one of the Clementine bands. The algorithm of Bhatt et al. (2015) estimates a low Fe content for fresh craters, whereas the algorithm of Wöhler et al. (2014) tends to estimate a high Fe content for them. In contrast, small fresh do not appear as small-scale anomalies in the Fe abundance map obtained by the proposed MLR approach considering LP GRS as a reference.

[https://doi.org/10.1051/0004-6361/201935773]

Solar Filament Eruptions as Precursors to Flare–CME Events: Establishing the Temporal Connection (*Suvadip Sinha, Nandita Srivastava, Dibyendu Nandy)*

Suvadip Sinha

Solar filaments are known to have a connection with energetic events of space weather consequence (flares and coronal mass ejections (CMEs)). In this work, we explore the connection between the eruptive dynamics of filaments and the initiation of solar flares and CMEs by tracking the filament throughout its eruption phase. We define the filament eruption start time as the time from which the filament area starts to decrease as observed in Hα images. A total of 33 eruptive filament events are reported in this study, out of which 73% are CME associated and

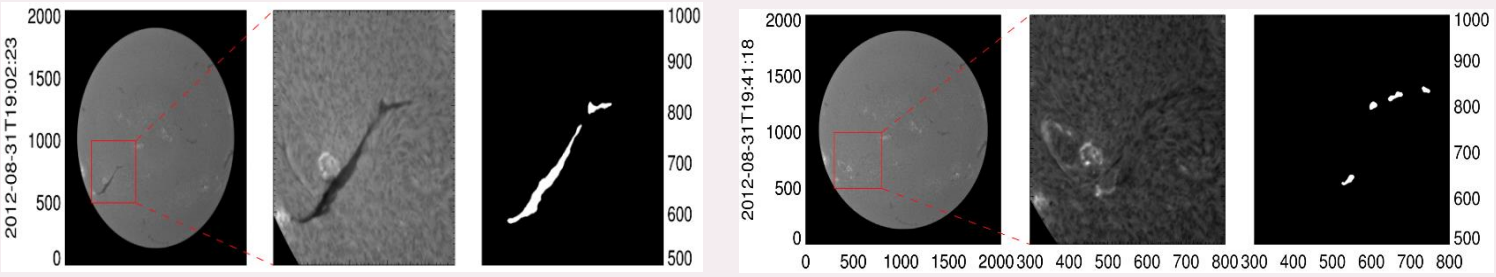

Figure 1. Time evolution of the filament. Left and right columns show the GONG full-disk H-alpha and cutout images, respectively. Right column shows the filament extracted by the algorithm.

76% are related to solar flares. We find a good correlation between area decay rate of the quiescent filaments and the speed of the associated CMEs with a correlation coefficient of 0.75. We show that in 83% of cases, filament eruption precedes the flare brightening in the EUV, which indicates that eruptive filaments can be considered as one of the

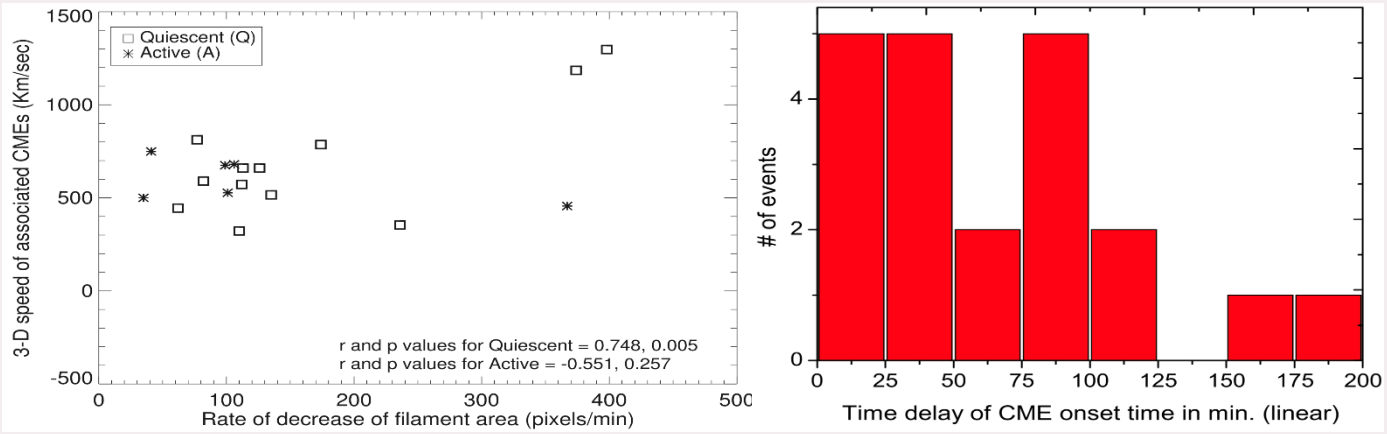

Figure 2. Left: The plot shows the variation of the CME speed with the rate of change of filament area. Right: Histogram of CME onset time following the eruption of the filament.

precursors for the occurrence of a solar flare. Finally, we study the time delay of the CME onset from the time of initiation of the filament eruption process and show that for most of the cases, CMEs occur within 2 hr from the start time of the filament eruptions. This study would be useful for space weather assessment and characterization based on automated trackers of solar filament dynamics. [www.doi.org/10.3847/1538-4357/ab2239]

Colloquia @ PRL

- Umesh Kadhane, (Associate Professor, IIST, Thiruvananthapuram) delivered a colloquium on "*Understanding radiation tolerance of PAHs in space and role of collective excitation*" on 18th September 2019.
- Dipankar Banerjee, (Professor, IIA, Bengaluru) gave a talk entitled "*Long Term Study of the Sun Using Kodaikanal Digitized Data*" on 19th September, 2019.
- Anil Bhardwaj, (Director, PRL, Ahmedabad) delivered a lecture on "*Indian Planetary and Space Missions*" under the Dr. Vikram Sarabhai Public Lecture Series on 24th September, 2019.

Foundation Day Celebrations 2019, Udaipur Solar Observatory PRL – 19 September 2019

The Foundation Day 2019 of the Udaipur Solar Observatory was celebrated on 19th September 2019 to commemorate the rich history and growth of the Observatory which was founded in 1975 under the zealous efforts of Prof. Arvind Bhatnagar and his team. This was an occasion to reminisce the tremendous growth and achievements of the facility over the last 44 years. The event was held at USO in the morning with a welcome address by Prof. Nandita Srivastava, Deputy Head USO-PRL, who highlighted the important technical and scientific milestones of the Observatory since its inception. The special lecture of the day was delivered by the guest of honour, Prof. Dipankar Banerjee, Professor, Indian Institute of Astrophysics Bengaluru on the Long-Term Study of the Sun using Kodaikanal Digitized Data, in which he spoke on the importance of historical observations to understand the processes governing the generation of magnetic fields on the Sun. This was followed by another talk by Prof. Wahab Uddin, Director In-charge, Aryabhatta Research Institute of Observational Sciences (ARIES) Nainital. His talk focused on the Observational facilities at ARIES including the recently commissioned 3.6-m Devasthal Optical Telescope for optical and near-infrared astronomy. The programme concluded with a vote of thanks by Dr. Rohan Louis.

Hindi Book Exhibition at Udaipur Solar Observatory

A Hindi Book Exhibition was organized in the USO Library as part of the Hindi Pahkwada from 23rd to 25th September 2019 which showcased a very good collection of books on various topics. These included (i) Biographies of Vikram Sarabhai, Sardar Vallabhbhai Patel, Swami Vivekanand, and Mahatma Gandhi, (ii) Reference books such as Prashashanik Kosh, Antarrashtriya Vyakti Kosh, etc., (iii) Magazines such as Sarita, Champak, Baal Bharti, etc., and (iv) Story books titled Electroniki ki Kahani, Bodh Dharm Ki Kahaniya, Gyaarah Lambi Kahani etc.

Librarians' Day Seminar on "Future Libraries – Overcoming Challenges"

ADINET organized a one-day seminar on 'Future Libraries – Overcoming Challenges' in association with PRL on 14th September 2019 to commemorate the Birth of Father of Indian Library and Information Science 'Dr. S.R. Ranganathan' and the Silver Jubilee of ADINET. Ms. Rhoda Bharucha, Hon. Director of the ADINET and former Head, Library, PRL gave a glimpse of how ADINET was formed in PRL and the way it has grown to a network of more than 2200 libraries in the state of Gujarat. On this occasion Dr. Anil Bhardwaj, Director, PRL virtually launched the ADINET APP and Union Catalogue of ADINET, he also felicitated Ms. Bharucha for her more than five decades of services to the profession of Library and Information Science. The distinguished guests also released the seminar proceedings and the Directory

of LIS. Prof K S Dasgupta, the Director of DAIICT in his inaugural address asserted upon the relevance of libraries and the need of the mechanism from 'Outside in to inside out' implying that librarians have to reach out to the community proactively. The keynote address was delivered by Dr. M.S. Sridhar. The Technical sessions saw various presentations from sub-fields of Library and Information science. A panel discussion by the panellists - Dr. Nishtha Anilkumar, Dr. N.D. Oza, Dr. T.S. Kumbar, Dr. Mitesh Pandya and Dr. Lalitha Poluru on the topic "Will Robots Replace Librarians?" was also conducted which saw a brainstorming session on the relevance of Librarians in the age of Artificial Intelligence. PRL Library organized a book exhibition on this occasion during 13th to 14th September, 2019. This exhibition saw visitors from PRL, i.e. Faculty, students and staff members and also the participants of the Seminar.

VOICE – 2019 (*Goutam K. Samanta, Partha Konar, and Kinsuk Acharyya)*

The VOICE 2019 (Vikram Sarabhai cOmpetitIon for Concept-Essay Writing VOICE – 2019) is a pan-India level essay competition organized for the school children. The competition is organized for science popularization among young students, recognition and nurturing of young talent within India. Besides, it can provide a prestigious national

platform to showcase their new ideas and imagination. The competition was organized into two categories. Category-I for 8-10 standard students, the theme of the essay was "Home at a distant planet." Category-II for 11-12 standard students, the topic was "Design innovative experiments for space station." We received about 1000 essays from 24

states and union territories starting from Jammu and Kashmir to Kerala, from Gujarat to Arunachal Pradesh, with more than 50 % participation from the girls. After three rounds of evaluation, 30 students from the category I and 20 students from category II, was invited for presentation at PRL on 11th August, which covered 14 different states. The presentations are judged by a panel of judges from PRL, SAC, IIT Gandhinagar and IPR. A cash prize of Rs. 20000, 15000, and 10000 for 1st, 2nd, and 3rd prize along with five special mention prizes of Rs. 2000 for category I, was awarded. For category II, a cash prize of Rs. 25000, 20000, and 15000 for 1st, 2nd, and 3rd and two special mention prizes of Rs. 2500 was awarded. These students also participated in the inaugural session of Vikram Sarabhai Centenary Celebration on 12th August organized by ISRO. (for more information: https://www.prl.res.in/prl-eng/voice2019).

Participation in the Pressing for Progress (PFP) 2019 – An IPA National Conference towards Gender Equity in Physics

The Gender in Physics Working Group of the Indian Physics Association in association with the University of Hyderabad organised a National Conference on Gender Equity in Physics during 19th to 21st September, 2019. This conference was first of its kind in India as it discussed Science and sociological aspects of Science as well. This Conference aimed at identifying the gender-ratio disparity related issues prevailing in Physics Profession especially in the Higher Academics and Research positions. It is important to mention that this conference saw high number of participation from male physicists from all over the nation. The conference saw a galaxy of talks, presentations, posters and sparklers from diverse fields of Physics, Women studies and Gender dynamics in Physics. Parallel sessions on Physics and one session on promoting gender equity was also conducted.

A group from PRL attended the conference- Prof. Srubabati Goswami, Dr. Megha Bhatt, Dr. Ananya Mukherjee and Dr. Pragya Pandey. Dr. Megha Bhatt delivered a talk on "Global mapping of lunar refractory elements mapping. Dr. Ananya Mukherjee presented a poster and a sparkler on "Origin of dark matter and baryon asymmetry of the universe in an A_4 flavour symmetric neutrino mass model". Dr. Pragya Pandey presented a poster and a sparkler on "Gender Disparity in Physics in India: Present Status". This poster got special mention by the judges in the gender poster's category.

Prof. Bimla Buti, a former PRL faculty was felicitated for her exemplary services to the Physics profession in India and her efforts on bringing to limelight the issues related to gender ratio disparity in higher education and research. In this Conference a book entitled "31 fantastic Adventures in Science: Women Scientists of India" by Nandita Jayaraj and Aashima Freidog was released by Prof. Megan Urry. This book depicts scientific achievements of 31 Indian Women Scientists. This book includes two chapters on two of our PRL scientists - Prof. Nandita Srivastava and Dr. Kuljeet Kaur.

Workshops on *Gender Equity*, S*exual harassment dynamics* and *Challenging Gender Stereotypes in Daily living* were conducted which were highly engaging and saw brain-storming sessions on various aspects of social reasons involved in upbringing of men and women in Indian societies which manifest gender disparities in society later on especially in work places.

Prof. Srubabati Goswami, Co-chair, PFP'19, concluded the conference along with Prof. Prajval Shastri, Chair-PFP'19 and gave recommendations drawn from the conference. These recommendations laid stress upon inclusivity in education, research and academics. It was proposed that gender breakup on websites of all departments and institutes should be published in the broader framework for determining inclusivity. It was proposed that creation of goals, both long term and short-term ones for correcting the gender gap in both mid and senior-level positions need to be set. Institutes and universities also need to be evaluated on how they mediate this over time. Recommendations were given on Spousal Hiring, Childcare facilities in Conferences, Gender-Neutral policies of selection for hiring, awards, leadership positions. It was also proposed that stronger committees and "water-tight" guidelines need to be made for sexual harassment and discrimination. Also, inclusion of the social sciences in the curriculum for students and the rest of the community alike, would help in educating one and all on gender issues in science.

Hindi Pakhwada – 2019 celebrations at PRL

Hindi Diwas is celebrated across the country on 14th of September every year to remember the historic occasion when Hindi was approved as the official language of India by the Constituent Assembly on this day in the year 1949. This year being Centenary Birth anniversary of Dr. Vikram Sarabhai is very special for us at PRL. We also dedicated competitions to our legendary founder figure as a tribute and remembered him for his contributions. A Remembrance session was organized to walk down the memory lane along with his students and colleagues. We celebrate Hindi Pakhwada to encourage members to do work in Hindi and also with a view to promote Official Language in other aspects. Many competitions pertaining to Hindi language were held in PRL. In few of them, school children were invited to participate and a dedicated Quiz Program on science was organized for them. Other competitions include Nibandh, Kavita Path, Typing, Word Quiz, Our Work contest, Vikram Sarabhai Gyan-Vigyan Pratiyogita etc. In a fortnight long celebration people participated wholeheartedly and it was great platform to initiate the enthusiasm among youths about the language. It motivates and brings positive perceptions about Hindi among the members.

A Hearty welcome to the New Entrants!

Ayisha Ashruf
Sci/Eng SC
SPASC

Nimma Vinitha
Sci/Eng SC
AMOPH

Chitra Raghvan
Sci/Eng SC
SPASC

Prajapati Prachi
Sci/Eng SC
AADTO

C. Sreevanishnava
Sci/Eng SC
AADTO

Rashmi
Sci/Eng SC
PSDN

Shreeya Natrajan
Sci/Eng SC
PSDN

Jappji Mehar
Sci/Eng SC
PSDN

Mohit K Soni
Sci/Eng SC
SPASC