EXTENDED CURRICULUM VITAE FOR PROF. (DR.) B. S. DAYA SAGAR

Content List **Page 1**

Extended Curriculum Vitae for Prof. (Dr.) B. S. Daya Sagar

Updated on 05 September 2017

1 Personal Background

1.1 Personal Data

Name	**B. S. Daya Sagar**
Preferred Name	**B. S. Daya Sagar**
Birth Date	February 24, 1967
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Citizenship	Indian
Permanent Resident	Canada (2009-14)
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Wikipedia Page	http://en.wikipedia.org/wiki/B._S._Daya_Sagar
IAMG Affiliation	Life Member

1.2 Business Affiliation

Professor and Founding Head
Systems Science and Informatics Unit (SSIU)
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1.3 Education

1994 Ph.D. in Remote Sensing and Geoengineering
Thesis: *Applications of Remote Sensing, Mathematical Morphology and Fractals to Study Certain Surface Water Bodies*
Thesis Advisors: SVLN Rao and BS Prakasa Rao
Andhra University, College of Engineering, Department of Geoengineering, India,

1990 M.Sc (Tech). in Resources Development Technology, Distinction, First Class, First rank
Thesis: *Identification of Groundwater Potential Zones by Using LANDAST TM Data*
Thesis Advisor: VV Rao
Andhra University, College of Engineering, Department of Geoengineering, India,

1987 B.Sc. in Earth Science, Distinction, First Class, Third rank
Andhra University, Faculty of Science, SDS College of Arts and Applied Sciences, India

1.4 Professional Expertise

Prof. Daya Sagar's two-decade long research contributions span both basic and applied fields in mathematical morphology with emphasis in complex terrestrial geomorphologic phenomena and processes. His works provided unique contributions for the theory of mathematical morphology applied in retrieval, analysis, reasoning and modeling the spatial and/or temporal phenomena of terrestrial and GISci relevance. The key links that Prof. Sagar has shown between the following aspects–(i) pattern retrieval, (ii) pattern analysis, (iii) simulation and modeling, and (iv) spatial reasoning and their importance in understanding spatiotemporal behaviors of several terrestrial phenomena and processes–was a significant success. Recently, he developed novel methods for spatial interpolation and spatial reasoning to visualize spatiotemporal behavior, generate contiguous maps, and to identify strategically significant set(s). His work that has spurred interdisciplinary activity has implications and has yielded insights for quantitative geomorphology and spatiotemporal GISci.

Sagar has made pioneering contributions to the field of geosciences, with special emphasis on development of spatial algorithms meant for geo-pattern retrieval, analysis, reasoning, modeling and visualization by using concepts of mathematical morphology and fractal geometry. These significant contributions have provided quantitative basis with insights for better understanding of spatiotemporal behavior of terrestrial phenomena and processes, and geospatial computations. These path breaking works have collectively provided an impetus to the understanding of spatio-temporal behavior of terrestrial geomorphic features and processes, and have had significant impact across remote sensing, terrestrial data analysis, quantitative geomorphology, and GISci. His work that has spurred interdisciplinary activity has implications and has yielded several insights for quantitative geomorphology and spatiotemporal GISci. His accomplishments have already been recognized (i) internationally evidenced through his selection for Georges Matheron Award-2011 (with Lectureship) of International Association for Mathematical Geosciences (IAMG), and (ii) nationally evidenced through his selection for Krishnan Medal-2002 of Indian Geophysical Union, Dr. Balakrishna Memorial Award-1995 of A.P. Akademi of Sciences, and several Fellowships.

2. Research Fields, Areas of Interest, Projects, and Accomplishments

Many space-time models explaining phenomena and processes of terrestrial relevance were of descriptive in nature. Efficient way of understanding the dynamical behavior of many complex systems of nature, society and science is possible through data acquired at multiple spatial and temporal scales. Earlier, several toy models were developed via classical mathematics to explain several possible phases in dynamical behaviors of complex systems. With the advent of computers with powerful graphics facilities, about three decades ago the interplay between numeric (generated via classical equations explaining the behaviors of dynamical systems) and graphics are shown. That progress provided initial impetus to visualize the systems' spatial and/or temporal behaviors that exhibit simple to complex patterns on graphical screens. Understanding the spatiotemporal dynamical behavioral complexity of terrestrial phenomena and processes both across spatial and temporal scales leads to a study of theoretical interest. The main motivation of his work stems out of the curiosity to know whether the terrestrial surfaces traversing the phases from irregular to regular or from regular to irregular? To get proper physically viable answers to such curiosity one requires terrestrial data at various spatial and temporal scales. Since last two decades, we have been seeing significant breakthroughs in data acquisition procedures with precision. Data related to terrestrial (geophysical) phenomena at spatial and temporal intervals are now available in numerous formats facilitating visualization at spatiotemporal intervals. Availability of such data from a wide range of sources in a variety of formats poses challenges to Geosciences community. The utility and application of such data could be substantially enhanced through related technologies developed in the recent past.[1-9] The varied but coherent phases involve in developing cogent domain-specific models include information retrieval from the source data, information analysis, information reasoning, and simulation and spatiotemporal modeling. These coherent phases that he has been dealing with are basic ingredients required for developing models that provide valuable insights in understanding the complex spatiotemporal dynamical behavioral patterns. His research uses fusion of computer simulations and modeling techniques in order to better understand certain terrestrial phenomena and processes with the ultimate goal of developing cogent models in discrete space further to gain a significantly good understanding of complex terrestrial systems in a way that is not possible with lab experiments. Effectively attaining these goals presents many computational challenges, which include the development of frameworks. While perceiving the terrestrial surfaces (e.g. geophysical and geomorphic basins (e.g. Digital Elevation Models, Digital Bathymetric Models, cloud fields, microscale rock porous media etc) as functions, planar forms (e.g. topographic depressions, water bodies, and threshold elevation regions, hillslopes) as sets, and abstract structures (e.g. networks and watershed boundaries) as skeletons, he made attempts that unraveled key links between the following aspects, and provided rich clues for understanding spatiotemporal behaviors of several of terrestrial phenomena and processes: (i) terrestrial pattern retrieval,[12-19] (ii) terrestrial pattern analysis,[20-42] (iii) simulation and modeling,[43-56] and (iv) reasoning[57-59] and visualization[60-64] of terrestrial phenomena and processes of terrestrial geomorphologic relevance.

2.1. Terrestrial Pattern Retrieval[12-19]

Availability of spatiotemporal data—for natural, anthropogenic, and socio-economic studies—acquired from a wide range of sources and a variety of formats, opens new horizons to the remote sensing and geosciences communities. Retrieving relevant information from such precisely acquired spatial-temporal data of varied types about a specific complex system is a basic prerequisite to understand the spatial-temporal behavior of a system. He developed original spatial algorithms based on non-linear morphological transformations for retrieval of unique networks, landforms, threshold elevation regions for efficient characterization, and segmentation of various geophysical objects and spatial fields.

2.1.1. Unique Topological Networks[12-15]: He has taken the advantage that use curvatures in the elevation contours over the terrain for the simultaneous retrieval of both channel and ridge networks. In contrast to other recent works, which have focused on extraction of channel networks via algorithms that fail to precisely extract networks from non-hilly regions (e.g. tidal regions), the algorithms proposed by him can be generalized to both hilly (e.g. fluvial) and non-hilly (e.g. tidal) terrains, and also pore connectivity networks[12-15]. This work helps solve basic problems that all algorithms meant for extraction of unique terrestrial connectivity networks have faced for over three decades.

2.1.2. Segmentation of Spatial Objects and Spatial Fields: Until recent past, mapping the features has been done through tedious field work and visual interpretation of topographies. He proposed a morphology-based segmentation approach to map physiographic features such as mountains, basins, and piedmont slopes from DEMs.[16] The approach based on computation of complexity measures of morphologically significant zones decomposed from binary fractal sets via multiscale convexity analysis—which can be implemented on several geophysical and geomorphologic fields (e.g. DEMs, clouds, binary fractals etc) to segment them into regions of varied topological significance—has been demonstrated on **DEMs** derived directly from elevation field and cloud fields derived from MODIS data to better segment the regions within the cloud fields that have different compaction properties with varied cloud properties.[17-18] This approach solves a basic problem by preserving the spatial variability which could not be achieved by conventional geomorphometric quantities of topological relevance. planimetric-based measures.

2.1.3. Ranking of Best Pairs of Spatial Fields: A new metric to quantify the degree of similarity between any two given spatial fields is proposed.[19] This metric of morphological significance can be used to derive best pair(s) of spatial fields among a large number of spatial fields available in a database. This metric can be used in the image classification, in particular hyperspectral image classification.

2.2. Terrestrial Pattern Analysis[20-42]

Multiscale analysis for characterization of terrestrial phenomena and processes is one of his innovative new directions of research. He has developed original approaches that yield measures that are scale invariant but shape-dependant to explain characteristics of terrestrial phenomena and processes.

2.2.1. Scale Invariant Measures: Towards analyzing terrestrial surfaces he has shown unique ways to quantitatively characterize the spatiotemporal terrestrial complexity via scale-invariant measures that explain the commonly sharing physical mechanisms involved in terrestrial phenomena and processes. Other unique contributions[20-24] by his group also highlighted the evidence of self-organization via scaling laws—in water bodies and their zones of influence.[20-28] that evidently belong to different universality classes, networks and hierarchically decomposed subwatersheds,[29-33] and pore connectivity networks and other topological components of relevance to porous medium[32-34]—which possess excellent agreement with geomorphologic laws such as Horton's Laws, Hurst exponents, Hack's exponent, and other power-laws given in non-geoscientific context.

2.2.2. Scale Invariant but Shape Dependant Measures: In sequel works on terrestrial analysis, he argued that these universal scaling laws[20-36] possess limited utility in exploring possibilities to relate them with geomorphologic processes. These arguments formed the basis for alternative methods.[37-41] Shape and scale based indexes provided in[37-41] to analyze and classify non-network space (hillslopes),[37-39] and terrestrial surfaces[38-39] received wide attention. These methods that preserve the spatial and morphological variability yield quantitative results that are scale invariant but shape dependent, and are sensitive to terrestrial surface variations. "Fractal dimension of non-network space of a catchment basin",[37] provides an approach to show basic distinction between the topologically invariant geomorphologic basins. It introduced morphological technique for hillslope decomposition that yields a scale invariant, but shape dependent, power-laws.[37-39] Further granulometric indexes derived for spatial elevation fields also yield scale invariant bust shape-dependent measures.[40-41]

2.2.3. Geodesic Spectrum[42]: He provided a novel geomorphologic indicator by simulating geodesic flow fields within a basin consisting of spatially distributed elevation regions, further to compute a geodesic spectrum that provides a unique one-dimensional geometric support. This one-dimensional geometric support, in other words geodesic spectrum, outperforms the conventional width function based approach which is usually derived from planar forms of basin and its networks--construction involves basin as a random elevation field (e.g. Digital Elevation Model, DEM) and all threshold elevation regions decomposed from DEM for understanding the shape-function relationship much better than that of width function.

2.3. Modeling and Simulation[43-56]

Besides providing approaches to simulate fractal-skeletal based channel network model,[43] and fractal landscapes,[44] he has shown via the discrete simulations the varied dynamical behavioral phases of certain geoscientific processes[13-18] (e.g. water bodies, ductile symmetric folds, sand dunes, landscapes) under nonlinear perturbations caused due to *endogenic* and *exogenic* nature of forces. For these simulations he employed nonlinear first order difference equations, bifurcation theory, fractal geometry, and nonlinear morphological transformations as the bases.

2.3.1. Fractal-Skeletal Based Channel Network Model[43]: His work on channel network modelling[43] represents unique contributions to the literature, which until recently were dominated by the classic random model. Fractal-skeletal based channel network model (F-SCN) was proposed by following certain postulates. He developed this model by employing nonlinear morphological transformations to construct other classes of network models, which can exhibit various empirical features that the random model cannot. In the F-SCN model that gives rise to Horton laws, the generating mechanism plays an important role. Homogeneous and heterogeneous channel networks can be constructed by symmetric generator with non-random rules, and symmetric or asymmetric generators with random rules. Subsequently, the F-SCNs in different shapes of fractal basins are generated and their generalized Hortonian laws are computed which are found to be in good accord with other established network models such as Optimal Channel Networks (OCNs), and realistic rivers. F-SCN model is extended to generate more realistic dendretic branched networks.

2.3.2. Fractal Landscape via Morphological decomposition[44]: By applying morphological transformations on fractals of varied types are decomposed into topologically prominent regions (TPRs) and each TPR is coded and a fractal landscape organization that is geomorphologically realistic is simulated.

2.3.3. Geomorphologic Modeling: Concept of Discrete Force[45]: Concept of discrete force was proposed from theoretical standpoint to model certain geomorphic phenomena, where geomorphologically realistic expansion and contractions, and cascades of these two transformations were proposed, and five laws of geomorphologic structures are proposed. A possibility to derive a discrete rule from a geomorphic feature (e.g. lake) undergoing morphological changes that can be retrieved from temporal satellite data was also proposed in this work, and explained. Laws of geomorphic structures under the perturbations are provided and shown, through interplay between numerical simulations and graphic analysis as to how systems traverse through various behavioral phases.

2.3.4. Water Bodies' Dynamics[46-49]: He has shown via the discrete simulations the varied dynamical behavioral phases of certain geoscientific processes (e.g. water bodies) under nonlinear perturbations. Spatio-temporal patterns of small water bodies (SWBs) under the influence of temporally varied streamflow discharge behaviors are simulated in discrete space by employing geomorphologically realistic expansion and contraction transformations[47]. Expansions and contractions of SWBs to various degrees, which are obvious due to fluctuations in streamflow discharge pattern, simulate the effects respectively owing to streamflow discharge that is greater or lesser than mean streamflow discharge. The cascades of expansion-contraction are systematically performed by synchronizing the streamflow discharge, which is represented as a template with definite characteristic information, as the basis to model the spatio-temporal organization of randomly situated surface water bodies of various sizes and shapes.

2.3.5. Ductile Symmetrical Fold Dynamics[50]: Under various possible time-dependent and time-independent strength of control parameters, in other words nonlinear perturbations, the two-limb and three-limb symmetrical folds are transformed in a time sequential mode to simulate various possible fold dynamical behaviors mimicking the realistic fold dynamical behaviors. He employed normalized fractal dimension values, and interlimb angles as parameters along with strength of nonlinear parameters in this study. Bifurcation diagrams are constructed for both time-dependent and time-independent fold dynamical behaviors, and the equations to compute metric universality by considering the interlimb angles computed at threshold strengths of nonlinearity parameters are proposed.

2.3.6. Symmetrical Sand Dune Dynamics[51-56]: Certain possible morphological behaviors with respective critical states represented by inter-slip face angles of a sand dune under the influence of non systematic processes are qualitatively illustrated by considering the first order difference equation that has the physical relevance to model the morphological dynamics of the sand dune evolution as the basis. It is deduced that the critical state of a sand dune under dynamics depends on the regulatory parameter that encompasses exodyanmic processes of random nature and the morphological configuration of sand dune. With the aid of the regulatory parameter, and the specifications of initial state of sand dune, morphological history of the sand dune evolution can be investigated.[51-55] As an attempt to furnish the interplay between numerical experiments and theory of morphological evolution, the process of dynamical changes in the sand dune with a change in threshold regulatory parameter is modeled qualitatively for a better understanding. An equation to compute metric universality by considering attracting interslipface angles is also proposed. Avalanche size distribution in such a numerically simulated sand dune dynamics have also been studied.[56]

2.4. Spatial Reasoning[57-59]

He developed and demonstrated algorithms to (i) identify strategically significant set(s) for spatial reasoning and planning, (ii) determine directional spatial relationship between areal objects (e.g.: lakes, states, sets) via origin-specific dilations, and (iii) spatial interactions via modified gravity model.

2.4.1. Strategically Significant State (s) [57]**:** Identification of a strategically significant set from a cluster of adjacent and/or non-adjacent sets depends upon the parameters that include size, shape, degrees of adjacency and contextuality, and distance between the sets. An example of cluster of sets includes continents, countries, states, cities, etc. The spatial relationships, deciphered *via* the parameters cited above, between such sets possess varied spatial complexities. Hausdorff dilation distance between such sets is considered to derive automatically the strategic set among the cluster of sets. The (i) dilation distances, (ii) length of boundary being shared, and (iii) degrees of contextuality and adjacency between origin-set and destination sets, which together provide insights to derive strategically significant sets with respect to distance, degree of contextuality, degree of adjacency and length of boundary being shared. Simple mathematical morphologic operators and certain logical operations are employed in this study. Results drawn—by applying the proposed framework on a case study that involves spatial sets (states) decomposed from a spatial map depicting country India—are demonstrated and discussed.

2.4.2. Directional Spatial Relationship[58]: He provided an approach to compute origin-specific morphological dilation distances between planar sets (e.g.: areal objects, spatially represented countries, states, cities, lakes) to further determine the directional spatial relationship between sets. Origin chosen for a structuring element (*B*) that yields shorter dilation distance than that of the other possible origins of *B* determines the directional spatial relationship between A_i (origin-set) and A_j (destination set). He demonstrates this approach on a cluster of spatial sets (states) decomposed from a spatial map depicting country India. This approach has potential to extend to any number (type) of sets on Euclidean space.

2.4.3. Spatial Interactions[59]: Hierarchical structures include spatial system (e.g. river basin), clusters of a spatial system (e.g. watersheds of a river basin), zones of a cluster (e.g. subwatersheds of a watershed), and so on. Variable-specific classification of the zones of a cluster of zones within a spatial system is the main focus of this work on spatial interactions. Variable-specific (e.g. resources) classification of zones is done by computing the levels of interaction between the *i*th and *j*th zones. Based on a heuristic argument, we proposed a modified gravity model for the computations of levels of interaction between the zones. This argument is based on the following two facts: (i) the level of interaction between the *i*th and *j*th zones, with masses m_i and m_j is direction-dependent, and (ii) the level of interactions between the *i*th and *j*th zones with corresponding masses, situated at strategically insignificant locations would be much different (lesser) from that of the *i*th and *j*th zones with similar masses but situated at strategically highly significant locations. With the support of this argument, we provide a modified gravity model by incorporating the asymmetrical distances, and the product of location significance indexes of the corresponding zones. This modified gravity model yields level of interaction between the two zones that satisfies the realistic characteristic that is level of interaction between the zones is direction-dependent.

2.5. Visualization[60-65]

His works also include (i) visualization of spatiotemporal behavior of discrete maps via generation of recursive median elements,[60-62] (ii) point-polygon conversion,[63] and (iii) cartogram generation.[64]

3.5.1. Spatial (Morphological) interpolation[60-61, 65]**:** This work concerns the development of frameworks with a goal to understand spatial and/or temporal behaviors of certain evolving and dynamic geomorphic phenomena. In[60-61] we have shown the importance of non-Euclidean metrics for categorization of spatial-temporal maps (e.g. geophysical fields, epidemic spread, etc), and nonlinear morphological interpolation for spatiotemporal modeling of various terrestrial phenomena were shown. (i) how Hausdorff-Dilation and Hausdorff-Erosion metrics could be employed to categorize the time-varying spatial phenomena, and (ii) how thematic maps in time-sequential mode can be used to visualize the spatiotemporal behavior of a phenomenon, by recursive generation of median elements. Spatial interpolation, that was earlier seen as a global transform, is extended in[60-61] by introducing *bijection* to deal with even connected components. This aspect solves problems of global nature in spatial-temporal GIS.

2.5.2. Morphing[62]: He demonstrates the application of grayscale morphological interpolations, computed hierarchically between the spatial fields, to metamorphose a source-spatial field into a target-spatial field. Grayscale morphological interpolations are computed with respect to both flat and non-flat structuring elements, and found that the morphing, shown for transform source- spatial field into target- spatial field, created with respect to non-flat structuring element is more appropriate as the transition of source- spatial field into the target-spatial field across discrete time steps is smoother than that of the morphing shown with respect to flat structuring element. This morphing shown via nonlinear grayscale morphological interpolations is of immense value in geographical information science, and in particular spatiotemporal geo-visualization.

2.5.3. Point-to-Polygon Conversion via WSKIZ[63]**:** Data about many variables are available as numerical values at specific geographical locations. He developed a methodology based on mathematical morphology to convert point-specific data into polygonal data. This methodology relies on weighted skeletonization by zone of influence (WSKIZ). This WSKIZ determines the points of contact of multiple frontlines propagating, from various points (gauge stations) spread over the space, at the travelling rates depending upon the variable's strength for a better geographic visualization. He demonstrated this approach for converting rainfall data available at specific rain gauge locations (points) into a polygonal map that shows spatially distributed zones of equal rainfall.

2.5.4. Cartograms[64]: Visualization of geographic variables as spatial objects of size proportional to variable strength is possible via generating cartograms. He developed a methodology based on mathematical morphology to generate contiguous cartograms. This approach determines the points of contact of multiple frontlines propagating, from centroids of various planar sets (states), at the travelling rates depending upon the variable's strength. The contiguous cartogram generated via this algorithm preserves the global shape, and local shapes, and yields minimal area-errors. It is inferred from the comparative error analysis that this approach could be further extended by exploring the applicability of additional characteristics of structuring element, which controls the dilation propagation speed and direction of dilation while generating variable-specific cartograms, to minimize the local shape errors, and area-errors. This algorithm addresses a decade-long problem of preservation of global and local shapes of cartograms.

2.6. Statement regarding collaboration with scientists abroad

Since 1998, Prof. Sagar has been collaborating with scientists abroad. His collaboration activities are fourfold:

2.6.1. Collaboration on academic research while working at overseas Universities (1998-2006): collaboration with overseas scientists while working in the National University of Singapore, and Multimedia University-Malaysia, and collaboration with overseas scientists while working in India. He served Centre for Remote Imaging Sensing and Processing, The National University of Singapore, as Grade-A Research Scientist during 1998-2001. During this period he worked with other research scientists, whose origins are from China, Taiwan, Germany, Singapore, France, on monitoring a Cambodian Lake (Tonlesap) through remotely sensed data. from Singapore, France, USA, Canada, Brazil, Greece, Iceland, Italy, Denmark, and China.

*2.6.2. Collaboration with scientists abroad on Research Projects (2005-2011)***:** On research projects, Sagar has collaboration with a group coordinated by Prof. Jean Serra (inventor of Mathematical Morphology) on Modelling and Simulations of Natural Disasters (under ICT-Asia Programme funded by French Government). He continues collaboration with his former colleagues from Malaysia on applications of mathematical morphology and fractal geometry in terrestrial analysis. Prof. Sagar is collaborating with Prof. Bala Venkatesh of Ryerson University of Canada on solar radiation mapping in three-dimensions for proper planning of renewable energy sources.

*2.6.3.Collaboration with Co-Guest Editors abroad for special theme issues of Journals (2003-2012)***:** He was a Guest Editor for several special issues of journals, and collaborated with co-guest editors from various parts of the world. Those collaborators include Prof. Daniele Veneziano of Massachusetts Institute of Technology (MIT), Prof. Lori Mann Bruce of Mississippi State University, Prof. Jean Serra of University of Paris-EST, Prof. Laurent Najman of University of Paris-EST, Prof. Petros Maragos of National Technical University of Athens, Prof. Dan Schonfeld of University of Illinois-Chicago, and Prof. Junior Barrera of University of São Paulo, Prof. Lorenzo Bruzzone of University of Trento, Prof. Avik Bhattacharya of Indian Institute of Technology-Bombay, Dr. Paul Rosen of Jet Propulsion Laboratories-NASA, Caltech, Prof. Qiuming Cheng of Yur University-Canda, Frits Agterberg of Canada Geological Survey. Success out of these collaborative activities related to releasing special theme issues for various journals of repute is obvious. The details of those special issues edited along with foreign academics are (i) B. S. Daya Sagar, G. Rangarajan and Daniele Veneziano (Eds.) “Fractals in Geophysics” for Chaos Solitons & Fractals, v. 19, no. 2, p. 237-462, 2004, (ii) B. S. Daya Sagar and Lori Mann Bruce (Eds.), “Surficial Mapping” for IEEE Geoscience and Remote Sensing Letters, v. 2, no. 4, p. 375-408, 2005, (iii) B. S. Daya Sagar and Jean Serra (Eds.), “Spatial Information Retrieval, Analysis, Reasoning and Modelling” of International Journal of Remote Sensing, v. 31, no. 22, 2010,

p. 5747-6031, (iv) Laurent Najman, Junior Barrera, B. S. Daya Sagar, Petros Maragos, and Dan Schonfeld (Guest Editors), "Filtering and Segmentation with Mathematical Morphology" for IEEE Journal on Special Topics in Signal Processing, v. 6, no. 7, 2012, p. 737-886, (v) Avik Bhattacharya, Lorenzo Bruzzone, B. S. Daya Sagar, and Paul Rosen (Guest Editors), "Applied Earth Observation and Remote Sensing in India " for IEEE Journal on Special Topics in Applied Earth Observation and Remote Sensing (forthcoming), and (vi) B. S. Daya Sagar, Qiuming Cheng and Frits Agterberg (Editors) Handbook of Mathematical Geosciences: Fifty Years of IAMG, Springer Publishers, 2018 .

*2.6.4. Collaboration with co-organizers abroad for Courses / Workshops (2009-2011)***:** Prof. Sagar also actively collaborates with foreign academics and scientists to organize short-term courses and training programmes, and workshops. Of late, he organized a four-day course and a two-day workshop on ‘Mathematical morphology in image analysis, geomorphology, GISci’ in collaboration with a group headed by Prof. Jean Serra of University of Paris-EST. The details of these events could be seen at: www.isibang.ac.in/~bsdsagar/cwjs70.

2.7. Special Topics of Lectures Prof. Sagar Delivers Upon Invitation

Lecture 1: Introduction to Mathematical Morphology (120 mins)
Lecture 2: Mathematical Morphology in Terrestrial Pattern Retrieval (120 mins)
Lecture 3: Mathematical Morphology in Terrestrial Pattern Analysis (60 mins)
Lecture 4: Terrestrial Surface Characterization: a Quantitative Perspective (60 mins)
Lecture 5: Size distributions, Spatial Heterogeneity and Scaling Laws (60 mins)
Lecture 6: Morphological Shape Decomposition: Scale Invariant but Shape Dependent Measures (60 mins)
Lecture 7: Granulometries, Convexity Measures and Geodesic Spectrum for DEM Analyses (60 mins)
Lecture 8: Mathematical Morphology in Geomorphologic Modelling and Simulation (60 mins)
Lecture 9: Fractal-Skeletal-Based Channel Network Model (60 mins)
Lecture 10: Synthetic Models to Understand Spatio-Temporal Dynamics of Certain Geo(morpho)logical Processes (60 mins)
Lecture 11: Mathematical Morphology in Quantitative Spatial Reasoning and Visualization (60 mins)
Lecture 12: Mathematical Morphology in Spatial Interpolations (60 mins)
Lecture 13: Conversion of Point-Data into Polygonal Map via WSKIZ (60 mins)
Lecture 14: Visualization of spatiotemporal behavior of discrete maps via generation of recursive median elements (120 mins)
Lecture 15: Quantitative Characterization of Complex Porous Phase via Mathematical Morphology and Fractal Geometry (90 mins)

2.8. Sagar's two most distinctive application of engineering, science, and technology contributions

Professor Sagar's two-decade long contributions for development of spatial algorithms meant for geopattern retrieval, analysis, reasoning, modeling and visualizations have collectively helped quantitative understanding of complex terrestrial geomorphologic phenomena and processes, and also for addressing challenges encountered in GIScience through the applications of mathematical morphology and fractal geometry. These contributions have made a significant impact in the geo–sciences, remote sensing, GIS and computer science. He authored and/or edited nine books and/or journal special issues on these advanced topics. The original ideas reflected through his sixty high impact journal publications—with H-index of over 13—have spurred interdisciplinary activity, deepened our understanding the complex spatiotemporal organization of terrestrial phenomena and processes of which the dynamical behaviors ranging from 'simple' to 'strange'. For his accomplishments in this cutting edge research, he was conferred Georges Matheron Award-2011 of IAMG. Sagar is the first Asian, and the youngest among the recipients so far received this international award. His significant contributions have also been recognized by awarding him 'Dr. Balakrishna Memorial award-1995' by AP Academy of Sciences, ‘Krishnan Gold Medal–2002’ by Indian Geophysical Union.

To get physically viable solutions for quantitative understanding of the spatiotemporal behavioral complexity of terrestrial phenomena and processes, one requires terrestrial data acquired through various remote sensing mechanisms at multiple spatial and temporal scales, and simple but computationally viable algorithms meant for modeling the spatial temporal behaviors along with computations of certain associated parameters. Since last three decades, we have been witnessing significant breakthroughs in data acquisition procedures with precision, and its availability at numerous spatial and temporal intervals in varied formats facilitating visualization of process/phenomenon-specific spatiotemporal behaviors. However, the techniques and novel algorithms that can address the challenges encountered in predicting the behavioral patterns of various terrestrial phenomena and processes are in high demand. Among many excellent spatial algorithms that he developed and demonstrated, most worthy of mentioning, two algorithms stand out most prominently: 1) He (Sagar) attacks the deep problem of analyzing mathematically the forms of landscapes by mathematical tools, in particular by involving mathematical morphology and fractals. There has been a long–standing interest in an analytical understanding and retrieval of unique terrestrial networks (channel and ridge). In his paper, "Morphological operators to extract channel networks from digital elevation models", (IJRS, 2000), Sagar has put forward a novel approach for the simultaneous extraction of channel and ridge networks. In a sequel, "Analysis of geophysical networks derived from multiscale digital elevation models: a morphological approach" (GRSL, 2005), he elucidates techniques for multi–scale analysis of the same. He combines systematically experiments on numerical synthetic landscape models with experiments on real DEMs derived from multispatial and temporal remotely sensed satellite data. This work that has also led to a deeper understanding of complex terrestrial phenomena across spatiotemporal scales helps solve fundamental problems that have plagued algorithms for extracting terrestrial connectivity networks for over two decades. 2) Visualization of spatially represented time varying thematic information mapped from multiscale and multitemporal remotely sensed data is important in GIS applications. The median element between the two thematic maps, perhaps belonging to two different time instants, is a global transform that ignores connectivity, but many situations require to introduce a bijection between the connected components of the corresponding time-specific thematic maps. To address this, his sole-author work "Visualization of spatiotemporal behavior of discrete maps via generation of recursive median elements" (TPAMI, 2010) provides an excellent algorithm developed based on a nice intuition—that deals with the generation of intermediary maps in sequences of thematic (geographic) maps generated from remotely sensed satellite data. In this paper, shape-based layered information is treated as sets and are made into 5 categories of spatial-temporal maps (e.g. geophysical fields, epidemic spread, etc) for establishing relationship between pairs of sets. Distance between two sets is computed in terms of Hausdorff distance using morphological operations (erosion and dilation). Also computed median interpolation between the sets using morphological operations. The two well-treated cases—1)Water bodies and 2)Spatial spread of bubonic plague1896 to 1906—considered to demonstrate the robustness of the algorithm served to test the quality of interpolation over the other existing interpolations. The main motivation behind this paper was to develop a framework with a goal to understand spatial and/or temporal behaviors of certain evolving and dynamic terrestrial phenomena and processes. This paper that is indeed a nice original solution in the GISci area solves problems of global nature in spatial-temporal GIS. Further, he demonstrates the application of grayscale morphological interpolations, computed hierarchically between the spatial fields, to metamorphose a source-spatial field into a target-spatial fields.

2.9. Sagar's three most important items of tangible and verifiable evidence of technical accomplishments

Part-1:

[1]- Sagar, B.S.D., Venu, M., and Srinivas, D., Morphological operators to extract channel networks from digital elevation models, Int. Jour. Rem. Sen," 21(1)21-29, 2000. Significance: This paper provides an algorithm based on binary morphological transformations that can be used to extract channel and ridge networks from DEMs, and can generalized to both fluvial and tidal type terrestrial systems.

[2] Tay, L.T. (Nominee supervised Tay for PhD), Sagar, B.S.D., Chuah, H.T., Analysis of geophysical networks derived from multiscale digital elevation models: a morphological approach, IEEE GRSL, 2(4)399-

403, 2005. Significance: This paper provides an improved algorithm based on directional-grayscale morphological transformations that extracts channel and ridge networks from DEMs. This algorithmically and computationally simple approach that is computationally more efficient than the first paper can be generalized to both fluvial and tidal type terrestrial systems. This paper further shows applications of fractal geometry in modeling channel networks to understand scale–invariance characteristics of various terrestrial phenomena.

[3]Sagar, B.S.D., "Visualization of spatiotemporal behavior of discrete maps via generation of recursive median elements," IEEE TPAMI, 32(2)378-384, 2010. This paper proposes a new nonlinear spatial interpolation technique useful for spatial-temporal GIS, and is of immense value in geographical information science, and in particular spatiotemporal geo-visualization.

Part 2-1: Terrestrial Pattern Retrieval

[1]- Sagar, B.S.D., Murthy, M.B.R., Rao, C.B., and Raj, B., "Morphological approach to extract ridge-valley connectivity networks from digital elevation models (DEMs)," Int. Jour. Rem. Sen, 24(573–581), 2003. Significance: This paper provides stable algorithm based on grayscale morphological transformations to retrieve unique networks and landforms from Digital Elevation Models of both fluvial and tidal regions, and serve to demonstrate the superiority over the other algorithms which cannot be generalized for all types of terrestrial regions.

[2]-Sathymoorthy. D., Radhakrishnan, P., and Sagar, B.S.D. Morphological segmentation of physiographic features from DEM, International Journal of Remote Sensing, v. 28, no. 15. 2007. Significance: Until recent past, mapping the features has been done through field work and visual interpretation of topographies, which proved to be tedious. We proposed a morphology-based segmentation approach to map physiographic features such as mountains, basins, and piedmont slopes from DEMs.

Part 2-2: Terrestrial Pattern Analysis

[3]-Sagar, B. S. D., and Tay, L. T. Allometric power-law relationships in a Hortonian Fractal DEM, Geophy. Res. Let, 31(6)(L06501), 2004.

[4]-Sagar, B.S.D., "Universal scaling laws in surface water bodies and their zones of influence," Water Resources Research, 43(W02416), 2007. The evidence of self-organization was shown for the first time in the above two papers via scaling laws in networks, hierarchically decomposed subwatersheds, and water bodies and their zones of influence that actually belonging to different universality classes.

[5]-Sagar, B.S.D., and Chockalingam, L., Fractal dimension of non-network space of a catchment basin, Geophy. Res. Let, 31(L12502), 2004. Signifcance: Well demonstrated original algorithms that Sagar developed for quantitative characterization of dynamically changing terrestrial surfaces provided insights for understanding spatiotemporal behavioral patterns of terrestrial phenomena and processes. In this paper, Sagar provides an approach towards explaining basic distinctions between topologically invariant geo–morphologic basins. It introduced morphological techniques for hill–slope decomposition that yield scale–invariant, but shape–dependent power laws.

[5]-Chockalingam, L., and Sagar, B. S. D. Morphometry of networks and non-network spaces, Journal of Geophysical Research-Solid Earth, 110(B08203), 2005.

[6]-Tay, L.T., Sagar, B.S.D., Chuah, H.T. "Granulometric analysis of basin-wise DEMs: a comparative study," Int. Jour. Rem. Sen., 28(15)3363-3378, 2007. In the above three papers, it is argued about the limited utility of universal scaling laws in relating them with terrestrial processes. Based on this argument novel methods proposed in those papers provide shape–dependent but scale–invariant indexes for quantitative characterization of terrestrial surfaces. Chockalingam, Tay, Lim obtained PhDs respectively in 2006, 2008, 2011 under the Nominee's supervision.

Part 2-3: Modeling and Visualization of Terrestrial Phenomena and Processes

[7]-Sagar, B.S.D., Rajesh, N., Vardhan, S.A., and Vardhan, P. Metric based on morphological dilation for the detection of spatially significant zones, IEEE GRSL, 10(3)500-504, 2013. Geometric-based criteria introduced in this paper to solve a problem of identifying 'strategic' zones among a cluster of zones would be a big leap towards quantitative spatial reasoning an essential part of GISci. Follow-up work entitled "Ranks for pairs of

spatial fields via metric based on grayscale morphological distances" by BSDSagar and SL-Lim, IEEE TIP, 24(3)908-918, 2015.
[8]-Vardhan, S.A., Sagar, B.S.D., Rajesh, N., and Rajashekara, H. M., Automatic detection of orientation of mapped units via directional granulometric analysis, IEEE GRSL, 10(6)1449-1453, 2013. Developed one-dimensional pattern-spectra analysis to map automatically the orientations of mapped unit. Rajashekhara, Vardhan, and Rajesh pursuing PhD under the nominee's supervision.
[9]-Sagar, B.S.D. 2014, Cartograms via mathematical morphology, Information Visualization, 13(1)42-58. Significance: We developed an algorithm--addresses a decade-long problem of preservation of global and local shapes of cartograms--based on mathematical morphology to generate contiguous cartograms. This algorithm also converts point-data into contiguous zonal map for better visualization, which is first of its kind.
Part 2-4: Education
[10]-B.S.D. Sagar "Mathematical Morphology in Geomorphology and GISci", (CRC Press-Taylor & Francis: p.546, 2013). Significance: This sole-author monograph that helps addressing basic challenges of relevance to geosciences and remote sensing and GIS communities provides a host of original spatial algorithms of fundamental importance to deal with following coherent challenges (i) geospatial information retrieval from remotely sensed data, (ii) analysis, (iii) quantitative spatial reasoning, and (iv) modeling and visualization of the terrestrial phenomena and processes. This path breaking contribution is imminent for developing physics-based models for several terrestrial phenomena and processes. Stalwarts including several IAMG Krumbein Medalists, Fellows of IAMG, IEEE, Royal Society of London, French Academy of Sciences, Russian Academy of Sciences, National Academy of Sciences-USA have provided excellent reviews and endorsements for this book. These endorsements and short reviews are appended in 7.1 (Appendix). This book is available in over 200 Libraries across the world including MIT, Stanford University, Princeton University, Yale-Univ, NYU, Cornell-Univ, UIUC, UC-Berkeley, RPI, Univ-Maryland, Purdue-University, ETH-Zurich, NTU-Singapore, CUHK-Hongkong, UWA-Australia, Dalhousie-University-Canada; and it also received excellent reviews by ACM-Computing Reviews, Journal Mathematical Geosciences, Geomatica, and Mathematical Reviews-American Mathematical Society.
The aforementioned mathematical frameworks and original spatial algorithms that are meant for dealing with a host of challenges in geosciences and GISci have formed the main content of his 110 papers (out of which 80 papers appeared in Journals of high impact factors) listed below. The reputed journals (with impact factors given in parentheses), to name a few, that he opted to publish aforementioned original ideas / algorithms / methods / results, to name a few, include IEEE TPAMI (IF: 8.329), IEEE JSTSP (IF: 5.301), IEEE TIP (IF: 4.828), IEEE TETC (IF: 3.826), IEEE TPD (IF: 3.218), IEEE JSTARS (IF: 2.913), IEEEE GRSL (IF: 2.761), IEEE GRSM (IF: 2.676), Geophysical Research Letters (IF: 4.253), Journal Geophysical Research-Solid Earth (IF: 3.350), Journal Geophysical Research-Atmospheres (IF: 3.454), Water Resources Research (IF: 4.397), Nonlinear Processes in Geophysics (IF: 1.329), Mathematical Geosciences (IF: 2.022), Computers & Geosciences (IF: 2.533), Chaos, Solitons & Fractals (IF: 1.455), Fractals (IF: 1.540), International Journal of Remote Sensing (IF: 1.724), Discrete Dynamics in Nature and Society (IF: 0.711). His recent sole-author monograph (B.S.D. Sagar "Mathematical Morphology in Geomorphology and GISci", (CRC Press-Taylor & Francis: p.546, 2013)) that helps addressing basic challenges of relevance to geosciences and remote sensing and GIS communities provides a host of original spatial algorithms of fundamental importance. This path breaking contribution is imminent for developing physics-based models for several terrestrial phenomena and processes. Stalwarts including several IAMG Krumbein Medalists, Fellows of IEEE, Royal Society of London, French Academy of Sciences, National Academy of Sciences-USA have endorsed this book with excellent reviews; it is available in over 200 Libraries across the world including MIT, Stanford, Princeton University, Yale-Univ, NYU, Cornell-Univ, UIUC, UC-Berkeley, RPI, Univ-Maryland, Purdue-University, ETH-Zurich, NTU-Singapore, CUHK-Hongkong, UWA-Australia, Dalhousie-University-Canada; and it also received excellent reviews, to name a few, by ACM-Computing Reviews, Journal Mathematical Geosciences, Geomatica.

3 Publications of Prof. B. S. Daya Sagar

3.1 Books / Edited Special Issues of Journals[1-9]

1. 

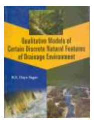
B. S. Daya Sagar (Ed.): For a special issue of *Journal of Mathematical Geosciences*, In memory of the Late Professor SVLN Rao. v. 33, no.3, p.245-396, 2001. (Publisher: Kluwer Academic Publishers)

2. 

B. S. Daya Sagar and C. Babu Rao (Eds.) For a special issue of *International Journal Pattern Recognition and Artificial Intelligence*. Quantitative Image Morphology. v. 17, no. 2 p. 163-330, 2003). (Publisher: World Scientific Publishers).

3. 

B. S. Daya Sagar, G. Rangarajan and Daniele Veneziano (Eds.) For a special issue of *Chaos Solitons & Fractals*, Fractals in Geophysics, v. 19, no. 2, p. 237-462, 2004 January). (Publisher: Elsevier Science).

4. 

B. S. Daya Sagar (Monograph), 2005, *Qualitative models of certain discrete natural features of drainage environment*, Allied Publishers Limited , ISBN: 81-7764-446-7, p. 232.

5. 

B. S. Daya Sagar and Lori Mann Bruce (Eds.), Surficial Mapping for *IEEE Geoscience and Remote Sensing Letters* (ISSN 1545-598X). v. 2, no. 4, p. 375-408, October 2005. (Publisher: IEEE Society).

6. 

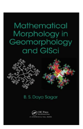
B. S. Daya Sagar (Ed.), Proceedings on "*Spatial Information Retrieval, Analysis, Reasoning and Modelling*" Seminar held during 18-20 March 2009, p. 231.

7. 

B. S. Daya Sagar and Jean Serra (Eds.), Special Issue of *International Journal of Remote Sensing*, "Spatial Information Retrieval, Analysis, Reasoning and Modelling", v. 31, no. 22, Nov, 2010, p. 5747-6032. (Publisher: Taylor & Francis).

8. 

Laurent Najman, Junior Barrera, **B. S. Daya Sagar**, Petros Maragos, and Dan Schonfeld (Guest Editors). Special Issue of *IEEE Journal of Selected Topics in Signal Processing*, Filtering and Segmentation in Mathematical Morphology, v. 6, no. 7, p. 736-886, 2012. (Publisher: IEEE Society).

9. 

B. S. Daya Sagar (Monograph), "*Mathematical Morphology in Geomorphology and GISci*" 2013, (ISBN-10: 1439872007, ISBN-13: 9781439872000. Pages: 546, Publisher: Chapman & Hall (Taylor & Francis Group). Foreword and Afterword on this monograph are respectively written by Jean Serra (Founder of Mathematical Morphology) and Arthur P Cracknell (Co-Editor-In-Chief of International Journal of Remote Sensing). Several other pioneering scientists and academicians have written quotes (see the Appendix in page. 31) on this book.

10. 

Avik Bhattacharya, Lorenzo Bruzzone, **B. S. Daya Sagar**, and Paul Rosen (Guest Editors). Special Issue on *Applied Earth Observation and Remote Sensing in India*, *IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing*, v. xx, no. xx, p. xxx-xxx, 2017. (Publisher: IEEE Society).

11  **B. S. Daya Sagar**, Qiuming Cheng, and Frits Agterberg (Editors), *Handbook of Mathematical Geosciences: Fifty Years of IAMG*, Springer Publishers, 2018

3.2 Journal Publications[12-74]

3.2.1. Terrestrial Pattern Retrieval[12-19]:

12. B. S. Daya Sagar, M. Venu and D. Srinivas, 2000, Morphological operators to extract channel networks from Digital Elevation Models, *International Journal of Remote Sensing*. v. 21, no. 1, p. 21-30.

13. L. Chockalingam and B. S. Daya Sagar, 2003, Automatic generation of sub-watershed map from Digital Elevation Model: a morphological approach, *International Journal of Pattern Recognition and Artificial Intelligence*, v. 17, no. 2. p. 269-274.

14. B. S. Daya Sagar, M. B. R. Murthy, C. Babu Rao and Baldev Raj, 2003, Morphological approach to extract ridge-valley connectivity networks from Digital Elevation Models (DEMs), *International Journal of Remote Sensing*, v. 24, no. 3, 573 – 581.

15. Teo Lay Lian and B. S. Daya Sagar, 2005, Reconstruction of pore space from pore connectivity network via morphological transformations, *Journal of Microscopy* (Oxford), v. 219, Pt 2, p. 76-85.

16. Sathymoorthy. D., P. Radhakrishnan, and B. S. Daya Sagar, 2007, Morphological segmentation of physiographic features from DEM, *International Journal of Remote Sensing*, v. 28, no. 15.

17. Lim Sin Liang and B. S. Daya Sagar, 2008, Cloud field segmentation via multiscale convexity analysis, *Journal Geophysical Research-Atmospheres*, 113, D13208, doi:10.1029/2007JD009369. (17 pages).

18. Lim Sin Liang, Voon Chet Koo, and B. S. Daya Sagar, 2009, Computation of complexity measures of morphologically significant zones decomposed from binary fractal sets via multiscale convexity analysis, *Chaos, Solitons & Fractals*, v. 41, no. 3, p. 1253-1262.

19. B. S. Daya Sagar and Lim Sin Liang, 2015, Ranks for pairs of spatial fields via metric based on grayscale morphological distances, *IEEE Transactions on Image Processing*, v. 24, no. 3, p. 908-918.

3.2.2. Terrestrial Pattern Analysis[20-42]:

20. B. S. Daya Sagar and B S Prakasa Rao, 1995, Fractal relation on perimeter to the water body area, *Current Science*, v. 68, no. 11, p. 1129-1130.

21. B. S. Daya Sagar, M. Venu and B S Prakasa Rao, 1995, Distributions of surface water bodies, *International Journal of Remote Sensing*, v. 16. no. 16, p.3059-3067.

22. B. S. Daya Sagar, G. Gandhi and B S Prakasa Rao, 1995, Applications of mathematical morphology on water body studies, *International Journal of Remote Sensing*, v 16, no.8. p. 1495-1502.

23. B. S. Daya Sagar, 1999, Estimation of number-area-frequency dimensions of surface water bodies, *International Journal of Remote Sensing*, v. 20, no. 13, p.2491-2496.

24. B. S. Daya Sagar, 2000, Fractal relation of medial axis length to the water body area, *Discrete Dynamics in Nature and Society*, v. 4, no.1. p.97. (an International Journal from Taylor & Francis).

25. B. S. Daya Sagar, 2001, Quantitative spatial analysis of randomly situated surface water bodies through f-α spectra, *Discrete Dynamics in Nature and Society*, v. 6, no. 3, p. 213-217.

26. B. S. Daya Sagar, C. Babu Rao and Baldev Raj, 2002, Is the spatial organization of larger water bodies heterogeneous?, *International Journal of Remote Sensing*, v. 23, no. 3, p. 503-509.

27. B. S. Daya Sagar, M. Venu, and K. S. R. Murthy, 1999, Do skeletal network derived from water bodies follow Horton's laws?, *Journal Mathematical Geology*, v. 31, no. 2, p.143-154.

28. B. S. Daya Sagar, 2007, Universal scaling laws in surface water bodies and their zones of influence, *Water Resources Research*, v. 43, no. 2, W02416, 2007.

29. B. S. Daya Sagar, 1996, Fractal relations of a morphological skeleton, *Chaos, Solitons & Fractals*, v. 7, no. 11, p. 1871-1879.

30. B. S. Daya Sagar, Charles Omoregie, and B. S. Prakasa Rao, 1998, Morphometric relations of fractal-skeletal based channel network model, *Discrete Dynamics in Nature and Society*, v. 2, no. 2, p. 77-92.

31. Lea Tien Tay, B. S. Daya Sagar and Hean Teik Chuah, Allometric relationships between travel-time channel networks, convex hulls, and convexity measures, *Water Resources Research* (American Geophysical Union), v. 46, no.2, W06502,10.1029/2005WR004092.
32. Lea Tien Tay, B. S. Daya Sagar, and Chuah Hein Teik, 2005, Analysis of geophysical networks derived from multiscale digital elevation models: a morphological approach, *IEEEGeoscience and Remote Sensing Letters*. v. 2, no. 4, p. 399-403.
33. Lim Sin Liang, B. S. Daya Sagar, Koo Voon Chet, and Tay Lea Tien, 2011, Morphological convexity measures for terrestrial basins derived from Digital Elevation Models, *Computers & Geosciences*, v. 37, no. 9, p. 1285-1294.
34. Lay Lian Teo, P. Radhakrishnan and B. S. Daya Sagar, 2004, Morphological Decomposition of Sandstone Pore-Space: Fractal Power-Laws, *Chaos Solitons & Fractals*.
35. P. Radhakrishnan, B. S. Daya Sagar, and Teo Lay Lian, 2004, Estimation of fractal dimension through morphological decomposition, *Chaos Solitons & Fractals* (an International Journal from Elsevier) v 21, no. 3, p. 563-572.
36. Teo Lay Lian and B. S. Daya Sagar, Modeling, Characterization of Pore-channel, throat and body, Discrete *Dynamics in Nature and Society* (an International Journal), v. 2006, Article ID 89280, p. 1-24.
37. B. S. Daya Sagar and L. Chockalingam, 2004, Fractal dimension of non-network space of a catchment basin *Geophysical Research Letters*, (American Geophysical Union), v.31, no.12, L12502.
38. B. S. Daya Sagar, and Tay Lea Tien, 2004, Allometric power-law relationships in a Hortonian Fractal DEM, *Geophysical Research Letters*, (American Geophysical Union), v. 31, no. 6, L06501.
39. L. Chockalingam and B. S. Daya Sagar, 2005, Morphometry of networks and non-network spaces, *Journal of Geophysical Research-Solid Earth*, (American Geophysical Union), v. 110, B08203, doi:10.1029/2005JB003641.
40. Lea Tien Tay, B. S. Daya Sagar, and Chuah Hein Teik, 2005, Derivation of terrain roughness indicators via Granulometries, *International Journal of Remote Sensing*, v. 26, no. 18, p. 3901-3910.
41. Lea Tien Tay, B. S. Daya Sagar and Hean Teik Chuah, 2007, Granulometric analysis of basin-wise DEMs: a comparative study, *International Journal of Remote Sensing*, 28, 15, p. 3363–3378.
42. Lim Sin Liang, and B. S. Daya Sagar, 2008, Derivation of geodesic flow fields and spectrum in digital topographic basins, *Discrete Dynamics in Nature and Society*. Volume 2008 (2008), Article ID 312870, 26 pages, doi:10.1155/2008/312870.

3.2.3. Modeling and Simulation[43-56]**:**

43. B. S. Daya Sagar, D. Srinivas, B. S. Parakasa Rao, 2001, Fractal skeletal based channel networks in a triangular initiator basin, *Fractals*, v. 9, no. 4. p. 429-437.
44. B. S. Daya Sagar and K S R Murthy, 2000, Generation of fractal landscape using nonlinear mathematical morphological transformations, *Fractals*, v. 8, no. 3, p.267-272.
45. B. S. Daya Sagar, M. Venu, G. Gandhi, and D. Srinivas, 1998, Morphological description and interrelationship between force and structure: a scope to geomorphic evolution process modelling, *International Journal of Remote Sensing*, v. 19, no. 7, p. 1341-1358.
46. B. S. Daya Sagar and B. S. Prakasa Rao, 1995, Computation of strength of nonlinearity in Lakes, letter to the editor, *Computers & Geosciences*, v. 21, no. 3, p. 445.
47. B. S. Daya Sagar and B S Prakasa Rao, 1995, Possibility on usage of return maps to study dynamics of lakes : Hypothetical approach, *Current Science*, v. 68, no. 9, p. 950-954.
48. B. S. Daya Sagar and B S Prakasa Rao, 1995, Ranking of Lakes: Logistic maps, *International Journal of Remote Sensing*, v. 16, no. 2, p. 368-371.
49. B. S. Daya Sagar, 2005, Discrete simulations of spatio-temporal dynamics of small water bodies under varied streamflow discharges, (invited paper), *Nonlinear Processes in Geophysics*, (American Geophysical Union), v. 12, 31-40.

50. B. S. Daya Sagar, 1998, Numerical simulations through first order nonlinear difference equation to study highly ductile symmetric fold (HDSF) dynamics: a conceptual study, *Discrete Dynamics in Nature and Society*, v. 2 no. 4, p. 281-298.
51. B. S. Daya Sagar, 1999, Morphological evolution of a pyramidal sandpile through bifurcation theory: a qualitative model, *Chaos, Solitons & Fractals*. v.10 no 9. p. 1559-1566.
52. B. S. Daya Sagar, 2000, Multi-fractal-interslipface angle curves of a morphologically simulated sand dune, *Discrete Dynamics in Nature and Society*, v. 5, no. 2, p. 71-74.
53. B. S. Daya Sagar, 2001, Hypothetical laws while dealing with effect by cause in discrete space, Letter to the Editor, *Discrete Dynamics in Nature and Society*, v. 6, no.1. p. 67-68.
54. B. S. Daya Sagar and M. Venu, 2001, Phase space maps of a simulated sand dune: a scope, *Discrete Dynamics in Nature and Society*, v. 6, no.1. p. 63-65.
55. B. S. Daya Sagar, 2001, Generation of self organized critical connectivity network map (SOCCNM) of randomly situated surface water bodies, Letters to Editor, *Discrete Dynamics in Nature and Society*, v. 6, no. 3, p. 225-228.
56. B. S. Daya Sagar, M. B. R. Murthy, and P. Radhakrishnan, 2003, Avalanches in numerically simulated sand dune dynamics, *Fractals*, v. 11, no. 2, p. 183-193.
3.2.4. Spatial Reasoning[57-59]
57. B. S. Daya Sagar, N. Rajesh, S. Ashok Vardhan, and Pratap Vardhan, 2013, Metric based on morphological dilation for the detection of spatially significant zones, *IEEE Geoscience and Remote Sensing Letters*, v. 10, no. 3, p. 500-504.
58. S. Ashok Vardhan, B. S. Daya Sagar, N. Rajesh, and H. M. Rajashekara, 2013, Automatic detection of orientation of mapped units via directional granulometric analysis, *IEEE Geoscience and Remote Sensing Letters*, v. 10, no. 6, p. 1449-1453.
59. B. S. Daya Sagar, 2018, Variable-specific classification of zones, pairs of zones, and clusters in a spatial system via modified gravity model, *IEEE Transactions on Emerging Topics in Computing*, (In Press, Early Access), DOI: 10.1109/TETC.2016.2633436.
3.2.5. Visualization[60-65]
60. B. S. Daya Sagar, 2010, Visualization of spatiotemporal behavior of discrete maps via generation of recursive median elements, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, v. 32, no. 2, p. 378-384.
61. B. S. Daya Sagar, 2014, Erratum to “Visualization of Spatiotemporal Behavior of Discrete Maps via Generation of Recursive Median Elements”, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, v. 36, no. 3.
62. B. S. Daya Sagar and Lim Sin Liang, 2015, Morphological interpolations for morphing, *IEEE Journal on Selected Topics in Applied Earth Observation and Remote Sensing*, v. 8, no. 11, p. 5190-5198 (DOI: 10.1109/JSTARS.2015.2490098).
63. HM. Rajashekhara, Pratap Vardhan, and B. S. Daya Sagar, 2012, Generation of Zonal Map from Point Data via Weighted Skeletonization by Influence Zone, *IEEE Geoscience and Remote Sensing Letters*, v. 9, no. 3, p. 403-407.
64. B. S. Daya Sagar, 2014, Cartograms via mathematical morphology, *Information Visualization*, v. 13, no. 1, p. 42-58.
65. Aditya Challa, Sravan Danda, B. S. Daya Sagar, and Laurent Najman, Some Properties of Interpolations Using Mathematical Morphology, *IEEE Transactions on Image Processing* (Revised Version Under Review), 2017
3.2.6. Other Publications[66-74]
66. S. Gunasekaran, B. Venkatesh, and B. S. Daya Sagar, 2003, Convergence index for BPN training, *Neurocomputing*, v. 55, p. 711-719.

67. S Gunasekaran, B Venkatesh and B. S. Daya Sagar, 2004, Fractal Characterization of BPN Weights Evolution, *International Journal of Neural Systems*, v. 14, no. 2 (2004).
68. P. Radhakrishnan, B. S. Daya Sagar, and B. Venkatesh, 2005, Morphological image analysis of transmission systems, *IEEE Transactions of Power Delivery*, v. 20, no. 1, p. 219-223.
69. Alan W. C. Tan, M. V. C. Rao, and B. S. Daya Sagar, 2007, A composite signal subspace speech classifier, *Signal Processing*, v. 87, no. 11, p. 2600-2606.
70. Alan W. C. Tan, M. V. C. Rao, and B. S. Daya Sagar, 2007, Robust signal subspace speech classifier, *IEEE Signal Processing Letters*, v. 14, no. 11, p. 844-847.
71. Alan W. C. Tan, M. V. C. Rao, and B. S. Daya Sagar, 2007, A discriminative signal subspace speech classifier, *IEEE Signal Processing Letters*, v. 14, no. 2, p. 133-136.
72. Alan W. C. Tan, M. V. C. Rao, and B. S. Daya Sagar, 2007, A signal subspace approach for speech modeling and classification, *Signal Processing*, v. 87, p. 500-508.
73. Raghvendra Sharma and B. S. Daya Sagar, 2015, Morphological analyses of spatial binary image, *Image Analysis & Stereology*, v. 34, no. 2, p. 111-123.
74. Gouri Ginde, Snehanshu Saha, Archana Mathur, Sukrit Venkatagiri, Sujith Vadakkepat, Anand Narasimhamurthy, B. S. Daya Sagar, 2016, ScientoBASE: a framework and model for computing scholastic indicators of nonlocal influence of journals via native data acquisition algorithm, Scientometrics, v. 108, no. 3, p. 1479–1529, DOI: 10.1007/s11192-016-2006-2.

3. 3 Book Reviews[75-78]

75. B. S. Daya Sagar, 2001, (book review) Computer Processing of Remotely-Sensed Images, An Introduction, Second Edition, by Paul M. Mather, John Wiley & Sons, 1999, 292 pp. for *Computers & Geoscience*, v.27, no. 2, p. 251-251. (an International Journal from Elsevier).
76. B. S. Daya Sagar, 2001, (book review) Fractals and chaos in geology and geophysics, Second Edition, by Donald L Turcotte, Cambridge University Press, 1997, *Mathematical Geology*, v. 33, no. 2, p. 239-240. (an International Journal from Plenum Press).
77. B. S. Daya Sagar, 2002, (book review) GIS and Geocomputation, 1st Edition, by Peter M Atkinson and David Martin, Taylor & Francis, 2000, *Computers & Geosciences*, v. 28, no. 1, p. 87.
78. B. S. Daya Sagar and Lea Tien Tay, 2005, (book review) GIS – A computing perspective, Second Edition, by Michael Worboys and Matt Duckhem, 2004. *The Photogrammetric Record*, 20 (112), p. 397-398

3.4 Editorials, News Items and Items about Individuals[79-85]

79. B. S. Daya Sagar, 2001, "Introduction on the special issue in memory of Professor SVLN Rao", *Journal Mathematical Geology*, v. 33, no. 3, p. 245-247. (an International Journal from Plenum Press).
80. B. S. Daya Sagar, 2001, "Biographic information of Professor SVLN Rao", *Journal Mathematical Geology*, v. 33, no. 3, p. 249-250. (an International Journal from Plenum Press).
81. B. S. Daya Sagar and C. Babu Rao, 2003, Editorial on "Quantitative Image Morphology", *International Journal of Pattern Recognition and Artificial Intelligence*, v. 17, no. 2, p.163-165.
82. B. S. Daya Sagar, G. Rangarajan, and D. Veneziano, 2004, Introduction to "Fractals in Geophysics", *Chaos Solitons & Fractals*, v. 19, no. 2, p. 237-239.
83. B. S. Daya Sagar and Jean Serra, 2010, Preface: Spatial Information Retrieval, Analysis, Reasoning and Modelling, *International Journal of Remote Sensing*, v. 31, no. 22, p. 5747-5750.
84. Laurent Najman, Junior Barrera, B. S. Daya Sagar, Petros Maragos, and Dan Schonfeld, 2012, Introduction to the Issue on Filtering and Segmentation with Mathematical Morphology, *IEEE Journal of Selected Topics in Signal Processing*, v. 6, no. 7, p. 736-737.
85. B. S. Daya Sagar and Saroj Kumar Meher, 2013, Bangalore Section Chapter of the GRSS, *IEEE Geoscience and Remote Sensing Magazine*, v. 1, no. 2, p. 72-73. DOI: 10.1109/MGRS.2013.2260918.

3.5 Conference Proceedings Papers[86-109]

86. B. S. Prakasa Rao, P. Mruthyunjaya Rao and B. S. Daya Sagar, Development of methodology for location of percolation tanks – A case study, National Workshop on percolation ponds, held in Madras, December, 1991.
87. S. V. L. N Rao, B. S. Daya Sagar and B. S. Prakasa Rao, 1991. Morphologic changes of Minor river courses of Visakhapatnam district as revealed by topographic and remotely sensed data. Proceedings of National seminar on Applications of Remote Sensing for Agriculture and Rural Development. Organized by IIM, Ahmedabad and Computer Society of India, Ahmadabad, 22nd – 24th February, 1991.
88. B. S. Daya Sagar and B. S. Prakasa Rao, 1992. "Sources of Shape variations in surface water bodies: fractal Analysis", paper communicated to International space year conference on Spectral sensing research", Hawaii, USA, 16th – 20th November, 1992.
89. B. S. Daya Sagar and B. S. Prakasa Rao, 1992. "Applications of Morphological statistical methods in evaluations of sources of water body shape variations in different geological terrains" Published in the proceedings in 6th Australia Asian Remote Sensing Conference, Wellington, New Zealand, 2nd – 6th November, 1992.
90. B. S. Daya Sagar and B. S. Prakasa Rao, 1992. "Study of water body shape analysis using Mathematical Morphological methods", Published in the proceedings of VIII APD congress on Hydraulic research, Pune, 2-th – 23rd October, 1992.
91. B. S. Daya Sagar J. Kiran Kumar and B. S. Prakasa Rao, 1992. "Integrated topographic and Remotely sensed data for effective water potential zone identification. International conference on Remote Sensing and GIS (ICORG), 26th – 28th February, 1992.
92. B. S. Daya Sagar, J. Kiran Kumar and B. S. Prakasa Rao, 1993. "Quantitative hydrogeomorphometric Analysis using remote sensing techniques". International conference on Man and Environment ICOMAN was held on 23rd & 24th October, 1993.
93. B. S. Daya Sagar and B. S. Prakasa Rao, 1997. Characterization of Natural Water bodies through fractals, International Conference on Remote Sensing and GIS, held on 18th to 20th June, 1997 at Hyderabad.
94. B. S. Daya Sagar and B. S. Prakasa Rao, 1997. Fractal structures, Morphological solutions: fractal relations, International Conference on Remote Sensing and GIS held on 18th to 20th June, 1997 at Hyderabad.
95. B. S. Daya Sagar and B. S. Prakasa Rao, 1998. National conference on Nellore Schist Belt, National Conference on Major Bridges, Green Park, Visakhapatnam, January, 1998.
96. B. S. Daya Sagar, and K. S. R. Murthy, Automatic measurement of basin outline forms, presented at VIII APD-IAHR congress organized at the Central Water and Power Research Station, Pune, 1992. Proceeding of CWPRS Conference.
97. B. S. Daya Sagar, and B. S. Prakasa Rao, Basic measure computations of surface water bodies, presented at VIII APD-IAHR congress organized at the Central Water and Power Research Station, Pune, 1992. Proceeding of CWPRS Conference.
98. B. S. Daya Sagar and B. S. Prakasa Rao, Studies on Railway Track Disaster using IRS 1a data, Paper presented at the National conference on the Impact of May 1990 Cyclone. This work has been published subsequently in a book as a chapter.
99. Charles Omoregie and B. S. Daya Sagar, Federal GIS use for resource management (SPIE Proceedings Paper),Proceedings of SPIE Volume: 1943, 1993.
100. M. Venu, T. C. M. Rao, B. S. Prakasa Rao and B. S. D. Sagar, Texture characterization: morphological approach, Proc. SPIE, Vol. 2055, 512 (1993); doi:10.1117/12.150165

101. B. S. Daya Sagar and B. S. Prakasa Rao, Usage of fractals in drainage environment (SPIE Proceedings Paper), DOI: 10.1117/12.157167, 1993.
102. T. L. Lian, and B. S. Daya Sagar, Fractal analysis of multiscale pore connectivity networks, in: Image and Signal Processing and Analysis, 2003. ISPA 2003. Proceedings of the 3rd International Symposium, 2003, Volume: 2, p. 686- 689.
103. N.A.B.A. Aziz, A. W. Mohemmed, B. S. Daya Sagar, 2007, Particle Swarm Optimization and Voronoi diagram for Wireless Sensor Networks coverage optimization, International Conference on Intelligent and Advanced Systems, 2007. ICIAS 2007. 25-28 Nov. 2007, Page(s): 961 - 965. DOI: 10.1109/ICIAS.2007.4658528.
104. Raghvendra Sharma and B. S. Daya Sagar, 2014, Fractal Characterization via Morphological Analysis, IAMG Conference Proceedings, 17-20 October 2014, New Delhi.
105. H. M. Rajashekara, S. Ashok Vardhan, and B. S. Daya Sagar, 2014, Computations of Bi-Variable Spatial Relationships Between the Political Divisions of Karnataka, India via Mahalanobis Distance, IGARSS-2015 Proceedings, 26-31 July 2015, Milan, Italy.
106. Sravan Danda, Aditya Challa, B. S. Daya Sagar, 2016, A morphology-based approach for cloud detection, IEEE International Geoscience and Remote Sensing Symposium (IGARSS) 2016 Pages: 80 - 83, DOI: 10.1109/IGARSS.2016.7729011
107. Aditya Challa, Sravan Danda, B. S. Daya Sagar, 2016, Morphological interpolation for temporal changes, IEEE International Geoscience and Remote Sensing Symposium (IGARSS) 2016 Pages: 3358 - 3361, DOI: 10.1109/IGARSS.2016.7729868
108. Sravan Danda, Aditya Challa, B.S. Daya Sagar, Laurent Najman, 2017, Power Tree Filter: A Theoretical Framework Linking Shortest Path Filters and Minimum Spanning Tree Filters, Mathematical Morphology and Its Applications to Signal and Image Processing Pages: 12 pages, DOI: 10.1007/978-3-319-57240-6_16
109. Aditya Challa, Sravan Danda, B.S. Daya Sagar, and Laurent Najman, 2017, An Introduction to Gamma-Convergence for Spectral Clustering, DGCI 2017 Volume: LNCS 10502 Pages: 12 Pages, DOI: 10.1007/978-3-319-66272-5_16

4. Academic, Scientific, Technical and Management Experience

4.1. Employment History including Administrative Positions

2013—Present: Professor, Systems Science and Informatics Unit (SSIU), Computer and Communication Sciences Division (CCSD), Indian Statistical Institute-Bangalore Centre, India

2009—Present: Founding Head, Systems Science and Informatics Unit (SSIU), Computer and Communication Sciences Division (CCSD), Indian Statistical Institute-Bangalore Centre, India

2007—2013: Associate Professor, Systems Science and Informatics Unit (SSIU) , Computer and Communication Sciences Division (CCSD), Indian Statistical Institute-Bangalore Centre, India

2001-2007: Associate Professor, Faculty of Engineering and Technology (FET), Telekom University Malaysia (Multimedia University), Melaka Campus, Malaysia.

2003-2007: Deputy Chairman, Centre for applied Electromagnetics (CAEM), Telekom University Malaysia (Multimedia University), Melaka Campus, Malaysia.

1998-2001: Grade-A Research Scientist, Centre for Remote Imaging Sensing and Processing (CRISP), Faculty of Science, The National University of Singapore, Singapore.

1998-1998: Senior Research Associate-CSIR, Department of Geoengineering, College of Engineering, Andhra University, India.

1996-1997: Research Scientist/Principal Investigator -DST, Department of Geoengineering, College of Engineering, Andhra University, India.

1995-1995: Research Associate-CSIR, Department of Geoengineering, College of Engineering, Andhra University, India.

1992-1994: Senior Research Fellow-CSIR, Department of Geoengineering, College of Engineering, Andhra University, India
1991-1992: Project Fellow -MHRD, Department of Geoengineering, College of Engineering, Andhra University, India.
1996: Short Term Visiting Fellow, Tata Institute for Fundamental Research (TIFR), Bangalore, India
1998: Guest Faculty, Centre for Space Science Technology-Asia Pacific (CSSTE-AP), Affiliated to United Nations, Dehradun, India.
2008-2009: Guest Faculty, Department of Geoengineering, College of Engineering, Andhra University, India.

4.2. Memberships, Professional Contributions, Professional Activities, Honors and Awards

4.2.1 Professional Activities

- Member of Selection Committee for the 2015-Computers & Geosciences Research Scholarships (Co-Sponsored by Elsevier and IAMG)
- Speaker at Tutorial on "Mathematical Morphology in Geosciences and GISci" at IGARSS 2015, 2017
- Organized three GRSS Distinguished Lecture Talks ever since Bangalore Section IEEE GRSS Chapter was established
- 'Letter of Appreciation' from IEEE-Bangalore-Section
- IEEE-Bangalore-Section ExeCom Member
- Founding Chair of Bangalore Section IEEE GRSS Chapter (since 2012-)
- IEEE Member since 2003 (12 years)
- IEEE Geoscience and Remote Sensing Society Member since 2003 (12-years)
- IEEE Senior Member since 2003 (12-years)
- Established IEEE Bangalore Section GRSS Chapter in 2012.
- Member, IEEE Senior Member Applications Review panel on 29-March-2013, Bangalore.
- Member, Technical Program Committee IGARSS-2006, 2008-2014
- Received Felicitation Certificate with Cash Prize from IEEE Bangalore Section-2011, 2013
- Guest Editor (Associate Editor) special section on “Surficial Mapping” for IEEE Geoscience and Remote Sensing Letters (v.2, no.4, 375-408, 2005)
- Guest Editor (Associate Editor) special issue on “Filtering and Segmentation with Mathematical Morphology” for IEEE Journal on Selected Topics in Signal Processing (v.6, no.7, 736-886, 2012).
- Guest Editor (Associate Editor) special issue on “Applied Earth Observation and Remote Sensing in India” for IEEE Journal on Selected Topics in Applied Earth Observation and Remote Sensing (December 2017 issue).
- Convener/Chairman for IEEE Sponsored workshops on "Spatial Statistical Tools in Data Processing and Analysis (26-30 Nov 2012)", "Mathematical Morphology and Pattern Recognition: Theory and Applications (26-28 March 2013)", "Image Pattern Analysis and Applications (09-10 Nov 2013)", "Mathematical Morphology in Interpolations (Last week of Feb 2014)".
- Provided support letters to twelve qualified IEEE members to upgrade their status to Senior member.
- Published papers in IEEE Journals/Transactions/Letters namely, IEEE Geoscience and Remote Sensing Letters (GRSL), IEEE Signal Processing Letters (SPL), IEEE Transactions on Power Delivery, IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI), and IEEE Journal on Selected Topics in Signal Processing (JSTSP), IEEE GRSS Magazine, and . IEEE-GRS-Newsletter.
- Reviewed papers for IEEE GRSL, IEEE TGRS, IEEE SPL, IEEE TKDE, IEEE JSTSP, and IEEE TPAMI.
- Organized first ever GRSS DL talk in India on 27 Jan 2014.

4.4.2 Professional Activities, Awards, Certificates

- Editor, Golden Anniversary Book of IAMG

- Guest Editor, IEEE Journal on Selected Topics in Applied Earth Observation and Remote Sensing
- Guest Editor, IEEE Journal on Selected Topics in Signal Processing
- Associate Editor, Image Analysis & Stereology
- Review Editor, Frontiers: Environmental Informatics
- Member AGU
- Member ACM SIGSPATIAL
- Elected Fellow of Royal Geographical Society (London)
- Elected Fellow of Indian Geophysical Union
- Member New York Academy of Sciences
- Life Member International Association for Mathematical Geosciences
- Editorial Board Member, Computers & Geosciences (Elsevier Journal)
- Editor, Discrete Dynamics in Nature and Society (Hindawi Publishers, USA)
- Editor, ICTACT Journal of Image and Video Processing
- Guest Editor, Journal Mathematical Geosciences (Springer)-2001
- Guest Editor, International Journal of Pattern Recognition and Artificial Intelligence (World Scientific Publishers)-2003
- Guest Editor, Chaos Solitons & Fractals-2004
- Guest Editor for IEEE Geosciences and Remote Sensing Letters-2004
- Guest Editor, International Journal of Remote Sensing-2010
- Member, Technical Program Committee ISMM-2013, 2015, 2017
- Member, Scientific Advisory Committee IAMG-2014, 2015, 2018
- Advisor, 6 Doctoral and 5 Masters Thesis Students Graduated
- Presenter, Over 200 Invited Talks Internationally and Nationally
- Funding, Over INR 30 Million in Research Grants
- Instructor, Over 10 Different Undergraduate and Graduate Courses
- Krishnan Gold Medal-2002 from Indian Geophysical Union
- Dr. S. Balakrishna Memorial Award-1995 from Andhra Pradesh Akademi of Science
- NSF Grant Proposal Reviewer 2010 & 2014
- Expert Committee Member, Board of Research in Nuclear Science (BRNS), 2014
- Convener for Two-Day Workshop on "Image Pattern Analysis and Applications", jointly organized by the Systems Science and Informatics Unit (SSIU), Indian Statistical Institute-Bangalore Centre and the Amrita School of Engineering, Bangalore, 09-10 November, 2013. (Workshop Webpage: http://www.isibang.ac.in/~bsdsagar/Amrita-ISI-Poster.pdf)
- Convener for Three - Day Workshop on "Mathematical Morphology and Pattern Recognition: Theory and Applications", Indian Statistical Institute - Bangalore Centre, India, 26 - 28 March, 2013. (Workshop Webpage: http://www.isibang.ac.in/~mmprta/);
- Convener for Five-Day Course on "Spatial Statistical Tools in Data Processing and Analysis", Indian Statistical Institute, Bangalore, India, 26-30 November, 2012. (Workshop Webpage: http://www.isibang.ac.in/~sstdpa/);
- Convener for Workshop on "Advanced Methods in Spatial Data Analysis and Processing", Indian Statistical Institute, Bangalore, India, 6-7 March 2012. (Webpage: https://sites.google.com/site/advancedmethodsssiu/home);
- Convener for Course on "Mathematical Morphology in Image Analysis, GISci, Geomorphology", Indian Statistical Institute, Bangalore, India, 19-25 October 2010 (Organized jointly by Systems Science and Informatics Unit (SSIU) and ESIEE Engineering, Universit Paris-Est, France). (Webpage: http://www.isibang.ac.in/~cwjs70/);
- Convener for Workshop on "Honouring Professor Jean Serra", Indian Statistical Institute, Bangalore, India, 26-28 October 2010. (Webpage: http://www.isibang.ac.in/~cwjs70/);

- Convener for International Seminar of "Spatial Information Retrieval Analysis, Reasoning and Modelling (SIRARM)", Indian Statistical Institute, Bangalore, India, 18-20 March 2009. (Webpage: http://www.isibang.ac.in/~sirarm/);
- Coordinator for Two-Week DST Summer School on Mathematical Morphology in Geosciences (24 March-08 April 2015) (Webpage: http://www.isibang.ac.in/~dst-ss-mmg/);
- Program Chair for Ninth International Conference on Advances in Pattern Recognition (ICAPR- 2017) December 28-30, 2017 (Webpage: http://www.isical.ac.in/~icapr17/index1.php).
- Book entitled "Mathematical Morphology in Geomorphology and GISci" (Scheduled for Release May 2013, ISBN-10: 1439872007, ISBN-13: 9781439872000. Pages: 536, Publisher: Chapman & Hall (Taylor & Francis Group)).
- "Georges Matheron Award-2011 (with Lecturership) of International Association for Mathematical Geosciences (IAMG)".
- Reviewer University Press (India) Limited, (an associate of Orient Longman Ltd), Journal Mathematical Geology, International Journal of Remote Sensing, Computers & Geosciences, International Association for Pattern Recognition, International Journal of Pattern Recognition and Artificial Intelligence, Chaos Solitons & Fractals, Tribology International, Discrete Dynamics in Nature and Society, NSF Grant Proposal Reviewer.
- Member, International Association for Mathematical Geologists (IAMG), 2006-2014
- Biography included in Who's Who in the World (Marquis), 15th Edition, 1997; International Who's Who of Intellectuals (Marquis) 13th Edition, 1998; 20th Century Outstanding Achievement Award (International Biographical Centre, Cambridge); Dictionary of Who's Who in the World (International Biographical Centre, Cambridge)27th Edition, 1998; Who's Who in the Science and Engineering (Marquis)2004; Who's Who in the Asia (Marquis) 2006;
- Travel grant arranged by Science & Technology Corporation, Virginia, USA To Present paper in the International Space Year Conference on Spectral Sensing Research, Hawaii 1992
- Awards of Senior Research Fellowship, Research Associateships Council of Scientific and Industrial Research, India 1992-1996
- Award of Young Scientist Scheme, Department of Science and Technology, India, 1996-97
- Finalist for INSA Young Scientist Medal, Indian National Science Academy 1996 & 1998
- Finalist for Swarnajayanthi Fellowship Department of Science and Technology, India, 1999

4.2.3 Invited Contributions to Workshops, Courses, Seminars and Conferences

Prof. Sagar has delivered several invited lectures in India and abroad, organized international conferences / workshops, and chaired various technical sessions. These details are given below

- Symposia and a Workshop on "Mathematical Morphology in Geosciences and Geoinformatics", at the 35th IGC, Cape Town, South Africa, 2016.
- Half-Day Tutorial on "Mathematical Morphology in Geosciences and GISci", was organized on 26 July 2015 at the IGARSS-2015, Milan, Italy.
- A Two-Week Long Summer School on "Mathematical Morphology in Geosciences", was organized during 24 March 2015 to 08 April 2015 at the Indian Statistical Institute-Bangalore Centre, India.
- Pre-IAMG Conference Short Course on "Mathematical Morphology in Geosciences and GISci", organized at Jawaharlal Nehru University (JNU), New Delhi, India, during 15-16 October 2014.
- Workshop on "Mathematical Morphology and Pattern Recognition: Theory and Applications" 26 - 28 March, 2013, Indian Statistical Institute - Bangalore Centre. (Website: http://www.isibang.ac.in/~mmprta/)
- Convener, 5-Day course on "Spatial Statistical tools in data processing and analysis, 26-30 Nov 2012, Bangalore, India. (Website: http://www.isibang.ac.in/~sstdpa/)
- Convener, 4-Day course on "Mathematical morphology in image analysis, geomorphology, and GISci', 19-23 Oct 2010, Bangalore, India (Website: http://www.isibang.ac.in/~cwjs70/)

- Co-Convener, Workshop on 'Advanced methods in spatial data processing and analysis', 6-7 March 2012, Bangalore, India. (Website: https://sites.google.com/site/advancedmethodsssiu/home)
- Chair, 'Workshop Honoring Jean Serra' October 25-26, 2010, Bangalore, India, 2009 (Website: http://www.isibang.ac.in/~cwjs70/)
- Chair, International Seminar of Spatial Information Retrieval Analysis, Reasoning and Modelling (SIRARM), Bangalore, India, 2009 (Website: http://www.isibang.ac.in/~sirarm/)
- Chair, M2USIC-2002, Multimedia University, Cyberjaya, Malaysia, 2002
- Convener, A Course on Mathematical Morphology in Image Analysis, GISci, Geomorphology, Bangalore, India, 2010.
- Invited talk on 'Application of mathematical morphology to compute basic measures' Summer School on Application of Mathematical Morphology in Pattern Studies, Centre for Remote Sensing and Information Systems, Department of Geoengineering, Andhra University, Visakhapatnam, 1992
- Invited talk on 'New mathematical tools to study structural dynamics' Andhra University Research Forum, Visakhapatnam, 1995.
- Invited talk on 'Attempts to establish an integrated mathematical approach to study certain geoscientific aspects' A.P. Akademi of Sciences, Visakhapatnam, 1995.
- Invited talk on 'Advanced mathematical tools to study certain geo-scientific aspects' Indian National Science Academy (INSA), New Delhi, 1996.
- Invited talk on 'Mathematical tools to study shapes' Tata Institute of Fundamental Research (TIFR), Bangalore, 1996.
- Invited talk on 'Fractal and mathematical morphological applications to study natural processes' Centre for Space Science Technology and Education-Asia Pacific (CSSTE-AP), Dehra Dun, 1998.
- Invited talk on 'Numerical simulations using first order nonlinear difference equation to study highly ductile symmetrical fold dynamics: a conceptual approach' Indian National Science Academy (INSA), New Delhi, 1998
- Invited talk on 'Extraction of river networks from digital elevation models by applying mathematical morphological transformations' Centre for Remote Imaging Sensing Processing (CRISP), National University of Singapore, 1999.
- Invited talk on 'Exploring complex networks', Faculty of Engineering and Technology, Multimedia University, Malaysia, 2003.
- Invited talk on 'Conducting research, and writing papers for Journals and Conferences' Kolej University Technical Kebangsan Malaysia, Melaka, Malaysia, 2003
- Invited talk on 'Geophysical networks in a DEM, and allometric power-law relationships' Multimedia University, Melaka, Malaysia, 2003.
- Invited talk on 'Morphological analysis of Digital Elevation Models (DEMs) and associated features' Centre for Soft Computing Research, Indian Statistical Institute, Kolkata, 2008.
- Invited talk on 'Mathematical morphology in spatial information analysis' Andhra University College of Engineering, Visakhapatnam, 2008.
- Invited talk on A series of eight lectures on 'Mathematical Morphology' , Centre for Remote Sensing Andhra University College of Engineering, Visakhapatnam, 2009.
- Invited talk on 'Techniques for characterization and modeling of spatial phenomena' Curzonco-Seshachalam lecture (5) 2009, Sarada Ranganathan Endowment for Library Science, Bangalore, 2009.
- Invited talk on 'Network extraction from Digital Elevation Models and analyses of networks via mathematical morphology' University Centre for Earth and Space Sciences (UCESS), University of Hyderabad, Hyderabad, 2009.
- Invited talk on 'Visualization of spatiotemporal behavior of discrete maps via recursive generation of median elements', University Centre for Earth and Space Sciences (UCESS), University of Hyderabad, Hyderabad, 2009.

- Invited talk on 'Cellular Automata (CA) model for urban analysis' Workshop on Applying CA Model for Peri-Urbanization of Bangalore-An ISRO Sponsored Major Project work, Bangalore University, Bangalore, 2010.
- Invited talk on 'Cartograms via mathematical morphology' Workshop honouring Jean Serra, Indian Statistical Institute-Bangalore Centre, Bangalore, 2010.
- Invited talk on 'Median Maps and Cartograms via Mathematical Morphology', Indian Statistical Institute-Karnataka Chapter, Bangalore, 2011.
- Invited talk on 'Mathematical Morphology in Terrestrial Surface Characterization', Electronics & Radar Development Establishment (LRDE), DRDO, Bangalore, 2011.
- Invited talk (Georges Matheron Award Lecture of IAMG) on 'Mathematical Morphology in Geomorphology and GISci', IAMG Conference, Salzburg, Austria, 2011.
- Lecture on 'Introduction to Mathematical Morphology and its applications in Visualization', Five-Day Course on Spatial Statistical Tools in Data Processing and Analysis, 26 Nov 2012
- Lecture on 'Binary and Grayscale Granulometries', Five-Day Course on Spatial Statistical Tools in Data Processing and Analysis, 28 Nov 2012.
- Lecture on 'Spatial Interpolation and Extrapolation', Five-Day Course on Spatial Statistical Tools in Data Processing and Analysis, 30 Nov 2012.
- Delivered a series of eight lectures on 'Mathematical Morphology and Applications' at Kongu Engineering College, Tamilnadu, 8th-9th May 2013.
- A series of six lectures on "Image Pattern Analysis and Applications", at the Amrita School of Engineering, Bangalore, 09-10 November, 2013.
- Delivered invited lecture on 'Mathematical Morphology in Earth Systems Science" Contact Programme Workshop on "Earth Surface Dynamics" at Indian Institute of Technology-Gandhinagar, 10th December 2013.
- Delivered Inaugural lecture on 'Overview on Mathematical Morphology in Image Analysis' at a AICTE-Sponsored National Seminar on "Recent Trends and Developments in the Field of Computer Vision", VR Siddhartha Engineering College, Vijayawada, Andhra Pradesh, 20th December 2013.
- Delivered Inaugural lecture on 'Overview on Mathematical Morphology in Intelligent Systems' at a BMS College of Engineering, Bangalore, 23 January 2014.
- Delivered three lectures at a workshop on “Spatial Information Analytics” at PESIT, Bangalore, 28 Feb 2014.
- Delivered Inaugural talk on “Mathematical Morphology in Image Processing and Analysis”, at ICICT conference, PESIT, Shimoga, 04 April 2014.
- Delivered three lectures at a workshop on “Mathematical Morphology in Signal Processing” at National Institute of Technology-Surathkal, 10 April 2014.
- Delivered three invited lectures at a training program on “Earth and Space Sciences” at University of Hyderabad, 29 Sep 2014.
- Delivered a series of 8 lectures at a short course on “Mathematical Morphology in Geosciences and GISci”, at Jawaharlal Nehru University (JNU), Delhi, 15-16 Oct 2014.
- Delivered Invited Talk on "Mathematical Morphological Interpolations for Morphing", at Multidisciplinary International Workshop on Artificial Intelligence-2014 (MIWAI-2014), 10 December 2014, Bangalore, India.
- Delivered a series of 15 lectures at a winter school on “Spatial Ecology & Remote Sensing”, at Indian Institute of Technology-Kharagpur, 15-26 December 2014.
- Delivered an invited talk on "Overview on Mathematical Morphology and Applications", Recent Emerging Trends in Computer Science", PESIT, Bangalore, 09 January 2015.

- A series of 26 Lectures (90 minutes each) on "Mathematical Morphology in Geosciences", 24 March - 08 April 2015, during SERB-DST Summer School on "Mathematical Morphology in Geosciences", at Indian Statistical Institute-Bangalore, India.
- Invited lecture on "Spatial Interpolations: Weighted Skeletonization by Influence Zones (WSKIZ) and Morphological Medians", IIT-Bombay, 05 June 2015.
- Three Hours Lectures on "Mathematical Morphology" at the First Workshop on Computing: Theory and Applications, at the Indian Statistical Institute (ISI) North-East Centre at Tezpur, Organized by: Computer and Communication Sciences Division (CCSD), ISI, 14 – 18 March, 2016.
- A Talk on "Applications of Mathematical Morphology in Remote Sensing and Geosciences: An Overview", at ITPAR Phase Three Concluding Workshop, held at IIT-Bombay, 18 April 2016.
- A series of 3 Lectures at the Amrita University-Coimbatore, 20 April 2016.
- A series of 6 lectures during One Week Faculty Development Programme on "Recent Trends in Signal and Image Processing", June 06-12, 2016, PSG College of Technology, Coimbatore, India.
- Keynote Address on "Overview on Mathematical Morphology and its Applications with Emphasis on Morphological Interpolations" at International Multi-Conference on Information Processing–2016, on 21 August 2016, at Capitol Hotel, Raj Bhavan Road, Bangalore, India.
- A series of 4 lectures at the Workshop on 'Mathematical Genomics' jointly organized by the Applied Statistics Unit of Indian Statistical Institute-Kolkata, and the Bioinformatics Centre, Tripura University, Agartala, India, 27 January 2017.
- Delivered 20 Lectures (Three-Credit Hour Course) on "Mathematical Morphology & Applications" during 02-05 May 2017 for Doctoral Students of Information and Communication Technology (ICT), International Doctoral School of the University of Trento, Italy.
- A Series of 4 lectures on "Mathematical Morphology and Image Analysis", 28 June 2017, Nirma University, Ahmadabad.
- A technical Talk on "Mathematical Morphology in Processing and Analyses of Digital Elevation Models (DEMs): An Illustrative Review", at IEEE BOMBAY GRSS CHAPTER, Indian Institute of Technology-Bombay, 19 July 2017.
- Full-Day Tutorial on "Mathematical Morphology in Interpolations and Extrapolations", on 23 July 2017, During IGARSS 2017, Fort Worth, Texas, USA, 23-28 July 2017.

4.2.4 Computer Simulations

- Epidemic spread: http://www.isibang.ac.in/~bsdsagar/AnimationOfEpidemicSpread.avi
- Population Cartogram: http://www.isibang.ac.in/~bsdsagar/AnimationOfPopulationCartogram.wmv
- Perimeter Cartogram: http://www.isibang.ac.in/~bsdsagar/AnimationOfPerimeterCartogram.wmv
- Point-Poly-Conversion: http://www.isibang.ac.in/~bsdsagar/AnimationOfPointPolygonConversion.wmv
- Direction-Relate: http://www.isibang.ac.in/~bsdsagar/AnimationOfDirectionalSpatialRelationship.wmv
- Spatial-Interaction: http://www.isibang.ac.in/~bsdsagar/MGM-Spatial-Interaction.avi
- Morphing-1: http://www.isibang.ac.in/~bsdsagar/Morphing-1.avi
- Morphing-2: http://www.isibang.ac.in/~bsdsagar/Morphing-2.avi
- Morphing-3: http://www.isibang.ac.in/~bsdsagar/Morphing-3.avi

4.3. Supervision of PhD and Master Students and Short-Term Interns

4.3.1 Doctoral Students

- P. Radhakrishnan, "Discrete simulation, spatial modelling and characterisation of certain geophysical phenomena", Faculty of Engineering & Technology, Multimedia University, Melaka, Malaysia, 2004, Current Position: Assistant Professor, King Khaled University, Saudi Arabia
- L. Chockalingam, "Analyses of Complex Topological and Surficial features Retrieved from Contour

based Digital Elevation Models (DEMs) and Remotely Sensed Data", Faculty of Engineering & Technology, Multimedia University, Melaka, Malaysia, 2005,
Current Position: Senior Lecturer, Faculty of Information Science & Technology, Multimedia University, Malaysia

- Teo Lay Lian, "Quantitative Characterisation of Complex Porous Phase via Mathematical Morphology and Fractal Geometry", Faculty of Engineering & Technology, Multimedia University, Melaka, Malaysia, 2006
  Current Position: Senior Lecturer, Faculty of Information Science & Technology, Multimedia University, Malaysia
- Tay Lea Tien, "Scaling and Morphologic Analyses of TOPSAR DEMs: A Quantitative Characterization Perspective", Faculty of Engineering, Multimedia University, Cyberjaya, Malaysia, 2008
  Current Position: Senior Lecturer, University of Sains Malaysia, Malaysia
- Alan Tan Wee Chet, "Signal Modelling and characterization", Faculty of Engineering & Technology, Multimedia University, Melaka, Malaysia, 2008
  Current Position: Associate Professor, Faculty of Engineering & Technology, Multimedia University, Malaysia.
- Lim Sin Liang, "Derivation of novel quantitative characteristics from certain geophysical fields via mathematical morphological analysis" Faculty of Engineering & Technology, Multimedia University, Melaka, Malaysia, 2011
  Current Position: Senior Lecturer, Faculty of Engineering, Multimedia University, Malaysia
- Rajashekara H. M (PhD Thesis Submitted in 2016, Bharathiar University)
- K. Nagajothi (pursuing PhD, Bharathiar University)
- Ashok Vardhan Sanda (pursuing PhD, Bharathiar University)
- Sravan Danda (pursuing PhD, Indian Statistical Institute-Bangalore, 2013-2018)
- Rajendra Mohan Panda (pursuing PhD, Indian Institute of Technology-Kharagpur)
- Aditya Challa (pursuing PhD, Indian Statistical Institute-Bangalore, 2014-2019)
- Sampriti Soor (pursuing PhD, Indian Statistical Institute-Bangalore, 2016-2021)
- Geetika Barman (pursuing PhD, Indian Statistical Institute-Bangalore, 2017-2022)

4.3.2 Masters in Engineering Science Thesis Students

- Dinesh Sathyamoorthy, "Extraction of Hydrogeomorphic Features From Digital Elevation models DEMs Using Morphology", Faculty of Engineering & Technology Multimedia University, Melaka, Malaysia, 2006.
- Uma Devi, "DNA Landscape Analysis via Mathematical Morphology", Faculty of Engineering & Technology, Multimedia University, Melaka, Malaysia
- Nihal Alam (currently working for Tata Consultancy Service, New Delhi), "Overview of GIS and GIS Resources", Documentation Research and Training Centre, Indian Statistical Institute, Bangalore, India, 2009
- Shion Guha (currently pursuing PhD at Computer Science Department of Cornell University, US), "Social Network Analysis", Documentation Research and Training Centre, Indian Statistical Institute, Bangalore, India, 2010
- Debayan De (currently working at Facebook, Hyderabad), Documentation Research and Training Centre, Indian Statistical Institute, Bangalore, India, 2011
- Usashi Chatterjee (currently pursuing PhD at Computer Science Department of Dalhousie University, Canada), Documentation Research and Training Centre, Indian Statistical Institute, Bangalore, India, 2012

4.3.3 Visiting Students

- Prakash, Department of Geoengineering, Andhra University, Waltair, Andhra Pradesh, Current Position: Doctoral Candidate, CSRE, IIT-Bombay, Mumbai.
- Sarif Hasan, Applied Statistics Unit, Indian Statistical Institute, Kolkata, Current Position: Doctoral Candidate, Applied Statistics Unit, Indian Statistical Institute-Kolkata, India.
- Shreya Roy Chaudhuri, National Institute of Technology, Surtahkal, Current Position: Software Engineer at HP Labs.
- Pratap Vardhan, National Institute of Technology, Bhopal, Current Position: Research Assistant at Super Computer Education and Research Centre, Indian Institute of Science
- Saransh Singh, Indian Institute of Technology-Bombay, Mumbai, Current Position: PhD student, CMU
- Ranjeet Rout, Applied Statistics Unit, Indian Statistical Institute, Kolkata, Current Position: Doctoral Candidate, Applied Statistics Unit, Indian Statistical Institute-Kolkata, India.

4.3.4 Scientists Visited Prof. Daya Sagar

- William J Emery (FIEEE), Colorado University-Boulder, USA, 2017
- Paul A. Rosen (FIEEE), Jet Propulsion Labs-NASA, California Institute of Technology, USA, 2015-17
- Akira Hirose (FIEEE), Department of Electrical Engineering and Information Systems, The University of Tokyo, Japan, 2014
- H. K. Ramapriyan (SMIEEE), NASA, USA, 2014.
- Katsuaki Koike, Department of Urban Management, Kyoto University, Japan, 2014.
- Vera Pawlowsky-Glahn, Universitat de Girona, Spain, 2014
- Juan Jos´e Egozcue, Technical University of Catalonia, Spain, 2014
- Qiuming Cheng, President, International Association for Mathematical Geosciences (IAMG-USA), York University, Canada, 201
- Francesca Bovolo, Department of Computer Science, University of Trento, Italy, 2014.
- Lorenzo Bruzzone (FIEEE), Department of Computer Science, University of Trento, Italy, 2014.
- John (Jack) Schuenemeyer (President), Statistical consulting Corporation, Colorado, USA, 2012.
- Peter M. Atkinson (Professor), University of Southampton, 2012
- Robert Marschallinger (Professor), University of Salsburg, 2012
- Wolfgang-Martin Boerner (FIEEE) (Emeritus Professor), University of Illineois-Chicago, 2005, 2011, 2012, 2014
- Sitarama Iyengar (FIEEE) (Professor and Chairman), Lousiana State University, USA, 2009, 2010, 2011
- Eduardo Beira (EDAM Professor), University of Minho, Portugal, 2011
- Pedro Pina (Professor), IST –Instituto Superior Técnico, CERENA –Centro de Recursos Naturais e Ambiente, Lisboa, Portugal, 2010
- Laurent Najman (Professor), ESIEE, France, University of Paris-EST, 2010
- Jean Cousty (Professor), ESIEE, France, University of Paris-EST, 2010
- Christer Kiselman (Emeritus Professor), Department of Mathematics, Uppsala University, Sweden, 2010
- John Stell (Senior Lecturer), Department of Computer Science, University of Leeds, Leeds, London, 2009
- Jean Serra (Director), Centre for Mathematical Morphology, Paris School of Mines, Fontainbleau, France, 2005 & 2007, 2010.
- B. L. Deekshatulu (FIEEE), (Visiting Professor), School of Computers and Information Systems, University of Hyderabad, India, 2007-2014.

4.3.5 Administrative Positions & Activities

2012—2013 : Member of National-Level Committee for Validating Normalization formula of Class XII Board Marks

2009—2013 : Head of the Systems Science and Informatics Unit (SSIU), Indian Statistical Institute, Bangalore Centre
2004—2007 : Deputy Chairman, Centre for Applied Electromagnetics (CAEM), Multimedia University, Malaysia
2009—Present:Ex-Officio Member of Work Advisory Committee, Indian Statistical Institute-Bangalore Centre
2009—Present: Purchase Order Committee, Indian Statistical Institute-Bangalore Centre
2009—2010: Central Computer Committee (CCC), Indian Statistical Institute-Bangalore Centre
2005-2007: Research and Development Committee, Faculty of Engineering and Technology, Multimedia University, Malaysia
2002—2003: Member of Advisory Committee for Bachelors Program in Bioengineering, Faculty of Engineering and Technology, Multimedia University, Malaysia

4.3.6 External Funding Procured for Projects

2016-2019: B. S. Daya Sagar (PI), Department of Space (INR 28.00 lakhs)
2016-2019: B. S. Daya Sagar Co-PI: Department of Science & Technology (INR 140.09 lakhs)
2016-2019: B. S. Daya Sagar (PI), Project from Science and Engineering Research Board (SERB), Department of Science and Technology (DST), Government of India, INR 60 lakhs
2013-2014: B. S. Daya Sagar (PI), Science and Engineering Research Board (SERB), Department of Science and Technology (DST), Government of India, provided grant to organize a Summer School during 24 March-08 April 2014, INR 6 lakhs.
2013-2016: B. S. Daya Sagar (PI), Project from Internal Grants of Indian Statistical Institute, INR 10 lakhs
2010-2013: B. S. Daya Sagar (PI), Project from Internal Grants of Indian Statistical Institute, INR 7 lakhs
2010-2010: B. S. Daya Sagar (PI), Board of Research in Nuclear Sciences (BRNS), provided grant to organize a Course and a Workshop held in succession during 19-27 October 2010, INR 3 lakhs.
2007-2010: B. S. Daya Sagar (PI), MOSTI (Malaysian Govt fund), MYR1,10,000
2006-2008: Jean Serra (PI) and B. S. Daya Sagar (Leader Representing Malaysia), “Modeling and Simulations of Disasters”, ICT-ASIA Project, French Government
1998-2000: B. S. Daya Sagar (PI), EMCAB Project from Indira Gandhi Institute for Development Research (IGIDR), World Bank Project, INR 10 lakhs
1998-1998: B. S. Daya Sagar (PI-Research Associate), Council of Scientific and Industrial Research, India
1996-1997: B. S. Daya Sagar (PI-Research Scientist), “Studies on structure Behaviour Relationship of 2-D Discrete Natural Features”, Department of Science and Technology (Govt. of India), INR 5.5 lakhs
1995-1995: B. S. Daya Sagar (PI-Research Associate), “Studies on Morphometry and Discrete Simulation of Channel networks”, Council of Scientific and Industrial Research, India
1992-1994: B. S. Daya Sagar (PI-Senior Research Fellow), “Applications of Remote Sensing, Mathematical Morphology and Fractals to study certain surface water bodies” Council of Scientific and Industrial Research, India

4.4. Examiner for PhD Theses

- Adjudicator/Supervisor in Doctoral Committee for 7 candidates, Faculty of Engineering and Technology, Multimedia University, Malaysia, 2003—2007
- Adjudicator in Doctoral Committee, Manonimanian Sundarnar University, India, 2005
- Adjudicator in Doctoral Committee, Alagappa University, India, 2006.
- Adjudicator in Doctoral Committee, Jawaharlal Technological University (JNTU), India, 2008
- Adjudicator in Master in Engineering Science (by Research) Doctoral Committee for 5 Candidates, Faculty of Engineering and Technology, Multimedia University, Malaysia (2002—2007).
- Adjudicator in Doctoral Committee, University of Hyderabad, India, 2011, 2012, 2017.

- Adjudicator in Doctoral Committee, Indian Institute of Science (IISc), India, 2011.
- Adjudicator in Doctoral Committee, Andhra University College of Engineering, India, 2012, 2013, 2014.
- Member Doctoral Committee, Indian Institute of Space Science and Technology, Trivandrum, 2011-2014, 2017
- Member, Board of Studies of Computer Science and Systems Engineering, RV College of Engineering, Visweswariah University of Technology, Bangalore, 2008-2012
- Member Doctoral Committee, Indian Institute of Technology, Bombay, 2015, 2017
- Member Doctoral Committee, Bharathiar University, Coimbatore, 2017
- Member Doctoral Committee, Multimedia University, Malaysia, 2017

4.5. Teaching Expertise

4.5.1. At The Andhra University

M.Tech Subject, Mathematical Morphology, 2008-2009
M.Tech Subject, Digital Image Processing, 1992-1996
M.Tech Subject, Remote Sensing & GIS, 1992-1996
M.Tech Subject, Quantitative Geomorphology, 1992-1996

4.5.2. At The National University of Singapore

Fortnightly Seminar, Remote Sensing Data Analysis, 1999

4.5.3. At The Telekom University Malaysia (Multimedia University)

PEM1016, Engineering Mathematics-1, Trimesters 1 & 2: 2001-07
PEM2036, Engineering Mathematics-3, Trimester 3: 2001-07
ECP3056, Digital Image Processing, Trimester 3: 2002
EMM4076, Computer Graphics and Virtual Reality, Trimester 3: 2003-06
ECT1026, Field Theory, Trimester 1: 2002

4.5.4. At The Indian Statistical Institute

Paper 6, Elements of Mathematics-1, Semester 1: 2008-09
Paper 12, Elements of Mathematics -2, Semester 2: 2009, 2011
Paper 8, Elements of Statistics and Research Methodology (Part 2), Semester 2: 2009
Paper 10, Data Structures and Computer Programming (Part 2), Semester 2: 2009
Paper 13, Information Storage, Retrieval and DBMS, Semester 3: 2009-2015
Paper 21, Geographic Information Systems, Semester 4: 2010-2016
Elective, Mathematical Morphology and Applications, Semester 5: 2015
Special Topics on Mathematical Morphology in Geomorphology and GISci, 2010, 2011, 2012

4.5.5. At following Institutes, Dr. Sagar introduced a subject "Mathematical Morphology and Applications"

The Indian Statistical Institute, BMath, MTech-Computer Science, JRF-Computer Science
The National Institute of Technology-Karnataka, BE (Electrical and Electronics Engineering)
ICT Doctoral School, University Trento, Italy (Doctoral Students)

5 Descriptive Biography of Prof. Daya Sagar

5.1. Two-Page Brief CV of Prof. Daya Sagar (1200 words)

Dr. Behara Seshadri Daya Sagar was born on February 24, 1967 in Eluru, Andhra Pradesh, India. Dr. Daya Sagar is currently a Full Professor and the Founding Head of the Systems Science and Informatics Unit (SSIU) at Indian Statistical Institute. He holds a B.Sc. (1987) in Geology from the Andhra University, and a M.Sc. (1991) and Ph.D. (1994) in Geoengineering and Remote Sensing from the Faculty of Engineering of the Andhra University. He held various research positions starting his research career as a Project Fellow (1991-92), CSIR-Senior Research Fellow (1992-94), Research Associate (1995), DST Young Scientist/Principal Investigator (1996-97), and again as Research Associate in 1998. Dr. Sagar spent over two years (1998-2001) as a Grade-A Research Scientist in the Centre for Remote Imaging Sensing and Processing (CRISP) at the National University of Singapore before taking an Associate Professor position in the Faculty of Engineering and Technology at the Multimedia University-Malaysia (2001-07). He has moved to the Indian Statistical Institute in 2007, and has been the founding Head overseeing the activities of SSIU. He [Sagar] has been working in the area of applications of mathematical morphology since the early 1990s. Terrestrial surfaces of Earth and Earth-like planets exhibit variations across spatio-temporal scales. Recent advancements in remote sensing technologies that take the advantage of wavelength bands of wide ranging electromagnetic spectra paved a way to properly sense the terrestrial-oceanic-atmospheric fields. Now various different satellites provide optical and microwave remotely sensed data. Optical images are usefully acquired by employing the solar radiation as main energy to sense the terrestrial and/or ocean surfaces. While such optical data have limitations due to cloud cover, microwave sensing mechanisms that are operated via backscatter strength of the radar signal provide data that are useful under all weather conditions. It is recently mentioned that such data that are being acquired with huge expenditure are being underutilized. His works mainly address the (i) feature retrieval from remotely sensed data of both the types, (ii) analysis, (iii) reasoning and modeling phenomena that are retrieved at multiple spatial and temporal scales. To address the these topics, which are intertwined, Sagar's research works in the past and present involve development of original algorithms and modeling techniques that are mainly based on mathematical morphology, fractal geometry, and chaos theory. In order to develop models, synthetic data sets are considered. The success of the model is further validated through testing the model on realistic data such as remotely sensed data. In several studies he has employed, concepts form mathematical morphology, fractal geometry, and nonlinear studies in computations, modeling, simulation and characterization of phenomena of interest to geoscientists. The phenomena that were addressed in these investigations include small water bodies, channel networks, watersheds, sand dunes, sand stone porous media. He has done very significant work on mathematical morphology applied to terrestrial geomorphology and geospatial computing. He is primarily interested in applications of fractals, multifractals, mathematical morphology and 1-D maps to deal with various aspects of geomorphic and geophysical phenomena (e.g. water bodies, channel networks, sand dunes, symmetrical geological fold). To deal with these studies, he has used nonlinear mathematical morphological concepts to understand the spatio-temporal dynamics in discrete space; and fractals, multifractals and 1-D maps to characterize and quantify the heterogeneities in spatio-temporal dynamics in discrete space. His interests also include the usage of multiscale and multi-temporal digital elevation models derived from various remotely sensed data to extract complex topological information further to characterize these features and to quantify the degree of heterogeneities which are of interest to geomorphologists and geophysicists. He is also involved in applying fractals and non-linear transformations to generate fractal graphics/fractal landscapes, and watershed algorithms for map based hydrological modeling. The applications of the research works, where he is involved, can be foreseen in the fields of simulation and modeling of various surface processes, analysis of remotely sensed satellite digital data and digital elevation models, geocomputation, and spatial analysis. His recent interests include modeling and simulation of lake dynamical behavior in a lattice space. Under his supervision, SIX doctoral degrees and FOUR MENGSc (by research) degrees have been awarded. He has over 85 scientific publications to his credit in renowned international journals, which are indexed in Institute for Scientific Information. His research results have been published in various international journals such as Journal Geophysical Research-Solid Earth, Journal Geophysical Research-Atmospheres, Geophysical Research Letters, Water Resources Research, Nonlinear Processes in Geophysics, IEEE Geoscience and Remote Sensing Letters, IEEE Signal Processing Letters, IEEE Transactions on Power Delivery, Signal Processing, Chaos Solitons & Fractals, Computers & Geoscience, Current Science, Discrete Dynamics in Nature and Society, Fractals, International Journal of Remote Sensing, IEEE Transactions on Pattern Analysis and Machine Intelligence, IEEE Transactions on Image Processing, IEEE Transactions on Emerging Topics in Computing, IEEE Journal on Selected Topics on Applied Earth Observation and Remote Sensing, IEEE Journal on Selected Topics in Signal Processing, and Journal Mathematical Geoscience. He has been an invited editor for special issues of Mathematical Geosciences (in memory of the Late Professor SVLN Rao), International Journal of Pattern Recognition and Artificial Intelligence (Quantitative Image Morphology), Chaos Solitons & Fractals (Fractals in Geophysics), and a special section on "Surficial Mapping" for I.E.E.E Geoscience and Remote Sensing Letters (GRSL), International Journal of Remote Sensing (Spatial Information Retrieval, Analysis, Reasoning and Modelling), IEEE Journal on Selected Topics in Signal Processing (Filtering and Segmentation with Mathematical Morphology), IEEE Journal on Selected Topics in Remote Sensing and Applied Earth Observation (Remote Sensing and Applied Earth Observation in India) which are released in 2001, 2003, 2004, 2005, 2010, 2012, and 2017. He served as an Editor of Discrete Dynamics in Nature and Society: a Multidisciplinary Research and Review Journal, Computers & Geosciences, Frontiers: Environmental Informatics, Image Analysis & Stereology, and served as an Associate Editor of IEEE GRSL (2004-06) and IEEE JSTSP (2011-12). He has reviewed books and scientific articles for University Press (India), IEEE GRSL, Chaos Solitons & Fractals, Computers & Geosciences, International Association for Pattern Recognition, International Journal of Pattern Recognition and Artificial Intelligence, International Journal of Remote Sensing, Journal Mathematical Geology, Discrete Dynamics in Nature and Society, IEEE Transactions on Pattern Analysis and Machine Intelligence, Tribology, IEEE Transactions on Geoscience and Remote Sensing, IEEE Geoscience and Remote Sensing Letters. He has delivered lectures/talks as participant/contestant/invited speaker/guest faculty in Andhra University, A.P. Akademi of Sciences, Indian National Science Academy (INSA), Tata Institute of Fundamental Research, United Nation's affiliated Centre for Space Science Technology Education-Asia Pacific Region (CSSTE-AP), Centre for Remote Imaging Sensing, Processing, National University of Singapore, Multimedia University, Malaysia, Indian Statistical Institute-Kolkata, University of Hyderabad, and at Bangalore University. He is a recipient of Dr. Balakrishna Memorial Award from Andhra Pradesh Akademi of Sciences in 1995. He is a recipient of prestigious Krishnan Gold Medal-2002 from Indian Geophysical Union. He was a finalist, for INSA young scientist medals in 1996 and 1998, and Swarnajayanthi Fellowship 1999. In 2011, he received 'Georges Matheron Award with Lecturership' from International Association for Mathematical Geoscientists (IAMG). He was a short-term visiting fellow at Jawaharlal Nehru Centre for Advanced Scientific Research, Tata Institute of Fundamental Research, and Indira Gandhi Centre for Atomic Research. He was an elected Fellow of Royal Geographical Society (FRGS), Fellow of Indian Geophysical Union, and was a member of New York Academy of Science during 1995-96. He is an elected Senior Member to IEEE (Geoscience and Remote Sensing Society, and Computer Society). He is a technical Program Committee (TPC) member of IGARSS 2006, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017. For more details regarding his research works and professional activities, his official homepage may be referred at http://www.isibang.ac.in/~bsdsagar/. He can be reached via e-mail bsdsagar@isibang.ac.in, bsdsagar@yahoo.co.uk.

5.2. Brief CV of Prof. Daya Sagar (413 words)

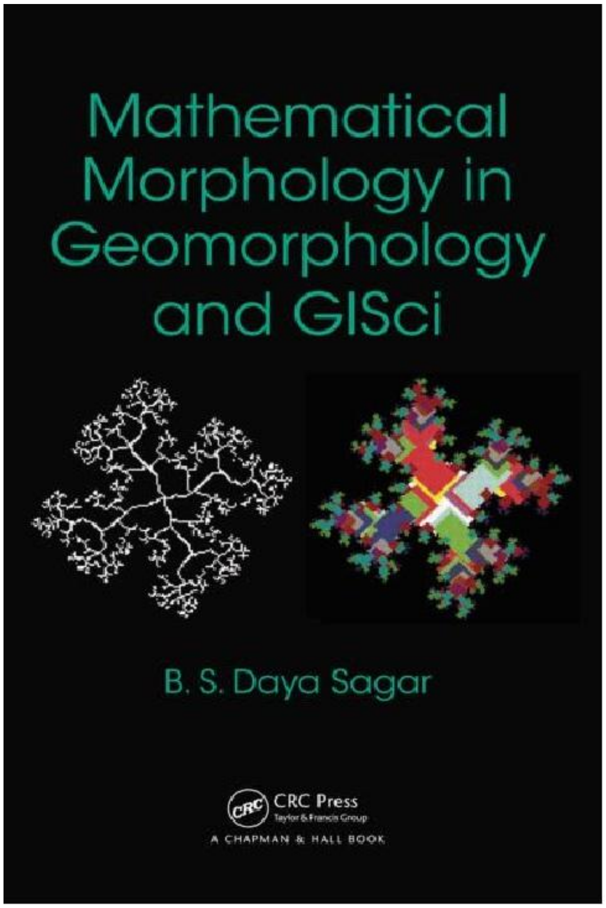
Prof. B. S. Daya Sagar obtained B.Sc (majoring in Earth Sciences), M.Sc (Geoengineering), and PhD degrees from Andhra University, India respectively in the years 1987, 1990, and 1994. His PhD thesis is on Applications of remote sensing, mathematical morphology, and fractals to study certain surface water bodies. B. S. Daya Sagar is a full Professor of the Systems Science and Informatics Unit (SSIU) at the Indian Statistical Institute. Sagar received the M.Sc and Ph.D degrees from the Faculty of Engineering, Andhra University, Visakhapatnam, India, in 1991 and 1994 respectively. He is also the founding Head of the SSIU. Earlier, he worked in College of Engineering, Andhra University, and Centre for Remote Imaging Sensing and Processing (CRISP), The National University of Singapore in various positions during 1992-2001. He served as Associate Professor and Researcher in the Faculty of Engineering & Technology (FET), Multimedia University, Malaysia during 2001-07. His research interests include mathematical morphology, GISci, digital image pro-cessing, fractals and multifractals their applications in extraction, analyses, and modeling of geophysical patterns. He has published over 85 papers in journals, and has authored and/or guest edited 11 books and/or special theme issues for journals. He recently authored a book entitled "Mathematical Morphology in Geomorphology and GISci," CRC Press: Boca Raton, 2013, p. 546. Along with Laurent Najman, Dan Schonfeld and Petros Maragos, he recently edited a special issue on "Filtering and Segmentation with Mathematical Morphology" for IEEE Journal on Selected Topics in Signal Processing (6 (7): 737-886, 2012). He is editing, along with Qiuming Cheng and Frits Agterberg, "Handbook of Mathematical Geosciences: Fifty Years of IAMG", which would be published by the Springer Publishers to release during IAMG-2018 at Olomouc. Currently he is also editing along with Avik Bhattacharya, Lorenzo Bruzzone and Paul Rosen a special issue on "Remote Sensing and Applied Earth Observation in India" for IEEE Journal on Selected Topics in Remote Sensing and Applied Earth Observation (IEEE JSTARS). He is an elected Fellow of Royal Geographical Society (1999), Indian Geophysical Union (2011), and was a member of New York Academy of Science during 1995-96. He received Dr. Balakrishna Memorial Award from Andhra Pradesh Akademi of Sciences in 1995, Krishnan Gold Medal from Indian Geophysical Union in 2002, and 'Georges Matheron Award-2011 (with Lecturership)" of International Association for Mathematical Geosciences. He is the Founding Chairman of Bangalore Section IEEE GRSS Chapter. He is on the Editorial Boards of Computers & Geosciences, and Frontiers: Environmental Informatics. More details about him can be seen at http://www.isibang.ac.in/~bsdsagar

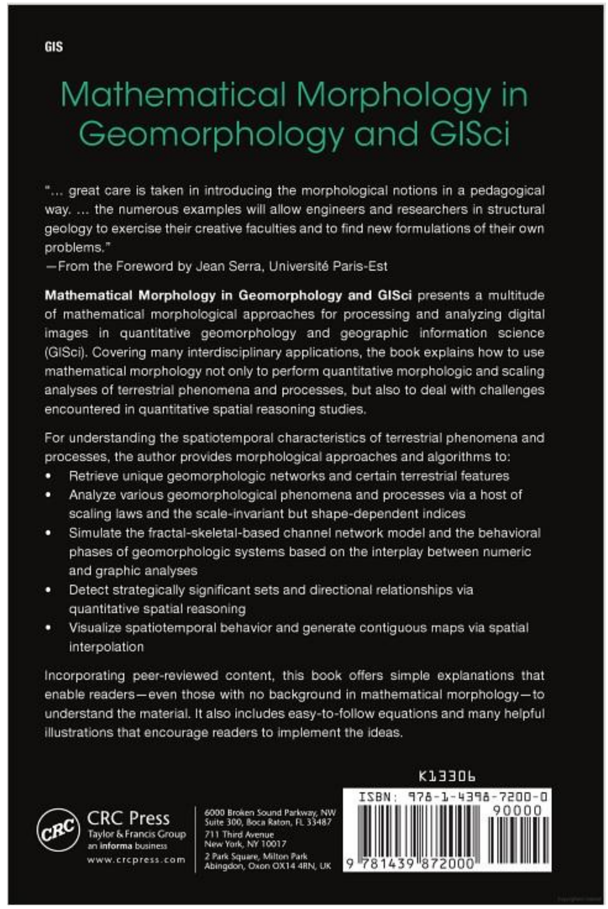
6 Summary of Credentials of Prof. B. S. Daya Sagar

- Professor, Systems Science and Informatics Unit (SSIU), Indian Statistical Institute, 2013-Present
- Head, Systems Science and Informatics Unit, Indian Statistical Institute
- Associate Professor, Systems Science and Informatics Unit (SSIU), Indian Statistical Institute, 2007-2013
- Associate Professor, Faculty of Engineering and Technology (FET), Multimedia (Telekom) University, Malaysia, during 2001-2007
- Grade-A Research Scientist, Centre for Remote Imaging, Sensing and Processing (CRISP), Faculty of Science, The National University of Singapore during 1998-2001
- Various Research positions at Department of Geoengineering, Centre for Remote Sensing and Information Systems, Faculty of Engineering, Andhra University during 1991-1998
- Doctor of Philosophy (PhD) from Faculty of Engineering of Andhra University, India in 1994 for a thesis entitled "Applications of mathematical morphology, remote sensing and fractal geometry to study surface water body systems".
- Life Member, IAMG
- Elected Senior Member, IEEE (Affiliated to GRSS and Computer Society)
- Founding Chairman, Bangalore Section IEEE GRSS Chapter (since 2012)
- Elected Fellow, Royal Geographical Society
- Elected Fellow, Indian Geophysical Union
- Editor, Computers & Geosciences (Elsevier)
- Editor, Discrete Dynamics in Nature and Society (Hindawi Publishers, USA)
- Editor, Image Analysis & Stereology (International Stereological Society)
- Editor, Environmental Informatics-Frontiers
- Editor, ICTACT Journal of Image and Video Processing
- Guest Editor for SEVEN Special Issues of Journals: Guest Editor, Journal Mathematical Geosciences (Springer)-2001; Guest Editor, International Journal of Pattern Recognition and Artificial Intelligence (World Scientific Publishers)-2003; Guest Editor, Chaos Solitons & Fractals (Elsevier Publishers)-2004; Guest Editor for IEEE Geosciences and Remote Sensing Letters-2004; Guest Editor, International Journal of Remote Sensing (Taylor & Francis Publishers, UK)-2010; Guest Editor, IEEE Journal on Special Topics in Signal Processing-2012; Guest Editor, IEEE Journal on Selected Topics in Applied Earth Observation and Remote Sensing-2017.
- Technical Program Committee Member for IGARSS 2006, 2008-2017
- Author, Over 110 Technical Papers (85 papers in International Journals)
- Advisor, 14 Doctoral (6 awarded so far) and 20 Masters Thesis Students Graduated
- Presenter, Over 200 Invited Talks Internationally and Nationally
- Funding, Over INR 30 Million in Research Grants
- Instructor, Over 10 Different Undergraduate and Graduate Courses
- Recipient of Krishnan Gold Medal-2002 from Indian Geophysical Union
- Recipient of Dr. S. Balakrishna Memorial Award-1995 from Andhra Pradesh Akademi of Science
- Convener for a Two-Day Conference on the theme of 'Spatial Information Retrieval Analysis, Reasoning and Modelling-2009'; a Four-Day course on "Mathematical Morphology in Image Analysis, GISci, Geomorphology-2010"; a Two-Day "Workshop Honouring Prof. Jean Serra-2010"; a Workshop on "Advanced Methods for Spatial Data Processing and Analysis-2012"; a Five-Day Course on "Spatial Statistical Tools in Data Processing and Analysis-2012"; Workshop on "Mathematical Morphology and Pattern Recognition: Theory and Applications (26-28 March 2013)"; Workshop on "Image Pattern Analysis and Applications (09-10 Nov 2013)".
- Book entitled "Mathematical Morphology in Geomorphology and GISci" (2013, ISBN-10: 1439872007, ISBN-13: 9781439872000. Pages: 546, Publisher: Chapman & Hall (Taylor & Francis Group)).
- Recipient of "Georges Matheron Award (with Lecturership)-2011 of International Association for Mathematical Geosciences (IAMG)".

7. Appendix

B. S. Daya Sagar (2013) ***Mathematical Morphology in Geomorphology and GISci****, CRC Press, Boca Raton, FL, p. 546.*





What is so appealing about this book is that the author introduces geomorphology using models of mathematical structure that are rooted in new approaches to geometry, particularly fractals and chaos. He adopts a basic model of a fractal river basin from which he extracts skeletal structures, thereby introducing ideas about networks in the landscape in an entirely natural way. He uses this as a basis for developing many other aspects of mathematical morphology – the use of sets to generate partitions of areas, the use of interpolation to produce surface representations and the identification of spatial clusters. Towards the end of the book, he generalises many of these ideas to more human spatial systems using the regionalisation of India as his exemplar and in so doing, he has produced as comprehensive a treatment of morphology in geographic information science as you will find anywhere. This is an important book that should be explored by all those who profess to be interested in spatial morphologies.

—**Michael Batty**, FRS, University College London

Since the initial birthing of computational geography and GIS over fifty years ago, the field of Geography has been evolving with many contributions from both the academic and research side as well as the application world. I am happy to see the emergence of the book "Mathematical Morphology in Geomorphology and GISci". This text further extends our understanding of GIScience how fundamental quantitative approaches can extend how we understand geography and our world.

—**Jack Dangermond**, President, Esri

This is a unique book on the analysis of various Geomorphology problems using mathematical morphology. The author is an acknowledged expert on the subject and this specialized book is the outcome of over fifteen years of continued research by him. Spreading over more than 500 pages in fourteen chapters, the book elaborately deals with feature extraction, analysis, reasoning, and modelling of spatio-temporal terrestrial data. The topics are described in a lucid manner with many examples and figures, making them easy to understand. Though primarily aimed for geo-morphologists, this book will be helpful for researchers working in problems of geography, cartography, geology, remote sensing and pattern recognition.

—**Bidyut B Chaudhuri**, FIEEE, Indian Statistical Institute

The monograph provides, in a consolidated manner, an application of mathematical morphology to structural geology, particularly addressing the issues like quantitative, morphologic and scaling analyses to terrestrial phenomena and processes. Texts on retrieval, modelling and reasoning, for example, are also useful to other application domains related to machine learning and pattern analysis.

—**Sankar K Pal**, FIEEE, Indian Statistical Institute

"... book on “Mathematical Morphology in Geomorphology and GISci” by Daya Sagar considers various topics—like pattern retrieval, pattern analysis, spatial reasoning, and simulation and modelling—of geoscientific interest. ... these intertwined topics which are useful for understanding the spatiotemporal behaviour of many terrestrial phenomena and processes, various original algorithms and modelling techniques that are mainly based on mathematical morphology, fractal geometry, and chaos theory have been presented in this book of 14 chapters. ... the journey through this book should provide geomorphologists and GISci specialists a new experience and exposition, and a host of new ideas to explore further in the contexts of quantitative geomorphology and spatial reasoning. ... book should be of immense value to the postgraduates, doctoral and post-doctoral students who would like to venture into applications of mathematical morphology in geomorphology and GISci."
—From the Afterword by **Arthur P Cracknell**, FRSE, University of Dundee

Prof Daya Sagar is a leading authority who has made major research contributions in most aspects of the applications of mathematical morphology and fractal geometry in terrestrial geomorphology and spatial informatics. This unique book on “Mathematical Morphology in Geomorphology and GISci”—highlighted numerous cases, imminent for those interested in venturing into developing physics-based models useful in geocomputation, and spatial informatics—takes an algorithmic approach to efficiently handle with topics related to (i) retrieval of complex terrestrial phenomena, (ii) analysis and reasoning of such retrieved phenomena, (iii) modeling and visualization of various terrestrial processes, and (iv) spatial informatics. The choice of the author, in this book, to combine mathematical morphology and fractal geometry, being the most powerful ideas in geometric sense, is perfectly right and appropriate for quantitative characterization of terrestrial phenomena and processes that exhibit plethora of geometric features and processes ranging from ‘simple’ to ‘strange’.
—**B. L. Deekshatulu**, FIEEE, Institute for Development and Research in Banking Technology

This enticing book introduces mathematical morphology to GI scientists in way that is persuasive and accessible using ideas that the author himself has pioneered in the last 20 years. It should be read by all those with an interest in how we represent surfaces in the environmental and urban domain.
—**Michael Batty**, FRS, University College London

“…great care is taken in introducing the morphological notions in a pedagogical way. … the numerous examples will allow engineers and researchers in structural geology to exercise their creative faculties and to find new formulations of their own problems.”
—From the Foreword by **Jean Serra**, Co-Founder of Mathematical Morphology, Université Paris-Est

"A wide-ranging treatise by an erudite scholar"
—**Jayanth Banavar**, Dean, College of Computer, Mathematical, and Natural Sciences, University of Maryland

"This book attacks the deep problem of analyzing mathematically the form of landscapes by mathematical tools, in particular by involving the discipline founded by geoscientists Matheron and Serra, Mathematical Morphology. The approach is original and pedagogic. It combines systematically experiments on numerical synthetic landscape models with experiments on real digital elevation models. Some chapters are very original, as they aim at the explanation of complex geomorphological phenomena. For example the formation of dunes is explored by its underlying bifurcation theory."
—**Jean-Michel Morel**, Editor-In-Chief of *SIAM Imaging Science*, Ecole Normale Supérieure de Cachan, Department of Mathematics, CMLA, France

"The book describes several techniques of mathematical morphology to address problems of image processing and data analysis with applications in geophysical information retrieval, analysis, reasoning, and modeling. Some of the specific topics presented include functions, sets, and skeletons as terrestrial surfaces; threshold-decomposed features; and geophysical networks. The aims of the methods described in the book are to extract information about the geometrical structure of an object, such as a water body, basin, channel network, and section of a water body, using concepts of mathematical morphology. The book provides not only details of various techniques of mathematical morphology, but also several illustrations of application. In some of the interesting illustrations in the book, specific geomorphological features are subjected to transformations by using various of structuring elements to achieve multiple effects and different results. Examples are provided to demonstrate how the main characteristics of a structuring template, such as shape, size, origin, and orientation, affect the results in different ways. It is shown how the topological characteristics of a water body, such as spatial distribution, morphology, connectivity, convexity, smoothness, and orientation, can be characterized by different structuring templates. One of the several novel aspects of the book is the integration of mathematical morphology and fractal analysis. Various examples are provided on the generation of fractal landscapes and fractal digital elevation models as well as the extraction of flow direction networks. Illustrations are provided to demonstrate the derivation of simulated fractal digital elevation models through morphological decomposition procedures. The book shows how physiographic and geomorphologic processes can be analyzed by quantitative representations of concavities and convexities. Valley and ridge connectivity networks are shown as abstract structures of concave and convex zones of terrestrial surfaces. Applications of the methods to extract features of terrestrial significance are provided. The features include unique ridge and channel networks, physiographic features such as mountains, hierarchically decomposed subwatersheds, and topologically significant regions of cloud fields. Methods are presented for the extraction of valley connectivity, ridge connectivity, and drainage networks from digital elevation models. Grayscale skeletonization methods are described to derive ridge and valley connectivity networks. Particularly interesting illustrations are provided of automatically extracted channel networks, ridge networks, and subwatershed maps. The book contains extensive discussion and illustration of many more applications of image and data analysis in geomorphology and geographic information science. Coming from a different background in biomedical signal and image analysis, I find the illustrations and examples provided in the book to be not only interesting but also attractive and intriguing. The detailed procedures described in the book along with the large number of illustrations of application should assist researchers and practitioners in geographic information science and other areas of application of image processing and data analysis."
—**Rangaraj M Rangayyan**, FIEEE, University of Calgary

"This book represents an interesting application of approaches of mathematical morphology to digital terrain modelling."
—**Igor Florinsky**, Russian Academy of Sciences

"Professor Daya Sagar's book is a tour-de-force. He approaches mathematical morphology in depth from a variety of perspectives and practitioners and researchers from many fields will find much to learn. His linking of pattern retrieval, pattern analysis and modelling is innovative and powerful."
—**Sir Alan Wilson**, FRS, University College London

"The 546-page book "Mathematical Morphology in Geomorphology and GISci" by B. S. Daya Sagar published by Chapman and Hall/CRC is a welcome addition to the literature. It fills a gap that has existed for some time in the field of image analysis by providing a comprehensive mathematically-based overview of methods to systematically analyze the great variety of features observed at the surface of the Earth. The study of shapes and sizes of objects and their mutual interrelationships is paramount in Geoinformation Science (GISci) which has become a new flourishing field of scientific endeavor. The author has included numerous instructive examples of application with a substantial number of them related to the analysis of fractal patterns. Overall, the treatment of the subjects is thorough and the book can be regarded as a follow-up to the original approach to mathematical morphology commenced by Georges Matheron in the 1970s and 1980s. These fathers of the field had introduced the use of Minkowski operations such as dilation, erosion and the opening or closing of sets by means of iterative processes. Since then, there has been significant progress both from an observational and a theoretical point of view. Important new high-precision products that have become available include digital elevation models (DEMs). With respect to underwater topography, there now are the digital bathymetric maps (DBMs). Many of the examples in the book use DEMs or DBMs. During the past 25 years we also have witnessed important new developments in the fields of fractal modeling and chaos theory. The author offers excellent explanations and examples of application of non-linear process modelling; for example, he uses the logistic equation to study fold dynamics and applies spatiotemporal dynamical modeling to understand geomorphological processes. At the annual conference of the International Association for Mathematical Geosciences held in Salzburg, Austria, September 5-9, 2011, Professor Sagar delivered the Georges Matheron Lecture providing the audience in this plenary session with an overview of his contributions to mathematical morphology. I am happy to see that this material now has been expanded in book-form, so that it can be studied by scientists working in the field all over the world. I also highly recommend the new book to all teachers engaged in presenting courses on geomorphology and GISci to university students."
—**Frits Agterberg**, Emeritus Scientist, Geological Survey of Canada

Geomorphology is practiced in many earth science disciplines in the study of shape and form and their changes over time. Increasingly the challenges of climate change, population growth and shifts, and conflicting uses of resources have brought geomorphology to the forefront of scientific investigation. The new book addressing the application of mathematical morphology to problems in geomorphology by Dr. B.S. Daya Sagar is timely and fills a needed gap. Dr. Sagar is one of the worlds's leading experts on mathematical morphology. This book is large (515 pages) but well organized and clearly written. It is accessible to those with no knowledge of mathematical morphology, as early chapters introduce the basic structuring elements and provides numerous examples. There are practical examples throughout the book and the theoretical underpinnings are tied to examples. As a statistician, I found the quantitative spatial relationships and reasoning especially interesting. Many of us educated in North America perhaps may have had limited exposure to this subject but it merits serious consideration, given the importance of spatial-temporal relationships and clustering.
—**John H.(Jack) Schuenemeyer**, President, Southwest Statistical Consulting, LLC, USA. Professor Emeritus, Mathematical Sciences, University of Delaware. Fellow, American Statistical Association

"Professor Daya Sagar's book is a triumph in the literature on morphology. It provides rich, comprehensive insight into the mathematics of morphology, using problems and examples from the geographic sciences. In addition, scholars of image processing, computer vision, and medical imagery will also find useful material in shape analysis and recognition."
—**Kentaro Toyama**, Visiting Scientists, School of Information Science, University California Berkeley

"This work was written by a well-known geomorphology expert, Daya Sagar, for other geomorphology experts. Therefore, if you are not a part of that group, then this book is probably not for you. Knowledge in geomorphology and geographic information systems (GIS) is required to be able to follow the material. Chapter 1 summarizes the content of the book. Chapter 2 introduces all the formulas for the mathematical morphology. The author describes every operator in detail, with many examples. Some readers might find the structure of this chapter confusing, but the explanations and descriptions are of very high quality. A general description of the datasets used in the book is given in chapter 3, and several different real-world geographic environments are discussed in detail. In the following chapters, the author shows how mathematical morphological operators can be used to obtain several different geomorphologic and geographic features, such as mountains, basins, and ridges. The author assumes that the reader is an experienced geomorphologist, familiar with this subject (GIS), who might want to learn more about using mathematical morphology for related tasks. However, I found these chapters very dense and hard to follow. Furthermore, the structure of these chapters is not always clear and sometimes the author seems to go back and forth between concepts, which can make the reading somewhat uncomfortable for any reader. The book does include extensive documentation and numerous references for further reading. I note that many of the references are by the author of this book and his colleagues. While this provides evidence that Sagar is really an expert in the field, it seems that including references from other researchers might broaden the scope for further reading to resources with different points of view. Unfortunately, the book has been published in grayscale. In this type of book, color images are almost mandatory. Color illustrations would have helped me better comprehend the material. The geographic images introduced in chapter 3 and used throughout the book should have appeared in color for improved understanding. Overall, this book provides solid information about using mathematical morphology for geographic imaging from a real expert in the field. Because of the level of expertise required, the book is suitable only for proficient geomorphologists. Novices in this field should not start with this book."
—**Jose Manuel Palomares Munoz**, ACM Computing Reviews

Jean Serra in the Foreword to this book states that it is intended for an audience of "geomorphologists" while Arthur Cracknell in the Afterword suggests that it will be of "immense value" to postgraduates, doctoral and postdoctoral students. But if this is so, the intended readers will have to be exceptionally, mathematically erudite and adept at programming as well, for although Sagar provides an introduction to his version of mathematical morphology, no computer code, pseudo or otherwise, is included in the text. Sagar's audience may well be geomorphologists but he frequently cites the work of human geographers. Consequently, this text will be of great interest to all scientists who believe that space can be utilized as a powerful explanatory variable. Chapter 1 describes the general organization of the book and includes a synopsis of each of the 13 remaining chapters. Chapter 2 explains the various concepts behind mathematical morphology, both binary and mulitiscale operations, that were originally introduced by Georges Matheron in 1975 and then further developed by Jean Serra and others. The third chapter describes the diverse data sets amenable to investigation using the techniques of mathematical morphology. These include simulated and actual Digital Elevation Models, Digital Bathymetric Maps, fractal basins that exhibit self-similarity and indeed any remotely sensed image displayed as a numerical array. Fractal basins can be decomposed into topologically prominent regions but, as usual, William Warntz' seminal contributions to the determination of the critical points, lines and areas of a surface are overlooked (Waters, 2009). Feature extraction, covered in Chapter 4, is a topic of interest to physical and human geographers, for the feature concerned might be a watershed or a commuting district, a river or a road. The segmentation algorithm described on p.80 does reference Warntz' concept of peaks and pits but not the passes and pales and other critical features that are equally useful in surface segmentation. Sagar's primary focus on geomorphological applications is asserted in Chapter 5 where he demonstrates the use of the techniques of mathematical morphology for terrestrial surface characterization. Here he builds upon the pioneering research of Horton and Strahler. The stream order models developed by Horton and revised by Strahler are shown to have a fractal structure and therefore to be scale invariant. In addition, Sagar references Shreve's 1967 paper but Shreve's iconoclastic article (Shreve, 1966) from a year earlier demonstrated that "the law of stream numbers is indeed largely a consequence of random development of channel networks according to the laws of chance". Thus, by and of themselves, these "laws" yield little geomorphological insight. Scaling Laws are the focus of Chapter 6 (and also Chapter 7) but these too have been shown to have little explanatory power unless they are supported by other lines of evidence (see the literature reviewed in Waters, 2013). Sagar does an excellent job of reviewing research from the early days right up until the most recent contributions including his own extensive oeuvre and thus it was pleasant to see both Mike Kirkby and Adrian Scheidegger's work being cited (even if the Scheidegger reference has a few errors). References to the work of Mark Melton and Richard Chorley on morphological systems are, unfortunately, conspicuous by their absence. Particularly, innovative is the discussion of spatial-temporal dynamics in Chapter 9, where Sagar has made extensive and seminal contributions. It would have been reassuring to see an in depth account of the limitations of these approaches, especially the concepts of equifinality, or convergence, where different system trajectories may result in the same end state or the converse of this, multifinality or divergence, where the same initial conditions can result in a variety of end states (Skyttner, 2005, p.54). The methodologies introduced here are illustrated with applications to sand dune avalanches and flood water dynamics. The final chapters of the book discuss Spatial Relationships and Spatial Reasoning (Chapter 10), Derivation of Spatially Significant Zones from a Cluster (Chapter 11), Directional Spatial Relationships (Chapter 12), the intriguing concept of Between Space (Chapter 13) and Spatial Interpolation (Chapter 14). As these chapters cite the work of Mike Batty, Mike Goodchild, Bob McMaster and Alan Wilson, among others, they are likely to be of considerable interest to the community of human geographers. A small quibble: Sagar provides a list of symbols and notations, three pages long, but no such summary of the acronyms used in the book. My overall assessment is that this book is a truly remarkable contribution that is likely to make a significant impact in the GISci community far beyond its primary target audience of geomorphologists. Mathematical Morphology in Geomorphology and GISci is also a celebration of the remarkably innovative contributions of Daya Sagar over the last two decades.

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—**Nigel Waters**, Geomatica, v. 67, no. 4, p. 283-284, 2013

"As hydrologists, we are permanently confronted with problems where the geometrical vision of realty is of paramount importance for quantifying the flow. This is the case, for instance, of river networks, when their geometry is characterised by a fractal dimension, as well as in the case where the estimates of the contaminant concentration in a river water has to be made using Random Functions on a non-Euclidian graph with successive branching. Mathematical morphology tools are required to describe these graphs and to explain why, for instance, the spreading of infectious diseases, like cholera, differs between two different river systems, due to their geometrical properties. The automatic extraction of these river networks from Digital Elevation Models, or those of other surface-water bodies, is also a great challenge. Similarly, for porous media, when the flow is analysed at the pore scale, the governing equations are those of Navier-Stokes, and not Darcy's law, which only applies at the macroscopic scale. With modern tools, e.g. X-ray tomography, 3-D images of the pore space can be obtained, which need to be described by morphological tools to extract from these images the relevant microscopic properties that govern the flow, at both the pore scale and the macroscopic scale. For all these problems, the book Mathematical Morphology in Geomorphology and GISci by Professor Daya Sagar is invaluable. All the basic concepts of mathematical morphology, as originally defined by Matheron and Serra in the 1970s and later extended by many authors, are clearly presented with many practical examples of how to use them. As Professor Sagar has himself largely contributed to the modern theory of geomorphology, his book is rich in new concepts and methods. Hydrologists will be happy to find that many of the examples given in the book deal with rivers, water bodies, and the morphology of drainage basins."

—**Ghislain de Marsily**, Membre French Académie des Sciences, Université Paris 6, France.

I am sure that this very dense and useful work will appeal to geomorphologists, structural geologists and geographers open to new research ideas and approaches. They will find in this book a rich source of inspiration for their own research that, I expect, will foster their desire to deepen their knowledge of mathematical morphology. As a mathematical morphologist myself, I found themany case studies presented stimulating; they have aroused my thinking on morphological tools and approaches that would further refine the solutions proposed. As such, this book can also be

considered as an efficient instrument of dialogue, a bridge between image processing and geosciences, giving rise to fruitful discussions and exchanges about emerging issues and possible solutions, thereby contributing to disseminate mathematical morphology. Thanks to Daya Sagar!
—**Serge Beucher**, Center for Mathematical Morphology, Mines ParisTech, Paris, France, Mathematical Geosciences, 2014

Today in the hinterlands, there are some mathematical geoscientists doing very original work involving applications that we'd barely thought about earlier. I'll mention one of today's pioneers, whose focus is on mathematical morphology of geological features, Daya Sagar of the Indian Statistical Institute at the Bangalore Centre. Notably he's been at it for two decades and has published a lot, including a seminal 546-page book in 2013 entitled "Mathematical Morphology in Geomorphology and GISci" that spans much of the field. Let's face it, the shapes or forms of geological objects are tantalizing, and some can be astoundingly complex. Landscapes, for example, often exhibit complex forms. Trying to describe their shapes alone can be challenging , but the greater challenge is to explain the processes and morphological forms that affect each other. Everyday features, such as stream meanders on broad floodplains, or lakes on floodplains with short lives, may be common, but they are not simple to categorize or analyze. All the while we're dealing with interdependencies between features and processes. Interdependencies are invariably accompanied by complex cyclic and chaotic behavior. So do you still want to make predictions? Take heart, though, because there are some new tools to help you, and that's where Daya's work is relevant.
—John W. Harbaugh, Stanford University, USA, IAMG Newsletter, No. 89, p. 5.