

ANALYSIS OF UNCERTAINTIES IN VISUALIZING REMOTE SENSING AND SPATIAL DATA

B.POOVALINGA GANESH S.RAJENDRAN AND A.THIRUNAVUKKARASU
Department of Earth Sciences, Annamalai University, Annamalai Nagar – 608 002,
Tamil Nadu, INDIA. E-mail: sankaranrajendran@yahoo.com

KEY WORDS: Remote Sensing, Image Processing, Iron Ore, Spatial Data, Visualization, Uncertainties

ABSTRACT

The maintenance of satellite and spatial data quality is an important task and escalating interest amongst geospatial community. The visualization of perfect earth surface features by relative response of spectral signatures in the remotely sensed satellite data is unique domain. The present work deals to identify and visualize the certainty and uncertainties that are occurred during the interpretation of magnetite quartzite iron ore formations of Godumalai region of granulite region of Pre-Cambrian age of part of Salem district, Tamil Nadu state, India. The Godumalai is made up of mixed type of rocks such as gneisses, amphibolites, quartzite, chlorite-schists, feldspathic schists and granites. The iron ore formation forms in the crest of the hill with an east-west trend. The applicable image processing techniques and associated put forth of field knowledge has been utilized in interpretation of IRS P6 LISS IV MX Satellite data to discriminate the iron formations of the study area. The visual interpretation of FCC of digital data shows that the formation have the raw pixel values of iron ore bands in the blue ranges 95 to 120, green ranges 85 to 125 and red ranges 55 to 75 and provided better delineation for iron formations. During this study, the image processing of Minimum Noise Fraction transform (MNF), band rationing, principal component analysis and contrast enhancements are carried out under the environment for visualizing images using ENVI 4.2 and ERDAS Imagine 8.7. The interpretation shows that the iron ore band exhibits in dark color, linear shape, fine texture and sharp contact with associated rock types. The dark bands arise suspicious due to the impact of hill shadows, hill ridges, sun azimuth and others. To rectify and reduce misinterpretation all above image processing techniques are undertaken along with the detailed field-check in the selected test sites using GPS 178 and delineated the in situ iron formations. The observations show that the weathered formations can also be traced on the imagery along with massive formations since the absorption's themselves are different. The availability spectral absorption of formation is inferred highly in near infrared region (0.77-0.86 μm). Similarly, the information content of 3D view is infinitely greater than the 2D perspective view, since it is viewing imagery beyond GIS requires to environmentalist, geologist and others. In which, the real model quality depends fistful of issues such as reference, range, reflection of the surface, reflectivity, resolution of the scanner and the reconstruction of the software. Under these circumstances, the visualization confirms few uncertainties in mapping of iron ore deposits. The inter-visibility of deposits and trend of formations are perceptibly seen in real 3D geometric environ brought to the study area by x, y values together where z values serves as actual elevations. Here, the maximum perception for interpretation is carried out by the adjustment of sun positioning (azimuth, angle and elevation) and headlight.

1. INTRODUCTION

Uncertainty is an important issue with geospatial data sets and there many ways to understand and visualize the uncertainty that are (a) mapping uncertainty information as an additional piece of data, and (b) creating new visualization primitive and abstractions that incorporate uncertainty information. The first method incorporates uncertainty information into the visualization by mapping it as transparency, haze, blur, shadow, and associations etc. to alter the appearance of the underlying data. The second method modifies the visualization primitive itself so that uncertainty can be encoded with the data, and usually in such a way that the interpretation of both data and uncertainty cannot be visually separated. A different spatial and spectral remote sensing data is being subjected to various types of computer-assisted manipulation, to arrive at derived data sets tailored to different types of application. Error and uncertainty in remotely sensed data come from several sources, and can be increased or mitigated by the processing to which that data is subjected (e.g. resampling, atmospheric correction). Here, analysis of uncertainty in the remotely sensed data with respect to iron ore exploration study by considering spatial, spectral, and positional accuracy are studied. The aim of the present work is to analyze the uncertainty of different resolution data and applying suitable image processing techniques for better visualization and objectives are

1. to identify the uncertainty from the satellite data based on interpretation of iron ore mapping,
2. to improve the comprehension by focusing on methods of image processing techniques for viewing data together with uncertainty information raised by spatial, spectral, positional accuracy of GPS data and
3. to create the 3D visualization to interpret the relation between uncertainty in the

spatial extent of objects and their thematic uncertainty.

2. STUDY AREA

The study area (Figure.1) Godumalai hill lies between the north latitude $78^{\circ}16'35''$ to $78^{\circ}25'20''$ and east longitude $11^{\circ}38'15''$ to

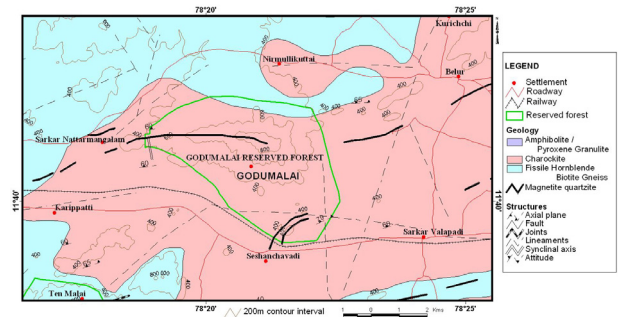


Fig 1. Study area & Geology map of Godumalai

Figure 1. The geology and structure of study area.

$11^{\circ}43'30''$ covering an area of 175 sq.km. towards East to West direction. The hill was in synclinal form, undulating terrain with

elevation ranges from 300m to 960m and classified as medium to low dense forest. Iron ore formations are strongly exposed in the crest up to tail end of the hill which direction is parallel to the hill elongation.

3. MATERIALS AND METHODS

A combination of satellite remote sensing data of Landsat (30m, 7 bands) and IRS P6 LISS IV (5.8m, 4bands) and GPS (GARMIN 178 MAP) and integrative software's of GIS (ENVI 4.2, ERDAS Imagine 8.7) has been used in the present study. GPS is used in the field during sample collection and insitu mapping of iron ore formations. The different spatial and spectral resolution data was employed during image processing to visualize and demarcate the iron ore deposits, geological and geo-morphological features. The contours were digitized with 20m interval to create the DEM and DTM for better visualization and preserve the originality of the area, where the sun angle,

elevations, ambience was adjusted for interpretation accuracy.

4. RESULTS AND DISCUSSIONS

Uncertainty in the same data affects the different analysts in different ways. Multiple ways to communicate data (image) quality exist, such as tabular listings of metadata, narrative descriptions, and visualization. Of these methods, visualization has often been hailed as a valid and proven tool for quality communication especially useful for geospatial data (Beard and Mackness, 1993; Van der Wel et al., 1994). The advantages of using visualization are that the visual channel can transport a lot of information at the same time, and it is the primary sensor input channel for most people (Beard and Battenfield, 1999). The quality attributes that we choose to convey the overall image data qualities are: *positional accuracy, scale, resolution, completeness, consistency, and currency.*

Our approaches here to examine different spatial data and study the uncertainties are introduced in the iron ore exploration and then to present the data together with these uncertainties. We are interested in the effectiveness of various visual mappings, and want to emphasize that effectiveness depends on the purpose of the visualization. We have found a synergistic relationship among application and image processing, where we have found the uncertainties in the FCC image and processed image for explorative study.

4.1 Spatial approach

The term *uncertainty* is used in various ways; one being that the resolution of the data does not allow a user to make an assured decision about the content of the data. For example, pixels in remotely sensed images might contain uncertain information because of sub-pixel mixing or sensor sampling bias (Bastin et al., 2002). Worboys and Duckham (2004) use the term uncertainty to describe the doubt

that users have about the right use of data. In this sense, it is a measure that describes the state of mind of the user.

A poor resolution of multi (7 bands) spectral data of Landsat image has capability of larger area coverage with resolution of the 30m as shown in Figure 2. For the pixel based study its merely allows the user to interpret the image as comparatively low in the sense of accuracy level at local level mapping. The high-resolution multi spectral LISS IV (Figure. 3) imagery is suitable for any kind of application at local level study up to cadastral survey mapping. Based on the geological derived mapping in the center part of the hill, there is a one-cliff form, a prominent landmark that is composed of magnetite quartzite rock. Along the strike of this hill, the ore is exposed in the linear direction at the

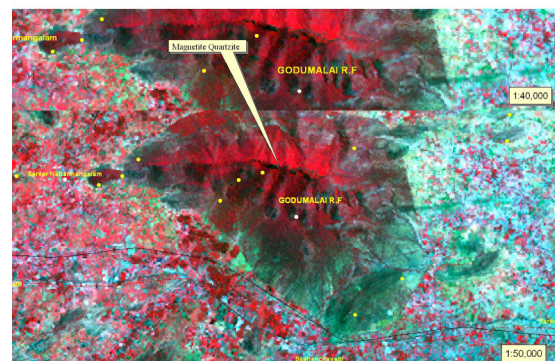


Figure2. Occurrence of iron ore bands in Landsat TM in different scales (Yellow points represent the GPS field locations)

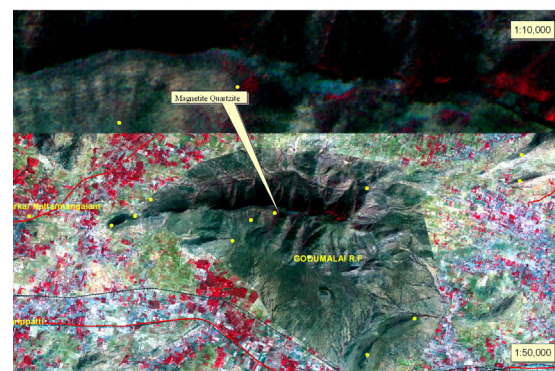


Figure3. Occurrence of iron ore bands in IRS P6 LISS4 data in different scales (Yellow points represent the GPS field locations)

crest. The thickness of the band is increases towards in the eastern direction and makes synclinal basin structure exhibit at the eastern maximum height of the hill. The exposed iron ore bands are seen as discontinuity towards in the western direction up to tail end where the hill is low elevated and involved under anthropogenic factors and natural weathering activities. Due to that spatial resolution difference the iron ore demarcation is well mapped in the LISS IV than the Landsat satellite imagery. Spatial resolution makes uncertainty while maximizing the area of interest as desired zoom level this is due that pixel breakage at study site. The total number of pixels for the entire study area of Landsat and LISS IV are 1159 x 721 and 2829 x 1758 respectively. The increase of image clarity or quality always depends on the number of pixel covered per sq.km. The pixel breakage is not only makes uncertainty but also pixel overlap is one of the causes to identifying the objects differences. Poor spatial resolution makes high uncertainty at the overlap region. With the concept of these, iron ore bands does not create sharp boundary or edges unless it's spread over the regions. Therefore, to explore the exposed and alteration zone of iron ore bands and its location can be mapped well through LISS IV than LANDSAT.

4.2 Spectral approach

In general, there are two basic approaches for lithological mapping (magnetite quartzite rock discrimination for the present study) when use of remote sensing data. One is produce a high quality image or high spatial resolution image suitable for geological interpretation in which geologist makes decisions about locating boundary units. The other method is image-processing computer itself to divide the image into areas of different spectral response, which is known as classification or thematic mapping (thematic accuracy). Spectral reflectance is controlled by absorption features, in which rocks are due to either electronic or vibrational process in specific minerals. The lattice environment of the atoms modifies the wavelength of these

absorptions and the position of features due to equivalent processes in different minerals may vary by one or two hundred nanometers. As described by Hunt & Salisbury (1970), Hunt et.al (1971, 1974), Hunt & Ashley (1979) and Blom et.al. (1980) we consider fresh or weathered surfaces of igneous rocks, the only metallic element causing strong absorptions in the visible and near infrared regions are iron. Ferrous iron produces an electronic transition band near 1.0-1.1 μm , ferric iron produces 0.9 μm and weathering products such as hydrated iron oxides 'limonite' is responsible for the absorption at wave length shorter than about 0.55 μm region may be of significance in remote sensing. The second method of image processing method is adopted for visualizing the uncertainty from the remote sensing data. A widely accepted method of band ratio, decorrelation stretching, principal component analysis, and edge enhancement were used to discriminate the iron ore formations from the other rock units.

4.2.1 Band ratio: The study area exhibits considerable topographic relief demanding a TM and LISS IV data processing procedure that suppresses variation in reflectance due to variations in slope, angle of elevation and azimuths. The reflectance ratios are to suppress the variations due to topography and variations in over reflectance, while emphasizing difference in shapes of spectral reflectance curves (Rowan and others, 1975; Abrams and others, 1977). Ratio should also suppress brightness differences related to grain size variations. TM band 5 (1.55 – 1.75 μm) lies between, major vibrational absorption at longer wavelengths generally, reflectance values should be high for the band 5 region, except rocks with high content of opaque minerals and broad absorptions associated with ferrous related absorptions centered near $\leq 1.0 \mu\text{m}$. The product of TM and LISS IV band ratios of 5/4 and 3/2 (Figure. 4) shows good results and both data plays a significant role in the outcrop of iron bearing silicates at test site. In fact, the presence of identified rock types and

unidentified rock types in the images that have ratio values that range fall within limits of ratio values only can do mapping unless it is less significant. The uncertainty must be rises while analyze the monochromatic ratio



Figure. 4 Occurrence of iron ore bands in 3/2 band ratio processed image of IRS P6 LISS IV data.

or two band ratio alone to identify the different rock types in the same study test site. Dual or component band ratio color combinations may be yield good results for the geological mapping.

4.2.2 Decorrelation stretching: The image processing technique is not so simple methods need to be study about logically derived spectral information (absorption, reflection, emissive) about individual minerals and its assemblages in the rock units. Color variation in the remotely sensed image due to different band combinations should be interpreted by considering possible absorption features.

Landsat TM: An attempt had been made by different band combinations among the 7 TM bands out of which 7, 5, 4 gave good results for discriminating rock units and also obtained some possible combinations were also derived. The band combinations of band 5, 4, 3 is useful for detecting short wavelength ferric iron absorption but give poor quality images when compared to other combinations, however it was applied in image processing techniques to discriminate especially in the iron ore formations from

other type of rocks in the study regions. Decorrelation stretching is simple stretches applied to each band separately i.e., it allows to stretch the principal components of an image; it means that can turn the original image with poor contrast into one with a full range of brightness. The iron ore bands are well exhibiting dark in color in the crest of the hill and vegetation areas in bright green and low lying lands/denudational area were in dark pink to pink in color. Few of the iron ore bands are clearly identified from the processed image at SSE and NNE of the hill than the false color composite of band 4, 3, 2. Decorrelated mono band 4 image is highly useful to demarcate the iron ore formations than others.

IRS P6 LISS IV: The iron ore bands exhibits in dark blue at top of the hill and behind the crest the image was appeared as dark color in FCC. Whereas, the decorrelated image band 3,2,1 shown in Figure.5 diminish the dark appearance at the nearest ore locations makes it blue with black appearance.

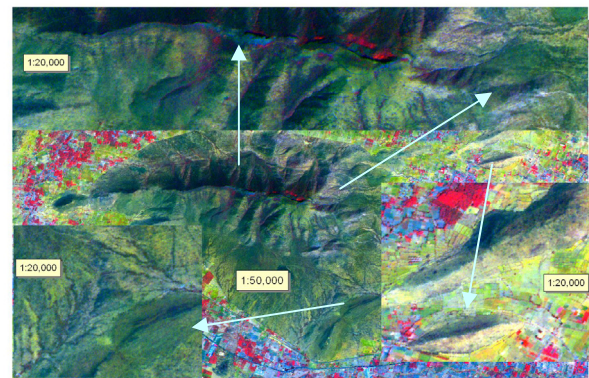


Figure 5. Occurrence of iron ore bands in Decorrelated Stretched image of IRS P6 LISS IV in Band 3, 2 and 1.

The eroded and deposited iron ore blocks along the course of tributaries exhibit bluish color. The banded iron ore formations here can see well than FCC image. Decorrelated panchromatic image (band 3) exhibit exposed iron ore in dark color when correlated with the surrounding features that exhibit in grey scale. Decorrelation stretching is becoming widely used in geological remote sensing and proved particularly informative in this study.

4.2.3 Principal Component Analysis:

Principal Components Analysis (PCA) is often used as a method of image compression. It allows redundant data to be compacted into fewer bands than is; the dimensionality of the data is reduced. The bands of PCA data are non-correlated and independent, and are often more interpretable than the source data. PCA can be performed on up to 256 bands. The first PC band contains the largest percentage of data variance and the second PC band contains the second largest data variance, and so on. The last PC bands appear noisy because they contain very little variance, much of which is due to noise in the original spectral data or uncertainty in the data. Principal Component bands produce more colorful color composite images than spectral color composite images because the data is uncorrelated. The result of the PCA shows terrain as projected in the band 3 of LISS IV (Figure. 6) and band 2 of LANDSAT than the FCC image. All linear features like dyke, lineaments, ridge of the hill are well highlighted due to the high spectral variance than the FCC where submerged or mired features. The final results of PCA iron ore bands image were seen well due to the nature of formation is linear, formed at top of the hill with exposed, banded formations etc.

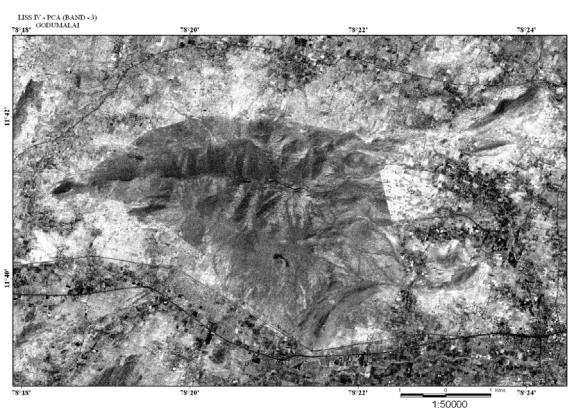


Figure. 6 Occurrence of iron ore bands in PCA processed image of IRS P6 LISS IV data.

4.2.4 Edge Enhancements: Due to formation of iron ore is linear in shape and direction, the edge enhancement technique is quite suitable and employed. Such that the resultant image clearly shows trend of formations (continuity

of bands) and depositional directions in entire images of both data of Landsat and LISS IV band combinations of band 5,4,3 and 3,2,1 (Figure.7) respectively.

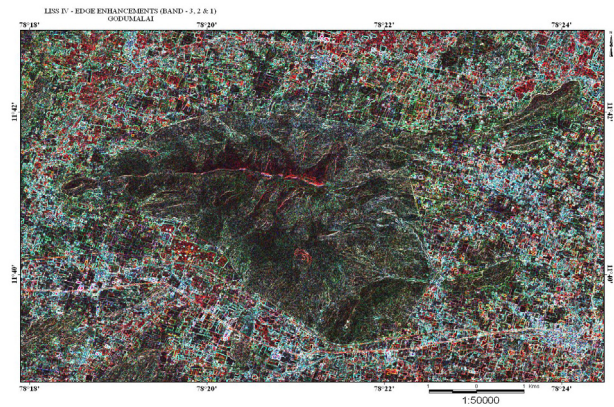


Figure 7. Shows the Edge enhanced image of IRS P6 LISS IV in band 3, 2, 1

5. 3D

If we only want to visualize one feature uncertainty itself a 3D representation technique can be readily used. The plane coordinates represent the location of a pixel. The third dimension (elevation) represents the uncertainty value of a pixel. Uncertainty is increased when a point moves from the inside to the outside area of an object. If we want to represent not only uncertainty but also the corresponding thematic value, 3D and colour techniques can be used. For example, in 2D data the geomorphological features are valley fills or bajada in the terrain can have doubtful to demarcate while use of 3D data it may be confirmed as it is. And the exposed iron ore at crest of the hill make uncertainty found depression between adjacent tops of the hill due to elevation differences. Depressed areas must be contains iron ore it may be hindered that means spectral reflectance is high (dark color). To eliminate the uncertainty, this can adjust the ambience and sun azimuth in 3D environment to visualize the original representation of features how in the filed it is as shown in Figure. 8.

6. CONCLUSION

Visualization is a valuable tool in understanding large amounts of data and the phenomena represented by these data. Complete specification of data should include uncertainty. Our work concentrates on this often-neglected aspect of data visualization.

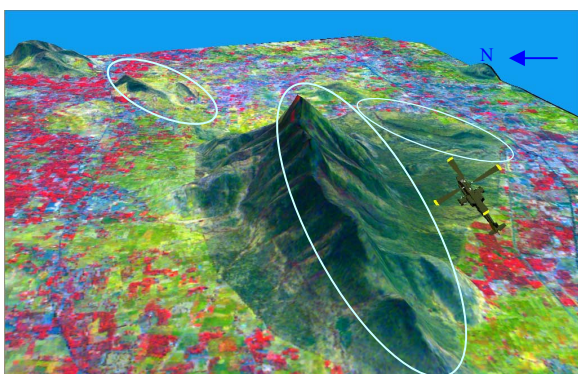


Figure. 8 Shows the 3D view of Godumalai in the decorrelated image of IRS P6 LISS 4 data

The techniques that we adopted should significantly improve all visualization and graphics applications where data uncertainty is concern. Integrated data and uncertainty visualizations make more accurate interpretations and improved decisions possible for many disciplines.

The advent of computer technology facilitates in an exploratory analysis for instance, iron ore exploration with the use of a set of remotely sensed data to arrive at cost effective explorative basis. Various general measures are already practiced for extracting uncertainty information from the remote sensing data, here remove the uncertainty by the way of valid image processing technique have been handled. These techniques however, moderately capture the distribution and extent of the uncertainties underlying images and, as a consequence, must be lead to provide good information. However, these techniques are purely depends on the field survey, spectral properties etc. and attained the results as in the images forms again therefore it leads straightforward

visualization. The approach suggested in this paper can be used to generate accurate exploration map, even in the presence of uncertainties in the form of mixed pixels. We hope that the techniques introduced in this paper may contribute to an effective assessment of fitness for use of a set of remotely sensed data in the exploration iron ore deposits.

ACKNOWLEDGEMENT

The present work is carried out with the partial financial assistance of the Indian Space Research Organization ISRO-RESPOND project "ELGIORD" and the authors are thankful to the Indian Space Research Organization, Bangalore for the same.

REFERENCES

- Abrams, M.J., Ashley, R.P., Rowan, L.C., Goetz, A.F.H., and Kahle, A.B, 1977, Mapping of Hydrothermal Alteration in the Cuprite Mining District, Nevada, using aircraft scanner images for the spectral region 0.46 to 2.36 μ m. *Journal of Geology*, v.5.p.713-718.
- Bastin, L., Fisher, P.F. and Wood, J., 2002. Visualizing Uncertainty in Multi-spectral Remotely Sensed Imagery. *Computers & Geosciences*, 28(3): 337-350.
- Beard, M.K. and Mackaness, W., 1993. Visual Access to Data Quality in Geographic Information Systems. *Cartographica*, 30(2+3): 37-45.
- Beard, M.K. and Battenfield, B.P., 1999. Detecting and Evaluating Errors by Graphical Methods. In: P.A. Longley, M.F. Goodchild, D.J. Maguire and D.W. Rhind (Editors), *Geographical Information Systems - Principles and Technical Issues*. John Wiley & Sons, New York, pp. 219-233.
- Blom, R.G., Abrams, M.J., and Adams, H.G., 1980, Spectral reflectance and discrimination

of plutonic rocks in the 0.45 to 2.45 μm region. *Journal of Geophysical Research*, v.85.p.2638-2648.

Hunt, G.R., & Salisbury, J.W., 1970. Visible and Near infrared spectra of minerals and rocks: I. Silicate minerals. *Modern Geology*, 1,283-300.

Hunt, G.R., & Salisbury, J.W., 1971 Visible and Near infrared spectra of minerals and rocks: II. Carbonates. *Modern Geology*, 2, 23-30.

Hunt, G.R., Salisbury, J.W., & Lenhoff, C.J., 1971. Visible and near infrared spectra of minerals and rocks: III. Oxides and Hydroxides. *Modern Geology*, 2, 193-205.

Hunt, G.R., Salisbury, J.W., & Lenhoff, C.J., 1974. Visible and near infrared spectra of minerals and rocks: IX. Basic and Ultrabasic igneous rocks. *Modern Geology*, 5, 15-22.

Hunt, G.R., & Ashley, R.P.1979. Spectra of altered rocks in the visible and near infrared, *Economic Geology*, 74, 1613-29

Richards, J.A., 1999. *Remote Sensing Digital Image Analysis: An Introduction*, Springer-Verlag, Berlin, Germany, p. 240.

Rowan, L. C., Wetlaufer, P.W., Goetz, A.F.H., Billingsley, F.C., and Stewart, J.H., 1975, Discrimination of rocks and hydrothermally altered areas in South central Nevada by use of computer and satellite images. *U.S.Geological Survey Professional Paper* 883.35p.

Worboys, M.F. and Duckham, M., 2004. *GIS: A Computing Perspective*. CRC Press.

Van der Wel, F.J.M., Hootsmans, R.M. and Ormeling, F., 1994. Visualization of Data Quality. In: A.M. MacEachren and D.R.F. Taylor (Editors), *Visualization in Modern Cartography*. *Modern Cartography* Pergamon, pp. 313-331.