

SATELLITE-DERIVED INTER-ANNUAL VARIATION IN THE CHANNEL OF THE NUN RIVER WITHIN THE NIGER DELTA SYSTEM

KINGSLEY O. ITIVEH and GRANT R. BIGG

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ABSTRACT

Understanding fluvial hydraulics and geomorphology are very important factors in the study of any river process. It becomes a difficult task when faced with a river that has very limited data. The only known survey of the Niger Delta is that by the Netherlands Engineering Consultants (NEDECO) conducted between 1959 and 1963. The study reported herein aims to determine the extent of changes that have occurred over time in the river channels and to establish the present position of the river relative to the maps used in the construction of a hydrodynamic model of the Niger Delta. Selected locations along the river channel of the River Nun sub-system and the Niger river bifurcation were sampled. Changes in channel bankline in the sampled regions over the last 40 years have been established using LANDSAT images, supported by NEDECO survey data.

The rapid changes that were discovered suggest a very dynamic fluvial system, which is characterised predominantly by accumulation of weak and highly compressible alluvial sedimentary deposits. These changes suggest the Nun River moved towards the northeast in the upstream reaches, and to the south in the downstream reaches, between 1963 and 1998. However, between 1999 and 2002, the Nun River moved back to the approximate location determined in 1963 by NEDECO. Thus, the changes have been roughly reversed in the Nun River, but not completely in the downstream reach. Other sampled regions of the Niger delta have shown a less stable behaviour, including westward propagation of the sandbar's bar-head at the junction of the Nun and Forcados Rivers and southward movement of the channel of Oguobiri Creek.

KEYWORDS: Niger Delta, Bifurcation, LANDSAT, Sandbar, Bankline.

INTRODUCTION

Due to the nature of the loosely packed sediments in the Niger delta, it is expected that the river dynamics could cause significant changes in channel morphology. After a mapping survey of the Niger system carried out between 1959 and 1963 by the Netherlands Engineering Consultants (NEDECO), there was extensive damming of the Upper Niger, well north of the delta, over the following decade. The impoundment of 49 dams in the Niger catchment area with a combined reservoir capacity of 36 million m³ has had a direct impact on the Niger delta, resulting from the reduction in flow and sediment delivered to the coast (Abam, 1999).

The Niger Delta can be considered to be under studied as the only reports covering the whole delta are those of NEDECO and the 1980 Korean report (Abam, 1999). Apart from these studies, a number of studies on rivers impacting on the Niger Delta have been done. Hydrological problems of the Niger Delta and their possible solutions in relation to small areas were addressed by these studies.

More recently, a study by Abam (1999) on the impact of dams on the hydrology of the Niger Delta described the hydro-morphological history and processes in the Niger Delta since the creation of the upstream dams. Consequently, the change in hydrology between the pre-dam and post-dam regimes can influence variations in the Niger Delta river dynamics and morphology. The aim of this study is to investigate the morphological variations at selected locations in the Niger delta in the last 40 years. Here we use images from LANDSAT satellites spanning 1984-2002 and NEDECO survey maps of 1959-1963 to determine post-damming inter-annual variability in the channel morphology of the Nun River and the bifurcation point of the Niger into the Nun and Forcados Rivers. We also compared the channel evolution with the pre-dam baseline survey. Visibility was a major factor in the selection of the areas investigated because of seasonal cloud cover and

atmospheric moisture content. Figure 1 shows the Niger delta region and the region under investigation in dashed lines.

Understanding the ways in which river channels have migrated through time is critical to tackling many geomorphologic and river management problems. Because of the large magnitude and rapid rate of change, special surveillance systems are needed to efficiently measure and monitor channel migration (Yang *et al*, 1999). A number of studies of river dynamics have used remote sensing and image processing techniques to investigate river dynamics. Satellite images allow evaluation of changes in a river's morphology through time. Lane *et al* (2003), developed a methodology for channel change detection, coupled to the use of synoptic remote sensing, for erosion and deposition estimation, which was applied to a wide, braided, gravel-bed river. The method was based on construction of digital elevation models (DEM) using digital photogrammetry, laser altimetry and image processing. Their results show there was no difference in the ability of this method in detecting erosion and deposition when compared with the traditional cross-section survey.

Digital photogrammetry was employed to derive high resolution DEMs of a simulated landscape in a laboratory study (Brasington and Smart, 2003). This was used to recover the sediment budget through the experiment and to examine local- and basin-scale rates of sediment transport. A comparison of directly observed and morphometric estimates of sediment yield at the basin outlet was used to quantify the closure of the sediment budget over the simulation.

Drastic channel adjustments in the alluvial rivers of Tuscany have been investigated with the aid of aerial photographs (Rinaldi, 2003). Bed-level adjustments were identified both by comparing available topographic longitudinal profiles of different years, and through field observations. Changes in channel width were investigated by comparing available aerial

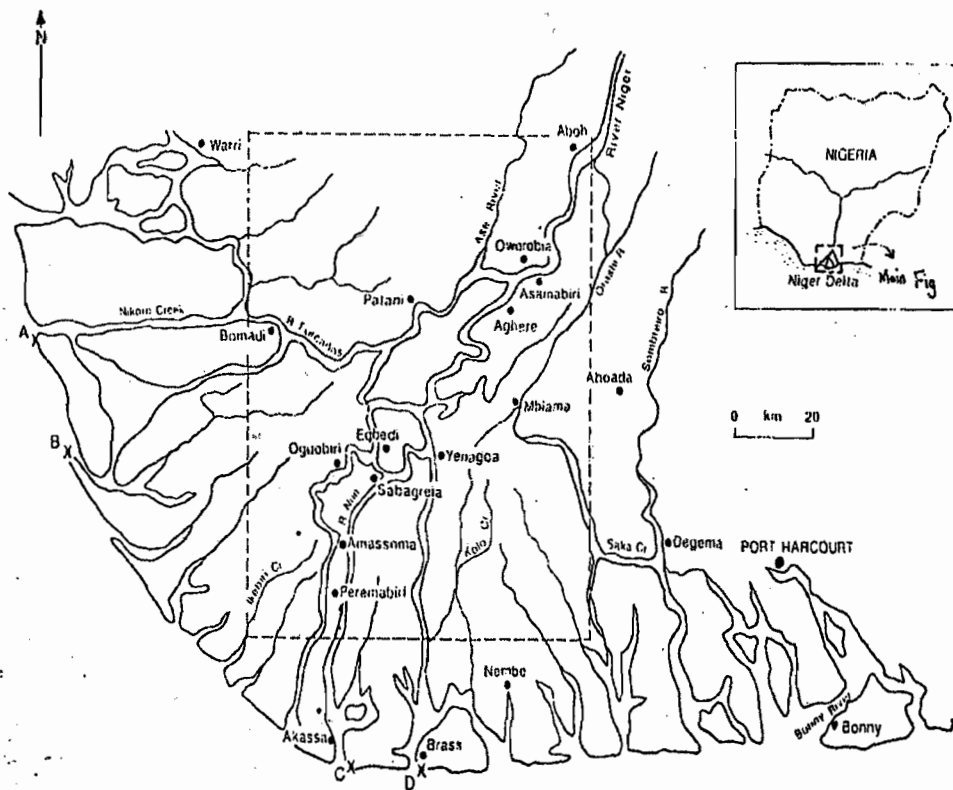


Figure 1: Map of the Niger Delta showing landmarks sampled in determining the offset between the two instruments

photographs. Based on the initial channel morphology and on the amounts of incision and narrowing, a regional scheme of channel adjustments was derived.

Stabel and Fischer (2001), used Synthetic Aperture Radar (SAR) systems to detect structural changes in the river Odra passing through the Czech Republic and forming the border of Germany and Poland. Vulnerability maps showing high risk areas in the floodplain of the river Odra were produced using DEM, Land and infrastructure maps. Structural changes in the floodplain surface, as well as areas of erosion and accumulation indicating morphological dynamics, were discovered and analysed.

Multi-temporal remote sensing data acquired from different instruments can be used in investigating the form of river sedimentation, and the planform movement of river channels. Also, the temporal trend of channel evolution, and the spatial distribution of sedimentation observed by satellite data may be used to infer present sedimentation rates and future developments (Samarakoon *et al.*, 1996). For example, multitemporal analysis using satellite images obtained over 30 years revealed abrupt changes in the course of the Taquari River in the Pantanal, Brazil (Assine *et al.*, 1999). Kotera *et al.*, (1997), relied on satellite images to extract and interpret the locations of waterway systems in Bangladesh in order to generate a base map for a seismic survey. They utilized the LANDSAT Thematic Mapper (TM), which has the advantage of detecting water systems less than 5m wide, and RADARSAT SAR images. Petrie *et al.*, (1993) also used satellite images to locate both natural and anthropogenic features, to determine, quantitatively, the extent of flooding, and to characterize flood effects and flood dynamics in the 1993 flood areas in the mid-west of the U.S.A. Al-Khudhairy *et al.*, (2001) used LANDSAT

TM data to indirectly provide remotely sensed observation of water levels within channels and ditches. Satellite images have much to offer in providing an historical regime of wetlands and complementary approaches to field monitoring. For a better understanding of morphological dynamics of large rivers, the spatial and temporal distribution is studied with satellite radar images (Stabel and Fischer, 2001).

The main objectives of studying Niger delta satellite images are to determine the extent of changes that have occurred over time in some of the river channels and to establish the present position of the river relative to that shown in maps which date from around 1960, before the extensive changes to the river's hydrology due to upstream dams. One may ask, "How morphologically dynamic is the Niger delta river system?". The Niger delta has mainly been built up by the accumulation of weak and highly erodible alluvial sedimentary deposits (Oguara, 2002). The landscape is a product of both fluvial and marine sediment build-up since the upper Cretaceous, and shows some relief that is responsible for the meandering and frequent shifting of the Niger and its branches (NEDECO, 1961). No work has been done to report variation in the position of the river since the Netherlands Engineering Consultants (NEDECO) survey of 1959 to 1963.

The Niger Delta satellite images

LANDSAT images have been used in the investigation of river dynamics such as flooding (Mertes *et al.*, 1995; Nellis *et al.*, 1998; Profeti and Macintosh, 1998; Townsend and Walsh, 1998; Yang *et al.*, 1999; Frazier *et al.*, 2000; Bhuyan *et al.*, 2002) and geomorphology (Ciavola *et al.*, 2000; Kravtsova and Cherepanova, 2003; Abam *et al.*, 2004).

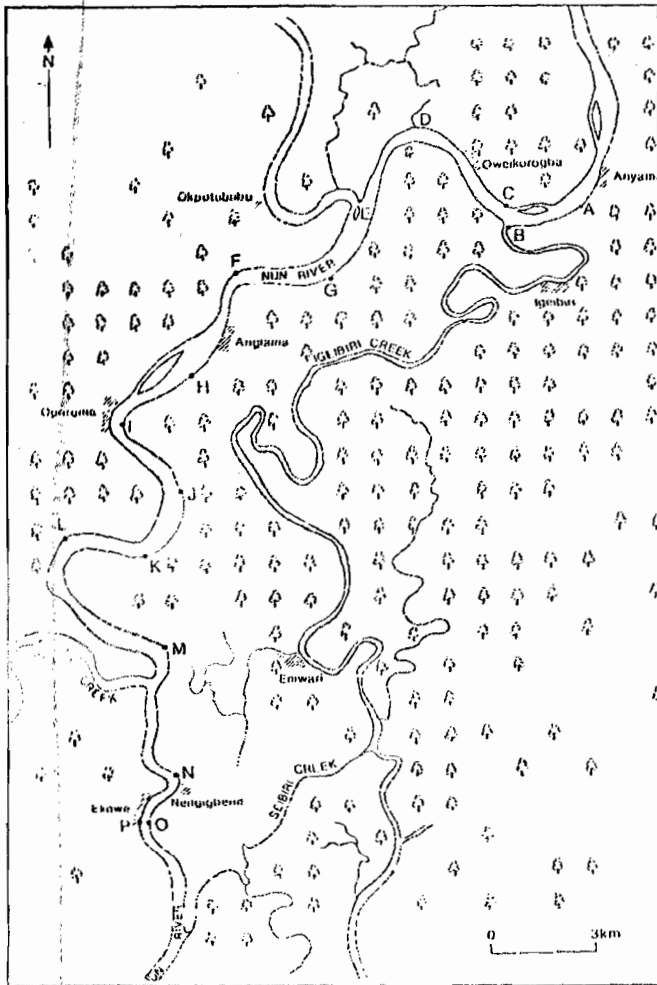


Figure 2: Section of the Nun River and marked locations used for investigation (NEDECO survey, 1963).

Investigating large geomorphology changes on the Niger Delta requires almost yearly sampling but only moderate spatial resolution. LANDSAT TM and ETM images made available through the USGS website (<http://glvis.usgs.gov>) were used. Two sets of LANDSAT satellites available are used; LANDSAT 4/5 and LANDSAT 7. LANDSAT 4/5 satellites carried a sensor called the Multi-Spectral Scanner (MSS) for earth imaging and a second more advanced sensor called a

Thematic Mapper (TM). The Thematic Mapper is an imaging sensor that can resolve features about three times smaller than earlier LANDSAT instruments and can collect data in more wavelength bands. LANDSAT 7 flew with a new sensor called the Enhanced Thematic Mapper plus (ETM+). The ETM+ has eight bands sensitive to different wavelengths of visible and infrared radiation and has better resolution in the thermal infrared band than the Thematic Mapper (TM) instrument carried by LANDSAT 4/5.

The satellites were able to capture pictures of the major rivers in the Niger delta, such as the Nun and Forcados. The difference in the images between the LANDSAT 4/5 and LANDSAT 7 is that the on-line position map for the two instruments is slightly different. This made it impossible to simply relate and compare values from the same location of the river between the two satellites. There is an offset between

the images from the two satellites. The removal of this offset is vital for any meaningful interpretation of the rivers' (the Nun and the Bifurcation) morphological trends. This is done in a later section of this paper.

The time of year of the photograph also determined the clarity and, hence, the effective resolution of the images. Generally, this was found to be higher in the dry season (between December and May) than in the wet season (between June and November) because of a reduced amount of water vapour and cloud in the atmosphere.

The information available from the satellite images via the on-line analysis system is a latitude and longitude cursor. This appears highlighted when it encounters a water boundary. This way you can accurately position the centre of the cursor on a given location of investigation.

The satellite images available for viewing from LANDSAT 4/5 TM and LANDSAT 7 ETM+ range from June 1984 to 2002. LANDSAT 4/5 has images of June 1984 to February 1999, while LANDSAT 7 ETM+ has images from 16th August 1999 to the most recent image. There is data from the year 1999 in the dataset from the two satellite instruments. The only gap is where images are not available in the months of March and October, which represent part of the rainy season. Hence not much would have been found from those months in any case. Not all the images were considered in this study but only those with clarity in the regions of investigation. The data collected are expressed in kilometres relative to each location's position in latitude and longitude on the earliest clear image.

LANDSAT TM images and LANDSAT ETM images were used at resolutions of 480m and 240m respectively. Bands 3, 2 and 1 were used in a time colours arrangement. The website images proved sufficient to investigate banklines in the Niger Delta rivers, whilst providing high temporal resolution at no cost. Nevertheless, a set of four full resolution images (30m and 15m) TM and ETM images from 1987 and 2002, were used to validate the use this dataset.

Study areas and data

Study areas

The Nun River

The Niger Delta is made up of weak and highly compressible alluvial sedimentary deposits. This characteristic quality makes it a region where significant change can occur within a short period. To provide a baseline for the study, a map of 1963 is used to determine the initial position of the river. Figure 2 shows a base map of this survey for our region, including the locations of investigation in the satellite study.

The locations considered for the investigations are those locations where bank erosion or breaching is more likely to take place (e.g. around bends). Many bank failures in the Niger delta (up to 78%) are located on the concave bends of rivers at locations just downstream of maximum curvature

(Abam and Omuso, 2000). The higher velocities and eddies at the bends scour and steepen the banks (Crickmay, 1960; Bathurst, 1979). Locations investigated for bankline changes between images are marked with letters.

The investigation is conducted by sampling all the positions on the different satellite pictures that are sufficiently clear in the available years. The data was later grouped in terms of satellite type and position. The early satellite data were collected and all similar positions investigated were grouped with the time. That is, all positions "A" for the different months/years from the early satellite (LANDSAT 4/5 TM) were grouped together. The same sorting was done to the dataset from LANDSAT 7 ETM+.

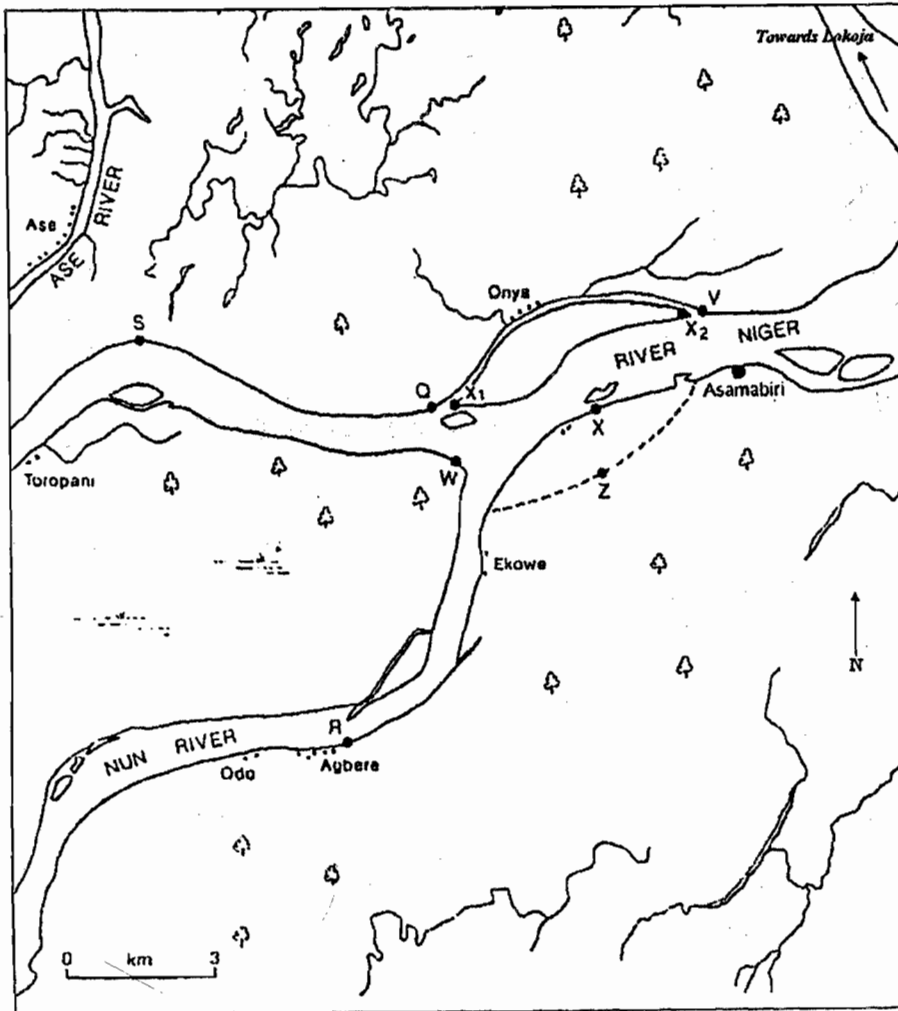


Figure 3: Bifurcation point showing sandbar position and marked locations used for investigation (NEDECO survey, 1963).

Table 1a: Means of sampled points

Point	Landsat 4/5 (1987-1999)		Landsat 7 (1999-2002)	
	Latitude (°N)	Longitude (°E)	Latitude (°N)	Longitude (°E)
A	5.065±0.013	5.366±0.012	5.1203±0.0056	5.3832±0.0099
B	4.840±0.020	5.443±0.015	4.9134±0.0022	5.4566±0.0084
C	4.196±0.015	6.0706±0.0051	4.2766±0.0044	6.0626±0.0081
D	4.225±0.015	6.2255±0.0046	4.3003±0.0037	6.2058±0.0086

The Bifurcation

The bifurcation of the Niger into the Nun and Forcados Rivers is another vital part of the Niger Delta system. This part is important for concurrent development of a hydrodynamic model of the Niger Delta (to be reported on in the future) because it will serve as a validation area for the modelling results as it is where most data is available. Selected locations were also chosen for the investigation around the bifurcation

with the same criteria used as in the case of the Nun River above. Figure 3 shows the bifurcation and the selected locations used in the study. Note that location X is an outer bank while location Z is used to describe a possible channel that is developing along side during overflow as seen from satellite images.

The sandbar at the bifurcation of the Niger River into the Nun River and Forcados River is of interest because the location,

Table 1b: Latitude and Longitude difference between the two satellites (i.e. Landsat 7 – Landsat 4/5)

Point	Latitude (km)	Longitude (km)
A	0.055±0.014	0.017±0.016
B	0.073±0.020	0.013±0.017
C	0.080±0.012	-0.0080±0.014
D	0.075±0.015	-0.0197±0.017
Mean Difference	0.071±0.031	0.0007±0.032

instruments of LANDSAT 4/5 TM and LANDSAT 7 ETM+, there is also an offset between the software settings of the same feature from the two LANDSAT satellites. It was therefore necessary to quantify this offset. The next subsection will highlight how the data from the early satellite were corrected to the same coordinate system as the higher resolution data.

Correction of the Early Satellite (LANDSAT 4/5 TM) Data
 Correction of the early satellite dataset was achieved by using the following steps: a) identifying landmarks from along the coastline of Nigeria and road junctions (hopefully) unchanging during the 20 years of data to be sampled; (b) quantitative sampling of these landmarks; (c) determining statistically the degree of offset between the two instruments (LANDSAT 7 ETM+ and LANDSAT 4/5 TM); (d) application of the correction factor to remove the offset in the dataset.

The means and variance of different datasets (Table 1) at each sampled location (see Figure 1) were calculated in terms of Latitude and Longitude. From the value calculated in Table 1b, the average of the mean difference for the latitude value is $0.071 \pm 0.031^\circ$ and that of the longitude is $0.0007 \pm 0.032^\circ$. The latitude difference exceeds that due to errors in the measurement (that is the operator's ability to relocate the same location, using the cursor). The average of the mean difference of the longitude values of the dataset is not significantly different from zero. Thus, there was a latitude displacement only between the images of the two LANDSAT satellites.

Correction of the dataset is then necessary because of the significant difference in the latitude values. From considering the resolution of the satellites and, most importantly the position of the river as determined by NEDECO (Table 2) in 1963, the correction value of 0.071° was applied to the latitude values of the LANDSAT 4/5 TM. This made these values consistent with those of LANDSAT 7 ETM+ and the NEDECO survey of 1963.

RESULTS AND DISCUSSION

The changes associated with the different areas investigated are presented graphically in the appendices. From the plots, it is evident that the river is dynamic and that it changes on two timescales. Large short term excursions, such as that in 1991 (see Appendixes 1 and 2) are quickly reversed to a significant extent but similar amplitude changes can also occur over years. The dramatic change in 1991 is not peculiar to the Nun River but similar changes are also expressed in the dataset for the upstream location of the Bifurcation. These large excursions were towards the southeast and reversed in the northwest direction, although not fully returning to the original latitude.

Table 2: Nun River as Surveyed by NEDECO, 1963

Points	Latitude (°N)	Longitude (°E)
A	4.8647	6.2064
B	4.8589	6.1889
C	4.8633	6.1898
D	4.885	6.164
E	4.8653	6.1484
F	4.8478	6.1171
G	4.845	6.1398
H	4.8178	6.1019
I	4.8061	6.0856
J	4.7853	6.1028
K	4.7742	6.0926
L	4.7794	6.0074
M	4.7508	6.099
N	4.7189	6.1014
O	4.7069	6.094
P	4.7069	6.0916

shape, and size of this sandbar are altered in response to the fluvial and morphological dynamics of the reach, and this intrinsically determines the distribution of discharge into the river tributaries (Abam and Omuso 2000).

Data Quality

Apart from the resolution difference between the two

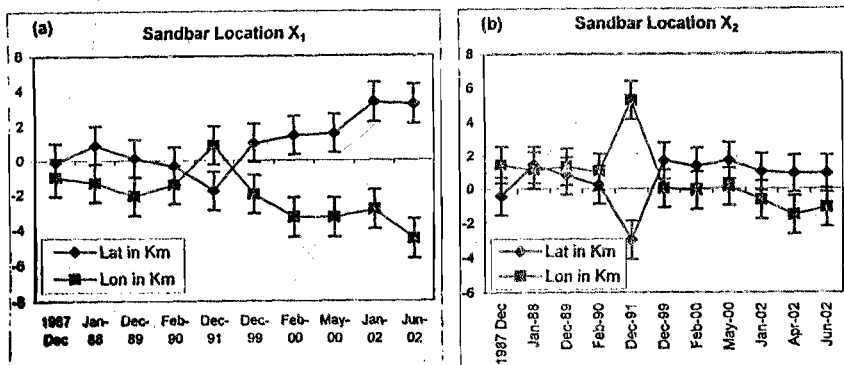


Figure 4: Variation in Sandbar positions as seen from the satellite images: (a) at location X₁ (bar-head); (b) at location X₂ (bar-tail).

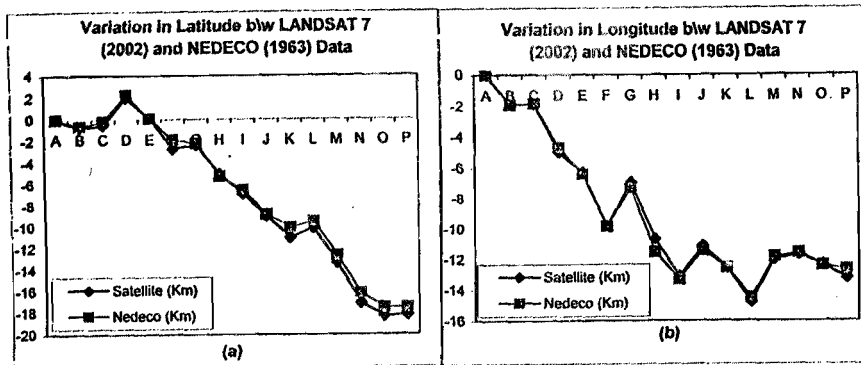


Figure 5: Comparison between NEDECO and Satellite observations of the Nun River: (a) variation in Latitude between Satellite (2002) and NEDECO (1963) data; (b) variation in Longitude between Satellite (2002) and NEDECO (1963) data.

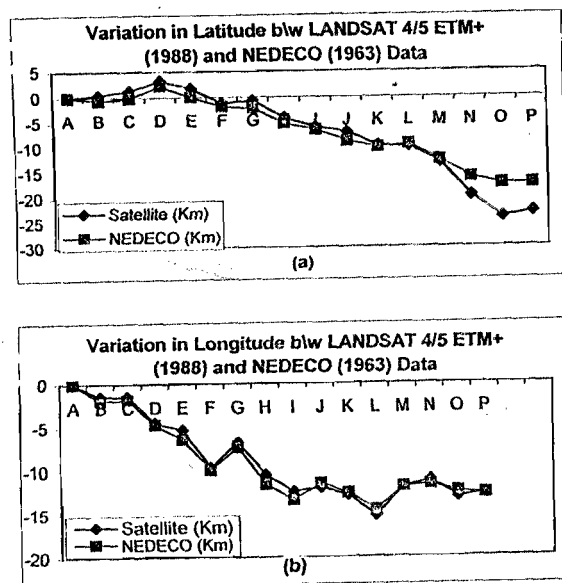


Figure 6: Comparison between NEDECO and Satellite observations of the Nun River: (a) variation in Latitude between Satellite (1988) and NEDECO (1963) data; (b) variation in Longitude between Satellite (1988) and NEDECO (1963) data.

The catastrophic change evident in 1991 in the various plots can only indicate a major event happening in that year. High water levels and early floods could be genuine reasons for the change noticed in 1991. Monthly water level at three sections of the Nun River show an unusual distribution in 1991 (Abam, 1999). In all selected locations, the water levels started to rise earlier than in other years. Also, the average water level in the three locations was higher in the year 1991 than any other year in the dataset. Consequently, the water discharge in the Nun was greater in 1991 than any other year during 1984 to 1994. Such high water levels can lead to severe flooding and thus cause changes in the river structure over a short period, since the Niger delta is characterised predominantly by accumulation of weak and highly compressible alluvial sedimentary deposits.

On the other hand, as everywhere (Nun River and bifurcation) that is visible in the December 1991 image has this sharp change, it could be due to a one-off error in the on-line grid. But the non-return of the latitude to its pre-1991 value suggests the change is real. The water levels monitored at three different locations on the Nun suggest an unusual event. Nevertheless, it is important to remember that the change could be due to an error in grid of the software used by the satellite since it is reflected in all 1991 data.

Apart from the major changes in 1991, seen in all parts of the Nun investigated, the Nun has also experienced some significant changes over longer periods of time. The early locations in the 1980s (first three locations on plots A – E, see Appendix 1) show a significant difference in both latitude and longitude when compared to the same locations in 2001 to 2002 (last three locations on graphs). While the river tends to be moving gradually towards the southwest from locations A to F in the Nun River (Appendix 1) between early 2001 and 2002 by 2-3 km, it appears to have remained approximately in the same position between 1987 and 1990, although less so at location F. Location I also showed some gentle movement due west in the early years but more marked between 2001 and 2002 to about 1 km. The maximum change of about 3-4 km in northwest movement of the Nun occurred between locations N and P. A number of locations remained essentially static over the time period apart from the 1991 excursion (e.g. locations G, H and J). Also, some locations do not exhibit these trends; they are rather eccentric in their orientation. An example is Nun location K, which displayed no regular pattern of change.

At the Niger's bifurcation into the Nun and Forcados, in addition to the dramatic change of 1991, the long-term changes tend to be from southeast to northwest (Appendix 2, Bifurcation locations). The bifurcation sandbar as seen from

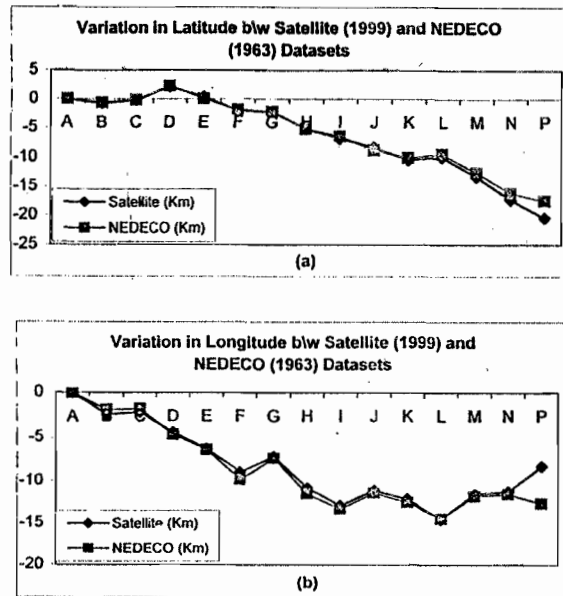


Figure 7: Comparison between NEDECO and Satellite observations of the Nun River: (a) variation in Latitude between Satellite (1999) and NEDECO (1963) data; (b) variation in Longitude between Satellite (1999) and NEDECO (1963) data

the satellite picture of 2002 (<http://glovis.usgs.gov>) seems to have elongated and partly moved into the Forcados River when compared to the 1963 NEDECO survey in Figure 3. From the satellite data, the bar-head (location X₁) of the sandbar moved southwest between 1987 and 1990, with a

sharp jump in 1991 (Figure 4a and 4b). There was a reverse movement towards the northwest after that period. The bar-tail (location X₂) remained in approximately the same position between 1987 and 1990, but in 1991 there was a sharp movement towards the southeast. Between 1991 and 2002, the bar-tail has moved to the northwest almost returning to the mid 1980s location.

Comparison of NEDECO and Satellite surveys of the Nun River

As seen from Figure 5a and 5b, the LANDSAT 7 ETM+ satellite data of 2002 has remarkable similarity to the NEDECO survey locations (1963) of the Nun River locations (Figure 3). Most of the locations tallied except for differences of a few hundreds of metres especially in the latitude plot (Figure 5a, locations F, K to P and Figure 5b, locations H and P). These changes occurred more in the downstream location of the river and are towards the south. In the longer term therefore, the Nun's channel appears to be stable.

However, on a shorter time-scale changes have been more marked. In Figures 6a and 6b (a comparison of the NEDECO survey with a 1988 image), the river appears to have moved towards the northeast in the upstream and to the south in the downstream regions relative to 1963 NEDECO survey data. By 1999 the river had moved back to the southwest in the upstream region almost to the location determined by NEDECO survey (Figures 7a and 7b). The downstream part of the river tended to have moved some hundreds of metres due northeast. Recent movement in the upstream reach, relative to the position of the river in 1999, has been a limited movement towards the southwest in the upstream and northeast in the downstream region.

CONCLUSIONS

The study showed that changes in the dynamic river channels of the Niger River system could be monitored using satellite

data. The sediment through which the river cuts its channels is characterised predominantly by accumulation of weak and highly compressible alluvial sedimentary deposits. The prevailing changes suggest the river has moved towards the northeast in the upstream and to the south in the downstream regions between 1963 and 1998. However, between 1999 and 2002, the Nun River moved back in the upstream, approximately, to the location determined in 1963 by NEDECO but less so in the downstream locations. Thus, while there have been considerable changes in bankline of the Nun River, these have been approximately reversed over the years in the upstream locations. Bankline shift of some few hundreds of metres towards the north as compared to the location determined by NEDECO in 1963 (Figure 5) is apparently visible in the downstream reaches (locations K-P).

Although, there was a temporary northeast movement between 1991 and 2001, the dominant change observed at the bifurcation is a southwest shift of the bifurcation. Erratic changes occurred at the sandbar in contrast to the NEDECO survey of 1963. The bar-head of the sandbar has tapered and migrated into the Forcados arm of the bifurcation as seen in satellite picture of 2002 (<http://glovis.usgs.gov>). The sandbar has elongated northwest into the Forcados River. The tail-end, however, has almost consistently maintained the same position, moving only slightly westward between 1987 and 2002.

Changes and trends exhibited by the selected banklines of the Niger Delta system have suggested a very dynamic fluvial landform. These may be related to variations in the river discharge and sediment transport before and after the dams were built. However, further investigations have to be carried out to estimate the pre- and post-dam shear stress distribution from the mean monthly and yearly discharges in the Niger Delta system.

ACKNOWLEDGEMENTS

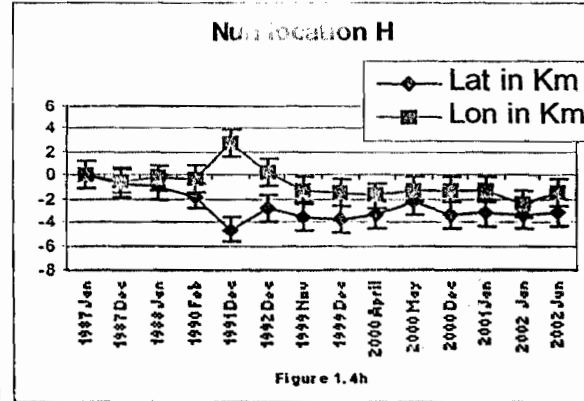
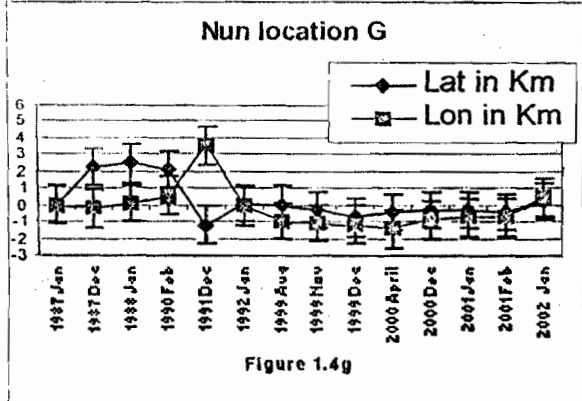
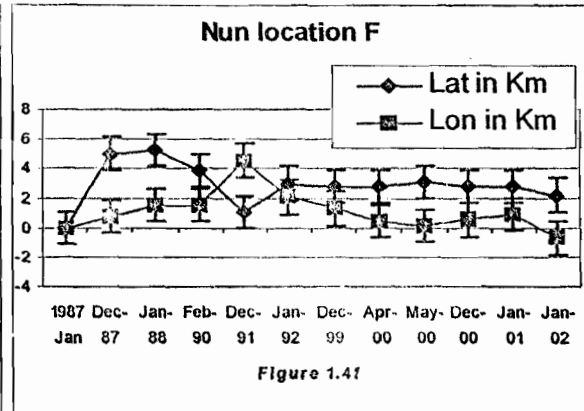
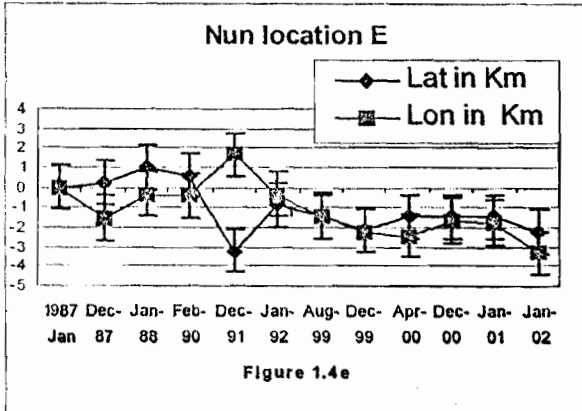
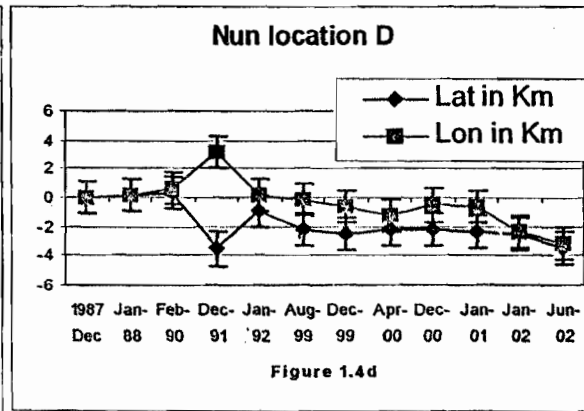
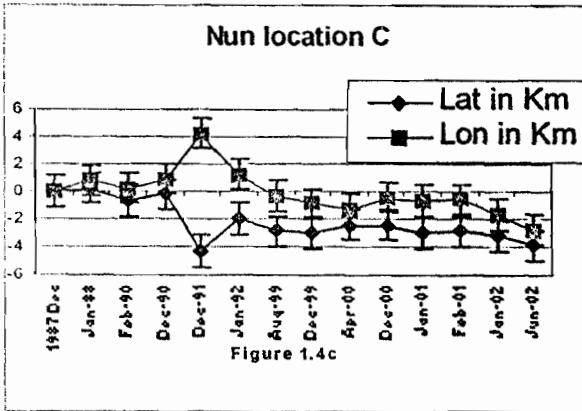
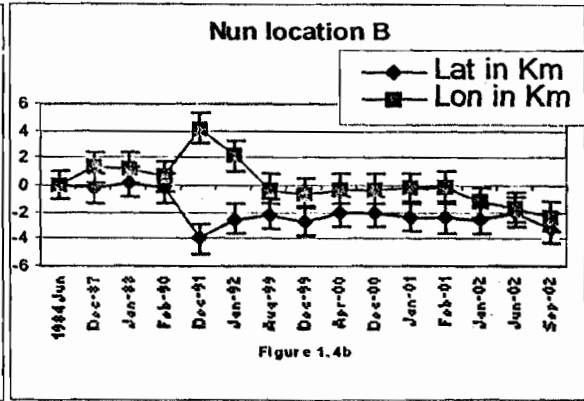
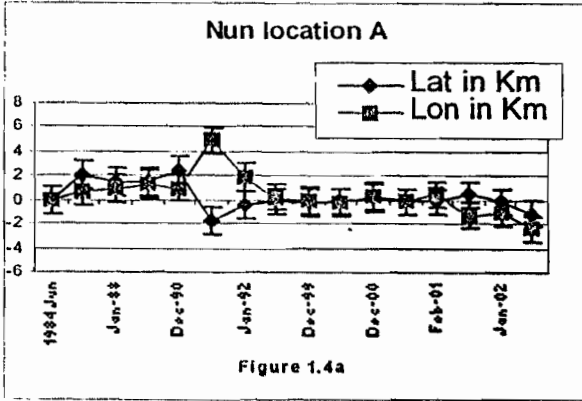
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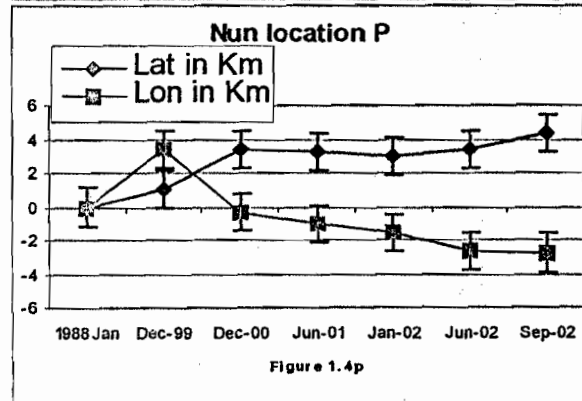
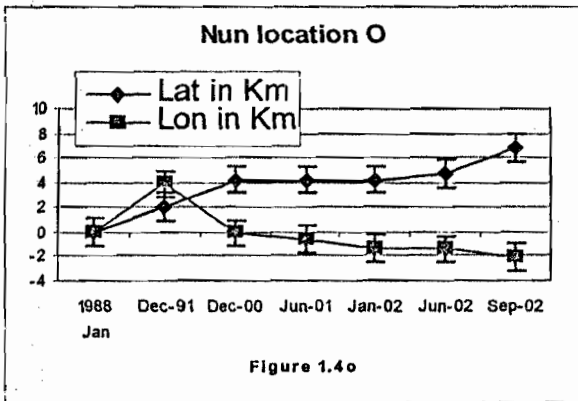
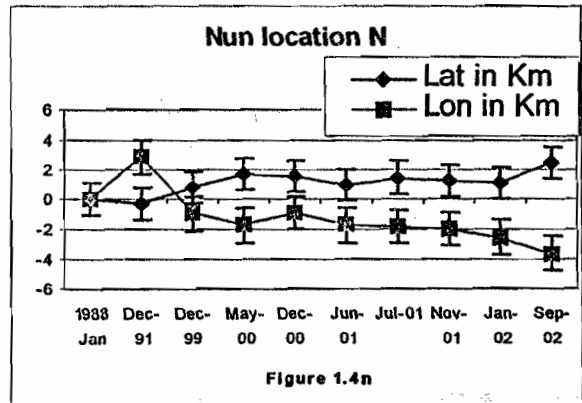
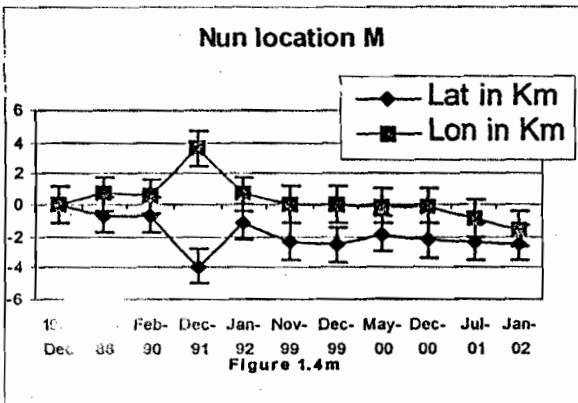
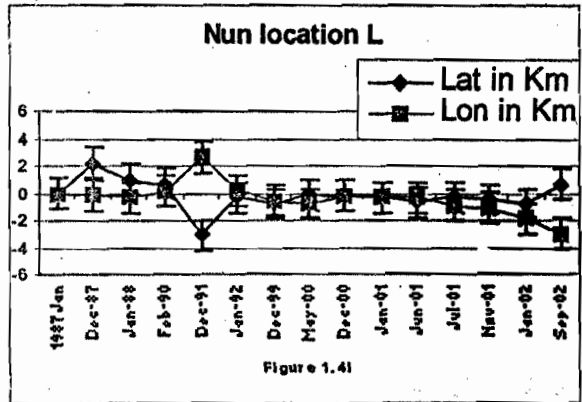
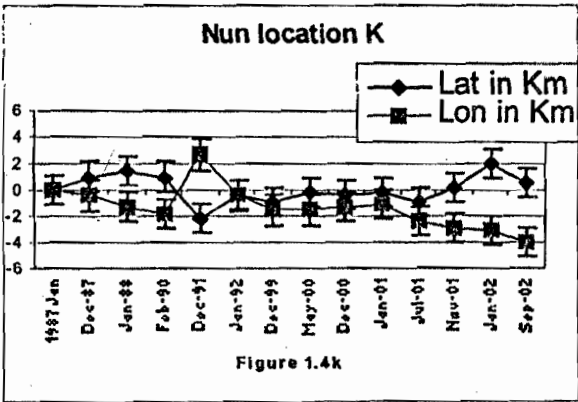
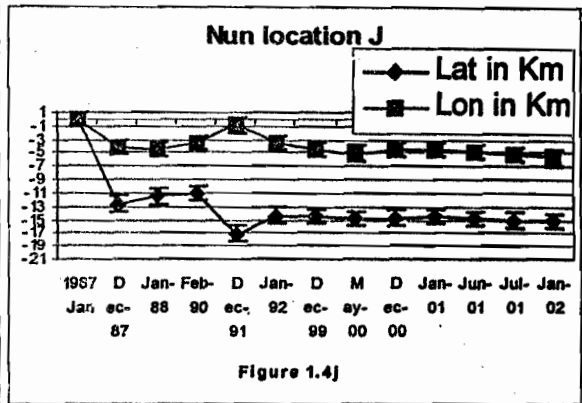
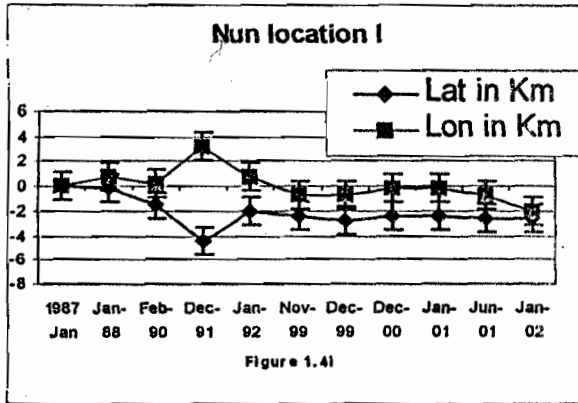
(<http://glcfapp.umiacs.umd.edu:8080/glcf/esdi>). We are grateful to the Delta State Government of Nigeria for providing the funds for Kingsley Itivh's PhD research, of which this work is a part, and also to HiPACT for administering the funds. We also acknowledge the assistance of HR Wallingford UK for providing the NEDECO survey (baseline) data.

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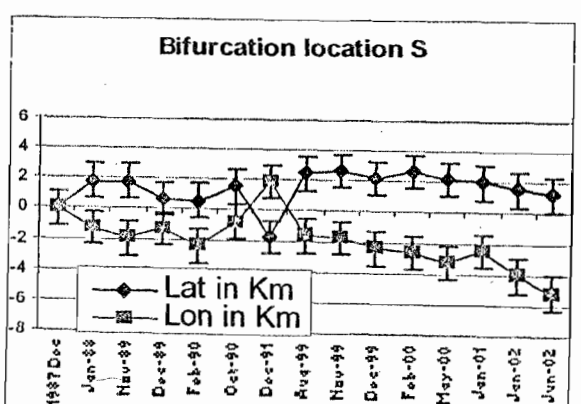
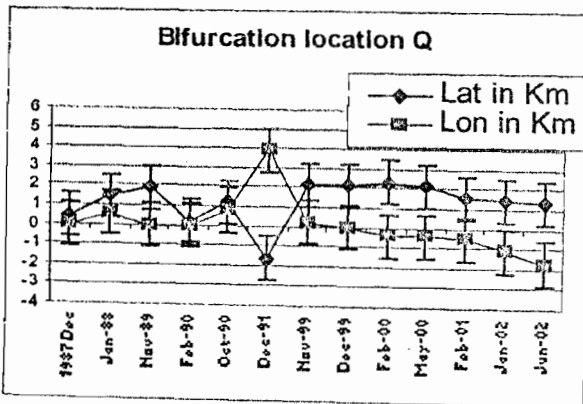
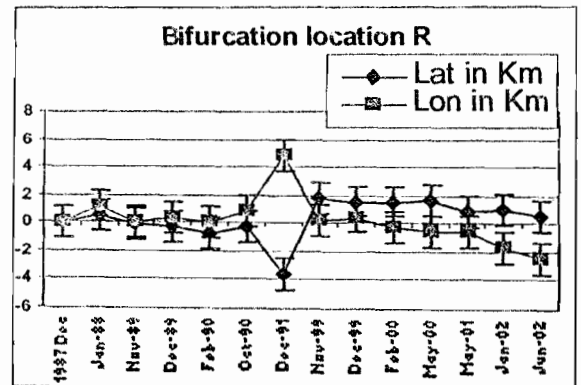
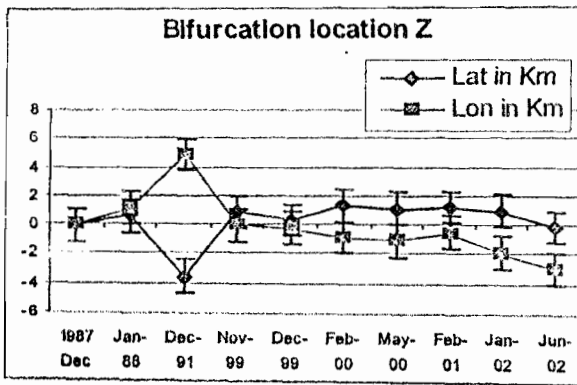
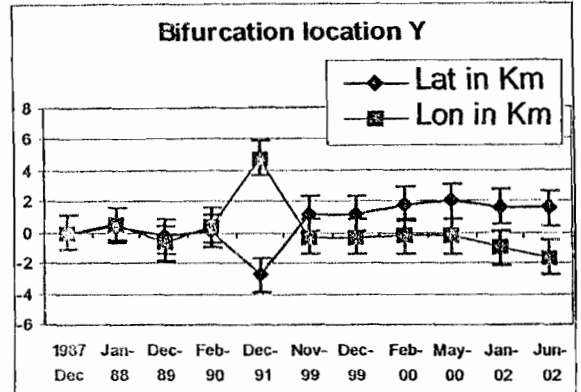
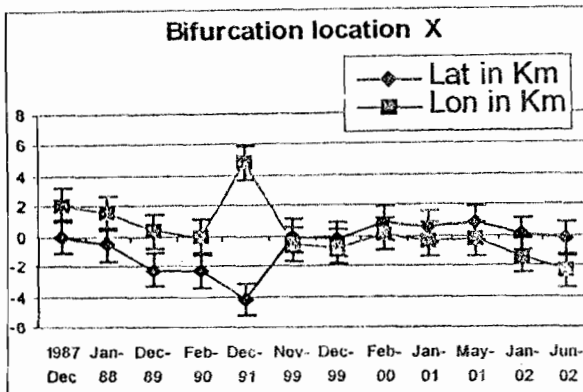
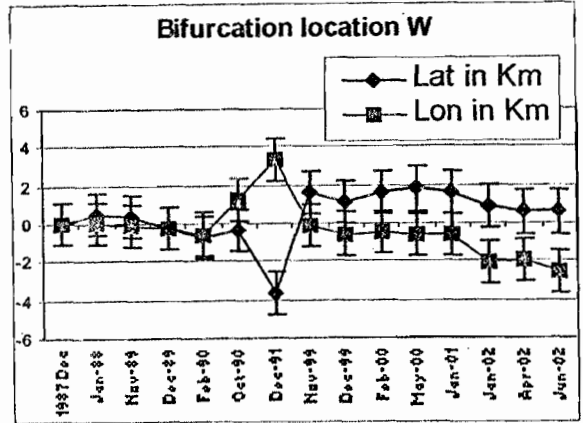
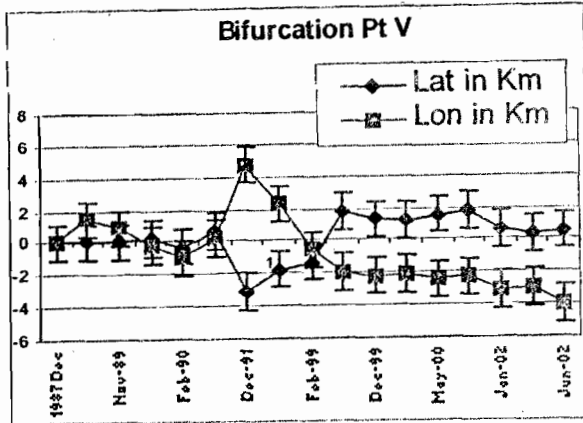
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Appendix 1: Nun River Locations





Appendix 2: Bifurcation Locations



TITLE: FUNDAMENTALS OF APPLIED GEOPHYSICS
 BOOK REVIEWER: BY PROF. M. O. OLORUNFEMI
 YEAR OF PUBLICATION: 2004.
 TOTAL PAGES: 135

Chapter 1: INTRODUCTION

Requires lots of editorial corrections as indicated in the text.

Table 1.1: Self Potential "Operative" Physical Property should include fluid streaming, chemical, heat, pressure gradient etc.

Table 1.2: Is the seismic method really relevant in sand and gravel deposit exploration?

EM can be relevant in engineering site investigation.

Chapter 2: SEISMIC EXPLORATION

Requires lots of editorial corrections as indicated.

Figs. 2.2a-c carry no caption

Griffiths and King, 1983 not King, 1983; This error repeats itself all over, including as King et al. 1983. I wonder if the author ever accessed this book but only cross referenced it and wrongly too!

Fig. 2.3d: Slope I/V, not properly placed.

Poor T-X graphs on pages 32 & 33.

No clear cut description of field procedures otherwise a fairly well written chapter.

Chapter 3: GRAVITY SURVEYING.

This chapter discusses corrections applied to gravity data without first discussing how gravity data are collected. This is very absurd. The author needs to answer the following questions – What are the different modes of gravity survey?, What are the field procedures?. Instrumentation was inadequately discussed. Very poorly packaged chapter. See several comments in the text.

Chapter 4: ELECTRICAL SURVEYING

Too many editorial errors.

- (a) Self Potential: Very poorly written with limited useful information. Poor diagrams (see text)
- (b) Induced Polarization: Very poor write up and poor illustration. Needs to be rewritten.

Chapter 5: ELECTRICAL SURVEYING (Resistivity Method)

Author cannot introduce the resistivity method by first detailing its applications. No elementary theory of any sort. No discussion of field procedures. Inconclusive equations e.g. equation 5.

Schlumberger Array: Why don't you use the common arrangement of 2I for P₁ – P₂ spacing and SL for C₁ – C₂ spacing (see text).

Interpretation of apparent resistivity data (section 5. 4) – Discussion here is relevant to Wenner array only and must be so stated.

Page 76/77: Curve used for interpretation is a 2 –Layer curve. How come the author has a thickness (90 m) for the bottom layer that is supposed to be infinitely thick?. The described interpretation technique is outdated.

It is difficult to appreciate that the author is familiar with interpretation of VES data. How is horizontal profiling data interpreted?.

Several things are wrong with this chapter as shown in the text.

Exercise 5, pp. 89: The author strangely is asking reader to solve a problem using procedures that were never discussed in the book!. Not fair.

Very poorly packaged chapter

I suggest this chapter should be merged with chapter 4.

Chapter 6: MAGNETIC SURVEYING

No description of the different modes of carrying out magnetic survey. No description of field procedures, instrumentation and data reduction. It is an incomplete chapter.

Chapter 7: ELECTROMAGNETIC SURVEYING

Very Poor introduction. Is it the ground that respond or conductor within the ground?.

Check equation 1.

Tilt Angle Methods: There are different versions. State and discuss them. What are the anomalies like ?

Very strange the ground EM methods do not include Horizontal Loop and Turam.

The former remains the most widely used EM method.

What are the different Airborne EM methods. The current presentation is too generalized.

Interpretation of electromagnetic data: How does the author expect the reader to appreciate this when the text contains no single anomaly curve!.

GENERAL COMMENT

The effort of the author to write a book on Applied Geophysics is appreciated and commendable. However, anything worth doing is worth doing well. Except perhaps chapter 2 no Seismic methods, all other chapters are either poorly written or outright incomplete. In its present form, the book cannot and will not serve the purpose imagined by the author for which the book was written. It needs to be completely overhauled. The author needs to take advantage of experts in the field of Geophysics in his immediate environment, so that the quality of the book can be improved. The book in its present form is no use to a student of Applied Geophysics who needs to know how geophysical data are generated, collected, processed and interpreted in term of the geology. Several of these aspects are not covered in the text, in respect of the different methods. Somewhere at the end of the description of each method effort should be made to highlight application of the different methods.

I hope the author finds the above comments useful. They are meant to assist in enhancing the quality of the book and to ensure that the readers (students) are at the end of the day educated and not mis-informed.