



SDI FINAL EVALUATION FORM 1.1

PART 1:

Journal Name:	Physical Science International Journal
Manuscript Number:	Ms_PSIJ_31581
Title of the Manuscript:	SPATIAL VARIATION MODELING OF GEOTHERMAL GRADIENT AND HEAT FLOW IN EASTERN PARTS OF NIGER DELTA SEDIMENTARY BASIN, NIGERIA.
Type of Article:	Review paper

PART 2:

FINAL EVALUATOR'S comments on revised paper (if any)	Authors' response to final evaluator's comments
The authors did not address the main concern of the paper (and the revised Figures 9 and 10 introduce more questions). Their responses to comments do not provide any usable information concerning the verification/validation of the model results. As most of the comments from the first review still apply, I have copied my comments below with some modifications. The biggest issue is the lack of ANY PRESENTATION OF THE VALIDATION AND VERIFICATION OF THE MODEL. Why should a reader accept the results? Additionally, a number of the minor comments/edits were completely ignored. I have added them to the end of the major comments. Original Review Comments: The paper lacks a review of the model and the validation of the model results. The interpretations of the model are ill presented given the lack of information on the model output. Specifically, the cluster of data used to generate the model are not distributed in a way to confirm that any of the geothermal gradient information presented along the eastern edge of the domain are real. In the revised draft, the authors have produced a modified version of the model that may conform better to the data, but nothing is provided to indicate the error. Given the values seem to be off by about 5 °C/km, I still worry about the results from the model. While kriging and variograms are effective tool, the models need to be validated. How well do the modelled values compare to the observed/measured values. What is the confidence of the model outside of the area of the data? Speaking to the data, there is no information provided about the vertical distribution of the gradient and heat flow data. If at different depths and formations, how do the authors justify there inclusion in the model? Within the discussion, the authors present possible reasons for the spatial distribution of the gradient and heat flow patterns. The first issue (stated above) is how realistic are the model outputs? Second, the authors suggest a number of factors influencing the thermal regime including tectonic evolution, depth to basement, sedimentary thickness and hydrothermal convection. A statement is made (line 230-234) that the gradients and heat flow are in agreement with other regions that are tectonically inactive, but no data or references are provided to vet the statement. Seismic activity (faults) are stated as a possible migration network for fluid, but no information about the distribution or orientation of the faults are provided. Are the faults aligned with in a manner that supports the given pattern? Given the differing trends of the heat flow and the gradient, a map showing the distribution of faults would be insightful, but another question needs to be asked concerning the connectivity of the faults to the zones from which the data were derived. Finally, the thickness of the sediment is postulated; however, no information about the thickness of sediment is provided nor is there any information on the distribution of the sediment thickness within the basin (or model domain). While the potential factors may be real, there is no support and reasoning behind any of them. Within the conclusion, the authors state, "The ordinary kriging maps obtained from the variogram models shows a very good estimate of the missing data at the unsampled points." – There is no verification of this statement within the paper. How is "very good estimate" defined and determined? A presentation of how the modeled data compare to the observed data would help speak to this point. More information about the lithostratigraphy is needed. How thick are the individual	The figures have been corrected by adjusting the model parameters The minor comments /edits have been noted and effected The models outputs have been given The cluster of the data was the reason for the research. The objectives of the work are to determine the values of the data in the other parts of the study area where there are no boreholes and to examine the spatial distribution of the data. Some of information of the geostatistical analysis were not given in order to reduce the volume of the manuscript The model values were validated with the sampled values used for the modelling at thr various location. The confidence of the model outside the area of data is high because the model data within the sampled region is almost the same. It was the average of vertical heat flow and geothermal gradient at each borehole that was used for the spatial analysis, The models are realistic because their values compare favourably with the original values used for the modeling Example is Anambra basin in Nigeria Seismic section in part of the study area showing faults is provided. The fault complex is within the Agbada formation where the data were obtained in the borehole Information about the thickness of the sediment within the area has been provided References have been given for the support



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units/formations? What is the distribution of the thicknesses? How do the geothermal gradients and heat capacity data relate to the formations presented? Lines 41-50 – Different set of units are presented for geothermal gradient. Both °F/ft and °C/Km are used. Line 46 capitalize d in delta; there are other instances of this capitalization error within the paper that need to be corrected. Line 51 – “...spatially vary from place to place.” Is redundant Line 71 – insert “to” before predict for parallel phrases Line 79 – “Longitude” does not need to be capitalized Line 86 – insert a comma after Agbada. Line 89 – insert a comma after sands Line 89 – replace underlies with underlain Line 90 – insert a coma after Formation Line 101 – insert a comma after phase Line 103 – insert a comma after Delta Figure 1 – Insert a “)” at the end of the caption. Lines 109-115 – Are the data used distributed consistent along the vertical dimension? The authors state in their response that “The vertical distribution was not consider because the maximum bottom hole temperature per well is 4. ...Model is from different depth but within the Agbada formation of the Niger delta.” I am not concerned with the vertical distribution as to how that was modelled, I am more interested in how the different depths compare in terms of gradient and heat flow. If there are differences based upon the depth of the well (or bottom of the well), then the model is using data incorrectly in terms of generating variograms because depth does play a role. Any assumption concerning the x-y location would be trumped by the z-dimension. How were outliers defined and identified? Line 139 _ capitalize gaussian Line 154 – add an “s” to account Figures 4 & 5 –In line 111, the authors mention temperatures from 19 wells were used. The distribution for Figure 4 sums to 18 and for Figure 5 sums to 17. Why the discrepancies between the number of data points used? If an outlier was removed from one why not the other, i.e. why the difference between the two data sets?+ Figures 9 – Label the axes (i.e. Lat and Long). Since the reader will have to do the comparison of the observed data to the modelled data themselves, make sure the scales between 3 and 9 are the same. Figure 10 – Label the axes (i.e. Lat and Long). Since the reader will have to do the comparison of the observed data to the modelled data themselves, make sure the scales between 3 and 9 are the same. I am having problems reconciling the observed data with the modelled data. Within Fig. 4 between 6oE an 7oE and 4 oN and 5 oN there are values for heat flow that are between 48 mW/m² to ~60 mW/m², but the model provides values only ~50 mW/m². This speaks back to my original concern about the model and how was it verified or validated? I am also very concerned about the difference in results presented in this draft as compared to the previous draft. The results show not resemblance what so ever further question the process. If the methods have not changed, why have the results changed so dramatically. Line 211 – the data are stated to be normally distributed, but a visual review of the histograms (Figure 4 and 5), suggest that both datasets are skewed. Were the datasets subjected to normality tests to determine if they are indeed normal distributions?	The statement was based on the closeness of the model data to the initial values used for the modeling Reference to the distribution of the individual thicknesses is given The various researchers used different units to present their findings An isopach map of the area showing the variation sedimentary thickness is now provided The observations have been noted and effected The kriging maps obtained from the variogram models have been used compare with the initial maps Figs 3 and 4 for verification of the justification of the models It was the average of vertical heat flow and geothermal gradient at each borehole that was used for the spatial analysis, effected The data points have been harmonized to 18 effected effected effected effected Model parameters adjusted and observation corrected Surfur 10 software was used for the modelling and as the variogram model parameters are varied the the kriging output also changes. The difference between the two out is as a result of comments from some of the reviewers that suggested trying more models for the work until a good fit is obtained It was a mistake and has been corrected. Corrected to 18
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