



INTERNATIONAL CONFERENCE GIS-IDEAS 2023

PROCEEDINGS

Geospatial Integrated Technologies for Natural Hazards and Environmental Problems

HUNRE, Ha Noi, Viet Nam
07-09 November 2023



PUBLISHING HOUSE FOR SCIENCE AND TECHNOLOGY



INTERNATIONAL CONFERENCE

GEOSPATIAL INTEGRATED TECHNOLOGIES FOR NATURAL HAZARDS AND ENVIRONMENTAL PROBLEMS

**PUBLISHING HOUSE FOR SCIENCE AND TECHNOLOGY
HA NOI - 2023**

Organized by

Hanoi University of Natural Resources and Environment (HUNRE)
Osaka Metropolitan University (OMU)
The Japan - Viet Nam Geoinformatics Consortium (JVGC)

Co-organizers

Ha Noi University of Mining and Geology (Vietnam)
Japan Geotechnical Consultant Association
Japan Society of Geoinformatics

With the support and collaboration of

Department of National Remote Sensing (Vietnam)
Department of Survey, Mapping and Geographic Information (Vietnam)
Ho Chi Minh University of Natural Resources and Environment (Vietnam)
National Centre for Hydro-Meteorological Forecasting (Vietnam)
Vietnam Institute of Geosciences and Mineral Resources
Institute of Resources Geography, Ho Chi Minh (Vietnam)
Vietnam Disaster and Dyke Management Authority
Ho Chi Minh City Space Technology Application Center (Vietnam)
Institute of Marine Geology and Geophysics (Vietnam)
Nong Lam University, Ho Chi Minh (Vietnam)
NextTech Group of Technopreneurs (Vietnam)
Vietnam National University, Hanoi
Vietnam Academy for Water Resources
Vietnam National Forestry University
Association of Vietnam Geographers
Military Technology Academy (Vietnam)
Asian Institute of Technology (Thailand)
Naresuan University (Thailand)
Thuy Loi University (Vietnam)
University of Phayao (Thailand)
Everest Schools (Vietnam)

CONFERENCE FOUNDERS

Late Prof. Takashi FUJITA (Japan)

Dr. Nghiem Vu KHAI (Vietnam)

SYMPOSIUM CHAIRS

Prof. Dr. Huynh Thi Lan HUONG (Vietnam)

Prof. Venkatesh RAGHAVAN (Japan)

ORGANIZING SECRETARIES

Assoc. Prof. Dr. Le Thi TRINH (Vietnam)

Dr. Go Yonezawa (Japan)

CONFERENCE COORDINATORS

Ms. Tanyaluck CHANSOMBAT (Thailand)

Dr. Tatsuya NEMOTO (Japan)

Ms. Vu Thi Thuy NGAN (Vietnam)

Dr. Truong Xuan QUANG (Vietnam)

STEERING COMMITTEE

Dr. Ho Dinh DUAN (Vietnam)
Dr. Duong Van HAI (Vietnam)
Prof. Dr. Tran Thanh HAI (Vietnam)
Assoc. Prof. Hoang Anh HUY (Vietnam)
Dr. Mai Van KHIEM (Vietnam)
Prof. Yasuyuki KONO (Japan)
Prof. Nguyen Kim LOI (Vietnam)
Prof. Truong Xuan LUAN (Vietnam)
Prof. Shinji MASUMOTO (Vietnam)
Prof. Alaa A MASOUD (Vietnam)
Prof. Muneki MITAMURA (Japan)
Dr. Doan Thi Tuyet NGA (Vietnam)
Dr. Lam Dao NGUYEN (Vietnam)
Assoc. Prof. Huynh QUYEN (Vietnam)
Dr. Trinh Hai SON (Vietnam)
Assoc. Prof. Nguyen Canh THAI (Vietnam)
Prof. Nitin TRIPATHI (Thailand)
Dr. Chu Hai TUNG (Vietnam)
Prof. Yasushi YAMAGUCHI (Japan)

WORKSHOP COMMITTEE

DAO Hoang Tung (Vietnam)
Natraj VADDADI (India)

SCIENTIFIC COMMITTEE

Dr. Tran Thi AN (Vietnam)
Dr. Tran Van ANH (Vietnam)
Dr. Vansarochana CHAIWIWAT (Thailand)
Dr. Sittichai CHOOSUMRONG (Thailand)
Dr. Nguyen Dai DONG (Vietnam)
Dr. Nguyen Duc HA (Vietnam)
Prof. Dr. Pham Hoang HAI (Vietnam)
Assoc. Prof. Dr. Nguyen Hai HOA (Vietnam)
Dr. Pham Thi HOA (Vietnam)
Assoc. Prof. Dr. Nguyen Thanh HUNG (Vietnam)
Assoc. Prof. Dr. Trinh Le HUNG (Vietnam)
Dr. Atsushi KAJIYAMA (Japan)
Prof. Dr. Vo Chi MY (Vietnam)
Dr. Tatsuya NEMOTO (Japan)
Dr. Sarawut NINSAWAT (Thailand)
Dr. Susumu NONOGAKI (Japan)
Assoc. Prof. Dr. Pham Quy NHAN (Vietnam)
Dr. Nguyen Quoc PHI (Vietnam)
Dr. Vinayaraj POLIYAPRAM (Japan)
Assoc. Prof. Dr. Nguyen An THINH (Vietnam)
Assoc. Prof. Dr. Le Thi TRINH (Vietnam)
Assoc. Prof. Dr. Pham Thi Mai THAO (Vietnam)
Assoc. Prof. Dr. Nguyen Tien THANH (Vietnam)
Assoc. Prof. Dr. Phi Truong THANH (Vietnam)
Dr. Pham Thi Mai THY (Vietnam)
Dr. Pham Hong TINH (Vietnam)
Assoc. Prof. Dr. Nguyen Nhu TRUNG (Vietnam)
Dr. Le Quang TUAN (Vietnam)
Dr. Nghiem Van TUAN (Vietnam)
Assoc. Prof. Dr. Ho Thanh VAN (Vietnam)
Assoc. Prof. Dr. Pham Thi Mai THAO (Vietnam)

TABLE OF CONTENT

1.	DETERMINATION OF THE OPTIMAL DENSITY CONTRAST IN THE SEAFLOOR DEPTH INVERSION FROM GRAVITY ANOMALIES USING THE GRAVITY-GEOLOGIC METHOD ON THE CENTRAL EAST SEA Nguyen Dinh Hai, Nguyen Van Sang, Tran Tuan Dung.....	1
2.	IMPACT OF URBANIZATION ON SEAWATER QUALITY IN QUANG NINH PROVINCE Nguyen Tran Dinh, Le Thanh Son, Nguyen Tran Dien, Vu Anh Tuan, Nguyen Hong Quang, Le Cao Khai	9
3.	FORECAST OF SUBMARINE LANDSLIDES RELATED TO THE REACTIVE PROBABILITY OF THE FAULT SYSTEM IN THE SOUTHEAST VIETNAM CONTINENTAL SHELF AND ADJACENT AREAS Tran Tuan Duong, Tran Tuan Dung, Nguyen Quang Minh, Tran Trong Lap.....	20
4.	APPLYING MACHINE LEARNING ALGORITHMS TO CLASSIFY FOREST COVER TYPE FROM SENTINEL 2 MSI DATA Trinh Le Hung, Tran Xuan Bien, Pham The Trinh, Le Van Phu.....	29
5.	EFFECTS OF THE STRONG EL NINO 2015-2016 ON THE SEA SURFACE SALINITY OVER SOUTHERN VIETNAM AS OBSERVED BY REMOTE SENSING DATA Le Van Thien.....	41
6.	RESEARCH THE APPLICATION OF TERRESTRIAL LASER SCANNING TECHNOLOGY FOR MINING MANAGEMENT (A CASE STUDY AT KHE CHAM MINE SITE, QUANG NINH PROVINCE) Nguyen Ba Dzung, Dang Tuyet Minh, Vu Quoc Lap	49
7.	APPLICATION FOR GIS TECHNOLOGY TO COMPARISON OF ORDINARY LEAST SQUARES AND GEOGRAPHICALLY WEIGHTED REGRESSION MODEL IN THE ASSESSMENT OF THE MARKET RESIDENCE LAND IN THUY VAN WARD, HUE CITY, VIETNAM Le Huu Ngoc Thanh, Nguyen Huu Ngu, Pham Thi Thao Hien, Duong Quoc Non.....	58
8.	QUANTITATIVE CORRELATION OF FRACTURE ORIENTATION DISTRIBUTION AND THEIR RELATIONSHIP WITH TECTONIC CHARACTERISTICS IN NAM DU ARCHIPELAGO AREA, KIEN HAI DISTRICT, KIEN GIANG PROVINCE, VIETNAM Phi Truong Thanh, Vu Ngoc Binh, Van Duc Tung, Nguyen Quang Minh, Do Manh Tuan, Vu Thi Hong Cam	67
9.	APPLICATION OF RANDOM FOREST ALGORITHM AND GOOGLE COLAB FOR LAND COVER CLASSIFICATION Hoa Thanh Thi Pham, Ngoc Quang Vu, Nghi Thanh Le, Nam Phuong Thi Doan.....	75

10.	ESTIMATION OF LAND SURFACE TEMPERATURE AND VEGETATION DRYNESS INDEX (TVDI) IN BAC BINH - BINH THUAN USING REMOTE SENSING IMAGES Linh Nguyen Thi Thuy, Minh Hoang Thi Nguyet, Linh Phung Thi	84
11.	COLORIZATION OF BLACK-AND-WHITE AERIAL PHOTOGRAPHS USING DEEP LEARNING FOR OBJECT-BASED IMAGE ANALYSIS LAND USE CLASSIFICATION Arunothai Waesonthea, Sarawut Ninsawat, Nitin Kumar Tripathi, Sanit Arunplod , Thantham Khamyai.....	99
12.	SPATIAL-TEMPORAL ANALYSIS OF NO2 CONCENTRATION IN BINH DUONG PROVINCE, VIETNAM Nguyen Thi Bich Ngoc, Pham Thi Mai Thy, Nguyen Le Tan Dat, Tran Thi An.....	109
13.	DEVELOPMENT OF WEB GIS FOR INVENTORY OF VIETNAM MARINE PROTECTED AREAS Van Ngoc Truc Phuong.....	117
14.	MONITORING SURFACE WATER BODIES CHANGES FROM SENTINEL-2A IMAGERY WITH MODIFIED NORMALIZED DIFFERENCE WATER INDEX: APPLICATION IN DALAT, LAM DONG, VIET NAM Trung Van Nguyen, Ha Thu Thi Le.....	125
15.	METHOD FOR FORECASTING LANDSLIDE RISKS AND IDENTIFYING LANDSLIDE FORMS FOR RESETTLEMENT AREAS OF SONLA HYDROPOWER PLANT Phung Vinh An, Nguyen Van Thang.....	135
16.	APPLICATION OF AHP MODEL TO ESTABLISH A LANDSLIDE PROBABILITY ZONING MAP IN A LUOI DISTRICT, THUA THIEN-HUE PROVINCE, VIETNAM Nguyen Thi Thuy Hanh, Quach Thi Chuc	146
17.	GEOSPATIAL OVERVIEW OF THE VEGETATION ENVIRONMENT SUGGESTED BY COMMUNITY LEVEL PLACE NAMES IN THE AREA OF NORTHEASTERN THAILAND AND NORTHERN CAMBODIA Nagata Yoshikatsu.....	160
18.	PRESENTING OF THE MILITARY TERRAIN ANALYSIS BETWEEN THAILAND AND MYANMAR'S HISTORICAL BATTLEFIELD, OVER 200 YEARS (THE 9 -ARMIES WAR) WITH GEO-INFORMATIC TECHNIQUES Kittitouch Naksri, Rangsak Ket-ord, Gistada Panumonwatee, Chaiwiwat Vansarochana	165
19.	OPTIMIZING BROILER HOUSE MANAGEMENT TO REDUCE COSTS AND REDUCE LOSSES WITH THE INTERNET OF THINGS TECHNOLOGY AND WIRELESS SENSOR NETWORK Sittichai Choosumrong, Rhutairat Hataitara, Kampanart Piyathamrongchai, Tossaporn Incharoen, Venkatesh Raghavan, Thanwamas Phasinam, Khongdet Phasinam.....	172
20.	DEVELOPMENT OF WATER LEVEL MEASURING SENSOR PROTOTYPE EQUIPMENT FOR ANALYSIS AND ALERTING FLOOD RISK SITUATIONS IN THE FORM OF A 3D SIMULATOR ON A WEB GIS APPLICATION Natima Udon, Kampanart Piyathamrongchai, Sittichai Choosumrong.....	179

21.	IMPACTS OF URBANIZATION AND POPULATION GROWTH ON LAND COVER AND COASTLINE CHANGES BASED ON REMOTE SENSING AND GIS TECHNIQUE FOR VIETNAMESE COASTAL REGIONS Le Thi Thu Hang, Nguyen Hong Quang, Vu Anh Tuan, Nguyen Manh Hung, Nguyen Thi Phuong Hao	186
22.	THREE-DIMENSIONAL BUILDING MODEL USING DRONE POINT CLOUDS Sawarin Lerk-u-suke, Phaisarn Jeefoo, Pornthep Rojanavas, Jirabhorn Chaiwongsai, Nakin Chaikaew, Bowonsak Srisungsittisunti, Niti Iamchuen, Wipop Paengwangthong, Boonsiri Sukpromsun, Watcharaporn Preedapirom Jeefoo, Pranorm Khruewan, Jiraporn Kulsoontornrat, Suchatri Prasomsuk, Chatpong Pachanaparn, Nootchararat Thawadee.....	198
23.	WEBGL-BASED VISUALIZATION TOOL FOR 3D GEOLOGICAL STRUCTURES IN SHALLOW SUBSURFACE IN URBAN AREAS Susumu Nonogaki, Tsutomu Nakazawa	208
24.	BUILDING A 3D INFORMATION MODEL FOR UNDERGROUND COAL MINES Pham Van Chung, Cao Xuan Cuong, Le Van Canh, Nguyen Quoc Long, Le Thi Thu Ha, Nguyen Viet Nghia	213
25.	DETECTION OF LAND SURFACE TEMPERATURE CHANGE IN COAL MINING AREA USING REMOTE SENSING AND GIS TECHNIQUES - A CASE STUDY IN QUANG NINH PROVINCE, VIETNAM Le Thi Thu Ha, Nguyen Van Trung.....	228
26.	A COMBINATION OF ALOS-2, SENTINEL-1 IMAGERY FOR RAPID DEFORESTATION DETECTION IN VIETNAM Ngo Duc Anh, Vu Anh Tuan, Truong Tuan Nghia.....	237
27.	TSUNAMI EVACUATION SIMULATION USING MULTI-AGENT SYSTEM: A CASE STUDY OF WAJIMA CITY, ISHIKAWA PREFECTURE, JAPAN Tatsuya Nemoto, Aoi Sato, Venkatesh Raghavan	248
28.	REMOTE SENSING APPLICATION USING GOOGLE EARTH ENGINE PLATFORM TO ASSESS CROP BURN AREAS IN WINTER-SPRING RICE CROP IN THE MEKONG DELTA, VIETNAM Tran Van Dung, Lam Dao Nguyen, Hoang Phi Phung, Dang Pham Bao Nghi, Phung Chi Sy, Pham Thi Mai Thy	253
29.	SWASH MODEL APPROACH FOR FLOWS INDUCED BY LOW-FREQUENCY WAVES OVER WOODEN FENCES Hoang Tung Dao, Ngan Vu Thi Thuy, Ngo Thi Thuy Anh	259
30.	DEM GENERATION AND TOPOGRAPHIC CHANGES OF CENTRAL HANOI, VIETNAM Go Yonezawa, Tatsuya Nemoto, Xuan Luan Truong, Susumu Nonogaki, Do Thi Hang, Muneki Mitamura, Venkatesh Raghavan	268

31. DISTRIBUTION, FATE AND ECOLOGICAL TOXICITY OF SOME HEAVY METALS IN SEDIMENT: A CASE STUDY FROM DAY RIVER DOWNSTREAM, VIETNAM
Nguyen Khanh Linh, Trinh Thi Tham, Kieu Thi Thu Trang, Trinh Thi Thuy, Nguyen Thi Linh Giang, Luu Duc Hai, Tu Binh Minh, Le Thi Trinh 274
32. MANGROVE DEGRADATION ASSESSMENT USING WORLDVIEW-2 IMAGERY FOR MEKONG DELTA, VIETNAM
Pham Hong Tinh, Tran Dang Hung, Richard A. MacKenzie, Truong Van Vinh, Bui Thanh Huyen, Mai Huong Lam, Nguyen Thi Hong Hanh 285
33. UTILIZATION OF BOREHOLE DATA FOR CORRELATION SYSTEM OF STRATA: A CASE STUDY OF HANOI, VIETNAM
Kenichi Sakurai, Go Yonezawa, Luan Xuan Truong, Tatsuya Nemoto, Shinji Masumoto.. 293
34. DROUGHT MONITORING USING MODIS DATA AND THE GOOGLE EARTH ENGINE PLATFORM, CASE STUDY IN DAK LAK PROVINCE
Nguyen Ngoc Anh, Hoang Ngoc Khac, Tran Thi Ngoc Lam, Vu Thi Thuy Ngan 301
35. THAILAND COVID-19 CASE FATALITY SPATIAL CLUSTER AND DIRECTION ANALYSIS
Athitaya Sakunmungmee, Tanyaluck Chansombat, Pathana Rachavong 309
36. APPLICATION OF REMOTE SENSING AND GIS TO ESTABLISH SURFACE TEMPERATURE MAP OF PHU THO PROVINCE
Tran Thi Ngoan..... 316
37. THE ROLE OF OROGRAPHIC EFFECTS ON HEAVY RAINFALL EVENT OVER CENTRAL VIETNAM IN OCTOBER 2021
Phong Le Van, Phong Nguyen Binh, Thuong Le Thi 322
38. INVESTIGATE SAR INTENSITY AND OPTICAL IMAGES TO RAPIDLY DETECT SMALL AND MEDIUM LANDSLIDES IN MU CANG CHAI DISTRICT YEN BAI PROVINCE
Xuan Quang Truong, Van Anh Tran, Cam Chi Nguyen, Manh Dat Truong, Chi Cong Nguyen, Thi Phuong Anh Dao, Thi Thanh Thuy Pham..... 333
39. REGIONAL POST-EARTHQUAKE DAMAGE ESTIMATION USING GAUSSIAN GEOSTATISTICAL SIMULATION
Sunanthacha Pholkerd, Pathana Rachavong, Tanyaluck Chansombat..... 341
40. BA LAT DELTA EVOLUTION IN RESPONSE TO CHANGING FLUVIAL SEDIMENT SUPPLY BY THE RED RIVER, VIETNAM
Nguyen Hao Quang, Ha Nam Thang, Nguyen Van An, Nguyen Thanh Luan..... 348
41. SPATIAL PATTERN ANALYSIS OF THE SPREAD OF SARS-COV-2 VARIANT IN HANOI CITY, VIETNAM
Thi Quynh Nguyen..... 357
42. A NOVEL APPROACH OF NEURAL NETWORKS AND USLE IN SMART SOIL EROSION MODELING, CASE STUDY IN SOUTHERN COASTAL OF VIET NAM
Tran Thi Hoa, Tran Thanh Ha, Luan Cong Doan, Thu Minh Phan, Hung Van Nguyen 369

43.	ASSESSMENT OF THE DYNAMIC IMPACT OF DEBRIS FLOW ON STRUCTURE SAFETY: A CASE STUDY OF CHECK DAM IN VIETNAM	
	Nguyen Chi Thanh, Vu Quoc Cong, Vu Le Minh, Do Van Chinh, Tran Thi Nga, Luyen Le Dieu Linh	380
	COLLECTION OF ABSTRACTS	390

DETERMINATION OF THE OPTIMAL DENSITY CONTRAST IN THE SEAFLOOR DEPTH INVERSION FROM GRAVITY ANOMALIES USING THE GRAVITY-GEOLOGIC METHOD ON THE CENTRAL EAST SEA

Nguyen Dinh Hai¹, Nguyen Van Sang^{2*}, Tran Tuan Dung^{3,4}

¹Vietnam's People Naval Hydrographic and Oceanographic Department, Hai Phong, Vietnam

²Hanoi University of Mining and Geology, Hanoi, Vietnam

³Institute of Marine Geology and Geophysics, VAST, Vietnam

⁴Graduate University of Science and Technology, Vietnam Academy of Science and Technology

*Corresponding author. Email: nguyenvansang@humg.edu.vn

ABSTRACT

In the seafloor depth inversion from gravity anomalies using the Gravity-Geologic Method, the density contrast between the seawater and the ocean bottom topographic mass needs to be determined. In this study, the iteration method was applied to determine the optimal density contrast. Firstly, a density contrast is given. Then, the seafloor depths are calculated and compared with the shipborne depths. In the next step, change the density contrast and repeat the calculation. Finally, the optimal density contrast is determined corresponding to the smallest deviation between the gravity anomaly-derived depths and the shipborne depths. The experiment calculations were carried out on the central East Sea with eight density contrast values, which varied from 1.10 g/cm³ to 3.0 g/cm³. The results show that the optimal density contrast in the study area is 1.40 g/cm³.

1. INTRODUCTION

The world's oceans cover 71 % of the Earth's surface. Despite many attempts to measure, to date, only about 18 % of the ocean's area has been measured using echosounders (Wölfl, 2019). Measuring the entire ocean by direct depth measurement method is very difficult and expensive in terms of money and time.

Vietnam is a country with a coastline of up to 3260 km, a territorial sea area of over 64000 km² and an exclusive economic zone of nearly 1 million km². Seas and islands play an important role in the economic development of the country, security and defense work and international exchanges (Dang, 2008). Up to now, Vietnam has only established charts of 1:200,000 scale with about 53 % of the area of Vietnam's seas; completed seabed topographic surveys of about 24.5 % of Vietnam's sea area at the scales from 1:500,000 to 1:50,000 (Ministry of Natural Resources and Environment, 2019). Thus, there is still a large area of the East Sea that has not been measured and mapped. Measuring depth over the entire East Sea by direct measurement method is very difficult and expensive, especially not possible for the sea areas that are not directly accessible. In that context, indirect methods of depth determination need to be studied and applied. The Gravity Geologic Method (GGM) is one such indirect method.

In the GGM, it is very important to determine the optimal density contrast (DC) between the seafloor matter and seawater. Different seas have different density contrast. Globally, there

are some studies to determine the optimal density contrast: In the study (Yeon et al., 2018), the determined optimal contrast density over Korean waters is 5.0 g/cm^3 . In the reference (Yu et al., 2011), the Downward Continuation Method (DWC) was used to determine density contrast in two study areas in southern Greenland. The results of this study show that the optimal density contrast in the first experimental area is 1.47 g/cm^3 and in the second area is 1.30 g/cm^3 .

In this study, the iterative method will be studied and applied to determine the optimal density contrast for the area in the center of the East Sea.

2. STUDY AREA AND DATA

2.1 Study area

The study area is located in the center of the East Sea, between latitudes 8°N and 14°N and longitudes 110°E and 115°E (Figure 1), covering an area of about $363,000 \text{ km}^2$. This is an area located on the margin of the sea with diverse and complex architecture that has undergone a special geological development process, attracting the attention of many geophysicists and geologists in the world and abroad. The seafloor topography of the study area is diverse and complex. The Southeast of the study area is the sea of the Spratly Islands, with many submerged and floating islands. The Northeast of the study area is a deep depression of the East Sea, with the greatest depth is nearly $5,000 \text{ m}$. The Western side of the study area is the continental slope, with a depth of about $1,000 \text{ m}$ to $2,000 \text{ m}$, a steep slope (Bui et al., 2005).

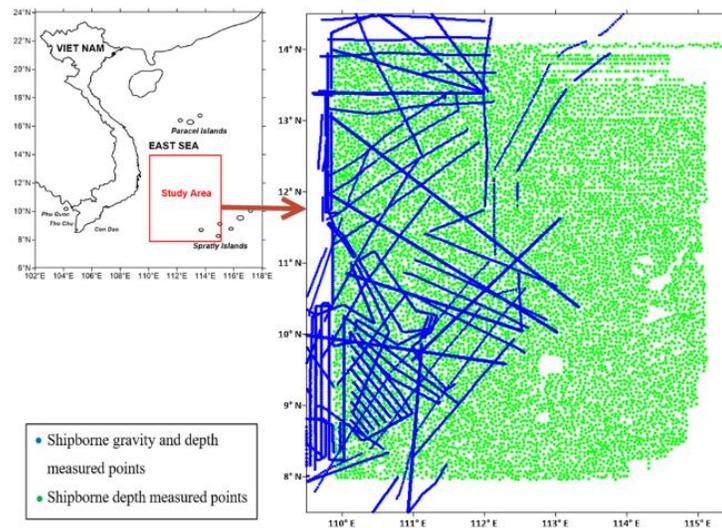


Figure 1. Study area and data.

2.2 Data used

2.2.1 Satellite-derived gravity anomaly data

In this study, the DTU17GRAV model is used. This is a model of the global marine gravity field, determined from satellite altimeter data and provided by the Technical University of Denmark (DTU) (Andersen et al., 2020). The gravity anomalies of this model are in the form of a square grid with a mesh size is $1 \text{ inch} \times 1 \text{ inch}$. The coordinates of this model are in the World Geodetic System WGS84. Over

the study area, a total of 151,200 gravity anomalous values of this model were used. The maximum gravity value is 135.40 mGal; the smallest is -53.70 mGal; and the average of 9.98 mGal.

2.2.2 Shipborne gravity and depth data

In this study, the 19,226 points, measured simultaneous gravity and depth, were used (blue points in Figure 1). These data were measured in 1987, 1990 and 1992 in cooperation projects between Vietnam and Russia and Vietnam and France in the East Sea, specifically as follows: the geophysical surveying project was implemented in 1987; the survey project of the Gagarinsky ship carried out in 1990-1992; the survey project of the Atalante ship carried out in 1993. These data have high reliability, the parameters are very clear and the gravimetric accuracy is ± 1 mGal (Bui et al., 2008). The coordinates of the measured points are in the World Geodetic System WGS-84. These data cover more than 0.5° study area.

2.2.3 Shipborne depth data

The shipborne depth data consists of 9,403 points (green points in Figure 1), measured by the Vietnamese Navy using a single-beam echosounder in 2009 and a multi-beam echosounder from 2010 to 2016. The measurement and process were carried out according to the standards of the International Hydrographic Organization (IHO). The coordinates of the measured points are in the WGS-84 (Khuong, 2018). The depths have been converted to the mean sea level of Vietnam based on the data of the tidal stations. It is important to note that the 9,403 points have the depth value only. Therefore, the gravity anomaly value for these points was further determined using the DTU17GRAV model.

The summary of the data used in this study is presented in (Table 1).

Table 1. Summary of the data used in this research.

No.	Data	Coverage (φ : latitude, λ : longitude)	Number of points
1	DTU17GRAV model	$7.5^\circ \leq \varphi \leq 14.5^\circ$; $109.5^\circ \leq \lambda \leq 115.5^\circ$	151,200
2	Shipborne gravity and depth measured points	$7.5^\circ \leq \varphi \leq 14.5^\circ$; $109.5^\circ \leq \lambda \leq 115.5^\circ$	19,226
3	Shipborne depth measured points	$7.5^\circ \leq \varphi \leq 14.5^\circ$; $109.5^\circ \leq \lambda \leq 115.5^\circ$	9,403

2.2.4 Data preparation

A total of 28,629 shipborne points were used, including 19,226 points measured in the period of 1987, 1990-1993 and 9,403 points measured in the period of 2009-2016. After processing, these points have both depth and gravity anomaly values. For analysis, these 28,629 shipborne points were further randomly divided into two parts (Figure 2): Part 1 consisted of 14,404 points (black points in Figure 2) and was used to compute the seafloor depths. While Part 2 contained 14,225 points (red points on Figure 2) and was employed for estimating the accuracy of the depths.

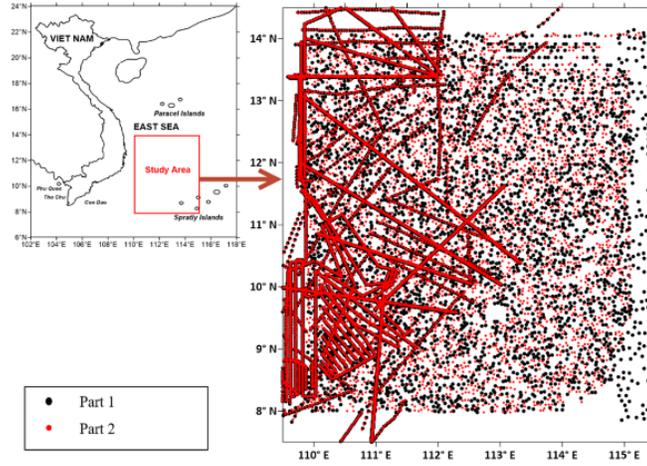


Figure 2. Shipborne data preparation.

3. THE METHOD OF DETERMINING THE OPTIMAL DENSITY CONTRAST IN THE SEAFLOOR DEPTH INVERSION FROM GRAVITY ANOMALIES

3.1 Principle of the seafloor depths inversion from gravity anomalies

To determine the depth of the gravity anomalies, according to studies (Yeon et al., 2018), (Yu et al., 2011), (Xueshuang et al., 2017), the gravity anomaly (Δg) is divided into 2 parts: the long-wavelength gravity anomaly (Δg^{long}) associated with deep and wide seafloor matter; and the short-wavelength gravity anomaly (Δg^{short}) related to the convexity of the seafloor topography.

For the points where the gravity anomalies and depths were known simultaneously, the short wavelength gravity anomaly is calculated using the equation:

$$\Delta g^{short} = 2\pi G\delta(D^{ship} - D_{max}) \quad (1)$$

where: G is the gravitational constant ($6,672 \times 10^{-8} \text{cm}^3/\text{gs}^2$); δ is the density contrast between the seawater and the ocean bottom topographic mass; D^{ship} is the shipborne seafloor depth; D_{max} is the maximum depth of the seafloor in the study area.

Then, the long-wavelength gravity anomaly is calculated by the equation:

$$\Delta g^{long} = \Delta g^{ship} - \Delta g^{short} \quad (2)$$

For the points where only gravity anomalies are known, depths should be determined (points of the DTU17GRAV model have been fitted with shipborne gravity anomaly, Δg^{fit}) and long-wavelength gravity anomalies are interpolated from the available points (Δg_{int}^{long}). Then, the short wavelength gravity anomalies of these points are calculated:

$$\Delta g^{short} = \Delta g^{fit} - \Delta g_{int}^{long} \quad (3)$$

The gravity anomaly-derived depth (D^{grav}) can be calculated using the equation:

$$D^{grav} = \frac{\Delta g^{short}}{2\pi G\delta} + D_{max} \quad (4)$$

3.2 Determination of the optimal density contrast between the seawater and the ocean bottom topographic mass by iterative method

To determine the optimal density contrast, the seafloor depth inversion from gravity anomalies is performed iteratively several times. At each time, a different density contrast is used: (1) First, a theoretically consistent density contrast value is given; (2) Next, the gravity anomaly-derived seafloor depths are calculated and compared with the shipborne seafloor depths to estimate the accuracy of these depths. Then, the density contrast value is changed and the calculation process is repeated. Finally, the optimal density contrast is determined corresponding to the smallest deviation between the gravity anomaly-derived depth and the shipborne depth. In other words, the accuracy of gravity depth is the best. The comparison between the gravity anomaly-derived depth with the shipborne depth is made as follows (Nguyen, 2023):

Depth deviations are calculated according to the equation:

$$\delta D_i = D_i^{grav} - D_i^{ship}, i = 1, 2, \dots, n; \quad (5)$$

where: n is the number of shipborne depth points; D_i^{ship} is the shipborne depth; D_i^{grav} is the gravity anomaly-derived depth.

The average depth deviation is calculated according to the equation:

$$\delta D_{ave} = \frac{1}{n} \sum_{i=1}^n \delta D_i \quad (6)$$

Standard deviation of the depth:

$$STD = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (\delta D_i - \delta D_{ave})^2} \quad (7)$$

Root mean square of the deviation:

$$RMSD = \sqrt{\frac{1}{n} \sum_{i=1}^n \delta D_i^2} \quad (8)$$

The Pearson correlation coefficient between the gravity anomaly-derived depths and the shipborne depths (McKean et al., 2003):

$$R = \frac{\sum_{i=1}^n (D_i^{ship} - D_{ave}^{ship}) \cdot (D_i^{grav} - D_{ave}^{grav})}{\sqrt{\sum_{i=1}^n (D_i^{ship} - D_{ave}^{ship})^2 \cdot \sum_{i=1}^n (D_i^{grav} - D_{ave}^{grav})^2}} \quad (9)$$

Based on the root mean square of the deviation (RMSD), the standard deviation (STD), the Pearson correlation coefficient (R), the average depth deviation (δD_{ave}), the maximum deviation and the minimum deviation between the gravity anomaly-derived depths and shipborne depths and the optimal density contrast is selected in the study area.

4. RESEARCH RESULTS

According to the theory presented above, the experiments were performed with different density contrast options. Since the theoretical density contrast is 1.67 g/cm^3 , the density contrast was investigated from 1.10 g/cm^3 . The density contrast value in the next calculation time is determined based on the results of the previous calculation time, with the target being to minimize the *RMSD* value and maximize the *R* values. To find the optimal density contrast, the eight experimental options were calculated. The experimental results are summarized and presented in (Table 2).

Table 2. Summary results of the experimental options.

Expe. Options	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8
DC (g/cm^3)	1.10	1.20	1.30	1.40	1.50	1.67	2.0	3.0
(m)	849.3	887.2	918.8	944.3	964.9	1,012.9	1,075.1	1,148.5
(m)	-913.7	-931.7	-948.5	-964.0	-972.9	-991.9	-1,023.7	-1,137.0
(m)	-1.5	-1.4	-1.3	-1.2	-1.1	-1.1	-1.0	-0.9
<i>RMSD</i> (m)	± 87.9	± 86.4	± 85.7	± 85.5	± 85.9	± 86.5	± 87.7	± 90.8
<i>STD</i> (m)	± 87.9	± 86.4	± 85.7	± 85.5	± 85.9	± 86.5	± 87.7	± 90.7
R	0.99679	0.99691	0.99697	0.99699	0.99697	0.99693	0.99685	0.99663

The chart of *RMSD* according to the experimental options is shown in (Figure 3).

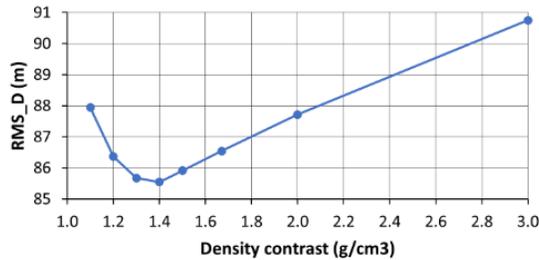


Figure 3. RMSD chart of the experimental options.

The chart of the Pearson correlation coefficient (*R*) according to the experimental options is presented in (Figure 4).

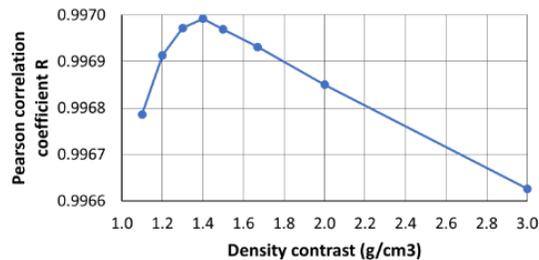


Figure 4. R chart of the experimental options.

The results of (Table 2), (Figure 3) and (Figure 4) show that as the contrast density (*DC*) increases from 1.10 g/cm^3 to 1.40 g/cm^3 , the *RMSD* decreases from $\pm 87.9 \text{ m}$ to $\pm 85.5 \text{ m}$, the Pearson

correlation coefficient increases from 0.99679 to 0.99699. As the contrast density continued to increase from 1.40 g/cm³ to 3.0 g/cm³, the *RMSD* increased from ±85.5 m to ±90.8 m and the Pearson correlation coefficient decreased from 0.99699 to 0.99663. These results prove that the optimal density contrast in the study area is 1.40 g/cm³.

5. CONCLUSION

The iterative method has been studied and applied to determine the optimal density contrast in the seafloor depth inversion from the gravity anomalies on the central East Sea. First, the density contrast is assigned a theoretically appropriate value. Then, the seafloor depths were calculated from the gravity anomalies corresponding to the given density contrast. Gravity anomaly-derived depths are compared with shipborne depths to evaluate their accuracy. Next, based on the accuracy evaluation results of the previous step to, change the density contrast value and repeat the calculation process. Finally, the optimal density contrast is selected based on the results of the accuracy evaluation of the experimental options.

From the experimental results of the eight options, the optimal density contrast on the central East Sea was selected as 1.40 g/cm³. Corresponding to this optimal density contrast shows that the root mean square deviation is the smallest, *RMSD* = ±85.5 m and the Pearson correlation coefficient between gravity anomaly-derived depths and shipborne depths is the largest, *R* = 0.99699.

6. ACKNOWLEDGMENTS

The authors wish to thank the Vietnam National Project ĐTĐLCN.07/23, Project B2021-MDA-06 and the Scientific Contract 07/2021/Đ6-DATS (belong to the Project of General investigation of meteorology, oceanographic, geological and environmental factors in the Spratly area at scale 1:200.000) for funding this research.

7. REFERENCES

- Andersen O. B., and Knudsen P., 2020. The DTU17 Global Marine Gravity Field: First Validation Results. In S. P. Mertikas, & R. Pail (Eds.), *Fiducial Reference Measurements for Altimetry* (pp. 83-87). Springer: *International Association of Geodesy Symposia*. Vol.150. https://doi.org/10.1007/1345_2019_65.
- Bui Cong Que, Tran Tuan Dung, 2005. Building a map of basic features of natural and environmental conditions in Vietnam and adjacent waters. *State-level thesis summary report, code KT-09-02*. Marine Research Program KT-09, Hanoi. Vietnam.
- Bui Cong Que, Tran Tuan Dung, Le Tram, 2008. Establishing a unified gravity anomaly map on the waters of Vietnam and adjacent. *Journal of marine science and technology*. No. 2, 29-41.
- Dang Nam Chinh, 2008. Research to complete the technical criteria and the technological process of the marine surveying in Vietnam. *Ministry-level Science and Technology Project, code B-2007-02-35*. Ministry of Education and Training. Vietnam.
- Khuong Van Long, 2018. Application of marine surveying technology and development orientation of the marine surveying industry after 2020. *Collection of reports of the National Conference on Science and Technology of Surveying and Cartography*. Vietnam Map and Resources Publishing House, ISBN: 978-604-952-272-7.
- McKean J. W. and Sheather S. J., 2003. *Statistic, Nonparametric*. in R. A. Meyers Editor, *Encyclopedia of Physical Science and Technology (Third Edition)* New York: Academic

Press, 891-914.

- Ministry of Natural Resources and Environment, 2019. Summary of “Master project on basic investigation and management of marine natural resources and environment to 2010, vision to 2020”. *Electronic newspaper of Natural Resources and Environment*.
- Nguyen Van Sang, 2023. Research and propose a method to determine seafloor depth from gravity anomaly data in the East Sea area, code: B2021-MDA-06. *Ministry level project*, Ministry of Education and Training, Hanoi, Vietnam.
- Wölfel, A.-C., Snaith, H., Amirebrahimi, S., 2019. Seafloor mapping-the challenge of a truly global ocean bathymetry. *Frontiers in Marine Science*, 283. <https://doi.org/10.3389/fmars.2019.00283>.
- Xueshuang Xiang, Xiaoyun Wan, Running Zhang, Yang Li, Xiaohong Sui and Wenbin Wang, 2017. Bathymetry inversion with Gravity-Geologic Method: A study of long-wavelength gravity modeling based on adaptive mesh. *Marine Geodesy*. ISSN: 0149-0419 (Print) 1521-060X (Online). Doi: 10.1080/01490419.2017.1335257.
- Yeon Yeu, Jurng-Jae Yee, Hong Sik Yun and Kwang Bae Kim, 2018. Evaluation of the Accuracy of Bathymetry on the Nearshore Coastlines of Western Korea from Satellite Altimetry, Multi-Beam and Airborne Bathymetric LiDAR. *Sensors, MDPI*. Doi:10.3390/s18092926.
- Yu-Shen Hsiao, Jeong Woo Kim, Kwang Bae Kim, Bang Yong Lee and Cheinway Hwang, 2011. Bathymetry Estimation Using the Gravity-Geologic Method: An Investigation of Density Contrast Predicted by the Downward Continuation Method. *Terr. Atmos. Ocean. Sci.*, Vol. 22, No. 3, 347-358. Doi: 10.3319/TAO.2010.10.13.01.

PUBLISHING HOUSE FOR SCIENCE AND TECHNOLOGY
A16, 18 Hoang Quoc Viet Road, Cau Giay, Ha Noi
Marketing & Distribution Department: **024.22149040**;
Editorial Department: **024.37917148**
Administration Support Department: **024.22149041**
Fax: **024.37910147**, Email: **nxb@vap.ac.vn**; Website: **www.vap.ac.vn**

GIS IDEAS
PROCEEDINGS INTERNATIONAL CONFERENCE GIS-IDEAS 2023
GEOSPATIAL INTEGRATED TECHNOLOGIES
FOR NATURAL HAZARDS AND ENVIRONMENTAL PROBLEMS

Hanoi University of Natural Resources and Environment,
Vietnam 07-09 November 2023

Hanoi University of Natural Resources and Environment (HUNRE)
Osaka Metropolitan University (OMU)
Japan-Vietnam Geoinformatics Consortium (JVGC)

Responsible for Publishing

Director, Editor in Chief

PHAM THI HIEU

Editors: **Nguyen Van Vinh, Nguyen Thi Chien**
Ha Thi Thu Trang

Computing Technique: **Nguyen Duc Manh**

Cover design: **Tran Thu Hien**

Corporate publishing:

Hanoi University of Natural Resources and Environment

Address: 41A Phu Dien Road, Phu Dien Ward, Bac Tu Liem District, Ha Noi

ISBN: 978-604-357-207-0

Printing 400 copies, size 20,5 × 29,5 cm, printed at Consulting Publishing and Media Viet Joint Stock Company. Address: No. 4/20, Lane 156 Hong Mai, Bach Mai Ward, Hai Ba Trung District, Ha Noi City, Vietnam.

Registered number for Publication: 3759-2023/CXBIPH/01-42/KHTNVCN.

Decision number for Publication: 87/QĐ-KHTNCN was issued on 15 December 2023.

Printing and copyright deposit were completed in the 4th quarter, 2023.



Organized by

Hanoi University of Natural Resources and Environment
The Japan - Vietnam Geoinformatics Consortium (JVGC)

Osaka Metropolitan University

<https://gis-ideas.org/2023/>

ISBN: 978-604-357-207-0



9 786043 572070

NOT FOR SALE