別紙　HP 公開資料

インドネシア スンダ海峡津波関連
国際緊急共同研究・調査支援プログラム（J-RAPID）
終了報告書　概要

１．研究課題名：「地震・津波・衛星画像データ解析による 2018 年スンダ海峡津波発生メカニズムの解明」

２．研究期間：2019 年 4 月～2020 年 3 月

３．主な参加研究者名：

日本側（研究代表者を含め６名までを記載）

	氏名	役職	所属	研究分担
研究代表者	綿田 辰吾	准教授	東京大学地震研究所	地震波解析
共同研究者	矢来 博司	研究室長	国土地理院	衛星画像解析
共同研究者	小林 知勝	主任研究官	国土地理院	衛星画像解析
共同研究者	Iyan Mulia	特任研究員	東京大学地震研究所	津波解析
共同研究者	Tungcheng Ho	JSPS研究員	京都大学	津波解析
研究期間中の全参加研究者数　５名				

相手側（研究代表者を含め６名までを記載）

	氏名	役職	所属	研究分担
研究代表者	Sri Widiyantoro	Professor	Bandung Institute of Technology (ITB)	地震波解析
共同研究者	David P. Sahara	Lecturer	ITB	地震波解析
共同研究者	Mirzam Abdurrachman	Lecturer	ITB	地震波解析
共同研究者	Hendra Gunawan	Research Associate	Geological Agency	火山モデリング
共同研究者	Andri Dian Nugraha	Lecturer	ITB	地震波解析
共同研究者	Zulfakriza	Lecturer	ITB	地震波解析
研究期間中の全参加研究者数　６名				

４．共同研究調査の目的

スンダ海峡津波は強い地震動を伴わなかったため、津波に対する注意の喚起はなく、津波が沿岸部を突然襲った。一方、津波到達の 30 分以上前に山体崩壊と共に発生した長周期地震動がスンダ海峡周辺のみならず、インドネシア国内外の地震計に記録されている。長周期地震動は微弱であるため人体には感じられなかった。本研究では、地震・津波・衛星画像データからアナク・クラカトア火山山体崩壊の統一的モデルを構築すると共に、長周期地震動の迅速な解析手法を発展させ、山体崩壊のような長周期地震動を伴う現象の連続モニタリングを可能にする技術を開発する。

５．共同研究調査の成果

５－１　共同研究調査の成果、被災地復興や今後の防災・減災への貢献

地震・津波・衛星画像データからアナク・クラカトア火山山体崩壊の統一的モデルを構築された。長周期地震動の迅速な解析手法を発展させ、山体崩壊のような長周期地震動を伴う現象の連続モニタリングを可能にする技術は開発された。それは、人体に感じることがない長周期地震波の連続モニタリングにより火山島山体崩壊のよう災害現象を把握する基本技術が確立されたと言ってよい。高精度の津波シミュレーションにより、山体崩壊による津波の定量的推定（到達時刻、浸水高）などが可能になった。

５－２　国際連携の成果

今回の研究交流を通じて、インドネシア側には若く優秀な研究者が多く人材が豊富なことが理解できた。今後は地震研究所の国際招聘事業や、学術振興会の研究者長期招聘事業などを利用して、研究交流や人材育成を継続して実施する。

６．本研究調査に関連したワークショップ等の開催、主な口頭発表・論文発表・その他成果物（例：提言書、マニュアル、ハザードマップ、プログラム、特許）、受賞等（5 件まで）

発表	口頭発表：綿田、「2018スンダ海峡津波の発生メカニズム」、日本地震学会
発表	口頭発表：Watada, S., ″The 2018 Sunda Strait Tsunami Caused by the Edifice Collapse of Anak Krakatau Volcano″, AGU, サンフランシスコ
論文	Ho Tung-Cheng, Kenji Satake, Shingo Watada, Ming-Che Hsieh, Ray Y. Chuang, Yosuke Aoki, Iyan E. Mulia1, Aditya Riadi Gusman, Chih-Heng Lu, Tsunami Induced by the Strike-Slip Fault of the 2018 Palu Earthquake (Mw=7.5), Sulawesi Island, Indonesia, JGR
論文	Iyan E. Mulia, Shingo Watada, Tung-Cheng Ho, Kenji Satake, Yuchen Wang, Arif Aditya, Simulation of the 2018 tsunami due to the flank failure of Anak Krakatau Volcano and recommendation for future observing systems, GRL

Attachment to be posted on HP

International Urgent Collaborative Projects
Regarding the Sunda Strait tsunami in Indonesia within the J-RAPID Program

1. Title of the Project : " Seismic, tsunami and satellite image analyses to study the generation mechanism of the 2018 Sunda Strait tsunami "
2. Research/Investigation Period : 2019.4 ～ 2020.3
3. Main Investigators :

Japanese Team (up to 6 people including Principal Investigator)

	Name	Title	Affiliation	Project role
Principal Investigator	Shingo Watada	Associate Professor	University of Tokyo, ERI	Seismic analysis
Collaborator	Hiroshi Yarai	Division Director	Geospatial Information Authority	SAR analysis
Collaborator	Tomokazu Kobayashi	Senior Researcher	Geospatial Information Authority	SAR analysis
Collaborator	Iyan Mulia	Project Scientist	University of Tokyo, ERI	Tsunami analysis
Collaborator	Tungcheng Ho	JSPS postdoctor	Kyoto University, DPRI	Tsunami analysis
Total Number of participating researchers in the project:5				

Counterpart Team (up to 6 people including Principal Investigator)

	Name	Title	Affiliation	Project role
Principal Investigator	Sri Widiyantoro	Professor	Bandung Institute of Technology (ITB)	Seismic analysis
Collaborator	David P. Sahara	Lecturer	ITB	Seismic analysis
Collaborator	Mirzam Abdurrachman	Lecturer	ITB	Seismic analysis
Collaborator	Hendra Gunawan	Research Associate	Geological Agency	Volcano modeling
Collaborator	Andri Dian Nugraha	Lecturer	ITB	Seismic analysis
Collaborator	Zulfakriza	Lecturer	ITB	Seismic analysis
Total Number of participating researchers in the project:6				

4. Objectives and Challenges

On December 22, 2018 without any strong ground shaking, disastrous tsunami suddenly hit the coast of Java and Sumatra islands near the Sunda Strait in Indonesia and claimed more than 400 lives. The tsunami was coeval with the Anak Krakatau volcano eruption. SAR satellite images show the topographical change of the island shape and relief. These observations suggest that an edifice collapse of Anak Krakatau volcano accompanied subareal and submarine landslides that generated the tsunami. A lack of strong ground shaking lead to no detection of a large earthquake in the area and no

tsunami waning was issued near the Strait.

Broadband seismograms recorded in Indonesia, however clearly indicate that a slow seismic event occurred about 30 min before the tsunami hit the coast. The long-period ground motion was likely caused by the landslide near the Anak Krakatau volcano. The long-period seismic waves were also detected outside Indonesia. The landslide-induced tsunamis were recorded by four tide gauges near the Strait. The change of surface morphology of the island has been recorded in the SAR satellite images taken before and immediately after the tsunami.

By analyzing the recorded seismic waveforms and we can determine a force model exerted on the earth as a reaction of the landslide. By assuming a motion submarine landslide the volume of the landslide can be estimated as a submarine tsunami source. A combined landslide physical model that explains the seismic and tsunami data can be constructed with constraints from subaerial SAR images.

If long-period seismic events were routinely monitored in Indoneisa, we could have detected the edifice collapse of the Anak Krakatau volcano and were aware of the possibility of tsunami generation prior to the arrivals of disastrous tsunami to the coasts. In this study we develop a technique to detect and model the landslide from seismic waveform analyses.

５. Results of the research/survey activities

５-1. Contribution to the rehabilitation of the disaster affected areas and the disaster risk reduction management.

We have constructed a kinematic model of the 2018 edifice collapse model of Anak Krakatau volcano from by using the seismic, tsunami and satellite image data. We developed a seismological analysis technique to monitor catastrophic landslides from continuous seismic recordings. We have succeeded to quantitatively estimate travel times and flow depth of the tsunamis based on the tsunami simulations.

５-2. Added Value from International collaborative work

We have learned through the academic communication with the Indonesian counterpart that there are many young talented scientists in Indonesia. In the future, we try to continue academic exchange and to develop human resources by using the international invitation program of the Earthquake Research Institute University of Tokyo and the long-term researcher invitation program of the Japan Society for the Promotion of Science.

6. Organized workshops/seminars, presentations, papers and other deliverables

Presentation	S. Watada, “The Mechanism of the 2018 Sunda Strait Tsunami”, Fall meeting of the Seismological Society of Japan
Presentation	S. Watada, ″The 2018 Sunda Strait Tsunami Caused by the Edifice Collapse of Anak Krakatau Volcano″, AGU fall meeting
Paper	Ho Tung-Cheng, Kenji Satake, Shingo Watada, Ming-Che Hsieh, Ray Y. Chuang, Yosuke Aoki, Iyan E. Mulia1, Aditya Riadi Gusman, Chih-Heng Lu, Tsunami Induced by the Strike-Slip Fault of the 2018 Palu Earthquake (Mw=7.5), Sulawesi Island, Indonesia, JGR
Paper	Iyan E. Mulia, Shingo Watada, Tung-Cheng Ho, Kenji Satake, Yuchen Wang, Arif Aditya, Simulation of the 2018 tsunami due to the flank failure of Anak Krakatau Volcano and recommendation for future observing systems, GRL