Use of high-frequency, high-definition topographic 3D data to develop geographic thinking of students

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Abstract

Various teaching methods including classroom lectures, physical experiments, and field excursions are useful for students to learn and understand the basic concepts of geography and earth sciences. However, due to constraints in the current curriculum of geographic education in Japanese schools, physical experiments and field excursions are rarely conducted, and classroom lectures tend to focus on memorizing some technical terms. This environment is not ideal for teaching processes and mechanisms of geographic phenomena. High-frequency, high-definition topographic data obtained using a TLS (Terrestrial Laser Scanner) and SfM-MVS photogrammetry with a UAS (Unmanned Aerial System) have become popular in geoscience. Those surveying approaches allow us to directly monitor rapidly changing landforms, while we can also use the obtained data to visualize geographic phenomena by various methods and materials including 3D print models, 3D virtual models, pictures, videos, and virtual/mixed reality. Here we explore the use of high-frequency, high-definition topographic data for educating geographic thinking. We arranged and conducted experimental teaching classes for elementary school students. First, we showed two 3D print models of the same sea cliff for years 2015 and 2017 constructed form high-definition topographic data. When students touched the two models, they were able to feel topographic changes due to erosion and sedimentation effectively. Furthermore, after exploring the 3D print models, many students were able to imagine how the sea cliff would change in the future. Next, we showed two images of fluvial deposits along a river segment in the area where the students live for July 2017 and September 2017. Then, they were able to imagine the transportation force of river flow. They also understood that the river flows typically in quiet but becomes powerful at high flow to move more sediment, and it might cause a disaster. Such visualized and touchable learning materials derived from high-frequency, high-definition topographic data enable students to enhance their geographic imagination of landforms, which are familiar to them but unexpectedly changing, at appropriate spatial and time scales.

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Introduction

To learn and understand basics of earth science and geography, various teaching materials and approaches including indoor experiments and presentation of outdoor photographs are necessary in addition to lectures. However, due to the constraints in the curriculum of geographic education in Japan, memorizing technical words is more focused than understanding the nature and mechanisms of geographical phenomena. High-frequency, high-definition topographic 3D data obtained from SfM-MVS photogrammetry by UAS (Unmanned Aerial System) and TLS (Terrestrial Laser Scanner) have widely been used in recent years, which enables to monitor rapid changes in landforms. Also, we can use them to visualize in various ways: three dimensional (3D) print models, 3D virtual models, videos, and pictures. In this research, we examine how students can expand their geographical imagination from high frequency, high definition topographic 3D data and their derivatives. We show two case studies and propose the effective use of high-frequency, high-definition topographic 3D data in classrooms.

Study area 1 ~Taya Cave~

○Taya Cave

- Designated as a cultural property of Yokohama City
- Being damaged and visitors due to weathering

○Preservation committee of Taya cave

- Conduct classes introducing conservation activities at Senshu elementary school
- Practice of building a landform model of surrounding landscape in “Satoyama” of Taya

⇒Evocation of geographical thinking

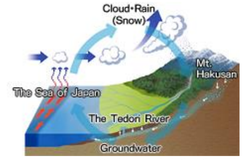
Study area2 ~Tedori River~

○Tedori River

- 72 km long
- Draining from Mt. Hakusan
  ⇒Steep gradient
- Facing the Sea of Japan
  ⇒Heavy snowfalls in winter

○Hakusan Tedori-River Geopark

- Thematic Story:
  “Trip of water and stones”
- Three Geosites
  - Mountain and Snow Area
  - River and Gorge Area
  - Sea and Alluvial Fan Area



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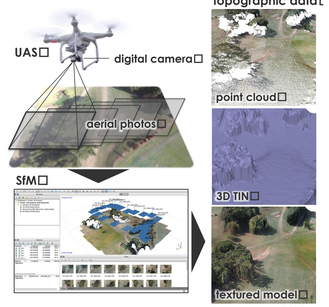
how to make high-frequency(HF), high-definition(HD) topographic 3D data?

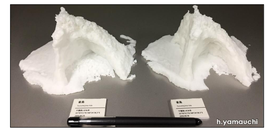
Take multiple images
using UAS
(Unmanned Aerial System)
↓
SfM-MVS photogrammetry
↓
Output
3D point clouds,
3D polygons,
DSMs （Digital Surface Models）

High-definition!!



(Hayakawa *et al.* 2016)

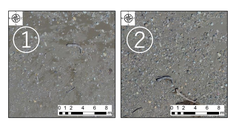
What kind of teaching materials for science education and outreach from HF and HD data?



3D printings
of different acquisition times

Videos from UAS

3D Virtual Models



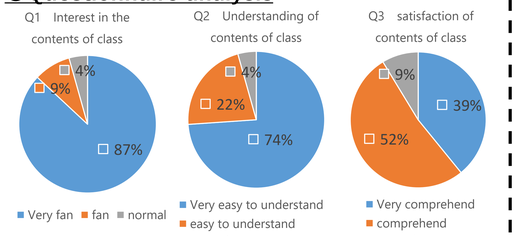
Ortho rectified images
of different acquisition time

Case1 ～Taya Cave～

Target : elementary school students (23 people)
Subject : Integrated Studies
Plan :

Number of classes	Style, Title	Contents
1	Lecture Introduction of environmental survey using drones	・Examples of environmental surveys using drone materials: movie, 3D Printings, 3D virtual models ・Method of topographic surveying ・Origin data of a large landform model
12	Training Creation of a large landform model	・Making of a large landform model using plastic boards
1	Dissemination of a large landform model	・Showing of a the large landform to local people in a public event

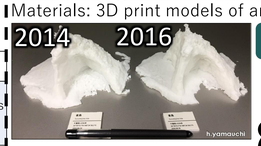
●Questionnaire analysis



“It was difficult, but fun” ⇒ Positive effects of learning materials

●Learning effects using 3D printing

Materials: 3D print models of an island with cliffs (2014, 2016)



Q. What is the difference between the two models?

A part of the island is lacking.

This is duw to erosion by waves.

It has changed a lot in two years... So does this island disappear in the future?

- Students could readily understand erosional changes by touching
- Promoting imagination of the future predictions

●Effects of landform model production training

- Spatial recognition abilities of 2D and 3D seemed to have increased
- Imagine the local environment by touching the model with hands from Gradients and irregularities

- Exchange of opinions with local residents

⇒Imaginations of the past landscapes discussion the past landscapes

Case2 ～Tedori River～

Target : elementary school students (90 people)
Subject : Science
“Erosion, transportation, and deposition by rivers”
Plan :

Number of classes	Style, Title	Contents
1	Lecture and training Erosion, transportation, deposition by river	・Learning about the force of rivers by looking at the pictures of the Tedori River ・Learning the time the primary school floods when flooding happens using Web-GIS
3	Field excursion Tour of control training in Tedori river	・Visiting the state of evacuation training at fire department and administration
1	Conclusion How can we protect my self from the flood?	・Thinking about what we can do to protect oureselvesyourself from floods

●Learning effects of using two time period ortho rectified images

Materials: Riverbed of Tedori River

Theme: What is the difference between the two pictures?

Small stones and branches have moved.

In order for the stones to move, water flow should have covered the riverbed. This is called “transportation”.

In order for a big stone to move, higher water must have gone through this river!

If a lot of water flows ... it may cause floods!

- To imagine what happened between the two time periods
- To imagine appeared the phenomenon that happened in 2 months

●Main topic: ” Expansion of spatial scale”

- Imagine the “past” disasters
  If bigger water comes, what happens to the river?

- Imagine the “future” disasters
  If flood occurs, how long the water will reach?
  How will the elementary school be damaged?
  Learn these using Web-GIS.

- Dealing with floods
  Participate in regional disaster prevention drills and see the activities of local people.

Discussion

・HF-HD data can expand imagination based on the short-term changes of the topography.

・Sometimes it is better to use 2D and other formats of data because it can transmit less information than 3D data.

・Showing subtle changes in a small space-time scale, which is an advantage of HF-HD data. This encourages students to readily understand easy topographic changes.

・With images of topographic changes revealed by the HF-HD topographic data, students can imagine the magnitude of the past disasters and possible disasters in the future.