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Japan Aerospace Exploration Agency (JAXA)
Research group on “Study on GLOFs in the Bhutan Himalayas”[*1]

Description of
Glacial Lake Inventory of Bhutan using ALOS (Daichi) Data

Abstract
This document aim to develop and publish the glacial lake inventory in the Bhutan Himalayas using optical instruments onboard the Advanced Land Observing Satellite (ALOS, nicknamed “Daichi”), which was launched on January 24, 2006. The Glacial Lake Outburst Flood (GLOF) is exposing to a risk for peoples living in downstream regions. The glacial lake inventory is newly developing using ALOS data under “Study on GLOFs in the Bhutan Himalayas” project supported by Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA) under the “Science and Technology Research Partnership for Sustainable Development (SATREPS)”. The field survey has been conducted in 2010, and the location accuracy of 9.5m (average) and 11.9m (RMS) has been achieved at a lake in the inventory. We are cordially announcing public release of “Glacial Lake Inventory of Bhutan using ALOS Data” (evaluation version).

Keywords: Glacial lake inventory, ALOS, PRISM, AVNIR-2, DSM

1. Introduction

Failures of glacial lake dams terminated by natural moraines can cause outburst floods and represents a serious hazard damages in downstream regions. The development and expansion of glacial lakes is sometime saying due to the recent global warming, on the other hand other researchers are saying no correlation between them. The fact is peoples living in such regions are exposing to a risk by glacial lake outburst floods (GLOFs). According to a study coordinated by the International Centre for Integrated Mountain Development (ICIMOD) there are 44 potentially dangerous glacial lakes in risk of GLOFs in Nepal and Bhutan (Mool et al., 2001). However, it may relatively be old and should be update to monitor existing conditions and re-evaluate a potential of GLOF objectively.
This study aim to develop and publish of new glacial lake inventory using the Panchromatic Remote sensing Instru- ment for Stereo Mapping (PRISM) and the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) onboard the Advanced Land Observing Satellite (ALOS, nicknamed “Daichi”). ALOS was launched on 2006, and continued to operate very well for more than five years (Shimada et al., 2010).

2. Data processing and status

PRISM has 2.5m spatial resolution, and performs along-track stereo observation by a forward-, nadir-, and backward-looking radiometer to extract precise Digital Surface Model (DSM) or Digital Elevation Model (DEM). AVNIR-2 has 10m resolution by four radiometric bands from visible to near infrared. Firstly, ortho-rectified image is processed for both of them using own developed software (Takaku and Tadono, 2009). The PRISM DSM can be simultaneously generated with ortho image. Secondly, pan-sharpened image is generated using them to obtain 2.5m resolution with color composite image.
Thirdly, water bodies are extracted manually using pan-sharpened image. If it is not available yet due to cloud covers in the image, the ortho-rectified AVNIR-2 image is used for this processing instead of it. Figure 1 shows status of processed pan-sharpened images and extracted lakes in Bhutan.
Finally, glacial lakes are screened from extracted water bodies based on the following definitions: Glacial lakes in our definition are bodies of water that lay between the terminus of the mother glacier and the Little Ice Age moraine. Lakes located within 2km of the Little Ice Age moraine down-valley are also included to take into account a possible flooding event with multiple lakes being involved. In addition, supraglacial lakes on debris- covered glaciers are included. We also set 0.01km^2 as the minimum lake size considering small lakes contribute a less amount of GLOFs’ risk. More detail of methodology is given by Ukita et al. (2011).

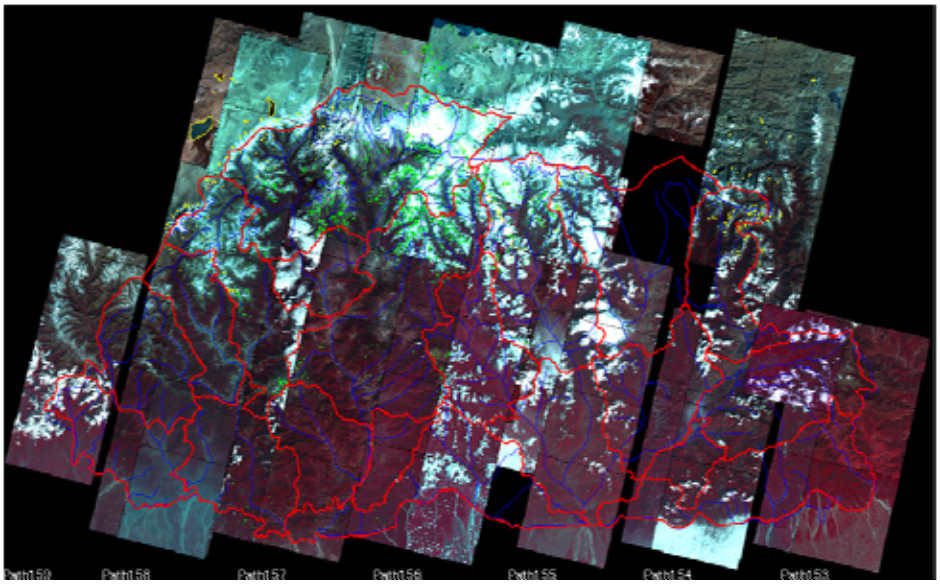

Figure 1: Coverage of pan-sharpened image (R, G, B=Band 4, 3, 2 as false color) by PRISM and AVNIR-2 and extracted water bodies (yellow and green polygons) in the Bhutan Himalayas (as of December 2010).

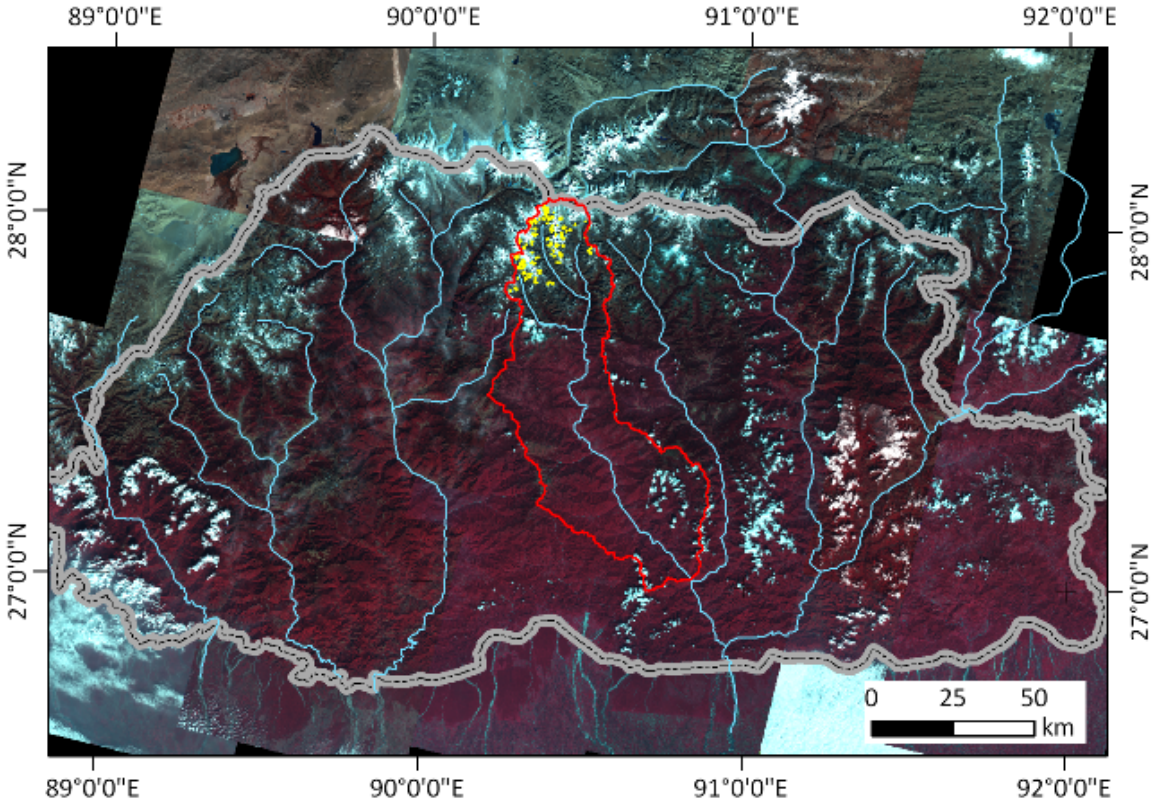

Figure 2: Enlarged image around Mangde Chu sub-basin with screened glacial lakes (yellow polygons).

3. Glacial lake inventory

ALOS-based glacial lake inventory is going on development for the Bhutan Himalayas region, and consists of two types of file: shape file and the description in CSV format, which includes mostly follow the ICIMOD convention, ID, coordinates in terms of latitude and longitude of the lake center, area, elevation, orientation, width, length, and auxiliary information such as type of lake (e.g., moraine-dammed, etc).

Each lake has its own ID based on the name of the river sub-basin and latitude and longitude of the lake centre. In addition we provide a cross-reference with respect to the ICIMOD code whenever available. Figure 2 shows example of developed ALOS-based glacial lake inventory (yellow polygons) overlaid with pan-sharpened image. At present, the inventory covers over 50% of the area, because there are some data-void areas due to the availability of synchronized cloud-free images of PRISM and AVNIR-2.

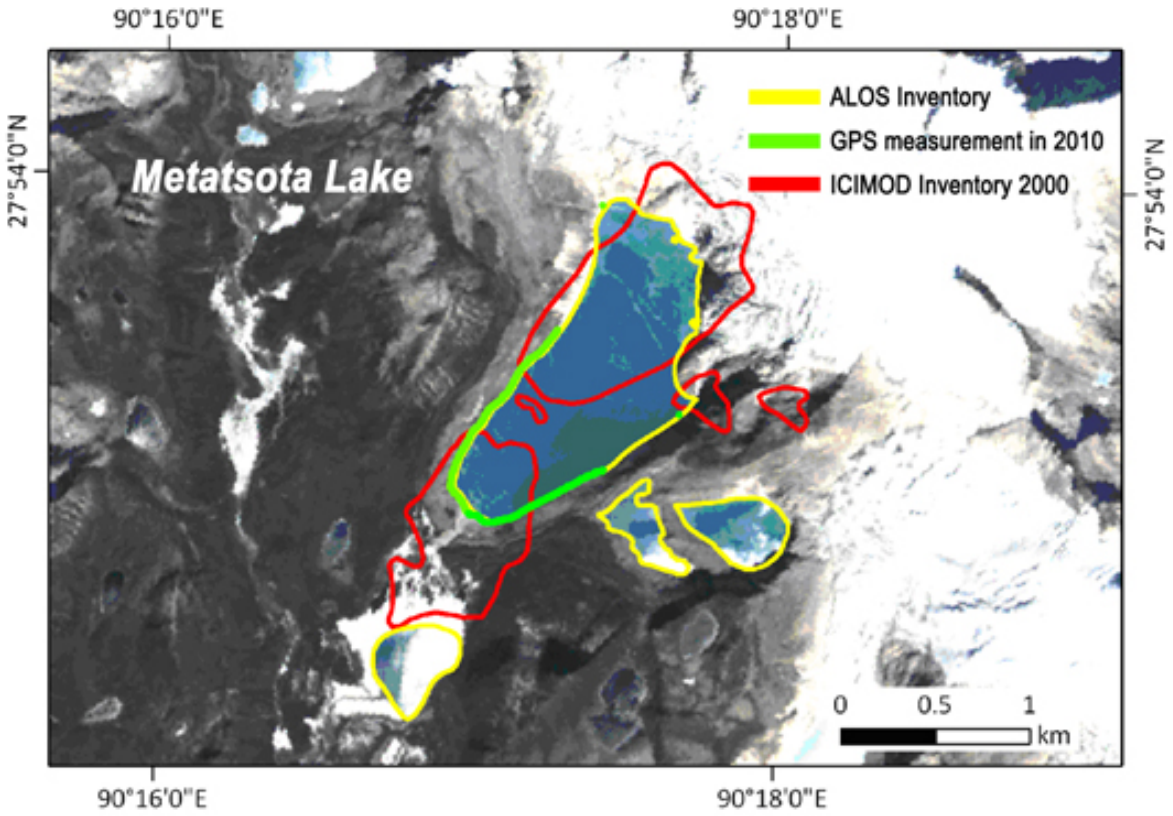

Figure 3: Comparison of polygons among our inventory (yellows), ground-based measurement (green) and ICIMOD inventory (reds) at Metatshota Lake.

As the validation of our inventory, we conducted the ground-based GPS measurement on Sep. to Oct. 2010 at Metatshota Lake in Mangde Chu sub-basin. Figure 3 shows comparison of polygons among ALOS-based inventory (yellows), ground-based GPS measurement (green), and ICIMOD inventory (reds) overlaid AVNIR-2 image. Unfortunately, there has not been a synchronous set of clear PRISM and AVNIR-2 images covering the area. Therefore, ALOS-based inventory was used here on AVNIR-2 image. In statistically, we confirmed that ALOS-based inventory has 9.5m of averaged error, and 11.9m of root mean square (RMS) error compared with ground-based GPS measurement, which was applied post processing with base station GPS data and selected 40 points out of about 4,500 points with a nearly equal spacing.

4. Public release of "Glacial Lake Inventory of Bhutan using ALOS Data" (evaluation version)

We are cordially releasing "Glacial Lake Inventory of Bhutan using ALOS Data" with free of charge only for research purpose. The motivation for this release is to support the research community and various domestic and international projects. By releasing the evaluation version covered the Mangde Chu sub-basin, we hope to collect comments and suggestions for the preparation of the full release of the inventory, now scheduled in the spring of 2012. Please feedback valuable comments to Z-GLOFST@jaxa.jp by e-mail.

References

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"Bhutan GLOF Project", Nagoya University
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