

## Monitoring changes in ecosystems in Latin America by ALOS

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### ABSTRACT:

Remote Sensing Technology Center of Japan (RESTEC) collaborates with the World Bank for the Adaptation to climate change threats in Latin America. The objective of the RESTEC activities is to provide ALOS data analysis technology and training to the scientists of the participating countries of the project on a state of the remote observing systems to be used for interpreting climate change impacts on ecosystems in Latin America. The outcomes of these activities are readiness of scientific and technical monitoring system by ALOS for the analysis of the dynamics of ecosystems in Latin America.

### 1. INTRODUCTION

Up-to-the-minute-data and expertise derived from the Advanced Land Observing Satellite (ALOS) developed and operated by JAXA has been contributing a better formation of measures to adapt to climate change threats in Latin America and the Caribbean.

Using highly advanced instrumentation, ALOS capabilities includes capturing high resolution photos (up to 2.5m) of land cover and natural resources. ALOS data has been used in the World Bank-financed adaptation projects as an effective tool to detect changes in vulnerable ecosystems in Colombia, Mexico, the Andes, and the Amazon.

For example, images taken by ALOS of the tropical glaciers in Andes are being used for the assessment of glacier dynamics. Gaining access to this valuable data will help the World Bank in its efforts to support countries better adapt to climate change.

ALOS has three sensors that allow very high resolution of land cover, unsurpassed by other alternative means in coverage and accuracy. This will allow countries in Latin America to monitor the evolution of land cover and landforms, including the extent of tropical glaciers, the evolution of mountain and coastal wetland as an input for decision making in adaptation.

### 2. TECHNICAL COOPERATION BETWEEN RESTEC AND THE WORLD BANK

Based on the agreement of Technical Cooperation between RESTEC and the World Bank, RESTEC has been working for the following Adaptation projects of the World Bank since 2007;

1) Regional Adaptation to the Impact of Rapid Glacier Retreat in the Tropical Andes Project (Regional Andes Project) in Bolivia, Ecuador, and Peru, with a focus on the mountain and glaciated areas.

2) Integrated National Adaptation Program (INAP) in Colombia, with a focus on biomass density and land cover

in high-mountain (Paramos and Glaciers) and coastal (wetland and mangroves) ecosystems.

3) Adaptation to Climate Impacts in the Gulf of Mexico in Mexico, with a focus on forest and coastal wetland and ecosystems.

4) Implementation of Adaptation Measures in Coastal Zones (SPACC) project in Dominica, Saint Lucia, and St.Vincent and the Grenadines, with a focus on coastal ecosystems and mangroves.

### 3. ALOS AND ITS DATA ANALYSIS TECHNOLOGY

The Advanced Land Observing Satellite (ALOS) has three remote-sensing instruments:

1) Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) for digital elevation mapping.

2) Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) for precise land coverage observation.

3) Phased Array type L-band Synthetic Aperture Radar (PALSAR) for day-and-night and all-weather land observation.

In order to provide ALOS data analysis technology, RESTEC prepared 11 kinds of textbooks as bellow.

1) Introduction of ALOS satellite and data  
2) ALOS data search  
3) ALOS data structure and format  
4) Geometric correction and pansharpener  
5) Image interpretation and stereographic analysis of ALOS data

6) DEM generation from PRISM data

7) Ortho rectification of ALOS data

8) Overview of Synthetic Aperture Radar (SAR)

9) Fundamental of SAR data Analysis

10) Interferometric SAR analysis

11) Time series data analysis

These textbooks include sample data analysis using three kinds of sensors, PRISM, AVNIR-2, and PALSAR data in Latin America regions.

#### 4. TRAINING

Training courses on monitoring changes in ecosystems in Latin America using ALOS data were held in Bolivia in 2007 and in Mexico in 2009 respectively.

The main conditions of the 1) Hardware and 2) Software for the training were as bellow.

- 1) Hardware : Windows PC  
CPU : Pentium4 3.0GHz  
OS : Windows XP  
RAM: 1GB
- 2) Software developed by RESTEC for ALOS analysis  
ALOS Viewer, ALOS 3D Viewer  
Pan Sharpen Processor  
ALOS Prism DEM  
PALSAR Processor  
PALSAR Interferometry

#### 5. OUTCOMES OF TRAINING AND ALOS DATA ANALYSIS

##### 5.1. ALOS data search

The Customer-Oriented RESTEC Online Service System (CROSS) provides with search and order features for earth observing satellite data being archived by RESTEC, JAXA/EOC and EROS Data Center (USGS, US) through internet. ALL users should access CROSS in order to search the ALOS data. As the outcome of this subject, the trainees learned the way to operate CROSS web-site.

##### 5.2. Geometric correction and Pansharpening

Panchromatic data has a single band image but its spatial resolution is relatively high. Meanwhile multi-band data can be displayed as a color composite image but its spatial resolution is not so high. Pansharpening is the process of making the images which has not only high spatial resolution but also color composite with panchromatic and multi data. And this image is called as pansharpen image. Using the ALOS AVNIR-2 and PRISM data, pansharpen image is created. As the first step for pansharpening, the image coordinate of AVNIR-2 data must be adjusted to that of PRISM accurately. This geometric adjustment is called as Geometric correction. Pansharpen image is more suitable for the image interpretation around the edge of the glaciers comparing with that of original AVNIR-2 or PRISM single image.

In this subject, trainees learned the concept of geometric correction and pansharpening at the first, and then learned how to operate to make pansharpen images using Pan Sharpen Processor.

##### 5.3. Image interpretation and stereographic analysis of ALOS data

Using PRISM data acquired by triplet mode, anaglyph images can be generated. PRISM observes same target 3 times from forward, nadir, and backward view. A pair of different viewing data is utilized to generate an anaglyph image. The shape of moraine and glacial lake can be understood by interpreting embossment structure of ground.

Thus, the anaglyph image is useful to image interpretation by providing the information of ground feature and topographical relief. It can be utilized not only for visual observation but also education of geography. Moreover, it can be applied to the initial glacier mapping, hazard mapping, etc...

##### 5.4. DEM generation by PRISM data

Digital Elevation Model (DEM) or Digital Surface Model (DSM) is the one of the most important parameters to estimate the volume of water resource in the glacier ice. Usual satellite image can be helpful to estimate the current actual area of glacier region but never estimate the height of this region.

ASTER is one of the few satellite sensors which can be detected the height information and had been most commonly used. But the pixel resolution of ASTER image is 15m and it is inadequate to analyze the glacier region accurately. On the other hand, PRISM has a potential for more accurate analysis because its pixel resolution is 2.5m (Figure 1).

As the first task of this subject, trainees learned the data format, how to acquire and open the data, and how to make shaded-relief from data about SRTM3. And then they learned the theoretical concept of DEM generation with satellite images and how to make the DEM (DSM) data using ALOS PRISM DEM software.

##### 5.5. Fundamental of SAR data analysis

Synthetic Aperture Radar (SAR) is a unique sensor to be able to observe the earth surface under the clouds. This characteristic is very effective for the monitoring in tropical region, because the tropical regions are frequently covered by cloud and there are very rare to be observed all regions by the optical sensors.

The brightness of SAR image shows the backscatter intensity of the microwave emitted from SAR antenna. Its characteristics are far from the brightness of optical sensors. Additionally, the affection of the terrain distortion in SAR image is larger than that in optical images. Therefore the interpretation of SAR image is difficult and requires some experiences. But, SAR images are effective for the interpretation in glacier region. Because the surfaces of the lakes are very flat and the backscatter intensity at the flat surface is very weak. Therefore the glacier lakes look like darker spot in PALSAR image.

Because almost all participants had not been familiar with Radar images, this subject spent much time for understanding of the theoretical concept of SAR through the making SAR image from the raw signal data (Level 1.0 product). And trainees learned how to interpret SAR images and differences of characteristics between SAR and optical images.

##### 5.6. InSAR analysis using PALSAR data

Interferometric SAR (InSAR) is one of the most effective applications of SAR data. InSAR can detect the elevation of ground surface using two SAR data acquired from very slightly different positions in different time. Therefore InSAR with PALSAR data provide DEM as well as the stereographical analysis of PRISM triplet data. The accuracy

of DEM detected by InSAR of PALSAR data is poorer than that of PRISM DEM. But InSAR can detect the height information under clouds. Mountainous glacier regions are often covered by clouds or thin snow smokes. These conditions preclude the possibility of making DEM from PRISM data. Therefore InSAR DEM is variable to interpolate the error of PRISM DEM, especially around mountainous regions.

InSAR technique for the detection of ground surface change is called as Differential Interferometric SAR (DInSAR). In case of glacier region, DInSAR have a possibility to detect the glacier flow velocity or landslide caused by the melting of frozen ground.

**5.7. Time series data analysis**

ALOS started the stable observation since October 2006 and will continue the valuable observations for several years. On the other hand, ALOS does not have archive data acquired before 2006. Therefore analysts must use not only ALOS data but also other satellite's data for change detection during a few years. The representative satellites (sensors) of continuing the observation in long time are LANDSAT and SPOT series. LANDSAT has been continuing the observation since 1972 and SPOT has observed since 1986. ASTER on Terra satellite has continued the observation since 1999. JERS-1 had continued the observation since 1992 to 1998. The data of suitable satellite or sensors should be selected for the purpose of the time series data analysis.

In this subject, trainees learned the way of time series data analysis using several satellite data. And they learned the concept of topographic normalization. And then they made time series data analysis using LANDSAT and ALOS AVNIR-2 data.

**5.8. Image Classification using AVNIR-2 Data**

Digital image classification uses the spectral information represented by the digital numbers (DN) in one or more spectral bands, and attempts to classify each individual pixel based on this spectral information. One of the elements for determining the accuracy of image classification is number of spectral bands. Comparing with Landsat-7 ETM+, which has 6 bands between visible blue and short wavelength infrared region, the number of the spectral band of AVNIR-2 is small. Actually in the case of the classification using by AVNIR-2 data, it is very difficult to distinguish the bare soil and residential region because AVNIR-2 does not have short wavelength infrared band. The most important spectral band for the classification of the costal wetlands is near infrared. Therefore AVNIR-2 image have a possibility to classify the costal wetland effectively (Figure 2).

The first task of trainees in this subject is to learn the theory of classification, especially supervised classification. And then they learned how to classify the ALOS AVNIR-2 image using by Remote-10/win software. After the classification, we discussed the accuracy by comparing the classification result with existing GIS information about the land types around wetland area.

**6 CONCLUSION**

For Glacier Monitoring in Andean region and Forest and Coastal Wetland Monitoring, the training courses were completed successfully in Bolivia and Mexico. These projects were very meaningful for trainees and the experiences of the training course can help their work and study in the near future. Due to the limited time and budget, this training course covered only a few images for sample analysis. The condition and circumstance of ecosystems are slightly different each other and the analytical approach should be modified to fit the situation. Each trainee should build up the experiences of analysis for their own target areas by themselves. RESTEC is always ready to respond to required support.

For the project in the Caribbean, with a focus on coastal ecosystem and mangroves, RESTEC is planning for training courses and data analysis in 2010.

RESTEC expects that the success of technical cooperation between RESTEC and the World bank for the adaptation projects using data obtained by ALOS "daichi" to help formulate measures to cope with climate change on ecosystems in Latin America and the Caribbean.

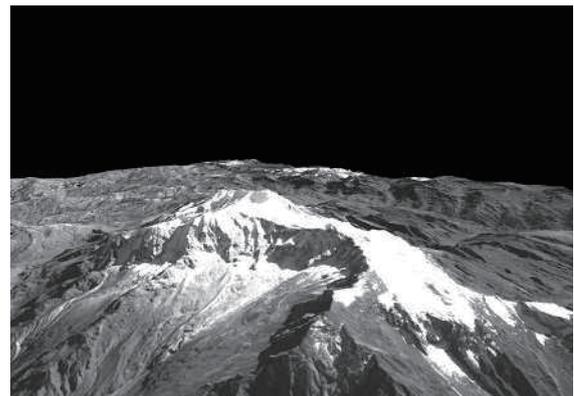


Figure 1. 3D-view image of DEM created from PRISM triplet data

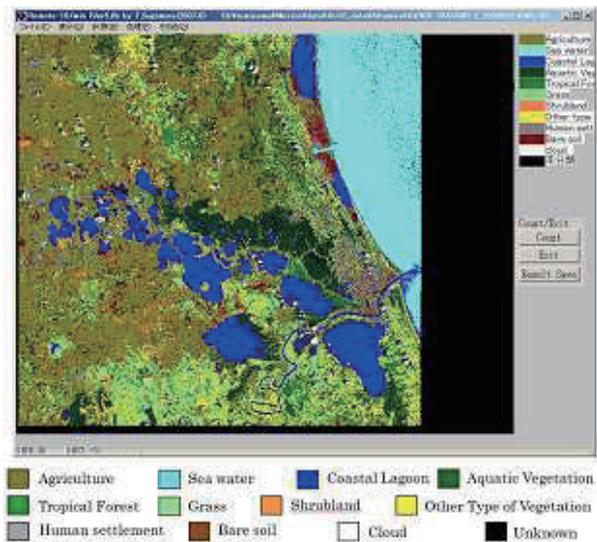


Figure 2. Classification of the costal wetland around Altamira region by ALOS AVNIR-2 image