2.1.5 Product provision and utilization by users for disaster management

2.1.5.1 Product provision

JAXA created over 1,700 products using satellite data from Daichi and data provided by the International Disaster Charter and Sentinel Asia. These were distributed to government ministries involved in disaster risk management as well as to local governments and other disaster prevention institutions.

Standard processed data from Daichi were also provided to users involved in disaster management for analysis purposes, and were utilized by various organizations.

Table 2.1-8 Major analysis products provided by JAXA

Main type	Details	Satellite data used	Forms
Daichi satellite image Map	Geographical information is superimposed on images acquired by Daichi with several reduced-scale. Daichi satellite image maps are arranged as standard.	Daichi (emergency observation data) Daichi (archive)	Geo PDF Geo TIFF JPEG (low resolution) JPEG (high resolution) PDF Online delivery Shape file PowerPoint Large printed paper Excel (numerical data)
Mapping product	Geographical information is superimposed on data acquired by overseas satellite images with several reduced-scale.	Provide by the Disaster Charter and Sentinel Asia	
Area damage analysis	Production of images for areas where there is a need, and processing of already-acquired images Identification of changes between pre- and post-disaster images Stereoscopic images from disaster areas Interferograms generated from ALOS/PALSAR data using the differential interferometric SAR (DInSAR) technique	Daichi (emergency observation data) Daichi (archive) Provided by the Disaster Charter Provided by Sentinel Asia	
Flood damage analysis	Time series analysis for areas of tsunami flooding Calculation the overall flooded area Interpretation of liquefaction	Daichi (emergency observation data) Daichi (archive) Provided by the Disaster Charter	
Nuclear power plant	Images of facilities and buildings of the Fukushima Dai-ichi Nuclear Power Station Superimposition of images showing the plant's range scales and nuclear evacuation zones Comparison of before-/after-earthquake images showing the plant's facilities and buildings Comparison of before-/after-earthquake images showing other nuclear power plants, e.g., the Onagawa facility	Daichi (emergency observation data) Daichi (archive) Provided by the Disaster Charter	
Accident analysis	Identification of changes in marine debris/flotsam and related analysis Analysis of fires (in mountainous areas and complexes) Analysis of sediment damage	Daichi (emergency observation data) Daichi (archive) Provided by the Disaster Charter Provided by Sentinel Asia	

2.1.5.2 Utilization by parties involved in disaster management

Feedback from users of products provided by JAXA is summarized below.

(1) Cabinet Secretariat (in charge of security and risk management)

In response to a request from the Crisis Management Center of the Prime Minister's Office to take initial action immediately after the earthquake, Daichi images and satellite data provided through the Disaster Charter were used to create mapping products for comparison of pre- and post-disaster conditions at the Japan Air Self-Defense Force's Matsushima Airbase and Sendai Airport (as potential bases for the transport of patients and goods), for determination of changes in the status of buildings at the Fukushima Dai-ichi Nuclear Power Station, and for monitoring of the expanded evacuation zone and stay-indoors zone around the plant. In addition, in response to a request for data to be used in identifying an area in which evacuees would be allowed to return home for a limited period of time, the results of satellite data analysis for tsunami-flooded areas were provided. On March 15, a flight restriction was issued for areas within 30 km of the Fukushima Dai-ichi Nuclear Power Station, making it difficult to determine local conditions using aircraft. Against this background, optical images of the power plant and surrounding areas (including high-resolution data from the

Disaster Charter) were provided almost every day until April 19, and were utilized to identify changes in the status of buildings at the plant.

It was difficult to obtain an overall picture of local damage immediately after the earthquake, and these images from Daichi and other satellites were the first post-disaster data provided. They enabled direct and uniform determination of local conditions over wide areas, and were the most utilized geospatial information products during the early stages of post-disaster response. To meet a variety of needs, particularly from the Prime Minister's Official Residence, the products were flexibly made according to the scale of the area of interest (i.e., from individual buildings to whole regions) and presented for comparison with relatively recent pre-disaster images. They were also frequently utilized in combination with aerial photos provided later.

Figure 2.1-49 Pre- and post-disaster images of Sendai Airport from Daichi (left) and satellite images of the Fukushima Dai-ichi Nuclear Power Station provided by the Disaster Charter (right)

(2) Cabinet Office (disaster management)

After the disaster, a contact system between the Cabinet Office and JAXA was promptly established. Based on this setup, emergency observation plans to support the selection of disaster zones for observation and for other purposes, and the details of the products to be created were discussed in the Cabinet Office.

Immediately after the earthquake, a set of Daichi satellite image maps (57 maps; 46 on a scale of 1:50,000 and 11 on a scale of 1:200,000) created using Daichi data collected from Pacific coastal areas in the Tohoku region before the disaster were printed in wide format and hand-carried by JAXA staff to the Cabinet Office because transportation services in the Tokyo metropolitan area were suspended. On March 12, the day after the earthquake, 19 maps were added as requested, and totally 76 pre-disaster Daichi satellite image maps were provided and distributed to the disaster countermeasures offices of individual prefectures via the Cabinet Office.

Daichi emergency observation results and pre-disaster archive data were continuously provided in GeoTIFF, orthorectified or standard processed data format. Geographical information of various types was merged with onto Daichi data to create a range of map products, which were provided as digital data or printed in large format. These data were utilized by the Crisis Management Center of the Prime Minister's Office and by other organizations.

In response to a request for provision of information on flooded areas ranging from Hokkaido to Chiba in order to support determination of the extent of tsunami damage across the affected areas, the results of data analysis for the entire disaster-stricken region (together with those for the Tohoku and northern Kanto regions provided in line with requests from other institutions) were made available to the public. Products from the Disaster Charter were also provided as needed.

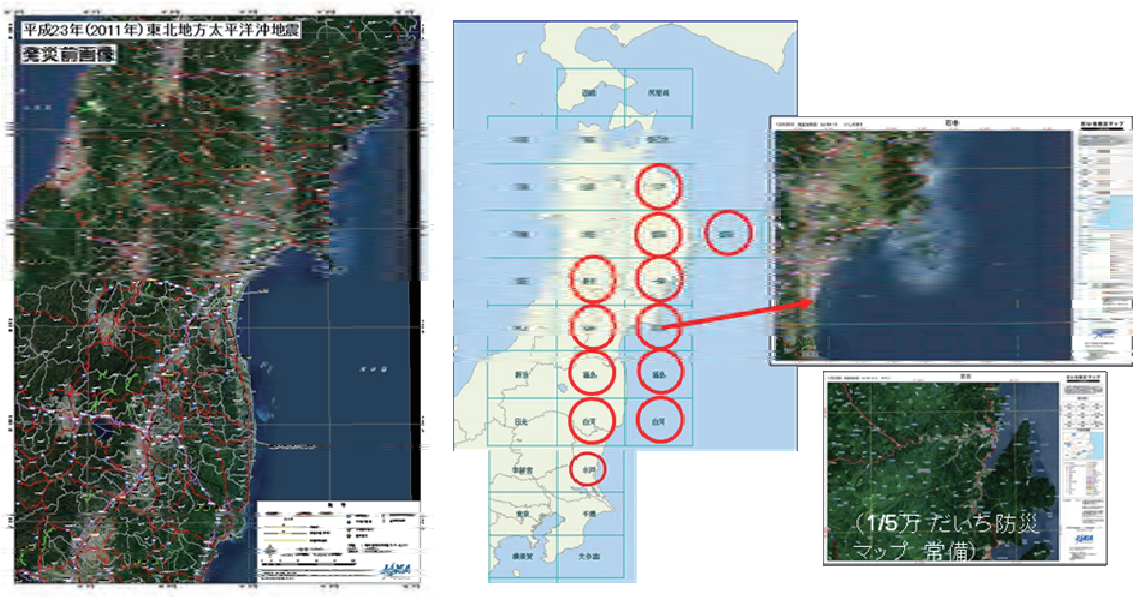


Figure 2.1-50 Daichi satellite image maps: special scale (1:400,000) (left) and regular scale (1:200,000) (right)

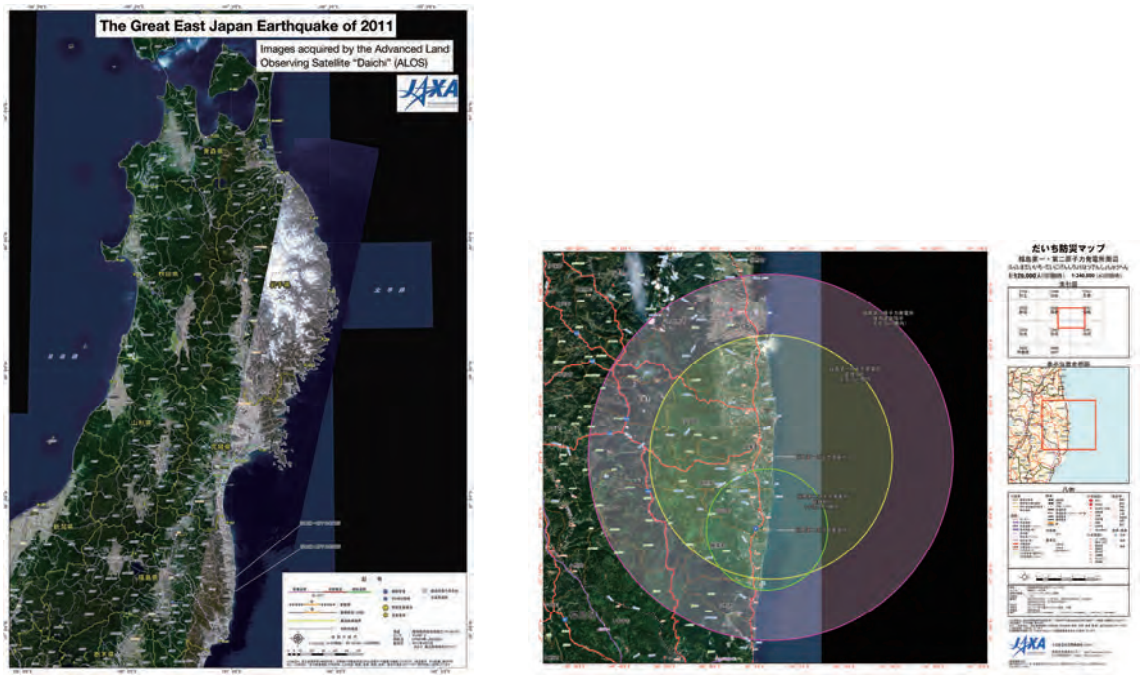


Figure 2.1-51 Daichi satellite image maps: with a post-disaster Daichi image merged with onto a pre-disaster one (left), and with information on distances from the Fukushima Dai-ichi Nuclear Power Station superimposed onto a pre-disaster one (right)

(3) National Police Agency

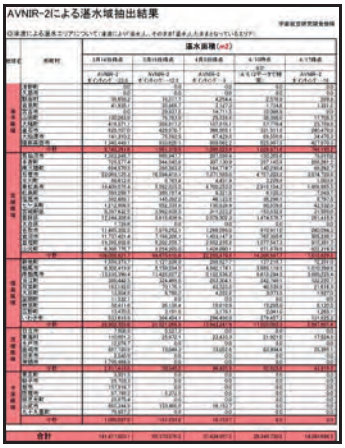
Observation images posted on Daichi Bosai WEB were downloaded by the National Police Agency, and a range of related products were created. These were printed in large format and sent to on-site disaster countermeasures offices in individual disaster-affected prefectures.

(4) Ministry of Land, Infrastructure, Transport and Tourism

(a) River Bureau, City and Regional Development Bureau, Housing Bureau, Kanto and Kinki Regional Development Bureaus

In response to a request for provision of Daichi emergency observation data immediately after the disaster, information on plans for observation of coastal Tohoku and on cloud coverage information in AVNIR-2 images was provided. In line with a further request for provision of information on flooding in tsunami-hit areas to help clarify the growing tsunami damage, information on flood areas as determined from data interpretation and from calculation using the output of PALSAR and AVNIR-2 was provided from March 21 through April 22. These results were used for comparative verification with other information.

Another request was also received for provision of satellite data to be used in determining the extent of the damage and detecting wildfires in Pacific coastal areas of eastern Japan. In response, information extracted from Daichi images of the Sanriku coast in Iwate and satellite images of liquefaction areas in Chiba from the Disaster Charter were provided.



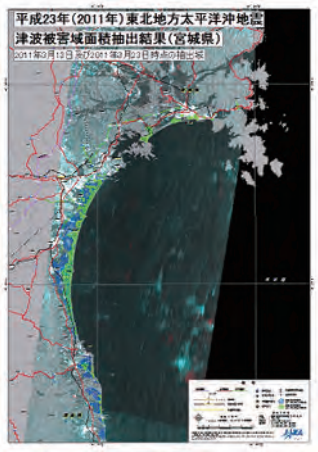
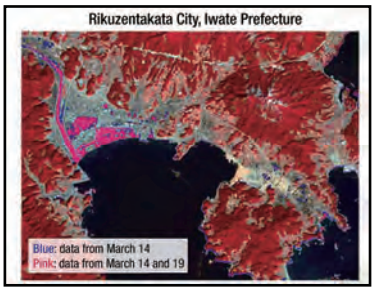


Figure 2.1-52 List of flooded areas (m^2) extracted from AVNIR-2 data (left) and an image of flooded areas extracted from PALSAR data (right)



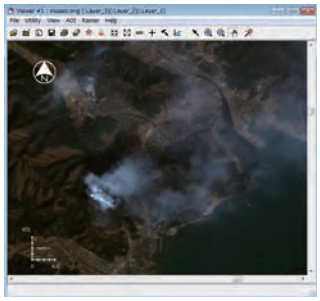


Figure 2.1-53 Image of flooded areas extracted from AVNIR-2 data (left), identification of liquefaction areas (middle) and identification of a wildfire (Otsuchi Town, Iwate) (right)

(b) National Institute for Land and Infrastructure Management

Prompt investigations were needed in light of the high risk of landslides in the 40,000 km^2 area where a seismic intensity of 5-upper was experienced. There were also fears that extensive collapses might trigger secondary landslides due to aftershocks and rainfall. In response to a request from the National Institute for Land and Infrastructure Management, JAXA performed emergency observation using Daichi. The images collected (AVNIR-2, PRISM, pan-sharpened and forward view) were provided to the institute, where they were interpreted by specialists, and automatic landslide identification was performed. As a result, approximately 200 actual and potential landslides were pinpointed. It was also confirmed that no major rivers had been blocked by landslides, and that no intensive landslides had occurred.

It was impossible to survey every hazard event based only on visual observation from helicopters. In addition, as only satellite-based observation could be conducted in the no-fly zone (within 30 km of the nuclear power plant), images captured by Daichi proved very effective.

These results were reported to the Sabo (Erosion and Sediment Control) Department of the Ministry of Land, Infrastructure, Transport and Tourism and released as emergency inspection results.

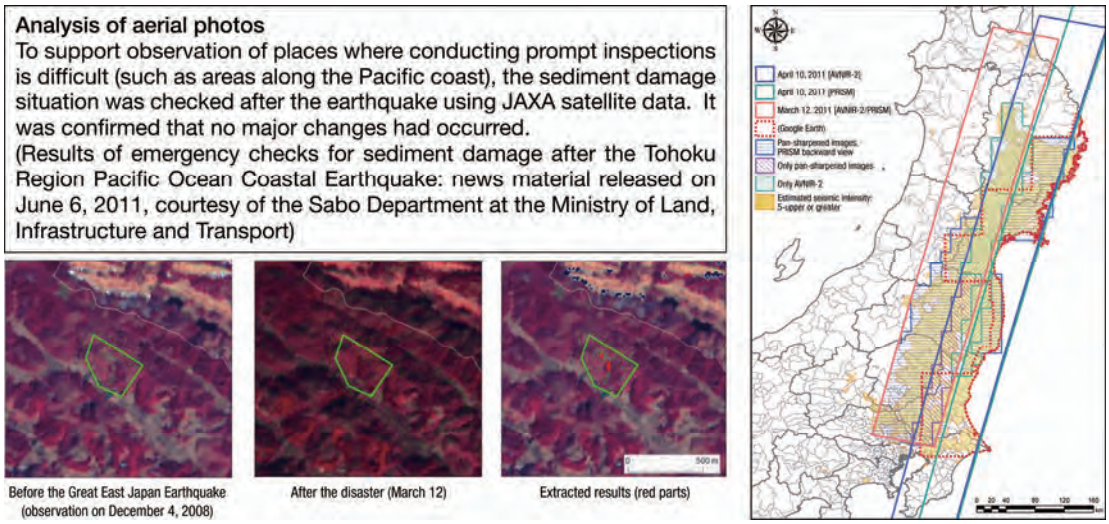


Figure 2.1-54 Satellite image interpretation

(5) Ministry of Agriculture, Forestry and Fisheries

The Ministry of Agriculture, Forestry and Fisheries asked JAXA to provide Daichi data for prompt determination of the extent of damage to farmland in tsunami-hit areas. In response, JAXA analyzed tsunami-related flooding using PALSAR and other satellite data and provided the results to the ministry. These data were utilized to clarify the situation on farmland and as information to be taken into consideration together with later information when devising methods of related restoration.

Daichi images from Daichi Bosai WEB were also downloaded by the Ministry of Agriculture, Forestry and Fisheries and used as base maps. These images were further used to assess damage and current conditions at Ogaki irrigation dam, which could not be observed directly because it was located within 20 km of the Fukushima Dai-ichi Nuclear Power Station.

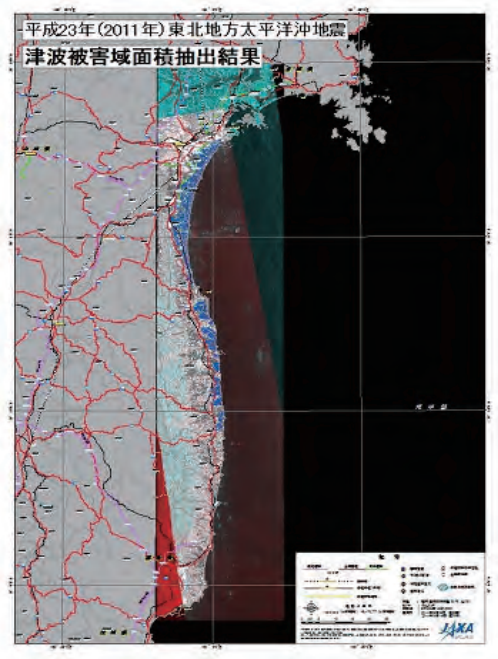


Figure 2.1-55 Results of flooding analysis using PALSAR data provided to the Ministry of Agriculture, Forestry and Fisheries

(6) Fisheries Agency

As reference information to support the assessment of damage to aquaculture rafts, Daichi images of Yamada Bay in Iwate and coastal areas of Kesennuma City in Miyagi were provided to the Fisheries Agency's Fish Ranching and Aquaculture Division.

JAXA contacted the Resource Management Department to offer data for use in searching for fishing boats, but the information was not needed due to the constantly changing nature of the situation.

Figure 2.1-56 Floating debris in the sea as captured in a Daichi image provided to the Fisheries Agency

(7) Japan Coast Guard

The Japan Coast Guard's Navigation Guidance Office (part of the Maritime Traffic Department's Navigation Safety Division) requested information covering a wide area to support the tracking of Marine debris off the coast of Miyagi. Daichi data collected on April 18 were analyzed and provided, although further scheduled data provision was canceled due to the suspension of Daichi's observations. Data were also provided as reference information to the Japan Coast Guard's Guard and Rescue Department.

(8) Ministry of the Environment

In response to a request for satellite data analysis from the Ministry of the Environment to support investigation of floating debris distribution along the Sanriku coast, changes between pre- and post-disaster observation data (November 16, 2010 vs. March 14, 2011) were identified. As a result, the presence of floating debris over an area of approximately 560,000 m^2 in the Rikuzentakata region alone was determined. This result was largely consistent with that of a study by the Ministry of the Environment, and provided useful data to determine the amount of floating debris and matter washed up on beaches where access was not possible and along coasts and on beaches where evaluation was difficult. The results were also provided to the Japan Coast Guard.

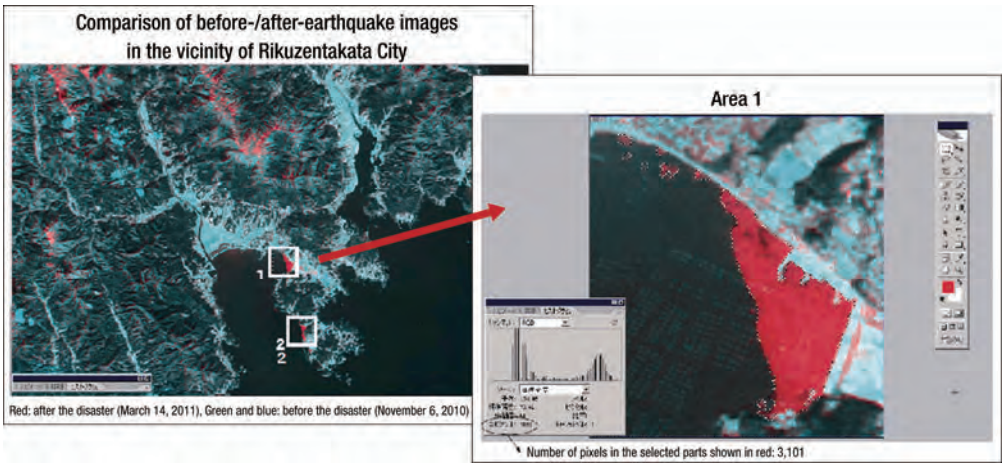


Figure 2.1-57 Daichi image of debris washed up along the coastline

(9) Ministry of Education, Culture, Sports, Science and Technology

In line with a request from the Nuclear Damage Compensation Office (part of the Research and Development Bureau at the Ministry of Education, Culture, Sports, Science and Technology), a product in which range indications and nuclear evacuation zones for the Fukushima Dai-ichi Nuclear Power Station were merged with onto Daichi images and a variety of other products related to the plant were created, printed on a large scale and provided to the office.

Figure 2.1-58 Fukushima Dai-ichi Nuclear Power Station range scales

(10)　National Research Institute for Earth Science and Disaster Prevention

In response to a request from the Disaster Risk Research Unit of the National Research Institute for Earth Science and Disaster Prevention to release Daichi images, related data covering the Tohoku region and Niigata and Nagano prefectures were provided.　Based on WMS (ISO 19128 － an international standard for geospatial information distribution), these Daichi images were distributed by the institute as a matter of urgency for use at volunteer centers and other facilities in the affected areas via the ALL311 Great East Japan Earthquake Information Platform website, and were also transmitted as information to support disaster response and recovery in affected areas.

Figure 2.1-59 Web page with information on Daichi image distribution (left) and WMS distribution of Daichi images (right)

(http://bosai-drip.jp/alos/wms.htm)

(11) Geospatial Information Authority of Japan and Earthquake Working Group

At the Geospatial Information Authority of Japan and the Earthquake Working Group, SAR interferometry was performed using data acquired by Daichi before and after the disaster, and the results were released. The data identified crustal deformation of up to 4 m near the Oshika Peninsula ― a result that corresponded with the outcomes of continuous GPS observations (movement of approximately 5.3 m in an east-southeast direction and subsidence of approximately 1.2 m). Local crustal deformation resulting from inland earthquakes triggered by the main shock (M 9.0) of March 11 was also seen in several locations.

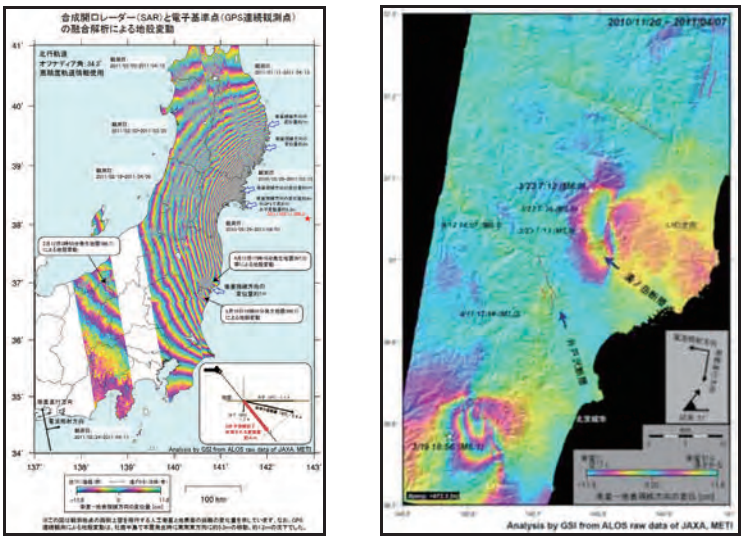


Figure 2.1-60 Analysis of crustal deformation caused by the main shock (left) and identification of crustal deformations caused by aftershocks (right)

(12) Iwate and Fukushima Prefectural Disaster Countermeasures Offices, on-site technical emergency control forces, government agency regional bureaus and departments

In cooperation with Professor Yokoyama from the Laboratory of Remote Sensing Data Analysis at Iwate University, Daichi data provided by JAXA were analyzed by the university, and products were created and printed in long format. Professor Yokoyama visited local organizations in Iwate and other prefectures to distribute the results. Related local organizations faced extreme difficulties in determining the extent of the damage because communications networks were disrupted and gasoline shortages restricted the sphere of activity. Against this background, Daichi images were utilized in various ways by local organizations involved in disaster response.

(a) List of Daichi image products created

① AVNIR-2 images taken on Mar. 14, 2011
② Pan-sharpened (PS) images taken on Mar. 24, 2011
③ PS images and PS stereoscopic images taken on Apr. 10, 2011
④ PS images from before the disaster

(b) Major organizations receiving data

① Iwate Prefecture Disaster Countermeasures Office and Iwate Air Rescue Team

■ Daichi images of coastal Iwate on a scale of 1:30,000 taken before and after the disaster and printed on

paper measuring 7 m in length were provided.

- The print gave an overall picture of the affected areas, and was posted in the control center and used to share information with relevant parties.

② Ground Self-Defense Force Iwate and Miyagi Disaster Relief Headquarters

The same 7-m printout was provided in response to a request from the Ground Self-Defense Force for use in rescue operations in the affected areas.

- Daichi images of coastal Iwate on a scale of 1:30,000 taken before and after the disaster and printed on paper measuring 7 m in length were provided.
- Daichi images of coastal Miyagi on a scale of 1:30,000 taken before and after the disaster and printed on paper measuring 6 m in length were provided.

③ Fukushima Prefecture Disaster Countermeasures Office

- PS stereoscopic images of coastal Fukushima on a scale of 1:30,000 taken on Apr. 10, 2011, were provided.
- The print gave an overall picture of the affected areas, and was posted in the control center and used to share information with relevant parties.

⑤ Tohoku Construction Association

- Daichi images of coastal areas from Hachinohe City, Aomori, to Iwaki City, Fukushima, on a scale of 1:30,000 taken before and after the disaster and printed on paper measuring 17.5 m in length were provided.

⑥ Tohoku Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism (provision through the Tohoku Construction Association)

- Daichi images of coastal areas from Hachinohe City, Aomori, to Iwaki City, Fukushima, on a scale of 1:30,000 taken before and after the disaster and printed on paper measuring 17.5 m in length were provided.

⑦ Tohoku Regional Agricultural Administration Office, Ministry of Agriculture, Forestry and Fisheries

- Pre-disaster PS images (covering the area from Hachinohe City, Aomori, to Iwaki City, Fukushima) printed on a scale of 1:25,000 were provided.
- Post-disaster AVNIR-2 images (observed on Mar. 14, 2011, covering the area from Hachinohe City, Aomori, to Iwaki City, Fukushima) printed on a scale of 1:25,000 were provided.
- PS stereoscopic images of coastal Fukushima taken on Apr. 10, 2011, printed on a scale of 1:30,000 were provided.
- AVNIR-2 images taken on Apr. 14, 2011 were used.

➢ Data on Tohoku areas hit by the tsunami were analyzed, and the extent of the damage was determined to provide information in the early stages. AVNIR-2 images supported damage evaluation even in areas for which aerial photos were unavailable. This type of support was not taken into consideration on many other flood maps.

➢ Images and analysis results were shared within the office and used in explanations given to visitors.

- PS stereoscopic images acquired on Apr. 10, 2011 were used.

➢ Satellite images were used to identify massive landslides in coastal areas of Fukushima where aerial photos were unavailable after the earthquake.

➢ Satellite images were used to identify geographical features, areas of greenery and other characteristic areas. Field reconnaissance of landslides was then conducted in Iwaki City and the surrounding areas, and an earthquake fault in Iwaki City forming as a result of an aftershock on April 11 was surveyed.

➢ These images were useful in identifying geographical conditions over a wide area.

Figure 2.1-61 PS stereoscopic image of an affected area (created by Prof. Yokoyama)

⑧ Tohoku Regional Environment Office, Ministry of the Environment

Daichi images of Pacific coastal areas from Hachinohe City, Aomori, to Iwaki City, Fukushima, taken at six different times after the disaster and before it were provided (see Section 3.2.1.2 for details).

⑨ Yamada Cho, Iwate prefecture

Pan-sharpened images taken by Daichi on Sep. 10, 2006, were provided in response to a request for data to be used in confirming locations where aquaculture facilities were installed before the earthquake, and in supporting the identification of borders within which such facilities washed away by the tsunami could be re-established in Yamada Bay.

⑩ Hachinohe City, Aomori prefecture

Comment from a city official in charge: The Daichi Bosai map covering Hachinohe City (provided as a result of the Cooperation for Joint Exercises of Aomori and Iwate for Citizen Protection in 2010 project) provided very useful data to which information on flooded areas could be added, and was very helpful in explaining disaster-related matters to local residents.

(13) Wakayama Prefecture

Wakayama Prefecture promotes activities to demonstrate experimental disaster management applications under an agreement with JAXA. Before prefectural government employees were dispatched to Iwate Prefecture as part of the activities of the Union of Kansai Governments in response to the earthquake, it was necessary to consider how to ensure their safety and clarify the local situation, as the relevant personnel were unfamiliar with the affected areas and had little information on the situation there. In response to a request for information from Wakayama Prefecture on March 14, JAXA conducted emergency observations and also provided a Daichi Bosai map showing Iwate Prefecture before the earthquake as well as products created after it. A number of large prints of these products were created by Wakayama Prefecture in advance, and were brought to Iwate Prefecture along with a CD-R at the time of the dispatch at the end of April. These resources were utilized to check routes to the affected areas and shed light on the situation there. Wakayama Prefecture also provided the CD-R to the Tohoku Regional Bureau of the Ministry of Land, Infrastructure, Transport and Tourism.

The activities carried out in Wakayama Prefecture to support Iwate Prefecture are a typical example of inter-regional and wide-ranging collaborative initiatives implemented when major disasters occur. The continuous efforts of Wakayama Prefecture and JAXA to demonstrate disaster management applications enabled the prefecture to utilize information on other prefectures with the help of the Agency.

(14) Miyagi Prefecture

Based on a report from the United States Geological Survey (USGS; a member of the Disaster Charter), an SOS signal in Onagawa Sports Park in Onagawa City, Miyagi, was identified in satellite imagery on March 19. The matter was promptly reported to Miyagi Prefecture, and it was confirmed a few hours later that the park had been used as an evacuation shelter and the situation had been resolved, thereby allaying fears that access to the village had been cut off.

Figure 2.1-62 SOS signal identified in satellite imagery

(15) Disaster Prevention Research Institute, Kyoto University

After the disaster, an Emergency Mapping Team (EMT) was launched, and Daichi images were provided and utilized for mapping in response to a request to JAXA for collaboration (see Section 3.2.1.1 for details).

(16) Other organizations

Flood analysis results (for the prefectures of Iwate, Miyagi, Fukushima and Ibaraki) obtained using the AVNIR-2 and PALSAR satellites were provided to the Ministry of Defense and utilized to identify costs and plan searches for missing people in the evacuation zone of the Fukushima Dai-ichi Nuclear Power Station.

2.1.5.3 Web-based information provision

(1) Daichi Bousai WEB (https://bousai.jaxa.jp/)

To support the prompt provision of information to users involved in disaster management, a page for the Great East Japan Earthquake was established on the Daichi Bosai WEB site. This enabled the posting of Daichi emergency observation plans and results in addition to various products created using Daichi data and output developed by the Disaster Charter, Sentinel Asia and other overseas institutions. Providing this data to users around the clock, the website received totally more than 1,500 hits from central government ministries/agencies, local governments and other organizations.

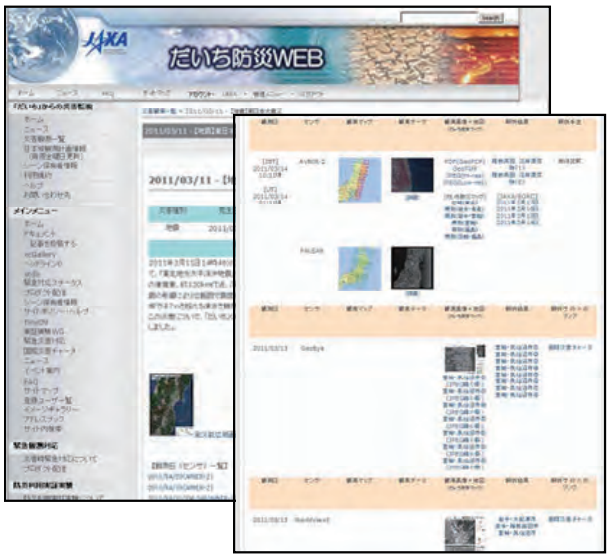


Figure 2.1-63 Great East Japan Earthquake page on Daichi Bosai WEB

(2) EORC ALOS website (http://www.eorc.jaxa.jp/ALOS/en/index_j.htm)

Satellite data analysis results were regularly updated on JAXA's Earth Observation Research Center (EORC) website, which received up to 20,000 visits per day after the quake. The site is usually accessed by between 100,000 and 200,000 hits monthly, but received 550,000 hits in March and 340,000 in April. Inquiries were fielded from people in the affected area who had viewed the analysis results, and requests were received from individuals involved in the operation of ships in affected sea areas for updated information on driftage at any time.

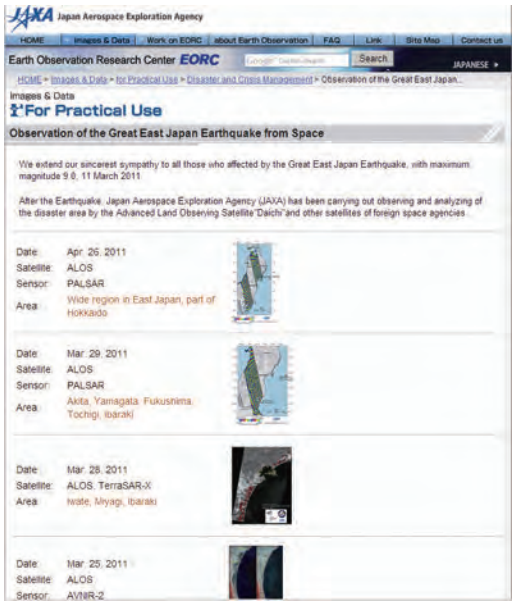


Figure 2.1-64 EORC ALOS website