The Sichuan Earthquake (2)

In May 2008 an earthquake struck the Chinese province of Sichuan. Geo-information experts were able to support emergency response through the immediate provision and analysis of satellite imagery. Infoterra and IRSA-CAS used SAR satellite imagery to rapidly extract accurate information. Both institutions independently chose a very similar approach: visual interpretation of the data and pre-earthquake remote-sensing data for reference.<P>

The earthquake destroyed infrastructure and caused a large number of landslides, landslide lakes, dams and debris flows, the quantity, scale and dimensions of which broke historic records. Landslides buried towns and villages, blocked river channels and destroyed road networks, making rescue work particularly difficult. This paper describes the emergency-response support ef-forts of Infoterra and the Institute of Remote Sensing Applications (Chinese Academy of Sciences). Both followed a similar approach: TerraSAR-X data was visually interpreted and pre-earthquake remote-sensing data from other space-borne data sources and ancillary information gathered to effectively assess damaged infrastructure and identify potential threat from natural river dams formed by landslides.

Pre-earthquake Data

The Infoterra risk-management team, the DLR German Centre for Satellite Based Crisis Information, the international Respond Network, and UNOSAT immediately initiated rapid mapping. Focus areas were Beichuan and Maowen, mountainous, remote areas severely affected and assumed to be out of reach for rescue workers for the first few days. Collecting information on infrastructure status seemed appropriate in preparation for subsequent emergency response efforts. Figure 1 shows timeline and milestones for the rapid mapping activity. TerraSAR-X tasking revealed that the sensor would be in position to acquire imagery from the areas of interest within 72 hours, the first promising acquisition opportunity. Weather conditions limited the capabilities of space-borne optical sensors at the time. The waiting period was used to collect and prepare pre-earthquake reference data that would prove significant input for rapid and reliable image analysis. Pre-event data acquired by the same earth-observation sensor would have been ideal; however, TerraSAR-X has only been in operational service since early 2008, data archives are still limited and no imagery had been acquired of either region. As alternative Infoterra used an existing mosaic of Spot5 satellite images.

Interpretation Tasks

To derive the most urgently needed information, a series of succeeding working steps were taken. First a panchromatic Spot5 acquisition with 2.5m resolution (from 2006) was used to map major roads, transport lines, bridges and urban areas, then the pre-earthquake situation was displayed as vector data in a topographic map. This map and the underlying SPOT mosaic formed the basis for subsequent image interpretation and damage analysis. The post-earthquake TerraSAR-X acquisition (StripMap mode, 3m-resolution, acquired on 15th May) was visually interpreted and compared to the reference data in order to derive a detailed damage analysis for infrastructure networks and affected urban areas:Beichuan City, on Jiangjiang River, suffered severe damage. Two larger landslides (southern area of town) and damaged or destroyed bridges are visible. The river itself is dry, blocked by further landslides upstream. The numbers (1-4) in Figure 2 correspond to events documented in the timeline in Figure 1. Steep terrain around the selected cities impeded spotting destroyed bridges or roads blocked by landslides; the availability of sound pre-event reference data proved vital for this task of interpretation.

Stereoscopic Sense

The majority of in-country interpretation work on remote-sensing data was performed by the Institute of Remote Sensing Applications (IRSA) at the Chinese Academy of Sciences (CAS). Institute experts applied SAR imagery from various sources to build damage assessments and detect landslide and monitor landslide lakes. Figure 3 gives an example of the work done; red lines indicate destroyed buildings, and the purple line marks a destroyed bridge in An Chang Town, where most buildings were demolished during the earthquake. Unlike buildings in good condition, a damaged building has no clear texture or shadow. Buildings that remained standing are imaged as orderly arrangements showing well-organised texture and clear, straight shadows. Bright features alternate with dark grey features in SAR imagery because of the corner reflector effect between the building's wall and the ground surface of the street. Fallen, destroyed or collapsed buildings lack a clear shadow and orderly arranged texture, because there is no corner reflector. The wreck of a devastated building is depicted as a rough surface, showing a patch of bright features. Using high-resolution SAR images, IRSA experts were also able to detect landslides and landslide lakes. Thanks to the good stereoscopic sense of SAR imagery, it was possible to identify back scars, debris deposits and tracks, and precisely measure total area and distance travelled by these landslides. One of the largest extended seven square kilometres and tracked a distance of four kilometres, virtually flying from one side of the river to the opposite bank. It was possible to reliably monitor the development of landslide lakes using continuously acquired multi-temporal SAR imagery.

As water levels rose, small towns such as Xuan Ping, Zhicheng and Sheng Kenzi and many roads along the Jian River were gradually inundated. Tangjiashan Landslide Lake extended gradually upstream, widening the river channel. Figure 4 shows details of the Tangjiashan Landslide, one of the most dangerous of the numerous landslide lakes. The SAR image shows a back scar and debris deposit, proving that a large amount of material travelled across the river to its opposite bank. Experts find it hard to use ordinary concepts to explain the behaviour and scale of such giant, catastrophic landslides; moving such unusually huge volumes of material requires tremendous energy and leaves some questions unsolved to date.

Summary and Outlook

Efforts aimed at infrastructure assessment and detection, and monitoring landslides and landslide lakes, illustrate the potentialand applicability of high-resolution SAR data for various aspects of disaster monitoring. TerraSAR-X, among other data sources, played an important role in these emergency-response efforts. SAR sensors are particularly well suited: cloud-independent image acquisition makes acquisition plans reliable, enabling decision-makers to count on timely data assessment. Pre-event information proved helpful, sometimes necessary, for the interpretation of post-event data. Pre- and post-event data from the same sensor will simplify interpretation and allow the development of automated change-detection methods that support visual analysis. The growing archives of new remote-sensing missions like TerraSAR-X increase the likelihood of pre-catastrophe data from the same data source being available. The importance of intelligent planning and preparation of significant data archives is therefore a key conclusion drawn from recent emergency response experience. The ongoing TerraSAR-X background mission, i.e. continuous data acquisition for pure archiving purposes, has been designed to support the collection of archive data for areas threatened by natural disaster.

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Further Reading

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Textbox:
This is the second in a series of three articles jointly prepared by Infoterra and the Chinese Acadamy of Sciences. The first provided an overview of the disaster, its effects and the suitability of satellite imagery for rapid emergency-response activities. The last article will highlight the complementary benefits of optical and radar imagery.

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Continued: The Sichuan Earthquake (3)