Applications and utilisation

Applications

The TanDEM-X mission design is flexible. In course of the mission, imaging technologies may be selected from the available range as needed for use in various applications and experiments. In this context, a basic distinction must be made between across-track and along-track synthetic aperture radar interferometry. Both methods are based on measuring the path length difference when the same radar transmission is received separately by the antennas of the two satellites. With both satellites moving parallel to each other, such path differences in across-track direction can be used to compute elevation information needed in the applications described below.

Along-track synthetic aperture radar interferometry offers entirely new opportunities. This application uses two separate radar antennas arranged longitudinally along the direction of flight, a method that permits the measurement of the speed of moving objects as the two satellites image the same area successively, with a brief interval in between. The method is used particularly in oceanography, glaciology and traffic monitoring.

Across-track synthetic aperture radar interferometry

Topographical maps

Local topographical maps are generally available in industrialised regions. On a global scale, however, the information they provide is inadequate. The existing gaps can however be filled by a digital elevation model derived from synthetic aperture radar interferometry data. Current research focuses particularly on the development of algorithms for validating and calibrating elevation data. Another important aspect is the development of tools for visualising three-dimensional elevation maps.

In addition, high-resolution elevation models are needed to eliminate distortions caused by surface relief from Earth observation images. 'Orthorectification' enables images to be superimposed and blended with geometrical precision. Terrain models subsequently integrated in geographical information systems may be linked to additional physical and socioeconomic data for further evaluation. Municipalities, for instance, use geographical information system data for zoning.

Land use and vegetation

High-resolution synthetic aperture radar interferometry also makes it possible to survey vegetation in three dimensions. Such surveys reveal the size of treetops, their vertical distribution and gaps in the forest. Forest and fire protection services, as well as conservation efforts, stand to benefit from this information, which also improves the quality of land use and forest rehabilitation planning. Data supplied by observing forests and charting their growth phases improves our understanding of the global carbon cycle and assists in biodiversity research. The data provided by the TanDEM-X mission is unrivalled in its resolution and temporal coherence.

Navigation

The need for a high-quality, homogenous global terrain database is particularly urgent in safety-critical applications. Warning systems in aircraft cockpits are a case in point. One of these, the ground proximity warning system, gathers various flight data at low altitudes and sounds the alarm if the aircraft’s altitude falls below a critical limit. Precise terrain models would improve the reliability of these systems. The same holds true for synthetic vision systems that provide pilots with a three-dimensional view of their current environment, even in conditions of low visibility.

The databases currently used by these systems are derived from various sources that conform to diverse specifications and standards. In future, terrain databases will have to adhere to reliable, validated and standardised quality parameters. The contribution made by TanDEM-X data will certainly be very important in this context.

Crisis management

Disaster management is another field in which terrain models are urgently needed. Whenever a disastrous flood or earthquake occurs, satellite images and three-dimensional terrain maps provide relief agencies with precise information about the situation on the ground, even before they reach the area. TerraSAR-X has become a vital part of satellite-based crisis management. Even when a location is under dense cloud cover, radar images can complement optical images, providing additional important information about the extent of the areas affected. TanDEM-X is increasing the effectiveness of these applications.

Hydrology

High-resolution digital elevation models are also used to generate maps of areas at risk of flooding. These serve to assess risks and to identify hydrological and topographical characteristics. Information about drainage channels and soil moisture may be used as input parameters for weather and climate models set up on geographical scales of various sizes. Data from TanDEM-X may close the gaps in these hydrological models.

Another example is the transnational modelling of watershed yields that depends on reliable and consistent data and information about the local topography and vegetation. The option to monitor minor changes in topography or vegetation over space and time is a novelty in remote sensing. TanDEM-X will facilitate this even in the remotest regions

Geology

Terrain models form an essential basic element of geological research. Geological maps showing volcanic regions and earthquake zones are particularly interesting because, given a resolution of about one metre, they will show precisely what changes occur after an eruption or an earthquake. Unlike volcanic regions that are mostly well mapped, data of comparable quality are often lacking in regions threatened by earthquakes or ground subsidence. Similarly, the elevation data required to assess the tsunami risk across coastal areas is often incomplete. Here, TanDEM-X is a rich new source of information.

Glaciology

Changes in the mass of polar ice caps and glaciers represent evidence that the climate is changing. TanDEM-X is surveying the surface topography and size of these bodies of ice. Repeated measurements should permit scientists to measure ice losses and gains – important input parameters for climate models and forecasts that estimate global mass balances.

TanDEM-X may also help us understand the dynamics of the Antarctic ice sheet. One important parameter for the detection of ice sheet changes is its 'grounding line'. Although this point of anchor on the ground is hidden under several hundred metres of ice, it can be identified by synthetic aperture radar interferometry. Differences in elevation that occur as the ice is raised and lowered by the tides can be measured by differential synthetic aperture radar interferometry so that the borderline between land and water concealed beneath the ice can be determined. So far, this method has been applied successfully only in a few locations. TanDEM-X will facilitate mapping of this marginal zone more systematically.

Along-track synthetic aperture radar interferometry

Oceanography

As TanDEM-X is capable of measuring water currents, its data will help to draw conclusions on several related features and processes, including the relief (bathymetry) of seafloors and riverbeds and silt deposition in navigation channels. Coastal current maps are also of great value in the planning of tidal power plants.

Only the combination of TanDEM-X and along-track synthetic aperture radar interferometry can permit, for example, measurement of the flow rates of otherwise inaccessible rivers so that their transport volume can be calculated. At present, radar altimeters can only measure water levels directly rather than flow.

Traffic monitoring

The ability to identify moving objects and measure their velocity is of great interest for traffic monitoring. TerraSAR-X can do this on its own but only for one direction of motion. With two satellites working in tandem it is now possible to monitor different speed velocity ranges – adjustable through shifting the distance between the satellites. In so doing, TanDEM-X may well be the precursor of a space-based system for assessing traffic flow.

Glaciology

Along with the topography of ice caps and glaciers and grounding line positions, flow rates are an important parameter for ice and climate researchers. To monitor the flow rate of fast-moving glaciers, images have to be taken at intervals of about one day or less. The high-resolution imaging mode of TanDEM-X will enable the determination of glacier flow rates with unprecedented precision.

Innovative new radar techniques and applications

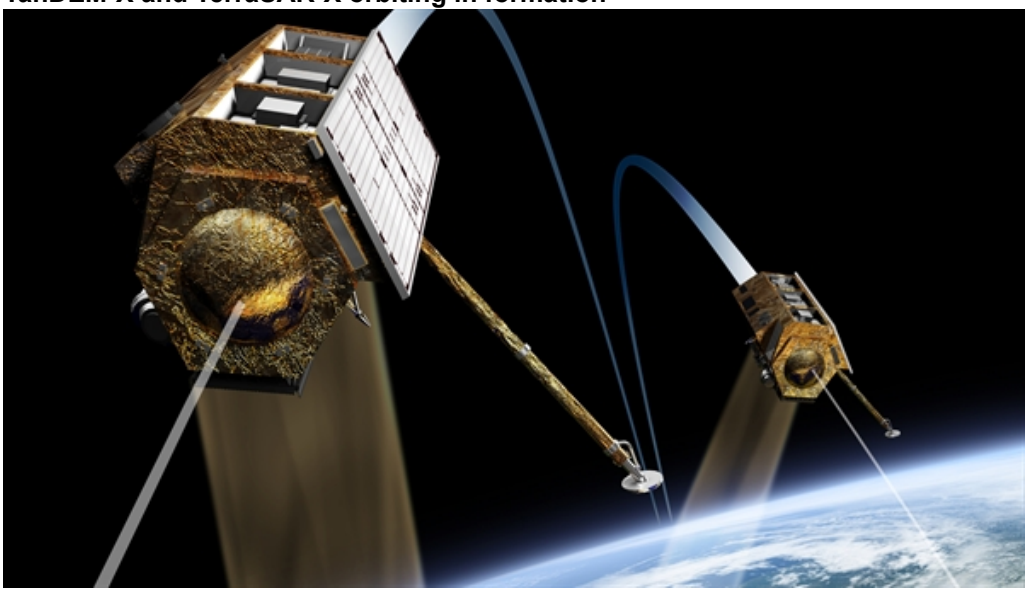
TanDEM-X will also test innovative radar technologies such as polarimetric synthetic aperture radar interferometry. This is an innovative remote sensing technique that allows the investigation of the three-dimensional structure of natural volume scatterers. Interferometric observables are very sensitive to the spatial variability of vertical structure parameters and allow accurate three-dimensional localisation of the scattering centre. At the same time, scattering polarimetry is sensitive to the shape, orientation and dielectric properties of scatterers and allows the identification and/or separation of scattering mechanisms of natural media. In polarimetric synthetic aperture radar interferometry, both techniques are combined together to provide sensitivity to the vertical distribution of scattering mechanisms. Hence, it becomes possible to investigate the three-dimensional structure of volume scatterers such as agricultural fields and to extract information about the underlying scattering processes. In addition, TanDEM-X will demonstrate a number of other innovative technologies such as bistatic observation and digital beam forming.

Contacts

Elke Heinemann
German Aerospace Center (DLR)
Corporate Communications
Tel.: +49 2203 601-2867
Fax: +49 2203 601-3249
elke.heinemann@dlr.de

Dr.-Ing. Stefan Buckreuß
German Aerospace Center (DLR), DLR Microwaves and Radar Institute
Tel.: +49 8153 28-2344
Fax: +49 8153 28-1449
Stefan.Buckreuss@dlr.de

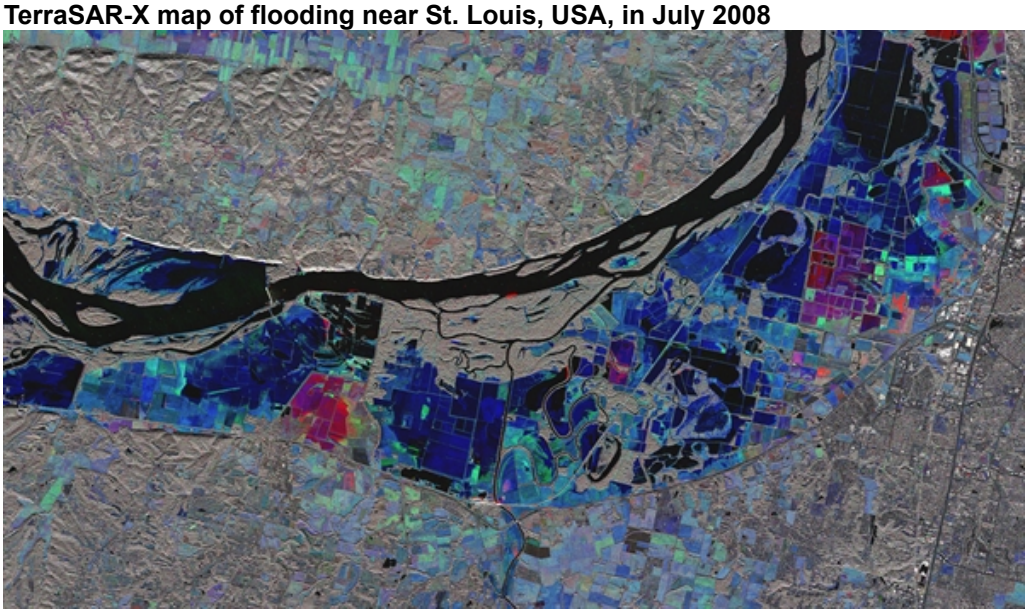
TanDEM-X and TerraSAR-X orbiting in formation



TanDEM-X and TerraSAR-X orbit in formation to acquire data for a highly accurate global digital elevation model.

Credit: DLR.

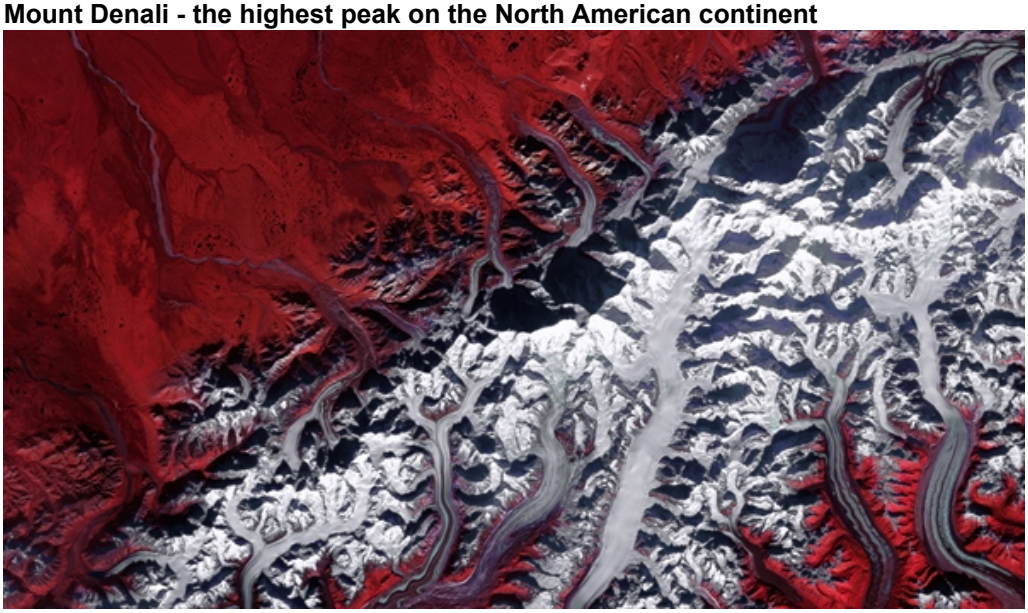
TerraSAR-X map of flooding near St. Louis, USA, in July 2008



TerraSAR-X map of flooding near St. Louis, USA, in July 2008. After earthquakes and volcanic eruptions, hurricanes are among the worst natural disasters in the Pacific region. People are threatened not only by high winds but also, and much more severely, by massive rainfall and the floods and landslides they cause. TerraSAR-X and TanDEM-X will provide important data for crisis management in the event of a catastrophe.

Credit: DLR.

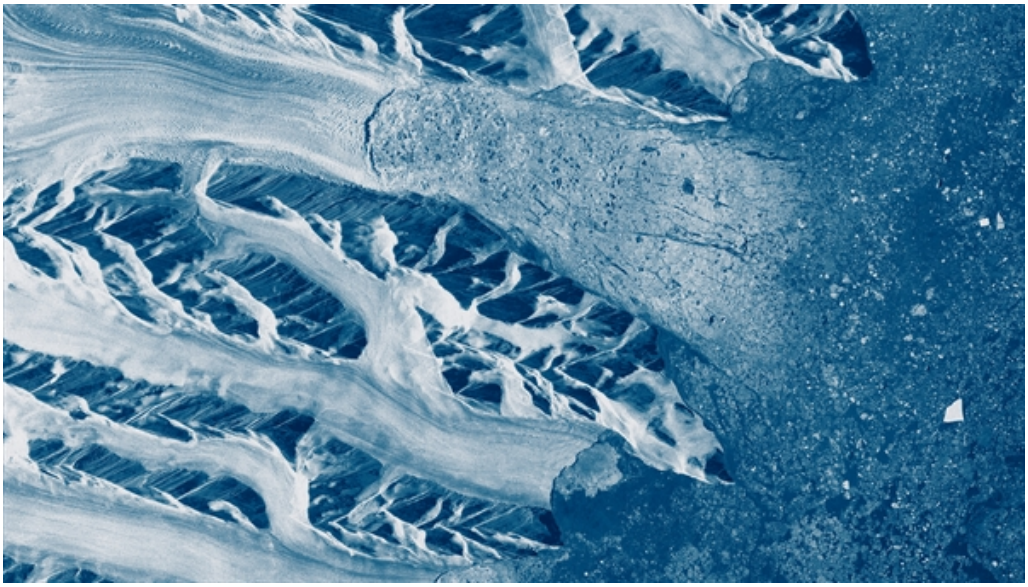
Mount Denali - the highest peak on the North American continent



At 6194 metres, Mount Denali (also known as Mount McKinley) is the highest peak on the North American continent. TerraSAR-X and TanDEM-X will permit continuous observations of inaccessible glaciers everywhere in the world.

Credit: DLR.

The Larsen ice shelf



This TerraSAR-X radar image shows a region that was completely covered by an ice shelf five years ago. Under current conditions, calving glaciers drop ice directly into water that is largely covered by sea ice. The Larsen ice shelf has been shrinking at a rate of about one kilometre per year for the last 60 years.

Credit: DLR (CC-BY 3.0).

Contact details for image and video enquiries as well as information regarding DLR's terms of use can be found on the DLR portal imprint.