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TanDEM-X – Start of the Science Phase of the mission

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After four years of successful data acquisition for the new global topographical map of Earth, the Science Phase is beginning.

The radar satellite TerraSAR-X has been orbiting the Earth since June 2007; in June 2010 its twin, TanDEM-X, followed it into space. For almost four years, the two satellites have been operated in a close flight formation by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR). During this time, the satellites have been acquiring data to generate a new global topographical map of the Earth.

The goal of the TanDEM-X (TerraSAR-X add-on for Digital Elevation Measurement) mission is to produce a highly precise, three-dimensional image of the Earth with uniform quality and unprecedented accuracy. For large parts of the Earth, there currently exist only approximate, inconsistent or incomplete elevation models derived from different data sources and collection methods. TanDEM-X is filling in these gaps and providing a homogeneous elevation model to be used as an indispensable basis for numerous commercial applications and scientific investigations.

With the start of the TanDEM-X science phase, another significant milestone in the mission has been reached. "In the coming 15-month mission phase, the orbit and imaging mode will be configured and optimised so that new radar techniques and innovative applications can be tested and demonstrated. The expectations of the scientific user community for the science phase are very high, and more than 100 science proposals have already been submitted," explains Alberto Moreira, Director of the DLR Microwaves and Radar Institute and Principal Investigator for the TanDEM-X mission.

New flight formation – new opportunities

The initial preparations for the science phase began with the transition to the new formation on 17 September 2014. TanDEM-X moved away from TerraSAR-X and has been flying at a distance of 76 kilometres behind its twin since 20 September 2014. This has resulted in a time delay of 10 seconds. Since the Earth rotates at approximately 500 metres per second at the Equator, the orbit of TanDEM-X has also had to be displaced laterally by five kilometres so that both satellites are imaging the same area on the surface. TanDEM-X continues to follow a helical orbit. Unlike the imaging for the Digital Elevation Model (DEM) of the Earth, the helix will not be adhered to for weeks at a time; instead, significantly greater variations will be permitted. The distance between TanDEM-X and the nominal orbit of TerraSAR-X will vary between zero and 1000 metres over the next five months.

The aim is to continue to operate both satellites using interferometry, to enable three-dimensional imaging of the surface of the Earth to continue. After changing the orbit of TanDEM-X in recent weeks, the two satellites are being operated independently of one another, in what is known as 'Pursuit Monostatic Mode'. The advantage of this new orbital configuration is that the distance between the satellites – the baseline – can be made substantially more flexible. "In the new orbital configuration, data for elevation models can be generated with an elevation accuracy of a few tens of centimetres, for example. This opens up new applications in the areas of the geosphere, cryosphere and hydrosphere. This data is unique and will be used in the investigation of volcanic eruptions, the melting of ice as well as, for example, tomographic imaging of cities," says Moreira. The orbital configuration will be changed again in the spring of 2015 to enable other applications and demonstrations.

One topical subject is the thawing of permafrost soils, which is being caused by global warming. It is causing massive damage to roads and houses and is leading to landslides. At present, it is known that huge areas are involved, although the precise extent is still unclear. "In the new phase of the mission, one of the things TanDEM-X will do is map these areas with a very high spatial resolution and contribute valuable insights into climate change," explains Irena Hajnsek, the Scientific Coordinator for the TanDEM-X mission.

Global elevation model of the Earth is being created

On 17 September 2014, the imaging for the DEM was completed, with the exception of a few images. A data set of over 2500 terabytes forms the basis for the new topographic map of the Earth. The quality of the elevation models generated to date exceeds all requirements. Final DEM tiles for more than a quarter of the land area – for example, for the flat areas of Australia, North America, Siberia, South and West Africa and South America – have already been processed. The new 3D map should be available in its entirety by the end of 2015. "Both satellites are functioning well, and the propellant supplies are certain to last until 2020," adds Manfred Zink, DLR scientist and Project Manager for the TanDEM-X ground segment. "We are already thinking beyond the science phase. The operation of two SAR satellites in close flight formation is a unique achievement and demonstrates Germany's leading position in radar technology. We can generate even more accurate elevation models or more precise coastline maps."

The success of TanDEM-X forms the basis for the development of innovative radar technologies. Researchers at DLR are already working on a new mission proposal with a digital radar antenna – Tandem-L. The aim is to achieve a significantly higher imaging capability, which will exceed that of TanDEM-X by a factor of 100. While TanDEM-X only enables one global image of the Earth to be acquired per year, Tandem-L will image the entire landmass of the Earth at a higher resolution twice a week. Hence, Tandem-L will be able to capture dynamic changes on the surface of the Earth with the required imaging repetition frequency and provide urgently needed information for solving topical scientific questions involving the areas of the biosphere, geosphere, cryosphere and hydrosphere. Such a mission could be launched in 2020.

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Background

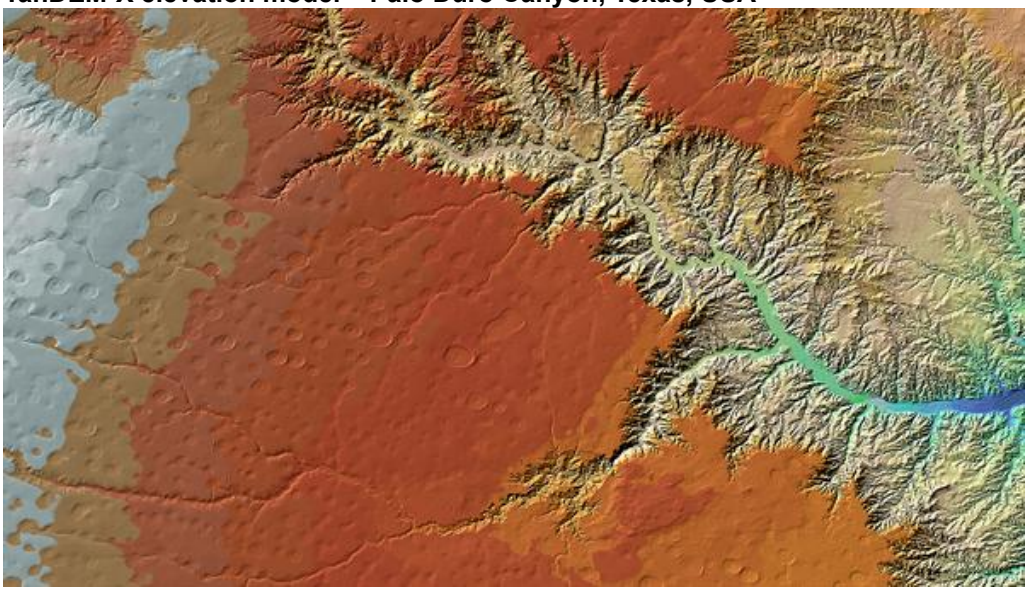
TanDEM-X is being implemented on behalf of DLR using funds from the Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie). It is a Public Private Partnership (PPP) project operated in conjunction with Airbus Defence and Space (formerly Astrium). DLR is responsible for the scientific utilisation of the TanDEM-X data, planning and implementing the mission, controlling the two satellites and generating the DEM. For this purpose, it also develops the necessary facilities on the ground, referred to as the Ground Segment. The DLR Microwaves and Radar Institute, the DLR Earth Observation Center and the DLR Space Operations Facility in Oberpfaffenhofen are participating in the development and operation of the ground segment of TerraSAR-X and TanDEM-X. Scientific coordination is the responsibility of the Microwaves and Radar Institute. Airbus Defence and Space built the satellites and is sharing the development and operating costs. The company is also responsible for the commercial marketing of the TanDEM-X data.

Contacts

Miriam Poetter
German Aerospace Center (DLR)
Communications Oberpfaffenhofen
Tel.: +49 8153 28-2297
Fax: +49 8153 28-1243
Miriam.Poetter@dlr.de

Prof. Dr.-Ing. Alberto Moreira
DLR German Aerospace Center (DLR)
Director, Microwaves and Radar Institute
Tel.: +49 8153 28-2306
Fax: +49 228 447-747
Alberto.Moreira@dlr.de

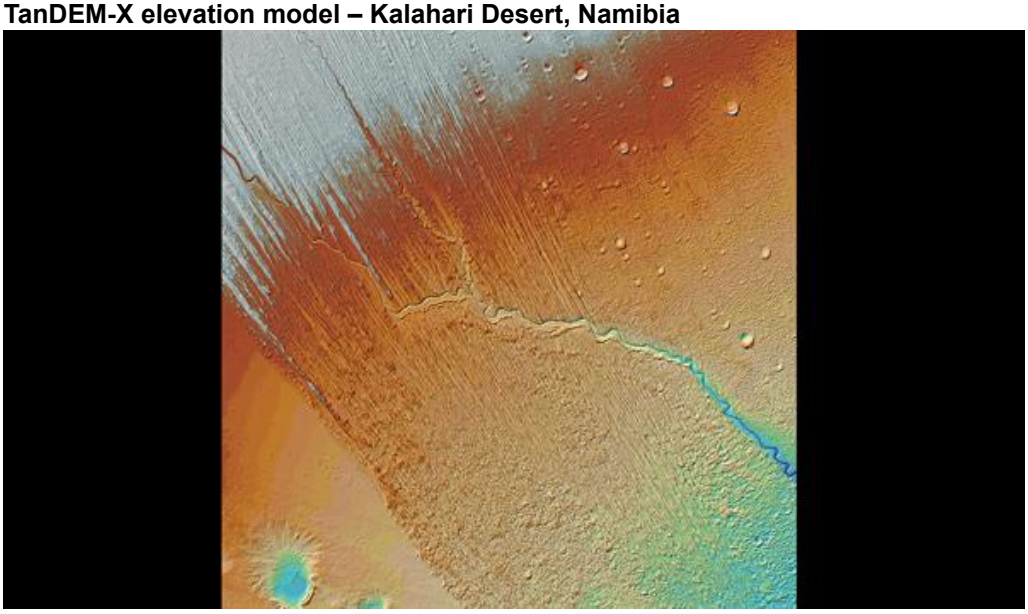
TanDEM-X elevation model – Palo Duro Canyon, Texas, USA



Palo Duro Canyon looks impressive in this TanDEM-X elevation model because of its fine branching. The second largest canyon in the USA draws numerous visitors to northern Texas every year because of its unusual geological structure, which has been formed over millennia by the wind and the waters of the Red River.

Credit: DLR.

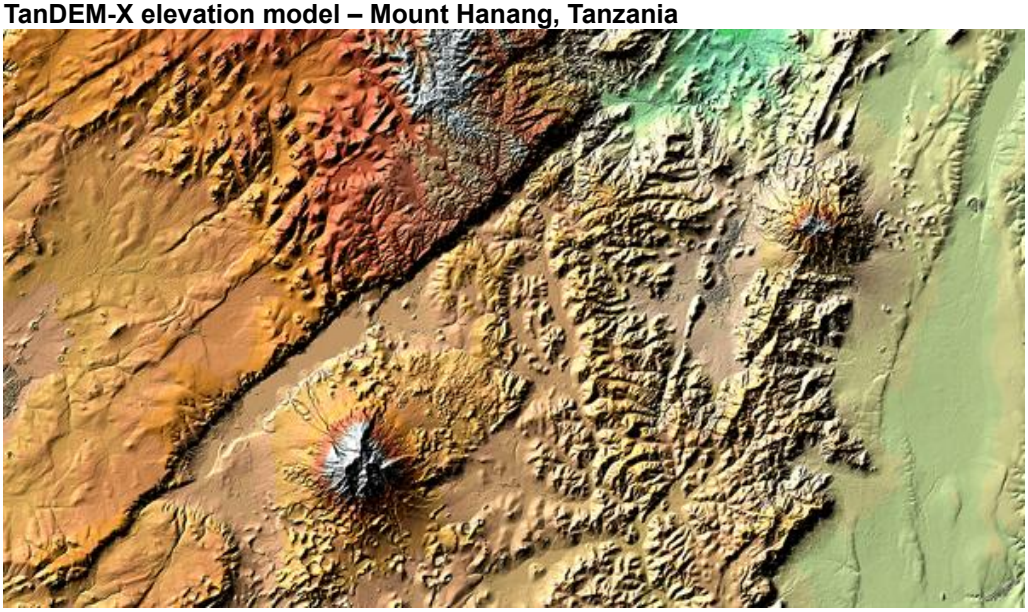
TanDEM-X elevation model – Kalahari Desert, Namibia



The offshoots of the Kalahari extend into eastern Namibia. The salt lakes, sandstone dunes shaped by the wind, and rock formations in this savannah landscape, which is dominated by grasses, thorn bushes and acacias, are striking.

Credit: DLR.

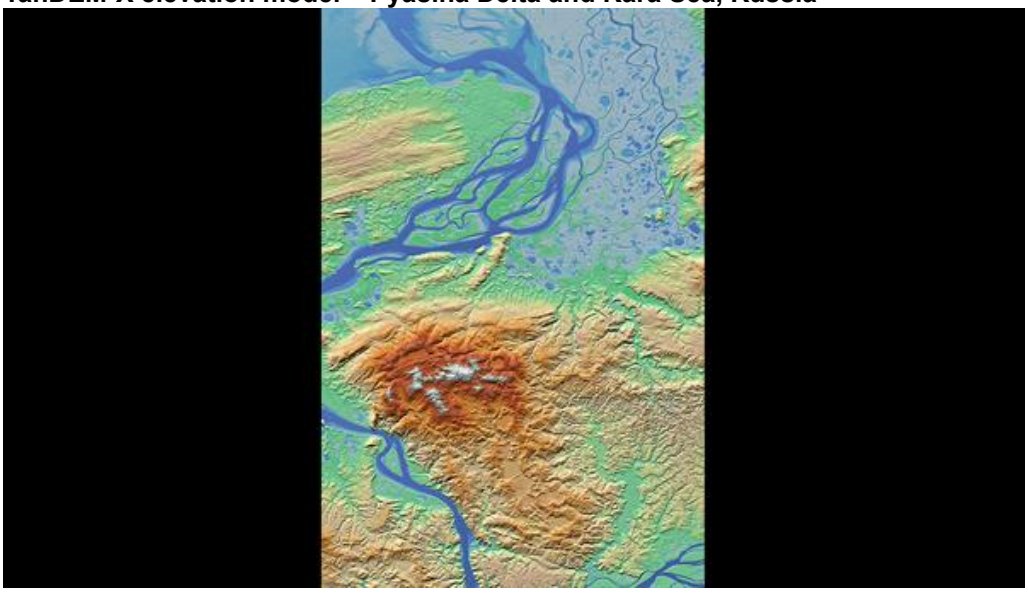
TanDEM-X elevation model – Mount Hanang, Tanzania



This TanDEM-X elevation model shows the 3418-metre-high crater of Mount Hanang in the north of the Maasai Steppe in Tanzania. Volcanoes and craters such as Mount Hanang bear witness to the tectonic faulting in this region of the East African Rift Valley.

Credit: DLR.

TanDEM-X elevation model – Pyasina Delta and Kara Sea, Russia



The Pyasina River in northern Siberia forms a broad, fascinating delta in its final kilometres from the sea, meandering extensively before draining into the Pyasino Gulf, which is part of the arctic Kara Sea.

Credit: DLR.

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