DLR’s TerraSAR-X contributes to international fleet of radar satellites to map the Arctic and Antarctica

The polar regions play an important role in the Earth system. The snow and ice covered ocean and land are sensitive indicators of global climate change and are themselves drivers for change. In March 2007 the International Polar Year (IPY) initiated collaborative polar research on a worldwide scale. The IPY is successor to the International Geophysical Year (IGY) of 1957/1958 which ushered in the modern era of polar science. Today’s IPY goes beyond IGY by enabling scientists to use for the first time data from spaceborne instruments. By using innovative remote sensing methods and techniques, detailed views of the entire Arctic and Antarctica can be achieved and placed in a global context. They complement observations from ground stations or air- and shipborne measurement campaigns.

The World Meteorological Organisation (WMO), one of the initiators of the IPY, has established the Space Task Group (STG) tasked with coordinating Earth Observation missions in support of IPY projects. This includes satellite operations but also data reception, processing and dissemination. The STG goals are particularly important for high resolution missions with optical and microwave sensors since their data acquisition requires appreciable planning efforts. Microwave instruments comprise Synthetic Aperture Radar (SAR) instruments capable of making observations through clouds and during either the day or night. Thus the properties of ice sheets even at the most remote locations can be systematically investigated year round. Among the radar goals formulated by STG are:

- For the first time, pole to coast multi-frequency Interferometric SAR (InSAR) measurements of ice-sheet surface velocity
- For the first time, repeat fine-resolution SAR mapping of the entire Southern Ocean sea-ice cover for sea ice motion
- For the first time coordinated radar observations of selected areas in the Arctic and Antarctica with high scientific potential, so-called ‘super sites’.

DLR is a member of the Space Task Group. It contributes capabilities of its X-band mission TerraSAR-X. Other partner space agencies with operational radar sensors are the European Space Agency ESA (ASAR on ENVISAT, C-band), the Italian Space Agency ASI (Cosmo Skymed, X-band), the Canadian Space Agency CSA (Radarsat-2, C-band) and the Japanese agency JAXA (PALSAR on ALOS, L-band). The X-band operates at a wavelength of \( \lambda = 3 \) cm (frequency 9.65 GHz) and permits mapping with high spatial resolution down to the submeter range. At C-band the Earth’s surface is scanned at \( \lambda = 6 \) cm (5.36 GHz) and at L-band \( \lambda = 24 \) cm (1.25 GHz). Observations at all frequencies help better characterize the physical properties of the icy surface.

Under the scientific auspices of the GIIPSY project (Global Inter-agency IPY Polar Snapshot Year) November 2008 marked the beginning of the IPY coordinated activities for TerraSAR-X with acquisitions over a tributary ice stream feeding into the Recovery Glacier (81°S, 20°W) in Antarctica. This area is presently being imaged in parallel by the Canadian Radarsat-2 satellite. Most spaceborne SARs are built such that the radar beam points to the right with respect to the satellite ground track which does not pass exactly over the Poles. Therefore over Antarctica the areas South of about 80°S can not be imaged by right looking radar sensors. TerraSAR-X and Radarsat satellites have a unique attribute to image left and right, thus enabling observation of the portion of Antarctica close to the South Pole. Using its large swath width (150 km) Radarsat-2, is carrying out the first dual polarization mapping of Antarctica at a spatial resolution of 25 m. TerraSAR-X has a narrower swath (30 km), but extremely fine 3 m spatial resolution. So it will focus on selected, smaller, very complex areas of high scientific interest on the ice sheet. In the case of snow and ice the penetration depth of the microwaves is reduced for the smaller wavelength. Therefore the radar response at X-band is more sensitive than at C-band to surface and near surface physical properties like wetness and roughness of the imaged area. This makes
TerraSAR-X a valuable tool for regular and spatially extended investigations of fine structures on ice and snow surfaces. Features like flow lines and crevasses can be observed in detail and used to study flow dynamics of glaciers and ice streams.

Up to now, the only available SAR mapping of the Recovery Glacier system was carried out in 1997 with Radarsat-1, the predecessor of Radarsat-2. The planned TerraSAR-X acquisitions repeated at 11 day intervals will allow decadal scale comparison to the 1997 data for change detection and will also provide for the first time the surface velocity field of the entire glacier. Velocity is derived by means of SAR interferometry (InSAR) technique which uses phase difference between two coherent SAR images of the same scene to retrieve surface motion. Ice sheet surface velocity is a crucial parameter for evaluating ice sheet mass balance and for estimating important controls on ice sheet dynamics. These investigations will help address a critical limitation in climate models which do not yet have the ability to predict the observed rapid changes in the ice sheet behaviour with consequent impacts on local oceanography and global sea level.

Figures

1. TerraSAR-X flying over Antarctica.
2. Location of Recovery Glacier (inset) and planned acquisitions with TerraSAR-X (white boxes) overlaid on the Radarsat-1 Antarctic Mapping Project mosaic (courtesy K. Jezek, Ohio State University).
3. Flow lines (long curvilinear bands) and crevasses (bright patch in lower center) on the Beardmore Glacier flowing through the Transantarctic Mountains (left) as seen by TerraSAR-X.
4. Left: TerraSAR-X backscattering over Recovery Glacier acquired on 30.10.2008. Right: the corresponding interferogram calculated with 11 day repeat pass. Area size is about 30 x 50 km².

Contact

Dr. Dana Floricioiu
German Aerospace Center
Remote Sensing Technology Institute, SAR Signal Processing
Tel: +49 8153 28 1763
Fax: +49 8153 28 1420
E-mail: dana.floricioiu@dlr.de

Dr. Manfred Gottwald
German Aerospace Center
Remote Sensing Technology Institute, Space Task Group
Tel: +49 8153 28-1591
Fax: +49-8153 28-1446
E-mail: manfred.gottwald@dlr.de

Links

1. TerraSAR-X at DLR: http://www.dlr.de/tsx/
2. GIIPSY homepage: http://bprc.osu.edu/rsl/GIIPSY/
3. IPY homepage: http://www.ipy.org/