Satellite-based DEM for Monitoring Antarctic Surface Topography, with a Special Focus on Glaciers

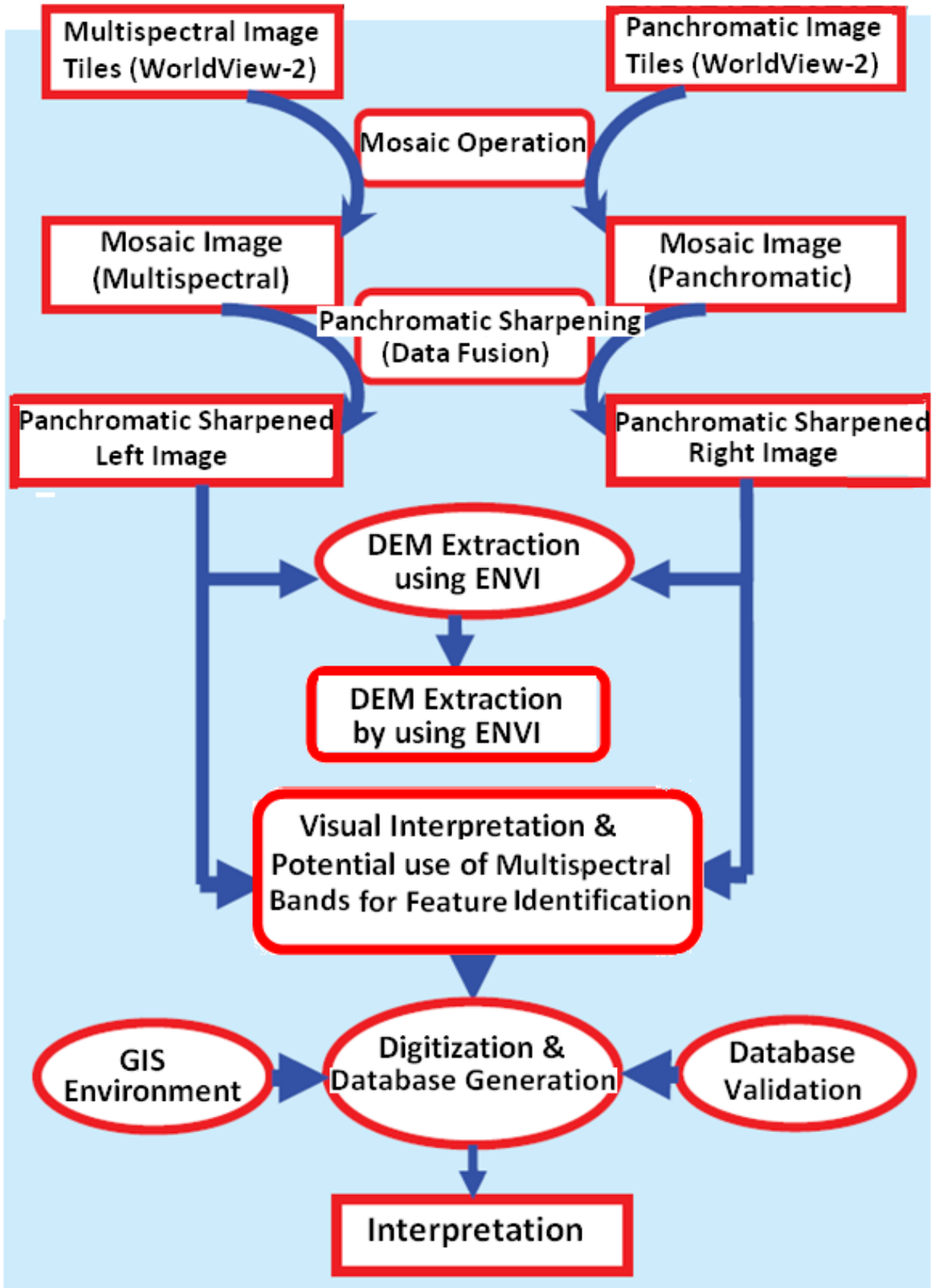
Objectives of the study

- Generation of highly accurate Digital Elevation Model (DEM) of Dronning Maud Land in the vicinity of Maitri station, Larsemann Hills, and surrounding glaciers, using SAR, ERS 1 & 2 stereo pairs, CARTOSAT-1 & 2, ICESat/GLAS and ASTER GDEM & RADARSAT
- To quantify and study the trends in surface elevation changes using ICESat satellite altimetry and InSAR DEM;
- To compare the ASTER, ICESAT/GLAS and SAR DEM for accuracy and to validate them using ground survey global position system points.

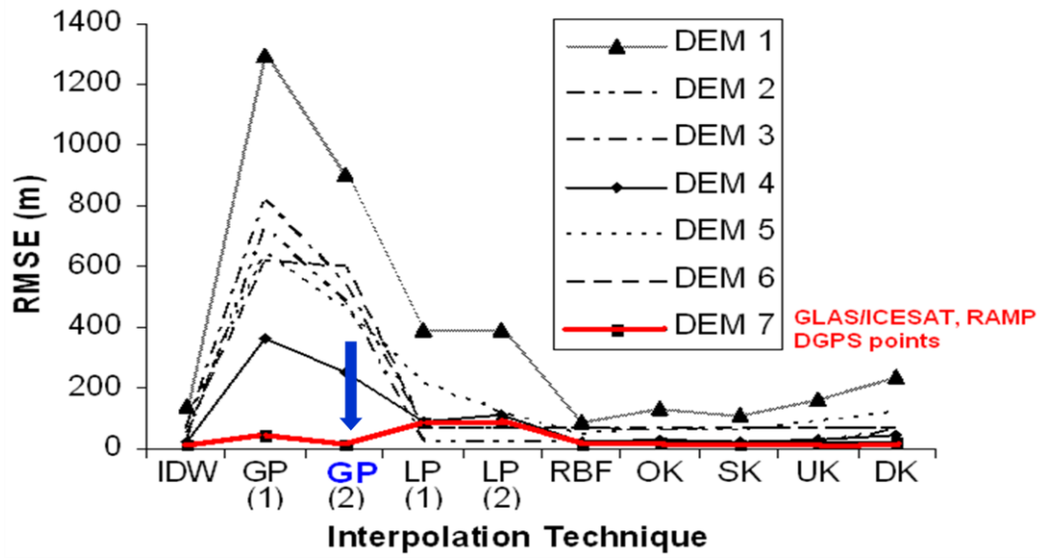
Rationale

For the first time in the history of Indian Antarctic research, NCAOR began generating a highly accurate and improved DEM (over the existing coarse RAMP DEM) of Antarctic regions by using high resolution Cartosat-2 satellite remote sensing data and advanced SAR technologies. This will be the first India's effort to construct a DEM of any part of Antarctica using GLAS/ICESat and SAR technologies. Moreover, to date, there is not a single DEM of Antarctic region developed in India which is based on synergistic use of GLAS/ICESat and SAR technologies. Conventional methods used in India during the past years for elevation map generation were GPS and triangulation techniques. The Survey of India (SOI) developed a DEM of Larsemann Hills and Schirmacher Oasis using ground survey only. During 1991, in the XI Indian Expedition to Antarctica, a survey of 'Maitri and Environs' on scale 1:5,000 with 5 meter contour interval was generated by SOI team. This was the first Indian production of a topographic map of any part of Antarctica. The first DEM model can be derived from contour digitization and GIS operations. In the XIX Indian Antarctic Expedition (1999), a large-scale mapping of northwest of Maitri station, was carried out by SOI. During this expedition large scale original plane table survey on 1:1000 scale with l m contour interval for an area of 400 × 500 m was done and a digital map was prepared. In the XXVII Indian Antarctic Expedition (2007), large-scale topographical mapping in Schirmacher Oasis and Larsemann Hills were carried out. The elevation map has been prepared with elevations measurements at 410 sites along with longitude and latitude, using Global positioning system receiver, in autonomous mode and WGS84.

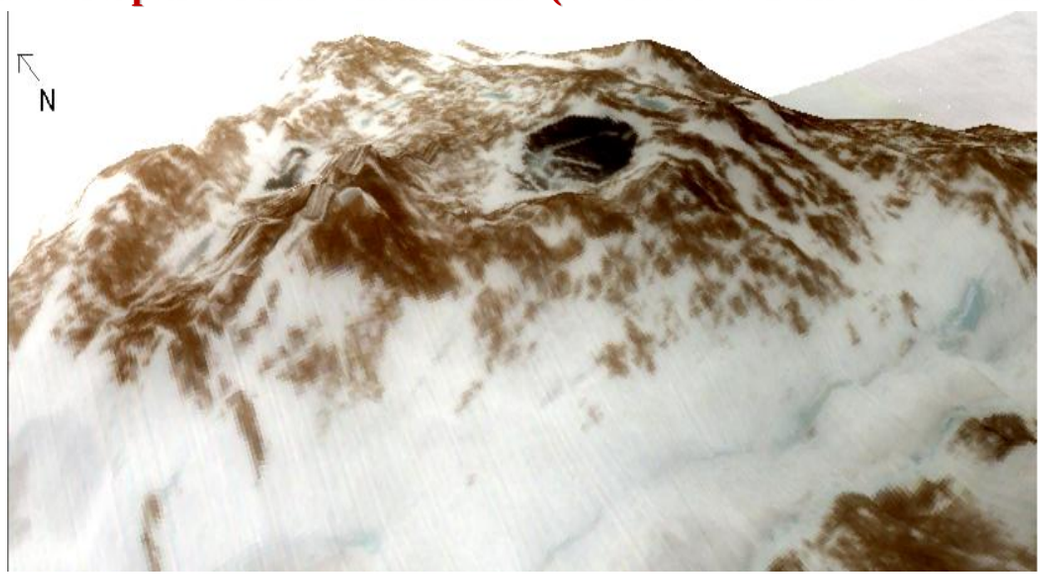
Protocol for Generation of DEM using P**anchromatic** and Multispectral data



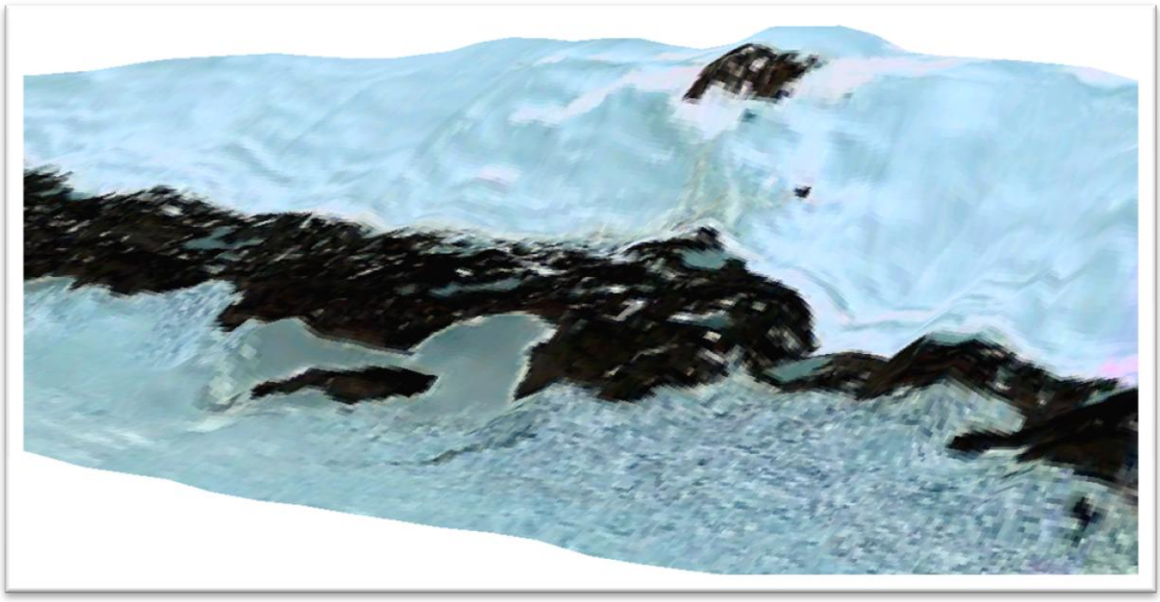
Interpolation schemes for DEM with least root mean square error



3-D view of a part of Larsemann Hills (Worldview-2 and CartoDEM)



DEM of Schirmacher Oasis using Cartosat Stereopair (Google image draped on CartoDEM)



Significant Findings

Theme: Synergistic use of multitemporal RAMP, ICESat and GPS to construct an accurate DEM of the Larsemann Hills, Antarctica

DEM of limited area of Larsemann Hills has a vertical accuracy of about 1.5 times better than RAMPv2 DEM and seven times better than GLAS/ICESAT-based DEM.

The newly constructed by synergistically merging GLAS/ICESAT, RAMP and 46 differential GPS points achieves highest accuracy with the least average elevation difference of 0.27 m.

Theme: A spectral index ratio (SIR)-based Antarctic land-cover mapping using hyperspatial 8-band WorldView-2 imagery

A novel multifold methodology is used to evaluate the effect of pan-sharpening algorithms on spectral characteristics of satellite data, and a set of existing pan-sharpening algorithms was implemented in order to fuse PAN with multispectral data to generate multiple SIRs for extracting target land-cover classes.

Theme: Very high-resolution satellite data for improved land cover extraction of Larsemann Hills, Eastern Antarctica

Four different image classification methods are compared to improve the accuracy of cryospheric land-cover mapping by using high resolution WorldView-2 data. Three classes of land cover—land mass/rocks, water/lakes, and snow/ice—were classified using identical training samples. The final thematic land cover map of Larsemann Hills, east Antarctica, was integrated using ensemble classification based on a majority voting–coupled winner-takes-all method.

Theme: Improved land cover mapping using high resolution multiangle 8-band WorldView-2 satellite remote sensing data

A novel multifold methodology protocol was designed to estimate the consequences of multiangularity and germane PAN-sharpening algorithms on the spectral characteristics (distortions) of satellite data and on the resulting land use/land cover mapping using an array of Spectral Index Ratios.

This method helps to overcome the atmospherically triggered spectral distortions of multiangular acquisitions, which facilitates better mapping and understanding of the earth's surface.