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SCIENTIFIC ACTIVITIES REPORT OF SURVEY OF INDIA DURING XVII IAE 1997-98

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Introduction

Man always endeavours to understand nature, for nature has profound influence on his living. Study of Plate movements is just not an academic interest but it has utility in understanding the past geology and in monitoring the present tectonic processes. Survey of India, NGRI and the Institute of Planetary Geodesy, University of Dresden, Germany have taken up combined work in the field of Planetary Geodesy in Antarctica duting the 17th Indian Scientific Expedition to Antarctica 1997-98. In this report the main objectives, field activities, general considerations for the studies and the results of some of the activities will be presented.

Main objectives

a) Study of Antarctica Plate movements with reference to other plates.
b) Study to understand the Ice-shelf dynamics.

Plate movements study in Antarctica

Plate tectonics explain the dynamic system of lithospherical growth and destruction of, plates. This continual process of growth and destruction are driven by the convection calls in the mantle. Tectonic Processes take place throughout the earth. The Antarctica

plate is encircled by divergent plate boundaries along roughly 95% of its perimeter and is broken internally by numerous large rift structures.

Tectonic setting of Antarctica

In geological parlance Antarctica is divided into two major tectonic units : the East Antarctic shield and the microplates of West Antarctica.

The larger East Antarctica shield is defined as the region, bounded on the seaward and northern side by the South Atlantic and Indian Ocean. On the landward side it is bounded by the Transantarctic Mountains, the Pensacola Mountains and the east of the Filchner-Ronne Ice Shelf.

The West Antarctica encompasses the Scotia Arc region, the Antarctic Peninsula, Ellsworth Land and Mountains, Marie Byrd Land and other areas not included in East Antarctica (Tingey, 1991).

General considerations of the study

To study plate movements a well defined geodetic network is to be established and geodetic observations are to be carried out in various epochs with time interval of several years. For this the points observed should be of permanent nature and with proper documentation so that they can be reoccupied at future dates. For each epoch a detailed data screening analysis and adjustment has to be carried out, resulting in estimated co-ordinates for all stations, which represents the currently valid geometry of the network.

The suspected movements are derived by a rigorous statistical analysis, using the co-ordinate sets x of the points and covariance matrices σxx of atleast two epochs.

Field activites

A new GPS bench mark MAI1 was established near Maitri on a hill top adjoining the Priyadarshini (Zub) lake on its eastern

side. This was made on the bed rock by driving the specially designed GPS marker by a mechanical drilling system developed for bolting in mountain climbing and on speleology. The GPS marker has thread on its top upon which the receiver antenna can be firmly mounted. The problem of power supply was overcome by installing a small wind charger which supplied power to the receiver by charging the battery. This point was chosen as the originally monumented point behind the 'Tirumala Hut' was abandoned as the digging operations for Seismic vault was going on in the same area which might interfere with the data reception. The old GPS point FORI near Russian station Novolazarevskaya was also chosen for GPS observations and here the power supply is made through cable from the station. Continuous GPS observations are made with 15 seconds epoch interval from 20th January (00.00 UTC) to 10th February (24.00 UTC), 1998 as part of SCAR GPS campaign, 1998. The data is downloaded every third day at the MAI1 point and on every seventh day at the FOR 1 point.

Data processing and Results

The GPS data of these two points and other SCAR GPS campaign points which were observed throughout Antarctica during the same period are being screened and adjustments are made. The collective data of SCAR GPS campaign, 1998 will be processed through Bernese software using co-ordinates of IGS sites in the southern hemisphere as a-priori reference co-ordinates in order to connect the Global Antarctic network to the ITRF (IERS-International Earth Rotation Services - Terrestrial Reference Frame). Other a-priori infomations to be used in this processing are : the final IGS orbits and the Earth Rotation Parameters (ERP) associated with them. The final processing will be carried out once all the a-priori informations are obtained. The results will be published combinedly by the German and Indian teams.

Ice Shelf dynamics study

The Ice Shelf floating on sea has both vertical and horizontal motions. The vertical motion is mainly due to the tidal forces of the sea and the horizontal motion is due to the pressure

exerted along the bounding line separating the land ice and shelf ice and other factors of ablation, accumulation etc.

General considerations of the study

Heights observed of the ice shelf during the low tide and the high tide will give the vertical motions of the ice shelf. For horizontal motions, points on the ice shelf are to be observed with reference to fixed points on the land ice and repeat observations after made few days gap will give the differences in the positions of the points and hence the horizontal motion of the ice shelf.

Field activities

To study the vertical motions, GPS observations are made in kinematic mode. The observations are made from the land ice to the shelf ice during low tide kinematically and after waiting few hours till the high tide set in, observations are again made following the same path from the shelf ice to the land ice. As the bounding line separating the land ice and shelf ice are not exactly known, near the suspected boundary many circular paths are observed in kinematic mode before starting and ending to ensure that there is no ellipsoidal height difference for the land ice as it is not influenced by the tidal forces.

For horizontal motions, GPS observations are made on the land ice to serve as reference in static mode. Suitable points are selected on ice shelf for observations and stakes are made using tripods which are firmly fixed on the ice. Angles and distances are observed to these points by EDM with respect to the reference points. GPS observations are also made as additional measure. Repeat observations are made after few days gap.

The processing of data will be carried and the results will be published combinedly by German and Indian teams.

Vertical Datum Measurement

Self recording tide guages were installed the epishelf lake Predgornoye, 3 km north east of Maitri and in the epishelf lake

Oshidaniya, 4 km north west of Maitri along with German team. Tide guages were also installed in the open Ocean, close to the Russian discharge base (instrument was lost) and in the epi shelf lake Cholodnoye, in the eastern part of Schirmacher Oasis by the German team. The sea level was also connected to the nearby ground mark by levelling which was also observed by GPS. These measurements will be helpful in the vertical datum determination and also in the Geoid modelling.

Ice Mass balance study

Assisted the German team in remeasuring the old traverse stakes of the Untersee traverse by GPS and classical geodetic methods which will be used for the Ice Mass balance studies. The changing ice loads also affects the underlying lithosphere.

Provision of additional GPS points

Additional short term GPS observations are made in Schirmacher Oasis and on the Nunatak (Vittaiah top) near the communication booster mast. These additional GPS observations will be helpful in local GPS campaign as reference and also for mapping purposes.

Field activities

GPS observations were made during SCAR GPS campaign, 1998 with Astech Z-12 receivers with 15 seconds epoch interval. Observations are made also at the old Survey of India GPS marker point at Maitri station (old name MAITRI) now renamed as SOU for fairly longer period of nearly 3 days. Power supply is made by regularly exchanging the batteries and data downloaded every day. The new name was given for convenience of data processing and comparison. Other points were observed from 4 to 8 hours except for one point which was observed for only two hours. All points are made on bed rocks with deeply engraving a circle and dot mark which was also painted and cairn made at each point. All these points will be of much use especially the following : SADL point as reference for work in the shelf ice, SETOP and VTAI points as

reference for work in the adjoining cap ice. SOU and ANT1 (NGRI) can serve as an excellent short base for future operations.

Data processing and Results

The data collected was processed along with the relevant data of FORI and MAIL The final co-ordinates of FORI in the datum of ITRF94 (epoch 1995.1) was used as a-priori information in processing. Solution was also found out for ANT1 (NGRI) point. The data was processed using Prism software with 15° cut off angle for elevation and final fixed Double Difference solution (Lc) are arrived at. The geodetic co-ordinates are with reference to WGS-84 and the Cartesian co-ordinates are in UPS. The results are given below :

Station	X(m)/ Latitude	Y(m)/ Longitude	Z(m)/ Ellipsoidal lit.(in)
SOU	2063603.2384	428632.6345	-5999794.7718
	70° 45' 51.552" S	11" 44' 2.755" E	132.4976
ANTI	2063437.6660	428659.4567	-5999849.2340
	70" 45' 56.903" S	11° 44' 08.621" E	132.3101
VTAI	2061470.6928	423927.4141	-6001259.9010
	70" 47' 39.754" S	11" 37' 13.756" E	514.9234
SADL	2063756.4807	429876.2985	-5999686.7114
	70" 45' 38.117" S	11" 45' 58.851 E	163.3519
SETOP	2062867.5478	428622.4240	-6000094.9580
	70" 46' 16.750" S	11" 44' 16.424" E	219.5559
STHS	2062924.4495	429258.3774	-6000026.6861
	70" 46' 10.383" S	11" 45' 16.242" E	174.5039

MAITRI (Old) : X(ra)=2063593.433 Y(m)=428628.665 Z(m)= -5999781.989

A comparison of co-ordinates of old MAITRI point and the new SOU point reveals that the Cartesian co-ordinates differ : in X - direction by 9.8m, in Y - direction by 4.0m and in Z - direction by 12.8m. The difference in the length between the old

position and the new position is given by : dl = 16.6m. This is because earlier the old MAITRI was observed using single receiver (in point positioning mode) without any reference receiver operating and co-ordinates are based on average of several observations made, while the new SOU (old MAITRI) position are observed with the reference receiver operating at FOR1 station (in relative positioning mode) and the co-ordinates are computed by processing the common data of both FOR1 and SOU, using the co-ordinates of FOR1 as a-priori information.

Dakshin Gangotri Snout Monitoring Programme

To monitor the DG Snout which is being carried out by GSI, the profile of the Snout is studied by observing the distances and angles with reference to two fixed points G and H on bedrock by classical geodetic methods. A chart was prepared for the profile observed in 1:1000 scale digitally and the same is attached in the end.

Other activites

Assistance was provided to NGRI team to store data on-line to the computer as the internal memory of NGRI's Astech Z-12 receiver was damaged due to accidental fall. Also GPS data observed and given to NPL team for their study of Ionospheric effect on the GPS signal transmission. Assistance was also provided to NAL team in their drilling operations for installing wind mills.

Further Scope

. For the first time, Survey of India has taken collaborative project with a foreign team and the nature of work is more of application oriented. Application of Geodetic methods for other studies like plate tectonics not only has utility but will also improve the scope of the science of Geodesy. Provision of additional points in the Orwin Mountains area were not taken up as already sufficient points are there and they need to be only reobserved during the next campaign. But points are required to be made further south of the Orwin Mountains which can be taken up during the next campaign. A complete set of points which are to form the local

network for the plate movement study can be decided in advance and logistics planned accordingly for ease of operations. Continuing co-operation among the participating teams help in sharing knowledge and in improvising the methods as necessitated.

Conclusion

It was new experience, personally, for me to visit the Ice Continent and to take part in the field activites in the interior using skidoos. Also the methods adopted, the innovations made for specific problems and the quickness of operations that is required in hat hostile conditions taught me many things. By contributing to science we also gain knowledge which were hitherto unknown

Participating in the Indian Scientific Expedition to Antarctica not only benefit survey of India but also individually satisfying to me . I am thankful to both my department and to the department of Ocean Development for the same.

DG SNOUT PROFILE - 1998

ANGLES AND DISTANCES FROM GROUND POINTS 'G' AND 'H'

POINTS	Angle < HGR(i) >	GR(i) in metres	Angle < HR(i) >	HR(i) in metres
R1	130° 18' 09"	249.25	39° 45' 47"	297.19
R2	129° 07' 47"	152.43	35° 53' 13"	201.72
R3	125° 50' 41"	144.44	37° 38' 28"	191.72
R4	114° 17' 25"	138.03	45° 24' 47"	176.66
M1	108° 37' 06"	137.47	49° 32' 15"	171.23
M2	94° 11' 34"	137.58	60° 36' 28"	157.48
M3	83° 29' 13"	140.15	69° 45' 46"	148.40
M4	80° 24' 32"	139.67	72° 17' 51"	144.57
R5	78° 08' 11"	147.89	75° 43' 24"	149.34
R6	76° 29' 05"	151.87	77° 52' 10"	151.03
R7	74° 40' 25"	169.78	82° 13' 35"	165.26
M5	74° 42' 25"	176.89	83° 07' 28"	171.86
R9	72° 25' 35"	199.67	87° 56' 36"	190.43
R10	72° 15' 43"	248.30	92° 02' 20"	236.65