Recent Progress of Geodetic Research in the Japanese Antarctic Research Expedition (JARE) Area

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Outline of my presentation

a. Kinematics (VLBI, GPS, DORIS)
   − Future improvements
b. Gravimetry
   − Absolute gravity measurements
   − Airborne survey
c. Ocean Observations
   − Syowa BPG observations
   − OBP comparison
d. Summary
Syowa Station

DORIS

VLBI

BPG

GPS

AG
a. Kinematics

1. **All are linked to International Network**
   
   - **GPS** = IERS DOMES Number 66006S002 SYOG
   - **VLBI** = IERS DOMES Number 66006S004
   - **DORIS** = IERS DOMES Number 66006S003 SYPB

2. **All monuments have stability of decadal time scale**
   
   - Monument sheet is prepared and log notes are complete.
   
   Description includes:
   
   - Geocentric coordinate values,
   - Definition of antenna reference point,
   - Antenna overview,
   - Sketch of the reference mark,
   - Offset from the IGS GPS mark,
   - Notes on local geodetic ties,
   - Chronology,
   - References

3. **Monument sheets are in**
   
Topocentric velocities of the Syowa reference points

<table>
<thead>
<tr>
<th>Up (mm/yr)</th>
<th>East (mm/yr)</th>
<th>North (mm/yr)</th>
<th>reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6 ± 2.2</td>
<td>-2.5 ± 0.6</td>
<td>4.0 ± 0.7</td>
<td>VLBI (1999–2003), Fukuzaki et al. (2005)</td>
</tr>
<tr>
<td>1.0 ± 1.2</td>
<td>-4.2 ± 0.3</td>
<td>2.9 ± 0.4</td>
<td>VLBI (1999–2004), Fukuzaki et al. (2006)</td>
</tr>
<tr>
<td>2.3 ± 0.3</td>
<td>-4.4 ± 0.2</td>
<td>-0.2 ± 0.2</td>
<td>GPS (1999–2003), Fukuzaki et al. (2005)</td>
</tr>
<tr>
<td>2.5 ± 0.3</td>
<td>-5.4 ± 0.1</td>
<td>0.8 ± 0.1</td>
<td>GPS (1999–2004), JPL website</td>
</tr>
<tr>
<td>1.4 ± 0.2</td>
<td>-4.1 ± 0.1</td>
<td>1.1 ± 0.1</td>
<td>GPS (1998–2004), Ohzono et al. (2006)</td>
</tr>
<tr>
<td>8.6 ± 1.9</td>
<td>-0.3 ± 1.3</td>
<td>1.5 ± 1.9</td>
<td>DORIS (1999–2002), IDS website (2005)</td>
</tr>
<tr>
<td>3.6 ± 0.2</td>
<td>-6.5 ± 0.8</td>
<td>3.2 ± 0.9</td>
<td>DORIS (1999–2004) from P. Willis</td>
</tr>
</tbody>
</table>

Future Improvements

All (VLBI, GPS, DORIS) suggested 1-3 mm/yr uplift rate at Syowa Station, but detailed comparison is required.

1. **GPS**
   Current accuracy from each daily file is 1.5 – 2.5 cm, and more accurate modeling of tropospheric correction (mapping function) and ionosphere correction specific to the Antarctic region are required. → **JARE-48 experiments**
   High rate sampling (1 s instead of current 30 s) is planned.

2. **VLBI**
   Speed up of data recovery and correlator processing using Intelsat data link are required. → **More experiments than now** (8 sessions per year)!

3. **DORIS**
   No further efforts are required from the beacon side.
b. Gravimetry

1. Repeated AG measurements at the IAGBN #0417 Syowa Station

±2 $\mu$ Gal accuracy came to be obtained with an FG5. Secular gravity decrease came to be detected.

2. Gravity anomalies are obtained in 2006 by Japan–Germany joint airborne geophysical survey flights around Syowa Station

Detailed analysis is ongoing. Preliminary results indicate large negative anomaly in the Shirase Glacier area.
Coordinates of Geodetic Monument at Syowa Station, Antarctica, Sheet 8.

Monument type: Absolute Gravity Station
Identification code: IAGBN(A) #0417

Geodetic coordinate values:
\( \phi_{AAGBN} = 69° 00' 24.1274'' \text{S} \)
\( \lambda_{AAGBN} = 39° 35' 08.0951'' \text{E} \)
\( h_{AAGBN} = 21.493 \text{ m} \)

Reference frame and Ellipsoid: ITRF2000 and GRS80 Ellipsoid

Definitions of reference point: Cross point of the brass disk in the concrete base of 1.5 m by 2.5 m in the GOH.

Offset from the IGS GPS mark
\((dx, dy, dz) = (28.448 \text{ m}, -71.868 \text{ m}, -17.129 \text{ m})\).

Notes on IAGBN(A)#0417 mark and leveling survey:
The GOH was constructed in February 1991 by JARE-32. A marble plate 1.0 m by 1.4 m was placed within a concrete base 1.5 m by 2.5 m. At the center of the marble plate, a brass disk of 8 cm diameter was buried. The station marker is IAGBN(A) SYOWA STATION JARE32 1991 S. Nakajima (JARE-32) and K. Watanabe (JARE-33) did a leveling survey from the BM1040 height standard to the IAGBN(A)#0417 mark. The height above mean sea level of the mark was \( h_{AAGBN} = 21.4927 \text{ m} \) (1992.0). M. Iwata (JARE-39) did a conventional survey in January 1998 to obtain the station coordinates of the mark.

Notes on local geodetic tie:
Because IAGBN(A)#0417 is situated in the GOH, direct GPS positioning could not be done. The given coordinates are combined results from relative GPS positioning and a conventional survey. There was some inconsistency in the original offset vector \((dx, dy, dz) = (28.355 \text{ m}, -71.933 \text{ m}, -17.000 \text{ m})\) given by the log note; the vector components were adjusted to give consistent results with the geodetic coordinates reported by the Geographical Survey Institute (2002). For this adjustment, \( N_{AAGBN} = 21.076 \text{ m} \), the same value as at SYOG, was assumed. This resulted in \( h_{AAGBN} = 21.493 \text{ m} + 21.076 \text{ m} = 42.569 \text{ m} \) on the GRS80 Ellipsoid.

Chronology of absolute gravity measurements:
1. Measurements by GSI GA60 (JARE-33), NAOM2 and AGRVP by JARE-34 were described and summarized in the Working Group for Syowa Station Absolute Gravimetry (1994).
4. JARE-45 (Y. Hirooka from GSI, and Y. Fukuda from Kyoto Univ.) made measurements during December 2003 – February 2004 by using FG5#203 (GSI) and FG5#210 (Kyoto...
Secular Gravity Change at IAGBN #0417 Syowa

\[ +982 \, 524 \, 000 \, \mu \text{Gal} \]

\[ -0.27 \pm 0.42 \, \mu \text{Gal/yr} \]

Fukuda et al. (2004)
Japan-Germany Joint Airborne Geophysical Surveys around Syowa Station, Antarctica

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• Formation and breakup of Gondwana
• Dynamics of Shirase Glacier
Gravity Anomalies (free-air)
c. Sea level observations for 1 mm/yr accuracy

Ocean tide observations over 20 years → apparent 5 mm/yr RSL fall

a. There is some uncertainty in the long-term stability of BPG zero level.
b. Is the sensor compensated year-round for air pressure variation?
c. Different quality of tidal data at two access sites.
14 daily files of 5 min sampling/ 1 cm resolution at JHOD before calibration
   http://www1.kaiho.mlit.go.jp/
   --> http://www1.kaiho.mlit.go.jp/KANKYO/KAIYO/jare/tide/tide_index.html/
GLOSS Number 95 Syowa yearly files of 1 hr sampling/ 1 cm resolution at PSMSL;
this is the mirror data of JARE Data Reports Oceanography Series after calibration
   http://www.pol.ac.uk/psmsl/programmes/gloss.info.html
d. Does the sensor at shallow coastline (Syowa Station) give the same observation
data from the sensor in deep open ocean?

Future improvements
d. GPS buoy experiments by JARE-46, and for JARE-48
   10 s sampling year-round observation by a backup power system
e. Comparison with BPG in Lutzow Holm Bay and OBP in Southern Ocean
Southern Ocean \((66.9^\circ S, 37.8^\circ E)\)
d. Summary

We summarized current status of JARE geodetic (VLBI, GPS, DORIS, AG, Tide) observations. The results are consistent each other, indicating a slight crustal uplift rate. The obtained data are consistent with the geomorphological surveys in the region concerned and the glacial isostatic adjustment model by Ivins and James (2005).

Near-future improvements for obtaining accuracy of 1 mm/yr change rate for each item will tell more detailed difference.

JARE geodetic data will be used to study ice mass variation in the Shirase Glacier area and annual change of the gravity field in relation to the calibration/validation of the satellite mission such as GRACE and GOCE.