B-10 Clarification of Effects of Sea Level Rise Caused by Global Warming
(2) Absolute Sea Level Monitoring by Space Geodetic Techniques
① Positioning of Tide Gauge by VLBI and GPS

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Abstract

Models used for prediction of the sea level change should be updated through comparison with observational evidences. This investigation focuses on an absolute measurement of the variation of the ocean surface.
The sea surface change is measured by the tide gauges fixed on the earth crust; the crustal movement is determined by the space geodetic technologies as referred to the center of mass of the earth. The combination of the technologies give us the true sea surface change.
We use the Very Long Baseline Interferometry (VLBI) and Global Positioning System (GPS) as the space technologies. The current bottle neck of the VLBI is the poor mobility. In this investigation, a down-sized VLBI is developed for the easy VLBI observation near the tide gauge. On the other hand, the GPS permanent network is established by GSI to monitor the crustal movement all over Japan.
In this year, we use the VLBI and the GPS network to measure the movement of the tide gauges.
We established some precise control points nearby the tide gauges by this research. The points are connected to the terrestrial reference system. We can monitor the movement of the tide gauges using VLBI and GPS network that is operated by GSI.

Key Words Global Warming, Sea Level Change, VLBI, GPS, Tide Gauge

1. Introduction

It is said that the sea level rise caused by the earth warming may be 4 or 5 mm/year.
The precise measurement of the sea level change using tide gauge is most important to decrease the disaster caused by it. Geographical Survey Institute (GSI) has been conducting the tide observation using more than 20 tide gauges all over Japan. However, the tide gauge itself can be moved by crustal movement. It means that tide observation records include sea level change with crustal movement.
We can use the space geodetic techniques such as VLBI and GPS to measure the movement of the tide gauges. It makes the precise measurement of true sea level change possible.
GSI and Communication Research Laboratory (CRL) had developed a small VLBI

equipment that can be used nearby the tide gauge. Fig.1 shows the small VLBI antenna that is 2.4m parabola. This system makes that VLBI can be used nearby the tide gauges. Some precise control points has been established using the VLBI and GPS system in this research. And possibility of the correction some tide observation error caused by current, temperature etc. was discussed.

2.Geodetic Observation

Tide observation should be conducted for a long time. It means their position should be monitored using stable reference system such as ITRF (IERS Terrestrial Reference Frame). GSI conducted the VLBI or GPS observations at Kanozan, Tonami, Mikuni, Susa, Soma, Oga and Mizusawa to give the ITRF coordinate to the control point nearby the tide gauges. The VLBI stations and the baselines established by GSI are shown in Fig. 2. Fig.3 is an example of the survey network by GPS to connect the tide gauge and the GPS permanent network. Because of the establishment of the GSI's GPS permanent observation network that covers all over Japan, shown in Fig. 4, the tide gauges are connected easily to some GPS stations in the network. VLBI should keep the reference frame to maintain the GPS network precisely.

We conducted the VLBI observation at Kanozan (GSI) - Kashima 34m (CRL) baseline to check the performance of the small VLBI system. The result is shown in below.

Baseline vector:

$X = -5901.8252 \pm 0.0128$ m

$Y = -78371.0067 \pm 0.0113$ m

$Z = 63053.5450 \pm 0.0121$ m

Distance:

$D = 100760.0901 \pm 0.0049$ m

The performance of small VLBI system is as same as others. But the system can not receive the S band data that is necessary for ionospheric correction.

At Shintomi VLBI station, the observation has been conducted three times. It give us the velocity of the point shown in below.

Velocity at Shintomi:

1.8mm/year to the north

10.3mm/year to the east

2.8mm/year to upward

Analysis of all observations is under going now because all data should be processed in a same way. The VLBI and GPS are one of the latest technique, it means the measurement and the analysis procedure is changed many times. It is necessary to re-processed all data in a same way to use the data as a reference.

3.Tide observation correction

VLBI and GPS make the precise monitoring of the movement of tide gauges possible. The precision is about 1 centimeter. However, tide observation data is affected by a lot of phenomena such as atmospheric pressure, ocean water density, ocean current, wind, rain etc.

The first three elements affect much more than the others. The first one can be corrected precisely. If we can get the precise data of the ocean temperature at every depth, the second one can be corrected. However, it is very difficult to get the data. We tried to find another way to correct the effect of the ocean water density. The SST (Sea Surface Temperature) are followed by sea level with some phase delay. It delay is 1 or 2 months. The SST is measured at many points around Japan. We can use the data to correct the tide observation data.

The effect of the ocean current is not easy to correct. We should continue to study about it.

4.Conclusion

During the research, GPS technology progress very much. The GPS network of GSI makes the precise monitoring of the movement of tide gauges easy. It means VLBI observation nearby the tide gauges is not necessary. However, VLBI is inportant to keep the GPS network precisely by maintaining a reference frame.

It is most important that VLBI, GPS and tide gauge should cooperate each other to get the long term precise sea level change.

Fig.1 Antenna of small VLBI system

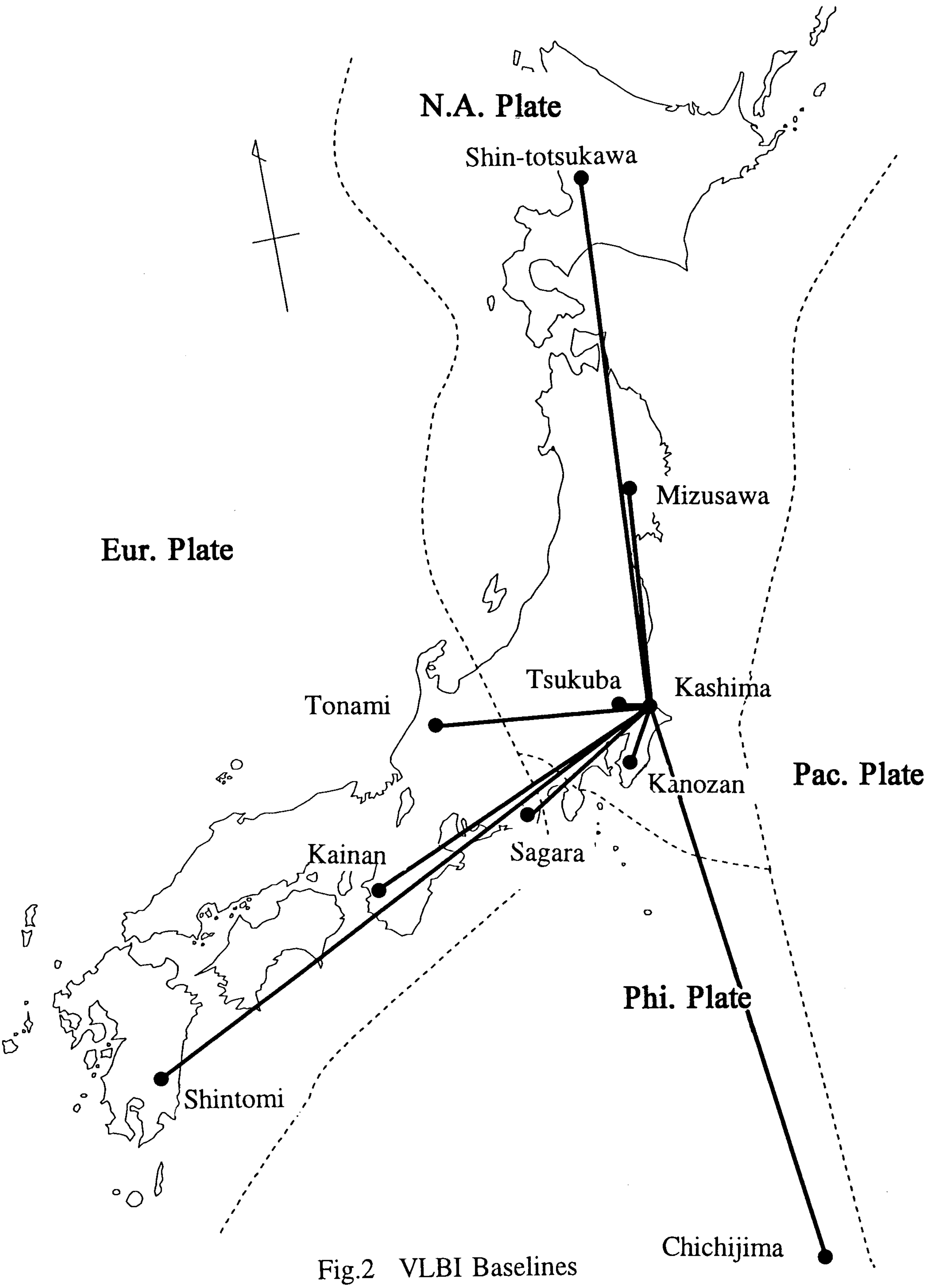

Fig.2 VLBI Baselines

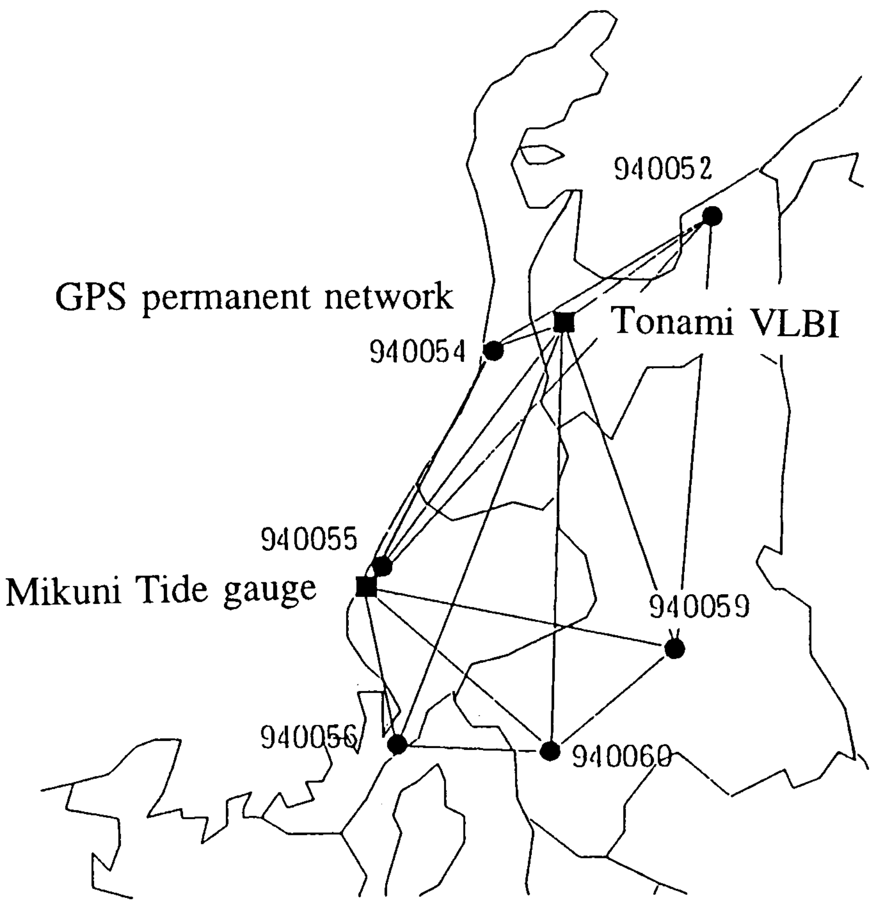

Fig.3 Example of GPS survey network

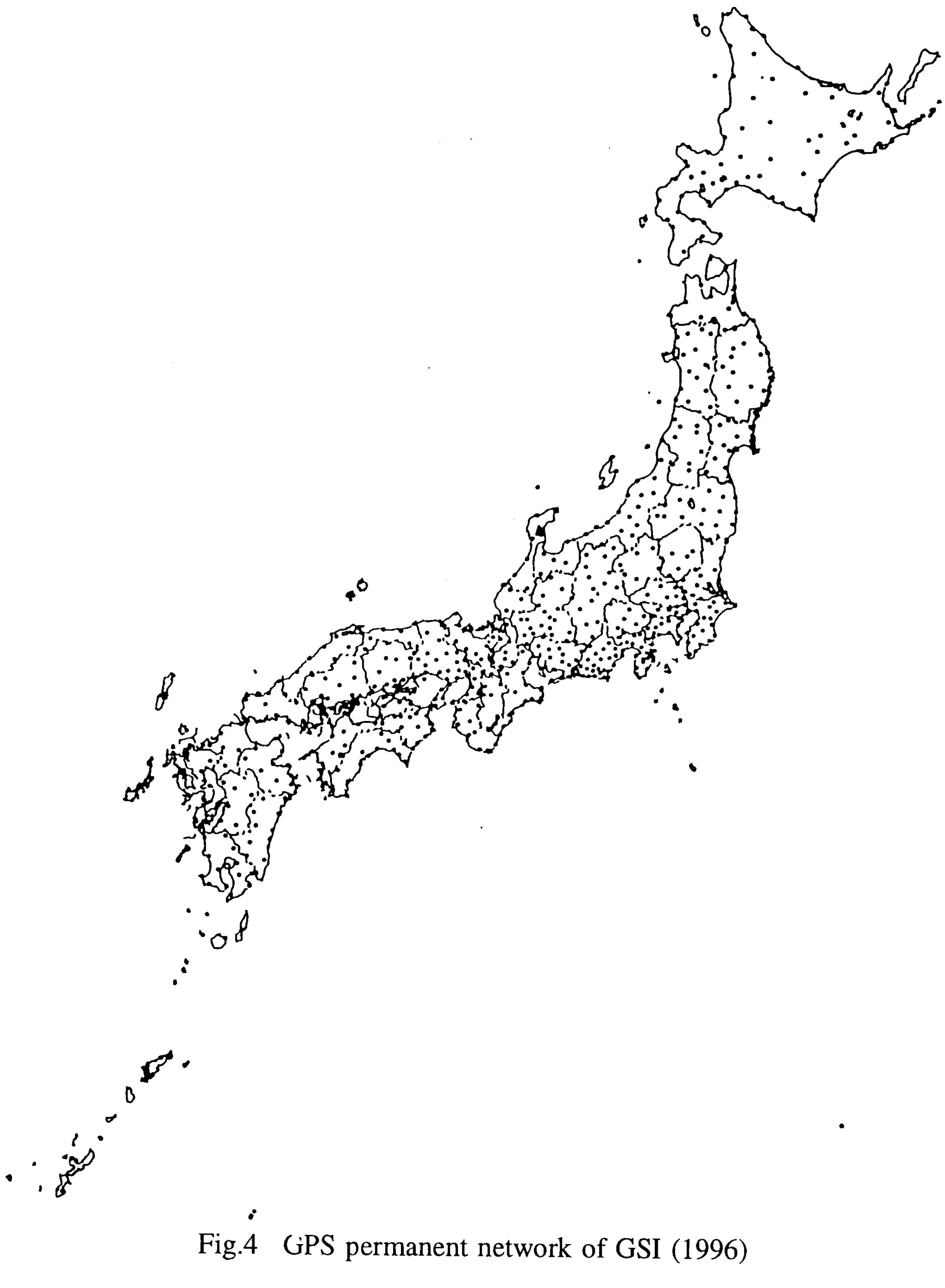

Fig.4 GPS permanent network of GSI (1996)