Tsunami Monitoring System for early warning by using GNSS

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Background

• The Earthquakes and Tsunamis have caused extensive and severe damages in Japan
• The systems to provide accurate and necessary information for tsunami evacuation more quickly and surely have been researched and developed
Tsunami Monitoring System (current)

- Existing System uses RTK-GPS, therefore the accuracy is getting decrease if the distance from coast is more than 20 km
  - condition due to the length of base line of RTK and communication line
  - Coastal base station necessary
  - inadequate time from detecting Tsunami to warning and evacuation
Precise Point Positioning (PPP) by via QZSS LEX signal can provide precise position (target accuracy: less than ±10cm)

- No coastal equipment necessary -> the buoy can be put more than 100 km far from costal area
- More time for early warning and evacuation after Tsunami detection
- Decreasing data amount by sending only positioning results
Experiment 2011-2012

Hitachi Zosen Corp., Tokyo Univ., Kochi national College of Technology and JAXA
Application to Tsunami buoy system

- Install GNSS receiver on tension mooring buoy
- Compare LEX-PPP with Kinematic (BL=13, 47km)
- 1st gen orbit/clock estimation system

Data analysis in postprocess

Compare LEX-PPP with kinematic method
Current Configuration for Precise Point Positioning (PPP) Technical Experiment

- GPS
- QZSS
- QZSS Monitoring Station (nine stations for QZSS)
- Tracking & Control Station (Okinawa)
- Precise orbit/clock estimation
  Master Control Station (MCS)
- Tsukuba Space Center

LEX signal

- LEX signal

PPP Application Demonstration

demonstrations of various applications of precise positioning
(ex) Tsunami Monitoring
Precise Agriculture
...
# Experiment Results (Availability)

## 1day statistics (15sec interval)

<table>
<thead>
<tr>
<th>Date(UTC)</th>
<th>Kinematic*1 (BL13km)</th>
<th>Kinematic*1 (BL47km)</th>
<th>LEX-PPP*2</th>
<th>Wind Speed*3 [m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep10. 2011 (calm)</td>
<td>92.7%</td>
<td>72.3%</td>
<td>100%</td>
<td>Ave. 4 Max 6.1</td>
</tr>
<tr>
<td>Sep16. 2011 (procellous)</td>
<td>97.0%</td>
<td>77.8%</td>
<td>100%</td>
<td>Ave. 11.2 Max 15.6</td>
</tr>
</tbody>
</table>

## 1hour statistics (1sec interval)

<table>
<thead>
<tr>
<th>Date/Time (UTC)</th>
<th>Kinematic*1 (BL13km)</th>
<th>Kinematic*1 (BL47km)</th>
<th>LEX-PPP*2</th>
<th>Wind Speed*3 [m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep10. 2011 10:00-11:00</td>
<td>82.1%</td>
<td>76.2%</td>
<td>100%</td>
<td>Ave. 2.4</td>
</tr>
<tr>
<td>Sep16. 2011 10:00-11:00</td>
<td>100%</td>
<td>88.1%</td>
<td>100%</td>
<td>Ave. 11.3</td>
</tr>
</tbody>
</table>

*1 Count fix solution  
*2 Count PPP solution  
*3 At Muroto cape
Experiment Results (Vertical Accuracy)

Sep.10 (calm) 10:00-11:00 (UTC)

Sep.16 (procellous) 10:00-11:00 (UTC)
Experiment Results (Horizontal Accuracy)

Sep.10 (calm) 10:00-11:00(UTC)


East-West axis [m]  North-South axis [m]

60sec  1 hour

East-West axis [m]  North-South axis [m]

60sec  1 hour
NEXT STEP:
experiment 2012-2013

JAMSTEC - TOHOKU UNIV. - JAXA
Background

Requirements

• Real-time tsunami detection of more than 100km coastal areas.
• Real-time positioning of the buoy for seafloor crustal movement measurement.

Objective

• Study the applicability and effectiveness of QZSS in tsunami disaster.
Antenna

Solar Panel

GNSS Receiver, Logger, Modem for Satellite Communication

Batteries, controller for base station

m-TRITON buoy

Crustal deformation Observation

ocean bottom pressure sensor
JAMSTEC - Tohoku UNIV. – JAXA Collaboration

- Development of New buoy observation system for tsunami and crustal deformation under strong sea current
  - JAMSTEC
    - Buoy for Strong Sea Currents environment
    - Tsunami Monitoring by using an ocean bottom pressure sensor
  - Tohoku Univ.
    - Crustal deformation Observation
  - JAXA
    - PPP (Precise Point Positioning)
    - Satellite Communication

We put the new buoy system on the ocean. The test and data analysis will be conducted soon.
Next-gen high accuracy positioning platform

Including precise orbit and clock of Multi-GNSS

Current target accuracy is less than 10cm.

Various demonstration experiments example:
- detection and warning of Tsunami
- precise agriculture
- estimation of precipitable water

MADOCA: Multi-gnss Advanced Demonstration tool for Orbit-and-Clock Analysis
Summary

• The systems to provide accurate and necessary information for tsunami evacuation more quickly and surely have been researched and developed.

• As a result of experiment 2011 – 2012, PPP can provide the similar level of accuracy and availability with RTK.

• As Next Step, New buoy observation system for tsunami and crustal deformation under strong sea current was developed. The test and data analysis will be conducted soon.