Using SLR, The GPS accuracy verification of ALOS

JAXA

Precise Orbit Determination Team

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Introduction

ALOS Launch

Date : 24th January, 2006

Vehicle : H2A

Site : Tanegashima Space Center, Japan

The value of the orbit

Orbit Type	Solarsynchronous, sub-recurrent, frozen
Height	691.65km (above the equator)
Period	98.7 min
Eccentricity	1/1000
Inclination	98.16deg
Recurrent days	46 days
Local time of descending node	AM 10h30m±15m

Mission Requirement

Mission: High-resolution land observation

To achieve this mission, highly accurate sensor pointing is required.

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Orbit determination accuracy is required within 1m (peak to peak).

→ To fulfill this requirement, we performed precise orbit determination by using onboard GPSR data.

Necessity of SLR

We need to verify that the position which the onboard GPS receiver shows is right.

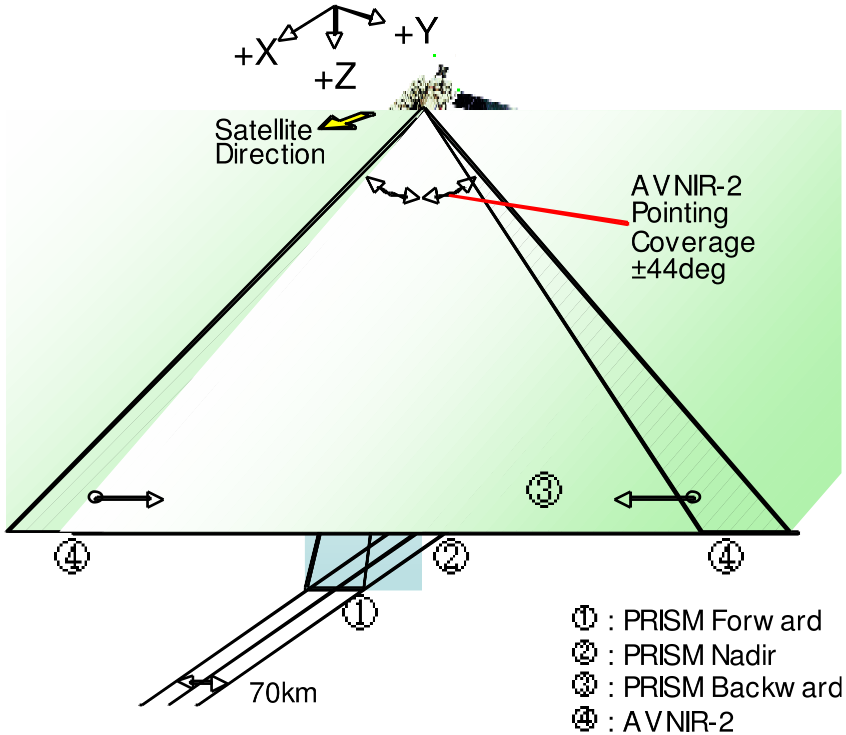
→ Whether or not there is offset

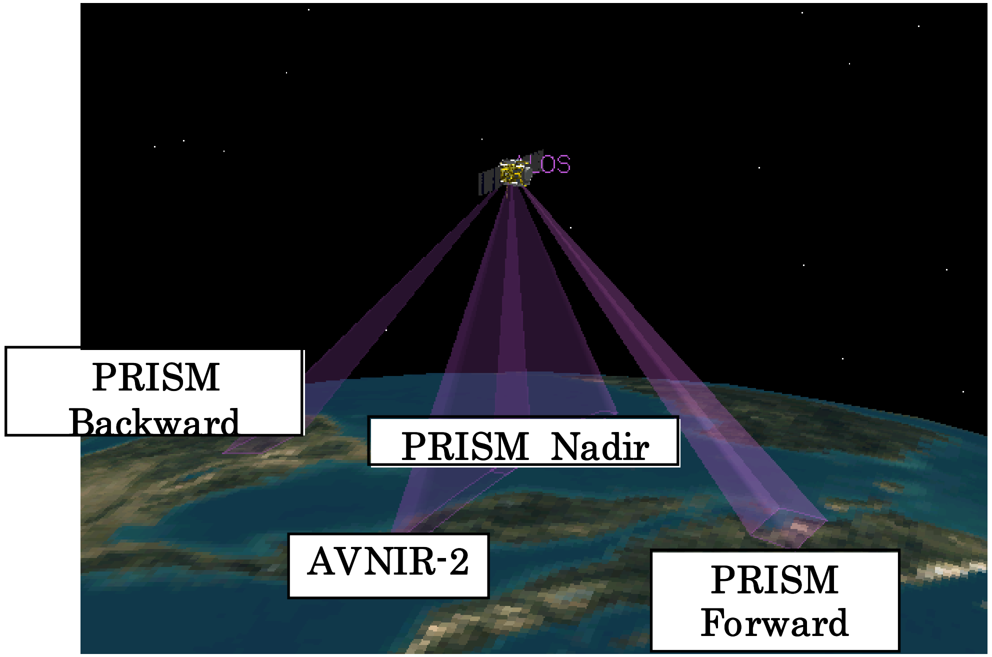
Restricted Laser Tracking

Before the verification, we analyzed whether laser transmitted from ground stations damaged ALOS sensors.

We checked it by considering the maximum incident energy and used the specifications of each station.

→ The result showed that laser could damage the sensors.





Sometimes the ranging pass was divided into 2, 3 or 4.

Restricted Tracking

We used a restricted tracking technique standardized in ILRS.

- **Tracking with Closed Network**
  We confirmed the interface between JAXA and candidate SLR stations (TIRV, SLR-SUP file, Go/NoGo file).
  And then we asked limited SLR stations to track.

- **Pass start and end time control**
  The pass start and end time was controlled by SLR-SUP file interface. Within the visible time of ALOS, the time which dose not interfere with the sensors was calculated for each SLR station. We sent the results to SLR stations.

- **Control by the Go/NoGo file**
  The Go/NoGo file was interfaced with each station as the method by which all laser ranging should be stopped.

Participation Stations

CDP pad ID	SLR Stations	ID	
7825	**Mt. Stromlo**	**STL3**	**Australia**
1884	**RIGA**	**RIGL**	**Latvia**
7308	**Koganei(KOGC)**	**KOGC**	**Japan**
7838	**Simosato**	**SISL**	**Japan**
7110	**NASA/MonumentPeak(Moblas-4)**	**MONL**	**USA**
7501	**NASA/ Hartebeesthoek (Moblas-6)**	**HARL**	**South Africa**
7090	**NASA/ Yarragadee(Moblas-5)**	**YARL**	**Australia**
7358	**JAXA/Tanegashima**	**GMSL**	**Japan**
7810	**Zimmerwald**	**ZIML**	**Switzerland**
7840	**Herstmonceux**	**HERL**	**United Kingdom**
7105	**NASA/GreenBelt (MOBLAS-7)**	**GODL**	**USA**
7130	**NASA/GreenBelt (TLRS-4)**	**GO4T**	**USA**

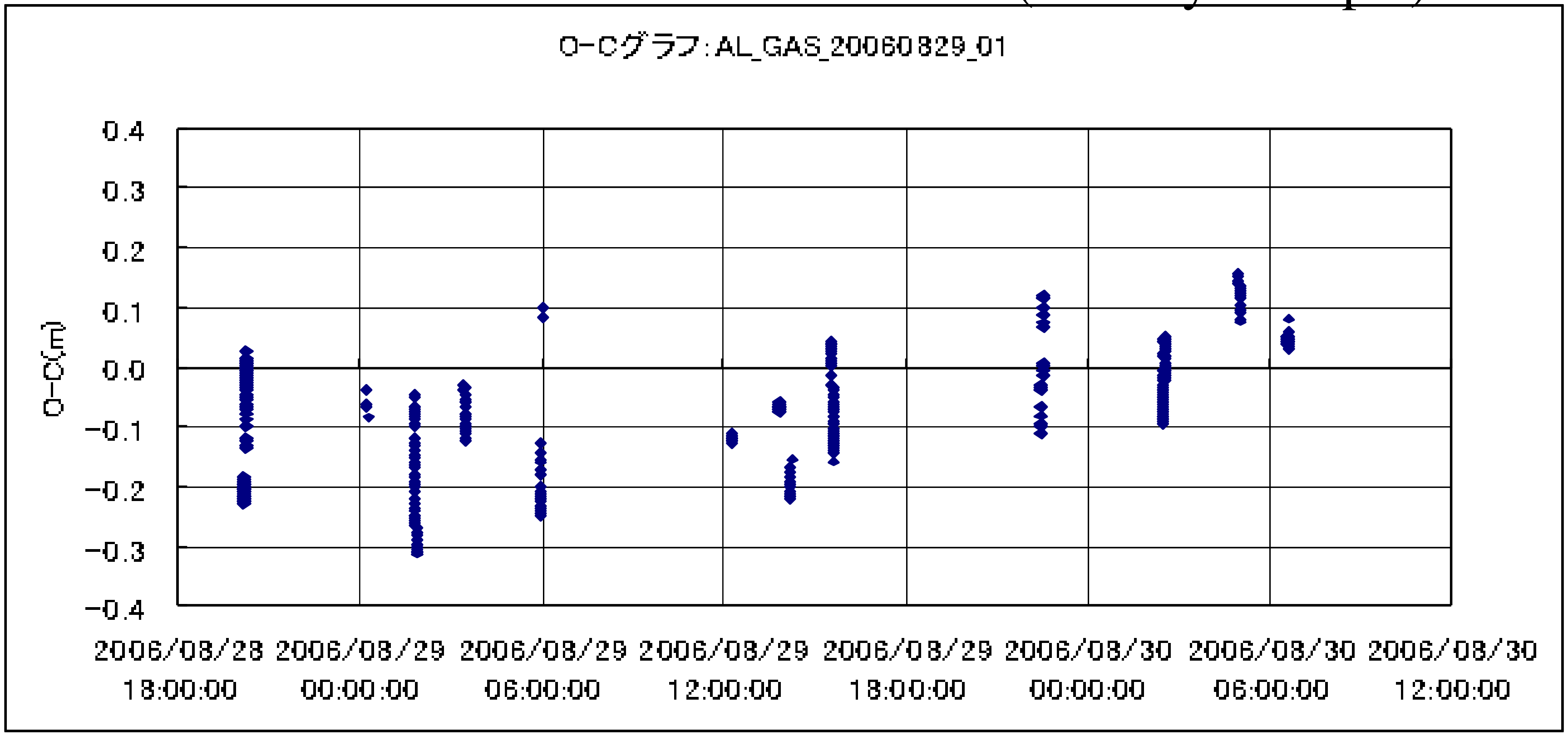
Campaign Period (UT): 14th Aug 2006 00:00:00 31st 16:00:00

Thanks to this campaign, we obtained 100 pass, 2979 data.

Analysis(1)

At first, we confirmed the consistency between SLR data and GPS orbit.

Difference of SLR data from GPS orbit (one day example)



For this analysis, we used all SLR data.

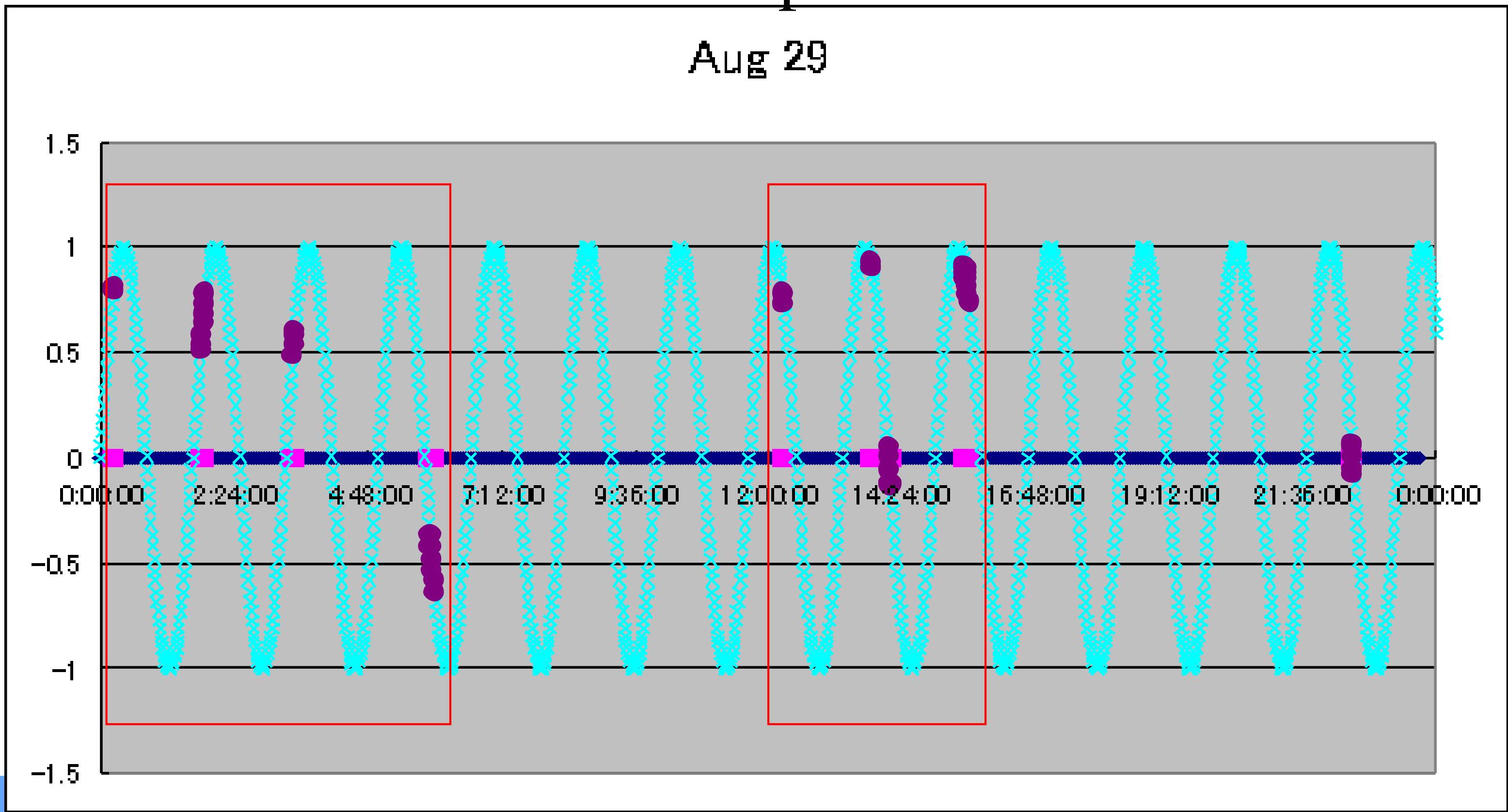
Average difference : -4.78 ±12.03 cm

This result shows GPS and SLR agree within the error (1 σ).

Analysis(2)

That analysis did not have the resolution for each direction (radial, cross, along direction) in evaluating the GPS orbit.
So we carried out the orbit determination only using SLR data in the following period, and calculated the difference from the orbit by GPS.
The period is that over 3 stations carried out ranging during a few revolution.

Example



Analysis (3)

We calculated the difference between SLR orbit and GPS orbit. (unit: cm)

		Radial direction	Cross Track direction	Along Track direction	difference(3D)		OD Arc (min)
					RMS	MAX	
8/21		2.92±7.31	6.97±8.70	11.01±18.25	25.00	52.43	257
8/22		-24.07±28.68	2.38±7.77	-4.81±44.63	57.79	119.65	204
8/23		4.08±1.69	-7.35±30.39	-11.89±5.06	33.11	45.23	88
8/24	A	-2.77±17.62	12.94±14.31	-1.98±4.27	26.20	42.65	120
	B	4.20±4.51	21.60±4.24	6.40±4.86	24.14	29.27	186
8/25	A	6.84±13.84	4.05±9.81	-5.60±20.06	27.52	55.48	400
	B	6.50±31.60	-64.46±49.76	-51.38±44.95	109.96	168.62	199
8/28		-0.50±11.47	-14.03±27.01	-12.15±3.89	34.36	51.97	108
8/29	A	-11.36±12.12	5.23±4.77	7.24±22.36	29.12	37.00	348
	B	2.57±13.18	9.02±7.79	-5.14±13.09	22.33	29.29	202
8/30		2.13±8.37	14.27±20.23	-3.40±13.21	28.90	56.57	254

The weighted mean (cm)

Radial	Cross	Along	Distance
3.58±1.47	10.80±2.45	-5.16±3.02	12.50

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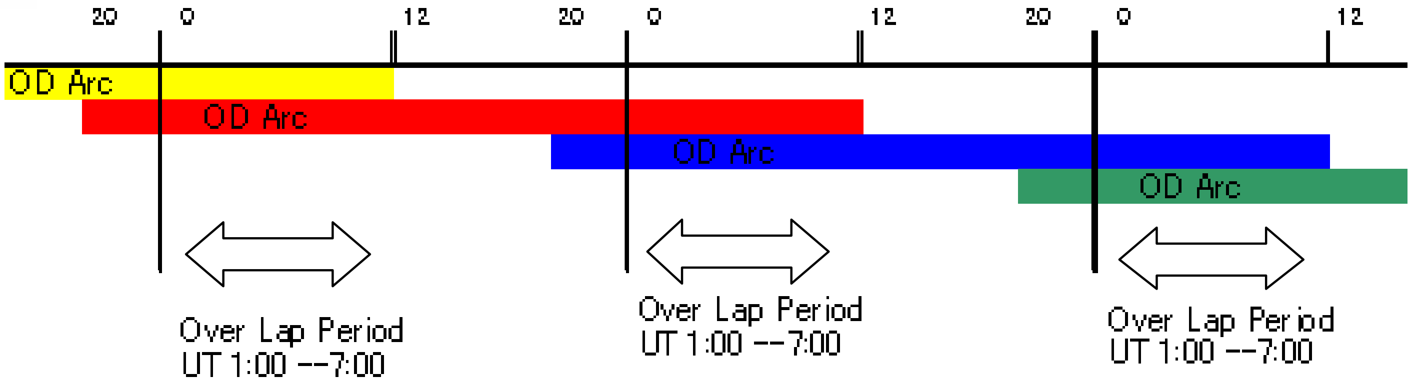
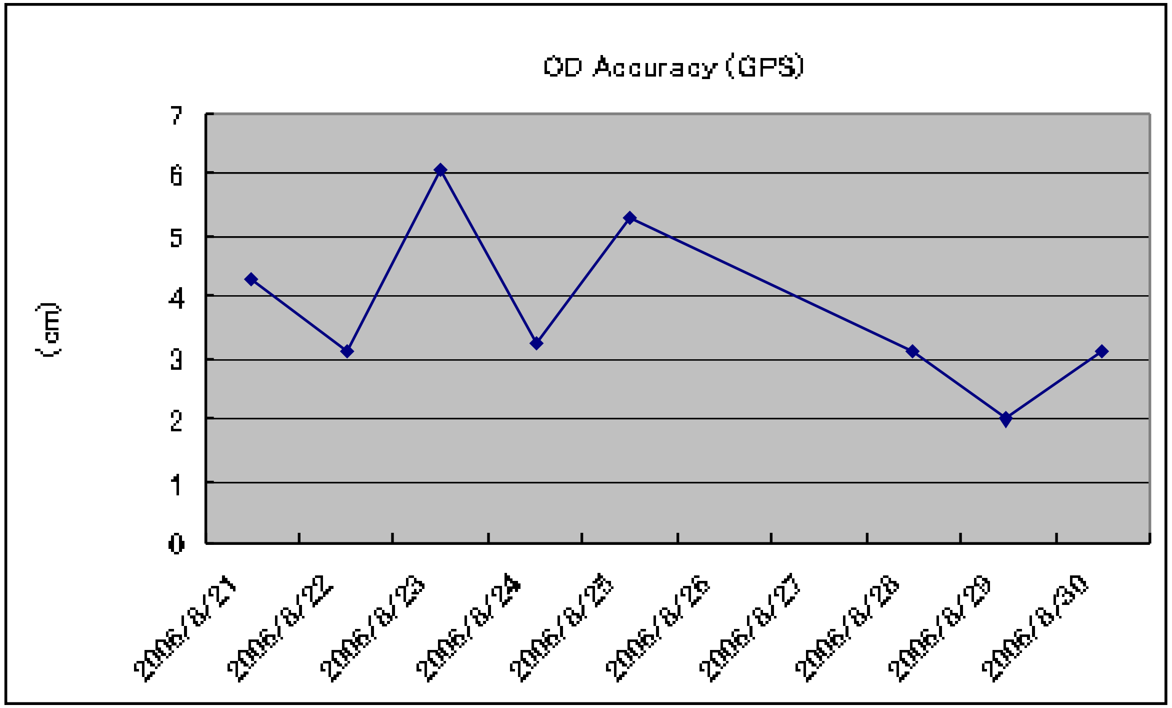
We compared this result with the accuracy of GPS orbit determination.

Analysis (4) GPS OD Accuracy



We used Overlap Method to calculate the accuracy of GPS OD

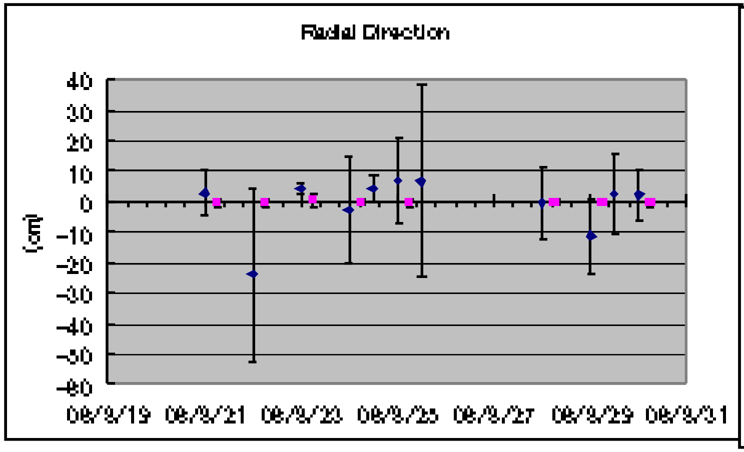
We defined the RMS value as an orbit determination (OD) accuracy.

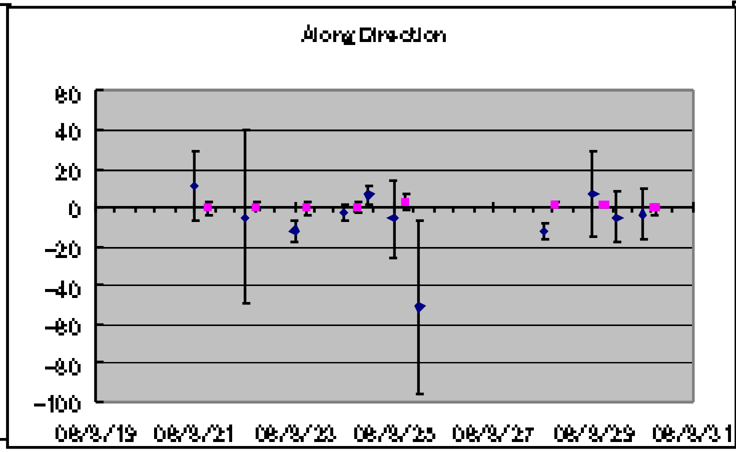


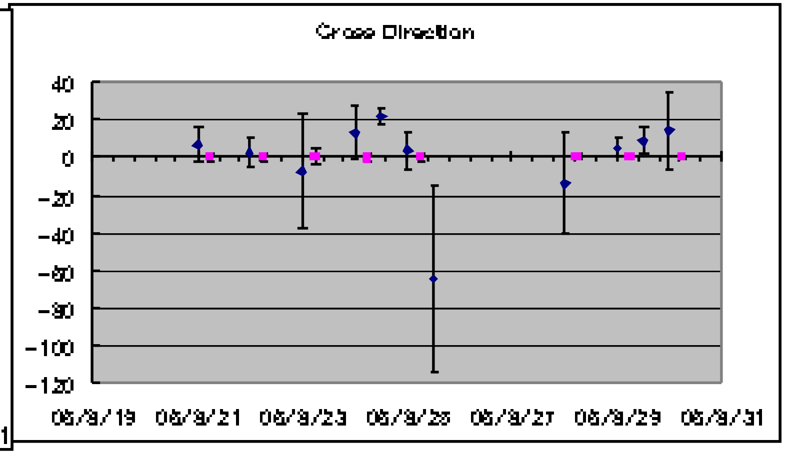
OD accuracy (RMS value) by GPS is 2 cm --- 7cm.

Analysis (5)

We compared the **Accuracy of GPS OD** (analysis(4)) with the **Difference between SLR orbit and GPS orbit** (analysis(3)).







Radial direction　　　Along direction　　　Cross direction

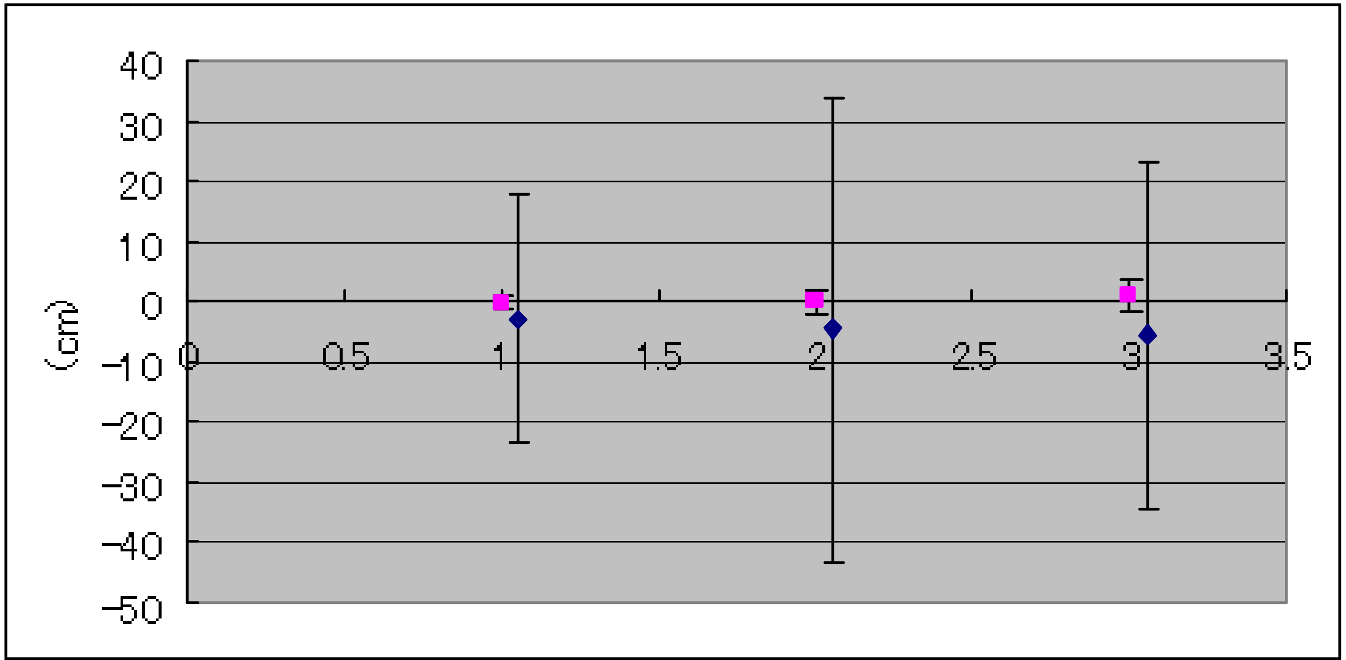
Blue point with long error bar : Difference SLR – GPS orbit

Pink point with short error bar : Accuracy of GPS OD

These graphs show that Accuracy of GPS OD (including error) is within the error of difference between SLR orbit and GPS orbit.

Analysis (6)

The weighted mean of each direction



1. Radial
2. Cross
3. Along

The accuracy of GPS OD (including error) is within the error of difference between SLR orbit and GPS orbit.

This results show that the accuracy of GPS OD is about a few (2-7) cm (within mission requirement : 1m), and there is no offset in any directions within the resolution of SLR in this campaign.

Conclusion

We needed to verify the accuracy of ALOS orbit determination by the onboard GPS receiver by comparing with SLR.

Because laser might damage ALOS sensors, we performed the restricted laser tracking campaign (about 2 weeks).

As the result of this verification, the accuracy of ALOS orbit determination by GPS is about a few cm and there is no offset in any directions.

This result also fulfills the requirement from ALOS mission.

Acknowledgement :

ALOS tracking campaign was performed successfully with the cooperation of **ILRS** and participating SLR stations, to all of which we would like to express our deep appreciation.