

High-accuracy Positioning Method for RTK Base Stations using PPP

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Why do we have to determine the position of base stations ?

- When we carry out RTK (Real Time Kinematic), positioning it is necessary to survey the true position of each base station.
- For base stations, this true position must be known with very high accuracy.
- Currently, RTK (carrier-phase DGNSS provides the highest level of positioning accuracy.
- However, if pre-surveyed base stations do not already exist, it is impossible to carry out RTK.



- **We focus on PPP (Precise Point Positioning) that does not depend on nearby base stations.**

What is PPP ?

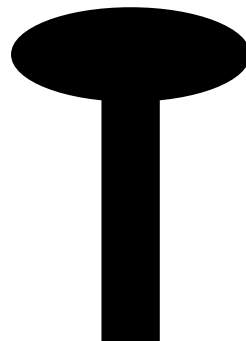
Satellites (GPS, GLONASS, BeiDou, Galileo and QZSS ...)



Observation Values necessary for
Positioning
(ex. Pseudo-range (code), Carrier-phase)



Precise Orbits and Clock Corrections
(Necessary for high-accuracy
positioning.)



How do we use PPP ?

- When we determine true position using PPP, it is necessary to consider the frequency of the receiver being used.
- Currently, GPS receivers can be divided into **single frequency (only L1)** and **dual frequency (L1 and L2)** classes.
- Comparison of single frequency and dual frequency receivers:

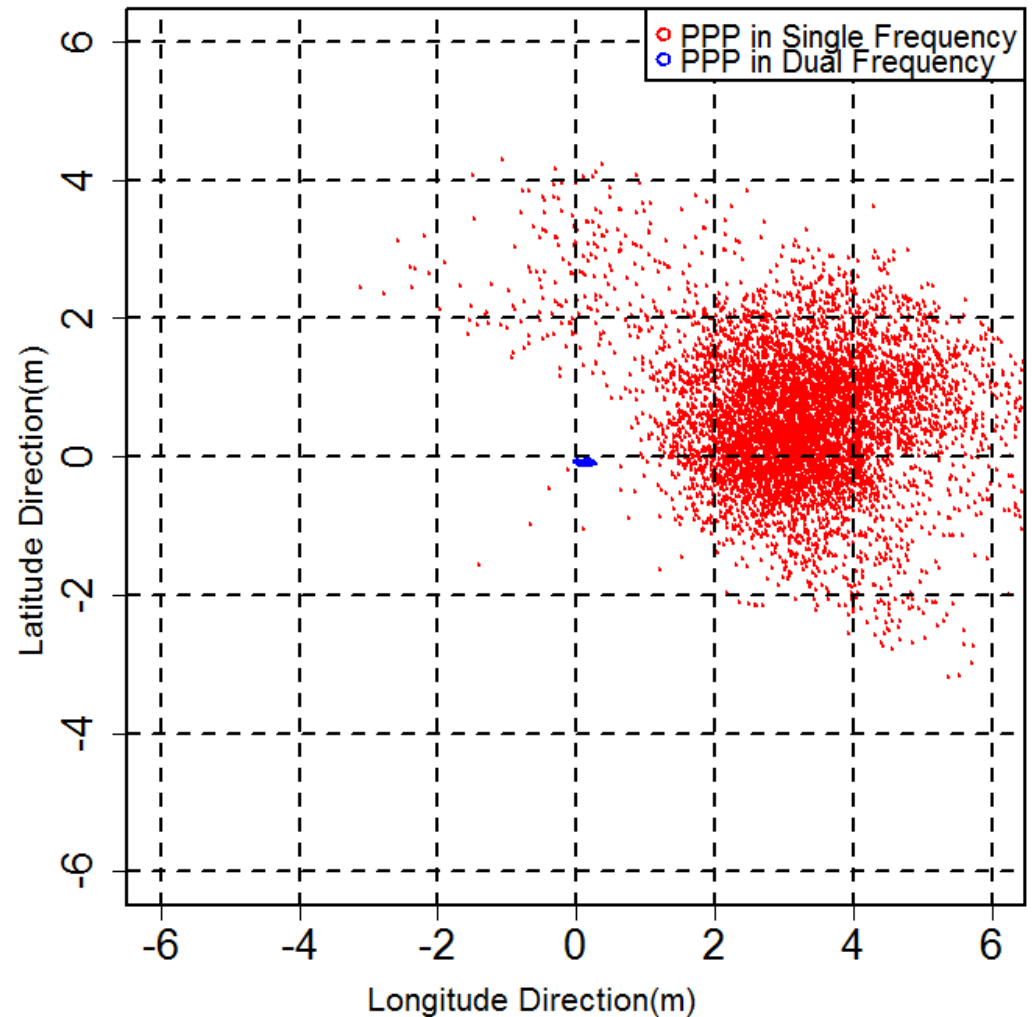
	Single Frequency	Dual Frequency
Price	Low Cost	High Cost
PPP Positioning Accuracy	50-100 cm	1-10 cm

- **If we estimate position using dual frequency, we will achieve higher accuracy than if we use single frequency.**

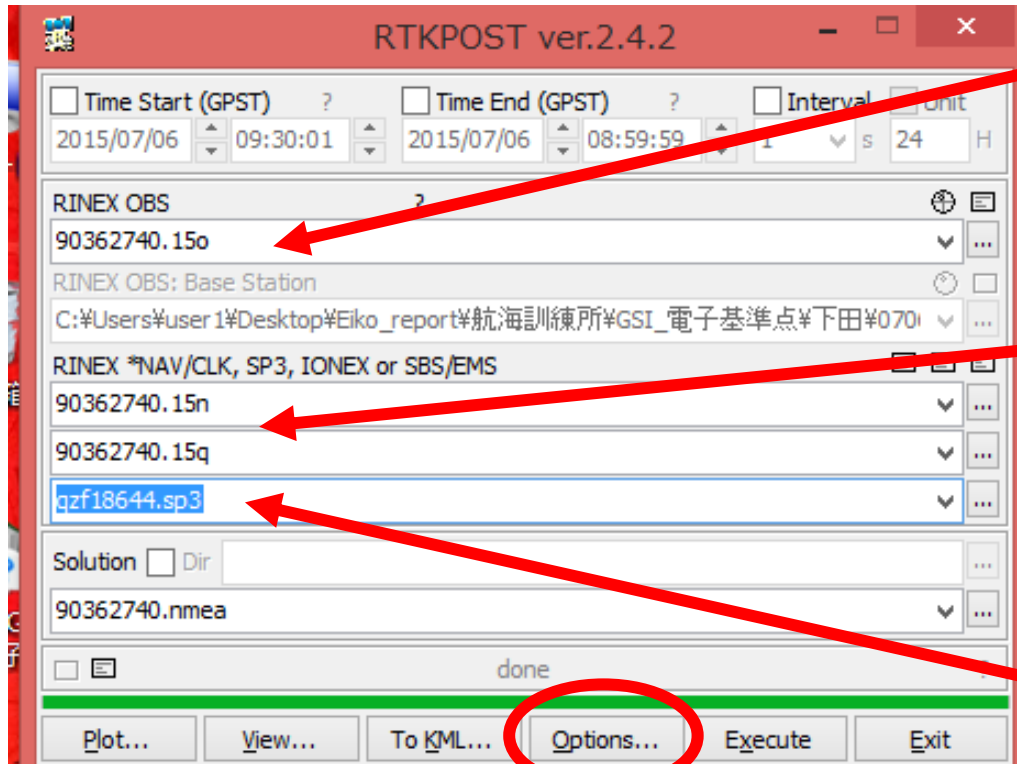
PPP Positioning Accuracy

Static Receiver Locations (in Thailand): Phangan Island (Single Frequency),
Chula Univ. (Dual Frequency)

When we estimate the position using single frequency, there is a limit to the improvement of positioning accuracy using PPP.



PPP Positioning using RTKLIB



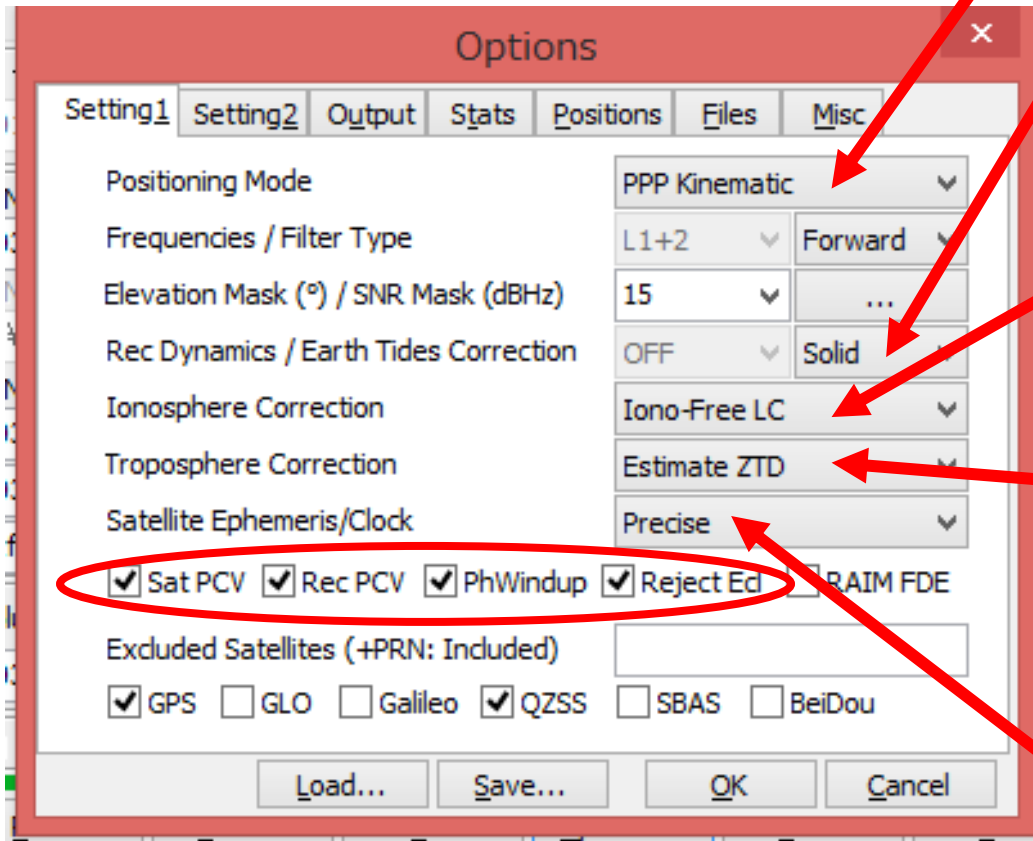
Select the observation data file.
(ex. File name is "90362740.15o".)

Select the navigation data file.
(ex. File name is "90362740.15n".)

Select the precise orbit and clock
(PPP) data file.
(ex. File name is
"qzf18644.sp3"(QZSS Final).)

Once you have finished this setup, please click "Options..."

PPP Positioning using RTKLIB



Select "PPP Kinematic".

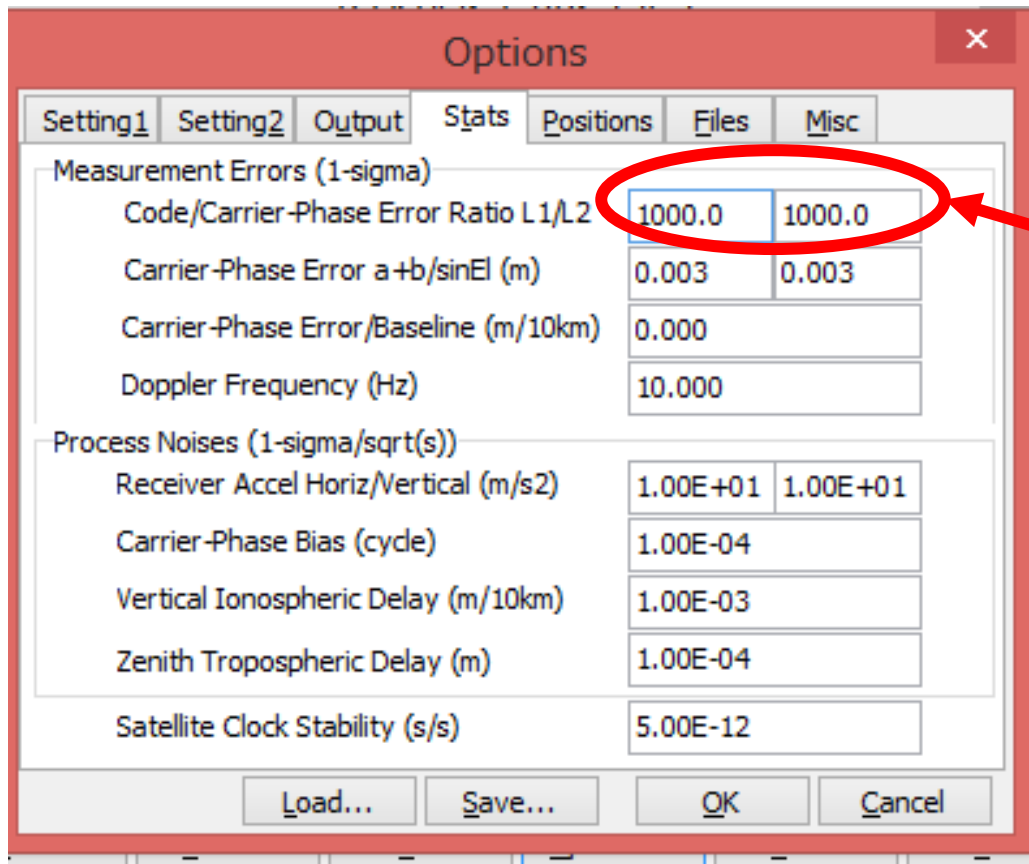
Earth Tides Correction is "Solid".

Ionosphere Correction is "Iono-Free LC".

Troposphere Correction is "Estimate ZTD".

If you use precise orbit and clock information provided in sp3 format, please check "Precise".

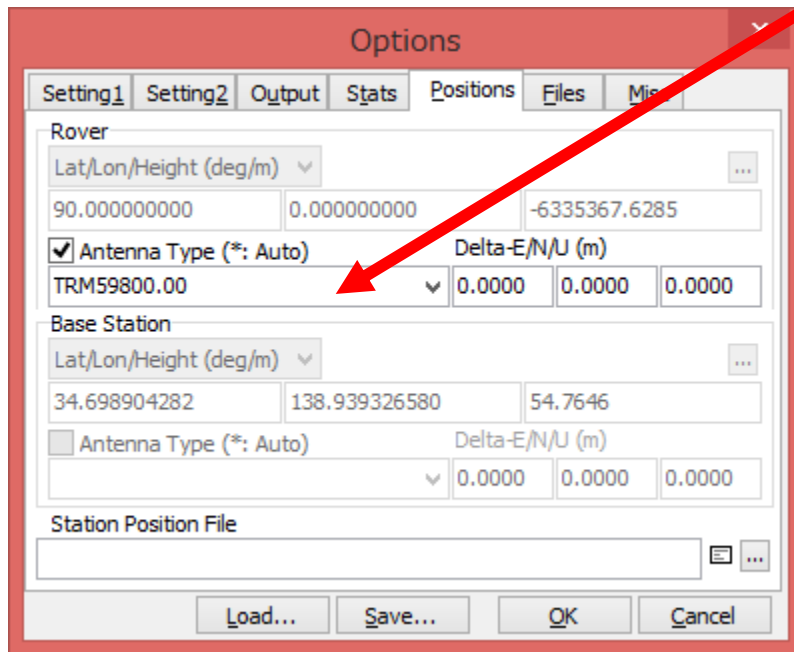
PPP Positioning using RTKLIB



Code/Carrier-Phase Error Ratio L1/L2 has to be set as "1000.0".

PPP Positioning using RTKLIB

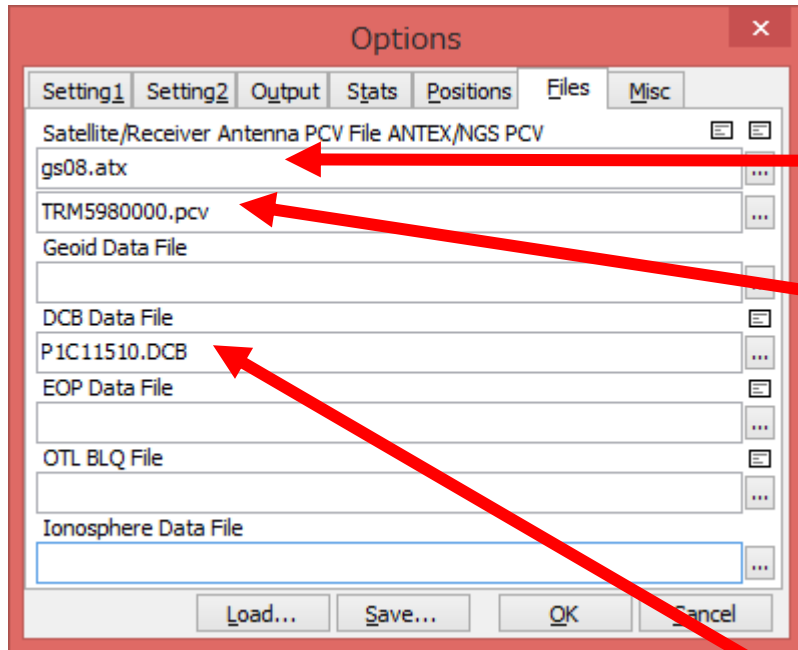
Select the antenna type.



The screenshot shows the 'Options' dialog box in RTKLIB. The 'Rover' section is active, and the 'Antenna Type' dropdown menu is highlighted with a red arrow. The 'Antenna Type' is currently set to 'TRM59800.00'. The 'Delta-E/N/U (m)' fields are all set to 0.0000. The 'Base Station' section is also visible, with its 'Antenna Type' dropdown menu currently empty. The 'Station Position File' field is empty. The 'Load...', 'Save...', 'OK', and 'Cancel' buttons are at the bottom.

Setting	Setting	Output	Stats	Positions	Files	Misc
Rover						
Lat/Lon/Height (deg/m) ...						
90.000000000	0.000000000	-6335367.6285				
<input checked="" type="checkbox"/> Antenna Type (*: Auto)	Delta-E/N/U (m)					
TRM59800.00	0.0000	0.0000	0.0000			
Base Station						
Lat/Lon/Height (deg/m) ...						
34.698904282	138.939326580	54.7646				
<input type="checkbox"/> Antenna Type (*: Auto)	Delta-E/N/U (m)					
	0.0000	0.0000	0.0000			
Station Position File						
...						
Load... Save... OK Cancel						

PPP Positioning using RTKLIB



Select Satellite Antenna PCV File
ANTEX/NGS PCV.
ANTEX file is provided by ".atx".

Select Receiver Antenna PCV File
ANTEX/NGS PCV.
Receiver antenna pcv file is
provided by ".pcv".

Select DCB(Differential Code Bias) File.

WEB Site to Download Precise Orbit and Clock (PPP) Information

- QZ-vision (<http://qz-vision.jaxa.jp/USE/en/finalp>)

The screenshot shows a web browser window displaying the QZ-vision website. The browser's address bar shows the URL qz-vision.jaxa.jp/USE/en/finalp. The website's header features the 'QZvision' logo and navigation tabs for 'PLAY', 'READ', and 'USE'. Below the header, there is a large 'USE' button and a sub-header 'QZSS+GPS データダウンロード 使う、みちびき。' with language selection buttons for '日本語' and 'English'. A breadcrumb trail indicates the path: Home > USE > Final Products.

The left sidebar contains a list of navigation links, each with a right-pointing arrow:

- QZSS+GPS SkyPlot
- QZ-radar
- IS-QZSS
- QZSS Interface Specification
- Message
- Message Pattern Table
- NAQU Messages
- NAQU Message
- Mail Registration
- Data Almanac
- Data Ephemeris
- Products Ultra Rapid Products
- Products Final Products
- QZSS LEX Data LEX
- Contact for Information in Generating Precise Ephemeris
- QZSS+GPS Data Custom Downloads

The main content area is titled 'QZSS+GPS Final Products Data Final Products'. It includes a sub-section 'QZSS+GPS Ultra Rapid Products Data Outline' with the following text:

Final products are the results of offline analysis on the orbits and the clock of the GPS satellites and QZS-1, generated at the Master Control Station (MCS) of QZSS.

They are lists data below for each satellite at each given time.

Consult the [sp3c_format](#) for more information.

In the products, "Time System" (Line 13 Columns 10-12) indicates "QZS", the time system that is identical to the GPST with a difference of tens of nanoseconds. Besides please note that the navigation messages are compliant with GPST.

The final products are to be released approximately 6 days later.

Approximately 20 cm (30, rms) of an overlap difference is achieved. Please note that the difference may increase during the events such as an attitude maneuvering.

Below this, there is a 'Definition' section for 'QZSS+GPS Final Products Data' with a list of data fields:

- x coordinate(km)
- y coordinate(km)
- z coordinate(km)
- clock (microsec)
- x standard deviation(mm)
- y standard deviation(mm)
- z standard deviation(mm)
- clock standard deviation(psec)

A 'PAGE TOP' button is visible at the bottom right of the page.

WEB Site to Download Precise Orbit and Clock (PPP) Information

The screenshot shows a web browser window displaying a table of Precise Orbit and Clock (PPP) information. The table lists various data products, their dates, and file sizes. Below the table, there are two buttons: 'Custom Download' and 'Archive'. The 'Custom Download' button is circled in red, and a red arrow points from a text box to it. The website footer includes the JAXA logo and the text 'QZ-vision'.

Product	Date	Size	File Name	Download
OZSS FINAL	2016-07-18 07:40PM	33,890	/2016/qzfa19052.sp3	
GPS FINAL	2016-07-18 07:40PM	710,402	/2016/qzfa19052.sp3	
OZSS+GPS FINAL	2016-07-17 07:40PM	733,730	/2016/qzfa19051.sp3	
OZSS FINAL	2016-07-17 07:40PM	33,890	/2016/qzfa19051.sp3	
GPS FINAL	2016-07-17 07:40PM	710,402	/2016/qzfa19051.sp3	
OZSS+GPS FINAL	2016-07-16 07:40PM	733,730	/2016/qzfa19050.sp3	
OZSS FINAL	2016-07-16 07:40PM	33,890	/2016/qzfa19050.sp3	
GPS FINAL	2016-07-16 07:40PM	710,402	/2016/qzfa19050.sp3	
OZSS+GPS FINAL	2016-07-15 07:40PM	733,730	/2016/qzfa19048.sp3	
OZSS FINAL	2016-07-15 07:40PM	33,890	/2016/qzfa19046.sp3	
GPS FINAL	2016-07-15 07:40PM	710,402	/2016/qzfa19046.sp3	
OZSS+GPS FINAL	2016-07-14 07:40PM	733,730	/2016/qzfa19045.sp3	
OZSS FINAL	2016-07-14 07:40PM	33,890	/2016/qzfa19045.sp3	
GPS FINAL	2016-07-14 07:40PM	710,402	/2016/qzfa19045.sp3	
OZSS+GPS FINAL	2016-07-13 07:40PM	710,402	/2016/qzfa19044.sp3	
OZSS FINAL	2016-07-13 07:40PM	33,890	/2016/qzfa19044.sp3	
GPS FINAL	2016-07-13 07:40PM	687,074	/2016/qzfa19044.sp3	
OZSS+GPS FINAL	2016-07-12 07:40PM	710,402	/2016/qzfa19043.sp3	
OZSS FINAL	2016-07-12 07:40PM	33,890	/2016/qzfa19043.sp3	
GPS FINAL	2016-07-12 07:40PM	687,074	/2016/qzfa19043.sp3	

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qz-vision.jaxa.jp/USE/en/custom

QZ-vision

Click
"Custom Download".

WEB Site to Download Precise Orbit and Clock (PPP) Information

The screenshot shows a web browser window with the URL qz-vision.jaxa.jp/USE/en/custom. The page is titled "QZSS+GPS Data Custom Downloads".

On the left sidebar, there are several menu items: "Final Products", "QZSS LEX Data LEX", "Contact for Information in Generating Precise Ephemeris", "QZSS+GPS Data Custom Downloads", "Archive", "API", "Schedule Experiment Schedule", "Results Experiment Results", and "QZSS Signal Quality Report".

The main content area has a "Set a Period of Time" section with three calendar views for May, June, and July 2016. Below the calendars are "Start" and "End" date pickers. The "Start" date is set to 2016-06-28 and the "End" date is set to 2016-06-28. There are "OK" buttons for each date picker.

Below the date pickers is a "Data List" section. It shows the selected data: "QZSS+GPS : Final Products : sp3c Format". The results are from 2016-6-28 to 2016-6-28. There is an "XML Format" checkbox which is unchecked.

The data list table is as follows:

All	File Created Time(UT)	Size(byte)	File Name	Preview
<input checked="" type="checkbox"/>	2016-07-04 07:40PM	757058	/2016/qz19032.sp3	

At the bottom of the page, there is a large blue "Download !" button. A "PAGE TOP" button is also visible on the right side of the page.

Select "QZSS+GPS" and "Final Products".