



Shanghai Astronomical Observatory  
Chinese Academy of Sciences

# Status and prospects of SLR of Compass

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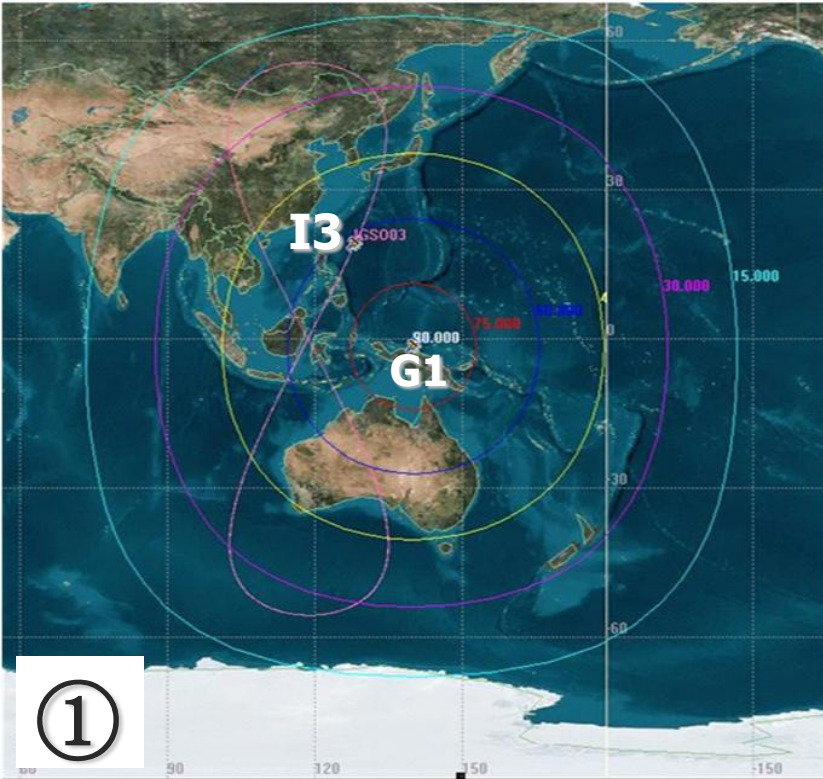


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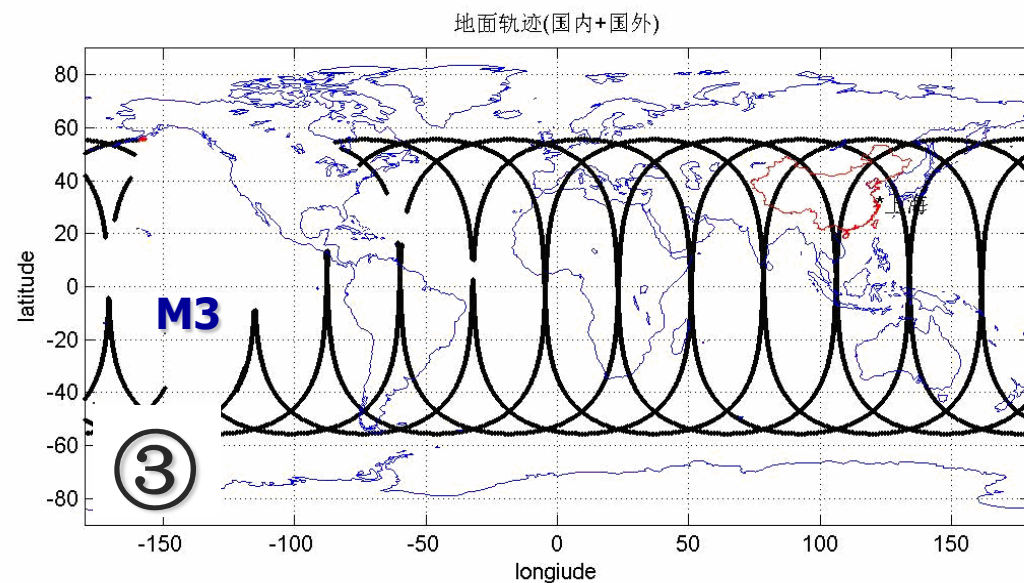
# Introduction

- **Compass is the Chinese satellite navigation system, consisting of GEO, IGSO and MEO satellites with altitudes of 21,500 km (MEO) to 36,000 km (IGSO/GEO)**
- **Up to now, total 16 compass satellites with LRAs into orbit and the final one (GEO) launched in last month.**
- **Compass-M1, Chinese first experimental GNSS satellite launched in April 2007, started being tracked by ILRS stations since December 2008.**
- **In May and July 2012, Compass-G1/-I3/-I5/-M3 were tracked by ILRS stations for precision orbit determination (POD) and microwave measuring technique calibration.**



## The trace of compass satellites

- ① Compass G1/I3
- ② Compass I5
- ③ Compass M3



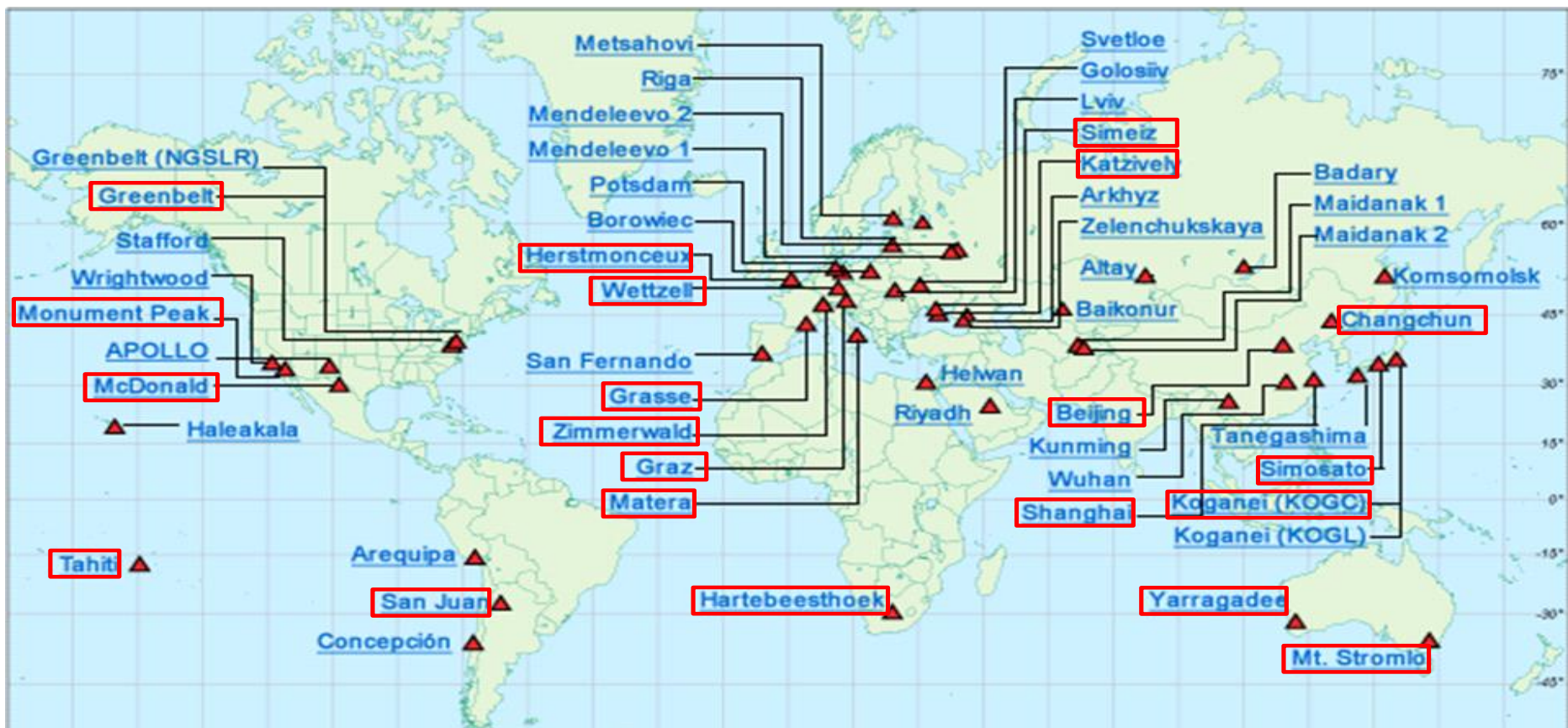


# LRAs for COMPASS satellites designed by SHAO

	MEO	GEO/IGSO
Size	32.6×28×3.0cm	49×43×3.0cm
Diameter of corner cube	33mm	33mm
Number of corner cube	42	90
Reflective area	360cm <sup>2</sup>	770cm <sup>2</sup>
Material	fused quartz	fused quartz
Divergence	7±1"	6±1"
Weight	2.45 kg	4.85 kg



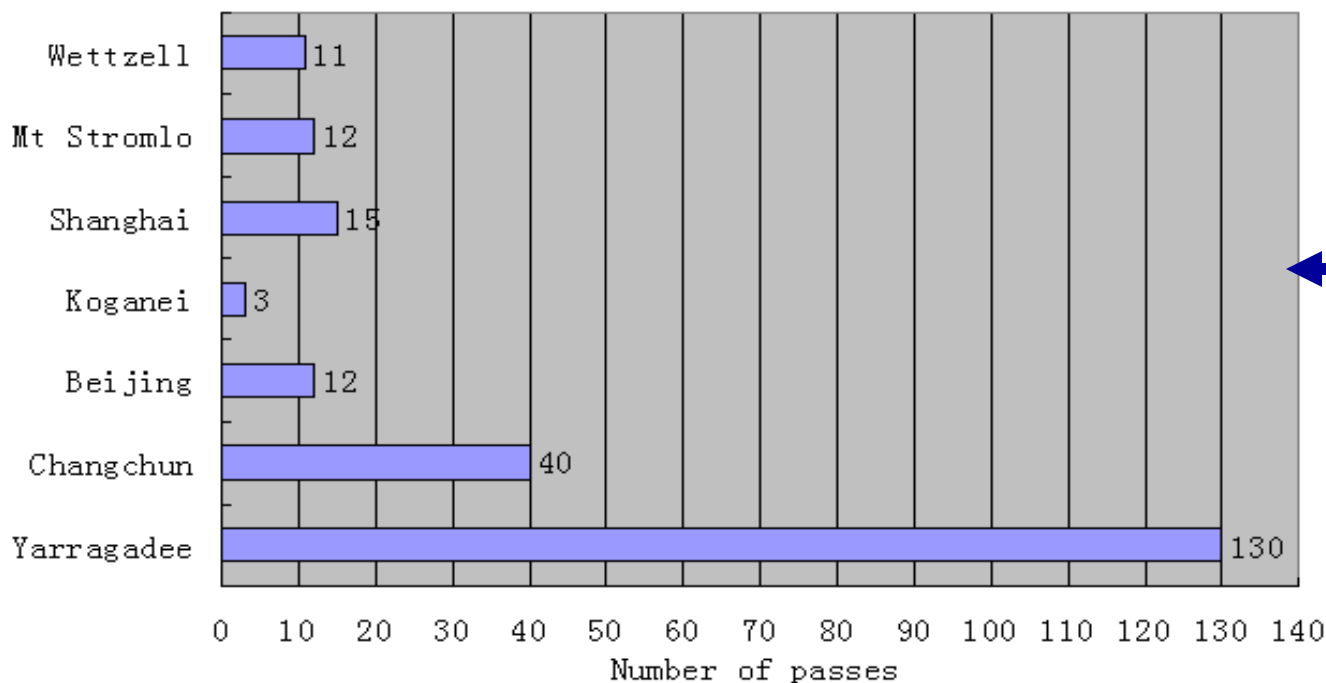
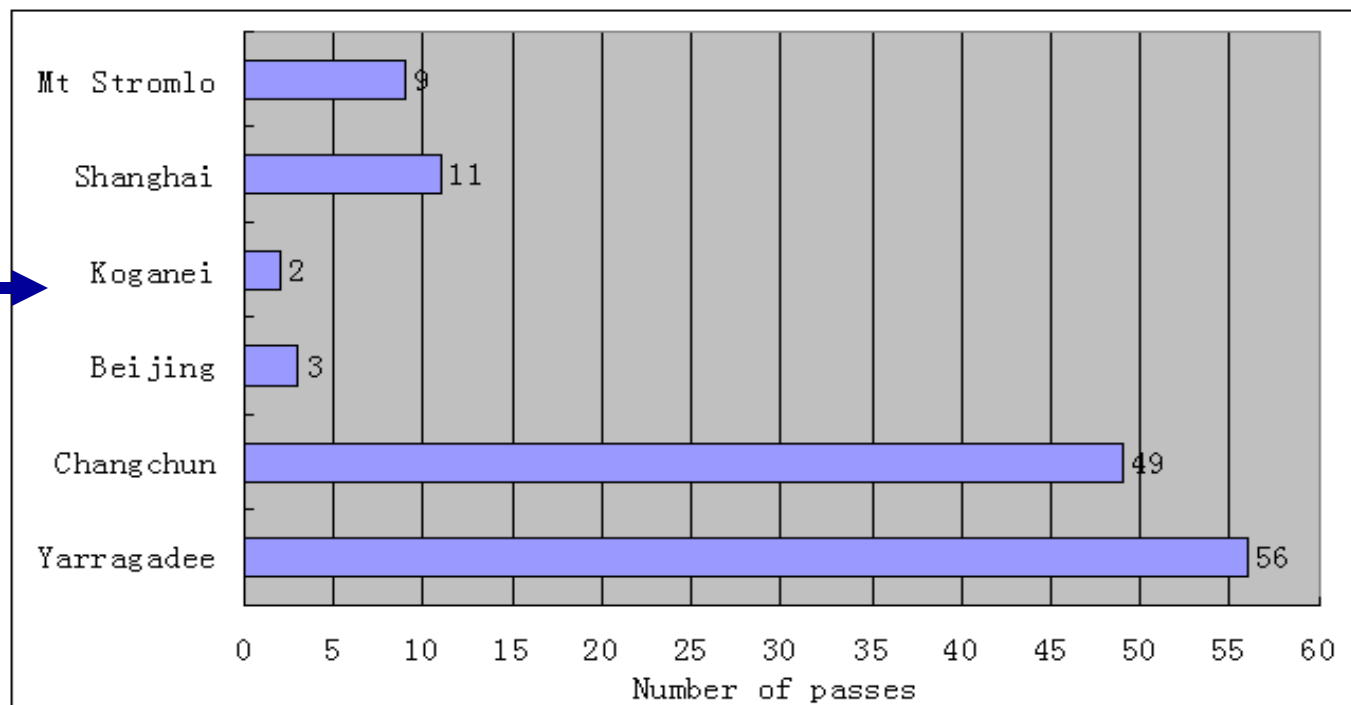
# SLR station distribution for tracking Compass satellites



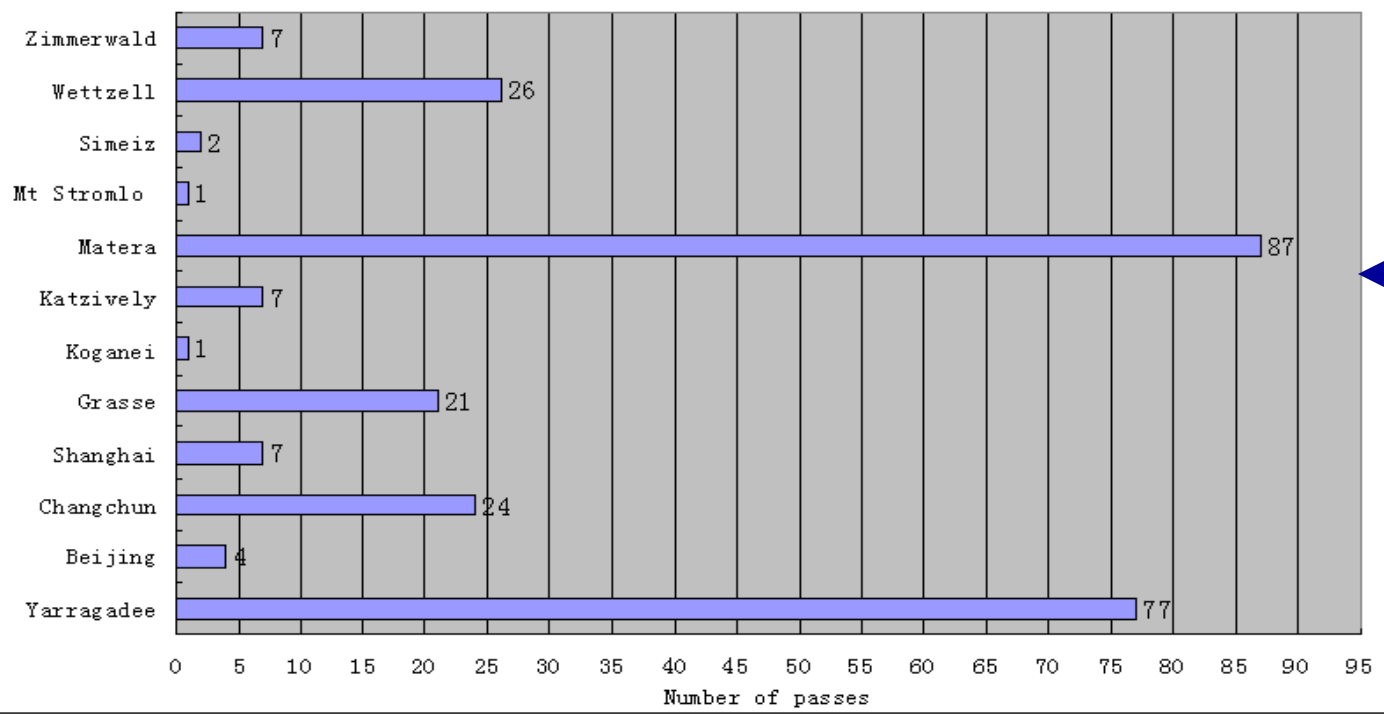
● At the end of October 2012, there are:

- 6 stations track Compass-G1
- 7 stations track Compass-I3
- 12 stations track Compass-I5
- 19 stations track Compass-M3

**Passes of  
COMPASS-G1  
(6 sites)**

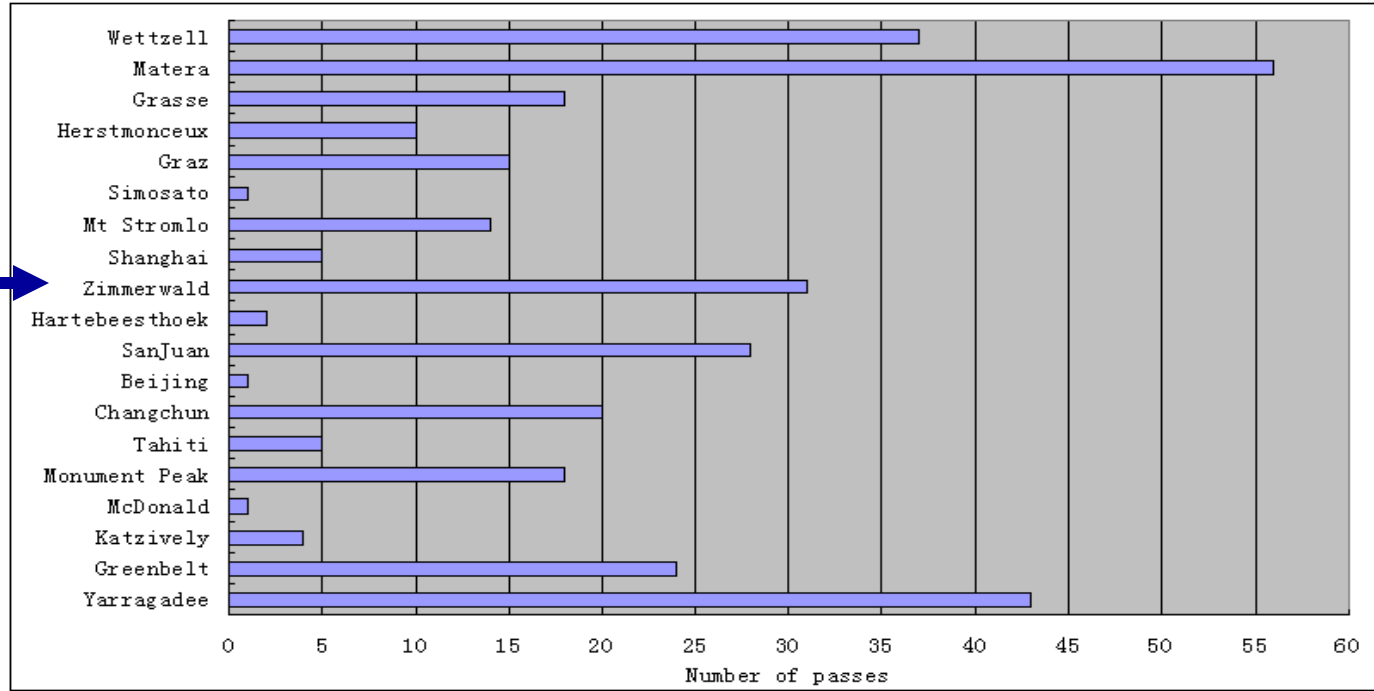


**Passes of  
COMPASS-I3  
(7 sites)**



**Passes of  
COMPASS-I5  
(12 sites)**

**Passes of  
COMPASS-M3  
(19 sites)**

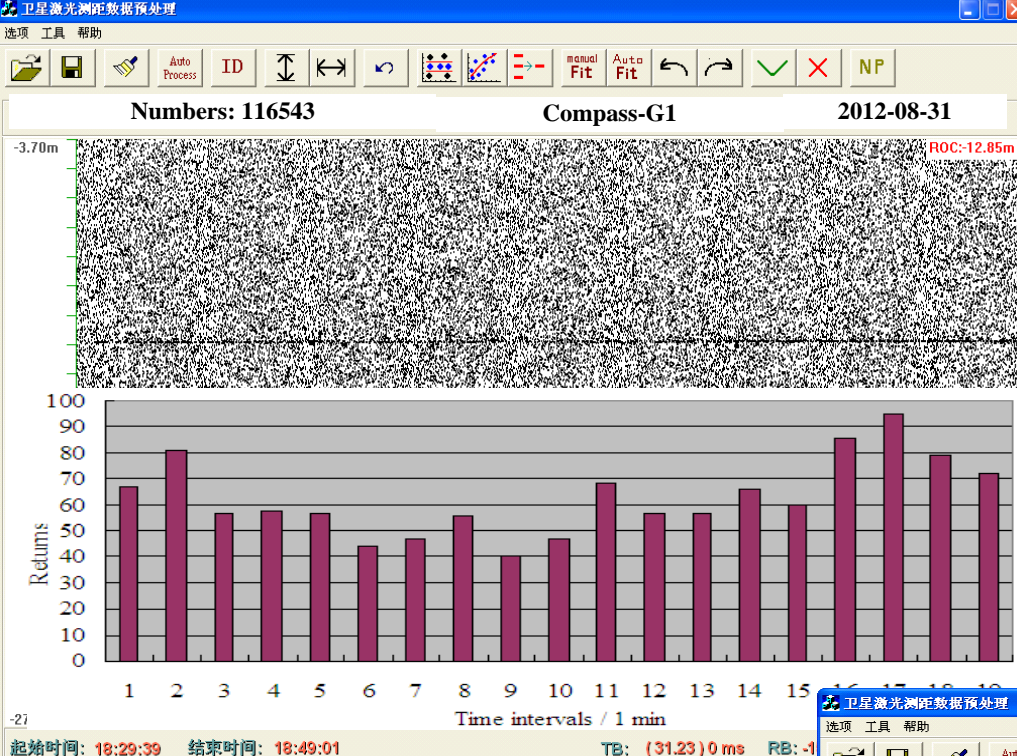






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**The following ones give the observations  
and the statistic of laser returns for  
COMPASS satellites by 1 kHz SLR system  
with laser power of  $\sim 1\text{W}$  at Shanghai  
Station.**



**COMPASS-G1**

distance of  $\sim 38,800\text{km}$

Average returns  $\sim 62$

per one min

Ranging RMS:  $\sim 1.1\text{cm}$

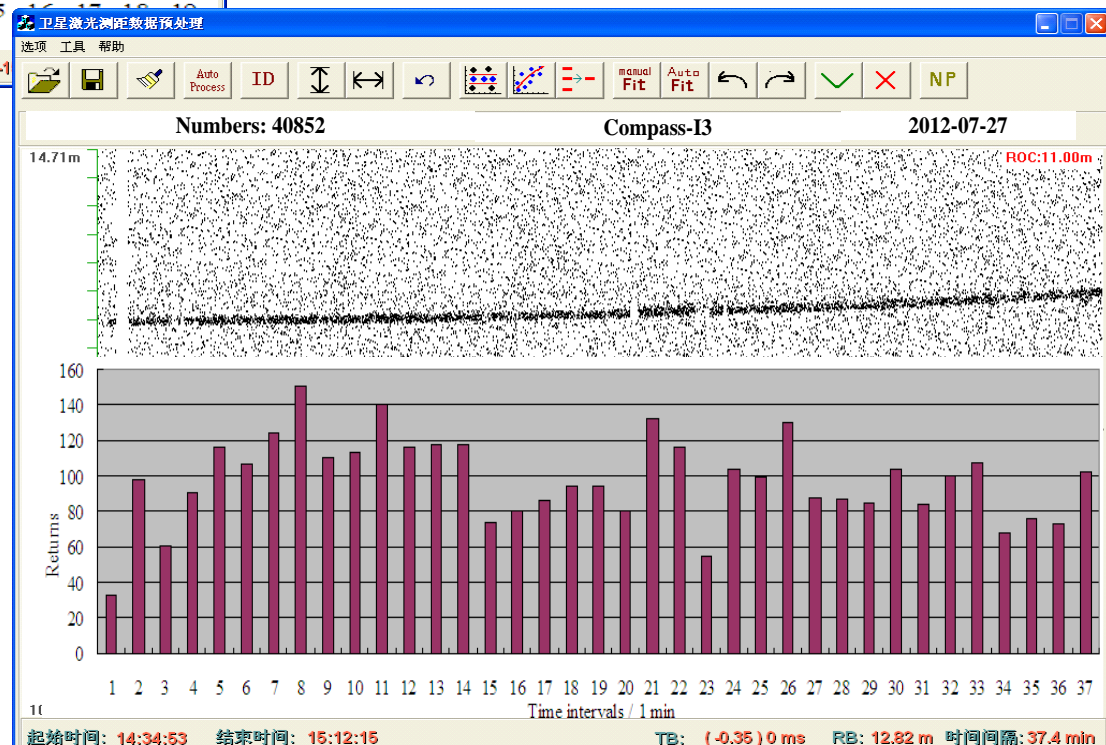
## COMPASS-I3

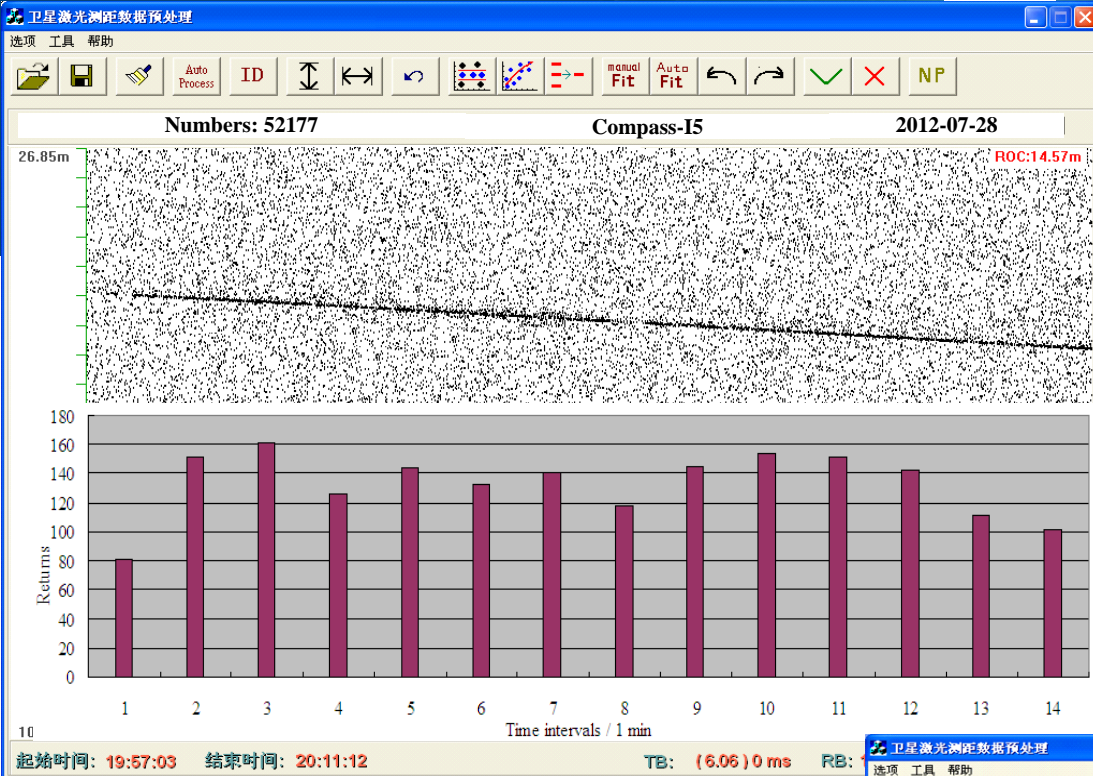
distance of  $\sim 36,000\text{km}$

Average returns  $\sim 98$

per one min

Ranging RMS:  $\sim 1.4\text{cm}$





## COMPASS-I5

distance of  $\sim 36,000\text{km}$

Average returns  $\sim 133$

per one min

Ranging RMS:  $\sim 1.4\text{cm}$

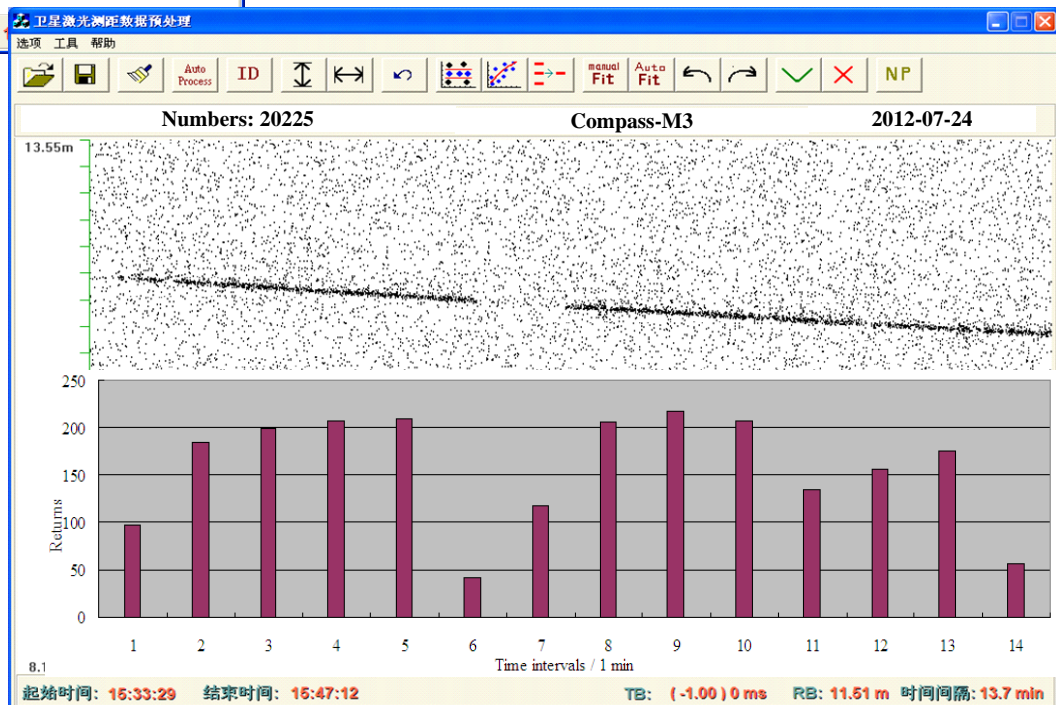
## COMPASS-M3

distance of  $\sim 22,000\text{km}$

Average returns  $\sim 158$

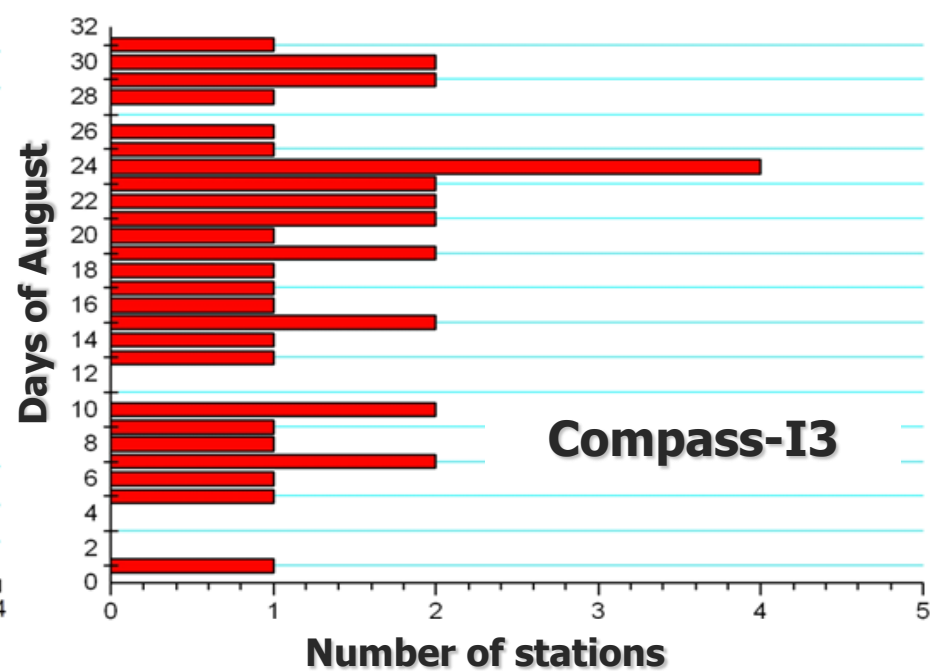
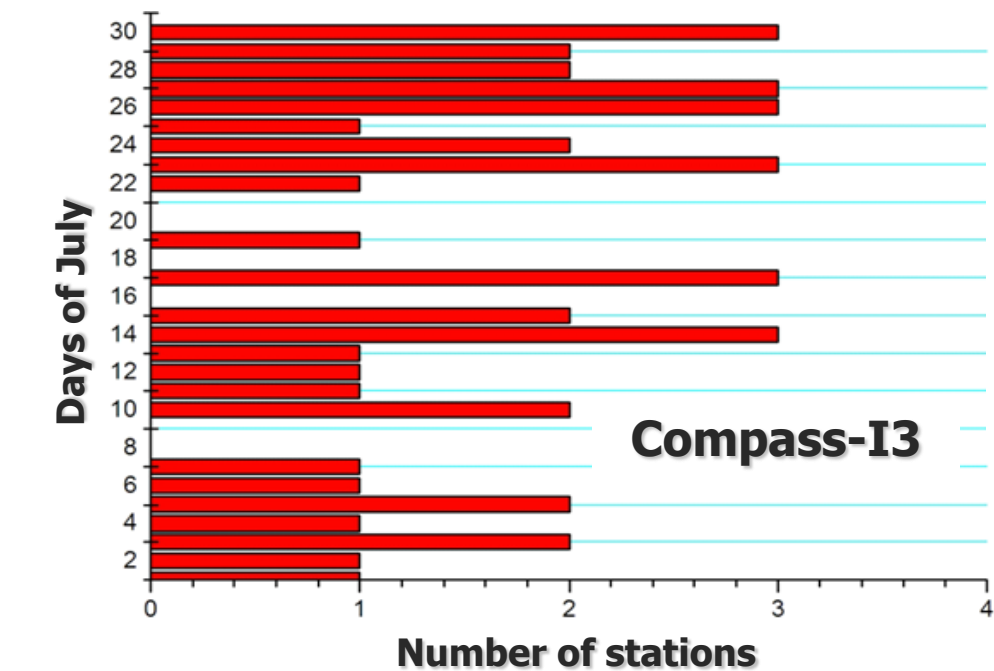
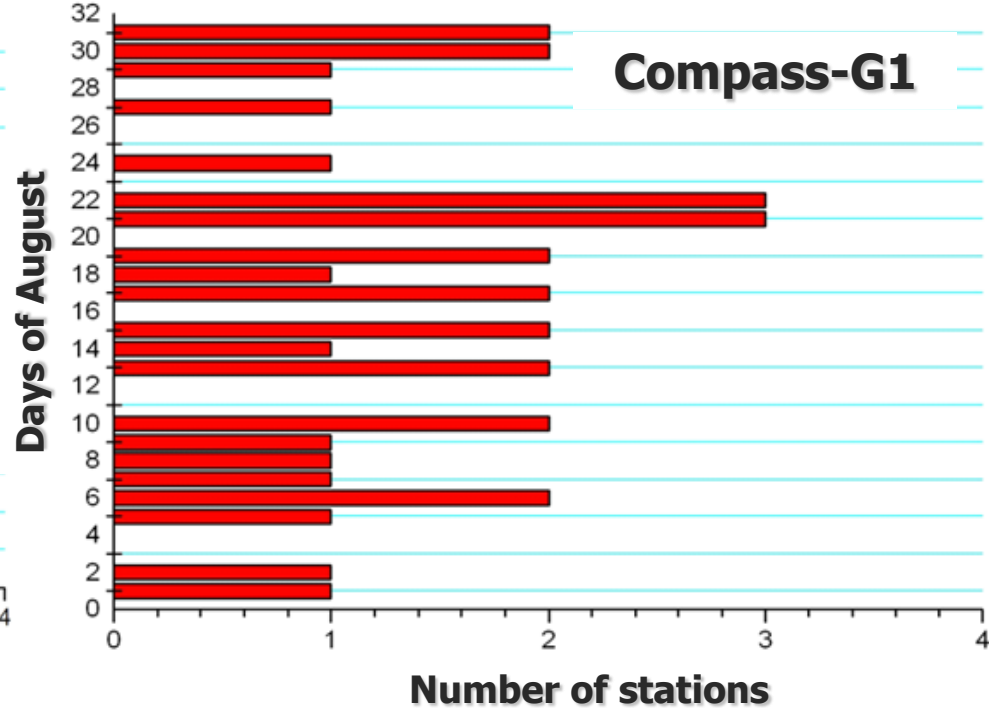
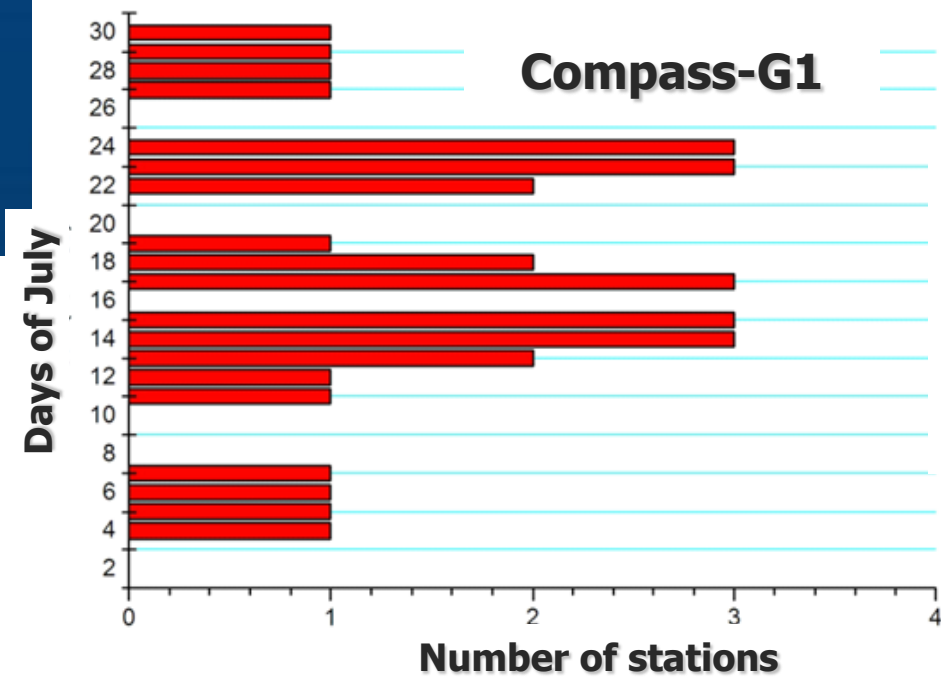
per one min

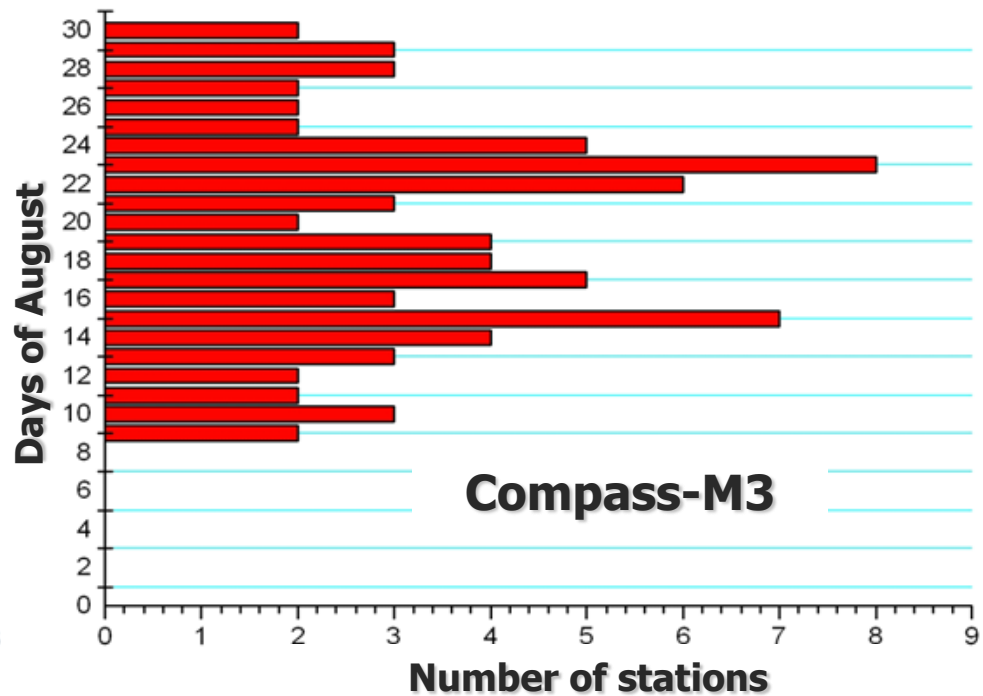
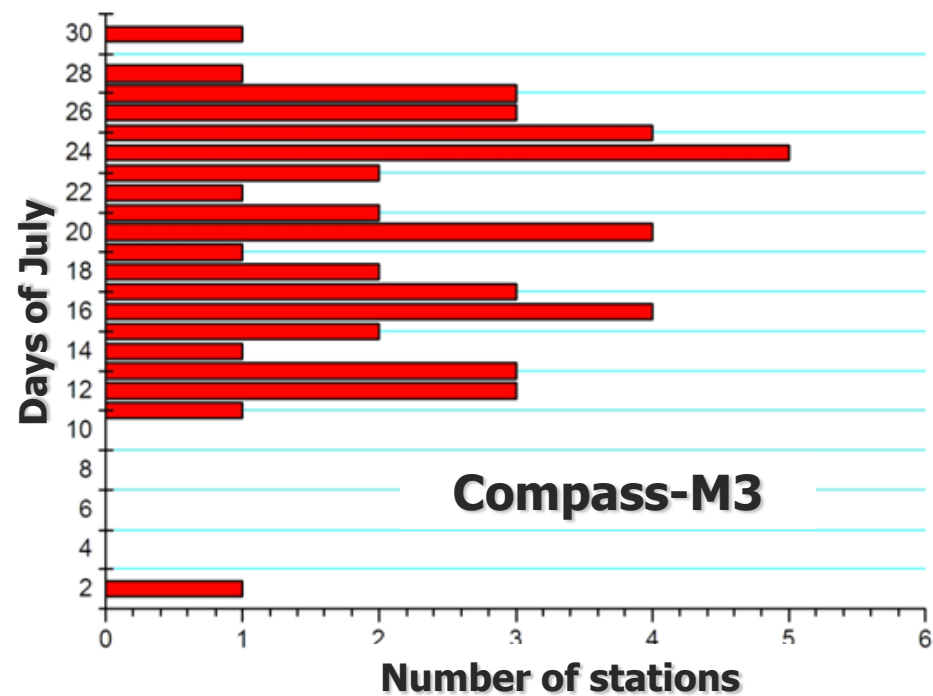
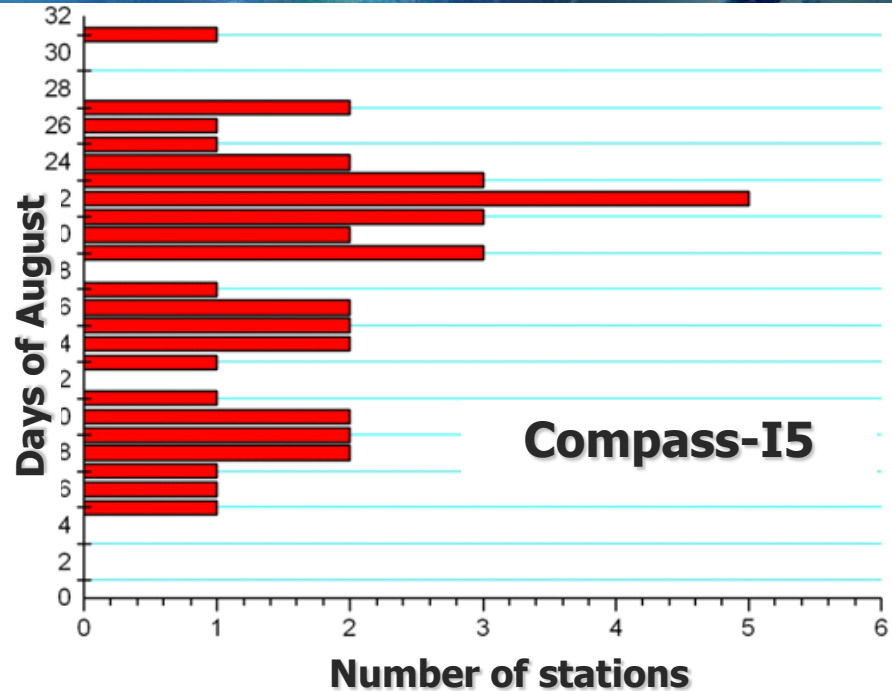
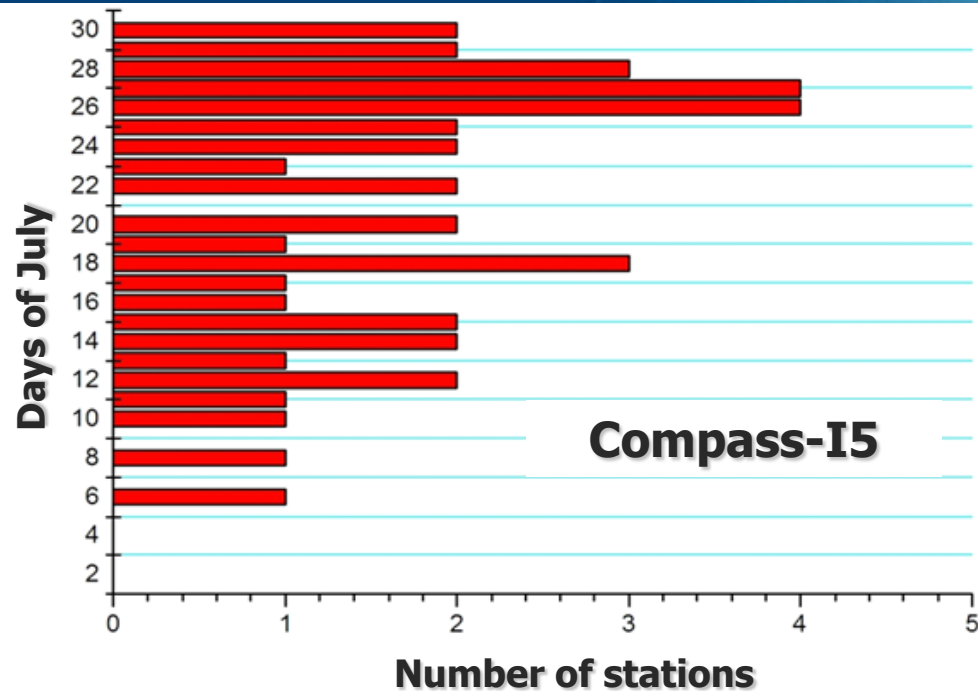
Ranging RMS:  $\sim 1.3\text{cm}$



- **The results of POD for Compass satellites have close relations to the number of tracking stations and the amount of SLR data.**
- **The following gives the statistic of the number of sites tracking to Compass satellites in days of July and August 2012.**







- **From the above results of statistic:**
  - **average 1 or 2** stations to track Compass-G1 per day
  - **average 2 or 3** stations to track Compass-I3/I5 per day
  - **average 4 or 5** stations to track Compass-M3 per day, the maximum up to **8** stations.
- **For Compass-G1/-I3/-I5, due to less number of tracking sites, the SLR data are only as for calibration or the combined process with microwave data**

- **For Compass-M3, the data process center of SHAO have implemented orbit determination, evaluation of SLR data and predictions.**

**Other three satellites of orbit predicts only by microwave.**

- **Tracking to other compass satellites (out of ILRS mission) for calibrations of microwave measurements have been done by the SLR stations within the Chinese regions at the periodic time.**



# Applications of Compass SLR data

## 1) The calibrations of satellite-station measuring system

SLR data as the observed value (O) and microwave data as calculated value (C)  $\rightarrow$  O-C residual.

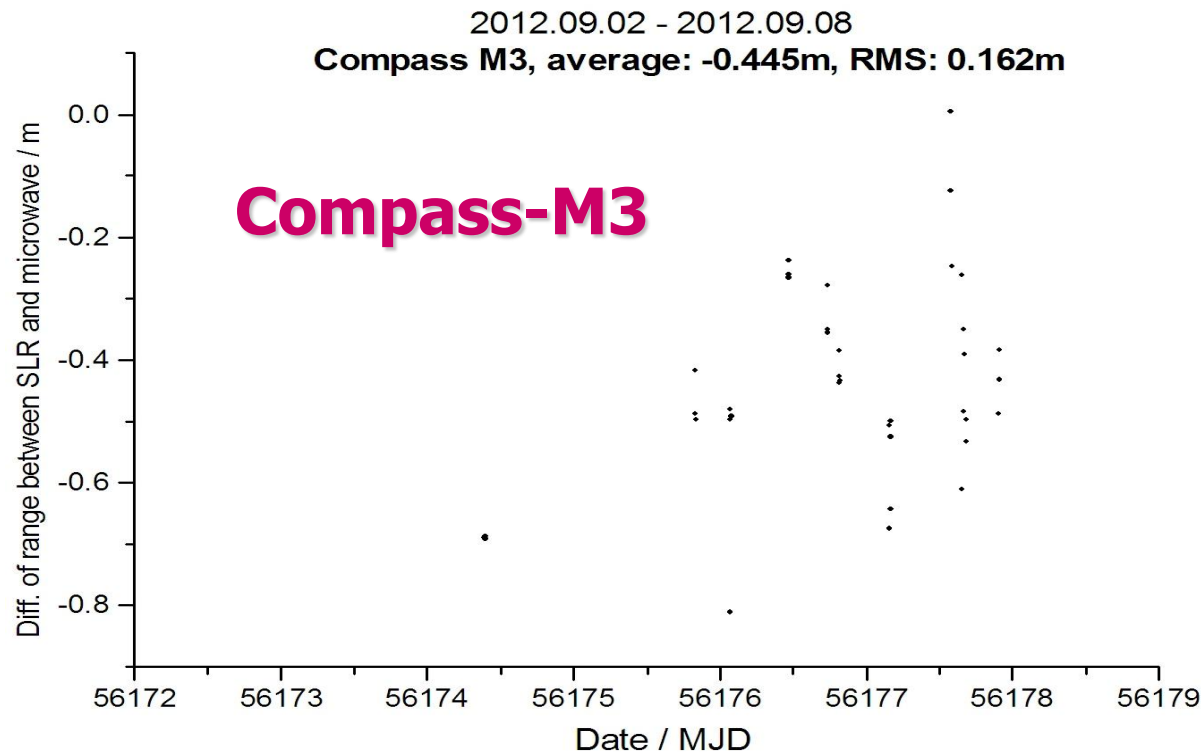
the satellite-station microwave measuring system error was less than 1 ns.

## 2) The calibrations of time synchronization at ground stations

Based on the error of satellite-station microwave measuring system obtained by using SLR data, the error of time synchronization between ground stations was at the level of 100ps.

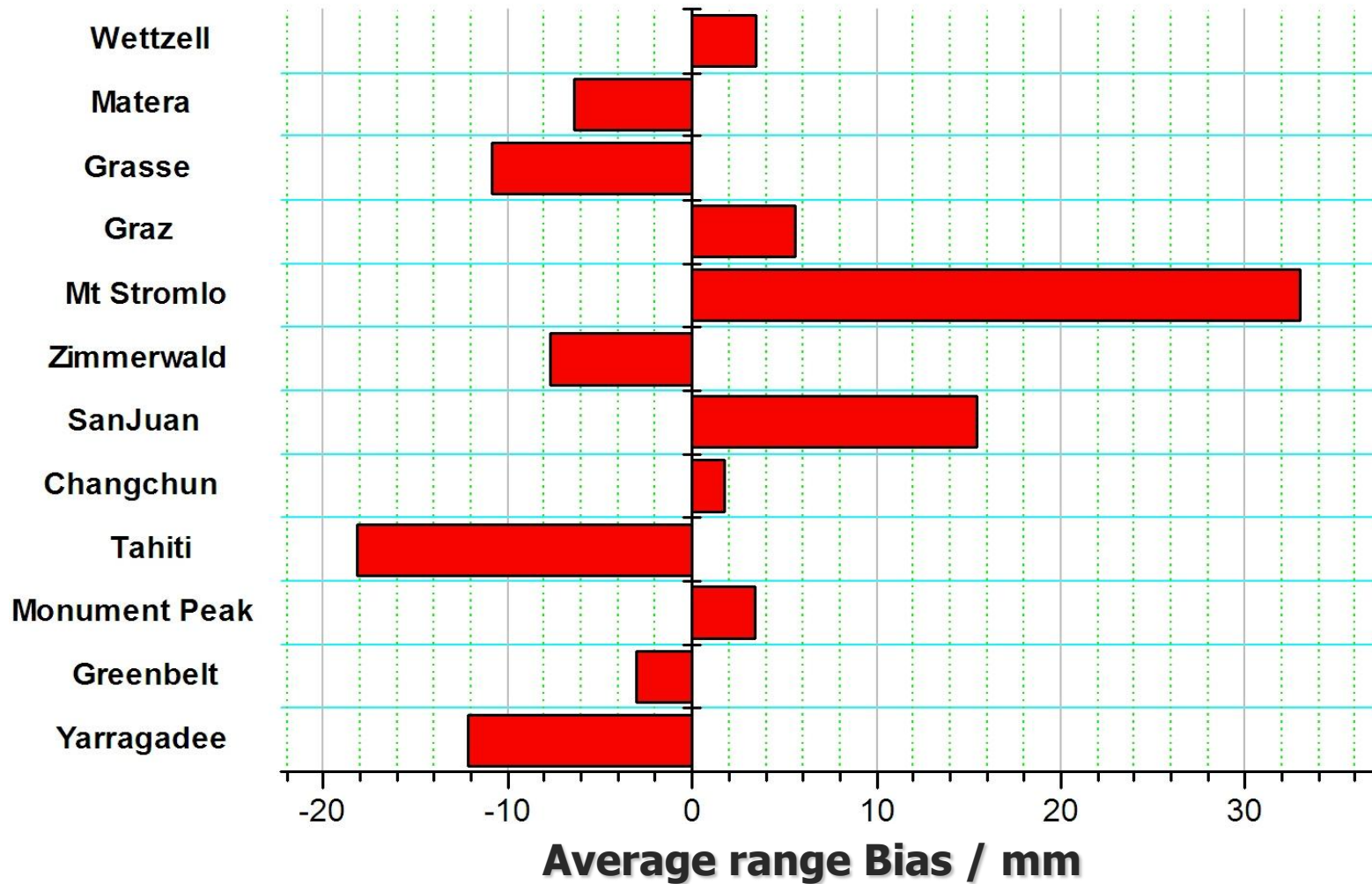
# Applications of Compass SLR data

## 3) Evaluation of satellites orbit measured by microwave techniques



**The average of range bias: -30 ~ -50cm**

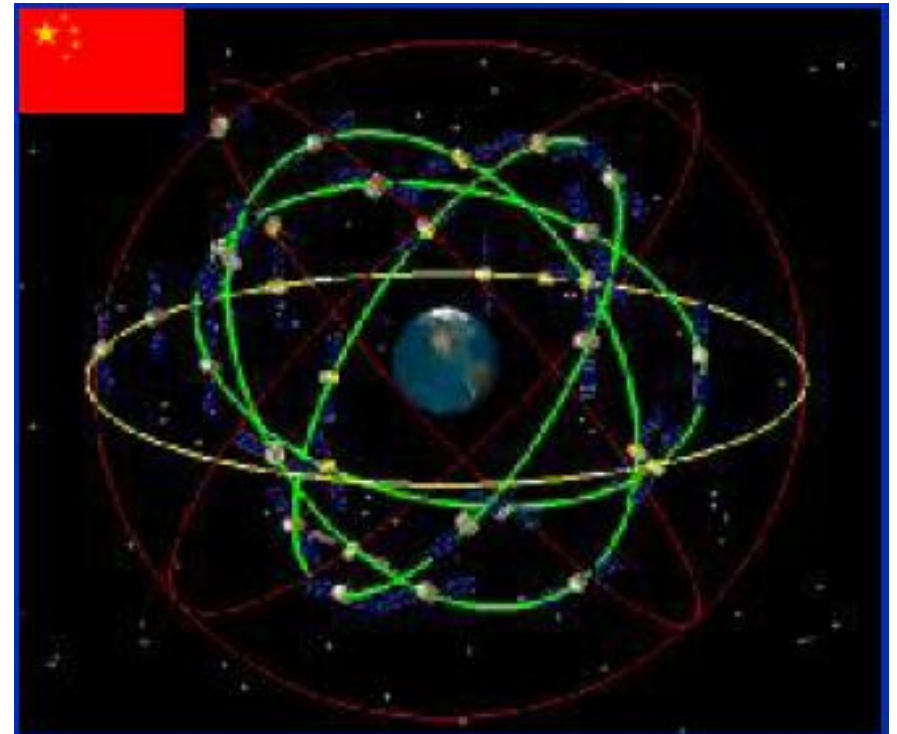
# SLR data analysis for Compass-M3 (2012.09)



**The average range bias is within the 3cm for tracking sites**

# Prospect of SLR to Compass Satellites

- At the end of 2012, Chinese Compass GNSS system will have the ability of the navigation services for the Asia-Pacific region.
- The global navigation services will be considered for Chinese Compass GNSS constellation.



# Prospect of SLR to Compass Satellites

- **More Compass MEO/IGSO satellites** will be launched and SLR technique will be considered as one of the important and indispensable ways of POD.
- For support of laser tracking to Compass satellites, the SLR systems with:  
**small type, automatism, flexibility, stability**  
proposed within domestic regions to meet the requirements of POD for Compass satellites.



# Summary

- **The International SLR observation on Compass satellites provides the opportunity for the ones who are interested in researching on different kinds of GNSS satellites.**
- **Need more stations which can track COMPASS satellites support the observations to Chinese satellites to support its POD and calibration.**
- **More compass MEO/IGSO satellites will join in the ILRS campaign in future.**
- **Proposition of small type SLR system for Compass satellites.**



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**Thanks to ILRS and stations  
for supports of tracking Compass!!!**