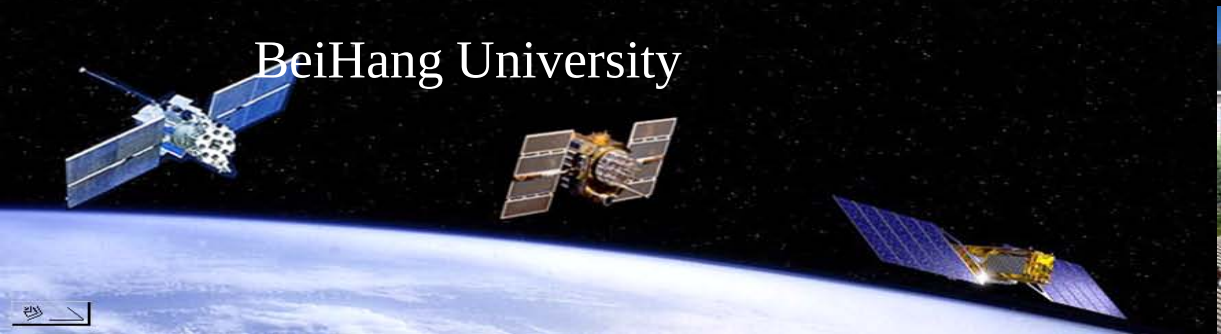
北京航空航天大学
BEIHANG UNIVERSITY

Non-PNT Applications from GNSS

Dr. Yang Dongkai edkyang@buaa.edu.cn

School of Electronics and Information

BeiHang University



Outline

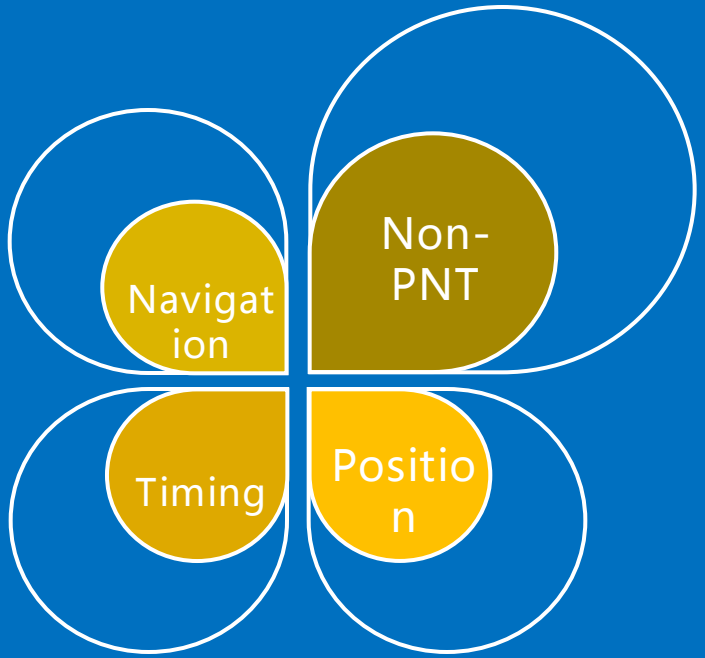
1. Introduction
2. Typical Non-PNT Applications
3. Potential Cooperation on GNSS-R

Introduction

- Satellite navigation has been evolved for around half century
- GPS+GLONASS+GALILEO+BeiDou (3G+B) with MEO, GEO and IGSO
- QZSS+GAGAN+IRNSS+MSAS+WAAS+EGNOS+SDCM
- The satellite number is 50 currently and will be more than 100 after 2020
- The satellite signals are around 10 and will be more than 30 after 2020

- **Positing, navigation and timing are the main applications for GNSS design, construction and operation. In economical, social and business fields, there are many applications such as transportation, emergency response, logistics, search and rescue and personal travel relying on PNT services from GNSS.**

- **However, satellite signal from GNSS has good characteristics and potential capability for applications other than PNT, which could be called non-PNT applications, and is the by products of GNSS.**
- **Non-PNT applications might include the detection of atmosphere, sea state, snow, soil moisture and vegetation water content, etc.**



PNT: The main purpose of GNSS

- Positioning
- Navigation
- Timing

Non-PNT: The Other applications from GNSS

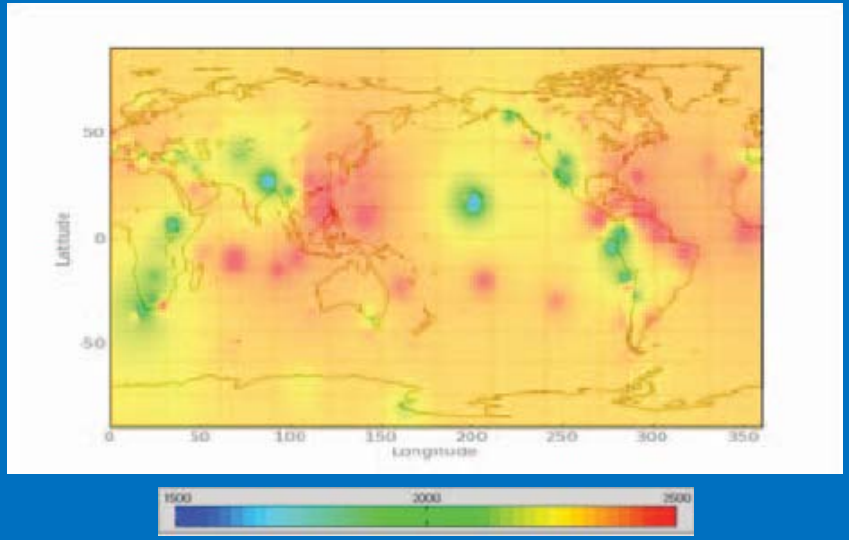
- Sounding Atmosphere
- Sea State Monitoring
- Snow Monitoring
- Water Level Detection
- Vegetation Water Content
- Soil Moisture

Typical Non-PNT Applications

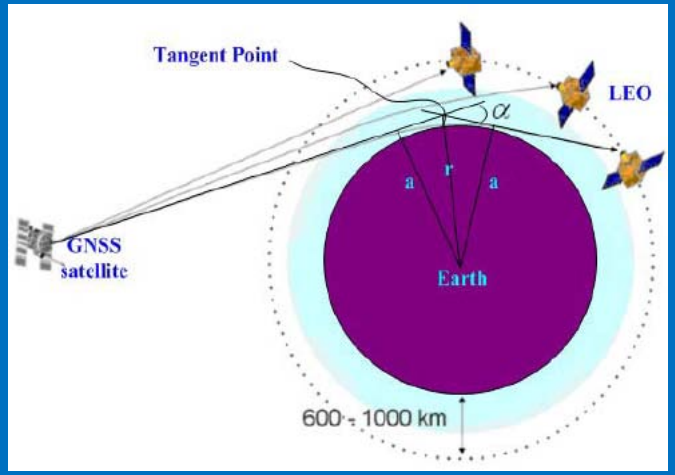
I. Sounding Atmosphere
II. Sea State Monitoring
III. Snow Monitoring
IV. Water Level Detection
V. Vegetation Water Content
VI. Soil Moisture

I. Sounding Atmosphere

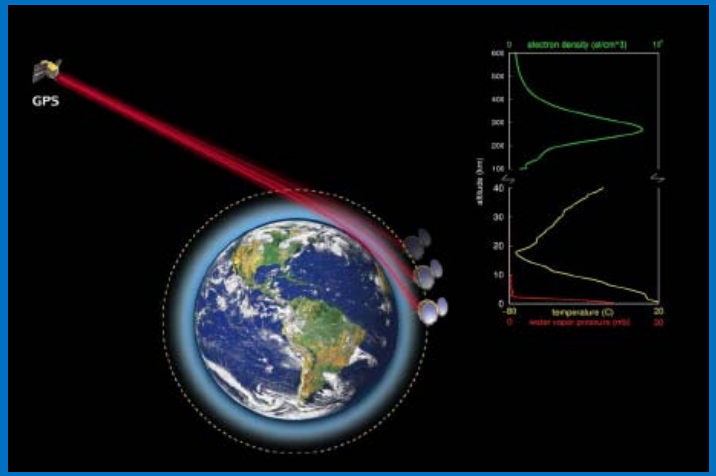
Atmosphere parameters could be extracted through GNSS signal processing, specially by multiple frequencies signal. For example, to Get Zenith Path Delay (ZPD) from IGS station as troposphere products for Meteorology purpose and also for the GNSS performance enhancement.



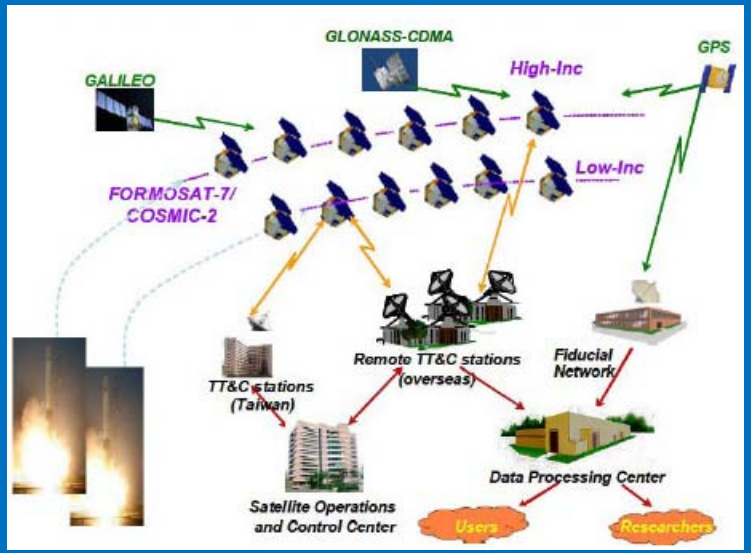
Satellite-based radio occultation techniques



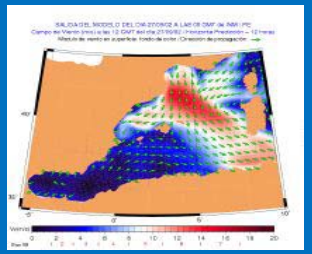
Another typical example on atmosphere is real-time GPS Radio Occultation (GPS-RO), which could provide abundant data through Low Earth Orbit (LEO) satellites to global users.



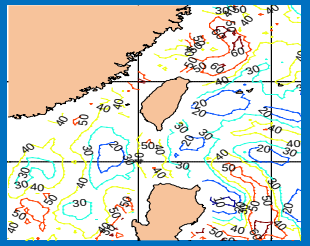
COSMIC



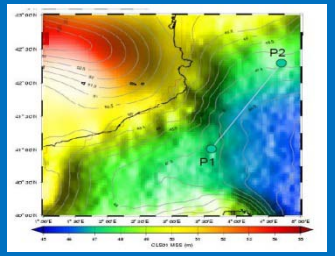
II. Sea State Monitoring



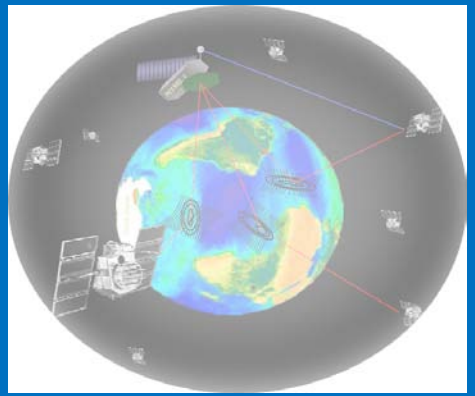
Ocean wind



Significant Wave Height



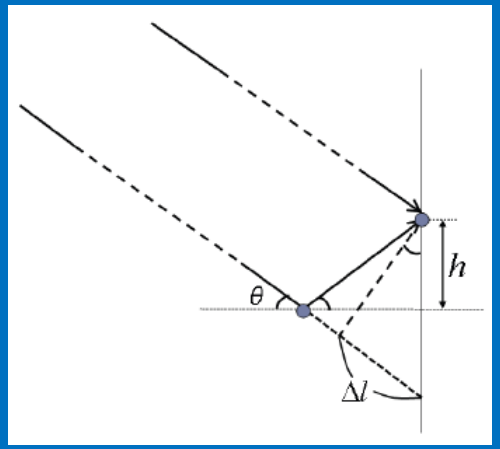
Altimetry

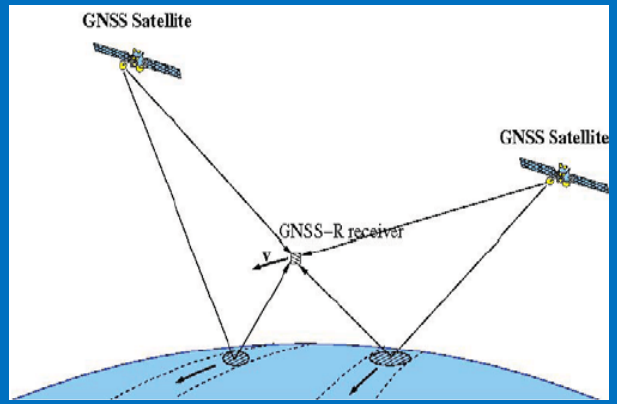


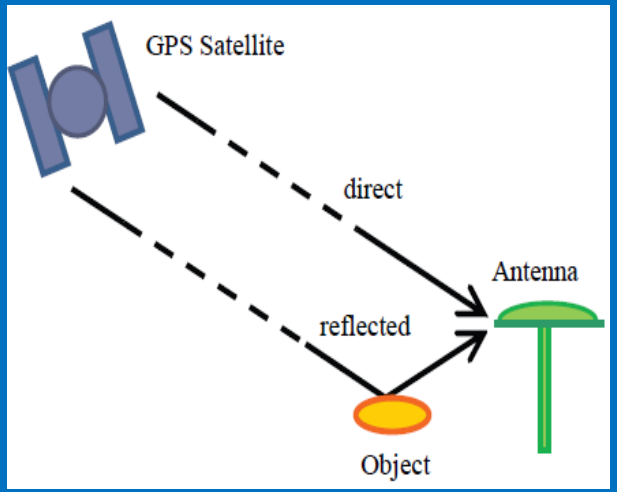
Sea salinity

Sea ice

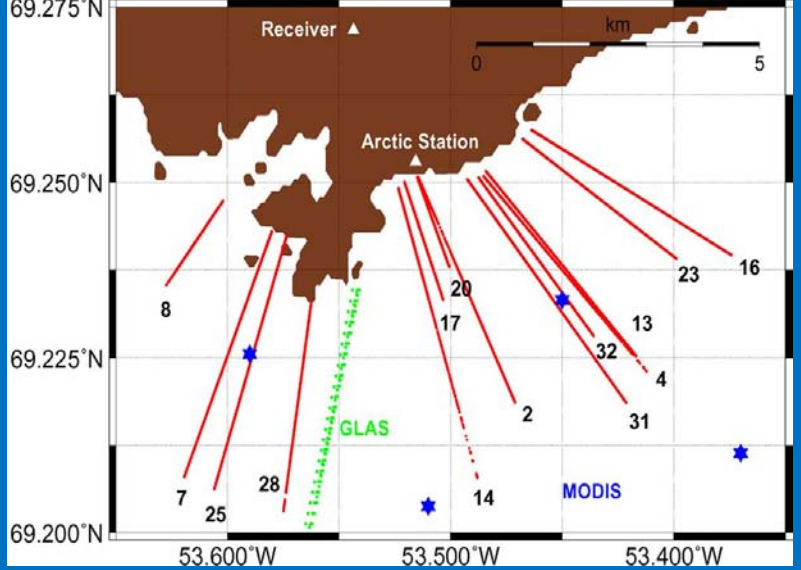
The Sea State could be monitored by detecting the GNSS signal reflected from the sea surface. The GNSS reflections have been probably different polarization, amplitude, frequency and phases over different sea state, i.e. altimetry, salinity, icy or not, wave height, surface wind speed and direction etc.








Direct GPS Signal
Reflected GPS Signal

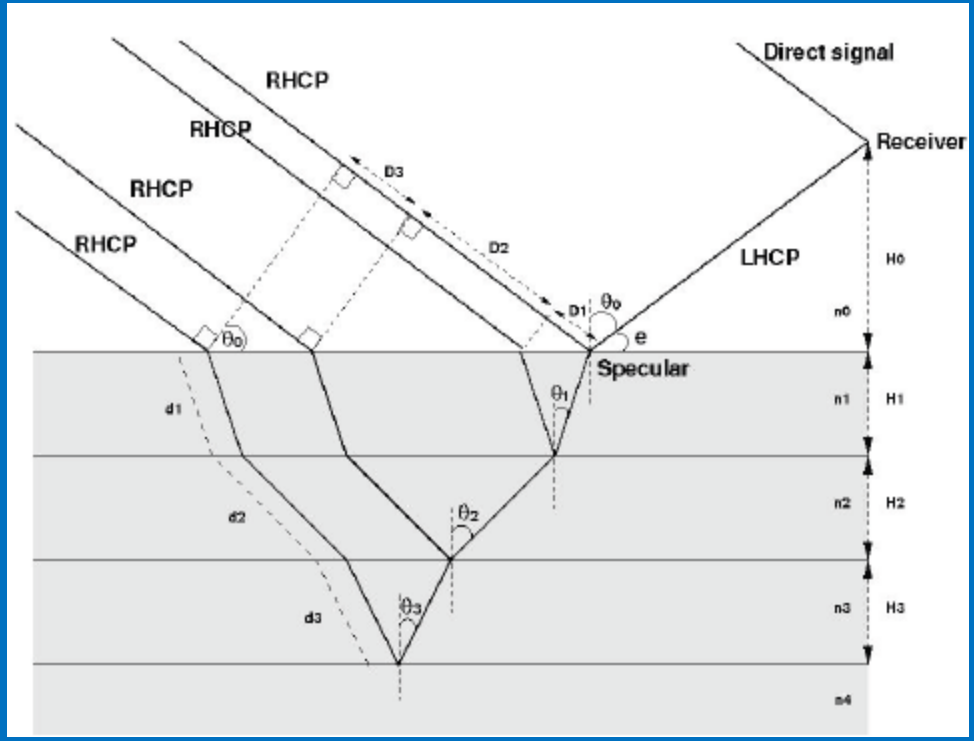


Ground tracks of the reflected GPS signals (with PRN number) obtained during raw acquisition for the whole campaign (red lines). Positions of GLAS and MODIS data samples are marked with green and blue respectively. White triangles mark the location of the receiver and the Arctic station.

Airborne test scenario

III. Snow Monitoring

Different reflections could be collected from different snow layer and thickness by the GNSS-R receiver.



The path followed by the contributions of the modeled reflected signal with 4 snow layers.

(a)

(b)

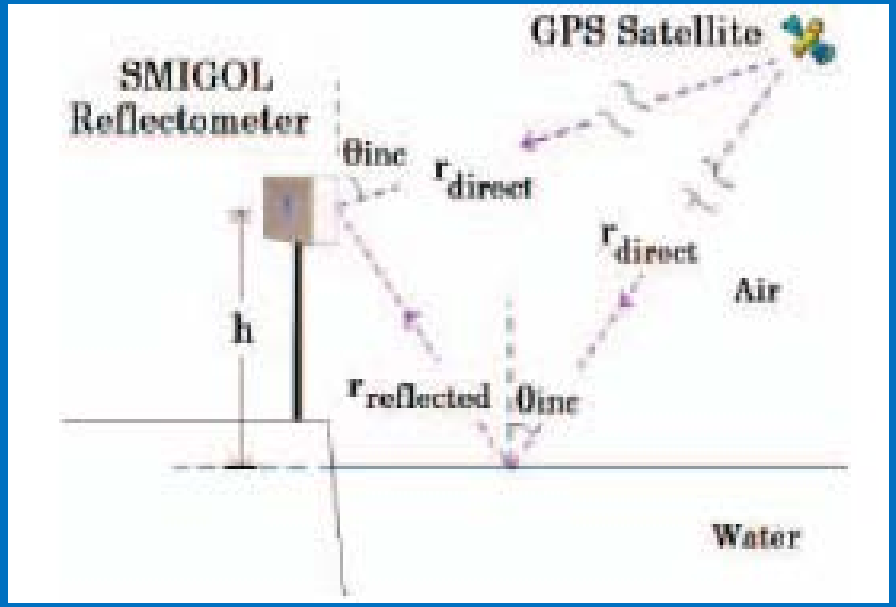
Field experiment at Comalada mountains, Spain)

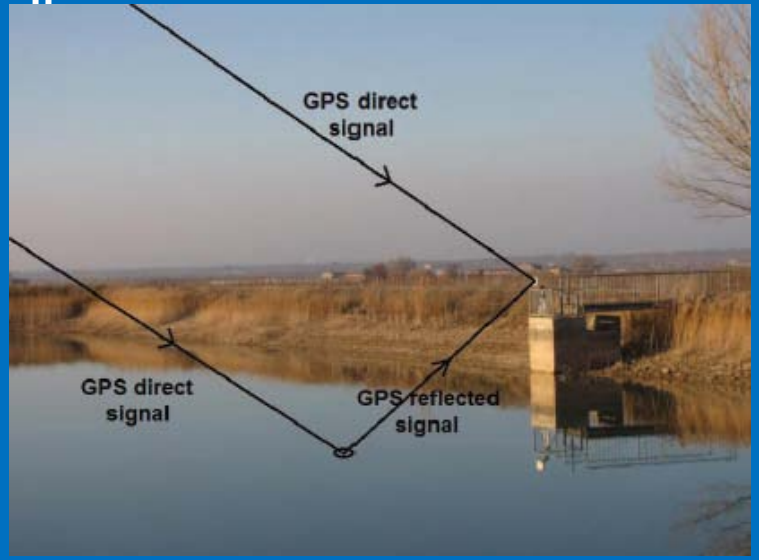
a) Reflectometer mounted in the pole of the meteorological station

b) Experiment field

IV. Water Level Detection

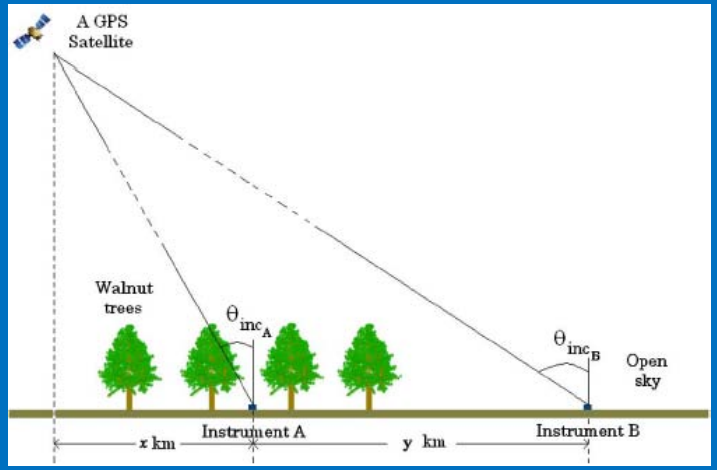
The time difference between the direct and reflected signals from the water surface might be used for the water level detection. The time difference could be calculated by the code phase, carrier phase or carrier frequency of the GNSS signal.




GPS direct
signal
GPS direct
signal
GPS reflected
signal

V. Vegetation Water Content

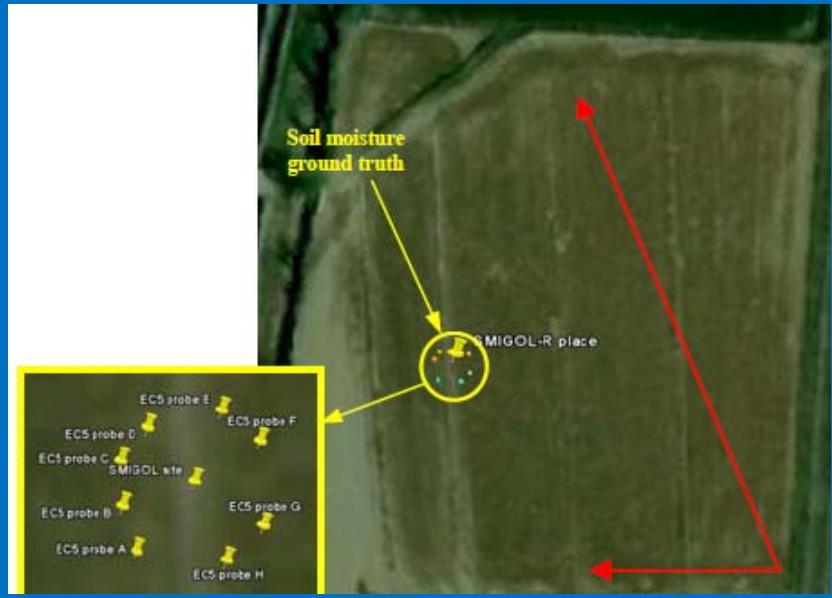
By measuring the received powers of the GPS signals in open sky, under the vegetation layer, the vegetation water content could be computed as they may affect the signal amplitude on different absorb ratio.



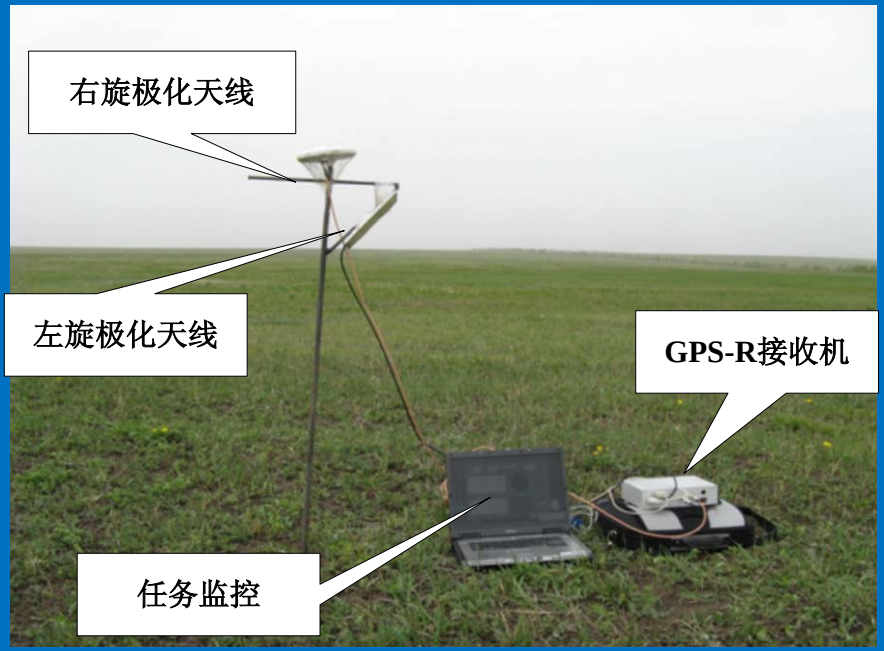
Experimental setup. Instrument A, deployed under trees, and instrument B, deployed under open sky, simultaneously measure GPS signals.

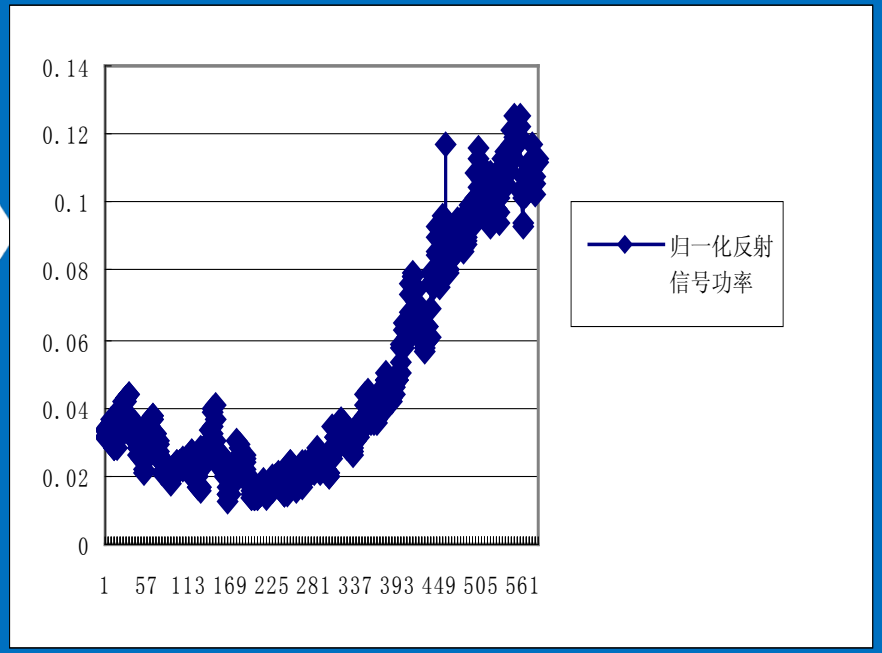
Walnut-tree effect detection on GNSS signal over different seasons with different leaves. The test result might be used to evaluate the ecological environment.

VI. Soil Moisture



The test on different Maize height (40cm left and 135 cm right) might give the different reflected signal features, which is the useful information to get the soil moisture for the agricultural evaluation.


右旋极化天线
左旋极化天线
GPS-R接收机
任务监控


0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
1 57 113 169 225 281 337 393 449 505 561
归一化反射
信号功率

Potential Cooperation on Non-PNT

1. Ocean Wave Detection during the typhoon
2. Geophysical investigation for land
3. Global climate changing detection with GNSS-R
4. Earth observation jointly by Satellite Navigation and Remote Sensing
5. etc.

Thanks for your attention