

2017 Dragon 4 Symposium

Soil Moisture Monitoring Using Reflected Signals of BDS GEO Satellites

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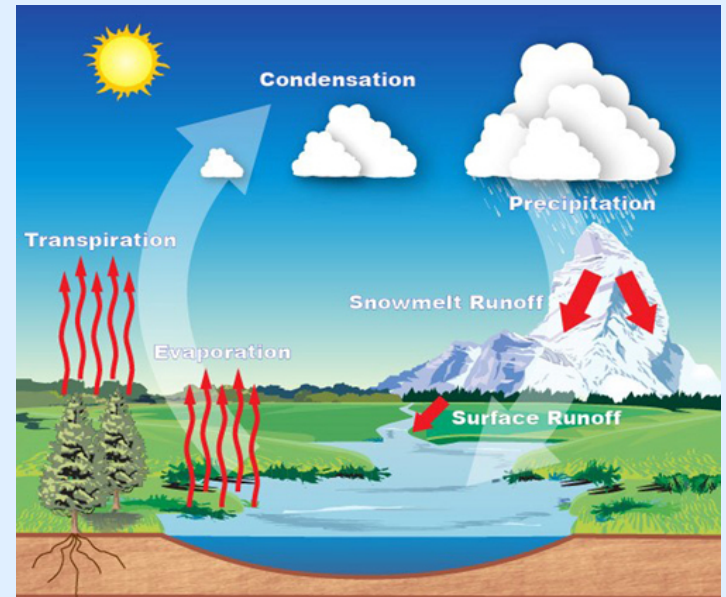
OUTLINES

1. GNSS-R FOR SOIL MOISTURE
2. WHY USE BDS GEO SATELLITES' SIGNALS
3. LAND-BASED EXPERIMENT
4. RESULTS AND CONCLUSIONS

1. GNSS-R FOR SOIL MOISTURE

Soil moisture is an environmental descriptor that integrates much of the land surface hydrology.

It does play an important role in human life.

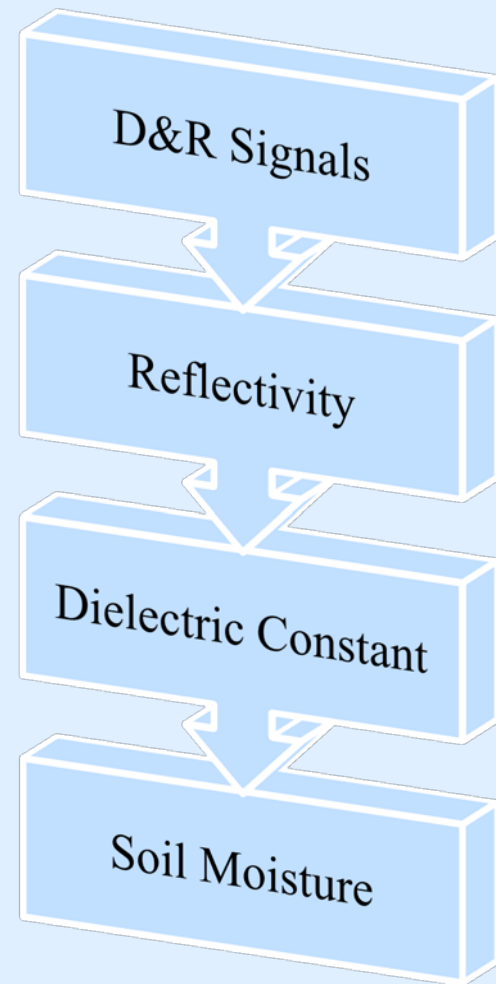
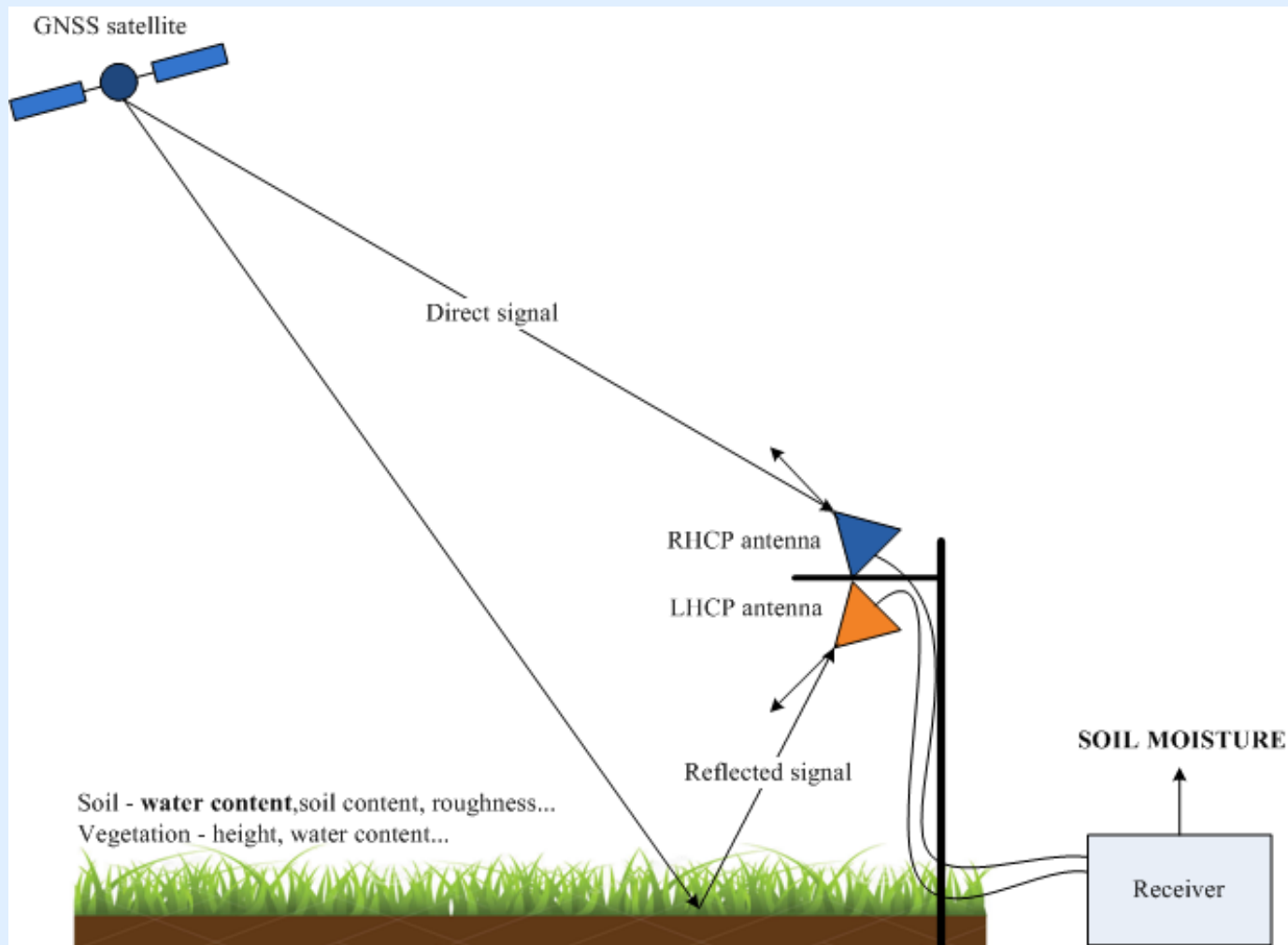


There are many methods for soil moisture measurement.

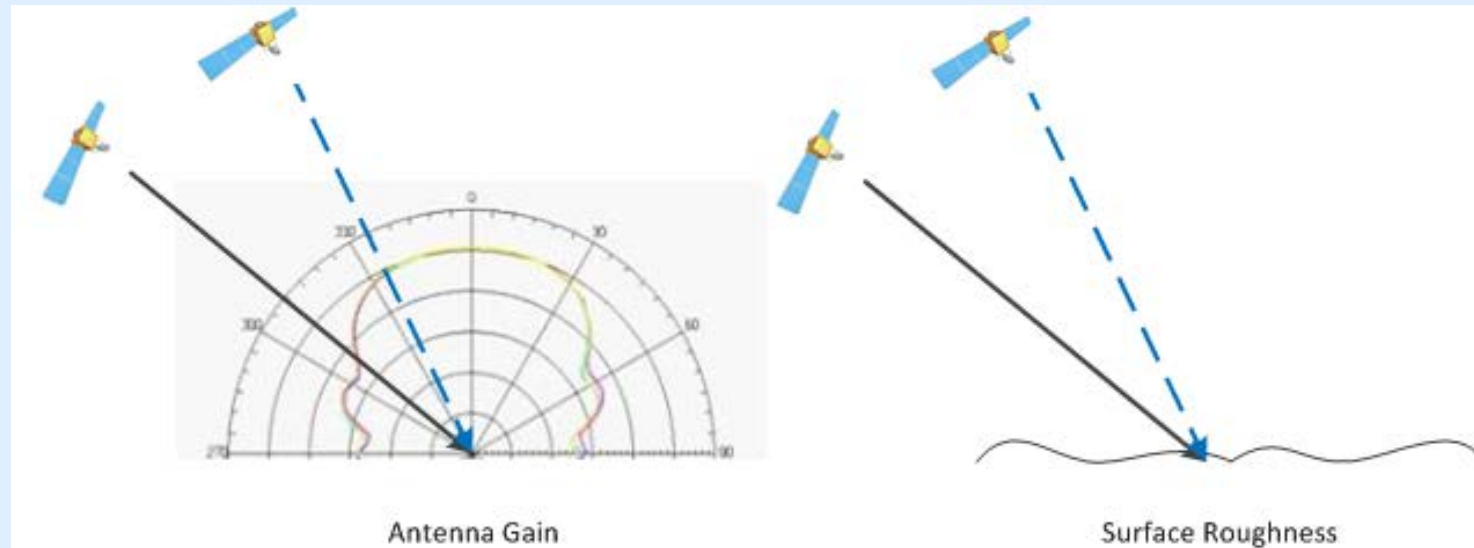
GNSS-R technique

- **Economical**
- **Flexible**
- **Work all weather and all day**
- ...

1. GNSS-R FOR SOIL MOISTURE



2. WHY USE BDS GEO SATELLITES' SIGNALS



Both antenna gain and surface roughness are involved with the elevation angle.

The problem is that the elevation angle always changes as the satellite move, resulting in mutative antenna gain and surface roughness .

2. WHY USE BDS GEO SATELLITES' SIGNALS

USE BDS GEO SATELLITES' SIGNALS!

Stationary relative to the Earth

- If visible, always visible
- Fixed specular point
- Fixed antenna gain & surface roughness

5 GEO satellites

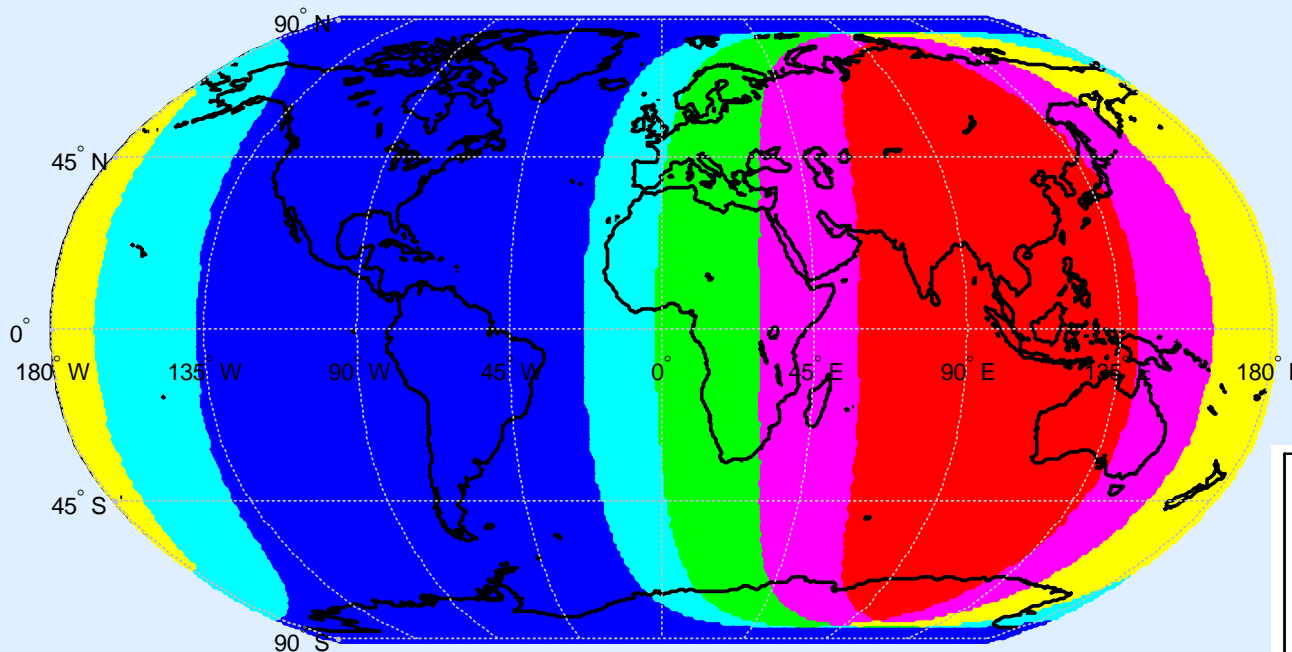
58.75° E

80° E

110.5° E

140° E

160° E



- visible BDS GEO sat num = 0
- visible BDS GEO sat num = 1
- visible BDS GEO sat num = 2
- visible BDS GEO sat num = 3
- visible BDS GEO sat num = 4
- visible BDS GEO sat num = 5

3. LAND-BASED EXPERIMENT



- Experiment site: Tai'an, Shandong, China
- Experiment period: 2014.11.26~28, 9:00am~5:00pm
- Including **signal reception & reference experiment**

3. LAND-BASED EXPERIMENT

3.1 Signal Reception

1) ABOUT SITE

Antenna location:

36.16091819N, 117.14908295E, 130m ASL

Vegetation:

wheat, height<10cm

Surface roughness:

Not measured, but smooth.



3. LAND-BASED EXPERIMENT

2) ABOUT SIGNAL SAMPLING SYSTEM

Antenna setup:

height~4 m

Low gain RHCP antenna for direct signals, up to sky

Mediate gain LHCP antenna for reflected signals, down to ground(with an angle)



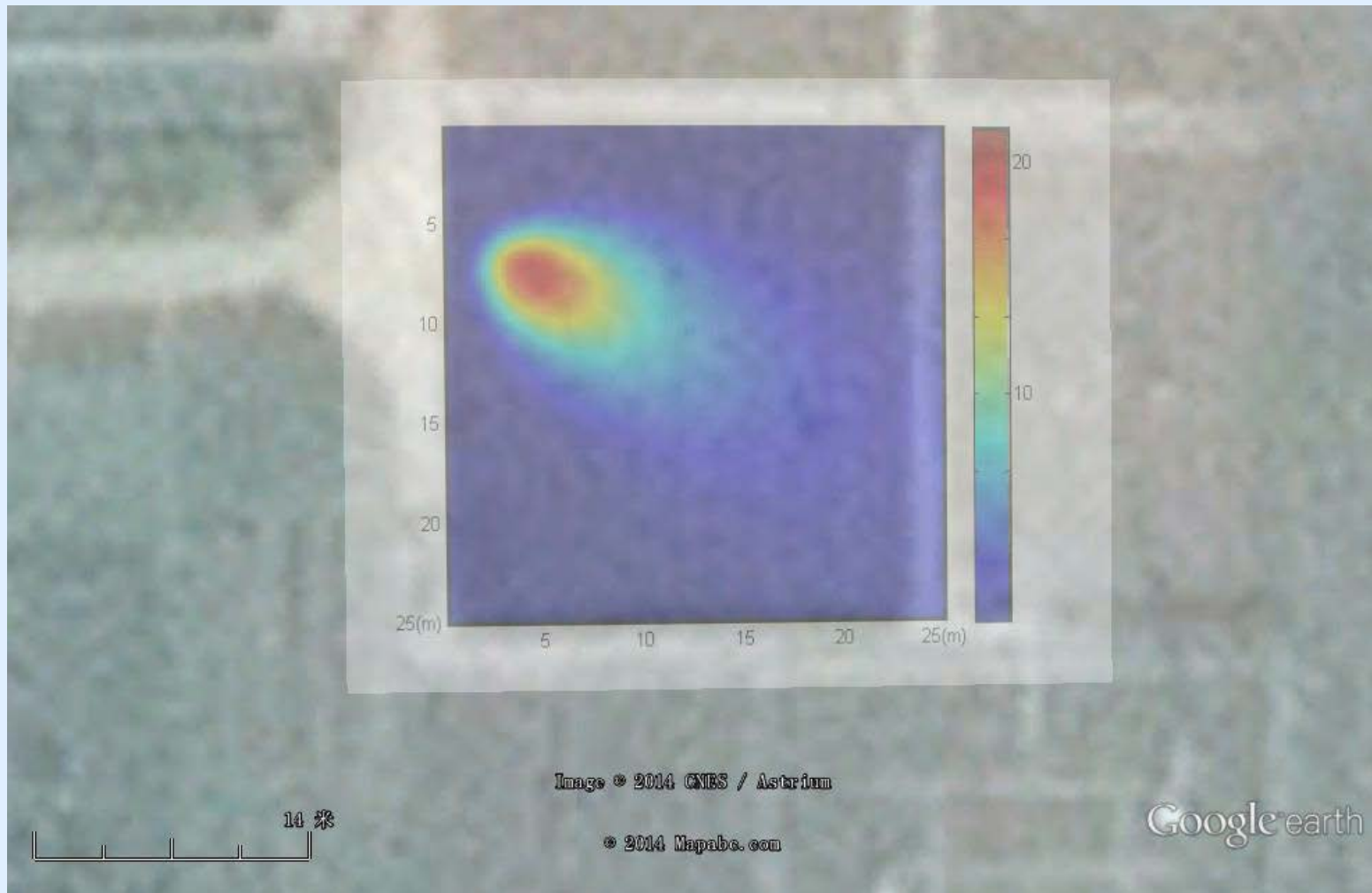
Signal sampler:

GPS L1/BDS B1

Quantization bits: 2 bits

3. LAND-BASED EXPERIMENT

Antenna gain distribution



3. LAND-BASED EXPERIMENT

3.2 Reference Experiment

While sampling the GNSS signals, use **weighting method** to obtain the ground truth soil moisture data.

Depth:

0~10cm

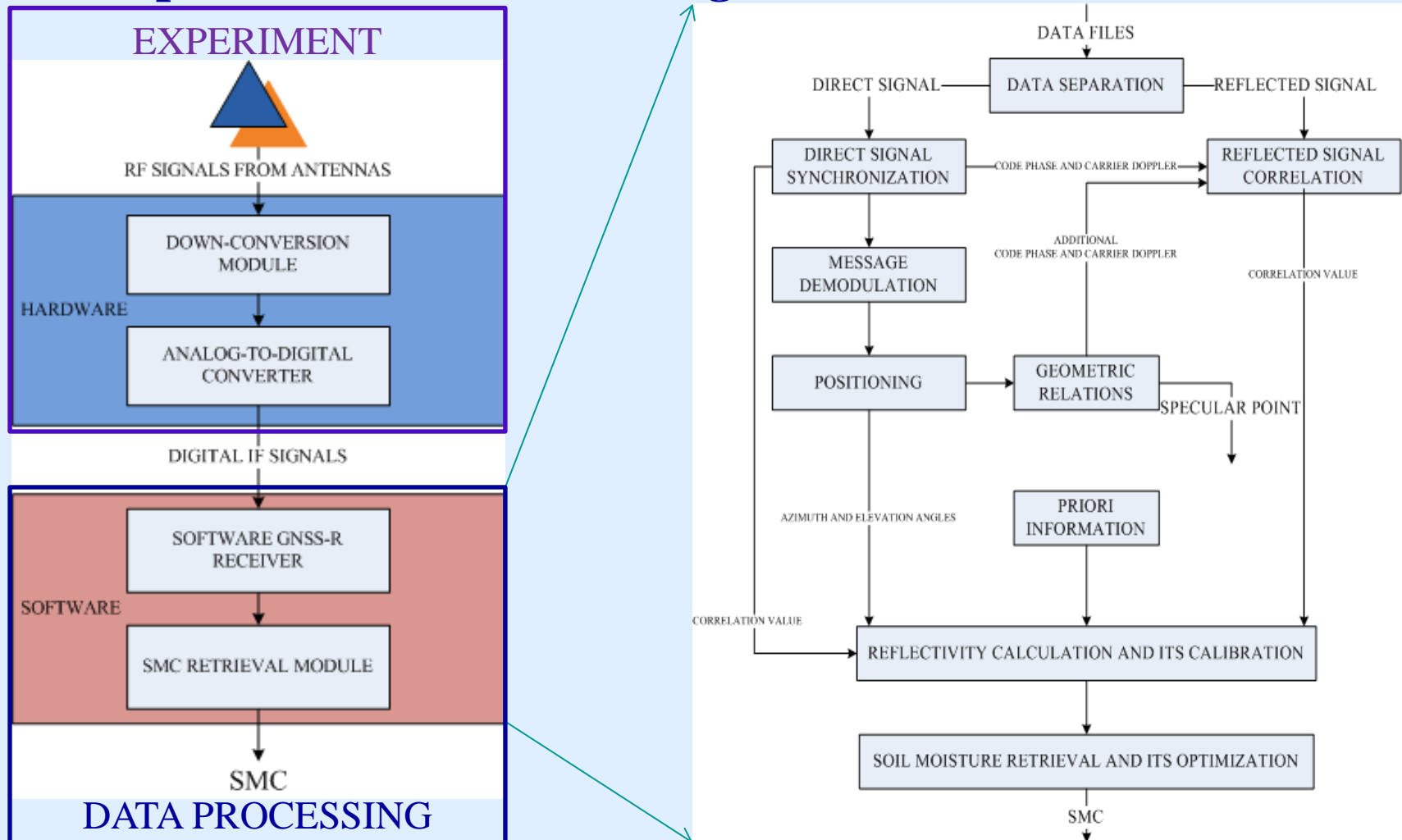
Frequency:

Once per hour



4. RESULTS AND CONCLUSIONS

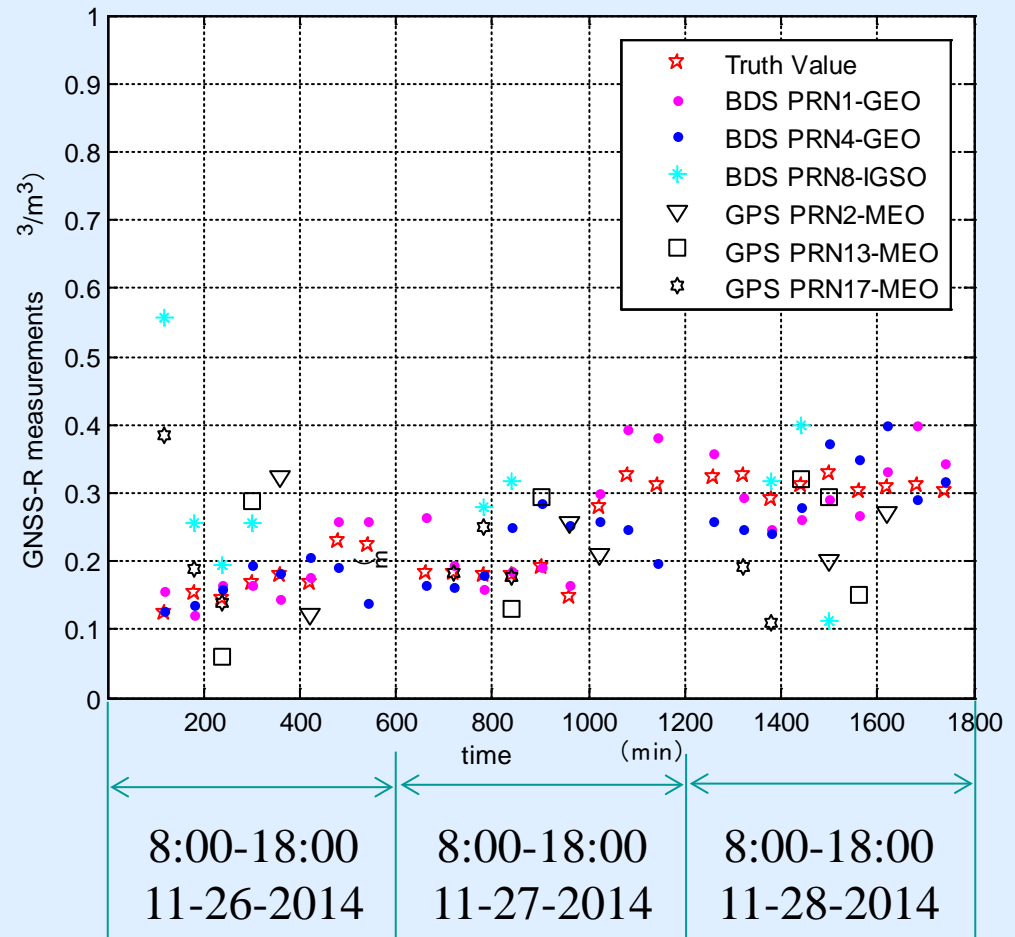
4.1 Experiment Data Processing



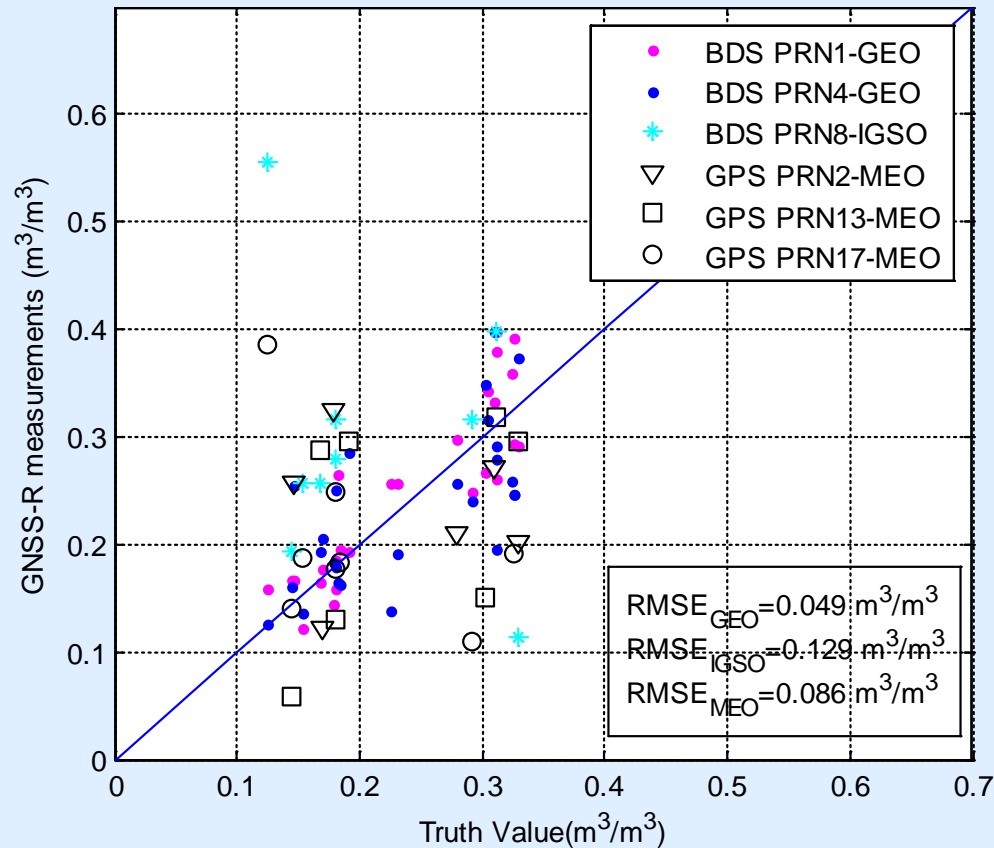
4. RESULTS AND CONCLUSIONS

4.2 Experiment Results

BDS GEO measurements perform better in **temporal continuity** than other GNSS-R measurements because the GEO satellites are **continuously visible**.



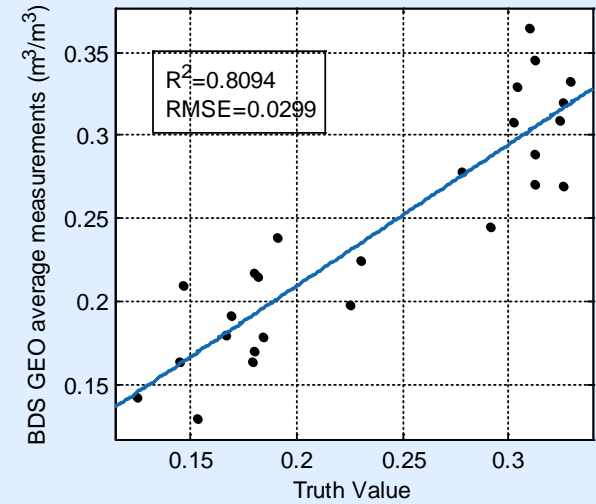
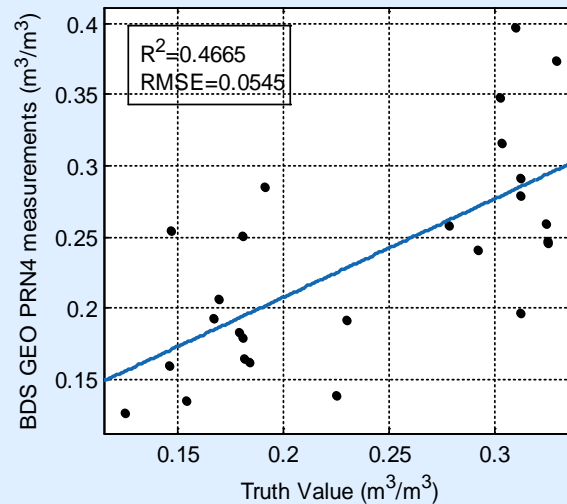
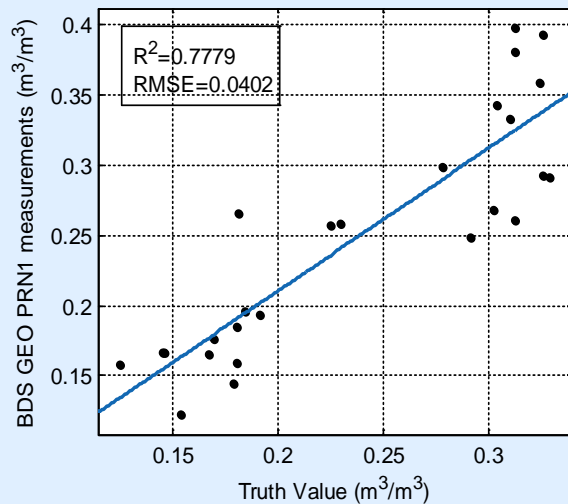
4. RESULTS AND CONCLUSIONS



BDS GEO measurements have a better performance in measurement error .

4. RESULTS AND CONCLUSIONS

Focus on BDS GEO measurements:



BDS GEO PRN	R-SQUARE	RMSE	ELEVATION ANGLE
PRN 1	0.7779	0.0402	41 degree
PRN 4	0.4665	0.0545	29 degree

High elevation results in better performance.

4. RESULTS AND CONCLUSIONS

4.3 Conclusions

- **BDS GEO measurements perform perfectly in temporal continuity.**
- **BDS GEO measurements have a better performance in measurement error .**
- **High elevation perform better than low elevation.**

FUTURE WORKS

- **BDS GEO reflectometry for soil moisture**
- **BDS GEO reflectometry for vegetation parameters**
- **Other GNSS-R soil moisture topics, especially air-borne and space-borne ones.**

Thanks for your attention!