High-Resolution Satellite-Based Land Surface Monitoring Using NavIC L5 Signal.

Bushra Ansari
Sanat K Biswas

Space Systems Laboratory, IIIT Delhi

What is GNSS

- GNSS is a generalized term used to refer the different global and regional satellite systems that provides Positioning, Navigation and Timing (PNT) services.

- Global satellite systems:
  - GPS
  - GLONASS
  - GALILEO
  - BeiDou
- Regional satellite systems:
  - NavIC
  - QZSS

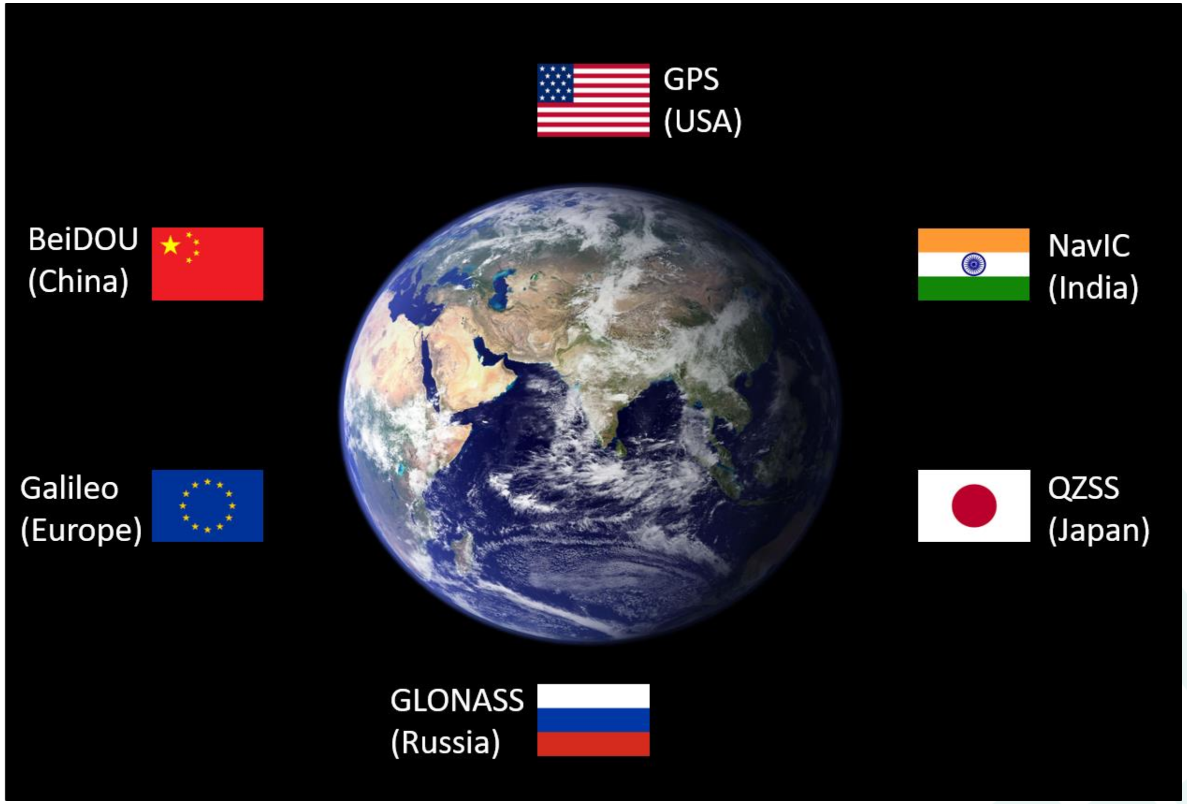

Fig1. GNSS Basics

What is GNSS-R

- GNSS-R (GNSS-Reflectometry) is an emerging remote sensing technique that uses GNSS signals as signals of opportunity.

- When the GNSS signals propagates through the atmosphere, the amplitude, phase and the polarization characteristics of the signal changes.

- The change in the characteristics of signal are used for remote sensing applications such as sea state, soil moisture, vegetation height, snow depth monitoring etc.

Benefits of GNSS for Earth Observation

- It provides 24 hour coverage i.e. continuous availability of GNSS-signals.
- Allow retrieving geophysical parameters that are interesting from both scientific and commercial points of view.
- Versatile and cost effective complement of existing earth observing systems.
- It is advantageous as it uses existing GNSS infrastructure.

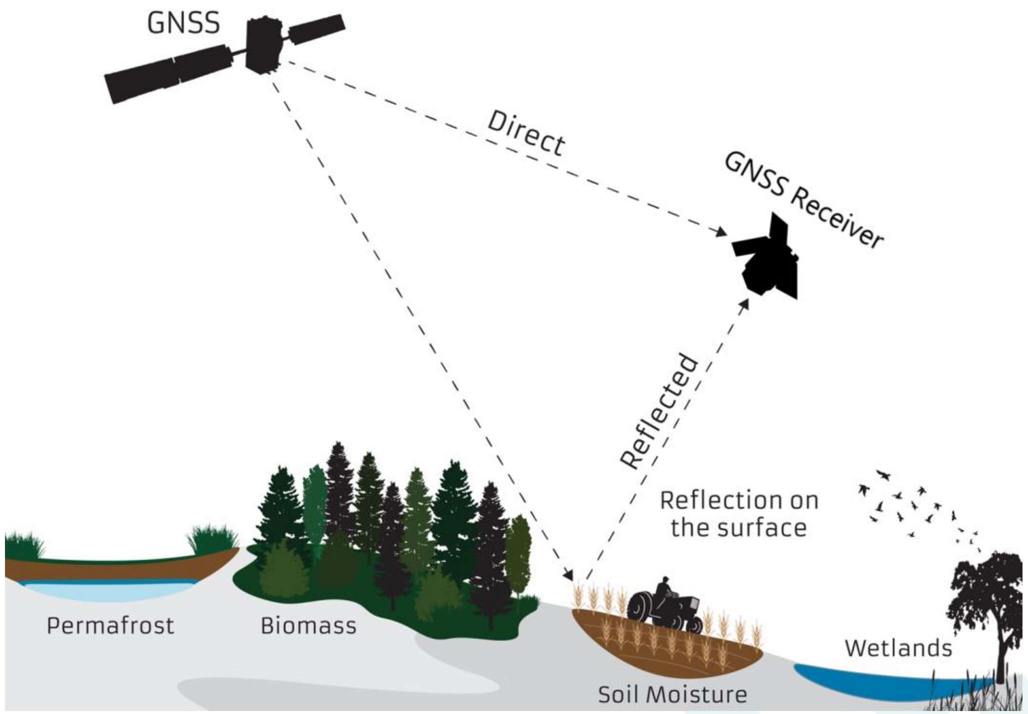

Fig2. GNSS-R Applications

Goals and Objective

- The major goal of the research is focused on performing reflectometry analysis using NavIC signals, and to develop SDR receiver, for receiving the NavIC signals, and further use these signals for soil moisture estimation.
- Obtaining and analyzing Delay Doppler Maps (DDMs) for the direct and reflected GNSS signal for soil moisture application.
- Development of an algorithm to efficiently acquire and modify received NavIC signals to measure soil water content.
- The long term goal is to perform agriculture monitoring, and estimating the related variables in real time, to predict and optimize the crop production.

NavIC: A Brief Introduction

- The Indian Regional Navigation Satellite System (IRNSS) also known as NavIC (NAVigation with Indian Constellation).

- IRNSS is an independent and autonomous regional navigation system aiming a service area of about 1500 km around India.

- The IRNSS constellation consist of 7 satellites with 3 satellites in the geostationary orbit and 4 satellites are in geosynchronous orbits.

- The IRNSS SPS (Standard Positioning Service) is transmitted on L5 (1164.45-1188.45 MHz) and S (2483.5-2500 MHz) bands.

Theoretical concepts

- The GNSS-R technique uses the navigation signals in the bi-static or the multi-static radar configuration.

- The reflected signal power responds to changing surface conditions.

- According to the bistatic radar equation the coherent reflected power at the receiver is a function of surface reflectivity Γp .

$$P_p^{coh} = \frac{P_t \lambda^2 G_t G_r}{(4\pi)^2 (R_{ts} + R_{rs})^2} \Gamma_p(\epsilon_s, \theta_i) \quad \text{.........(1)}$$

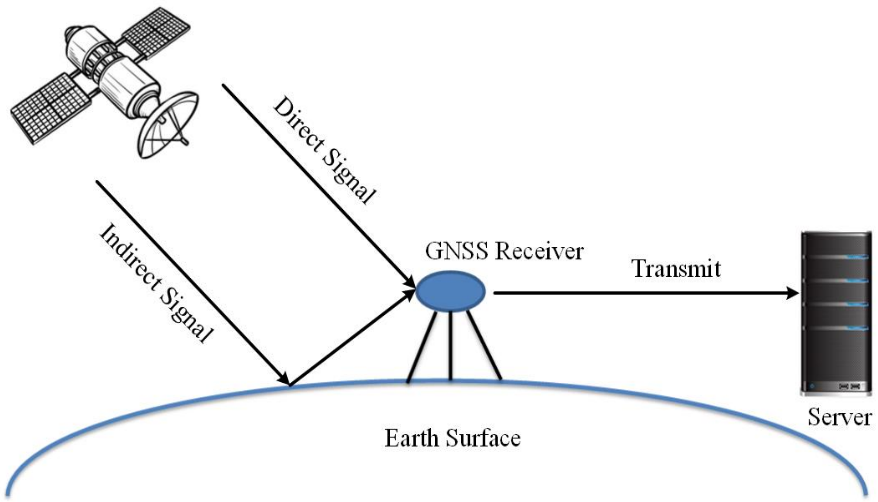

Fig3. GNSS-R Geometry

NavIC signal processing using SDR

- The NavIC signal is simulated using the GNSS Simulator SIMAC2.
- BladeRF SDR (Software-Defined Radio) receiver is configured accordingly to receive NavIC L5 signals. After that, the interfacing code is developed to receive the NavIC signals.
- The NavIC signals are further processed for reflectometry application in MATLAB environment.

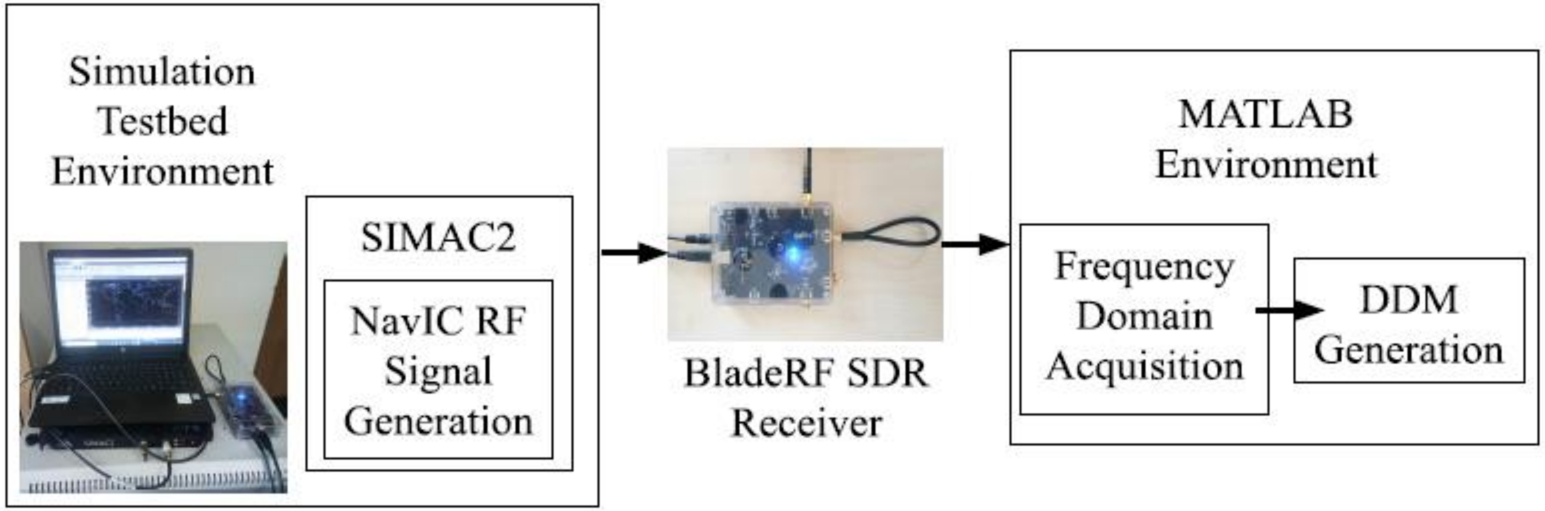

Fig4. HIL simulator testbed for NavIC DDM generation [1]

[1] Ansari B, Kaushik V, Biswas SK. Raw GNSS Data Compression using Compressive Sensing for Reflectometry Applications. In2020 XXXIIIrd General Assembly and Scientific Symposium of the International Union of Radio Science (pp. 1-4). IEEE.

Study of reflected DDMs

- The GNSS signal can be processed into the Delay-Doppler Map (DDM) which is the 2D representation of the power/amplitude distribution of the received GNSS signal.

- The peak power values of DDM are studied to calculate the soil moisture value.

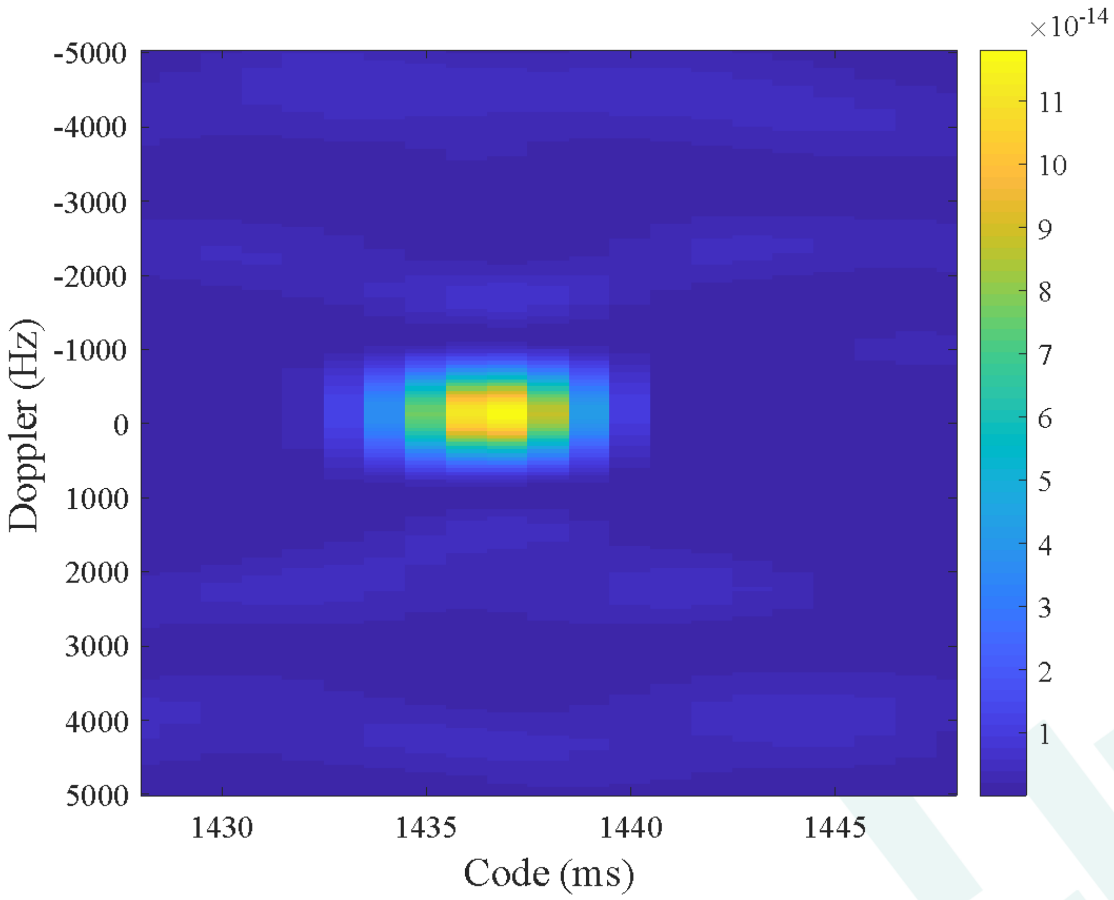

Fig5. NavIC DDM Example

Soil Moisture estimation

- The surface soil moisture increases with increase in the reflected peak power.

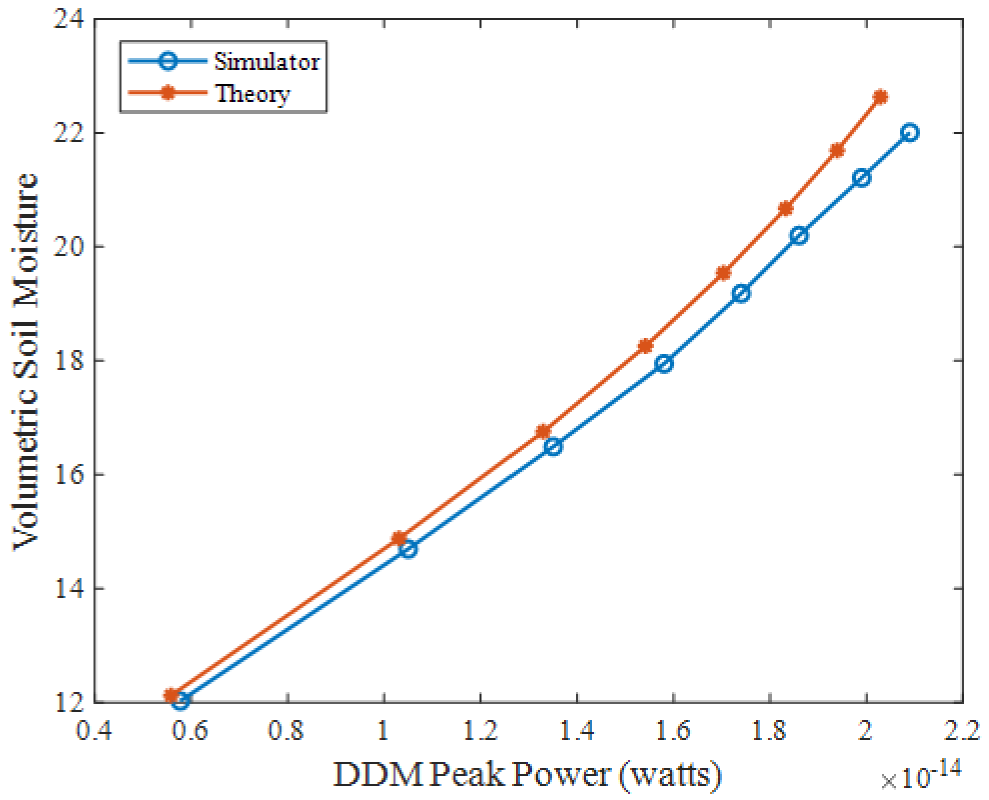

Fig6. Soil Moisture variation with change in DDM Peak Power

Benefits for the farming community

- It helps in better optimization of water resources for irrigation purpose.
- It use already existing satellite systems as transmitters, so, only need is to develop an appropriate receiver to estimate soil moisture.
- Cost effective technique, can help in inducing autonomous irrigation system and soil health monitoring using real-time analysis.
- The cost for developing the receiving unit will be approx. 1.5lakh (INR) or 2000 USD.

Future Works

- Implementing the algorithms and SDR based technique to estimate soil moisture.
- Receive the NavIC signals using the SDR receiver, placed on-board a drone, to study the surface soil moisture.
- It will provide fast information about the soil and crop condition to the agriculture sector, and can be used for research purpose as well.
- Real-time monitoring and the possibility of on-demand soil moisture estimation is feasible using the GNSS-R technique.
- The real time data for soil moisture estimation using the NavIC L5 signal will be published soon.
- We are looking for partners to commercialise the results of our work.

Thank You

Dr. Sanat K. Biswas

Assistant Professor,

Email: sanat@iiitd.ac.in

Bushra Ansari

PhD Scholar,

Email: bushraa@iiitd.ac.in

Space Systems Laboratory, IIIT Delhi
New Delhi, India
Website: https://ssl.iiitd.edu.in/