Sensitivity Analysis of *NavIC Multipath Observables* Towards Field Soil Moisture over Different Field Conditions

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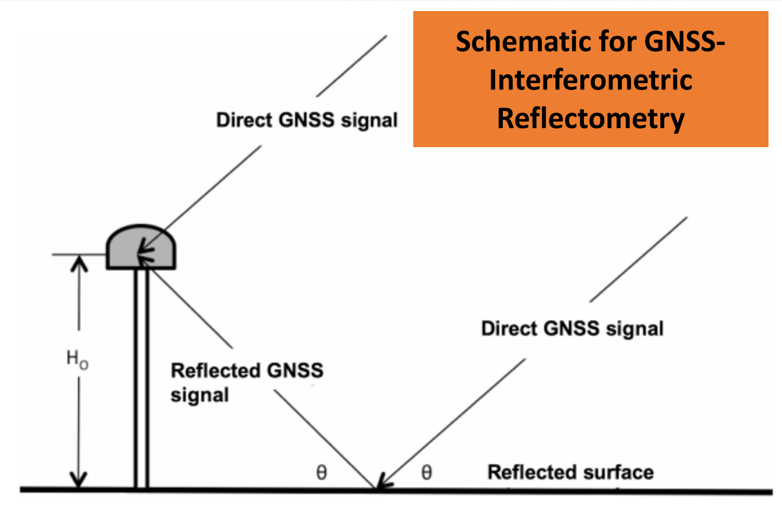
GNSS-IR Observables using NavIC



- Path difference causes interference at receiver.
- Multipath C/N_o is given as.

$$C/N_{\circ\, mpi} = A\cos\left(\frac{4\pi h}{\lambda}\sin\theta + \phi_{mpi}\right)$$

Where A is multipath Amplitude

ϕ_{mpi} **is the multipath phase.**

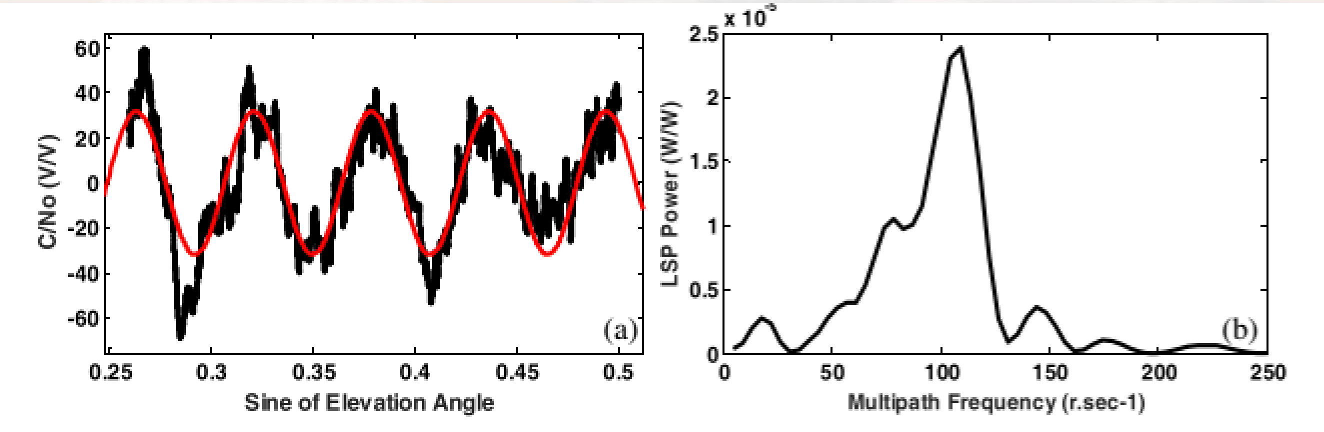


Figure 1. (a) Sine fitted plot using LSE for the estimation of multipath amplitude and multipath phase, (b) power spectrum analysis for the estimation of multipath frequency.

Field Experiments Set-up

- NavIC L5 band data utilized for Field experiments for Observations at Dehradun, Uttarakhand, India:

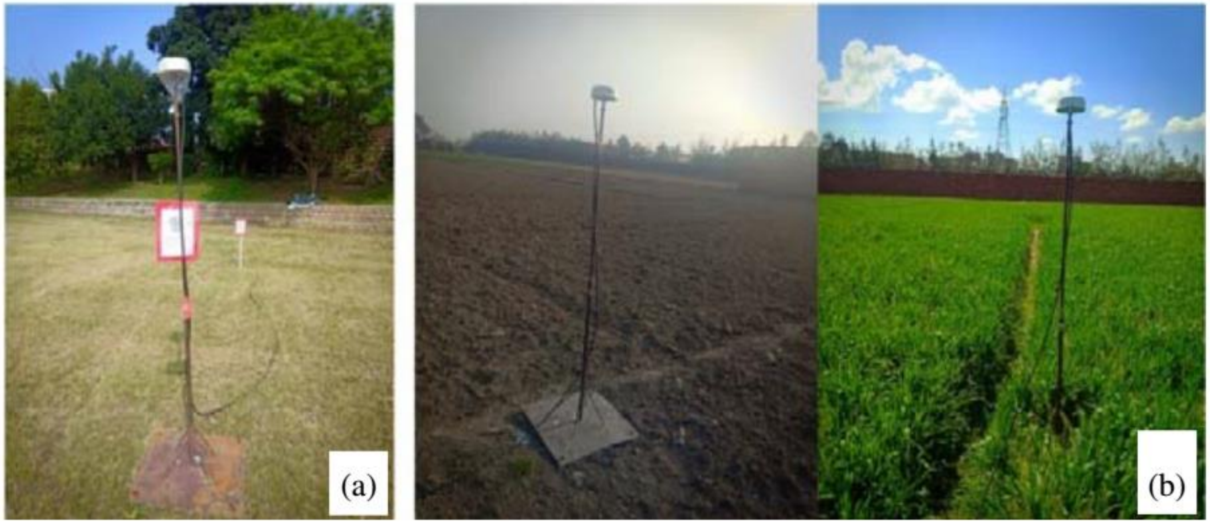


Figure 2. Experimental Setup with NavIC Antenna placement over two different land covers, (a) flat bare land and (b) agricultural land (with and without vegetation)

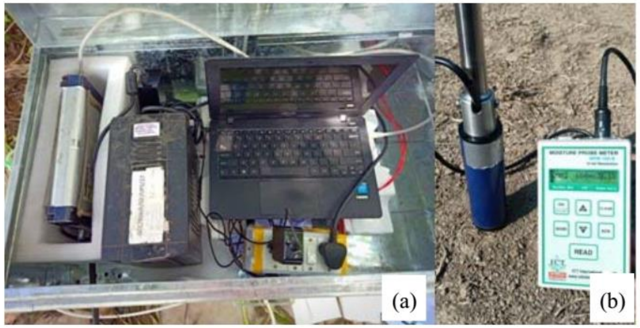
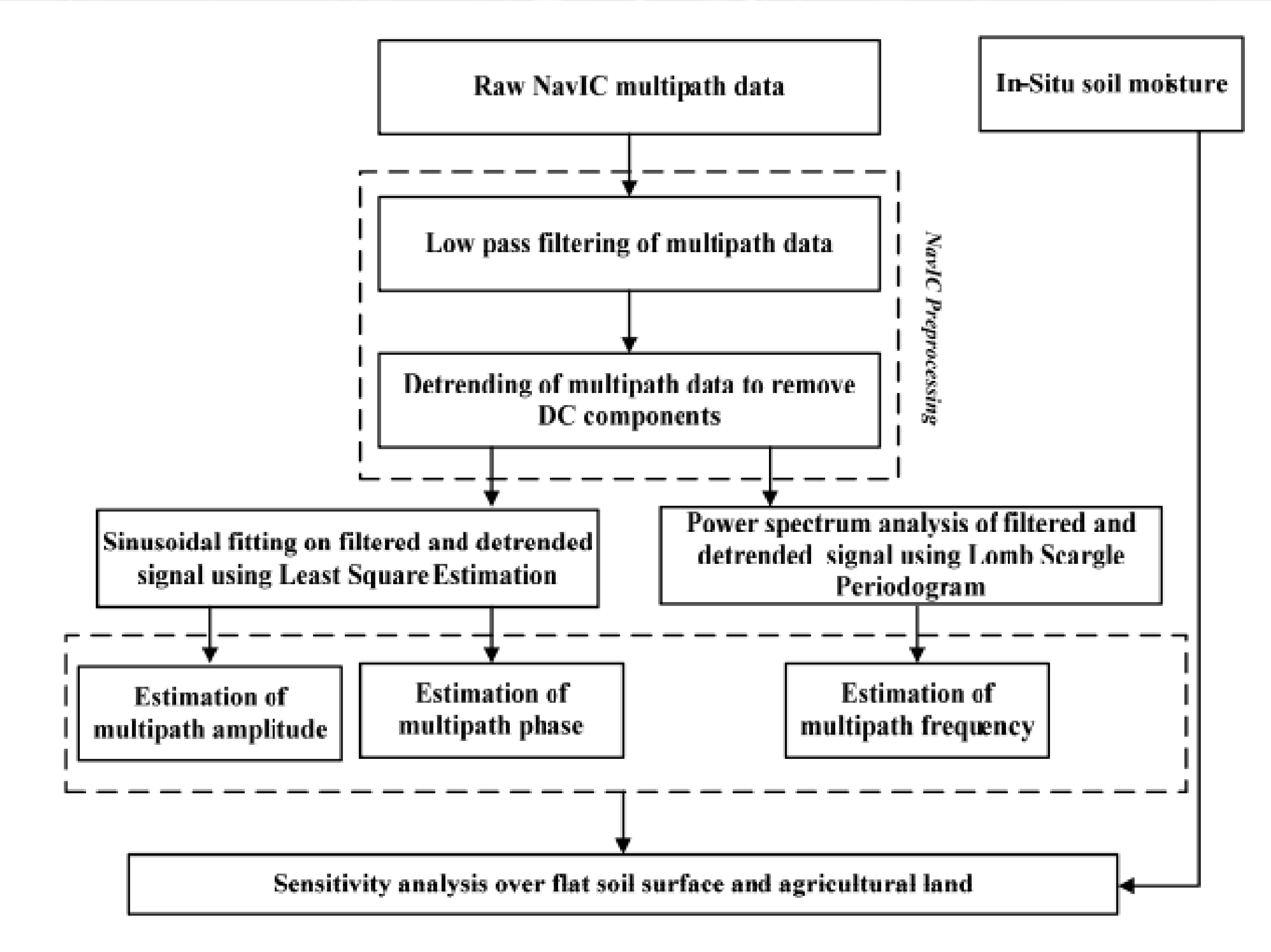


Figure 3. Experimental setup (a) NGS receiver and (b) soil moisture probe.

- **The in situ soil moisture was collected three times a day and reported soil moisture value is average of 20 samples.**

Methodology



Flowchart for performing the comparative analysis of the NavIC-IR observables

Correlation Analysis for Bare Soil

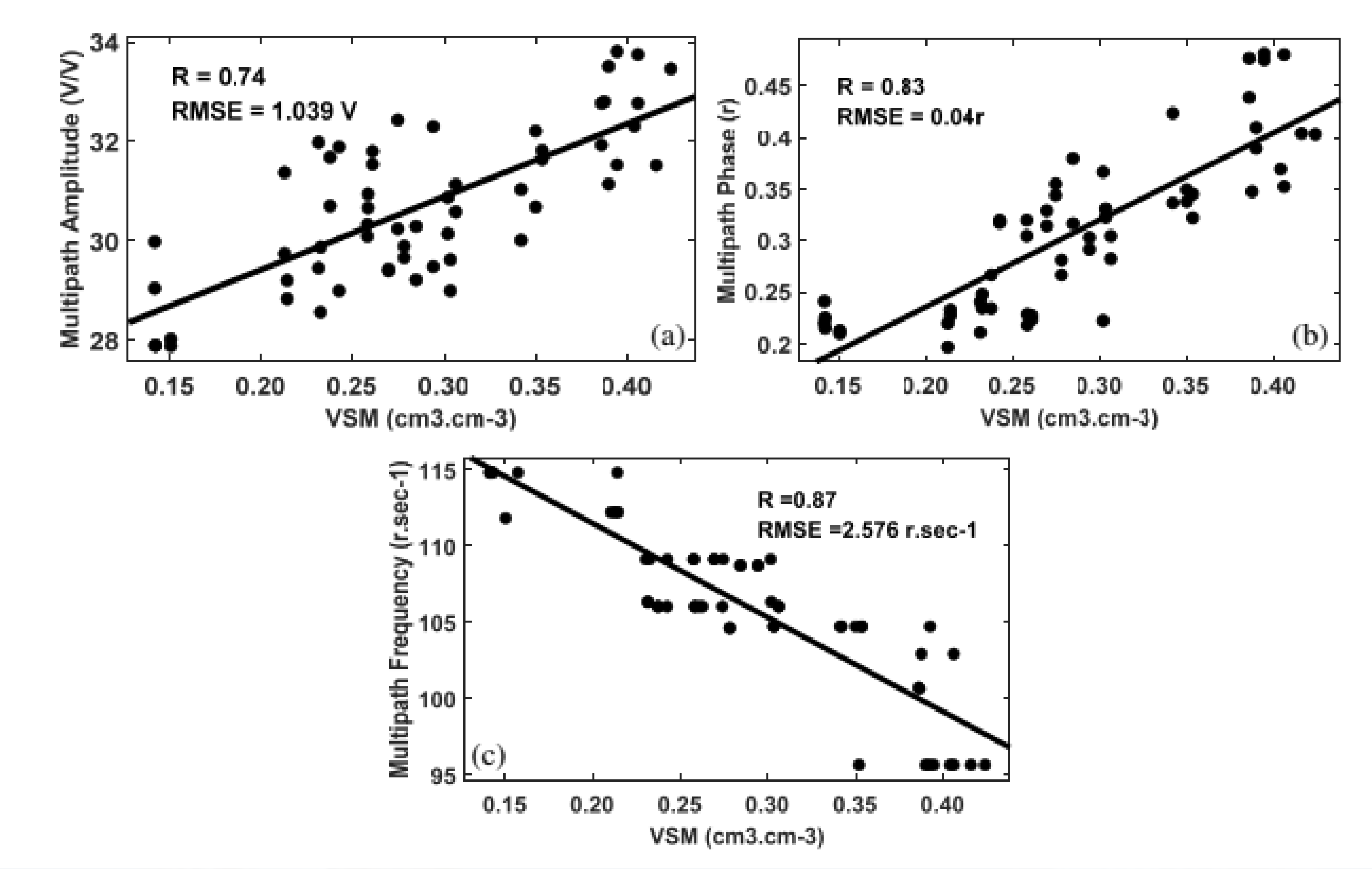


Figure 4. Linear regression performed between (a) multipath amplitude and soil moisture with correlation coefficient of 0.74, (b) multipath phase and soil moisture over with correlation coefficient of 0.83 and (c) multipath frequency and soil moisture with correlation coefficient of 0.87 over flat bare land.

Correlation Analysis for Agriculture Land

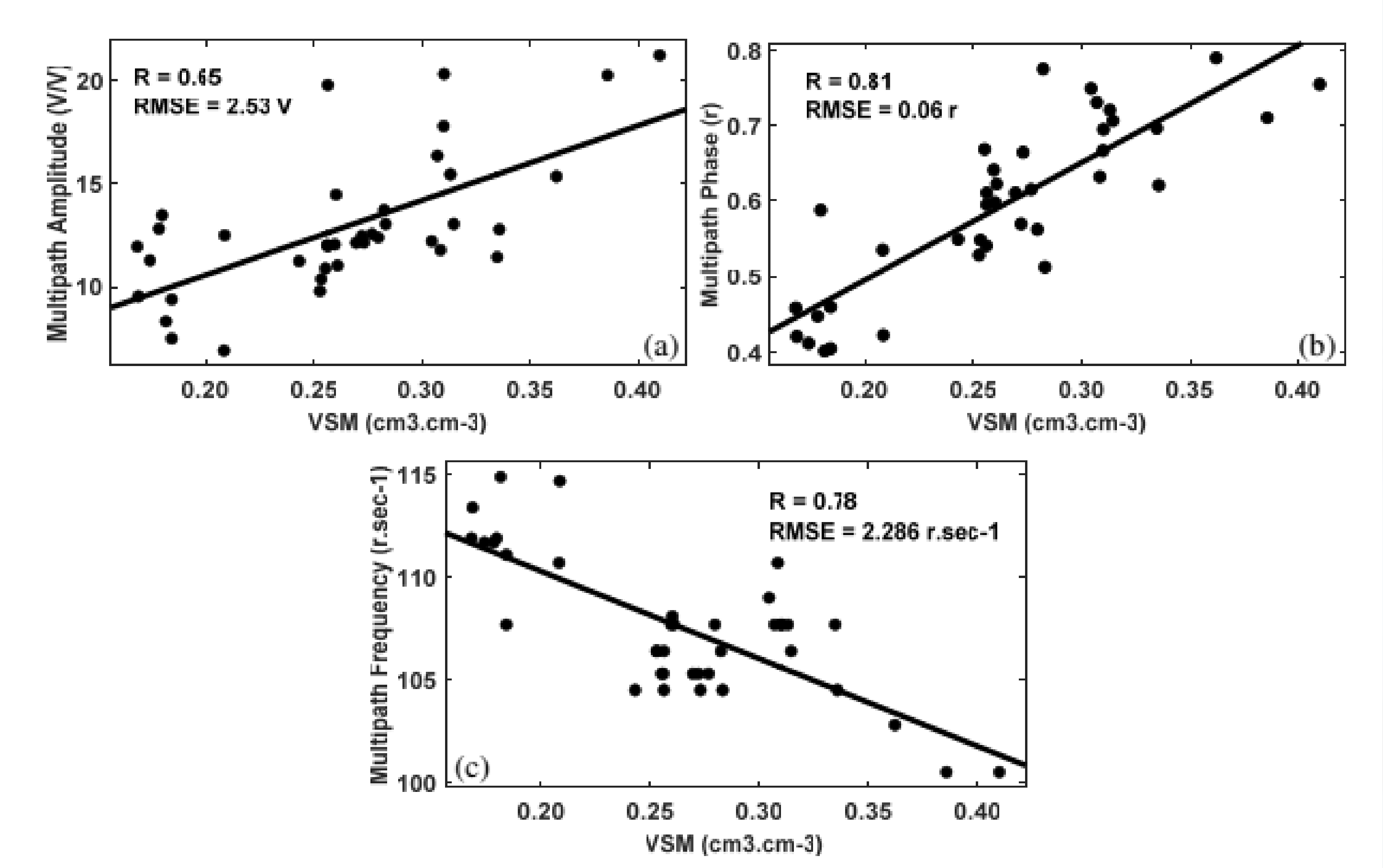


Figure 5. Linear regression performed between (a) multipath amplitude and soil moisture with correlation coefficient of 0.65, (b) multipath phase and soil moisture over with correlation coefficient of 0.81 and (c) multipath frequency and soil moisture with correlation coefficient of 0.78 over agricultural land.

Results

Table 1. Obtained goodness of fit between multipath signal parameters and soil moisture for both land covers.

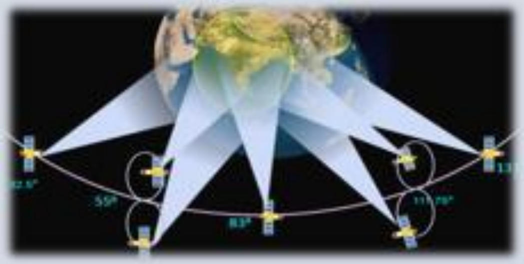
Goodness of Fit \ Parameter		Multipath Amplitude	Multipath Phase	Multipath Frequency
1^{st} Land Cover (Flat bare land cover)	RMSE	1.039 V/V	0.04 r	$2.576\,r{\cdot}sec^{-1}$
	R	0.74	0.83	0.87
	Slope	$14.7\,v/cm^3{\cdot}cm^{-3}$	$0.84\,r/cm^3{\cdot}cm^{-3}$	$-61.7\,r{\cdot}sec^{-1}/cm^{-3}{\cdot}cm^3$
2^{nd} Land Cover (Agricultural Land)	RMSE	2.53 V/V	0.06 r	$2.286\,r{\cdot}sec^{-1}$
	R	0.65	0.81	0.78
	Slope	$36.1\,v/cm^3{\cdot}cm^{-3}$	$1.55\,r/cm^3{\cdot}cm^{-3}$	$-32.8\,r{\cdot}sec^{-1}/cm^{-3}{\cdot}cm^3$

Conclusions & Future Scope

- This study shows significant correlation between multipath observables and soil moisture under different surface roughness and vegetation conditions. However, high correlation was observed for bare smooth soil, and its value decreases due to the presence of surface roughness and vegetation.
- Multipath phase shows the least effect whereas correlation coefficient of multipath amplitude and multipath frequency decreases significantly. Still the correlation coefficient value is sufficiently high, i.e., 0.65 and 0.78 for multipath amplitude and multiple frequency, and it can be considered as good correlation for observing the soil moisture for rough and vegetation covered soil surface.
- Further, good sensitivity has been observed for all the multipath observables for the change in soil moisture. Similar studies can also be carried out with GPS and Galileo which include the same frequency band, L5 and E5a, respectively. Further, not limited to GPS L5 and Galileo E5a, the results can also be explored for other L-band signals of GPS, GLONASS, Galileo, and BeiDou.

Publication

Sushant Shekhar, Rishi Prakash, Dharmendra K. Pandey, Anurag Vidyarthi, Deepak Putrevu, and Nilesh Desai (2023), *“Comparative Analysis of NavIC Multipath Observables for Soil Moisture over Different Field Conditions”*, Progress In Electromagnetics Research M, Vol. 117, 25–35, 2023



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