

# Using Differential SAR Phase for a Fuller Moisture Characterisation of Soils

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# SAR Moisture Retrieval

Currently, soil moisture measured using:

- incoherent backscatter

Retrieval

- empirical
- inverse model
- forward model

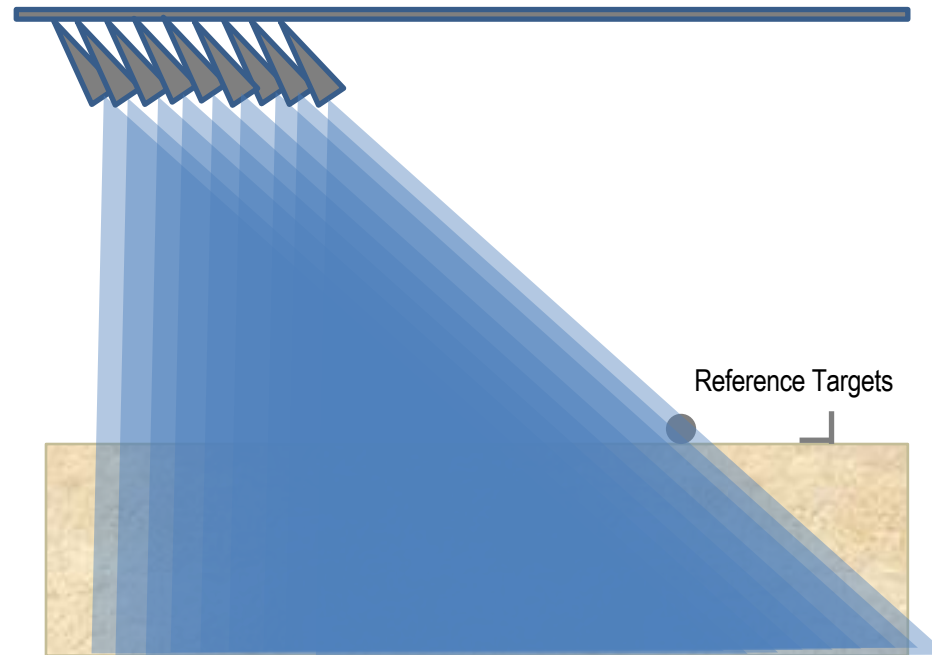
Complications

- ~~surface roughness~~
- ~~vegetation~~

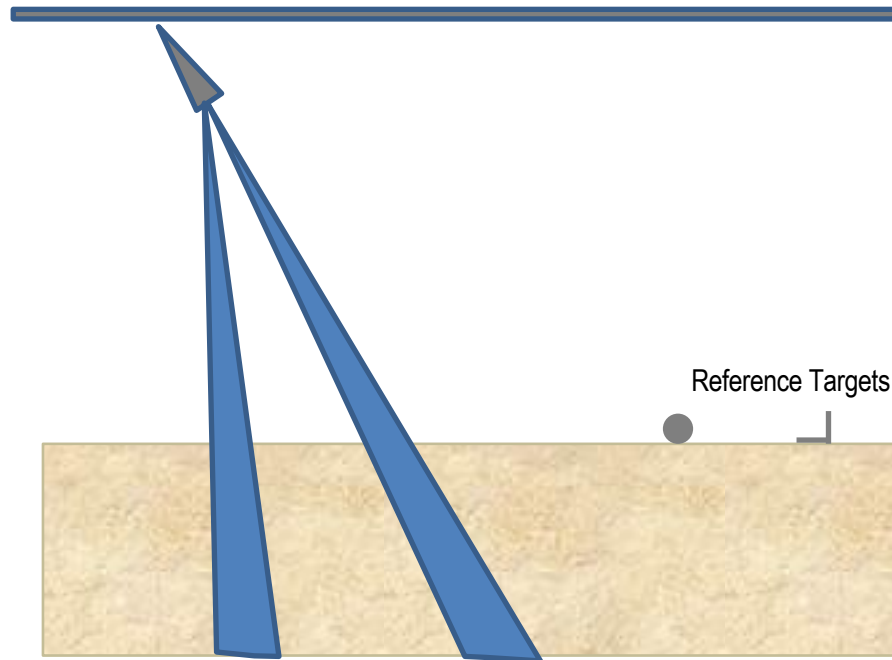
# Exploiting Phase

- contains additional information & insight
- robust complex backscatter product
- new products

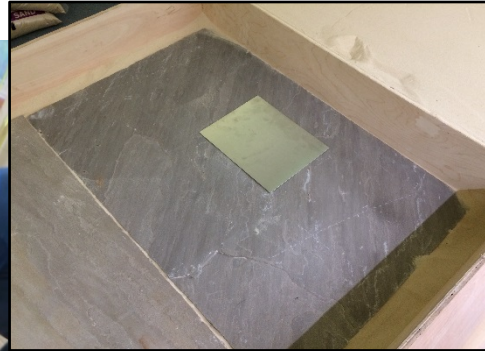
# TP Imaging



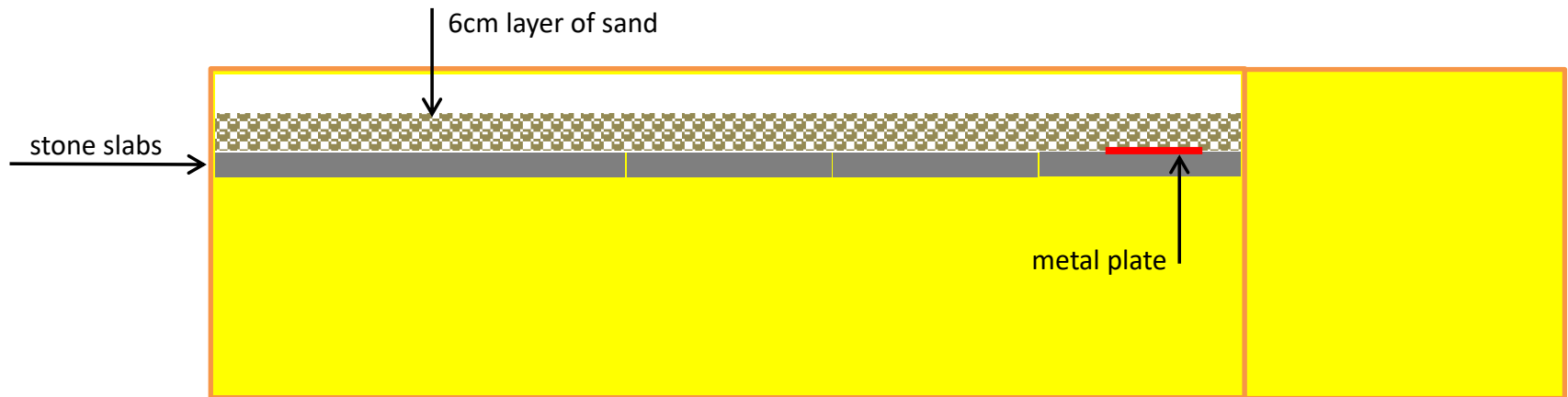
# TP Imaging



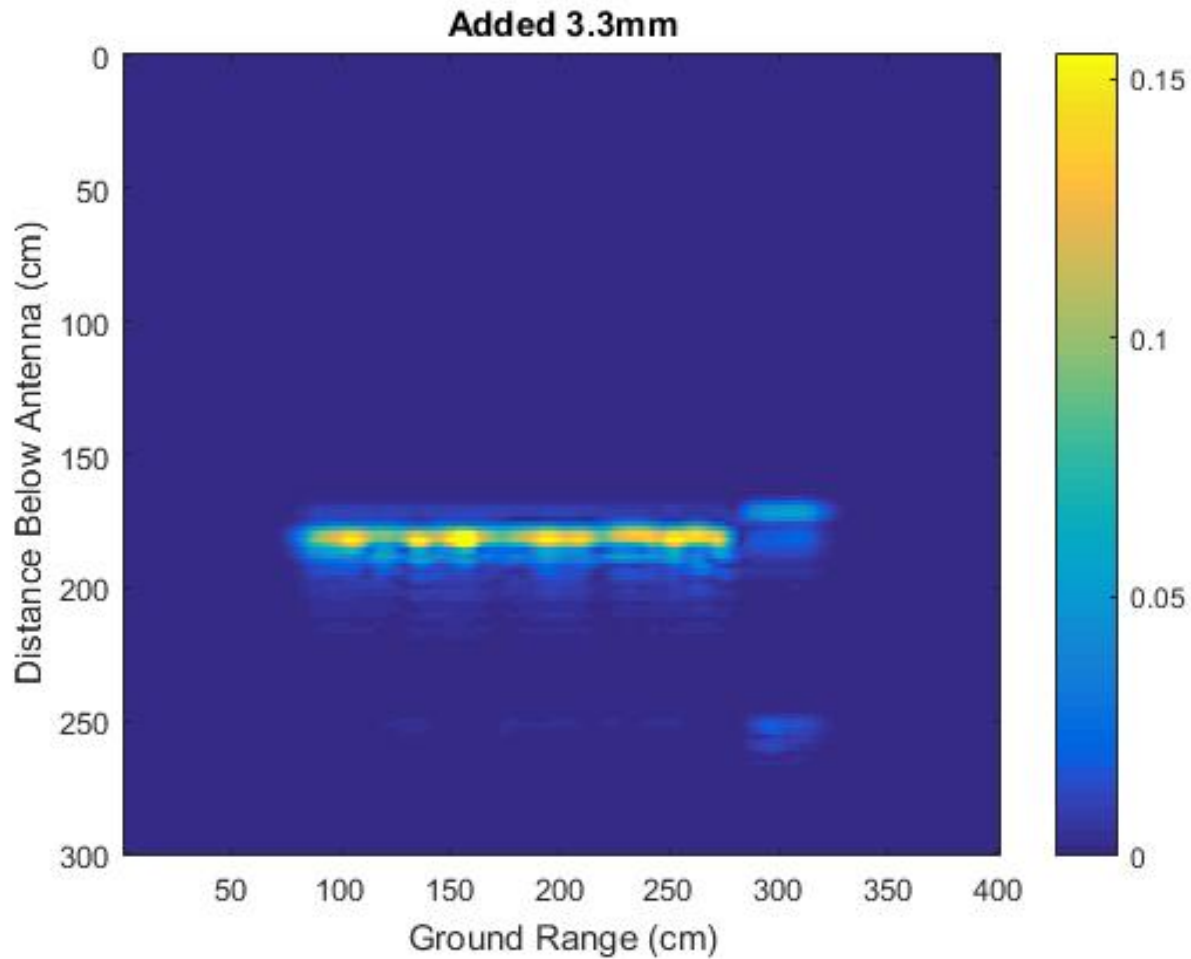
# Soil Trough



# Soil over Stone Layer

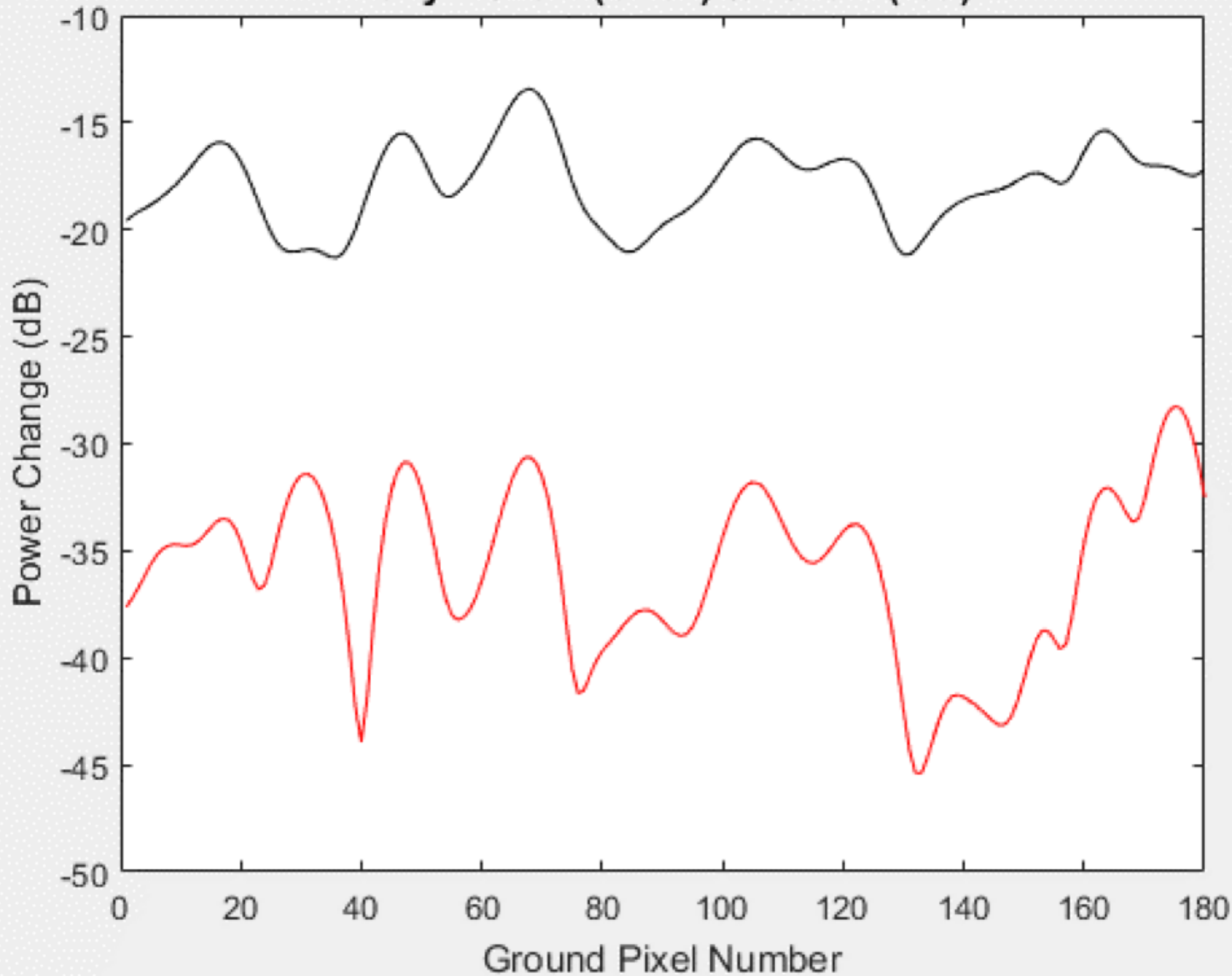


# Wetted Soil

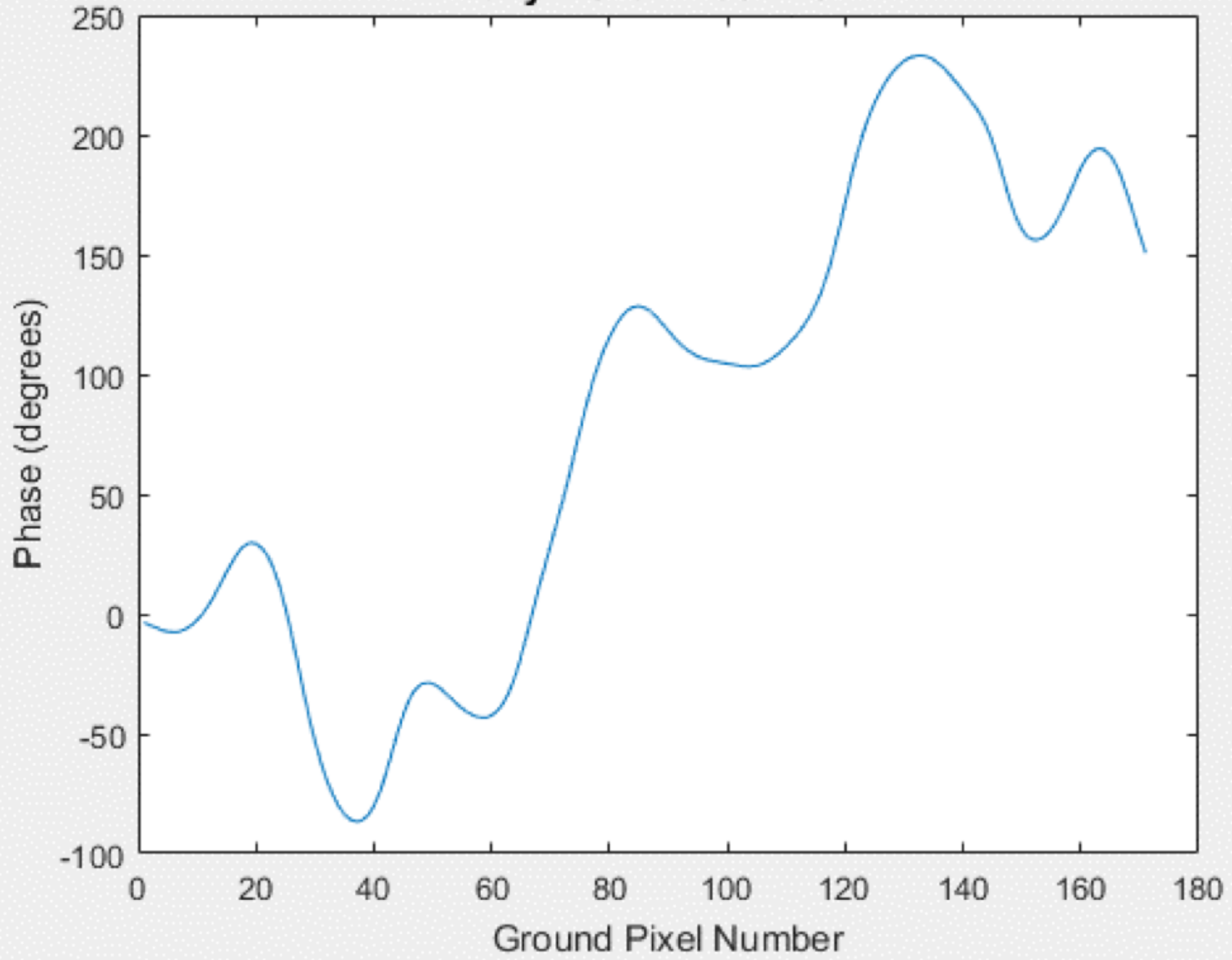




For  $y=182\text{cm}$  (black) &  $192\text{cm}$  (red)



For y=182cm ns31 4GHz



# Gravel Layer

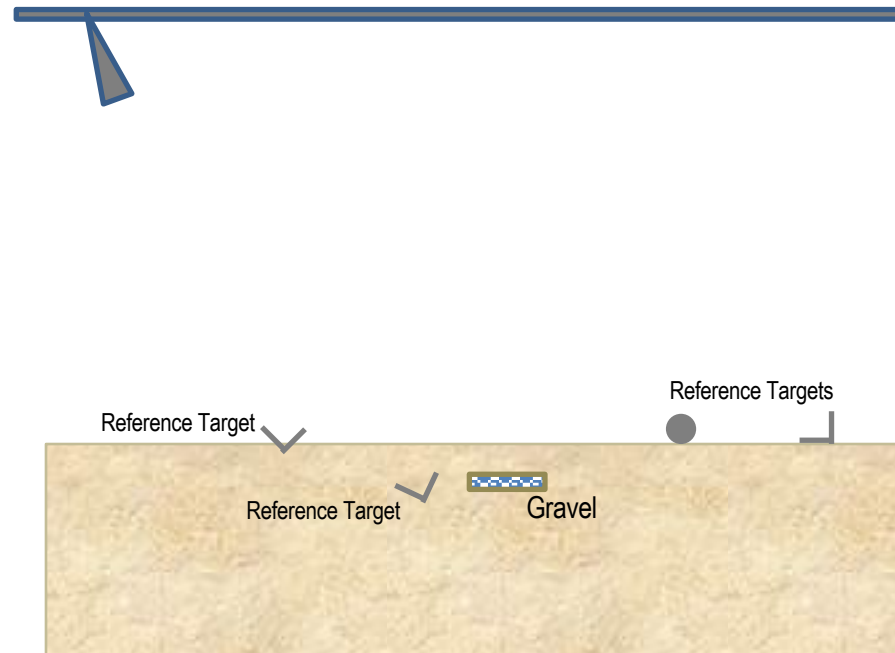


5mm of water added over 1.5m<sup>2</sup>

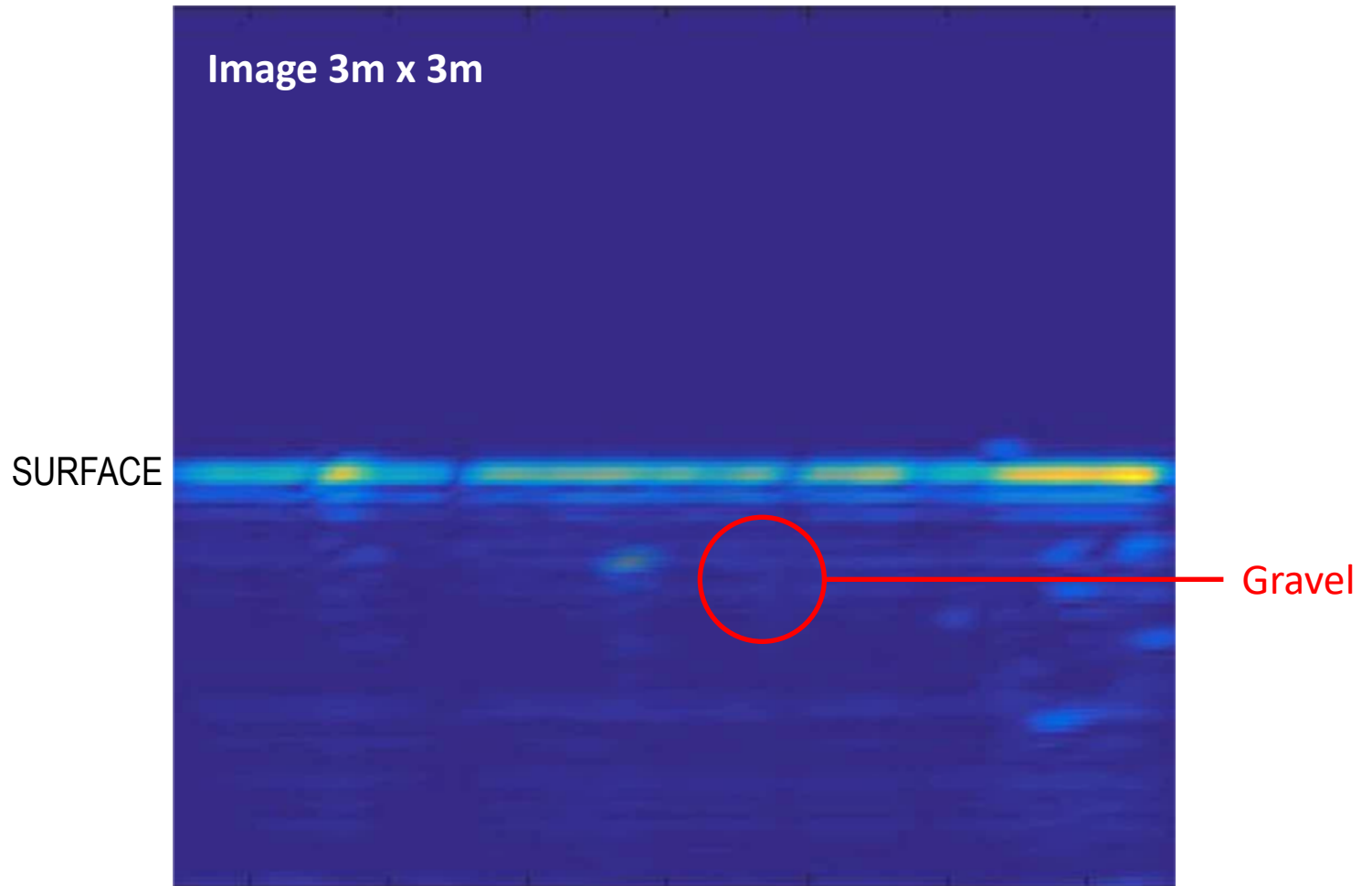


Drying over 22 days

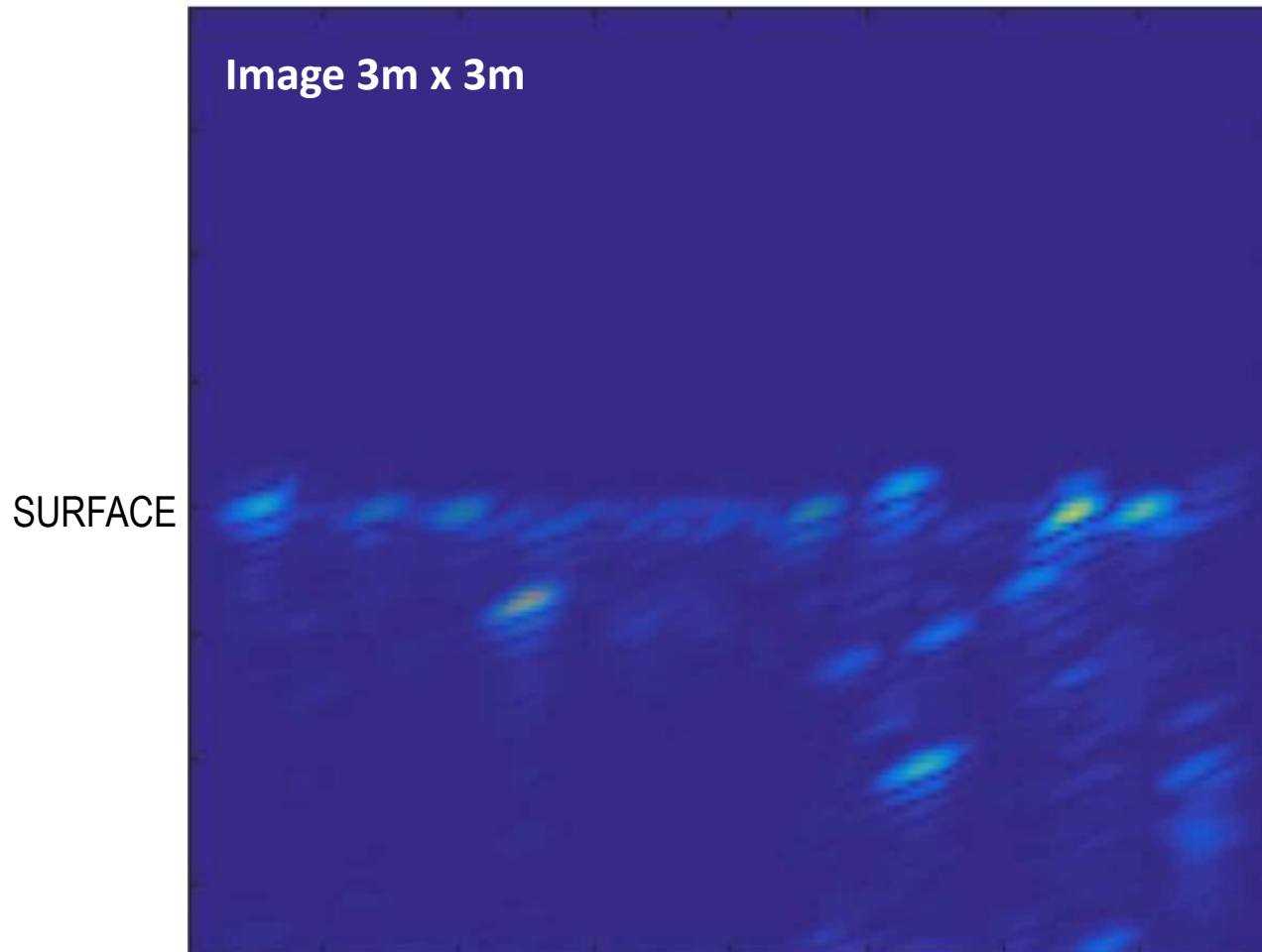
# Experimental Set-Up



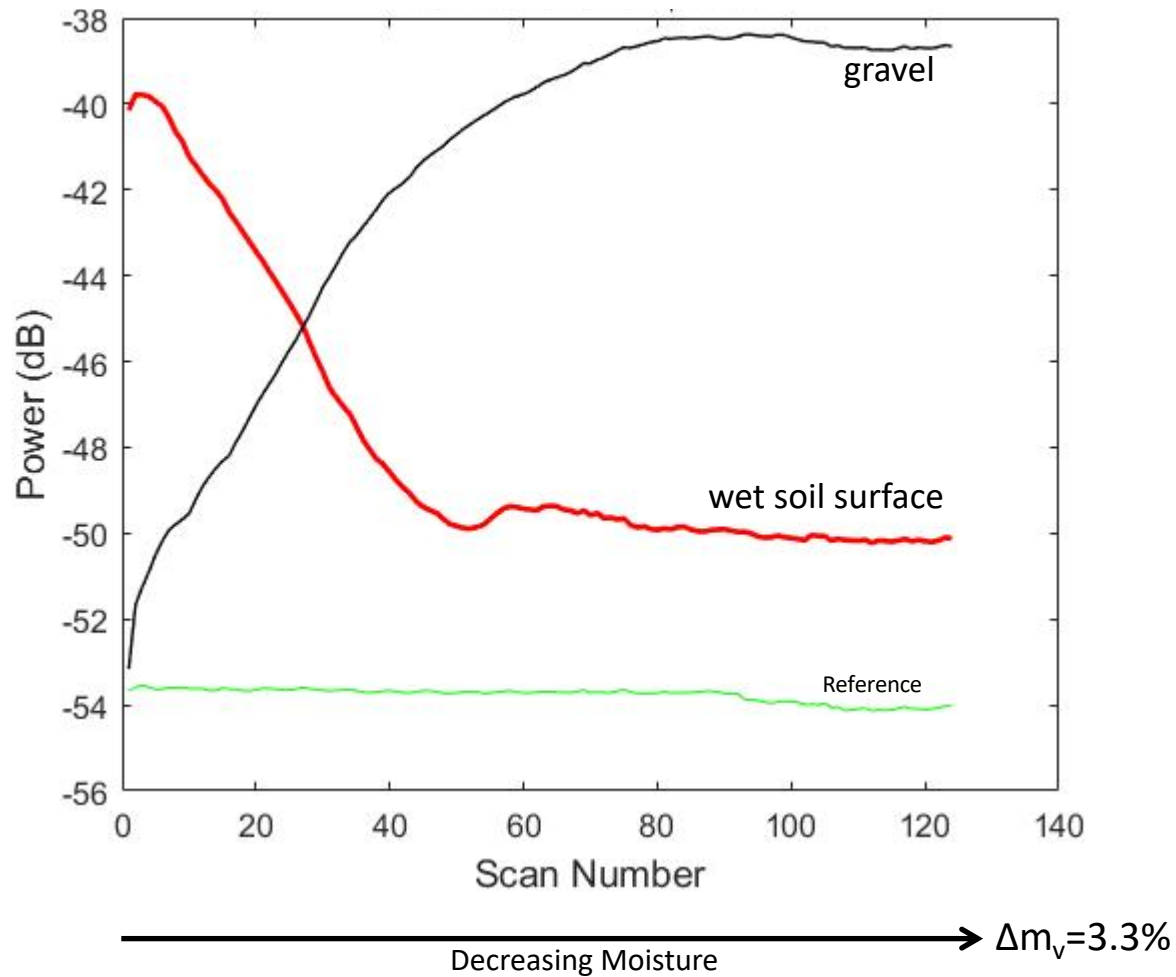
# VV Soil Movie: 0°



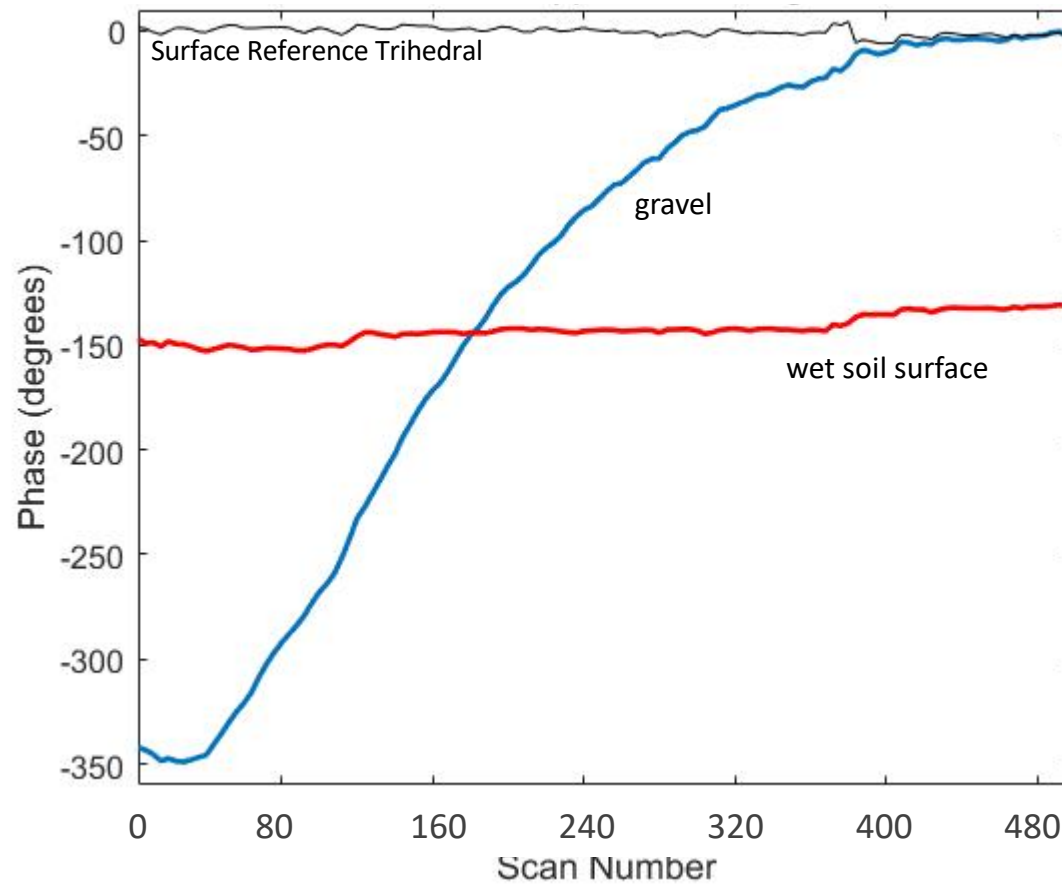
# VV Soil Movie: 20°



# Backscatter

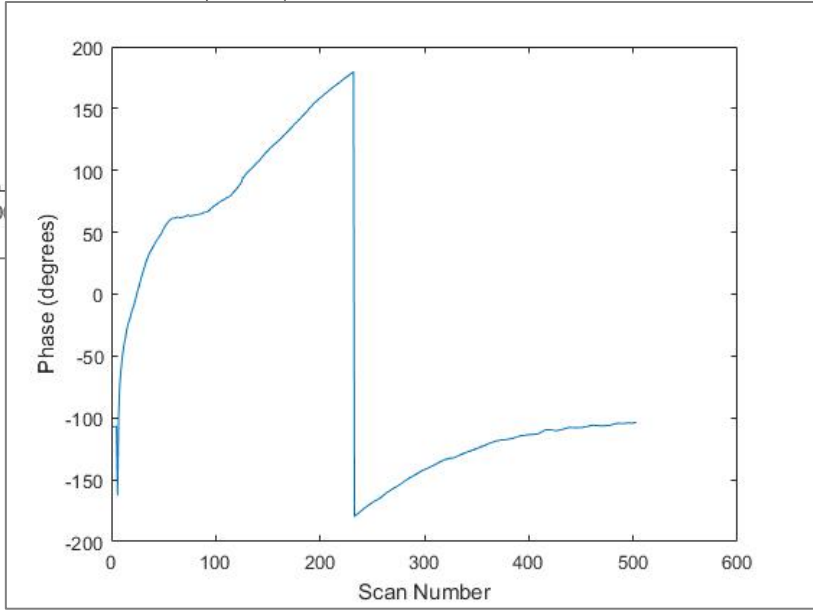
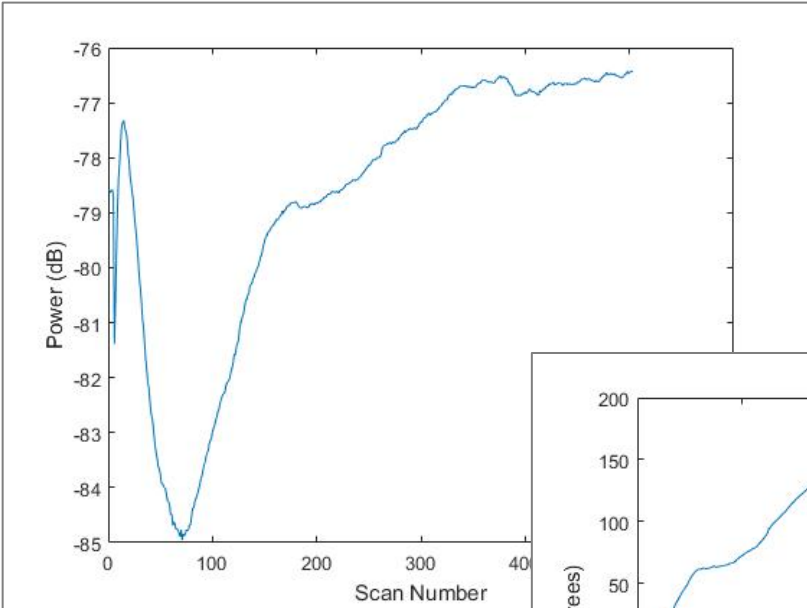
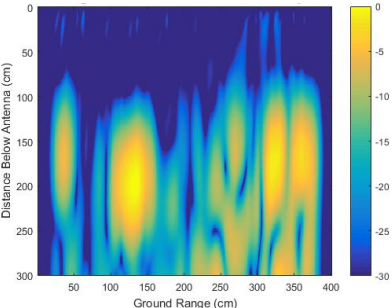
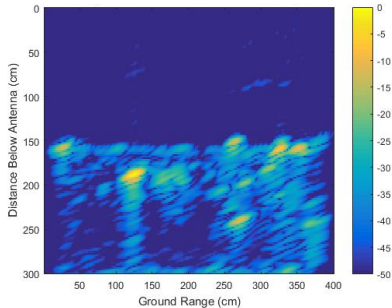


# Unwrapped Phase



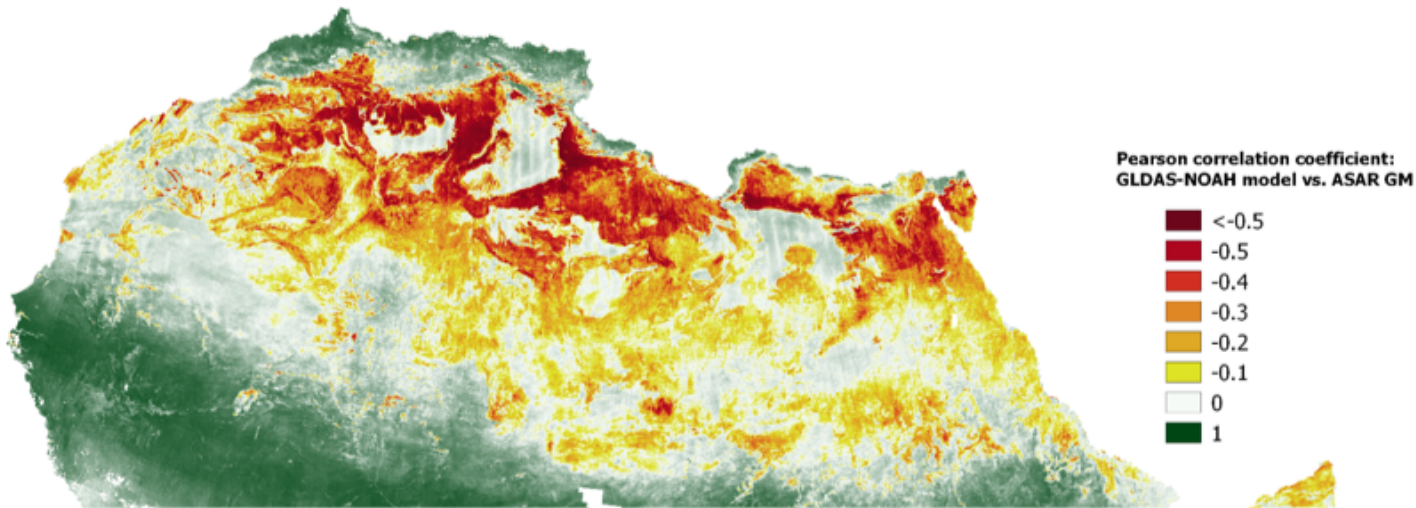


# Summed Behaviour



# Moisture Anomalies

Believed strong sub-surface signals are explanation for soil moisture anomalies



Here, phase would guide correct interpretation

## Phase Behaviour

*surface phase is static*

*sub-surface shows large phase changes*

*sub-surface targets appear deterministic*

*linear for a change in moisture for a sub-surface feature*

*independent of incidence angle for a sub-surface feature*

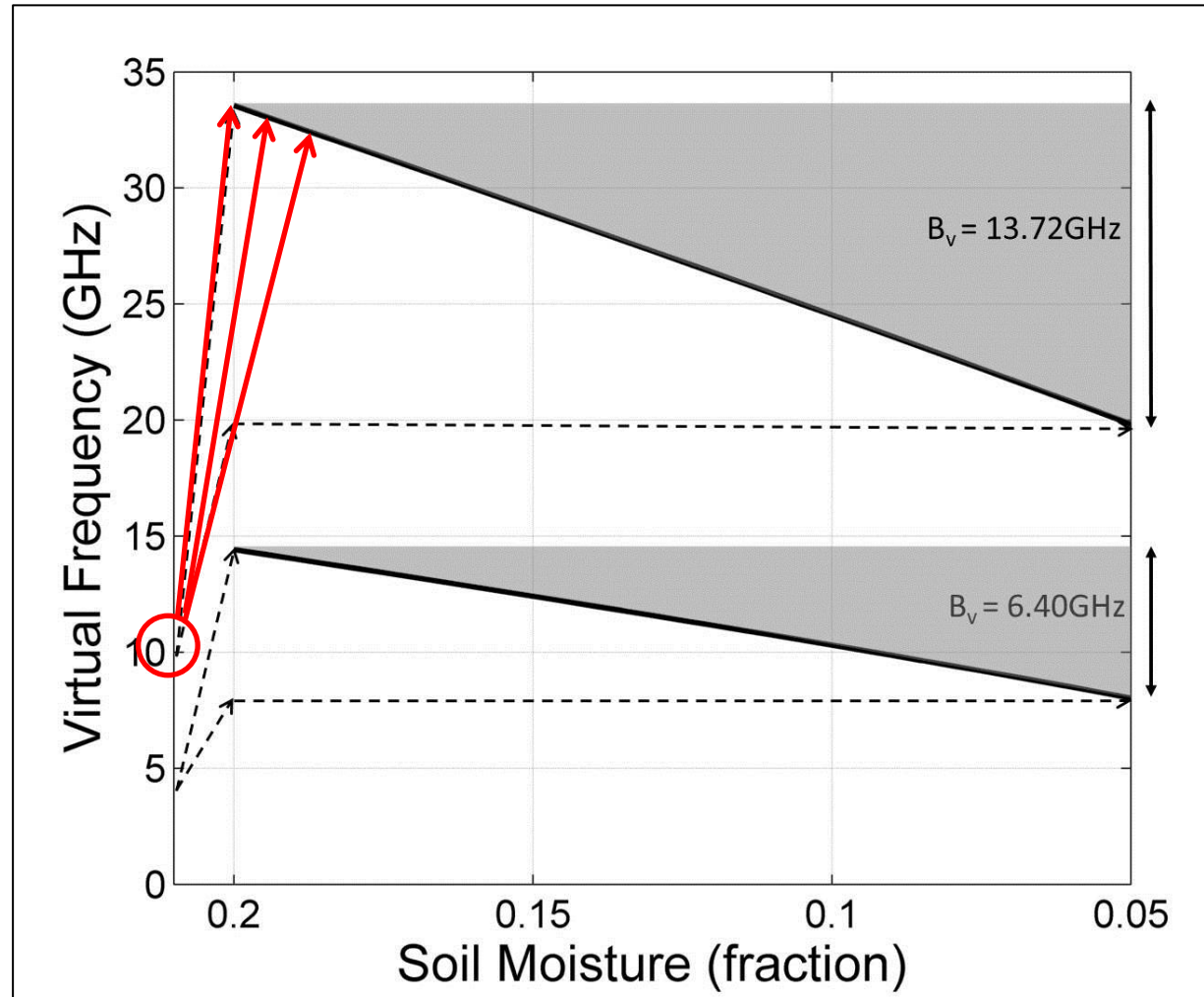
Verified  
Model Expt.



# Virtual Bandwidth SAR (VB-SAR)

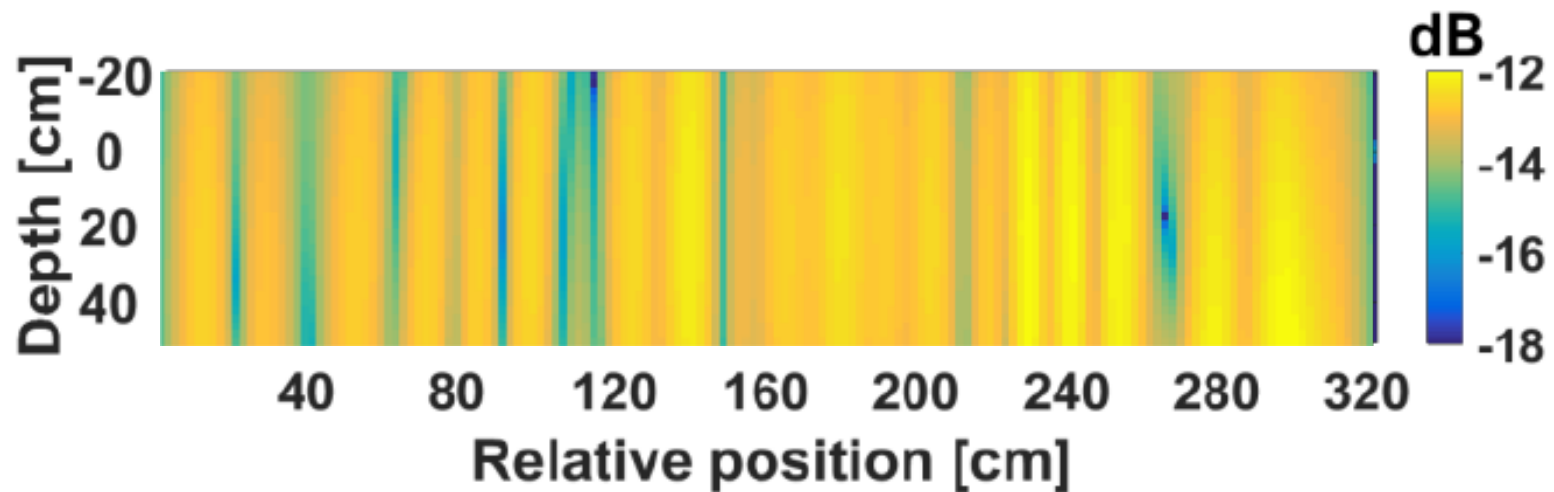
$$f_V = f_R \sqrt{\epsilon_r}$$

real frequency of the radar



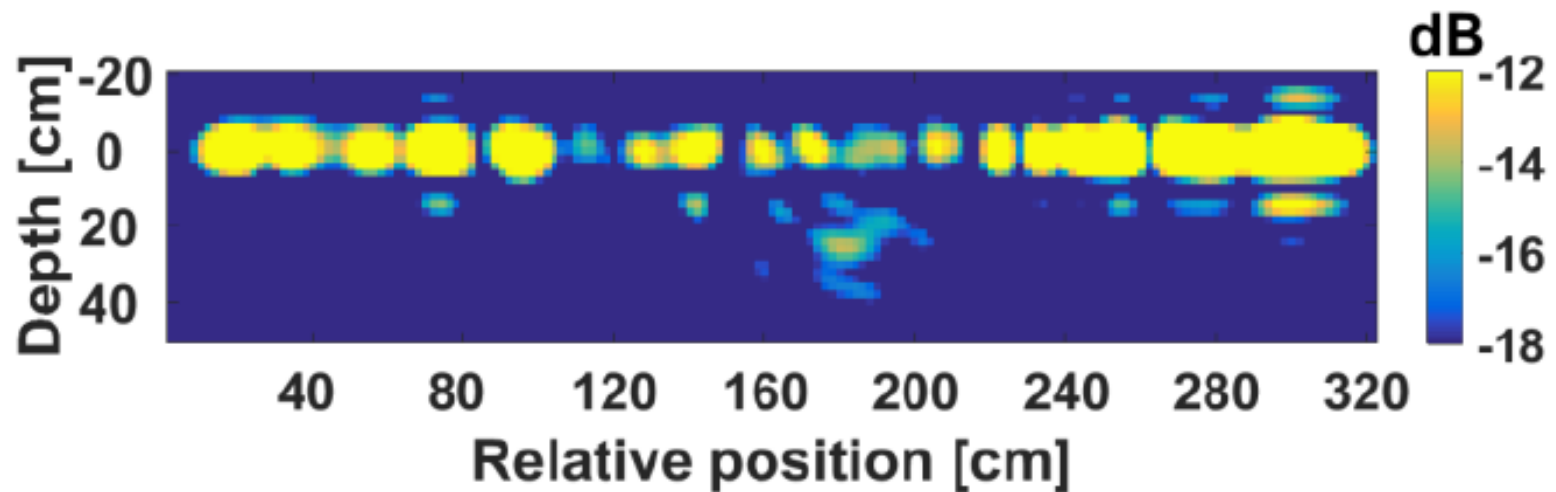
# TP (SAR) Image. $i = 10^\circ$

Real Bandwidth 0.15GHz



# VB-SAR Image

Virtual bandwidth 3.38GHz



# Summary



## Examined

- radar modelling + laboratory measurement
- moisture-amplitude-phase relationships
- imaging geometry

## Understand phase change as

- return from *within* soil

## Moisture Anomaly

- off-nadir geometry

## New Products

- previously inaccessible information
- more robust moisture product
- VB-SAR

## Future Study

- modelling + laboratory
- polarisation
- soil realisations
- airborne + satellite