Ming Hsieh Department of Electrical Engineering

USC Viterbi School of Engineering

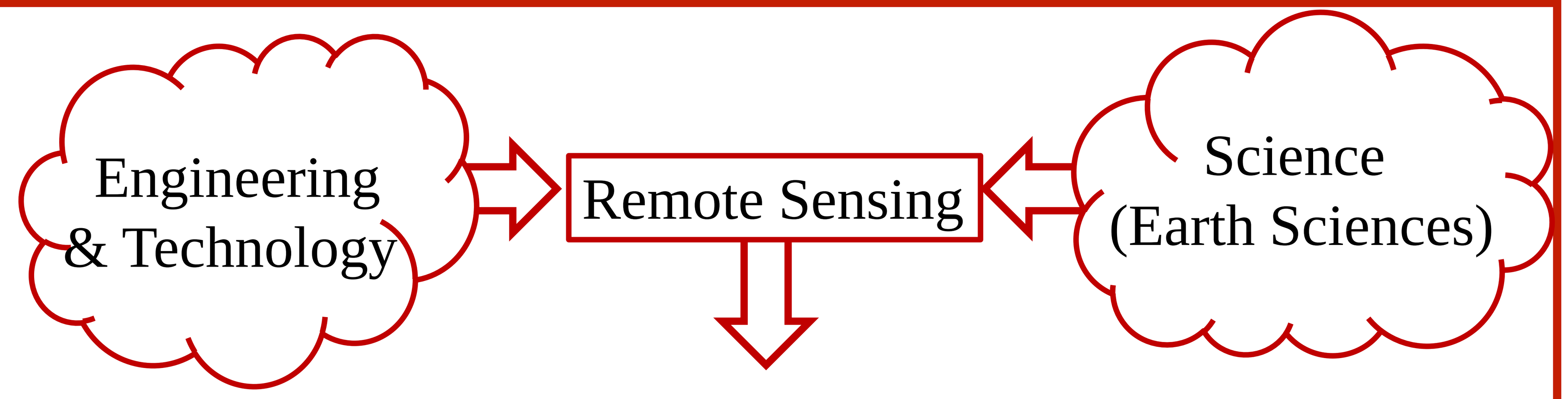
Environmental Remote Sensing to Retrieve Surface Soil Moisture

Ruzbeh Akbar[1], Mahta Moghaddam[2]
Electrical Engineering – Electrophysics

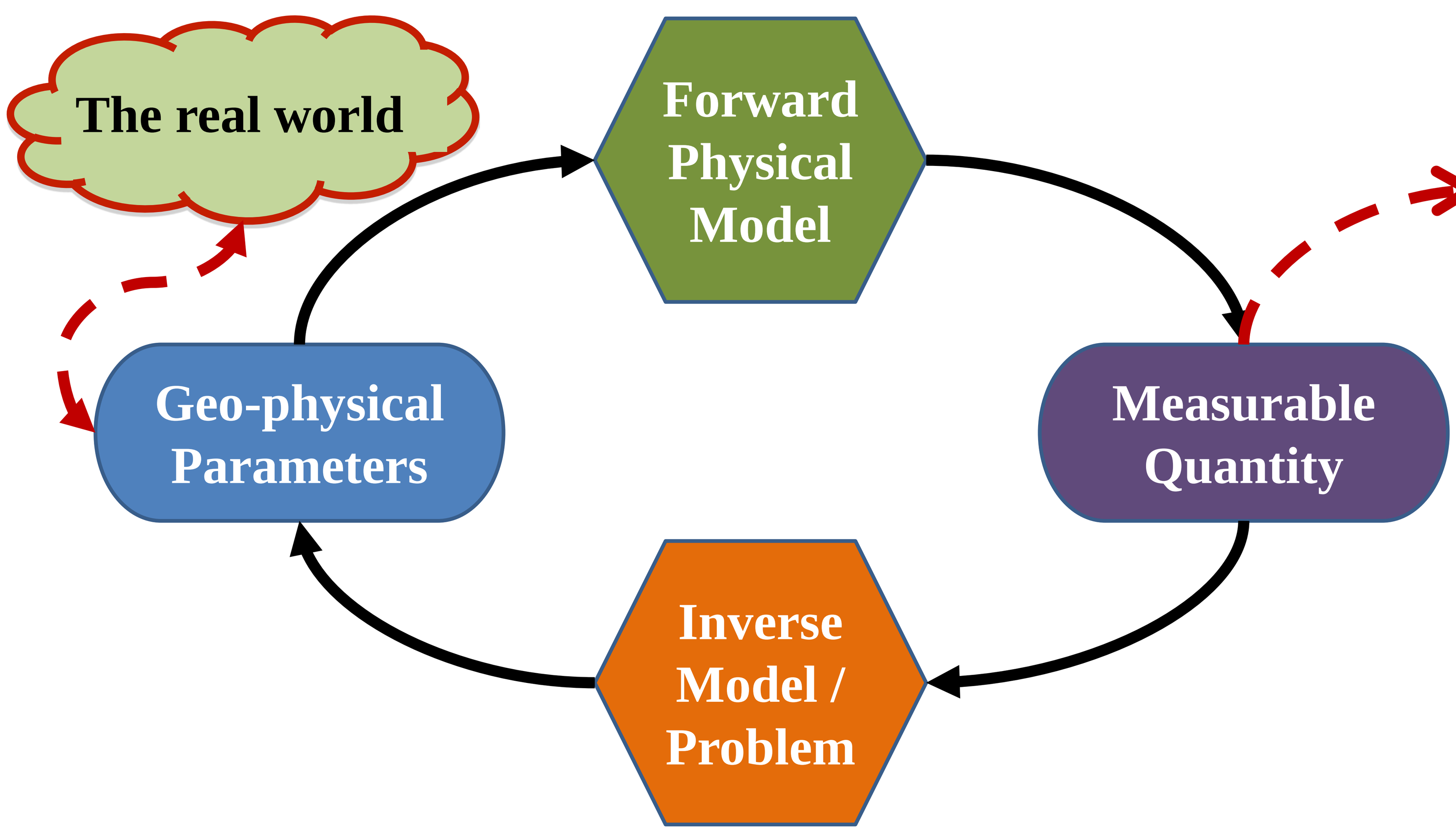
Motivation and Overview

One of the many important factors in further understanding climate change and it's dynamics is the amount of water in the soil i.e. ***soil moisture***. To list a few, knowledge of soil moisture becomes important because:

- At continental scales, soil moisture variations dictates weather and climate evolutions
- Enables better weather and seasonal climate prediction and forecasting
- Provides the means for drought monitoring
- Enhances agricultural productivity
- Improves flood prediction
- And many more…

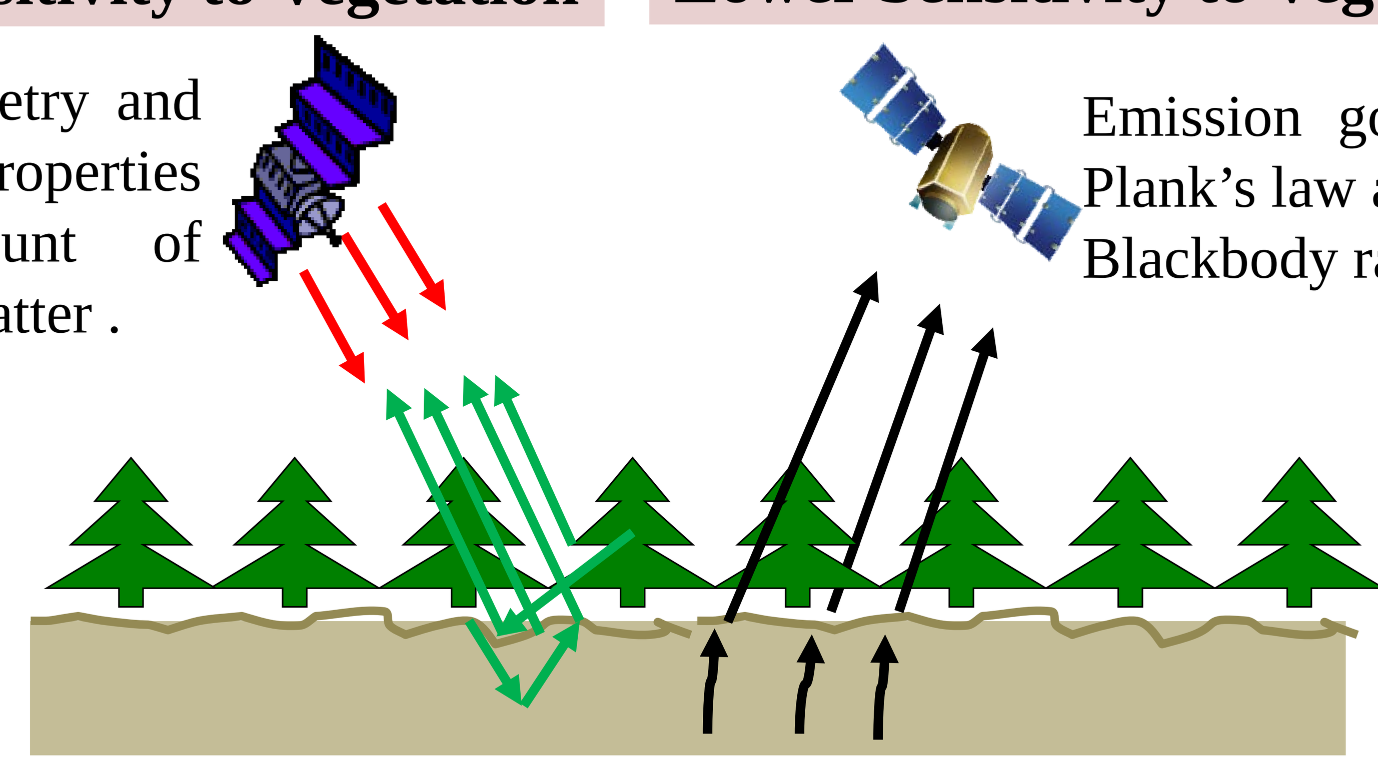


- Remote Sensing enables us to monitor the Earth by providing the necessary tools and methods.
- The focus of my research is on developing a subset of these methods to enable better soil moisture using space-borne data. Proper understanding and utilization of the underlying physics of the phenomena of interest becomes essential.



Radar (σ^0)	Radiometer (TB)
Scattered waves are measured	Natural emission is detected
High Spatial Resolution (3km)	Low Spatial Resolution (36km)
High Sensitivity to Vegetation	Lower Sensitivity to Vegetation

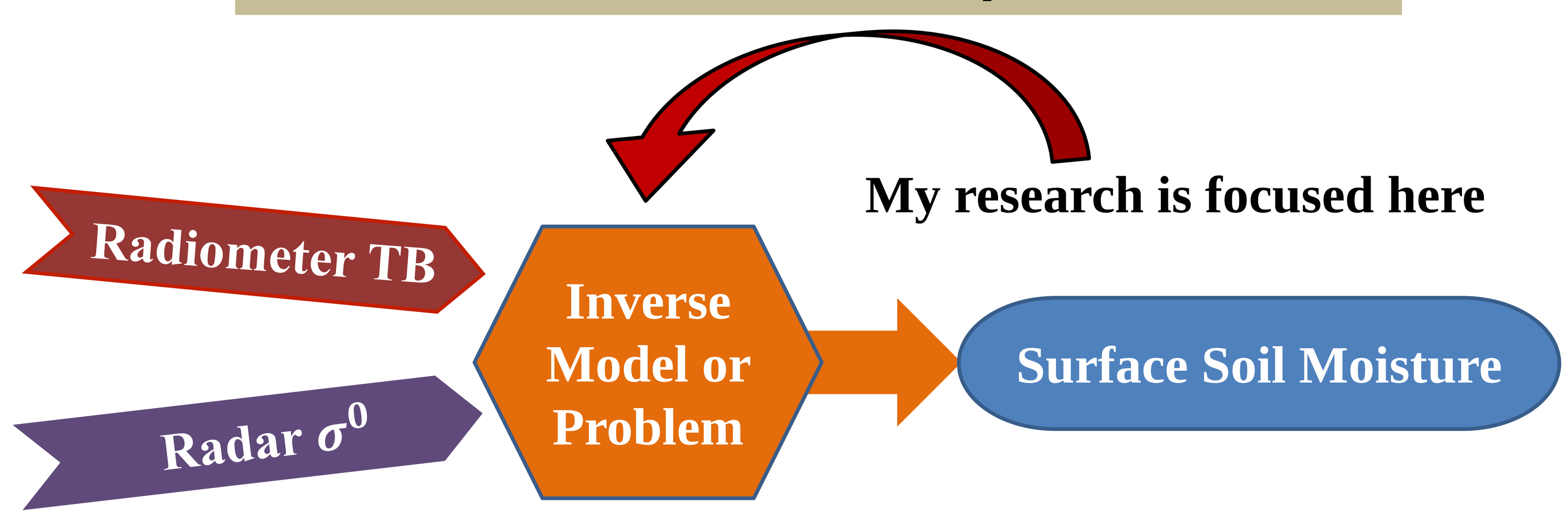
Target geometry and material properties effect amount of radar backscatter .



Emission govern by Plank's law and Blackbody radiation.

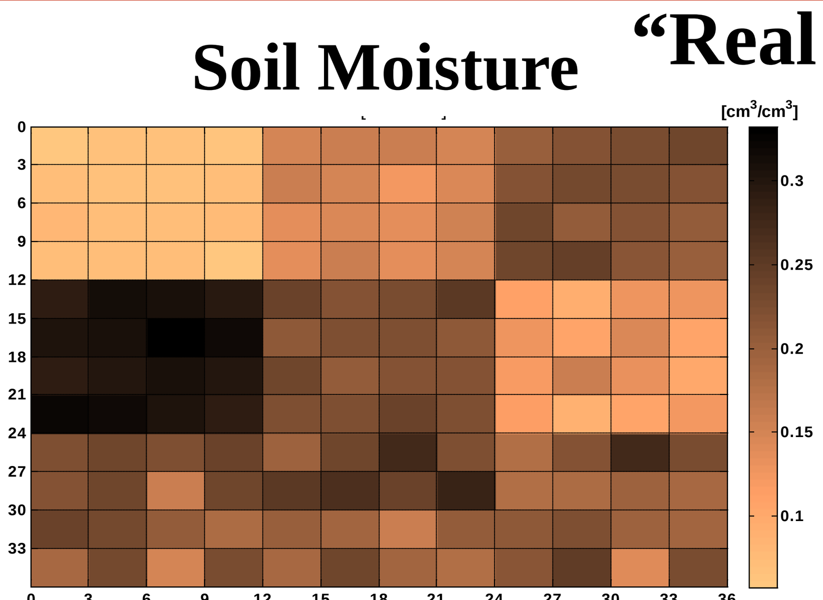
In the context of Earth Sciences Remote Sensing

Geo-physical Parameters	Measured Quantity
Soil Moisture	Backscatter from Radars
Vegetation Information	Emission from Radiometers
Ocean Salinity	Optical Imagery
Wind Speed	Lidar
And many more…	Others…

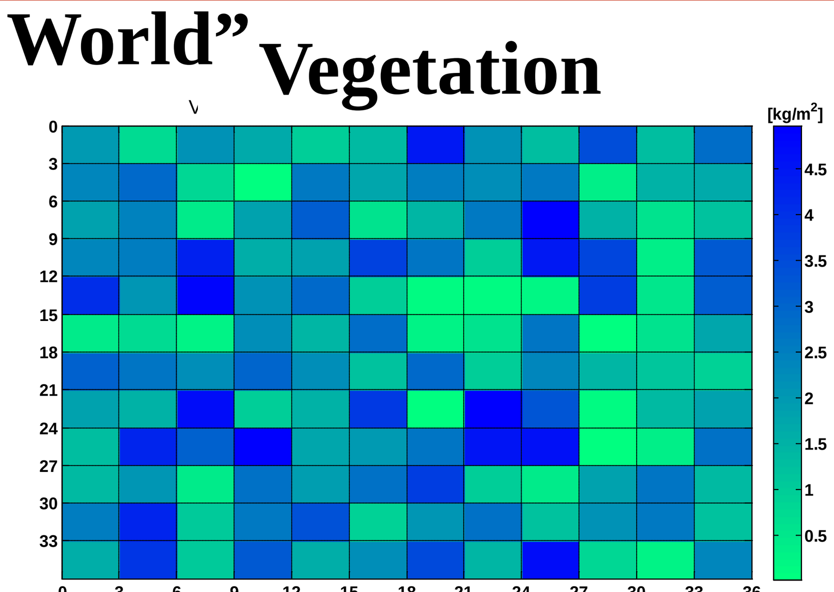


"Real World"

Soil Moisture



Vegetation

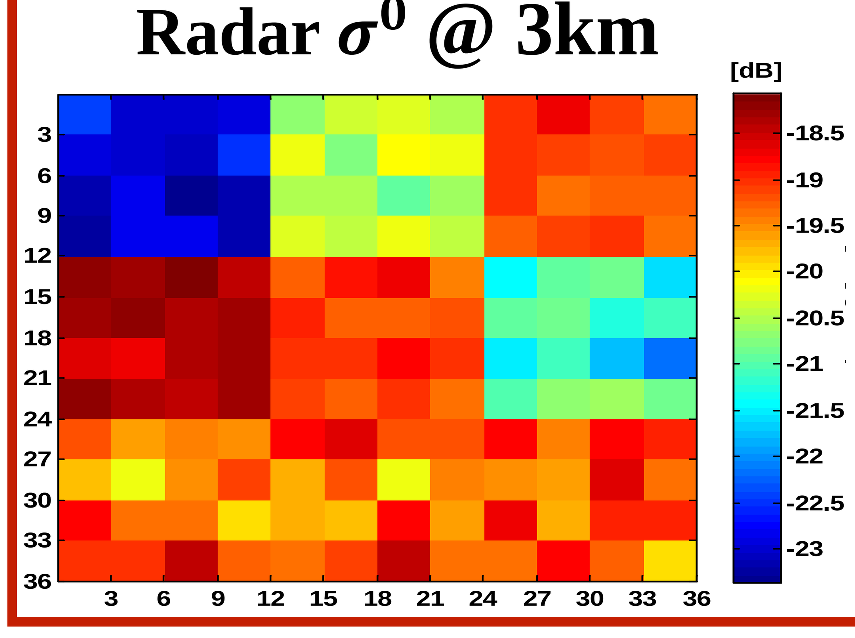


Soil Moisture and Vegetation distribution determine the actual radar and radiometer measurements and responses.

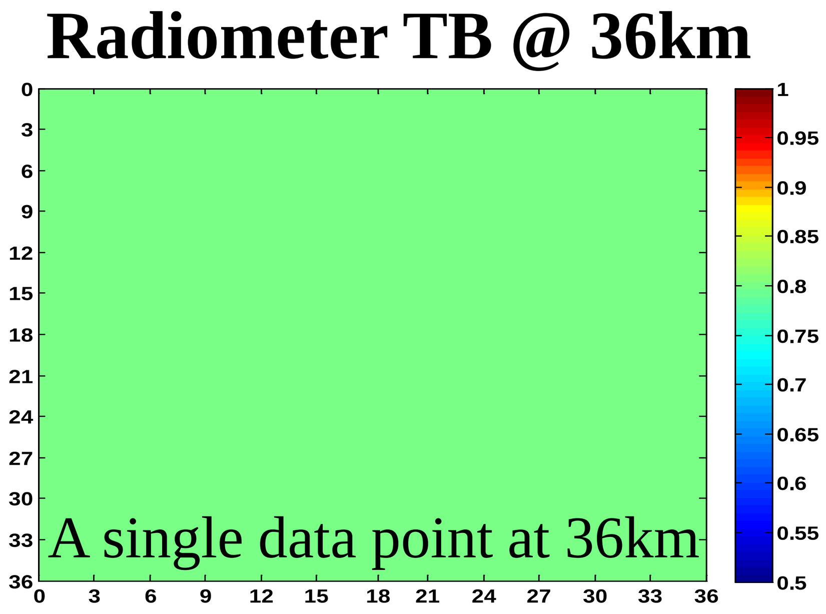
The greatest challenge in this work is the spatial resolution difference. To overcome this, radar and radiometer data must be constraint to each other in the cost function.

Measurements

Radar σ^0 @ 3km

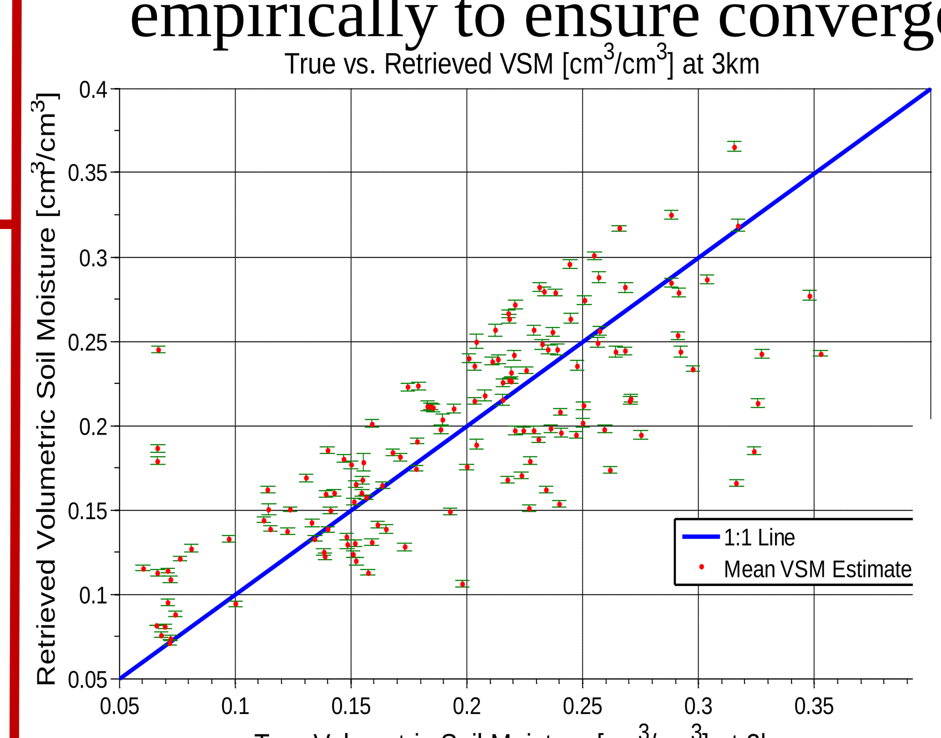


Radiometer TB @ 36km

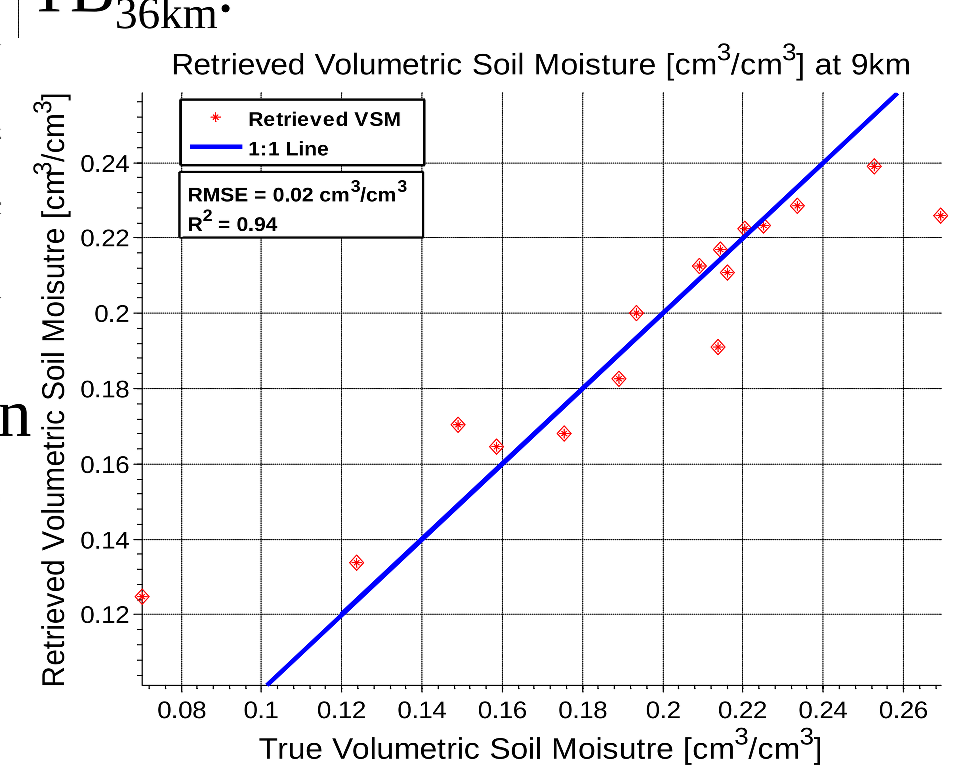


Soil Moisture retreival is performed via optimization

- Define a cost function: $L(\bar{X}) = \left\| \bar{d} - \bar{\bar{F}}(\bar{X}) \right\|_2^2$
- $\bar{X}$ are shared forward model ($\bar{\bar{F}}(\bar{X})$) parameters
- $\bar{d}$ is the vector of radar and radiometer data
- Minimization of the cost function follows the method of Simulated Annealing such that optimization parameters chosen empirically to ensure convergence of cost function



Example soil moisture retrieval at 3km(left) and 9km(bottom) resolutions given σ^0_{3km} and TB_{36km}.



Retrievals are evaluated based on their RMS errors and acceptable if RMSE ≤ 0.04 cm^3/cm^3

$RSME_{3km}$ ~0.045

$RMSE_{9km}$~ 0.02

1- rakbar@usc.edu, 2- mahta@usc.edu

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