VALIDITY OF TOP SOIL-MOISTURE ESTIMATION USING SAR DATA IN A RAINFED REGION

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Scope & Aim of work

- Soil moisture can be retrieved from the satellite data using three methods. i.e. Theoretical, Empirical, Semi empirical. Among these, Semi empirical models are promising to become operational. Dubois model, Oh model, Water cloud model.

- This particular work is done to analyse whether or not RISAT- MRS/CRS dual polarisation & Dual polarisation data can be used for regional soil moisture monitoring.

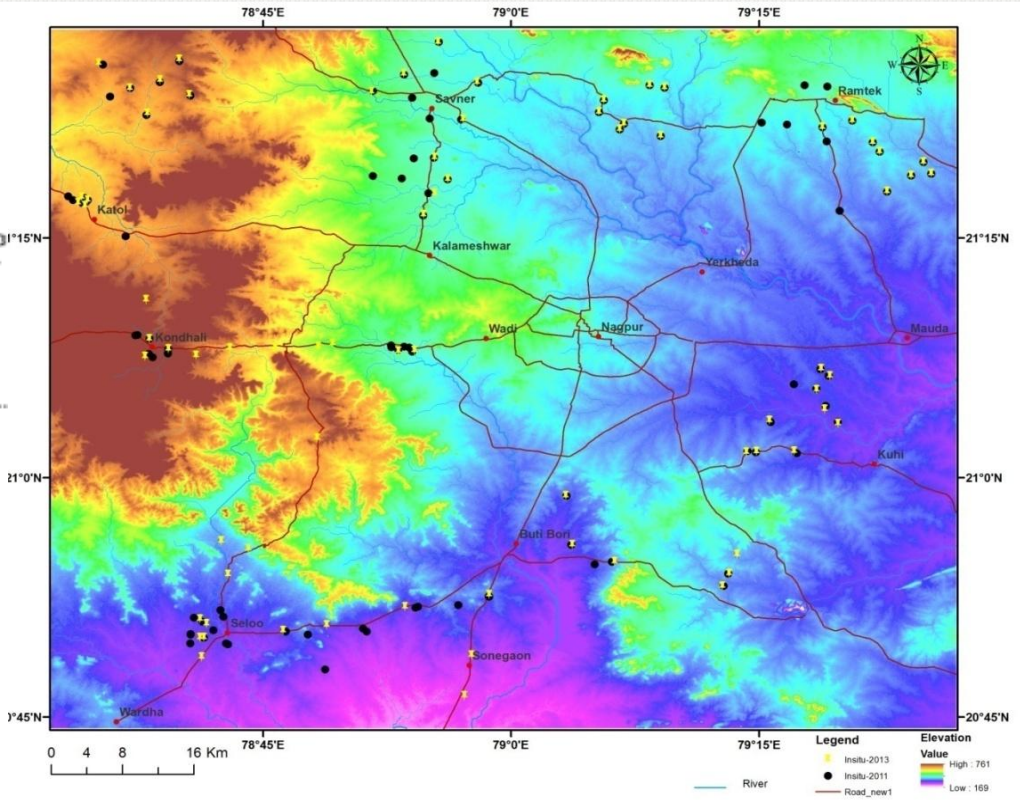
AIM

The aim of this project is to study the validity of an operational algorithm for monitoring soil moisture at regional scale using RISAT-1 data

Objective of study

1. Develop roughness model using difference of polarisation of high incidence angle RISAT-1 data.
2. Incorporate vegetation parameter in the soil moisture model.
3. Evaluate the results soil moisture model using in-situ soil moisture.
4. Compare the regional soil moisture product with Global soil moisture products.

Study area, Data & Software



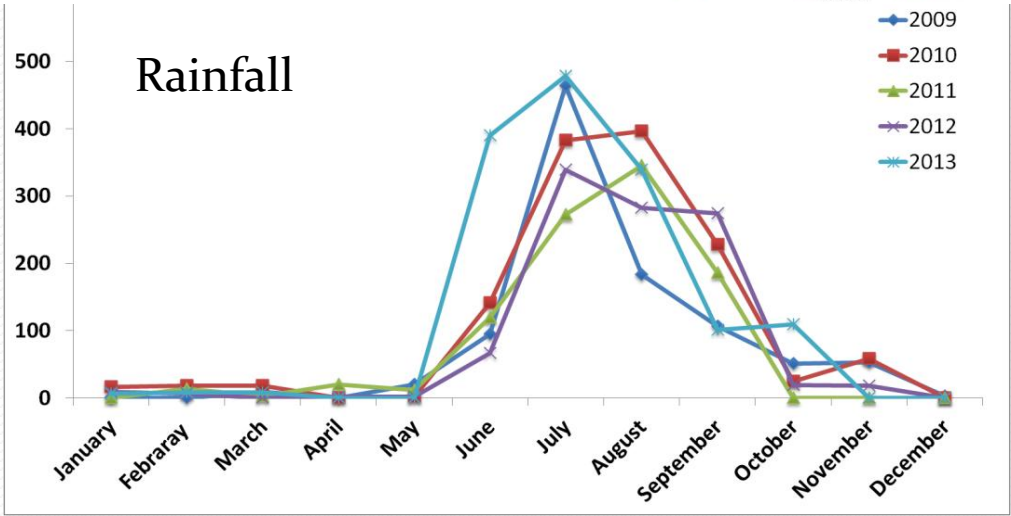
Data

In-situ Data

- Soil moisture
- Roughness
- Vegetation information

Satellite Data

- RISAT-1 data
- LISS IV data
- SMOS
- MODIS NDVI



Field Survey

- The soil moisture, roughness data collected for 75 locations.
- The soil samples were processed based on the conventional oven-dry method.
- There are three soil samples per site were collected in 0-5 cm depth of soil surface and average of these were used in the further study. The bulk density value was obtained for each soil sample.
- The soil samples were dried in oven at 105°C for 24 hours for obtaining gravimetric soil moisture value, which is converted to volumetric soil moisture by multiplying bulk density values.

Surface roughness is described as the surface variance compared with to a smooth reference surface . It is measured as Root mean square height.

RMS height $$S = \sqrt{\frac{\sum_{i=0}^{n}(Z_i - \bar{Z})^2}{n-1}}$$

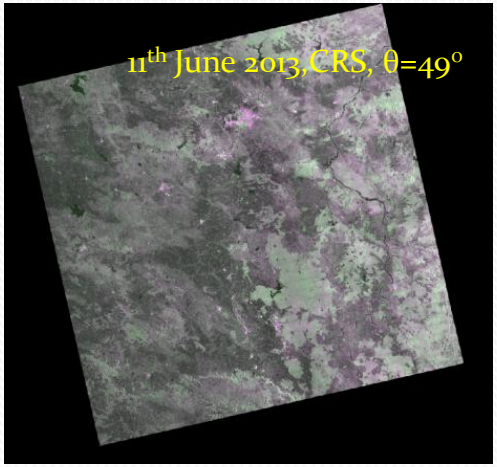
Here , Z_i denote the height of the point on X_I

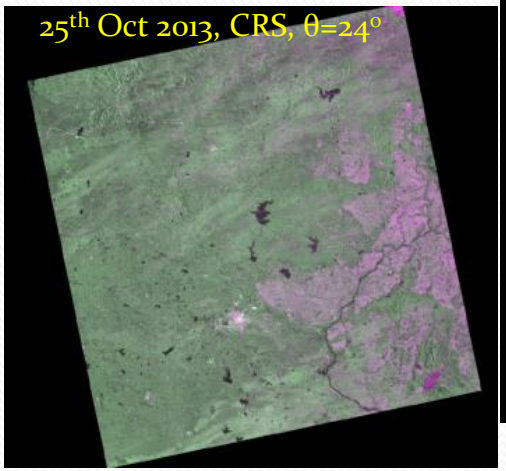
$\bar{Z}$ =Mean height

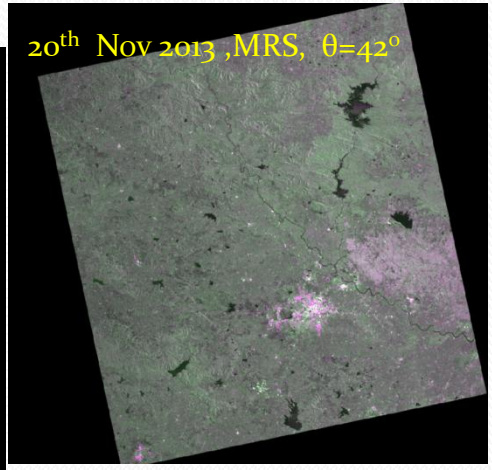
n=total number of points

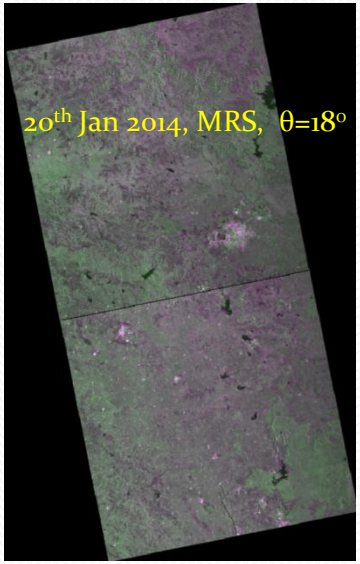
Detail of RISAT data procured

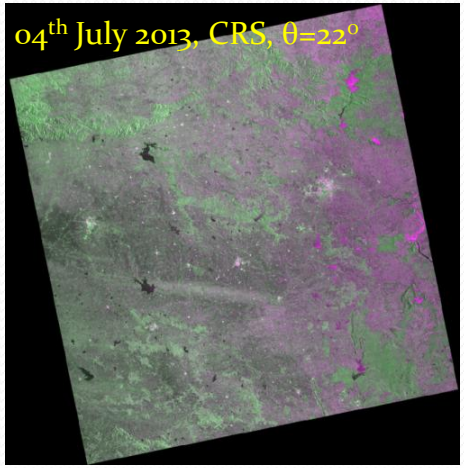
S.No	Date	Satellite	Imaging Mode	Polarization	θ
1	10/06/2013	Due to banding problem low angle data not received			
	11/06/2013	RISAT-1	CRS	HH,HV	45
2	04/07/2013	RISAT-1	CRS	HH,HV	22
	06/07/2013	RISAT-1	CRS	HH,HV	48
3	27/07/2013	RISAT-1	CRS	HH,HV	23
	28/07/2013	Due to flood problem high angle data not received			
4	25/10/2013	RISAT-1	CRS	HH,HV	24
	26/10/2013	RISAT-1	CRS	HH,HV	41
5	19/11/2013	RISAT-1	CRS	HH,HV	27
	20/11/2013	RISAT-1	CRS	HH,HV	42
6	14/12/2013	RISAT-1	CRS	HH,HV	27
	15/12/2013	RISAT-1	CRS	HH,HV	42
7	20/01/2014	RISAT-1	MRS	HH,HV	18
	20/01/2014	RISAT-1	MRS	HH,HV	18
	22/01/2014	RISAT-1	CRS	HH,HV	48

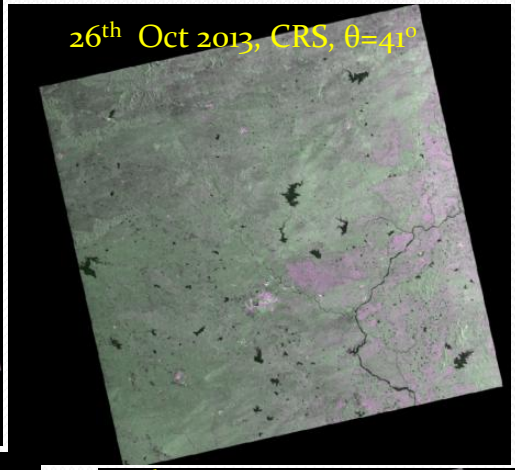

11th June 2013,CRS, θ=49°

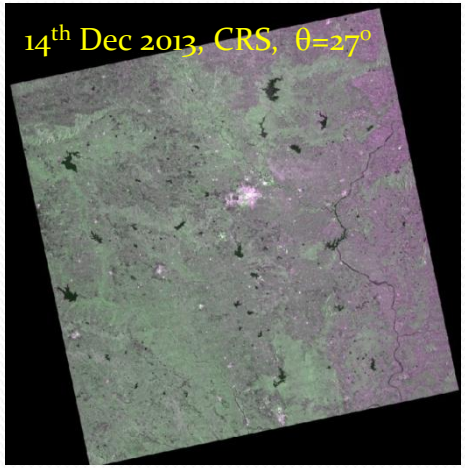

25th Oct 2013, CRS, θ=24°

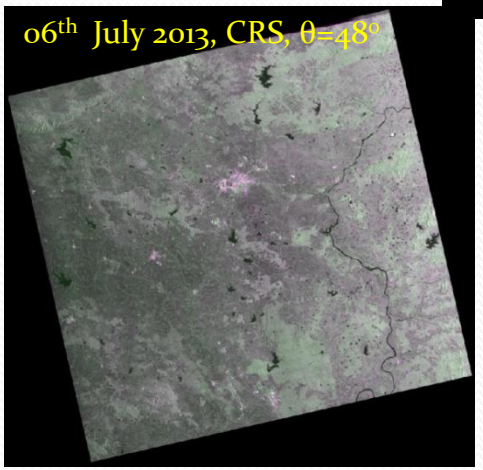

20th Nov 2013 ,MRS, θ=42°

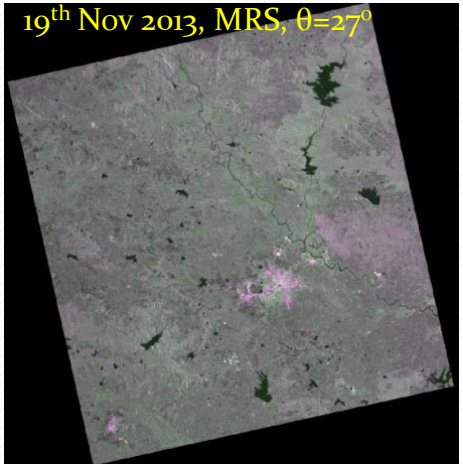

20th Jan 2014, MRS, θ=18°

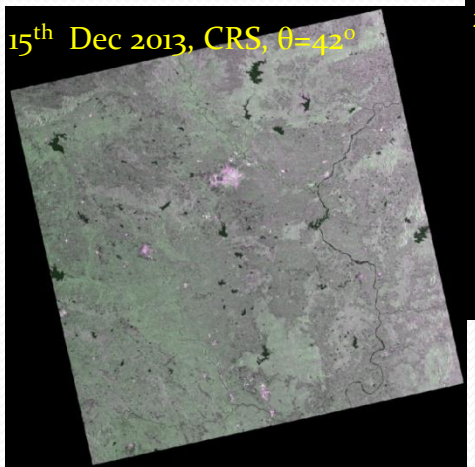

04th July 2013, CRS, θ=22°

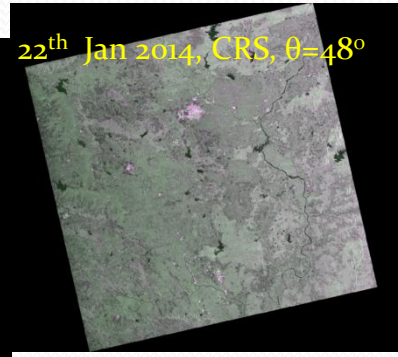

26th Oct 2013, CRS, θ=41°


14th Dec 2013, CRS, θ=27°


06th July 2013, CRS, θ=48°


19th Nov 2013, MRS, θ=27°

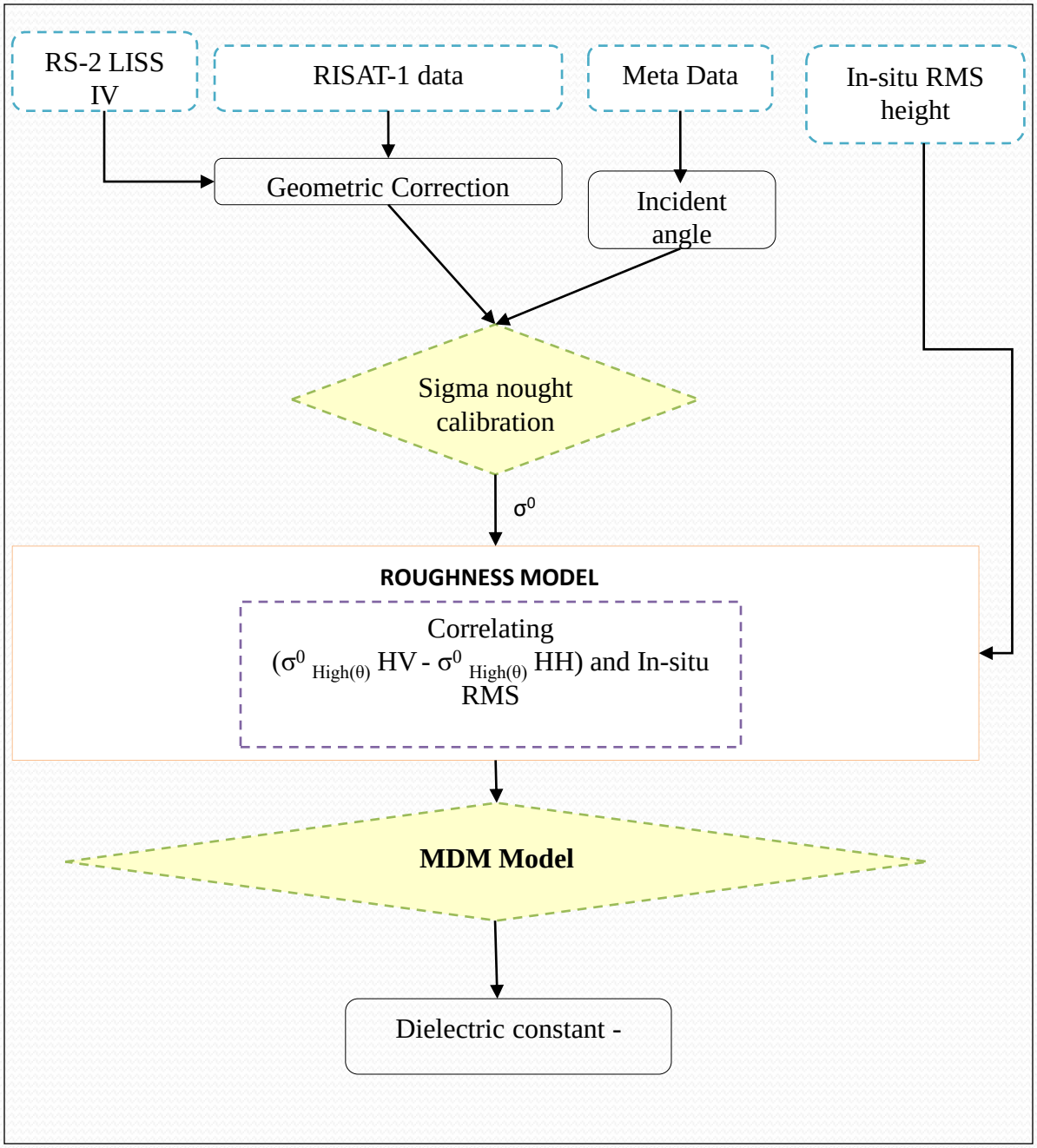

15th Dec 2013, CRS, θ=42°


22th Jan 2014, CRS, θ=48°

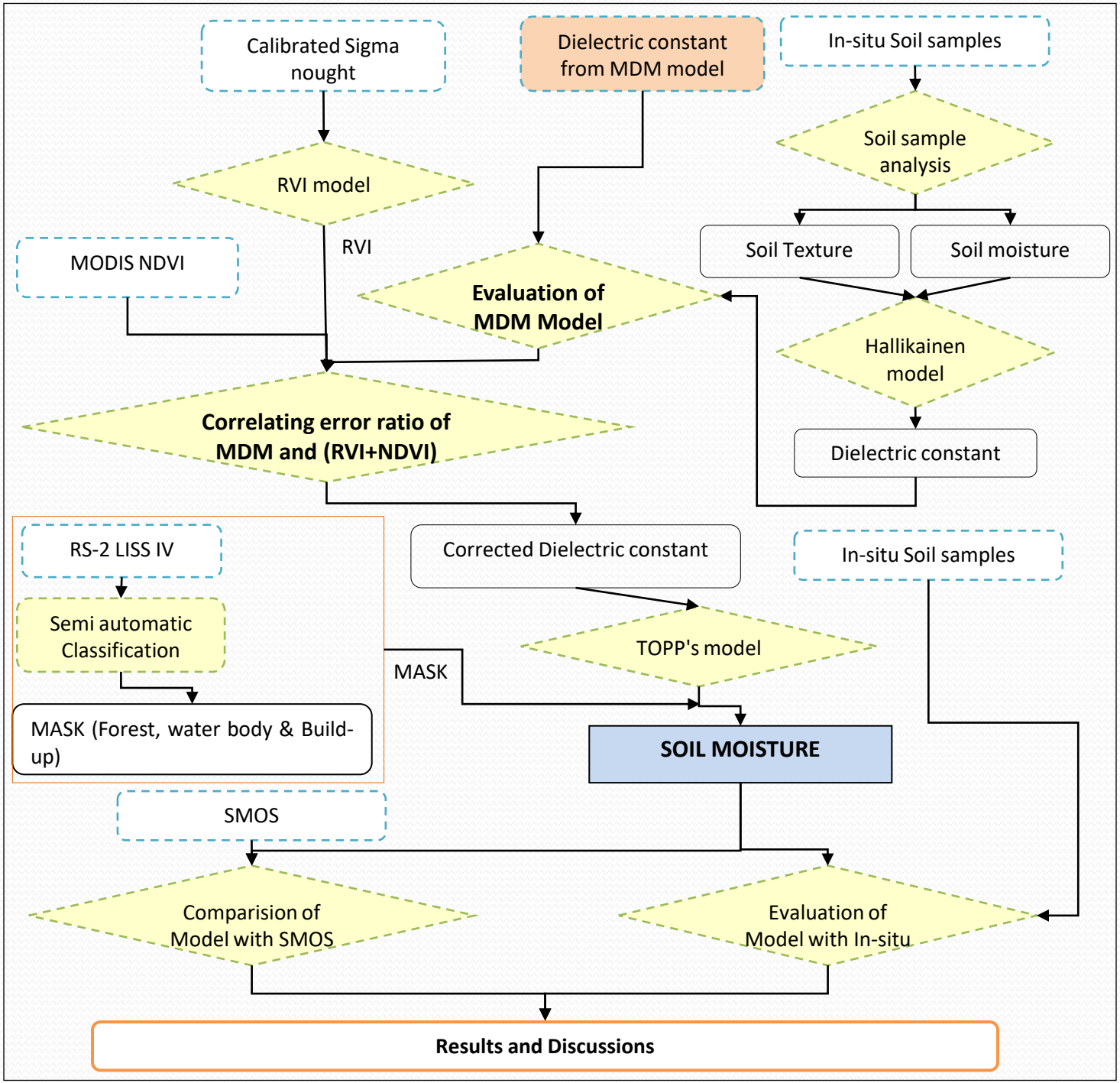
OBECTIVE OF STUDY

1. Examine the sensitivity of backscattering coefficient to target parameters i.e. dielectric constant, surface roughness and vegetation using Radarasat-1 data.
2. **Develop methodologies for soil moisture estimation with the combination low and high incidence angle RISAT-1 data.**
3. **Incorporate vegetation parameter in the soil moisture model.**
4. **Evaluate the results soil moisture model using in-situ soil moisture.**
5. Evaluate soil moisture of existing Global soil moisture products using in-situ measurements.
6. Compare the regional soil moisture product with Global soil moisture products.

Methodology Part-1



Methodology Part-2

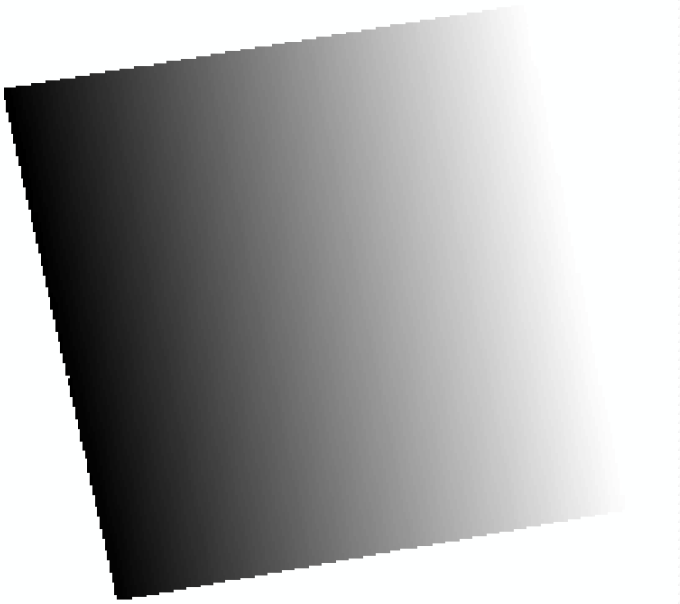


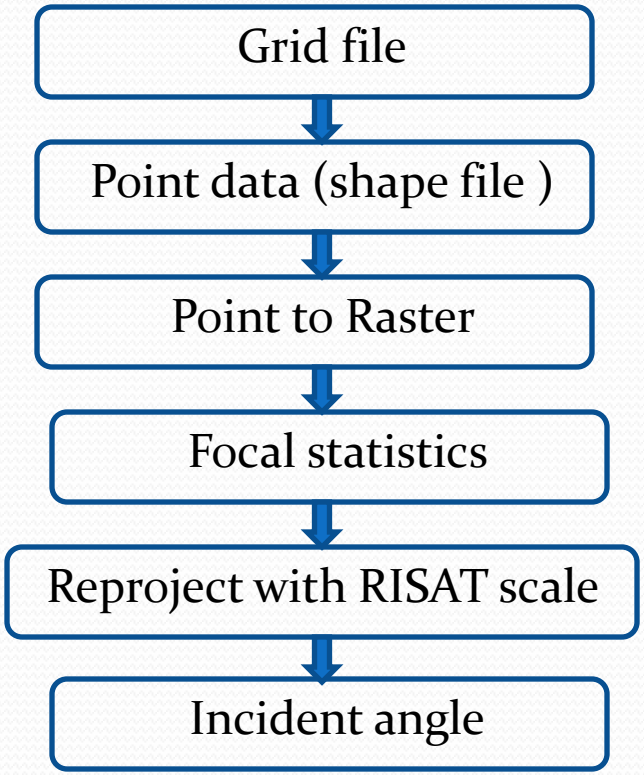
Geometric calibration

- Geometric correction was done with LISS-IV as base image.
- The shift is around 4 pixels.
- After correction, the accuracy was maintained with in the pixel.
- First order polynomial with Nearest neighbor technique were used for geometric correction.

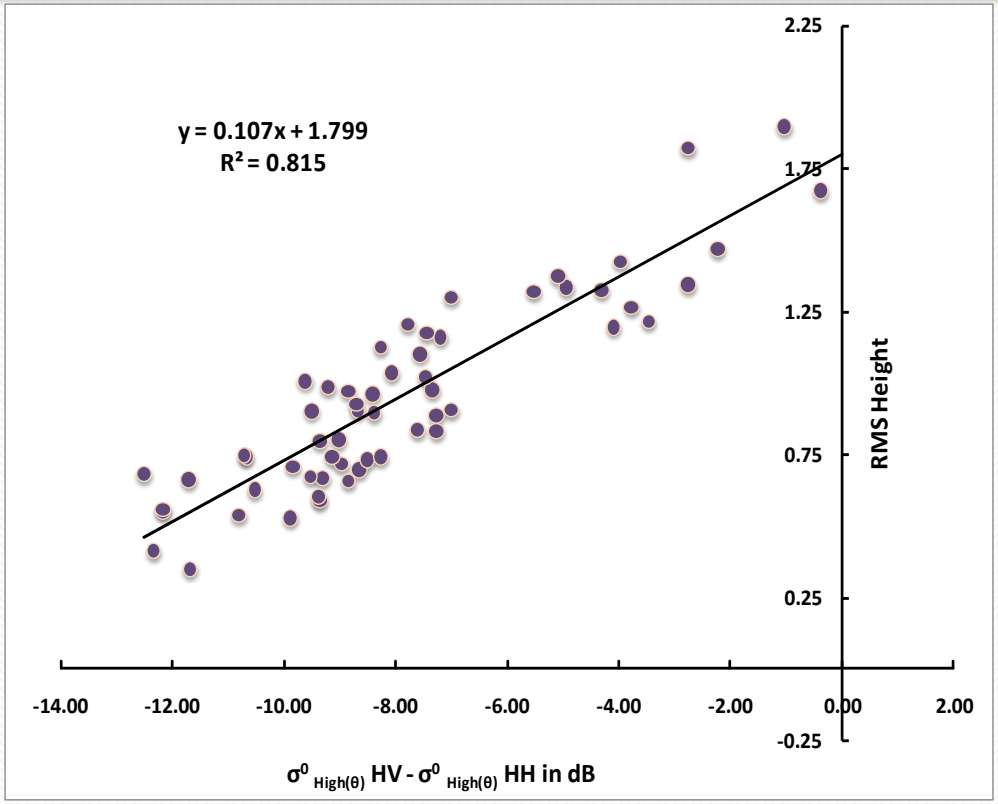
Radiometric calibration: $\sigma_o(dB)=20\log_{10}(DN_p)-K_{dB}+10\log_{10}(\sin(i_p)/\sin(I_{center}))$

Incident angle image generation





Roughness model by dual polarimetric approach with θ_{high} data



Model modified Dubois Model (Sahebi and Angles, 2010)

$$\sigma^0_{hh} = 10^{-3.67}\frac{\cos^{1.5}\theta}{\sin^5\theta}\times 10^{0.112\varepsilon\tan\theta}(ks\sin\theta)^{0.883}\lambda^{0.7}$$

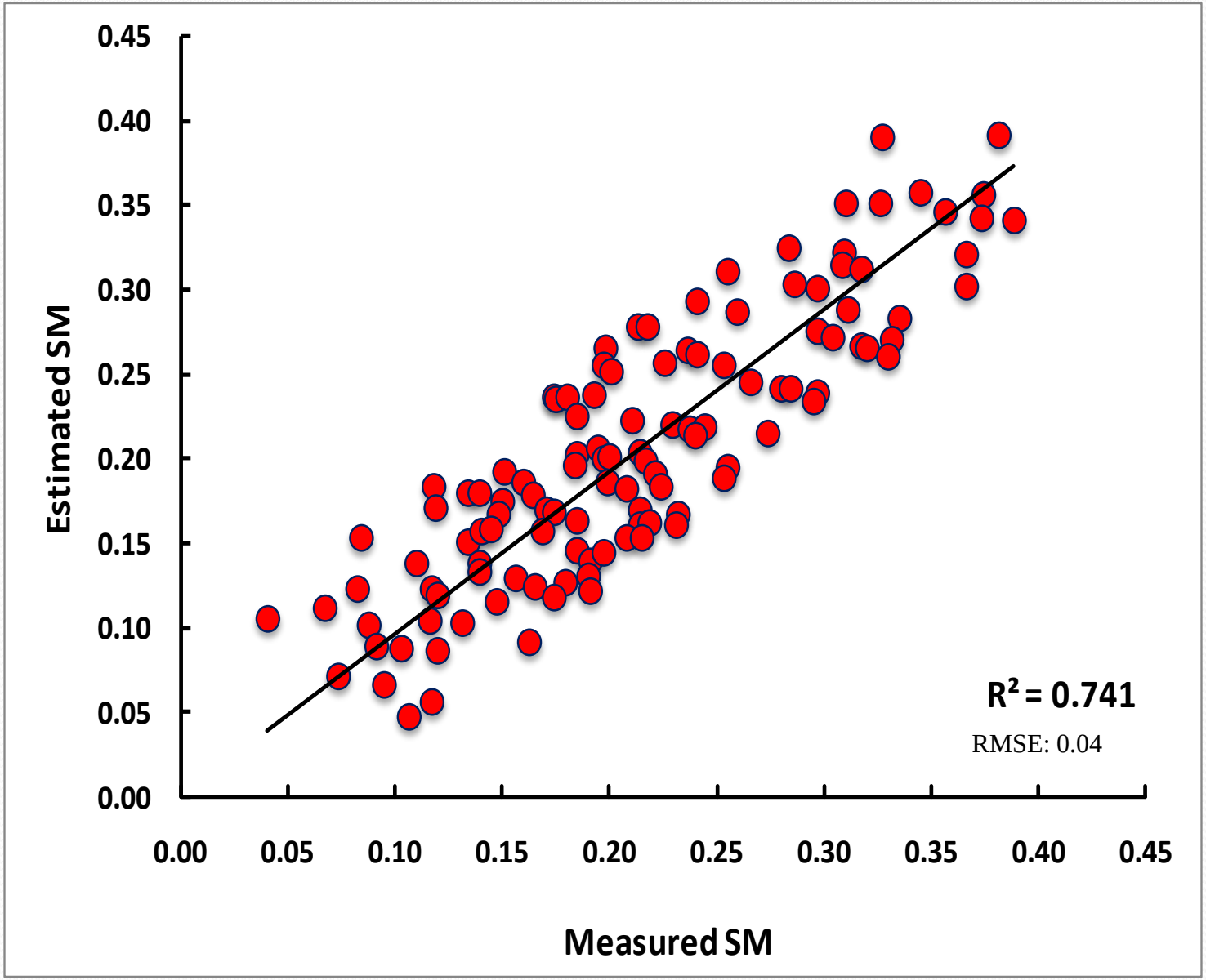
$$\varepsilon = \left(\frac{\log(\sigma^0_{hh}) - \log(AC)}{B}\right)$$

$$A = \left(10^{-3.67}\frac{\cos^{1.5}\theta}{\sin^5\theta}\right) \qquad B = 0.112\tan\theta \qquad C = (ks\sin\theta)^{0.883}\lambda^{0.7}$$

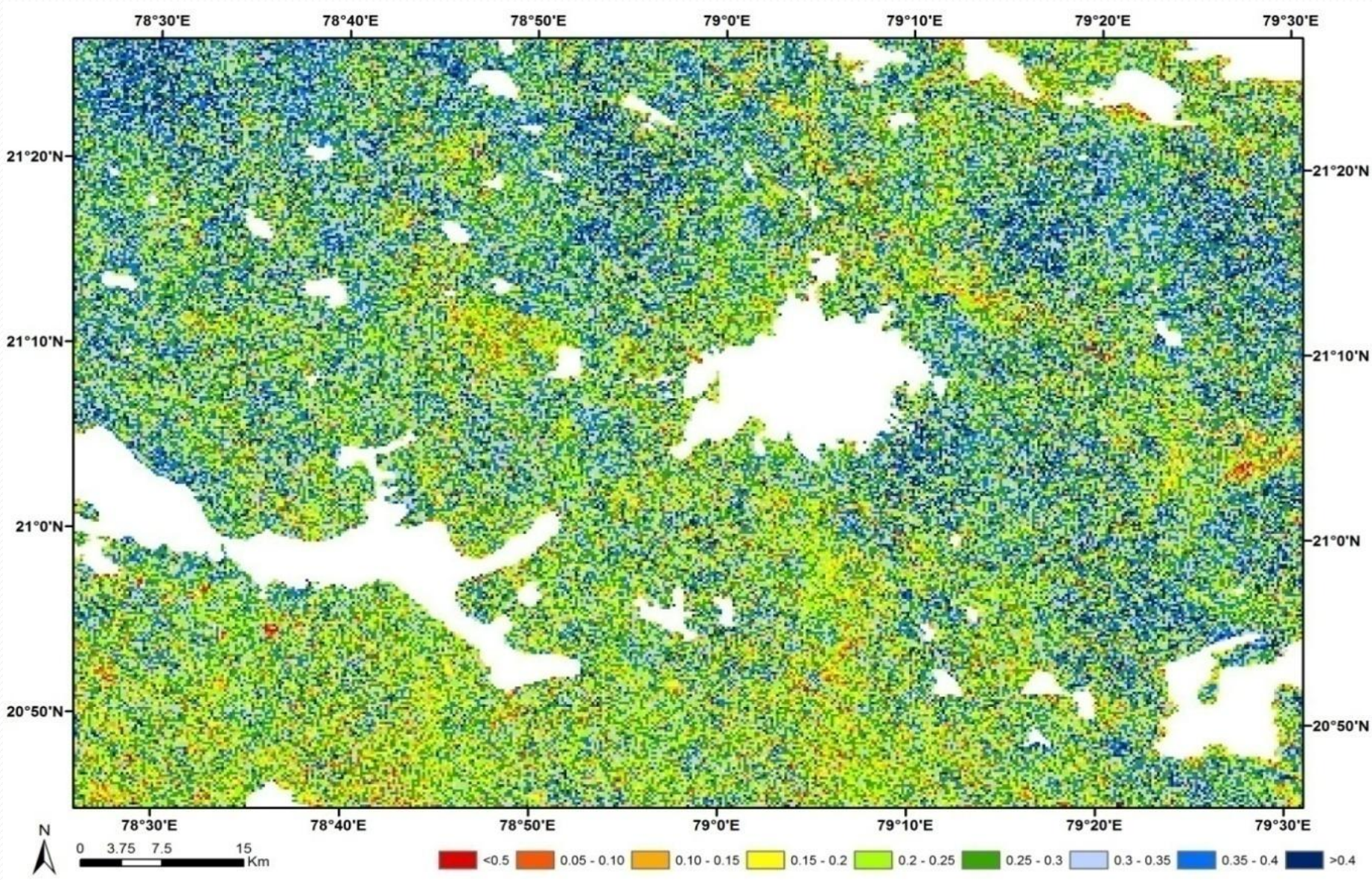
Model conditions s < 6 cm and 20° <Θ<50° and 14<SM<32

The Soil Moisture θ_v $\theta_v = -5.3\times10^{-2} + 2.92\times10^{-2}\varepsilon - 5.5\times10^{-4}\varepsilon^2 + 4.3\times10^{-6}\varepsilon^3$

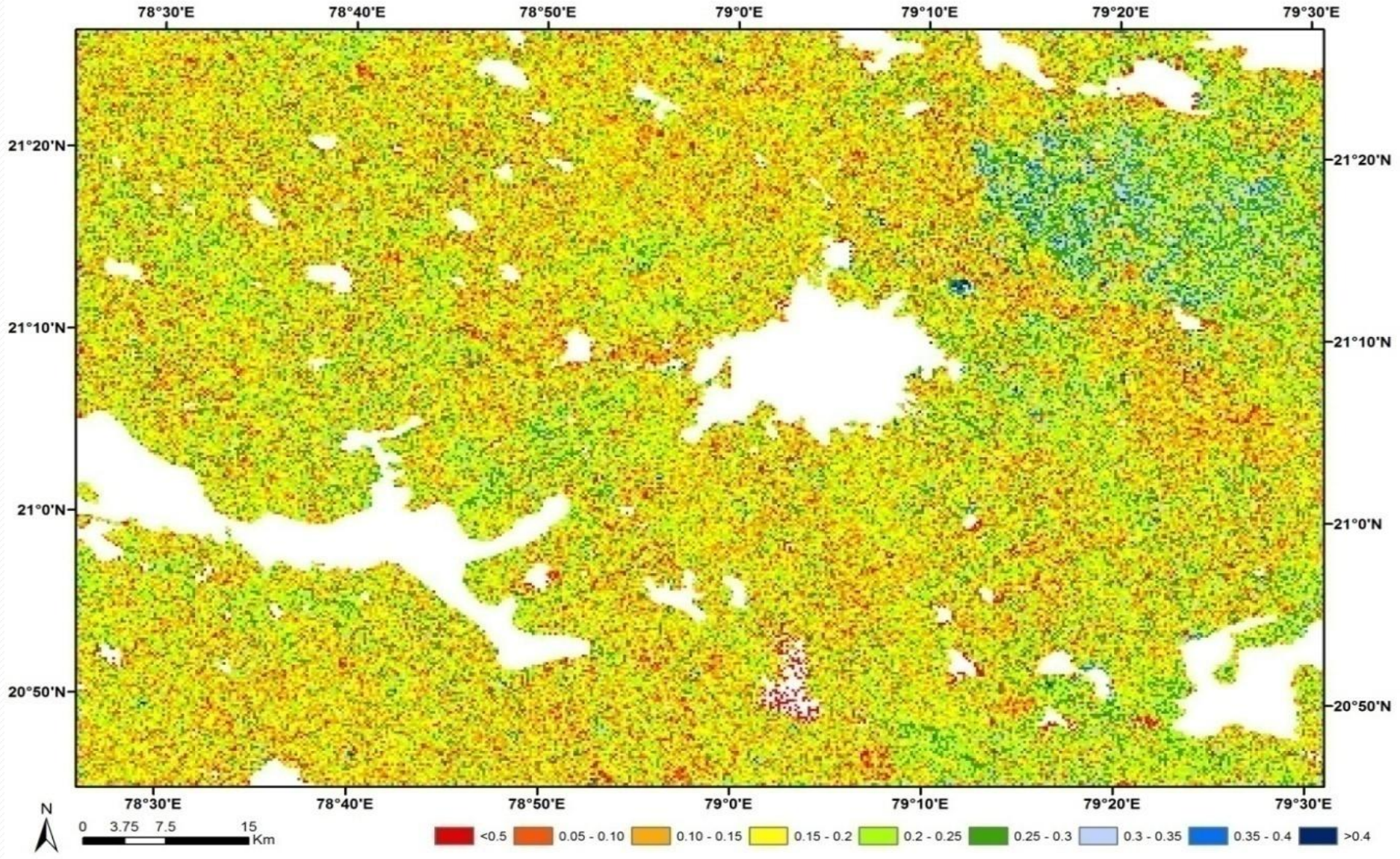
The correlation between Estimated SM against the measured SM



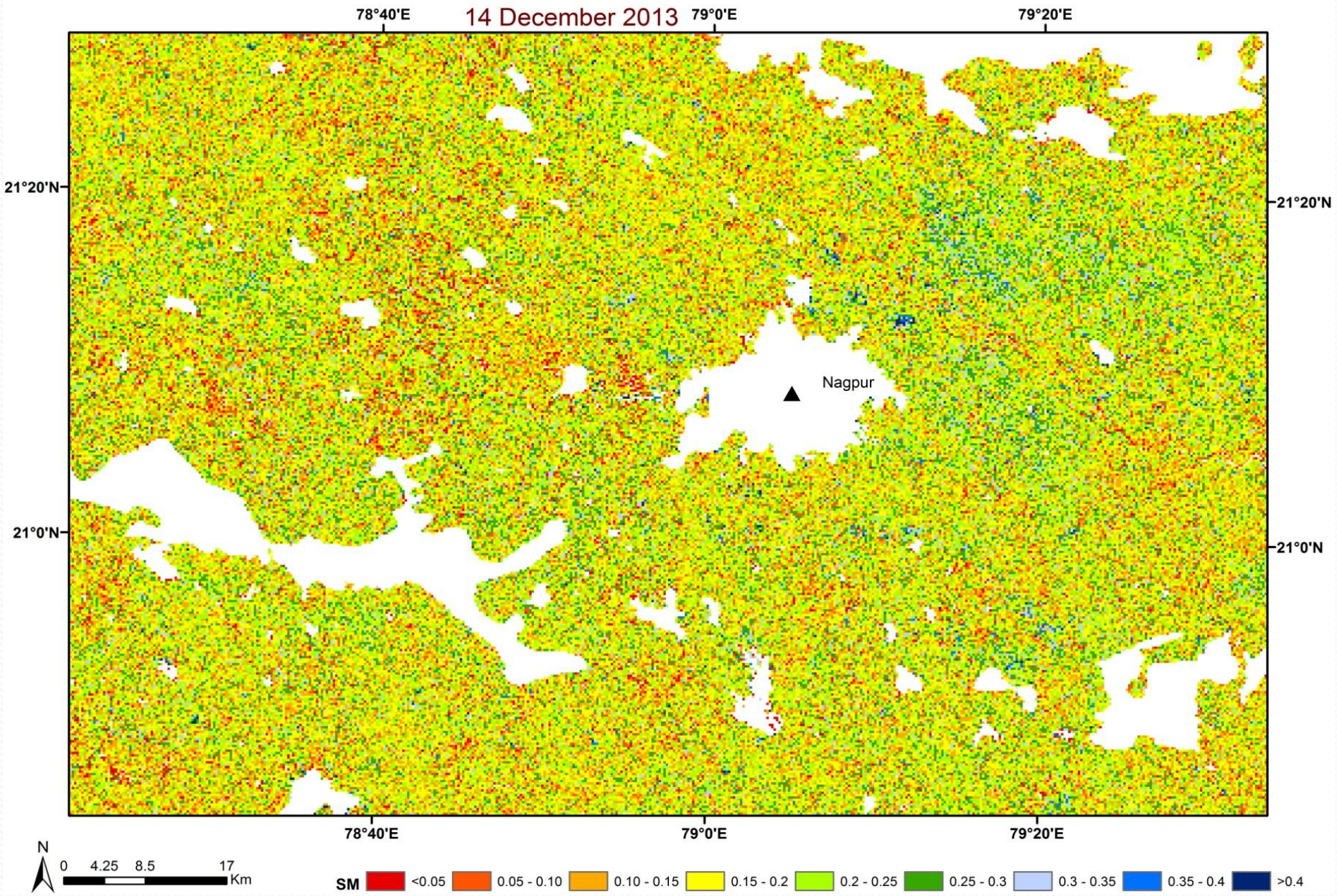
The soil moisture map on 04th July 2013



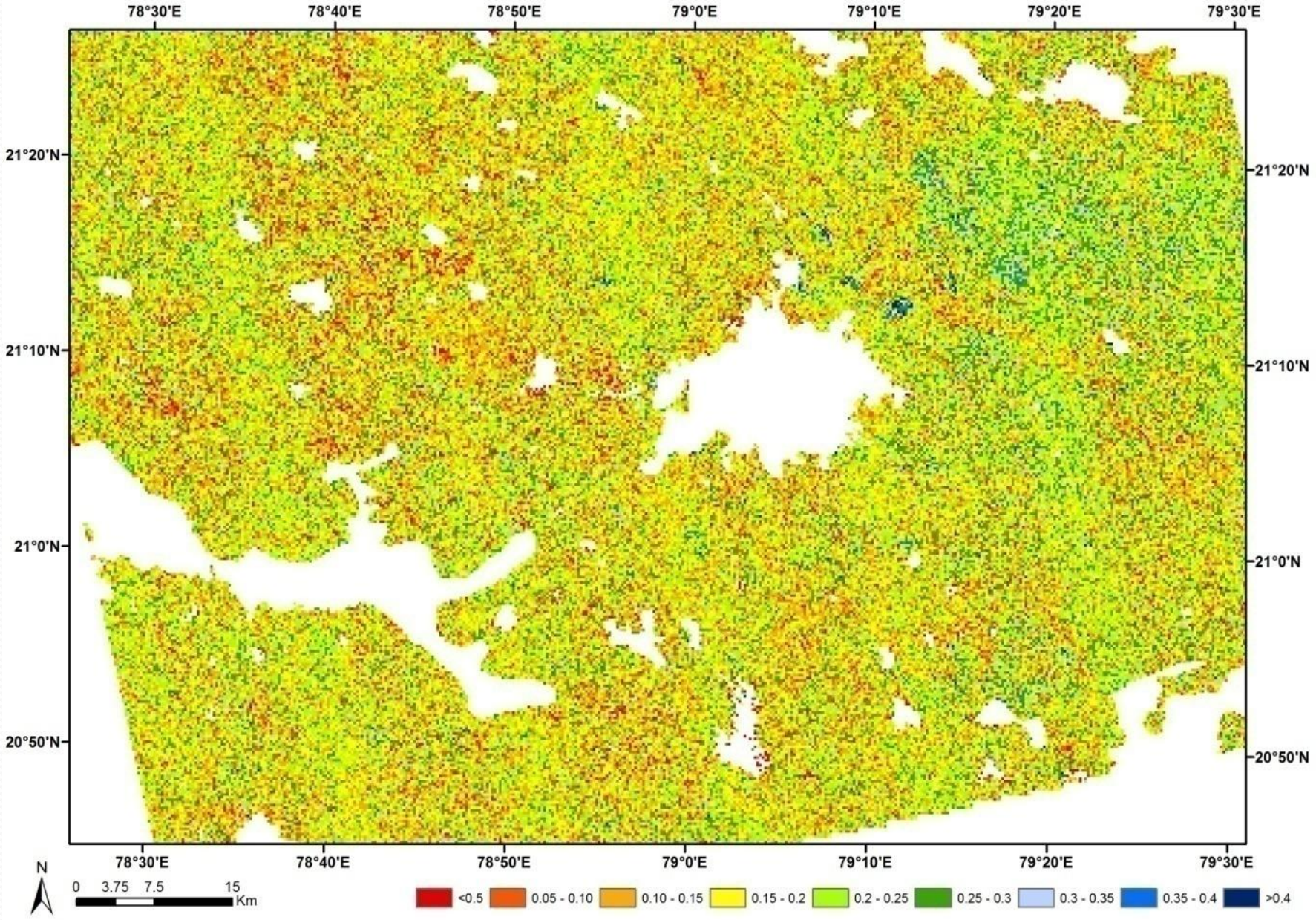
The soil moisture map on 25th October 2013



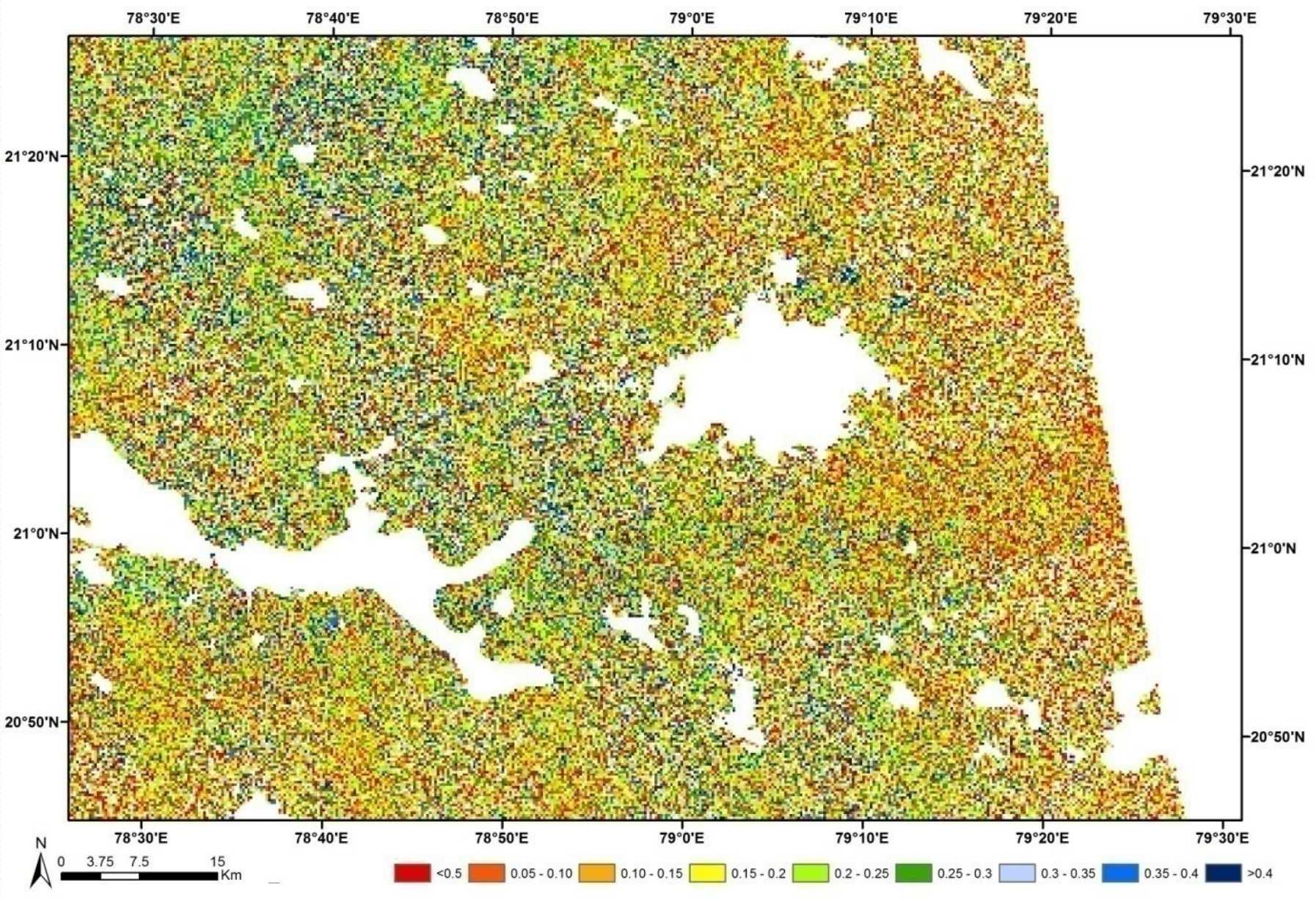
The soil moisture map on 14th December 2013



The soil moisture map on 19th November 2013



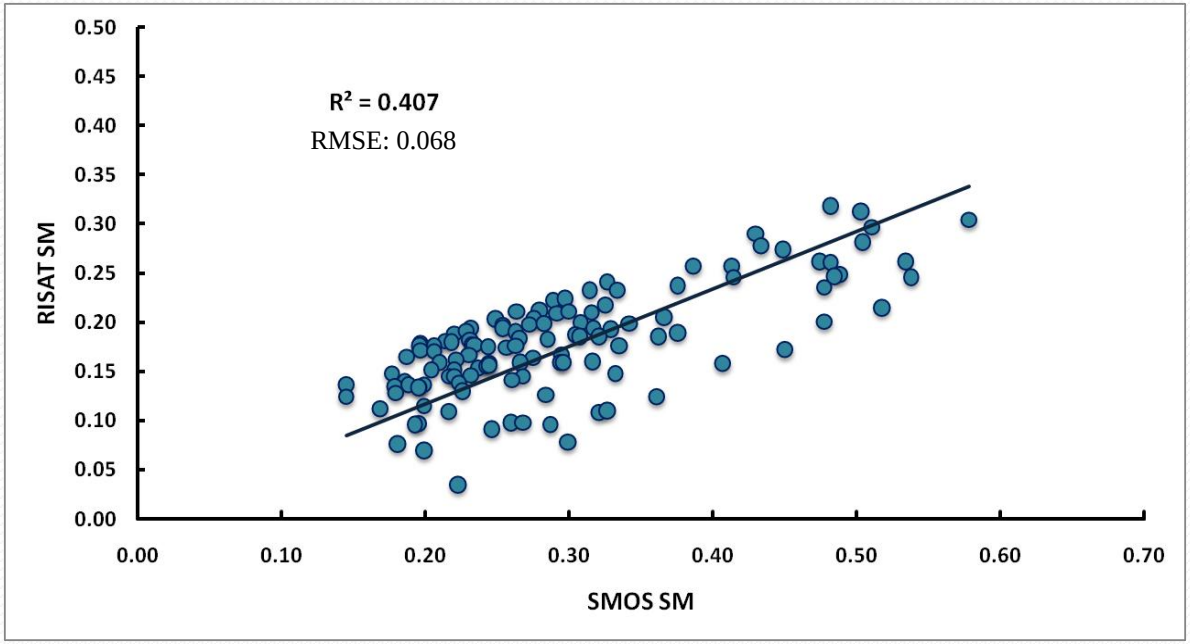
The soil moisture map on 20th Jan 2014

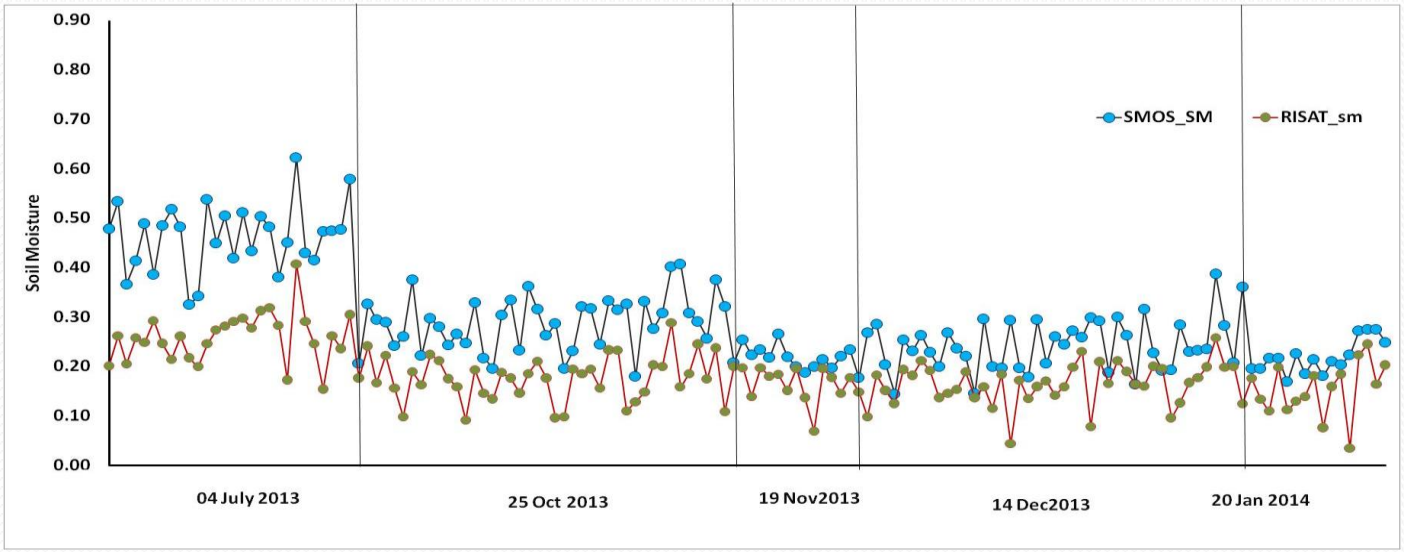


OBECTIVE OF STUDY

1. Develop a methodology for soil moisture estimation using dual polarization (HH and HV) Radarsat-1 SAR data.
2. Develop methodologies for soil moisture estimation with the combination low and high incidence angle RISAT-1 data.
3. Incorporate vegetation parameter in the soil moisture model.
4. Evaluate the results soil moisture model using in-situ soil moisture.
5. **Compare the regional soil moisture product with Global soil moisture products.**

Comparing RISAT-1 & SMOS soil moisture products





Results & Discussions

- The model developed by Sahebi, M. R., & Angles, J. (2009) modified for RISAT-1.
- The roughness model was made differences of cross polarisation and like polarisation backscatter values ($\sigma^{o}_{High(\theta)}$ HV - $\sigma^{o}_{High(\theta)}$ HH).
- The error due to vegetation in the MDM model was addressed using the combination NDVI+RVI.
- The corrected epsilon was converted into soil moisture using Topp's model.
- The derived soil moisture product from the Modified Dubois model was compared with SMOS product.

Future study

- Artificial neural network and other improved statistical methods can be tried to derive roughness and vegetation models instead of linear regression model as used in this study to increase model reliability in the new study area.
- Exploration RISAT-1 CRS data with soil moisture change detection study
- MRS combined ascending and descending mode capability for soil moisture using change detection study
- Exploration of active (RISAT-1)-passive sensor combination models

Acknowledgement

Thank you