Soil Moisture Retrieval over different regions of India from Sentinel-1 SAR observations

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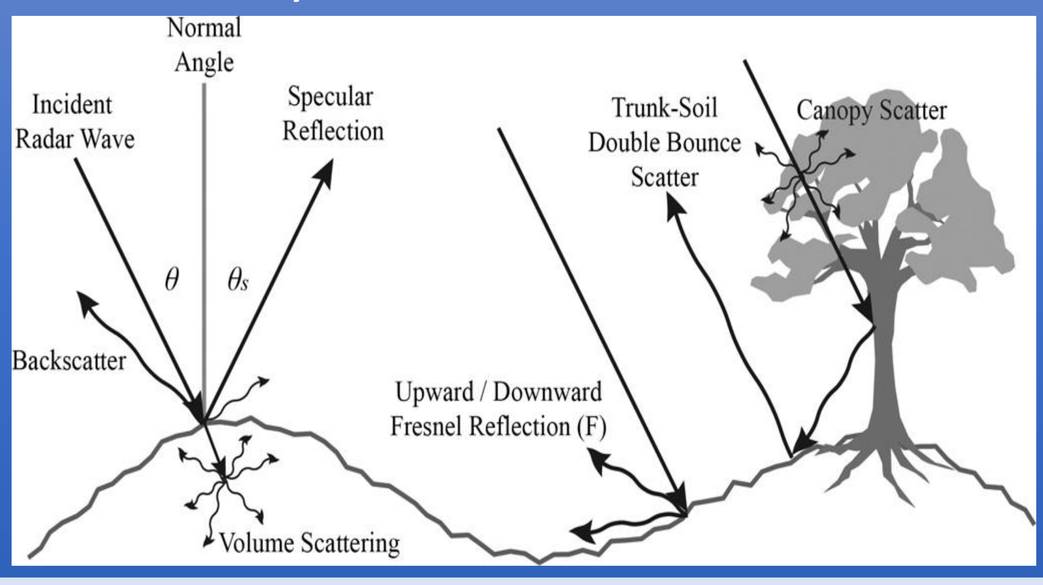
Introduction: The spatial and temporal distribution of soil moisture is a key state variable in various hydrological and atmospheric applications.

Backscattering coefficient (σ_0) depends

- effective dielectric property of surface (combined of vegetation and soil)
- probing wavelength
- kind of vegetation and its orientation
- subsurface volume
- surface structure (surface roughness)



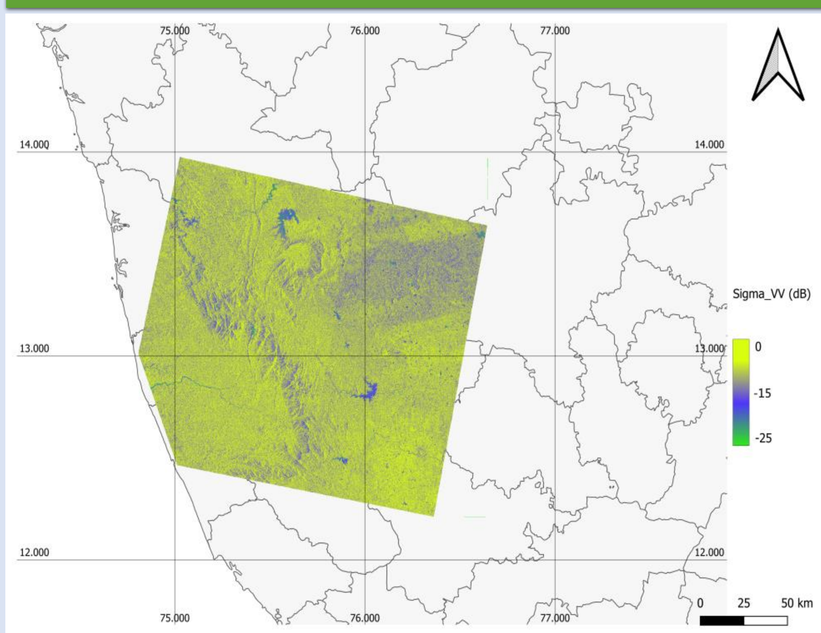
Methodology: Water cloud model

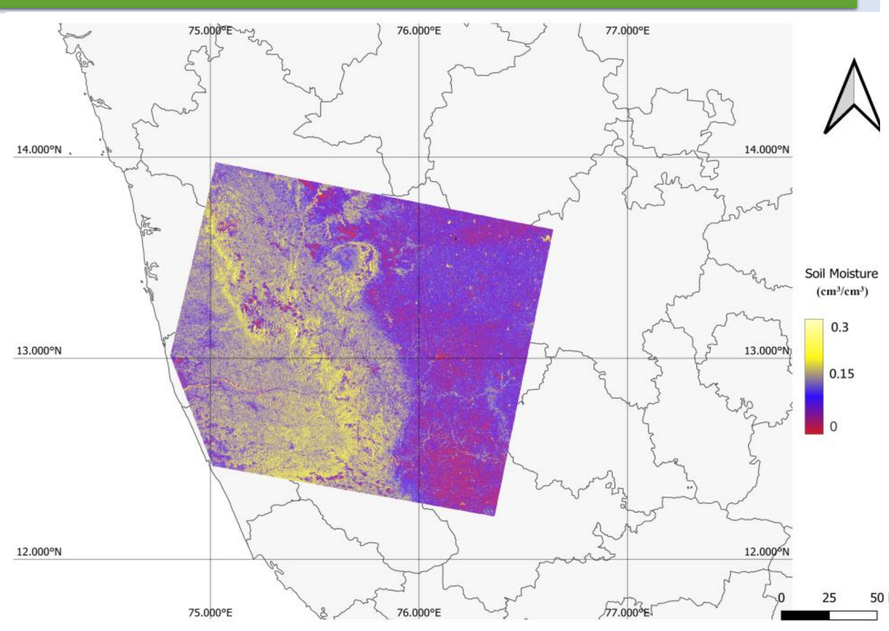
Radiation transport model and the vegetation canopy is assumed to be uniform horizontal clouds:

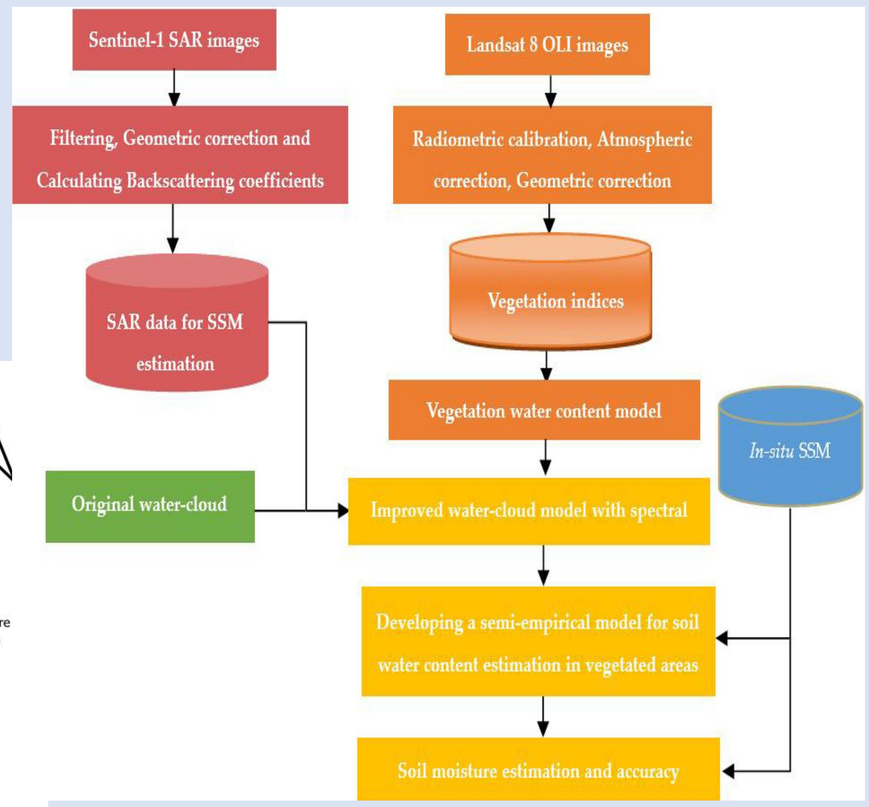
$\sigma^0 = \sigma^0_{veg} + T^2\sigma^0_{Soil}$; $\sigma^0_{veg} = AM_v \cos(\theta)(1-T^2)$; $T^2 = \exp(-2BM_v \sec(\theta))$

$SSM = k_1 + k_2\sigma^0 + k_3VI + k_4VI^2 + k_5VI^3 + k_6VI^4 + k_7\sigma^0 secsec(\theta) + k_8\sigma^0 VI sec(\theta) + k_9\sigma^0 VI^2 sec(\theta)$

$SSM = -0.12611 - (0.00468)\sigma^0 + (0.38311)NDVI + (0.91742)NDVI - (0.66693)NDVI^3 - (0.804)NDVI^4 + (0.00701)\sigma^0 secsec(\theta) - (0.00721)\sigma^0 NDVI sec(\theta) - (0.01792)k_9\sigma^0 NDVI^2 sec(\theta)$

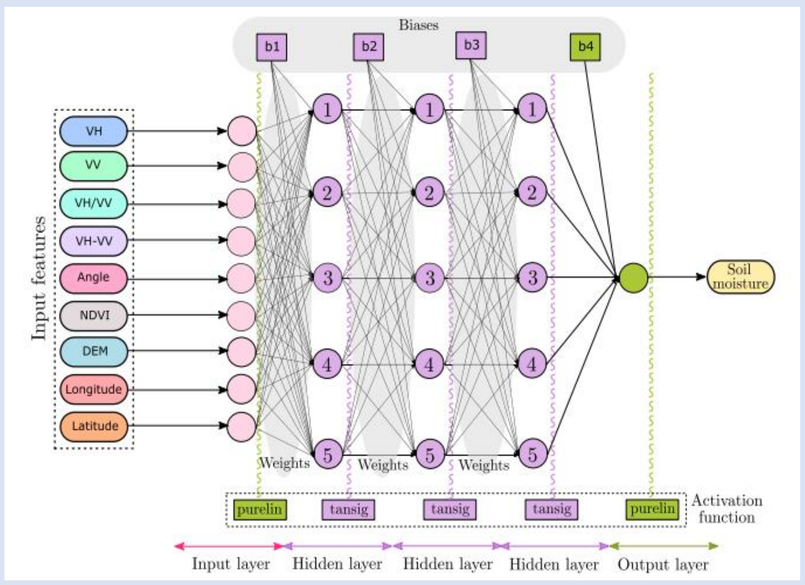


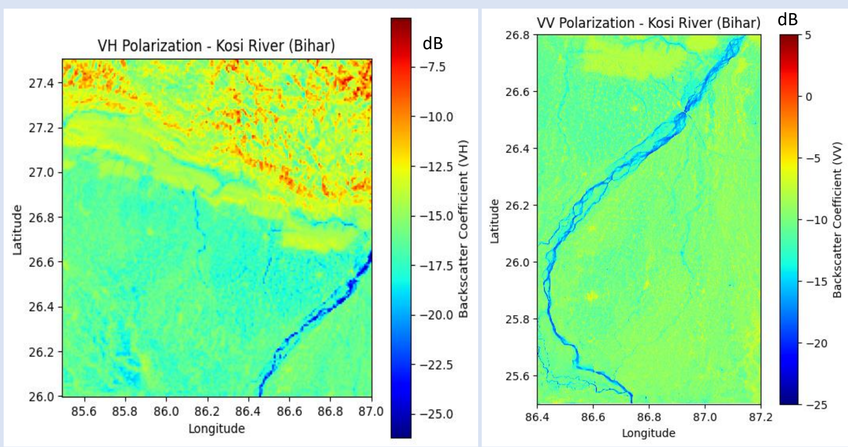




AI/ML based model for soil moisture retrieval

Feed-forward Artificial Neural Network (ANN) model to estimate surface soil moisture:





Methodology

Estimated SSM by the water cloud model:

- underestimated in the high soil moisture range
- overestimated in the low soil moisture range

Compared the performance of ANN model with different machine learning algorithms:

- Generalised Regression Neural Network (GRNN)
- Radial Basis Network (RBN)
- Exact RBN (ERBN)
- Gaussian Process Regression (GPR)
- Support Vector Regression (SVR)
- Random Forest (RF)
- Binary Decision Tree (BDT)

	Model	RMSE	MSE	R^2	Bias
0	ANN	0.875855	0.767123	0.833572	0.115928
1	GRNN	0.924089	0.853940	0.814737	-0.005332
2	RBN	0.942434	0.888182	0.807308	0.008903
3	ERBN	0.839493	0.704748	0.847104	-0.008363
4	GPR	6.173956	38.117732	-7.269685	-5.788644
5	SVR	1.190706	1.417782	0.692411	-0.078526
6	RNN	0.876642	0.768502	0.833273	-0.042846
7	BDT	0.509137	0.259221	0.943762	-0.005824

References:
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2) Ahmad, S., Kalra, A. & Stephen, H. Estimating soil moisture using remote sensing data: A machine learning approach. Adv.Water Resour (2010). 33, 69–80
3) Yansong Baoa, Libin Lina, Shanyu Wua, Khidir Abdalla Kwal Denga, George P. Petropoulos,Surface soil moisture retrievals over partially vegetated areas from the synergy of Sentinel-1 and Landsat 8 data using a modified water-cloud model, Int J Appl Earth Obs Geoinformation 72 (2018) 76–85.