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Assessing representative soil moisture at watershed scale of Maqu catchment using spatio-temporal statistical analysis

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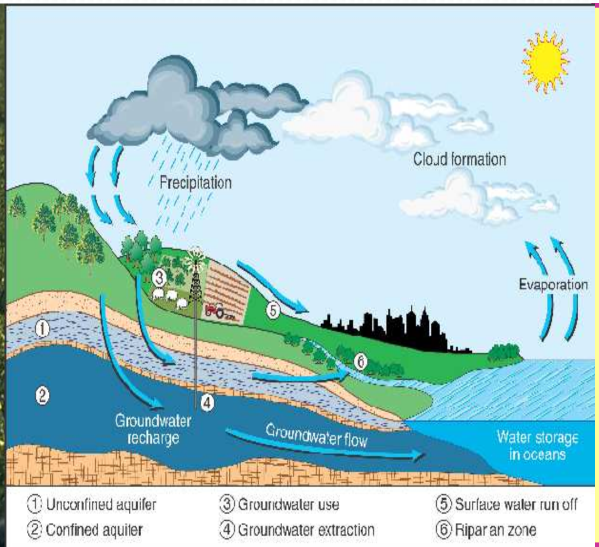
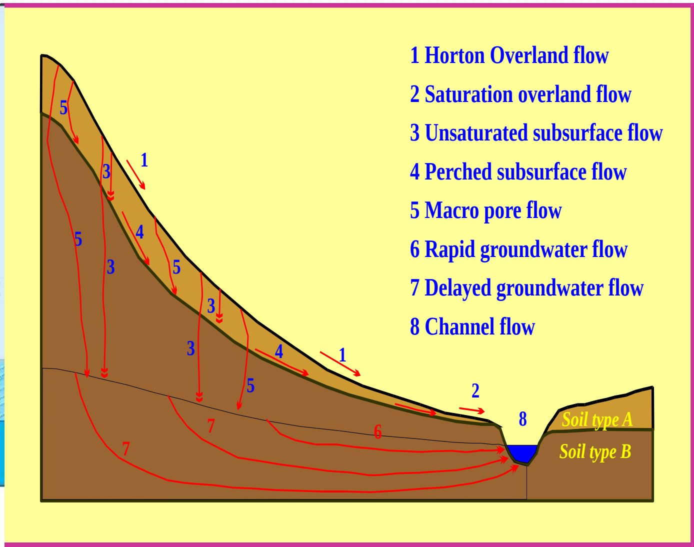
Introduction

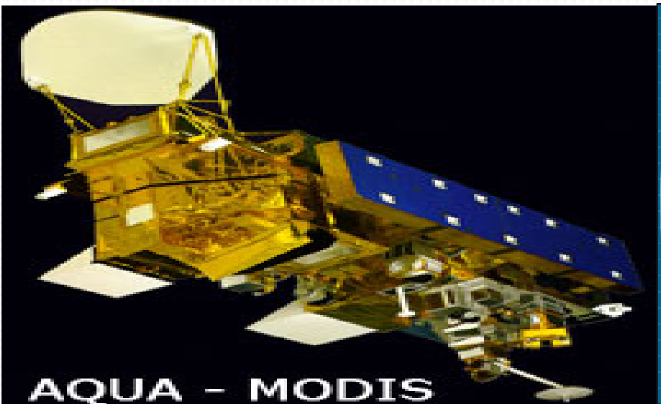
- Water management applications (RR/ Floods)
- Effects infiltration and governs redistribution of rain water in surface runoff and subsurface storage
- Partitioning of incoming radiative energy (ETa) for Land Surface Energy Balance

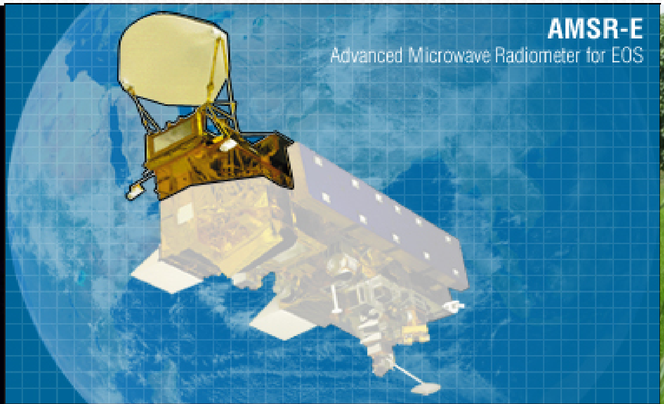




Problem Statement

- Soil moisture is (highly) variable in space-time
- Characterizing "wetness" at field scale is not straight forward
- Moisture estimates at field scale are often needed
- Use of satellites is often advocated but "pixel" scales are large!
- Can we observe "representative" moisture estimates?
- How to improve validation of satellite moisture estimates?

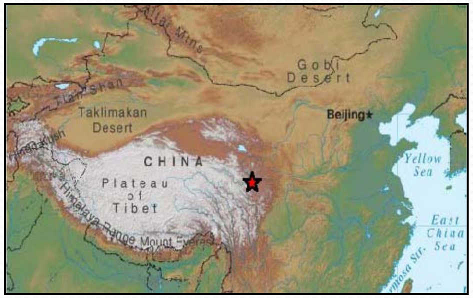




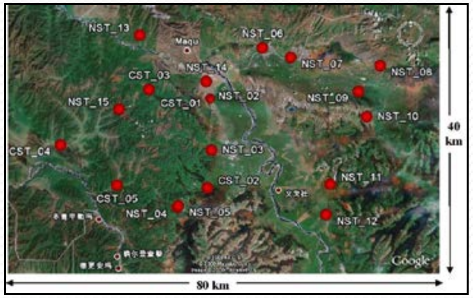
Study Area and Observation network

(Dente et al., 2009)

- NE part of Tibetan Plateau, Gansu Province, China
- Catchment lies at the first major meander of the Yellow river
- 20 data loggers
- El. ranges from 3160 - 4664 m.a.s.l
- Large topographic variation
- Catchment Area 3200 km^2
- Homogeneous and uniform land cover of grasslands and some wetlands
- Continental climate



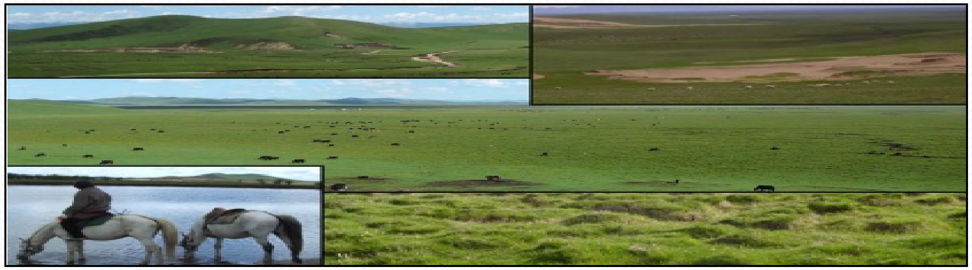
Geographical location of the Maqu catchment in the Tibetan Plateau



Location of 20 data loggers in the Maqu catchment

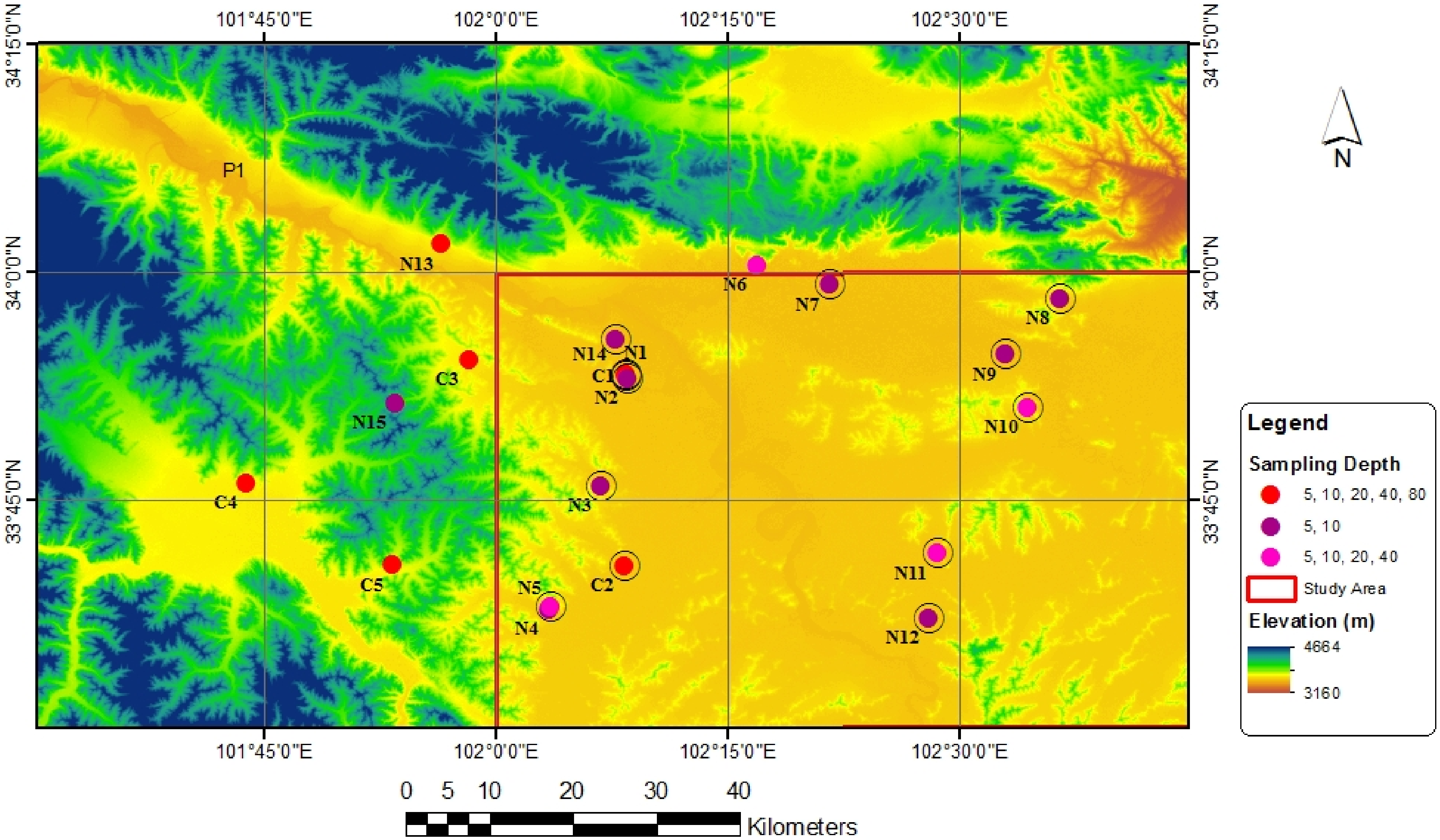
Installation of data Logger

Installation of probes at different depths



Typical landscapes of Maqu catchment

Study Area and Observation network (contd.)



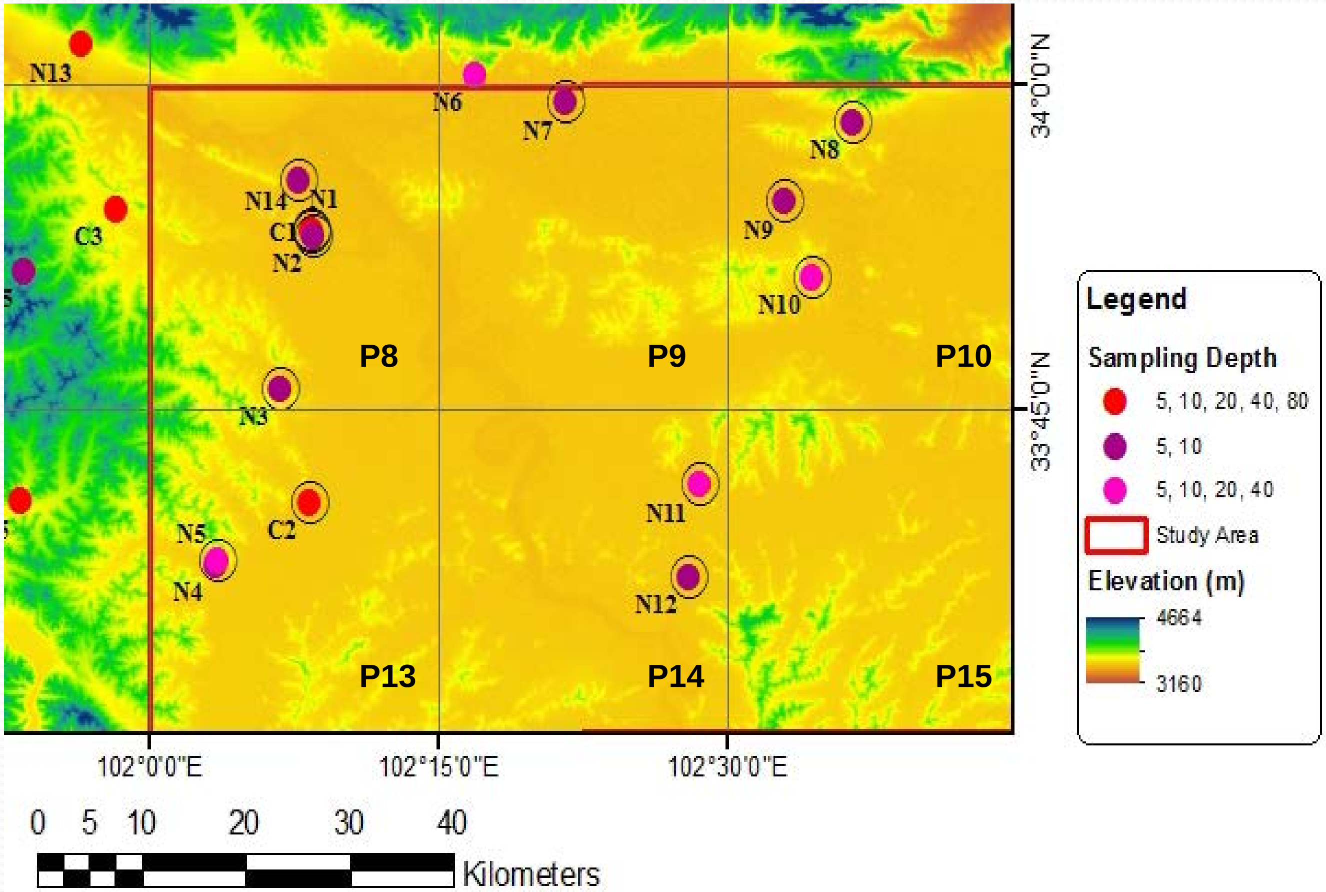
DEM of the Maqu catchment. Locations of the measuring sites are indicated by dots and stations selected for analysis are indicated by circular borders outside dots.

Research Objectives

- To identify the RMSM station for each probe depth
- To assess the variability of soil moisture at different depths
- To identify the soil depth that shows best RMSM
- To evaluate RMSM pixel from AMSR-E
- To evaluate how well the AMSR-E estimates match to observations at the RMSM stations for the respective depths
- To assess how temporal stability is affected by wetness
- To identify the minimum time for sampling to choose the RMSM station

Methodology

- Data screening
- Temporal stability analysis
  - MRD plot
    - MRD
    - SD
- RMSM station at each depth
- RMSM pixel
- Comparison
- Sampling period



Methodology (contd.)

- MRD Plot compares each soil moisture station estimate to the network average soil moisture estimates from all the stations
- Stations are ranked from lowest to highest on the basis of MRD
- Identifies wet, dry and RMSM stations of the catchment

Methodology (contd.)
MRD plot

$$\bar{\delta}_i = \frac{1}{m}\sum_{j=1}^{m}\delta_{ij} \qquad \delta_{ij} = \frac{S_{ij} - \bar{S}_j}{\bar{S}_j} \qquad \bar{S}_j = \frac{1}{N}\sum_{j=1}^{m} S_{ij} \qquad \sigma(\delta_i) = \left(\frac{\left(\delta_{ij} - \bar{\delta}_i\right)^2}{m-1}\right)^{\frac{1}{2}}$$

$\bar{\delta}_i$ = MRD soil moisture

m = number of sampling days$_i$

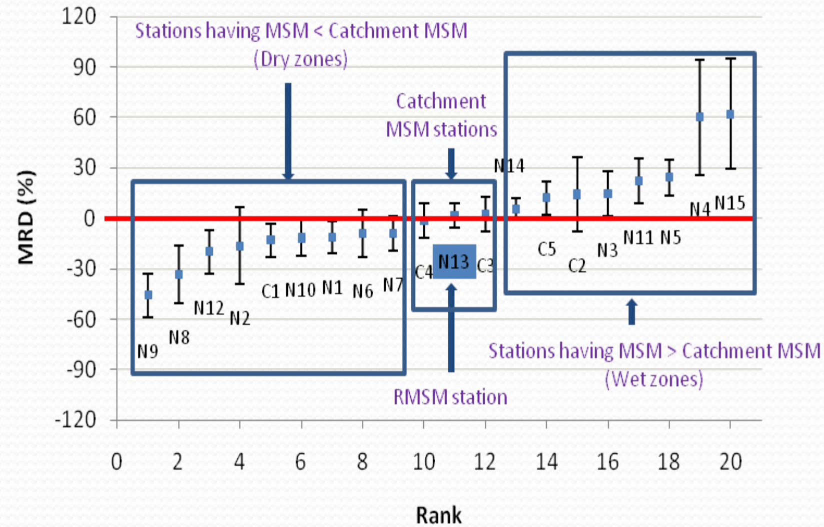
δ_{ij} = relative difference at location 'i' on day 'j'

S_{ij} = soil moisture at location 'i' on day 'j'

$\bar{S}_j$ = average soil moisture on day 'j'

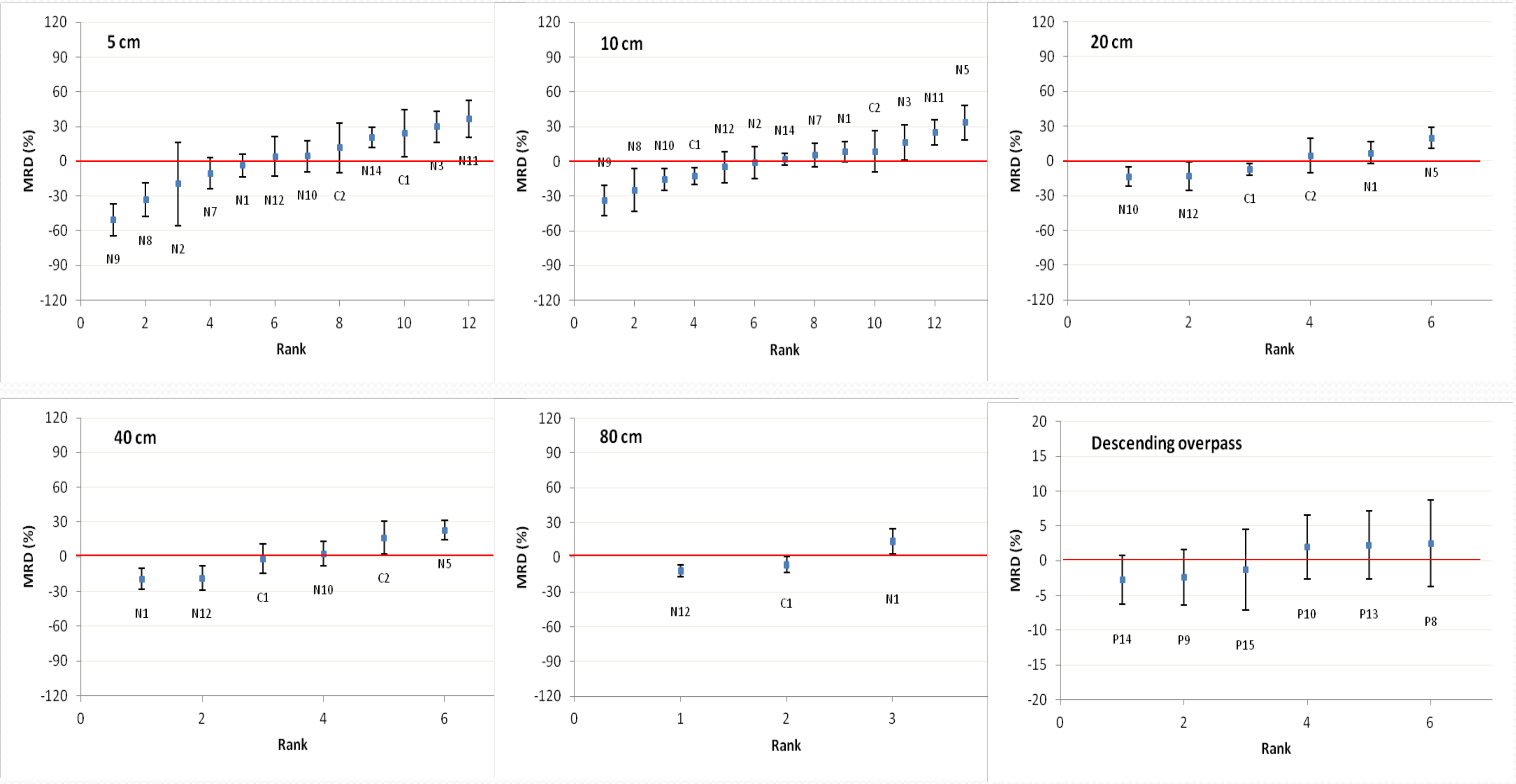
N = number of sampling locations

$\sigma(\delta_i)$ = SD of the MRD at each location



Typical MRD plot

RMSM stations and RMSM pixel

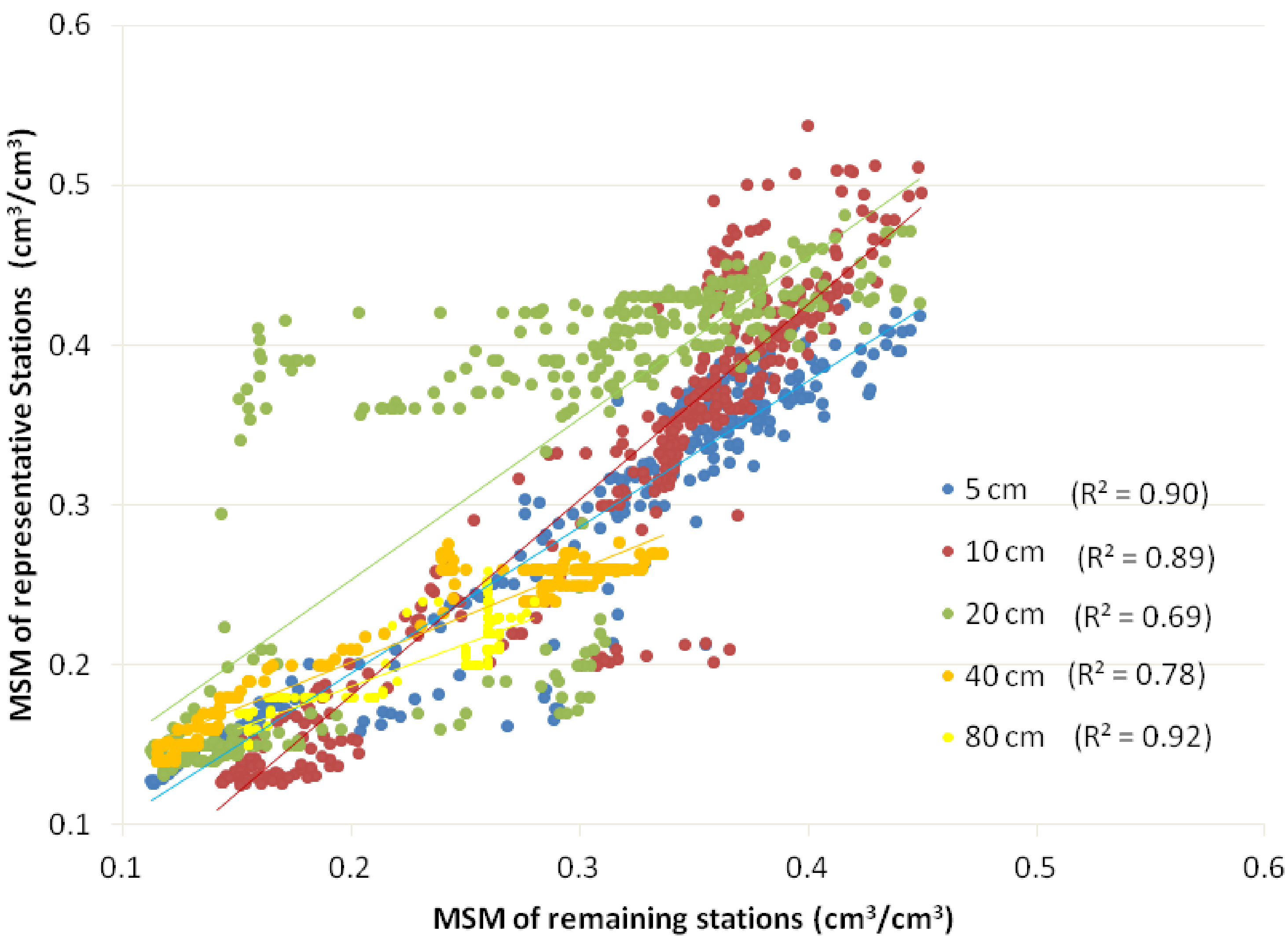


SM variability at different depths

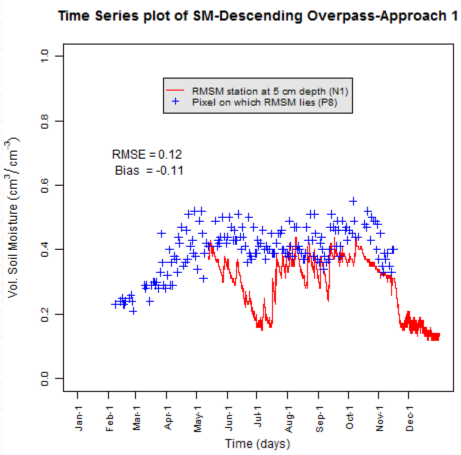
Depth (cm)	MRD (%)			SD(MRD) (%)		
	Min	Max	Range	Min	Max	Range
5	-51	+36	87	8	36	26
10	-34	+34	68	5	18	13
20	-13	+20	33	5	15	10
40	-19	+23	42	8	13	5
80	-12	+14	26	5	10	5

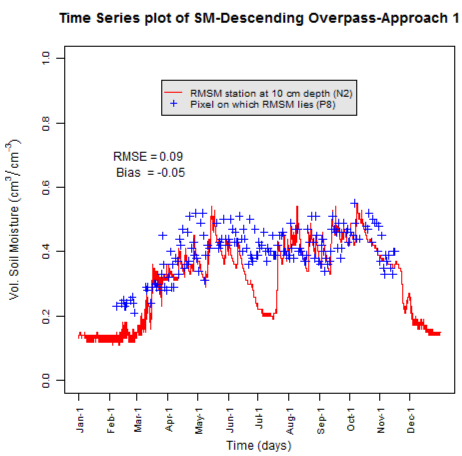
- Error bars of the stations either reduces or remains the same (except C1 at 40 cm depth)
  - Variability of soil moisture either decrease or remains the same as we move from ground to the soil profile.
- At 80 cm depth, MRD decreases at all stations. At this depth, the range of MRD values in general is smallest but also closest to the zero.
  - Probes installed at this depth best represent the catchment MSM.
- Range of SD(MRD) at 40 and 80 cm depth is smaller than the other.
  - Sensors installed at these depths are temporally stable.
- Summing up the above remarks, the MRD plot suggests that soil moisture observations at 80 cm depth is most representative for estimating the catchment MSM.

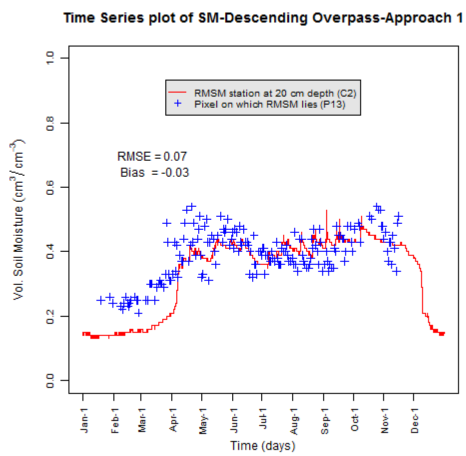
Coefficient of determination

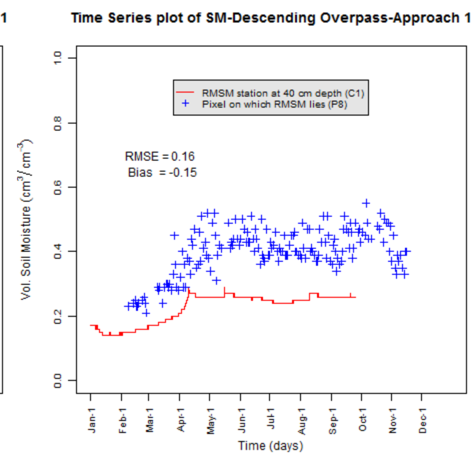


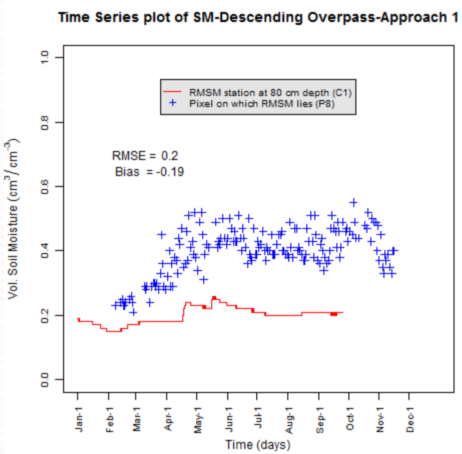
Time series analysis











Comparison between RMSM station and RMSM pixel

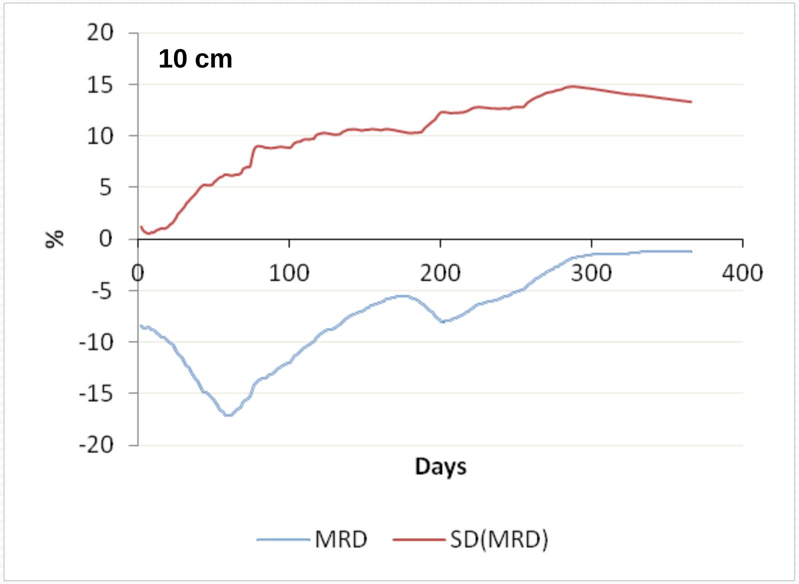
Depth (cm)	RMSM station	Pixel no.	RMSE	Bias
5	N1	P8	0.12	-0.11
10	N2	P8	0.09	-0.05
20	C2	P13	0.07	-0.03
40	C1	P8	0.16	-0.15
80	C1	P8	0.20	-0.19

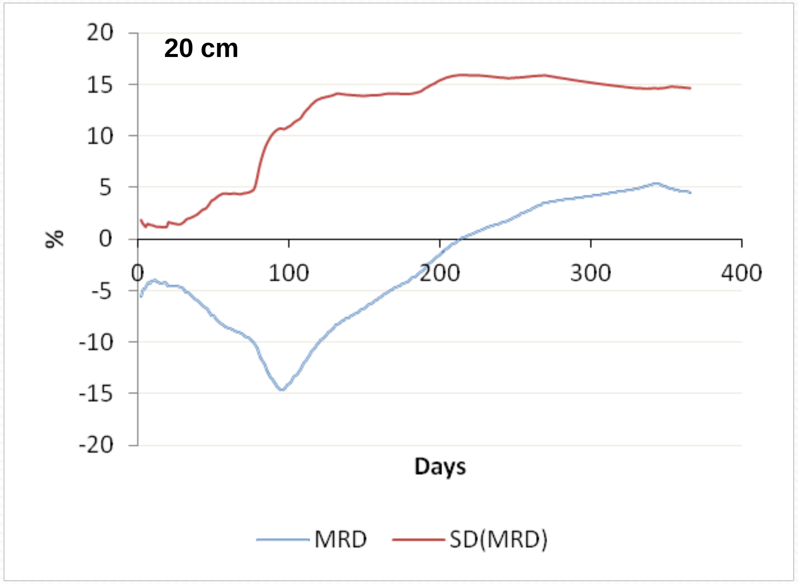
Wet and dry stations

Depth (cm)	Driest station		Wettest station	
	Name	SD(MRD) %	Name	SD(MRD) %
5	N9	14	N11	16
10	N9	13	N5	15
20	N10	8	N5	9
40	N1	9	N5	8
80	N12	5	N1	10

- As we proceed from top to bottom of the observation depth, the SD(MRD) value decreases for both the wettest and the driest station (except N1 at 40 and 80 cm depth for the driest and wettest stations respectively)
  - It suggests that at the bottom of the profile where climatic, biological and hydrological factors are less predominant, high temporal stability is observed in dry stations
  - It shows that dry stations are temporally stable than wet stations

Sampling period





- Stabilization of MRD and SD of (MRD) for 10 cm depth occurs at the end of the sampling period
- The trend of both the parameters is same at most of the locations (days) and the MRD is approaching towards the zero line at the end of sampling period
- However, it shows unstablity between MRD and SD(MRD) for the RMSM station at 20 cm depth

Conclusions

- RMSM varies at each probe depth and thus a single RMSM station cannot be identified (objective 1).
- Variability of soil moisture decreases as we proceed from top to bottom of soil profile (objective 2).
- High coefficient of determination between the selected RMSM station at each depth and MSM of the remaining catchment stations indicate that the temporal stability approach can be used to identify RMSM station for each respective depth.
- Sensors installed at 80 cm depth at each station are best representative of the catchment MSM (objective 3).

Conclusions (contd.)

- RMSM pixel can be identified by temporal stability approach. Identified pixels suggests that network may require optimization to represent MSM conditions (objective 4).
- Time series analysis suggests that satellite observations best match to observations indicating RMSM for probes installed at 20 cm depth (objective 5).
- Drier stations are more temporally stable than wet stations (objective 6).
- Minimum observation period should cover an annual cycle for the selection of RMSM station (objective 7).

Thanks for your attention!!

Questions
are
guaranteed in life;
answers
aren't….