Validation of in-situ soil parameters over India

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Introduction

•The Indian monsoon zone is one of the major 'hot spots' where soil-moisture variations have a significant impact on the precipitation even on the synoptic timescale.

•Soil moisture is highly variable and depends on the precipitation, land use/ land cover, soil texture. Satellite observation with a wide horizontal coverage is more useful than the in-situ observations. ASCAT soil moisture observations are assimilated in the NCMRWF land data assimilation system along with surface pseudo observations (2m temperature and humidity) through EKF method

•India meteorological Department (IMD) installed 200 Agromet Automatic Weather Stations (Agro-AWS) at District AgroMet Units (DAMUs) under Indian Council of Agricultural Research (ICAR) network to augment block level Agromet Advisory Services (AAS)

•These Agromet advisories are aimed to help farmers to make decisions on day-to-day agricultural operations.

•This in turn helps to optimize the resources at the farm level during deficient and extreme weather events to reduce loss and maximize crop yield

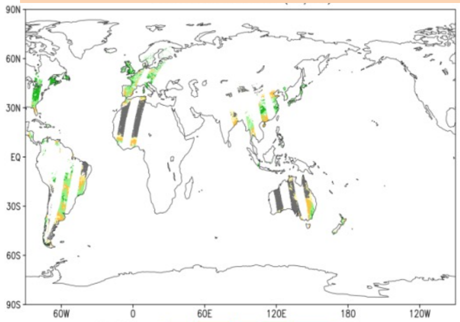
Soil Moisture assimilation at NCMRWF

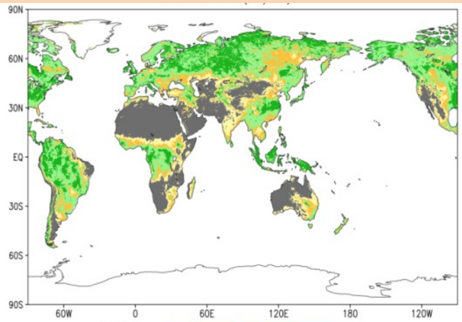
Improvements in Soil Moisture Assimilation

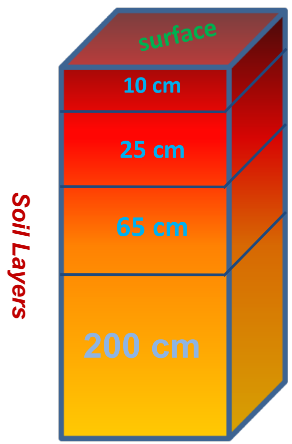
- Soil Moisture (SM) Nudging Scheme using Screen level analysis (July -2014)
- SM Nudging scheme (ASCAT + Screen analysis) (Aug- 2014)
- Extended Kalman filter for Soil Moisture Assimilation (Oct-2015)

NCUM Soil Moisture Assimilation	
Domain	Global & Regional
Resolution	12 km (Global), 4 km (regional)
Soil Levels	4
Data Assimilation (DA) Method	Extended Kalman Filter (EKF)
DA Frequency	6 hours
Observation	Satellite: ASCAT Soil Moisture (MetOp-A and MetOp -B) Pseudo observations: Screen level Temperature and Humidity

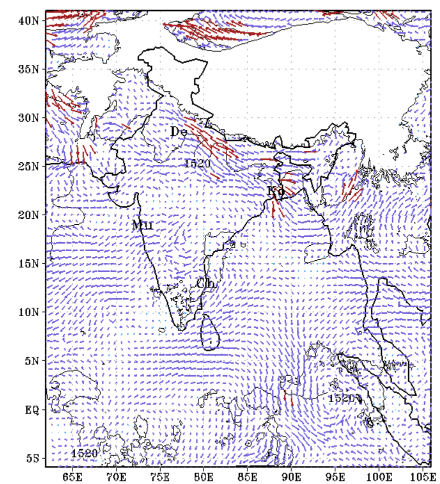
ASCAT Observation & SM Analysis







Regional Domain



Background

In-situ soil moisture observation sites (2016)

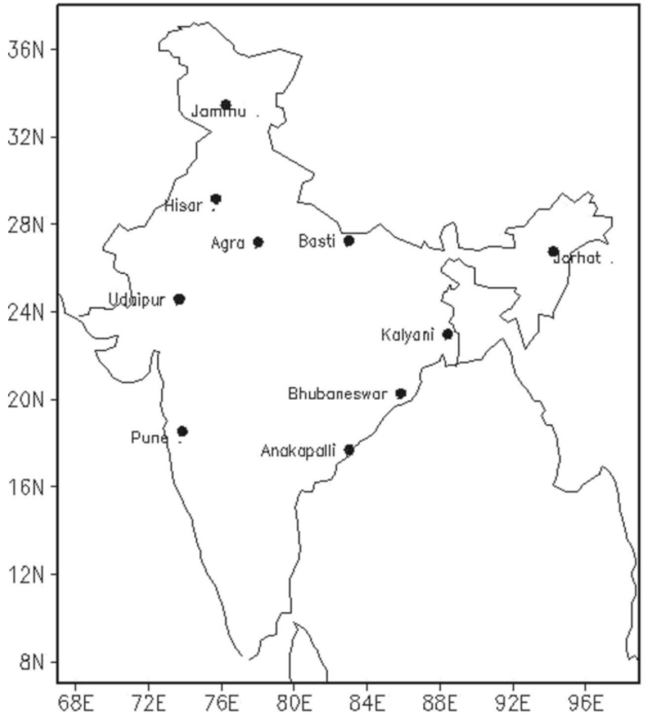


Table 2. *Seasonal mean soil moisture values (m^3/m^3) over central India (18°–27°N; 72°–85°E).*

Season/data	UKMO	NRSC	AMSR-2	Difference (NRSC−UKMO)	Difference (AMSR-2−UKMO)
Winter	0.071	0.157	0.290	+0.086	+0.219
Pre-monsoon	0.065	0.085	0.181	+0.02	+0.116
Monsoon	0.315	0.189	0.332	−0.126	+0.017
Post-monsoon	0.132	0.169	0.301	+0.037	+0.169

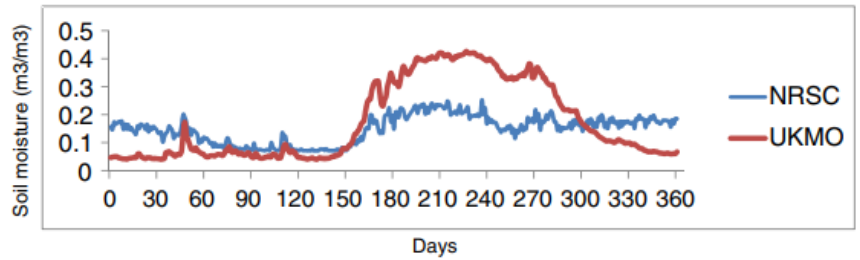


Figure 4. Time series of daily mean soil moisture (m^3/m^3) of NRSC and UKMO over central India during the year 2013.

https://doi.org/10.1007/s12040-016-0714-x (Unnikrishnan et al., 2016)

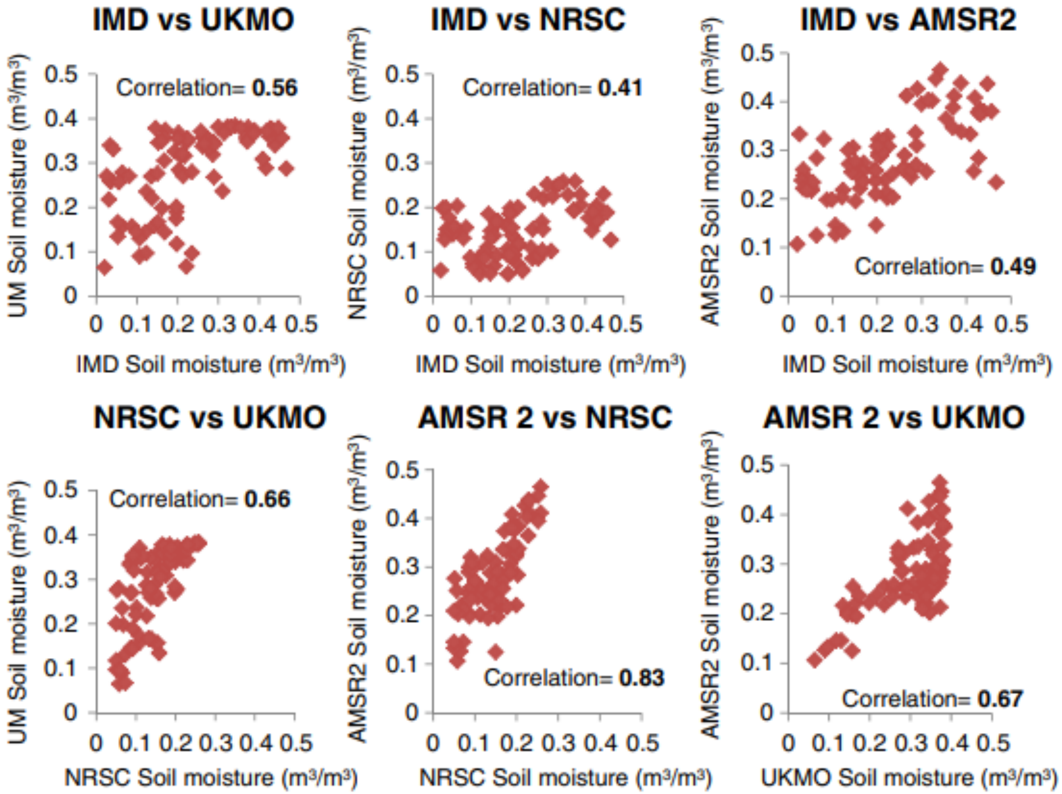
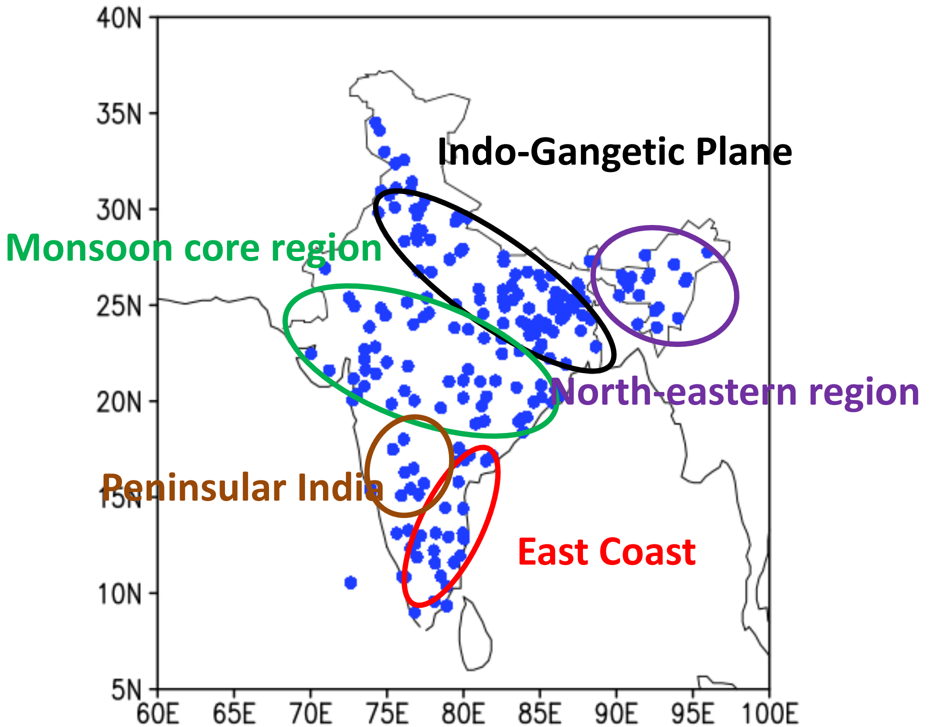


Figure 5. Scatter plots between different soil moisture data used in this study during monsoon 2013: IMD observations *vs.* UKMO soil moisture (top left), IMD *vs.* NRSC (top middle), IMD *vs.* AMSR-2 soil moisture (top right), NRSC *vs.* UKMO soil moisture (bottom left), AMSR-2 *vs.* NRSC (bottom middle) and AMSR-2 *vs.* UKMO soil moisture (bottom right).

https://doi.org/10.1007/s12040-016-0714-x (Unnikrishnan et al., 2016)

Current Network of Agro-AWS over India



State/UT	Number of stations	State/UT	Number of stations
Andhra Pradesh	9	Manipur	1
Arunachal Pradesh	3	Meghalaya	2
Assam	8	Mizoram	1
Bihar	14	Nagaland	2
Chhattisgarh	9	Odisha	10
Delhi	1	Punjab	5
Goa	2	Rajasthan	9
Gujarat	9	Sikkim	2
Haryana	6	Tamilnadu	10
Himachal Pradesh	4	Telangana	4
Jharkhand	17	Tripura	1
Jammu & Kashmir	4	Uttar Pradesh	17
Karnataka	12	Uttarakhand	3
Kerala	3	West Bengal	6
Madhya Pradesh	14	Puducherry	1
Maharashtra	10	Lakshadweep	1

Observation Depths: 10cm, 30 cm, 70 cm and 1m

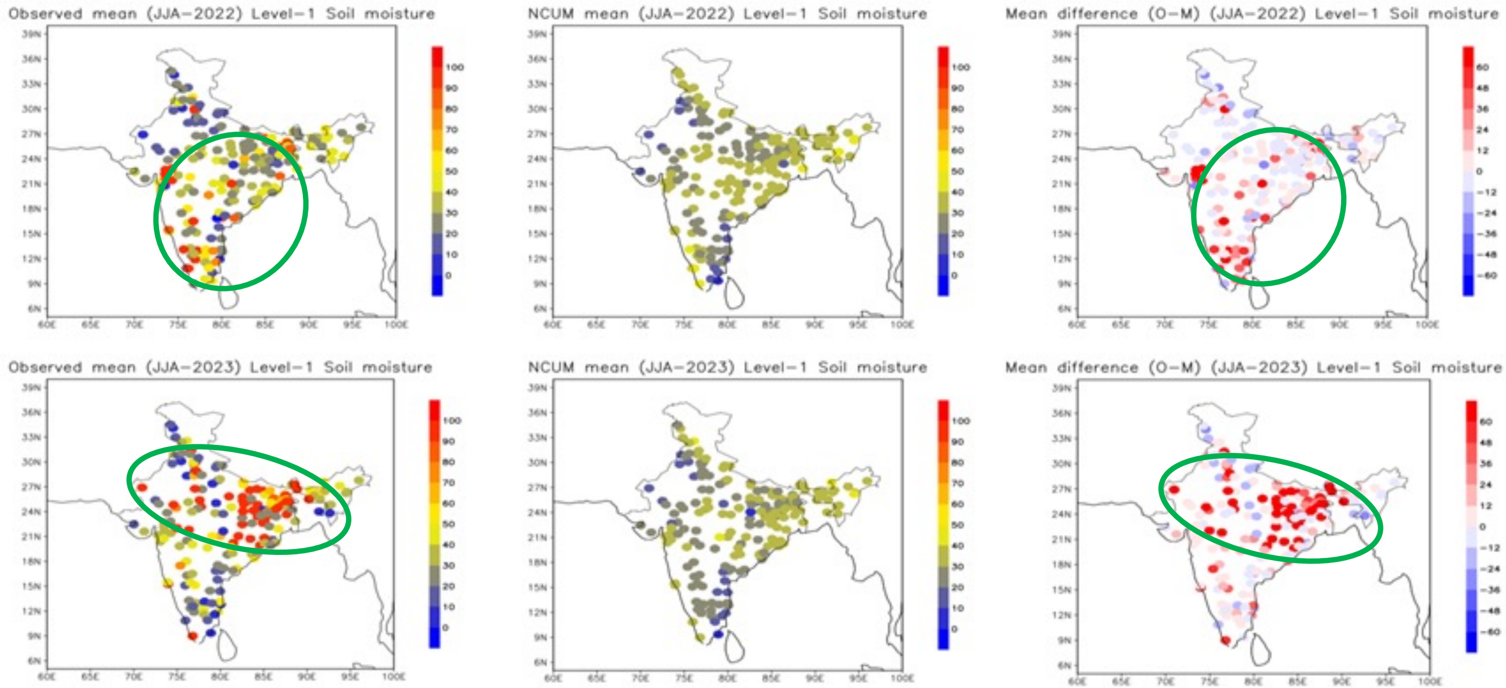
Model Levels: 10 cm, 25 cm, 65 cm and 2 m

Comparison of in-situ and model equivalent level-1 Soil Moisture during monsoon (JJA)

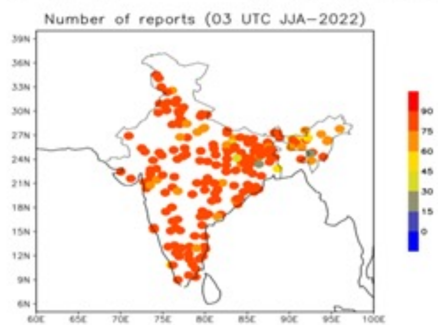
Observation | **Model** | **Observation - Model**

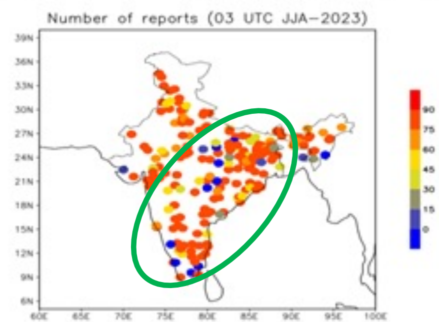
2022

2023



Count (2022)





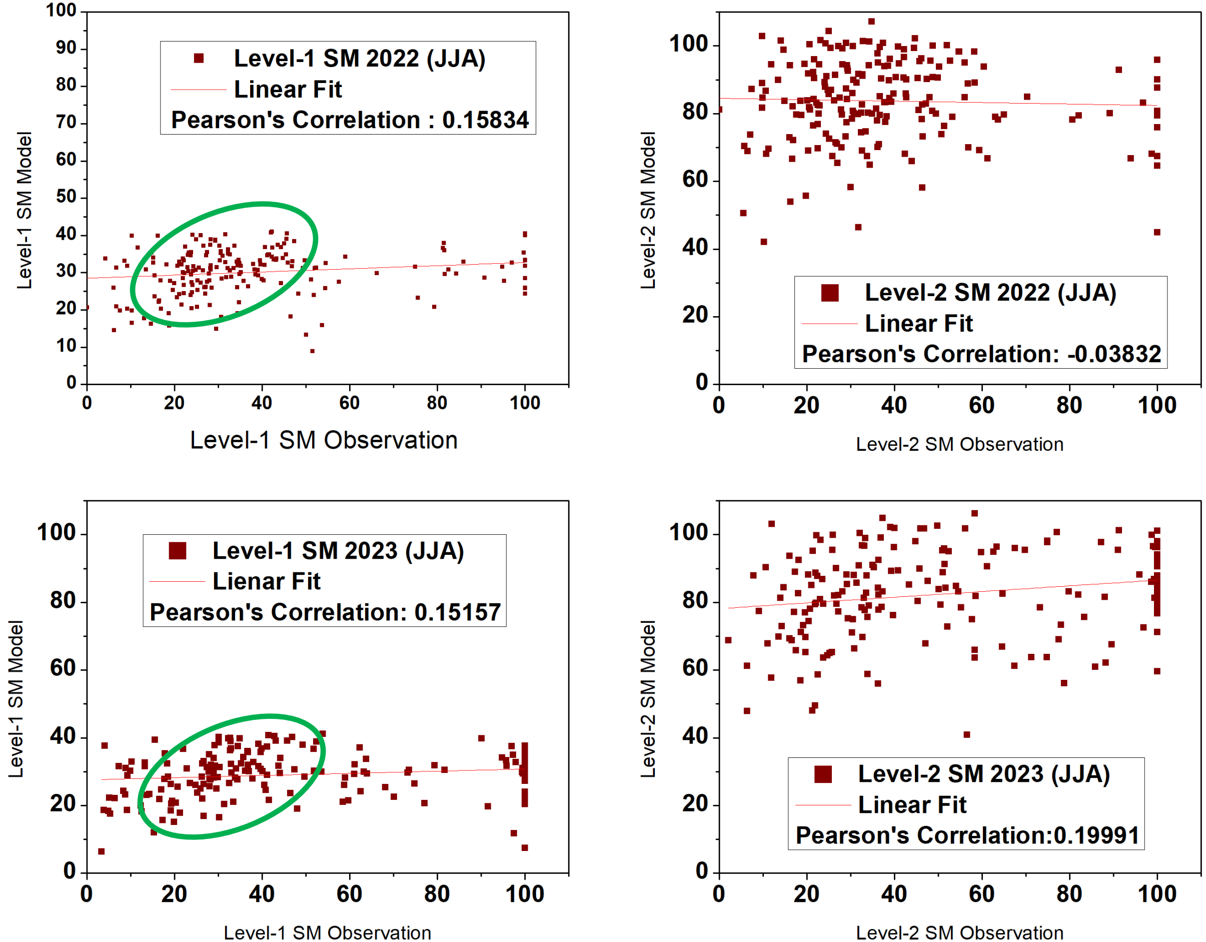
Count (2023)

Correlation between Observed and model equivalent soil moisture

Level-1 | **Level-2**

2022

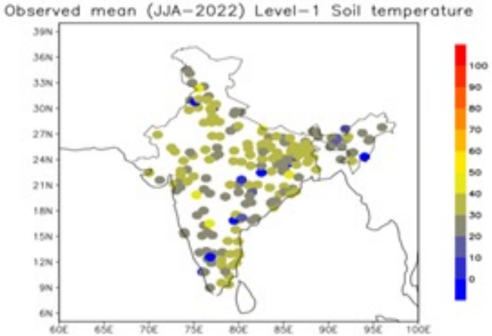
2023

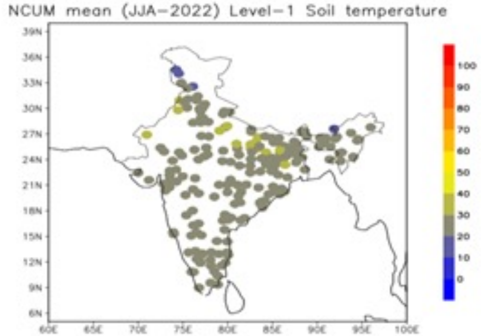


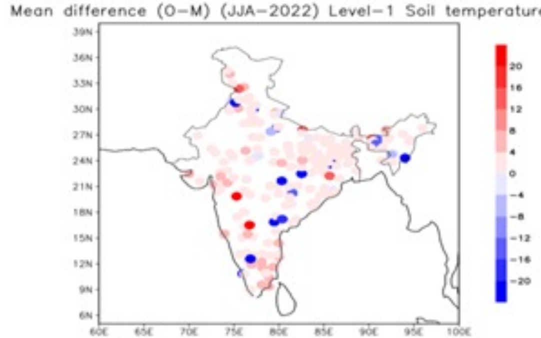
Comparison of in-situ and model equivalent level-1 Soil Temperature during monsoon (JJA)

Observation | **Model** | **Observation - Model**

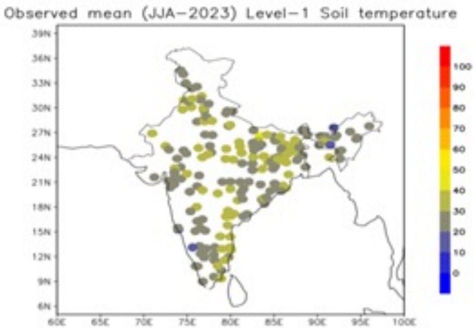
2022

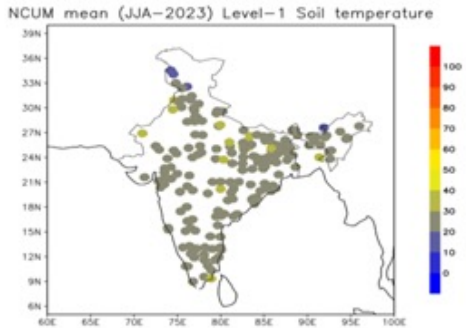


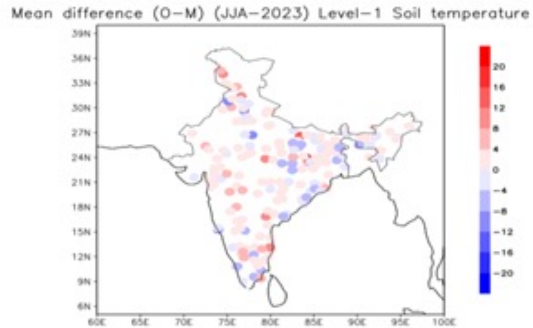




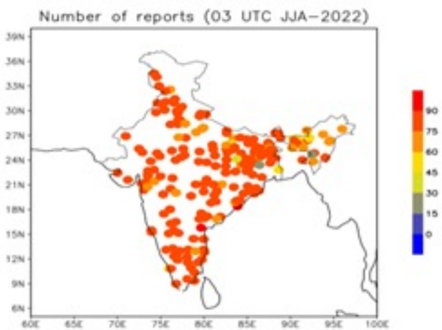
2023

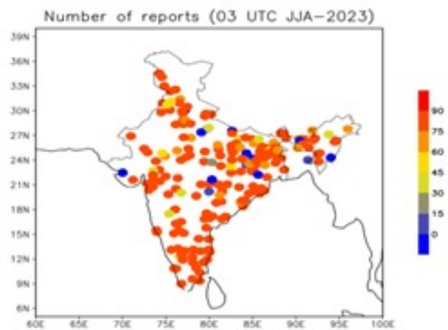






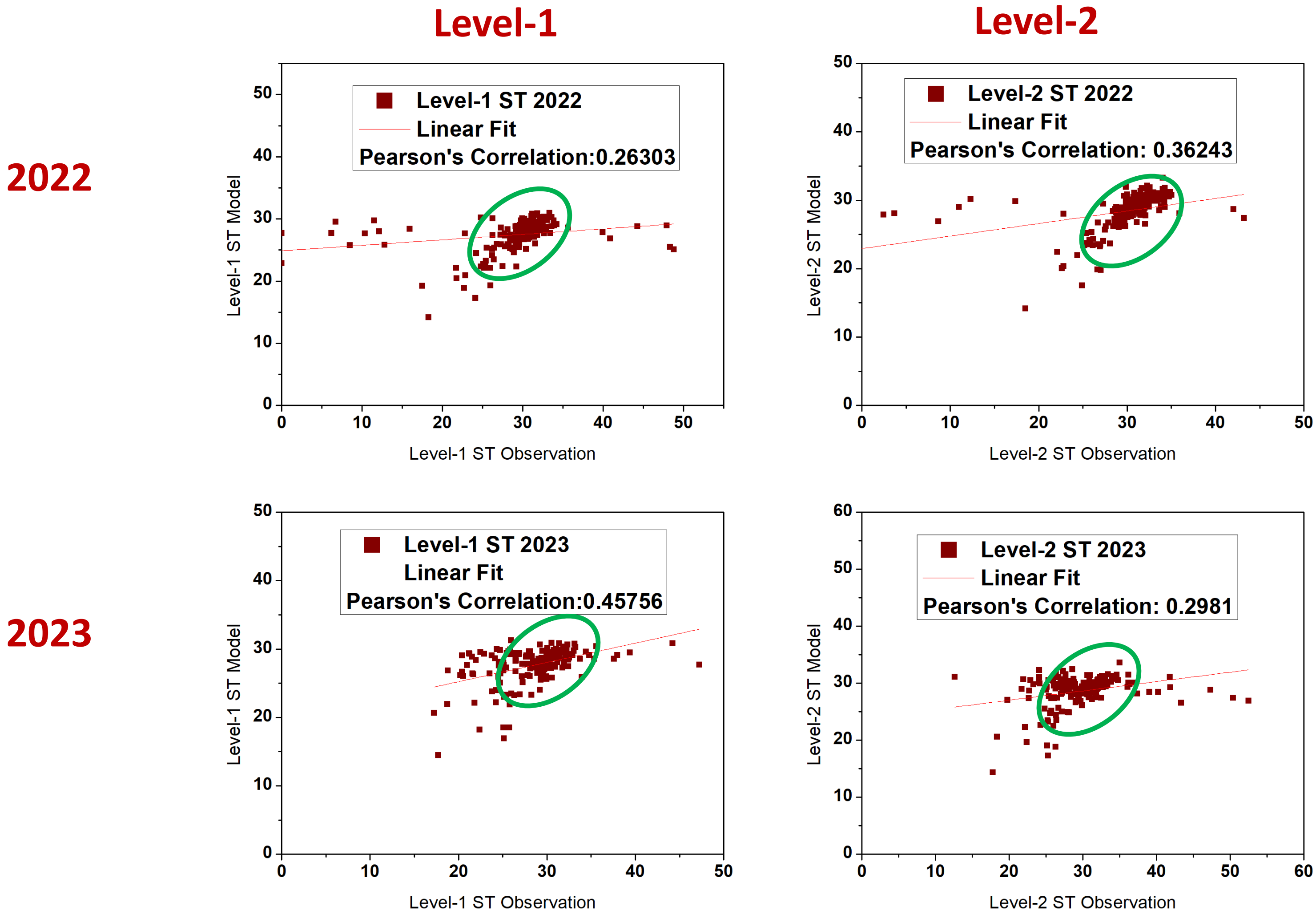
Count (2022)





Count (2023)

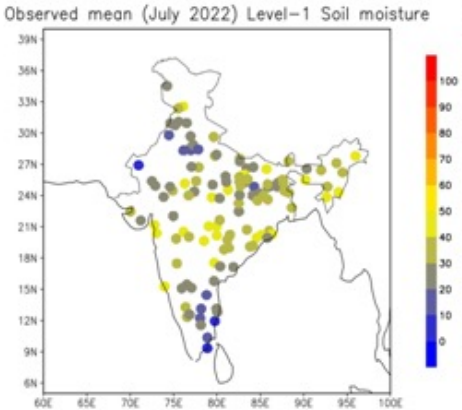
Correlation between Observed and model equivalent soil temperature

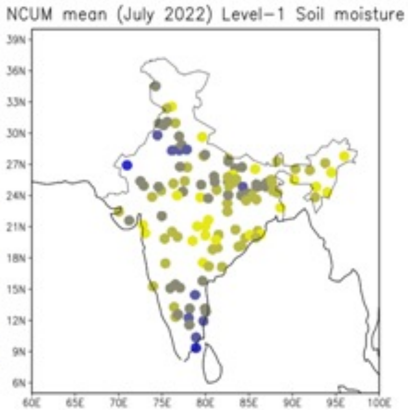


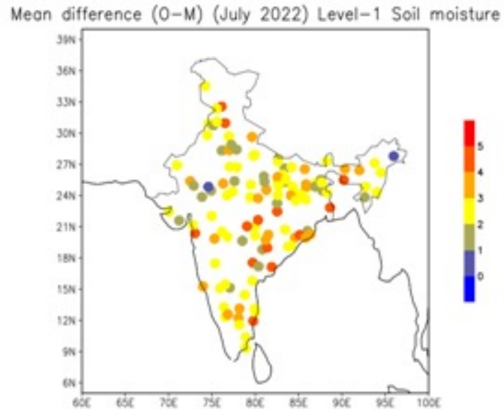
Comparison of in-situ and model equivalent level-1 Soil Moisture during monsoon (JJA) (Observation – Model < 5 kg/kg)

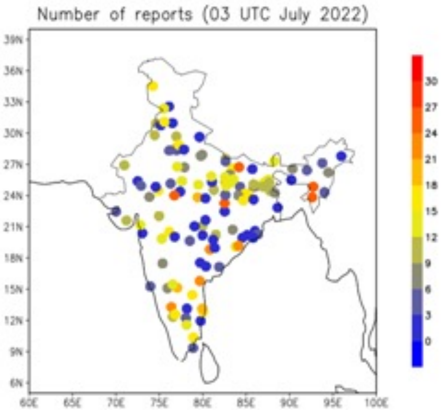
Observation | **Model** | **Observation - Model** | **Count**

2022

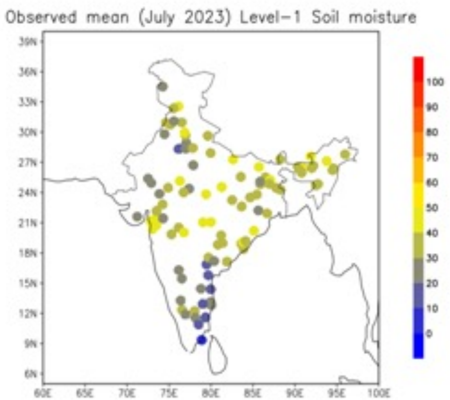


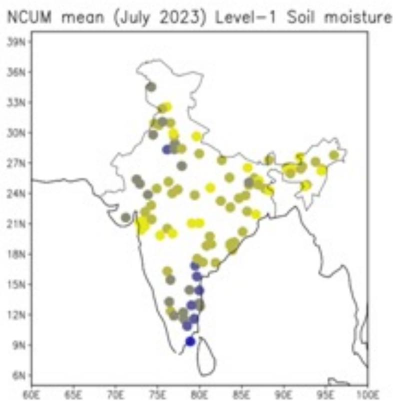


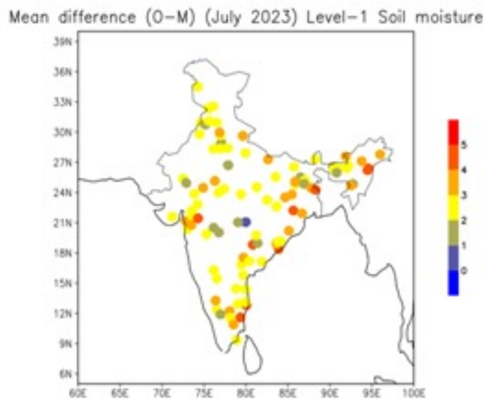


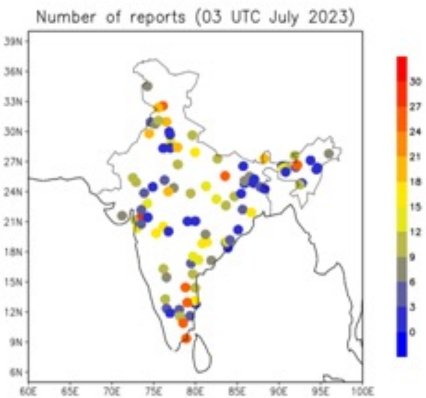


2023







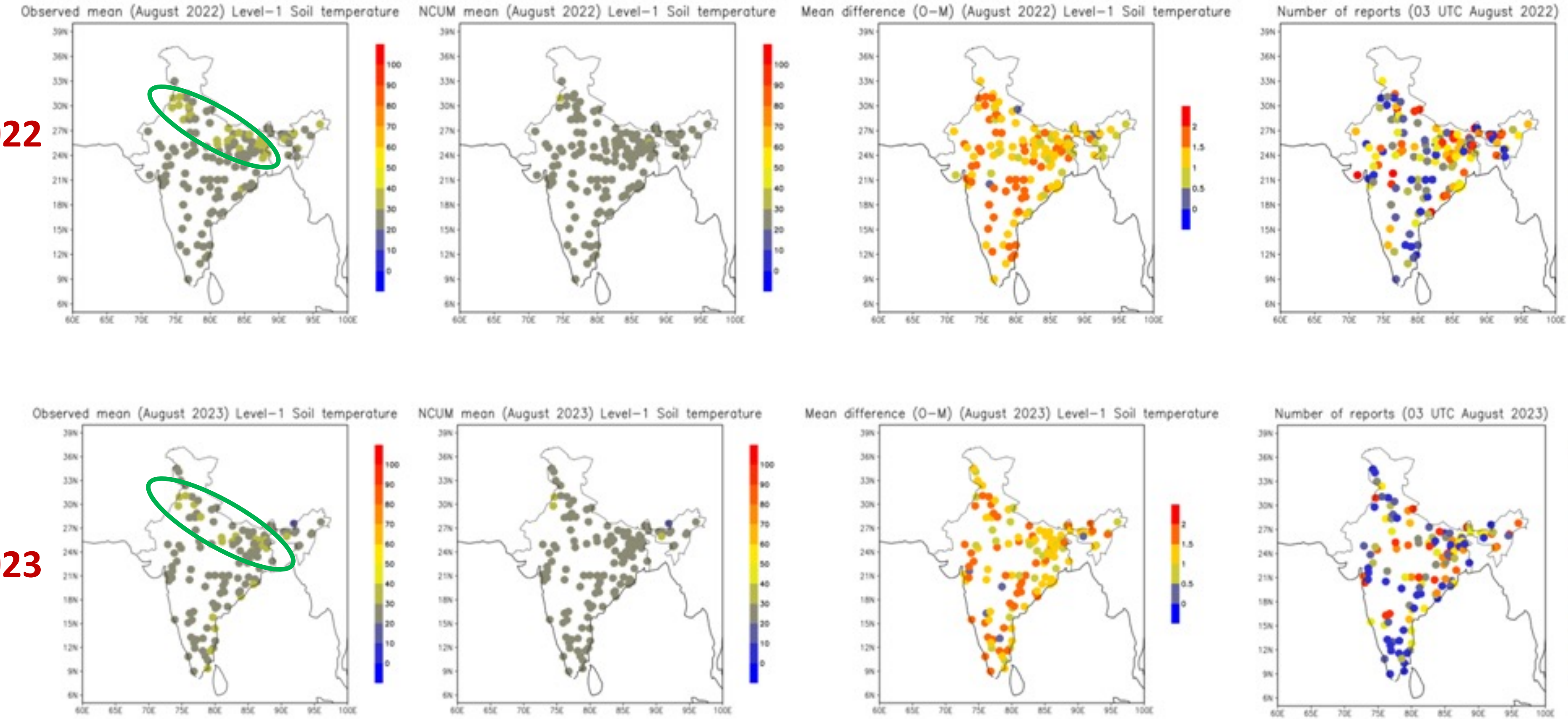


Comparison of in-situ and model equivalent level-1 Soil Temperature during monsoon (JJA)
(Observation – Model < 2K)

Observation | **Model** | **Observation - Model** | **Count**

2022

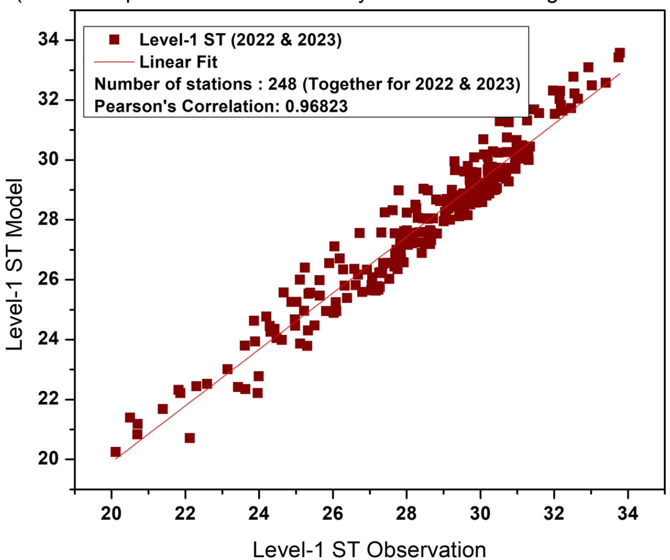
2023



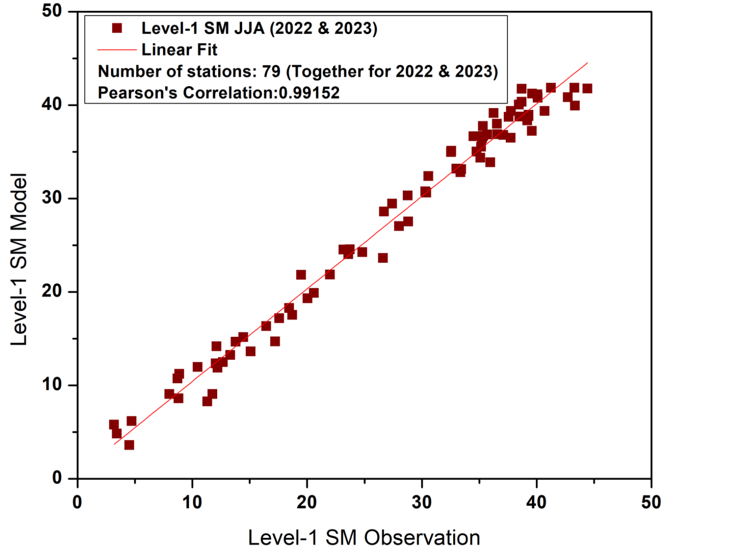
Number of stations which reported Soil Moisture and Soil Temperatures more than twenty days in a month

	Soil Moisture (Difference ≤ 5 kg/kg)		Soil Temperature (Difference ≤ 2 K)	
Month	**2022**	**2023**	**2022**	**2023**
June	**11**	**11**	**28**	**49**
July	**14**	**10**	**50**	**47**
August	**20**	**24**	**41**	**33**

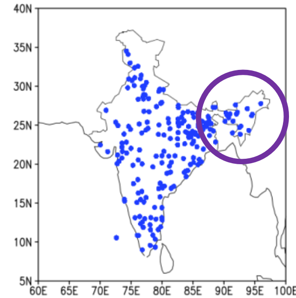
Soil Temperature Observation and Model equivalents with differences ≤ 2 K (stations reported more than 20 days in a month during JJA 2022 and 2023)

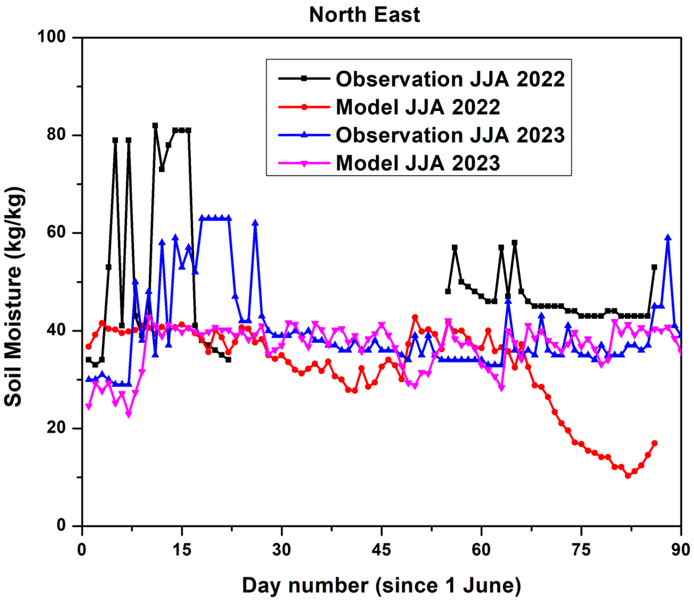


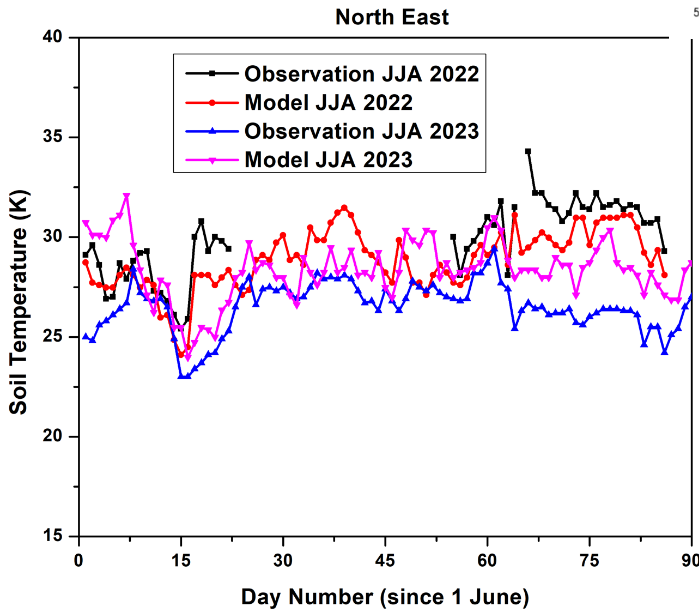
Soil Moisture Observation and Model equivalents with differences ≤ 5 kg/kg (stations reported more than 20 days in a month during JJA 2022 and 2023)



Time series: North East



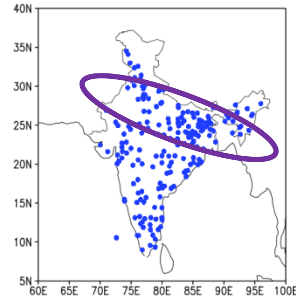


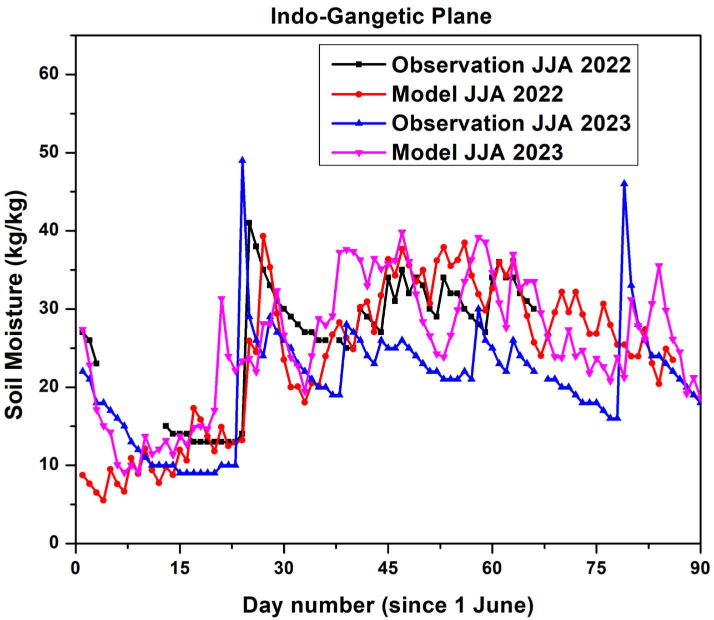


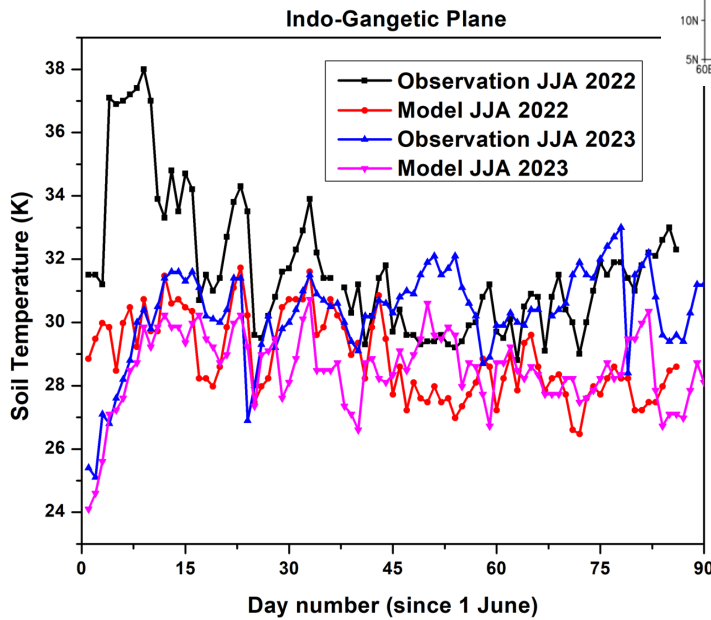
SM: Not much variation in the model compared to the observation

ST: Warm bias (2022) and cold bias (2023). Model able to captured the trend in the observations

Time series: Indo-Gangetic Planes



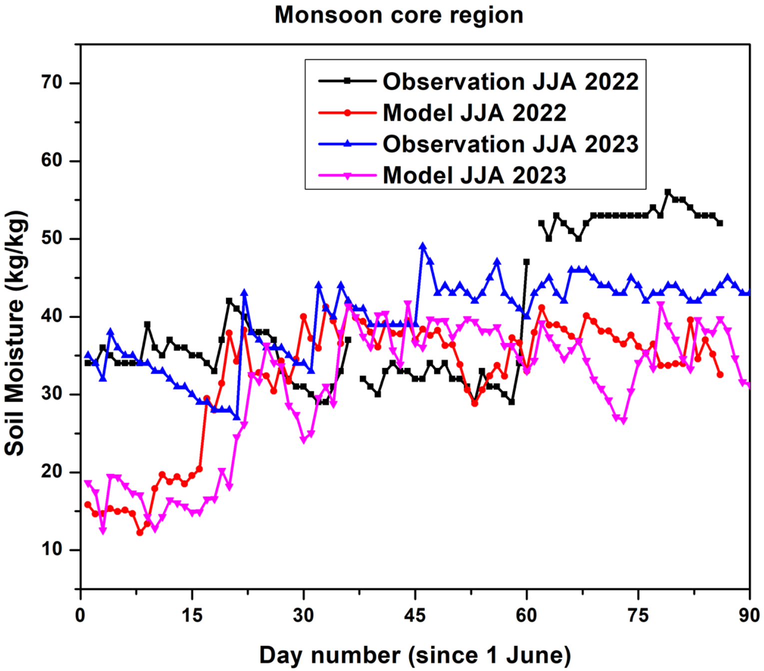


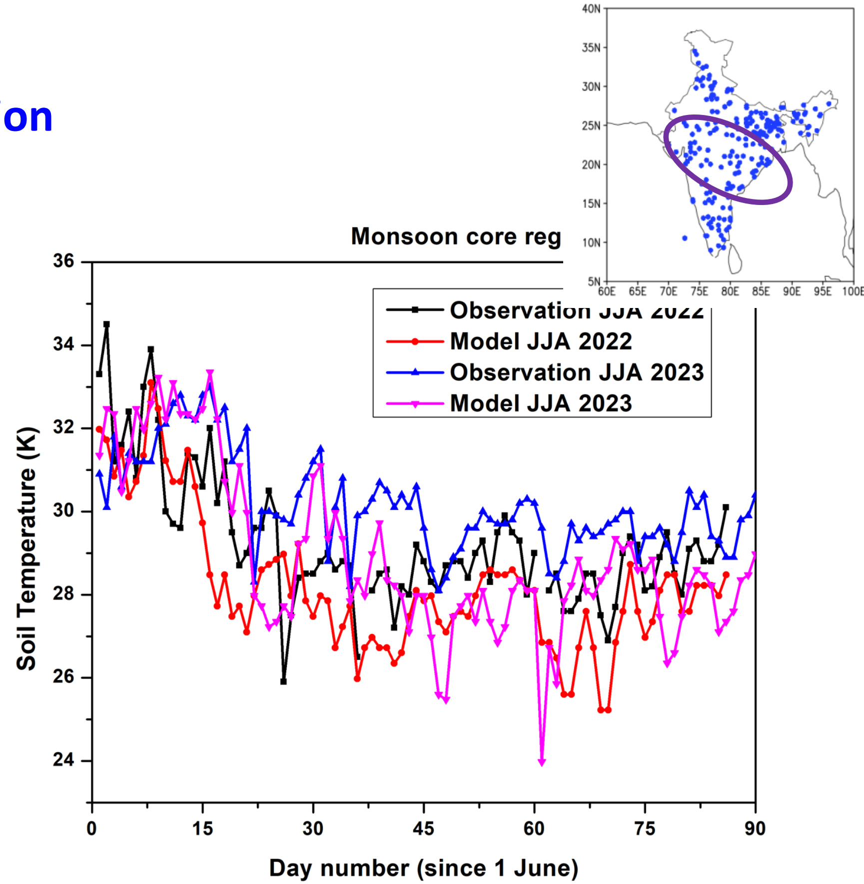


SM: Model captured the trend in the observation

ST: Warm biases. Model captured the trend in the observations

Time series: Monsoon Core Region

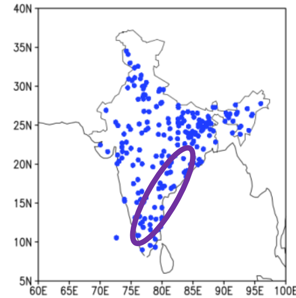


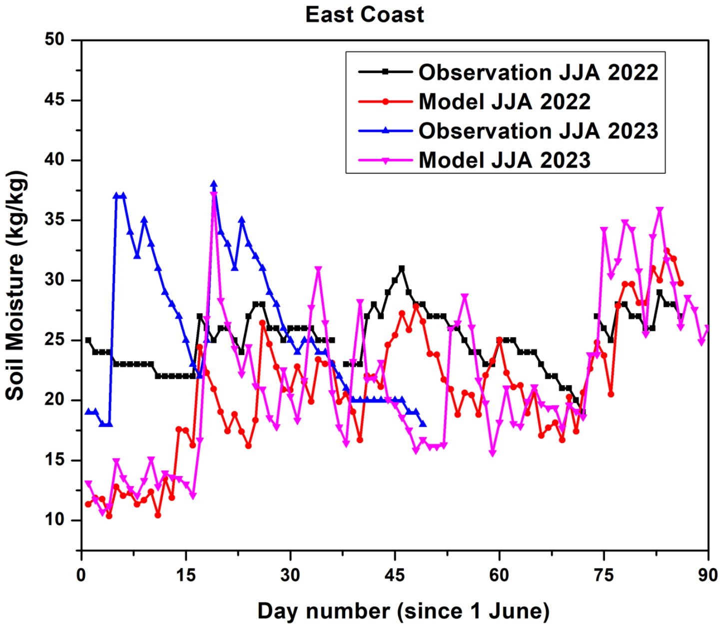


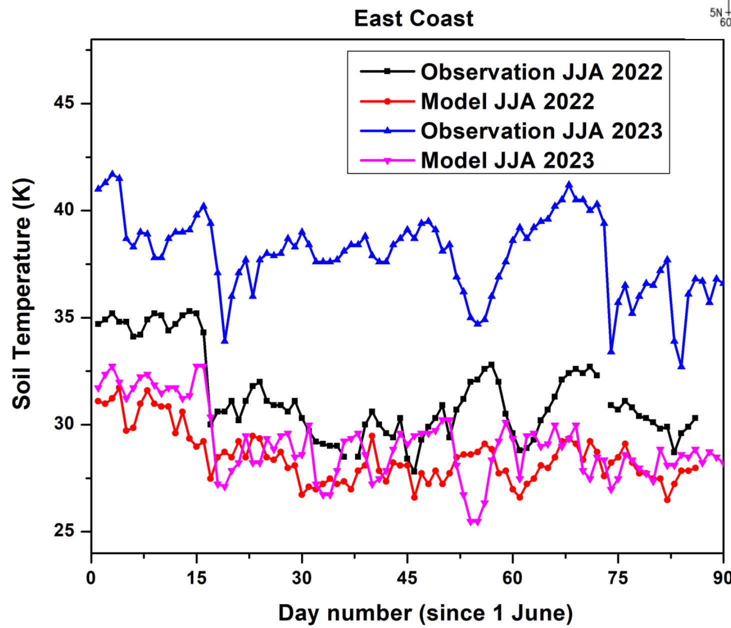
SM: Increasing trend in soil moisture during peak monsoon (July, August).

ST: Warm biases. Decreasing trend during peak monsoon

Time series: East coast



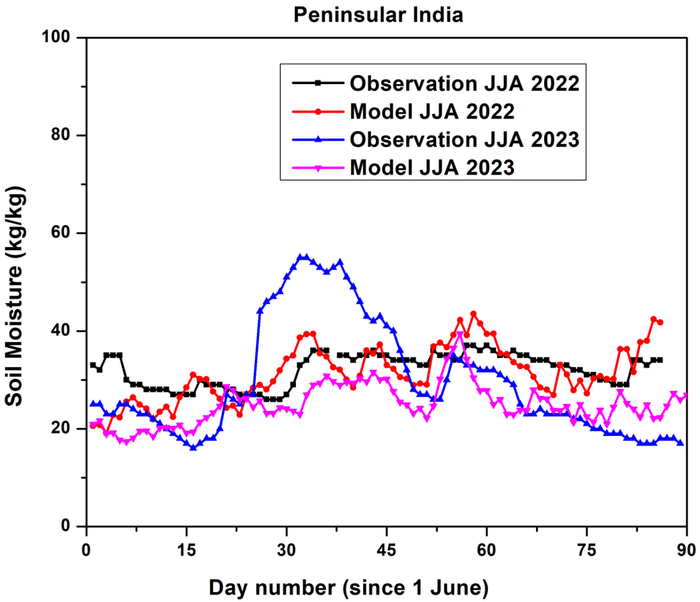


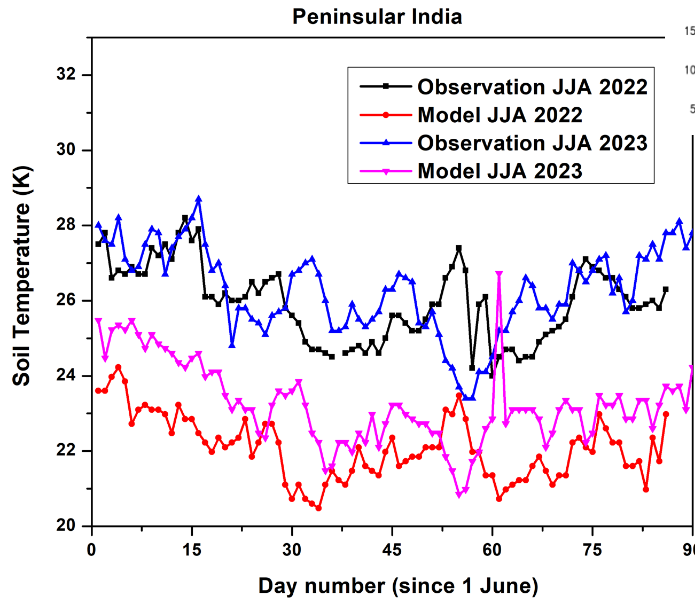


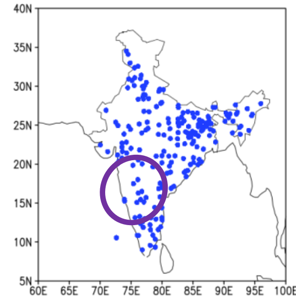
SM: Model captured the trend

ST: Warmer biases compared to other homogenous regions.

Time series: Peninsular India







SM: Model captured the trend

ST: Warmer biases compared to other homogenous regions.

Summary

•IMD has installed 200 Agro-AWS stations aimed to help farmers to make decisions on day-to-day agricultural operations

•Validated the insitu soil moisture and soil temperature from the Agro AWS against the model equivalents for two consecutive monsoon seasons (JJA 2022, 2023).

•Analysed SM and ST over different homogenous regions like north east, Indo Gangetic planes, Monsoon core region, east coast and peninsular India.

•Better agreement of ST observations with model than SM

•In general, biases were more over the East coast and peninsular India during 2022, while the biases were more over the monsoon core region during 2023.

•Poorer correlation over Pan India for both SM and ST. Improved correlation between the observation and the model equivalents for SM and ST (> .96), when the differences are less than 5 kg/kg and 2K. However the number of stations reporting the observations were lesser

•SM and ST show distinct characteristics over different homogenous regions, the influence of monsoon.

Thank you