Validation of two gridded soil moisture products over India with *in-situ* observations

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Surface level soil moisture from two gridded datasets over India are evaluated in this study. The first one is the UK Met Office (UKMO) soil moisture analysis produced by a land data assimilation system based on Extended Kalman Filter method (EKF), which make use of satellite observation of Advanced Scatterometer (ASCAT) soil wetness index as well as the screen level meteorological observations. Second dataset is a satellite soil moisture product, produced by National Remote Sensing Centre (NRSC) using passive microwave Advanced Microwave Scanning Radiometer 2 measurements. *In-situ* observations of soil moisture from India Meteorological Department (IMD) are used for the validation of the gridded soil moisture products. The difference between these datasets over India is minimum in the non-monsoon months and over agricultural regions. It is seen that the NRSC data is slightly drier (0.05%) and UKMO soil moisture analysis is relatively wet during southwest monsoon season. Standard AMSR-2 satellite soil moisture product is used to compare the NRSC and UKMO products. The standard AMSR-2 and UKMO values are closer in monsoon season and AMSR-2 soil moisture is higher than UKMO in all seasons. NRSC and AMSR-2 showed a correlation of 0.83 (significant at 0.01 level). The probability distribution of IMD soil moisture observation peaks at 0.25 m³/m³, NRSC at 0.15 m³/m³, AMSR-2 at 0.25 m³/m³ and UKMO at 0.35 m³/m³ during June–September period. Validation results show UKMO analysis has better correlation with *in-situ* observations compared to the NRSC and AMSR-2 datasets. The seasonal variation in soil moisture is better represented in UKMO analysis. Underestimation of soil moisture during monsoon season over India in NRSC data suggests the necessity of incorporating the actual vegetation for a better soil moisture retrieval using passive microwave sensors. Both products have good agreement over bare soil, shrubs and grassland compared to needle leaf tree, broad leaf tree and urban land cover types.

1. Introduction

The soil moisture information is an important input for many applications including numerical weather prediction (NWP), drought monitoring and prediction (Narasimhan and Srinivasan 2005), watershed management (Susan Moran *et al.* 2004),

flood monitoring and prediction (Teodosio *et al.* 2005), agricultural activities, etc. Several studies have shown that (Panareda *et al.* 2010; Dharssi *et al.* 2011; Stefan *et al.* 2014) accurate soil moisture input in the NWP model can improve the prediction of weather parameters. The *in-situ* land surface observation network is very limited and is

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inadequate to represent the spatial distribution of the land surface variables, over most parts of the world including Indian region. So, the only practical way to observe the land surface on regional to global scales is via satellite remote sensing, which becomes reality in recent decades. Soil moisture from satellite is estimated either using passive radiometer or active sensors like scatterometers. High resolution satellite based soil moisture products and soil moisture analysis products, which make use of satellite observations, are now available routinely over Indian region. However, validation of these soil moisture datasets with *in-situ* observations are required to understand the accuracy of the dataset which can be used not only for NWP models but also for many other applications as well.

It was shown by earlier studies that the active and passive microwave satellite sensors based soil moisture data are comparable with ground observations (Gruhler *et al.* 2010). In passive method, the natural emission of land surface is measured at microwave wavelengths using a radiometer. This method is sensitive to the surface temperature, vegetation, surface roughness and soil moisture. However in active method, a microwave pulse is sent and its backscattering is measured. This method is sensitive to surface vegetation, soil roughness and soil moisture. However, this method is not sensitive to surface temperature. Recent passive microwave soil moisture missions include the Soil Moisture Ocean Salinity (SMOS) (Mecklenburg *et al.* 2012) and Advanced Microwave Scanning Radiometer (AMSR)-2 (Parinussa *et al.* 2015). Presently, active soil moisture product is also available from Advanced Scatterometer (ASCAT) in Metop satellites (Wagner *et al.* 2013). Recently launched Soil Moisture Active Passive mission (Entekhabi *et al.* 2010) has both passive and active sensors for the retrieval of the soil moisture information. But both active and passive satellite based soil moisture products are sensitive to the surface roughness and vegetation, depending on the retrieval frequency. It was observed that over India region both SMOS and ASCAT soil moisture products have relatively high error due to type of surface vegetation cover (Yaari *et al.* 2014). They are also indicated that ASCAT soil wetness has less correlation over desert regions and has highest correlation over tropical semi-arid regions. They also found that the performance of both ASCAT and SMOS surface soil moisture to a great extent, depend on surface vegetation and underlying land cover. The Multifrequency Scanning Microwave Radiometer (MSMR) onboard the Indian Remote Sensing Satellite IRS-P4 was used to derive daily soil wetness index over Indian region with reasonable accuracy (Thapliyal *et al.* 2005). The study of

Sasmita *et al.* (2011) showed that the presence of high vegetation and mountains have higher impact on the soil moisture retrieval from AMSR-E over India. They found that the soil moisture over such locations were underestimated. A time series algorithm was used to estimate the soil moisture from AMSR-E brightness temperature over Indian sub-continent (Sasmita *et al.* 2012). They have showed that the location specific algorithm tuning over the Indian region can reduce the error in the soil moisture estimate. Parinussa *et al.* (2011) reported high contamination of radio frequency interference on the C band frequency on soil moisture estimates over India. These previous studies suggest that the sources of errors in passive microwave soil moisture estimations are mainly contributed by the vegetation, surface roughness and radio frequency interference.

The potential of the soil moisture estimation from the evolution of near surface air temperature and humidity were demonstrated by Mahfouf (1991). Several operational NWP centres like UK Met Office (Best *et al.* 2007) and ECMWF are operationally using the evolution of surface meteorological observations in the preparation of soil moisture analysis routinely. The scarcity of real time soil moisture observations made to depend on these indirect observations and sometimes these relationships failed to give the actual soil moisture estimates (Dharssi *et al.* 2011). Presently a land data assimilation system based on extended Kalman filter (EKF) method making use of both near surface temperature and humidity as well as ASCAT soil wetness observation operationally at Met Office, UK.

The present study uses National Remote Sensing Centre (NRSC), Indian Space Research Organisation (ISRO) prepared gridded daily soil moisture estimates over Indian region (Maurya and Rao 2014) and UK Met Office (UKMO) global soil moisture analysis. NRSC-ISRO soil moisture product is prepared using passive AMSR-2, X band (10.65 GHz) measurement from the GCOM satellite. The UKMO soil moisture analysis system based on EKF technique uses the evolution of surface meteorological observations of temperature and humidity as well as active satellite measurements of soil wetness by ASCAT of Metop satellite. The soil moisture analysis is prepared at 25 km spatial resolution on daily basis. This product was used for initializing the National Centre for Medium Range Weather Forecasting (NCMRWF) Unified model. In this paper, we have compared these two (NRSC and UKMO) high resolution surface soil moisture gridded datasets over Indian region during 2013–2014 period and validated it with *in-situ* observations during 2013 monsoon season. The details about the datasets used in this

study are given in section 2 of this paper. The results of the comparison and validation of soil moisture are provided in sections 3 and 4. Section 5 summarizes the results.

2. Data

UKMO soil moisture analysis, AMSR-2 based NRSC soil moisture, standard AMSR-2 global soil moisture and *in-situ* observations from India Meteorological Department are used in this study. Land cover data from ISRO IRS P6 AWiFS satellite sensor is also used here.

The 25 km spatial resolution UKMO analysis product contains soil moisture at four soil levels (10 cm, 30 cm, 60 cm and 2 m) and is available at 6-hr intervals (four soil moisture analysis per day valid for 00, 06, 12 and 18 UTC). Top 10 cm level (close to surface) soil moisture data is used for comparison in the paper. The UK Met Office uses an EKF scheme to estimate the soil moisture analysis. The EKF scheme uses the soil wetness index from the ASCAT instrument (Dharssi *et al.* 2011) and model screen level humidity and temperature (Best *et al.* 2007). ASCAT is microwave real aperture radar onboard the polar orbiting satellite Metop. It operates at 5.255 GHz with vertically polarised antennas. The satellite is in an orbit around 837 km above surface. It has two 550 km swaths, which are separated about 336 km along the satellite path. Backscattering is measured at incidence angles ranging between 25° and 60°. The satellite backscatter measurements are converted to surface soil wetness (Wagner *et al.* 1999). This quality controlled soil wetness is converted to volumetric soil moisture and assimilated with in a

window of 6 hr using EKF method. Figure 1 shows the detailed schematic diagram of EKF scheme and generation of soil moisture analysis. A short forecast of the unified model atmospheric forcing is given as input to JULES land surface model ensembles. The soil moisture from JULES model ensembles, screen level analysis and ASCAT soil moisture observations are given as input to the EKF scheme. Candy *et al.* (2012) documented the details of this scheme.

NRSC soil moisture is derived from AMSR-2 observations. AMSR-2 instrument is onboard the first generation satellite of Global Change Observation Mission-Water (GCOM-W) satellite. It is a multi-frequency microwave radiometer. The satellite is in a sun-synchronized orbit, and it has an ascending orbit around 13:30 LT and descending orbit around 01:30 LT. The specifications of AMSR-2 instrument is given in table 1. Description and development of NRSC dataset can be found in Maurya and Rao (2014). Land Parameter Retrieval Model (LPRM), a forward radiative transfer model is used to estimate the soil moisture (Owe *et al.* 2008). The brightness temperature of 37 GHz (V) is used to

Table 1. Specifications of AMSR-2 satellite instrument.

Frequencies (GHz)	6.925, 7.3, 10.65, and 36.5
Bandwidth (GHz)	0.35, 0.35, 0.10, and 1.0
Footprint size (km)	C band = 35 × 61 X band = 24 × 41 Ka band = 7 × 12
Incidence angle	55
Altitude (km)	700
Swath width (km)	1450

Figure 1. Schematic diagram of EKF scheme and generation of soil moisture analysis.

derive the surface temperature. The brightness temperature of channel 10.65 GHz is used for soil moisture estimation. The microwave polarization index derived from different polarizations is used to estimate the vegetation optical depth. This soil moisture represents the soil depth of approximately 0–3 cm (Maurya and Rao 2014). The horizontal resolution of this soil moisture product is 25 km. The standard AMSR-2 soil moisture product (AMSR-2) is also used for the comparison of NRSC product and validated with IMD *in-situ* observations. LPRM is used to derive this soil moisture. This is a global daily product with a resolution of 25 km.

Locations of the India Meteorological Department (IMD) *in-situ* observations used for the validation of the gridded datasets are shown in figure 2. IMD weekly observations of soil moisture available at 0–5 and 5–10 cm soil depths are combined here to produce the first 10 cm level soil moisture. This is required for the comparison, since the first level of the UKMO soil moisture corresponds to 10 cm. Also, comparison between IMD observation

of 0–5 and 5–10 cm soil moisture shows very good correspondence. The *in-situ* soil moisture observations from 10 locations over India for June to September 2013 period is used in this study for validation. The gridded soil moisture products are linearly interpolated to the IMD observation locations and compared with IMD observations. Land surface type observations derived from ISRO's AWiFS satellite sensor (Unnikrishnan *et al.* 2016) is also used in this study to identify the biases of soil moisture observation over different land-use/land-cover categories. The land-cover types considered in this study are: broad leaf tree, needle leaf tree, C3 grass, C4 grass, shrubs, urban, inland water, bare soil and land ice.

3. Comparison of gridded soil moisture products

The seasonal variations of soil moisture in the two gridded datasets over India are discussed in this section. The mean seasonal mean spatial maps of both NRSC soil moisture and UKMO

Figure 2. Locations of IMD *in-situ* soil moisture observations used in this study.

Figure 3. Seasonal mean geographical distribution of NRSC (left) and UKMO (right) soil moisture (m^3/m^3) for different seasons: winter (top), pre-monsoon (second from top), monsoon (second last) and post-monsoon (last row).

soil moisture are prepared during winter (January–February), pre-monsoon (March–May), monsoon (June–September) and post-monsoon (October–December) in 2013–2014 period. Figure 3 shows the seasonal comparisons with NRSC soil moisture which is given in the left panel and UKMO soil moisture is shown in the right panel. In the winter season, the maximum soil moisture values are seen over Northern Gangatic planes ($0.2\text{--}0.35\text{ m}^3/\text{m}^3$), northeast India and some areas over the coastal regions in NRSC data. However, UKMO soil moisture analysis shows relatively drier soil moisture content over central India ($18^\circ\text{--}27^\circ\text{N}$ and $75^\circ\text{--}85^\circ\text{E}$) regions ($0.03\text{--}0.1\text{ m}^3/\text{m}^3$) compared to NRSC ($0.06\text{--}0.2\text{ m}^3/\text{m}^3$). During pre-monsoon season, NRSC dataset shows small soil moisture values ranging from 0.06 to $0.1\text{ m}^3/\text{m}^3$, with the exception that certain areas of northeast and coastal regions show higher soil moisture values. Spatial distribution of both NRSC and UKMO soil moisture broadly agree over Indian region during the pre-monsoon season; however, the UKMO analysis shows relatively smaller values ($0.03\text{--}0.06\text{ m}^3/\text{m}^3$) compared to NRSC dataset. During monsoon season, maximum soil moisture values are seen over central India, over Western Ghats regions and NE India in both gridded datasets and the minimum values are over northwest parts of India (desert region) and semi-arid regions of south-east regions of India. However, the UKMO soil moisture values are higher, mainly over central India, compared to NRSC dataset, with magnitude more than $0.1\text{ m}^3/\text{m}^3$. The NRSC soil moisture is not

able to capture the higher soil moisture values. However, in other seasons, the UKMO soil moisture values over central India are slightly less compared to NRSC soil moisture: winter ($0.086\text{ m}^3/\text{m}^3$), pre-monsoon ($0.02\text{ m}^3/\text{m}^3$) and post-monsoon ($0.037\text{ m}^3/\text{m}^3$). The mean seasonal soil moisture over central India is given in table 2. The pre-monsoon season has minimum soil moisture values over central India and both datasets are comparable. The comparison of standard AMSR-2 with UKMO revealed that the AMSR-2 soil moisture is slightly higher than UKMO in all seasons. The standard AMSR-2 values are closer to UKMO in monsoon season; however, these products showed higher differences in winter season (table 2). The daily mean time series of soil moisture over central India is shown in figure 4. The maximum values of soil moisture over central India are observed during the monsoon season in both data. However, there are differences between the soil moisture mean values, UKMO shows a mean value of $0.315\text{ m}^3/\text{m}^3$ and NRSC shows a mean value of $0.189\text{ m}^3/\text{m}^3$ during the monsoon season. The UKMO values are more consistent with previous reported soil moisture values ($0.3\text{--}0.35\text{ m}^3/\text{m}^3$) over central India during monsoon season (Unnikrishnan *et al.* 2013). Also, in general, seasonal variation of soil moisture (comparing with rainfall distribution) is represented well in the UKMO analysis over central India (figure 4) compared to NRSC dataset. The previous study of Sasmita *et al.* (2011) showed that the presence of high vegetation reduces the estimate of retrieved soil moisture from passive

Table 2. Seasonal mean soil moisture values (m^3/m^3) over central India ($18^\circ\text{--}27^\circ\text{N}$; $72^\circ\text{--}85^\circ\text{E}$).

Season/data	UKMO	NRSC	AMSR-2	Difference	
				(NRSC–UKMO)	(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.

microwave satellites over India. NRSC data shows similar feature. Our result shows that there is a scope to improve the vegetation process in the retrieval process in LPRM used for the NRSC data generation. The NRSC soil moisture represents the first few centimetres of soil surface (Maurya and Rao 2014) compared to IMD product of 10 cm, may also reflect on the comparison. However, the comparison of IMD soil moisture at 0–5 and 5–10 cm does not show any significant difference except the fact that the magnitude of maximum soil moisture values are generally high in the layer close to surface. Consistency of both these data products during post-monsoon shows the potential for monitoring Rabi season soil moisture for irrigation purpose.

4. Validation with *in-situ* observations

IMD *in-situ* soil moisture observation locations are shown in figure 2. Observations from these 10 stations are used to validate the gridded datasets over Indian region. However, the *in-situ* observations were available only for a limited period (June–September 2013). The scatter plots between the *in-situ* and gridded soil moisture is presented in figure 5. The UKMO soil moisture analysis shows

higher correlation (0.56) with IMD *in-situ* observations than NRSC soil moisture (0.41) at 0.01 significant level. The standard AMSR-2 product shows a better correlation with IMD observations (0.49) compared to NRSC data. The correlation between NRSC and standard AMSR-2 product is 0.83 (figure 5). This suggests that both the soil moisture product anomalies have good agreement over India. Similarly, the correlation between the NRSC and UKMO gridded products is 0.66. High correlations between these products (compared to the correlation with IMD *in-situ* observations) may be due to comparable resolution (both have horizontal resolution of 25 km) of these datasets. The standard AMSR-2 and UKMO have a correlation of 0.67. Both products showed higher soil moisture values, AMSR-2 values are slightly higher compared to UKMO. The comparison of UKMO soil moisture with IMD observations shows that UKMO analysis is slightly overestimated the soil moisture values by $0.06 \text{ m}^3/\text{m}^3$ and whereas NRSC soil moisture dataset underestimated the soil moisture by $0.07 \text{ m}^3/\text{m}^3$. Stationwise mean biases against the *in-situ* observation at various locations are also estimated. The UKMO analysis overestimated soil moisture against the *in-situ* observations at Agra (+0.01), Annakapalli (+0.2), Basti (+0.05), Bhuvaneshwar (+0.16), Jammu (+0.05), Jorhat

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).

(+0.03) and Udaipur (+0.04). The NRSC soil moisture (m^3/m^3) dataset underestimated the soil moisture values against the *in-situ* observations at Agra (−0.11), Basti (−0.12), Bhuvaneshwar (−0.01), Hisar (−0.08), Jammu (−0.15), Jorhat (−0.1), Kalayani (−0.22), Pune (−0.28) and Udaipur (−0.11). Results suggest the UKMO soil moisture is slightly better compared to NRSC product during monsoon season. The UKMO soil moisture analysis takes the advantage of ASCAT satellite observation and EKF land data assimilation method. Thus the UKMO soil moisture analysis is slightly better than NRSC passive soil moisture product. The probability distribution functions (PDF) are for different soil moisture value ranges (less than 0.1, 0.1–0.2, 0.2–0.3, 0.3–0.4 and 0.4–0.5 m^3/m^3) are also prepared (figure 6). The PDFs are separately calculated for IMD observations and corresponding NRSC and UKMO soil moisture over various *in-situ* observation locations. It is observed that IMD observations peaks in 0.2–0.3 m^3/m^3 range whereas UKMO soil moisture peaks at 0.3–0.4 m^3/m^3 range and NRSC peaks around 0.1–0.2 m^3/m^3 range. The standard AMSR-2 soil moisture probability function is centred over 0.2–0.3 m^3/m^3 ; however, the standard AMSR-2 product is not able to capture the low soil moisture values compared to observation.

Figure 6. Normalized probability distribution function of soil moisture values (m^3/m^3) over different soil moisture ranges: IMD observations (top left), UKMO (top right), AMSR-2 (bottom left) and NRSC (bottom right).

The difference between the UKMO and NRSC data may be mainly due to the sensitivity of microwave radiometer to the underlying vegetation cover, especially in low wavelength remote sensing measurements. However, relatively high wavelength (compared to AMSR-2 X band) measurement of ASCAT (C band) was found better for soil moisture estimation over the vegetation regions (Yaari *et al.* 2014). The differences in the soil moisture estimate may be a result of the frequency used (X band or C band) and the type of sensors (active or passive). The use of model background soil moisture in the soil moisture analysis system also becomes beneficial for the accurate soil moisture estimate in UKMO data.

The differences between the two gridded soil moisture datasets (NRSC–UKMO) are compared over different land cover type. The nine land cover type data considered in this study are (broad leaf tree, needle leaf tree, C3 grass, C4 grass, shrubs, urban, inland water, bare soil and land ice) derived from ISRO AWiFS sensor measurements. Table 3 shows the land cover types and corresponding absolute differences between the data. It is observed that gridded soil moisture datasets are comparing (each other) well over the following land cover types: bare soil, shrubs, C3 and C4 grass. However, the following land cover types: needle leaf trees, broad leaf trees and urban show higher differences between the datasets. The NRSC and AMSR-2 products showed magnitude differences with UKMO in comparison with respect to surface land cover types; however, there is a similarity in the differences (table 3). Higher differences indicate higher uncertainty in soil moisture estimation by satellites, because both gridded products are making use of satellite remote sensing observations. The main crop types in India falls under the vegetation category of C3 grass and C4 grass. The differences between the soil moisture estimates in the regions of C3 and C4 vegetation is minimum,

Table 3. Difference between NRSC and UKMO soil moisture values (m^3/m^3) and AMSR-2 and UKMO soil moisture values (m^3/m^3) over India during the year 2013.

Land cover	Soil moisture difference	
	NRSC – UKMO	AMSR-2 – UKMO
Broad leaf tree	0.07	0.05
Needle leaf tree	0.13	0.10
C3 Grass	0.03	0.04
C4 Grass	0.05	0.06
Shrubs	0.02	0.03
Urban	0.07	0.06
Inland water	Not compared	Not compared
Bare soil	0.02	0.02
Land ice	Not compared	Not compared

which suggest that these soil moisture products can be utilized for drought monitoring and irrigation management for the agricultural activities.

5. Conclusion and summary

This paper evaluated the uncertainties of two high resolution soil moisture products over India by validating against IMD *in-situ* observations. Both UKMO and NRSC gridded datasets are validated at 10 IMD observation locations during 2013 monsoon period. The UKMO soil moisture shows higher correlation (0.56) than NRSC soil moisture (0.41). The standard AMSR-2 soil moisture shows a correlation of 0.49 with IMD observations. The correlation of AMSR-2 and NRSC is 0.83. The standard AMSR-2 and UKMO showed a correlation of 0.67. Both values are comparable in monsoon period and AMSR-2 soil moisture is slightly high in all seasons. The differences between these products are high in winter season. It is observed that UKMO soil moisture is overestimated ($0.06 \text{ m}^3/\text{m}^3$) and NRSC soil moisture is underestimated ($0.07 \text{ m}^3/\text{m}^3$) with respect to IMD *in-situ* observations at observation locations. UKMO analysis shows higher soil moisture values over central India during monsoon season. UKMO soil moisture is slightly dry during other seasons compared to NRSC soil moisture: winter pre-monsoon and post-monsoon. The probability distributions of IMD observations show the maximum soil moisture values, around $0.25 \text{ m}^3/\text{m}^3$. However, the distribution peaks are shifted in NRSC and UKMO soil moisture products. The distribution peaks at $0.15 \text{ m}^3/\text{m}^3$ in NRSC and $0.35 \text{ m}^3/\text{m}^3$ in UKMO. The standard AMSR-2 probability distribution is centred at $0.25 \text{ m}^3/\text{m}^3$ and this peak matches with observation. However, this product is not able to capture the low soil moisture values. The low values of soil moisture during the monsoon season over India in NRSC data suggest the necessity of incorporating the regional vegetation processes in the retrieval algorithm. It is encouraging that the both gridded datasets have good correlations between them (0.66). However, the correlation and bias computed against IMD *in-situ* observations show that the UKMO soil moisture analysis is relatively better. The NRSC data and AMSR-2 products show significant correlation between them. The difference between the NRSC and UKMO over similar land cover type is also compared. The results indicate that the both gridded datasets match better over bare soil, shrubs, C3 and C4 grass regions (regions of agricultural crop). Over regions of broad leaf trees, needle leaf trees and urban areas, the differences in the soil moisture between the two datasets are high. Similar results are observed in

the differences between the AMSR-2 and UKMO. Result also clearly shows that both NRSC and UKMO gridded soil moisture products have higher degree of similarity over C3 and C4 grass. This shows the potential to use these products in near real time for the agricultural activities. Relatively high accuracy of the UKMO soil moisture analysis suggests the importance of land data assimilation system which makes use of different information to produce realistic estimate of soil moisture values (soil moisture analysis) in reasonably high spatial (25 km resolution) and temporal resolutions (6 hourly).

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