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Monthly actual evapotranspiration estimation using Google Earth engine in the Godavari districts of Andhra Pradesh

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Abstract
Evapotranspiration (ET) plays a major role in taking decisions related to water resource and agricultural management. It is difficult to measure at large spatial scales due to its spatial variability. In order to overcome this challenge, satellite remote sensing is a promising technology which has been used to provide reasonable estimate of ET under the assumption that energy storage by the canopy is negligible. The actual ET remote sensing product is being generated at 5.5 Km^2 spatial resolution under National Hydrology Project (NHP). Google Earth Engine is a cloud computing platform used to analyse the actual ET across various spatial scales. Therefore, estimation of average monthly actual ET was determined using Google Earth Engine and monthly actual ET products during 2019-2020 in the Godavari districts of Andhra Pradesh. From the analysis, high values of monthly AET during 2019-2020 was observed in the months of June, July, August and September whose values are 4.25 mm/day, 4.69 mm/day, 4.81 mm/day and 4.84 mm/day. The low values of monthly AET during 2019-2020 was observed in the months of January, February and December 1.79 mm/day, 2.53 mm/day and 1.49 mm/day.From the above analysis, it is clear that satellite remote sensing ET products and Google earth engine plays crucial role in analysing the datasets spatially as well as temporally.

Keywords: Evapotranspiration, Google Earth Engine, Godavari Districts

Introduction
Evapotranspiration is a complex process at a regional scale which is influenced by the regional climate, land use changes due to human interventions in the landscape, water withdrawals from the rivers for agricultural practices. It is also a vital component of the hydrological cycle along with precipitation, runoff, seepage and sub-surface hydrology. This component also plays a major role in hydrology, meteorology and agriculture which governs the water and energy exchange between the hydrosphere, biosphere and atmosphere. The main significance for the accurate estimation of evapotranspiration is essential for efficient crop water management, drought assessment and irrigation scheduling. The information on ET will help monitor crop water requirement, crop phenology, better irrigation water management and crop production estimation. Several parametric models have been developed to estimate the actual Evapotranspiration (AET) flux based on the assumption that AET is limited by water availability in terms of precipitation (P) under very dry conditions and energy availability in terms of Potential Evapotranspiration (PET) under very wet conditions (Fu, 1981) [3]. Also, various conventional techniques of estimating the ET such as Lysimeters (Allen *et al*., 1991) [4], Eddy covariance (EC) stations (Baldocchi *et al.* 2001) [5], Bowen ratio (Bowen, 1926) [6] and sap flow (Vertessy *et al*., 1997) [7] techniques are largely restricted to the site specific measurements. So, parametric models and conventional techniques may not be suitable for obtaining regional estimates of actual Evapotranspiration. In order to obtain the regional estimates of actual evapotranspiration, remote sensing technology is now recognised as the only viable means of obtaining globally consistent estimates of actual evapotranspiration at varying spatial and temporal scales.

Across the globe, various researchers have developed several models for estimating the Actual Evapotranspiration (Allen *et al*. (2007a) [1]; Alsenjer *et al*. 2023b) [2]. Based on the spatial scale as well as the climatic conditions are concerned, the present study mainly focuses on applying the developed model for the study area. The study area considered in this study are the erstwhile Godavari districts of Andhra Pradesh i.e., East and West Godavari districts. Under National Hydrology project, satellite based regional evaporative flux monitoring system for the entire India was developed by National remote sensing Center (NRSC). This system provides the monthly satellite data products of actual Evapotranspiration for the entire India. Based on these satellite products, monthly actual evapotranspiration estimation for the study area is taken as a study for understanding the hydrological process at the regional scale.

In order to analyse the satellite products from the developed model, Google earth engine plays a major role in remote sensing big data processing spotlight. It is a cloud based platform that enables parallelized processing of geospatial data on global scale using Google's cloud.

The estimation and mapping of AET is an active area of applied research in agriculture and water resources. In order to analyze the spatial estimates of the ET, Google Earth Engine plays a major role in determining the quantitative ET estimates across the study area. Therefore, present study uses this platform for analysing the actual Evapotranspiration using GEE for the entire study area.

Materials and Methods

Study area

The East and West Godavari districts of Andhra Pradesh were selected as the study area (Fig 1). A brief description of the study area is given below:

The Godavari districts is situated on the north east of the Andhra Pradesh with the geographical coordinates ranging from 16° 15' and 18° 20' north latitude and 80° 55' and 82° 36' eastern longitude. The district is bounded on the north by Visakhapatnam, Khammam district and the state of Orissa, on the east by the Bay of Bengal, on the west and the south by Krishna district and Bay of Bengal. It has an area of about 21,112 sq. km. It consists of 112 mandals and 12 revenue divisions.

The climate is comparatively moderate and very warm in May with a maximum temperature of 36.9 °C and minimum temperature of about 23.85 °C in the month of January. This area receives rainfall mostly from the south west monsoon compared to north east monsoon (EG district, CPO, 2019).

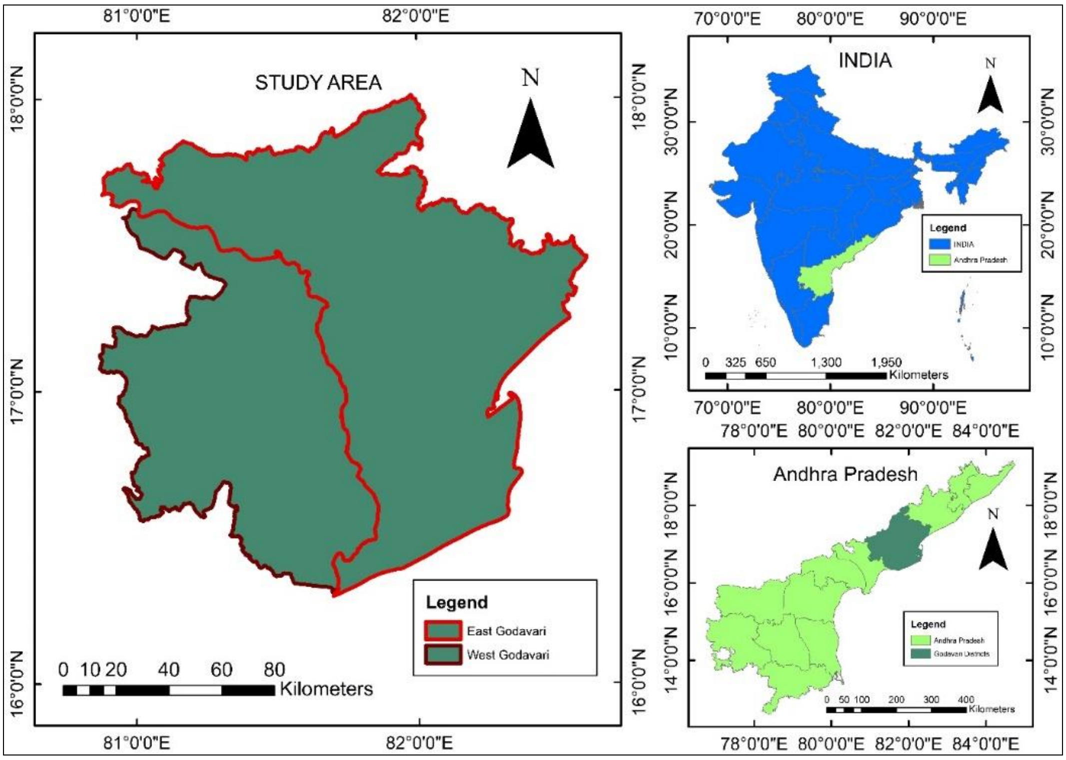


Fig 1: Location map of the study area

Satellite Data collection

Under the National Hydrology Project (NHP), spatial Actual Evapotranspiration (AET) is estimated using with energy balance and water balance approach. Computational framework is developed using satellite and meteorological datasets for near real time daily AET product at 3' x 3' spatial resolution over the entire Indian sub-continent. Energy balance based AET products are presently available for the clear sky condition. The development of energy balance based AET product is estimated from the Modified Priestly-Taylor (PT) algorithm by NRSC. The components of surface energy balance equation are derived using satellite remote sensing data and meteorological products.

In the present study, monthly AET products were downloaded for the years 2019 and 2020 from NRSC Bhuvan website (https://bhuvan.nrsc.gov.in/nhp/webgis-et/map) in the Godavari districts of Andhra Pradesh.

Google earth engine

Google earth engine is a cloud based geospatial processing platform for large scale environmental monitoring and analysis. It is a cloud based platform that enables parallelized processing of geospatial data on a global scale using Google's cloud.

The GEE platform leverages the Google's computational infrastructure to enable parallel geospatial data processing to reduce computational time. The GEE provides various functions to perform spectral and spatial operations on either a single image or a batch of images. Different operations within the GEE platform, ranging from simple mathematical operations to advanced image processing and machine learning algorithms were used to analyse the single or batch of images.

Methodology

The monthly actual ET satellite products for the years of 2019 and 2020 were downloaded from the NRSC Bhuvan website (https://bhuvan.nrsc.gov.in/nhp/webgis-et/map). These satellite products were imported to the Google Earth Engine for the Quantitative estimate of ET for the entire study area. In order to estimate the average monthly actual ET in the study area across spatially as well as temporally, functions such as mean and reduce region functions were used. Finally, the AET was determined for the study area spatially and temporally.

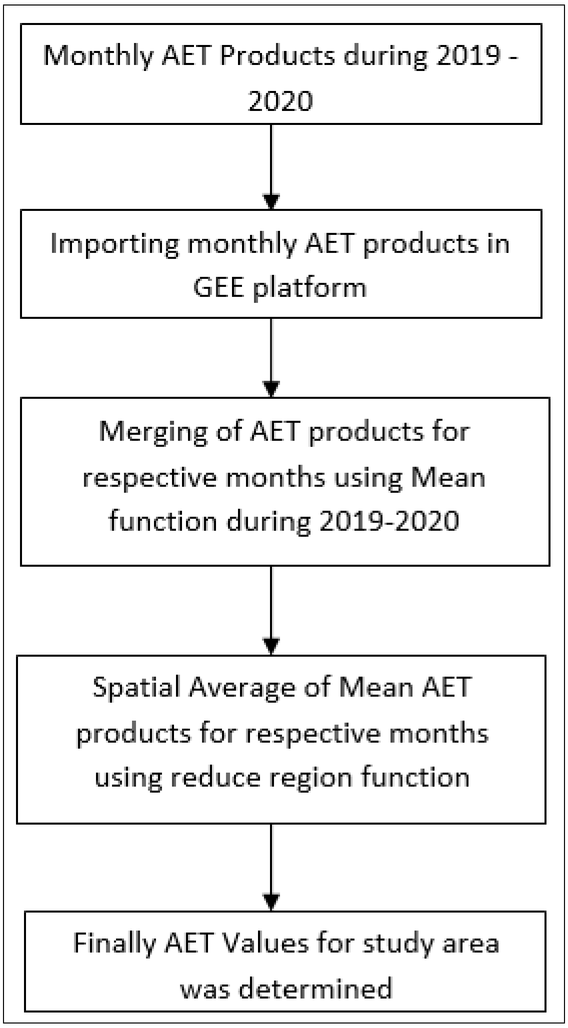


Fig 1: Process flowchart for estimation of AET for the entire study area at regional scale

Results and Discussions

Temporal variation of AET

In the year 2019, average daily AET observed in the months of June, July, August and September whose values are 4.03 mm/day, 4.53 mm/day, 4.74 mm/day and 4.90 mm/day. There was a low AET observed in the months of January, February and December whose values are 1.79 mm/day, 2.62 mm/day and 1.48 mm/day. In the year 2020, June, July, August and September whose values are 4.41 mm/day, 4.81 mm/day, 4.84 mm/day and 4.75 mm / day.

There was a low AET observed in the months of January, February and December whose values are 1.77 mm/day, 2.41 mm/day and 1.50 mm/day. The average daily AET during 2019-2020 were displayed in the table 1. The high values of monthly AET during 2019-2020 was observed in the months of June, July, August and September whose values are 4.25 mm/day, 4.69 mm/day, 4.81 mm/day and 4.84 mm/day. The low values of monthly AET during 2019-2020 was observed in the months of January, February and December 1.79 mm/day, 2.53 mm/day and 1.49 mm/day.

In the year 2019, monthly AET observed in the months of June, July, August and September whose values are 120.90 mm/month, 140.43 mm/ month, 146.94 mm/ month and 147.00 mm/ month. There was a low AET observed in the months of January, February and December whose values are 55.49 mm/ month, 73.36 mm/ month and 45.88 mm/ month. In the year 2020, June, July, August and September whose values are 132.30 mm/ month, 149.11 mm/ month, 150.04 mm/ month and 142.50 mm/month. There was a low AET observed in the months of January, February and December whose values are 54.87 mm/ month, 67.48 mm/ month and 46.50 mm/ month.

The average monthly AET during 2019-2020 were displayed in the table 2. The high values of monthly AET during 2019-2020 was observed in the months of June, July, August and September whose values are 127.50 mm / month, 145.39 mm / month, 149.11 mm/ month and 145.20 mm / month. The low values of monthly AET during 2019-2020 were observed in the months of January, February and December 55.49 mm/ month, 70.84 mm/ month and 46.19 mm / month.

Table 1: Average daily actual Evapotranspiration (mm/day) in each month for the years 2019 and 2020

Month	2019	2020	Average
	ET (mm/day)	ET (mm/day)	ET (mm/day)
January	1.79	1.77	1.79
February	2.62	2.41	2.53
March	2.98	2.88	2.96
April	3.25	3.36	3.33
May	3.55	3.83	3.71
June	4.03	4.41	4.25
July	4.53	4.81	4.69
August	4.74	4.84	4.81
September	4.90	4.75	4.84
October	3.51	3.57	3.55
November	2.33	2.22	2.28
December	1.48	1.50	1.49

Table 2: Monthly actual Evapotranspiration (mm/day) in each month for the years 2019 and 2020

Month	2019	2020	Average
	ET (mm/month)	ET (mm/month)	ET (mm/month)
January	55.49	54.87	55.49
February	73.36	67.48	70.84
March	92.38	89.28	91.76
April	97.50	100.80	99.90
May	110.05	118.73	115.01
June	120.90	132.30	127.50
July	140.43	149.11	145.39
August	146.94	150.04	149.11
September	147.00	142.50	145.20
October	108.81	110.67	110.05
November	69.90	66.60	68.40
December	45.88	46.50	46.19

From the fig.1 and 2, In the year 2019, there is an increase in daily and monthly Actual ET from January to July whose values are varied from 1.79 to 4.53 mm/day and 55.49 to 140.43 mm/month. In the months of August and September, the daily and monthly Actual ET was almost constant whose values are varying from 4.74 to 4.90 mm/day and 140.43 to 146.94 mm/month. From October to December, there is decrease in the daily and monthly AET whose values are varying from 3.51 to 1.48 mm/day and 45.88 mm/month to 108.81 mm/month. In the year 2020, there is an increase in daily and monthly Actual ET from January to July whose values are varied from 1.77 to 4.81 mm/day and 54.87 to 149.11 mm/month. In the months of August and September, the daily and monthly Actual ET was almost constant whose values are varying from 4.75 to 4.84 mm/day and 150.04 to 142.50 mm/month. From October to December, there is decrease in the daily and monthly AET whose values are varying from 3.51 to 1.48 mm/day and 46.50 mm/month to 110.67 mm/month. The yearly average values of daily and monthly AET were increased from the months of January to July whose values are ranging from 1.79 to 4.61 mm/day and 55.49 to 149.31 mm/day. In the months of August and September, the the daily and monthly Actual ET was almost constant whose values are varying from 4.81 to 4.84 mm/day and 145.20 to 149.11 mm/month. From October to December, there is decrease in the daily and monthly AET whose values are varying from 3.55 to 1.49 mm/day and 46.19 mm/month to 110.05 mm/month.

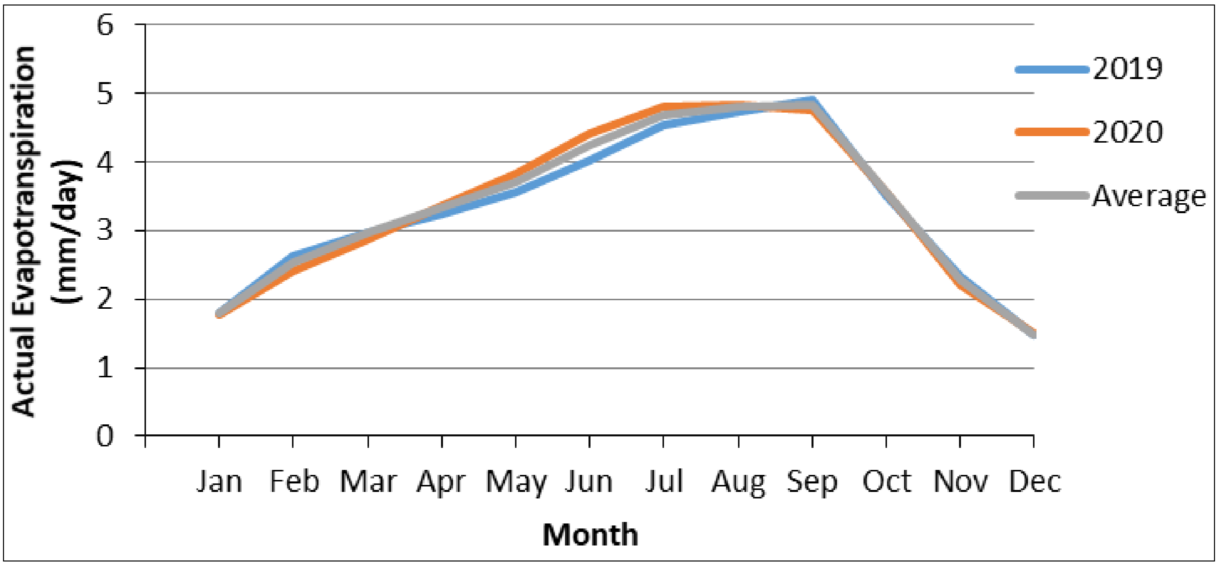


Fig 1: Average daily actual Evapotranspiration (mm/day) in each month for the years 2019 and 2020

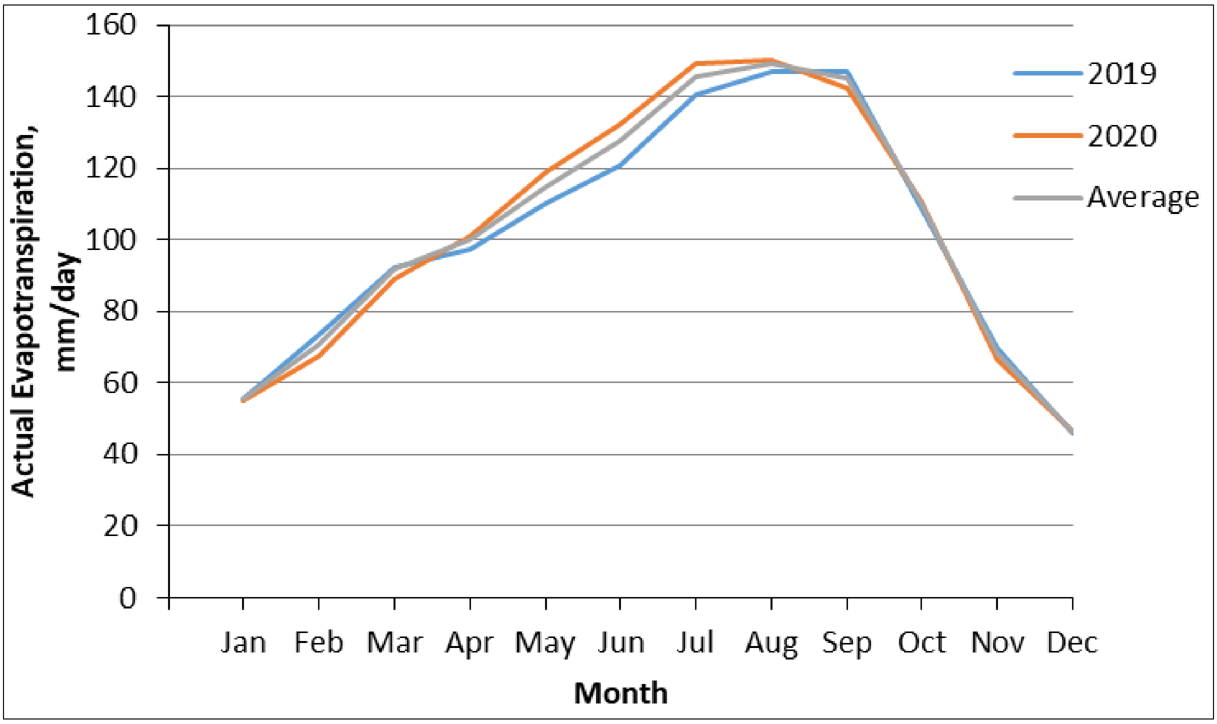
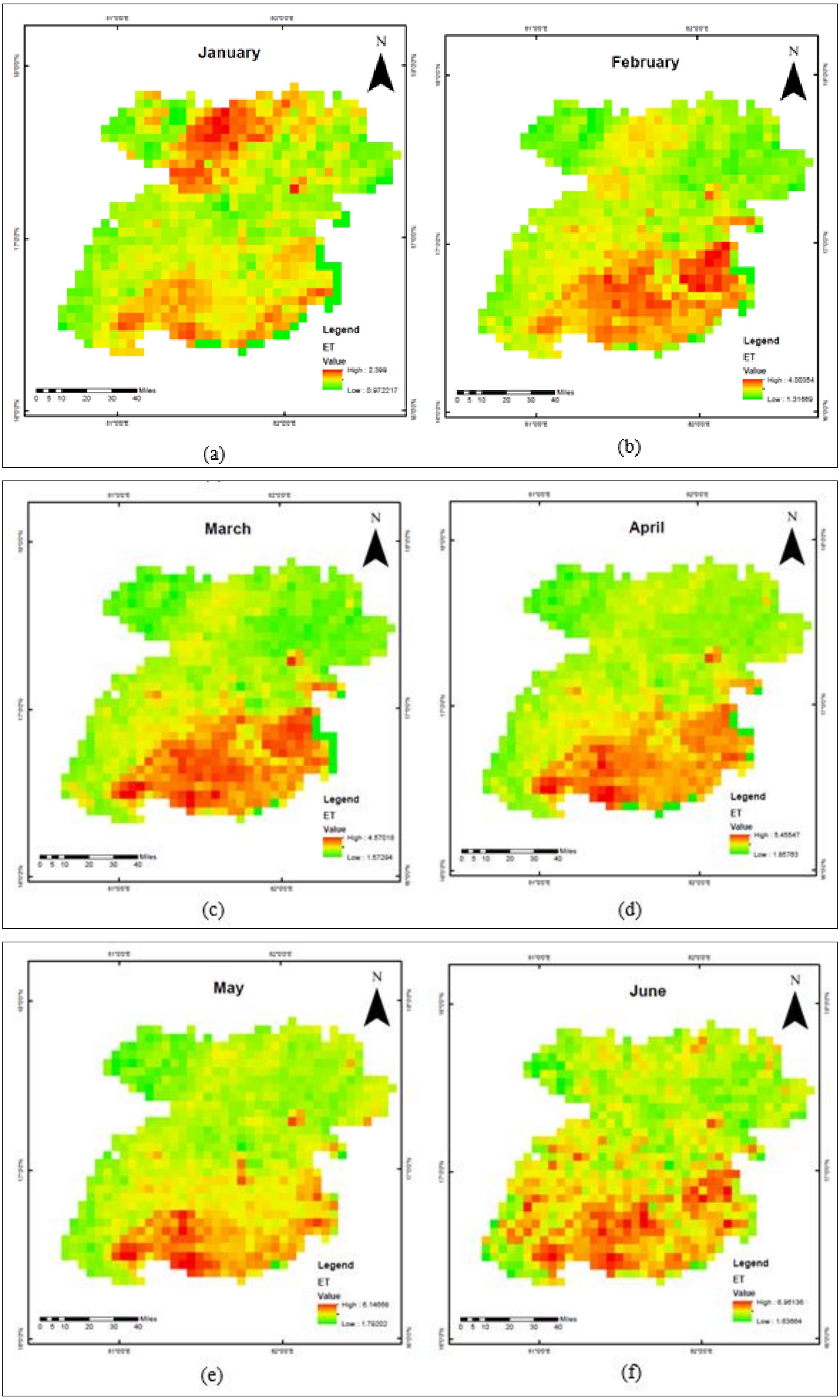


Fig 2: Monthly actual Evapotranspiration (mm/day) in each month for the years 2019 and 2020


January
(a)
February
(b)
March
(c)
April
(d)
May
(e)
June
(f)

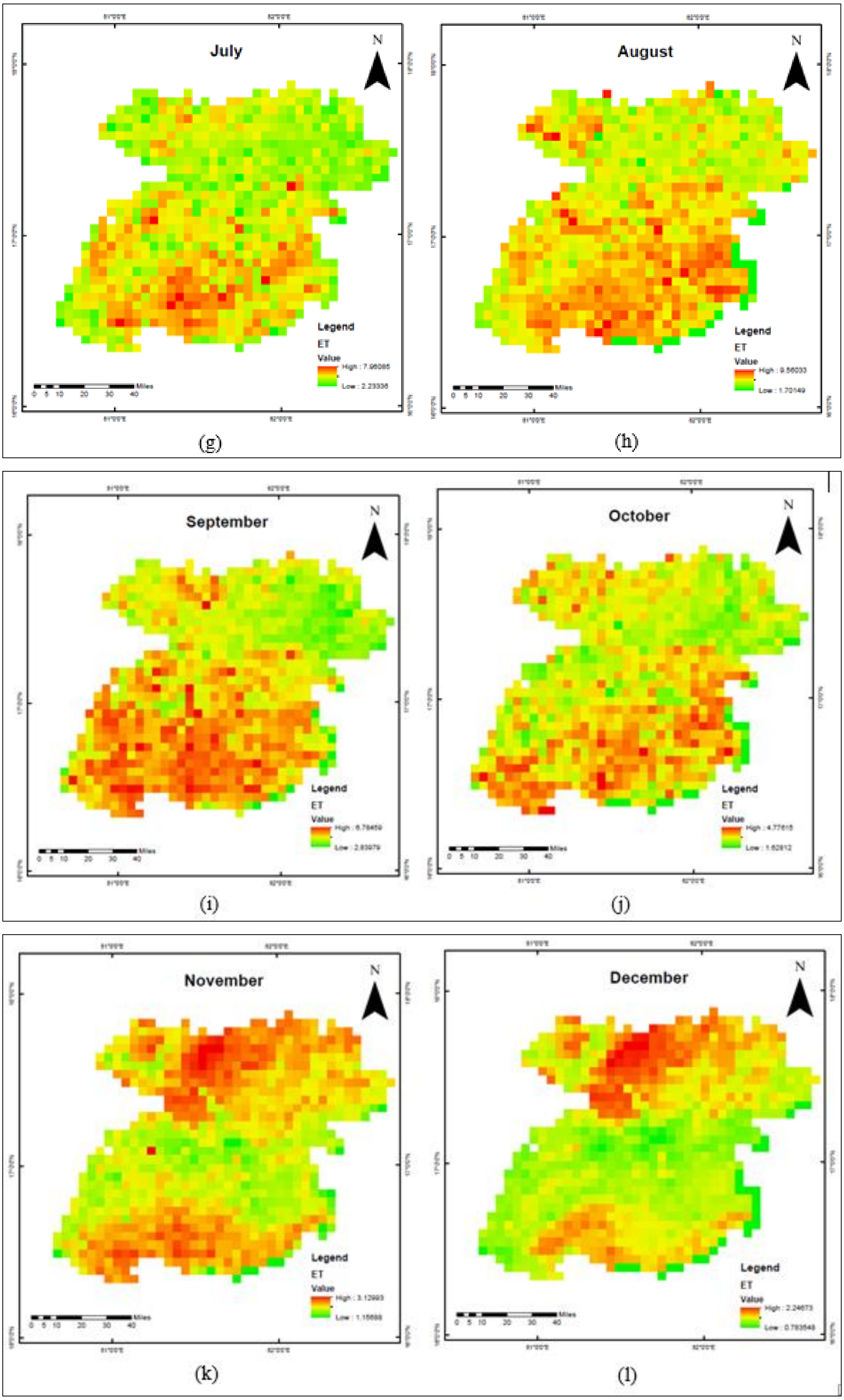


Fig 3: Yearly average Spatial variation of daily Actual Evapotranspiration in the Godavari districts of Andhra Pradesh for the following months (a) January (b) February (c) March (d) April (e) May (f) June (g) July (h) August (i) September (j) October (k) November (l) December

Spatial variation of daily AET

In the month of January, the AET was high in the upstream areas of East Godavari district and a small portion of area in West Godavari district whose values are nearer to 2.3 mm/day. In the month of February, the AET was high in the downstream areas of East and West Godavari districts whose values are nearer to 4 mm/day. In the month of March, maximum AET was observed in the downstream areas of East and West Godavari districts whose values are nearer to 4.57 mm/day. In the month of April, AET was high in downstream areas in study area whose intensity is more in West Godavari district compared to East Godavari. The maximum AET values in April were nearer to 5.45 mm/day. In the month of May, AET was high in downstream areas West Godavari district whose values are nearer to 6.15 mm/day. In the month of June, AET was high in downstream areas of study area whose intensity is more in West Godavari district. The maximum AET values in June were nearer to 6.96 mm/day. In the month of July, AET was high in West Godavari district whose values are nearer to 7.96 mm/day. In the month of August, maximum portion of the downstream area and small portion in the upstream area have higher AET whose values are nearer to 9.56 mm/day. In the month of September, almost the entire west Godavari district has high AET compared to East Godavari whose values are nearer to 6.79 mm/day. In the month of October, downstream areas of East and West Godavari districts have high AET whose values are nearer to 4.78 mm/day. In the month of November, high AET was observed in the upstream and downstream areas of East and West Godavari districts whose values are nearer to 3.13 mm/day. In the December month, high AET was observed in the upstream of East and West Godavari districts compared to downstream areas in the study area whose values are nearer to 2.25 mm/day.

Conclusions

The remote sensing technology plays a major role in understanding complex Evapotranspiration process at a regional scale. The developed model satellite products of AET by NRSC plays a vital role for determining the monthly actual evapotranspiration in Godavari districts of Andhra Pradesh. In the year 2019, monthly AET observed in the months of June, July, August and September whose values are 120.90 mm/month, 140.43 mm/ month, 146.94 mm/ month and 147.00 mm/ month. There was a low AET observed in the months of January, February and December whose values are 55.49 mm/ month, 73.36 mm/ month and 45.88 mm/ month. In the year 2020, June, July, August and September whose values are 132.30 mm/ month, 149.11 mm/ month, 150.04 mm/ month and 142.50 mm / month. There was a low AET observed in the months of January, February and December whose values are 54.87 mm/ month, 67.48 mm/ month and 46.50 mm/ month. Therefore, satellite data products are useful for efficient crop water management, drought assessment and irrigation scheduling.

References

1. Allen R, Tasumi M, Morse A, Trezza R, Wright JL, Bastiaanssen W, *et al.* Satellite-based energy balance for mapping evapotranspiration with internalized calibration, METRIC (Applications). Journal of Irrigation and Drainage Engineering. 2007;133:395–406.
2. Alsenjar O, Cetin M, Aksu H, Golpinar MS, Akgul MA. Actual evapotranspiration estimation using METRIC model and Landsat satellite images over an irrigated field in the Eastern Mediterranean Region of Turkey. Mediterranean Geoscience Reviews. 2023;5:35–49. https://doi.org/10.1007/s42990-023-00099-y.
3. Fu BP. On the calculation of the evaporation from land surface. Scientia Atmospherica Sinica. 1981;5:23-31.
4. Allen RG, Howell TA, Pruitt WO, Walter IA, Jensen ME. Lysimeters for evapotranspiration and environmental measurements. New York: American Society of Civil Engineers (ASCE); c1991.
5. Baldocchi D, Falge E, Gu L, Olson R, Hollinger D, Running S, Anthoni P, Bernhofer C, Davis K, Evans R. FLUXNET: A new tool to study the temporal and spatial variability of ecosystem-scale carbon dioxide, water vapor, and energy flux densities. Bulletin of the American Meteorological Society. 2001;82:2415-2434.
6. Bowen IS. The ratio of heat losses by conduction and by evaporation from any water surface. Physical Review. 1926;27:779.
7. Vertessy R, Hatton T, Reece P, O'sullivan S, Benyon R. Estimating stand water use of large mountain ash trees and validation of the sap flow measurement technique. Tree Physiology. 1997;17:747-756.