26-05-2021

Comparison of agrometeorological products of ISRO and JAXA

Indian Space Research Organisation (ISRO) & Japan Space Exploration Agency (JAXA)

1. Background and Objective

This study was conducted under the Implementation Arrangement between Indian Space Research Organisation (ISRO) and Japan Space Exploration Agency (JAXA) concerning collaborative activities on APRSAF/SAFE Agromet Project.

The agrometeorological (agromet) products of ISRO and JAXA are compared from the point of view of agricultural monitoring. Precipitation, land surface temperature (LST) and normalized difference vegetation index (NDVI) products are selected as agromet products and study sites are selected in India and Thailand incorporating major rice production areas. The product comparison involves not only sensitivity of both products to detect extreme agrometeorological events but also mutual agreement between both. A cross comparison between JAXA and ISRO's products to extreme agrometeorological events will improve the reliability and deep understanding of our products towards these events.

2. Schedule

This study was proceeded on the schedule summarized in Table 2.1. Trial study was conducted in 2019 and results were reported in APRSAF-26 (25 Nov. 2019). Further study with additional data was continued in 2020. The study was completed with satisfied results and final results were reported in SAFE WS (28 Jan. 2021).

Table 2.1 Schedule

Contents	**Organization in charge**	**2019**			**2020**				**2021**
Analysis planning	ISRO, JAXA	→				→			
Data set preparation for ISRO products	ISRO		→	→		→	→		
Data set preparation for JAXA products	JAXA		→		→	→			
Compare results in study area	ISRO & JAXA			→	→		→	→	
Disccussion	ISRO & JAXA	▲	▲	▲▲▲	▲▲	▲▲	▲▲	▲	▲
APRSAF/SAFE WS	ISRO & JAXA			11/25 ▲				11/19 ▲	1/28 ▲

3. Satellite Data Products

This study comprises of satellite based Agromet data products (Precipitation, LST and NDVI). These data are summarized in Table 3.1 and Table 3.2.

Table 3.1 JAXA's Agromet products

JAXA's Products	Data Base	Satellites	Spatial Resolution	Temporal Resolution	Data Availability
Precipitation	JASMIN	GCOM-W, GPM, Himawari, etc	0.1 deg (≒10 km)	half month	Jul 2002 - present
LST	JASMIN	Terra/Aqua	5 km	half month	Jul 2002 - present
NDVI	JASMIN	Terra/Aqua	5 km	half month	Jan 2009 - present
NDVI	JASMIN	GCOM-C	5 km	half month	Apr 2018 - present

Table 3.2 ISRO's Agromet products

ISRO's Products	Data Base	Satellite	Spatial Resolution	Temporal Resolution	Data Availability
Precipitation (HEM)	MOSDAC	INASAT-3D	4 km(≒0.04 deg)	Daily	Jul 2015 - present
LST	MOSDAC	INASAT-3D	4 km(≒0.04 deg)	Daily	April 2015 - present
NDVI	VEDAS	OCM-2	250 m (≒0.025 deg)	2 days	Jul 2012 – present

4. Study Areas

This study involves two rice-producing regions to understand ISRO and JAXA products in detecting extreme events (Flood and Drought). In India, a major rice producing region i.e. Eastern zonal council of India is selected which comprised of Bihar, West Bengal, Odisha and Jharkhand. In these states, first three are selected. Those administrative districts, which are major rice producing areas in these states, are chosen further. In Thailand, central administrative provinces including GISTDA ground stations (ADM: Automatic Drought Monitoring system) are selected for the study (Figure 4.1).

・**Thailand**

Event: Drought (April 2016); Year: Jul 2015- Jun 2019

Place: 8 provinces in the central part of Thailand

Table 4.1 Target provinces in Thailand

Provinces	Note
Ang Thong	Previous trial site
Suphanburi	2 ground stations (P1 & P2) in paddy field are included, Rice crop monitoring site
Pathum Thani	1 ground station (P2) in paddy field is included
Phitsanulok	Rice crop monitoring site
Saraburi	1 ground station (P2) in paddy field is included
Kamphaeng Phet	1 ground station (P2) in sugarcane farm is included
Nakhon Pathom	1 ground station (P1) in asparagus farm is included

Phetchabun	1 ground station (P1) in tamarind farm is included

Table 4.2 GISTDA ground stations (ADM)

Station Name	Type	Province	Lat	Lon	Duration
GISTDA-05	Phase 1	Nakhon Pathom	13.89915	99.96021	04/2019-02/2020
GISTDA-07	Phase 1	Phetchabun	15.75285	101.01074	04/2019-02/2020
GISTDA-21	Phase 1	Suphanburi	14.40854	100.00275	04/2019-02/2020
GISTDA-23	Phase 1	Pathum Thani	14.15514	100.68599	04/2019-02/2020
Station2	Phase 2	Saraburi	14.75400	101.10900	01/2018-12/2019
Station7	Phase 2	Kamphaeng Phet	16.49575	99.74736	01/2018-12/2019
Station14	Phase 2	Suphanburi	14.47853	100.08611	01/2018-12/2019

・**India**

Event: Flood (Sep 2018); Year: Jul 2015- Jun 2019

Place: 10 districts in the Eastern zonal council of India (Bihar, West Bengal and Odisha)

Table 4.3 Target districts in India

States	**Provinces**
Odisha	Jagatsinghpur, Kendrapara , Bhadrak, Baleshwar
West Bengal	South 24 Parganas, East Medinipur, West Medinipur
Bihar	Vaishali, Samastipur, Darbhanga

Figure 4.1 Study sites in the central part of Thailand

Figure 4.2 Study sites in India (Eastern Zonal Council of India)

5. Study Period

This study is based on four agricultural years i.e. start year 2015 to end year 2019, of Agromet data each starting from 01st July and ending to 31st June. In cases, where weekly composites are required for analysis, weekly composites are prepared based on standard meteorological weeks (SMW) as defined by India Meteorological Department (IMD).

The SMW weeks are demonstrated in Table 5.1

Table 5.1 Standard meteorological weeks (SMW)

Standard Meteorological Weeks

Week No.	Dates	Week No.	Dates
1	01 Jan – 07 Jan	27	02 Jul –08 Jul
2	08 Jan – 14 Jan	28	09 Jul – 15 Jul
3	15 Jan – 21 Jan	29	16 Jul – 22 Jul
4	22 Jan – 28 Jan	30	23 Jul – 29 Jul
5	29 Jan – 04 Feb	31	30 Jul – 05 Aug
6	05 Feb – 11 Feb	32	06 Aug – 12 Aug
7	12 Feb – 18 Feb	33	13 Aug – 19 Aug
8	19 Feb – 25 Feb	34	20 Aug – 26 Aug
9*	26 Feb – 04 Mar	35	27 Aug – 02 Sep
10	05 Mar – 11 Mar	36	03 Sep – 09 Sep
11	12 Mar – 18 Mar	37	10 Sep – 16 Sep
12	19 Mar – 25 Mar	38	17 Sep – 23 Sep
13	26 Mar – 01 Apr	39	24 Sep – 30 Sep
14	02 Apr – 08 Apr	40	01 Oct – 07 Oct
15	09 Apr – 15 Apr	41	08 Oct – 14 Oct
16	16 Apr – 22 Apr	42	15 Oct – 21 Oct
17	23 Apr – 29 Apr	43	22 Oct – 28 Oct
18	30 Apr – 06 May	44	29 Oct – 04 Nov
19	07 May – 13 May	45	05 Nov – 11 Nov
20	14 May – 20 May	46	12 Nov – 18 Nov
21	21 May – 27 May	47	19 Nov – 25 Nov
22	28 May – 03 Jun	48	26 Nov – 02 Dec
23	04 Jun – 10 Jun	49	03 Dec – 09 Dec
24	11 Jun – 17 Jun	50	10 Dec – 16 Dec
25	18 Jun – 24 Jun	51	17 Dec – 23 Dec
26	25 Jun – 01 Jul	52**	24 Dec – 31 Dec

* Week No. 9 will be 8 days during leap year
** Week No. 52 will always have 8 days

6. Precipitation

6.1 Input image data

Original data specification is summarized in the Table 6.2. To compare the products, daily composite products in the Table 6.3 are prepared for both JAXA and ISRO precipitation products as base data. The daily precipitation is the sum of precipitation in a day and calculated for each pixel. The average precipitation per hour is calculated from the data for a day in a pixel. The daily precipitation is calculated as the multiplication of the hourly average precipitation by 24 hours. Daily precipitation images (GeoTiff files) are shared between JAXA and ISRO.

The weekly composite products in the Table 6.4 are also generated from daily composite products. The weekly precipitation is the sum of precipitation in a week and calculated for each pixel by multiplication of the daily average precipitation by 7 days. If the data include the loss of measurement, weekly precipitation is calculated from average precipitation per day. The null value is applied when no data is available for a pixel.

Table 6.2 Precipitation data from JAXA/JASMIN and ISRO/MOSDAC

Products	Spatial resolution	Observation	Unit	Data Availability

		frequency		
(JAXA/JASMIN) GSMaP	0.1 deg (≒10 km)	every 1 hr	mm/hr	Jul 2015 – present
(ISRO/MOSDAC) INSAT-3D HEM DLY L2B	4 km (≒0.04 deg)	every 30 min	mm/hr	Jul 2002 – present

Table 6.3 Precipitation (Daily Composite)

Products	Spatial resolution	Temporal resolution	Unit	Study Period
(JAXA/JASMIN) GSMaP	0.1 deg (≒10 km)	1 day	mm/day	Jul 2015 – Jun 2019
(ISRO/MOSDAC) INSAT-3D HEM DLY L2B	4 km (≒0.04 deg)	1 day	mm/day	Jul 2015 – Jun 2019

Table 6.4 Precipitation (Weekly Composite)

Products	Spatial resolution	Temporal resolution	Unit	Study Period
(JAXA/JASMIN) GSMaP	0.1 deg (≒10 km)	1 week	mm/week	Jul 2015 – Jun 2019
(ISRO/MOSDAC) INSAT-3D HEM DLY L2B	4 km (≒0.04 deg)	1 week	mm/week	Jul 2015 – Jun 2019

6.2 Precipitation for each region

The **weekly precipitation for each region (province in Thailand / district in India)** is calculated from the weekly precipitation image and polygon data (**Natural Earth** data for Thailand and Indian District Boundary, Survey of India for India) as regional average value. Weekly normal year and anomaly values are calculated to detect anomaly events. Standard meteorological weeks in India is used as definition of weeks (Table 6.1). Anomaly value of precipitation is expressed as relative value compared to average value for all term data.

$$\bar{P}_{week} = \sum_{y=start\ year}^{y=end\ year} P_{week,y} / (\text{end year} - \text{start year})$$

$$P'_{week,y} = P_{week,y} - \bar{P}_{week}$$

Where, $P_{week,y}$ is the integrated precipitation value for a week in a year (y) and $\bar{P}_{week}$ is the normal year precipitation for a week in the target duration (end year – start year). $P'_{week,y}$ is the anomaly precipitation for a week in a year (y). Weekly precipitation, normal year precipitation and anomaly precipitation for each province are exported as weekly precipitation data (csv format) for each province and are shared between JAXA and ISRO. Table 6.5 is the example of precipitation data for a region.

Table 6.5 Example of weekly precipitation data for a province

Date*	Precipitation (mm)	Normal year (mm)	Anomaly (mm)
2016/1/3	0	9	-9

2016/1/10	2	1	1
2016/1/13	13	2	11
2016/1/20	0	7	-7

*Date is the middle day of each week.

6.3 Comparison of raw values

Weekly precipitation data derived from JASMIN/GSMaP and MOSDAC/HEM are compared for target provinces. Correlation coefficients between two products are calculated for every year in study period for each year ignoring no data values in the series. It is observed that raw precipitation values are more correlated than anomaly values. In general, correlation between both products varied every year but a satisfactory agreement was found. In Thailand regions, at Phetchabun and Phitsanulok correlation is found consistent and high (>=0.75). In Indian regions, Darbhanga, Vaishali and South 24 Parganas are among districts where a consistently high correlation is found. This comparison of raw values correlation are given in Appendix-I.

6.4 Comparison of anomaly values

Weekly precipitation anomaly derived from JASMIN/GSMaP and MODIS/HEM are compared for target provinces. Correlation coefficients between two products are calculated for every year in study period ignoring no data values in series. For Vaishali, South 24 Parganas and Samastipur, correlation was found high (>=0.7) that is relatively more than others. Similar to raw values, in Thailand regions correlation is found consistent and high at Phetchabun and Phitsanulok. The comparison of anomaly values correlation are given in Appendix – I.

7. NDVI

7.1 Input image data

Original data specification is summarized in the Table 7.1. To compare the products, daily composite products in the Table 7.2 are prepared for both JAXA and ISRO precipitation products as base data. The daily NDVI is the average of NDVI in a day and calculated for each pixel. NDVI images, at daily (JAXA/JASMIN) and two-day (ISRO/MOSDAC) frequency, (GeoTiff files) are shared between JAXA and ISRO.

The weekly composite products in the Table 7.3 are also generated from daily composite products. The weekly NDVI is the maximum NDVI in a week and calculated for each pixel. The null value is applied when no data is available for a pixel.

Table 7.1 NDVI data from JAXA/JASMIN and ISRO/MOSDAC

Products	Spatial resolution	Observation frequency	Unit	Data Availability
(JAXA/JASMIN) MODIS: NDVI	5 km	2 times/day	-	Jan 2009– present

(JAXA/JASMIN) GCOM-C: NDVI	5 km	1 time /day	-	Apr 2018 - present
(ISRO/MOSDAC) Oceansat-2/OCM-2:NDVI	250 m	every 2 days	-	Jul 2012 – present

Table 7.2 NDVI (Daily Composite)

Products	Spatial resolution	Temporal resolution	Unit	Study Period
(JAXA/JASMIN) MODIS: NDVI	5 km	1 day	-	Jul 2015– Jun 2019
(JAXA/JASMIN) GCOM-C: NDVI	5 km	1 day	-	Apr 2018 – Jun 2019
(ISRO/MOSDAC)Oceansat-2/OCM-2: NDVI	250 m	2 days	-	Jul 2015– Jun 2019

Table 7.3 NDVI (Weekly Composite)

Products	Spatial resolution	Temporal resolution	Unit	Study Period
(JAXA/JASMIN) MODIS: NDVI	5 km	1 week	-	Jul 2015– Jun 2019
(JAXA/JASMIN) GCOM-C: NDVI	5 km	1 week	-	Apr 2018 – Mar 2019
(ISRO/MOSDAC)Oceansat-2/OCM-2: NDVI	250 m	1 week	-	Jul 2015– Jun 2019

7.2 NDVI for each region

The weekly NDVI for each region (province in Thailand / district in India) is calculated from the weekly NDVI image and polygon data for the province as regional average value. Cropland polygon (Climate Change Initiative (CCI) Land Cover, ESA) is also used to extract cropland area. Cropland defined in CCI Land Cover is summarized in Table 7.4. Pixels in NDVI image which include crop land more than 50% are extracted. Figure 7.1 shows the example of crop area extraction in a province. In addition, Pixels where NDVI value is less than 0.2 are not considered into averaging considering them as non vegetation pixels. Weekly normal year and anomaly values are calculated to detect anomaly events. Anomaly value of NDVI is expressed as relative value compared to average value for all term data.

$$\bar{N}_{week} = \sum_{y=start\ year}^{y=end\ year} N_{week,y} / (\text{end year} - \text{start year})$$

$$N'_{week,y} = N_{week,y} - \bar{N}_{week}$$

where, $N_{week,y}$ is the maximum NDVI value for a week in a year (y) and $\bar{N}_{week}$ is the normal year NDVI for a week in the target duration (end year –start year). $N'_{week,y}$ is the anomaly NDVI value for a week in a year (y). Weekly NDVI, normal year NDVI and anomaly NDVI for each province are exported as weekly NDVI data (csv format) for each province and are shared between JAXA and ISRO. Normal year and anomaly values are calculated for MODIS and OCM-2 products but not for GCOM-C due to shortage of data.

Table 7.4 CCI Land Cover values categorized as croplands

Value	Label
10,11,12	Rained cropland

20	Irrigated croplands
30	Mosaic cropland (> 50%) / natural vegetation (tree, shrub, herbaceous cover) (< 50%)
40	Mosaic natural vegetation (tree, shrub, herbaceous cover) (< 50%)/cropland (20-50%)/cropland(<50%)

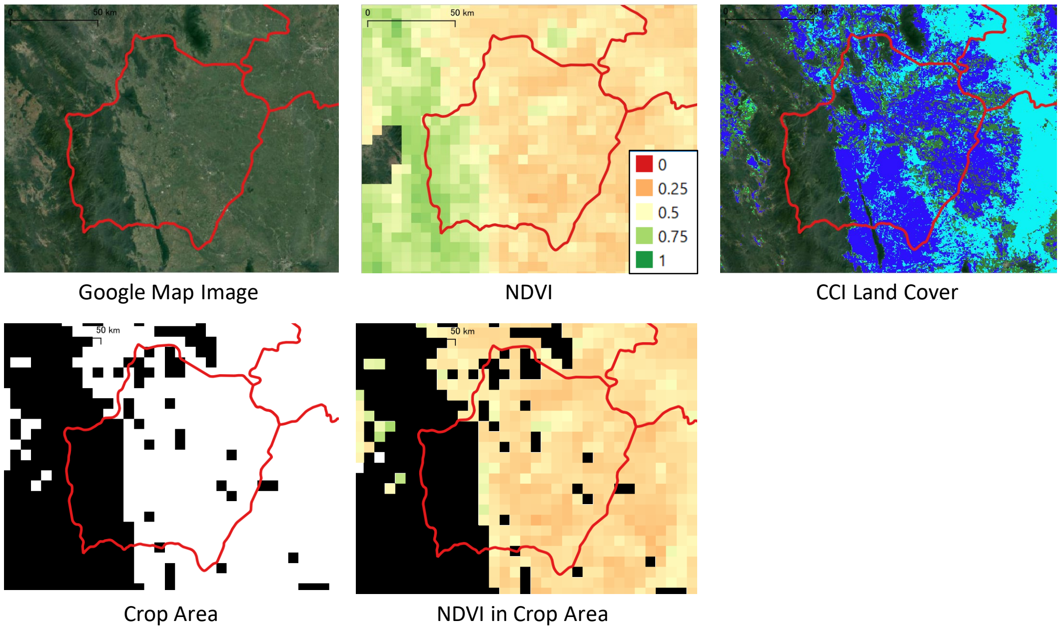


Figure 7.1 Example of crop area extraction

7.3 Comparison of raw values

Weekly NDVI data derived from JASMIN/MODIS (or JASMIN/GCOM-C) and VEDAS/OCM-2 are compared for target provinces. Correlation coefficients between two products are calculated for each year ignoring no data values in the series. As given in Appendix-I, most of the regions of India and Thailand has a good correlation between both products for raw values of NDVI.

7.4 Comparison of anomaly values

Weekly NDVI anomaly derived from JASMIN/MODIS and VEDAS/OCM-2 are compared for target provinces. Correlation coefficients between two products are calculated for each year ignoring no data values in the series. The anomaly correlation is seen as a little less but satisfactory with respect to correlation of raw values.

8. LST

8.1 Input image data

Original data specification is summarized in the Table 8.1. To compare the products, daily composite products in the Table 8.2 are prepared for both JAXA and ISRO precipitation products as base data. The daily LST data are day time (DT-LST) and night time LST (NT-LST) in a day and calculated for each pixel. Day and night times are 10:30 and 22:30 at local time, respectively. UTC times for day time are 5:00 in India and 3:30 in Thailand. UTC times for night time are 17:00 in India and 15:30 in Thailand. Daily LST images (GeoTiff files) are shared between JAXA and

ISRO. The weekly composite products in the Table 8.3 are also generated from daily composite products. The weekly LST is the average LST in a week and calculated for each pixel. The null value is applied when no data is available for a pixel.

Table 8.1 LST data from JAXA/JASMIN and ISRO/MOSDAC

Products	Spatial resolution	Observation frequency	Unit	Data Availability
(JAXA/JASMIN) MODIS: LST	5 km	4 times/day	Kelvin	Jul 2015– present
(JAXA/JASMIN) GCOM-C: LST	5 km	2 time /day	Kelvin	Apr 2018 - present
(ISRO/MOSDAC) ISRO/ INSAT 3D LST: 3DIMG_L2B_LST	4 km (≒0.04 deg)	half hour	Kelvin	Apr 2015– present

Table 8.2 LST (Daily Composite)

Products	Spatial resolution	Temporal resolution	Unit	Study Period
JAXA/MODIS LST (Day time)	0.05deg(≒5.5 km)	1 day	Kelvin	Jul 2015 – Jun 2019
JAXA/MODIS LST (Night time)	0.05deg(≒5.5 km)	1 day	Kelvin	Jul 2015 – Jun 2019
JAXA/GCOM-C LST (Day time)	0.05deg(≒5.5 km)	1 day	Kelvin	Apr 2018 – Jun 2019
JAXA//GCOM-C LST (Night time)	0.05deg(≒5.5 km)	1 day	Kelvin	Apr 2018 – Jun 2019
ISRO/ LST (Day time)	4 km(≒0.04 deg)	1 day	Kelvin	Jul 2015 – Jun 2019
ISRO/ LST (Night time)	4 km(≒0.04 deg)	1 day	Kelvin	Jul 2015 – Jun 2019

・Times for observation (UTC); India: 5:00 (day), 17:00 (night); Thailand: 3:30(day), 15:30 (night)

Table 8.3 LST (Weekly Composite)

Products	Spatial resolution	Temporal resolution	Unit	Study Period
JAXA/MODIS LST (Day time: 10:30)	0.05 deg(≒5.5 km)	1 week	Kelvin	Jul 2015 – Jun 2019
JAXA/MODIS LST (Night time: 22:30)	0.05 deg(≒5.5 km)	1 week	Kelvin	Jul 2015 – Jun 2019
JAXA/GCOM-C LST (Day time: 10:30)	0.05 deg(≒5.5 km)	1 week	Kelvin	Apr 2018 – Jun 2019
JAXA/GCOM-C LST (Night time: 22:30)	0.05 deg(≒5.5 km)	1 week	Kelvin	Apr 2018 – Jun 2019
ISRO/INSAT 3D LST (Day time: 10:30)	4 km(≒0.04 deg)	1 week	Kelvin	Jul 2015 – Jun 2019
ISRO/INSAT 3D LST (Night time: 22:30)	4 km(≒0.04 deg)	1 week	Kelvin	Jul 2015 – Jun 2019

8.2 LST for each region

The **weekly LST for each region (province in Thailand / district in India)** is calculated from the weekly LST image and polygon data for the province as regional average value. Crop land polygon (CCI Land Cover) is also used to extract crop land area. Weekly normal year and anomaly values are calculated to detect anomaly events. Anomaly value of LST is expressed as relative value compared to average value for all term data.

$$\bar{L}_{week} = \sum_{y=start\ year}^{y=end\ year} L_{week,y} / (\text{end year} - \text{start year})$$

$$L'_{week,y} = L_{week,y} - \bar{L}_{week}$$

Where, $L_{week,y}$ is the average LST value for a week in a year (y) and $\bar{L}_{week}$ is the **normal year LST** for a week in the target duration (end year – start year). $LST'_{week,y}$ is the **anomaly LST** value for a week in a year (y). Weekly LST, normal year LST and anomaly LST for each province are exported as **weekly LST data (csv format)** for each province and are shared between JAXA and ISRO. Normal year and anomaly values are calculated for MODIS and INSAT-3D products but not for GCOM-C due to shortage of data. Only weekly LST values are included in weekly LST data for GCOM-C.

Comparison of raw values

Weekly LST data derived from JASMIN/MODIS and MOSDAC/INSAT-3D are compared for target provinces. Correlation coefficients between products are also calculated for each year ignoring no data values in the series. Mutual correlation between products for each year is found to be highest in LST as compared to precipitation and NDVI. This shows very good agreement in both products in terms of LST. Indian region showed very good correlation i.e. more than 0.8 for almost all regions. Similar observations are seen for Thailand regions. More details can be found in Appendix – I.

8.3 Comparison of anomaly values

Weekly LST anomaly derived from JASMIN/MODIS and MOSDAC/INSAT-3D are compared for target provinces. Correlation coefficients between 2 products are calculated for each year ignoring no data values in the series. Similar to other agromet products, LST anomaly series has a correlation less than raw value series as analyzed from Appendix - I. Indian as well as Thailand regions displayed a very good anomaly correlation as compared to other agromet products. In general, DT-LST anomaly correlation is seen greater than NT-LST anomaly correlation.

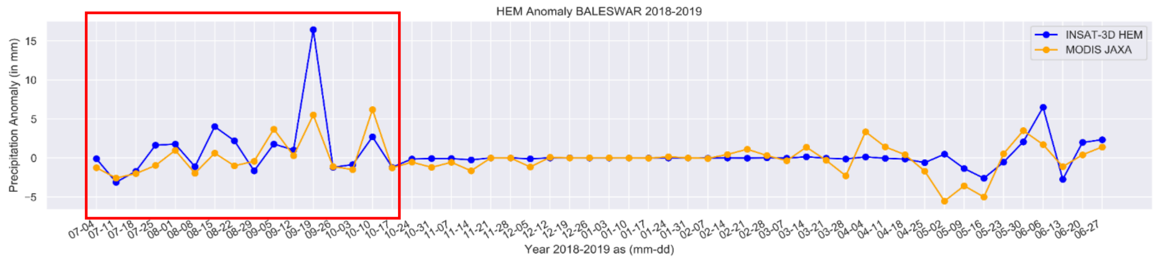
8.4 Comparison with ground station data

Daily LST data derived from JASMIN/MODIS, GCOM-C and MOSDAC/INSAT-3D are compared with GISTDA station data in 2019. Correlation coefficients between satellite derived data and GISTDA station data are calculated, respectively.

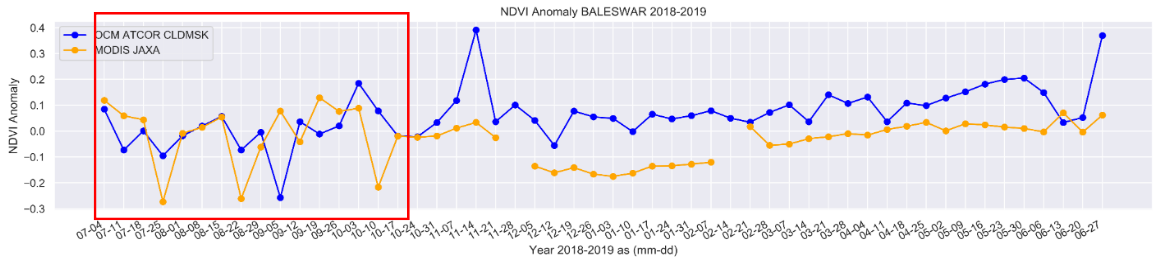
9. Case Studies and Discussions

9.1 Flood in Baleshwar, Odisha (Sep, 2018)

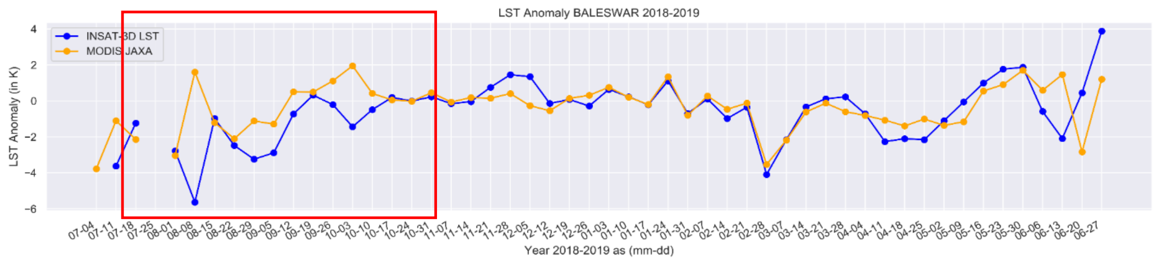
The weekly anomaly time series Agromet data is analyzed for an extreme event, Flood, in Baleshwar, Odisha, India. As per the reports, this region witnessed heavy rainfall in August and September in 2018 causing flood in the region.



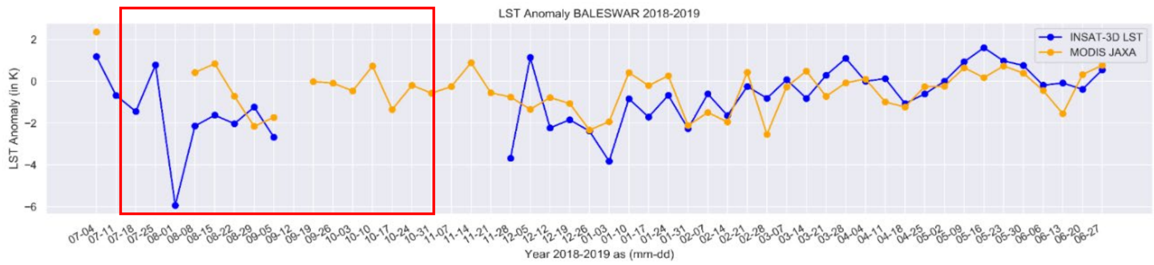
(a) High Positive Precipitation Anomaly



(b) Negative NDVI Anomaly



(c) High Negative Day Time LST Anomaly



(d) Night Time LST Anomaly

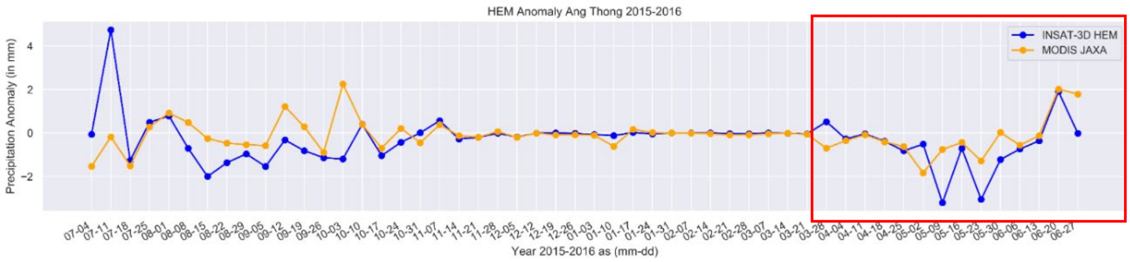
Figure 9.1 Agromet Anomalies for Flood in Baleshwar, Odisha (Sep, 2018)

From Figure 9.1(a), it can be shown that there was a high rainfall during Aug-Sep months of 2018 resulting into a high positive anomaly. This rainfall submerged coastal regions of Baleshwar causing damage of rice crop. This is evident from Figure 9.1(b) where there is negative NDVI anomaly in later period. The clouds causing rainfall covered the region and blocked outgoing longwave radiations and increased concentration of water vapor and humidity. This increased land surface temperature in nearby areas are causing positive anomaly as shown in Figure 9.1(c) and (d).

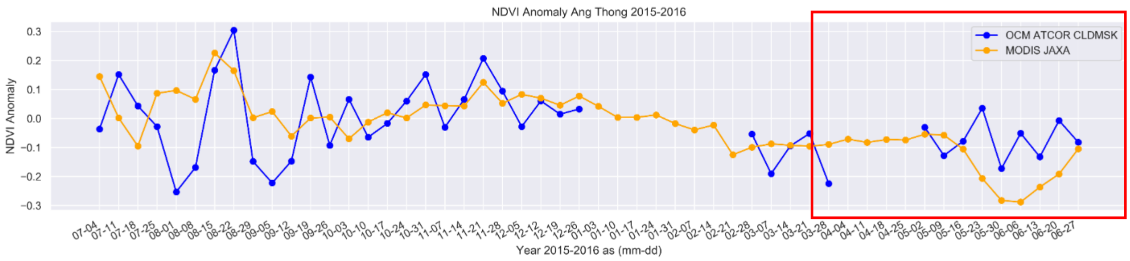
No conclusive inference could be made regarding night time LST anomaly due to partially absence of data but on a broad level, a similar anomaly trend was followed by night time LST as day time LST in the region.

9.2 Drought in Ang Thong, Thailand (Apr, 2016)

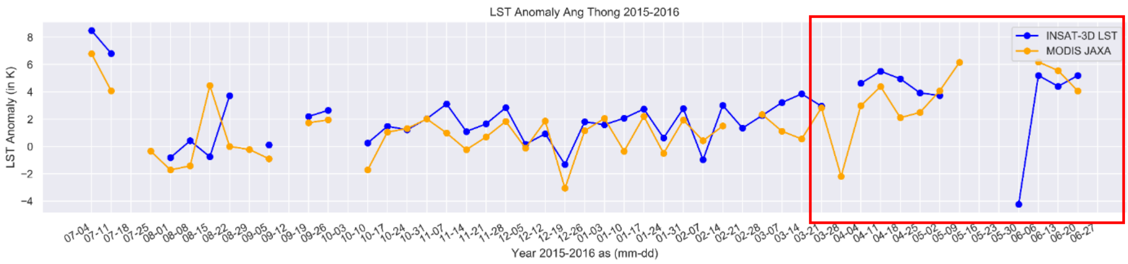
In this study, an attempt is made to understand behavior of both agromet data products in the event of drought in Ang Thong province of Thailand in Apr-May 2016. This drought was declared as severe drought by agencies and said to be caused due to strong El Nino phenomenon in the Pacific Ocean.



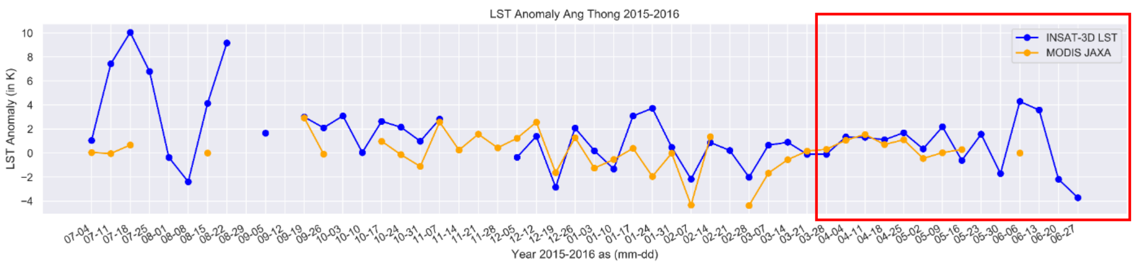
(a) Negative Precipitation Anomaly



(b) Negative NDVI Anomaly



(c) Highly Positive Day Time LST Anomaly



(d) Highly Positive Night Time LST Anomaly

Figure 9.2 Agromet Anomalies for Drought in Ang Thong, Thailand (Apr, 2016)

The El Nino phenomenon results low or late precipitation in Thailand. Thus, precipitation anomaly chart shows that there was high negative anomaly in Apr-May in 2016 as shown in Figure 9.2(a). The El Nino also resulted into rise in temperature that was recorded in 2016 extending dry season longer than non El Nino years by 2-3 months. It can be confirmed by high LST anomaly in day time (DT-LST) and night time (NT-LST) LST temperatures as shown in Figure 9.2(c) and (d). Both, temperature rise and absence of precipitation, made adverse effect on rice crop by damaging it. This explains negative NDVI anomaly in the Ang Thong region demonstrated by Figure 9.2(b).

9.3 Comparison of LST data with ground station data in Thailand

Figure 9.3 and 9.4 show the scatter plots and time series graph of LST at GISTDA-07 in 2019. Correlation at each station is summarized in Table 9.1. Station 7 has only a few data for 2019 and analysis was skipped for this station. Ground station data and each satellite derived LST show moderate to high correlations.

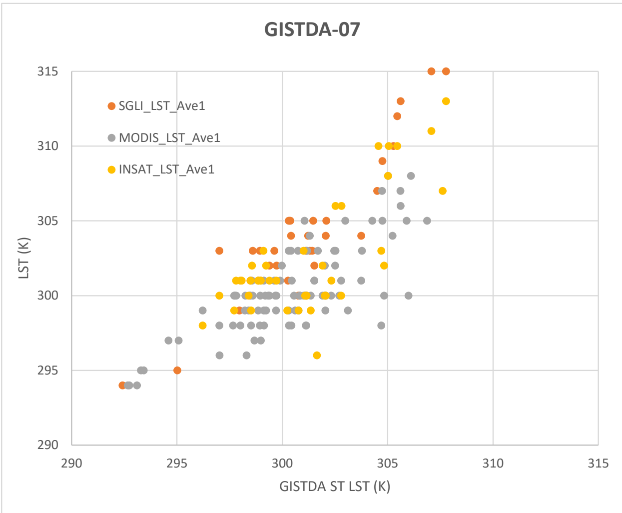


Figure 9.3 Scatter plots of LST at GISTDA-07

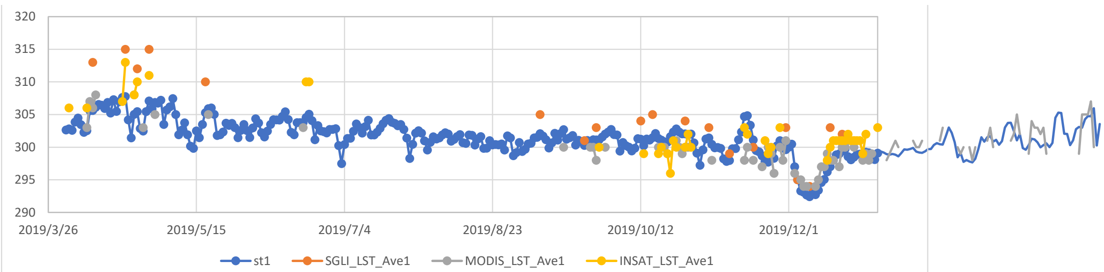


Figure 9.4 Time series LST graph at GISTDA-07

Table 9.1 Correlation of LST between GISTDA stations and satellite products

	Correration		
Station Name	**JASMIN/SGLI**	**JASMIN/MODIS**	**INSAT/LST**
GISTDA-05	0.914	0.847	0.637
GISTDA-07	0.907	0.774	0.750
GISTDA-21	0.910	0.864	0.712
GISTDA-23	0.724	0.856	0.640
Station2	0.890	0.737	0.552
Station7	—	—	—
Station14	0.869	0.922	0.598

10. Conclusions

This study attempted to understand sensitivity of ISRO and JAXA products to extreme events viz. flood and drought as well as agreement between both products to explain these events. There is a strong correlation when agromet products (Precipitation, NDVI, and LST) are compared weekly in study period. Correlation of NDVI series with JAXA/JASMIN-MODIS improved when ISRO/MOSDAC-OCM data is atmospherically corrected and masked with cloud. Thus, it is observed that both products are able to detect flood and drought events in major rice producing areas in India and Thailand respectively with a good mutual agreement in their agromet products. Daily LST data from JASMIN and MOSDAC are also compared with GISTDA ground station data and there are high correlations between each satellite derived LST and ground station data. It also proves compatibility of our products. The results of this study are expected to contribute to practical usage of agromet products for crop outlook.

11. Contributors

- **Implementation Arrangement**
  - JAXA: Mr. Toshiaki Sato, Mr. Takeshi Hirabayashi, Dr. Shinichi Sobue
  - ISRO: Mr. Shantanu Bhatawdekar, Dr. Raj Kumar, Dr. K.R. Manjunath
- **Working plan for this study**
  - JAXA: Dr. Tatsuyuki Sagawa, Dr. Kei Oyoshi
  - ISRO: Mr. Shashikant Sharma, Mr. Ujjwal K. Gupta

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Appendix – I

Correlation between ISRO and JAXA agromet products

1. Indian Districts

(a) Baleshwar

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.68	0.94	0.91	0.77	0.46	0.74	0.49	0.59
2016-17	0.68	0.86	0.83	0.66	0.48	0.52	0.22	0.53
2017-18	0.84	0.79	0.88	0.36	0.44	0.62	0.32	0.28
2018-19	0.59	0.89	0.9	0.63	0.25	0.45	0.5	0.6

(b) Bhadrak

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.7	0.92	0.79	0.7	0.33	0.55	0.42	0.55
2016-17	0.72	0.81	0.92	0.54	0.39	0.52	0.29	0.45
2017-18	0.86	0.81	0.85	0.39	0.3	0.59	0.36	0.36
2018-19	0.53	0.95	0.87	0.82	0.09	0.51	0.46	0.72

(c) Darbhanga

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.46	0.94	0.96	0.76	0.39	0.72	0.05	0.64
2016-17	0.53	0.93	0.9	0.87	0.33	0.74	0.18	0.81
2017-18	0.77	0.96	0.97	0.92	0.59	0.71	0.55	0.87
2018-19	0.61	0.94	0.95	0.72	0.37	0.67	0.73	0.56

(d) East Medinipur

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.64	0.94	0.94	0.76	0.31	0.71	0.34	0.52
2016-17	0.69	0.9	0.89	0.63	0.24	0.66	0.41	0.52
2017-18	0.79	0.89	0.88	0.55	0.46	0.56	0.58	0.42
2018-19	0.6	0.89	0.93	0.41	0.12	0.4	0.52	0.37

(e) Jagatsinghpur

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.56	0.95	0.85	0.89	0.22	0.77	0.43	0.8
2016-17	0.67	0.95	0.85	0.71	0.34	0.76	0.15	0.6
2017-18	0.78	0.89	0.83	0.69	0.36	0.78	0.27	0.58
2018-19	0.63	0.87	0.9	0.78	0.22	0.6	0.45	0.67

(f) Kendrapara

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.53	0.93	0.91	0.83	0.38	0.65	0.56	0.78
2016-17	0.65	0.88	0.93	0.54	0.37	0.65	0.43	0.5
2017-18	0.8	0.84	0.84	0.6	0.32	0.58	0.48	0.61
2018-19	0.62	0.93	0.89	0.9	0.16	0.44	0.51	0.86

(g) Paschim Medinipur

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.6	0.97	0.94	0.84	0.48	0.76	0.24	0.67
2016-17	0.83	0.82	0.87	0.77	0.23	0.42	0.52	0.55
2017-18	0.81	0.92	0.93	0.58	0.41	0.83	0.63	0.36
2018-19	0.67	0.91	0.94	0.49	0.25	0.72	0.53	0.28

(h) Samastipur

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.56	0.96	0.98	0.88	0.44	0.67	0.33	0.77
2016-17	0.5	0.86	0.95	0.59	0.1	0.68	0.51	0.56
2017-18	0.61	0.94	0.96	0.9	0.53	0.74	0.64	0.82
2018-19	0.58	0.97	0.95	0.86	0.22	0.69	0.64	0.74

(i) South 24 Parganas

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.63	0.87	0.93	0.76	0.34	0.51	0.35	0.62
2016-17	0.8	0.9	0.87	0.74	0.32	0.59	0.3	0.61
2017-18	0.87	0.85	0.93	0.77	0.52	0.5	0.53	0.55
2018-19	0.58	0.87	0.91	0.53	0.09	0.43	0.41	0.54

(j) Vaishali

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.3	0.97	0.97	0.75	0.3	0.63	0.31	0.71
2016-17	0.38	0.93	0.95	0.68	-0.04	0.67	0.51	0.64
2017-18	0.62	0.96	0.97	0.93	0.42	0.71	0.59	0.85
2018-19	0.55	0.97	0.97	0.88	0.14	0.78	0.63	0.78

2. Thailand Provinces

(a) Ang Thong

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.53	0.93	0.54	0.43	0.4	0.75	0.38	0.32
2016-17	0.35	0.8	0.47	0.58	0.34	0.56	0.21	0.55
2017-18	0.28	0.81	0.63	0.81	0.32	0.6	0.2	0.73
2018-19	0.59	0.84	0.6	0.81	0.41	0.39	0.5	0.66

(b) Kamphaeng Phet

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.62	0.88	0.67	0.84	0.42	0.7	0.23	0.6
2016-17	0.46	0.66	0.59	0.75	0.31	0.39	0.41	0.56
2017-18	0.59	0.82	0.83	0.81	0.2	0.75	0.52	0.68
2018-19	0.64	0.86	0.63	0.92	0.35	0.6	0.51	0.81

(c) Nakhon Pathum

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.53	0.86	0.5	0.71	0.42	0.47	0.12	0.57
2016-17	0.32	0.61	0.52	0.74	0.3	0.4	0.36	0.65
2017-18	0.49	0.84	0.43	0.83	0.24	0.54	0.09	0.69
2018-19	0.49	0.75	0.74	0.7	0.26	0.51	0.4	0.66

(d) Pathum Thani

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.65	0.89	0.31	0.59	0.5	0.52	0.03	0.46
2016-17	0.48	0.64	0.36	0.74	0.34	0.28	0.27	0.69
2017-18	0.58	0.54	0.55	0.8	0.1	0.52	0.09	0.63
2018-19	0.65	0.78	0.44	0.88	0.38	0.67	0.16	0.78

(e) Phetchabun

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.76	0.9	0.66	0.9	0.48	0.63	0.36	0.81
2016-17	0.61	0.84	0.47	0.79	0.2	0.56	0.26	0.69
2017-18	0.72	0.75	0.57	0.85	0.36	0.53	0.55	0.74
2018-19	0.73	0.79	0.6	0.88	0.44	0.34	0.5	0.74

(f) Phitsanulok

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.69	0.91	0.8	0.87	0.42	0.64	0.62	0.83
2016-17	0.62	0.8	0.79	0.86	0.31	0.38	0.54	0.83
2017-18	0.71	0.84	0.6	0.79	0.2	0.77	0.56	0.64
2018-19	0.7	0.88	0.53	0.84	0.37	0.52	0.44	0.66

(g) Saraburi

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.59	0.66	0.6	0.44	0.32	0.26	0.04	0.31
2016-17	0.46	0.76	0.29	0.63	0.12	0.31	0.36	0.47
2017-18	0.51	0.71	0.63	0.8	0.22	0.61	0.08	0.7
2018-19	0.72	0.81	0.64	0.8	0.46	0.23	0.4	0.74

(h) Suphan Buri

Correl	Raw Value Series				Anomaly Value Series			
Year	NDVI	DT-LST	NT-LST	Pre	NDVI	DT-LST	NT-LST	Pre
2015-16	0.6	0.94	0.56	0.64	0.49	0.85	0.27	0.56
2016-17	0.26	0.74	0.15	0.64	0.47	0.57	0.38	0.62
2017-18	0.5	0.7	0.46	0.86	0.37	0.48	-0.04	0.73
2018-19	0.62	0.81	0.63	0.86	0.34	0.6	-0.001	0.67