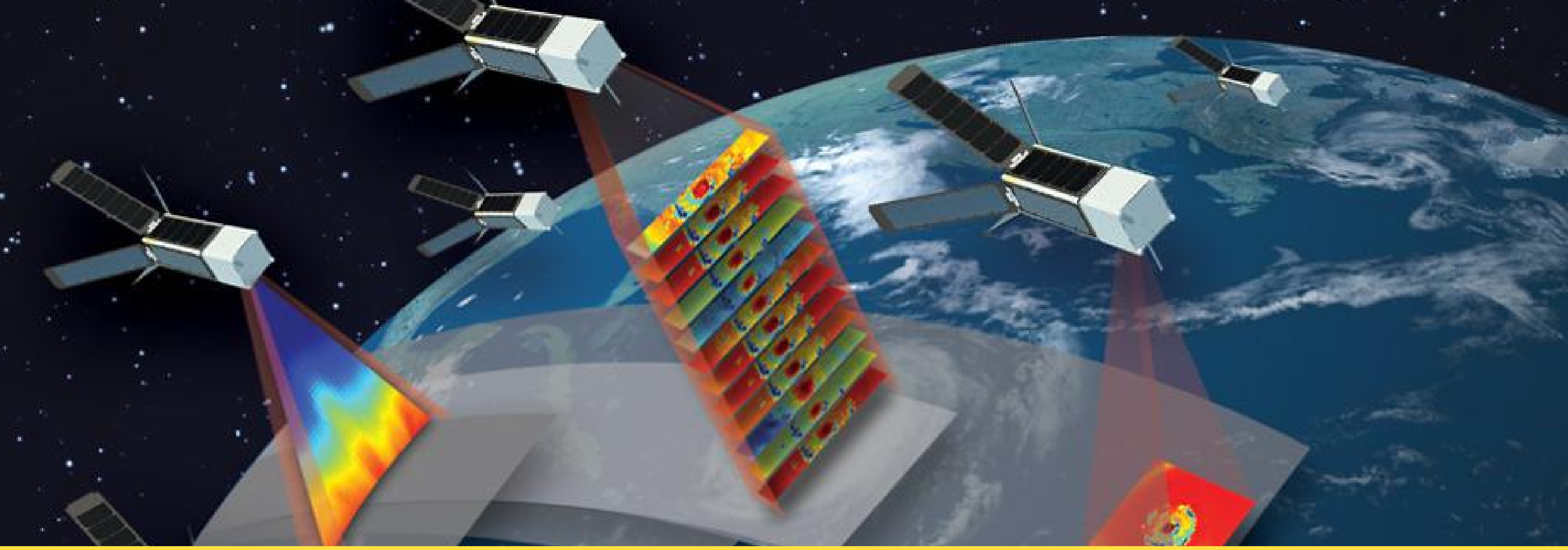

Trinity in Space for Agriculture

Image Courtesy: www.jpl.nasa.gov

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Farmers may not be interested in a space mission for searching 'water' in Mars or Jupiter. They may sometimes, ignore the breaking news of astronaut harvesting 'red roman lettuce' in space. For them the news of PSLV failed while lifting off at the bad weather is no much important.....! Farmers in India still believe that these all are for administers or scientists. They lost their faith in scientists and administrators. Farmers started ignoring the pieces of advice and the gap between the 'agricultural research' and the 'farming' widened today to a greater extent.

Farmers stopped listening to speeches about climate change and water resources. They don't want any 'expert advice' or 'complicated graphs' from a research paper to understand that water resources are depleting and climate is negatively changing. They already know much better than what we know and they take measures in a sustainable way without seeking any reward.

Farmers know how to cultivate crops better than any agricultural scientists. They always lack certain precise information which is critical to the crops and its atmosphere, which they cannot guess based on their experiences. They need scientists or research centers or administers to help them by measuring climatic variables or forecast parameters with sophisticated instruments.

They seek some simple answers.

They want somebody to tell them that when does the next rain going to come? Is that our village is drying up gradually? Is this dry spell will last for a coming week also? Is that the available water in dams is enough for the coming crop season? Is that our crops are stable or gradually wilting?

Too many unanswered questions, make them live and die in uncertainty. Here we are trying to analyze how optical, thermal and microwave remote sensing can help to reduce their agricultural uncertainties. 'Trinity' or the combination of these remote sensing techniques can deliver farmers with value-added products for improving their farming.

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Satellite Images - Still a Research Tool ?

Scientists have developed many indices to monitor crops. For example, the NDVI (Normalized Difference Vegetation Index) is one among them. Hundreds of papers published in every year in peer-reviewed journals where NDVI is a scientific term of discussion. But, how many farms in India are monitored or by satellite images to understand their relative variation in canopy signal strength. Whether we are attempting to monitor the crop heath from space in routine basis to help the farmers? Have we ever alerted any farming community saying that your sugar cane or paddy is gradually dying?

In India, INCOIS inform fisherman about the coordinate where fish is plenty on each day. For farmers beyond weather updates, we deliver nothing to them. They still not fully aware that there is a mighty camera in the space as earth observation satellites to help them to improve their farming situations.

Farmers do not have any technology to get directly connected with that friend at high heavens. They need some intermediate people like scientists to connect to them. 'Intermediate people' or 'middlemen' are always a problem to the farmers in their experience. In agricultural markets, they have bitter experiences with 'middlemen', looting them by taking the lion's share from the profit. In seed shops, fertilizer shops, crop insurance, agricultural subsidies, everywhere the 'middlemen' appear and disappear with the money they made by toiling in the hot sun and puddles.

Need of Satellite Missions for Farmers

Many space agencies have launched satellites to help the farmers. But finally, many of them became just a tool for administrators to take a decision about agricultural policies. They use satellite images to know about crop loss acreage, crop statistics, expected agricultural production, etc. Farm-level information that can be used by farmers are not being collected (may be collected) and processed to a greater extend.

Farm-level information related to crops, soil and micro climate can be collected directly by sensors. Installing sensors for soil moisture, leaf temperature, Evapotranspiration and climatic variable turns to be a costly affair for a small-scale farmer in India. Moreover, it's a point measurement and has no reliability for a larger area.

In remote sensing, we use different satellites for understanding different variables on the ground. But choosing satellite for the service of farmers has to be based on cost and reliability as a prime factor. Satellite images which are freely available can be used as data sources. Sentinel-1A, Sentinel-2A, Landsat 8, MODIS etc. are such satellites provide free satellite images for users. 'Free availability' sometimes don't serve the purpose of farmers. We should see whether the spatial resolution and temporal resolution suits for farm level applications. MODIS has a very good temporal resolution (1 day) but the spatial resolution is not suitable for farm level applications. Where as Landsat 8 and Sentinel-2A have better spatial resolution. Landsat 8 senses the same place on earth at 16 days interval and Sentinel-2A at 5 days interval. Sentinel-1A is an active remote sensing satellite which uses SAR (Synthetic Aperture Radar) technology. It has a spatial resolution of 20m and temporal resolution of 6 days. In India, we get Sentinel-1A images at 12 days interval.

When we look into the specialty of these satellites they give specific and mutually exclusive information about the land. Sentinel-2A has a red-edge region, which is centered at 705, 740 and 783 nm. It can give reliable information about Leaf area index (LAI) and chlorophyll content. The improved spectral capabilities of Sentinel-2A make it a unique friend of farmers. The values of LAI and Chlorophyll content can tell many things about the crops and vigor. LAI gives insights into density and crop height from empirical relationships.

Landsat 8 has no red edge bands. It has two thermal bands centered at 10890 and 12000 nm.These bands are used for estimating the Land Surface Temperature (LST). LST is one of the major parameters to calculate evapotranspiration (Loss of water from crops by evaporation and transpiration).The measure of evapotranspiration in mm will give us an idea how much water is lost from the cropped areas in a day (for eg. 1mm Evapotranspiration means 1 liter/day from 1m2 of land is lost to the atmosphere). There are many well-known efficient models which can give evapotranspiration values such as METRIC, SEBAL, TSEB etc.

Sentinel-1A data also has its own unique features. It records information about the ground in different bands of polarisations. It sends active microwave pulses and records its scattering by different objects in the ground. It gives information about the geometrical properties as well as dielectric properties of targets. When agriculture is concerned the geometric properties are crop height, leaf density, trunk density etc., whereas dielectric properties are the canopy water content and soil moisture content.

Question of Availability of Three Satellites Together.....

Will this trinity of satellites make us available the remote sensing data for the same day? If the satellites give data for three different dates for a single

Satellite	Uniqueness	Agricultural Aplications
Landsat 8	Thermal band	Estimation of evapotranspiration
Sentinel-2A, 2B	Red edge bands	For crop health monitoring
Sentinel-1A, 1B	SAR polarimetry	Structural parameters of crops, soil moisture

Table 1. Satellite and their unique sensor application in agriculture

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area, the correlation is meaningless. For instance, When we are able to correlate soil moisture content with the growth of crops for the same day we get meaningful results. At present this trinity visits on the same day above a particular place, once in 240 days.This gap of 240 days is too long for a farmer to assess his crop.

Does this tell us the importance of a constellation of satellites with a thermal band, red edge bands and SAR capabilities which revisit the area together at every day or every 5 days?

Keeping this in mind, we have conducted studies near Hyderabad in a village called Warangal where most of the farmers with small land holding primarily fed by monsoon and no canal irrigation facilities available. We were able to derive leaf area index, soil moisture variability, evapotranspiration values for the area for the same day and was validated with an extensive ground truth. The data from Landsat 8, Sentinel-1A and Sentinel-2A obtained for single a day is used. The meteorological observatory owned by the Nagarjuna innovation center located in the midst of the study area was used for validating evapotranspiration values. Three satellites missions together were able to deliver a large amount of information pertaining to each cropped field in moderately high resolution. The only limitation was that the revisit period was too long for these satellites.

Satellites with high resolutions dedicated to agriculture is a need of the time. Optical remote sensing along with thermal and microwave remote sensing can deliver value-added information products to the farmers. This trinity in the space can definitely safeguard the agriculture in our country, provided scientists have to be a better 'middlemen' for them.

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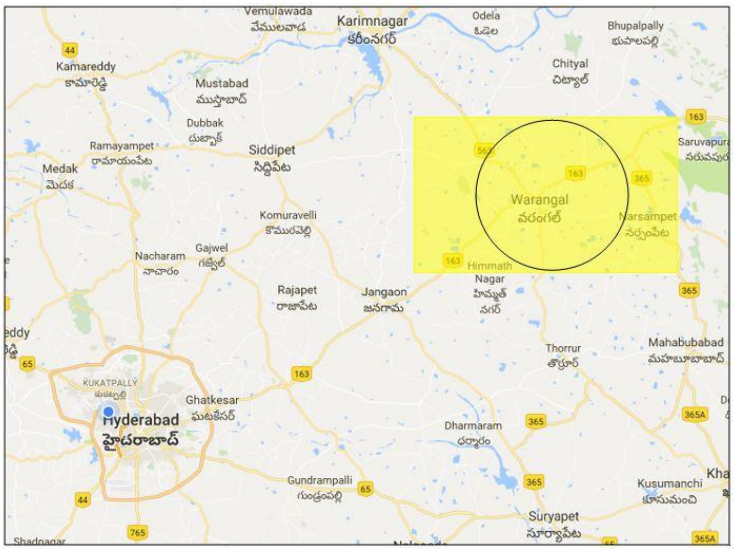

Figure 1. Study area demarcated on Google Maps

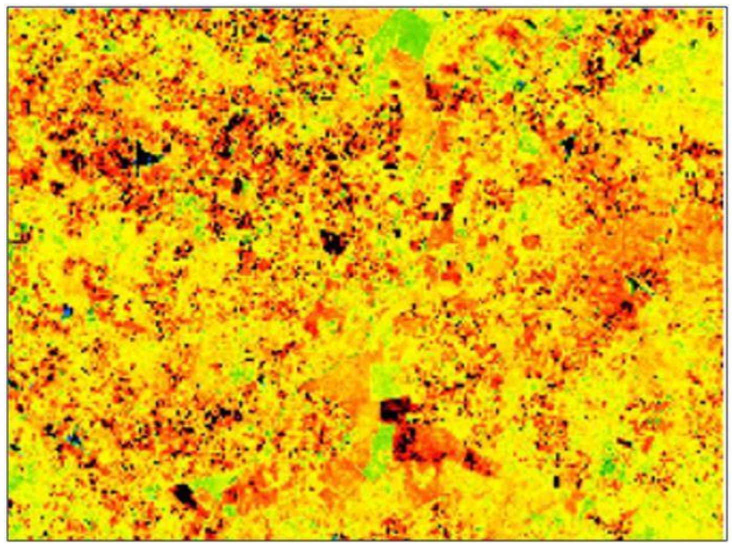

Figure 2. LAI image from Sentinel-2A
Values range from 0.2 - 3
(Red - High LAI, Yellow - Medium LAI, Green - Low LAI)

All satellite images were taken on February 03, 2017

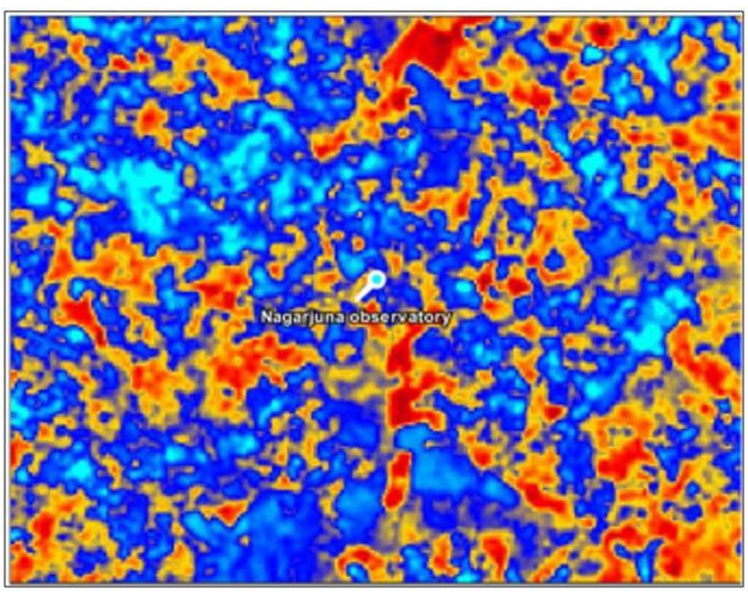

Figure 3. LST image from Landsat 8
Values range from 300 - 306K
(Red - High LST, Orange - Medium LST, Blue - Low LST)

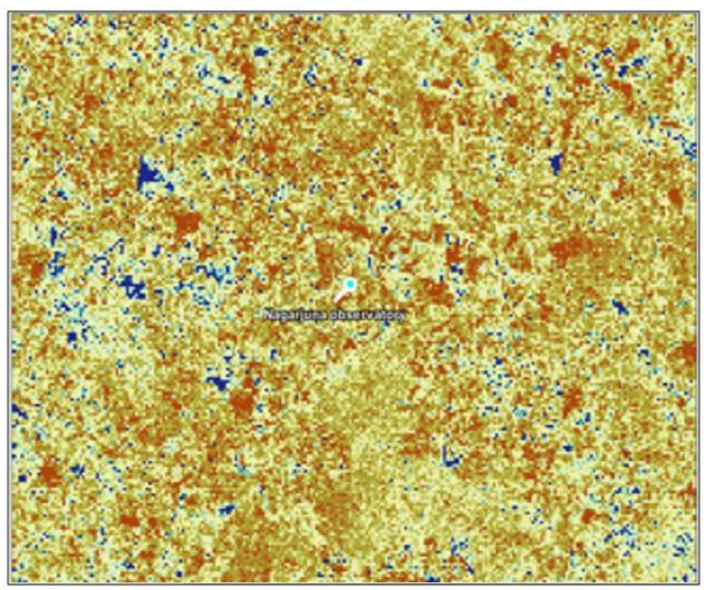

Figure 4. Soil moisture from Sentinel-1A
Values range from 0.1 - 3 %
(Brown - High moisture, Blue - Low moisture)