COMPARISON BETWEEN ACTIVE AND PASSIVE OPTICS SENSORS TO MONITOR SPECTRAL BEHAVIOR DURING RICE GROWTH STAGES

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ABSTRACT: The use of existing technologies within the science of remote sensing has increasingly contributed to the development of agriculture. Thus, our objective with this research was to compare performance to quality read between active and passive optics sensors are considerably greater to monitor spectral behavior of rice at different dates during their growth stages. This project will present correlations between active optical sensors with Sentinel 2 (S-2) satellite spectral bands. The vegetation indices to be used were: NDVI and CIRE. All the data simple linear regression and Pearson correlations were performed to compare active and passive sensors (satellite imageries data) with active crop canopy sensor technology. The averaged data were used along rice phenology to illustrate the dynamic of both sensors during the entire rice season. The active sensor presented better results than the passive sensor due to its being more stable for data collection under some different weather conditions.

KEYWORDS: Remote sensing, saturation issue, satellite imageries, Pearsons correlations, regression analysis.

1 I INTRODUCTION

Remote Sensing Techniques (RS) have greatly supported decision-making in agricultural production systems. Its use extends from the coverage of large geographic areas to collecting information. The information collected can be effectively acquired in real-time and used to analyze the spectral characteristics of crops.

Thus, among the RS applications, the monitoring of crop growth parameters has shown potential results in the studies of estimates of essential variables for managing rural properties, such as biomass, productivity, and biophysical characteristics of plants (Carneiro et al., 2022; Tedesco et al., 2021; Oliveira et al., 2022).

Estimating crop biophysical parameters before harvest helps growers proactively detect problems. It also assists in making decisions about irrigation, fertilizer applications, and pest and weed control. Therefore, active and passive sensors are commonly used to generate information that contributes to farmers' responses. The hypothesis of this work is active sensor has low range level than passive. This ways, we can use active sensor for reduce the range level from passive sensor, as calibration.

The main objective was to compare performance to quality read between active and passive optics sensors are considerably greater to monitor spectral behavior of rice at different dates during their growth stages

2 I MATERIAL AND METHODS

This project was conducted in 2021 across the biggest rice production region of the United States. With commodity board leaders and stakeholder partnerships we selected 3 groups that are well distributed in the Louisiana rice production region. In each group 3 fields were sensed weekly from the beginning of the rice cycle until panicle initiation, totalizing 4 weeks and dates for data collection. For each commercial field, we selected a target over canopy, bare soil and grasses to be able to calibrate imagery across dates and to correct Sentinel 2 satellite image using ground truth data. The sensor was mounted over an aluminum bar, and a handheld data logger (Holland Scientific - Geoscout) was used to record 2 minutes in 3 close locations on the rice canopy and 2 more (bare soil and grasses). Around 600 readings per site was done. For these same locations we selected a subfield region that corresponded to an area of 60 m that can cover 20x20 m pixel of Sentinel 2 for red edge and 10x10m for NIR and red bands. Obviously the frequency of cloud free images are not the same as an active sensor, but we tried to download satellite images closer to the day when active sensors were used to collect data.

The sensor used was a Holland Scientific ACS430 plus a ACS43X, that when coupled together is called *Phenom system*. This sensor is an active sensor that uses modulated LED lights that is different from sunlight, consequently we do not have interference and we are able to work even at night. The sensor records data every second linking the geographical coordinates with NIR, red and red edge bands, additionally to the optical it also records, LAI, canopy and ambient temperature, incident and reflected PAR, chlorophyll content estimation, relative humidity and atmospheric pressure. For this project we will present correlations between active optical sensors with Sentinel 2 satellite spectral bands. The vegetation indices to be used were: NDVI and CIRE.

All the data simple linear regression and Pearson's correlations were performed to compare satellite passive data with active crop canopy sensor technology. The averaged data was used along rice phenology to illustrate the dynamic of both sensors during the entire rice season.

3 I RESULTS AND DISCUSSION

3.1 Comparison between active and passive sensors

Reflected photosynthetically active radiation (PAR_R) had higher incident photosynthetically active radiation (PAR_I) values, in which it is observed that the values are inversely proportional to what there was a reduction in the PAR_R values until the third date (May 26th) and increase on the fourth date (June 9th), while in PAR_I the opposite occurs. This result can be explained due to the rice growth stages since it is known that the smaller the plant, has less canopy closure on the ground; on the other hand, it is not cover 100% of the ground, and by the way, having more percentage of soil that plant. Therefore, there will be interference in the reading due to other targets not being evaluated, such as soil reflectance. In addition to the results, the evaluated vegetation indices corroborate with what was mentioned in which the smaller the plant, the lower the vegetation index (VI) value due to the reflectance of other targets, such as, in the case of this work, the soil. As for the comparison between sensor readings, data from liabilities underestimate the values in relation to assets in field #2 (Figure 1) while at fields # 3 (Figure 2) and #4 (Figure 3) overestimated the values of both indices. The CIRE had its values overestimated in all analyzed Fields. Thus, the importance of using active sensors to calibrate passive sensors at all stages of crop growth is verified. There are specific indices, such as the NDVI, that are sensitive to saturation (Gu et al., 2013) as the plant's biomass increases, and its use is recommended at the beginning of the crop's growth; that way, when there is an increase in biomass, using other vegetation indices that do not have this problem. Another fascinating result related to the NDVI was when there was a field change, as in fields #3 and #4 (Figures 2 and 3), the NDVI readings of the S-2 were overestimated, emphasizing the importance of calibration so that this does not occur again due to error reads from noises. Data from active sensors are recommended for calibration due to their low reading variability, as they are not affected regardless of the time of day. On the other hand, passive sensors have great reading variability as they are influenced by the hours of light available, especially if there is the presence of clouds, a fact that greatly affects the reading quality of passive optical sensors. Therefore, the active sensor showed us that it could be an excellent tool to identify this issue during the crop growth stages. The active sensor can be used to detect VI saturation issues.

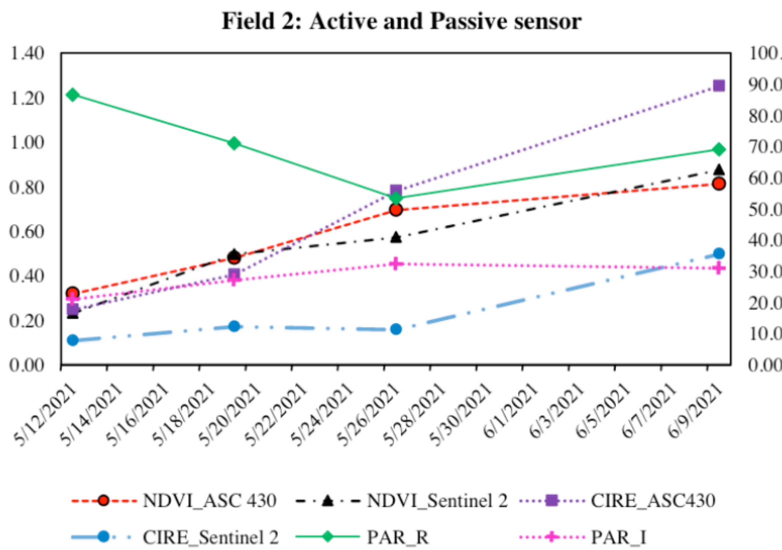

Figure 1. Comparison between active and passive sensor, according to date collection and field. PAR_I and PAR_R: incident and reflected photosynthetically active radiation, respectively; CIRE: Chlorophyll Index - Red-Edge; and, NDVI: Normalized Difference Vegetation Index.

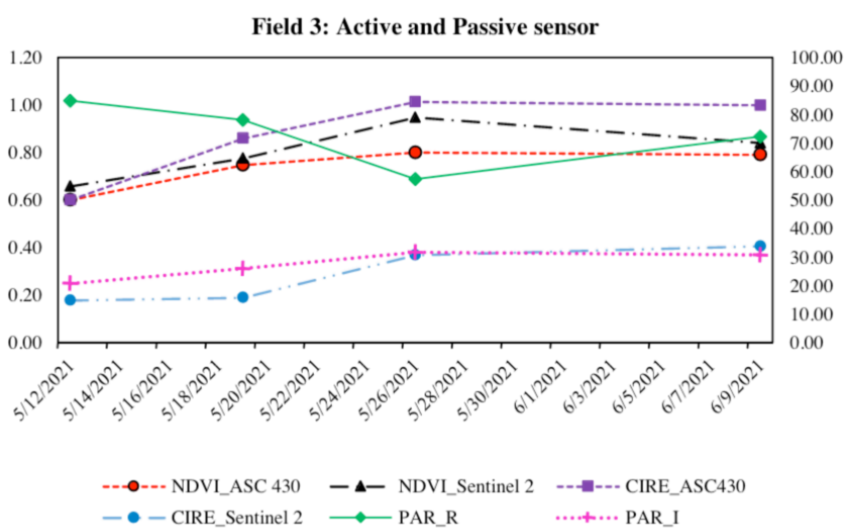

Figure 2. Comparison between active and passive sensor de according to date collection and field. PAR_I and PAR_R: incident and reflected photosynthetically active radiation, respectively;CIRE: Chlorophyll Index - Red-Edge; and,NDVI: Normalized Difference Vegetation Index.

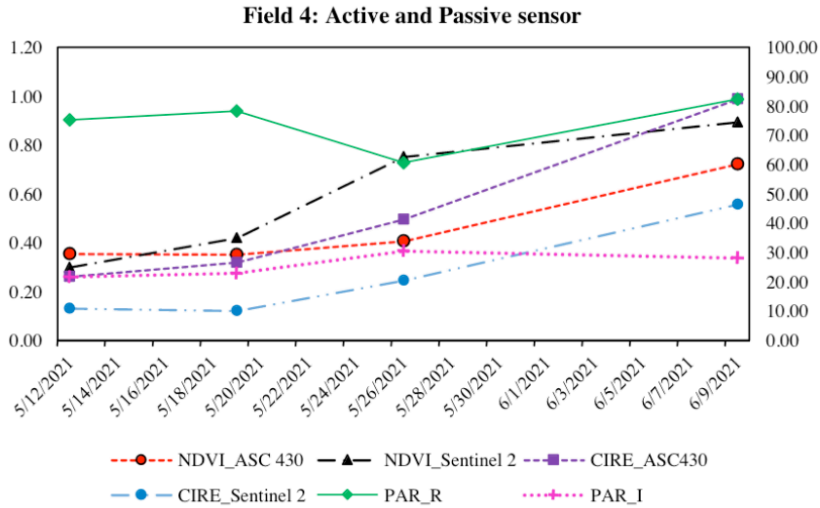

Figure 3. Comparison between active and passive sensor de according to date collection and field. PAR_I and PAR_R: incident and reflected photosynthetically active radiation; CIRE: Chlorophyll Index - Red-Edge; and NDVI: Normalized Difference Vegetation Index.

3.2 Pearson Correlation

The overview for all fields analyzed, the vegetation indices (NDVI and CIRE), and spectral bands (R - red, RE - red edge, and NIR - infrared) were with greater correlation were: biophysical characteristics (LAI - leaf area index, CCC - canopy chlorophyll content, CAN_TEMP - canopy temperature, and CH1 - chlorophyll a, and CH2 - chlorophyll b); PAR_I and PAR_R (incident and reflected photosynthetically active radiation).RE (red edge) and red spectral bands got opposite values to biophysical characteristics (LAI, CCC, and canopy temperature) and air temperature. In addition, NIR and RE bands had similar results due to wavelength located near each other and having the same behavior to crop spectral. These results can be explained due to during begging growth stages to reproductive stages absorbing greater the red spectral band rate than NIR and RE due to crops doing photosynthesis and having greater chlorophyll rate responsible for absorbing blue and red bands. At the same time, in NIR and RE, there is more reflectance than red.

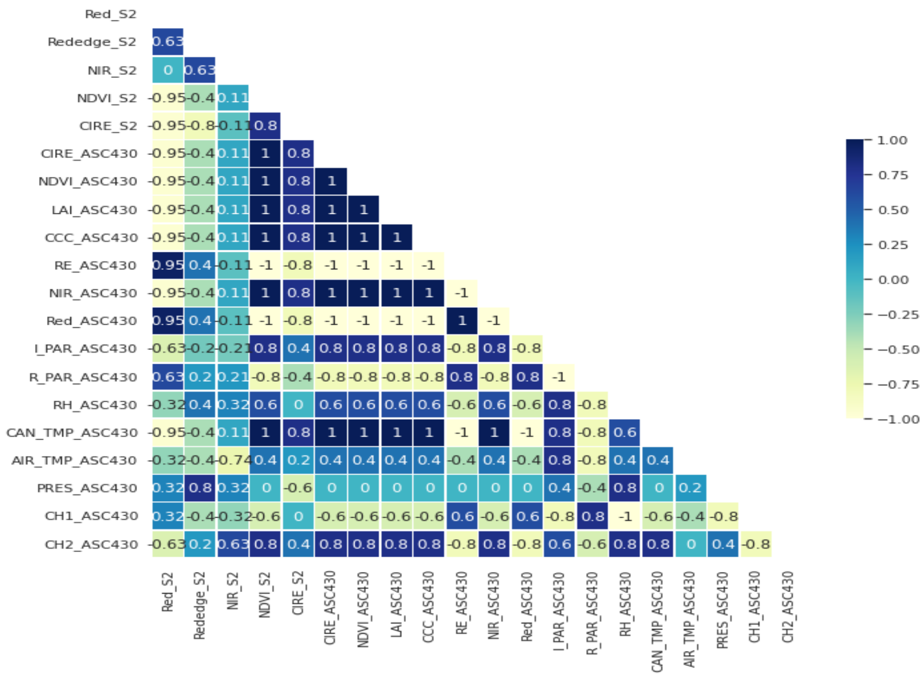

Figure 4. Pearson correlation using heat map to field 2 among active and passive sensor during rice growth stages.

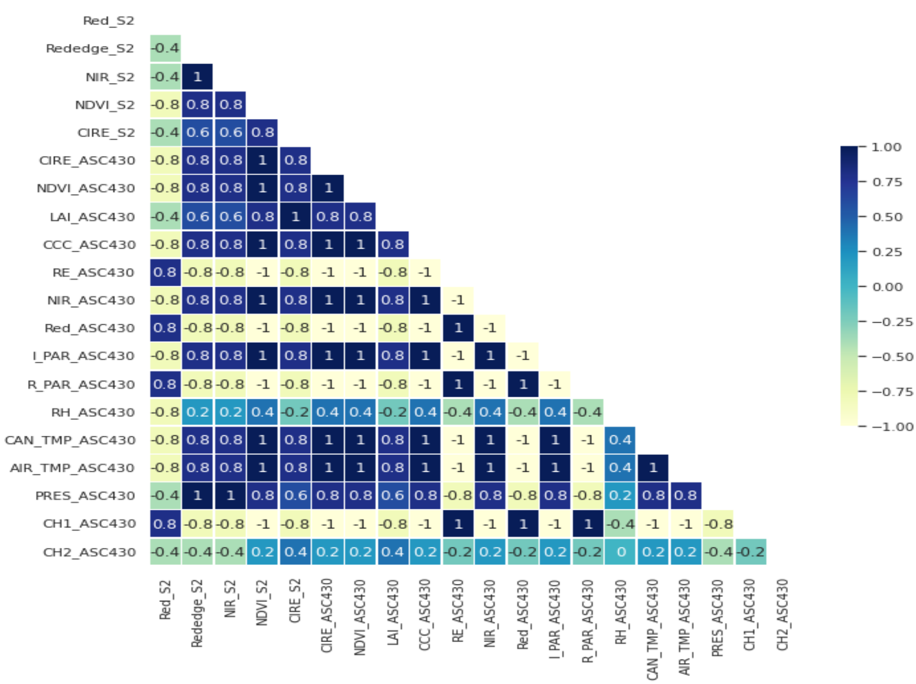

Figure 5. Pearson correlation using heat map to field 3 among active and passive sensor during rice growth stages.

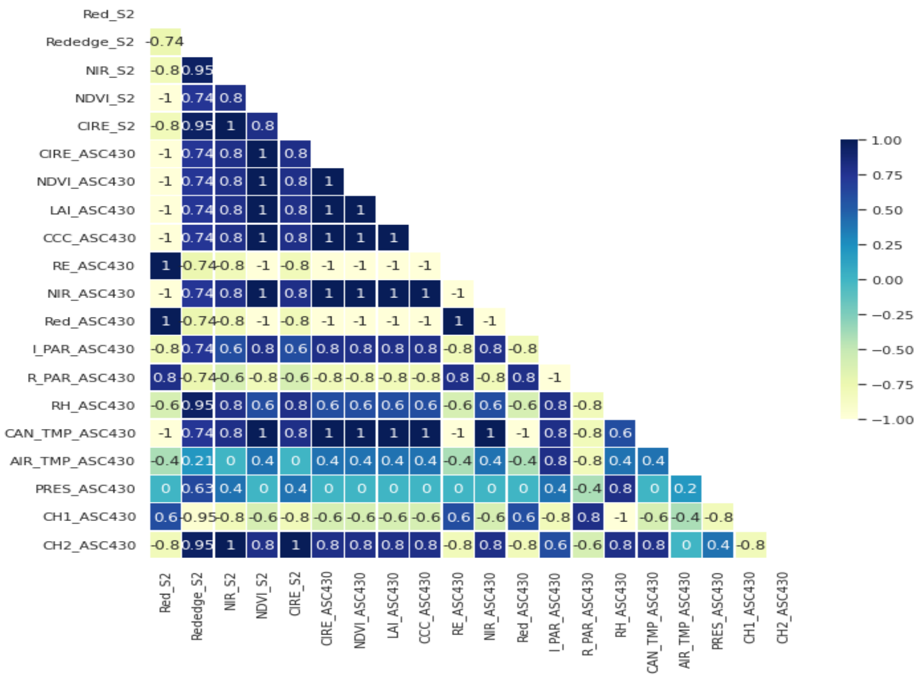

Figure 6. Pearson correlation using heat map to field 4 among active and passive sensor during rice growth stages.

3.3 Regressions Analysis

Regression analysis was calculated in three different scenarios from field 4: (i) active and passive sensors; (ii) vegetation indices and active sensors; and (iii) vegetation indices and passive sensors. The first scenario, CIRE got greater results than NDVI (Figures 6a and 6b). It can be explained due to NDVI being more susceptible to the saturation issue (Zanzarini et al., 2013; Carneiro et al., 2020). For the second and third scenarios, incident photosynthetically active radiation (PAR_I) was better to active than passive sensor (Figures 6c, 6d, 6e, and 6f).

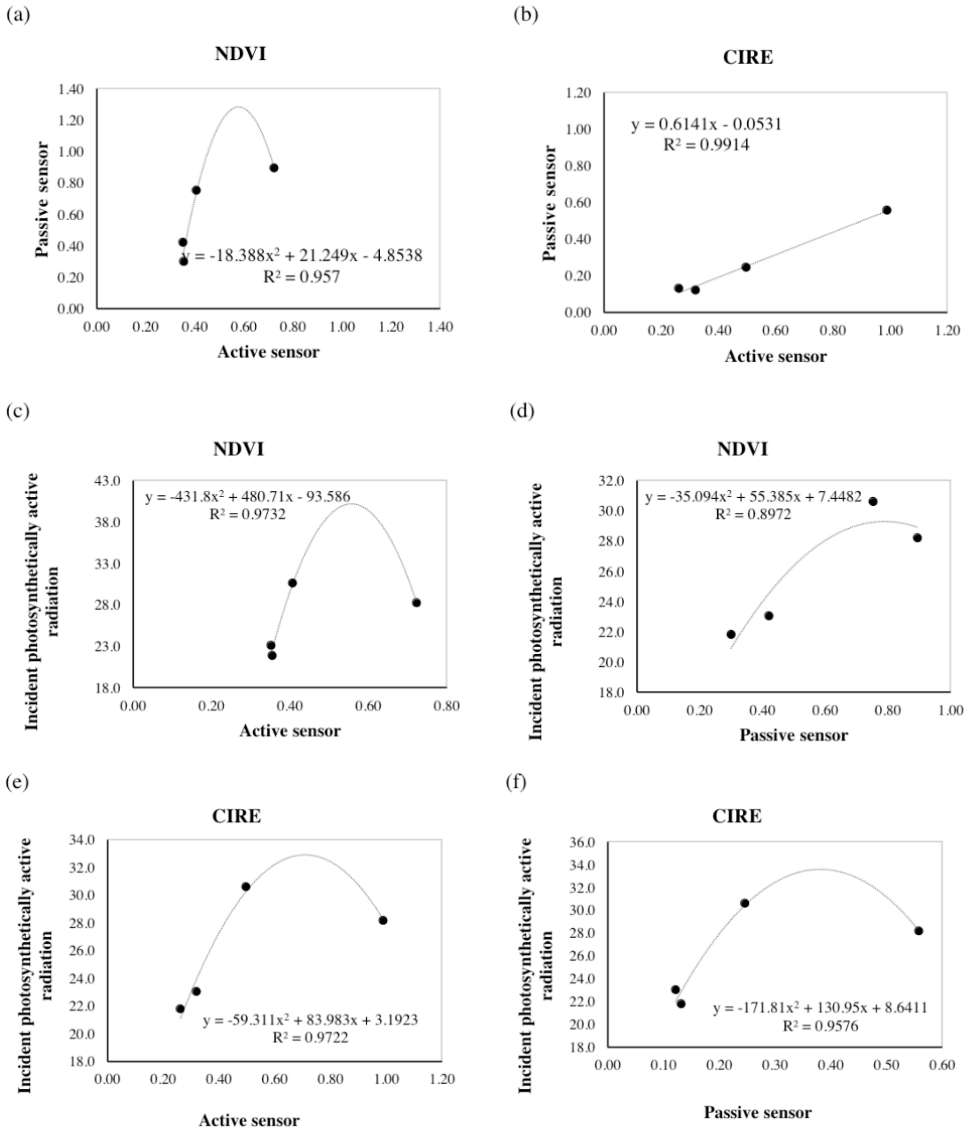

Figure 6. Regression analysis from field 4 among active and passive sensor during rice growth stages.

4 I CONCLUSIONS

The active sensor performed better than the passive sensor due to fewer weather effects and consequently being more stable for data collection. By the way, the active sensor can be used to calibrate the passive sensor. How this work shows that a passive sensor is more susceptible to effects from weather conditions (cloud percentage and rainfall) and the time of the day. While the active sensor, these issues do not appear in how we observed the results from this work. Furthermore, this work shows us interesting results and uses different platforms, mainly passive and active sensors, to get different results even with the same vegetation index.

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