Proceeding Series of the Brazilian Society of Computational and Applied Mathematics, v. 12, n. 1, 2026.

Trabalho apresentado no XLIV CNMAC, Fundação Getulio Vargas - Rio de Janeiro - RJ, 2025.

Proceeding Series of the Brazilian Society of Computational and Applied Mathematics

Statistical and Comparative Analysis of Spectral Index Combinations for Burned Area Detection

Cândida C. S. de S. Leite[1], Giovanni Guarnieri[2], Liana O. Anderson[3]
INPE, São José dos Campos, SP
Leonardo Santos[4]
CEMADEN, São José dos Campos, SP

With the advancement of technologies such as Big Data and Artificial Intelligence, an increasing number of medium and high spatial resolution satellite images are being made available for free, enabling environmental studies. The integration of well-established methodologies, such as the use of spectral indices for detecting burned areas, with machine learning techniques, continues to contribute to the implementation of impact mitigation strategies and contingency plans for these events.

Therefore, this study aimed to evaluate the performance of different combinations and logical operations between spectral indices for detecting burned areas (NBR, NBR2, MIRBI) and the Near-Infrared (NIR) band, using 2019 Landsat OLI sensor images. To achieve this, we tested 44 combinations of the indices mentioned above and spectral band, along with their temporal differences, using "OR" and "AND" operations, with combinations ranging from two to three indices, including all indices with and without temporal differences.

Initially, we classified the burned areas and subsequently used the 2019 burned area mapping by the Labgama team at UFAC [2] as reference data. We used this data to generate 900 stratified random points, with 200 in non-burned areas and 700 in burned areas, to evaluate the resulting classifications [1]. We created 44 confusion matrices and, for each one, calculated the performance metrics: i) Overall Accuracy, ii) Precision, and iii) Recall, in order to identify which approaches performed best in detecting burned areas, both in forested and agricultural areas, and to assess the distribution of these metrics.

As a result, we have Figure 1, which displays the violin plots showing the distribution of the performance metric values (Accuracy, Recall, and Precision). Analyzing the violin plots, we observe that Precision has higher values, concentrated near 1, while Recall shows greater dispersion and lower values, indicating the model's difficulty in detecting all burned areas. On the other hand, accuracy has an intermediate distribution, with a central tendency between 0.25 and 0.75 and an average of around 0.50.

[1] candidaleite.geo@gmail.com
[2] giovanniguarnierisoares@gmail.com
[3] liana.anderson@inpe.br
[4] santoslbl@gmail.com

© 2026 SBMAC

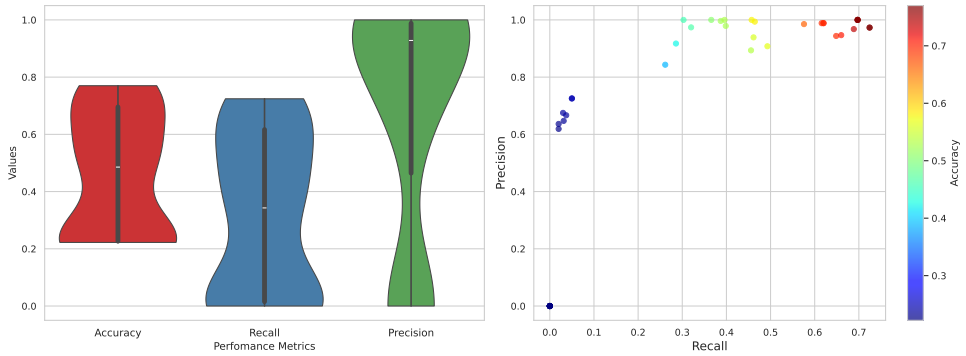

Figure 1: Left: Distribution of performance metric values for the 44 combinations and logical operations between the indices and the spectral band used. Right: Scatter plot representing the relationship between Precision and Recall values and Accuracy in color. Source: Author's own.

We can see in Figure 1 that in the scatter plot, the green, yellow, and red points represent combinations with higher Accuracy, while the blue points have lower performance. Additionally, from this plot, we can highlight the existence of a group of seven combinations (red points) with high Precision and high Recall (Table 1). On the other hand, some combinations have very low Recall, close to zero, indicating the difficulty of these combinations in detecting burned areas.

Table 1: Group of combinations between spectral indices and the spectral band with the best performance

Combination	Overall Accuracy	Precision
MIRBI & NBR & NIR w/o temporal differences	0.76	1.00
NBR2 & NBR & MIRBI & NIR w/o temporal differences	0.76	1.00
NBR2 & NBR & NIR w/o temporal differences	0.76	1.00
NBR2 & NBR & MIRBI & NIR w/o temporal differences	0.76	1.00
NBR2 & NBR & MIRBI & NIR w/o temporal differences	0.77	0.98
NIR & NBR2 w/o temporal differences	0.77	0.98
NBR or NIR with temporal differences	0.74	0.98

We conclude that this study achieved the objective of identifying the optimal combinations between spectral indices and the NIR band. We also observed that for the methodology used in the mapping, the inclusion of temporal differences does not result in improvements. The graphs used in the analysis of performance metrics also helped us gain a broad view of the distribution of the behavior of the classifications performed.

References

[1] C. Leite, L. Anderson, and L. Santos. "Mapeamento de áreas queimadas na Amazônia: Eficiência e precisão de combinações de índices espectrais". In: **Anais do XXI Simpósio Brasileiro de Sensoriamento Remoto**. 2025.

[2] S. Silva, L. Anderson, A. Melo, F. Willian, and D. Sallisbury. "Queimadas e incêndios florestais na região fronteiriça Brasil, Peru e Bolívia em 2021 na Amazônia sul ocidental". In: **Ambiente e Sustentabilidade na Amazônia**. 2023. DOI: 10.5281/zenodo.8122236.

© 2026 SBMAC