Neural Network model for classification of net CO2 fluxes scenarios in Tapajós Forest, in Amazon

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Abstract

The Amazon rainforest has a great influence on the global energy balance and carbon fluxes, responsible for the net removal of approximately 4 million tons of carbon per year, via photosynthetic activity. Climate change and deforestation have impacts on the carbon budget in Amazonia, transforming CO2 sink areas into sources. Given the complexity of the factors that govern the carbon exchange in the Amazon and its influence on biological processes, the use of Data science strategies can promote a better understanding about the main environmental factors for different scenarios, and also, assist in public policies to mitigate the global warming effects. This study aims to identify the environmental factors that determine the temporal variability of carbon exchanges between the biosphere and the atmosphere in the Tapajós National Forest, in the Amazon, applying Data Science strategies in an integrated set of environmental data from energy and carbon fluxes and remote sensing data. The specific objective is to assess the influence of a selected set of environmental variables on the variability of carbon exchanges, with the use of an artificial neural networks classification model to identify the variables with great impact on source, sink and neutrality scenarios in Tapajós National Forest. Data Science strategies were applied to an integrated dataset of ground-based carbon flux measurements and remote sensing data, considering the period between 2002 and 2006. An artificial neural network (ANN) classification model was developed to identify the environmental variables with great impact on carbon source, sink and neutrality conditions. The average global score of ANN model was 65%. It was possible to identify the predictor variables with greatest impact to the carbon sink condition: radiation at the top of the atmosphere, sensible and latent energy fluxes and leaf area index. Thus, the ANN model with an ensemble of Data Science strategies can improve a better understanding of variability CO2 fluxes and be a powerful tool to promote new knowledge.
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INTRODUCTION

The Amazon rainforest has a great influence on the global energy balance and carbon fluxes, being responsible for the net removal of approximately 4 million tons of carbon per year, via photosynthetic activity [1]. Climate change and deforestation have impacts on the carbon budget in Amazonia, transforming CO₂ sink areas into sources [2]. Given the complexity of the factors that govern the carbon exchange in the Amazon and its influence on biological processes, the use of Data Science strategies can promote a better understanding about the main environmental factors for different scenarios, and also, assist in public policies to mitigate the global warming effects.

OBJECTIVE

This study aims to identify the environmental factors that determine the temporal variability of carbon exchanges between the biosphere and the atmosphere in the Tapajós National Forest, in the Amazon, applying Data Science strategies in an integrated set of environmental data from energy and carbon fluxes and remote sensing data. The specific objective is to assess the influence of a selected set of environmental variables on the variability of carbon exchanges, with the use of an artificial neural network classification model to identify the variables with great impact on source, sink and neutrality scenarios in Tapajós National Forest.

MATERIALS AND METHODS

A daily dataset was integrated from ground-based carbon flux measurements and remote sensing data, considering the period between 2002 and 2006.

Data sources (All variables used in this experiment are presented in Table 1):

LBA dataset [1]:
- Satellite Data MCD19A2 [2]:
- Satellite Data NOAA/AVHRR [3]:

Used libraries:
- Data processing - earth library (available in R), netCDF4 library (available in Python)
- Deep Learning - sklearn and keras (both available in Python)

RESULTS

Accuracy - 63.81% (training) 61% (testing) Average global score - 65.44% ± 0.06%

Figure 1 presents the ANN predictions and below are presented Precision metrics:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source</td>
<td>CO₂ flux change from soil to atmosphere</td>
</tr>
<tr>
<td>Sink</td>
<td>CO₂ flux change from atmosphere to soil</td>
</tr>
<tr>
<td>NEE</td>
<td>Net ecosystem exchange of CO₂</td>
</tr>
</tbody>
</table>

Table 1: Variables used to training the Artificial neural network for NEE classification.

REFERENCES


CONCLUSIONS

Although ANN model did not had a great performance, it is possible to find patterns which lead to each CO₂ exchange scenario, exploring the data, selecting those variables with strong impact for predictions (Figure 3). Thus, the ANN model with an ensemble of Data Science strategies can improve a better understanding of variability CO₂ fluxes and be a powerful tool to promote new knowledge. However, it is essential to have better environmental data availability and an integrated and multidisciplinary approach to net ecosystem exchange.

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