

SEBAL ALGORITHM IMPLEMENTATION ON GOOGLE EARTH ENGINE

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ABSTRACT: The determination of evapotranspiration (ET) is of great importance for the estimation of water balance in watersheds, serving as an aid to the efficient management of water resources. Thus, the objective of the present work was to develop a tool to estimate the actual evapotranspiration by the SEBAL algorithm using a cloud computing platform. SEBAL has been widely used to estimate actual evapotranspiration and carbon sequestration, but requires significant pre-processing and computational resources if it is necessary to run the algorithm for a number of days. The Google Earth Engine (GEE) platform simplifies the pre-processing steps, allowing the focus on the algorithm. The implementation of the SEBAL algorithm in the GEE favors the reduction of errors during its execution as well as the feasibility of executing an extensive and complex algorithm for a wider historical series.

KEYWORDS: Cloud computing, Landsat, Remote Sensing.

IMPLEMENTAÇÃO DO ALGORITMO SEBAL NO GOOGLE EARTH ENGINE

RESUMO: A determinação da evapotranspiração (ET) é de grande importância para a estimativa do balanço hídrico em bacias hidrográficas, servindo de auxílio à gestão eficaz dos recursos hídricos. Diante disso, o objetivo do presente trabalho foi desenvolver uma ferramenta para a estimativa da evapotranspiração real pelo algoritmo SEBAL utilizando uma plataforma de computação em nuvem. O Surface Energy Balance Algorithms for Land (SEBAL) tem sido amplamente utilizado para estimar a evapotranspiração real, mas requer

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um pré-processamento significativo e recursos computacionais caso seja necessário a execução do algoritmo para uma série de dias. A plataforma do Google Earth Engine (GEE) simplifica as etapas de pré-processamento, permitindo o foco no algoritmo. A implementação do algoritmo SEBAL no GEE favorece a redução de erros durante a sua execução como também a viabilidade de executar um algoritmo extenso e complexo para uma série histórica mais ampla.

PALAVRAS-CHAVE: Computação em nuvem, Landsat, Sensoriamento Remoto.

INTRODUCTION

The determination of evapotranspiration (ET) is of great importance for the estimation of the water balance in watersheds, serving as an aid to the effective management of water resources. With conflicts of use, saving water use in agriculture through the correct determination of ET is essential. In this context, The SEBAL algorithm allows the estimation of evapotranspiration by satellite image, and it has been adopted by many researchers for water resources management purposes, investigating crop water consumption to avoid loss, as well as to assess the influence of climate change on crop evapotranspiration, estimation of evapotranspiration and carbon sequestration (Papadavid et al., 2017; Kamali & Nazari, 2018; Losgedaragh & Rahimzadegan, 2018).

However, to create a series of images of the products of this algorithm requires a significant investment of time and computational cost in the pre-processing, in data management and execution of the algorithm, taking excessive computer time to develop and run a single Landsat scene on a common computer.

Thus, the search for a fast processing of remote sensing images and the urgent demand for the results, culminated in an increase in the availability of high-performance cloud computing (Midekisa et al., 2017). The Google Earth Engine (GEE) has been highlighted in regards to open cloud computing, composing a petabyte catalog of satellite imagery and geospatial data set, with high processing capacity, that allows the user to view information extremely superior to conventional GIS (Geographic Information System) desktop methods (Gorelick et al., 2017).

Huntington et al. (2017), affirmed that the development of a cloud computing web application for processing is due to demand to the visualization remote sensing and climate data, being motivated by the needs of scientists and managers of natural and climate resources

related to drought, ecology, and agriculture, which can be addressed through advanced processing and viewing of Earth observation files.

Once an algorithm has been developed from GHG, users can produce systematic data products or deploy interactive applications backed by GHG resources without having to be an expert in application development, Web programming or HTML (Gorelick et al. 2017). Therefore, the objective of the present work was to develop a tool to estimate the real evapotranspiration by the SEBAL algorithm using a cloud computing platform.

MATERIAL AND METHODS

SEBAL uses multispectral remote sensing data with complementary meteorological data to estimate instantaneous and daily surface energy balance components, calculating latent heat (without discrimination between soil and canopy components) as a residue of the energy balance equation. The daily real evapotranspiration (ET, mm d⁻¹) estimated by SEBAL is obtained through the following equation (Bastiaanssen, 2000):

$$ET=0,035 \left(\frac{LE}{R_n-G} \right) [(1-\alpha)R_s-110\tau_{24h}] \quad (1)$$

Where: LE - Latent Heat Flux (W m⁻²); R_n - net radiation at the surface (W m⁻²); G - soil heat flux (W m⁻²); α - surface albedo; R_s- Global solar radiation daily (W m⁻²); τ_{24h} –average daily atmospheric transmissivity.

The main supposition of the algorithm is considered the linearity between the air temperature (dT) and the surface temperature (dT= a + b T_{sup}) difference, whose calibration constants “a” and “b” are obtained in pixels with conditions extremes of temperature and water availability: a cold pixel (located in the Tapacurá river reservoir) with H = 0 and a hot pixel (area with little or no vegetation and low moisture content), where LE = 0, in others words, H = R_n -G , the that made it possible to get the values of the calibration constants (Bastiaanssen et al., 1998; Papadavid et al., 2013; Oliveira et al., 2014).

The developed SEBAL algorithm was implemented in the GEE using the JavaScript language, developed exclusively for Landsat-8 images. GEE has free access with a large and growing user base, access to all LandSat images, direct management of time series stacks, and parallel processing ease to accelerate computing.

GEE is a system designed to enable petabyte-scale scientific analysis and visualization of geospatial data sets, providing a consolidated environment, including a massive data catalog co-located with thousands of computers for analysis (Xiong et al., 2017). Users can request to add new catalogs to the public catalog or can upload their own private data through a REST interface using command-line or browser-based tools and sharing with other users or groups as desired (Gorelick et al., 2017).

Users can access and analyze public catalog data as well as their own private data using a operator library provided by API from GEE. These operators are implemented in a large parallel processing system that subdivides and automatically distributes computations, providing high throughput analysis capabilities (Figure 1).

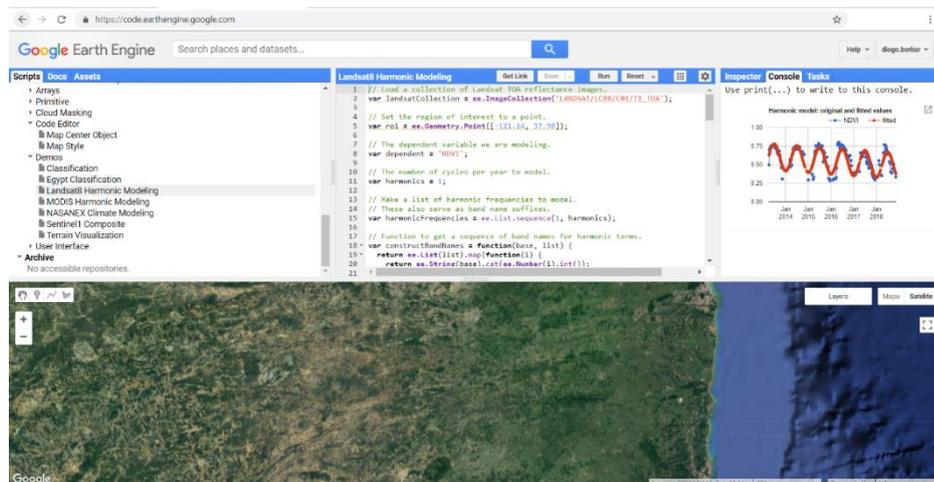


Figure 1. GEE interactive development environment.

Users can sign up to access the Google Earth Engine homepage, <https://earthengine.google.com> and access the user interface, as well as a user guide, tutorials, examples, training videos, role reference, and educational curriculum. Although previous GIS, remote sensing, and scripting experience make getting started easier, they are not strictly necessary, and the user guide is for domain novices. Accounts come with a quota for uploading personal data and saving intermediate products, and any entries or results can be downloaded for offline use. (Gorelick et al., 2017).

RESULTS AND DISCUSSION

The SEBAL algorithm has been structured in the GEE in a way that can be executed in different areas and dates. The user must create three variables before executing the script. The

first variable to be created is the "geometry", which corresponds to the area of interest for executing the SEBAL algorithm. To create it, the user must click insert geometry and draw the geometry in the GEE map. This variable will appear in the script (Figure 2).

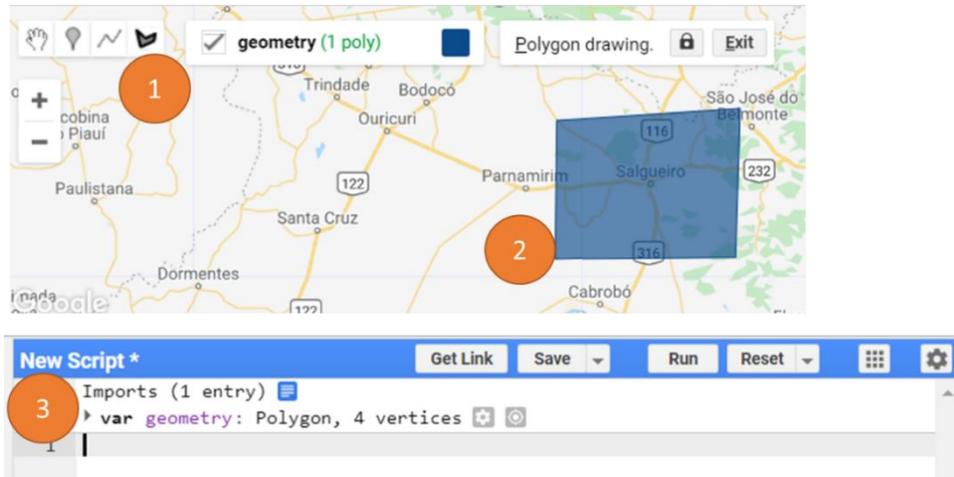


Figure 2. Entering area of interest for running SEBAL on GEE.

The other two variables that must be created correspond to the hot pixel and the cold pixel. To create them one must add a new layer (Figure 3A), insert a marker on the map (Figure 3B) and click anywhere within the area of interest (Figure 3C). After that, the same procedure must be done to create the cold pixel, naming the markers for "cold_pixel" for the cold pixel and "hot_pixel" for hot pixel, and the GEE code must conform to Figure 3D.

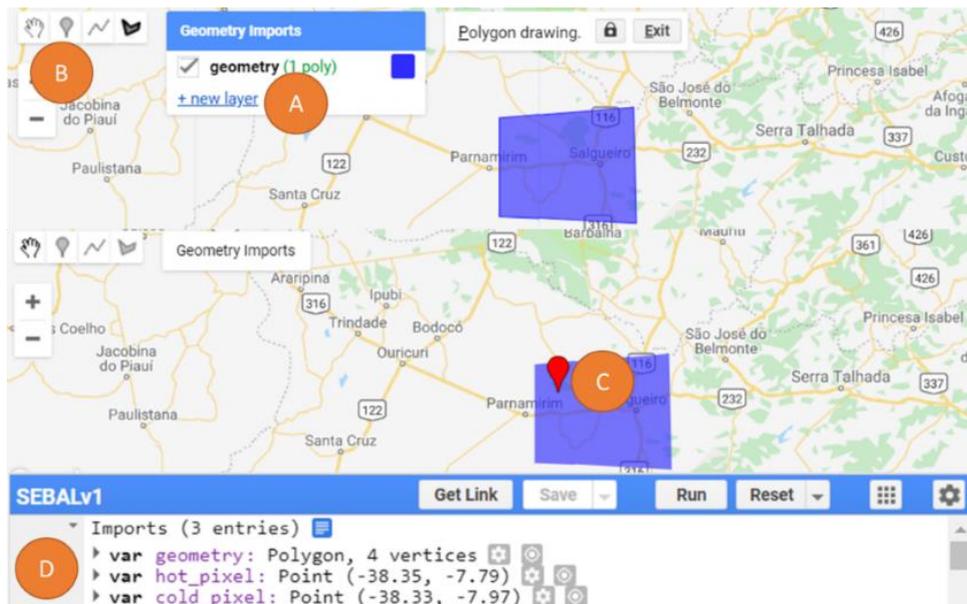


Figure 3. Inserting the variables "hot pixel" and "cold pixel" of SEBAL in the GEE.

After creating the three variables, the user must copy and paste the code that is available in the address. Figure 4 shows the part of the code in which the user must interact by inserting the meteorological variables of a station present in the area of interest. The meteorological variables of this station will serve as ground source data for SEBAL, being: average air temperature (°C), from 10:00 a.m. to 12:00, average altitude (m), wind speed (m/s), average from 10h to 12h, accumulated solar radiation (w/m²), transmittance in 24 hours, temperature of the month with maximum NDVI, average daytime temperature (°C). Finally, the user must insert the image data in the following format: year, month, and day, and Landsat8 path/row.

```

/*****
*****Algoritmo SEBAL v1*****
*****/

/*1-Dados da estação meteorológica e Imagem L8*****
*****/

//1.1 Temperatura do ar média em °C das 10:00 as 12:00
var Tar =27.4333;
//1.2 Altitude média (m)
var Alt = 461.0000;
//1.3 Velocidade do Vento (m/s) (média das 10h as 12h )
var Vento =2.1333;
//1.4 Radiação solar acumulada (w/m2)
var Rs24= ee.Number(198.0370);
//1.5 transmitância 24h
var tsw24= ee.Number(0.4405);
//1.6 Topt temperatura do mês com máximo NDVI
var Topt = 25.6419
//1.7 Temperatura média do dia °C
var Tdia = 29.6250
//1.8 Data da Imagem
var data ='20171212'
//1.9 Path/Row
var pathRow ='216065'

/*1-FIM*****
*****/

```

Figure 4. Space to fill the date and the meteorological data

After entering the weather variables and setting the date and path/row of the scene in the code, the user must click the "Run" button to execute the code. The anchor pixels were inserted randomly. To perform the anchor pixels positioning correction, it is necessary to select the layer that corresponds to the surface temperature, and with the help of the map, the hot pixel must be positioned on the surface that is at higher red levels, and the cold pixel in place with darker blue pixel, according to Figure 5.

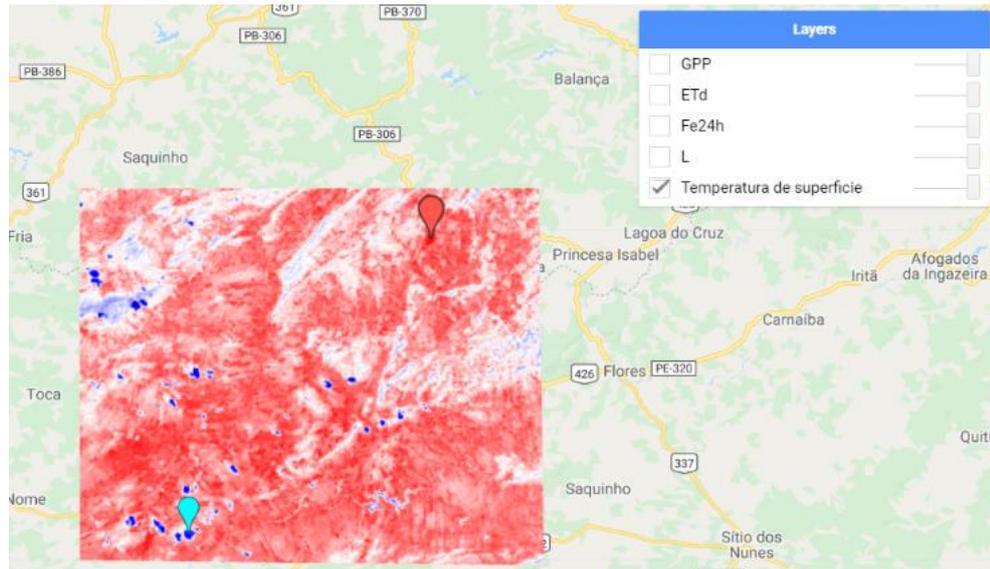


Figure 5. Positioning the anchor pixels on the surface temperature map.

After the correct placement of the anchor pixels, the user must press the "Run" button again to execute the script. Figure 6 shows an overview of how the script behaves after its execution in the GEE, in the "Task" tab (Figure 6A). The images of the SEBAL product can be downloaded in GeoTiff, GPP images, daily real evapotranspiration (ETd), latent heat flux (L), sensible heat flow (H), soil heat flux (G), radiation (Rn), surface albedo and NDVI. In Figure 6B, one can observe the layers that are active (Figure 6C). The script can be changed as required by the user.

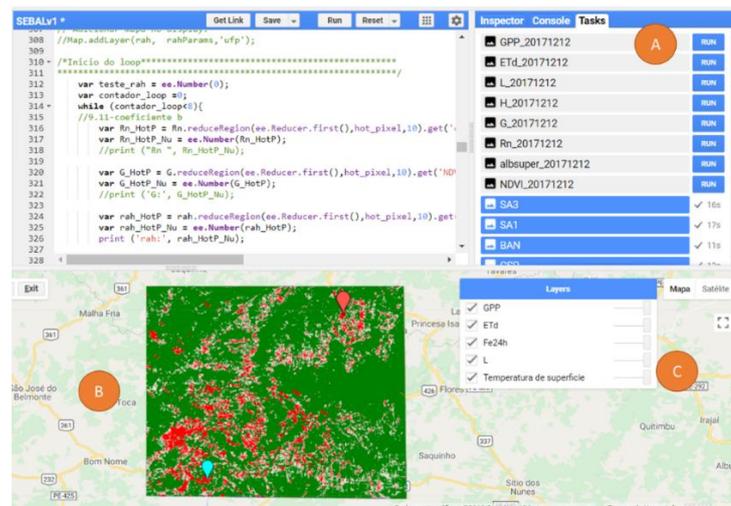


Figure 6. Overview of GHG after execution of the SEBAL algorithm

The authors Bhattarai and Liu (2019) developed an automated platform for the determination of ET by SEBAL and METRIC (Mapping ET at High Resolution with

Internalized Calibration), limiting the use of paid software and hardware, which corroborates the expectation of innovation and practicality of this project.

Using GEE as a tool for the automated extraction of urban areas from Landsat images, Patel et al. (2015) evaluated that automated GEE classification, producing accurate urban extension maps and the integration of GEE-derived urban extensions, improved the quality of population mapping results.

CONCLUSIONS

The implementation of the SEBAL algorithm in a cloud computing platform as GEE represents a great gain for studies using this algorithm, since it allows the researchers to focus on the product of SEBAL, which is the actual evapotranspiration and its applications, and not in its implementation in traditional GIS tools. The development of a user interface that enables the selection of images according to the number of clouds, the adaptation of the algorithm to perform the SEBAL with images of Landsat-5 and MODIS, should be improvements to be implemented in future works.

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