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Effects of climate anomalies on the soil-atmosphere interaction model and its convergence with conventional climate models

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Abstract.- The application of the Determination of the Effect of Climate Anomalies on Soil-Atmosphere Interaction (DECASAI) model is described, which allows estimating the water evaporation over bodies of water and soils, based on a thermodynamic and kinetic approach. The model studies seasonal climate anomalies with emphasis on prolonged droughts (ENSO), to predict the vulnerability of selected water bodies, in their hydraulic and pluvial aspects. The model is integrated into the Biotic Pump Theories, evapotranspiration, and other conventional models such as Orchidee using the new absent information provided by the model in their calculations. The analysis estimated the critical radius of the condensed water droplets, for application in the conventional models. The proposed model is sufficiently robust and complementary for use in certain localities located in the Hadley cells, depending on their continentality.

Keywords: DECASAI, climate anomalies, soil-atmosphere interaction, conventional models.

Efectos de las anomalías climáticas en el modelo de interacción suelo-atmósfera y su convergencia con los modelos climáticos convencionales

Resumen: Se describe la aplicación del modelo DEACISA (Determining the Effects of Climate Anomalies on Soil-Atmosphere Interactions-DECASAI), que permite estimar la evaporación de agua de cuerpos de agua y suelos con base en métodos termodinámicos y cinéticos. El modelo estudia anomalías climáticas estacionales, con énfasis en sequías prolongadas (ENSO/ENOS), para predecir la vulnerabilidad de cuerpos de agua seleccionados, en sus aspectos hidráulicos y pluviales. El modelo se integra con las Teorías de la Bomba Biótica, la evotranspiración y otros modelos convencionales como el de Orchidee a través de la nueva información faltante que proporciona el modelo en sus cálculos. El análisis estimó el radio crítico de las gotas de agua condensada, para su aplicación en modelos convencionales. El modelo propuesto es suficientemente robusto y complementario para su uso en determinadas localidades ubicadas en las celdas de Hadley, dependiendo de su continentalidad.

Palabras clave: DECASAI, anomalías climáticas, interacción suelo-atmósfera, modelos convencionales.

I. INTRODUCTION

Climate models are important tools for predicting future climate change. It is essential that these models accurately capture the changes already observed to increase confidence in future projections. Regardless of the space-temporal scale, dynamic models of conventional climate systems generally share the same basic structure, considering the same variables, and are governed by the same physical principles of conservation of mass, energy, and momentum, just like any natural system. These models can be used for climate and weather prediction and range from planetary to microscale.

Atmospheric behaviors are assumed to behave like ideal fluids in these models. Climate systems with a smaller dimension of local space are modeled with their local characteristics. The model "Determination of the Effect of Climate Anomalies on Soil-Atmosphere Interaction" (DECASAI/ DEACISA in Spanish) [1], determines the effect of climate anomalies on soil-atmosphere interaction for different tropical belt topographies according to the Hadley cell. It focuses on the entropic characterization of the associated thermodynamics, effects of water evaporation from the considered water bodies, moisture evaporation from the associated soils, and existing coupling force. It also considers the kinetics with the characteristics of the vulnerable soils of affectation such as porosity, permeability, and density. It also takes into account the humidity necessary to maintain biodiversity, affected areas that host water bodies of reservoirs and water basins, and biodiverse areas considered microclimates. The model determines the formation of water droplets, the behavior of the relative humidity for precipitation, and the amount of entropy exchanged between the air masses.

The estimate of total evaporation is separated into the evaporation of biomass (evapotranspiration) and that of the water mirrors of reservoirs and water basins, including the Amazon rainforest. The model was compared with other conventional models such as the Biotic Pump and Orchidee [2], [3], to establish convergences in the spatial variations of the coupling force and the observed forces, taking into account the differences in parameterization, climatology, and hydrological regimes.

In this article, we discuss the importance of the evaporation rate for the DECASAI Model, the theory of the Biotic Pump, and the Orchidee approach. It explains the methodology used to calculate relative humidity and condensation, the adiabatic gradient of the atmosphere, and the radius of a water drop in a vapor cloud. These calculations are essential for applying DECASAI to the evaporation of biomass for the Biotic Pump and Orchidee. Finally, we present the DECASAI results for the selected biomass and draw our conclusions.

II. DEVELOPMENT

The DECASAI model [1] is a climate model designed to study the impact of non-seasonal climate anomalies on soil-atmosphere interaction, water bodies, and surrounding biomass. It primarily focuses on the hydraulic and pluvial dependence of bodies of water on the water currents that feed them.

The DECASAI model [1] complements conventional climate models such as Orchidee and Biotic Bomb [3], [2], by taking into account the topography and sentimentality of regions within the tropical belt. It specifically accounts for the role of inland water bodies in the evaporation process and considers their hydraulic and pluvial behavior, as well as other convective and thermodynamic ranges. The model studies the interrelationship between these factors, with a focus on how hydrological regimes [4], impact climate prediction. The transversal approach for real-time assessment of the vulnerability of water bodies to climatic anomalies is also considered. The results are presented in numerical and perceptual formats, similar to those of more complex models.

A. Importance of evaporation rate for the DECASAI Model

It's essential to keep in mind that the amount of water evaporated by one hectare of tropical forest can vary significantly in different weather conditions, such as temperature changes, relative humidity, wind speed, and solar radiation. Moreover, the amount of water evaporated also depends on the forest's density and the total amount of rainfall in the region. To determine the precise quantity of water evaporated by one hectare of tropical forest in different meteorological stations, it is necessary to collect meteorological data such as temperature, relative humidity, wind speed, and solar radiation. These data can be obtained from monthly agro-climatic databases [5].

In addition, the theories of the biotic pump [2], and the ORCHIDEE [3], were useful in associating the approach of the DECASAI Model [1], by calculating convection and evaporation considering: the prevailing winds and the geopotential height to obtain the adiabatic gradient of the air (υ) below 11km, based on this, the radius of a condensed drop can be obtained from convective water vapor, driving the energy of the liquid phase in compensation and decreasing entropy. The model can be coupled to conventional models, in particular the Biotic Pump Theory and ORCHIDEE, which needs the generated information on water vapor convection in the tree crowns and evapotranspiration to measure foliar behavior, respectively; taking as an example the evaporation of the Amazon rainforest.

B. The Biotic Pump Theory (PBT)

As per the theory, the biotic pump plays a crucial role in driving the circulation of air and water in the atmosphere and on the Earth's surface, which is essential to maintain the climate and ecological balance [2], [6], [7]. This mechanism releases moisture from vegetation, which turns into clouds and precipitation, contributing to maintaining soil and vegetation moisture. Besides, vegetation also acts as a natural filter, removing carbon dioxide and other pollutants from the air.

Also, by regulating local and regional temperatures, the biotic pump contributes to a cooling effect on the environment through plant transpiration and soil evaporation. Vegetation also has the advantage of reducing wind speed and protecting against soil erosion. This causes the relatively high-pressure air below to draw in more humid air from the sea or the forest surface [2], [8], [9]. Although temperature is not the primary determinant of air and water circulation in the atmosphere and on the Earth's surface, the biotic pump theory acknowledges that temperature plays a crucial role in the ability of air to contain water vapor [3].

C. The Orchidee Approach

To relate the proposed model to Orchidee (Organizing Carbon and Hydrology in Dynamic Ecosystems) [4], the calculation of reference evapotranspiration (ET0) using the FAO Penman-Monteith equation, which is one of the most accurate methods for calculating evapotranspiration [10], is considered. That equation uses the aforementioned meteorological data to calculate the average evaporation rate.

$$5c + gt + fb + v = 0 \qquad (1)$$

To estimate the actual evapotranspiration, the calculated ET0 is used, which depends on the density of the biomass, the amount of rainfall the area receives, and other factors specific to the area. It is important to consider the limitations when relating DECASAI [1] with Orchidee [3], in its soil-atmosphere interaction, it is necessary to consider limitations and the fact that the average evaporation rate obtained may vary depending on the specific conditions of the associated biomass.

The estimated average Total Field Evapotranspiration (TFE) value measures the total amount of water transferred from the land to the atmosphere, including soil evaporation and plant transpiration. For example, recent research using the ORCHIDEE-CAN-NHA model has simulated water and carbon fluxes in tropical forests to predict tree mortality in response to drought. The model was tested in the Caxiuanã rainfall exclusion experiment in eastern Amazonia, obtaining an average value of 0.18 m^3/m^3 of water in the soil, measured at a depth of 5 cm, for soil moisture evaporation calculations [11]. The model evaluation was based on a comparison of DECASAI data, which were included in the original TFE curves shown in Figure 1, with fairly good agreement.

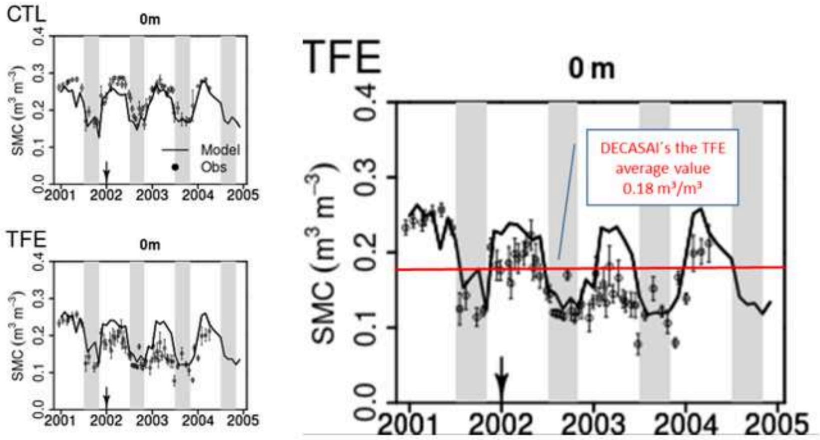

Fig. 1. Modeled (ORCHIDEE-CAN-NHA, black line) versus observed (black dots) volumetric soil moisture content (SMC) 915 at different depths. Due to the limited time duration of observation data, we only show the modeled SMC from 2001 to 2004. **(a)** The partitioning of evapotranspiration (ET) was compared between CTL and TFE **(b)** The red line running horizontally represents the estimated average TFE value. Source: [11], edited by AUTHORS.

III. METHODOLOGY

The study presents the relevant parameters that affect the seasonal climate prediction of a certain region or microclimate, specifically in the evaporation process, and how it is related to the behavior of the type of soil and water bodies. For the application of the model, significant climatological data were selected from NASA's MERRA-2 Modern-Era Retrospective Analysis [12], combining it with the modern global meteorological model in 50 km grids. (FAOH, Global Land Cover SHARE database) [13], [14] Based on a historical hourly climatological statistical analysis and model reconstructions from 1980-2016 (Meeus J., Astronomical Algorithms) [15],[2].

The selection of the Gurí Reservoir, for the application of the proposed model, included, on the one hand, its conditions of internal continentality, Topography (The elevation data "SRTM") [16], and the characteristics that influence the values of relative humidity and evaporation conditions of the water mirror and proximity to the Amazon Rainforest. On the other hand, it is hydrological and pluvial dependence. To analyze the convergence of the results.

The DECASAI model [1] is based on the premises outlined in the introduction and focuses on the thermodynamics variables and local parameters described in Table 2 in previous paper describing the DECASAI model [1]. To analyze model convergence, climatic and meteorological data from the Gurí-Venezuela Reservoir [1] were used as a reference point for its tropical location and proximity to the Amazon rainforest. This allowed for comparisons with other locations within the tropics.

This study utilizes the DECASAI model [1] to analyze evaporation, convection, and entropy in a specific region. The model incorporates geographic and meteorological data such as:

- Geographic: Water body size, biomass size, elevation (ASL), annual average soil temperature, solar radiation, and wind speed.
- Meteorological: Airflow speed (varying based on climatic conditions such as Northern Trades 20-22km/hr, ENSO>28km/hr, tropical depressions>117, and storms) and DELTA T (°C) air-water vapor evaporation (2.5 ºC/g H20 evap.kg air).

The model includes two domains (continental and regional) and considers standardized soil porosity values for a specific soil surface layer (-5cm to 10cm). Boundary conditions are applied assuming flow over a flat plate.

The work focuses on complementary analysis of the models, with a specific focus on evaporation, convection, and entropy. All calculations were performed using the optimization tool (DECASAI [1]) in MS Excel®, assuming a standard deviation of 0.2% error for all correlation coefficients obtained. The coherence of the comparison of the results confirms the physics of DECASAI [1], which has profound implications for current mathematical climate models. This not only helps in predicting the consequences of widespread evaporation but also helps in better understanding atmospheric processes that lead to the formation of air masses.

The equations involved in the DECASAI model are the following:

D. Relative Humidity and Condensation

In this section of the analysis for the DECASAI model [1], it is considered that the relative humidity is represented as the energy of the liquid phase in compensation, and condensation is assumed as the presence of decreasing entropy, to calculate the partial pressure variation of the water vapor. Therefore, when considering thermodynamics, the relative humidity Ǿ is defined as the ratio between the partial pressure of water vapor Pv= 101.324 kPa and the saturating vapor pressure Pºsat.

$$Ǿ = Pv / P^{o}sat \quad (1)$$

Taking as premises that: If <1, the vapor state is maintained to wait for condensation, If >1, overcoming the activation energy. The free energy for the evaporation of n moles of water is expressed as:

$$dG = (ɯliq - ɯvap)\, dn + \Upsilon\, dA \quad (2)$$
$$dɯ = -RT\, Ln\, Ǿ \quad (3)$$

Using Kelvin's equation to calculate the radius of the drops, the radius of the drops is calculated by the expression:

$$r = 2\Upsilon.Vliq/rt\, lnǾ \quad (4)$$
$$log10(Psat[mmHg]) = A - B/(T[°C] + C) \quad (5)$$
$$El\, \Delta G = 4/3\, (\Pi.\Upsilon.rc2) \quad (6)$$

Assume that: steam behaves like an ideal gas, -dA = 8Π.r.dr, (7), A= 8.0713, B=1730.83, c= 233.42. Taking the saturation of Equation Antoine [17]

$$\log_{10} Ps\,(mmHg) = A - \left(\frac{B}{T(°C)+C}\right) \quad (7)$$

The laws of Newtonian physics indicate a strong correlation (R^2> 0.9) between temperature and saturated pressure as illustrated in Figure 2, which is used to calculate the rate of evaporation. The curve obtained is represented mathematically:

$$y = 13.447e^{0.2817x}, \; R^2 = 0.9992 \qquad (8)$$

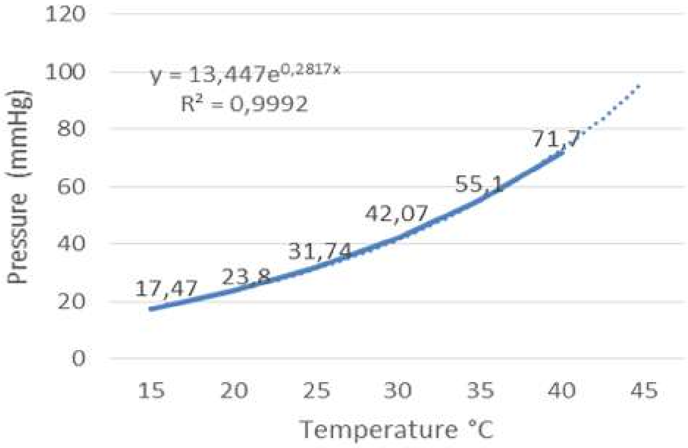

Fig. 2. Variation of saturated pressure (mmHg) as a function of temperature (T°C). Source: Authors

E. Adiabatic Gradient of the atmosphere

It is assumed that within the control volume, there are adiabatic processes, to calculate the Adiabatic Gradient of Air (Ƴ), rescuing the thermodynamic evolution, Below 11km, Using Mayer's Relation and Clapeyron's Equation

$$(\Upsilon) = -dT/dh = M.g/Cp \qquad (9)$$

Variation of pressure as a function of height

$$(P/Po) = (1 - \Upsilon.h/To)EXP.(Cp/R) \qquad (10)$$

The relationship between pressure and height is illustrated in Figure 3a, which shows an inverse proportionality, as reflected by the formula. Like Fig. 3b, the relationship is also inversely proportional to the variation in air temperature as a function of height (km); the empirical equation that describes it is displayed in Figures 3a and 3b. The following empirical equation can represent the inversely proportional relationship between the temperature and the altitude.

$$\text{(a)} \quad y = -22.881x + 22.744, \qquad (11), \qquad R^2 = 0.9993$$
$$\text{(b)} \quad y = -9.7426\text{x} + 306.55, \qquad (12), \qquad R^2 = 1$$

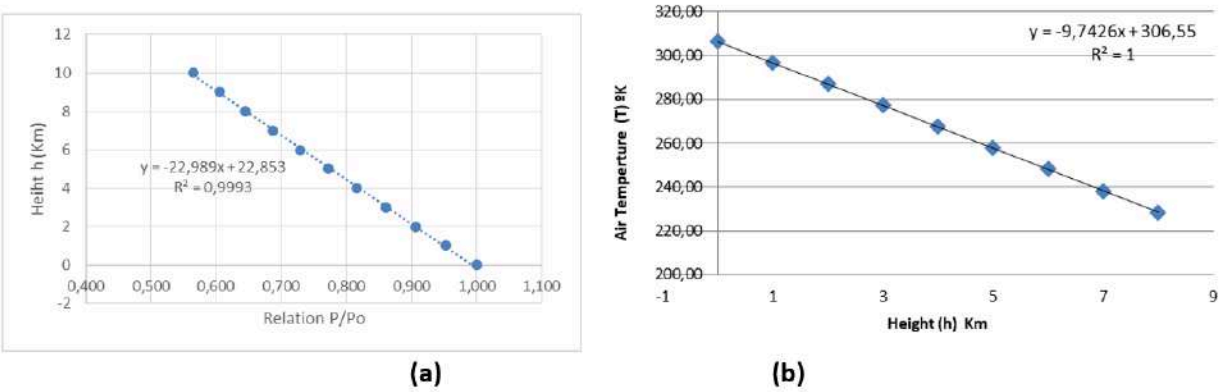

Fig. 3. Effect of the altitude on the Pressure **(a)** and temperature **(b)** values.
Source: Authors.

F. Radius of a water drop in a vapor cloud

For rain to form, the droplets must contain air that is more than 100% saturated. Droplets with r<rc evaporate, while those with r>rc grow through condensation on the surface. A drop of water of radius r in equilibrium with its vapor in a cloud, at a given temperature T, with an internal pressure Pº1 and the vapor around it Pv, is verified by the Laplace and Kelvin equations.

The Relationship between Water Droplet Size and Water Vapor Pressure, was determined by using the Laplace and Kelvin equations, the researchers determined that droplets with a radius greater than a critical value (rc) will grow through condensation, while those smaller than rc will evaporate. The study aimed to illustrate this relationship at a temperature of 20°C and estimate the radius of the water droplets [18]. The results, depicted in Figure 4, show a clear correlation between the size of the water droplets and the surrounding water vapor pressure.

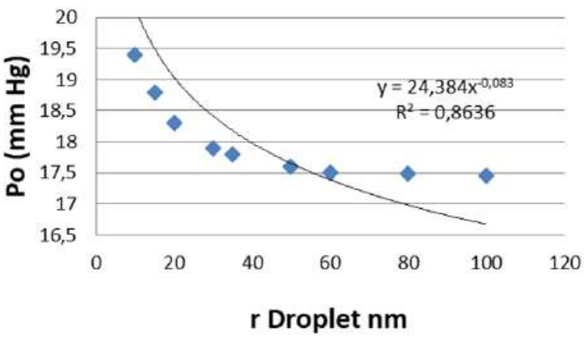

Fig. 4. Variation of droplet size (nm) in vapor clouds with vapor pressure Po.
Source: Authors.

G. Application of DECASAI to biomass evaporation

The equations involved in the DECASAI model for biomass evaporation are interrelated as follows:

Evaporation of water bodies of water

Calculating water evaporation in bodies of water is obtained with increasing entropy, as uncompensated energy. In case of flat plate forced convection in laminar flow, at a distance x downstream of the plate edge, in a simple way Re <5 ×, Pr>0,6, We have Re<2300 laminar flows and Re>2300 for turbulent flows, ρ= fluid density, L= length (cm), Sa= air volume (m/sec), v= air speed (m/sec), ρ= density of atmospheric air at water level 15°C=1.225 kg/m^3 Prandtl number Pr air = 0.71000, α = thermal diffusivity heat transfer coefficient, Ʊ = moment of diffusivity, Ʊ = viscosity of air (cc/sec).

Convection arises naturally in the atmosphere. This process is governed by the Ideal Gas Law, which describes the relationship between the pressure, volume, temperature, and quantity (in moles) of an ideal gas such that the amount of evaporated water (EC water) given in gr/h.m^2 , would be:

$$\mathrm{ECw}\left(\frac{\mathrm{gr}}{\mathrm{h}\, m^2}\right) = \mathrm{hp} * \frac{\mathrm{Pvv}-\mathrm{Pv}}{0.082*(\mathrm{Tm}+273)} \quad (13)$$

E(C water) expressed in m^3 , t = anomaly time (hr), Vca = volume of body of water

$$\mathrm{ECw}\ (m^3) = \left(\mathrm{ECw} * \frac{\mathrm{Vol\ ca}}{10^7}\right) * \frac{t_{anomaly}}{10^{-5}}(hr) \quad (14)$$

In this way obtain

$$\%\ Water\ Evap = \mathrm{Effect}\frac{\mathrm{Enso}}{\mathrm{C}}\mathrm{w} * \frac{100}{Vca} \quad (15)$$

Soil Water Evaporation

Soil water evaporation is a crucial process in the hydrological cycle due to its role in regulating atmospheric temperature and water resource availability. The evaporation of water from soil follows similar patterns to evaporation from water bodies. Momentum conservation equations are applied to the entire porous medium to understand the environmental behavior [1, 19].

Considering soil conditions, where σ represents stress terms, ρ represents porous medium density, and g represents gravitational acceleration, the following assumptions are made: ρ = 1225 kg/m^3 (density of atmospheric air at 15°C), Pr_air = 0.71000 (air pressure), V0 = 3.95 cm^3 (volume occupied by air at 273.15 K), Water vapor pressure (Pv) = 4.44 g/cc, The convection coefficient or surface transmission coefficient (h) quantifies the influence of fluid, surface, and flow properties during convective heat transfer. It is modeled using Newton's Law of Cooling:

$$Q = h * A * (Ts - T\infty) \quad (16)$$

where Q is convective heat transfer (W), h is the film coefficient (W/K), A is the body's surface area in contact with the fluid, Ts is the body's surface temperature (K), and T∞ is the fluid temperature at a distance.

Additional parameters include: Vapor heat transfer coefficient (hv) = 6000-15000 W/°C, Steam heat transfer coefficient (h_steam) = 0.02422 Cal/(h°F), Total volume (Vt), Volume occupied by pores (Vp), Volume occupied by solids (Vs), Volume of water (Vw), Volume of air (Va), Mass of solids (Ms), Mass of water (Mw). Assumed values include: Air pressure (Pa) = 254 g/cc, water and air temperature (Ta, Tg), soil density (ρs) = 2.2 g/cc, soil porosity = 5 (sandy loam soil), Floor humidity (%). The weight of soil solids without pores per unit volume considered as a mineral soils average 2.65 g/cc. The ideal gas law governs the relationship between pressure, volume, temperature, and quantity of an ideal gas, leading to the following equation for water evaporated above the soil (EC water-soil) in g/hm^2:

$$\mathrm{ECw} - \mathrm{s}\left(\frac{\mathrm{gr}}{\mathrm{h}\, m^2}\right) = \mathrm{hp} * \frac{\mathrm{Pvs}-\mathrm{Pv}}{0.082*(\mathrm{Tair}+273)} \quad (17)$$

Where hp= transfer coefficient, water vapor pressure above the ground Pvs=6.28; Vapor pressure Pv(gr/cc)=4.42; Air Temp ºC. The soil humidity (gr/cc) is taken into account, comparing it with Soil humidity % (data from the region under study)

$$\mathrm{H\ s}\left(\frac{\mathrm{g}}{\mathrm{cc}}\right) = \frac{\mathrm{Ds}\left(\frac{\mathrm{kg}}{\mathrm{cc}}\right) x\ \mathrm{Vol.V\ air\ \%}}{100}\ x\ 18 \quad (18)$$

E(C water) expressed in m³ , t = anomaly time (hr), Vca = volume of body of water

$$\mathrm{ECwater-soil}\ (m^3) = \left(\mathrm{ECwater-soil}\left(\frac{\mathrm{g}}{\mathrm{h}\ m^2}\right) * \frac{\mathrm{Vol\ ca}}{10^7}\right) * \frac{t_{anomaly}}{10^{-5}}(hr) \qquad (19)$$

In this way obtain

$$\%\ Evaporated\ Water - soil\ = Effect\frac{\mathrm{ENSO}}{\mathrm{C}}\mathrm{w} * \frac{100}{Vca} \qquad (20)$$

H. Evaporation of biomass for Biotic Pump and ORCHIDEE

Massive flows of water in the form of vapor, known as "flying rivers," originate from the tropical Atlantic Ocean and are fed by moisture evaporation from the Amazon. These atmospheric rivers travel swiftly across the atmosphere and cause rain more than 3,000 kilometers away. They are essential for agricultural production [20, 21]. To apply this concept for DECASAI [1], the evaporation rate in the Amazon jungle is estimated at approximately 4 millimeters per day per square meter. This corresponds to four liters of water accumulated above the ground. This data can be used to calculate tree transpiration rates by measuring the area of the tree's crown [21].

$$Evap = biomass\ area\ (km^2) * water\ layer\ \frac{mm}{day} * 1\ m^2 \qquad (21)$$

$$Evap = biomass\ area\ (km^2) * \frac{4mm}{day} * 1m^2 * 1000 \qquad (22)$$

A leafy tree, with a crown 20 meters in diameter, transpires more than 1,000 liters in a single day. As an example, the Amazon has 5.5 million square kilometers occupied by native forests, with approximately 400 billion trees of the most varied sizes. Obtaining 20,000 million tons (or 20 billion liters) of water are transpired every day by the trees of the Amazon basin. The Amazon (tropical rainforest), with approximately 400 billion trees (of varied sizes) would be represented

$$Evap_{\square} = 20x10^6\frac{ton}{day} = 20\ x10^9\ lt\ \mathrm{water} \qquad (23)$$

I. Evaporation Rate of the model

Applying the DECASAI and equations in the methodology section yields climatic parameters and the evapotranspiration equation.

$$Evap_{plant} = biomass\ area(km^2) * 4lt \qquad (24)$$

Considering the effect of the anomaly on the body of water would remain m^3:

$$\mathrm{Effect}\frac{\mathrm{Enso}}{\mathrm{C}}\mathrm{water} = \mathrm{ECw}\ (m^3) + \mathrm{Evs}\ (m^3) \qquad (25)$$

It is assumed that DECASAI

$$\mathrm{Etotal}\ (m^3) = \mathrm{ECw}\ (m^3) + \mathrm{ECwater-soil}\ (m^3) \quad (26)$$

RESULTS

A. Case of application Evaporation Rate of the model

Applying the DECASAI [1] and equations in the methodology section yields climatic parameters and the evapotranspiration equation (23)–(26). Biomass soil evaporation is equivalent to plant evaporation. It accounted for 5.2% of the trees. The amount of biomass evaporation varies depending on the selected biomass, such as in the case of Gurí Reservoir in Venezuela. Using the meteorological variables described in Table 2 in previous paper on the DECASAI model [1], along with the equations involved and shows the results obtained in table 3 from applying in Gurí Dam-Venezuela, which includes the estimates from DECASAI model [1], [15], and the variation of biomass evaporation.

The calculations of the DECASAI model allowed us to estimate the critical radius of the condensed water droplets, in the order of 4.58 nm. This value is assumed constant for its application in the Orchidee and Biotic Pum models. For the analysis of the TFE values, these are obtained from Figure 1 assuming an average value of 0.18 m³/m³ of water in the soil. Table 1 summarizes the results of our analysis on soil water evaporation.

Table 1. Comparison of evaporation index of the studied models. Source: Authors.

Model	DECASAI	Orchidee	Biotic Pump Theory
Evaporación Rates %	0.31	0.18	0.46

The comparative values in Table 1 provide a preliminary indication, though not exhaustive, that the evaporation rates of DECASAI and Orchidee are of the same order of magnitude. In the comparison parameters, for the three cases calculated by the DECASAI model where the final soil moisture result converges at 2.19 gr/hm^3., the soil water removal (g/h.m^2) ranges above 30%. The DECASAI model, as described in [1], demonstrates its convergence and robustness by considering the topography and continentality of the different area bodies.

CONCLUSIONS

The results of the exercise indicate the complementarity of the DECASAI model with the Biotic Pump and the Orchidee, being considered sufficiently robust, under its thermodynamic, moment, and physical approach for certain localities located in the Hadley cells, according to their continentality, to study the seasonal or non-seasonal climate anomalies, with special emphasis on periods of prolonged drought (such as ENSO) at a global level or microclimates (microscale) and that can predict the vulnerability of selected water bodies, in their hydraulic and pluvial aspects.

The developed model provides promising avenues for future research in the assimilation of experimental data to parameterize convection, evaporation, and condensation due to the effects of water evaporation from the considered water bodies, and the associated soil moisture evaporation, induced by the prolonged drought.

Furthermore, the findings suggest the relevance of the integrated approach provided by the DECASAI model, which combines thermodynamic, momentary, and physical elements, to address the challenges associated with climate variability in specific regions. This holistic approach allows for a more complete understanding of atmospheric processes and the interaction with local water bodies, which in turn improves the predictive ability of the model in terms of extreme weather events and their impact on water supply and availability. Of ter resources.

On the other hand, the successful implementation of the model in the studied regions highlights the importance of considering both local and global factors in predicting water vulnerability. This highlights the need for international collaboration and the adoption of transdisciplinary approaches to address challenges related to climate change and sustainable water management, to develop effective adaptive strategies and foster community resilience to extreme climate events.

RECOGNITION

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