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Typology and Seasonal Variation of Solid Household Waste at the Kossihouen Landfill Center (Autonomous District of Abidjan, Côte d'Ivoire)

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Abstract

Solid waste management has become a major challenge in multiple African cities due to rapid population growth, urbanization, and shifting consumption patterns. This study analyzes the seasonal variations in municipal solid waste disposed of at the Kossihouen landfill center in the Autonomous District of Abidjan, Côte d'Ivoire over the period 2019-2024. Waste composition was determined using data from a physical characterization campaign of miniciapal solid waste collected from the 13 municipalities of the District. The analysis consisted of manual sorting, weighing and categorization of waste, making it possible to calculate their respective proportions. The results show a predominance of organic matter (31%), plastics (21%), and fine residues (17%), reflecting local consumption habits. Waste quantity at the landfill center increased by 17.4%, with an average collection rate of 84.2%. The analysis of seasonal trends showed that the amount of buried waste was higher in the rainy seasons than in the dry seasons, primarily because increased humidity led to greater waste accumulation. To achieve sustainable waste management, it is essential to

integrate the principles of the circular economy by developing specialized centers focused on recycling and resource recovery.

Keywords: Municipal solid waste, waste composition, seasonal variation, landfill, organic matter, Abidjan

Introduction

Rapid population growth, along with evolving production and consumption habits, is resulting in a growing volume and variety of solid household waste (JICA, 2022; Kasem et al., 2025). The management of this waste has become a critical issue in Africa, where accelerated urbanization, demographic growth and changing consumption habits are exerting unprecedented pressure on infrastructures and services (Lagobo et al., 2018; Ouédraogo, 2024). Studies by the Japan International Cooperation Agency (JICA, 2022) and the African Clean Cities Platform (ACCP, 2019) estimate that annual waste production in sub-Saharan Africa, a region with the highest urban growth in the world, could triple by 2050 (Bajpai et al, 2022).

Côte d'Ivoire is also affected by this issue. The country faces insufficient management infrastructure, irregular collection and low recycling and recovery capacity (Mondal & Mandal, 2024; Ayemou et al., 2025). Urbanization, which increased from 32% in 1975 to 53.5% in 2021 (INS, 2021), was not accompanied by adequate planning, hindering the control of household solid waste management (JICA, 2025). The Autonomous District of Abidjan has experienced a notably intensified situation, its population rising from 4.3 million to over 6 million residents between 2014 and 2021 (INS, 2021). This demographic growth has led to heightened pressure on collection and processing infrastructures (Lumami et al., 2016; Djimarabeye et al., 2024). As a direct consequence, illegal dumping proliferates, aggravating health and environmental risks (Ndiaye et al., 2021; Wong, 2022). Despite the commissioning of the landfill center in 2018, the accumulation of waste in public spaces remains a recurring problem (ACCP & JICA, 2019), a source of various pollution and diseases (Yeo et al., 2020).

Furthermore, the humid tropical climate in the Autonomous District of Abidjan, characterized by alternating dry and rainy seasons, presents additional challenges for effective waste management. Climatic variations not only influence the flows and composition of waste, but also require adaptation of infrastructure, management methods and logistical means (Téya et al., 2022; Salim et al., 2023). To address these challenges, the legal framework was strengthened by new laws, namely the Law No. 2023-899 of November 23, 2023, related to the Sanitation and Hygiene Code, as well as the Decree No. 2013-327 of May 22, 2013, which prohibits the production,

importation, and use of plastic waste in Côte d'Ivoire. Multiple awareness campaigns and waste collection improvement actions are being implemented by the National Agency of waste management and its partners across the various municipalities of the District. This study aims to analyze the seasonal variations of solid waste at the Kossihouen landfill center, which handles household waste from the 13 municipalities of the Autonomous District of Abidjan. Specifically, we aimed at (i) determining the typology of waste produced across the district and (ii) quantifying the volumes buried at the landfill center depending on the seasons, in order to provide key data for optimizing the management system.

Methodology

Study area

The Kossihouen landfill center is located in the Sub-Prefecture of Songon (5°40 and 5°30 N and 4°10 - 4°20 W) in the Autonomous District of Abidjan in Côte d'Ivoire (Fig.1). It extends over 100 ha, approximately 2 km from the motorway, 4 km from the village of Kossihouen and 10 km from the nearest tributary of the Agnéby river. Four streams, three of which are seasonal, flow nearby (Ahoussi et al., 2012).

Figure 1: Location of the Kossihouen landfill center, Autonomous District of Abidjan, Côte d'Ivoire

Data Collection

Two datasets were used in this study. The first dataset consisted of waste composition data obtained from the 2023 Clean Eburnie waste characterization campaign. The second dataset comprised daily weighbridge records of waste quantities received at the Kossihouen landfill between 2019 and 2024. The authors did not participate in the waste characterization campaign but conducted a secondary analysis of the datasets provided by Clean Eburnie.

Methods for characterizing waste typology

The physical characterization of household and related solid waste followed a standardized protocol from the ADEME guidelines (ADEME, 2024) and other international references (e.g., UNEP, 2009). It consisted of manual sorting of waste into predefined categories, followed by weighing to determine the mass proportion of each category. The mass percentage (P%) is calculated according to the formula (UNEP, 2009; ADEME, 2024):

$$\boldsymbol{P_i}\ (\%) = \frac{\boldsymbol{m_i}}{\mathbf{M}} \times\ \mathbf{100}\ (\boldsymbol{équation}\ \mathbf{1})$$

Whre P_i is the percentage of waste category i, m_i is the mass (kg) of waste category i, and M is the total mass (kg) of the sorted waste sample.

Sampling

The sampling campaign took place from October 24 to November 15, 2023, covering the 13 municipalities of the Autonomous District of Abidjan. Sixteen (16) sampling points were selected, including consolidation stations and three transfer centers (TC). The inclusion of the TCs aimed to capture the composition of the waste which is directly transported there, without going through the grouping stations, thus guaranteeing better representativeness. An approach combining systematic and composite sampling was used. At each point, six (6) samples of 250 kg were taken, that's to say a total mass of 1,500 kg per point. In total, 96 samples were collected, representing a mass of 24,000 kg (Clean Eburnie, 2023). After homogenization, each 250 kg sample was sorted manually, and the different categories were weighed separately (ASTM, 2003). The location of the sampling points is shown in Fig. 2.

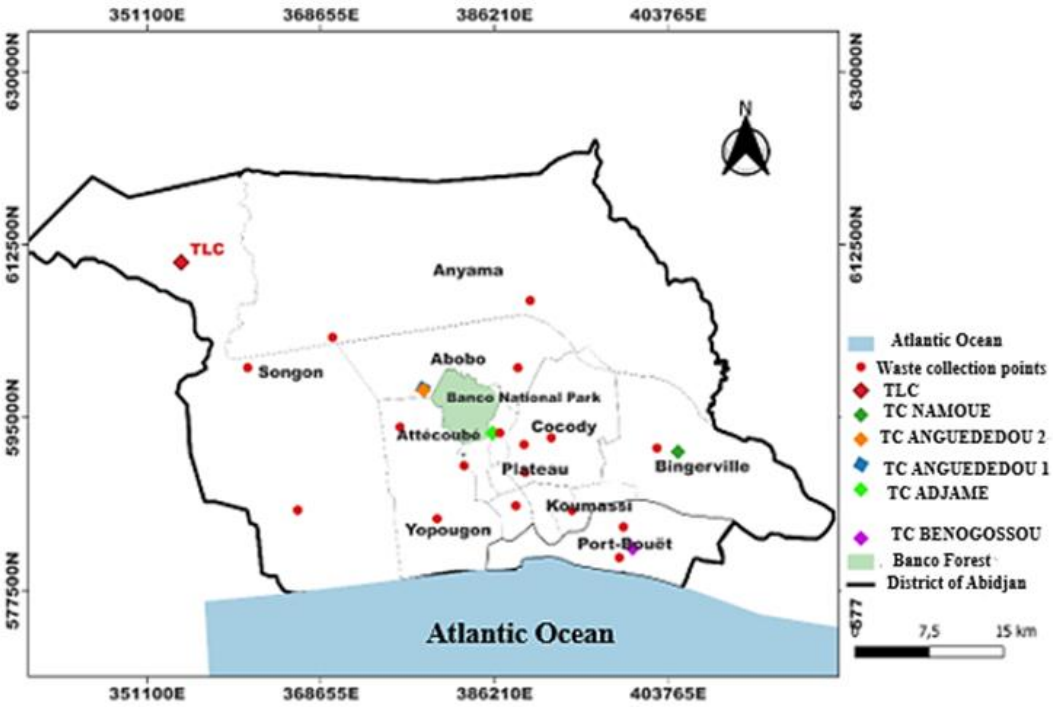


Figure 2: Map of sampling points at Kossihouen landfill center

Method for quantifying waste buried at Kossihouen landfill center

Annual quantity received

The quantity of waste received at the landfill center is determined by gravimetric weighing on a weighbridge, according to the principle of double weighing (Setec, 2014). Each truck is weighed at entry (Mass of Loaded Truck, MLC) and at exit (Mass of Empty Truck, MET). The Mass of Waste Received (MWR) is calculated as follows (Wavrer et al., 2010).

$$\boldsymbol{MWR = (MLT - MET)/1000} \quad \text{(Equation 2)}$$

With:

- MWR: Mass of waste received (T)
- MLT: Mass of loaded truck (Kg)
- MET: Mass of empty truck (Kg)

The daily masses are then summed to obtain the monthly, then annual masses.

Annual quantity produced and collection rate

The annual quantity of waste produced in the Autonomous District of Abidjan was estimated from the average production per inhabitant (0.75 kg/inhabitant/day, JICA, 2025) and demographic projections from the National Institute of Statistics (INS):

$$\textbf{Monthly mass of waste} = \sum \textbf{Daily masses of waste received}$$ (Equation 3)

$$\boldsymbol{AP = \frac{N \times G \times 365}{1000}} \ (\textbf{Equation 3})$$

Where:

- AP is the annual waste production (tons/year);
- N is the population served (inhabitants);
- G is the daily waste generation rate (kg/capita/day);
- 365 is the number of days per year;
- 1000 is the conversion factor from kilograms to tons.

Finally, the collection rate was calculated using the formula in equation 5 (UNEP, 2025):

$$\boldsymbol{CR}\ (\%) = \frac{\boldsymbol{Q_c}}{\boldsymbol{Q_p}} \times\ \mathbf{100}\ (\textbf{Equation 4})$$

- CR is the waste collection rate (%);
- Q_c is the quantity of waste collected (tons/year)
- Q_p is the total quantity of waste generated (Tons/year).

Seasonal quantity

To analyze seasonal variations, the year was divided into four seasons: Long Dry Season (LDS), Long Rainy Season (LRS), Short Dry Season (SDS) and Short Rainy Season (SRS). The quantity of waste buried for each season was calculated by adding the corresponding monthly tonnages over the period 2019-2024.

Data processing

Data were processed using R (version 4.5.0) and Excel (version 2021) software. Descriptive statistics (means, standard deviations, minimum and maximum values) were performed for annual and seasonal quantities. Boxplots were made to visualize the distribution of seasonal data.

Results

Typology of waste from the Autonomous District of Abidjan

The analysis of household and related solid waste composition revealed a clear predominance of the organic fraction (31%), followed by plastics (21%) and fine residues less than 20 mm (17.8%). Of the total mass of 24,000 kg sampled, these three categories represent 7,440 kg, 5,040 kg and 4,272 kg respectively. The other fractions (textiles, glass, metals, paper and cardboard, etc.) are present in smaller proportions (Fig. 3).

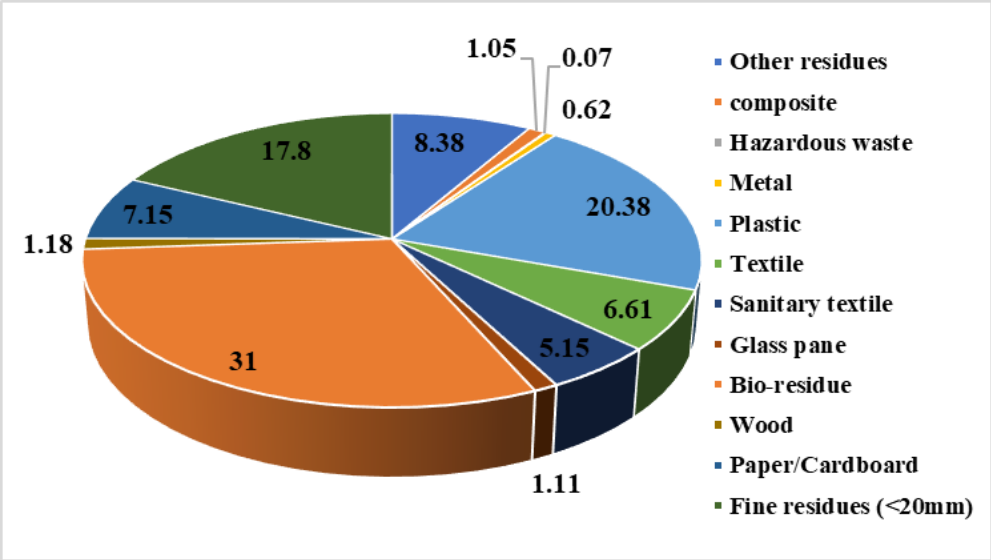
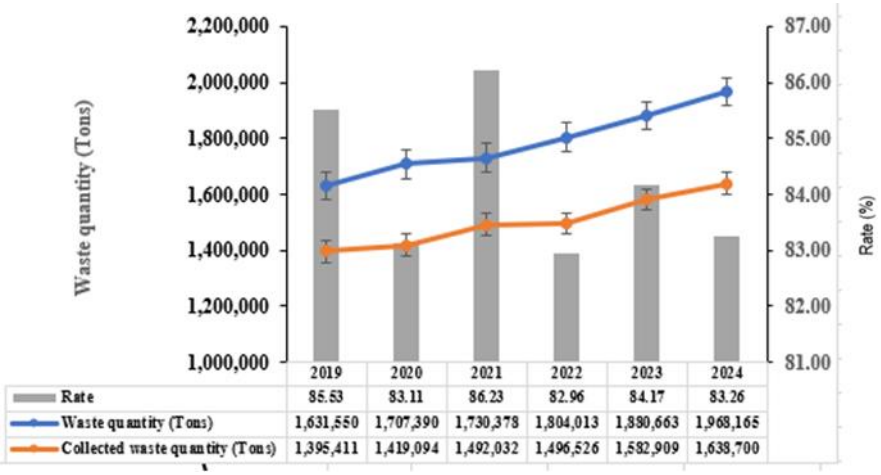


Figure 3: Typology of solid household waste in the Autonomous District of Abidjan, Côte d'Ivoire

Annual evolution of quantities of waste buried at Kossihouen landfill center (2019-2024)

The evolution of the quantities of waste estimated and collected throughout the Autonomous District of Abidjan between 2019 and 2024 is presented in Figure 4. An increasing trend of waste collected was observed over the entire period, with quantity of waste received at the landfill center increasing by 17.4% over the 6-year period, from 1,395,411 t in 2019 to 1,638,700 t in 2024 (Fig. 4). At the same time, estimated production increased by 20.6%, reaching 1,968,165 t in 2024 compared to 1,631,550 t in 2019.



	2019	2020	2021	2022	2023	2024
Rate	85.53	83.11	86.23	82.96	84.17	83.26
Waste quantity (Tons)	1,631,550	1,707,390	1,730,378	1,804,013	1,880,663	1,968,165
Collected waste quantity (Tons)	1,395,411	1,419,094	1,492,032	1,496,526	1,582,909	1,638,700

Figure 4: Trends in waste production and collection in the Autonomous District of Abidjan (2019-2024)

Table 1 presents descriptive statistics of the quantities collected per year. The average collection rate over the period was 84.2%, with annual variations between 82.9% (2022) and 86.2% (2021). The years 2019 and 2021 showed collection peaks, while 2022 recorded the lowest rate.

Table 1 presents statistical indicators (mean, standard deviation, minimum, maximum) and waste collection rates for the period 2019-2024.

Table 1**:** Descriptive statistics of annual monthly waste quantities collected at the CVET (2019-2024).

Years	Mean (tons/month)	Standard deviation(tons)	Maximum (tons/month)	Minimum(tons/month)	Collection rate (%)
2019	116,284	7,328	130,733	104,776	85.53
2020	118,258	5,903	130,771	108,404	83.11
2021	124,336	4,510	130,389	115,208	86.23
2022	124,710	7,139	136,975	110,076	82.96
2023	131,909	6,218	143,964	119,539	84.17
2024	136,558	8,466	154,874	119,190	83.26

Seasonal variations in quantities of waste buried

The analysis of average seasonal quantities of waste buried over the period 2019-2024 showed a marked difference between the short seasons (Table II). The SRS recorded the highest average with 131,801 tons, a difference of 7,805 tons compared to the SDS. On the other hand, the averages for the LDS (123,978 t) and rainy seasons (124,152 t) were relatively close; only a difference of 174 tons was observed.

The distribution of seasonal averages confirms these trends (Fig. 5). The SRS is distinguished by a high median and a large dispersion, indicating systematically higher tonnages and greater variability during this season.

Table 2 presents the statistical parameters (mean, standard deviation, minimum, maximum) for the different seasons over the period 2019-2024.

Table 2: Descriptive statistics of seasonal quantities of waste collected at the landfill center of Kossihouen (2019-2024)

	Mean(tons/month)	Standard deviation(tons/month)	Maximum(tons/month)	Minimum(tons/month)
LDS	123, 978	10,424	144,180	104,776
LRS	124, 152	8,217	138,305	109,985
SDS	123, 996	9,251	137,565	108,404
SRS	131, 801	7,498	137,863	120,547

LDS: *Long dry season (December-March)****; LRS:*** *Long rainy season (April-July)* ***; SDS:*** *short dry season (August- September)* ***; SRS:*** *short rainy season (October- November).*

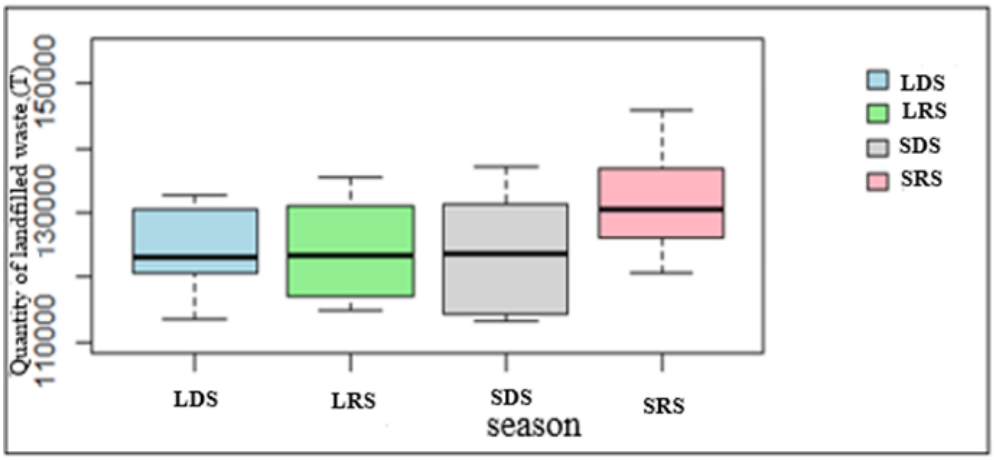


Figure 5: Distribution of seasonal averages of waste buried at Kossihouen landfill center from 2019 to 2024

Discussion

Typology dominated by organic matter, reflecting consumption habits

The results of the characterization indicate a predominance of bio-waste (31%) in the Autonomous District of Abidjan. This composition is characteristic of cities in developing countries and corroborates previous studies carried out in sub-Saharan African cities. Bangoura et al. (2024) in Conakry, Guinea, reported an higher proportion of organic matter (46%), while JICA (2019) in a study involving 21 African cities estimated the share of food waste at around 50%. Our results are consistent with previous studies carried out in Côte d'Ivoire, e.g., in Treichville (Kôkôh et al., 2017) and Bouaké (Attouoman et al., 2025). The high proportion of organic matter is consistent with the dietary habits of households in Côte d'Ivoire, where fresh and minimally processed foods account for a substantial share of domestic consumption (Téya et al., 2022). The place of plastics (21%) as the second category, similar to the observations of Saliba (2021) in Beirut, highlights the impact of changing consumption patterns and product packaging. The predominance of organic matter opens up significant prospects in terms of valorization. The production of biogas by methanization, already possible given the existence of a biogas burning system at the landfill center, could be optimized to produce energy. As Bourouis (2023) points out, this path not only makes it possible to generate renewable energy, but also to reduce greenhouse gas emissions from the decomposition of waste in landfills.

A continued increase in flows, a marker of anthropogenic pressure and progress in collection

The 17.4% increase in the quantities of waste received at the landfill center between 2019 and 2024 reflects increasing anthropogenic pressure on

the territory, associated with an improvement in the collection system. This upward trend, also observed for production (+20.6%), is explained by three main factors. First, population growth and urbanization are powerful drivers of increasing waste flow. As pointed out by Voukkali et al. (2024), urbanization is a double-edged sword: a driver of economic development, it also generates major environmental challenges, including an increase in the volume of waste produced. Secondly, socio-economic dynamics and changing consumption patterns, linked to economic growth, lead to an increase in waste production per capita (UNEP, 2024). Thirdly, and this is a crucial point, the improvement in the performance of the collection system has made it possible to capture a greater share of the waste produced, thereby reducing illegal dumping. The strengthening of logistics, with the increase in the truck fleet (215 for ECOTI SA, 2025) and the deployment of infrastructure (5 transfer centers, 549 trunk sites), made it possible to achieve an average collection rate of 84.2%.

Significant seasonal variations, linked to climatic factors

The analysis highlights a notable difference between seasons, with higher buried tonnages in rainy seasons, particularly marked during the short rainy season. This outcome may appear surprising, as one might anticipate a decrease in collection during rainy periods due to difficult traffic conditions and impassable roads. Several explanatory hypotheses can be put forward. The first, and most likely, is the increase in the mass of waste due to its humification. In the rainy season, waste, especially the predominant organic fraction, absorbs rainwater, which considerably increases its weight without necessarily changing in volume (Sidibé & Tra, 2025). The humid tropical climate of Abidjan exacerbates this phenomenon. The second hypothesis is linked to collection difficulties. Paradoxically, obstacles to collection in certain areas (precarious neighborhoods, unpaved roads) during heavy rains can lead to an accumulation of waste over several days. When conditions improve, catch-up operations are carried out, generating massive and occasional contributions to the landfill center, which could explain the high variability observed during short rainy seasons. This phenomenon is aggravated by the insufficient number of bins in peripheral neighborhoods, encouraging illegal dumping (Atta et al., 2013; Lagobo et al., 2018). The accumulation of waste in public spaces, in gutters or lagoons, has serious health consequences, favoring the proliferation of diseases such as malaria, diarrhea or typhoid fever (Téya, 2022; Moro et al., 2023; Okin et al., 2024; Kenichi & Nchia, 2025).

The near identical tonnages recorded during the long dry season and the long rainy season can be attributed to the interplay of two main factors. First, there is increased waste generation in the dry season driven by higher

consumption of beverages and heightened tourist activities. Second, during the rainy season, the humification process causes wastes – especially organic matter – to absorb moisture, significantly increasing its weight. These opposing effects offset each other, resulting in comparable waste volumes across both seasons.

Conclusion

We characterized the typology of waste in the Autonomous District of Abidjan and analyzed seasonal variations in the amount of soild waste buried at the Kossihouen landfill center between 2019 and 2024. The results indicate the predominance of organic matter (31%), a reflection of eating habits, followed by plastics (21%), a marker of changing consumption patterns. There was a continuous increase in collected waste (+17.4% in six years), as a consequence of demographic growth, urbanization and improvement of the collection system which reached an average rate of 84.2%. Moreover, a marked seasonal variation, with higher tonnages during rainy seasons was observed, highlighting a phenomenon attributable to the humidification of waste. An in-depth study of the composition of the organic fraction and plastics, as well as a detailed analysis of the correlations between rainfall and incoming flows, would help refine our results and optimize waste management strategies.

Conflict of Interest: The authors reported no conflict of interest.

Data Availability: The data used in this research come from records collected by the company Clean Eburnie, which manages the Centre de Valorisation et d'Enfouissement Technique (CVET). They mainly concern the quantities of waste collected and landfilled during the study period (2019–2024). These operational data provided the basis for the analysis and interpretation of the results presented in this work. The authors did not participate in the waste characterization campaign carried out in 2023 by the company Clean Eburnie. The authors conducted a secondary analysis of these data, including their processing, statistical validation, analysis, and scientific interpretation.

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