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Idealized sub-kilometer scale simulations for CCN effects on Amazon deep convection

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Changes in concentrations of anthropogenic and natural aerosols influence cloud microphysical properties, in large part by altering the number of available cloud condensation nuclei (CCN) and ice nuclei (IN). It has long been understood that increased CCN concentrations lead to a population of smaller and more numerous cloud droplets [1]. The higher-order effects of perturbed aerosol concentrations on latent heating, updraft velocity, precipitation production, and storm structure and lifetime in deep convection remain an area of active research. Much recent work has been done on potential increases in updraft intensity with increased CCN concentrations ("aerosol invigoration effects"), though results have been mixed [2]. Modelling studies have suggested that cold pool intensity may be reduced in higher-CCN environments [3,4].

We use MIMICA, a 3D, non-hydrostatic atmospheric model, to simulate idealized deep convection based on a well-observed case from 14 January 2023, during the CAFE-Brazil field campaign in the Amazon. The convection occurred near the Amazon Tall Tower Observatory, in an environment with very little vertical wind shear. We run simulations at 100 m horizontal grid spacing with different levels of fixed CCN and IN concentrations, as well as simulations with prognostic aerosol concentrations. We compare the model results with observations and with each other for differences in precipitation timing and intensity, cold pool intensity, and storm duration. In particular, any changes in cold pool intensity with varying CCN and IN concentrations could have implications for storm organization, depending on the vertical wind shear context [3].

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Classification of Electrified Clouds using Radar and Machine Learning

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The study's area of interest is the Brazilian state of Paraná, which is responsible for 35% of the national hydroelectric power generation [1]. Thus, the aerial transmission lines that perpass this state are of national importance. Aerial transmission lines are highly sensitive to lightning – according to the national electricity operator, 25% of outages recorded on this type of asset are due to lightning [2]. Understanding cloud electrification is vital for this sector. The Paraná Environmental Technology and Monitoring System (Simepar) has a comprehensive radar coverage in the state, including two S-band and one X-band radars. The polarimetric S-band radar located in Cascavel-PR, is used as the primary data source for this study, to characterize the cloud electrification process, focusing on the period preceding the first lightning in a storm. Polarimetric variables are valuable for understanding severe convection and lightning production. Convection can significantly favor cloud electrification, as intense updrafts promote the non-inductive charging process through the collision and subsequent charge transfer among hydrometeors [3]. This study aimed to understand the behavior of polarimetric variables that precede the first lightning stroke. The findings, therefore, provide a significant contribution to the detection of initial cloud electrification and lightning monitoring. The application of a Random Forest, an ensemble learning method based on decision trees, model yielded a high-performance classification of electrified cloud behavior, with an accuracy of 84% on the test dataset. The variables that proved most determining for this classification were high reflectivity at a higher height than non-electrified clouds, and the type of hydrometeor, with graupel being the most critical. Knowledge of these properties can be utilized to infer the physical processes responsible for cloud electrification and convective nowcasting.

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Impact of Cold Pools on the Intermittence of Precipitation in a General Circulation Model

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Simulation of precipitation intermittence/frequency remains a long-standing challenge for atmospheric General Circulation Models (GCM): rainfall usually occurs too often. This study aims at testing the hypothesis that improving cold pool properties in a prognostic cold pool parameterization can alleviate the precipitation frequency bias in GCMs.

We hereby test this hypothesis using LMDZ, the atmospheric component of the IPSL GCM, which includes a prognostic parameterization of cold pools. It assumes the cold pool number density (number of cold pools per unit area) is a fixed parameter globally, so that cold pools are not numerous enough over oceans. We first increase the cold pool number density in the GCM to a value more representative of cold pools over tropical oceans, in a 1D Single-Column Radiative-Convective Equilibrium (RCE) framework, using Cloud-Resolving Model (CRM) simulations as a guide. Cold pool thermodynamic anomalies become much weaker, which reduces cold pool ability to maintain convection. We then perform 3D simulations with the modified parameter and show that it improves the intermittence of convective precipitation: convective precipitation becomes significantly more sporadic, in particular over oceans. There is a monotonous sensitivity of convective rainfall intermittence to cold pool number density, while it does not affect mean precipitation, which is promising for GCM tuning.

This work shows that a better representation of cold pools in GCMs can help alleviate the precipitation frequency bias.

Evaluation of the RegCM5 Model in Simulating Consecutive Wet Days Events in São Paulo

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The study of consecutive wet days (CWD) is essential for understanding extreme events such as floods and landslides that affect many regions. In recent years, the São Paulo Metropolitan Area has shown significant changes in CWD patterns, including variations in event intensity, frequency, and maximum duration. Many of these prolonged rainfall episodes are linked to the presence of organized convective systems, such as mesoscale convective systems, squall lines, and cold-pool-driven propagation mechanisms, which enhance the persistence and spatial anchoring of convection over urban areas.

Assessing whether regional climate models can represent both these systems and the rainfall patterns they generate is crucial for urban planning, agriculture, and water resource management. In this context, the RegCM5 model is widely used for high-resolution simulations, providing the ability to investigate not only precipitation characteristics but also features of convective organization in complex environments such as the São Paulo region.

In this study, we assess RegCM5's ability to reproduce the rising frequency and intensity of consecutive wet days in the São Paulo Metropolitan Area (SPMA) over 2018–2021, with a particular focus on the convective-organization modes driving these persistent rainfall events.. We examine the extent to which the model captures the occurrence and maintenance mechanisms of organized convective systems, aiming to understand how changes in these processes may contribute to rising vulnerability to precipitation-induced natural disasters in the region.

How does overshooting convection contribute to stratospheric moistening in the Canadian Atmospheric Model?

Karen Garcia Perdomo

Poster Abstract

Overshooting convection occurs when powerful updrafts of air in large storm clouds have enough momentum to penetrate from the lower atmosphere, the troposphere, into the upper atmosphere, the stratosphere. These powerful updrafts carry ice particles, which can increase the concentration of water vapour in the stratosphere, a process known as stratospheric moistening. Overshooting convection is one of the main sources of stratospheric moistening and plays an important role in the stratospheric water vapour budget. Though the amount of water vapour in the stratosphere is much lower than other gases, even small increases or decreases can have large impacts on Earth's climate. The role of overshooting convection in how water enters and exits the stratosphere and the spatial and temporal distribution of stratospheric water vapour has yet to be studied in the Canadian Atmospheric Model output. This poster will present preliminary analysis of overshooting convection and its role in stratospheric moistening using Canadian Atmospheric Model simulations.

Aerosol-Cloud Interactions in Tropical Deep Convective Clouds

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The interactions between aerosols and deep convective clouds are one of the most uncertain components of aerosol-cloud interaction. Shipping lanes in the Indian ocean have a very high aerosol concentration and they are surrounded by a relatively cleaner environment. Lighting, an indicator of storm intensity, is found to be higher in these shipping lanes, compared to their surrounding region with similar meteorological conditions [1,2]. Several mechanisms have been suggested for the larger number of lightning events, triggered by higher aerosol concentrations, such as convective invigoration [3], and mesoscale circulation between shipping lane and its environment [4], but none of these have been verified from observational data. Higher concentration of aerosol has also been linked to larger anvil-cloud fraction [4]. We investigate the physical mechanisms behind the interactions between shipping aerosols and tropical convective clouds and how these interactions affect the associated cloud anvils. To do this, we compare deep convective systems that develop over shipping lanes and those that develop in nearby cleaner environment using a database which tracks the evolution of individual deep convective systems from geostationary satellites [5]. This database is then matched with the MODIS satellite data, so that the MODIS data can be composited based on the origin of deep convective systems. This allows us to compare cloud properties for clouds which originated in more polluted conditions vs clouds which originated in cleaner conditions. Using this, we study the impact of higher aerosol concentration on the particle size of cloud anvils. Our preliminary results indicate that in the thin anvil cloud, the cloud fraction is larger for the clouds originating in the shipping lanes, suggesting that a larger aerosol concentration can lead to larger, more persistent anvils.

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Simulating the 2025 hurricane Melissa across spatial scales

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Melissa was a major hurricane that formed in the Caribbean in late October 2025. After an unusually rapid intensification from tropical storm to Category 5 hurricane, Melissa made landfall in Jamaica on 28 October, then weakened slightly in organization before crossing eastern Cuba as a major hurricane (Category 3) approximately 12 hours later. This study evaluates the skill of the atmospheric component of the Model for Ocean–laNd–Atmosphere predictioN (MONAN) in simulating Hurricane Melissa using a global domain with horizontal resolutions ranging from 120 km to 3 km, using the scale-aware Grell–Freitas convection parameterization. MONAN is a community Earth system model under active development, led by Brazil's National Institute for Space Research. Its atmospheric component is based on the dynamical core of the MPAS atmospheric solver (Model for Prediction Across Scales), with additional developments and subgrid-scale parameterizations tailored to conditions typical of South America and the Caribbean. Here, two sets of 72 h simulations spanning the aforementioned resolutions are analyzed: one initialized on 25 October, covering Melissa's explosive development over the warm Caribbean; and another initialized on 27 October, capturing Melissa's passage over Jamaica and Cuba and its subsequent weakening. Furthermore, a sensitivity test with deep convection disabled at 3 km resolution is analyzed. The simulated track, wind speeds, and accumulated precipitation are compared against NOAA-NHC's forecasts and reanalysis data.

Characterizing Deep Convective Organization In Multi-Year Km-Scale ICON Simulations

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Tropical deep convection plays a fundamental role in the global hydrological cycle and the occurrence of extreme rainfall. Recent advances in kilometer-scale modeling enable an explicit representation of deep convection at the global scale, providing unprecedented opportunities to study these storms and their role in the weather and climate system. Here, we analyze new DYnamics of the Atmospheric general circulation Modeled On Non-hydrostatic Domains (DYAMOND)-3 [1] global ICON (Icosahedral Nonhydrostatic) model simulation at 2.5-km horizontal grid spanning four years.

To detect and characterize deep convective clouds, we apply the MOAAP multi-object tracking algorithm [2] to satellite-based datasets (IMERG precipitation and MERG-IR brightness temperatures) and to the ICON outputs. This approach enables a unified analysis of diurnal, seasonal, and interannual variability of deep convection, its spatial distribution, precipitation characteristics, size, lifetime, propagation speed, and other features.

Comparing observed and simulated characteristics reveals both regional over- and underestimations in convective frequency. In particular, the ICON simulation tends to underestimate mean mesoscale convective system (MCS) rainfall intensity and produce fewer long-lived systems over tropical oceans, while MCSs are too frequent over tropical land regions. However, ICON captures the large-scale patterns and many structural characteristics of organized convection. To better understand the biases of the simulation, we incorporate complementary observational datasets, including multiple gridded precipitation products, ice water path (IWP) retrievals, and ground-based radar measurements over selected tropical regions.

Overall, this research provides a comprehensive evaluation of convective systems in the multi-year global ICON DYAMOND-3 simulation. By integrating state-of-the-art object tracking, multi-sensor observations, and convective-process diagnostics, our study offers new insights into the strengths and limitations of global kilometer-scale simulations in the tropics. The results directly support ongoing efforts to improve ICON's skill in representing tropical convection and extreme rainfall in future global storm-resolving modeling initiatives.

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What controls trade-inversion cloud sheets?

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About two thirds of cloud cover variability in the trades comes from clouds near the trade inversion. These inversion clouds are often organized in stratiform layers atop shallow mesoscale convective structures, but their controlling processes and their sensitivity to warming are not well-understood. Here, we therefore investigate how inversion height, strength and cloudiness relate, and what controls them, using dropsondes, airborne lidar and large-eddy simulations from the EUREC[4]A field campaign. We find that large-scale diagnostics, such as the estimated inversion strength and lower-tropospheric stability, are poor measures of the daily variability in trade inversion strength and its cloudiness. Instead, the observed and simulated variability in inversion cloudiness is explained by variability in the actual trade inversion strength, the column humidity and the surface fluxes; that is, the drivers of convection itself. We explore this further by diagnosing the controlling balances that form and dissipate inversion sheets atop several different shallow mesoscale convective systems in large-eddy simulation. The results suggest that inversion cloudiness depends on the mesoscale patterning of the convection that produces it. That is, to get inversion sheets and their climate sensitivity right, one must get the mesoscale-organized convection that produces them right.

Data-Driven Modeling of Self-Organization and Tropical Cyclogenesis in Rotating Radiative-Convective Equilibrium

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In the atmosphere, predicting the time evolution of tropical cyclone intensity remains challenging, even with state-of-the-art numerical weather prediction models. It is well known that spontaneous aggregation of convective clouds is followed by the formation of tropical cyclones in cloud-resolving numerical simulations in an idealized framework without a background vortex[1]. The timing of cyclogenesis is highly sensitive to the initial conditions of the numerical simulations. In this study, we conducted an ensemble of three-dimensional radiative–convective equilibrium simulations that include the effect of planetary rotation. Ensemble time series of macroscopic atmospheric variables were used to develop a data-driven model based on reservoir computing[2], which reconstructs the dynamics of the emergence of self-organization and cyclogenesis. We performed Lyapunov exponent analyses on both the cloud-resolving simulation data and the data-driven model to quantify the degree of chaos at each stage. As a result, a chaotic regime was identified during the cyclogenesis stage. We also found that error growth was fastest during the mature stage of tropical cyclones.

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Relationship Between Properties of Mesoscale Convective Systems and Electrical Activity in Southeastern Brazil

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Southeastern Brazil frequently suffers from natural disasters such as floods and landslides resulting from intense rainfall associated with Mesoscale Convective Systems (MCS). These systems are also responsible for high lightning rates, and characterizing their electrical activity is crucial for forecasting severe events. This study aimed to analyze the influence of MCS properties on intracloud (IC) and cloud-to-ground (CG) lightning activity, comparing systems without lightning, with purely IC lightning, and with CG lightning. Using data from 2015 to 2017 from the Earth Networks Total Lightning Network (ENTLN) and GOES-13 satellite images, SCMs were identified and tracked by the ForTraCC algorithm. The results showed that SCMs with CG lightning tend to be larger in area (average of 3308 km²), have a longer duration (average of 2.8 h), a higher initial expansion rate (258×10^{-6} s^{-1}), and colder cloud tops (average Tmin of 214 K) when compared to systems with purely IC lightning or no lightning. Life cycle analysis revealed that the largest differences in area and temperature occur before and during the maturation phase. While IC lightning peaked in the early phase of the SCM, CG lightning peaked in the intermediate phase (T2). The density of all types of lightning was highest in the initiation phase. The findings detail the morphological, physical, and electrical characteristics of different types of SCMs, improving understanding for potential improvements in severe storm forecasting in the region.

The South American High-Impact Weather Reports Database

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Despite southern South America being recognized as a hotspot for deep convective storms, little is known about the socio-environmental impacts of high-impact weather (HIW) events. Although there have been past efforts to collect severe weather reports in the region, they have been highly fragmented among and within countries, sharing no common protocol, and limited to a particular phenomenon, a very specific region, or a short period of time. There is a pressing need for a more comprehensive understanding of the present risks linked to HIW events, specifically deep convective storms, on a global scale as well as their variability and potential future evolution in the context of climate change. A database of high-quality and systematic HIW reports and associated socio-environmental impacts is essential to understand the regional atmospheric conditions leading to hazardous weather, to quantify its predictability, and to build robust early warning systems. To tackle this problem and following successful initiatives in other regions of the world, researchers, national weather service members, and weather enthusiasts from Argentina, Brazil, Chile, Paraguay, and Uruguay have embarked on a multinational collaboration to generate a standardized database of reports of HIW events principally associated with convective storms and their socio-environmental impacts in South America. This unprecedented initiative over the region, is presented, together with its first results.

Correlating cloud organization with precipitation efficiency in the Amazon

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Precipitation is the result of multiple chaining and non-linear processes that depend on factors such as the large-scale meteorological context and cloud field dynamics. Among these environmental factors, vertical profiles of atmospheric moisture, aerosol concentrations [1], and vertical wind shear [2] are the ones that could be relevant for the Amazon. For a given vertically integrated water vapor amount, we aim to evaluate whether fewer but larger clouds (highly aggregated cloud fields) are more efficient than more numerous but smaller clouds (low aggregation) to convert water vapor into precipitation over the Amazon. While the specialized literature teaches us that cloud depth is proportional to accumulated precipitation, thus potentially having higher efficiency, there are still many open questions that need to be addressed for better representations of the local hydrological cycle [3]. We will address this issue for locally driven convection over the Amazon, pertaining to the transition of shallow cumulus clouds to deep convection. We will apply a quantification to the level of aggregation of cloud fields and correlate it to atmospheric characteristics such as the vertical profiles of temperature, moisture and winds, as well as aerosol concentrations. This will be achieved by a combination of observational datasets (including vertically pointing radars, satellites and GPS) and reanalysis data (ERA-5) to unveil the relative roles of individual atmospheric properties, as well as a combination between them, on cloud aggregation. Later, we will correlate cloud aggregation to precipitation efficiency to assess the validity of our main hypothesis, that is, the higher efficiency of highly aggregated cloud fields. This effort will benefit the representation of the Amazonian hydrological cycle, including the daily precipitation cycle that has been a longstanding problem for the tropics [4].

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Evaluation of deep convection and cold pool representation in MONAN for simulating a major agricultural Haboob in Southeast Brazil

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This study investigates the critical role of deep convection and resultant convective cold pools in generating the intense winds responsible for a massive "haboob" dust storm in the agricultural region of São Paulo state, Brazil. The main objective is to evaluate how the representation of these convective processes influences the modeling of dust-generating winds. The simulation utilizes Brazil's Unified Earth System initiative MONAN (Model for Ocean-laNd-Atmosphere PredictioN) to reproduce the "haboob" dust storm event. The haboob, which swept the region on September 26, 2021 (extending up to 200 km and increasing PM10 to 200µg/m3), was directly caused by strong outflow winds emanating from a convective system combined with very dry soil conditions. To specifically model the gust front forcing, the physically based Leung et al. (2024) dust emission scheme is used, driven by MONAN meteorology. The study incorporates the Freitas et al. (2024) cold pool edge parameterization; a physics scheme incorporated into the MONAN physics to explicitly test the influence of the gust front on the dust emission mechanism. Simulations are run at multiple spatial resolutions (10, 30, and 60 km) to examine the sensitivity of the modeled cold pool structure and resultant winds. By comparing the modeled meteorological results with satellite imagery, surface observations, and weather radar data, this work assesses the efficacy of convective cold pools deep representations within MONAN. The findings provide crucial insights into the requirements to accurately predict and forecast extreme wind-driven dust events like the haboob dust storm seen in Sao Paulo countryside.

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PREDICTING MONTHLY RAINFALL VIA SST ANALOGS

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On monthly and seasonal timescales, precipitation is modulated by large-scale boundary conditions [1,2]. Based on this knowledge, we developed an analog framework that maps monthly forecast sea-surface-temperature (SST) anomaly patterns from dynamical models (SEAS5/ECMWF and CFSv2/NOAA) to expected precipitation anomalies over South America. First, we get the hindcasts from both models and compute monthly SST climatologies. For each target month of precipitation forecast, we compute SST anomalies (forecast monthly mean minus climatology), and an ensemble mean of the anomalies. Then, we search in a historically observed SST database for analog months with similar spatial anomaly patterns (e.g., using pattern correlation or Euclidean distance). Precipitation anomalies are estimated by compositing observations corresponding to the top-k analogs. Finally, we show the performance of the method through comparisons of past forecasts with the observed data.

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Intense Convective Precipitation in Belém: Insights from Polarimetric Radar

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In the Northern region of Brazil, extreme rainfall events are commonly linked to deep convection and the development of Mesoscale Convective Systems (MCS). Over the Belém Metropolitan Area (PA), these systems account for a significant fraction of daily rainfall, posing serious flood risks. Dual-polarization radar observations are therefore essential to characterize convective organization and improve quantitative precipitation estimates (QPE). This study investigates an intense rainfall event that occurred on July 3, 2025, associated with a MCS over Belém. The system was classified as an MCS because, following the classification used by Maddox [1] it presented a continuous cloud cover exceeding 100,000 km², with temperatures at the cloud tops below -32°C and a duration exceeding six hours. Hourly rainfall exceeded the 99th percentile for July based on a 10-year MERGE-CPTEC climatology [2], confirming the event's extreme nature. Dual-polarization S-band radar RMT0200 observations (CENSIPAM/Belém) were processed using a 3-km CAPPI (Constant Altitude Plan Position Indicator) and three QPE methods:(i) Ryzhkov et al. [3]: $R(Z, Z_{DR}, K_{DP})$; (ii) Marshall–Palmer [4]: classic $R(Z)$; and (iii) K_{DP}-only: $R(K_{DP})$ [5], suitable for heavy rainfall. The spatial fields revealed persistent intense cores (> 30 mm/h) between 19–21 UTC, consistent with deeper cloud-top signatures from GOES-19. CDF analysis showed that Ryzhkov's method best reproduced MERGE rainfall distribution (Kolmogorov-Smirnov KS = 0.054), outperforming Marshall-Palmer (0.309) and K_{DP}-only (0.297). For the most extreme rainfall rates (> 40 mm/h), PDF results indicated a slight advantage for the K_{DP}-only approach. Comparisons with 14 automatic rain gauges (CEMADEN & INMET) showed performance consistent with spatial analyses: Spearman correlations were 0.72 for K_{DP}-only, 0.62 for Ryzhkov et al. [3] and 0.57 for Marshall-Palmer. Lowest errors were obtained by K_{DP}-only (RMSE = 10.6 mm), although Ryzhkov remained the most robust for capturing spatial extremes. Overall, polarimetry-based QPE substantially reduced precipitation uncertainty during this tropical mesoscale convective system, reinforcing the operational value of dual-polarization radar for real-time monitoring of severe convective storms. This tool is crucial for hydrometeorological disaster warning systems. Future work will expand the sample of cases to refine statistical calibration and enable automatic detection of the convective core.

[1] Maddox, R. A. (1980). Mesoscale Convective Complexes. Bulletin of the American Meteorological Society, 61(11), 1374–1387.
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[4] Marshall, J. S., Palmer, W. McK. (1948). The distribution of raindrops with size. Journal of Meteorology, 5, 165–166.
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Al Dirigente Scolastico

dell'Istituto Comprensivo "Divisione Julia"

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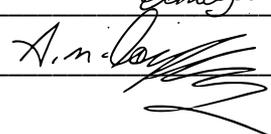
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Il/la proprio/a figlio/a a partecipare, nel corso dell'anno scolastico **2025/2026** a visite didattiche, visite guidate, musei, mostre, monumenti, escursioni naturalistiche nel comune di Trieste ed in comuni limitrofi, ad attività sportive non agonistiche scolastiche ed extrascolastiche ed a tutte le altre iniziative ed attività integrative extrascolastiche deliberate dagli Organi Collegiali della scuola.

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IN CASO DI UNICO GENITORE FIRMATARIO,

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"Il sottoscritto genitore unico firmatario, consapevole delle conseguenze amministrative e penali per chi rilasci dichiarazioni non corrispondenti a verità, ai sensi del DPR 245/2000, dichiara di aver effettuato la scelta/richiesta in osservanza delle disposizioni sulla responsabilità genitoriale di cui agli artt. 316, 336 ter e 337 quater del codice civile, che richiedono il consenso di entrambi i genitori". (l.54/2006) "Dichiarazione di assunzione di responsabilità ai sensi degli artt. 46, 47, 76 del D.P.R. n. 445 del 2000".

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allegato 3

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