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P01

Abstract for Poster: Predicting Atmospheric Electric Discharges with Radar Data and Machine Learning

Ana Luz Alabi Nassr

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Facultad de Matemática, Astronomía, Física y Computación (Universidad Nacional de Córdoba)
Observatorio Hidrometeorológico de Córdoba

The province of Córdoba, located in central Argentina, frequently experiences intense thunderstorms that produce significant electrical discharges. These events are indicators of severe weather phenomena such as heavy rainfall, hail, and tornadoes, emphasizing the importance of their detection and prediction.

This study analyzes five multicellular storms observed between 2022 and 2024 using data from the RMA1 polarimetric radar and the World Wide Lightning Location Network (WWLLN). Results show that, at points associated with lightning discharges, radar variables indicate large hydrometeors, hail presence, higher liquid water content, mixed-phase regions, and deeper vertical development of clouds.

A dataset was constructed combining radar polarimetric parameters at WWLLN-detected discharge points and randomly selected control points without discharges. This dataset was used to train a deep neural network, which achieved 83% accuracy on the validation set. When applied to a more realistic, imbalanced dataset, model performance decreased, producing a higher rate of false positives. However, comparisons with lightning data from the GOES-16 satellite's GLM sensor showed that 81% of these false positives corresponded to real discharges undetected by WWLLN.

These findings demonstrate that the model effectively learned patterns related to lightning activity from RMA1 radar data, allowing the identification of regions with a high probability of electrical discharges, even in the absence of ground-based detection.

P02

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

Luke R. Allen[1], **Annica M. L. Ekman**[1], **Nazario Mastroianni**[1]

[1] *(Presenting author underlined) Department of Meteorology and Bolin Centre for Climate Research, Stockholm University, Stockholm, SE*

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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P03

Analysis of the Extreme Characteristics of a Destructive Convective Event over Central Argentina: December 16–17, 2023.

Matias Ballarin [1] , Paola Salio [1,2,3] , Ramon D'Elia [4]

[1] Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Ciencias de la Atmósfera y los Océanos.
[2] CONICET - Universidad de Buenos Aires. Centro de Investigaciones del Mar y la Atmósfera (CIMA).
[3] CNRS - IRD - CONICET - UBA. Instituto Franco-Argentino para el Estudio del Clima y sus Impactos (IRL 3351 IFAECI).
[4] Servicio Meteorológico Nacional (SMN).

On December 16, 2023, a windstorm developed over central Argentina causing significant damage, mainly in the cities of Bahía Blanca and Buenos Aires, where widespread wind damage was reported. Because of its spatial extent and intensity, the event can be classified as a "derecho." Using ERA5 reanalysis data and observational soundings, this study aims to assess the dynamical and thermodynamical environment that favored the development of the storm, as well as to analyze its predictability.

Observational soundings from Santa Rosa Aero (the nearest upper-air station to Bahía Blanca, located 290 km away) at 12-UTC from 1998 to 2023 were used to assess thermodynamical parameters during the pre-convective environment, such as Most Unstable CAPE (MUCAPE), Downdraft CAPE (DCAPE) and precipitable water (TPW) with respect to climatological values. The MUCAPE was 3017 J/kg, reaching the 95th percentile for days with MUCAPE values greater than 0 J/kg (1760 J/kg). The TPW was 49 mm, which also reached the 95th percentile (46 mm).

From a dynamical perspective, the event developed within a strong synoptic setting associated with a mid-level trough over the Pacific Ocean, off the coast of Chile. The Trough Axis Index (TAI) and the Trough Intensity Index (TII) [1] were used to assess the intensity of the trough relative to climatological data from 1990 to 2023. The results show that the intensity of the trough linked to the case not only reached the 95th percentile for troughs identified in summer (DJF), but also reached the 95th percentile for troughs identified in winter (JJA), when the passage and intensity of the meteorological systems tend to be highest [2].

Finally, the predictability of the TAI and TII was evaluated using the European Centre for Medium-Range Weather Forecasts Ensemble Prediction System (ECMWF-EPS), showing good skill up to one week before the event, with the ensemble forecast members converging toward the observed values approximately seven days in advance. These results underscore the potential of the ECMWF-EPS to anticipate the synoptic conditions leading to high-impact convective wind events in subtropical South America.

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P04

Influence of equatorial waves on convection organization and extreme events in Northern South America

Alejandro Builes-Jaramillo [1]

[1] *Facultad de Arquitectura e Ingeniería. Institución Universitaria Colegio Mayor de Antioquia. Medellín-Colobmia*

Equatorial Waves are key drivers of intraseasonal variability in the tropics, exerting a strong influence on convection and rainfall over northern South America [1, 2, 3, 4]. This variability arises from a broad spectrum of quasi-periodic and aperiodic modes operating on synoptic to global scales [5]. Although each wave exhibits distinct dynamics and seasonality, isolating the individual effects of these waves on precipitation remains challenging. For the region of northern South America, the contribution of African Easterly Waves may be up-to 30% of the seasonal precipitation and/or up to 11% of the monthly positive rainfall anomalies [6, 7,]. The relationship between extreme events and Equatorial Waves have been studied in regions over the world [8, 9,10], but for Northern South America the research limits to mostly on Kelvin Waves and African Easterly Waves [10, 1]. Recent work in the region highlighted the intricacies of extreme events formation over the Andean complex topography [11], in which the intraseasonality of such processes is still understudied. Therefore, some questions arise from the interactions of the diverse Equatorial Waves, the complex Andean terrain and the convection processes leading to extreme precipitation events in the region.

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P05

Classification of Electrified Clouds using Radar and Machine Learning

Cachucho da Silva D.[1] , Pavam L. [1,2] , Paz S. [2], Oliveira L. [1] and Zanata M. [1]

[1] *Federal University of Paraná (UFPR)*

[2] *Paraná Environmental Technology and Monitoring System (Simepar)*

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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P06

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

<u>Maxime Colin</u> [1,2,3] **, Jean-Yves Grandpeix** [3] **, Sandrine Bony** [3] **, Steven Sherwood** [2]

[1]*Leibniz Centre for Tropical Marine Research (ZMT), Bremen, Germany*
[2] *Climate Change Research Centre (CCRC), University of New South Wales, Sydney, Australia*
[3]*Laboratoire de Météorologie Dynamique (LMD), Sorbonne University, Paris, France*

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.

P07

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

<u>Naurinete J. C Barreto</u> [1], **Maria L. da Silva**[2], **George U. Pedra**[3]

[1]*Instituto Nacional de Pesquisas Espaciais (INPE) – São José dos Campos, SP, Brazil*
[2] *The Abdus Salam International Centre for Theoretical Physics (ICTP) - Trieste, Itália*
[3] *Centro Nacional de Monitoramento e Alertas de Desastres Naturais (CEMADEM) – São José dos Campos, Brasil*

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.

P08

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.

P09

Aerosol-Cloud Interactions in Tropical Deep Convective Clouds

Tanisha Garg[1], Casey Wall[1], Frida Bender[1]

1. Department of Meteorology, Stockholm University, Sweden

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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P10

Simulating the 2025 hurricane Melissa across spatial scales

Eduardo Georges Khamis[1], Carlos Renato de Souza[1], Daniel Massaru Katsurayama[1], João Messias Alves da Silva[1], Marcelo Paiva Ramos[1], Sylvio Villas Boas Neto[1], Lianet Hernández Pardo[1], Saulo Ribeiro de Freitas [1]

[1] *(Presenting author underlined)National Institute for Space Research, Brazil*

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.

P11

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

K. Santiago Hernández [1], **and Andreas F. Prein** [1]

[1] *(Presenting author underlined) Institute for Atmospheric and Climate Science, ETH Zürich, Zürich, Switzerland*

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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P12

What controls trade-inversion cloud sheets?

Martin Janssens[1] **and Raphaela Vogel**[2]

[1] *Wageningen University*
[2] *University of Hamburg*

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.

P13

Observations of clouds in central Amazonia

Friederike Lipken[1] , **Rachel Ifanger Albrecht**[1] , **and Luiz T. A. Machado**[1,2]

[1]*Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, São Paulo, Brazil*
[2] *Instituto de Fisica, Universidade de São Paulo, São Paulo, Brazil*

Aerosol-Cloud-Interactions (ACI) strongly influence cloud properties, precipitation, and atmospheric dynamics, yet their role in the Amazon rainforest remains uncertain [1, 2]. This study investigates cloud characteristics and their relation to aerosol size distributions and meteorological regimes in central Amazonia using observations from 2022 and 2023 at the ATTO site (Amazon Tall Tower Observatory).

Clouds are detected using a combination of cloud radar, ceilometer, and disdrometer measurements at the Campina site, while aerosol particles are measured at 60 m height on the ATTO tower with a Scanning Mobility Particle Sizer. Based on cloud-top height, clouds are classified into low (top < 4km), middle (top <7km), and high (top >7km) clouds. The resulting dataset contains cloud base and top heights, detection duration, and other cloud and rain properties, enabling the investigation of precipitating and non-precipitating clouds and their surrounding atmospheric conditions in different regimes.

The analysis provides distinct differences between seasons and cloud types in relation to temporal occurrence and precipitation. Meteorological regimes are used to relate aerosol particles, wind conditions, and precipitable water vapor to cloud behavior.

Previous findings from the GoAmazon2014/5 experiment provide the foundation for improving the observational understanding of ACI in tropical regions such as the Amazon rainforest [2, 3].

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P14

Sensitivity of Extreme Rainfall Simulations to Microphysical Parametrisations in the ALARO Regional Model over the Amazon Basin

Debasish Mahapatra[1,2], David Němec[3], Thiago Biscaro[4], Scott Giangrande[5], Radmila Brožková[3], Michiel Van Ginderachter[2], Bert Van Schaeybroeck[1,2], and Kwinten Van Weverberg[1,2]

[1] *Department of Geography, Ghent University, Ghent, Belgium*
[2] *Royal Meteorological Institute of Belgium, Brussels, Belgium*
[3] *Czech Hydrometeorological Institute, Prague, Czech Republic*
[4] *Instituto Nacional de Pesquisas Espaciais, Cachoeira Paulista, SP, Brazil*
[5] *Environmental Science and Technologies Department, Brookhaven National Laboratory, Upton, NY, USA*

Extreme rainfall is increasing in many tropical regions and is projected to intensify further with continued global warming, increasing the risk of damaging floods in basins such as Amazonia. This study quantifies the sensitivity of the ALARO (ALADIN-AROME) regional climate model to its representation of microphysics over the Amazon Basin. We conducted simulations at 4 km grid spacing over two years to understand how microphysical assumptions shape extreme rainfall statistics and convective organisation. Three configurations form a microphysics ladder: a baseline single-moment scheme, a single-moment scheme augmented with graupel, and a newly developed double-moment warm-rain scheme that predicts both mass and number for liquid hydrometeors. The evaluation uses a synergy of multi-scale observations, including measurements from the GO-Amazon 2014/2015 field campaign, the S-band radar of SIPAM (Sistema de Proteção da Amazônia) near Manaus, and satellite precipitation and radar products. We tested the hypotheses that double-moment warm rain reduces light-rain biases and improves extreme tails by enabling environment-dependent drop spectra and evaporation, and that adding graupel modifies ice-phase pathways that modulate cold-pool strength and mesoscale structure. The results point to systematic regime-dependent differences among the three schemes in nocturnal rainfall, convective, and stratiform partitioning, and spatial coherence of mesoscale systems. The analysis provides the first focused assessment of the ALARO model at grey-zone scales over Amazonia and offers guidance for prioritising microphysics developments to provide more accurate tropical extreme rainfall simulations.

P15

Measuring updraft strength from successive radar scans during the WesCon and KASBEX field campaigns

Mark Muetzelfeldt[1], Christopher Holloway[1], Thorwald Stein[1], Brian Lo[1], Robert Thompson[1], Brenda Dolan[2], Susan van den Heever[2], Ryan Neely[3], and Christopher Walden[4],

[1] *(Presenting author underlined) Meteorology Dept., University of Reading, UK*
[2] *Colorado State University, USA*
[3] *University of Leeds, UK*
[4] *National Centre for Atmospheric Science, UK*

Convective updrafts are integral to mesoscale convective systems (MCSs), with the release of energy driving a vertical transport that leads to the production of large anvil clouds surrounding the MCS convective cores. However, direct observation of updrafts is difficult. We build on the delta-Z method [1], in which successive radar scans are differenced to identify the characteristic signal of updraft strength and cloud growth. We make use of thousands of scans from the Wessex Convection Experiment (WesCon) field campaign in southern England [2, 3] to build a statistical picture of the delta-Z method for the first time from observations. We further use information from the Ka- and S-band Experiment (KASBEX) to characterize the differences of the delta-Z method between these two radar frequencies. We track clouds using the UK Met Office's operational rainfall product, RadarNet [4], and match this information to growth and updraft strength from the delta-Z method.

Our work stands alone, but also informs the upcoming INvestigation of Convective UpdraftS (INCUS) satellite mission [5], which will use the delta-Z method from three satellites flown in a tight convoy. This will provide a tropics-wide estimate of updrafts for the first time. In particular, the statistical information we produce, the matching of the delta-Z signal to cloud lifecycle, and the characterization of the differences between S-band and Ka-band radars help to understand the delta-Z method from observations in more detail.

The work forms part of the UPFLO (Improving understanding and modelling of convective UPdraFts and anvil cLOuds) project, by allowing us to diagnose updraft strength from radar reflectivity alone. It contributes to the wider Advancing the Frontiers of Earth System Prediction (AFESP) programme, a 15-year programme hosted at the University of Reading [6], with collaboration from ECMWF, the UK Met Office, and the National Centre for Atmospheric Science (NCAS).

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Targeted probabilistic trigger for the representation of organized deep convection in a global forecasting ensemble

Mark Muetzelfeldt[1], Robert Plant[1], Hannah Christensen[2], Zhixiao Zhang[2], Tim Woollings[2], and Warren Tennant[3]

[1] *(Presenting author underlined) Meteorology Dept., University of Reading, UK*
[2] *Atmospheric, Oceanic and Planetary Physics, University of Oxford, UK*
[3] *Met Office, UK*

Representing organized convection in atmospheric models that are too coarse to explicitly simulate it remains a major challenge. A novel class of stochastic parametrization scheme representing an underlying atmospheric phenomenon is described. The effects of mesoscale convective systems (MCSs) are represented in a targeted manner, based on probabilistically triggering an MCS scheme in regions of enhanced environmental total column water vapour, where there is a high likelihood of MCS occurrence. In combination with the probabilistic trigger, patterns with appropriate spatiotemporal scales determine where and when the scheme is active. Our scheme builds on the multiscale coherent structure paramtrization (MCSP) [1, 2, 3], which represents the top-heavy heating structure associated with MCSs and their attendant anvil clouds.

The stochastic scheme is compared with a control and vanilla MCSP to determine the space and time correlation statistics of precipitation. Results with the stochastic trigger are closer to observations when compared to the control, and the new scheme performs well over larger spatial and temporal separations, although it does not perform as well as the default MCSP at reproducing the spatial correlations at small (near grid scale) separations. When tropical spread-error statistics of geopotential at 500hPa are analysed in an ensemble, we find that our scheme marginally boosts spread compared to the default MCSP as expected, improving the underdispersion of the ensemble. The improvement in spread is clearer for precipitation, and the stochastic scheme improves the spread with little degradation in the error compared to MCSP.

The work was carried out as part of the Mesoscale Convective Systems: PRobabilistic forecasting and upscale IMpacts in the grey zonE (MCS:PRIME) project, a collaboration between the University of Reading, the University of Oxford and the UK Met Office.

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P16

The South American High-Impact Weather Reports Database

Ernani de Lima Nascimento [1], Hernan Bechis [2,3,4], Vito Galligani [2,3,4], , Bruno Ribeiro [5], Paola Salio [2,3,4]

[1] *Instituto Nacional de Pesquisas Espaciais —INPE, São José dos Campos, Brazil*
[2] *Facultad de Ciencias Exactas y Naturales, UBA, Buenos Aires, Argentina*
[3] *CONICET–UBA, Centro de Investigaciones del Mar y la Atmósfera (CIMA), Buenos Aires, Argentina*
[4] *CNRS–IRD–CONICET–UBA, IFAECI (IRL 3351), Buenos Aires, Argentina*
[5] *Defesa Civil do Rio Grande do Sul, Brazil*

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.

P17

Correlating cloud organization with precipitation efficiency in the Amazon

Pugliesi, Andre C.[1] and Cecchini, Micael. A.[1]

[1]Institute of Astronomy, Geophysics and Atmospheric Sciences (IAG). University of São Paulo (USP), Brazil

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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P18

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

Nilton Rosario [1], **Saulo Freitas** [2], **Danny Leung**[3], **Demerval Moreira**[4], **Karla Longo** [2]

[1] *Environmental Sciences Department, Sao Paulo Federal University, Diadema, Brazil*
[2] *National Institute for Space Research (INPE), São José dos Campos, Brazil*
[3] *NSF National Center for Atmospheric Research, Boulder, CO, United States*
[4] *Faculdade de Ciências, Universidade Estadual Paulista, Bauru-SP, Brazil*

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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P19

Analysis and classification of deep convective organization modes and their associated environments in idealized numerical simulations

Esteban Semino[1], Jorge Gacitúa Gutiérrez[1, 2], Juan Ruiz[1,2,3], Paola Salio[1,2,3]

[1] Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Departamento de Ciencias de la Atmósfera y los Océanos. Buenos Aires, Argentina
[2] CONICET – Universidad de Buenos Aires. Centro de Investigaciones del Mar y la Atmósfera (CIMA). Buenos Aires, Argentina
[3] CNRS – IRD – CONICET – UBA. Instituto Franco-Argentino para el Estudio del Clima y sus Impactos (IRL 3351 IFAECI). Buenos Aires, Argentina.

Understanding how the pre-convective environments control storm organization requires analyzing many cases across diverse conditions. For that purpose, numerous idealized numerical simulations were carried out using the Weather Research and Forecasting (WRF) model, in which the initial conditions in terms of stability, vertical wind shear and moisture content were systematically varied using 5 parameters. Three were responsible for modifying the vertical wind profile, 1 the vertical temperature profile and the last one the moisture vertical profile. Each simulation lasts 4 hours, with a horizontal resolution of 2000 m (80 x 80 grid points) and 41 vertical levels with a mean resolution of 500 m. A warm bubble was used to trigger convection, and the WRF Single-Moment 6-Class Microphysics Scheme (WSM6, [1]) is employed to represent cloud and precipitation processes.
Using a reduced dataset consisting of 100 simulations, an expert-based classification was performed based on their intensity and convective organization mode by analyzing the time evolution of relevant variables such as reflectivity and vertical velocity. Six organization modes were determined from this analysis: inhibited cell, ordinary cell, multi-cell, supercell with upscale growth, and ordinary cell with upscale growth. Subsequently, time series of maximum vertical velocity and updraft helicity were used to perform an unsupervised classification of the convective mode using the K-Means method, resulting in clusters that reliably match the expert-based classification.
Based on the resulting convective mode and additional metrics that characterize different aspects of the deep convection organization, a variance-based sensitivity analysis was performed to investigate the impact of the environmental conditions on the properties of the resulting deep convection. Single-parameter variance contributions explain well-known relationships between large-scale environments and deep convection; for example, supercells require high CAPE and strong, curved vertical wind shear, while ordinary cells occur in environments with low shear and moderate CAPE. Variance contributions associated with parameter combinations provide further insight into how environmental conditions impact deep convection organization and evolution.

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P20

PREDICTING MONTHLY RAINFALL VIA SST ANALOGS

Christie A. Souza [1] **, Michelle S. Reboita** [1]

[1]Federal University of Itajubá (UNIFEI), Brazil

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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P21

Convective Cold Pools and Hurricane Intensification: A Case Study of Hurricane Helene (2024)

Sasanka Talukdar[1], Alejandro Casallas[4] , Caroline Muller[4], Zong-Liang Yang[1], Sundararaman Gopalakrishnan[5] and Dev Niyogi[123]

[1] (Presenting author underlined) Department of Earth and Planetary Sciences, Jackson School of Geosciences, University of Texas at Austin, Austin, TX
[2]Department of Civil, Architectural, and Environmental Engineering, Cockrell School of Engineering, University of Texas at Austin, Austin, TX
[3]Center for Space Research, Cockrell School of Engineering, University of Texas at Austin, Austin, TX
[4]Institute of Science and Technology Austria, Klosterneuburg, Lower Austria, Austria
[5]Hurricane Research Division, The Atlantic Oceanographic & Meteorological Laboratories, Miami, USA

Convective cold pools—dense, cooled air masses generated by rainfall evaporation—are key regulators of atmospheric convection, yet their role in hurricane dynamics remains poorly understood. This study investigates their impact on the intensification of Hurricane Helene (2024) using simulations conducted with a modified Hurricane Weather Research and Forecasting model (HWRFxUT). Hurricane Helene, which originated in the Caribbean and intensified into one of the deadliest hurricanes in recent history, provides a valuable case for exploring cold pool–hurricane interactions. The modeling framework employs nested domains at 9 km, 3 km, and 1 km resolution over the contiguous United States and incorporates a series of sensitivity experiments. In these experiments, the rainfall evaporation rate within the Ferrier–Aligo microphysics scheme is modified to 50% and 150% of the control run to assess how variations in cold pool properties influence storm behavior.

The influence of cold pools on hurricane tracks is found to be negligible, whereas stronger cold pools are associated with reduced storm intensity. Their effect on hurricane-associated precipitation differs between the initiation and mature stages of the storm. Diagnostic analysis reveals that enhanced cold pools in hurricane environments increase surface latent heat flux in the outer core and lead to a general rise in surface sensible heat flux, while simultaneously reducing latent heat flux in the inner core. Additionally, stronger cold pools are linked to an expansion of hurricane size.

The results demonstrate that variations in cold pool intensity can produce substantial changes in hurricane structure and evolution. These findings underscore the importance of accurately representing cold pool processes in numerical models to improve tropical cyclone forecasts and highlight the need for continued investigation into this critical yet underexplored aspect of hurricane dynamics.

Intense Convective Precipitation in Belém: Insights from Polarimetric Radar

Priscila da Silva Tavares [1], **Nelson Mateus**[1], **Werik Rodrigues**[1], **Jaime Fernando Antonio**[1]

[1]*IACIT Technological Solutions. São José dos Campos, Brazil*
E-mail: priscila.tavares@iacit.com.br, nelson.mateus@iacit.com.br, werik.rodrigues@iacit.com.br, jaime.fernando@iacit.com.br

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.

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P23

COMPARATIVE ASSESSMENT OF PHYSICAL PARAMETERIZATIONS IN WRF AND ETA MODEL SIMULATIONS OF HEAVY RAINFALL EVENTS OVER THE PIURA REGION, PERU

Juan Carlos Tufino [1] , **Aldo Moya** [1,2] , **Alexis Ibañez** [3] , **Marco Bojorquez** [4]

[1] *National Agrarian University La Molina, Peru*
[2] *National Agrarian University La Molina, Peru* [3] *National Agrarian University La Molina, Peru*
[4] *Federal University of Sao Paulo, Sao Paulo, Brazil*

Intense rainfall events in northern Peru are strongly associated with the Coastal El Niño phenomenon, which has produced significant socio-economic impacts over the past decades [1, 2]. Despite the operational use of the WRF model in Peru [3], systematic intercomparisons with other regional models such as Eta remain limited, particularly under homogeneous boundary and experimental conditions. This study addresses this gap by evaluating the performance of both WRF [4] and Eta models in simulating heavy rainfall during the 2023 Coastal El Niño event in Peru's Piura region.
Both models were configured with identical domains and lateral boundary conditions derived from the Global Forecast System (GFS, 0.25° resolution), ensuring methodological consistency. Sensitivity experiments tested different physical parameterizations, revealing that the WRF configuration with WDM5 (microphysics), New Tiedtke (convection), and ACM2 (planetary boundary layer) schemes demonstrated superior performance.
Evaluation using data from 28 SENAMHI stations complemented with ERA5 reanalysis showed that this optimal WRF configuration achieved the lowest bias and RMSE values, effectively capturing rainfall intensity and distribution, particularly during the most intense precipitation peaks. In contrast, the Eta model exhibited a marked tendency for systematic rainfall overestimation across most of the domain, regardless of parameterization combination, with this deviation being most pronounced using the Betts-Miller-Janjic convective scheme.
This study identifies an optimal WRF configuration for the region and highlights systematic limitations in Eta model simulations, providing valuable insights for improving operational forecasting and early warning systems for extreme rainfall events in northern Peru.

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P24

Monitoring thunderstorms using atmospheric electric field: a preliminary study

Yasmin R. Velazquez [1,2,4] , M. Gabriela Nicora [2,4,5], Vito Galligani [1,3,4] , and Raúl L. D'Elia[2]

[1]Universidad de Buenos Aires, Departamento de Ciencias de la Atmósfera y los Océanos (DCAO), Av. Intendente Cantilo, C1428, Cdad. Autónoma de Buenos Aires, Argentina.
[2] UNIDEF (MINDEF – CONICET), Departamento de Investigaciones en Láseres y sus aplicaciones (DEILAP), J. B. de La Salle 4397, 1603 Villa Martelli, Pcia. de Buenos Aires, Argentina.
[3] CONICET - Universidad de Buenos Aires. Centro de Investigaciones del Mar y la Atmósfera (CIMA), Av. Intendente Cantilo, C1428, Cdad. Autónoma de Buenos Aires, Argentina.
[4] CNRS - IRD - CONICET - UBA. Centro de Investigaciones del Mar y la Atmósfera (CIMA), Av. Intendente Cantilo, C1428, Cdad. Autónoma de Buenos Aires, Argentina.
[5] Universidad Nacional de La Plata. Facultad de Ciencias Astronómicas y Geofísicas, Paseo del Bosque, C1900, Pcia. de Buenos Aires, Argentina.

Deep convection is commonly examined using remote sensing observations, lightning datasets, and numerical model outputs. In this study, we enhance the analysis of convective initiation and evolution by incorporating high-temporal-resolution measurements of the atmospheric electric field (PG), which provide valuable insight into the internal electrification and structural changes occurring within storms.

This preliminary study explores the potential of PG as a complementary tool to monitor convective initiation and storm evolution. We analyze a set of thunderstorms in the vicinity of Buenos Aires using PG data recorded at the Instituto de Investigaciones Científicas y Técnicas para la Defensa (CITEDEF). The aim is to evaluate the use of variations in PG as early indicators of nearby thunderstorm development (or dissipation). We evaluate the contigency table of a method that exploit these variations in PG under different thresholds using lightning observations from the Geostationary Lightning Mapper (GLM) onboard GOES-16, and the Thunder Hours database developed by DiGangi et al. (2022). Additionally we evaluate how these variations relate to the spatial and temporal patterns of lightning activity. By focusing on a site-scale analysis, this study contributes to understanding how surface electrical measurements can enhance storm monitoring capabilities in regions where conventional observation networks are limited.

P25

Role of Deep Convection in Isoprene Transport and Mixing in the Upper Troposphere over the Amazon

Axel Ventre[1,2], Thibaut Dauhut[1], Christelle Barthe[1], Rachel I. Albrecht[2], Isabella D. Valenti[2,1]

[1]Laboratoire d'Aérologie, Université de Toulouse, CNRS, UT3, IRD, Toulouse, France.
[2]Institute of Astronomy, Geophysics and Atmospheric Sciences, University of São Paulo, São Paulo, Brazil.

This study aims to understand the role of convection in the transport of isoprene from the Amazonian canopy, its mixing with LiNOx produced by electrical activity within clouds, and the subsequent oxidation processes leading to the formation of ultra-fine particles at high altitudes, using a case study from the CAFE-Brazil campaign (January 22–23, 2023) [1]. Simulations with the Meso-NH model [2] at 3.2 km, 1.6 km, and 800 m resolutions capture the evolution of convective systems, from strong nocturnal organization to less intense morning convection. An external air mass trajectory algorithm is used to illustrate isoprene transport pathways. Results emphasize how convective organization modulates vertical redistribution and mixing. Future work will include chemistry simulations (CLEPS) [3] to explore oxidation processes under varying convective regimes.

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