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T01

Investigating Life Cycle of Mesoscale Convective Systems using global high resolution simulations and artificial intelligence

In this study, we investigate to what extend the first hours of development of a mesoscale convective system determine its final life cycle. In other words, we question whether a few hours after its emergence MCS carry its expiration date. Using the global high-resolution SAM-Dyamond simulations (Stevens et al 2019), on which the MCS tracking algorithm TOOCAN (Fiolleau & Roca 2013) is applied, we attempt to predict the ranges of duration, maximum extension and time of maximum extension by knowing the evolution of the cloud shield of the systems during five hours. To this end, we train a classifier composed by a convolutional neural network, and a fully connected layer, to discrimine short to large systems. Our algorithm show a 90% (F1 score metric) accuracy on the test set for classification. Overall, these encouraging results suggest that the evolution of the shape of storms encodes the conditions for their persistence.

T02

A new conceptual picture of the trade-wind transition layer

The physical processes producing the transition layer in the trades -- a thin atmospheric layer thought to be important for regulating convection -- are not yet well understood. Using extensive observations from the recent EUREC4A field campaign, we find that the cloud-free convective boundary layer structure, with an abrupt discontinuity in thermodynamic variables, is infrequent, despite cloud-base cloud fraction being small. We show that very shallow clouds both forming and dissipating within the transition layer smooth vertical gradients compared to a jump, except in large (O(200 km)) cloud-free areas. This condensation-evaporation mechanism, which is fully coupled to the mixed layer, does not appear to affect the rate of entrainment mixing, but rather the properties of air incorporated into the mixed layer. In parallel to the observations, we use large-eddy simulations of a 'flower' cloud (Dauhut et al., 2022) to examine the interplay of the transition layer structure and physical processes such as mesoscale vertical velocity. Open questions we would like to explore include observationally testing theoretical expectations for the lapse rate conditions over the transition layer that are thought to be favorable to the development of mesoscale circulations and cloud organization.

T03

Intensification of tropical precipitation extremes from more organized convection

Tropical precipitation extremes and their changes with surface warming are investigated using global storm resolving simulations and high-resolution observations. The simulations demonstrate that the spatial organization of convection at mesoscale, a process that cannot be physically represented by conventional global climate models, is important for the variations of daily tropical precipitation extremes. In both the simulations and observations, daily precipitation extremes increase in a more organized state, in association with larger, but less frequent, storms. Repeating the simulations for a warmer climate results in a robust increase in monthly-mean daily precipitation extremes. Higher precipitation percentiles increase faster than Clausius-Clapeyron (CC) scaling due to a greater sensitivity to convective organization, which is predicted to increase with warming. Without changes in organization, extreme precipitation over the tropical oceans increases are a rate close to CC scaling. Thus, in a future state with increased organization, the strongest precipitation extremes can increase at a faster rate than CC scaling. Moreover, as precipitation distribution becomes more uneven with increased organization, the tropics may not only face heavier precipitation extremes, but also more frequent dry spells.

T04

Investigating the Spatial Clustering of Convective Thermals in Large-Eddy Simulations of Shallow-to-Deep Convective Transitions

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Due to the continuing increase in resolution of atmospheric circulation models, convective processes that used to be fully parameterized are gradually becoming partially resolved, a situation referred to as the convective "grey zone". This necessitates the development of parameterizations that are scale-aware and scale-adaptive, an area of intense current research. A recently pursued way of achieving this goal is to formulate population-dynamical models that adopt the convective thermal as the smallest unit or building block of convection. To help develop and improve such next-generation convective parameterizations, in the current study we analyze large-eddy simulations of diurnal cycles of shallow-to-deep convective transitions observed at the ARM Southern Great Planes site. Based on previous algorithms from the literature, we develop a tracking algorithm to gain insight into the behavior of populations of such thermals. We present an analysis of thermal characteristics, covering among others life-time, trajectory and geometric information, and kinematic and thermodynamic properties. Of particular interest is the spatial distribution of thermals, to gain insight into what drives their clustering and organization.

T05

A dimensionless parameter for predicting the onset of convective self-aggregation in a stochastic reaction-diffusion model of tropical radiative-convective equilibrium

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Deep convective clouds can be observed in a variety of organizational states, from spatially random distributions to more coherent structures spanning a wide range of spatial scales. One puzzling mode of organization found in idealized numerical studies is the so called convective self-aggregation, in which the clouds spontaneously transition from a random distribution in space to a regime where they are clustered. This phenomenon can have important implications for tropical climate and its sensitivity, but the problem is that the models do not agree on their representation of it.

To shed light on the discrepancies among models, we introduced a much simpler stochastic reaction-diffusion model of tropical convection, which, in spite of its minimal complexity, is still adequate to reproduce the behavior of full-physics systems and captures the transition to aggregation at parameter values that are a reasonable approximation of the present-day tropical atmosphere. The simplicity of the model allowed us to derive a dimensionless parameter, referred to as the aggregation number, whose value robustly indicates whether a given experimental configuration would undergo aggregation or not at all.

The aggregation number incorporates the model key parameters, namely, a tropospheric radiative overturning timescale, the efficiency of horizontal moisture transport and the strength of the convection-vapor feedback, as well as the domain size and the horizontal resolution, in an attempt to explain these latter sensitivities detected in modeling studies. We suggest that this quantity can help understand the differences between full-physics models of the atmosphere.

T06

On the role of mesoscale vertical motions in the organisation of shallow and deep convection

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Tropical convection exhibits a large diversity of spatial organisations at the mesoscale, both in shallow and deep convective regimes. The mesoscale organisation of convection matters for different aspects of climate, and therefore it is important to understand its underlying mechanisms. Modeling studies have pointed out the importance of mesoscale atmospheric circulations in triggering and maintaining the organisation of convective clouds. Using observations from field campaigns and from satellites, and numerical simulations from LES and CRM models, we will discuss some of the physical mechanisms through which mesoscale vertical motions in the lower and middle troposphere contribute to the organisation of shallow and deep convection. Then, we will present new opportunities to study observationally the interplay between mesoscale circulations and convective organisation, and to assess the universality of organisation mechanisms between shallow and deep convection. This includes new estimates of mesoscale vertical velocities inferred in clear-sky from geostationary satellites, and an airborne field campaign that will be conducted over the tropical Atlantic in Aug-Sept 2024.

T07

Clouds in Focus: Assessing Cumulus Cloud Characteristics using Camera Observations and Large-Eddy Simulations

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Accurately capturing the spatio-temporal characteristics of cumulus cloud fields is crucial for accurate weather predictions and reduced uncertainty in climate simulations. With the current advancements in computational power, high-resolution circulation models have gained significance, resolving processes at turbulent-convective scales. Hence, it becomes essential to also evaluate the accuracy of these models in doing so, at the same scales. To meet this requirement, we have developed an instrument simulator for hemispheric optical camera networks at meteorological sites. The method combines path tracing techniques with a stereo reconstruction algorithm. Our main objective is to find proof of principle for this approach, to support its future application for evaluating the spatial organization and other geometric and dynamical characteristics of cumulus cloud fields in LES against camera data. Our study focuses on selected summertime diurnal cycles of shallow convection at the Jülich Observatory for Cloud Evolution (JOYCE) between 2019 and 2022. Through the integration of observational data, LES simulations, and ray tracing, our research provides insights into the spatio-temporal transformations of cumulus clouds and encourages its application in: i) evaluating LES models, ii) enhancing our understanding of cumulus cloud geometry and dynamics, and iii) ultimately improving circulation models to achieve more accurate weather predictions and climate simulations.

T08

Self-Organization of tropical convection: Role of the Free Convection Distance

This study investigates the impact on convective organization of twenty-four combinations of different horizontal mixing, planetary boundary layer (PBL), and microphysical parameterizations in Radiative-convective equilibrium simulations. The simulations show both organized and random convective configurations. We argue that the development of organization depends on the variables that can control the number of convective cores, the Maximum free Convection Distance (d_{clr}), which are inversely related, and the Cold-Pool (CP) intensity. In general, organization is favored when the number of convective cores is small, the d_{clr} is large and the CP intensity is weak since these increase the probability of producing a dry enough zone, that grows on a divergent flow (exporting Moist Static Energy) generated by a high-pressure anomaly on subsidence and radiative cooling. The sub-grid scale mixing can increase the entrainment, reducing the number of cores, and increasing d_{clr}, favoring organization. The non-local PBL schemes favor organization since they dry the non-cloud environment, reducing the places where convection can be triggered and supporting the onset of a dry patch. They also have weaker CP in comparison to local schemes, which reduce gust-front convergence and convective triggering. In terms of microphysics, the experiments show that the evaporation of rain is key, weak evaporation of rain, decreases CP intensity, favoring organization, but it also reduces the number of convective cores and increases d_{clr}, by changing the amount of humidity on the environment and also by modifying the gust-front convergence.

T09

Capturing the diversity of mesoscale trade wind cumuli using complementary approaches from self-supervision.

At the mesoscale, trade wind clouds organize with a wide variety of spatial arrangements. Past studies used high-resolution satellite measurements and clustering/labeling techniques to classify trade wind clouds into distinct classes. However, these methods only capture a part of the variability and fail to describe transitions between organizational stages. This work proposes an integrated framework using two-step self-supervised deep learning approaches based on cloud optical depth (COD) from the GOES-16E satellite. The neural network learns cloud system structure and distribution, verified through visualizations of different layers focusing on semantics. Our analysis compares classes defined by human labels with machine-identified classes, aiming to address the uncertainties and limitations of both approaches. Additionally, we illustrate a case study of sugar-to-flower (S2F) transitions, a novel aspect not covered by existing methods.

T10

Mesoscale Convective Systems Modulated by Convectively Coupled Equatorial Waves

Mesoscale convective systems (MCSs) produce over 50% of tropical precipitation and account for the majority of extreme rainfall and flooding events. MCSs are considered the building blocks of larger-scale convectively coupled equatorial waves (CCEWs). While CCEWs can provide favorable environments for convection, how CCEWs can systematically impact organized convection and thereby MCS characteristics is less clear. We examine this question by analyzing a global MCS tracking data set. During the active phase of CCEWs, MCS frequency increases and MCSs rain harder, produce more lifetime total rain, and grow larger in size. The probability of extreme MCSs also elevates. These changes are most pronounced when MCSs are associated with Kelvin waves and tropical depression-type waves while less so with the Madden-Julian Oscillation. These results can be benchmarks to improve model representation of MCS interactions with large-scale circulations and can be leveraged for operational forecasts of high-impact MCSs at extended lead times.

T11

The Role of Surface Thermodynamic Gradients on the ITCZ Properties in Reanalyses and Idealised Simulations over an Aquapatch

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The tropical rain band is the most prominent feature of organised convection at global scales. The associated InterTropical Convergence Zone (ITCZ) is relatively thin over the ocean compared to land, where monsoons dominate. Previous studies have shown that the ITCZ position is partly controlled by the boundary layer moist static energy. What controls the ITCZ width is less clear, although wind stress and Ekman balance may be involved. Other aspects of the ITCZ shape are rarely described. This study attempts to further clarify the role of surface thermodynamic gradients in determining the ITCZ features. Additionally, it systematically compares the atmospheric processes over land vs. ocean.

Using reanalysis data, we show that over land and at global scales, thermodynamic variables control precipitation relatively well. In particular, the ITCZ precipitation over land follows moisture and MSE, and appears less directly constrained by temperature, hinting at a moisture and energy availability control. But this fails over the ocean, where thermodynamics is not a sufficient driver of precipitation. Our results also show that thermodynamic variables control the ITCZ peak position more than the ITCZ width and shape, especially over ocean.

We then run a series of idealised ITCZ simulations at 30-km grid spacing with the WRF model, in an aquapatch domain from 63S to 63N. The model is forced by a meridional contrast of surface temperature, with comprehensive physics, rotation, and symmetric boundary conditions at the North and South boundaries. Under this atmosphere-only setup, summer solstice equilibrium simulations capture the main general circulation features. Turning on or off the convective parameterization does not impact the latitudinal distribution of mean precipitation, but it impacts the eddies at smaller spatiotemporal scales, indicating a limited role of convection. By varying the forcing, we show that monsoon intensity follows a highly non-linear (logarithmic) relationship with surface temperature gradient, and that a finite temperature contrast is necessary to generate any cross-equatorial difference.

Simulations with a seasonal cycle forcing reveal four non-linearities in time, despite a smooth and idealised surface temperature forcing: (1) an abrupt and delayed monsoon onset, (2) a rapid monsoon retreat, (3) asymmetric monsoon precipitation before and after the monsoon peak, (4) an ITCZ sticking at the Equator for an extensive period. These analyses also suggest a description of the ITCZ with at least two intermittent precipitation peaks. We also compare seasonal cycle simulations over ocean and over an idealised land to tell apart the influence of land in the delayed ITCZ migration.

Overall, this study emphasizes the non-negligible hysteresis behaviour of the atmosphere when analying the tropical rain band. It also shows the need for a refined description of the ITCZ in which a one-peak shape and a two-peak shape alternate with the seasons.

T12

Super Clausius Clapeyron increase in MCS extreme rainfall related to increased MCS convective fraction with temperature over Europe

Floods related to heavy precipitation are common over Europe during both the warm and the cold seasons. Recently, we found that the contribution of Mesoscale Convective Systems (MCS) to extreme rainfall events is dominant over Europe and a few studies based on numerical simulations suggest that mid-latitude MCS may become more intense in a warming climate. Here, we investigate European MCS extreme precipitation through the temperature-precipitation extreme relationship in a German weather station network. The detection and tracking of MCSs is based on the recent Integrated Multi-satellitE Retrievals for Global Precipitation Measurement satellite precipitation climatology. We use the EUropean Cooperation for LIghtning Detection (EUCLID) lightning dataset to distinguish between stratiform (or shallow convective) and deep convective rain patches without introducing bias in precipitation intensity. We select the temperature upstream of the MCS tracks, to limit potential contamination from cold pools. We find two main regimes for MCS rainfall extremes (99th percentile; 10 minutes): below 14°C of dew-point temperature, MCS extreme rainfall increases with a Clausius-Clapeyron (CC) rate; above 14°C of dew-point temperature, the increase of MCS rainfall extremes is much more pronounced, exceeding 2-CC. Our analysis suggests that cold temperatures MCS are often embedded into large-scale synoptic frontal rain-bands while warm temperatures MCS are generally smaller and convectively more active. Therefore, this study suggests that MCS could shift from a large-scale to a convective dominated nature in a future warmer climate, and that the transition could be associated with a super-CC increase in MCS rainfall extremes.

T13

The sensitivity of cloud organisation to environmental mesoscale heterogeneities: the case of Flower trade-wind clouds

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Trade-wind clouds are a great source of uncertainty for the future climate as their net radiative effect is hardly represented in global models. The spatial organization of these clouds, that drives their radiative effect, has been categorized into 4 major patterns: Sugar, Flower, Gravel and Fish [1]. The processes governing their spatial organization and the relationships with the environmental properties remain however unclear. This study investigates the sensitivity of the Flower organization to the environmental mesoscale heterogeneities in water vapor and winds. A case of Flower organization, producing 100-km wide cloud clusters, is selected from the EUREC4A-ATOMIC campaign that took place east of Barbados in January-February 2020. A Large-Eddy Simulations using the Meso-NH model and a 100-m horizontal grid-spacing has been extensively validated by satellite and aircraft high-resolution observations [2] and serves as a reference. By removing alternatively the humidity or the wind heterogeneities, we show that mesoscale humidity anomalies play a critical role in driving cloud organisation. Further investigations indicate that humidity heterogeneities in the cloud layer influence the development of a shallow mesoscale circulation and have a larger impact than the heterogeneities in the sub-cloud layer. Different chains of processes are proposed to explain such a sensitivity.

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[2] Dauhut, T., Couvreux, F., Bouniol, D., Beucher, F., Volkmer, L., Pörtge, V., ... & Wirth, M. (2023). Flower trade-wind clouds are shallow mesoscale convective systems. *Quarterly Journal of the Royal Meteorological Society*, *149*(750), 325-347.

T14

Convective rolls and cells, momentum transport and wind turning in shear and buoyancy driven atmospheric boundary layers

The organisation of turbulence in atmospheric boundary layers gradually changes from rolls in purely shear-driven atmospheric boundary layers to a cellular structure if a surface buoyancy flux is added. Large-eddy simulations were performed for boundary layers that were forced by strong wind shear, where each case was imposed to a different surface buoyancy flux. It is confirmed that the surface buoyancy flux plays a key role in modifying the organisation of turbulent structures. However, it is also found that the turning of the mean wind vector with height is affected by the magnitude of the surface buoyancy flux. This is an important notion as the magnitude of the cross-isobaric wind velocity component strongly controls the synoptic-scale vertical velocity. A diagnosis of eddy-viscosities (Km), to be applied to the two horizontal wind components U and V, reveals a distinct asymmetry. By use of a conceptual model it is argued that these observed differences in Km are critical to faithfully capture the horizontal wind profile in weather and climate models.

T15

Organized patterns in *greenCu*; continental shallow convective clouds

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The emergence of organized patterns in cloud fields, such as closed or open-hexagonal cells and cloud streets, is ubiquitous, observed throughout different cloud types across a wide range of scales. These patterns play a key role in determining the cloud fields' radiative effects, thereby affecting the climate.
A subset of continental shallow convective Cumulus (Cu) cloud fields has been shown to share distinct properties and to form mostly over forests and vegetated areas, thus referred to as *greenCu* [1]. The greenCu are distinguished by their unique organization, forming regular patterns that often take the shape of cloud streets. Here, we explore the patterns formed by this newly defined class of clouds by utilizing polar-orbiting as well as geostationary satellites. We use data driven organization metrics, and apply an Empirical Orthogonal Function (EOF) analysis to quantify the organization of greenCu in space and time. We show that the greenCu clouds form highly organized mesoscale-sized patterns that sustain throughout the day for several hours, much longer than expected for these ~1 km sized features [2, 3].

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[2] Dror, T., Silverman, V., Altaratz, O., Chekroun, M. D., & Koren, I. (2022). Uncovering the Large-Scale Meteorology That Drives Continental, Shallow, Green Cumulus Through Supervised Classification. Geophysical research letters, 49(8), e2021GL096684.

[3] Dror, T., Chekroun, M. D., Altaratz, O., & Koren, I. (2021). Deciphering organization of GOES-16 green cumulus through the empirical orthogonal function (EOF) lens. Atmospheric chemistry and physics, 21(16), 12261-12272.

T16

Wind, Rain, and the Closed-to-Open MCC Transition

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Mesoscale Cellular Convection (MCC) is classified into three archetypal regimes in four marine subtropical stratocumulus regions: Open cell MCC, Closed cell MCC, and Disorganized, but cellular cloud scenes [1,2]. Classifications are made by a human-trained, automated, machine learning routine applied to daytime MODIS images. A Lagrangian analysis is developed in order to follow cloud scenes that begin as closed cell MCC, but evolve into either open cell MCC or disorganized scenes on 12-72 hour time scales.

Results focus on the closed-open MCC transition, which is preceded by strong wind speeds at lead times of at least 72 hours, and by heavy rain at lead times of 12-36 hours. A two-part mechanism is proposed where strong wind speeds lead to stronger moisture fluxes and greater moisture content in the boundary layer, and this increased moisture content is associated with subsequent increases in rainfall. Heavier rain may initiate the closed-open MCC transition through cold pool convergence, though verifying this mechanism is outside the scope of this study, motivating future research. The closed-open transition contrasts strongly with the closed-disorganized transition, which is instead associated with increased dry-air entrainment into the cloud deck [3].

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[2] McCoy, I.L, D.T. McCoy, R. Wood, P. Zuidema, and F.A.-M. Bender, Geophysical Research Letters, **50**, e2022GL101042 (2003)
[3] Eastman, R., I.L. McCoy, R. Wood, Journal of Geophysical Research: Atmospheres, **127**, e2022JD036795 (2022)

T17

Mesoscale convective systems differences causing precipitation extremes on separate scales

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Mesoscale convective systems (MCSs) are the elementary unit of atmospheric convection to account for when investigating precipitation extremes in the tropics. This work explores the connection between precipitation extremes on two separate scales (a gridded, Eulerian perspective), and MCSs dynamics (an object-based, Lagrangian perspective), in a hierarchy of models, from an idealized cloud resolving model to a global high-resolution model, using a state-of-the-art Lagrangian MCS-tracking algorithm. We first show that extreme rain rates diagnosed on kilometric (1km) and meso- (100km) scales correspond to distinct sets of points, and occur within mesoscale convective systems with distinct rainy areas and different morphological properties. These families appear as two distinct ensembles of MCS in the form of a "Y" pattern for the joint probability distribution of these events. Then, large-scale measures of humidity, convergence, wind shear and instability, as well as morphological and lifecyle characteristics of individual MCS events, are mapped onto these two classes of extremes to quantify their degree of correspondence with each class.

This work reveals that heavy rain results from separate mechanisms depending on the scale considered. We conclude by commenting on the uncertainties when projecting future extreme rainfall at the kilometer scale with coarse climate models – even with statistical downscaling – due to the scale gap between synoptic and convective processes inherent to the model geometry. We argue for the importance of further refining the connection between extremes and the diversity of storm structures that emerge from their collective dynamics, in order to bridge this scale separation.

T18

A parameterization for sub-grid scale evaporation-driven cold pools; Impacts on simulating squall lines over the Amazon Basin

When the negatively buoyant air in the cloud downdrafts reaches the surface, it spreads out horizontally, forming cold pools. A cold pool can trigger new convective cells. However, when combined with the ambient vertical wind shear, it can also connect and upscale them into large mesoscale convective systems (MCS). Given the broad spectrum of scales of the atmospheric phenomenon involving the interaction between cold pools and the MCS, a parameterization was designed. Then, it is coupled with a classical convection parameterization to be applied in an atmospheric model with an insufficient spatial resolution to explicitly resolve convection and the sub-cloud layer. A new scalar quantity related to the deficit of moist static energy detrained by the downdrafts is proposed. This quantity is subject to grid-scale advection, mixing, and a sink term representing dissipation processes. The model is then applied to simulate moist convection development over a large portion of tropical land in the Amazon Basin in a wet, dry, and dry-to-wet 10-days period. Our results show that the cold pool parameterization improves the organization, longevity, propagation, and severity of Amazon MCS, namely squall lines and bow echoes. At the same time, there is no degradation in the mean spatial and diurnal cycle of modeled precipitation, with most cases even offering improvements.

T19

Seeing doldrums from space

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We term doldrums as mesoscale regions of low wind-speeds (<3 m s^{-1}), usually seen dividing two simultaneous zonal bands of clouds. These features (also noted in early literature, e.g. [1, 2]) together often manifest as the inter-tropical convergence zone (ITCZ), particularly over the Atlantic. While the doldrums seemed to have departed from current discussions [3], recent cross-equatorial ship-borne observations in the Atlantic [4] have brought back attention to them and their role in shaping the distribution of convection. We use satellite measurements spanning 15 years to report statistics of doldrums over the Atlantic and the East Pacific. Along with their spatial extents, we document their zonal and meridional positioning as well as the seasonal and inter-annual variability therein. Co-located measurements of column moisture, surface rain rate and cloud liquid water provide us an idea of the environmental conditions that are associated with the presence of doldrums. Particularly, we see an anomalously dry atmospheric column over the doldrums compared to that over the adjacent convergence bands, which is similar to those observed from the ship-based observations. We also find long periods (ca. 1 month) of westward propagation of doldrums, but there can be large differences in their spatio-temporal persistence among different years. Our characterization enables frameworks attempting to explain the physical mechanism of doldrums as well as their role in the mesoscale organization of the ITCZ.

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T20

Diurnally driven scaling properties of tradewind cloud fields: an analytical and geometrical approach to mesoscale turbulence

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An improved modelling of weather and climate phenomena requires a better understanding of the complex atmospheric system. The EUREC4A campaign took place in the subtropics to examine the interplay between clouds and atmospheric circulations in the climate system. In this study, we use high-resolution large eddy simulations, satellite imagery and aircraft observations to quantify turbulence fluctuations and the scaling behavior of the manifested spatial structure. Measures of spatial heterogeneity such as Lacunarity and Fractal dimension are combined with spectral metrics of wind and moisture fields to understand the diurnal cycle of this coupling relationship. We find an intrinsic relationship between the two concepts of form and motion and a similarity in the long-term memory correlations. These insights allow us to model cloud organization evolution by incorporating statistical properties and scaling parameters in a simple probabilistic based growth model.

T21

Relationships between clouds, circulation, and radiation in long-channel radiative convective equilibrium simulations

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Idealised radiative equilibrium simulations have long been used for studying tropical convection. By using a long-channel configuration (i.e. a narrow yet long domain), these simulations can be run with sufficiently high resolution to resolve convective scales over domains that are sufficiently large (in one direction) to resolve the large-scale circulation. As such, these types of simulations are becoming increasingly widely used for studying the coupling between clouds and circulation, which remains a key driver of uncertainty for cloud feedbacks.

In this presentation, we describe long-channel radiative convective equilibrium simulations using the UK Met Office Unified Model. These simulations are run for a variety of fixed sea surface temperature (SST) patterns, including SSTs fixed to a single value and SSTs that vary spatially in an approximation of observed SST gradients.

We discuss the extent to which these simulations reproduce the observed large-scale circulation in the tropics and highlight low frequency oscillations that occur both in our simulations and in other models. In the context of these results we present further analysis of the coupling between clouds and circulation in the simulations and how this coupling affects climate sensitivity.

T22

Characteristics of Station-Derived Convective Cold Pools Over Tropical Africa

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Due to their potential role in organizing mesoscale convective systems, a better understanding of cold pool dynamics in tropical regions is critical, particularly over land where the diurnal cycle further boosts convective activity. Numerical models help to gradually disentangle the involved processes but lack observational benchmark studies so far. To close this gap, we analyze several years of surface time series from multiple weather stations across tropical Africa. We identify cold pools based on common criteria for temperature and wind, adapted to the employed data as well as the climatological framework. The identified cold pools exhibit a median temperature drop of $4.7\,K$. Both the magnitude of the related temperature drop and the number of cold pools detected depend on the time of the day and show a clear diurnal cycle with an afternoon peak. Aiming to unveil basic climatological properties of convective cold pools over a continental equatorial region, our results can provide a benchmark for numerical models, which may benefit high-resolution modeling studies in more accurately simulating convective organization through cold pool interaction.

T23

Sensible heat fluxes control cloud trail strength

Convective cloud bands known as “cloud trails” (CTs) are commonly found downwind of small islands (< ~100 km^2) throughout the world. They occur primarily in the afternoon, and are known to form in response to land–sea contrasts under the presence of background flow. A set of idealized numerical experiments with 100-m horizontal grid spacing is performed to quantify the relationship between the surface forcing produced by an island and the strength of the resulting CT circulation. These experiments are based on observed environmental conditions for which a CT occurred off Bermuda, a small subtropical island. For these simulations, the CT circulation is found to be controlled by the strength of the integrated excess heating of the flow as it passes over the island. This excess heating is in turn controlled by the strength of the island heat fluxes when the wind speed and the island geometry are kept constant. Our experiments show, all else equal, a linear relationship between CT circulation strength and the island surface heat flux. Additional experiments varying the background wind speed show that interesting interactions with cold pools can occur when clouds begin to produce rain.

T24

Complexity in Colombian precipitation extremes from a non-extensive approach.

We evaluate the complexity of Colombian precipitation via the extreme behavior in the framework of Tsallis' nonextensive entropy principle, which is based on physical information. In this framework, climate extremes are the result of weather conditions far from equilibrium emerging from spatiotemporal multi-scale interactions, long-term memory, a high degree of information content, and persistent positive feedback. The spatial structure of precipitation extremes was characterized by the non-additive q-index parameter, which contains the information of universality underlying the extreme behavior, which means, the affinity with other systems lying in the same kind of dynamic processes, which gives us a clue of useful models to explain the extremes. Our results evidence the high dynamical variability of regional climate expressed in the broad range of values of q-index and the high degree of non-extensivity in extremes of precipitation.

T25

The Unreasonable Efficiency of Total Rain Evaporation Removal in Triggering Convective Self-Aggregation

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The role played by rain evaporation in the onset of convective self-aggregation is investigated. Previous studies have found that removing rain evaporation in the boundary layer leads to self-aggregation even in the absence of radiative feedback ("moisture-memory aggregation") [1, 2]. The absence of cold pools, which are known to hinder aggregation, has been suggested as the leading cause, but the precise physical mechanisms underlying this type of aggregation remains unclear. Our study aims to fill this gap. We conducted cloud-resolving simulations (L = 128 and 256 km; Δx = 1 and 4 km) with homogenized radiation and progressively reduced rain evaporation by multiplying it with a factor α = [0.0, 0.2, 0.4, 0.6, 0.8]. Surprisingly, self-aggregation only occurred when rain evaporation is almost completely removed ($\alpha \approx 0$). Similar to radiatively-driven aggregation, a low-level (LL) circulation that leads to an upgradient MSE transport is found to be responsible for the aggregation, but in this case it is the additional convective heating of the wet patch resulting from the reduced evaporative cooling that is the driving mechanism that kick-starts aggregation, before the virtual effect takes over to maintain it. Hence, this type of aggregation is more accurately referred to as "convectively-driven aggregation". Contrary to radiatively-driven aggregation, where temperature and moisture anomalies (proxies for density anomalies that drive the LL circulation) in the BL act in concert to aid aggregation, in convectively-driven aggregation there is a competition of effects between T and q_v anomalies in maintaining the LL circulation. This competition explains the very low α threshold: only when rain evaporation is almost completely removed can the additional heating trigger aggregation. Lastly, we found radiative cooling and not cold pools to be the leading cause of the domain size dependence of convectively-driven aggregation. Runs with similar amounts of cold pools aggregate in the big but not small domain due to the stronger LL radiative cooling in the big domain.

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T26

Shallow circulations rooted in shallow convection across the trade-wind mesoscales

Several lines of evidence indicate that trade cumuli likely contribute weakly to the cloud feedback. Observations taken during the EUREC4A field campaign attribute this resilience to a strong, omnipresent coupling between cloudiness at cloud base, and shallow mesoscale overturning circulations (SMOCs). We investigate this mesoscale cloud-circulation coupling through idealised large-eddy simulations (LESs) with perturbed physics, large-domain LES with realistic forcings and EUREC4A observations. Our models and observations produce comparable SMOCs, under similarly weak mesoscale boundary-layer buoyancy gradients. In our models, the SMOCs are the outcome of balanced convective heating fluctuations at all scales between 10-400 km, hinting that the same may be true in nature. This leaves us to wonder what controls mesoscale shallow convective heating fluctuations: Cloud-controlling forcing anomalies, to which the convective heating simply adjusts, or self-reinforcing feedbacks? We discuss evidence that indicates both elements may play a role in setting the cloud-circulation coupling across the trade-wind mesoscales.

T27

Convective steady state (CSS) as a baseline for shallow cloud organization

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We show that common cases of shallow cloud fields exhibit a delicate balance between convective sources and sinks. We define such a balance as a convective steady-state (CSS) [1]. In such cases, the lifetime of convective cells, which are the field's dynamical building blocks, approaches the lifetime of the whole cloud field, i.e., much longer than the assumed by scaling lifetime of a single cell.

We refer to cases where rain can push the system away from CSS. Such perturbation yields oscillations around the CSS for which the recharging phase approaches CSS, but instabilities yield fast discharge that prevents the system from reaching there.

The emergence of CSS and its oscillating state simplifies the large-scale dynamical view of such cloud fields. It provides a clear and simple dynamical reference state that helps predict cloud properties and the patterns they form on the field scale.

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T28

High-resolution Coupled Mesoscale to Microscale Simulations of Mixed-Phase Convective Clouds Observed during the Cold-Air Outbreaks in the Marine Boundary Layer Experiment (COMBLE)

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Cold-air outbreaks, a consequence of equatorward excursion of cold polar air masses, result in development of mesoscale circulations and have significant effect on surface fluxes. Intense air mass transformations happen during CAO events when cold polar air is advected over a warmer ocean. Near the ice edge strong winds associated with CAOs combined with significant positive surface heat fluxes result in formation of helical mesoscale convective circulations and cloud streets. Further downwind helical convective structures transition into cellular convection in the form of open cell cloud structure.

We study the evolution of a CAO using high-resolution coupled mesoscale to microscale simulations with the Weather Research and Forecasting model. We focus on an intense CAO observed on 13 March 2020 during Cold-Air Outbreaks in the Marine Boundary Layer Experiment (COMBLE) [1]. COMBLE deployed Department of Energy Atmospheric Radiation Measurement (ARM) Mobile Facility 1 (AMF1) at Andenes, Norway to observe a range of CAO conditions. Our coupled mesoscale-microscale WRF setup features a mesoscale domain with horizontal grid cell size of 1050 m coupled online with a cloud-resolving domain with horizontal grid cell size of 150 m that stretches from the ice edge to Andenes (~1000 km fetch). Within the cloud-resolving domain are nested two high-resolution domains with 30 m grid cells. One of the high-resolution domains is focused on the region of cloud streets while the second one is downwind, focused on open cells. Such configuration allows us to simulate the CAO airmass transformation at high resolution, thus providing unprecedented insight into the mixed phase cloud (MPC) transition from rolls to cells. We study the interaction between large-scale forcing, surface fluxes, radiative transfer, and cloud processes in the formation and evolution of mesoscale organization and MPCs. As part of this effort, we utilize the Cloud Resolving Model Radar Simulator (CR-SIM) to compare WRF more directly to the measurements. Our CR-SIM analysis suggests that convective cell structures and properties are well modeled at the AMF1 site when using turbulence-resolving resolutions.

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T29

Analyzing the ability to identify convective organization by indices

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Convective organization is a phenomenon that has been first pointed out in idealized radiative-convective equilibrium simulations. Subsequently, a lot of effort has been done in order to determine the physical mechanisms leading to convective organization, and to explore the possible consequences on climate, both using simulation and observation. However, quantifying the strength of convective organization is challenging and there is still no general consensus on the method to use. In recent years, various convective organization indices, have been proposed but the results are still uncertain and different indices may lead to diverging results.

In this work, we study and compare the properties of seven organization indices [1, 2, 3, 4, 5, 6, 7], by computing them from cold IR brightness temperature images over the tropical ocean. We will present for the first time a statistical comparison of the quality of these multiple indices, showing the strengths and weaknesses of each organization index. Moreover, the outcome of this study led us to develop a new improved index. The results that will be presented come down to a guideline that will help to advance our description of deep convective organization.

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T30

3rd Workshop on Cloud Organisation and Precipitation Extremes - WCO3

Evolution of Cloud Production across Trade Wind Mesoscale Morphology Types

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Mesoscale morphological organization of boundary layer clouds modulates the cloud radiative effect. Trade wind cumulus clouds, a source of uncertainty in climate projections, exhibit mesoscale organization that has been categorized into four morphology types with distinct appearance, size, and radiative properties: Sugar, Gravel, Flowers, and the synoptically driven Fish. The wintertime 2020 EUREC4A-ATOMIC joint campaign utilized multiple platforms to develop a synergistic observational dataset sampling these clouds and their environment. Motion-stabilized Doppler-lidar measurements from the RV Ronald H. Brown and the downwind Barbados Cloud Observatory indicate that relationships between cloud amount, cloud base velocity, and cloud base mass flux vary by morphology. We investigate whether there is a relationship between cloud morphology and the efficiency of cloud production, defined as a relationship between overall cloud properties and cloud base properties and dynamics. We utilize Lagrangian frameworks to further investigate cloud production efficiency. Large-eddy simulations[1] provide insight into cloud production evolution during Sugar to Flower transitions. Boundary-layer trajectories are used to link the EUREC4A-ATOMIC multi-platform dataset with satellite retrievals and reanalysis, providing additional information about the influence of environmental factors on cloud production.

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T31

The diurnal cycle of the trade winds in the presence of (un)organized shallow convection

EUREC4A observations suggest that there is a marked difference in (shallow) convective momentum transport between days with predominantly unorganized shallow convection and days with deeper organized shallow convection. The latter days tend to have weaker friction in the prevailing wind direction, but more cross-wind eddy momentum flux divergence, which leads to a larger veering of the wind. Our hypothesis is that mesoscale flows accompanying deeper shallow convection are responsible for different wind tendencies, and possibly help set the diurnality in wind. In this analysis we will use the newly developed open-boundary large-eddy simulation (DALES) that is double nested into HARMONIE (a regional weather model) to study the diurnal wind tendencies produced by small-scale turbulence, coherent convection and mesoscale flows. Compared to the cyclic boundary DALES that was used in a preceding study on momentum transport in organized shallow convection, the open boundary nested DALES version can help to better separate the dynamical tendencies that stem from large scales and from resolved physics, including the mesoscale circulations that accompany organized convection. We will present the momentum budget separated into contributions from flows with different scales as a composite diurnal cycle to address our hypothesis. Furthermore, we will use a sampling from highest to lowest column water vapor to create a composite picture of the along-wind and cross-wind circulations of the most juicy convective cells. Results will be cast in light of the observed wind tendencies for a few overlapping days of EUREC4A observations and simulations.

T32

TAMS: A Tracking, Classifying, and Precipitation-Assigning Algorithm for Mesoscale Convective Systems in Simulated and Satellite-Derived Datasets

The Tracking Algorithm for Mesoscale Convective Systems (TAMS) is a tracking, classifying, and precipitation-assigning algorithm for mesoscale convective systems (MCSs). TAMS was initially developed to analyze MCSs over Africa using satellite-derived datasets. First, I'll introduce TAMS with an overarching description of the algorithm followed by discussion on how TAMS has been applied for African easterly waves and tropical cyclone research. Since its beginnings, TAMS has now evolved as a model and observations tool that is user-friendly, open-source, and publicly available as a Python package. Description of TAMS's latest version will be provided including optional settings and helper functions for the user. I'll go over the latest research applications of TAMS as a forecasting tool in recent field campaigns NASA PRECIP and CPEX-CV and as part of a multi-MCS-tracking intercomparison study. Finally, I will be sharing some of the current development goals for TAMS.

T33

Observational study of the coupling between deep convection, clear sky regions and mesoscale circulations in the ITCZ

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Modeling studies pointed out the importance of clear-sky regions in the triggering of convective self-aggregation [1]. Here, we use satellite observations in order to investigate the coupling between those clear-sky regions and surrounding convection within the Intertropical Convergence Zone (ITCZ).

An object-based analysis of the edge of clear-sky regions within the ITCZ is performed by combining observations of brightness temperatures (GOES, Meteosat), moisture, temperature (IASI), surface winds (ASCAT), and cloud fraction (Cloudsat/Calipso). Also, new observations of mid-tropospheric vertical velocity are used that are based on brightness temperature variations in the water vapor channel of geostationary satellites.

It is found that clear sky areas with a drier free troposphere are surrounded by more widespread convection, with colder cloud tops. To better understand this correlation, we analyze circulations in the clear sky.

On the one hand, around deep convection, strong compensating subsidence is observed in the middle troposphere, and appears to be caused by gravity waves as suggested by [2].

On the other hand, drier clear-sky areas are associated with a shallow circulation that may be radiatively driven. Indeed, clear-sky regions with a drier free troposphere have a colder and moister boundary layer. These observations are consistent with in situ measurements from recent field campaigns [3], whereas they differ from numerical simulations, where dry patches tend to be drier also in the boundary layer [4].

Therefore, in line with [5], these observations let us hypothesize that strong top-heavy circulations are caused by gravity waves, whereas radiative mechanisms could be responsible for controlling the bottom-heaviness of the circulations. New observations, including vertical velocity observations from geostationary satellites, retrievals of radiative cooling rates from IASI, as well as the oncoming EC-TOOC and MAESTRO field campaigns, will provide a unique opportunity to test these hypotheses.

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T34

Forecasting precipitation in Tropical West Africa

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While numerical weather forecasting has made incredible progress over the last decades, in tropical west Africa (TWA), a similar improvement is left missing. Operational Weather forecasts having little to no skill in TWA.[1] While resolving deep convection is only possible in high resolution models, rainfall is substantially modulated by planetary waves, requiring global scale models in order to be resolved. This project builds on research of the trans regional Collaborative Research Center "Waves to Weather, that showed (a) current dynamical models have little skill;[1] (b) statistical post processing (PP) can cure considerable calibration issues but that does not necessarily lead to predictions better than a climatological reference; [2] and (c) statistical methods building on the relation of rainfall with more predictable coherent wave modes can compete with dynamical models that struggle to represent the involved physical processes. [3]
In our research we systematically assess a large and diverse set of weather forecasting methods in tropical Africa, both in terms of quality and required resources. We are comparing (a) an extended probabilistic climatology; [4](b) ensemble predictions, generated by post processing single deterministic models with the "EasyUQ" method; (c) statistical and statistical-dynamical models, based on Observations (extended with ensemble/ analysis data); and (d) raw and post processed ensembles.
In this comparison we aim to understand the interplay of precipitation and atmospheric waves, take a deep dive at the treatment of convection and whether convection-permitting models substantially improve the precipitation forecast.

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T35

Impact of the mesoscale organization of deep convection on the tropospheric humidity and vapor isotopic composition: satellite observations, cloud-resolving models and general circulation models

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In the tropics, mesoscale organization of deep convection has been shown to impact both tropospheric humidity [1] and the vapor isotopic composition [2,3]. To what extent is this impact missing in general circulation models (GCMs)? This depends on whether the mesoscale organization directly impacts its environment through convective processes, or whether the relationship with the environment is mediated by covariations with the large-scale circulation.

To address this issue, we investigate relationships between mesoscale convective organization, mean rain rate, tropospheric humidity, vapor isotopic composition and large-scale circulation using a blend of satellite observations, reanalyses and organization properties diagnosed from the TOOCAN convective tracking algorithm [4]. We compare these relationships with those simulated by cloud-resolving models (CRMs) and coarse-resolution (>200km) GCMs. In radiative-convective equilibrium (RCE), CRMs can simulate different forms of mesoscale organization (e.g. pop-corn, squall lines, tropical cyclones) with identical large-scale circulation. In contrast, nudged by winds from reanalyses, GCMs capture variations in the large-scale circulation while being blind to the mesoscale organization.

While for a given mean rain rate, tropospheric relative humidity mainly depends on convective aggregation [1], we find that the vapor isotopic composition rather depends on the duration of convective systems, their propagation velocities and their internal mesoscale dynamics. For humidity, CRMs in RCE capture the drier troposphere associated with more aggregated convection [5]. However, GCMs nudged by winds and blind to mesoscale organization also capture about half of the aggregation-humidity relationship. We find that the shape of the vertical profile of vertical velocity and the convective activity during the previous days play a key role in the aggregation-humidity relationship. For the vapor isotopic composition, CRMs in RCE with identical large-scale circulation are not able to capture the more depleted vapor around squall lines and tropical cyclones relative to pop-corn convection. In contrast, GCMs nudged by winds and blind to mesoscale organization capture most aspects of the isotope-organization relationships, except for the depletion around squall lines.

These results suggests that much of the relationships between mesoscale organization and environment properties are mediated by the large-scale circulation, although this does not preclude an impact of mesoscale organization on the large-scale circulation. Implications for GCM parameterization development are discussed.

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T36

Characterizing Trade-wind Cold Pool ‘Cloud Holes’ from the Barbados Cloud Observatory

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Rain-induced cold pools are key modulators of convective organization and cloud cover in the trades. They are usually associated with mesoscale cloud arcs encircling large clear-sky areas, here called ‘cloud holes’. However, most detection methods find cold pool periods to be much cloudier than the average winter trades, suggesting that the picture of arcs surrounding clear-sky areas might be less common than expected. Nonetheless, cloud suppression might be hypothesized to mainly occur at late stages of cold pool development. Effects such as the daily cycle of surface temperature pose challenges to the accurate characerization of the cold pool end using surface-based detection methods, potentially leading to a detection bias towards younger, cloudier cold pools. As a consequence, cold pool cloud holes remain largely unexplored.

We raise the question: can we characterize cold pool cloud holes from the ground? A prerequisite for answering this question is to obtain a better definition of the end of a cold pool. To do so, we modify the surface temperature based cold pool detection method of [1] and combine it with a mixed layer height threshold following [2]. We derive mixed layer heights from backscatter and virtual potential temperature profiles measured by the Raman lidars at the Barbados Cloud Observatory (BCO) over the past 12 years. We distinguish cloud holes from cloudy periods by combining observations from the cloud radar at the BCO and satellite images over Barbados. In this presentation we discuss the occurrence frequency of cloud holes, describe their vertical structure of moisture and stability, and hypothesize on whether the cloud holes arise due to the cold pools themselves or the pre-existing environmental conditions.

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T37

Competing Effect of Radiative and Moisture Feedback in Convective Aggregation States in Two CRMs

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The radiative-convective equilibrium (RCE) of two models exhibiting convective aggregation has been compared. The goal of the work, following the suggestion from the RCE Model Intercomparison Project (RCEMIP), is to identify key parameters controlling self-aggregation in RCE for both models, to discuss the processes controlled by these parameters and to underline the models similarities and differences. The two cloud resolving models studied, the SAM (System for Atmospheric Modeling) and the ARPS (Advanced Regional Prediction System), present similar statistics concerning precipitation, but different warming, and drying of the atmosphere, within the spread of the RCEMIP values. On the other hand, the two models show different strengths of the moisture feedback, due to the different saturation of the sub-cloud layer. A saturated sub-cloud layer in ARPS (which was not artificially imposed in the numerical setup) allows the localization of convection in moist regions, by weakening the negative influence of cold pools. Such a mechanism leads to a lower degree of aggregation (based on three organization metrics) and a weaker effect of the organized state on the average domain statistics in ARPS. Stronger cold pools in SAM, instead, help the creation of shallow clouds in dry regions, increasing the longwave feedback responsible for their expansion; while delocalizing convection in moist regions and therefore opposing high-cloud radiative-feedback. Further experiments are needed to generalize such findings to other RCEMIP models, also investigating the role of microphysics and turbulence schemes in regulating such mechanisms.

T38

The role of momentum mixing in shallow cloud organisation

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Momentum transport by shallow convection (SC) is a relatively unexplored process, which plays an important role in regulating mesoscale circulations in organized cloud fields. Simulations of a marine cold air outbreak with the mesoscale weather model HARMONIE suggest that parameterized shallow convective momentum transport (SCMT) diminishes circulations, leading to an underestimation of cellular cloud structures and precipitation. In this study we test this hypothesis in the trade-wind region by focusing on the effect of (convective) momentum mixing on precipitation and cloud distributions. An area in the western Atlantic encompassing the EUREC4A campaign is simulated with HARMONIE for the period from January 1st to February 28th 2020. The study uses a control run, an experiment without momentum mixing by SC, and an experiment without the entire SC parameterization. Our results show strong differences among the runs for most organization metrics, including a reduction of the cloud size and an increase of the cloud number when SC parameterization is turned off. The mean cloud cover is similar among the runs, but using a SC parameterization broadens its distribution and enhances its diurnality, increasing the nighttime cloud cover and diminishing it during daytime. Removing momentum mixing decreases cloud cover during the night, but has little effect during daytime, resulting in a net reduction of rain rate. In contrast, without SC parameterization altogether, thus without shallow mass transport of heat and moisture, rain production is strongly increased. By analyzing mass and momentum transport, we will elucidate the processes underlying these cloud and precipitation changes.

T39

Mesoscale organization of shallow convection under different aerosol concentrations

A major uncertainty in the cloud-feedback to a warming climate can be attributed to shallow convection in the trades. With recent advances in observational and computational resources, the potential impact of the mesoscale organization of these clouds became apparent. While the processes leading to the mesoscale organization are not resolved in current climate models, observations of these features and more importantly their interaction with different scales became available through field campaigns like EUREC4A. Here we present large-domain large-eddy simulations based on these observations to quantify how well mesoscale processes are captured at hm-scale resolutions. We further quantify the sensitivity of the mesoscale organzation to changes in the aerosol concentration and in particular to the intensity of precipitation.

T40

Numerical diffusion and turbulent mixing in convective self-aggregation

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Spontaneous aggregation of deep convection is a common feature of idealized numerical simulations of the tropical atmosphere in Radiative-Convective Equilibrium (RCE). However, at coarse grid resolution where deep convection is not fully resolved, the occurrence of this phenomenon is extremely sensitive to subgrid-scale processes. This study focuses on the role played by mixing and entrainment, either provided by the turbulence model or the implicit numerical dissipation. We have analyzed the results of two different models, WRF and SAM, and we have compared different configurations by varying the turbulence models, the numerical schemes and the horizontal spatial resolution. At coarse grid resolution (3 km), removing turbulent mixing prevents the occurrence of Convective Self-Aggregation (CSA) in low numerical diffusion models, while delaying it in high numerical diffusion models. When the horizontal grid resolution is refined to 1 km (thus reducing the implicit numerical dissipation), CSA is achieved only by increasing the explicit turbulent mixing. In this case, CSA was found to occur even with a small amount of shallow clouds. Therefore, this study suggests that the sensitivity of CSA to horizontal grid resolution is not primarily due to the corresponding decrease in shallow clouds. Instead, it is found that turbulent mixing and dissipation at small scales regulate the amplitude of humidity perturbations introduced by convection in the free troposphere: the greater the dissipation at small scales, the greater the size and the strength of humidity perturbations in the free troposphere that can destabilize the RCE state.

T41

Unravelling the convective controls on organisation one process at a time.

Convective organisation can be viewed as an emergent response to a set of controlling processes. Some of these are external to the convective lifecycle (for example, sea breezes), and others are internal, self-generated feedbacks (for example, cold pools). While the external controls can more readily be identified, it can be difficult to identify the relative contributions to organisation from within the convective lifecycle itself. However, one route to doing this is to build a model of convection and varying the strength of the different components of the convective system. As part of the ParaCon programme, we have built just such a model called CoMorph, which is a new convection parametrisation to be used in Met Office systems. In this talk, I shall give an overview of how different physical processes within CoMorph influence the emergent organisation, and from this how we can use knowledge of convective organisation in different environments to infer what the balance of different convective processes should be.

T42

Extreme Precipitation Events over the Mexican coast of the tropical Eastern Pacific: Synoptic precursors and WRF modeling

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This research explores the synoptic-scale precursors of Extreme Precipitation Events (EPE) over the tropical northeastern Pacific (EPAC), focusing on the coastal regions of the southeastern Mexican state of Oaxaca. The location was selected given the social vulnerability of people inhabiting the region and its closeness to the second-most cyclogenetic region in the world, as it is the EPAC.

EPE were determined using observational data from the Mexican National Weather Service. Selected events had precipitation values above the 99th percentile from the gamma distribution fit during the rainy season of June to September from 1963-1996. Results show that most of these EPE are more frequent in the region of the Isthmus of Tehuantepec where elevations do not exceed 400 m in height, with threshold values ranging from 80 mm day^{-1}, up to more than 110 mm day^{-1}. Most of these EPE occurred during the presence of the convective phase of the Madden-Julian Oscillation (MJO) over the EPAC.

Composite analysis showed that the while the presence of the MJO within the region is a necessary precursor for these events, the MJO is not sufficient to produce these events; the presence of tropical waves, such as Easterly Waves (EWs) and Kelvin waves is also necessary.

Finally, WRF modeling of some case studies is presented to evaluate the impacts of microphysics, which will benefit regional offices in the forecast of these events.

T43

Atmosphere-Ocean Coupled Energy Budgets of Shallow and Deep Tropical Convective Discharge-Recharge Cycles

An energy budget combining atmospheric moist static energy (MSE) and upper ocean heat content (OHC) is used to examine the processes impacting day-to-day convective variability in the tropical Indian and western Pacific oceans. Feedbacks arising from atmospheric and oceanic transport processes, surface fluxes, and radiation drive the cyclical amplification and decay of convection around suppressed and enhanced convective equilibrium states, referred to as shallow and deep convective discharge-recharge (D-R) cycles respectively. The shallow convective D-R cycle is characterized by alternating enhancements of shallow cumulus and stratocumulus, often in the presence of extensive cirrus clouds. The deep convective D-R cycle is characterized by sequential increases in shallow cumulus, congestus, narrow deep precipitation, wide deep precipitation, a mix of detached anvil and alto-stratus and alto-cumulus, and once again shallow cumulus cloud types. Transitions from the shallow to deep D-R cycle are favored by a positive ``column process'' feedback, while discharge of convective instability and OHC by mesoscale convective systems (MCSs) contributes to transitions from the deep to shallow D-R cycle. Variability in the processes impacting MSE is comparable in magnitude to, but considerably more balanced than, variability in the processes impacting OHC. Variations in the quantity of atmosphere-ocean coupled static energy (MSE + OHC) result primarily from atmospheric and oceanic transport processes, but are mainly realized as changes in OHC. MCSs are unique in their ability to rapidly discharge both lower tropospheric convective instability and OHC.