# Combinatorial Optimization of Cumulus Convection Scheme Parameters in RegCM5 Using a Micro-Genetic Algorithm for Extreme Precipitation Event Simulations in Southeast Asia

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Abstract

This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

## Introduction

➢ **Recent release of RegCM5**

- The fifth version of the regional climate model (RegCM5) has recently been released, incorporating updates in several model components such as the **dynamic core** and **physical parameterizations**.

➢ **The Need for Streamlining Optimization Processes**

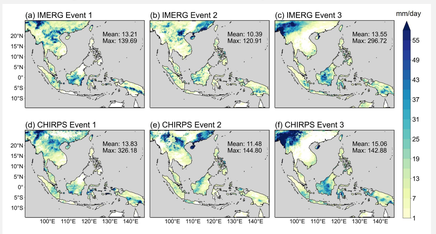
- Traditionally, climate modelers conduct sensitivity tests using either manually selected physic scheme combinations or a limited sampling of parameter values within specific schemes → **computationally expensive and time intensive**
- To overcome these limitations, advanced optimization techniques like micro-genetic algorithm (μGA) have emerged to efficiently **explore the complete range of possible combinations**, without relying solely on random-based sensitivity tests.

➢ **Objectives**

- This study aims to conduct the first coupling of the latest version of RegCM5 and the μGA algorithm (RegCM5-μGA) to enhance the **effectiveness and efficiency** of regional climate model optimization, benefitting the RegCM user community.

## Data & Method

➢ **Selecting the extreme events for optimization**




❖ **Observation Products**

- Integrated Multi-satellitE Retrievals for GPM (IMERG)
- Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)

❖ **Selection Criteria:**

- precipitation anomalies exceeding the 99th percentile in both observation datasets
- duration of at least two days.

- These three cases exhibit different maximum intensities across the domain, providing a reasonable basis for **optimizing parameters in a generalizable manner**.

➢ **Key RegCM5 configurations**

**Initial and Boundary Conditions: ECMWF Reanalysis v5 (ERA5) data (0.25° × 0.25°, 6-hourly)**

**Parameterization schemes optimized by Modeling Center ICTP***

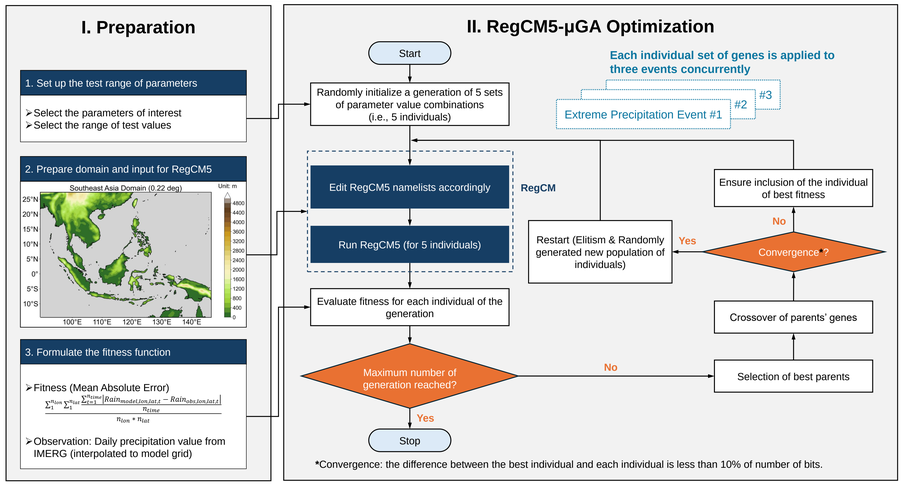
- MOLOCH dynamic core
- Cumulus convection: Tiedtke
- Microphysics: Nogherotto/Tompkins
- PBL: Holtslag
- Land surface: CLM4.5
- Radiation: CCM3
- Ocean flux: Zeng

**Selected key Tiedtke parameters for fine-tuning**

| Parameter | Description | Default | Test Range (# of samples) |
|---|---|---|---|
| entrdd | Entrainment rate for cumulus downdrafts | 0.0003 | 0.0002~0.0004 (16) |
| entrpen_lnd | Entrainment rate for penetrative convection (land) | 0.00175 | 0.00005~0.00225 (32) |
| entrpen_ocn | Entrainment rate for penetrative convection (ocean) | 0.00175 | 0.00005~0.00225 (32) |
| detrpen_lnd | Detrainment rate for penetrative convection (land) | 0.000075 | 0.00005~0.0002 (16) |
| detrpen_ocn | Detrainment rate for penetrative convection (ocean) | 0.000075 | 0.00005~0.0002 (16) |

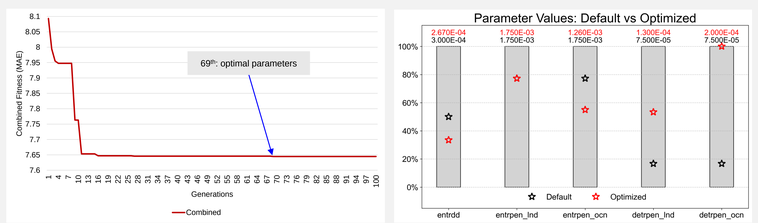
*Coppola, E., Giorgi, F., Giuliani, G., Pichelli, E., Ciarlo`, J. M., Raffaele, F., et al. (2024, January 16). The Fifth Generation Regional Climate Modeling System, RegCM5: the first CP European wide simulation and validation over the CORDEX-CORE domains. Preprints. https://doi.org/10.22541/essoar.170542078.80092084/v1

## RegCM5-μGA Framework

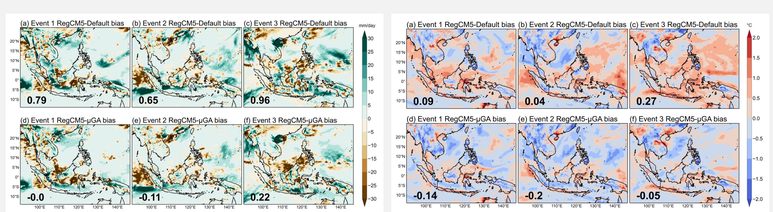



## Optimization over Three Extreme Precipitation Events

➢ **Efficiency of the RegCM5-μGA Framework based on the three selected extreme precipitation events**



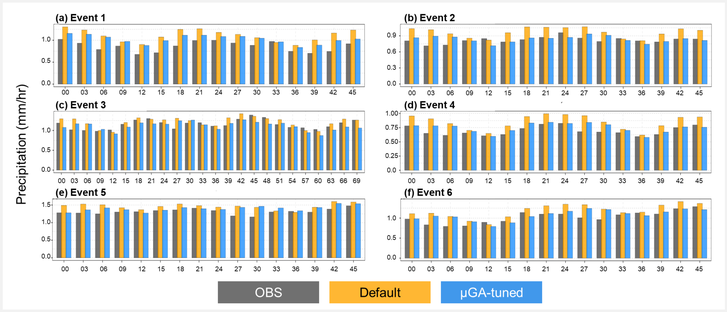

➢ **Effectiveness of the RegCM5-μGA Framework based on the three selected extreme precipitation events**




- The developed framework greatly streamlined the optimization processes, exploring **40+ million combinations in 36 hours**.
- RegCM5-μGA successfully **mitigates the wet and warm biases** in RegCM5-Default simulations, especially over the oceans.

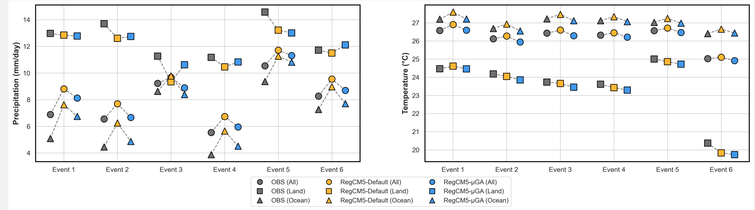
## Validation over Additional Extreme Precipitation Events

➢ **Temporal evolution of 3-hourly precipitation patterns simulated by default and optimized Tiedtke parameters**



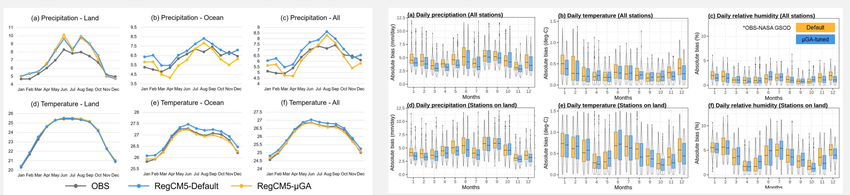

- The temporal evolution reveals a prevalent **enhanced coherence** between RegCM5-μGA simulated and observed patterns, with notable improvements in **representation of both precipitation's timing and magnitude**.

➢ **Area mean of temporally averaged precipitation and temperature over different domains**




- Although the optimized simulation effectively **reduces the warm and wet biases** in RegCM5-Default over the ocean and the whole domain, it tends to **exacerbate the dry and cold bias on land**, stressing fitness function definition's importance.

➢ **Monthly climatology simulated during longer periods (2007-2010) over different domains**




- The optimized parameters are also applied to **longer-term simulations** for validation, which demonstrate consistent improvement in **reducing the wet and hot biases** across different months.

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