

# NUMERICAL WEATHER SIMULATIONS OF HAILSTORMS FOR HAZARD MAPPING AND RISK MITIGATION

MARENOSTRUM5 GPP

*Led by*



**I. GUERRERO**

Mitiga Solutions

# 1 WHY FOCUS ON EVENTS LIKE HAILSTORMS?



**Hailstorms** are very localized, extreme events: one town can be hit by one while a neighbouring town barely sees a cloud

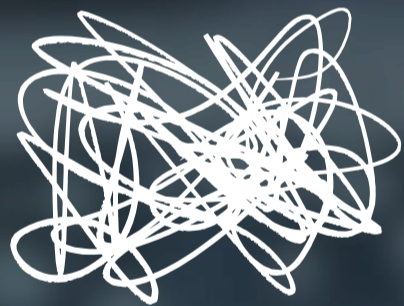
They can be highly destructive and have **severe socio-economic impacts**



However, they are **very difficult to predict and simulate** because they depend on **very specific conditions** that weather models can't reproduce

# WHY ARE HAILSTORMS SO HARD TO SIMULATE 2

Widely used weather models like WRF have **millions of possible configurations**



Choosing the wrong parameters **changes the outcome completely**

This project addresses these limitations by using a different approach: **a genetic algorithm** that evolves different WRF configurations



# 3 WEATHER FORECASTING GENETIC ALGORITHMS

Genetic algorithms are inspired by **natural evolution** to automatically **find the best-performing configuration** to predict hailstorms



The algorithm starts with a set of **default settings** and it selects the ones that perform best to **evolve into the next generation**

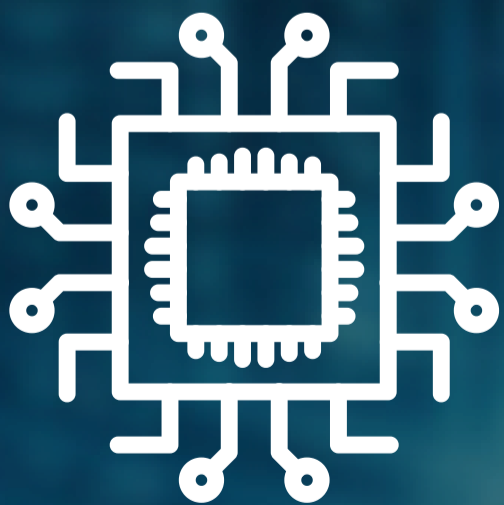
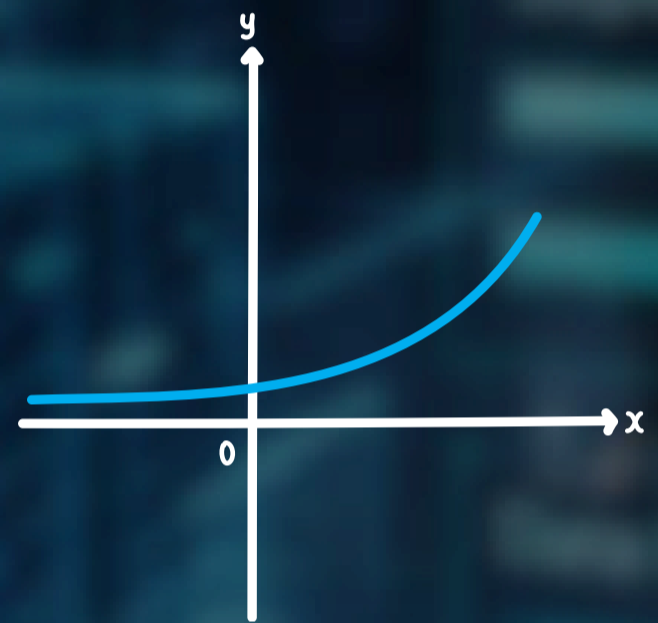
Generation after generation, the model refines the best set of configurations **that can predict hail**



# THE ROLE OF HPC RESOURCES

# 4

There is a **large number of physical parameters** in these models, with more than **2.4 million configurations**

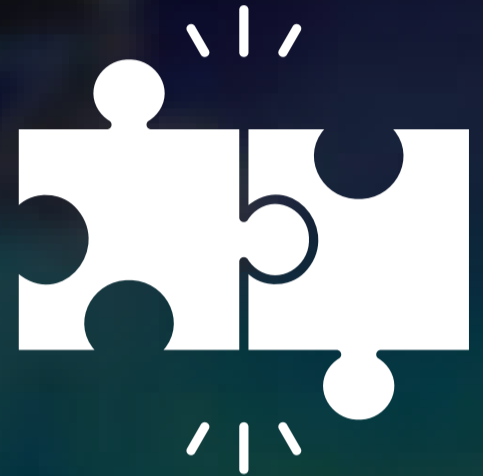


HPC resources have been essential to explore such a large number of configurations **in a reasonable timeframe**

# 5

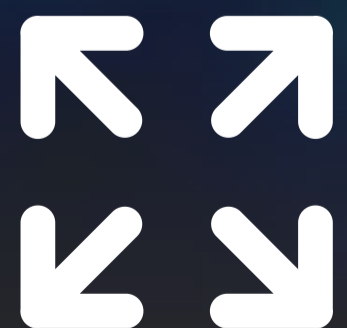
## A FRAMEWORK FOR THE FUTURE

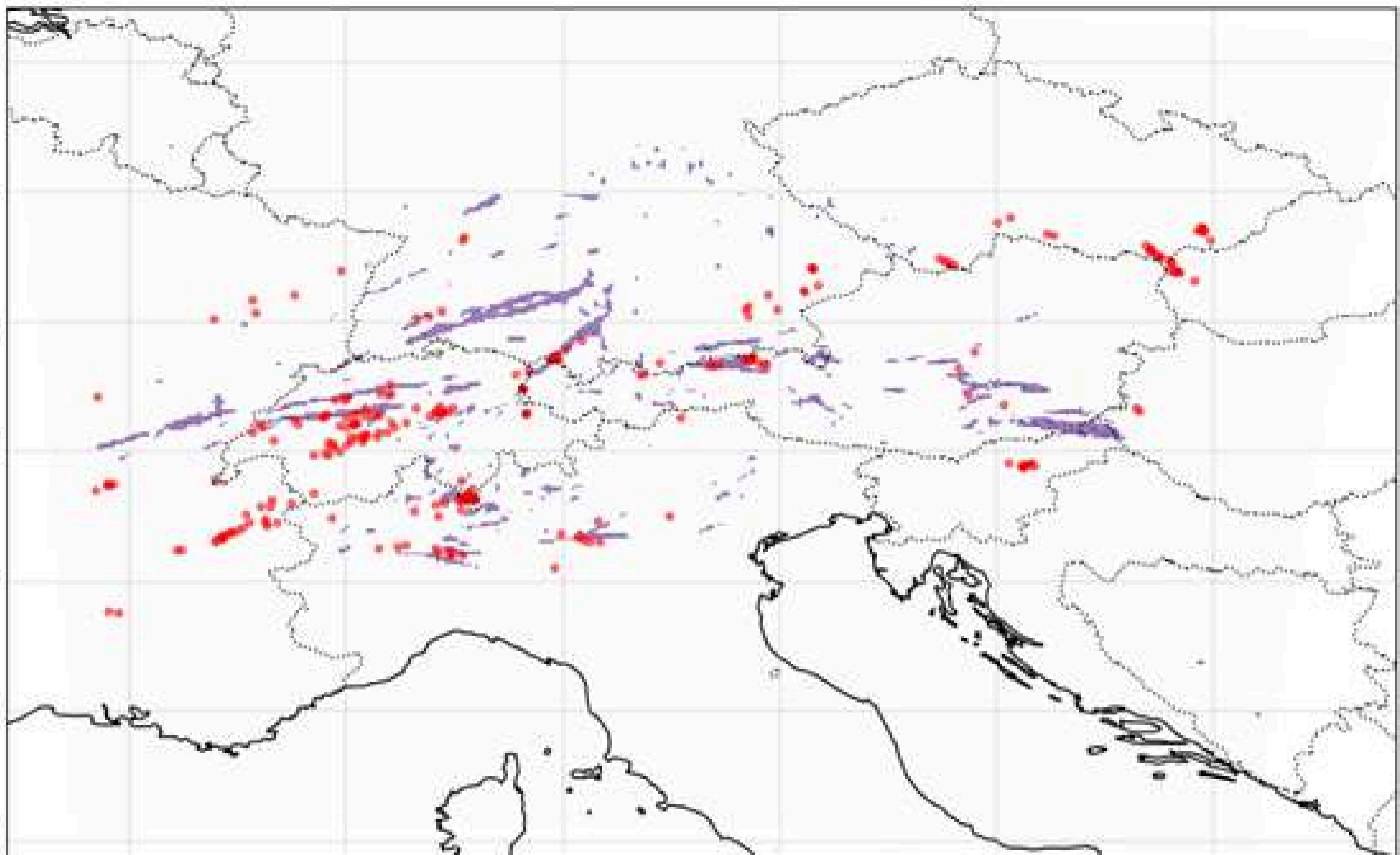
The genetic algorithm predicted hailstorms that **aligned closely with observations**



There were small **differences** due to model uncertainty and observational limitations, but the results show that **the approach works and is valid**

This algorithm improves hailstorm simulations, and **can be extended to other extreme events**





Comparison between observed hail events (red dots) and simulated hail occurrences (purple) using the best-performing WRF configuration. The map focuses on the inner domain (3 km resolution), highlighting the alignment of storm clusters and the model's ability to reproduce hail events.

