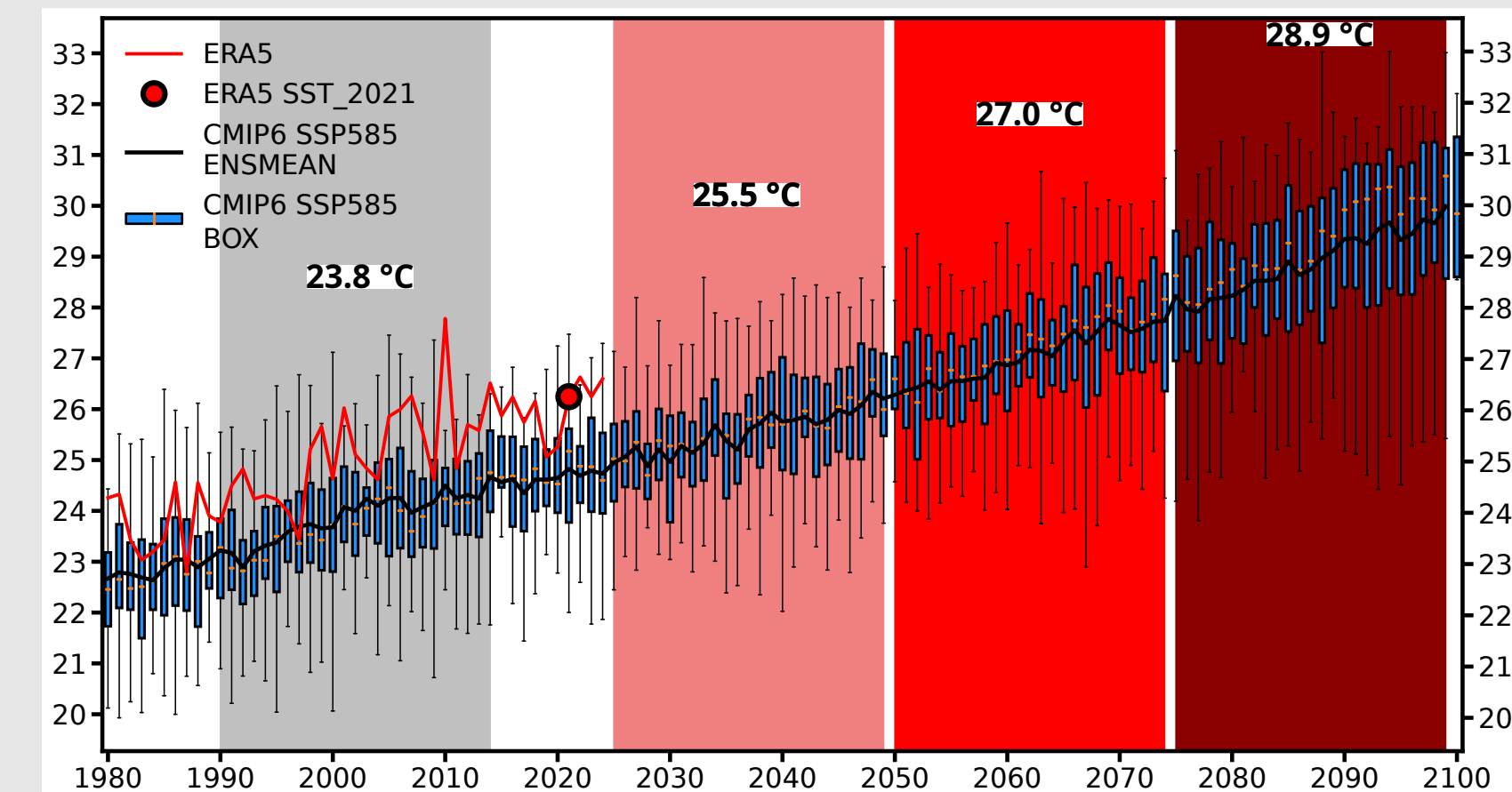


# Convective Permitting Simulations for Excessive Precipitation Event Under Pseudo-Global Warming in the Black Sea Region

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## Introduction

Yearly Variation and Projection of the Black Sea SST (°C) in August



The Black Sea is **climate change hotspot area**, highly vulnerable to extreme events. Sea Surface Temperature (SST) over the Black Sea increases **0.67°C/decade** in August, which raises the likelihood of extreme weather events over the region.

What did we investigate in this study?

Excessive precipitation in Northern Türkiye (2021 August), 400mm+ measured in two days

How could this event happen under future global warming conditions?

Applying future climate conditions using **Pseudo-Global Warming (PGW)** method and performing numerical simulations in Weather Research and Forecasting Model (WRF)

## PGW Method

$$\Delta = \text{CMIP6Future}(\text{time}) - \text{CMIP6Hist}(\text{time})$$

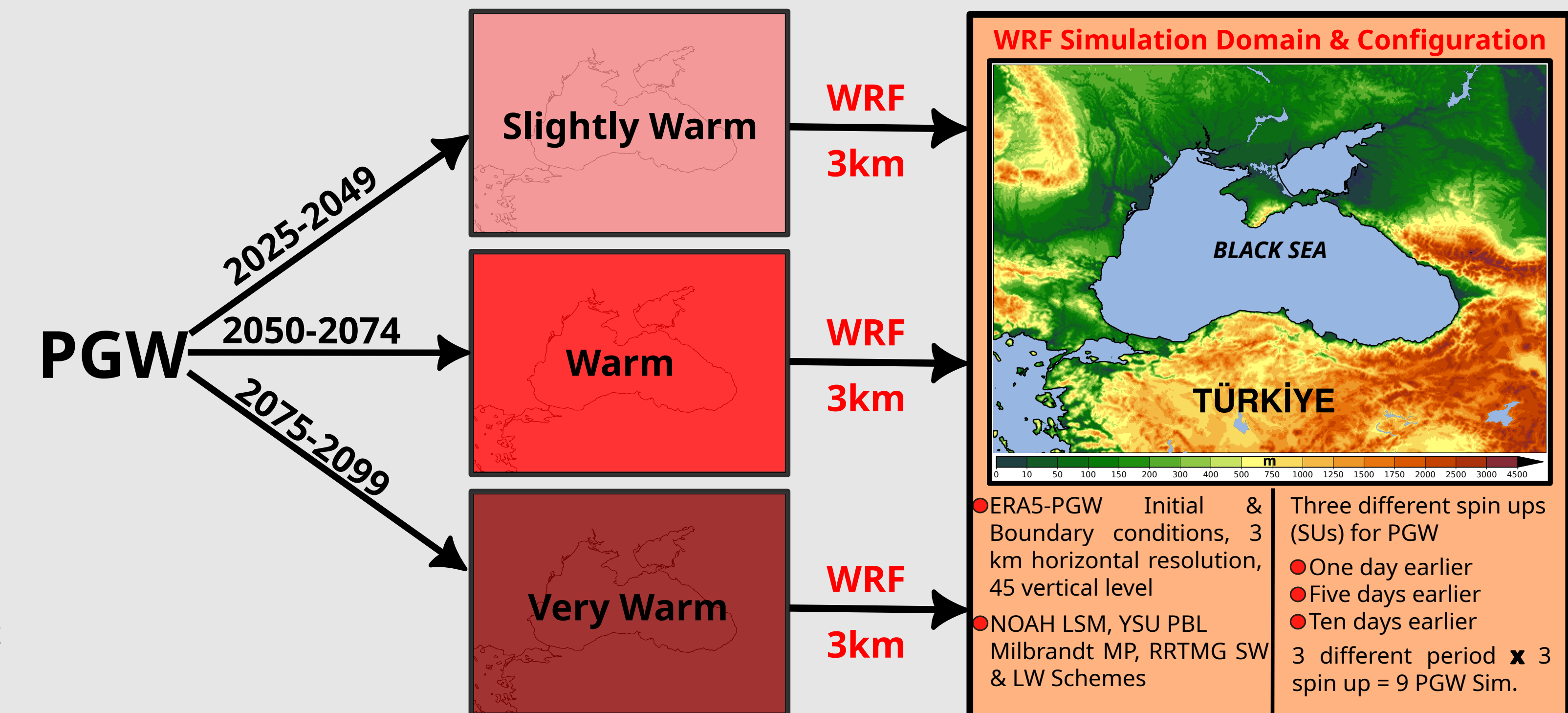
PGW = ERA5 +  $\Delta$

25 CMIP6 ESMs which has ocean model over The Black Sea, ensemble means in SSP585 scenario is used.

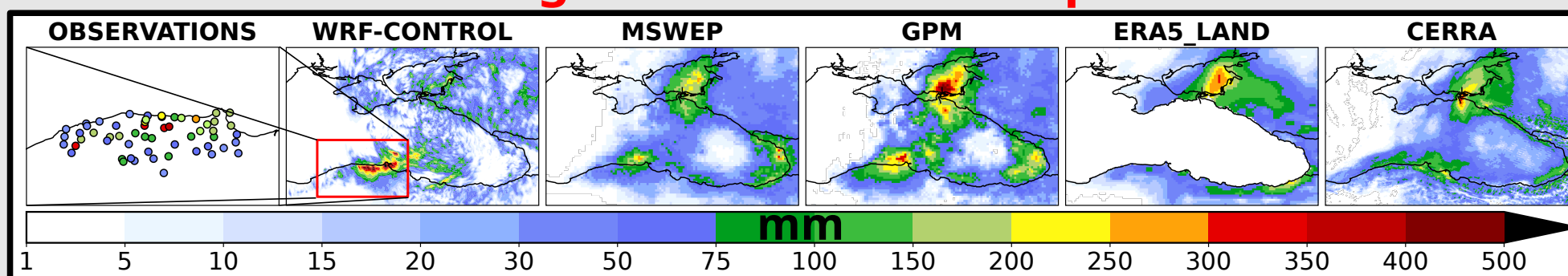
Temperature, relative humidity, velocities, surface pressure, SST, skin temperature are perturbed using long term August mean.

Computationally cheap and easy to apply (using monthly means).

CMIP6 underestimates SST (see figure on left side), by using PGW method we are getting rid of the bias using climate deltas.



### 10-16 August 2021 Total Precipitation

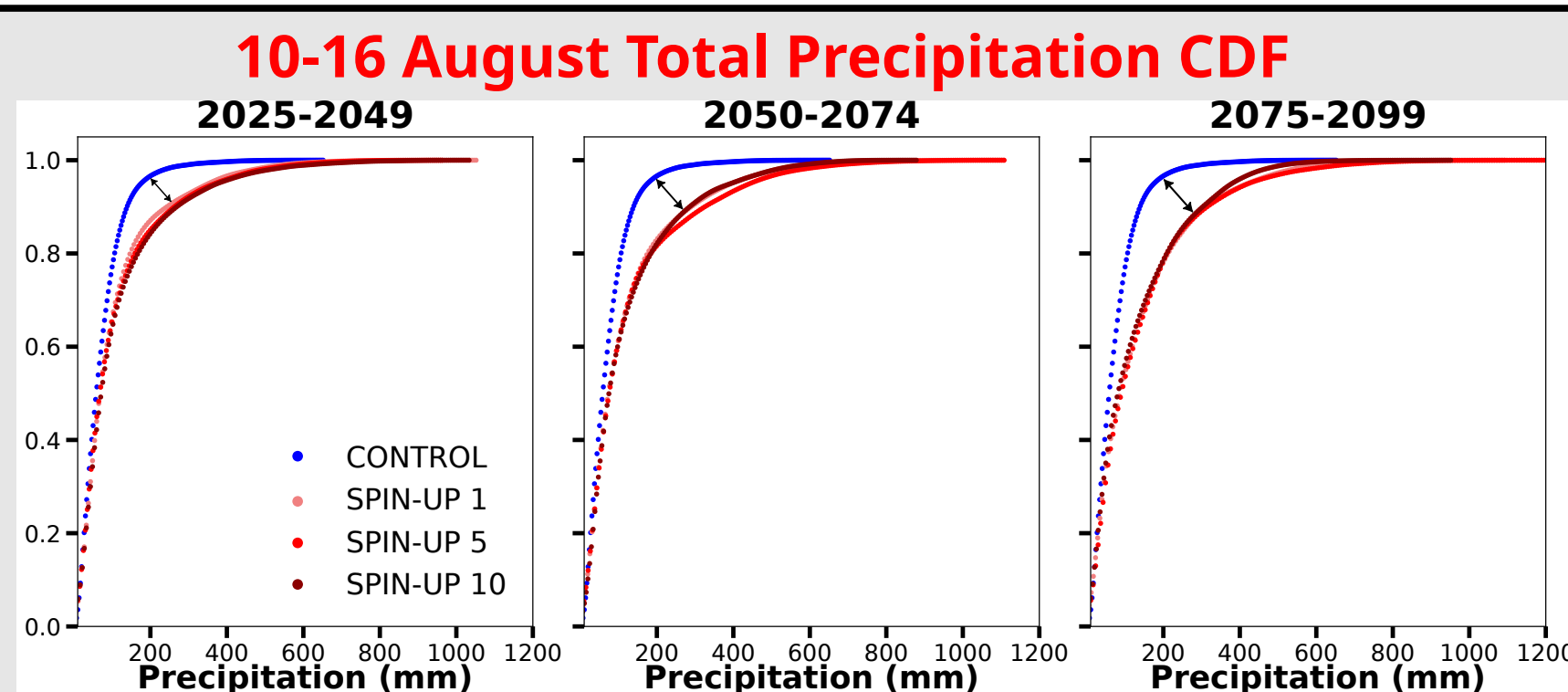


After applying PGW to WRF model Initial & Boundary conditions, the results are...

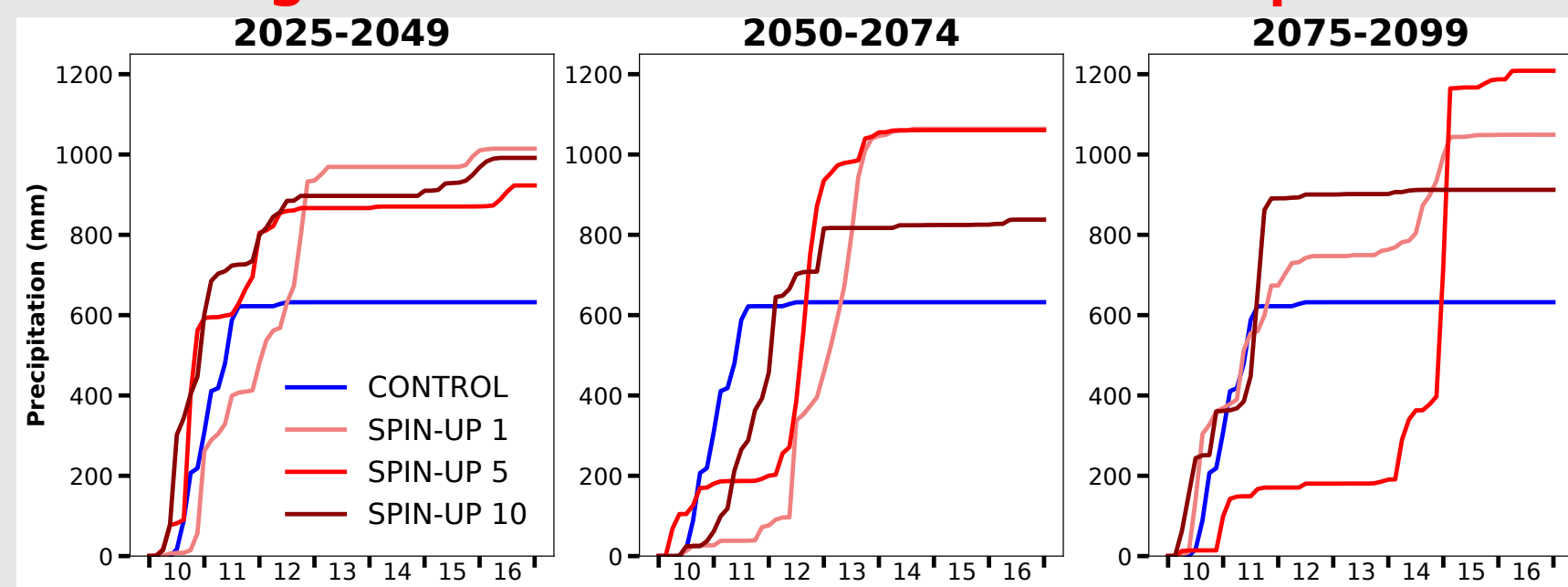
- As the climate becomes warmer, area of excessive precipitation and extremes are increasing compared to control simulation as labeled on plots.
- The low pressure system hits more strongly coast of Ukraine compared to control simulation.
- Total precipitation exceed **1000mm** in 5 out of 9 PGW simulations. Most of the precipitation falls in a very short duration of period
- In some cases, most of precipitation falls over the sea

Warmer climate leads to changes of precipitation extremes...

- Across all time periods, the PGW scenario (warmer climate) tends to produce more frequent higher precipitation events compared to the CONTROL.
- The difference becomes more substantial in the late century, reflecting a warming-enhanced hydrological intensification.
- Maximum accumulated precipitation in a single grid point shows that precipitation falls in a very short time of period (less than 24 hours) and exceeds 800mm in one day.

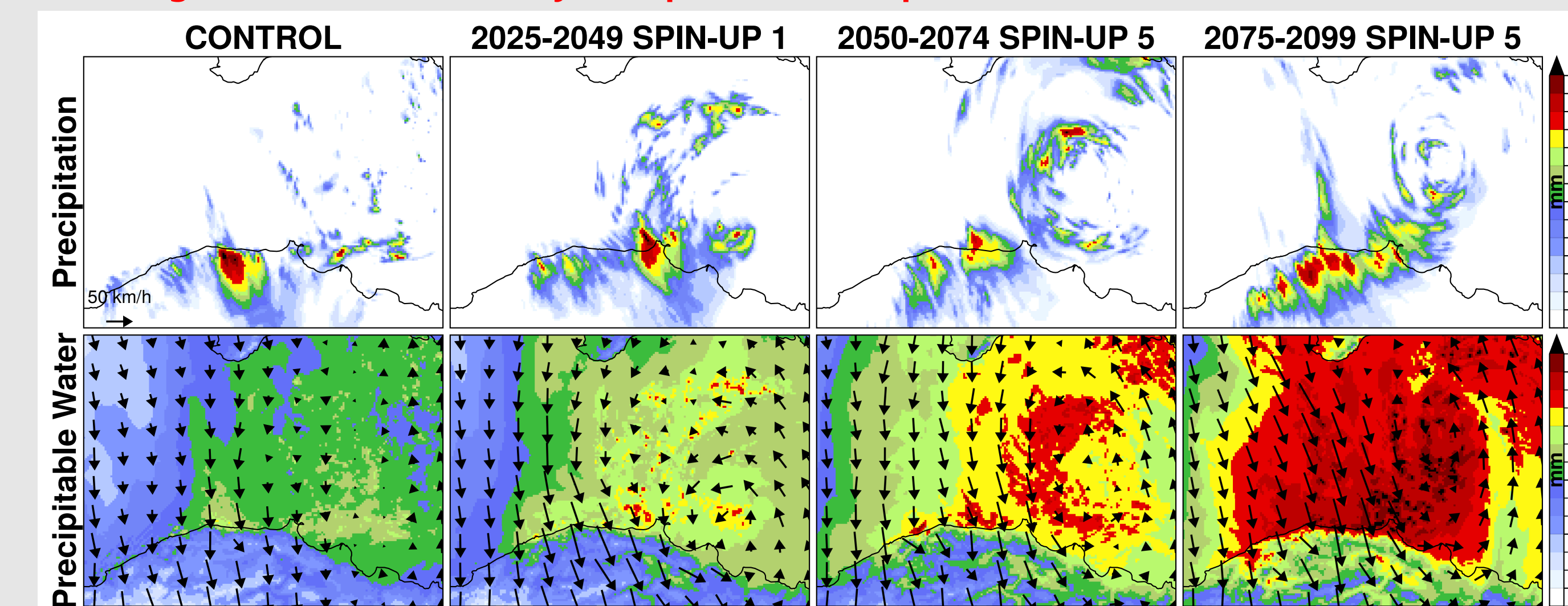


### 10-16 August Maximum Accumulated Precipitation



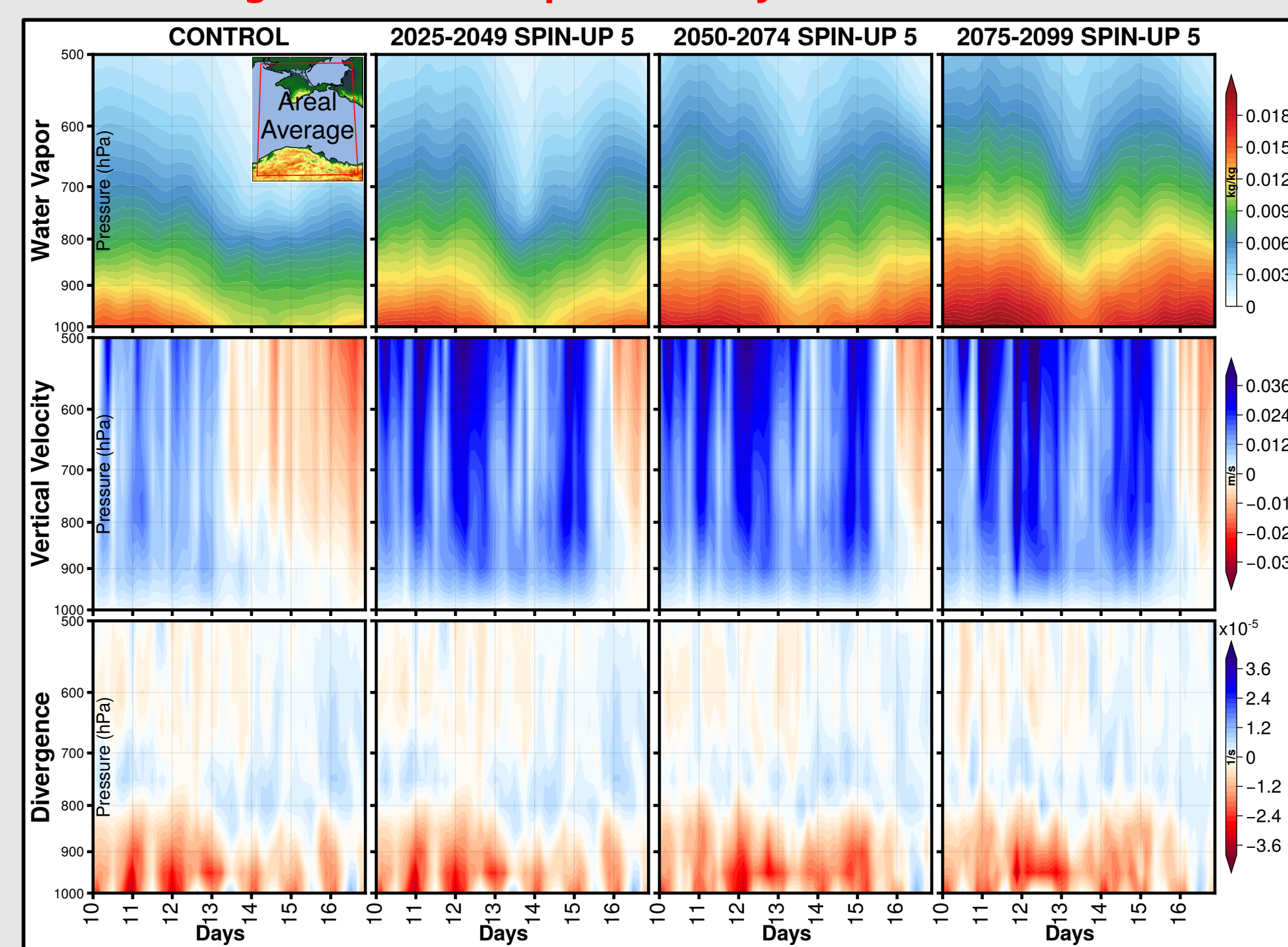
## Changes of dynamics that leads to excessive precipitation

11 August Maximum 3 Hourly Precipitation, Precipitable Water and 700 hPa Wind Vectors



- 3 hourly precipitation amount does not change much. However, excessive precipitation area changes in the warmer climate simulations.
- Substantial increase of precipitable water in the atmosphere column as a result of warming which supplies excessive moisture for storm cells over the sea.
- In warmer climate, 700 hPa wind speed significantly increases and because of this storm cells may easily displaced through the land areas compared to control.

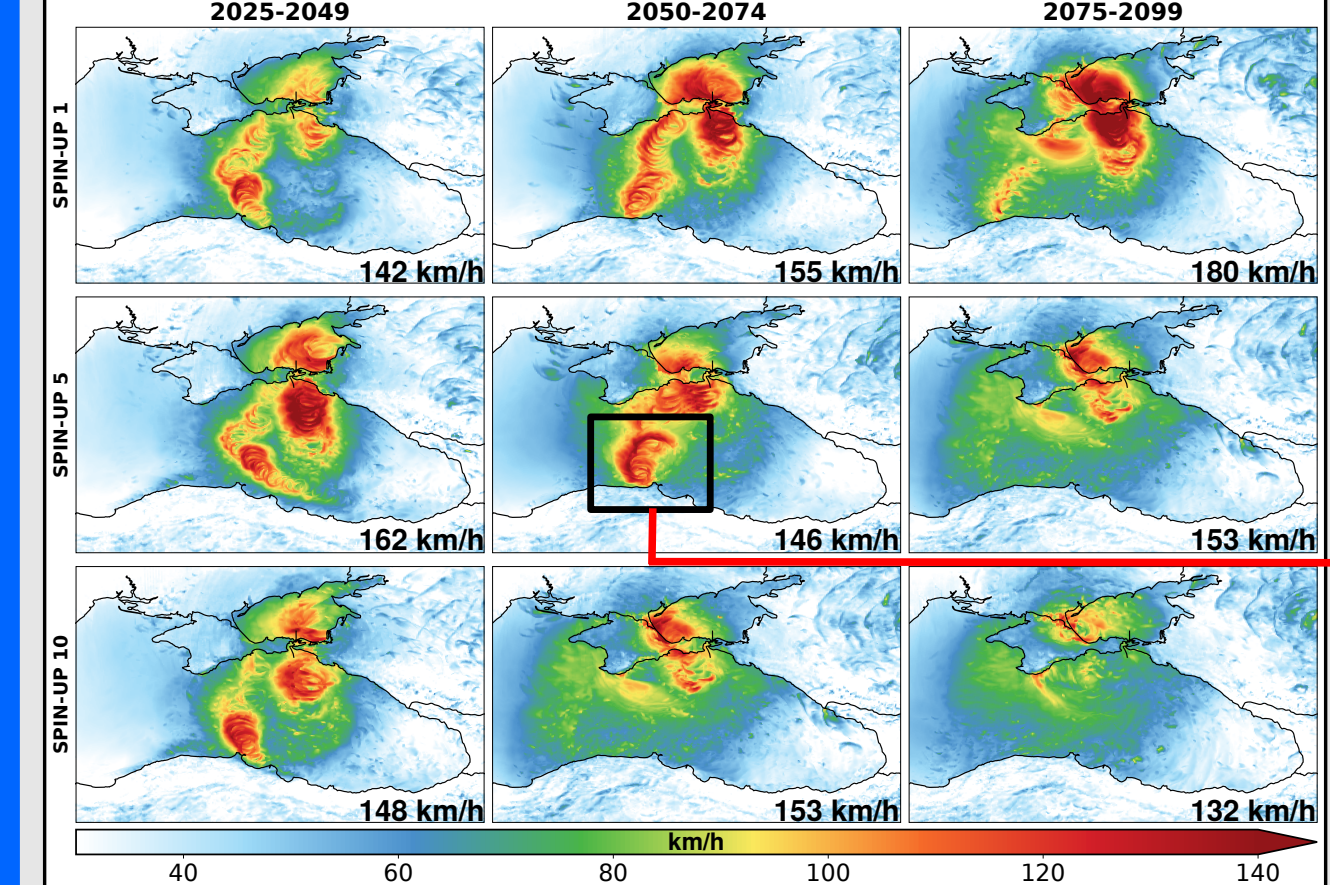
## Areal Changes of Water Vapour and Dynamics Over The Black Sea



- Excessive water vapor in atmospheric column not limited to boundary layer, reaches up to 700 hPa as atmosphere warms up. It describes the 800mm+ precipitation and extreme precipitation rate over the domain.
- Vertical velocity values over The Black Sea increases which creates favourable environment for storm evolution.
- Horizontal divergence does not change over time but this result should be interpreted in the scope of event based.

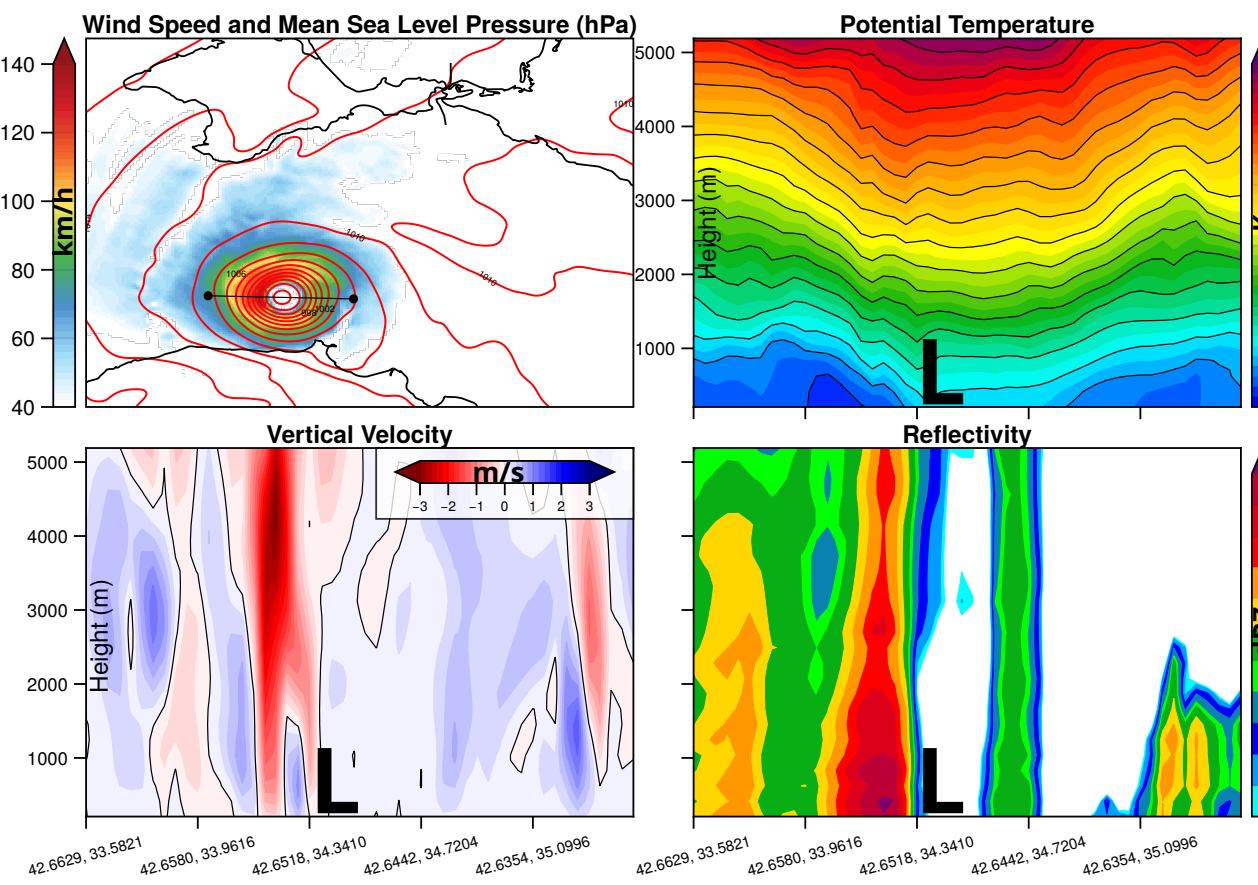
## Emergence of Tropical-Like Cyclone (TLC) in Warmer Climate

10-16 August Maximum Wind Speed PGW Simulations



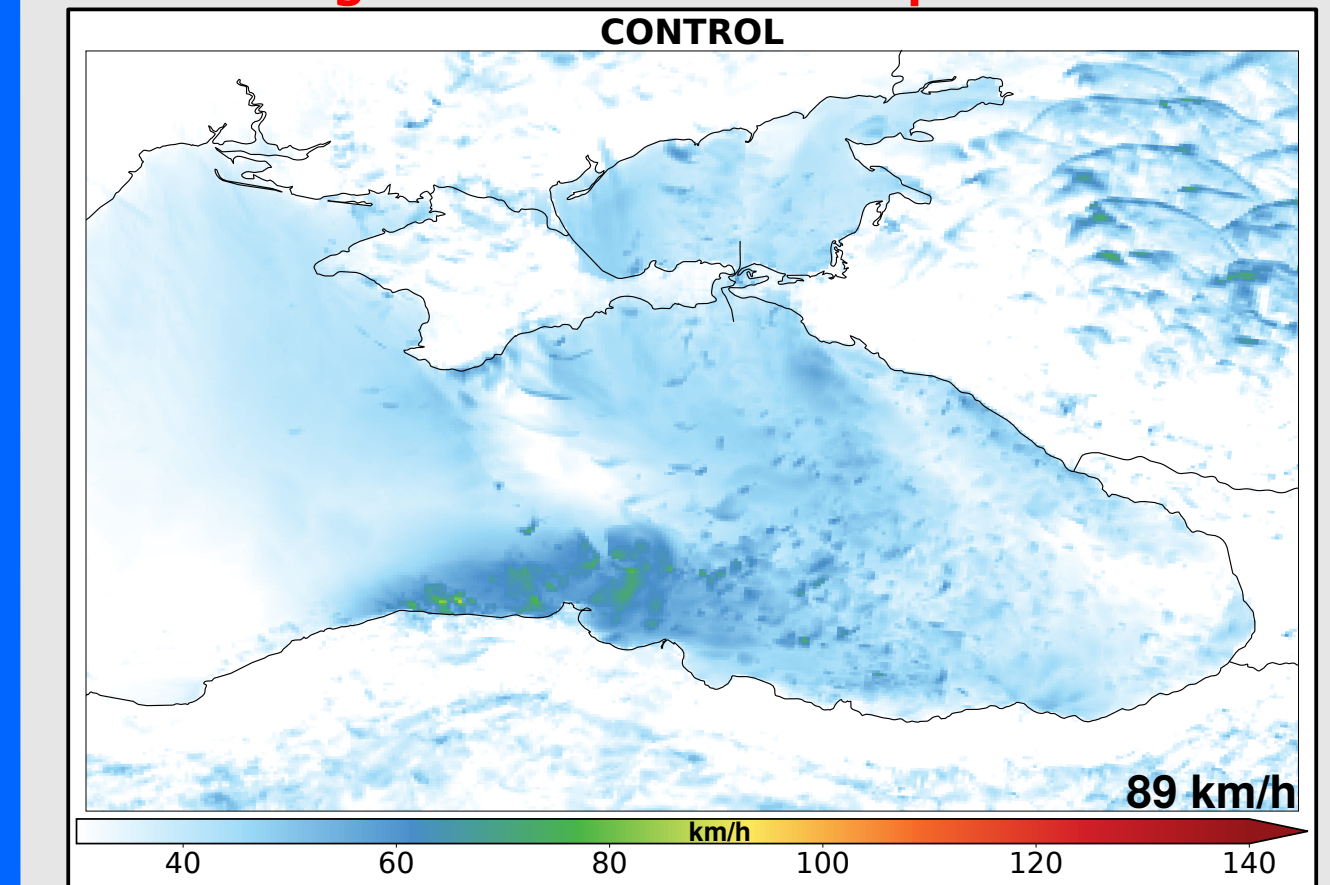
- Maximum wind speeds in all PGW simulations increases remarkably compared to control simulation.
- It reaches **180 km/h** in 2075-2099 climate conditions, doubles the control simulation as labeled on plots.
- In 5 out of 9, TLC formation is seen in PGW simulations. Which is not seen in the Black Sea ever before **beginning of the instrumental and satellite measurements**.

14 August 17Z Cross Section Along Black Line

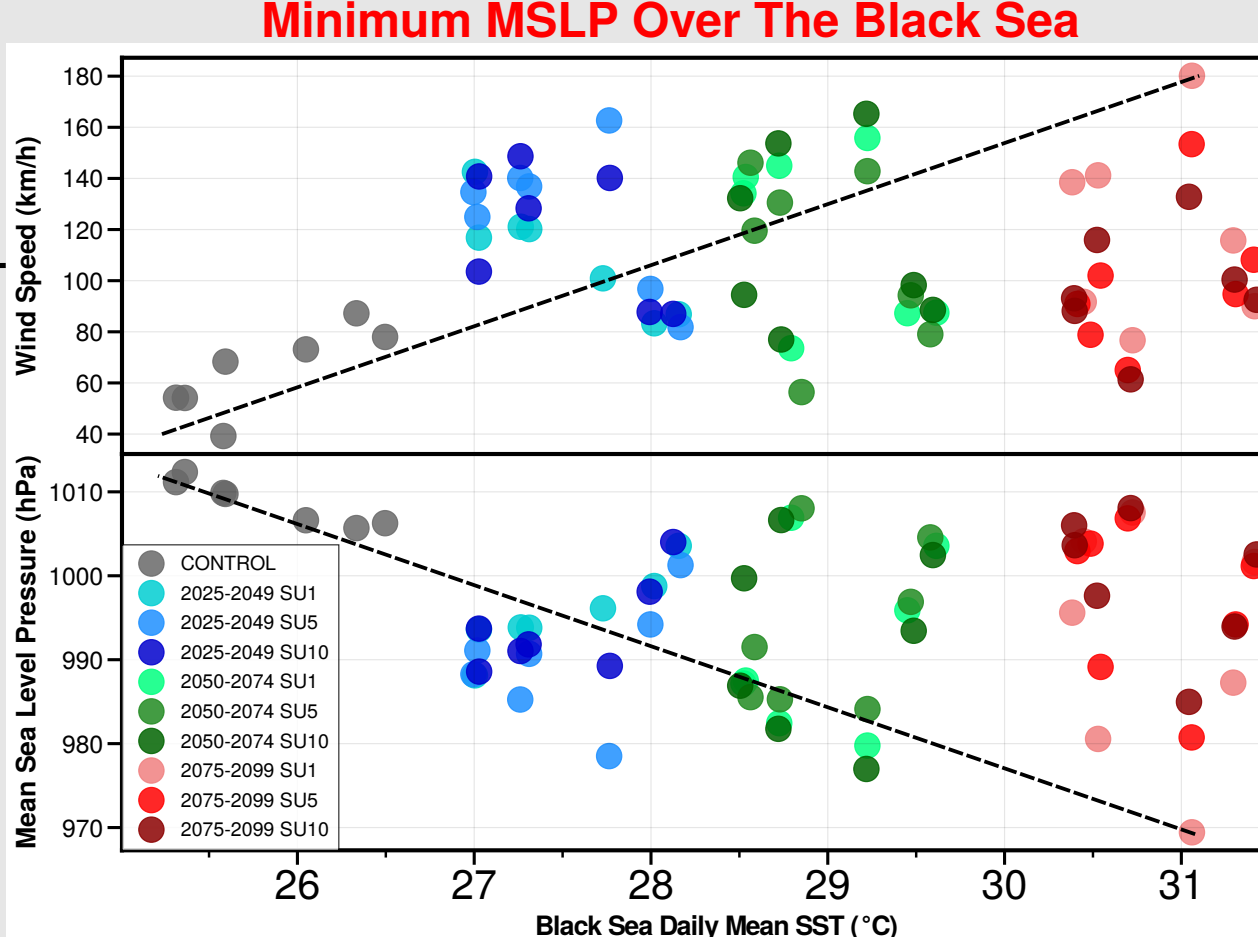


- Warm core of the cyclone extends up to **5000 meter** accompanied by eye-wall structure and strong winds at left flank.
- As the SST exceeds **30 °C**, MSLP drops to **969 hPa** and wind speed reaches 180 km/h.
- Strength of the both wind speed and MSLP is highly sensitive to model initialization time.

### 10-16 August Maximum Wind Speed Control



### 10-16 August Daily Maximum Wind Speed Minimum MSLP Over The Black Sea



## Acknowledgment

The numerical calculations reported in this poster were partially performed at TUBITAK ULAKBIM, High Performance and Grid Computing Center (TRUBA resources).

## Concluding Remarks

- Excessive precipitation can be explained by increased atmospheric water vapor which comes from water mass and vertical motions.
- Precipitation extremes increases by warming up the atmosphere compared control simulation
- As the SST increases, TLC formation is seen over The Black Sea in 5 of the PGW simulations which is never seen before.