# Sensitivity analysis of WRF model PBL schemes in simulating temperature extremes over the Middle-East – North Africa (MENA) region

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# Motivation – Research Objectives

A correct **representation** of the planetary boundary layer (**PBL**) is **critical** to achieve **realistic regional climate simulations**, especially regarding **surface variables**.

In this study:

1. **Examine the sensitivity** of the performance of the Weather Research and Forecast **(WRF) model** to the use of three **PBL schemes**

2. **Explore the differences** among the WRF **simulated temperature** and heat **extremes** resulting from the choice of PBL schemes

3. **Reveal the most suitable scheme** for the Middle-East - North Africa (**MENA**) domain

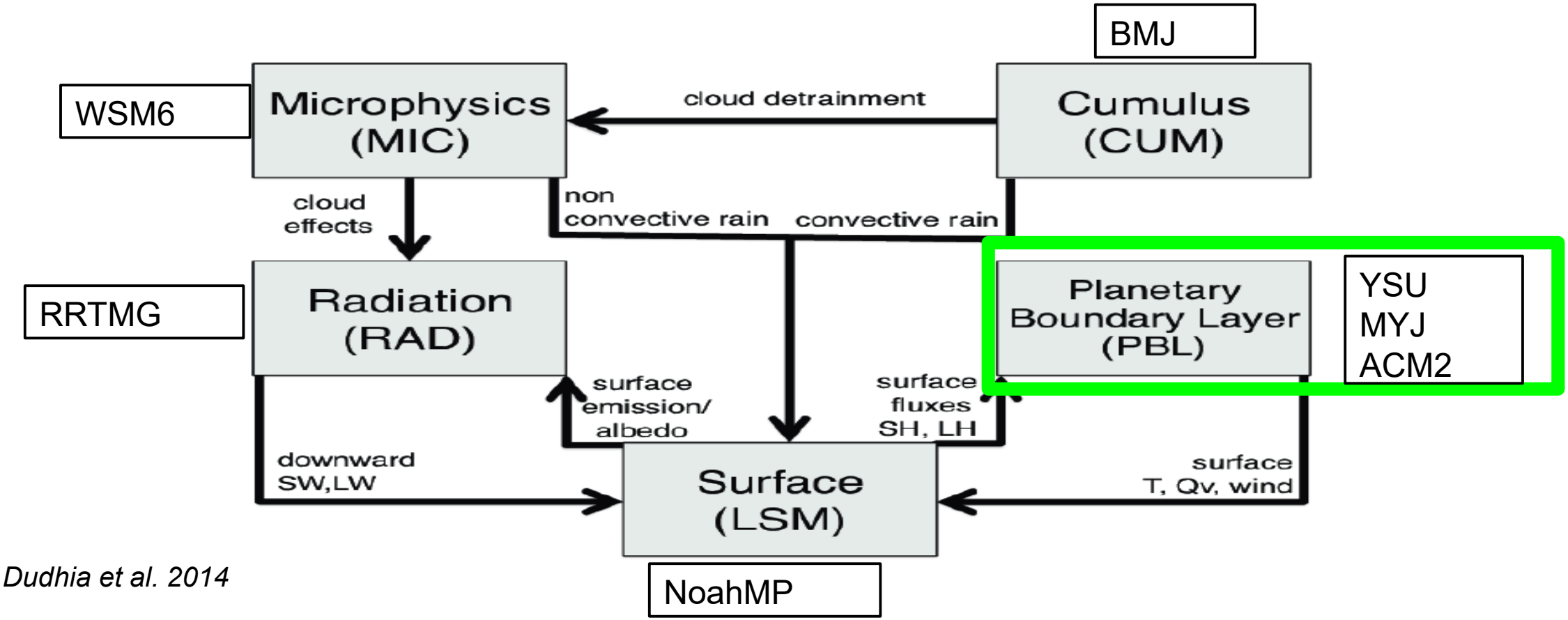
# WRF – Model Configuration

WRF version 4.2.1

0.22°( ~24km) horizontal resolution, 35 vertical levels

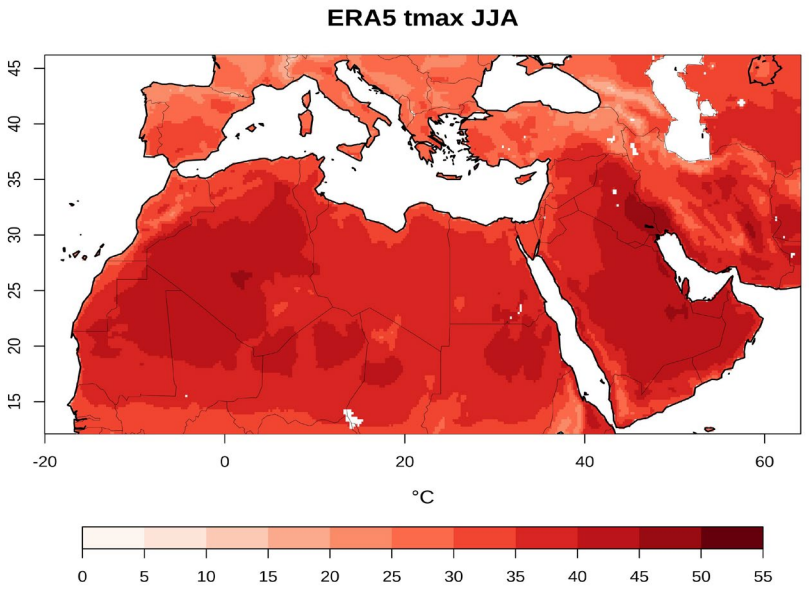
MENA-CORDEX domain, 2000-2010 period

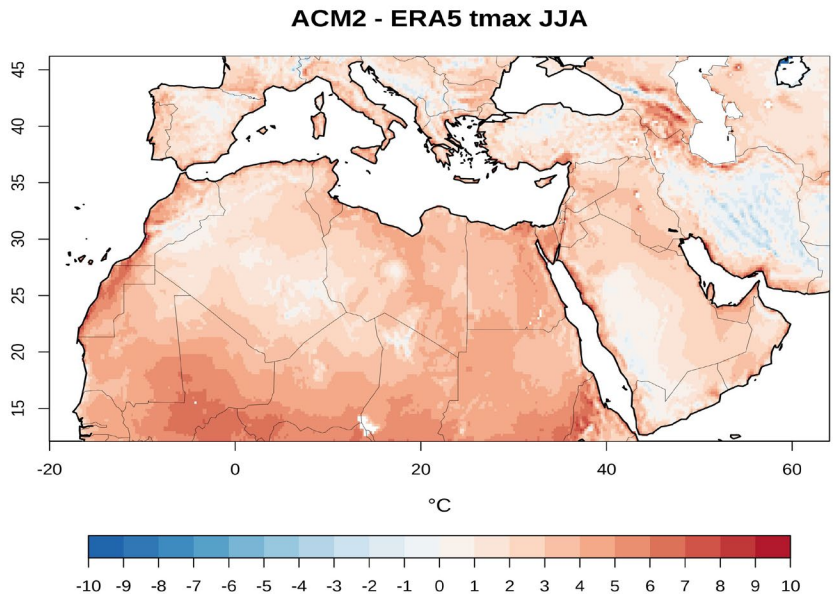
**Lateral Boundary Conditions:** ERA – Interim reanalysis

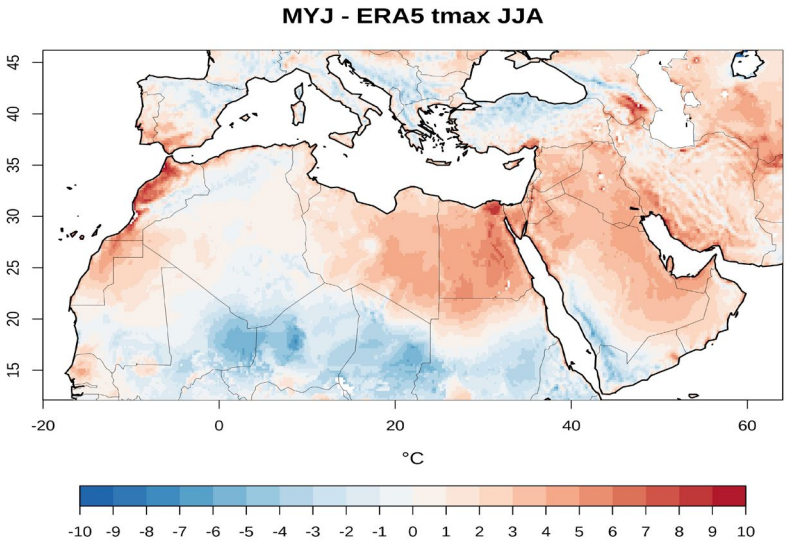


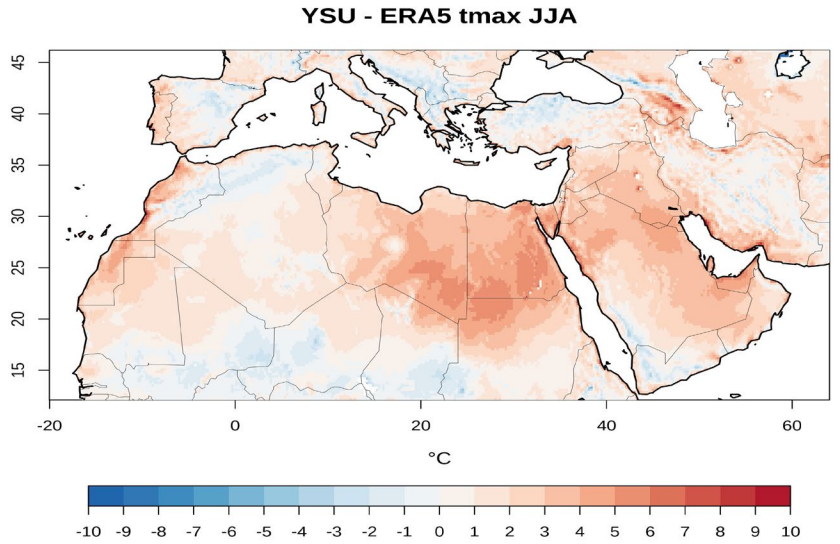

*Dudhia et al. 2014*

# Results – Summer TMAX (JJA)



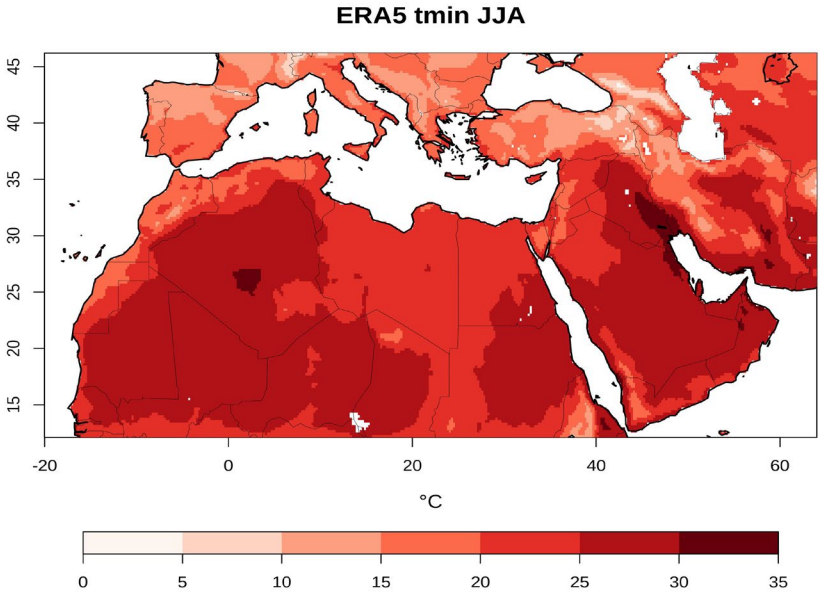



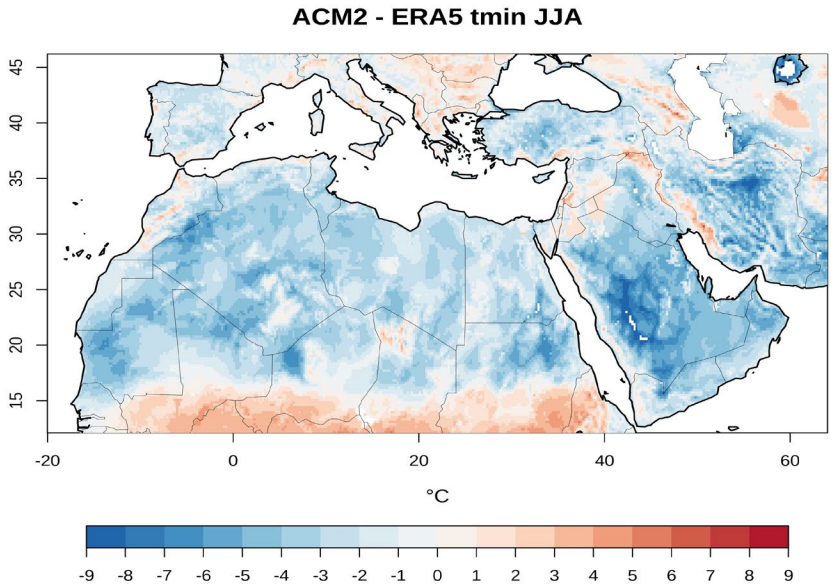



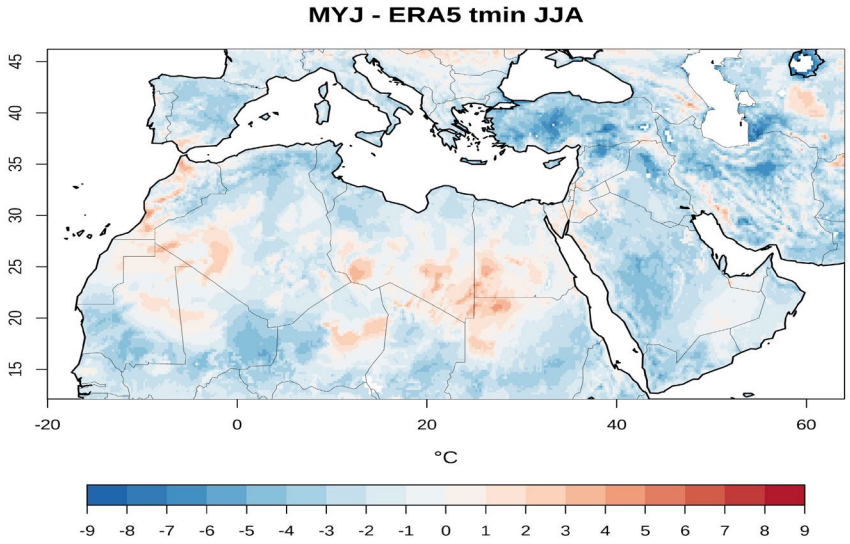



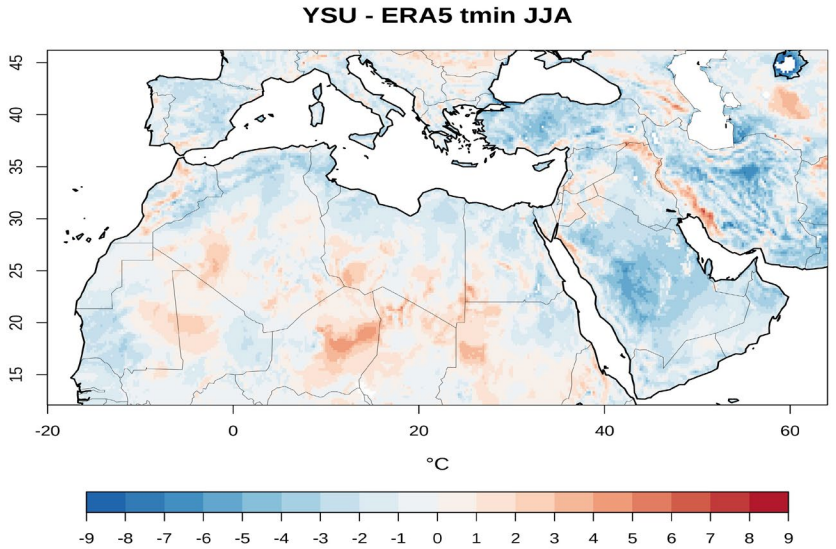

- **Model biases** strongly vary according to **geographic location**
- **ACM2** scheme quite **warmer** than MYJ and YSU (**opposite signs** in parts of **Northern Africa**)
- **MYJ** shows strong **biases** in some areas
- Overall, **YSU** scheme shows **better performance**

# Results – Summer TMIN (JJA)



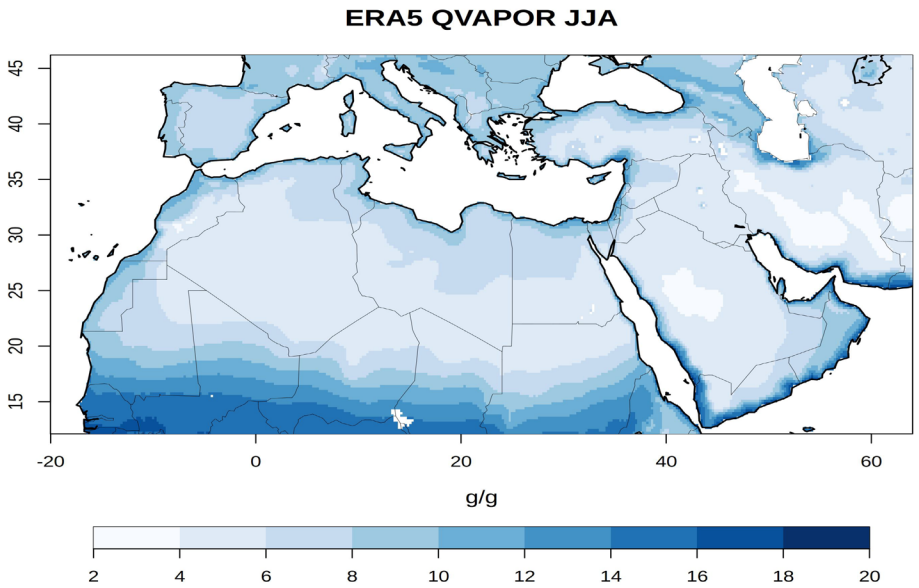



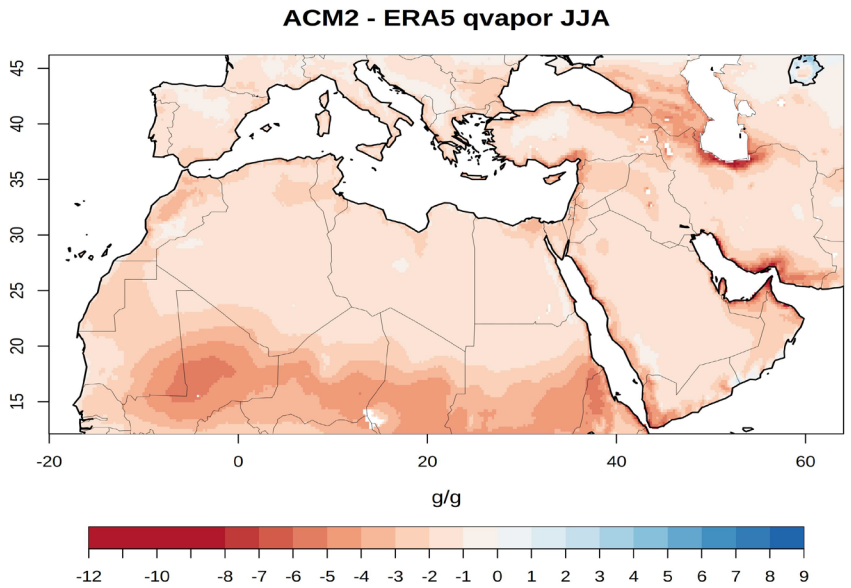



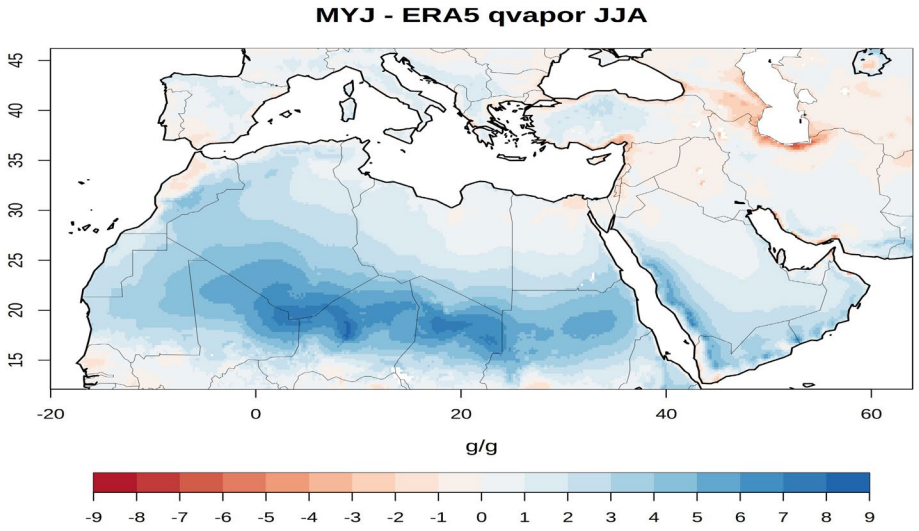



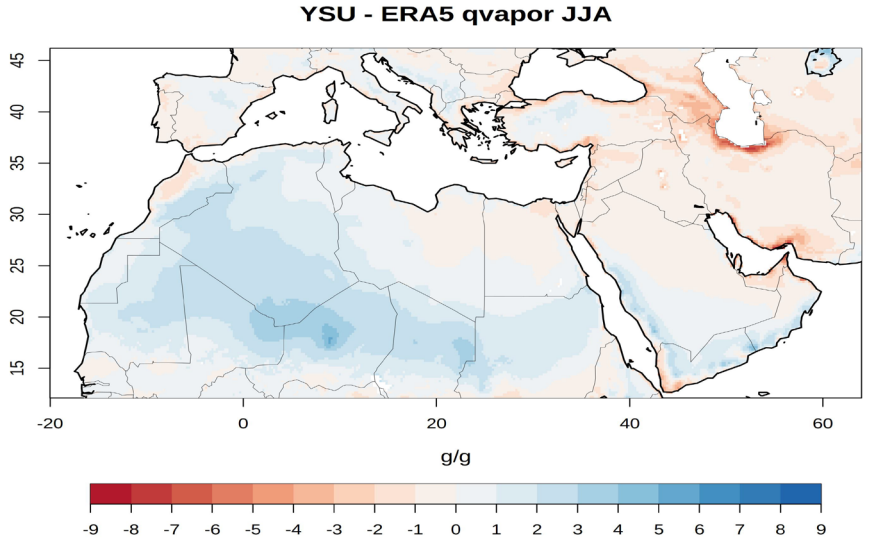

- Model biases strongly vary according to geographic location
- **Cold biases** in many areas
- **ACM2** shows the **strongest cold biases** in north Africa – Arabian peninsula
- Smaller biases in YSU scheme

# Results – Summer surface specific humidity



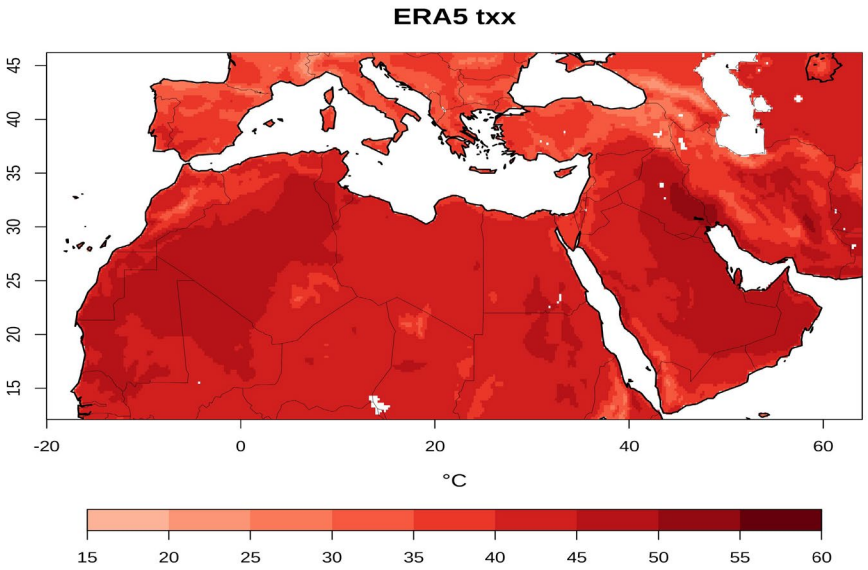



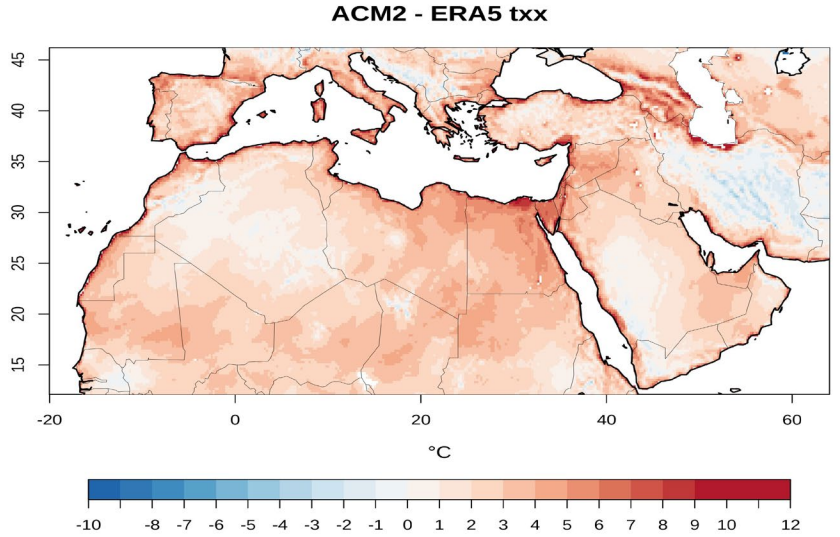



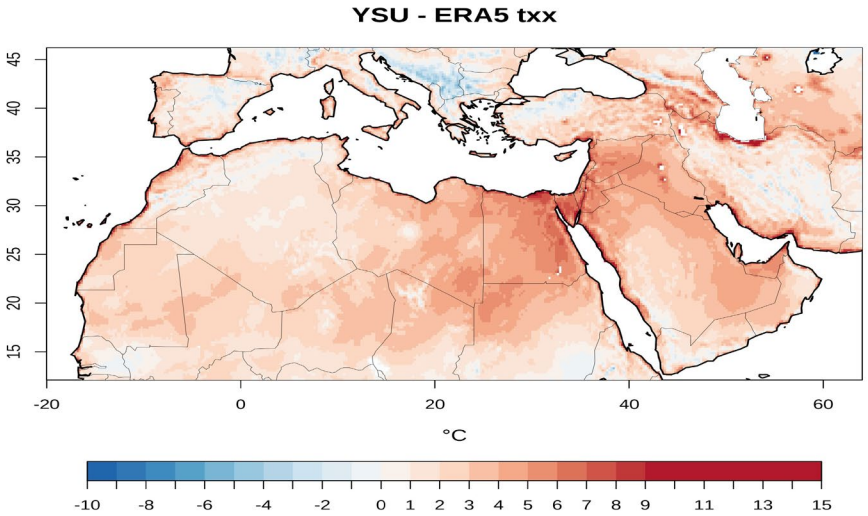



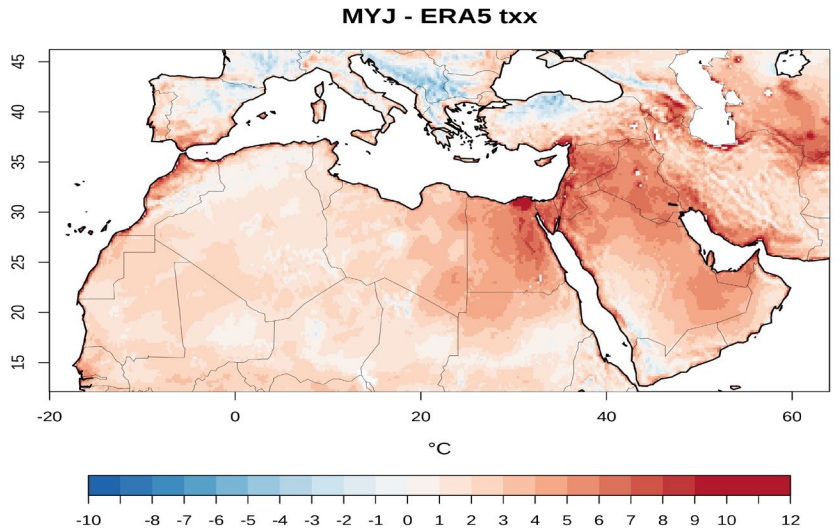

- ACM2: **Dry** biases across MENA
- MYJ: **overestimates moisture** in many parts of MENA
- Notable **differences** among the 3 schemes in **north Africa** that can be linked with the differences in TMAX
- **MYJ** predicts **lower temperature** and **more moisture** possibly due to weaker **vertical mixing**
- Smallest biases in YSU scheme

# Results – Warmest Day (TXx)



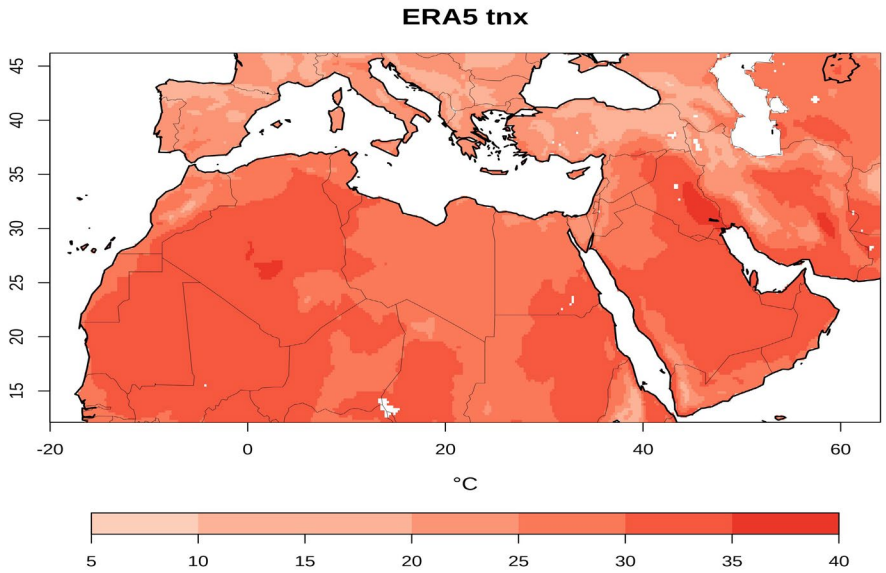



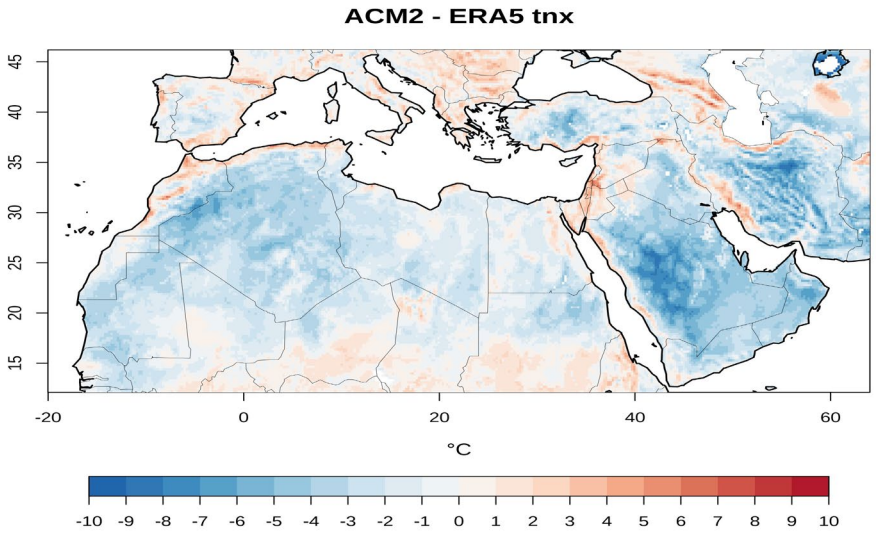



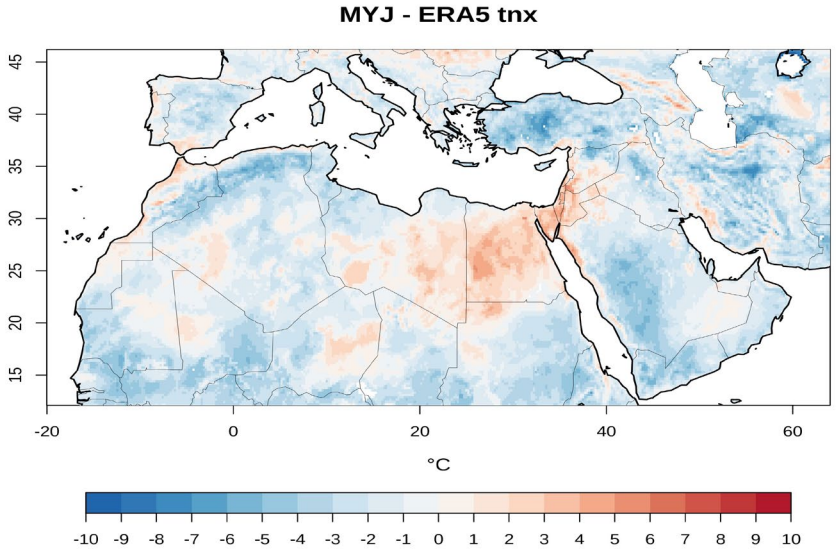



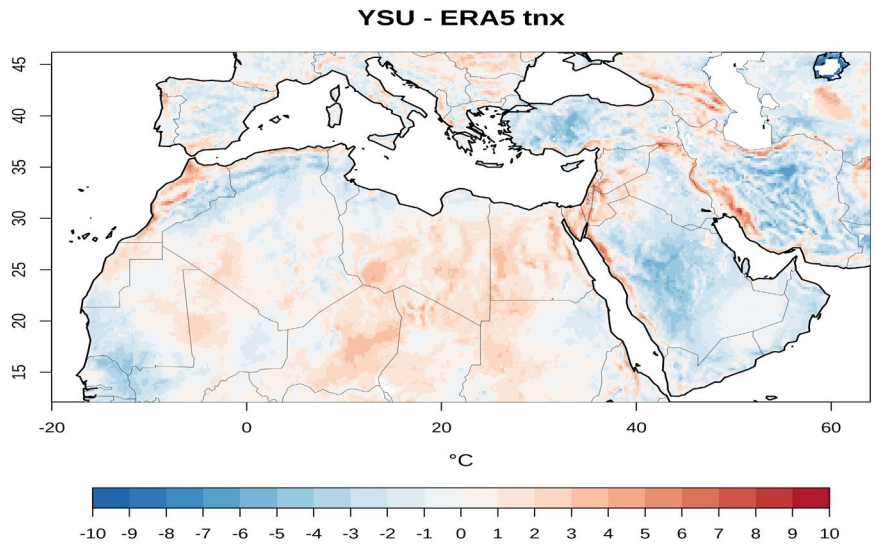

- **WRF** simulations **overestimate** the index in most areas
- **ACM2**: **Warm biases** in most areas (especially around the Mediterranean region)
- **MYJ:** Substantial **warm biases** in parts of Egypt and the Middle East

# Results – Warmest Night (TNx)




- **WRF** simulations produce **cold biases** in many areas (in contrast with TXx)
- Model biases very dependent on the geographical location
- **<u>ACM2 – MYJ:</u>** Significant **cold biases** on some areas
- **<u>YSU:</u> Warmer** - weaker biases on average

# Conclusions – Further Work

- Model **biases** are dependent on **geographical location** and **time of the day** (nightime/daytime)
- On average, **WRF** simulations tend to **overestimate TMAX and TXx** index and **underestimate TMIN and TNx** index in many parts of MENA
- Overall, we can identify the **YSU** as the scheme with the **least bias**
- **MYJ** scheme **overestimates moisture** while **ACM2** produces the **driest** and **warmest** daytime PBL among the 3 schemes
- **Cold and moist PBL's** can be caused by and **underestimation** of **vertical mixing** and entrainment
- **Further research** should be conducted to confirm the above conclusion (analysis of vertical profiles, estimation of PBL height/fluxes) and reveal the **physical causes of model biases**

# Thank you !!!