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

Athanasios Ntoumos, Panos Hadjinicolaou, George Zittis and Jos Lelieveld
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

WSM6
Microphysics (MIC)

RRTMG
Radiation (RAD)

BMJ
Cumulus (CUM)

YSU
MYJ
ACM2
Planetary Boundary Layer (PBL)

NoahMP
Surface (LSM)

downward SW,LW

cloud effects

cloud detrainment

non convective rain

convective rain

surface emission/ albedo

surface fluxes

SH, LH

surface T, Qv, wind

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
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
• **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
WRF simulations produce cold biases in many areas (in contrast with TXx).

Model biases very dependent on the geographical location.

ACM2 – MYJ: Significant cold biases on some areas.

YSU: 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 !!!