Evaluation of the performance of WRF model in extreme precipitation estimation concerning the changing model configuration and the spatial and temporal variations

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Introduction

- The fundamental aim of the study is to discuss the sensitivity of WRF-derived precipitation against different model configurations based on large ensembles.
- The effects of the initial data source, model physics, and spatial resolution on WRF sensitivity are examined.
- The study investigates the sensitivity by focusing on the extreme precipitation events in the Mediterranean (MED) and Eastern Black Sea (EBLS) regions of Turkey.
- General Directorate of Meteorology in Turkey records the extraordinary meteorological events, and according to their records, summer and autumn are the most vulnerable seasons against flooding during the last decade.
- In the view of such information, two events per region, one from summer and one from autumn, are selected, and the sensitivity analyses are performed for each incident separately to show the temporal variability in addition to the spatial variation.
- The most representative parameterizations are determined for different spatial resolutions.

Model Configuration

Table 1 Parameters used for the sensitivity analysis. MP: Microphysics Parameterization, CP: Cumulus Parameterization, PBL: Planetary Boundary Layer, SR: Spatial Resolution, INITIAL: Initial Data Source.

MP	CP	PBL	SR (km)	INITIAL
Kessler Scheme (KS)	Kain–Fritsch Scheme (KF)	Yonsei University Scheme (YSU)	3	GFS
Eta (Ferrier) Scheme (ES)	Betts–Miller–Janjic Scheme (BMJ)	Mellor–Yamada–Janjic Scheme (MYJ)	9	ERA5
WRF Single–moment 6–class Scheme (WSM6)	Grell–Freitas Ensemble Scheme (GFES)			
Aerosol–aware Thompson Scheme (AATS)				

4 x 3 x 2 x 2 x 2

= 96 scenarios are tested for each event

WRF Domain

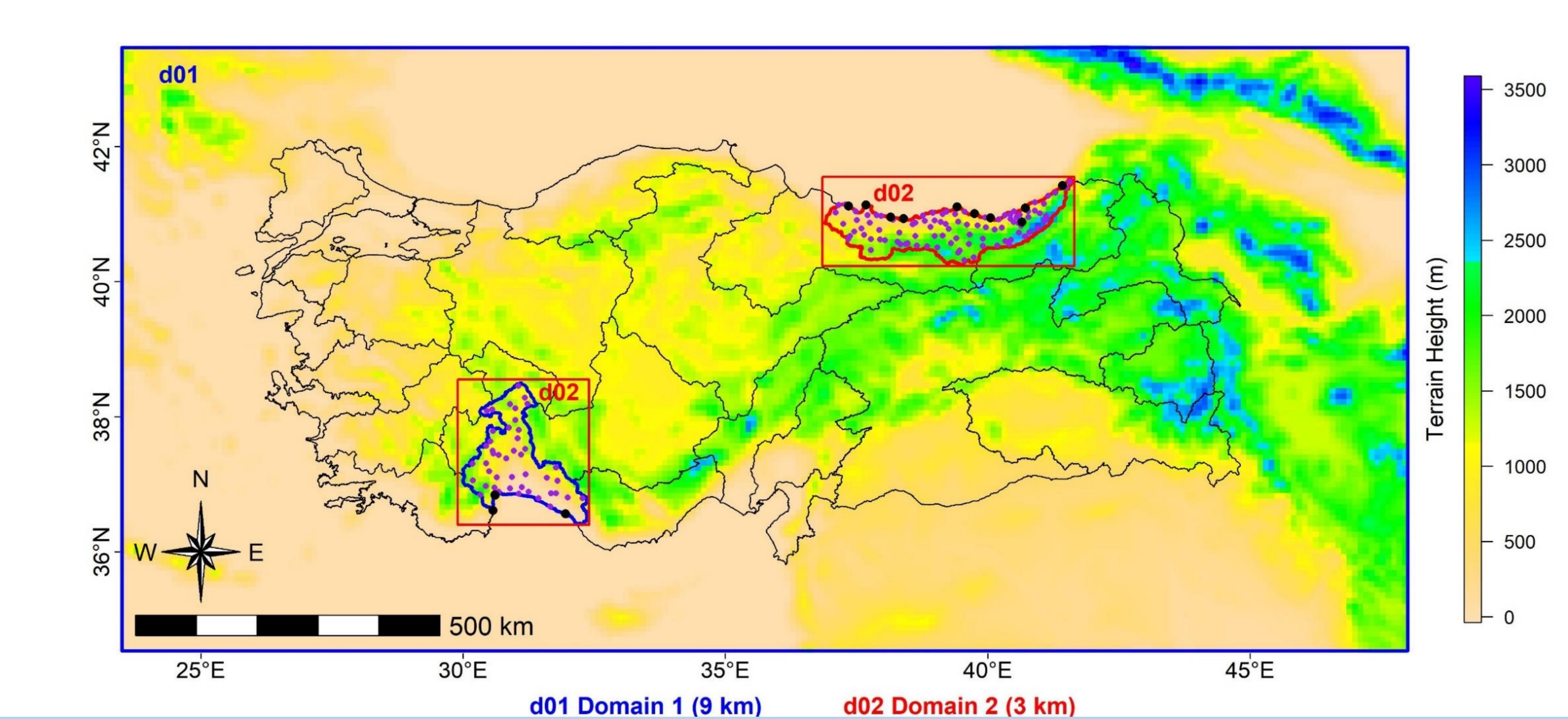

Figure 1 The domains of the WRF model. The blue rectangle shows the outer domain, whereas the red ones show the inner domains. The regions having red and blue borders are EBLS and MED, respectively. The purple points show the precipitation measurement stations that pass the quality control and used to evaluate WRF-derived precipitation. The black points indicate the eliminated stations. The background is the terrain height, the output of the geogrid program.

Performance Metrics

METRICS ARE CALCULATED BETWEEN THE STATIONS AND THE CLOSEST GRID TO EACH STATION

CATEGORICAL METRICS

POD: Probability of Detection

FAR: False Alarm Ratio

CSI: Critical Success Index

PC: Percent Correct

FBI: Frequency Bias Index

STATISTICAL METRICS

RMSE: Root Mean Square Error

MBE: Mean Bias Error

SD: Standard Deviation

CORR: Spearman's Rank Order Correlation

Determining the hierarchy between the scenarios on the basis of these nine metrics requires the usage of a multi-criteria decision-making method. TOPSIS Method is used in this study.

Results and Discussion

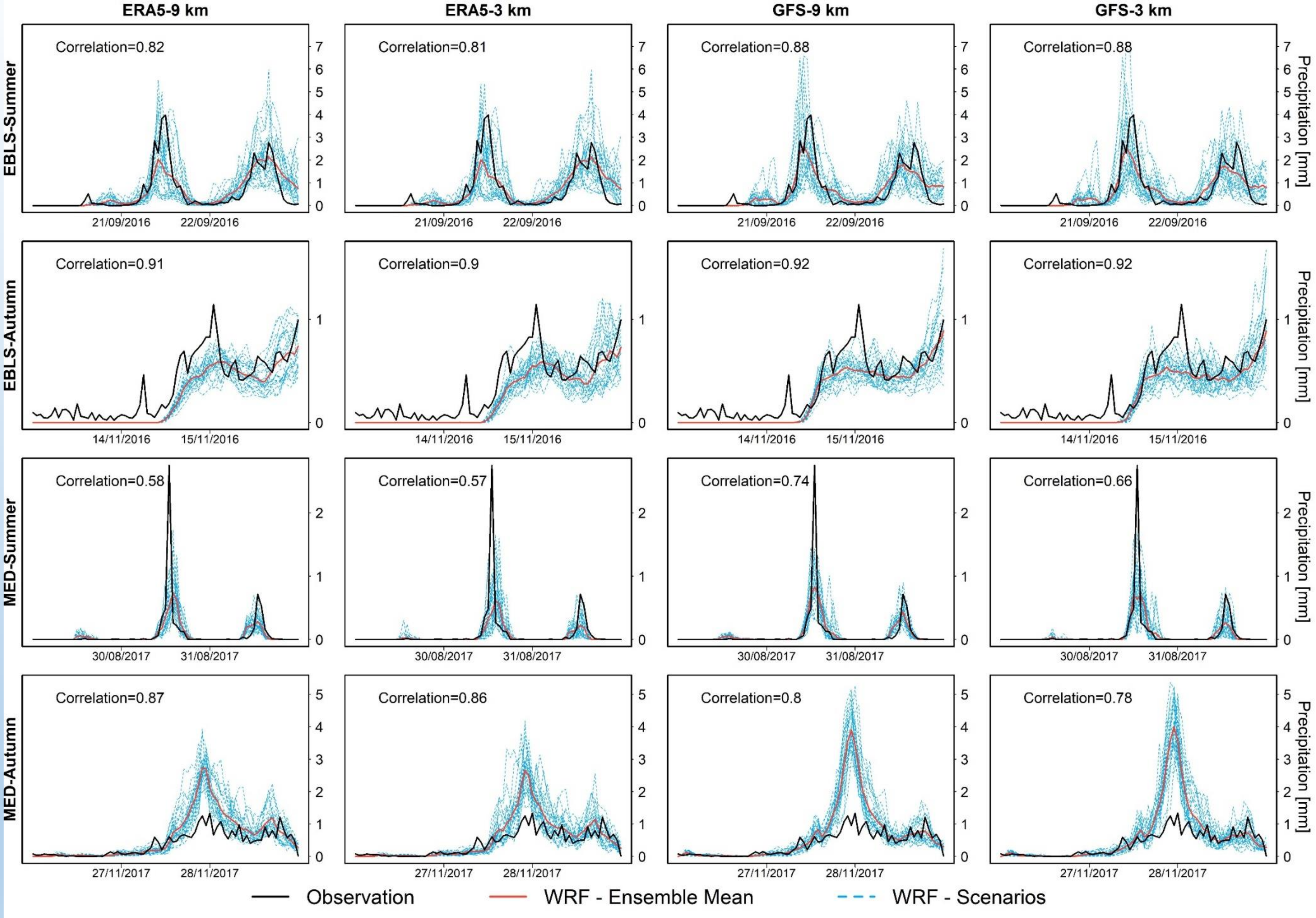

Figure 2 The area-averaged observed and WRF-derived precipitation considering different initial data & spatial resolution combinations. The correlation values are calculated between the observation and corresponding WRF ensemble mean.

Table 2 The best five scenarios based on TOPSIS algorithm for different spatial resolutions. The cumulus parameterization of 3 km scenarios is colored with red because it is kept inactive in simulations. Those show the cumulus scheme of the collaborating coarse domain.

	9 km				3 km			
	MP	CP	PBL	INITIAL	MP	CP	PBL	INITIAL
EBLS Summer	AATS	BMJ	MYJ	ERA5	AATS	BMJ	MYJ	ERA5
	ES	GFES	MYJ	ERA5	AATS	GFES	MYJ	ERA5
	WSM6	BMJ	MYJ	ERA5	WSM6	BMJ	MYJ	ERA5
	KS	BMJ	MYJ	ERA5	WSM6	GFES	MYJ	ERA5
	AATS	GFES	MYJ	ERA5	ES	GFES	MYJ	ERA5
EBLS Autumn	WSM6	KF	MYJ	ERA5	WSM6	KF	MYJ	ERA5
	WSM6	GFES	YSU	ERA5	WSM6	GFES	YSU	ERA5
	WSM6	GFES	YSU	GFS	AATS	KF	MYJ	ERA5
	WSM6	GFES	MYJ	ERA5	AATS	BMJ	YSU	ERA5
	AATS	KF	MYJ	ERA5	WSM6	GFES	YSU	GFS
Antalya Summer	ES	BMJ	YSU	ERA5	AATS	GFES	MYJ	GFS
	KS	BMJ	YSU	GFS	AATS	GFES	MYJ	ERA5
	AATS	BMJ	MYJ	ERA5	KS	GFES	MYJ	GFS
	WSM6	GFES	MYJ	GFS	AATS	KF	YSU	GFS
	AATS	GFES	MYJ	ERA5	AATS	GFES	YSU	GFS
Antalya Autumn	ES	KF	MYJ	GFS	ES	GFES	YSU	ERA5
	ES	GFES	YSU	ERA5	ES	GFES	MYJ	GFS
	ES	GFES	MYJ	GFS	ES	KF	YSU	GFS
	ES	KF	YSU	GFS	ES	GFES	MYJ	ERA5
	ES	GFES	MYJ	ERA5	ES	BMJ	YSU	GFS

Conclusions

- The ensemble means for the events underestimate the area-averaged precipitation amounts except for the MED-autumn event.

- The microphysics scheme selection is more influential on the WRF outputs than the other physics options, particularly for the autumn incidents.

- WSM6 and ES are used as the microphysics option for the EBLS- and MED-autumn events, respectively. According to the TOPSIS results, the combinations of these microphysics with the cumulus scheme of GFES yields better results.

- In general, the ERA5 improves the WRF-derived precipitation performance more than GFS, when it is used as initial data in the EBLS region, whereas the GFS is a better data source for the simulations of the MED region.