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HIGH-RESOLUTION WRF HINDCASTS OVER CENTRAL GREECE: CHARACTERISTICS OF SIMULATED CONVECTIVE ACTIVITY AND MODEL EVALUATION

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1.INTRODUCTION

The Thessaly plain, which is located in central Greece (Fig. 1), has a vital role in the financial life of the country, because of its significant agricultural production.
The aim of the rain enhancement project DAPHNE is to tackle the problem of drought in this area by means of Weather Modification in convective clouds.

Aims:

- Investigate the characteristics of convective activity simulated by WRF-ARW (ver3.5.1), under different synoptic conditions, in central Greece
- Evaluate the model performance.

2. DATA AND METHODOLOGY

Numerical Model:	WRF-ARW (ver.3.5.1), 2-way telescoping nesting (Fig. 1)
Grid increment:	15km x 15km (D01) - Europe 5km x 5km (D02) - Greece 1km x 1km (D03) - Central Greece – Thessaly region
Initial time:	1200 UTC before each day of interest
Duration:	36 hours
Vertical levels:	39 sigma levels (up to 50 hPa)
Initial and lateral boundary conditions:	6-hourly ECMWF operational analyses (0.25°x0.25° lat.-long.)
Sea-Surface Temperatures:	NCEP (1/12°x1/12° lat.-long.)
Microphysics:	WRF Single Moment 6-classes (WSM6)
Cumulus convection:	Kain-Fritsch
Longwave/ Shortwave Radiation:	RRTMG
Surface Layer:	Monin-Obukhov (MM5) scheme
Boundary layer:	Yonsei University
Soil Processes:	NOAH Unified model

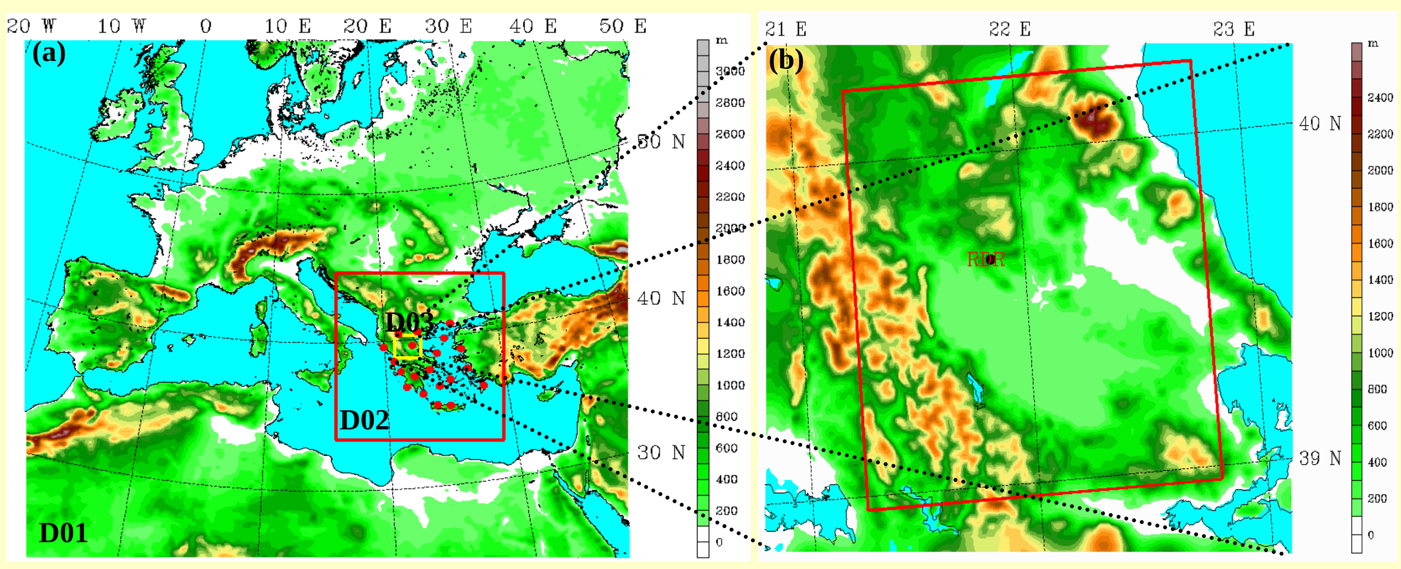

Figure 1. The topography of (a) D01 and (b) D03 nest used by WRF-ARW. On panel (a), the available Greek stations are indicated in red. On panel (b), RDR denotes the location of the weather radar while the red frame over Thessaly encompasses the region with radar data.

Period of interest: April to September 2006-2010.

Area of interest: an 140km x 140km region (red frame in D03; Fig. 1b) covering most of Thessaly region.

The 10 prevailing upper-air synoptic circulation types over Greece are: 1) zonal flow (ZON), 2) northwest flow (NW), 3) open trough (OPTR), 4) closed low (CLO), 5) cut-off low (CUT), 6) southwest flow (SW), 7) open ridge, 8) closed high, 9) omega blocking and 10) undefined (high – low) cases.

Six (6) representative days with convective activity are selected from each one of the first six (6) upper-air categories (accounting for 99% of days with convection). A total of 36 cases was simulated.

The cloud top, cloud base, area of convective activity and max reflectivity are studied using WRF-D03 and radar data [a C-Band (5cm) weather radar at Liopraso (39.674°N, 21.837°E; RDR in Fig. 1b)].

Convective activity is considered to occur at the locations, where the max reflectivity of the column -in the model or radar data- is higher than 35 dBz.

3. RESULTS

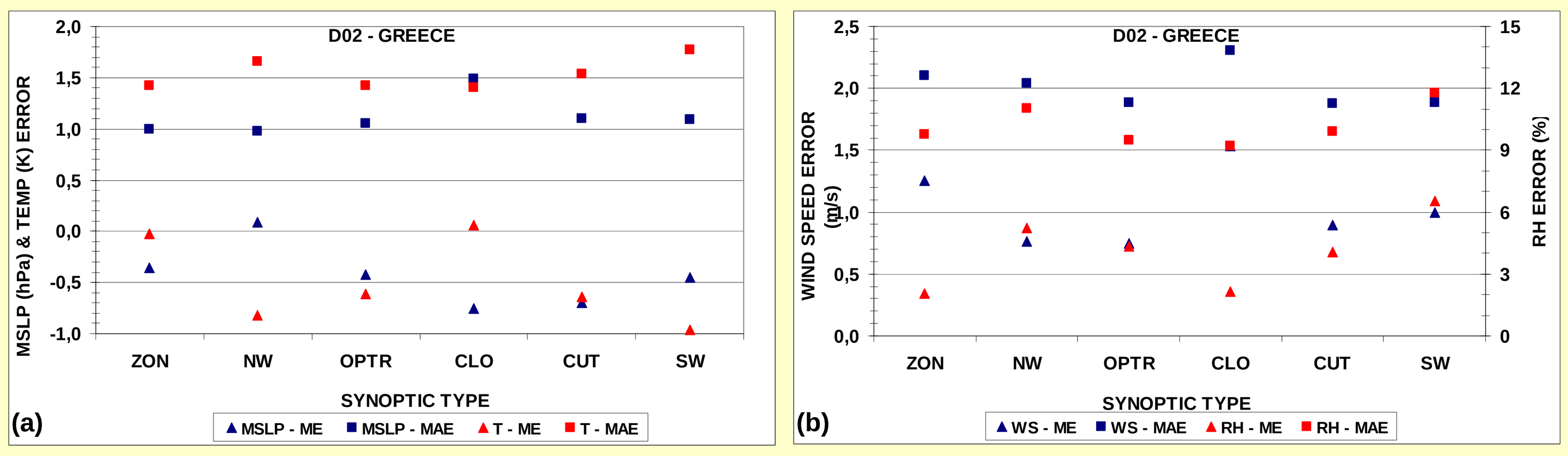

Figure 2. The Mean Error (ME) and Mean Absolute Error (MAE) of a) mean sea-level pressure, 2m air temperature, and b) 10m wind speed, 2m relative humidity (WRF-D02), at the locations of the 20 Greek stations (Fig. 1a), as a function of upper air synoptic type.

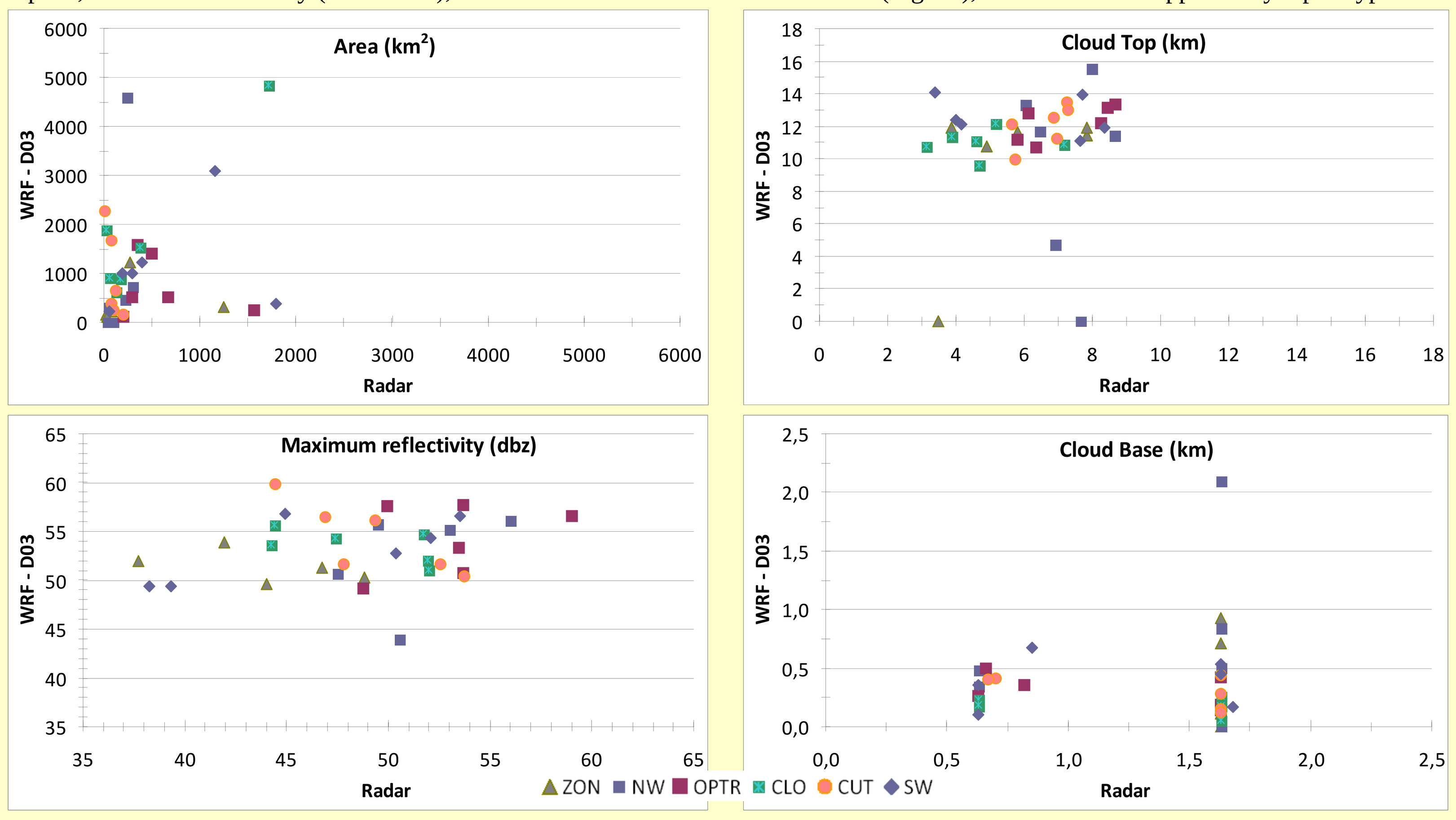

Figure 3. Scatter plots of WRF-D03 predicted vs radar max convective area, max reflectivity, max cloud top and min cloud base of all cases in the area of interest for different synoptic types using daily extreme values. Sample size=36.

	Max Area	Max Reflectivity	Cloud Top	Cloud Base
ME	618.85	1.87	4.91	-0.91
MAE	849.06	7.52	5.65	0.94

Table 1. Mean Error (ME) and Mean Absolute Error (MAE) of WRF-D03 predicted max convective area (km^2), max reflectivity (dBz), max cloud top (km) and min cloud base (km) of all cases in the area of interest using daily extreme values. Sample size=36.

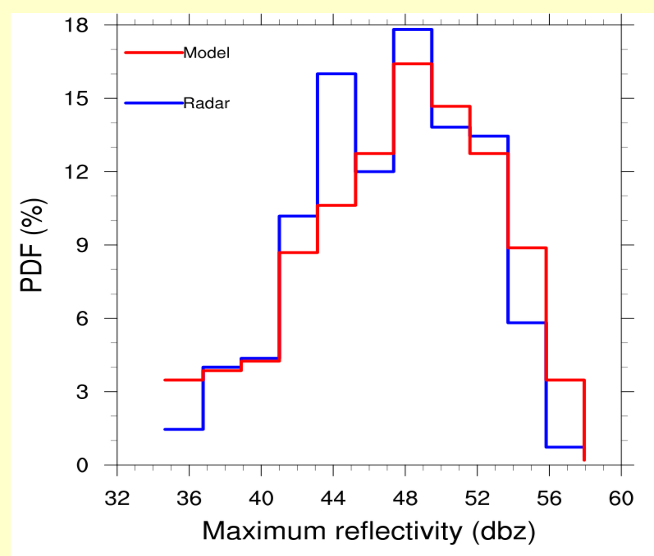

Figure 4. The frequency distribution of hourly values of WRF-D03 and radar max reflectivity in the area of interest using all events with reflectivity > 35 dBz.

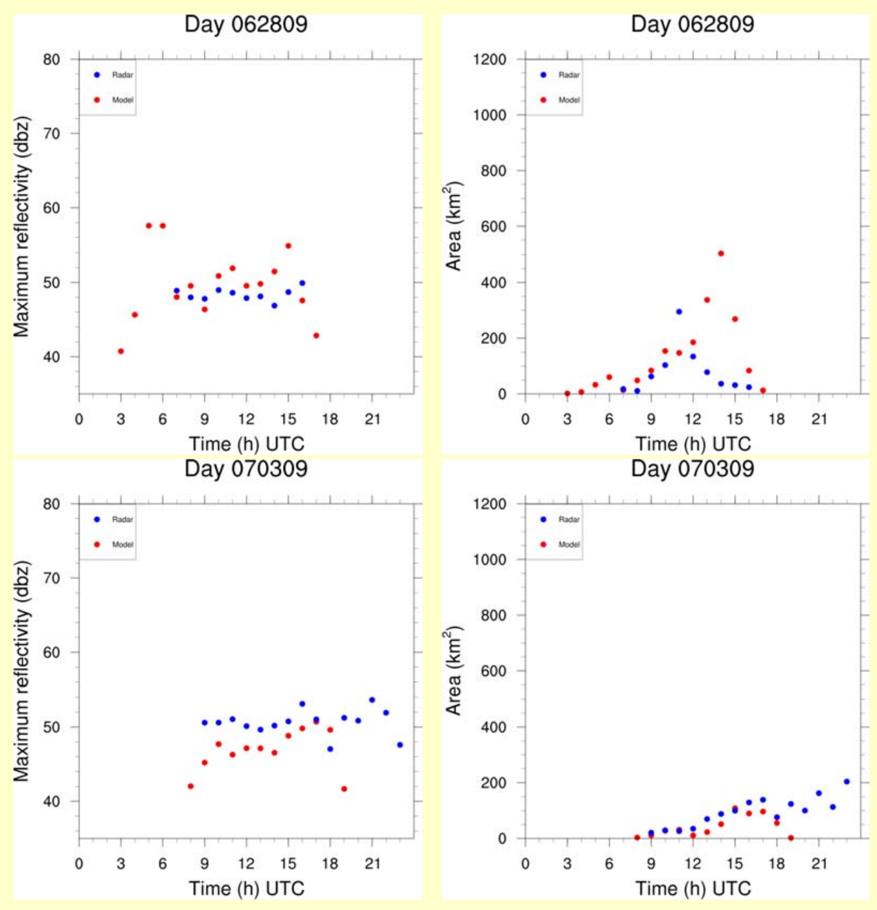

Figure 5. Timeseries of hourly values of WRF-D03 and radar max reflectivity and max convective area (at locations > 35 dBz) in the area of interest on 28 June 09 and 3 July 09.

4. DISCUSSION

- The model underestimates mslp and 2m temperature at almost all synoptic types, while it overestimates 10m wind speed and 2m relative humidity (Fig. 2). The MEs and MAEs are in agreement with the ones of our operational WRF-ARW over Greece.
- The area and max intensity of moist convection are overestimated (Fig. 3, Table 1). The cloud depth is also overestimated, mainly due to the adopted methodology. Current work tries to overcome this problem and provide more definite results on cloud depth.
- The WRF-D03 distribution of max reflectivity is in very good agreement with the observed one at all aspects (Fig. 4), except from the lack of the observed secondary peak at about 44 dBz.
  WRF simulated only one peak at about 48 dBz with an underestimation of only 1.5% in its frequency.
  The secondary peak is mainly observed in SW flow when unstable, rich in moisture, maritime air masses are advected in the area of interest. The maximization of temperature and relative humidity errors in SW flow (Fig. 2) suggests that the underestimation of the secondary peak by about 6% is likely to be associated with model initialization errors in the data sparse sea region southwest of Greece.
- In the two presented cases studies, WRF represented quite well the intensity, the area and the time evolution of the convective activity, despite some discrepancies on the onset and termination of activity (Fig. 5).
- Further work is underway utilizing more cases of all the prevailing synoptic categories in this area.

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