16th Annual WRF Users' Workshop | Boulder, Colorado | USA | 15 - 19 June 2015

VERIFICATION OF THE OPERATIONAL HIGH-RESOLUTION WRF FORECASTS PRODUCED BY WAVEFORUS PROJECT

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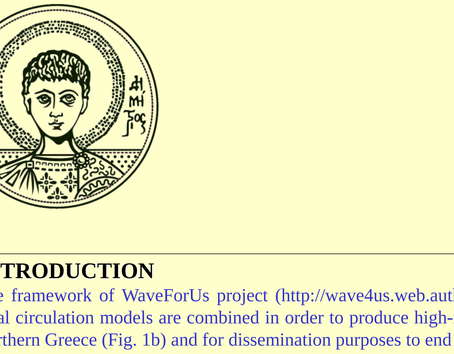
1.INTRODUCTION

In the framework of WaveForUs project (http://wave4us.web.auth.gr) the most recent meteorological, storm surge, wave and coastal circulation models are combined in order to produce high-resolution operational sea-state forecasts for Thermaikos Gulf in northern Greece (Fig. 1b) and for dissemination purposes to end users and the public.

The goal of this research is to investigate the performance of the operational numerical weather predictions produced by WaveForUs project.

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) – Central & Eastern Mediterranean 1.667km x 1.667km (D03) – Northern Greece
Initial time:	1200 UTC daily (D02 and D03 initialized at T+6 in order to reduce model spin-up)
Duration:	96 hours (4 days)
Vertical levels:	39 sigma levels (up to 50 hPa)
Initial and lateral boundary conditions:	NCEP/GFS operational analyses and 3-hourly forecasts (0.5°x0.5° lat.-long.)
Sea-Surface Temperatures:	NCEP operational analyses (0.083°x0.083° lat.-long.)
Microphysics:	Ferrier
Cumulus convection:	Betts-Miller-Janjic
Longwave/ Shortwave Radiation:	RRTMG
Surface Layer:	Monin-Obukhov (Eta) scheme
Boundary layer:	Mellor-Yamada-Janjic
Soil Processes:	NOAH Unified model



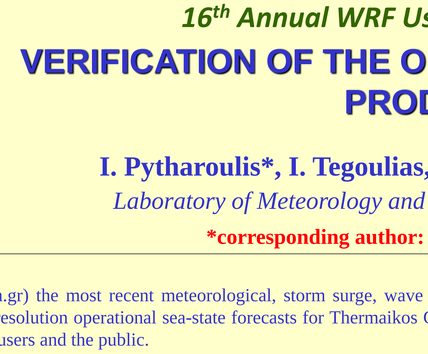


Figure 1. The topography (m) of (a) the first – D01 and (b) the third – D03 nest used by the operational WRF-ARW forecasting system of WaveForUs project. D02 (red box) and D03 (yellow box) are depicted in panel (a). The locations of the utilized stations of the Hellenic National Meteorological Service are also indicated in panel (a). The airports of Thessaloniki (LGTS) and Larissa (LGLR) are shown in red colour.

Period of interest: March 2014 - February 2015

Statistical evaluation has been performed, using the operational gridded ECMWF analyses and the available meteorological stations of the World Meteorological Organization network in D02 (up to 92 stations) and D03. The available 17 stations of the Hellenic National Meteorological Service (HNMS) are shown in Fig. 1a.

The mean sea-level pressure (mslp), 10m wind speed (WS10m), 2m air temperature (T2m), 2m relative humidity (RH2m) and total 12-hourly accumulated precipitation (06-18 & 18-06 UTC) have been studied.

The variability of the scores, with the synoptic circulation type that prevailed in Greece, has been examined using the 10 upper-air categories of Karacostas et al. (1992): 1) zonal flow (ZON), 2) northwest flow (NW), 3) open trough (OPTR), 4) closed low (CLOL), 5) cut-off low (CUTL), 6) southwest flow (SW), 7) open ridge (OPRG), 8) closed high (CLOH), 9) omega blocking (OME) and 10) undefined (High – Low) cases.

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3. RESULTS

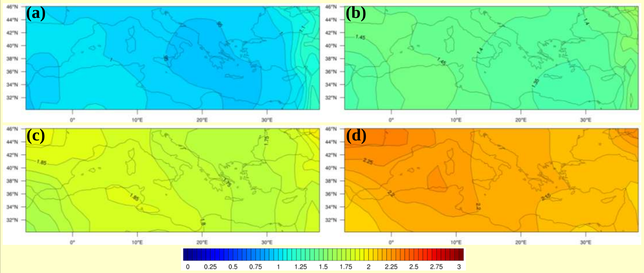

Figure 2. The Mean Absolute Error (hPa) of the mean sea-level pressure forecasts of D01 at a) T+24, b) T+48, c) T+72 and d) T+96 hours against the operational ECMWF analyses for the period of March 2014 – February 2015.

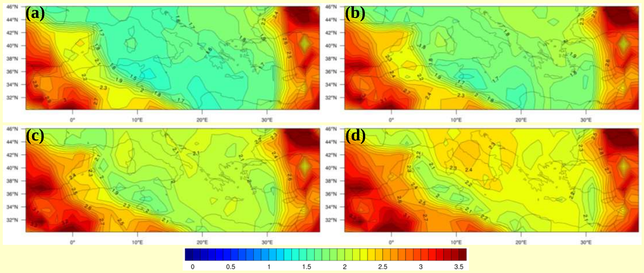

Figure 3. The Mean Absolute Error (m/s) of the 10m wind speed forecasts of D01 at a) T+24, b) T+48, c) T+72 and d) T+96 hours against the operational ECMWF analyses for the period of March 2014 – February 2015.

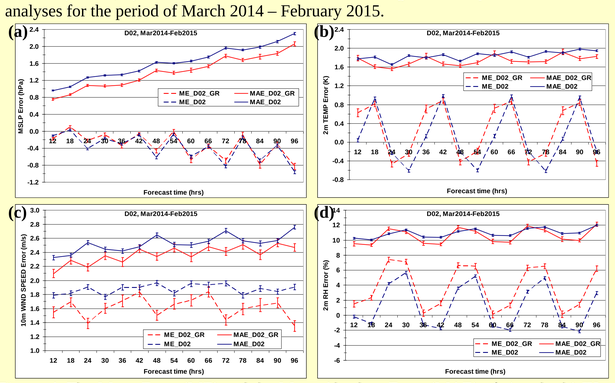

Figure 4. The Mean Error (ME) and the Mean Absolute Error (MAE) of a) mslp, b) T2m, c) WS10m and d) RH2m forecasts of WRF-D02 at the locations of all the available stations (D02) and the Greek stations (D02-GR). The 95% confidence intervals are indicated.

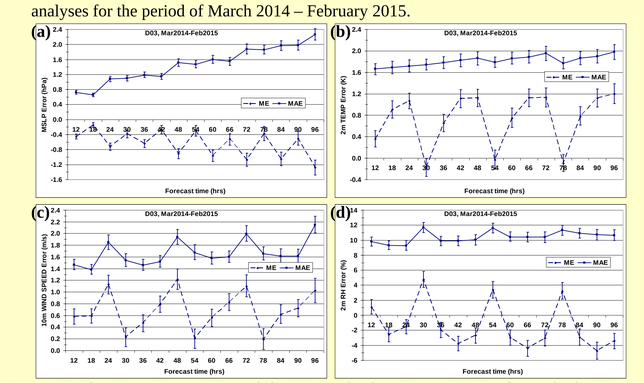

Figure 5. The Mean Error (ME) and the Mean Absolute Error (MAE) of a) mslp, b) T2m, c) WS10m and d) RH2m forecasts of WRF-D03 at the locations of Thessaloniki (LGTS) and Larissa (LGLR) airports. The 95% confidence intervals are indicated.

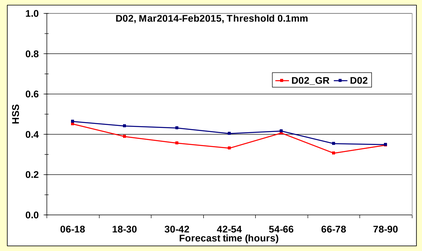

Figure 6. Heidke Skill Score (HSS) of the 12-hourly precipitation forecasts of WRF-D02 at the threshold of 0.1mm at the locations of all the available stations (D02) and the Greek stations (D02-GR).

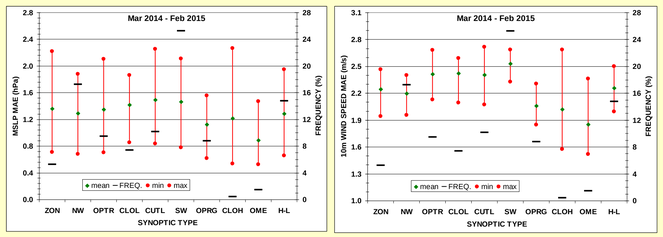

Figure 7. MAE of mslp (hPa) and WS10m (m/s) forecasts of WRF-D02 at the 17 HNMS stations versus the synoptic type from March 2014 to February 2015. The frequency of occurrence (%) of each synoptic type is indicated. The MAEs correspond to the forecasts from T+12 hrs to T+96 hrs.

4. DISCUSSION

- The MAE of WRF-D01 forecasts of mslp (against the ECMWF analyses) ranges from about 0.95 hPa at T+24 hrs to about 2.15 hPa at T+96 hrs in Greece (Fig. 2). The MAE of WS10m in D01 varies from 1.6-1.7 m/s at T+24 hrs to about 2.2-2.3 m/s at T+96 hrs (Fig. 3).
- In D02 and D03, the model underestimates the mslp and systematically overestimates WS10m (Figs. 4, 5). In D02, the maximum (minimum) daily temperatures are underestimated (overestimated). In Greece, the WRF-D02 MAE of mslp ranges from about 0.8 to 2.1 hPa, the one of T2m varies between 1.6 and 1.9 K, the error of WS10m lies between 2.1 and 2.5 m/s, while that of RH2m is at about 9-12% (Fig. 4). At Thessaloniki and Larissa airports, the WRF-D03 MAEs of mslp, WS10m, T2m and RH2m range between 0.7-2.3hPa, 1.4-2.1m/s, 1.7-2.0K and 9-12%, respectively (Fig. 5). The predictability of WS10m, T2m and RH2m appears to be maintained with forecast time.
- The Heidke Skill Score of the 12-hourly precipitation forecasts of WRF-D02, taking into account all the events (> 0.1mm/12hours), varies from 0.46 in the first forecast day to 0.35 in the fourth forecast day (Fig. 6).
- The most frequently observed upper air synoptic type in Greece from March 2014 to February 2015 was the SW flow (25.3%). Figure 7 shows that the largest mean errors of mslp were associated with cut-off lows (1.5 hPa), followed by SW flow and closed lows, while the largest mean errors of WS10m occurred in SW flow (about 2.5 m/s).

ACKNOWLEDGMENTS

This research is co-financed by the European Union (European Regional Development Fund) and Greek national funds, through the action "COOPERATION 2011: Partnerships of Production and Research Institutions in Focused Research and Technology Sectors" (contract number 11SYN_9_975 – WaveForUs project) in the framework of the operational programme "Competitiveness and Entrepreneurship" and Regions in Transition (OPC II, NSRF 2007-2013).