THE SURFACE WIND SIMULATION OVER THE PERSIAN GULF

by

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ABSTRACT

An accurate estimation of the near-surface wind field over the sea is a prerequisite for many engineering and scientific activities in the offshore and coastal areas. As an example, the proper assessment of the wind waves as the most important factor in the design of coastal and offshore structures is highly depended on the accurate estimation of the wind fields. Ocean circulation, morphological processes, coastal management, design and operability of the ports and pollution transport studies are some other activities that directly or indirectly require appropriate knowledge about surface wind field. Therefore, accessibility of the accurate wind data is a major challenge of academic and industrial society.

The main purpose of this study is to simulate the Wind field over the Persian Gulf using WRF meso-scale model and to investigate its effective parameters. This study is a part of a comprehensive project named monitoring and modeling studies of Khuzestan province coastal areas. In this regard, ARW Dynamical core of WRF version 8-3 was used that has been developed by NOAA. Two nested computational domain was defined over Persian Gulf and the neighborhood coastal areas. The coarse domain included 0.3 degree resolution grids and the fine one included 0.1 degree resolution grid. It was found that using ECMWF Era Interim data as the initial and boundary condition of WRF model leads to better results rather than those of FNL data. In Addition, USGS, MODIS and Gtopo30 data sets were employed as static and terrestrial data including Albedo, green fraction, soil humidity, soil temperature, landuse and etc. It was revealed that selection of the appropriate boundary and initial condition and location of the computational domain have significant effect on the simulation of the surface wind field over the Persian Gulf. In order to validate WRF performance in surface wind field simulation over Persian Gulf, the model outputs were compared with different measurements including buoys, synoptic and satellite observations.
The assessment of WRF outputs depicts that WRF model can accurately simulate both stormy and calm winds also during cold and warm seasons that are affected by different atmospheric conditions and global circulations. To quantitatively compare, error Indices represent acceptable performance of WRF model in wind simulation over study area. For example, wind speed correlation coefficient at Bushehr Buoy and AbuDhaby International Airport synoptic stations are 0.82 and 0.78 respectively, while Root Mean Square Error for these stations are 1.60 and 1.56 m/s, respectively. The Bias Parameter for these stations are -0.54 and -0.88, respectively. The Outputs of the WRF model will be used in other hydrodynamic models for simulating waves, currents etc.

1. INTRODUCTION

Surface wind field is one of the most important factors in the generation of the marine hydrodynamic phenomena. Therefore, accessibility to the correct wind field is of great importance for accurate prediction and simulation of the hydrodynamic variables. Nowadays numerical mesoscale weather models are widely applied as powerful tools to simulate wind and other atmospheric variables with predefined temporal and spatial resolution in desired areas. Despite appropriate results of the

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numerical models in many regions, there are still some complications in the simulation of the surface wind field especially over the enclosed and semi-enclosed basins with complex orography since the surface wind field is highly affected by the local topography, land-sea discontinuity, temperature gradient etc. [1].
The main goal of the current study is to simulate surface wind field over the Persian Gulf considering by WRF modeling system, which is one of the main tasks of the project of monitoring and modeling studies of Khouzestan province coasts. To verify the model results, the simulated wind speeds were compared with meteorological and buoy measurements and satellite observations.

2. Data and Methodology

In the present research, ARW dynamical core of WRF model V3.8 was employed to simulate surface wind field over the Persian Gulf. Two nested domains were considered for model configuration with 0.3 and 0.1 degree resolutions for coarse and fine domains alternatively, which is presented in Fig. 1. Also, 38 vertical levels are used in the model.

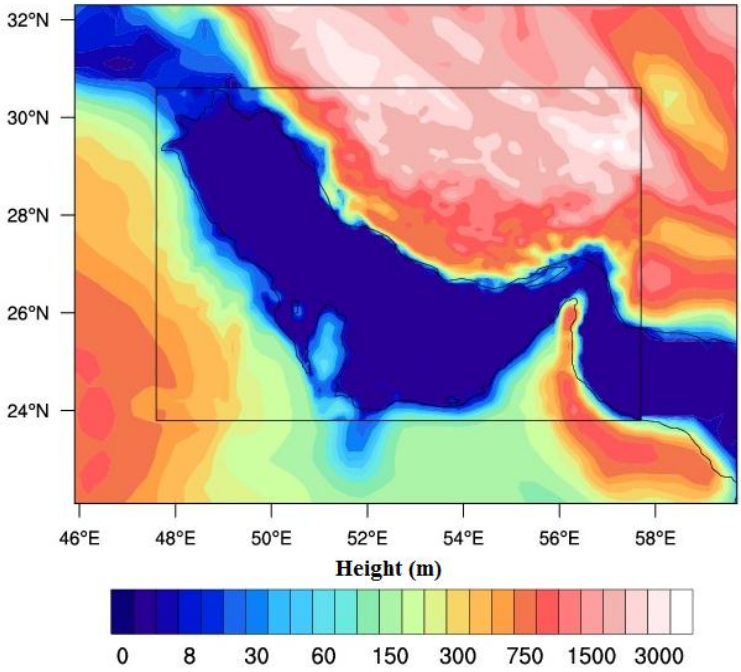

Fig. 1: The modeling domain

ECMWF Era interim data set with 0.75 degree resolution was used for initial and boundary condition of WRF modeling system. The boundary condition updated every 6 hour and the initial condition updated every 30 hour with 6 hour spin-up time. Also, USGS, MODIS and Gtopo30 data sets were employed as static and terrestrial data including Albedo, green fraction, soil humidity, soil temperature, landuse and etc In addition, the Asymmetric Convective Model Version 2 ACM2 scheme for the planetary boundary layer, Pleim-xiu land surface model for land surface and surface layer, Thompson scheme for microphysics, Rapid Radiative Transfer Model for longwave radiation Dudhia scheme for shortwave radiation and Kain–Fritsch scheme for cumulus for Physical parameterization were used.
Furthermore, synoptic and ASCAT satellite observations are used to verify WRF model performance in surface wind simulation over the Persian Gulf. Four synoptic stations which are named Bushehr, Wafra, King Fahad International Airport (KFIA) and Abudhabi are selected in different locations of the Persian Gulf to estimate model results over coastal areas. Busher synoptic station is located in northern coast of Persian Gulf while the others are located in southern coasts.
And three point of ASCAT satellite are opted in the offshore area to assess offshore simulated wind. The location of observations is shown at Fig 2.

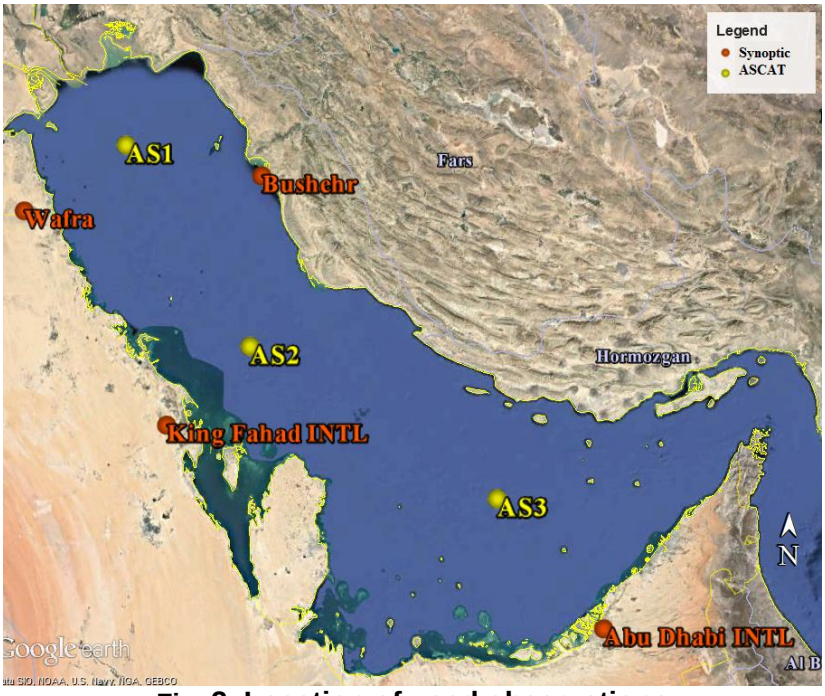

Fig. 2: Location of used observations

3. Results

In the present study, WRF model results are verified during two different season of the study area by comparing 10 meter wind speed and its components with above mentioned observations.
Table 1 presents error indices; correlation coefficient, Root Mean Square and Bias, of the simulations wind speed and wind components at U and V directions, with the mentioned synoptic stations data. According to the error indices, WRF model simulated data have a good accuracy.
Also, Fig. 3 to Fig 9 display time series of WRF simulated wind and its components with Bushehr, Wrra, KFIA and Abudhabi synoptic stations alternatively in February and June 2008. As seen in these figures simulated wind speed has good agreement with synoptic data, the agreements is more significant in the southern part of Persian Gulf such as Wafra, KFIA and Abudhabi due to smooth topography in this region.

Station	Month	February			June		
	Parameter	WSPD	U	V	WSPD	U	V
Bushehr	CC	0.78	0.48	0.91	0.70	0.54	0.79
	BIAS	-0.14	0.49	1.03	-0.25	0.98	1.26
	RMSE	1.92	2.89	2.52	1.81	2.37	2.31
Wafra	CC	0.85	0.89	0.94	0.88	0.86	0.87
	BIAS	0.28	-0.21	-0.08	0.16	-0.18	-0.01
	RMSE	1.25	1.31	1.25	1.37	1.41	1.54
KFIA	CC	0.86	0.88	0.92	0.84	0.78	0.90
	BIAS	-0.77	-0.95	0.03	-0.87	-1.34	0.20
	RMSE	1.78	2.16	1.62	2.05	2.36	1.84
Abudhabi	CC	0.87	0.91	0.82	0.86	0.84	0.86
	BIAS	-0.79	-0.60	0.43	-0.56	-0.13	-0.07
	RMSE	1.56	1.66	1.71	1.30	1.58	1.44

Table 1: Error indices with synoptic stations

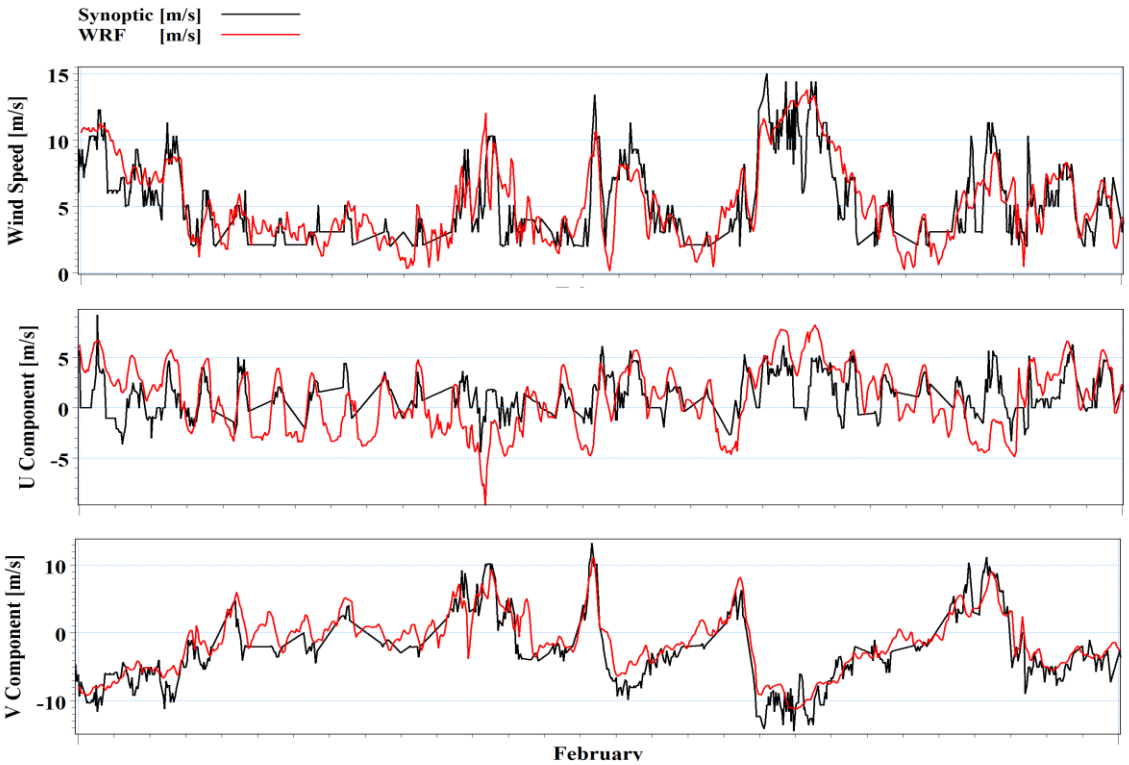

Fig. 3: Comparison between simulated (red) and Bushehr synoptic station (red) data, wind speed (top) U (middle) and V (down) component during February 2008

Fig. 4: Comparison between simulated (red) and Bushehr synoptic station (red) data, wind speed (top) U (middle) and V (down) component during June 2008

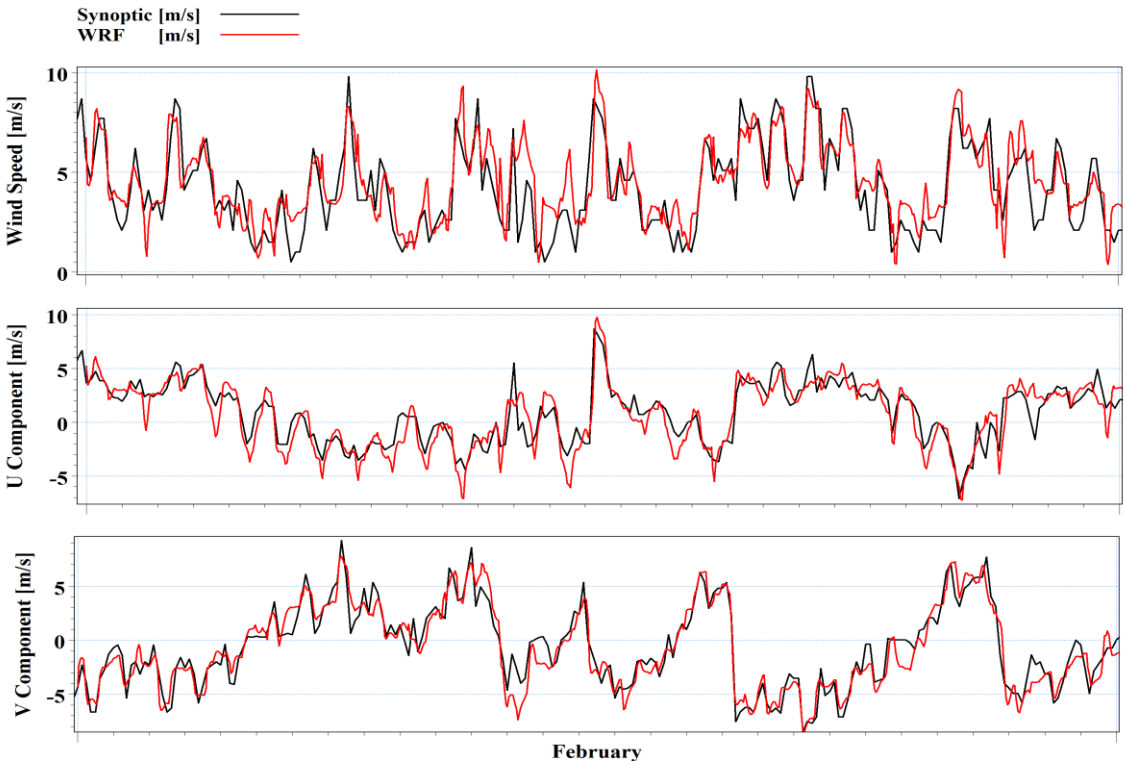

Fig. 4: Comparison between simulated (red) and Wafra synoptic station (red) data, wind speed (top) U (middle) and V (down) component during February 2008

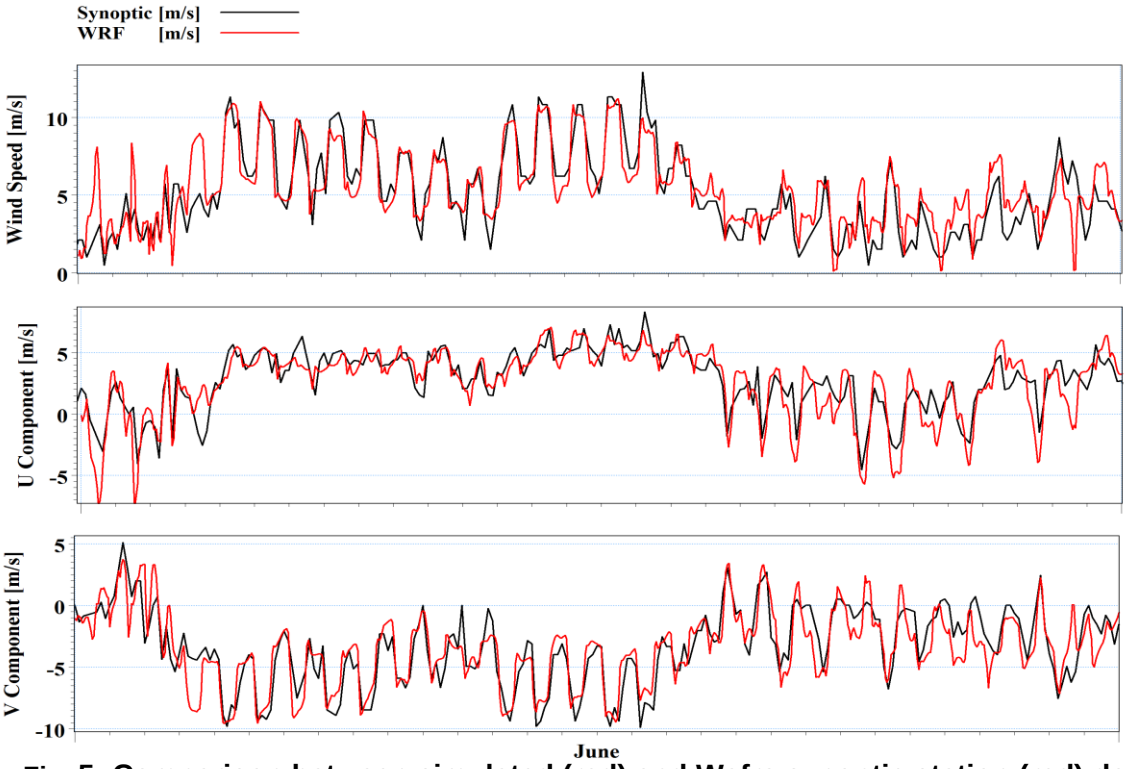

Fig. 5: Comparison between simulated (red) and Wafra synoptic station (red) data, wind speed (top) U (middle) and V (down) component during June 2008

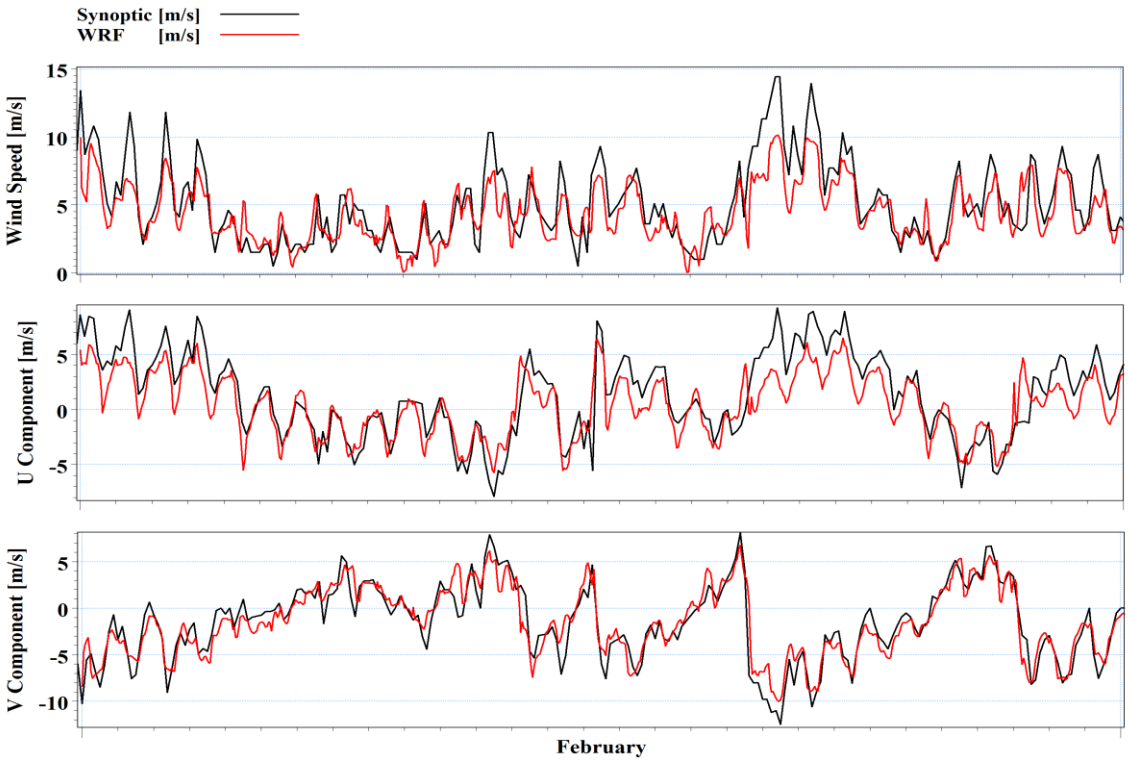

Fig. 6: Comparison between simulated (red) and KFIA synoptic station (red) data, wind speed (top) U (middle) and V (down) component during February 2008

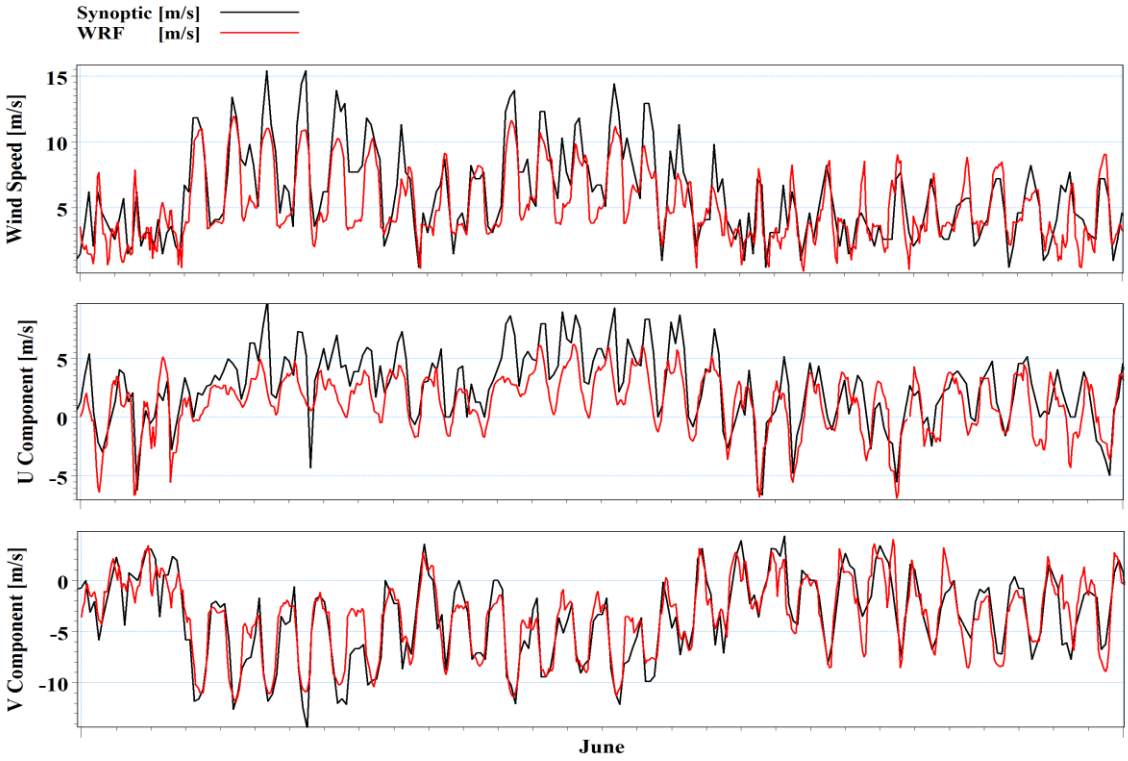

Fig. 7: Comparison between simulated (red) and KFIA synoptic station (red) data, wind speed (top) U (middle) and V (down) component during June 2008

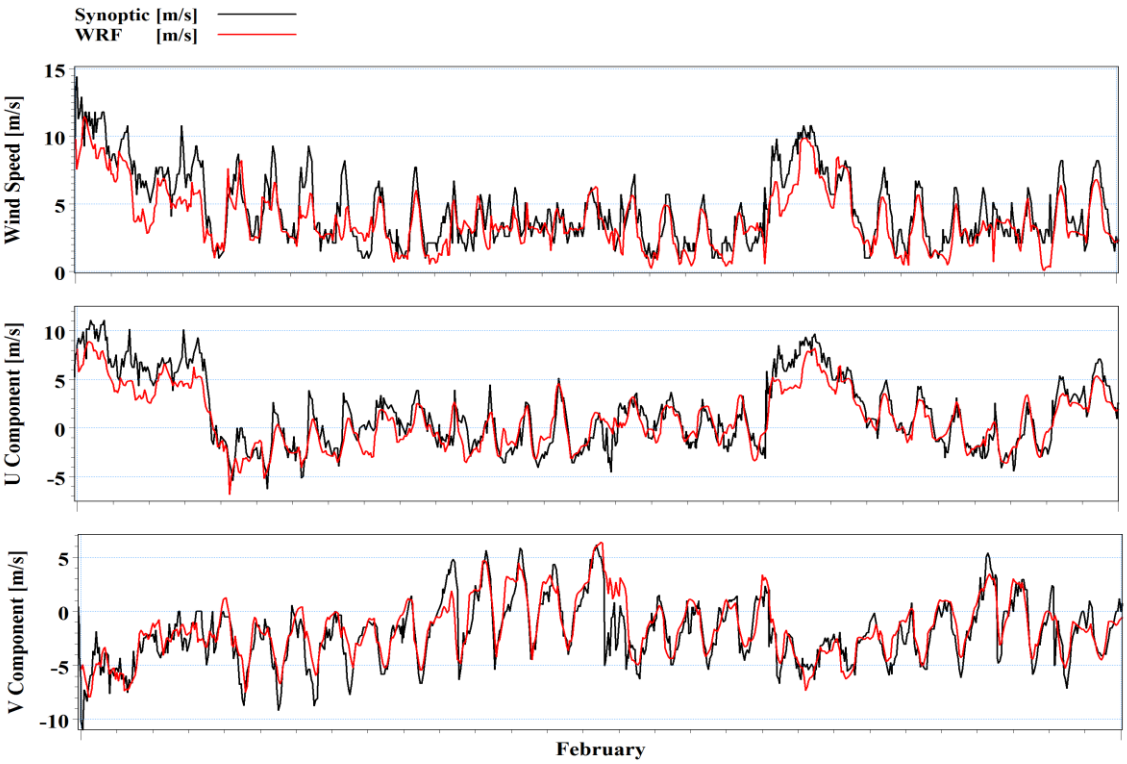

Fig. 8: Comparison between simulated (red) and Abu-Dhabi synoptic station (red) data, wind speed (top) U (middle) and V (down) component during February 2008

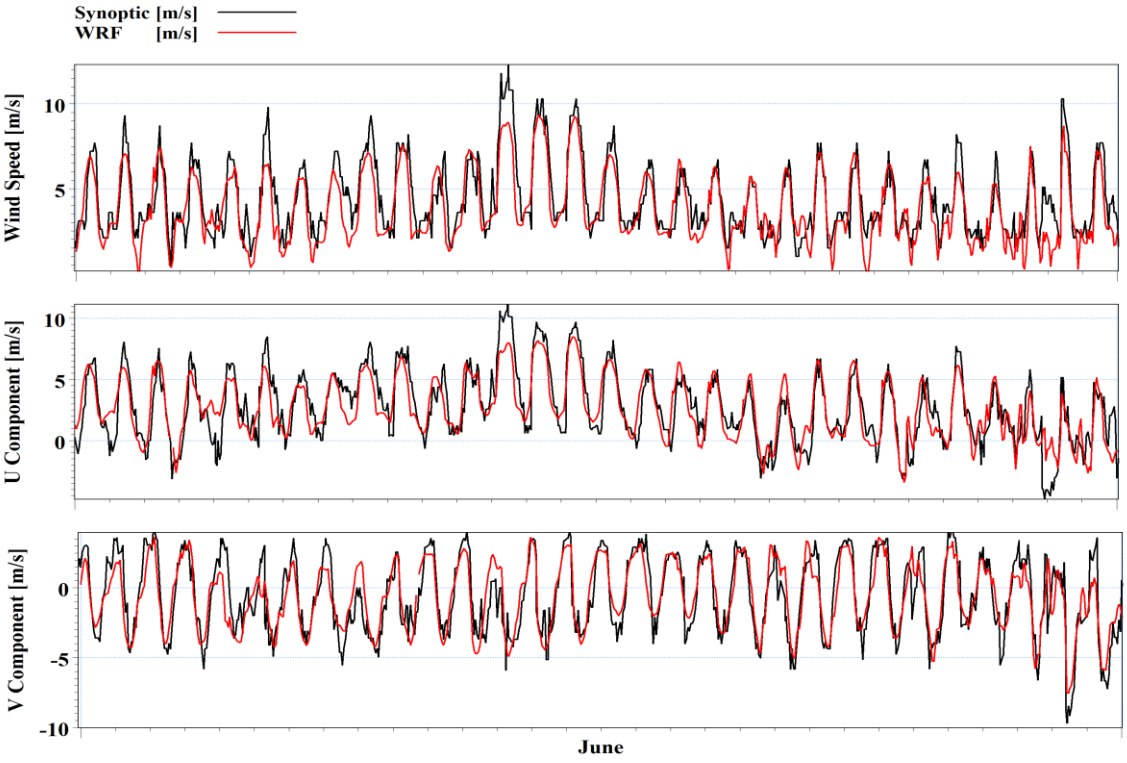

Fig. 9: Comparison between simulated (red) and Abu-Dhabi synoptic station (red) data, wind speed (top) U (middle) and V (down) component during June 2008

Regarding charts of Fig.9m that presents Abudhabi synoptic station, wind speed and components during June 2008, the see-land breeze circulation obviously predicted by WRF model, which is main characteristic of coastal areas during warm months. That demonstrate the model able to simulate local phenomena too.
Furthermore, WRF wind outputs were compared with ASCAT satellite observations in 3 points; AS1, AS2 and AS3; on the middle of Persian Gulf. The calculated error indices are presented in Table 2 same as synoptic stations. The results express high accuracy of simulated wind field over offshore area of Persian Gulf.
In the continue, Fig. 10 to 15 represent time series of wind speed, U and V component of wind in the AS1 to AS3 that is display how simulated wind follow the observation accurately.

Station	Month	February			June		
	Parameter	WSPD	U	V	WSPD	U	V
AS1	CC	0.94	0.96	0.97	0.94	0.87	0.89
	BIAS	0.47	0.46	-0.16	1.79	1.15	-0.76
	RMSE	1.11	1.14	1.25	2.04	1.73	1.93
AS2	CC	0.81	0.95	0.95	0.97	0.88	0.95
	BIAS	-0.51	-1.52	0.97	0.46	0.11	-0.30
	RMSE	2.04	2.00	1.95	1.05	1.25	1.09
AS3	CC	0.96	0.94	0.96	0.90	0.88	0.65
	BIAS	0.47	-0.17	-0.18	1.54	1.27	-0.90
	RMSE	1.17	1.66	1.06	2.02	1.98	2.12

Table 2: Error indices with ASCAT satellite observations

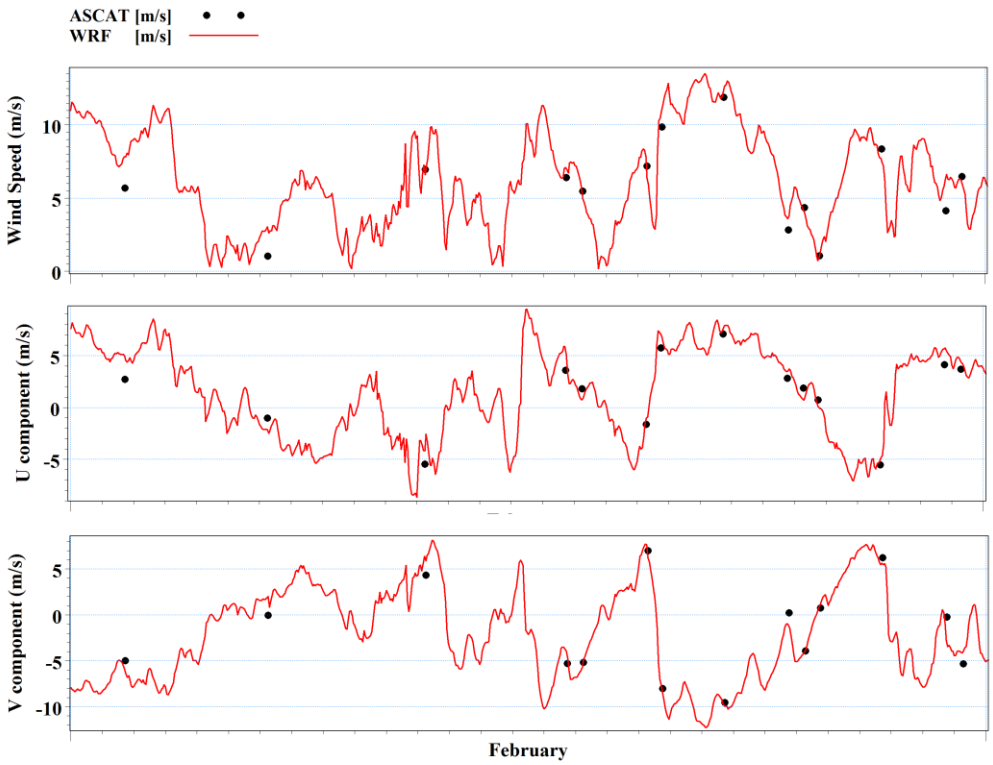

Fig. 10: Comparison between simulated (red) and AS1 point (red) data, wind speed (top) U (middle) and V (down) component during February 2008

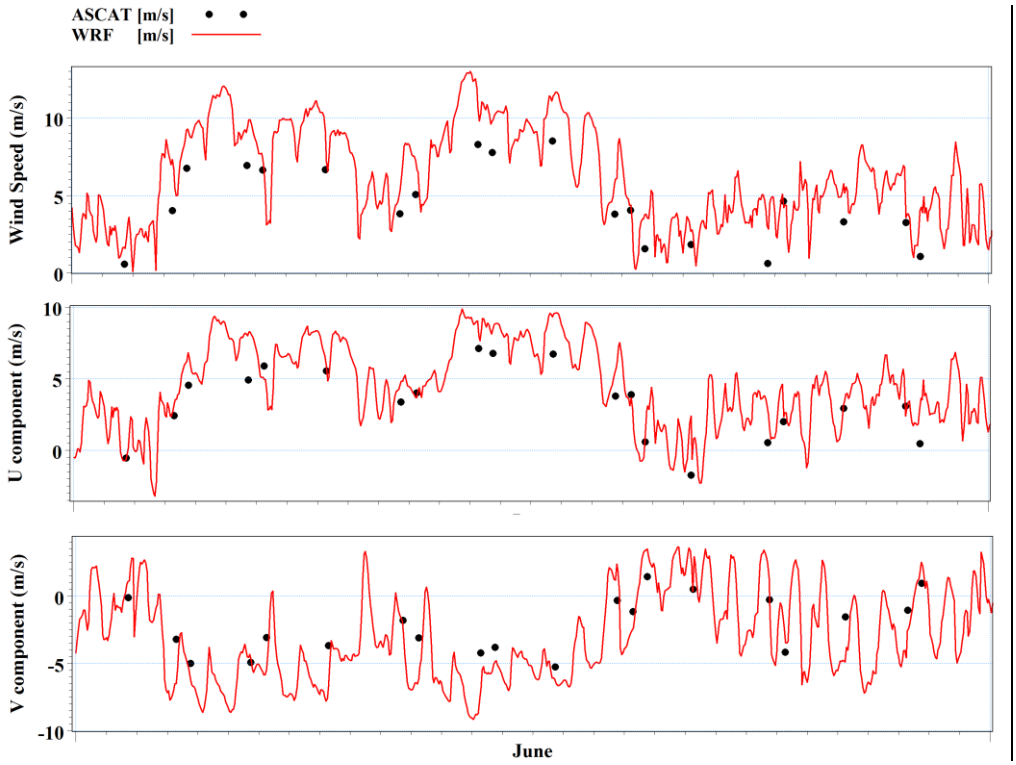

Fig. 11: Comparison between simulated (red) and AS1 point (red) data, wind speed (top) U (middle) and V (down) component during June 2008

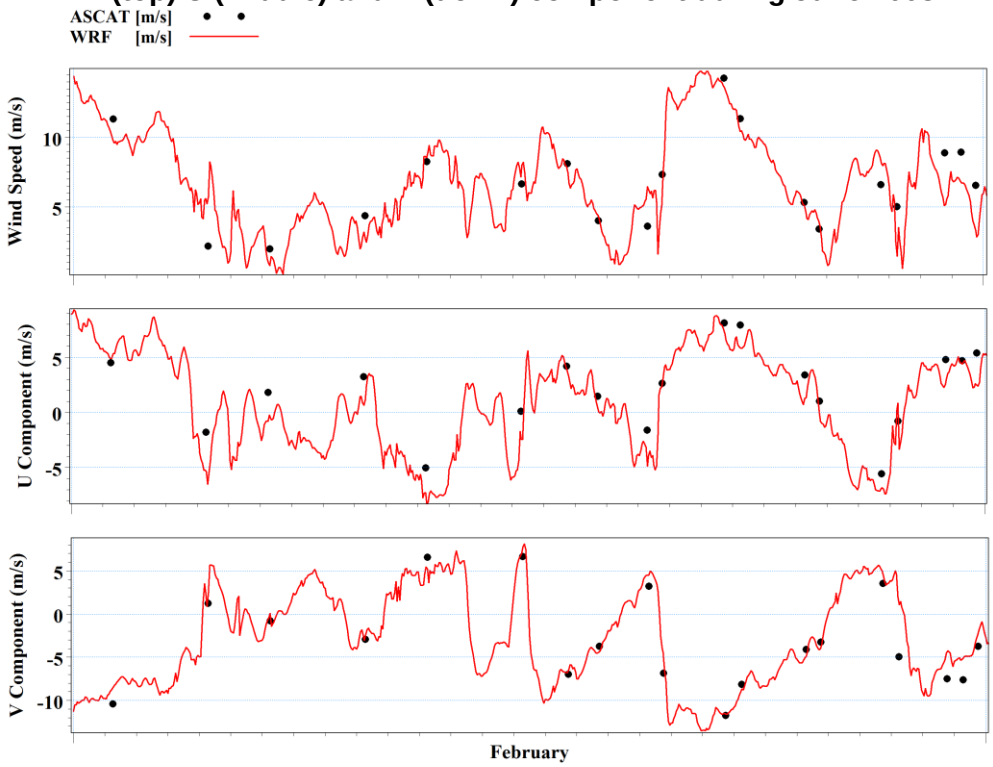

Fig. 12: Comparison between simulated (red) and AS2 point (red) data, wind speed (top) U (middle) and V (down) component during February 2008

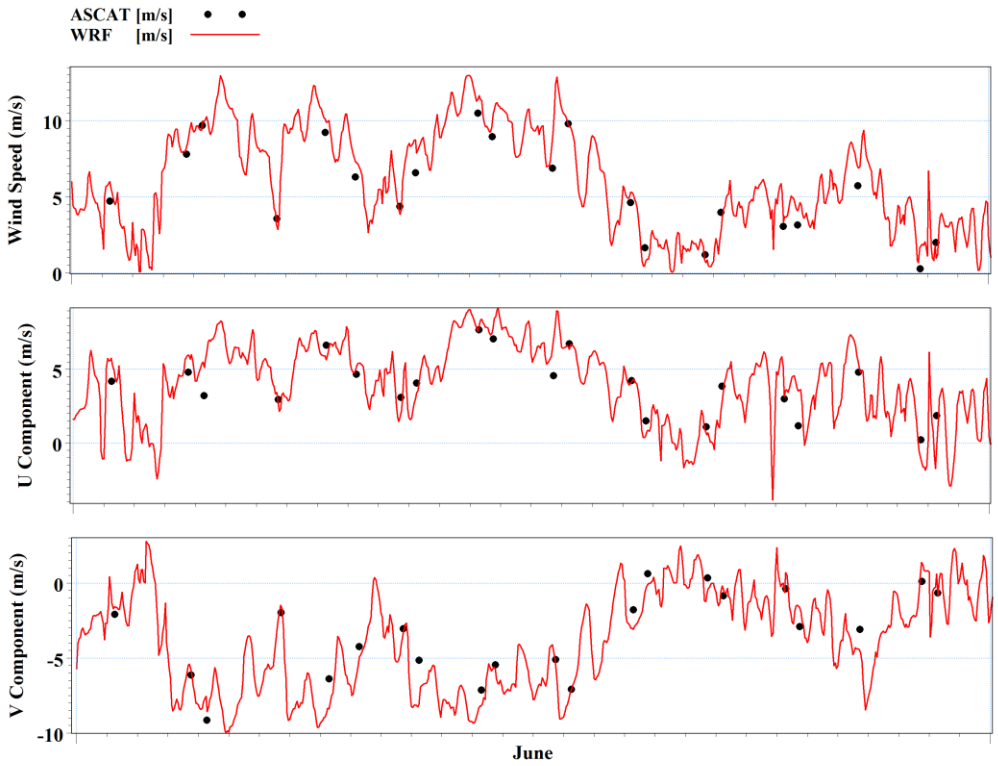

Fig. 13: Comparison between simulated (red) and AS2 point (red) data, wind speed (top) U (middle) and V (down) component during June 2008

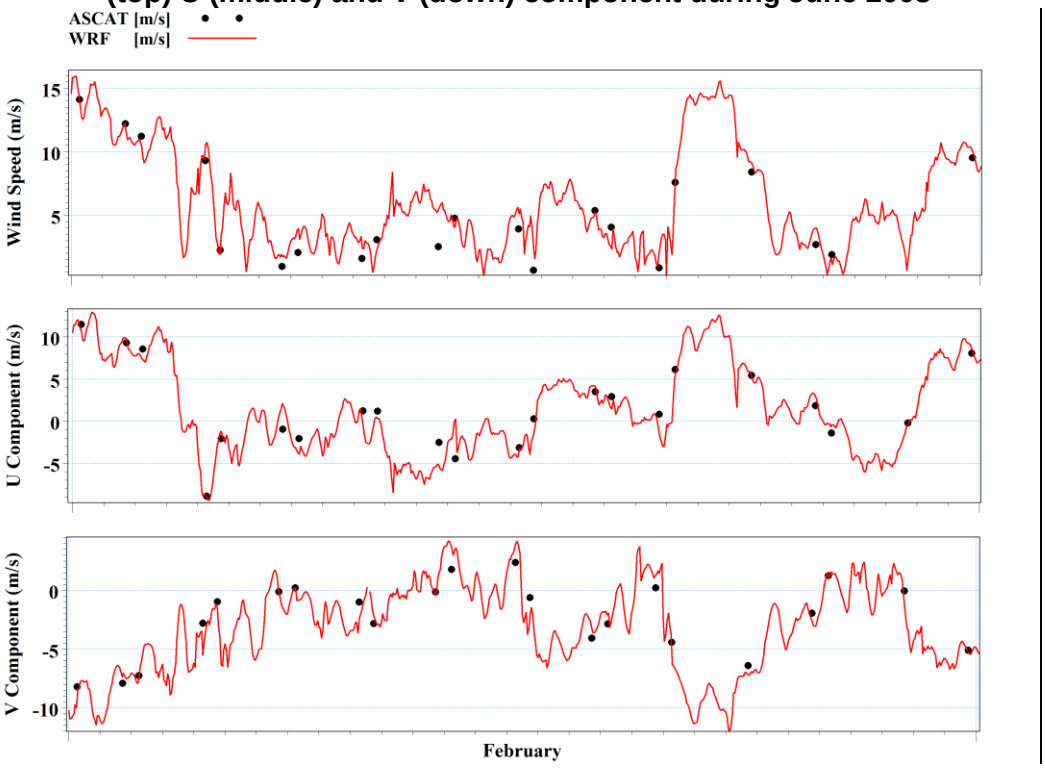

Fig. 14: Comparison between simulated (red) and AS3 point (red) data, wind speed (top) U (middle) and V (down) component during February 2008

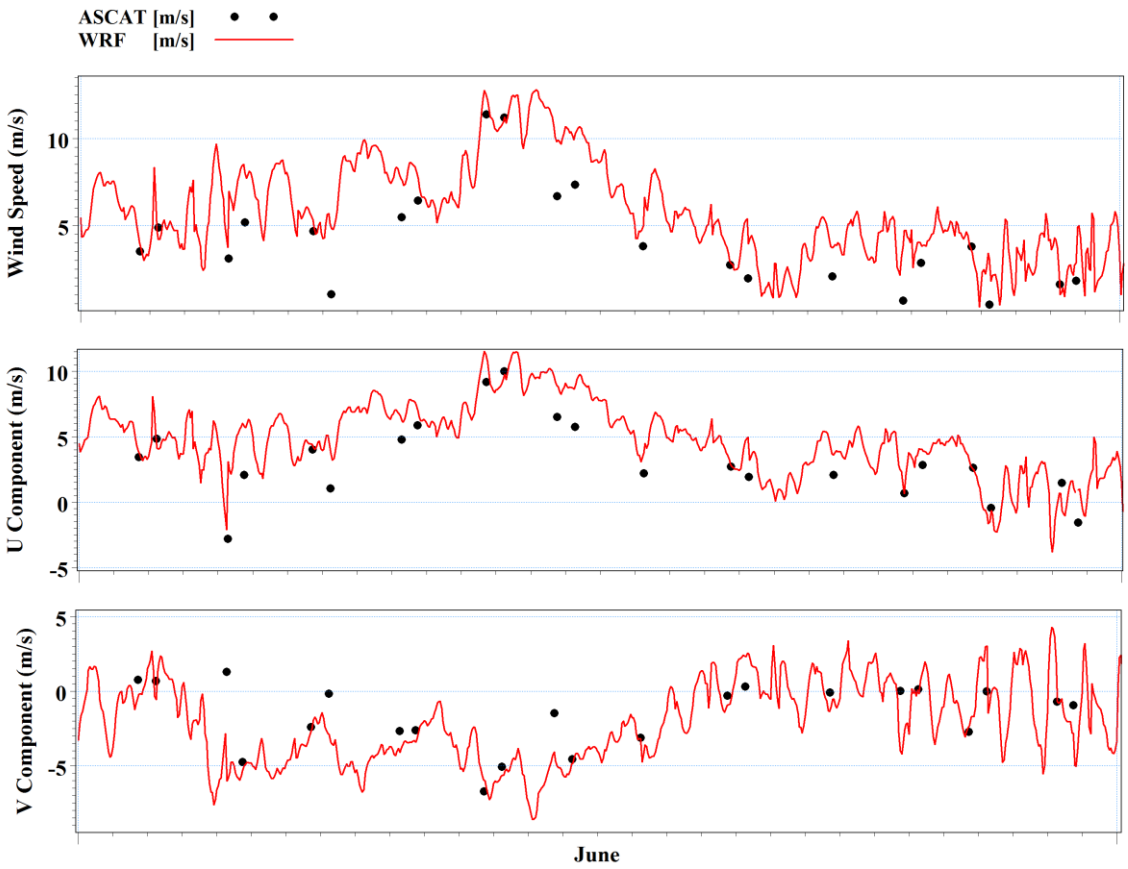

Fig. 15: Comparison between simulated (red) and AS3 point (red) data, wind speed (top) U (middle) and V (down) component during June 2008

Conclusion

The study evaluate WRF ARW model version 3.8 in simulating wind field over Persian Gulf. According to presented results, WRF model has good accuracy in both coastal and offshore zones, also the model performance is quiet well during both stormy and calm periods.

Acknowlegment

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Keywords

WRF, wind, Offshore, Coastal, Persian Gulf

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