WRF Mircophysics Performance in Forecasting Rotor Events in Las Vegas

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1. Introduction

Severe downslope wind and rotor events occur throughout the United States. These events often cause large amounts of wind damage to property and dangerous conditions for aviation. Much analysis has been done on the dynamics and certain mesoscale parameters of the rotors. These results have been used to better forecast models for areas that experience these events often. However, most of these forecast models still lack a certain accuracy and timing. Especially when considering the microphysics that accompany rotors.

Regarding microphysical effects on rotors, a study using RAMS model found that level 3 bulk microphysics schemes produced much more accurate wind speed results than the level 2 bulk microphysics schemes in a Fort Collins, Colorado rotor event (Cotton et al. 1993). However, a more recent study using the WRF model found that the Thompson et al. microphysics scheme produced the most accurate data in wind speed, temperature, and precipitation when compared to observation sites in an area around Mt. Öræfajökull in South Iceland (Rögnvaldsson et al. 2011). It is obvious that microphysics plays a role is accuracy of forecasting rotors and severe downslope wind events.

In the present study, in order to better understand the effects of the microphysical process on the mesoscale factors of the rotor events in the Las Vegas and San Bernardino areas, we compare and examine the outputs of two case studies ran with six different microphysics schemes from a high resolution WRF model with observed data.

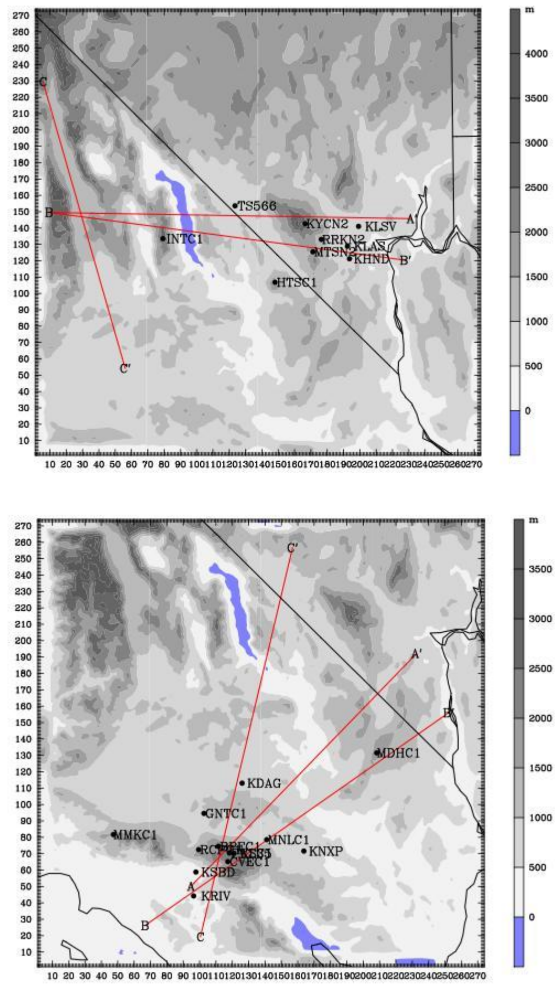

Figure 1. Domain 2 for the (a) 27 April 2010 event and the (b) 20 March 2011 event

2. Numerical Model and Experimental Design

The WRF ARW Version 3.3 model was used to produce the synthetic results for the 27 April 2010 and 20 March 2011 rotor events. A two way nested simulation is configured with the grid spacing of 4 km and 1 km for the domains 1 and 2. Figure 1a and 1b show the domain 2 configurations, RAWS station locations, vertical

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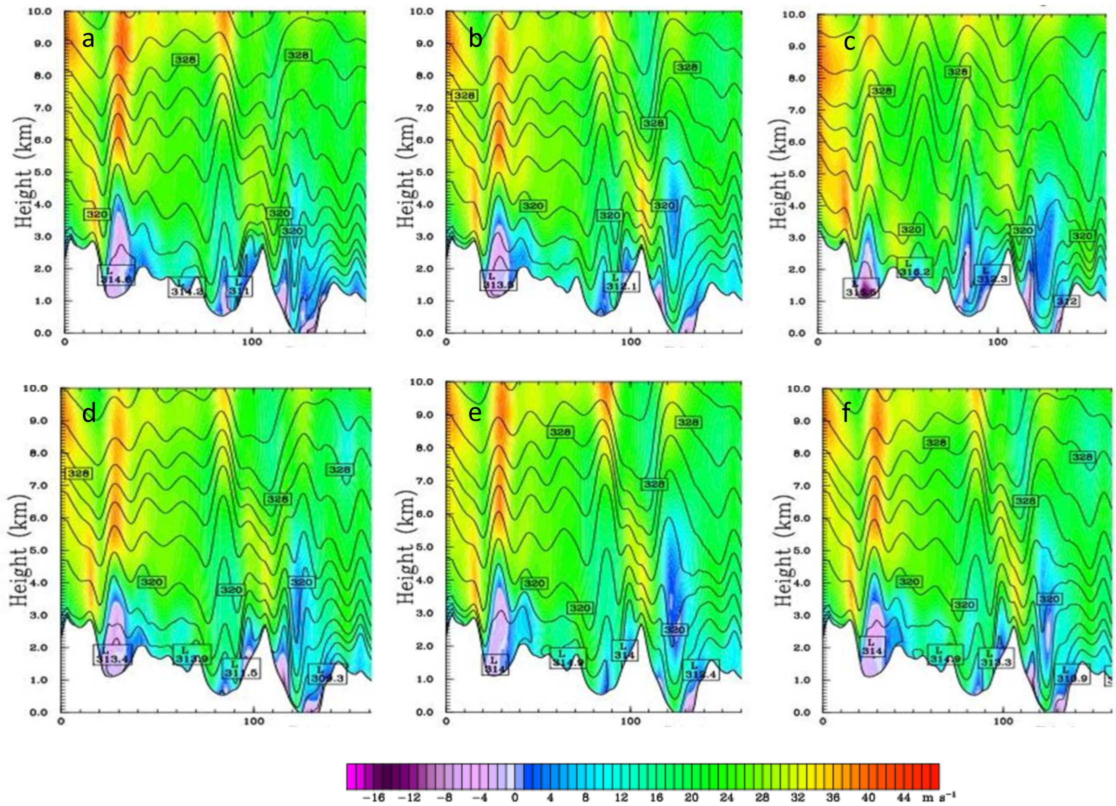

Figure 2. April event cross section AA' showing horizontal wind component parallel to AA' (color) and equivalent potential temperature (K) (contour) at 0000UTC for (a)Kessler,(b)Lin et al., (c)WSM3, (d)WSM5, (e)WSM6, (f)Thompson microphysics schemes.

cross sections, and terrain. The initial conditions were derived from the North American Mesoscale Model (NAM 218 12km grid spacing) from NCEP. A 36 hour simulation was ran starting at 1800 UTC 2010 April 26 and 2011 March 19. Six microphysics schemes were employed to test the WRF model sensitivity. These schemes were the Kessler scheme, Lin et al. scheme, WRF single-moment 3-class, WRF single-moment 5-class, WRF single-moment 6-class, and Thompson scheme.

These results were then compared to observed surface data from the RAWS stations.

3. Results

This section will discuss the results of the sensitivity test and there correlation results to the surface RAWS stations.

3.1. 27 April 2010 event

The 27 April 2010 rotor event began around 2100 UTC – 0000 UTC. Surface station observations reported winds on the lee of the Spring Mountains around 20 ms^{-1} with 40 ms^{-1} wind gusts. A moisture surge passed the Spring Mountains with a sector of dry air on the lee of the mountains. All six microphysics schemes were analyzed during this time to determine the best scheme that most accurately determined wind speed and temperature. All schemes display significant rotor formation and severe downslope winds. Nevertheless, the WSM3 scheme displays the most intense and accurate wind results. Figure 2 shows WRF simulation results of the horizontal wind component in the vertical cross of AA' at 0000 UTC 28 April 2010. One can see that WSM3 has the strongest negative wind speeds at about 16 ms^{-1}, which

Table 1: April event Microphysics Correlation		
Station ID	Wind speed	Temperature
HTSC1	WSM6 0.71	KESSLER 0.84
KHND	WSM3 0.81	WSM3 0.95
KLAS	WSM3 0.79	WSM5 0.95
KLSV	WSM5 0.91	WSM3 0.96
KVGT	WSM3 0.86	WSM3 0.97
KYCN2	WSM3 0.91	WSM6 0.80
MTSN2	WSM3 0.91	WSM3 0.87
RRKN2	WSM3 0.77	WSM3 0.75
TS566	WSM3 0.93	WSM3 0.96

Table 2: March event Microphysics Correlation		
Station ID	Wind speed	Temperature
BPFC1	WSM6 0.62	WSM3 0.64
CVEC1	WSM6 0.39	THOMPSON 0.51
FWSC1	LIN 0.74	THOMPSON 0.64
GNTC1	WSM3 -0.25	WSM6 0.73
KDAG	LIN 0.37	LIN 0.80
KL35	WSM6 0.50	WSM6 -0.07
KNXP	WSM6 -0.43	LIN 0.67
KRIV	WSM6 0.79	KESSLER 0.84
MDHC1	WSM5 0.30	THOMPSON 0.71
MNLC1	WSM3 0.69	LIN 0.79
RCPC1	KESSLER 0.82	WSM6 0.80

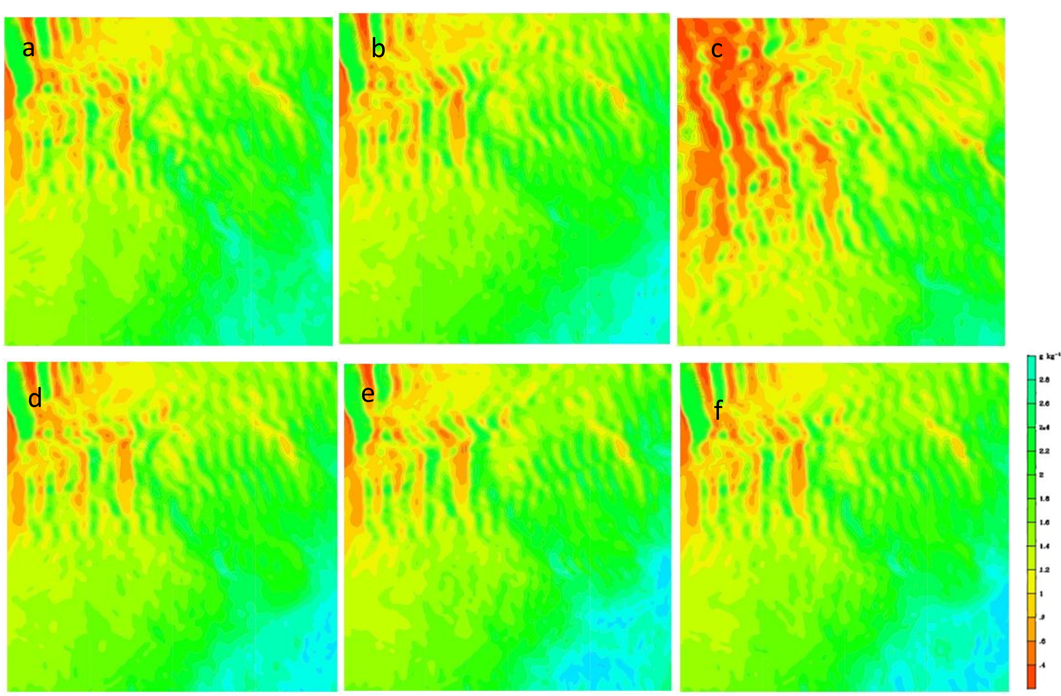

Figure 3. April event horizontal water vapor mixing ratio over domain 2 at 0000 UTC for a)Kessler,(b)Lin et al., (c)WSM3, (d)WSM5, (e)WSM6, (f)Thompson microphysics schemes.

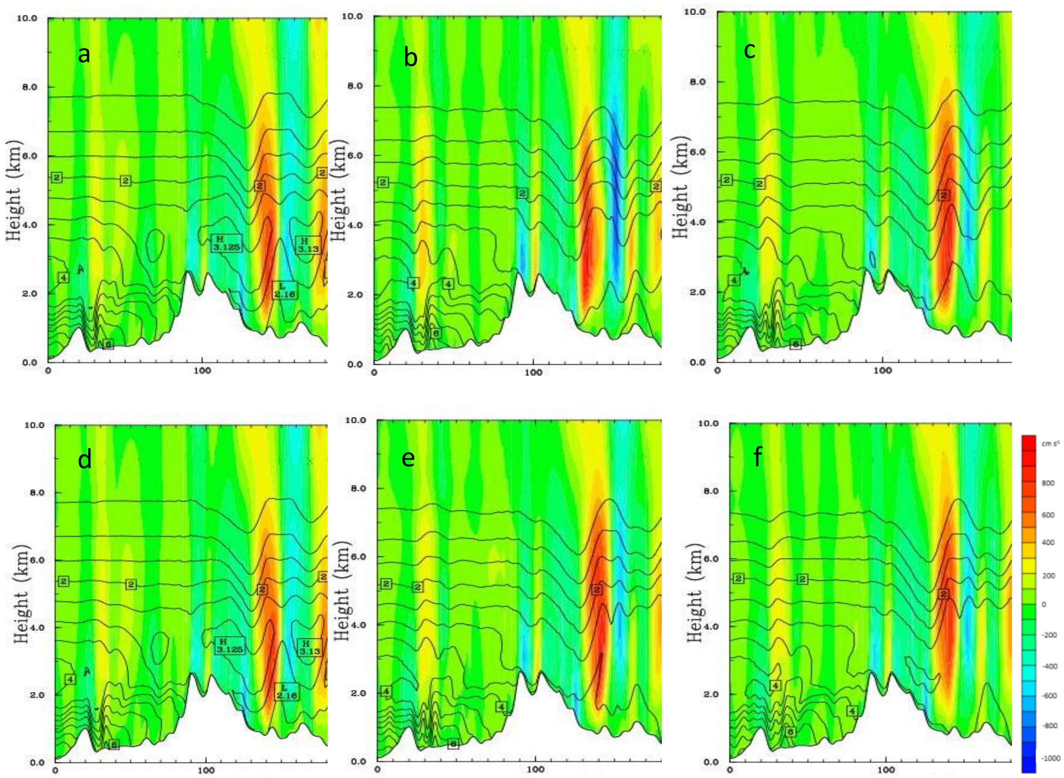

Figure 4. March event cross section BB showing vertical wind component parallel to BB' (color) and water vapor mixing ratio (g/kg) (contour) at 2100UTC for (a)Kessler,(b)Lin et al., (c)WSM3, (d)WSM5, (e)WSM6, (f)Thompson microphysics schemes.

illustrates strong rotor formation. In addition, the WSM3 scheme has strong downslope winds on the leeside of both the Owens Valley and the Spring Mountains (Fig 2c). WSM3 also has a strong dry sector signature on moisture plots which is a key factor in rotor formation (Fig 3).

The correlation results from the WRF simulations and RAWS stations were also examined. For both wind speed and temperature, the WSM3 scheme most accurately fit the observed values (Table 1). However some stations exhibited the WSM5 and the WSM6 scheme as a high correlation. This could be due to the fact that these stations are located in complex terrain, thus different results at different elevations. Further study of this event will look into the reasons for these results.

3.2. 20 March 2011

The 20 March 2011 rotor event began around 1500 UTC – 2100 UTC. Winds at Burns Canyon on the lee of the mountains increase drastically to about 60-65 m s^{-1} with gusts up to 90 m s^{-1} and winds further downwind reported 20 - 40 m s^{-1}. During the event, plane crashes and property damage were reported in the lee of the mountains. Although the WRF simulation results displayed rotor formation and severe downslope winds, there was no significant microphysics scheme that accurately depicted the event. Figure 4 shows the WRF simulation results of the vertical wind component in the vertical cross of BB' at 2100 UTC 20 March 2011. One can see that the Lin et al. scheme has the highest negative/downward wind flow, but this does not correlate with the observed data (Table 2). Unfortunately, very few of the RAWS station observations correlate with the WRF simulation results. It is hypothesized that not only would the complex terrain play a role in the inaccuracy, but also the marine meteorology that occurs in California daily.

4. Conclusion

WRF model microphysics schemes are ran for two rotor events and compared to observations in this study. The rotor formation and severe downslope winds are captured well in the horizontal and vertical wind components. The model performs well in forecasting wind speeds and temperatures for the April event. However, the majority of the March event's model run was under forecasted with low correlation values except for the stations located in lower terrain. This is most likely due to coastal meteorological conditions and most of the stations location in or around the mountain range. Further studies will investigate temperature inversions in complex terrain and the formulation of an ensemble forecast model.

5. Acknowledgements

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6. References

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