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# High Resolution Simulation of a Microburst Event occurred in Ankara Turkey by using the WRF Model

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# Introduction

- Thunderstorm (TS) outflow winds have been based on laboratory tests and numerical simulations by means of jet or thermodynamic models. Today there are limited numbers of research which has explained some differences between basic structures of TS wind profiles. High-resolution full-scale data collected with two mobile Doppler radars provides a deeper understanding of the evolutionary characteristics of thunderstorm outflow winds and wind profiles, (Gunter and Schroeder, 2015). This method also allows understanding the vertical structure of the outflow.

## **Introduction (cont.)**

The velocity profile and loads associated with a microburst wind field vary significantly with the microburst configurations (Shehata, Nassef and Damatty, 2008). An optimization technique and a finite element model identify the critical microburst parameters that lead to maximum forces in various members of a transmission tower structure in this study. Moreover, the coupled genetic algorithms–finite element code is employed to determine the critical members that are likely to fail during a microburst event and the associated critical microburst configurations.

In 2008, North American monsoon season, 140 microburst events were identified in Phoenix, Arizona, and the surrounding Sonoran Desert, (Willingham, Thompson, Howard and Dempsey, 2010). The Sonoran microbursts were studied and examined for their frequency and characteristics, as observed from data collected by using three Doppler radars and electrical power infrastructure damage reports. Sonoran microburst events were wet microbursts and occurred most frequently in the evening hours (1900–2100 local time). Stronger maximum differential velocities ( $20\text{--}25\text{ ms}^{-1}$ ) were observed more frequently in Sonoran microbursts than in many previously documented microbursts. Damage reports show that microburst winds caused more significant damage than gust-front winds. Severe winds from microbursts can threaten aviation operations, damage property, and interrupt communications, transportation, and electrical power transmission. Because of rapid urban expansion and the rising population density of central Arizona, specifically in the Phoenix metropolitan area, the potential socioeconomic impacts of Sonoran microbursts have increased. Sonoran microbursts pose a critical challenge for forecasters. Skill scores for forecasting the Arizona monsoon thunderstorms that can generate microburst.

# INDICATORS

- Turbulence and convection, which are mainly responsible of formation of thunderstorm, microburst, macroburst, and tornado, are classified as one of the atmospheric hazards that can cause weather related accidents. Microbursts are also pronounced as a part of turbulent and convective activities and they usually may not easily be predicted depending on the local effects
- A wet microburst event occurred on August 2, 2011 at 15:00 UTC in Ankara Esenboga Airport, is simulated by using the WRF Model. Wind speed was 146 km/h at Esenboga Airport with a mild thunderstorm.
- There are 3 main indicators to predict the convective storms:
  1. Unstable Atmosphere
  2. High moisture in surface level
  3. Lifting mechanism
- WRF Model is used to simulate the event.

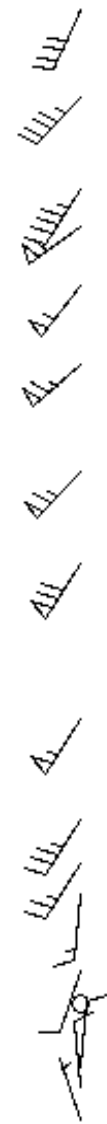
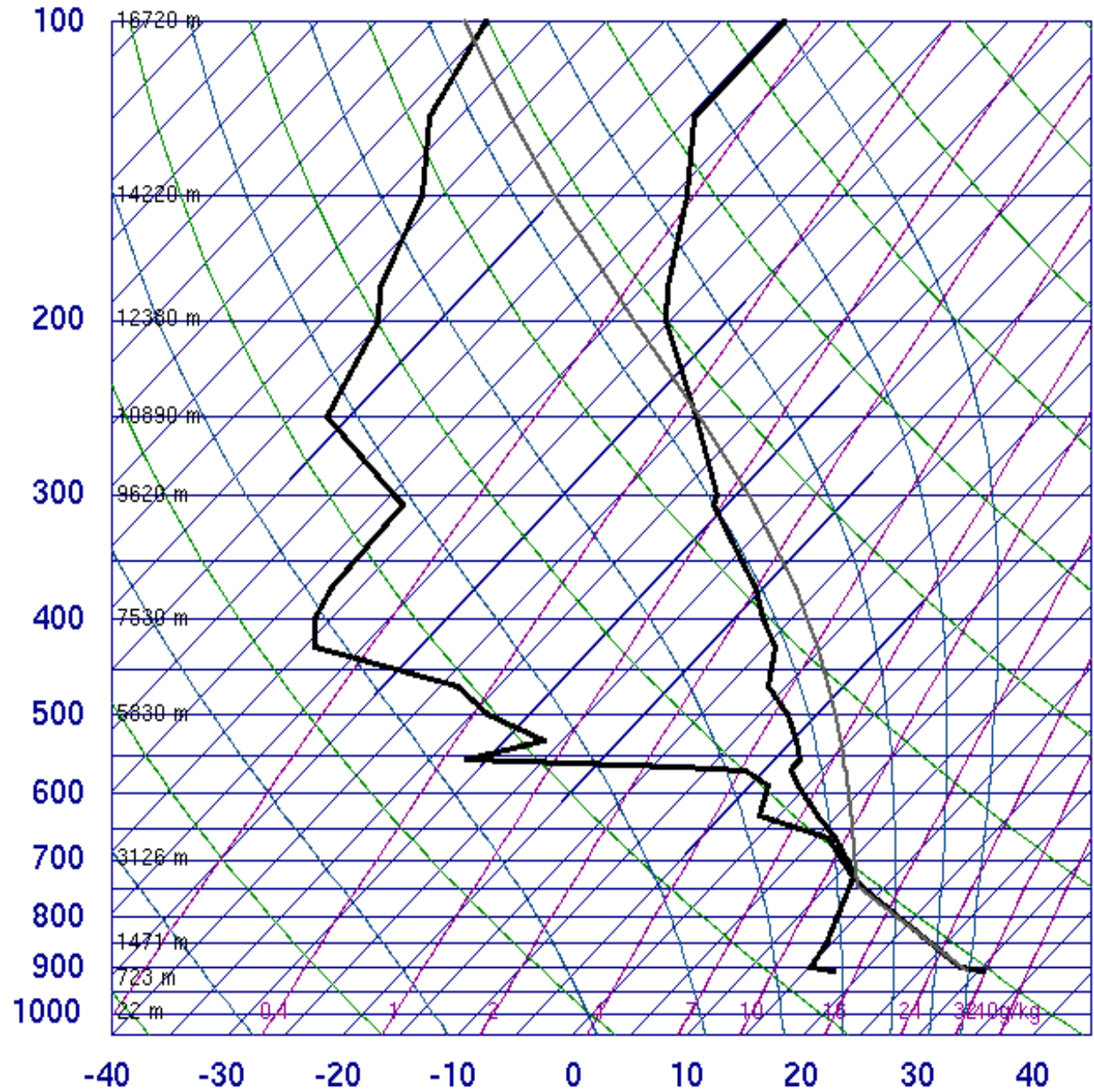
# WRF Model Configuration

(Settings)	WRF
PBL Scheme	YSU
Micro Physics Scheme	Thompson
Cumulus Scheme	No Cumulus
Domain resolution	1 km resolution
Grid numbers	151x136
Vertical levels	28
Initial Data	ECMWF Operational

# Study Area



# 17130 Ankara



SLAT	39.95
SLON	32.88
SELV	891.0
SHOW	-4.16
LIFT	-4.18
LFTV	-5.09
SWET	311.1
KINX	45.30
CTOT	22.10
VTOT	31.10
TOTL	53.20
CAPE	978.8
CAPV	1124.
CINS	-7.05
CINV	-5.01
EQLV	243.3
EQTV	242.5
LFCT	732.9
LFCV	735.3
BRCH	22.61
BRCV	25.97
LCLT	285.7
LCLP	744.5
MLTH	310.8
MLMR	12.47
THCK	5808.
PWAT	35.70

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# Results

# Surface Temperature, Sea Level Pressure, and Wind

REAL-TIME WRF

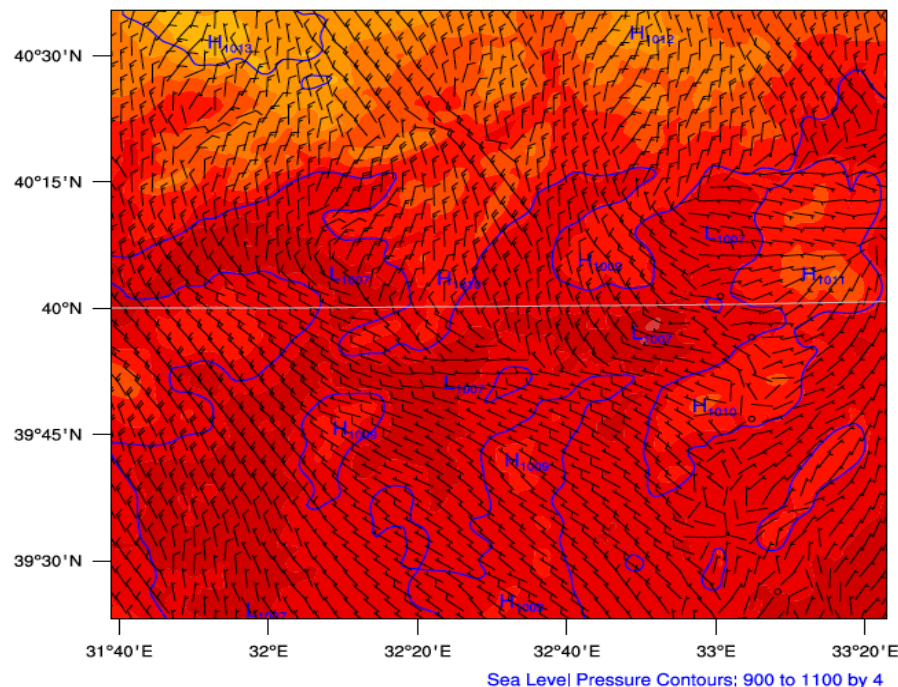
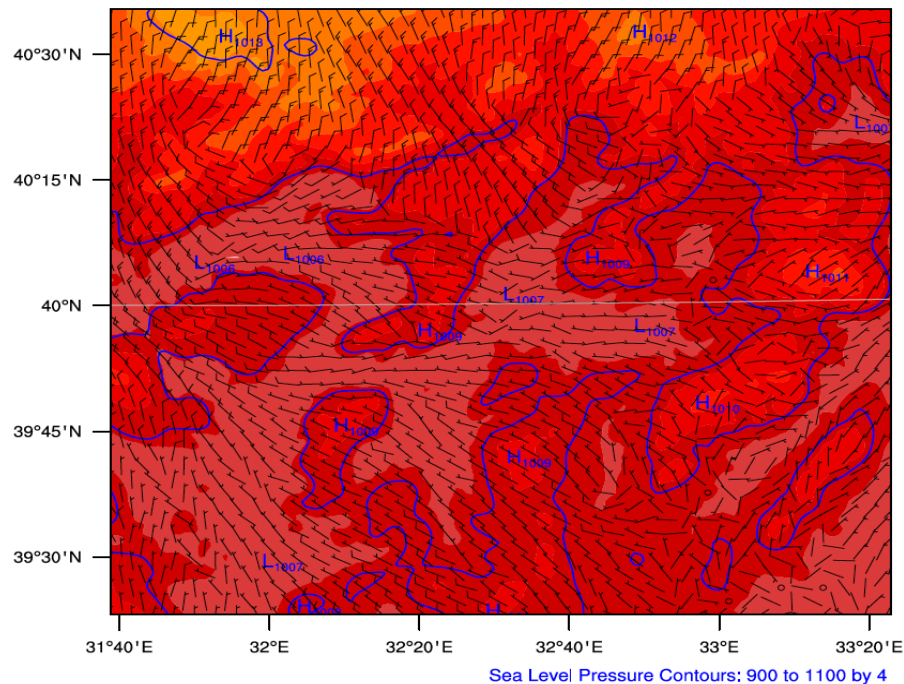
Init: 2011-08-02\_06:00:00  
Valid: 2011-08-02\_15:00:00

Surface Temperature (F)  
Sea Level Pressure (hPa)  
Wind (kts)

REAL-TIME WRF

Init: 2011-08-02\_06:00:00  
Valid: 2011-08-02\_16:20:00

Surface Temperature (F)  
Sea Level Pressure (hPa)  
Wind (kts)



Esenboga Airport and its nearby are under the effect of a low pressure system. Temperature is 35 °C at 1500 UTC and this is the highest temperature at the domain shown above on the left. Wind is 10 kt from West and Southwest at surface level. Temperature is reduced to 23 °C at 1620 UTC. Low pressure system is still on the domain. Wind is increased to 15 kt by changing its direction to North and Northwest.

# Storm Relative Helicity

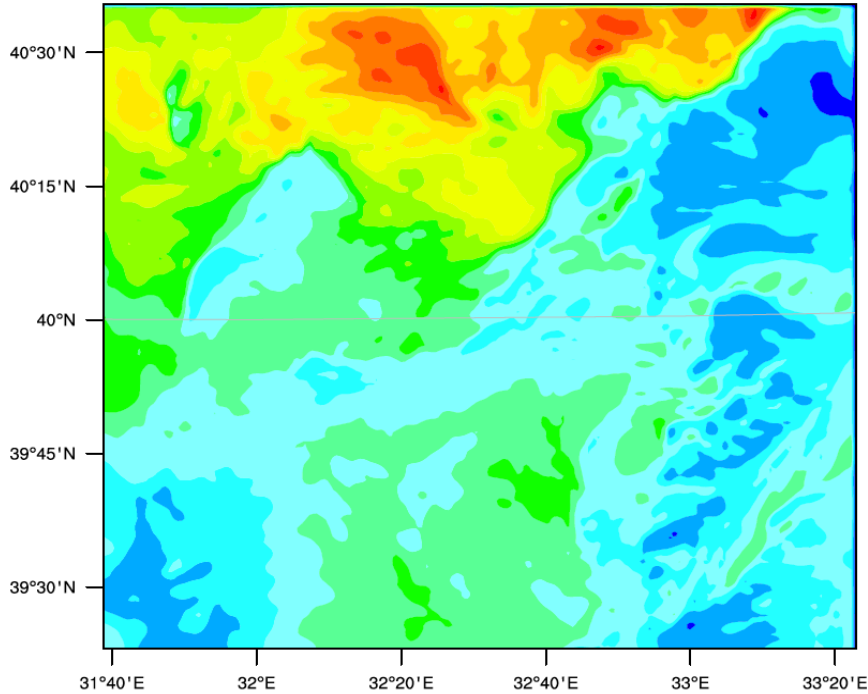
REAL-TIME WRF

Init: 2011-08-02\_06:00:00  
Valid: 2011-08-02\_15:00:00

REAL-TIME WRF

Init: 2011-08-02\_06:00:00  
Valid: 2011-08-02\_16:20:00

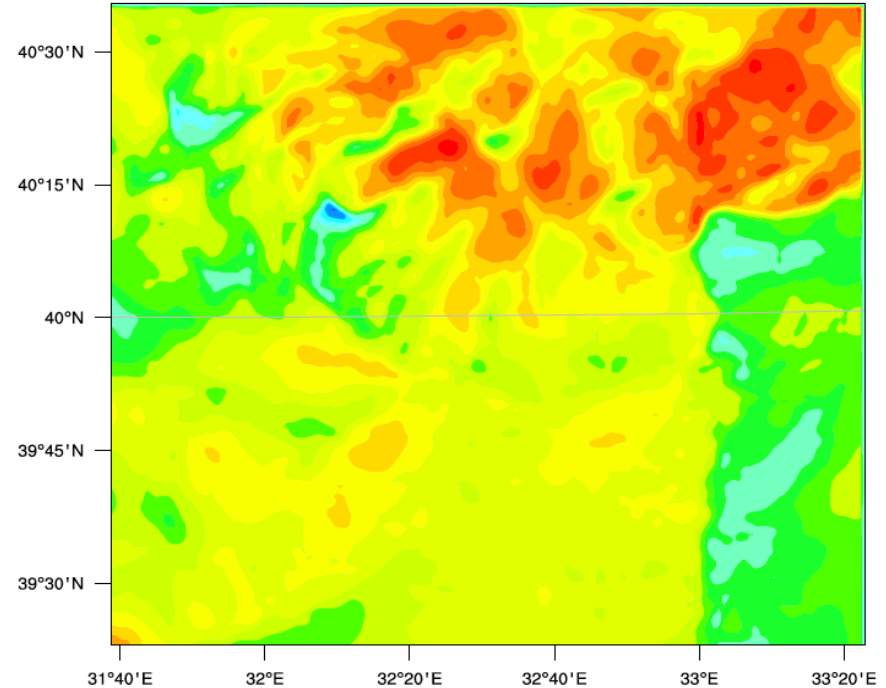
Storm Relative Helicity (m<sup>2</sup>/s<sup>2</sup>)



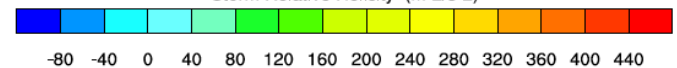
Storm Relative Helicity (m<sup>2</sup>/s<sup>2</sup>)



Storm Relative Helicity (m<sup>2</sup>/s<sup>2</sup>)



Storm Relative Helicity (m<sup>2</sup>/s<sup>2</sup>)



Storm Helicity values over Esenboga Airport is around 240 m<sup>2</sup>/s<sup>2</sup> at both 1500 UTC and 1620 UTC. The Northern and Northeastern part of domain has values are between 440 m<sup>2</sup>/s<sup>2</sup> and 520 m<sup>2</sup>/s<sup>2</sup> from 1500 to 1620 UTC. Storm Helicity threshold value is 150 m<sup>2</sup>/s<sup>2</sup> for supercell development. If it is between 150-299 m<sup>2</sup>/s<sup>2</sup> this might be signal of weak tornado. Strong tornado value is between 300 m<sup>2</sup>/s<sup>2</sup> to 449 m<sup>2</sup>/s<sup>2</sup>. Violent tornado can occur over 450 m<sup>2</sup>/s<sup>2</sup>.

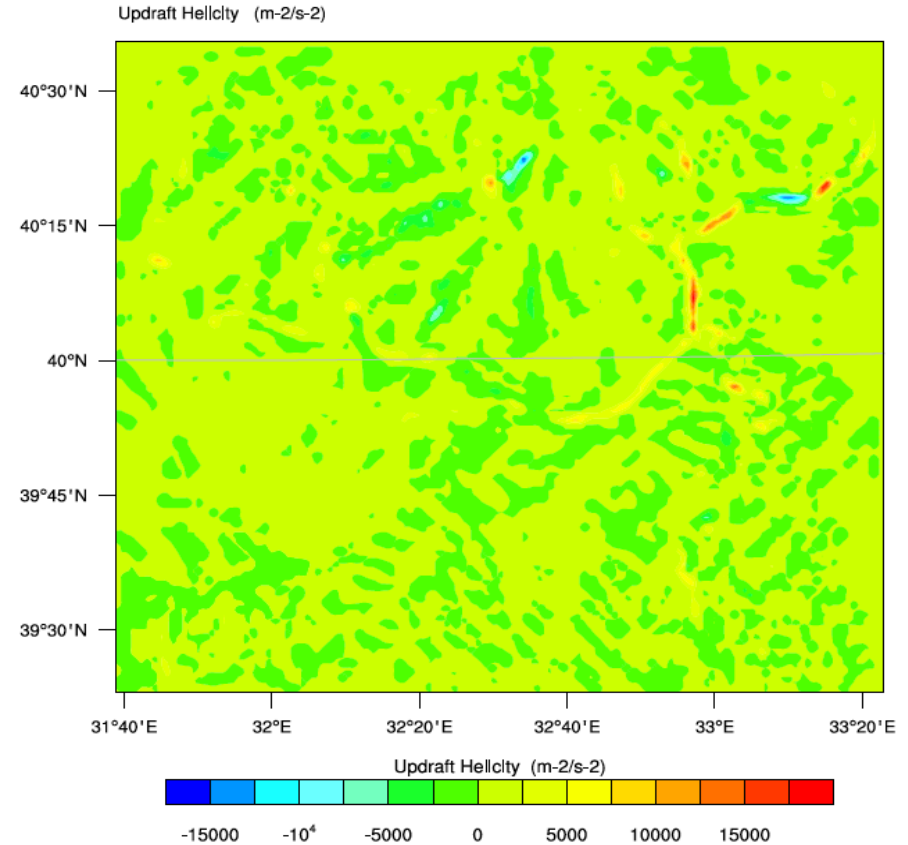
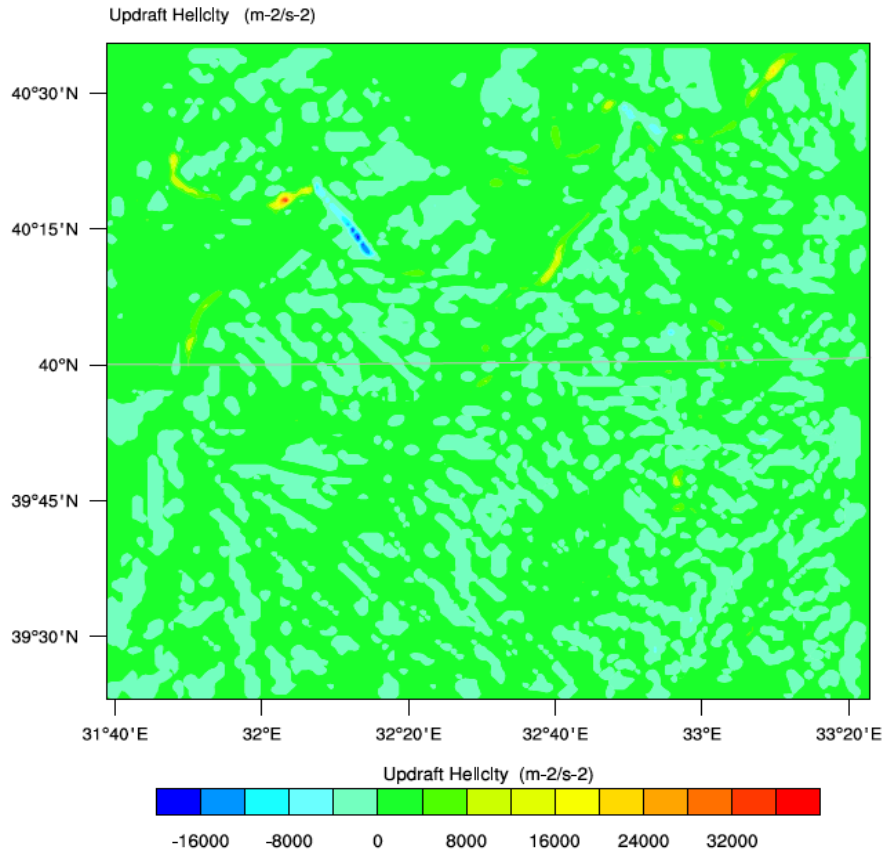
# Updraft Helicity

REAL-TIME WRF

Init: 2011-08-02\_06:00:00

REAL-TIME WRF

Init: 2011-08-02\_06:00:00



Updraft Helicity values over Esenboga Airport is around  $8000 m^2/s^2$  at 1500 UTC and  $2500 m^2/s^2$  1620 UTC. There are some spots indicate higher updraft and downdraft values ( $30000 m^2/s^2$  and  $-18000 m^2/s^2$ ). WRF simulations show us strong instability conditions due to deep low pressure system, strong helicity values, rapid change in wind speed and direction and high temperature. Since microburst indices are greater than critical values, we can expect a strong vertical activity.

## RESULTS

- Microburst indices are also calculated by considering 1200 UTC analyses. These indices are WINDEX, MPDPI, and WSMI. Microburst occurrence criteria for these indices are 30,  $\geq 1$ , and  $\geq 10$ , respectively. Based on the EsenBoga Case, WINDEX (WI)= 75.46, MDPI =1.17, and WMSI = 34.55. As a result, all these three indices indicate a probability that a microburst can occur. WRF Model results for surface temperature, seal level pressure, wind, surface dew point, updraft helicity, and storm relative helicity also indicate a microburst probability but the model cannot simulate the occurrence time of the event accurately.

# References

- W.S. Gunter and J.L. Schroeder, (2015): “High-resolution full-scale Measurements of thunderstorm outflow winds”, Journal of Wind Engineering and Industrial Aerodynamics, Volume 138, March 2015, Pages 13-26
- A.Y. Shehata, A.O. Nassef and A.A. El Damaty, (2008): “A coupled finite element-optimization technique to determine critical microburst parameters for transmission towers”, Finite Elements in Analysis and Design, Volume 45, Issue 1, December 2008, Pages 1–12
- K. M. Willingham, E. J. Thompson, K. W. Howard and C. L. Dempsey, (2010): “Characteristics of Sonoran Desert Microbursts”, Weather and Forecasting, Vol. 26, p. 94-108, DOI: 10.1175/2010WAF2222388.1, \_ 2011 American Meteorological Society