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

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ABSTRACT

Spring and summer are especially important seasons for aerial sports such as paragliding, since thermals can occur in these unstable conditions. On the other hand, local convective events can be dangerous during these seasons; therefore it is crucial to predict these extreme events. 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. In this study, 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. Initial and boundary conditions of the WRF model are obtained from ECMWF operational forecast dataset and the domain resolution is downscaled to 1 km starting from 9 km with the ratio of 3km. 3 nested domains are used and the highest resolution domain (1 km) has 151 x 136 grids horizontally and 41 vertical levels covering Ankara Esenboga Airport. YSU PBL and WSM6 microphysics parameterizations are used. Cumulus parameterization scheme is not used for the 3 km and 1 km domain; Grell3D Cumulus parameterization is used for the 9 km resolution domain. Microburst event is evaluated by using surface temperature, sea level pressure, and wind speed and direction, first. Since these parameters are not enough to indicate the event, microburst indices (WINDEX, MDPI, and WMSI) are calculated by using observations. WINDEX is found 75.46 where the critical value for microburst is 30; MDPI is 1.17 where the critical value is greater than 1, and WMSI is calculated 34.55 where the critical value for the possible microburst event is greater than 10. WRF Model performance is tested by analyzing the spatial distribution of the storm relative helicity value, which is reached to 200 m2/s2 during the microburst event. On the other hand, WRF Model surface wind speed results could not capture the event, the maximum wind speed of the domain is 37 km/h. Therefore it is important to analyze helicity or microburst indices, where only wind speed analyses are not enough. Although the microburst cannot be captured locally by the WRF Model, the results shows us that the model can predict the microburst with small spatial shifts, which can be enough to warn people who live in that area.

INTRODUCTION

Further studies to understand thunderstorm (TS) outflow winds have been based on laboratory tests and numerical simulations using 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.

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 ad 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 (20–25 m s-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.

STUDY AREA

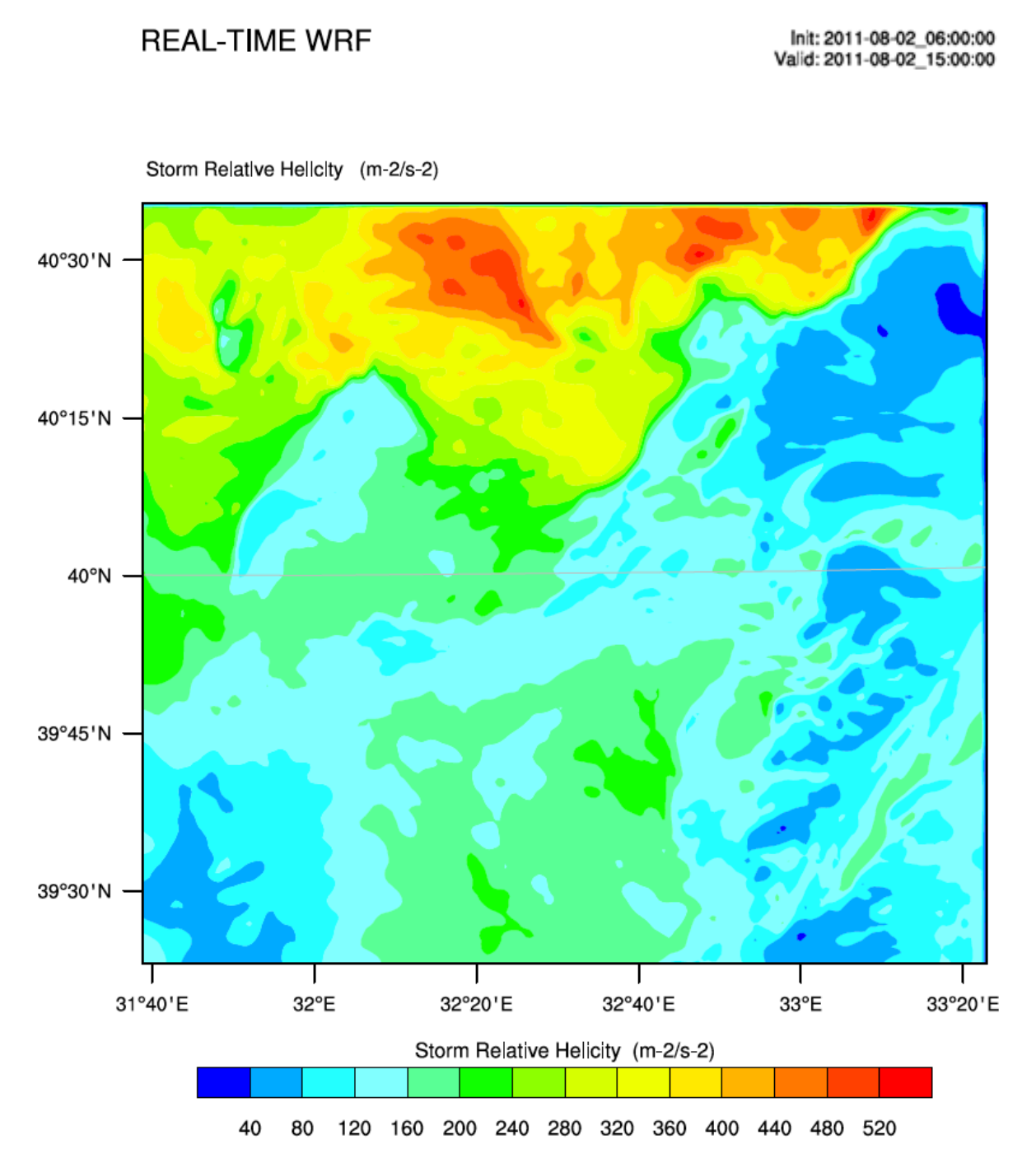
Ankara Esenboga Airport

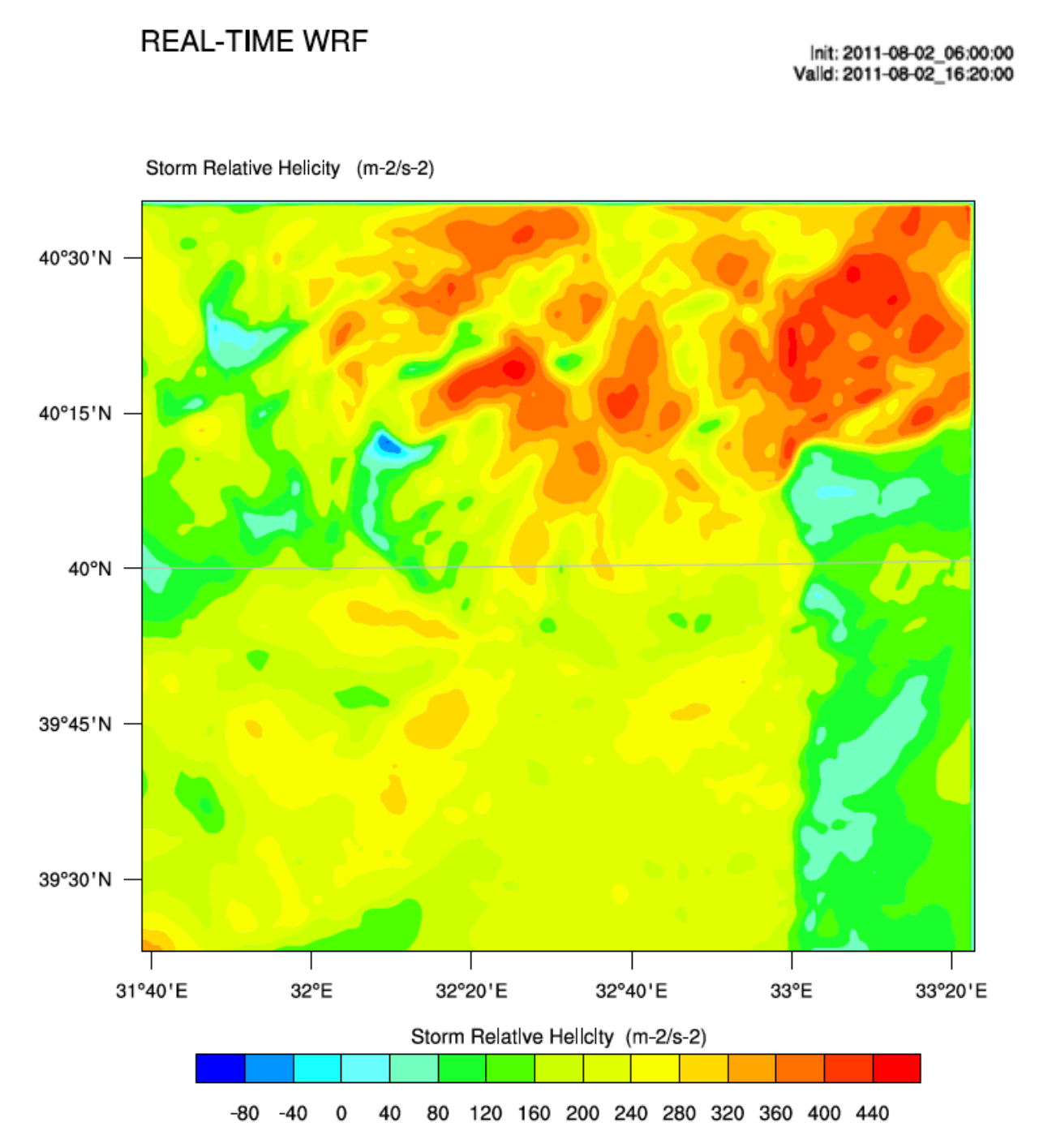
DATA AND METHODS

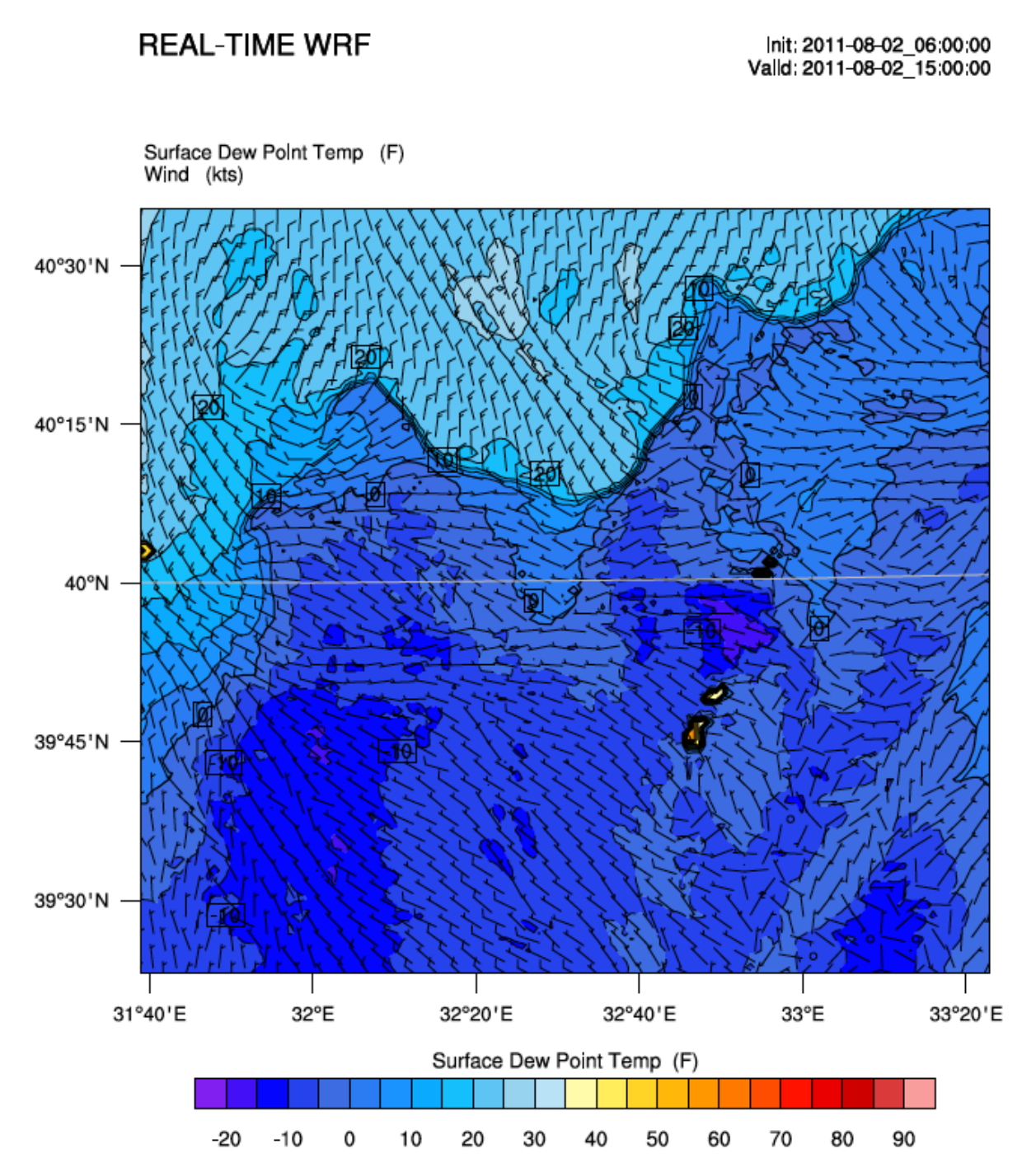
The WRF model is a next generation mesoscale weather forecasting system that can be used for comprehensive meteorological applications. The model has mainly two model structures for research and operational usage purposes. In this study, 3.1 version of the research based WRF model core, called Advanced Research is used. Since ARW has more physics options than operational one, called WRF-NMM (WRF Nonhydrostatic Mesoscale Model), it is more appropriate for research purposes. The WRF model can be used in both hydrostatic and non-hydrostatic mode, it uses terrain following hydrostatic pressure coordinate system, and its grid structure is based on Arakawa-C grid scheme

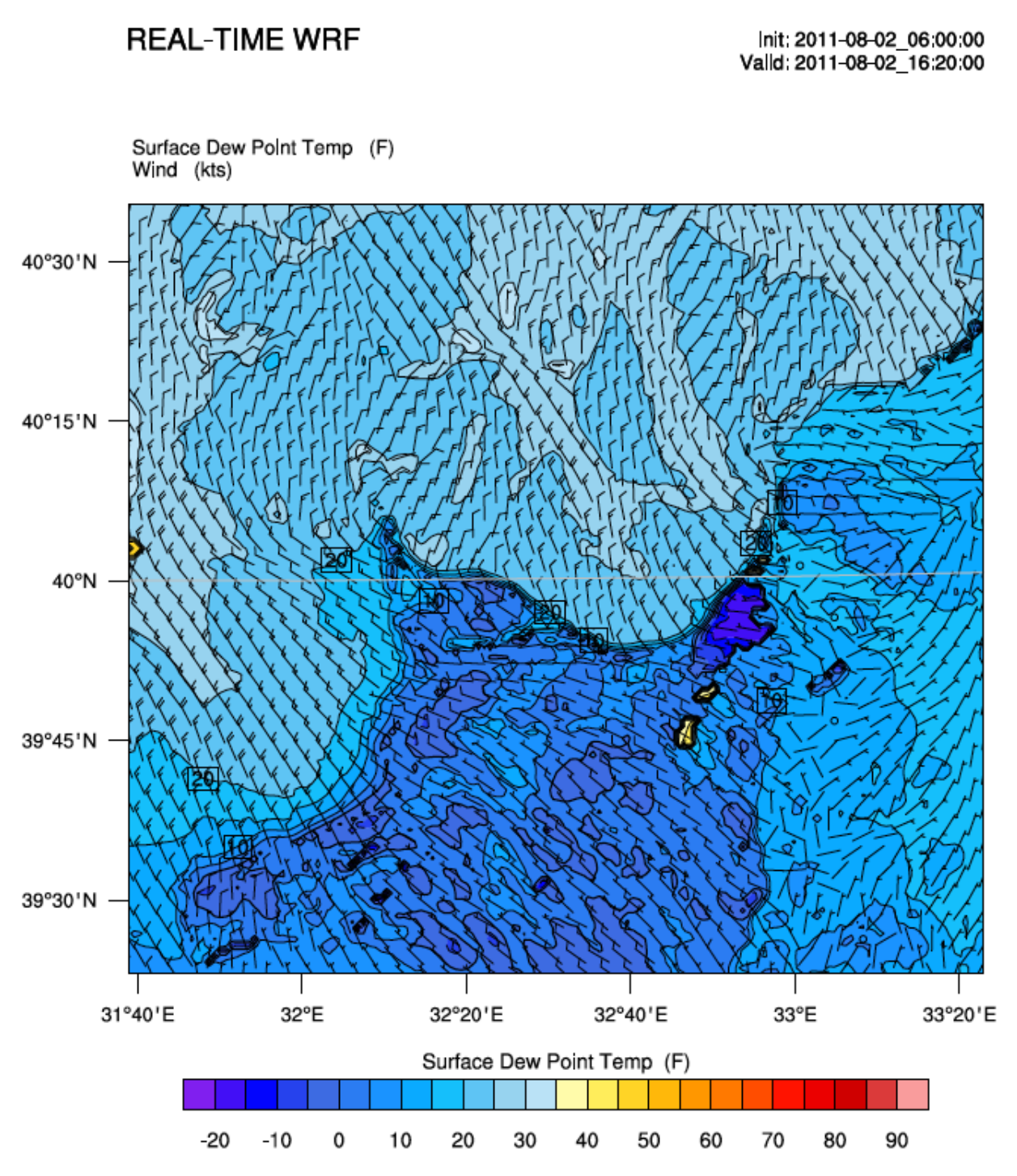
(Settings)	WRF
PBL Scheme	YSU
Micro Physics Scheme	Thompson
Cumulus Scheme	No Cumulus
Domain resolution	1 km resolution
Grid numbers	151x136
Vertical levels	28
Initial Data	ECMWF Operational

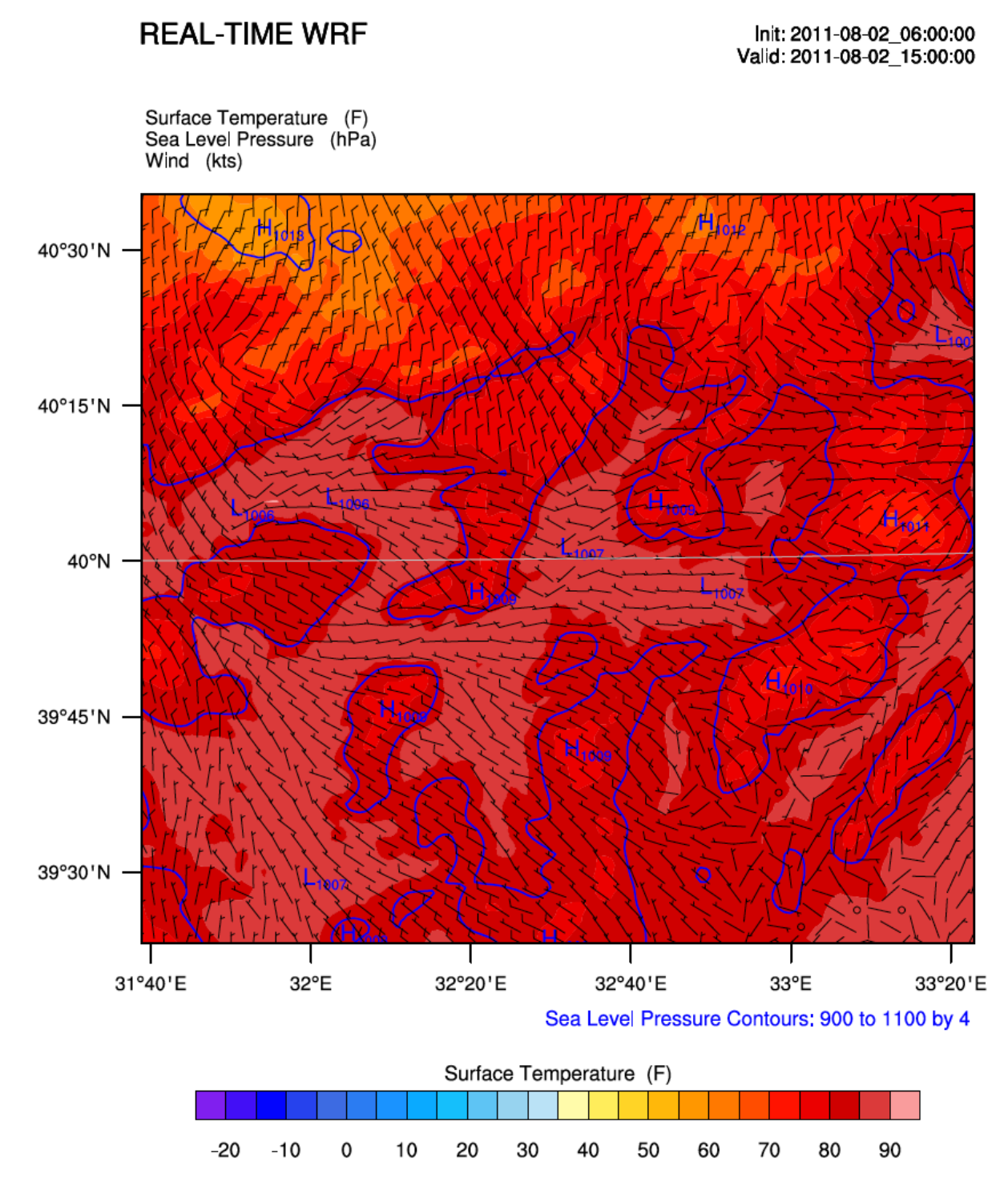
ANALYSIS

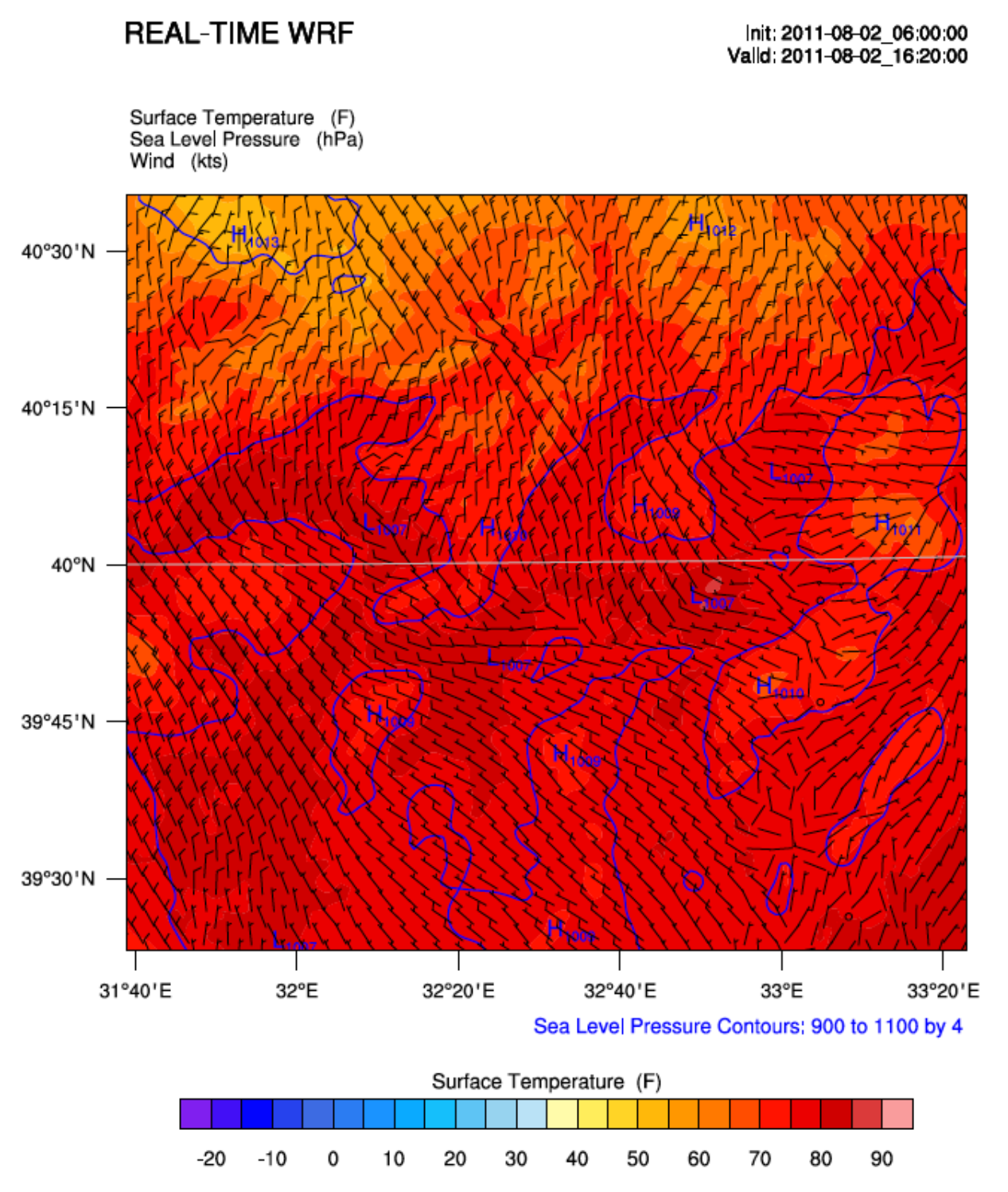


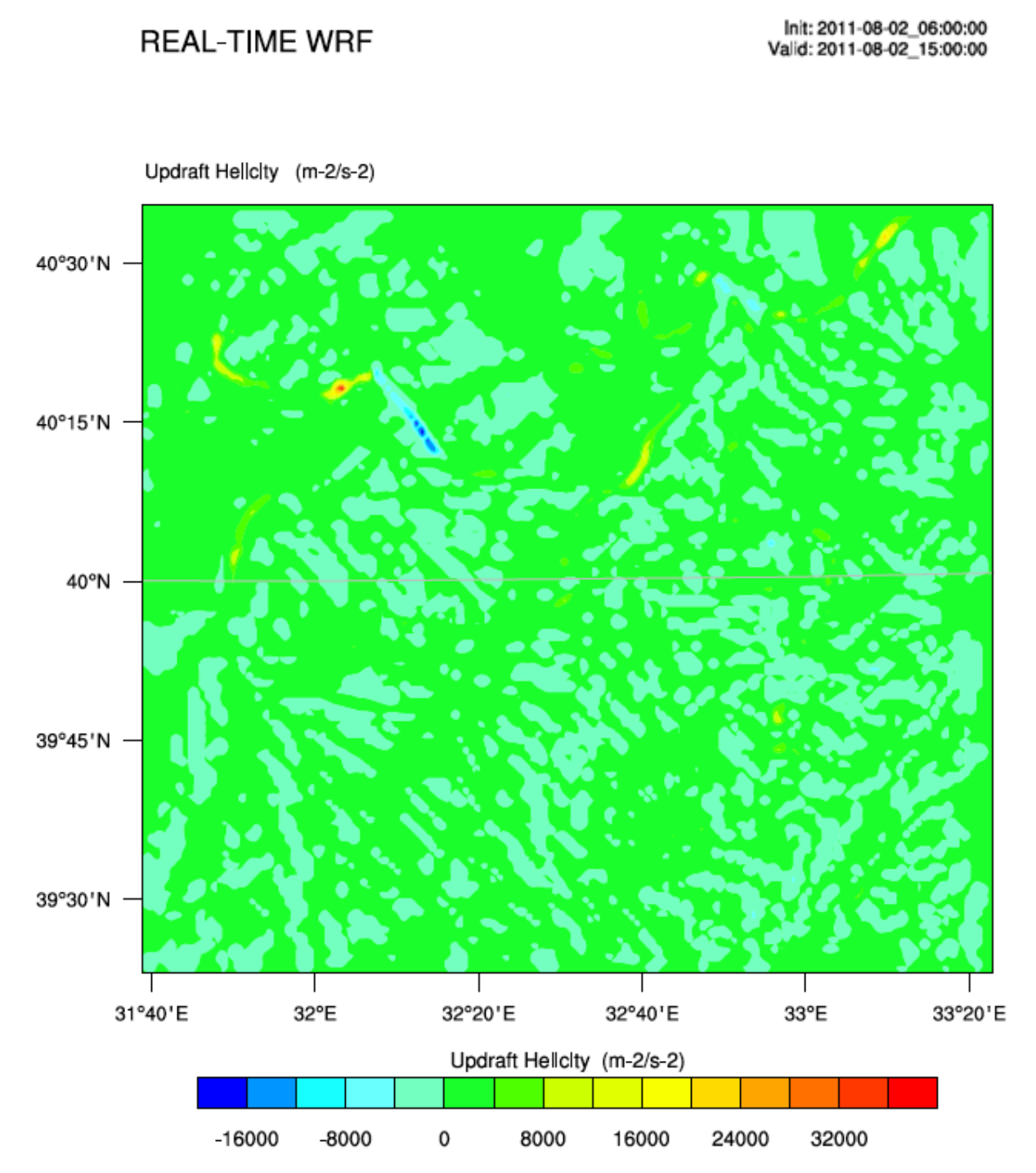


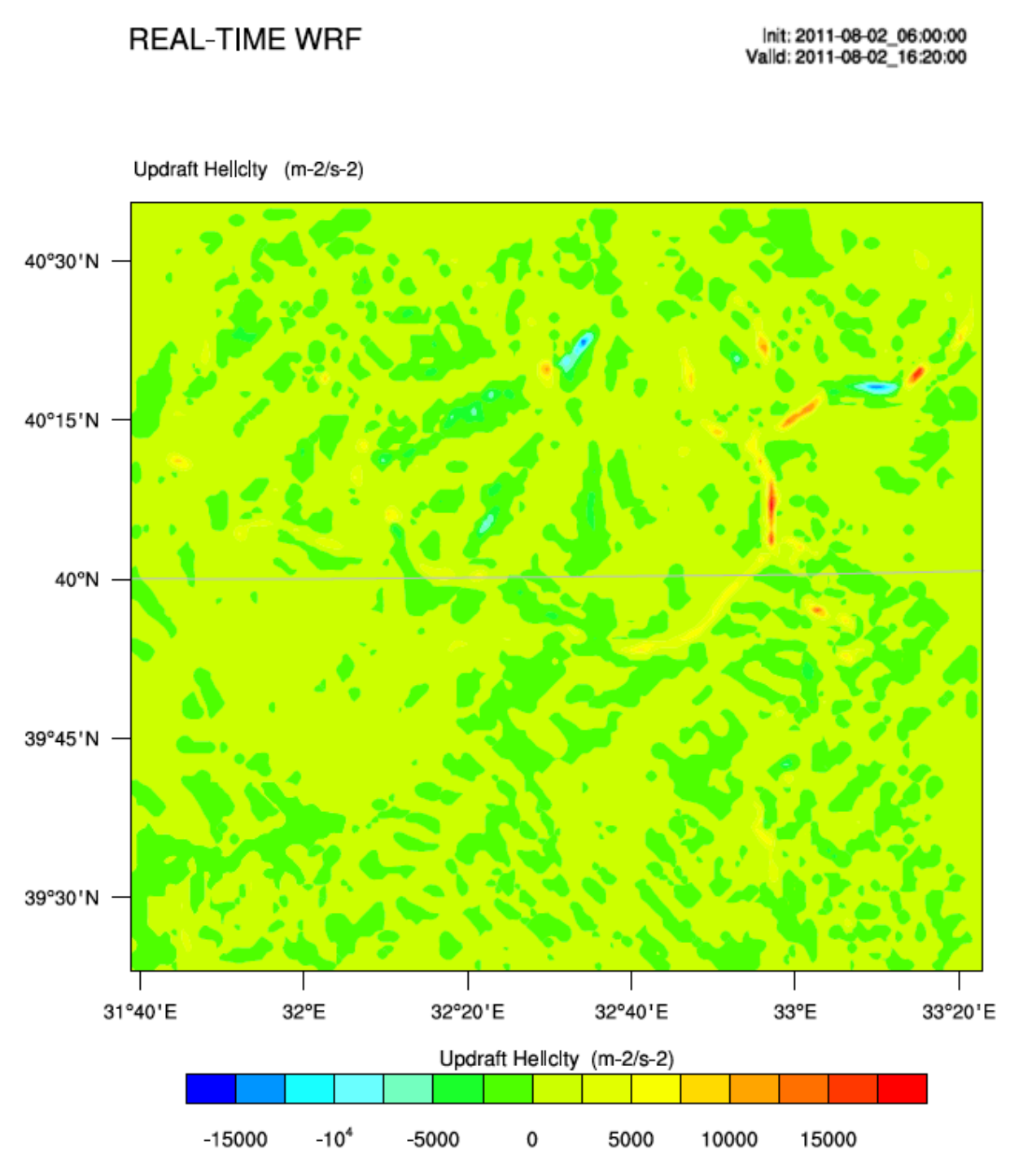












RESULTS

There are 3 main indicators to predict the convective storms: 1. Unstable Atmosphere 2. High moisture in surface level, and 3. Lifting mechanism

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, ≥ 1, and ≥ 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.

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