ADVANCED WARNING OPERATIONS COURSE

SIMULATION GUIDE: MAY 15, 2012 EVENT

Presented by:
The Warning Decision Training Branch

Facilitator Version

Acknowledgments

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- David Sharp (SOO) and the National Weather Service (NWS) Weather Forecast Office (WFO) in Melbourne, FL for providing the AWIPS data, case analysis, and feedback on the simulation content

Cover image is of Volusia County lifeguard signaling people to get out of the water as a shelf cloud approaches Ormond Beach, FL on May 15, 2012. Image courtesy of Jason Weingart.

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Document History

The document history is provided to track any updates or changes to the WES simulation guide. The version number, seen at the bottom of every page, will be updated as each significant change is made to the simulation guide.

Version	Date	Description
1.0	June 6, 2013	Initial Release

To provide feedback, comments, or ideas related to this document, please visit our web site at: http://www.wdtb.noaa.gov

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1: How to Use This Document

Welcome to the ***May 15, 2012 Event*** Simulation Guide! The purpose of this guide is to provide the training facilitator at a forecast office with case-specific materials needed to prepare and deliver effective simulations in support of the ***Severe Track*** of the ***Advanced Warning Operations Course (AWOC)***. The simulations for this event complement the material provided in the AWOC Severe Track. This includes course content and objectives related to short-term threat assessments, lifting mechanisms, storm interrogation strategies, and the warning decision making process.

Since this document outlines the answers to the objectives of this event, it is specifically meant for the use of the training facilitator only.

It is recommended that you use the materials provided here, since they are specifically tailored to the events of May 15, 2012. You may choose to use this simulation to help design additional training exercises related to severe convective weather forecasting and warning decision making scenarios. You may also choose to use the materials provided here as a template for training with other convective weather cases.

In order to create effective simulations with this case, you will need to familiarize yourself with the details of this event. We recommend installing the case first, followed by reading each section in order with the static data available in a D-2D display. See Table 1-1 for a description of the layout of this document.

After reviewing the simulation guide and becoming familiar with the details of this event, you, the training facilitator, will be ready to begin loading these simulations for the trainee. You will need to understand the performance objectives associated with this simulations. You will be able to evaluate the trainee's performance either during or after the simulation. Each performance objective has a corresponding suggested evaluation criteria to allow you to assess the trainee's performance. All of the performance objectives and associated evaluation criteria are provided in Chapter 3 and Chapter 4 of this document.

Table 1-1: Simulation Guide Layout
Chapter 1: How to Use This Document
This introduction describes the overall content and use of the simulation guide.
Chapter 2: Background Information
The background information provides details regarding the WES simulation, including the WES build and AWIPS data provided with the case.
Chapter 3: Simulation Objectives
The simulation objectives section describes the performance objectives and evaluation criteria for the displaced real-time simulation.
Chapter 4: The May 15, 2012 Event Overview
The event overview provides a description of the synoptic and environmental setup, radar evolution of convection, and summary of the event.

Supplemental simulation material is provided on the AWOC Severe Track web page at the following location:

http://www.wdtb.noaa.gov/courses/awoc/awoc.html#SevereTrack

The student is required to view the pre-brief and post-brief articulates regarding this simulation. The pre-brief is provided in the NWS Learning Center and on the WDTB web page. The student will need to view the entire pre-brief articulate before starting the simulation. The test questions provided in the end of simulation quiz include questions regarding information from the pre-brief.

Pre-Brief: http://www.wdtb.noaa.gov/courses/awoc/assets/sims/preBrief/player.html

The post-brief is provided at the end of the simulation (via WESSL script) and on the WDTB web page (for the trainer only). It provides a general overview of the event and warning decision making considerations.

Post-Brief: http://www.wdtb.noaa.gov/courses/awoc/auxiliary/postBrief/player.html

At the end of the simulation, you will need to log in to the NWS Learning Center and complete the end of simulation quiz. There is also a facilitator survey regarding the simulation.

Training research indicates that ***one-on-one*** training where the ***training facilitator and trainee participate together for the optimum learning experience*** is the most effective way to run a simulation. However, this simulation contains effective ways of incorporating immediate feedback to the trainee without training facilitator interaction, and it is possible for the trainee to start and complete the training without the training facilitator present. While time consuming, one-on-one training with the trainee can insure that:

1. The trainee remains focused on the objectives of the simulation,
2. The trainee receives essential feedback on his/her performance, and
3. The training facilitator develops a solid understanding of how well the trainee comprehends the training and how well the trainee transfers the training to application.

In order to manage a simulation session, the training facilitator must be able to run a simulation as documented with the WES install and testing instructions included with the WES software. The simulation will be much more relevant if the local AWIPS customizations (e.g. preferences, procedures, color tables, etc.) are ported to the WES machine as outlined in the WES installation instructions. For more information regarding the WES and its installation, visit http://www.wdtb.noaa.gov/tools/wes/index.htm.

More information regarding the ***Severe Track*** of the ***Advanced Warning Operations Course*** can be found at the following page:
http://www.wdtb.noaa.gov/courses/awoc/index.html

2: AWIPS Background Information

I. Weather Event Simulator

This simulation requires that you have at least WES9.10 loaded on your WES machine. Do not continue with these simulations until you have successfully installed and tested WES9.10 in a simulation. Full information on this can be found at http://www.wdtb.noaa.gov/tools/wes/index.htm

II. Loading the Case from DVD

There is one install DVD for the May 15, 2012 Event simulations that was shipped to each AWOC facilitator. This AWIPS data occupies approximately **26 GB** of disk space when untarred, so please plan your disk space accordingly. A README document is provided on the install DVD. This README document will provide instruction on how to install the AWIPS data from the DVD and how to start each part of the simulation.

III. Data Characteristics

The original AWIPS data was provided by the National Weather Service (NWS) Melbourne, FL (MLB) Weather Forecast Office (WFO). Most data is accessible during the simulations. While there may be some incomplete or missing data due to the archiving process and to reduce the overall size of the case on your WES hard drive, there is enough data present for the trainee to be able to satisfy the learning objectives. This section will outline the details of the various AWIPS data that are available.

Radar Data:

KMLB is the primary radar for the simulation. Three secondary radars are also provided in the simulation for additional radar coverage over the MLB CWA. Table 2-1 lists the available radars in the simulation, including the radar location, primary VCP, and the availability of FSI, SCAN, and DMD.

Period of Available Data: 15 May 2012 -- 1800 UTC to 2329 UTC

Table 2-1

Radar ID	Location	VCP	Dual-Pol	FSI	SCAN/DMD
KMLB	Melbourne, FL	212	x	x	x
KJAX	Jacksonville, FL	212	x		
KTBW	Tampa Bay, FL	212	x		
KAMX	Miami, FL	212	x		

Upper Air Soundings:

Upper-air soundings are available for most RAOB sites in the simulation. Soundings are not launched from the Melbourne, FL WFO and are launched intermittently from Cape Canaveral, FL (KXMR). However, since a sounding was not launched from KXMR during this event, use the list of recommended sounding locations in Table 2-2 to assist the trainee in his/her regional analysis.

Period of Available Data: 15 May 2012 -- 1200 UTC

Table 2-2

RAOB ID	Location	Location With Respect to MLB WFO
KTBW	Tampa Bay, FL	West
KJAX	Jacksonville, FL	North
KMFL	Miami, FL	South

Model Data:

Table 2-3 lists all of the available model data provided in the simulation. Please note which models are available and for which model run times. Some files are missing or have been removed in order to reduce the overall size of the case on your WES hard drive.

Table 2-3

Model	Grid Folder	Model Runs Available
LAPS	LAPS	Hourly 1200-2200 UTC
MSAS	MSAS	Hourly 1200-2200 UTC
Eta (NAM80)	CONUS211	1200 UTC
Eta (NAM40)	CONUS212	1200 UTC
GFS40	CONUS212	1200 UTC, 1800 UTC
MesoEta (NAM12)	CONUS212	1200 UTC, 1800 UTC
SREF	CONUS212	1500 UTC
GFS90	CONUS213	1200 UTC, 1800 UTC
MesoEta (NAM12)	CONUS215	1200 UTC, 1800 UTC
DGEX	GRID185	1800 UTC
Eta (NAM12)	GRID218	1200 UTC, 1800 UTC
RUC40	GRID236	Hourly 1300-2100 UTC
ECMWF	LATLON	1200 UTC
ECMWF_HiRes	LATLON	1200 UTC
ENSEMBLE	LATLON	1200 UTC
GFSGuide	LATLON	1200 UTC
UKMET	LATLON	1200 UTC
LAMP	NDFD	Hourly 1200-2100 UTC
MOSGuide	NDFD	1200 UTC
NamDNG5	NDFD	1200 UTC, 1800 UTC
RTMA	NDFD	Hourly 1200-2100 UTC

Satellite Data:

The majority of the base satellite products are available from the ***conusC/*** and ***eastConus/*** directories in the case folder. The satellite products are viewable from the CONUS to WFO scales (i.e., not available within the North American and N. Hemisphere scales). None of the satellite sounder and derived imagery products are available in this case, while some of the derived satellite plots are available. GOES soundings are also available through the Volume Browser.

Period of Available Data: 15 May 2012 -- 1215 UTC to 2315 UTC

Procedures:

Procedures were created to assist in basic radar/satellite threat assessment. The procedures can be accessed by selecting *Procedures* under the *File* menu in D-2D, and then select *Open* from the sub-menu that appears. In the Open Procedure GUI, the procedure bundle "**Radar_SAT**" contains the procedures specific to this simulation. Table 2-4 contains the description for each procedure.

Table 2-4

Procedure Name	Description
SatIR_KMLB	GOES IR Satellite, KMLB 0.5° Reflectivity, METAR
SatVis_KMLB	GOES Visible Satellite, KMLB 0.5° Reflectivity, METAR
KMLB_0.5Z/V	KMLB 0.5° Reflectivity, KMLB 0.5° Velocity
KMLB_AllTilts_Z/V	KMLB All-Tilts Reflectivity, KMLB All-Tilts Velocity
KMLB_DualPol	*Four Panel:* **1)** KMLB 0.5° Reflectivity, Velocity, and Melting Layer **2)** KMLB 0.5° ZDR, SRM Velocity, and Melting Layer **3)** KMLB 0.5° CC, Spectrum Width, and Melting Layer **4)** KMLB 0.5° KDP, HC, and Melting Layer
KMLB_DualPol_AllTilts	*Four Panel:* **1)** KMLB All-Tilts Reflectivity, Velocity, and Melting Layer **2)** KMLB All-Tilts ZDR, SRM Velocity, and Melting Layer **3)** KMLB All-Tilts CC, Spectrum Width, and Melting Layer **4)** KMLB All-Tilts KDP, HC, and Melting Layer
KMLB_DMD/TVS	KMLB 0.5° Reflectivity, KMLB 0.5° Velocity, DMD Table, TVS

IV. WESSL Script

The WESSL script used in this simulation provides information for the trainee that will impact the warning decision making process, such as local storm reports and Storm Prediction Center (SPC) products. The WESSL script will also provide the student the opportunity to practice communicating potential impacts to core partners (e.g., NASA's Kennedy Space Center). The details for the WESSL script can be found in Table 2-5.

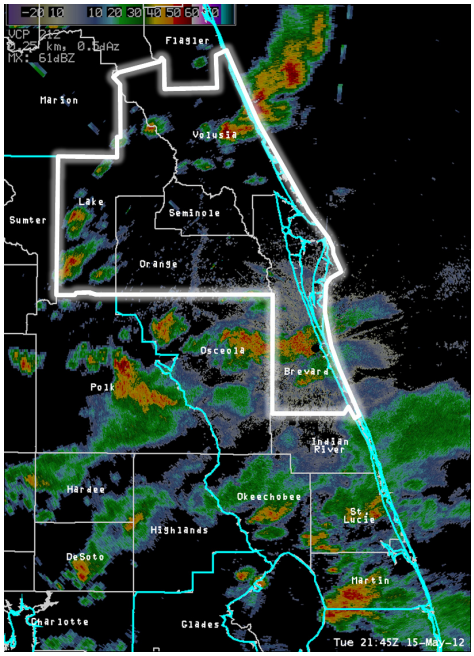
Loading the WES macro file for simulation will automatically insert the WESSL script into the simulation.

Table 2-5

Time	WESSL Event
2145 UTC	Simulation starts; Statement reminding student to view pre-brief before continuing
2145 UTC	Firefox window with valid SPC products, PW climatology, and radar map
2211 UTC	LSR: Trained spotter reports 45 mph wind, 0.70 in. hail (3 N Lake Ashby)
2228 UTC	LSR: Chaser reports wall cloud (3 W I-95 at mile maker 244)
2230 UTC	Response window to provide timing/impacts to Kennedy Space Center
2250 UTC	LSR: Florida DOT camera shows hail on I-95 (4 NE Maytown)
2255 UTC	LSR: USAF tower measured 49 mph wind (4 SSE Kennedy Space Center)
2300 UTC	LSR: USAF tower measured 52 mph wind (3 WNW Kennedy Space Center)
2302 UTC	LSR: Trained spotter reports sustained 50 mph winds with higher gusts, wind blown debris, and 0.75 in. hail (2 NNW Scottsmoor)
2306 UTC	LSR: COOP observer reports torrential rain, 0.70 in. hail, and 70 mph wind that downed several trees (Scottsmoor); USAF tower measured 62 mph wind (Scottsmoor)
2308 UTC	LSR: Brevard County EM reports trees down on Hwy 76 (Mims)
2310 UTC	LSR: USAF tower measured 54 mph wind (3 SE Kennedy Space Center)
2315 UTC	LSR: Brevard County EM reports downed tree (Lagrange)
2317 UTC	LSR: USAF tower measured 63 mph wind (8 SSE Playalinda Beach)
2319 UTC	Firefox window with debrief presentation

3: Simulation Objectives

I. Introduction



This is a Displaced Real-Time (DRT) simulation designed to apply the learning objectives from the Advanced Warning Operations Course (AWOC) Severe Track into an operationally representative environment. The student is responsible for convection within the northern part of the Melbourne, FL (MLB) county warning area (CWA), which includes the following Florida counties: Volusia, Lake, Seminole, Orange, and Brevard Counties (see figure at right).

Two areas of convection develop during the course of the simulation that will require warning consideration (Volusia County and central Brevard County). The performance objectives focus on radar/satellite interrogation with respect to severe weather hazards and address the warning decision making process. ***The student is required to view the pre-brief and post-brief articulates regarding this simulation.*** Test questions at the end of the simulation include questions regarding information found in these articulates. You will need to log in to the NWS Learning Center to complete the end of simulation quiz and facilitator survey.

Pre-Brief: http://www.wdtb.noaa.gov/courses/awoc/assets/sims/preBrief/player.html
Post-Brief: http://www.wdtb.noaa.gov/courses/awoc/auxiliary/postBrief/player.html

Defining effective performance objectives and evaluation criteria are essential to a successful simulation. The performance objectives outlined in this guide focus on the analysis of the AWIPS data and their warning decision making process during the event. It is recommended that you use the objectives provided, since they are specifically tailored to this DRT simulation. The facilitator is encouraged to use and/or modify these objectives as a template for training other severe convective weather and warning decision cases. The student should have a clear understanding of the objectives prior to starting the simulation.

II. Simulation Details

Case Folder:	2012May15
WFO Localization:	Melbourne, FL (MLB)
Simulation Start Date/Time:	15 May 2012 - 2145 UTC
Simulation End Date/Time:	15 May 2012 - 2320 UTC
Simulation Mode:	Displaced Real-Time (DRT)
WESSL Script File:	MLB.wessl
Estimated Completion Time:	95 minutes for DRT Simulation

III. Instructions for Launching Simulation:

1. On your WES machine, open a terminal window and launch the Weather Event Simulator (WES).

   $ start_simulator

2. In the WES GUI, select 'Run Simulation.' A pop-up will appear prompting you to close any active D-2D session. Ensure that there are no D-2D windows open, and click 'OK.'

3. In the Simulation Entry GUI, select 'Load Saved Settings' in the bottom-right of the window. When the Load window appears, select the following WES macro and click 'OK.'

   AWOC_SVR_MLB

4. Confirm the following information in the Simulation Entry GUI. When ready, click 'OK' to load the simulation.

   FXA_DATA: ***[path]*****/2012May15**
   FXA_INGEST_SITE: MLB
   Case Start Time: 201205152145
   Case End Time: 201205152320
   WESSL Script: ***[path]*****/2012May15/wessl/MLB.wessl**

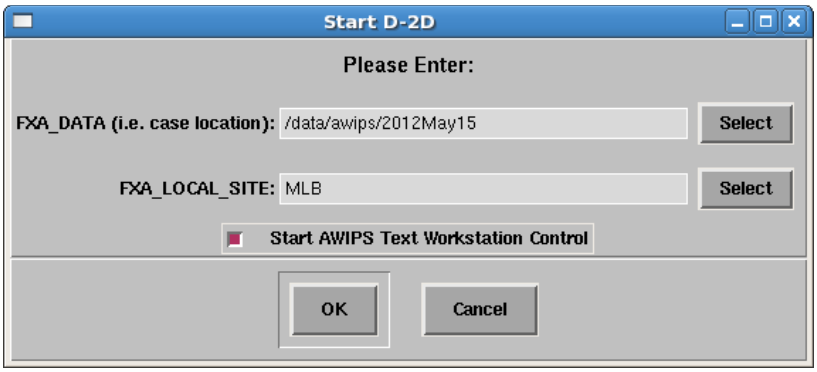
5. Once the case is loaded and the Simulation Control window appears, click 'OK' to begin.

6. The main WES window will prepare and load the case data for this simulation application. When it has finished preparing the data, the Entry Verification & Simulation Control window will appear. Verify the data again and click 'Run Simulation.'

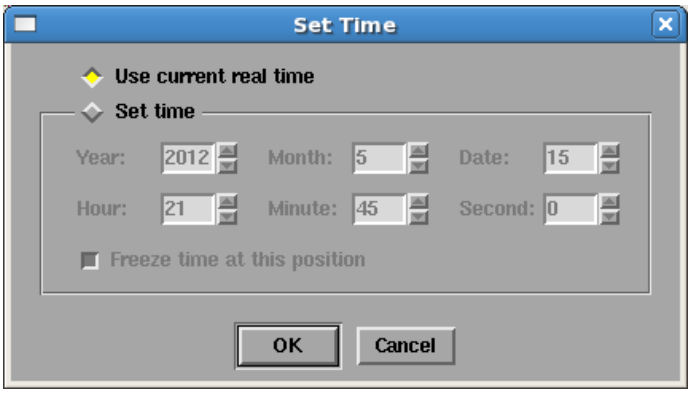
7. When prompted, load a D-2D. Open a terminal window and enter the following command:

```
$ start_awips
```

8. In the Start D-2D window, ensure that the FXA_DATA has the correct case (**2012May15**) and ensure that the FXA_LOCAL_SITE in appears as **MLB**. Also, select 'Start AWIPS Text Workstation Control' so that it is turned on. When ready, click the 'OK.'



9. After D-2D finishes loading, left-click on the time located in the bottom-right portion of the window. Ensure that the "Use current real time" option is selected and click 'OK' to continue with the simulation.



IV. Near-Storm Environmental Assessment

This section focuses on the near-storm environment and how it impacts the potential for the primary severe weather hazards (hail, wind, and tornadoes). This section uses various plan-view and sounding analyses from AWIPS and the 2100 UTC RAP sounding for Daytona Beach, FL that are provided in the pre-brief presentation.

Performance Objective #1: Severe Hail Potential

Using the 2100 UTC RAP analysis sounding, severe hail (diameter ≥ 1.00 inch) is possible due to large MUCAPE values (estimated at 1755 J/kg; Figure 3-1), including substantial CAPE in the hail growth zone (-10°C to -30°C; figure not shown). However, both the freezing level (13,474 ft.) and the wet-bulb zero height (12,050 ft.) are a bit high, which suggests that any marginally severe hail-stones aloft will melt to below severe criteria before they reach the ground.

Significant hail (diameter ≥ 2.00 inches) appears unlikely due to weak effective bulk shear ("Lower Half Storm Depth" shear of 27 kts), which also does not favor a supercell storm mode. The Significant Hail Parameter (SHIP) contains a value less than 1.0, which also favors hail with diameter of < 2.00 inches. Both of these parameters are shown in Figure 3-1.

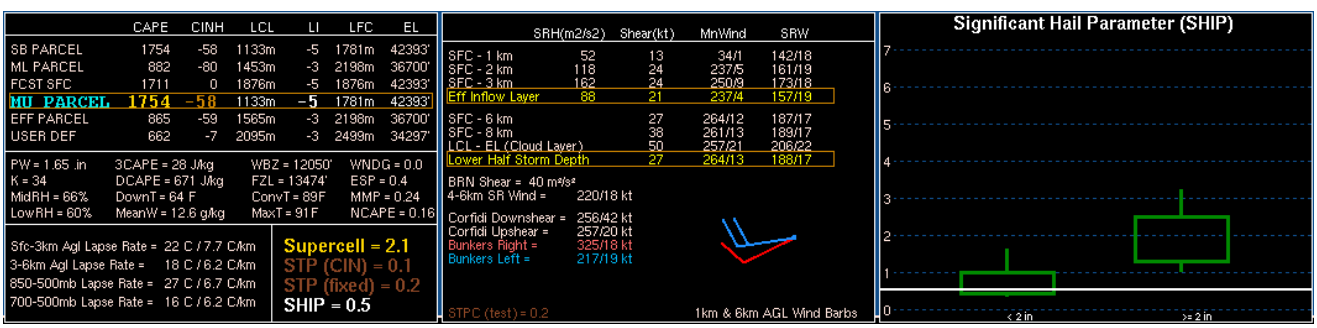


Figure 3-1. Parameter analysis of the 2100 UTC RAP point sounding from Daytona Beach, FL. The left panel contains common severe weather parameters, including values for varying lifting methods and lapse rates for different layers. The center panel displays varying shear and storm relative helicity layers. The right panel displays a box-whisker plot of the Significant Hail Parameter (SHIP) and the value computed from the 2100 UTC RAP sounding (white line).

Performance Objective #2: Severe Straight-Line Wind Potential

Microburst type winds are possible given the forecast soundings, which indicate steep low-level lapse rate below the cloud base. Using a forecast NAM point sounding valid at 2100 UTC 15 May 2012 in the vicinity of northern Brevard county (not shown), students should note a nearly dry adiabatic lapse rate from the surface to the 850 mb pressure level. The lifting condensation level (LCL) height from lifting a surface-based parcel is approximately 3,661 ft. (1,089 m) above ground level (AGL). The temperature of the rising air parcel at the LCL is 19°C. The level of free convection (LFC) is approximately 4,080 ft. (1,245 m) AGL, yielding a CAPE value of 1700 J/kg with negligible CIN (-19 J/kg).

The 2100 UTC RAP analysis sounding indicates a 0-3 km lapse rate of 7.7°C/km (Figure 3-1). For comparison, the NAM 3-hour forecast plan-view plot of 0-3 km AGL lapse rates for 2100 UTC (Figure 3-2) shows values ranging from 6.6-8.4°C/km across the northern half of the MLB CWA. The DCAPE value from the 2100 UTC RAP sounding analysis was 671 J/kg (Figure 3-1). Theta-E differences from both the 500 and 600 mb pressure level to the surface ranged from 20-25°C, which is favorable for typical wet and hybrid microburst events. Large dew point depressions approaching 30°F across portions of east-central Florida indicate a deeper sub-cloud layer adiabatic lapse rate for downbursts to travel and develop negative momentum.

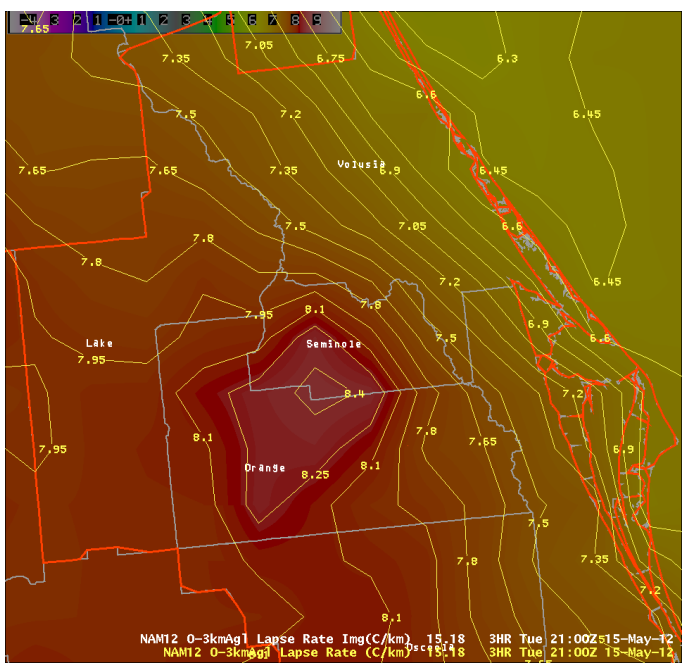


Figure 3-2. NAM12 forecast 0-3 km lapse rates (contours and image) valid for 2100 UTC 15 May 2012.

Performance Objective #3: Tornado Potential

The potential for mesocyclonic tornadoes appears relatively low with forecast westerly 0-1 km (1-6 km) shear of 5 kts (20 kts) from the 1800 UTC NAM12 model valid at 2100 UTC (see Figure 3-3a on the next page). In addition, high dew point depressions (> 25°F) occupy the unspoiled airmass in most of the interior of Florida, resulting in mixed layer LCLs that are too high to allow for buoyant outflows (Figure 3-3b).

However, the east coast sea breeze offers a slightly more favorable westerly shear for the 0-1 km level at about 10 kts, as well as mixed layer LCLs down in the optimal range to allow buoyant outflows. As a result, the estimated 0-1 km storm-relative helicity (SRH) rises to near 50 m^2s^{-2}. Even though the 0-1 km shear and 0-1 km SRH is slightly more favorable, the 0-1 km shear is still below the lower bound threshold for a mesocyclonic tornado.

On the favorable side, there is no significant MLCIN (Figure 3-3c), and the low-level lapse rates are high (Figure 3-3d). Should the sea breeze produce stronger easterly flow, then the 0-1 km shear could reach 20 kts. In fact, some of the 2100 UTC surface observations (e.g., KMLB) show 10 m winds that are approximately 4 kts stronger (Figure 3-3b) than the NAM12 analysis; thus, the 0-1 km shear could approach 15 kts.

While the odds of mesocyclonic tornadogenesis appear quite low, the east coast sea breeze front appears to contain some significant vertical vorticity that exceeds $8 \times 10^{-5}s^{-1}$ from the NAM12 model analysis. The lack of CIN, high 0-1 km lapse rates (approximately 9°C/km; Figure 3-3d), and the potential inclusion of vorticity suggest that the non-mesocyclonic tornado threat is high enough to seriously consider.

For a tornado threat of any kind to be strong, an updraft must persist for on the order of 15 minutes or more. The lack of deep layer shear suggests supercell potential is limited. In addition, the dry air in the interior of Florida, and likely overlying the sea breeze, suggests a strong downdraft potential. Thus, the potential for an updraft to stretch any available supplies of vertical vorticity will be limited in time.

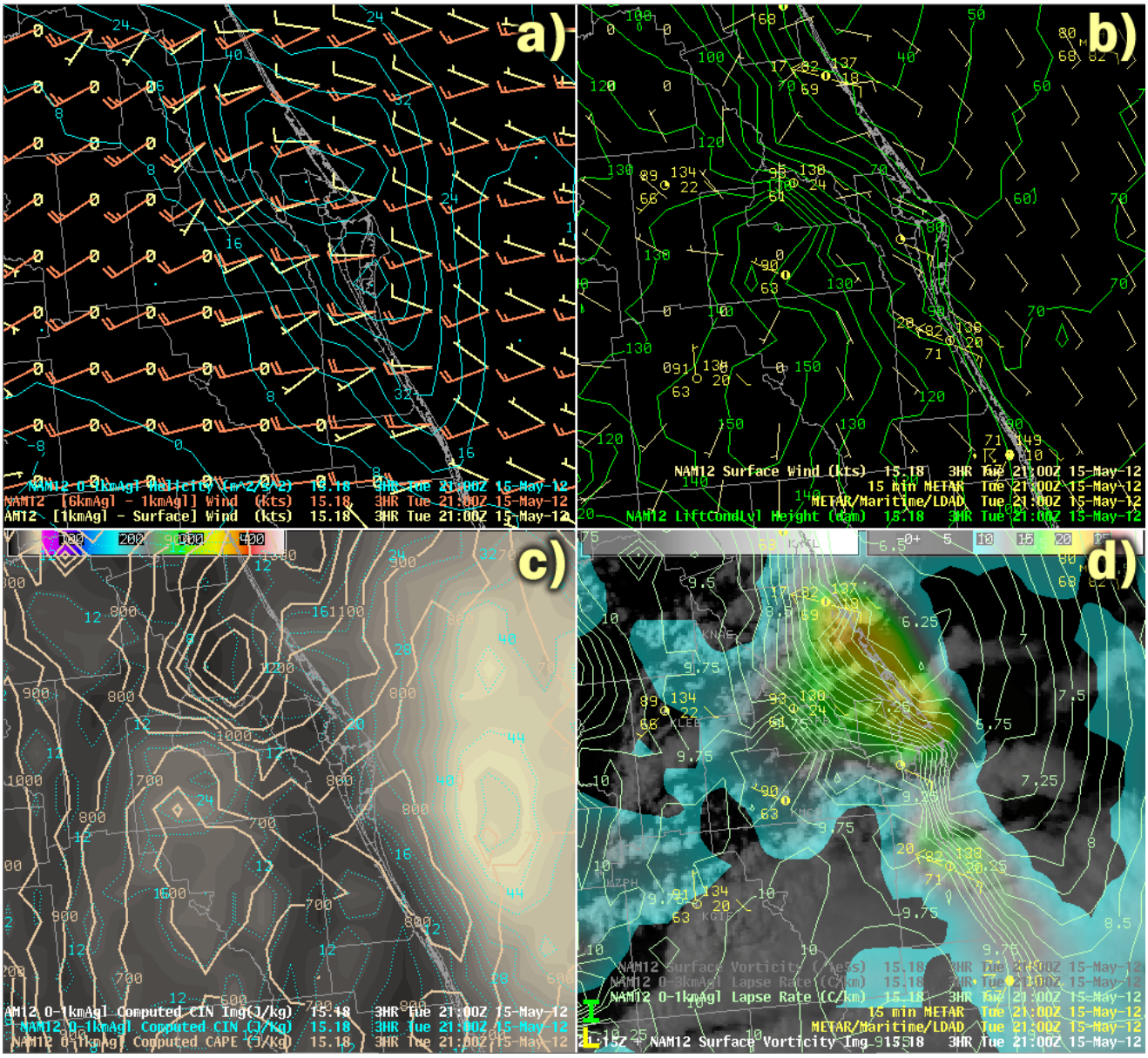
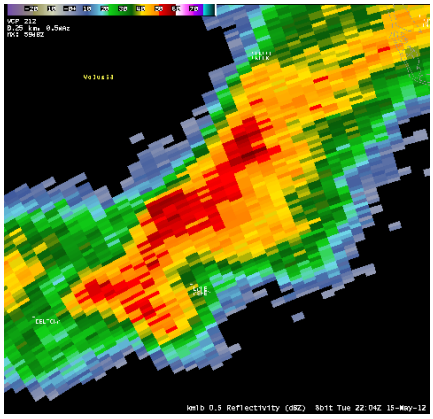


Figure 3-3. 1800 UTC NAM12 model analysis valid for 2100 UTC 15 May 2012 that displays the following information: **a)** 0-1 km wind shear (tan barb; kts), 1-6 km wind shear (orange barb, kts), 0-1 km helicity (cyan contour; m^2s^{-2}), **b)** LCL height (green contour; dam), surface wind (tan barb; kts), METAR (yellow station observations), **c)** 0-1 km computed CAPE (tan contour; J/kg), 0-1 km computed CIN (cyan dashed contour and image; J/kg), and **d)** surface vorticity (image; $10^{-5}s^{-1}$), 0-1 km lapse rate (light green contour; C/km), METAR (yellow station observations).

V. Storm #1 - Volusia County/Northern Brevard County



As stated in the Introduction section, the student is responsible for the counties highlighted in the northern half of the MLB CWA as shown on Page 3-1. At the start of the simulation (2145 UTC), there are three main areas of convection in the student's area of responsibility:

- Along a southward moving outflow boundary in east-central Volusia County
- Along the west-coast sea breeze moving east into Lake County
- Along an area of two outflow boundaries colliding in southern Brevard County

During the first 15 minutes of the simulation, new convective initiation occurs to the west of the storm in Volusia County along the outflow boundary where it intersects with the east-coast sea breeze. The storm that develops in this location will become the first of two severe storms that are within the student's area of responsibility. The performance objectives listed in this section focus on this first storm.

Performance Objective #1: Satellite Analysis

The satellite objectives listed focus on the convective initiation of the storm in Volusia County from 2145-2210 UTC. This performance objective can be addressed at any time during the simulation.

Evaluate the updraft intensity and severe potential of the convective storm that develops in Volusia County using the various satellite techniques that are described over the next few pages:

- Estimate cloud top temperature cooling rate
- Estimate cloud top height growth rate
- Identify key satellite features

Cloud Top Cooling Rate: Previous convection have been generated along this boundary with the most recent radar-detected initiation occurring four miles south of Tiger Bay State Forest (11 miles SW Daytona Beach). Cooler clouds tops from this initiation can be seen over Daytona Beach (Figure 3-4a). New convective initiation occurs SSE of the previous convection and about three miles north of Lake Ashby from 2145-2210 UTC (Figure 3-4). Cooling cloud tops from this convection are located about seven miles SSW of Daytona Beach.

Minimum cloud top temperatures shown in the GOES infrared (IR) satellite imagery cooled from -9°C at 2145 UTC to -56°C by 2202 UTC. Cloud top cooling rates were estimated to be -4.5°C/min during peak cooling from 2155-2202 UTC (see Figure 3-5). These cloud top cooling rates easily exceed the pre-anvilgenesis cooling rates of -2°C/min for severe storms as described by Adler et al. (1985). *Cloud top temperatures and the latitude/longitude sampling points used in this analysis are provided in Table 3-1 on Page 3-11.*

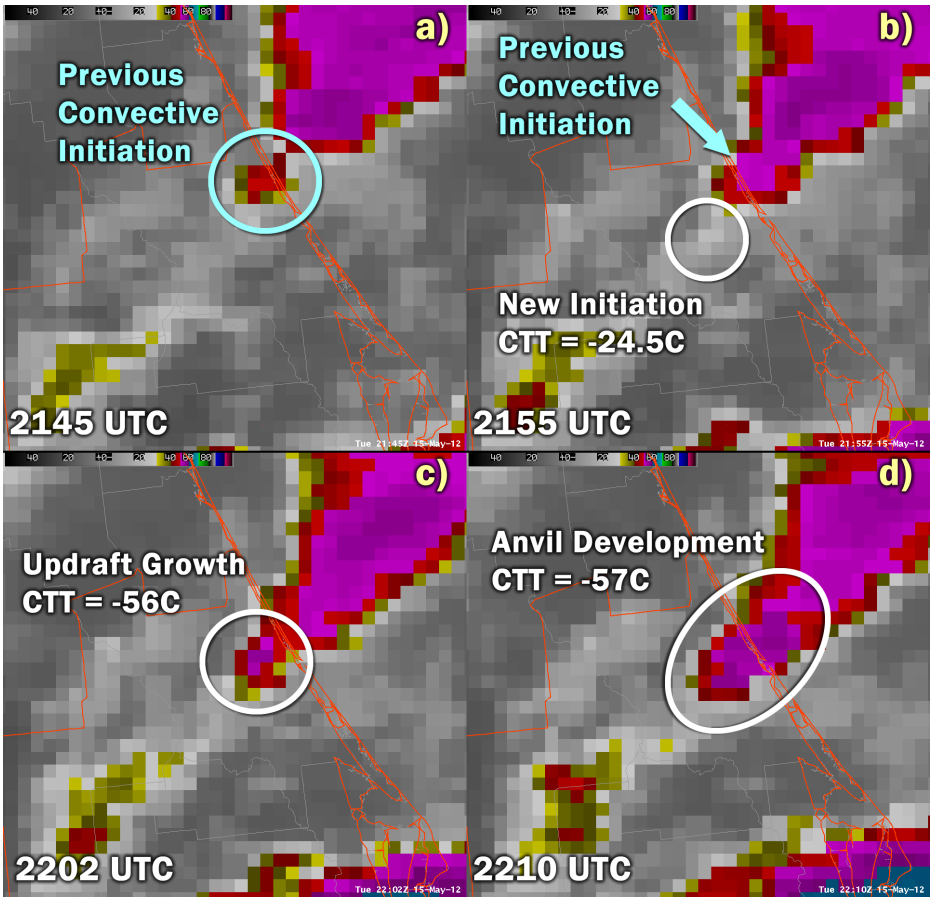


Figure 3-4. GOES infrared (IR) satellite imagery of the convection in Volusia County at a) 2145 UTC, b) 2155 UTC, c) 2202 UTC, and d) 2210 UTC 15 May 2012. Ongoing convection prior to the start of the simulation is annotated in cyan and the new convective initiation is annotated in white. Minimum cloud top temperature (CTT) from 2155-2210 UTC are also provided.

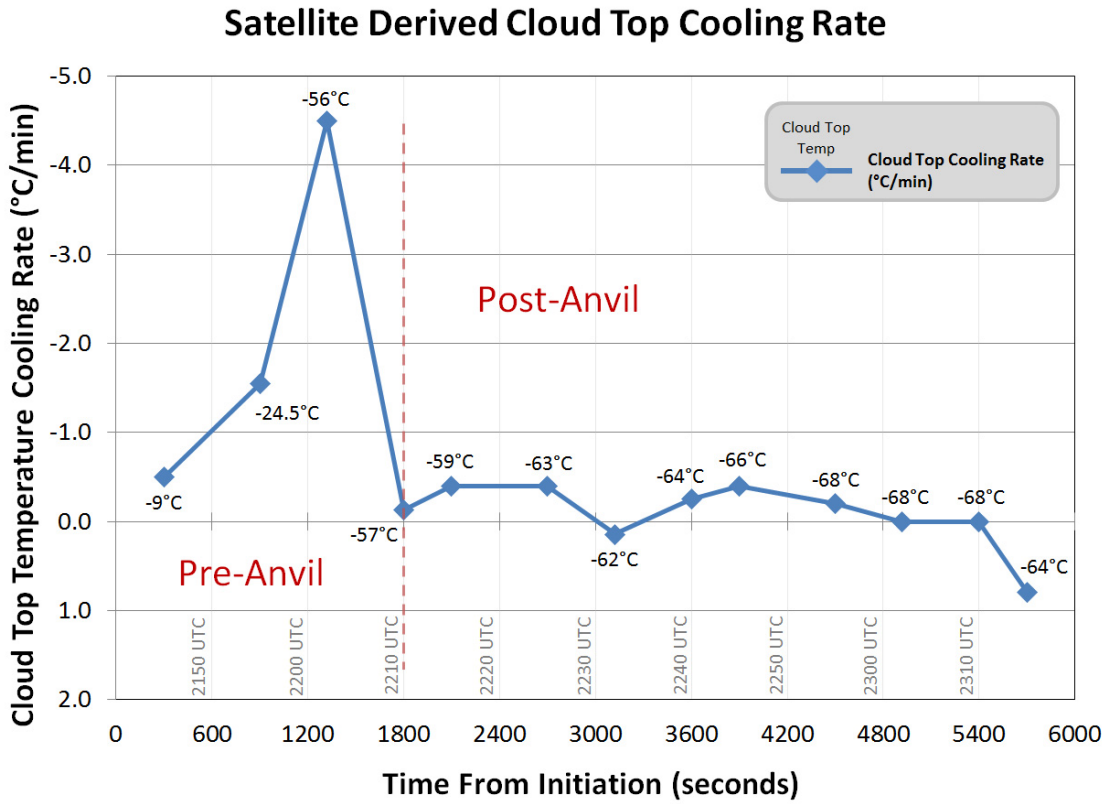


Figure 3-5. Derived cloud top cooling rate (C°/min) from GOES IR satellite imagery of the Volusia/Brevard County storm from 2145-2315 UTC 15 May 2012. The cloud top cooling rate is plotting with respect to time from initiation (seconds). Each point in the graph represents an IR satellite image that is labeled with the minimum cloud top temperature. The cloud top cooling rate during the pre-anvilgenesis (post-anvilgenesis) period is to the left (right) of the red dashed line.

Cloud Top Growth Rate: The cloud top growth rate can be used to extrapolate the vertical velocity of the initial updraft. This can be done by determining the change in height of the cloud top over time. Cloud height data can be sampled in D-2D by selecting the “Sample Cloud Heights/Radar Skew-T” option in the pop-up menu (press and hold the right mouse button to generate the pop-up menu). The analysis described in this section uses the RUC model analysis option. Table 3-1 shows the cloud top vertical velocity estimation during convective initiation. Peak growth occurred between 2155-2202 UTC with RUC estimated cloud top heights increasing by 15.1 kft. in this seven minute period. This increase in the cloud top height translates to an estimated vertical velocity of about 11 ms^{-1} (24.5 mph).

Table 3-1

Time (UTC)	Cloud Top Min Temperature (°C)	Cloud Top Height (kft.)	Vertical Velocity (ms^{-1})	Vertical Velocity (mph)	Lat/Lon Location
2140	-6.5	18.4			29.01°N, -81.18°W
2145	-9.0	19.7	1.3	3.0	29.01°N, -81.13°W
2155	-24.5	26.9	8.2	3.7	29.05°N, -81.13°W
2202	-56.0	42.0	11.0	24.5	29.11°N, -81.08°W
2210	-57.0	42.6	0.4	0.9	29.05°N, -81.06°W

Satellite Features: Overshooting tops can be occasionally observed with the convection in satellite imagery, beginning at 2215 UTC (Figure 3-6). Other overshooting tops are noted at 2240, 2255, and 2315 UTC. These overshooting tops are identified in visible satellite imagery by the shadow it casts on the anvil and by the localized cooler cloud tops in the infrared imagery (not shown). There are no distinguishable enhanced-V signatures in the IR imagery of the anvil.

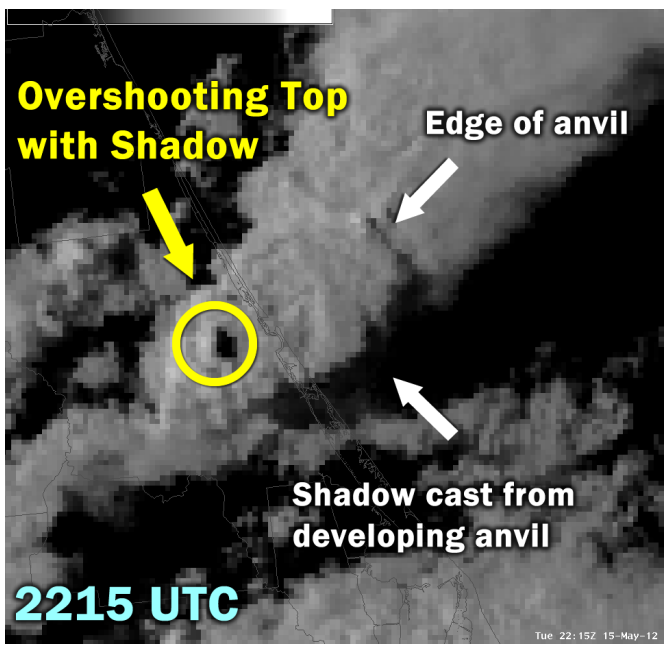


Figure 3-6. GOES visible satellite imagery at 2215 UTC 15 May 2012 of the developing storm in Volusia County. The overshooting top and other anvil features are identified in the figure.

Performance Objective #2: Radar Interrogation of Hazards

This performance objective focuses on storm-scale radar analysis to determine the potential of severe weather hazards (hail, wind, and tornadoes).

Hail Threat: At 2159 UTC, the KMLB WSR-88D indicated severe hail developing aloft with storm over northern Volusia County, FL (335° @ 57 nm) as revealed via a three-body scatter spike TBSS from the 1.3° to 3.1° elevation scans. The dual-polarization products also favor severe hail with ZDR< 0 dB and CC < 0.9 aloft. Storm top divergence increases during the development of this storm and is estimated to be over 90 kts by 2204 UTC (see Figure 3-7). However, a lack of high reflectivity values (> 55-60 dBZ) above the -20°C level and high freezing level/wet-bulb zero heights suggest that the hail may only be marginally severe and may melt below severe size before reaching the surface.

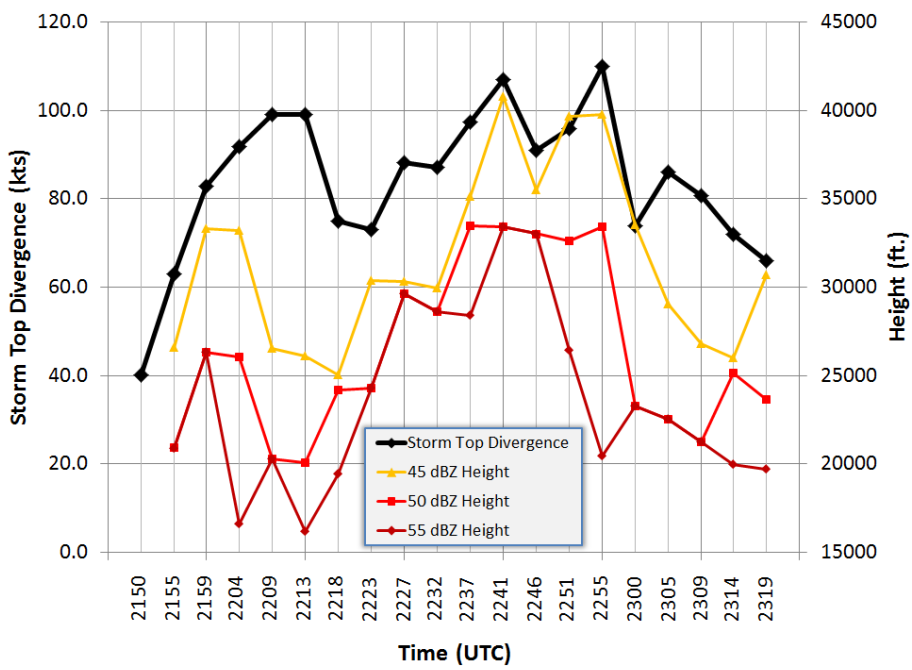


Figure 3-7. Estimated storm top divergence (black; kts.) of the Volusia/Brevard County storm plotted with maximum reflectivity height of 45 dBZ (orange), 50 dBZ (red), and 55 dBZ (dark red) values based on KMLB WSR-88D.

Between 2218-2223 UTC, the KMLB WSR-88D indicates that a new cell (338° @ 52 nm) within that same isolated multicell storm obtains transient supercell characteristics suggestive of severe hail potential. These transient supercell features include a strong reflectivity gradient on the low-level inflow (southeast) side of the storm, a weak echo region (WER), echo top displaced over the WER (see Figure 3-8), and moderate updraft rotation below ~19 kft AGL (not shown).

At 2223 UTC, the cell exhibits severe hail signatures aloft, including high reflectivity values in or above the hail growth zone (e.g., 66 dBZ at -27°C), negative ZDR values, and CC values around 0.94. This hail core descends to the surface during the next 30 minutes, producing sub-severe hail reports, mainly due to melting. This hail swath fell across a mostly rural area with conservation lands. So, it is possible that severe size hail reached the surface and was not reported.

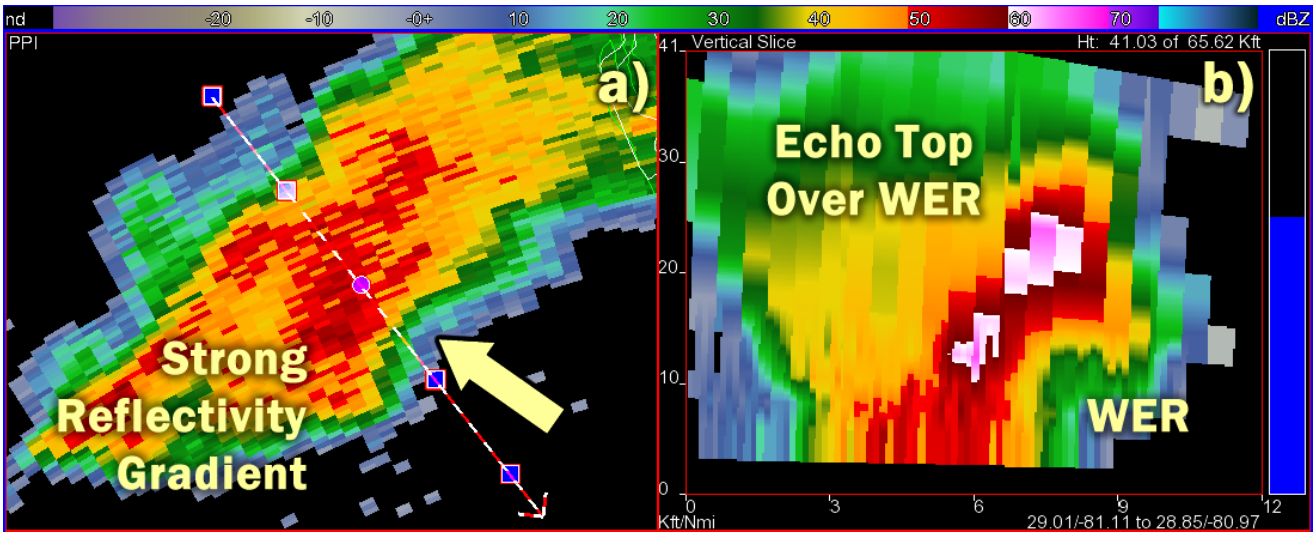


Figure 3-8. KMLB a) 0.5° elevation base reflectivity (dBZ) and b) Four-dimensional storm investigator (FSI) cross-section through storm as denoted in a) at 2223 UTC.

Wind Threat (Part I): This large storm that develops in Volusia County between I-4 and I-95 undergoes intensification from 2204 UTC to 2237 UTC and eventually develops the potential for damaging winds. From DLOC Topic 7 - Lesson 5, the student should recognize the enhanced downdraft and subsequent strong wind potential due to several factors that occur from 2204 to 2237 UTC:

- Enhanced negative buoyancy due to favorable lapse rates *vs.* precipitation loading
- Strengthening updrafts as indicated by reflectivity cores of 46-63 dBZ to near 31 kft. have been increasing from 2209-2218 UTC as the KMLB WSR-88D indicates a new updraft pulse developing just east of Lake Ashby (335° @ 54 nm)
- KDP values have increased to 6.5 deg/km below the developing updraft pulse east of Lake Ashby to depth of 12 kft. (-5°C level), but column does not deepen as updraft reforms to the southeast
- ZDR values also are sporadically high (approaching 6.5 dB) with updraft growth at 2218 UTC

A new reflectivity core of 63 dBZ to 23,969 ft. forms east-southeast of Lake Ashby (337° @ 52 nm) at 2227 UTC as the storm shows signs of increasing rotation with a developing weak mesocyclone (see Figure 3-9). The strengthening downward pressure forcing due to increasing rotation within developing updraft is a precursor to severe winds at the surface. With increasing convergence at the base of updraft developing east southeast of Lake Ashby, the storm is intensifying and should be considered becoming increasingly capable of producing severe winds.

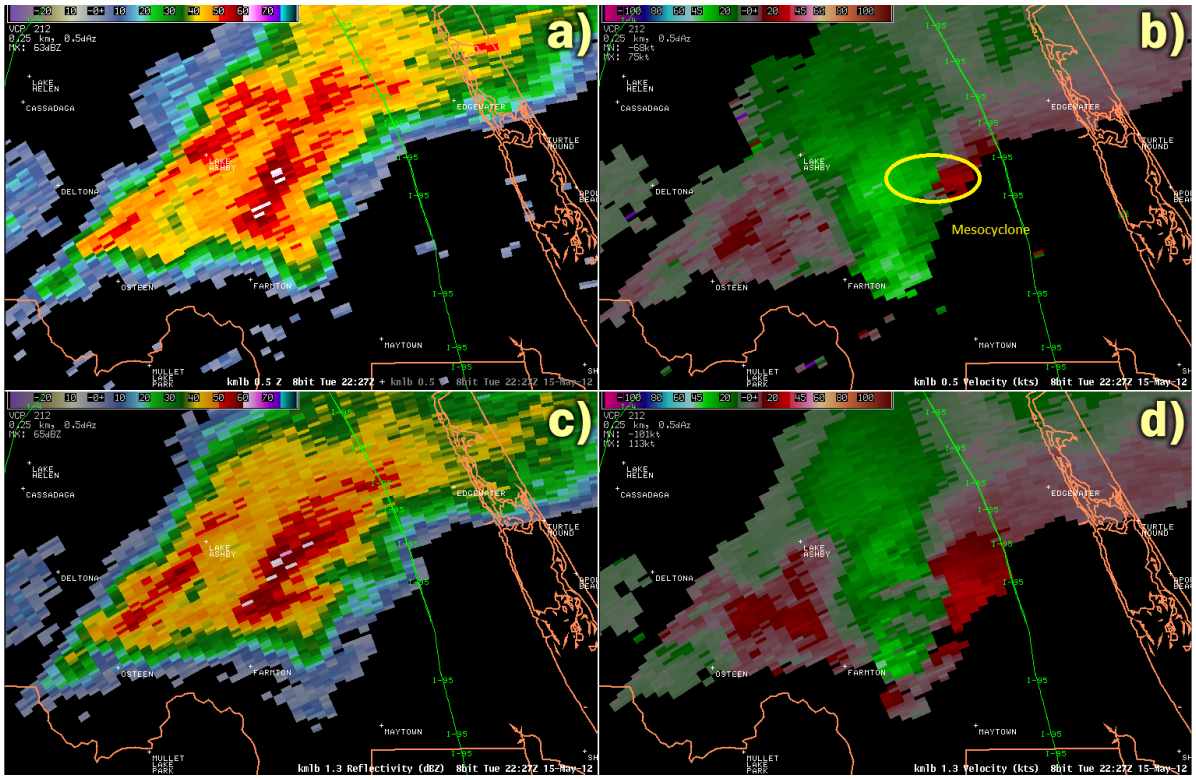


Figure 3-9. KMLB a) 0.5° elevation base reflectivity, b) 0.5° elevation base velocity, c) 1.3° elevation base reflectivity, and d) 1.3° base velocity at 2227 UTC. The developing weak mesocyclone is denoted by a yellow circle in b).

Students should also note via the Four-dimensional Stormcell Investigator (FSI) or all-tilts that the height of the reflectivity core increased dramatically in response to the increased low-level convergence and increased updraft strength from 2227 UTC to 2237 UTC. The max reflectivity core (338° @ 53 nm) increased to 65 dBZ @ 22,548 ft AGL as the storm developed a WER and inflow notch as it approached I-95. Storm-top divergence was also increasing and approached 100 kts by 2237 UTC (see Figure 3-7). An example velocity image of the storm top divergence during this phase of the storm (2232 UTC) is depicted in Figure 3-10.

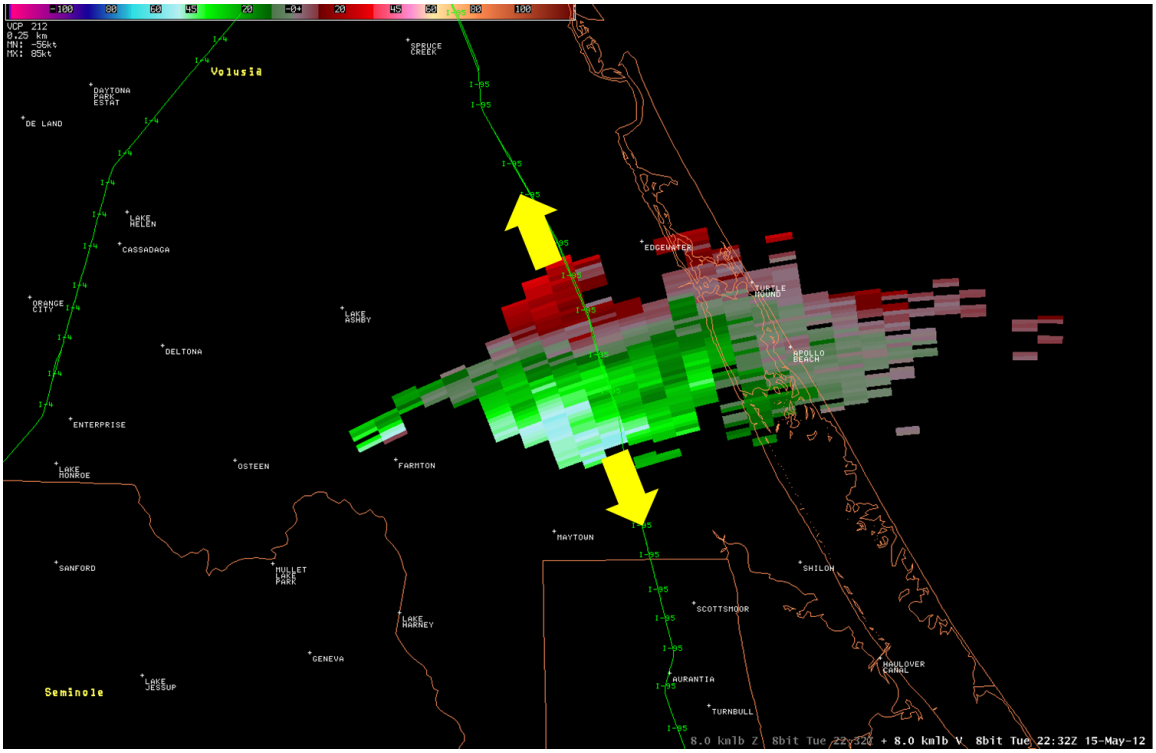


Figure 3-10. KMLB 8.0° elevation base velocity at 2232 UTC.

A negative factor for downburst potential is the fact that the gust front is pushing out ahead of the storm and starting to undercut the updraft. This process is causing new updrafts to continue to develop southeastward as the initial mesocyclone weakens and forms along the outflow boundary. A loop of base reflectivity and velocities at both the 0.5° and 1.3° elevation scans show this evolution nicely.

Wind Threat (Part II): The large storm complex in Volusia County has already undergone updraft intensification from 2204 UTC to 2237 UTC but updrafts have not been sustained as the storm's gust front has started to undercut the updraft. However, there is still a moderate severe wind threat as the complex has progressed south southeastward. Thus far, severe verification has been hard to come by, but there is a local storm report at 2302 UTC (sustained 50 mph winds w/ higher gusts, wind blown debris; 0.70 in. hail) approximately 2 NNW of Scottsmoor in southern Volusia County. However, the first legitimate severe wind report is not received until 2310 UTC from the town of Mims in northern Brevard County with trees down.

For the second phase of this wind threat objective, the student will need to observe that the storm, now reforming its updraft approximately 3 N Maytown, has intensified and is evolving to a forward propagating multicell from 2241 UTC to 2305 UTC. The severe wind threat increases during this period based on the following features:

- Interaction with an outflow boundary moving northward and a persistent moderate strength mesocyclone
- Strong convergence (67 kts ΔV) at 2300 UTC along a forward propagating gust front
- A convergence rotational signature (35 kts Vr shear at the 0.5° elevation scan) persists at 2255 UTC between Maytown and Scottsmoor as the gust front swings southward to the southwest of the main updraft
- Cold pool becomes apparently stronger as hydrometeors expand immediately above the sloped gust front with the leading edge west of Aurantia
- KMLB WSR-88D indicates base velocity 45-50 kts at the 2300 UTC 0.5° elevation scan (3,245 ft AGL) immediately behind the surging gust front (Figure 3-11)
- High spectrum width values (20-25 kts) with low CC values (around 0.5) also confirm strong to severe winds along the surging gust front, which can produce some lead time for report of severe winds at 2310 UTC

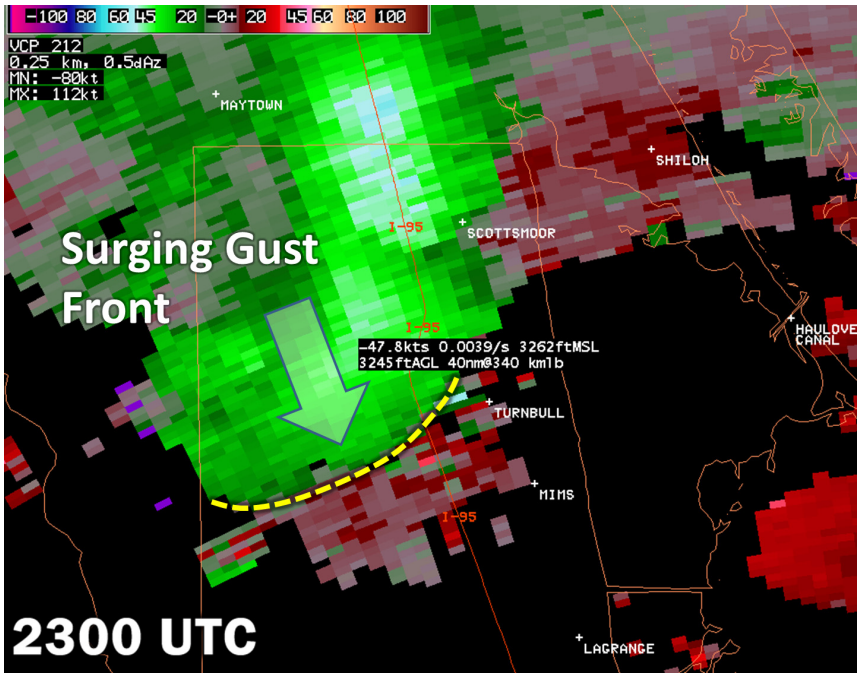


Figure 3-11. KMLB 0.5° elevation base velocity at 2300 UTC with surging gust front denoted by dashed line.

Tornado Threat: From 2145-2155 UTC, the developing Volusia County storm featured a three-dimensional correlated shear signature extending from approximately 5 kft. above radar level (ARL) from the 0.5° elevation scan to about 11 kft ARL (1.3° elevation scan) according to the Mesocyclone Detection Algorithm (MDA; figure not shown). Low-level rotational velocity (LLVr) peaked at only 21 kts, which is also the maximum rotational velocity Vr of the developing mesocyclone (see Figure 3-12).

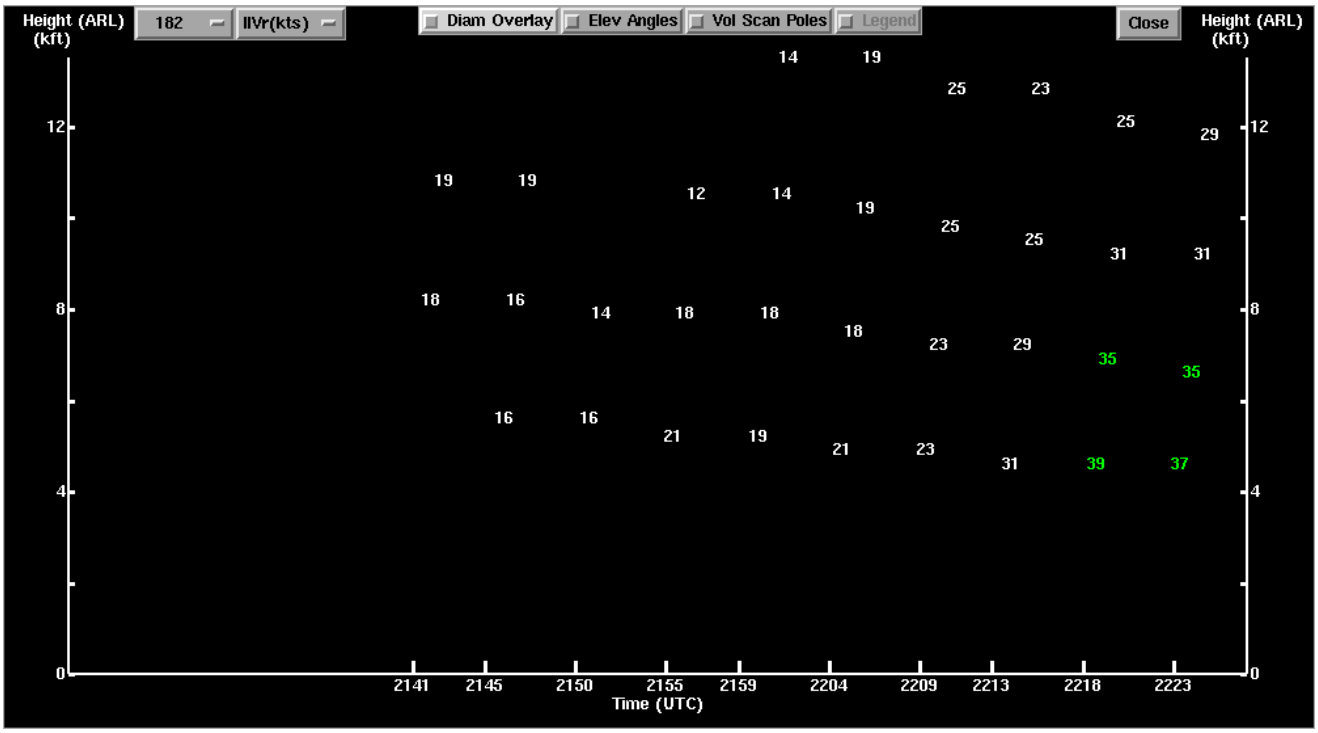


Figure 3-12. Low-level rotational velocity (LLVr) time-height trend of the mesocyclone present in the Volusia County storm through 2223 UTC as computed from the Digital Mesocyclone Detection (DMD) algorithm.

The mesocyclone strengthened and deepened to 13 kft ARL (1.8° elevation scan) between 2204-2213 UTC. Manual inspection of the low-level radial velocity during this time show an area of convergence west of an area of convergent azimuthal shear where the LLVr was estimated by the MDA. The manual LLVr corresponds quite well with the MDA. Given the aforementioned strengthening signatures (elevated core strength, storm top divergence, and ZDR column), the updraft should be strong enough to stretch any sufficient low-level vorticity into the tornado scale. The three-dimensional correlated shear profile that is seen within this storm also represents a method to enhance the updraft through non-hydrostatic pressure deficits, but the strength of the shear suggests this updraft enhancement process should be minimal.

According to the relationship between the LLVr and proportion of tornadic vortices presented in TWG 2013 - Lesson 2 (Storm-Scale Pre-Tornadic Signatures), the likelihood that the three-dimensional correlated shear was associated with a tornado is less than 5%. This value should be lower considering that the guidance was for environments favorable for tornadoes, whereas this environment has been shown to be unfavorable.

As the updraft intensified and the storm exhibited a front low-level inflow notch and strong echo overhang (WER) from 2213-2218 UTC, the three-dimensional correlated shear also intensified into a Rank 5 mesocyclone east of Lake Ashby, according to the MDA, where the LLVr peaked at 39 kts. Comparing the LLVr to the proportion of tornadic mesocyclones reveals a 25% chance of this mesocyclone being tornadic. A LLVr of 39 kts is also quite close to the optimal skill in discriminating tornadic from non-tornadic mesocyclone. Manual inspection concurs with the algorithm LLVr although the maximum and minimum velocity peaks became separated by three radials by 2218 UTC, and may have accompanied two smaller vortices, each with an LLVr of roughly 20 kts (Figure 3-13). One was located at 337° @ 53 nm from the KMLB WSR-88D and the eastern one was located at 339°@ 52 nm. Both vortices extended up 6.8 kft ARL before merging into the larger mesocyclone. The eastern vortex triggered a TVS detection by the TDA at 2218 UTC with a low-level delta velocity (LLDV) of 50 kts (LLVr of 25 kts). This value was below the value at which optimal skill occurs in discriminating tornadic and non-tornadic vortices (60 kts).

By 2223 UTC, the eastern vortex became the center of the larger mesocyclone and the western vortex weakened as the locally strong inbound radial velocity spread eastward. The TDA was still detecting a TVS with a LLDV of 55 kts, while the LLVr of the larger mesocyclone was about 37 kts. Manual inspection revealed a similar value for each. However, the forecaster must be aware that the TDA derives its LLDV from the recombined velocity product and not the super-resolution velocity. Also, the LLDV from a TVS should be calculated from the maximum and minimum radial velocity up to two radials apart in the super-resolution velocity data. If V_{max} and V_{min} are farther part, then the vortex signature is a Tornado Signature (TS; see DLOC Topic 7). One major difference for which the algorithms don't detect this TS was the large increase in inbound velocities west to southwest of the vortex center. These inbounds indicated a strong surge in outflow to the south. This was not surprising considering the dry air aloft. Although the TVS was likely under the updraft and was to the east of the surge, its lifespan was likely limited by the building cold pool.

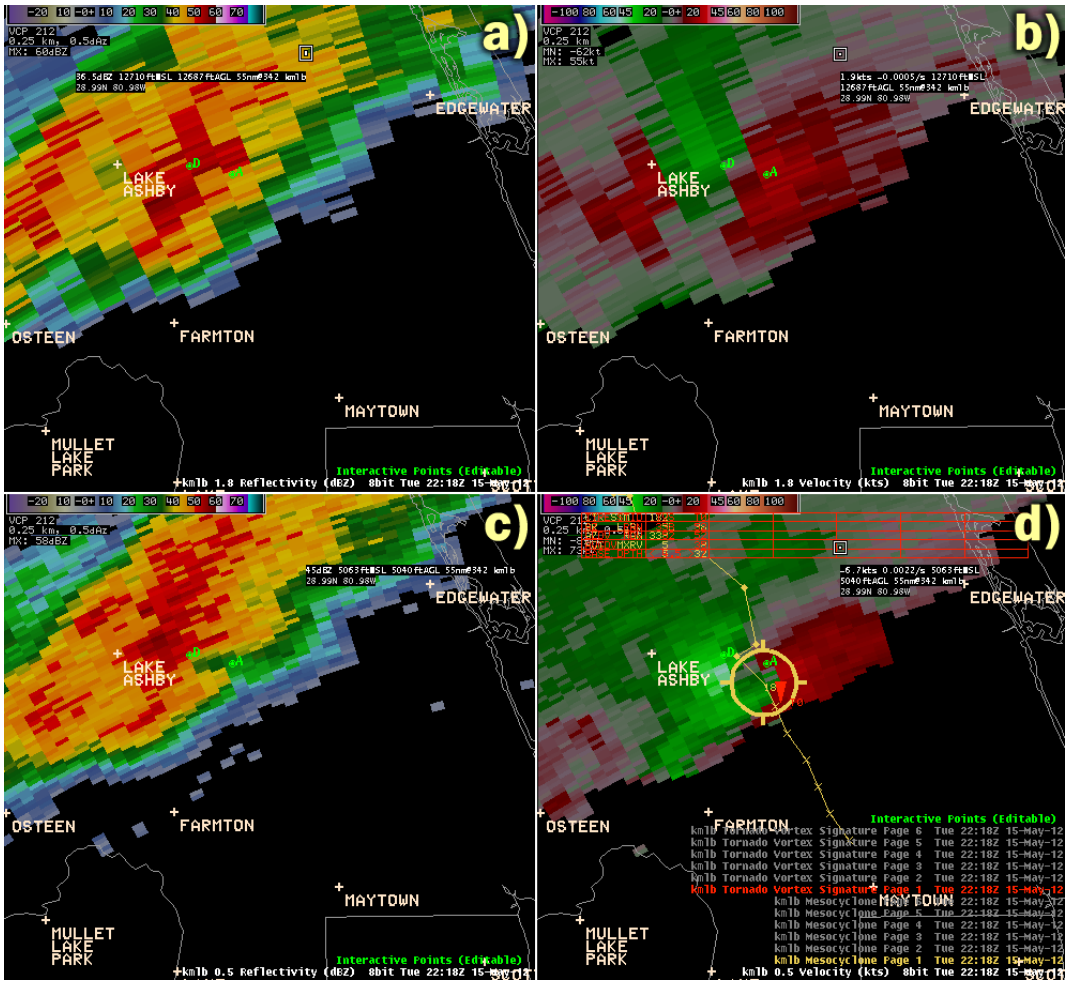


Figure 3-13. Four panel image from KMLB at 2218 UTC displaying a) 1.8° base reflectivity, b) 1.8° base velocity, c) 0.5° base reflectivity, and d) 0.5° base velocity overlaid with Mesocyclone Detection Algorithm (MDA) and Tornado Detection Algorithm (TDA). Green letters (A and D) highlight just north of the lowest scan vortex signatures of which vortex A is the TVS detected by the TDA.

Performance Objective #3: Warning Decision Process

Evaluate the trainee's warning decision making process during the course of the simulation for this storm that tracks through Volusia and Brevard Counties. The discussion provided in this section will focus on the following warning aspects:

- Threat type
- Storm motion
- Warning duration

Threat Type: During the early phases of the storm, the primary severe weather threats are hail up to one-inch in diameter and winds up to 60 mph. This is based on a number of factors, including a descending reflectivity core of > 60 dBZ, strong updraft growth with storm top divergence exceeding 80 kts, and low-level velocity convergence of about 40 kts. Both the hail and wind threats continue through the life-cycle of the convection; however, there is little observational evidence to suggest any change in the magnitude of these threats through 2300 UTC. This includes the fact that no severe hail or wind reports are received during the simulation through this time.

When the storm begins to gust out and become more downdraft dominant, both radar signatures and local storm reports favor an increase in estimated wind magnitude in the warning to 65-70 mph. Reflectivity values are also on a downward trend after 2300 UTC. The largest hail reports are dime-size (0.70 inch).

> ***It is recommended that the first Severe Thunderstorm Warning (SVR) should be issued with this storm following the 2204 UTC volume scan.***

One of the challenging warning decisions to be made during this simulation is whether or not to issue a tornado warning. There were a number of factors to consider during this particular warning decision making process. The pros and cons of the tornado warning decision making process are listed here:

- Tornado Warning Pros:
  (1) Rank 5 mesocyclone with LLVr indicating 25% tornado probability
  (2) Strenghtening updraft aloft
  (3) TDA defined TVS

- Tornado Warning Cons:
  (1) Mesocyclone LLVr was probably an overestimate given the double vortex signature
  (2) Environment was not quite favorable for tornadoes, though a narrow corridor of non-mesocyclonic tornado conditions may have been met
  (3) Cold pool strenghtening may have quickly cut off the window of opportunity to stretch vorticity underneath the updraft

If the student issues a Tornado Warning (TOR), the warning should be issued following the 2218 or 2223 UTC volume scans.

Storm Motion: Average storm motion prior to 2230 UTC is from 315 degrees (i.e., from the NW) at 14 kts. Storm motion increases slightly to 20 kts from 325 degrees (i.e., from the NW). The forward propagating gust front described in the Wind Threat assessment accelerates ahead of the storm at an estimated 24 kts. Initial warning text should depict a storm motion of 15 mph to the southeast. Storm motion should then increase to 20-25 mph towards the southeast as the storm accelerates to the southeast after 2230 UTC.

Warning Duration: The primary storm is an isolated multicell that does not have a sustained updraft (i.e., contains multiple updraft pulses), but exhibits some supercell characteristics. Since there is some uncertainty in the storm evolution, it is recommended that the SVR warnings should have a duration of no more than 45 minutes. If the student issues a TOR warning, the duration of the warning should be no more than 30 minutes given the marginal environmental conditions and velocity signatures.

Note: This simulation guide does not cover Special Marine Warnings (SMWs). You, the facilitator, have the option to address this warning type in the student's warning decision making process. SMW criteria includes gusts of 34 kts (39 mph) or greater, hail 0.75 inches in diameter, and/or waterspouts.

Performance Objective #4: Communicating Impacts

This performance objective assesses the student's ability to evaluate the severe weather threat and communicate this threat to core partners. In this simulation, it will be done through a WESSL window that allows the student to type in a response. Here is the prompt that is given to the student at 2230 UTC:

> *"Your office has just received a call from the Cape Canaveral Air Station at the Kennedy Space Center asking when you expect the storm in southern Volusia County to impact them and what impacts they should expect from the storm. What do you tell them?"*

When analyzing the student's response, the student should recognize that the storm has accelerated over the past few volume scans due to a downburst (as seen on the 0.5° elevation angle). Storm motion at 2230 UTC is approximately from 315 degrees at 21 kts. This would place the storm at the northern boundary of the Kennedy Space Center property around 2330-2340 UTC. Given the environment, the student should remark that the greatest hazards would be straight-line winds up to 60 mph, small hail near severe criteria, and frequent cloud-to-ground lightning. Travel impacts can also be considered with I-95 as the main N-S thoroughfare in the area and the bridges that cross over the intercoastal regions to Cape Canaveral.

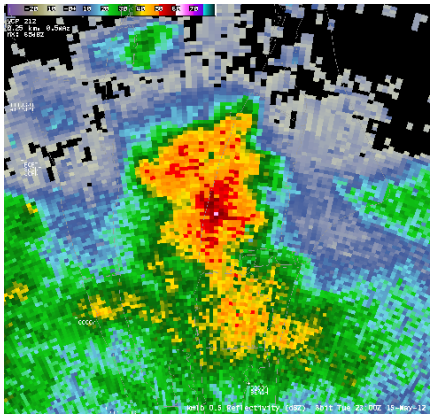
The student's response can be found in the following text file in the case folder:

```
[path]/2012May15/wessl/MLB.log.YYYYMMDD_HHMM
```

The "`YYYYMMDD_HHMM`" is the date/time that the trainee responded to the question in the WESSL window.

VI. Storm #2: Central Brevard County

As the simulation progresses, the convection that earlier developed in southern Brevard County and eastern Osceola County generated a new outflow boundary. As the boundary progressed northward, new convection developed near the town of Cocoa around 2230 UTC. The storm that develops here will become the second of two severe storms within the student's area of responsibility in the MLB CWA. The performance objectives listed in this section focus on this second storm.



Performance Objective #1: Satellite Analysis

Evaluate the updraft intensity and severe potential of the convective storm that develops in Volusia County using the various satellite techniques listed here:

- Estimate cloud top temperature cooling rate
- Estimate cloud top height growth rate
- Identify key satellite features

Satellite Features: This storm is more difficult to observe by satellite since its initiation is obscured by pre-existing anvil cloud from a leftward-propagating multicell in eastern Osceola and central Broward Counties. However, a cell on the north flank of the multicell began to produce small overshooting tops above the anvil canopy southwest of Cocoa near 2210 UTC. Small overshoots continued to move to the northeast towards Merritt Island and the Rte. 520 causeway by 2232 UTC. By 2240 UTC, no overshooting top was visible despite development of a new updraft and precipitation core visible from the KMLB WSR-88D.

A new overshooting top appeared in visible imagery over Cape Kennedy at 2246 UTC. The strength of this updraft became quite apparent by 2255 UTC as its overshooting top produced the longest shadow of the event. It was only at this time that IR imagery showed substantial cooling (-1.1°C/min) relative to the anvil canopy. ***This sequence shows the disadvantage of satellite data with respect to detecting convective initiation under pre-existing cloud cover.***

Performance Objective #2: Radar Interrogation of Hazards

This performance objective focuses on storm-scale radar analysis to determine the potential of severe weather hazards (hail, wind, and tornadoes).

Hail Threat: In the development phase of the updraft (2237-2251 UTC), the student should note a tilted updraft and a feature resembling a weak-echo region (WER) with a high reflectivity core (> 60 dBZ) around the -20°C level (based on RAP/NAM environmental sampling; see Figure 3-14). A three-body scatter spike (TBSS) is evident primarily between the 5.1° and 10.0° elevation scans between 2237-2251 UTC. A ZDR column is also present with CC values at the surface of approximately 0.95 and KDP values ranging from 1.2 to 4.3 deg/km, indicating that melting hail is taking place (not shown).

The hail threat continues with noted reflectivity values of 62 dBZ at -30°C at 2251 UTC, which decreases to 53 dBZ at -30°C by the end of the simulation period (2320 UTC). A TBSS remains visible throughout this period as well with CC values decreasing in the 0.5° elevation scan to 0.85. These lower CC values are co-located with negative ZDR values; however, KDP values range from 5.0-8.0 deg/km, which should increase confidence in identifying this as melting hail. This will then limit the maximum potential hail size to 1.00 inch (quarter size) to 1.25 inches (half-dollar size).

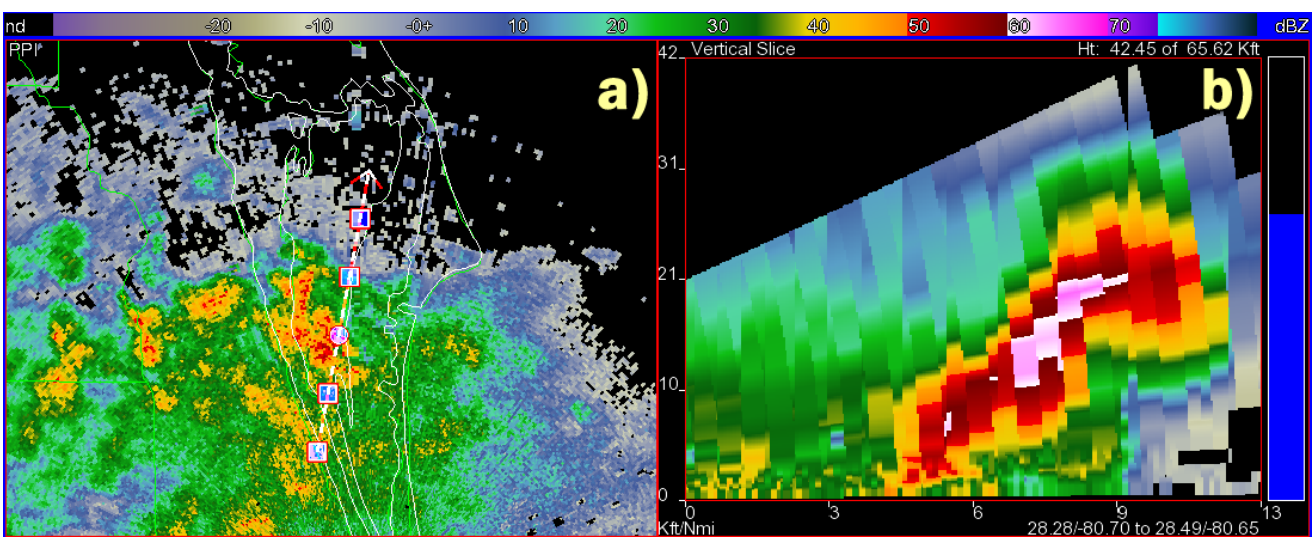


Figure 3-14. KMLB a) 0.5° elevation base reflectivity (dBZ) and b) Four-dimensional storm investigator (FSI) cross-section through storm as denoted in a) at 2246 UTC.

Wind Threat: Aside from the favorable environmental cues described on Page 3-5, it is hard to discern any radar-based feature in terms of a wind threat. Convergence aloft can be seen starting with the 2237 UTC volume scan and continuing through the 2251 UTC volume scan (Figure 3-15). At 2251 UTC, the high reflectivity core begins to collapse, further indicating the potential for stronger winds to reach the surface.

The velocity magnitude can be seen increasing in the 0.5° elevation angles from 2251-2315 UTC, further enhancing confidence of a surface-based wind threat. This threat is confirmed by several reports from United States Air Force (USAF) wind towers over the Kennedy Space Center property. Damaging wind potential also is indicated by continued convergence aloft and the continued collapse of the storm through the remainder of the simulation period.

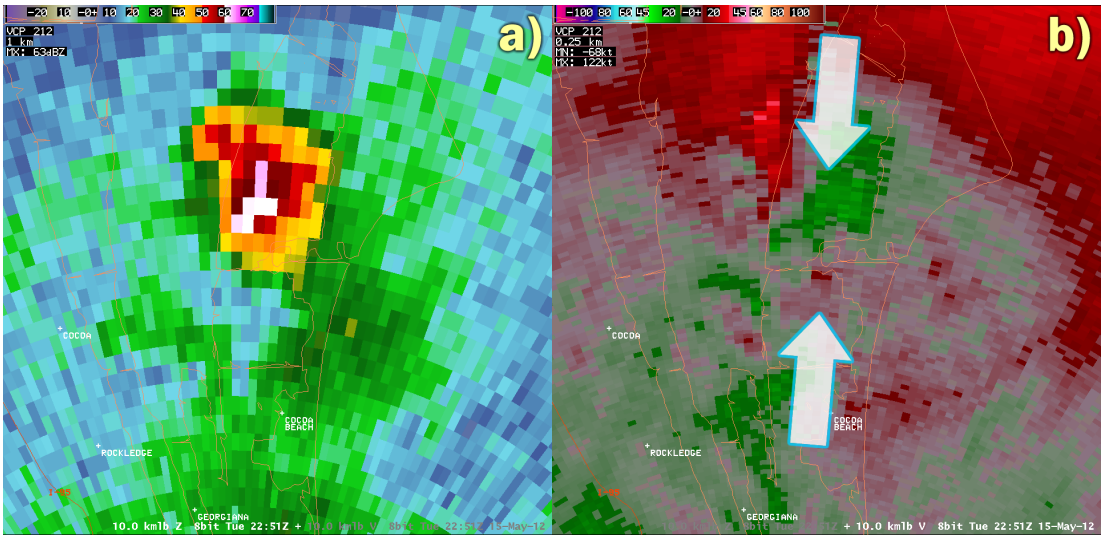


Figure 3-15. KMLB 10.0° elevation a) base reflectivity and b) base velocity with area of convergence denoted by arrows at 2251 UTC.

Tornado Threat: A very limited tornadic threat exists with this storm based on environmental and KMLB WSR-88D observations. Conditions along boundaries appear to contain some vertical vorticity. Combined with the lack of CIN, high 0-1 km lapse rates, and the potential inclusion of vorticity suggest that the non-mesocyclonic tornado threat should be considered. Tornado/waterspout potential increases whenever rapid cell growth occurs along a boundary or surging gust front, especially if moving across a surface of significant differential friction (i.e., land to water). Based on velocity data from the KMLB WSR-88D, the storm does not exhibit any significant low-level or mid-level rotation.

Performance Objective #3: Warning Decision Process

Evaluate the trainee's warning decision making process during the course of the simulation for this storm in central Brevard County. The discussion provided in this section will focus on the following warning aspects:

- Threat type
- Storm motion
- Warning duration

Threat Type: The primary severe weather hazards with this cell over central Brevard County are hail up to one-inch in diameter and winds up to 60-65 mph. The hail threat is based upon a reflectivity core of > 60 dBZ descending at 2251 UTC, a tilted updraft, and a sizeable three-body scatter spike (TBSS). Although there is a lack of clear base velocity signatures suggesting any severe winds, the student should consider the favorable wet microburst environment that the storm resides in.

> ***It is recommended that a SVR should be issued with this storm as early as the 2241 UTC volume scan and no later than the 2251 UTC volume scan.***

Storm Motion: Average storm motion prior to 2300 UTC is from 215 degrees (i.e., from the SSW) at 18 kts. Storm motion increases to around 22 kts after 2300 UTC. The warning text should depict a storm motion of 20-25 mph to the northeast.

Warning Duration: Warning duration should be constrained by the time when the storm is predicted to move offshore. Using an average storm motion of 20 kts from 215 degrees, the storm is expected to be completely over open water around 2330 UTC. The warning duration should coincide with an expiration time of 2330 UTC.

Note: This simulation guide does not cover Special Marine Warnings (SMWs). You, the facilitator, have the option to address this warning type in the student's warning decision making process. SMW criteria includes gusts of 34 kts (39 mph) or greater, hail 0.75 inches in diameter, and/or waterspouts.

4: The May 15, 2012 Event Overview

A marginal severe weather environment developed along the eastern coast of Florida in the county warning area (CWA) of the National Weather Service (NWS) Weather Forecast Office (WFO) of Melbourne, FL (MLB). Convection developed along multiple sea breeze and outflow boundaries across the Florida peninsula during the afternoon hours. The most significant storm developed along the intersection of the east coast sea-breeze and a southward moving boundary in northern Volusia County. This storm was reported to have sub-severe hail and wind gusts estimated up to 70 mph. Another severe storm developed off a northward moving outflow boundary generated by convection in central Brevard County and produced strong winds over the intercoastal region and the Kennedy Space Center property. This overview provides a basic environmental analysis, a radar overview in the area, and a summary of the event.

Environmental Analysis:

Weak unidirectional flow was dominant over the central Florida peninsula as a result of split upper-level flow associated with a positively tilted trough over TX/OK and a ridge over the southwest Caribbean near Panama. The NAM40 model forecast analysis for 2100 UTC at the 300 mb pressure level depicts this split flow over the region with jet streaks of 60-75 kts over the central Gulf of Mexico and southern Appalachian Mountains at 2100 UTC. Flow over northeast and east-central Florida is forecast to be no more than 30-40 kts and located in an area of weak upper-level divergence. Top-down analysis for the 2100 UTC 15 May 2012 forecast period portrays the weak WSW-ENE flow over northern and central Florida, with an average 850-300 mb wind of 15-20 kts at 250 degrees. Forecast bulk shear at 2100 UTC for the 0-6 km (0-10) km layers were 25-30 kts (30-40 kts).

Surface analysis at 2100 UTC (Figure 4-1) shows the light, variable winds across the Florida peninsula with more uniform SE winds behind the east coast sea breeze (in regions unmodified by convective activity). Analysis ahead of the sea breeze shows surface temperatures generally ranging from 89-93°F with dew point temperatures ranging from 60-64°F across Seminole and Orange Counties. Behind the sea breeze, surface temperatures are about 10°F cooler with dew point temperatures $\geq$ 70°F, with some dew point temperatures around 80°F in northern Brevard County.

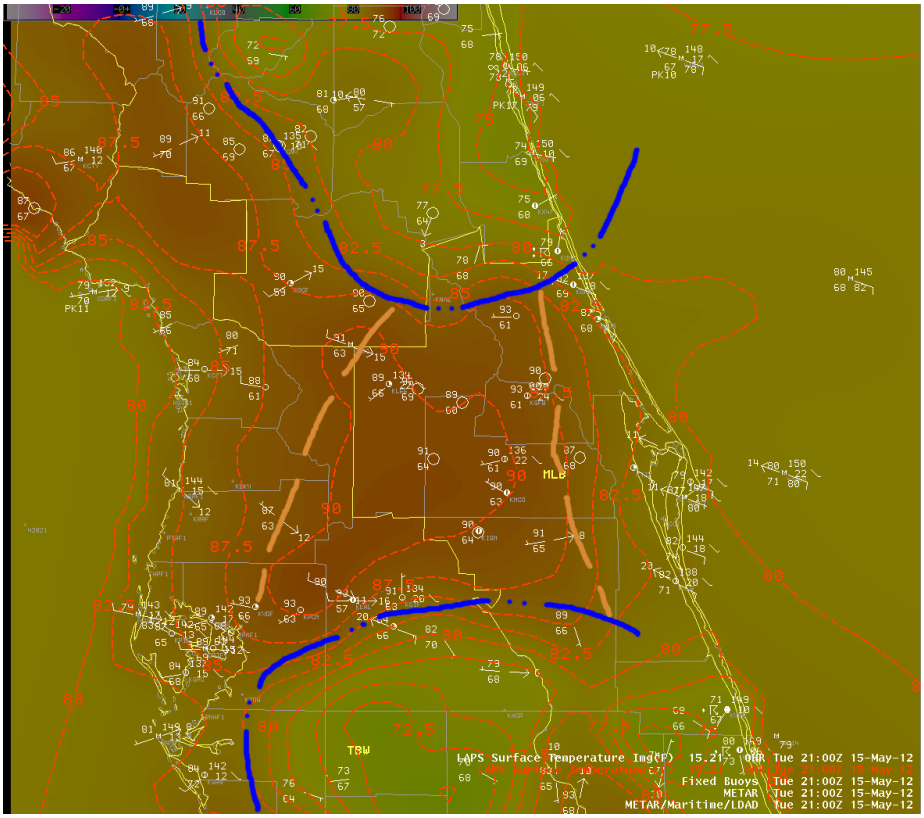


Figure 4-1. METAR/Maritime/LDAD surface observations for the central Florida peninsula at 2100 UTC with sea breeze (orange dashed lines) and outflow boundaries (blue dot/dashed line) delineated.

Figure 4-2 shows a RUC analysis sounding taken near Daytona Beach, FL (Volusia County) at 2100 UTC 15 May 2012. Note that the initial parcel surface temperature and dew point temperature is 83°F/67°F, which is representative of the environment along the coastal areas of Volusia County behind the east coast sea breeze and less moist than the environment over northern Brevard County. Some notable features regarding this RUC analysis sounding and NAM12 sounding from Daytona Beach (not shown) include:

- Estimated CAPE values ranging from 1700-2400 J/kg with very little CIN
- Warm cloud layer of ~9500 ft. with precipitable water value > 1.60 inches
- 0-3 km lapse rates near 8°C/km
- DCAPE values of 600-700 J/kg with Theta-E differences of 20-25°C from the surface to the 500/600 mb pressure level
- 0-1 km storm relative helicity of approximately 50 m^2/s^2 with 0-1 km bulk shear of approximately 10 kts
- Vertical profile representative of wet/hybrid microbursts with some mid-level dry air, weak shear, and near-surface “inverted-V” profile

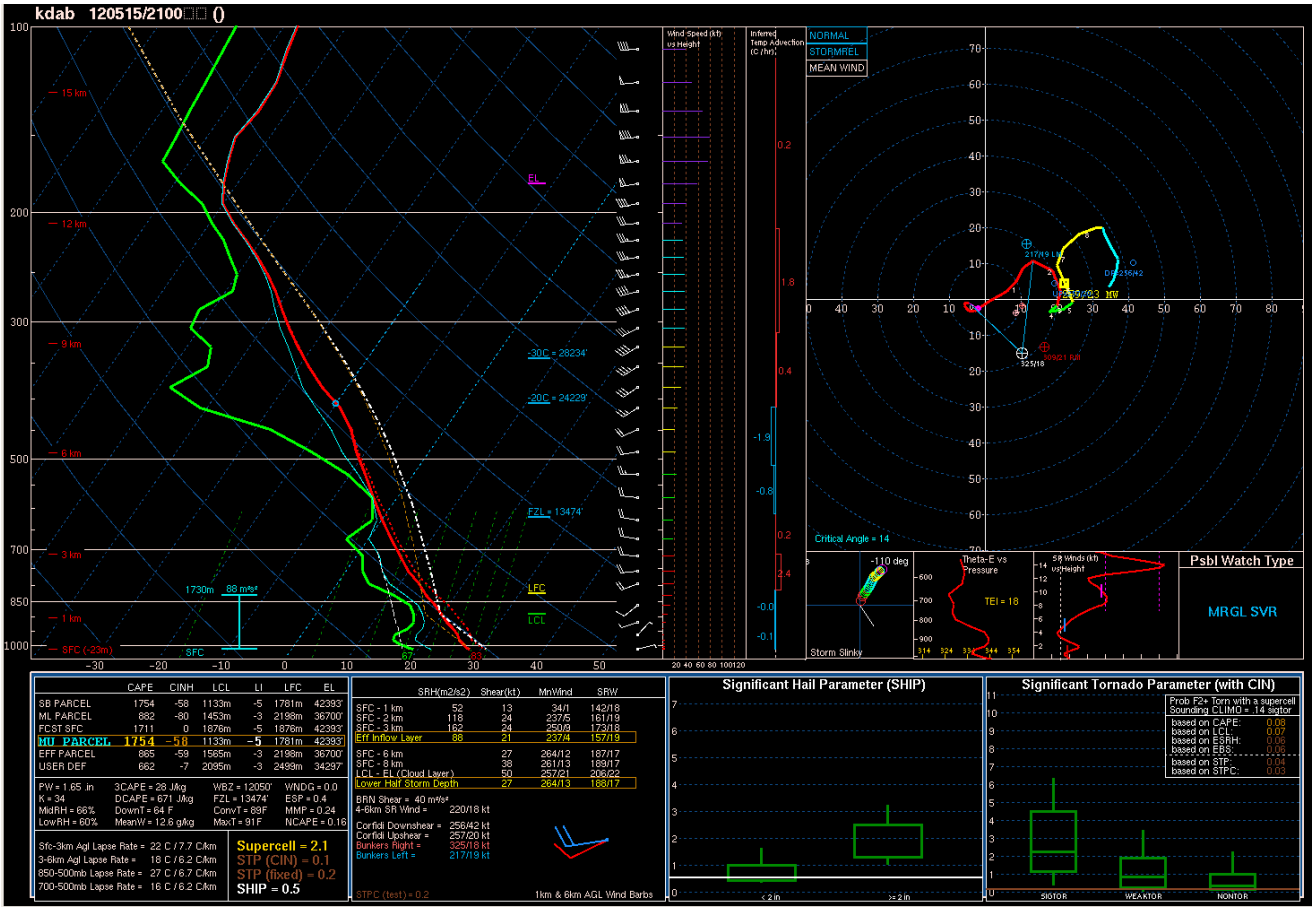


Figure 4-2. RUC analysis forecast sounding, hodograph, and severe weather parameters/box-whisker plots from Daytona Beach, FL (Volusia County) valid at 2100 UTC 15 May 2012.

The Storm Prediction Center Day One Convective Outlook at 2000 UTC extended a categorical slight risk southward into the Jacksonville (JAX) CWA while the MLB CWA was within the general thunderstorm area. The tornadic probability was less than 2% while the hail and wind probabilities were both 5-14%. A Mesoscale Convective Discussion (MCD) was issued at 2138 UTC describing a moderately unstable air mass with the potential for a few marginally severe storms with the potential for wet microbursts. The MCD stated that a weather watch was unlikely for the area (and no weather watches were issued for the MLB CWA). The following page provides the text from the MCD valid for this region.

MESOSCALE DISCUSSION 0819
NWS STORM PREDICTION CENTER NORMAN OK
0438 PM CDT TUE MAY 15 2012

AREAS AFFECTED...MUCH OF THE FL PENINSULA AND PARTS OF SERN GA

CONCERNING...SEVERE POTENTIAL...WATCH UNLIKELY

VALID 152138Z - 152315Z

PROBABILITY OF WATCH ISSUANCE...20 PERCENT

SUMMARY...A THREAT FOR STRONG STORMS WILL CONTINUE INTO EARLY EVENING. A MARGINAL/ISOLATED SVR THREAT CANNOT BE RULED OUT WITH THE STRONGEST STORMS. THE ISSUANCE OF A WW IS UNLIKELY.

DISCUSSION...NUMEROUS BOUNDARIES ACROSS THE REGION...INCLUDING INLAND-MOVING SEA BREEZE BOUNDARIES AND CONVECTIVE OUTFLOW BOUNDARIES...CONTINUE TO FOSTER SCATTERED DEEP CONVECTION ADMIST A MODERATELY UNSTABLE AIR MASS. THROUGH EARLY EVENING...THE ACTIVITY WILL LIKELY REMAIN MOST CONCENTRATED ACROSS THE SRN HALF OF THE FL PENINSULA...SOUTH OF A LINE FROM MELBOURNE TO NEAR SARASOTA. IN THIS REGION...WATER VAPOR IMAGERY INDICATES THE PRESENCE OF WEAK MID-LEVEL ASCENT IN ASSOCIATION WITH A SUBTLE/LOW-LATITUDE IMPULSE.

WHERE CONVECTIVE OVERTURNING HAS NOT ALREADY OCCURRED...THE COMBINATION OF STEEP LOW-LEVEL LAPSE RATES AND FAIRLY RICH LOW-LEVEL MOISTURE -- SURFACE DEWPOINTS IN THE MIDDLE 60S -- IS SUPPORTING MLCAPE VALUES OF 1000-1500 J/KG. THIS WILL YIELD A THREAT FOR STRONG STORMS...AND PERHAPS A MARGINALLY SVR STORM OR TWO. VERTICAL WIND PROFILES PER VWP DATA SUGGEST ONLY MODEST DEEP SHEAR IN PLACE...WITH 0-6-KM BULK SHEAR MAGNITUDES GENERALLY 30 KT OR LESS...WHICH WILL YIELD A PRIMARILY MULTICELLULAR CONVECTIVE MODE. STRONG WIND GUSTS AND SMALL HAIL WILL BE THE MAIN CONCERNS WITH THESE STORMS. HOWEVER...GIVEN PW VALUES OF 1.55-1.75 INCH PER GPS DATA...WATER-LOADING PROCESSES MAY SUPPORT A FEW INSTANCES OF WET MICROBURSTS CONTAINING MARGINALLY SVR WIND GUSTS. WEAK MID-LEVEL LAPSE RATES AND WEAK MID/HIGH-LEVEL FLOW WILL PRECLUDE A MORE SUBSTANTIAL SVR THREAT.

STORMS SHOULD DECREASE IN COVERAGE/INTENSITY AFTER 00Z IN ASSOCIATION WITH THE DEVELOPMENT OF THE STABLE NOCTURNAL BOUNDARY LAYER.

..COHEN/CORFIDI.. 05/15/2012

ATTN...WFO...MFL...MLB...TBW...JAX

Radar Overview of Event:

Convection initiated along the sea breeze boundary in eastern Martin County around 1800 UTC and later in central Brevard County and St. Lucie County by 1900 UTC. Sub-severe convection continued to develop in Okeechobee County along a northward-moving lake breeze boundary from Lake Okeechobee and along the sea breeze in Indian River County between 1900-2000 UTC. The convection in Okeechobee and along the Highlands/Polk County border (Tampa Bay CWA) generates an outflow boundary that propagates NNE through Osceola and southern Brevard Counties. An ordinary cell south of Port Saint John in central Brevard County also generates an outflow boundary in the 1900-2000 UTC time frame that locally accelerates the westward propagating east coast sea breeze. In the far northern part of the MLB CWA, a line of convection along a previously generated outflow boundary moved south along the coastline into northern Volusia County. These storms products some wind damage in St. Johns and Flagler Counties (JAX CWA).

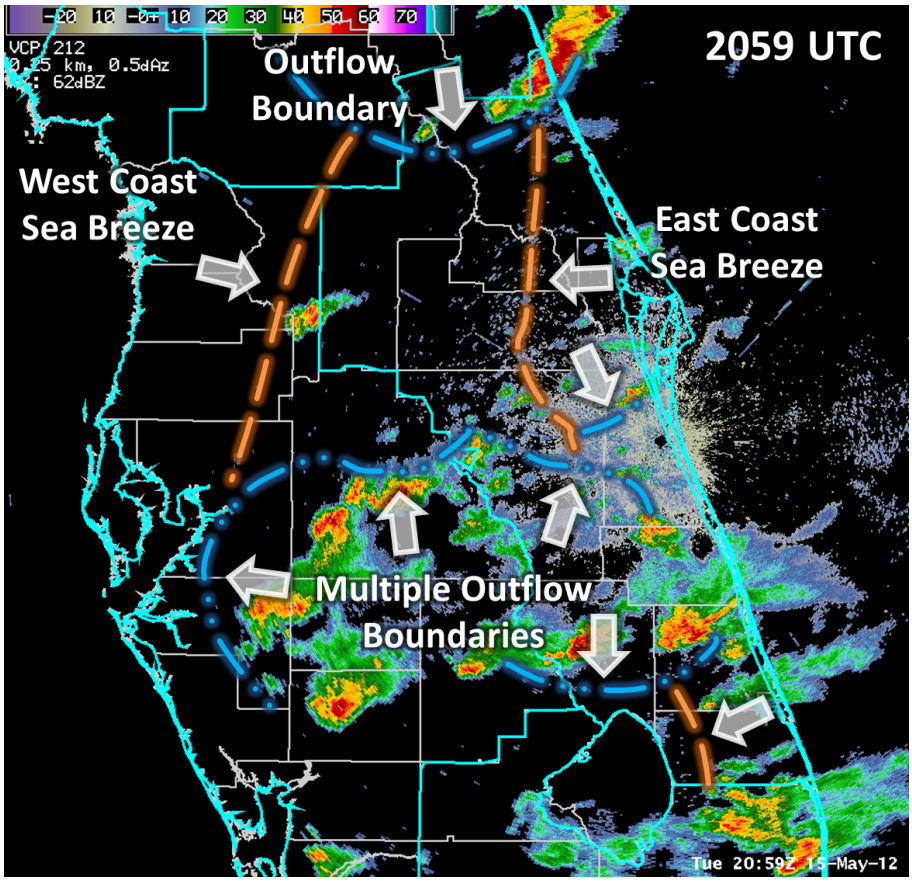


Figure 4-3. KMLB 0.5° reflectivity of convection over central Florida at 2059 UTC. Sea breeze (outflow) boundaries are highlighted by orange (blue) dashed lines with direction of boundary motion annotated by light gray arrows. CWAs are outlined in cyan.

Figure 4-3 on the previous page depicts the complex boundary situation across the central Florida peninsula at 2059 UTC, including multiple boundary intersections and potential boundary interactions. Two outflow boundaries and the east coast sea breeze collide in eastern Osceola and southern Brevard Counties by 2120 UTC, generating sub-severe convection. The northern line of convection across Volusia County continues to move southward, with new convection developing along the intersection of the outflow boundary and sea-breeze south of Tiger Bay State Forest around 2127 UTC. Convection also develops along the west coast sea breeze and moves into western Lake County, producing a small downburst 3 SSW of Groveland, FL around 2140 UTC (downed trees and blown over screen enclosure).

Figure 4-4 shows the boundary and convective evolution across the central Florida peninsula at 2145 UTC. Figure 4-4 also highlights the area where the first of two severe convective storms that develop in the MLB CWA during the simulation period.

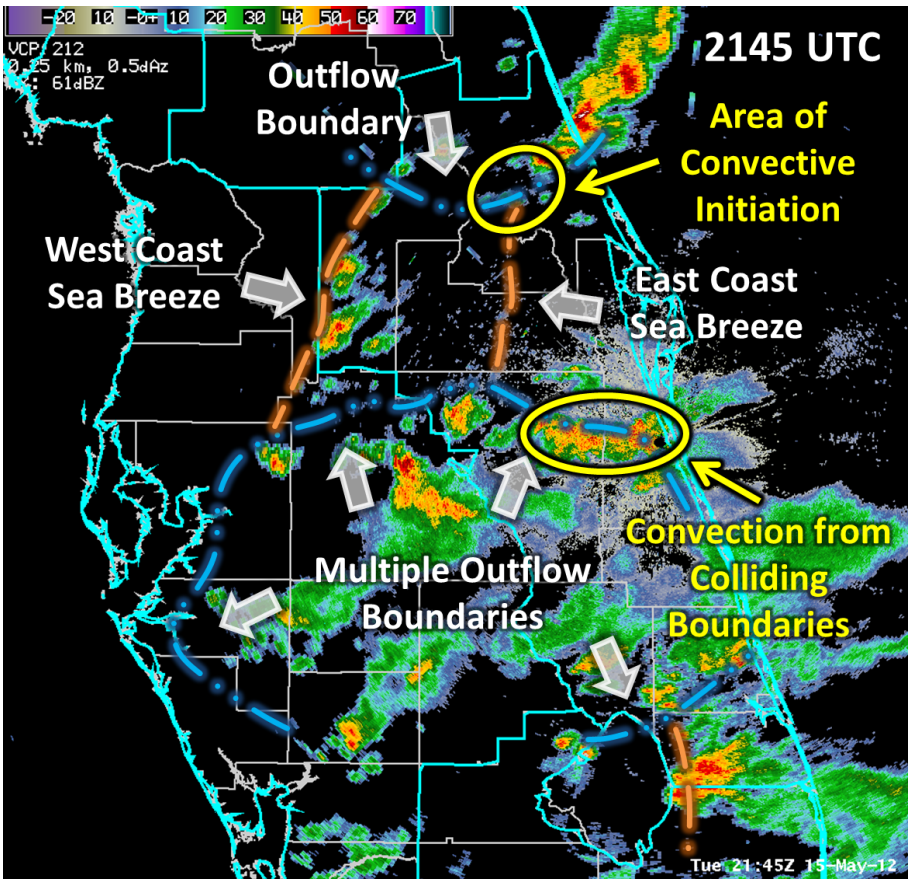


Figure 4-4. Same as Figure 4-3 except at 2145 UTC. Highlighted regions include an area where convection developed from boundary collisions and region of expected convective initiation of first severe storm described in text and simulation objectives.

The first significant storm was detected by the KMLB WSR-88D at 2150 UTC near an outflow boundary and sea breeze intersection west of previously developed convection (see Figure 4-4), and quickly developed a high reflectivity core (> 60 dBZ) aloft. The life cycle of the storm was not characterized by a single, sustained updraft but by a series of strong updraft pulses similar to that of a isolated multicell (including one updraft that produced a descending reflectivity core with maximum reflectivity values ≥ 70 dBZ). The storm moved to southeast through rural portions of Volusia County, and appear to acquire some supercellular characteristics (developing inflow notch, a weak echo region (WER), and broad mesocyclone with a depth of ~15,000 ft.).

Severe winds occurred with the storm after 2300 UTC as multiple factors allowed for a downburst to impact cities along Highway 1 in northern Brevard County. These factors included mid-altitude radial convergence, descending reflectivity core, and interaction with a northward moving outflow boundary. The storm generated a forward propagating gust front along the western flank with winds estimated to 70 mph. The storm began to collapse by 2320-2330 UTC. Figure 4-5 shows the reflectivity evolution of this storm as it traveled southward from Volusia County into northern Brevard County.

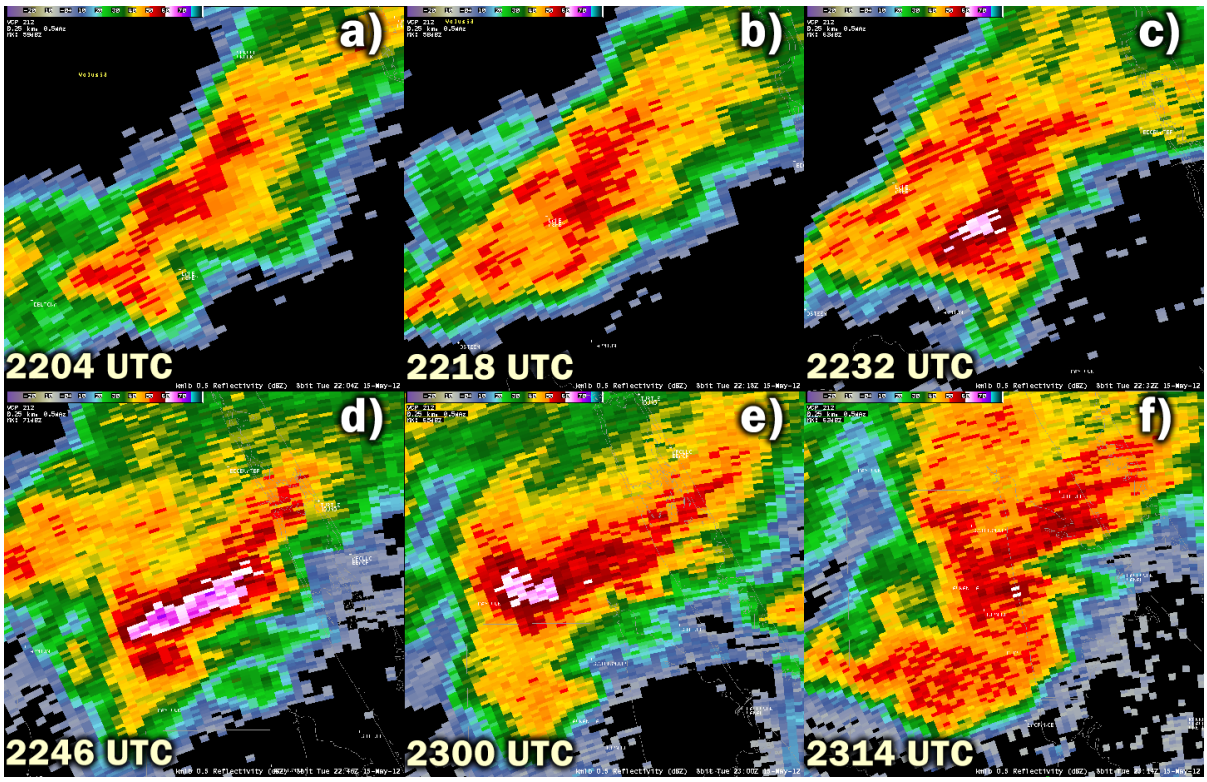


Figure 4-5. KMLB 0.5° reflectivity of Volusia/Brevard County storm from a) 2204 UTC to f) 2314 UTC.

The second significant storm developed in central Brevard County around 2230 UTC along an outflow boundary generated from the convection in southern Brevard County that was a result of an earlier boundary collision (see Figures 4-3 and 4-4). A mid-level reflectivity core and tilted, rotating updraft became more noticeable and continued to develop in the 2232-2246 UTC time frame. The reflectivity core descended and downbursted over the intercoastal region and southern part of the Kennedy Space Center property. Severe winds of > 60 mph were measured by U.S. Air Force (USAF) towers on the property. Figure 4-6 shows the reflectivity evolution of this storm as it traveled northeastward along the outflow boundary over the intercoastal region towards the Atlantic Ocean.

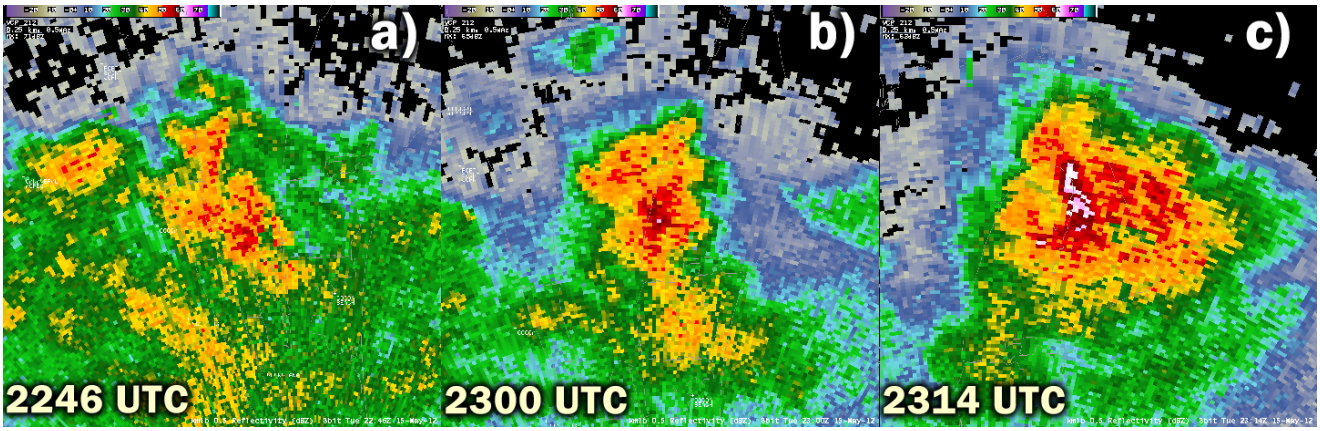


Figure 4-6. KMLB 0.5° reflectivity of central Brevard County storm from a) 2246 UTC to c) 2314 UTC.

Summary:

The primary severe weather threat in the MLB CWA from 2145-2330 UTC was focused on two convective storms. Since these storms passed over rural areas, it is unknown whether they produced severe-criteria hail. However, based on the local storm reports, both storms produced severe straight-line winds, which includes measurements from USAF towers. The Volusia/Brevard County storm also produced hail up to the size of pennies (0.75 inches), and a storm chaser noted a large wall cloud with low-level rotation, but no funnels or tornadoes. Damage was limited to downed trees and small wind-blown debris in Scottsmoor, Mims, Lagrange, and Titusville.

Figure 4-7. Storm over Cape Canaveral (courtesy of Elizabeth May).