P1.16 A Tactical Decision Aid to Limit the Impacts of Thunderstorms on Climb and Descent Traffic at the Orlando International Airport

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1. INTRODUCTION AND BACKGROUND

Thunderstorms are a dominant cause of commercial aircraft delays in the United States and their impact is worsening (Weber et al. 2007). This is particularly true for the Orlando International Airport (MCO) in Florida. With regard to traffic volume, MCO is one of the twelve busiest airports in the United States. It is a major commercial service airport located about 10 km southeast of the central business district of the city of Orlando, and is close to Orlando's tourist district. The airport handled nearly 36 million passengers in 2007 (Federal Aviation Administration, 2008). Deep convective storms are common which can cause significant aircraft departure and/or arrival delays. According to Huffines and Orville (1999), the Florida peninsula experiences the highest annual frequency of cloud-to-ground (CG) lightning strikes and associated number of thunderstorm days in the country. This is particularly evident in the region from Tampa to Orlando (Hodanish et al. 1997) where, for example, in July 2007 thunder was reported at MCO on 77% of the days. The combination of a large volume of traffic and frequent thunderstorms makes MCO one of the more vulnerable airports to convective weather-related delays.

As part of the demonstration initiative to address the issue the National Weather Service (NWS) collaboratively produced thunderstorm forecasts for the volume of air space within a 75 nm (~140 km) radius of MCO during the summer of 2008. This effort sought to build upon the results of an initial demonstration which took place in 2007 (Fahey et al. 2008) at Minneapolis, MN, with the purpose of developing a convective forecast product that fills the gap between the Terminal Aerodrome Forecast (TAF) for take-off and landing traffic and the Collaborative Convective Forecast Product (CCFP) for en route traffic (Fahey et al. 2006). That is, the intent was to provide an operational tactical decision aid for traffic flow management and related decision-makers to help ease the negative impacts of thunderstorms on climb and descent traffic as controlled through the Terminal Radar Approach Control (TRACON) center serving MCO.

As part of the Transportation Secretary's Acceleration Demonstration in Florida for the Next Generation Air Transportation System (NextGen), an experimental product suite for MCO was developed which consisted of a series of six individual 1-hour thunderstorm coverage graphics issued twice per day at 1515 UTC and 1815 UTC (see Fig. 1 and Table 1). The graphics depicted the expected thunderstorm coverage during each successive hour and were collaboratively produced by the Weather Forecast Office (WFO) in Melbourne, FL (MLB), and the Center Weather Service Units (CWSU) in Jacksonville, FL (ZJX) and Miami (ZMA). The aviation section of the United Parcel Service (UPS) also provided critical industry insight toward product development and the collaborative forecast process. The jointly produced graphics conveyed thunderstorm coverage information with much greater temporal and spatial detail than the larger scale CCFP, and therefore was titled the Enhanced Collaborative Convective Forecast Product (ECCFP). Each ECCFP map was color-coded to readily convey the geographic distribution of storm coverage indicated as being either None, Isolated, Scattered, Numerous, or Widespread (e.g., Line). It is hoped that once matured, the ECCFP would be advocated for operational implementation. If so, this tactical decision aid would result in benefits which support increased air traffic in and out of MCO, while decreasing the average amount of fuel per aircraft. It would also help to minimize flight cancellations and total delay minutes from thunderstorms.

The remainder of this paper will further describe the ECCFP and the collaborative forecast methodology employed during the demonstration period. A case study example will be used to show a measure of its utility, along with a verification of the twice daily forecasts. Also, specific experiences regarding forecast workload and preliminary industry feedback will be shared.

2. PRODUCT DESCRIPTION

The provision of high resolution thunderstorm forecasts has obvious user benefits. But for mesoscale meteorologists, it is replete with inherent challenges pertaining to both the creation and communication of the intended message. The primary goal is to succinctly denote the abundance of thunderstorm information, relative to defined area(s), in a user-friendly format. Graphic expressions seem most expedient for this purpose, especially when accompanied by its corresponding gridded underlay. With advancements in high-resolution numerical weather prediction, it is tempting to simply provide explicit model output of various thunderstorm proxy parameters at hourly (or sub-hourly) time intervals. This approach can even provide depictions having visual similarity to real-time weather radar displays. However, generating explicit thunderstorm forecasts based on high-resolution model output is a narrow approach that accounts very little for

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inherent uncertainties. In some instances, this may do more harm than good (leading to unsafe decisions) if not tempered by experienced meteorologists or bolstered by an ensemble modeling system which can give credence to forecast variance. The optimal configuration and maintenance of an ensemble modeling system which can resolve individual convective cells within its separate members is a very ambitious effort. For a given WFO to generate 1-hour thunderstorm forecasts (either explicit or probabilistic in nature) would require computational resources and system administration demands that necessarily prohibited this as a practical approach at this time. This will undoubtedly change over the coming years as many aspects related to the overall future of weather forecasting are headed in this direction. Nonetheless, even contemporary observational data assimilation systems which robustly offer diagnostics that are rapidly refreshed, and can, in turn, support subsequent short-term prognostics, struggle beyond 2- to 3-hour projections. Thus, the most profitable solution for now resides largely within the expertise of skilled meteorologists who can best discern the context of the situation and determine the appropriate means to prudently address and communicate it.

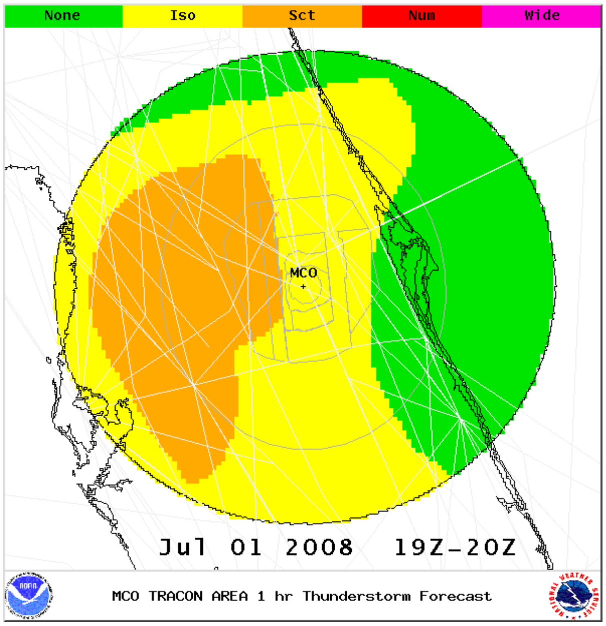


Fig 1. An example of the Enhanced Collaborative Convective Forecast Product (ECCFP) developed for the Orlando International Airport (MCO) as a tactical decision aid. The product is part of an experimental graphic suite which depicts 1-hour thunderstorm coverage, within 75 nm (~140 km) of MCO, successively across a 6-hour forecast period.

During the summer of 2007, an experimental TRACON thunderstorm forecast was produced for the Minneapolis air space. Many graphical display options were considered by the Minneapolis demonstration team (Fahey et al. 2008). The display option that was selected can be seen in Figure 2. Here a suite of plan view maps was produced to convey successive 1-hour thunderstorm probabilities using color-coded polygons which were allowed to change in shape and dimension (e.g., not fixed) to better fit the evolving weather pattern across the six hour forecast period. This greatly improved the means for expressing both the temporal and spatial variability, and was favored among solicited users. An additional benefit to this option, when compared with other options, was the ability to easily furnish corresponding gridded information to a digital database. The only significant drawback in product format was that it was unlike either the TAF or CCFP in its essence.

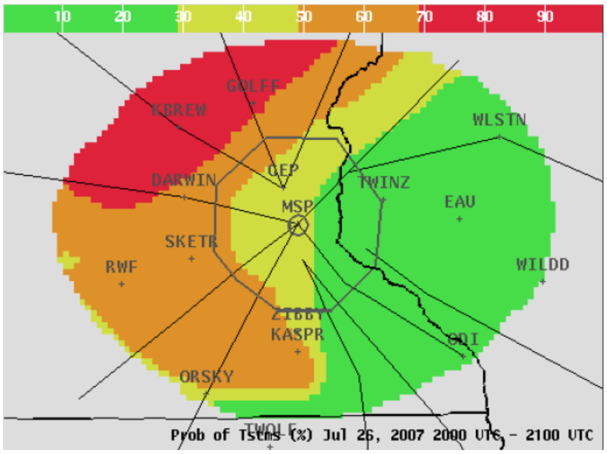


Fig 2. An example of the experimental TRACON Thunderstorm Forecast Product prototyped for the Minneapolis International Airport (MSP) as a tactical decision aid.

For the summer of 2008, the Secretary of Transportation called for a field demonstration to accelerate pathfinder efforts for NextGen in Florida. The Orlando prototype was initiated at the request of the NWS Aviation Services Branch and coordinated through NWS Southern Region Headquarters. Developers at WFO MLB opted to build upon the strengths of the Minneapolis prototype, but to also seek a more intuitive linkage to the larger scale CCFP. Since the CCFP already depicts thunderstorm coverage, adjustments were made to produce locally enhanced collaborative 1-hour thunderstorm coverage products (instead of probability products) to be depicted on color-coded maps. Fig. 1 provides an example depiction of the ECCFP with cooler colors (green and yellow) representing low percentage coverage, and warmer colors (orange, red, and purple) representing moderate to high percentage coverage. Table 1 associates a color palette with coverage descriptors and percent coverage values. Initial coverage categories were closely aligned with standard NWS coverage categories for convective precipitation. This made it easier for forecasters to streamline associated workload responsibilities. Through limited feedback, this display option was also deemed more intuitive for users. It also gave the developers the needed leverage to promptly deliver daily verification statistics to help calibrate daily forecasts and to assess product utility as a function of forecast accuracy.

Color	Coverage Descriptor	% Coverage
🟩	None (or Few)	0% - 9%
🟨	Isolated	10% - 24%
🟧	Scattered	25% - 54%
🟥	Numerous	55% - 74%
🟪	Widespread (or Line)	75% - 100%

Table 1. Thunderstorm coverage categories.

In practice, the ECCFP consisted of six 1-hourly thunderstorm coverage forecasts issued twice per day with output graphics embedded within NWS/CWSU web pages for real-time customer use. Issuance times were 1515 UTC and 1815 UTC (Table 2). Forecast depictions were integrated across the prescribed hour.

Issued	ECCFP: Six 1-hourly Graphics (integrated across the prescribed hour)					
1515 UTC	15-16Z	16-17Z	17-18Z	18-19Z	19-20Z	20-21Z
1815 UTC	18-19Z	19-20Z	20-21Z	21-22Z	22-23Z	23-24Z
	Hr 1	**Hr 2**	**Hr 3**	**Hr 4**	**Hr 5**	**Hr 6**

Table 2. A listing of the valid times for the six 1-hour thunderstorm coverage forecast graphics. Forecast packages were issued twice per day.

The operational availability of the ECCFP for use as a tactical decision aid was from Wednesday, June 18, 2008 to Friday, September 12, 2008. The graphics were produced Monday through Friday, but were suspended on weekends, holidays, and during tropical cyclone situations due to demonstration staffing constraints.

3. LOCAL DEVELOPMENT PROCESS

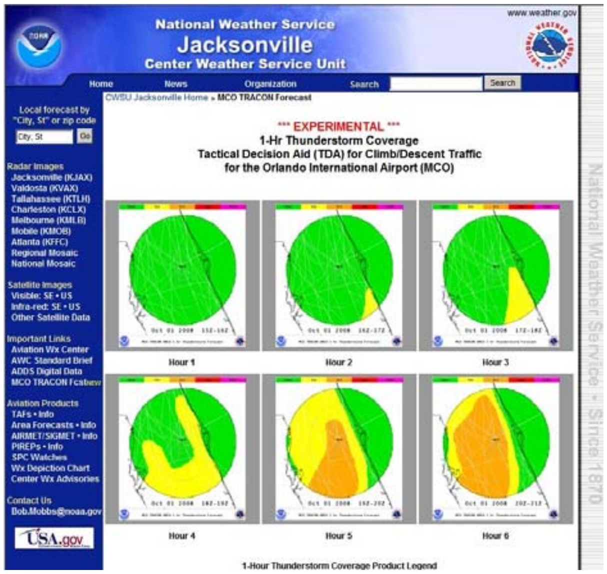
3.1 AWIPS/GFE Configuration

To support the production and verification of the experimental ECCFP, unique configurations were needed for WFO MLB's Graphical Forecast Editor (GFE) within their Advanced Weather Information Processing System (AWIPS). Two new discrete 1-hour thunderstorm coverage weather elements were added to GFE to handle the 1515 UTC and 1815 UTC forecast packages respectfully. A customized color table was also developed and associated to these two new elements. To improve information context, customized *shapefiles* of established airways, Class B airspace, the MCO identifier, range rings, etc., were added to AWIPS and GFE as screen display map backgrounds. These were also added to the output graphics themselves, in order to elevate product utility. Several scripts were then coded to make the graphic images in portable network graphic (PNG) format, and to upload them to the web site(s). Additional scripts were coded to archive and library all of the finalized graphics.

To assist with verification, an existing GFE Smart Tool (called *LightningTools*) was downloaded from the NWS Smart Tool Repository and installed. The tool was then modified for thunderstorm coverage verification. The Smart Tool operated on archived National Lightning Detection Network (NLDN) data to locate CG strikes within defined 1-hour time periods and applied a set radius of influence for each strike to create a geographic thunderstorm footprint. For further details, please refer to Section 5.

3.2 Web Site Development

To facilitate user interaction and forecaster collaboration, it was necessary to develop two similar, but separate, web pages. The first page was designed as a user interface for posting and displaying finalized ECCFP graphics (Fig. 3). The page resided on the ZJX web site where any user could evaluate the ECCFP as a tactical decision aid. The web page was designed according to agency standards including a Product Description Document (PDD) and user feedback mechanism. The main page simultaneously displayed smaller versions of all six individual 1-hour forecast graphics in a top and bottom row. This was done to give users a big picture perspective, temporally and spatially, on the evolving thunderstorm coverage situation. For a detailed hour by hour perspective, users could click on any image to examine a full-sized view with clickable functionality to conveniently advance to the next 1-hour graphic.


National Weather Service
Jacksonville
Center Weather Service Unit

*** EXPERIMENTAL ***
1-Hr Thunderstorm Coverage
Tactical Decision Aid (TDA) for Climb/Descent Traffic
for the Orlando International Airport (MCO)

1-Hour Thunderstorm Coverage Product Legend

Fig 3. An example of the experimental ECCFP as displayed on the CWSU Jacksonville web site. The site was made available to all users.

The second web site was created strictly to aid the collaboration forecast process among the demonstration participants. For each ECCFP package, initial forecast graphics were made by WFO MLB and then uploaded to the collaboration site. This served as a common workspace to view and offer suggested improvements. Using inter-site collaboration techniques (see section 4), forecasts were then finalized on GFE and posted to the user site. Both the user site and collaboration site were clearly labeled as providing experimental information. By executing select scripts, all graphics were immediately cleared from the collaboration site as soon as the collaboration process was ended. Graphics on the user site remained through their valid period and were either replaced by the next package or cleared at the end of the day.

4. LOCAL FORECAST PROCESS

The ECCFP forecast process was comprised of two fundamental phases. During the first phase, an initial forecast package was created by WFO MLB meteorologists. The following phase resulted in refinement of the package into a final forecast state through utilization of a highly effective, interactive collaborative process.

The daily forecast process began with an examination of the CCFP (national scale) to ensure overall consistency, but also to consider potential times when, and locations where, down-scaled details could be incorporated to produce a value-added suite of local forecast graphics. Other preliminary steps typically involved reviewing trends of archived lightning strikes from the previous day (especially important during persistent flow/moisture patterns) and evaluating a local gridded lightning climatology based on the prevailing synoptic flow. Together, these initial assessments helped define a general 'first guess' field, which could next be further refined by mesoscale and local analyses and forecast model output.

Forecasters continually monitored high-resolution local analyses and real-time total lightning information as well as satellite and WSR-88D radar time lapses to gauge development of convective trends associated with sea/river/lake breeze boundaries and outflow boundaries. Multiple high resolution models (ranging from the 40 km NAM to a locally run 2.5 km WRF) and an experimental model-based statistic lightning forecast scheme were closely and continuously examined. After carefully evaluating each of the previously identified data sets, forecasters then used GFE to manually create six individual graphical forecasts, with each one-hour time period depicting the expected categorical coverage of lightning storms. A final assessment was then performed on each graphic, which often resulted in minor expansions or reductions of contoured regions based on forecaster expertise of the local convective patterns. On average, MLB forecasters invested approximately 1 hour per forecast package or 2 hours per day to analyze trends, evaluate forecast guidance and create the graphics

Once the initial graphical forecasts were completed and uploaded to the collaboration web-site, the second phase of the process was initiated. During the first half of the demonstration period (June-July) WFO MLB hosted online collaboration meetings using commercially available software called *GoToMeeting*[1]. During the second half of the project (August-September), CWSU ZJX hosted the online meetings in order to fully test bi-directional operational capabilities and potential backup service functionality. Throughout the project, WFO MLB forecasters began each collaboration session by describing the synoptic and mesoscale meteorological situations related to the initial package. CWSU ZJX then lead group discussions by chronologically assessing each individual forecast graphic. Using computer pens, participants drew suggested refinements on the displayed graphic using *GoToMeeting* (Fig. 4) while MLB forecasters made the actual changes within GFE. Each participating forecaster was encouraged to provide input for each of the six 1-hour thunderstorm coverage forecasts. Once each forecast graphic was evaluated and modified if warranted, the finalized package was uploaded to the user web site for tactical decision-making. The collaboration process took an average of 15 minutes per session to perform, or 30 minutes per day.

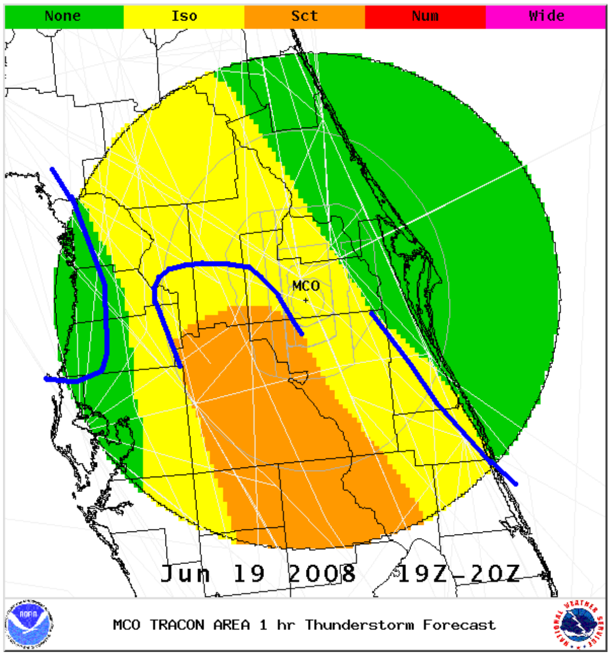


Fig 4. An example 1-hour thunderstorm coverage forecast graphic as displayed on the collaboration web site. The initial forecast graphic (the underlay) was produced by WFO Melbourne. Online interactive collaboration sessions were conducted to give CWSUs Jacksonville and Miami, as well as United Parcel Service, the opportunity to suggest refinements (the blue lines) to the forecast.

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[1] NOTE: Mention or display of a trademark, proprietary product, or firm in text or figures does not constitute an endorsement by the National Weather Service, NOAA or the Department of Commerce, and does not imply approval to the exclusion of other suitable products or firms.

5. VERIFICATION

5.1 Verification Process

An objective verification scheme was developed to assess each thunderstorm coverage area for every 1-hour forecast generated during the demonstration period. Specifically, the verification methodology calculated individual and composite statistics for each unique lightning coverage category relative to a thunderstorm footprint grid which was derived by taking a 6.5 km radius around each lightning strike for all lightning strikes that occurred during each hour of the forecast. The area of influence around each lightning strike was calculated by a GFE Smart Tool and then compared to the area defined by each coverage category that was made for each hour.

A four step process was employed in GFE to calculate the verification statistics.

1. Archived lightning strike data were copied into the forecast database via a GFE procedure.
2. A Lightning Radius Tool was run to calculate a predefined (6.5 km) radius around each strike.
3. An edit area was selected for each thunderstorm coverage area forecast.
4. The *LightningStats* tool was run based on a selected thunderstorm coverage area to generate the needed statistics.

The *LightningStats* tool displayed statistics for each coverage area forecast. These statistics included: total number of grid boxes in the coverage area, total area (e.g., grid boxes) influenced by lightning strikes, percent of area influenced and total number of strikes in the coverage area. All derived statistics were entered into an Excel spreadsheet to track performance on a daily and cumulative (e.g., project to date) basis. Some of the calculated statistics included: percent of forecasts below, within, or above the target category for each hour; and overall percent averages for each coverage category for the 1515 UTC, 1815 UTC and the combined forecasts

5.2 Analysis of Results

Over the course of the three month project, a total of 1439 individual coverage areas (see Table 1) were forecast and verified (e.g. depictions of 'none', 'isolated' and 'scattered' regions for a particular forecast hour would result in three coverage areas). Of this total, areas of 'none' were forecast 656 times (46% of total),' isolated' 538 times (37%), 'scattered' 235 times (16%), 'numerous' only ten times (1%) and 'widespread' was never forecast. Cumulatively, a majority (874 or 60%) of the forecasts verified within the expected category, with the remaining 400 (27%) being over-forecast (e.g. a forecast of 'scattered' verifying as 'isolated') and 191 (13%) under-forecast. Stratifying by category revealed that forecasts of low (87% of 'none' forecasts within category) and high (60% of 'numerous' forecasts within category) coverage verified best. A general over-forecast bias was evident for the 'isolated' (47% over-forecast, 40% within category and 16% under-forecast) and 'scattered' (60% over-forecast, 32% within category and 6% under-forecast) categories.

While the over-forecast bias for isolated and scattered convection first appears substantial, it should be noted that the objective verification scheme treated any verification of greater than 0.5% below the target range as an over-forecast. Thus, a 'scattered' forecast (25-54% target range) which verifies with 24.4% coverage counts as an over-forecast, whereas a visual comparison between the forecast graphic and actual radar and lightning data would most likely result in a beneficial forecast for users of the product. Similarly, a coverage forecast which objectively verified poorly due to a small temporal or geographical displacement versus ground truth verification, may also still offer highly useful guidance for those evaluating the graphics for convective trends. For these reasons, an alternative phenomenological-based verification method may be explored in the future (Lambert, 2006) to provide a more realistic view of the utility of the graphical forecasts.

For now however, we will continue with the objective statistical approach to examine relative forecast accuracy. For each forecast package, the percent of cumulative forecasts occurring within each categorical target range were tabulated for each forecast hour. In other words, all category forecasts were verified individually and forecasts within the correct category were summed then divided by the total number of category forecasts. The results of this analysis are shown in Fig. 4.

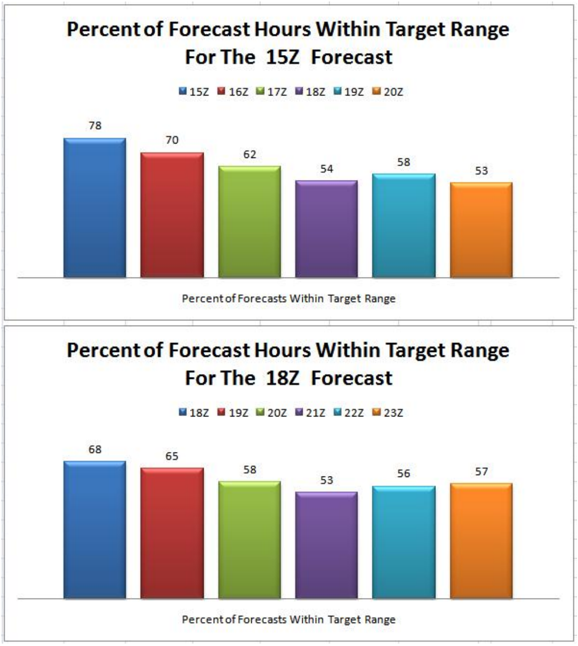

Fig. 4 Percentage of category forecasts within the expected target range (Table 1) at each forecast hour for each forecast package.

The first item to note in Fig. 4 is that a majority of forecasts verified in the proper category at every forecast hour. The most accurate forecasts are those at the shorter time ranges, with a gradual lessening of accuracy with time through hour 4 (averaging near -10% per hour), then a nearly steady rate at hours 5 and 6. The morning forecasts for hours 1-3 were 4-10% more accurate than the corresponding afternoon forecast hours, perhaps due to an abundance of accurate ‘none’ forecasts due to lower lightning prospects early in the day, on average (Fig. 5). It is interesting to note that cumulative forecast accuracy at the time of maximum lightning occurrence (19-21 UTC/hours 5-6; Fig. 5) for the morning package differed little from the accuracy exhibited during the previous lower coverage hour (18-19 UTC/hour 4), even though complex boundary interactions were typically initiating new convective development resulting in a seemingly more difficult forecast. For the afternoon package, the time of peak lightning occurred during forecast hours 2-3, yet the rate of forecast accuracy decrease with time was nearly the same as during the corresponding, yet relatively easier forecast hours of the morning forecast package.

In summary, the verification data revealed:

- a skillful percentage of forecasts verified within the correct category for all forecast hours.
- a relative measure of forecast skill in the overall percent coverage averages for each thunderstorm coverage category.
- a small over-forecast bias was apparent, primarily within the scattered category.

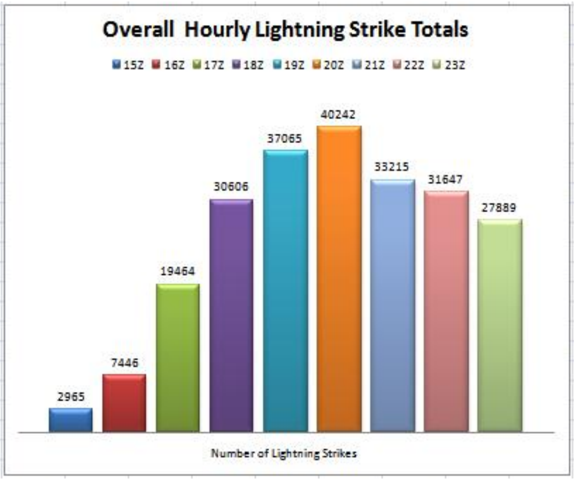

Fig. 5 The cumulative number of cloud to ground lightning strikes by hour within 75 nm of MCO for all forecast days of the demonstration period. The data shows a peak in lightning activity from 20Z-21 UTC across central Florida. Although the overall hourly lightning strike data statistics are based on one summer season, the climatological forecast trend with a peak of thunderstorm activity in the late afternoon is pronounced and may be useful itself for general flight planning.

6. CASE STUDY – 26 June 2008

A convectively active day was expected across the central Florida peninsula on 26 June 2008. The synoptic flow regime included a low level ridge axis between Cape Canaveral and Jacksonville at 925 mb (Fig. 6). As evidenced by the 15 UTC Cape Canaveral sounding (Fig. 7), a very moist and unstable air mass was across Central Florida. Precipitable water values were near 2.25 inches with cold mid-level temperatures of -9C at 500 mb. The mid layer flow was south-southwest to southwest at 10 to 15 knots due to an upper level trough across the western Gulf of Mexico (not shown).

The east coast sea breeze became active by mid morning from Melbourne south to Fort Pierce with the first lightning strike of the day in the MCO TRACON area in southeast Brevard County by 14 UTC. Early morning lightning storms over the southeast Gulf of Mexico produced an outflow boundary which moved onshore the southwest Florida coast and initiated additional convective storms south of Tampa Bay by 18 UTC.

The challenge for the 15 UTC ECCFP forecast package was to accurately delineate a high coverage of thunderstorms temporally and spatially based on the expectation of a continued expansion of early east coast storms forced by the sea breeze boundary and additional storms that would likely develop in association with the outflow boundary moving ashore the southwest Florida coast.

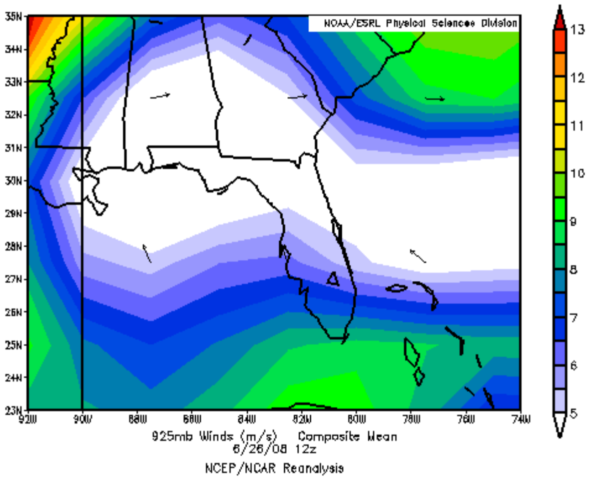

Fig. 6 925mb wind field over Florida from NCEP/NCAR Reanalysis data (Kalnay et al. 1996) at 12 UTC 26 June 2008. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder, CO; http://www.cdc.noaa.gov.

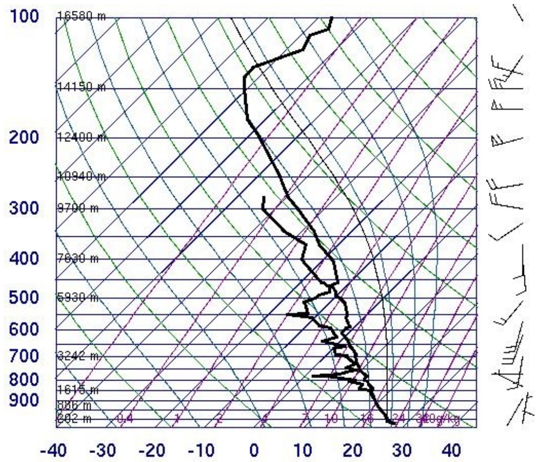

Fig. 7 Cape Canaveral (KXMR) sounding for 15 UTC 26 June 2008.

The 15 UTC forecast introduced a scattered area of thunderstorms between 18 and 19 UTC (Fig. 8) and a numerous area of thunderstorms west of Orlando between 20 and 21 UTC (Fig. 9). This day was one of only four days which numerous storms were forecast during the project. Radar, satellite and high-resolution local analysis (Fig. 10) trends through early afternoon confirmed that the morning forecast was on track and confidence increased that a high coverage of storms would occur during the mid to late afternoon. Only small modifications were required to the location of the maximum storm coverage within the afternoon package, with an extension of the high coverage into hour 4 (21-22 UTC), then a gradual lowering and slow eastward advance of convection for hours 5 and 6 (22-24 UTC). The objective statistical verification for this day revealed a very skillful set of high coverage forecasts.

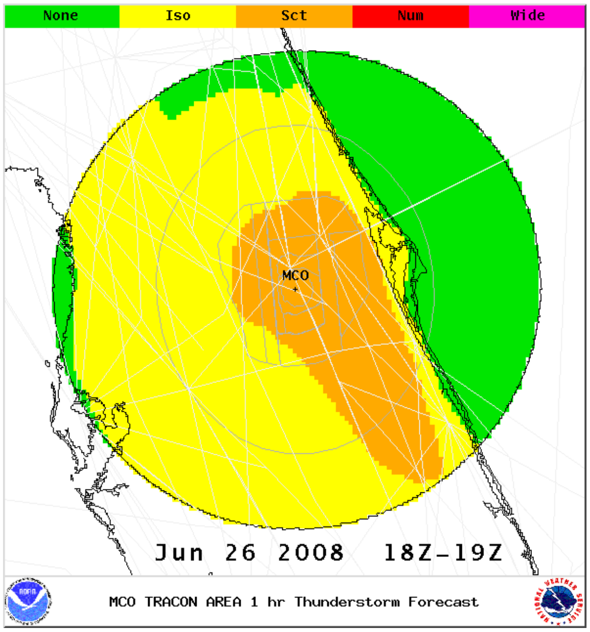

Fig. 8 ECCFP 4-hr forecast produced at 15 UTC 26 June 2008 and valid for 18 to 19 UTC.

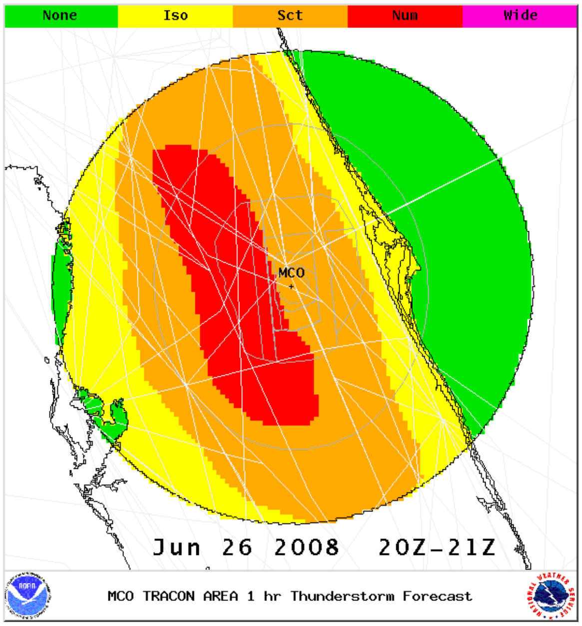

Fig. 9 ECCFP 6-hr forecast produced at 15 UTC 26 June 2008 and valid for 20 to 21 UTC.

The morning forecast accurately depicted areas of scattered convection from 18 to 21 UTC (hours 4-6), with an embedded area of numerous storms from 20-21 UTC (hour 6). The afternoon package continued the established trend and correctly identified areas of scattered-numerous coverage 18-21 UTC (hours 1-3) and properly extended the numerous storms an additional hour (21-22 UTC, hour 4). The area of high storm coverage dissipated faster than anticipated however between 22-24 UTC, resulting in an over-forecast bias of scattered coverage during these hours. Overall, all three numerous coverage forecasts verified and six of nine scattered coverage forecasts were within the target range. A phenomenological verification approach likewise indicated favorable results when comparing the forecast graphics to areas of deep convection within radar imagery (Fig. 11).

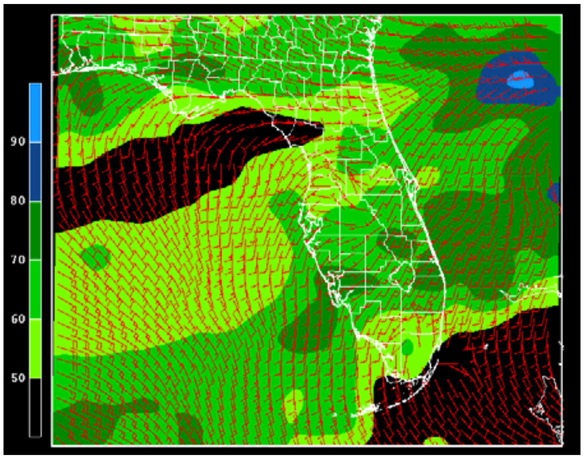

Fig. 10 ADAS analysis 850-650 mb layer average relative humidity and winds valid at 18 UTC 26 June 2008.

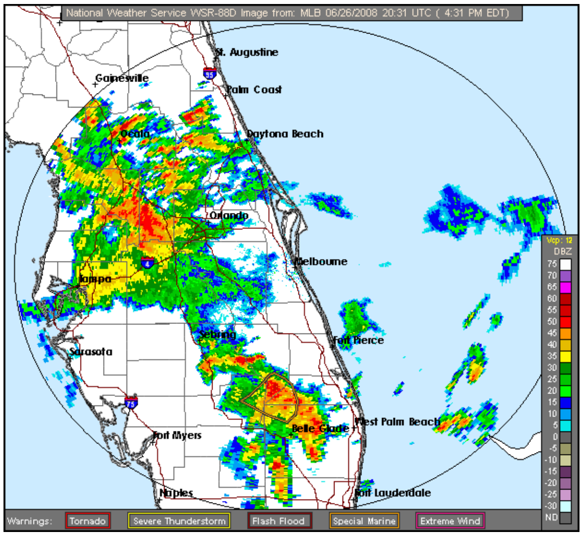

Fig. 11 MLB 88D Base Reflectivity 2031 UTC 26 June 2008

7. USER FEEDBACK AND SUMMARY

During the demonstration, user feedback was solicited through the PDD which was posted on the ECCFP web site. Additional surveys were distributed to select users who were responsible for traffic flow within the MCO TRACON area during the summer of 2008. Informal commentary was also accepted from additional segments of the aviation community. Although still preliminary and limited in scope, most of the returned comments were considered positive. Users found the ECCFP sound in technical quality and easy to use. High marks were given to NOAA/NWS to continue its development toward operational provision. Most often the forecast graphics were used on a daily basis for short-range (traffic flow) planning and plan amendments. Use was frequent, but not continuous (such as with weather radar or satellite). Many stated that they would like to see the ECCFP issued for other major airports in Florida (e.g. Miami and Tampa Bay). Since the ECCFP graphics were generated from gridded information, convective forecasts of 1-hour thunderstorm coverage are plausible as a forecast component within NextGen, especially given that NOAA/NWS has a leading role in contributing to its design (Miner et al. 2009).

Some users inquired about the value of the product vs. the extent of collaborative effort poured into the forecast process. At this point, this comment is difficult to counter since the ECCFP is not (yet) mature and still lacks several of the informational amenities currently found within the CCFP. These amenities include expressions of confidence per forecast, and other thunderstorm parameters like growth tendency and storm top heights. Users also commented that perhaps the audience was too narrow, and that general aviation users might also benefit from the ECCFP. More so, other user groups outside of the aviation industry might derive a tactical benefit, appreciating its short-term value.

As it relates to workload, WFO MLB forecasters strongly felt that the considerable investment in time and expended expertise should yield a product (suite) with more universal leverage. To collaboratively produce the ECCFP, MLB forecasters spent an average of 2.5 hours per day assessing the convective environment, drawing initial coverage contours on GFE, and coordinating the final product among CWSUs and industry partners before posting. Since thunderstorms can adversely impact many people in different ways, it is a weather element that commands high priority for the forecaster's attention. Therefore, operational duty priorities need to correspondingly adjust, but the payoff should yield enhancements to all forms of first-period forecasts and not just aviation. It is not deemed feasible to continually provide and maintain the ECCFP (e.g., 7 days per week, 24 hours per day) without adding forecasters to existing staffing profiles and/or adjusting current duties (based on forecaster impressions during the demonstration). Finally, for CWSU and UPS meteorologists, the process required about 1.0 hours per day.

In summary, overcoming the challenges of providing timely and responsible 1-hour thunderstorm coverage forecasts is best accomplished through an orchestrated man-machine mix. Automation is necessary to assimilate the abundance of observational data and to produce short-term convective forecast solutions. However, forecaster expertise is required to differentiate day to day (run to run) model performance, and to account for forecast variability. There is no substitute for knowing when to infuse past experience, persistence, climatological, statistical, and historical forecast approaches into the process and to what extent. Further optimization is achieved through multi-perspective collaboration.

If another phase of the demonstration is supported for 2009, it is recommended that the items below be considered:

1. refinement of the forecast process
2. development of additional GFE Smart Tools
3. examine the possibility of adding growth tendency, storm top heights, and forecast confidence as information elements
4. provide daily on-line verification
5. include additional Florida airports
6. produce additional packages per day
7. introduce the product to other user groups
8. consider service backup implications
9. offer forecast output in gridded form
10. improve use of man/machine guidance
    a. short-range ensembles
    b. automated nowcasting schemes

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