Project Report
ATC-441

CoSPA and Traffic Flow Impact Operational Demonstration for the 2017 Convective Season

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16. Abstract

Massachusetts Institute of Technology Lincoln Laboratory (MIT LL) personnel conducted field observations of the Consolidated Storm Prediction for Aviation (CoSPA) 8-hr deterministic convective forecast, and the decision support tool, Traffic Flow Impact (TFI), from 6 June to 31 October 2017. Four field observations were performed during the demonstration period. Six MIT LL observers collected nearly 190 person-hours of operational observations across four (4) Federal Aviation Administration (FAA) Air Route Traffic Control Centers (ARTCCs), one (1) Terminal Radar Approach Control (TRACON), the Air Traffic Control System Command Center (ATCSCC) and two (2) airlines. CoSPA was available on dedicated situation displays (SDs) and accessible through the web. The 8-hr TFI product was available on the dedicated SDs while a 12-hr research version of TFI was available on CoSPA web. Observers gathered information on how the CoSPA weather forecast was used in operations, obtained feedback on the TFI capability, performed in-situ training and collected comments and suggestions for improvement of both decision support applications.

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EXECUTIVE SUMMARY

Massachusetts Institute of Technology Lincoln Laboratory (MIT LL) personnel conducted field observations of the Consolidated Storm Prediction for Aviation (CoSPA) 8-hr deterministic convective forecast, and the decision support tool, Traffic Flow Impact (TFI), from 6 June to 31 October 2017. Four field observations were performed during the demonstration period. Six MIT LL observers collected nearly 190 person-hours of operational observations across four (4) Federal Aviation Administration (FAA) Air Route Traffic Control Centers (ARTCCs), one (1) Terminal Radar Approach Control (TRACON), the Air Traffic Control System Command Center (ATCSCC) and two (2) airlines. CoSPA was available on dedicated situation displays (SDs) and accessible through the web. The 8-hr TFI product was available on the dedicated SDs while a 12-hr research version of TFI was available on CoSPA web. Observers gathered information on how the CoSPA weather forecast was used in operations, obtained feedback on the TFI capability, performed in-situ training and collected comments and suggestions for improvement of both decision support applications.

Three key CoSPA forecast deficiencies were evident during the 2017 observations:

- CoSPA forecasts convective initiation later than the actual onset.
- CoSPA under-forecasts precipitation intensities.
- CoSPA under-forecasts echo top heights.

However, the Vertically Integrated Liquid (VIL) bias measured in 2017 improved over the previous 2016 Severe Weather Avoidance Program (SWAP) season. The echo tops under-forecast bias increased across the regions. The TFI application guidance mimicked CoSPA's ability by more accurately predicting large-scale events. Small scale and low area coverage thunderstorm events challenged TFI to correctly translate convective activity into Air Traffic Control (ATC) impact.

Observers documented 114 instances of CoSPA and/or TFI operational usage during the field observation period, with 43 attributed to TFI. The most common use was for situational awareness. There were 82 observations of General Situational Awareness (SA and SA-TFI, 51 and 31 respectively) and 21 observations of support for Airspace Flow Program (AFP) go/no-go decisions (one for AFP and eleven for TFI-AFP). Specifically in the 6- to 8-hour period, TFI was observed to improve AFP execution management during the planning phase of SWAP. Observers documented improved Ground Delay Program (GDP) management and execution in the medium range (3 to 5 hours) because planners utilized the translational guidance built into TFI.

The presence of forecast confidence in TFI was one factor that encouraged planners to use the decision support tool in both AFP and GDP planning. However, users find the confidence bound shading display not easily understandable. There have been requests to further develop the confidence display and present possible variations for evaluation during 2018. Users also requested that detailed case studies be provided during the season for post-analysis evaluation in order to augment Plan, Execute, Review, Train, Improve (PERTI) day-of planning and to drive future TFI improvements. Users would also like TFI to provide route closure guidance, possibly in the form of AFP rates along with the permeability. For a third season, users requested that current operational AFP regions be added to TFI, and that the CoSPA forecast be extended to twelve hours, matching the web version of TFI. Users also want the Offshore Precipitation Capability (OPC) product to be accessible from the CoSPA website rather than a separate OPC website. Finally, there were several requests to add current wind direction and speed information to the CoSPA product suite.

Web usage analytics were expanded during the 2017 season. CoSPA was used by 2642 individual users, from 189 different groups, and on average 590 individual users logged into CoSPA throughout a typical day. In total, throughout the season, 3267 of the 4168 registered users (as of Oct 31, 2017) logged into CoSPA and/or the Corridor Integrated Weather System (CIWS). Airlines constitute over 91% of the web users, because most of the FAA users have dedicated SDs, reducing their need for website access. The three most-used products were Precip, Echo Top Tags, and Satellite. The 2017 statistics provide a baseline that can be used to target training for the 2018 convective season. The desire is for future user statistics to help target training and thus improve application usage within air traffic flow-management.

The Northeast Corridor directive was set in motion by the NextGen Advisory Council (NAC) to focus on improved strategic convective weather decision support, with focus on the New York trio of Newark Liberty International Airport (EWR), John F. Kennedy International Airport (JFK), and LaGuardia Airport (LGA). Weather has accounted for 60–70% of all delay in this region for more than fifteen years and yet little common ground exists upon which Traffic Management Initiatives (TMI) discussions about the best plan of action should be taken. There is a need to define explicit, validated weather translations that provide an objective and operationally relevant measure of truth against which forecasts can be compared. There is also an urgent need to reconsider the guidelines for AFP throughput reductions in the operational concept for setting Flow Constrained Areas (FCA) throughputs. However, air traffic managers and planners have made it clear that convective weather forecasts must be accompanied by a measure of accuracy predictions (confidence) in order to lower the risk of TMI decisions made during SWAP events. The combination of the CoSPA convective forecast and the Decision Support Tool (DST) found in TFI begin to address the goal set forth by the NAC. CoSPA provides the deterministic outlook while TFI adds the Air Traffic Flow Management (ATFM) translation of weather to impact with a measure of confidence to reduce risk during TMI planning.

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To the Traffic Management Officers at Boston, Cleveland, New York, and Washington DC Air Route Traffic Control Centers, and New York TRACON (N90) for allowing access to the facilities and the Traffic Management Unit (TMU) staff.

To the TMU staff at these Centers for giving generously of their time and expertise to help us understand and document the decision-making process.

To the management at Delta and JetBlue for allowing MIT LL observers into their facilities and providing access to their staff. Also to the air traffic control staff at these airlines for sharing their insights into the decision-making process.

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1. INTRODUCTION

The 2017 Consolidated Storm Prediction for Aviation (CoSPA) [i] observation was conducted from 6 June to 31 October 2017. As part of the observation, Federal Aviation Administration (FAA) facilities and commercial airlines were visited by MIT Lincoln Laboratory (MIT LL) observers, including initial training visits prior to the start of the observation season (March/April). Targeted field observations were conducted by MIT LL observers to gather information on how the CoSPA weather forecast and Traffic Flow Impact (TFI) [ii] decision support tools were used in operations. Feedback on decision-support tool capabilities and comments for improvement were collected as well. During the field demonstration, the 0- to 8-hr CoSPA Vertically Integrated Liquid Water (VIL) and Echo Tops (ET) forecasts, as well as TFI, were available via web to all registered users through the dedicated website http://cospa.wx.ll.mit.edu. CoSPA and TFI were also available on the Corridor Integrated Weather System (CIWS) Situation Displays (SDs) for the second convective season. Multiple requests from users in previous years prompted the return of CoSPA to these dedicated displays in both FAA Traffic Management Units (TMU) and airline operations centers (AOC).

1.1 BACKGROUND AND MOTIVATION

MIT LL has been working with the FAA and the air-traffic control community since the 1970s. MIT LL has provided unbiased support to the FAA in solving time sensitive air traffic and weather issues while developing strong technical expertise and establishing long-term system and technology awareness. Enabling rapid assessment and prototyping with extensive user interaction is the cornerstone of MIT LL's success in promoting technology transfer from government to industry. The weather and air traffic specialists at MIT LL have been supporting FAA and airline operations in the field for more than thirty years, embedding themselves in TMUs and AOCs across the National Airspace System (NAS). The Laboratory fields prototypes and trains users while gathering subject matter expertise and looking ahead to the next solvable issue or new and efficient technology.

In September of 2010, the NextGen Advisory Committee (NAC) was formed by the FAA to provide advice on issues facing the modernization of the U.S. aviation system. In April of 2017, the NAC was tasked with developing "FAA, airport, operator and community initiatives that focus on implementing NextGen in the Northeast Corridor (NEC)" [iii]. Objectives to complete this task were established and prioritized. Emphasis was placed on airport and airspace throughput, as well as improving flow management capabilities and implementing new flow management decision support tools. The 0- to 8-hr weather forecast guidance provided by CoSPA and the translational decision support tool TFI directly address several of the key needs set forth by the NAC. CoSPA and TFI target weather impact factors, including intensity of storms, location, scale, permeability[1], and timing (onset, duration, clearing of impact). These factors often determine the type of mitigation needed to offset the adverse effects of weather and can guide planners in the implementation of strategic Traffic Management Initiatives (TMIs) such as:

- Playbook re-routes,
- GDPs, and
- FCAs associated with Airspace Flow Programs (AFPs).

All of the above TMIs are used to improve flow management capabilities and airspace throughput during convective or “off-nominal” operations in the NAS.

The need for 2- to 8-hr storm forecasts, and beyond, for aviation decision support arises from three key decisions that need to be made. Aircraft must be held on the ground before they depart their origin airport, they must be assigned a different route, which entails a longer flight distance, or the aircraft can depart as planned along its filed route. When making these decisions, two important characteristics of flight planning must be considered:

• Airlines are expected to file their flight plans 60 minutes before departure. Airline dispatchers typically begin to plan their domestic flight routes two to four hours prior to departure, especially when weather impacts are expected.

• The overall distribution of domestic flight times for many key airports is such that if significant arrival demand reductions need to be accomplished (e.g., 50% reductions), a number of long duration flights (>4 hours) must be held on the ground.

Most flights are one to two hours in duration (Figure 1), thus the weather impact prediction horizon associated with holding flights at their origin airport would be 2.5 to 4 hours, including 1.5 to 2 hours of pre-flight planning. If one assumes a weather impact on airspace capacity duration of about two to four hours, then airline dispatchers and FAA traffic managers need weather forecasts extending out to 4.5 to 8 hours to specify both the start and expected end of a severely constraining TMI.

[1] Permeability is the degree to which airspace that appears to be impacted by convective weather actually is usable by air traffic. Key elements of permeability are the spatial distribution of weather intensity and storm echo tops.

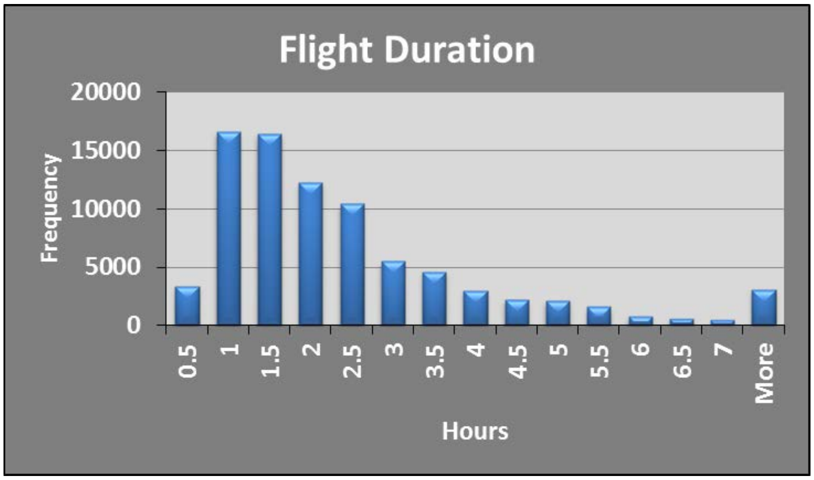

Figure 1. Flight duration (wheels up to wheels down) from five summer days in 2016 (June through August) for all flights (except General Aviation) in the NAS.[iv]

The focus on improved strategic convective weather decision support remains a priority in the eastern NAS, specifically in the "golden triangle" region defined by the major terminals of New York, Chicago, and Atlanta (Figure 2). The highest throughput density exists around the New York Terminal Radar Approach Control (TRACON; N90).

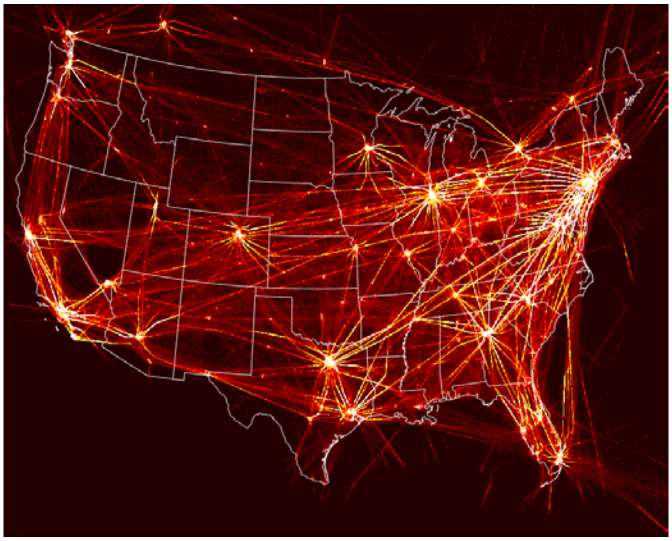

Figure 2. A plot of aircraft density across the NAS spanning the most "active" commercial hours (0900 UTC through 0400 UTC). This particular example is from 0900 UTC 18 October 2015 through 0400 UTC 19 October 2015.[v]

Weather accounts for 65% of all delay in the NAS (Figure 3a). Figure 3b shows the top ten weather-delayed airports for 2017. The Newark International Airport (EWR), LaGuardia International Airport (LGA), and Kennedy International Airport (JFK) airports are combined into the NY3 category; due to airspace constraints, typically, when one of these airports is impacted by weather all three suffer delays. The high demand-to-capacity ratio for these major airports, along with the frequency of weather impacts on operations, results in significant weather-related delay in the New York airspace.

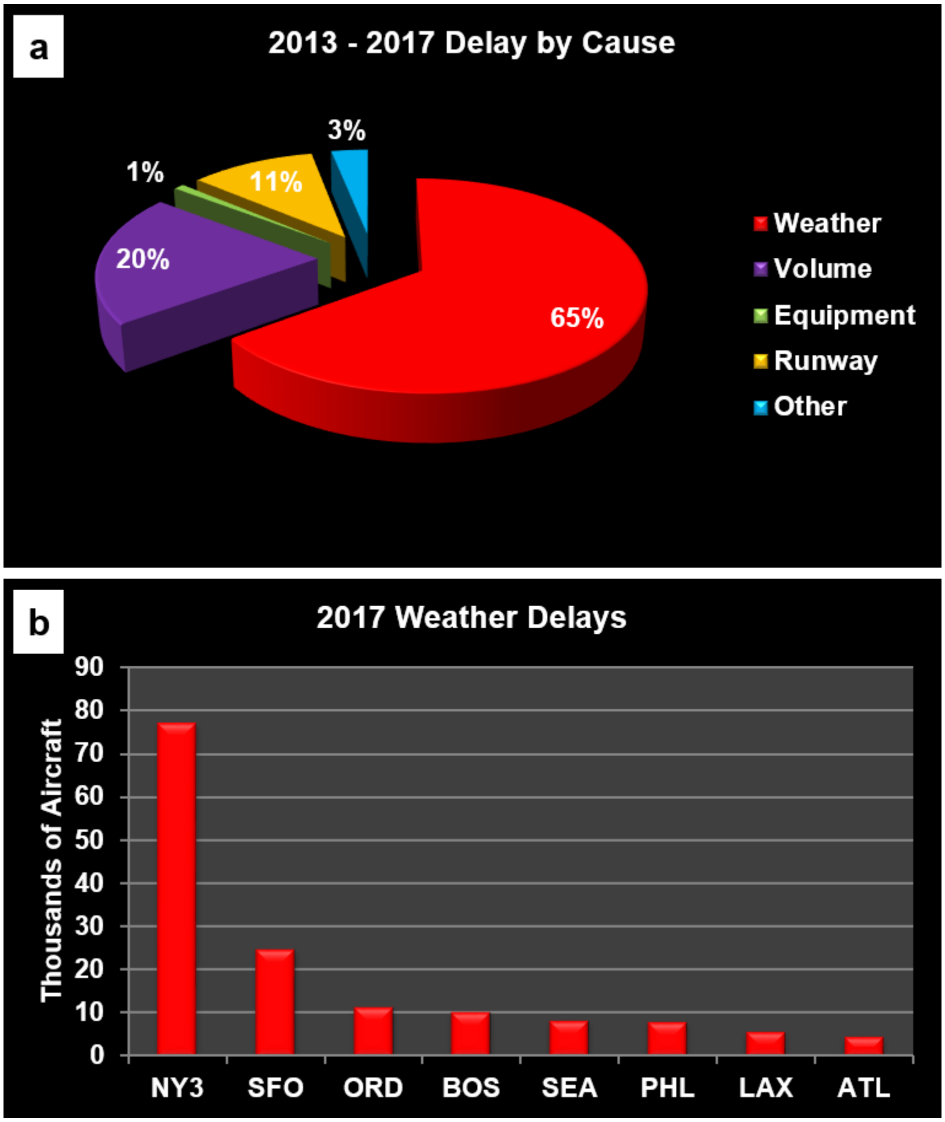

Figure 3. (a) Causes of delayed flights for 2013 - 2017 and (b) 2017 top weather-delayed airports, derived from the FAA Operations Network (OPSNET) delay data. Note that NY3 is comprised of JFK, LGA, and EWR.

Weather impacts in the Northeast are often handled by traffic initiatives known as Severe Weather Avoidance Planning (SWAP). SWAP requires both strategic and tactical initiatives in order to manage throughput in and around the New York metroplex.

Table 1 provides an overview of TMIs implemented from March through September 2017 for six Northeast airports (EWR, JFK, LGA, BOS, PHL, DCA).[vi] During this period, 547 GDPs were issued with an average duration of 7.0 hours, the majority of those (452) were due to weather. Of the 549 GSs implemented, 443 were due to weather.

Table 1 also provides statistics on selected AFPs issued, which include A08, OB1, A05, A01, and DC3. These AFPs are most commonly used for weather impacts on the six Northeast airports included in this table. From March through September, 42 AFP were issued, and only one (1) was NOT due to weather. The average lead time (3.4 hours) supports the need for the 4.5- to 8-hr forecasts discussed above.

TABLE 1

Traffic Management Initiative Statistics for 1 March through 30 September 2017[2]

Metric	2017
Total GDPs Issued	547
Average Duration (hrs)	7.0
Average Lead Time (hrs)	1.1
Total GSs Issued	549
Average Duration (hrs)	1.6
Total AFPs Issued	42
Average Duration (hrs)	5.0
Average Lead Time (hrs)	3.4

[2] Airports included in GDP and GS counts are EWR, JFK, LGA, BOS, PHL, and DCA; the reasons include weather, volume, runway, equipment, and other. AFP counts are for A08, 0B1, A05, A01, and DC3; reasons include weather, volume, equipment and other.

1.2 CURRENT SHORTFALLS IN STRATEGIC PLANNING

The Traffic Flow Impact product has been deployed as a prototype during the last three convective seasons. TFI remains the only translational forecast algorithm tested in the enroute air-traffic flow management (ATFM) operational field. Current air-traffic flow management operations use a variety of weather forecast sources to develop the safest and most efficient plan on a daily basis. This weather information consists of both deterministic and probabilistic forecasts that are typically interpreted by human forecasters. That interpretation of weather impact in relation to air traffic is then translated into Air Traffic Control (ATC) management decisions. However, the explicit and unbiased translation of weather forecasts into capacity resource constraints does not currently exist operationally in today's enroute traffic-management arena. TFI currently exists only as an experimental model.

There are several consequences of this translational shortfall. First, without explicit translation there is a lack of an operationally relevant methodology to assess weather forecast resource impact and overall forecast performance. Each participant [e.g., Air Traffic Control System Command Center (ATCSCC), Air Route Traffic Control Center (ARTCC), TMU, and AOC] comes to the collaborative strategic planning process with their own set of operational objectives, favorite forecast information, risk tolerance, etc. This wide and often divergent range of opinions and goals must somehow be melded into a plan of action. There is little common ground upon which to base discussions about the best plan of action without addressing the many different, but legitimate concerns of stakeholders. Second, the utility of convective weather forecasts is directly related to the quality of decisions and NAS performance outcomes that the forecasts can support. Defining explicit, validated weather translations provides an objective and operationally relevant measure of truth against which forecasts can be compared. Without translation-based forecast evaluations, it is difficult to determine how much of the operational shortfall in convective weather mitigation is due to poor weather forecasts and how much is the result of poor interpretation and application of forecast information.

One of the current strategic TMIs that managers use to mitigate delay is the AFP. AFPs were introduced in the summer of 2006 and marked a new way to manage traffic in enroute airspace during severe weather events. The AFP process was meant to identify constraints in the enroute system using FCAs, and allow for equitable distribution of delay across these FCAs based on historical traffic rate data. Table 2 is an example of the initial rate structure that was developed during the AFP concept release.

TABLE 2

Example of AFP Rates across ZOB ARTCC

			Throughput Rate for Impact Level:		
AFP Name	Sustained Throughput (No Impact)	Used for Weather Impact on	High	Medium	Low
A05	110	ZOB	65 - 70	70 - 80	85 - 90
A01	115	ZBW/ZNY	70 - 80	80 - 90	90 - 100
OB1	120	ZBW/ZNY/ZDC	80 - 90	90 - 100	100 - 110
BW1	40	ZBW	25	32	35
	OR				
	% Reduction of Actual Traffic		30%	20%	10%

The Flow Evaluation Team (FET), which is a sub-team of the Collaborative Decision Making (CDM) group, was tasked in 2010 to investigate and recommend an FCA capacity estimation [vii] which could be applied to the AFP traffic management process. The report identified the top problems within the system. Specifically, the current system:

- Lacks a method to determine practical and achievable capacity and throughput of an FCA
- Relies on inaccurate historical tables of volume or a simplified averaging calculation
- Does not take into account any constraints in the system
- Does not consider airspace complexity
- Does not provide an evaluation of risk associated with using different throughput values

The report further states that "Recent NAS convective weather events and post-event analyses have shown that there is an urgent need to reconsider the guidelines for AFP throughput reductions in the operational concept for setting FCA throughputs." A post convective weather event analysis referenced in the FET report indicated that the estimates used for the major New York metro region traffic flows consistently exceeded the available capacity.

The AFP rates in Table 2 were initially developed in 2006, based on air traffic demand from that period in time. Only minor modifications to those rates have been made since that time, despite the decrease in total demand over the last ten years. Note that even the "high" impact rates listed in Table 2 amount to a 30% reduction of the maximum throughput. The FET report concluded that, in order to avoid excessive amounts of unrecoverable delay, throughput rates during high-impact convective events need to be reduced by as much as 50% to 70% of the sustained throughput rates shown. Achieving NAS-wide approval from users (both FAA and airline) for rate reductions of this magnitude is a considerable challenge in the daily collaborative decision making process. The user is being asked to greatly reduce throughput and risk a potentially large amount of unrecoverable capacity based on weather that is not yet influencing operations. Current strategic SWAP requires AFPs to be issued by 14 UTC to 16 UTC, in order to capture enough demand to sufficiently reduce throughput rates. This timeframe is often well in advance of typical thunderstorm development.

1.3 REPORT SCOPE AND OUTLINE

This report provides a synopsis of the CoSPA and TFI forecast products utilized during the 2017 SWAP season and documents the results in support of the main objectives stated in Section 1.1. Section 2 presents the field observation process and highlights current operational impacts and observed climatology of convective storms. A detailed forecast assessment of both CoSPA and TFI can be found in Section 3 while observed operational use case benefits are documented in Section 4. The report closes out with user and product analytics in Section 5 as well as a closing summary and future work in Section 6.

2. FIELD OBSERVATIONS

2.1 OBSERVATION RELEVANCE AND PROCEDURE

Given the importance of convective forecasts to air traffic management in the NEC and across the eastern NAS in general, MIT LL subject matter experts conducted field observations during the 2017 summer season. These observations were held on four days when thunderstorms were forecast to develop across the eastern United States and potentially create an imbalance between demand and the usable capacity for enroute and terminal airspace in the NEC. Field observations were conducted on three separate events covering four convective days (19 June, 27 July, and 3-4 August).

Convective multi-day weather forecasts are produced by MIT LL meteorologists on a daily basis throughout the summer beginning in April. Each medium range (three- to seven-day) forecast is evaluated in order to determine the potential severity and placement of storms across the NAS, to help plan a field observation. When the forecast indicates the potential for convective weather impact for the northeast United States, the MIT LL observer assigned to a facility reaches out to the facility's designated point-of-contact to request permission to visit. MIT LL observers arrive at their respective facility between 1000 UTC (6 AM Eastern) and 1100 UTC (7 AM Eastern) in preparation for, and participation in, the first Strategic Planning Telecon/Webinar (SPT) of the day. They remain at the facility until the end of the weather impact, some nights as late as 0100 UTC (9 PM Eastern). This season, each observer was at their facility an average of 10 hours per day, totaling approximately 190 hours of in-situ observations. Not all airlines and FAA facilities were visited each observation day. Direct communications with FAA and airline operations not visited were made (post-event) in order to gather feedback on the day's operations and use of the CoSPA and TFI applications.

MIT LL observers visited four FAA ARTCCs, one TRACON and the ATCSCC; all considered primary participants in the strategic planning process. The ARTCCs included Boston Center (ZBW), Washington DC Center (ZDC), Cleveland Center (ZOB), New York Center (ZNY) and New York TRACON (N90). Two airlines were also visited which included Delta Airlines (DAL) and JetBlue (JBU).

The main objectives of the 2017 field observation study were to:

- Train and evaluate CoSPA and the TFI decision support application
- Observe and document usage of the TFI application specifically noting:
    - If and how the application is used in strategic planning of AFPs
    - If the impact timelines provide information in an easy-to-interpret format
    - If the Permeability plot is accurate and useful
    - If the addition of Forecast Confidence bounds on the Permeability plot fulfills the user-requested need for some measure of the accuracy of the 2- to 8-hr deterministic forecast

- Determine if and how the CoSPA forecast is effectively being used in strategic TMI decision-making
- Document comments, criticisms, and concerns regarding CoSPA to provide insights on how the application could be improved for decision support
- Investigate and document user preferences that pertain to current CoSPA capabilities and performance, such as update rate, forecast interval, etc.
- Document the decision-making process currently employed within traffic management and gain a more in-depth understanding of the process, in order to be able to design and assess potential CoSPA adaptations and improvements
- Document user suggestions and ideas to help identify unmet needs and define requirements for enhancements to the 2- to 8-hr deterministic forecast

In addition to the focused observations, refresher training for existing personnel and training of new FAA traffic managers, as well as airline operations and dispatchers, was conducted.

Observers resided primarily in the TMU or operations area of the facility in order to gather observations on the use of CoSPA and TFI and ask any potential operational questions. Questions were asked only when they did not interfere with the TMU's primary mission of traffic management. To ensure consistency across observers and facilities, each observer used a standardized data-entry sheet to record events in which personnel referred to or otherwise interacted with CoSPA or TFI. Entries included the date, time, user, type of interaction, and notes detailing the context or other stakeholders involved. Benefits results are summarized in Section 4.1 and are provided in detail in 0. User comments and requests are discussed in Section 5.

2.2 MEASURING OPERATIONAL IMPACT

Thunderstorm activity and the use of AFPs to manage enroute capacity in the eastern NAS began in early March. The first MIT LL observation was performed on 19 June. Figure 4 provides a snapshot example of the weather that developed on each of the observation days. Individual thunderstorms and fronts varied in size, shape, location and timing as well as organization (i.e., scattered, line, or cluster). Severity of storm intensity, as well as ATC/ATFM impact also varied greatly across the four observed days. Each day's weather translated into very different perceived and realized impact in terms of traffic flow management.

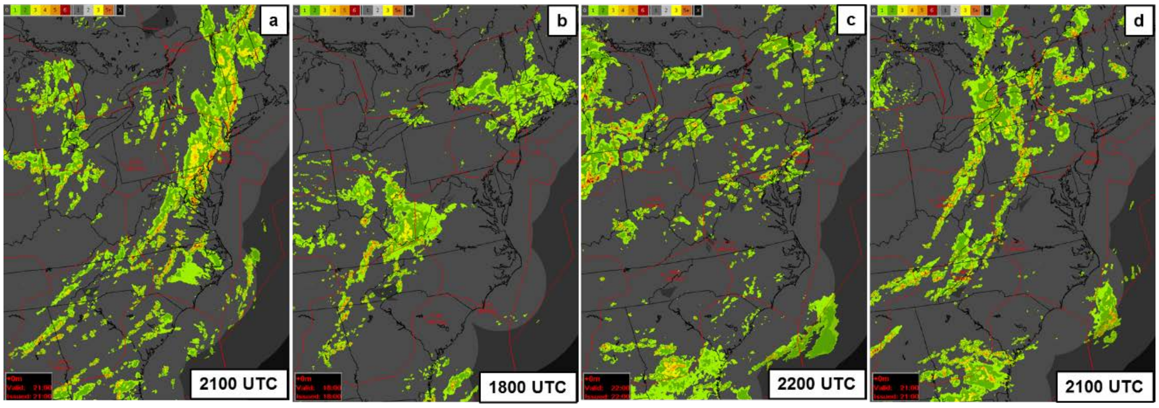

Figure 4. Representative VIL images of each CoSPA observational visit: (a) 19 June, (b) 27 July, (c) 3 August, and (d) 4 August 2017.

TABLE 3 provides a look into the "realized" ATC impacts to the system on each of the observations days presented above[3]. Four additional convective weather days are listed in TABLE 3 that were not MIT LL observation case days. The four additional days are provided as a baseline for throughput disruption across the NAS in comparison to the four planned MIT LL observation days. TABLE 3 consists of traffic data and delay statistics commonly used by the FAA and airline management to gauge daily performance. The eight Northeast Operational Evolution Partnership[4] (OEP) terminals included in the data are Boston International Airport (BOS), EWR, JFK, LGA, Philadelphia International Airport (PHL), Baltimore Washington International Airport (BWI), Washington Dulles International Airport (IAD), and Reagan National Airport (DCA).

[3] Data gathered using the FAA Aviation System Performance Metrics (ASPM) Air Traffic Organization Efficiency Report Online database.

[4] OEP airports are commercial U.S. airports with significant activity, which service major metropolitan areas, and also serve as hubs for airline operations. More than 70% of passengers move through these airports.

TABLE 3

Aviation System Performance Metrics (ASPM)

based on eight core airports in the Northeast NAS

indicating the severity of the impact of thunderstorms on air traffic demand

Northeast Terminal Operations: Delays and Statistics						
Day	Total Ops	Cancellations (Departure/Arrival)	Airborne Holding(min/hr.)	Diversions	Completion Rate(%)	Airspace Flow Programs
*19 Jun	6667	969/963	5640 (94)	126	77.4	OB1/A08
13 Jul	8338	340/306	3758 (62.6)	76	93.1	OB1/DC3/DC4
*27 Jul	9141	23/32	659 (11.0)	7	99.3	-
*3 Aug	8604	346/398	4481 (74.7)	63	91.1	-
*4 Aug	8005	544/601	2049 (34.2)	43	86.4	OB1/A08
11 Aug	8604	151/157	1328 (22.1)	10	96.4	OB1/A08
22 Aug	8269	218/196	1243 (20.7)	38	95.4	OB1/A08
5 Sep	7918	230/214	2155 (35.9)	54	94.7	A01/DC3/ID2

*MIT LL Observation Day

The ‘Total Operations’ count includes all arriving and departing aircraft at each of the eight core terminals. The ‘Cancellations’ count includes aircraft from originating terminals (arrivals) and aircraft departing the core airports. The ‘Diversions’ count includes those aircraft that were destined to one of the eight terminals but had to divert to another airport. Airborne holding minutes are characterized in three ways [viii]:

1. Flights held within 100 nautical miles (nmi) of the airport when the destination-airport arrival rate was not met

2. Flights held within 100 nmi of the airport when the destination airport arrival rate was met

3. Flights held outside 100 nmi without consideration of the destination airport arrival rate

The “Completion Rate” is defined by the percentage of scheduled arrivals that were not cancelled, calculated as:

Completion Rate = 100*[1 - Cancelled Arrivals/Number of Scheduled flights] (1)

Cancelled Arrivals are determined on the next day using flight plan cancellation messages for ASPM carriers and all other carriers reporting schedule data, and scheduled flights not flown.

It is often difficult to conclude that traffic was disrupted more on one day than another based solely on individual delay statistics. The operational impact statistics do not necessarily indicate when a day was difficult for air traffic managers. It might be that the weather impact was severe (e.g., solid squall line) but consistent, accurate forecasts by all the major models helped air traffic managers plan effectively. Conversely, other days might have had significant weather impacts, but unreliable forecasts and/or an overall complicated weather pattern (in space and time) resulted in less effective planning. The fact is that delay can be the result of a multitude of different initiatives that exist to manage air traffic, and the complexity of the airspace involved. Severe weather introduces complexity into air traffic management that at times can be difficult to predict. However, the CDM community uses statistics like these in many post-analysis discussions and forums. The statistics in TABLE 3 provide a comparison to the most challenging convective days in 2017 for managing air traffic across the NAS while quantifying the level of severity of each MIT LL observation day.

2.3 OBSERVED CONVECTIVE CLIMATOLOGY ANALYSIS

MIT LL has an extensive database archive that includes Enhanced Traffic Management System (ETMS) flight plans, multiple convective weather forecast models, and the corresponding weather truth fields for VIL and ET. This database was used in the development of a new procedure for analyzing the climatology of the entire convective season (April–September). The most recent season (2017) along with the prior three seasons were used in this comparison. For each convective season, the archived VIL fields were used to determine the frequency of occurrence of level 3 or higher VIL (associated with a higher probability of thunderstorms) at each grid point on the map. This frequency is then converted to percentage and the result is shown in Figure 5. While these percentages may seem low, it is important to remember that level 3+ VIL values are not present all of the time every day. A percentage of 1.5 translates to almost 7 hours of level 3+ over the entire convective season. The red lines in Figure 5 represent ARTCC boundaries across the eastern NAS.

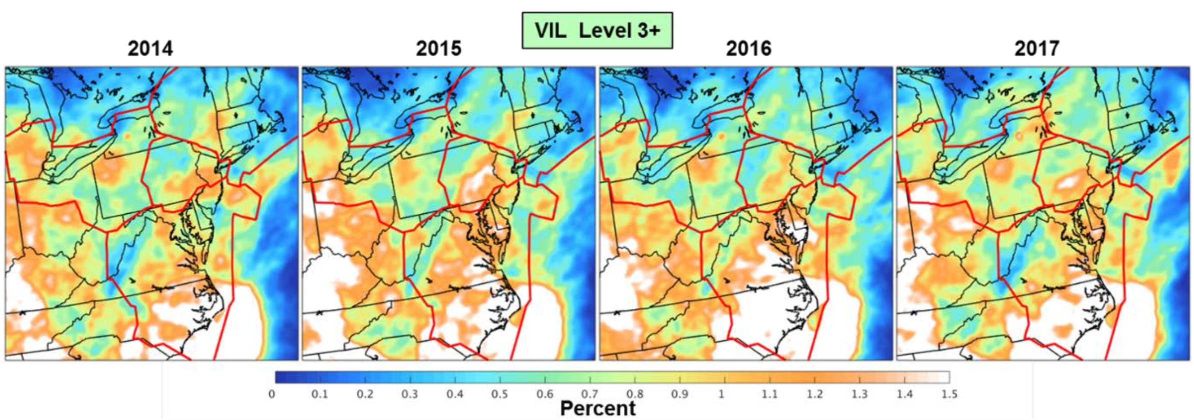

Figure 5. Occurrence of VIL level 3+ in the Northeast U.S. during the convective seasons (April through September) of 2014 through 2017.

The often cooler, less convective spine of the Appalachian mountain chain stands out across all four seasons, as well as the more active Tennessee and southern Ohio Valley. There is also a strong signal for the well-known thunderstorm activity off the North Carolina coast due to the Gulf Stream that stretches back to the hot and humid Carolina plains. Figure 6 is a National Weather Service (NWS) map of average thunderstorm days per year that correlates closely with the VIL level 3+ plots in Figure 5 and the aforementioned climatological signals.

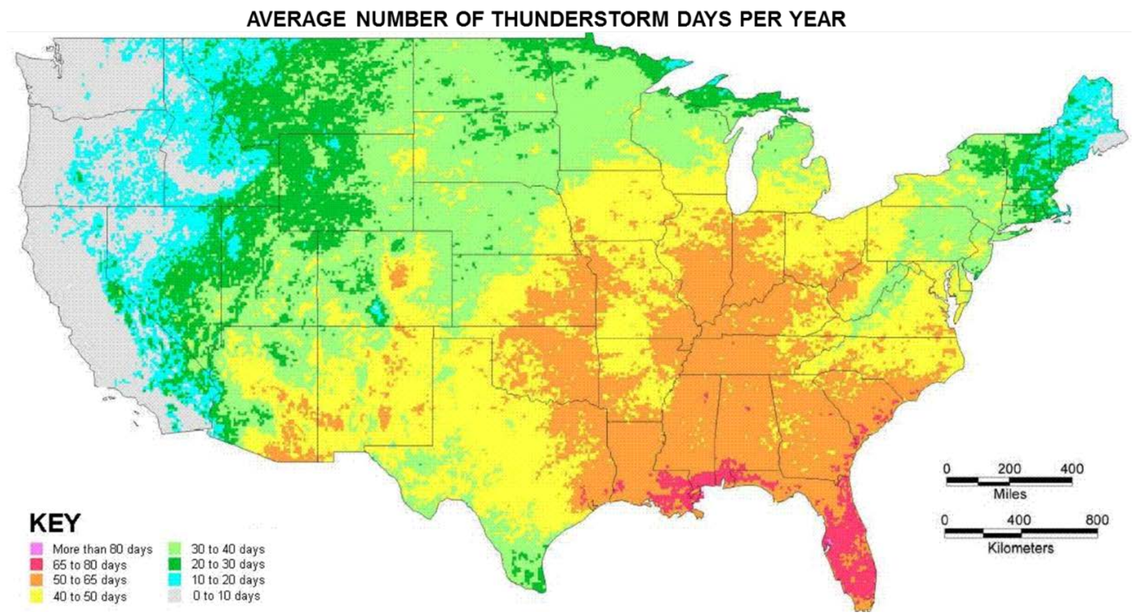

Figure 6. The average number of thunderstorm days per year (2002–2013) released by the National Weather Service.

The Northeast and mid-Atlantic ARTCCs represent some of the busiest airspace across the NAS in terms of total traffic count. The average frequency of occurrence of Level 3+ VIL in these ARTCCs (averaged over every grid point within the ARTCC for the convective season) is shown in Figure 7. The centers of ZBW, ZNY, and ZOB all experienced a rise in Level 3+ activity that may indicate increased thunderstorm activity across those regions. However, ZDC waned in Level 3+ percentage. Geographically, this decrease can be observed in the regional map in Figure 5 across eastern Virginia, Maryland, and Delaware.

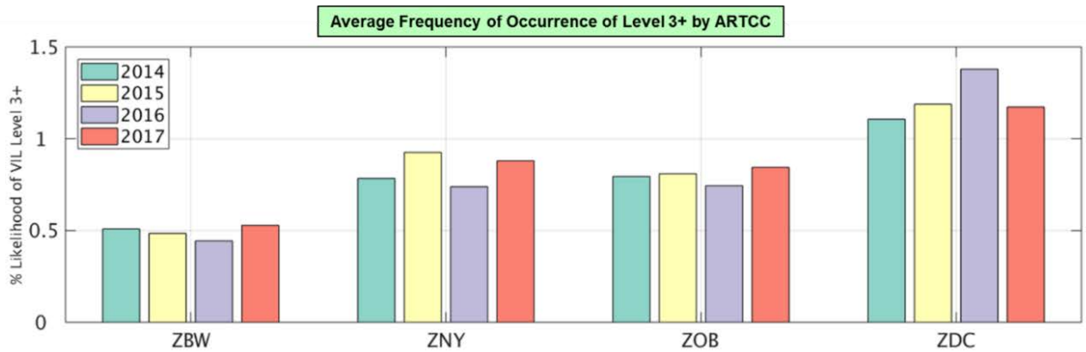

Figure 7. Average frequency of occurrence of Level 3+ VIL within the ARTCC for the convective season (April through September) for 2014 through 2017.

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3. FORECAST ASSESSMENT

In-field observations during live SWAP events continues to prove invaluable when measuring operational benefits and assessing the accuracy of the forecasts utilized. The ability to monitor air traffic managers, obtain on-the-spot feedback of fielded decision support tools, and provide immediate training is extremely helpful in the user-provider loop. The following operational examples will provide discussion of the use of CoSPA and TFI by air traffic managers during observation days and illustrate forecast strengths and weakness in the prediction and translation of CoSPA and TFI.

3.1 COSPA

CoSPA's 0- to 8-hr forecast of ET and VIL, as well as the 0- to 8-hr translational TFI forecast were available through MIT LL's dedicated SDs. During the 2016 observation period, observers documented multiple requests for longer lead-time forecasts. As a result, in 2017 a 12-hour version of TFI was available on the CoSPA website. Planners and severe weather managers of AFPs and routes at ATCSCC stated they needed longer lead times to plan through 0000 UTC allowing for more efficient strategic planning during SWAP.

CoSPA continued to show skill during large-scale events in 2017 (e.g., cold fronts), more accurately than forecasting individual thunderstorms in the 2- to 8-hr range. This skill has been noted every season since CoSPA's inception in 2009. CoSPA's use of the High Resolution Rapid Refresh (HRRR) [ix] 3km storm resolving model contributes greatly to this accuracy in the longer lead forecast range (2- to 8-hr). The large-scale forecast accuracy displayed by the CoSPA 8-hr forecast is useful to air traffic managers at various east coast facilities. Strategic air traffic planning involves moving large flows of aircraft, many hours in advance of the development of the weather, through the implementation of initiatives such as Playbook re-routes, GDPs and AFPs. The CoSPA 2- to 8-hr forecast allows traffic managers to view how storms may or may not eventually impact large regions of airspace and to assess the need for TMIs. AFP planning, in particular, requires eight or more hours of coordination in order to manage West Coast demand expected to traverse impacted airspace in the eastern United States. Key decisions involving weather classification type (line, scattered), timing (onset, duration), scope, and rates of traffic need to be made for aircraft from the West Coast before they depart, since it is easier and more efficient to manage demand from aircraft on the ground rather than in the air.

Figure 8 provides one example of this accuracy from the 19 June observation day. An extended cold front draped along the east coast from southeastern Canada into the Appalachian Mountains generated a long line of thunderstorms on this day. Placement of the scattered lines of thunderstorms as well as intensity was captured in the forecast. Timing of the NY terminal impact was particularly accurate on this day as the image shows a line of VIL level 4–6 moving through N90 at 2100 UTC.

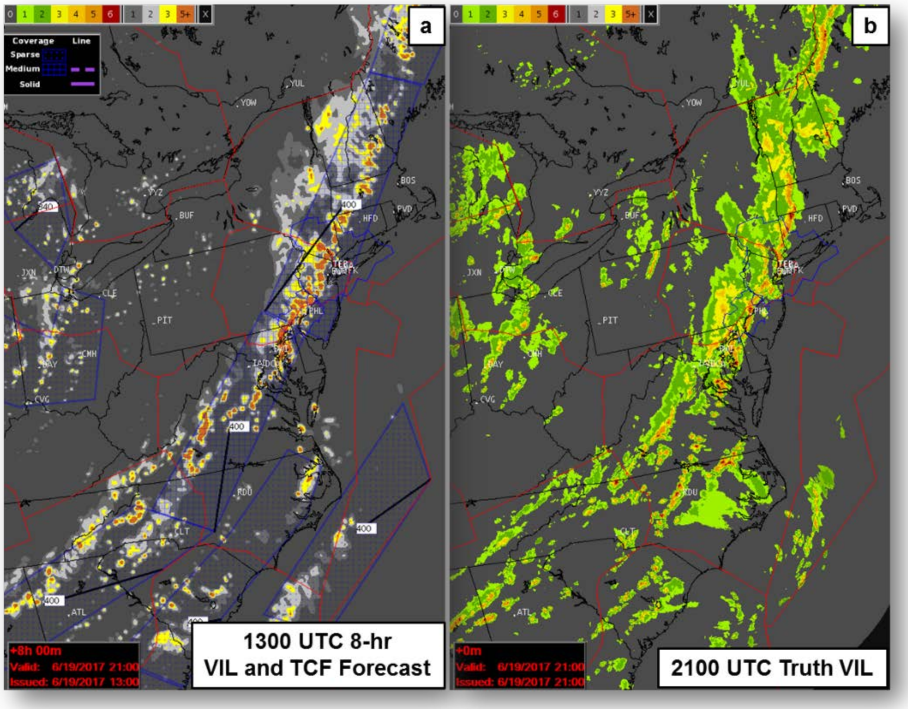

Figure 8. The (a) 8-hr CoSPA VIL forecast and TCF issued at 1300 UTC along with the (b) corresponding VIL truth at 2100 UTC on 19 June 2017.

CoSPA's 8-hr forecast is tested on days dominated by smaller-scale events and the scattered thunderstorm activity that accompanies a weak, synoptic summer pattern. Three key CoSPA deficiencies were evident and repeated during the 2017 observations:

- CoSPA forecasts convective initiation later than the actual onset.
- CoSPA under-forecasts VIL intensities.
- CoSPA under-forecasts Echo Top heights.

Figure 9 shows the 4- and 6-hour CoSPA VIL forecast and truth VIL from 14 July 2017. One of the key ATC issues for traffic managers on this day was the cluster of storms that developed within the ZNY boundary early in the morning. Note that CoSPA did not correctly forecast the initiation of the storms and never fully developed the intensity. Although not a large area and not very intense, this cluster of convection lingered across ZNY and the NY TRACON region which wreaked havoc on the arrival and departure structure in the Northeast.

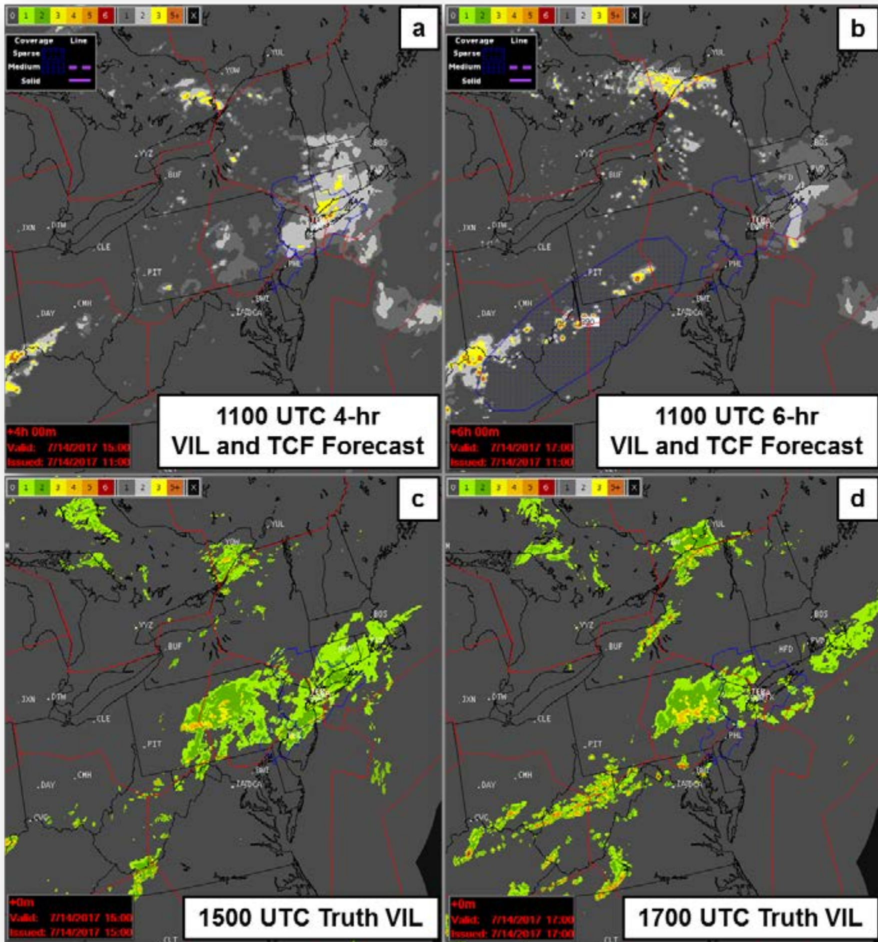

Figure 9. The (a) 4-hr and (b) 6-hr CoSPA VIL and TCF forecasts issued at 1100 UTC and valid at 1500 UTC and 1700 UTC, respectively, and the corresponding VIL truth for (c) 1500 UTC and (d) 1700 UTC on 14 July 2017.

A detailed quantitative analysis of the CoSPA VIL forecast was performed using the same MIT LL archive data-analysis technique depicted in Figure 5. Figure 10 utilizes the CoSPA VIL forecast of level 3+ and covers the entire convective season (April–September). This analysis reinforces qualitative observations relating to the under-forecast of VIL intensities, particularly in the 2- to 4-hour forecast range. Areal coverage of under forecasting is observed in the 3-hr forecast panel across eastern ZOB, western ZNY and throughout much of ZDC. Slight over forecasting of VIL (level 3+) is detected in hours 6 and 8 across these same regions but particularly along the spine of the Appalachians from NY state through PA and into WV and into the southeast.

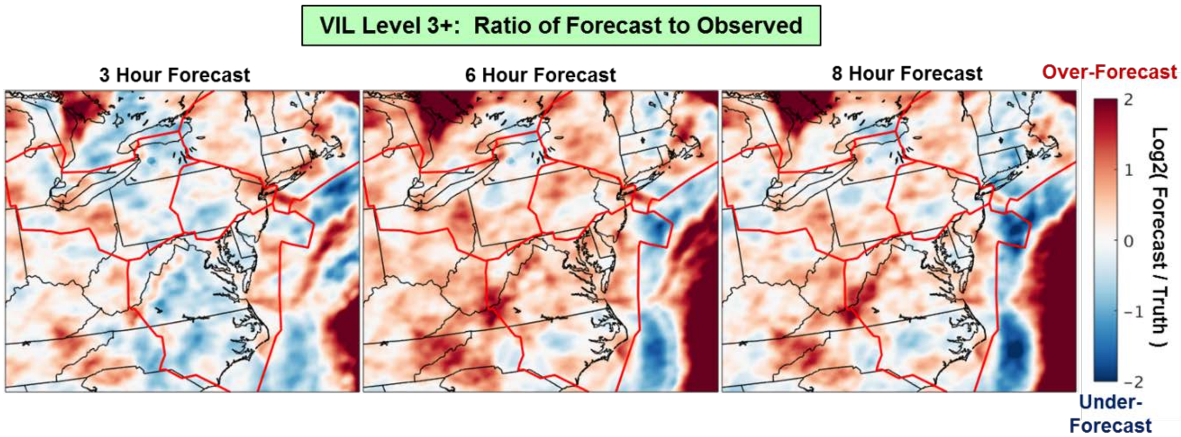

Figure 10. The archive analysis of CoSPA VIL (level 3+) for the 3-, 6-, and 8-hour forecast. The analysis was performed over the convective season (April-September 2017) across ZNY, ZOB, ZDC, and ZBW.

Although the under forecast of VIL (level 3+) has been noticed continually over the past several years, improvement in this bias has been realized. Figure 11 is a comparison of the VIL (level 3+) bias over the entire 0- to 8-hour forecast period performed over the convective season (April–September) between 2017 (Figure 11a) and 2016 (Figure 11b). This analysis was calculated across four ARTCCs including ZNY, ZOB, ZDC, and ZBW. There are two key feature changes to note. First, the bias “dip” in the 2- to 4-hour time period remains, however there has been slight improvement in the 2017 convective season. Second, there is a shift from the under-forecast bias in the 4- to 6-hour timeframe to slightly over-forecasting across all ARTCCs. The bias across all four ARTCC regions are more tightly packed and show similar characteristics in the model VIL.

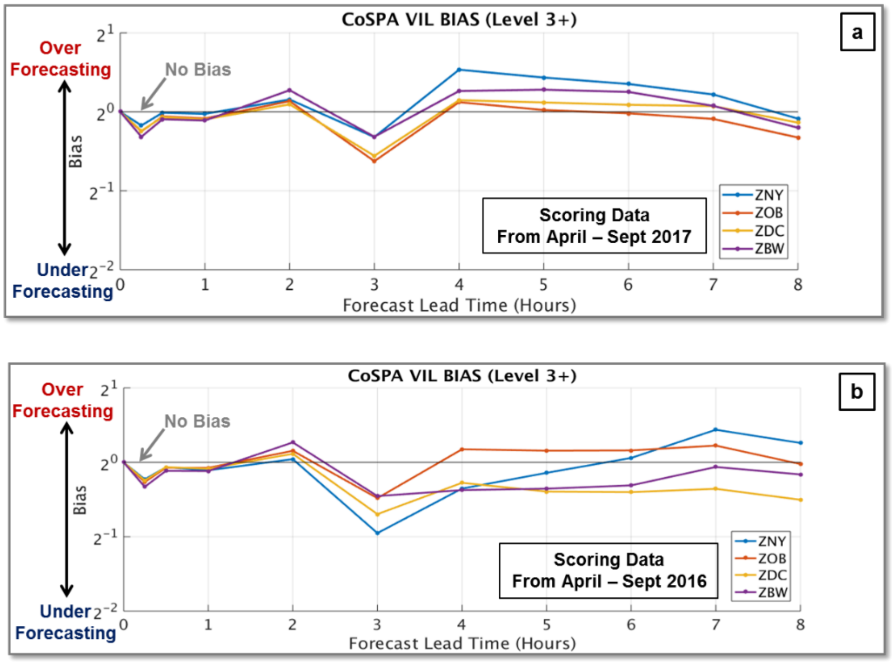

Figure 11. VIL (level 3+) bias over the entire 0- to 8-hour forecast period for (a) 2017 and (b) 2016. Analysis was performed over the convective season (April–September) across ZNY, ZOB, ZDC, and ZBW.

An example of late convective initiation along with under-representation of ET height can be seen in Figure 12. A particularly strong line of thunderstorms developed in eastern Pennsylvania just outside of N90. CoSPA was unable to predict the initial development of storms that began at 1600 UTC. Also, note the line of storms in Figure 7 to the west of CLT (Charlotte, NC). The ET height of the developing line was under-forecast during this time. The line of 35kft+ storms affected ATC operations and traffic management patterns at CLT and ZTL.

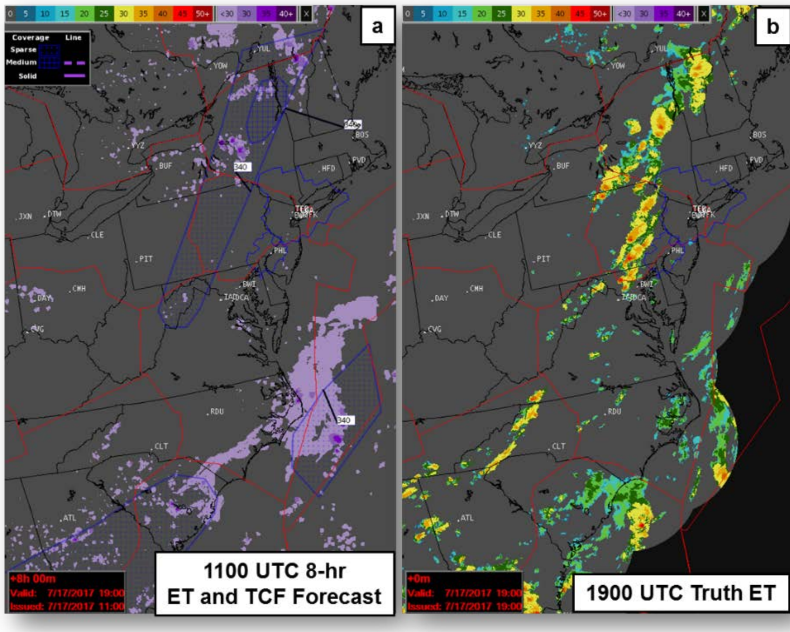

Figure 12. The (a) 8-hr CoSPA ET forecast and TCF issued at 1100 UTC along with (b) the corresponding ET truth at 1900 UTC on 17 July 2017.

A detailed quantitative analysis of the CoSPA ET forecast was similarly performed over the same 2017 period and regions. Qualitatively, a significant amount of lower than observed echo tops has been noted over the entire Continental United States (CONUS) during the convective season. Figure 13 quantifies this visually with under forecasting signals (blue) depicted across all ARTCC's with larger areas showing up in ZDC, eastern ZOB and across much of ZBW. This bias is present across all three time periods as well and is represented in Figure 14a. The comparison to 2016 is plotted in Figure 14b. Almost no bias was present in 2016 throughout the first four hours of the forecast, whereas the 2017 ET data now shows a dip in the 3-hour forecast period. This under-forecasting ET bias has also grown in the 5- to 8-hour period in 2017. This climatological analysis of the actual weather and forecast product is important to help drive improvement in the product-generation algorithms. It is also important to relate these biases to the yearly ATC delay statistics in order to effectively measure the decision-making process.

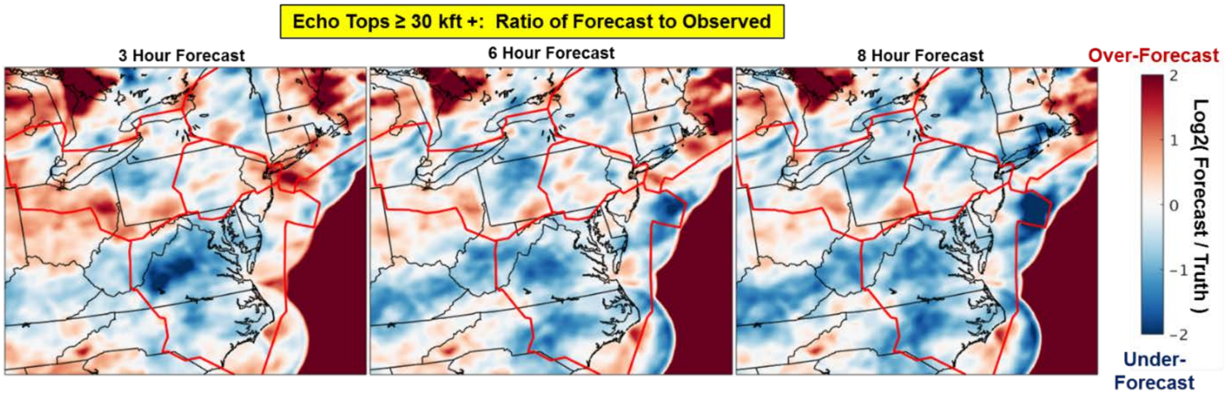

Figure 13. The archive analysis of CoSPA Echo Top (30kft and higher) for the 3-, 6-, and 8-hour forecast. Analysis was performed over the convective season (April–September 2017) across ZNY, ZOB, ZDC, and ZBW.

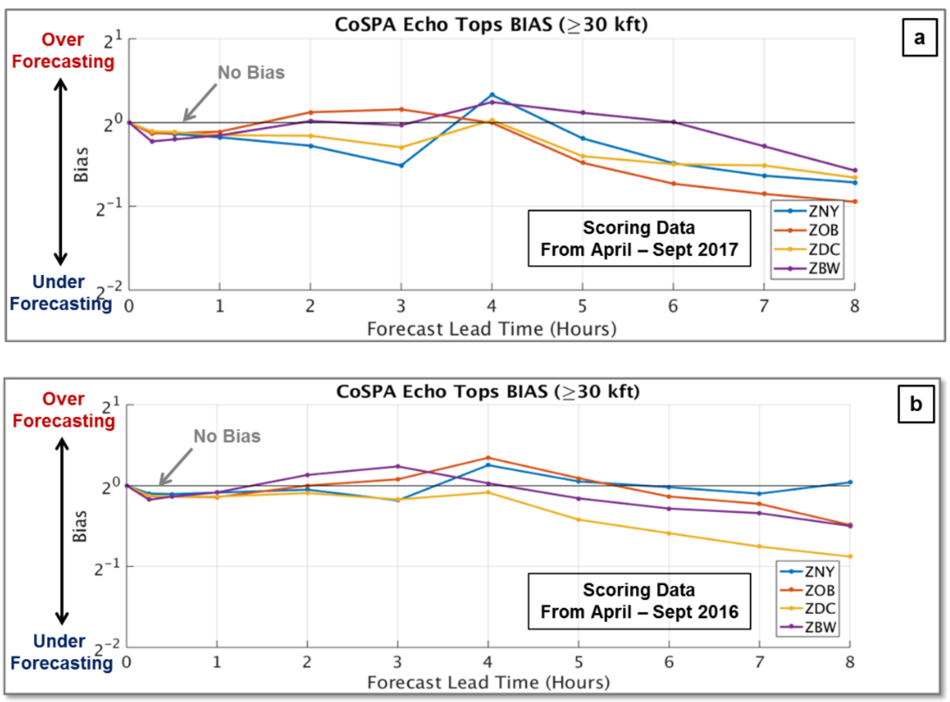

Figure 14. The ET (>30 kft) bias over the entire 0- to 8-hour forecast period for (a) 2017 and (b) 2016. Analysis was performed over the convective season (April–September) across ZNY, ZOB, ZDC, and ZBW.

3.2 TRAFFIC FLOW IMPACT (TFI)

Translating convective weather forecasts into coherent air traffic impact continues to be paramount in TFM strategic decision-making. Air traffic managers and planners have made it clear that convective weather forecasts must be accompanied by a measure of accuracy predictions (confidence) in order to lower the risk of TMI decisions made during SWAP events[5]. Airspace impact is a key piece of information needed to make efficient traffic management decisions in a time-constrained and often unpredictable environment when thunderstorms limit capacity across the NAS. Translation of a convective weather forecast is also the next step to developing skillful and intelligent strategic decision support for air traffic management. TFI begins by providing an estimate of airspace permeability. In simple terms, permeability is computed from the overlap of forecasted weather with an airspace resource to determine the amount of usable airspace within the resource [ii]. Figure 15 is an example plot of the web-based TFI display used in the field during the 2017 operational observation. A 12-hour TFI timeline is shown below the CoSPA deterministic forecast indicating severity of airspace impact in either green (low), yellow (moderate) or red (high). Also seen in the upper-left hand corner is a “drill-down” permeability plot used to analyze individual regions of airspace (cyan dashed) for throughput availability due to thunderstorms.

[5] Information gathered during multiple CoSPA/TFI field observations at various facilities, (ATCSCC, ZOB, ZNY, ZDC, and ZBW) 2015–2017.

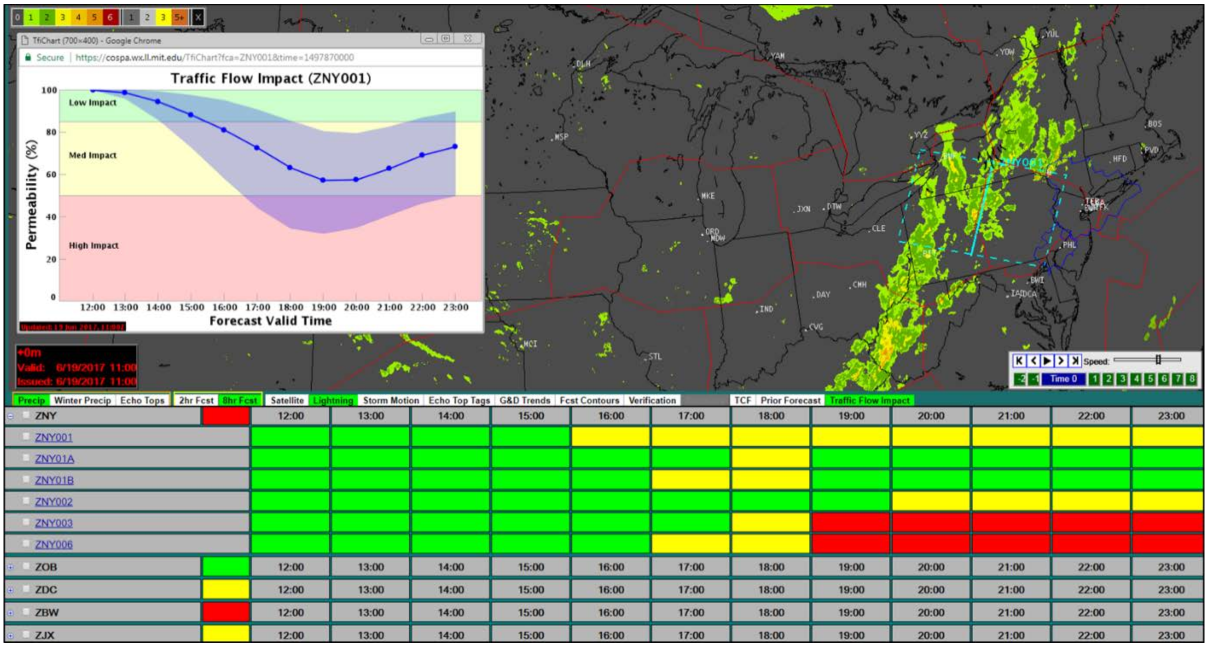

Figure 15. Example of TFI web-based display (including timeline and permeability plot) used during the 2017 operational observation.

Figure 16a is a plot of the TFI forecast (blue) and verification (black) on 1 May 2017 issued at 1500 UTC. The meteorological case on this day presented a long synoptic cold front stretching from north to south across the eastern third of the NAS, a known high confidence/high accuracy forecast scenario. The CoSPA VIL forecast (Figure 16b) and associated VIL truth (Figure 16c) shows that the general placement, timing, and intensity of thunderstorm was captured across this important ATC airspace region. Despite the incorrect placement of the northern end of the squall line, the TFI forecast was able to accurately predict the permeability or loss of throughput between ZOB and ZNY. Forecast confidence is indicated by the blue shaded region in Figure 16a. The narrower the band of blue shading, the higher the confidence in the translational forecast.

It is well documented that even the best weather forecast model can produce erroneous data due to the chaotic nature of the atmosphere. Chaos theory [x] shows that the atmosphere is susceptible to small changes or errors introduced in initial analysis of current forecasting models. An ensemble forecast is a series of predictions run using slightly different perturbations in the initial state of which the outcomes will provide a range of potential predictions. The TFI forecast is not based upon one forecast model alone, it is a true ensemble comprised of both probabilistic, deterministic and time-lagged predictions. Figure 16d is a plot of the same 1500 UTC forecast on 1 May 2017 seen in Figure 16a, however, each of the ensemble members predictions are shown. TFI incorporates the latest HRRR model as well as the past three time-lagged runs of the HRRR. It also uses probabilistic thunderstorm forecasts contained in the [xi] (Localized Aviation MOS Product (LAMP) and [xii] Short-Range Ensemble Forecast (SREF) produced by the NWS.

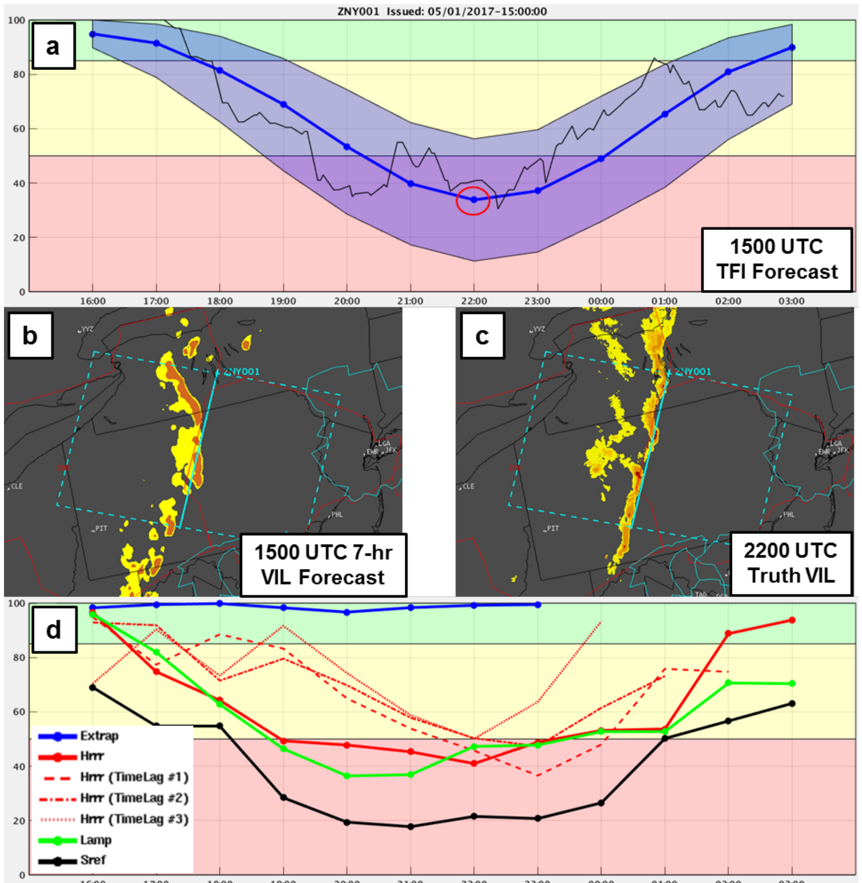

Figure 16. (a) Traffic Flow Impact forecast (blue) and verification (black) on 1 May 2017 for the location centered between the ZOB and ZNY airspace, (b) 7-hr VIL forecast issued at 1500 UTC and (c) corresponding 2200 UTC VIL truth, (d) individual model forecast plots that contributed to the ensemble TFI forecast in (a).

The basis of the TFI forecast is a direct translation of weather impact into ATFM impact. Therefore, the same forecast challenges in the CoSPA forecast can also manifest themselves in TFI as well. Figure 17a is an example on 15 June 2017 using the 1500 UTC issued forecast. Although there was high confidence in the weather forecast (exhibited in the narrow blue shaded area) note the large deviation in the actual TFI truth (black). The TFI forecast did not correctly predict the explosive growth in convection and did not realize the severity of the loss in permeability. Visually, the 6-hr CoSPA forecast (Figure 17b) and 2100 UTC VIL truth (Figure 17c) show the lack of thunderstorm coverage in the southern portion of the TFI evaluation region (cyan dash). The ensemble forecast breakout in Figure 17d shows that only the LAMP predicted close to the actual permeability loss, however, it also did not capture the rapid growth.

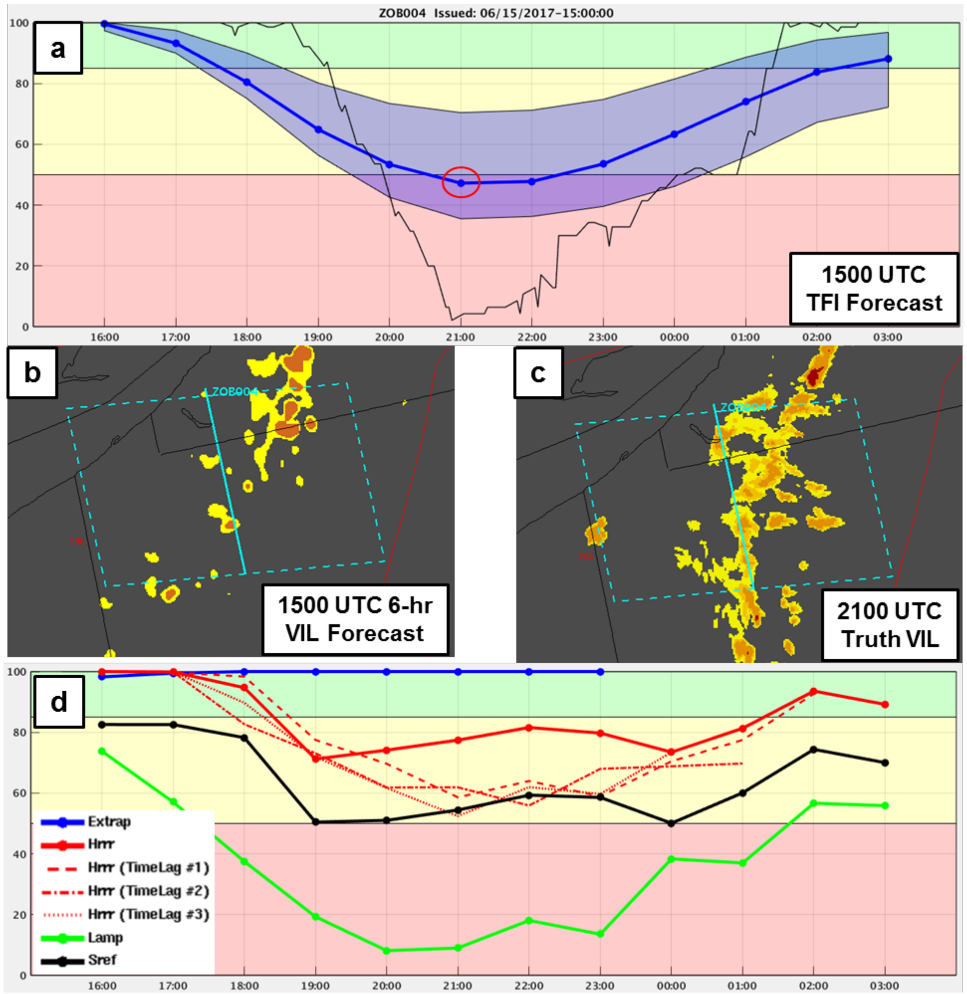

Figure 17. (a) Traffic Flow Impact forecast (blue) and verification (black) on 15 June 2017 for the region located in eastern ZOB airspace, (b) 6-hr VIL forecast issued at 1500 UTC, (c) corresponding VIL truth at 2100 UTC, and (d) individual model forecast plots that contributed to the ensemble TFI forecast in (a).

4. OBSERVED OPERATIONAL BENEFITS

4.1 BENEFITS CLASSIFICATION

Observations recorded during field evaluations were analyzed to identify operational decisions where CoSPA and/or TFI provided a benefit to users. These benefits are divided into categories shown in TABLE 4.

Figure 18 provides the distribution of benefits for each field observation day for all facilities visited on the particular day, and the totals across all days and facilities. The observations from which these statistics are derived are found in 0. Observers documented 114 instances when CoSPA and/or TFI were used operationally, with 43 attributed to TFI. The most common use was for situational awareness, for which there are five categories (SA, SA-AFP, SA-R, SA-T, and SA-TFI), defined in TABLE 4. There were 82 observations of General Situational Awareness (SA and SA-TFI, 51 and 31 respectively) and 21 observations of support for AFP go/no-go decisions (1 for AFP and 11 for TFI-AFP).

TABLE 4

Benefits Categories

	Key	Benefit Category
Using CoSPA	AFP	**Improved AFP Execution / Management** Assigned when CoSPA used to make AFP Go/No-Go decisions, AFP decisions on start time, stop time, rate, plan modifications, etc.
	C-GDP	**Improved Ground Delay Program Execution / Management** Only assigned when decision aided to explicitly avoid GDP, to implement GDP, to modify rate/scope, or to end GDP, based on CoSPA
	Coord	**Enhanced Inter/Intra-Facility Coordination**
	ERP	**Enhanced Reroute Planning** Includes avoiding reroutes by recognizing viability of nominal routes, proactive reroute implementation, and ending reroutes/returning to nominal routes sooner, etc., based on CoSPA
	SA	**General Situational Awareness**
	SA-AFP	**Enhanced Situational Awareness – AFP** Assigned when FCA forecast confidence estimate plots viewed in reference to AFP rate decision, based on CoSPA
	SA-R	**Enhanced Situational Awareness – Route (Enroute Airspace) Impact Monitoring**
	SA-T	**Enhanced Situational Awareness – Terminal Impact Monitoring (TRACON to Terminal Airspace)**
	Staffing	**Staffing** Assigned when CoSPA used to determine staffing levels.
Using TFI	SA-TFI	**General Situational Awareness**
	TFI-AFP	**Improved AFP Execution / Management** Assigned when TFI used to aid in an AFP Go/No-Go decision, AFP decisions on start time, stop time, rate, plan modifications, etc.
	TFI-GDP	**Improved Ground Delay Program Execution / Management** Only assigned when decision aided to explicitly avoid GDP, to implement GDP, to modify rate/scope, or to end GDP, based on TFI
	TFI-Plan	**Improved Traffic Management Initiative Planning**
	TFI-R	**Enhanced Reroute Planning** Includes aiding in reroute decisions by recognizing viability of nominal routes, proactive reroute implementation, and ending reroutes/returning to nominal routes sooner, etc., based on TFI

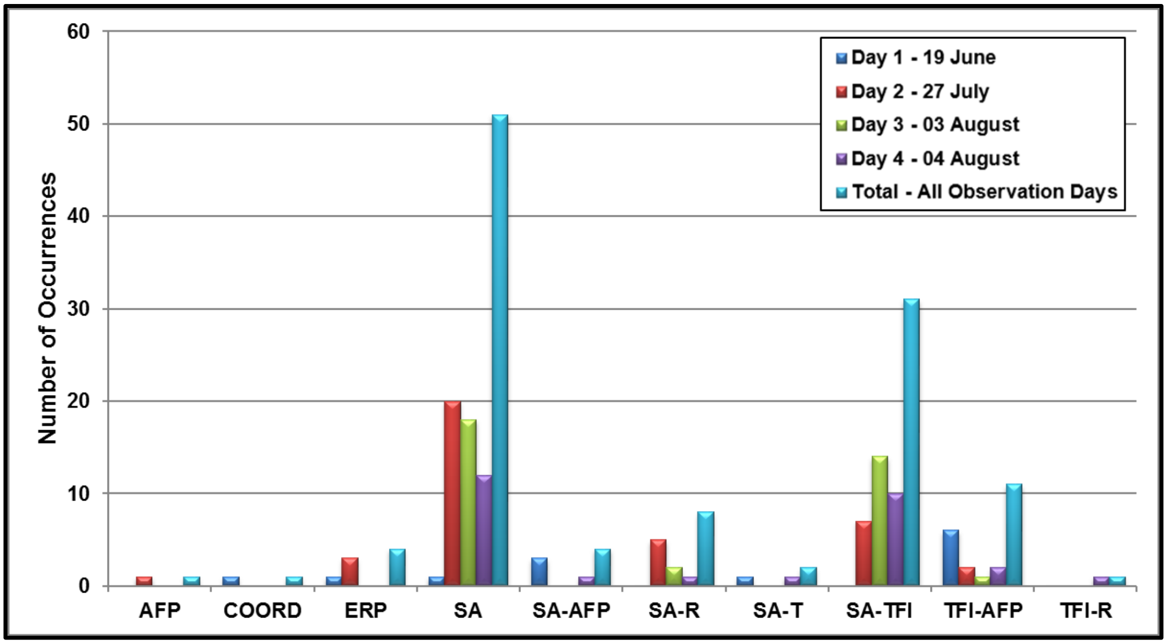

Figure 18. Distribution of benefits by observation day across all facilities visited in 2017. Only those categories for which benefits were measured are included in the chart.

4.2 OPERATIONAL USE EXAMPLES

Section 4.1 above provides an explanation of the types of operational uses that were observed and a statistical breakdown of each category by day. This section documents specific operational uses of CoSPA and TFI on those days.

4.2.1 Improved AFP Execution Management and TMI Planning (19 June 2017)

A consistent weather pattern emerged early on the morning of 19 June. AFPs were considered prior to the first strategic planning teleconference (SPT) of the day based on consultations with National Aviation Meteorologists at ATCSCC and Central Weather Service Meteorologists (CWSU) at ZOB and ZDC. Several consecutive early morning computer-forecasting models were consistently producing a line of storms throughout the northeast corridor and indicating a loss in throughput by1700 to 1900 UTC. Two CoSPA model VIL forecasts are shown in Figure 19. The 8-hr forecast from 1100 UTC and the 6-hr forecast from 1300 UTC both indicate significant convective development by 1900 UTC across central ZNY. Storm placement, intensity, and timing are consistent.

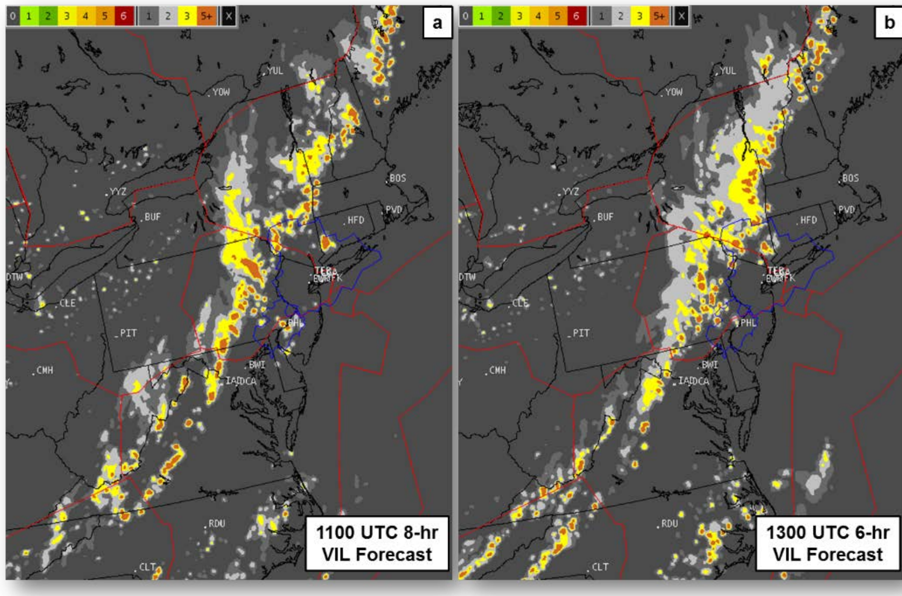

Figure 19. Images of the (a) 8-hr and (b) 6-hr CoSPA VIL forecasts issued at 1100 UTC and 1300 UTC respectively on 19 June 2017. Both forecasts are valid at 1900 UTC.

MIT LL observers at ATCSCC have been working closely with operations planners for the past three years to develop a concept of operations for TFI. Many of the changes/improvements since TFI's inception in 2014 have been based on recommendations directly from ATCSCC operational personnel. Figure 20 is a snapshot image taken from the National Operations Manager (NOM) situation display at ATCSCC. The NOM, Planner, and National Aviation Meteorologist (NAM) were discussing AFP usage prior to the 1315 UTC SPT. CoSPA and two TFI regional graphs are displayed in Figure 20. ZNY006 in eastern Pennsylvania and ZBW002 in eastern New York were being evaluated for convective constraints. Of particular interest was the time between 1730 and 2130 UTC, during which TFI indicated severe impact (more than 50% reduction in throughput) to the airspace in question.

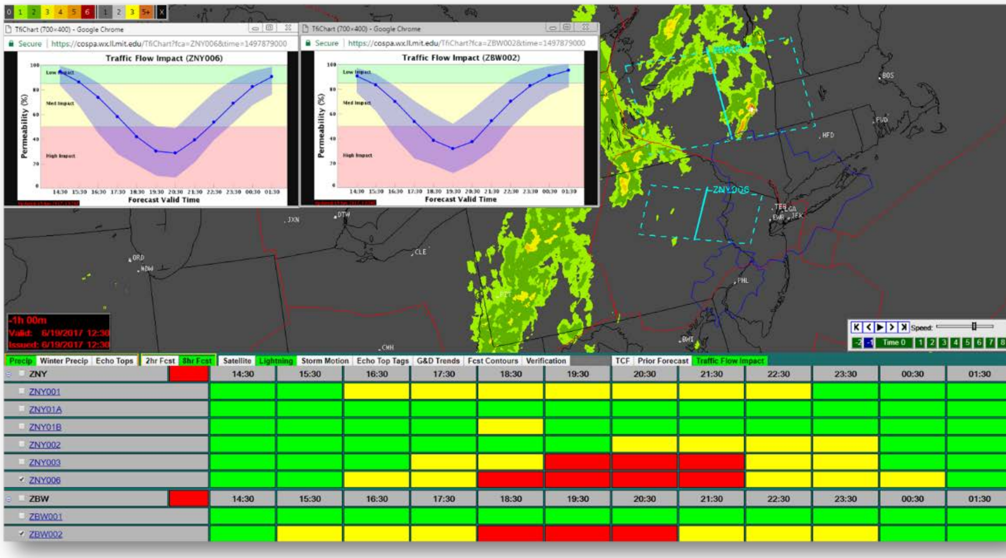

Figure 20. Image taken from the ATCSCC National Operations Manager display at 1325 UTC. Display shows CoSPA VIL, TFI timeline for ZNY and ZBW, as well as plots of permeability for ZNY006 and ZBW002.

The planner on duty had worked with MIT LL and the TFI tool since it was first introduced at ATCSCC. He is considered a “super-user” at this particular facility, having been involved with many Lincoln decision support products dating back to CIWS and Route Availability Planning Tool (RAPT) in early 2002. He was also aware that TFI often underestimated the permeability impact during severe weather events. After review of the current forecast information along with the NAM and several other operational personnel, the decision was made to plan and publish AFPs OB1 and A08 by 1330 UTC.

Both AFPs were planned to begin at 1700 UTC. The planner along with severe weather managers reviewed CoSPA and TFI plots at 1720 UTC just after the AFPs were initiated. This can be seen in the snapshot taken at the severe weather-planner situation display in Figure 21. ATCSCC operations personnel wanted to confirm that the forecast of timing and intensity had not changed significantly.

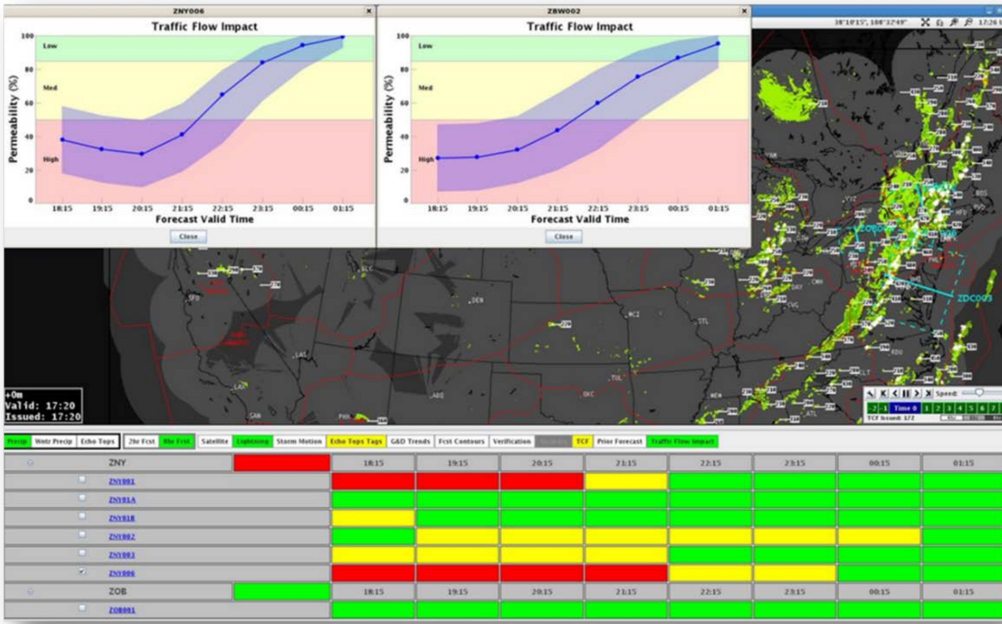

Figure 21. Image taken from the ATCSCC National Operations Manager display at 1720 UTC. Display shows CoSPA VIL, TFI timeline for ZNY and ZOB, as well as plots of permeability for ZNY006 and ZBW002.

4.2.2 Improved Ground Delay Program Execution/Management (02 August 2017)

Severe weather observations by MIT LL always include at least one AOC. TMI planning is performed in a collaborative environment and customer participation is encouraged by the FAA. An example of this collaboration occurred on 2 August 2017, one day prior to the MIT LL observation. However, an MIT LL observer for this particular airline had arrived one day early to perform training and was present in the AOC.

One of the airline sector managers who quarterbacked the operations on this particular SWAP day shared commentary and opinion at the end of the day. Figure 22 provides one example of the CoSPA forecast used on this day by those in charge of airline operations. The 5-hr forecast illustration and accompanying truth at 1700 UTC demonstrates the accuracy of CoSPA in placement, coverage, and intensity of the developing storms. The placement of the storms near and within the N90 region and the scattered nature presents challenging demand issues for airline and FAA managers. The fact that the forecast also indicated direct terminal impact within N90 constituted discussions for GDPs at all three NY terminals. This particular airline advocated for specific rates and start time of the GDP based on a series of CoSPA forecasts over several hours on this morning. The manager also noted that CoSPA in past years has had significant trouble with scattered or "popcorn" thunderstorms, however, he had been watching and verifying the forecast much of the summer leading up to this day. He had observed improvement in this type of disorganized convection and was willing to take a "leap of faith" on this forecast to champion use of moderate GDPs. He declared, "I know it's (CoSPA) not always perfect and I am actually surprised that it did so well yesterday with air mass development. I don't have any data to support this but as I have been watching this summer the tool has been performing pretty well."

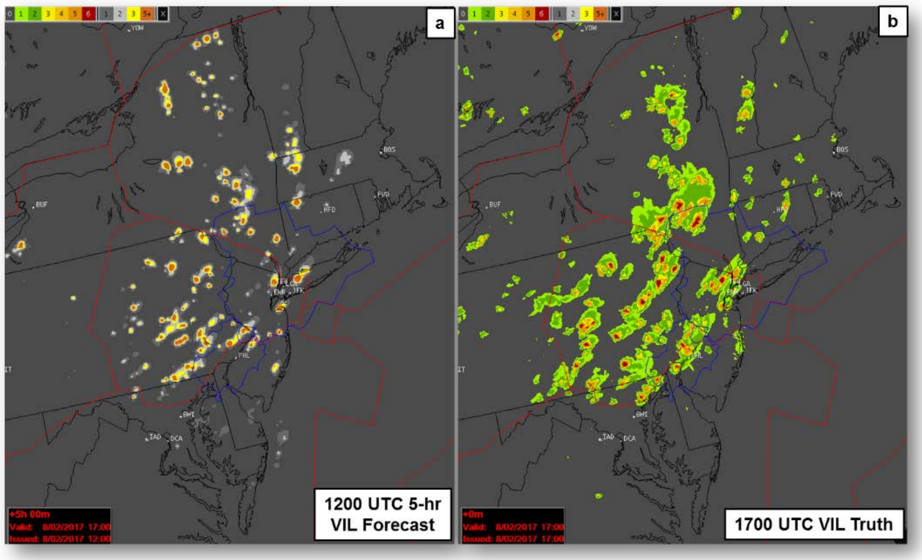

Figure 22. The (a) 5-hr CoSPA VIL forecast issued at 1200 UTC along with (b) the corresponding VIL truth at 1700 UTC on 2 August 2017.

The use of CoSPA by the airline AOC was two-fold on this day. The manager shared that the CoSPA forecast was also used to plan the end of the GDP. He stated that if a GDP is extended beyond the end of thunderstorm activity, capacity in the system is lost and therefore demand at the terminals "dries up" and is lost. Therefore, it is critical to estimate an accurate ending to the GDP and begin to raise rates. One must remember that during a GDP flights are held on the ground at surrounding airports and it could take as much as 45 min to 3 hours before the demand at those airports can reach the destination terminals. Accordingly, it becomes crucial to determine the decay of thunderstorm activity.

The CoSPA VIL forecast and truth snapshots in Figure 23 are several of the exact forecast times the AOC examined late in the day to propose ending the GDP to command center early on 2 August. The manager stated to the MIT LL observer "The guys on SPT last night were advocating with the FAA starting at 23 UTC to start raising arrival rates based on diminishing thunderstorms supported by CoSPA. Very good call. This would have gotten out of a lot of delay we were still experiencing in the GDP, a 20 rate at 00 UTC, and 24 rate at 01 UTC. GDP canceled at 0144 UTC with no revision beforehand."

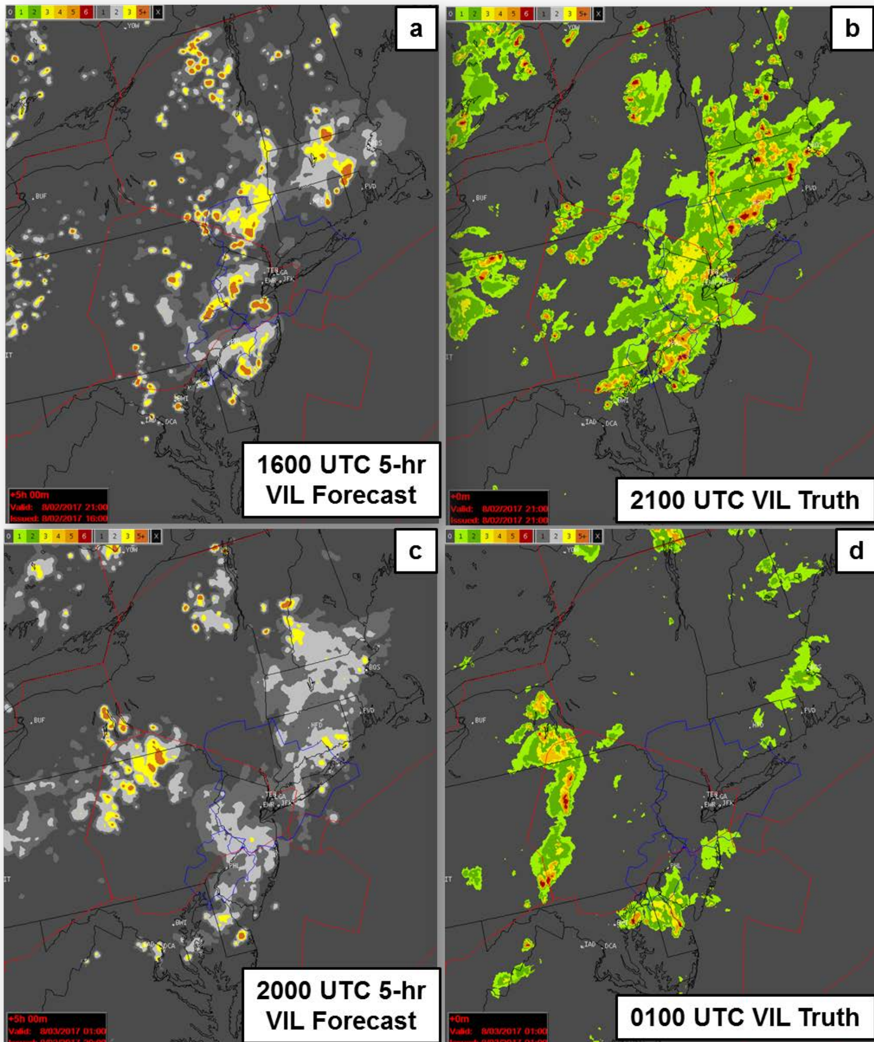

Figure 23. The (a) 1600 UTC 5-hr CoSPA VIL forecast, (b) 2100 UTC VIL truth, (c) the 2000 UTC 5-hr CoSPA VIL forecast, and (d) 0100 UTC VIL truth on 2 and 3 August 2017.

5. USER COMMENTS AND WEB USAGE ANALYTICS

5.1 USER COMMENTS

User comments concerning CoSPA and TFI products were recorded for further analysis. The comments documented during the 2017 season are provided in TABLE 5. Some of the comments indicate a general misunderstanding of the TFI product. Users tend to think that the level of impact should coincide with whether or not particular routes are open or closed, rather than provide guidance for setting AFP rates. More training is required to overcome these misconceptions. Some users feel the TFI forecast is not sufficiently accurate for making decisions.

TABLE 5

User Comments Documented During Field Observations

Facility	User Comment
FAA ATM	User comment: OMIC feels the TFI colors (Low, Medium, High impact) are too optimistic and that pilots will refuse to fly through areas TFI flags as yellow.
Stakeholder	TFI has been green all day and the stakeholder notes that TFI is not capturing the weather situation well; J48/J75 will be impacted but are not in the FCA. This will cause problems for ZDC.
Stakeholder	The user said that TFI is too conservative; showing green all day but routes have been closed. The observer explained that TFI is for AFP guidance and shows that no AFPs were needed.
FAA ATM	The observer discussed TFI with the NOM who thinks TFI is too "linear" and not forward thinking; the forecast seem to be only "keeping up." He commented that TFI plans the way it has always been done, "stuck in the past." He believes TFI is on the right track with non-traditional AFP boundaries, but that the FCAs need to be more dynamic.
Stakeholder	A stakeholder user commented to the observer that CoSPA was a great planning tool.
FAA ATM	The STMC, discussing CoSPA, says he prefers CIWS/CoSPA to WARP. CoSPA has better echo tops filter options, overlays, and pan/zoom.
FAA ATM	The observer discussed TFI with the STMC, who insists it is useless for ZNY. For the STMC to plan based on TFI, the TFI forecasts must be *exact* in location and timing. He *will not* reduce traffic or close an airway based on a weather forecast. Only after weather develops and pilots refuse to fly will he close anything. Doing otherwise would be inefficient and incur the wrath of airlines. Forecasts must tell him with certainty which airways will close and when.
FAA ATM	The STMC said that combining all of the routes that are captured in ZNY001A and ZNY001B, only about 5% of normal traffic is on the routes, but TFI shows 95% permeability. The 23 UTC TFI permeability plot shows 45–50% permeability. So traffic is more restricted than TFI would indicate.

5.2 USER REQUESTS

Observers documented user requests for changes or additions to the CoSPA and TFI product suite; these are provided in Table 6. Two users discussed the need for a better forecast of winds; which directly affects airport capacity. Another user requested detailed case studies of TFI.

TABLE 6

User Requests Documented During Field Observations

Facility	User Comment
FAA ATM	One TMC provided unsolicited comments concerning winds reports and forecasts. Winds forecasts are "terrible and always wrong". Winds at EWR are typically 30 degrees off in direction. ATIS winds do not match other wind reports. The wind sensor for EWR is near a turnpike and is impacted by traffic. This user wants improved winds forecasts and wants the EWR sensor "fixed."
FAA ATM	There was a request for TCF to be available on CoSPA earlier. (Slow update?)
FAA ATM	The observer provided training on OPC to the CWSU and reviewed TFI. The user liked OPC but was not convinced he would use it very much. This user requested a BOS sector for Prior Forecast that would include more of Maine, Nova Scotia, and Canada north of NY state and New England. This would be helpful for CAN routes.
FAA ATM	Requested detailed TFI case studies
Stakeholder	A dispatcher told the observer that he used CoSPA today for flight planning and asked if the forecast will be extended to 12 hours. The ATC suggested that CoSPA integrate current reroutes.
Stakeholder	The user does not want to access OPC from another website and asks that OPC be integrated on the CIWS/CoSPA SD.
Stakeholder	Stakeholder user asked (during training of TFI) if FCA labels could be changed to something more meaningful.
FAA ATM	The observer trained a data specialist on the use of REPEAT. This user suggest the following changes to REPEAT: show echo tops tags, aircraft colors should be configurable, add jet ways (very important), add the ability to customize the aircraft plots and change the tail to 5-10-15 minutes.
FAA ATM	The Area Supervisor expressed the need for an accurate winds forecast. Today's forecast was not accurate and EWR is now looking at a GS/GDP situation. The Area Manager uses ITWS Terminal Winds to manage compression on final and believes they are accurate.
Stakeholder	The users want TFI to provide route closure guidance in some way.
FAA ATM	The observer helped the STMC with the CoSPA display, demonstrating some products. The STMC would like an echo tops tags-like display on echo tops forecast.
FAA ATM	The user believes that TFI is on the right track with non-traditional AFP boundaries, but that the FCAs need to be more dynamic.

5.3 WEBSITE USER ANALYTICS

Prior to 16 May 2016, users logged into the website via a shared account system, allowing multiple users at the same facility, airline, and institution to log in with the same username/password. Security concerns forced MIT LL to eliminate the "shared account" access and institute unique login access for each individual user; the same login credentials are used to access either CIWS or CoSPA websites. In addition to increasing security, this allowed MIT LL to provide better service to users by contacting them directly. It also provided MIT LL with an opportunity to study how users made use of the websites.

Many CIWS and CoSPA users, even those with dedicated SDs, access the products via the websites. In order to better understand how the websites are used, and to potentially improve users' experiences with the websites, a new tracking software module was developed that collects website usage statistics. In particular, the module tracks each user session, from the initial login, through product selection and forecast state changes, to the end of the session (logout or browser close). This methodology allows for fine-grained statistics of when users performed certain actions. For example, it is now possible to develop statistics on the average number of users who use the *Echo Top Tags* product at 12:30 PM every Tuesday.

The goal of the module is to collect data to measure how CoSPA and CIWS are used over time; to record when products are used, and for which weather conditions and time of day. It is of particular interest to determine whether the products and display options are used differently during convective events versus e.g., winter weather events. In addition, more traditional web metrics, such as daily number of visitors (users), time spent using the tools, level of user engagement in (or interaction with) the tools, and the rate of adoption by new users, can be computed.

As comprehensive as these metrics are, however, they come with important caveats.

- These metrics represent **website usage only**; some FAA facilities and airline dispatch centers have dedicated SDs and SD usage is not tracked. While users with a dedicated SD may also use the website, it is likely that they access the website less often than users without an SD. In addition, website access at many FAA facilities is limited to a few computers that are often used for other required tasks. This further reduces website usage at these facilities.
- Users may log in to the websites for personal use from any computer or mobile device, even when they are not on-position. This personal use cannot be separated from work-related use in the data.
- Great care must be taken when attempting to correlate user-interaction with the display with actual use of the products. Users often design a display configuration that allows them to simply glance at the display to access the information they need; reducing the need to interact with the display further. So, interacting with the display is not the same as "using" the products. However, when such interactions happen, they are likely to support a specific need.

Website usage was analyzed for the entire 2017 Convective Season, and focused analyses of the four field observation days was conducted; only 3 August 2017 is discussed here.

5.3.1 Convective Season

Usage data are analyzed from 6 June 2017 (when the software was deployed) through 31 October 2017 (defined here as the end of the convective season); a total of 148 days. During that period, CoSPA was used by 2642 different users, from 189 different groups (e.g., individual airlines, various air traffic control facilities, research entities, etc.); CIWS was used by 1144 different users from 195 different groups; some users are represented in both counts. On average, 590 individual users per day logged into CoSPA and 125 individual users per day logged into CIWS. Figure 24 shows this breakdown of users.

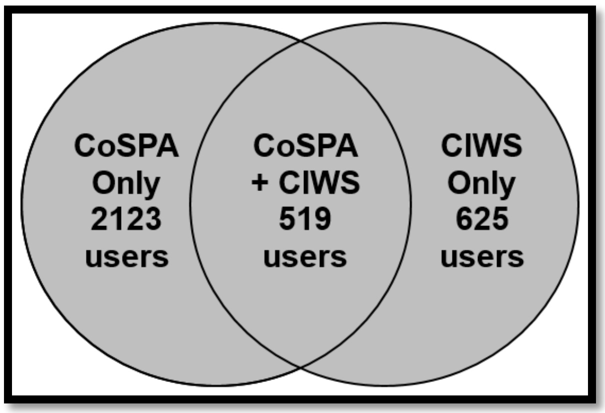

Figure 24. Breakdown of unique users who accessed the CoSPA website only, the CIWS website only, and both.

At the beginning of the study period (6 June), there were 3825 registered website users; by 31 October 2017 there were 4168, with new accounts being added daily. Seventy-eight percent of 4168 registered users logged into CoSPA and/or CIWS websites at least once between 6 June and 31 October 2017.

Airline users account for over 90% of all registered web users. Figure 25 shows the top fifteen organizations whose individual users logged into the CIWS/CoSPA websites at least once between 6 June 2017 and 31 October 2017. Very few airlines have dedicated SDs; their only access to the products is via the websites. However, two of the top three organizations in Figure 25 do have access to dedicated displays, yet they have a large number of website users. Over the 148-day period, an average of 202 users were simultaneously logged onto the websites, with the maximum number of 347 at 2050 UTC on 3 August 2017.

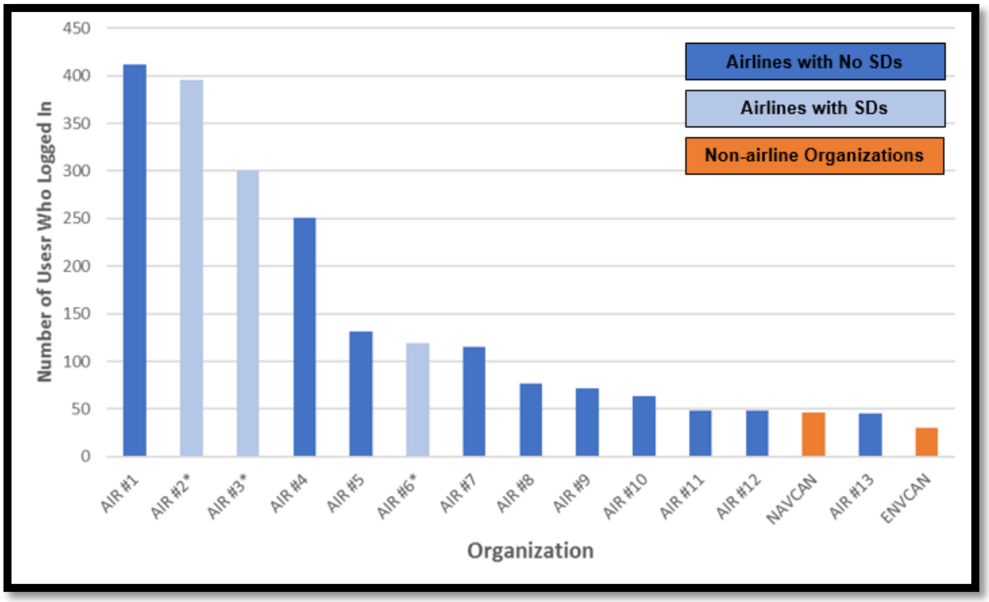

Figure 25. Top 15 organizations whose website users logged in between 6 June 2017 and 31 October 2017.

Figure 26 shows the base products displayed by website users. In general, most users prefer to display Precip base product to Echo Tops. The decrease in number of users after 00 UTC (8 PM Eastern) coincides with the decrease in air traffic demand through the night. The slight dip in usage between 1730 and 1930 UTC presumably coincides with shift changes. Figure 26 shows that Winter Precip is little used; primarily because these data are from the summer months. From this point forward, Winter Precip will not be included in further analyses.

Figure 27 compares usage of the two base products, Precip and Echo Tops (solid lines), and their associated forecasts (dashed lines) throughout the day. In general, Precip is viewed more than three times more often Echo Tops, while Precip Forecast is viewed nearly five times more often than Echo Tops forecast. Observers have noted during field observations that users generally prefer the Echo Tops Tags product over the Echo Tops base product, which can be overlaid on the Precip product.

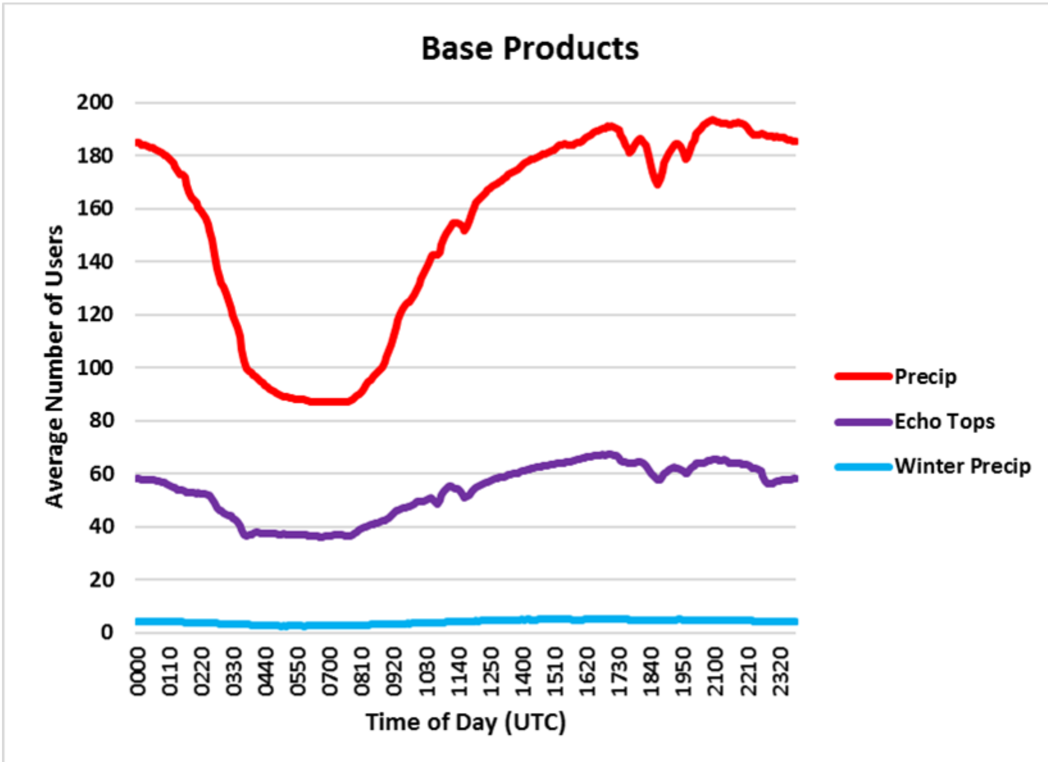

Figure 26. Average number of users of base products (Precip, Echo Tops, and Winter Precip).

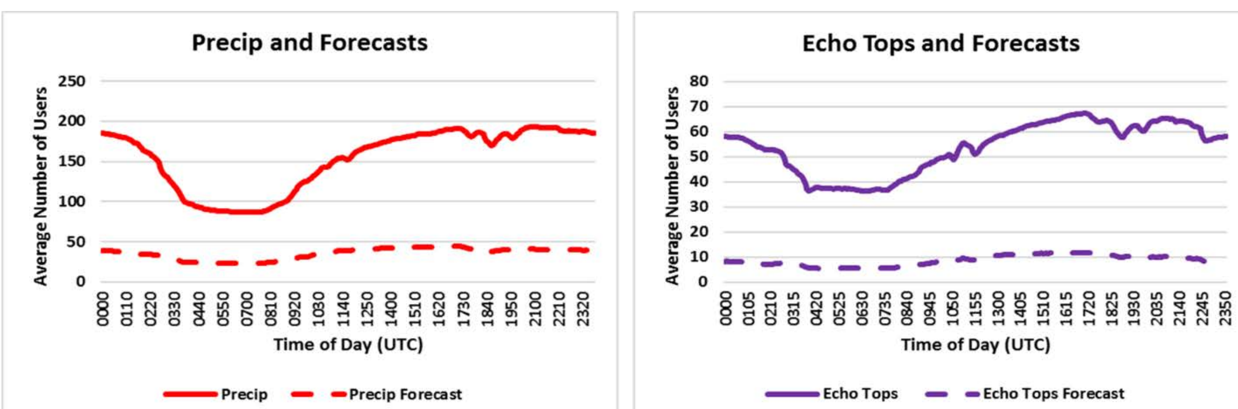

Figure 27. Comparison of usage of Precip vs. Precip Forecasts and Echo Tops vs. Echo Tops Forecasts.

Figure 28 provides a comparison of product usage as a function of time of day. Winter products are not included in this analysis. In addition, products used less often than Echo Tops Forecast (dashed purple) were deemed to have been used too infrequently to be included in the analysis. The order of product usage for the remaining products, from most used to least, is:

1. Precip
2. Echo Tops Tags
3. Satellite
4. Lightning
5. Storm Motion
6. TCF
7. Echo Tops
8. Growth and Decay Trends, which is nearly tied with…
9. Precip Forecast
10. Echo Tops Forecast

This analysis includes all 148 days in the analysis period regardless of the significance of weather impact.

Figure 29 illustrates product usage as a function of time of day for 3 August 2017, a day of significant weather impact. Product usage patterns follow average use as described above. TFI was added to demonstrate its use on a weather-impacted day.

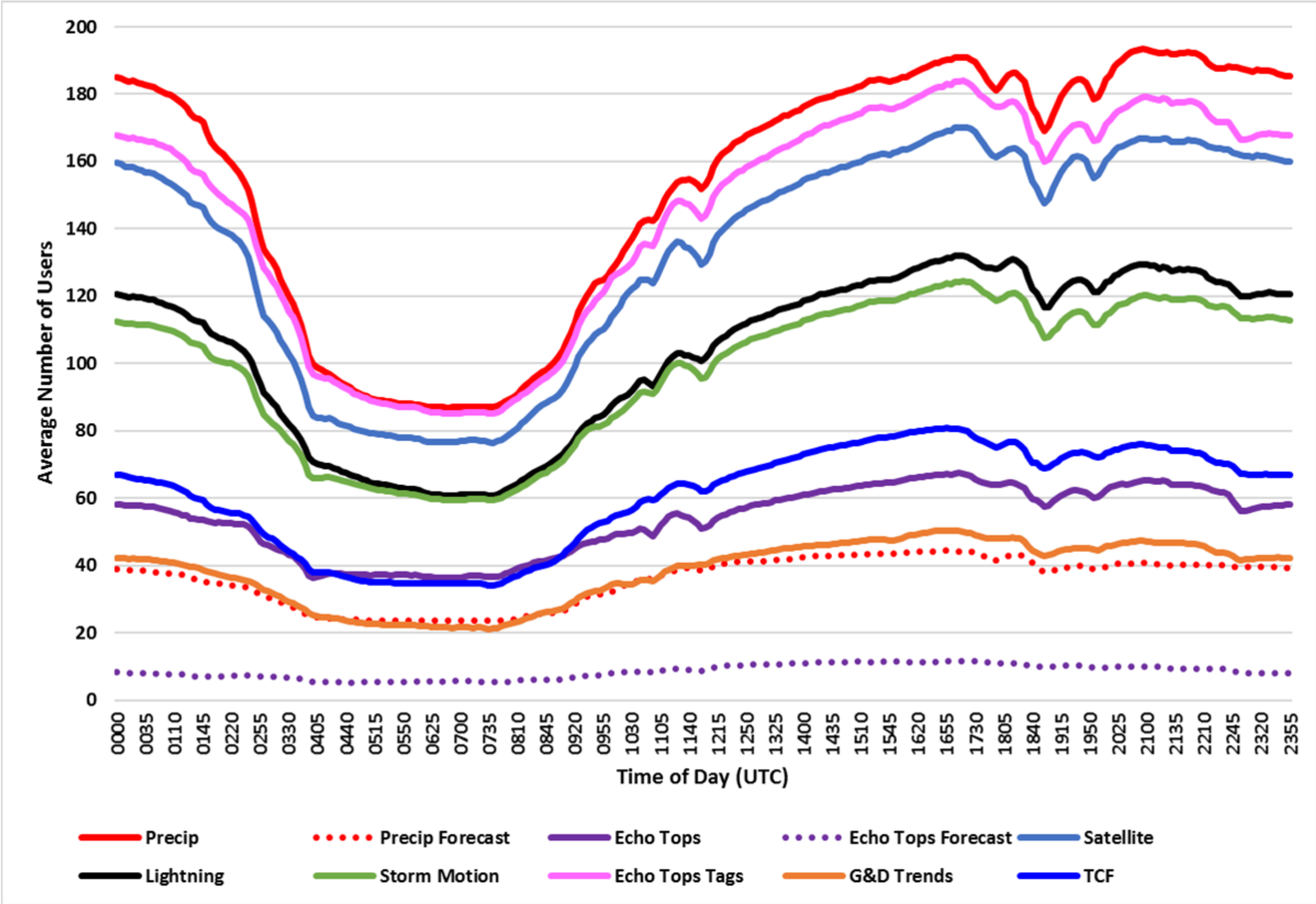

Figure 28. Comparison of product usage as a function of time of day averaged over all 148 days.

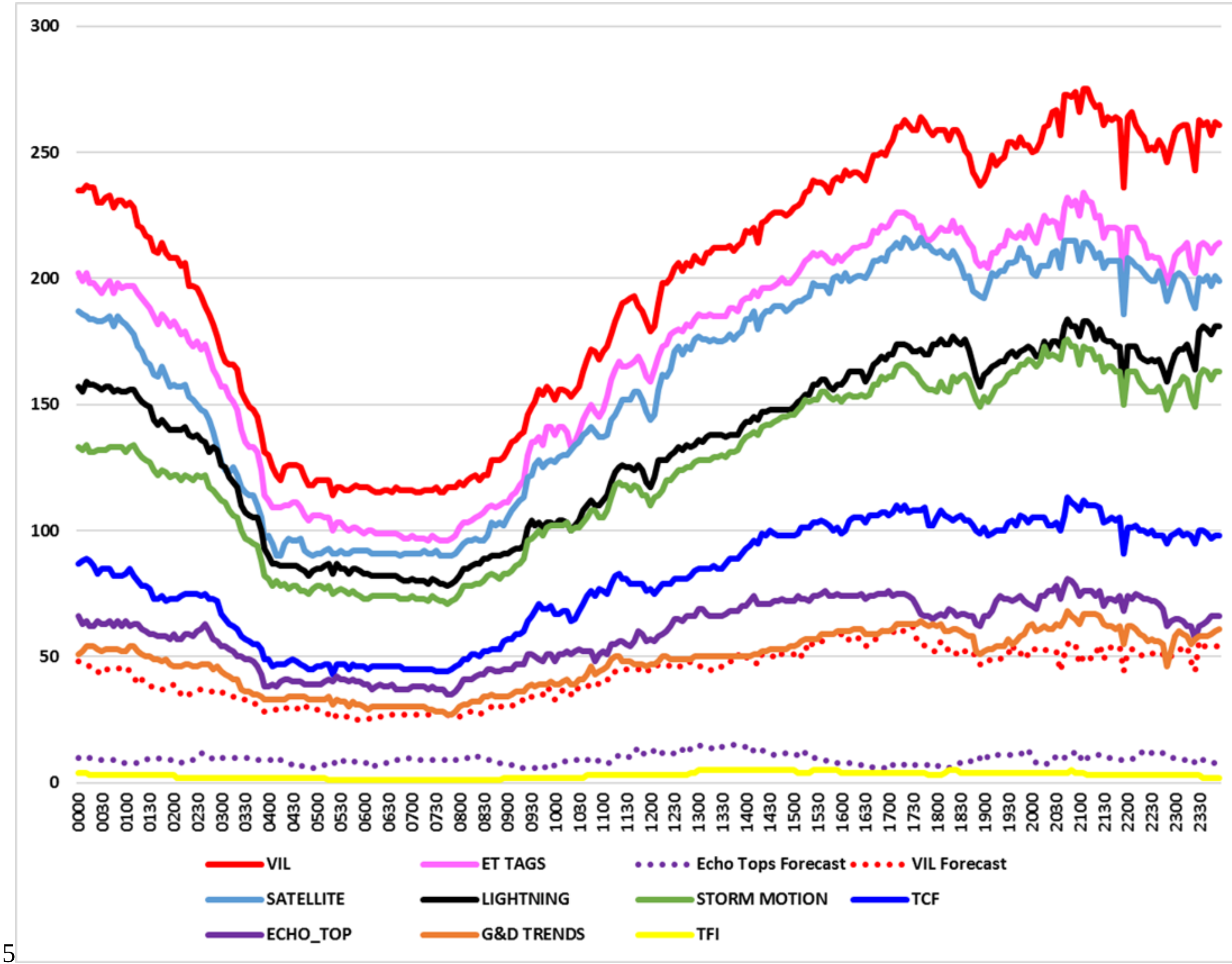

Figure 29. Comparison of product usage as a function of time of day for 3 August 2017.

5.3.2 User Browsers and Operating Systems

It is useful for MIT LL to track the browsers and operating systems being used in order to provide compatible software and better support. In some cases, users are actively encouraged to change browsers for a better experience. In particular, the CIWS and CoSPA websites do not work well with Internet Explorer, due to compatibility issues with the underlying framework. Many users are able to switch to Google Chrome or Mozilla Firefox, but nearly 19% of users still log on from Internet Explorer, and may experience problems.

More than 95% of users use Windows, a small number use a Linux variant, and just over one percent use a mobile platform to access CIWS/CoSPA. Low usage by mobile users is likely due to the inherent incompatibility of touchscreen devices with the web applications. Many users have requested a mobile capability for these applications and MIT LL hopes to develop this in the future.

Figure 30 provides a breakdown of browsers and operating systems used by CIWS/CoSPA website users.

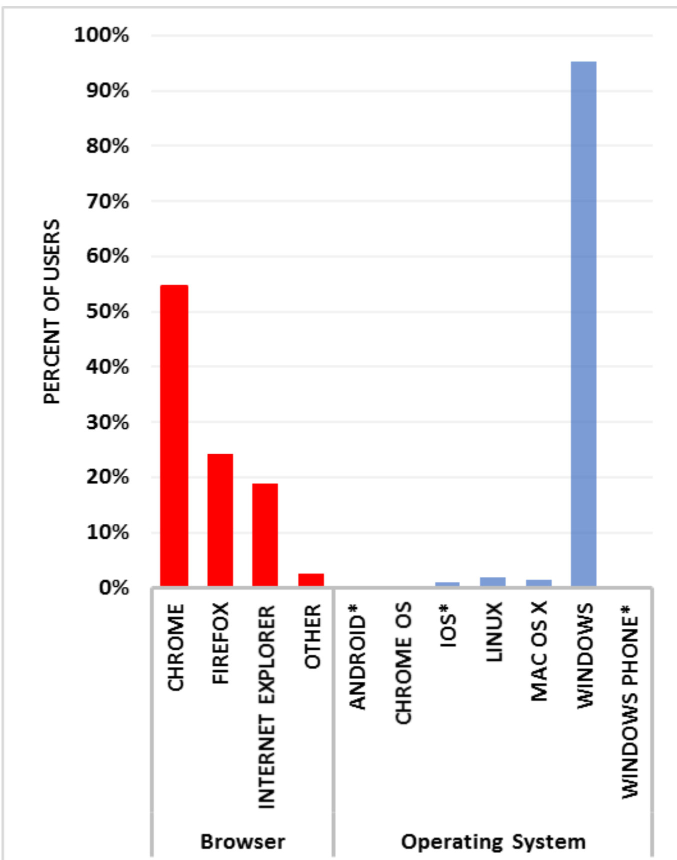

Figure 30. Analysis of user browser and operation system.

6. SUMMARY

The CoSPA 8-hr deterministic forecast has been fielded in FAA ATFM operations for nine consecutive summers and the translational decision support tool, TFI, for the previous four years. The most recent MIT LL operational observation was in place from 6 June to 31 October 2017 with three observation periods performed over four separate days. Six MIT LL observers collected nearly 190 person-hours of operational observations across four FAA ARTCCs, one (1) TRACON, the ATCSCC, and two (2) different airlines. CoSPA was available on dedicated SDs and accessible through the web. The 8-hr TFI product was available on the SD while a 12-hr research version of TFI was also available on CoSPA web. Observers gathered information on how the CoSPA weather forecast was used in operations, obtained feedback on the newest TFI capability, performed in-situ training and collected comments and suggestions for improvement of both decision support applications.

Three key CoSPA forecast deficiencies were evident and recurred during the 2017 observations:

- CoSPA forecasts convective initiation later than the actual onset.
- CoSPA under-forecasts VIL intensities.
- CoSPA under-forecasts Echo Top heights.

However, the VIL bias measured in 2017 was improved over the previous SWAP season. The echo tops under forecast bias appeared to increase in the northeast and mid-Atlantic regions. The TFI application guidance mimicked CoSPA's ability to more accurately predict large-scale events. Small scale and low areal coverage thunderstorm events challenged the TFI application to correctly translate convective activity into ATC impact across the northeast.

Observers documented 114 instances when CoSPA and/or TFI were used operationally, with 43 attributed to TFI. The most common use was for situational awareness. There were 82 observations of General Situational Awareness (SA and SA-TFI, 51 and 31 respectively) and 21 observations of support for AFP go/no-go decisions (1 for AFP and 11 for TFI-AFP). Specifically in the 6- to 8-hour period, TFI was observed to improve AFP execution management during the planning phase of SWAP. Improved GDP management and execution was also observed in the medium range (3- to 5-hour) because planners utilized the translational guidance built into TFI.

The presence of forecast confidence in TFI was one factor that encouraged planners to use the decision support tool in both AFP and GDP planning. However, users find the confidence bound shading display not easily understandable. There have been requests to further develop the confidence display and present possible variations for evaluation during 2018. Users also requested that detailed case studies should be released during the season for post analysis evaluation in order to augment PERTI day-of planning and to drive future TFI improvements. Users would also like TFI to provide route closure guidance, possibly in the form of AFP rates along with the permeability. It was also requested, for a third time, that current operational AFP regions be added to TFI. It was proposed that the CoSPA forecast be extended to 12 hours, matching the web version of TFI. Previously, this request could not be met due to CoSPA's reliance on the 0–8hr HRRR model and blending from NCAR [xiii]. However, the operational HRRR model now produces an 18-hour forecast that could be utilized to extend the current 8-hour VIL and ET products. Users would also like the Offshore Precipitation Capability (OPC) to be accessible from the CoSPA website. Finally, there were several requests to add current wind direction and speed information to the CoSPA plot.

Web usage analytics were greatly expanded during the 2017 season. CoSPA was used by 2642 individual users, from 189 different groups and on average, 590 unique users logged into CoSPA throughout a day. In total, throughout the season, 3267 of the 4168 registered users (as of Oct 31, 2017) logged into CoSPA/CIWS, and airlines made up over 90% of the web users. The top three most-used products were Precip, Echo Top Tags, and Satellite. The desire is for future user statistics to help target training and thus improve application usage within air traffic flow management.

The Northeast Corridor directive was set in motion by the NAC to focus on improved strategic convective weather decision support, with focus on the New York trio of EWR, JFK, and LGA. Weather has accounted for 60–70% of all delay in this region for more than fifteen years and yet little common ground exists upon which TMI discussions about the best plan of action should be taken. There is a need to define explicit, validated weather translations that provide an objective and operationally relevant measure of truth against which forecasts can be compared. There is also an urgent need to reconsider the guidelines for AFP throughput reductions in the operational concept for setting FCA throughputs. However, air traffic managers and planners have made it clear that convective weather forecasts must be accompanied by a measure of accuracy predictions (confidence) in order to lower the risk of TMI decisions made during SWAP events. The combination of the CoSPA convective forecast and the Decision Support Tool (DST) found in TFI begin to address the goal set forth by the NAC. CoSPA provides the deterministic outlook while TFI adds the ATFM translation of weather to impact with a measure of confidence to reduce risk during TMI planning.

6.1 FUTURE WORK

Several of the user requests that were documented during the 2017 convective season were recurring from previous observations in 2015 and 2016. Enabling rapid assessment with extensive user interaction has been the key in successful prototype development and release within Group 43. This past year has added another season of convective weather observations and ETMS flights tracks of hundreds of thousands of planes to the case study research events database. These post-analysis results will be added to the previous three years of observations in the training database set used in the TFI algorithm. Additional prioritized areas for future work should include:

1. Addition of AFP rating scale to accompany permeability on TFI plots
2. Additional TFI FCA areas that match traditional AFP regions
3. Expand TFI FCA regions to include ZTL, ZID, and ZAU
4. Prototype new TFI confidence bounding for evaluation

5. Addition of OPC and wind direction and speed to the CoSPA application
6. Expand CoSPA convective forecast to 12 hours

The addition of specific AFP rates to the TFI “drill-down” plots has been explored in previous observation years. Users suggested that these rates would appear on the TFI graph along with the measure of permeability and would vary based on each specific TFI region. Research of enroute density and controller workload would contribute to the development of these rates. A follow-on operational observation would then be requested once these proposed developments have been appraised and implemented.

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APPENDIX A
FIELD OBSERVATIONS DURING WHICH BENEFITS WERE DOCUMENTED

19 JUNE 2017

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1030	ZOB	Yes	TFI training was conducted and the STMC left the display of TFI timeline and ZNY001 open all day. OB1 will begin at 17 UTC with a high impact rate. OB1 is good if weather is east of DTW.		SA-TFI
1112	N90	Yes	The observer trained the OMIC, STMC, and TMC. They were impressed that TFI was red at 18Z, which agrees with what they were briefed during the morning briefing.		SA-TFI
1315	N90	No	SPT: SWAP declared at 1250Z; STMC thinks this is too early and the JFK rate is set too low. The STMC displayed TFI timelines and noted red at 1815 UTC for ZNY006.		SA-TFI
1315	ZOB	No	TFI impact intensity is less than before the forecast updated. The STMC is monitoring ZNY001.		SA-TFI
1515	N90	No	The observer provided access to OPC to an analyst. The TMO uses CoSPA and TFI for situational awareness and was provided with a quick reference card. Another TMC is preparing for the next SPT.	SA	SA-TFI
1515	ZOB	No	TFI ZNY001 window is displayed throughout the day; appears to under-forecast the impact.		SA-TFI
2038	N90	Yes	A level 6 cell is overhead EWR. The observer was asked if there will be weather behind the main line of cells. The observer showed the users the CoSPA forecast which clearly indicates convection building in Central PA/NY for several more hours.	SA	
2134	N90	No	The STMC used CoSPA to familiarize himself following a break.	SA	
2303	N90	No	CoSPA is used to assess impacts on CAN routes and to coordinate with a co-worker. The STMC uses the CoSPA loop and states that MERIT and GREKI may open soon. He is coordinating and cancelling stops.	SA, COOR, ERP, SA-T	

27 JULY 2017

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1015	DAL	No	Enroute ATC position consulted HRRR and CoSPA for situational awareness. ATC states it would be good to keep open the northern airspace and CAN routes today. The ATC designed an FEA for the SEA-BOS route to support A05 operations. This provides him with a slot to use.	SA	
1045	DAL	No	CoSPA is displayed at three ATC desks. There is a GDP for ORD due to thunderstorms.	SA	
1045	ATCSCC	No	Planner used CoSPA 8-hr VIL forecast for situational awareness. He quickly viewed TFI overview for any significant impacts. Regions were filtered to show impact regions only.	SA	SA-TFI
1047	N90	No	CoSPA is displayed at both positions. The TMU is not expecting GDPs today; RBV offloads are expected and SWAP.	SA	
1100	DAL	No	Stakeholder internal briefing: Some thunderstorms are expected in the Northeast. Meteorologist used CoSPA for the briefing.	SA	
1100	ATCSCC	No	CIWS was displayed in the area where NY traffic is being planned. CoSPA/TFI is displayed in SvrWx with focus on ORD and ZOB. NAM uses CoSPA for situational awareness and REPEAT for the NWS review. The Planner is viewing CoSPA 8-hr VIL forecast across the CONUS with TFI filtered.	SA	SA-TFI
1115	ZBW	No	The STMC and TMU SDs displayed CoSPA VIL, satellite, lightning, and echo tops tags. The users noted the location of the precip. East and west CAN routes have been issued. There is some concern that wet runways in the afternoon will stop LAHSO.	SA	
1115	N90	No	SPT: The STMC used CoSPA looping forecasts for situational awareness throughout the SPT.	SA	
1115	ATCSCC	No	SPT: CoSPA VIL is displayed and looping at the Planner position; lightning, storm motion, and VIL. Most facilities do not anticipate the need for AFPs; reroutes should be sufficient.	SA	
1200	ZBW	No	CoSPA is displayed on the CWSU. The meteorologist said CoSPA was the "standard" now and that the TMU was used to it now.	SA	
1200	ZOB	No	ATCSCC called STMC to coordinate two eastbound CAN routes and JOT routes. STMC used CoSPA for situational awareness during the call.	SA	

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1223	ZOB	No	The STMC is concerned. The CoSPA 8-hr forecast shows weather impact on the ZID/ZOB/ZDC region. They are taking DC landing traffic (eastbound) north of the weather and through ZOB and it will go through this region. If the forecast verifies, there will be problems with the route.	SA	
1224	ATCSCC	yes	The observer discussed TFI with the ATCSCC manager for AFP planning.		SA-TFI
1315	ATCSCC	No	SPT: CoSPA was used to view potential impacts to J80/J75 through ZID. AFPs are not expected today. N90 does not expect significant impact.	SA	
1435	ZOB	No	ATCSCC called to ask about moving traffic off J6 onto J80. ZOB said to ask ZID because there is weather on J80. ZOB does not want to get shut off by ZID. ZID says no. The coordinator used CoSPA forecast to see J80 impact (ET, Precip, Precip forecast).	SA, ERP, SA-R	
1449	DAL	Yes	A dispatcher told the observer that he used CoSPA today for flight planning and asked if the forecast will be extended to 12 hours. The ATC suggested that CoSPA integrate current reroutes.	SA, ERP	
1450	ATCSCC	No	The observer trained the TMC on TFI. The Senior specialist is considering an AFP to guard against the loss of a key transition route (J34) into DC metro. CoSPA/TFI changes from hour to hour, indicating a low-confidence forecast. TFI is used to evaluate ZOB003 between 19 UTC and 21 UTC.		SA-TFI, TFI-AFP
1515	ATCSCC	No	The Planner is using CoSPA for situational awareness. No westbound CAN routes are planned.	SA	
1515	ZDC	Yes	SPT: PHL needs a GS. TFI was used for situational awareness and training was provided.		SA-TFI
1515	DAL	No	SPT: There are no CAN routes available today so NY will depart whatever way they can. ARs are open and their use is encouraged. A user noticed that CoSPA showed weather inland while the ARs look good for several hours. He sent a message to dispatchers to encourage use of the ARs.	SA, ERP, SA-R	
1518	ZOB	No	The STMC uses 8-hr forecast of ET to assess ZOB/ZID/ZDC area for DC met arrivals. He is concerned about development beyond 8-hr forecast. The CWSU briefed the STMC about impact on NY met airports; says southern "tail" of the line of weather moving through ZBW may impact the NY airports around 23 UTC and DC metros around 01 UTC. CoSPA and TCF do not show this impact.	SA-R	

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1605	ATCSCC	No	The observer discussed the need for AFP for J34 with the Planner. The use of TFI/CoSPA and Prior Forecast has given the planner enough confidence to say there will be no AFPs.	SA, AFP	TFI-AFP. TFI-SA
1715	ATCSCC	No	The Planner used CoSPA during the SPT for situational awareness.	SA	
1802	DAL	No	The stakeholder used CoSPA to assess the routes from Florida to the Northeast. The concern is that if aircraft fuel for a route but then receive a short cut, they will have too much fuel and will land heavy.	SA-R	
1903	DAL	No	TFI has been green all day and the stakeholder notes that TFI is not capturing the weather situation well; J48/J75 will be impacted but are not in the FCA. This will cause problems for ZDC.		SA-TFI
1915	ATCSCC	No	The planner uses CIWS/CoSPA for situational awareness prior to SPT and then references CIWS during terminal portion of plan. CoSPA is used during routes portion of plan in reference to OH valley/western VA storms	SA, SA-R	

03 AUGUST 2017

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1045	ZOB	yes	The observer displayed TFI on the display adjacent to the STMC desk to encourage use throughout the day. At this time there was no significant weather in the east and TFI timelines were all green for 8 hours. The STMC display shows CoSPA echo tops and echo tops forecast, lightning, and ET tags. TCF shows weather at 8-hr in Canada and northern ZOB. TCF on the TSD has low confidence, sparse coverage in ZAU. It appears that the TCF forecast is available on the TSD before it is "published"	SA	

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1303	ZDC	No	When the observer arrived, TFI was displayed on the STMC SD. Most ARs are closed due to off-shore storms. Three SWAP routes have been issued for LAX, LAS, and PHL. TCF forecasts weather west of NYC at 21 UTC.		SA-TFI
1315	ATCSCC	No	SPT: The Planner examines TFI; TFI impacts are not sufficiently severe (yellow/red for extended periods) to support AFPs. Due to the scattered nature of the storms, AFPs appear to be off the table at this time.		SA-TFI,TFI-AFP
1315	ZDC	yes	SPT- Storms are expected in the Gulf all day today. AFPs A01 and A02 are being considered for today. The ZDC STMC requested A08. The observer displayed ZDC001 on TFI for the STMC, who commented that ZDC001 covers Boston traffic (routes) in ZDC. N90 is expecting storms around 19 UTC (as CoSPA shows). JFK runways 4R/22L are closed. One stakeholder asks for AFPs; another wants to discuss them. The ZDC STMC wants an earlier implementation of AFP than was proposed by SCC. This STMC told the observer that AFPs should have been put in place earlier and described the balancing act needed to get the correct timing in place.		SA-TFI
1345	ATCSCC	No	Planners use CoSPA for situational awareness.	SA	
1419	ZDC	Yes	GDPs at N90 airports for later in the day. The STMC ask why no ZDC TFI impact, based on forecast. The observer reviewed the TFI charts, showing that the forecast is currently showing low impact but not "yellow" impact yet. CoSPA shows scattered storms across ZOB by 20 UTC. The STMC discussed AFP's start time of 19 UTC; ZOB wants OB1, ZDC requested A08. The STMC says the 1115 UTC SPT is most important of the day for planning and the forecast at that time needs to be right. A SWAP statement was issued during the AFP discussion. A08 is being modeled after 19 UTC.	SA	SA-TFI

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1515	ATCSCC	No	SPT: CoSPA is displayed at the NOM position looping echo tops. The NOM used TFI to evaluate ZOB airspace. C90 references CIWS/CoSPA. N90 feels the sparse coverage forecasted by TCF supports pushing GDPs start times out to 19 UTC to 20 UTC; EWR rates 36 down to 34-32, LGA 34 down to 32/30, JFK 42 down to 36/38. The SvrWx SDs are display CoSPA VIL. The Terminal NTMO is assessing the 2- to 8-hr forecasts with TCF. ZDC wants AFPs and ATCSCC is considering A01/A02. Stakeholders support GDPs but not AFPs. A CAN East route is available, along with the MGM3 and SERMN north and south routes.	SA	SA-TFI
1515	ZDC	No	SPT: CAN routes are available. AFPs were only under consideration because CAN routes were not available, so AFPs are no longer being considered. ATCSCC is expecting sparse coverage and storms growing through 23 UTC and later. TFI shows yellow impacts on ZOB001 and ZOB002. All ZDC timelines are green. GDPs are planned for EWR and LGA with 32 and 30 rate, respectively. N90 expects the SWAP start time to be pushed back. ATCSCC mentions that ZDC will be getting more traffic. JFK rates will step down from 52 to 40. The ZDC STMC wanted AFP A08 but they are going with structured rates instead. C90 referred to CIWS/CoSPA during the SPT, mentioning the inconsistent forecasts. C90 expects impact after 17 UTC and major impact at ORD. ATCSCC has issued three south routes and the CAN route. ZKC, ZME, and ZID traffic are on wind routes. The MGM route is issued. Weather on the AR routes is decreasing and they are expected to open after 21 UTC. ZMP has a playbook to get out. ZJX has lots of weather off shore.	SA	
1552	ZDC	Yes	The observer showed the STMC that ZOB001 and ZOB002 timelines were forecasting more impact. The STMC notes that traffic through AFP A08 (unrestricted) is 130 to 140 flights during the 19 UTC hour, which is well above the nominal rates. The STMC called ATCSCC to discuss the plan; no GDPs have been issued. ZDC expects to pass back 30 MIT to ZTL, ZID, and ZJX. ATCSCC says that adding AFPs to GDPs and structured routes is "triple control."		SA-TFI

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1615	ATCSCC	No	The observer discussed TFI with the NOM who thinks TFI is too "linear" and not forward-thinking; the forecast seem to be only "keeping up." He commented that TFI plans the way it has always been done, "stuck in the past." He believes TFI is on the right track with non-traditional AFP boundaries, but that the FCAs need to be more dynamic.		SA-TFI
1620	ZDC	No	TFI continues to forecast no impact for ZDC. CoSPA shows storms developing in northern VA, in the critical path between DC and NYC. The EWR GDP is issued at a 36 rate at 19 UTC, dropping to a 32 rate at 22 UTC. The STMC noted that TFI for ZDC and ZOB show some impact.		SA-TFI
1654	ZDC	No	The STMC noted that TFI shows no impact for ZDC.		SA-TFI
1700	JBU	No	The stakeholder uses CoSPA for situational awareness; more storms are expected in the NYC area.	SA	
1705	ATCSCC	No	The SvrWx TMC is using CoSPA on the SD. In addition, he is using the CoSPA website to view 12-hr TFI. He is trying to manage the volume through ZDC that is the result of multiple reroutes.	SA	SA-TFI
1708	ATCSCC	No	The ORD and NAM TMCs are discussing the storms in NY/PA that may be developing earlier than expected. CIWS is used for the short term while CoSPA/TFI is being used to assess ZOB airspace for a potential GDP.	SA	SA-TFI
1719	ZNY	No	TMCs are using CoSPA, and RAPT on the TSD, to brief the status of routes.	SA	
1731	ZNY	No	The meteorologist used the STMC SD with CoSPA in the TMU to brief potential impacts to several south routes (J75, J48, J175, J60/J64).	SA	
1800	JBU	No	Many stakeholder users are using CoSPA for situational awareness. ZDC is asking for AFPs today but it appears that the impact will be on the terminals.	SA, SA-R	
1802	ZNY	No	The meteorologist briefed the TMU on upcoming impacts near the ZNY/ZDC border. TFI timelines are all green for the next 8 hours.		SA-TFI
1841	ATCSCC	No	CoSPA is paused on the 6-hr VIL forecast. TFI for ZJX is being evaluated for a large impact potential and to determine when it will end or move out of ZJX/ZTL boundary region.	SA	SA-TFI
1912	ZNY	No	The STMC reviews CoSPA in preparation for the SPT; ZNY TFI timelines are all green.	SA	SA-TFI

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
2020	ATCSCC	No	All SvrWx SDs are displaying CoSPA VIL in different regions from the Northeast to the mid-Atlantic and Southeast. A CoSPA website is displayed to monitor ZAU (VIL, satellite, echo tops tags at time 0).	SA	
2036	ZNY	No	The STMC turned off TFI on the SD and simply viewed the CoSPA 8-hr forecast. TFI was all green and not helpful.	SA	
2057	ZNY	No	The STMC is using CoSPA for planning and to determine if WAVEY pathfinder will have problems. DIXIE is impacted.	SA, SA-R	
2120	ZNY	No	One user came into the TMU and viewed CoSPA on two SDs, then left.	SA	
2210	ZNY	No	Area Supervisor using/viewing the STMC's SD for weather over and near Chicago.	SA	

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Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1015	ZOB	Yes	ZNY called to move traffic. There is a thunderstorm over EWR with echo top of 38kft. They are coordinating with ZBW. The STMC CoSPA display shows echo tops and echo tops forecast. The observer offered to display TFI and the STMC agreed. The display was set to loop precipitation forecast with TFI timelines.	SA	SA-TFI
1035	SCC	No	CoSPA/TFI is displayed at the NOM desk; AFPs and reroutes are being considered. The forecasts are very accurate so far and the NAM stresses that AFPs are likely. The NOM's SD is looping CoSPA VIL with ZOB TFI displayed; he is examining the region for the AFP discussion. The Planner is using CIWS VIL to monitor small developing cells in eastern PA and near DEN.	SA, SA-AFP	SA-TFI
1117	ZOB	No	The STMC looked at CoSPA ETF and TCF for situational awareness.	SA	SA-TFI
1130	SCC	Yes	The observer shows 12-hr TFI ZNT001 to NOM/NAM/SvrWx. The timing of the AFP, as well as step down rates, are being derived from the TFI plot.		SA-TFI-TFI

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1140	ZDC	Yes	The observer noted TFI ZOB004 was red at 2230 UTC and 2330 UTC. The observer displayed TFI shadow, which shows the impact beginning much earlier (1730 UTC for ZOB001 and ZOB003, red by 1930 UTC for ZOB003). The STMC was busy and only able to glance at the graphs, but understands the situation. The STMC says that when he does not have time to examine the CoSPA forecast, a quick look at TFI is valuable; he believes the earlier/stronger forecast of shadow TFI is more likely. ZTL is unable to support traffic on both VUZ and MGM and says to expect all traffic on VUZ; they are worried ZJX will not be able to take traffic on MGM given the weather in their airspace. Shadow TFI shows ZNY red impact; ZDC is green.		SA-TFI
1150	JBU	No	The observer showed the stakeholder shadow TFI with the longer timelines. The stakeholder likes to look at the CoSPA 8-hr forecast with TCF; TFI does not go far enough into the future.	SA	SA-TFI
1220	JBU	Yes	The observer showed shadow TFI to the stakeholder; ZOB impact looks particularly severe, but with all the reroutes there will be reduced demand.		SA-TFI
1235	SCC	No	The CoSPA 8-hr forecast with TFI is displayed. TMCs are trying to gauge the timing and rate for OB1 using TFI. CHICA East is approved but Canada does not want any westbound traffic in this area. TFI ZOB timelines are being viewed by TMCs.	SA	SA-TFI, TFI-AFP,
1235	ZDC	No	The observer overheard someone talking about CoSPA on telecon while talking about the GDP at N90 airports.	SA-T	
1245	ZDC	Yes	TFI shows only yellow impact in ZOB beginning 1730 UTC. The observer believes this is optimistic given the uncertainty in the forecast. The STMC agrees and feels that ZOB may not be able to move 20% of their normal traffic. That would suggest a rate of around 30 per hour. There is no metric for setting a rate that low. CoSPA forecasts a line of storms impacting ZOB earlier than TFI forecasts. The STMC called ATCSCC and found they were planning to start required routes around 14 UTC. LGA is in GS with 60+ min delays. The STMC said ZBW was having problems with reroutes.	SA	SA-TFI, TFI-AFP, TFI-R
1315	SCC	No	SPT: The NOM examines CoSPA and TFI while preparing for the internal AFP discussion. ATCSCC is allowing the GDPs to "settle" and would like to publish AFPs by 14 UTC.	SA	SA-TFI
1330	ZOB	No	The Area Sup visited the TMU and the STMC briefed the plan using CoSPA forecasts.	SA	

Time (UTC)	Facility	Observer Assist	Observation	CoSPA Benefit	TFI Benefit
1645	ZOB	No	STMC hand-off briefing. STMC used CoSPA to describe the plan to the incoming STMC.	SA	
1655	SCC	No	The SvrWx TMC uses CoSPA to evaluate the viability of the published CAN routes. The TMC is also concerned about GDP rates with storms now developing in ZNY and across eastern PA. TFI ZNY001A and ZNY001B are being viewed to evaluate gate impact for N90.	SA, SA-R	
1720	ZOB	No	An Area Sup visited the STMC to discuss staffing. The STMC used the CoSPA display to describe the plan and weather forecast.	SA	
1845	ZNY	No	In a hand-off briefing, STMCs used CIWS and CoSPA to explain the route structure.	SA	

GLOSSARY

AFP	Airspace Flow Program
AOC	Airline Operations Center
AR	Atlantic Route
ARTCC	Air Route Traffic Control Center
ASPM	Aviation System Performance Metrics
ATC	Air Traffic Control
ATCSCC	Air Traffic Control Systems Command Center
ATFM	Air Traffic Flow Management
ATIS	Automated Terminal Information System
BOS	Boston International Airport
BWI	Baltimore Washington International Airport
C90	Chicago TRACON
CDM	Collaborative Decision Making
CIWS	Corridor Integrated Weather System
CONUS	Continental United States
CoSPA	Consolidated Storm Prediction for Aviation
CWSU	Center Weather Service Unit
DAL	Delta Airlines
DCA	Reagan National Airport
DEN	Denver International Airport
DST	Decision Support Tool
DTW	Detroit Metropolitan Wayne County Airport
ET	Echo Tops
EWR	Newark International Airport
FAA	Federal Aviation Administration
FCA	Flow Constrained Area
FEA	Flow Evaluation Area
FET	Flow Evaluation Team
GDP	Ground Delay Program
GS	Ground Stop
HRRR	High Resolution Rapid Refresh
IAD	Washington Dulles International Airport
ITWS	Integrated Terminal Weather System
JBU	JetBlue
JKF	Kennedy International Airport
LAHSO	Land And Hold Short Operations
LAMP	Localized Aviation MOS Product

LAS	Las Vegas McCarran International Airport
LAX	Los Angeles International Airport
LGA	LaGuardia International Airport
MIT LL	Massachusetts Institute of Technology Lincoln Laboratory
MOS	Model Output Statistics
N90	New York TRACON, New York TRACON
NAC	NextGen Advisory Committee
NAM	National Aviation Meteorologist
NAS	National Airspace System
NEC	Northeast Corridor
nmi	Nautical Miles
NOM	National Operations Manager
NTMO	National Traffic Management Officer
NWS	National Weather Service
OEP	Operational Evolution Partnership
OMIC	Operations Manager in Charge
OPC	Offshore Precipitation Capability
OPSNET	Operations Network
ORD	Chicago O'Hare International Airport
PERTI	Plan, Execute, Review, Train, Improve
PHL	Philadelphia International Airport, Philadelphia International Airport
RAPT	Route Availability Planning Tool
REPEAT	RAPT Evaluation Post-Event Analysis Tool
SD	Situation Display
SPT	Strategic Planning Telecon/Webinar
SREF	Short-Range Ensemble Forecast
STMC	Supervisory Traffic Management Coordinator
SvrWx	Severe Weather Specialist
TCF	TFM Convective Forecast
TFI	Traffic Flow Impact
TMI	Traffic Management Initiative, Traffic Management Initiative
TMU	Traffic Management Unit
TRACON	Terminal Radar Approach Control
TSD	Traffic Situation Display
UTC	Coordinated Universal Time
VIL	Vertically Integrated Liquid Water
WARP	Weather and Radar Processor
ZAU	Chicago Air Route Traffic Control Center
ZBW	Boston Air Route Traffic Control Center
ZDC	Washington DC Air Route Traffic Control Center
ZID	Indianapolis Air Route Traffic Control Center

ZJX	Jacksonville Air Route Traffic Control Center
ZKC	Kansas City Air Route Traffic Control Center
ZME	Memphis Air Route Traffic Control Center
ZNY	New York Air Route Traffic Control Center
ZOB	Cleveland Air Route Traffic Control Center
ZTL	Atlanta Air Route Traffic Control Center

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