Impact-Based Decision Support Services for the National Airspace System

FEB 24, 2023

Joe (Joey) Carr
National Aviation Meteorologist

BACKGROUND

Born in NOLA - grew up in Metairie, LA
1987 – Graduated Riverdale High School right across the river
1987-1989 – Attended University of New Orleans
1989-1991 – Graduated Florida State University

Summer 1990 … NWSFO New Orleans (Slidell) - **Summer Intern**

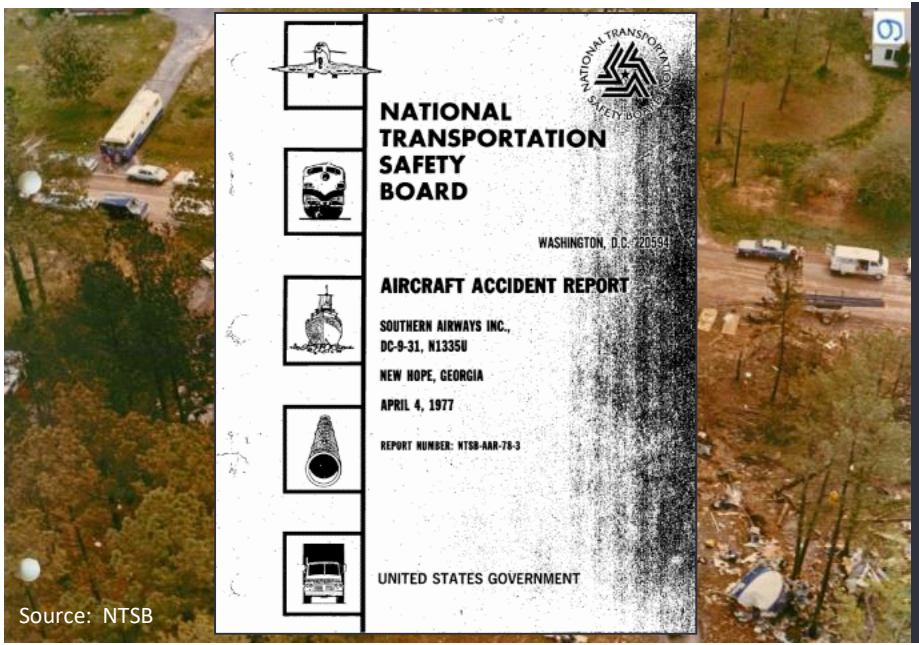
Mar 1992 – Mar 1995 … NWSFO Raleigh-Durham - **Intern/Fire Weather Forecaster**

Mar 1995 – Oct 2004 … WPC (Weather Prediction Center) Formerly HPC (Hydro-meteorological Prediction Center)
- **Development and Training Meteorologist**

Oct 2004 – July 2014 … NCEP Central Operations (NCO)
- **Senior Operations Specialist (Supercomputer Operations)**
- **Senior Duty Meteorologist**
- **Senior Duty Meteorologist Team Lead**
- **Production Management Team Lead**
- **Dataflow Team Lead**
- **Senior Duty Meteorologist Team Lead**

July 2014 – Current … Aviation Weather Center (AWC) - **National Aviation Meteorologist (NAM)**

Why Are Meteorologists at CWSU's?



Southern Airways Flight 242 crash in New Hope, GA on April 4, 1977…72 souls lost (22 on-board survived)

Total loss of thrust from both engines due to damage from ingest of water/hail while penetrating an area of severe thunderstorms

NTSB recommendation A-77-068 to formulate procedures for the timely dissemination of all available severe weather information by controllers

One year later (1978) FAA had 3 NWS meteorologists in 13 ARTCCs;
August 1981 - FAA had 4 NWS meteorologists in all 21 ARTCCs
Partnership continues to this day!

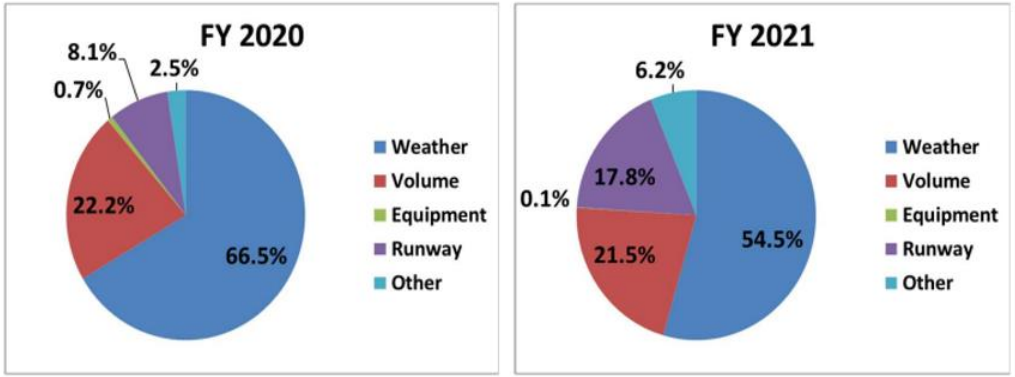
Brief History of the NAMs

- Pre-1995
  - NWS Meteorologists at ATCSCC
- Post-1995
  - FAA Weather Specialists at ATCSCC
- May 2012
  - NWS Returned to ATCSCC (2 Meteorologists)
- August 2014
  - 1 Meteorologist & 1 Manager Added
- July 2016
  - 2 Meteorologists Added
- January 2019
  - Last FAA Specialist Retires
- NOW
  - 1 Manager (Vacant) (Meteorologist), 5 Meteorologists

Causes of National Airspace System Delays

Delays by Category

The two charts below show the sources of delays at Core 30 airports by type of delay.



Note: System impact delays are delays assigned to causal facilities in OPSNET and are composed of delays due to TMIs, departure delays, and airborne delays. System impact delays are also the basis for delays by class and delays by cause in OPSNET. (http://aspmhelp.faa.gov/index.php/OPSNET_Reports:_Definitions_of_Variables)

Source: Federal Aviation Administration, Air Traffic Organization, Office of Performance Analysis (AJR-G), Operations Network (OPSNET), March 7, 2022.

As much as 67% of the delay in the NAS can be attributed to weather, resulting in US economic losses of roughly 23,000,000,000 USD annually.

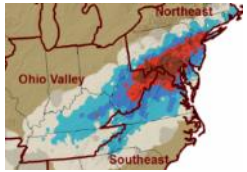
Multi-Million Dollar Losses to Aviation

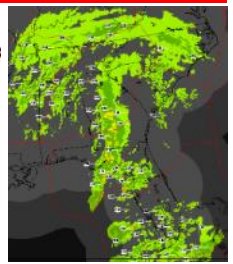
18,411 Cancellations

1/22-1/25 2016 – Winter Storm and Thunderstorms

~$8K Loss / Flight
(variable per flight/aircraft type)

~$150M Losses





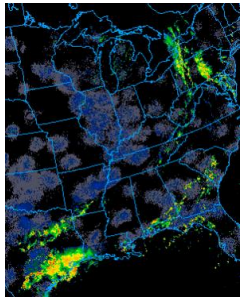
Cancellations ✈ Mostly due to Snow/Ice
Diverts ✈ Mostly due to TS/CIGs/VSBY
Delays ✈ Mostly due to TS/CIGs/VSBY

Cancel/Divert/Delay Data Provided by: MITRE

211,226 Min of Delay

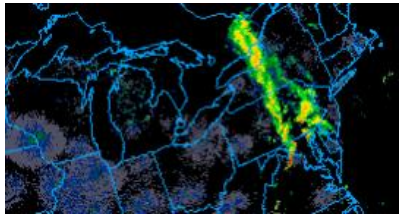
8/20/15 - Thunderstorms

~$74 Loss / Minute



AM & PM TS
EWR, LGA, JFK & PHL (Routes Blocked)

AM TS
IAH ↔ DFW (Routes Blocked & TS at Terminal)



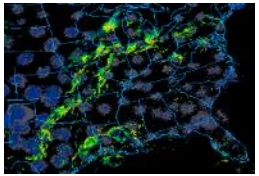
~$16M Losses

Cost Data provided by: Airlines for America — We Connect the World

322 Diversions

6/15/15 Thunderstorms

~$8K Loss / Flight
(variable per flight/aircraft type)



TS Impacting:
ORD – NY/PHL/DC
ORD – DFW
DFW – IAH

~$2.6M Losses

Types of Losses

Airline Crew (timeout)
Missed connection
Missed meeting/vacation
Hotel (airline/passengers)
Reimbursing Tickets
Food
Taxis
Rental Cars
Fuel (airlines & passengers)
Maintenance (airlines)
Lost demand (passenger uses other means)
GDP reduced
Tarmac rule (> 3 hours)
$27,500 per passenger (paid to Trans Dept)

**Some airlines build divert costs into budgets*

Source: Eckert, 2017

NOAA/NWS Aviation Program

122 Weather Forecast Offices

21 Center Weather Service Units

3 Meteorological Watch Offices

2 Volcanic Ash Advisory Centers

NWS Meteorologists provide embedded Impact-Based Decision Support Services at the ATCSCC as well as the 21 ARTCCs

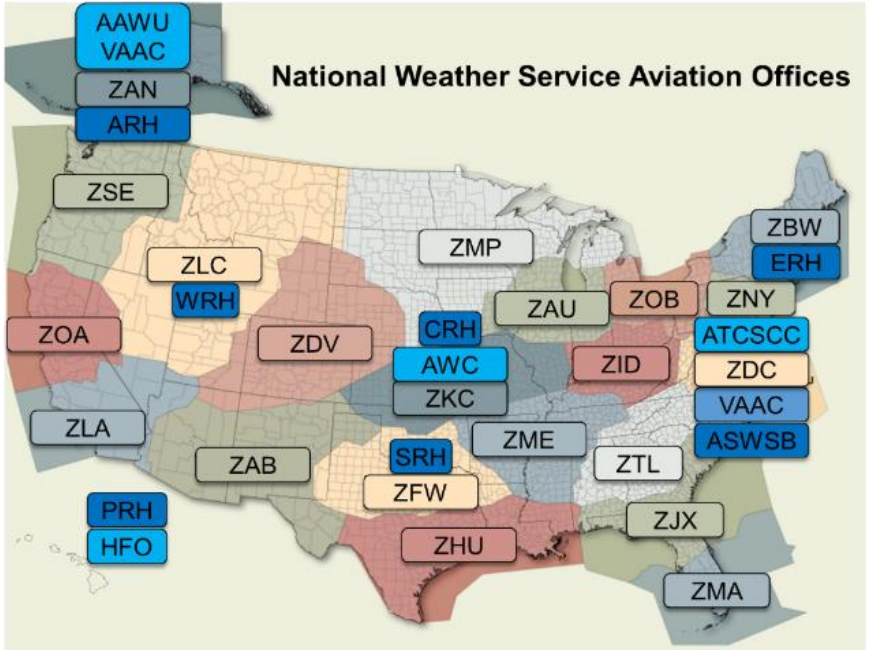
NOAA/NWS Aviation Program

MWO
AWC, AAWU, HFO

VAAC
AK/DC

CWSU

WFO



NWS Meteorologists provide embedded Impact-Based Decision Support Services at the ATCSCC as well as the 21 ARTCCs

Aviation Weather Center

The Aviation Weather Center, located in Kansas City, MO, shares a facility with National Weather Service Central Region Headquarters, as well as the NWS Training Center.

This is Our Mission

AWC Mission

The Aviation Weather Center's highly skilled people deliver global operational aviation weather products and services essential to safe and efficient flight, and economic well-being.

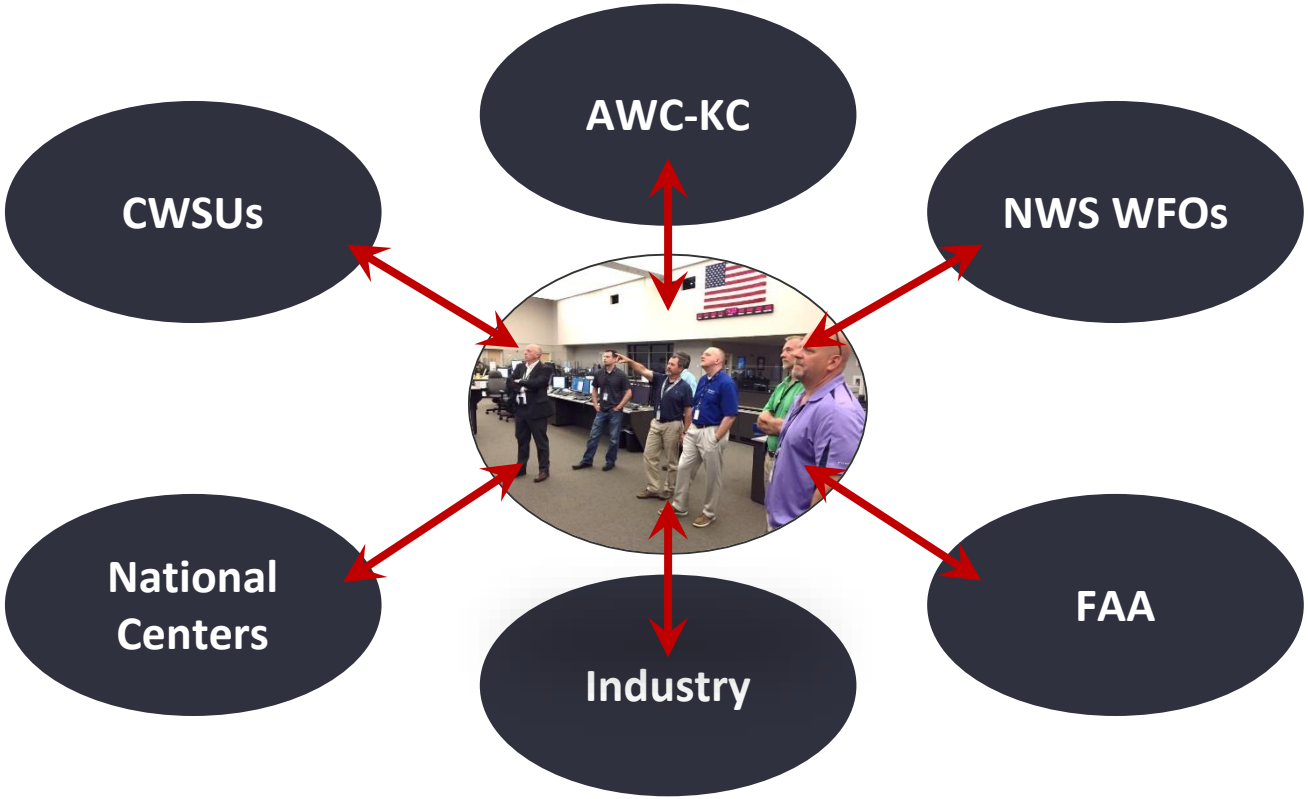
NAM Mission

Ensure the safe and efficient operation of the National Airspace System through the provision of timely, relevant, accurate and consistent environmental information to decision makers.

Key Aviation Stakeholders

Federal Aviation Administration (FAA)	National Transportation Safety Board (NTSB)	Airlines For America (A4A)
International Air Transportation Association (IATA)	National Business Aviation Association (NBAA)	General Aviation Community
Aircraft Owner and Pilot Association (AOPA)	International Meteorological Service Providers	International Civil Aviation Organization (ICAO)

Coordination and Collaboration

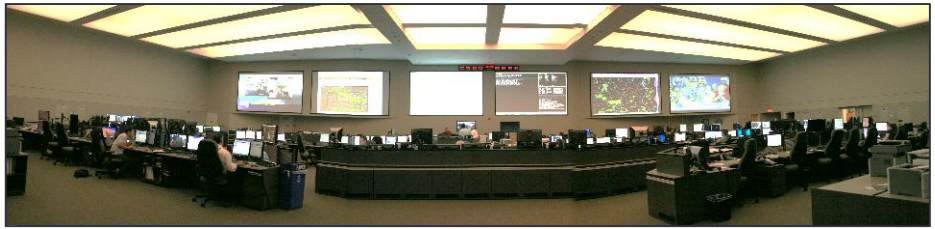


NWS Support to ATCSCC

Improve safety, efficiency, and decision making for the National Airspace System

Support Collaborative Decision Making

Balance air traffic demand with system capacity



Fully Integrated and Embedded IDSS

Collaborative Forecast Process (NWS and Industry)

Focus on weather with potential system impact

Our goal is to paint a cohesive national weather picture to the Command Center to improve safety, efficiency, and decision making.

Impact-Based Decision Support Services

"Information is cheap. Meaning is expensive."

- George Dyson, Science/Technology Historian

*Weather information is voluminous. This can lead to "**paralysis by analysis**."*

Experience, training, interpretation *and* ***insight***

= keys to aiding in smart, safe, & effective decision making!

"We don't care where your forecasts are correct or have the highest confidence … tell us where you could be wrong … because that is where all the planes are going" – Retired FAA Controller

"NAM forecasters are meteorologists, but more importantly, we are risk managers who assess weather risk and communicate that risk in a manner which allows users to make decisions."

Impact-Based Decision Support Services

Decision support includes, but not limited to:

- *Real-time assessments of current & forecast weather*
- *Collaboration with NWS and airline meteorologists*
- *Planning outlooks out to 4 days – including PERTI*
- *Post-event forecast reviews and debriefings*
- *Meteorological insight supporting traffic management initiatives*
- *And much, much more…*

Daily Products and Briefings

- Customized TAF Updates: 05, 07, 09, 11, 13, 15, 17, 19, 21 (Local)
- TCF Collaboration – 06, 0730, 10, 12, 14, 1530, 18, 20 (Local) (March - October)
- 4-Day Terminal Outlook – 0730 Local
- NWS HQ Standup Briefing – 0745 Local
- ATCSCC Standup Briefing – 0800 and 1600 Local
- Caribbean/Snowbird Outlook - 0815 (Apr-Oct, Fri; Nov-Mar, Fri-Sun)
- AWO Update #1 – 0830 Local
- NAS Weather Outlook Graphics (up to Day 8) – 0930 Local
- TCF Daily Review on NSR – 1000 Local (Mon-Fri)
- SysOps Director VTC (8-Day Outlook) –1030 Local (Tue)
- PERTI Outlook – 1030 Local
- PERTI Webinar Pre-Brief – 1300 Local
- PERTI Planning Webinar – 1430 Local
- AWO Update #2 – 1530 Local
- Day 2 NAS Weather Outlook Update (PERTI) – 2015 Local (Mon-Fri)
- Scheduled and Ad-hoc ATCSCC briefings: ~15 to 20 per day
- Space Weather (SWPC), Ozone & Volcanic Ash -- as needed
- Ad-hoc Telecon Briefings/NWS Chat for coordination/collaboration
- Special weather packages … Winter Weather, Tropical systems, 5G … etc

TAF Impacts Board

Potential Impact: None | Slight | Moderate | High

Valid at: 1000 UTC 07 Feb 2020

Time	OBS	07/10Z	07/11Z	07/12Z	07/13Z	07/14Z	07/15Z	07/16Z	07/17Z	07/18Z	07/19Z	07/20Z	07/21Z	07/22Z >>
@TOPE														
KBOS	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	WSpd	WSpd	WSpd	WSpd	WSpd
KCLE	WX	WX	WX	WX	WX	WX	WX	WX	WX	WX	WX	WX	WX	WX
KLGA	VIS	VIS	VIS	VIS	VIS	WX	WGst	WSpd	WSpd	WSpd	WSpd	WSpd	WSpd	WSpd
KEWR	CIG	VIS	VIS	VIS	VIS	WX	WSpd	WGst	WGst	WGst	WGst	WSpd	WSpd	WSpd
KJFK	VIS	VIS	VIS	VIS	VIS	CIG	CIG	WX	WGst	WGst	WGst	WGst	WGst	WGst
KPIT	WX	WX	WX	WX	WX	WX	WX	WX	WX					
KPHL	VIS	VIS	VIS	VIS	VIS	CIG	CIG	WGst	WGst	WGst	WGst	WGst	WGst	WGst
KBWI	VIS	[VIS]			WGst	WGst	WGst	WGst	WGst	WGst	WGst	WGst	WGst	
KIAD	VIS	VIS			WGst	WGst	WGst	WGst	WGst	WGst	WGst	WGst	WGst	
KDCA	CIG	CIG	CIG	CIG	CIG	WGst	WGst	WGst	WGst					
KCLT	WGst	WGst	WGst	WGst	WGst	WGst	WGst	WGst	WGst	WGst	WGst	WGst	WGst	
KATL														
KMCO														
KTPA														
KFLL		WX	[WX]											
KMIA		WX	[WX]	WX										
@TOPC														
KMSP	WX	WX	WX	WX	WX	WX	WX							
KDTW	WX	WX	WX	WX	WX									
KORD	WX	WX												
KMDW	WX	WX	WX											
KCVG	WX	WX	WX	WX	WX	WX	WGst	WGst	WGst	WGst	WGst	WGst	WGst	
KSTL	WX	WX	WX											
KMEM	WX													
KDFW														
KIAH														
@TOPW														
KSEA	VIS	VIS	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG	CIG
KPDX	WSpd	WSpd	WSpd											
KSLC														
KDEN	VIS	[WX]	WX	WX	WX	WX	WX	WX	WX	WX	WX	WX	WX	WX
KSFO				VIS	VIS	[CIG]	[CIG]	[CIG]	[CIG]					
KLAS														
KLAX					CIG	CIG	CIG	CIG	CIG					
KPHX														
KSAN														
Time	OBS	07/10Z	07/11Z	07/12Z	07/13Z	07/14Z	07/15Z	07/16Z	07/17Z	07/18Z	07/19Z	07/20Z	07/21Z	07/22Z

Potential impacts noted are airport-specific, based on Aviation Wx Impacts Catalog

Aviation Weather Impacts Catalog

	WINDS (wind speed or gusts triggers category) [(>= WDIR1 & <= WDIR2) AND ((> WSPDmin & <= WSPDmax) OR (> WGSTmin & <= WGSTmax))]								CIG (If coupled with wind, then both are needed to meet CAT), otherwise needs to meet CAT on its own. & [(>= CIGmin & < CIGmax)]				VSBY - (If coupled with wind, then both are needed to meet CAT), otherwise needs to meet CAT on its own & [(>= VISmin & < VISmax)]				WEATHER (Independent of Wind)		
Airport	>= WDIR1	<= WDIR2	> WSPDmin	<= WSPDmax	> WGSTmin	<= WGSTmax	CAT	Wind Notes	>= CIGmin	< CIGmax	CAT	CIG Notes	>= VISmin	< VISmax	CAT	VIS NOTES	WX	CAT	WX NOTES
ANY	000	360	0	999	0	999	0		000	999	0		0	0.55	3	Generic; see airport criteria	SN	3	
ANY	000	360	0	999	0	999	0		000	002	3	Generic; see airport criteria	0	999	0		FZRA	3	
ANY	000	360	0	999	0	999	0		000	999	0		0.55	0.8	2	Generic; see airport criteria	FZDZ	3	
ANY	000	360	0	999	0	999	0		000	999	0		0.8	1.55	1	Generic; see airport criteria	IP	3	
ANY	000	360	0	999	0	999	0		002	005	2	Generic; see airport criteria	0	999	0		TS	3	
ANY	000	360	0	999	0	999	0		005	008	1	Generic; see airport criteria	0	999	0				
ANY	000	360	29	999	34	999	3	Generic; see airport criteria	000	999	0		0	999	0				
KBOS	20	170	20	999	25	999	3		000	999	0		000	999	0		RA	1	
KBOS	20	170	0	20	0	25	0		000	999	0		0	1	3	?	SHRA	1	
KBOS	20	170	0	20	0	25	0		000	999	0		1	5	2	?	DZ	1	
KBOS	20	170	0	20	0	25	0		000	005	3	AAR=28	000	999	0		FU	1	
KBOS	20	170	0	20	0	25	0		005	015	2	AAR=32	000	999	0		BLDU	1	
KBOS	20	170	0	20	0	25	0		015	035	1	AAR=38	000	999	0		VCFG	1	
KBOS	180	10	0	17	22	25	0		000	005	3		0	999	0		BCFG	1	
KBOS	180	10	0	17	22	25	0		005	009	2		0	999	0				
KBOS	180	10	0	17	22	25	0		009	031	1	AAR=38	0	999	0	?			
KBOS	180	10	0	17	22	25	0		000	999	0		3	4	1				
KBOS	180	10	0	17	22	25	0		000	999	0		1	3	2				
KBOS	180	10	0	17	22	25	0		000	999	0		0	1	3				
KBOS	180	10	17	999	25	999	3	AAR=30-32	000	999	0		0	999	0				
KLGA	280	350	11	17	17	23	1	04/22 X-WIND	000	999	0		0	999	0		RA	1	
KLGA	280	350	17	20	23	30	2	04/22 X-WIND	000	999	0		0	999	0		SHRA	1	
KLGA	280	350	20	999	30	999	3	04/22 NOT USED; AAR=28-30	000	999	0		0	999	0		DZ	1	
KLGA	360	90	6	12	16	20	2		000	999	0		0	999	0		FU	1	
KLGA	360	90	12	999	20	999	3		000	999	0		0	999	0		BLDU	1	
KLGA	100	160	11	17	17	23	1	04/22 X-WIND;	000	999	0		0	999	0		VCFG	1	
KLGA	100	160	17	20	23	30	2	04/22 X-WIND;	000	999	0		0	999	0		BCFG	1	
KLGA	100	160	20	999	30	999	3	04/22 NOT USED;AAR=28-30	000	999	0		0	999	0				
KLGA	170	270	6	12	16	20	2		000	999	0		0	999	0				
KLGA	170	270	12	999	20	999	3		000	999	0		0	999	0				
KLGA	10	360	0	999	0	999	0		000	999	0		3	5	2				
KLGA	10	360	0	999	0	999	0		000	999	0		0	3	3				
KLGA	10	360	0	999	0	999	0		010	032	1		0	999	0				
KLGA	10	360	0	999	0	999	0		000	003	3	AAR=32	0	999	0				
KLGA	10	360	0	999	0	999	0		003	005	2	AAR=34	0	999	0				
KEWR	110	160	11	15	16	20	2	04/22 CROSSWIND	000	999	0		0	999	0		RA	1	
KEWR	110	160	15	999	20	999	3	04/22 CROSSWIND									SHRA	1	
KEWR	170	260	11	15	15	20	1	11 NOT USED	000	999	0		0	999	0		DZ	1	
KEWR	170	260	15	29	20	34	2												
KEWR	270	330	11	15	15	20	1												

TAF Updates – Every 2 hours or as needed

10Z **FRI 02/07/20**

```
BOS 01006KT 6SM -RA BR OVC005
    FM071500 13011G20KT 1SM -RA BR OVC003
    FM071800 21021G35KT 4SM BR BKN010 WS020/20050KT
    FM072100 24027G46KT P6SM OVC020 WS020/22055KT…LLWS ends 00Z

N90 08006KT 2SM -RA OVC005 WS020/20035KT
    FM071300 13008KT 2SM -RA OVC006 WS020/17040KT
    FM071400 16010KT 5SM -RA OVC007 WS020/17045KT
    FM071500 20017G29KT 5SM -RA BKN012 BKN026 WS020/21055KT
    FM071600 24022G39KT 5SM -RA BKN019 BKN045 WS020/20050KT …G45KT 17Z

PHL VRB05KT 1SM BR OVC004
    TEMPO 0710/0712 1/4SM FG VV002
    FM071300 17009KT 4SM BR OVC008 WS020/16040KT
    FM071400 23020G32KT 5SM BR OVC009 WS020/19045KT
    FM071600 26022G39KT 6SM -SHRA BKN015 …VFR at 19Z.

DC  16005KT 1/4SM -RADZ FG BKN002 OVC008  (IFR at DCA)
    FM071100 18010G17KT 5SM -SHRA BKN008 OVC050
    FM071300 27018G38KT 5SM -SHRA BKN015 OVC050
    FM071600 28018G38KT P6SM BKN050 ….15G30KT at 18Z.

CLT 24020G32KT P6SM SCT050       FM072200 28012G21KT P6SM SCT200

ATL TEMPO 0710/0712 -RA BKN015

TPA/MCO  NSW

MIA/FLL 21015G25KT P6SM VCTS BKN040CB OVC060
    TEMPO 0711/0712 24020G35KT 4SM TSRA BKN015CB OVC025
    FM071300 30012G22KT 6SM SHRA OVC025 …VFR at 16Z.

DTW 36008KT 3SM -SN BR OVC015 …Less than 1" snow
    FM071400 34013G20KT P6SM OVC025 …VFR at 19Z.
==========================================================
ORD 34009KT P6SM -SHSN FEW015 SCT025 BKN035 …NSW at 11Z.

MSP VRB02KT 3SM -SN BR OVC035
    TEMPO 0710/0711 2SM -SN OVC025
    FM071100 34004KT P6SM -SN OVC035 ….Snow ends 16Z….Less than 1/2"

DFW/IAH/SLC/SAN/LAS/PHX NSW

DEN 25012KT P6SM VCSH SCT010 OVC050
    TEMPO 0710/0711 5SM -SN BR BKN015
    FM071100 21006KT 5SM -SN BR SCT015 OVC024
    TEMPO 0712/0716 2SM -SN BR BKN012
    FM071700 18007KT 5SM -SN BR SCT010 OVC025 ….1" snow

SEA FM071100 24012KT 4SM -DZ BR OVC004
    FM071900 18009KT P6SM VCSH OVC010

SFO FM071200 00000KT 5SM BR FEW003
    TEMPO 0714/0718 BKN004
    FM071800 VRB03KT 6SM HZ FEW004 ..NSW at 22Z.

LAX FM071300 VRB03KT 4SM BR BKN005 …VFR at 18Z.
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FOR INTERNAL USE ONLY

10Z SKI COUNTRY **FRI 02/07/20**

```
ASE 00000KT 1 1/2SM -SN BKN021 OVC027 WS020/31045KT
    FM071300 30009KT 1SM -SHSN OVC008 WS020/30040KT
    FM071500 30010G20KT 3/4SM -SHSN OVC009
    FM080000 30009KT 3SM -SHSN BKN011      5-11" Through Afternoon

EGE 23010KT 3SM -SHSN OVC027
    FM071200 25008KT 1 1/2SM -SN BR OVC015
    FM072000 25015G23KT 5SM -SHSN OVC028….. 2-4" total snow

RIL 26008KT 2SM -SHSN OVC024
    FM071800 26010KT 4SM -SHSN OVC030
    FM072000 26010KT 6SM -SN OVC040 …2-4" total snow

JAC 22007KT 1 1/2SM -SN SCT005 OVC015
    FM071200 24015G25KT 1 1/2SM -SN BLSN OVC015
    FM080000 23014G20KT 3SM -SN SCT015 BKN030     3-7" total snow

SUN NSW

BZN VRB06KT 4SM -SN BR SCT015 OVC040
    TEMPO 0710/0711 1SM -SN OVC015
    FM071100 VRB06KT 1 1/2SM BR SCT007 OVC015
    TEMPO 0711/0715 3/4SM -SN BR OVC007
    FM071700 VRB06KT 3SM -SN OVC020  2-4" total snow
    FM071800 VRB06KT P6SM VCSH BKN035
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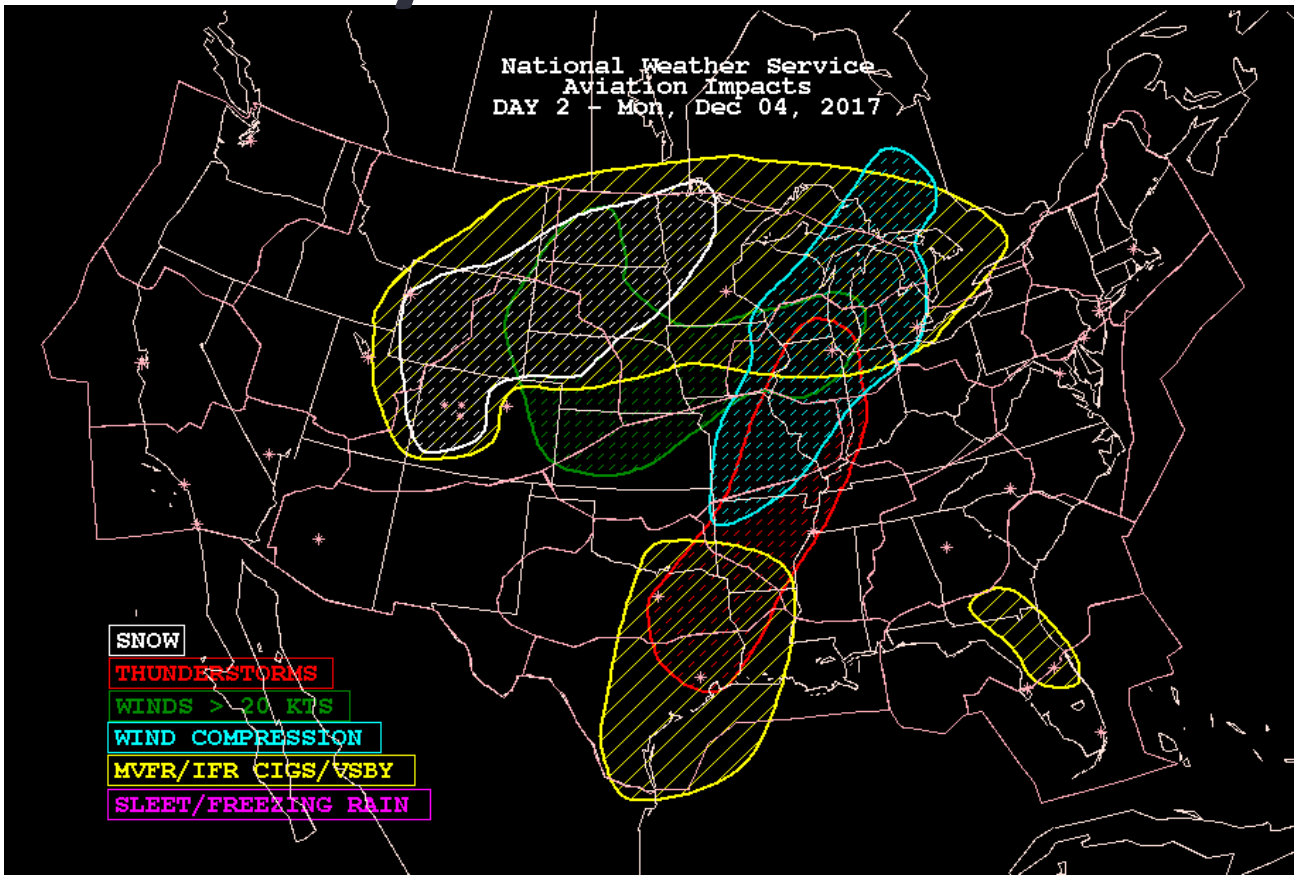
FOR INTERNAL USE ONLY

4-Day Terminals Outlook

ATCSCC MAJOR AIRPORTS FORECAST **Tuesday, January 24, 2023**

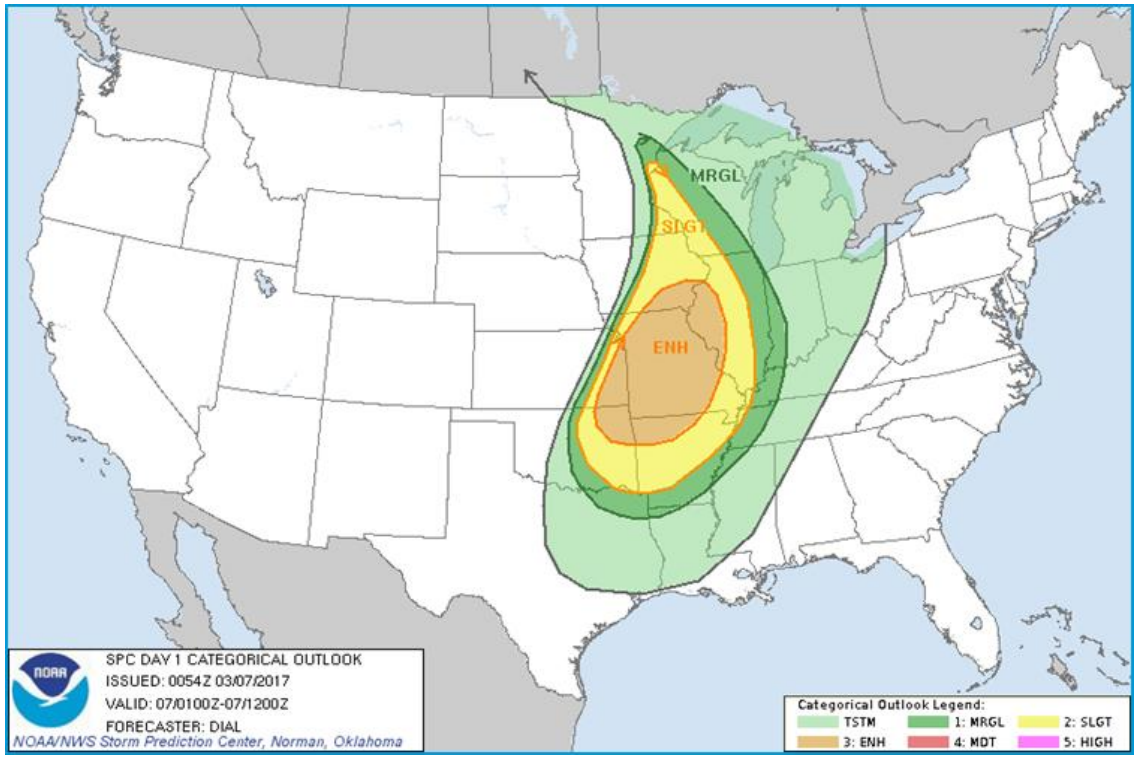
ARPT	WED JAN 25	THU JAN 26	FRI JAN 27	SAT JAN 28
BOS	PM MVFR/IFR/SN (1")→ RASN EVE COMPRESSION	AM MVFR/IFR/RA PM WSW 20G30KT	NSW	NSW
NYC	MVFR/IFR PM E15G25KT AM SN (0.5")/PM RA PM COMPRESSION	AM MVFR PSBL WSW 20G30KT	NSW	NSW SW 10-15KT
PHL	MVFR/IFR PM E 10-15KT AM SN (<0.5")/PM RA PM COMPRESSION	NSW W 20G30KT	NSW	NSW
DC	MVFR/IFR AM RASN→RA / PM RA PM COMPRESSION	NSW W 20G30KT	NSW	NSW
CLT	MVFR/IFR/RA S 15G25KT	NSW	NSW	NSW
ATL	AM MVFR/IFR/SHRA/ ISOLD TS SSW 15G25KT	NSW WNW 15G25KT	NSW	NSW
C FL	AM MVFR/IFR PM SHRA/ISOLD TS	AM MVFR/IFR	NSW	NSW
S FL	NSW	PM CHC SHRA	NSW	NSW
DTW	MVFR/IFR/SN (3-5") PM NE 15G25KT	AM MVFR	PM MVFR/CHC SN SW 15G25KT	MVFR/AM IFR PSBL
ORD	MVFR/IFR/SN (2-4") PM NE→N 15G25KT	MVFR/CHC SN (0.5")	MVFR/CHC SN SW 15G25KT	EVE MVFR/CHC SN
MSP	MVFR/IFR/CHC SN (1")	NSW	AM MVFR/CHC SN	NSW
MEM 02Z-08Z	MVFR	NSW	NSW	MVFR/IFR/RA
DFW	AM MVFR/IFR	NSW	NSW	MVFR PSBL/ISOLD SHRA
IAH	NSW	NSW	NSW	MVFR/PM SHRA
DEN	MVFR PSBL/AM CHC SN (0.5")	NSW	NSW	MVFR PSBL/PM CHC SN
SLC	NSW	NSW	NSW	AM MVFR/CHC SN
SEA	AM MVFR/IFR	AM MVFR/IFR	MVFR/IFR/CHC RA	MVFR/IFR/CHC RA EVE CHC RASN
SFO	NSW	NSW	NSW	AM MVFR
LAX	NSW	NSW AM NE 10-15KT	NSW	NSW
SAN	NSW	NSW	NSW	AM MVFR/IFR PSBL
LAS	NSW	NSW	NSW	NSW
PHX	NSW	NSW	NSW	NSW

NAS Daily Weather Outlook



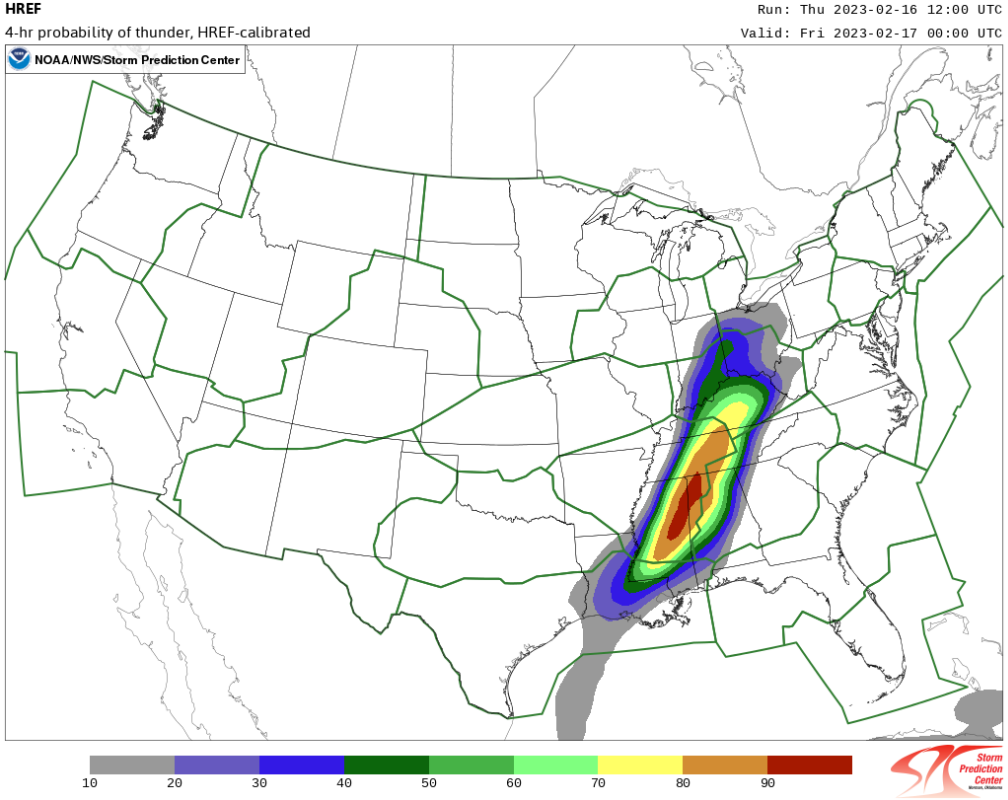
NAS Daily Weather Outlook - Inputs

SPC THUNDERSTORM OUTLOOK



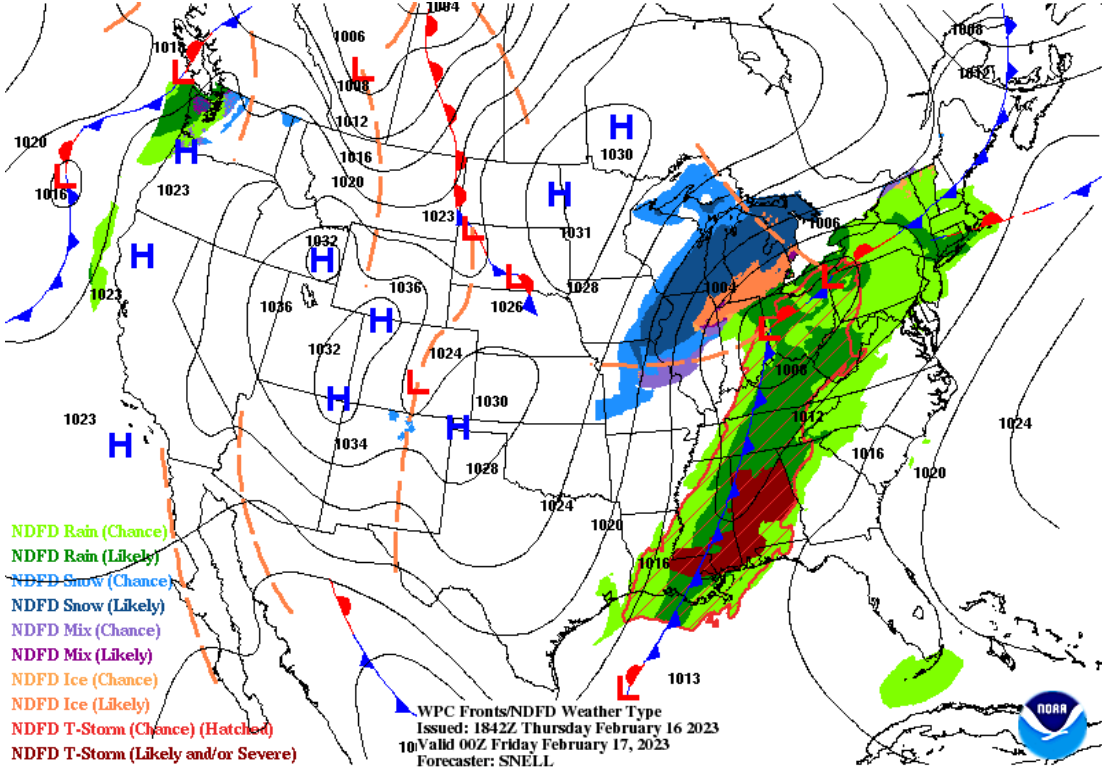
NAS Daily Weather Outlook - Inputs

HREF 4-HR PROBABILITY OF THUNDERSTORMS - CALIBRATED



NAS Daily Weather Outlook - Inputs

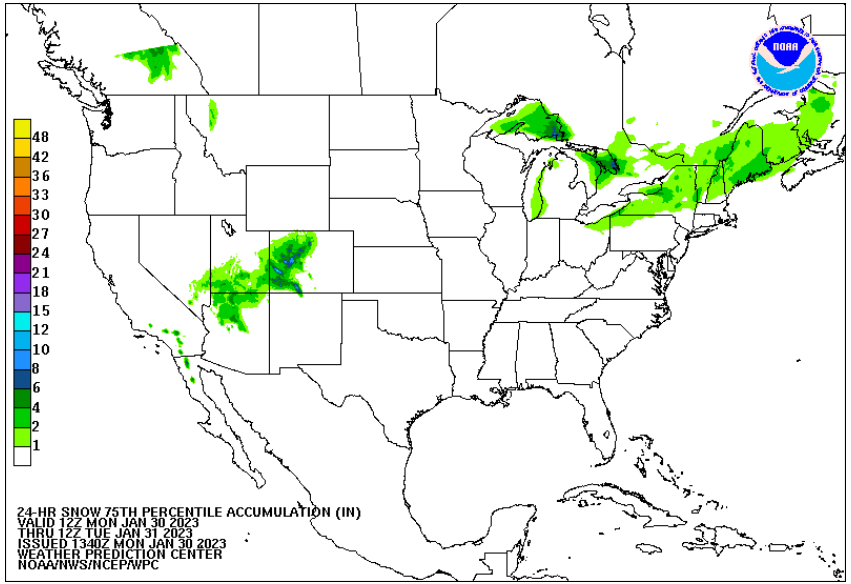
WPC FORECAST GRAPHICS



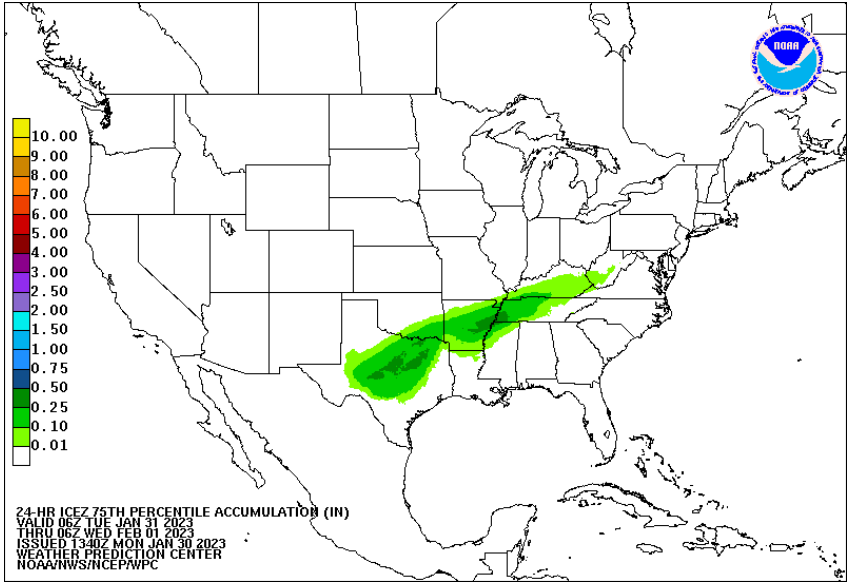
NAS Daily Weather Outlook - Inputs

WPC WINTER WEATHER GRAPHICS

SNOW FORECAST

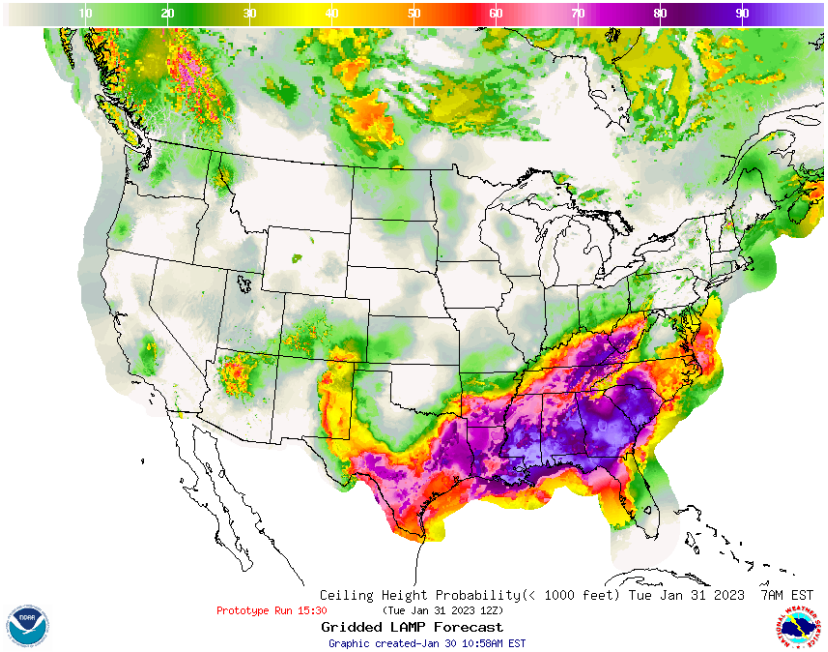


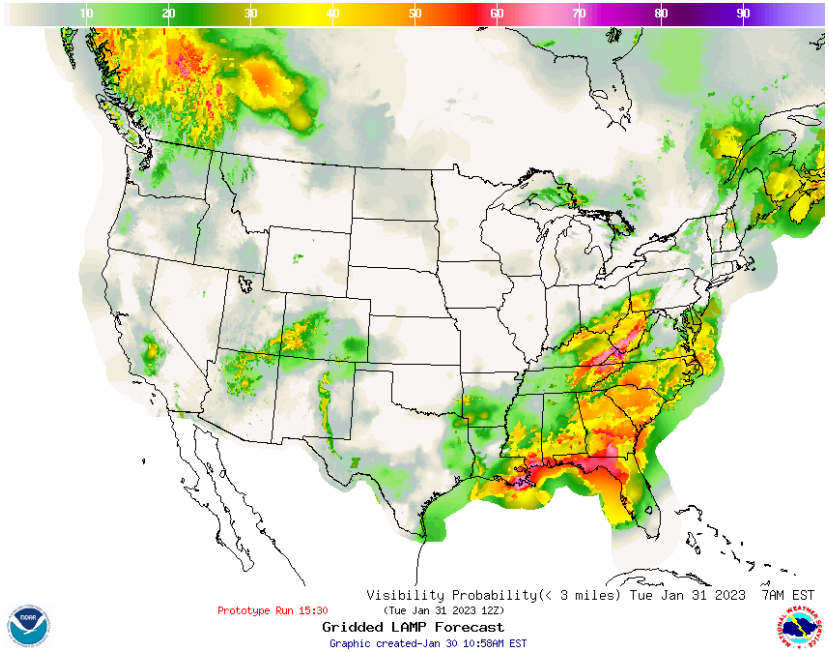
ICE FORECAST



NAS Daily Weather Outlook - Inputs

MDL GRIDDED LAMP FORECAST – CEILINGS/VSBY





NAS Daily Weather Outlook - Inputs

COMPRESSION OUTLOOKS - ZNY

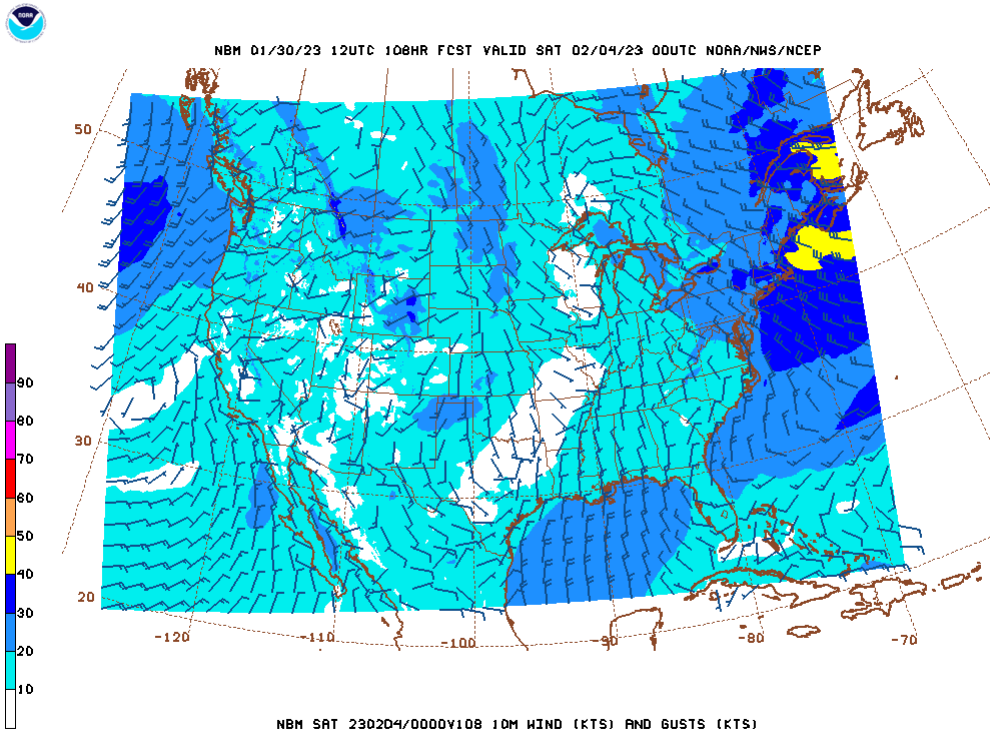
COMPRESSION … WHAT IS IT? UNFAVORABLE WIND AT MULTIPLE VERTICAL HEIGHTS LEADS TO A STACKING OF AIRCRAFT ATTEMPTING TO LAND.
CONFIGURATION DEPENDENT – NOT LLWS

EXAMPLE:
- 75 KT TAIL WIND (SOUTHWESTERLY AT FL030)
- 15 KT HEAD WIND (SOUTHWESTERLY AT SFC)
- RESULTS IN 90 KT OF COMPRESSION
- DESCENDING AIRCRAFT FORWARD SPEED ACCELERATES WITH TAIL WIND … THEN THEY FACE AN ABRUPT HEAD WIND RESULTING IN DECELERATION.

RESULT:
- CONTROLLERS MUST ALLOW FOR ADDITIONAL SPACING BETWEEN AIRCRAFT … **DELAYS!!**

NAS Daily Weather Outlook - Inputs

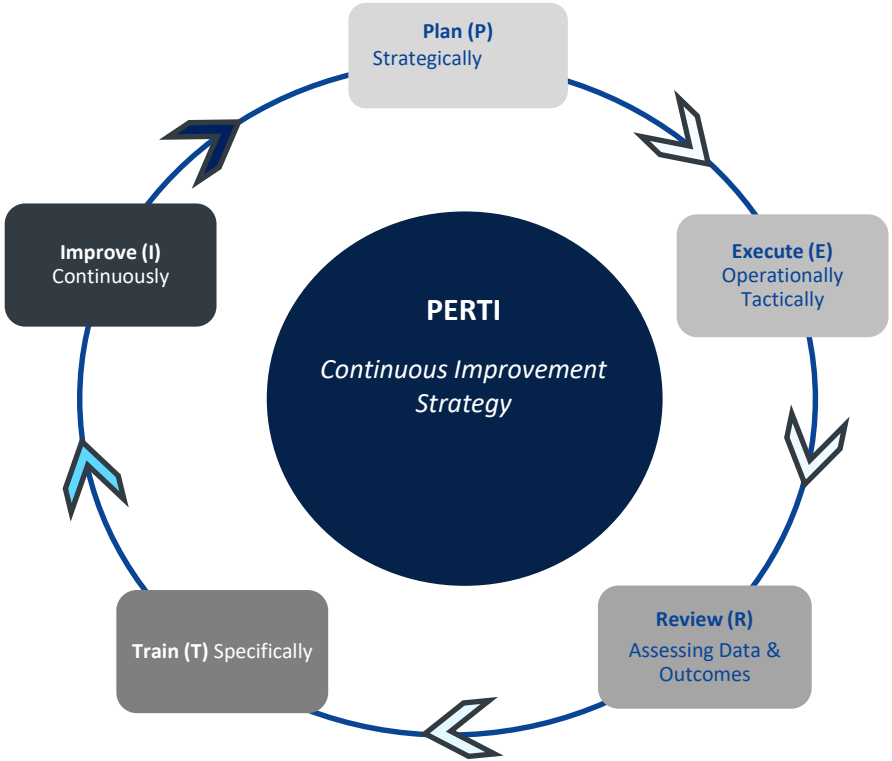
SURFACE WIND FORECAST



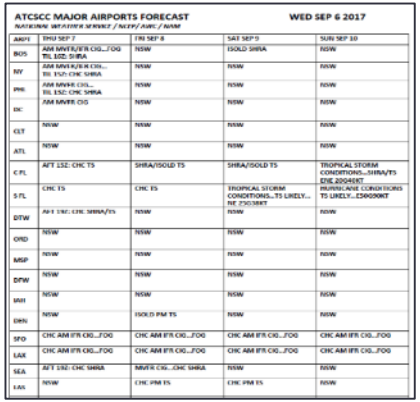
PERTI Planning

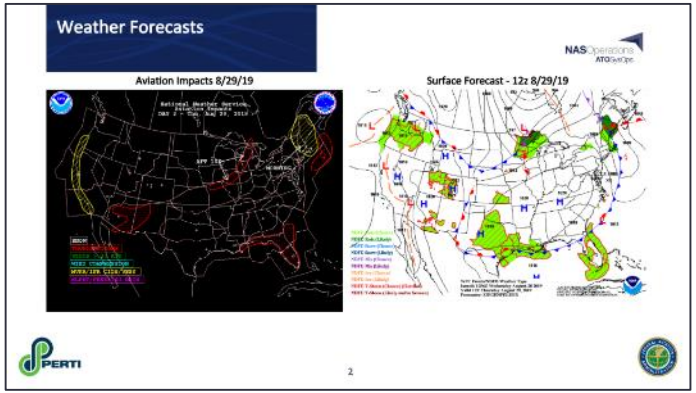
What is PERTI?

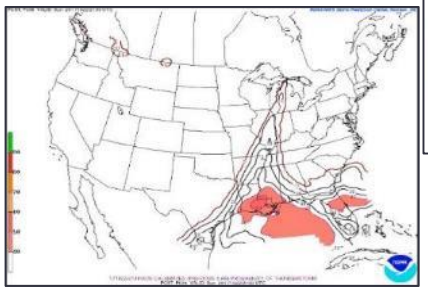
- NAS-wide initiative, part of the Continuous Improvement Strategy
- Involves resources, processes, and analytics
- Advanced Planning window with an outlook ranging from 2-8 days
- Development of strategic plans and Critical Decision Window timing and goals for the operational “day of”

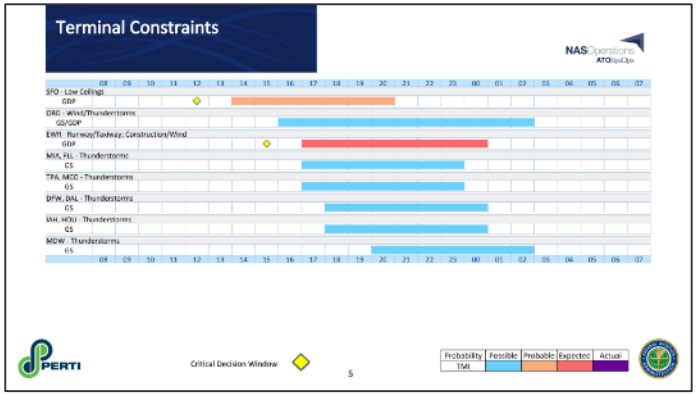


PERTI Planning









QC Assessments – On Demand/As Needed - Let's look back

How did we do?

Seattle Low IMC Fog Event - 11/20/18

Overview: A period of low instrument meteorological conditions occurred at Sea-Tac International Airport from approximately 1050Z to 1830Z on Tuesday, November 20, 2018. During this period, ceilings lowered to 100ft AGL with an indefinite ceiling reported for up to an hour at times. Visibility was reduced to less than 1/16 mile with periods of Runway Visual Range as low as 300ft. A brief period of improvement occurred between 1348-1435Z, with visibility 4SM and no ceiling, however, LIMC conditions returned and persisted until the end of the period.

Forecast: Discussion Monday emphasized continued high pressure in place across the region, with patchy fog likely overnight Monday into early Tuesday morning, and areas of IMC fog possible. Near surface moisture, with dry/stable air above it, was forecast, with light southerly winds aloft. This supported conditions favorable for radiation fog development, particularly near moisture sources and valleys, but typically not widespread or long duration.

Forecast confidence in a LIMC fog event increased Monday evening, as lowland fog began to develop earlier than anticipated. DCC weather, NWS and DAL all began forecasting a low or very low IMC fog at Sea-Tac early Tuesday morning, with a larger coverage area.

Northeast Winter Storm – 11/15/18

Overview: Low pressure developing along the southeastern U.S. coast moved north into the Mid-Atlantic and northeastern US. A variety of precipitation occurred with mostly snow inland and a mixture of snow, sleet, freezing rain and rain along and east of the I-95 corridor.

Model forecasts, from November 13th-14th, were mostly favoring the rain/snow line moving west of the I-95 corridor Thursday morning in the DC area, with PHL and N90 airports turning over to rain during the afternoon. The rain/snow line moved westward much slower than anticipated, and resulted in a more lengthy period of heavier snow and sleet than originally forecast.

06z TAFs were used, due to the fact that they were based on the 00z model guidance. Early morning decisions were being made on the overnight TAFs. After 12z the TAFs were frequently amended to better fit the ongoing weather situation(s) at the individual airports.

Verification: The High Resolution Rapid Refresh model (HRRR) seemed to resolve the rain/snow line position and movement much better than other guidance for this event in the DC to PHL corridor. The HRRR was too quick with the change to rain from PHL to N90.

Images included:
- 24 hour snow/ice accumulation analysis
- 11/15/18 - 00Z HRRR (High Resolution Rapid Refresh) forecasts of precipitation type valid 12z, 15z, 18z, 21z & 00z

Key Data Included:
- 06Z NWS TAFs for DCA, IAD, BWI, PHL, EWR, LGA & JFK
- 06Z DAL TAFs for DCA, LGA & JFK
- 06Z UAL TAFs for IAD & EWR
- 07Z AAL TAF for DCA, PHL & JFK
- Key METARs for DCA, IAD, BWI, PHL, EWR, LGA & JFK

Sea-Tac IAP (SEA) TAF & METAR

NWS TAF 18Z Monday, 19 November

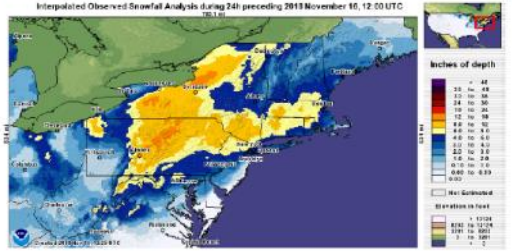
SEA KSEA 191743Z 1918/2024 VRB03KT P6SM VCFG
FEW002
TEMPO 1918/1919 5SM BR SCT002
FM192000 35005KT P6SM SKC
FM200500 05004KT P6SM SKC
FM201000 05004KT 2SM BR BKN005
TEMPO 2012/2016 1SM BR BKN002
FM201600 05005KT 5SM BR SCT005 SCT200
FM201800 34006KT P6SM SCT200
FM202100 35006KT P6SM SCT150 BKN200

DAL TAF 23Z Monday, 19 November

FM192300 26005KT P6SM SKC
FM200400 05004KT P6SM SKC
FM201100 05004KT 1/2SM FG BKN002
TEMPO 2011/2016 1/4SM FG OVC001
FM201700 04004KT 1SM BR BKN004
FM201900 32005KT P6SM SCT250
FM210000 15004KT P6SM BKN200

Both NWS and DAL TAFs begin forecasting potential for LIFR Ceilings Tuesday morning the day prior with similar start and end times. DAL TAF is slightly more aggressive, with cig/vis lower and longer.

Snow/Sleet Totals – Valid 12z 11/15/18 – 12z 11/16/18



Customer Feedback

10:03	PHL GDP CRITIQUE: PROPOSAL SENT. CONF ABOUT 1245Z. 40 RATE WITH EXPECTED TSTM IMPACT TO FIELD AND ROUTES FOR MOST OF DAY. AAL AND PHL AGREED TO 40 RATE. EARLY TAF'S DO NOT SHOW TSTMS AT PHL, BUT DCC WX SAYS THE TSTM LINE JUST NW OF PHL IS BEARING DOWN ON PHL AND WILL HIT AIRPORT BY 15Z. ON CONF, ALL GOOD WITH PLAN...AT ABOUT 1510Z, 2 ABOUT 1550Z, G 1840 GDP REVIS AFPs...EQ 2050 SECOND TIER GROUND STOP DUE TO EN ROUTE WEATHER OVER DEPARTURE FIXES PTW/MXE...EQ 2 0

AAL	01:02	VERY GOOD COMMUNICATION THROUGHOUT THE AFTERNOON/EVENING IN REFERENCE TO ORD. THE PLAN WAS SOUND BASED ON THE ORD FORECAST AND THE TCF. WE WOULD HAVE LIKED TO SEE THE 2ND TIER AIRPORTS WEST OF ORD NOT INCLUDED IN THE GS, BUT THIS WAS DONE IN THE LATER GS FOR ZNY/ZDC/ZBW FLIGHTS. THIS WAS ONE OF THE BETTER HANDLED OSO,S IN THAT THERE WERE NO SURPRISES FOR AAL WHEN THE TMI,S WERE INITIATED AND WHAT WAS DISCUSSED IN THE PRIOR CONFERENCE. N90/ZAU/ORD TOWER ALL WORKED OUR TRAFFIC WELL TONIGHT.

ZJX	TMC	01:20	ZJX DAY SHIFT SUMMARY: AREA OF WEATHER THAT RAN NORTH AND SOUTH FROM THE COASTLINE OF MIA THROUGH ZJX IN THE ATLANTIC UP TO ZDC. THE SAME AREA OF WEATHER ALSO COVERED AS FAR WEST AT CEW AND RAN NORTH EAST PAST ILM. THE WEATHER IMPACTED MCO ARRIVALS AND DEPARTURES. LEESE GATE WAS SHUT DOWN, CAMDT DEPARTURES WERE ALSO STOPPED. THERE WERE SEVERAL REPORTS OF SEVERE TURBULENCE TONIGHT. NONE WITH INJURIES OR DAMAGE. LOTS OF DEVIATIONS DUE TO THE CONVECTIVE ACTIVITY. CENTRAL AREA WAS EXTREMELY BUSY. TMI'S WERE USED TO TRY TO CONTROL THE VOLUME. ROUTES: BEDMINSTER RTES / MMUN RTES / OHIO VALLEY AND MW TO FLORIDA / NE TO FLORIDA VIA J121 / STOP EAST COAST TO MIA AND FLL

17:19	SNTMO DAY SHIFT: THE MAIN AREA OF CONVECTION TODAY STRETCHED THROUGH THE GULF OF MEXICO TO THE MID-MISSISSIPPI VALLEY. THE TCF WAS ACCURATE IN THAT THIS AREA FIRED UP IN THE MORNING AND DISSIPATED IN THE AFTERNOON. THE RESULTANT INITIATIVES INCLUDED: L, M, AND Q-ROUTE CLOSURES, AS WELL AS TACTICAL ADJUSTMENTS INTO IAH FROM ZFW AND ZME. DCC ALSO ISSUED AN ARRIVAL ROUTE INTO ATL FOR THE MORNING ARRIVAL BANK. THE LINE IS NOW JUST WEST OF ATL AND MAY REQUIRE ADDITIONAL. ZTL HAS MILE IN TRAIL OUT ON AND WILL BE ADJUSTING THE FLOWS AS THE FRONT MOVES THROUGH THE TERMINAL AREA

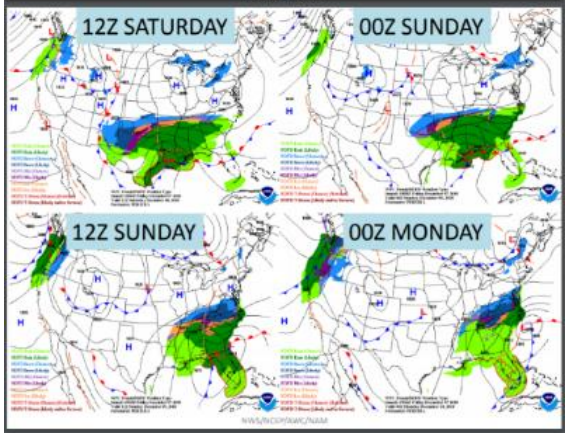
Significant Event Updates – Winter Weather Event

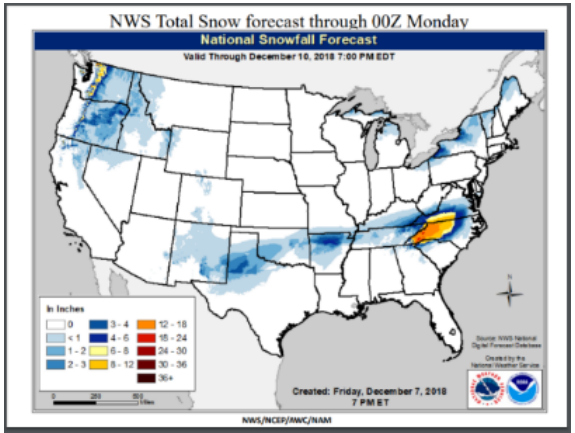
Southern U.S. Winter Storm
12/8/18 - 12/10/18
Issued 00Z SAT 12/8/18

Summary:

- Low pressure will develop tonight over southeast Texas and move east-northeast off the North Carolina coast by 00Z Monday. Winter precipitation will spread east from Texas/Oklahoma tonight across portions of Arkansas, Missouri, Kentucky on Saturday and across North Carolina and southern Virginia on Sunday.
- Significant accumulations of snow and sleet are likely across portions of northern Texas, northern Arkansas, Tennessee, Kentucky, North Carolina and Southern Virginia. Significant icing (freezing rain) is possible across upstate South Carolina, northeast Georgia and portions of North Carolina.
- The only major terminal with potential significant impacts at this time is Charlotte North Carolina.

NWS/NCEP/AWC/NAM





NWS Snow Amount Forecasts - Terminals

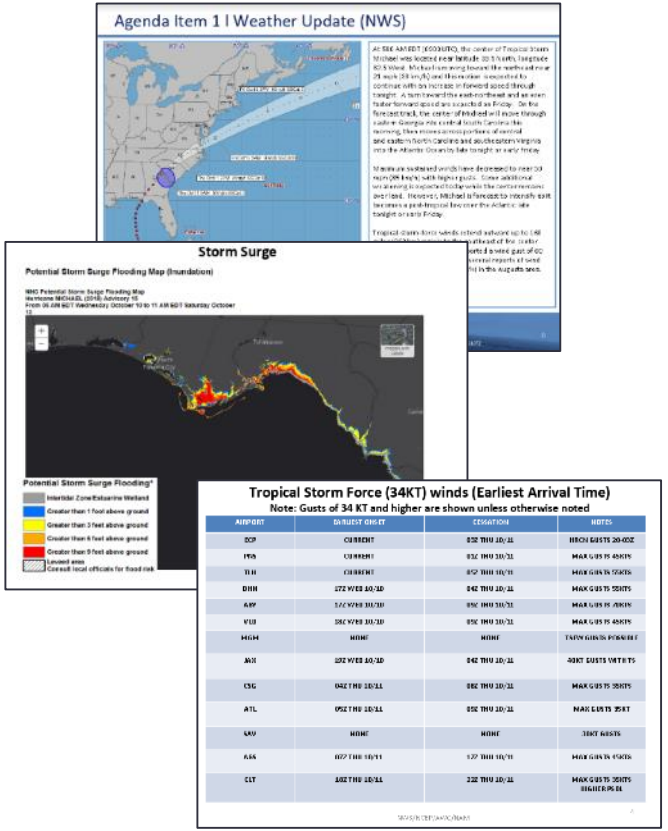
AIRPORT	SAT	SAT NGT	SUN	SUN NGT
OKC	Sleet/Snow. 1-2"	Flurries	NSW	NSW
TUL	Sleet/Snow. <1"	Flurries	NSW	NSW
ROA	NSW	Snow after midnight. 1"	Snow. 3-5"	Snow. 1"
LYH	NSW	NSW	Snow. 2-4"	Snow. 1"
RIC	NSW	NSW	Snow. <1"	Snow. <1"
RDU	NSW	Sleet/Snow. <1"	Sleet/Snow. 2-4"	Rain/Sleet/Snow. <1"
CLT	NSW	Snow/Sleet/FRZA. 2-4"	Snow/Sleet/FRZA. 3-5"	Snow/Sleet/FRZA. <1"

NWS/NCEP/AWC/NAM

JATOC/J-CAT Support

What is the JATOC Crisis Action Team?

- Part of the Joint Air Traffic Operations Command's (JATOC) Incident Command System
- NAMs provide support during J-CAT activation similar to NWS support to State/Federal Emergency Operations Centers
- Activation triggered by a wide spectrum of events, from civil unrest to natural disasters
- Routine support to ATO Watch Officer (AWO) continues when J-CAT not active (Twice per day updates)



Severe Weather Avoidance Plan (SWAP)

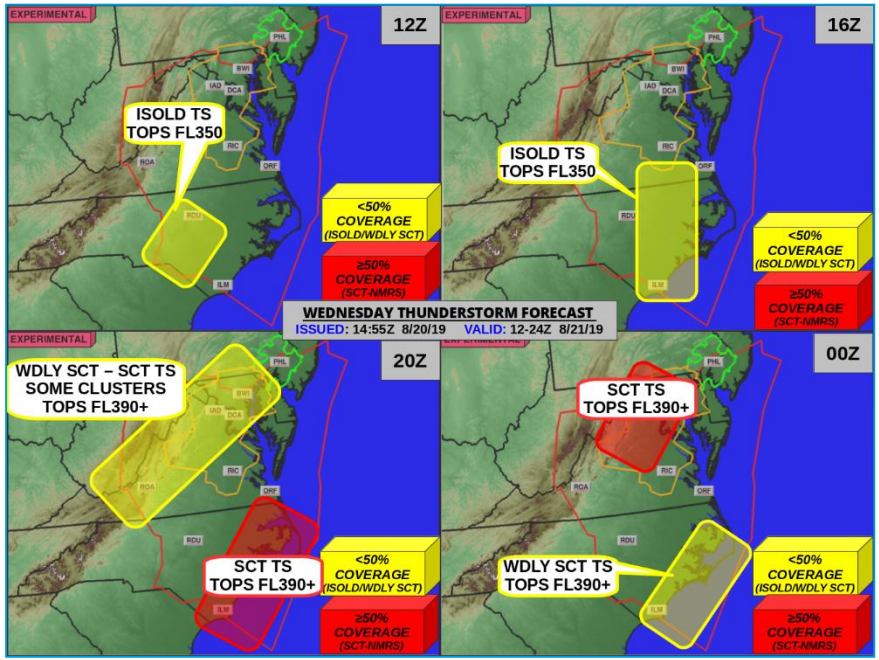
- A formalized program developed for areas susceptible to disruption in air traffic flow due to thunderstorms (provides the least disruption to the NAS)
  Note: This is not the same definition the NWS uses for severe weather

- Each facility (ARTCC) develops its own strategy for managing severe weather events (some develop joint plans with adjacent facilities) and alternatives to minimize/mitigate airspace impacts

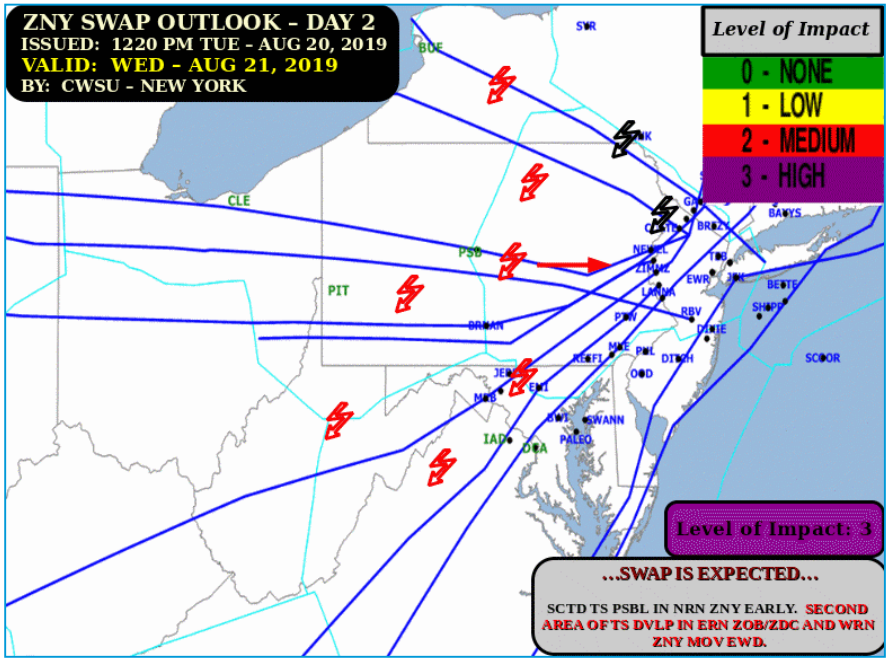
- Facility plans (SWAP statements) are delivered to the ATCSCC and may become part of the daily NAS Operations Plan (SWAP advisories)

- Responses are tailored to meet forecast/actual weather events: Planned Routes (open/closing highways) , Control Air Flow space by limiting the number of aircraft over a given time in a defined region

SWAP Outlook (ZNY/ZDC)



https://www.weather.gov/images/zdc/DAY1_IMPACTS.png



https://www.weather.gov/zny/SWAP_1

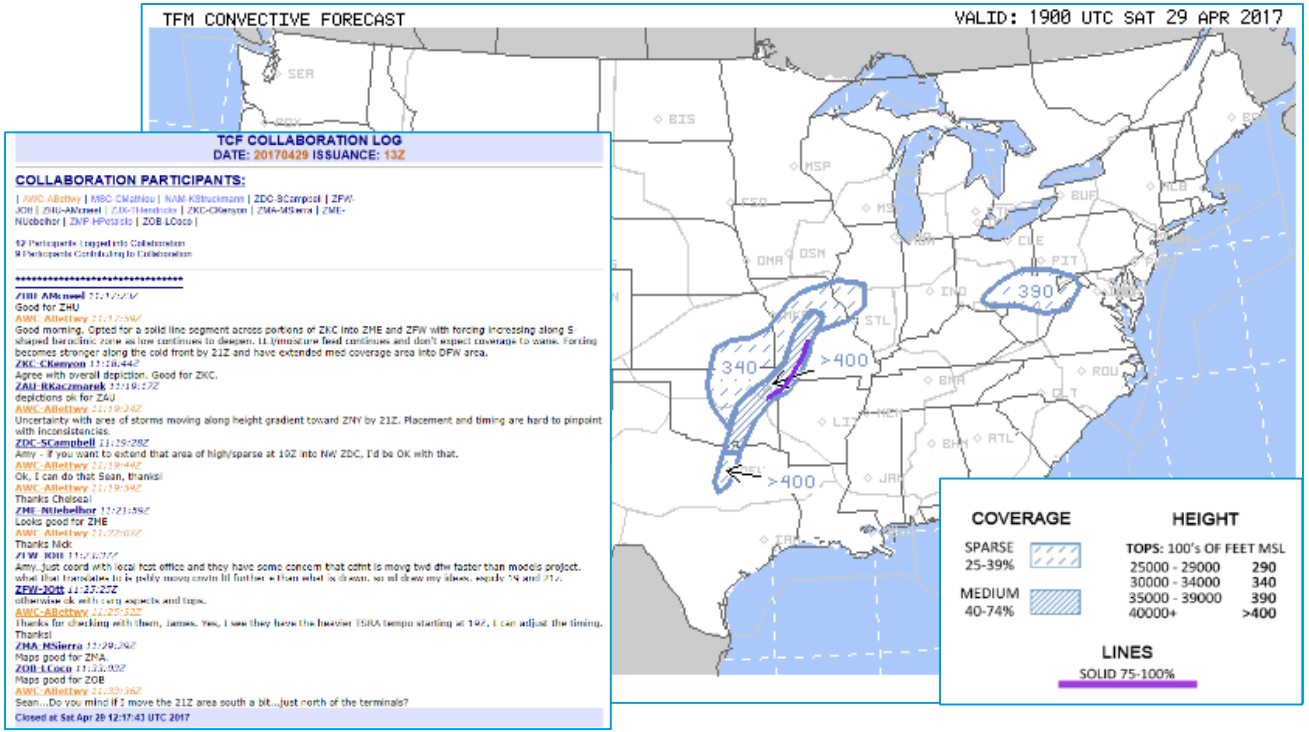
Traffic Flow Management Convective Forecast (TCF)

Collaborated forecast issued every 2 hours, 24/7
Forecast lead times of 4, 6, and 8 hours
High Confidence areas only…Does **NOT** account for lightning
Available on internal FAA systems and web (www.aviationweather.gov/tcf)

- Areal coverage ≥25% sparse, >40% medium
- Linear coverage ≥75%, ≥100NM
- ≥40dBz Reflectivity
- Echo Tops ≥FL250

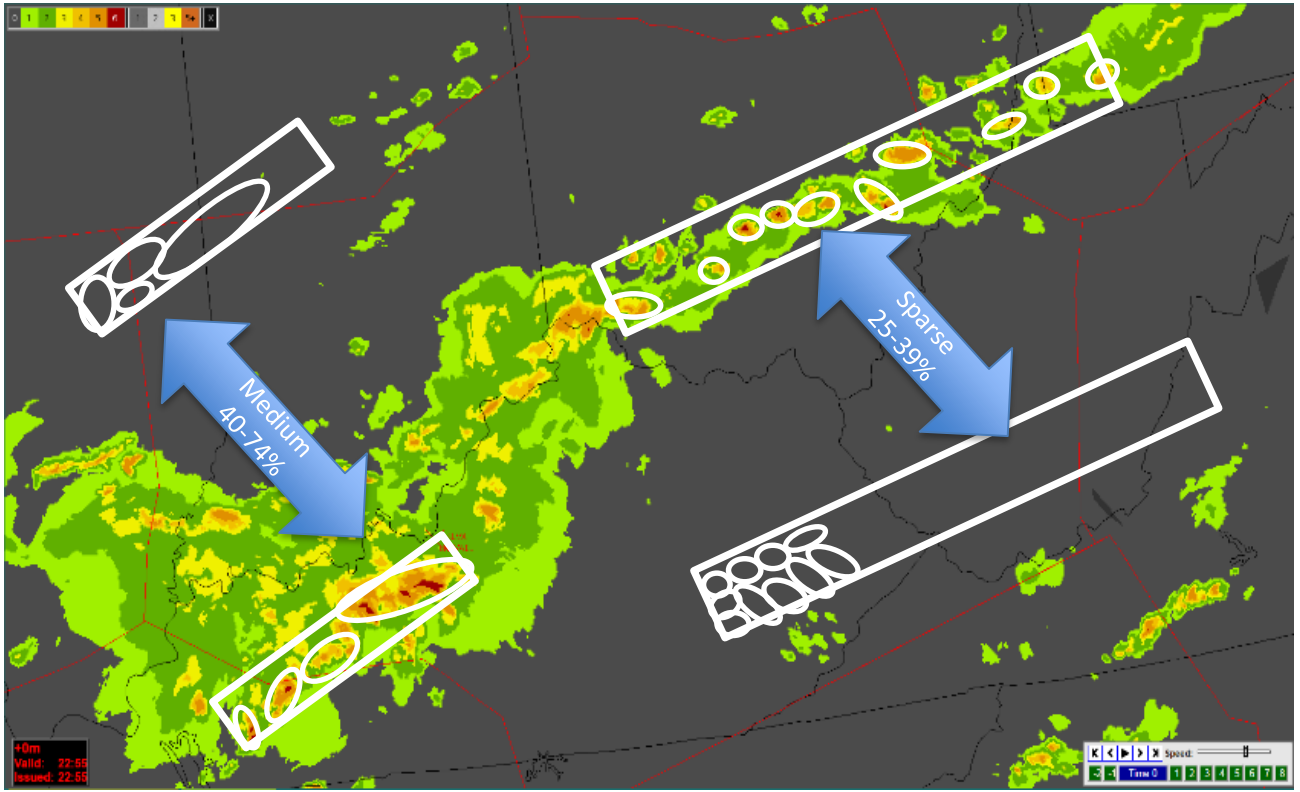
First Issuance: 1 March 0230 EST
Last Issuance: 31 October 1830 EDT
(Southern Ontario/Quebec: 1 Apr-30 Sep)
*Automated TCF continues Nov-Feb

Traffic Flow Management Convective Forecast (TCF)



Collaboration is vital! **TCF is the primary convective guidance for the FAA to determine Traffic Management Initiatives.**

TCF Coverage Example



TCF Echo Top Forecast

Does not represent maximum echo top height!

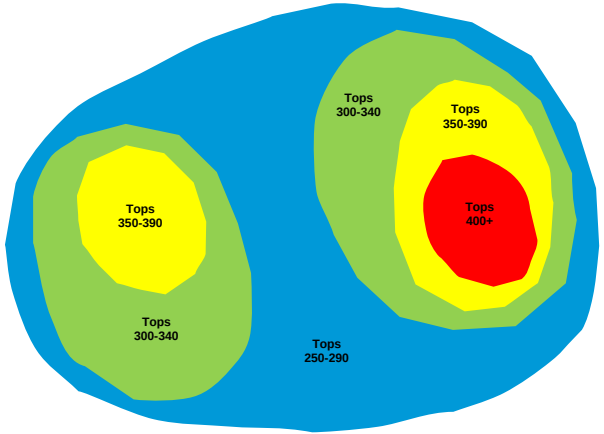
Represents the highest tops with coverage at least 25% within the polygon…
some tops could be higher.

TCF Echo Top Forecast

Start at highest tops and work down

Height	Total Area
400+	10%
350-390	20%
300-340	30%
250-290	40%

= 10% total area
= 20% total area
= 30% total area
= 40% total area



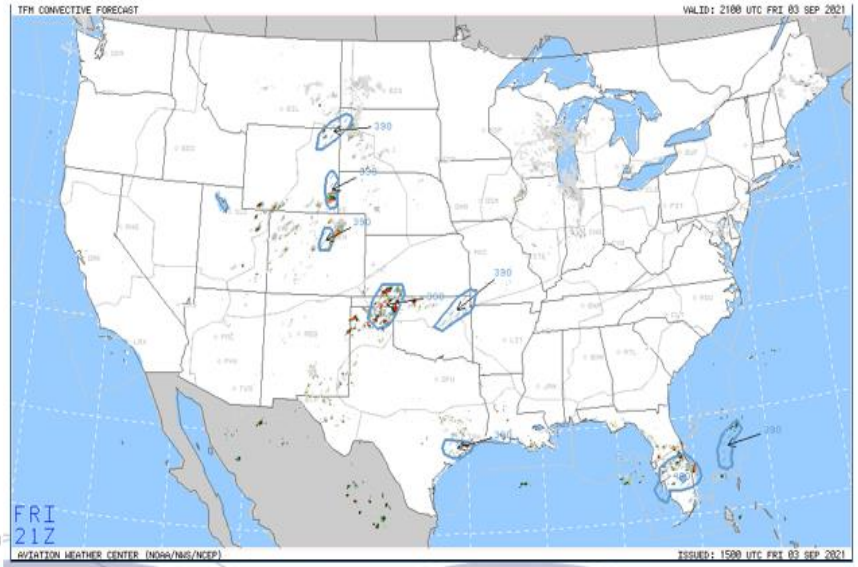
What is the first instance of ≥ 25% total area?

Echo tops forecast is 340

Per FAA feedback, FL320 is a critical level for operations.
Focus is given to this threshold while forecasting tops during the collaborative sessions.

TCF Verification and Daily Review

Fri Sep 3 2021



ATOSysOps

- Verified Well
  - ZMA (FL)
  - ZKC (OK/TX Panhandle)
- Verified Close
  - ZHU
  - ZDV
- Over-forecast
  - ZMA (Offshore)
  - ZKC (NE OK)
- Missed

https://www.aviationweather.gov/tcf/help

Federal Aviation Administration

Key Aviation Weather Websites

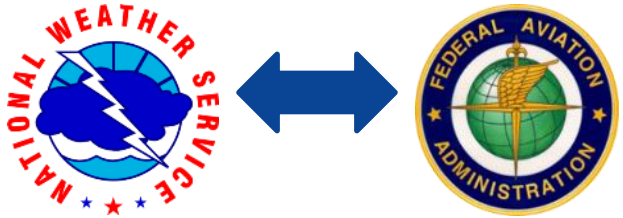
- https://www.weather.gov/aviation/
  NWS Aviation Weather Services Homepage
- https://www.aviationweather.gov/
  Aviation Weather Center Homepage
- https://www.aviationweather.gov/trafficflowmgmt/portal
  Traffic Flow Management Portal
- https://www.weather.gov/###
  Center Weather Service Units (### is ARTCC…e.g. zdc)\
- https://mobile.weather.gov/
  Mobile browser friendly page
- @NWSAWC
  AWC Social Media (Facebook & Twitter)

“First, it should be understood that forecasts possess no intrinsic value. They acquire value through their ability to influence the decisions made by users of the forecast.”

- Allan H. Murphy, Weather and Forecasting (June 1993)

“Weather is intertwined with nearly every decision we make.”

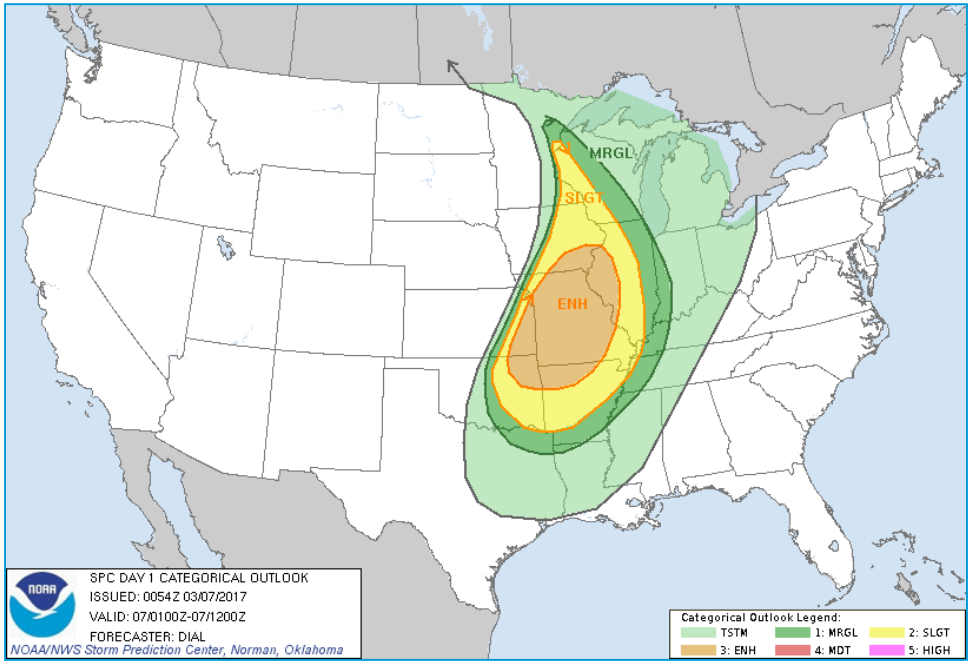
- Bryan Beck, ATCSCC National Operations Manager



Questions?

NWS Thunderstorm Products

Convective Outlooks Issued by SPC
(Out Through Day 8)

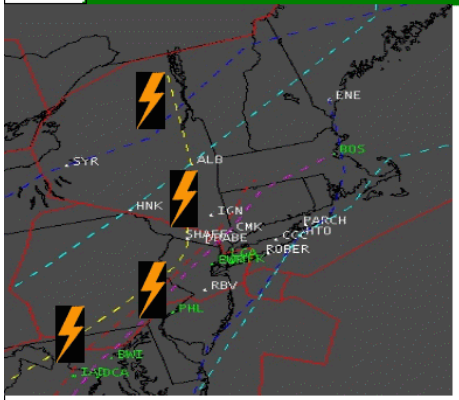


Days 1-2 Probability Outlooks for Tornado, Wind and Hail
https://www.spc.noaa.gov/products/outlook/

Arrival/Departure Gate Forecast (ZBW/ZNY/ZDC)

EXPERIMENTAL Graphical MIS – Domestic Arrival/Departure Fix Planning Forecast

CWSU BOSTON
Issued at: 2305Z SAT 17 AUG 2019
Next Update: 1300Z SUN 18 AUG 2019
Valid Times:
Start: 1800Z SUN 18 AUG 2019
End: 0300Z MON 19 AUG 2019



Fix	18Z-21Z	21Z-00Z	00Z-03Z
BUGSY	N	N	N
NOVON / TULEG / RAKAM	P	P	N
SYR/GOATR/GONZZ	P	P	N
HNK/DNY	P	L	N
ALB/CAM	P	L	P
IGN and VCY	N	P	P
GREKI/MERIT	N	P	P

BOS and Gates	18Z-21Z	21Z-00Z	00Z-03Z
BOS	N	N	N
SEETS/JFUND	N	N	N
OOSHN	N	N	N
PATSS / BLZZR / REVSS	N	N	N
PROVI	N	N	N
SSOXS	N	N	N

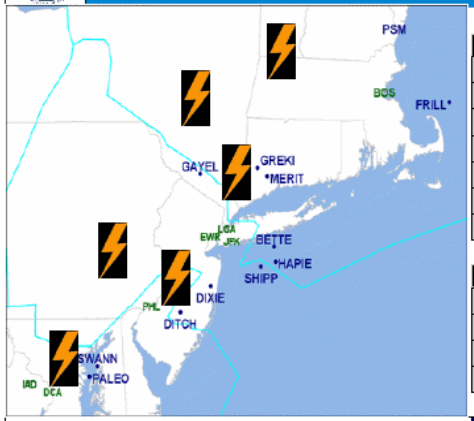
Discussion: Widely scattered to scattered thunderstorms are expected once again Sunday afternoon and evening from portions of NY into the Mid-Atlantic region and spreading eastward. Significant impacts are again possible.

Thunderstorm Probability	
NONE (N)	Less than 25%
POSSIBLE (P)	25-54%
LIKELY (L)	55-74%
EXPECTED (E)	75% or greater

This is an experimental graphic for domestic fixes in ZBW. Graphic will be issued along with IDGF at 1230z/2230z daily. Comments to zbw.operations@noaa.gov.

Northeast Corridor International Departure Gate Planning Forecast

CWSU BOSTON
Issued at: 2245Z THU 30 JUN 2016
Next Update: 1300Z FRI 01 JUL 2016
Valid Times:
Start: 1800Z FRI 01 JUL 2016
End: 0300Z SAT 02 JUL 2016



Gate	18Z-21Z	21Z-00Z	00Z-03Z
LBSTA (PSM)	N	P	L
CELTK (FRILL)	N	P	P
GREKI/MERIT	N	P	P
BETTE/HAPIE/SHIPP	N	P	P
GAYEL	L	L	P
DIXIE/DITCH	P	L	P
SWANN/PALEO	L	L	P

Core Airport	18Z-21Z	21Z-00Z	00Z-03Z
BOS	P	L	L
NY Metros	L	L	P
PHL	L	L	P
DC Metros	L	L	P

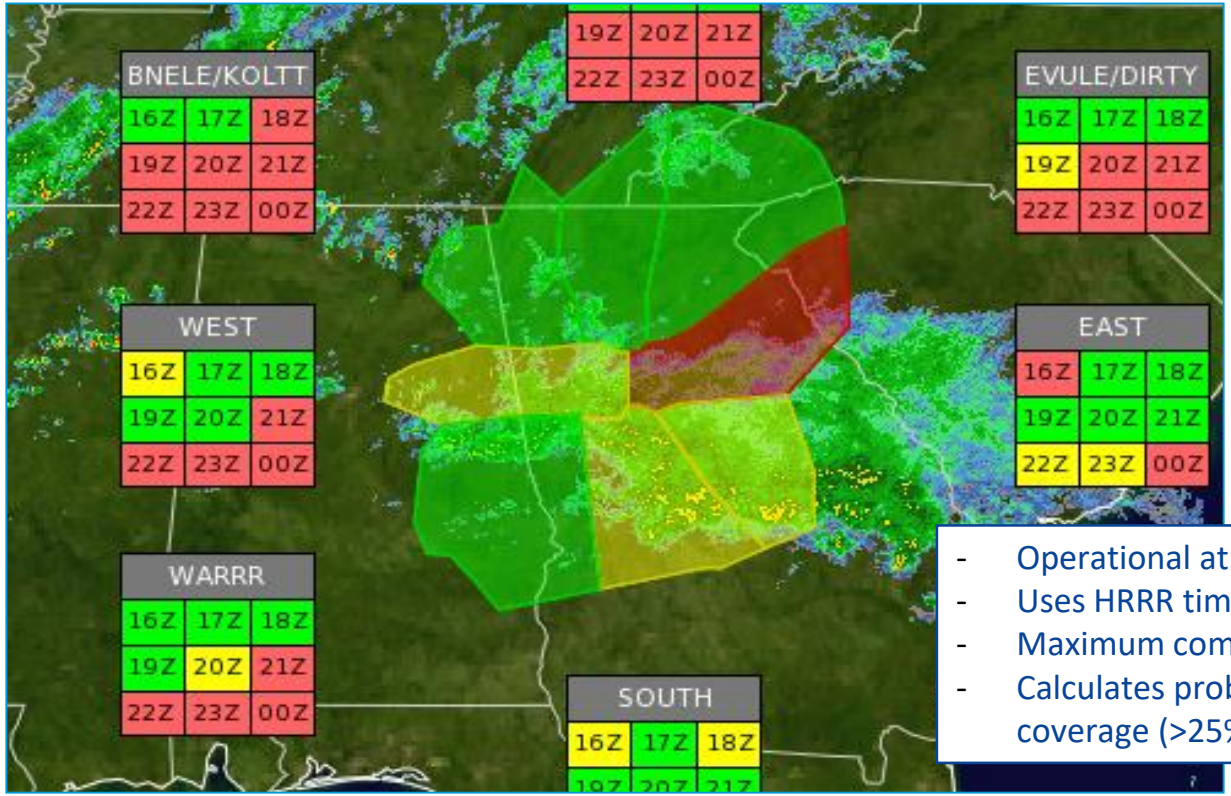
Discussion: An approaching cold front will combine with an increasingly moist and unstable air mass to result in SCT-NMRS TSRA across much of the Northeast Corridor during Friday afternoon and evening. Significant aviation impacts are likely... especially for the NY Metros...PHL and their associated Gates southwestward through the DC Metros and Gates. High confidence forecast on TS location and coverage.

Thunderstorm Probability	
NONE (N)	Less than 25%
POSSIBLE (P)	25-54%
LIKELY (L)	55-74%
EXPECTED (E)	75% or greater

http://www.nws.noaa.gov/survey/nws-survey.php?code=EIADGF

https://www.weather.gov/zbw/IGF

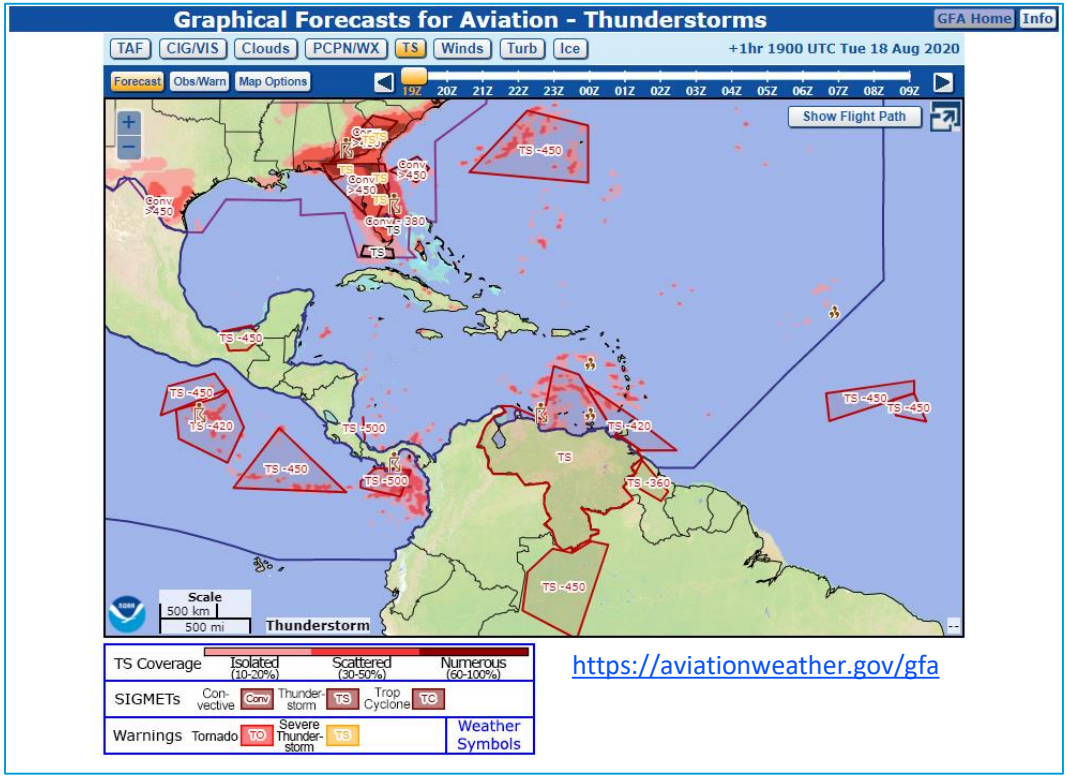
TFM Gate Forecasts



- Operational at 14 sites…automated
- Uses HRRR time-lagged ensemble
- Maximum composite reflectivity
- Calculates probability, gate sector coverage (>25% yellow, >60% red)

https://www.aviationweather.gov/trafficflowmgmt/gate

Graphical Forecasts for Aviation (GFA)



https://aviationweather.gov/gfa

TCF Summary

Issuance	24 x 7, every 2 hours	Collaborated 60-90 min prior
Source	AWC Webpage/TSD	
Forecast Projections	4, 6, 8 hours	
Confidence/Coverages	High Confidence Sparse High Confidence Medium Solid Line	*25% to 39% coverage* *40% to 74% coverage* *75% and higher*
Access	TSD and Web	www.aviationweather.gov/tcf
Graphic / Text	Graphic only	

Numerical Weather Prediction

There Are Many Weather Models

US

- GFS/GEFS
- NAM (3, 12, 36 km)
- RAP
- HRRR & HRRR-X
- WRF - ARW
- WRF - NMM
- NSSL - WRF
- LAMP/LAMP-X
- SREF

Others

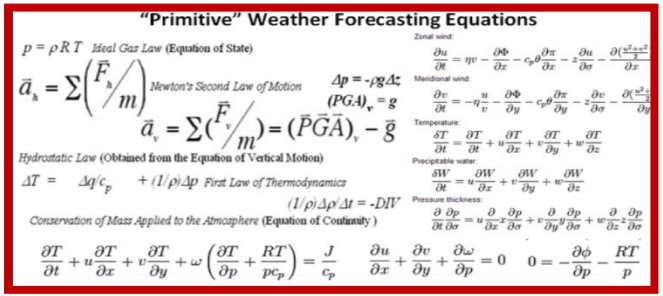
- ECMWF
- UKMET
- CMC
- RGEM
- NOGAPS
- NAVGEM
- JMA

Numerical Weather Prediction

- Gives snapshots and/or animations of future state of atmosphere
- Requires **significant experience / training** to correctly interpret model output
  - Scientific basis / knowledge of how models work
  - Systematic biases, strengths, weaknesses
  - Comparison with current weather to cross-check initialization
  - “Reasonableness” (smell-test)
  - Dprog/Dt : i.e. trends
- There are dozens of models out there…which one is the right one?

Deterministic vs. Probabilistic

- **Probabilistic - <u>establishes a likelihood for a particular event</u>**
- **Benefits to Probabilistic approach – many scenarios are considered, and the "most likely" solution is presented**

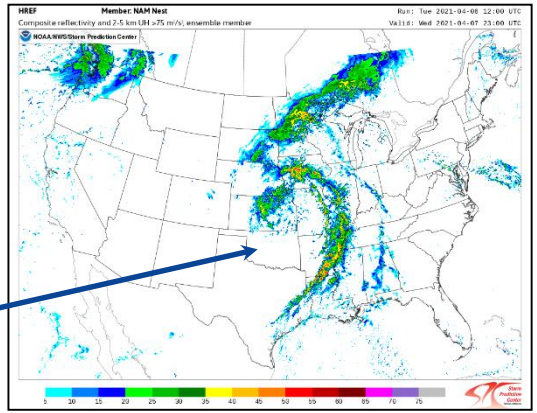


- **Deterministic - <u>every event is the result of known inputs</u> (Ex: predicting a bank account balance…you know the initial deposit and the interest rate)**
- **In weather, there can be <u>hundreds</u> of inputs!**
- **Benefits to deterministic models – one solution!**
- **Drawbacks – that one solution probably isn't correct!**

Deterministic vs. Probabilistic

HRRR/NAM/WRF/NMM
and most Global models
are deterministic

Forecast Reflectivity
(snapshot of what
the radar is expected
to look like)



SREF, HREF, and LAMP
are Probabilistic

TSRA Probability
(areas most likely to
see convection)