The FAA's Convective Weather Research Program

January 23, 2017

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FAA

NextGEN

Presentation Overview

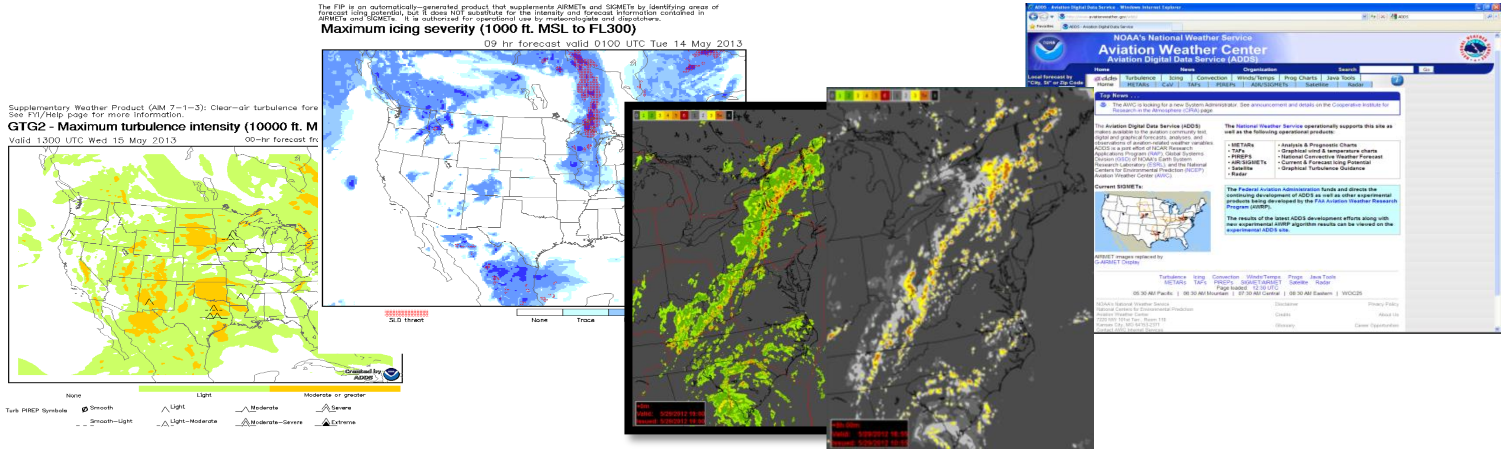
- FAA organizational overview
- Convective Weather Research Program mission and goals
- Current convective weather research projects
- Challenges

Federal Aviation Administration

- FAA Mission: Provide the safest, most efficient aerospace system in the world
- Next Generation Air Transportation System (NextGen): National Airspace System (NAS) being implemented across the United States by the FAA
  - NextGen transforms America's air traffic control system from a ground-based system to a satellite-based system
  - Satellite-enabled technology is used to shorten routes, save time and fuel, reduce traffic delays, increase capacity, and permit controllers to monitor and manage aircraft with greater safety margins
  - A major component of NextGen is improved weather support
    - Stovepiped systems consolidated into a single national weather information system, updated in real time
    - Common weather picture across the NAS to enable better air transportation decision making

Timely, accurate weather information is critical in operational decision-making for pilots, controllers, flight operators, and airport operators

Aviation Weather Research Program (AWRP)



- Research to minimize the impact of weather on the NAS via:
  - Programs to meet specific NextGen Operational Improvements in NextGen Implementation Plans
  - Collaborative, complementary initiatives with National Weather Service (NWS) to transition legacy capabilities to meet NextGen requirements
  - Focused projects to help mitigate safety and/or efficiency issues associated with well-documented weather problems

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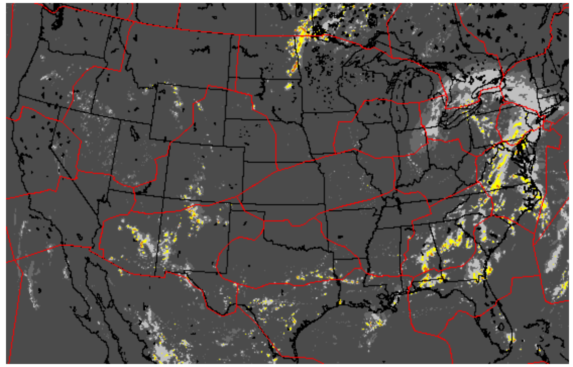
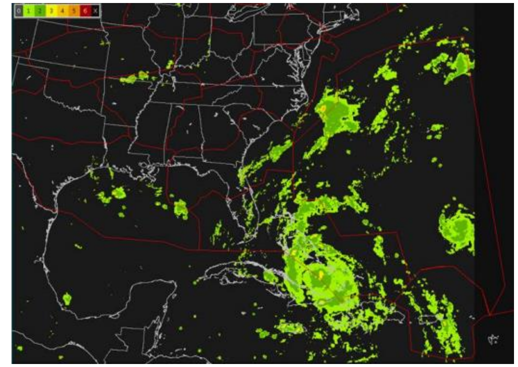
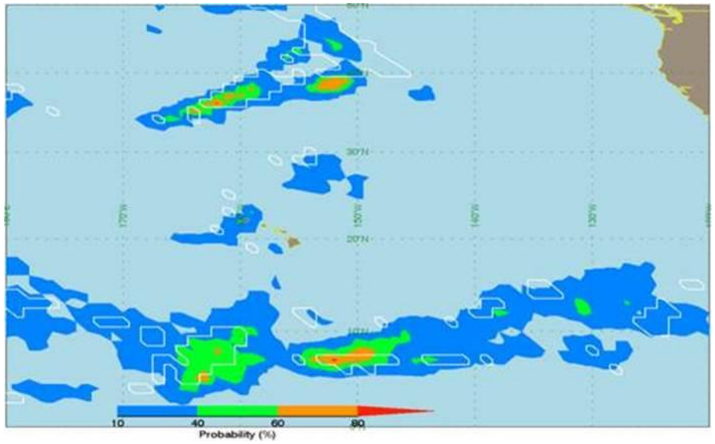
Convective Weather Research Program

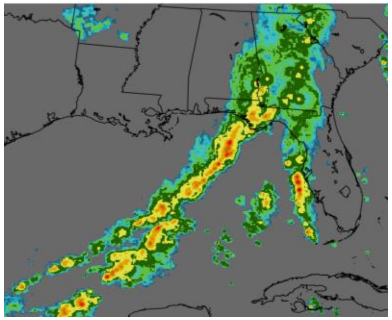





- The mission of the program is to provide improved thunderstorm analyses and forecasts that enable more efficient use of available airspace, thus increasing NAS efficiency, capacity, and safety
- The program manages and funds research projects that:
  1) Explore how thunderstorm information is used to make decisions and assess the need for improved information
  2) Increase the fundamental understanding of how thunderstorms form, behave, and impact the NAS
  3) Develop advanced thunderstorm analysis and predictive capabilities

Convective Weather Research Program

- Not just research for research sake
  - Ensure that convective weather algorithms, products or methods developed through the research program are scientifically accurate
  - Provide value in terms of forecast worth to the individual decision-maker within their operational aviation decision processes
  - Can be transitioned to appropriate FAA or NWS systems





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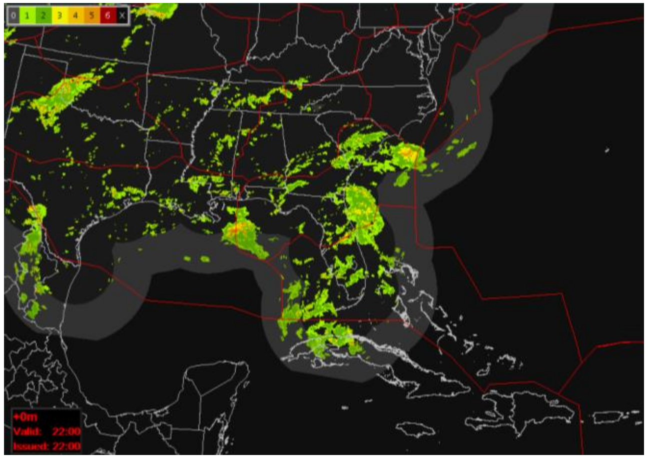
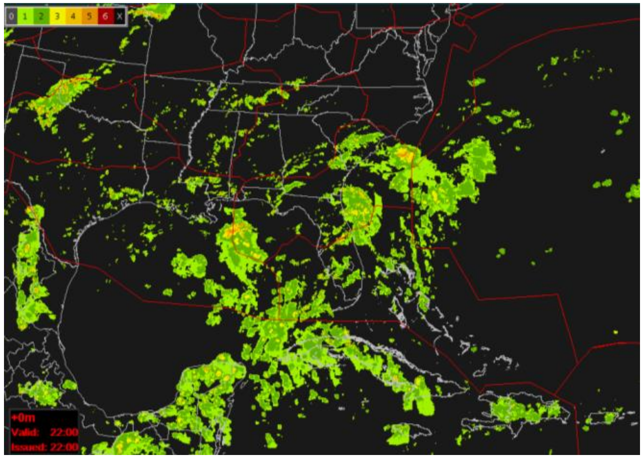
Offshore Precipitation Capability (OPC)

- OPC blends weather satellite imagery, lightning data and weather model data to produce a near-real-time estimate of convective and non-convective precipitation for areas that lack radar coverage
- Machine learning techniques and updated data are used to create new images at intervals of about 5 minutes, can be refreshed every minute or better
- Merged seamlessly with NEXRAD data
- Initial domain is Caribbean, Gulf of Mexico and Western Atlantic Ocean
- MIT Lincoln Lab (MITLL)

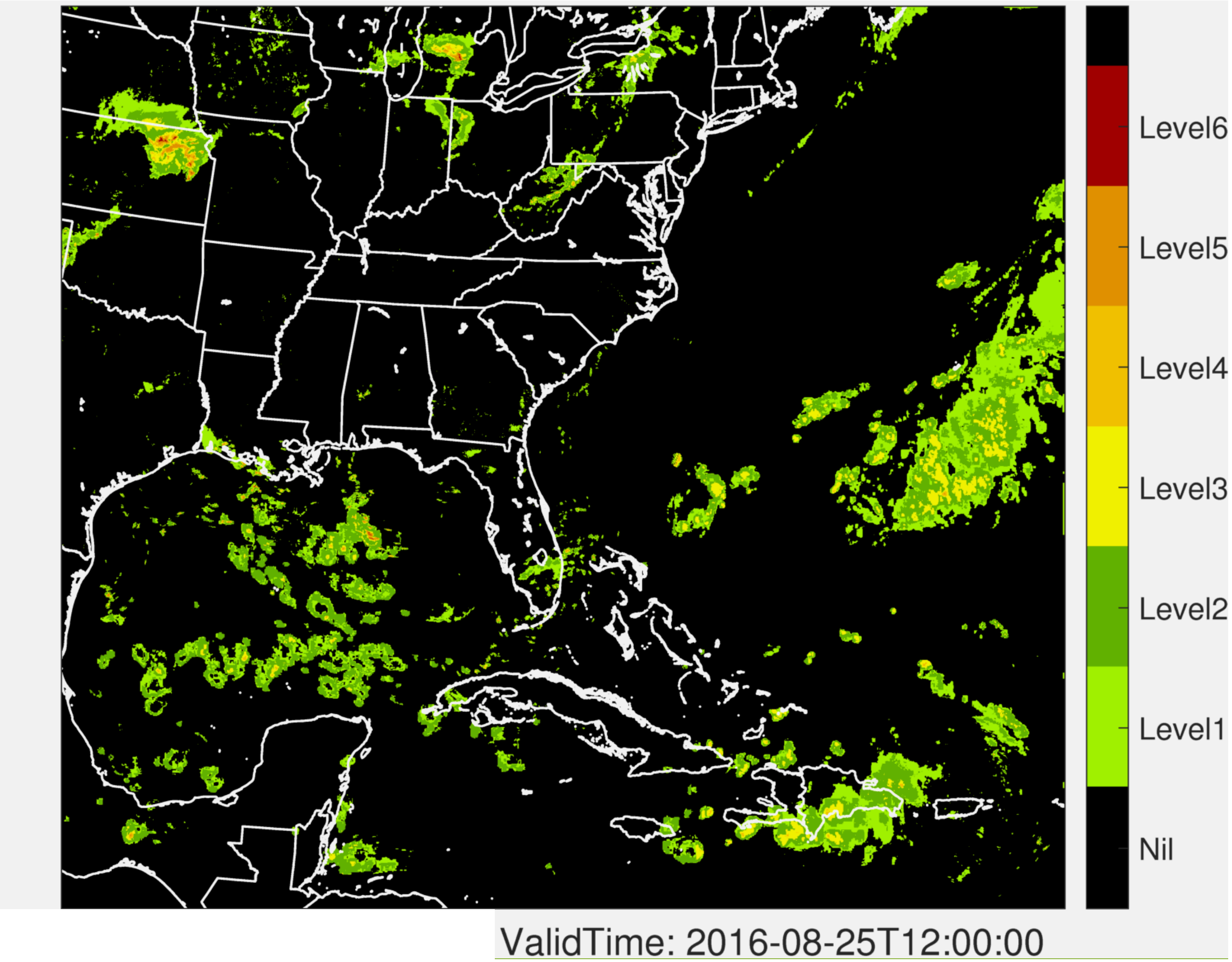


NEXRAD Only



Merged OPC and NEXRAD

OPC Aug 25th 2016

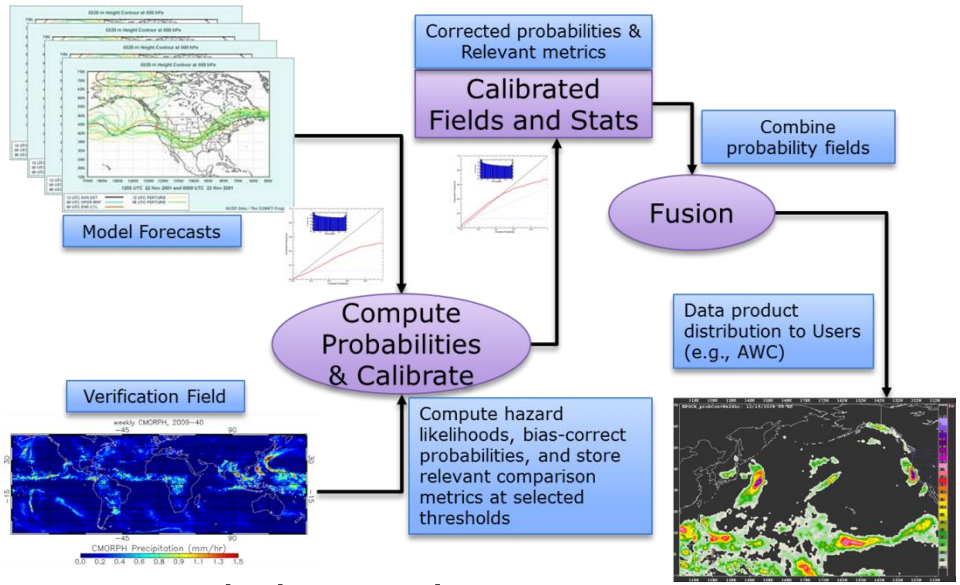


Future OPC Work

- Integrate GOES-R imagery and Geostationary Lightning Mapper data into OPC
- Safety risk assessment and additional quality assessment
- Expand the OPC geographical domain
  - Pacific area: Guam and Hawaii potential candidates, testing with Himawari data
  - US West Coast
- Transition to operations
  - Use website as interim solution for ATC facilities – use output as guidance
  - Integrate into FAA’s NextGen Weather Processor (NWP) Work Package #2 (2021-2022)
  - Initial discussions with NWS on transition
  - Interest by Coast Guard, DoD, energy companies, shipping companies, etc.

Ensemble Prediction of Oceanic Convective Hazards (EPOCH)

- Global-scale probabilistic convection forecast guidance out to 48 hours to support strategic planning of transoceanic flights in coordination with World Area Forecast Centers (WAFC)
- Forecasts are generated by harvesting global ensemble model output from select Numerical Weather Prediction centers around the world
- Optimally combines forecast information from multiple weather model ensembles into a single, reliable, calibrated forecast depicting the chance of aviation-impacting convection to occur at a given location and time
- National Center for Atmospheric Research (NCAR)



Ensemble Prediction of Oceanic Convective Hazards (EPOCH)

- **Product(s)**: Likelihood (0 to 1) of thunderstorm occurrence and convective cloud tops exceeding 30, 35, and 40 kft
- **Inputs:** CMCE and GEFS global ensembles
- **Status**: Beta Testing

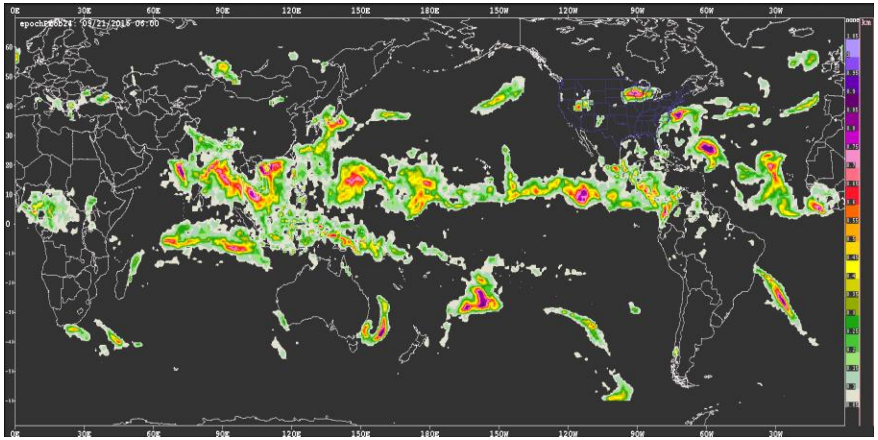
Features (driven by underlying models):

- **Forecast Lead Time Range**: 12h to 48h with 6 hour resolution
- **Update Rate**: 0Z, 6Z, 12Z, 18Z
- **Domain:** 0E – 360E, 60S – 60N; 1 degree resolution
- **Calibration**: Automated first order unconditional bias correction

Methodology:

- Based on number of ensemble members jointly exceeding specified thresholds for fields of interest (Accumulated precip, CAPE; and Outgoing Longwave Radiation)
- Model-specific thresholds chosen based on comparisons with CMORPH and CTH

Output format: GRIB2



Future EPOCH Work

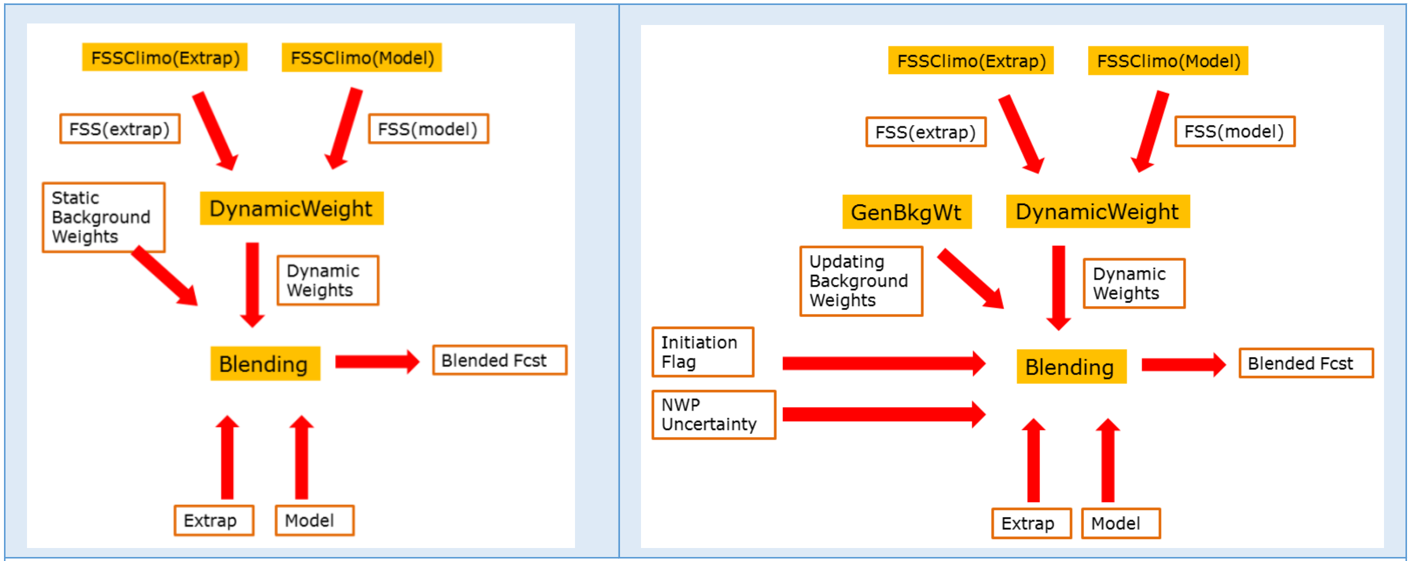
- Develop and test the regional calibration capability
- Conduct independent quality assessment
- Establish a near-real-time feed of the UK Met Office Global/Regional Ensemble Predication System (MOGREPS) to support a pseudo-operational WAFC EPOCH configuration
- Investigate first data from GOES-R in providing benefits to proxy-truth field
- Coordinate with WAFC and potentially host nations to obtain, integrate and test additional international weather model data in the algorithms

Forecast Model Blending Improvements

- Provide blending upgrades for the 0 – 8 hour convective forecast to be used as part of the FAA's NextGen Weather Processor (NWP)
- Goals:
  - Improve the performance (skill and continuity) of both the Vertically Integrated Liquid (VIL) and Echo Top (ET) forecasts in the 1-4 hour outlook period
  - Smooth transition between radar mosaic extrapolation and weather forecast model by eliminating the artificial start lead time of the blending at 2h15m of the forecast
  - Enhanced heuristic treatment of storm initiation and growth nowcasts
  - Earlier introduction of modeled storm forecasts in areas where time-lagged ensemble indicate high probability of an initiation event or storm growth
- Joint between MITLL and NCAR

Forecast Model Blending Improvements

- Technique/process is model agnostic



Schematic showing inputs (open rectangles) and algorithms (rectangles with yellow-orange fill) that produce inputs needed by the blending algorithm. Schematic on the left shows the current configuration and schematic on the right shows the new version of the blending that will be implemented in NWP Work Package 2.

Future Blending Work

- Finalize code updates, including improvements in the treatment of storm initiation and growth in blended forecasts
- Conduct quality assessment
- Update documentation to reflect latest changes to the software
- Perform technology transfer via coordination with FAA Program Management Office

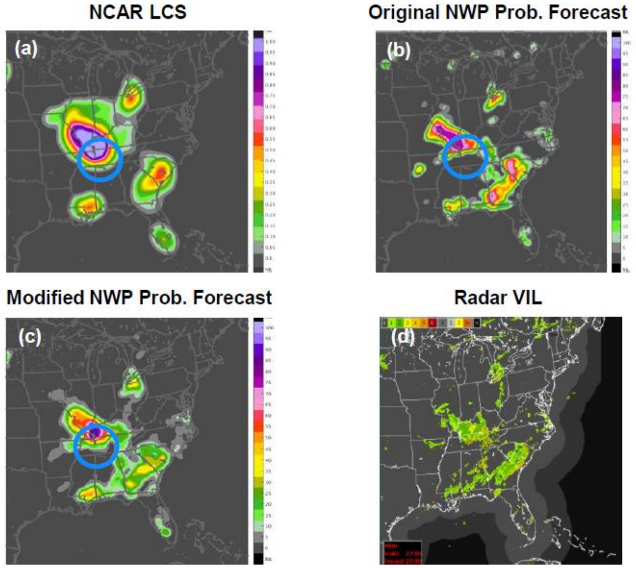
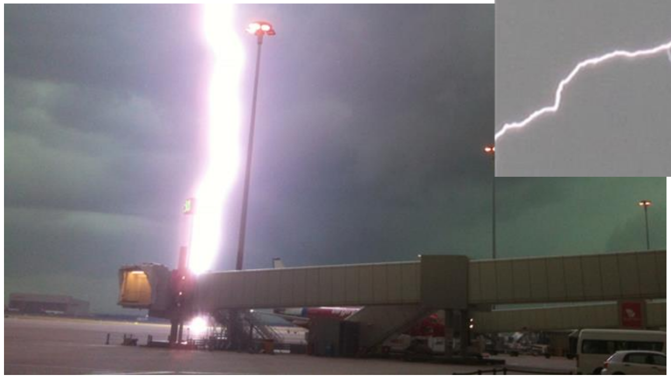


Figure 1. Comparison of the a) LCS field from NCAR with the b) original NWP probabilistic forecast and c) the modified NWP probabilistic forecast. This example is a 4 hour NWP probabilistic forecast made 18 UTC 6 July valid at 22 UTC. The modified forecast extends unto an area of predicted convection into TN (blue circle) which better matches the LCS field and d) the radar observations at 22 UTC. Note: NWP probabilistic values range from 0-100%, and the LCS can exceed 100%.

Lightning Impacts

- Assess the impact of airport ramp closures due to lightning on the NAS
- Identify key shortfalls and potential opportunities associated with improved lightning threat awareness for airport operations
- Develop lightning safety procedures that seek to optimize both safety and operational efficiency
- Joint between NCAR and AvMet Applications, Inc

A380 approach to Heathrow



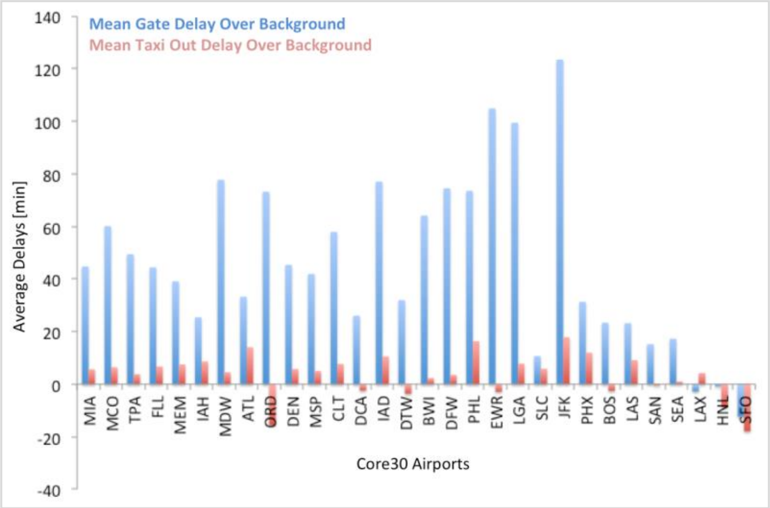
Lightning Impacts

- Major airports employ safety procedures that include observations and warnings of the onset and duration of lightning hazards
- However, there are no standardized lightning warning and ramp closure guidance for airports in the US, which yields situations where stakeholders utilize lightning information obtained from different sources (i.e., commercial vendors) and employ different procedures, sometimes at the same airport
- Many regional and small airports have no established lightning warning procedures in place at all

Rule	*Critical Distance (miles)*	*Waiting Period (min)*
1	3	6
2	3	10
3	5	10
4	5	15

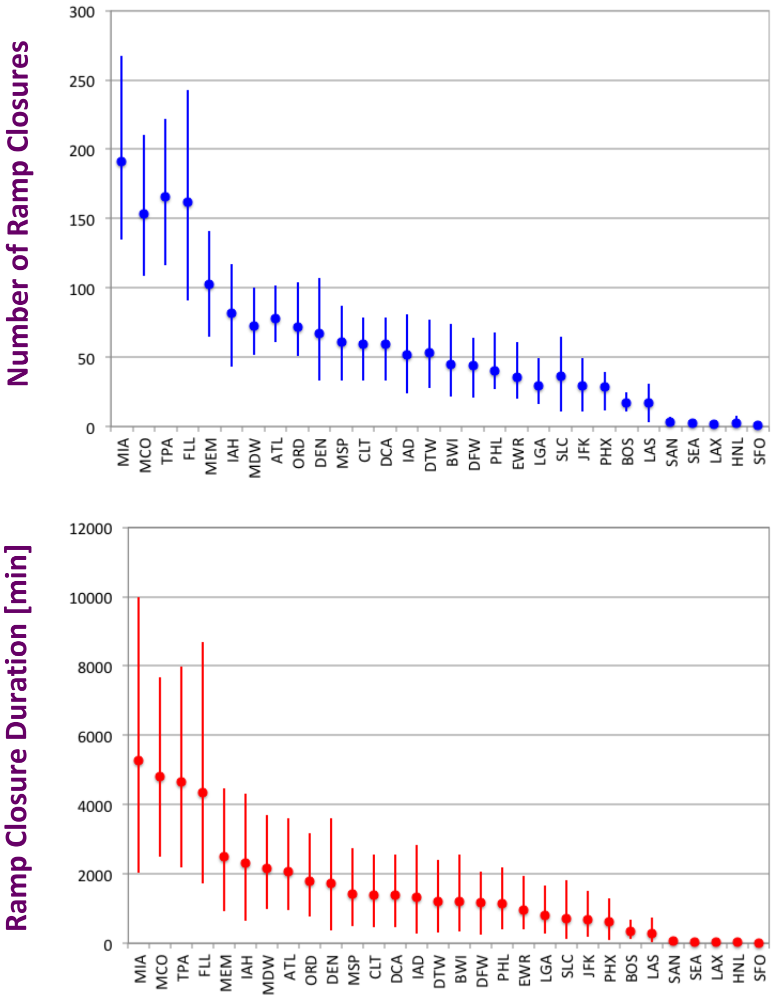
Commonly used safety rules

Mean gate departure and taxi out delays due to ramp closures for which average background delays were subtracted



Future Lightning Work

- Complete simulations of operational impacts and lightning risk analysis
- Conduct a service analysis on using lightning prediction methods instead of traditional lightning detection systems
- Develop guidelines and procedures for implementing lightning warnings that can be tailored for individual airports
  - ➢ In collaboration with FAA Airport Engineering Division and American Association of Airport Executives



30 major US Airports

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Challenges

- **Uncertainty –** How do we integrate uncertainty into convective weather products? Complex challenges need to be better clarified regarding not only uncertainty attributes of weather products but also the ability of NAS decision makers to apply uncertainty information
- **Integration** – Translating weather information into decisions and decision support tools
- **Role of Human forecaster versus need for automation** – Human-in-the-loop not going away anytime soon; how do we develop automated products while still taking into account the human's continued role in forecasting and decision making?

We welcome the opportunity to work with other agencies on convective weather research projects. Please contact me with questions or ideas

Convective Weather Research Presentations at AMS Annual Meeting

- OPC
  - Convective Weather Forecasts and Applications for Aviation
    - Monday, 23 Jan; 11:15 AM; Tahoma 3
    - Haig Iskenderian, MITLL
  - Using Convolutional Neural Networks to Create Precipitation Analyses for Aviation
    - Tuesday, 24 Jan; 4:15 PM; Skagit 2
    - Mark Veillette, MITLL
  - Enhanced Precipitation Estimation using GOES-16
    - Thursday, 26 Jan; 2:00 PM; Yakima 2
    - Chris Mattioli, MITLL
- EPOCH
  - Ensemble Prediction of Oceanic Convective Hazards
    - Monday, 23 Jan; 4:45 PM; Skagit 2
    - Ken Stone, NCAR

Convective Weather Research Presentations at AMS Annual Meeting

- Blending
  - Using model ensemble-based uncertainty information to blend modeled and extrapolated forecasts of convection
    - Monday, 23 Jan; 1:45 PM; Skagit 2
    - James Pinto, NCAR
- Lightning
  - A Location-Specific Lightning Risk Assessment Framework and its Application to Airport Ground Operations
    - Wednesday, 25 Jan; 9:45 AM; Tahoma 1
    - Matthias Steiner, NCAR
  - In Search of Effective Ramp Management Balancing Lightning Safety with Operational Efficiency
    - Thursday, 26 Jan; 3:30 PM; Skagit 2
    - Wiebke Deierling, NCAR

Questions?

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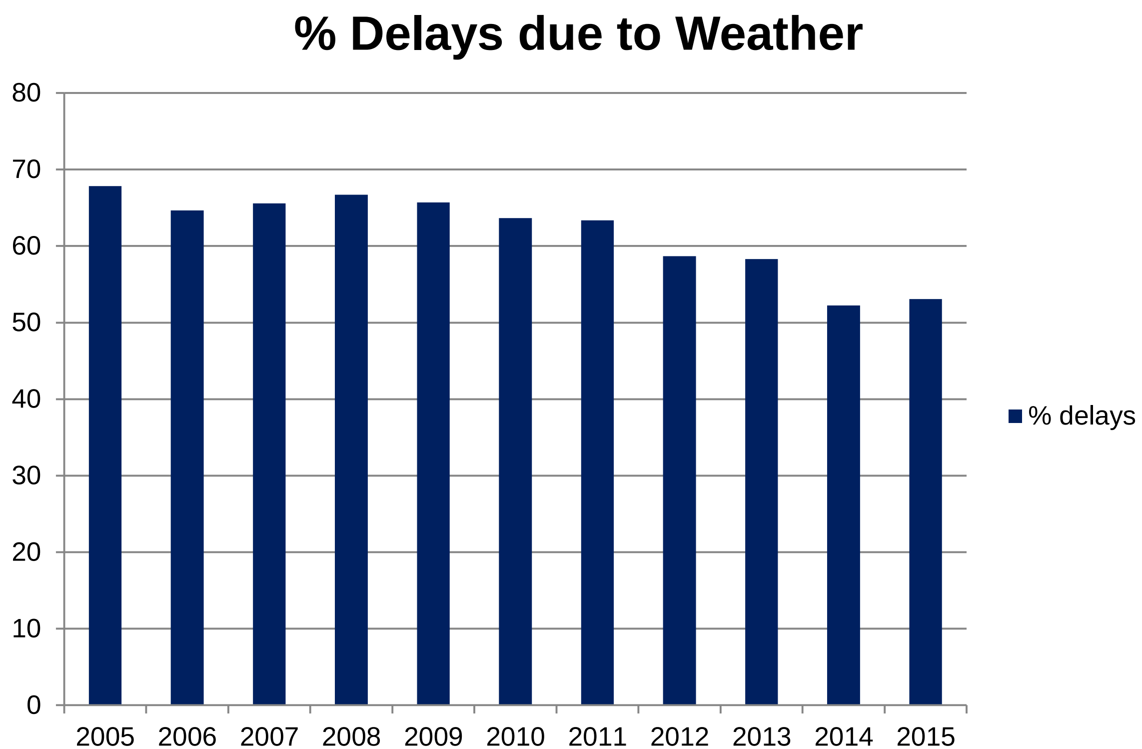
Delays Due to Weather



SOURCE: Federal Aviation Administration OPSNET

Airline delays in the National Airspace System (NAS) due to weather have steadily decreased since 2008 but still constitute the majority of all delays. Over 168,000 weather delays occurred last year.

Aviation Weather Division

- The FAA's Aviation Weather Division (AWD) supports weather-dependent Operational Improvements (OI) and Operational Sustainment (OS) integration in the NAS by leading shortfall analyses, concept and requirement definition, enterprise system engineering, and solution prototyping and evaluation
  - Aligns and manages the weather research portfolio toward new concepts/capabilities that reduce the impact of weather in the NAS
  - Represents U.S. MET Authority on International coordination/harmonization activity
- Assures development and integration of productive weather information into Air Traffic Management (ATM) decisions by pilots, controllers, flight operators, and airport operators through orchestration of:
  - Better quality weather information
  - Better access to weather information
  - Better utilization of weather
    - information