Turbulence Research in AWRP:

Current initiatives and future challenges

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Outline

- FAA's Aviation Weather Research Program (AWRP) sponsored initiatives
- Research Evolution Plan (REP) priorities
- Issues and Challenges as we move forward

FAA Aviation Weather Research Program (AWRP) Turbulence Goals

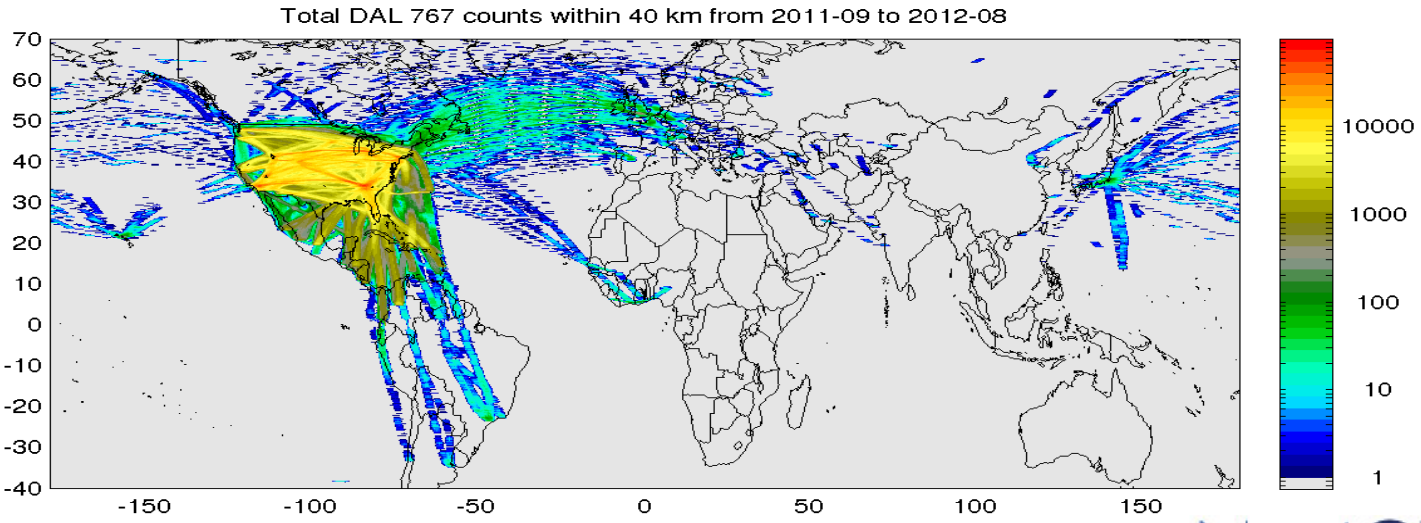
- Enhance NAS safety and increase capacity/efficiency through improved observation and forecasting of turbulence for strategic and tactical use by traffic flow managers, flight crews, and airline dispatch operators.
- To quantify the benefits of providing such data in order to determine the most cost effective and optimal solutions for integrating turbulence data into flight operations.
- AWRP-funded efforts
  - Improve and expand on current turbulence forecast capabilities
  - Support the development of the operational capability to remotely sense turbulence (i.e., satellites and radar)

Turbulence In Situ Observations

Eddy Dissipation Rate (EDR) Turbulence Detection Algorithm

- Software loaded on the Aircraft Condition Monitoring System (ACMS), uses existing sensors to derive a measure of atmospheric turbulence
- Provides turbulence metric: EDR - $\varepsilon^{1/3}$ ($m^{2/3}/s$), scale 0.0-1.0
- Aircraft independent
- Current deployment:

UAL: 72 757s, SWA: 1 737, DAL: 83 737s, 31 767s (~80 when complete)



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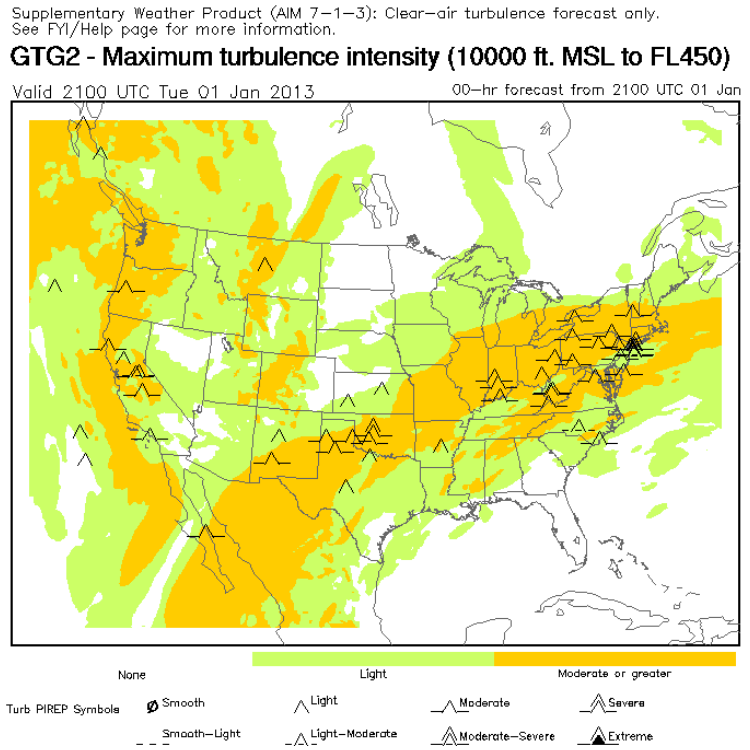
AWRP Turbulence Forecast Product Development
Graphical Turbulence Guidance

- Current Operational Version
  - Gridded high resolution (13 km) forecasts of turbulence for FL100-450
  - Available as a preflight tool on Operational Aviation Digital Data Service (ADDS)
  - Includes EDR observations as input
- Planned Enhancements
  - Explicit Mountain wave turbulence forecasts for all levels Sfc – FL450 (CY14)
  - “Nowcast” capability (CY14)
  - Satellite feature detectors
  - Convectively-induced turbulence
  - Probabilistic?



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The Research Evolution Plan (REP)

- **Purpose:** Provide overarching guidance and strategic direction to facilitate the ***identification***, ***selection***, ***prioritization***, *and* ***effective management*** of applied aviation weather research
- **Scope:** Foundational guidance for the AWRP and its aviation weather research partners during the planning and execution of focused, annual research projects.
- **Goal:** Harmonize end-user priorities in the shorter-term to NAS Enterprise Architecture (EA) and longer-term NextGen goals by developing a widely accepted R&D evolution strategy
  - Describe, when possible, specific deliverables, or incrementally improving line of deliverables in the short/mid-term that have line of sight connectivity to far-term NextGen goals
- REPs have been completed for C&V, Turbulence, In Flight Icing, and Convective Weather. REPs planned for next 15 months include Terminal Winter Weather Impacts, Terminal Winds, Numerical Modeling, and QA.

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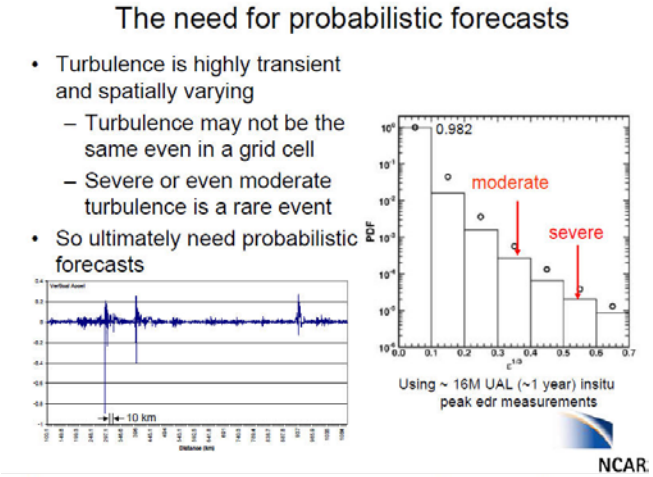
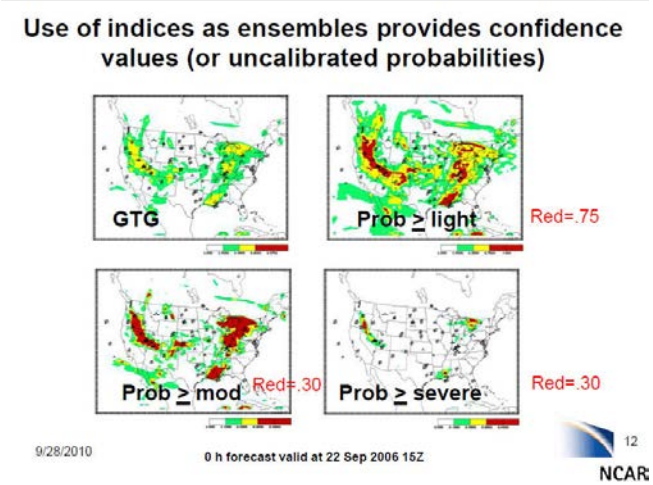
Top Priorities in the TURB REP

- Turbulence Priority Recommendation One
  - Implement GTG3 and determine if it is accurate enough for flight planning alone or if restrictions to its use are still needed
  - Determine how best to evaluate grid forecast accuracy and determine how accurate it needs to be to “stand alone” as “primary”
  - Build formatters to automate GTG grids into legacy text products augmented by forecasters
- Turbulence Priority Recommendation Two
  - Determine how to commonly share real-time (NTDA-derived presumably) turbulence information to NAS users for avoidance
  - Determine best methodologies to express forecast uncertainty in gridded TURB products
- Turbulence Priority Recommendation Three
  - Add GTG techniques to WAFS TURB Gridded Forecast creation

Probabilistic Turbulence Products

- Users want “deterministic” turbulence products, but all turbulence forecasts are loaded with uncertainty
- So how do craft probabilistic products that relay uncertainty effectively





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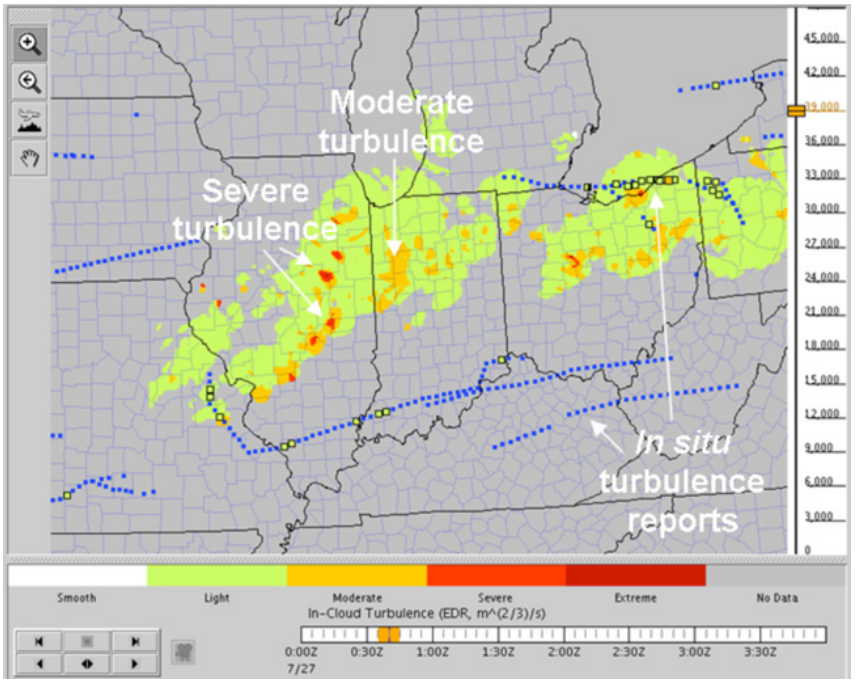
Strategic vs. Tactical

- Products designed for more tactical applications don't have a clear path to tactical exploitation
- Do products designed for strategic planning make a difference in tactical operations?
- What are the implications of making data available in the cockpit that is not available in ATC or to dispatch (and vice versa)?



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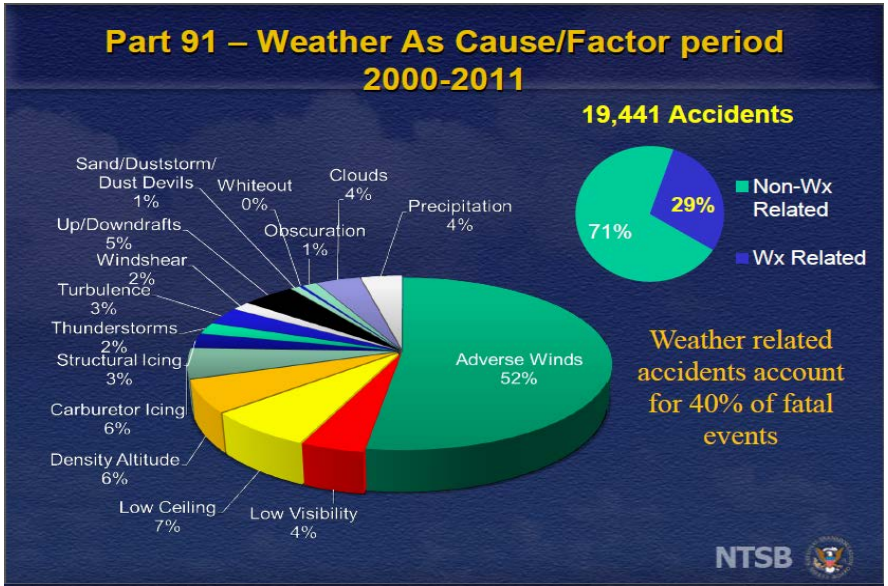
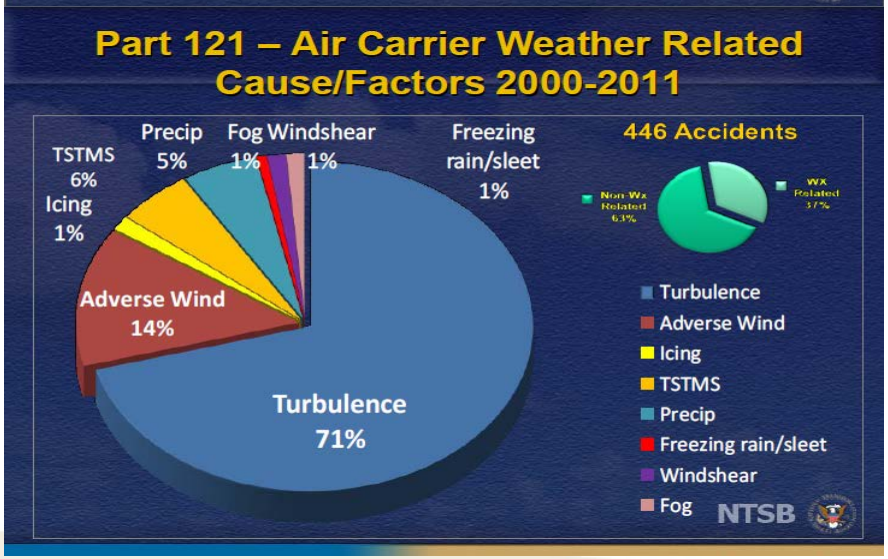
Commercial Carriers vs. GA

- Clearly one size turbulence product does not fit all (note that transition to EDR should help this issue)
- NTSB statistics indicate the relative differences in turbulence “incidents” between Part 91 and Part 121 carriers





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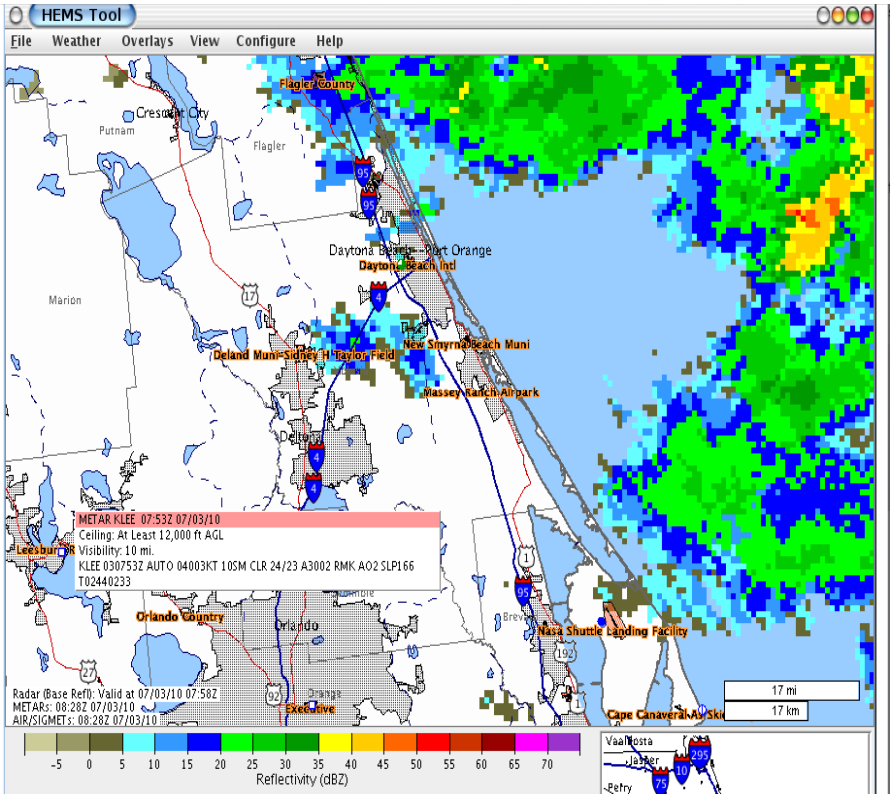
Limits of the Science

- Products like HEMS have been very helpful to the GA community, but can we ever realistically forecast turbulence at a resolution good enough to overlay on google maps?
- If indeed we have the compute power and resources to produce high resolution, rapidly updating products, will they be exploited operationally
- Can we educate users to understand the transient nature of turbulence?



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Role of the Human in/over the Loop

- We regularly underestimate the role of the human in the integration of weather information into NAS decision-making
- The confidence and situational knowledge available by the aviation meteorologist is clearly still valued (well, maybe not this guy!)
- However as higher resolution, rapidly updating models continue to be developed, the role of the human “over the loop” needs to evolve

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Policy/Proprietary Issues

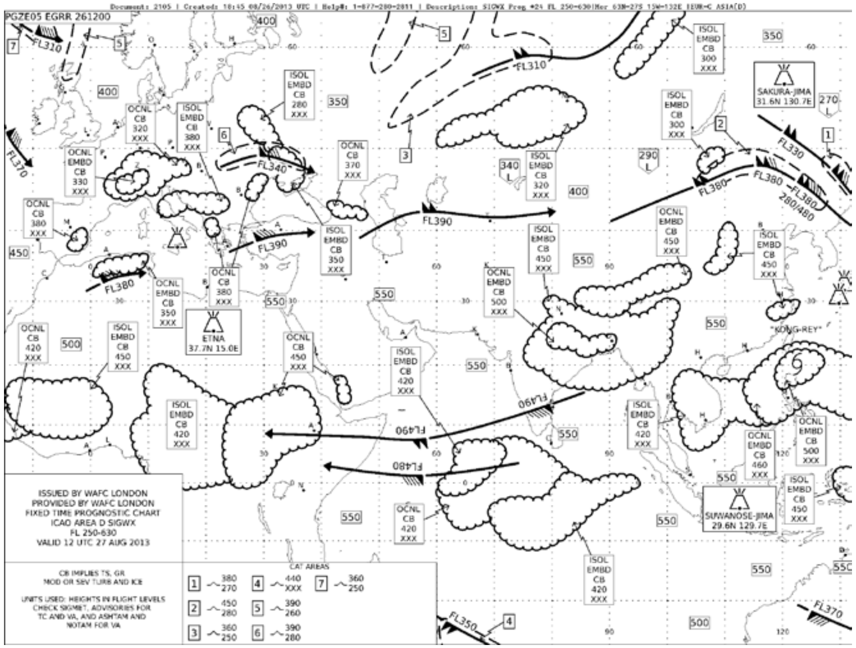
- While there seems to be general agreement that ATM leveraging a common weather picture (e.g. the same turbulence forecast for strategic planning) is beneficial, industry produces products and forecasts that airlines and others believe give a competitive advantage
- Clearly there is no interest in Government to dispute or challenge
- Can we share data between airlines and countries to maximize the availability of raw data for various applications

From “SVR” to “.3”

- Though the terms LGT, MDT, and SVR are full of subjectivity, a transition to application of objective turbulence measures is complex.
- GTG is producing forecasts of EDR but it is not yet clear how this will be made available to users effectively
- There is a significant training and education issue here that must be addressed.

Global Harmonization

- As the U.S. and many other countries develop higher resolution, more accurate forecasts, oceanic flights are looking for consistent forecasts on a global scale.
- Global models from different countries often produce conflicting forecasts.



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