Chapter 4

SERVICE AREA: Convective Hazards

1. Problem Description Convective hazards are associated with convective activity, such as thunderstorms and tropical cyclones, and also with clear air phenomena such as vertical currents caused by surface heating. These hazards include severe turbulence in and close to storms, intense up- and downdrafts, lightning, hail, heavy precipitation, and tornadoes. Additional related hazards, including icing, wind shear, microbursts, and strong low-level winds, are discussed in other Service Area descriptions. Convective hazards pose a danger to both en route and terminal operations.

According to the NASDAC analysis, between 1989 and early 1997 thunderstorms were listed as a contributing factor in 2-4 per cent of weather-related accidents, depending on the category of aircraft involved. Precipitation was listed as a factor in 6 per cent of commercial air carrier accidents, roughly 10 per cent of general aviation accidents, and nearly 19 per cent of commuter/air taxi accidents. Turbulence and winds are common factors in all categories of aircraft, but the NASDAC analysis does not differentiate between non-convective and convective turbulence. The implications are, however, that convective hazards of all kinds represent a significant threat to aviation safety.

Convection occurs when warm, humid air near the earth's land or sea surface rises into cooler air above it. If the density differences are large enough, the lighter air rises as strong updrafts that can reach above operational flight levels. The warm humid air can condense at altitude to form clouds which can produce icing and *heavy precipitation* in the form of*, snow, rain,* and *hail*. The humid, electrically charged air can also produce *lightning*, which in turn causes thunder. Falling precipitation and drier air entering the thunderstorms from the side can cause strong downdrafts.

A thunderstorm with a single updraft/downdraft system is called a *single-cell storm*. Many cells can coalesce into extended *squall lines* or convective complexes. These structures can extend for hundreds of miles and persist for hours. Winds aloft feeding a storm from different directions or upper air disturbances can induce rotation in the cell and lead to an extremely violent *supercell*. Tornadoes can be spawned by any thunderstorm, but are more likely to result from supercells.

Convective hazards also pose a problem for the efficient operation of the National Airspace System. Thunderstorms, tornadoes, turbulence, heavy precipitation, hurricanes, lightning, and hail can close airports, degrade airport capacities for acceptance and departure, and hinder or stop ground operations. Convective hazards en route lead to rerouting and diversions that result in excess operating costs and lost passenger time. Lightning and hail damage can remove aircraft from operations and result in both lost revenues and excess maintenance costs.

2. Objectives In order to mitigate the effects of convective hazards on safety and efficiency within the National Airspace System, the *National Aviation Weather Initiatives* establishes the following objectives:

- reduce the rate of convective hazard-related accidents in all categories of aviation, and
- reduce delays, diversions, cancellations, and increased operating costs that can result from convective storms and their related hazards.

3. Decision Makers In this Service Area the range of decision makers described in Chapter 2 should be extended to include airline station managers and airport ground operations managers.

4. Current Operations Concept

4.1 Pre-Flight Operations. The pre-flight routine described in Chapter 2 applies to the question of convective hazards. Pilots need to determine the extent of present and forecast hazards at all points along their intended route, and especially at their intended destination and identified alternates. The pilot must take the presence and severity of convective hazards into account and must plan avoidance actions to take once airborne.

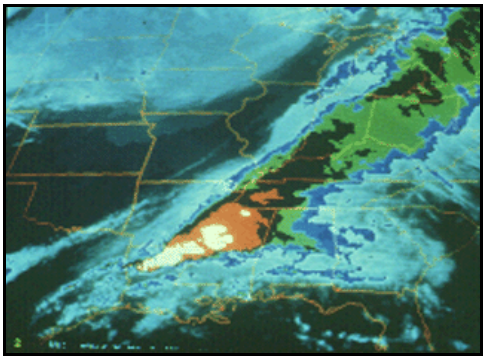
4.2 En Route Operations. Weather-related actions that pilots and aircrews need to take while en route are described in Chapter 2. Pilots must also use visual observations and whatever onboard sensors are available to monitor changing conditions and modify avoidance plans as needed. They should be especially alert for convective SIGMETs and other similar notices issued by central forecasting organizations, such as the Aviation Weather Center and the Tropical Prediction Center. Additionally, both the Air Traffic Control System Command Center and the Center Weather Service Units in the Air Route Traffic Control Centers monitor convective activity closely and issue advisories and regulate the flow of traffic as conditions dictate.

Pilots should not only avoid entering convective cells themselves but should also strive to maintain adequate distance in order to avoid associated downdrafts, turbulence, lightning, and hail that may occur outside the cell. Turbine aircraft may have the option of flying above convective cells; this is rarely an option for small, non-turbine general aviation aircraft.

4.3 Terminal Operations. Rapidly moving convective storms in the terminal area often require traffic management specialists to modify airport operations, either by reducing capacity or by opening/closing runways and/or approach gates. Pilots on landing approach should also be prepared for the possibility of sudden up/downdrafts and wind shifts associated with nearby convective activity. The presence of heavy precipitation and lightning can also alter ground operations such as baggage handling and refueling. Clear communication of such changes among traffic managers, ATC service providers, dispatchers, and pilots is essential for safe and efficient operations.

5. Needed Service Improvements Convective storms are a frequent occurrence throughout the U.S. at all times. Reducing the rate of accidents and delays relating to convective hazards requires ensuring that they are identified as quickly as possible and that sufficient information is disseminated to allow decision makers to plan avoidance strategies. A number of improvements in this Service Area are required.

5.1 Production of Weather Information. Observations from a wide range of sensors — ground-based, aircraft-based, satellite-based — need to be captured frequently and rapidly to identify convective storms as they develop. Once convective activity begins, data sampling rates need to be high enough to capture sudden storm intensification, tornadoes, hail production, and heavy precipitation development. Algorithms to allow more rapid assimilation of this information into models which produce accurate, timely, high-resolution forecasts need to be perfected.



Convective storms can coalesce into extensive complexes such as this one moving across the southeastern U.S.

5.2 Weather Product Generation and Delivery. Users must have products that are accurate, reliable, and readily understood. Graphics and text-based products that are applicable to specific requirements can be invaluable to ATC service providers, aircraft operations managers, and aircrews for planning rapid responses to convective hazards. These products would be most valuable if they quickly portray the expected intensity, duration, and forecast path of convective activity, especially in the terminal area. Downbursts/microbursts are a serious convective weather hazard, but they are addressed in Chapter 8, Terminal Wind and Temperature Hazards.

6. Convective Hazards Initiatives On pages 4-4 and 4-5 are the initiatives which have been identified for this service area.

Number	Convective Hazard Initiatives	Relative Rankings*	Cooperating Organizations
1	Develop and implement convective products covering phenomena such as hail, turbulence, tornadoes, lightning, and heavy precipitation, in a single display product which requires little or no interpretation or analysis and is applicable for use by ATC service providers, airline operations centers, and in the cockpit.	★★★★	NASA, NOAA/NWS, Industry**
2	Develop and implement ground-to-air Flight Information Services capabilities to readily disseminate convective storm observations within 5 minutes of availability and forecast products within 15 minutes of product generation in order to facilitate convective hazard avoidance.	★★★★	FAA, DoD, NASA, Industry
3	Develop and implement a multifunctional, color cockpit display which includes convective storm attributes such as hail, turbulence, tornadoes, lightning, and heavy precipitation along with terrain and other traffic hazards.	★★★★	NASA, Industry
4	Increase the types and number of aircraft capable of automatic reporting of winds, temperatures, humidity, turbulence, and icing.	★★★★	Industry, NASA, FAA
5	Improve the resolution, accuracy, and the update rate of observations of hail, turbulence, tornadoes, lightning, and heavy precipitation associated with convective storms affecting terminal operations.	★★★★	NOAA/NWS, FAA
6	Establish a quantitative ICAO standard for characterizing hail, turbulence, lightning, and heavy precipitation associated with convective storms.	★★★	FAA, NOAA/NWS, NASA, DoD
7	Develop and implement 0-1 hour forecast and modeling techniques that will improve hail, turbulence, tornado, lightning, and heavy precipitation products, including resolution and accuracy in time and space, associated with convective storms affecting terminal operations.	★★★	NOAA/NWS, DoD, FAA

8	Improve current ground-based communications systems to readily disseminate convective storm observations, pilot reports and forecast products to pilots, airline operations centers, and ATC service providers.	★★	FAA, NOAA/NWS, NASA
9	Improve the resolution, accuracy, and the update rate of observations of hail, turbulence, tornadoes, lightning, and heavy precipitation associated with convective storms affecting en route operations.	★★	NOAA/NWS, DoD, FAA
10	Develop and implement 0-1 hour forecast and modeling techniques that will improve hail, turbulence, tornado, lightning, and heavy precipitation products, including resolution and accuracy in time and space, associated with convective storms affecting en route operations.	★★	NOAA/NWS, DoD, FAA
11	Develop and implement 1-hour and greater forecast and modeling techniques that will improve hail, turbulence, tornado, lightning, and heavy precipitation products, including resolution and accuracy in time and space, associated with convective storms affecting en route operations.	★	NOAA/NWS, DoD, FAA
12	Develop and implement 1-hour and greater forecast and modeling techniques that will improve hail, turbulence, tornado, lightning, and heavy precipitation products, including resolution and accuracy in time and space, associated with convective storms affecting terminal operations.	★	NOAA/NWS, DoD, FAA

Convective Hazard Initiatives

* The relative rankings assigned to the initiatives are based on a qualitatively calculated benefit/cost ratio. It's possible that a high-benefit initiative which is costly to implement may rank lower than a medium- or low-benefit initiative which is medium or low in cost to implement. All these initiatives are considered to have a positive benefit to aviation; however, when benefits and costs are considered, some rank relatively higher than others. Details can be provided upon request. Four stars (★★★★) is the highest ranking.

** The term "Industry" in this context refers to private organizations (e.g., airlines, manufacturers, associations) which may represent both users and providers of weather information.