Expanding Air Traffic Controllers’ View of Offshore Weather

Air traffic controllers depend on weather radar for information that enables them to safely reroute aircraft around storms that may cause hail, turbulence, icing, and other hazardous conditions. While land-based radar systems provide reliable weather data covering the continental United States, their effectiveness in capturing data about offshore and over-the-ocean weather systems is limited or nonexistent. Controllers who manage the large number of aircraft traversing oceanic sectors of the National Airspace System (NAS) are faced with an imperfect weather picture that can threaten the safety of air travel and can lead to inefficient routing of aircraft in the NAS.

Researchers at the Laboratory, working with the Federal Aviation Administration, have designed the Offshore Precipitation Capability (OPC) to address this lack of airspace situational awareness. The OPC provides radar-like depictions of precipitation intensity and storm height for regions where radar data are inadequate or unavailable. OPC creates the depictions by fusing together various non-radar data sources—lightning detections, information from geostationary satellites, and outputs from numerical weather prediction models—available within these offshore regions.

“Lightning is a strong indicator of convective weather, that is, weather capable of generating the powerful updrafts that can cause severe turbulence and other safety hazards like damaging hail,” explained Dr. Mark Veillette, Air Traffic Control Systems, Group 43, team lead. “In OPC, we use a global lightning dataset that covers areas far offshore and over oceans.”

Current land-based weather radar coverage (left) compared to the improved accuracy of the Offshore Precipitation Capability (right). Both images depict storm height according to the color bar at the far right.

Geostationary satellites positioned around the globe provide visible and infrared imagery of much of the Earth, while numerical weather prediction models simulate many meteorological measurements, including environmental temperature, pressure, and humidity, and other relevant parameters, such as radar reflectivity, rain rate, and convective cloud-top height.
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Data from these non-radar sources are combined by using a supervised machine learning framework. The OPC model is “trained” to generate products normally derived from actual weather radar measurements. Results from OPC are blended with outputs from existing radar-based systems to create seamless mosaics of weather systems that extend into offshore and oceanic regions.

“OPC fills in gaps in radar coverage on controllers’ displays of offshore regions beyond radar range. The output data from OPC are presented in a style and format that matches what air traffic controllers are used to seeing on existing weather processing systems,” said Veillette.

OPC also applies a motion-tracking algorithm to estimate storm motion. This estimated motion is used to spatially shift the features obtained from satellite imagery and numerical models so that OPC can generate up-to-date mosaics in between satellite data updates.

To evaluate the capability’s performance, the research team compared OPC-generated displays of weather to over-land radar displays produced by Next Generation Radar and to offshore and oceanic radar displays produced by the spaceborne radar on board NASA’s Global Precipitation Measurement Mission’s Core Observatory Satellite. “The comparisons showed that over land meteorological datasets into a single, accurate, and familiar-looking product,” said Veillette. “In addition, by including high-resolution inputs, such as visible satellite imagery and lightning density, OPC is able to resolve some finer-resolution storm characteristics that are missed by systems that rely only on infrared satellite or lightning data.”

Both the NOAA and FAA have begun assessments of the OPC system’s accuracy and suitability for deployment to air traffic control centers. While developed primarily for use by U.S. air traffic controllers working in Oceanic Air Route Traffic Control facilities, work is also being done to extend OPC coverage for broader applications such as hurricane tracking, disaster response, and global weather forecasting to monitor all areas lacking radar coverage.