3.4 OCEANIC WEATHER: A PROGRAM TO ENHANCE THE QUALITY AND TIMELINESS OF AVIATION WEATHER INFORMATION FOR REMOTE AND OCEANIC REGIONS

Tenny A. Lindholm*
The National Center for Atmospheric Research, Boulder, Colorado
Captain Joe Burns
United Airlines

1. INTRODUCTION

At present, aircrews for long-range oceanic flights receive a general weather briefing before departure, including a summary of flight level winds and expected en route weather conditions. Frequently, the main products are a series of text summaries of the expected weather along the flight path, augmented by a facsimile copy of a weather summary produced by the Aviation Weather Center in Kansas City, or equivalent products provided by a foreign weather service, commercial vendor, or an airline weather office. Once aloft, the aircrew can receive updated weather information in the form of text messages via the ACARS multi-purpose data link, or when in contact with an air traffic control center via HF or VHF radio communication. While the current weather products do provide valuable information for strategic planning, the information is already hours old by the time the aircraft depart and only the most general weather updates are provided during the flight. In particular, little or no information can be provided about rapidly changing weather systems that may be encountered.

Air traffic control centers and airline dispatch offices, of course, have ready access to some meteorological information, often including near real-time imagery from geostationary satellites that cover most or all of the long-range oceanic routes. Most controllers and dispatchers, however, are not trained meteorologists, hampering their ability to provide *detailed and timely* updates of meteorological hazards to individual aircraft. The three legs of the operational “triad”—pilots, dispatchers, and controllers—clearly do not share the same temporal and spatial weather information when attempting to make collaborative decisions. The FAA-sponsored Oceanic Weather Product Development Team (OWPDT) is addressing this often-recognized void through applied research on oceanic weather phenomena and the development of advanced techniques to create information from sparse data sources. The Research Applications Program from the National Center for Atmospheric Research (NCAR-RAP) leads the OWPDT. Core Team members include the Naval Research Laboratory, MIT Lincoln Laboratories, the National Weather Service Aviation Weather Center (Kansas City, USA), ARINC, Oakland Air Route Traffic Control Center (ARTCC) Center Weather Service Unit (CWSU), and United Airlines.

The OWPDT is performing applied research toward developing diagnoses, nowcasts, and forecasts of convection, all forms of turbulence, volcanic ash dispersion, in-flight icing, and flight level winds for oceanic/remote regions where data is sparse. In parallel, the Team is investigating and implementing appropriate methods of end-user dissemination, such as ground displays and data link to airborne flight crews. The focus is on informational products, not data products, which are more readily used by non-meteorologists for decision support. This paper describes early progress of OWPDT research and development activities, and results of user evaluations of higher resolution (time and space) informational weather products never before available to flight crews, dispatchers, and air traffic managers.

2. IFFDP—INTERNATIONAL FLIGHT FOLDER DOCUMENTATION PROGRAM

A quick review of the current weather information products and how they support the emerging global aviation environment will illustrate the problems being addressed by the OWPDT. With the globalization of the world’s economies, flight operations over oceanic and remote areas have increased by at least two orders of magnitude in the last 50 years. Long-range flights approaching 15 hours in duration are routine, many with wide body twin engine aircraft. We also see operations on routes never before used by commercial airlines to alleviate congestion, to seek more economical flight times (“minimum cost flight planning”), and to address extended twin operation (ETOP) requirements. Examples include the L888 route between Bangkok and London, which was coordinated by QANTAS, and the recent start of ETOPS over the North Pole. South American and Gulf of Mexico services have also increased significantly. A common need expressed by the user community is for higher resolution (time and space) and more accurate weather information to

**Corresponding author address:* Tenny A. Lindholm, NCAR-RAP, 3450 Mitchell Lane, Boulder CO 80301; email lindholm@ucar.edu.

support efficient flight planning and weather hazard avoidance.

In an effort to standardize meteorological services for the international aviation community, the International Civil Aviation Organization (ICAO) specifies a consistent level of aviation services in Chapter 9, Annex 3 to the Convention of International Civil Aviation. In 1998, the Aviation Weather Center began providing these standard weather products to the international aviation weather community via the International Flight Folder Documentation Program (IFFDP). The information was initially available via a FAX-back service. It is now available on an operational Internet site:

http://www.aviationweather.noaa.gov/

Target users include dispatchers and flight crews for preflight and en route planning. Available products, pertaining to route of flight and altitude, include:

- Wind and temperature aloft forecast charts,
- Significant weather charts (with abbreviated plain language descriptions of forecasts as appropriate),
- Terminal Aerodrome Forecasts (TAFs) for departure, destination and alternate,
- Significant meteorological information (SIGMET) charts of tropical cyclones and/or volcanic ash as appropriate,
- And for flights of 2 hours or less, aerodrome reports (METAR), special reports (SPECI), SIGMETs (for any phenomena), and appropriate special air reports (AIREPs).

The IFFDP has been a tremendously popular service and extremely valuable to aviation user community. But, for oceanic and remote regions, data to support weather diagnoses and forecasts is typically very sparse when compared to the Continental United States. Therefore, the information available is necessarily very coarse in time and space and is difficult to relate to the aviator's 4-dimensional world. For example, refer to the SIGWX charts found on the IFFDP web site. Note the coarse spatial granularity and the fact that the valid time for the information can be as long as 24 hours. Similarly, note the coarse spacing of the wind grid points on upper-level winds/temperature charts from the IFFDP. Furthermore, vertical resolution is only 4-6000 feet at en route flight levels. Below are examples of significant weather alerts (SIGMETs) which are textual, very coarse, and difficult to relate to a 4-dimensional flight profile.

WSGL31 BGSF 311810
BGGL SIGMET 4 VALID 311815/312215 BGSF-
SONDRESTROM FIR OCNL SEV TURB FCST BLW FL100 OVER EAST-COAST OF
GREENLAND BTN N6630-N63, EXTENDING S 15KT, NC=

WSIL31 BICC 311700
BIRD SIGMET 3 VALID 311415/311700 BIRK-
REYKJAVIK CTA MOD TO SEV TURB OBS AND FCST OVER GREENLAND S OF 68N,
BTN FL220/FL340. STNR, NC.=

If we truly want to positively impact the value of critical weather information to users who are concerned with oceanic and remote aircraft operations, we need to consider

- The sparseness of meteorological data—making the most intelligent use of the limited available data.
- Increasing the spatial resolution of weather hazard products such that they can be related to a 4-dimensional flight profile.
- Increasing the temporal resolution of weather hazard products in two ways: design an automated product generation system that ingests new data as it becomes available, and implement methods of disseminating new information to en route flights as it is generated.
- Providing the weather information in graphical form.

3. OCEANIC WEATHER RESEARCH AND DEVELOPMENT

We all recognize that the quality of oceanic or remote weather information may never approach that for continental regions, primarily because of the limited availability of observed and sensed data. Oceanic and remote regions are also quite large, and so numerical modeling of the atmosphere using current global models and computational capabilities results in a spatially coarse description of the state of the atmosphere. Research is just beginning on analytical techniques and novel use of available data to mitigate these limitations and concerns. In addition, other elements of the FAA's Aviation Weather Research Program are trying to address the limited in situ reporting of certain state of the atmosphere variables and hazard metrics in oceanic/remote regions. In particular, we are working on:

- Enhancing the Meteorological Data Collection and Reporting System (MDCRS) and similar international cooperative programs (such as AMDAR, AUTOMET). Participating airlines in these programs routinely downlink flight level winds and temperature. These data are ingested into global numerical models, greatly enhancing their performance. We are gradually adding the capability to sense and downlink water vapor and turbulence metrics in the same data stream.
- Increasing our understanding of the phenomenology and physical processes

associated with oceanic convection and turbulence (clear air and convective induced). A clearer understanding will allow us to create or identify algorithms that become part of an automated expert system framework, which generates weather products.

- Implementing novel ways of ingesting visual and infrared satellite imagery into expert systems that diagnose and nowcast convection, turbulence, flight level winds, and even volcanic ash dispersion. Global satellite imagery generally updates every 30 minutes and represents the most timely and revealing data source in remote regions.
- Identifying and ingesting all data sources and diagnostics that add skill to a particular objective function into the expert systems, including the underlying research to quantify the incremental skill.

An example of an initial product from the OWPDT's work is the cloud top height product. Infrared satellite imagery is used to determine cloud temperatures and merged with global model soundings to map cloud tops to aircraft flight level. Future enhancements will merge diagnostics and algorithms to distinguish hazardous convection from high altitude cirrus that may not be hazardous. Spot winds from visible and infrared satellite imagery are assimilated into global numerical model output to create a uniform wind field, which will be merged with other data sets and diagnostics into an expert system that will nowcast other oceanic weather hazards, such as turbulence and volcanic ash dispersion.

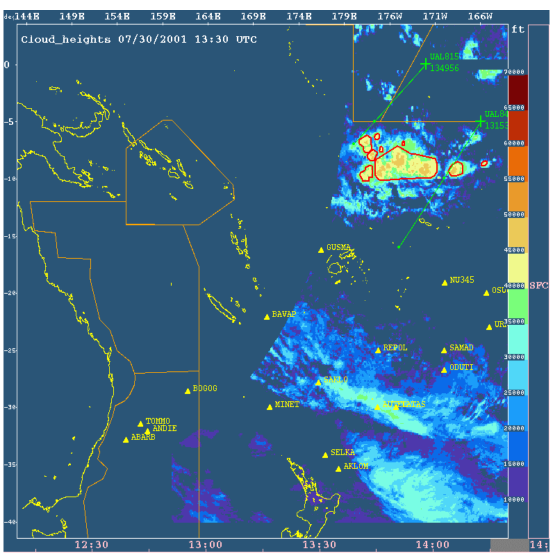

Figure 1. Cloud Top Height, South/Central Pacific

Figures 1 and 2 are examples of the cloud top height product, currently somewhat simplistic and still in research and development. Figure 1 shows the South/Central Pacific and is overlaid with real-time aircraft tracks; Figure 2 shows the North Pacific. Contouring on these example ground displays is based on cloud top heights in excess of 40,000 feet. These products are updated every 30

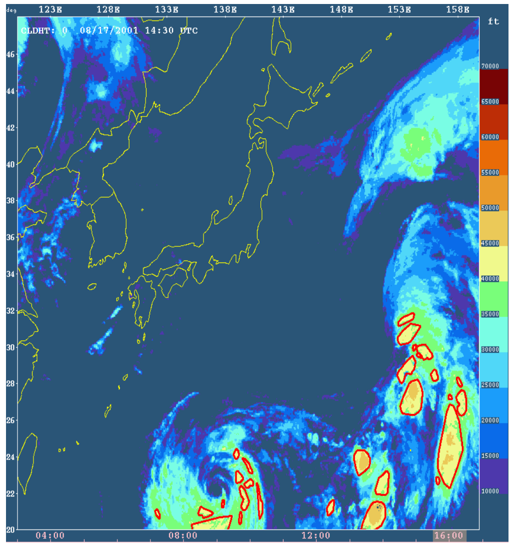
Figure 2. Cloud Top Height, North Pacific

minutes as new geostationary satellite data is received. The OWPDT web site has links to these displays, plus a similar display for the Gulf of Mexico, South America, and North Atlantic (to 40W):

http://www.rap.ucar.edu/projects/owpdt/

Look here for future products as they are developed.

4. DISSEMINATION TO END-USERS

Timely updating of dynamic weather conditions has no value unless there is an infrastructure available to get the information to the end users, the "triad." Furthermore, the information must be presented in such a format that it can support decision making without requiring a great deal of analysis by the non-meteorologist user. Supplying the information to the users as soon as possible in the development process also supports verification activities, as pilot observations may be the only verification data available in oceanic and remote regions. For these reasons, display development for ground and airborne users, plus identifying and testing efficient data links, are an important element of the OWPDT's activities.

An important consideration when creating a product distribution infrastructure is to make the most use of existing communications and display devices. Product distribution to users should not drive new technologies and cockpit displays and the associated certification and non-recurring costs. Nearly all international carriers currently use a display device that interfaces with ARINC or SITA data link communications. Since informational weather products tend to be simple graphics and lend themselves to be formatted in grids, a complex color graphical device and broadband communications are not necessary. Current, simple character displays can convey as much information as a high-resolution color display. The gridded format can also support aircraft with existing color displays. Re-equipage, however, is not necessary.

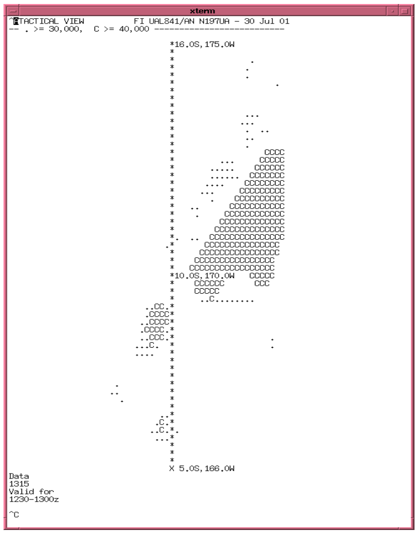

Figure 3. Character Graphic (ACARS) Display for the Flight Deck

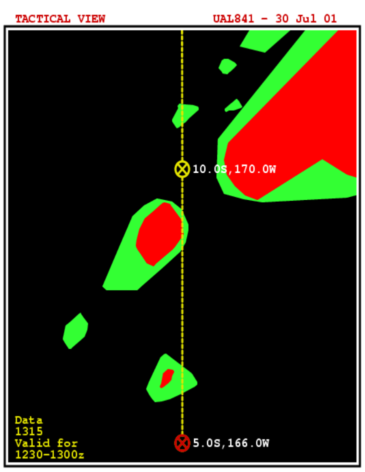

Figure 4. High-resolution Color Display for the Flight Deck

Figure 3 shows an example of a simple character graphic from an ARINC Aircraft Communication and Reporting System (ACARS) thermal printer. Here, the cloud top height is contoured FL300-400 (represented by dots) and above FL400 (represented by "C"). Figure 4 is an example of a possible color graphic rendition of the same weather information. Note that, in both cases, the weather graphic is referenced to an aircraft's actual flight track obtained from Automatic Dependent Surveillance (ADS) position reports. Data link and in-flight display of oceanic weather information has been demonstrated and is currently being evaluated by United Airlines.

5. USER FEEDBACK

Initial and follow-on versions of the simple cloud top height product have been available to airline and air traffic control users for about two years. Formal evaluations by pilots, dispatchers, air traffic controllers, and meteorologists from airlines and CWSUs will begin soon in the Pacific, focusing on utility and meteorological accuracy. Meanwhile, informal feedback has been very positive from United Airlines' dispatchers, pilots, U. S. Department of Defense, AirServices Australia, Oakland ARTCC, and the Oakland CWSU. Some pilots have reported that they routinely visit the OWPDT web site before departing on long-range oceanic trips.

6. CONCLUSION

The work of the OWPDT is considered a long-term research and technology transfer effort; however, given the limitations of the current remote area weather information we will emphasize getting each incremental improvement to users as soon as possible. There is a formal process for moving the products of R&D into the operational world that emphasizes a number of user issues, including verification. This process includes exposure to users as soon as possible during product development. The cloud top height product is available on the OWPDT web site now (not monitored 24/7 yet, however), and will begin its verification and user evaluations soon. Once these are complete, product generation and dissemination will most likely be transferred to a NWS or FAA operational entity. A similar process will be followed for other products in the next few years—turbulence (all types), volcanic ash dispersion, high-resolution winds, and in-flight icing. Expansion of capability to other regions of the world will also be accomplished as the need arises.

Stay tuned to the OWPDT web site for program updates and further developments!

7. ACKNOWLEDGMENT

This research is in response to requirements and funding by the Federal Aviation Administration (FAA). The views expressed are those of the authors and do not necessarily represent the official policy or position of the FAA.