Motivation: Reduce Efficiency and Safety Costs

- In 2005, FAA AWRP commissioned a study by MCR Federal, Inc. to analyze annual costs of oceanic hazards to U.S. air carriers
  - U.S.-controlled airspace in Pacific, Atlantic, Caribbean & Gulf of Mexico

- Hazards examined:
  - Convective Weather/Lightning
  - Convectively-Induced Turbulence (CIT)
  - Clear Air Turbulence (CAT)

- Annual efficiency costs estimated at $46.3 million ($56.9 million)*
  - Largest impact: additional fuel required to avoid Convective Weather and CAT

- Annual safety costs estimated at $5.0 million ($6.1 million)*
  - Largest impact: serious and minor injuries due to Convective Weather and CAT encounters

* Adjusted for inflation to 2016 dollars
Global Hazards Weather (GHW) Project

BCI, NCAR, Lufthansa Airlines and MeteoStar collaboration

- Improving efficiency and safety by operational display of oceanic convection hazard products on electronic flight bag (EFB)
  - Cloud Top Height (CTH, gray), Convective Diagnosis Oceanic (CDO, green)
- Lufthansa Airlines B747-8 and Brussels Airlines aircraft (~90 aircraft)
  - EFB display: Lido EnRoute Flight Manual (eRM) that runs on Microsoft Surface Pro 3
  - Navigation charts show own-ship position and flight route
- Improved situational awareness of weather hazards leads to better strategic routing decisions (pilot can see beyond range of onboard radar)
1. IR and water vapor channels from each satellite
2. Data from each satellite are parallax corrected

Building a Geostationary Satellite Mosaic for the CTH and CDO Products

IR 10.8 micron brightness temperature

1. IR and water vapor channels from each satellite
2. Data from each satellite are parallax corrected
3. Mosaic created using weighted combinations
4. Nominal 15 min updates with most recent data

Convection Weather Products

Cloud Top Height (CTH)
- Satellite IR brightness temperature converted to pressure by comparing to Global Forecast System (GFS) model sounding
- Pressure converted to flight level through standard atmosphere eqn.
- Polygons at FL300, FL350, FL400, FL450, FL500

Convective Diagnosis Oceanic (CDO)
- Data fusion of scaled and weighted inputs to create interest map
  - CTH, Global Convective Diagnosis, Overshooting Tops, EarthNetworks global lightning
  - Maximum value is 6

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  - Maximum value is 6
- Convective hazards defined as CDO > 2
- CDO > 3 means lightning/OTops
- Polygons at 2, 3, 4, 5 interest

Why Two Convective Products?

- Two products fully characterize convective storm structures
- CTH gives full extent of anvil cloud cover and flight level heights
  - Regions of possible turbulence, possible high ice water content, anvil lightning
- CDO shows location of updraft/lightning hazards
Data Base:
- CTH Polygons (XML)
- CDO Polygons (XML)
- Max CTH within CDO (XML)
- Storm motion vector (XML)
- Missing data polygons (XML)

Convert gridded CTH and CDO to XML polygons

EarthNetworks Lightning GFS
Geo-satellites

Lufthansa Airlines
Brussels Airlines

Link Protocol Box
WIFI Router

eRM Pilot Display
WIFI

Lufthansa Servers
Frankfurt, Germany

Web Feature Service
(NextGen & SESAR)

MeteoStar
Englewood, Colorado

Lido EnRoute Flight Manual (eRM)
EFB on a Microsoft Surface Pro 3

NCAR algorithms
BGI Servers at MeteoStar
Example #1 of Pilot Referencing of CTH

- Frankfurt-Newark flight
- Pre-flight information showed storms near Newark

WAFC SigWx Chart, valid 18 UTC

Sat-pictures, before flight, showing approx. flight route. Note that route was chosen to avoid 150kts + jets.
Example #1 of Pilot Referencing of CTH

• CTH uplink product:
  • Referenced to identify approximate position of cloud system east of Newark

Weather – system between JOBOC and Newark, around 15z. Note: 5hrs later, clouds had moved 150nm east. No update to yellow clouds obtained.
Example #1 of Pilot Referencing of CTH

- CTH uplink product:
  - Referenced to identify approximate position of cloud system east of Newark
  - Position: Information referenced to time the cabin service so as to have it end before entry into the cloud-system
  - Position and height of CTH uplink product were accurate

Weather – system between JOBOC and Newark, and clouds had moved 150nm east. No update to yellow.
Example #2 of Pilot Referencing of CTH

- Frankfurt-Buenos Aires flight
- Storms expected in South America; re-routing expected
Example #2 of Pilot Referencing of CTH

- Because pilot could reference that storms were present along flight route and expected to persist, an earlier deviation to the west was requested.

Info: deviation without use of satellite-information
Example #2 of Pilot Referencing of CTH

- Because pilot could reference that storms were present along flight route and expected to persist, an earlier deviation to the west was requested.
- Conclusion: Fuel savings realized and safety enhanced.

Info: deviation without use of satellite information.

Info: deviation with use of satellite information.
Summary and Future work

- Global Hazards Weather project is uplinking convective weather products into cockpit of Lufthansa Airlines B747-8 and Brussels Airlines aircraft
- CDO and CTH computed over a global domain, 15 min updates
- Pilot feedback is that CTH and CDO are accurate and reliable
  - Efficiency and safety are enhanced; costs reduced
- GOES-16 (satellite formerly known as GOES-R) will simplify one of GOES satellite merger processes, once available
  - Full disk scans at 15 min intervals
- GOES-16 Geostationary Lightning Mapper (GLM) means better total lightning observations, particularly over the oceans
- FAA Weather Technology in the Cockpit program has a similar effort underway to demonstrate CTH and CDO with domestic airlines, begins later this year
  - Remote Oceanic Meteorological Information Operational (ROMIO) demonstration
- For Fred Carr: Observations to validate convective products are needed. Low earth orbit satellites like NASA Global Precipitation Measurement are important as are measurements such as in situ EDR over global airspace.
THE GLOBAL HAZARDS WEATHER PROJECT

Thank you!

Questions?

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