Demonstration of a Convective Weather Product into the Flight Deck

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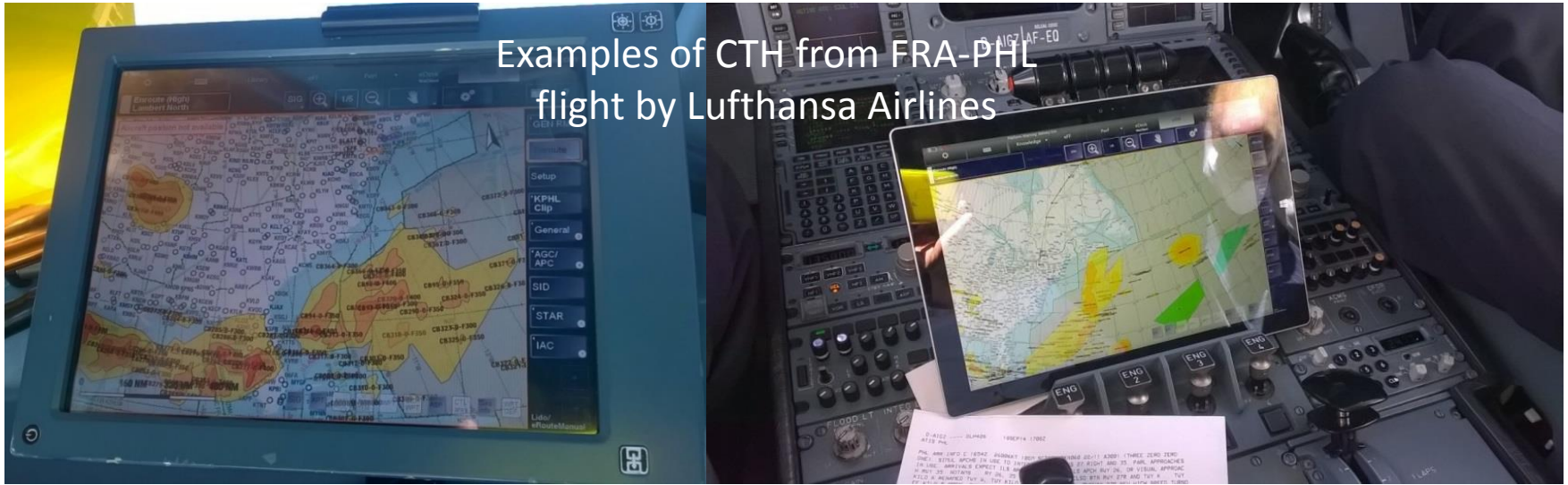
The eFlightOps Atlantic Weather Hazard Trial

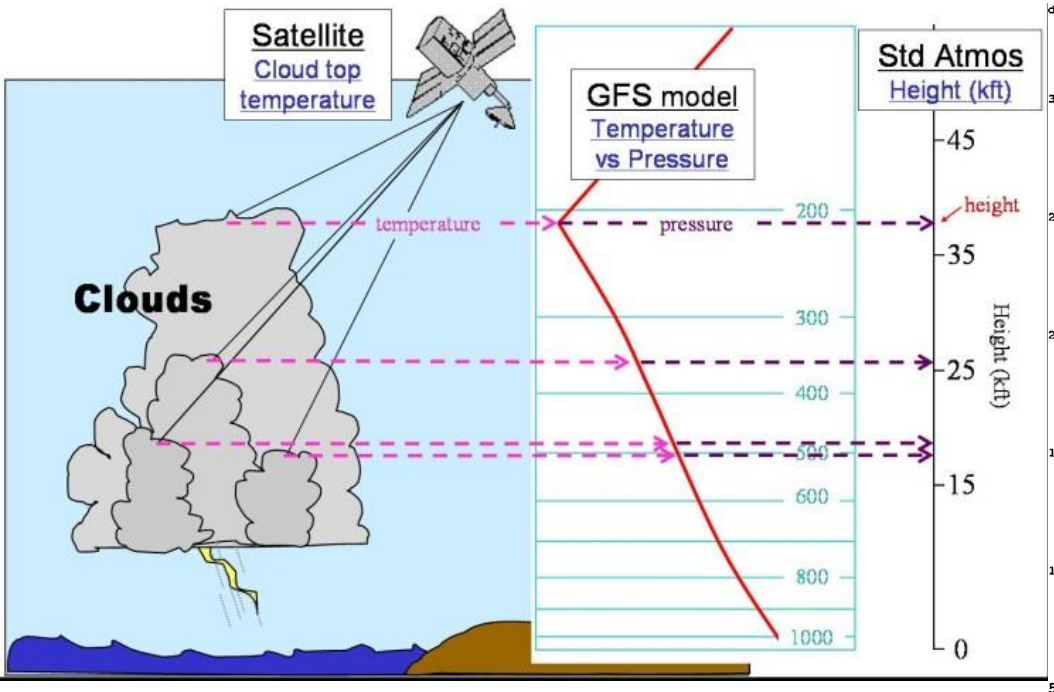
- Next Generation Air Transportation System (NextGen) in the U.S.A. and the Single European Sky Air Traffic Management Research (SESAR) in Europe have common goal to provide inflight display of weather hazards for pilots
  - Transoceanic pilots have particular need for high resolution weather information
- Partnership between NCAR, BCI and Lufthansa Airlines to test feasibility of realtime, flight deck display of convective weather hazards using the Cloud Top Height (CTH) product

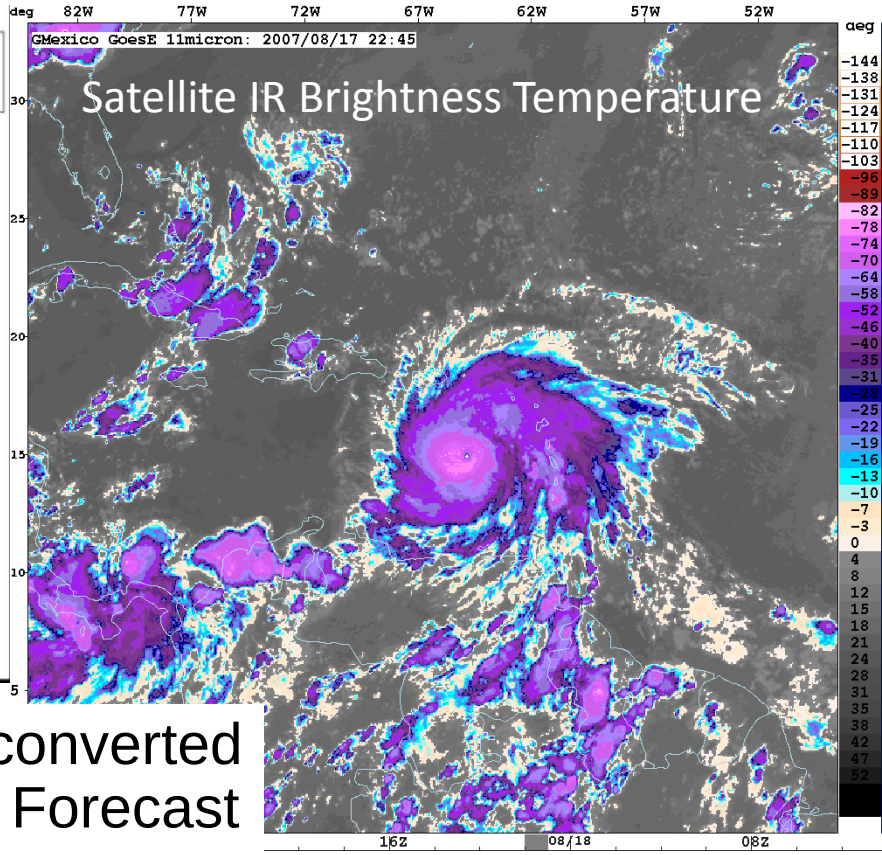


History of Weather in the Cockpit Efforts and of CTH at NCAR/RAL

- Research efforts:
  - 1991: NASA Cockpit Weather Information (CWIN) Program
  - 1997: NASA Aviation Weather Information (AWIN) Program
  - 1999-2001: NASA & FAA Aviation Weather Research Program (AWRP) Oceanic Convective Nowcasting Demonstration
  - 2005-2011: NASA ROSES total of six grants for Oceanic Convection
- 2001-2006 FAA AWRP Oceanic Weather Product Development Team (OWPDT)
  - 2005: FAA Aviation Weather Technology Transfer (AWTT) D3 approval of CTH as an experimental product; Validation of CTH by Quality Assessment PDT
  - 2006: CTH uplinked to United Airlines aircraft between LAX/SFO to Sydney, Australia
- Operational demonstrations:
  - 2012: FAA Weather Technology in the Cockpit (WTIC), demonstration in the WJHTC Next Generation Integration and Evaluation Research Cockpit Simulator (NIEC RCS): *Human factors evaluation of CTH (**ARAM poster #769A**)*
  - **2014-15: NCAR/BCI/Lufthansa Airlines: eFlightOps Atlantic Weather Hazard Trial**
  - 2014-15: FAA WTIC Oceanic Convection demonstration: *Operational demonstration of CTH with interested airlines (**ARAM poster #769A**); Starts fall of 2015.*

Creation of Cloud Top Height Product





- Satellite IR brightness temperature converted to pressure by comparing to Global Forecast System (GFS) model sounding.
- Pressure converted to flight level by comparing to standard atmosphere.
- CTH sees tops of deep convection, not internal structures
  - Anvil clouds can have much larger area than the convective region
  - Can be created globally as all satellites have the 11 micron channel

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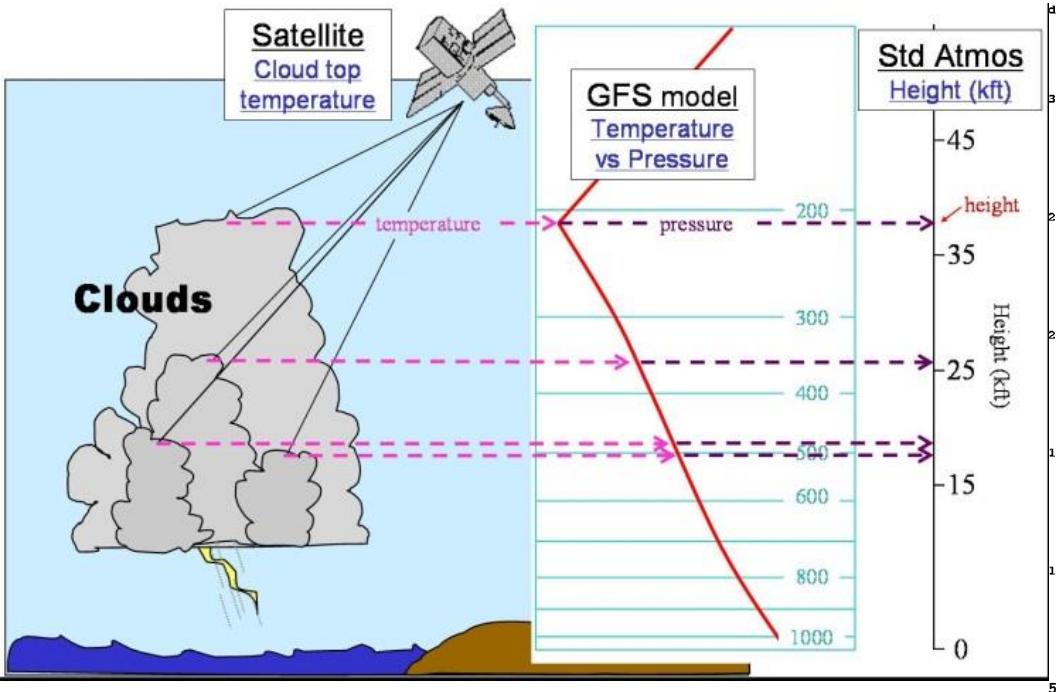

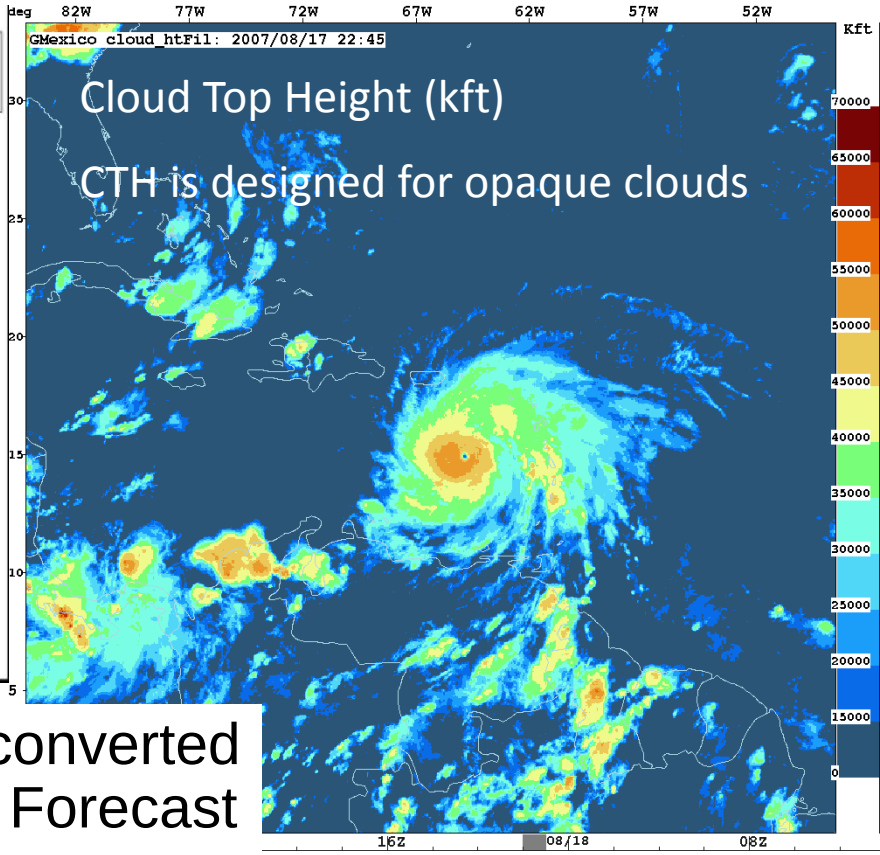

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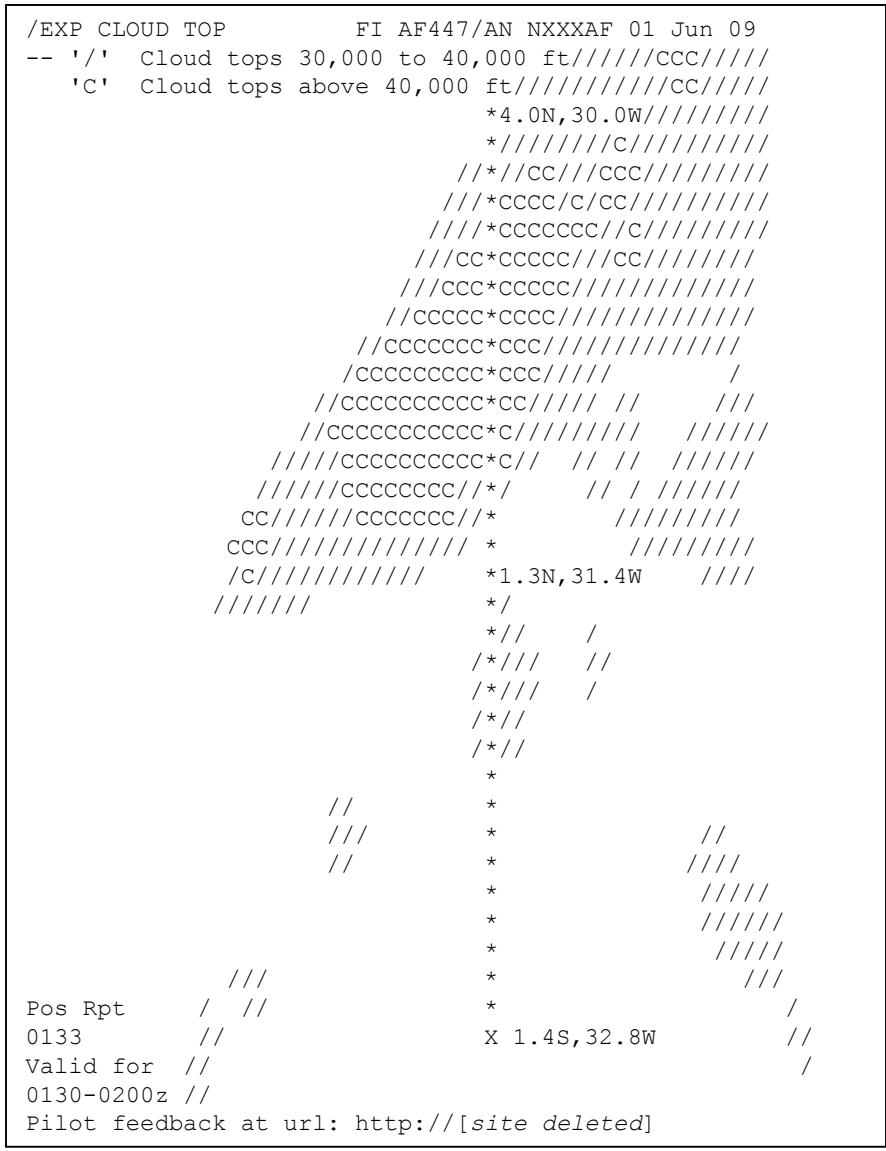
Evolution of CTH Uplink Display

- For 2006 United Airlines display, an ASCII graphic was sent to the ACARS printer
  - No equipage required
  - / = FL300-399, C = FL400+
  - Triggered on position reports



Text-based view for ACARS printer

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  - Same flight levels
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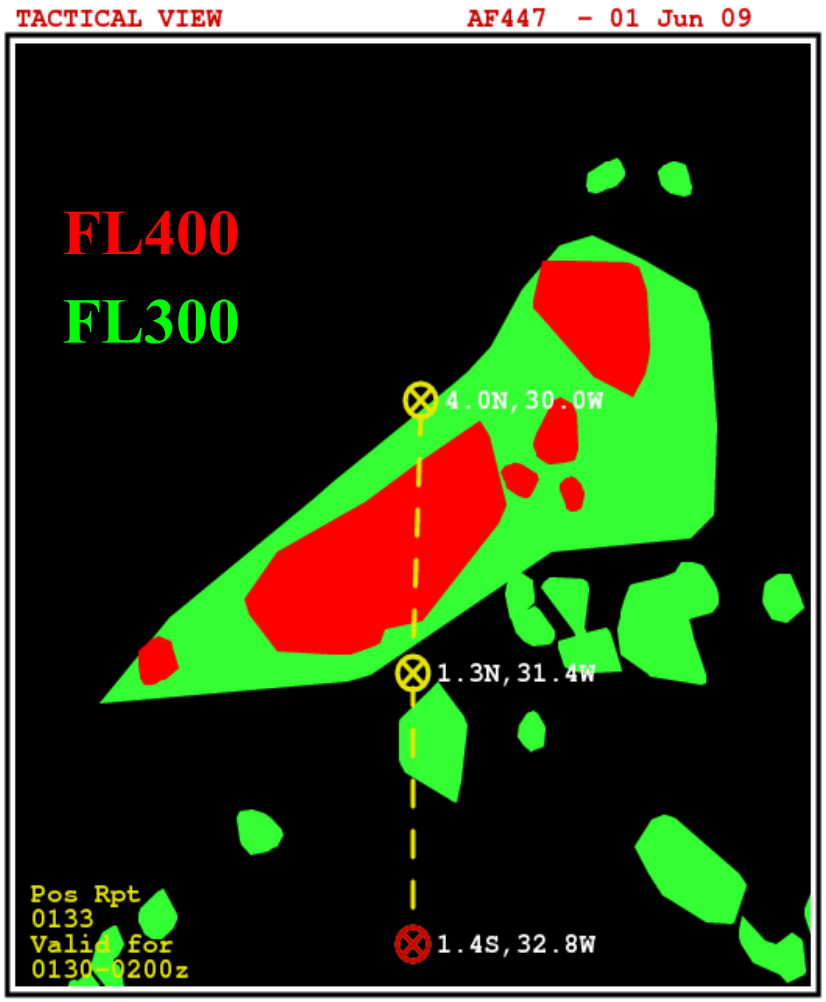

Graphical view – has more area

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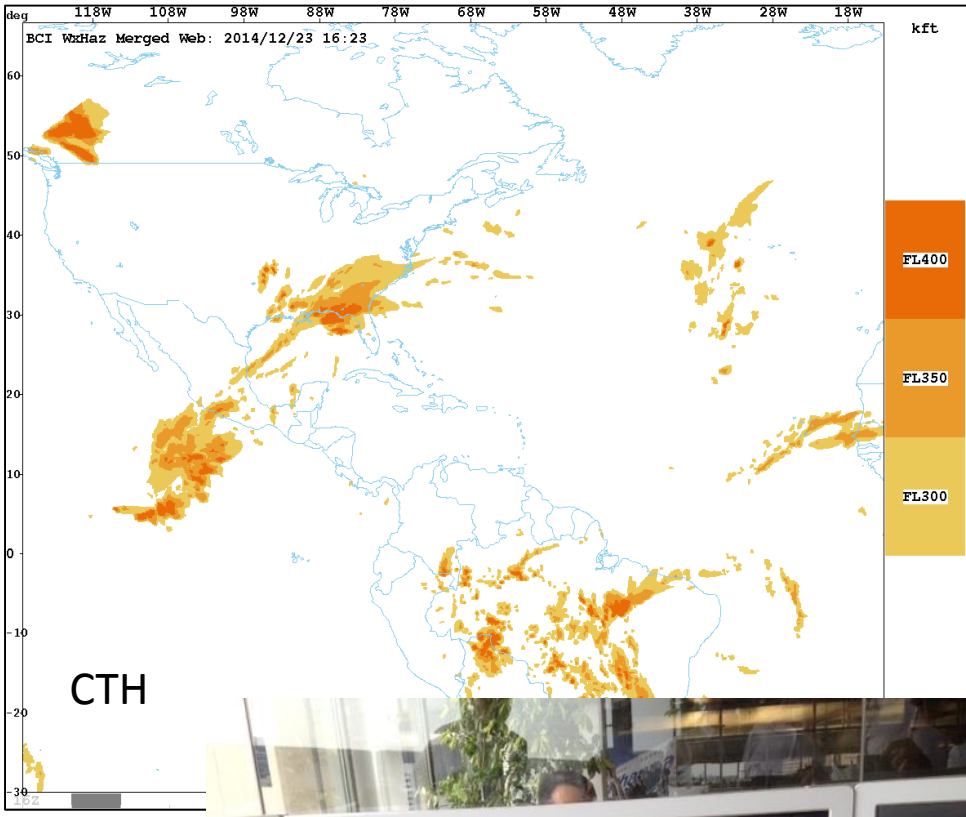
- For 2012 NIEC RCS demo, a color graphic was added and displayed on Electronic Flight Bag (EFB)
  - Same flight levels
  - Triggered on position reports
- For 2014 trial with Lufthansa, three flight levels used, displayed on EFB and Tablet
  - FL300, FL350 and FL400
  - Trigger on new data, not position

Lufthansa Airlines A380 EFB

The eFlightOps Atlantic Weather Hazard Trial

- NCAR runs CTH realtime system
- NCAR sends CTH polygons to BCI through Open Geospatial Consortium (OGC) interface using Web Feature Service (WFS) and is compatible with NextGen
  - GOES-East domain
  - 15 min updates
  - FL300, FL350, FL400 polygons
- Lufthansa pulls polygons from WFS server at BCI
  - Displays CTH on EFB/Tablet and in Mission Support
- Operational period Jun 2014–Jan 2015
  - 2-4 flights per month

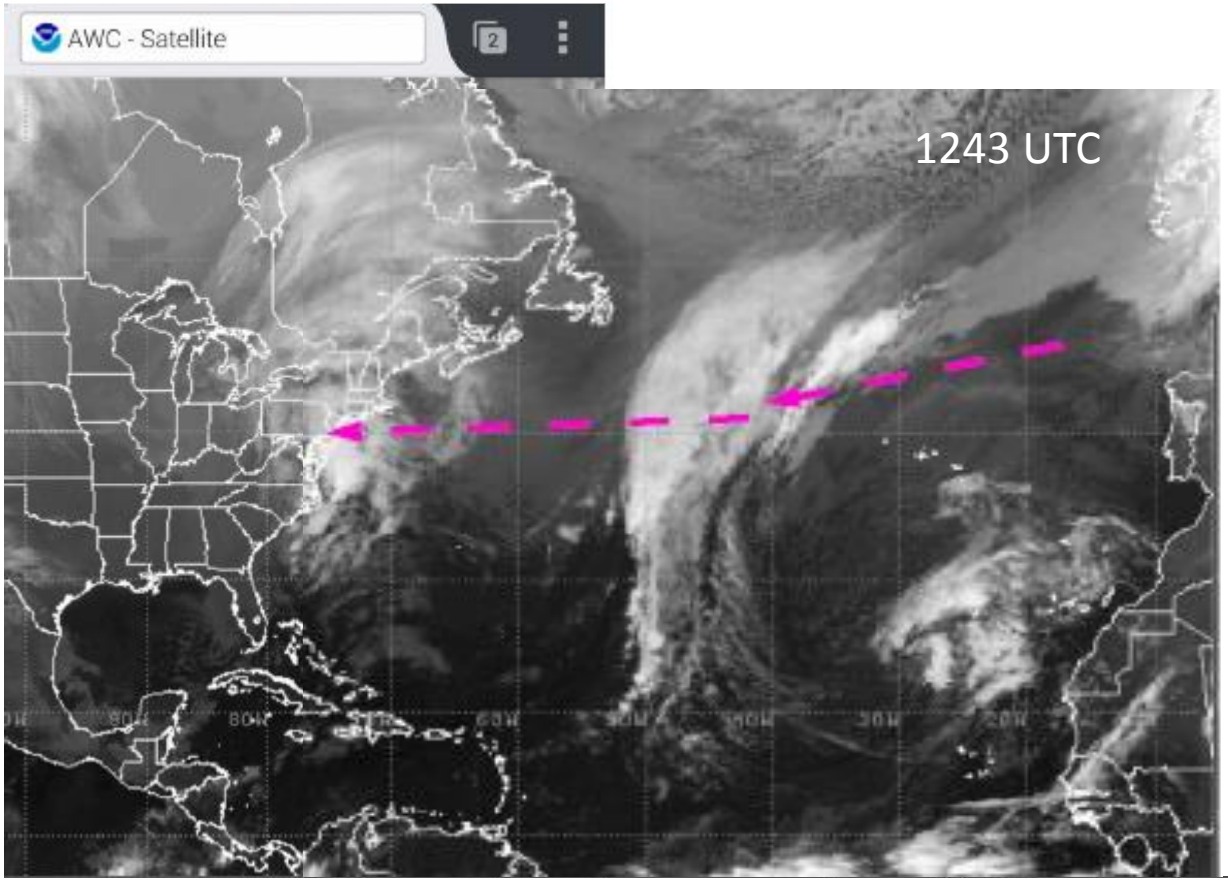


Example #1 of Pilot Use of CTH

- Capt. Klaus Sievers, 747, flight Frankfort-Newark on 9 Dec 2014
- Pre-flight information showed storms near Newark

SigWx Chart, valid 18 UTC

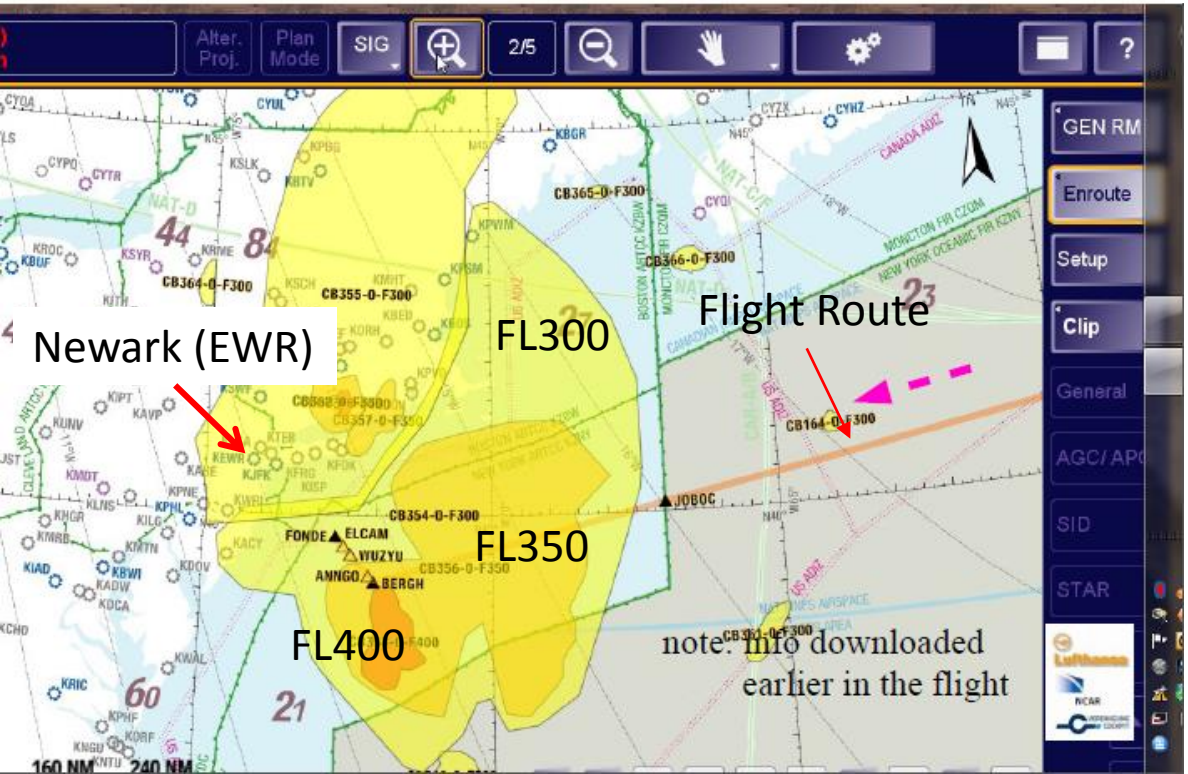
Sat-pictures, before flight, showing approx. flight route.
Note that route was choosen to avoid 150kts + jets.



Example #1 of Pilot Use of CTH

- CTH uplink product:
  - Used to identify the position of the cloud system east of Newark
  - Position: Information was used to time the cabin service so as to have it end before entry into the cloud-system

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



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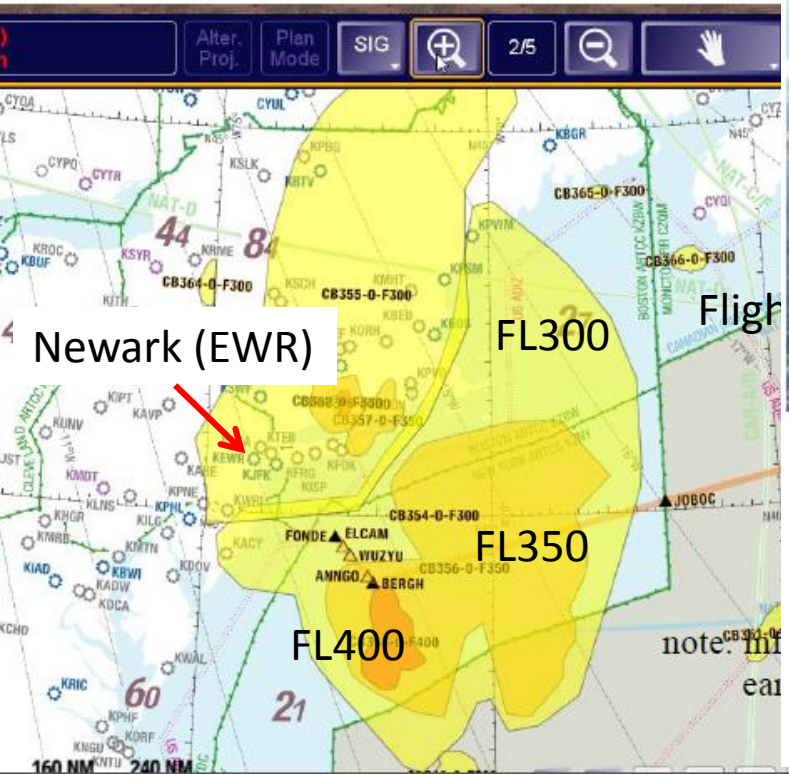
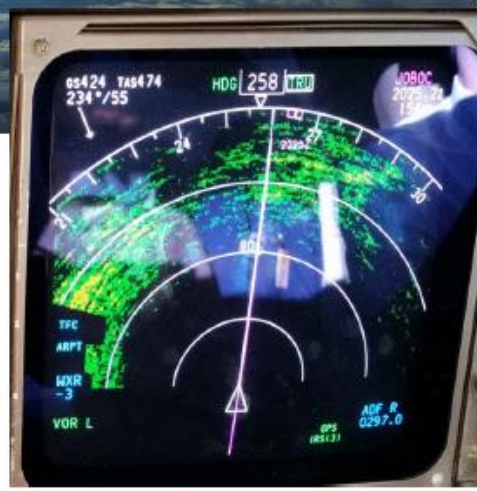
- CTH uplink product:
  - Used to identify the position of the cloud system east of Newark
  - Position: Information was used to time the cabin service so as to have it end before entry into the cloud-system
  - Position and height of CTH uplink product were accurate.

Weather – system between JOBOC and Newark, ar
clouds had moved 150nm east. No update to yellow

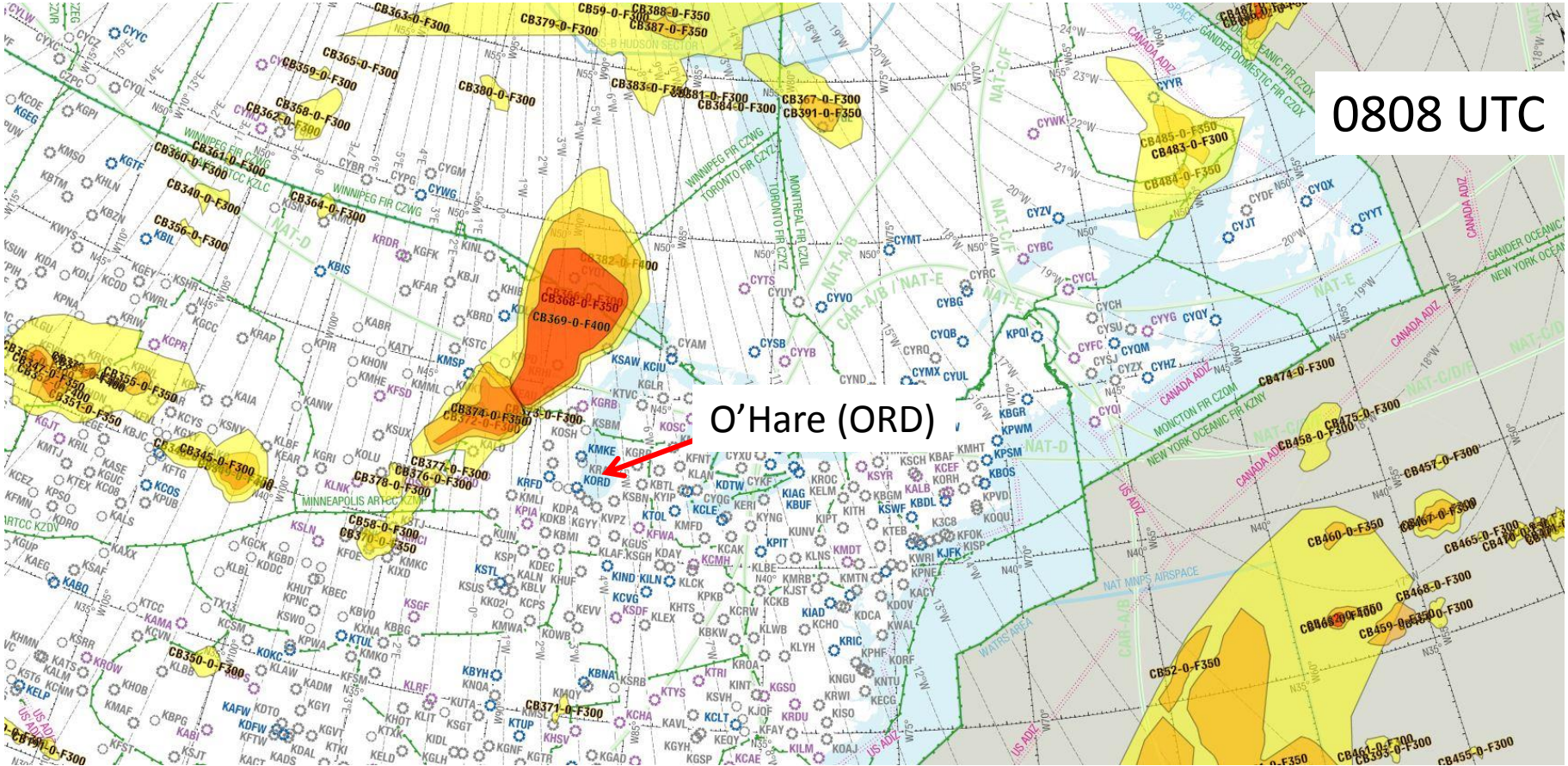


150 nm from JOBOC, 20:03z
clouds are approx. at airplane
FL 370 and contain moisture.
See radar, Airplane ahead reported
moderate turbulence at same FL
Our flight experienced light, occasional
moderate turbulence.



Example #2 of Pilot Use of CTH

- 25 August 2014, Frankfurt-O'Hare
- Pre-departure image shows large CTH area, west of ORD
- Scheduled time of arrival ~1750 UTC



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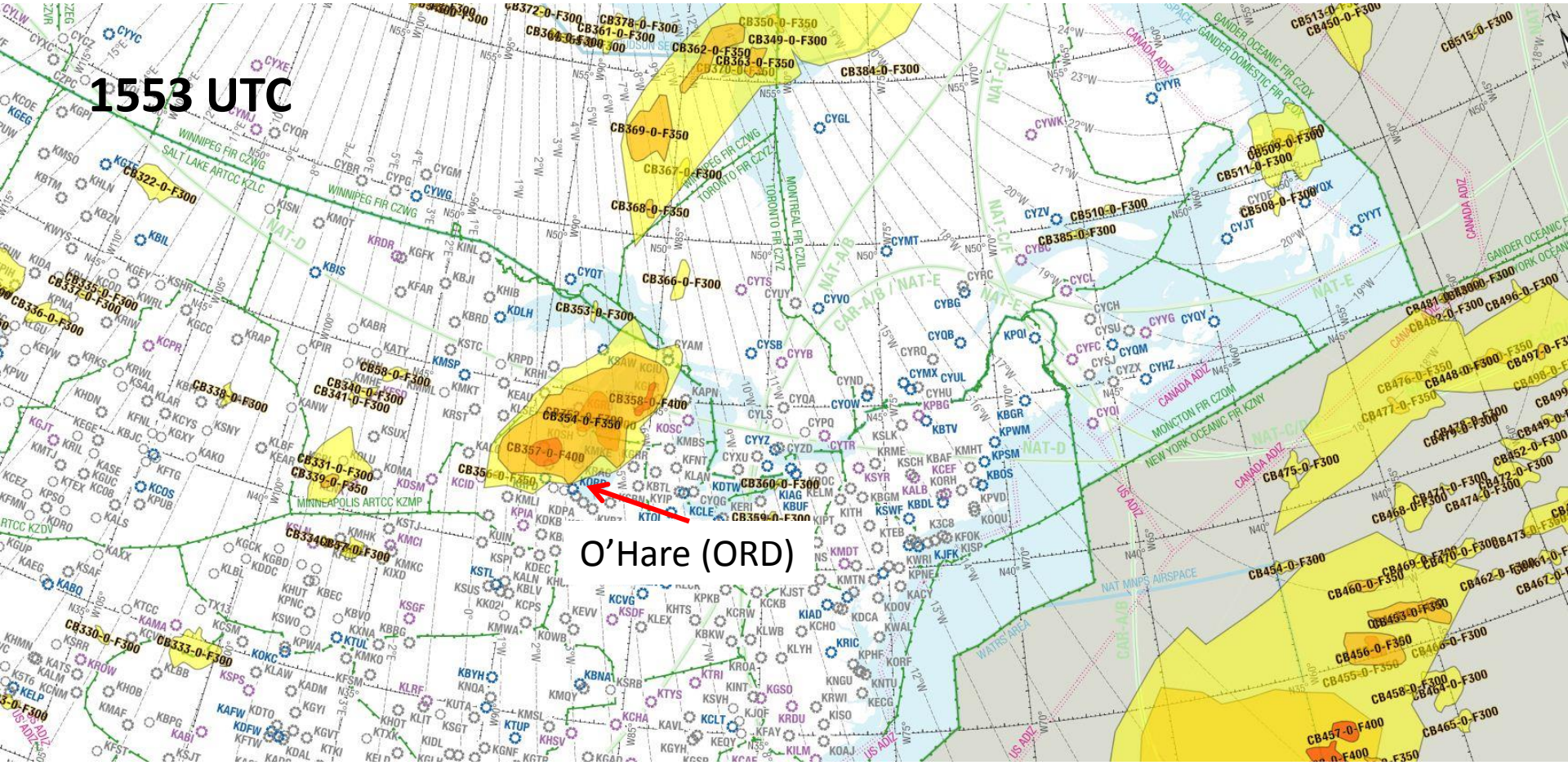

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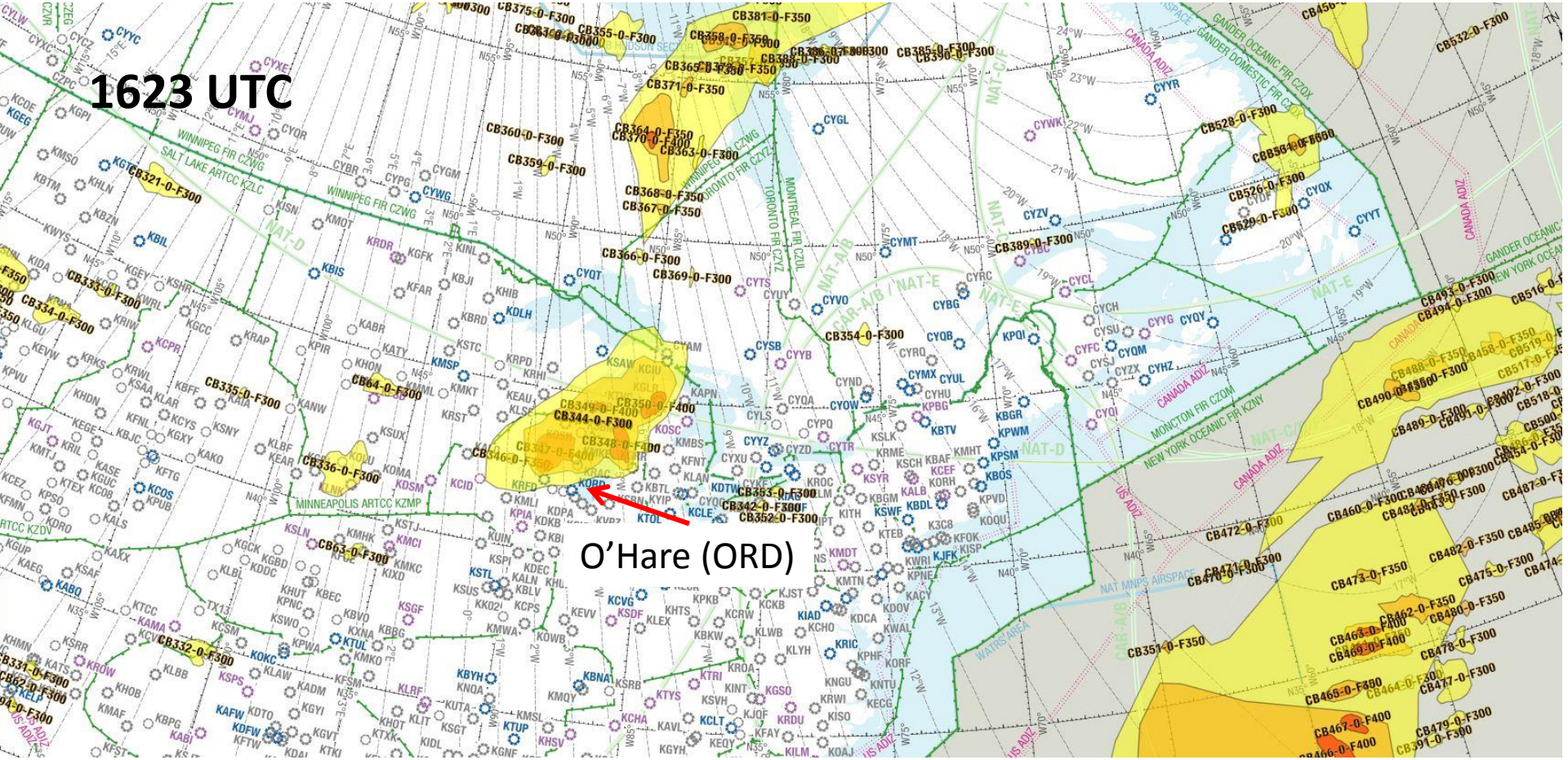

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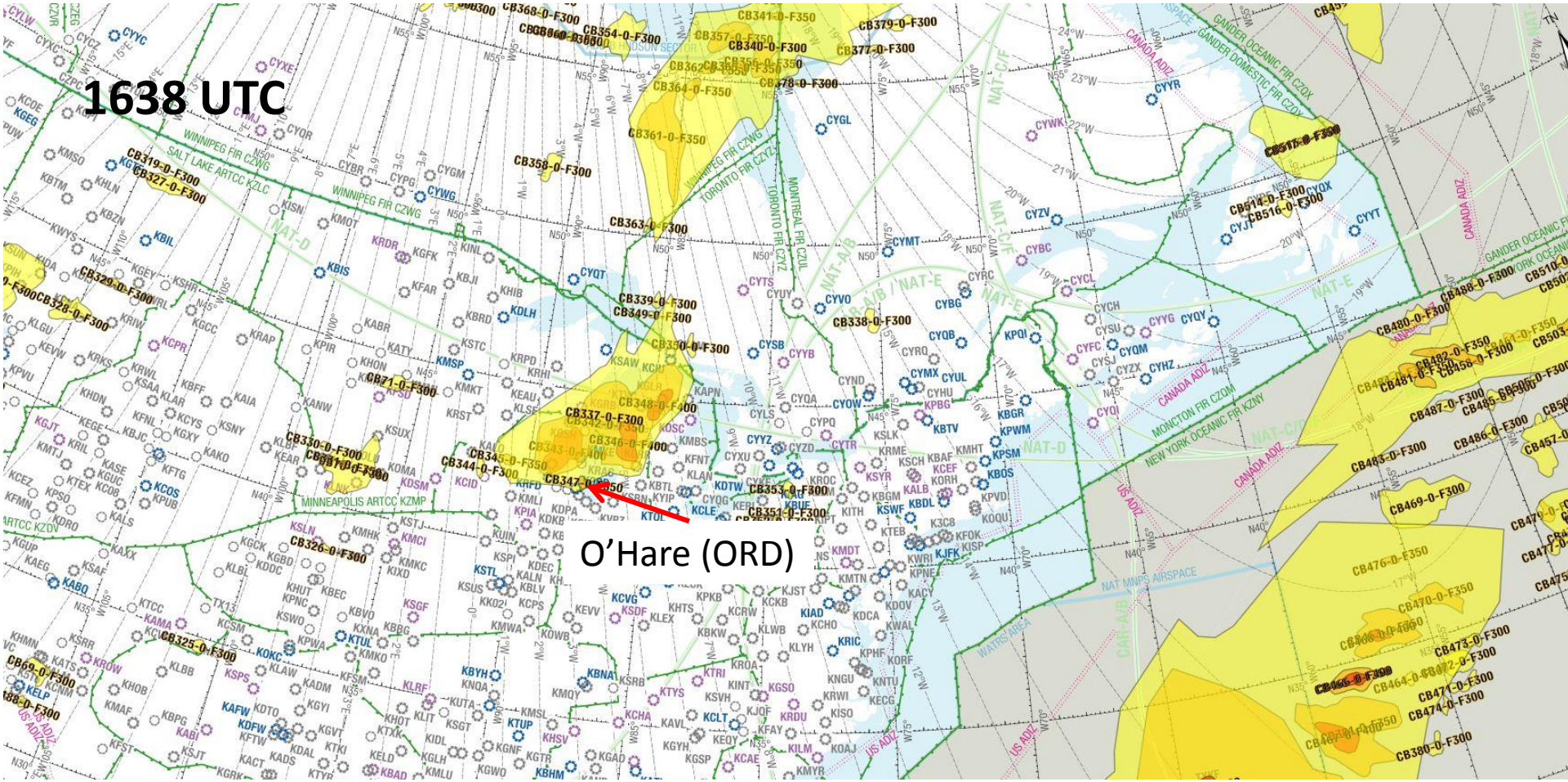

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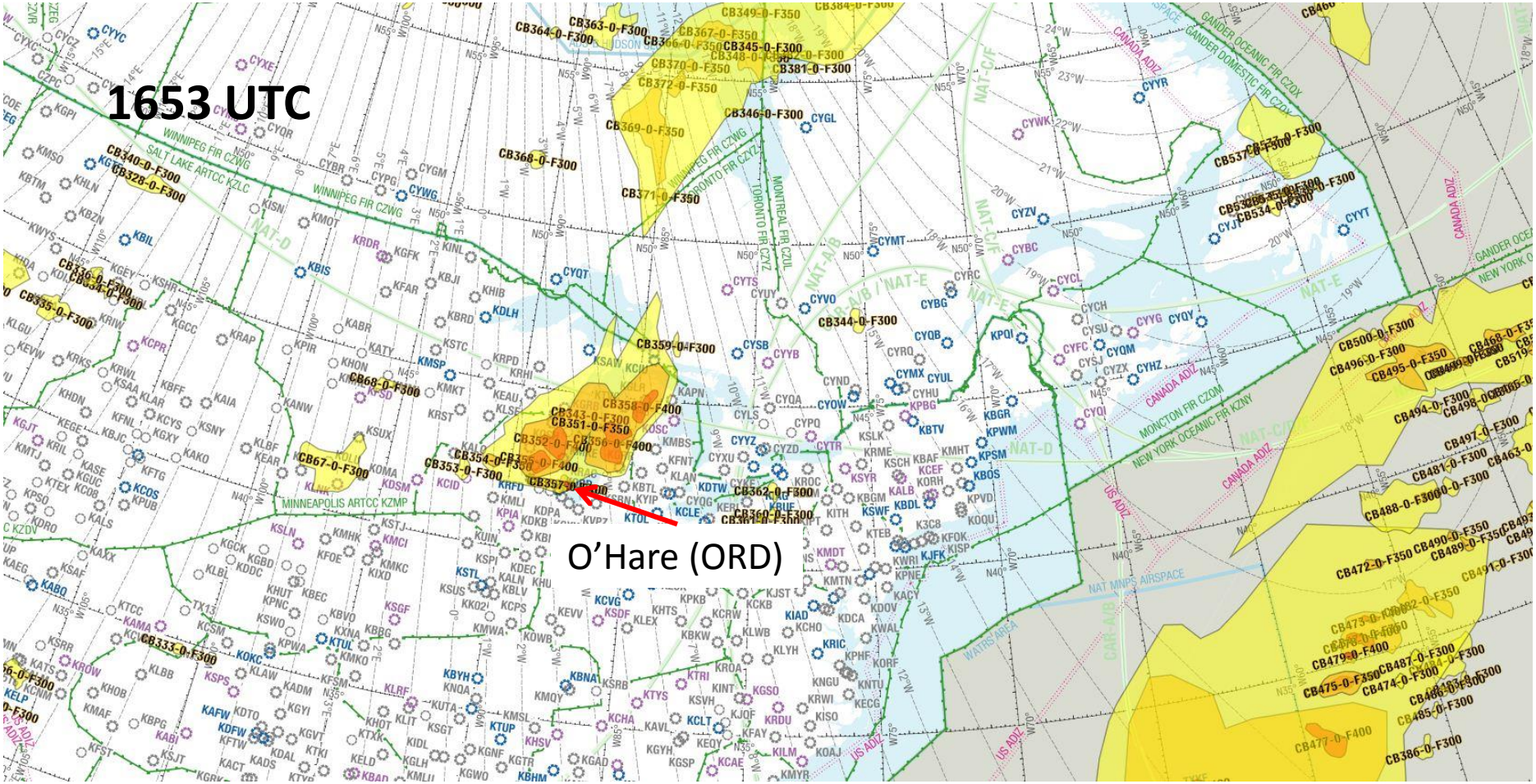

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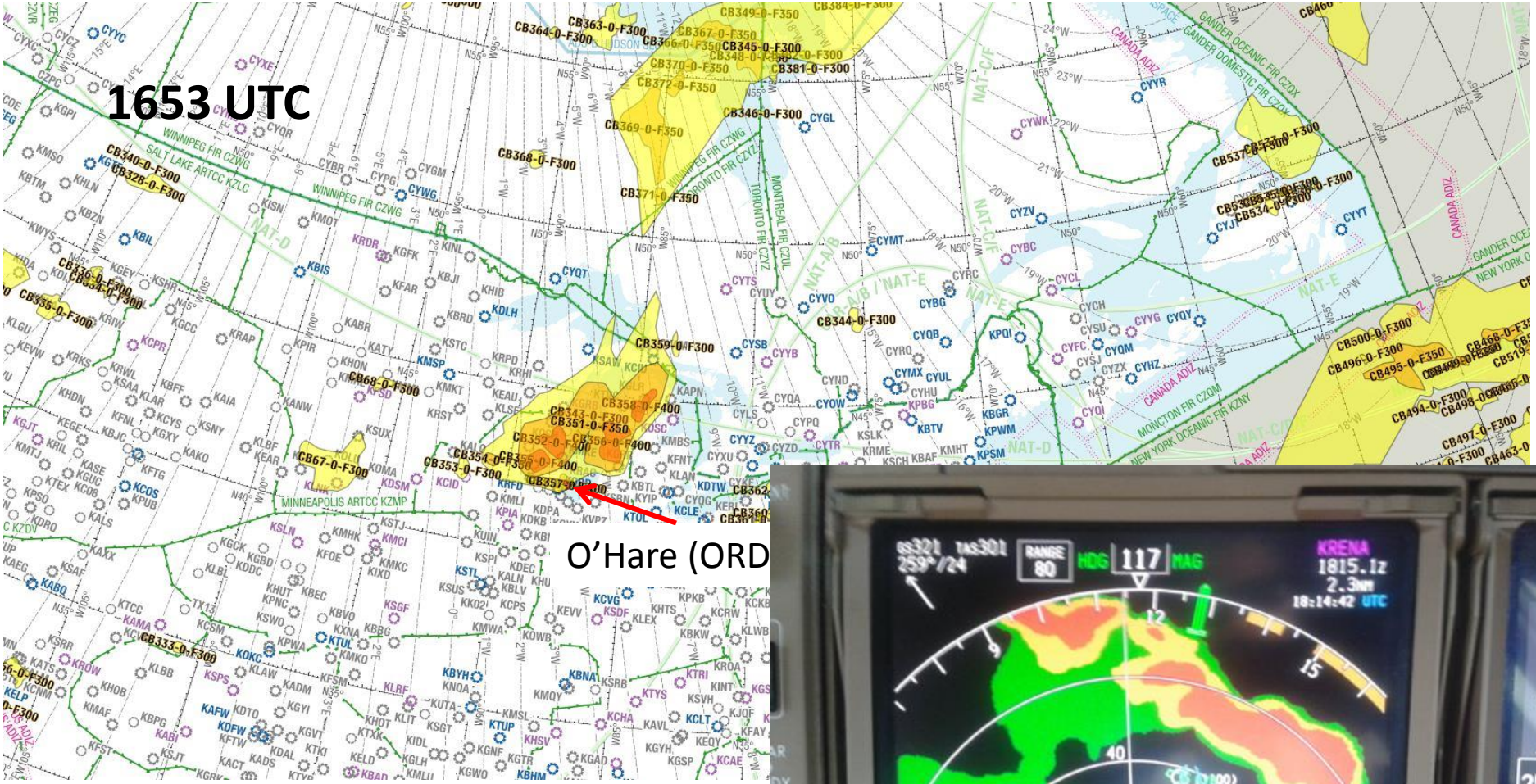
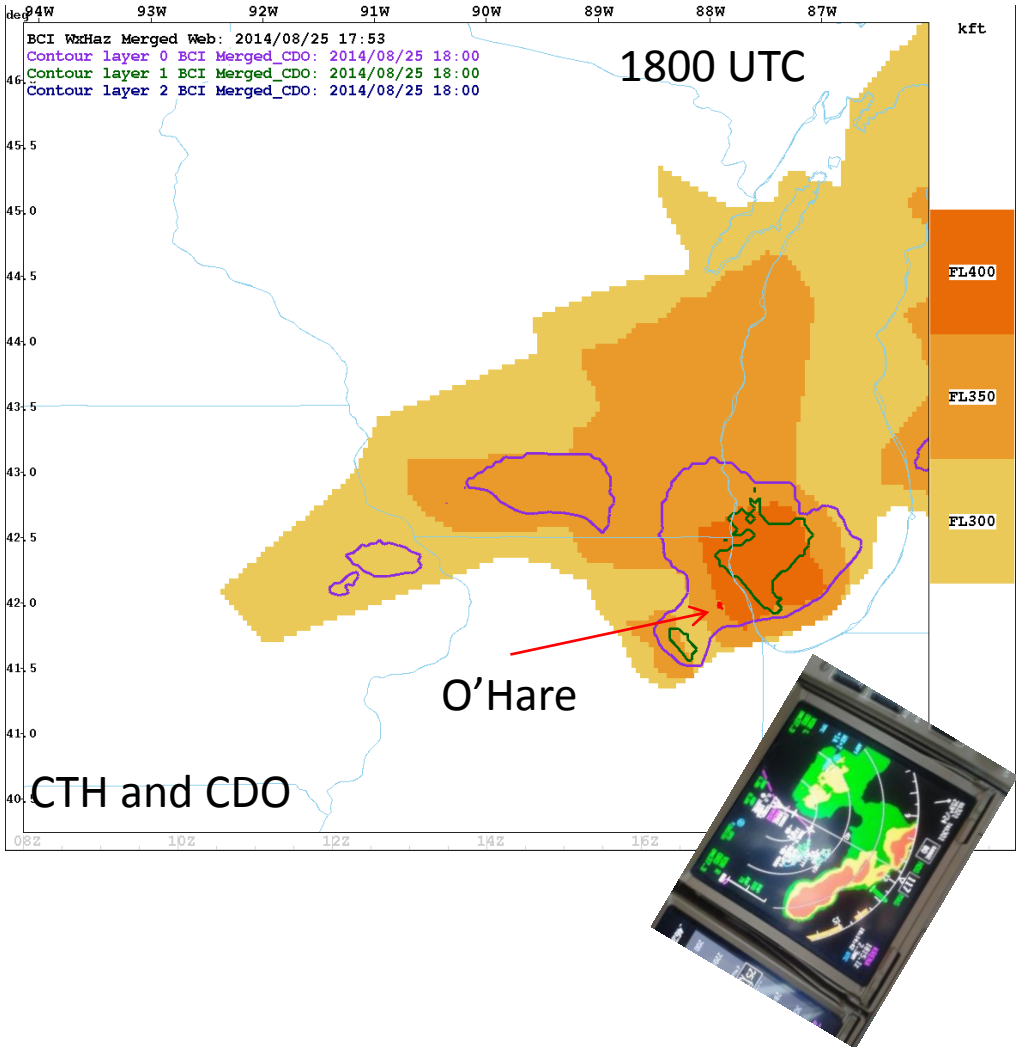


- Onboard radar on approach at 1815 UTC showed convective hazard was east of KORD

Example #2 of Pilot Use of CTH

- As a result of this flight, the Convective Diagnosis Oceanic[1,2] (CDO) product will be added to uplink as an overlay to CTH
- CDO, fuzzy logic data fusion of:
  - Two satellite-based detection algorithms (CTH[3], GCD[4])
  - Global lightning
  - Overshooting tops[5]
- Adding CDO better defines convective region; smaller area than CTH is typical



References:

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[4]Mosher, 2002: Detection of deep convection around the globe. *Preprints, 10th Conf. Aviation, Range, Aerospace Meteor.*, AMS, Portland, OR, 289-292.

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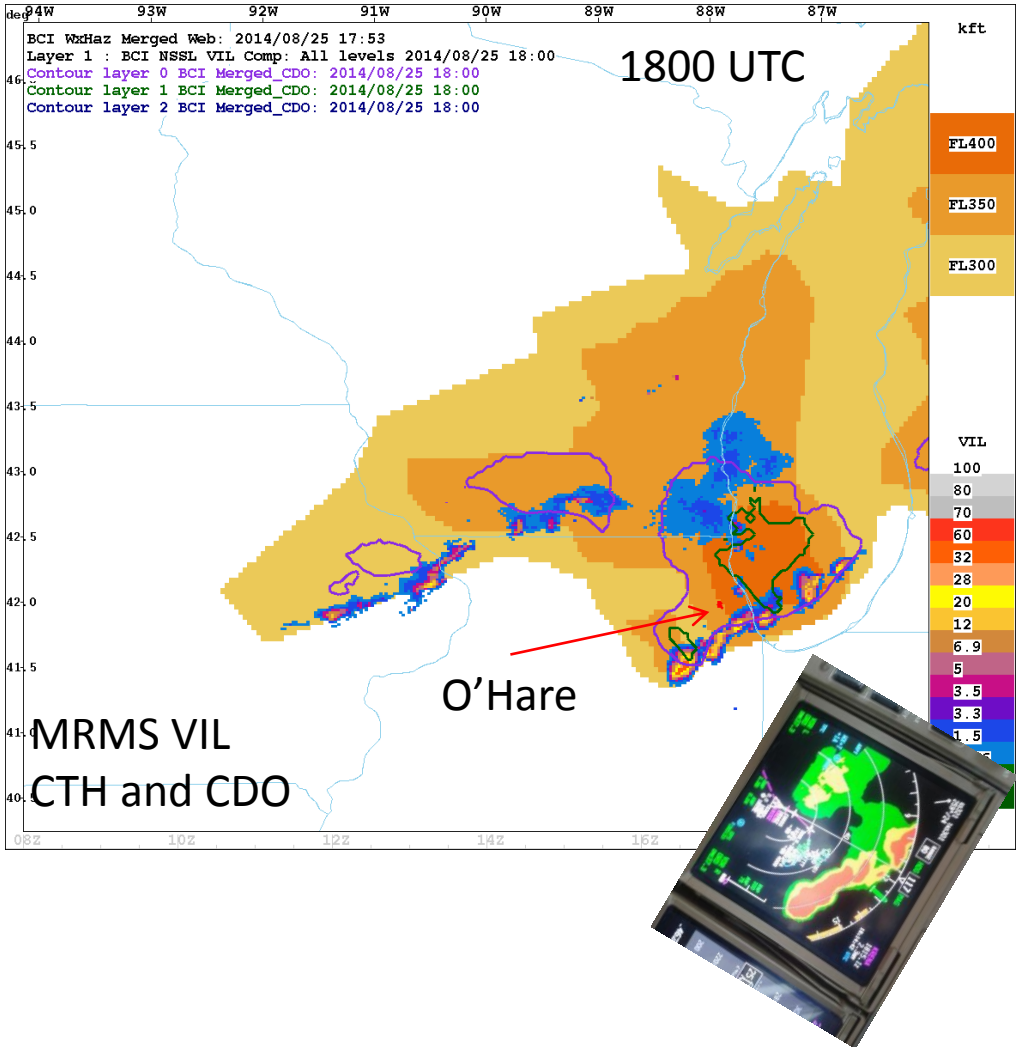

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Summary

- Cloud top height polygons being uplinked into select Lufthansa Airlines aircraft and displayed on an EFB or Tablet
  - eFlightOps Atlantic Weather Hazard Trial
- Trial results have been successful with the CTH product showing good skill and accuracy
- Second phase is to provide CTH and CDO polygons to entire Lufthansa fleet with additional enhancements for storm motion, extrapolation

Thank you!

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