THE GLOBAL HAZARDS WEATHER PROJECT

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Motivation: Reduce Efficiency and Safety Costs

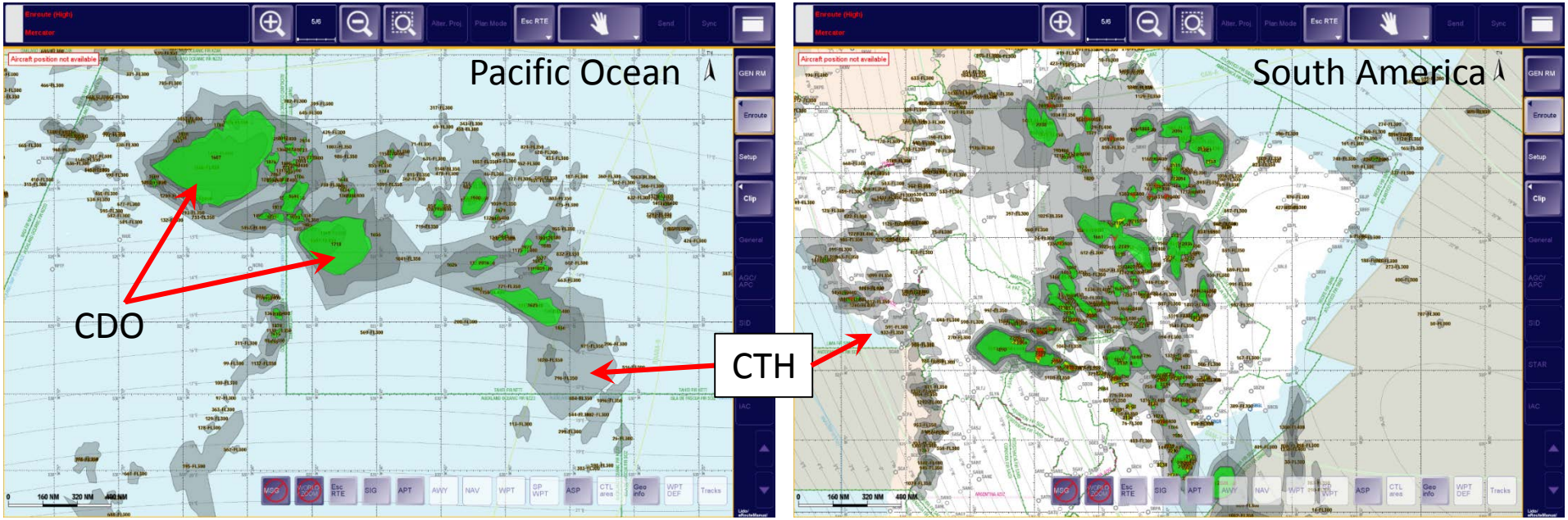
NCAR

- 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

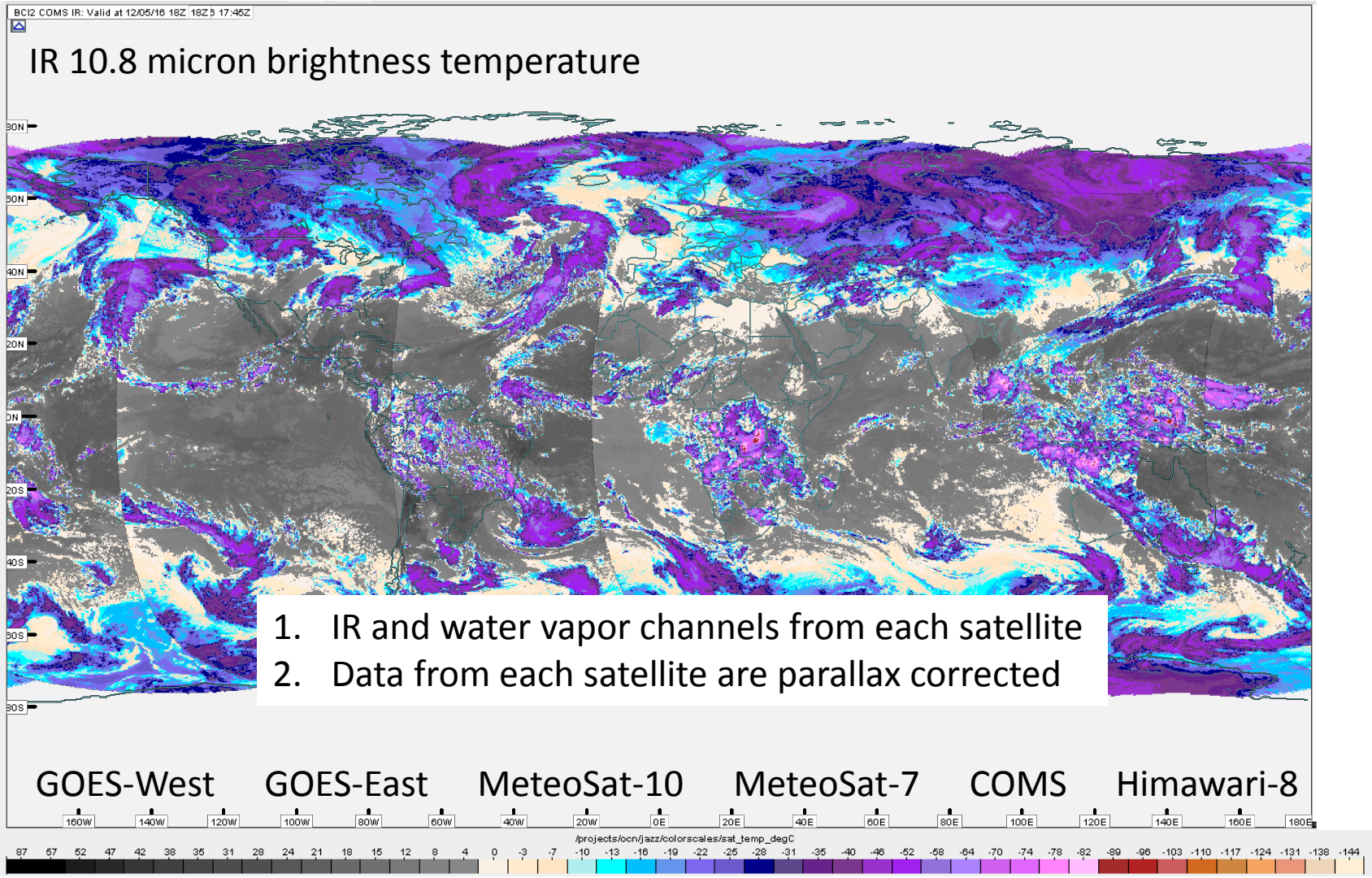
Global Hazards Weather (GHW) Project

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)

Building a Geostationary Satellite Mosaic for the CTH and CDO Products



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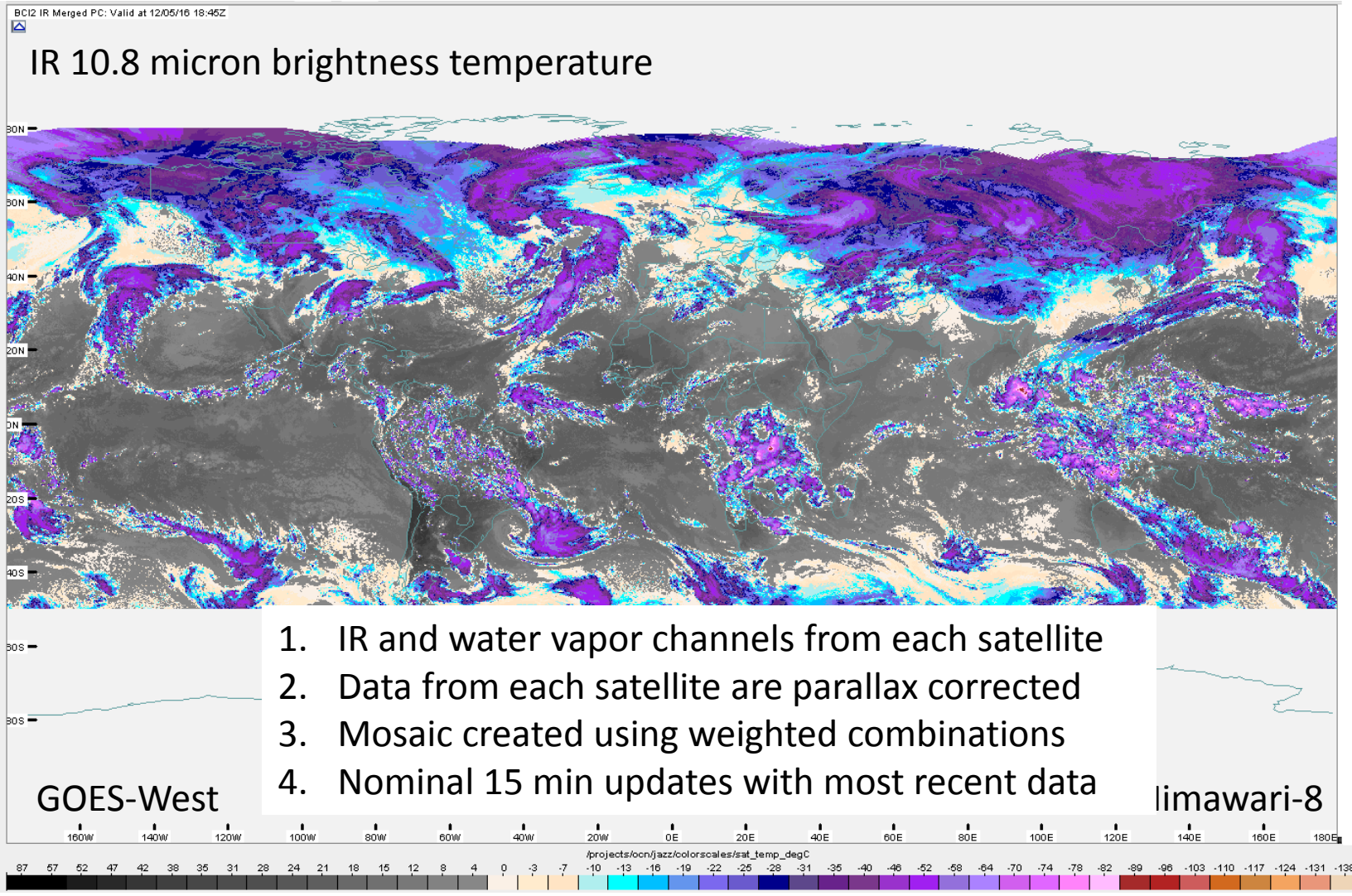

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Convection Weather Products

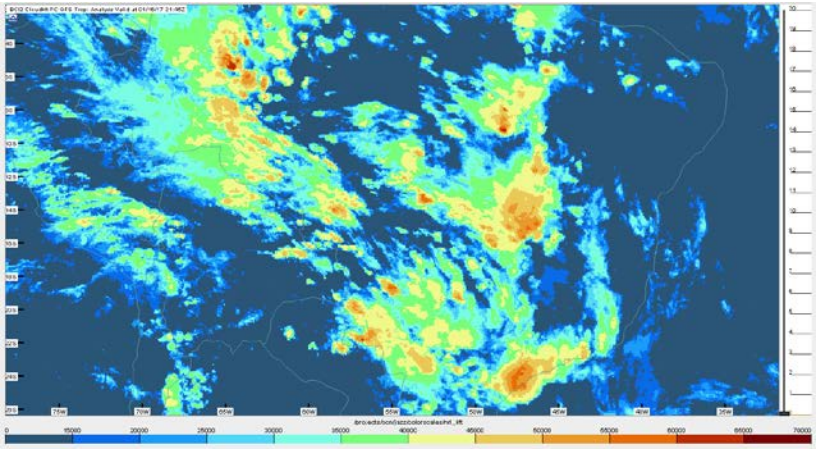
NCAR

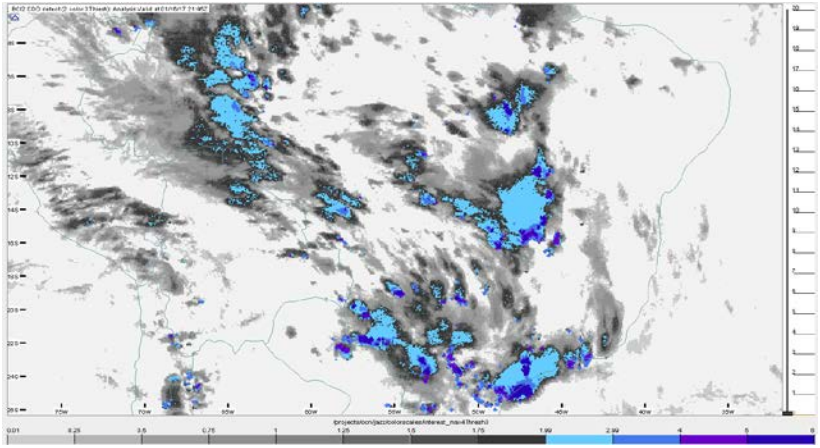
Cloud Top Height (CTH)

- 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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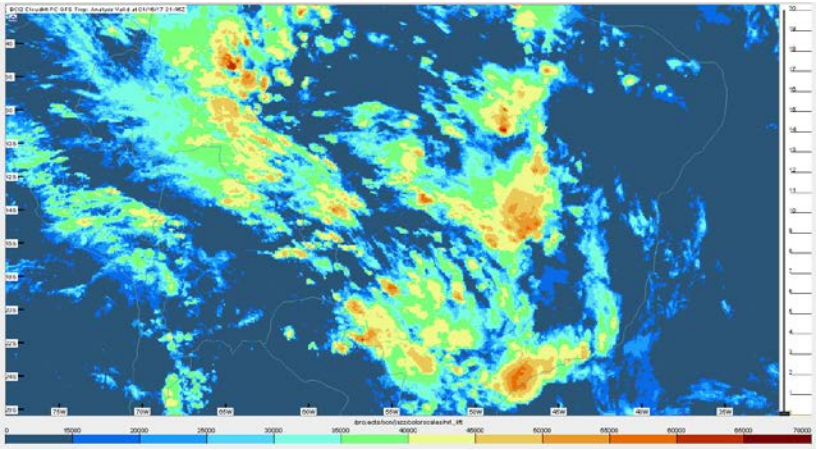
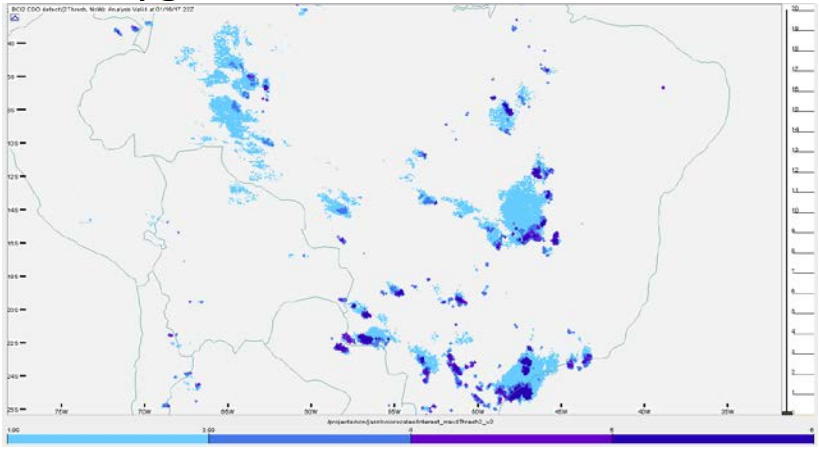


Convective Diagnosis Oceanic (CDO)

- Data fusion of scaled and weighted inputs to create interest map
  - CTH, Global Convective Diagnosis, Overshooting Tops, EarthNetworks global lightning
  - Maximum value is 6
- Convective hazards defined as CDO≥2
- CDO ≥3 means lightning/OTops
- Polygons at 2, 3, 4, 5 interest



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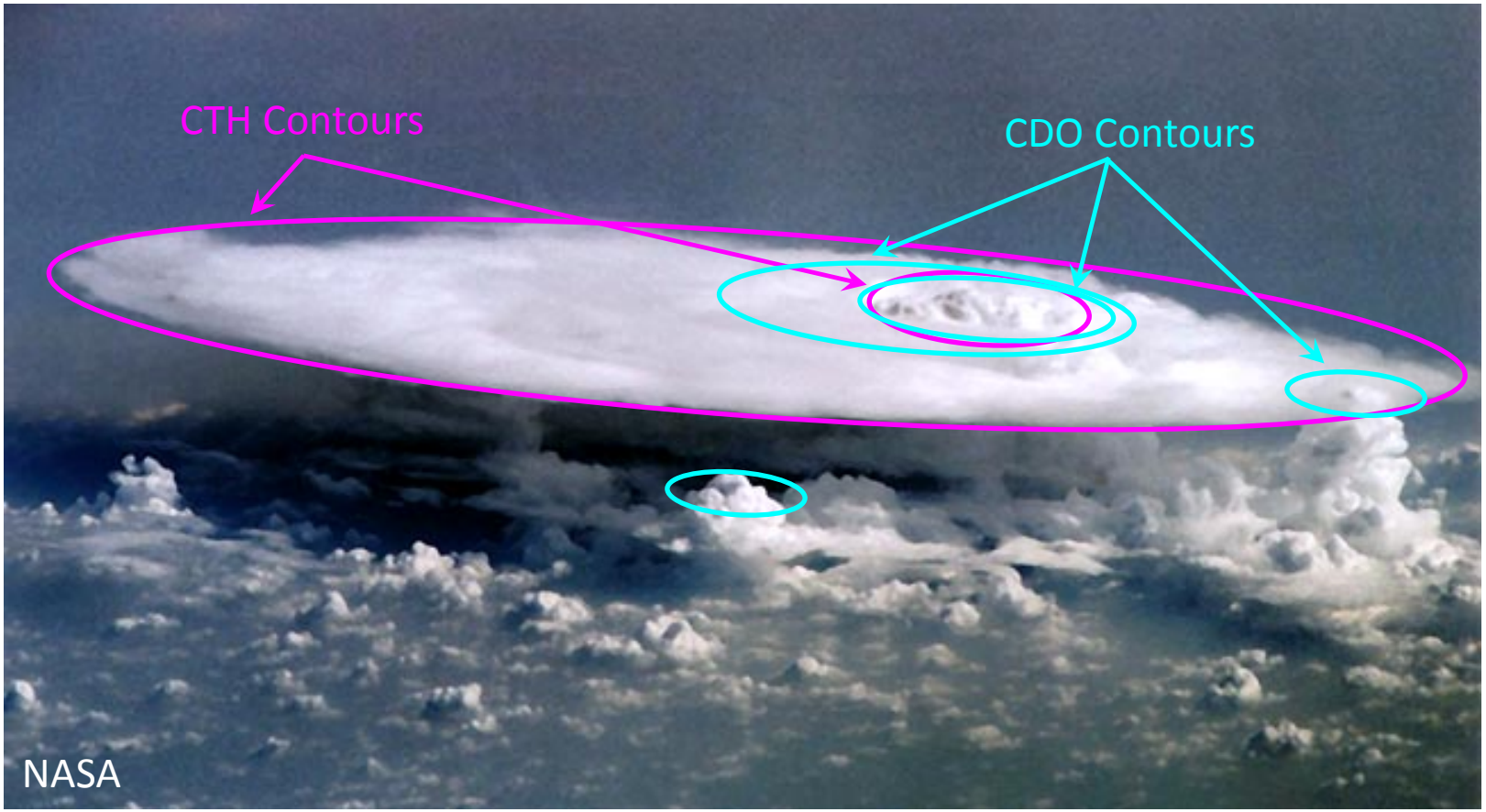
Why Two Convective Products?



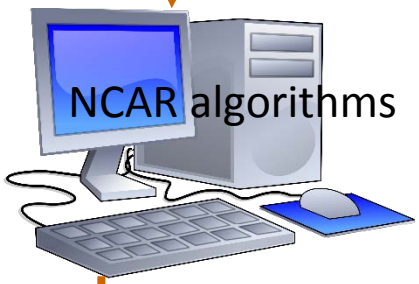
- Two products fully characterize convective storm structures
- CTH gives full extent of anvil cloud cover and flight level heights
  - Regions of possible turbulence, possible high ice water content, anvil lightning
- CDO shows location of updraft/lightning hazards

Engineering Design of Product Creation and Dissemination

Geo-satellites

EarthNetworks Lightning
GFS

MeteoStar
Englewood, Colorado



NCAR algorithms

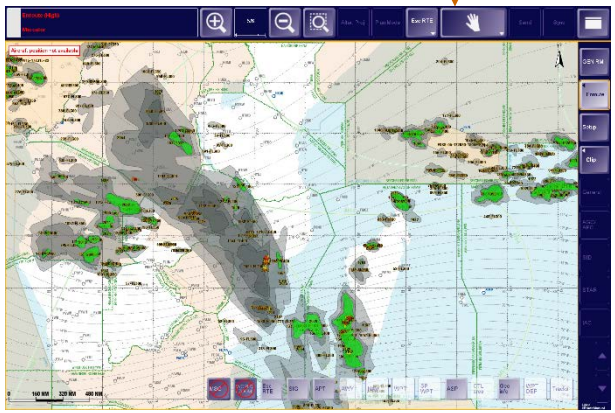
Data link &
Broadband

Lufthansa Airlines
Brussels Airlines

Link Protocol
Box
WIFI Router

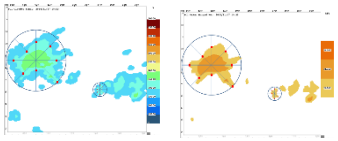
eRM Pilot
Display
WIFI

Lufthansa Servers
Frankfurt, Germany



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

BCI Servers at MeteoStar



Convert gridded
CTH and CDO
to XML polygons

Data Base:

- CTH Polygons (XML)
- CDO Polygons (XML)
- Max CTH within CDO (XML)
- Storm motion vector (XML)
- Missing data polygons (XML)

Web
Feature
Service
(NextGen
& SESAR)

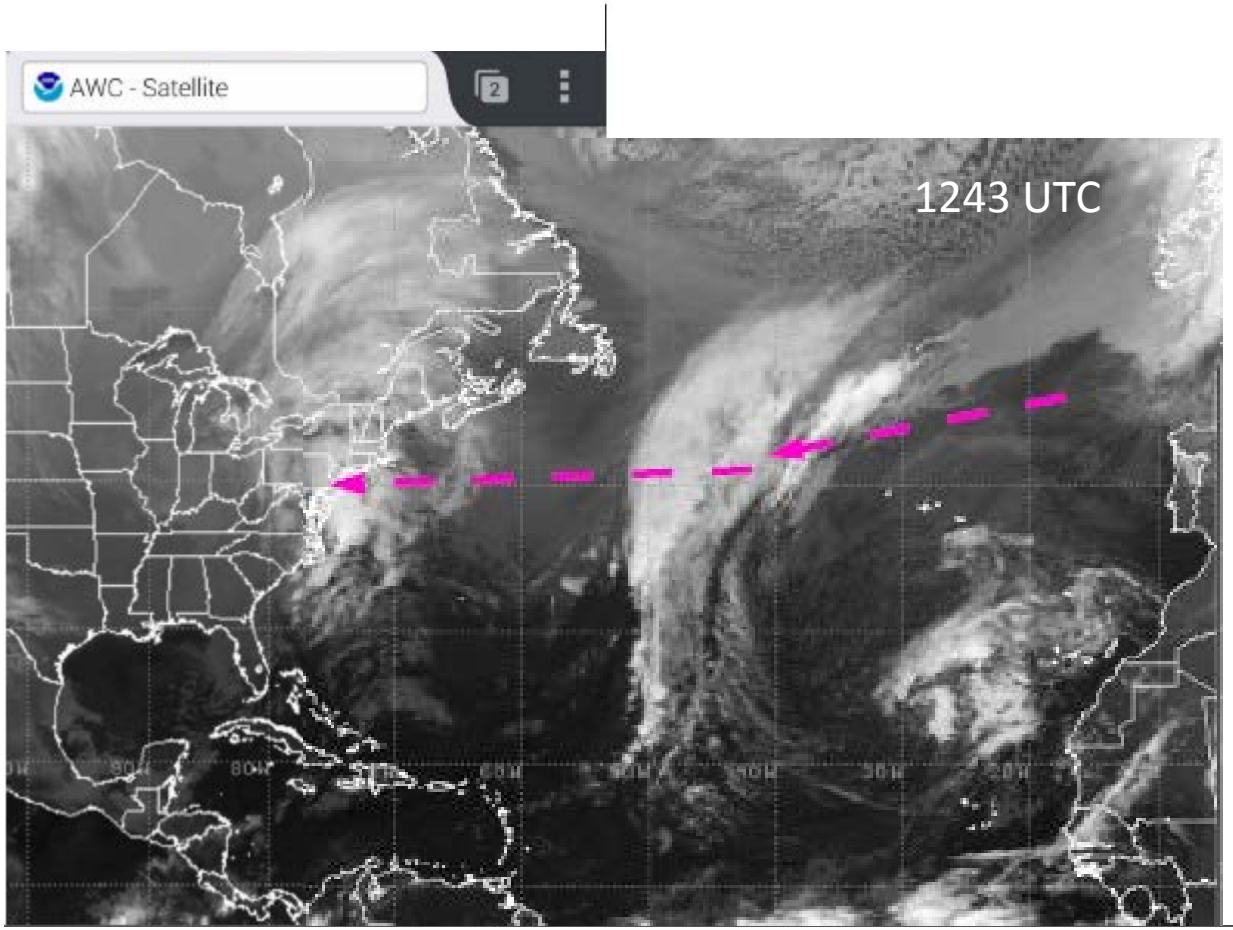
Example #1 of Pilot Referencing of CTH

NCAR

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

WAFC SigWx Chart, valid 18 UTC

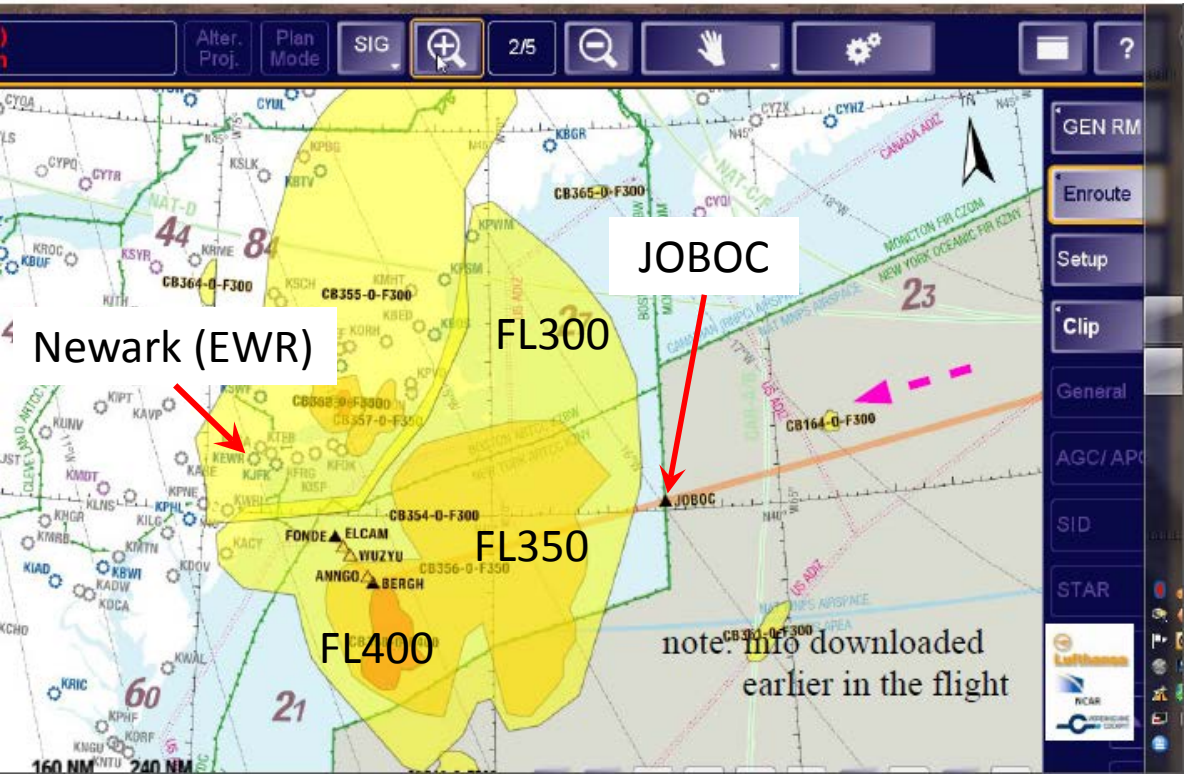
Sat-pictures, before flight, showing approx. flight route.
Note that route was choosen to avoid 150kts + jets.



Example #1 of Pilot Referencing of CTH

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

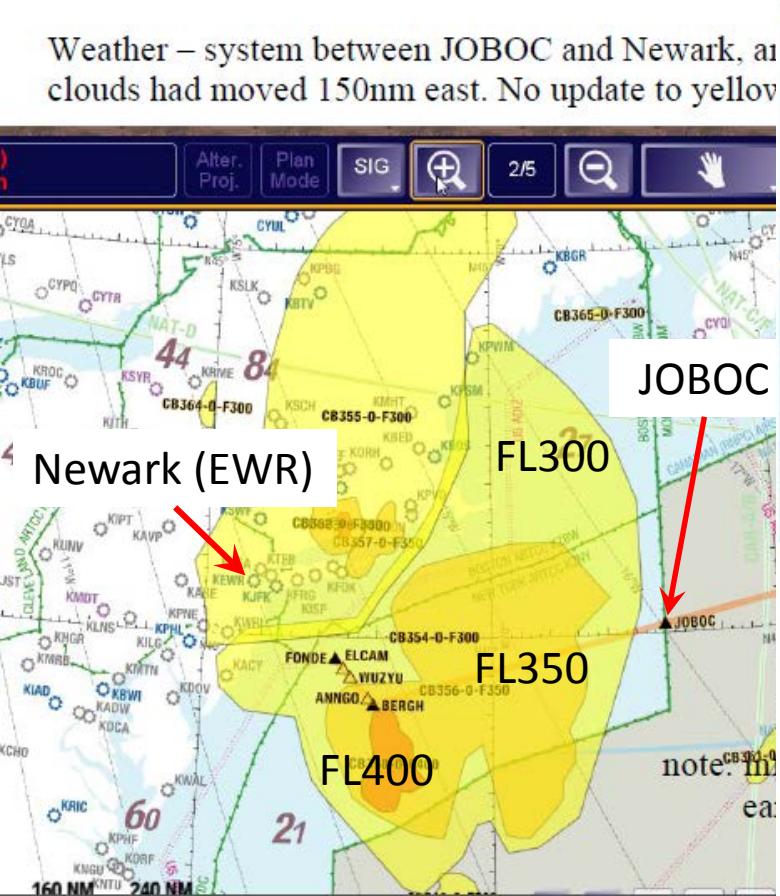
Weather – system between JOBOC and Newark, around 15z.Note: 5hrs later, clouds had moved 150nm east. No update to yellow clouds obtained.



Example #1 of Pilot Referencing of CTH

NCAR

- 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



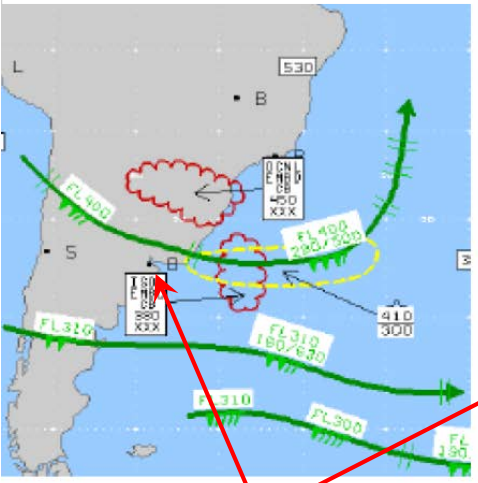
150 nm from JOBOC, 20:03z clouds are approx. at airplane FL 370 and contain moisture. See radar, Airplane ahead reported moderate turbulence at same FL Our flight experienced light, occasional moderate turbulence.

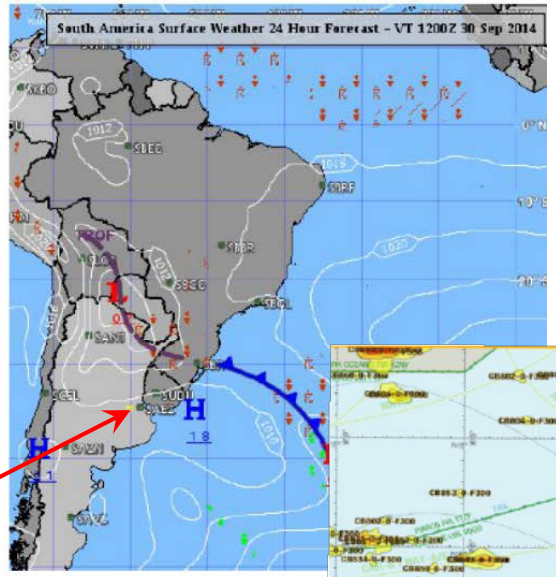
Example #2 of Pilot Referencing of CTH

NCAR

- Frankfurt-Buenos Aires flight
- Storms expected in South America; re-routing expected

WAFC SigWx Chart





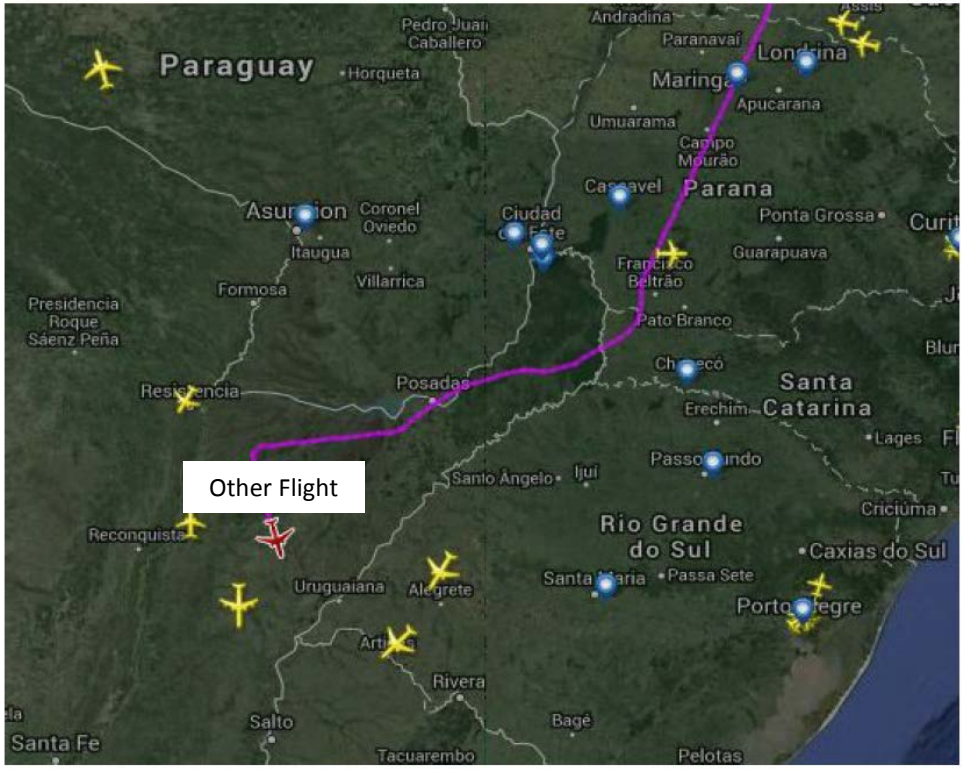
Buenos Aires

Flight Route

Storms are present!

eRM at
2108 UTC

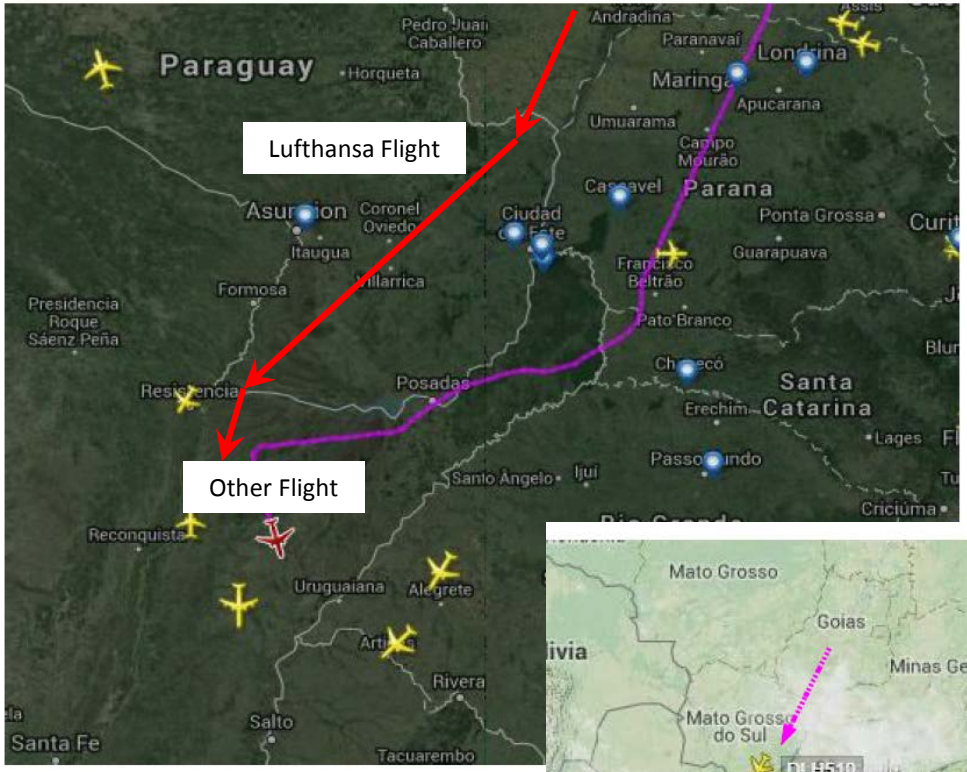
Example #2 of Pilot Referencing of CTH



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

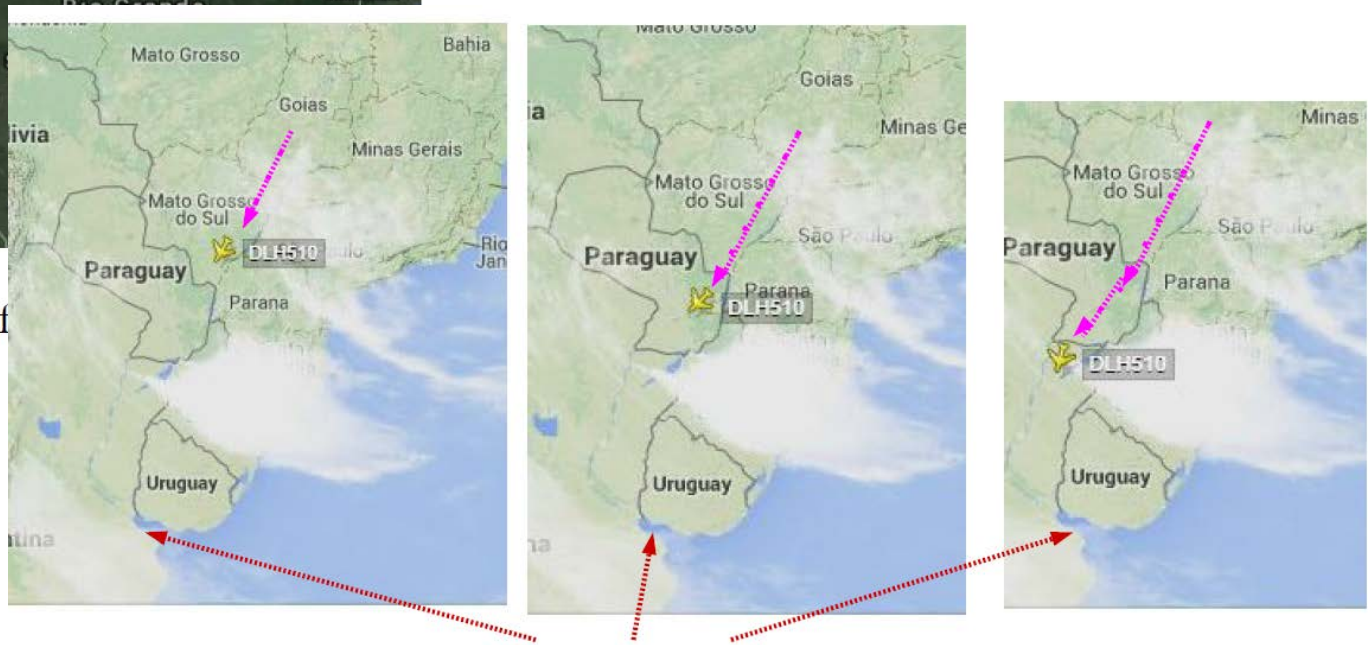
Info: deviation without use of satellite-information

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



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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A COLLABORATION BETWEEN BCI MeteoStar Lufthansa NCAR