Enhancements to the Global Weather Hazards Project

Cathy Kessinger[1], D. Megenhardt[1], James Olivo[2], L. Lin[2], V. Hoang[2], Mike Nayote[2], Oliver Matz[3], A. Ritter[3], D. Wolf[3], Klaus Sievers[4], Robert Scheinhartz[5], J. Cahall[5]

[1]National Center for Atmospheric Research, Boulder, CO / [2]Basic Commerce and Industries, Inc., Moorestown, NJ

[3]Lufthansa Airlines, Frankfurt, Germany / [4]German Airline Pilots' Association, Frankfurt, Germany / [5]MeteoStar, Englewood, CO

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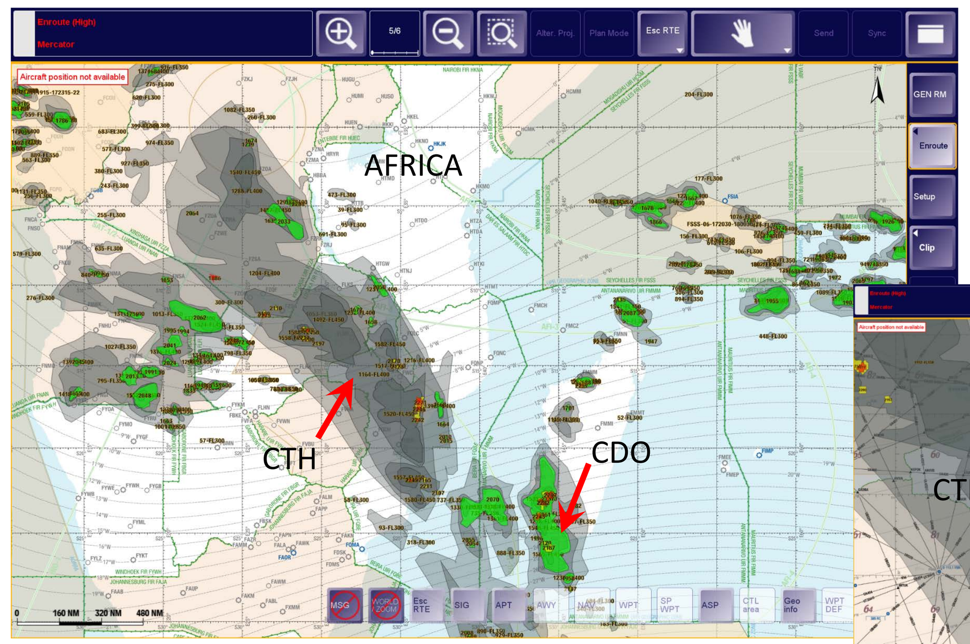
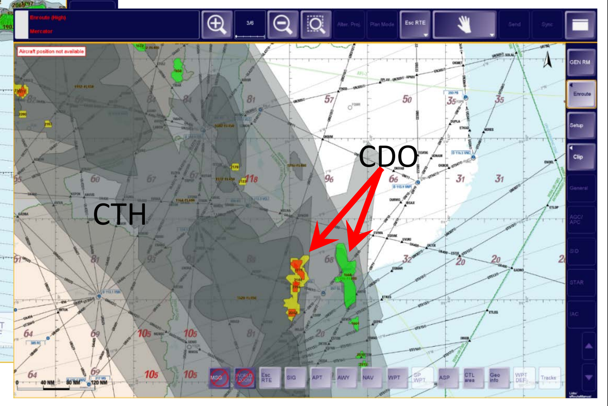
Global Weather Hazards Project

The Global Weather Hazards (GWH) Project, operational since 2015, has proven that the capability exists to uplink and display weather products in the flight deck that are accurate, timely and useful for strategic decision making by commercial pilots (Kessinger et al. 2017a; Kessinger et al. 2017b; Olivo et al. 2018). For the past few years, a suite of standard and convective hazard products have been uplinked and displayed on the Electronic Flight Bag (EFB) as an overlay on the navigational charts. Standard products (i.e., Significant Meteorological Information (SIGMETs) and Airmen's Meteorological Information (AIRMETs) for convection, turbulence and icing as well as Volcanic Ash Advisories are displayed to give hazard information to pilots. In addition, two convective weather products, called the Cloud Top Height (CTH) and the Convection Diagnosis Oceanic (CDO), are uplinked for display on the EFB in Lufthansa Airlines B747-8 aircraft. The EFB, is comprised of a Microsoft Surface Pro 3, and uses the Lido EnRoute Flight Manual (eRM), shown below. These two products are computed over a global domain using geostationary satellite data and lightning data. The products are available in near-realtime and have a 15 min update rate using the latest available data.

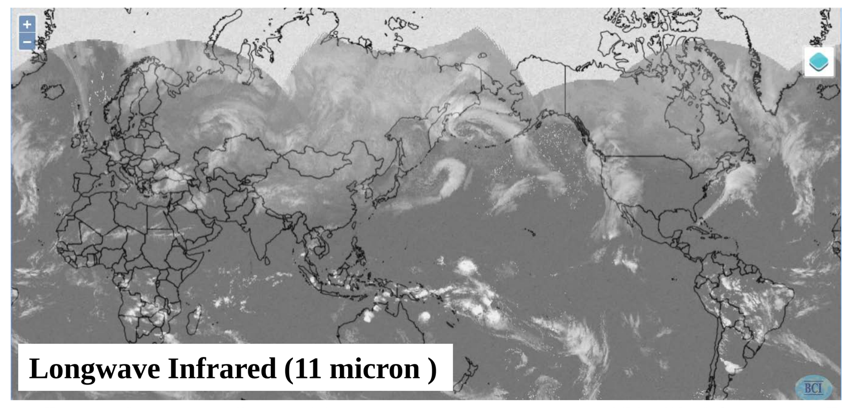
Enhancements made to the GWH system that effect the CTH and CDO products are presented. Changes in the constellation of geostationary satellites have been made by several nations as new satellites replace old ones. Two examples in particular, the replacement of GOES-13 with GOES-16 and the future replacement of GOES-15 with GOES-17, will result in much simpler processing steps within the GWH system as well as considerable improvements in resolution and accuracy of the products. Also, the GOES-16 and GOES-17 include the Geostationary Lightning Mapper (GLM) instrument, whose data will be input into the CDO as an additional source of lightning data that augments the ground-based lightning data.

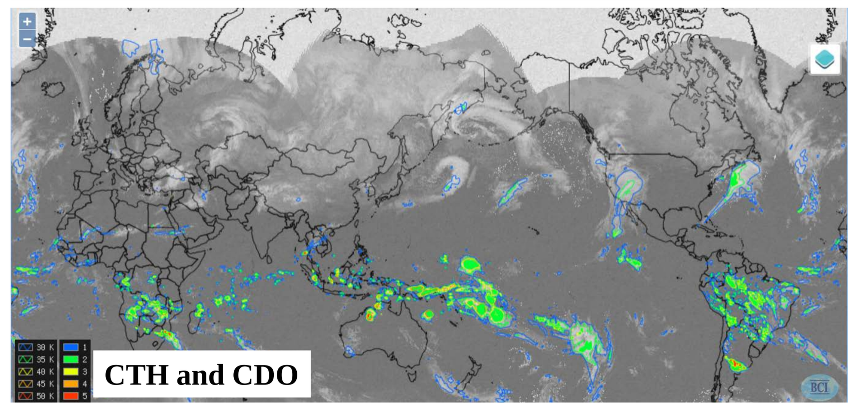


eRM display showing CTH (gray polygons) and CDO (green, yellow, red shapes)



Magnified view of large storm.





Wx Product Improvements and their positive impact with Flight Safety

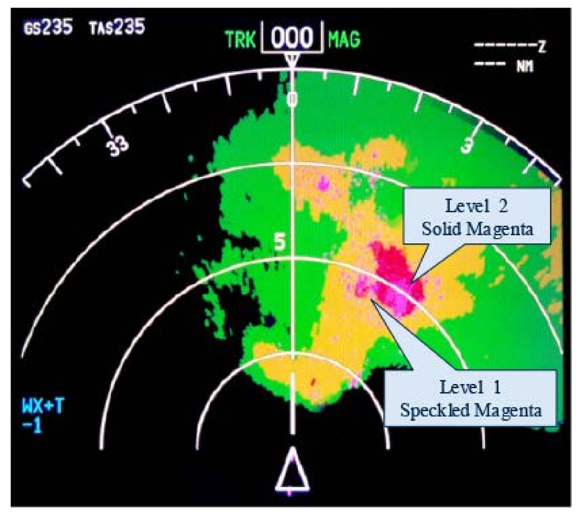
BCI's original work with Lufthansa Airlines entailed the use of data from five primary geostationary satellites, plus others for backup, to construct a global mosaic. The original set included: GOES-15 (West), GOES-13 (East), Meteosat-10, Meteosat-7, and MTSAT-2. The MTSAT-2, GOES-13 and Meteosat-7 have been replaced with Himawari-8, GOES-16 and Meteosat-10, respectively. Meteosat-11 was added as a new satellite. For all cases, the coverage, resolution and update rates have been greatly improved. In the case of GOES-16, some areas located in South America with previous update rates of 1 to 2 hours are now 15 minutes. These improvements, along with others, allow the use of satellite data in circumstances previously reserved for radar.

Replacing GOES-15 with GOES-17 will be done in 2019. Due to problems with overheating of the Advanced Baseline Imager (ABI) instrument, substituting GOES-15 imagery for GOES-17 is planned for channels when data are missing. NOAA plans to operate the two satellites in tandem for the first half of 2019 to allow better understanding of operational limitations.

Better Decisions for Safety and Flight Efficiency achieved by augmenting the Cockpit WxRadar with Global/Regional Wx Products

Conventional Cockpit Based Radar Display
Weather Phenomena limited to line of site

Real-time Data Display
125 NM Look Ahead
Reliable On-Board Feed
Approved for Navigation
Best tool for flying through Wx



Limited Lateral Awareness
~ 120 Degree Cone
Limited Range
125 NM Look Ahead
Lacks global awareness
Adds potential of "flying into box"

Trans-Oceanic Flight Routes demand Regional to Global Weather Products

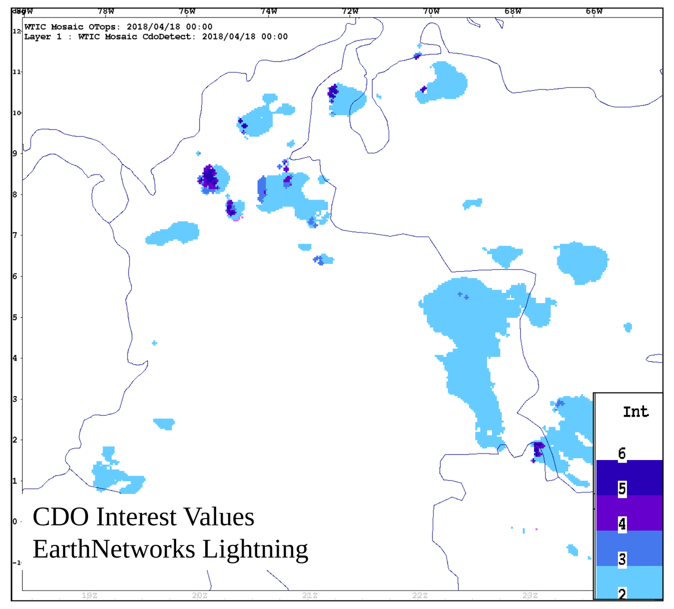
Geostationary Lightning Mapper (GLM)

The GOES-16 and GOES-17 satellites are equipped with the Geostationary Lightning Mapper (GLM) instrument, a new capability in lightning detection. The GLM has an advantage to see lightning over remote, oceanic regions with the same fidelity as over continental regions. Ground based detection networks have a reduced detection efficiency in remote, oceanic regions due to long distances between measuring stations.

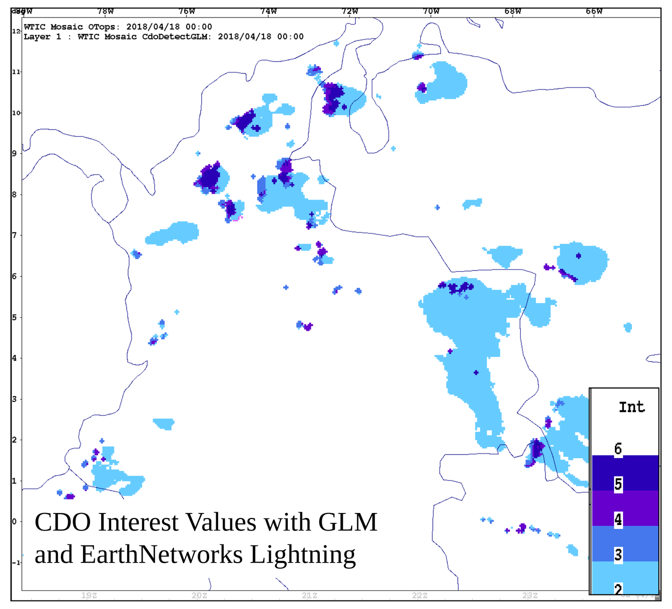
The GLM updates at 20 second intervals and has about a 20 second latency. The coverage region for the GOES-16 GLM is from 50S to 50N in latitude. Lightning strike accumulations are done at 15 minute intervals, matching the satellite mosaic update rate. The GOES-17 GLM will have a similar latitude coverage, once available. The GWH is not yet ingesting the GLM data but plans to begin in 2019. Quality control processing to combine the lightning flashes into lightning groups is done as is examination of the quality control flags. We are investigating whether a parallax correction is needed.

EarthNetworks provides global lightning data to the GWH and updates at 1 min intervals. Lightning accumulations are done for 15 minutes, 30 minutes and 60 minutes. For remote, oceanic storms where the detection efficiency may be reduced, using three accumulation periods ensures a margin of aviation safety in case only a few of the lightning strikes are detected.

The lightning accumulations from EarthNetworks and from the GLM are merged into a combined lightning interest field before being input into the CDO (Kessinger, 2017). CDO results using only the EarthNetworks data are shown at upper right figure while CDO results using both EarthNetworks and the GLM are shown in the lower right figure. As can be seen by comparing the two figures, more lightning strikes are measured with the GLM (note the increase in the areas with interest values $\geq$3). Also, for regions of lightning detected by EarthNetworks, when adding in the GLM strike accumulation, the regions become slightly larger.



CDO Interest Values EarthNetworks Lightning



CDO Interest Values with GLM and EarthNetworks Lightning

GLM CHARACTERISTICS

- Staring CCD imager (1372x1300 pixels)
- Near uniform spatial resolution 8 km nadir, 14 km edge fov
- Coverage up to 52 deg N lat
- 0-90% flash detection day and night
- Single band 777.4 nm
- 2 ms frame rate
- 7.7 Mbps downlink data rate (for comparison- TRMM LIS 8 kbps)
- 20 sec product latency

https://www.goes-r.gov/spacesegment/glm.html

Advanced Baseline Imager (ABI)

The GOES-17 ABI developed a problem with overheating that causes data outages for limited periods and for particular channels. The CDO uses the 6.2 micron water vapor channel, and that is one of the channels that has an outage each night. The 11.2 micron channel, also used by CDO, is less effected. While both GOES-15 and GOES-17 are operating in tandem, the GOES-15 data will be substituted for the GOES-17 data when there are outages. The GWH plans to ingest the GOES-17 data early in 2019.

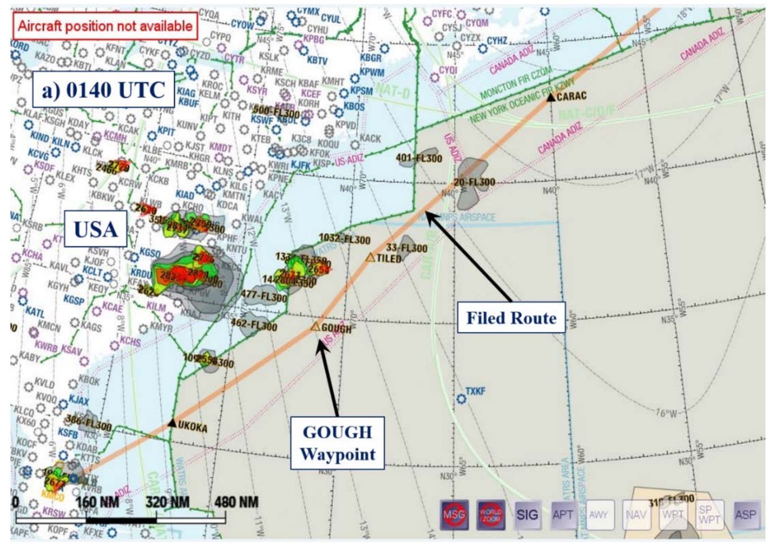


Figure 1

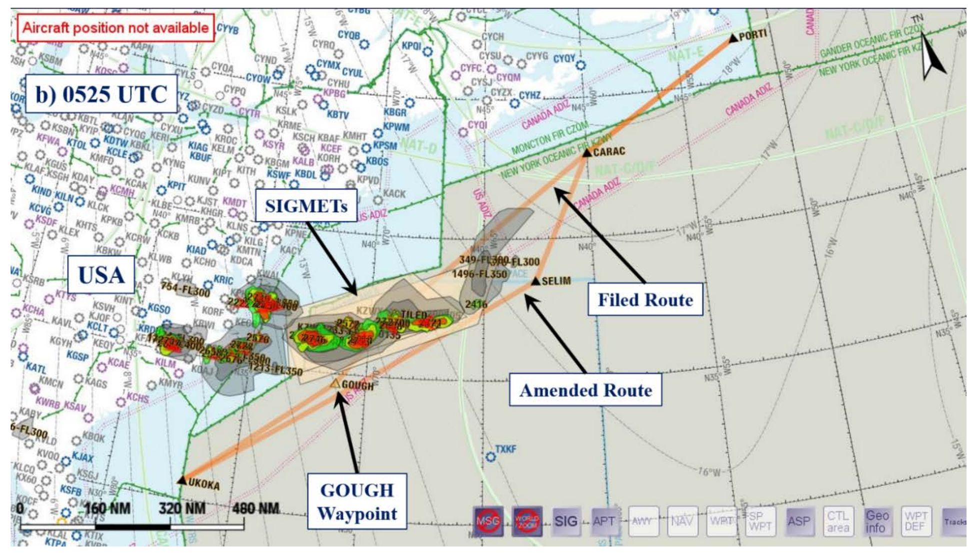


Figure 2

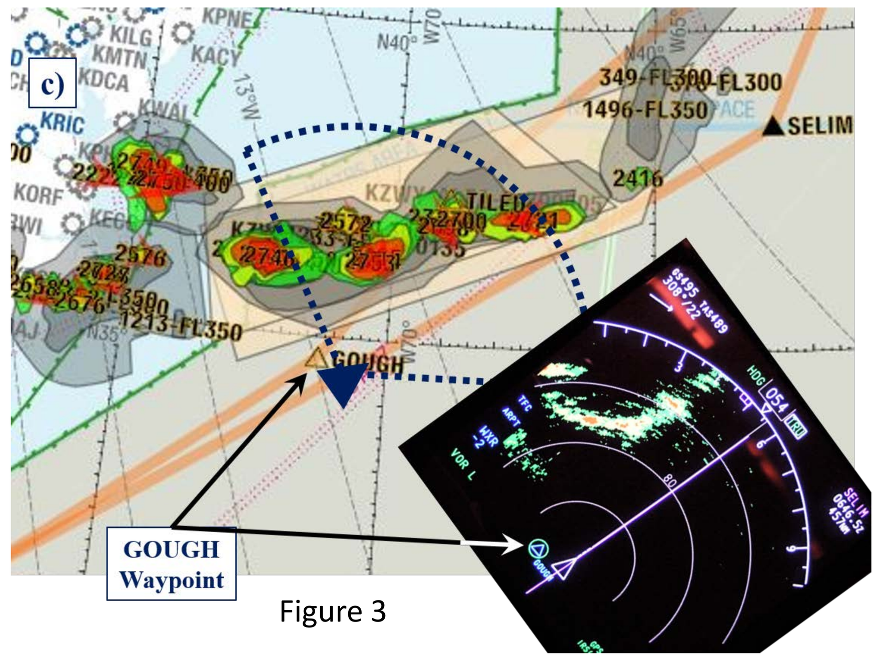


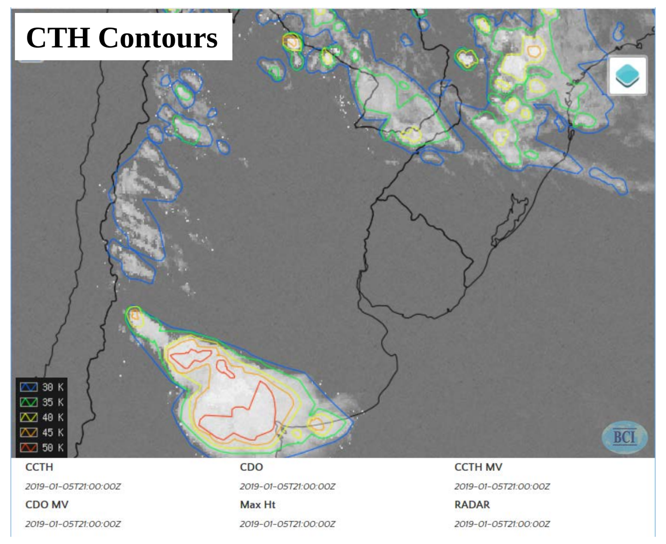
Figure 3

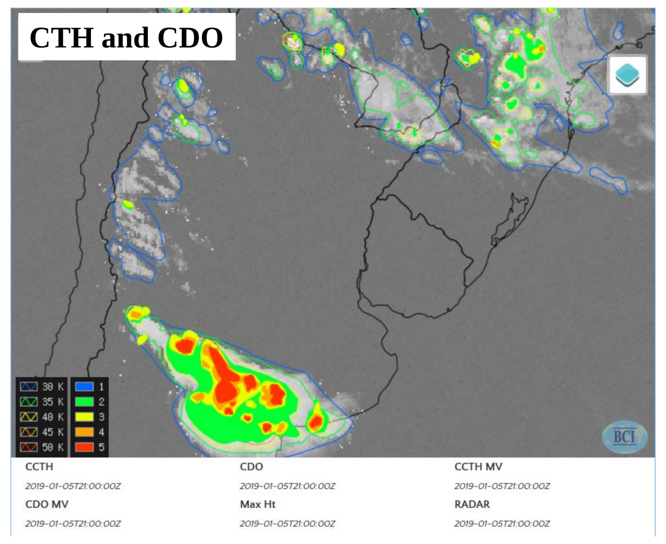
Case Study of CDO/CTH Use

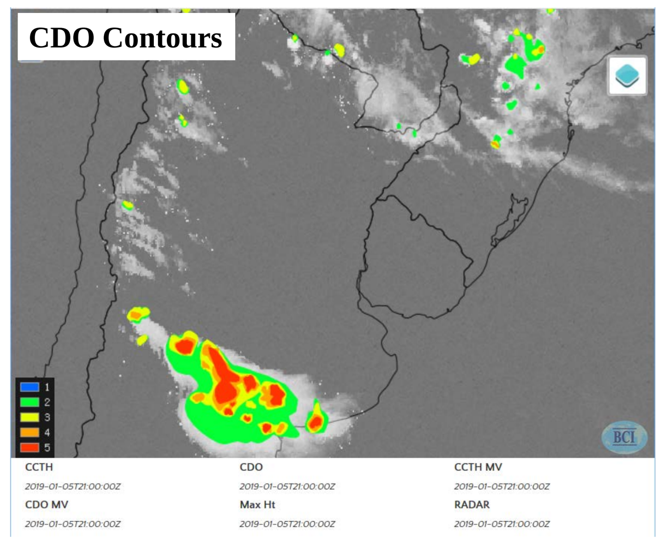
An example is shown of a flight reroute made to avoid severe convective storms on a flight from Orlando, Florida to Frankfurt, Germany on 29 April 2016 (Kessinger et al. 2017b). In Figure 1, the CTH and CDO polygons are displayed on the eRM at 0140 UTC, about 3 hrs prior to take-off at 0428 UTC.

In Figure 2, the eRM is shown at 0525 UTC shortly before the pilot received an amended flight route from the New York Oceanic Control Center. Convective SIGMETs are indicated by tan polygons under the CTH and CDO shaded polygons.

In Figure 3, the pilot photographed the onboard radar display as the GOUGH waypoint was passed on the amended flight route. The approximate area of the radar scan is displayed over the eRM for comparison of the CTH and CDO polygons to the radar reflectivity.







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Acknowledgements

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