CTH and CDO “Semi-Operational” Data Feed User Guide

The Cloud Top Height (CTH) and Convection Diagnosis Oceanic (CDO) products have been developed as a strategic aid for aviation within transoceanic regions. The CTH algorithm describes the heights of the convective clouds and is used by pilots to estimate distance from the storm contour at altitude and/or to know if it is possible to fly safely over the clouds. The CDO algorithm detects the region of convective hazards associated with strong updrafts/downdrafts. The products are produced by the University Corporation for Atmospheric Research (UCAR), Research Applications Laboratory (RAL) based on the available geostationary satellites. Currently only the Geostationary Operational Environmental Satellite (GOES) GOES-16 and GOES-17 satellites are available, providing data coverage from approximately 160 degrees East to 10 degrees West (Figure 1). The Himawari-8 geostationary satellite may be added at an unknown future date.

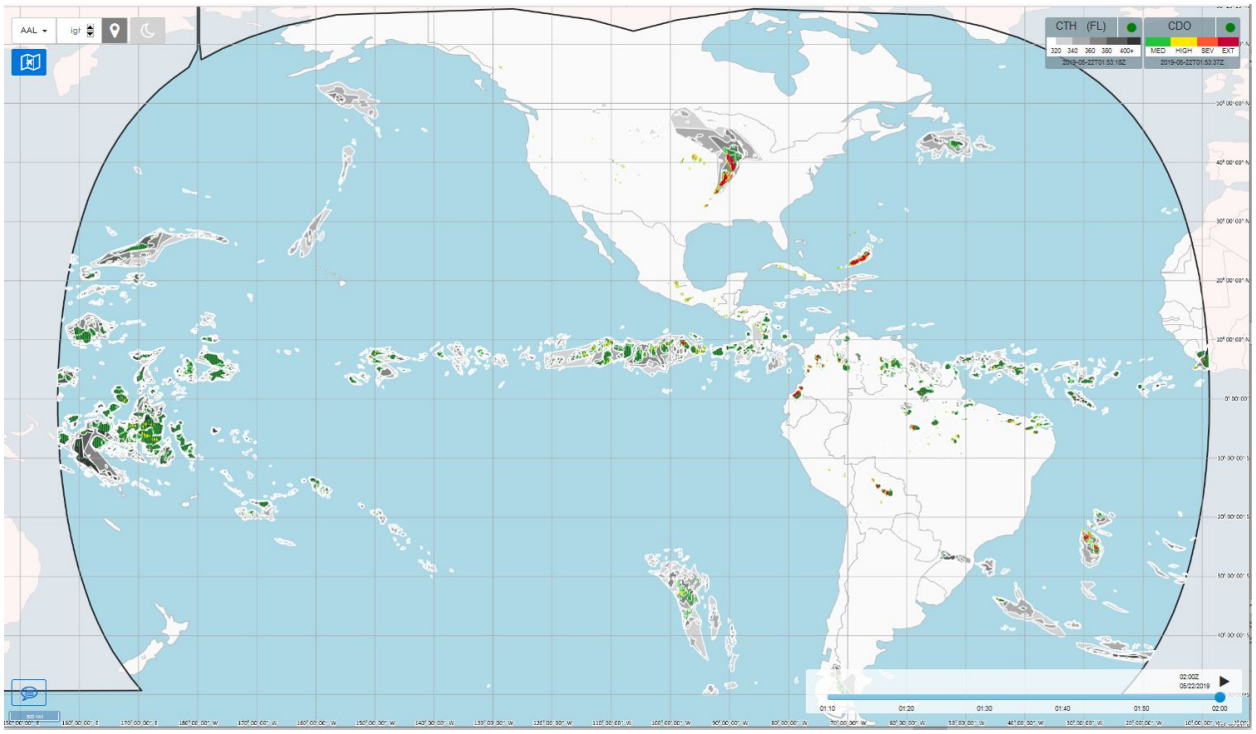

Figure 1: Current data coverage of CTH

Cloud Top Height (CTH; Figure 2) is computed by: 1) converting the satellite 10.8 micron infrared (IR) brightness temperature to pressure by comparison to the NCEP Global Forecast System (GFS) model sounding and then 2) converting the pressure to

a flight level through the standard atmosphere equation (Miller et al. 2005). The IR brightness temperature only measures the temperature of the tops of deep convection and cannot resolve internal structures. The anvil clouds frequently have a much larger area than the convective region as they enclose both the convective and stratiform regions. The CTH can be constructed with all geostationary satellites around the globe as they all contain this channel.

The Convection Diagnosis Oceanic (CDO; Figure 3) is computed via a fuzzy logic data fusion methodology utilizing four inputs: the CTH product described above, the Global Convection Diagnosis (GCD) product, the Overshooting Tops (OTops) product and a Combined Lighting Interest (CLI) product. The GCD product is computed by subtracting the brightness temperature of the IR channel from the brightness temperature of the water vapor channel (Mosher, 2002). The GCD indicates the location of mature updrafts when the channel difference is near zero. The OTops product is computed following Bedka et al. (2010) from IR brightness temperature gradients and the GFS model tropopause height values. During ROMIO, the CLI product was computed by accumulating lightning flashes from different sources and time intervals, including the GOES-16/17 Geostationary Lightning Mapper (GLM). However, for the CDO product that is available here, only the GLM is used in the CDO computation. This limits the availability of the CDO algorithm to be within the domain of $\pm$50 deg latitude north and south. The GLM data are accumulated with a period of 10 minutes to match the update rate of the GOES-16/17 satellites. The accumulated lightning output forms the CLI product.

The four inputs (CTH, GCD, OTops, and CLI) are scaled using a membership function that emphasizes the presence of convection by scaling the values to one. Once scaled, the inputs are weighted and summed. The CLI has a weight of 3 and all other inputs have a weight of one. This means that the maximum value of CDO is an interest value of six. Interest values are non-dimensional numbers that indicate the likelihood of the feature of interest (in this case, convection), is present.

A threshold with the interest value of 2 is the minimum value to indicate that convection is likely. For ROMIO, CDO values of 2 were given a green shading and labeled as “Medium”. CDO values of 2 indicate that the CTH and GCD algorithms are both positive indicators for the presence of convection. CDO values of 3 and above indicate that lightning and/or an overshooting top is present and the hazard intensity increases. In ROMIO, CDO values of 3 were given a yellow shading and labeled as “High”; CDO values of 4 were shaded orange and labeled “Severe” while CDO values of 5-6 were shaded red and labeled “Extreme”. A separate contour for 6 was not provided during ROMIO due to its rare occurrence.

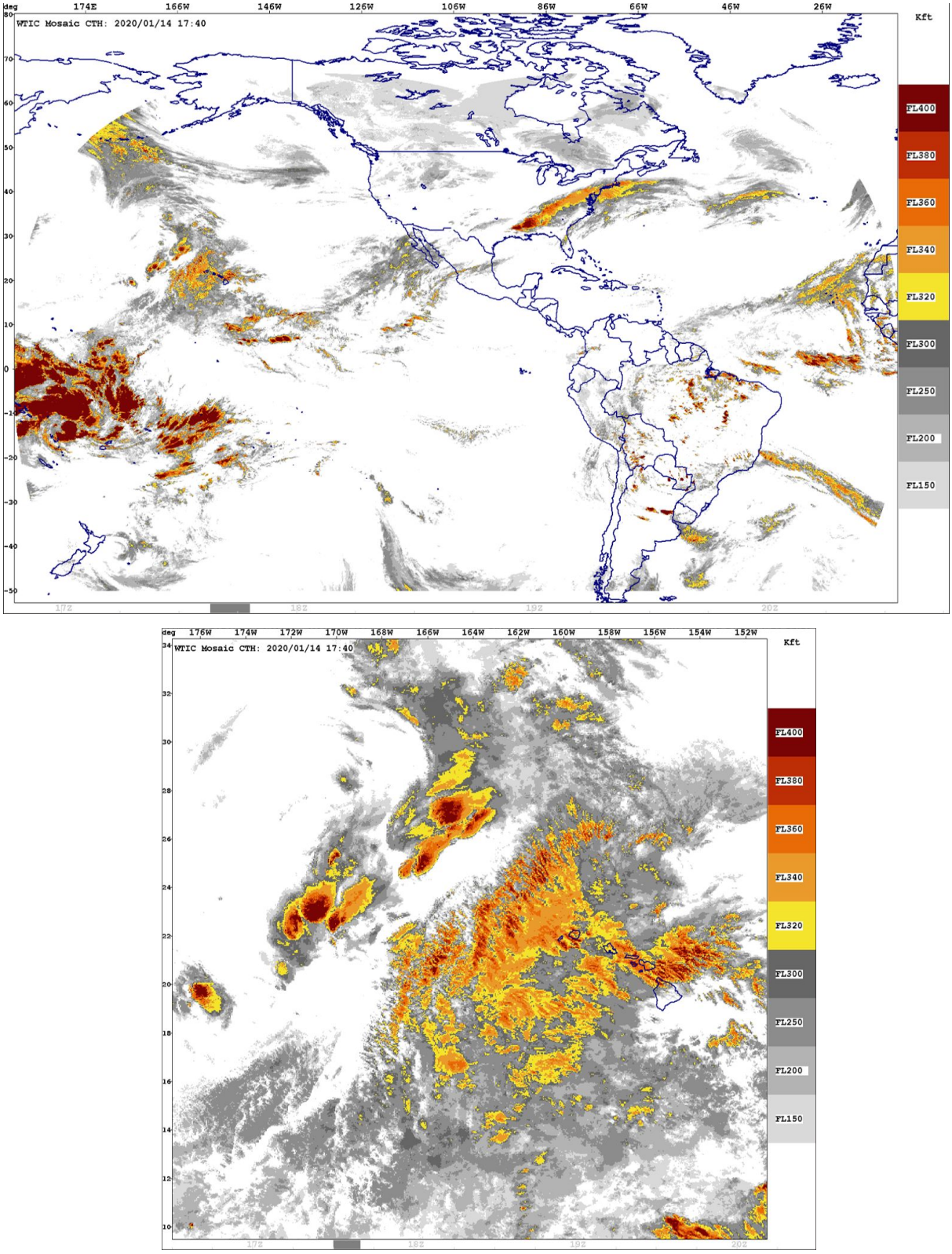

Figure 2: Example CTH product shown at the 2-satellite domain (top) and a magnified view near Hawaii (bottom).

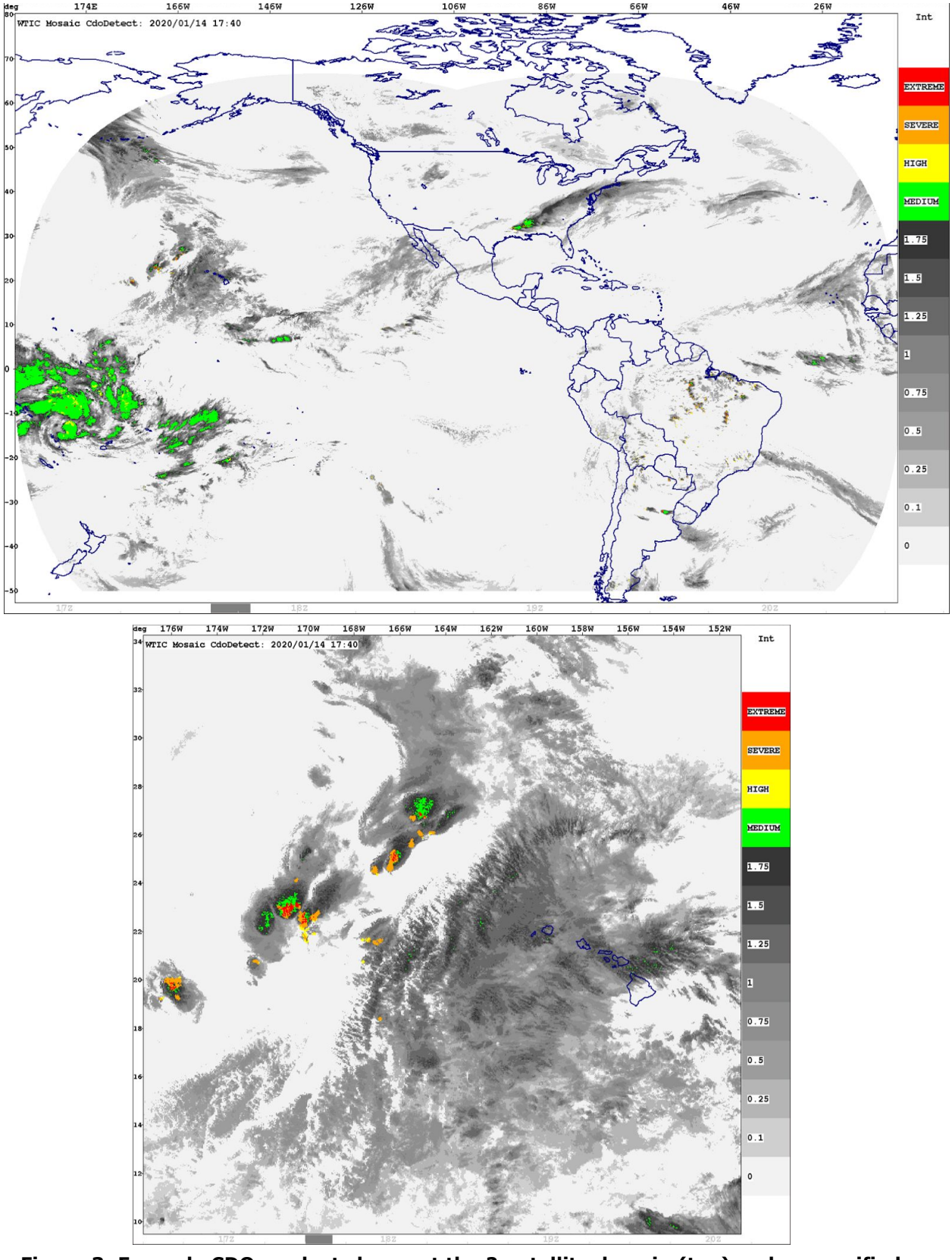

Figure 3: Example CDO product shown at the 2-satellite domain (top) and a magnified view near Hawaii (bottom).

The University Corporation for Atmospheric Research (UCAR) Research Applications Laboratory (RAL) has been tasked by the FAA Weather Technology in the Cockpit (WTIC) program to run the CTH and CDO system as "semi-operational" products and make the data available to users who have signed the license agreement with UCAR. Since UCAR is not a standard operational facility it does not have support 24/7 and as such there is no guarantee of data availability. UCAR may cease making the data available at any time if FAA funding is discontinued. UCAR will provide notice to users of planned and unplanned outages to the best of its ability.

The data provided to users is available in two different formats. The first format is the raw gridded data in the form of Gridded Binary edition 2 (GRIB2). This format is on a global Latitude-longitude grid with a 0.04 degree resolution. The second format is polygons created from the gridded data at various thresholds and in the form of Extensible Markup Language (XML). The thresholds used in polygon generation for CTH are: 32kft, 34kft, 36kft, 38kft, and 40kft and for CDO are: 2, 3, 4 and 5. Additionally a missing polygons XML file is provided for both CDO and CTH to define the areas where no data was available for polygon generation. Access to both data formats is provided via a Local Data Manager (LDM) client, server system. A local LDM client program will need to be installed and configured to request data from the UCAR LDM server. Once installed and ready please contact UCAR for the IP address to pull data from.

UCAR Point of Contact:

cdo-info@rap.ucar.edu

Grib2 Data Details:

Format: Grib2
Map projection: Latitude-longitude (equidistant cylindrical)
Grid spacing DX=DY=0.04 degrees latitude and longitude
Ny = 3126
Nx = 9001
Min/max latitude: -50 to +75
Min/max longitude: -180 to 180 (starts on the prime meridian, wraps around the date line)

CTH Grib2 Parameter Discipline: 0
CTH Grib2 Parameter Category: 6
CTH Grib2 Parameter Number: 12
CTH Grib2 Parameter name: "HGT", "Geopotential Height"
CTH Grib2 Surface Type Number: 3
CTH Grib2 Surface Type Name: "CTL", "Level of Cloud Tops"

CTH Grib2 Units: meters

CDO Grib2 Parameter Discipline: 0
CDO Grib2 Parameter Category: 6
CDO Grib2 Parameter Number: 2
CDO Grib2 Parameter name: “CDCON”, “Convective Cloud Cover”
CDO Grib2 Surface Type Number: 10
CDO Grib2 Surface Type Name: “EATM”, “Entire Atmosphere’’
CDO Grib2 Units: Numeric (0-6)

GRIB2 format resources:
https://www.wmo.int/pages/prog/www/WMOCodes/Guides/GRIB/GRIB2_062006.pdf

https://www.nco.ncep.noaa.gov/pmb/docs/grib2/

LDM Details:
Grib2 File Names: CTH_YYYYMMDD_HHMM.grb2
CDO_YYYYMMDD_HHMM.grb2
XML File Names: CTH_YYYYMMDD_HHMM.xml
CTH_MISS_YYYYMMDD_HHMM.xml
CDO_YYYYMMDD_HHMM.xml
CDO_MISS_YYYYMMDD_HHMM.xml
LDM Feedtype: EXP
LDM Server IP: Please contact UCAR to request the IP address.
LDM Request Example: REQUEST EXP “^(CTH|CDO).*”
LDM Grib2 Action Example:

```
EXP  ^CTH_(.......)_(..)(..).grb2  FILE  /d1/ldm/data/cth/\1\2\3/CTH_\1_\2\3.grb2
EXP  ^CDO_(.......)_(..)(..).grb2  FILE  /d1/ldm/data/cdo/\1\2\3/CDO_\1_\2\3.grb2
```

LDM Program resources:
https://www.unidata.ucar.edu/software/ldm/