# The GLOBE Clouds and Civil Air Patrol Collaboration for Aviation-Focused Missions

Ashlee Autore[1,2], Marilé Colón Robles[1,2], Jessica Taylor[2]

(1) ADNET Systems, Inc., Bethesda, MD
(2) NASA Langley Research Center, Hampton, VA

# The GLOBE Program

Since 1995
125+ countries
50+ science protocols
400+ publications
40k+ schools
290k+ citizen scientists
3M+ cloud observations

Global Learning and Observations to Benefit the Environment (GLOBE)

Sponsored by: NASA Supported by: NOAA NSF

## The Civil Air Patrol

Civilian auxiliary of the US Air Force

34,000+ cadets and 35,000+ adult members

Opportunities in: aviation, leadership, emergency services, STEM education


## The Space Act Agreement

NASA and CAP to “provide meaningful, hands-on STEM experiences”

Announced 21 April 2026

**Read about it here**

# 2025 Aviation Weather Mission

The mission: collect aviation-relevant observations including airport conditions, commercial aircraft information (e.g., registration and altitude), and GLOBE Cloud observations and satellite collocations

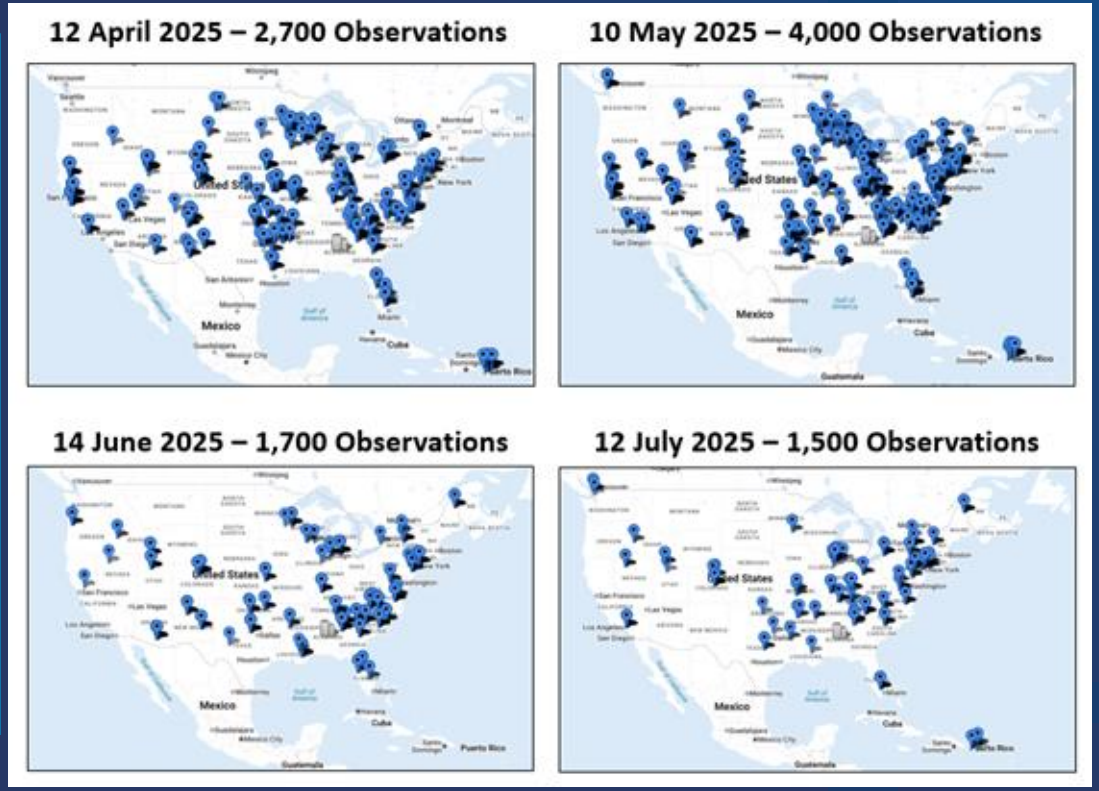
4 collection dates between April - July 2025

42 states, Puerto Rico, and Washington D.C.

Utilize SatCORPS' contrail formation potential maps

**Data are publicly available in zenodo**

# 2025 Aviation Weather Mission Results




>3,800 CAP volunteers

>1,300 commercial airplanes tracked

Nearly 10,000 observations

The GLOBE Clouds team submitted 2 papers to BAMS from this mission

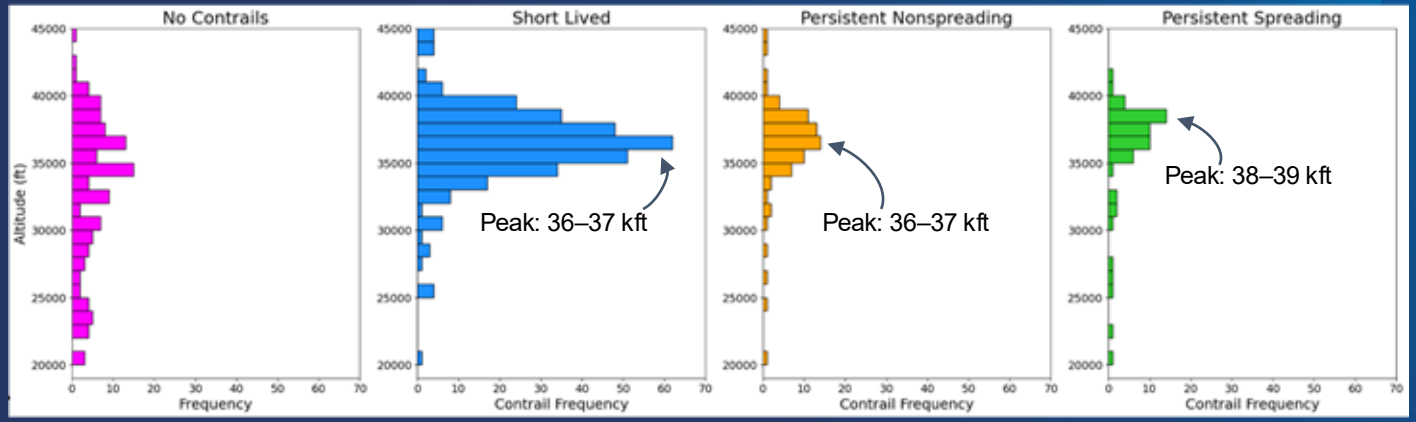
# 2025 Aviation Weather Mission Results

| Observation Type | Description | Notes |
|---|---|---|
| Aircraft Information | CAP members selected a commercial airplane to observe every 15 minutes. Altitude, registration number, and aircraft type were obtained using flight following software. | Only commercial airplanes above 20,000ft were selected. |
| Cloud Conditions | Percent of cloud cover and record of cloud types present through the GLOBE Observer app. If a contrail was being created by the airplane tracked, it was classified as short-lived, persistent non-spreading or persistent spreading. | GO app Clouds tool (Colón Robles et al., 2020) was used to report clouds. The GO app guides users to take photographs in each cardinal direction at a 14-degree angle. |
| Orienteering | CAP members practiced basic orienteering to collect latitude and longitude of their location. The azimuth was measured for the tracked airplane using a compass. Sextants were used to measure direction and angles. | Latitude and longitude are measured automatically by the GO app. |
| Sky photographs | In addition to sky photographs taken through the GO app, CAP members took photographs once an aircraft passed through their area. | The patch of sky the aircraft passed through was monitored and photographed 3, 5, 10, and 15 minutes after the plane passed to note any changes, particularly to contrails present. |

**Table 1. Detailed description of each observation type collected by CAP members.**

CAP selected 12 cadets and 6 adult members for a 6-week internship program to correct dataset issues (missing GLOBE ID, incorrect airplane types, etc) and produce a clean mission dataset

# 2025 Aviation Weather Mission Results - May



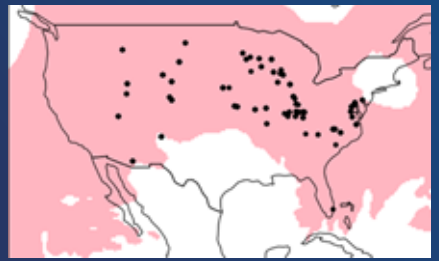

Altitude histogram by contrail type

From May:

- 4100 observations
- 103 unique locations
- 710 unique airplane reg

SAC contrail location verification

250 mb

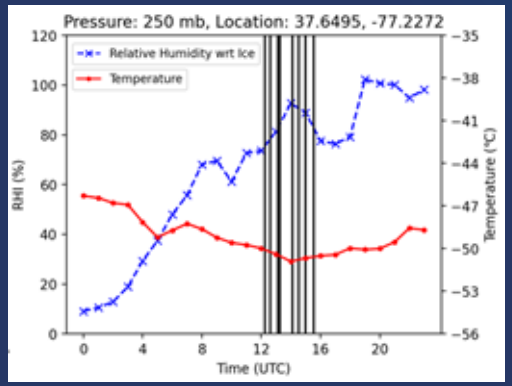


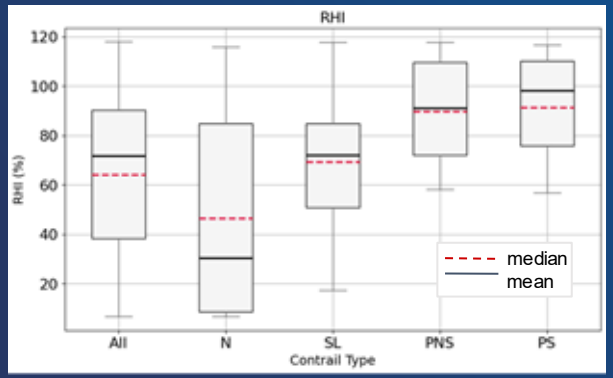
225 mb

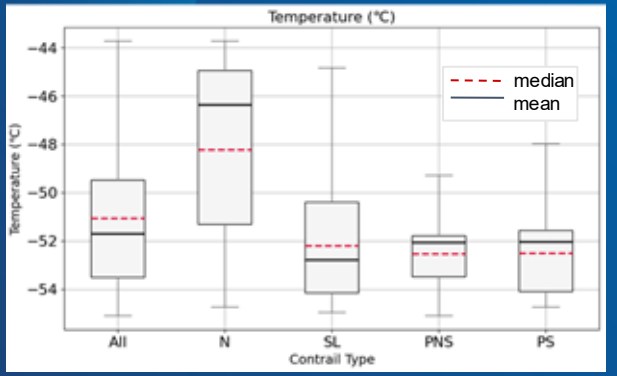
200 mb

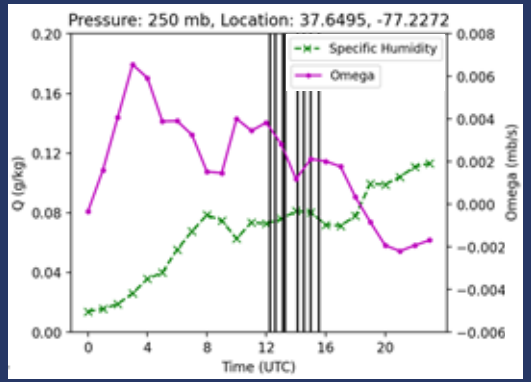
# 2025 Aviation Weather Mission Results - May

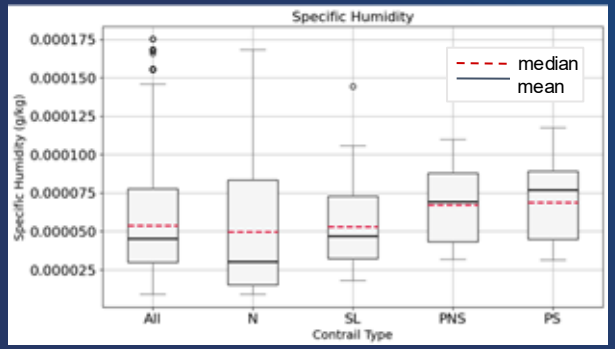
## Observations collocated with ERA5 data

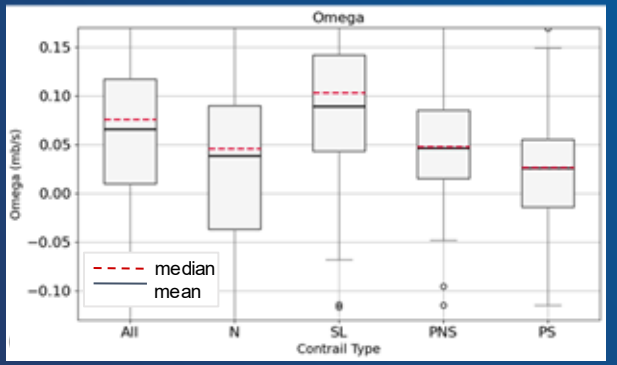


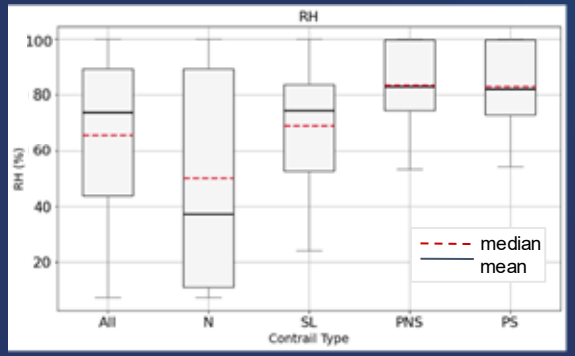



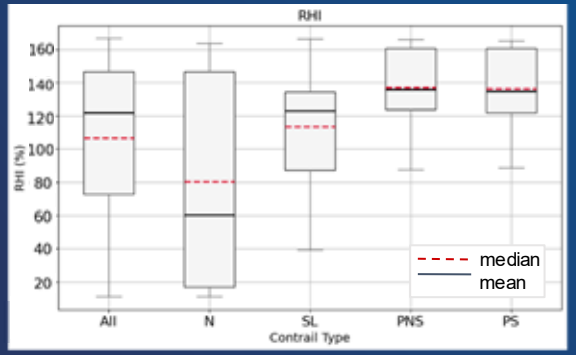



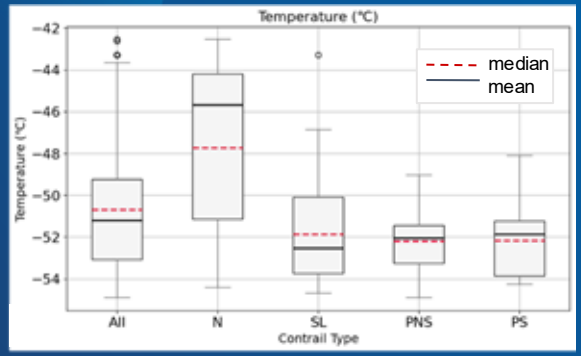



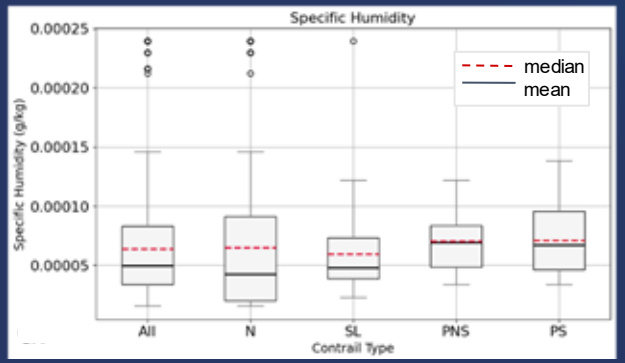
# 2025 Aviation Weather Mission Results - May

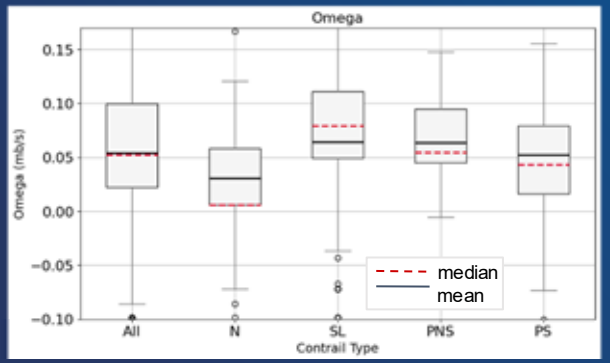
## Observations collocated with MERRA-2 data



# 2025 Aviation Weather Mission Results - May

= SL = PNS = PS = None

SL & PS (7)

SL & PNS (7)

SL & None (5)

PNS & PS (5)

PS & None (2)

PNS & None (1)

Other (3)

# 2025 Aviation Weather Mission Results - May

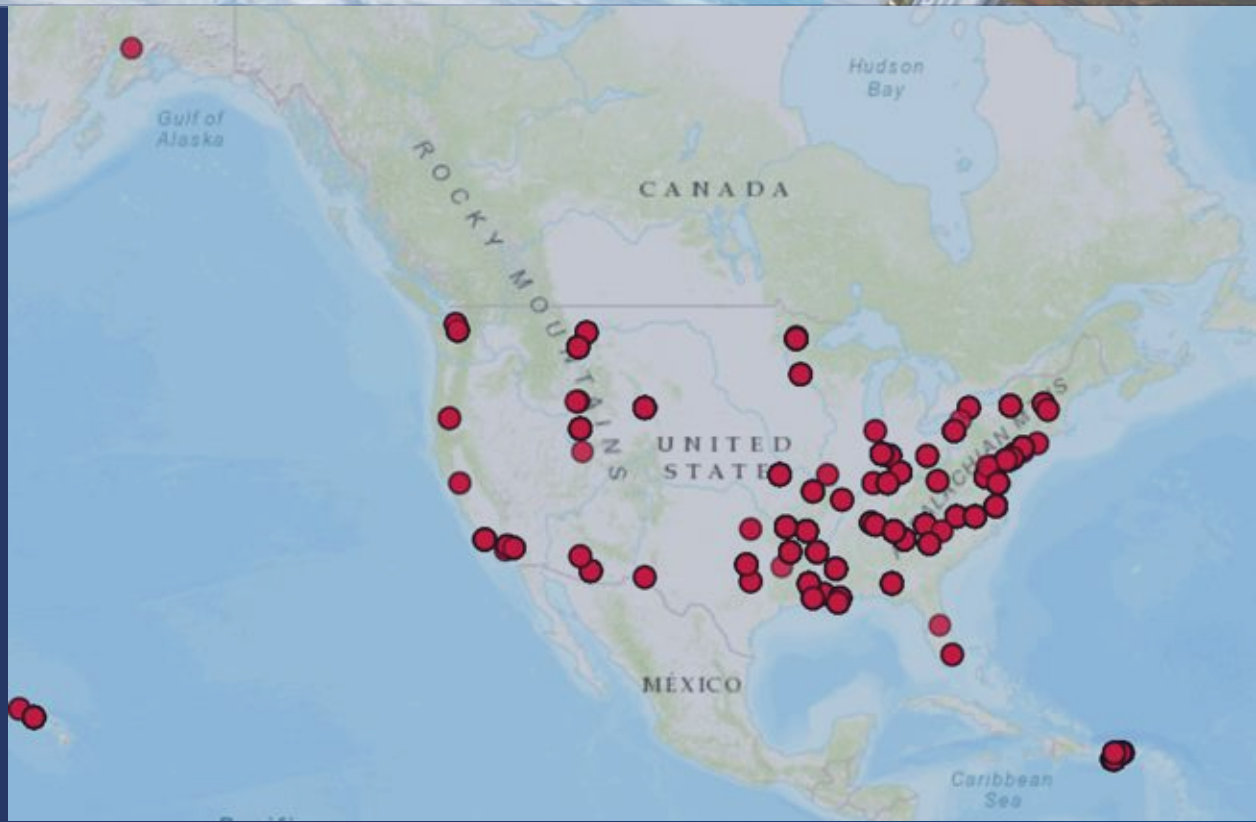
| | a) With vs Without Contrails | | | b) Persistent vs Short-lived Contrails | | | c) Persistent Spreading vs Persistent Non-spreading Contrails | |
|---|---|---|---|---|---|---|---|---|
| | With Contrails | Without Contrails | | Persistent | SL | | PS | PNS |
| Higher $RH_i$ | 5 | 5 | | 9 | 4 | | 2 | 2 |
| Higher Temp | 4 | 6 | | 4 | 7 | | 3 | 1 |
| Higher Specific Humidity | 4 | 6 | | 5 | 7 | | 3 | 2 |
| Higher Omega | 3 | 7 | | 4 | 11 | | 0 | 3 |

# 2026 Aviation Skywatch Mission

The mission: similar to 2025, but now with *planned* aircraft tracked by multiple squadrons

3 collection dates
March - May 2026

47 states, Puerto Rico, and D.C., with support from squadrons in Belgium, Germany, Guam, Japan, South Korea, and the United Kingdom



# Civil Air Patrol Data

Location Data: Lat, Lon *and* City, State

Time Data: Local (with Time Zone) *and* UTC

Aircraft Data: Registration, Type, Altitude, Direction of Travel

Photo Data: Location, Time, Direction, Altitude Angle

Contrail Data: Type (SL, PNS, PS, None)

Weather Data: METAR

Other Data: GLOBE ID, Unit Charter #

| | Date (DD-MM | Unit Charter # | Latitude | Longitude | City | State | GLOBE User | Aircraft Regist | Aircraft Type | Preassig | Aircraft Altitu | Direction of | Photo Sec | Time of Photo | Time Z | Time of Photo (24 | Photo Di | Altitude | Contrail | Contrail Type (N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182800533 | N8900L | B737MAX8 | No | 35000 | 100 | 0 | 08:04:00 | ET | 12:04:00 | 60 | 30 | Yes | PNS |
| 3 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182800533 | N8900L | B737MAX8 | No | 35000 | 100 | 3 | 08:07:00 | ET | 12:07:00 | 60 | 30 | Yes | PNS |
| 4 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182800533 | N8900L | B737MAX8 | No | 35000 | 100 | 5 | 08:09:00 | ET | 12:09:00 | 60 | 30 | Yes | PNS |
| 5 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182800533 | N8900L | B737MAX8 | No | 35000 | 100 | 10 | 08:14:00 | ET | 12:14:00 | 60 | 30 | Yes | PNS |
| 6 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182800533 | N8900L | B737MAX8 | No | 35000 | 100 | 15 | 08:19:00 | ET | 12:19:00 | 60 | 30 | Yes | PNS |
| 7 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182552206 | 9VDHE | B777F | No | 36000 | 258 | 0 | 08:25:00 | ET | 12:25:00 | 85 | 10 | Yes | PNS |
| 8 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182552206 | 9VDHE | B777F | No | 36000 | 258 | 3 | 08:28:00 | ET | 12:28:00 | 85 | 10 | Yes | PNS |
| 9 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182552206 | 9VDHE | B777F | No | 36000 | 258 | 5 | 08:30:00 | ET | 12:30:00 | 85 | 10 | Yes | PNS |
| 10 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182552206 | 9VDHE | B777F | No | 36000 | 258 | 10 | 08:35:00 | ET | 12:35:00 | 85 | 10 | Yes | PNS |
| 11 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182552206 | 9VDHE | B777F | No | 36000 | 258 | 15 | 08:40:00 | ET | 12:40:00 | 85 | 10 | Yes | PNS |
| 12 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182904076 | N8508W | B737H4 | No | 36000 | 262 | 0 | 08:43:00 | ET | 12:43:00 | 90 | 10 | Yes | PNS |
| 13 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182904076 | N8508W | B737H4 | No | 36000 | 262 | 3 | 08:46:00 | ET | 12:46:00 | 90 | 10 | Yes | PNS |
| 14 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182904076 | N8508W | B737H4 | No | 36000 | 262 | 5 | 08:48:00 | ET | 12:48:00 | 90 | 10 | Yes | PNS |
| 15 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182904076 | N8508W | B737H4 | No | 36000 | 262 | 10 | 08:53:00 | ET | 12:53:00 | 90 | 10 | Yes | PNS |
| 16 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182904076 | N8508W | B737H4 | No | 36000 | 262 | 15 | 08:58:00 | ET | 12:58:00 | 90 | 10 | Yes | PNS |
| 17 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182800533 | N8803L | B737MAX8 | No | 34000 | 346 | 0 | 08:58:00 | ET | 12:58:00 | 330 | 30 | Yes | SL |
| 18 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182800533 | N8803L | B737MAX8 | No | 34000 | 346 | 3 | 09:01:00 | ET | 13:01:00 | 330 | 30 | Yes | SL |
| 19 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182800533 | N8803L | B737MAX8 | No | 34000 | 346 | 5 | 09:03:00 | ET | 13:03:00 | 330 | 30 | Yes | SL |
| 20 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182800533 | N8803L | B737MAX8 | No | 34000 | 346 | 10 | 09:08:00 | ET | 13:08:00 | 330 | 30 | Yes | SL |
| 21 | 14-03-26 | GLR-IN-126 | 38.303937 | -85.795420 | New Albani | Indiana | 182800533 | N8803L | B737MAX8 | No | 34000 | 346 | 15 | 09:13:00 | ET | 13:13:00 | 330 | 30 | Yes | SL |

# Civil Air Patrol Micro-Internships

To help with data QA/QC, CAP takes cadet applicants for micro-internships for each mission

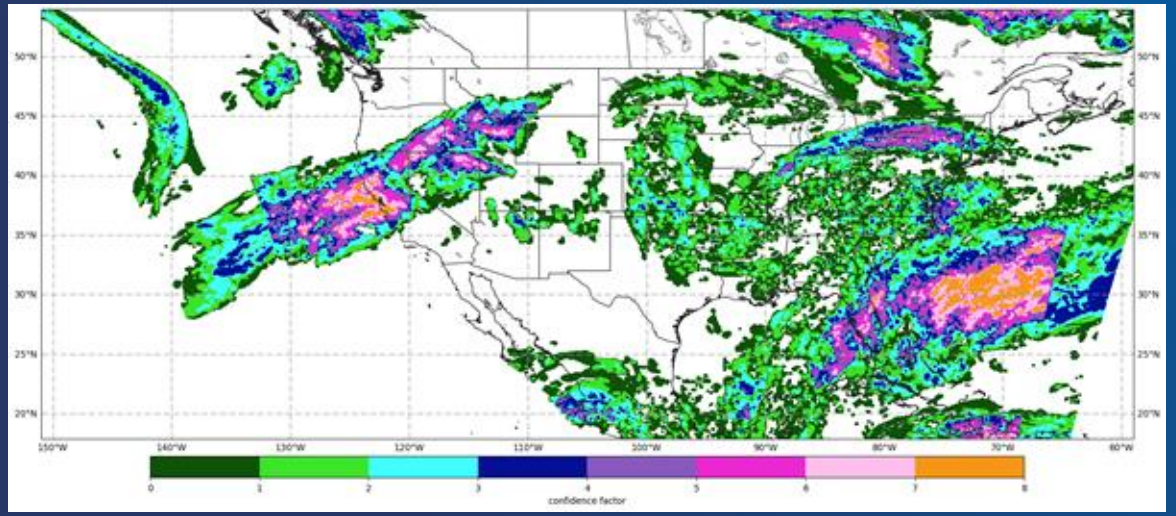
| | | |
|---|---|---|
| 01 | **NASA examines the level-0 data** | • GLOBE Observer submissions are in one file<br>• CAP reports are in another<br>• We try to merge the files so all clouds reports are connected with the aircraft information |
| 02 | **Micro-interns move through a list of tasks** | • Based on issues with merging the data, we make a list of suggested tasks to correct and fill in data<br>• Micro-interns work with senior member guidance to gather necessary information and edit the data |
| 03 | **NASA can then analyze the corrected data file** | • With more complete and accurate data, the analysis is stronger and correlations may be more significant |

# SatCORPS & CERES Support

GLOBE Clouds Team made 173,651 satellite comparisons in 2025

Coming soon: PACE comparisons!

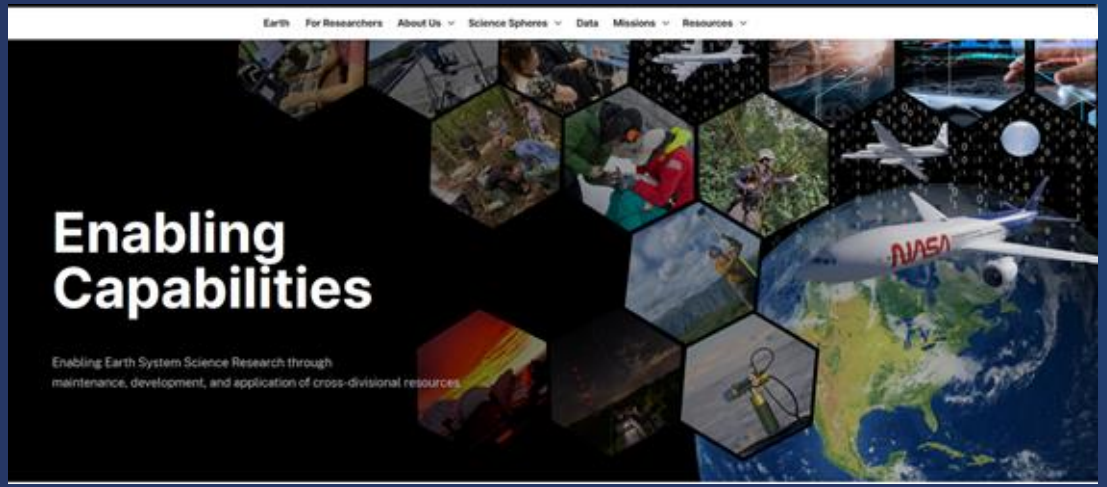
Big thank you to the SatCORPS team for supporting our missions with CAP and providing contrail formation potential maps



# GLOBE Updates

GLOBE is now Crowdsourcing (John Sullivan) under Earth Science Division's Enabling Capabilities

The team will continue satellite comparisons to clouds and expand to more missions and observables




Enabling Capabilities includes:

- Airborne Science
- Early Career Research
- Ground Networks and Calibration Labs
- Integrated Modelling Capabilities
- Space Geodesy Program

# 2027 Outlook

Could you benefit from a nationwide, ground-based dataset from highly-trained individuals?

CAP is looking for another nationwide mission in 2027

Send us your requests!

marile.colonrobles@nasa.gov
or
ashlee.m.autore@nasa.gov