Project 078 Contrail Avoidance Decision Support and Evaluation

Massachusetts Institute of Technology

Project Lead Investigator

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- FAA Award Number: 13-C-AJFE-MIT, Amendment Nos. 086, 100, 115, 125, 128, 133, 139, and 143
- Period of Performance: October 1, 2021, to August 31, 2027
- Tasks:
  1. Contrail Forecast Module
  2. Contrail Identification Module
  3. Contrail Observability Module

Project Funding Level

The Federal Aviation Administration (FAA) provided $2,250,000 in funding and $2,250,000 was received in matching funds. The sources of matching funding are approximately $333,100 from MIT, plus third-party in-kind contributions of $469,000 from Savion Aerospace Corp., and $463,000 from Google, LLC, and $984,900 from Earth Force Technologies.

Investigation Team

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Project Overview

Condensation trails (contrails) are the line-shaped ice clouds that form behind aircraft. These contrails and subsequent contrail cirrus are thought to account for around half of the climate warming attributable to aviation. Contrail avoidance through vertical flight path changes is estimated to cause fuel burn penalties at the few percent level. As such, it is a potentially cost-effective way to mitigate aviation's climate impacts. However, contrail avoidance has not been demonstrated at scale, and a comprehensive toolset to support the approach has not been developed. The goal of this project is to create a contrail avoidance decision support and evaluation tool that can be trialed to optimize and evaluate the benefits, costs, and practicality of contrail avoidance. In addition, subject to agreement with industry partners, our team will seek to test contrail avoidance in a way that has no negative implications for air traffic control or safety.

This project aims to satisfy four specific objectives: (1) to develop the capabilities necessary to predict the formation and impacts of contrails from a given flight, (2) to evaluate the financial costs and environmental benefits of deviating from that path to avoid a contrail, including uncertainty, (3) to integrate these capabilities into an operational tool that can provide near-real-time estimate of the costs and benefits of a contrail avoidance action, informed by automated, coordinated observational analysis and modeling, and (4) to evaluate the effectiveness of these tools in a safe, scientifically sound real-world experiment.

The objectives outlined above will be met through a work program that comprises the following tasks:

1. Contrail forecast module
2. Contrail identification module
3. Contrail observability module

The following tasks will be included under future periods of performance (i.e., not funded through current submission) but provide an outlook for follow-on work in future project years.

4. Airline and air traffic control integration
5. Contrail radiative impacts analysis
6. Experiment evaluation module

What follows in this document is a description of the tasks, including research progress and next steps.

Task 1 - Contrail Forecast Module

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Objective

The objective of this task is to develop a contrail forecast module that predicts the likelihood of persistent contrail-forming conditions in the hours before the flight, and in real time during a flight. This is intended to allow airlines to decide ahead of time to consider whether flights should use contrail avoidance, to file flight plans accounting for the best estimated cruise altitude, and to adjust in real time (subject to pilot workload and air traffic control constraints).

Research Approach

Development of the MIT Contrail Avoidance Support Tool and MIT Contrail Avoidance Support Tool-Board

The MIT Contrail Avoidance Support Tool (MCAST) Board has been enhanced with new features that further the research use of the tool. A new calendar view has been developed that shows the contrail coverage over the year (as detected by the machine learning model) along with higher resolution Visible Infrared Imaging Radiometer Suite (VIIRS) satellite imagery. Additionally, an improved contrail detection model has been tested and deployed on MCAST board. Furthermore, to support ongoing efforts to attribute flights to contrails, an efficient flight data assimilation framework has been developed.

Development of Contrail-Flight Matching Algorithms

Matching contrails to the flights which formed them is a necessary component for verifying a contrail avoidance strategy's effectiveness. It provides a quantitative measure, on a per flight basis, of the change in contrail length due to an avoidance action based on a given contrail-forming region forecast. It can also be used to complement these forecasts by providing additional altitude information about the detected contrails; for a contrail matched to a given flight, Automatic Dependent Surveillance-Broadcast (ADS-B) data provide the altitude of the contrail at the time it was created, an approach we investigate further in Task 2. Two flight-attribution algorithms have been developed under ASCENT Project 078. The first one, described in a previous report and in Barbosa (2024) matches contrail segments to flight segments, while the second one, the Contrail Attributor and Tracker (CAT) takes a different approach by analyzing contrail masks to match contrails to flights waypoints.

Barbosa (2024) Algorithm

This section details the updates to the flight-attribution algorithm described in Barbosa (2024). Broadly, it matches contrails identified automatically on satellite imagery to discretized and advected aircraft trajectories derived from ADS-B data and numerical weather prediction. The matching process considers lateral and heading distances to pair flight segments and linearized contrails.

The algorithm has since been improved with regards to computational performance resulting in runtime reduction of 10 to 100 times for larger scenes by only considering flight segments within a certain relevant distance from each contrail segment before initiating the pairwise comparison in lateral and heading distance, respectively to determine potential flight matches.

The attribution accuracy of the algorithm has further been improved by considering the match likelihoods for all flight segments of an individual flight to a contrail, rather than looking at the match likelihood of each flight segment individually. This allowed us to also rank all considered flights regarding whether they might have formed a certain contrail and to express the likelihood for each flight.

Accuracy is evaluated on a dataset of manual labels of contrail-flight attribution pairs where some pairs were labeled in several subsequent time steps. The size of the 1980 manual contrail-flight attributions dataset was increased from 1,980 to 2,571 since the last reporting period. Though instrument limitations and labeler errors can sometimes lead to misattributions, this dataset is used as the basis of algorithm performance comparisons.

Moving from an attribution on a per-flight segment basis to a per-flight basis resulted in an increase of 3 percentage points in accuracy of the attribution output compared to our manual attributions. For this dataset, the algorithm's most likely flight match now agrees with the manually attributed flight for 79.8% of the contrails. The probability of identifying the correct contrail-forming flight increases to 93.9% and 95.6% when considering the top three and top five most likely flights, respectively.

Contrail Attributor and Tracker

The CAT is a new algorithm designed to explicitly consider the temporal evolution of contrails and uncertainty in wind advection through a probabilistic framework. In addition, it also accounts for the waypoint level uncertainty by computing for each flight waypoint the probability that it formed a contrail. This is necessary to accurately capture the horizontal extents of contrail forming regions.

The CAT differs from existing contrail attribution algorithms (Barbosa et al., 2024, Chevallier et al., 2023, Geraedts et al., 2024, Sarna et al., 2025) by focusing on attributing the new contrails in each satellite image instead of solving the entire attribution problem at each timestep. By doing so, the CAT effectively declutters images and limits match candidates to new contrails and recent flights waypoints, limiting the accumulation of advection error due to uncertain wind data. The CAT is intended to be run over multiple consecutive timesteps, allowing the algorithm to build knowledge of the scene by attributing contrails and flights incrementally.

In practice, the filtering process at a timestep T involves three steps. First, the contrail masks corresponding to the previous timestep are warped with the numerical weather prediction winds serving as a prior to where we expect existing contrails to be on the image at T. Second, these warped masks are aggregated by a Bayesian filter, the output of which is a new contrail mask where each pixel encodes the likelihood of it being a contrail pixel. Finally, the filtered mask from T-1 to T is subtracted to the masks at T to identify newly formed contrails. This approach enables the CAT to isolate newly formed contrails from those that were present in previous frames while the Bayesian filter handles the case where the segmentation of the contrail is noisy and the contrails flicker in and out between frames.

The matching process consists of Bayesian updates, where the posterior from the previous time step naturally informs the prior for the next, so each update simply incorporates the latest evidence. An intermediate step is necessary to take into account the uncertainty of tracking contrails between frames since contrails might split or merge over time. The prior for next step is therefore a weighted average of the posterior from previous steps based on the likelihood that the contrail in the current frame is a particular contrail in the previous frame. This process makes attribution temporally consistent, computationally efficient, and well-suited to real-time contrail avoidance.

The new contrail-flight matching algorithm is now complete and is ready to be tested and compared to our existing algorithm by using the synthetically generated contrails in Task 2. Figure 1 shows the outputs of the new contrail-flight attribution algorithm.

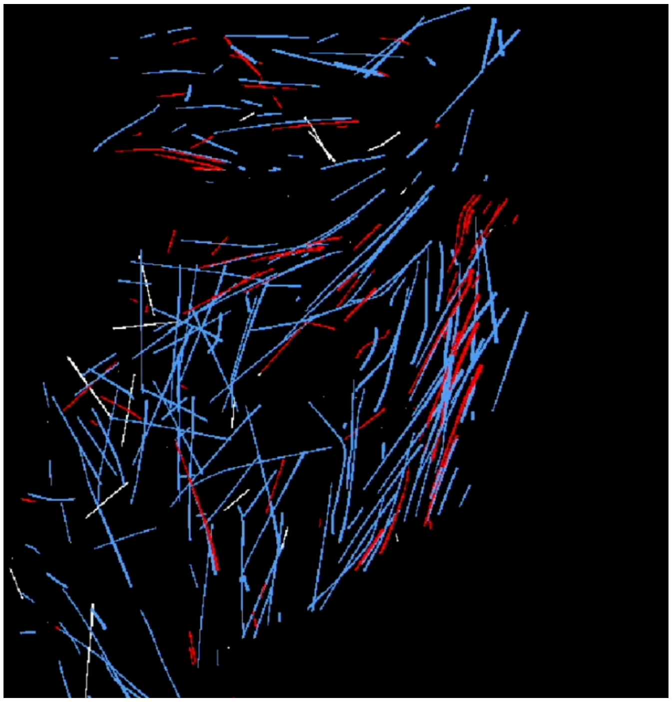

Figure 1. Outputs of the new contrail-flight attribution algorithm. Blue contrails correspond to those with a correct top match while red contrails have an incorrect top match. White features represent contrails for which the algorithm could not find a good fit and are therefore left unattributed.

Updates to the Aircraft Plume Chemistry, Emissions, and Microphysics Model (APCEMM)

APCEMM has been updated to allow users to bypass its early plume simulation, enabling users to directly input ice crystal number and size distribution to initialize the mature plume evolution model. By decoupling the early and mature plume models, this facilitates inter-model comparisons undertaken in ASCENT Project 058. This work also enables the initialization of APCEMM from in-situ measurements collected during the 2023 Boeing® ecoDemonstrator campaign which will be used to validate and constrain the model.

Milestone

- Expanded dataset of manual attributions.
- Created the new contrail-flight matching algorithm, now ready to be tested on synthetic contrails in Task 2.

Major Accomplishments

Improved attribution algorithm performance in both speed and accuracy and established a “ranking” of potential contrail-forming flights.

Publications

None.

Outreach Efforts

Presented at the ASCENT Spring Meeting 2025, online.

Awards

None.

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Student Involvement

The research and communication for this task were conducted primarily by MIT graduate research assistants, Marlene V. Euchenhofer, Olivier Ng'weno Kigotho, and Louis Robion.

Plans for Next Period

Conduct a canonical sensitivity study of the two attribution algorithms performance under different scenarios (i.e., flight density, errors in advection data, etc.).

References

Barbosa, M. P. (2024). *Relationship between synoptic scale meteorology, aircraft parameters, and observable contrails* [Master's Thesis. Massachusetts Institute of Technology]. Massachusetts Institute of Technology.

Chevallier, R., Shapiro, M., Engberg, Z., Soler, M., and Delahaye, D. (2023). Linear Contrails Detection, Tracking and Matching with Aircraft Using Geostationary Satellite and Air Traffic Data. *Aerospace*, *10*(7), 578.

Geraedts et al. (2024).

Meijer, V. R., Kulik, L., Eastham, S. D., Allroggen, F., Speth, R. L., Karaman, S., & Barrett, S. R. (2022). Contrail coverage over the United States before and during the COVID-19 pandemic. *Environmental Research Letters*, *17*(3), 034039.

Sarna, A., Meijer, V., Chevallier, R., Duncan, A., McConnaughay, K., Geraedts, S., McCloskey, K. (2025). Benchmarking and improving algorithms for attributing satellite-observed contrails to flights. *Atmospheric Measurement Techniques*, 18, 3495–3532.

Task 2 - Contrail Identification Module

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Objective

The objective of this task is to develop a real-time contrail identification module that locates contrails both horizontally and vertically.

This module will be necessary to evaluate whether avoidance has been successful. Furthermore, this module will enable contrail forecasting approaches that are based on contrail detections, and that might prove to be more reliable for shorter lead times than approaches based on numerical weather forecasts. The initial version will use Geostationary Operational Environmental Satellite (GOES) satellite observations combined with an MIT-developed (under National Aeronautics and Space Administration sponsorship) deep learning approach to identify contrails from space. Future developments could add other satellite products and ground and other observations.

Research Approach

New Contrail Height Estimation Approach

The ASCENT Project 078 team's previous height estimate approach was purely based on remote sensing and relied on the radiances of pixels that our model identifies as part of a contrail. Using the radiances of all available wavelengths, an altitude probability distribution is calculated for each pixel (Meijer, 2024). Currently, the mean of this distribution is used to retrieve the altitude of the contrail pixel. During the assessment of our computing pipeline, our team identified that this approach was not sufficiently accurate for our operational purposes – potentially due to temperature variations in the upper troposphere being too small to provide sufficient information to distinguish nearby altitudes.

Therefore, the ASCENT Project 078 team decided that a new approach to estimate the altitude of detected contrails is required. Our team attributes contrails to flights and takes advantage of the flights' known altitude to estimate the altitude of the contrails. This approach was updated to also estimate the latitude and longitude of the contract-forming region using the new contrail-flight matching algorithm. Given that the new algorithm outputs the likelihood a contrail was formed at any given point along the flights' trajectory, the set of all flights can be interpolated using a radial basis function to estimate both the height and horizontal extents of contrail likely regions.

Synthetic Contrail Imagery

Quantifying the performance of contrail-flight attribution algorithms requires an evaluation dataset where contrails and their associated flights are known. While a human labeled dataset was developed at MIT and used to quantify attribution performance in Barbosa (2024), it remains limited in number of samples and is subject to human error. The following work was initially developed to create a synthetic dataset of contrail geometries and masks where we directly simulate which flight forms which contrail, in support of the flight attribution tasks.

This approach is scalable and is not prone to matching error, given that by construction, we know all contrail-flight pairs. It comes with associated contrail modeling and numerical weather predictions limitations, but the contrail masks serve as an appropriate test dataset for attribution purposes. The methods described here for mask generation are similar to the ones in Sarna et al. (2025) though they were developed independently.

With a systematic approach to simulating contrail masks (see Figure 2), we can go a step further and generate synthetic satellite observations of contrails. We do so by explicitly solving the radiative transfer problem using the Community Radiative Transfer Model (CRTM, Johnson et al., 2023) which directly models the radiative signature of the contrail in the visible to near infra-red bands as measured by a satellite sensor. The simulated responses are effectively synthetic contrail images, and they can be compared directly to observations informing our understanding of our abilities in contrail forecasting, and modeling:

- Forecasting: to what extent can the modeled contrail forming regions appearing in synthetic images reproduce observations? What does this imply on historical and future estimates of contrail radiative forcing?
- Modeling: when are contrail process models able to reproduce observed contrail radiative properties? This is particularly interesting in the later phases of contrail lifetime as this is where most radiative impacts occur. Satellite imagers are the primary source of observations in that phase, and this method allows for direct comparison of modeling with satellite radiances.

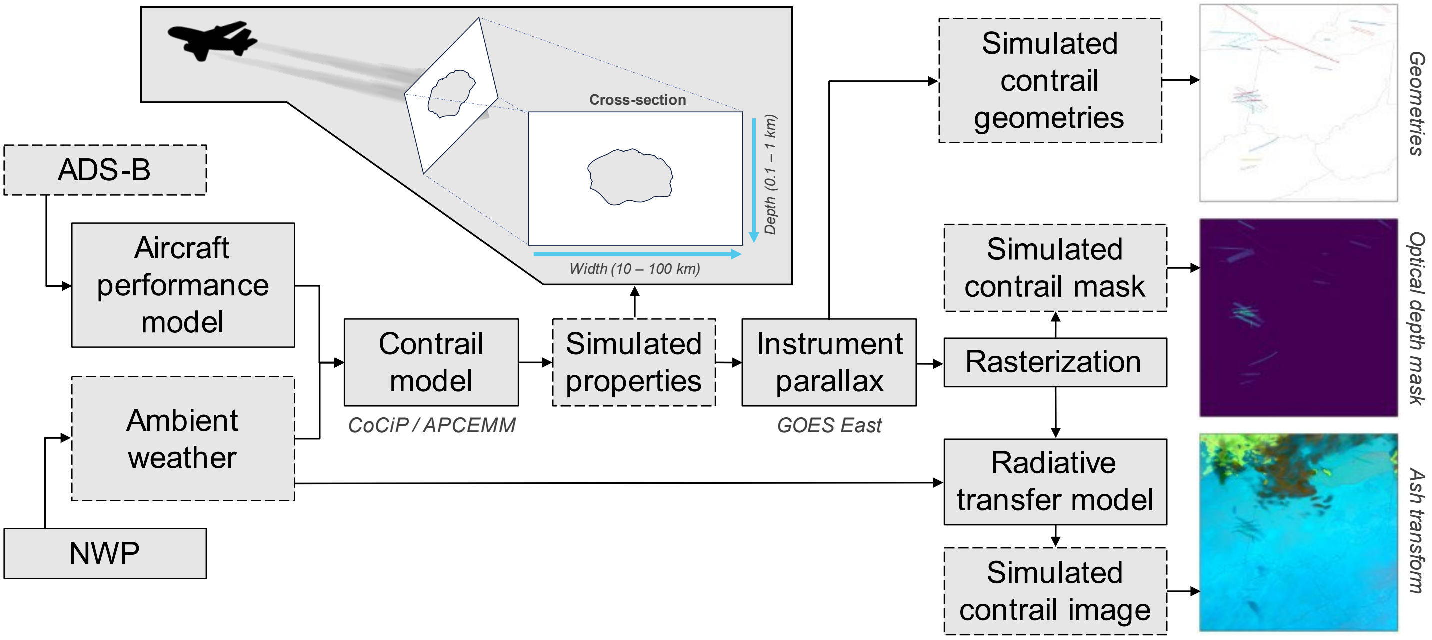

Figure 2. Model diagram detailing processing steps from Automatic Dependent Surveillance-Broadcast (ADS-B) data to synthetic contrail images. Ambient weather is taken from numerical weather prediction (NWP) and used both for contrail modeling and background weather for the radiative transfer simulation. In addition to accounting for sensor specific radiative response, the synthetic images also account for the sensor's viewing geometry by modeling the parallax correction and instrument's image grid. The example here is for Geostationary Operational Environmental Satellite (GOES)-16 Advanced Baseline Imager (ABI), but Community Radiative Transfer Model (CRTM) supports most existing satellite sensors. APCEMM: Aircraft Plume Chemistry, Emissions, and Microphysics Model, CoCiP: Contrail Cirrus Prediction.

Currently, synthetic contrail images can be generated with contrails simulated with ERA5[1] meteorology and Contrail Cirrus Prediction (CoCiP) (Schumann, 2012), using its *pycontrails* (Shapiro et al., 2025) implementation. We aim to extend this to contrails simulated by APCEMM (Fritz et al., 2020) as well as High-Resolution Rapid Refresh (HRRR) for meteorology. Weather data for the non-contrail background can be from ERA5 or HRRR. This flexibility allows us to compare the ability of the entire system, numerical weather prediction (NWP) data and contrail model, to match observed radiative properties. Existing approaches to generate synthetic contrail datasets either are not physics-based (Lee & Yoo, 2025) or do not explicitly simulate the satellite response (Chevallier et al., 2023, Sarna et al., 2025).

Preliminary simulations combining CoCiP and ERA5 data as well as HRRR for the background are presented in Figure 3. Using different NWPs for contrail and background simulations leads to inconsistent humidity fields and will be changed in the future. The simulation results below are for illustration purposes.

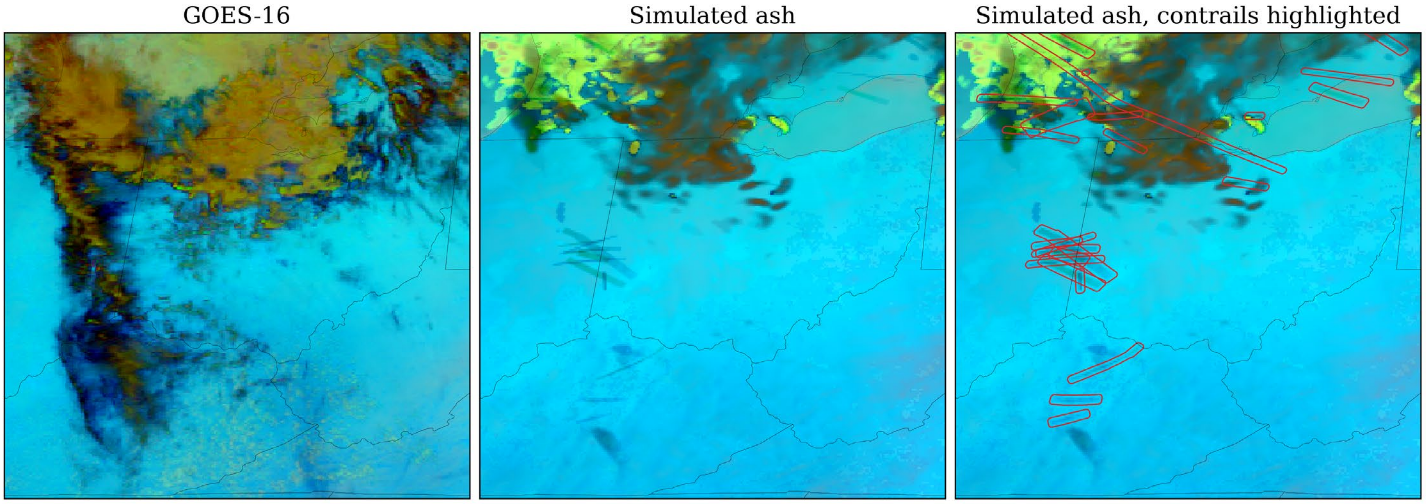

Figure 3. Synthetic images of contrails for Geostationary Operational Environmental Satellite (GOES)-16 at 2024-07-02T21:00Z over Ohio. Left: Ash-like transform of GOES-16 Advanced Baseline Imager (ABI) image. Middle and right: Simulated contrails using CoCiP and ERA5 meteorology, with background conditions taken from HRRR data.

Figure 3 shows that NWP predictions disagree with observations both for background cloud placement (thick brown cirrus clouds here) as well as contrails. This is significant for contrail climate impacts because those are dependent on the presence of other clouds below or above the contrail. This also provides insights into the observability of contrails: simulated contrails over Lake Erie are difficult for a human to distinguish from the background even though they are over clear sky. While we do not expect modeling to be able to reproduce individual contrail instances, this framework allows us to test this hypothesis and expand it to contrail cluster level statistics.

Milestone

Developed a framework that simulates contrails, their geometries and synthetic satellite contrail images enabling new comparisons of modeling to satellite observations.

Major Accomplishments

Generated physics-based synthetic satellite contrail images.

Publications

None.

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[1] European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis v5 (fifth generation ECMWF atmospheric reanalysis of the global climate). Produced by the Copernicus Climate Change Service (C3S) at ECMWF, it provides hourly, high-resolution (31km) global data on atmospheric, land, and ocean-wave variables from 1940 to the present.

Outreach Efforts

None.

Awards

None.

Student Involvement

The research and communication for this task were conducted primarily by MIT graduate research assistants, Olivier Ng'weno Kigotho and Louis Robion.

Plans for Next Period

- Implement contrail simulations using HRRR data.
- Implement contrail simulation using APCEMM.
- Benchmark altitude predictions from the output of the altitude estimation algorithm.

References

Barbosa, M. P. (2024). *Relationship between synoptic scale meteorology, aircraft parameters, and observable contrails* [Master's Thesis. Massachusetts Institute of Technology]. Massachusetts Institute of Technology.

Chevallier, R., Shapiro, M., Engberg, Z., Soler, M., and Delahaye, D. (2023). Linear Contrails Detection, Tracking and Matching with Aircraft Using Geostationary Satellite and Air Traffic Data. *Aerospace*, *10*(7), 578.

Fritz, T. M., Eastham, S. D., Speth, R. L., & Barrett, S. R. (2020). The role of plume-scale processes in long-term impacts of aircraft emissions. *Atmospheric Chemistry and Physics*, *20*(9), 5697-5727.

Johnson, B. T., C. Dang, P. Stegmann, Q. Liu, I. Moradi, and T. Auligne, (2023). The Community Radiative Transfer Model (CRTM): Community-Focused Collaborative Model Development Accelerating Research to Operations. *Bulletin of the American Meteorological Society*, 104, E1817–E1830.

Lee, Y., and Yoo, J. (2025) Improving Contrail Detection via Diffusion-Based Data Augmentation Framework. *ICLR 2025 Workshop on Tackling Climate Change with Machine Learning*.

Meijer, V. R. (2024). *Satellite-based analysis and forecast evaluation of aviation contrails* [Doctoral dissertation, Massachusetts Institute of Technology]. Massachusetts Institute of Technology.

Sarna, A., Meijer, V., Chevallier, R., Duncan, A., McConnaughay, K., Geraedts, S., McCloskey, K. (2025). Benchmarking and improving algorithms for attributing satellite-observed contrails to flights. *Atmospheric Measurement Techniques*, 18, 3495–3532.

Schumann, U. (2012). A contrail cirrus prediction model, *Geoscientific Model Development,* 5, 543–580.

Shapiro, M., Engberg, Z., Teoh, R., Stettler, M., Dean, T., Abbott., T. (2025). pycontrails: Python library for modeling aviation climate impacts (v0.59.0). *Zenodo.*

Task 3 - Contrail Observability Module

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Objective

The objective of this task is to assess the limitations of the sensing platform used and to develop an understanding for how this quantitatively affects our capabilities in performing and measuring successful operational contrail avoidance. Furthermore, this module aims to provide insights into the practical observability implications of contrails on satellite imagery. While recent work (Driver et al., 2024) investigated the resolution-based observability limitations of remote sensing for satellite detection using synthetic data of linear contrails over clear sky ocean background, there is a need for a systematic analysis using real satellite imagery and a larger breadth of scenarios. The ASCENT Project 078 team has therefore generated a comparison dataset of contrails identified on infrared imagery from two different satellite imagers with different spatial resolutions and will eventually open source the data to support the research efforts of the broader scientific community.

Research Approach

Contrail Observability Limitations

Our now-casting pipeline currently fully relies on imagery from the Advanced Baseline Imager (ABI) onboard the geostationary satellite GOES-16. The platform's continental United States (CONUS) product covers the full contiguous United States (U.S.) and has a temporal resolution of one image every five minutes, making it operationally feasible for our approach. However, the limited spatial resolution of the images (2 to 3 km per pixel) is a limitation that can result in a previously not quantified number of unobserved contrails. This partially results from an observability lag, i.e., contrails do not appear on the imagery right after formation but only once they have grown wide enough relative to the remote sensing instruments spatial resolution. Further, some contrails might not be observable at any point throughout their life due to not reaching a critical width or optical depth, or by not being distinct enough from the background. In either of these cases, our method could miss clusters or regions of contrails due to limited spatial resolution and thus not initiate deviations where they might be necessary.

Quantification Approach

We generated a dataset up manually labeled (and manually checked by a second trained labeled) contrails in infrared imagery of 12 scenes over the contiguous U.S. For each scene, we labeled one image from VIIRS, an instrument that is currently onboard three satellites in the low Earth orbit (NOAA-20, NOAA-21, SUOMI NPP) and one image from GOES-16 ABI. The polar orbits of the VIIRS-carrying satellites, however, limit use to two overpasses over the U.S. per satellite per day (not allowing for continuous real-time observations), as well as coverage of maximum half the contiguous U.S. Therefore, our team cannot use the imagery from VIIRS for our nowcasting pipeline, but it allows us to assess resolution-based contrail observability limitations by comparing images between GOES-ABI and VIIRS when data from the latter are available. VIIRS, while also being an imperfect imager and not representing "ground truth," generates images at a spatial resolution at a factor 3.5 times higher and serves as the benchmark for this comparison.

The contrail labels on the VIIRS and the ABI images for each of the 12 scenes were then analyzed to determine observation limitations of ABI with respect to VIIRS.

Results

The ASCENT Project 078 team found that on average over all scenes, ABI captures only about 20% of all contrails and only about half of the total contrail length observable from VIIRS (higher resolution). Figure 4 presents parity plots for the two metrics where each marker represents one scene and with the scene's metric for VIIRS on the x-axis and for ABI on the y-axis. We found that VIIRS captures significantly more short contrails. These could become observable in subsequent ABI frames, once they spread enough to meet a certain width. Further, we assume that VIIRS also allows us to identify my non-persistent contrails which will likely not appear on ABI at all but are also expected to be of negligible climate impact.

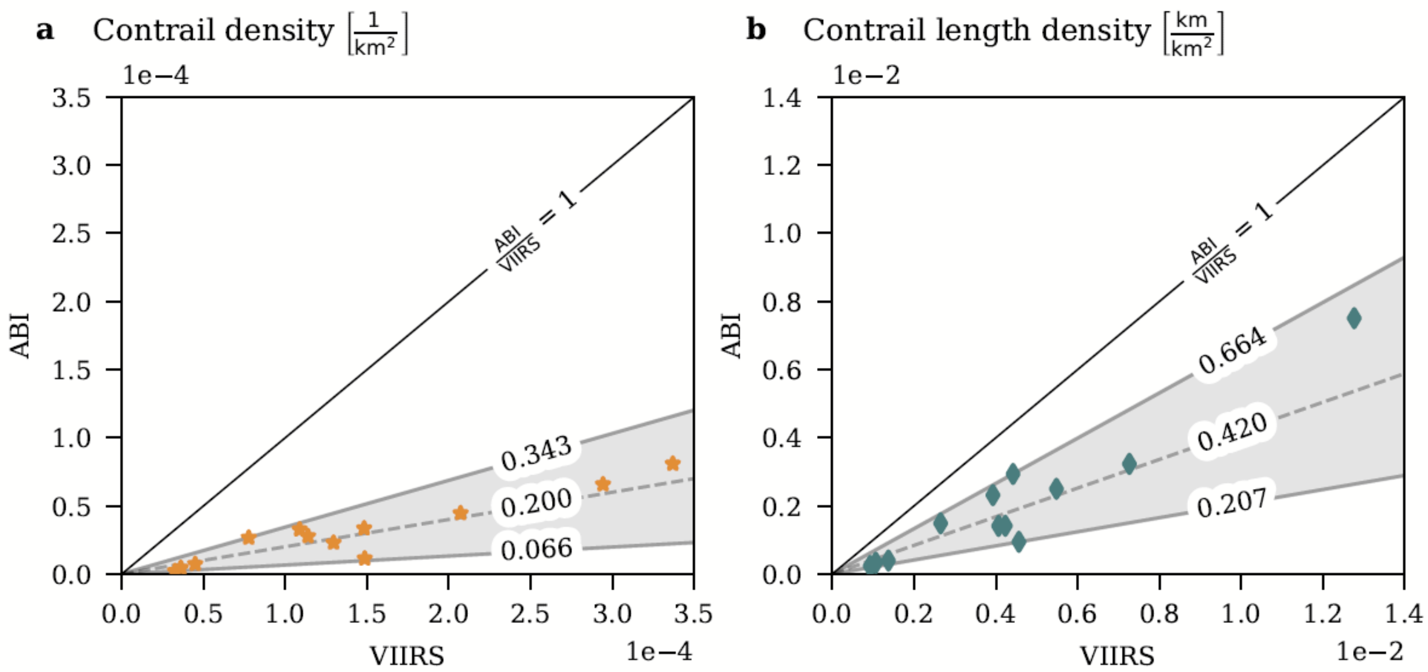

Figure 4. Comparison of (a) contrail density (number of contrails per unit area) and (b) contrail length density (total contrail length per unit area) for each of the 12 scenes in the dataset. The slope of the line through each point represents the ABI/VIIRS ratio, where a value of 1 would represent equality. The solid grey lines represent the minimum and maximum ratios, respectively. The dashed lines indicate the average ratio over all scenes.

We further found that contrail widths determined from ABI contrail observations represent and overestimate compared to higher resolution labels and subsequently an overestimate in individual contrail area. In some cases, this overestimate can result in a contrail cover that exceeds the value derived from the up to five-times as many contrails observed with VIIRS.

Our work highlights limitations for contrail observations from geostationary satellite imagers, but we point out that the high temporal resolution and large spatial coverage of these imagers is what makes them the key provider of observational data for observation-based contrail avoidance. We see an opportunity in combining observational data from multiple sensors to address some of these shortcomings and to gain a more comprehensive dataset of contrail observations and contrail evolution.

Milestone

Generated a dataset with manual labels of several thousand contrails in infrared imagery from VIIRS and ABI.

Major Accomplishments

Quantified the number of missed contrail observations for ABI in comparison to a higher resolution imager (VIIRS).

Outreach Efforts

The research progress was presented at the Fall ASCENT meeting 2025, in Alexandria, Virginia.

Publications

Euchenhofer, M. V. (2025). *An investigation into contrail observability from different satellite platforms* [Master's thesis, Massachusetts Institute of Technology]. Massachusetts Institute of Technology. https://hdl.handle.net/1721.1/162925

Euchenhofer, M. V., Prashanth, P., Parke, S. A., Eastham, S. D., & Waitz, I. A. (2025). Contrail observation limitations using geostationary satellites. *Geophysical Research Letters, 52*, e2025GL118386. https://doi.org/10.1029/2025GL118386

Awards

None.

Student Involvement

The research and communication for this task were conducted primarily by MIT graduate research assistant, Marlene V. Euchenhofer.

Plans for Next Period

Publish the dataset on Zenodo after acceptance of the above manuscript.

References

Driver, O. G. A., Stettler, M. E. J., & Gryspeerdt, E. (2024). *Factors limiting contrail detection in satellite imagery* (p. 1-28). EGUsphere. https://egusphere.copernicus.org/preprints/2024/egusphere-2024-2198/