Webinar "CONTRAILS, Climate, and AI-Driven Observation: Research Insights and Future Directions"

Q&A

Answers by LATMOS, Thales cortAIx Labs, and Reuniwatt

IR ALL-SKY IMAGERS

Q. What is the use of IR cameras for contrail detection? Do you use infrared cameras with broadband or single-channel capabilities? What is the frequency of taking images?

A. Reuniwatt: Infrared all-sky imagers can be used to detect contrail day and night. IR could also be used to characterize the radiative forcing of the contrails, some R&D is still needed on this topic. the Sky InSight™ spectral range is 8-14µm (broadband), with a 30-second temporal resolution.

Q. What is the surface covered by the all-sky imagers at contrail typical altitude i.e. 10 km?

A. Reuniwatt: The surface radius is around 30 km.

Q. Could you use the thermal IR all-sky imager for optical properties and RF information?

A. Reuniwatt: Yes. Cloud optical depth, for instance, can be retrieved from our thermal infrared camer (Sky InSight).

Bertin, C., Cros, S., Saint-Antonin, L., & Schmutz, N. (2015, October). Prediction of optical communication link availability: real-time observation of cloud patterns using a ground-based thermal infrared camera. In *Optics in atmospheric propagation and adaptive systems XVIII* (Vol. 9641, pp. 66-73). SPIE.
RF retrieval is still an ongoing research topic

DETECTION, AI & VALIDATION

Q. Among mixed clouds, how could you identify the contrails formed due to flights or natural?

A. THALES: A human visual selection has been made using temporal sequences in which contrails appear and disappear through time. These were used to annotate the ground truth images. In the future, matching presumed contrails with flight trajectories is a promising path to remove ambiguities.

Q. Will clouds generate problems for contrail detection?

A. THALES: Detecting contrails in RGB images using AI is easy when the contrail remains sharp and well-contrasted, and therefore visually identifiable, even if it passes through other types of clouds. However, detection becomes difficult, or even compromised on a single RGB image, for

both the AI model and the human operator, when the distinction between cloud and contrail is no longer visually possible in the RGB image (due to blending or overlap of clouds with a contrail and/or due to a cirrus cloud with an appearance that is very similar from the one of a contrail and creating false positives). Using different sensors (e.g. specific IR channels in satellite imagers) isolating specific types of ice crystals can help disambiguate.

Q. You write you could assess contrail lifetime, which is key to assess their warming effect. But contrails rather quickly evolve to simple cirrus / mix with them, to my understanding. Cirrus that are not identified as contrails by your model. So, how can you assess contrail lifetime?

A. THALES: Our presented work on automatic contrails detection in RGB images using AI is one technological building block towards monitoring contrails. For instance, assessing their lifespan would require extending the presented static approach from image level to image sequence level, in order to leverage the temporal context provided by image sequences to identify and then track each detected trail. It could then be possible to try to determine if a cirrus cloud results from a condensation trail, which is not possible to establish from a single image.

Q. How can you confirm you are truly identifying contrails and not cirrus clouds when you detect "potential" contrails?

A. THALES: Our presented work on automatic contrail detection in RGB images using AI can be made more robust to false positives during the training and evaluation of AI models, through the annotated examples and correction functions provided to the model. The verification of a contrails' detection could also be confirmed after the detection by integrating and leveraging the temporal context of RGB image sequences to confirm detection persistence and/or other types of sensors. This step and its automation without human operator intervention are among the future avenues to explore in the study of contrails.

Q. How do you test the performance of the UNet detection model? Can I ask about the results?

A. THALES: The performance of our U-Net model for automatic contrails detection is evaluated by calculating a quantitative semantic segmentation metric (Dice score) on a subset of images unseen during training and for which a human annotator provided a reference annotation. Our model achieves satisfying detection performance on the different RGB data sources seen during training, as well as a good ability to generalize to new RGB data sources unseen during training, which can be well improved after finetuning on a small volume of annotated data. Detection on RGB images remains challenging in difficult cases of low contrast of contrails, and/or of difficult visual distinction between very old contrails and cirrus. More quantitative and qualitative details are provided in the presentation slides.

DATA, MODELING, AND NWP MODELS

Q. Are the images from your contrail dataset issued from multiple locations? And if yes, can you give more details?

A. THALES: The data is issued from two locations in the South of France.

A. REUNIWATT: Within the contrail project we setup two pairs of camera (visible + IR). One pair was setup at the Observatoire de la Haute Provence, the second pair was setup at Obseravatoire SIRENE. The two sites are 20 km appart.

Q. Do you assume a single altitude for the whole contrail when doing the stereoscopy? And how does the retrieved altitude compare to the ADS-B altitude (corrected for the temperature profile given that it is a barometric altitude)?

A. REUNIWATT: Yes, we assume a single altitude for the whole contrail. We haven't compared the estimated altitude with the ADS-B altitude yet but that's something we plan to do.

Q. Did you focus on specific geographic locations for the NWP approach?

A. THALES: We have considered the Meteosat-10 observation disk over Europe, Africa and the surrounding oceans.

LIDAR & REMOTE SENSING

Q. Could it be possible to do LIDAR from space?

A. REUNIWATT: Of course. CALIPSO and EarthCare already host spaceborne lidar systems: https://science.nasa.gov/mission/calipso and https://earth.esa.int/eogateway/missions/earthcare

CLIMATE IMPACT

Q. Contrails persist for a very short period in climate, how can they have a huge impact on climate?

A. THALES: Contrails have a relevant impact on climate because of the large number of high-altitude flights that are operated daily across the globe. Among these, a fraction will generate contrails. In terms of magnitude, contrails' impact on climate is not among the largest within human activities. Non conservative estimates indicate that aviation determines 5% of the total anthropogenic climate forcing, of which 2/3 might be associated to contrails.

Q. When do contrails have the biggest impact: during the day or at nighttime?

A. THALES: During night-time. During day-time, they also reflect a part of solar light back to space, thus determining a cooling contribution that matches part of their warming contribution.

OPERATIONAL

Q. Which companies use your solutions as of today? Are you currently using this AI model for operational flights? Are you planning to commercialize your product?

A. THALES: Our presented work on automatic contrail detection in RGB images using AI is currently in the research stage, not yet commercialized into a product.

A. REUNIWATT: EUROCONTROL as well as a few airlines uses our solutions. However, it is still an emerging market.

Q. When we implement contrail avoidance operations in the future, will we have to use the skycam systems and lidars, and satellites to make it work? Or will we just use the ML models to predict the persistent contrails?

A. THALES: Future contrails avoidance operations will need to rely on sensors to attribute any contrail to the right responsible flight, to confirm the models' predictions and permit the correct imputation and eventual flight polices and taxes. Therefore, such sensors will most probably be still involved in this kind of operations.

Q. What is the lead time for predicting contrails?

A. REUNIWATT: The operational requirements are not yet fully defined, but it can be anticipated that contrail formation forecasts could be valuable over a range of lead times, from several days ahead for flight planning purposes to a few hours ahead for in-flight rerouting decisions.

Q. Is the mitigation of contrails achieved by rerouting the contrail-prone areas? Is there a possibility to consider cooling contrails?

A. THALES: Given the current levels of uncertainty in determining those contrails-prone climate sensitive areas, such possibility might be ill-advised. Should our forecasting capability grow, this scenario of generating cooling contrails on purpose might be considered, as long as the extra fuel burnt to travel across those areas does not determine a too large cost and a too large CO2 emission.

GENERAL QUESTIONS

Q. What opportunities for students/interns do you have?

A. THALES: Thales/CortAix labs trainee offers are regularly updated at Parcourez les offres d'emplois avec Thales

A. REUNIWATT: Reuniwatt offers student internships in meteorology, machine learning and related topics. To find out more, take a look at our internship page: https://reuniwatt.com/en/master-student-internships-data-science-for-renewables/

Q. How can I contact you?

A. You can contact our webinar speakers if you have specific questions.

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