

# BIG picture

Reuniwatt's all-sky imagers have been proved to be a key tool in observing contrails and avoiding costly 'big hits'

**C**ontrails created by air traffic certainly have a net warming effect, but there are still many uncertainties about their precise impact and it is crucial to pursue dedicated research. In fact, there are several research projects currently taking a closer look at the effects of aviation on global warming and aiming to find ways to make air traffic more sustainable. Reuniwatt's all-sky imagers are a key tool for the observation of contrail formation and evolution and helping to find the best strategies to mitigate their impact.

Linear contrails are formed at cruising flight altitude, typically 8-12km above ground, when water

vapor and soot particles are released by aircraft into an ice-supersaturated cold atmosphere. Sometimes, depending on the specific environmental conditions (temperature and ice supersaturation), linear contrails persist and spread into extended ice clouds, adding their local contribution to the warming of the area's underlying air layers.

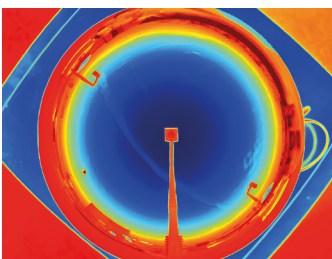
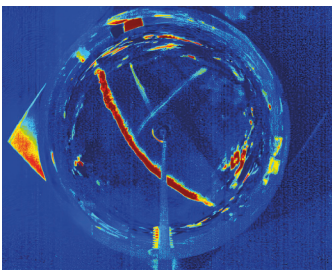
Contrail cirrus clouds have a proven effect on climate change, with about two-thirds of aviation's climate change impact believed to come from sources other than the aircraft's CO<sub>2</sub> emissions. To mitigate their



**RIGHT:** Sky InSight creates raw thermal infrared images that can be processed to study contrails

**BELOW LEFT:** Contrails as seen by Sky InSight, with raw thermal infrared image (bottom) and post-processed image with contrails enhancement (top)

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environmental effect it is necessary to understand how and when they will form, so as to develop the best strategies to route flights over non-cirrus contrail forming regions.

## Big hits

A small number of specific events – referred to as big hits – cause most of the total radiative forcing and result in the warming of the atmosphere. Therefore, understanding and forecasting contrail formation and persistence are key to implementing strategies to avoid the formation of such contrail cirrus clouds. Rather than targeting all flights, it is first crucial that the aircraft responsible for these big hits should take an alternative route in drier air.

The use of infrared sky cameras on the ground enables better estimation and forecasting of cloud optical thickness than numerical weather models, and opens up new possibilities for contrail

## Aviation

Linear contrails  
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researchers and better flight planning to avoid the trails.

### Combining all-sky cameras, AI and physical models

Reuniwatt is part of the CONTRAILS project consortium, a bilateral Franco-German cooperation comprising other partners: DWD (the German Meteorological Service), Thales Group, and the French research institute LATMOS. The project aims to develop and combine advanced, trustworthy AI methods with physical models to improve contrail identification, characterization, data assimilation and forecasting.

Reuniwatt's ground-based all-sky cameras – Sky InSight and Sky Cam Vision – are used to observe contrail cirrus cloud formation in the infrared and visible ranges respectively. They are installed in a closed perimeter but several hundred meters apart to obtain a stereoscopic view of the sky. This setup, compared with using satellite data or only one sky camera, results in improved depth perception. Furthermore, underestimating the degree of supersaturation will lead to overly low estimates of cloud optical thickness and consequently overly low estimates of radiative forcing of the contrails. The use of infrared all-sky imagers overcomes this problem by measuring the clouds' optical properties from the ground.

Using all-sky cameras (specially set up to give a stereoscopic view) enables the observation of the formation and evolution of contrail cirrus clouds, and the determination of their occurrence and impact. The images taken by sky cameras are used to classify contrails and analyze their features (shape, evolution in height and spread, lifetime). These observations and analyses serve to identify the appropriate actions to reduce the environmental impact of aviation.

### Aviation sustainability

As well as CONTRAILS, several other research projects also aim to make the prediction of persistent contrails a reality applicable in daily operations. For instance, Eurocontrol has just set up a brand-new contrail observatory on the roof of its Eurocontrol Innovation Hub (EIH) in Brétigny, France, using Reuniwatt's visible and infrared sky cameras. It combines satellite and ground-based observations.



“Using all-sky cameras ... enables the observation of the formation and evolution of contrail cirrus clouds”

This synergy of ground-based imaging systems, such as those from Reuniwatt, with satellite data is expected to play a key role in contrail observation and monitoring. In several research projects, the data collected from sky imagers will be annotated and combined with satellite data, correlated with aircraft traffic data, and used to develop a machine-learning-based contrail detection algorithm. Geometric deep learning approaches will enable the processing of this data in their native geometry. They are well suited for processing three-dimensional data and therefore especially appealing in the context of the stereoscopy analyses that will be conducted by Eurocontrol and the partners in CONTRAILS.

### Contrails, no longer a cold case

The aviation industry has long been committed to finding ways to mitigate the impact of flights on the environment. Contrail prevention is one of the main challenges to move toward aviation sustainability, with regard to avoiding big hits and offering more eco-efficient flights. Contrail coverage might increase, especially in the regions where they were rare in the past, as the whole aviation sector continues to grow.

In view of the innovative work of the CONTRAILS project, a network of all-sky imagers installed along plane routes could become a monitoring network for contrails. It would allow air traffic managers to receive warnings about contrail generation, and airlines to reduce costly consequences. Avoiding those big hits with the largest warming impact is an important step to making aviation more environmentally sound. ■



**TOP:** Contrails observation with several sky imagers enables stereoscopy experiments

**ABOVE:** Sky Cam Vision (pictured) works with Sky InSight on EIH to observe contrails