Webinar "Contrails in the climate system – enhancing NWP through cloud observation and AI"

Q&A

Answers by DWD, Reuniwatt, and Thales

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?

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. The Sky InSight spectral range is 8-14µm (broadband).

Q. How much better could be the contrail elevation derived from the TIR-camera compared to the satellite contrail elevation retrieval? What is the elevation uncertainty deriving contrail elevation from ground-based stereo-images?

A. Reuniwatt: Contrail elevation retrieval using satellite is not obvious. Standard Cloud Top Height products (e.g SAFNWC) were not designed for contrail and may require some fine tuning. Specific training using GOES-16 and CALIPSO LIDAR data has been demonstrated by (Meijer et al., 2024), achieving a root mean square error (RMSE) of 570 m.

Ground based stereo-images can be used to derive the base altitude of the contrails with a greater accuracy (< 100m). However, this accuracy depends on the camera resolution, the distance between the camera but also the distance between the contrail and the cameras.

Reference

Meijer, V. R., Eastham, S. D., Waitz, I. A., & Barrett, S. R. (2024). Contrail altitude estimation using GOES-16 ABI data and deep learning. *Atmospheric Measurement Techniques*, *17*(20), 6145-6162.

Q. Which camera and technique do you use for estimating the cloud COD?

A. Reuniwatt: Cloud Optical Depth can be estimated from the Sky InSight images. The principles of estimation are described here https://hal.science/hal-01649679v1/document

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Q. Do you also try to make use of the contrail shape, which is visible in the camera images, for deriving more complex atmospheric parameters?

A. DWD: We focused in the project on improving the representation of high clouds and contrails in our NWP model. We developed a contrail detection in camera images as a diagnostic tool to potentially monitor the performance and improvements in our NWP system. We do not use shape parameters here.

A. Reuniwatt: There are indeed a lot of atmospheric parameters you could assess with an all-sky imager: contrail altitude, geometrical spread, optical depth, radiative forcing.

Q. How can you pair a contrail to a flight on sky cam images?

A. DWD: We had no flight on sky images available. In general, meta data like location of the sensor need to be provided to the NWP system and a specifically designed observation operator simulates a virtual measurement of the NWP model. Then spatial verification methods are used to statistically compare observations and simulations.

A. Reuniwatt: Our cameras are geometrically calibrated: we match every pixel of the images with its azimuth and zenithal angle in the sky. Thus, it is quite easy to project ADS-B data on the images and match a forming contrail with a flight path. Matching an old (persistent) contrail that has formed out of the field of view of the camera is more challenging. In this case, a synergetic use of sky camera, satellite imagery and wind data can be used: this is still an ongoing research topic.

ICON / NWP MODELS

Q. Are you aware of any other numerical weather prediction (NWP) models than ICON which incorporate a two-moment cloud ice scheme and produce comparable results in terms of range-height indicator (RHI) forecasting?

A. DWD: WRF has always included a two-moment cloud ice representation in the Thompson microphysics scheme. The current version also provides quite good RHi forecasts, e.g., Thompson, G., Scholzen, C., O'Donoghue, S., Haughton, M., Jones, R. L., Durant, A., & Farrington, C. (2024). On the fidelity of high-resolution numerical weather forecasts of contrail-favorable conditions. *Atmospheric Research, 311*, 107663. Apart from that, the IFS of ECMWF, which follows the Tompkins approach, has also been quite successful but adopts a different philosophy. In radar meteorology, "RHI" actually stands for "range-height indicator." However, in this context, "RHi" refers to "relative humidity over ice."

Q. How good is your weather model in predicting ISSRs?

A. DWD: With our Ensemble Prediction system we are able to detect ISS regions in a 12h forecast with a probability above 80% and a false alarm rate less than 20%. These results are derived from verification against radiosonde Vaisala 41 TEMP data.

Q. What methods are used to model the changing shape of clouds along their trajectory, considering dynamic metamorphosis?

A. DWD: Cloud observations enter the NWP model by the cycled data assimilation scheme. Between the data assimilation steps, clouds in the NWP model are dynamically propagated with the model dynamics.

CONTRAILS

Q. Which satellites, which instruments do you use to observe contrails?

A. DWD: In this project, we focused on the use of visible reflectances from geostationary satellites. We used SEVIRI on METEOSAT10. We have been assimilating these data into our regional model since 2023 and have gained a lot of experience regarding the quality and use of these data. The results generalize to other VIS instruments.

Q. Are you aware of investigations with LEO satellites? Would you recommend tasking a satellite specifically for this investigation, or conducting trials timed to coincide with existing satellite overpasses?

A. DWD: We prepare the use of the ice cloud imager on board the EPS Satellites of EUMETSAT to be launched in 2026.

Q. Besides the ground-based tools, can you say a word on the validation of persistent contrails over ocean (flights to/from outermost regions of EU are included in the current scope of the EU MRV system on non-CO2).

A. DWD: Our project developments were done with our global NWP system that also models high cirrus clouds over the ocean. For NWP purposes, we consider contrails as cirrus clouds and as such they are included in our investigations.

Q. Do you have the flight levels of the contrail-forming aircraft as an input? And do you have the aircraft-type as an input, so that you could calculate the modified-Schmidt-Appleman criterion more precisely using the propulsion efficiency?

A. DWD: The DWD NWP model provides input to tools like pycontrail that predict contrails. Flight information is not part of the NWP system.

Q. Are you part of the Eurocontrol ContrailNet?

A. DWD: No

A. Thales: Yes, Thales is one of the founding partners alongside EUROCONTROL and Airbus (EUROCONTROL launches ContrailNet - the new network to create a common repository of contrail observation data | EUROCONTROL)

GENERAL QUESTIONS

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

A. DWD: DWD offers internships for master students with a focus on NWP and AI for weather and climate related topics.

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/

A. Thales: Check the Thales career page with internship offers in many countries: Student and Graduates | Thales

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Q. How can I contact you?

A. For any other questions, be sure you will be forwarded to the right counterpart when contacting us here:

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