Contrail

From Wikipedia, the free encyclopedia

Contrails (short for "condensation trails") or **vapour trails** are artificial clouds that are the visible trails of condensed water vapour made by the exhaust of aircraft engines. As the hot exhaust gases cool in the surrounding air they may precipitate a cloud of microscopic water droplets. If the air is cold enough, this trail will comprise tiny ice crystals.[1]

Airliner contrails, some new, some old and much spread out by wind shear

The wingtip vortices which trail from the wingtips and wing flaps of aircraft are sometimes partly visible due to condensation in the cores of the vortices. Each vortex is a mass of spinning air and the air pressure at the centre of the vortex is very low. These wingtip vortices are not the same as contrails.

Depending on atmospheric conditions, contrails may be visible for only a few seconds or minutes, or may persist for many hours which may affect climate.[2]

The image on the left shows the sky above Wuerzburg, Germany without contrails after the grounding of air traffic in 2010 and the image on the right shows the sky with regular air traffic

Contents

Condensation from engine exhaust

The main byproducts of hydrocarbon fuel combustion are carbon dioxide and water vapor. At high altitudes this water vapour emerges into a cold environment, and the local increase in water vapor can push the water content of the air past saturation point. The vapour then condenses into tiny water droplets and/or deposits into ice. These millions of tiny water droplets and/or ice crystals form the vapour trail or contrails. The vapor's need to condense accounts for the contrail forming some way behind the aircraft's engines. At high altitudes, supercooled water vapor requires a trigger to encourage deposition or condensation. The exhaust particles in the aircraft's exhaust act as this trigger, causing the trapped vapor to rapidly turn to ice crystals. Exhaust vapour trails or contrails usually occur above 8000 meters (26,000 feet), and only if the temperature there is below -40°C (-40°F).[3]

Contrails from a Qantas Boeing 747-400, Australia

Condensation from decreases in pressure

Main article: Wingtip vortices

As a wing generates lift, it causes a vortex to form at each wingtip, and sometimes also at the tip of each wing flap. These wingtip vortices persist in the atmosphere long after the aircraft has passed. The reduction in pressure and temperature across each vortex can cause water to condense and make the cores of the wingtip vortices visible. This effect is more common on humid days. Wingtip vortices can sometimes be seen behind the wing flaps of airliners during takeoff and landing, and during landing of the Space shuttle.

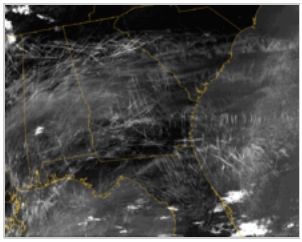
The visible cores of wingtip vortices contrast with the other major type of contrails which are caused by the

combustion of fuel. Contrails produced from jet engine exhaust are seen at high altitude, directly behind each engine. By contrast, the visible cores of wingtip vortices are usually seen only at low altitude where the aircraft is travelling slowly after takeoff or before landing, and where the ambient humidity is higher. They trail behind the wingtips and wing flaps rather than behind the engines.

During high-thrust settings the fan blades at the intake of a turbo-fan engine reach transonic speeds, causing a sudden drop in air pressure. This creates the condensation fog (inside the intake) which is often observed by air travelers during takeoff. For more information see the Prandtl-Glauert singularity effect.

Vapour trails or contrails and climate

Vapour trails or contrails, by affecting the Earth's radiation balance, act as a radiative forcing. Studies have found that vapour trails or contrails trap outgoing longwave radiation emitted by the Earth and atmosphere (positive radiative forcing) at a greater rate than they reflect incoming solar radiation (negative radiative forcing). Therefore, the overall net effect of contrails is positive, i.e. a *warming*.[4] However, the effect varies daily and annually, and overall the magnitude of the forcing is not well known: globally (for 1992 air traffic conditions), values range from 3.5 mW/m² to 17 mW/m². Other studies have determined that night flights are mostly responsible for the warming effect: while accounting for only 25% of daily air traffic, they contribute 60 to 80% of contrail radiative forcing. Similarly, winter flights account for only 22% of annual air traffic, but contribute half of the annual mean radiative forcing.[5]



MODIS tracking of contrails generated by air traffic over the southeastern United States on January 29, 2004.

September 11, 2001 climate impact study

The grounding of planes for three days in the United States after September 11, 2001 provided a rare opportunity for scientists to study the effects of contrails on climate forcing. Measurements showed that without contrails, the local diurnal temperature range (difference of day and night temperatures) was about 1 degree Celsius higher than immediately before;[6] however, it has also been suggested that this was due to unusually clear weather during the period.[7]

Condensation trails have been suspect of causing “regional-scale surface temperature” changes for some time.[8][9] Researcher David J. Travis, an atmospheric scientist at the University of Wisconsin-Whitewater, has published and spoken on the measurable impacts of contrails on climate change in the science journal *Nature* and at the American Meteorological Society 10th Annual conference in Portland, Oregon. The effect of the change in aircraft contrail formation on the 3 days after the 11th was observed in surface temperature change, measured across over 4,000 reporting stations in the continental United States.[8] Travis’ research documented an "anomalous increase in the average diurnal temperature change".[8] The diurnal temperature change (DTR) is the difference in the day's highs and lows at any weather reporting station.[10] Travis observed a 1.8 degree Celsius departure from the two adjacent three-day periods to the 11th-14th.[8] This increase was the largest recorded in 30 years, more than "2 standard deviations away from the mean DTR".[8]

Head-on contrails

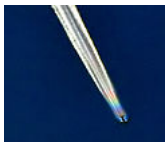
A contrail from an aeroplane flying towards the observer can appear to be generated by an object moving vertically.[11][12] On 8 November 2010 in California, USA, a contrail of this type gained wide media attention as a "mystery missile" that could not be explained by US military and aviation authorities[13], and its explanation as a contrail[11][12][14][15] took more than 24 hours to become accepted by US media and military institutions.[16]

Distrails

A 'distrail' is short for dissipation trail. Where an aircraft passes through a cloud, it can clear a path through it; this is known as a distrail. Because the plane's contrail is not yet visible (contrails usually form above 26,000 feet, depending on the temperature and other factors) the distrail looks like a tunnel through the cloud if the cloud is very thin.[17]

Distrails are created by the elevated temperature of the exhaust gases absorbing the moisture from the cloud. Clouds exist where the relative humidity is 100% but by increasing the temperature the air can hold more moisture and the relative humidity drops below 100%, even for the same absolute moisture density, causing the visible water droplets in the cloud to be converted back into water vapour.

A distrail is the opposite of a contrail



Contrails with iridescent colors

B-17 Propeller tip contrails

Crow instability contrail over San Francisco

Trail from the flap of a landing airliner

A shadow cast by vapour trail

Decaying contrails from aircraft on similar tracks

Decaying contrails over a military airbase before an airshow

Decaying contrail spread by upper winds until it looks like cirrus cloud, Manchester, England, 13 May 2010

Decaying contrails and some cirrus clouds over south-east Sheffield, United Kingdom, 27 October 2010

Decaying contrails mixed in with some Cirrocumulus clouds over Santa Clarita, CA, 27 October 2010

This was not a normal contrail

See also

- Aviation and climate change
- Chemtrail conspiracy theory
- Cirrus cloud
- Global dimming
- Ship tracks
- Skywriting

References

1. ^ http://www.britannica.com/EBchecked/topic/623212/vapour-trail
2. ^ *Contrails, Cirrus Trends, and Climate* (http://www.areco.org/minnis.pdf) - joint paper by Patrick Minnis, Atmospheric Sciences, NASA Langley Research Center; J Kirk Ayers, Rabinda Palikonda and Dung Phan, Analytical Services and Materials
3. ^ NASA, Contrail Education FAQ (http://asd-www.larc.nasa.gov/GLOBE/faq.html)
4. ^ Ponater, M.; S. Marquart, R. Sausen and U. Schumann (2005). "On contrail climate sensitivity" (http://www.agu.org/pubs/crossref/2005/2005GL022580.shtml) . *Geophysical Research Letters* **32** (10): L10706. doi:10.1029/2005GL022580 (http://dx.doi.org/10.1029%2F2005GL022580) . http://www.agu.org/pubs/crossref/2005/2005GL022580.shtml. Retrieved 2008-11-21.
5. ^ Stuber, Nicola; Piers Forster, Gaby Rädel, Keith Shine (2006-06-15). "The importance of the diurnal and annual cycle of air traffic for contrail radiative forcing". *Nature* **441** (7095): 864–867. doi:10.1038/nature04877 (http://dx.doi.org/10.1038%2Fnature04877) . PMID 16778887 (http://www.ncbi.nlm.nih.gov/pubmed/16778887) .
6. ^ Travis, D.J.; A.M. Carleton and R.G. Lauritsen (3 2004). "Regional Variations in U.S. Diurnal Temperature Range for the 11–14 September 2001 Aircraft Groundings: Evidence of Jet Contrail Influence on Climate" (http://facstaff.uww.edu/travisd/pdf/climatepapermar04.pdf) . *J. Clim.* **17**: 1123–1134. doi:10.1175/1520-0442(2004)017<1123:RVIUDT>2.0.CO;2 (http://dx.doi.org/10.1175%2F1520-0442%282004%29017%3C1123%3ARVIUDT%3E2.0.CO%3B2) . http://facstaff.uww.edu/travisd/pdf/climatepapermar04.pdf. Retrieved 2008-11-06.
7. ^ Kalkstein and Balling Jr., Climate Research, 26, 1-4, 2004

8. ^ *a b c d e* Travis, D.J.; A. Carleton and R.G. Lauritsen (8 2002). "Contrails reduce daily temperature range.". *Nature* **418** (6898): 601. doi:10.1038/418601a (http://dx.doi.org/10.1038%2F418601a) . PMID 12167846 (http://www.ncbi.nlm.nih.gov/pubmed/12167846) .
9. ^ Only partial content available on-line. Reed, Christina (September 2006). "Hot Trails" (http://www.webcitation.org/5jx4Tvb7E) . *Scientific American* **295** (3): pp. 28. doi:10.1038/scientificamerican0906-28 (http://dx.doi.org/10.1038%2Fscientificamerican0906-28) . ISSN 0036-8733 (http://www.worldcat.org/issn/0036-8733) . OCLC 1775222 (http://www.worldcat.org/oclc/1775222) . Archived from the original (http://www.scientificamerican.com/article.cfm?id=hot-trails) on 21 September 2009. http://www.webcitation.org/5jx4Tvb7E. Retrieved 21 September 2009
10. ^ Perkins, Sid. “September’s Science: Shutdown of airlines aided contrail studies.” Science News. Vol. 161, No. 19. Pg. 291. 11 May 2002. Science News Online http://www.sciencenews.org/articles/20020511/fob1.asp
11. ^ *a b* McKee, Maggie (2010-11-09). "Mystery 'missile' likely a jet contrail, says expert" (http://www.webcitation.org/5u93Z5zKm) . New Scientist. Archived from the original (http://www.newscientist.com/article/dn19704-mystery-missile-likely-a-jet-contrail-says-expert.html) on 2010-11-09. http://www.webcitation.org/5u93Z5zKm. Retrieved 2010-11-10.
12. ^ *a b* West, Mick (2010-11-10). "A Problem of Perspective in the OC - New Year's Eve Contrail" (http://www.webcitation.org/5u97HNveF) . Archived from the original (http://contrailscience.com/a-problem-of-perspective-in-the-oc-new-years-eve-contrail/) on 2010-11-10. http://www.webcitation.org/5u97HNveF. Retrieved 2010-11-10.
13. ^ "Pentagon Can't Explain "Missile" off California" (http://www.webcitation.org/5u94tq4N8) . CBS. 2010-11-09. Archived from the original (http://www.cbsnews.com/stories/2010/11/09/national/main7037857.shtml) on 2010-11-10. http://www.webcitation.org/5u94tq4N8. Retrieved 2010-11-10.
14. ^ Pike, John E. (2010-11). "Mystery Missile Madness" (http://www.globalsecurity.org/org/news/2010/101110-contrail.htm) . GlobalSecurity.org. http://www.globalsecurity.org/org/news/2010/101110-contrail.htm. Retrieved 2010-11-11.
15. ^ Bahneman, Liem (2010-11-09). "It was US Airways flight 808" (http://www.webcitation.org/5u98XSi9j) . Archived from the original (http://blog.bahneman.com/content/it-was-us-airways-flight-808) on 2010-11-10. http://www.webcitation.org/5u98XSi9j. Retrieved 2010-11-10.
16. ^ "Pentagon: 'Mystery missile' was probably airplane" (http://www.webcitation.org/5u99qdJVl) . Mercury News/AP. 2010-11-10. Archived from the original (http://www.mercurynews.com/news/ci_16574898) on 2010-11-10. http://www.webcitation.org/5u99qdJVl. Retrieved 2010-11-11.
17. ^ Distrail on Earth Science Picture of the Day (http://epod.usra.edu/archive/epodviewer.php3?oid=110784)

External links

- Contrails.nl: Pictures of Contrails and Aviation Cirrus (-Smog), from 1995 on. (http://www.contrails.nl/index.htm)
- Abstract of article in *Nature* announcing research results of contrail temperature change study (http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v418/n6898/abs/418601a_fs.html&filetype=)
- Clouds Caused By Aircraft Exhaust May Warm The U.S. Climate (http://www.sciencedaily.com/releases/2004/04/040428061056.htm)
- Contrails over the USA (http://antwrp.gsfc.nasa.gov/apod/ap041013.html)
- Effects of contrails on ground astronomy (http://news.bbc.co.uk/2/hi/science/nature/4755996.stm)
- Contrail simulator (Java applet) (http://profhorn.aos.wisc.edu/wxwise/AckermanKnox/chap15/contrail_applet.html) — interactively shows how temperature and humidity of the surrounding air affect contrail formation and characteristics
- Contrails: What's Left Behind Is Bad News, article by Nick Onkow from March 4, 2006 (http://www.airliners.net/articles/read.main?id=85)
- Night flights give bigger boost to global warming (http://www.newscientist.com/article.ns?id=mg19025564.900&feedId=online-news_rss20)
- NASA Langley Contrail Page(Contrails not Chemtrails) (http://www-pm.larc.nasa.gov/newcontrail.html)
- NASA Contrail Education (http://asd-www.larc.nasa.gov/GLOBE/)
- NASA Contrail Studies (http://mynasadata.larc.nasa.gov/P4.html)
- What is a contrail and how does it form? (http://www.wrh.noaa.gov/fgz/science/contrail.php) , National Weather Service
- Vapor Trails (http://books.google.com/books?id=KCcDAAAAMBAJ&pg=PA55&dq=popular+science+antitank+1941&hl=en&ei=KgiXTNPbOsuhnAeItuD7Bw&sa=X&oi=book_result&ct=result&resnum=5&ved=0CDkQ6 March 1943 article

Retrieved from "http://en.wikipedia.org/wiki/Contrail"
Categories: Aviation terminology | Cloud types