



## THE POWER FOR THE PEOPLE ®

<a href="#">Aids</a>	<a href="#">Air Traffic</a>	<a href="#">Alaska</a>	<a href="#">Alaska Pipeline</a>	<a href="#">Antarctica</a>	<a href="#">Apes</a>
<a href="#">Arctic</a>	<a href="#">Arctic Ozone</a>	<a href="#">Arctic Refuge</a>	<a href="#">Atmosphere</a>	<a href="#">Bio-Terror</a>	<a href="#">Climate Change</a>
<a href="#">Comments</a>	<a href="#">Coral Reefs</a>	<a href="#">Digital Divide</a>	<a href="#">Drought</a>	<a href="#">Earth</a>	<a href="#">Earth Day</a>
<a href="#">Electricity</a>	<a href="#">Elephants</a>	<a href="#">Energy</a>	<a href="#">Everglades</a>	<a href="#">Fossil Fuels</a>	<a href="#">Frogs</a>
<a href="#">Genesis</a>	<a href="#">Glaciers</a>	<a href="#">Global Warming</a>	<a href="#">Goals</a>	<a href="#">Hunger</a>	<a href="#">Icebergs</a>
<a href="#">La Nina/EL Nino</a>	<a href="#">Links</a>	<a href="#">Middle East</a>	<a href="#">Music</a>	<a href="#">News</a>	<a href="#">Nuclear Power</a>
<a href="#">Oceans</a>	<a href="#">OPEC</a>	<a href="#">Ozone</a>	<a href="#">Ozone Hole</a>	<a href="#">Pandas</a>	<a href="#">People</a>
<a href="#">Permafrost</a>	<a href="#">Polar Bears</a>	<a href="#">Pollution</a>	<a href="#">Poverty</a>	<a href="#">Rainforest</a>	<a href="#">Resources</a>
<a href="#">Recycle</a>	<a href="#">Rhinos</a>	<a href="#">Save The Earth</a>	<a href="#">Sep 11, 2001</a>	<a href="#">Solar Max</a>	<a href="#">Solar Power</a>
<a href="#">Species</a>	<a href="#">Super Volcano</a>	<a href="#">The Sun</a>	<a href="#">Tigers</a>	<a href="#">U.S. Energy Policy</a>	<a href="#">Visitors</a>
<a href="#">Volcanoes</a>	<a href="#">War</a>	<a href="#">Water</a>	<a href="#">West Nile Virus</a>	<a href="#">Whales</a>	<a href="#">Wind Power</a>

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## Air Traffic

Contributing to Climate Change and Ozone Destruction



1 round trip from NY to LA or Trans Atlantic round trip = 2,000 pounds of CO<sub>2</sub>  
 In a year air travel releases 600 million tons of carbon dioxide into the atmosphere



**Contrail Streaming From An Aircraft**

By the year 2050, increased flights by jet airplanes will impact global climate through the greater number of contrails they will produce, according to a study completed in 1999 and published in *The Journal of Geophysical Research Letters*.



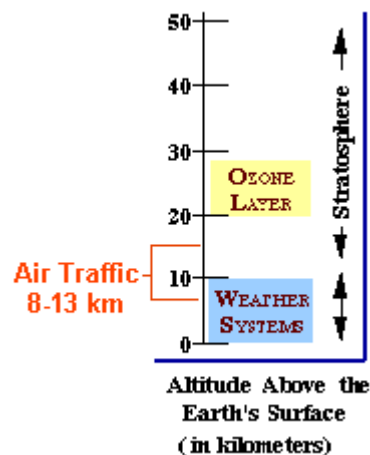
**Contrail Formation**

A research team of American and German scientists, headed by Patrick Minnis of the NASA Langley Research Center in Hampton, Virginia, reports evidence that contrails cause a warming of the Earth's atmosphere. Currently their impact is currently small as compared to other greenhouse effects. They predict, however, that it may grow by a factor of six over the next 50 years. The researchers emphasize that these are conservative estimates, which take into account only the thicker contrails that can be readily observed.



### Contrails

Thinner contrails and contrails that have developed into natural-looking cirrus clouds also affect climate, but their impact cannot yet be predicted. Other factors that would play a role include natural cloud cover, overlapping of contrails, and size of the ice particles that form in them. They call for further research into the full extent of current contrail coverage and the specific effect of contrails in forcing climate change.



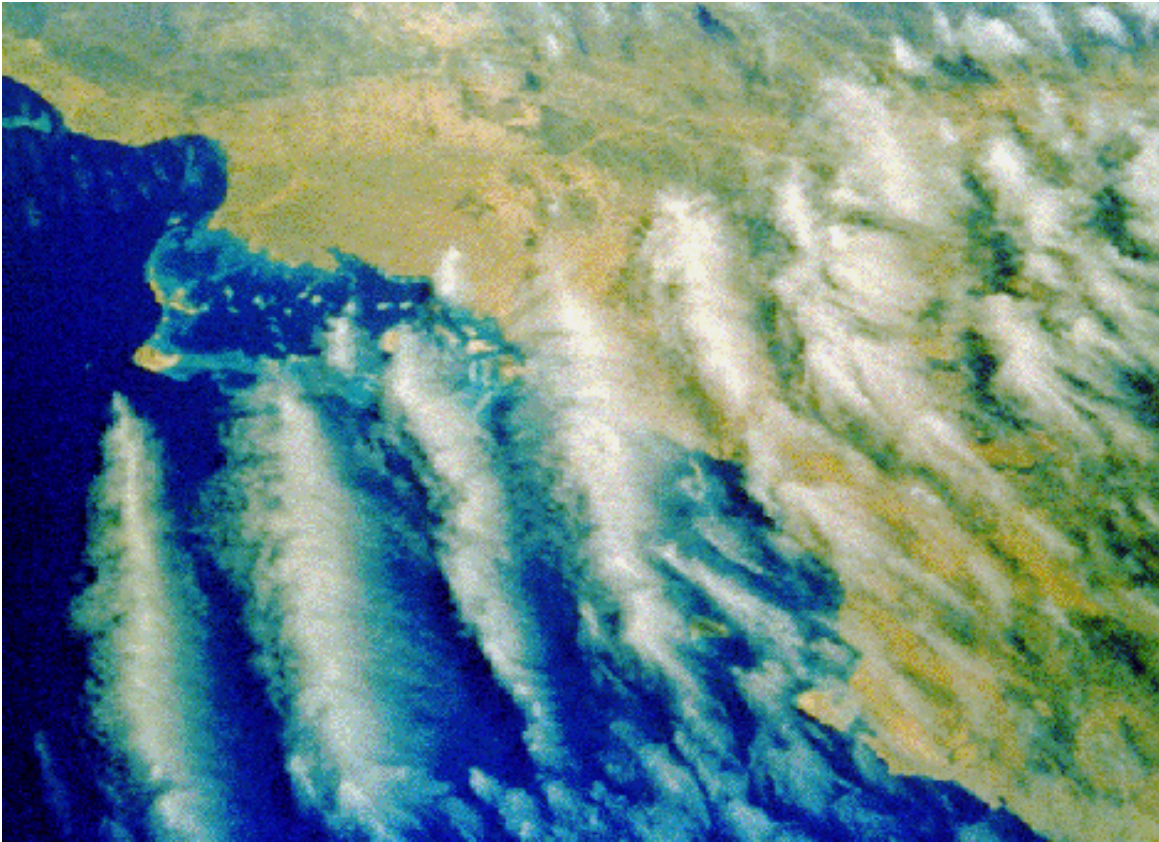
Several scientific studies have suggested that aviation may contribute to detrimental chemical changes in the atmosphere (particularly ozone content), as well as possible climate modification. The most widely accepted assessments are those conducted by United Nations (U.N.) scientific organizations. Ozone trends are monitored by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO).



NASA Wake Vortex experiment forming of contrails

Air traffic and, therefore, contrails, are not evenly distributed around the globe. They are concentrated over parts of the United States and Europe, where local warming reaches up to 0.7 watts per square meter, or 35 times the global average. The ghostly white trails following airplanes and rockets through the sky, called contrails, are probably adding to global warming, according to scientists at NASA's Langley Research Center, Hampton, Va. The contrails often turn into cirrus clouds, a thin, wispy type of cloud made of ice crystals. The most common form of high-level clouds are thin and often wispy cirrus clouds. Typically found at heights greater than 20,000 feet (6,000 meters), cirrus clouds are composed of ice crystals that originate from the freezing of super cooled water droplets. Cirrus generally occur in fair weather and point in the direction of air movement at their elevation. While some clouds tend to help cool the globe and negate the affects of global warming, thin cirrus clouds are heat trappers, holding in more heat than they reflect back into space.





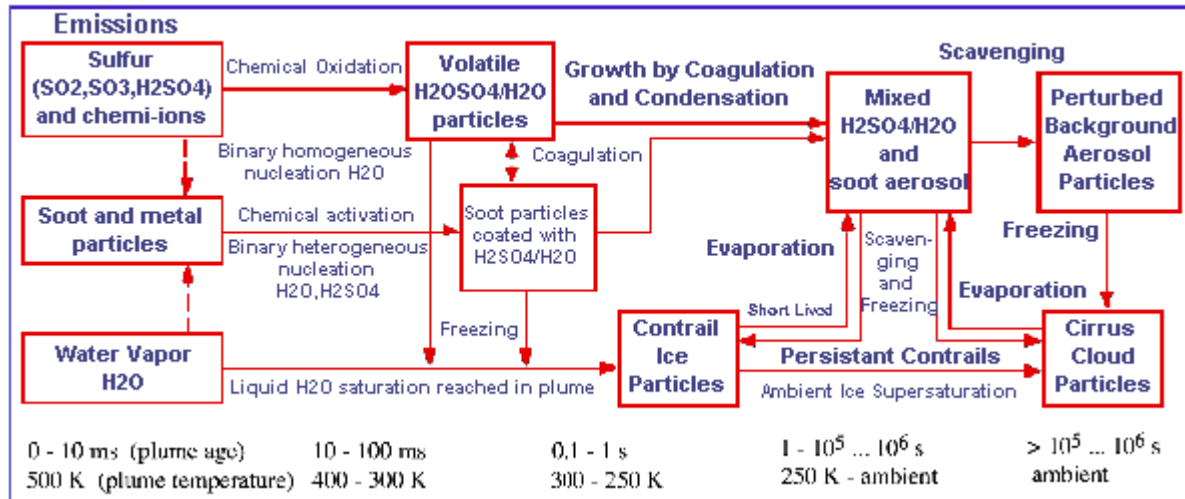
**NASA Space Shuttle view from space of cirrus clouds over Saudi Arabia**

Contrails are human-induced clouds that only form at very high altitudes (usually above 8 km) where the air is extremely cold (less than  $-40^{\circ}\text{C}$ ). If the air is very dry, they do not form behind the plane. If the air is somewhat moist, a contrail will form immediately behind the aircraft and make a bright white line that lasts for a short while. Persistent contrails form immediately behind the airplane in very moist air. Persistent contrails can exist long after the airplane that made them has left the area. They can last for a few minutes or longer than a day. However, because they form at high altitudes where the winds are usually very strong, they will move away from the area where they were born. Persistent contrails are those most likely to affect climate.



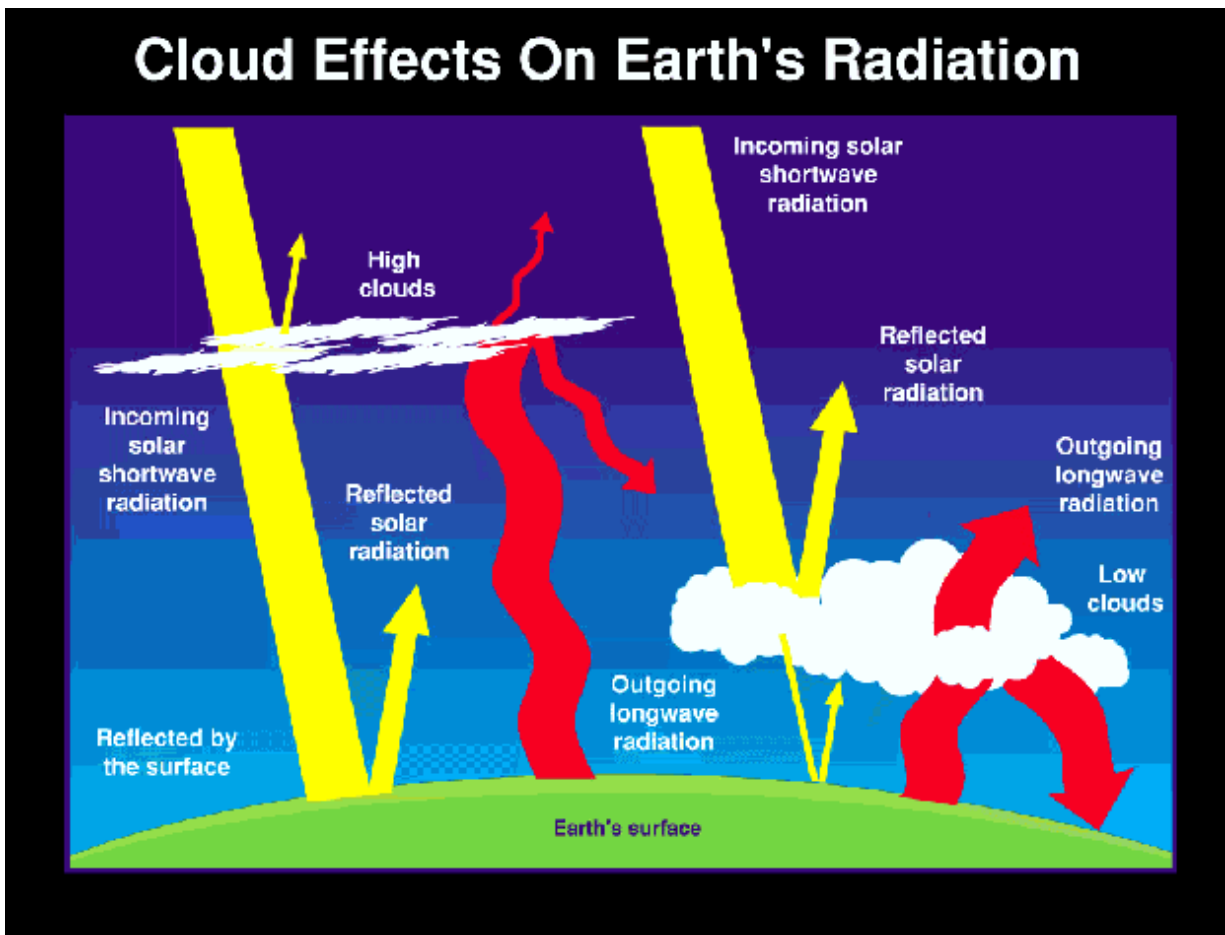
Present commercial aircraft fly at altitudes of 8-13 km. The emissions from such air traffic can change the atmospheric composition: Directly: by emitting carbon dioxide (CO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub> = NO + NO<sub>2</sub>), water vapor, hydrocarbons, soot, and sulfate particles. Indirectly: by a chemical reaction chain similar to smog-formation the greenhouse gas ozone (O<sub>3</sub>) can be formed. In this reaction chain nitrogen oxides act as a catalyst under the influence of sunlight. As a result of these chemical reactions also the concentration of methane (CH<sub>4</sub>), another greenhouse gas, decreases. These changes can have effects on climate: Ozone, CO<sub>2</sub>, and water vapor are greenhouse gases and their increase has a warming effect. Methane is also a greenhouse gas and its decrease has a cooling effect. Aerosols (sulfate particles, soot) could have a cooling effect. Contrails formed due to the emission of particles and water vapor can increase the cloud cover in the upper troposphere. This may result in a cooling or heating depending on the size and optical depth of the ice crystals of which the contrails consist. Presently it is believed that contrails lead to a net warming effect. There may be changes in (non-contrail) upper level clouds: Most contrails decay after minutes to hours, but some continue to exist and are then not distinguishable from natural cirrus clouds .

### Aircraft and contrail formation in aircraft exhaust plumes



Schematic based on DLR German Aerospace Center graphic and text

Schematic of aerosol and contrail formation processes in an aircraft plume and wake as a function of plume age and temperature. Reactive sulfur gases, water vapor, chemi-ions, soot aerosols, and metal particles are emitted from the nozzle exit planes at high temperatures. H<sub>2</sub>SO<sub>4</sub> increases as a result of gas-phase oxidation processes. Soot particles become chemically activated by adsorption and binary heterogeneous nucleation of SO<sub>3</sub> and H<sub>2</sub>SO<sub>4</sub> in the presence of H<sub>2</sub>O, leading to the formation of a partial liquid H<sub>2</sub>SO<sub>4</sub>/H<sub>2</sub>O coating. Upon further cooling, volatile liquid H<sub>2</sub>SO<sub>4</sub>/H<sub>2</sub>O droplets are formed by binary homogeneous nucleation, whereby the chemi-ions act as preferred nucleation centers. These aerosols grow in size by condensation and coagulation processes. Coagulation between volatile particles and soot enhances the coating and forms a mixed H<sub>2</sub>SO<sub>4</sub>/H<sub>2</sub>O-soot aerosol, which is eventually scavenged by background aerosol particles at longer times. If liquid H<sub>2</sub>O saturation is reached in the plume, a contrail forms. Ice particles are created in the contrail mainly by freezing of exhaust aerosols. Scavenging of exhaust particles and further deposition of H<sub>2</sub>O leads to an increase of the ice mass. The contrail persists in ice-supersaturated air and may develop into a cirrus cloud. Short-lived and persistent contrails return residual particles into the atmosphere upon evaporation. The scavenging timescales are highly variable and depend on the exhaust and background aerosol size distributions and abundances, as well as on wake mixing rates



NASA Graphic from The TERRA Program

Clouds play a complex role in the Earth's radiation budget. Low Clouds reflect much of the sunlight that falls on them, but have little Effect on the emitted energy. Thus, low clouds act to cool the Current climate. High clouds reflect less energy, but trap more of The energy emitted by the surface.

### **The Atmospheric Effects of Aviation Project**

For the past 10 years NASA has held a conference on The Atmospheric Effects of Aviation Project (AEAP). Several hundred researchers from around the world attend annually. In 1997 Researchers from NASA Langley Research Center in Hampton, Virginia, presented evidence that contrails are contributing to global warming and causing local effects over areas with heavy air traffic. This was reported by Jim Scanlon a journalist in attendance at the conference. He also reports that Fred Singer held a session where he presented a session that argued that the steady increase in air traffic for the last 20 years was responsible for the nighttime warming detected over North America.

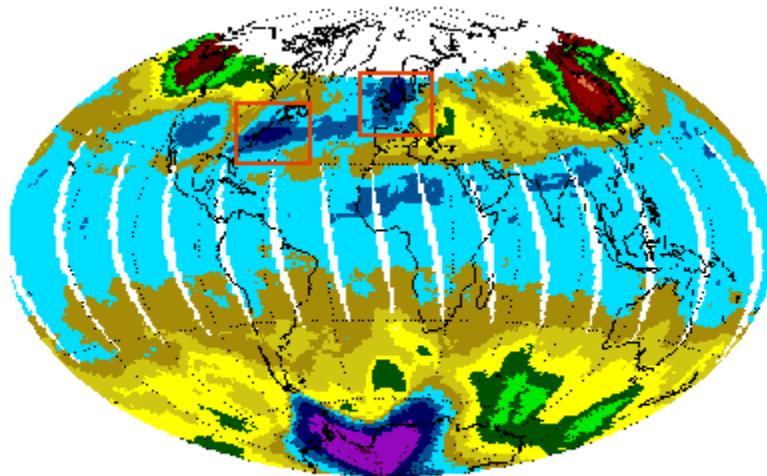




NASA

The Atmospheric Effects of Aviation Project (AEAP) consists of two major efforts to assess the effect of aircraft on the atmosphere. The Atmospheric Effects of Stratospheric Aircraft (AESA), sponsored by the High-Speed Research (HSR) Program at Langley Research Center, is a study of the potential effects of the operation of a projected future fleet of high speed civil transport aircraft (HSCTs). The Subsonic Assessment program (SASS) is a study of the effects of the present subsonic aircraft fleet and of projected future subsonic fleets, and is sponsored by the Advanced Subsonics Technology Program (AST) at Langley Research Center. Objective Develop scientific basis for assessment of atmospheric impact of subsonic and supersonic aviation, particularly commercial aircraft cruise emissions.

### Possible Ozone Destruction Connection



 Low Ozone Event Formation

NASA TOMS mage November 26, 1999

A low ozone event occurred over The Northern Hemisphere in the days following the busiest air traffic days in The United States in late November and early December 1999. Traditionally the days leading up to and after Thanksgiving are the busiest of the year. Could there be a connection between the air traffic and the low ozone event?

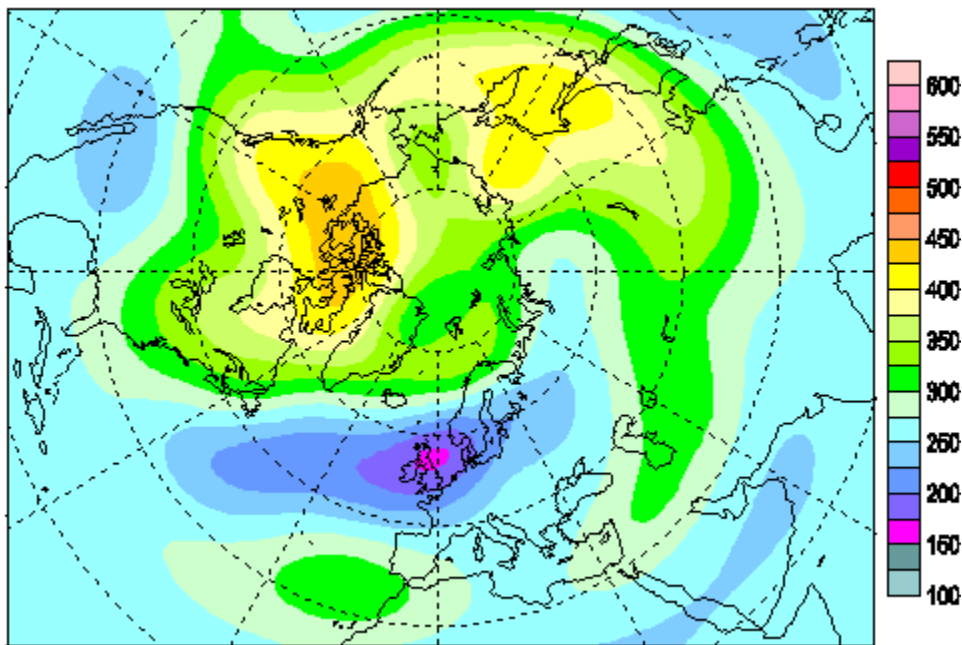
**Ozone layer over Europe dwindling -European Space Agency 2 December 1999**

PARIS - The ozone layer over Britain, Belgium, the Netherlands and Scandinavia has dwindled to worrying levels nearly as low as those found in the Antarctic, the European Space Agency (ESA) said Thursday.

Measurements taken in the Netherlands showed local ozone levels were some two-thirds below the norm for this time of year, confirming the abnormally low levels detected over northwest Europe this week, ESA said in a statement.

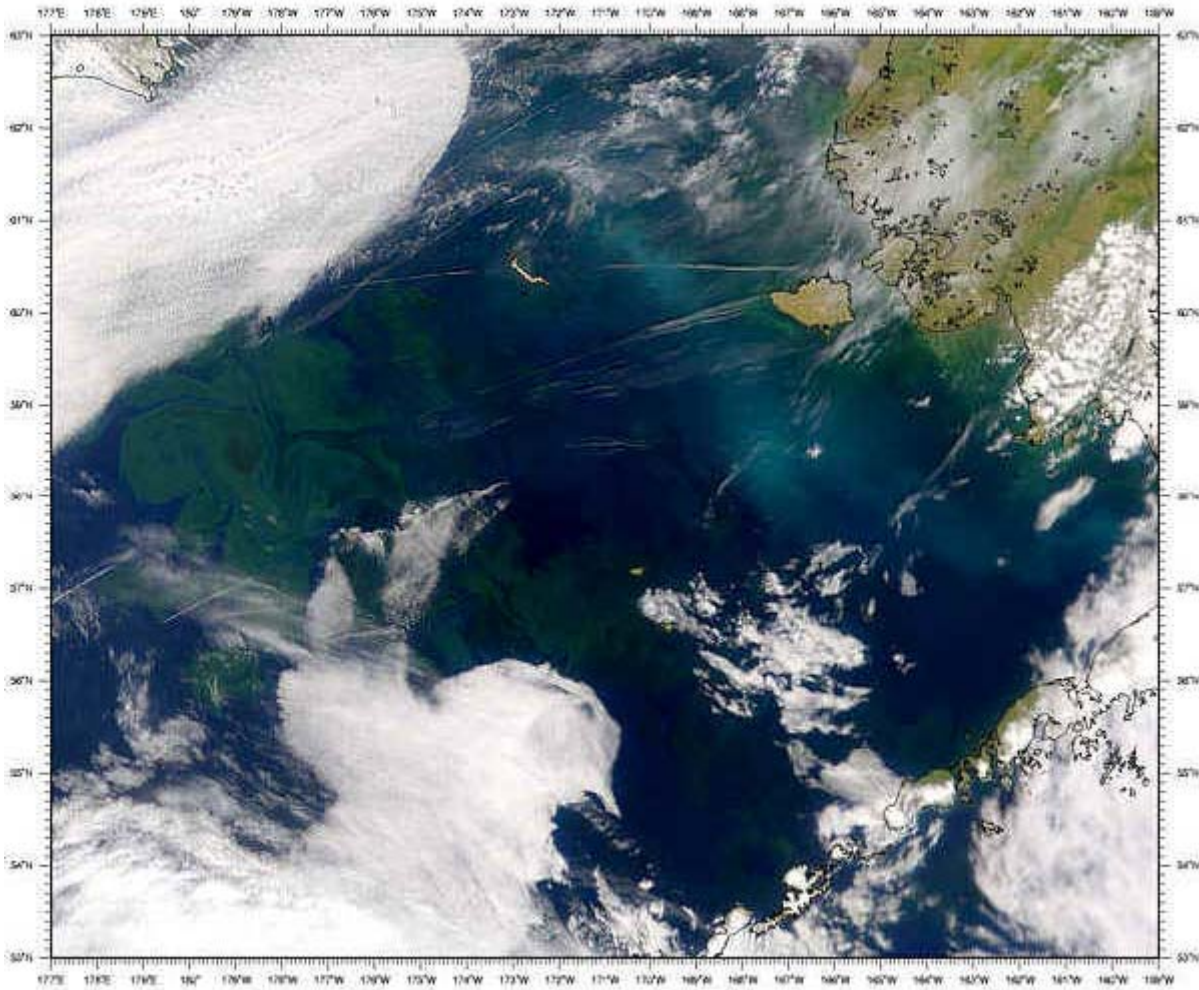
The ozone layer, high up in the atmosphere, shields Earth from much of the sun's harmful ultraviolet rays. A gradual thinning due to emissions of damaging man-made chemicals has increased the occurrence of skin cancer and other illnesses related to over-exposure to ultraviolet rays, scientists say.

**Total ozone (DU) / Ozone total (UD), 1999/11/30**



Environment Canada Image

### **Chemtrails or Contrails: Conspiracy or Simple Science?**



Contrails over Bering Sea

Sea WiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE Satellite: OrbView-2 Sensor: SeaWiFS

The conspiracy theory is that government officials are conducting experiments in atmospheric science, and some of them involve a highly classified military project which involves protecting us from some as yet unknown threat. The side effects of people getting sick is part of the price we pay for defense.





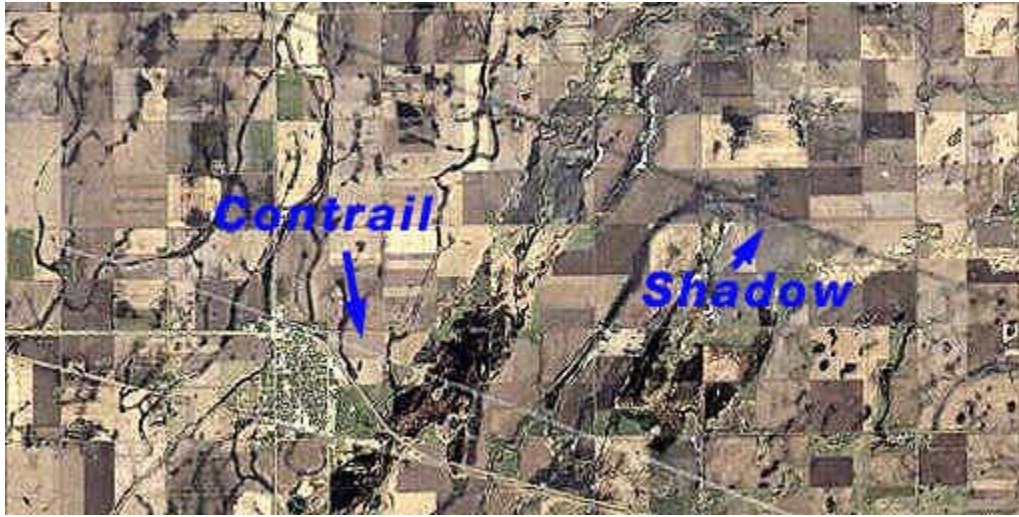
Contrails Over Lake Superior

SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE Satellite: OrbView-2 Sensor: SeaWiFS

People worldwide are reporting what they describe to be unusual activity in the sky, including jets leaving trails at low altitudes, spray lines creating X's, S's and parallel lines, lines that slowly spread to create a canopy of haze, and reports of unusual smells, tastes, and even illness related to the trails.







This conspiracy theory has been sweeping the Internet and radio talk shows has set parts of the federal government on edge. The US Government has recieved thousands of phone calls, e-mails and letters in recent years from people demanding to know what's being sprayed and why.



The Environmental Protection Agency, NASA, the Federal Aviation Administration and the National Oceanic and Atmospheric Administration published a fact sheet explaining the science of contrail formation.

<http://www.epa.gov/otaq/regs/nonroad/aviation/contrails.pdf>

A few months earlier, the Air Force had put out its own fact sheet, which tries to refute its opponents' arguments point by point. "If you try to pin these people down and refute things, it's, 'Well, you're just part of the conspiracy,' " says atmospheric scientist Patrick Minnis of NASA's Langley Research Center in Hampton, Va. "Logic is not exactly a real selling point for most of them."

					
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