Outer Limits

Goddard Space Flight Center DAAC

by Dan Whipple

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Ten to fifteen kilometers above the horizon lies a scientific frontier where chemistry, dynamics and energy balance are the unsettled territories. Beyond the reach of balloons and most aircraft, the upper atmosphere's role in Earth's climate remains to be determined.

Studies of the upper atmosphere are further complicated by the possibility of man-induced change to these outer reaches. For instance, Mark Schoeberl, senior scientist for atmospheric sciences at Goddard Space Flight Center (GSFC), and colleagues assessed the environmental impact that may result from a fleet of supersonic aircraft planned to fly in the stratosphere. The flights could cause a one or two percent loss of stratospheric ozone, he said..

According to Schoeberl, most of the supersonic aircraft will fly in the mid-latitudes, releasing water vapor and nitric oxide with engine exhaust. Both substances impact the level of upper atmospheric ozone. Nitric oxide is a powerful destroyer of ozone; water vapor can indirectly destroy ozone through formation of polar stratospheric clouds, thought to be responsible for the large polar ozone depletions seen in the last two decades.

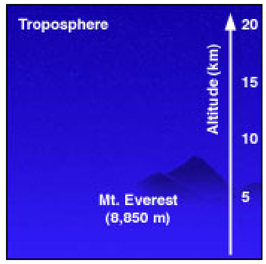
The research team examined Upper Atmosphere Research Satellite (UARS) data from the GSFC DAAC to see how isolated the tropics are from the mid-latitudes. "This question is important because aircraft exhaust emitted at mid-latitudes in the stratosphere can get into the tropical-latitude stratospheric air, where it can be lofted to very high altitudes and cause ozone depletion," Schoeberl says.

Every 26 months, east-west winds switch direction in the tropical stratosphere, Schoeberl says. The oscillation creates a change in the signature of trace gases because the concentration of trace gases changes with the change in wind direction.

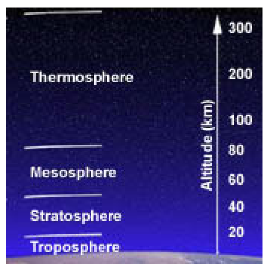
"I was able to use the UARS measurements to look at whether the change in trace gas fields was consistent with wind changes in the quasi-biennial (occurring roughly every two years) oscillation," Schoeberl says.

Schoeberl studied nitrous oxide and methane trace gases data from two instruments mounted on the UARS, the High Resolution Doppler Imager (HRDI) for winds and the Cryogenic Limb Array Spectrometer (CLAES).

"If the winds and the tracers were in good synchronization, I could say that the effects of mid-latitude air mixing into the tropics and diluting the gases was weak," Schoeberl says, calculating that the amount of time necessary for air sample exchange at varying heights to be 18 months or longer.



The troposphere is the lowest 20 km of the Earth's atmosphere. (Image courtesy of Goddard Space Flight Center)



Above the Earth's troposphere is the stratosphere, mesosphere, and thermosphere. Scientists are concerned that supersonic airplanes flying above the troposphere could harm the stratospheric ozone shield. (Image courtesy of Goddard Space Flight Center)

The Goddard Space Flight Center used UARS data in conjunction with a United Kingdom Meteorological Office atmospheric chemical model to measure how ozone varies daily in the stratosphere. For more information, see:
UARS Data from the Goddard Space Flight Center DAAC (now named the GSFC Earth Sciences DAAC)
UARS Home Page

"A number of other researchers using different observations came up with the same estimate, so it seems to be a robust result, indicating that aircraft exhaust emitted in mid-latitudes slowly reaches the tropical regions," Schoeberl says.

"We are now in the process of comparing model simulations of aircraft exhaust dispersal with this observational result. Right now it looks like the models generate too much exchange which would increase the predicted lifetime of the exhaust products in the stratosphere." Using this result NASA scientists hope to improve the aircraft exhaust models and thus provide a more realistic simulation of the environmental effects of aircraft exhaust.

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