

Black Carbon Emissions by Rocket Engines

<u>Types of rocket engines</u>	<u>Emissions</u>
Liquid Hydrogen and Oxygen	Mainly H_2O , and some NO .
Aluminum/Ammonium Perchlorate	HCl and Al_2O_3
Rockets that use hydrazine (N_2H_4) and tetroxide (N_2O_4)	Large amounts of nitrogen oxides.
Kerosene Rockets	CO_2 and black carbon (soot).

Focus: New Hybrid rocket engines are being used by private companies which output CO_2 , and large amounts of black carbon in the stratosphere. The large amount of black carbon emitted by these engines is caused by the incomplete combustion of fuel, due to the lower levels of oxygen in the upper atmosphere.

Problem: After about 1,000 rocket launches per year, the potential heating effect of black carbon is estimated to be 100,000 times larger than that of CO_2 in ten years. The black carbon will also cause changes in ozone.

Note: Black carbon does not deplete ozone. What happens is the black carbon emissions from the rocket exhaust displaces the ozone around it. Since the black carbon is "pushing" the ozone around, the effects are a question. Black carbon absorbs visible light, and has a lifetime in the upper atmosphere from 5-10 years.

Impacts:

- * Polar surface temperature changes are estimated up to one degree Kelvin.
- * Changes in the pressure gradient. (This could have various effects on weather systems which are somewhat unknown.)
- * Ozone changes in the tropics are estimated around 1%, and in the Polar regions around 6%. (Computer models show there will more loss of ozone in the Antarctic region during the summer time, when the ozone hole is not present.)
- * Global warming. (This would only add to a problem which we already have.)

Black carbon in the Troposphere: Black carbon in the troposphere usually never makes it to the stratosphere, because it gets rained out.

Other black carbon emissions: The number one contributor to black carbon is burning biomass. Also airplanes, diesel trucks and power plants.

One good thing about black carbon: Black carbon is not a carcinogen.

