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Nimbus 7 SBUV/TOMS Measurements of the Springtime
Antarctic Ozone Hole

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The satellite data from the Nimbus 7 TOMS and SBUV instruments significantly extend our view of the growing ozone minimum during the South Polar spring and places constraints on possible mechanisms for explaining the phenomenon. The deep minimum, or hole, has a structure that looks much like the polar vortex. The areas of maximum decrease are clearly confined spatially. There appears to be a smaller decrease in the ozone maxima surrounding the polar region over the 7 years studied. These are harder to interpret because of the strong planetary waves in this region.

A most important mechanism constraint placed by this is that the decrease takes place in September during twilight, not in the polar night. During the period of polar night the parcels in the vortex are not strictly confined to darkness but do spend a large fraction of their time there with little exchange with air parcels outside the vortex. The maximum rate of decrease occurs after most of the pole is sunlit. The rate of falloff of the minimum values is about 0.6% per day extended over 40-50 days in 1983.

Any explanation of the ozone change must be simultaneously consistent with the year-to-year change as well as the rate of decrease through September. These appear to be consistent with a chemical mechanism but the problem is finding one which can affect ozone on such a short time scale. The obvious chemicals are the halogens, bromine and chlorine. Of these chlorine is the more likely because of the increase of its concentration with time, although bromine may enhance the rate of ozone loss in the lower stratosphere through its interaction with chlorine. A crude calculation indicates that for chlorine at its 1983 concentrations to cause the 0.6% per day decline in September would require all of the chlorine to be in its active state, i.e. Cl and ClO with little or no interference from NO_x. Thus a mechanism must be found which removes the chlorine from both the HCl and ClONO₂ reservoirs and ties up NO_x, preferably as HNO₃.

Until such a mechanism is found and demonstrated correct, it is not clear what the implications are for global predictions of the effects of fluorocarbons on stratospheric ozone. The magnitude of the predicted fluorocarbon effect on ozone has been uncertain because of the interaction among the chlorine, nitrogen and hydrogen containing species and ozone itself. The constraint placed on a chlorine mechanism by the data appears to require stripping away these interactions under special conditions and observing the pure active chlorine effect on ozone. The reactions forming this simple catalytic cycle have never been in much doubt.