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Global warming spreads wings

Global warming would affect the ozone layer too, says S.Ananthanarayanan.

Global warming, heavy penalty the earth may pay for filling the atmosphere with greenhouse gases, is feared to cause melting of Arctic ice, raise ocean levels and alter the climate world-wide. This would cause not only economic and demographic upheavals, but even biodiversity and life forms in the seas and on the land would be affected.

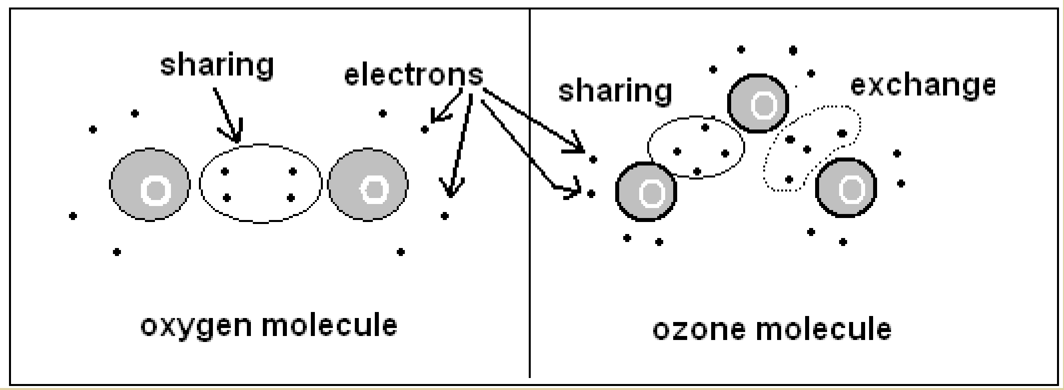
According to a paper by Michaela Hegglin and Theeodore Shepherd, of Toronto, Canada, in ***Nature Geoscience***, the levels of ozone in the stratosphere and the intensity of ultra violet light striking the earth would also change.

The ozone layer is known to shield the earth from high energy radiation. Had high levels of UV light been coming in, the survival of most living things and the beginning of life itself on earth would not have been possible. When it was found that this protective layer was getting depleted by the effect of chemicals called chloroflourocarbons (CFCs), the world got together (Montreal Protocol, 1989) to limit emissions. Now it appears that a lot more may need to be done, as there are other forces affecting the ozone layer!

Ozone and its uses

Ozone is a form of oxygen. The usual oxygen gas consists of two atoms of oxygen paired to form a molecule. The oxygen atom consists of a nucleus and sixteen electrons in orbit around it. The electrons are distributed as 2,8 and 6, which is to say that there are six electrons in the outer orbit. Now, atoms are most stable when they have eight electrons in the outer orbit and they tend to combine with other atoms so that they can, together, get as close to this ‘eight electron state’ as possible. Two oxygen atoms, then, get together and ‘share’ two of their outer electrons, so that each of them can create an impression of eight.

Another form that oxygen can take is that three atoms get together – with one atom sharing two electrons with another, but the second also passing on one electron to a third. The last two atoms thus only approximate to seven electrons, but this combination is a little stable too, and does get created when the conditions are right.



The useful feature of ozone is that it can absorb Ultra Violet light at the frequency that is the most harmful. Ozone thus acts as a filter and it is formed in good quantity by the action of UV light itself on oxygen. But ozone also readily combines with free oxygen atoms to form ordinary oxygen. This breakdown of ozone is slow in the stratosphere, the part of the atmosphere after the first sixteen km and till fifty km from the earth, an in this region, ozone accumulates. The trouble is that even in the stratosphere, the breakdown of ozone hastened when certain chemical groups are present, particularly of CFCs which are there in aerosol sprays and refrigerants.

Atmospheric currents

Like the ocean, which has massive currents, like cold, saline water sinking in the north and flowing down to the south, deep under the surface, or warm water flowing up the surface in ***upwellings*** and ocean currents like the ***Gulf Stream***, there are also currents in the larger atmosphere, quite apart from winds and monsoons and cyclones.

The atmosphere also has a peculiar structure – it grows cooler as one goes higher, for the first sixteen km or so. This region is called the ***troposphere*** and the main process is that with the falling pressure as one goes higher, air expands and cools. But when one ventures higher, the effect of expansive cooling reduces and the warming due to the sun increases as also absorption of UV, and temperature rise takes over. The atmosphere is thus 'stratified' and this region is called the ***stratosphere***. These two regions of the atmosphere are separated by a layer called the ***tropopause*** and there is markedly low mixing of the atmosphere across this boundary
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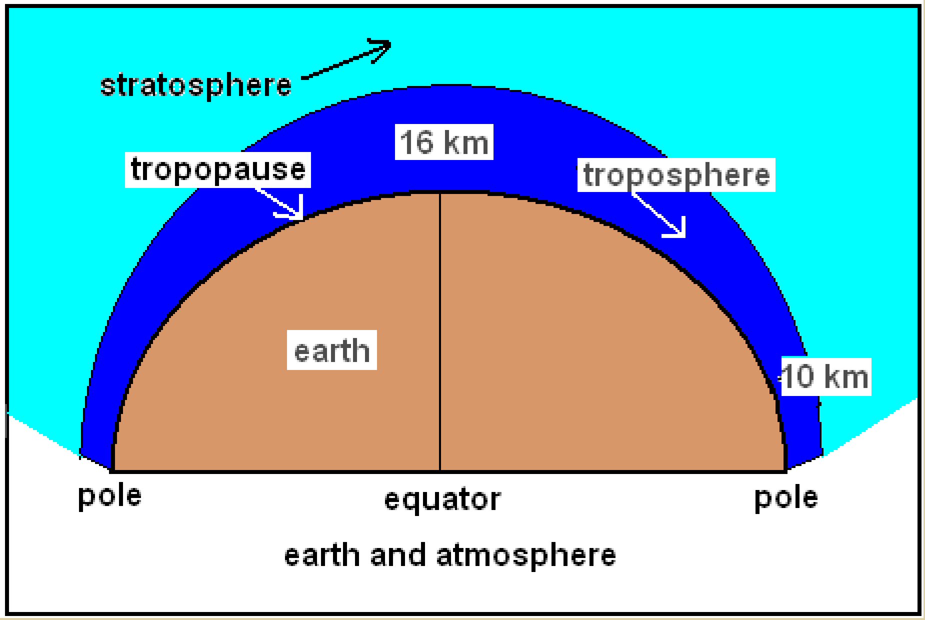

One model of flow across the boundary, which also explains the accumulation of ozone in the stratosphere is the ***Brewer-Dobson Circulation***, which relies on the earth's radiation equilibrium and the behavior of waves in the atmosphere when winds pass over deformities on the surface, like mountains, far below. When these waves break, like ocean waves, they release energy, which propels air masses upwards. This movement is separate for each hemisphere and is more marked in the northern hemisphere, perhaps because there are larger land mass promontories in the north

It is this Brewer-Dobson Circulation that carries the ozone, most copiously produced by the action of sunlight, in the tropics, up to the stratosphere and then away to higher latitudes. The result is the distribution of ozone within the stratosphere and the concentration at higher latitudes, although the production is at lower latitudes.

Global warming

The rising of global temperatures results in warming of the troposphere and cooling of the stratosphere. The boundary is about sixteen km high in the tropics but is only about ten km high at the mid latitudes. The warming of the troposphere and the cooling of the stratosphere then creates gradients across latitudes, which give rise to winds, breaking of waves and more Brewer-Dobson circulation

Hegglin and Shepherd, at Toronto, developed a model of climate and stratospheric chemistry to simulate the effect of climate change on ozone distribution. The significant finding is that there would be greater transfer of ozone from the stratosphere to the troposphere as the globe warms. Down in the troposphere, ozone becomes effective as a greenhouse gas. With its larger molecular structure than oxygen, ozone, like CO_2 or methane, can store energy and adding this ozone to the troposphere would spur the pace of global warming. But global warming also creates other, ozone limiting agencies and the net effect is not clear.

But the immediate effect is that stratospheric ozone levels at different latitudes would change and hence the levels of UV received at the earth's surface. The study shows a 9% reduction in UV levels in northern high latitudes, a 4% increase in the tropics and up to 20% increase in Antarctica in the spring and summer. This change would be not due to emissions of harmful chemicals, etc, but purely because of global warming.

There would then be need for even more stringent control of emission rates, etc.. There is also need for vigorous research initiative into the dynamics and chemistry of the stratosphere and the troposphere.