

1. THE OZONE BUCKET ANALOGY

The ozone bucket analogy (useful to explain the natural production and destruction of ozone)

- a) Ozone is formed naturally by the sun and so the sun is filling up our bucket of ozone
- b) Chemicals naturally destroy ozone (chemical families of Nitrogen, Hydrogen and Chlorine)

These natural destruction methods are like holes in the bucket, thereby reducing the amount of ozone in the bucket.

The result is that the ozone layer or sometimes called, the ozone column (which means total column of ozone from the ground to the top of the atmosphere), is in some balance. Water comes in, water leaks out, or in our case, ozone is produced (by the sun) and ozone is destroyed (by natural chemicals). The result is an equilibrium is reached.

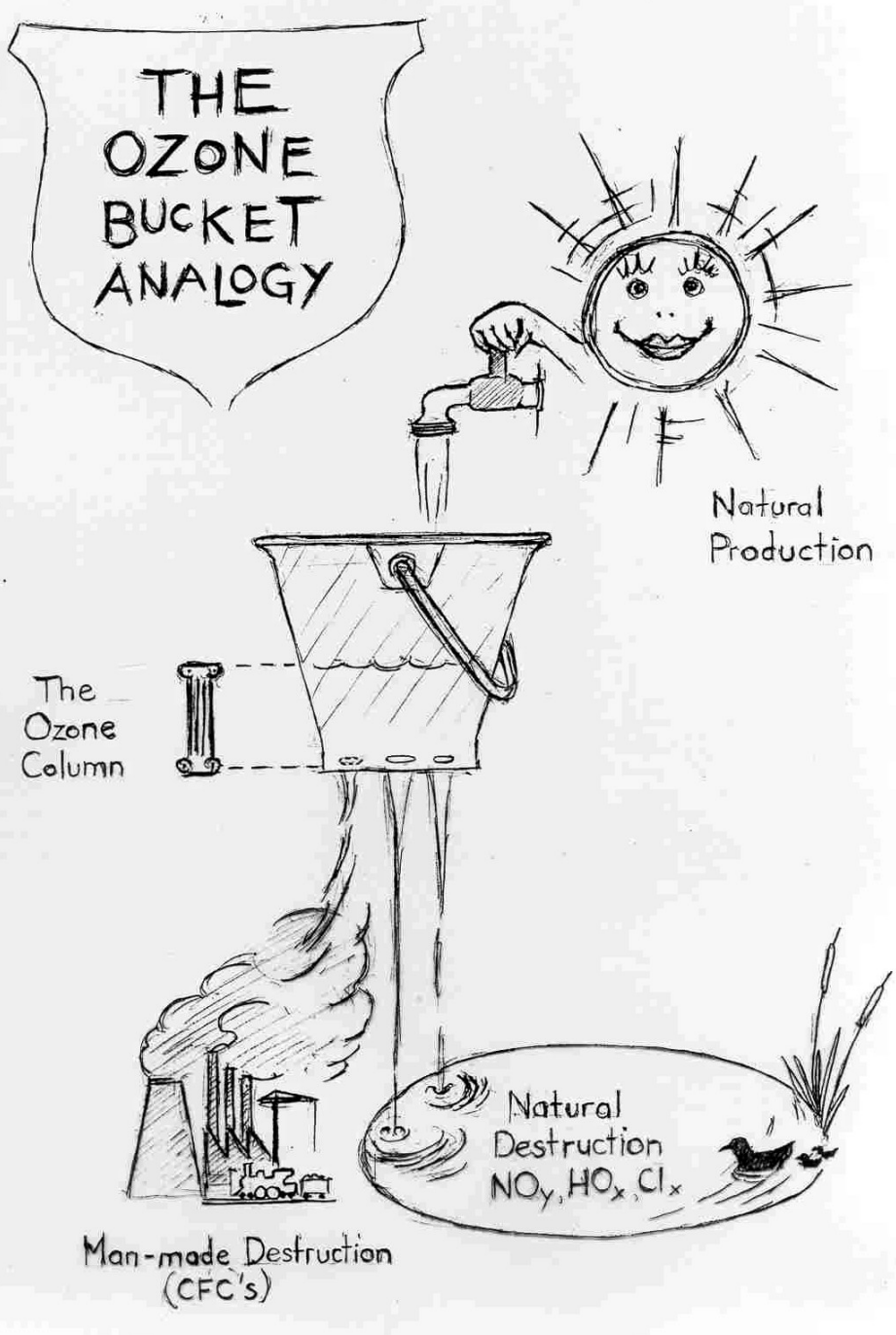
However, if we add man-made chemicals (e.g. CFC's) to the atmosphere, then this adds an extra hole to our bucket because these chemicals also destroy ozone. The result is that the ozone column (or ozone layer) will get thinner.

If we plug up the man-made holes, by reducing the amount of ozone-destroying chemicals (i.e. CFC's, then eventually, the ozone column (or ozone layer) will come back to the same balance as it had before.

Aim:

This figure is intended help students conceptualize the natural production and destruction of ozone in the atmosphere. It also serves explain the concept of ozone depletion, and what will happen in the future if we plug up the holes.

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2. GOOD / BAD OZONE

People often get confused about ozone in the stratosphere (upper atmosphere), and ozone in the troposphere (lower atmosphere). They are both the same chemicals, only produced in different ways. In the upper atmosphere, ozone is produced mainly by the sun while in the troposphere, ozone is also called photochemical smog and is produced by humans.

Ozone exists from the ground up to more than 35 km in the altitude (e.g. planes fly up to 30,000 ft or 10km).

Most of the Earth's ozone exists around 25 km in altitude, which is what we call the ozone layer.

However, near the ground where we live, ozone is also produced from automobile pollution. Because ozone is harmful to human health if breathed in, this is what we call 'smog' or 'air pollution'.

Thus, we have the good ozone, in the upper atmosphere, and bad ozone in the lower atmosphere. They are the same gas, but one is produced naturally and the other by automobile pollution.

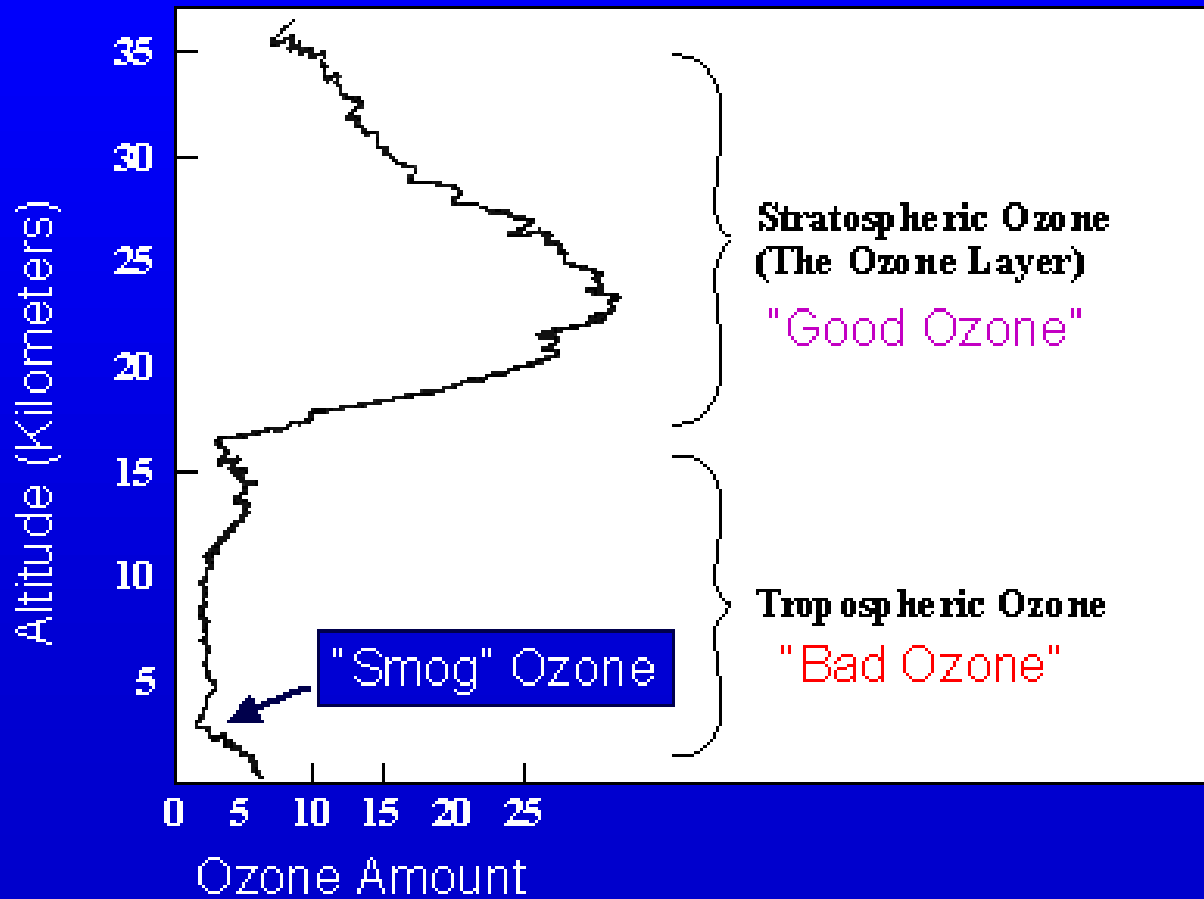
Unfortunately, 'bad ozone' doesn't help much with absorbing UV radiation since the amounts are relatively small. So, although we have more 'bad ozone' because of auto pollution, it doesn't help protect us from UV radiation much.

Aim:

This figure is intended to help students visualize and understand the concept of 'good' and 'bad' ozone.

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Layers of the Atmosphere



3. OZONE CHANGES DURING THE DAY

Influence of sun angle on surface UV radiation

This figure illustrates how the amount of surface UV radiation changes during the day. In early morning and late afternoon, UV levels are relatively low. This is because the sun has to pass through more of the ozone layer, thereby being absorbed more. However, at midday, say around 12:00 noon, the sun rays only have to pass through a smaller path of ozone, and thus do not get absorbed as much. Thus, UV values depend on time of day.

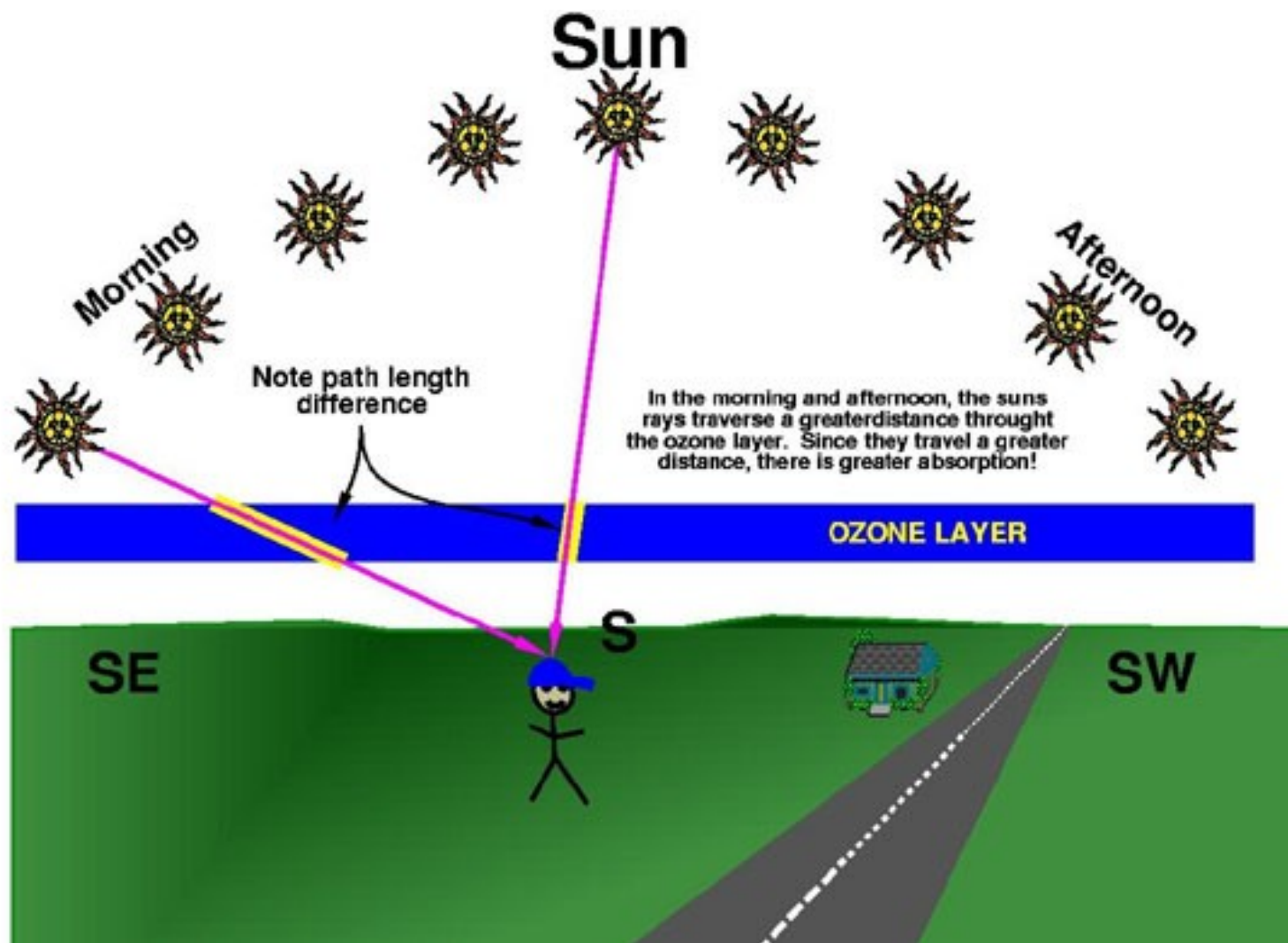
The same explanation is also valid for why UV radiation is higher during summer than winter. In summer, the sun get higher in the sky at noon, compared to winter. This change in angle of the sun, is the primary reason ozone values change dramatically between summer and winter.

Aim:

This figure illustrates why the amount of UV radiation reaching the ground radiation changes with the angle of the sun.

Note: Many people associate UV radiation with temperature, thinking that the warmer it is, the more UV radiation there is. This is not strictly true.

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4. TOTAL OZONE OCTOBER 14, 1997

Here is a picture of satellite observations of total ozone for the Southern Hemisphere on October 14, 1997.

This graphic is a map of the Southern Hemisphere (see Australia etc.) where the colors represent values of total ozone given in Dobson Units. Dark colors, purple and dark purple represent low values of ozone, while red represent high values of ozone.

The ozone hole is roughly identified by the purple colors.

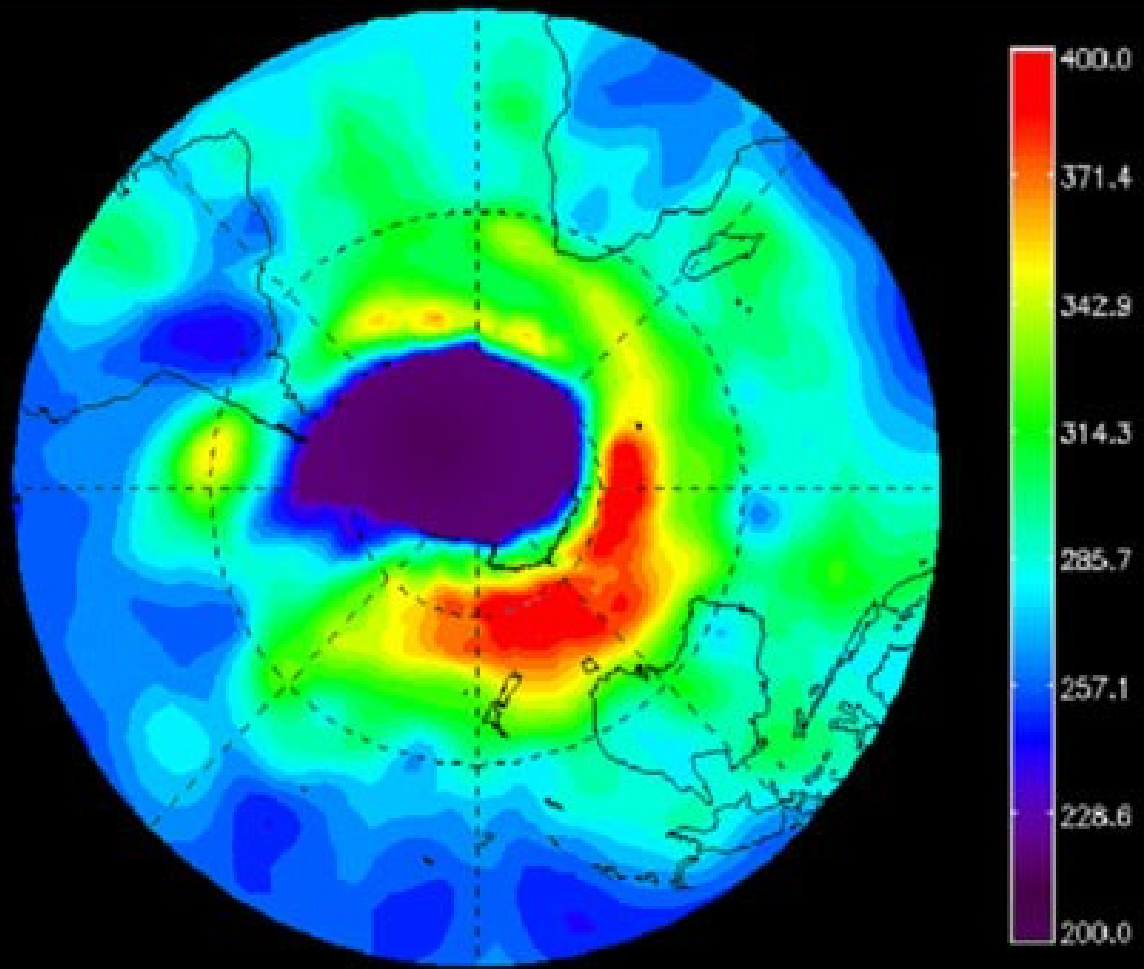
On this particular day, the ozone hole was mainly over Antarctica, and over the tip of South America. In a manner similar to how the winds move clouds around the atmosphere, winds in the atmosphere also can move ozone around. So, every day a map of the ozone layer looks slightly different, as you will see in the ozone animation. However, the ozone hole normally stays over Antarctica, and never comes over Australia.

Aim:

This graphic demonstrate what the ozone looks like, and for them to notice, that indeed, it is not located over Australia.

Note: Total ozone is the amount of ozone from the ground to the top of the atmosphere. Total ozone, or sometimes called, column ozone is measured in Dobson Units (DU). Total ozone values below 220 DU are what we call the ozone hole.

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5. OZONE LEVELS FROM THE 70s AND 90s

These are satellite maps of total ozone over the Southern Hemisphere for eight different years. The larger Total Ozone (Dobson units) the less UV radiation that reaches the earth.

In the 1970's ozone levels over the Southern Hemisphere were much higher than in the 1990s. For example, the red colors, often seen during the 1970's indicate ozone values above 400 Dobson units. In the 1990, blue and purple colors over Antarctica, which represent ozone levels below 200 Dobson units, can be seen. The large difference between the 70's and 90's is clearly apparent.

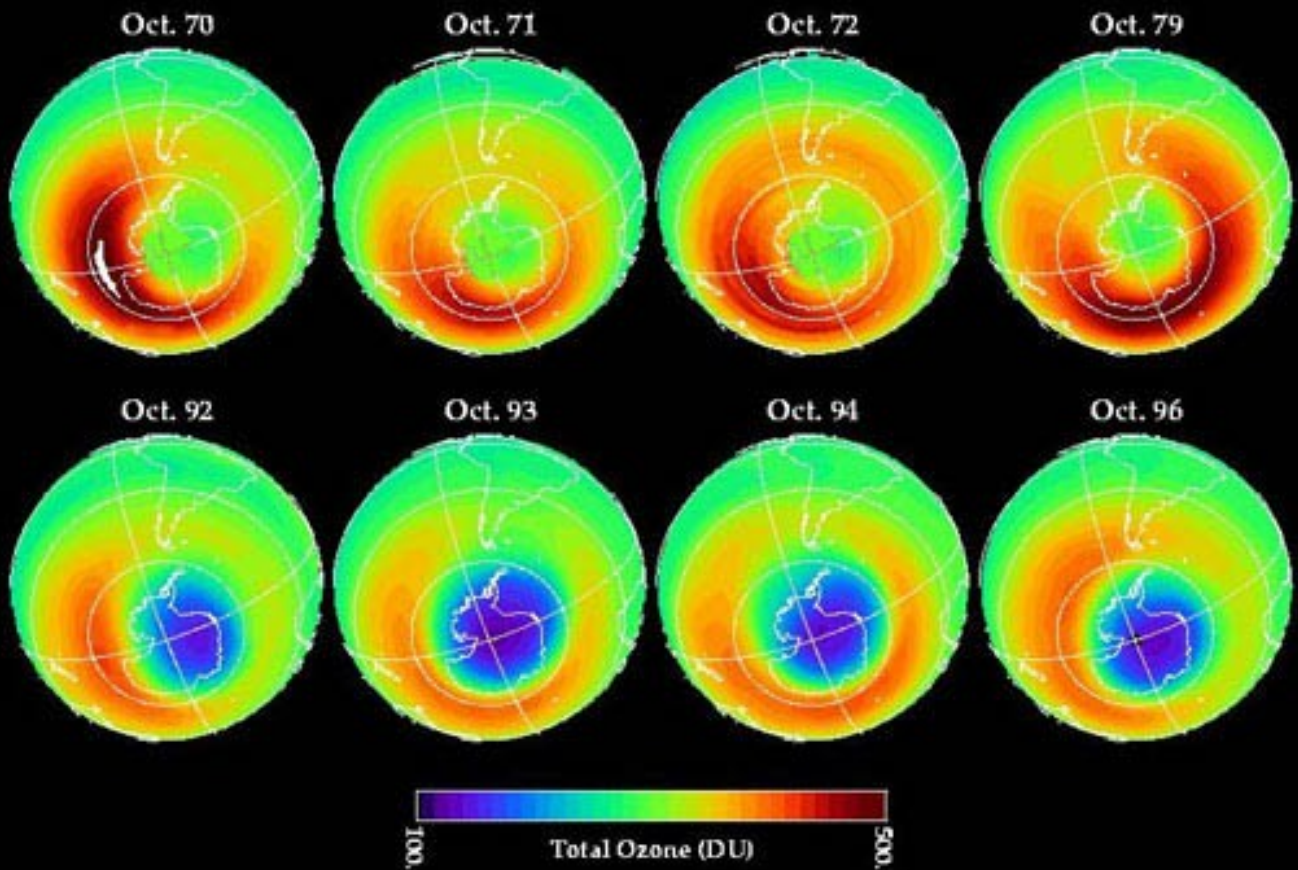
Aim:

This this figure is intended to illustrate visually the large change in ozone amounts over Antarctica over just the last 20 years.

Note: The ozone hole, which by definition is total ozone values below 220 DU, is roughly defined by the purple colors.

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BUV & TOMS total ozone



6) GROWTH OF THE OZONE HOLE

This is a graph showing the size of the ozone hole, measured as area where total ozone values are below 220 Dobson units, from the 1980's through 2000.

It is clear, that from the middle of the 1980's, through to the middle of the 1990's, the size of the ozone hole each year grew rapidly. However, since 1995, the size of the ozone hole has not grown much, rather stayed near about 25 million square kms.

Many people have the perception that the ozone hole (and ozone in general) is getting much worse. This is likely due to press reports that often report, 'the ozone hole reached it's largest size...' etc. The reality is that in the last decade, the size and severity of the ozone hole have stayed about the same, compared to rapid changes seen in earlier years.

Why has the ozone hole stayed nearly constant for the last 10 years?

The short answer is that it's about as bad as it can get. The size of the ozone hole is largely controlled by atmospheric weather conditions, such as how cold the winter is, and how variable winds are. Even if there was more chlorine in the atmosphere, that doesn't necessarily change the temperature (this may be happening with global warming, but we'll talk about that later). So, we don't expect the size of the ozone hole to increase much more in the future. In fact, it is expected that because of chlorine controls by the Montreal Protocol, we should see the size of the ozone hole gradually begin to get smaller. However, this may take quite some time, maybe up to 50 years or more before the ozone hole disappears.

Aim:

The graphic serves to illustrate how in the 80's, the size of the ozone hole increased rapidly, while in the 90's and 2000, things stayed about the same.

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