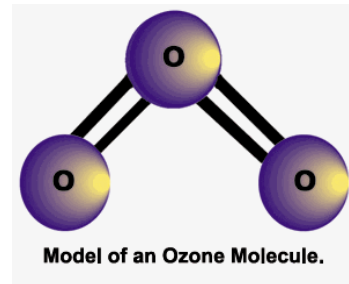


# Ozone levels in the atmosphere – who should worry, why and when?

## 1. Introduction

Ozone is an important substance for a variety of reasons. You have most likely heard about the ‘hole in the ozone layer’. There is a lot more to the ozone story than just the hole.



## 2. Ozone in the atmosphere.

Some questions for you to investigate:

What is ozone?

How is it produced?

Does it have any medicinal effects?

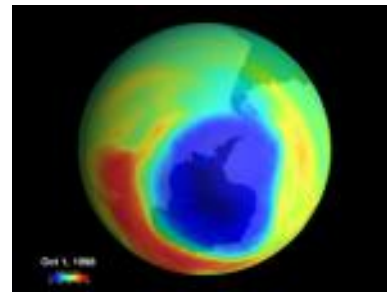
What is the ozone layer?

Why are ozone levels monitored?

What is the Australian standard for an acceptable level of ozone in the atmosphere? How does this compare the US acceptable level?

Is there any evidence to suggest exposure to levels lower than this may be harmful?

There is ‘good’ and ‘bad’ ozone. Describe the difference.



## 3. Some data.

The data (over-leaf) about Ozone levels were collected in New York City on 111 successive days from May to September in 1973.

### Attribute Description

Day: Day of measurement

OzoneLevel: Ground-level ozone in parts per billion (ppb)

Radiation: Level of solar radiation (sunlight) in langleys

Temperature: Maximum temperature in degrees F

WindSpeed: Wind speed in miles per hour

Data taken from TinkerPlots sample data set.

[www.keypress.com/tinkerplots/](http://www.keypress.com/tinkerplots/)

Originally taken from StatLab, The University of Western Ontario, at [www.stats.uwo.ca/faculty/aim/mviz/default.htm](http://www.stats.uwo.ca/faculty/aim/mviz/default.htm)

Use the data to investigate the following questions:

1. How many of these days had an ozone level that exceeded the Australian accepted maximum level?
2. How many of these days had an ozone level that exceeded the US accepted maximum level?
3. Are there any easily measured indicators from which ozone levels may be predicted? List any limitations to your answers to these questions.
4. Did you find any outliers as you investigated? If you did, explain them.

| Day | Ozone level | Radiation | Temperature | WindSpeed |
|-----|-------------|-----------|-------------|-----------|
| 1   | 41          | 190       | 67          | 7.4       |
| 2   | 36          | 118       | 72          | 8         |
| 3   | 12          | 149       | 74          | 12.6      |
| 4   | 18          | 313       | 62          | 11.5      |
| 5   | 23          | 299       | 65          | 8.6       |
| 6   | 19          | 99        | 59          | 13.8      |
| 7   | 8           | 19        | 61          | 20.1      |
| 8   | 16          | 256       | 69          | 9.7       |
| 9   | 11          | 290       | 66          | 9.2       |
| 10  | 14          | 274       | 68          | 10.9      |
| 11  | 18          | 65        | 58          | 13.2      |
| 12  | 14          | 334       | 64          | 11.5      |
| 13  | 34          | 307       | 66          | 12        |
| 14  | 6           | 78        | 57          | 18.4      |
| 15  | 30          | 322       | 68          | 11.5      |
| 16  | 11          | 44        | 62          | 9.7       |
| 17  | 1           | 8         | 59          | 9.7       |
| 18  | 11          | 320       | 73          | 16.6      |
| 19  | 4           | 25        | 61          | 9.7       |
| 20  | 32          | 92        | 61          | 12        |
| 21  | 23          | 13        | 67          | 12        |
| 22  | 45          | 252       | 81          | 14.9      |
| 23  | 115         | 223       | 79          | 5.7       |
| 24  | 37          | 279       | 76          | 7.4       |
| 25  | 29          | 127       | 82          | 9.7       |
| 26  | 71          | 291       | 90          | 13.8      |
| 27  | 39          | 323       | 87          | 11.5      |
| 28  | 23          | 148       | 82          | 8         |
| 29  | 21          | 191       | 77          | 14.9      |
| 30  | 37          | 284       | 72          | 20.7      |
| 31  | 20          | 37        | 65          | 9.2       |
| 32  | 12          | 120       | 73          | 11.5      |
| 33  | 13          | 137       | 76          | 10.3      |
| 34  | 135         | 269       | 84          | 4         |
| 35  | 49          | 248       | 85          | 9.2       |
| 36  | 32          | 236       | 81          | 9.2       |
| 37  | 64          | 175       | 83          | 4.6       |
| 38  | 40          | 314       | 83          | 10.9      |
| 39  | 77          | 276       | 88          | 5.1       |
| 40  | 97          | 267       | 92          | 6.3       |
| 41  | 97          | 272       | 92          | 5.7       |
| 42  | 85          | 175       | 89          | 7.4       |
| 43  | 10          | 264       | 73          | 14.3      |
| 44  | 27          | 175       | 81          | 14.9      |
| 45  | 7           | 48        | 80          | 14.3      |
| 46  | 48          | 260       | 81          | 6.9       |
| 47  | 35          | 274       | 82          | 10.3      |

|    |     |     |    |      |
|----|-----|-----|----|------|
| 48 | 61  | 285 | 84 | 6.3  |
| 49 | 79  | 187 | 87 | 5.1  |
| 50 | 63  | 220 | 85 | 11.5 |
| 51 | 16  | 7   | 74 | 6.9  |
| 52 | 80  | 294 | 86 | 8.6  |
| 53 | 108 | 223 | 85 | 8    |
| 54 | 20  | 81  | 82 | 8.6  |
| 55 | 52  | 82  | 86 | 12   |
| 56 | 82  | 213 | 88 | 7.4  |
| 57 | 50  | 275 | 86 | 7.4  |
| 58 | 64  | 253 | 83 | 7.4  |
| 59 | 59  | 254 | 81 | 9.2  |
| 60 | 39  | 83  | 81 | 6.9  |
| 61 | 9   | 24  | 81 | 13.8 |
| 62 | 16  | 77  | 82 | 7.4  |
| 63 | 122 | 255 | 89 | 4    |
| 64 | 89  | 229 | 90 | 10.3 |
| 65 | 110 | 207 | 90 | 8    |
| 66 | 44  | 192 | 86 | 11.5 |
| 67 | 28  | 273 | 82 | 11.5 |
| 68 | 65  | 157 | 80 | 9.7  |
| 69 | 22  | 71  | 77 | 10.3 |
| 70 | 59  | 51  | 79 | 6.3  |
| 71 | 23  | 115 | 76 | 7.4  |
| 72 | 31  | 244 | 78 | 10.9 |
| 73 | 44  | 190 | 78 | 10.3 |
| 74 | 21  | 259 | 77 | 15.5 |
| 75 | 9   | 36  | 72 | 14.3 |
| 76 | 45  | 212 | 79 | 9.7  |
| 77 | 168 | 238 | 81 | 3.4  |
| 78 | 73  | 215 | 86 | 8    |
| 79 | 76  | 203 | 97 | 9.7  |
| 80 | 118 | 225 | 94 | 2.3  |
| 81 | 84  | 237 | 96 | 6.3  |
| 82 | 85  | 188 | 94 | 6.3  |
| 83 | 96  | 167 | 91 | 6.9  |
| 84 | 78  | 197 | 92 | 5.1  |
| 85 | 73  | 183 | 93 | 2.8  |
| 86 | 91  | 189 | 93 | 4.6  |
| 87 | 47  | 95  | 87 | 7.4  |
| 88 | 32  | 92  | 84 | 15.5 |
| 89 | 20  | 252 | 80 | 10.9 |
| 90 | 23  | 220 | 78 | 10.3 |
| 91 | 21  | 230 | 75 | 10.9 |
| 92 | 24  | 259 | 73 | 9.7  |
| 93 | 44  | 236 | 81 | 14.9 |
| 94 | 21  | 259 | 76 | 15.5 |
| 95 | 28  | 238 | 77 | 6.3  |
| 96 | 9   | 24  | 71 | 10.9 |

|     |    |     |    |      |
|-----|----|-----|----|------|
| 97  | 13 | 112 | 71 | 11.5 |
| 98  | 46 | 237 | 78 | 6.9  |
| 99  | 18 | 224 | 67 | 13.8 |
| 100 | 13 | 27  | 76 | 10.3 |
| 101 | 24 | 238 | 68 | 10.3 |
| 102 | 16 | 201 | 82 | 8    |
| 103 | 13 | 238 | 64 | 12.6 |
| 104 | 23 | 14  | 71 | 9.2  |
| 105 | 36 | 139 | 81 | 10.3 |
| 106 | 7  | 49  | 69 | 10.3 |
| 107 | 14 | 20  | 63 | 16.6 |
| 108 | 30 | 193 | 70 | 6.9  |
| 109 | 14 | 191 | 75 | 14.3 |
| 110 | 18 | 131 | 76 | 8    |
| 111 | 20 | 223 | 68 | 11.5 |

*For the teacher.*

Some information about Ozone.

There are two types of ozone. "Good" ozone in the upper atmosphere screens out harmful ultraviolet rays. This is the ozone that we worry is being depleted over the South Pole. But ozone also forms at ground level, one way being when sunlight hits pollution in the air. This "bad ozone" is a health risk, especially for older people and those suffering from asthma.

The U.S. Environmental Protection Agency (EPA) has set a standard of ground level ozone at 120 parts per billion, meaning that it considers levels higher than this to be unsafe. But research suggests that for people with asthma, long periods of exposure to a level of even 50 ppb can be harmful.

Gaseous ozone is measured as an indicator of the level of photochemical smog in the atmosphere.

It is a secondary pollutant, which is formed from the reaction of a mixture of hydrocarbons and oxides of nitrogen (principally NO<sub>2</sub>) in the presence of sunlight.

The acceptable maximum level of ozone in the Australian atmosphere is 0.10 ppm. It is exceeded on an annual basis in some of the larger cities.