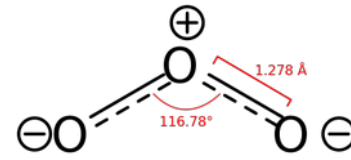
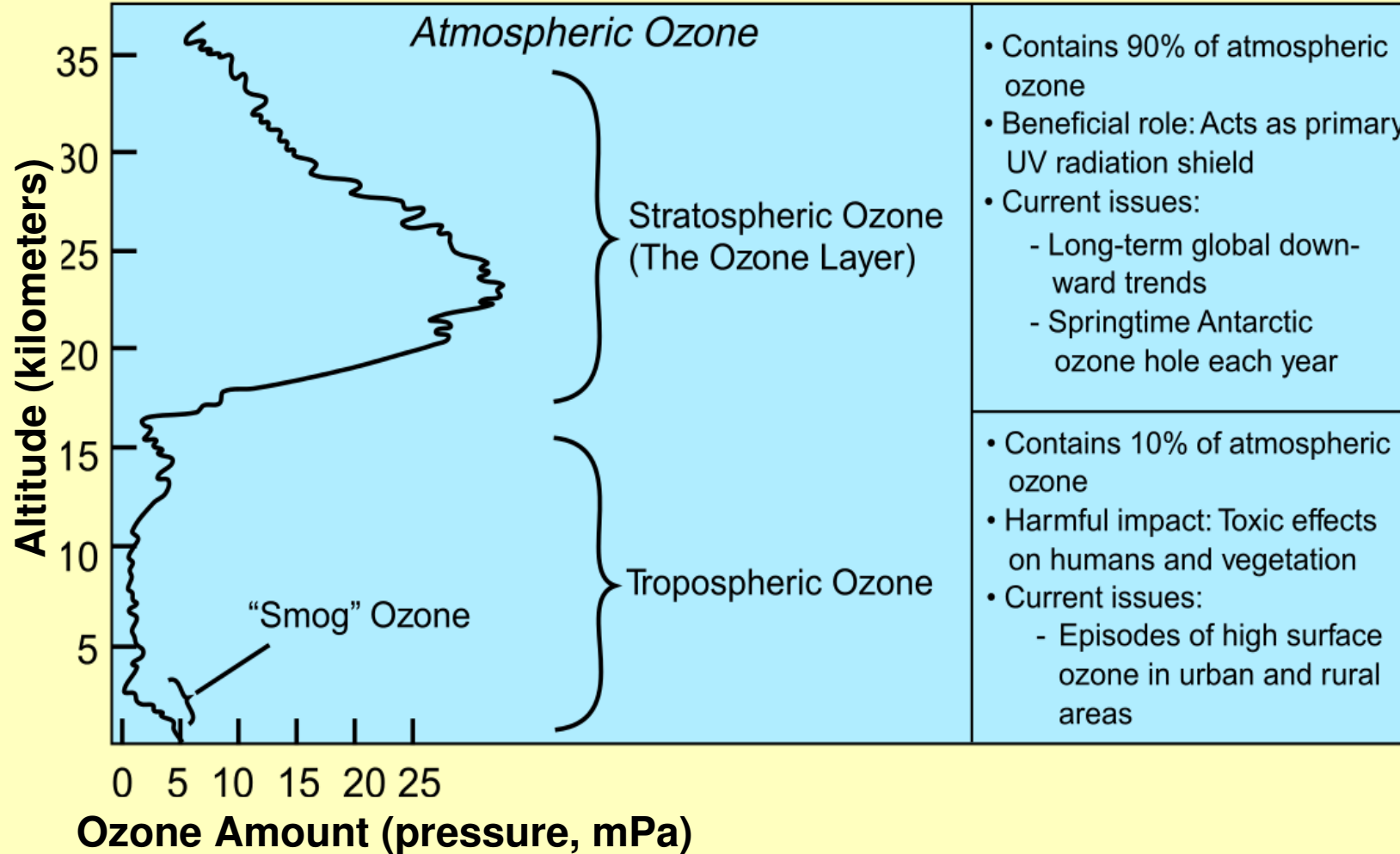


Air Quality and Ozone



For more information:
Introduction to Atmospheric Chemistry, by Daniel Jacob, Edition 1, Chapter 12



Oxygen Cycle

Photosynthesis: $n\text{CO}_2 + n\text{H}_2\text{O} \xrightarrow{h\nu} (\text{CH}_2\text{O})_n + n\text{O}_2$

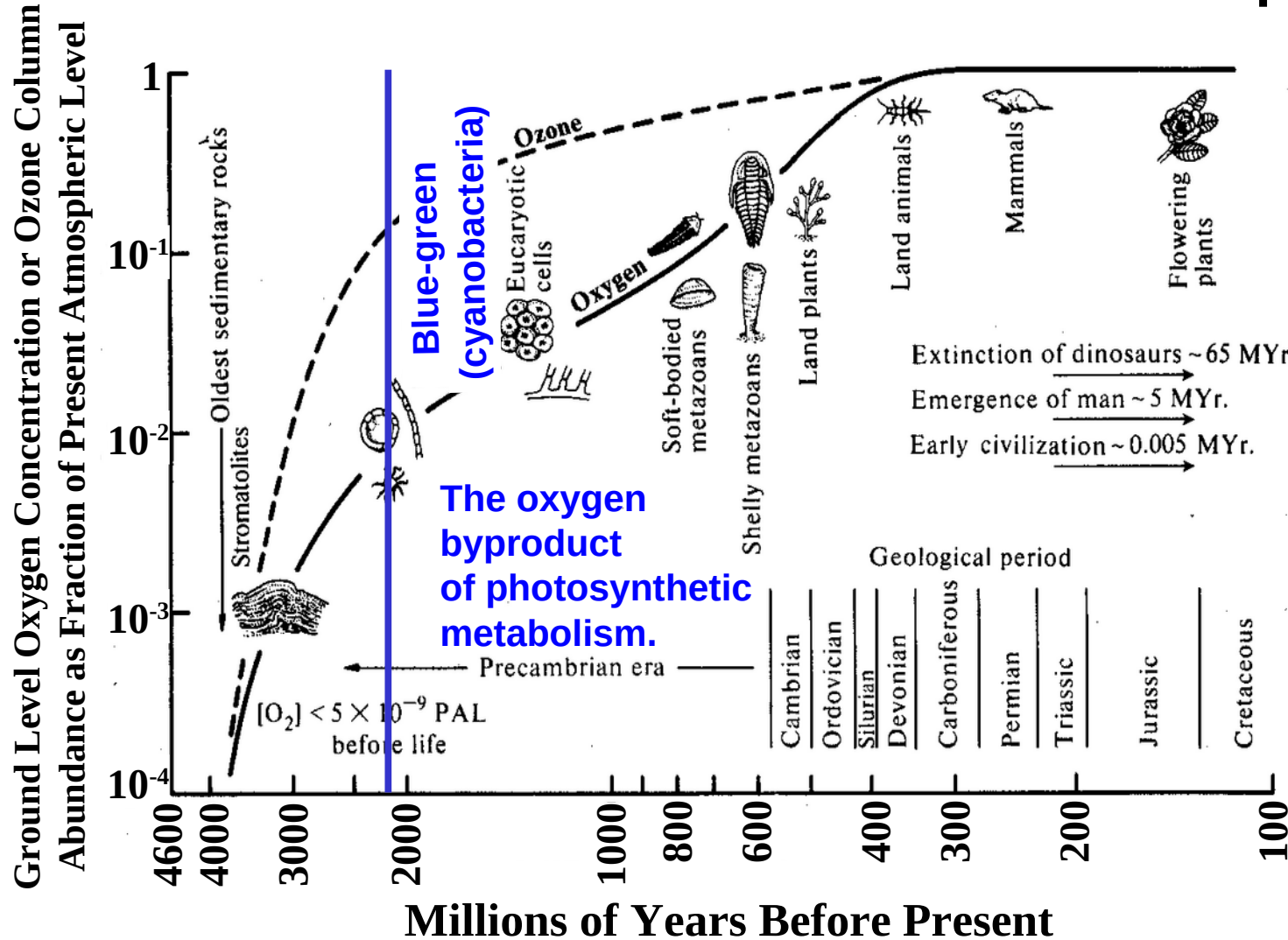
What does “n” represent?

What does $h\nu$ represent?

What the stoichiometric representation of respiration and microbial decay?

What does M represent?

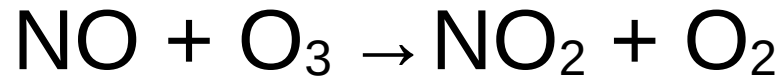
Evolution of O₂ and O₃ In Earth's Atmosphere



What are Algae?
Has O₂ declined recently?

Original figure courtesy
of Daniel J. Jacob,
text added.

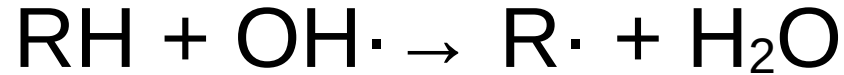
Photochemical Formation of Ozone From Nitrogen Dioxide



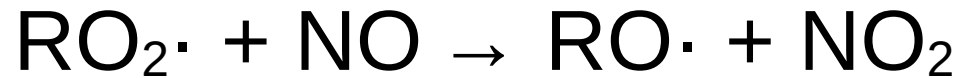
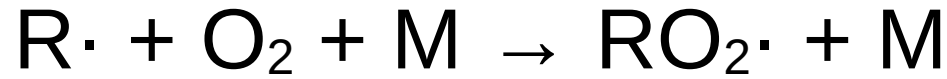
What does M represent?

What does λ represent?

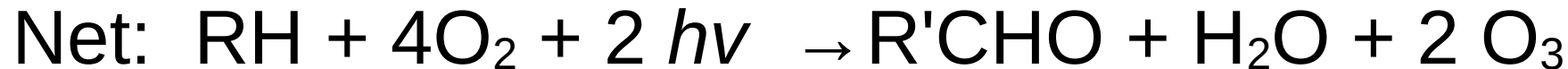
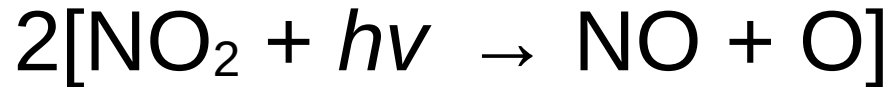
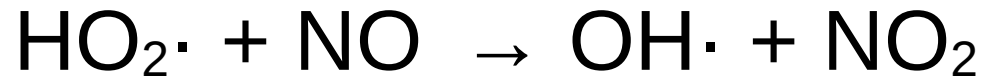
Scheme for O₃ by Oxidation of Carbon in Presence of NO_x



What does R represent?

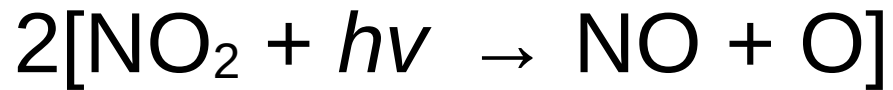
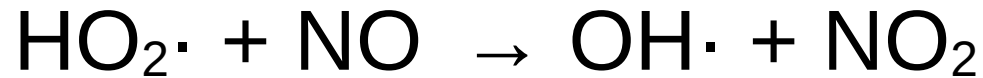
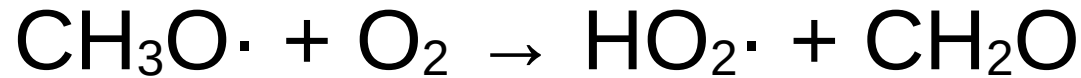
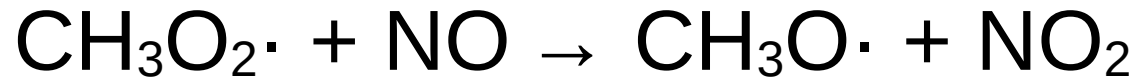
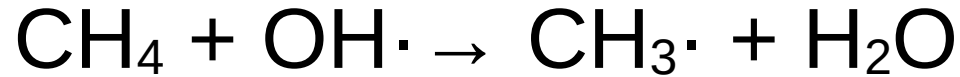


What does R' represent?



Oxidation of Methane Mechanism:

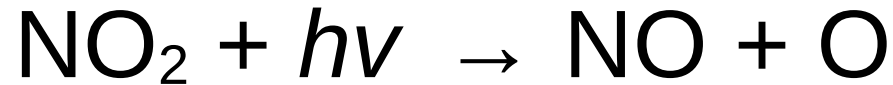
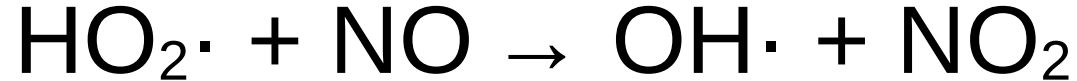
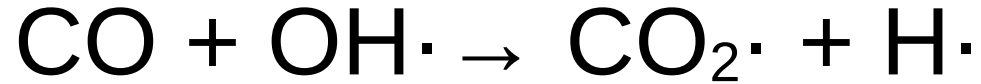
NMVOC Concentration is Low



What does NMVOC
represent?

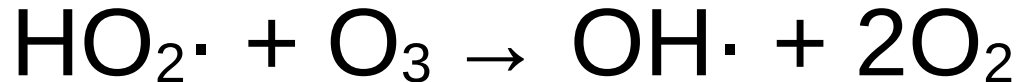
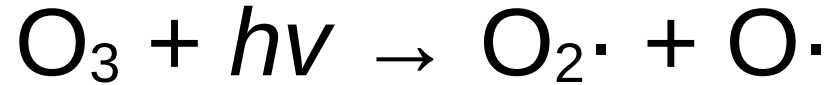


Carbon Monoxide Mechanism:



Remove of Ozone Deposition onto Earth's Surface

Photochemical Lost:



Lifetime of Ozone in Troposphere

Season	Altitude	40 °N Lat	20 °N Lat
--------	----------	-----------	-----------

Summer	0 km	8 days	5 days
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Winter	0 km	100 days	17 days
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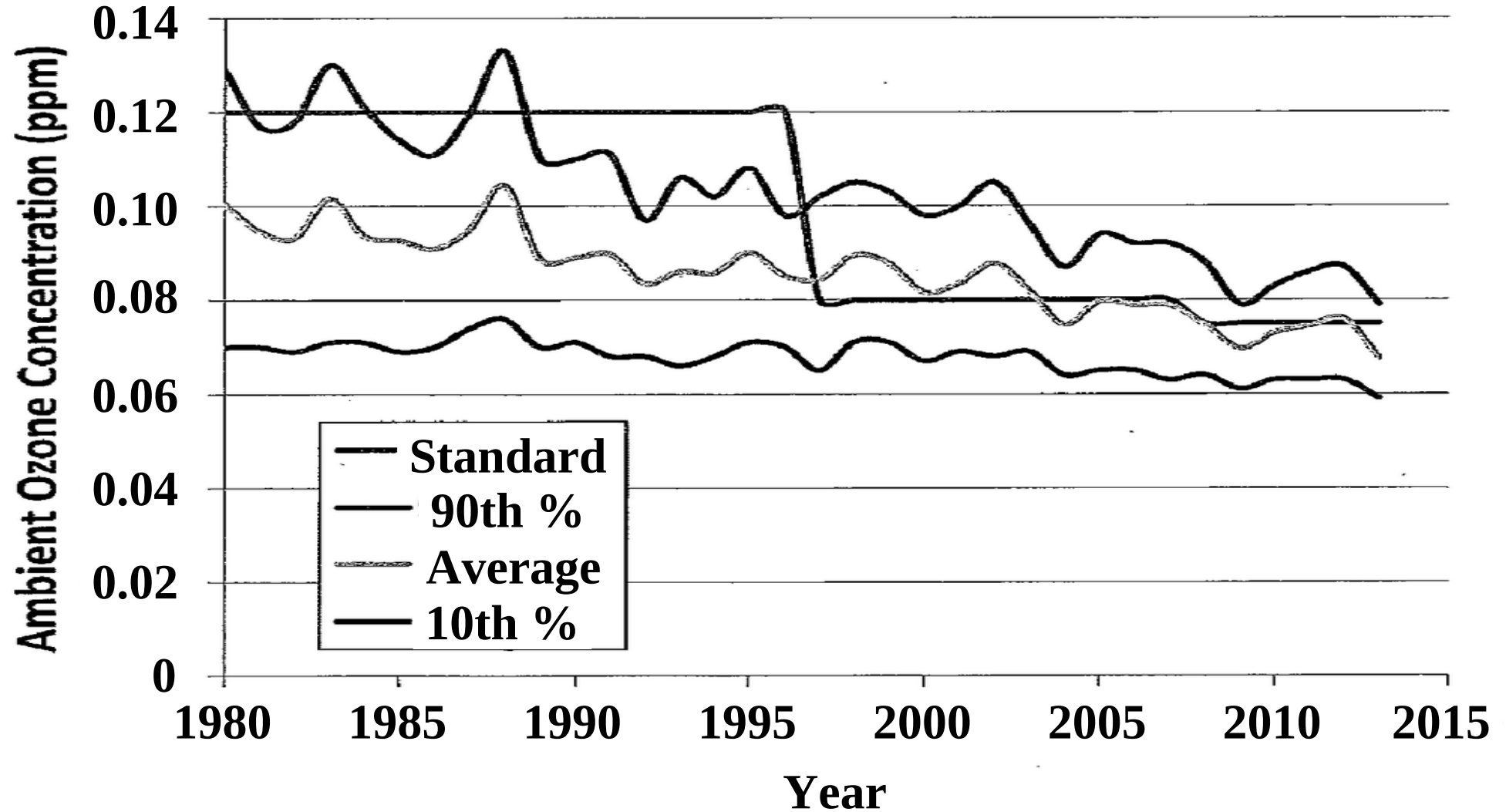
Summer	5 km	15 days	10 days
--------	------	---------	---------

Winter	5 km	160 days	35 days
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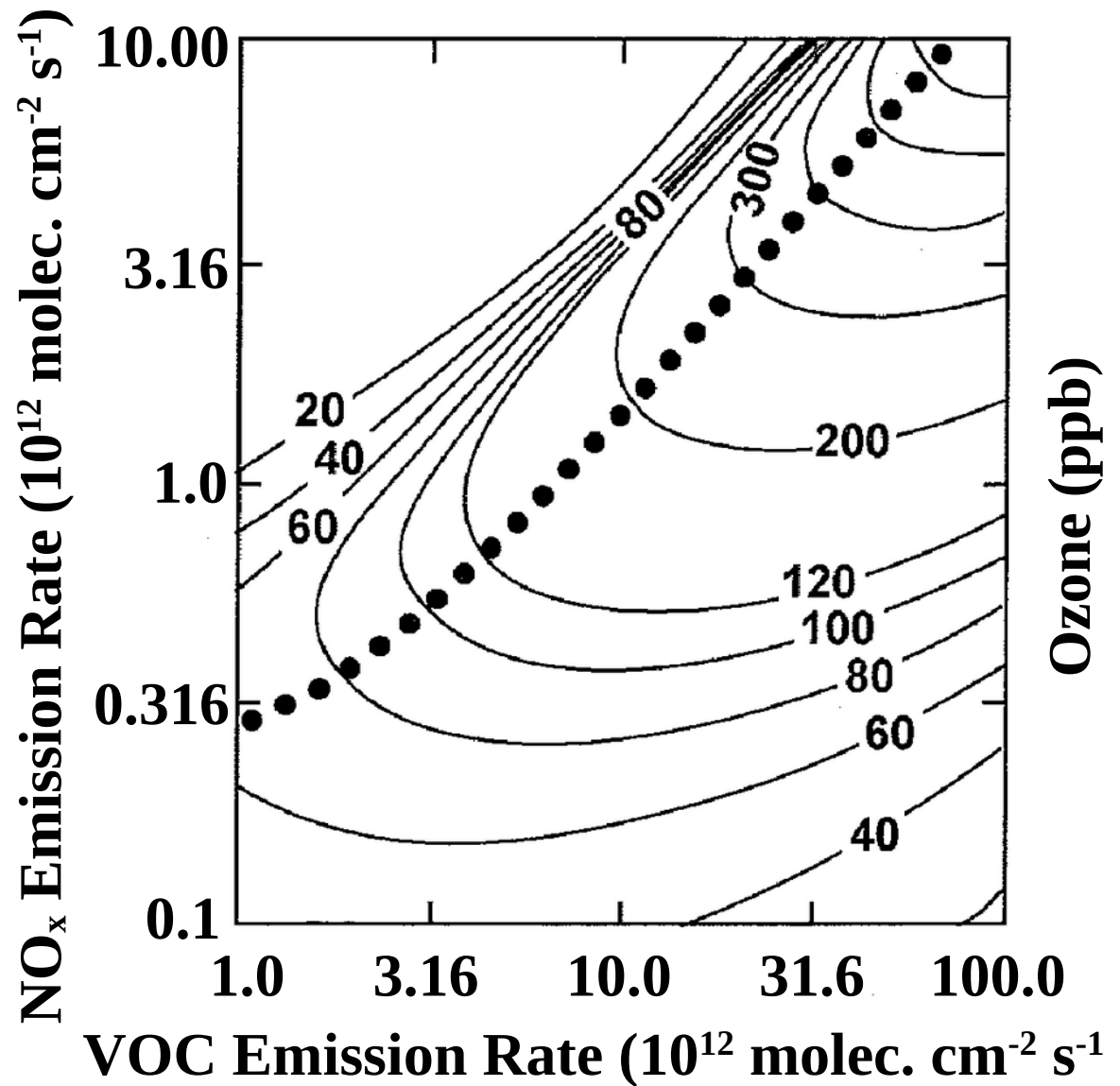
Summer	10 km	40 days	30 days
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Winter	10 km	300 days	90 days
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Ambient Ozone Trend

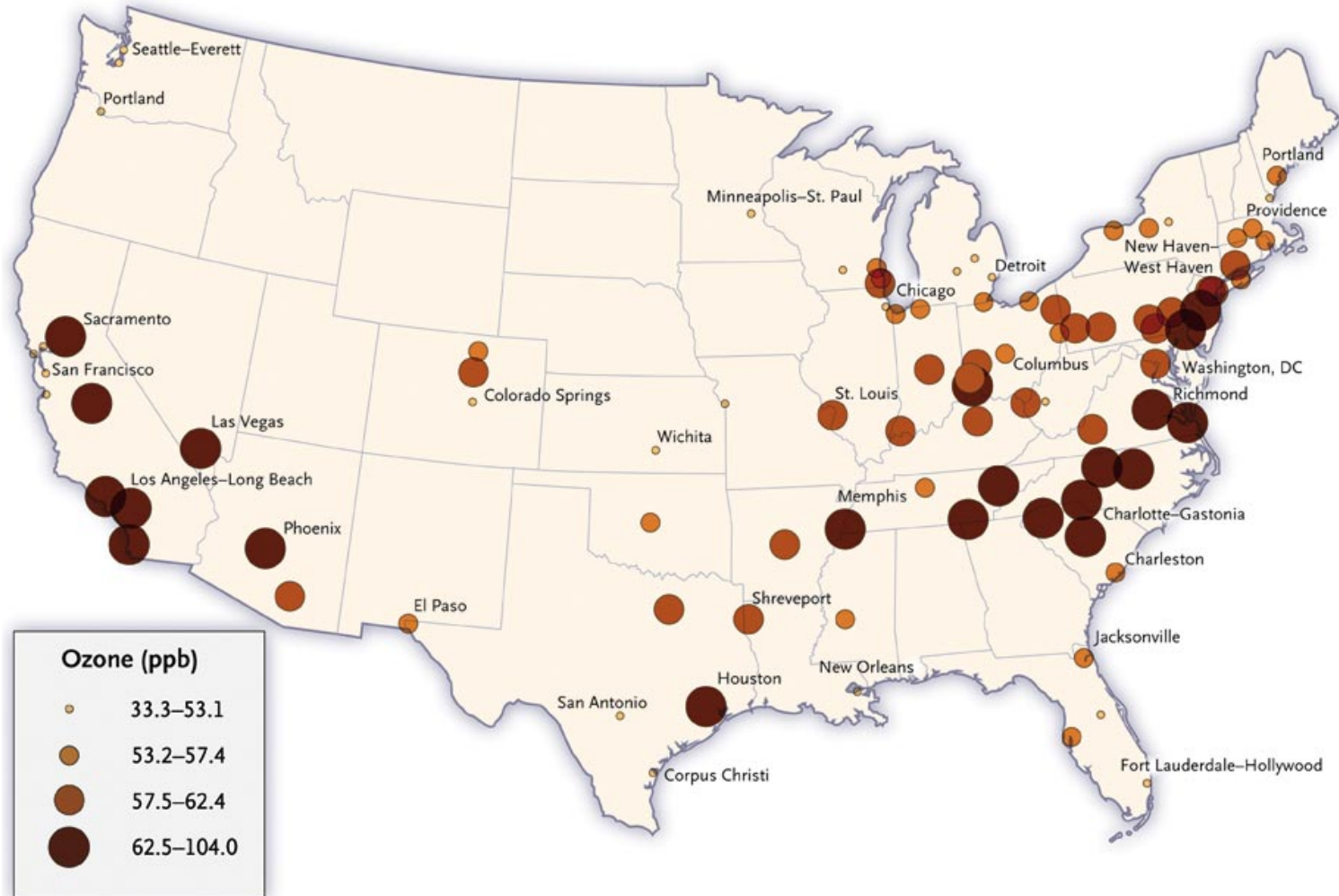


Ozone Isopleths



Ref: Air Pollution: Engineering,
Science, and Policy by
Steven Sternberg, Figure 12-5

Ozone Concentrations in the 96 Metropolitan Statistical Areas in Which Members of the American Cancer Society Cohort Resided in 1982

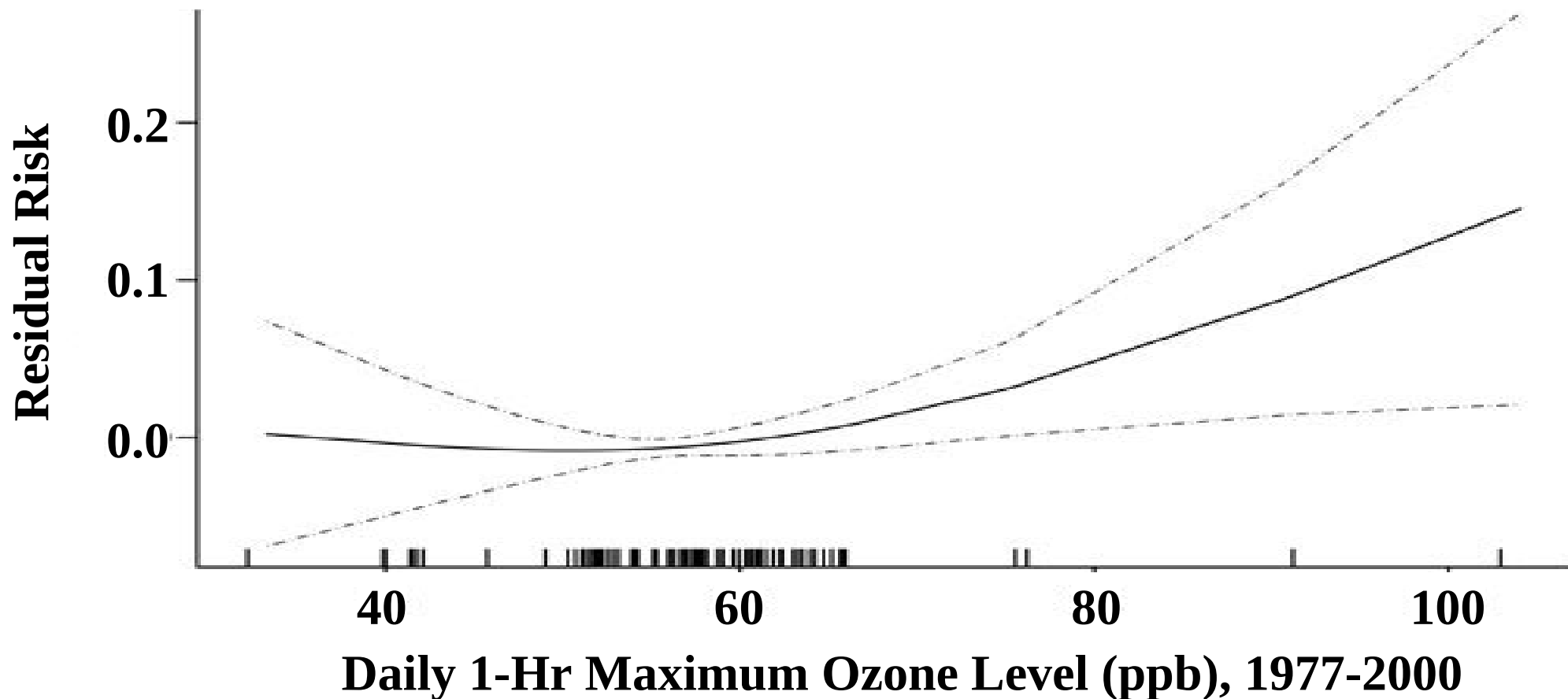


Number of Deaths in the Entire Cohort and According to Exposure to Ozone

Cause of Death	Entire Cohort	Concentration of Ozone [ppb]			
		33.3-53.1	53.2-57.4	57.5-62.4	62.5-104.0
	N=448,850	N=126,206	N=95,740	N=106,545	N=120,359
Any Cause	118,777	32,957	25,642	27,782	32,396
Cardiopulmonary	58,775	16,328	12,621	13,544	16,282
Cardiovascular	48,884	13,605	10,657	11,280	13,342
Heart Disease	27,642	7,714	6,384	6,276	7,268
Respiratory	9,891	2,723	1,964	2,264	2,940

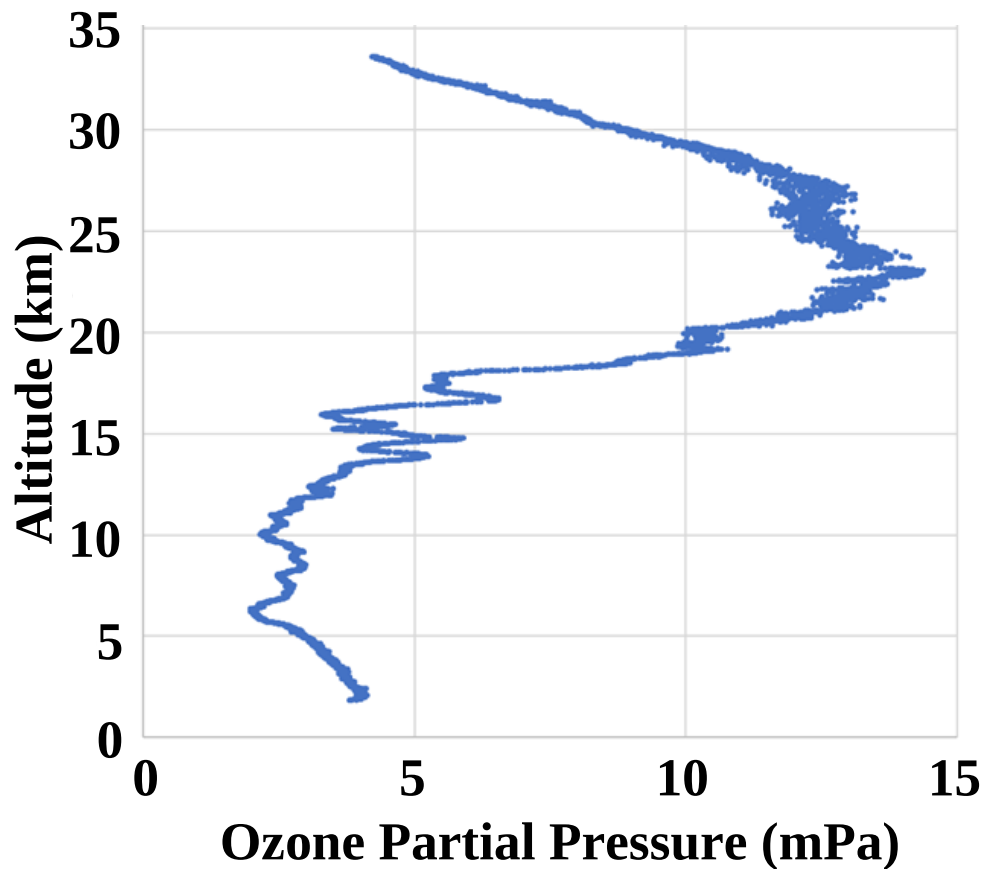
Jerrett M et al. N Engl J Med 2009;360:1085-1095

Exposure-Response Curve



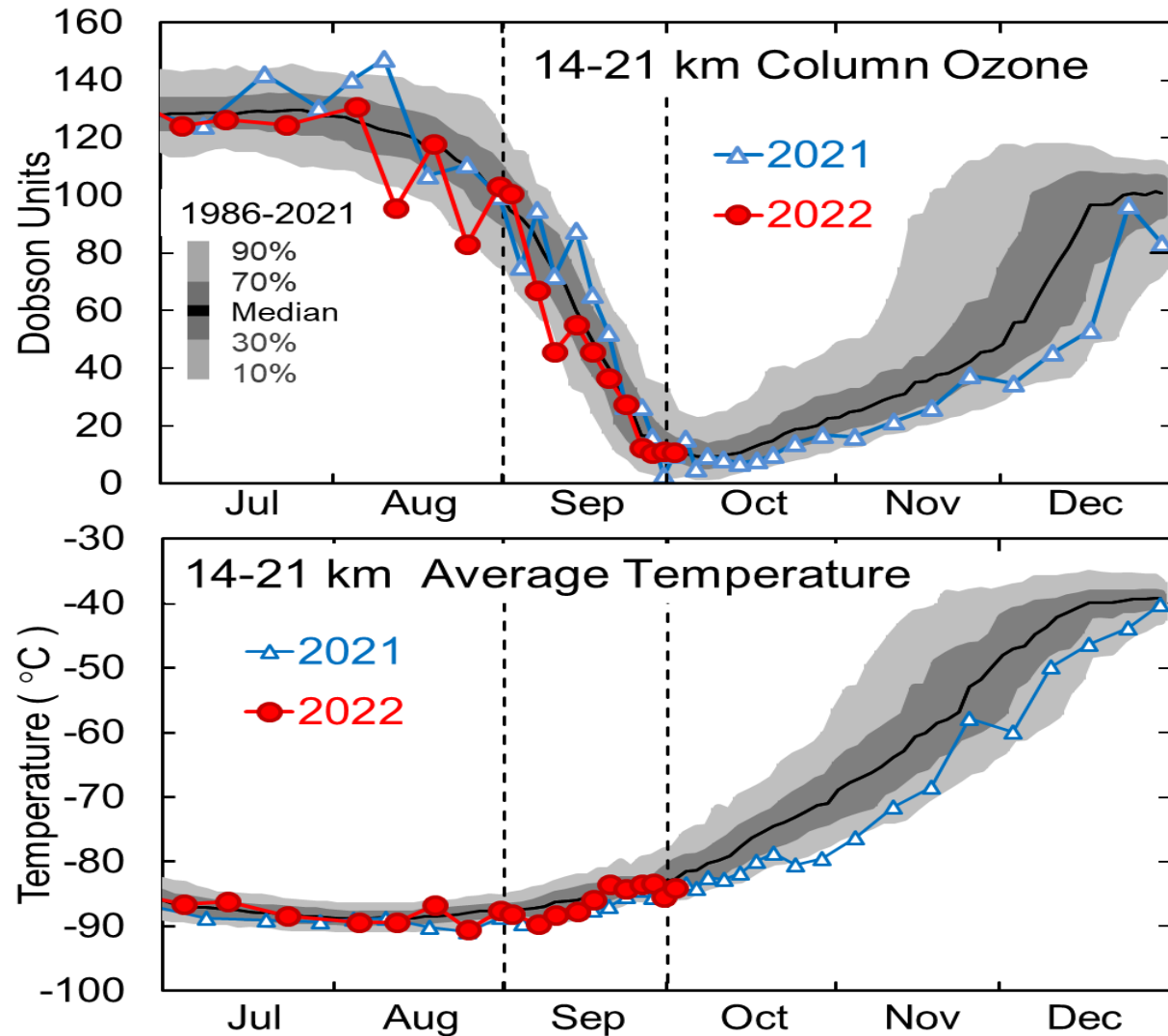
The curve is based on a natural spline with 2 df estimated from the residual relative risk of death within a metropolitan statistical area (MSA) according to a randomeffects survival model. The dashed lines indicate the 95% confidence interval of fit, and the hash marks indicate the ozone levels of each of the 96 MSAs. Ref: Jerrett M et al. N Engl J Med 2009;360:1085-1095

Boulder Ozone Profile: June 5, 2022



Profile obtain with ECC Ozonesonde using the NOAA 1% reduced buffer sensor solution. The sonde on the evening before the launch and cells leads left plugged in. The profile looked good; therefore, it is find to get the sonde all ready the previous afternoon and just note the background running on zero air for a couple minutes when first turning on the sonde.

South Pole Station NOAA ozonesondes: 2022 ozone hole



Record Low →

Min 2021 →

Latest:
2022
Oct 03
11 DU



1986-2021		
14-21 km Column Ozone		
Year	Minimum	Date of Min
2006	1	10/9/2006
1997	2	10/8/1997
2001	2	10/4/2001
2020	2	10/1/2020
1993	3	10/12/1993
1998	3	10/5/1998
1999	3	9/29/1999
2000	3	10/1/2000
2005	3	9/28/2005
2011	3	10/9/2011
2021	3	10/1/2021
1995	4	10/11/1995
1996	4	10/8/1996
2003	5	9/26/2003
2007	5	9/29/2007
2015	5	10/12/2015
1994	6	10/5/1994
2009	6	9/29/2009
2018	6	9/29/2018
2008	7	10/5/2008
2016	7	10/5/2016
1987	10	10/16/1987
2010	10	10/2/2010
1992	12	10/11/1992
2004	12	10/4/2004
2014	13	10/8/2014
2012	14	10/5/2012
1989	15	10/9/1989
1991	15	10/7/1991
2013	16	9/29/2013
2017	17	10/8/2017
1990	20	10/19/1990
2002	27	10/8/2002
1986	32	10/16/1986
2019	44	10/10/2019
1988	50	10/10/1988

Summary

- **Fine particulate air pollution was associated with increased mortality**
- **Ozone Pollution:**
 - **Not able to detect an effect of ozone on the risk of death from cardiovascular causes when the concentration of PM_{2.5} was taken into account.**
 - **There is a significant increase in the risk of death from respiratory causes in association with an increase in ozone.**