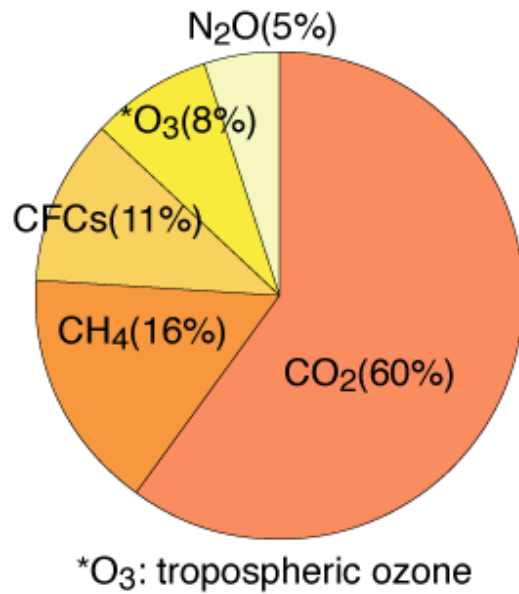
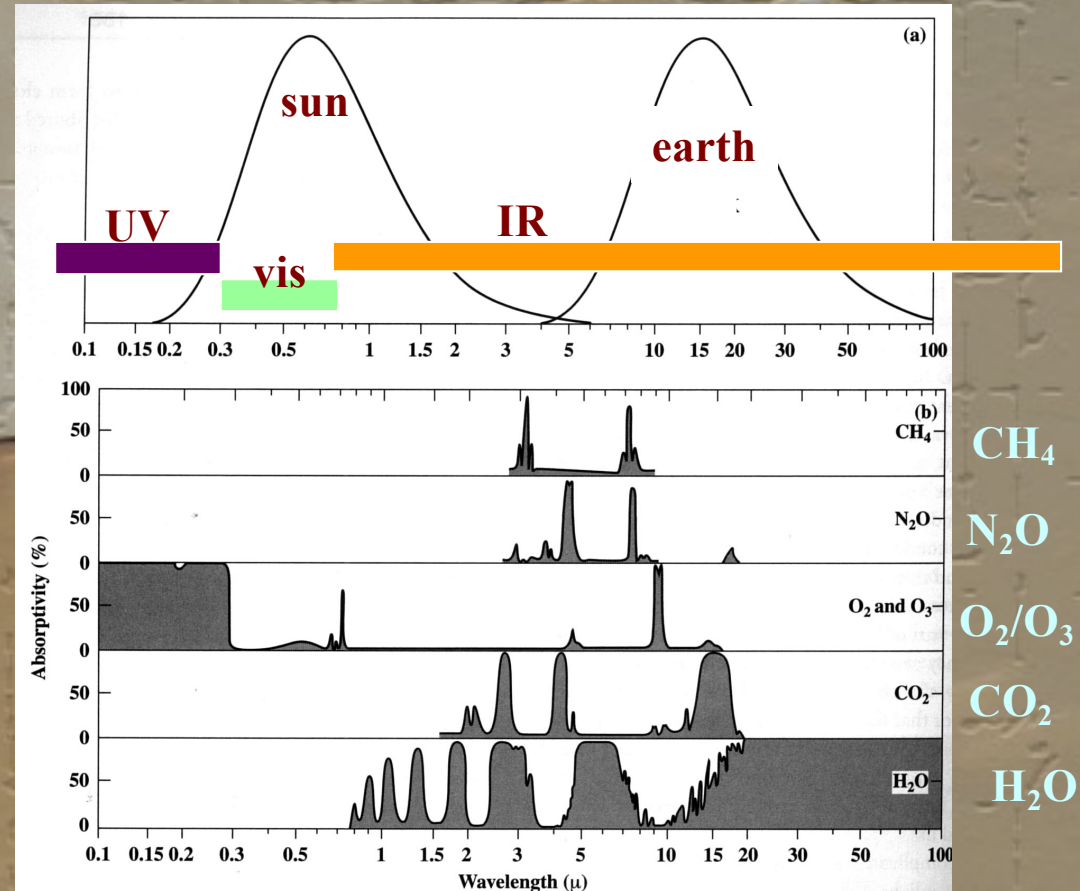


Ozone – O₃

Relative Contribution to Warming



- Ozone greenhouse gas
- Ozone hole NOT related to global warming!



- 10ppm at 20-25km altitude

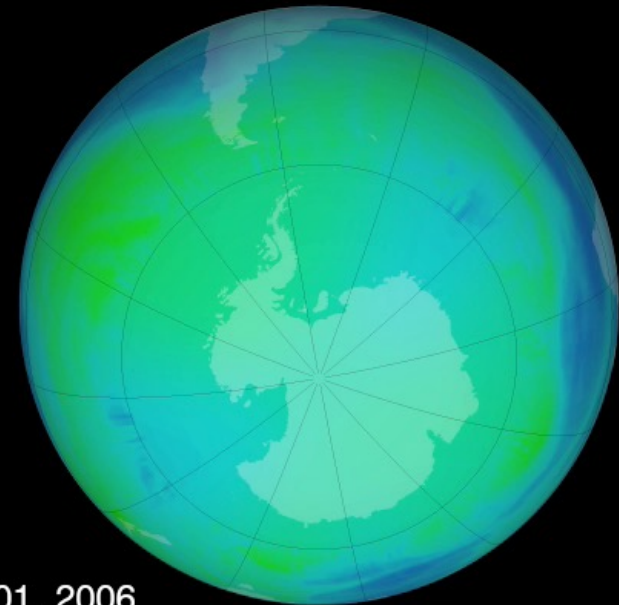
The Ozone Hole

OZONE, O₃

- not released from Earth's interior nor plants
- on ground when NO_x react with sunlight
- **pollutant on ground**
(corrosive and unhealthy)
- in stratosphere when O₂ reacts with sunlight
(10 ppm at 20-25 km altitude)
- **UV protector in stratosphere**

Ozone hole:

- **needs light**
- **needs very low T**
- > **springtime phenomenon**



Jul 01, 2006

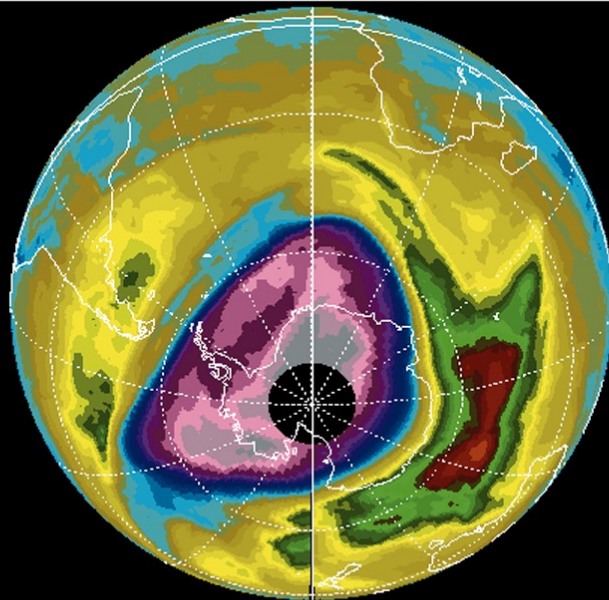
Jul 01

Nov 14

The Ozone Hole

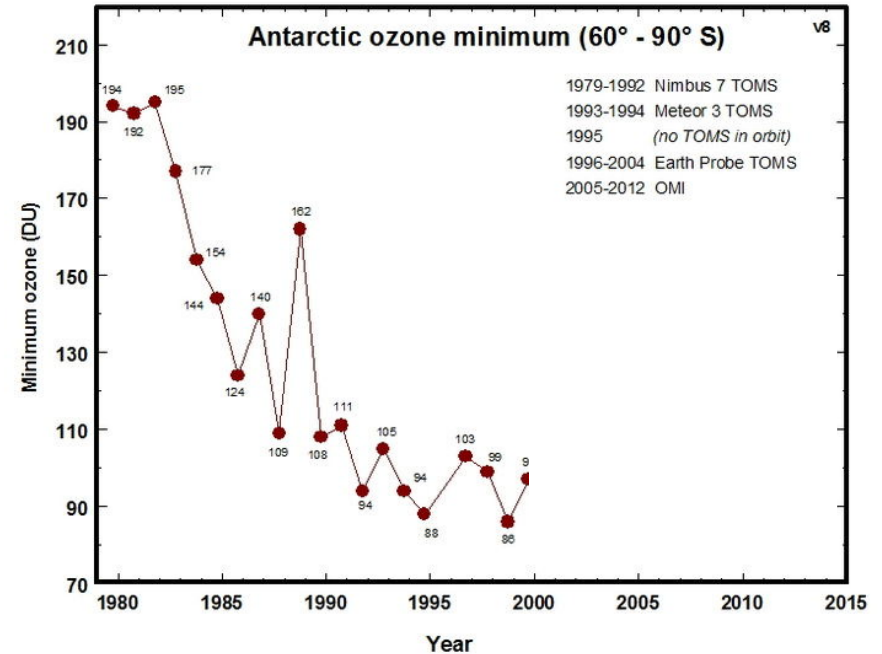
- decline first noticed in 1980s
- most severe in early spring
- CFCs (chlorofluorocarbons) not natural (refrigerators, air conditioning, spray cans) (also greenhouse gas)
- light in stratosphere reacts with CFC (Cl then combines with O)

Earth Probe TOMS Total Ozone September 16, 2000



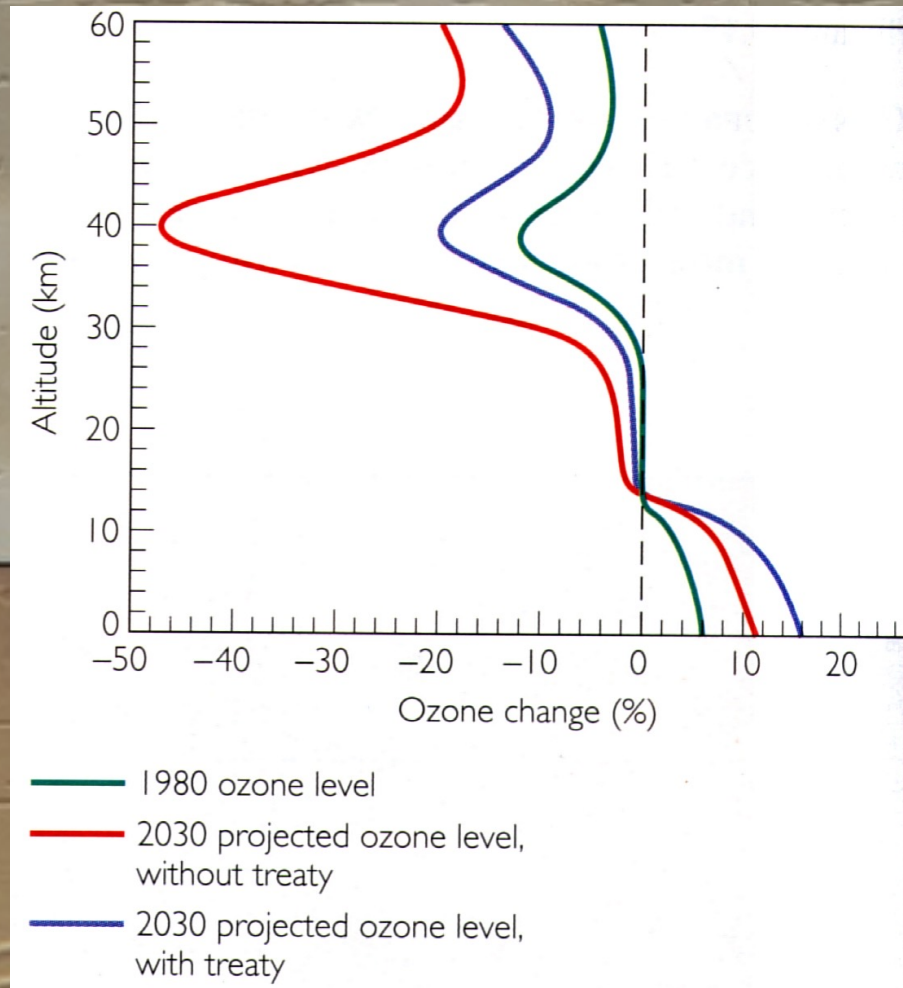
Ozone (Dobson Units)

<120	200	280	360	440	520
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The Ozone Hole – The Montreal Protocol

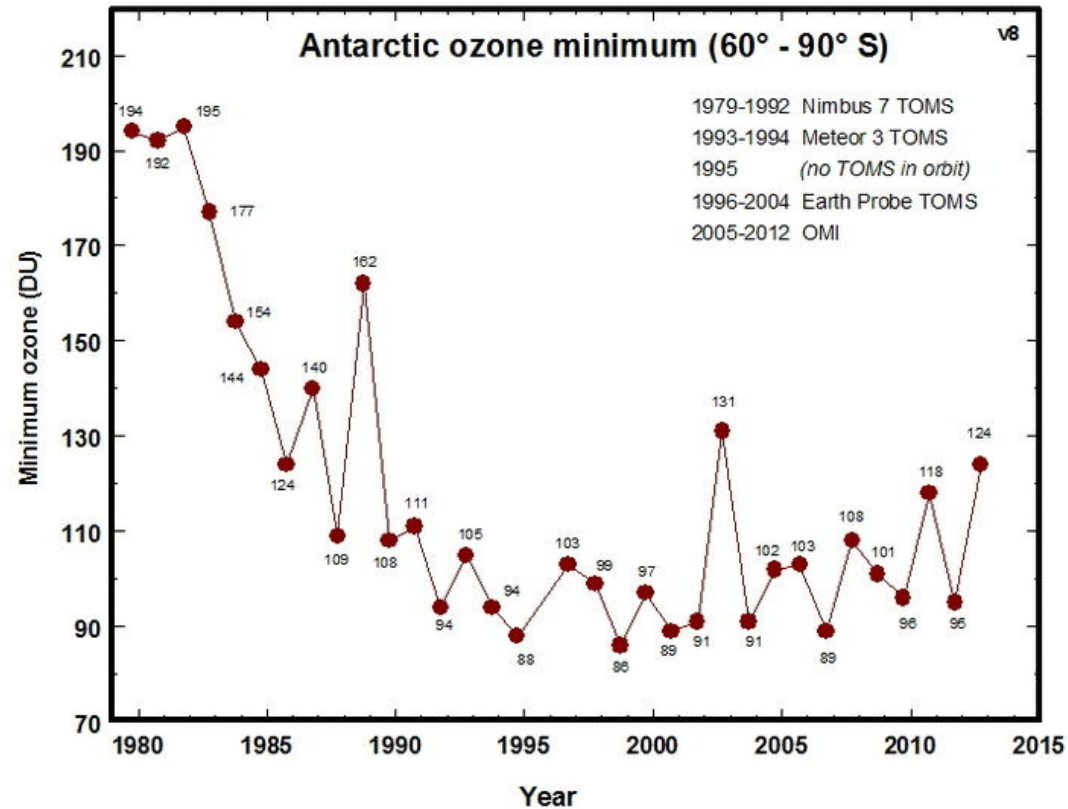
dire predictions -> Montreal Protocol



The Ozone Hole – The Montreal Protocol

- 1987 Montreal Protocol
- CFC phased out by 1996 by 140 countries
- CFC have very long lifetime!
- ozone hole will continue until > 2030
- 2006 ozone hole largest ever
- 2011 deepest **Arctic** ozone hole ever (40%)

The Ozone Hole – The Montreal Protocol



**careful optimism:
2007 Ozone hole was smallest in decades**

Other Ozone Killers - Methyl Bromide



- CH₃Br (bromomethane)
- until 2000 used for termites fumigation
- phased out as ozone killer after Montreal Protocol
- now use sulfuryl fluoride (SO₂F₂); greenhouse gas
- 5000 times more effective than CO₂ to trap heat
- residence time up to 40 years?
- but only 2000 tons/year injected vs. 30 billion tons/year of CO₂

Other Ozone Killers - Methyl Bromide



- CH₃Br
- still used in CA strawberry farming
- soil sterilant
- critical-use exemption from Montreal Protocol
- > 75% used by developed countries (43% U.S.; 24% Europe)

Other Ozone Killers – N₂O

- after phase out of CFCs now #1 emitted ozone killer
- N₂O not covered by Montreal Protocol
- but N₂O also naturally occurring (emitted by bacteria in soil)