Atmospheric Chemistry

Lecture 13

Comparison Ozone vs Climate

○ Vienna Convention (1985)	⟷	○ UNFCCC Framework Convention on Climate Change (Bonn, 1992)
○ Montreal Protocol (1987)	⟷	○ Kyoto Protocol (1997)

Why has one worked so well while the other has not?

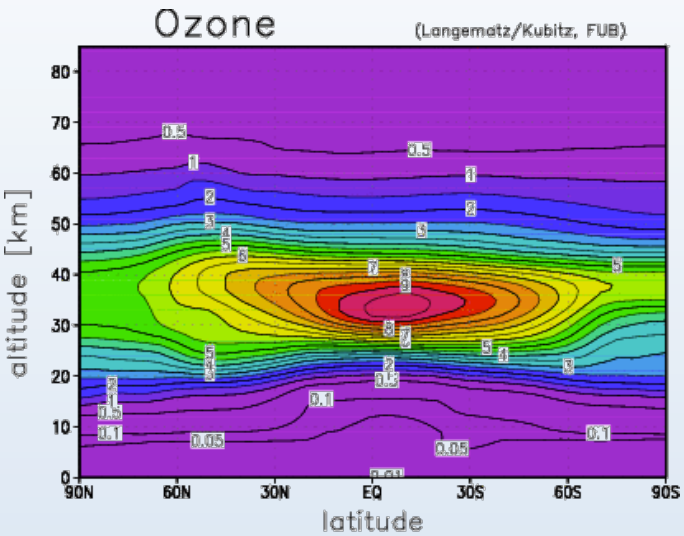
What do you think?

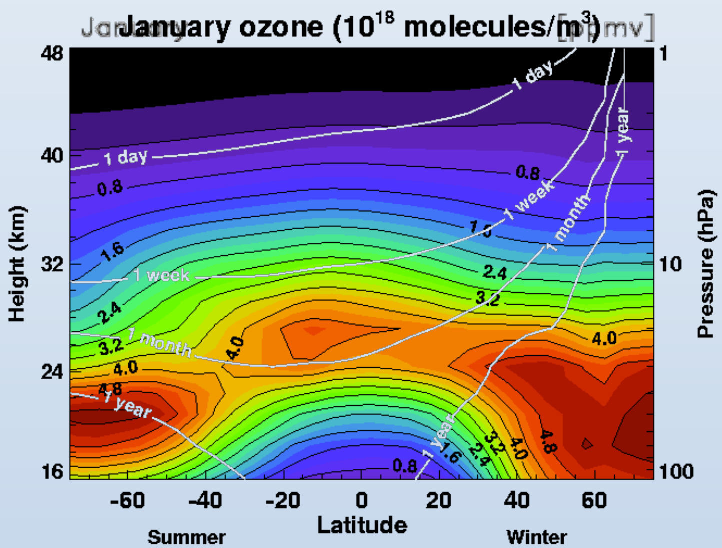
Some possible reasons for success of Montreal Protocol relative to Kyoto Protocol

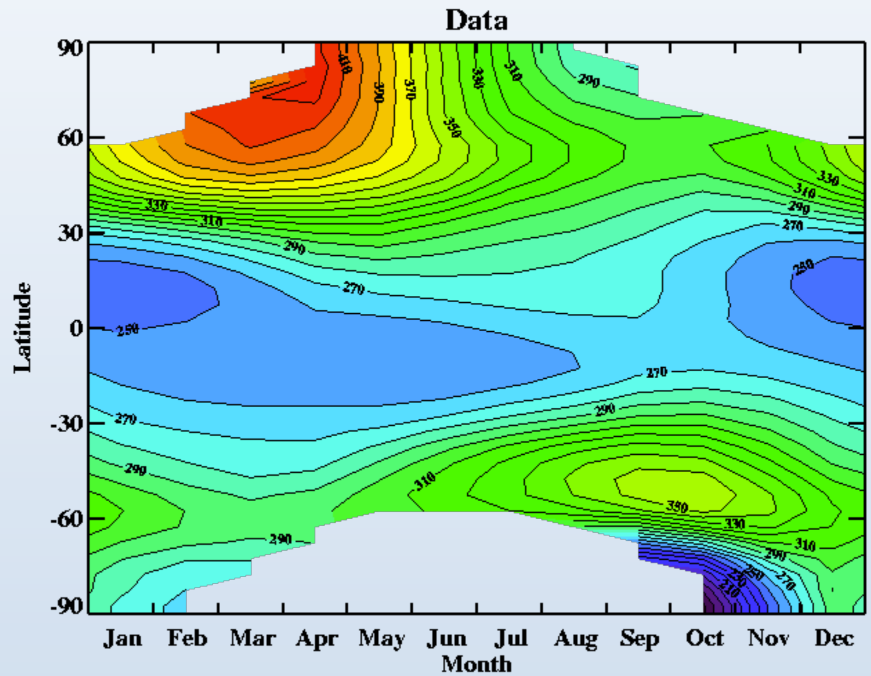
- **Smoking gun, i.e. ozone hole?**
- **Availability of replacements?**
- **CFCs less integral to our society?**
- **Press coverage?**
- **Nay-sayers/non-believers?**
- **IPCC vs Ozone Assessment?**
- **Regulating emission vs production?**
- **Nature of the problem (size and time scale of perturbation relative to natural variability)?**
- **Scare scenarios overplayed?**

What else?

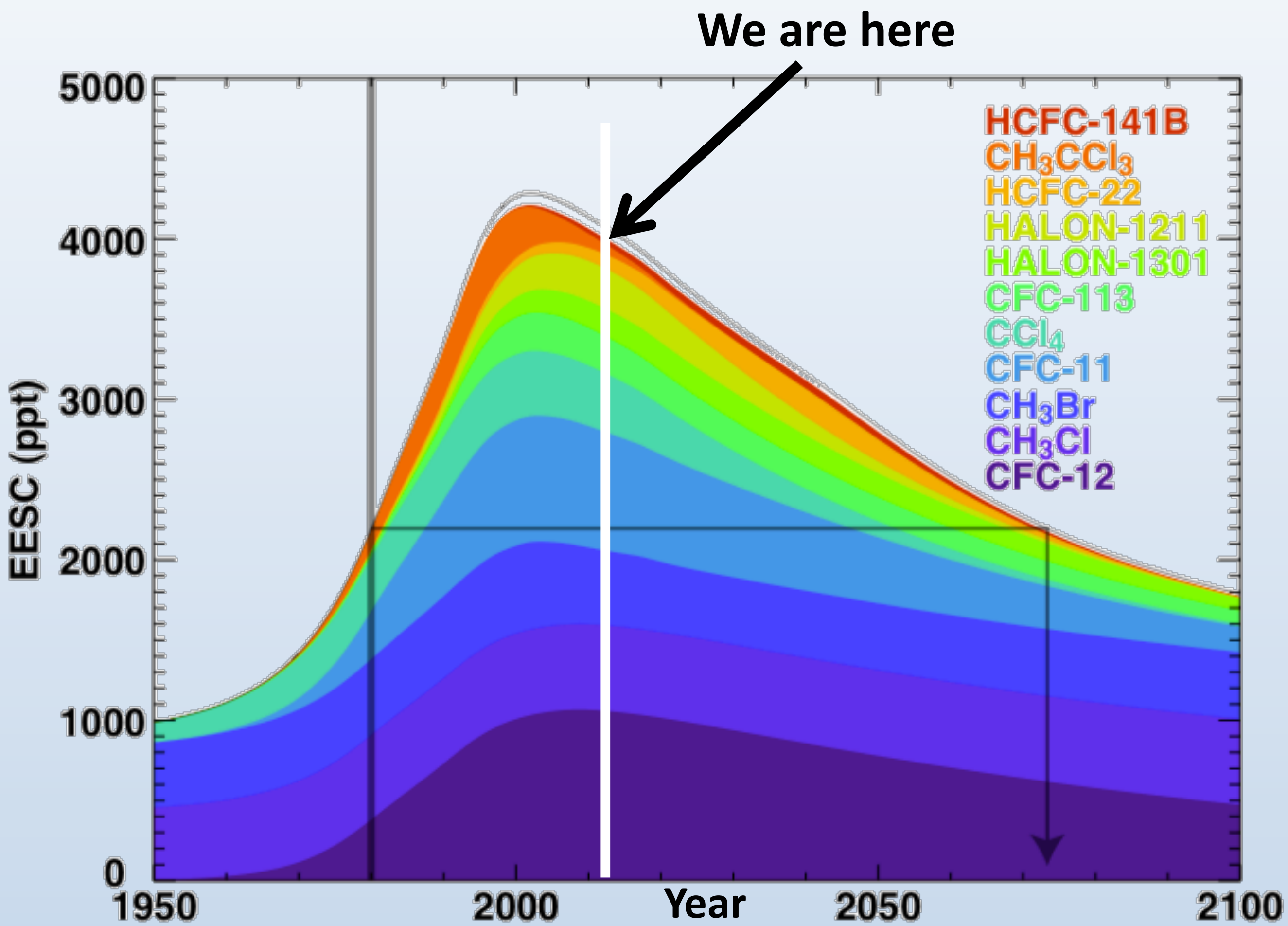
Two-dimensional structure of the stratospheric ozone layer

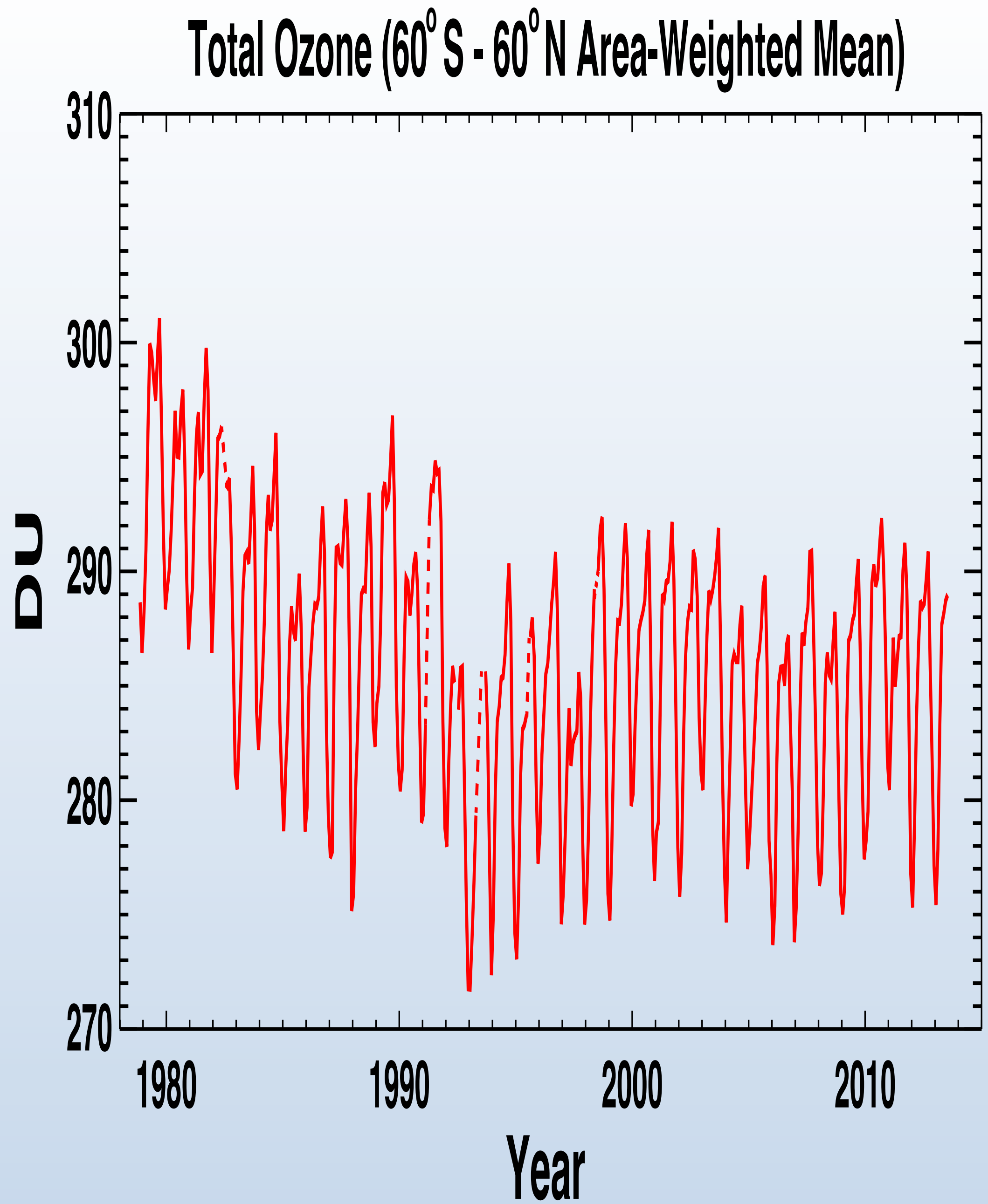






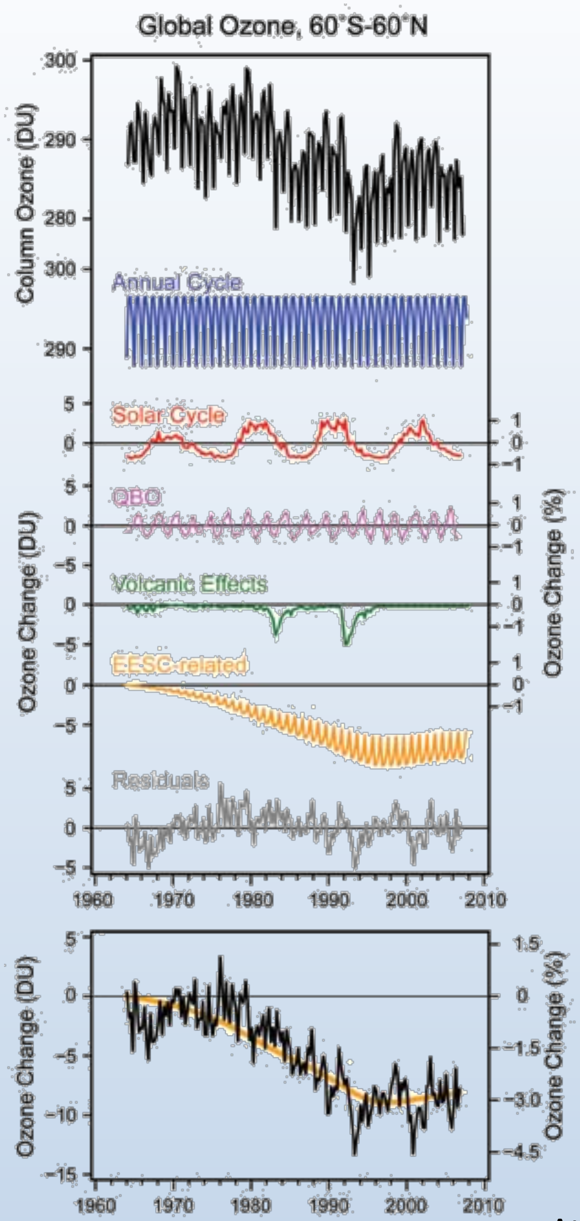
We put these together into an "Equivalent Effective Stratospheric Chlorine" or EESC





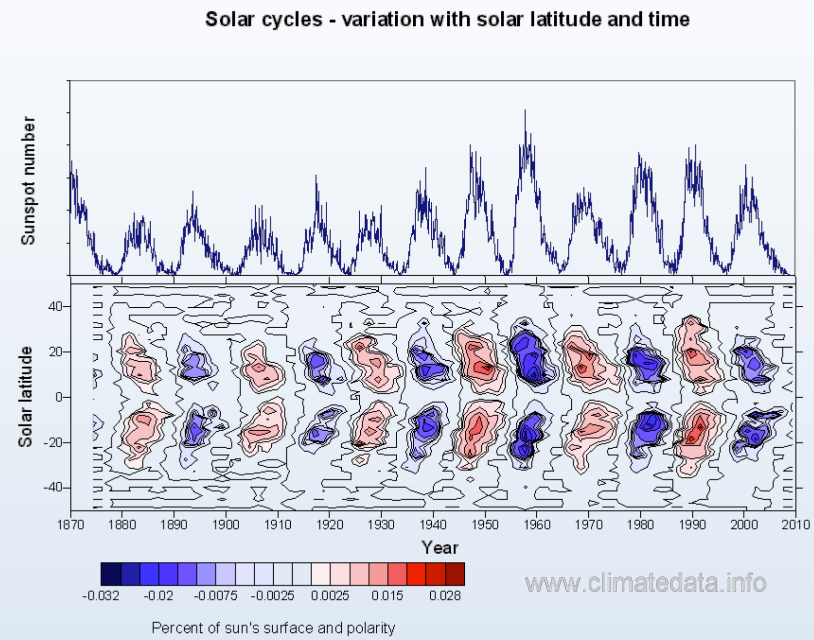
Total Ozone (60° S - 60° N Area-Weighted Mean)
310
300
290
280
270
DU
1980
1990
2000
2010
Year

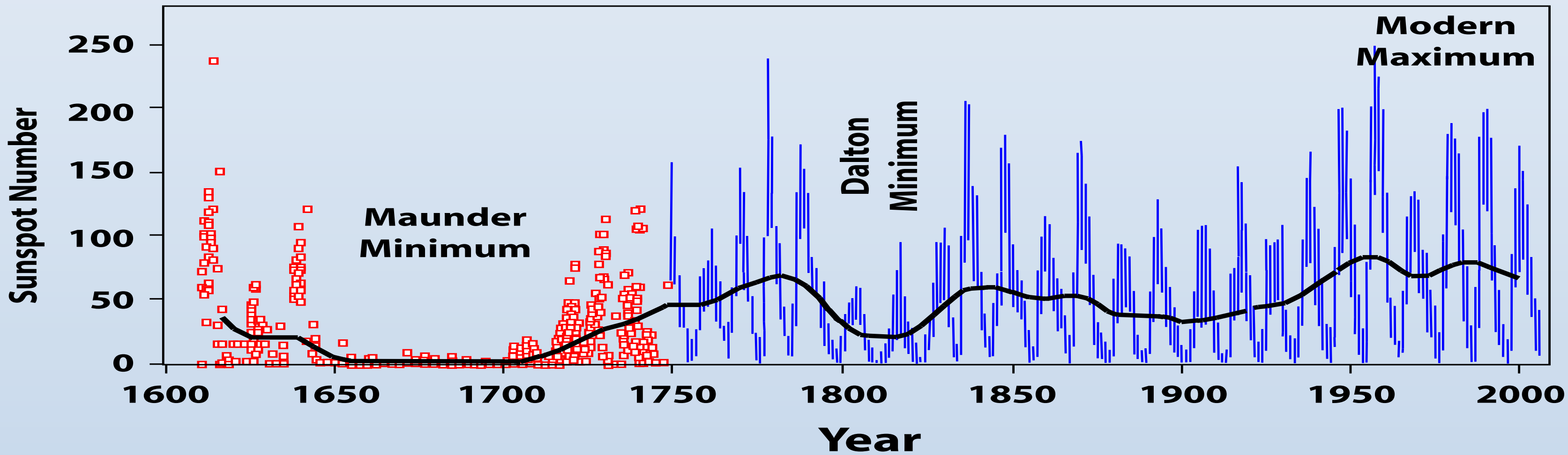
What else affects the ozone record?



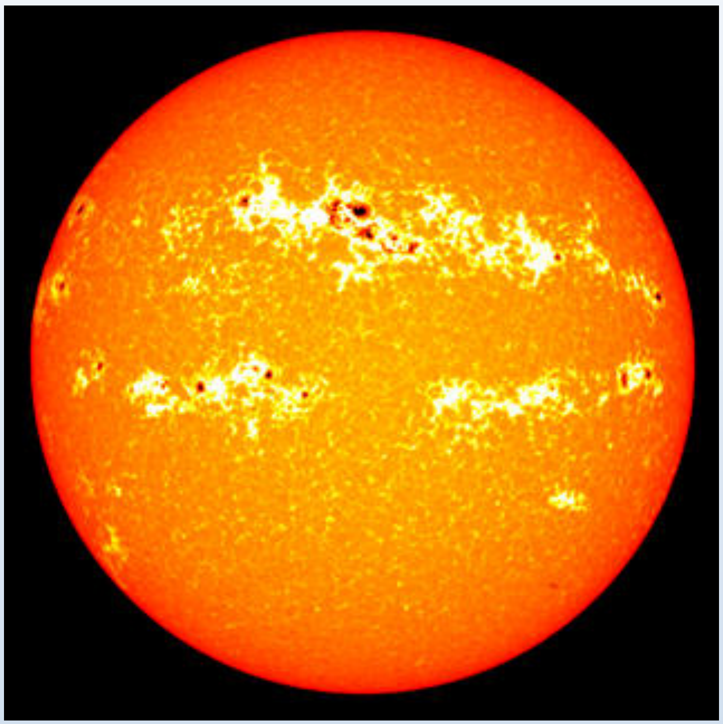
- **Seasonal cycle**
- **11-year sunspot cycle**
- **Quasi-biennial oscillation (internal variability with 26-27 month period)**
- **El Nino Southern oscillation (ENSO)**
- **Volcanoes**

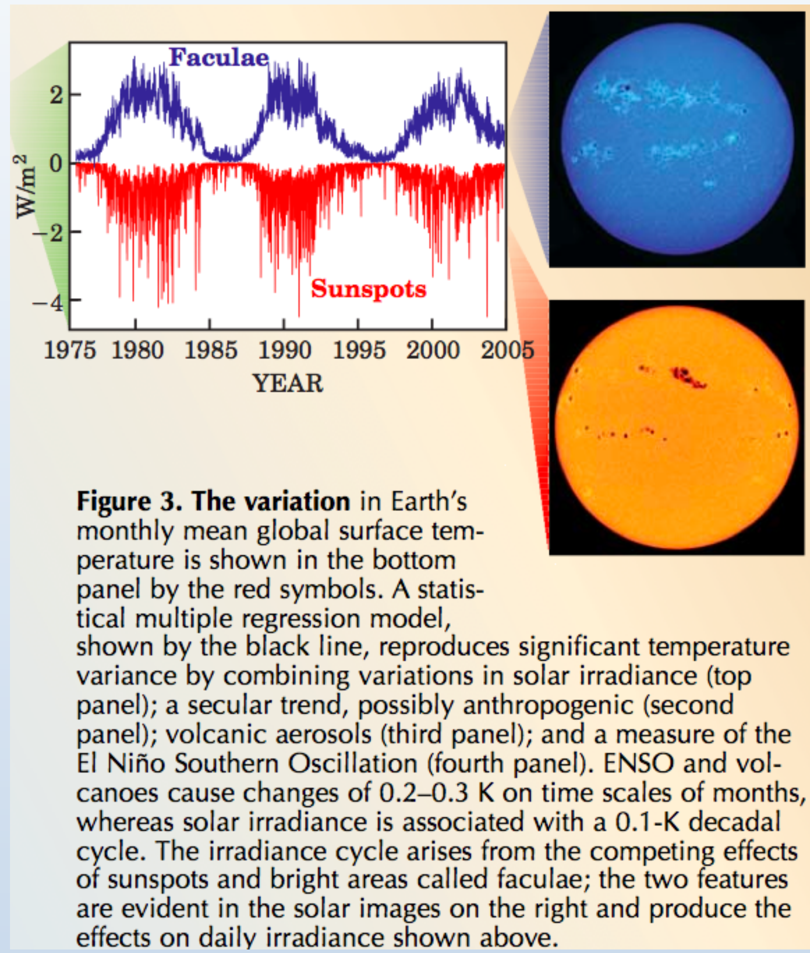
11-Year Sunspot Cycle





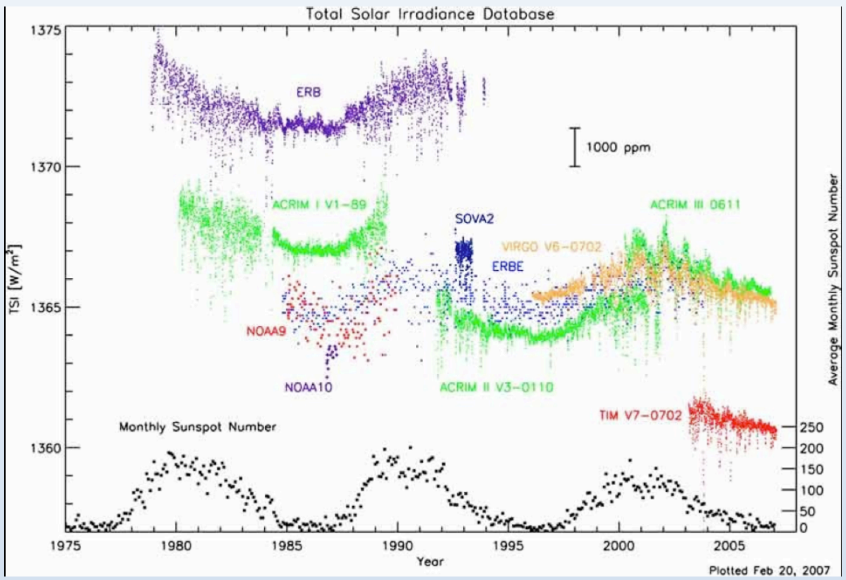
Sunspots are dark areas that are surrounded by bright faculae



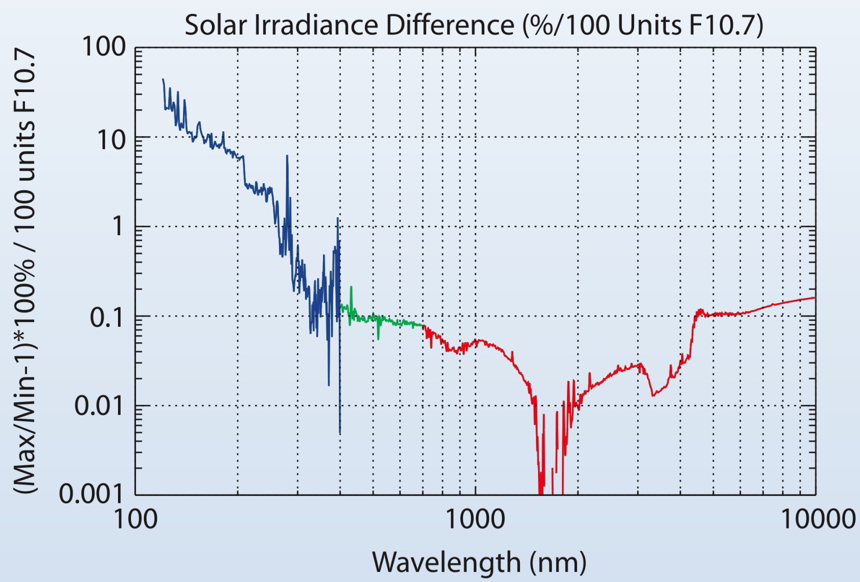


Solar Irradiance varies over the 11-year cycle; amount of variation is dependent on wavelength

Total Solar Irradiance varies with the 11-year cycle



Stronger variations in the uv than in the visible



We monitor the solar variations by measuring the 10.7 cm radio wave flux from the sun (f10.7)

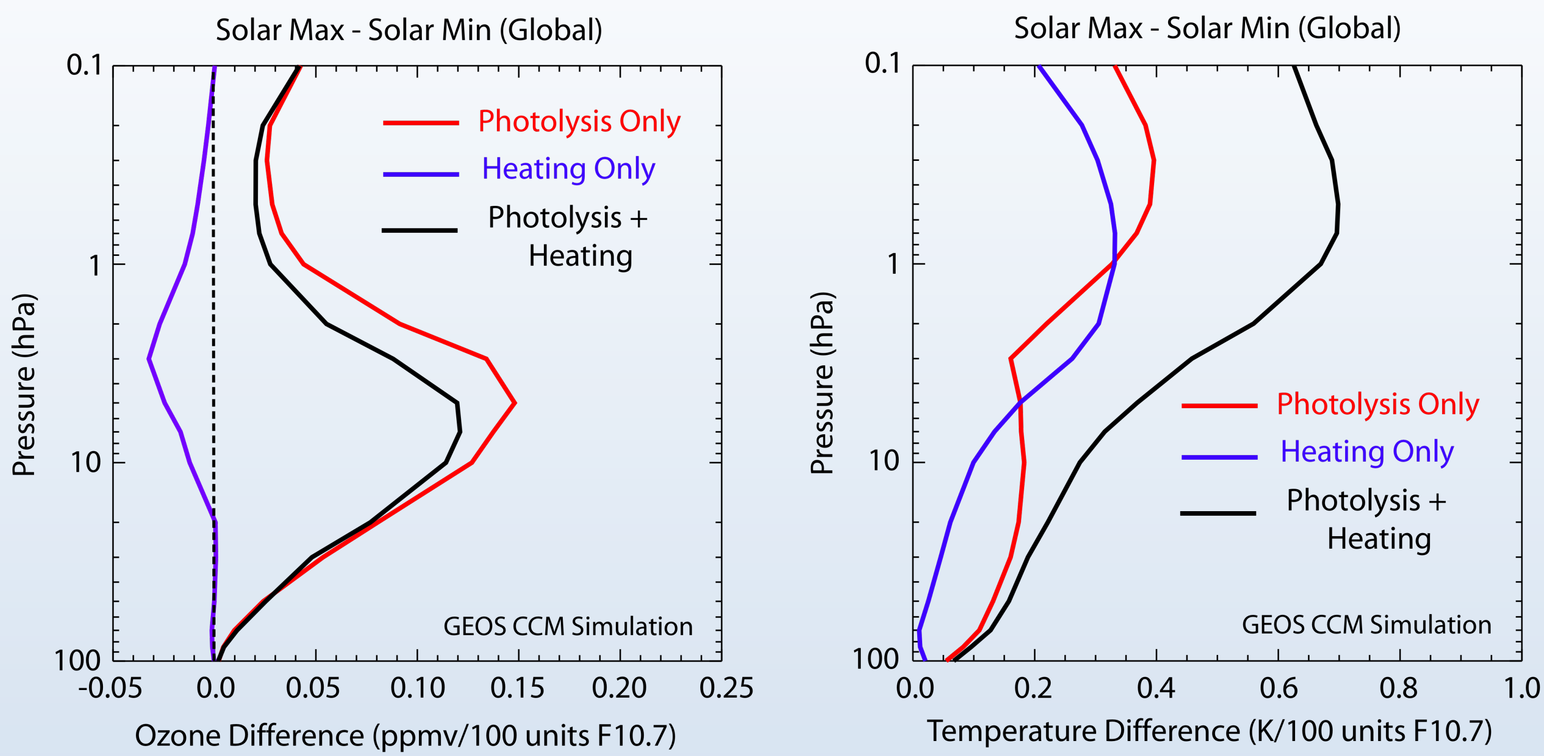
How do stratospheric ozone and temperature respond to the solar cycle?

- Direct heating
  - hν + O_2, O_3 → T increase
  - speeds ozone loss reactions → O_3 decrease
- Photolysis
  - hν + O_2 produces O_3 → O_3 increase
  - More O_3, more heating → T increase

Same direction for temperature

Opposite direction for ozone

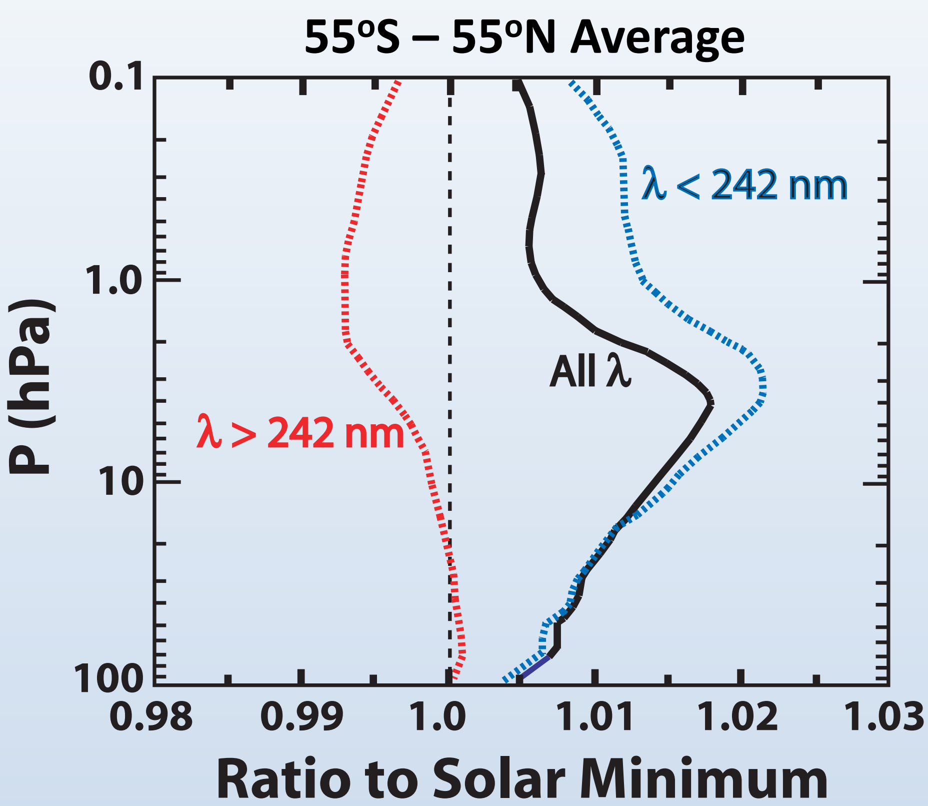
Global Average Response to Solar Variation



Ozone response to heating is much smaller than response to photolysis and in opposite direction.

Temperature response to photolysis is comparable to and is in same direction as response to heating.

Impact of Solar Flux Depends on Wavelength

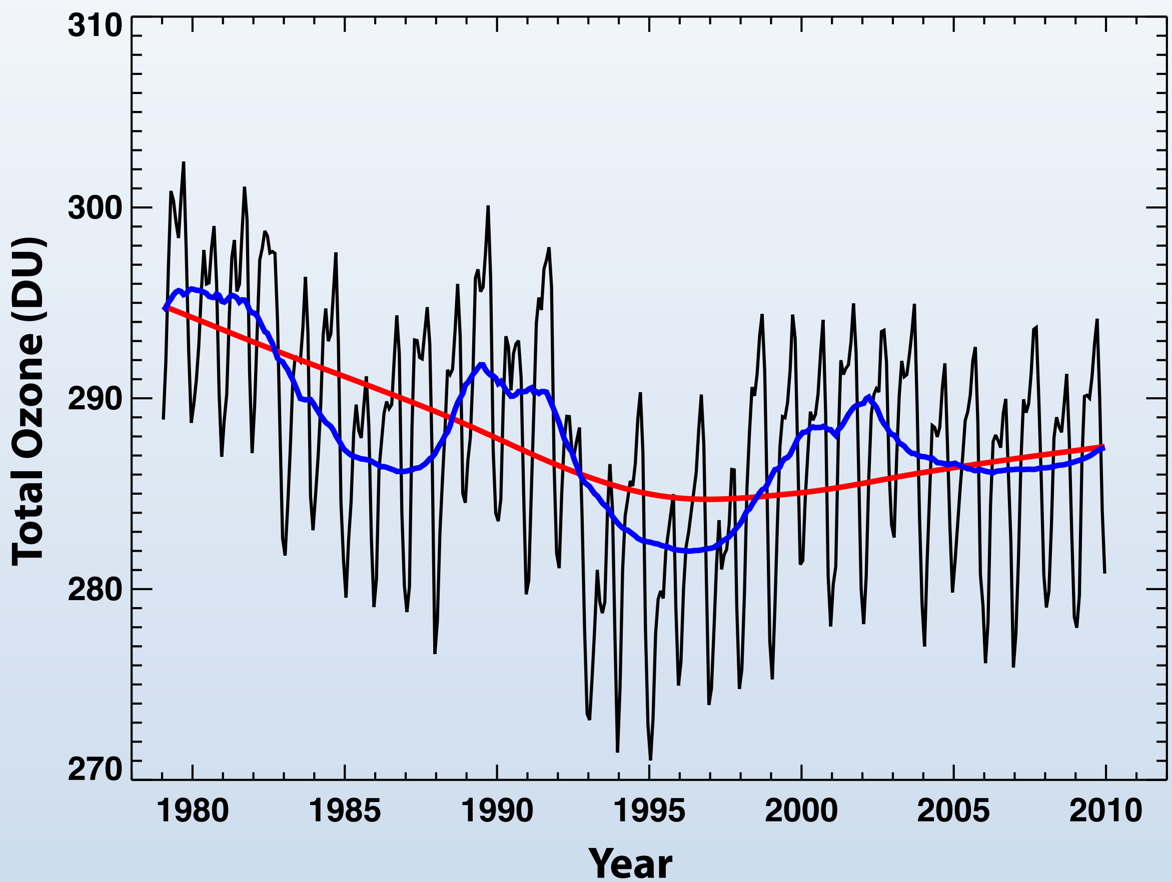


λ < 242 nm → J_{O2} and J_{O3} perturbations: J_{O2} dominates leading to ozone increase at solar maximum

λ > 242 nm → J_{O3} perturbation only: leading to ozone decrease at solar maximum

All λ is based on Lean's breakdown of UV changes for wavelengths > 242 nm vs those for wavelengths < 242 nm

Fitting the Quasi-Global Data



Fit with seasonal cycle removed