Environmental Factors
Other factors – Ozone and UV-B Radiation

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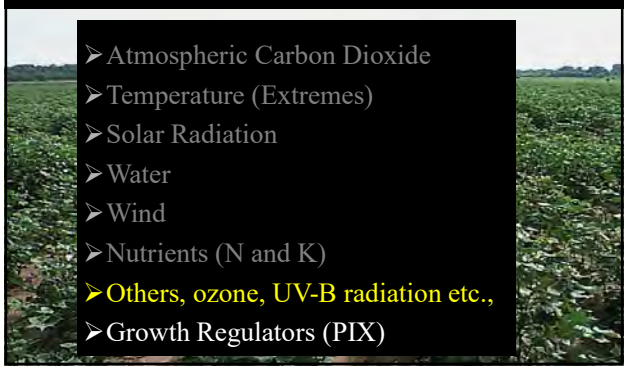
Environmental and Cultural Factors Limiting Potential Yields



- Atmospheric Carbon Dioxide
- Temperature (Extremes)
- Solar Radiation
- Water
- Wind
- Nutrients (N and K)
- Others, ozone, UV-B radiation etc.,
- Growth Regulators (PIX)

Ozone and Ultraviolet-B Radiation - Objectives

The objectives of this lecture are to:

- Learn about the ozone story and climate change.
- Learn global and regional trends in ozone and ultraviolet-B levels.
- Influence of ozone and ultraviolet-B on plants.

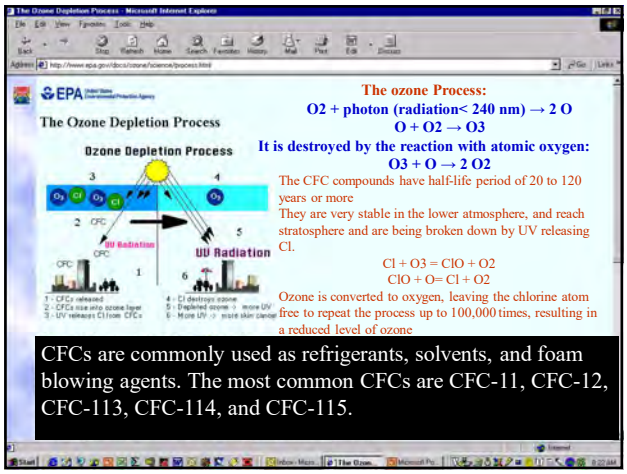
The Ozone Story

The ozone story and the greenhouse effect are two separate phenomena, though confused with one another.

Ozone plays two roles in the atmosphere:

1. Near the ground, ozone is an air pollutant and a minor greenhouse gas.
2. In the upper atmosphere, particularly in the stratosphere (15-40 km or 10-25 miles above the Earth's surface), it forms a layer that helps protect us and other organisms from the deleterious effects UV radiation which causes increased skin cancers and cataracts and potential damage to some marine organisms, plants, and plastics, by absorbing UV radiation from the Sun.

The current research evidence shows that the ozone layer is gradually thinning and more UV is reaching the earth surface.



CFCs are commonly used as refrigerants, solvents, and foam blowing agents. The most common CFCs are CFC-11, CFC-12, CFC-113, CFC-114, and CFC-115.

Other Ozone Depleting Chemicals

Other chlorine-containing compounds include Methyl Chloroform, a solvent, and Carbon tetrachloride, an industrial chemical. Halogen, extremely effective fire extinguishing agents, and Methyl bromide, an effective produce and soil fumigant, contain bromine. All of these compounds have atmospheric lifetimes long enough to allow them to be transported by winds into the stratosphere. Because they release chlorine or bromine when they break down, they damage the protective ozone layer.

At the Earth's Surface

The ozone Process:

N_2O + photon (radiation, >240 and <310 nm) → NO + O

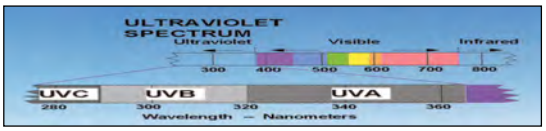
O + O_2 → O_3

NO + O_3 → N_2O + O_2

NOx + VOC + Photon (Sun Light) → O_3 + Other compounds

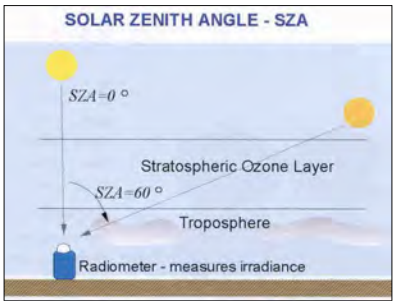
- Ground-level ozone is considered "bad."
- Motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents as well as natural sources emit NOx and VOC that help form ozone.
- Ground-level ozone is the primary constituent of smog. Sunlight and hot weather cause ground-level ozone to form in harmful concentrations in the air.
- As a result, it is known as a summertime air pollutant. Many urban areas tend to have high levels of "bad" ozone, but even rural areas are also subject to increased ozone levels because wind carries ozone and pollutants that form it hundreds of miles away from their original sources.

Ultraviolet Radiation

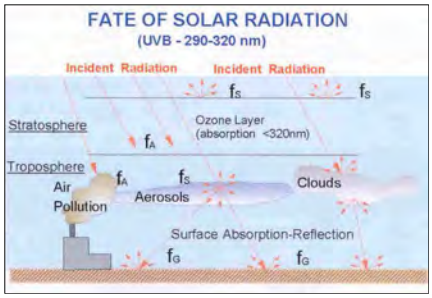


- **UVC: <280), UVB: 280-320, and UVA: 320-400.**
- UVA is not absorbed by ozone.
- UVB is mostly absorbed by ozone, although some reaches the Earth.
- UVC is completely absorbed by ozone and normal oxygen.

The Sun Angle determine the length of the path of radiation and the level of UV-B radiation



Three Major Factors that Affect the Transmission of Solar Radiation to the Earth's Surface



f_A = Absorption by ozone and other pollutants.

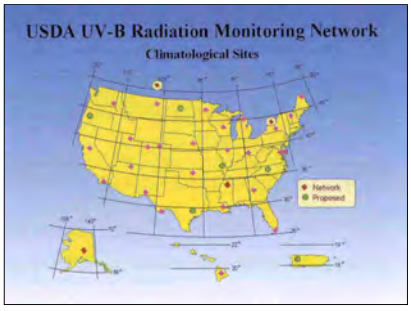
f_S = Scattering back to space by molecules, clouds, and aerosols (haze).

f_g = absorption by the ground.

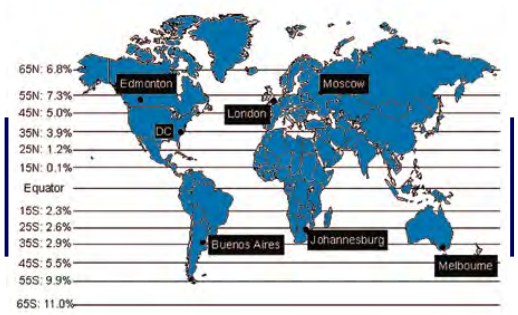
Ultraviolet Radiation - Instrumentation

- Broadband UV meters measure ultraviolet radiation in the UV-B spectral range of 280-330 nanometers.

Ultraviolet Radiation Monitoring Program



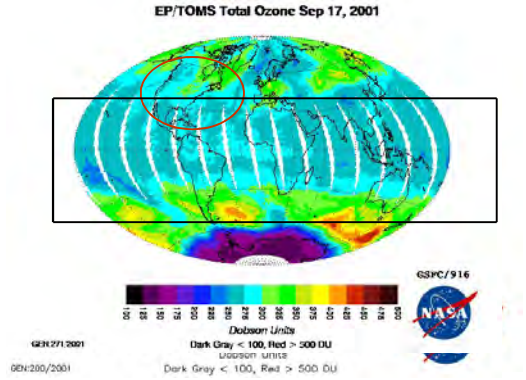
Satellite Based Percent Change in Global UV Radiation – 1986 to 1996



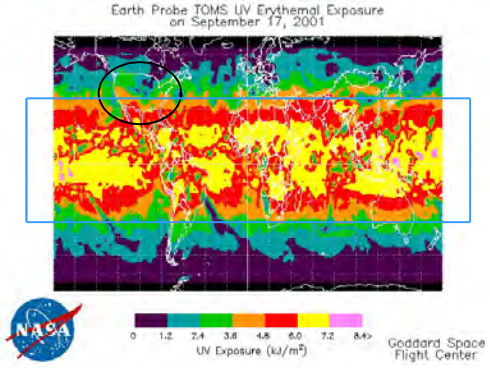
Satellite Based Ozone levels - 2001

- Global data are estimated from satellites such as NASA's TOMS (Total Ozone Mapping Spectrometer), GOME (Global Ozone Monitoring Experiment) and Aura, launched in 2003, satellites.
- These satellite measurements are compared to ground-based measurements to ensure that the satellite data are valid.

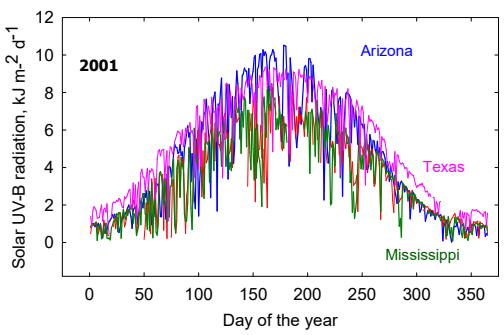
Satellite Based Ozone levels - 2001



Satellite Based UV Radiation levels - 2001



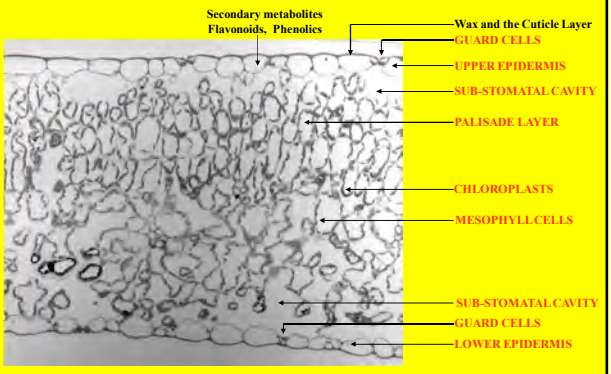
Temporal and Spatial Trends in UV-B Radiation in the US



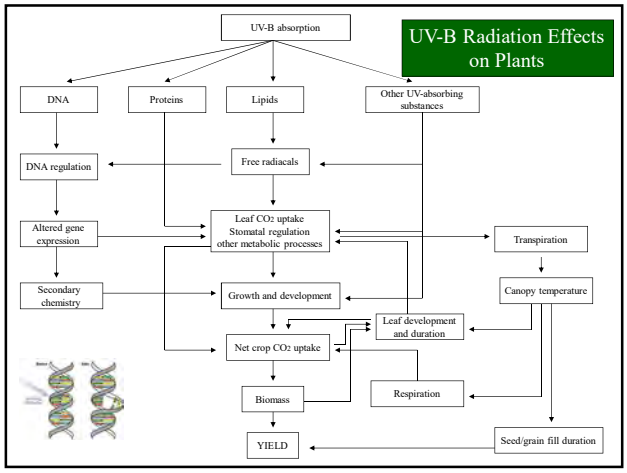
Ultraviolet Radiation and Ozone - Plants

Current evidence suggest that several plants are sensitive to changes in ozone and UV-B light and the responses with other environmental variables are not always additive.

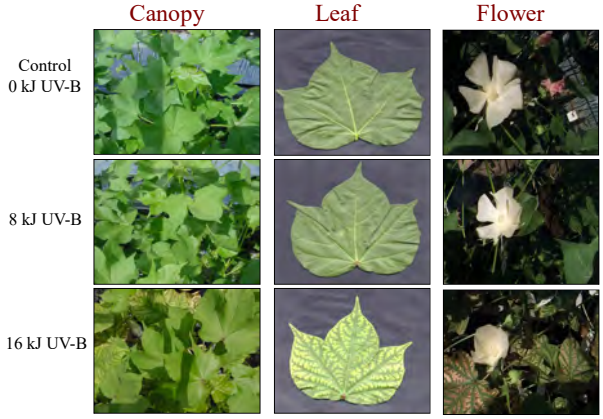
Leaf Components Affecting Spectral Properties and UV-B Penetration



UV-B Radiation Effects on Plants



UV-B Radiation Effects on Cotton Growth



Ozone and UV-B Radiation

Suggested Reading Material

UNEP Websites:

- http://www.gcrio.org/UNEP2002/index.html
- http://uvb.nrel.colostate.edu/

Recent Articles:

- http://www.gcrio.org/UNEP2002/13unep2002QAs.pdf
- Kakani, V. G., K. R. Reddy, D. Zhao and K. Sailaja. 2003. Field crop responses to ultraviolet-B radiation: A review. **Agricultural and Forest Meteorology** 120: 191-218.