Effects of Ozone Depletion on Humans

New Mexico Military Institute (Team #20)

Supercomputing Challenge Final Report

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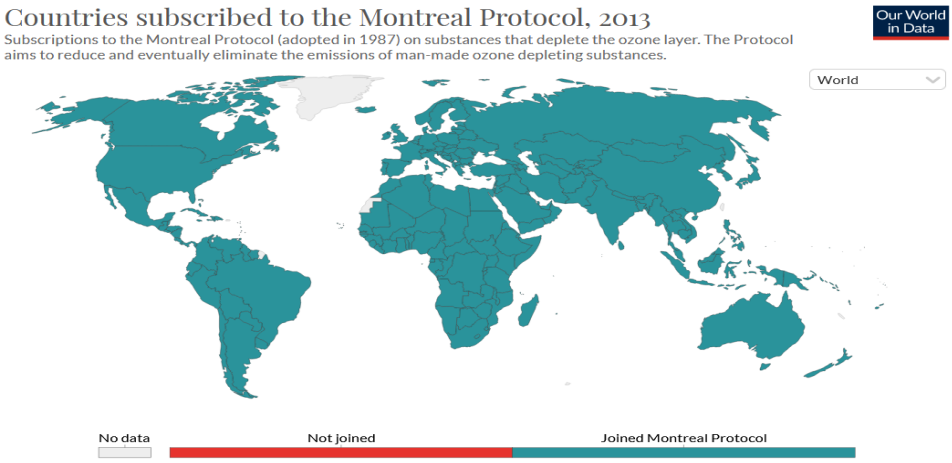
Contents

1. Executive Summary

Until nowadays, ozone depletion is one of the major environmental problems in our world. During 1980s, scientists discovered the holes and the thinning in the ozone layer which became a huge issue.



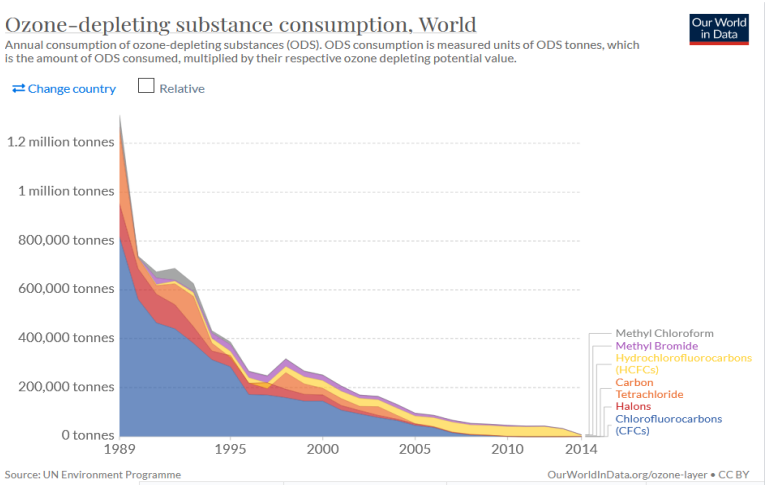
There have been numerous efforts around the world to prevent the ozone depletion such as the Montreal Protocol which was an international agreement to cease the import and consumption of the harmful chemical substances to protect stratospheric ozone layer. These attempts awaken seriousness of the problem as well the significance of the ozone layer. Ozone is a highly reactive gas composed of three oxygen atoms that causes various health problems on humans, mainly a skin cancer subject to different types of UV lights such as UVA, UVB, and UVC. Because of the increase in the depletion rate in ozone and critical health defects on humans from the ozone depletion, our team decided to work on finding solutions that will decrease the rate of ozone depletion, analyzing the results of the damages from various UV lights into our skin layers. Our team used Netlogo-based program to create a model that visualizes how much damage do different UV lights do both with and without the ozone layers. From our research and program that we made, we found out that change of the air conditioning fluid from

Freon (R-22) to Puron (R-410A) will lower the ozone depletion rate because Puron is more energy efficient as well environmentally friendly substance that does not deplete the ozone. Moreover, we discovered that sunscreen is crucial to protecting the layers of our skin. We believe that our program will help make aware of the severity of the ozone depletion and will help to provide as a guide to align others to create potential solutions.

2. Introduction

2.1 About Ozone

Ozone is defined as a highly reactive gas composed of three oxygen atoms and it is written as O_3 in a chemical formula. Ozone is located both in atmosphere where people breathe in the air and in stratosphere where which helps filtering out the damaging ultraviolet radiation from the sun.



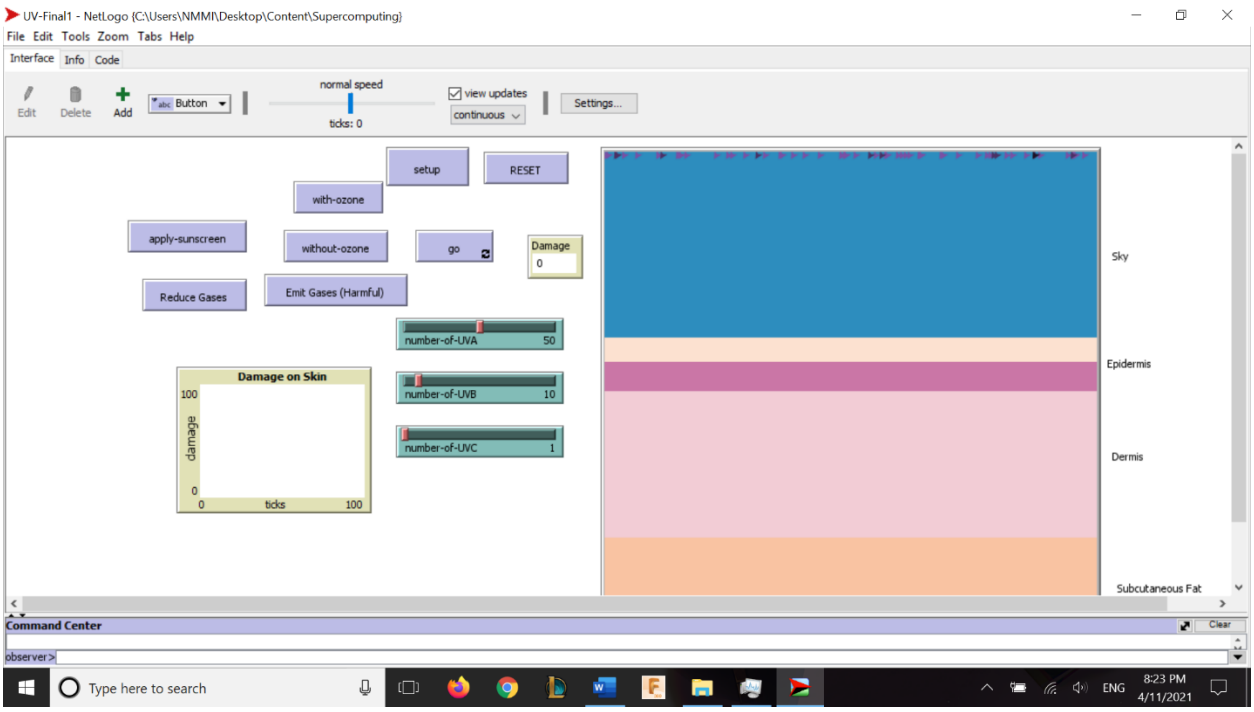
Harmful chemicals such as chlorofluorocarbon (CFC) and Hydrofluorocarbon (HCFC) interacting with the sunlight emit chemicals to the environment accompanied by high concentration of pollutants. Ozone layer plays significant role by protecting our environment and humans from the ozone. For example, it prevents Earth from ultraviolet (UV) rays, allows life to be existent, and lastly protects humans from different types of skin damage such as aging and burning. This tells us how essential ozone layers are in our world as well how critical ozone depletion is.

2.2 Statement of the Problem

The chemical equation $Cl + O_3 = ClO + O_2$ explains how chlorofluorocarbon destroys the ozone layer. When the molecule of chlorine monoxide (ClO) meets another molecule of oxygen (O), it breaks up, releasing chlorine (Cl), which can “destroy” another molecule of ozone (O3), creating the catalytic cycle of chlorine. This equation shows how chlorine itself as can harm humans’ health as well continues to break the ozone. Skin problem is one of the huge health issues people get varied by different types of UV rays. UVA, UVB, and UVC’s different frequency and strength damages on humans’ skins differently such as skin aging and skin cancer. So, harmful chemical substances exposed from ozone depletion and respective levels of damage from different UV rays are the main problems our team has discovered from our project.

3. Methods

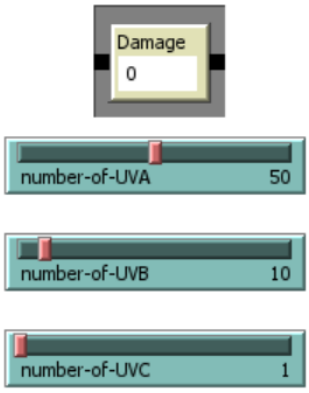
3.1 The Interface



The language used for this simulation is Netlogo. When the program is loaded, it will show the interface with some buttons, sliders, screen, and graph. To set up the program, press setup and reset button to enable the go button. When the go button is pressed, it will run the program. There are going to be three kinds of turtles. The violet one, dark purple one, and black one. Violet is UVA which penetrates the most in the skin but does the most damage. Dark purple is UVB which penetrates through epidermis and known to be the main factor of skin cancer. Black is UVC which would do the most damage if it penetrated skin, but it is usually reflected on the surface of the skin. When the skin absorbs the UV light the damage will increase. UVA does 1 damage when absorbed, UVB does 10 and UVC does 100. Even though you might see more UVA penetrating and being absorbed deep inside the skin, UVB would do most of the damage. UVC would be reflected most of the time so it doesn't do much damage. The base setting is

with-ozone, which means there is ozone layer, and it is fine. When pressed without-ozone, there is no ozone layer and all the UV would come straight to the skin, which is critical. The apply-sunscreen button applies a white layer on the skin which is sunscreen. We used the most common Sun Protection Factor rate which is SPF 30 and it blocks 98% of UVB. When applied, it will show significantly low damage compared to the first. Since SPF only measures UVB.

3.2 Variables




```
breed [beam sunlight]
globals [damage]
turtles-own [penetration chance-of-absorbing]
```

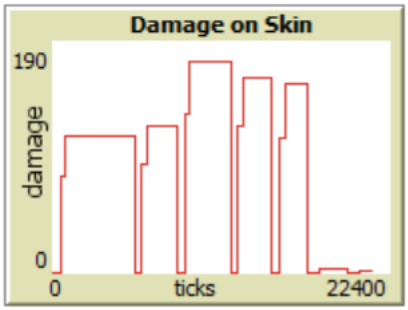
The variables used in this program are number of UVA, UVB, UVC, damage, beam, sunlight, penetration, chance-of-absorbing. Number of UVA, UVB, and UVC is determined by the presence of ozone and harmful gas. It is basically percentage of UV light penetrating the ozone layer so if the number of UVA is 50 it is actually 50% of all UVA coming to the earth. So, if the without-ozone button is pressed, all the number of UV will be 100. When gas is emitted, the number of UV will increase. The turtles are bred to beam, and the shape is also beam. It doesn't have huge difference from the default but the size, so it doesn't look awkward when pen

is down. Every turtle has their own penetration and chance-of-absorbing. Penetration is given to different types of UV. Since UVA penetrates the most through the skin it has 3. UVB has 2 and UVC has 1. Chance-of-absorbing changes the chance of UV to absorb into skin. This variable has been made to change the chance when sunscreen is applied. Normally skin would absorb most of UVA and UVB, but UVC. When the UV is absorbed, it will increase the global variable damage. Since UVA merely does any damage, it increases by 1. UVB does moderate damage so it increases by 10. UVC is critical when absorbed so it increases by 100, but the number of UVC and the chance-of-absorbing is so low that it doesn't do much damage.

3.3 The Code

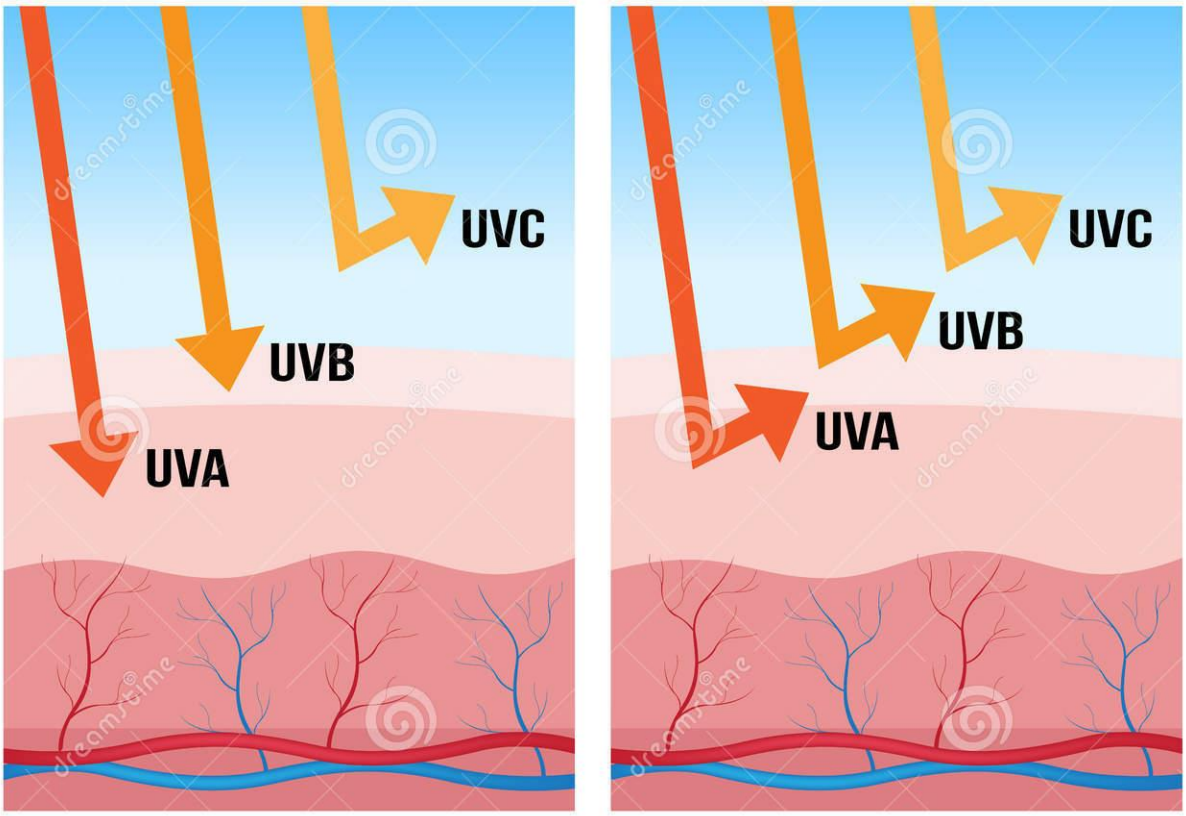
```
breed [beam sunlight]
globals [damage]
turtles-own [penetration chance-of-absorbing]

to setup
  clear-patches
  clear-turtles
  clear-drawing
  set damage 0
  ask patches [
    if pycor > 12 [set pcolor sky]
    if pycor <= 12 [set pcolor 29]
    if pycor < 8 [set pcolor 127]
    if pycor < 2 [set pcolor 138]
    if pycor < -28 [set pcolor 28]
  ]
  set-default-shape beam "beam"
  create-beam number-of-UVA [
    set size 4
    set color 115
    setxy random-xcor 49
    set heading 210
    pen-down
    set penetration 3
  ]
  create-beam number-of-UVB [
    set size 4
    set color 113
    setxy random-xcor 49
    set heading 210
    pen-down
    set penetration 2
  ]


    create-beam number-of-UVC [
    set size 4
    set color 111
    setxy random-xcor 49
    set heading 210
    pen-down
    set penetration 1
  ]
end

to go
  tick
  ask turtles [
    if penetration = 3 and [pcolor] of patch-ahead -0.1 = white [set chance-of-absorbing random 10 if chance-of-absorbing < 1[set heading 330]]
    if penetration = 2 and [pcolor] of patch-ahead -0.1 = white [set chance-of-absorbing random 100 if chance-of-absorbing < 98 [set heading 330]]
    if penetration = 1 and [pcolor] of patch-ahead -0.1 = white [set chance-of-absorbing random 1000 if chance-of-absorbing < 999 [set heading 330]]
    if penetration = 3 and ycor < -24 [set chance-of-absorbing random 3
      ifelse chance-of-absorbing < 2
        [set damage damage + 1
          die]
      [set heading 330]]
    if penetration = 2 and ycor < 8[set chance-of-absorbing random 10
      ifelse chance-of-absorbing < 8
          [set damage damage + 10
            die]
    [set heading 330]]
    if penetration = 1 and ycor < 12[set chance-of-absorbing random 20
      ifelse chance-of-absorbing < 2 and ycor < 12
          [set damage damage + 100
           die]
      [set heading 330]]
    fd 0.1
    If ycor > 49 [stop]
  ]
end
```

```
to with-ozone
  set number-of-UVA 50
  set number-of-UVB 10
  set number-of-UVC 1
  setup
end

to without-ozone
  set number-of-UVA 100
  set number-of-UVB 100
  set number-of-UVC 100
  setup
end

to emit-gas
  if number-of-UVA < 100 [set number-of-UVA number-of-UVA + 5]
  if number-of-UVB < 100 [set number-of-UVB number-of-UVB + 2]
  if number-of-UVC < 100 [set number-of-UVC number-of-UVC + 1]
  setup
end

to reduce-gas
  if number-of-UVA > 0 [set number-of-UVA number-of-UVA - 1]
  if number-of-UVB > 0 [set number-of-UVB number-of-UVB - 1]
  if number-of-UVC > 0 [set number-of-UVC number-of-UVC - 1]
  setup
end
to apply-sunscreen
  ask patches[
   if pycor <= 14 and pycor > 12 [set pcolor white]
  ]
end
```



The setup button does not simply clear all. It is to avoid it from resetting the ticks. The ticks need to be kept for the graph. With the go command keep on running, as long as the reset button is not clicked, the graph will not reset so it makes it easier to compare the damage on skin when the number of UV is different, or sunscreen is applied. The setup button also colors the patches to label the skin layers and creates the turtles with the numbers given by number of UV. To prevent unnecessary process the turtles will die when absorbed and stop moving when it reaches the end of sky after being reflected. The apply-sunscreen button adds a white layer and when the turtle passes through, it will be reflected. Since 98 percent of UVB is blocked by SPF 30 sunscreen, most of UVB and UVC will be reflected, but some of UVA will still penetrate, but not as much as before.

4. Results & Significance



Our team was able to create a program that calculates the amount of UV rays that enter the human skin. More specifically, we differentiated the UV-A, UV-B, and UV-C rays that penetrate our skin, when it is exposed to the ultraviolet light from the sun due to the excessive depletion of Earth's ozone layer. The program divides the layers of the skin into the epidermis, dermis, and the subcutaneous fat. When the three UV rays penetrate the skin from the sky, there is a different rate of diffusion for each type of UV ray and layer of the skin. From those different reflection or penetration rates, we were able to calculate the amount of damage UV rays have on our skin when the surface of the skin was applied with and without sunscreen with different depletion rates of the ozone.

We were able to derive relative numerical values of the damage that was done to the skin. Ultimately, when the ozone layer was less depleted the damage done to the skin was

approximately 113 whereas, when the ozone layer was “weak” the relative damage was between five hundred to two thousand depending on how much the ozone layer had been depleted; when sunscreen was applied to the surface of the skin, we observed that approximately 82% of the original damage (the damage done without the sunscreen) was reduced. From this agent-based program that visualizes the amount of relative damage that could be done to our skin, we hope that this could be a step forward into making aware of the severity of ozone depletion and how much harm it could give to humans.

5. Acknowledgement

Our team would like to first give a huge thanks to the New Mexico Supercomputing Challenge organization for providing valuable resources and keep notifying our team with updated news, align us to come this far in our journey. We would also like to thank our school-teachers CPT Mark Stone, who always helped us to stay on track with everything we needed to for this project as well assisting us on programming and researching. Also, LTC Mia Yang who gave us feedbacks on what we can improve for our project as well as assisting us with our research.

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