WEARABLE TECHNOLOGY

Problem Statement

- Augmented reality (AR) is implemented in the training regime for astronauts to prepare for the environmental conditions of space. A culprit in the malfunction of the internal components of the virtual reality headsets is sweat. The VR Wearable technology team aims to create a cost-effective design implementing Arduino sensors and certain fabrics surrounding the headset to mitigate sweat secretion while not sacrificing mobility, comfort, or time. Sweat will be detected as it reaches a critical level where the internal components can be potentially compromised.

Physiological aspects of sweat

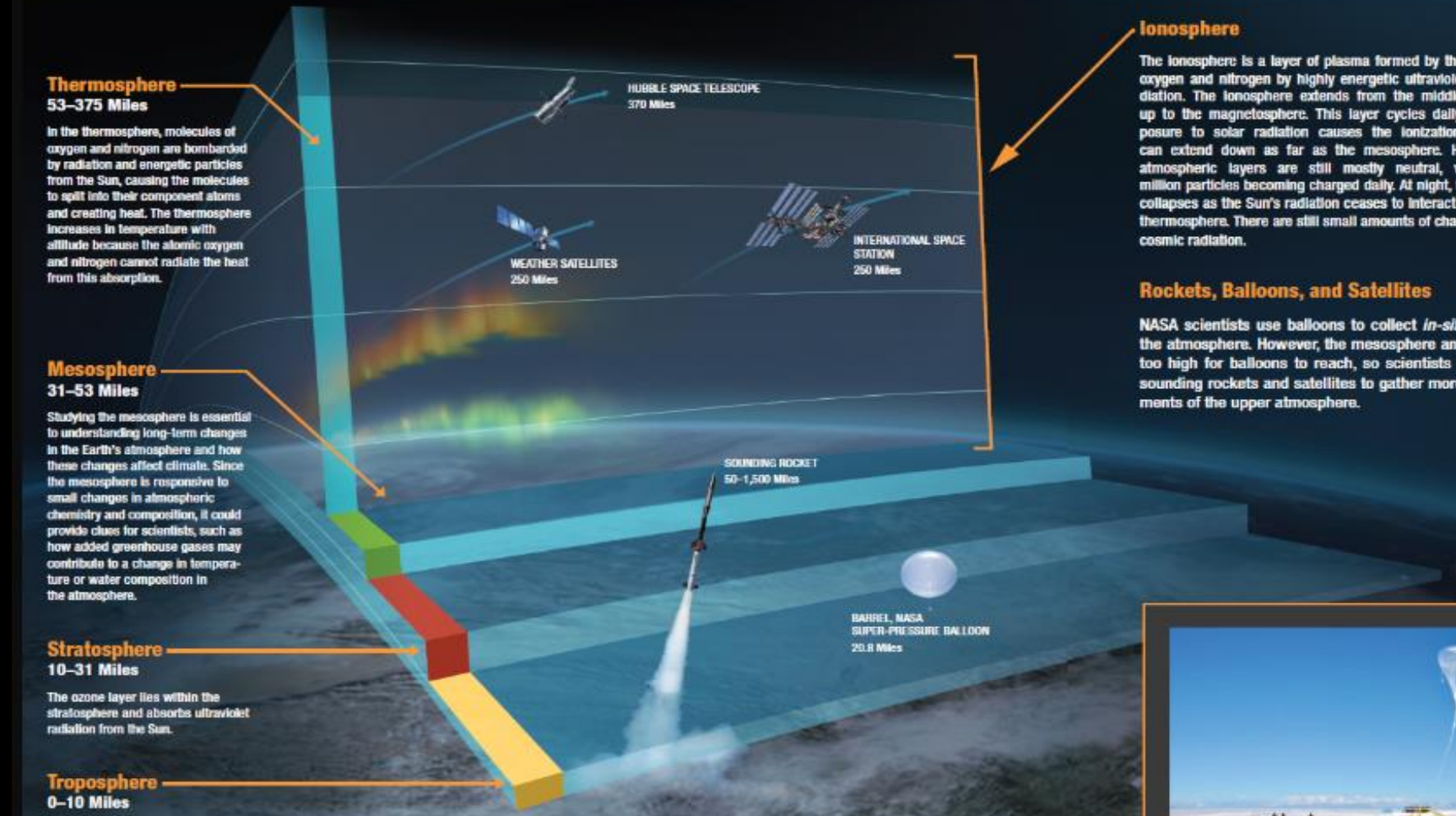
- Human body is constantly regulating its internal temperature.
- Increase in environmental temperature greater than the skin temperature → heat retention via radiation and conduction → increase in internal body temperature
- Body lowers internal body temperature through heat loss via evaporation (or sweat)
- Components of sweat:
  - Sodium - Chloride - Urea - Lactic acid - Potassium ions
- Air is circulated adjacent to the skin → heat loss via convection.
- Certain clothing traps more air next to skin → decreases the rate of heat loss → increase internal body temperature

Upper Atmosphere

The Earth's atmosphere has four primary layers: the troposphere, stratosphere, mesosphere, and thermosphere. These layers protect our planet by absorbing harmful radiation.

Aeronomy of Ice in the Mesosphere (AIM)

NASA's Aeronomy of Ice in the Mesosphere (AIM) satellite can remotely sense night-shining clouds in the mesosphere. These noctilucent clouds are made of ice crystals that form over the summer poles at an altitude too high and a temperature too cold for water-vapor clouds.



Thermosphere
53–375 Miles

In the thermosphere, molecules of oxygen and nitrogen are bombarded by radiation and energetic particles from the Sun, causing the molecules to split into their component atoms and creating heat. The thermosphere increases in temperature with altitude because the atomic oxygen and nitrogen cannot radiate the heat from this absorption.

Mesosphere
31–53 Miles

Studying the mesosphere is essential to understanding long-term changes in the Earth's atmosphere and how these changes affect climate. Since the mesosphere is responsive to small changes in atmospheric chemistry and composition, it could provide clues for scientists, such as how added greenhouse gases may contribute to a change in temperature or water composition in the atmosphere.

Stratosphere
10–31 Miles

The ozone layer lies within the stratosphere and absorbs ultraviolet radiation from the Sun.

Troposphere
0–10 Miles

The troposphere is the layer of the Earth's atmosphere where all human activity takes place.

Ionosphere

The ionosphere is a layer of plasma formed by the ionization of atomic oxygen and nitrogen by highly energetic ultraviolet and x-ray solar radiation. The ionosphere extends from the middle of the mesosphere up to the magnetosphere. This layer cycles daily as the daytime exposure to solar radiation causes the ionization of the atoms that can extend down as far as the mesosphere. However, these upper atmospheric layers are still mostly neutral, with only one in a million particles becoming charged daily. At night, the ionosphere mostly collapses as the Sun's radiation ceases to interact with the atoms in the thermosphere. There are still small amounts of charged atoms caused by cosmic radiation.

Rockets, Balloons, and Satellites

NASA scientists use balloons to collect *in-situ* measurements in the atmosphere. However, the mesosphere and thermosphere are too high for balloons to reach, so scientists use instruments on sounding rockets and satellites to gather more detailed measurements of the upper atmosphere.

Communication

A unique property of the ionosphere is that it can refract short-wave radio waves, enabling communication over great distances by "bouncing" signals off this ionized atmospheric layer. Variability of the ionosphere can interrupt satellite communication, such as errors in GPS signals for commercial air navigation. During solar storms, this layer can even shut down communication between ground stations and satellites.

Noctilucent Clouds in the Mesosphere

Evidence of change in the behavior of noctilucent clouds has been observed by the AIM mission. Recent data show dramatically lower ice content, leading scientists to speculate about changes in weather conditions and pole-to-pole atmospheric circulation.

BARREL

The Balloon Array for Radiation-belt Relativistic Electron Losses (BARREL) is a balloon-based mission to augment the measurements of NASA's RBSP spacecraft. BARREL seeks to measure the precipitation of relativistic electrons from the radiation belts during two multi-balloon campaigns operated in the Southern Hemisphere.

Outgassing Emissions

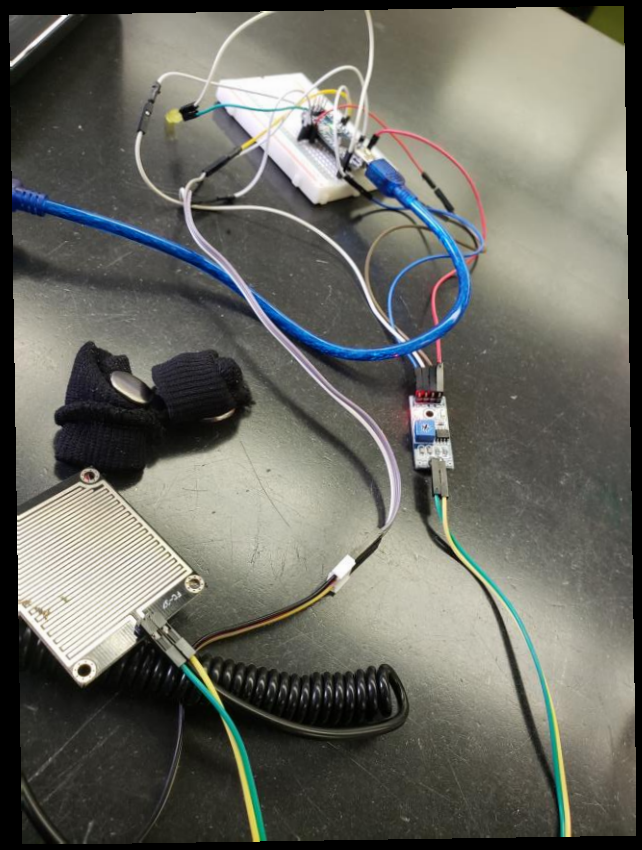
- Off-gassing is what occurs when materials are subjected to the Earth's atmosphere. Outgassing is what occurs when materials are subjected to the vacuum of space. Outgassing occurs due to extreme temperature fluctuations created by the sun's unfiltered radiation.
- Chemical compounds can produce significant off-gases that can accumulate in an isolated environment which lacks free-flowing air circulation. This accumulation can create a poisonous environment for astronauts.

Design Requirements

- Cost-effective
- Must not limit mobility
- Materials used must not release more than the acceptable levels of outgases
- Easy to sanitize

Hardware

- Arduino Nano
- LED/Cellphone Buzzer
- Arduino water Sensor
- Galvanic Sensor
- Welding Cap
- Coolant Towel



Software

Coding used to detect sweat and relay signal when sweating: As the sweat level increase both the water and galvanic sensor begin reading levels. The thresholds' are designed to alert the wearer of too much sweat .

```
// sweat Detection Module
const int LED=12;
const int GSR=A2;
int threshold=0;
int sensorValue;
int sweatsense= A0; // analog sensor input pin 0
int buzzerout= 10; // digital output pin 10 - buzzer output
int countval= 0; // counter value starting from 0 and goes up by 1 every second
int ledout= 11; // digital output pin 11 - led output


void setup(){
   Serial.begin(9600);
   pinMode(LED, OUTPUT);
   pinMode(LED, OUTPUT);
   pinMode(sweatsense, INPUT);
   long sum=0;
    pinMode(LED,OUTPUT);
  digitalWrite(LED,LOW);
  delay(1000);
    for(int i=0;i<500;i++)
  {
  sensorValue=analogRead(GSR);
  sum += sensorValue;
  delay(5);
  }
  threshold = sum/500;
   Serial.print("threshold =");
   Serial.println(threshold);
}

void loop(){
   int temp;
  sensorValue=analogRead(GSR);
  Serial.print("sensorValue=");
  Serial.println(sensorValue);
  temp = threshold - sensorValue;
  if(abs(temp)>60)
  {
    sensorValue=analogRead(GSR);
    temp = threshold - sensorValue;
    if(abs(temp)>60){
    digitalWrite(LED,HIGH);
    Serial.println("Emotion Changes Detected!");
    delay(3000);
    digitalWrite(LED,LOW);
    delay(1000);
  }
 }
  int sweatSenseReading = analogRead(sweatsense);
  Serial.println(sweatSenseReading); // serial monitoring message
  delay(250);// sweat sensing value from 0 to 1023.
  // from heavy sweat - no sweat.
  if (countval >= 35){
     Serial.print("Heavy sweat");
     digitalWrite(LED, HIGH);  //raise an alert after x time
     digitalWrite(LED, HIGH);  // led glow
  }
  //sweating for long begin buzzing
  // there is no sweat then reset the counter value
  if (sweatSenseReading <500){
     countval++; // increment count value
  }
  else if (sweatSenseReading >500) { // if not sweating
     digitalWrite(LED, LOW); // turn off buzzer
     digitalWrite(LED, LOW); // turn off led
     countval = 0; // reset count to 0
  }
  delay(1000);
}
```

Methods (Experiment 1)

- The towels were compared to see which would be better for the project.

2= exceed the requirements

1= pass the requirements

0= failed the requirements

Compare	Absorber	Cool	Aqua Dry
Should cool a person down	0	2	2
should hold over 100 mL of liquid	2	2	2
the amount of water held after 2 minutes	150mL	250mL	300mL

Methods (Experiment 2)

- The requirement of the project with the VR sweat protector vs. Just wearing the VR headset.

2 = exceed the requirements

1= passed the requirements

0 = failed the requirements

REQUIREMENTS	SWEAT GLADIATOR	With just the VR headset
Should be removable under 2 minutes	2	2
Should have removing indication	2	0
Should be washable	2	0
Should kills 95< bacteria when being washed	2	0
Should not cause outgasses	1	2

Results

We found the coolant towel to be best material to integrate along with the wearable tech to mitigate sweat. It exceeded the requirements and did not trap as much water as the aqua dry fabric. Additionally, a manageable amount of outgasses were produced and removal of moisture was done quickly.

Acknowledgments

- Cody Burkhart – NASA Engineer, VR Division
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