



Creative Data Display with the Parker Solar Probe Challenge



# Earth, Wind & Flare

Feel the wind, get to know it, and stay ahead!



Boston, MA, USA & Sagamihara, Japan



# Team Members



**Hanna** 7th grader

Likes reading, cooking, camping and arcade games.

Good at coding & tennis.

Studies piano and music theory at New England Conservatory.



**Akari** 7th grader

Plays the piano and badminton.

Likes playing Minecraft and watching Minecraft videos.

Dreams of being a scientist at JAXA.



**Yuto** 6th grader

Loves playing soccer!

Regularly participates and volunteers in a local IoT electronics and coding program.

Supported a fundraising challenge for people in need as a local backer in 2021 and 2022.



**Kurumi** 5th grader

Good at figure skating and coding with Python, Scratch and Unity.

Built an award-winning IoT device (baby monitor) with Raspberry Pi and Kintone.

Likes playing Nintendo Switch games.

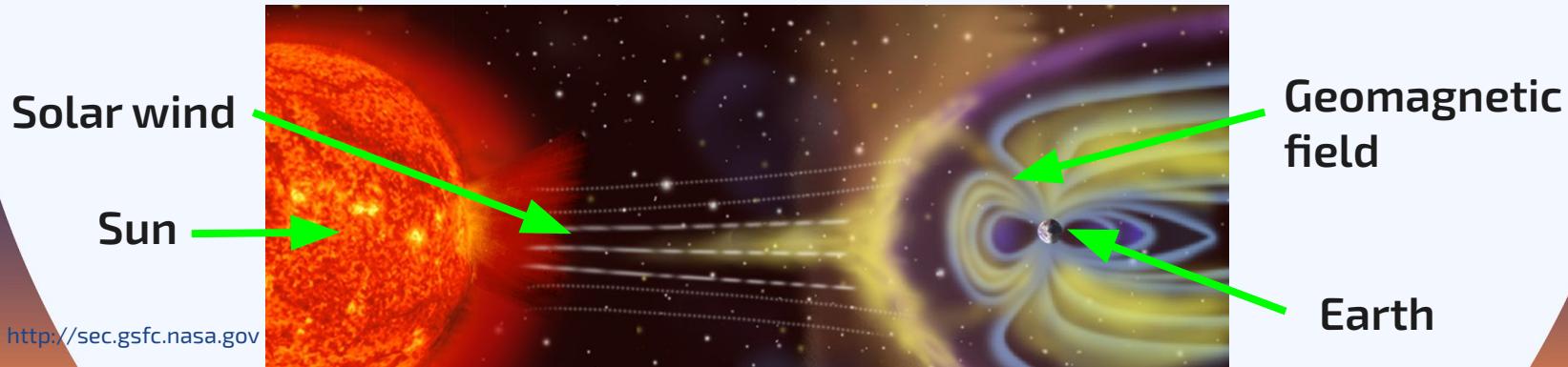
# **Objectives:**

## **Creative Data Display with the Parker Solar Probe Challenge**

- Build an Internet of Things (IoT) device to publicize space weather in an interactive and artistic way.
- Use our diverse skills and experience.
  - Coding (~7 yrs), Raspberry Pi hacks (~2 yrs), music (~10 yrs)
- Ultimately, help raise public awareness of space weather and its impacts on Earth.

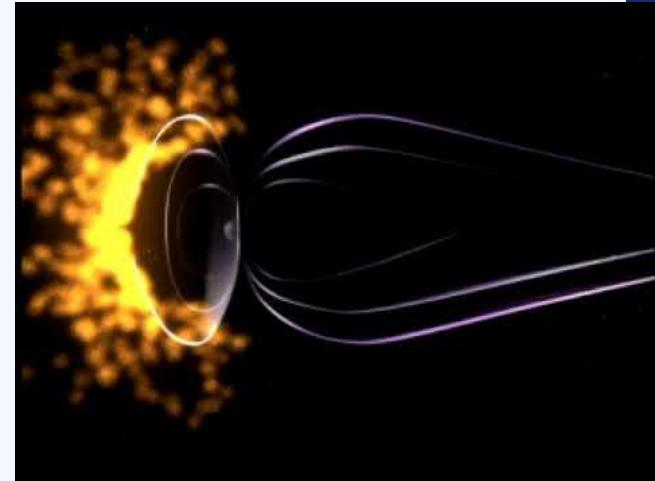
# Space Weather: Solar Wind

- The Sun constantly spreads charged particles from its atmosphere called the corona.
  - This invisible stream is called “solar wind.”
    - Speed: 400 km/h (560 miles/h)
- The geomagnetic field shields the Earth against it.



# Space Weather: Sun Flares and CME

- The Sun gets very active every 11 years or so.
  - Blows up huge flares and shoots out “Sun stuff” like fire balls.
    - This phenomenon is called “Coronal Mass Ejection (CME)”.
- CME increases the speed and density of solar wind A LOT.
- Solar wind can disturb the geo-magnetic field and enter Earth's atmosphere.
  - This is called “geomagnetic storms”.



Credits: NASA/ Walt Feimer

# Impacts of Geomagnetic Storms

- Blackout due to power plant and grid failures
  - 9M people affected for 9 days in Quebec, Canada, in '89
  - Equipment damage at a nuclear power plant in NJ, '89
  - Possible secondary disasters
    - Outage of cloud platforms, cell phone towers, etc.
    - “Geomag storm day” at school!
- Communication disruption with satellites
  - US weather forecast satellite ('89), GPS ('00), JAXA ('03), etc.
- Satellite drag and lost
  - JAXA ('00), SpaceX ('22), etc.



# Issues

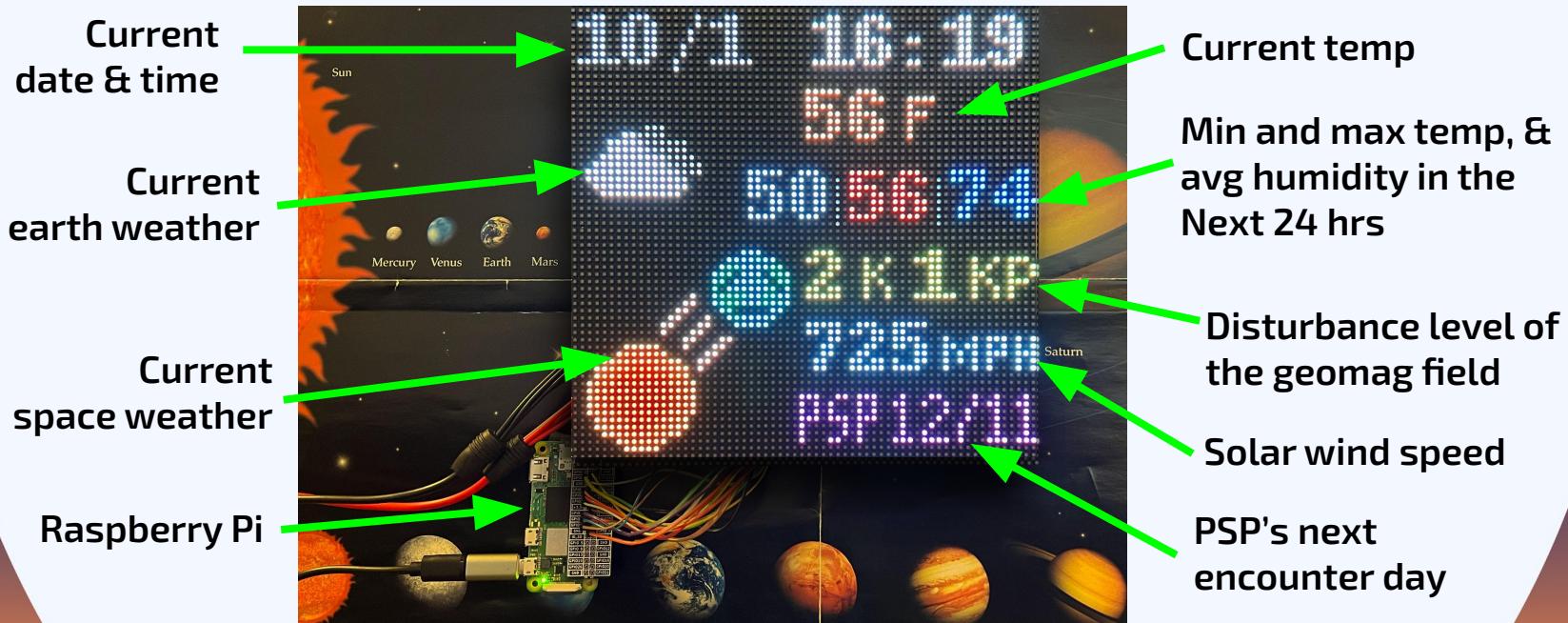
- Most people don't know about space weather.
  - Most of our parents, grandparents, friends and teachers didn't.
- Geomag storms will happen around 2024 or 2025, more or less.
- Many are not prepared enough; some may be in panic.

# Solution Ideas

- Build an LED panel that shows both earth and space weather with visual and acoustic effects.
  - Help LED panel viewers know and interpret space weather as they do for earth weather.
  - Help them get informed and prepared as individuals.

# Our LED Panel: Overview

- A 64x64 LED matrix board that a Raspberry Pi controls.
  - Upper half for earth weather, and bottom half for space weather



# Python Programs

- Wrote Python programs to download earth and space weather data and display that on a LED panel.
  - Earth weather data: OpenWeatherMap.org
  - Space weather data:
    - Geomag disturbance (K-index) in the US and Japan:
      - NOAA and Kakioka Geomag Observatory
    - Planetary K-index (Kp-index):
      - NOAA, German Research Center for Geosciences
    - Solar wind speed:
      - NOAA; Data from NASA's ACE satellite
    - Parker Solar Probe's (PSP's) next encounter day:
      - NASA Website
    - Video of solar corona: PSP Science gateway Website

```
def getSolarWindData(metric):
    solarWindSpeed = "0"
    year, month, day, hr, min = getCurrentTime()
    if int(month) // 10 == 0:
        month = "0" + str(month)
    solarWindFileNameToDownload = year + month + "_ace_swe"

    with ftplib.FTP() as ftp:
        try:
            ftp.connect(noaaFtpHost, port)
            ftp.login(user, passwd)
            ftp.cwd(noaaSolarWindDir)
            with open(solarWindFileName, "wb") as f:
                ftp.retrbinary("RETR " + solarWindFileName,
                           f.write)
        except ftplib.all_errors as e:
            print("FTP error: ", e)

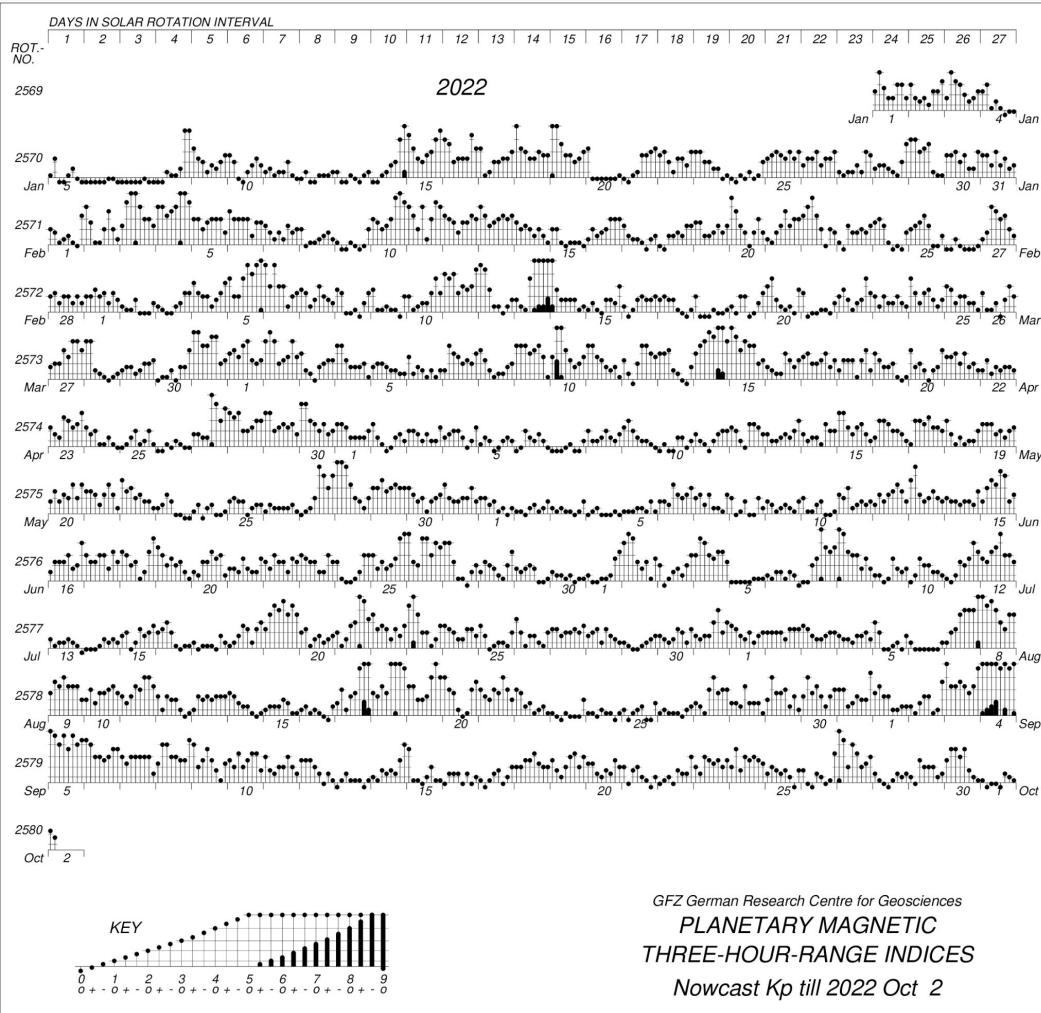
        with open(solarWindFileName) as f:
            lines = f.readlines()

        lineIndex = len(lines) - 1
        while not lines[lineIndex].startswith("#"):
            speed = lines[lineIndex].split()[8]
            if speed != "-9999.9":
                solarWindSpeed = speed
                break
            else:
                lineIndex = lineIndex - 1

        solarWindSpeed = float(solarWindSpeed)
        if metric == "imperial":
            solarWindSpeed = solarWindSpeed * 1.609
            solarWindSpeed = int(solarWindSpeed)
            print("Solar wind speed (mph): ", solarWindSpeed)
        elif metric == "metric":
            solarWindSpeed = int(solarWindSpeed)
            print("Solar wind speed (kph): ", solarWindSpeed)
    return solarWindSpeed
```

# Interactive and Artistic Features

- Motion-activated.
  - A motion sensor is connected to Raspberry Pi.
  - RapPi turns on the panel when the sensor detects nearby motion.
- Shows GIF animation files as videos.
- Produces a piece of “music” with downloaded Kp values and plays it with a Bluetooth speaker.
  - The Kp graphical notation looks like an ancient musical score.
  - This motivated us to map Kp values to musical notes, considering 3 properties of sound: pitch, duration and intensity.



GFZ German Research Centre for Geosciences  
**PLANETARY MAGNETIC**  
**THREE-HOUR-RANGE INDICES**  
 Nowcast Kp till 2022 Oct 2

# Demo Video

## Earth weather & Decoration



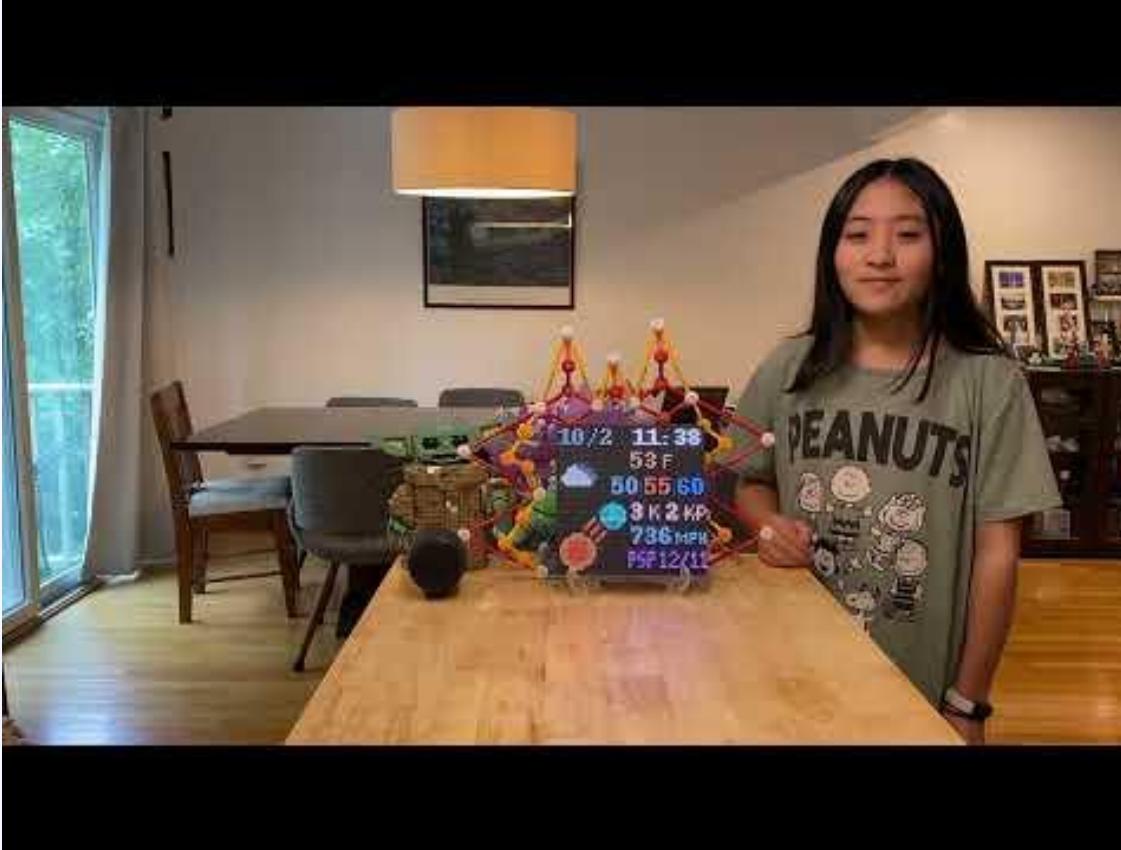
## Sensor monitor & Space weather



## 64x32 Panel / Data in Japan

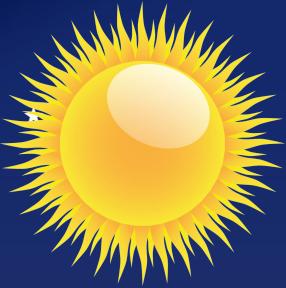


## Kp values to Musical notes



# Future Work

- Enhancing technical components
  - Tile multiple LED panels to produce a larger and crisp panel.
  - Build **Voice recognition** features with smart speakers to display the forecast when called out as, "What's the space weather tomorrow?"
- Raising public awareness of space weather
  - Place our panels in schools, libraries, town halls and other places where many people are passing by.
  - Ask our science teachers to cover space weather with our panels in class.
  - Question our principals about potential “geomag storm days” and discuss what students and teachers should expect and prepare.
  - Create and publicize **Space Weather Day** like Earth Day in schools & towns.



# *Thank you!*

Feel the wind, get to know it, and stay ahead!

**Earth, Wind & Flare**

(Hanna, Akari, Kurumi & Yuto)

