A 10-day Unit Plan for Grade 5 to 8 in the Gifted and Talented Program

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Decoding the Mysteries of the Sun: Solar Activity Data Analysis

Statement of Purpose

1) *How will integrating math or science enhance your students' understanding of each?*

   In this lesson, students will explore complex solar dynamics by collecting and analyzing three different sets of solar activity data: sunspot numbers, radio flux index, and CMEs (Coronal Mass Ejections) measurements. The data sources are from reputable sources like NASA, NOAA, and other governmental space observatory agencies. By integrating math and science, students are expected to enhance their understanding of solar phenomena, such as solar storms, and strengthen their math proficiency, making the subjects more relatable and practical. Math will help them analyze scientific data, while science will bring real-world meaning to math concepts.

2) *How is this unit developmentally appropriate for your students?*

   I believe this unit is developmentally appropriate for my students in the gifted and talented program (grades 5 to 8) because it offers a challenging yet engaging real-world learning experience. They will have an opportunity to explore three complex scientific data sets and learn how to collect and extract relevant data for their analysis. While this process may be particularly challenging for younger students, it will benefit their critical thinking and problem-solving skills. Through this process, they will recognize the significance of data analysis in understanding real-world scientific phenomena and concepts. Furthermore, the interdisciplinary approach, involving science, math, data analysis, and social science (history & societal impact analysis of solar storms), will provide a holistic learning experience for advanced learners, fostering enthusiasm for learning and curiosity.

3) *What skills will students develop in math? Specifically tie skills in with your thematic unit of study.*

In this unit, students will develop several important math skills during the solar activity data analysis. Specifically, they will:

a) Data Collection, Organization, and Interpretation: Students will learn how to gather/extract relevant solar activity data, including sunspot numbers, radio flux index, and CMEs measurements, from reliable sources like NASA and NOAA. They will practice organizing this data into charts and tables, and then interpret the data to identify trends and patterns.
b) Computation Skills: Students will utilize computation skills to calculate means and averages from the solar activity data. This will be particularly important when extracting yearly mean data from the raw monthly data, allowing them to understand the overall trends in solar activity over time.
c) Mathematical Reasoning: Through analyzing solar activity data, students will apply mathematical reasoning to identify correlations and relationships among variables. They will make evidence-based conclusions about how sunspot numbers, radio flux, and CME measurements relate to solar phenomena like solar storms.
d) Graphing Skills: Students will enhance their graphing skills by creating visual representations of the solar activity data. Graphs will be used to visualize trends and patterns effectively and help them understand the behavior of the Sun over time.
e) Inferring Graphing Functions (for 7~8th graders): In the process of graphing solar activity data, students will infer graphing functions to understand the functional relationships between different variables. This skill will enable them to make predictions and draw evidence-based conclusions based on the data.

By developing these math skills in the context of analyzing solar activity data, students will not only gain a deeper understanding of scientific knowledge but also strengthen their overall proficiency in mathematics.

4) *Describe of how lesson provides for differentiation in content, process and product.*

a) Content Differentiation: For content differentiation, I will offer three different solar activity data sets to the students. Each data set may vary in complexity and quantity of data, allowing students to choose one that fits to their own readiness and abilities. Some students may be more comfortable with data sets that have larger amounts of

information, while others might prefer to start with simpler datasets. By providing multiple options, I can accommodate different levels of challenge among students.

b) Process Differentiation: The lesson incorporates process differentiation by offering various learning approaches for data analysis. Students can choose either work independently or with a small group to explore the solar activity data sets. Some students may excel in independent investigations, while others may thrive in collaborative settings. The flexibility in the process ensures that students can pursue the analysis in ways that align with their strengths and preferences.

c) Product Differentiation: In terms of product differentiation, students will be encouraged to present their findings in various ways, such as written reports, slide or poster presentations, data visualizations, or other creative projects. This allows them to showcase their understanding in methods that suit their talents and skills. For example, some students might prefer creating visual data representations, while others excel in engaging presentations.

The lesson provides differentiation in content, process, and product, enriching gifted and talented students to explore solar activity data sets according to their preferences and abilities. This approach ensures each student is appropriately challenged and supported, while expressing their individual strengths.

5E Model

This lesson plan and its activities are entirely original and have never been tested or used by any educators or educational organizations. As the lesson progresses, I will make modifications and adjustments based on students' reception and feedback. The plan utilizes authentic data and resources from reputable governmental agencies such as NASA and NOAA. The primary purpose of developing this lesson plan is to address a key essential question: How can data analysis and math connections enhance students' scientific learning and deepen their understanding?

In the following sections, I have outlined detailed teacher and student activities, aligning them with the 5E instructional model, all within a 10-day time frame with each class lasting 45 minutes. I also have included specific essential questions that will be posed and answered in each phase to guide students' learning effectively.

	Teacher activities	***Student Activities***	***Essential questions***	***Materials***

				needed
Engage (Day 1)	-Show captivating images and videos of solar phenomena such as 1989 Quebec Blackout and 2003 Halloween Storm. -Facilitate a class discussion to spark students' observations and questions about the solar activity.	-Actively participate in the discussion, sharing their thoughts and curiosity about the Sun. -Ask questions and express their interests in exploring solar dynamics and related topics.	-"What causes solar storms, and how do they affect Earth?" -"How can data analysis help us understand the mysteries of the Sun?"	-Images and videos of solar phenomena (e.g., solar flares, CMEs, sunspots, solar storms). -Smartboard for class discussion
Explorer (Day 2,3,4)	-Provide hands-on activities for students to collect solar activity data sets (sunspot numbers, radio flux and CMEs). -Guide students in making observations and recording their findings.	-Engage in data collection and exploration, recording observations and patterns. -Work in groups to analyze solar activity data and form connections between the variables.	-"What patterns can we identify among sunspot numbers, radio flux and CMEs and solar storms?" -"How do variations in radio flux index and CMEs relate to solar activity?"	-Solar activity data sets (provided by the teacher or their own research from reliable sources). -Data collection tools (e.g., graph paper, data tables, graphing calculators). -Solar activity data sheets or handouts.
Explain (Day 5,6,7)	-Present explanations about the significance of data analysis in understanding solar phenomena. -Review math concepts such as calculating means	-Listen to explanations and take notes to deepen their understanding of solar activity and data analysis. -Discuss their	- "How do sunspot numbers, radio flux and CMEs correlate with the solar cycle?" -"What can data analysis tell us about the	-Visual aids or slides for explaining the significance of data analysis in understandi ng solar phenomena.

	and averages from the data and their relation to solar dynamics. -Review math concepts, including graph functions and the functional relationship between two quantities by analyzing a graph.	understanding and interpretations of the data, seeking answers to essential questions.	occurrence of solar storms?"	-Calculators for mathematical explanations.
Elaborate & Extend (Day 8,9,10)	-Assign research projects on historical solar storm events and their social impact. -Guide students to answer the essential questions	-Conduct research on historical solar storm events and societal consequences. -Analyze data and draw connections between past solar disturbances and their effects on society. -Present their findings and insights to the class.	-"How have solar storms affected communication and technology in the past?" -"What can we learn from historical solar storm events to prepare for future occurrences?"	-Historical solar storm event information for research projects. -Access to online research resources or library for gathering information.
Evaluate	-Conduct formative assessments, quizzes, and discussions -For the summative assessment, have students present their analyses and conclusions in various formats, such as written	-Demonstrate their understanding through assessments, presentations, and project submissions. -Reflect on their learning journey, the significance of data analysis in	- “How data analysis and math connection enhance students’ understanding and learning about solar dynamics?”	-Formative assessment materials (quizzes, discussion prompts). -Google Survey Forms -Presentation tools

	reports or presentations. -Evaluate their ability to address essential questions and demonstrate mastery of the subject matter.	understanding solar phenomena, and the connections between science, math, and social studies perspectives.		(projector, whiteboard) for student presentations

Measurable Objectives

I will evaluate the students' learning performances (LP) based on the following objectives, addressing Webb's Depth of Knowledge (DOK):

- ✓ LP-01: Students will accurately collect, extract and summarize solar activity data, including sunspot numbers, radio flux index, and CMEs measurements (DOK2).
- ✓ LP-02: Students will analyze solar activity data to identify patterns and correlations between sunspot numbers, radio flux, and CMEs and the occurrence of solar storms (DOK3).
- ✓ LP-03: Students will use scientific reasoning to explain the relationship between solar activity data and solar phenomena, such as solar storms, in their own words (DOK2).
- ✓ LP-04: Students will demonstrate an understanding of solar dynamics and the significance of data analysis in explaining solar phenomena (DOK1).
- ✓ LP-05: Students will calculate means and averages from the solar activity data, including yearly means from raw monthly data (DOK2).
- ✓ LP-06: Students will graphically represent solar activity data to visualize trends and patterns effectively (DOK3).
- ✓ LP-07: Students will apply mathematical reasoning to analyze and interpret relationships among variables, such as sunspot numbers, radio flux, and CMEs sizes (DOK3).
- ✓ LP-08: Students will utilize data visualization tools and software to present their findings and analysis effectively (DOK3).
- ✓ LP-09: Students will research and analyze historical solar storm events, such as the 1989 Quebec Event and 2003 Halloween Storm, to understand their societal impact and historical significance (DOK3).
- ✓ LP-10: Students will critically evaluate the potential future impact of solar phenomena on technological infrastructure, emergency preparedness, societal impact, global collaborations, and draw

comparisons to historical events to make evidence-based predictions (DOK4).

Math and Science Standards

Archdiocese of Newark Catholic Schools Math Curriculum Maps
(https://catholicschoolsnj.org/mathematics-prek-12)

- **NBT.3** - Read, write, and compare decimals to thousandths
- **NBT.7** - Add, subtract, multiply, and divide decimals to hundredths. (Students can use their understanding of decimal operations to calculate the sums of 12-month data and then divide by 12 to find the average.)
- **SP.1 & 2, 4** – Recognize statistical questions as one that anticipates variability in the data related to the questions and accounts for it in to answers & Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.& Display numerical data in plots on a number line, including dot plots, histograms, and box-and-whisker plots.
- **SP. 5c** - Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.
- **RP.3** - Use ratio and rate reasoning to solve real-world and mathematical problems.
- **SP.5c** - Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.
- **7.EE.4** - Use variables to represent quantities in a real-world or mathematical problem. Students can use variables to represent time and sunspot numbers in their mathematical model.
- **8.F.5** – Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g. where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

NGSS Standards
While my school does not follow NGSS, I referenced the NGSS website (https://www.nextgenscience.org/) to identify standards that align with my lesson. The standards that align with my lesson are as follows:

- **MS-ESS1-1:** Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

- **MS-ESS1-2:** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
- **MS-ESS1-3:** Analyze and interpret data to determine the scale properties of objects in the solar system.
- **MS-PS4-2:** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Assessment/ Rubric

I will use the following Diagnostic Assessment to test the prior knowledge of students. This assessment will help me identify students' existing knowledge and misconceptions. The sample assessment is as follows:

Diagnostic Assessment: Solar Phenomena Knowledge Pre-Test

Please answer the following questions based on what you already know about solar phenomena.

1. What are sunspots, and how are they related to solar activity?
   a) Dark spots on the Sun caused by shadows
   b) Areas of high magnetic activity on the Sun's surface
   c) Sunspots are unrelated to solar activity

2. How do scientists measure solar activity using the F10.7 index?
   a) It measures the number of sunspots on the Sun's surface
   b) It measures the noise level generated by the Sun at a specific wavelength
   c) It measures solar wind speed

3. What are CMEs (Coronal Mass Ejections), and how do they impact Earth?
   a) Explosions on the Sun's surface caused by solar flares
   b) Large expulsions of plasma and magnetic field from the Sun's corona
   c) They have no impact on Earth
4. How can data analysis help us understand solar phenomena like solar storms?
   a) Data analysis is not relevant to understanding solar phenomena
   b) By identifying patterns and correlations in solar activity data
   c) Data analysis only applies to other scientific fields

5. What is the significance of the solar cycle in relation to solar activity?
   a) The solar cycle has no effect on solar activity
   b) It affects the sunspot numbers and intensity of solar activity

c) The solar cycle determines the number of sunspots on the Sun

Throughout the lesson, I will regularly check their progress in each phase of the 5E model by observing students' activities. A sample rubric for assessment could be as follows:

Performance Level	Excellent	Good	Satisfactory	Improvement Needed
Engage (I will observe their participation and evaluate)	Actively participates in the discussion, sharing insightful thoughts and displaying curiosity.	Engages in the discussion and contributes meaningful ideas and questions about solar activity.	Participates in the discussion, but contributions are limited or lack depth.	Does not actively participate or contribute to the discussion about solar phenomena.
Explorer (I will collect their data sheet and evaluate)	Actively explores data, records accurate observations, and effectively forms connections.	Engages in data exploration, but may have minor inaccuracies in observations or connections.	Makes some effort in data exploration and forming connections, but with notable gaps or errors.	Little to no effort in data exploration or forming connections between the variables.
Explain (I will collect their notes and evaluate)	Actively listens, takes comprehensive notes, and demonstrates a deep understanding of solar activity.	Engages in listening and note-taking, but may have some limitations in understanding or note clarity.	Participates in the discussion but demonstrates limited insight or understanding of the subject.	Does not actively participate in listening, note-taking, or understanding the solar phenomena.
Elaborate & Extend (Students will be asked to submit a one-page write up on their research)	Conducts thorough research, analyzes data with insightful connections, and presents findings clearly.	Conducts research and analysis with some gaps or limited clarity in presenting findings.	Makes some effort in research and analysis but lacks depth or clarity in presenting insights.	Presents incomplete or inaccurate information, lacking substantial research or analysis.

At the end of the lesson, I will distribute the following survey (Google Form) to collect their feedback on the overall lesson and learning experience. The sample survey is as follows:

1. How would you rate your overall understanding of solar activity data analysis after completing this lesson?

2. Which specific data sets did you work with during the lesson? (Check all that apply)
    - Sunspot numbers
    - Radio flux index
    - CME measurements

3. How confident do you feel in collecting and organizing solar activity data sets?

4. Did you find the data analysis activities helpful in identifying patterns and correlations between solar activity variables?

5. How comfortable are you in using mathematical reasoning to interpret relationships among solar activity variables?

6. Describe one mathematical pattern or correlation you observed between sunspot numbers, radio flux, and solar storms during the data analysis activities.

7. Which part of the lesson did you find most challenging, and why?
    - Data collection
    - Data Organization through tables and graphs
    - Data and Pattern Interpretation
    - Connection data to solar phenomena
    - Others (Please specify)

8. How do you think data analysis enhances your understanding of solar phenomena, such as solar storms?

9. What subjects of the interdisciplinary approach involving science, math, data analysis, and social studies (history & societal impact analysis of solar storms) did contribut to your overall learning experience the most?
    - Science
    - Math
    - Data Analysis
    - Technology
    - Social Studies

10. What improvements could be made to the lesson to enhance your learning further?

11. What did you enjoy the most about this unit?

12. What skills or knowledge do you feel you have developed the most throughout the 10-day lesson?
    - Scientific reasoning
    - Data Analysis
    - Societal Impact Analysis
    - Others (Please specify)

13. How well do you think the lesson prepared you to analyze and interpret solar activity data in the future?

14. Overall, how satisfied are you with this 10-day unit on Solar Data Analysis?

References

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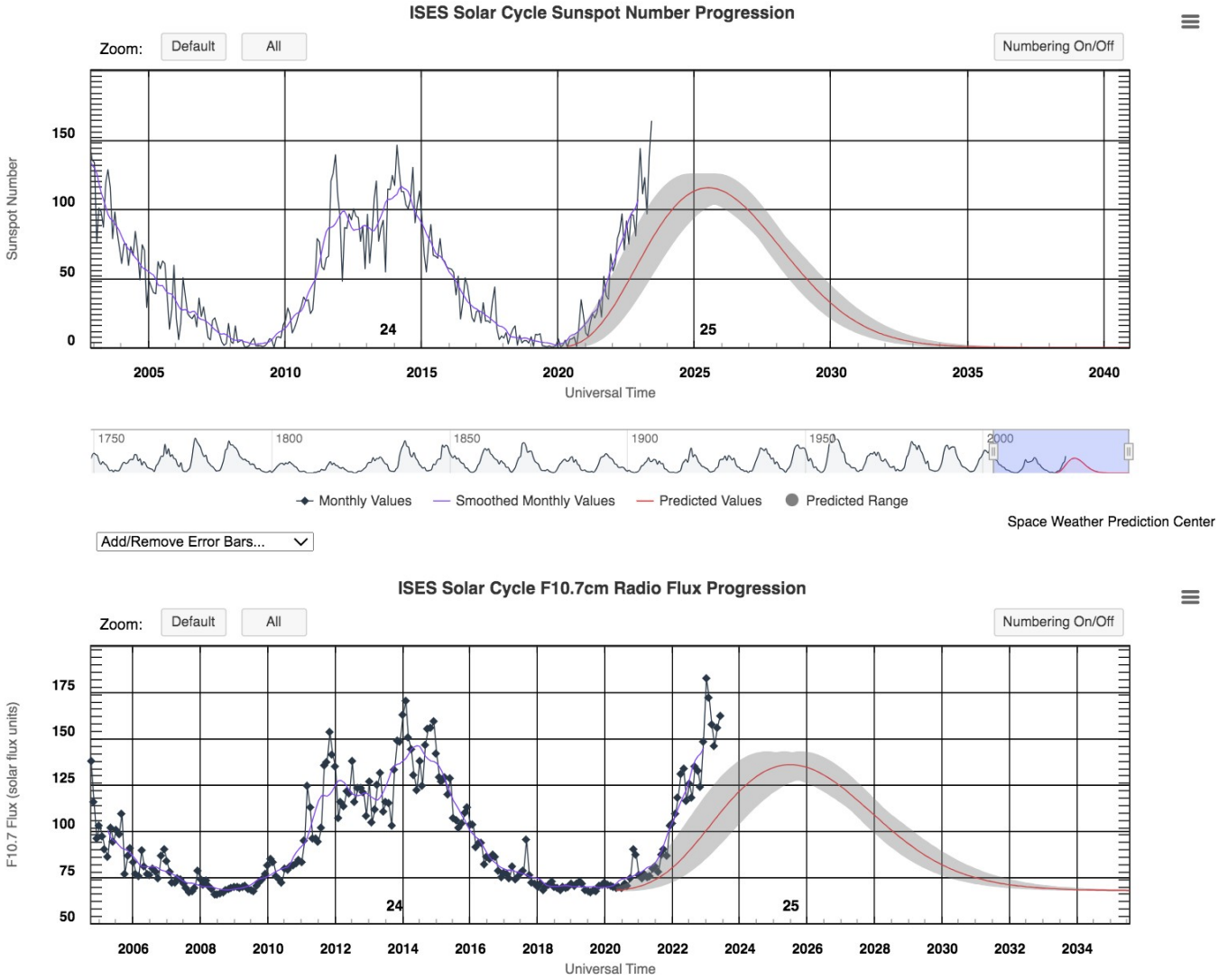
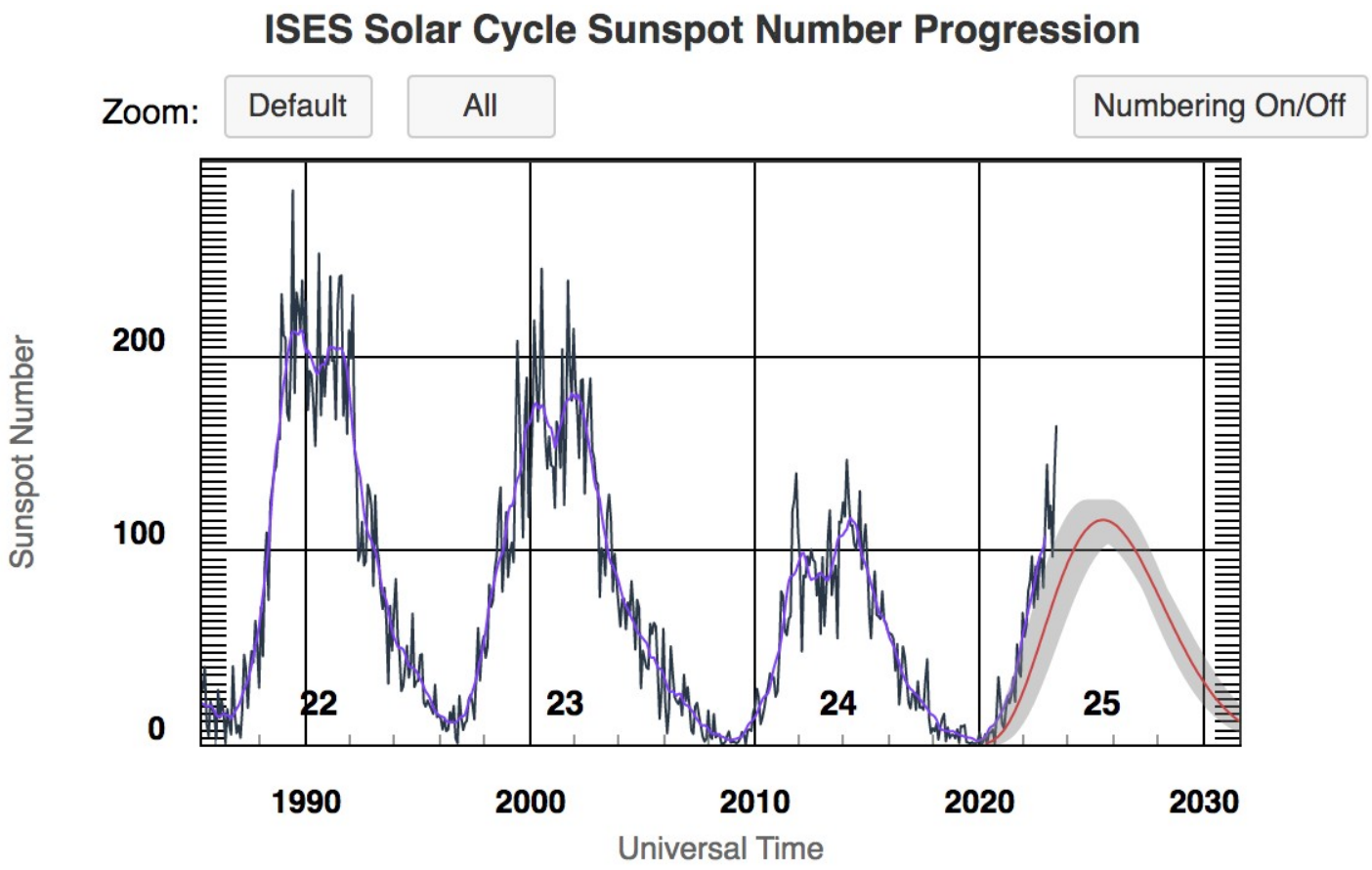
Appendix

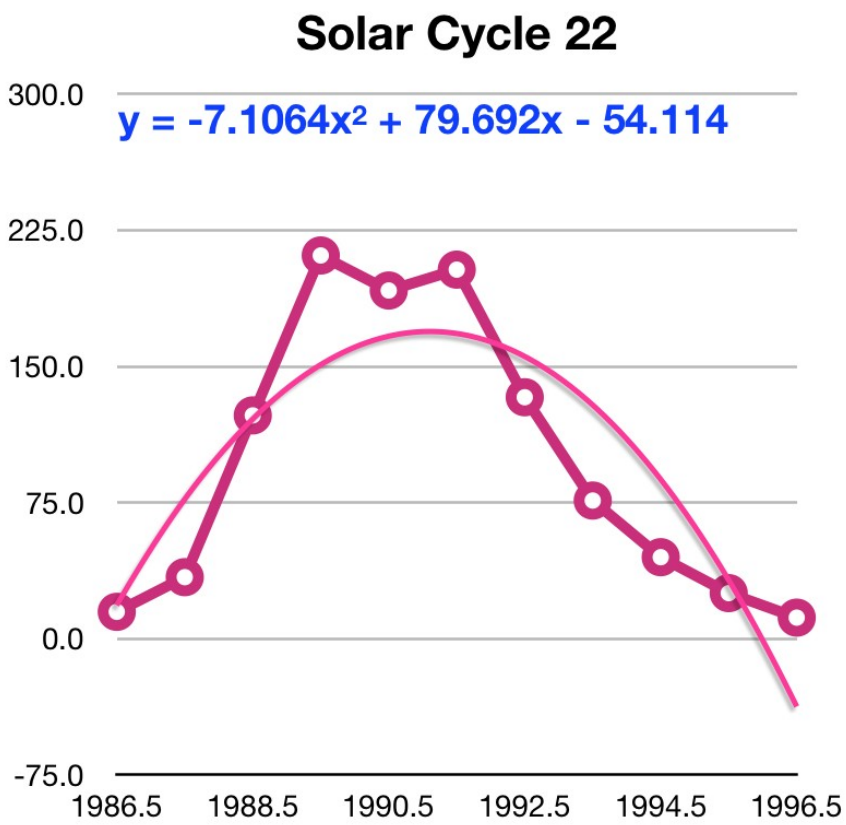
Data and Graphs that I extracted and plotted for the lesson.



(Figure 1: Sunspot Numbers-Radio Flux Patterns Comparison from 2004 to Present, Source: https://www.swpc.noaa.gov/products/solar-cycle-progression)



(Figure 2: Sunspot Numbers Fluctuation during Solar Cycle 22, 23, 24, and 25)



(Figure 3: Graphing and Inferring Function on Sunspot Numbers Data during Solar Cycle 22, Software Used: Apple Numbers)

(Table 1: Monthly Averages of Solar 10.7cm Radio Flux from 2004 to Present, Source: https://spaceweather.gc.ca/forecast-prevision/solar-solaire/solarflux/sx-5-mavg-en.php)

Monthly averages of solar 10.7 cm flux

Year	Month	Observed Flux	Adjusted Flux	Absolute Flux
2004	10	137.56	135.60	122.04
2004	11	115.98	113.46	102.12
2004	12	95.66	92.69	83.42
2005	01	102.86	99.59	89.63
2005	02	97.30	94.95	85.45
2005	03	90.04	89.14	80.22
2005	04	85.92	86.55	77.90
2005	05	101.65	103.90	93.50
2005	06	94.09	97.06	87.36
2005	07	100.64	103.93	93.54
2005	08	98.24	100.66	90.60
2005	09	109.55	110.77	99.69
2005	10	76.71	76.21	68.60
2005	11	86.38	84.47	76.02
2005	12	90.85	88.01	79.21
2006	01	83.32	80.67	72.60
2006	02	76.52	74.67	67.20
2006	03	75.50	74.75	67.28
2006	04	89.27	89.90	80.91
2006	05	80.83	82.62	74.36
2006	06	76.68	79.10	71.18
2006	07	75.88	78.36	70.53
2006	08	79.59	81.58	73.43
2006	09	78.02	78.87	70.99
2006	10	74.43	73.95	66.55
2006	11	86.43	84.56	76.10
2006	12	90.39	87.58	78.83

(Table 2: SOHO CMEs monthly measurements from 1996 to present, Source: https://cdaw.gsfc.nasa.gov/CME_list/)

SOHO LASCO CME CATALOG

YEAR	MONTH											
1996	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1997	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1999	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2018	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2019	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2022	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2023	Jan	Feb	Mar									

(Table 3: Yearly mean Sunspot numbers during Solar Cycle 22, Source: https://www.sidc.be/SILSO/datafiles)

1986.5	14.8
1987.5	33.9
1988.5	123
1989.5	211.1
1990.5	191.8
1991.5	203.3
1992.5	133
1993.5	76.1
1994.5	44.9
1995.5	25.1
1996.5	11.6