Solar Storm heading towards Earth

CESAR Scientific Challenge

Calculate the Sun rotation with
ESA SOHO satellite

Beatriz González García on behalf of the CESAR Science Cases Team

S.O.S! Solar Storm heading towards Earth

Message from the European Space Agency's missions monitoring the Sun:

"S.O.S! STOP. S.O.S! STOP. SOHO has detected a CME towards Earth. STOP. Take cover! STOP. "

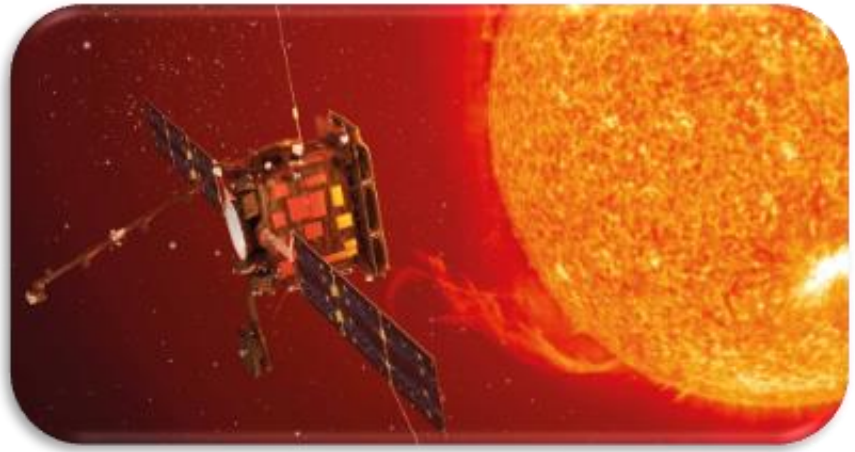


Figure 1: Solar Orbiter satellite (Créditos: www.agenciasinc.es)

Solar Orbiter has confirmed that the CME is coming to Earth.

Figure 2. Coronal mass ejection (CME). (Créditos: https://www.quo.es/explosion-solar/)

How long do we have to take cover on Earth? **Help us!**

Can we count on you?

Didactics

Figure I: *The considered top 10 skills in the 2020. (Credits: Rethinking).*

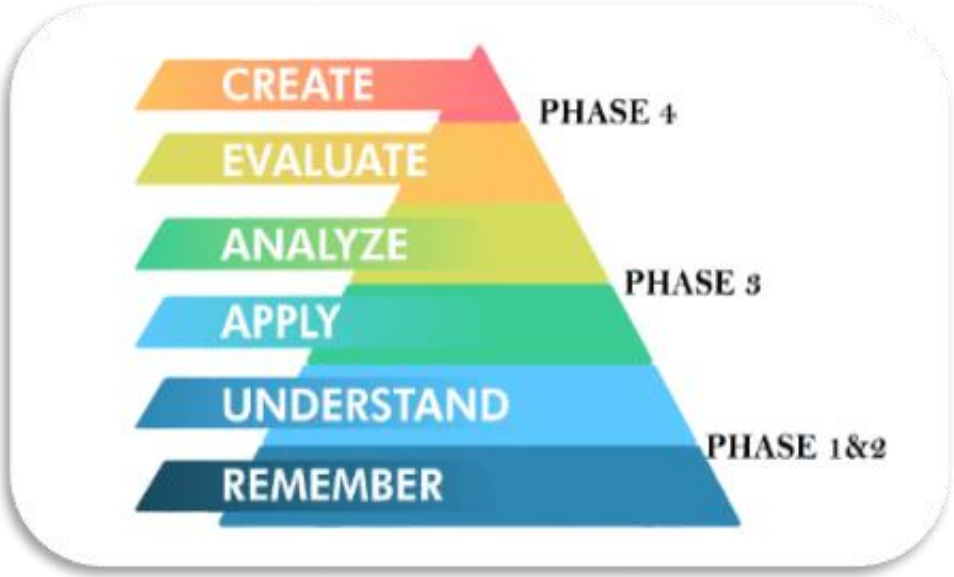


Figure II: *Bloom's Taxonomy diagram. (Credits: https://medium.com/@ryan.ubc.edtech/)*

Challenge ID		Team Number (1-6):	
Members			
Professions	**Mathematics Software Engineer**	**Astrophysicists**	**Engineers**	**Biologists/ physicist**
Roles	Leads the correct execution of the calculations	She/he guides the solar telescope	She/he is in charge of finding agreements and leading the team.	She/he addresses the need for further research.
References				
(female)	Katherine Johnso n 	Vera Rubin 	Samantha Cristoforetti 	Marie Curie 
(male)	Steve Wozniak 	Matt Taylor 	Pedro Duque 	Albert Einstein 

Fast Facts

- **Recommended target age range:** (14-16) years old
- **Recommended academic courses:** (3-4) ESO
- **Type:** Student activity, **Complexity:** Medium
- **Teacher preparation time:** (2+) hours, depending on the Type of Experience and contents selected.
- **Lesson time required:** (4 hours – several days), depending on the Type of Experience and contents selected by the teacher.
- **Location:** Indoors
- **Includes use of:** Computers, internet

The students should already know…

- The concepts of velocity and acceleration.
- The equation of uniform line motion and uniformly accelerated line motion.
- Time units conversion.

Currículum relevance

Physics and Chemistry

- The need of strategies in the scientific activity, the use of ICT and communication skills. Research project.
- Uniform and uniformly accelerated line movement.
- The periodic system of the elements. The chemical reaction.
- Errors in measurement

Mathematics

-
- Planning of the problems solution process. Generation and presentation of scientific forms. Mathematical studies of daily life concepts.
- Interpretation of phenomena by statements, data in tables/plots or by analytical expressions.

Scientific culture

- The scientific method. The use of ITC.
- Research and exploration of the Universe. The solar system. The evolution of the stars and the origin of the elements.
- Working in teams. Debates.

Students will learn …

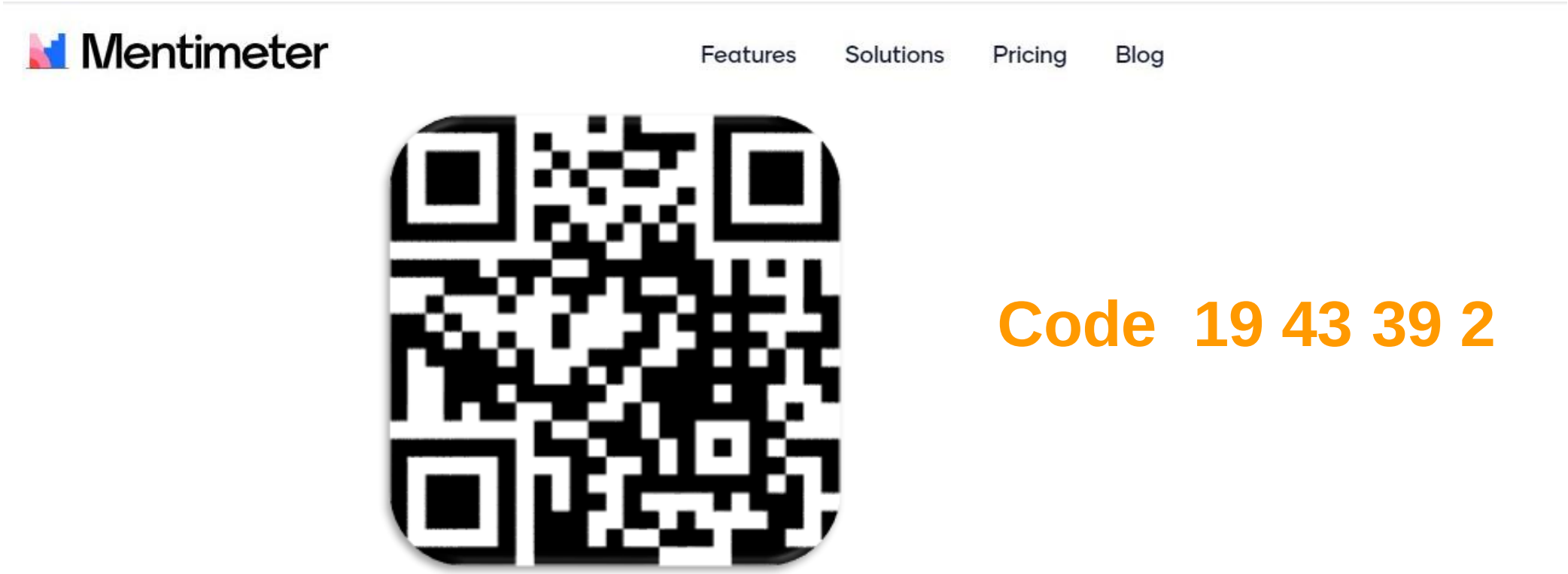
- The basics of solar activity.
- How to make scientific measurements.
- How to obtain information from astronomical images.

Students will improve …

- Their understanding of scientific thinking.
- Their strategies of working scientifically.
- Their teamwork and communication skills.
- Their evaluation skills.
- Their ability to apply theoretical knowledge to real-life situations.
- Their skills in the use of ICT.

What did you know?

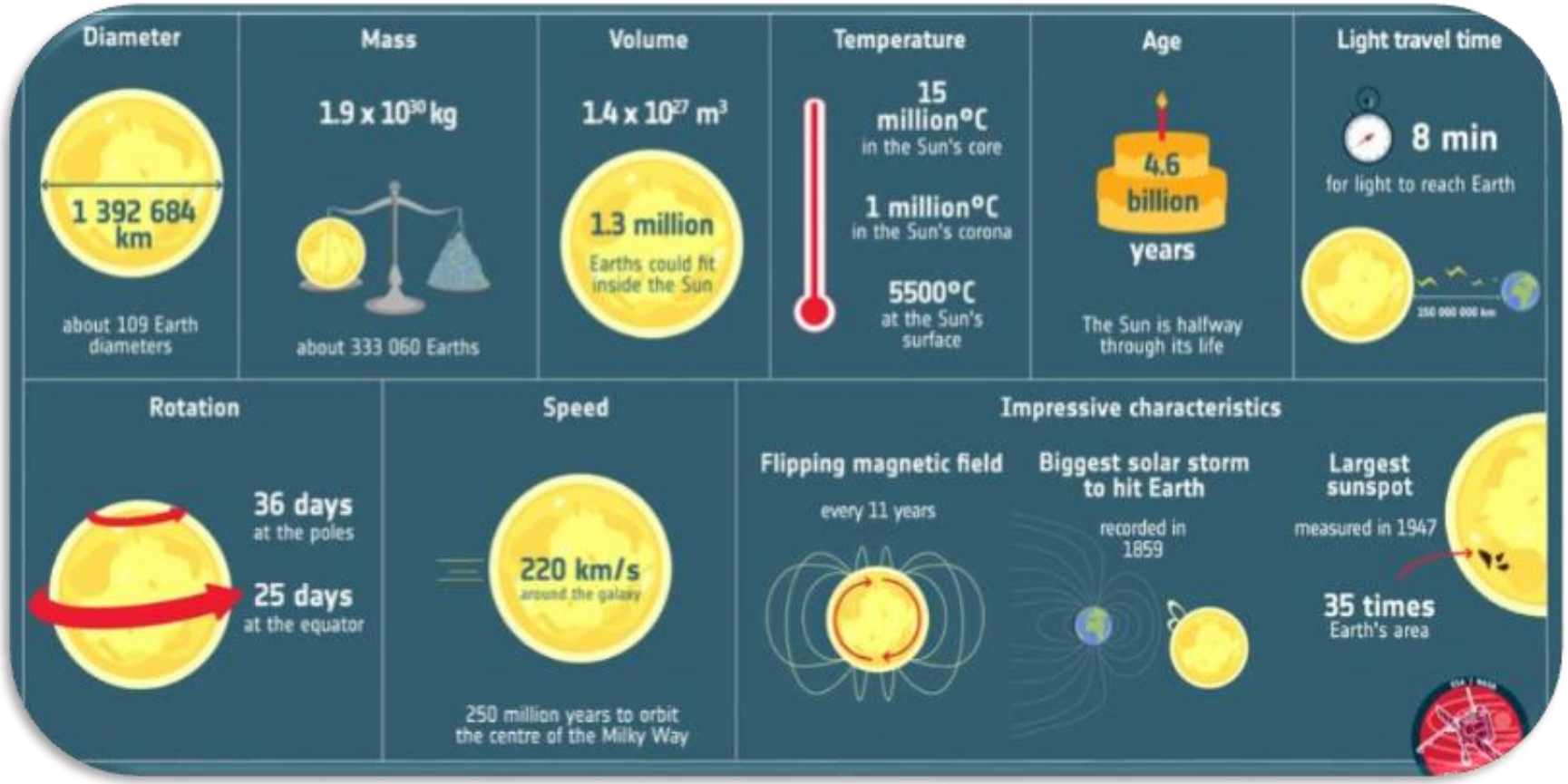
Menti.com – what do you know about the Sun?



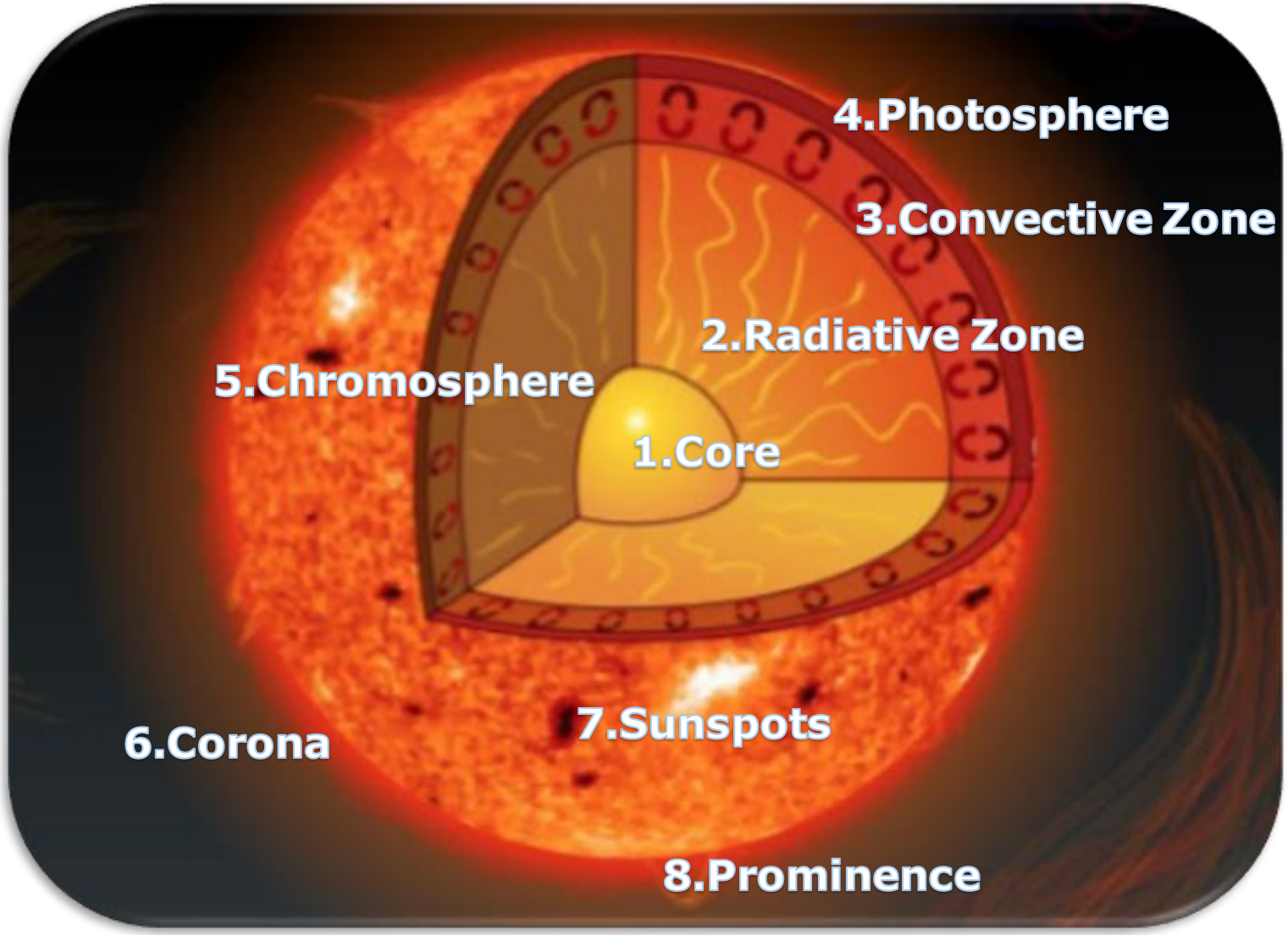
Code 19 43 39 2

1.The Sun

The Sun is a star of hot ionized gas or "plasma“, which generates energy through nuclear reactions inside it, consuming about four million tons of hydrogen fuel every second.



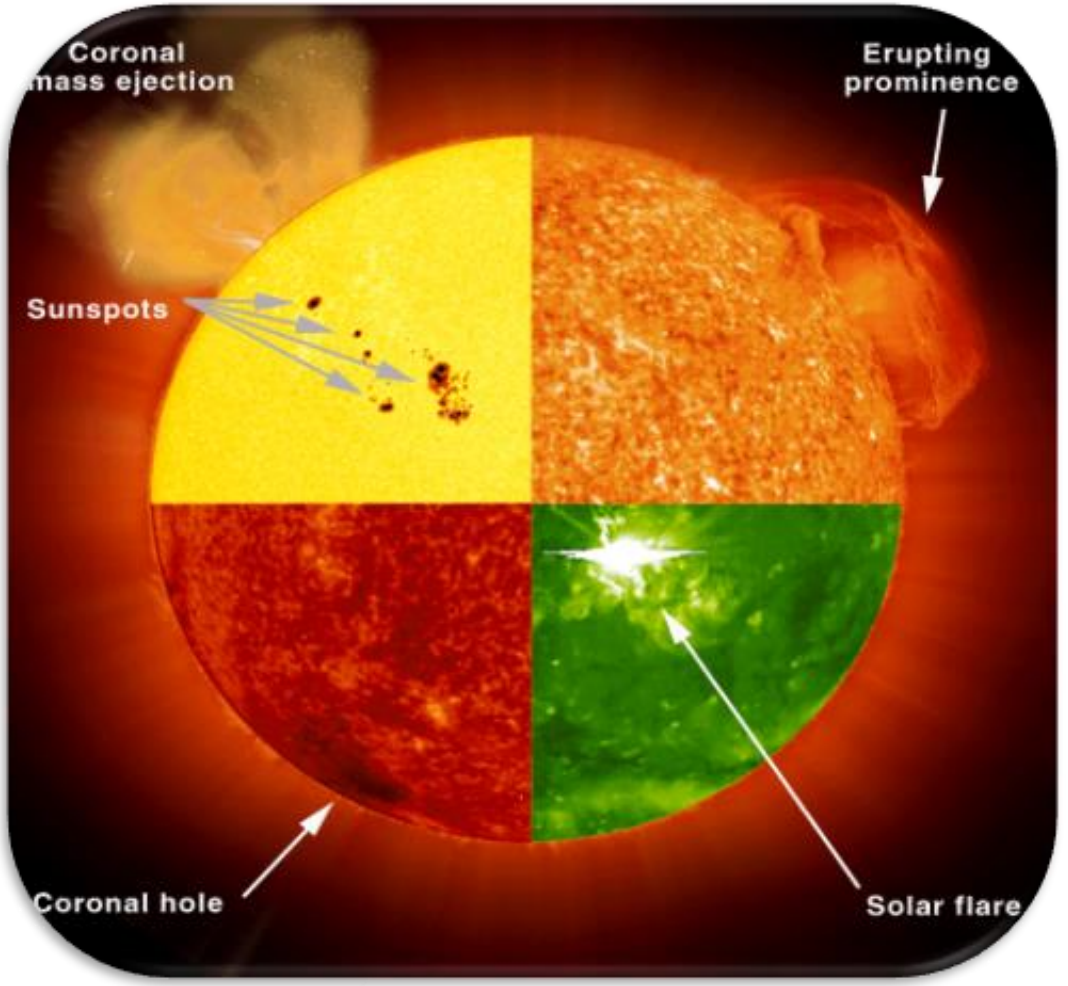
1.1 The Sun Structure



2. The magnetic activity of the Sun

- The Sun is a large ball of gas in a state of plasma. Its gaseous ionized material circulate through its magnetic fields that come out of the interior crossing the surface of the sun.

- The magnetic activity of the Sun produces numerous effects, which together are known as solar activity.



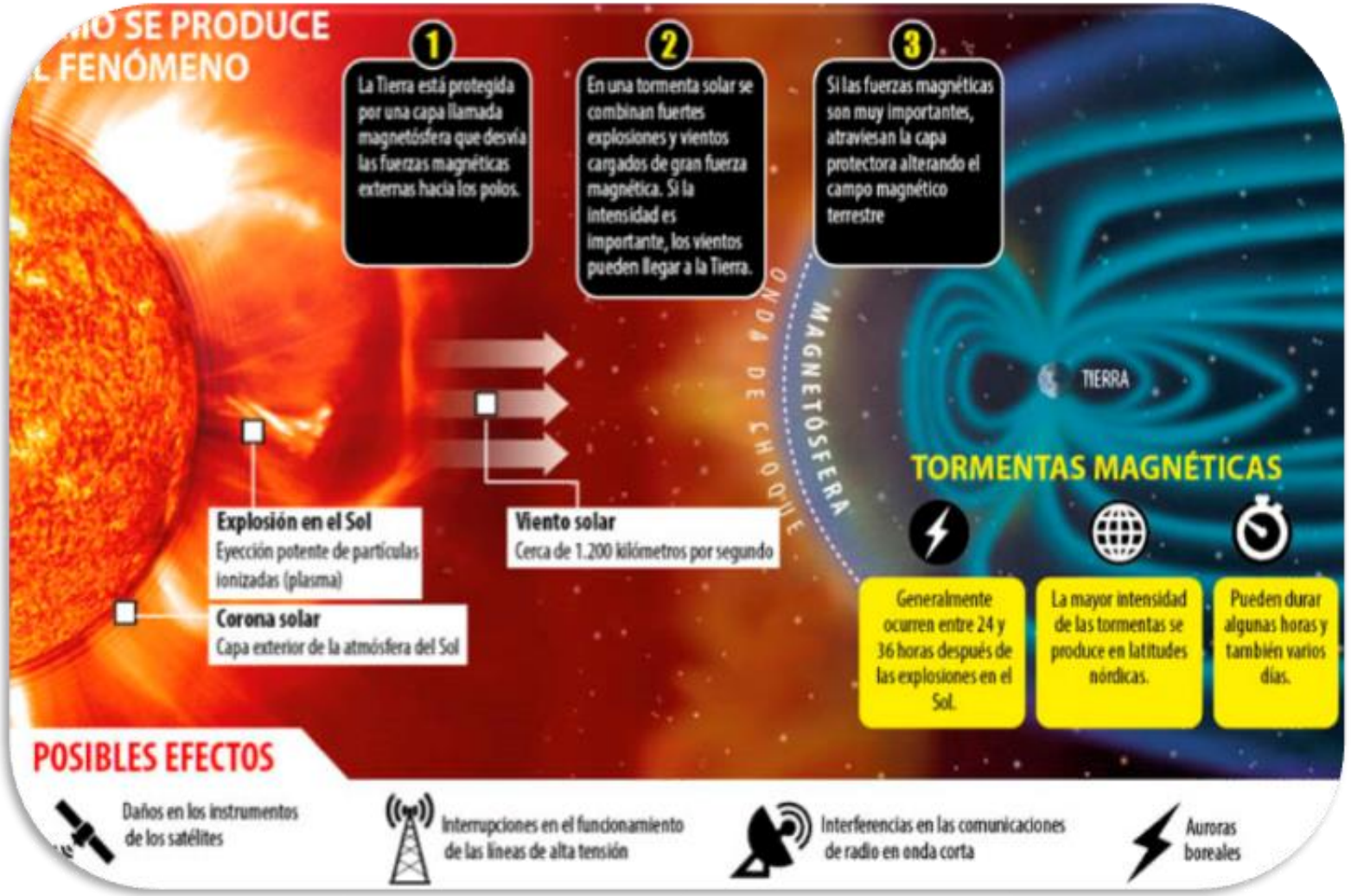
2.2 The influence of the Sun on the Earth

The Sun is the star that allows the existence of life (zone of habitability), as we know it on Earth, and the variations in its activity impact on Earth at many levels.

What impact do you think it has on the Earth? Answer in the Chat

2.2 The influence of the Sun on the Earth

What impact do you think it has on the Earth? Answer in the Chat



2.2 The influence of the Sun on the Earth

Do you think there is any relationship between the Sun and the Northern Lights?

Answer in the Chat

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Answer in the Chat

The Earth is protected by a magnetic field, which is the union point between the Earth and Space, and the charged particles, emitted by the Sun, can produce very impressive visual effects, such as the Northern Lights.

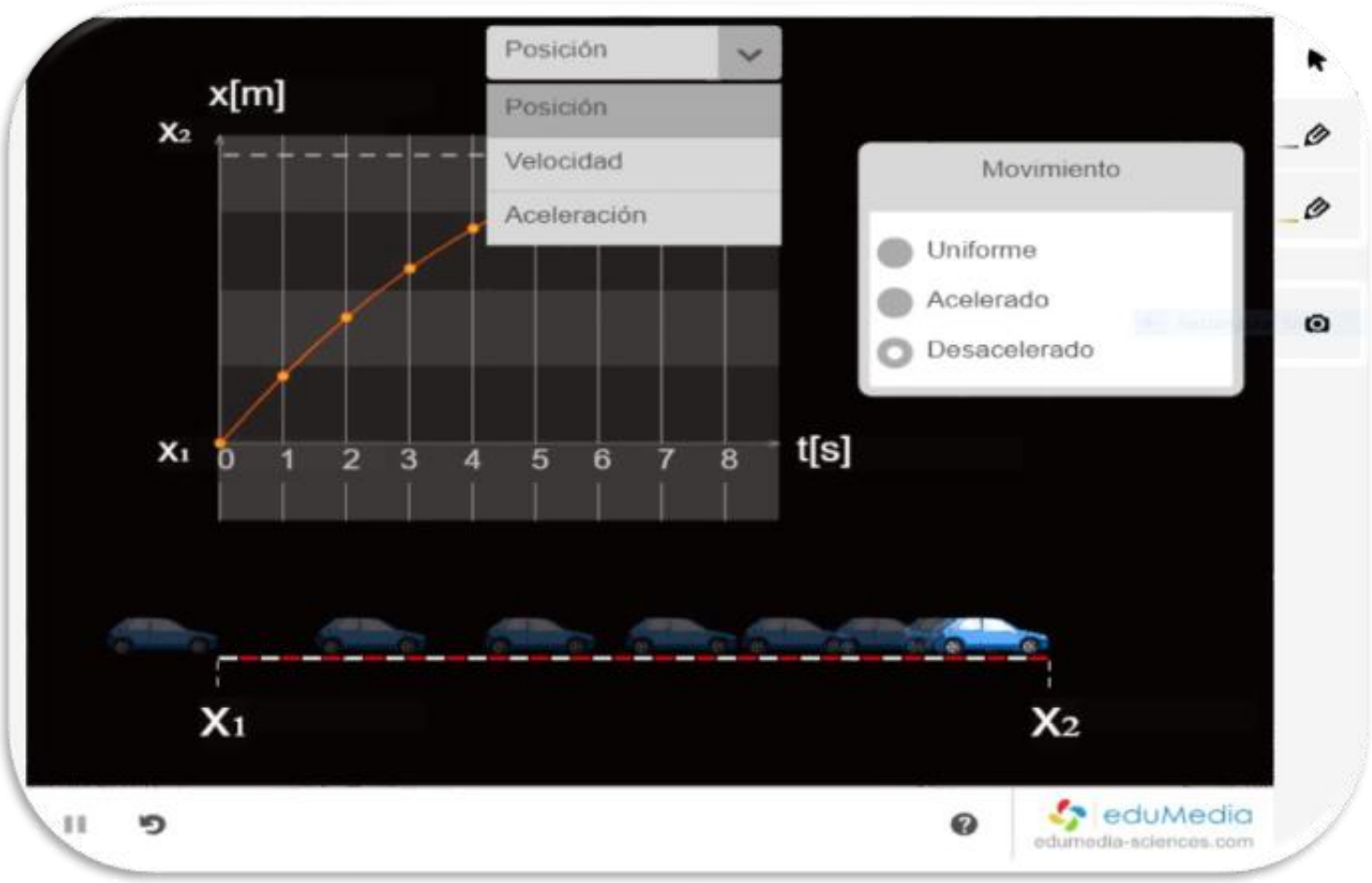
2.2 The influence of the Sun on the Earth

The Sun is the star that allows the existence of life on Earth

(circumstellar habitable zone simulator)

Rectilinear uniform motion and **Motion under constant acceleration:**

simulation



Let's start the Challenge

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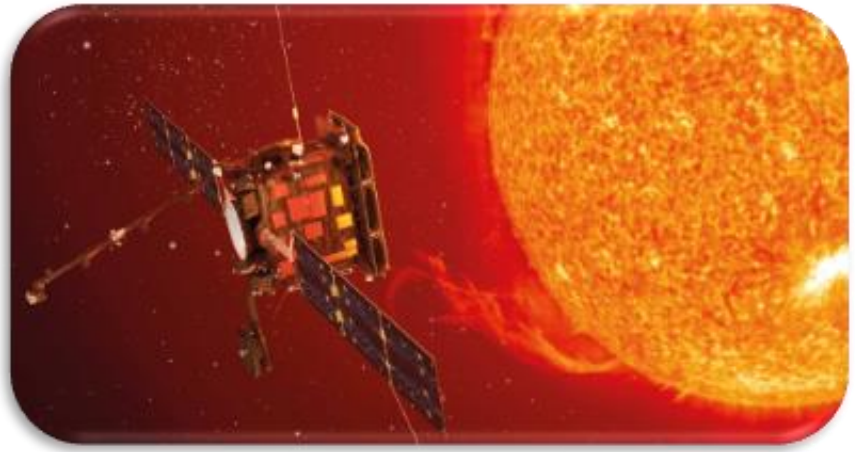

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How long do we have to take cover on Earth? **Help us!**

Can we count on you?

Step 1

How long would it take for a solar storm to reach Earth?

(Linear Uniform Movement)

Hypothesis

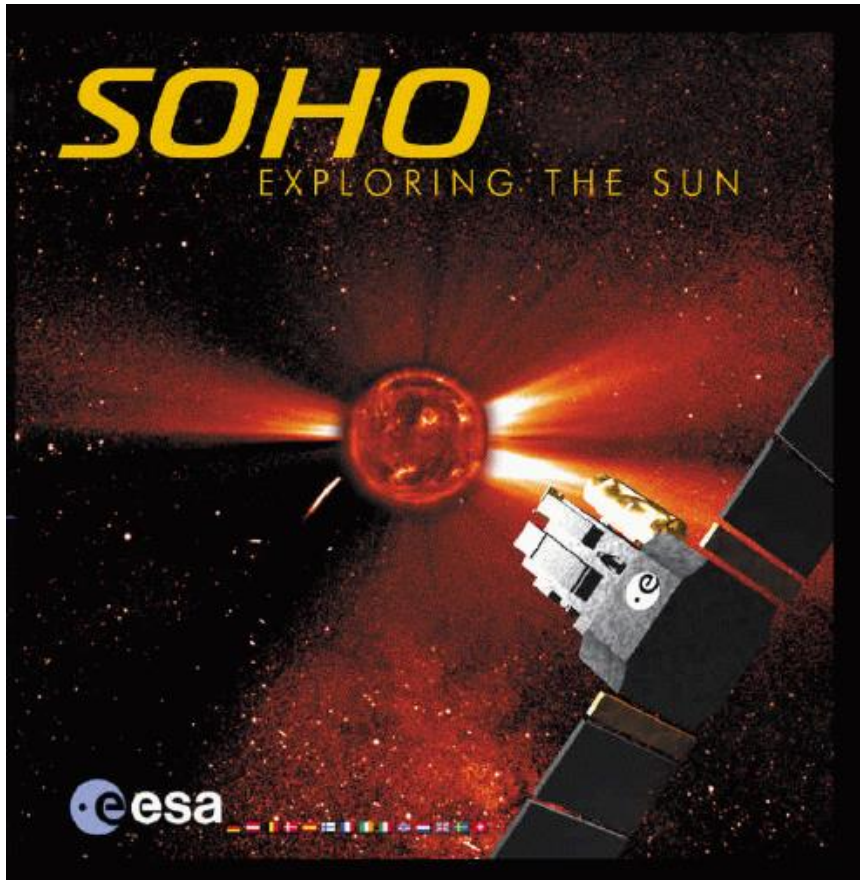
How long would it take for a solar storm to reach Earth?

Answer in the Chat

REAL SCIENTIFIC DATA

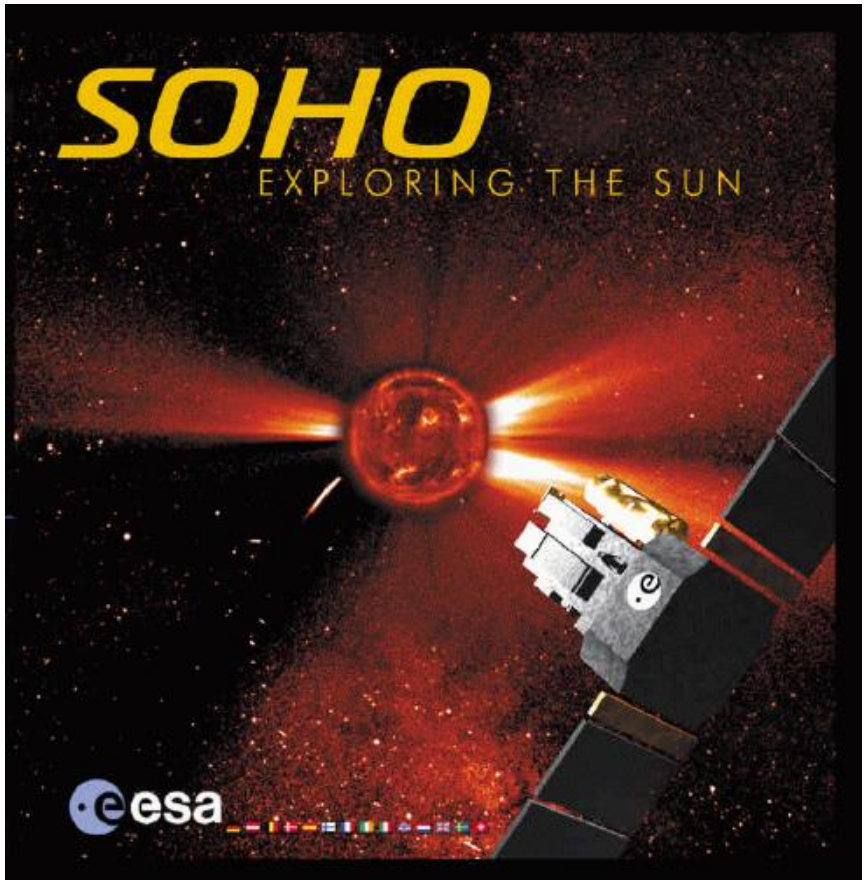
Access to of the Sun taken by the SOHO

You **will inspect the evolution of a CME over several days** to calculate its speed and time to arrive to Earth



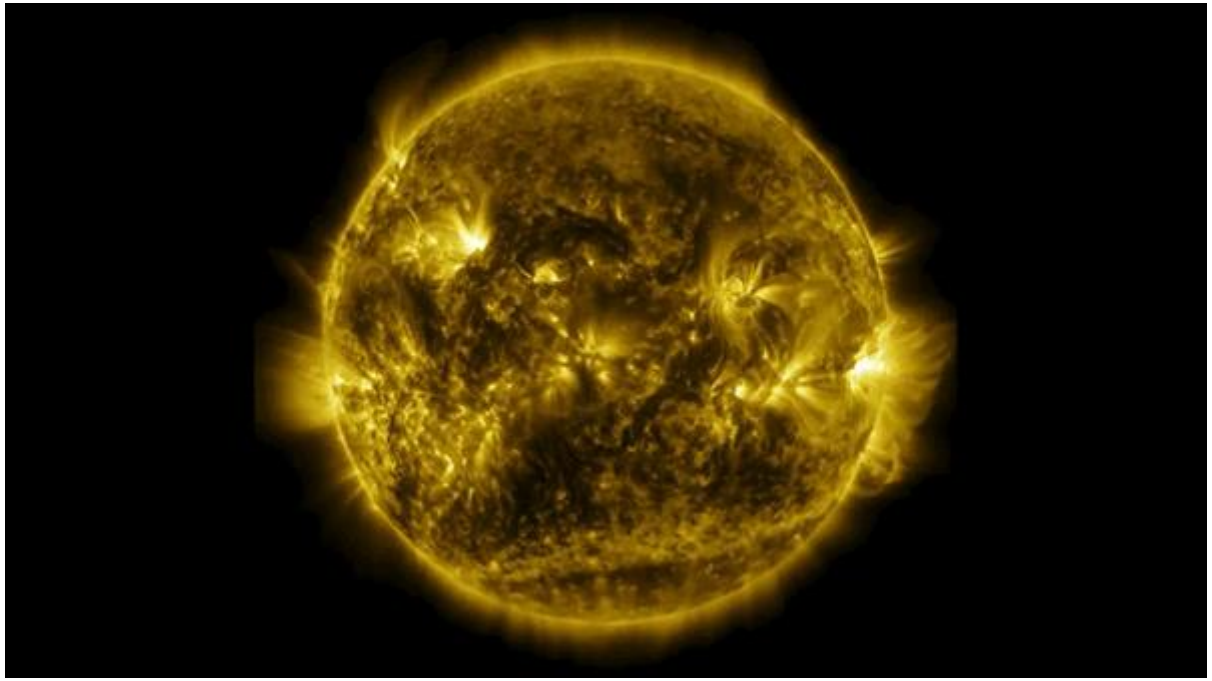
FAST FACTS — SOHO

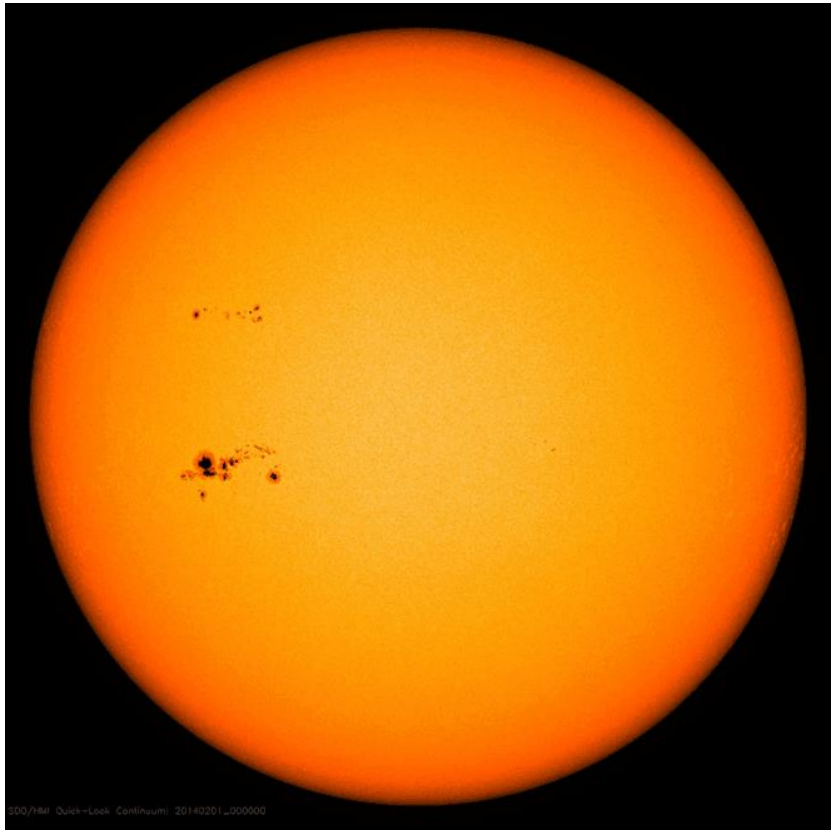
Launch date:	02-Dec-1995 08:08 UT
Mission end:	31 December 2022 (subject to a mid-term review in 2020)
Launch vehicle:	Atlas II-AS (AC-121)
Launch mass:	1850 kg
Mission phase:	Operational
Orbit:	SOHO is operated from a permanent vantage point 1.5 million kilometers sunward of the Earth in a halo orbit around the first Lagrangian point.
Achievements:	Discoveries from SOHO include: ▪ Complex currents of gas flowing beneath the visible surface of the Sun ▪ Rapid changes in the pattern of magnetic fields SOHO has: ▪ Made the largest and most detailed database of solar surface features. ▪ Become the most prolific discoverer of comets in the history of astronomy, although not designed for the purpose.



https://sci.esa.int/web/soho

REAL SCIENTIFIC DATA





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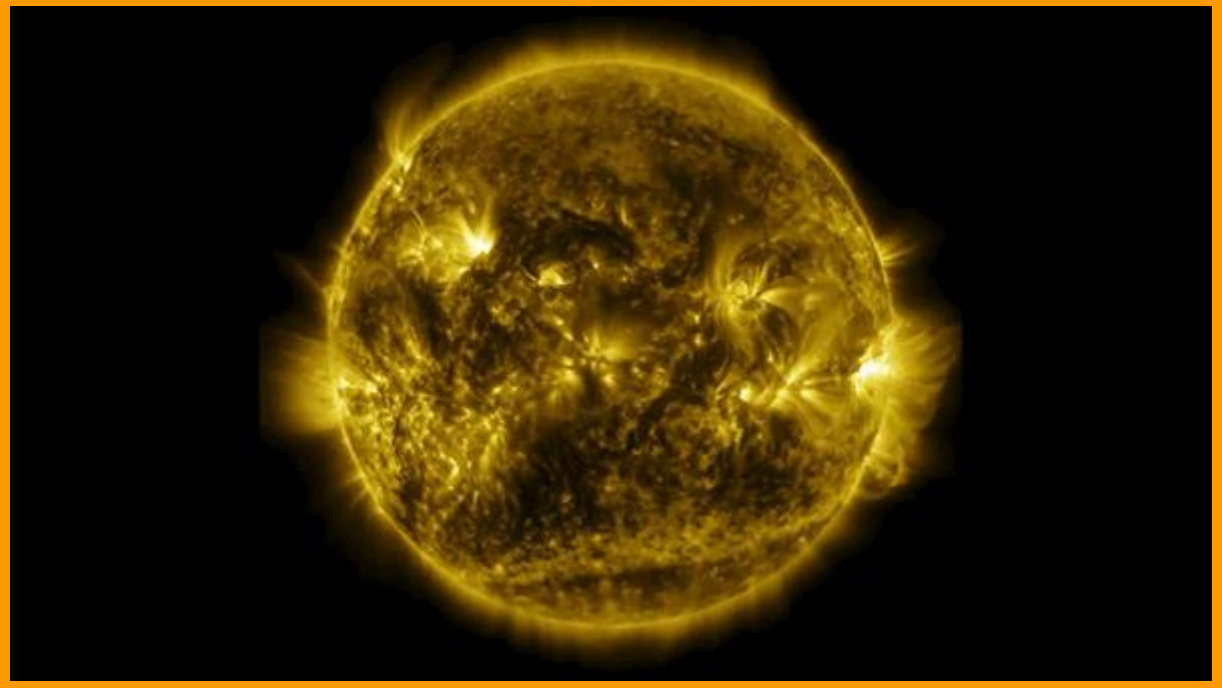
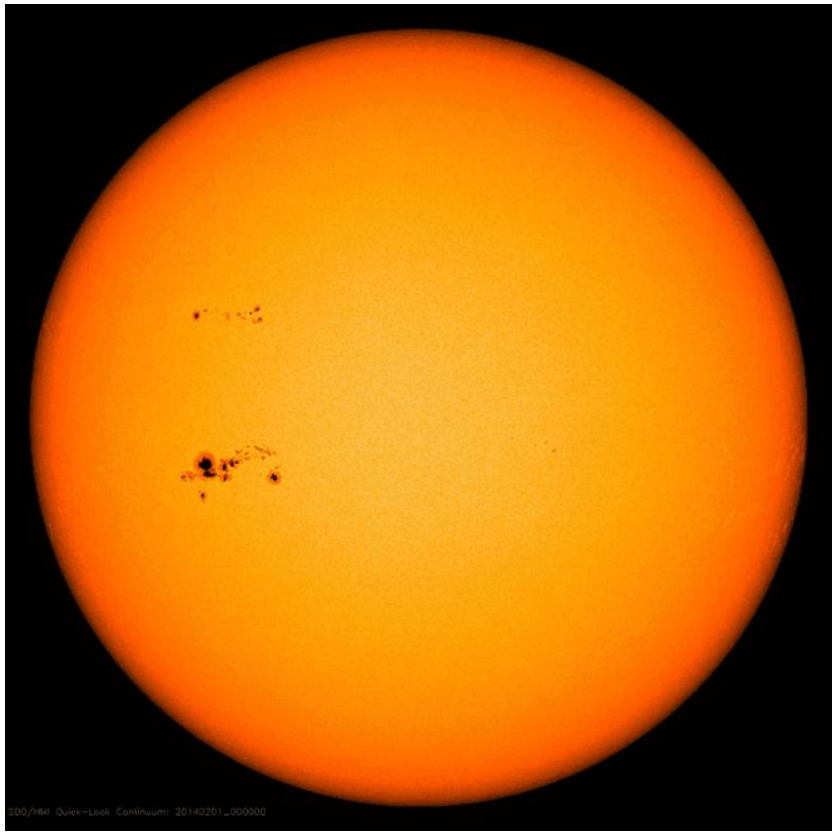


CME



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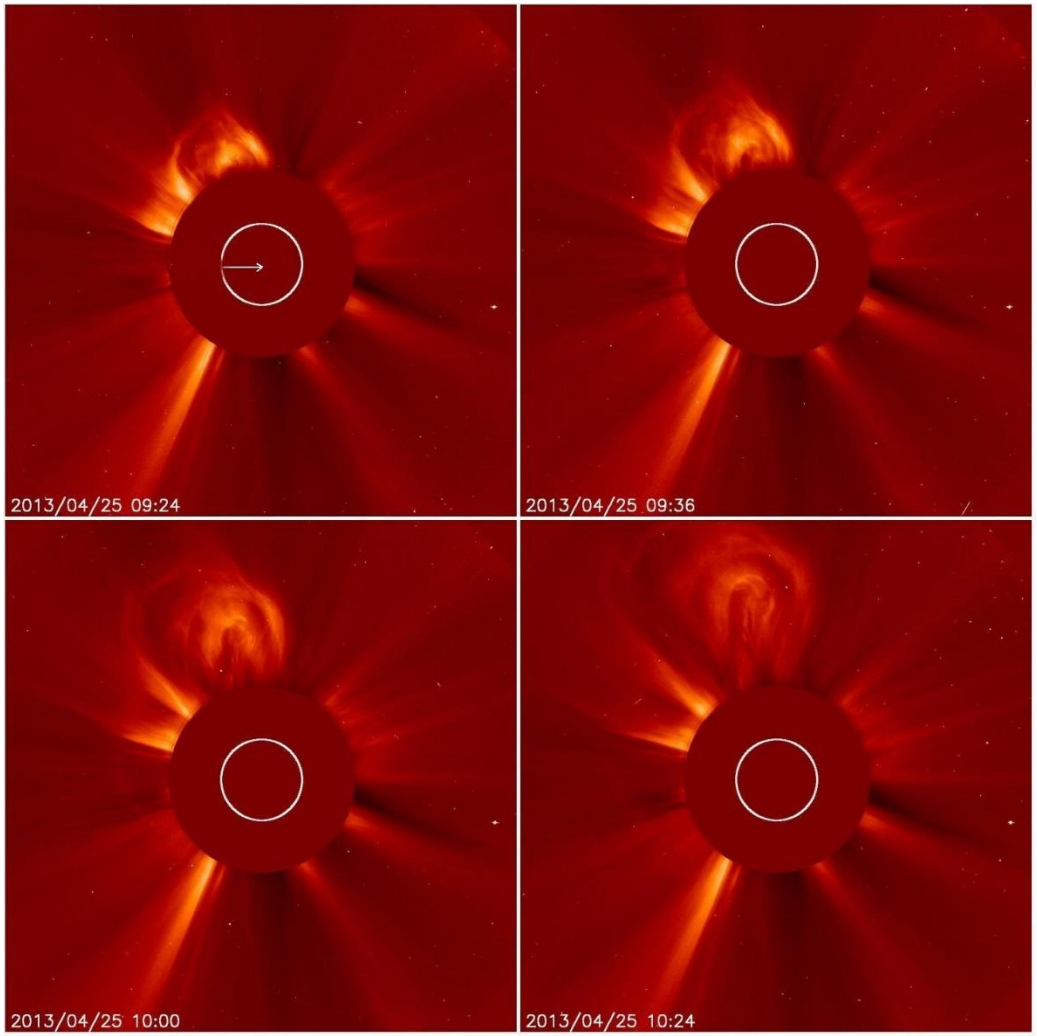
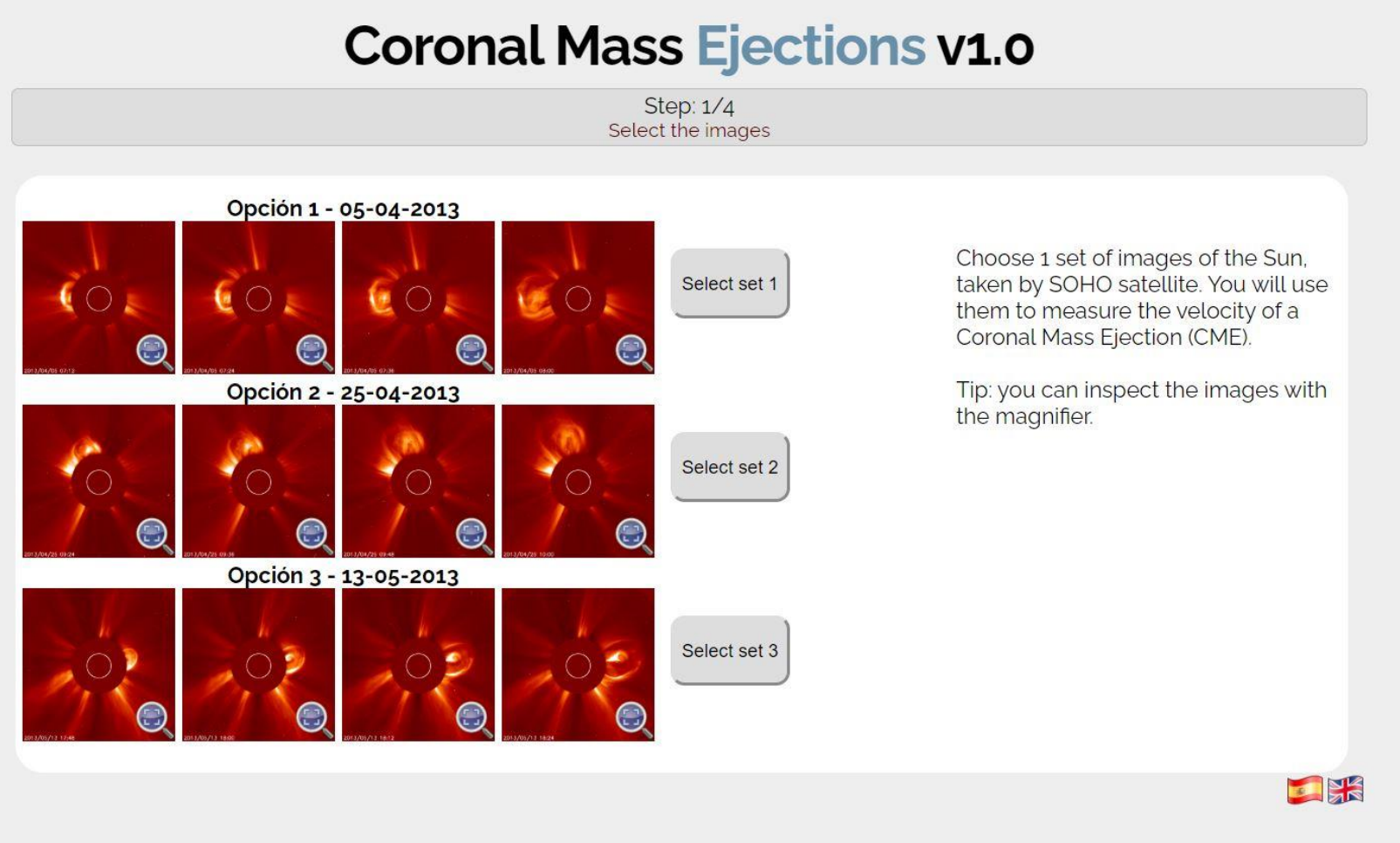


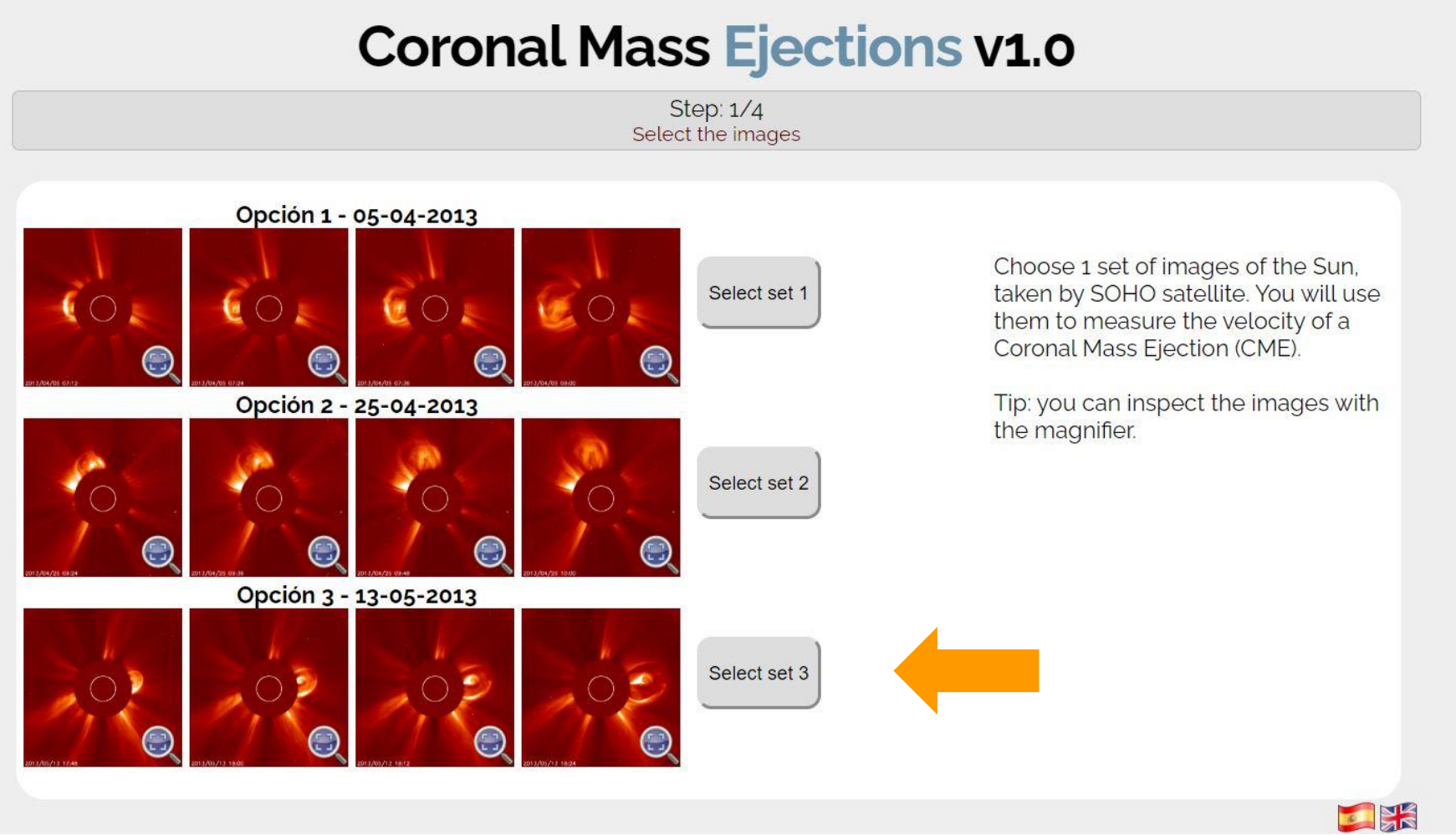
ACCESS TO THE DATA REAL SCIENTIFIC DATA



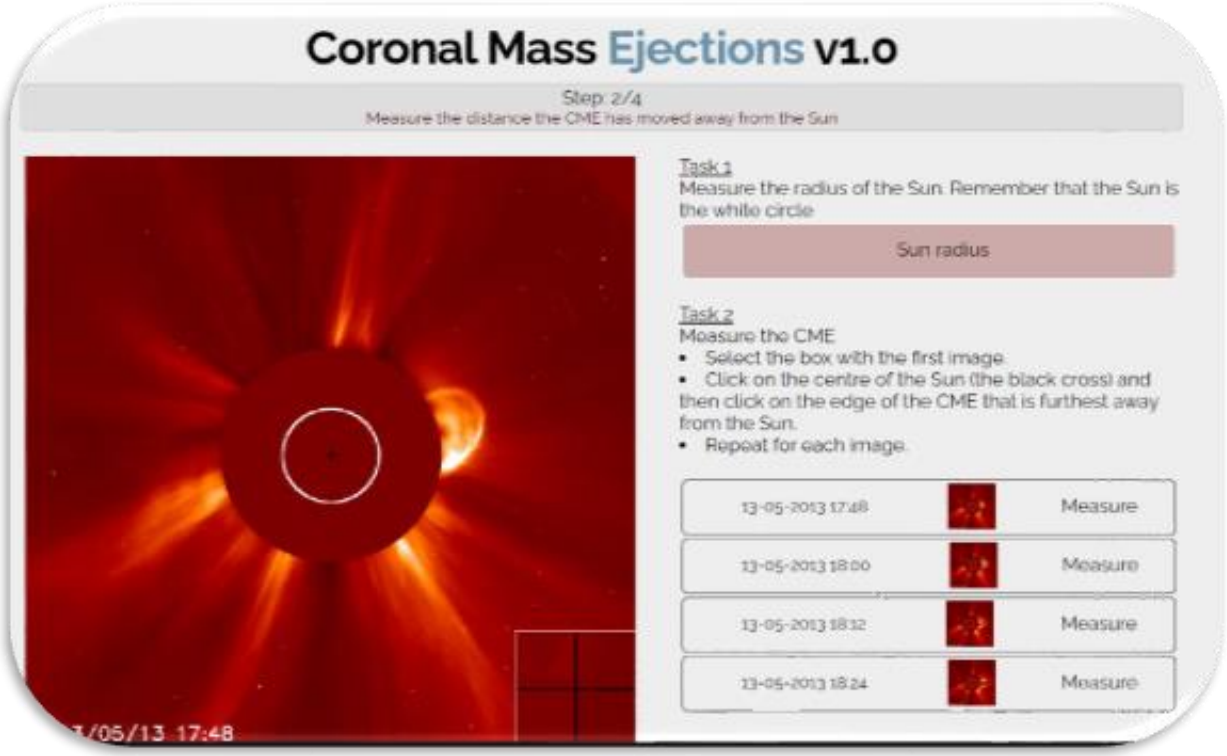
- **The CESAR web tool http://cesar.esa.int/tools/15.coronal_mass_ejections/index.php?**

Procedure

- **Step 1/4: Choose a set of images** (for example, **Option 3).** Each of them corresponds to four consecutive images of the evolution of an ejection on different dates.



- **Step 2/4 (I): Calculate the radius of the Sun** to know the scale of the image.
  - Click with the mouse on the center of the Sun (black cross) and then on any part of the white circle



- **Step 2/4 (II):** For each image **measure the length of the coronal mass ejection.**

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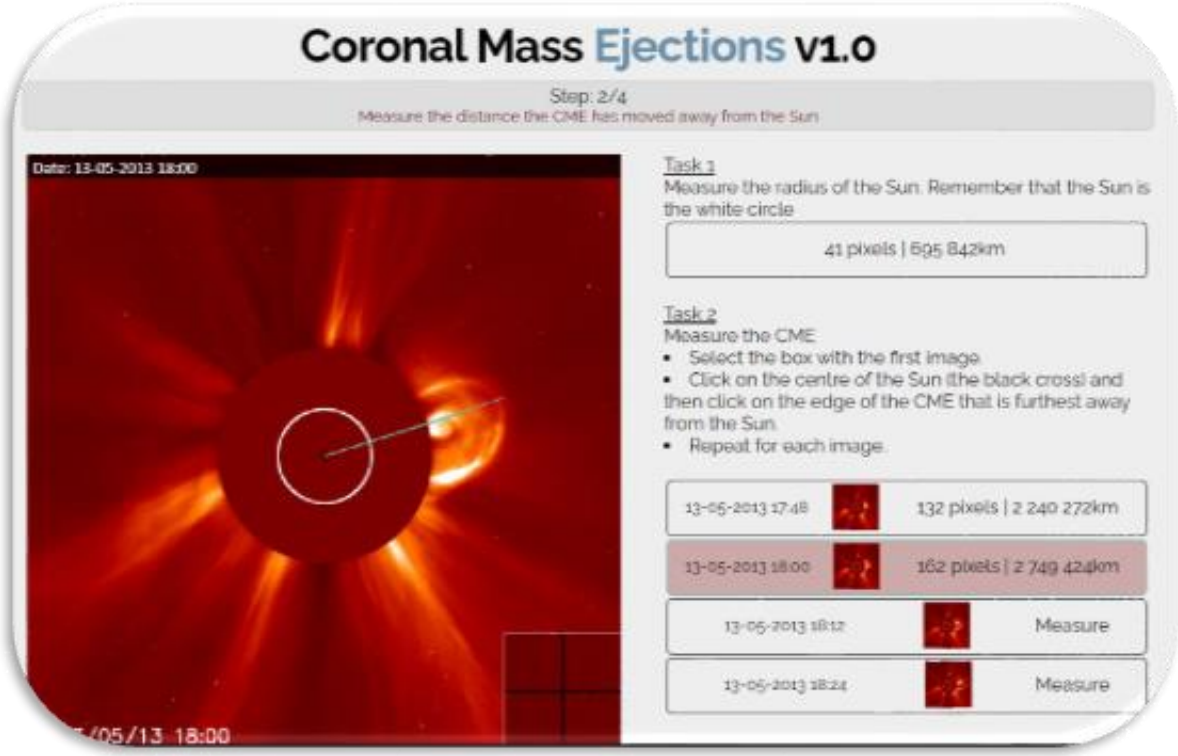
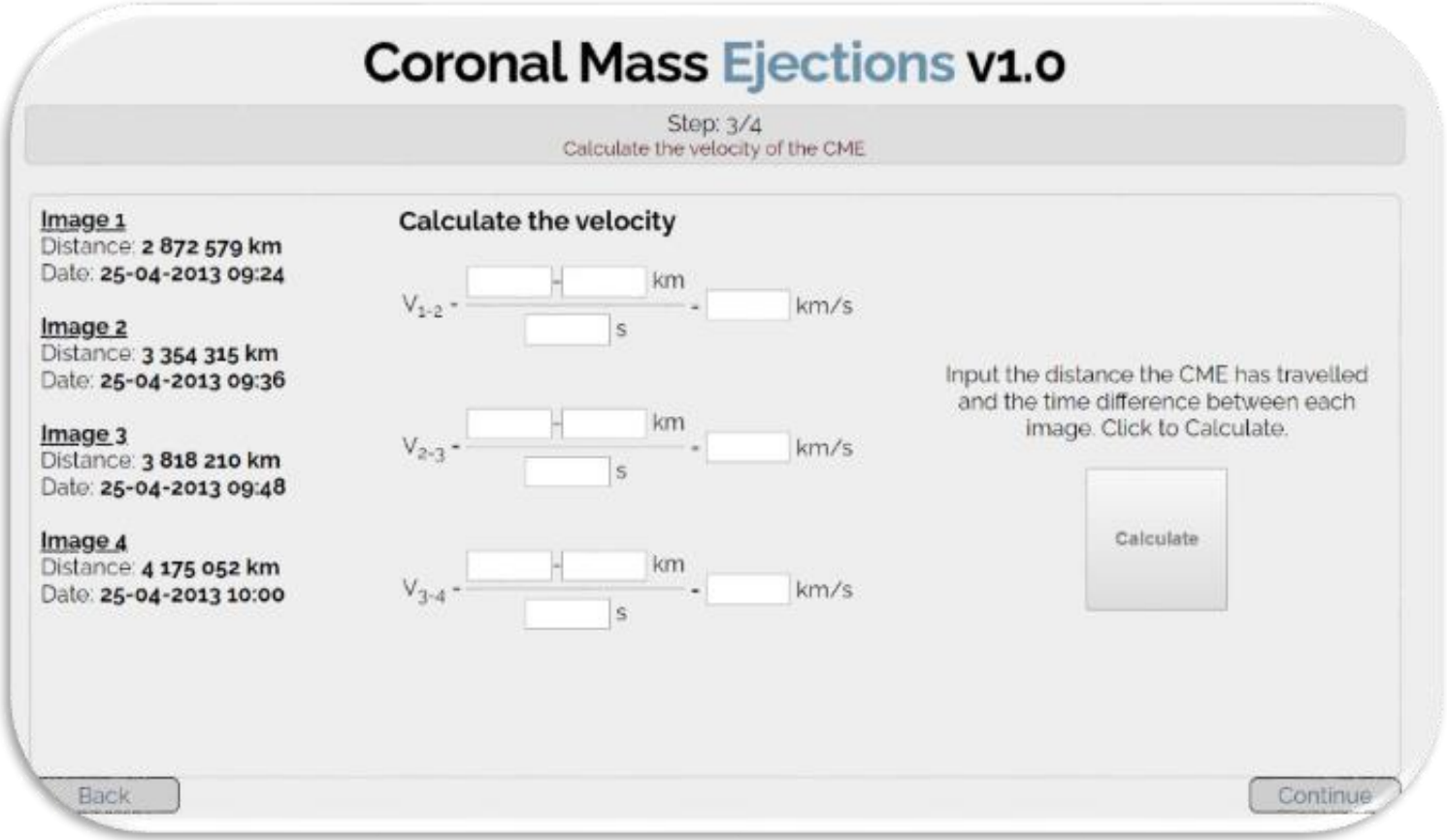


- **Step 2/4 (II):** For each image **measure the length of the coronal mass ejection.**

- **Step 3/ 4: Calculates the speed of ejection between images.**
  - Fill in in the numerator the length of the ejection CME.
  - Fill in the denominator with the time difference between the image(N) and image(N-1), **in second**s.



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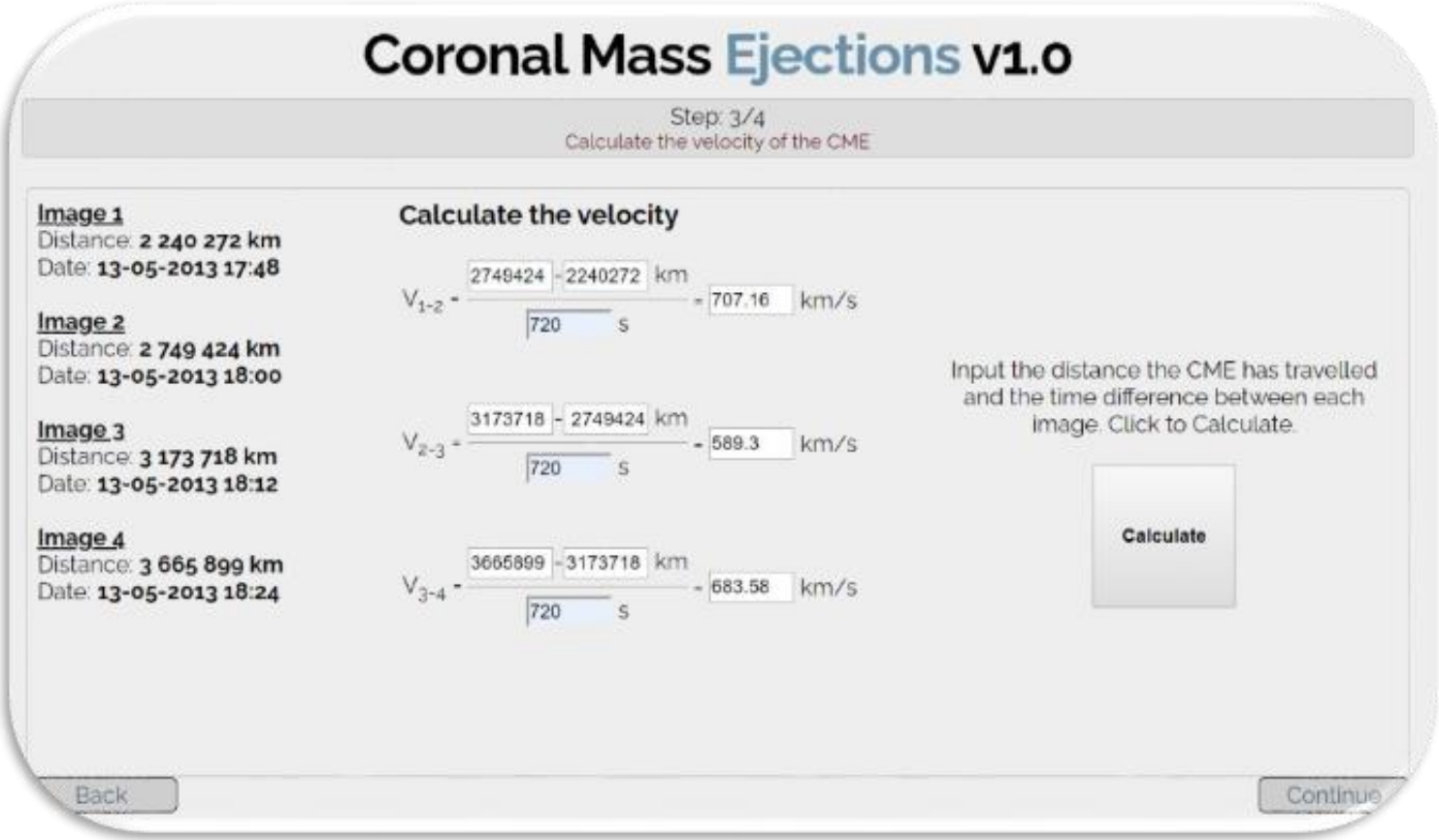
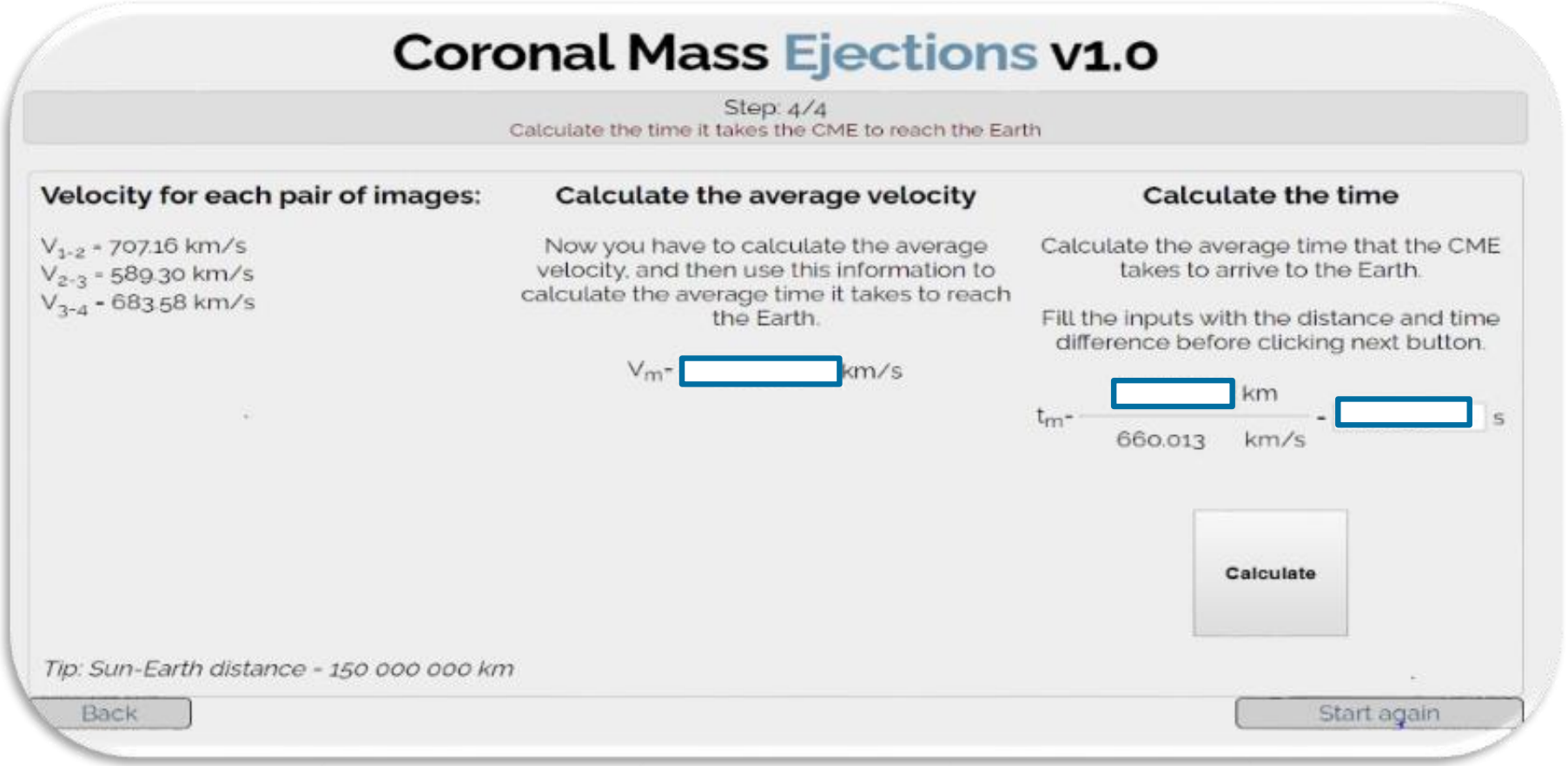
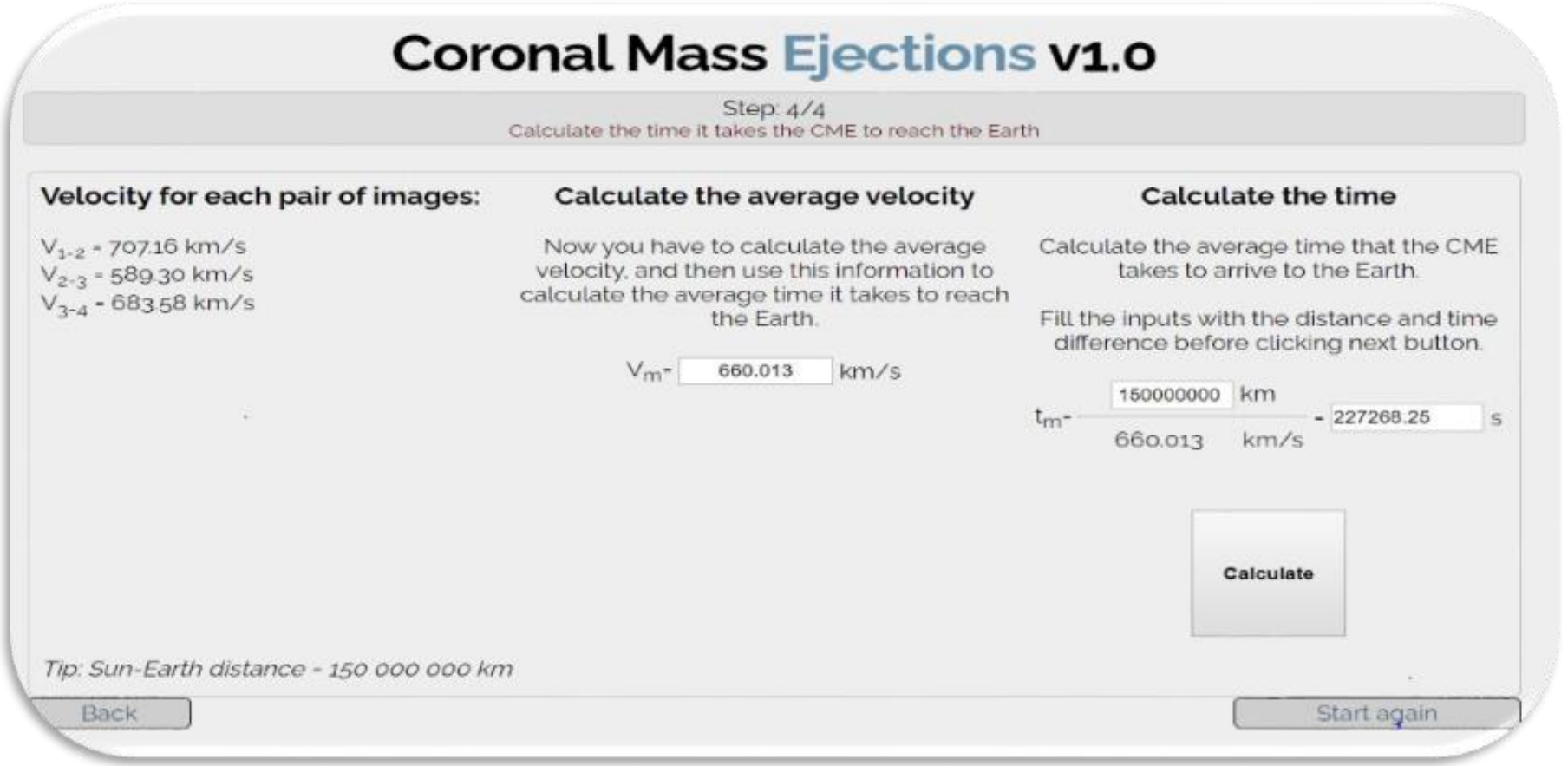


- **Step 4/4 (I): Calculate the average ejection speed.**
  - Use the values of the three instantaneous speeds (calculated between pairs of images) in Step 3 and calculate the average speed.



- **Step 4/4 (II): Calculate the time it would take for the ejection to travel the Sun-Earth distance**.
  - Enter the average speed you have calculated into the tool.
  - Enter the Sun-Earth distance, which is 150 000 000 km

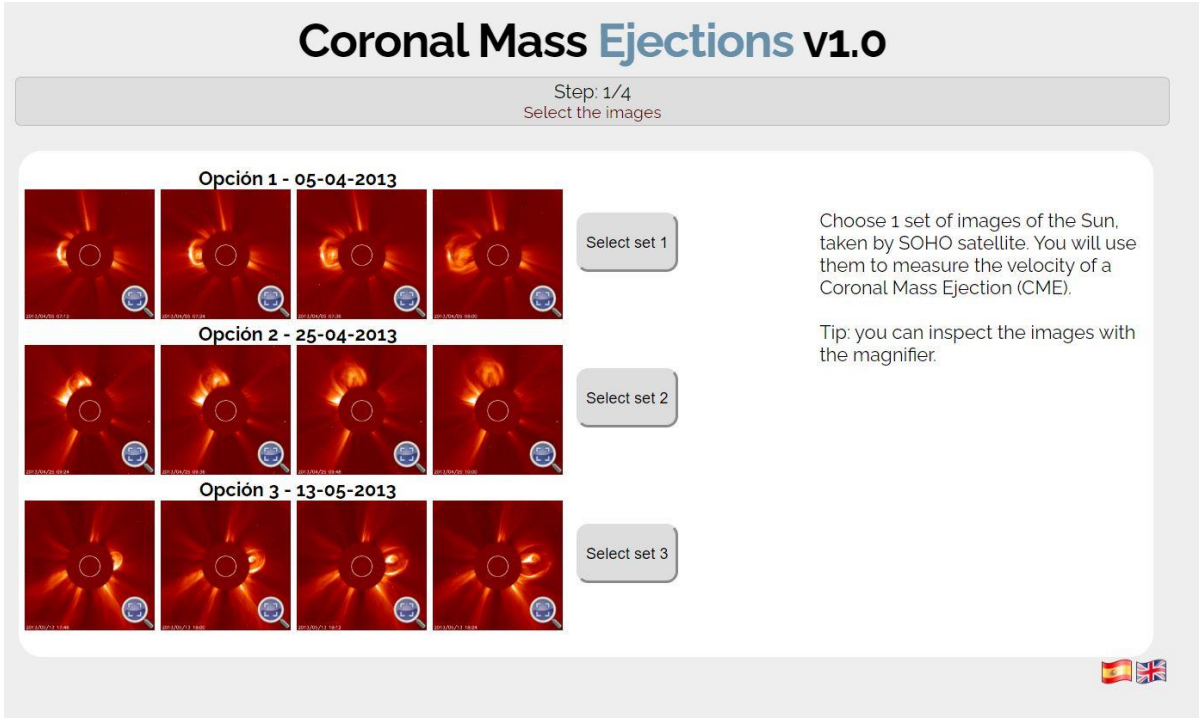


Team 1

Team 2

Team 4

Team 3



Step 2

How long would it take for a solar storm to reach Earth?

((De)Acelerated Linear Movement)

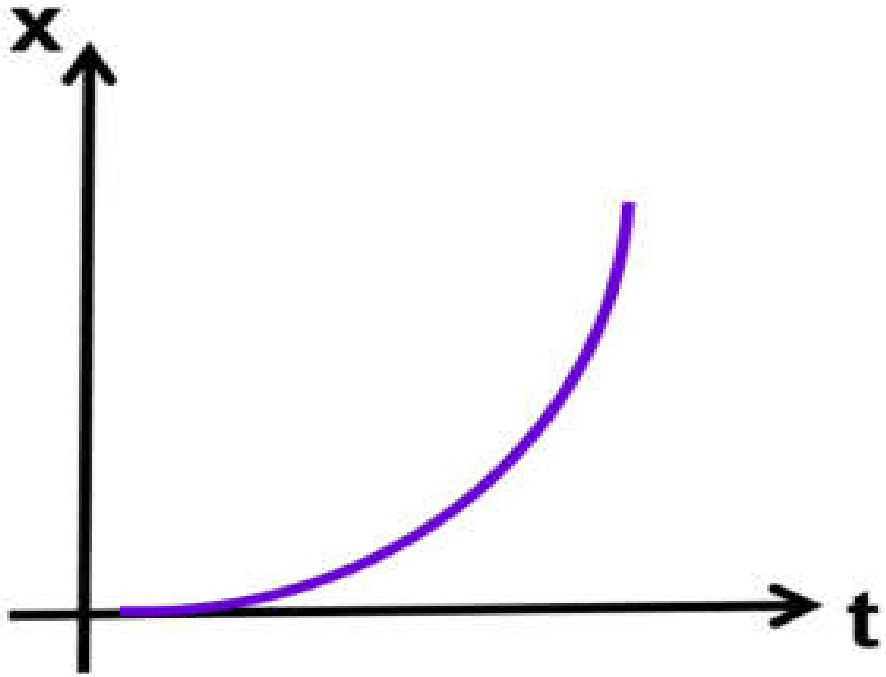


Figure 31: *Chart that students should obtain when representing the position against time*

Note: The real movement of the ejection does not have this constant acceleration, but rather it decreases due to the friction with the interplanetary medium, especially with the solar wind that is in its path. In the Figure 32 we can see the density of this material, and also the velocity distribution as the ejections move away from the Sun.

Figure 32: Velocity-Distance to Sun Chart (Credits: SpaceWeather)