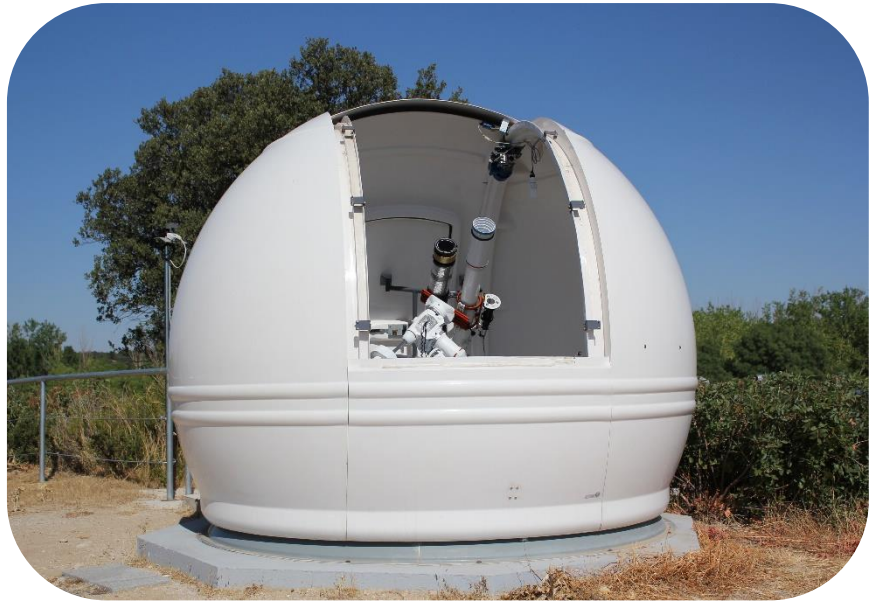
Following Sunspots

CESAR Scientific Challenge

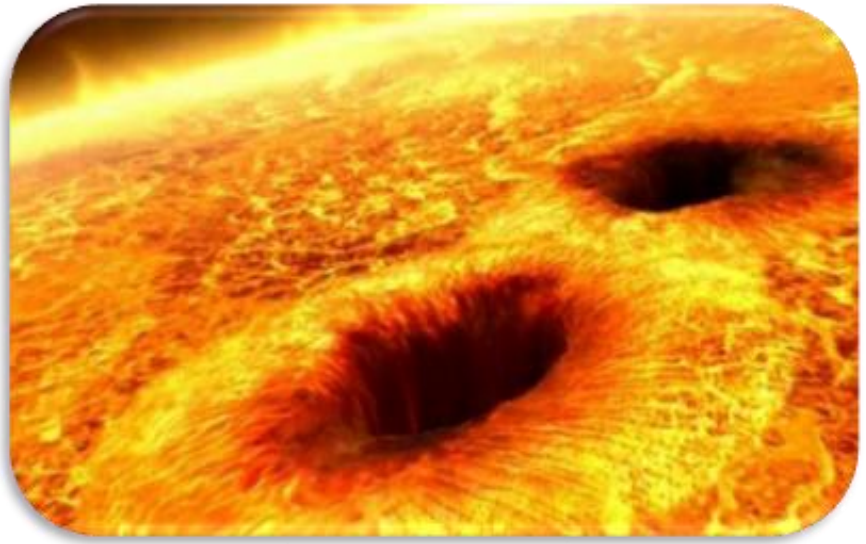
Calculate the Sun rotation with
the CESAR Solar Telescope



Beatriz González García on behalf of the CESAR Science Cases Team

We have received a message:
"¡ Solar storm to Earth detected! Take cover!"

Figure 1: *Coronal Mass Ejection (CME) (Credits: https://www.libertaddigital.)*



In addition, the Solar Observatory HELIOS at ESAC, that was observing the Sun at the time, detected spots on the surface of the Sun close to the place where the SOHO satellite detected the coronal mass ejection.

Didactics

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

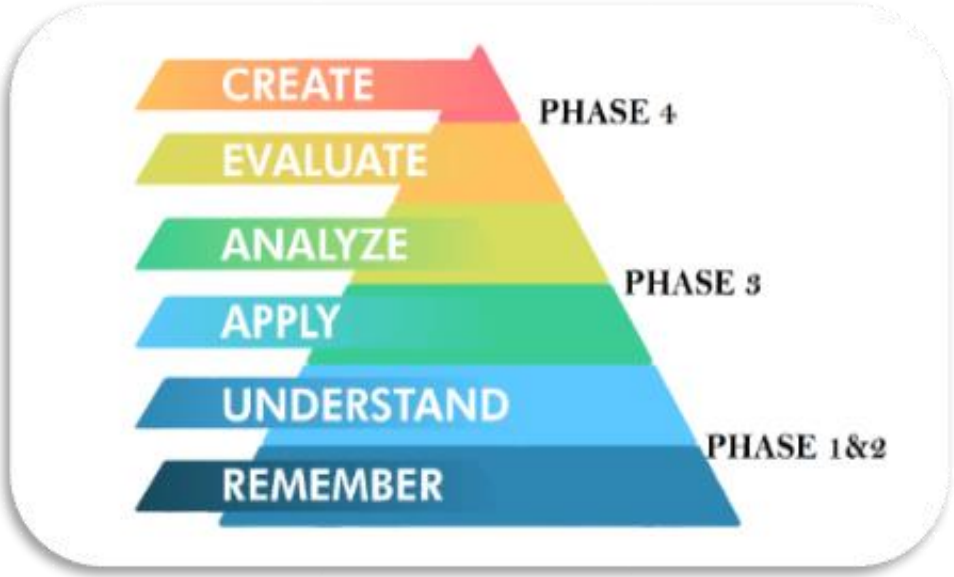


Figure II: *Bloom's Taxonomy diagram. (Credits: https://medium.com/@ryan.ubc.edtech/)*

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:** (12-14) years old
- **Recommended academic courses:** (1-2) ESO
- **Type:** Student activity
- **Complexity:** Medium
- **Teacher preparation time:** (1-3) hours
- **Required time for the lesson:** (4h – several days), depending on the activities requested by the teacher.
- **Location:** Indoors
- **Includes use of:** Computers, internet

The students should already know…

- The rotation period concept.
- Longitude and Latitude.
- The concept of velocity
- Angles measurements
- 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.
- Velocity and period.
- The periodic system of elements. Chemical reactions

Mathematics

- Ability to carry out small mathematical investigations and present the results.
- Interpretation of a phenomenon by means of a statement, table, graph or analytical expression

Geography

- Latitude and longitude.

Scientific Culture

- Use of ITC for seeking information. Research and exploration of the Universe. Working in teams. Debates.

Students will learn …

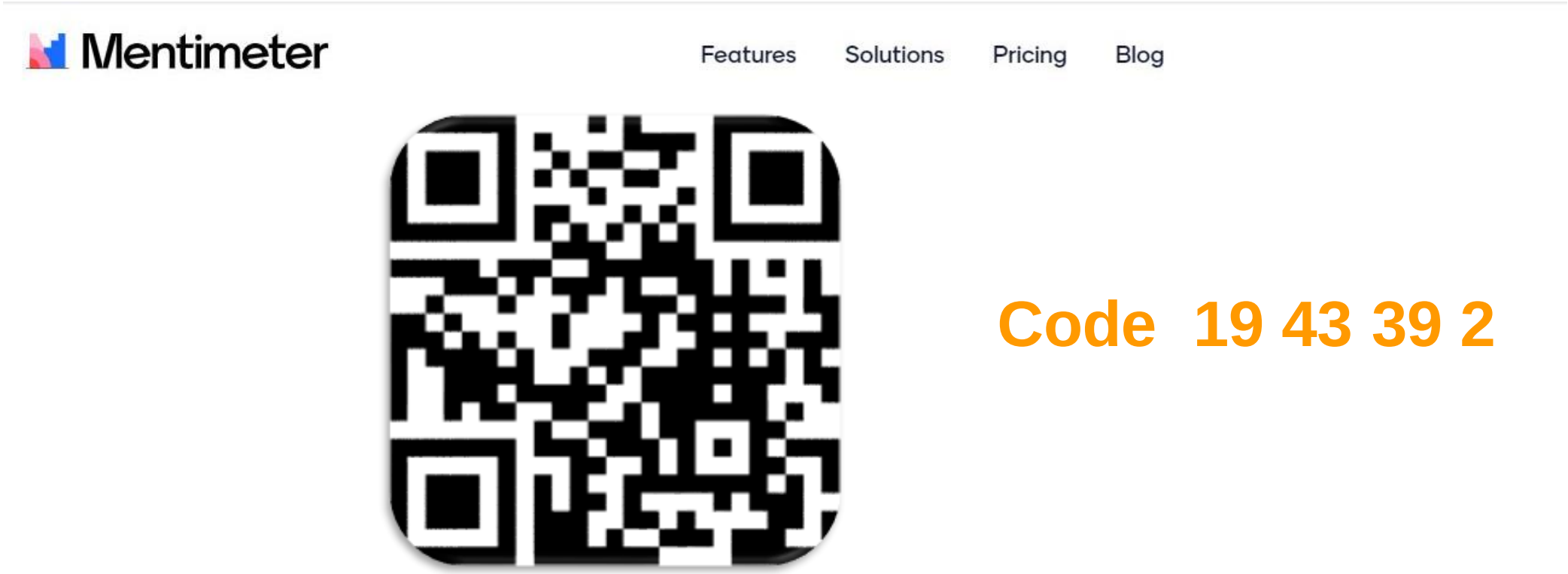
- To get information from astronomical images (positions).
- To calculate velocity and periods of rotating object, in this case from the Sun, from fixed reference points (sunspots) on its surface

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?

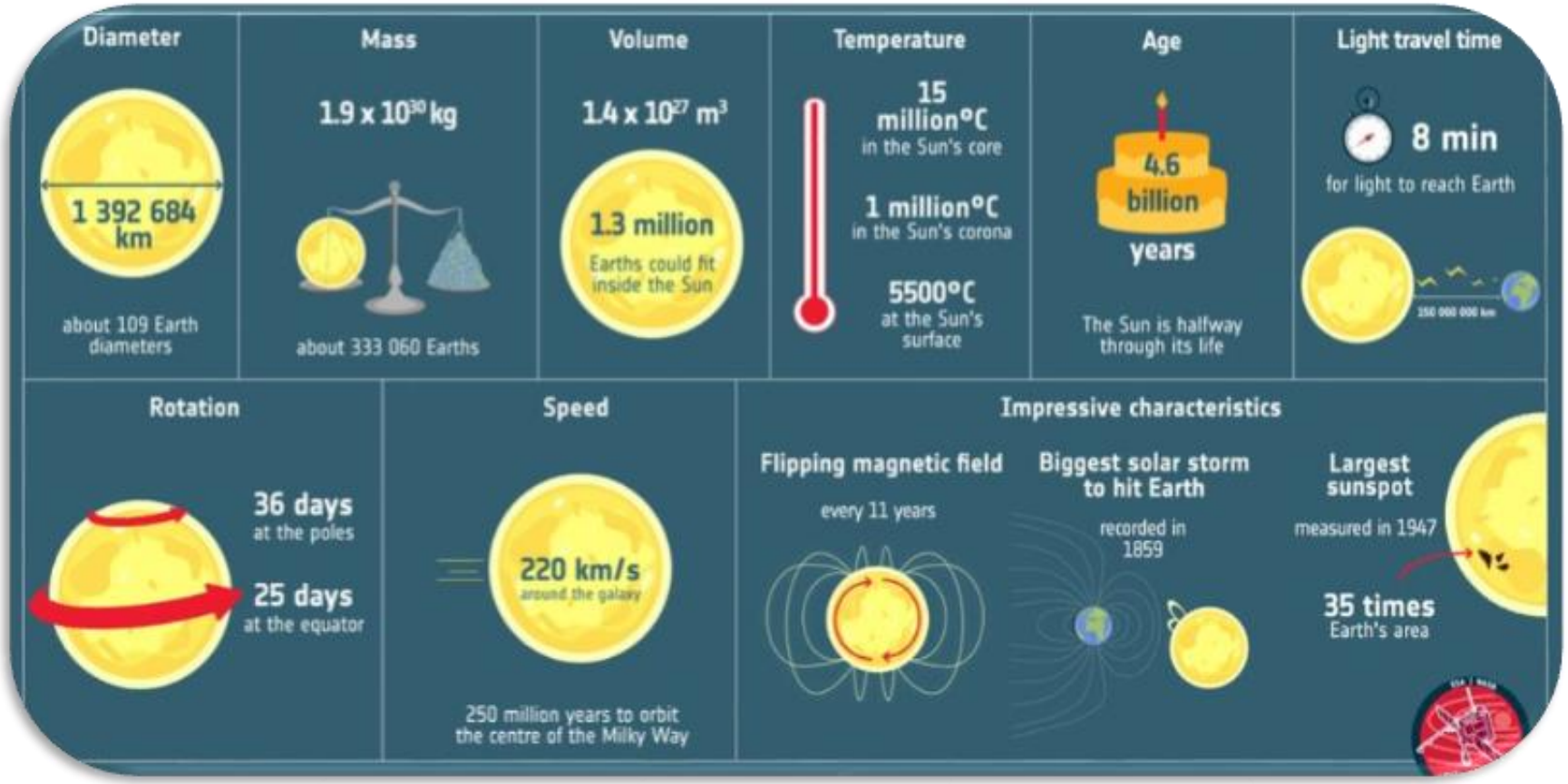
Menti.com – what do you know about the Sun?



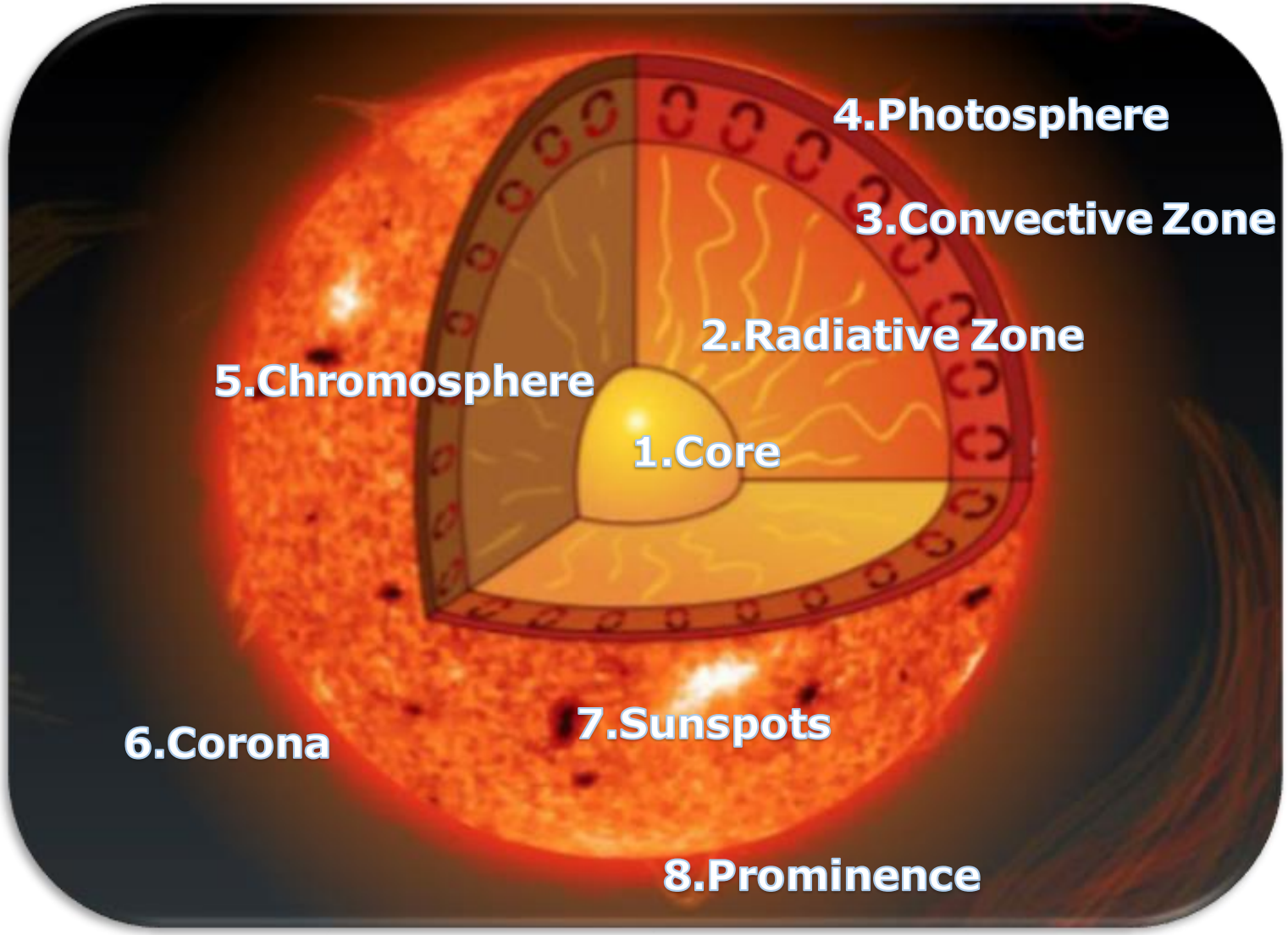
Code 19 43 39 2

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.



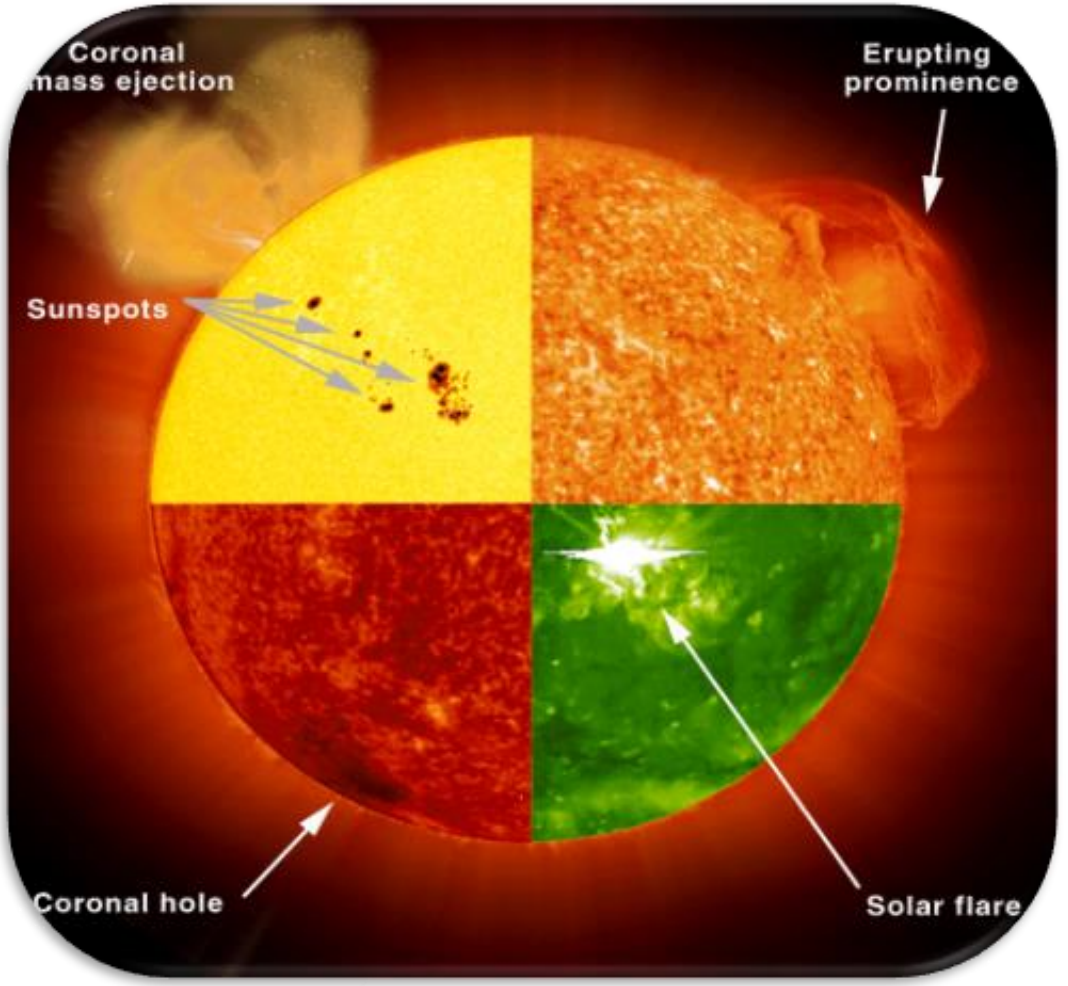
1.1 The Sun Structure



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.



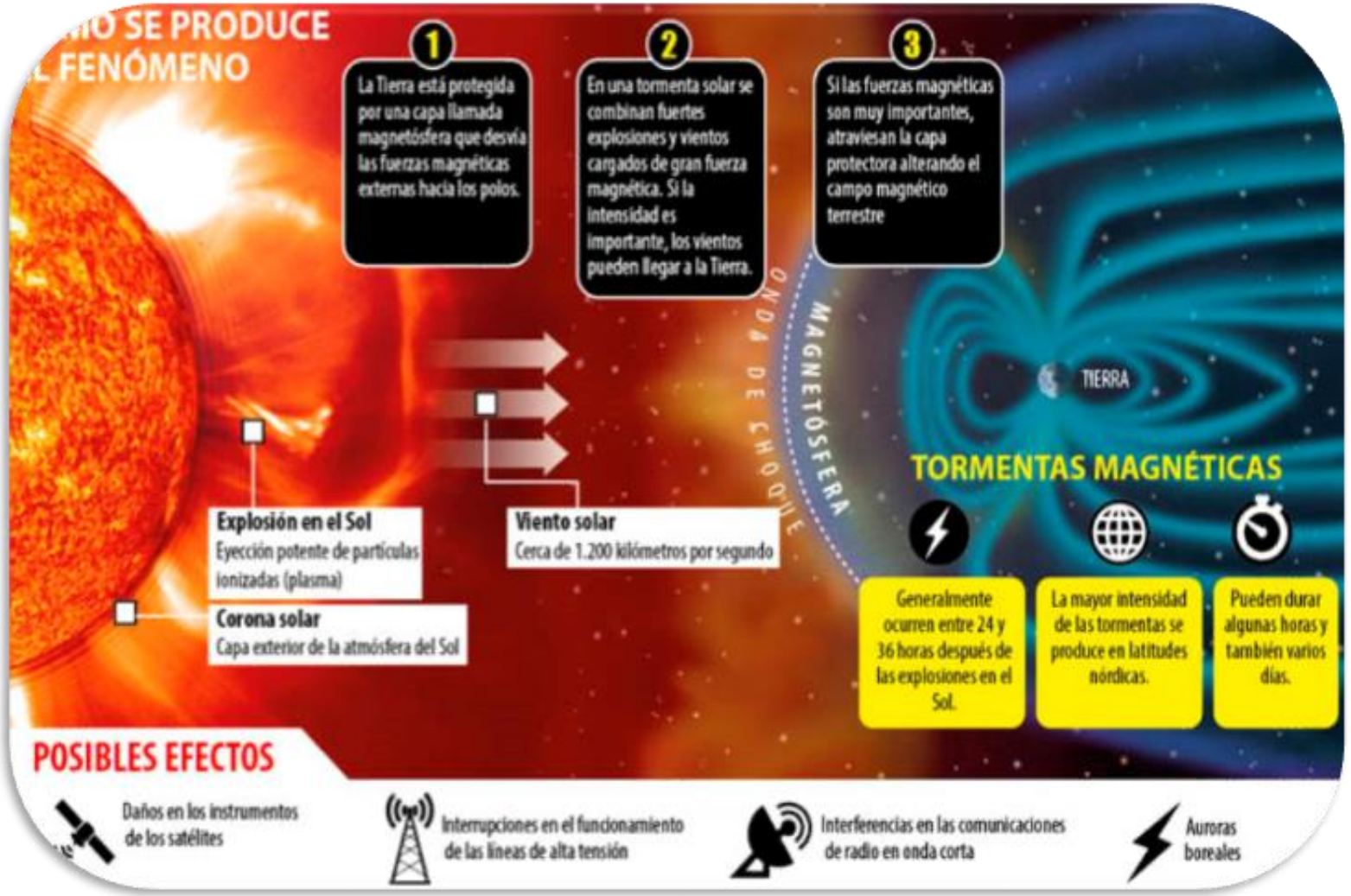
2.2 The influence of the Sun on the Earth

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

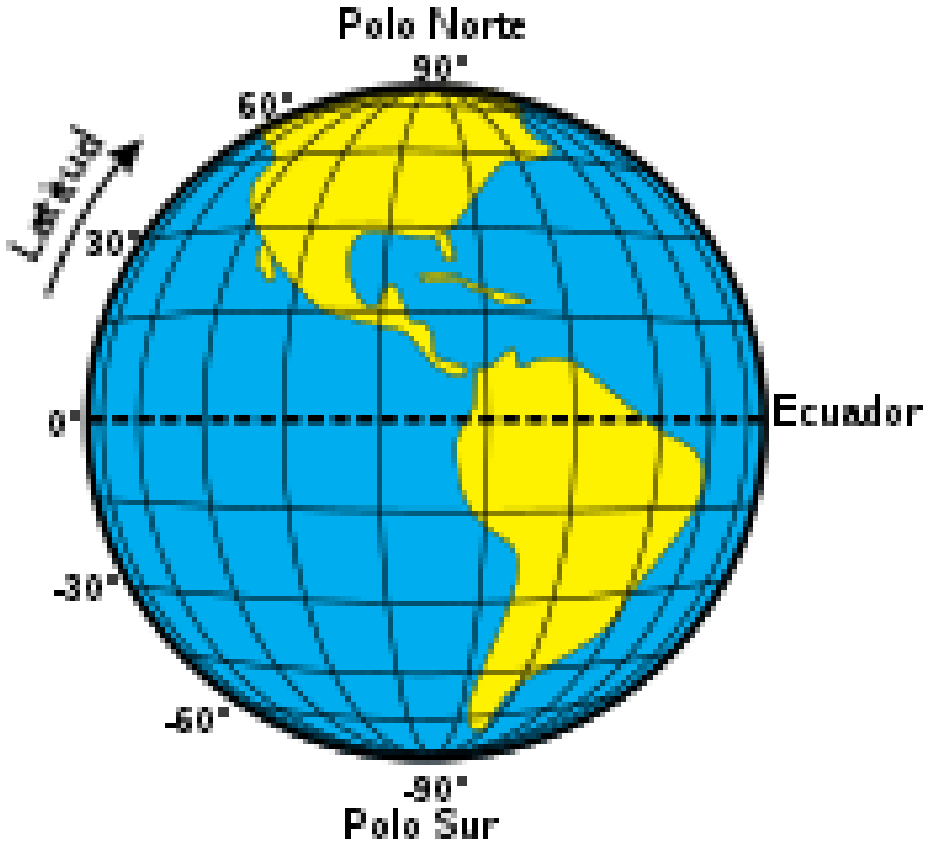
Answer in the Chat

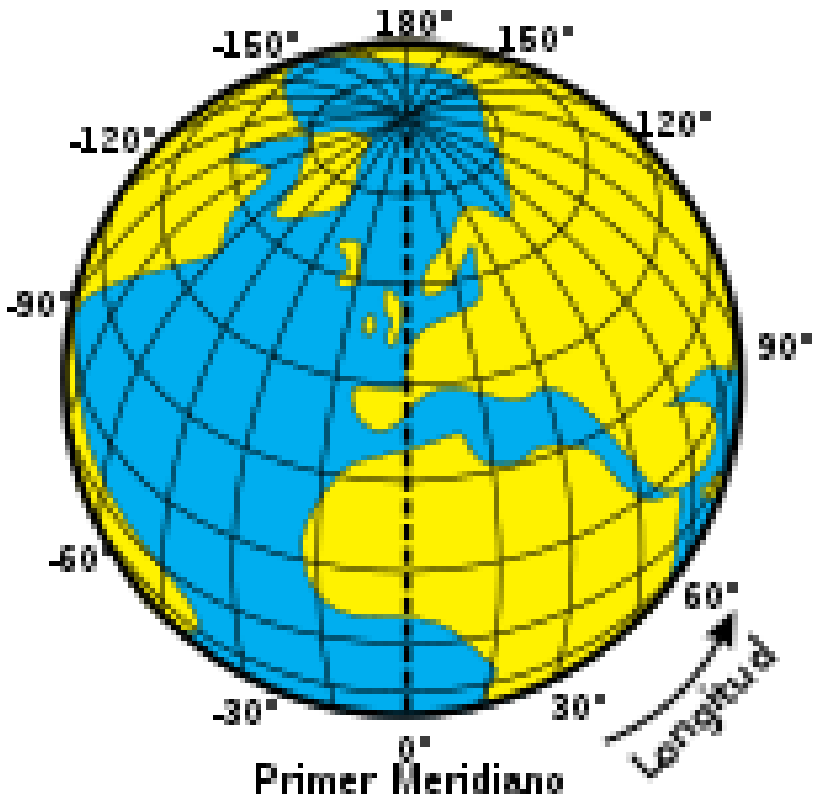
The Earth is protected by a magnetic field, which is the union point between the Earth and Space, and the charged particles, emitted by the Sun, can produce very impressive visual effects, such as the Northern Lights.

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)

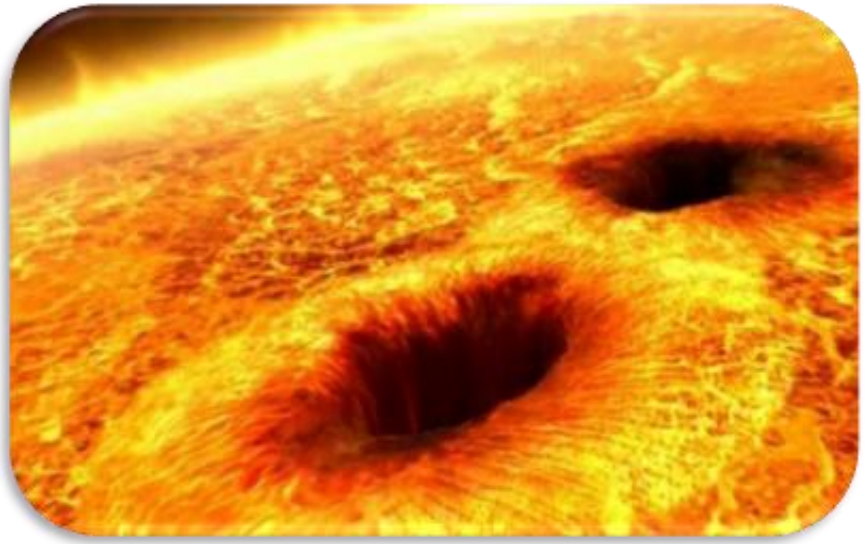




Let's start the Challenge

We have received a message:
"¡ Solar storm to Earth detected! Take cover!"

Figure 1: *Coronal Mass Ejection (CME) (Credits: https://www.libertaddigital.)*



In addition, the Solar Observatory HELIOS at ESAC, that was observing the Sun at the time, detected spots on the surface of the Sun close to the place where the SOHO satellite detected the coronal mass ejection.

Step 1

Calculation of the Sun rotation

Hypothesis

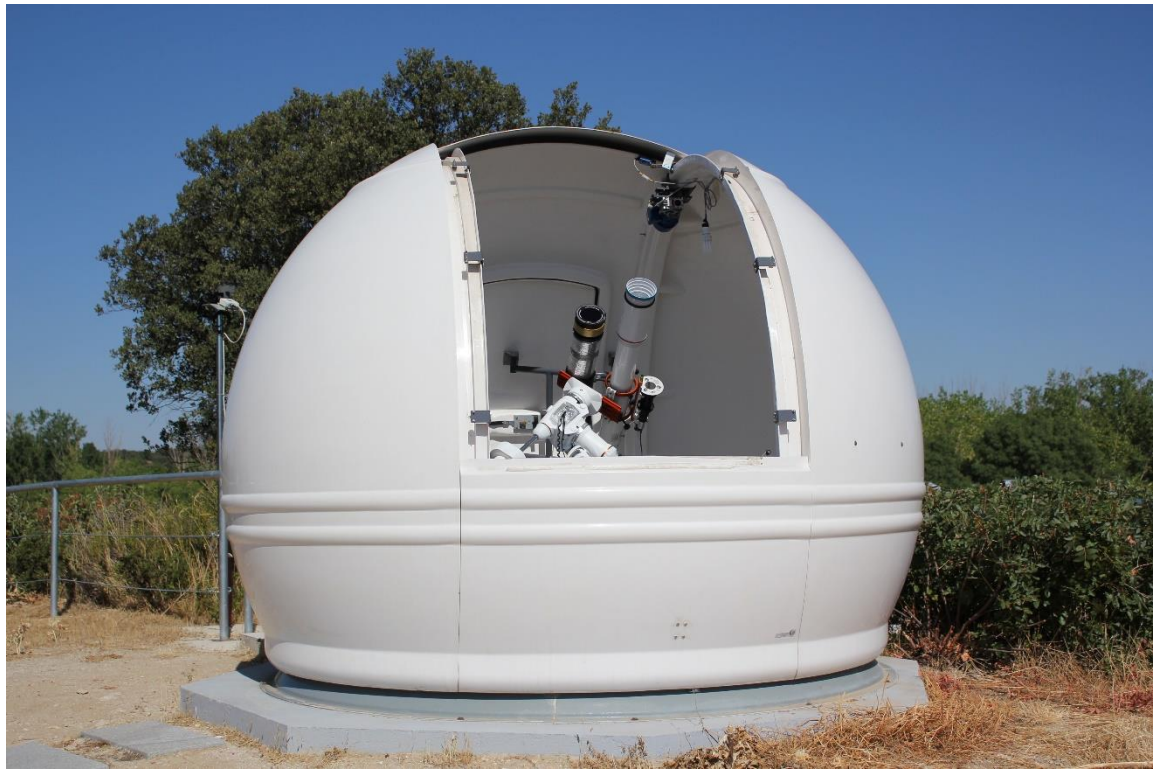
How long does it takes to the Sun to spin?

Answer in the Chat

REAL SCIENTIFIC DATA

Access to of the Sun taken by the Solar Observatory HELIOS.

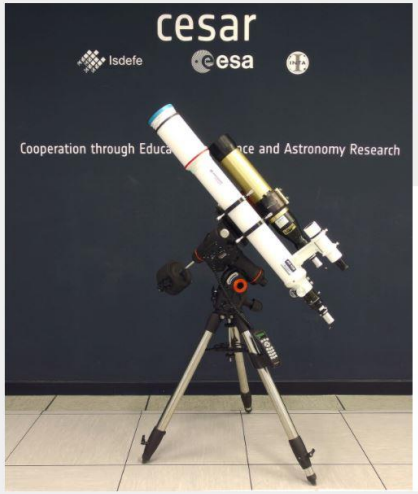
You **will measure the movement of a sunspot over several days** to calculate the rotation of the Sun.



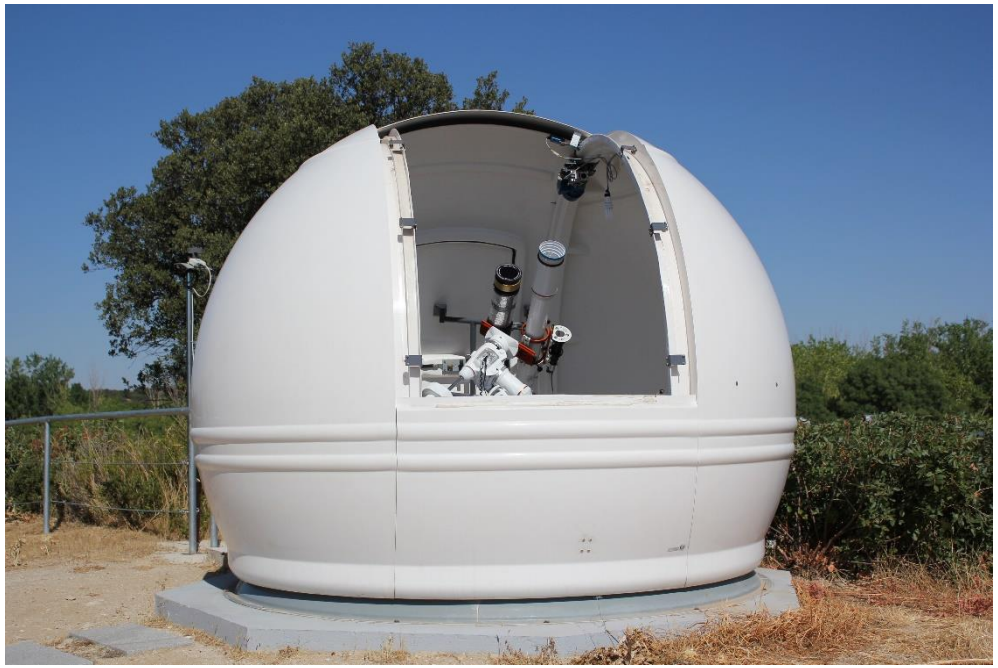
TECHNICAL SPECIFICATIONS

It consists of a 3 meter remotized classical dome with roof sliding door (Scopedome 3M). The enclosure protects the following observing equipment from the weather:

- Two solar telescopes:

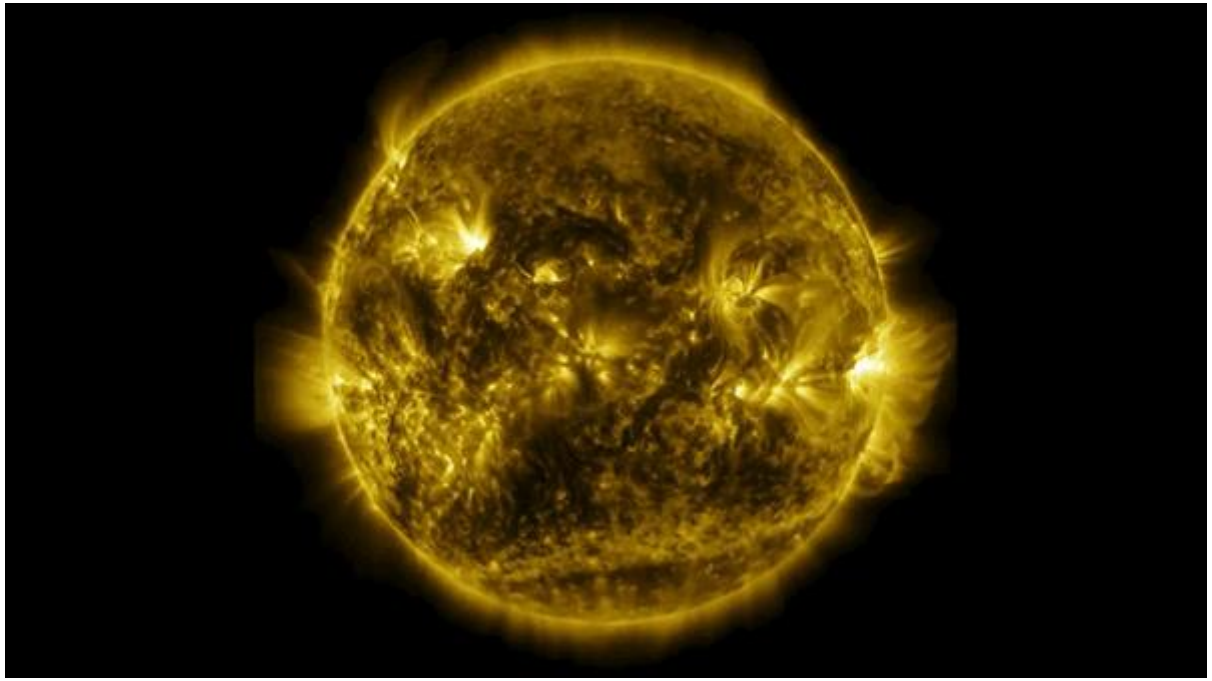


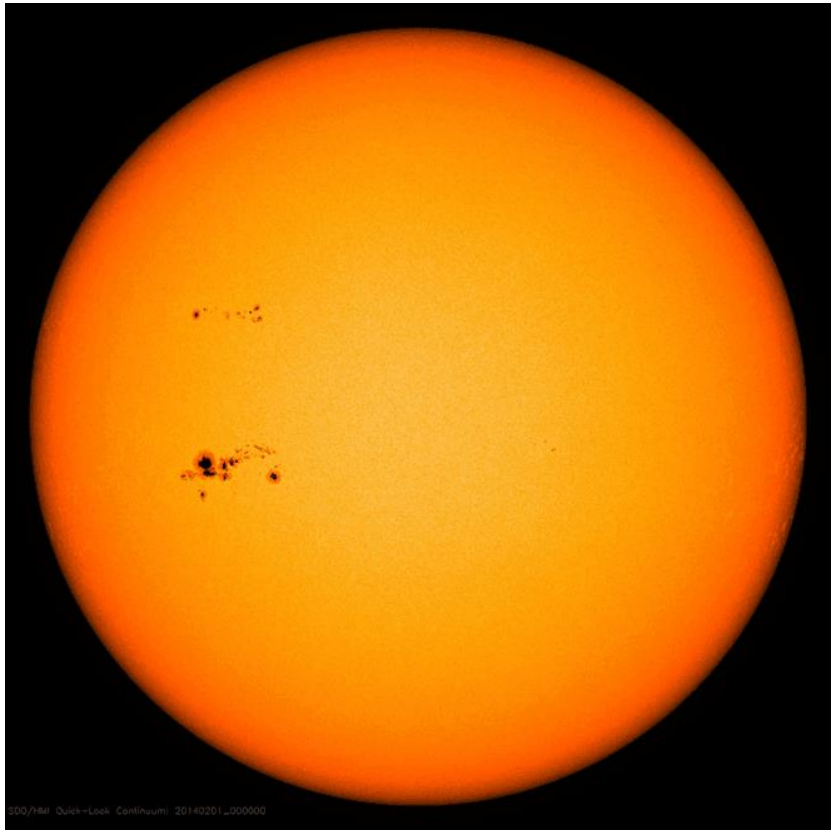
- Coronado Solarmax II 90, in H-alpha, with double stack :
  - Aperture: 90mm
  - Focal Length: 800mm
  - Bandwidth: <0.5 Å
  -



http://cesar.esa.int/index.php?Section=Observatories_ESAC_Sun

REAL SCIENTIFIC DATA





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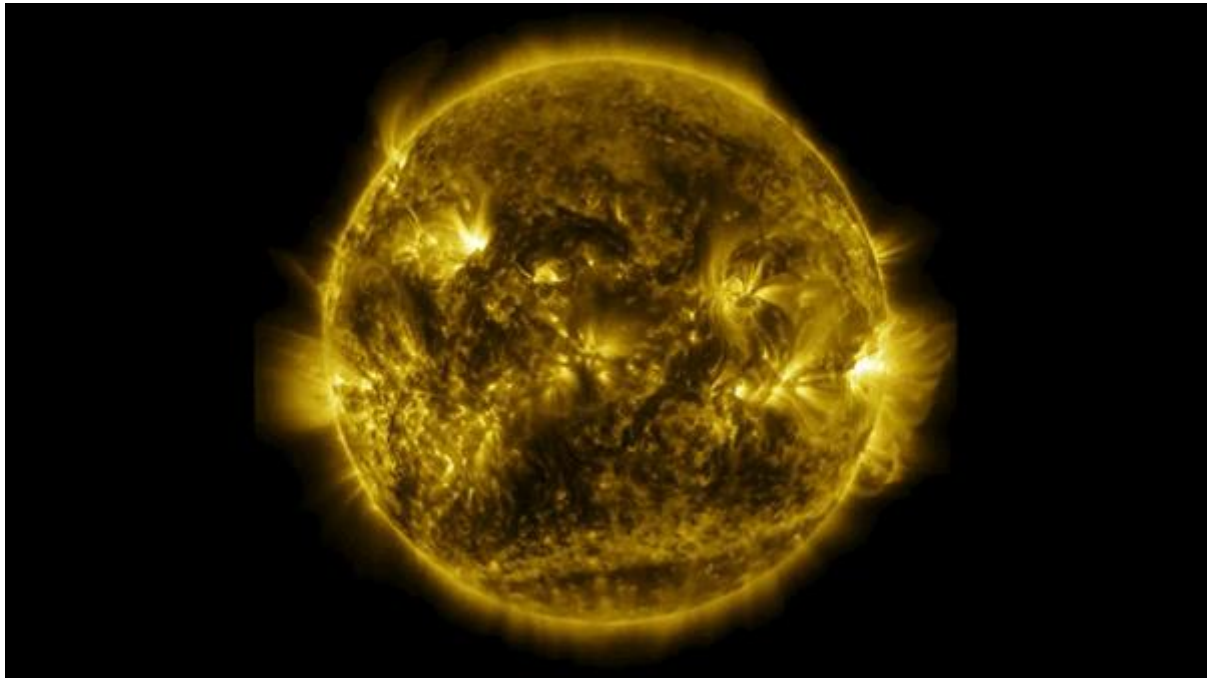
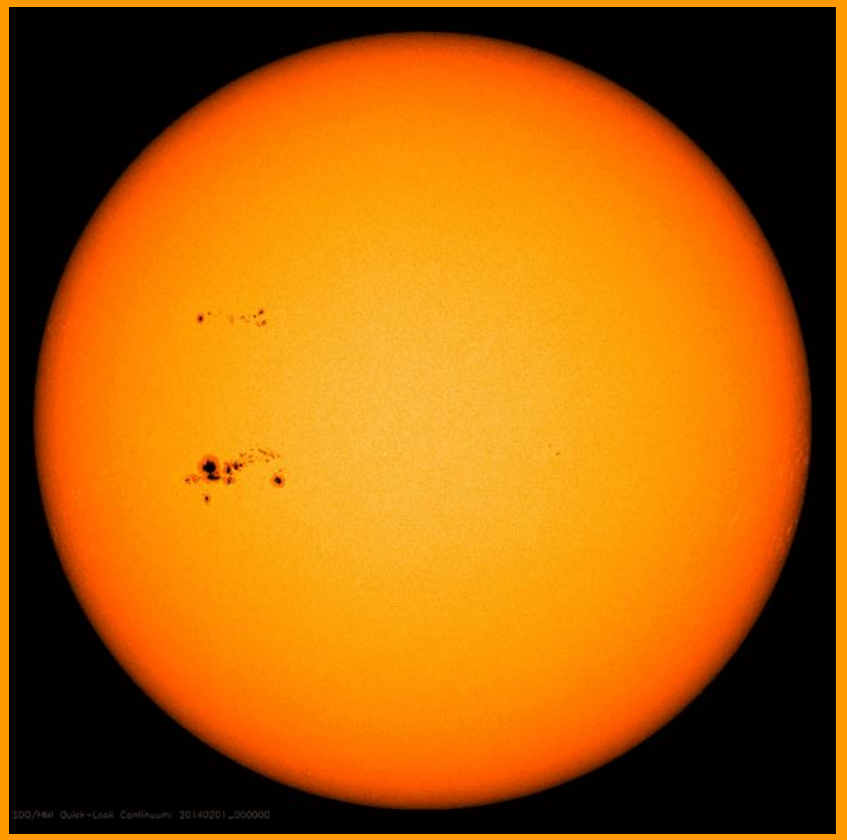
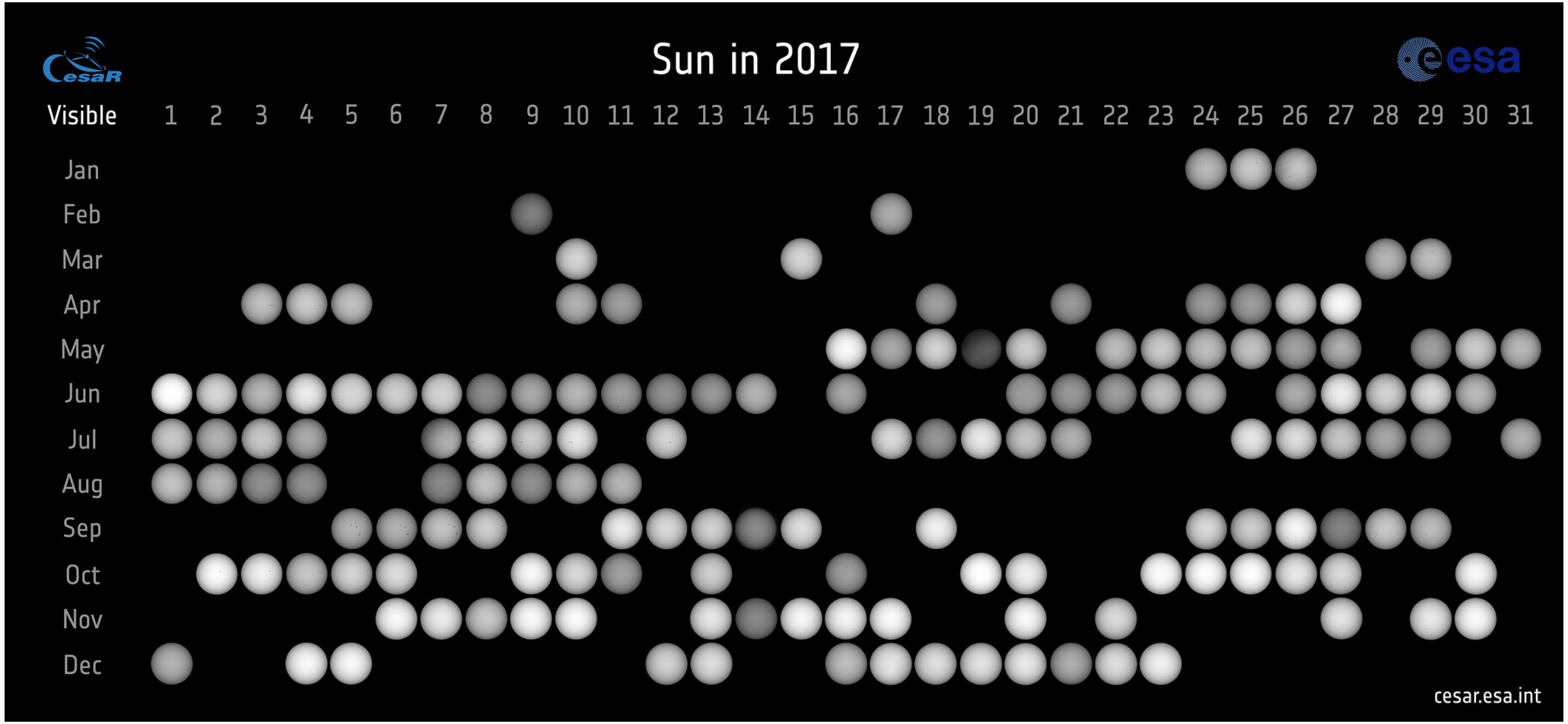
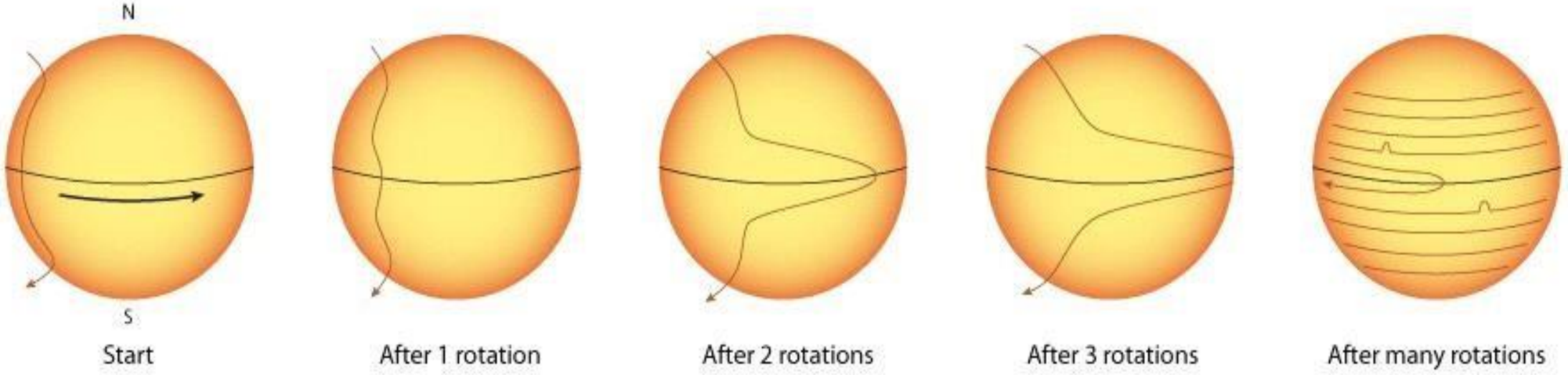




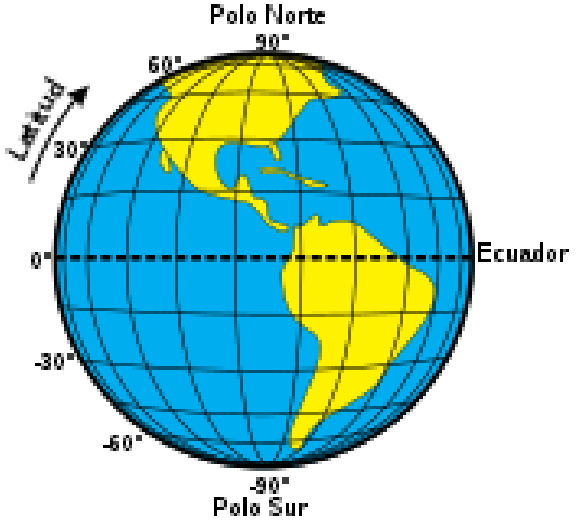
SUNSPOTS

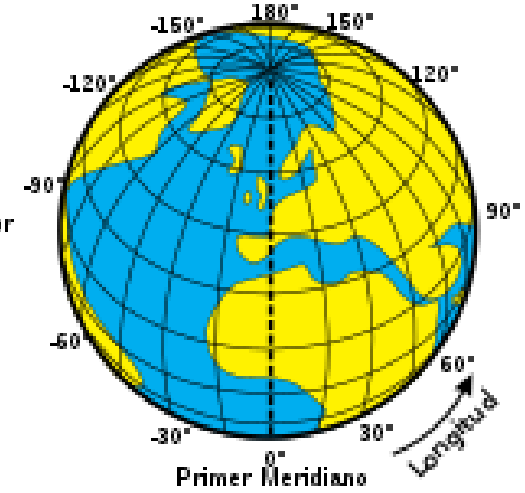
REAL SCIENTIFIC DATA



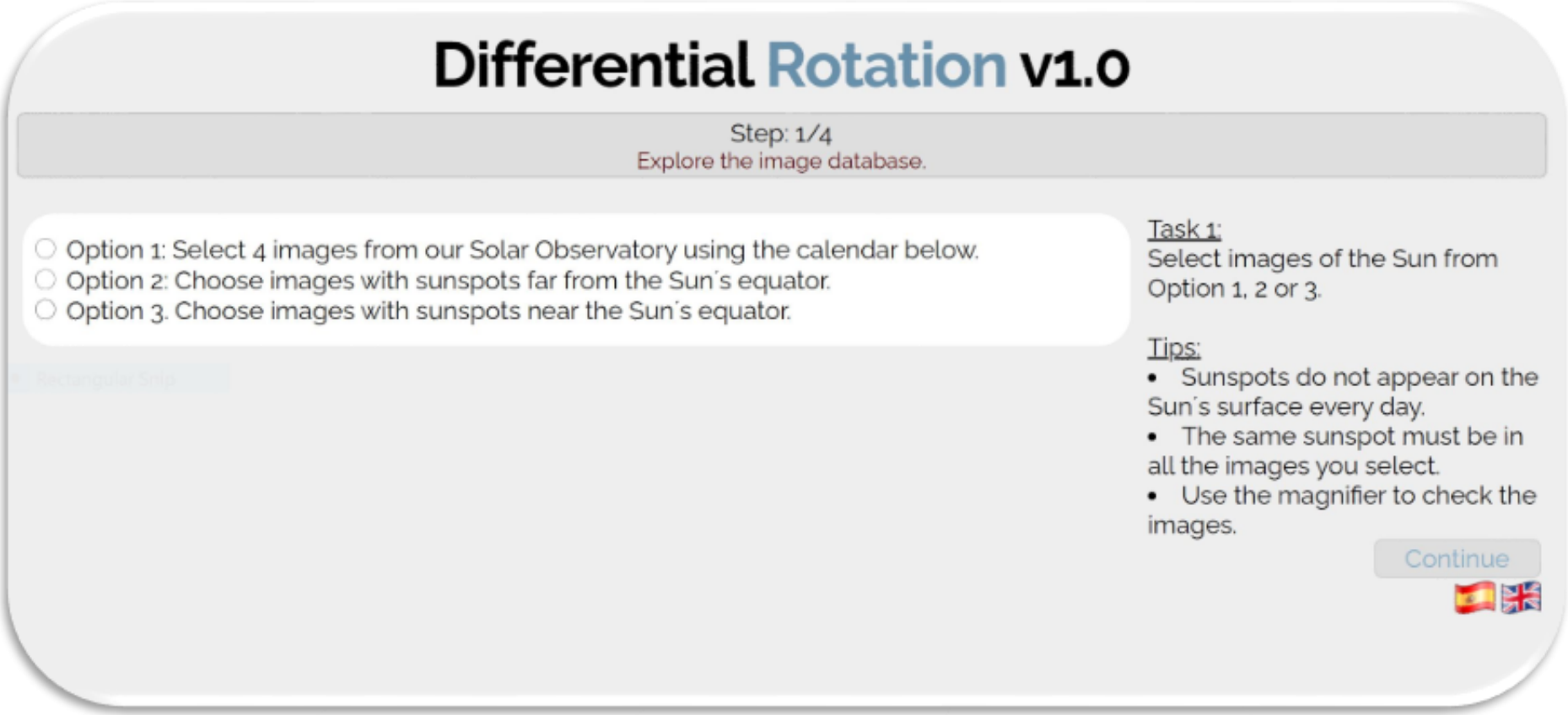


- **Follow the evolution of the sunspots in longitude**



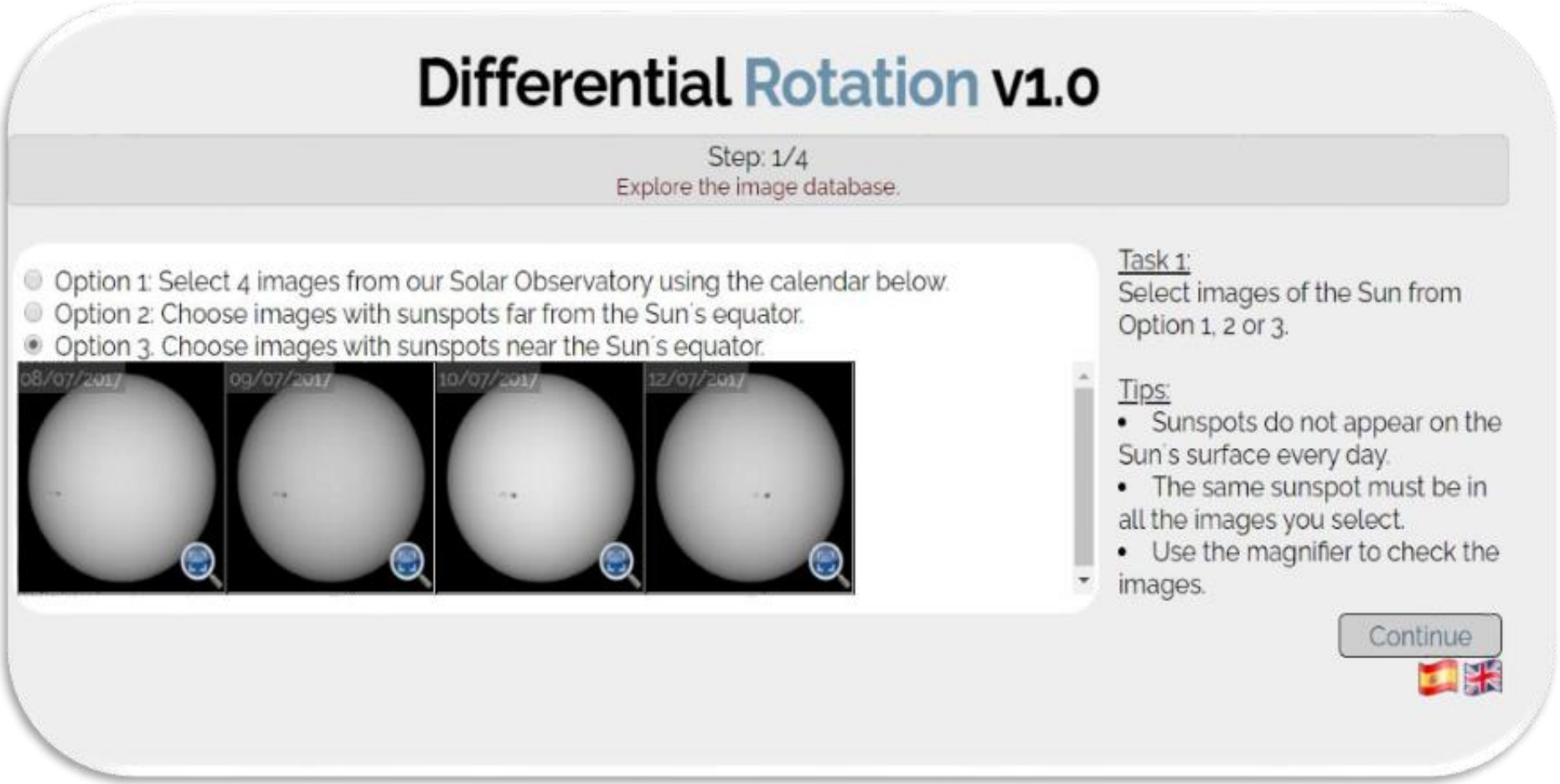


ACCESS TO THE DATA



- **The CESAR web tool http://cesar.esa.int/tools/14.differential_rotation/index.php**

REAL SCIENTIFIC DATA



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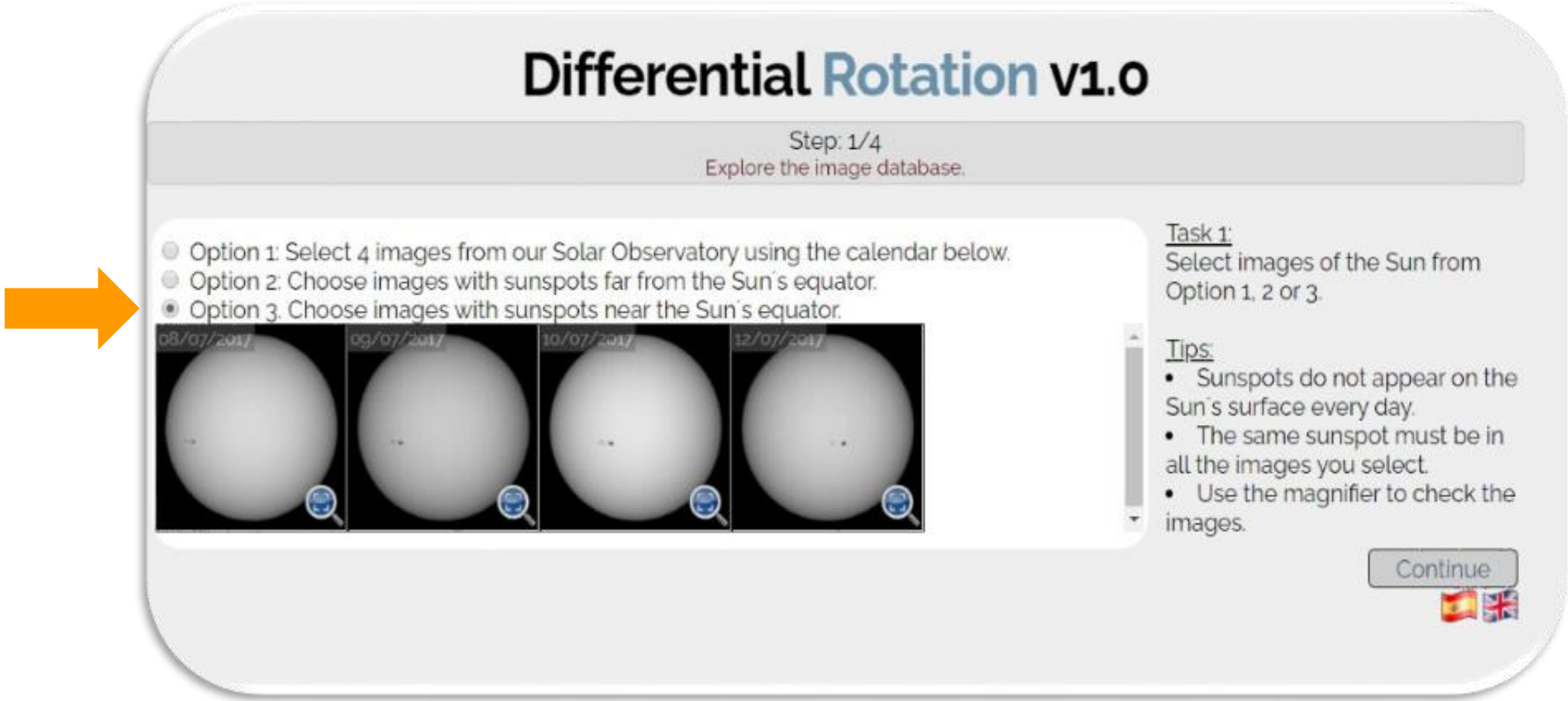
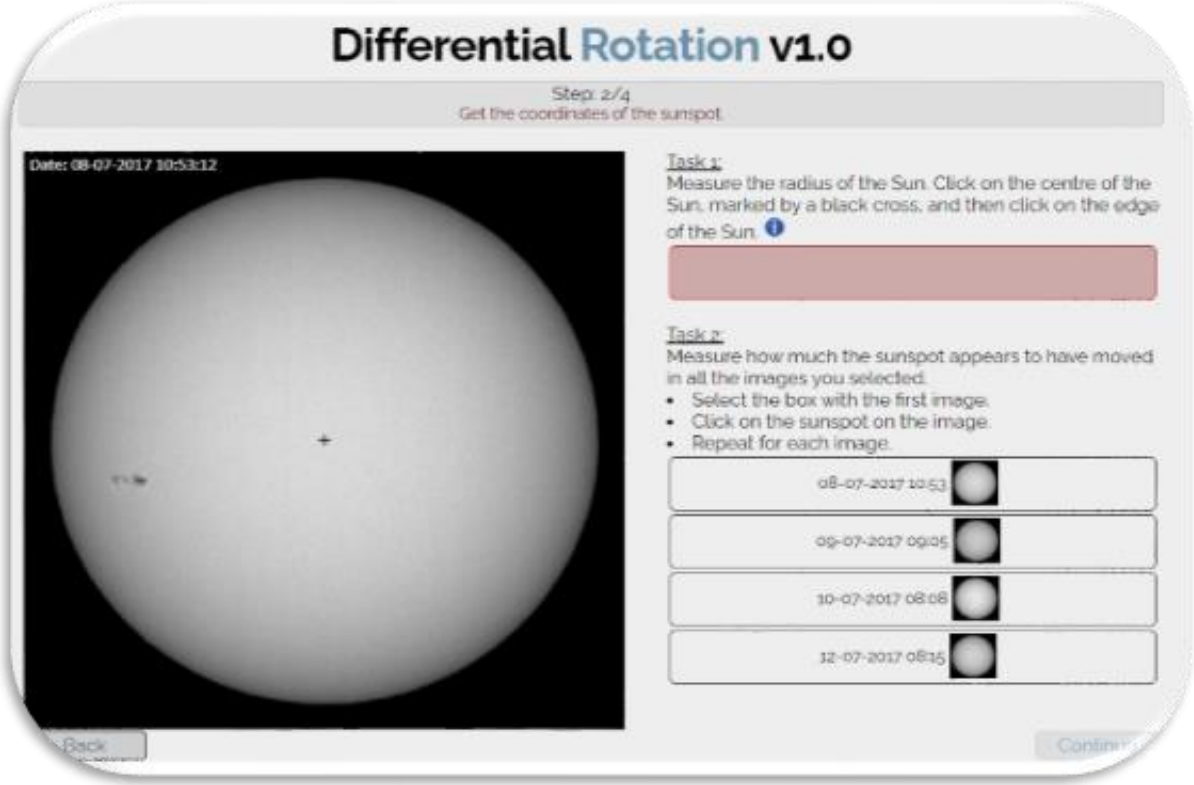
PROCEDURE (REAL SCIENTIFIC DATA)

- **Step 1/4:** Choose a set of images (for example, Option 3).

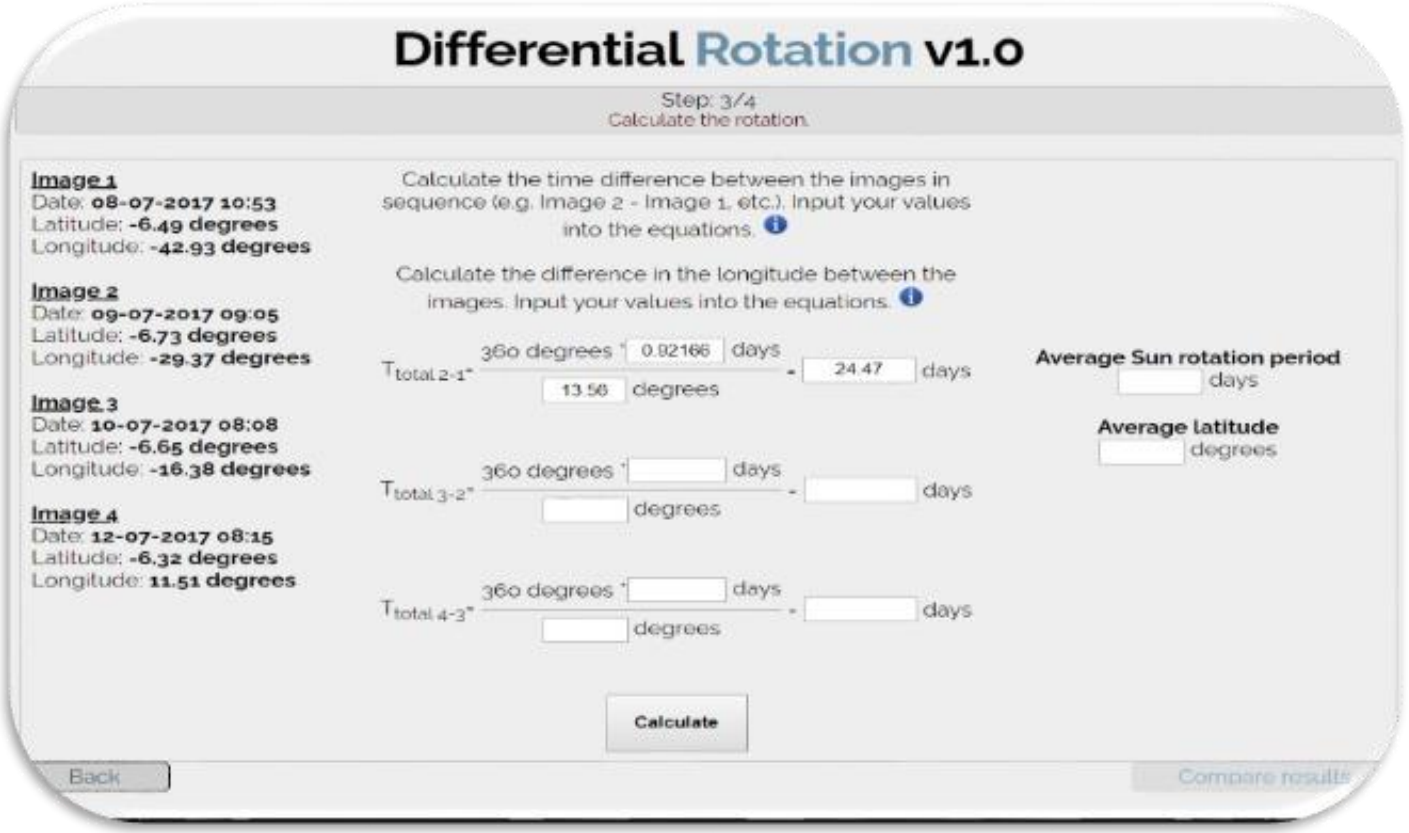


- **Step 2/4 (I):** Calculate the radius of the Sun to know the scale of the image. Click with the mouse in the center of the Sun (black cross) and then on the end of the disk.

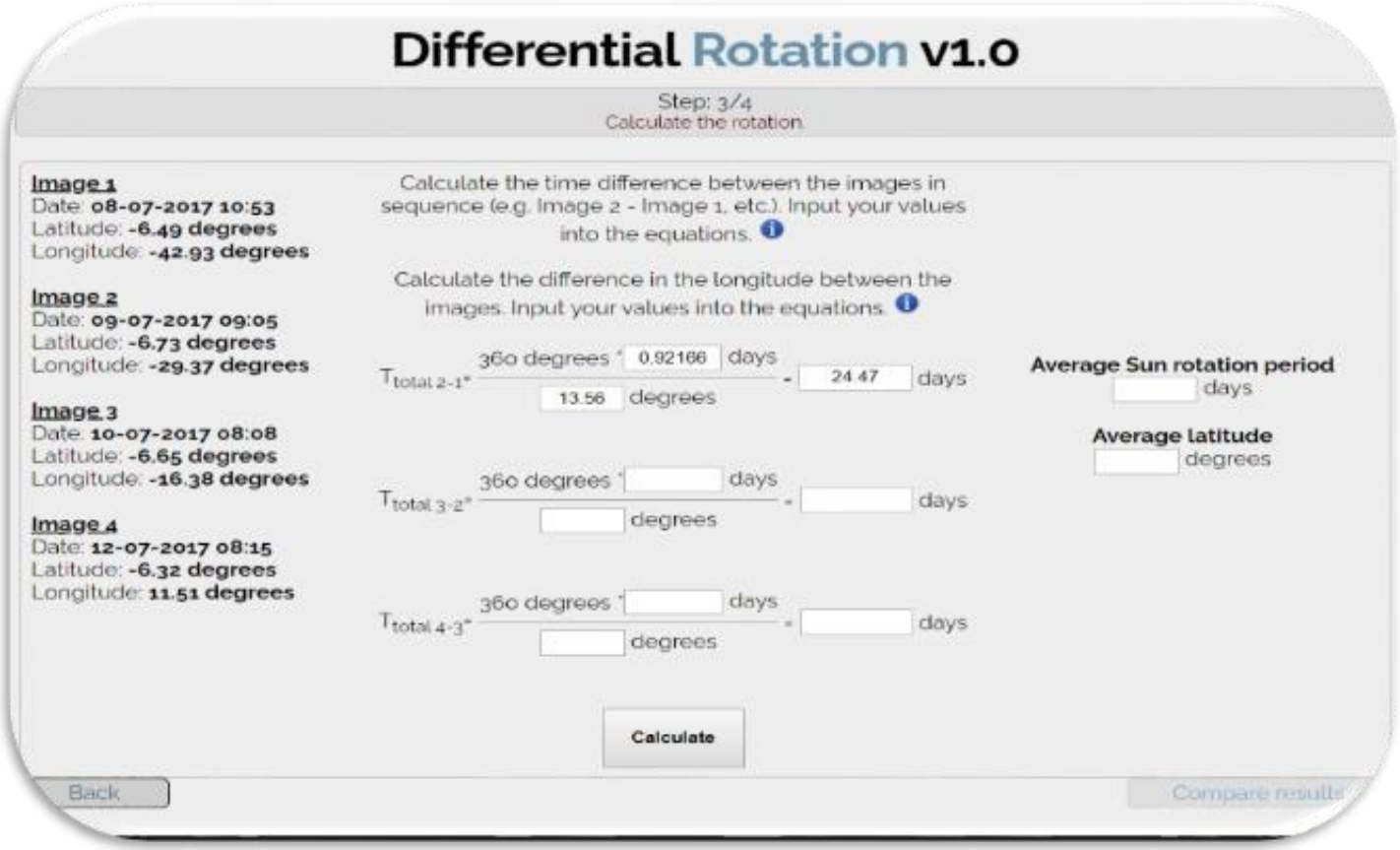


- **Step 2/4 (II):** For each image select the position where the stain is.

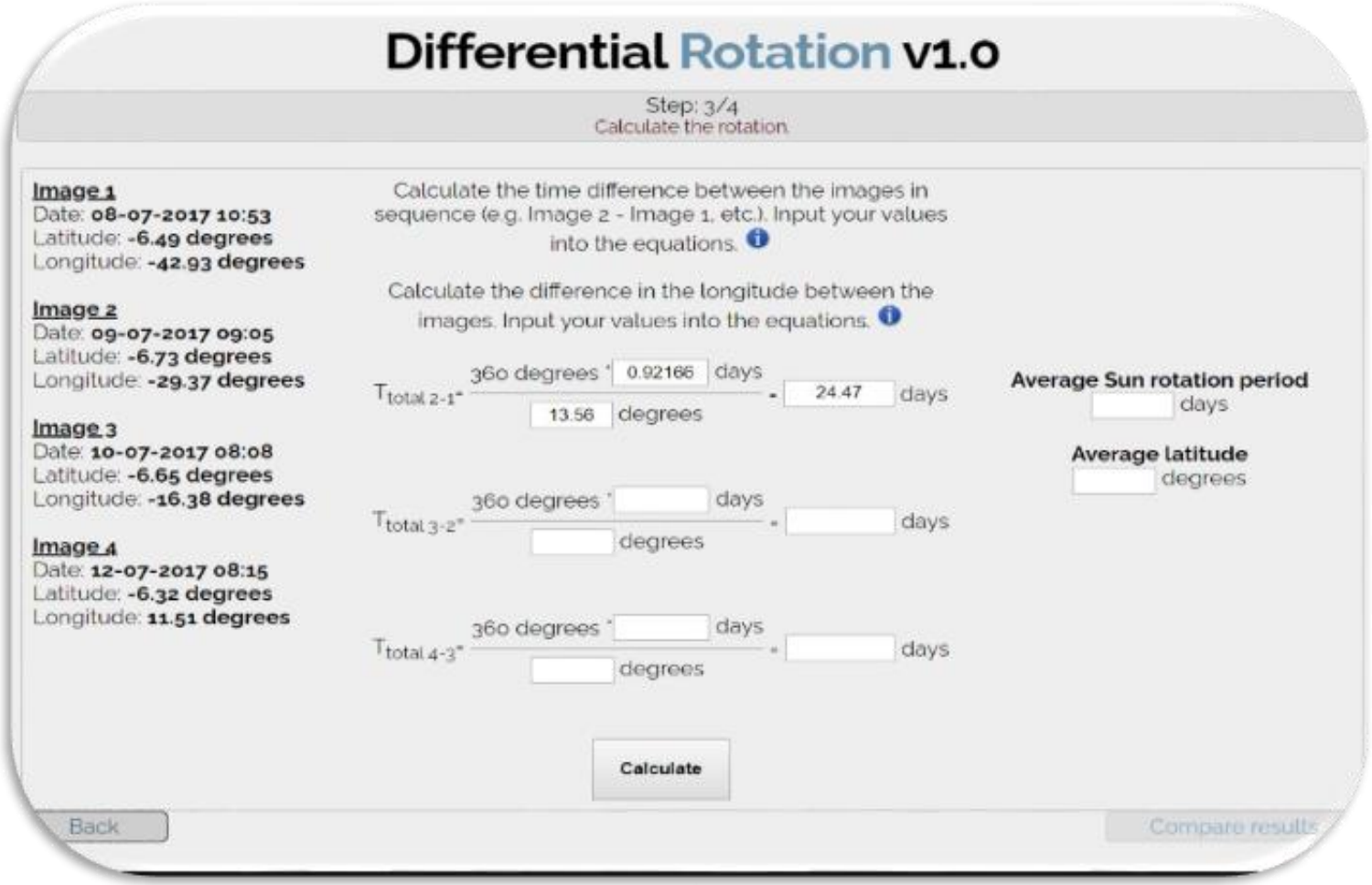
- **Step 3/4 (I): Calculate the rotation period of the Sun:**
  - Fill in the time difference between the image(N) and the image(N-1), in days in the numerator. Fills in the denominator the difference in length between the image(N) and the image(N-1), in degrees



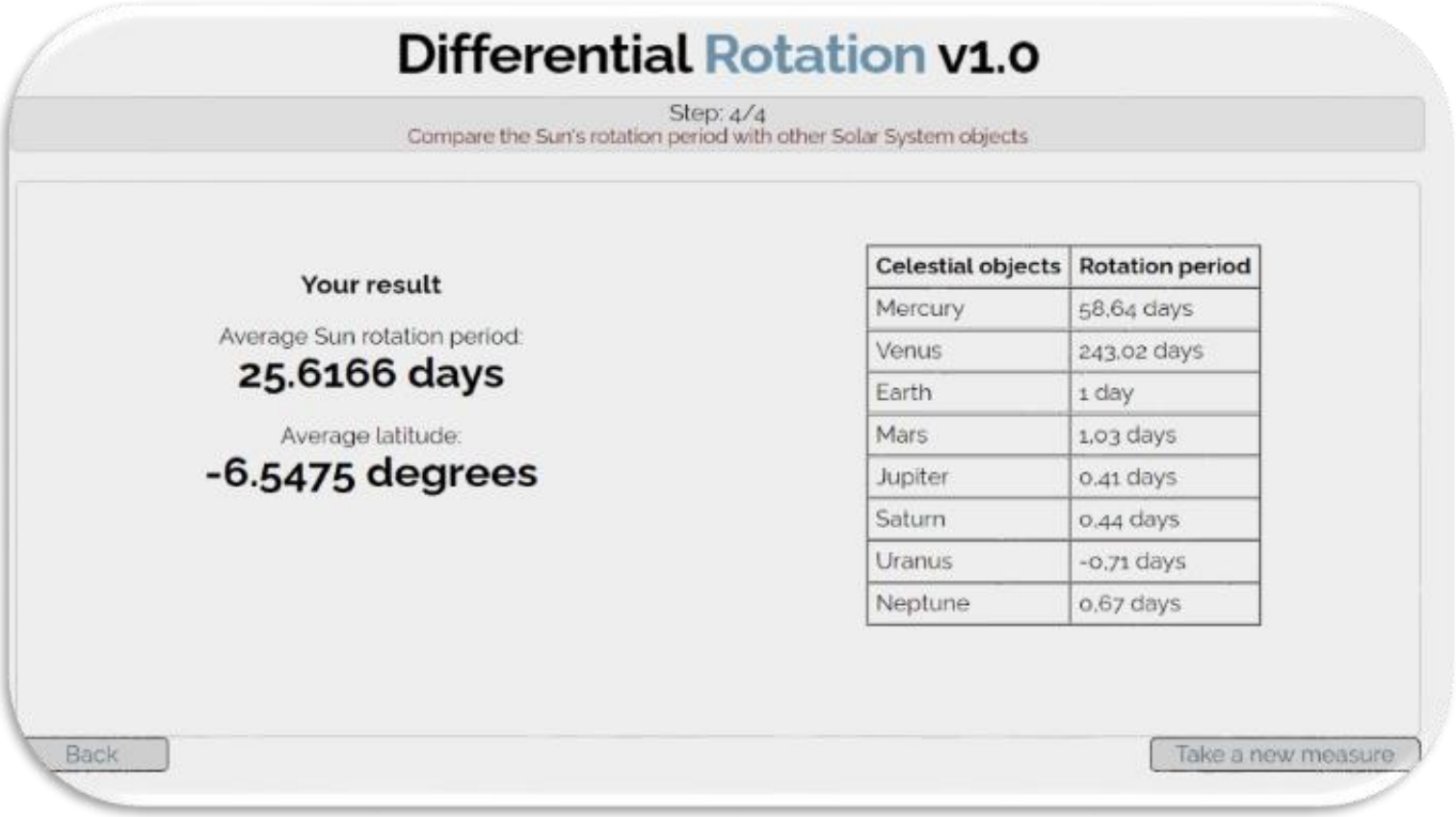
- **Step 3/4 (II): Calculate the average value of the rotation period:**
  - Use the values of the three instantaneous rotation periods (calculated between pairs of images) and calculate the average value.



- **Step 3/4 (III): Calculate the average value of the stain latitude:**
  - Enter the average latitude of the spot from the latitude of the four images.



- **Step 4/4:** Compare your result of the rotation period with that of the solar system planets



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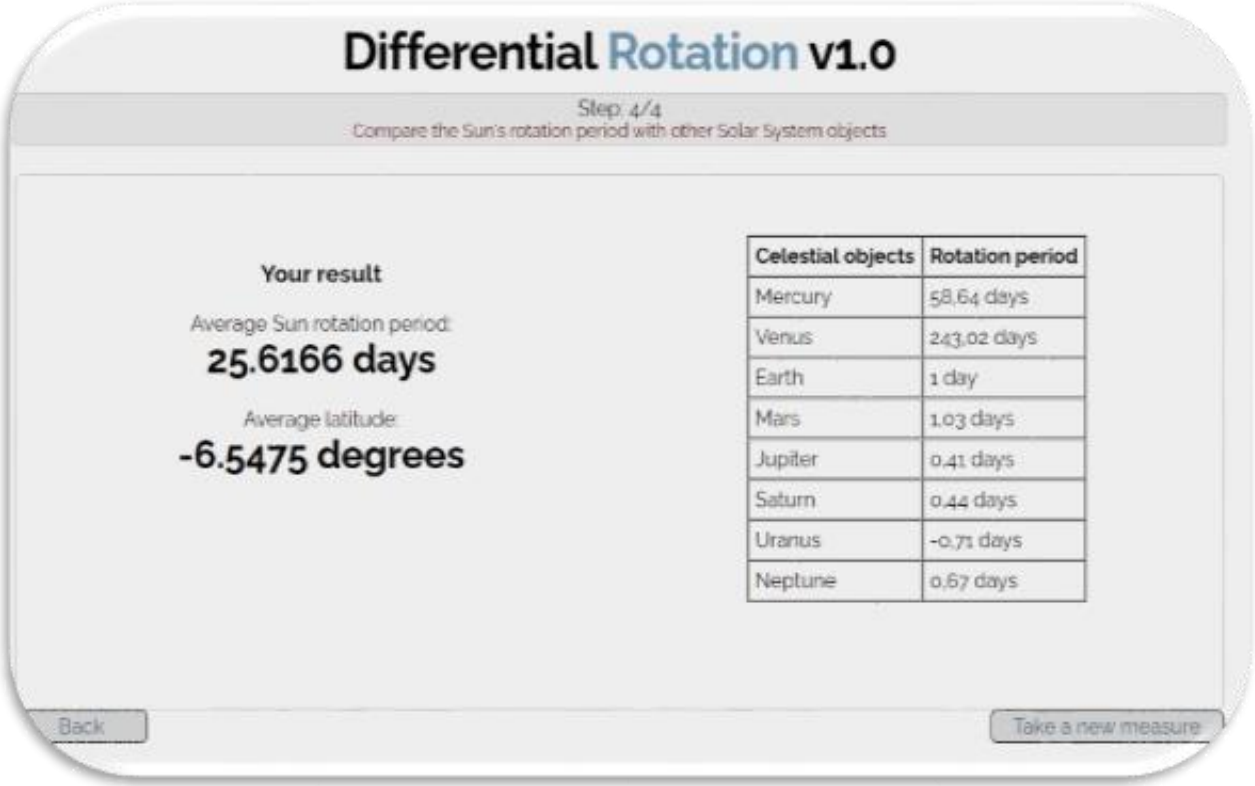

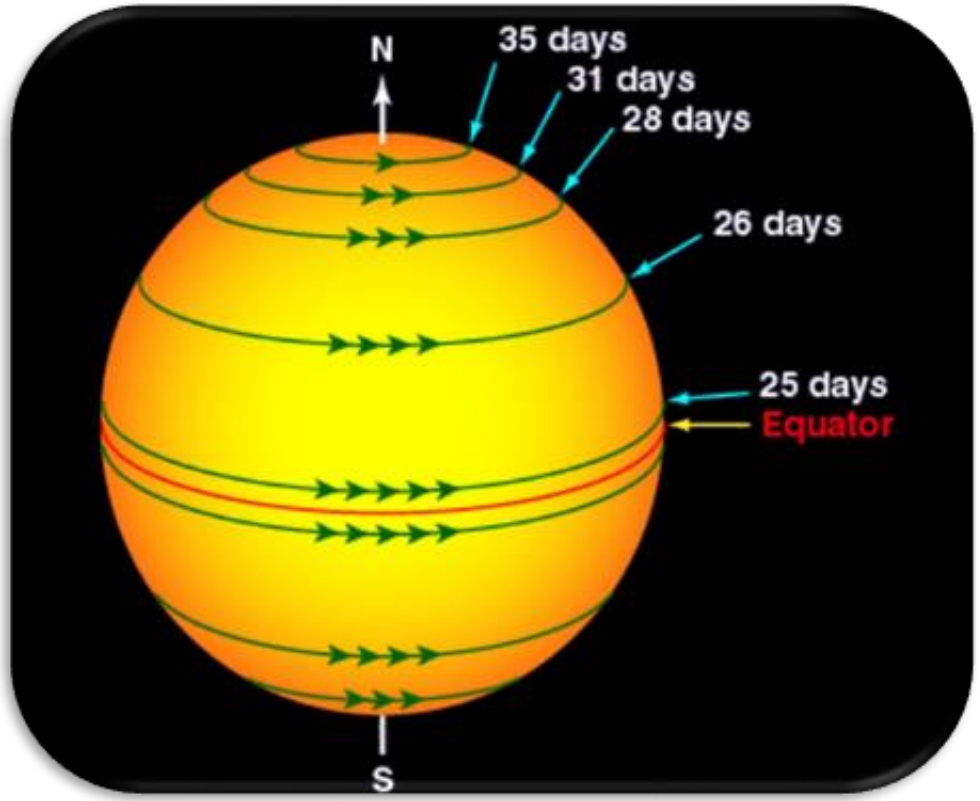

Team 1

Team 2

Team 4

Team 3