1.1 Sun4all. Does the Sun Rotate ?

Name of the Institution: University of Coimbra

Title of the educational scenario template: Inquiry-based teaching

Title of the educational scenario: Sun4all. Does the Sun Rotate ?

Version: 1.2

Educational problem:

The Sun is the nearest star to the Earth. Our planet is, therefore, dependent from this star since its formation. This dependency isn't just because of the yearly Earth translation movement around the Sun. It is much more than that. The Sun is the Earth's main source of heat and light, essential to all the life it holds. The phenomena that occur (occurred or will occur) inside the Sun and on its surface cause impact on Earth's surface. It is not always easy to understand or measure this impact and, in many cases it is equally complex to establish cause-effect relations. It all depends on the phenomenon and its intensity. However, there are confirmed results, which show the Sun-Earth interaction.

But the Sun-Earth interaction can be observed in different ways besides the ones related to the climate. Solar flares, being extremely energetic, can interfere with daily life. On the 30th of October of 2003, a solar "storm" damaged North American's power-station systems, causing a 9 hour blackout in many Canadian cities. On the "Space Weather" web site (http://www.solarstorms.org/SRefStorms.html) one can find a journalistic register of many solar storms that occurred between 1859 and 2003, many of them responsible for material damages. Therefore, studying the Sun, besides being interesting itself, presents an important tool to understand much of what happens on our Planet's surface. Specifically, studying the Sun through the analysis of solar activity, which turns out to be the key theme of this particular project and the activities proposed below. The majority of these activities are mainly focused on sunspots. In the next chapter a privileged space is given to this issue. The other manifestations of solar activity such as prominences and faculae will also be part of the proposed activities.

The project is based on an asset of over 30000 images of the Sun (spectroheliograms) that are kept at the Astronomical Observatory of the University of Coimbra, as result of a

work of over 80 years of daily solar observations, started in 1926. Presently all images are digitised images available to the general Public.

Educational scenario objectives:

K-7 – Physics – Universe and Solar System

Learning Objectives:

- ☼ Know that the Sun is the biggest object in the Solar System
- ☼ Know that the Sun rotates around itself
- ☼ know that the Sun has cooler regions in its surface – sunspots

Characteristics and needs of students:

The scenario will be an opportunity for students to solve problems related to the analysis of real data, obtained by a professional observatory. This will be accomplished through interactive tools, which are much more direct than school textbooks.

The exercise will also allow students to interact (e.g. by working in pairs) and develop social and collaboration skills, allowing them to see that Science can be a group activity and not only a solitary one. This change of perception may trigger an increased interest in Science in many of them, and possibly a turn to Science careers.

Rationale of the Educational approach and Parameters guaranteeing its implementation:

- ☼ In this exercise students will increase their understanding of our nearest star – the Sun.
- ☼ They will use the same images as professional astronomers did and figure out an explanation for the behavior of the Sun. It's important to emphasize that these activities aim to guide teachers and students interest in the use of spectroheliograms and its database.
- ☼ Students will use Salsa J to analyze images of the Sun kept in the Astronomical Observatory of the University of Coimbra http://www.mat.uc.pt/sun4all/index.php/pt/

Learning activities:

Phase 1: Question Eliciting activities

Discussions, led by the teacher or leader, on the following topics

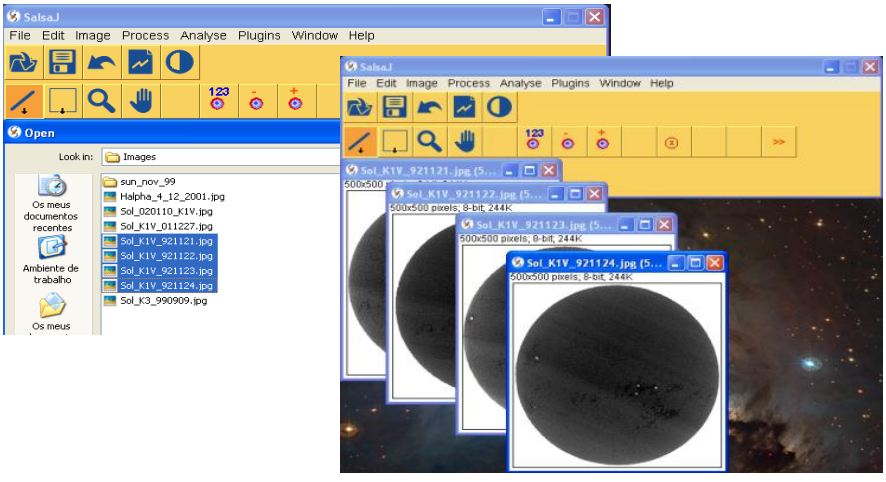
- what is Sun made of ?
- how the Sun is comparable to the earth (temperature, mass, radius, etc.)
- Sunspots: what is it ?
- Rotation of the Sun: what about it ?

Phase 2: Active investigation

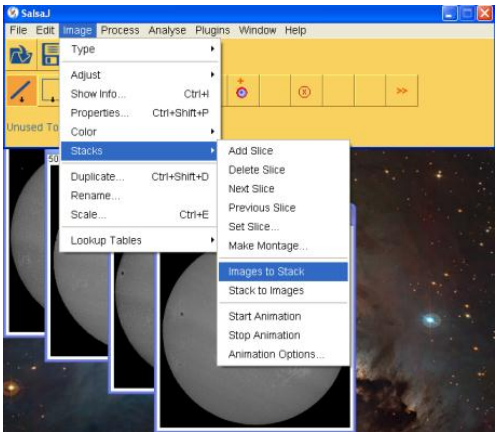
a) **Does the Sun rotate ?**

Students should now be invited to discuss if the Sun has a proper motion or not and propose experiments to validate their hypothesis

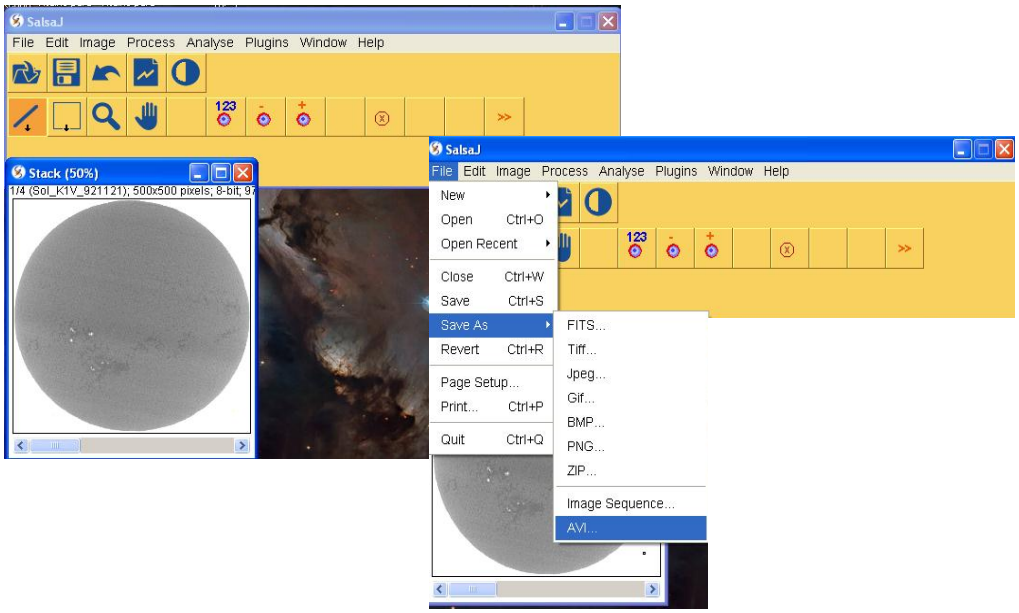
- Open the four images, with approximate dates, so that the movie reflects the Sun's rotation movement correctly.



Choose **Image**, then **Stacks** and then **Image to Stack.**.

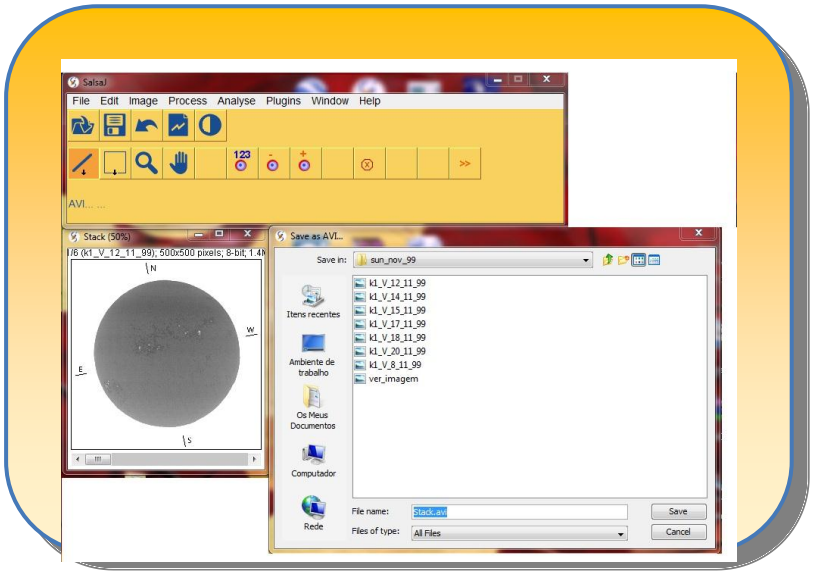


- Result of the stacking



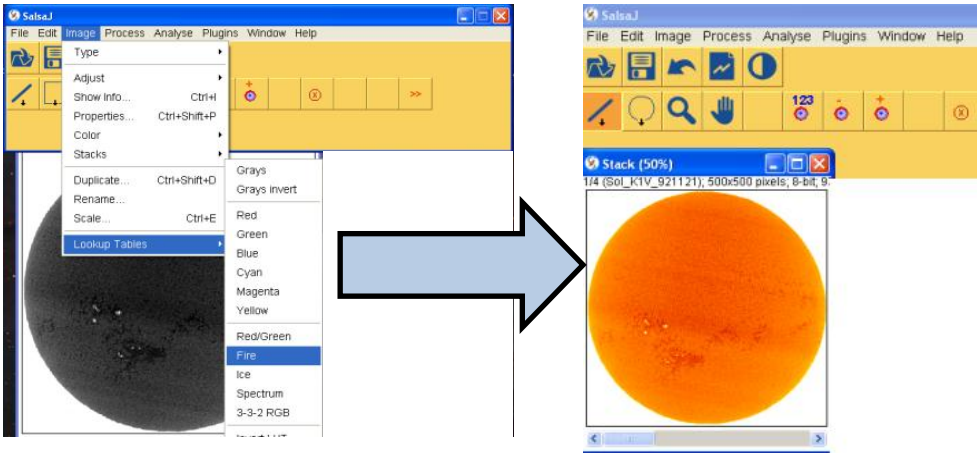
- Save the file under AVI format by selecting the options: **File** then **Save as**. Make sure you add the extension (avi): "Filename.avi".

- Select the folder where you want to save the file

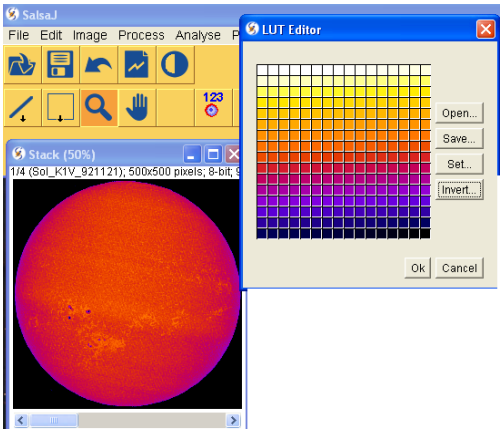


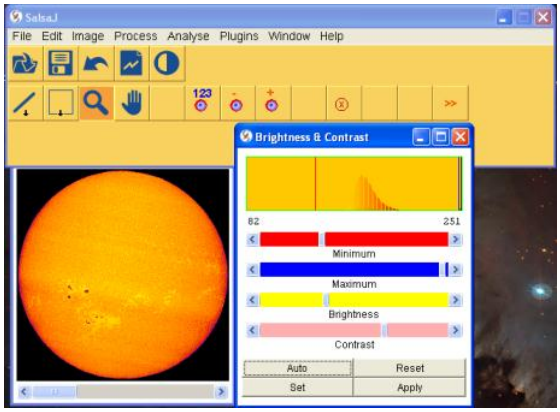
- Select **Image**, then **Lookup Tables** and then **Fire.**

Optional operations: In order to enhance the visible sunspots in the image, it is possible to do some changes, both in color, brightness and contrast.



- Choose **Image**, then **Lookup Tables** and then **Edit LUT**. What do you see





Phase 3: Discussion

After doing the solar rotation movie students should discuss again if the Sun rotates or not and what evidence they find. Many will point to the motion of the spots. Now is the time to discuss the possibility of these being transits.

Phase 4: Reflection

Students appreciate the implication of their results and begin to see a connection with current topical research. For example,

- How do we know these spots are not objects transiting the Sun?
- Can the rotation period be determined using this images ?

Students should now be invited to participate in the motivation activities and brief introduction. They will learn about the history of Solar observation and how Galileo concluded that the spots are part of the solar disc.

- **Solar movies – ESA vodcast:**
  http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=46594&fattributeid=885

1. **History of sunspots observations**
   http://galileo.rice.edu/sci/observations/sunspots.html

Participating roles:

Students

- Access to the site www.mat.uc.pt/~sun4all
- Gain experience of data taking
- Estimate what results are to be expected and compare with measurements
- Consider the implications of their results

Teacher

- Encourages the students to read the Manual as a starting point.
- Guides the students in their investigations on the WWW.
- Helps the students in evaluating their results
- Guides the student to further open-ended study

Tools, services and resources:

Time required:

☼ 3 didactic hours.

Prerequisites:

☼ Excel Spreadsheet use.

☼ SalsaJ use.

☼ Know the Solar System.

☼ Know the Sun as an energy supplier.

Technical Requirements

☼ Computers with Salsa J.

☼ Internet access for research purposes.

☼ Images of the Sun kept in the Astronomical Observatory of the University of Coimbra.