Stellarium – a valuable resource for teaching astronomy in the classroom and beyond

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Introduction

A hurdle to effective astronomy education in schools is often the lack of ready-to-go teaching materials. This article is a brief introduction to a computer program, *Stellarium*, which is a teaching resource that can be used to teach the basics of astronomy. A major advantage of the program is that it is free and can be downloaded from the internet for Mac, PC and Linux computers at www.stellarium.org . The version described in this article is version 0.10.2. It is possible that future versions will look slightly different from this version. A manual and a large amount of educational material for all school grades is available from the Stellarium website.

Using Stellarium

Stellarium is very easy to use. When Stellarium is first run, the first thing to do is to set the location (by default its Paris, France). To do this move the mouse to the left hand side of the screen and a set of icons will appear as shown in figure 1. Once the location has been set (figure 2) every time the program is run the sky is displayed for the current time. To display the view of the sky for a different date move the mouse over the clock icon and set the desired date and viewing time.

Set location – set the country and city of the observation site

Set the time – initially the computer time is used, but this can be reset

Viewing options – e.g. set the type of landscape

Find an object – type the name into the search window – e.g. "moon"

Configuration – e.g. run eclipse simulations etc.

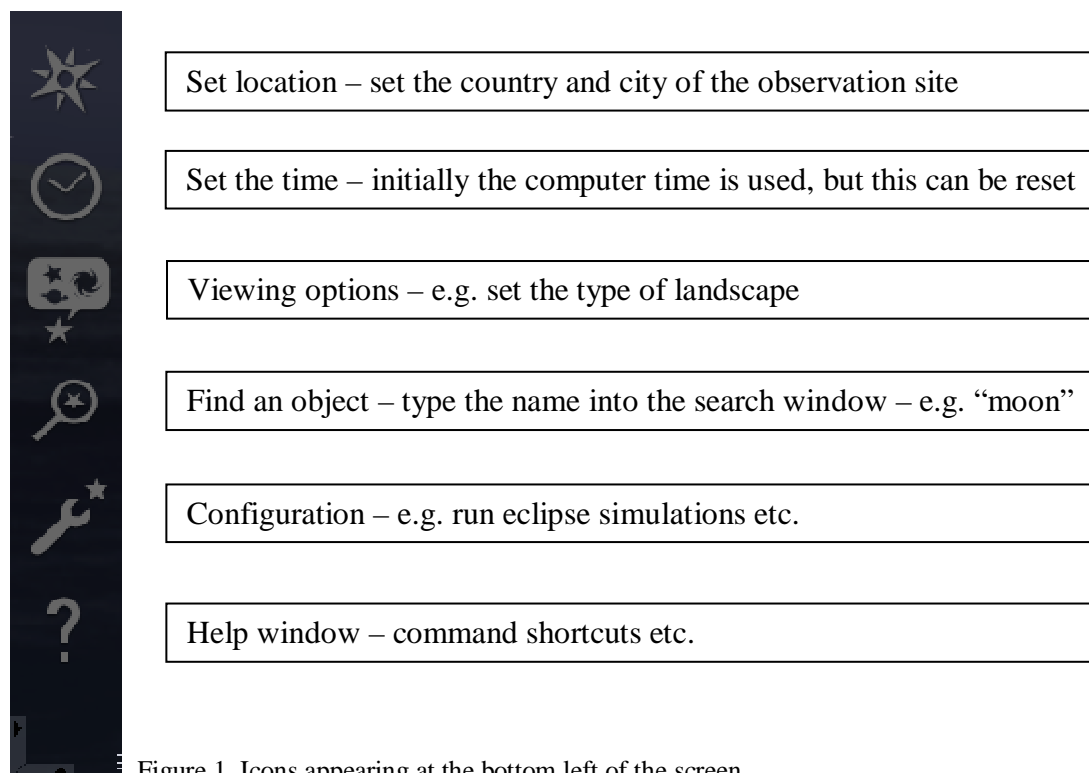Help window – command shortcuts etc.

Figure 1. Icons appearing at the bottom left of the screen.

Figure 2. The location window in this case being used to set the location to Rockhampton. When the Use as default box us checked, the next time Stellarium is run the location will be set to Rockhampton.

The view from Rockhampton on the night of Friday 11th September 2009 is shown in figure 3. Stellarium produces a very realistic display of the sky. The initial view of the night sky is similar to what is actually seen outside. However, there are a number of useful additions to the basic view of the starry night. For example, the constellations can be drawn in as lines joining stars along with the name. There is also an option to draw artwork over the lines to aid the imagination and different landscapes (e.g. paddock, ocean etc) can be selected to increase realism.

Another useful feature is the ability to draw lines of 'latitude' and 'longitude' on the celestial sphere. This is effectively projecting lines of latitude and longitude on the earth out into space. There is also an option to display azimuthal lines, which are similar to the latitude and longitude lines except the 'pole' is directly overhead at the zenith and the equator is at the horizon. When Stellarium is run, the sky moves in real time, however the speed can be increased so that it is easy to see how the stars move. For example, when the celestial sphere grid lines are switched on the stars are seen to rotate around the South Celestial Pole south of the equator.

Stellarium is also a good tool for learning the constellations and in some ways is easier than using a static star chart. Stellarium has a night mode that displays text in red so that dark adaption of the eyes is maintained when viewing the screen. This option enables the program to be used on a notebook computer under dark skies.
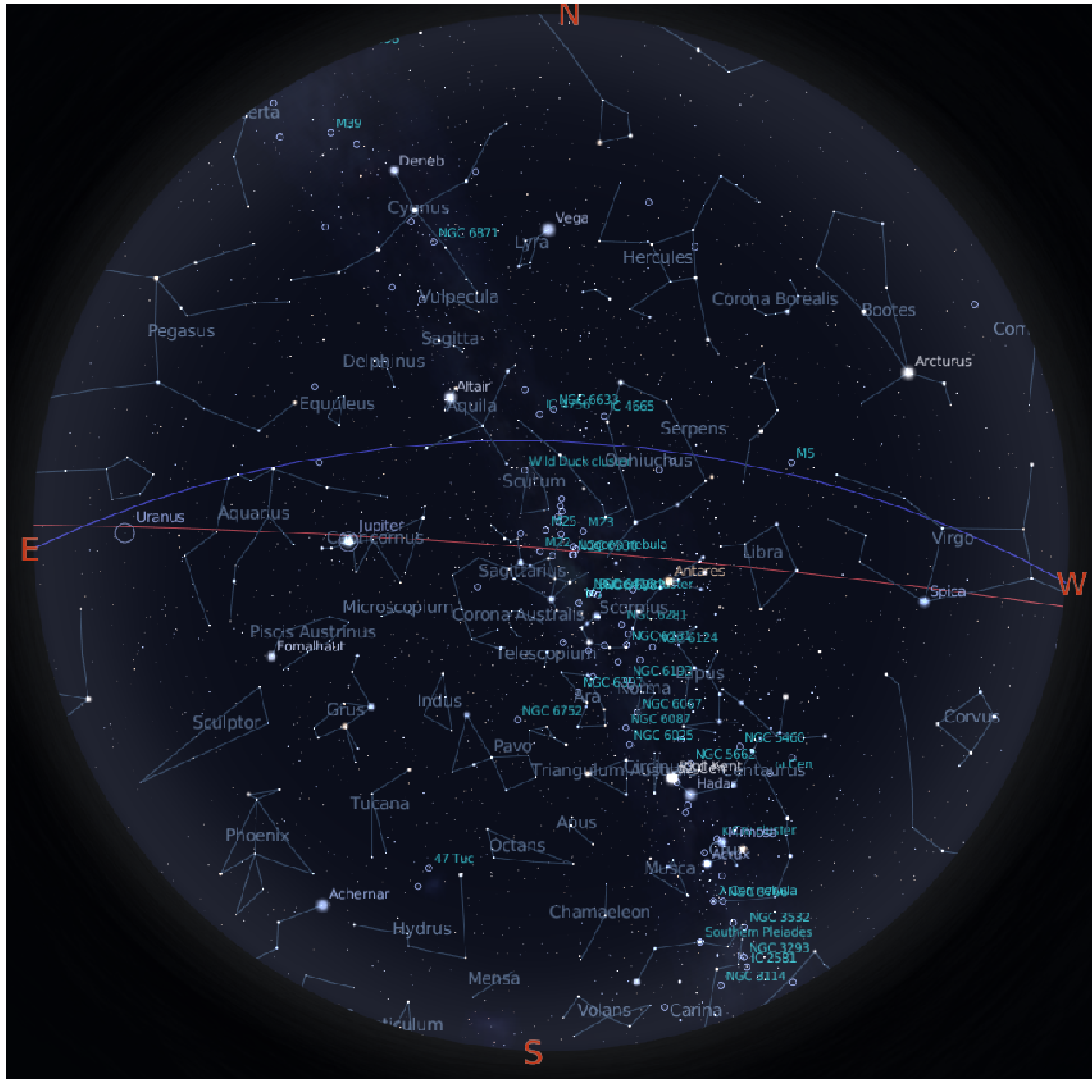
Figure 3. The complete view of the night sky from Rockhampton at at 7 pm on Friday 11th September. The red line is the ecliptic – i.e. the path followed by the Sun, Moon and planets amongst the distant 'fixed' stars from night to night. The blue line is the celestial equator, i.e. the dividing line between the north and south celestial hemispheres.

The location view can be opened and the cursor moved across a map of the world. As the cursor moves, the view of the sky from that point on the earth's surface is displayed. If the cursor is moved horizontally a point is reached where the sun sets and it becomes dark – this is the terminator – the dividing line between day and night. If the date is set to the *vernal equinox*, i.e. 21st March, the sun will rise exactly in the east and set in the west. If the date is advanced one month at a time it will be seen that the sun rises either south or north of east depending on the time of year. The path of the sun in the sky, called the ecliptic, can also be switched on[α]. (The planets also travel close to the ecliptic).

Navigating amongst the stars
Stellarium is a powerful tool for teaching students the basics of celestial coordinates. As knowledge of the terrestrial coordinate system (i.e. latitude and longitude) is

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[α] This is the passage of the sun against the fixed stars and not the path of the sun in the sky during the day

required to successfully navigate on the earth[β], so knowledge of celestial coordinates is required to navigate across the celestial sphere. In astronomy, the coordinates of a celestial object with respect to the lines of longitude and latitude are known as *right ascension* (RA) and *declination* (DEC).

The position of a celestial object above or below the celestial equator is known as the *declination* of the object, or DEC for short. The DEC varies between 0 and +90° for stars north of the celestial equator and 0 and -90° for stars south of the celestial equator. The DEC coordinate of a star is equivalent to latitude. The RA is a measure of angular distance of a celestial object from a fixed point on the celestial equator. This is equivalent to longitude in terrestrial coordinates where the longitude of a location is the angle between the *Greenwich meridian* (the 0° longitude that passes through London, UK) and the meridian passing through that point on the earth's surface.

The question is, in astronomy which longitude line is equivalent to the Greenwich meridian on the earth? This line is the celestial meridian that passes through one of the two intercepts of the ecliptic and the celestial equator. These intercepts are known as the *equinoxes* and are the points where the sun crosses the celestial equator, i.e. the point in time when the centre of the sun is directly overhead at the equator. These dates are around 20th March (*vernal equinox*) when the sun crosses from south to north and about 23rd September (*autumnal equinox*) when the sun travel from north to south. The vernal equinox is the point that has been chosen as the RA origin.

This intersection point is known as the *First Point of Aries*, given the symbol ♈ (However, due to something known as the *precession of the equinoxes*, ♈ is now in the constellation Pisces on its way to Aquarius). ♈ is sort of equivalent to the intersection of, known as the *Greenwich meridian*, with the terrestrial equator. You can see this point in Stellarium by switching on the Equator Line and the Ecliptic Line (figure 1). You will see the two equinoxes – the vernal equinox is the point with RA and DEC coordinates close to zero.

In 2008 the sun crossed the celestial equator at 5:48 GMT. You can experience this event in Stellarium by setting the date to 19th March 2008 and advancing through the 20th March to the 21st – you will see the sun cross the celestial equator. If you zoom into the sun you can find the time the exact time the sun crosses the celestial equator. If you go to around 23rd September you can see the sun go the other way.

The location of a star on the celestial sphere is specified in term of the angle between the meridian of the object and the meridian of ♈. This is effectively the celestial longitude of the object, however, the angle is specified in terms of time rather than degrees. The earth takes 24 hours to rotate on its axis so 24 hours is equivalent of 360° of RA and therefore 1 hour of RA is equal to 15°. Since the sun, moon and planets move against the face of the celestial sphere they do not have fixed celestial coordinates but have coordinates specified for a particular moment in time. If an object cannot be seen with the naked eye it would be almost impossible to point a telescope in the right direction without knowing the celestial coordinates. The earthly

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[β] GPS navigation units use latitude and longitude to calculate routes

and heavenly coordinate systems are brought together in *celestial navigation* – the technique used by the ancient mariners to sail across the oceans.

In Stellarium whenever a point on the sky is clicked, the celestial coordinates appear in the top left hand corner. To explore this feature it is best to switch on the celestial coordinate system. It is easy to see that all points above the celestial equator have a positive DEC and all those below a negative DEC.

The movement of the planets (their name in Greek means *wanderers*) against the backdrop of the celestial sphere can easily be seen by using the magnifying glass symbol to locate the planet (e.g. Jupiter) and advancing the date a month at a time. The planet will move relative to the constellations. (The movement can be seen more clearly if the constellation drawings are switched on).

As the earth goes on its way around the sun the rotation axis of the earth points in more or less the same direction[1δ]. This means that as the year progresses the view of the night sky changes. Each night the stars in the east rise four minutes earlier than the previous night. This can be demonstrated on Stellarium by setting up a view facing the eastern horizon and advancing time one day at a time so that the same time is displayed for each night. Each night, the stars will appear higher and higher above the eastern horizon. After 365 days, i.e. one year, the stars arrive back at the same position relative to the horizon.

Another useful feature in the latest version of Stellarium is the display of star colour. Stars are effectively classified according to their colour. For example, red stars, e.g, Betelgeuse in the constellation Orion and Antares in Scorpio are M type stars. Yellow stars like our sun are G type stars. Stellarium also gives the brightness and colour ratio of selected stars, for example the star Betelgeuse in Orion has a magnitude of 0.45 and a colour ratio B-V = 1.52. A positive colour ratio indicates that a star is red in colour. A useful feature of Stellarium, is that information about a star is displayed in text of similar colour to the star.

How can Stellarium be used in the classroom?
A burning question is how Stellarium be best be used in the classroom? A teacher could introduce Stellarium to students in the classroom and encourage them to explore the program at home. Maybe an assignment could be based around Stellarium. As an example, Stellarium could be used to get students to explore the reason why it gets darker quicker at lower latitudes (i.e. closer to the equator). Students who live in the north of Australia – say from Brisbane up, who have visited southern states may have noticed that the twilight period last longer in the south compared to home.

Students could be set the task of 'visiting' various places between the equator and either the south or North Pole and use Stellarium to measure how long it takes the sun to set. This can be done by measuring the interval of time between first and last

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[δ 1] Over the course of a year there is a change in the direction that the rotation axis points due to precession of the equinoxes – but it is extremely small – only about 0.014°. Precession of the equinoxes can be demonstrated using a spinning top – when the top is spun the end of the spindle goes round in circles or *precesses*.

contact of the sun with the horizon[2γ]. For example I used Stellarium to measure the time for the disc of the sun to cross the horizon when viewed from Brisbane and Adelaide on the 21st June 2008 – in Brisbane it took 2 minutes and 20 seconds and in Adelaide 2 minutes and 50 seconds – 30 seconds longer in Adelaide. This means that it will take longer for the sun to drop to the point below the horizon where the sky becomes dark, hence the period of twilight is longer in Adelaide than Brisbane.

Students will be able to discover that the angle of the path of the setting sun with respect to the horizon varies with latitude. At the *solstices* (effectively the dates in the calendar exactly half way between the equinoxes) the sun sets at right angles to the horizon at the equator and so sets in the shortest possible time. At either pole, at the solstices, the sun travels through the sky at a constant height above the horizon. Stellarium can be used to demonstrate that above the Arctic and Antarctic circles the sun stays either above or below the horizon for six months at a time.

Stellarium is an excellent teaching resource for teaching astronomy at all levels. In this article I have only touched on a few of the features, there are a whole host more. The current government in Australia is committed to increasing the number of computers in school classrooms and improving the broadband internet access throughout the country. Over time, this will make it easier for teaching resources, such as Stellarium, to be used in the teaching of science.

[γ 2] I switched off the atmosphere and ground to be able to accurately measure how long it took the disc of the sun (which appears in actual size) to cross the zero degree azimuthal line.