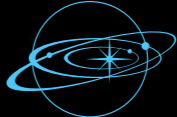


COSMICWATCH  
SWISS MADE

# USER GUIDE 2.0

WITH AN INTRODUCTION  
TO THE MOTIONS OF THE SKY



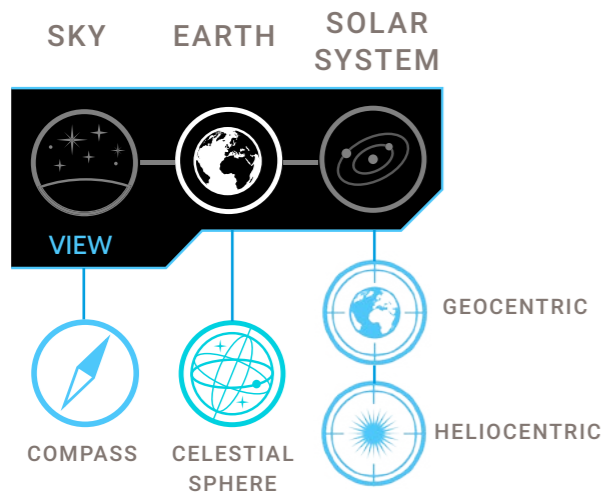
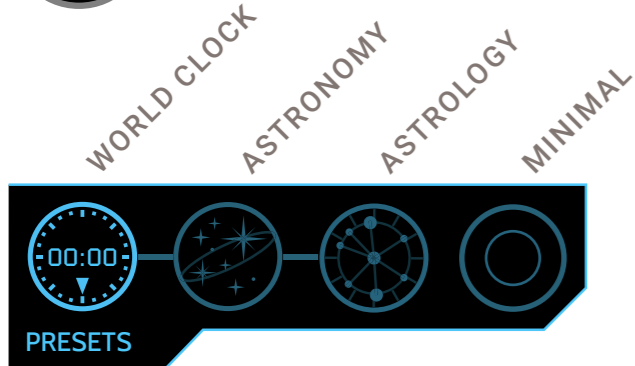
Celestial Dynamics

2019

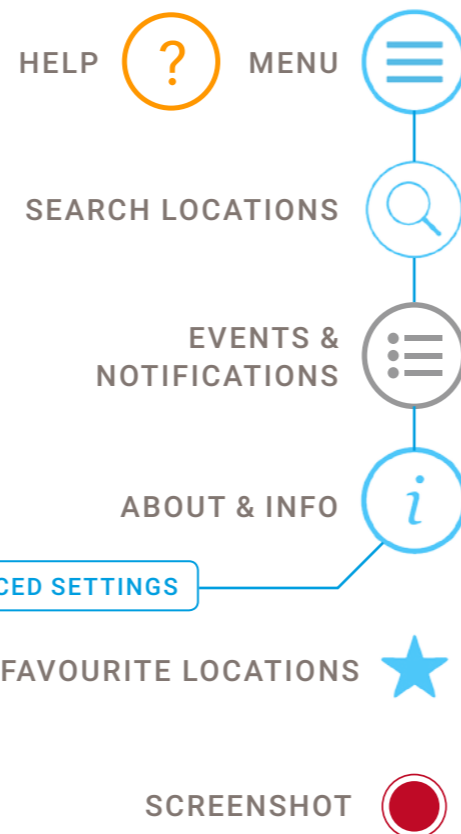
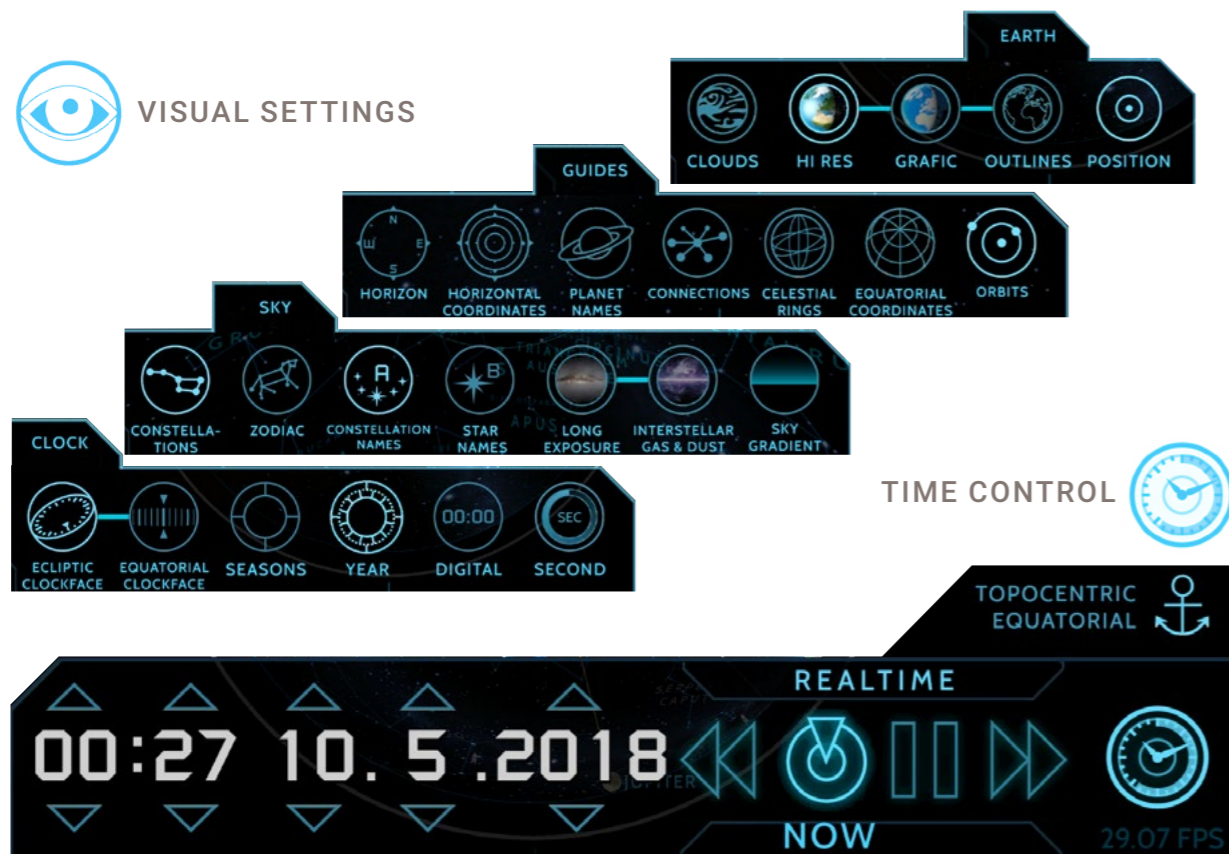
FULLSCREEN



# COSMIC WATCH



VISUAL SETTINGS

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## SYSTEM REQUIREMENTS

To run the Cosmic Watch all you need is a mobile device such as a phone or tablet running android 4.1 Jelly Bean or iOS 8.0. We recommend the use of a tablet as the bigger screen will allow you to appreciate more details.

[Download for iPhone and iPads \(iOS\)](#)

[Download for Android devices](#)

If you don't succeed in running the Cosmic Watch, please see [Troubleshooting](#).

The Cosmic Watch is not just a clock, it's an astronomical instrument to visualize the cycles of Earth and the solar system, helping to understand how we measure and experience time since thousands of years.

It stays mainly centered on Earth and can be used to demonstrate the apparent movement of the sky and celestial objects around us. It also shows beautifully the concept of the celestial sphere and celestial coordinates used in navigation and to locate objects in the sky.

The Cosmic Watch teaches you these things about the universe:

- ★ everything is in motion
- ★ motion and position are relative
- ★ everything is connected



## INTRODUCTION

The Cosmic Watch is a virtual planetarium on your mobile device. It calculates the positions of the Sun, Moon, planets, stars and constellations, in relation to the Earth and time. It gives us the possibility of observation from different points of view as well as to add several layers of information.

The Cosmic Watch may be used as a clock, as an educational tool for teaching about the night sky and the Solar System, as an observational aid for amateur astronomers wishing to plan a night of stargazing, or simply to get a perspective of where we are in the cosmos.

You can also use it to create sky maps for describing regions of the sky or planetary position charts for newsletters and magazines. The Cosmic Watch 2.0 is able to calculate the next astronomical and time related events at your location and inform you via [notifications](#).



The Cosmic as clock on a desktop and in a meeting room

## BASIC CONCEPTS

There are some things you need to know when using the Cosmic Watch.

### CENTRED ON EARTH

The Cosmic Watch is mostly centred on Earth. We call this a **geocentric** point of view. The Sun, the planets and the sky rotating around Earth is an optical effect which happens because the Earth is rotating every day on its own axis. The Moon is the only **celestial body** actually rotating around the Earth.

We all know that the Earth and all the planets orbit around the Sun. The Earth takes one year to complete one orbit. Seen from Earth it looks like the Sun is revolving around us, passing through all the zodiac constellations in a year.

### THE CELESTIAL SPHERE IS A PROJECTION

The **Celestial Sphere** is a simplified model of the sky, where all the stars are represented as being the same distance away from us, on the surface of a sphere. In reality the stars and the planets are all at different distances. Note that when seeing the Celestial Sphere from the outside the constellations appear mirrored.

The main advantage of this representation is that you get an overview of the sky, which is impossible to have otherwise, as from the Earth's surface we are only able to see one portion of the sky at the time.



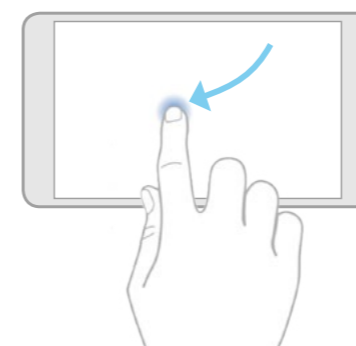
## A FIRST TOUR

When the Cosmic Watch starts up, we see the illuminated Earth surrounded by the **celestial sphere**. The Sun, Moon and planets are visible around the **ecliptic**. The Moon shows the actual Moon phase.

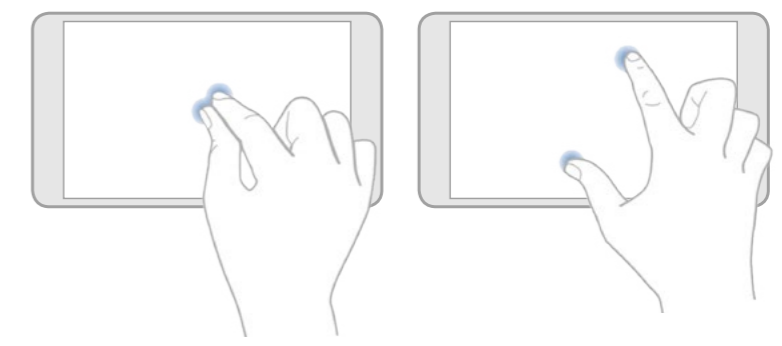
It starts in the clock mode as the Cosmic Watch was originally created as a timepiece. You see a 24-hour ecliptic clock face with a dial aligned to your position. You can also see an ecliptic circular calendar in which the Sun operates as an indicator.

### LOOK AROUND, ZOOM IN AND OUT

These are the main gestures to control the Cosmic Watch.



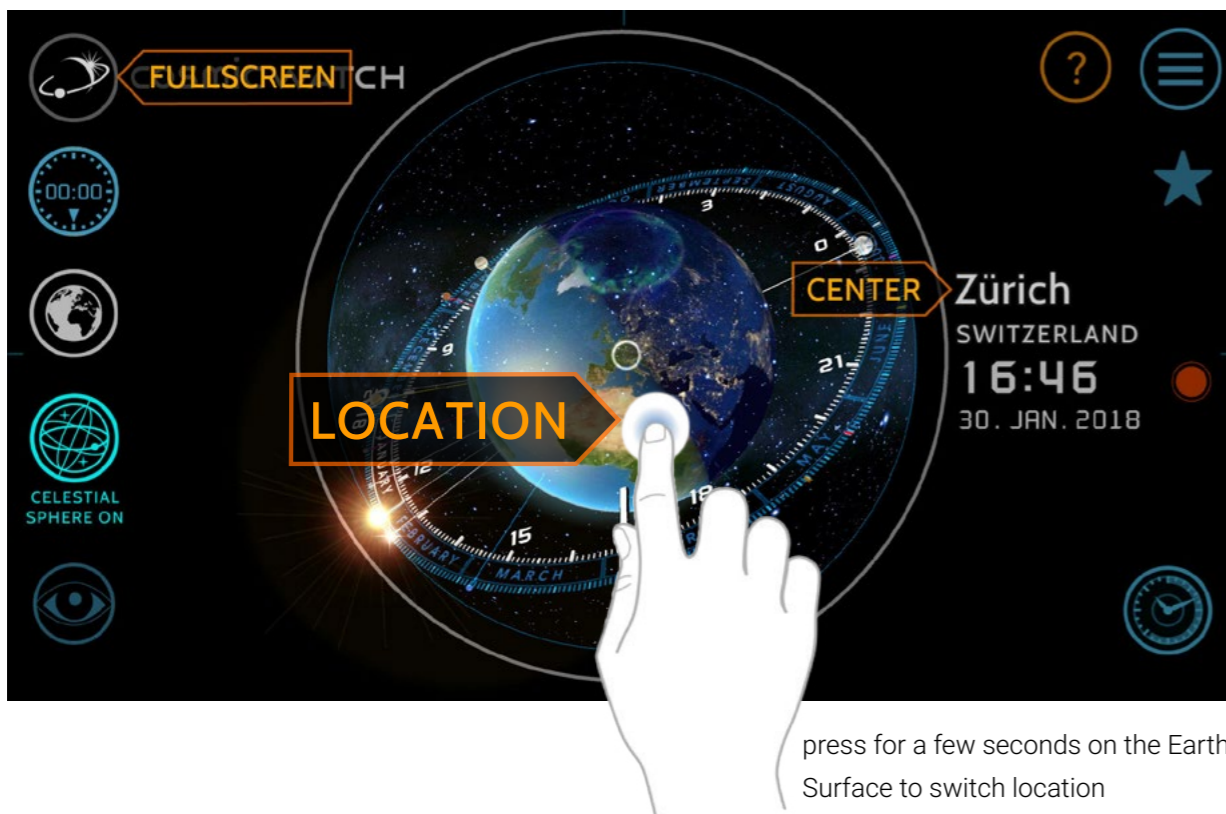
Swipe the screen in a direction to rotate the globe or your view



Pinch the screen to zoom in or zoom out



The Earth and the celestial sphere: an overview of what's around



At start up the Cosmic Watch will attempt to detect your position using the localisation data of your phone or GPS, if activated. If for some reasons this is not possible you can always set it manually (see search locations typing).

## SEARCH LOCATIONS ON THE GLOBE

Long-press (press down for a few seconds) anywhere on the globe to change location and show the local time and horizon. This is also a nice way to discover new cities around the world. On the dark side of the Earth you can recognize a lot of cities because of their lights. Zoom in and explore the World!




## CENTER YOUR VIEW

Tap on the location name to centre the view at that particular location. In the Sky View it will face South or North depending on which hemisphere you are on.


## FULLSCREEN

Tap on the Cosmic Watch logo on the top left to show or hide the control buttons.

## SEARCH LOCATIONS TYPING

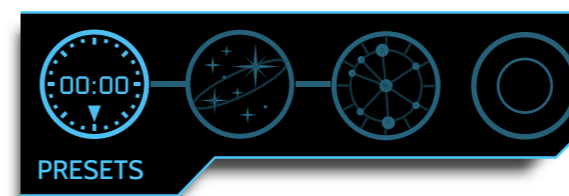
-  Tap on Menu on the top right corner
-  Tap the magnifying glass to search for a location.
  - | Type in the location you are looking for. If you can't find it, try the nearest big city.
-  Click on the plus sign icon to save your location.

## FAVOURITES

-  Save up to three locations and switch between them by opening your favourite locations with the star icon.

## PRESETS AND VIEWS

The Cosmic Watch has three presets for the visual settings and one to switch all layers off. It has three points of view, each having one option.



### PRESETS (MODES)

Presets to the most useful visual settings: World Clock, Astronomy and Astrology. Use the minimal mode to reset all settings.



### VIEWS

Switch between different points of view to understand what you see in the sky and the apparent motions to be observed.



#### SKY

The sky in augmented reality, discover the sky around you!



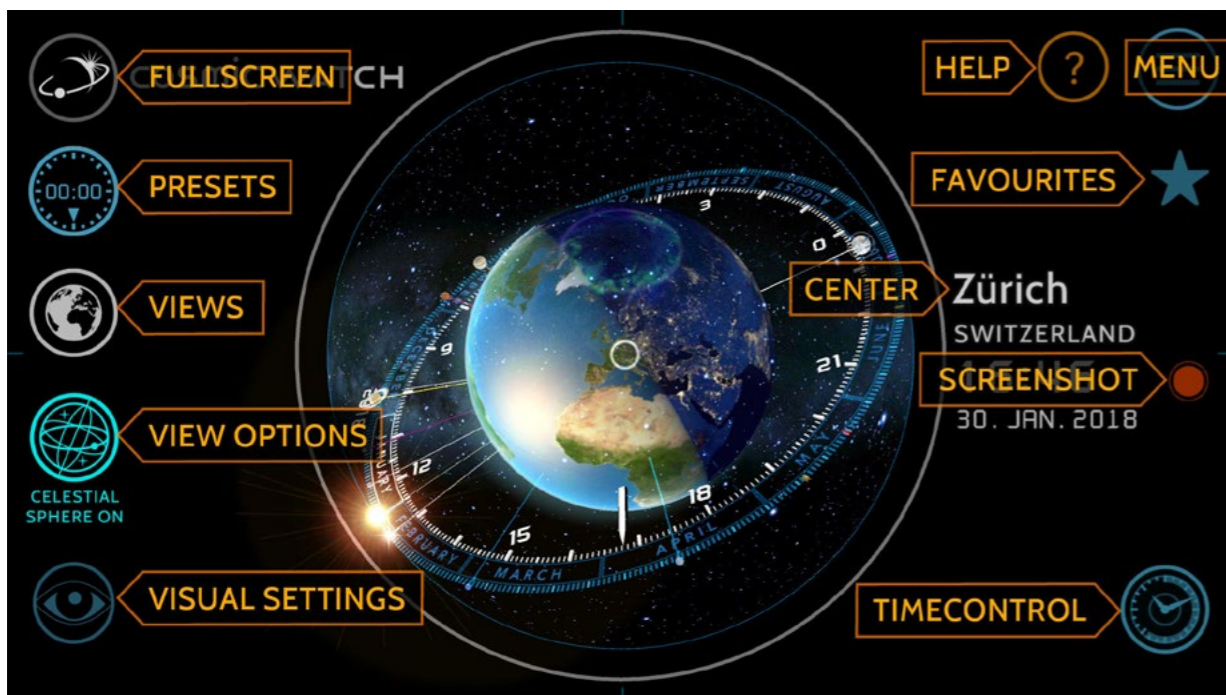
#### EARTH

Earth centred view with the option of having the [celestial sphere](#) on or off.





#### SOLAR SYSTEM



Zoom the solar system, accelerate time to see it move and switch between a [geocentric](#) and a [heliocentric](#) point of view.



## VIEW OPTIONS

- 

**CELESTIAL SPHERE ON / OFF**  
Activate a projection of the sky in a sphere or see the Earth from an astronaut's point of view.
- 

**COMPASS ON / OFF**  
Use the sensors of your device to automatically orientate your view. Identify planets, stars and constellations with this augmented reality experience. [Calibrate the compass](#) for accuracy.
- 


**GEOCENTRIC / HELIOCENTRIC**  
Watch the solar system movement with the Sun in the centre or the Earth as its focal point. Discover the difference between a [geocentric](#) and a [heliocentric](#) point of view.





Celestial Sphere ON – an abstract view





Celestial Sphere OFF – a realistic view


## THE USER INTERFACE


- 

**VISUAL SETTINGS**  
Play with different layers of information and [visual settings](#) to explore the basic concepts of orientation in the sky. Customise your Cosmic Watch.
- 

**TIME CONTROL**  
Accelerating time is a mind blowing experience. The [Time Control](#) is a key instrument to observe and understand the apparent motion of the sky.
- 

**MENU**  
Search for a [location](#) out of the 23'000 cities available. Modify your [notification settings](#) and see which [astronomical events](#) are taking place next. Find more [information](#) about the Cosmic Watch and access some [advanced settings](#).
- 

**EVENTS AND NOTIFICATIONS**  
Here you can see the next [astronomical and time related events](#) and you can choose which ones you would like to send as [notifications](#) so you don't miss those cosmic moments.
- 

**SCREENSHOT**  
Capture that special moment. Save it or [share](#) it with your friends.
- 

**HELP**  
Access a short description of the main features of the Cosmic Watch.

## HOW TO EXIT

### ANDROID

Swipe from the right. Press home to go to home screen or the icon with two squares to access the recent apps screen where you can swipe away the cosmic watch to close it.

### iPHONE - iPAD

Press the home button to go to your home screen.

► [how to close an app](#)

Now you know the main features of the Cosmic Watch and how to move around in the app. Let's take a closer look to those functions and what you can learn from them.



## PRESETS

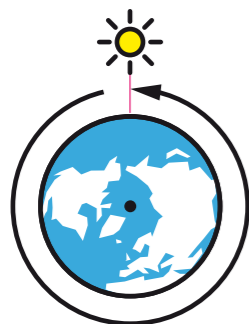
The Cosmic Watch has three main modes. These are quick presets to the most useful settings. To start from scratch use the minimal mode. Note that pressing on a preset will reset your visual settings.

The main modes are:

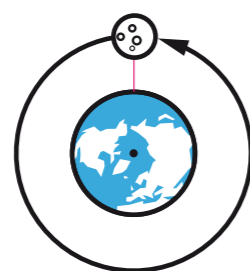
- WORLD CLOCK : time at any city and timekeeping (calendar)
- ASTRONOMY : constellations and planets on your sky
- ASTROLOGY : a different kind of astral chart

In ancient times these three disciplines were one and the same. We thought it would be interesting to show the relationship between these disciplines, as they are founded on the same basic knowledge but for different purposes.

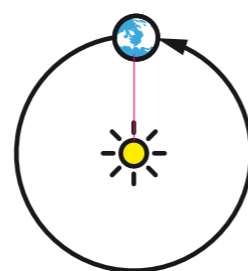
## THE EARTH IS THE CLOCK, THE SUN AND THE STARS THE CALENDAR.



1 DAY = 1 EARTH ROTATION  
AROUND IT'S AXIS  
WITH RESPECT TO THE SUN  
[SOLAR DAY]



1 MONTH ≈ 1 LUNATION  
APPROX. THE CYCLE OF MOON PHASES  
[SYNODIC MONTH = 29.53 DAYS]



1 YEAR = 1 EARTH REVOLUTION  
AROUND THE SUN  
[COMMON YEAR = 365 DAYS / LEAP YEAR = 366 DAYS]  
[JULIAN YEAR = 365.25 DAYS]

The measurement of time is based on astronomical observations. A day is a rotation of Earth on its axis relative to the Sun. A year is a revolution of Earth around the Sun and a month is based on the Moon rotation around the Earth.

## WORLD CLOCK

Observing the Position of the Sun in the sky is the origin of time reading. The Cosmic Watch brings this origin back to the present and a step forward. It changes the way we read time, from an abstract number to what it really is: our actual position in the solar system. It's the most beautiful way to see what time it is.

Before mechanical clocks were invented people relied on the sky to know time and date. The Cosmic Watch wants to reconnect the user with this knowledge while rising awareness of where you are: on the surface of a beautiful planet, peacefully floating in space, surrounded by a universe full of wonders.



The Cosmic Watch is as a new way of visualising time.

## THE COSMIC WATCH AS YOUR DESKTOP CLOCK

The World Clock is the default setting to use the Cosmic Watch as a desktop clock. Connect your tablet to the power outlet and find a nice tablet stand. To disable the automatic sleep mode of the tablet go to the device settings and choose "don't sleep while recharging". (on iOS is called Kiosk mode). [Find out more here.](#)






Using the Cosmic Watch as a clock is a pleasing experience. See the actual position of the Sun, if it has reached the highest point in the sky (true mid-day) or if it will soon set on the horizon. Discover which planets and constellations are visible on the night sky and know the actual Moon phase at one glance.






To use the Cosmic Watch as your world clock search for three desired locations and save them as your favourites. Longpress on the globe to instantly know time anywhere.

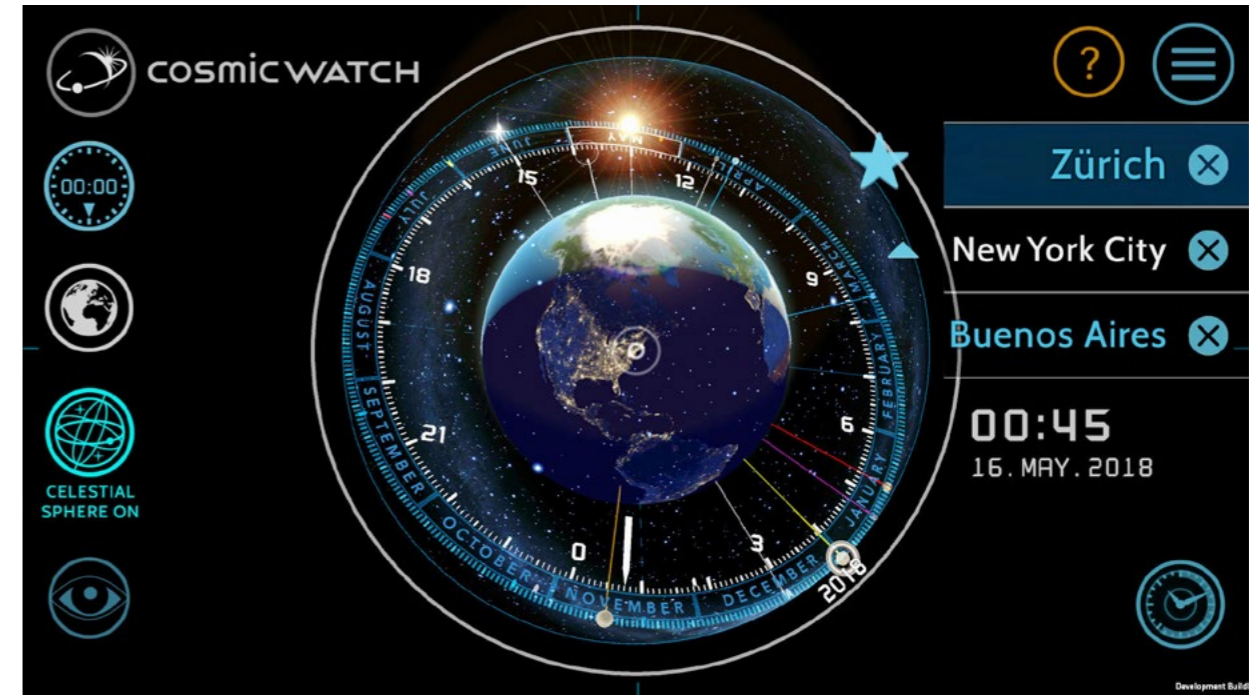
### SEARCH LOCATIONS TYPING

-  Tap on Menu on the top right corner
-  Tap the magnifying glass to search for a location.
  - | Type in the location you are looking for and tap it on the pop up list. If you can't find it, try the nearest big city.
-  Click on the plus sign icon next to the location name to save that location.

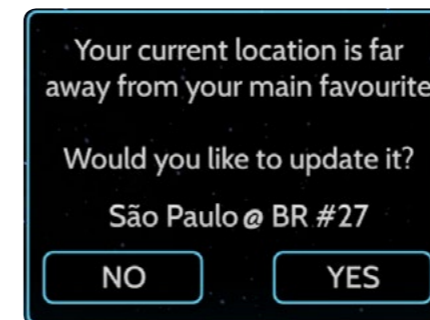
### FAVOURITES

-  You can save up to 3 locations and switch between them by opening your favourite locations with the star icon and taping on the location names.
-  Use the upwards triangle to rearrange your locations
-  Tap on the X icon next to the favourite to delete that location.

★ tapping on the favourite location is also a way to center your view, especially when you have location turned off in Earth settings.



It is important that your actual location is the first on the list of favourites to correctly calculate the events for the [system notifications](#). You can move locations up by taping on the upward triangle in the Favorites panel.



If your current location at start up is not your main favourite the Cosmic Watch can update it for you. If you press "no" it will just change your location to the detected one without changing your favourites. This is convenient if you are just for a short period somewhere and don't want to recalculate the [system notifications](#).

**TRICK:** The Cosmic Watch needs **location services** or GPS activated to detect your current location. A quick trick is to open your maps application, in most cases this will activate location services and the Cosmic Watch will be able to access this information.

To customize your World Clock check the [clock options](#) on the visual settings.



- TROUBLESHOOTING
- > Can't find my city or town
  - > Time and date are not correct for my city
  - > The Cosmic Watch shows UTC





## TIME TRAVEL

When the Cosmic Watch starts up it will show you a real time view of how the Earth is illuminated, the positions of celestial bodies and what to observe on the sky. Cosmic Watch offers you the option to change how fast time should pass, and even to make time go backwards!

The Time Control is a key instrument to observing and understanding the [apparent motions](#) of the sky. To fast-forward time is a mind blowing experience. It's like watching a time-lapse video.

Let's take a look at the time control panel at the bottom right hand corner.

### FAST REWIND / FAST FORWARD

Decrease or increase the rate at which time passes. Tap this buttons consecutive times to speed up the time.



The Cosmic Watch releases its anchor at the rate of one day per second. This is to reduce confusion that fast rotational motion on the display would otherwise cause! Note that on an Earthly scale this rate looks fast but in relation to the solar system, it is still very slow.



### NOW

Return to the current time & date . Use this button to go back to the present.



### PAUSE

Make time pass as normal. Stop fast-forwarding or rewinding time. You can't stop time on the Cosmic Watch. This seems to be a quality of time: it never stops, it just keeps going!

## TIME AND DATE

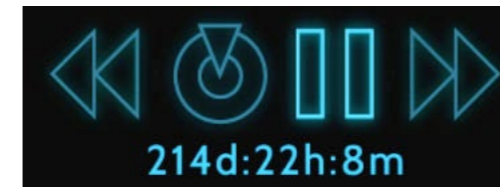
Choose any moment you like. You can see how the planets where positioned at the moment of your birth, or find out when the next full Moon will be.

Moving through time in daily steps is a good way to see how much the [celestial bodies](#) change position in a day. Tap on the arrow over the day number to achieve this effect.



We can't predict the future, but we know where the planets and the Moon will be. The Cosmic Watch should be accurate for the next hundred years.

## TIME DIFFERENCE TO NOW



At the bottom of the time control you can see the time difference to now. With this feature you can find out how many days old you are or how many days are left to your next birthday!

## ANCHOR



The ANCHOR is a very important function. With this button you can anchor the camera and rotate with the Earth or release it and float freely in space around the Earth. Note that the Anchor is automatically released at the rate of one day per second.

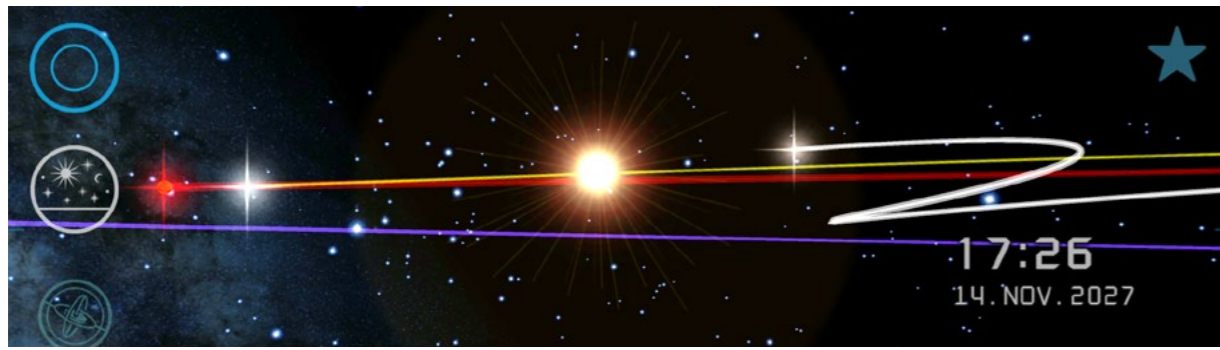
### ANCHOR ON

This is a [topocentric](#) point of view. It's like a geostationary satellite, like the ones we use for weather monitoring. With the anchor on, it looks like the sky is rotating around the Earth giving us the same experience we have from the Earth's surface.

### ANCHOR OFF

By releasing the Anchor you can float freely in space around the Earth. You are still [geocentric](#), the Earth is at the center, but able to see that it's actually the Earth which rotates around its own axis. The stars are the only objects that are fixed. Like this you can observe the Moon moving around the Earth, and the Sun's apparent movement through the zodiac constellations.



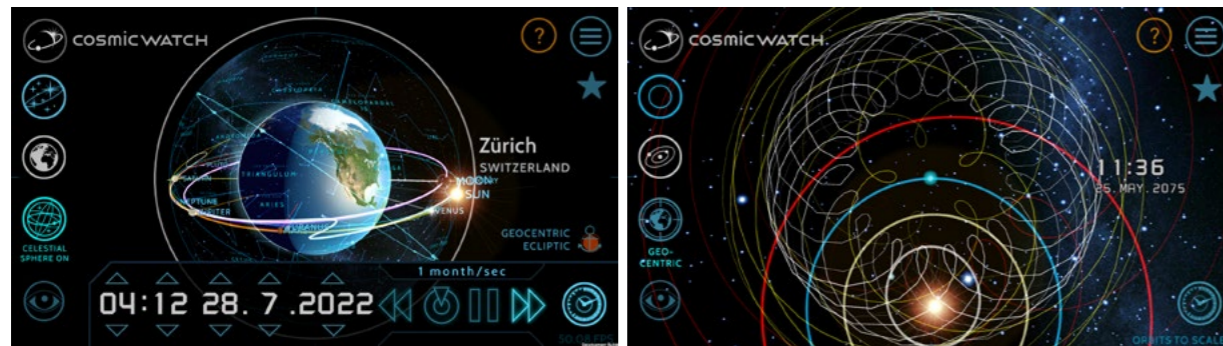


Planet trace in the sky view

## PLANET TRACE

While fast forwarding time, the planets will leave a trace of their apparent movement as observed from Earth.

This makes it easier to understand what the [retrograde motion](#) of the planets is. Combined with the solar system view one has a clear representation and visual understanding of how this phenomenon occurs.



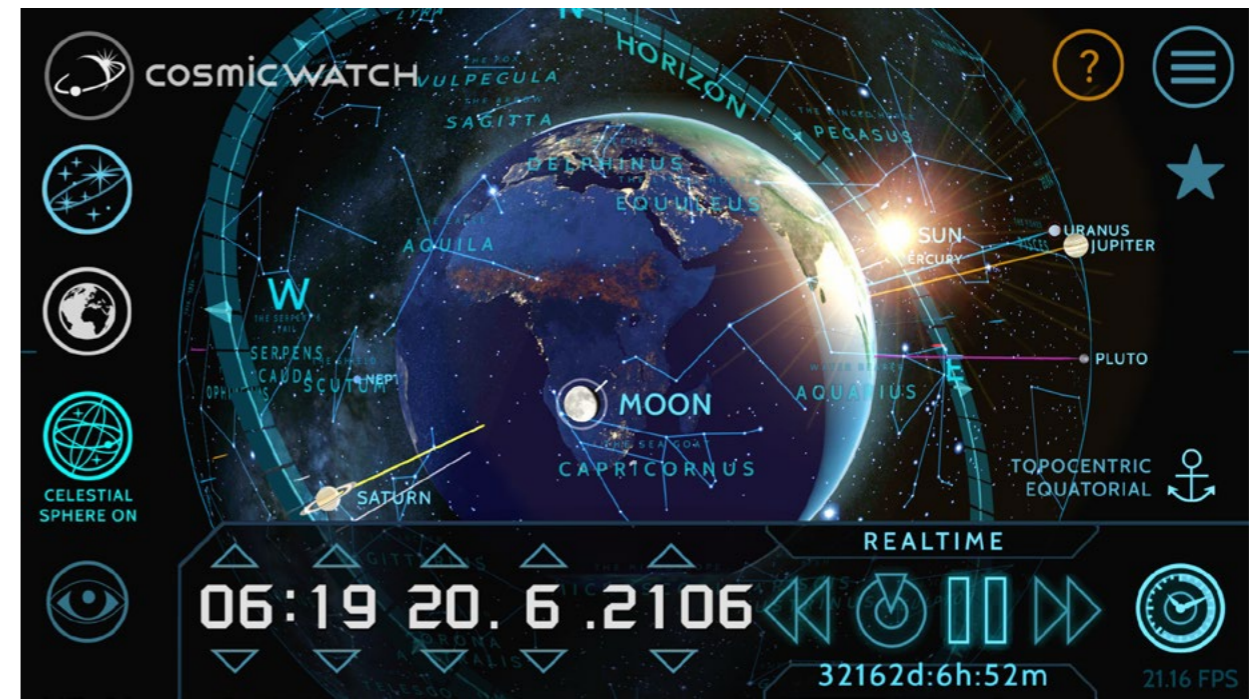
Planet trace in the Earth view and solar system view

## EVERYTHING IN THE UNIVERSE IS IN MOTION

Motions in space can be very subtle and slow to our perception of time. It's like when you watch the clouds, they seem not to move but look a minute later and they changed their shapes. The same happens with the sky, it's constantly moving due to the [rotation of Earth](#). Try to make a photograph of the Moon with a stativ, zoom in and center it on your composition, by the time you have made your camera settings it's probably out of your composition already!

Try it on the Cosmic Watch. Zoom in the most you can and watch the whole sky change every second! Speeding up time is the perfect way to get conscious about this motions!

Due to the [annual Earth revolution](#) around the Sun, the Sun appears to move about 1° per day relative to the stars. The [Moon](#) is also rotating around Earth, moving eastward at about 12.2° per day. The solar system is revolving the [galaxy core](#) in a complex motion at an average speed of 448,000 mph (720,000 km/h) and even the stars are not fixed! This is called proper motion of stars.



## ASTRONOMY MODE

The Astronomy mode shows the [constellations](#), the [horizon](#) and the [planet names](#). Use this mode to find the planets and constellations and stars in your local sky.

The two great circles to orientate yourself on the sky are also shown. This are the [celestial equator](#) in blue and the [ecliptic](#) in turkis.

In combination with the [time control](#) you can find out the time of rising, meridian transit and setting of the celestial bodies. When the Sun, the Moon or a planet cross the horizon on the East it's [rising](#) and on the West it's [setting](#). When a body reaches the highest point in the sky we call it culmination, maximum altitude or [meridian transit](#).

The [meridian](#) is the vertical line which runs from the North towards the [zenith](#) and further to the South. You can find the meridian in the [horizontal coordinates](#) in the guides tab on the visual settings.



**TIP:** Use the astronomy mode in the sky view as it will swicht the most important information layers on.



## ASTROLOGY MODE












The Astrology mode shows the planets with their ancient symbols in the zodiac signs. Set your birthday on the time control to show your natal chart. Use the [horizon](#) on visual settings > guides to find out which sign is your ascendant. You can see the Moon nodes, the points where the eclipses take place. Use the planet [connections](#) to see if a planet is at [opposition](#) or [conjunction](#). The interpretation is up to you!

In menu > about > about > [advanced settings](#) you can choose between the [tropical](#) or [sidereal zodiac](#). You can also switch off the color ring of the zodiac signs.

In the visual settings > [sky](#) you can switch the zodiac constellations on and observe how this are shifted with the zodiac signs due to the [axial precession](#) of Earth.

The Cosmic Watch is a **must have** for people interested on astrology. It's not the most advanced astrology software and many features astrologers use are missing, but it allows the user to understand the fundamentals of astrology.

### ANCIENT ASTRONOMICAL SYMBOLS

 Sun	 MERCURY	 JUPITER	 NEPTUNE
 Moon	 VENUS	 SATURN	 PLUTO
 Moon NODE	 MARS	 URANUS	



## MINIMAL MODE

The minimal mode disables all guidelines and shows just the Earth surrounded by the stars and the milkyway, the Sun, Moon and planets. This is the best mode to start discovering the Cosmic Watch and experiment with the many [visual settings](#).

With the celestial sphere off, you get a realistic perspective of our planet from space.

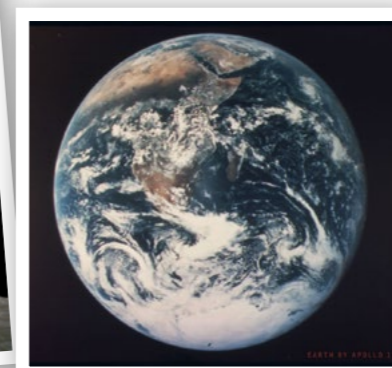
### DID YOU KNOW?

Only a few persons had the chance to see the full disk Earth. The astronauts of the Apollo missions to the Moon where the only humans to have this experience in real life. Luckily they made pictures and shared their experience with us! – Check [overview effect](#) for a description of this phenomenon.

Now and then, when a spacecraft leaves Earth to an intrepid mission in space, we mostly take the chance to point a camera back to our planet and get that cosmic perspective. Weather satellites are also constantly making shots of the full disk Earth and since 2015 there is a camera looking at Earth from the Sun's point of view, sending images of the lit side of our planet almost in realtime. Check this link to find out [more photos of Earth!](#)



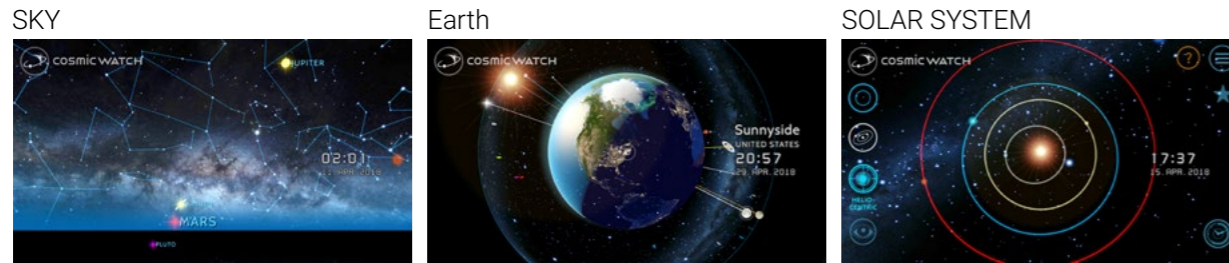
Earthrise, Apollo 8  
24<sup>th</sup> of December 1969



Full disk Earth, Apollo 17  
17<sup>th</sup> of December 1972



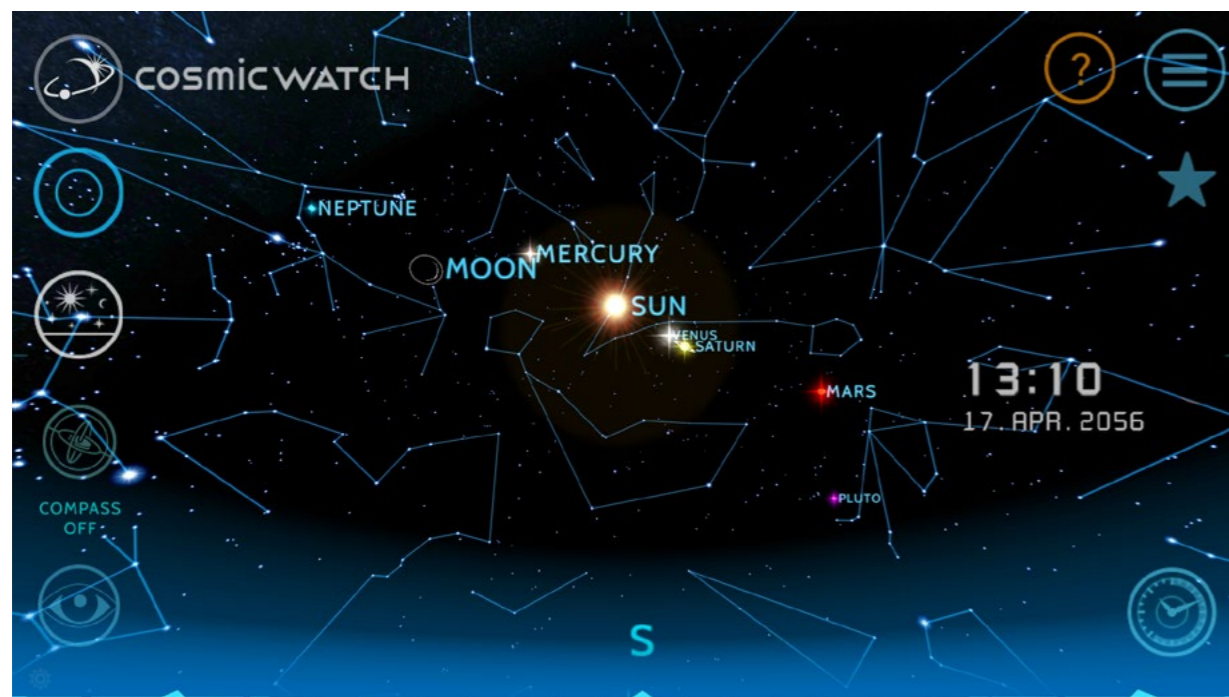
DSCOVR: EPIC Earth Polychromatic Imaging Camera  
15<sup>th</sup> of October 2015



## THE VIEWS

A very powerful experience on the Cosmic Watch is switching views. It gives you different **perspectives** to observe our cosmic surroundings as seen from space or from a specific location, visualising our position in the solar system.

This feature allows you to understand what you are seeing in the sky and to grasp the interlaced motions observable: the **daily rotation of Earth**, the monthly revolution of the Moon and the **yearly orbit of Earth** around the Sun. Recognise the **apparent motion** of the planets as viewed from Earth observing the celestial bodies move. Speed up time and switch between the sky, Earth and solar system view. Tap on the views button (white button left of the screen) and choose one of the three options.



## SKY VIEW

This view lets you experience the sky as seen from your location on the surface of the Earth. Point your phone or tablet towards the sky and get a real-time look at the constellations, stars and planets in space.

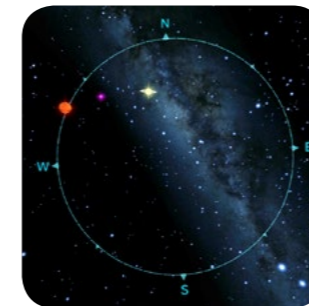
- Discover star constellations and the names of the brighter stars.
- Have fun locating celestial objects in the sky in augmented reality.
- Experience the sky in ways that are invisible to the naked eye.



### COMPASS ON / OFF

When you switch to the Sky View the **compass** will be turned on. Move your device around to see what's around you. Swiping or zooming on the screen will turn it off, just press the compass button again to return to the augmented reality mode.

**TIP:** We recommend using the Sky View while in Astronomical Mode. This mode gives you an interesting set of information while you observe the sky.



### THE COMPASS ROSE

When you look downwards holding your mobile device horizontal (looking towards the **nadir**) and the **horizon** is activated, the Cosmic Watch will serve as a compass, indicating where to find the **cardinal points**.

**TIP:** It's always a good idea to **calibrate** your compass waving your device in a figure 8 motion when you want to use the Sky View.



A peculiar detail of the Cosmic Watch Sky View is that you are watching a **3D solar system**. When planets get near they will appear bigger. You can show the **orbits** of the planets to get a sense of the solar system, that's how we would see the solar system from Earth. Please note that the celestial bodies are not to scale. When watching the sky the planets look like stars. Only the classical planets are visible by naked eye. They can be brighter than the brightest star sirius (specially Venus) and they don't twinkle as much as the stars.

Explore the many **visual settings**. One of our favorites is watching the sky with the **interstellar gas and dust layer**. It allows you to clearly see the plane of the milky way.



Move your device in every direction to calibrate the Compass

### HOW IT WORKS

Mobile devices have a small built in magnetometer, which can measure the Earth's magnetic field. This information is combined with an accelerometer that acquires data about the position in space of your device, measuring its tilt and movement.

The accuracy of the compass strongly depends on the sensors build in on your device. Even small magnetic fields on your proximity can cause the view to be slightly off. Move away from any interference like large metal objects or electrical devices and re-calibrate by waving your device in a figure 8 motion.



## EARTH VIEW

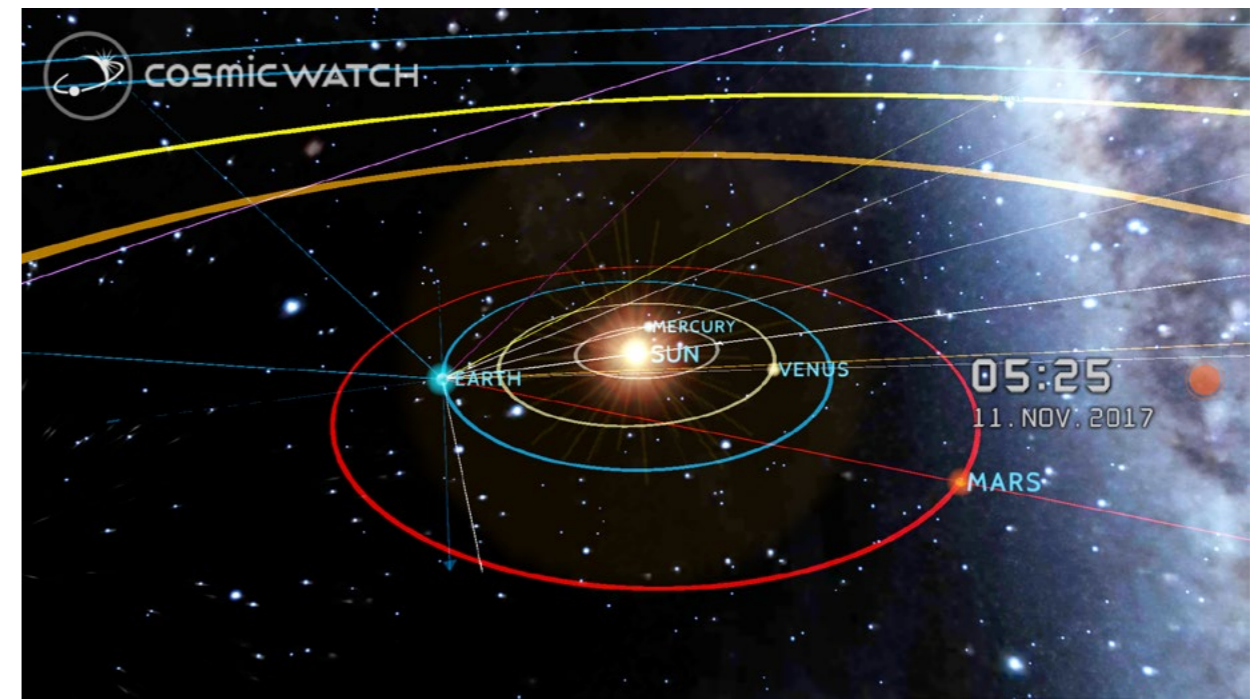
This is the main view of the Cosmic Watch. We wanted to recreate the beauty of our home planet illuminated by our star the Sun. On the **day side** you can see the oceans, the relief of the sea floor and where the plankton changes the color to a beautiful turkis. On the land you see the different kinds of vegetation zones, deserts and mountains. On the **night side** you can discover the many populated areas of the world by their lights or their fires marked as a tenue red. On the poles we included auroras, a phenomenon occurring when charged particles hit the upper atmosphere of the Earth. Zoom in to see all the details of our beautiful world.



### CELESTIAL SPHERE ON / OFF

Around the Earth are the stars and the Milky Way, planets, Moon and the Sun. With the **celestial sphere** on you will see them all at same distance just surrounding Earth. Remember this is a projection used for orientation in space and is not real. It just has the advantage of showing an **overview** of the space around us with at one glance. Switching the celestial sphere off you will get a more realistic view and feel like you would be floating in space in front of Earth, surrounded by the magic of space.

Play with the **Visual Settings** to get the view you like the most.



The Solar system is the clockwork of the Cosmic Watch.

## SOLAR SYSTEM VIEW

Zoom in and out to observe the inner and outer solar system and the orbit of the Moon. All orbits are represented in a realistic scale. The Sun, Moon and planets are not to scale, as they would just be little dots almost invisible to the eye.



### GEOCENTRIC / HELIOCENTRIC

This view has the option to see it from a **geocentric** or **heliocentric** perspective. The former has the Earth fixed in the centre and the latter the Sun - showing the real motion of the planets around their star. The geocentric view is handy to understand how we experience the solar system from Earth.



Fast-forward time with the geocentric option to see the planets moving and understand their apparent motion as seen from Earth. This is the answer to the **retrograde motion** of the planets!

Observe how the solar system is oriented in the Milky Way. The Solar System is traveling at an average speed of 828,000 km/h (230 km/s or 514,000 mph) within its trajectory around the galactic center. It is common to think of the Solar System moving like a frisbee but it is actually tilted towards the plane of the galaxy at an angle of about 60 degrees. It also wobbles and goes up and down with respect to the galactic plane.

**TIP:** switch to minimal mode as it will reduce the amount of information displayed.

## VISUAL SETTINGS

The Visual Settings let you to learn intuitively by switching layers on and off. Acces them by taping on the eye icon on the bottom left corner. Selecting the **minimal** preset first is a good idea, as it allows you to concentrate on the selected layer.



### CLOCK SETTINGS

To customize your clock tap on the visual settings (the eye icon at the bottom left hand corner of the screen) and tap on the clock tab.



### ECLIPTIC CLOCK FACE

This clock face is set on the **ecliptic**. The Sun, Moon and planets are always to be found around this imaginary line, as this is somehow the plane of the solar system.

The **time dial** points from the selected location to the 24-hour clock face. You can visualise the day as a circle, see how much time has lapsed and how much of the day is left.

The ecliptic clock face gives you an idea of time around the world. An interesting property of this clock face is that it shows at which approximate time the celestial bodies will be at the highest point in the sky (meridian transit). For example, the Sun passes the meridian approximately at 12 o'clock at midday and a full Moon passes the meridian at approximately 12 o'clock in the night. Switch the **connections** on to check it out.



### EQUATORIAL CLOCK FACE

This is a contemporary and comprehensive visualisation of the 24 hours of the day. It's the most logical way to display time on Earth, perfect for locations near the tropic regions of the world.

For many centuries time was measured with the Sun (local time). Midday was the moment when the Sun was at it's highest point in the sky. From an Earth perspective this means that, on the equator, it is 6 o'clock in the morning at the Earth's east **terminator**, the line that divides the daylight side and the dark night side and 6 o'clock in the evening at the west **twilight zone**.



The equatorial clock face also looks nice in the sky view. Place your tablet looking south if you are in the northern hemisphere, or looking north if you are in the southern hemisphere, and get an augmented view of your sky on your clock.



Find in the clock settings the option to display the **year** as a circular calendar where the Sun marks the date. You can see visually where in the year you are right now and when the next **season** will start.



The **digital** button is useful if you want to have the cosmic watch as your daily clock, as I do. Like every clock the cosmic watch has a **second** indicator visualising the minute.



## SKY SETTINGS

### CONSTELLATIONS

Show the “stick figures” lines of the 88 Western constellations. They help us separate the sky in smaller portions. The ancient Sumerians, and later the Greeks, established most of the northern constellations in use today. When explorers mapped the stars of the southern skies new constellations for that region were proposed. In 1922, the International Astronomical Union (IAU) adopted the modern list of 88 constellations.



The drawings are based on designs originated by H. A. Rey and published in “The Stars: A New Way to See Them” in 1952.



### ZODIAC

This are the 12 constellations along the ecliptic, the apparent path of the Sun across the celestial sphere over the course of the year. The paths of the Moon and visible planets are also within the belt of the zodiac. The zodiac is divided into twelve signs, each occupying

30° of ecliptic longitude. They form an ecliptic coordinate system, which takes the ecliptic as the origin of latitude and the Sun’s position at vernal equinox as the origin of longitude.

The origins of the zodiac probably date back into prehistory, whose astrological divisions became prominent c. 400 BC within Babylonian or Chaldean astronomy.

### CONSTELLATION NAMES

Draws the names of the constellations. Official latin names set by the IAU and an english description are provided. Many of the myths associated with the constellations were probably invented to help farmers to remember when to plant and harvest. Note that different cultures have different constellations figures and names.

### STAR NAMES

Of the roughly 10,000 stars visible to the naked eye, only a few hundred, the brightest ones, have been given proper names in the history of astronomy. Astronomers assembled *star catalogues* that identify the known stars. Medieval Islamic astronomers gave Arabic names to many stars that are still used today. A star is a luminous spheroid of plasma held together by its own gravity. The nearest star to Earth is the Sun.

### LONG EXPOSURE

Watch the **Milky Way** as it looks when you take a long exposure photograph. The Milky Way is the galaxy that contains our Solar System. Until the early 1920's, most astronomers thought that the Milky Way contained all the stars in the Universe. Observations by Edwin Hubble showed that the Milky Way is just one of many galaxies. The Milky Way is a barred spiral galaxy estimated to contain 100–400 billion stars. The oldest stars in the Milky Way are nearly as old as the Universe itself.



### INTERSTELLAR GAS & DUST

In a clear night away from city lights you can see our home galaxy the Milky Way in the sky. You can notice that there are parts obscured as there would be clouds blocking the light of the stars behind. This are actually giant clouds of interstellar gas and warm dust called infrared cirrus. They can be found in almost every direction of space, absorbing and scattering optical light. That’s why from Earth we can’t see the 10 million Suns bright center of the galaxy.

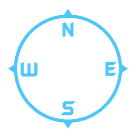
The gas is mostly hydrogen and helium, the most abundant elements in the Universe, released by supernova explosions and expanded by the stellar wind.

### SKY GRADIENT

Turns on and off the rendering of a band of fog/haze along the horizon.



## GUIDES



### HORIZON

The horizon is a very important guide because it defines your actual vision of the sky. You can only see half of the sky because the other half is under the horizon. In combination with the time control you can find out when a **celestial body** is rising (pass the horizon to the East) and setting (pass the horizon to the West).



### HORIZONTAL COORDINATES

The **horizontal coordinate system** help you locate objects in the sky giving you angles using the horizon and the North as a reference. This coordinate system is widely used in astronomy and celestial navigation. It also shows the **zenith** and the **meridian** of your location.



### PLANET NAMES

Shows the names of the planets. Moving from the Sun outwards, the planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Pluto has been relegated to a dwarf planet along with bodies such as Ceres and Eris.

The word "planet" comes from the Greek "wanderer". Unlike the stars whose relative positions remain more or less constant, the planets seem to move across the sky over time.



### CONNECTIONS

Everything is connected in the universe. The connections are a special part of the Cosmic Watch and can be used as dials. You can read the time at which the celestial object will be at its highest point in your local sky or use them to find conjunctions and oppositions. On the sky view they transform to finders which help you locate the celestial bodies.

#### CONJUNCTION

When these lines overlap, the celestial bodies are in conjunction. This means they are aligned with the Earth. A new Moon is a conjunction of the Moon with the Sun.

#### OPPOSITION

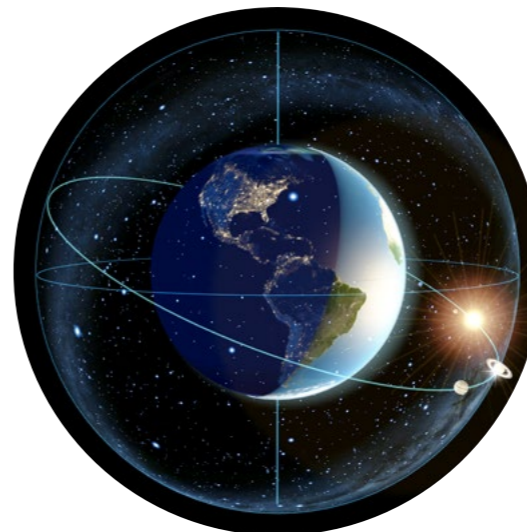
There is a little marker opposite each planet position. This marker helps to find planetary oppositions. In this case the celestial bodies are aligned, with the Earth in between them. A full Moon is an opposition of the Moon with the Sun.



### CELESTIAL RINGS

This feature has important educational value. It is named after the **Armillary Sphere**, which is still used to demonstrate the apparent movement of the sky and means "the instrument with the rings".

These are the main guidelines, great circles and points handy for observation of the sky. You can switch the labels on or off.



#### ECLIPTIC

The **ecliptic** is the plane of Earth's orbit around the Sun. Seen from the Earth it is the optical path of the Sun in one year. The 12 constellations on this plane are the zodiac. The Sun, the Moon and the planets are always found close to the ecliptic.

#### CELESTIAL EQUATOR

The **celestial equator** is the projection of the Earth's equator in the sky. The stars appear to move parallel to this line. The Orion constellation is of great help to find the celestial equator. This line is in a right angle (90°) with the celestial north and south poles, which are the center points of the apparent rotation of the sky because the axis of the Earth points towards them. The Celestial Equator crosses the horizon exactly East and West and its altitude is 90° minus your Latitude on Earth.

Find also the **northward and southward equinox** and the **northern and southern solstice**.



### EQUATORIAL COORDINATES

Draws grid lines for the **RA/Dec coordinate system**. This is the preferred coordinate system to pinpoint objects on the celestial sphere because they are independent of the observer's location and the time of the observation. They are used to set a telescope.



### ORBITS

In the sky view and solar system view you can show the orbits of the planets. They allow us to see the solar system. An orbit is the gravitationally curved trajectory of an object.

When you zoom in on the Solar System View you can see the **lunar orbit**. It is shown as a perfect circle around the Earth at its average distance. This makes it easy to check if the Moon is near or far from Earth.





## EARTH SETTINGS



### CLOUDS

Displays a cloud layer on the Earth. Note that a picture of the Earth without clouds is a globe. We hope one day being able to render the actual clouds on Earth to get a realistic view of our home planet.

The clouds shown are from February 2002, done with MODIS data, an instrument on the Terra satellite.

Credit: NASA Goddard Space Flight Center, Reto Stöckli.



### HI-RES

Displays high resolution textures of Earth. These are based on the blue marble texture provided by NASA with added bathymetry for the oceans floor and spiced up with auroras and fires on the night side.



### GRAFIC

This is a low resolution graphic texture of Earth showing just coastlines.



### OUTLINES

Low resolution graphic texture of Earth. Sometimes it's handy to show a darker Earth to better appreciate constellations and stars.



### POSITION

Switch on/off the position marker and location name on your Cosmic Watch.



## THE MOON



### THE MOON IN THE COSMIC WATCH

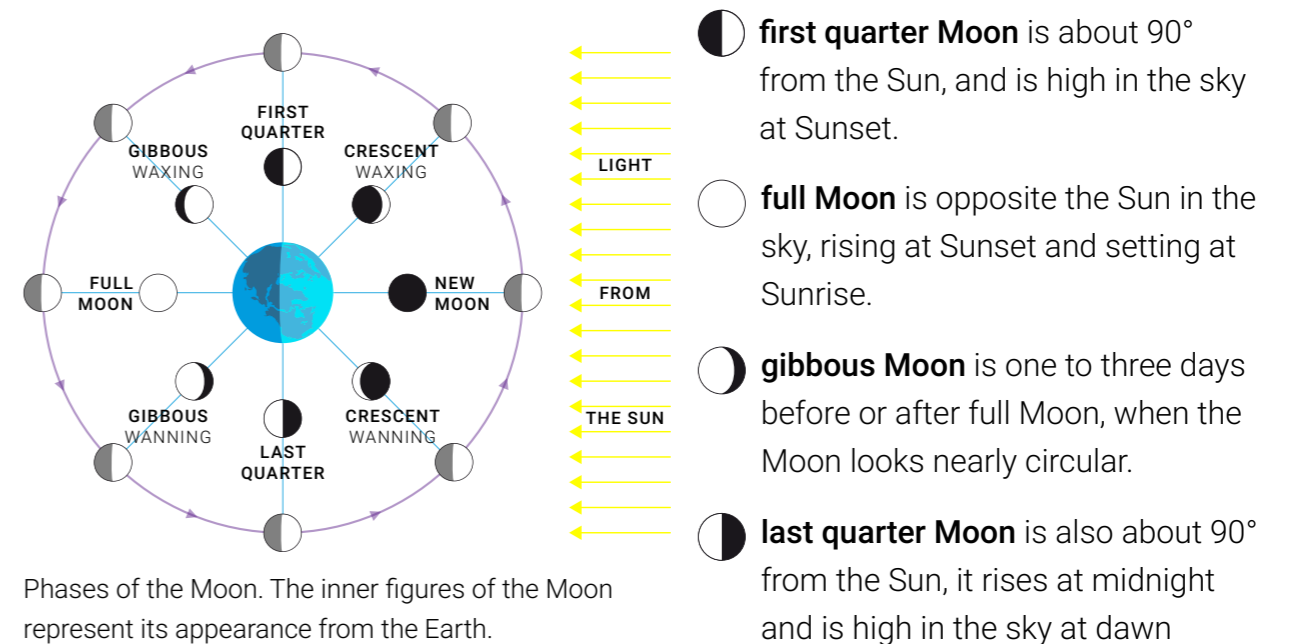
In the [Earth view](#) the Cosmic Watch shows the **Moon phase** and not the real illumination of the Moon. Seen from space, the Moon and the Earth are equally illuminated, as both bodies are being lit by the same light source, the Sun. In the [sky view](#) you see the Moon illuminated correctly.

The size of the Moon is greatly exaggerated to make it easier to find. Keep in mind that all the celestial bodies on the Cosmic Watch are not to scale and displayed bigger for the same reason.

### MOON PHASES

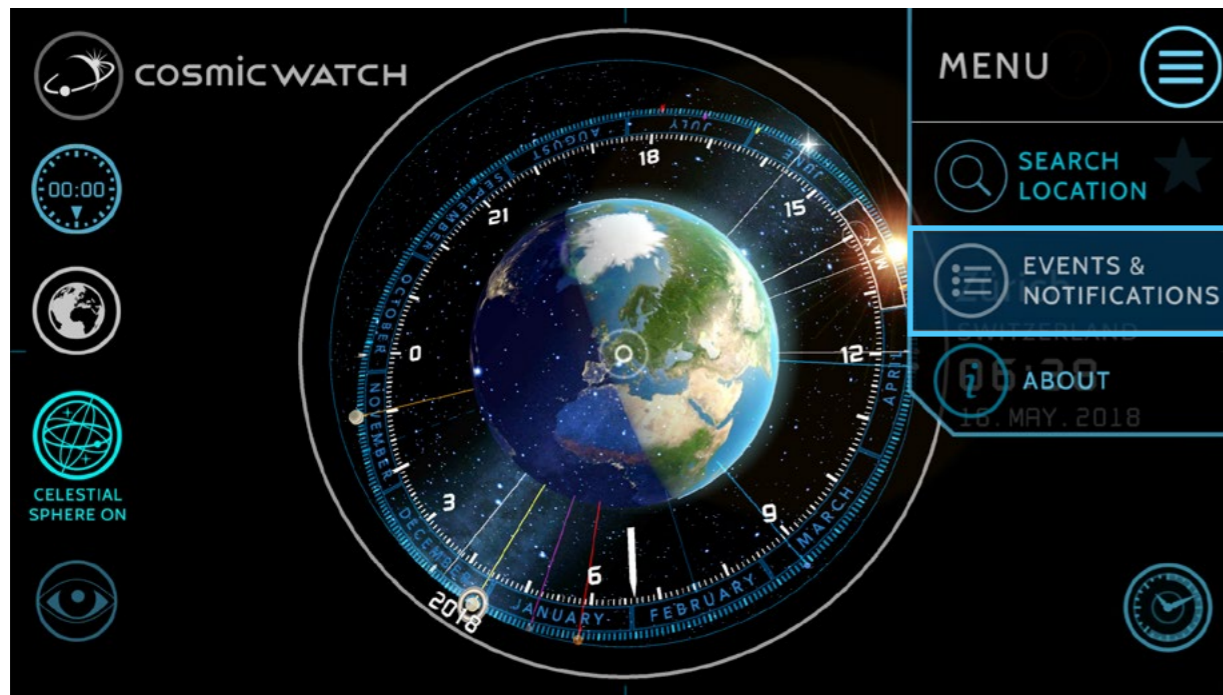
The Moon's phases are caused because as the Moon orbits the Earth, we can only see part of the half of the Moon that the Sun lights up.

- **new Moon** is approximately between the Earth and the Sun, and hence invisible.
- ◐ **crescent Moon** is one to three days before or after new Moon. It can be observed low in the west after Sunset when waxing and before Sunrise when waning.



# EVENTS & NOTIFICATIONS

The Cosmic Watch 2.0 calculates the next astronomical and time related events and is able to send system notifications to the user as reminders of these moments. It displays rise, transit and set times for the Sun and Moon, lunar phases, equinox and solstice, lunar and solar eclipses, and daylight saving time.



To access the Events & Notification settings and information tap on the menu button on the top right hand corner and choose Events & Notifications. Here you can adjust settings related to the notifications or use it as a calendar to see when the next new Moon will take place or when you will have to switch your clock an hour backwards or forwards (daylight saving time).

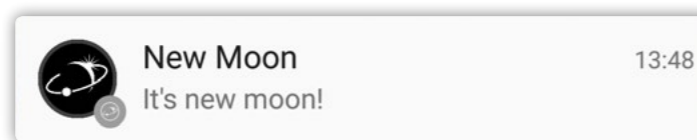
**Daylight Saving Times** might not be correct everywhere - countries, territories, and states sometimes make adjustments which are announced just days or weeks ahead of the time change.

## ACCURACY OF ASTRONOMICAL EVENTS

We have observed an accuracy of about 1 minute in the astronomical calculations.

Moonrise	: 07. DEC. 2017 22:06
Moonrise	: 07. DEC. 2017 22:11
Moon Transit	: 08. DEC. 2017 04:25
Moon Transit	: 08. DEC. 2017 04:28
Sunrise	: 08. DEC. 2017 05:52

In app notifications



System notification on android about the new Moon



## SETTINGS

### SYSTEM NOTIFICATIONS

Turn system notifications on or off and choose if you want to get a sound when being notified. These are messages sent to the operating system of your mobile device and will be played even if the Cosmic Watch is not running. Taping on the notification will open the app.

System notifications are calculated for 7 days when you open the app. After that period you have to open the app again for it to calculate the next daily events for your location. Note that the system notifications are calculated for the location that is saved on the first slot in your favourites (star). If your actual location isn't the first in the list move it up tapping on the upward triangle.

### IN APP NOTIFICATIONS

These messages are displayed on the app screen while running the Cosmic Watch. They are useful if you are using the Cosmic Watch as your daily clock or while trying out the various functions of the app. You have the option to pause time when an event takes place. This is handy when searching for specific events, for example the next full Moon or solar eclipse.

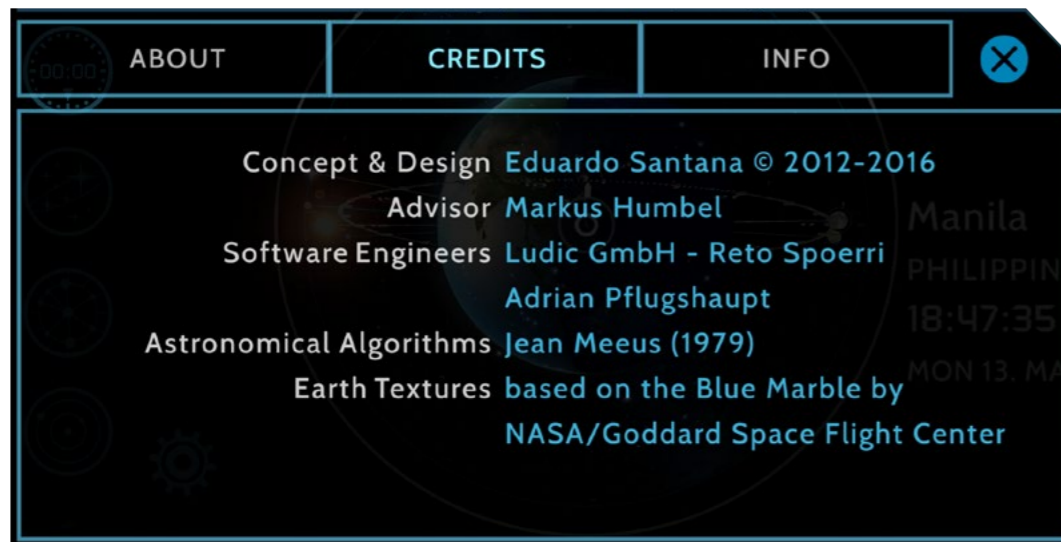
**TIP:** calculating a large number of events can slow down your device. Especially Moon calculations can be heavy to your CPU. If you are viewing the Cosmic Watch in Accelerated Time Mode to observe planetary movements you may want to switch notifications off for better performance.

## ABOUT

On the menu (top right corner) you will find an about button. Clicking on it will open a panel where you can find additional information about the Cosmic Watch, a short introduction, our motivation, a credits section, and the advanced settings panel.

In the Info section you can find the link to the [online manual](#) and a link to our [facebook page](#). We encourage you to click on it, check it out and like the Cosmic Watch page. We are constantly posting about our planet Earth, astronomy and time related subjects.

In the About section you can find the link to our webpage: [cosmic-watch.com](http://cosmic-watch.com) and to our [privacy policy](#). It's also the place where you can find the **advanced settings**.



## ADVANCED SETTINGS

On Menu > About > About > Advanced Settings you can do additional settings. Choose if you want to show the Tropical or the Sideral Zodiac on the astrology preset. You can also switch off the color ring of the zodiac signs.

The **Tropical Zodiac** is mainly used in western astrology and dates back to 290 BC. It is adjusted with the northward equinox or first point of aries as it's 0° point. It doesn't take into account the precession of Earth's axis and is therefore shifted with the actual zodiac constellations. That's why it is important to distinguish between zodiac signs and zodiac constellations.

The **Sideral Zodiac** is used in vedic astrology and is in sync with the actual constellations. The shift to the northward equinox is 24° (this angle is called Ayanamsa).



There is also a button to switch on/off the connection labels. These are the Milky Way Center (Galaxy Core) label and a Earth's shadow and Earth's direction label, including the average speed of Earth traveling around the Sun of 107'226 Km/h.

If you are used to do [screenshots](#) on your device with a buttons combination and know how to share them using the share feature of the operating system you may want to hide the screenshot button on the Cosmic Watch user interface.


## ASTRONOMICAL ALGORITHMS

The Cosmic Watch uses the Astronomical Algorithms of Jean Meeus to calculate the positions of the celestial objects. These algorithms have an astonishing precision and should be accurate enough for the next hundred years.

However, to save computation time, some concessions were made in astronomical accuracy by using simplified models. If you want to simulate the historical sky of many centuries in the past we recommend using other tools, f.e. stellarium.



## SCREENSHOT

 The Cosmic Watch has a built-in button to take screenshots and save or share them.

To take a screenshot just press the red dot button. Press save to save it to your device gallery. Press close to delete it. Press share to share it via the services you use on your device.

If you don't use the screenshot button or you are used to do screenshots otherwise you may want to hide the red button. Go to menu > about > about > advanced options.


Sharing a Cosmic Watch screenshot is a nice way of capturing a special moment like your birthday or anniversary and present it to your friends and family. You can record how the sky looks like, a peculiar planetary alignment, a celestial body just on top of your location, the geometric patterns of the planets with accelerated time or just the beauty of our home planet floating in space.

Sharing a screenshot is also a good way of spreading the word about the Cosmic Watch. We don't have huge marketing budgets and depend on word of mouth communication. Remember to add the [#cosmicwatch](#) hashtag to your post or the download links for the app store!

★ SHARING IS CARING ★



## HELP

 When you press the question mark symbol you get access to a short description of the user interface and the main functions of the Cosmic Watch. To get a deeper understanding read the online manual. To exit the Help Mode press on the Exit Help button.

## FINAL THOUGHTS

We think we have created a fantastic and beautiful app which is ahead of its time.

You may be using it as your daily clock, to locate planets and constellations on the night sky or to enlighten your peers about the motions in the sky, our place in the cosmos or the cycles of our home planet Earth.

If you enjoy the Cosmic Watch App please show it to your friends and spread the word!

[Download for iPhone and iPads \(iOS\)](#)

[Download for Android devices](#)

In case that the Cosmic Watch is your desktop or wall clock we would love to see a picture of it :) Just drop us an email or message via [facebook](#) or [twitter](#)!

# TROUBLESHOOTING

## \* THE COSMIC WATCH APP DOESN'T START

If you downloaded the Cosmic Watch but don't succeed starting it try deinstalling the app and installing again.

ANDROID: To deinstall the App on Android go to Settings > Apps. Select the Cosmic Watch and tap on uninstall. You can also press the Apps button on the bottom of the home screen (icon with 9 dots), longpress on the Cosmic Watch icon and move it to the deinstall icon on the top right corner. Go to the Play Store > Menu > My Apps and download it again.

iOS: To deinstall on iOS just tap-and-hold on the Cosmic Watch icon on the home screen. After a couple seconds, all your icons will start to do a wiggle dance, and the app icons will get an (X) icon in the upper left. Tapping that (X) icon will delete the app. You can re-download it from the App Store without paying again.

## \* TIME AND DATE ARE NOT CORRECT FOR MY CITY

The Cosmic Watch uses the internal system time of your device. If you see an incorrect time and date displayed please correct the time and date settings of your device.

Also check on the [time control](#) that you are in NOW.

## \* CAN'T FIND MY CITY OR TOWN

There are 23'000 cities in the Cosmic Watch database including cities with more than 15'000 population or capitals. If you find an important location which you think should be included in the database please write us an [email](#).

## HOW TO CLOSE THE APP

### ANDROID

Swipe from the right of the screen to show the overview button, a small square icon at the top right (on Samsung phones, it's a physical button in the appearance of two overlapping rectangles). Tap this button and the Recent Apps menu appears (a screen which showcases every app that you have currently running in the background). Swipe away the Cosmic Watch App to close it.

### iPHONE - iPad

1. On an iPhone X or later or an iPad with iOS 12, from the Home screen, swipe up from the bottom of the screen and pause slightly in the middle of the screen. On an iPhone 8 or earlier, double-click the Home button to show your most recently used apps.
2. Swipe up the app's preview to close the app.

Note from Apple: When your recently used apps appear, the apps aren't open, they're in standby to help you navigate and multitask. You should force an app to close only if it's unresponsive.

# CONTACT

The Cosmic Watch was created by Celestial Dynamics, a small and enthusiastic team of dreamers, visionaries and profound seekers with the mission to create beautiful and inspiring apps to raise awareness of the Earth, sky and the cosmos.



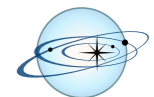
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**website:** [cosmic-watch.com](http://cosmic-watch.com)





Celestial Dynamics

## SOCIAL MEDIA


 Follow us on Facebook to get news and videos about astronomical events  
<https://www.facebook.com/CosmicWatch>


 Find trendy images about the Cosmic Watch on Instagram  
<https://www.instagram.com/cosmicwatchapp/>

 Get personal notes about the Cosmic Watch App on Twitter  
<https://twitter.com/CosmicWatch>

 See our Researchs and Cosmic Pins on Pinterest  
<https://www.pinterest.com/cosmicwatch>

 See our newest videos on Vimeo  
<https://vimeo.com/cosmicwatch>

 Curated playlists about the cosmos and our videos on YouTube  
<https://www.youtube.com/channel/UC36NA9Pxt7g1vWhbF944ZvA>

 A nice page with Cosmic Watch content on Tumblr  
<http://cosmic-watch.tumblr.com>

 Google Plus  
<https://plus.google.com/+Cosmic-watch>

# ASTRONOMICAL CONCEPTS

## CELESTIAL BODY

Natural object beyond Earth's atmosphere, such as the Moon, the Sun, planet, asteroid or star. Also called celestial object, astronomical object or heavenly body.

## POSITION AND MOTION ARE RELATIVE

Celestial bodies are in constant motion. There is no fixed position in space from which one can observe absolute motion. Since all motion is relative, the position of the observer must be noted.

## GEOCENTRIC

We speak of geocentric if the position is relative to the center of the Earth. Not to be confused with the [geocentric model](#) or [geocentrism](#).

## TOPOCENTRIC

A topocentric position is relative to an observer on the surface of the Earth.

## HELIOCENTRIC

A position relative to the Sun.



## THE CELESTIAL SPHERE

Look up on a clear night and you will notice the sky looks like a vast hemispherical dome with stars fixed to its inner surface. If the Earth were transparent, you would see the stars on the other half and you'd get the impression you were standing at the center of a black sphere speckled with stars. Astronomers and navigators call this the celestial sphere.

It's a simplified model of the sky, where all the stars are considered to be the same distance away from us, like on the surface of a sphere. It's used for orientation and to locate objects in the sky.

## HOW FAR ARE THE STARS?

The nearest star is the Sun at 8 light minutes distance. The Sun's nearest neighbour Alpha Centauri, a triple-star system, is 4.3 light years away. Most of the stars visible at naked eye will be in a range of 1500 light years (the milky way is estimated to be around 120'000 light years in diameter)

## HORIZON

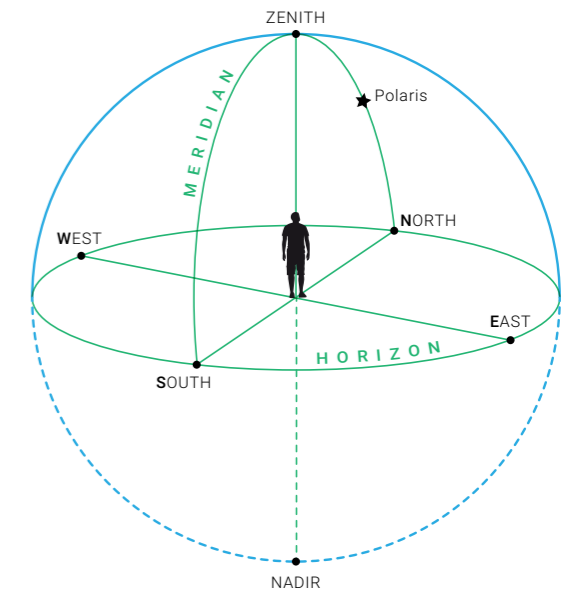
This is the full circle surrounding you at which the Earth's surface and the sky appear to meet.

## ZENITH

The imaginary point on the celestial sphere that is directly overhead, and therefore 90 degrees above the horizon.

## NADIR

The point that is 90 degrees below the horizon, opposite the zenith and below your feet passing through the center of the Earth.

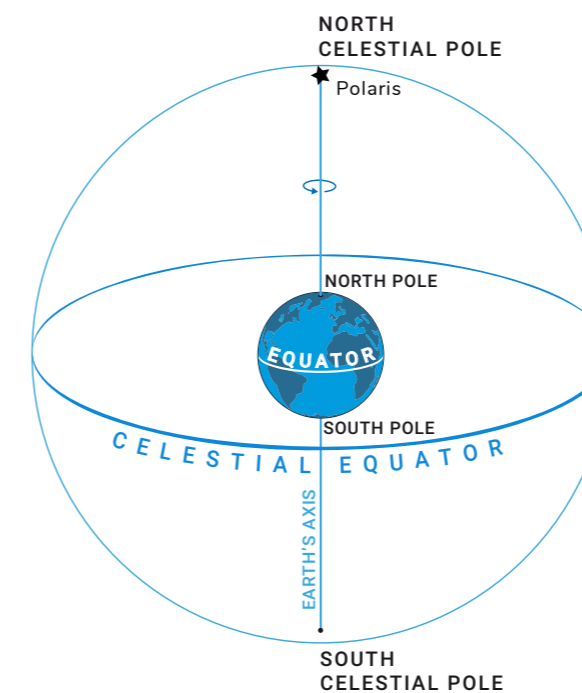


## CARDINAL POINTS

The imaginary points on the horizon which indicate the main directions, north, south, east, and west. To find out where is north use a compass, a smartphone, find the star Polaris (north star) or use the constellation Orion. The rising and setting points of the Sun can give you an idea of your cardinal points, but be careful, only in the Equinoxes the Sun rises and sets exactly East and West respectively.

## CELESTIAL MERIDIAN

The semi-circle which runs from the North point towards the zenith and further to the South point for an observer.



## NORTH CELESTIAL POLE (NCP)

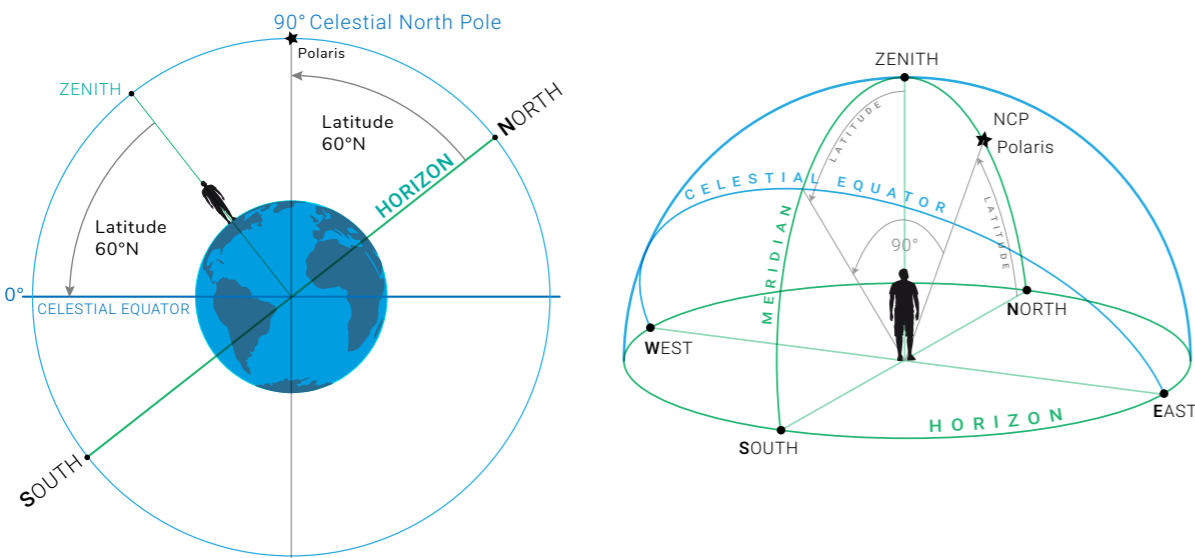
The point directly above the Earth's north pole on the celestial sphere. The North Star, also called Polaris, lies almost exactly at this point.

## SOUTH CELESTIAL POLE (SCP)

The point directly above the Earth's south pole.

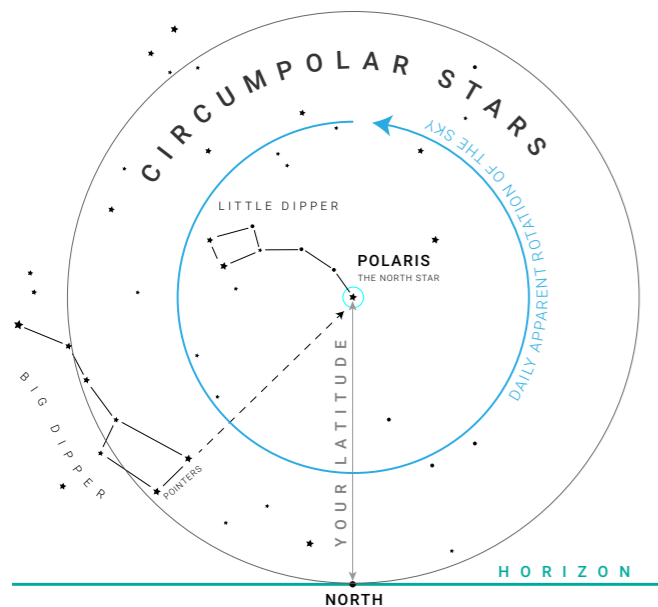
## CELESTIAL EQUATOR

This is the projection of Earth's equator onto the celestial sphere.



The **North Celestial Pole** is located due north on the meridian, at an altitude equal to your latitude on Earth.

At 10° N latitude, Polaris would lie 10° above the horizon. This is how navigators have determined their latitude for thousands of years, by measuring the angle of Polaris above the horizon.



Everything in the sky appears to be rotating around the celestial pole because the Earth is rotating.

The Moon, planets, and stars rise in the east and set in the west like the Sun.

**Circumpolar stars** are those in the north or south which never set, but make circles around the celestial poles.

The "pointer" stars of the Big Dipper point to the North Star, nearly 30° away.

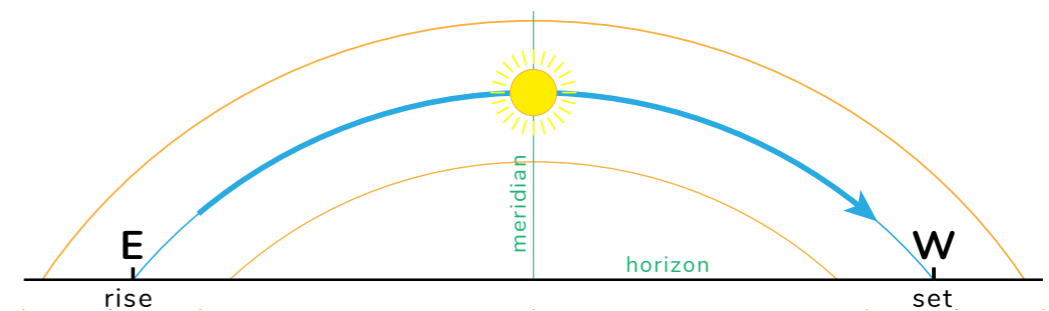
The **celestial equator** is 90° away from the north and south celestial pole and it always goes through the points on the horizon due **east** and **west**.

All the stars appear to move parallel to the celestial equator, at the same time as they appear to rotate around the celestial poles.

## APPARENT MOTION DUE TO THE EARTH'S DAILY ROTATION

Every day we see an apparent motion of the sky due to the Earth's rotation. When discussing the rising or setting of a body on a local horizon, we must locate the observer at a particular point on the Earth because the setting Sun for one observer may be the rising Sun for another. In fact the daily path of the Sun is an apparent motion.

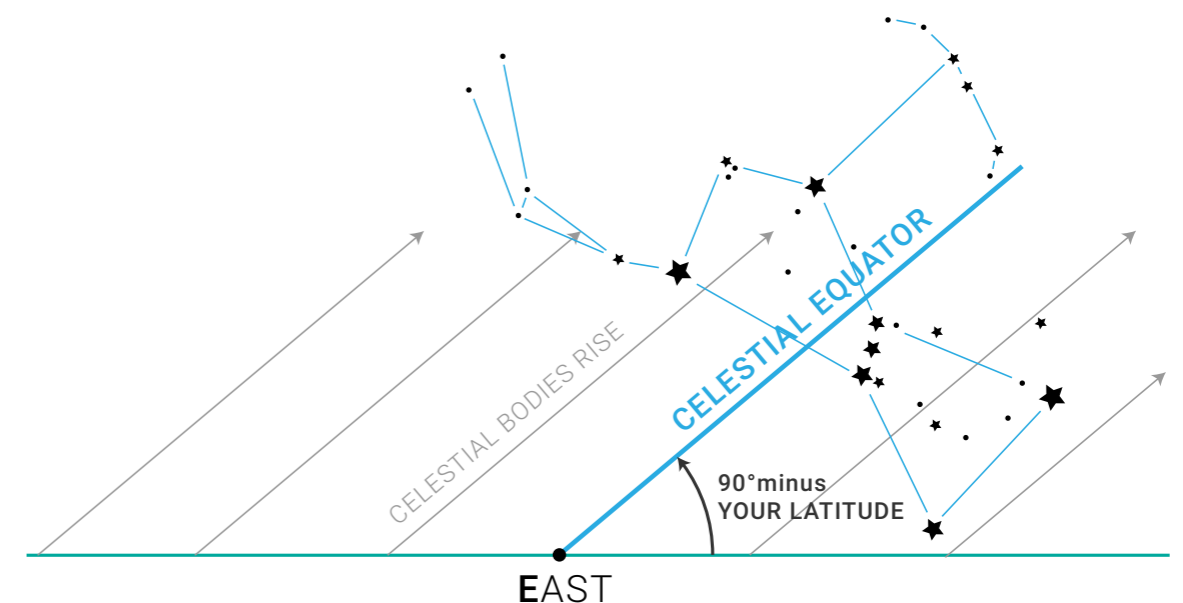
It is this motion that causes celestial bodies to **rise** along the eastern horizon, climb to **maximum altitude** as they cross the **meridian**, and **set** along the western horizon, at about the same point relative to due west as the rising point was to due east.



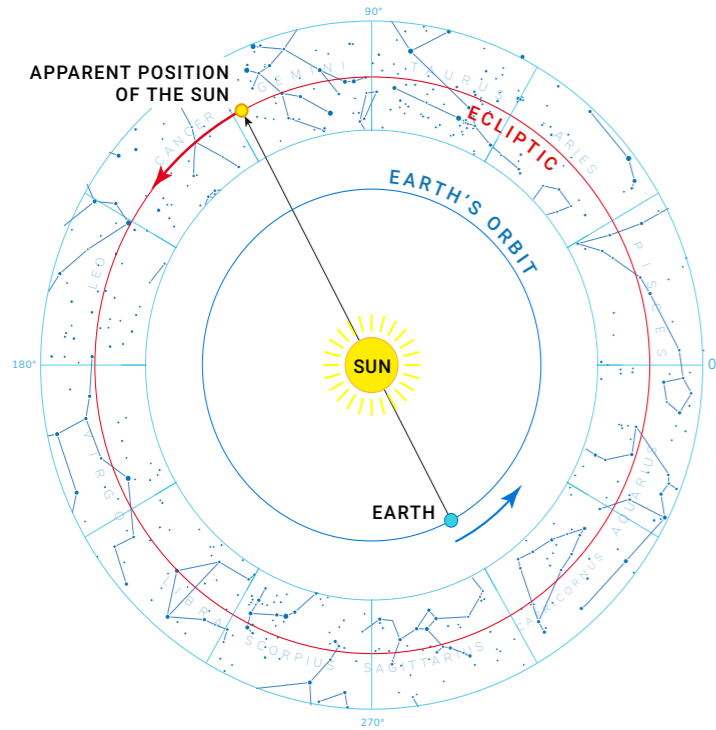
This apparent motion along the daily path, or diurnal circle, of the body, happens parallel to the plane of the **equator**.

The **latitude** of the observer defines the angle at which a body rise and sets, the length of time above the horizon and its maximum altitude. It also defines the part of the celestial sphere that never sets (circumpolar) and the direction of the apparent rotation of the sky.

In the tropics, days and nights are always about the same length. As the latitude increases the change of length of the day becomes greater and twilight lasts longer.



## APPARENT MOTION DUE TO THE ANNUAL REVOLUTION OF THE EARTH



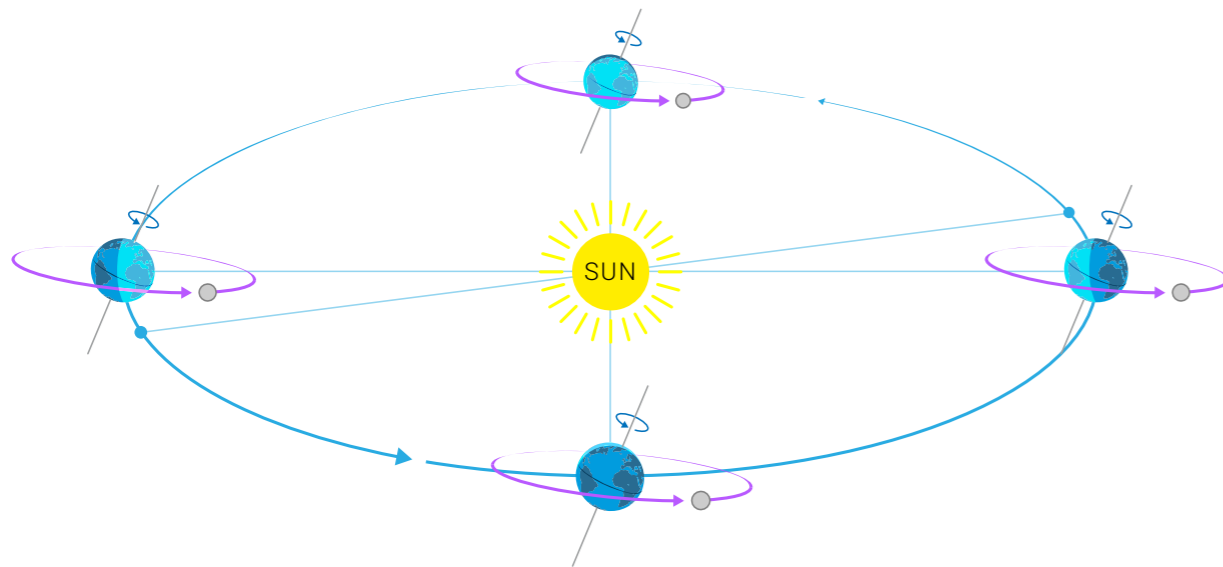
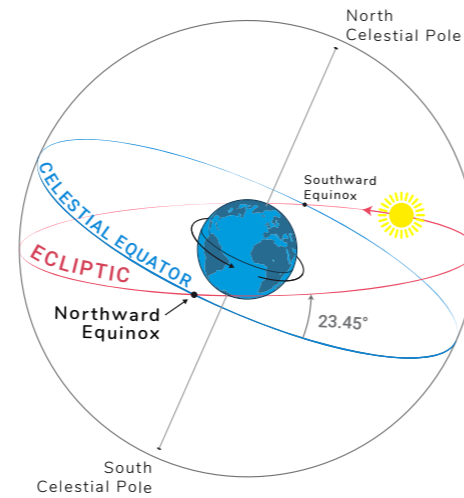
In one year the Sun appear to make one complete trip around the Earth, from west to east, a little less than  $1^\circ$  per day.

This motion can be observed by watching the constellations at the same time each night. On any night a star rises nearly four minutes earlier than on the previous night. Thus, the celestial sphere appears to shift westward nearly  $1^\circ$  each night, so that different constellations are associated with different seasons of the year.

## ECLIPTIC

The ecliptic is the plane of the Earth's orbit. This is also the path of the Sun's yearly apparent motion.

The ecliptic is inclined by approximately 23.45 degrees to the celestial equator. This inclination is due to the fact that the axis of rotation of the Earth is not perpendicular to its orbit. It is this inclination which causes the Sun to have different maximum altitude during the year, giving the Earth its seasons and changing lengths of daylight.



The ecliptic intersects the celestial equator at two points: The Vernal Point (or "the first point of Aries"), and the Autumnal Point. The Vernal Point is the point of origin for the equatorial coordinates and the ecliptic coordinates.

Vernal Equinox = Spring Equinox = March Equinox = Northward Equinox  
 Vernal Point = first point of Aries

Autumnal Equinox = September Equinox = Southward Equinox  
 Autumnal Point = first point of Libra

Summer solstice = June solstice = Northern solstice  
 Winter solstice = December solstice = Southern solstice

The 12 constellations found along the ecliptic are called the **zodiac**. Each year the Sun spends about one month in each constellation of the zodiac.

The Moon and most of the planets are always found close to the ecliptic.

For most latitudes, the Sun rises due east in March, in the north-east in June, then back in the east in September, and finally in the south east in December.

Ancient people built monuments and markers to indicate these directions to track the seasons. Stonehenge in England, the "medicine wheels" of the native americans and the maya temples are examples of this knowledge.

## EQUINOX

The **equinoxes** are about March 21 and September 23. They happen when the Sun is located at the intersection of ecliptic and celestial equator, on the vernal point or autumnal point.

The days and nights are equal in length and the Sun rises exactly due east and sets exactly due west. That's why this moments are important since ancient times, they are key to synchronize the calendar.

## SOLSTICE

The **northern solstice** is about June 21. This day the Sun rises farthest north, at  $23.45^\circ$  North-East. In the northern hemisphere the days are the longest and the Sun reaches maximum altitude in the sky.

The **southern solstice** is about December 21. This day the Sun rises farthest south, at  $23.45^\circ$  SE. In the northern hemisphere the days are shortest and the Sun reaches it's minimum altitude at true midday.

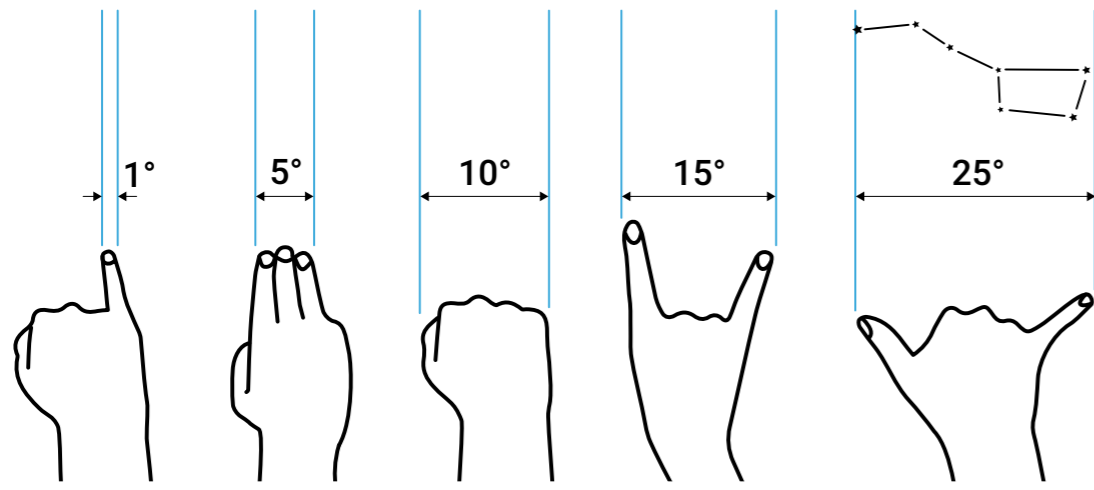


## MEASURING THE SKY

Astronomers measure angular separation of objects in degrees. There are 360 degrees in a circle. The angular separation of the horizon and the point directly overhead, the zenith, is 90 degrees. Halfway from the zenith to the horizon is 45 degrees.

To measure smaller angles your hands and fingers are a convenient measuring tool. When you hold your hand at arm's length, you can estimate angles like this:

- ★ Stretch your thumb and little finger as far from each other as you can. The span from tip to tip is about 25 degrees
- ★ Do the same with your index finger and little finger. The span is 15 degrees
- ★ Clench your fist at arms length, and hold it with the back of your hand facing you. The width is 10 degrees
- ★ Hold your three middle fingers together; they span about 5 degrees
- ★ The width of your little finger at arm's length is 1 degree.



When you look through a telescope, you see a field of view of 1 degree or less, a very small slice of sky.

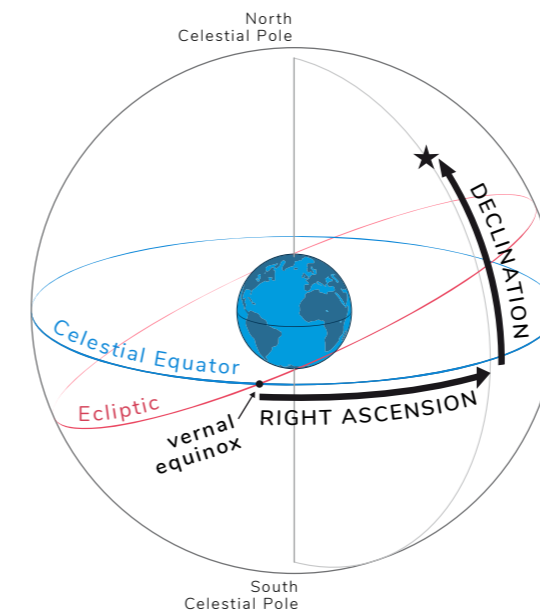
Astronomers measure angles smaller than 1 degree in arcminutes. There are 60 arcminutes in one degree, so 1 arcminute is 1/60 degree. The symbol for arcminutes is  $'$ . So the full Moon, for example, is about 30' (thirty arcminutes) across. Coincidentally, so is the Sun.

Each arcminute is divided into 60 arcseconds. So 1 arcsecond is 1/60 arcminute and 1/3600 degree. The symbol for arcseconds is  $"$ . Jupiter as seen from Earth is about 50" across. A good optical telescope can resolve down to about 1" (one arcsecond).

## CELESTIAL COORDINATE SYSTEMS

### EQUATORIAL COORDINATE SYSTEM

This celestial coordinate system is widely used to specify the positions of celestial objects and to set telescopes.



The fundamental plane is the **celestial equator** and the 0 point is the **vernal equinox**. From there we measure in hours using a right-handed convention and is called **right ascension**. The full circle has 24 hours, the hours are subdivided by arc minutes and arc seconds.



Measuring northward or southward the celestial equator is called **declination** (positive to the North) and is measured in angles. The Sun is at declination  $0^\circ$  at the **equinoxes** and

$23.45^\circ$  at the **northern solstice** and  $-23.45^\circ$  at the **southern solstice**.

This coordinate system is fixed against the background stars and remain the same for any observer on Earth.

**Sidereal time** is the right ascension which is currently passing the **meridian** line. It is useful when observing, as it let's you know what part of the celestial sphere is in your local sky. When visiting observatories, you will see clocks that have been set to run in sidereal time.

### HORIZONTAL COORDINATE SYSTEM

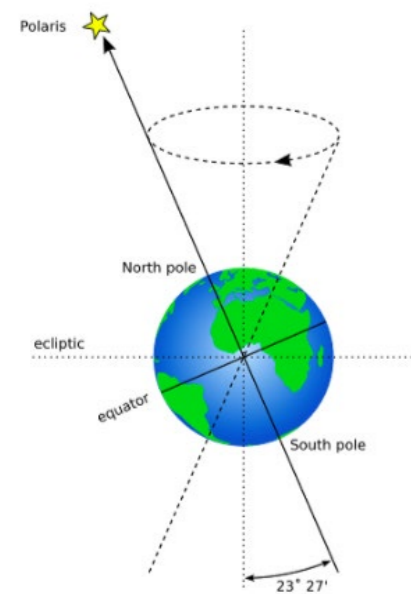
Celestial coordinate system that uses the observer's local horizon as the fundamental plane. Coordinates of an object in the sky are expressed in terms of altitude and azimuth.

**AZIMUTH:** The angle along the horizon measured from North through East (clockwise) to the point directly below the desired point in the sky.

**ALTITUDE:** (or elevation) The angle from the horizon measured vertically up to the point of interest.

## PRECESSION

Precession is the slow change in the direction of the rotational axis of a spinning object caused by some external force such as gravity.



Earth's Precession is caused by the gravitational forces of the Sun and the Moon, and to a lesser extent other bodies. As a result, the celestial poles move in circles around the ecliptic poles, in a cycle of about 25,772 years (~26,000) also called Platonic year.

This changes the **pole stars**. Currently the North Star is Polaris, which is located about one degree from the Celestial North Pole. In ancient Egyptian times (~3000 BC) the North Celestial Pole pointed close to Thuban in Draco (the Dragon). The brilliant star Vega in the constellation Lyra fulfilled the role of the North Star around 12,000 BC and will do so again around the year 14,000.

Precession also causes the plane of the Earth's equator to wobble, which changes the directions of the equinoxes and solstices against the background stars. That's why it's also called **precession of the equinoxes**.

In ancient times, the Vernal Equinox was in Aries and the Summer and Winter Solstices were in Cancer and Capricornus, hence the names "Tropic of Cancer" and "Tropic of Capricorn."

The motion of the equinox westward along the celestial equator at a rate of approx. 50" (50 arcseconds) per year continuously alter the right ascensions and declinations of stars. Measurements of the positions of stars recorded using the equatorial coordinate system must also include a date ("equinox") for those coordinates, for example J2000.

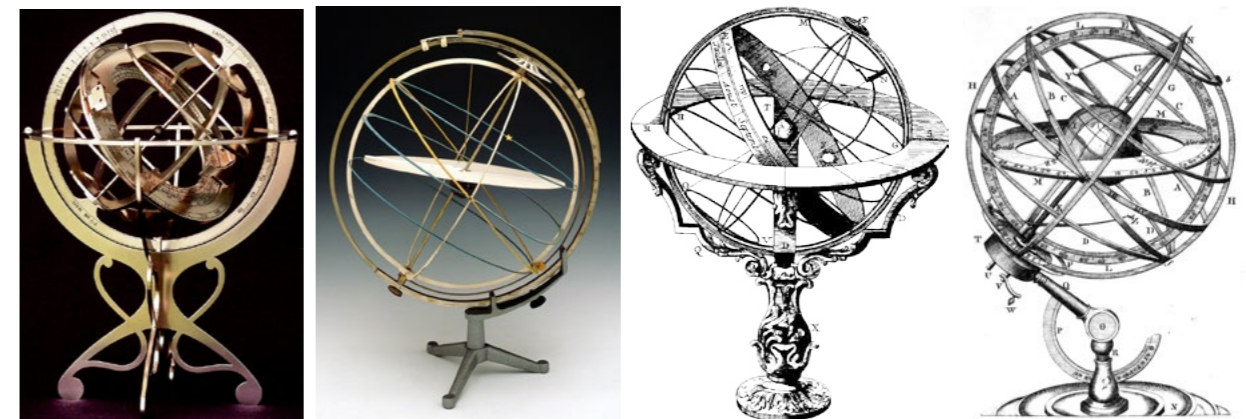
Right now, the Earth is closest to the Sun (at perihelion) in January and furthest (at aphelion) in July. In 13,000 years, the Earth will be closest to the Sun in July and furthest in January. Several ancient civilizations knew of the precession of the equinoxes from careful observations of the stars.

In addition, there is a small elliptical oscillation of the polar axis with a period of 18.6 years (compare with the Saros cycle), called **nutation**, which causes the equinoxes to travel along the celestial equator at a periodically changing rate.

## TERMINATOR

The terminator or twilight zone is the line that divides the daylight side and the dark night side of a planetary body. An observer on the terminator experiences Sunrise or Sunset and if the planet has an atmosphere, also experiences twilight due to light scattering by particles in the gaseous layer.

## ASTRONOMICAL INSTRUMENTS



### THE ARMILLARY SPHERE

An armillary sphere is a model of the [celestial sphere](#) consisting of a spherical framework of graduated rings representing the great circles of the heavens (equator, ecliptic, meridians and parallels) and revolving on an axis within a horizon.

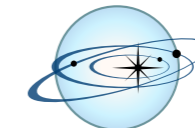
The armillary sphere survives to the present day as useful for teaching. It is used to demonstrate the apparent motion of the stars and celestial bodies around the Earth. The armillary sphere used to be the prime instrument of all astronomers in determining celestial positions.

Armillary spheres were among the first complex mechanical devices. The Hellenistic Greeks (Eratosthenes, Hipparchus) used them as teaching tools already in the 3rd century BC. In larger and more precise forms they were also used as observational instruments.

Renaissance scientists and public figures often had their portraits painted showing them with one hand on an armillary sphere, which represented the height of wisdom and knowledge.

With the Earth as center, an armillary sphere is known as Ptolemaic. With the Sun as center, it is known as Copernican.

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