esa

2- The Earth *viewed from space*

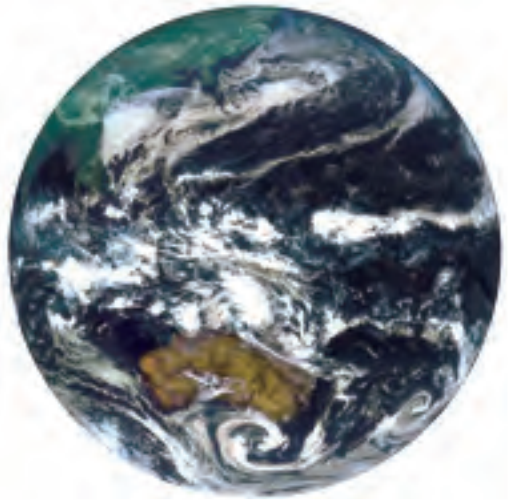
European Space Agency
Agence spatiale européenne

the Living Planet

1

GEOSTATIONARY VIEWS OF THE EARTH

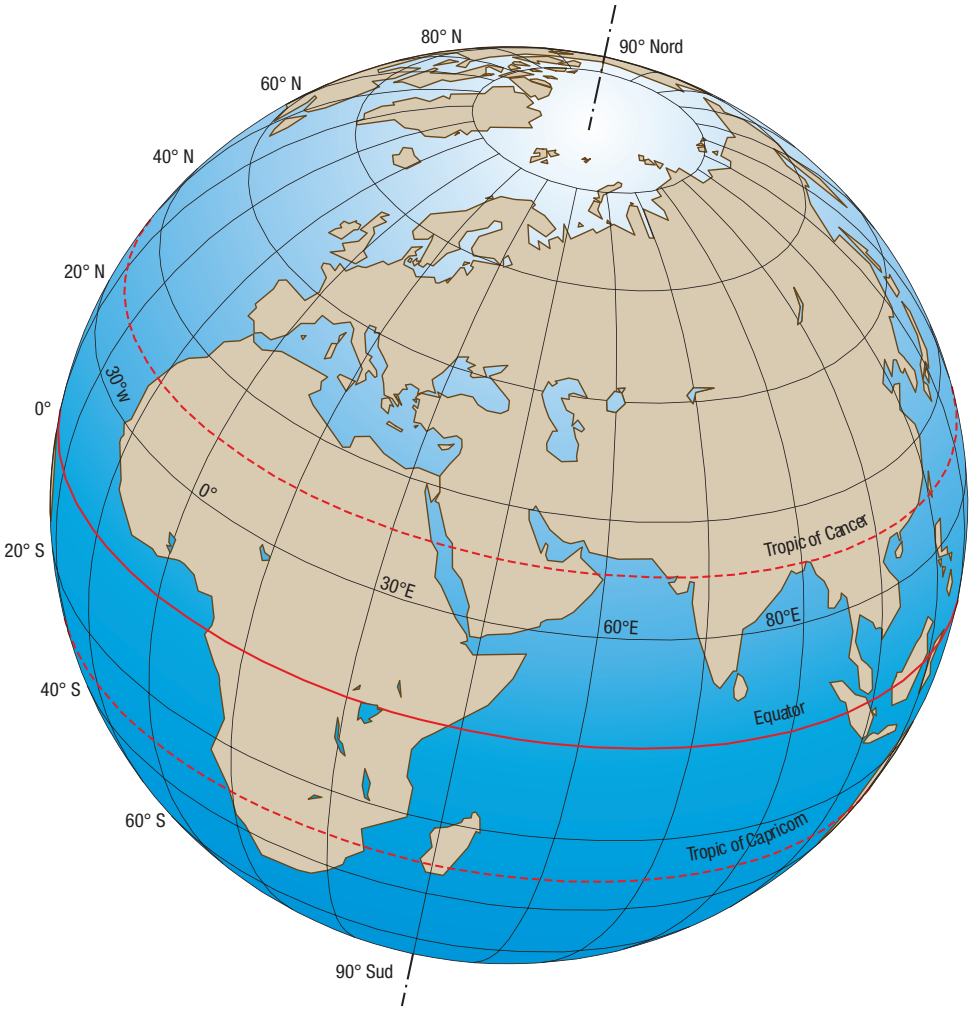
Typically, weather satellites operate from a geostationary orbit 36,000 km above the Equator, from where they observe meteoro logical activity on the Earth.



SOURCE GMS 5

These images were produced by the US satellite GOES 8, stationed at 75º west, and Japan's GMS satellite, stationed at 140º east.

2



THE CONTINENTS AND OCEANS

The continents, which are mainly situated in the northern hemisphere, account for less than a third of the total surface of the Earth.

There are five continents:
Eurasia, Africa, the Americas, Australia/ Oceania and Antarctica.
There are five oceans:
the Pacific, Atlantic, Indian, Arctic and Antarctic.

So as to be able to pinpoint their exact location on Earth, human beings have defined imaginary lines:

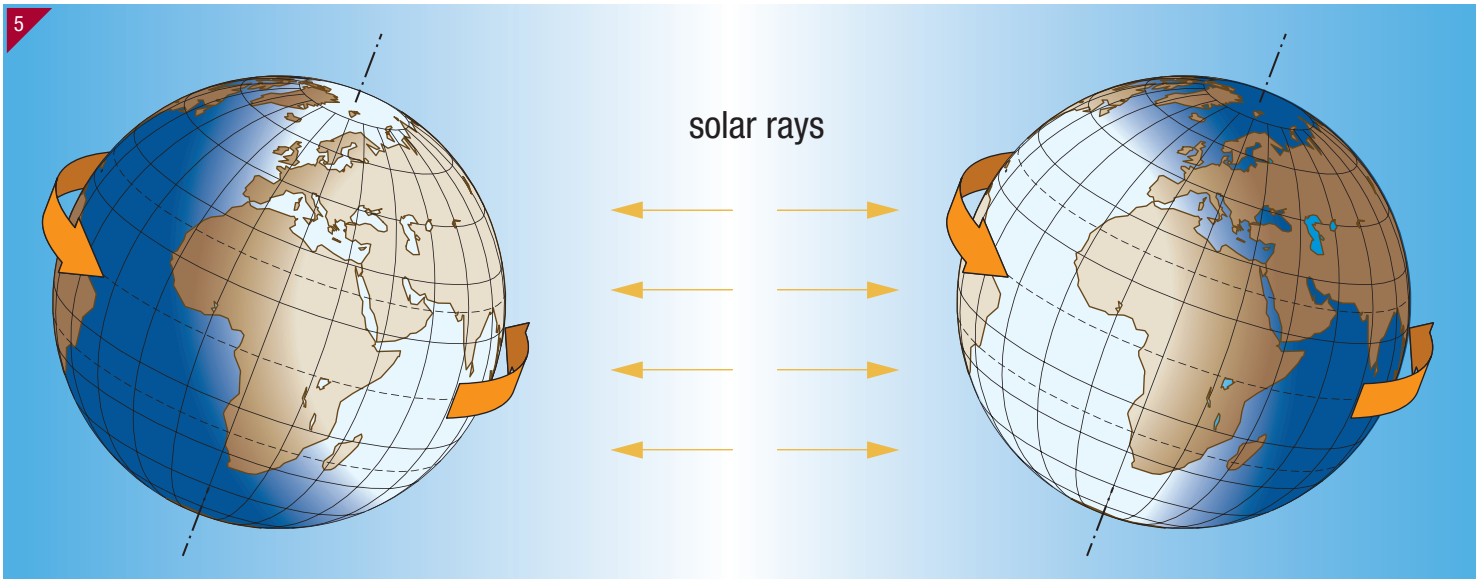
The Equator is a circle located at equal distance from the North and South Poles. It separates the Earth into two hemispheres.
The parallels are imaginary circles parallel to the Equator.
The meridians are also imaginary circles but cut across the North and South Poles.

The layer of atmosphere that surrounds the Earth is very thin, measuring only in the tens of kilometres. This corresponds to less than a millimetre in this picture of the Earth.

The Earth turns on its axis every 24 hours and around the Sun every 365.25 days. These movements are known as rotation and revolution respectively. Its centre is over 6,000 km below our feet and its circumference is about 40,000 km.

EARTH INCLINATION AND THE SEASONS

The northern hemisphere in winter when the icecaps are expanding.



In the summer the North Pole is constantly bathed in sunshine, while in the northern hemisphere the days are longer. The South Pole remains in the dark.

In the winter it is the South Pole which is constantly sunny while sunlight never reaches the North Pole, where it remains dark for six months.

The northern hemisphere in the summer when the icecaps recede.

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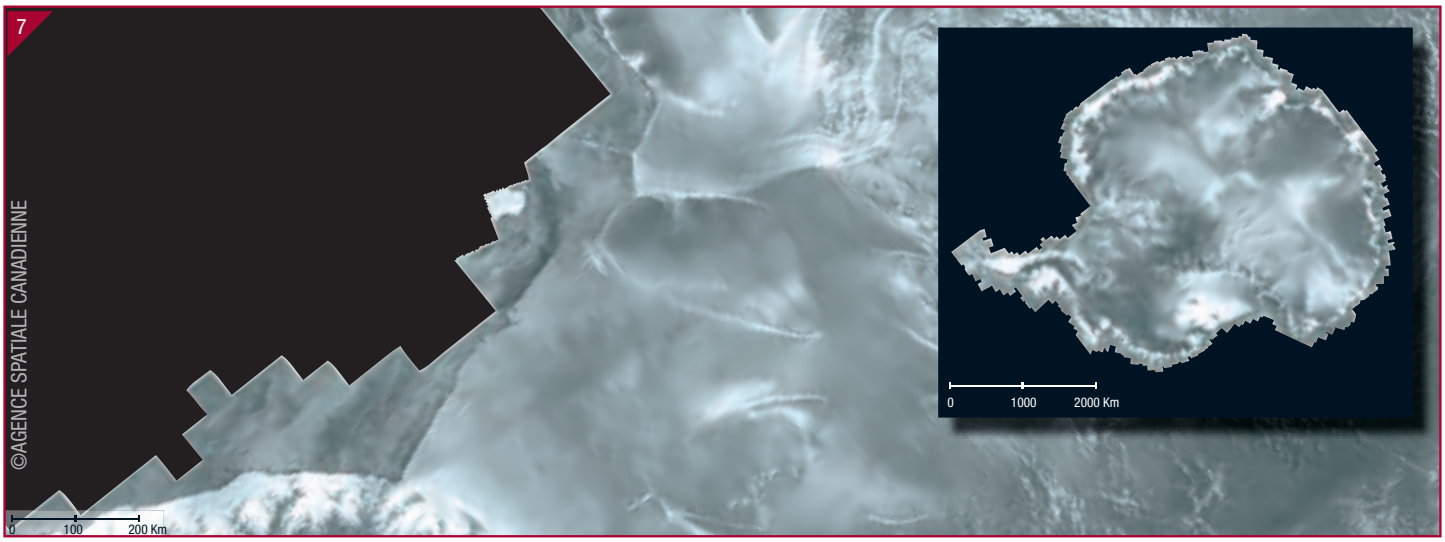

Radar image of the Antarctic taken by the Canadian satellite, Radarsat

Radar can be used to distinguish relief. However, it does not display colour in the same way as we perceive it. The framed image above is a "composite" of several thousand small images. Combining them has produced this image of the Antarctic as a whole.

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Views of the northern and southern hemispheres reconstituted from an image mosaic taken by the Envisat satellite. Colour has been artificially added. This is an unusual representation of the Earth since we normally see it from the equatorial plane.

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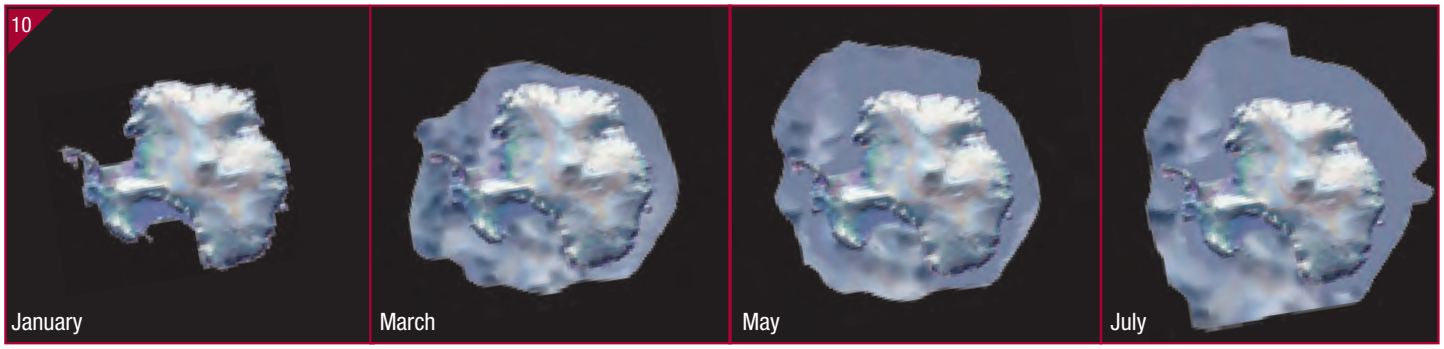


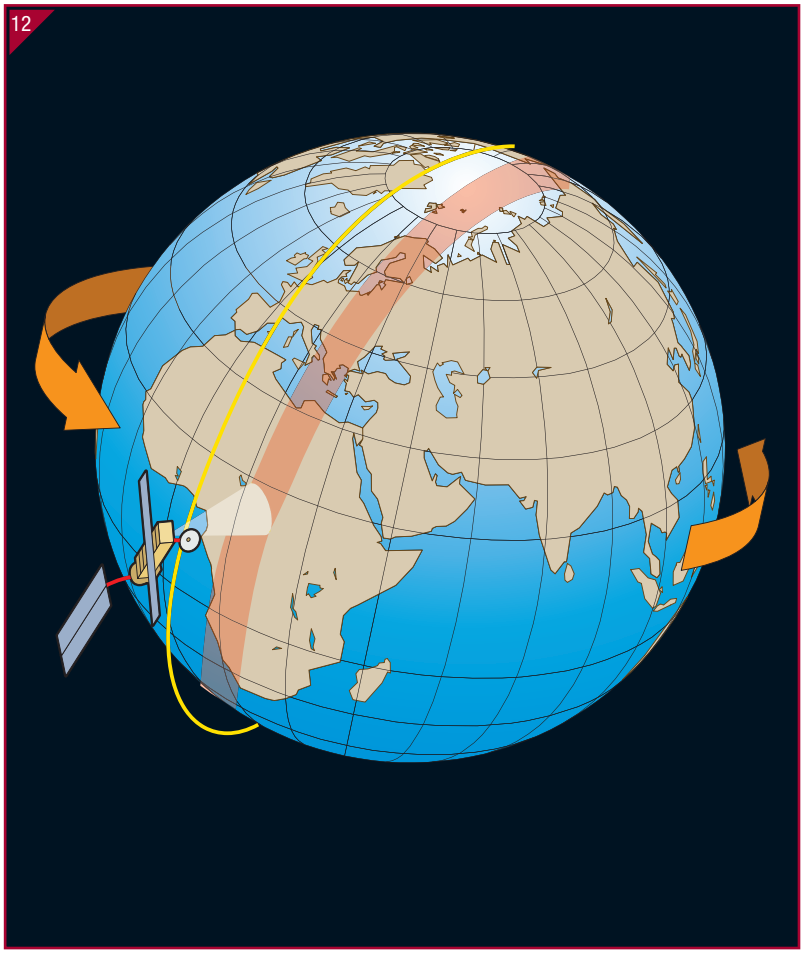
These four images taken by the ERS-1 satellite show the formation and evolution of sea ice in the Antarctic during the austral (southern) winter. Sea ice takes nearly six months to form and reach its maximum extent.

How do satellites work?

The planisphere

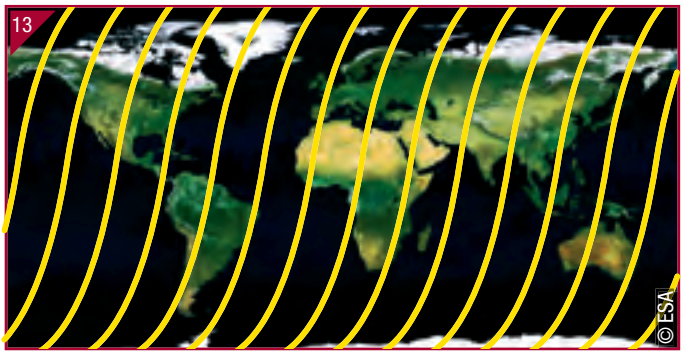
Planet Earth is not always shown in the form of a sphere. It can also be represented as a flattened image as in this planisphere. That way it is possible to see both of the Earth's hemispheres on just one map. This technique leads to certain distortions. For example, here the Antarctic and Greenland appear much larger than they actually are.

The rotation of satellites around the Earth



The satellite revolves around the Earth, passing almost over the poles. However, at the same time the Earth is turning around its axis. Therefore, the areas the satellite passes over form a slightly curved path over the Earth when it is shown as a planisphere.

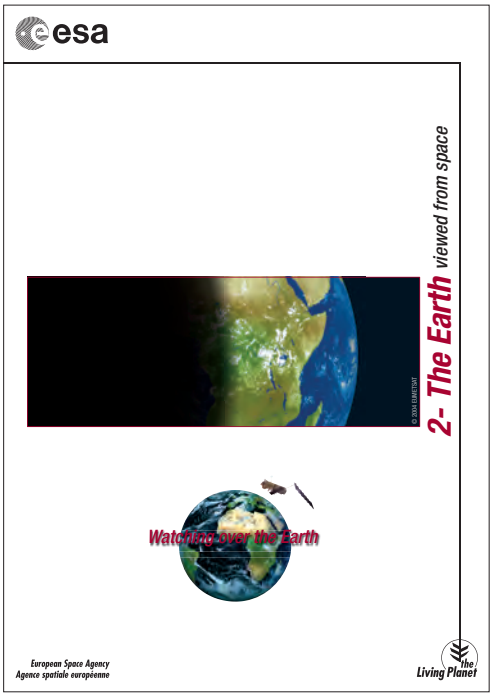
On the image below, the yellow lines show the trajectory of the orbiting satellite as it circles the Earth 14 times a day.



Information for teachers

The "Information for teachers" sheets are designed to offer assistance with the preparation of classes and complement the worksheets handed out to pupils. They contain useful information for the presentation of the subject, additional information relating to the satellite images, and a list of websites dealing with the subjects concerned.

Worksheet 2: The Earth viewed from space



Worksheet 2 focuses on the geographical aspects of the globe.

This worksheet can be used to:
- locate and identify the planet's continental masses and ocean basins;
- familiarise pupils with vocabulary specific to fundamental concepts in geography (poles, tropics, Equator, atmosphere, etc.);
- discuss the effects of the Earth's rotation and revolution;
- apply concepts such as longitude, latitude, radiation, etc.

The Earth

The Earth is one of nine planets in the solar system. It is not perfectly round: its diameter at the poles is slightly less than its diameter at the Equator (the imaginary line separating the Earth into two identical hemispheres). The Earth differs from the other planets in that it has surface water, life, and human societies. The surface of the Earth, nicknamed the "blue planet", is 71% seas and oceans, and 29% continents.

The Earth is constantly going through two types of motion: rotation and revolution. The term rotation refers to the Earth's spinning from west to east around an axis that goes through the two poles. This axis is inclined at 23°27' with respect to the vertical axis. The term revolution refers to the Earth's orbit around the Sun, which it completes in 365.25 days. As a result of these two simultaneous motions we have the alternation of day and night and of the seasons (more or less distinctive depending on how close one is to the poles), respectively.
The Earth's surface is divided by lines of latitude (imaginary lines drawn parallel to the Equator, also known as "parallels") and lines of longitude (imaginary lines drawn from the North to the South Pole, also known as "meridians"). Latitude describes the angular distance of a point on the Earth's surface from the Equator. Longitude is used to describe the angular distance of a point on the Earth's surface from the Prime Meridian—at Greenwich in London. Every point on Earth is at the intersection of these two measurements, so maps use latitude and longitude as cartographic coordinates on the Earth's surface. The Tropic of Cancer in the northern hemisphere and the Tropic of Capricorn in the southern hemisphere delimitate the zone between the tropics—the only part of the globe where solar rays can be perpendicular to the Earth's surface. The planet's bioclimatic zones also change as one moves away from the Equator and towards the poles.
People around the world do not have the same time of day on their watches. Instead the planet's surface has been divided into 24 time zones.
Gaseous masses which envelop the Earth make up the atmosphere. Processes in the atmosphere contribute to the different climates present on Earth and the way these are distributed. They have had major implications for human societies.

The satellite images

Cover page

Cover image: Crescent Earth (image by Meteosat)

With respect to satellite images, it is useful to point out those characteristics specific to geostationary satellites.
Geostationary satellites, located almost 36,000 km from the Earth in the equatorial plane, are able to produce complete views of the planet. This is because, at that altitude, they revolve at the same speed as the Earth and thus remain stationary relative to locations on the Earth's surface.

Other observation satellites, typically at an average altitude of about 800 km, and in polar orbit, provide only partial views which have to be reassembled (as with a mosaic) to reconstitute a complete view of the globe.

Core content

Image 1: Two geostationary views of the Earth

The left-hand page shows two geostationary views, one by US satellite GOES 8 (Geostationary Operational Environmental Satellite 8), located 75° west and the other by Japan's GMS (Geostationary Meteorological Satellite), located 140° east. With these two views, the whole surface of the Earth can be kept under constant observation. They show the true extent of the oceanic masses and are essential to the monitoring of meteorological phenomena. In total, there are 9 meteorological satellites in geostationary orbit around the Earth: GOES W and GOES E (USA), Meteosat-7 and Meteosat-8 (Europe), GOMS (Russia), Insat (India), FY-1 and FY-2 (China) and GMS (Japan).

Image 3: The globe

This image was produced by the Meteosat satellite, located at 0° longitude above the Gulf of Guinea. Due to this location, this satellite always observes the same side of the globe and in particular the European and African continents. This image was taken early in the morning when it was still night-time over the Atlantic. A few hours later, as the Earth continues its rotation, it turns the Greenwich meridian to face the Sun. At midday, therefore, the geostationary satellite will be able to show a view of the Earth entirely bathed in sunlight.

Images 4 and 6: The northern hemisphere in winter and in summer

On the right-hand panel of the worksheet core content are two partial views of the northern hemisphere (one in winter and one in summer). One can notably see Canada and Greenland in the first and Siberia in the second. This serves to highlight seasonal differences in the lighting of the Pole by the Sun.

Page 5 - The Earth's Poles

Image 7: Radar image of the Antarctic

The Poles are usually covered in cloud and remain in darkness for 6 months of the year, so it is mainly radar instruments which are used to record this data. They accurately reproduce relief and ice cover, as can be seen in this image of the Antarctic from the Canadian satellite, Radarsat.

Images 8 and 9: The northern and southern hemispheres seen from vertically above the poles

Geostationary satellites cannot provide satisfactory observation of the Earth's Poles. Satellites in polar orbit, on the other hand, which provide a large number of partial images of the Earth's surface, bridge that gap. Thus, by assembling several images it is possible to reconstitute views of the Earth as it appears from above the North or South Pole.

These unusual views provide another perspective on the Earth, highlighting for example the extent of the oceanic mass in the southern hemisphere, the relatively size of the Antarctic or the geographical proximity of Siberia and Alaska.

Image 10: Annual evolution of ice cover in the Antarctic

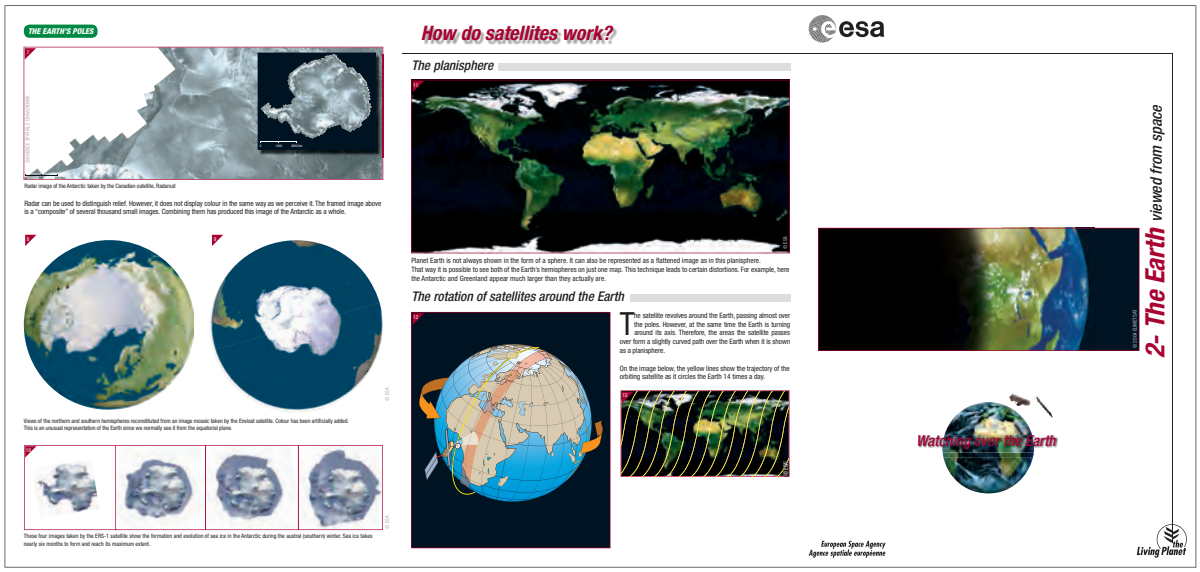
Likewise, the data gathered by the European satellites ERS and Envisat are used to reconstitute changes to sea ice around the Antarctic. Such precise and regular observations provide essential information, notably for the study of long-term climate change.

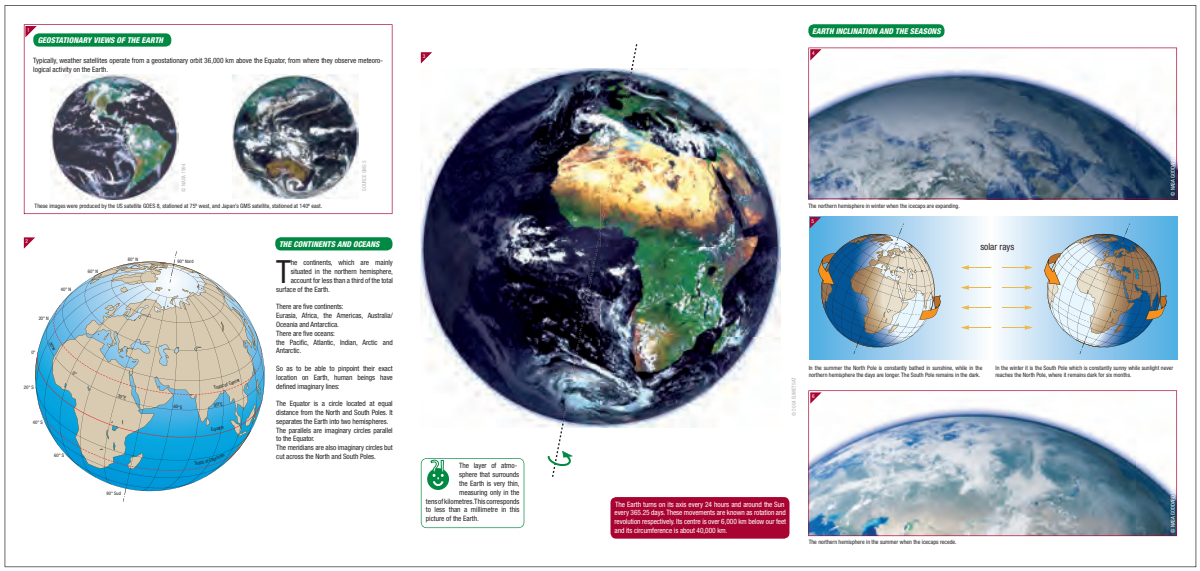
Page 6 – "How do satellites work?"

Images 11 and 13: Earth planisphere (Envisat - MERIS)

Satellites in polar orbit are able to produce views of the Earth as a planisphere. These satellites perform 14 rotations of the Earth each day, recording a continuous swath as they go. Taking advantage of the Earth's rotation, they can thus map the entire planet in 2 or 3 days.

The Envisat image shown here is reconstituted from images selected to eliminate cloudy periods. This view is a composite made up of partial images taken over a 1-month period. Oceans, which are covered by substantial masses of cloud, were not taken into account, and are thus shown here in black.





Online resources

www.esa.int	ESA (European Space Agency) website
www.esa.int/SPECIALS/ESRIN_SITE/index.html	ESRIN (European Space Research Institute) website ESRIN is ESA's centre for Earth observation
www.esa.int/eo	ESA Earth observation website
earth.esa.int/earthimages	Gallery of ESA satellite imagery
www.esa.int/education	ESA educational website
www.eduspace.esa.int	Earth observation educational website (EDUSPACE)
www.cnes.fr	CNES (Centre National d'Etudes Spatiales) website Presentation of the French national space agency's missions and activities
www.cnes-edu.fr	CNES educational website
www.spotimage.fr	SPOT IMAGE gallery

GEODESIC SYSTEMS AND THE SEASONS

www.eduspace.esa.int/Background/default.asp?document=504&language=en	Climate and the seasons

PRESENTATION OF THE EARTH

www.cnes.fr/web/1116-earth.php	CNES "pocket guide" to the Earth
www.edumedia-sciences.com/m132_l2-the-earth.html	eduMedia resources – the Earth pedagogical resources / Presentation of the Earth

THE ANTARCTIC

www.space.gc.ca/asc/eng/default.asp	Website of the Canadian Space Agency
www.space.gc.ca/asc/eng/satellites/radarsat1/antarctic.asp	Antarctic Mapping Mission (AMM)
www.space.gc.ca/asc/eng/satellites/radarsat1/antarctic_csa.asp	The Antarctic as seen by Radarsat

Satellite images

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Worksheet N° 2 – The Earth viewed from space

Once you have read and carefully examined the worksheet, please answer the following questions :

1 – Name the continents and oceans covering the surface of the Earth? What proportion of the surface of the Earth is covered by the oceans?

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2 – Name the different imaginary lines used by humans to orient themselves on the Earth's surface.

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3 – Which continent is fully visible on the large satellite image in the middle of the worksheet? Which European countries can you identify?

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4 – The left side of the Earth is in the dark; it is night time. Is it morning or afternoon on the part of the globe being illuminated by the Sun?

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5 – What pole stays in the sunlight throughout the winter? Why?

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6 – On the page entitled "The Earth's Poles", what is being shown in the two images in the centre? What difference do you see between the satellite image on the right and the image on the left?

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7 – What do you call a map showing the entire surface of the globe on a single plane?

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8 – How many times does a low orbit satellite circle the Earth in a day?

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