esa

@ NASA/DLR (MODIS/DMSP)

Watching over the Earth

The Arctic region consists mainly of ice shelves and has little land mass. In the winter, when these ice shelves form, certain hunters such as the Inuit may temporarily inhabit the area.


The city of San Francisco has 7.5 million inhabitants. Some major cities have population densities in excess of 15,000 inhabitants per square kilometre.

In 2005, the Earth's population stood at 6.5 billion. Population density was 50 inhabitants per square kilometre. However, the distribution of the human population on the Earth's surface is very uneven, with some areas deserted and others home to large concentrations of population.
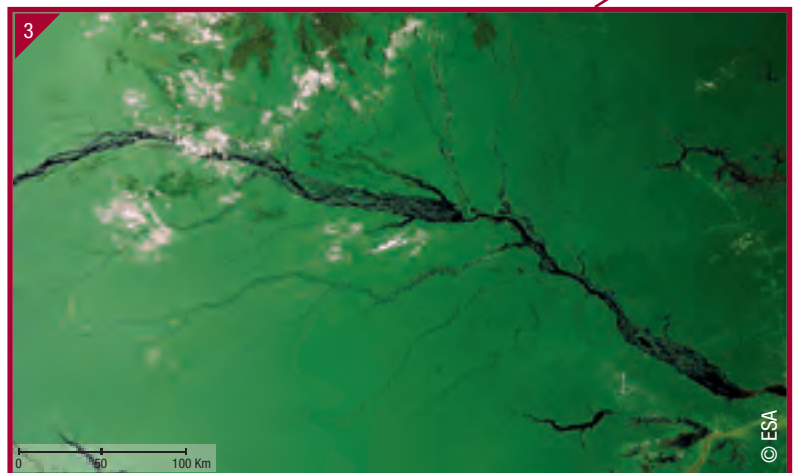
Many Indian communities live in the heart of the Amazon Forest. However, it can be reached only with great difficulty and is not an easy environment for outsiders to live in. In those areas which have not yet been colonised, the natural environment is well-preserved. Population density in Amazonia is 4 inhabitants per square kilometre.

Tropic of Cancer

Equator

Tropic of Capricorn
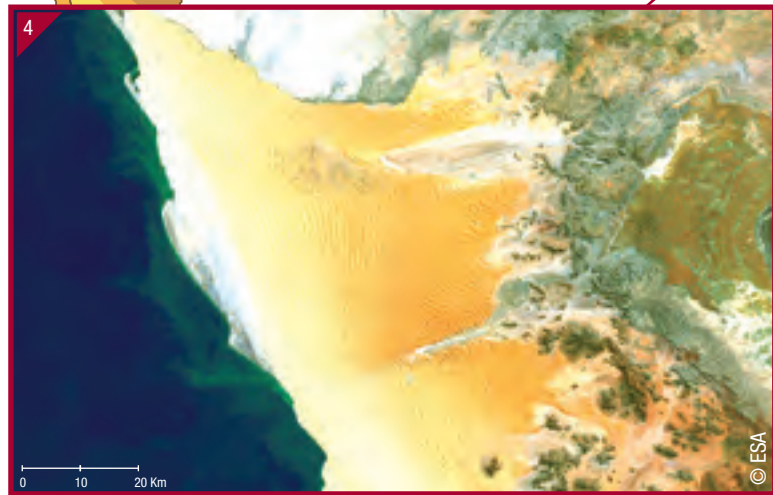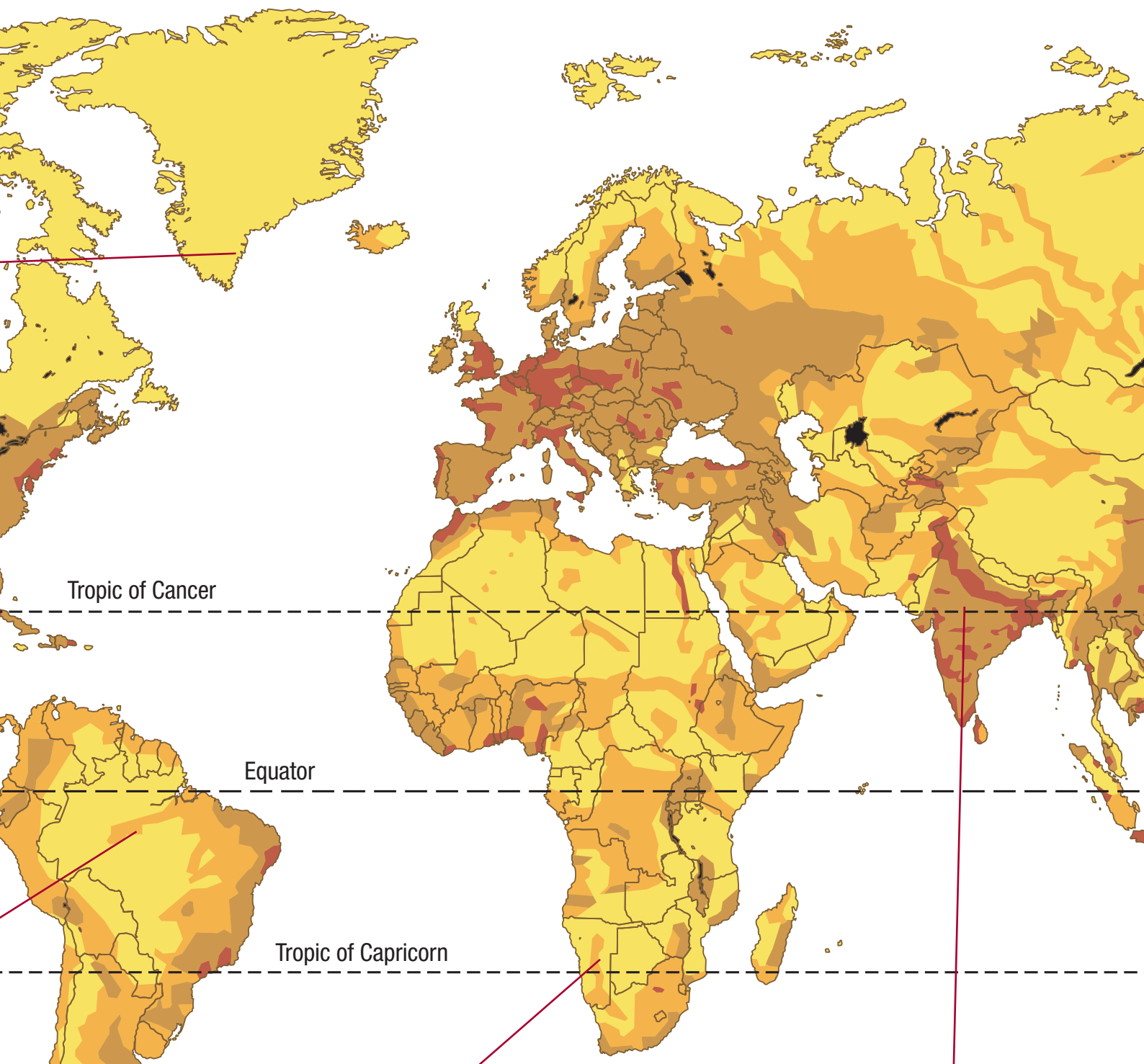
Certain regions of the Earth are very sparsely populated due to cold temperatures, drought or high altitude. The Namib Desert, shown here, is one of the hottest on the planet and is virtually devoid of all human habitation.

© ESA
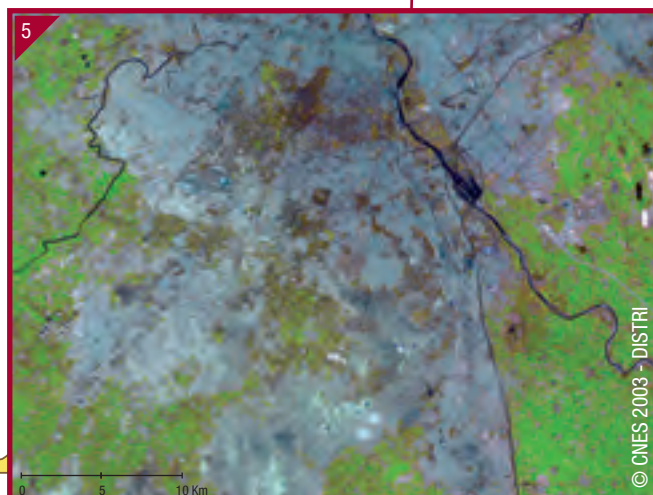
New Delhi, which has over 17 million inhabitants, is the capital of India. It is a new city, founded in 1931 and set up alongside the old capital Delhi.
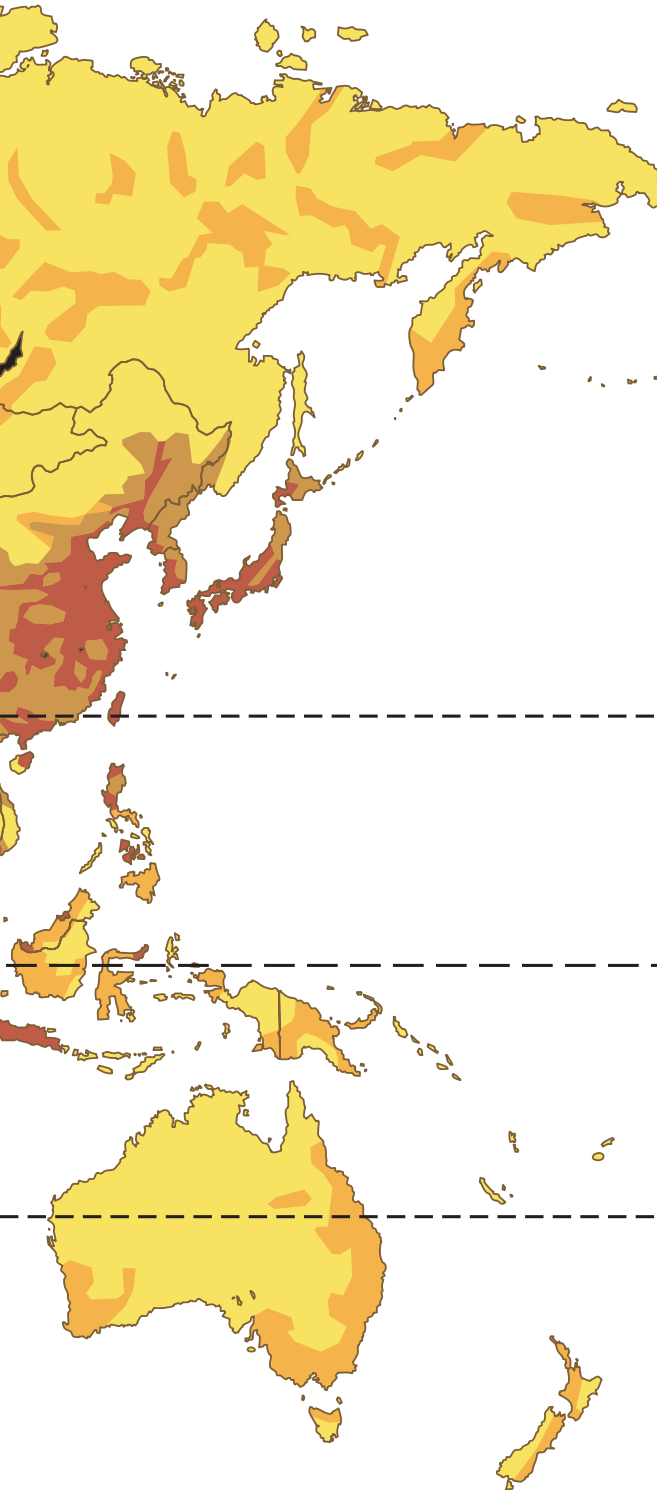
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The points of light in this satellite view indicate urban electricity consumption (public lighting, communication routes, town centres, industrial areas and so on). These points are signs of high population density but above all indicate areas of high economic activity. Of course, certain regions may be poor as well as very densely populated and therefore consume very little energy and electricity.
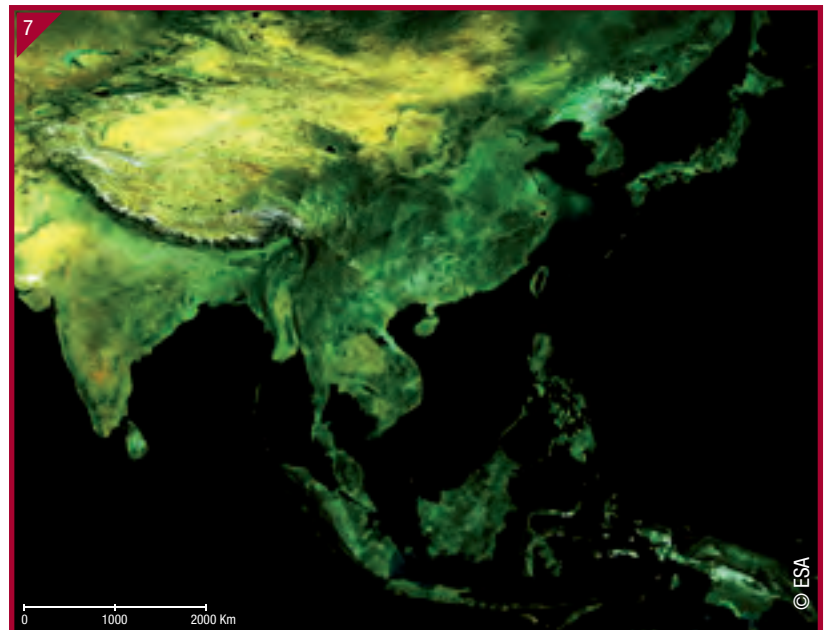
The two largest population clusters are to be found in Asia. Very often, human communities gather in valleys or along coastlines. Clearly distinguishable at the foot of the Himalayas is the Ganges valley, whose waters eventually flow into the Indian Ocean. Such valleys are well suited to agriculture, a factor which in itself often promotes strong demographic growth.
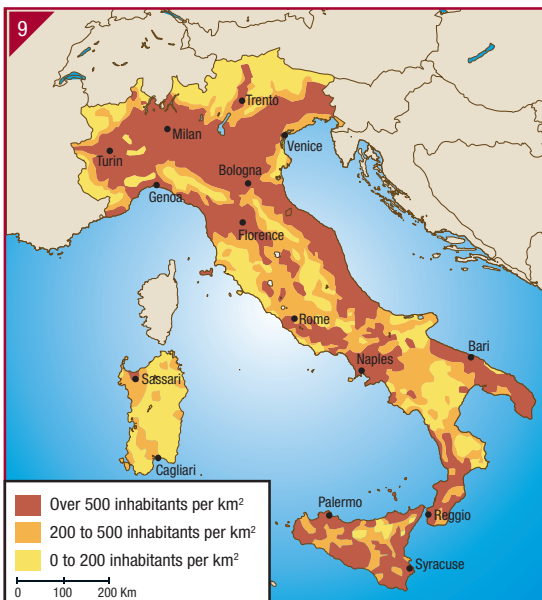
Nowadays, increasing numbers of people are living in urban areas, and such urban living accounts for 50% of the world's population.
Moreover, half the world's population occupies less than 3% of the Earth's surface.

High population density
Medium population density
Low population density
Very low population density

The Po plain as seen by Envisat.

Population distribution in Europe is also very uneven. The Po plain at the foot of the Italian Alps is extremely fertile with a good climate, factors which have encouraged the development of agriculture. Urban centres have also sprung up there, as has a great deal of industrial activity. In the picture above, the white areas to the north indicate the presence of snow and glaciers. Further south are banks of cloud skirting the Apennine mountains.

In Italy the most populated areas are in the north. This is also where most of the country's industrial activity is concentrated.

Demographic map of Italy
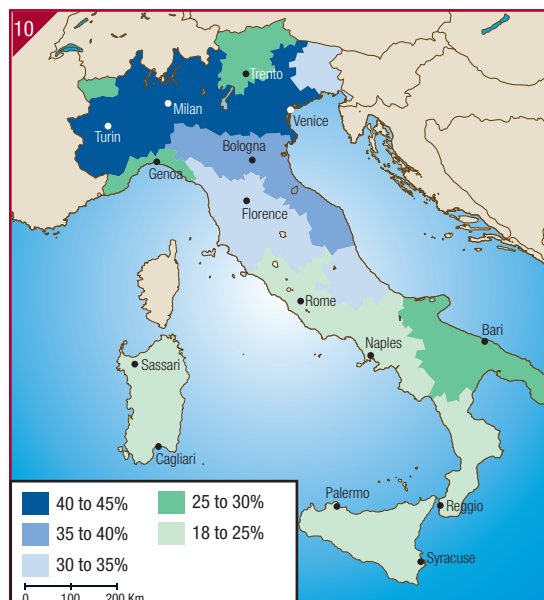
Italy's regions classified according to percentage employment in the industrial sector.

How do satellites work?

Satellites that measure pollution

A map of nitrogen dioxide (NO_2) emissions above Europe, produced using measurements from special instruments on board Envisat. Regions where emissions of this pollutant gas are at their highest are shown in yellow and red. These also correspond to areas of high population density and major industrial activity (measured between July 2003 and July 2004).
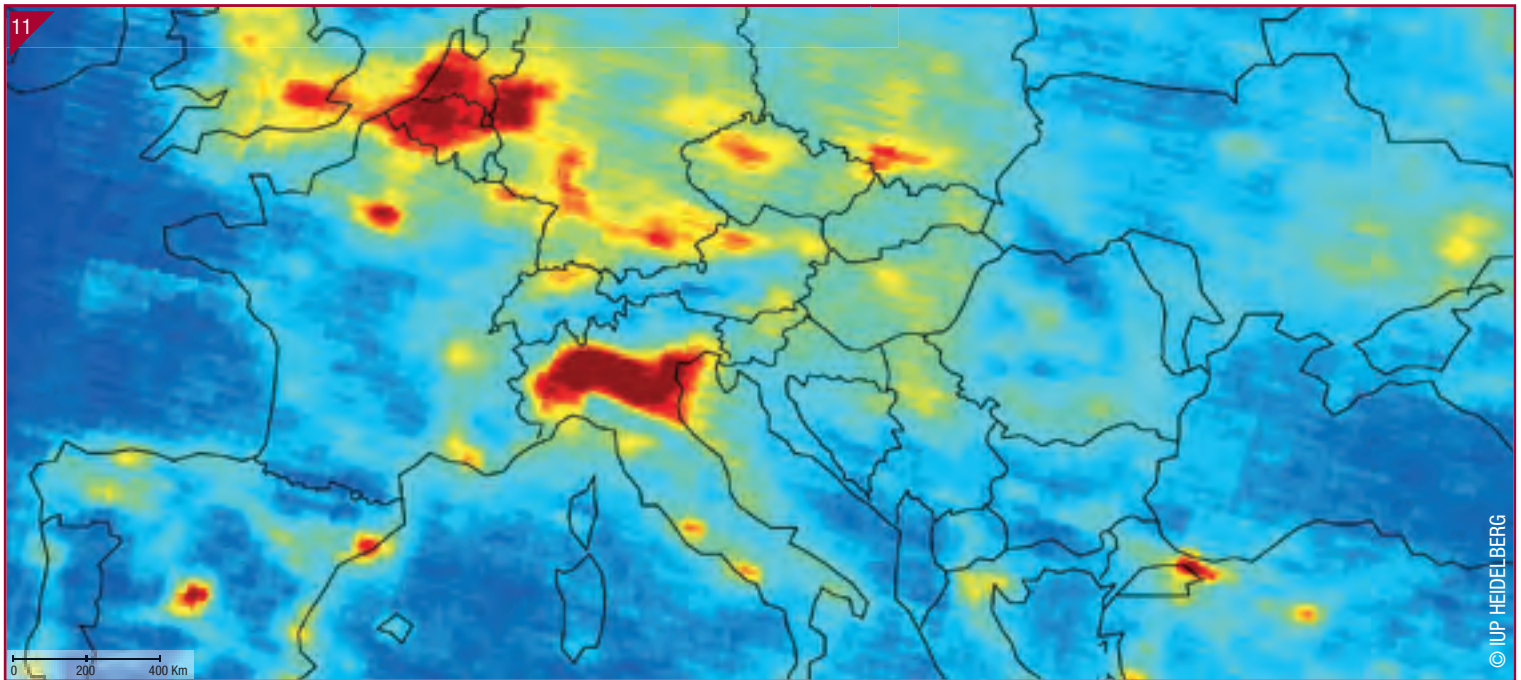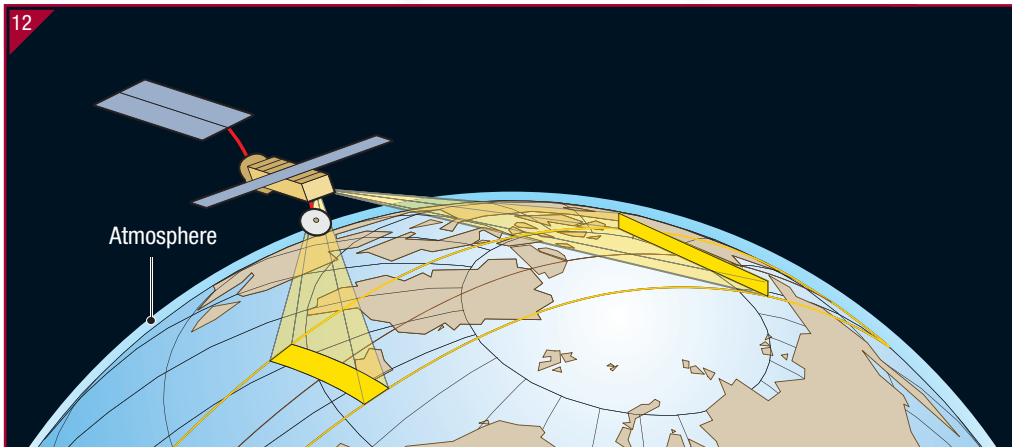
How satellites analyse the atmosphere

Satellites can measure the composition of pollution clouds in the atmosphere in various ways.

In the first illustration to the left, the satellite analyses the chemical spectrum of the atmosphere of a given zone from two different angles and at a few minutes' interval, and is thus able to obtain more precise information on the different layers of pollution clouds.
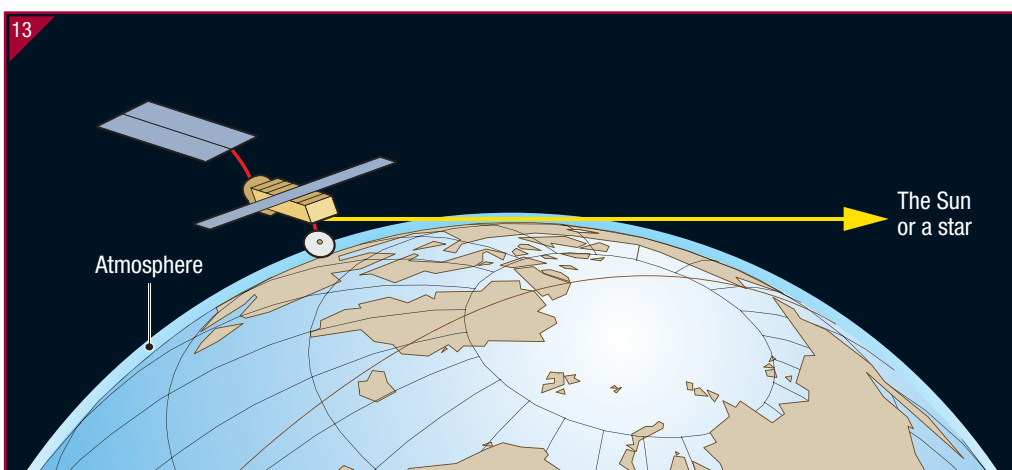
Another technique, shown in the second illustration, involves aiming the satellite's sensor at a known star or the Sun on the horizon.
The light these objects emit is measured through the atmosphere, which acts as a kind of filter. Since the characteristics of light emitted by these stars are well known, any variations (for example, in colour or intensity) will provide clues as to the chemical composition of the upper atmosphere (ozone, aerosols and so on).

DISTRIBUTION OF THE WORLD'S POPULATION

Tropic of Cancer

Equator

Tropic of Capricorn

High population density
Medium population density
Low population density
Very low population density
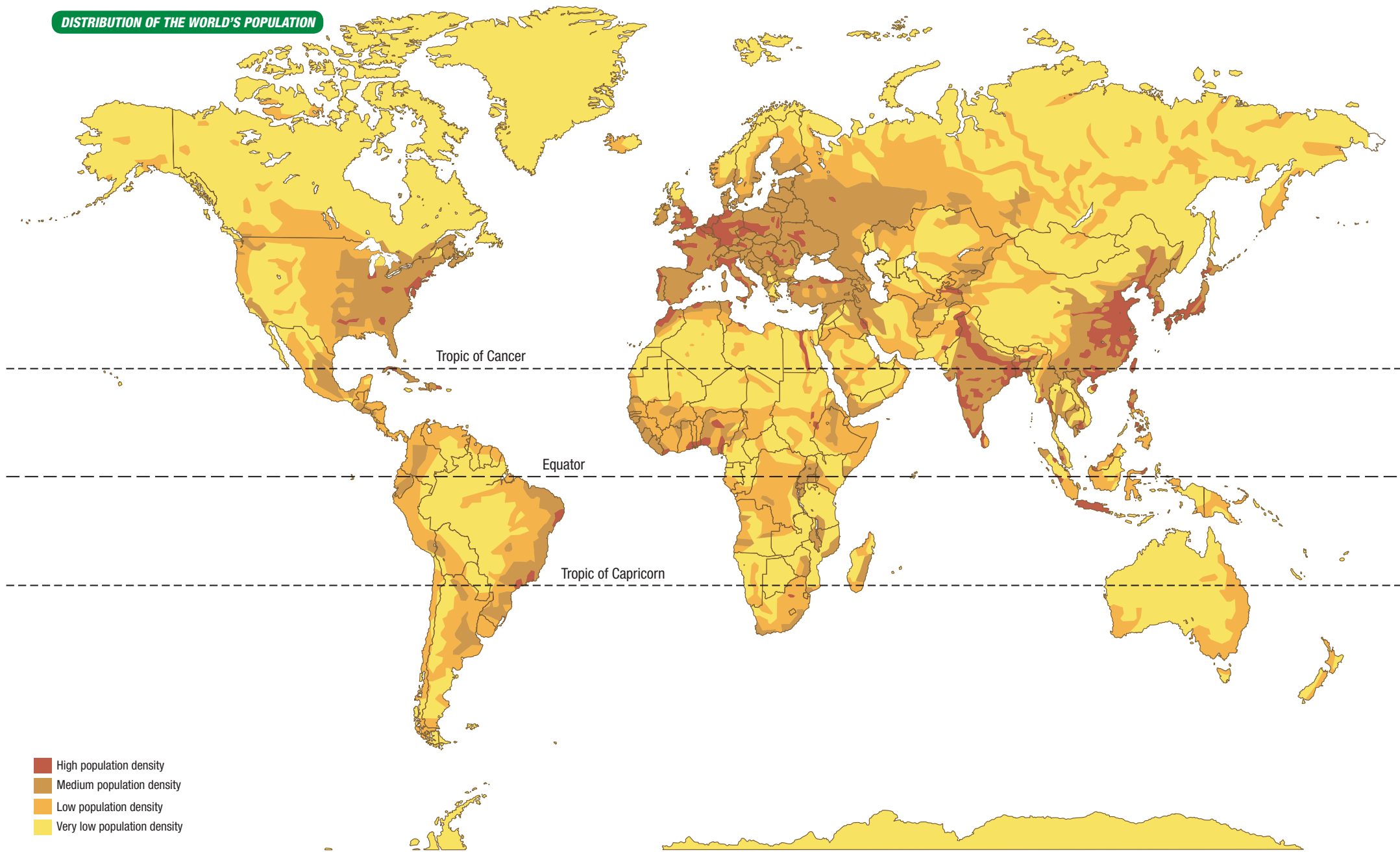
This image belongs to the 'Watching over the Earth' teaching pack from the European Space Agency (ESA).
The Living Planet programme.

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 3: Humans on Earth

Worksheet 3 discusses human population distribution around the world. If you take a global perspective (see central illustration), the documents provided also offer views at different scales: continental, regional, and local.

This worksheet can be used to:
• locate and identify areas with the largest population concentrations in the world;
• analyse the relationship between spaces and societies at different levels;
• determine the reasons for which different areas of the planet have high or low population density.
• apply concepts such as population concentration, polarisation, density, coastal concentration, the Earth's inhabited surface, etc.

Population distribution

The Earth's inhabited surface—that space where human societies settle, create their living space and territories—is in a constant state of flux. By this we mean all those spaces that have been adapted, transformed, or built on by humans. The relationship between space and societies is what determines population density, and leads to imbalances in the distribution of the world's population around the globe. There are five major points that can be made about the way the human population is distributed on Earth:
Despite its population of 6.5 billion in 2005, the Earth is nonetheless an under-populated planet, with a low overall population density (50 inhabitants per square km of total land mass area). Human societies only live on continental and insular zones. If one were to exclude seas and oceans, hostile environments and cultivated areas, the world's population is essentially concentrated in a total area of 300 million hectares (3 million square kilometres) —barely 1% of the total surface of the Earth!

Population concentration is irregular and reflects the effects of polarisation. There are four major areas where human populations are concentrated. All four are in the Eurasian continent, the largest continent on Earth. The Far East accounts for 23% of the world's population concentrated on 3% of the Earth's landmass; the Indian subcontinent accounts for 21% of the population on just 2% of the Earth's landmass; Europe (which geographically extends to the Urals), is home to 12% of the world's population, living on 7% of all landmass; and Southeast Asia accounts for 8.5% of the world's population on 3% of all landmass. There are other regions considered to be secondary in terms of population density, such as the Gulf of Guinea, the Atlantic coast of Brazil, and the northeastern region of North America. Other regions on Earth, such as cold or hot deserts, the tropical forest belts in South America and Africa, are either unpopulated or very lightly populated. Population polarisation is also visible in terms of increased urbanisation. Today, 50% of the world's population is concentrated in cities.
Furthermore, the world's population is mainly distributed throughout the temperate zone in the northern hemisphere (the southern hemisphere is 75% ocean). Human populations are also increasingly concentrated around continent edges, while the heart of those continents is deserted. Currently, almost 1 billion of the Earth's inhabitants live near seas and oceans, indicating increased concentration of the world's human population in coastal areas. Lastly, there is also an altitudinal inequality: 80% of the world's population lives at an altitude of less than 500m on 57% of all landmass area.

The satellite images

Cover image: Night-time planisphere of the Earth (NASA/DLR)
This optical image reveals the consumption of electric light in cities and urban areas. It has been produced by combining partial captures obtained in cloudless, moonless periods. Adjustments to the contrast were made in digital processing to show the extent of urban centres. This image, from NASA, was processed by the German Remote Sensing Data Center.

Core content

A number of satellite images are presented showing very diverse regions, at different scales.
Image 1: Greenland ice field (MERIS/Envisat image, 17 May 2002)
This image shows the east coast of Greenland. The average thickness of the ice of the plateau of this island of almost 1.9 million km^2 is 2.3 km. While increases in snowfall at altitude are currently causing a slight increase in the ice layer, the ice surrounding Greenland and that forms the arctic icefield is receding rapidly.

With just over 55,000 inhabitants, the population density is very low at 0.029 inhabitants per km^2.

The near infrared channel used for this image makes it possible to differentiate between atmospheric elements (shaded red) and ice (shaded green).

Image 2: San Francisco (PROBA image)
This image of San Francisco was produced by the European Space Agency satellite PROBA from an altitude of 600 km. In it one can clearly see the geometrical layout that is characteristic of American cities.

Image 3: The Amazon Basin (MERIS/Envisat image)
The Rio Negro cuts right across this picture, while the Rio Solimões can be seen in the bottom right-hand corner. A narrow strip of cleared agricultural land is visible to the right of the picture.

The whole of Amazonia has barely 20 million inhabitants spread across close to 5 million km^2, representing an average density of about 4 inhabitants per km^2. Nearly half of that population is concentrated in very large towns, whose total area makes up less than 0.5 % of the overall territory.

Image 4: The Namib Desert (MERIS/Envisat image)
The Namib Desert is the oldest desert in the world. It extends along the Atlantic coastline for almost 2000 km. Namibia is one of the three countries with the lowest population densities in the world.

Image 5: New Delhi (SPOT 5 image)
New Delhi with its 14 million inhabitants is the capital of India. It extends over an area of 1,483 km^2.

Image 6: Asia by night (NASA/DLR)
The trailing urban conurbation formed by Japanese cities is particularly visible. The two highly developed regions of Taiwan and Hong Kong are also very easily recognised.

It is possible to make out thin strips of light emitted by the medium-sized cities located along China's main communication axes.

Image 7: Asia and the Indian subcontinent (MERIS/Envisat image)
In this image it is possible to see the geophysical characteristics of this vast region of the globe. For this image the Envisat satellite uses the MERIS (Medium Resolution Imaging Spectrometer) instrument , a wide field-of-view optical sensor which can notably be used to observe vegetation cover.

The "swath" of this instrument (width of the portion of land observed in its field of view) is 1,250 km and its resolution 300 m. MERIS provides full coverage of the Earth every 3 days.

Page 5 - Population zones in Italy

Image 8: Northern Italy and the Po Valley (MERIS/Envisat image)

This image shows the geophysical situation of the Po plain, Italy's most populated area. It is possible to make out Lake Maggiore, Lake Como and Lake Garda. The light green areas in the Venice lagoon and along the Adriatic coastline indicate the large quantities of sediment expelled into the sea.

Page 6 – "How do satellites work?"

Image 11: Map of nitrogen dioxide NO_2 emissions

This image is generated from measurements recorded by the SCIAMACHY instrument on-board the Envisat satellite. (Image by IUP, Heidelberg)

Based on 18 months of Envisat observations, this high-resolution global atmospheric map of nitrogen dioxide pollution makes clear the extent of the impact human activity has on air quality.

ESA's 10-instrument Envisat satellite was launched in February 2002 and is the world's biggest environmental monitoring satellite. Its Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY) instrument records the spectrum of sunlight shining through the atmosphere. These results are then carefully sifted to find spectral absorption "fingerprints" of trace gases in the air. Nitrogen dioxide (NO_2) is a mainly man-made gas, excess exposure to which causes lung damage and respiratory problems. It also plays an important role in atmospheric chemistry since it triggers ozone production in the troposhere, the lowermost layer of the atmosphere extending up to an altitude of eight to sixteen kilometres.

Nitrogen dioxide is produced by emissions from power stations, heavy industry, road transport and biomass combustion. Localised in-situ measurements of atmospheric nitrogen dioxide are carried out in many western industrial countries, but ground-based data sources are, generally speaking, very limited in number. Space-based sensors are the only way to carry out effective global monitoring.

The improved spatial resolution provided by SCIAMACHY means that it is able to identify many details, including towns which are sources of pollution. To give a sense of scale, the ratio of NO_2 particles above highly polluted large cities such as London can reach levels of one hundred parts per billion air particles.

Images 12 and 13: Illustrations showing the principles of atmospheric analysis by satellite

SCIAMACHY's average resolution is 60 x 30 km. It observes the atmosphere from two different angles – downwards or "nadir looking" as well as making "limb" observations in the direction of flight – hence its wide spectral range.

SCIAMACHY is a spectrometer which maps the air over a very wide wavelength range, thus allowing the detection of rare gases, ozone and related gases, as well as clouds and dust particles throughout the atmosphere. It works by measuring solar radiation transmitted, reflected and scattered by the atmosphere or the Earth's surface in the ultraviolet, visible and near infrared wavelength regions. With its 960 km swath, it covers the whole planet every six days.

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

GLOBAL POPULATION

esa.un.org/unpp	Nations Population Division – World Population Prospects: 2006 Revision
www.unfpa.org/swp/2006/english/introduction.html	State of the world's population in 2006.
	United Nations Population Fund (UNFPA)

NO$_2$ POLLUTION

www.esa.int/esaEO/SEM340NKPZD_index_0.html	Global air pollution map produced by SCIAMACHY
www.bnsc.gov.uk/content.aspx?nid=5677	BNSC website: measuring and modelling the Earth's atmosphere

Satellite images

Worksheet N° 3 – Humans life on Earth

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

1 – How is the Earth's population distributed? Look at the map and the satellite images and give two densely populated regions of the world and two regions with very low population density.

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2 – What is the average population density on Earth? What population density levels can be found in large agglomerations?

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3 – Look at the satellite image of China taken at night. What conclusions can you make regarding population density based on this image?

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4 – Look at the satellite image of Asia. What connection can you make between physical characteristics of this region, and its population density?

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5 – Carefully study the page entitled "Population Zones in Italy". What region is Italy is the most densely populated? Why?

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6 – Look at the satellite image of the north of Italy. Describe the main features of the landscape.

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7 – What do you see in the satellite image of Europe shown on the last page?
Compare this image with the population density maps included in this worksheet.
What connections do you see?

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