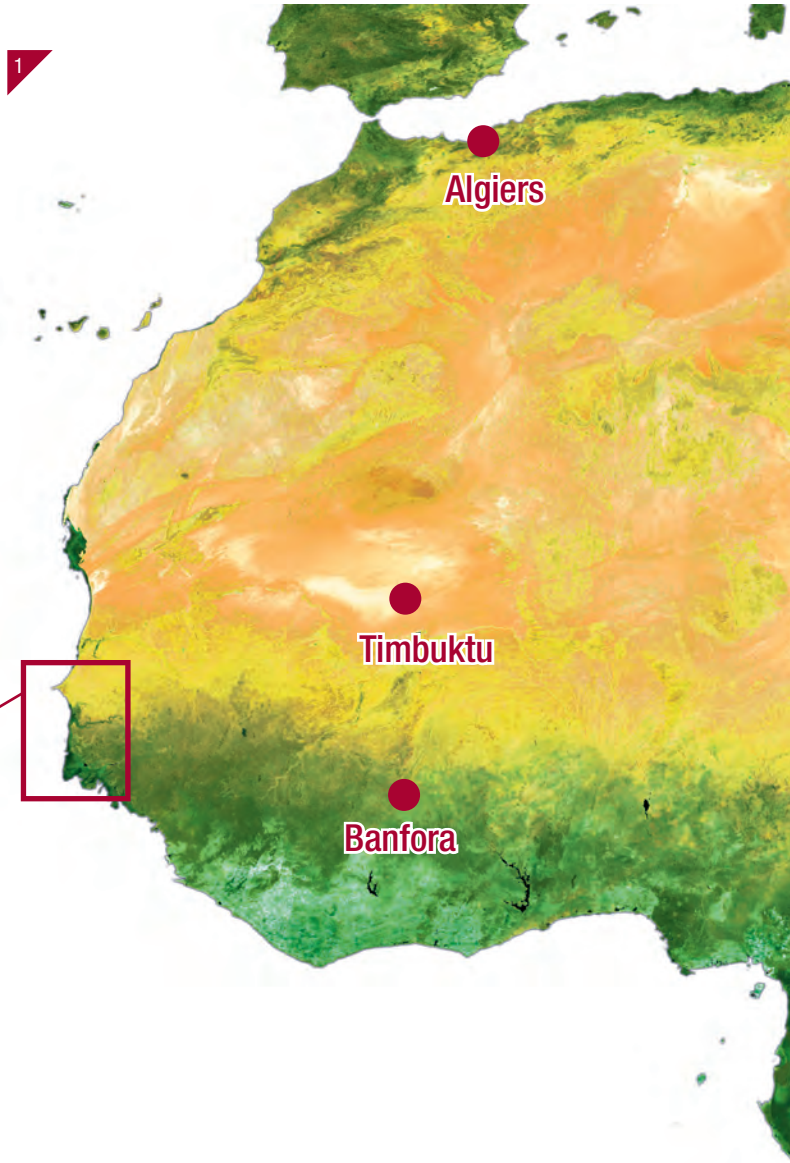
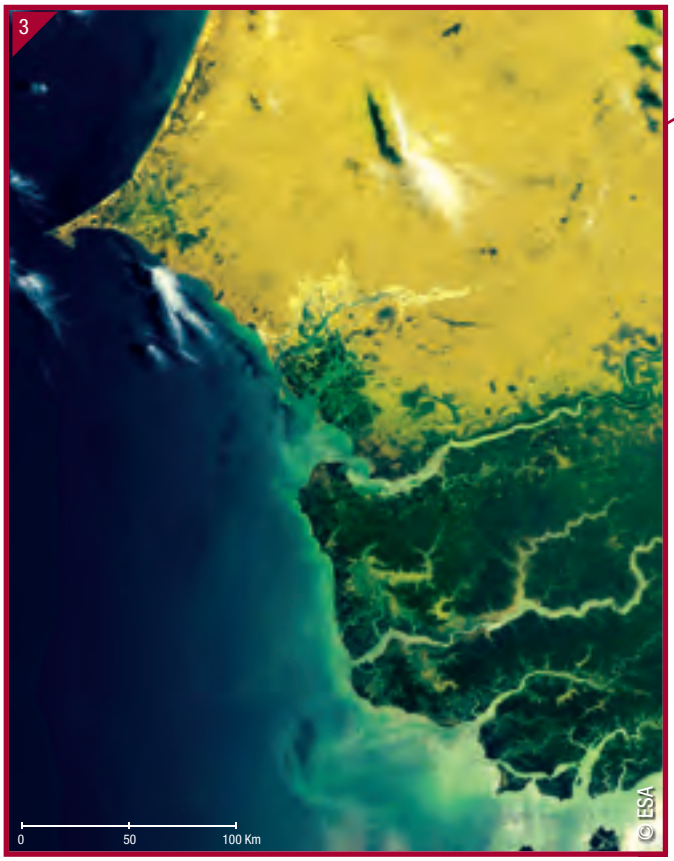
esa

4- Africa and environmental diversity

European Space Agency
Agence spatiale européenne

the Living Planet

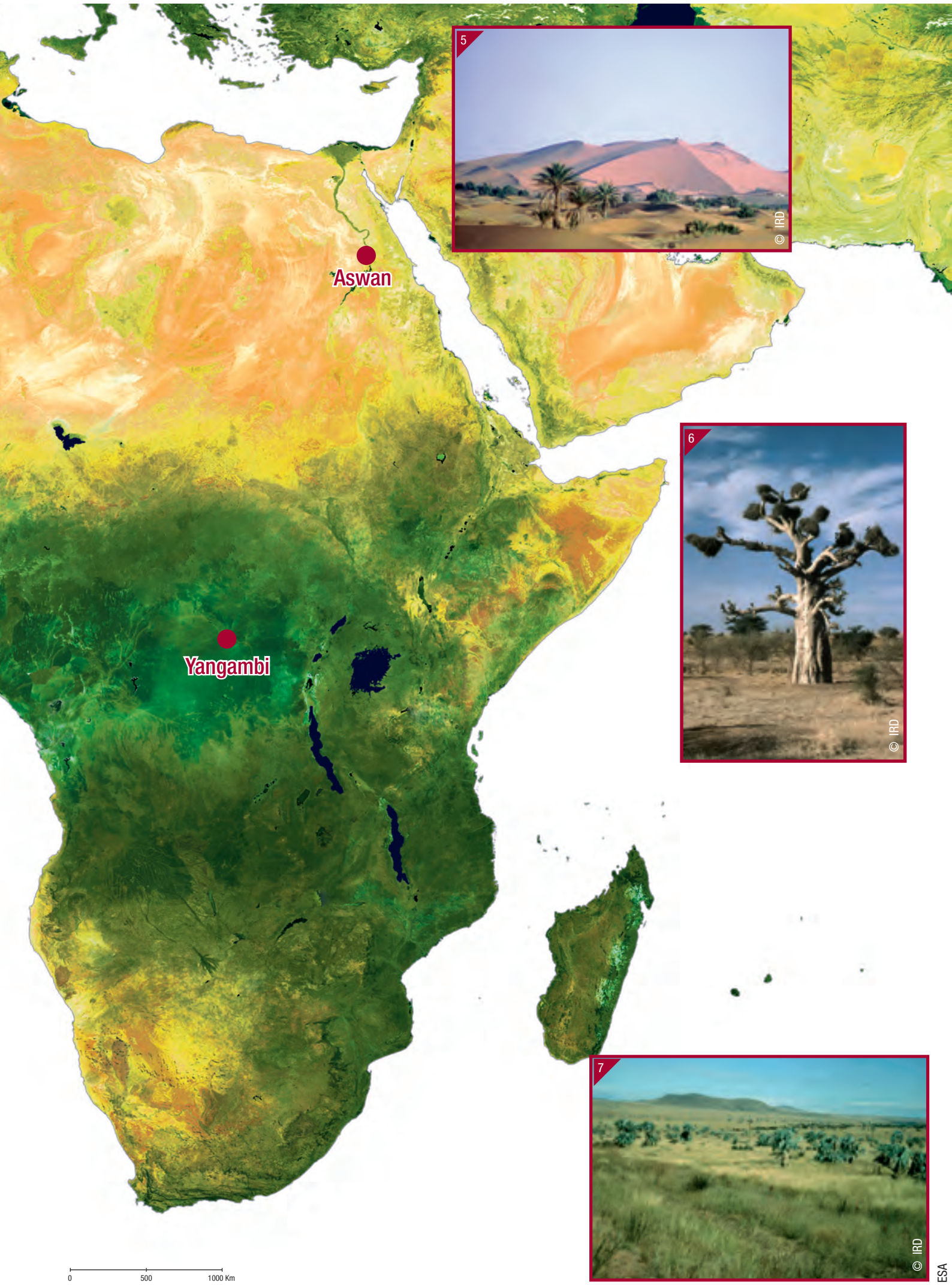




Satellite view of the coastal region of West Africa showing the difference between desert and tropical domains.

A continent the size of Africa (measuring over 8,000 km from north to south), contains a high degree of bioclimatic diversity due to the considerable variations in exposure to sun and precipitation from one region to the next. Although these vast domains are almost all hot, they constitute very contrasting environments which have an influence on vegetation, animal species and human occupation.

To produce this image of Africa, the Envisat satellite flew over the continent several times at an altitude of 800 km. With each pass it records a 1,200 km "swath", which then has to be combined with others to build up an image of the entire continent. No clouds can be seen since images containing cloud have been discarded in favour of those taken in good weather. These were then assembled to form a mosaic, or composite image. In reality, it is impossible to obtain a cloudless view of Africa by taking just one picture.



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Bioclimatic domains are areas that share the same type of climate, soil and natural vegetation.

The Mediterranean climate is hot and dry in the summer and mild and humid in the winter.

The desert climate sees only a few millimetres of rainfall per year.

The equatorial climate is characterised by high temperatures and high levels of precipitation all year round.

The dry tropical climate has only a brief rainy season.

The humid tropical climate alternates between a dry season and a rainy season.

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Equatorial climate
Humid tropical climate
Dry tropical climate
Desert climate
Mediterranean climate
Mountain influence

TEMPERATURE AND PRECIPATION

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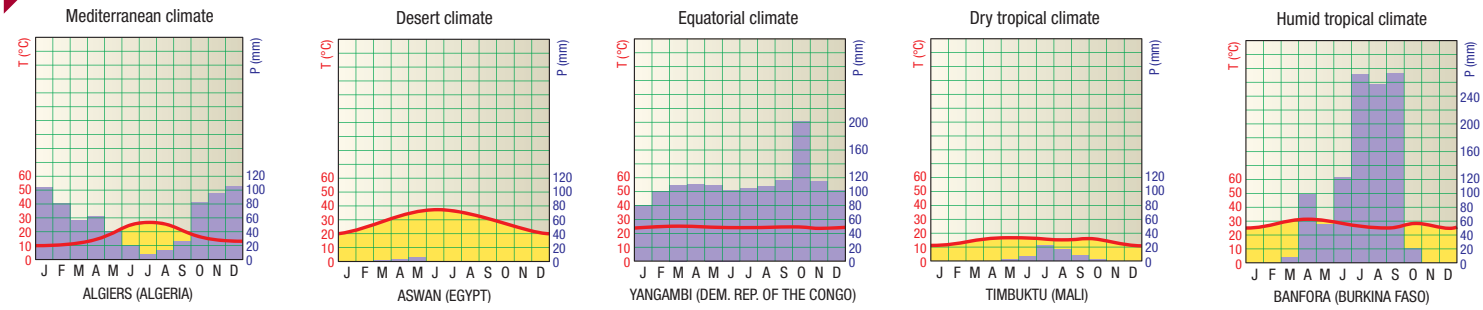

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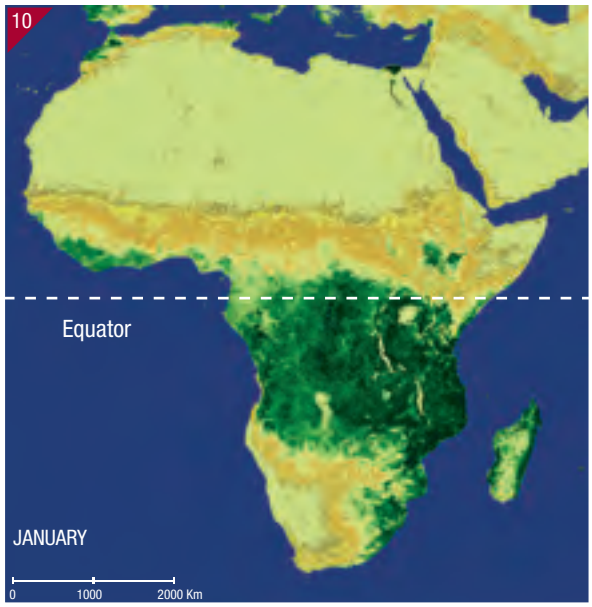

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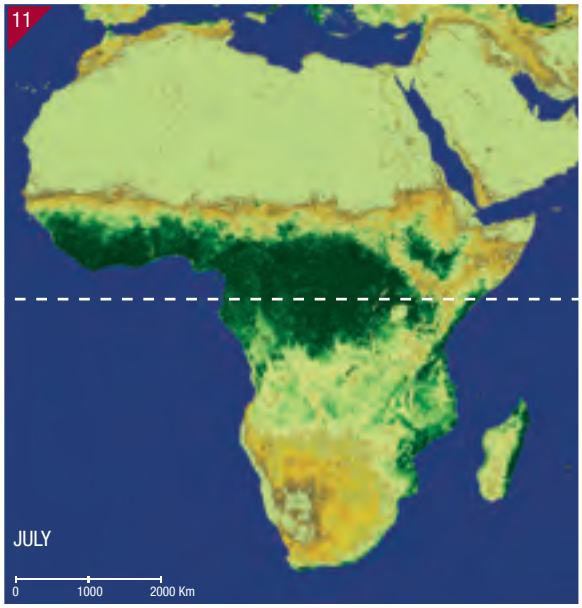

A typical feature of tropical regions is the alternation between rainy and dry seasons. Rainfall patterns are reversed depending on whether one is located north or south of the Equator. These two satellite images, taken six months apart, show vegetation growth and how it reaches its peak during the rainy season.

During its growth phase, vegetation undergoes strong photosynthesis activity, absorbing large amounts of visible light, while at the same time reflecting infrared rays. By processing satellite data obtained in these two wavelengths, it is possible to obtain images that clearly show those areas where strong vegetation growth is occurring. This index (NDVI) is often used to estimate the density of vegetation cover and how it evolves.

THE NILE VALLEY

Egypt has a Mediterranean climate on its north coast and a desert climate in the rest of the country. 95% of its surface area is desert. The narrow fertile strip along the banks of the Nile river and delta is the main area suited to the growing of crops and human habitation.

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The Nile stretches over 6,700 km. It is one of the longest rivers in the world.
To the bottom of the image is the large artificial lake created by the Aswan Dam.

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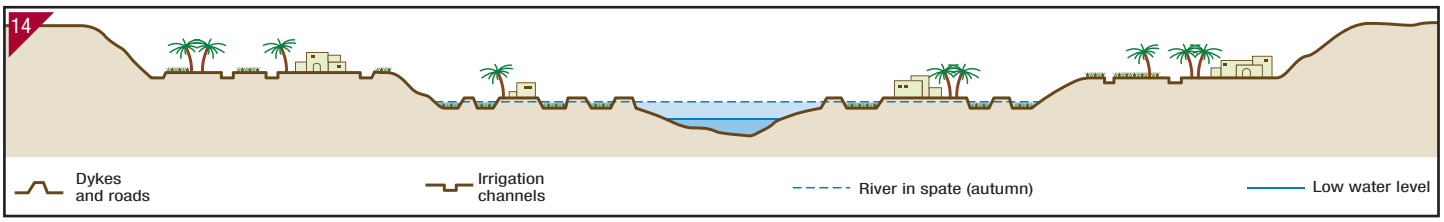

Cross-section of the Nile valley before construction of the Aswan Dam.

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Satellite image of the Nile valley

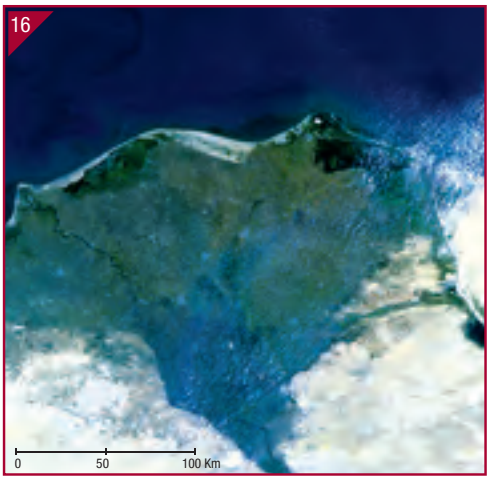
In the past, Egypt relied on the flooding of the Nile to deposit on the river banks the nutrient-rich sediment necessary for agriculture. But some years saw excessive, even dangerous flooding. Other years, meanwhile, the flooding was insufficient and resulted in a risk of famine. Thanks to the Aswan Dam it is now possible to control this flooding and thus irrigate 850,000 hectares of desert land. Nonetheless, the problem of water remains crucial to Egypt.

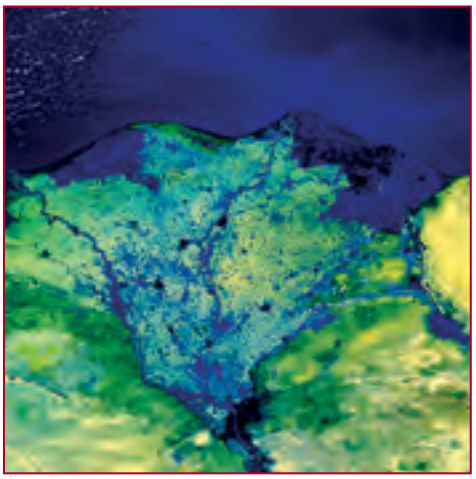
As a result of the dam, the river's rate of flow has fallen, sediment no longer reaches the sea in sufficient quantities and the Mediterranean is reclaiming land at a rate of several metres per year. In addition, the sediment previously dispersed by the flood waters no longer fertilises farmland, obliging farmers to use chemical fertilisers. The country is now facing fresh challenges such as the fight against pollution and erosion. When it comes to understanding such phenomena, satellite observation is an essential tool.

How do satellites work?

Single satellites that can produce different views of the same region

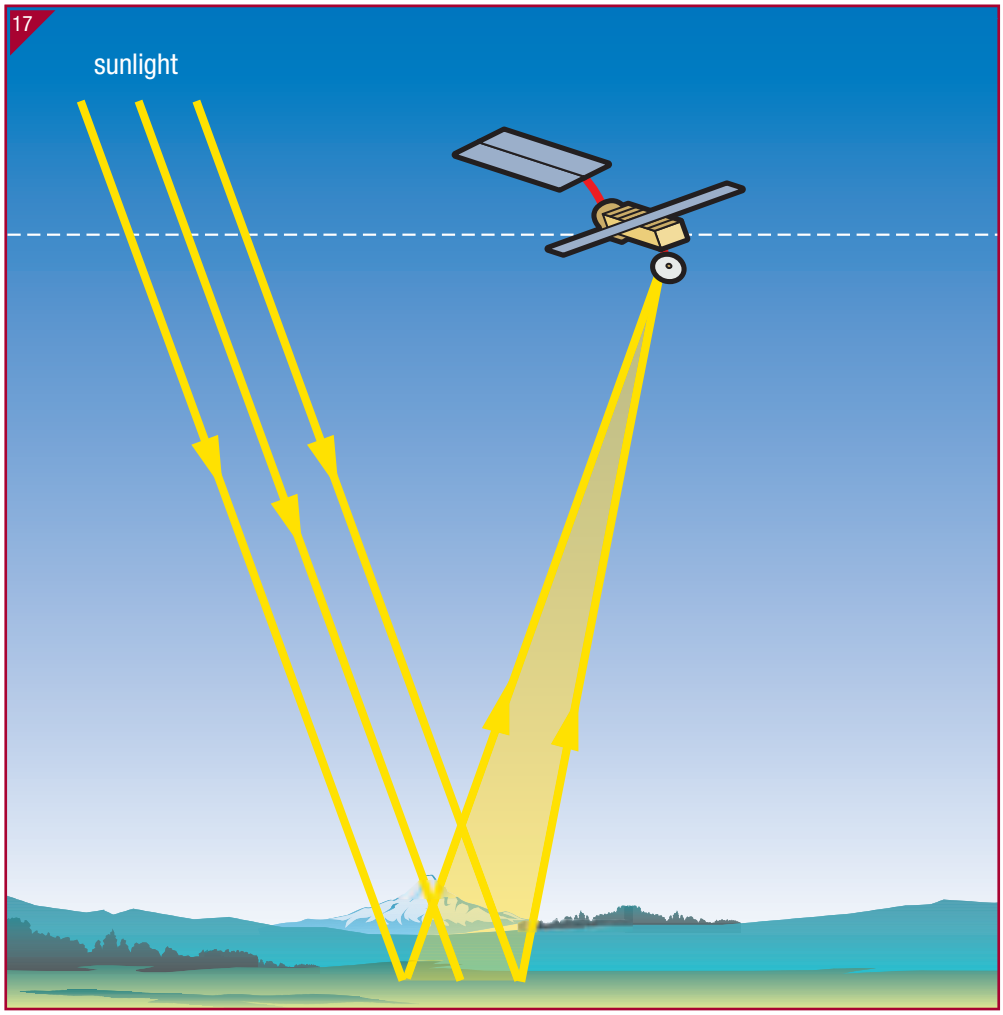
A single satellite may produce various images of a given region, each providing different information. In the left-hand image of this series representing the Nile delta, areas of vegetation are shown in dark green. In the middle image special processing techniques have been used to highlight the sediment deposited by the river into the Mediterranean. In the final image the most humid areas of the delta are shown in blue.





The Nile delta as seen by Envisat.

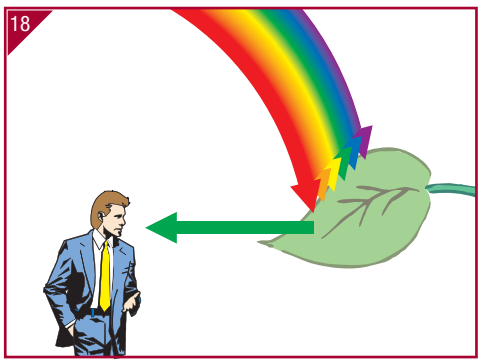
Satellites that detect the sunlight reflected by the Earth

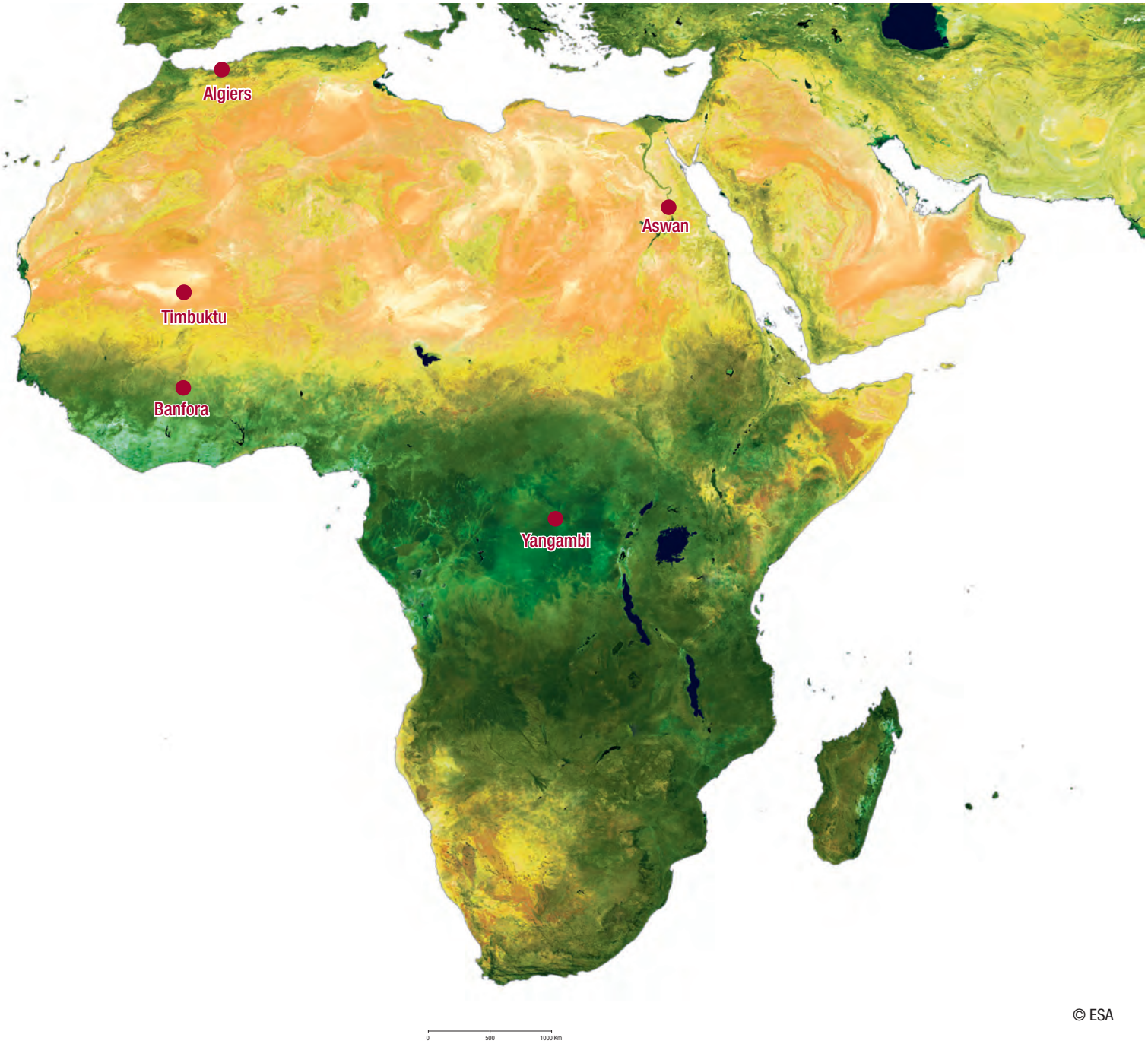


Satellites have on-board instruments able to record sunlight reflected by the Earth.

Although we perceive sunlight as white, it is in fact made up of a combination of all the colours, each with its own specific wavelength. This can be demonstrated using a glass prism which diffracts sunlight to produce a rainbow.

Different objects and materials have different colours because, depending on their composition, they absorb some wavelengths and reflect others. For example, we perceive vegetation as green because it absorbs red and blue and only reflects green back towards our eyes.





Africa

This image belongs to the 'Watching over the Earth' teaching pack from the European Space Agency (ESA). The Living Planet programme.

Information for teachers

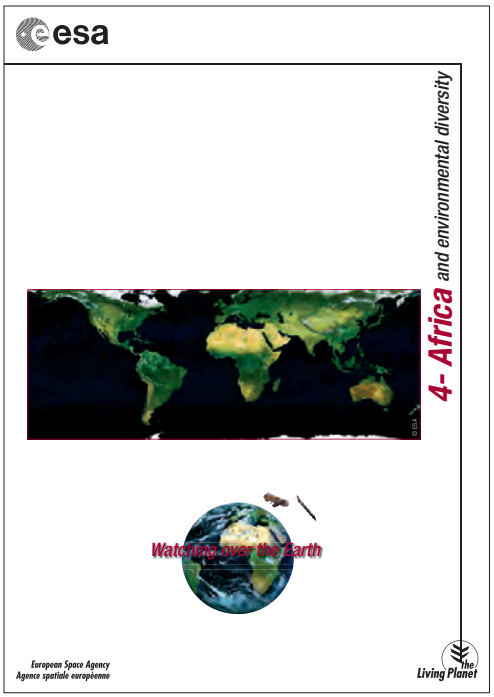
The "Information for teachers" sheets are designed to offer assistance with the preparation of classes and complement the worksheets handed out to pupils. They contain useful information for the presentation of the subject, additional information relating to the satellite images, and a list of websites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

Worksheet 4: Africa and environmental diversity

Worksheet 4 focuses on Africa. It takes a look at the "natural" environments on that continent and their geographical distribution in vast banded areas. Therefore, this worksheet essentially uses a continental scale, but does not preclude you from using these worksheet materials while taking a sub-regional approach.

This worksheet can be used to:

- locate and identify the major "natural" environments on the African continent as well as any inconsistencies;
- analyse bioclimatic domains in Africa and understand the factors that affect the location of these major environments;
- apply concepts such as climate, zones, environment, desert, savannah, etc.



Bioclimatic domains in Africa

Africa is the hottest of the continents. The Equator intersects it approximately half-way down, which is why most of the continent's regions do not have winter, whether they are equatorial or tropical. The northernmost and southernmost extremities of the continent have a few regions with temperate climates such as the North African coast and the South African Cape. Elsewhere, the trade winds coming from the Indian Ocean which could help cool down temperatures are blocked on the Eastern coast of the continent by coastal mountains. Africa is a continent that is less humid overall than Asia, despite its vast equatorial forest, because the African monsoon (rainy season) is far less significant in terms of precipitation volume, and thus has less impact.

North Africa and the South African coastline benefit from a Mediterranean climate. These regions are on the border between temperate and tropical regions. Winters are warm and the summers often bring water shortages which turn streams into mere trickles. Coastal mountains, which receive more water, are covered with scrub and shrub vegetation.

In the tropics, vegetation is nearly absent from the arid sand and rock deserts, the Namib and the Sahara (less than 250 mm of precipitation per year). There are large differences between daytime temperatures—driven by intense solar radiation—and night-time temperatures, when the Earth releases the energy absorbed during the day. The dry tropical region is covered in thorny bushes. It receives occasional rains, but not enough to create a true "rainy" season. This is what distinguishes it from regions with a humid tropical climate where rains fall regularly throughout the summer. Here you find grassy savannahs that become increasingly tree-covered as you approach the Equator and gallery forests lining watercourses.

By the time you reach equatorial Africa, the landscape is covered with dense forests where some trees are over 60 metres tall. The heat and the humidity levels stay constant throughout the year. More than 4 metres of precipitation can fall in a given year! Such differences between zones are the result of gradual change in distance to the Equator, homogeneity of the existing spaces, and also the presence of cold or hot currents along the coasts. The great Namib Desert and the Sahara can be explained by the presence of large tropical anticyclonic air masses, as well as by the presence of cold currents all along the coasts, which prevent the kind of evaporation process that would result in precipitation.

The satellite images

Cover page

Cover image: Earth planisphere

This satellite image highlights geophysical characteristics of the globe.
Of all the continents, it is the geographical extent of Africa and its unique nature resulting from the Sahara Desert which makes it particularly stand out.
To produce this image the Envisat satellite used the MERIS instrument, a wide field-of-view optical sensor which can notably be used to observe vegetation cover. The maximum “swath” of this instrument (the 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. Thus, its data can be used to produce regular representations of the entire globe.
This planisphere has been reconstructed from captures specially selected to eliminate cloudy periods. This view combines partial images which can have been taken a month apart. The oceans, over which substantial cloud masses are to be found, have not been taken into account, and are therefore shown here in black.
Otherwise, the background image used for the title of this series, "Watching over the Earth" was taken by the Meteosat geostationary satellite, which shows cloud mass in the Earth’s atmosphere.

Core content

Image 1: Africa

The image of Africa shown here is the same planisphere as shown on the cover page.

Images 2, 4, 5, 6 and 7: Five types of terrain representative of Africa’s differing bioclimatic domains

These photographs are numbered to allow associations to be made between the types of domain mentioned, terrain, and the 5 towns shown on the satellite image.

Image 3: Casamance

The framed satellite image shows the Casamance region of Senegal. It is one of the first images taken by Envisat, on 22nd March 2002. It shows the transition between savannah and tropical vegetation and the transport of sediment to the ocean. This kind of image provides precious clues as to changes in the soil and its erosion.

Image 9: Temperature and precipitation (five graphs)

These graphs show the meteorological data corresponding to the five towns shown in the main image.

Images 10 and 11: Seasonal variation in vegetation (NDVI image)

Differences between reflection in the visible and in the near infrared can help to determine photosynthesis and plant growth. According to this principle, the NDVI (Normalized Difference Vegetation Index) has been adopted to map worldwide distribution of vegetation. In these images, light green indicates areas where vigorous growth is occurring, while yellow and brown indicate an absence of growth.

A particular effort has been made to map local vegetation in more detail. Satellite data can be interpreted as kilograms of biomass per hectare with great precision (by measuring certain control zones on the ground in order to validate the models and adjusting the results from remote-sensing). Thus, this information, gathered at close intervals across vast geographical areas, allows more rapid detection of problems related to drought and its consequences.

Page 5 - The Nile Valley

Image 12: The Nile Valley and Red Sea

Image captured by the Envisat satellite’s MERIS instrument. The instrument’s resolution is 300 metres.

Image 15: Detail of the Nile Valley

The Nile, 300 km upstream from Cairo. Irrigated land under cultivation and inhabited areas (shown in grey) are concentrated in the valley. Paths, roads and irrigation canals are clearly visible. Assiut can be seen at the river’s edge, where the canal joins the river. The variations from beige to brown are due to the alternation from rock to sand. This image was produced by the SPOT 5 satellite with a resolution of 5m. With such a resolution it is possible to perceive many details, including variations in zones of cultivation.
Generally speaking, the standard resolution of SPOT images is 2.5m, 5m or 10m.

The satellite's various capacities are complementary. Thus, certain images provide information on the oceans, the continents, vegetation, the atmosphere etc., and require a very wide field of view. This is the case with Envisat. High-resolution images, on the other hand, such as those produced by SPOT, provide far more detailed information on a given region. The applications of these satellites are different and the usefulness of the images they produce is not dependent on the resolution of their instruments.

Page 6 – "How do satellites work?"

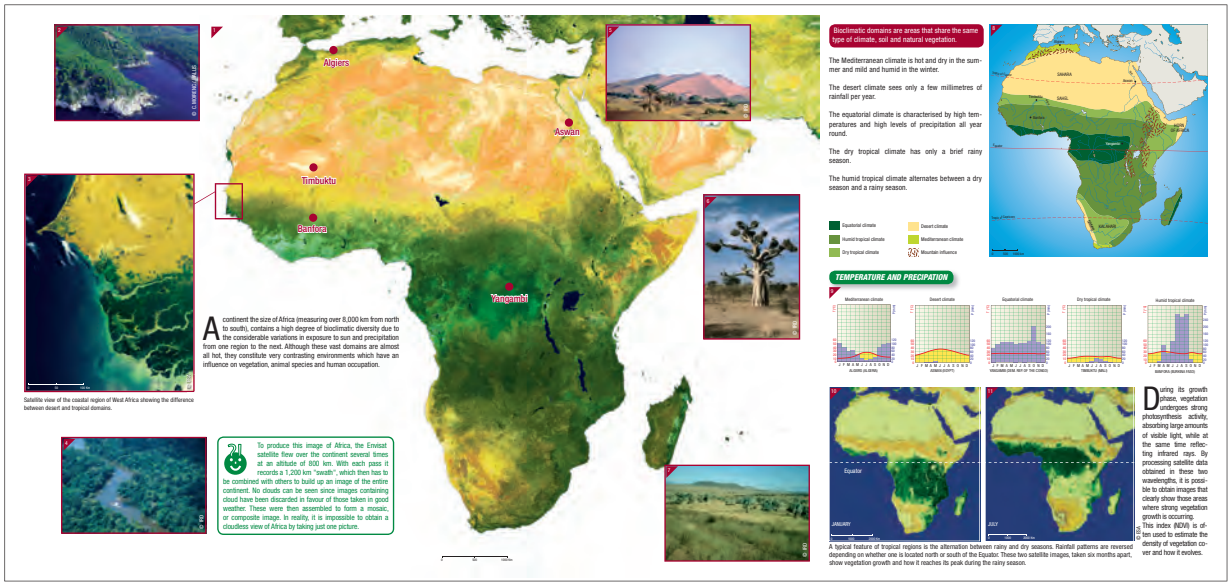
Image 16: Three views of the Nile Delta

These 3 images were taken by the MERIS instrument on board Envisat. By choosing the different spectral bands available on this instrument, it is possible to highlight sediments carried into the sea by the river or reveal the variations in humidity in the delta itself. The city of Cairo is visible at the base of the delta (very dark area in the right-hand picture).

Image 17: Satellites that detect sunlight reflected by the Earth

This graphic illustrates the principle of "passive" satellites, which detect light emitted or reflected by different bodies. A similar graphic, illustrating how "active" satellites work (by emitting a radar signal and recording its echo as it bounces back) is in the next worksheet (N°5: Asia and rice-growing).

With respect to passive satellites, it should be noted that instruments do not only detect sunlight reflected by the Earth, but also the radiation emitted directly by the atmosphere and the Earth.



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

CLIMATOLOGY

en.allmetsat.com/climate/africa.php	Climate data from more than 3000 weather stations
www.metoffice.gov.uk/index.html	Met Office website

NDVI INDEX AND VEGETATION MAPPING

www.eduspace.esa.int/subtopic/default.asp?document=295#vege	EDUSPACE website: remote sensing principles/vegetation mapping
postel.mediasfrance.org/en/BIOGEOPHYSICAL-PRODUCTS/NDVI	POSTEL website: information on soil and vegetation conditions derived from Earth observation satellite data

Satellite images

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Illustrations	Philippe Bouillon - Illustratek
Translations (ESA)	Colin McKinney / Anthony Blend
Production	Europimages - Aliette Cremer

Worksheet N° 4 – Africa and environmental diversity

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

1 – What is the main reason behind bioclimatic diversity in Africa?

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2 – Look at the five photographs, numbered 2, 4, 5, 6 and 7, in the worksheet inner pages. Write down the climate that corresponds to each of the pictures.

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3 – Look at the satellite image of Africa. What do you see between the North and South sections of the continent?

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4 – What large African river flows into the Mediterranean Sea? What can you say about the valley through which the river flows?

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5 – The humid tropical climate consists of alternating dry and humid seasons. During which part of the year do regions to the north of the equator experience the dry season? During which part of the year do regions to the south of the equator experience the humid season?

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6 – Carefully study the page describing the Nile valley. Give a description of the landscape. Briefly explain why this landscape has this appearance.

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7 – Find the three images of the Nile delta on the last page. Do you see anything unusual in the middle satellite image?

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