

Learning Material

# **South America – from coast to coast**

Accompanying Commentary

# Project Information

These learning materials were developed within the project „Columbus Eye – Live Imagery from the ISS in schools“. „Columbus Eye“ is funded by the German Air and Space Center with funds of the Ministry of economy and energy based on decision by the German Bundestag according to the funding code 50JR1307.

The overall project objective consists of the development of comprehensive digital learning materials for use in schools. This offer embraces interactive

learning tools and working sheets which are accessible via the web portal:

<http://www.columbuseye.uni-bonn.de>



## Overview

**Grade** 7-9

**Level** ● ● ● ● ●

**Time needed** 1-2 hours

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**Objectives**  
Pupils should...

- Get to know ISS earth observation
- Orientate spatially with the help of the ISS-panorama
- Identify different land surfaces due to different colour values and derive a thematic map by classification of the respective pixel
- Understand topography and climatic zones using the ISS images

### Topics

Maps

Land Cover and Land Use

Earth Observation from Space

Thematic Maps

### Media & Material

Accompanying Commentary

Online Tool

Exercise sheet

Sample Solution

# Accompanying Commentary

## Incorporation in curriculum and realization of learning unit

Maps represent a key element in geography classes as they serve as a tool for spatial orientation. Important is also the generation of maps which thereby includes the use of remote sensing or aerial photography from which information can be derived for a map.

Two sorts of competencies are addressed with the development of maps and their integration in schools.

- **Spatial Orientation Expertise:** Pupils learn to orientate in the geographical space leading to topographical knowledge
- **Map Expertise:** The perception of geographical space will be trained. Knowledge on the decent interaction with maps is gained and moreover topographic overview charts and simple maps can be developed by the pupils themselves.

The objective of the following learning unit “South America – from coast to coast” is to allow pupils to generate a thematic map out of a digital image with the help of a simple analysis tool. This helps to explain land surface compositions based on the resulting map.

The learning unit uses the computer to transfer knowledge with animation and interaction. A computer-based and interactive learning tool leads to the practical examination of this topic. The analysis tools in this learning unit are implemented in Flash and design-adjusted to enhance the pupils’ understanding.

Moreover, the computer-based learning unit considers the following aspects:

- The structure of the unit is research-oriented and therefore encourages the propaedeutic studying of research.
- The learning unit promotes the organization of lessons focusing on a strong autonomous activity and self-dependence of the pupils.
- The learning unit bears in mind the everyday reality of the pupils.
- As means of labor the computer is integrated here to not only serve as simple device to gather information and entertainment but also to be used as tool. Moreover, the dealing with new media and thereby the media competence of the pupils is strengthened.

## Content-related background

A map is an abstracting model of the earth surface. It can represent a simple and clear reality but its analysis has to be trained to afterwards value the presented contents and reflect about them. By this, the learning unit “South America – from coast to coast” focuses on the abstraction of complex information for map generation as a key competence. For this learning unit on South America, images of the overflight of the ISS – the International Space Station – of the 1st of August 2014 were used. This ISS-panorama provides a continuous depiction of the earth’s surface. With an experienced view of this image and the interpretation of structures and colors, certain land components can be distinguished from each other.

The “classification”, which is later on conducted online using the provided tool, is based on mathe-

mathematical operation best known in remote sensing. Here, color values of aerial and satellite images can be derived into discrete classes. Based on their similarity these are then linked to semantic information. The pupils are conducting a classification on the ISS panorama in several steps using the tool at hand. From a white-colored pixel, the class “ice” can be created automatically, while a grey-colored pixel is classified as “cloud” and so on. The map and its classification depend on how the pupils interpret the landscape of the panorama and how they value the similarity of the pixel in the image. The initial learning unit consists of the following contents:

- Spatial orientation and location of the ISS-panorama
- Identification of different land surfaces and their occurrence in the area
- Selection of training samples for the classification and discussion of the land cover in its spatial origin.
- Classification of the ISS-panorama

### Earth Observation from the ISS

The core of this tool is represented by an image taken during an overflight of the ISS. The International Space Station is the biggest artificial object in the orbit. Every day, the space station is rotating the earth 16 times. One circulation takes about 90 minutes.

The term „remote sensing“ describes the general remote observation of the earth’s surfaces with sensors attached to planes or satellites or – as in this case – to a space station. Via images of the earth’s surface, conditions of ecosystems and their greater environment can be analyzed by observing different surfaces. Also changes in land surfaces can be detected with earth observation if a certain area is crossed multiple times within a certain time frame and several images are provided for analysis.

Therefore, an important aspect of remote sensing compared to general field measurements is the more cost effective possibility to gather information without being in situ.

### Image detection – how is an image created and what is a “pixel”?

The ISS is equipped with four HD-cameras which cover three perspectives embedded in the NASA Experiment on High Definition Earth Viewing (HDEV). One of the cameras owns the so-called Nadir-position being most important for our project as this position most relevant for earth observation. Nadir-position means that the camera is picturing images vertical to the earth’s surface. The cameras of Columbus Eye contain so-called CMOS-sensors. These refer to two-dimensional images as known from digital cameras.

An image – like the ISS-Panorama used in this learning unit – consists of many equal-sized pixels. If you zoom into the image single pixels can be identified. Figure 1 shows a Landsat scene – one image of the sensor Landsat – from 2014 close to Dusseldorf, a city in Germany located north of Cologne in central-western Germany.



**Figure 1** An image consists of many equal-sized pixels. This figure shows an example taken from a Landsat Scene located close to Dusseldorf.

The resolution of the image is 2.1 megapixels. In combination with the flight altitude at 400km (~250 miles), this results in a spatial resolution of around 500m on the ground. This means, every pixel has a measurement of around 500m by 500m.

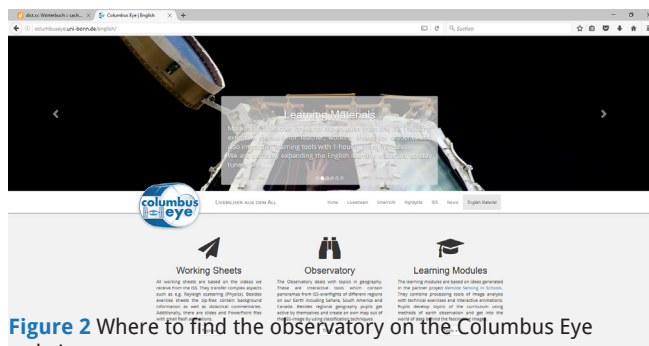
## Content, Structure and Targets of the learning unit.

Overall, the learning unit “South America – from coast to coast” consists of two parts. The first part gives the information that is needed for basic understanding and leads to the second part which deals with the interaction. In the second part the pupils actively create a map using the foregoing classification. The tool and the learning unit based on it can be accomplished in one to two school lessons.

### Structure of the learning unit

Via the Columbus Eye Website ([columbuseye.uni-bonn.de](http://columbuseye.uni-bonn.de)), the Observatorium can be accessed. Here, all learning units using images of the ISS can be found. They help the pupils to transfer their knowledge and understand it sustainably.

The Observatorium is found in „English Material“ on the far upper right on the website of Columbus Eye (Figure 2).



**Figure 2** Where to find the observatory on the Columbus Eye website.

In the observatorium the respective learning units can be found. Maps for orientation next to the unit show the overflight of the ISS with an added orange line which marks the flight path. By clicking on “Application start/close” beneath the overflight path documentation, the respective learning unit is chosen. Here, we choose South America. The pupils will get to the unit directly. The interactive work is conducted online within the main window of the learning unit.

Here, also information about the ISS-panorama and the pictured regions can be accessed. Besides that,

the main component – the classification – can be conducted which finally results in a self-created map.

Additional information can be accessed via “info points” within the image. By clicking those, a window pops up giving better insights in the area or a certain process occurring here. These points can also help to deepen knowledge on e.g. climate zones which might have been already discussed in one of the classes.

Due to the offered possibilities the units of the Observatorium lead to information and interaction of the pupils.

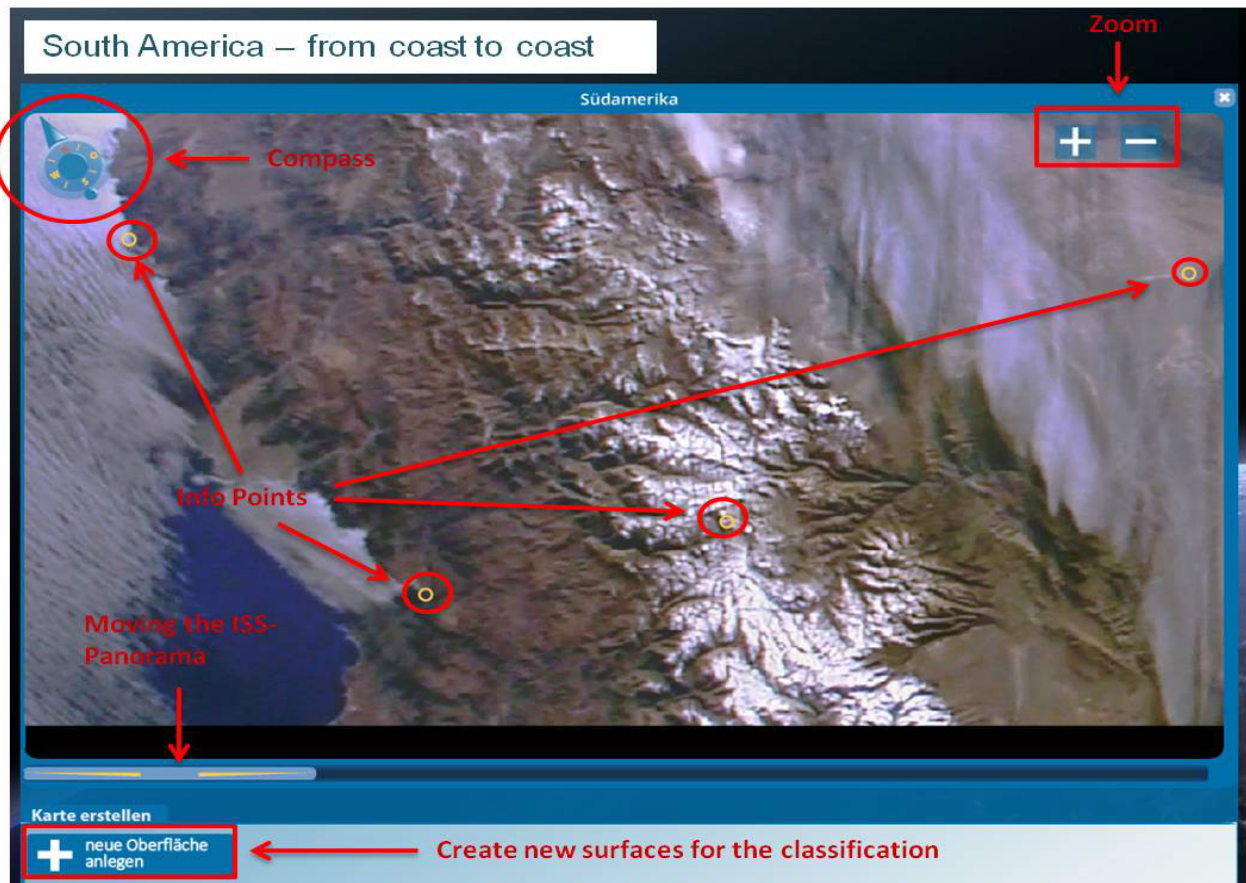
### 1. ISS-Panorama

When opening the tool “South America”, the ISS-panorama will appear. It shows the coast of Chile in the west bordering the pacific as well as the Andes Mountains with snow cover and the Pampas when navigating inland. The panorama was created out of a video of a 5-minute overflight of the ISS crossing the depicted area. Going more into details and by shifting the image, different land surfaces become visible. Looking at the Andean Mountains, snow covered areas can be identified. Some areas are covered by dense clouds or some areas show bare soil or no vegetation at all while others are densely vegetated. Last mentioned can especially be found inland and towards the Atlantic of Argentina.

In the beginning, pupils will get the superordinate assignment to get familiar with the picture of the overflight of the ISS. It is important to identify the different surfaces and assign them to the different climatic zones. Different tools which are listed and explained below the image again will help conducting the analysis.

In the left upper corner of the image a compass can be found which shows the geographical location of the ISS-panorama. The north arrow in this map is not leading to the top as seen by looking at the compass. If you click the north arrow you can take a look at the flight path of the overflight as well as the area which is crossed which explain the position of the north





**Figure 3** Main view and tools of the panorama

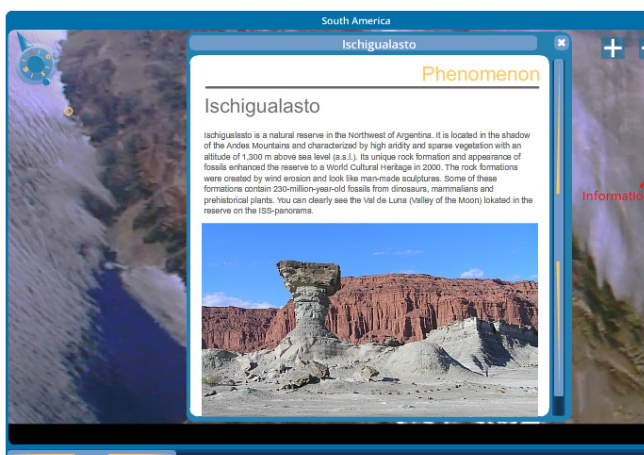
arrow. In the upper right corner of the image two tools can be found to zoom in (+) and out (-) of the image.

Moreover, at the bottom right of the image sliders are located with which you can navigate the image to the northwest (top) and southeast (right).

If you take a closer look, small yellow circles are visible on the map which represent information

points. If you click those points another window - the information box - pops up (Figure 4) which provides more detailed information for the viewers.

In total, this learning unit has nine information points to be found in the map. Besides a salt lake, where salt is quarried, you can find further information on the Andean Mountains, a nature reserve at the coast of Chile or the Pampa. The information points are divided into region and phenomenon. Four info points are embedded in the category phenomenon and five regions are listed. During the online “overflight”, the pupils can detect the region with its geo-ecological and socio-economic processes and natural phenomena. The information points support the discussion of reoccurring topics such as the climatic zones and its characteristics. Each group covers four topics.



**Figure 4** Information Points

**Table 2** List of regions and phenomena to be found in the information points of the panorama

Regionen	Phänomene
<ul style="list-style-type: none"> <li>• The Río Elqui</li> <li>• The Andes</li> <li>• The Río Quinto</li> <li>• Tropical Rainforest</li> <li>• Mar de la Plata</li> </ul>	<ul style="list-style-type: none"> <li>• Pingüino de Humboldt</li> <li>• Ischigalastro</li> <li>• The Salt Lake ‘Salinas del Bebedero’</li> <li>• The ruins of Villa Epecuén</li> </ul>

## 2. Classification

The knowledge of the region prepares the pupils for the classification. Before they start with the classification they should generate a list with land surfaces which they can spot on the ISS-panorama. Here, also structures such as courses of a river or heavy cloud cover that are remarkable can be named.

In the second part of the learning unit the interaction takes place. After the pupils classified the ISS-panorama they can then also create a personalized map to have a more detailed look at their classification.

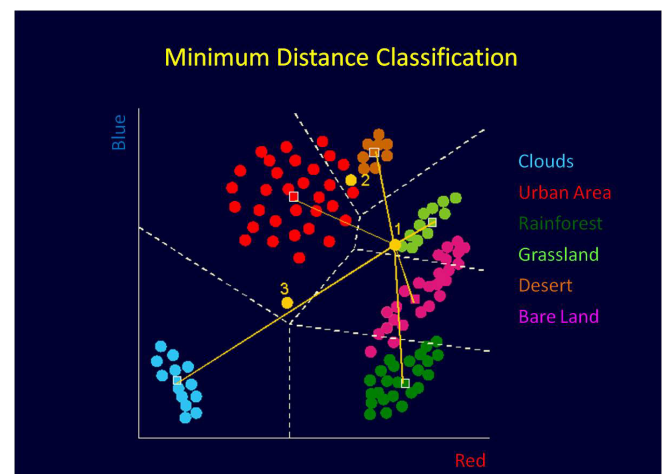
### How does the classification work?

The classification is conducted online. The pupils create so-called “surfaces” in the image. By defining these training samples – which are represented by the “surfaces” – the classifier is trained.

The classification is based on the Minimum-Distance Classification. It is a supervised classification which means that the classification is trained by several training samples. With these the color characteristics of a pixel within a certain area as well as their object characteristics – their distribution – is inquired. The determining variable is the distance of the classified pixel to the midpoint of the color characteristics which are represented by the training samples. The allocation of one pixel to a certain class is conducted via the least Euclidean Distance. The pixel with the

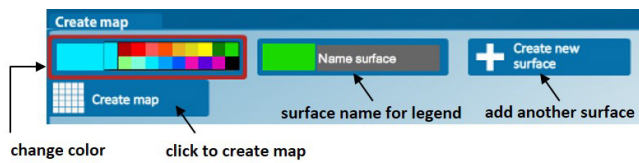
smallest distance to the midpoint of one class will be allocated to this class (see also Figure 5).

By creating a new surface, the pupils choose the respective training samples. On the bottom left information for the surfaces that lead to the classification are given.



**Figure 5** Minimum-Distance-Classification, based on Wageningen UR 1999

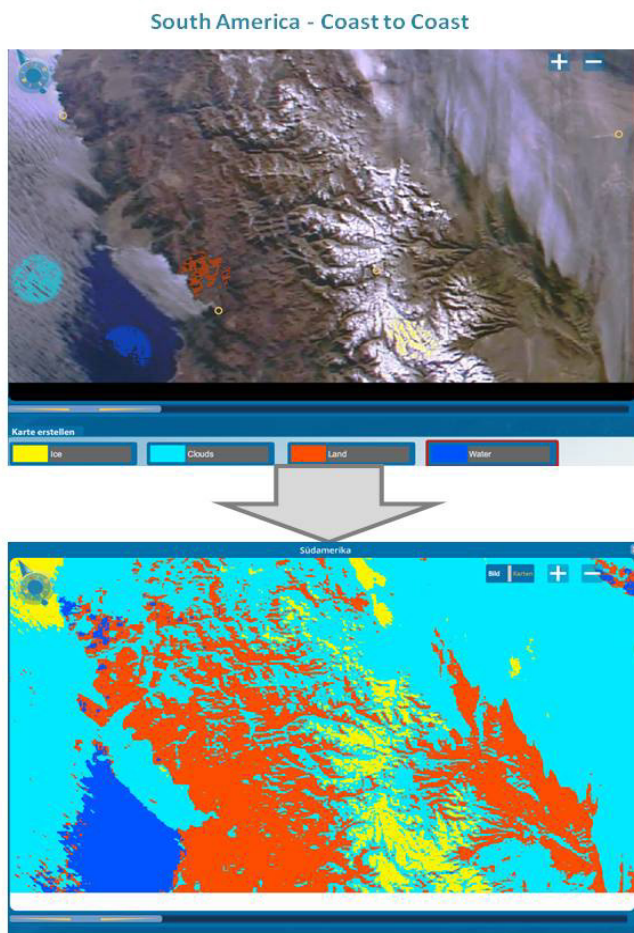
The surfaces represent the respective classes of the map which will be created afterwards. If a new surface is created first a name has to be given to the class. Pupils therefore have to think about how they want to classify the certain areas and have to define them accordingly.



**Abbildung 6** Creation of new surfaces

Among that a certain color can be assigned to each class to identify the surfaces by color. By clicking on the color left to the description you can rename it (Figure 6).

By crossing the picture with the mouse automatically colored circles occur on the map. These circles identify all pixel with the same color characteristics (Figure 7, top). If you click on one area this area is functioning as training sample for the later classification.



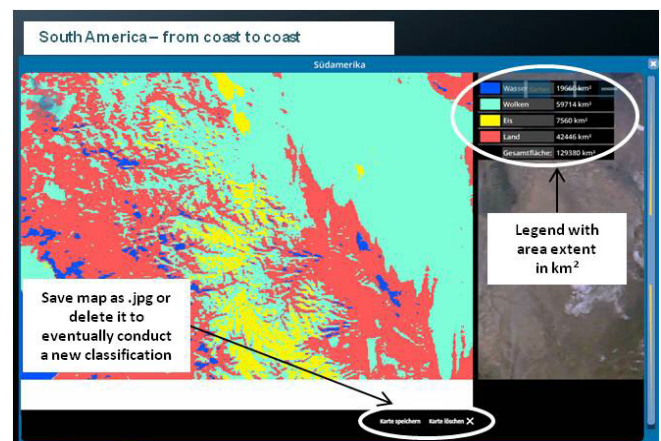
**Figure 7** Top: Identifying training samples “clouds”, “water” and “desert”. Bottom: classified image based on training samples

By activating “create map” the classification is conducted based on the training samples that were

generated before (Figure 7, bottom). All pixel with the same color characteristics as the ones before are assigned to the respective class. If you e.g. create three surfaces – “snow/ice”, “clouds” and “water” – a map with these three classes and their chosen colors is generated. The map refers to the extent area that was shown within the active window of the image. Figure 7 shows the classification of the northeastern part of the ISS-panorama. Here, mainly surfaces such as water, mountains and clouds can be identified. By using additionally the information points furthermore other surfaces can be detected. One of them is the Pampa or also the salt lakes in Argentina.

By testing different classifications, the pupils get more familiar with the region and the topics. When clicking the minus (-) – zooming out – the legend gets visible. Here, additional information is provided on the area that is covered by the certain classes.

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**Figure 8** Classified map with extension of areas and further options to export or delete the map.

Below the map there are furthermore two options: “save map” (as .jpg) or “delete” map. You can also delete the map to start a new classification or save the current classification and start a new one to afterwards compare both approaches (Figure 8).

When getting more in-depth information on climatic zones a certain extent can be chosen in which you



[illegible]

world by subduction: the Nazca-Plate and the South American plate. The process of subduction and how it developed is shown in Figure 9 where the Nazca plate subducts under the South American plate.

# Summary of the learning unit

## 1. ISS - Panorama

### Targets

- Link images of the earth surface to the spatial context.
- get to know the High Definition Earth-Viewing (HDEV)
- Explain the terms: remote sensing and classification
- Detect landscape elements in the ISS-Panorama

### Contents

- The ISS
- earth observation of the ISS
- spatial orientation with the use of earth observation
- Climatic zones

## 2. Classification

### Targets

- Allocating color characteristics of the land surfaces to environmental elements
- derive thematic maps from images of the earth surfaces
- locate deserts and tropical rainforest spatially with the help of surface classification
- explain principles of image classification based on color characteristics and similarities
- measure area extents of single land surfaces

### Contents

- Distinguish colors in an image based on different colors based on different spectral characteristics
- Classification: link color information with semantic information
- Differentiate between climate zones based on their characteristics (e.g. clouds, vegetation)
- Interpretation of developed map

# Stundenplanungshilfe

## Learning tool: „Westafrika - crossing the earth´s biggest desert“

Note: The following class structure is not binding but given for further orientation. Enhancements, additions or omissions can be considered at own will. The learning tool can cover 1 to 2 lessons depending on how certain contents should be intensified or not.

Phase	Content + Goals	Implementation/ Material
Introduction	<ul style="list-style-type: none"> <li>• Elucidations of the learning tool</li> <li>• Introduction to topic - What is the ISS und what is HDEV?</li> <li>• Structure of an image (raster / color characteristics)</li> <li>• Work order:               <ul style="list-style-type: none"> <li>• identify earth surfaces</li> <li>• recognize and describe characteristics of climate zones</li> <li>• develop a thematic map based on a conducted classification</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• lecture by teacher</li> <li>• computer, learning tool</li> </ul>
Preparation	<ul style="list-style-type: none"> <li>• structure of the image</li> <li>• Spatial orientation due to visual analysis of the ISS-Panorama, content-wise orientation due to the info points located in the image</li> <li>• Distinguishing land surfaces and allocation of climatic zones</li> <li>• Creation of training samples for the classification to afterwards generate a thematic map</li> </ul>	<ul style="list-style-type: none"> <li>• Group work (pair-wise)</li> <li>• Material: Computer, Learning Tool</li> </ul>



## Columbus Eye – Live-Imagery from the ISS in Schools

Remote Sensing Research Group (RSRG), Department of Geography, University of Bonn, Funding BMWi funding code: 50 JR 1307

Saving Results	<ul style="list-style-type: none"><li>• save map</li><li>• allocation of map to ISS-Panorama</li><li>• Listing land surfaces as derived from image</li><li>• Completion of exercise sheets to get more insights in classification topics as well as in characteristics of the region</li></ul>	<ul style="list-style-type: none"><li>• Group work (pairwise)</li><li>• Material: Computer, Learning Tool</li></ul>
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